



Textbook For Capacity Building of Environmental Management Units in Metal Sector

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Ankara, 2017

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SindNova



SINDICATUL

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FOREWORD

Close relation between the workplace and the environment as well as the impact of health and safety policies on environmental problems affect workers and the working conditions in a workplace. Environmental factors have impact upon workers both during production process and daily life together with their families, which in turn makes environmental protection an important topic from the perspective of trade unions.

In line with the environmental regulations in Turkey, workers take part at each step of the work while blue-collar workers are not legally required to be involved in environmental management units, and therefore they are not assigned as such. As a result of analysis carried out in enterprises, some companies have engaged blue-collar staff in environmental management, activated auto control mechanisms and enhanced efficiency of the system. Some other companies did not limit themselves with that; they included blue-collar staff in environmental committees and gained leverage in the system by doing so. In this scope, green-collar environment support staff can be identified in current Turkish system, which will increase efficiency of both communication and intervention in case of danger like environmental accidents.

Within this framework, Turkish Metal Union has carried out a joint project on “Capacity Building for Environmental Management Units in Metal Sector” (CBEM-MS) with SindNova (Trade Union Research Institute) and Ecoman (Urbino University Environmental Research Agency) from Italy and Sindicatul Metal Federation (ICA) from Romania.

A Pedagogical Committee has been established through project activities and this textbook has been created in order to provide environmental management units with support. Conferences have been organized both in Turkey and Italy with the aim of raising awareness by pointing out the differences between project outputs and current systems. A pilot training of 1 month – 2 weeks theoretical, 2 weeks practical – has been delivered in Italy to 15 workers from Turkey who are members of Turkish Metal Union and 5 workers who are members of Sindicatul Liber Independent ICA. Lectures throughout the training have been recorded and uploaded on website with subtitles with the purpose of ensuring sustainability and dissemination. 15 participants from Turkey have also been provided with the opportunity of attending Italian language courses in Turkey for a month before the training.

The Pedagogical Committee, established within the scope of CBEM-MS project at the preparation stage of this textbook, is made up of academicians from Uludağ University, Faculty of Environmental Engineering, sectorial experts from Çolakoğlu Metaruliji Co., environmental management engineers from Ford Otomotiv and INDESIT Company White Goods Ind. and Co. from Turkey as well as academicians from Italy Sapienza University, which have contributed in the preparation of textbook.

This textbook has been printed as 300 copies in Turkish, 100 copies in Italian, 100 copies in Romanian and 100 copies in English as well as 100 CDs in Turkish, Italian, Romanian and English.

In this regard, as Turkish Metal Union, our objective within the scope of “Capacity Building for Environmental Management Units in Metal Sector” (CBEM-MS) is to increase employability of young workers in metal sector, to promote professional expertise in the field of environment, to raise awareness on environmental safety and to enhance environmental conscience. As Turkish Metal Union, we believe that enforceability of environmental policies can only be achieved through providing people with scientific insight and increasing environmental awareness.



Pevrul KAVLAK
Turkish Metal Union
President

INTRODUCTION

“Capacity Building for Environmental Management Units in Metal Sector” (CBEM-MS) Project has been carried out in the scope of Erasmus+ strategic partnership programme coordinated by Turkish National Agency under the executive coordinator of Turkish Metal Workers’ Union.

With the project in coordination with Sindnova (Union Development Association) and Ecoman (Urbino University Environmental Research Agency) from Italy and Sindicatul Metal Federation (ICA) from Romania; we aimed capacity building in terms of environmental awareness in enterprises, communication, auditing and coordination mechanisms, inclusion of workers as green collar staff in environmental management units and an opportunity for prevention of environmental accidents.

In the framework of the principles established by Europe 2020 strategy and education and training 2020, the project has indented to establish a strategic partnership between social partners, research institute, educational/academic institutions, in order to strengthen their cooperation and fruitful exchange of good practices in the field of environmental policies.

The strengthening of European and Turkish network composed by social partners, research institute, educational and academic institutions, represents the key for better addressing the challenging topic of professional training and lifelong learning approach. The strategic partnerships between European and Turkish actors have allowed having a fruitful exchange of good practices in the field of environmental policies carried out at company level. The project also has responded to the need of identifying and developing the professional role of “environmental specialist”.

Within this framework, a pilot training of 1 month has been organized in Italy to 20 workers on environmental issues by SindNova and Ecoman experts.

In addition to this **“Textbook for Capacity Building for Environmental Management Units in Metal Sector”** has been prepared. At the preparation stage of this textbook a Pedagogical Committee has been established. The pedagogical committee has made several meetings, technical visits to ThyssenKrupp, Fiat and Whirlpool companies in Italy to examine environmental management systems during the project. Also a preliminary test on environmental issues has been administered in metalworking industry to 221 workers to measure their awareness and knowledge.

In this textbook; capacity building of environmental management units in metal sector, environmental sustainability, the role of trade unions on environmental issues, legislations in Europe and Turkey has been analyzed. Also the iron and steel industry, the household appliances productions, the motor vehicle industry scenarios, best available techniques (BAT), processes, technologies and main environmental issues and the treatment and valorization of materials at the end of the cycle of life issues has been submitted with great extent of scope.

Special thanks to the pedagogical committee staff Prof. Mario Beccari (Ecoman), Prof. Gaetano Cecchetti (Ecoman), Prof. Enrico Rolle (Ecoman), Prof. Paolo Cecchetti (Ecoman), Thomas Blasi (Ecoman), Sara Morelli (Ecoman), Silvia Fava (Ecoman), Federica Rolle (Ecoman), Claudio Stanzani (Sindnova), Michela Cirioni (Sindnova), Mairangela Zito (Sindnova), Arpad Suba (ICA), Gheorghe Alexandru Posedaru (ICA), Adnan Parcali (Turkish Metal Workers' Union), Cem Snaet (Turkish Metal Workers' Union), Prof. Dr. Feza Kara (Uludağ University), Doç. Dr. Fatma Olcay Topaç Sağban (Uludağ University), Araş. Gör. Dr. Efsun Dindar (Uludağ University), Özkan Erdem (Çolakoğlu Metaruliji A.Ş), Ceylan Aydın (Çolakoğlu Metaruliji A.Ş), Burak Yontar (Ford Motor Company), Afşar Ürüt Ülgen (INDESIT Company Beyaz Eşya San. Ve Tic. A.Ş) due to their contribution.

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A. Capacity Building of environmental management units in metal sector

At the beginning of 2014 the Turk Metal Workers' Union launched together with the University of Urbino "Carlo Bo" through its spin-off Ecoman - Ecological Management, the Sindicatul Liber Independent ICA of Romania and the Institute for the study of Innovation of the productive work transformations SindNova, a project under the Erasmus Community funding line + / STRATEGICAL PARTNERSHIP. Whose purpose is the transfer of knowledge through EU-Member countries to those in acceptance through education and high-level training in order to better pursue the reduction of greenhouse gases and combat climate change, as required by the EU 20-20-20 targets.

The project, entitled "Capacity Building of environmental management units in the metal sector" aims to create a strategic partnership between the social partners, research institutes, educational and academic institutions, in order to strengthen mutual cooperation and a fruitful exchange of good practices in the field of environmental policies.

The strengthening of European and Turkish network composed by social partners, research institute, educational and academic institutions, represents the key for better addressing the challenging topic of professional training and lifelong learning approach. The strategic partnerships between European and Turkish actors will allow to have a fruitful exchange of good practices in the field of environmental policies carried out at company level. The project responds to the need of identifying and developing the professional role of "environmental specialist".

The network consists of strengthening European and Turkish social partners, research institutes and educational and academic institutions, it is the key to tackling the challenging issue of vocational and continuing training. The strategic partnership between Europeans and Turks actors allow a fruitful dialogue on good practices in the field of environmental policies implemented at the corporate level. The project responds to the need to identify and develop environmental expert professional".

The project aims therefore, through a synergic partnership between Turkey, Italy and Romania at promoting the development of new skills and to job creation. The transfer and implementation of good practices at national and European level will represent the tool by which better improving vocational skills and knowledge of partners involved in project partnership. The project will provide the partners with proper tool of vocational training, aimed at developing professional paths on the environmental sector, in order to promote a better inclusion in the Turkish labour market, strengthen economic stability and growth through higher employment rates.

Among the positive impacts foreseen, the project will focus on the following results:

- Improving the levels of skills for employability;
- Improving a better understanding and recognition of skills and qualifications, in the field of environmental experts;
- Improving competences linked to the professional profile;
- Greater understanding of interconnections between formal, non-formal education, vocational training and labour market;
- Increasing opportunities for professional development.

The action has been conceived in order to promote professional expertise in the field of environment, in order to increase employability of young workers of metalworking sector. The long-lasting effect of the project will be represented by a greater economic stability and growth, through the raising of employability rates in Turkey. Training materials of the project will be developed and tested through the implementation of a pilot training course, addressed to young workers operating in the field of metalworking.

The definition of new professional profiles and paths will allow a better collocation in the Turkish labour market and will increase occupational opportunities for young workers. The needs and opportunities offered by the Turkish labour market will be met, according to the requirements expressed by Turkish social partners in the field of metalworking.

The strategic partnership established among organizations from Turkey, Italy and Romania will ensure a long-lasting synergy, based on the transfer good practices in the field of professional training and national case studies on environmental policies at company level.

The strategic partnership will pursue the following aims:

- enhancing the quality and relevance of the learning offer in training and youth work, by developing new and innovative approaches and supporting the dissemination of best practices;
- fostering the provision and the assessment of key-competences, in the field of environmental expertise;
- Increasing labour market relevance of learning provision and qualifications and reinforcing links between training and the labour market.

Among the priorities taken into account in the definition of the project, special focus will be given to the promotion of “young people’s social inclusion and well-being, notably through projects tackling the issue of youth unemployment.”

Through integration of green-collar environmental support personnel into the existing system in Turkey, it is envisaged that both effectiveness in communication and response to various dangerous situations such as environmental accidents will improve. By establishing a pedagogical committee with the participation of representatives of multi-national companies which have firms in partner countries, academicians who are experts in their field in Turkey and partner countries and representatives of metal workers union, a training infrastructure will be built upon the review of laws, regulations sectors and best practices in partner countries. Having benefited from a theoretical and applied training, target group will be tested within the system as green-collar personnel and in the end their integration into the system in Turkey will be supported.

Innovations in this context and elements that will improve current system in Turkey are as follows;

- Blue-collar personnel who have so far not been included into environmental management system by laws and regulations in Turkey will take part as green-collars in parallel to the needs of the sector,

- Environmental accidents will be minimized,
- Effective control mechanisms will be established in order to prevent environmental accidents thanks to blue-collar personnel who work at all of the departments in companies.
- Current blue-collar personnel will gain qualifications and skills within the framework of European Qualifications Framework (EQF) and besides, by helping unemployed young people acquire qualifications and skills in line with European Qualifications Framework, we will be able to increase their chances of getting employed.
- By raising awareness among companies in metal sector with regards to the need for environmental support staff, there will be new employment opportunities in many companies in the field of environmental management system depending on the needs.
- Open education resources and ICT based training materials which will be available for use of everyone working or willing to work in the metal sector will allow comparison and development in institutional and individual level.
- Target audience, which will be provided with mobility through training, will be exposed to best practice at international level and therefore be more beneficial to their enterprises. It will ensure that thanks to their improved or acquired skills, they will either be promoted or their chances of getting employed will be higher.

The project lasted 24 months and throughout this period various environmental aspects and issues related to steel production, home appliances and automobiles production have been discussed. The transnational scientific committee has prepared in support of the course a number of documents OER (Open Education Resources) that collect the best practices and their application in the environmental field to these three areas. These best practices studied have been collected from the BREF (IPPC Bureau) and by case studies and deployment of Italian and foreign companies in the identified industrial fields and they will likely be added in future BREF.

All the material produced has been included in this manual, and published in English, Turkish, Italian and Romanian language. Including all materials of the pilot course, which are freely available on the online platform.

Results of the test on the education level of the users

A pilot training course has been implement, from 20 August to 20 September 2016 with the presence of 20 people chosen by the Turkish Metal Workers' Union, Turk Metal and the Romanian ICA, which were the first to obtain the status of "Environmental Manager". The course was held at the campus of the University of Urbino and covered the transfer of good environmental practices.

To better focus the course on the actual level of the participants and end-users a short test was developed to assess the level of knowledge and understanding of environmental issues. The test was structured with general questions and multiple choice comprehension questions of texts taken from technical and scientific publications related to the implementation of good practices in the environmental field.

The test was administered to more than 200 workers and employees in the Turkish metalworking industry and the outcome has been that of a relatively poor overall environmental knowledge, however with a clear distinction by age group. Younger workers demonstrated a wider basic understanding about environmental sustainability than their older counterparts did.

B. Environmental sustainability

The increasing scale of human activities relative to the biosphere is inflicting serious damage to the natural global environment (World Commission on Environment and Development 1987).

One class of related environmental concerns includes global warming, ozone depletion, and loss of biodiversity, none of which are solvable without widespread fundamental change in the structure of political, economic, religious, and cultural systems. Another class includes concerns that can be identified and defined as environmental problems to

be solved or at least ameliorated through public policy and management efforts without basic systemic restructuring. Appropriate public policy and management responses to environmental problems are dependent on the quality of human thought. They involve complex considerations about ecology, goals, benefits, costs impacts, distributional effects, equity, implementation, and evaluation, among many other things. The quality of thought becomes relevant especially when the dimensions of the problems are not aligned with the way knowledge about these considerations is presented in institutions of learning.

Climate change and developing countries

There is growing scientific evidence that global warming due to greenhouse gas emission is causing climate change at an alarming rate thereby posing serious challenge to social, economic and ecological system across the globe. Existing and increasing concentrations of greenhouse gases seem likely to increase the mean and extreme air and ocean temperatures, rise in sea levels, changes in precipitation patterns, and increase in intensity of extreme events. These changes are in-turn likely to drive changes in the ecosystems upon which billions of people depend for their livelihoods and well-being. It is also hugely perceived that the poorest people in developing countries are going to be worst affected as they are heavily dependent on climate sensitive sectors. A number of scientific reports, in last few years, have further contributed to this apprehension and observed climate change as one of the greatest threats in ensuring welfare in both developed and developing nations.

Success in future environmental management in developing countries will rely heavily on improving the quality of the institutional arrangements through which social responses to problems are conducted. To successfully carry out effective environmental management programs, environmental decision makers need to recognize and understand: (1) the basic dimensions and classification of environmental problems, (2) the different modes of environmental management, and (3) how to integrate these modes to effectively manage different types of environmental problems.

Developing and implementing an environmental management program

In the conceptual design stages of developing and implementing

an environmental management program, the first requirement is to recognize the inherent dimensions of the target environmental problem. These basic dimensions can then be combined to form two classificatory attributes, (1) environmental complexity, and (2) political complexity. In general, as the level of environmental and political complexities involved in an environmental problem increases, the jurisdiction should gradually shift to central authorities. Effective environmental management demands different institutional responses that are aligned with the corresponding type of environmental problem.

In turn, this puts a premium on the capacity of environmental managers to interpret the problem in a way that enables them to match problem dimensions with institutional responses. The appropriate place to start responding to an environmental problem involving high levels of environmental complexity is with environmental planning. This enables information, scientific knowledge, and associated understanding of various disciplines to be integrated into environmental management practices.

The integrative management

The concept of integrative management represents SD's integrative view of aspects of social development, economic growth and environmental protection. Integrating social, economic and environmental concerns in planning and management for sustainable development has received considerable attention in recent years. It is believed that in order to achieve sustainability and ecological integrity, i.e. to preserve the natural capital stock, integrative and holistic management approaches are needed.

The Rio-Declaration (UNCED, 1992) states that the protection of nature should form an integral part of the development process. Chapter 8 of Agenda 21 (UNCED, 1992) notes that the prevailing systems for decision-making in many countries tend to separate economic, social and environmental factors at the policy, planning and management levels, influencing the actions of all groups in society and affecting the efficiency and sustainability of development. Therefore, it proposed integrated systems of management to ensure that environmental, social and economic factors are considered together in a framework for SD. Four broad areas of work are identified: integrating environmental

concerns and development at the policy, planning and management levels; providing an effective legal and regulatory framework; making effective use of economic instruments and market and other incentives; and establishing systems for integrated environmental and economic accounting. It argues that an adjustment or even a fundamental reshaping of decision-making may be necessary in order to put the environment and development at the centre of economic and political decision-making. The integrative approach for achieving sustainability, according to Agenda 21, seeks to bring together all stakeholders. It argues that the responsibility for bringing about changes lies with governments in partnership with the private sector and local authorities, and in collaboration with national, regional and international organizations. In addition, national plans, goals and objectives, national rules, regulations and law, and the specific situations in which different countries are placed are the overall framework in which such integration takes place.

Achieving sustainable development

Achieving sustainable development will require deep structural changes and new ways of working in all areas of economic, social and political life. Economic growth patterns that actively favour the poor should be promoted. Fiscal policies that negatively affect the poor or promote environmental damage will need to be reformed. In the longer term, countries will want to ensure that their net wealth, including natural, man-made and human capital, remains constant or increases. Innovation and investment in actions that promote sustainable development should be encouraged. Among other things, this will require the development of a market pricing structure in which prices reflect the full social and environmental costs of production and consumption.

Sustainable development therefore has important governance implications. At the national and local level, it requires cross-sectoral and participatory institutions and integrating mechanisms which can engage governments, civil society and the private sector in developing shared visions, planning and decision-making.

Governments, corporations and development cooperation agencies will also need to be more open and accountable for their actions. More generally, economic planning and policy-making will have to become more participatory, prudent and transparent, as well as longer term so

as to respect the interests of future generations. The difficulty of these challenges does not mean they can be shirked. A strategy can offer a framework to organize and coordinate action to address them.

Codes of environmental behaviour for businesses have also been developed in the 1990s, most notably, the Coalition for Environmentally Responsible Economies (CERES) principles. The CERES principles promote responsible economic activity for a safe, just and sustainable future. In 1990 the International Chamber of Commerce also developed a set of 16 guiding principles known as the Business Charter for Sustainable Development or the Global Environmental Management Initiative (GEMI) Principles.

A number of empirical studies have also concluded that adopting environmental management does bring certain advantages for the businesses.

Some studies illustrated that six critical elements are needed in order to create an effective proactive environmental management system. They suggest that a champion within the company is to assume responsibility for environmental issues. This environmental management champion must be a person with superior management skills and influence within the organization with the authority to allocate adequate resources to environmental management. He/she is likely to be a senior executive within the company. Proactive companies should also have environmental policies and strategies that reflect sound environmental goal. Furthermore, environmental goals and targets should be both clear and measurable. To ensure commitment to environmental policies, there is a need to decentralize environmental management. Everyone associated with the business must be involved in environmental management, including suppliers, customers and employees. Training and education programs are thus essential for employees. An environmentally proactive company should also engage in monitoring, auditing and reporting its environmental performance.

Achieving environmental excellence

Some studies emphasize that in order to manage change better, it is necessary to conduct assessments of environmental projects, manage human resources; employees share the common vision and are empowered to act on it. They suggest that adequate training will also

be needed for employees to avoid costly environmental mistakes and to increase environmental awareness. They also suggest that there is a need to hold managers accountable for environmental performance by linking merit systems to the achievement of environmental goals. “Empowerment”, “Education”, “Efficiency” and “Excellence” were introduced as a four key concepts:

“Empowerment” recognizes the importance of leadership and the corporate vision in achieving environmental excellence. “Empowerment” comprises involvement of employees in setting specific environmental goals to achieve the corporate environmental vision and the creation of “green” teams to implement environmental projects. “Education” consists of open communications and disclosure by the companies with their customers, suppliers, employees, regulators and other stakeholders with regard to environmental performance and practices. “Efficiency” recognizes the need for companies to improve their efficiency measures, which can be classified into three categories: (1) Pollution prevention. (2) Waste reduction. (3) Energy efficiency.

Total quality management (TQM) principles were merged with environmental management. The main underlying common concept for both TQM and environmental management is that both are trying to reduce waste. Zero defects mean zero waste. The importance of audits and benchmarking are also stressed under this concept. Welford (1994) suggests that for any company committed to improving its environmental performance, the starting point must be to make a clear statement of that commitment through an environmental policy. Appropriate organizational structures must also be set up with clear lines of authority and communication channels. All activities of the organization should be identified and documented. Environmental audits and reviews need to be carried out. The environmental impact of products must be evaluated via life cycle assessments.

Critical factors of environmental management explanation

(1) Top management commitment to environmental management

Setting an environmental vision or corporate policy. An overall strategy established to guide the company’s effort to achieve the vision. Strategic planning by top-level management incorporates environmental inputs. Environmental issues are being integrated into critical business

functions and operations. Participation of top-level managers in environmental projects. Sufficient resources allocated to implement certain environmental projects

(2) Total involvement of employees

“Green” teams are being set up to tackle environmental problems. Employees are empowered to handle environmental problems and are actively involved in the process of determining environmental goals. The company’s suggestion schemes encourage employees to give suggestions on environmental performance improvement. Employees are recognized for their contribution to improve environmental performance of the company. Performance evaluation is linked to the achievement of environmental objectives

(3) Training

Employees to be trained in skills that are required to fulfil their environmental responsibilities and achieve their environmental goals. Educate employees to increase their environmental awareness. Environmental training scope and content should also be regularly reviewed and improved. Resources must also be allocated for training.

(4) Green product/ process design

Design production processes and products in such a way that it minimizes adverse impact on the environment. Life cycle analysis used to assess the environmental impact of products throughout the entire life span of the products. Products are redesigned to reduce the negative environmental impact. Production processes are examined to reduce the amount of waste, energy consumption and emissions. Adopt a preventive approach and integrate environmental concerns into the product during its design phase. Recycling activities carried out to ensure full usage of resources

(5) Supplier management

Environmental performance used as one of the criteria when choosing a supplier. Environmental expectations of the company are clearly communicated to the supplier. The company should educate the supplier with regard to environmental issues and involve suppliers during the product development phase. Environmental audits or certification programs are to be carried out by the firm on its suppliers

(6) Measurement

Objective measures established to gauge the level of environmental performance. Life cycle cost assessment used to estimate the cost of environmental impacts of a product. Environmental audits carried out periodically to ensure compliance with environmental rules (7) Information management

Environmental information must satisfy four main criteria; timeliness, accessibility, accuracy, and relevance. An effective information management system is established to collect and maintain environmental information.

Challenges and opportunities for the environmental performance in developing countries

Industrial environmental problems can be related to energy use, resource use, water and air pollution, waste generation, environmental risks, biodiversity, transport, and so forth. The severity of these environmental consequences may vary, depending on the technologies used in the industrial production processes, the organization and management of the production, the coordination of the various steps in the production–consumption chain (in terms of information flows, substance flows, management preferences, etc.), the regulatory regimes at various levels (from local to supra-national), and the reactions from citizens and consumers towards products and production. These environmental problems occur within the context of a rapidly changing world where technological innovations, new organizational and management approaches, globalizing production–consumption chains, increasing communication and information exchange possibilities, and changing power balances. These economic, political and technological transitions provide new challenges but also new opportunities for the environmental performance in these countries. The export oriented character of most Asian industries forces them, for example, to include the global environmental requirements for the industrial chains and their products, a pressure which may be expected to become more intense in the coming years.

At the same time, the social, political, economic, cultural, and geographic conditions and resources of each country are unique, contributing to important particular challenges and novel solutions. Variations in

dynamics and conditions among Southeast Asian nations can be found at the national as well as at the local and sector levels.

At the same time, most of the small- and medium-sized enterprises need financial support and technological expertise to seriously tackle the resulting wide range of environmental problems, mainly caused by inefficient production processes and by the inability to adopt adequate environmental treatment measures.

Although sometimes rather simple organizational or technical measures, based on the principles of cleaner technology, could generate promising results in reducing pollution intensity at low or negligible costs, small- and medium-sized enterprises are yet constrained in implementing them by various attitudinal, institutional, organizational, technical and economic barriers.

In general, government authorities and social organizations increasingly realize that effective environmental governance depends on transparency, accountability, and the availability of high-quality information concerning economic processes and related environmental effects. Therefore, environmental concerns must be integrated across sectors and mainstreamed into economic policy and practice. Environmental protection must be considered an essential factor in the basic decision making process of firms, households and policy makers.

Thousands of enterprises across the EU are covered by the authorization scheme introduced by the Integrated Pollution Prevention and Control (IPPC) Directive. It aims to prevent, reduce and eliminate pollution at source, through the efficient use of natural resources and the establishment of an EU wide integrated permitting system.

The IPPC Directive represents a departure from the traditional command and control approach towards a more integrated and flexible approach as it does not prescribe the technology to achieve the desired environmental outcome. Emissions reduction and environmental improvements are required, on the basis of what is achievable with the best techniques available in the individual industrial sectors falling within the scope of the Directive.

C. The role of trade unions on environmental issues

Protecting the environment has increasingly become a matter of trade union relevance. It cannot be considered any longer just a sectoral topic addressed to professionals, neither a business opportunity for companies. Trade union social partners have raised their awareness about the tight interrelation between workplace and environment. The impact of health and safety policies on environmental issues affects workers at the workplace and their working conditions. Workers and their families are exposed to the negative impact of environmental dangers, both in the production process at the plant and in their daily lives.

Therefore, starting with their own members, trade unions should promote efforts towards society to raise awareness, warn workers about potential treats, and organize them. Trade unions should play a major part due to their role as workers' representatives and actors of industrial relations, key players in social interest groups, characterized by a strong commitment to workers' rights. They should be responsible for the challenges posed by environmental issues and work towards solutions for addressing them.

There is a wide range of trade union initiatives aimed at protecting the environment, as well as a range of strategies used by workers' representatives to promote the fight against climate change, even during negotiations. However, despite the urgency in addressing environmental issues, the capacity of intervention of trade union social partners differs from country to country.

Turkey, in its quality as Pre-Accession Country to the EU, is characterized by a heterogeneous background. It is not possible to assert that trade unions in Turkey have holistic environmental policies. In addition to the lack of social awareness and active involvement in environmental issues, the reason is due to the current conditions of trade unions, the increasing loss of social rights and high unemployment rates that impede a proper engagement on the environmental topic. Moreover, the tendency of Turkish trade unions to prioritize their members' problems instead of addressing new social issues like the environment, is one of the reasons that explain the lack of proper solutions on environmental issues.

Moreover, another element of controversy is the impact that environmental policies may have on workers. While, in most of the cases, white collars are not directly affected by them, blue collars (especially those working in manufacturing industry and underground mining) may face the side effects of environmental policies at their workplaces. Paradoxically, when environmental policies set strict rules there may be consequences in terms of workers' unemployment and financial instability for companies.

Another problem in Turkey refers to the lack of information and consultation of workers' representatives on environmental issues. Despite their role, workers' representatives do not have a voice in the decisions taken by the management. It remains a prerogative of the management whether to address or not the issue. In the majority of the cases, employers tend to avoid expenses that refer to environmental issues and usually they demonstrate the lack of pro-active attitude.

In this framework, in order to avoid conflicts trade unions can refer to collective bargaining, meetings, campaigns, national and international assemblies, training activities and media. They can also gain the support of civil society organizations and recur to judicial remedy in case it may be needed.

However, positive elements can be underlined in the Turkish scenario. Despite this general unbalance in prioritizing the impact of health and safety on environmental issues has a direct impact on workers, it is worth mentioning the role played by some trade union federations in addressing the issue with specific project and activities. In this context, Turk Metal Workers' Union has implemented a project titled "*Capacity Development in Environmental Administrations in Metal Sector Business*". The aim of the Federation was to increase the employability of young workers in metal sector and to encourage environmental professionalism, awareness on environmental safety and environmental sensibility. Turk Metal Workers' Union carried out the project in the belief that raising awareness on environmental issues would increase the adoption of environmental policies.

From the perspective of **EU Member States**, the improvement in manufacturing efficiency and the actions aimed at making production processes more secure, sustainable and green, represent nowadays

an area of trade union action that is in expansion. Nevertheless, the development of social dialogue in companies and in the local areas is limited to communication campaigns, vocational training programs, exchange of good practices and, sometimes, promotion in the use of renewable energies.

The system of industrial relations can play a key role in environmental protection, organizing, restructuring and re-orienting towards sustainability goals of productive sectors, accompanying the processes of transition to a green economy.

In order to accomplish such a goal, it is necessary that companies and policy makers recognize in trade unions the role of representing the interests of organized workers, but also of the families and population located in a given territory.

National trade unions of EU Member States are fundamental social actor for assessing and validating environmental risks, corporate policies of sustainability and assessing improved living and working conditions.

Concerning the most recent legislative initiatives, a major role in this regard will be played by social partners after the transposition at national level of the **Directive 2014/95/EU⁽¹⁾** of the European Parliament and the Council concerning the **disclosure of non-financial and diversity information** by certain large undertakings and groups. It amends the Directive 2013/34/EU ⁽²⁾ concerning the annual financial statements, consolidated financial statements and related reports, by including the reference to information on the “social accountability” of multinational companies. In this framework, workers’ representatives will be able to stress the importance of being informed about environmental issues that may affect the workforce. As stated in the Directive 2014/95/EU,

¹ Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups

² Directive 2013/34/EU of the European Parliament and of the Council of 26 June 2013 on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings, amending Directive 2006/43/EC of the European Parliament and of the Council and repealing Council Directives 78/660/EEC and 83/349/EEC

“Where undertakings are required to prepare a non-financial statement, that statement should contain, as regards environmental matters, details of the current and foreseeable impacts of the undertaking’s operations on the environment, and, as appropriate, on health and safety, the use of renewable and/or non-renewable energy, greenhouse gas emissions, water use and air pollution. As regards social and employee-related matters, the information provided in the statement may concern the actions taken to ensure gender equality, implementation of fundamental conventions of the International Labour Organisation, working conditions, social dialogue, respect for the right of workers to be informed and consulted, respect for trade union rights, health and safety at work and the dialogue with local communities, and/or the actions taken to ensure the protection and the development of those communities.[...].”⁽³⁾

European Member States are required to transpose the Directive by 6 December 2016.

Moreover, workers, through trade union organizations in enterprises, hold (according to EU legislation) the rights of information and consultation concerning raw materials used in production cycles, technologies, emissions into the air in water and soils, waste management, energy use and savings, prevention strategies. The exercise of these rights needs culture and support tools such as training and expert assistance.

Also for trade unions of EU Member States, there is still room for improvement in terms of workers’ safeguard on environmental protection. In companies, trade unions should be able to organize specific forms of representation that are similar or integrated with those already covered by the issues of protection of health and safety at work; these union delegates, competent on environmental matters, should be assigned specific rights of information and training and the opportunity to make use of experts of their choice.

Collective bargaining can be an important tool to guide and support the policies of environmental and energy sustainability of companies.

³ Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups

The employment crisis can also find in the new development of sustainability a real opportunity to enrich, innovate and create new skills and professional roles for new additional job opportunities such as green jobs, by enhancing and disseminating new skills already present in companies and institutions.

The importance of education and training addressed to workers' representatives and trade unions should be stressed, with the aim of increasing environmental awareness, especially among workers and their families. Trade unions, with educational activities and publications, can inform workers about health, security, and environment, ecologic problems and the effects of those problems on workers, the environmental dangers that production creates and the possible solutions.

Trade unions are entitled to ask employers for better prevention measures in terms of environmental training course, exchange of information on environmental rights, data on pollutant wastes released from workplaces and so on.

Those efforts could help workers to better understand the extent of the problems and produce possible solutions. Trade unions, in collaboration with employers' organizations and non-governmental organizations, should also be able to carry out an educational system for addressing society as a whole.

In order to be effective, environmental policies should be combined in a wider strategy, with other social policies like health, employment, education and urbanization. Thanks to this synergy, trade union social partner could achieve better results.

Chapter 1

“General aspects”

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1.1 The European Union environmental legislation

1.1.1 Introduction

In the European Union the production of legislative provisions that protect the environment begins in the mid-80s. Before this period the European Union does not have the competence to making law in environmental field. The Member state could make law on environment protection outside of the communitarian procedure. In reality, the environmental issue was not a central issue on the agenda of European governments.

The competence to legislate in the environmental field enter into the Treaty of Rome with the ‘Single European Act’, which inserts a new Title VII, dedicated to the environment. It consists of three articles: 130R, 130S and 130T. Article. 130R, paragraph 1, specifically assigns the task to Community law “*to preserve, protect and improve the environment, contributing to the protection of human health and ensure prudent and rational use of natural resources*”.

With the Single European Act in 1988, are approved for the first time all three legal principles underlying the European environmental law: *the principle of preventive action, the repair of damage at source and the polluter pays principle*.

The article. 130R provided that environmental policy should be integrated with other EU policies, such as industrial, agricultural and energy, calling the European Community to take all measures necessary to ensure effective development and a quickly execution. It also decided that the environmental decisions were taken unanimously.

These competences were later expanded with the Maastricht Treaty on European Union of 1993, which gives environmental action the status of a real EU policy. With the Treaty of Maastricht, environmental protection makes its entry in the Preamble, while among the tasks of the Community is entered “*developed sustainable non-inflationary respecting the environment*” (art. 2).

The environmental provisions are moved to a separate Title XVI, always entitled “*Environment*”, and the three basic principles included in the Treaty in 1987 was added a fourth, the *principle of precaution*. The EC

also introduced the principle that decisions in the environmental field may be adopted on the basis of a qualified majority. With the Treaty of Amsterdam in 1997, the Treaty on European Union receive new numbers of article. The articles of the environmental compartments become Articles 174, 175, 176.

In accordance with article 174, paragraph 2 of the Treaty, Community policy on the environment is based on the principles of precaution and preventive action, the principle of priority intervention at source to protect the environment, and the principle polluter pays.

The precautionary principle was introduced by the Maastricht Treaty in 1993, and has its origin in the international context. In particular Article 15 of the Rio Declaration signed in 1992 at the United Nations Conference on Environment and Development, included in its original formulation “*states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is not harmful, the burden of proof that it is not harmful falls on those taking an action*”

A Commission Communication on the precautionary principle later in 2000 specified the content of this principle ⁽⁴⁾.

The Communication also states that the Environmental and human health protection measures can be adopted under the precautionary principle. In particular, if an intervention is necessary, the measures must be proportionate to the chosen level of protection, non-discriminatory in their application and consistent with similar measures already adopted. They must also be based on an examination of the costs and potential benefits of action or lack of action and be the subject of revision in the light of new scientific evidence. The measures must be kept in force for as long as the data scientific remain incomplete, imprecise or inconclusive and as long as the risk is considered too high to be imposed to community.

The *polluter pays principle* was introduced into Community legislation in order not to allow the manufacturers to download the costs of their pollution on the community. In other words through the polluter pays principle, the Community legislature has tried to internalize

⁴ COM/2000/0001 def. <http://eur-lex.europa.eu/lega>

environmental costs in the companies responsible for environmental damage. From a legal point of view the application of the polluter pays principle must be connected to the so-called permitted pollution. In other words, if a company pollutes, despite the respect of its authorization, in particular the authorization granted under the IPPC (Integrated Pollution Directive 2008/1 / EC preventing control) the economic burden of such pollution will have to be covered by the polluter or the whole community. We will analyze this aspect in deeper way in the following para.

Starting from the legal basis of the EU Treaty, the Community Institutions over the last 30 years, has begun to approve a set of Directives and Regulations for environmental protection, in order to standardize the different national laws. Institution of European Community in compliance with the principles just mentioned has developed the Community legislation. Every Communitarian Act in the environmental field has been adopted in an attempt to apply the principles set out above.

In general, the last legal aspect that we have to stress in order to clarify the legal framework between the European Union and Members States in environmental field, regarding the sharing of legislative competence between State and Community institutions.

The EU has only the competences conferred on it by the Treaties (*principle of conferral*). Under this principle, the EU may only act within the limits of the competences conferred upon it by the EU countries in the Treaties to attain the objectives provided therein. Competences not conferred upon the EU in the Treaties remain with the EU countries. The Treaty of Lisbon clarifies the division of competences between the EU and EU countries. These competences are divided into 3 main categories:

- ✓ exclusive competences;
- ✓ shared competences;
- ✓ supporting competences⁽⁵⁾.

⁵ <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Aai0020>

Having said that these are the main forms of EU legislation:

Regulations - are addressed to all member states and are applied in full. They are directly applicable without the need for national legislation

Directives - are addressed to all member states and require an objective to be achieved by a given date. National authorities must draw up legislation in order to conform to the directive within a certain time frame (the date of implementation is known as the date of transpositions).

It is therefore clear that in the case of exclusive competence the EU should use the Regulation, while in the case of shared competence, given the need to leave some discretion to Member States, the right instrument will be the Directive.

The Member States have delegated to EU a legislative shared competence on Environmental issue. This means that the European Union has the task of adopting Community Directives to establish the environmental protection objectives to be achieved by Member States through the implementation of European Directive. Each Member State is free to choose the means and the way to reach the EU targets.

In truth, during the last ten years the EU Directives in the environmental field have become always more specific and have regulated not only the objectives of environmental protection but also the ways in which to reach them.

In some cases, the European directives have been adopted by EU in a specific and detailed so that the legal experts judged them directly applicable in the Member States, without the need for national transposition. (Directive self-executive).

In these cases it would be more appropriate that the European Union had used the instrument of Community Regulation, rather than Directives. But considering the fact that the European Union's competence in matters of environmental protection is shared competence, this approach would not be in line with the EU Treaty. The remainder of this section we will analyse in detail the various environmental protection instruments/institutions, which have been approved through the issuance of Directives. As of now, we can list them by associating them with individual environmental principles, such as: EIA (environmental

impact assessment) SEA (strategic environmental assessment); the IPPC (Integrated Pollution Prevention Control). These Directives are a concrete application of the prevention and precautionary principles. Just to give another example, the framework directive on waste management is based on the principle of polluter pay and Prevention precautionary principle.

In the following paragraph, we will describe an overview of the Community Environmental Legislation. The European Directive will not be listed and described on the basis of a time criterion for approval. For logical reason we will follow this kind of list:

- ✓ Administrative authorization for environmental protection; (EIA, SEA, IPPC)
- ✓ Waste Management
- ✓ Directives aimed at the protection of individual environmental elements (Directive on water management and atmosphere)
- ✓ Administrative procedures for environmental protection (remedial procedure, environmental responsibility).

1.1.2 Administrative authorization for environmental protection

Directive 85/337/ECC and Directive 2014/52/EU on Environmental Impact Assessment (EIA)

The European Union Directive 85/337/ECC on the Environmental impact assessment (EIA), known as the EIA Directive, sets the basic concepts related to the formal process used to predict the environmental consequences (positive or negative) of project prior to the decision to move forward with the proposed action. The most recently amended EIA Directive (**2014/52/EU**) simplifies the rules for assessing the potential effects of projects on the environment. It also improves the level of environmental protection, with a view to making business decisions on public and private investments more sound, more predictable and sustainable in the longer term. More attention is given to areas like resource efficiency, climate change and disaster prevention, which are now better reflected in the assessment process. The starting point of the Directive is that public and private projects, which are likely to have significant effects on the environment, should be allowed only after

prior assessment of the likely significant environmental effects. This assessment must be conducted by the competent authority taking into account the appropriate information supplied by the developer, which may be supplemented by the authorities and by the people who may be concerned by the project in question.

The European Union Directive 85/337/ECC and following amendment and revisions had identified the kind of projects subject the EIA procedure. The Members States are able to involve other project not listed in the Directive if it will assess appropriate to enlarge the project list.

Following, we will list the main kind of projects subject the EIA procedure:

- ✓ Crude oil refineries as well as the gasification and liquefaction of 500 tons per day of coal or oil shale, as well as regasification terminals liquefied natural gas.
- ✓ Installations for: - power stations and other combustion installations with power temperature of at least 300 MW; - Plants for the production of hydroelectric energy with power of 30 MW higher concession including dams and reservoirs directly subservient;
- ✓ Equipment for the extraction, as well as for the treatment and the transformation asbestos and products containing asbestos; Nuclear power stations and other nuclear reactors, including the dismantling or decommissioning of such power stations or reactors.
- ✓ rural roads with four or more lanes, or realignment and / or widening of existing roads to two lanes so as to provide four or more lanes, where such new road or the stretch of road straightened and / or widened in a continuous length of at least 10 km;
- ✓ The EIA procedure has to follow the following administrative steps:

- a) Defining the contents of the study of environmental impact;
- b) The presentation and publication of the project;
- c) Conducting consultations;
- d) The evaluation of the environmental study and the results of the consultations;
- e) The decision;
- f) Information on the decision;
- g) Monitoring.

The environmental impact study shall include at least the following information:

- ✓ Description of the project comprising information on its characteristics, to its location and its dimensions;
- ✓ Description of the measures envisaged to prevent, reduce and, if possible, remedy significant adverse impacts;
- ✓ the data required to identify and assess the main impacts on the environment and cultural heritage that the project can produce, both under construction and in operation phase;
- ✓ an outline of the main alternatives studied by the applicant, including the so-called zero option, specifying the main reasons for his choice, taking into account the environmental effects;
- ✓ Description of measures envisaged for monitoring.

During the consultations the public concerned can express opinions and considerations on the basis of the preliminary project and the environmental impact study.

The competent authority (CA) carries out the technical and investigative activities for the environmental impact assessment.

The competent authority can give a favourable opinion to the execution of the project. Otherwise, the competent authority shall give a positive opinion with prescriptions that the proponent will have to incorporate into the project. The last option the competent authority will not grant

authorization, and then the project cannot continue being assessed, due to its environmental impacts not in compliance with the standard requested by the EU directive.

Directive 2001/42/EC on Strategic Environmental Assessment (SEA)

The experience of the application of the EIA Directive in the Member States has made realized to the Community legislature the need for an environmental assessment tool at a stage prior to the presentation of a project (infrastructural and industrial project).

Just to make an example, when the proponent start the EIA procedure on a new stretch of highway the public authority has already decided that this mobility need will be addressed through the creation of a highway. Instead, in the earlier stage the public authority should evaluated whether respond to this need by building a highway or a railroad for example. Thus, the Community legislature at the beginning of the 2000s has begun to think of combining the phase of approval of plans and programs (for example the infrastructure plan, or mobility plan) with parallel proceedings in order to involve in the decision making also environmental concerns.

In order to respond to this needs the European Union adopted the **Directive 2001/42/EC on the Strategic environmental assessment (SEA)**, known as the **SEA Directive**. The SEA sets the basic concepts related to establish a systematic decision support process, aiming to ensure that environmental and possibly other sustainability aspects are considered effectively in plan and program making. Effective SEA works within a structured decision framework, aiming to support more effective and efficient decision-making for sustainable development and improved governance by providing for a substantive focus regarding questions, issues and alternatives to be considered in plan and program (PP) making. For the most part, an SEA is conducted before a corresponding EIA is undertaken. SEA is a legally enforced assessment procedure required by Directive.

The EU directive also includes other impacts besides the environmental, such as material assets and archaeological sites. SEA should ensure that plans and programmes take into consideration the environmental effects they cause. If those environmental effects are part of the overall

decision taking it is called *Strategic Impact Assessment*.

The SEA Directive applies to a wide range of public plans and programmes (e.g. on land use, transport, energy, waste, agriculture, etc.). The SEA Directive is in force since 2001 and should have been transposed by Member States in July 2004.

Plans and programmes in the sense of the SEA Directive must be prepared or adopted by an authority (at national, regional or local level) and be required by legislative, regulatory or administrative provisions.

The SEA Directive does not have a list of plans/programmes similar to the EIA.

An SEA is mandatory for plans/programmes which are:

- ✓ prepared for agriculture, forestry, fisheries, energy, industry, transport, waste/ water management, telecommunications, tourism, town & country planning or land use and which set the framework for future development consent of projects listed in the EIA Directive.

Or

- ✓ have been determined to require an assessment under the Habitats Directive

For the plans/program not included above, the Member States have to carry out a screening procedure to determine whether the plans/program are likely to have significant environmental effects. If there are significant effects, an SEA is needed. The screening procedure is based on criteria set out in Annex II of the Directive.

The SEA procedure can be summarized as follows:

- ✓ an environmental report is prepared in which the likely significant effects on the environment and the reasonable alternatives of the proposed plan or programme are identified.
- ✓ the public and the environmental authorities are informed and consulted on the draft plan or programme and the environmental report prepared.
- ✓

- ✓ as regards plans and programmes which are likely to have significant effects on the environment in another Member State, the Member State in whose territory the plan or programme is being prepared must consult the other Member State(s). On this issue the SEA Directive follows the general approach taken by the SEA Protocol to the UN ECE Convention on Environmental Impact Assessment in a Transboundary Context.

The SEA and EIA procedures are very similar, but there are some differences:

- ✓ the SEA requires the environmental authorities to be consulted at the screening stage;
- ✓ scoping (i.e. the stage of the SEA process that determines the content and extent of the matters to be covered in the SEA report to be submitted to a competent authority) is obligatory under the SEA;
- ✓ the SEA requires an assessment of reasonable alternatives (under the EIA the developer chooses the alternatives to be studied);
- ✓ under the SEA Member States must monitor the significant environmental effects of the implementation of plans/programmes in order to identify unforeseen adverse effects and undertake appropriate remedial action.
- ✓ the SEA obliges Member States to ensure that environmental reports are of a sufficient quality.

In the EIA procedure key players are: the proposing the project, usually a private subject, and the competent public authorities to assess the environmental impact study. In SEA procedure, the main players are usually all public entities: the competent authorities in charge to adopt the Plan, and the competent authorities in charge to assess the environmental impacts of the plan or program.

Just to give an example in the case of the adoption of the Energetic National Plan, the proposing authority is the Ministry on infrastructures; the competent authority is the Ministry of Environment. The environmental report will be prepared initiative of the Ministry of infrastructure through a continuous dialogue with the competent authorities / Environment Ministry.

The subject involved will develop the SEA procedure, according to the following administrative steps:

- a) The elaboration of the environmental report;
- b) conducting consultations;
- c) The assessment of the environmental report and the results of the consultations;
- d) The decision;
- e) Information on the decision;
- f) Monitoring actions.

In the environmental report must be identified, described and assessed the significant impacts that the implementation of the plan or the proposed program could have on the environment and cultural heritage, as well as reasonable alternatives that can be adopted.

The information, which the proposing authorities must include in the environmental report, are as follows:

- a) Outline of the contents, main objectives of the plan or program and relationship with other relevant plans and programs;
- b) The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or program;
- c) Environmental, cultural and landscape of areas likely to be significantly affected;
- d) Any existing environmental problems which are relevant to the plan or program including, in particular those relating to areas of particular environmental importance, culture and landscape.
- e) The environmental protection objectives, established at international, Community or Member States, relevant to the plan or program, and the way in which, during its preparation, the proponent authority has taken into account of those objectives and any environmental considerations;
- f) The likely significant impacts on the environment, including on issues such as biodiversity, population, human health, flora and fauna,

soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors. They should consider all significant impacts, including secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative;

g) The measures envisaged to prevent, reduce and offset as fully as possible any significant adverse impacts on the environment of implementing the plan or program;

The environmental report and the results of the consultations are taken into account before adoption. Once the authority adopts the plan or programme, the public is informed and relevant information is made available to them. In order to identify unforeseen adverse effects at an early stage, significant environmental effects of the plan or programme are to be monitored.

All citizens or entities concerned may submit comments to the Plan and program in order to achieve improvements to the environmental impact of plans and programs. After this, the competent authority shall issue its decision. Such decision to be implemented by the proponent in adopting the final plan or program in order to choose from the various options available, the most in line with the principle of sustainable development.

The European Union Directive 2010/75/EU on the Industrial emissions is the successor of the Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC).

The European Union **Directive 2010/75/EU** on the **Industrial emissions** is the successor of the **Directive 96/61/EC on Integrated Pollution Prevention and Control (IPPC)**. The Industrial Emissions Directive (IED) is aimed at minimizing pollution from various industrial sources throughout the European Union. Operators of industrial installations covered by Annex I of the IED are required to obtain an **integrated permit** from the authorities in the EU countries. The IED is based on several principles, namely integrated approach, best available techniques, flexibility, inspections and public participation. The **integrated approach** means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy

efficiency, noise, prevention of accidents, and restoration of the site upon closure. The purpose of the Directive is to ensure a high level of protection of the environment taken as a whole. Should the activity involve the use, production or release of relevant hazardous substances, the IED requires operators to prepare a baseline report before starting an operation of an installation or before a permit is updated having regard to the possibility of soil and groundwater contamination, ensuring the integrated approach. The permit conditions including emission limit values (ELVs) must be based on the **Best Available Techniques (BAT)**, as defined in the IPPC Directive. To assist the licensing authorities and companies to determine BAT, the Commission organizes an exchange of information between experts from the EU Member States, industry and environmental organizations. This work is co-ordinated by the European IPPC Bureau of the Institute for Prospective Technology Studies at the EU Joint Research Centre in Seville (Spain). This results in the adoption and publication by the Commission of the BAT conclusions and BAT Reference Documents (the so-called BREFs).

The IPPC Directive requires industrial and agricultural activities with a high pollution potential to have a permit. This permit can only be issued if certain environmental conditions are met, so that the companies themselves bear responsibility for preventing and reducing any pollution they may cause. Integrated pollution prevention and control concerns new or existing industrial and agricultural activities with a high pollution potential, as defined in Annex I to the Directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, livestock farming, etc.).

In order to receive a permit an industrial or agricultural installation must comply with certain basic obligations. In particular, it must:

- ✓ use all appropriate pollution-prevention measures, namely the best available techniques (which produce the least waste, use less hazardous substances, enable the substances generated to be recovered and recycled, etc.);
- ✓ prevent all large-scale pollution;
- ✓ prevent, recycle or dispose of waste in the least polluting way possible;

- ✓ use energy efficiently;
- ✓ ensure accident prevention and damage limitation;
- ✓ return sites to their original state when the activity is over.

In addition, the decision to issue a permit must contain a number of specific requirements, including:

- ✓ emission limit values for polluting substances (with the exception of greenhouse gases if the emission trading scheme applies-see below)
- ✓ any soil, water and air protection measures required;
- ✓ waste management measures;
- ✓ Measures to be taken in exceptional circumstances (leaks, malfunctions, temporary or permanent stoppages, etc.);
- ✓ Minimization of long-distance or transboundary pollution;
- ✓ Release monitoring;
- ✓ All other appropriate measures.

In order to coordinate the permit process required under the Directive and the greenhouse gas emission trading scheme, a permit issued in compliance with the Directive is not obliged to contain the emission limit values for greenhouse gases if these gases are subject to an emission trading scheme, provided there is no local pollution problem. The competent authorities can also decide not to impose energy efficiency measures targeted at combustion plants.

All permit applications must be sent to the competent authority of the Member State concerned, which will then decide whether or not to authorize the activity. Applications must include information on the following points:

- ✓ a description of the installation and the nature and scale of its activities as well as its site conditions;
- ✓ the materials, substances and energy used or generated;
- ✓

- ✓ the sources of emissions from the installation, and the nature and quantities of foreseeable emissions into each medium, as well as their effects on the environment;
- ✓ the proposed technology and other techniques for preventing or reducing emissions from the installation;
- ✓ measures for the prevention and recovery of waste;
- ✓ measures planned to monitor emissions;
- ✓ possible alternative solutions.

Without infringing the rules and practice of commercial and industrial secrecy, this information must be made available to interested parties:

- ✓ the public, using the appropriate means (including electronically) and at the same time as information concerning the procedure for licensing the activity, the contact details of the authority responsible for authorising or rejecting the project and the possibility for the public to take part in the licensing process;
- ✓ the other Member States, if the project is likely to have cross-border effects. Each Member State must submit this information to interested parties in its territory so that they can give their opinion.

Sufficient time must be allowed for all interested parties to react. Their opinions must be taken into account in the licensing procedure.

The decision to license or reject a project, the arguments on which this decision is based and possible measures to reduce the negative impact of the project must be made public and sent to the other Member States concerned. The Member States must, in accordance with their relevant national legislation, make provision for interested parties to challenge this decision in the courts.

The Member States are responsible for inspecting industrial installations and ensuring they comply with the Directive. An exchange of information on best available techniques (serving as a basis for setting emission limit values) is held regularly between the Commission, the Member States and the industries concerned. Reports on the implementation of the Directive are drawn up every three years.

Recalling what has been said in the preamble of this paragraph, the IPPC Directive and, in particular, the issuance of permit as a result of the above procedure, put on the table a complicated legal issue. If the installation complies with the emission limits set by the authorization, but in spite of this the competent authority finds some overcoming of pollutants in the soil or groundwater, who should be considered obliged to cover the costs of environmental restoration actions?

In the following paragraphs we will try to answer this question, when we describe the directive on environmental liability.

1.1.3 Waste Management European Union Directive 2008/98/EC

The European Union **Directive 2008/98/EC** sets the basic concepts and definitions related to **waste management**, such as definitions of **waste, recycling, recovery**. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odors, and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU Member States shall apply as a priority order the following waste management hierarchy:

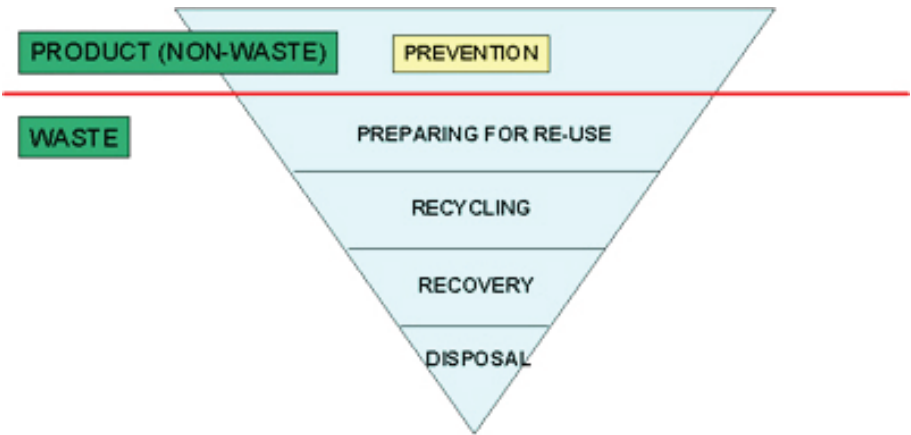


Fig. 1.1. Waste management hierarchy

The Directive has been adopted by the EU taking into account the “polluter pays principle” and the “extended producer responsibility”. The Directive requires that Member States adopt waste management plans and waste prevention program.

Having said that before to analyse in detail the waste management is appropriate to highlight a fundamental legal issue. Waste management, due to the negative implications on the environment and health that poor management can result, it is considered of public interest activities. So all operators in the sector to operate must first be authorized to carry out that particular activity (waste collection, recycling, recovery, treatment and disposal). If the operator performs any of the activities mentioned above without authorization or permit could be subject to criminal sanctions in court proceedings. In order to analyse the European legal framework for waste management is appropriate begin with an analysis of the definitions laid down by the Directive, such as:

- ✓ **Definition of waste:** means any substance or object which the holder discards or intends or is required to discard;
- ✓ **waste management** means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker;
- ✓ **Definition of waste producer :** means anyone whose activities produce waste (original waste producer) or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of this waste;
- ✓ **Waste holder:** means the waste producer or the natural or legal person who is in possession of the waste;
- ✓ **Dealer :** means any undertaking which acts in the role of principal to purchase and subsequently sell waste, including such dealers who do not take physical possession of the waste;
- ✓ **Prevention:** means measures taken before a substance, material or product has become waste, that reduce: the quantity of waste, including through the re-use of products or the extension of the life span of product or the adverse impacts of the generated

waste on the environment and human health or the content of harmful substances in materials and products;

- ✓ **Re-use** means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived;
- ✓ **Treatment** means recovery or disposal operations, including preparation prior to recovery or disposal;
- ✓ **Recovery** means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II sets out a non-exhaustive list of recovery operations;
- ✓ **Recycling** means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations;
- ✓ **Disposal** means any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I sets out a non-exhaustive list of disposal operations.

Definition of by product and secondary raw material (end of waste)

As mentioned previously, the Directive **2008/98/EC** has established a new hierarchy of actions for the management of wastes. Landfilling should be the last option available to producers.

First of all the legal framework has the objective to avoid the production of waste in this sense is useful to recall the prevention definition. On the basis of this new approach the European legislative predicted the new legal categories that allow not to consider certain products as waste in the case in which a series of conditions are met.

2. On the basis of the conditions laid down in paragraph 1, measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by-product and not as waste referred to in point (1) of Article 3. Those measures, designed to amend non-essential elements of this Directive by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39.

The examples of by-products within the industrial process can be manifold, just to give an example, in the steel industry for the machining of steel scraps, can be easily reused in the production process, without creating any danger for the environment and health. From an application point of view the requirements listed above must all be present in order to consider a substance or product as a by-product, and not Waste.

In Italy was fully implemented the definition of by-product. Article. 184 bis of Legislative Decree no. 152/2006 is a by-product and not waste any substance or object fulfils all the following conditions:

- a) the substance or object is originated from a production process, of which it constitutes an integral part, and whose primary purpose is not the production of such a substance or object;
- b) it is certain that the substance or the object will be used, in the course of the same or a subsequent production process or use, by the manufacturer or a third party;
- c) the substance or object can be used directly without any further processing other than normal industrial practice;
- d) further use is lawful, i.e. the substance or object fulfils, for the specific use, all relevant requirements relating to products and health and environmental protection and will not lead to overall adverse environmental or human health

The definition of by product is creating many problems in particular the definition of normal industrial practice. It would be appropriate that the European Commission approve the guidelines in order to specify better the meaning of normal industrial practice also to constrain national courts to uniform application.

In line with the new Community approach the Directive 2008/98/EU in Article 6 provides a legal category of “end of waste”, that is the moment in which a waste as a result of a recovery operation ceases to be and becomes commercially and legally a product. Essentially through this procedure the norm refers to the definition of secondary raw material already present in Community law.

Definition of *end of waste*:

Certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:

- (a) the substance or object is commonly used for specific purposes;*
- (b) a market or demand exists for such a substance or object;*
- (c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and*
- (d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.*

The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.

2. The measures designed to amend non-essential elements of this Directive by supplementing it relating to the adoption of the criteria set out in paragraph 1 and specifying the type of waste to which such criteria shall apply shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39(2). End-of-waste specific criteria should be considered, among others, at least for aggregates, paper, glass, metal, tyres and textiles.

3. Waste which ceases to be waste in accordance with paragraphs 1 and 2, shall also cease to be waste for the purpose of the recovery and recycling targets set out in Directives 94/62/EC, 2000/53/EC, 2002/96/EC and 2006/66/EC and other relevant Community legislation when the recycling or recovery requirements of that legislation are satisfied.

4. *Where criteria have not been set at Community level under the procedure set out in paragraphs 1 and 2, Member States may decide case by case whether certain waste has ceased to be waste taking into account the applicable case law. They shall notify the Commission of such decisions in accordance with Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services (24) where so required by that Directive.*

In order to be clear it is useful to underline the fundamental differences between by-product and secondary raw material. The by-product is a production residue that continues its life cycle without losing product quality. Secondary raw material become waste again becoming classified as products following recovery treatment, recycling and preparation for re-use.

Then the fundamental difference is that the by-products have never become waste. Secondary raw materials become waste, but because of various treatments again become products with an economic value on the market. Therefore recalling what we said previously the management of by-products does not require by operator to obtain specific permission, conversely, the end of waste can be implemented within a production site only after obtaining the authorization to the treatment of waste.

1.1.4 Directives aimed at the protection of individual environmental elements: Directive 2000/60/EC on water management and Directive 2008/50/EC air quality

Directive 2000/60/EC on water management

The European Union **Directive 2000/60/EC (EU Water Framework Directive)** sets a framework for the Community action for the **protection of inland surface waters, transitional waters, coastal waters and groundwater** which: (a) prevents further deterioration and protects and enhances the status of aquatic ecosystems, (b) promotes sustainable water use based on a long-term protection of available water resources; (c) aims at enhanced protection and improvement of the aquatic environment, (d) ensures the progressive reduction of pollution of groundwater and prevents **its further pollution**, and (e) **contributes to mitigating the effects of floods and droughts.**

Member States shall identify the individual river basins lying within their national territory and, for the purposes of this Directive, shall assign them to individual river basin districts. Small river basins may be combined with larger river basins or joined with neighbouring small basins to form individual river basin districts where appropriate. Member States shall ensure the establishment of a register or registers of all areas lying within each river basin district which have been designated as requiring special protection. The European Parliament and the Council shall adopt specific measures against pollution of water by individual pollutants or groups of pollutants presenting a significant risk to or via the aquatic environment, including such risks to waters used for the abstraction of drinking water.

Directive 2008/50/EC Ambient Air Quality and Cleaner Air for Europe (CAFE)

The European Union Directive 2008/50/EC on ambient air quality and cleaner air includes the following key elements:

- a) The merging of most of existing legislation (Framework Directive 96/62/EC, 1-3 daughter Directives 1999/30/EC, 2000/69/EC, 2002/3/EC, and Decision on Exchange of Information 97/101/EC) into a single directive (except for the fourth daughter directive) with no change to existing air quality objectives.
- b) New air quality objectives for PM_{2.5} (fine particles) including the limit value and exposure related Framework Directive 96/62/EC, 1-3 daughter Directives 1999/30/EC, 2000/69/EC, 2002/3/EC, and Decision on Exchange of Information 97/101/EC objectives – exposure concentration obligation and exposure reduction target.
- c) The possibility to discount natural sources of pollution when assessing compliance against limit values.
- d) The possibility for time extensions of three years (PM₁₀) or up to five years (NO₂, benzene) for complying with limit values, based on conditions and the assessment by the European Commission.

The starting point of UE has been the Sixty Community Environment Action Programme adopted by Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002. The decision

establishes the need to reduce pollution to levels, which minimize harmful effects on human health, paying particular attention to sensitive populations, and the environment as a whole, to improve the monitoring and assessment of air quality including the deposition of pollutants, and to provide information to the public.

In order to protect human health and the environment as a whole, it is particularly important to combat emissions of pollutants at source and to identify and implement the most effective emission reduction measures at local, national and Community level. Therefore, emissions of harmful air pollutants should be avoided, prevented or reduced and appropriate objectives set for ambient air quality taking into account relevant World Health Organization standards, guidelines and program.

This Directive 2008/50/ UE, seeking to reach the goals established by the Sixty Community Environment Action Program, lays down measures aimed at the following:

- ✓ Defining and establishing objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole;
- ✓ assessing the ambient air quality in Member States on the basis of common methods and criteria;
- ✓ obtaining information on ambient air quality in order to help combat air pollution and nuisance and to monitor long-term trends and improvements resulting from national and Community measures;
- ✓ ensuring that such information on ambient air quality is made available to the public;
- ✓ maintaining air quality where it is good and improving it in other cases;
- ✓ promoting increased cooperation between the Member States in reducing air pollution.

In order to implement the measures listed above the Member States shall designate at the appropriate levels the competent authorities and bodies responsible for the following activities:

- ✓ assessment of ambient air quality;
- ✓ approval of measurement systems (methods, equipment, networks and laboratories);
- ✓ ensuring the accuracy of measurements;
- ✓ analysis of assessment methods;
- ✓ coordination on their territory if Community-wide quality assurance program are being organized by the Commission;
- ✓ cooperation with the other Member States and the Commission.

The Directive gives some guidelines to Member States in order to guarantee the uniform application and better air quality in European territory. For example a common approach to the assessment of ambient air quality should be followed according to common assessment criteria. When assessing ambient air quality, account should be taken of the size of populations and ecosystems exposed to air pollution. It is therefore appropriate to classify the territory of each Member State into zones or agglomerations reflecting the population density. The article 4 of the Directive asks to Member States establish zones and agglomerations throughout their territory. Air quality assessment and air quality management shall be carried out in all zones and agglomerations.

In summary the CAFE directive introduces new objectives for fine particles PM_{2.5} but does not change the air quality standards. It does, however, by the Member States more flexibility in meeting some of these standards in specific areas in which you have particular difficulties in meeting the limits themselves. The deadlines for complying with the PM₁₀ limits may be postponed for three years after the entry into force of the Directive or to a maximum of five years for nitrogen dioxide and benzene. The CAFE Directive addresses the issue of periodic assessment of air quality through monitoring and modelling in agglomerations with more than 250,000 inhabitants, requires the development of action plans to improve air quality and defines obligations to inform the public on the air quality situation.

1.1.5 Directive 2004/35 EC Liability Directive

The European Commission, in 2001 decided to propose to Member States the proposal for a directive on environmental liability. The European Commission in its proposal emphasized the presence of many contaminated sites in the European territory. The non-intervention could lead to increased contamination of the environment and a significant loss of biodiversity. The remedial actions and preventing environmental damage should contribute to achieving the objectives and the principles of Community environmental policy, as set by the Treaty.

In April 2004, the Member States after three years of negotiations finally adopted the Directive 2004/35/EC. The Directive in accordance with article 17 gave until April 2007 to Member State for implementing it in their legislation.

Directive 2004/35/EC defines a legal framework for the prevention and remedying of environmental damage based on the principle of “*polluter pays*.” The Directive moves from the need to harmonize liability regimes of the Member States, very heterogeneous with regard to the charging of environmental damage and therefore likely to lead to distortions of competition between firms within the European market. The Directive had as target to standardize the different legal systems for this represents a fairly limited legal approach to the concept of environmental responsibility⁽⁶⁾. The approach is based on the polluter pays principle applied to the **prevention and remediation of the environmental damage** (ELD). As the ELD deals with the “*pure ecological damage*”, it is based on the powers and duties of public authorities (“administrative approach”) as distinct from a civil liability system for “traditional damage” (damage to property, economic loss, personal injury).

Environmental damage definition

The Directive defines “environmental damage” as damage to protected species and natural habitats, damage to water and damage to soil.

⁶ When the Directive was adopted in 2004, some Member States already had the laws on environmental damage, for example, Germany and Italy much more compelling and full of the same Directive. Other member states such as Spain and Portugal UK not had any legislation. The directive represented a compromise between these different situations.

damage means a measurable adverse change in a natural resource or measurable impairment of a natural resource service which may occur directly or indirectly. In this context, it is meant for service “function performed by a natural resource for the benefit of another natural resource and / or the public. The Directive take into account the environmental damage related to three categories of natural resources:

- ✓ **damage to biodiversity**, i.e. the damage to protected species and natural habitats, as well as regulated by Directives 92/43 / EEC and 79/409 / EEC:
- ✓ **damage to the waters**, that is, any damage affecting significantly on water status, as defined by Directive 2000/60 / EC establishing a framework for Community action in the field of water;
- ✓ **damage to the soil** , understood as any land contamination that creates a significant risk of adverse effects on human health as a result of direct or indirect introduction into the soil, the soil or subsoil of substances, preparations, organisms or microorganisms.

Recital 4 of the Directive specifies that the environmental damage “*also includes damage caused by airborne elements as far as they cause damage to water, land or protected species or natural habitats.*”

The Directive does not apply, by express provision, the damage caused by diffuse pollution, unless it cannot be established a causal link between the damage and the activities of individual operators.

The Directive does not address traditional damage, i.e. damage to property and people, obviously not regarding any right regarding these types of damage that are still governed through civil liability.

When the Directive has been adopted in 2004 by Member States, some of them already had the laws on environmental damage, for example, Germany and Italy much more compelling and full of the same Directive.

Other Member States such as Spain and Portugal, United Kingdom not had any legislation. The directive represented a compromise between these different situations. Just to make an example the Italian law on environmental liability adopted in 1986 article 18 of Law 349 had a wider definition of environmental damage, and includes all three

elements of the environment, without making distinctions between the polluting event capable of causing a danger to human health.

The real innovation introduced by the Directive in line with the precautionary principle is that the environmental liability system apply not only to the harm itself, but also to any imminent threat of damage, defined as a sufficient likelihood that damage occurs environment in the near future. In this context, prevention implies that the competent authority requires the operator to take the necessary preventive measures or takes itself immediately or in any case if the operator does not take. For preventive measures are intended, according to the Directive, the measures taken in response to an event, act or omission that has created an imminent threat of environmental damage, in order to prevent or minimize such damage.

The operators involved in the environmental liability system

Only the professional activities are subject to Directive regime. The professional activities are defined as those carried out in the course of an economic activity, commercial or business, whether public or private, with or without profit, the outcome of which involves an actual or potential health risk human and / or the environment. These activities (those listed in Annex III of the Directive) are identified with the environmental legislation in force at Community level already subjected to conditions (authorization, registration, etc.). However, in the case of damage to protected species and natural habitats caused by any occupational activities other than those listed in Annex III, whenever the operator has been at fault or negligent, the Directive shall be applied also for the operator do not listed in Annex III.

The responsibility to cover the costs for the environmental damage

The Directive scheme for damage caused to the 3 categories of environmental resources by the professional activities defined in Annex III of the Directive it makes the operator liable for the costs of preventive and remedial actions, without requiring proof of fault or fraud. The Directive, however, permit Member States to decide that the operator could be not liable for the remediation cost if the operators has had no negligent behaviour and if the damage in question derives from emissions or events explicitly authorized. The same approach we can find it in the directive in the event that the damage is the result of

activity or the use of harmful substances not considered by the scientific community at the time of the event of environmental damage.

Role of the competent authority

As mentioned previously, the Directive addresses the issue of environmental damage and leaves out of its scope of traditional damage to property and people. Since the environment does not belong to any single individual but to the community, the legal relationship that will be created in terms of environmental responsibility will be among the polluter / private entity and the competent authority / public entity.

Having said that the Member States will have to designate one or more competent authorities to be responsible for the execution of the tasks set by the Directive (to identify the operator who caused the damage or the imminent threat of damage, to assess the severity of damage, determine the measures repair to be taken). The competent authority shall be entitled to require the relevant operator to carry out his own assessment and to provide information and the necessary data. The competent authority, at any time, may request the operator to provide supplementary information on any damage that has occurred, take all practicable steps to limit or to prevent further environmental damage, take the necessary remedial measures. The Directive provides that, in cases where the operator has not been identified, or, even if identified, does not have sufficient financial means to take the necessary preventive or restorative measures, or is not required to bear the costs in accordance with Directive ⁽⁷⁾, the competent authority may itself take the necessary measures. The competent authority may recover from the operator the costs it has incurred in relation to the preventive and remedial actions.

Remedial action for environmental damage

Remedying of environmental damage, in relation to water or protected species or natural habitats, is achieved through the restoration of the environment to its baseline condition by way of primary, complementary and compensatory remediation, where:

⁷ In case the operator that has caused damage to biodiversity cannot be held responsible because you cannot prove that he acted negligently.

- ✓ **Primary remediation** is any remedial measure which returns the damaged natural resources and/or impaired services to, or towards, baseline condition;
- ✓ **Complementary remediation** is any remedial measure taken in relation to natural resources and/or services to compensate for the fact that primary remediation does not result in fully restoring the damaged natural resources and/or services;
- ✓ **Compensatory remediation** is any action taken to compensate for interim losses of natural resources and/or services that occur from the date of damage occurring until primary remediation has achieved its full effect;
- ✓ **interim losses** means losses which result from the fact that the damaged natural resources and/or services are not able to perform their ecological functions or provide services to other natural resources or to the public until the primary or complementary measures have taken effect. It does not consist of financial compensation to members of the public.

Where primary remediation does not allow to reach the restoration of the environment and the return to their baseline condition, then complementary remediation will be undertaken. In addition, the operator/pollutant will have to undertake a compensatory remediation to compensate for the interim losses. Remedying of environmental damage, in terms of damage to water or protected species or natural habitats, also implies that any significant risk of human health shall be removed.

The purpose of **complementary remediation** is to provide a similar level of natural resources and/or services, including, as appropriate, at an alternative site, as would have been provided if the damaged site had been returned to its baseline condition. Where possible and appropriate the alternative site should be geographically linked to the damaged site, taking into account the interests of the affected population. **Compensatory remediation** shall be undertaken to compensate for the interim loss of natural resources and services pending recovery. This compensation consists of additional improvements to protected natural habitats and species or water at either the damaged site or at an alternative site. It does not consist of financial compensation to members of the

public. In determining the complementary and compensatory remedial measures, the Directive requires, as a first choice, the use of resource-to-resource or service-service equivalence approaches in terms of type, quality and quantity. If this is not possible, you must provide resources and / or services of alternative type (eg., A reduction in quality could be offset by a greater amount of remedial measures).

Remediation of land damage

In the case of environmental damage on soil, the necessary measures shall be taken to ensure, as a minimum, that the relevant contaminants are removed, controlled, contained or diminished so that the contaminated land, taking account of its current use or approved future use at the time of the damage, no longer poses any significant risk of adversely affecting human health. The presence of such risks shall be assessed through risk-assessment procedures taking into account the characteristic and function of the soil, the type and concentration of the harmful substances, preparations, organisms or micro-organisms, their risk and the possibility of their dispersion. Use shall be ascertained on the basis of the land use regulations, or other relevant regulations, in force, if any, when the damage occurred.

Finally an approach followed by the Community Directive on repairing the damage is all tied to the return to the original conditions of the polluted site. Where this is not possible, unlike other national legislation such as the Italian, who have tried to economically quantify environmental damage, the directive sets a discourse of equivalence between the different environmental resources, requiring the polluter to give no money to the community but another environmental resource.

Temporal application

Environmental damage frequently occurs as the cumulative result of the most polluting activities, which operate separately or interact with each other. Therefore, the damage may also take place at a considerable distance from the point at which they occurred harmful actions (a typical example is that of acid rain) or come to light after a long period of time from the harmful act, and the resulting uncertainties in determining the date from which the limitation period run to.

For all these reason and also in order to give greater certainty for operators the Directive shall not apply to: damage, if more than 30 years have passed since the emission, event or incident, resulting in the damage, occurred. In addition, the Directive takes into account the right of the competent authority to take action against the polluter. The competent authority has the right to compensation that has provided the preventive measures and restoration of significant damage to the environment is a limitation period of five years from the date on which those measures have been completed or the date on which the polluter operator has been identified, whichever is the later.

1.1.6 Conclusion

In this section, we briefly described the main Community directives that form the basis of Community environmental law over the years implemented by Member States in their jurisdictions. In this summary we have not talked about the whole environment and energy issue mainly linked to the implementation in Europe of the requirements of the Kyoto Protocol, we have limited ourselves to analysing the environmental protection regulations in the strict sense.

As mentioned in the introduction of this paragraph all the environmental Community law, is based and inspired on this mentioned principles in the Treaty establishing the European Community, such as the principles of prevention and the precautionary and polluter pays principle and more generally on the principle of development sustainable.

We can say that at present the EU legislation to protect the environment provides all the necessary rules, so that the Community principles listed above, are operational and implemented.

It is evident that the technological progress in place will request the constant revision of the Community Legislation, in terms of environmental goals to be achieved.

In this regard, all EU legislation is periodically subject to review procedure in order to adapt the rules to changes in environmental knowledge.

1.1.7 Regulation cases in Turkey and Italy

Case study: Control of electrical and electronic equipment wastes in Turkey

The Turkish electrical and electronic equipment regulation (EEE) has the purpose to: “Protect human health and the environment from certain hazardous substances which are used in production of electrical and electronic equipment by limiting the excess usage. To control the imports of electrical and electronic goods, prevent formation of electrical and electronic excess waste that have to be disposed, and to arrange legal and technical principles of methods and goals to reuse, recycle and recover the amount of waste.”

This regulation has been arranged according to the European Union Directive ‘2002/95/EC – Limiting the usage of Certain Hazardous Substances in Electric and Electronic Equipment’ and has been prepared in parallel with directive ‘2002/96/EC - Waste of Electric and Electronic Equipment’.

By wasted electric and electronic goods is mean the entire component, contained elements and consumable product at the end of its usable life. After 05.30.2009, in imported or manufactured electronic goods, electric bulbs and domestically used lighting equipment out on the market; it is prohibited to use lead (Pb), mercury (Hg), hexavalent chromium (Cr6+), Polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDEs) and cadmium (Cd). In newly designed products, it has encouraged to use recycled materials.

In EEE regulation, priority is given to re-use the product as a whole. A recycling and recovery rate is achieved by ensuring the processing of collected products and in absence of the possibility of recycling or technically processing of EEE, it is permitted to dispose the waste.

In order to reduce the waste resulting from the processing of EEE, it is prohibited to burn and dispose of such materials to the environment against the legislation and Recycling, recovery and disposal of these products should be carried out in environmentally licensed facilities. Compensation and other costs associated with the environmental damage caused by the management of EEE, according to the principle of “polluter pays”, are a responsibility of the individual or the corporation.

In Turkey, the provincial directorate of environment and urbanization is responsible for monitoring, controlling, and ensuring necessary implementations take place in waste facilities that have appropriate licenses to process EEE.

While the municipalities are responsible for preparing EEE management plans, to inform the society about the proper collection program, in the framework of this program to collect or make sure that its collected, to allow EEE to be collected in suitable containers, is obliged to send the collected household EEE to the specified licensed processing plants.

Electrical and electronic equipment manufacturers and consumers are responsible for:

- Avoiding the use of harmful substances in the production of electrical and electronic products, product procurement, product development, Research & Development and design activities, to use safer alternative substances, to cover the shipping costs by filling forms for the declaration of the domestically used EEE collected by the municipality, ensuring the processing of EEE, in absence of a suitable processing facility , to meet the costs and set up a system for the disposal, the collection, processing and disposal of non-domestic EEE.
- When purchasing a new product, if it is requested by a consumer; electrical and electronic goods distributors are responsible for taking back the product regardless of its apparel, brand, or model, in cases where new products is not shipped to the address of the receiver, responsible for picking the household EEE up from the same place and not request any shipping charges or other extra fee for it.
- Consumers of electrical and electronic goods are required to accumulate EEE separately from other household waste, and bring or ensure it is brought to the right collection facilities, and not to those collectors working off record.
- Processing facilities must ensure to use appropriate methods and technologies to recycle and recover; after getting a license from the ministry for the environment, and through transfer stations, make sure EEE is collected.

In the processing plants, other parts should be stored separately from the recycled or disposed waste in electrical and electronic equipment containing certain hazardous substances in parts and materials in order to reduce the negative impact on the environment and human health. The list contains the following items:

- Polychlorinated biphenyls
- Compounds containing mercury,
- Batteries,
- Printed circuit boards of mobile phones,
- Liquid and solid toner cartridges,
- Polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE), plastics containing brominated flame retardants,
- Asbestine waste
- Cathode ray tubes,
- Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFC), hydrofluorocarbons and hydrocarbons (HC)
- Gas-discharge lamps,
- LCD screens that have an area larger than of 100 cm²
- External electrical cables,
- Fireproof ceramic fibers
- compounds containing radioactive materials,
- electrolyte capacitors
- Gases that harm the ozone layer
- Electrical and electronic Waste should be recycled or need to be disposed of in facilities that received environmental permits and licenses.

Separate collection is carried out according to a given groups:

- a) Fridge / Refrigeration / Air conditioning equipment;
- b) Large household appliances;
- c) TV and monitors;
- d) IT, telecommunications and consumer equipment;
- e) Lighting equipment;
- f) Small household appliances, electrical and electronic tools, toys, sports and leisure equipment, medical devices, monitoring and control instruments.

Producers are obliged to provide information to the consumers about the negative effects of the EEE on the environment and human health caused by the hazardous substances contained inside them, as well as to contribute to the separate collection system of EEE. On the other hand, manufacturers are obliged to establish a joint coordination center.

Case study: End-of-Life vehicles regulation in Turkey

Once a vehicle reaches its end-of-life and gets to be discarded, it is becoming an end of life vehicle. It has to be properly managed with the purpose of avoiding environmental pollution as well as recovering useful materials, especially metals. End-of-life vehicles (ELVs) management in Turkey has become a crucial issue in recent years owing to the impact of global warming, earthquakes, carbon footprint, and economic awareness. The production rate of local vehicles are increasing every year. That indicates the increasing rate of ELVs.

To protect human health and the environment, a regulation related to end-of-life vehicles came into force on December 30, 2009. This regulation entitled as “Regulation on Control of End-of-Life Vehicles” aimed to assess the standards and obligations that economic operators and temporary storage areas will be subject to. These obligations cover prevention of waste production due to vehicles, reuse, recycle and recovery of ELVs and parts of these vehicles and reduction of amount of vehicles to be disposed.

According to Regulation Article 5, the use of recycled materials in vehicles should be increased in order to extend recycling applications. It is also stated in article 5 that design and production of new vehicles and their parts and materials should be proper in order to make, dismantling, reuse, recovery and recycle activities easier after they completed their life.

In this context, manufacturers of vehicles and their parts and materials, distributors, exporters, people who perform the operations of collection, dismantling, cutting, breaking down, recovery, recycling of end-of-life vehicles, are put under various obligations.

In order to make recycling easier, to prevent the spread of hazardous substances to the environment and to reduce amounts of the hazardous wastes, use of hazardous substances in vehicles is expected to be minimized. Use of lead, mercury, cadmium, hexavalent chromium is prohibited in vehicles, their parts and materials which are introduced to the market. The regulation stated that vehicles should be designed to facilitate proper dismantling and to allow components and materials to be reused, recycled and/or recovered.

The producers should provide vehicle dismantling information for end of life vehicle processing plants. Vehicle dismantling information includes the exact places of plastics, iron and other metals, rubber and hazardous substances in the vehicle.

According to Regulation Article 16, in the cases where vehicle safety and environmental standards are met, the parts which are taken out from end-of-life vehicles will be reused. The parts which cannot be reused will be recycled or recovered if it is environmentally compatible. The required ratio of reuse and recovery is stated as at least 85% of the average vehicle weight; the required ratio of re-use and recycle is stated as at least 80% of average vehicle weight.

National regulation on content of ELVs as well as the economic benefit of ELVs recovery motivates the local automotive manufacturers in Turkey. Currently waste management and recycling firms served for processing end of life vehicles. Numerous licensed temporary storage facilities accepted the ELVss according to existing regulation and transferred to the licenced processing facilities. Firstly, fluids and other hazardous components, such as batteries are removed. The detrimental

liquids (fuel oil, engine oil, transmission oil, brake fluids, cooling fluids, etc.) are accumulated according to their types properly and transferred to contracted Licensed Recovery Facilities and their processing as well as recovery is ensured. Then, according to the market demand, components are dismantled and further reused, remanufactured or recycled. After these operations, hulks are baled and transported to a shredding plant where cars are reduced into pieces. The embodied materials are liberated and then sorted for recycling. 85% of the ELVs can be recovered by this processing chain, thus allowing a significant decrease in the amount of waste needing final disposal (landfill).

Case study: Management of soil excavated during construction activities in Italy

In Italy, in accordance with EU legislation, the legislature has sought to identify certain categories of products, which according to the Italian general principles on environmental protection, the operator should consider and handle them as waste. Conversely, when these materials or products have certain characteristics, the legal system allows the operator to manage them out of the legal framework on waste. This approach is in line with Community guidelines that ask to the Member States to reduce the production of waste.

First of all in generally the Article 184 bis of Legislative Decree 152/2006 (hereinafter TUA) provides that “ *It is a by-product and not as waste within the meaning of Article 183, paragraph 1, letter a), any substance or object fulfills all the following conditions:*

- a) the substance or object is originated from a production process, of which it constitutes an integral part, and whose primary purpose is not the production of such a substance or object;*
- b) it is certain that the substance or the object will be used, in the course of the same or a subsequent production process or use, by the manufacturer or a third party;*
- c) the substance or object can be used directly without any further processing other than normal industrial practice;*
- d) further use is lawful, i.e. the substance or object fulfils, for the specific use, all relevant requirements relating to products, health care and*

environmental protection, and will not lead to overall adverse impacts on environment or human health

2) Based on the conditions provided for in paragraph 1, actions may be taken to determine qualitative or quantitative criteria to be met for specific types of substances or objects to be regarded by-products and not waste. The adoption of these criteria will be defined by one or more decrees of the Minister of Environment and Protection of Land and Sea in accordance with the provisions of the Community guidelines.

The attention of the legislator has focused primarily on those materials which are generated by very common activities, such as the soil excavated, generating materials (soil excavated) that in the absence of specific laws, should be managed by the operator as waste. This in spite of the fact that these materials do not represent any danger to the environment and is immediately reusable

In Italy it happened to analyse the case of excavated soil as part of the EIA process for the construction of two diesel tanks of 50,000 m³ capacity each. This specific case also had the peculiarity that the excavations are carried out in an industrial area just undergone remediation and currently adjacent to an industrial area still subject to reclamation procedure

The Italian Ministry of Environment, pursuant to paragraph 2 of Article 184 bis, issued the Ministerial Decree 161/2012, just to establish with respect to excavated soil the qualitative or quantitative criteria to be met in order to consider those substances as by-products and not waste.

This Decree provides in charge of operator a series of requirements in order to manage the excavated soil as by-products. First of all the operator/ producer of waste has to prepare a fundamental document called “*Management Plan*” (hereinafter called MP). The operator must present the MP to the competent authority (CA) before the start of the works. The CA may approve, reject or ask for prescriptions.

In addition, the Ministry has predicted in Decree 161/2012 a series of requirements that, if not complied by the operator, causing the cessation of the by-product qualifies for soil and rock that automatically fall within the scope of the legislation on waste. Those requirements are listed below:

- ✓ The work must begin, unless founded exceptions, within two years from the presentation of the MP
- ✓ The operator must change the MP approved by the CA, in case of changing the destination of the excavated material or its use. The CA must approve the changes to the MP.
- ✓ The operator must change the MP approved by CA, in the event that changes the destination of the excavated material to an intermediate storage site different from the one indicated in the MP.
- ✓ The operator should notify through the specific document (called the certificate of use statement CUS) the end of the work, before the expiry of POU. The operator shall retain the CUS for five years in case the CA would need to make some control in the future

In the cases listed above, if the operator fails to comply with the procedures laid down by the Ministerial Decree 161/2012 the CA will consider the soil excavated as waste in line with the Legislative Decree 152/2006.

The loss of the by-product qualification by soil excavated automatically involves the application of substantial criminal charges. The operator will be in the situation of having managed excavated soil as by-products when it should have applied the stricter legislation on waste.

A matter in point of law is the definition of the time when determining the time moment at which the material is to be considered waste rather than product. In another words did the product become waste when the infraction of rules is occurred or should the material be considered as waste since the beginning (retroactive effects)? In my point of view According to the current interpretation, the loss of the by-product qualification should not be retroactive, in consideration of the criminal consequences associated with that case.

Taking into account the complicated procedures of the Ministerial Decree 161/2012 and surveys highlighted by industrial sectors, the Italian government is preparing a new decree that should simplify the procedures.

The new Decree, still under discussion, will be promulgated as *‘the simplified Discipline of the earth and rock excavation management, in accordance with Article 8 of Law Decree 12 September 2014, n. 133, converted with amendments by Law 11 November 2014 n. 164’* .

This Decree is addressed, unlike the previous, to manage specifically the cases of excavated soil from small yards, as well as the management of soil excavated in reclamation sites.

Therefore, in light of the legislation just exposed, the cases that may arise to the operator are as follows:

First option

Use of soil excavated under Article 185 paragraph 1 letter c of the Legislative Decree 162/2006 *“Do not fall within the scope of Part IV (waste management) of this decree: the uncontaminated soil and other unprocessed material excavated in the course of construction activities where it is certain that it will be reused for the purposes of construction in its natural state on the site from which it was excavated”*.

The legislature has created this law in order to handle the material excavated during construction work in residential areas. The premise of the rule is that being away from industrial areas the extracted soil is not polluted.

This specific law does not fit the case. The assumption as to obtain the non-contamination of the soil, in the present case, where it is digging at a site adjacent to an area to be reclaimed seems incorrect. Having said that the approach above described does not comply with the Italian legislation

Second option

Use of soil excavated as a by-product pursuant art. 184 bis Legislative Decree 162/2006 implementing Ministerial Decree 161/2012. The legal framework allows the operator, if the soil analysis shows that the soil complies with the limits set by the contamination threshold concentrations COT⁽⁸⁾, reuse of excavated soil in the same area. As briefly mentioned above, the operator must have a special attention in the application of by-products Regulation.

⁸ Definition COT *“the levels of contamination of environmental matrices that constitute values above which the characterization of the site and the risk analysis specific site is required. When a site is found these overruns the site should be classified as potentially contaminated”*

Third Option

The earth and rock excavation do not respect the limits of the COT, and then the operator will have the obligation to manage the earth as waste (in accordance with fourth part of Legislative Decree 162/2004) and no more as by product. In this case the operator shall handle the waste, effectively applying the discipline of ‘‘ end of waste ‘in accordance with art. 184b of the TUA and in the case of the good results of operations, in situ reuse the excavated soil. Otherwise, send waste to landfill after the necessary analyses required by the Landfill legislation.

Conclusions

As seen, in this case study, in Italy the soil excavated can be managed by the operator as by-products and then be re-used for filling activities or other purposes that may be made available.

The distinction between applying the rules on waste or by-products is seen in the results of the analyses on the site: if tests show that the site is not contaminated the extracted material does not fall within the scope of the rules on waste, otherwise waste legislation will be fully applied.

Case study: The presence of asbestos on the Italian territory

Asbestos, which in Greek means perpetual or inextinguishable, is a natural mineral with a microcrystalline structure and fibrous appearance belonging to the chemical class of silicates and mineralogical series of serpentine and amphibole.

Among its most interesting features, there is the fact that asbestos is made from thin fibers but very dense, which make it a material highly resistant from the mechanical point of view, but at the same time flexible. It has a good heat resistance, although it is not a refractory material; also withstands temperatures of 500 ° C and, mixed with other substances, even at higher temperatures. It is resistant to chemical and biological agents, abrasion and wear. Finally, a satisfactory behaviour in both thermal and mechanical wear.

It occurs naturally in many parts of the globe and is easily obtained from the main rock after grinding and enrichment, generally in open pit mines.

The fibrous texture is at the base of technological properties, but also properties of risk since it causes mainly serious respiratory pathologies. The dangerousness consists, in fact, in the capacity that asbestos materials have to release potentially respirable fibers and also in the extreme subdivision which these fibers can reach.

In products made with asbestos, fibers may be free or weakly bound, in this case it is defined as asbestos in friable matrix, while if they are strongly linked in a stable and solid matrix (such as cement-asbestos or the vinyl-asbestos), it is referred as asbestos in compact matrix.

The asbestos products in compact matrix are less susceptible to the dispersion of fibers, if they are put in the condition of not being subjected to processing (eg.: drilling, cutting with high-speed tools, etc.) or if they have not been damaged; become more dangerous if they are deteriorated in surface atmospheric wear.

Instead, the artefacts with friable asbestos, fibrous-looking, are easily penetrable by a pin. They have a high potential danger because the air currents, vibrations and the shocks can cause dispersions of fibers in the air.

Asbestos characteristics and uses

The unique characteristics of asbestos have led that it has been widely used in the past: in industries, constructions and in many household products.

More specifically, in **industry**, by weaving were obtained:

- **Ropes, tapes and sheaths** used to bind up hot piping tubes and avoid burns, to coat electrical wires close to intense heat sources such as furnaces, boilers, etc.
- **Fabrics** to manufacture fire-resistant protective suits used by firefighters, workers in the steel industry, blankets used as fire suppressors and tends to contain the heat of the tunnel furnaces.

By pressing were obtained:

- **Papers and cartons** used as fireproof barriers, such as oven or boiler gaskets, as a coating for table tops used for the storage of hot pieces of metal or glass, and as supporting surfaces on

welding benches. The cartons were employed inside of fire doors, inside of walls and inside safes.

- **Gaskets** or raw fibers **panel's tablets** were used for the insulation of pipes carrying steam at high temperature.
- **Filters** built with asbestos paper, or simply with compressed powder, have been widely used in the chemical and food industries; for many years, they have been used to filter wine and soft drinks.

By **mixing** asbestos with other materials, the following types of asbestos were obtained:

- **Asbestos spray.** This type of material has been used:
 - as thermal insulation in industrial cycles with high temperatures (e.g. thermal power plants, chemical industry, iron and steel, glass, ceramics and tiles, food processing, distilleries, sugar mills, foundries);
 - as thermal insulation in industrial cycles with low temperatures (e.g. Refrigeration systems, air conditioning systems);
 - as thermal insulation and fire resistant barrier in the pipes for electrical installations. It 'was used also in the transport sector for the insulation of railway carriages, ships, buses, etc.
- **Friction material.** Asbestos mixed with synthetic resins was used as friction linings for brakes and clutches of passenger cars.
- **Asbestos cement.** It is a building material in which asbestos fibers are used to reinforce thin rigid cement sheets.
- **Vinyl-asbestos.** Mixture of synthetic resins and asbestos, used for manufacturing tiles for floors. The release of fibers from this material is practically zero during normal use.

More specifically in **buildings**, the most common use was certainly that of the dough with asbestos cement. With asbestos-cement was possible to realize numerous artefacts such as:

- **Flat or wavy sheets**
- **Pipes**
- **Tiles**
- **Chimneys**
- **Tanks**
- **Plaster**

In addition, asbestos was used in the last fifty years in the production of various common household objects. It is still possible to find asbestos in some homes, for example:

- in some **household appliances**, within certain types of hair dryers, ovens and heating stoves;
- in some **kitchen tools**, sockets and oven gloves, ironing board covers and nets flame distributor;
- in cartons of asbestos situated behind the stoves to protect the wall.

With the passing of time these objects, that may still be present in our homes, can deteriorate and disperse fibers.

How to report and handle the presence of asbestos in Italy

The duty of every citizen is to protect the environment by reporting the presence of asbestos in both public and private facilities. The asbestos as explained earlier, can be compact and in the case of roofs, gutters, chimneys, or friable which is the most dangerous form and may be present in heating pipes, insulation of fireplaces or in the glasses and in fire doors, stoves or boilers.

In Italy, the obligation of asbestos removal is triggered if there are the extremes of a high state of degradation, when, in practice the material is friable and, therefore, able to release fibers. If asbestos is in conditions that do not destiny concerns, there is only the requirement of monitoring its degrading state over time. Moreover, the presence of asbestos cement does not in itself constitute risk to the health for the citizens or for the environment, since the risk depends on the probability of a dispersion

of asbestos fibers in the air and in the soil. The probability of the supply of fibers is in turn connected to the loss of firmness of the manufacture of asbestos cement, which is realized for a long exposure (several decades) to atmospheric agents or to damage by man. If the material is in good condition and is not tampered, it is unlikely that there is an appreciable risk of fiber release.

Since the end of the 80's on the market were sold materials that were identical to the asbestos cement in view, but which were free from asbestos. These materials were mainly used as roofing sheets and have a mark on it with a written certification of the absence of asbestos (eg. asbestos free). They are composed by corrugated sheets, consisting mainly of compressed cement which typically contains natural organic fibers and often synthetic fibers as a reinforcing material like polyvinyl alcohol, which can be commonly purchased from retailers of building materials.

Often it is not possible to verify the difference between asbestos and asbestos free material from the distance as in both the cement matrix (over 80%) prevents the distinction. Yet through a close look, it is possible to find that there are no fibers of asbestos-and read the "Asbestos free" markings.

In Italy, the verification of the maintenance status of a manufactured asbestos cement is an obligation of the owner. The owner must then call a professional technician which will do an assessment on the state of conservation of the building and who will be able to check one of the following three situations:

- ✓ The product is **still in good condition**: in these cases, it is necessary only to ensure a periodic evaluation of the maintenance status. It is the responsibility of the owner of the building to repeat the evaluation with the frequency indicated by the technician and in any case at least once per year.
- ✓ The product **needs maintenance**: in these cases, the assessment will indicate the mode of action, its timing and the schedule for a periodic verification of the state of maintenance (at least once per year).

- ✓ The product **has to be removed**: the assessment should include the timing for implementation of the action that needs to be done quickly, in the most favorable conditions, within one year from the survey evaluation.

The asbestos maintenance and removal

They are three types of action which can be done, two in the case of maintenance and the last is the definitive removal of the material from the site in which it is placed. The maintenance operations are the following:

1. **Encapsulation**, which consists in the treatment of the material with coating products that tend to incorporate the asbestos fibers, to restore the adhesion to the support and to form a protection coat surface for the exposed material;
2. **Confinement**, which consists of the installation of a watertight barrier that separates the material containing asbestos from the occupied areas of the building.

The adoption of each of these types of intervention is linked to the type and conditions of the material, to its location, to the will of the owner to eliminate the danger or to always keep it in a controlled manner through a periodic maintenance.

1.2 Overview of the main methodologies for evaluating and certificating the environmental performances

In the latest years, companies' attitude towards the environment has changed; environment is not seen as a restriction and a cost anymore. Instead, it is an opportunity of distinction and competitiveness in national and international marketplace. The reasons of this change are different and they evolved during years: firstly, the high costs which have been sustained by the companies in order to repair the damages they caused to the environment have lead them to supervise the environmental status, in order to prevent future costly incidents, following the awareness of populations and, as a consequence, of consumers which pushed the authorities to legislate and rewarded the companies which showed an interest about this topic.

As a consequence, the industry awareness of the new relation between companies, economy and environment has modified marketplace rules, which is why the companies which are able to take advantage of this new evolution in a competitive way, they are now gaining new market shares. So, the companies choices about environment are not merely regulatory obligations to fulfil anymore, but they become a free and thought out choice of market.

1.2.1 EMS – Environmental Management System

Environmental Management Systems (EMS) give a structured and systematic way to incorporate the environmental care in total management of the company.

To an organization, adopting an EMS means providing an “environmental policy” in order to establish its own development targets by safeguarding the environment with a continuous improvement reasoning.

The target of an EMS is to identify the main environmental aspects, keep them under control, organize all the activities with an environmental impact and assign specific responsibilities for their realisation, as the total environmental compliance comes from a befitting attitude of almost the whole staff of a company or an authority.

So, EMS is an instrument for management and systematic control of the effects which are bound to one’s activities on the territory and it has the main target of improving the total environmental performances.

Through the years, companies have produced different system of environmental management, which were mostly born as voluntary initiatives from the inside of companies. These systems have become subject of specific regulation by national, international and community institutions.

Rule ISO 14000, which has been introduced in 1996 and modified several times (2015 is the latest edition), it defines the EMS as “*the part of the system of general management which includes organisational structure, planning activities, responsibilities, practices, processes and sources for developing, realizing, re-exanimating and maintain the environmental policy.*” A comparable definition is included in the EMAS regulation (which has been instituted by EU): the EMS

is “*the part of the system of total management which includes the organisational structure, responsibilities, procedures, processes and sources for defining and realise the environmental policy.*”

Pressure factors which push organisations to adopt an EMS can be internal or external, for example:

- The greater environmental culture of different social actors as public administration, citizens, mass media, environmental associations;
- The rising demand of high performance, safe and eco-friendly products from final consumers;
- Banks, shareholders’ and investor’s needs which often require more guarantees of proper management speaking about environment, by minimizing in this way possible risks of environmental incidents;
- The rising market globalization, which induces organizations to adapt to management instruments which have been adopted by competitors and customers;
- Initiatives which have been promoted by institutions as strongly demanded in Regulation CE no. 1221/2009 (easy access to information, support funds and public contracts, technical assistance, district of organisation implementation);
- The organisations’ need to communicate to the outside their environmental performances and the efforts which have been done in the environmental management field.

Advantages and costs of an EMS

The realisation of an EMS in a company firstly requires the company directorate’s awareness that safeguarding the environment is an important part of business strategy. The directorate can give the necessary support to sustain the effort that the structures of the business must do, in order to apply and keep the EMS, only with this certainty. This means the process of actualisation of an EMS starts with a directorate’s decision, but then it must spread in the whole company.

The first and immediate advantage, for the companies which introduce an EMS (following the international rule ISO 14001 or the EMAS European Regulation) is to provide a systematic planning for the management of environmental aspects which causes a greater capability of pointing, working and deciding.

The definition of the role and the inner responsibilities allows a greater organisational efficiency, also in terms of the relationship costs/benefits.

An EMS main target is to promote continuous improvement of environmental performances of activities in companies, and guarantee the regulatory compliance through the induction and the actualization of policies, programs and organisational systems inside their own sites, by also verifying the efficiency of the total system through environmental internal audits.

The continuous attention to reaching the environmental performances (obtainable through BATs, Best Available Techniques) for environmental safeguard and the implementation of management procedures, operational instructions and controlling the environmental aspects of the productive process, all these things allow to obtain different benefits, such as:

- Reduction of some costs as: electrical energy; management (collection, transportation, treatment and disposal) of waste; water consumption; purification and wastewater dumping; purchase of raw materials and packaging material; insurance premiums;
- Prevention of necessary costs for post-cleaning up contaminated areas, because of irregular emissions, drops and incidents.

Other indirect advantages are bound to cost reductions which are related to administrative penalties and eventual closing of plants because of regulatory violations in environmental field.

Environmental certification, pursuant to ISO 14001 standard or EMAS registration, it allows to improve relationship between different subjects (such as banks and financial market) which often introduce a careful analysis of environmental risk for the company in the procedures of granting credit.

Indeed, this risks affects the companies both on an income level, through the increase of some types of costs (waste disposal, environmental recoveries, administrative penalties and so on) and on property level by compromising the value of some activities which can represent guarantees for financiers.

An active attitude towards environment safeguard provides for implementation of innovations which involve not just extremely environmental aspects, but also they generally increase competitiveness of the company which can deal with advanced products and processes.

Moreover, in a more and more careful market (speaking about environmental features of products and services), a company with a “green image” can positively differentiate from its competitors. So, companies are often able to reach new marketplaces with products which also care for environmental culture of the demand and which expresses itself with a higher availability of paying a “plus” for eco-friendly features of products, as showed in the latest years by different researches among consumers.

The marketplace is wary towards environmental positions which are detected as “misleading”. So, company affirmations speaking about environment need reliability and truthfulness. With the adoption of a certificated EMS, the organisation presents information which have been guaranteed by an accredited third part.

Another important aspect of EMS is openness, both internal and external to the company.

Publication of environmental performances information has the target to establish and/or reinforce a reliable relationship with community so it can promote contact with authorities in charge. As shown in some cases, this attitude can lead to time and bureaucracy reduction for the obtaining of necessary authorizations licences for the site activities.

Furthermore, it is possible to obtain support and approval from the community through the improvement of the image, since they are more and more necessary for strengthening the company on the territory.

In view of different advantages and their effects, which are mostly perceived in a middle-long term timing, some costs must be taken in consideration; they are related to the implementation of an EMS and improvement intervention which became necessary due to evaluation

of starting situation of the organisation. These costs have different importance depending on the dimension, technical and organisational features and they basically are:

- Costs of investments and technical intervention on processes, products, plants, management equipment and abatement systems which contain the emissions in the environment and improve working process and safety;
- Costs of adaptation to standards of current environmental regulation;
- Costs of monitoring external and internal environment of the factory;
- Costs of training courses and staff upgrading;
- Costs of potential external consultations;
- Costs of communication management and relationship with the local territory.

Next to economic costs, one must also consider “internal costs” which are ascribable to organisational efforts of the implementation and following maintenance of the EMS. These efforts include commitment of time and human resources in the organisation, formalisation of procedures and operative instructions of current practices and the commitment of directorate and the whole staff.

In order to start procedures of EMAS registration to in charge subjects, one needs to support the following costs:

- Request of certification at the chosen Accredited Verifier;
- Pre-test or documentary test;
- Audit and validation of Environmental Declaration;
- Issue of environmental certificate;
- Request of registration in the list of registered organisations;
- Supervision audits.

In any case, speaking about application of EMS, the experience gained these years shows a very positive “benefits-costs” comparison, above all if one analyses it in middle-long terms. Costs and efforts which

have been done by organisations during the EMS implementation step have been compensated for the efficiency of this kind of instrument on environmental problems.

The ISO 14000 EMS

International rules ISO 14000 represent a voluntary instrument for the improvement of environmental management inside the company or another kind of organisation. Current rules EN UNI ISO 14000 have been created by ISO technical committee (International Organisation for Standardisation). The purpose of these rules is to provide a practical guide for the creation and/or improvement of an EMS, provide means for evaluating specific aspects of an EMS and verifying its validity and provide valid and reliable means in order to give information about environmental aspects of products.

Rule ISO 14001 “*EMS – guide requirements for the usage*” is the only prescriptive rule, while the others are simple guides.

Table 1.1 Table of most important ISO environmental rules

ISO 14001	Environmental Management System <i>Requirements and instructions</i>
ISO 14004	Environmental Management System <i>Guidelines for principles, systems and techniques of realisation</i>
ISO 14010	Guidelines for environmental audits <i>Audits procedures – Environmental System Audits</i>
ISO 14012	Guidelines for environmental auditors <i>Qualification criteria for environmental auditors</i>

The EMS is composed by six steps in succession which repeat themselves in each reference period. These steps aim to the continuous improvement of environmental performances, and they are:

1. Starting environmental re-examination;
2. Definition of environmental policy;
3. Planning;
4. Realization and efficiency;
5. Supervisions and corrective actions;
6. Re-examination of management.



Fig. 1.2.EMS model (Source UNI EN ISO 14001)

Expected requirements by regulation are totally general and they are applicable to every kind of organisation and they can be schematised according to the continuous improvement model which is defined by Deming Plan-Do-Check-Act Cycle.

We can analyse the steps more deeply:

1. Starting environmental re-examination

A company which doesn't own an EMS must effectuate a starting environmental re-examination in order to establish starting situation and later decide the improvement actions. However, this analysis is also suitable for an organisation which has already implemented an EMS: in this case, we will speak about preliminary re-examination. The examination consists of an ample analysis of emissions, aspects, effects, environmental performances and the company activities bound to supervision. This analysis must cover four main areas, that is:

- Rule evaluation;
- Evaluation of gained experience by analysing the incidents which already happened;
- Identification of significant environmental aspects;
- Analysis of all existing procedures and practices in environmental field.

2. Definition of an environmental policy

This is the definition of the frame of reference in which activities and environmental targets can be set up. In other words, it is the definition of the company mission towards the environment and it represents the official responsibility undertaken by the directorate of the organisation for a continuous improvement, suitability and spread of EMS. It establishes the results to be aimed for in terms of responsibility levels and performances which are required by the organisation. Every consequent action will be evaluated in this sense.

Environmental policy is a public declaration of the responsibilities undertaken by the company, so it is important it is composed with a simple style, because it must be understandable by all involved groups.

3. Planning (PLAN)

It consists in realisation and maintenance of procedures in order to identify the «environmental aspects» of the organisation and to agree upon how activities, processes and business products can affect the environment, by defining an evaluation criterion of significance for these impacts. For example, we can analyse the case of automotive industry: emissions, dumping, PVC wastes, low environmental impact motors, reuse of waste oil. Instead, for engineering industry: emissions in atmosphere (for example, from soldering and painting plants), drains, dangerous chemicals (compliant labelling, safe transportation etc.), dangerous wastes (for example waste oils, painting wastes etc.).

Furthermore, one can identify application criteria of «legal provisions and other ones» which are defined and carried out in this phase, along with the fulfilment of «environmental targets and goals» and concerning «environmental programs» made to obtain them according to environmental policy and legislative provisions.

4. Realization and efficiency (DO)

What has been defined in policy, targets, goals and environmental programs has to be concretely realized through definition of «resources, roles, responsibilities and authorities» related to EMS. In particular, it is considered the definition of a «director representative» which is called in the majority “EMS responsible” by the companies. The EMS program is so formulated and it defines all following procedures:

- «proficiency, education and awareness» of people who work for the organisation or on behalf of it, whose activities have significant environmental impacts, must be suitable for needs and appropriate in accordance with environmental policy;
- Establishing and efficient «communication» system procedures, both inside the organisation and to the outside of it;
- Emission, re-examination, modification, upgrade, availability, accessibility, supervision of Documentation of EMS, along with environmental policy, targets, goals, registrations, procedures too;
- «Operative Supervision» procedures of EMS, activities and operations which concern significant environmental aspects and the ones related to the achievement of policy and goals;
- Damage identification and reduction procedures (negative environmental impacts reduction) of potential environmental emergencies. This represents the way the organisation sets up its «preparation and response to emergencies».

5. Supervisions and corrective actions (CHECK)

Defined and applied efficiency, according to the above-mentioned description, must be submitted to a suitable verification regime in order to keep under control the efficiency and accuracy of the management system actualization. This must take place through a recurring audit of environmental performances:

- «Supervision and measuring», that means definition, realisation and observance of procedures for continuous monitoring of those operation which could have significant environmental impacts,

achievement of set goals, right adjustment of environmental monitoring equipment;

- Through an «evaluation of regulations respect» system, the organisation must periodically verify and register how legal provisions and eventual ones are actually followed;
- Management of «non-conformities, corrective and precautionary actions». This is how the organisation has set its own system in order to face eventual failure of requirements and also preventing the failure causes, lessening negative effects and defining and monitoring countermeasures.

So, environmental audit consists in a systematic and documented verifying process in order to evaluate the EMS operation, in particular to verify if environmental management activities are in compliance with the declared program, if these activities are efficiently applied and how much EMS is able to satisfy environmental policy of the company.

An EMS must also include suitable communication instruments in order to give information to involved people both outside and inside the company. In this way, the company will gain additional advantages from its environmental performances, and it will also gain the trust of shareholders, banks, residents, governments, environmental organisation and consumers.

6. Re-examination of management (ACT)

High directorate must periodically re-examine the EMS in order to guarantee its uninterrupted suitability, efficiency and validity. The re-examination must be based on all necessary information which will allow the directorate to evaluate and provide documentary evidence of EMS state.

A modification of environmental policy, goals, happened changings, continuous improvement commitment and other EMS elements are expected from the directorate during this phase, pursuant to environmental test results, happened changings and continuous improvement commitment. This step is the last one of the Deming Circle (ACT) and it is the precondition to follow the road of continuous improvement.

Once the EMS is implemented (according to expected requirements by rule UNI EN ISO 14001) it can be certificated. Company evaluation procedures for the certification are totally equal to the ones which are used to confirm UNI EN ISO 90000 quality systems. Procedures for EMS certification consist in following steps:

1. Submission of certification request;
2. The certification authority verifies the request;
3. Evaluation visit of the company carried out by the certification authority;
4. Certification issue by certification committee;
5. Verification visits and annual supervision by the certification institution.



The certification has a duration of three years and it is renewed if all the requirements are kept, including continuous environmental improvement.

Once it is certified, the company has the right of reproducing certification document and brand with lots of image advantages in case of good marketing strategies.

EMAS registration

When the company has obtained the EMS certification, it can decide to stop or go ahead: rule ISO 14001 and EMAS regulation are voluntary, so the company must evaluate (in strategic terms) if it is better to restrict to certification or gaining EMAS registration and certification too. In the second case, the EMAS brand weight is superior because, after the national registration, it is published on the Official Journal of the European Union as a registered site according to EMAS regulation. The Eco-Management and Audit Scheme (EMAS) is a system to which companies and organisation can voluntarily subscribe. They can be both private and public, be located in the European Community territory or not, desire to commit to evaluate and improve their own environmental efficiency.

First EMAS regulation no.1836 has been issued in 1993. Later, it has been substituted with Regulation no.761 in 2001 which has been further reviewed and substituted with Regulation no.1221 in 2009.



In order to achieve an EMAS brand, a company has to issue an Environmental Declaration which needs to be convalidated. The environmental declaration is a document for outer community which furnishes proof of the activity on the site, it resumes all the environmental problems concerning this activity, shows all the data about factors of environmental impact of the site and displays policy, program and applied management system. After this, this document must be convalidated by an independent, accredited environmental auditor. The convalidation is sent to the authority in charge of the Member State where the site is located in order to make it available in a list of registered sites for the community.

1.2.2 LCA – Life Cycle Assessment

Life Cycle Assessments a method which values a group of interactions a product or a service has with the environment by considering its whole life circle which includes pre-production steps (extraction and production of materials) production, distribution, use (including re-use and maintenance) recycling and final disposal. Procedure LCA is standardized at international level by ISO rules 14040 and 14044

According to ISO rule 14040, LCA considers environmental impacts (of the case in question) towards human health, ecosystem quality and sources depletion, in addition to economic and social impacts. LCA wants to define a complete summary of a product or service interaction with the environment. In this manner, it helps to understand the environmental consequences which have been directly or indirectly

caused; so, it gives necessary information (to people who determine the regulations) for defining necessary attitudes, environmental effects of an activity, improvement opportunities in order to achieve best solutions to intervene on environmental conditions.

When one decides to realise an LCA analysis of a product, it must identify the processes involved in the life cycle of each product part and its packaging. Generally, analysis considers:

- Extraction and supply of raw materials
- Production
- Packaging
- Transportation from the production site to point of sale
- Use
- Disposal of product and packaging

According to rules ISO 14040 and ISO 14044, the analysis of life cycle happens in four steps:

1. Goals definition and application field: one defines study targets, functional unit (measure or amount of product which has been taken as a reference for impact analysis), system borders (scope of considered system).
2. Inventory: this is the step in which input and related emissions are assessed for each phase of life cycle.
3. Impacts evaluation: information obtained during the inventory step are classified and united in different impact categories.
4. Interpretation of results: obtained information and results are interpreted in order to traduce them into recommendations and interventions for reducing environmental impact.

We can analyse these four steps more deeply:

1. Goals definition and application field

Definition of study field and target of an LCA is a critical passage because it represents the step in which the most important decisions are made. According to intentions and specific interests, survey context is

defined and requests for successive steps are set. This point of view may concern the detail level of the study, quality of required data, selection of standards for the realisation of the environmental impact esteem and possible interpretations inside the context of evaluation; the result is generated by iterative processes of LCA. Among the other things, one must decide if (and eventually how) a commission of experts has to write an external report (a critical survey), as required by rule ISO 14040, which is useful for the realisation of comparative studies for community.

2. Inventory analysis

In the inventory analysis, material and energy flows are meticulously written down, by taking the whole life of the examined product into consideration. At first, structures of the total process are shaped, so one can have a support in order to set up all data. Material and energy flows are determined on the basis of entrances and exiting's of each partial process in relation to system borders. Then, by connecting the different analysed passages, one manages to simulate connection networks which exist between modules and environment: in this way, evaluation of mass and energy can be done, which become the real inventory of the total system. In the end, all material and energy flows which earlier cross the borders are quantitatively written down (the used measure units are the physics ones) by always referring to functional unit.

3. Environmental impact estimate

The target of environmental impact esteem is evaluation of material and energy flows (according to precise environmental parameters) which have been evaluated during the inventory analysis: so, this esteem is useful to identify, summarize and quantify possible environmental effects of the examined systems, and also to obtain basic information for their evaluation. Today, different commissions still work on the development of this method; the first international recognition can be found in rule ISO DIN 14042 pursuant to acceptance of SETAC recommendations in 1993. Each passage of impact evaluation, such as definition of impact categories, classification and characterisation, is shown below. In the "Classification" context material and energy flows (previously examined in the inventory analysis) are assigned to previously defined environmental categories, which can be assimilated

to real environmental effects. In LCA, the following impact categories are usually employed:

- Global warming (GWP)
- Ozone decrease in stratosphere (ODP)
- Photochemical ozone creation in troposphere (POCP)
- Nutrition (NP)
- Acidification (AP)
- Human toxicity (HTP)
- Ecotoxicity (ETP)
- Territory use

Impact categories describe potential effects on humans and the environment; among the other things, they diverge in relation to their spatial position (global, regional and local effects). In principle, each environmental effect may be included in a survey if necessary data for the analysis and a suitable model for description and effect parametrization are available. In the end, one must remember that a flow of material can be appointed to different environmental effects. During the “Characterization” phase, previous assigned portions are quantified: indeed, with the help of equivalence factors, different contributions of materials are united in a specific environmental effect and related to a matter which has been taken as a reference. Registered flows during the inventory analysis are multiplied by respective equivalence factors and added up: the so determined potential of impact represents the measure of a possible environmental damage (NB: values of different potentials of impact are not directly comparable to each other). During “Standardization”, determined potential of impact is put in relation to a reference value inside the same area. There are no groups of impact categories in one (or more) reiterative index; evaluation of individual criteria can be exclusively run on the basis of individual (marginal) parameters, which can’t often be translated into scientific language

4. Interpretation of results

Target of the interpretation step is analysis of obtained results, explanation of the meaning they acquire and the restrictions they establish. Fundamental facts, based on the results of inventory analysis and the environmental impact esteem, must be determined and verified regarding their completeness, accuracy and solidity. Assumptions made during the target definition step and in the analysis field must be quoted in this passage: indeed, it is possible to draw conclusions and produce recommendations only on the basis of these requirements.

By now, LCA is a well-known procedure on international level and its field of application are quickly expanding towards new sectors, as the environmental communication and the green marketing and with the help of instruments as the environmental product declaration and the carbon footprint, which have been thought in order to easily represent LCA results.

By studying in detail every aspect concerning each part of the product, LCA allows to examine the whole life cycle fully, allowing in this way to identify which phases mostly impact and need interventions. So, LCA can be considered as a guide for the improving of existing products and creation of new ones.

Furthermore, LCA results can be used for comparing different products (which share the same purpose) or similar ones, in order to require environmental certifications and to communicate the environmental performance of product.

1.2.3 Ecolabel

Ecolabel is a voluntary system of ecological labelling of products; its goal is to promote planning, production, marketing and use of products with a smaller environmental impact during the whole life cycle of products, on the basis of criteria of environmental impact evaluation which concern energy consumption, pollution (of water, atmosphere, sound, soil), waste management. It is a brand of environmental excellence, meaning that it helps consumers to distinguish which products impact less the environment, performances and quality being equal. Ecolabel is not the only existing environmental brand, but its strong point are the spreading in the whole EU and the fact that independent public

authorities guarantee the respect for ecological criteria.

Ecolabel brand, whose logo is embodied by a flower, is a voluntary and selective instrument which spread all over Europe. Ecological label is a certification of excellence, that's why only the products which have a small environmental impact can get it. Ecological and performing criteria are made in order to allow only the most excellent eco-friendly products to obtain the Ecolabel. When one needs, criteria are reviewed and become more restrictive in order to always reward excellence and promote continuous environmental improvement of products.



Differently from an ISO 14040 certification, Ecolabel (CE Regulation n. 66/2010) is the environmental quality brand of EU and it rewards best products and services in the environmental field; so, they can be diversified from competitors of the market by still keeping high performing standards. Indeed, label certifies the product or service has a small environmental impact in its whole life cycle.

The European dimension is the strong point of Ecolabel. The brand can be used in 27 EU Member States as is in Norway, Iceland and Liechtenstein. The Ecolabel brand stimulates producers to create “eco-friendly” products and it gives the possibility to consumers to make environmental aware and reliable choices of purchase. Products which can be proud holders of Ecolabel are consumer goods which passed prefixed selection criteria of the EU commission, whose goal is rewarding environmental and performing excellence of products.

Brand concession is based on a multi-criteria system which is characteristic of labels Type I (ISO 14024), applied to products divided by groups. Ecological criteria of each group of products are defined by using a type of approach named “from the cradle to the grave” (LCA – evaluation of life cycle) which measures all the impacts of products on the environment during all the phases of their life cycle, starting with raw materials extraction where the aspects for qualifying and selecting suppliers are considered. This happens through working processes

where the company impacts are controlled, from distribution (including packaging), use to disposal at the end of life cycle.

LCA studies (at the base of criteria) are focused on some aspects as energy consumption, water and air pollution, waste management, saving natural sources, environmental safety and soil protection. To obtain Ecolabel, criteria of suitability for use are added to environmental parameters which are also useful to qualify the product from the point of view of performances, in order to overtake a commonplace which depicts ecological products as low quality ones.

Criteria, once adopted by a qualified majority of Member States and European Commission, are valid until, after a Commission re-examination, one needs to make a revision: this could make them more restrictive in relation to market and scientifically, technological progresses, in order to improve environmental performances of the labelled product and keep the brand selectivity.

1.3 Italian experiences of development of eco-industrial parks

Industrial symbiosis (IS) is the sharing of services, utilities and by-product resources among industries in order to reduce environmental impacts and costs. IS systems engage traditionally separate industries in a collective approach that optimizes material and energy use through physical exchange of materials, energy, water and by-products. The most significant example of application of the Industrial Symbiosis is the development of *eco-industrial parks* (or *districts*), defined as “communities of manufacturing and service businesses located together on a common property, where the members pursue enhanced environmental and economic performances through collaboration in managing environmental and resource issues”. An added-value from the development of eco-industrial parks is given by the positive fall-out on the small and medium –sized enterprises (SMEs) that make up a large part of Europe’s economy. All but 1 % of Europe’s companies are SMEs, and SMEs generate 57% of economic activity in the EU. SMEs thus can play a primary role in shifting the European economy to more sustainable production and consumption patterns. SMEs invest in

innovation but their objectives often do not consider the environment and sustainability. The environmental impact of SMEs is hard to quantify, because SMEs activity are fragmented and useful data often don't exist. Initiatives are needed to improve the capacity to develop and use environmental technologies. These initiatives are likely to be more successful if carried out on the basis of cooperation across particular territories, or *Ecologically Equipped Productive Areas (EEPAs)*, rather than targeted as individuals SMEs.

In Italy the Legislative Decree 112/1998 (the so-called Decree Bassanini) entrusts the Regions to issue the laws on EEPAs lay out and management; afterwards two projects, sponsored and partially financed by the European Commission, promoted a promising application of the EEPAs.

The project LIFE ENV/IT/000524 SIAM (Sustainable Industrial Area Model), running from 2004 to 2007, was coordinated by ENEA (National Agency for New Technologies, Energy and the Environment), with the cooperation of 17 Italian public and private partners (universities, local public authorities, private enterprises), located in 8 industrial areas in every part of the country, in order to represent the economical, industrial and infrastructural heterogeneity that characterized the Italian productive settlements. In this way it was possible to reach over 3,500 companies and 25,000 workers, and involve numerous Local Bodies (Regions, Provinces, Municipalities, etc.).

The main objectives of the project SIAM were to integrate the sustainability principles in locating, settling and managing industrial areas; to develop innovative methods, based on a preventive approach, for reducing environmental impacts and favouring the use of clean technologies in these areas; to promote the continuous improvement of the environmental performances of the entire industrial areas and of the single local enterprises; to encourage a collaborative climate and to build effective relationships among the local authorities, citizen and industries; to create the conditions for increasing employment and training new professionals on the sustainable designing and managing of industrial areas. These objectives was pursued by defining and applying a new *Model of Sustainable Industrial Area* based on using, adapting and integrating three different community environmental policy instruments: Strategic Environmental Assessment (SEA) according to

the Directive 2001/42/EC; EMAS according to the Regulation 761/2001/EC; Environmental Accounting and Freedom Access to the Information on the Environment according to the Directive 90/313/EEC.

The key factors characterizing the SIAM approach were: a) to study the ecological situation of the chosen industrial areas; b) to define a model (set of parameters) for a better and more complete design of a sustainable area; c) to test the model in the chosen industrial areas; d) to set out the guidelines for a future utilization of the model.

After the complete definition and experimentation of the model for verifying its applicability to the selected 8 project's Industrial Areas, the model was also verified on the basis of the comments coming from the Local Committees and Forums activated in each area. The objective was to guarantee the active and systematic involvement, in each applicative phase of the model, of all the subjects territorially interested. The guidelines for the application of the model were produced to allow its reproducibility to other National and European realities too. The guidelines include criteria of Sustainability of the Industrial Area, the modality to apply these criteria and the process of verifying them.

The project Life plus 2009-2013 ENV/IT/000105 ETA-BETA (Environmental Technologies Adopted by small Business operating in Entrepreneurial Territorial Areas) was coordinated by Milano Metropoli (a public/private agency responsible for the promotion and sustainable development for the metropolitan area of Milan). The project aimed at strengthening and promoting the creation and development of EEPAs within the EU's economic system and regulatory framework, thus fostering sustainability. The project implemented a data base showing that in Italy 25 EEPAs are already operating.

The key factors characterizing the ETA-BETA approach were : a) to break down the information, technology and economic barriers that prevent SMEs from using environmental technologies as tools for promoting innovation in the field of environmental protection; b) to develop instruments and environmental performance requirements that will promote the idea of EEPAs in Europe; c) to outline the importance of "good practices" in EEPA management; d) to boost private and public demand for centralised environmental services in the EEPAs; e) to contribute to the development of a *European Environmental*

Technology Verification system, through the creation of guidelines for measuring the performance and environmental benefits resulting from technologies used in EEPAs.

The expected products of the project were: a) comprehensive guidelines for evaluating the environmental technologies; b) an EEPA management model covering : i) working tools for EEPA managing authorities; ii) financial tools for supporting SME investment in green technology in EEPAs; iii) better good practice communication tools; c) the appointment of at least one manager for each EEPA participating in the project; d) the testing of at least one environmental technology in each EEPA participating in the project.

Chapter 2

“The Iron and Steel Industry”

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2.1 The evolution of the sector

2.1.1 The world-wide scenario

According to valuations of the World Steel Association (WSA), the steel production will reach 2.3 billion annual tons within 2025, increasing more than 40% compared with current production (1.6 billion annual tons) headed (especially within emerging economies) by constructions, transports and mechanical engineering. From 2000 to date, the global demand of steel has continuously risen, with an annual expansion rate of 6% until 2011, when it reached 6,2%; in 2012, the data recorded an increase of just 2,1%, with a recovery in 2013 of 3,6%. The production data (in million annual tonnes) of the 11 main producing countries in the world are illustrated in Table 2.1, referring to year 2013.

Table 2.1 Steel production in the world (2013)

Country	Steel production	Variation % 2013-2012
China	779,0	+7,5
Japan	110,6	+3,1
USA	87,0	-2,0
India	81,2	+5,1
Russia	69,4	-1,5
South Korea	66,0	-4,4
Germany	42,6	-
Turkey	34,7	-3,4
Brazil	34,2	-1,0
Ukraine	32,8	-0,5
Italy	24,1	-11,7

The growth in the early 2000s has been widely caused (about 80%) by the incessant expansion of Chinese economy, which today represents 49% of worldwide steel production. China was a net importer, but thanks to the increase of Chinese production, which caused a capacity excess in the internal market, it suddenly became the greatest steel exporter in the world. Thanks to shale gas energy, which reduced the

price of energy supply, the U.S.A are boosting their productive potential too; soon, they could become a net steel exporter, which will probably cause further increasing of capacity excess in the global markets. Also other countries near Europe (Russia, Ukraine and Turkey) considerably improved their steel production capacity. In 2013 Asia confirmed its continental leadership with an annual production of 1.060 billion annual tonnes (with a rise of 6% compared with the previous year); it now represents 2/3 of global steel industry. In the next years, all the emerging countries will see their own production increase their productive capacity (expected rate of annual growth will be 3% for China, 4.6% for extra UE countries, 5% for Latin America, 6.3% for Middle East, 8% for Africa).

Facing the rise of productive capacity by most of producing countries, the global steel industry will record a further rise of excess of productive capacity, which now already exceeds of 500 million annual tons (about 200 million annual tonnes only in China).

2.1.2 The European scenario

In 2011, the steel industry operators were about 360,000 in the whole E.U; they were distributed in 500 production plants located in 23 member states, highlighting the strategic role which this base industry still plays in the continental economy, although the reducing due to the recession.

In all the European countries the inner steel request is strictly related to the economic and financial situation of those of the production sectors, which show insecurity speaking about their actual capability of recovery, especially buildings and automotive industry (which form, together, about 40% of the steel request), but also the mechanical industry and the industry of electrical and electronic machinery. Nevertheless, exportations started to rise again since 2010, with a trade surplus of 16.2 million dollars of tonnes (20 billion Euro) during 2012.

Dynamics of steel industry competitiveness is bound to energetic costs, which can reach 40% of total operating costs; in Europe, they affect more than in the rest of the world (between 2005 and 2012, European industry went through average increases of 38% on the price of electrical energy in real terms, while the percentage for U.S.A and Japan were respectively -4% and +16%).

The respect for environmental limits, imposed by Europe to the producers, risks to create a further damage on the capability of maintaining the industry competitive.

As observed by European Commission in the Action Plan 2013, steel industry seems to be quite old (especially for what is concerning blast furnaces, even if they are more modern than the American ones on average); also, for the steel industry it will be difficult to reduce the CO₂ emissions further without the introduction of innovative technologies.

The Action Plan highlights how competitiveness in European steel production depends, as the rest of manufacturing industry, on energetic costs, resources and raw materials, which are lacking in Europe and their price depends on the dynamics of global request.

Iron minerals of good quality “feed” the blast furnaces, and they’re intensely requested by the emerging economies, and that’s the reason why they keep the price elevated.

Instead, the decrease of coal request in U.S.A, caused by the boom of shale gas, involved a favourable reduction of the prices of the coal coke in the E.U, with a consequent increase of its use.

Some structural problems remain, such as: a) excess of productive capacity (European steel industry still presents about 80 million annual tonnes of productive excess against a EU total productive capacity of 217 million annual tons, although it already adopted adjusting measures by dismantling more than 30 million annual tons of productive capacity); b) the strength of emerging countries (Turkey ahead thanks to geographic position, rising internal market and an efficient structure regarding plants, logistic and organization); c) the need of a repositioning on higher added value segments (for a productive system which can aim at specialized products and quality as the European one, there is the need to increase the added value of steel products in order to differentiate from competitors and increase its competitiveness).

In the end, as the European Commission highlighted in the Action Plan, what’s most important is not to waste gathered professional capabilities, and to requalify the workers in order to anticipate changing and to maintain competitiveness in the industry, by using funds and instruments of European policy, so that the sector preserves its strategic nature for the European manufacturing industry and employment.

European policy show how executive modalities should privilege the progressive transition to new advanced production techniques and innovative products, but without excluding necessary renovation or reorganization.

In addition to iron minerals, also scraps represent a raw material for steel creation by using electric furnaces. In effect, steel can be repeatedly recycled without losing its endurance, ductility and formability. In this case too, the purpose is to keep the scrap trade competitive, and to face the forceful attitudes of emerging economies.

The European industry recovery can be influenced by another limit; the average age of workers is high in the majority of European steel industries (within 2015, about 30% of them will be out of the productive cycle). In order to keep the competitiveness, the steel industry will have to be capable of appealing young workers with adequate qualification in mid-term.

2.1.3 The Turkish scenario

The iron and steel industry grew in parallel to the growing economy. BMI expects further growth in the Turkish iron and steel industry in a climate where much of Europe will see slight increases or no growth at all in the industry. Turkey's success in the iron and steel industry is evident as it is among the top 10 crude steel producing countries in the world. Crude steel production is expected to continue and reach 47 million tonnes, which is an increase of approximately CAGR 5.5% by 2017. The cost of production is among the lowest in all of Europe. Turkey provides a level playing field in terms of access to raw materials. It has already established pertinent trade legislation for investors so they can easily access necessary raw materials and boost their competitiveness in international markets. Domestic and international investors are ramping up their investments for qualified steel and finished steel products to capitalize on Turkey's economically attractive iron and steel industry. Capacity expansion and new plant capacity will reach more than 7 million tonnes between the years 2013 and 2015. Strong growth is expected in steel-dependent industries such as auto manufacturing, infrastructure and construction, which will increase the demand for finished steel products. Turkey also has a highly skilled workforce within the industry that graduates from vocational training schools and universities, able

to serve the needs of the iron and steel industry. Turkey is fostering innovation through technology centres, where it will promote research and development along the whole value chain of the steel industry. Turkey has transparent and liberalized foreign direct investment laws that help international companies to easily establish companies within Turkey. International companies such as Posco and ThyssenKrupp are reaping the benefits of Turkey's sustainable growth and both are either building or expanding their steel production in Turkey.

Even though iron and steel makers around the world are being challenged by weak global demand, Turkey's iron and steel industry continues to grow, increasing its presence in the global arena. The iron and steel industry had an impressive growth rate of more than 5% in 2012, surpassing the GDP growth rate of 2.2% in the same period. Turkey maintained significant iron and steel industry growth rates between 2003 and 2009. The dip in 2009 indicates weak market conditions due to the global economic crisis, but the industry quickly recovered and continued growing strongly after the global economic crisis.

In 2012, the iron and steel industry's contribution to the GDP was 1.08%, up from approximately 1% in 2006. The iron and steel industry's share in the GDP is expected to continue to increase as new opportunities arise in the industry and is projected to gain a share of 1.35% by 2023⁹.

2.1.4 The Italian scenario

The classification of economic activities in Italy by the National Institute for Statistics (ISTAT) distinguishes the *primary steel sector* on which steel production is based (including such activities as the direct reduction of the iron ore and the fabrication of liquid or solid pig iron, the conversion of pig iron into steel and the fabrication of ferroalloys and steel products) from the *wider steel sector* including the fabrication of tubes, conduits, hollow profiles and related steel accessories. According to the ISTAT census of industries and services as at 31 December 2011, there were approx. 450 primary steel sector enterprises working in Italy, employing approx. 42.000 people directly. According to the estimates of the Italian Federation of Steel Enterprises (Federacciai) related to the total employment including all connected metallurgical sectors, employees amounted to approx. 70,000 (in 2011).

⁹ <http://www.invest.gov.tr/en-US/infocenter/publications/Documents/IRON-STEEL-INDUSTRY.pdf>

The outcome of the ISTAT census also stressed that the primary steel sector is strongly concentrated on large and medium-sized enterprises, with 80% of employees working for businesses with more than 200 employees. The Riva Group, with 7.7 billion revenues in 2010, was the only large group to be comparable to the European leaders, being the fourth steel producer in Europe and however a big player worldwide.

As far as production methods are concerned, the present configuration of the Italian steel industry is composed of 35% of integral cycle steelworks, while a larger share, approx. 65%, is based on the Electric-Arc Furnace (EAF). This configuration is the result of the evolution in the last 60 years. Originally Italy had an acceleration with large integral-cycle steelworks guided by the public sector. After the oil crises and privatizations, several large steel steelworks based on the integral cycle lost their weight and at the same time numerous EAF steelworks started to establish themselves on a national scale. Therefore, the Italian technologic choice is different from that of the rest of Europe and even more different from that of Germany, fully orientated towards the integral-cycle steel production.

Integral cycles, which use iron ore and coal as raw materials, produce a high-quality steel but the process is longer and more complex. The large dimensions of converters and their uninterrupted feeding by the blast furnace affect production strategy, which is based on the ability to obtain very significant scale economies in terms of production volumes. The optimal production capacity for the large integral-cycle steelworks ranges from 5 and 10 million tonnes of steel a year. To obtain such capacity, a steelworks must be equipped with appropriate logistic systems. The integral cycle in Italy is presently applied by three 3 steelworks: ILVA in Taranto (built in the 1960's), Piombino (started at the end of the 1970's to replace the three existing blast furnaces) and the Servola ironworks in Trieste, all production sites with an access to the sea.

EAF steel production is based on the melting of selected and prepared scrap. This technology is characterized by the smaller dimensions of steelworks (production capacity of 1÷2 million tonnes of steel a year, mainly used to obtain long products, i.e. bars, rods for reinforced concrete and wire rods) making the ratio between investments and production capacity more acceptable than the large integral-cycle steelworks. In

addition, this technology makes the production cycle less complex and more capable of adjusting itself to demand changes. In terms of general environmental impact, EAF steelworks are more sustainable than integral-cycle steelworks because energy consumption may be reduced by 75% compared to iron ore reduction, and atmospheric pollution by 86%, water consumption by 40%, water contamination by 76% and waste production from the mining activity by 97%.

According to Federacciai estimates, the Italian steel sector in strict sense reported a production loss of more than 3 million tonnes in 2013 compared to the preceding year with a drop of -11.7 % down to 24.1 million t a year. If compared to 2007, when production achieved 33 million tonnes, loss exceeded 27%. While exports had been steadily growing in the preceding years, they lost 11% in 2013. In comparison with Europe, the Italian steel industry is still significant, ranking second in terms of volumes in Europe following Germany. Italy's difficulties become apparent if we consider the levels of Spain (13.7 million tonnes a year) and France (15.6 million tonnes a year), which reported positive sales (although limited) in 2013 with a growth of +0.7 % and +0.5 % respectively compared to 2012. While the role of Italy is still key in Europe, the weight of the EU, equal to 10.5% of world production, explains the minimum incidence of Italy (1.5%) on the total production of steel worldwide; a percentage however affording Italy the 11th place among all world steel producers.

The negative dynamic trends reported in Italy in 2013 are the result not only of the continuous drop of internal demand of steel from manufacturing and construction companies, but also and above all the operating difficulties experienced by ILVA in Taranto (see par. 2.3).

To overcome the present difficulties of the Italian steel sector, competitiveness should be enhanced through the requalification of production processes and the organization of production. In this respect, three factors play an especially important role:

- *Process innovation*, through investments on new technologies making the production process cleaner, less energy intensive and more efficient. In this framework, also investments on management and product "quality" seem essential to open new market outlets and activate selective trade strategies.

- *Increasing investments on processes using second raw materials* (recycling of scrap and steel by-products), to allow for a progressive and more extended transition to less environmentally impacting technologies.

- *Investments on the creation of new professional figures*, able to contribute to the positioning of the Italian steel industry in more profitable market niches, and able to generate productivity levels equal to those recorded by the main foreign competitors.

On the other hand, it is necessary to bear in mind that the solution of difficulties cannot be based totally on the strengthening of internal factors in the steel industry (technology, human capital), but it also depends on external factors (e.g. the adoption of a domestic energetic policy decreasing the energy cost gap with other industrialized countries or the need to raise significant funds for R&D by promoting the cooperation between public and private research).

2.2 Processes, technologies and main environmental issues

The contents of paragraph 2.2 refer to the JRC Reference Report (2013) “BAT Reference (BREF) Document for Iron and Steel Production” that presents the results of an exchange of information between EU Member States, the industries concerned, non-governmental organizations promoting environmental protection and the European Commission. The document is in compliance with the Directive 2010/75/EU of the European Parliament and Council on Industrial Emissions (Integrated Pollution Prevention and control), see paragraph 1.1 (Overview of the European Union Directives for the environment protection). The original BREF Document on Iron and Steel Production was adopted by the European Commission in 2001. The review commenced in 2005.

Four routes are currently used worldwide for the production of steel (see Figure 2.1). The traditional routes are the classic Blast Furnace/Basic Oxygen Furnace (BF/BOF) route and the direct melting of scrap (EAF). Alternative steelmaking routes are the smelting reduction (SR) and the direct reduction (DR).

In 2006, the steel production in the EU-27 was based on the blast furnace/basic oxygen route (approximately 59.8%) and the electric arc furnace (EAF) route (approximately 40.2%).

The percentage of world crude steel production via direct reduction was about 6.8% in 2006 which corresponds to 59.8 million tonnes direct reduced iron (DRI). In Europe, the production of direct reduced iron (DRI) was limited to 704.000 tonnes in 2006, which represented approximately 1.5% of world output. In the EU-27, there are no smelting reduction units on a commercial scale. The primary environmental benefit claimed for DR and SR processes is that they can operate without coke or sinter. This prospect might prevent the necessity for coking plants and sinter machines that potentially have a significant environmental impact. Emissions from reduction plants are generally low, with particulate releases to air after abatement of the order of 10 mg/Nm³. Abatement tends to be based on wet technology leading to an aqueous waste stream, although this may be capable of being addressed by recycling the water or by dry cleaning. If DR or SR processes use iron pellets or sinter, then the emissions associated with the processing of these materials must be considered when comparing environmental performances of the various ironmaking routes.

2.2.1 Overview of the traditional routes

2.2.1.1 Blast furnace/oxygen furnace

Among the steelmaking routes, the classic blast furnace/basic oxygen furnace route is by far the most complex, taking place in large industrial complexes known as integrated steelworks, covering areas up to several square kilometres.

Integrated steelworks are characterized by networks of interdependent material and energy flows between the various production units (sinter plants, palletisation plants, coke oven plants, BF and basic oxygen steelmaking plants with subsequent casting).

In an integrated steelworks, the blast furnace is the main operational unit where the primary reduction of oxide ores takes place leading to liquid iron, also called 'hot metal'. Modern high performance BF require physical and metallurgical preparation of the burden. The two types of iron ore preparation plants are the sinter plants and the pellet plants.

In the sinter plant agglomeration of iron ore fines with other fine materials (residues, additives) takes place at $1,300\div1,480\text{ }^{\circ}\text{C}$. It consists of a large travelling grate of heat-resistant cast iron, where the combustion takes place to sinter the fine particles. A number of chemical and metallurgical reactions take place during the sintering process. On the underside of the sinter strand there is a series of wind boxes that draw the flue gas down through the material bed to a gas cleaning. The fused sinter is discharged at the end of the sinter strand, where it is crushed and screened. The sintered material proceeds to a cooler, such as water sprays, with possible heat recovery.

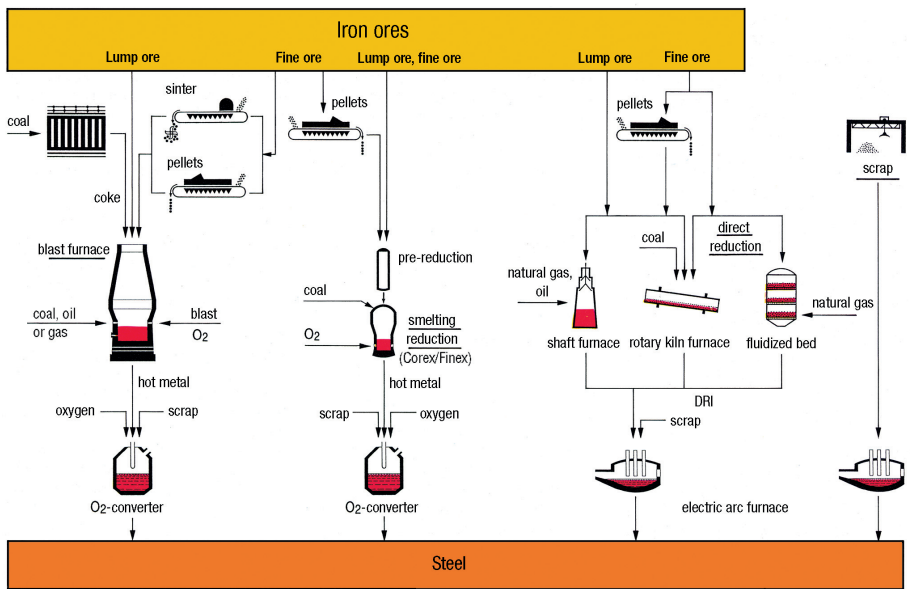


Figure 2.1 Crude steel production methods

The palletisation process consists of grinding and drying or dewatering, wetting and mixing, balling and induration followed by screening and handling. Pellets are nearly always made from one well-defined iron ore or concentrate at the mine and are transported in this form. In Europe, there is only one integrated steelworks also operating a palletisation plant.

The coke-making process, in coke oven plants, can be subdivided into: coal handling and preparation; battery operation (coal charging, heating/firing, coking, coke pushing, coke quenching); coke handling

(discharge, storage, conveyance) and preparation; coke oven gas (COG) treatment with recovery and treatment of by-products in the case of a conventional coking plant; recovery of the heat of the cooking and treatment of the flue gas in the case of a heat recovery coking plant. The main reducing agents in a blast furnace are coke and pulverized coal forming carbon monoxide and hydrogen, which reduce the iron oxides. Coke and coal also partly act as a fuel. Coke is produced from coal by means of dry distillation in a coke oven and has better physical and chemical characteristics than coal.

Around 25 to 30% of the weight of the coal charged to coke ovens is driven off as effluent gases rich in volatile matter and moisture. After drying this raw gas and separating tar, light oil and sulphur fractions (which have values themselves), COG is obtained. This gas has a heating value between $17\div 20$ MJ/Nm³ and is generally used for coke oven heating, heating of other furnaces and for power generation, both internally and externally. Although COG recovery is performed in most plants, it still offers a considerable potential. According to a 2007 study by International Energy Agency (IEA), approximately 70% of the COG was used in iron and steel making processes, 15% for coke oven heating, and 15% for electricity production. It was stated that by using more of the COG for power generation (preferably combined with more efficient combined cycle power generation techniques that can provide efficiencies of around 42% techniques as opposed to those based on steam cycles - with an average efficiency of around 30%) improvements in energy efficiencies can be realized.

In many cases, additional reducing agents/fuels are supplied by the injection of oil, natural gas and (in a few cases) plastics. A hot blast provides the necessary oxygen to form the carbon monoxide (CO), which is the basic reducing agent for the iron oxides.

The blast furnace is charged from the top with a burden. This consists of alternate layers of coke and a mixture of sinter and/or pellets, lump ore and fluxes. A simplified layout of a blast furnace consisting of the furnace itself, the cast house, the hot stoves and a two-stage treatment of BF gas.

In the furnace, the iron ore is increasingly reduced and liquid iron and slag are collected at the bottom of the furnace, where they are tapped.

The slag from the blast furnace is granulated, pelletized, or tapped into slag pits. The slag granules or pellets are usually sold to cement manufacturing companies. Slag from pits can also be used in road construction.

The liquid iron from the blast furnace (hot metal) is transported to a basic oxygen furnace, where the carbon content (approximately 4%) is lowered to less than 1%, thereby resulting in steel. Upstream ladle desulphurization of the hot metal and downstream ladle metallurgy of the steel is generally applied in order to produce steel with the required quality. On leaving the basic oxygen furnace, the liquid steel is cast either into ingots or by means of continuous casting. In some cases vacuum degassing is applied in order to further improve the quality of the steel.

Casting products, whether ingots, slabs, billets or blooms, are subsequently processed in rolling mills and product finishing lines in order to prepare them for the market.

The purpose of this oxidation process is:

- to reduce the carbon content to a specified level;
- to adjust the contents of desirable foreign elements;
- to remove undesirable impurities to the greatest possible extent.

The production of steel by the BOF process is a discontinuous process which involves the following steps: transfer from the BF and discharge; pre-treatment of hot metal (desulphurisation, deslagging); transfer, weighing and reloading; oxidation in the BOF (carburization and oxidation of impurities; secondary metallurgical treatment; casting (continuous or/and ingot).

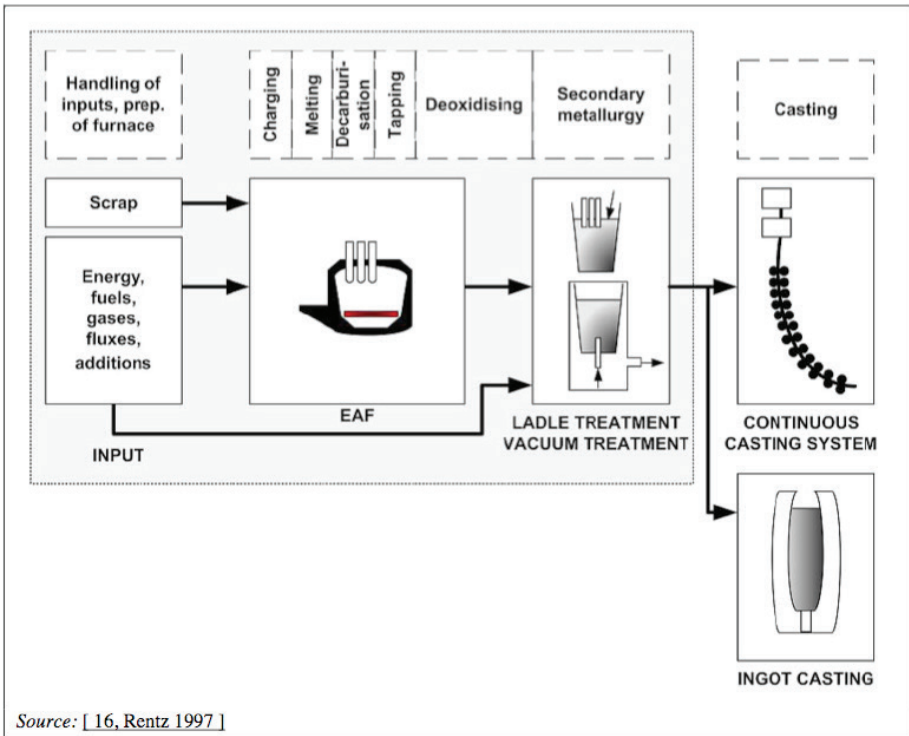


Figure 2.2 Overview of the processes related to EAF steelmaking

2.2.1.2 Electric arc furnace

As for the electric arc furnaces (EAF) (see Figure 2.2) the major feedstock is ferrous scrap, which may be comprised of scrap from inside the steelworks, cut-offs from steel product manufacturers (e.g. vehicle builders) and capital or post-consumer scrap (e.g. end-of-life products).

The ferrous scrap metal is loaded into baskets by magnets or grabs. Scrap is purchased based on specific international specifications which minimise non-metallic inclusions.

Some scrap sorting is carried out to reduce the risk of including hazardous contaminants. In- house generated scrap can be cut into manageable sizes using oxygen lancing.

The scrap is partly preheated by off-gas and partly by side wall burners.

Through the utilisation of the furnace off-gas during the heat cycle, scrap can be preheated to a temperature of approximately 800°C prior to the final melting in the furnace vessel. This means considerable energy and cost savings with a substantial reduction in tap-to-tap times.

During the initial period of melting, the applied power is kept low to prevent damage from radiation to the furnace walls and the roof whilst allowing the electrodes to bore into the scrap. Once the arcs have become shielded by the surrounding scrap, the power can be increased to complete the melting. Oxygen lances and/or oxy-fuel burners are used more and more to assist in the early stages of melting. Fuels include natural gas and oil. Furthermore, oxygen may be brought to the liquid steel by specific nozzles in the bottom or side wall of the EAF. The purpose of using oxygen is manifold:

- the combined injection of oxygen and granular carbon allows for the generation of a foamy slag thanks to the generation of CO bubbles. The 'foamy slag' technique, which is now in wide use in carbon steelmaking, improves the shielding of the furnace walls from the radiation of the arc and allows for an improved energy transfer from the arc into the steel bath;
- for metallurgical reasons, oxygen is used for decarburisation of the melt and removal of other undesired elements such as phosphorus and silicon;
- oxygen is also injected into the top of the furnace for 'post-combustion' in order to react with CO and hydrocarbons before the fumes leave the furnace with the aim of keeping as much of the heat as possible of the heat generated by the exothermic reactions within the furnace.

Oxygen injection results in an increase in gas and fume generation from the furnace. CO and CO₂ gases, extremely fine iron oxide particles and other product fume are formed. In the case of post-combustion, the CO content is below 0.5 vol %.

Argon or other inert gases may be injected into the melt to provide bath agitation and temperature balancing. The slag-metal equilibrium is also improved by this technique.

Fumes and gases generated from the melting operation are processed in a flue-gas treatment plant which includes the collection and treatment devices aimed at reducing pollutant emissions.

For the purpose of controlled solidification of EAF steel, basically the same techniques are applied as for BOF steel.

2.2.2 Overview of the alternatives routes

2.2.2.1 Direct reduction process

Direct reduction involves the production of solid primary iron from iron ores and a reducing agent (e.g. natural gas). The solid product is called direct reduced iron (DRI) and is mainly applied as feedstock in electric arc furnaces (EAF) (see Figure 2.3). The direct reduction process has been commercialized since the 1970s and a variety of processes have been developed.

Because there is no separation of iron from gangue in the reduction facility, high-grade ores or concentrates (68% Fe and a gangue content 27%) must be used for the reduction to metallic iron in the solid state. The process temperatures are less than 1000°C. DRI has a metallization rate of > 2% and a carbon content of < 2%. The direct reduced iron is normally used as feedstock for EAFs. DRI may have a high gangue content, and this reduces its value in EAF steelmaking, particularly in areas with high electrical power costs.

A drawback of DRI is that it can pose a fire hazard. Therefore, DRI can be melted into briquettes, as hot briquetted iron (HBI), when the product should be stored or transported over some distance.

The first commercial plants were built in the late 1960s. Because the leading direct reduction processes require a cheap source of natural gas, most of the plants are situated in the oil and gas rich belt around the equator. Two thirds of the world production of DRI in 2006 was concentrated in five countries: India (15.0 Mt), Venezuela (8.6 Mt), Iran (6.9 Mt), Mexico (6.2 Mt) and

Saudi Arabia (3.6 Mt). New plants were commissioned in India, Nigeria, Trinidad, Saudi Arabia, Qatar and Russia. The DR method has been successful, especially in producing powders.

DRI processes can be divided up by the type of reactor employed, namely:

- shaft furnaces;
- rotary kilns;
- rotary hearth furnaces;
- fluidised bed reactors.

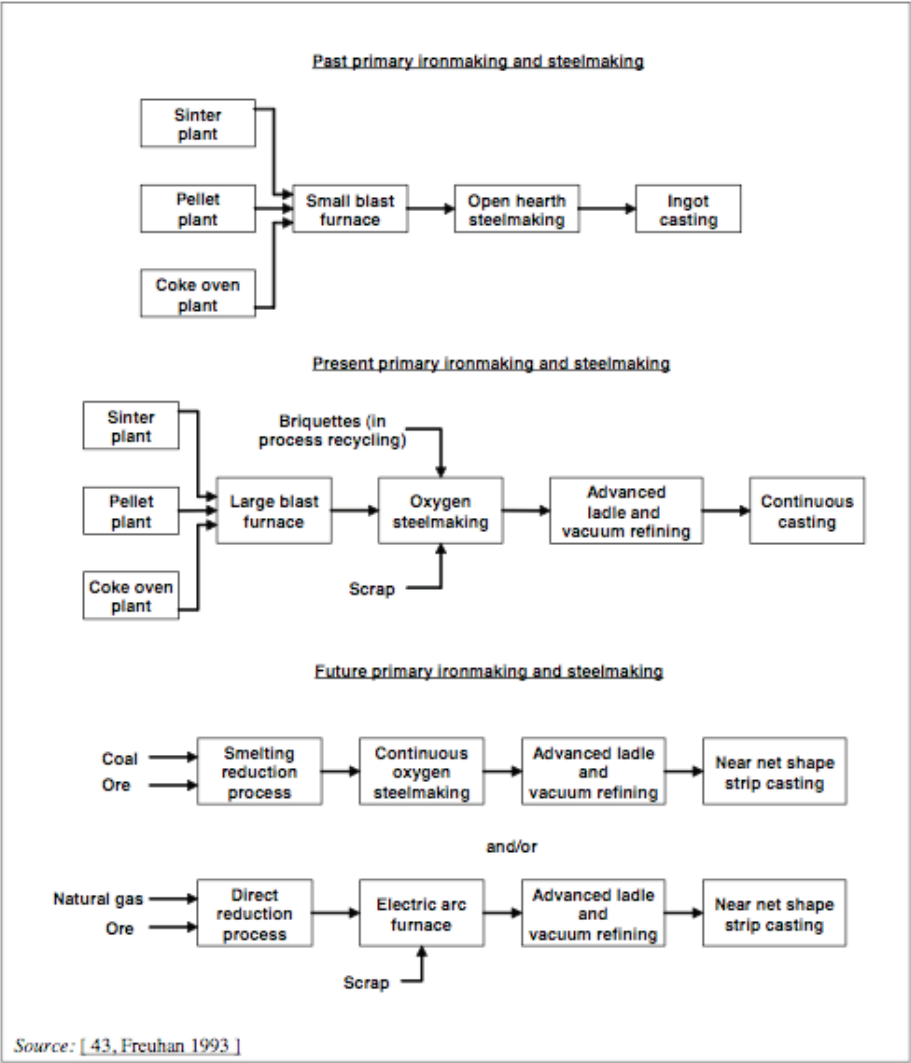


Figure 2.3 past, present and future routes for alternative ironmaking and steelmaking processes

Many of these solid-state processes use natural gas as the fuel and as the reducing agent (carbon monoxide and hydrogen). Approximately 92 % of the DRI is produced by using (reformed) natural gas as a fuel. In a limited number of sites, coal is used as a fuel.

As feedstock, iron ore pellets and lump ore are used in processes with a shaft furnace and fines and concentrates are used in processes with a fluidised bed or a rotary hearth furnace.

An alternative to DRI is iron carbide (Fe_2C). Iron carbide is produced by means of direct reduction also, but the product contains approximately 90 wt.-% Fe_3C . The carbon content is relatively high: 6 wt.-%, which provides enough energy to reduce electricity consumption in the EAF. Iron carbide can be used in the same applications as DRI. The first commercial iron carbide plant, of a capacity of 300,000 metric tonnes per year was commissioned in 1995 in Trinidad.

During the steelmaking process, DRI is superior to scrap in purity and uniformity of composition, but these benefits come at a higher cost.

DRI utilization is reasonable in the following situations:

- when good quality scrap runs short, thus causing the quality of the steel products to deteriorate, and making it necessary to add reduced iron to raise the quality of the raw material;
- in mini-mills built in regions where the delivery of iron sources such as scrap is difficult, or where the construction of an integrated steel plant with a blast furnace is not necessary from the viewpoint of the size of the demand, in which case reduced iron can be used as the main raw material;
- in blast furnaces where increased capacity of hot metal output is required.

In terms of environmental aspects, the main benefit of a direct reduction unit compared to a blast furnace is that the direct reduction unit uses natural gas or coal as a fuel. Therefore, a coke oven plant is no longer needed, significantly reducing emissions. The impact on the environment of a direct reduction unit itself is very limited. There is little dust emission, which is easy to collect. The water need is low and water can be recycled to a large extent. Furthermore, a methane-based

direct reduction unit produces much less CO₂ than a coal-based unit.

However, DRI contains some gangue (3÷6%) and this leads to an increased power consumption of the EAF with increasing DRI input. This can partly be compensated for by the direct hot charge of DRI.

2.2.2.2 Smelting reduction process

Smelting reduction (SR) is associated with the production of hot metal from iron ore without coke. SR employs two units: in the first, iron ore is heated and reduced by gases generated from the second unit, which is a smelter-gasifier supplied with coal and oxygen. The partially reduced ore is then smelted in the second unit, and liquid hot metal or (in some cases) liquid steel is produced. Smelting-reduction technology enables a wide range of coals to be used for ironmaking.

Examples of this technology include the Corex and Finex processes which are operating on a commercial basis.

Corex process

The Corex process is a smelting reduction process combining a melter gasifier with a reduction shaft. Similar to the blast furnace process, the reduction gas moves in counter flow to the descending burden in the reduction shaft. Then, the reduced iron is discharged from the reduction shaft by screw conveyors and transported via feed legs into the melter gasifier (see Figure 2.4).

The gas containing mainly of CO and H₂, which is produced by the gasification of coal with pure O₂ leaves the melter gasifier at temperatures between 1000 and 1050°C. Undesirable products of the coal gasification such as tar, phenols, etc. are destroyed and not released to the atmosphere. The gas is cooled to 800÷850°C and cleaned from dust particles. After reduction of the iron ore in the reduction shaft, the top gas is cooled and cleaned to obtain high caloric export gas. The main product, the hot metal can be further treated in either EAF or BOF or can be cast and sold as pig iron.

A modified version of the Corex process enables the recycling of off-gases back to the process and thereby reduces the energy consumption of the process further. It is also possible to use the off-gases in a combined cycle power plant to produce electricity.

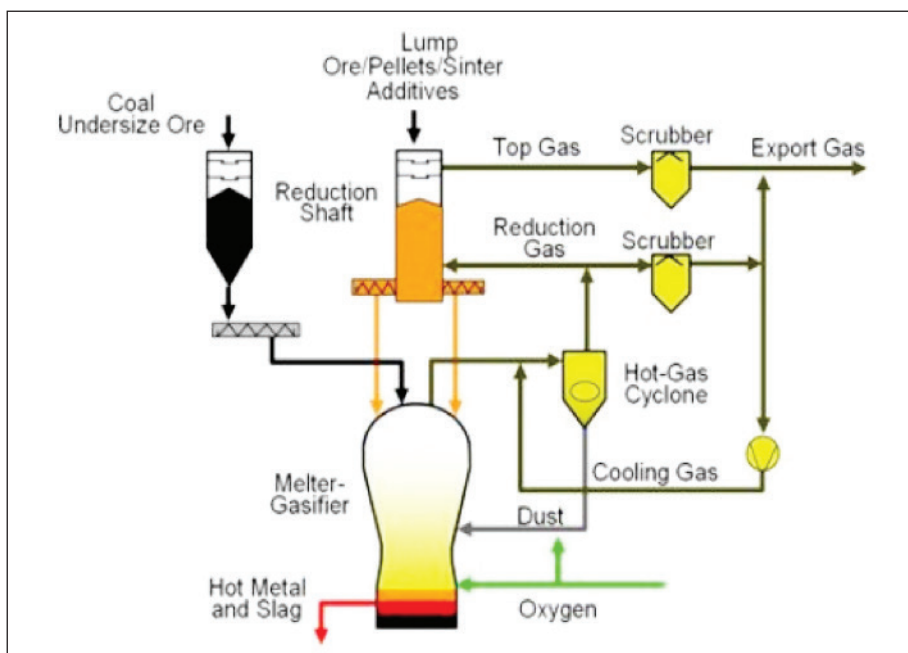


Figure 2.4 Corex process flowsheet

After leaving the melter-gasifier, the hot gas is mixed with cooling gas to adjust the temperature to approximately 850 °C. The gas is then cleaned in hot cyclones and fed into the shaft furnace as a reducing gas. When the gas leaves the shaft furnace, it still has a relatively high calorific value and may be used as an export gas where the opportunity exists. The calorific value of the gas is estimated at 7.5 MJ/Nm³ in the case of the use of a typical steam coal (28.5% volatile matter), but other coal types may result in other heating values of the export gas.

As for the achieved environmental benefits, the Corex process uses coal as an energy source. Therefore, emissions from the coke oven are prevented. All the higher hydrocarbons that are liberated from the coal are cracked into CO and H₂ in the melter-gasifier. Therefore, no by-products like tar, phenol, Benzene, Toluene, Xylene (BTX), polycyclic aromatic hydrocarbons (PAH), etc. are generated.

The sulphur charged with the coal into the process is, to a large extent, picked up in the shaft furnace by DRI and calcined additives and is

subsequently fed to the melter-gasifier. Here, most of the sulphur is transferred to the liquid slag as in the BF route and becomes harmless to the environment. The amount of sulphur discharged from the Corex process by gas and water ($2\div3\%$ of the total sulphur input) is much lower than from the traditional coke oven/sinter plant/blast furnace route ($20\div30\%$). The export gas contains $10\div70$ ppmv H_2S , depending on the type of coal used and the operational conditions. As oxygen (O_2) instead of air is used for the gasification of char, no significant nitrogen oxide (NO_x) and cyanide (CN) formation occurs. The required use of oxygen results in significant additional overall energy demands.

Dust emissions from the Corex plant are significantly lower than in the traditional production route. All dust emissions at the coke oven are prevented. The dust content of the export gas is less than 5 mg/Nm . Most of the dust which is captured in the gas cleaning system is recycled to the process.

The reduction gas from the melter-gasifier is cleaned in cyclones. The dust from these cyclones can be recycled to the melter-gasifier. The top gas from the shaft furnace and the cooling gas (to cool the reduction gas) are cleaned in scrubbers and thus a sludge is generated. The sludge can largely be recycled into the melter-gasifier after granulation or supplied to the cement industry. A small (not quantified) part may be disposed of.

The Corex process has a high specific coal consumption and a relatively large off-gas flow, with a medium-high calorific value. The use of this off-gas as an energy source largely determines the energetic efficiency of the process. Cooling water is supplied in a closed circuit.

Finex process

A further development of Corex is the Finex process (see Figure 2.5), jointly developed by Siemens VAI and the Korean steel producer Posco. The main difference between Corex and Finex is that Finex can directly use fine ore. In the Finex process a four-stage fluidized bed system is located upstream of a melter gasifier. After the reduction of the fine ores in the fluidized beds, the outcome gets hot-compacted prior to charging into the melter gasifier.

In addition to the Corex and Finex processes, the other smelting reduction processes that are not yet operating in commercial scale are briefly described below.

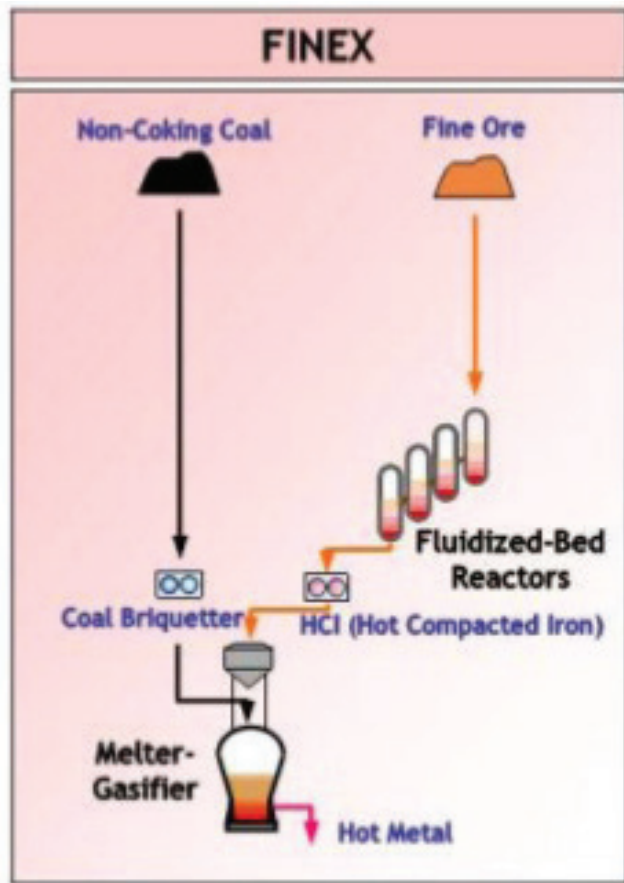


Figure 2.5 Finex process flowsheet

HIs melt process

In this process, ores, coal and fluxes are injected into an iron bath by a total of eight lances of which four tend to be used for the cold coal and lime and four serve to inject ore and dolomite (5%) in their hot condition $600\div 700^{\circ}\text{C}$. The ores are quickly reduced and melt directly in the slag causing the CO and H_2 fractions to be post-combusted in the off-gas. Hot metal tapping is performed continuously via a fore hearth, while slag tapping is performed by batch tapping every two to three hours via the slag tap hole. SR in the HIs melt process leads to lower silicone contents amounting to less than 0.01% and also lower phosphorus contents of less than 0.02% in the hot metal.

Compared to blast furnace ironmaking, fuel savings of 10% is predicted. Furthermore, operation of an iron ore pre-treatment plant (pellet plant, sinter plant) and a coke oven plant is no longer necessary. In contrast to the other smelting reduction processes, a hot blast is needed. This will probably influence the NO_2 emissions of this process in a negative way (see Figure 2.6).

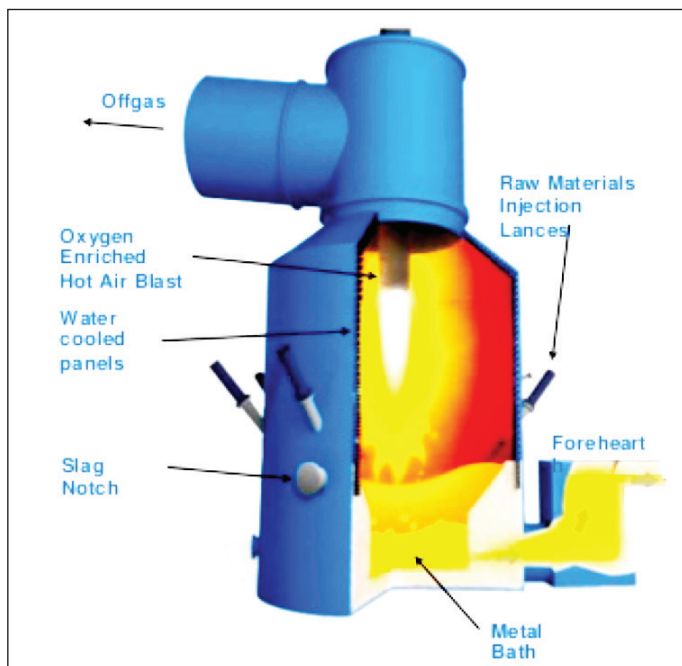


Figure 2.6 the Hismelt process

DIOS process

The Direct Iron Ore Smelting (DIOS) process consists of three sub-processes: a fluidized bed pre-reduction furnace (PRF) to pre-reduce the iron ore, a gas-reforming furnace (GRF) to mix coal powder into the gas, and a smelting reduction furnace (SRF) to further reduce and smelt the iron ore. Combustion oxygen is injected from the top of the SRF. The generated carbon monoxide (CO) is used to pre-reduce the iron ore in the PRF. Nitrogen is injected in the bottom of the SRF to agitate the slag in the furnace. It is expected that the energy consumption of DIOS will be 5÷10% lower compared to the blast furnace route. Furthermore, the iron pre-treatment plant and the coke oven plant are no longer needed.

AISI-DOE/CCF process

The aim of the AISI-DOE project is to produce steel from pre-reduced iron ore and coal in a vertical bath smelter. The most important part of the Cyclone Converter Furnace (CCF) project is the development of the cyclone reactor. In the cyclone, the iron ore is produced and melted. The molten mixture falls into the lower part of the vessel where reduction is completed. The fuel consists of granular coal which is injected together with oxygen in the lower part of the vessel. The high operating temperature of the cyclone reactor and the fact that it can handle a high level of entrained materials from the iron bath make a direct connection of the pre reduction and the final reduction stages possible. Combining the two stages means that the heat transfer efficiency is not critical since there is no inter-stage cooling. Since no coke oven plant, sinter plant or pellet plant is required, a marked reduction of emissions can be achieved. Energy consumption per tonne steel will also be lower. Furthermore, power can be generated from the flue-gases which exit the cyclone at about 1800°C.

Romelt process

The Romelt process is similar to other bath smelting processes, but does not use a pre-reducer. The process uses ore or waste oxides. Its coal consumption has been reported to be 900÷1200 kg/metric tonne. Since no coke oven plant, sinter plant or pellet plant is required, a significant reduction of emissions compared to conventional primary ironmaking can be expected. Energy consumption per tonne steel will be lower as well.

Plasmasmelt process

In plasma-based smelting reduction processes, the reactions take place in a coke-filled shaft furnace with tuyères spaced symmetrically around the lower part of the furnace. The shaft is completely filled with coke. Plasma generators and equipment for injection of metal oxides mixed with slag-forming material and possibly reductants are attached to the tuyeres. In front of each tuyère, a cavity is formed inside the coke column where reduction and smelting take place. At regular intervals, the produced slag and metal are tapped from the bottom of the shaft furnace.

Ausmelt process

The Ausmelt process was developed by Ausmelt Ltd. Australia. Lump ore or ore fines are fed continuously into a converter along with lump coal and flux. Fine coal, oxygen and air are injected to allow submerged combustion. The degree of oxidation and reduction is controlled by adjusting fuel to air and coal ratios as well as the proportion of fine coal injected down the lance. All reactions are completed in a single reactor.

2.2.3. Overview of the emerging techniques

The term ‘emerging technique’ is to be intended as an innovative technique that has not yet been applied in any industrial sector on a commercial basis. This paragraph contains those techniques that may appear in the near future and that may be applicable to the iron and steel production sector. Consequently, this paragraph:

- a) identifies any novel pollution prevention and control techniques that are reported to be under development and may provide future economic or environmental benefits;
- b) includes techniques to address environmental issues that have only recently gained interest in relation to the sector at hand.

2.2.3.1 Emerging techniques for carbon dioxide mitigation

The consortium ULCOS (Ultra-Low Carbon dioxide Steelmaking), made up of 48 European companies and organizations from 15 European countries, has launched a cooperative R&D initiative to enable a drastic reduction in CO₂ emissions from steel production. The consortium consists of all major EU steel companies, energy and engineering partners, research institutes and universities and is supported by the European Commission. The project is targeted to run beyond 2015 with some full size implementation in industrial production lines.

There are three areas to be explored under this rationale:

Capturing and sequestering CO₂ with optional transportation and storage.
An example of this area is given by the concept of the top gas-recycling blast furnace (TGR-BF), see Figure.2.7, based on the separation of the

off-gases so that the useful components can be recycled back into the furnace and used as a reducing agent. This would reduce the amount of coke needed in the furnace.

In addition, the concept of injecting oxygen (O_2) into the furnace instead of preheated air, is based on the removal of unwanted nitrogen (N_2) from the gas, facilitating carbon dioxide capture and storage. In a second stage, the captured CO_2 will be compressed and transported for storage in geological formations such as oil and gas fields, unamenable coal beds and deep saline formations (CO_2 -sequestration), in mineral carbonates, or for use in industrial processes.

To experimentally test this concept, a gas separation plant was constructed next to the experimental blast furnace at the MEFOS Research Institute in Sweden and successfully tested. On the experimental blast furnace, equipment was installed to operate with pure oxygen (O_2) and with the reinjection of carbon monoxide (CO) gas.

Use of carbon-lean fuels and reducing agents. This area entails the use of hydrogen and electricity that until today have been more expensive than coal, gas or oil. The picture may change completely in the future if the carbon constraints brought about by Kyoto and post-Kyoto policies would change the price structure of fuels.

Use of sustainable biomass. This area needs to also be seriously considered as an alternative for CO_2 mitigation. This would be an interesting historical twist, as iron was produced for millennia from biomass but this was not sustainable after the onset of industrialization when coal became a formidable competitor to wood and charcoal. Sustainable forestry has, however, become a reality today, attested by international certification bodies, such as the Forest Stewardship Council (FSC).

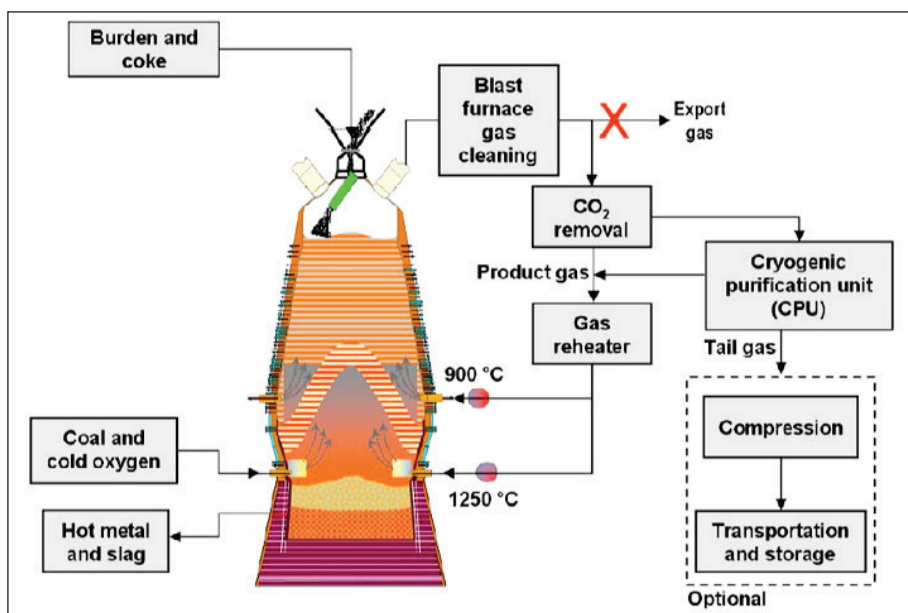


Figure 2.7 Schematic of the top gas recycling blast furnace to minimize GHG emissions

Moreover, forest biologists and ecologists have started to demonstrate that, under sustainable growing conditions, carbon plantations can indeed be neutral to the accumulation of Green House Gas (GHG) in the atmosphere. Last but not least, inventories of land that could be made available for growing energy crops without competition with food-crops seem to show that there are distinct possibilities of setting up more plantations that could have a clear contribution to the production of steel in the world. The matter needs very careful attention and is clearly not settled, but the necessary work will be carried out within the ULCOS project.

2.2.3.2 Emerging techniques for sinter plants

One of the most environmental problem in sinter plants is due to the presence of polychlorobenzodioxins/furans (PCDD/F) in off-gas emissions. Growing attention is paid in removing these pollutants by adsorption on carbon impregnated plastics. Working temperature are between 60÷80 °C. So far this technique has been applied in the waste incineration sector but not yet in the iron and steel sector.

An alternative route is the suppression of PCDD/F by addition of nitrogen compounds to the flue-gas. Considering that a relevant part of PCDD/F are formed by *de novo* synthesis in the wind boxes downstream of the sinter strand, the injection of compounds such as triethanolamine or monoethanolamine in the wind boxes to inhibit the formation of PCDD/F has been proposed. However, so far there is not any credible proof of beneficial effect of these nitrogen compounds on the emissions from the sinter plants.

Another technique to suppress PCDD/F formation in the wind boxes may be the quenching of the hot off-gas by injecting cold water mist into the wind boxes. The injection should take place as close as possible to the bottom of the sinter bed.

2.2.3.3 Emerging techniques for coke ovens

A few innovative techniques have been proposed for improving the performances of coke ovens. As an example, the national Japanese project SCOPE 21 was launched by the Japan Iron and Steel Federation (JISF) in the Nineties to develop a next-generation coke oven. A pilot unit was built. The aim of the project was to develop an innovative coke production process featuring environmental sustainability, high energy efficiency and high productivity. The project was supported by all of the major Japanese steelmakers in cooperation with the universities. The idea of the project is to combine well known coke plant techniques, such as preheating of the coal blend in a fluidized bed, transporting and charging the blend in a closed system without emissions, discharging the coke in a dry quenching facility. The project SCOPE 21 was finished in 2003. An industrial SCOPE 21 coke oven battery was built in 2008; the plant has a capacity of 1 million tonnes coke per year (coke blend pre-treated to 250 °C, flue temperature 1,270 °C, cooking time 13 hours).

Studies on the economic optimization of the overall system have found that a SCOPE 21 coking plant could lead to the following reported advantages: higher productivity, increased by 2.4 times compared to a conventional coke oven; better coke quality; increase in the rate of non-caking or slightly caking coal to 50 %; savings of 20 % in the energy consumed in the coke-making process; reduction in NO_x emissions by 30 %; prevention of smoke and dust.

Moreover, alternatives in coke oven gas (COG) utilization have been studied, focused on hydrogen recovery, methanol synthesis, and the injection of COG and tar as auxiliary reducing agents in the blast furnace or in direct reduction plant operation. Obviously, alternative utilization routes require different processing steps of COG pre-treatment. These alternative potentials for the utilisation of COG are subject to an overall assessment giving consideration to the relevant steelworks infrastructure. The benefits from direct and indirect coke oven products are dependent on the specific local and operational works requirements.

Finally, among the specific technological improvements proposed in recent years, particular attention has been given to the pressure control technique. In this regard, in conventional coke plants the flow of the distillation gas from a single oven to the collecting main is controlled by an on/off valve or by a variable pressure regulation technique. Recently, a new system of continuous pressure control has been designed to prevent overpressure during the first phase of the process, by maintaining a negative pressure in the collecting main, thus permitting a full reduction of the emissions from doors, charging holes, etc. Moreover, this system prevents negative relative pressure in the at the oven bottom during the last phase of distillation when the coke gas flows low, thus avoiding possible air infiltration with consequent coke combustion and material damage at the hearth level. The system has been tested in the Piombino (Italy) coke plant, showing full reliability and good operation.

2.2.3.4 Emerging techniques for blast furnaces

Potential innovative techniques concerning the operation of blast furnaces have been proposed in recent years, as reported below.

In the case of hot stoves designed with internal combustion chambers, high emissions of CO occur as a result of leaks from cracks in the refractory mass. This leakage seems to be inevitable and leads to emissions of unburned gas. It is, however, possible to reduce the impact of cracks (high CO emissions) by inserting steel sheets of an appropriate grade into the refractory wall during relining. Results from measurement before and after inserting steel sheets are yet not available.

Liquid slag from the blast furnace contains a large amount of sensible heat. Its temperature is approximately 1450 °C and around 250÷300 kg/tonne hot metal is produced in modern blast furnaces. None of the commercially applied systems in the world utilize this potential energy source. This is mainly caused by the technical difficulties in developing a safe, reliable, and energy efficient system.

Investigations have been carried out for the use of oil-contaminated mill scale together with fly ash. Injection rates up to 100 kg/tonne of hot metal were tested.

2.2.3.5 Emerging techniques for basic oxygen furnace and casting

Improving clean gas dust content in wet scrubber-based BOF plants by upgrading to Hydro Hybrid Filter

Most BOF plants worldwide are equipped with a wet scrubber-based gas cleaning plant. These plants can usually achieve residual dust contents of between 30 and 50 mg/Nm³. The idea is that the cleaning of the BOF gas should no longer be based only on the existing scrubber. Upgrading the existing plant with a downstream installation of a small wet electrostatic precipitator (wet ESP) can further reduce the clean gas dust emissions. The combined system is a “Hydro Hybrid Filter” that can achieve clean gas dust emissions of ≤ 10 mg/Nm³. The scrubber acts as a pre-dedusting device to precipitate coarse dust and as a cooling and conditioning tower for the downstream ESP. The pressure loss of the wet scrubber can be reduced significantly and hence, power consumption of the fan can be reduced. Furthermore, the gas volume decreases due to low temperature with few or no modifications. Existing BOF gas recovery is not affected by this modification. The technique is under development.

Whirl hood for secondary dedusting

Dust emissions caused by tapping the converter or by charging scrap into the converter are difficult to capture because the converter is tilted out of its upright position and the fume escapes diffuse to the production hall. The production steps need some free space above the lids of the converter for the crane and the scrap basket. Therefore, the

suction hood should have some distance to the dust source. To get a good capture ratio in the secondary dedusting system in spite of the construction conditions, there are different suction hood designs. A new development is the “whirl hood” or “hurricane hood”. There is an air roll produced in the hood by evacuating the air at both sides on the axes of the roll. These flow conditions move the particles in the axial area of the air roll by the pressure distribution in the roll and they are evacuated through the opening of the two opposite suction pipes to the dedusting system. It is important that the evacuation pressure in the roll suction hood be strong enough to ensure stability.

The engineering of this type of suction hood was developed some years ago. If the system is well designed, it should be able to reach a better capture rate of fugitive sources, which cannot be evacuated directly at the source itself. It is not possible to quantify this effect because the capture cannot be measured and must be estimated by judgement of visible dust emissions.

Recycling of BOF and EAF ladle slags as a flux agent in electric steelmaking

Several techniques have been tested to recycle BOF and EAF ladle slags: a) Recycling of liquid ladle slag into the EAF; a recycling rate of 80 % has been achieved. b) Recycling of solid ladle slag into the EAF; around 15 % of lime has been substituted by ladle slag; about 50 % of the generated ladle slag can be recycled. c) Recycling of spent refractory materials from EAF, BOF and secondary metallurgy; careful processing and quality controls are a prerequisite in recycling.

A step towards steelmaking without residues is the driving force for implementation of these techniques that have been tested by: RIVA Acciaio, Verona Works, Italy; Krupp Edelstahlprofile (KEP), Siegen, Germany; EKO Stahl, Eisenhüttenstadt, Germany

2.2.3.6 Emerging techniques for Electric Arc Furnace

Contiarc furnace

The Contiarc furnace evolved from electric-arc furnace technology, which uses a fixed annular shaft with a central electrode, a

corresponding bottom electrode, and a stationary shell. It is 30 feet in diameter and is continuously operated. Using the Contiarc, iron can be tapped continuously or intermittently. The Contiarc design allows raw materials to be fed into the top of the furnace uninterrupted, using a radially arranged conveyor to distribute the scrap throughout the ring shaft area. The maintenance of a full stack of charge material allows this material to be continuously pre-heated by the energy in the furnace off gases. The pre-heating significantly reduces the energy needs of the furnace and is one advantage of the Contiarc design.

The submerged, continuous nature of the furnace makes it more energy efficient than the cupola. In addition, it is now possible to both melt and smelt iron in the same furnace system producing 80 tonnes/hr while melting and smelting. The furnace can take low grade scrap (automobile shredding's), direct reduced iron (DRI) and/or hot briquetted iron (HBI) and combine it with coal and silica rock to produce quality ductile base iron with 3.5% carbon(C) and 2.5% silicon (Si).

The furnace is charged automatically through a hopper system that feeds a conveyor to the top of the furnace. Once the charge reaches the top of the furnace, it is deposited into one of eight hoppers that are positioned in a rotating carousel around the top of the furnace. The computerized charging system works in unison with the computerized furnace control system to determine where within the annular shaft a charge is required.

By maintaining a full stack of charge material, the heat content of the furnace gases acts as a preheater for the charge material. Due to the volume of gas, stack permeability is not an issue; however, the charge material must be sized properly to prevent bridging in the stack.

The continuous arc melting concept is driven by the central cathode (graphite electrode) inside the inner vessel and the corresponding conductive bottom anode. In a traditional arc furnace, when a charge is added, the electrode rises to the top of the charge. In the continuous arc furnace, the inner vessel keeps the electrode submerged. The central graphite electrode is protected against damage from falling scrap by the inner vessel. Its tip operates at a distance below the bottom of this vessel so that the long direct current arc burns between the electrode and the molten metal bath. The shell is shielded from the radiation of the direct current arc by charge materials.

The completely encapsulated melter ensures a reducing atmosphere in the lower part of the furnace and a slightly oxidizing condition in the shaft to achieve the desired process metallurgy and a utilization of gases. In addition, this design results in low losses of oxidised iron or silicon. A bag house system captures emissions.

The Contiarc furnace is designed to perform both melting and smelting operations. This provides the following advantages:

- a) the ability to melt low-cost and abundant shredded scrap, borings, HBI and/or DRI (thus maintaining tramp element control);
- b) quartz (SiO_2), through gravel used in the construction industry, can be substituted for high cost ferrosilicon as a means of developing the necessary silicon level in the melt;
- c) coal can be used instead of coke during melting to carburize the base metal and reduce the quartz because the carbon product is not required for heat generation;
- d) without the use of coke, the sulphur level of the molten metal is reduced;
- e) there is less slag with the Contiarc than that associated with the cupola since it is a reduction furnace which means that many oxides that normally act as slag are reduced back into the meta;
- f) during melting, the temperature control in the Contiarc furnace is flexible meaning it can be adjusted by a simple variation of the current/voltage ratio. This allows the iron to be superheated before tapping.

The first continuous submerged direct current electric arc (Contiarc) furnace went into operation at the American Cast Iron Pipe Company (ACIPCO), Birmingham, US in July 2001.

Another of its energy-saving advantages is the marked lessening of heat loss at the walls and roof of the furnace. The Contiarc's walls are shielded by charge materials, and the usual practice of opening the roof to charge the furnace is eliminated. The Contiarc also produces iron that contains less sulphur, an element detrimental to ductile iron production. Furthermore, with the Contiarc, ACIPCO acquires a wider choice of raw materials to use in its ductile iron. Among the low-cost

ferrous (detrimental element free) charge materials that the Contiarc accommodates are direct-reduced iron and hot-briquetted iron. These two raw materials produce an iron with lower residual quantities of manganese, chromium, and copper, three elements that can also impair the quality of ductile iron.

Finally, the Contiarc furnace greatly reduces air pollution. The Contiarc easily meets or exceeds all regulatory requirements. The scrap column acts as a preliminary dust filter, so that off gases contain some 40 percent less dust than in other furnaces. Gases rising from the lower furnace are collected by a ring header and fed to the emission control system. The long-time problem of emissions discharging into the furnace building is totally eradicated in the Contiarc.

The Contiarc's anti-pollution accoutrements at ACIPCO include a 50-foot bridge supporting a spray-cooling unit measuring 12 feet across. The spray cooler lowers the temperature of emissions from the furnace, making it possible to treat any pollutants. Pollution control also includes a lime spray dryer-absorber for sulphur removal, and a bag house, or filter building.

Intermetallic bag filter to minimise emissions of dust, PCDD/F and heavy metals

An intermetallic bag filter with high-temperature resistance combines filtering and catalytic operations and allows for a drastic decrease in dust and associated pollutant emissions.

In pilot tests at LME Trith-Saint-Léger, France, a dust reduction efficiency of 99.9 %, a PCDD/F reduction efficiency of more than 95 % and a heavy metal reduction efficiency of 95÷100 % (except for heavy metals present in the gas phase like mercury) were achieved.

Moreover, energy can be saved as a consequence of moderate waste gas cooling. This technique should be operated at 350÷550 °C, whereas traditional cleaning is operated at 150÷200 °C.

Recovery of old tyres in EAF

As has been applied in cement plants, old tyres can be recovered and can replace coal (anthracite) in electric steelmaking. An optimized recovery process in EAF requires an adapted addition of tyres, charged

at the right place, neither on top nor at the bath bottom, and oxygen lances should be operated in such a way as to prevent post-combustion anywhere else than in the arc furnace.

This technique allows for both the recovery of old tyres and a decrease in the demand of coal mining. Moreover, recovery of old tyres does not give extra emissions in terms of PCDD/F, heavy metals, PAH, SO₂, and VOC and does not demand extra energy

This technique has been tested in pilot plants at Ascometal Hagondange, SAM Neuves-Maisons and LME Trith-Saint-Léger, all three in France, a substitution rate of 1.7 kg old tyres for 1 kg anthracite was achieved. An addition of 5÷12 kg old tyres/tonne liquid steel (LS) is achievable if tyres are cut into small pieces at a length of no more than 10÷15 cm. Also ArcelorMittal, Belval and Differdange, both in Luxembourg, have carried out some trials.

2.2.4 Main environmental issues

The iron and steel industry is highly intensive in both materials and energy. Almost half of the input ends up as off-gases, process gases and solid production residues. Following the two most important steelmaking process routes via the sinter/pellet plant/coke oven/blast furnace/basic oxygen converter and the electric arc furnace, the key environmental issues for action in response to environmental concerns can be summarized below.

Air emissions

- *Sinter plants* - The main stack emissions of sinter plants account for up to 50 % of the total dust emissions from an integrated steelworks. The most relevant pollutants in the off-gas emissions from the sinter strand and the cooler are heavy metals, SO₂, HCl, HF, PAH, CO, NO_x, dust and persistent organic pollutants (such as PCB and PCDD/F) (see figure 2.8).

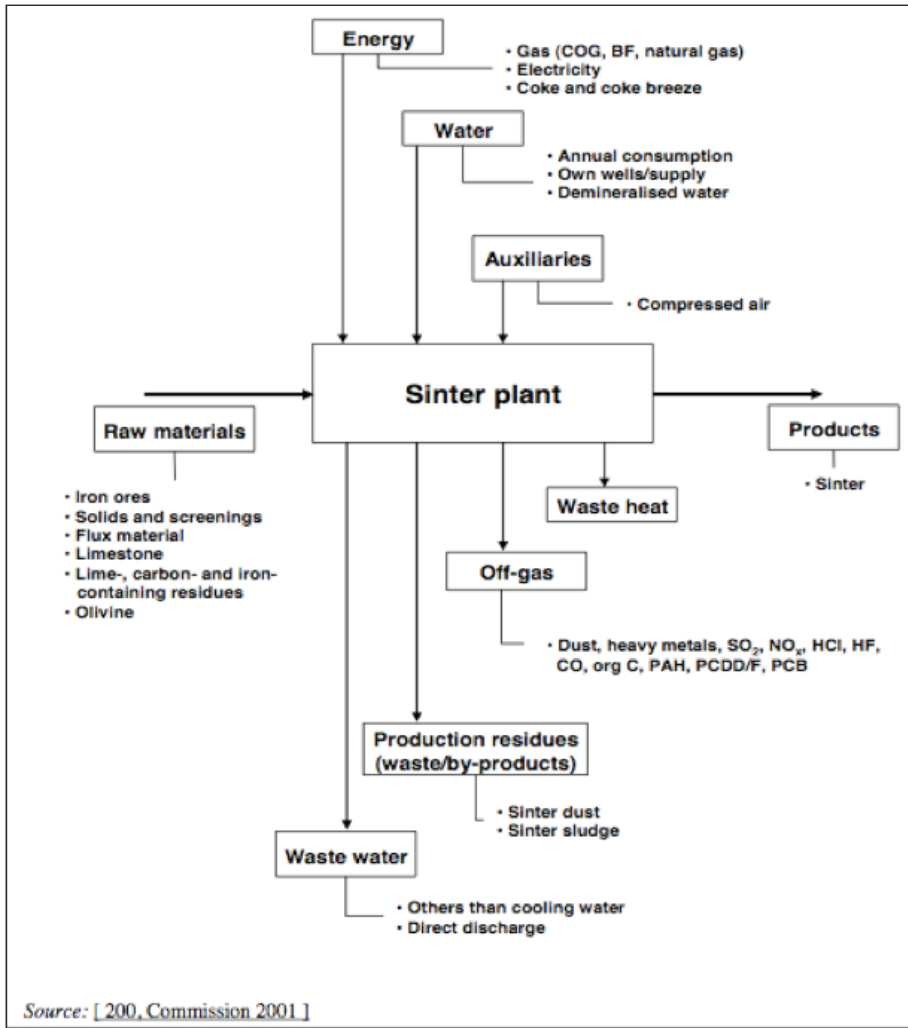


Fig. 2.8 Main stream overview of a sinter plant

- *Palletisation plants* - Palletisation is another process used to agglomerate iron materials. Emissions to air dominate the environmental issues. The off-gases are: dust, org C, VOC, SO₂, NO_x, CO, F, PCB, PAH, PCDD/F and heavy metals (see figure 2.9).

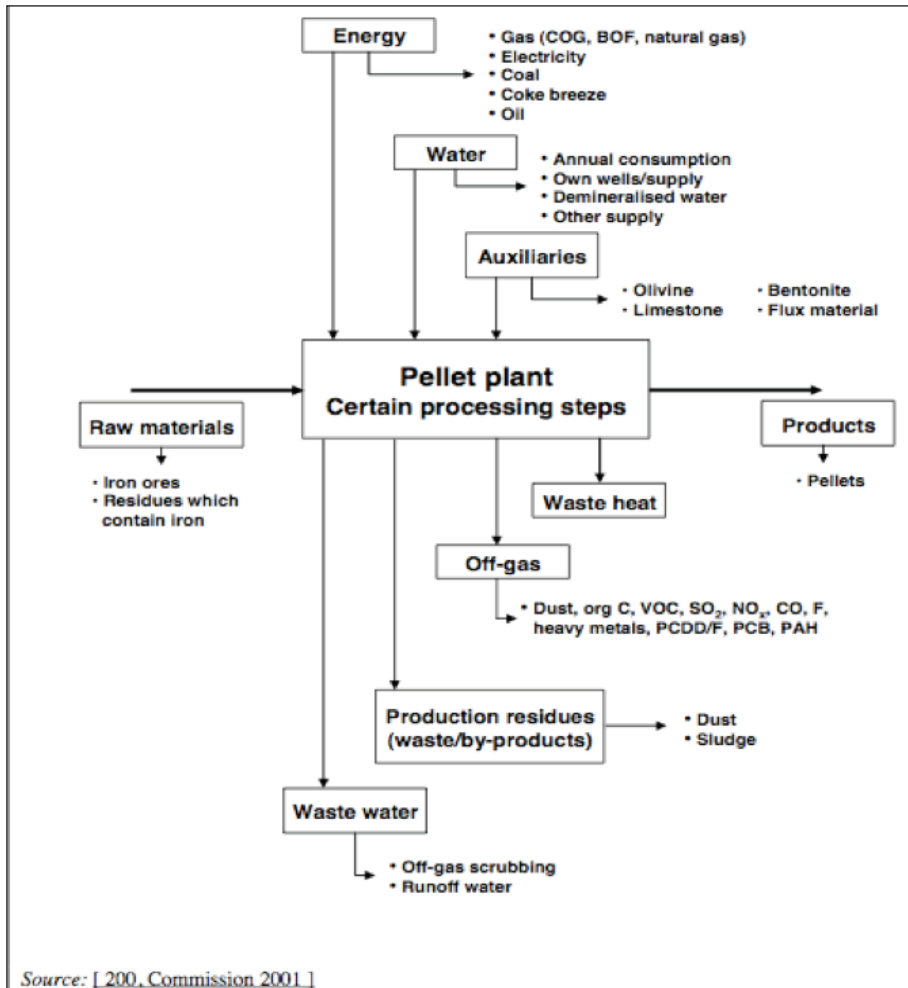


Figure 2.9 Mass stream overview of a palletisation plant

- *Coke oven plants* - A coke plant consists of one or more coke oven batteries with a coke oven firing system and the process gas treatment unit where emissions to air are the most significant. The main point source for emissions to air is the waste gas from under firing. Additionally, many of the emissions are diffuse emissions from various sources such as the unloading, storage, handling, crushing and blending (preparation) of coal, the leakages from lids and adherences onto frames, oven and leveller doors, the ascension pipes and charging holes of coal into and the pushing of coke out of the chambers, and finally, coke quenching and coke grading (crushing and screening),

transport, handling and storage. Diffuse/fugitive VOC emissions to air can occur from coke oven batteries and diffuse/fugitive ammonia and BTX emissions from by-products plants which all have the potential to create odour nuisances. Dust and SO₂ emissions at coke oven plants and other plants where coke oven gas is used as a fuel are a concern. Thus the desulphurisation of coke oven gas is a measure of high priority for minimising these emissions. A general view of mass streams in a coke oven plant is reported in Figure 2.10.

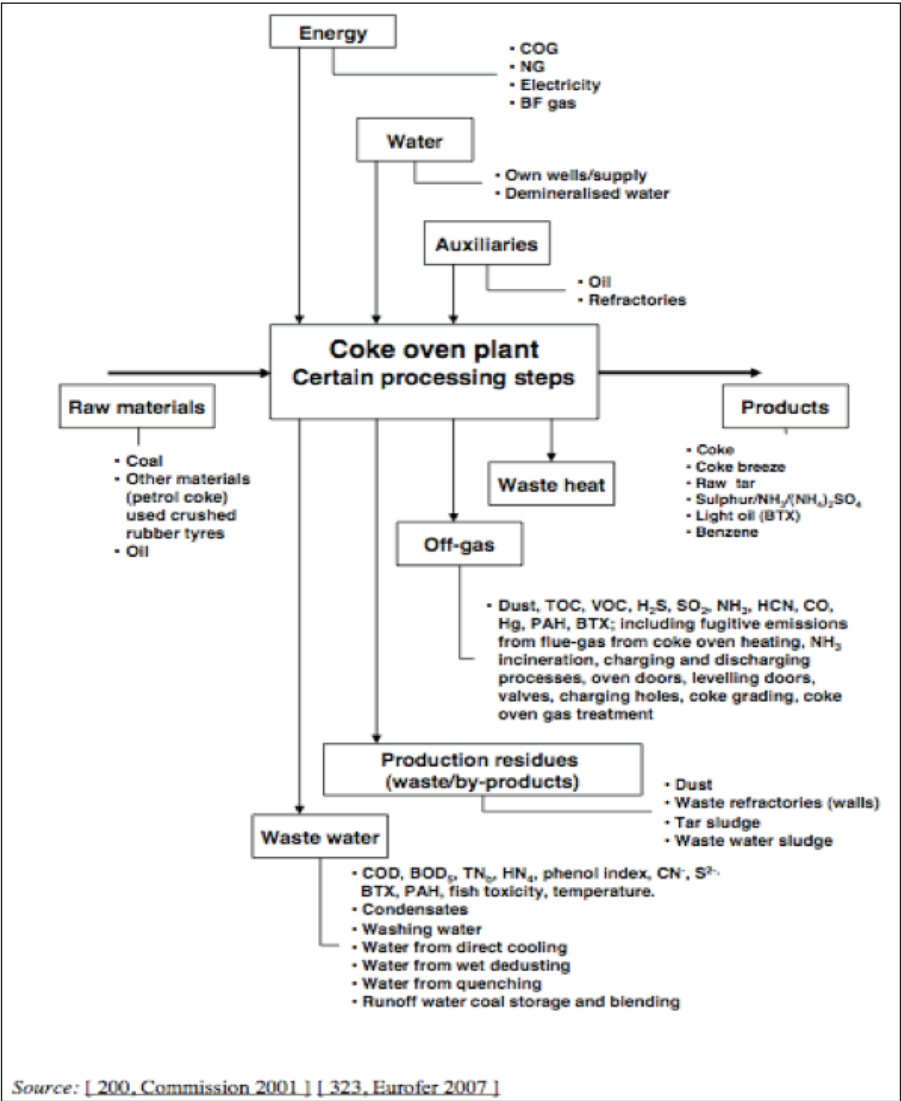


Figure 2.10 Mass stream overview of a coke oven plant

- *Blast furnace plants* - The off-gas are dust, org C, VOC, NO_x, SO₂ and H₂S from charging operations, flue gas from the hot stoves, blast furnace gas treatment, hydrocarbons from runner linings and tap hole clay, particulate matter from tapping, odour from slags (figure 2.11).

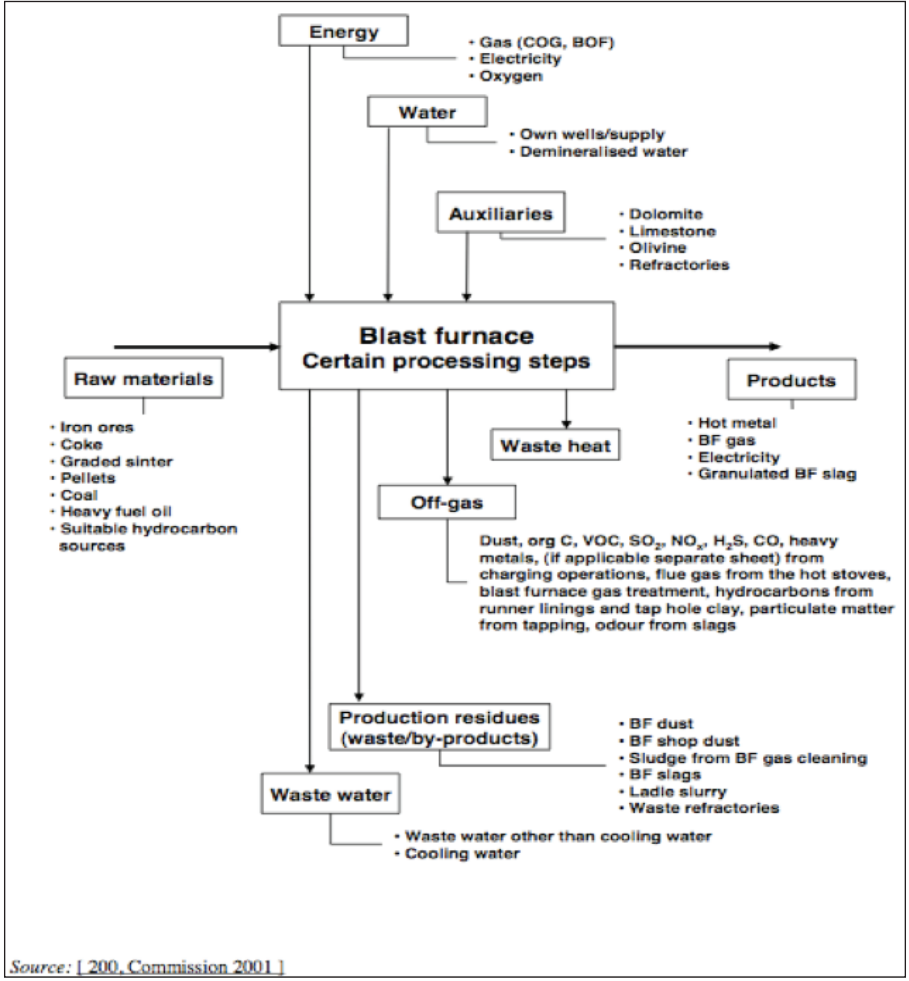


Figure 2.11 Mass stream overview of a blast furnace

- *Basic oxygen furnace plants* - Emissions to air from various sources such as primary and secondary dedusting, hot metal pre-treatment and secondary steelmaking and various solid process residues are the main environmental issues in oxygen steelmaking. Particular attention should be paid to diffuse dust emissions, which occur when

secondary emission collecting systems are insufficient. The off-gas are: dust, org C, VOC, SO₂, NO_x, CO, F, PCB, PAH, PCDD/F and heavy metals (figure 2.12).

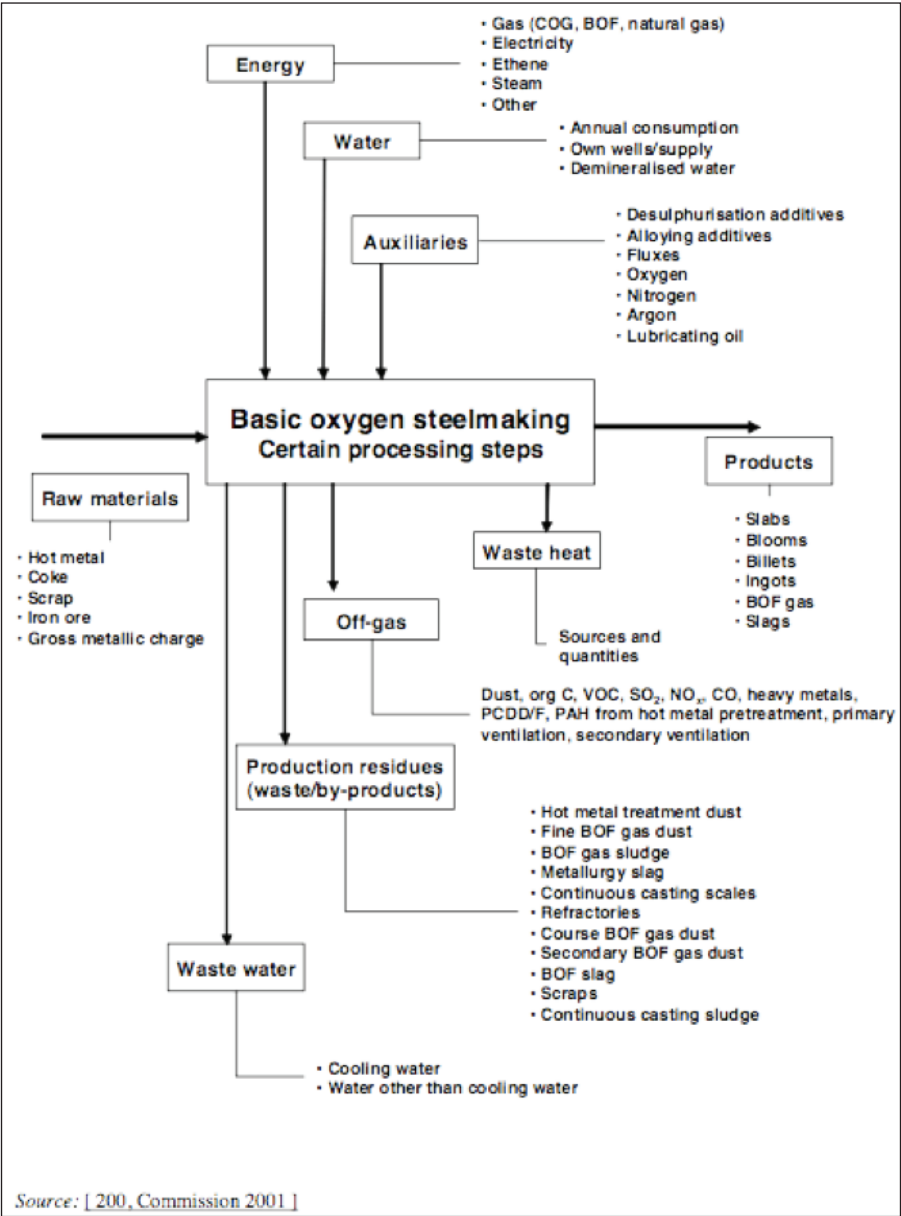


Figure 2.12 Mass stream overview of a basic oxygen steelmaking plant

- *Electric arc furnace plants* - The direct smelting of materials which contain iron (mainly scrap) is usually performed in electric arc furnaces which need considerable amounts of electrical energy and causes substantial emissions to air and solid process residues such as wastes and by-products (mainly filter dust and slag). The emissions to air from the furnace consist of a wide range of inorganic compounds (iron oxide dust and heavy metals) and organic compounds such as persistent organic pollutants (e.g. PCB and PCDD/F) (figure 2.13).

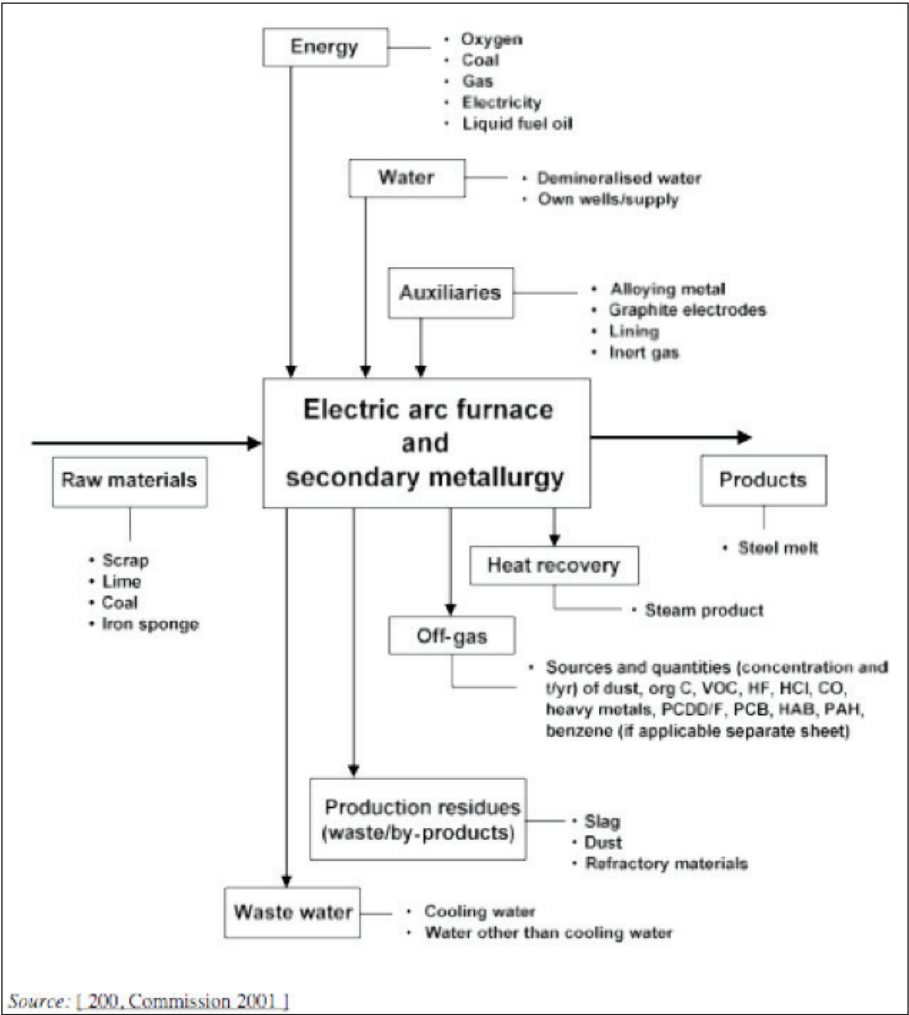


Figure 2.13 Mass stream overview of an electric arc furnace

Wastewater

- *Palletisation plants* - Other main issues in pellet plants are the use of sensible heat, the treatment of wastewater and the internal utilisation of process residues (see figure 2.9).
- *Coke oven plants* - Wastewater water disposal is another major issue for coke oven plants (see figure 2.10).
- *Blast furnace plants and electric arc furnace* – These plants produce cooling water and wastewater from blast furnace gas scrubbing (see figure 2.11).
- *Basic oxygen furnace plants* - the waste water arises from wet dedusting (when applied) and from continuous casting (see figure 2.12).

Waste and by products

- *Sinter plants* - Sinter, as a product of an agglomeration process of materials which contain iron, represents a major part of the burden of blast furnaces. Furthermore, the recovery of sensible heat and the utilisation of solid wastes are severe issues. Environmental benefits are linked to this process with the recycling of iron-rich solid by-products of downstream processes and the potential for heat recovery (see figure 2.8).
- *Coke oven plants* - Optimized management of coke oven gas and its use in other processes of integrated plants allow energy savings and minimize air emissions (see figure 2.10).
- *Blast furnace plants* - The production residues are BF dust, BF shop dust and sludge from BF gas cleaning, BF slags, ladle slurry and waste refractories (figure 2.11).
- *Basic oxygen furnace plants* - The production residues are: hot metal treatment dust, fine BOF gas dust, BOF gas sludge and other as can be observed in figure 2.12.

Energy consumption

Energy consumption in iron and steel making is considerable. CO₂ as a greenhouse gas is generated when energy is consumed. There are many

emissions points of CO₂ in the iron and steel processes and they are related to satisfy three main objectives:

- a) providing the sufficient temperature in order to carry out the chemical reactions and physical treatment needed;
- b) providing a reductant (mainly CO) to the system in order to reduce the iron oxide;
- c) providing the power and steam necessary to run the steelworks.

Therefore, energy savings have undergone a major change in purpose, and are now considered part of the solution to the problem of global warming which is a global-scale environmental issue. There is no unique option for climate change mitigating policies. The solution is rather a sequence of mitigating options for the stabilization of atmospheric greenhouse gas concentrations.

Regarding iron and steel making, the CO₂ emissions depend very much on the types and amounts of reducing agents (e.g. coke, coal, and oil) used in the blast furnace. For this reason, the steel industry has actively implemented a variety of measures to reduce the energy consumption in general and emissions of GHG such as CO₂ in particular. Extensive efforts have been made to reduce the reducing agent demand close to the stoichiometric minimum demand. Since 1980 the specific energy demand has been reduced from 23 GJ/tonne of liquid steel to approximately 18 GJ/t liquid steel for modern integrated steelworks.

The specific energy consumption for steel production in electric arc furnaces in Europe is on average about 1.8 GJ/t liquid steel. Considering the efficiency of energy supply, primary energy consumption will be considerably higher. Additionally there is a fossil fuel input of about 0.5 GJ/t liquid steel on average.

The energy consumption has been constantly reduced by introducing energy-saving equipment in steel manufacturing processes and improving the efficiency of energy conversion facilities such as power plants. Energy-saving equipment includes waste energy recovery equipment.

Another measure is the optimization of energy consumption and costs by the implementation of a total energy management system. To a certain

extent, direct reduction (DR) can be an option to reduce CO₂ emissions. Additionally, beyond energy savings and efficiency improvements, carbon dioxide mitigation projects are being developed to capture and store CO₂.

Other issues

Other relevant issues are nuisance by odour and noise emissions which can be quite considerable for certain processes.

Matters of concern for the iron and steel industry not covered by this textbook are local soil pollution and groundwater pollution.

Monitoring

See in the Chapter 6 a general view of the basic principles on monitoring (emissions, process and impact).

2.3 The Best Available Techniques (BAT)

The Commission Implementing Decision (2012/135/EU) reports the BAT conclusions contained in the chapter 9 of the BREF Document on Iron and Steel Production (2013). Specifically, the BAT conclusions concern the following processes involved in traditional routes:

- the loading, unloading and handling of bulk raw materials;
- the blending and mixing of raw materials;
- the sintering and palletisation of iron ore;
- the production of coke from coking coal;
- the production of hot metal by the blast furnace route, including slag processing;
- the production and refining of steel using the basic oxygen process, including upstream ladle desulphurisation, downstream ladle metallurgy and slag processing;
- the production of steel by electric arc furnaces, including downstream ladle metallurgy and slag processing;
- continuous casting (thin slab/thin strip and direct sheet casting (near-shape)).

A. General BAT conclusions

Environmental management system

An environmental management system is a technique allowing operators of installations to address environmental issues in a systematic and demonstrable way. An EMS can take the form of a standardised or non-standardised ('customised') system. Implementation and adherence to an internationally accepted standardised system such as EN ISO 14001:2004 can give higher credibility to the EMS, but, non-standardised systems can, in principle, be equally effective provided that they are properly designed and implemented.

1. BATs are finalized to implement and adhere to an environmental management system (EMS) that incorporates the following features:

- definition of an environmental policy that includes continuous improvement for the installation;
- planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment;
- implementation of the procedures paying particular attention to: structure and responsibility; training, awareness and competence; communication; employee involvement; documentation; efficient process control; maintenance programmes; emergency preparedness and response; safeguarding compliance with environmental legislation;
- checking performance and taking corrective action, paying particular attention to: monitoring and measurement; corrective and preventive action; maintenance of records; independent internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;
- following the development of cleaner technologies;

- consideration for the environmental impacts from a possible decommissioning, during the design phase of a new technical unit and throughout its operating life;
- periodic application of sectoral benchmarking.

The scope (e.g. level of details) and nature of the EMS (e.g. standardised or non- standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Energy management

In the context of energy management, see the Energy Efficiency BREF (ENE).

2. BAT is to reduce primary energy consumption by optimisation of energy flows and optimised utilisation of the extracted process gases (such as desulphurised and dedusted surplus coke oven gas, blast furnace gas and basic oxygen gas) in a plant for production of energy (in the form of steam, electricity and/or heat), using the possible excess of energy for district heating networks, if there is a demand from a third party.

Techniques to improve energy efficiency by optimising process gas utilisation include:

- the use of gas holders for all by-product gases or other adequate systems for short- term storage and pressure holding facilities;
- increasing pressure in the gas grid if there are energy losses in the flares;
- gas enrichment with process gases and different calorific values for different consumers;
- heating fire furnaces with process gas;
- use of a computer-controlled calorific value control system;
- recording and using coke and flue-gas temperatures;
- adequate dimensioning of the capacity of the energy recovery installations for the process gases.

Furthermore, BAT is to reduce thermal energy consumption by using a combination of the following techniques:

1. improved and optimised systems to achieve smooth and stable processing, operating close to the process parameter set points by using: process control optimisation including computer-based automatic control systems; modern, gravimetric solid fuel feed systems; preheating, to the greatest extent possible, considering the existing process configuration;
2. recovering excess heat from processes, especially from their cooling zones;
3. an optimised steam and heat management;
4. applying process integrated reuse of sensible heat as much as possible.

Specific aspects related to the application of the technique cited in point 1. are:

- optimising energy consumption;
- online monitoring for the most important energy flows and combustion processes at the site including the monitoring of all gas flares in order to prevent energy losses, enabling instant maintenance and achieving an uninterrupted production process;
- reporting and analysing tools to check the average energy consumption of each process;
- defining specific energy consumption levels for relevant processes and comparing them on a long-term basis;
- carrying out energy audits as defined in the Energy Efficiency BREF, e.g. to identify cost-effective energy savings opportunities.

Specific aspects related to the application of the technique cited in points 2. to 4. are:

- combined heat and power production with recovery of waste heat by heat exchangers and distribution either to other parts of the steelworks or to a district heating network;

- the installation of steam boilers or adequate systems in large reheating furnaces (furnaces can cover a part of the steam demand);
- preheating of the combustion air in furnaces and other burning systems to save fuel, taking into consideration adverse effects, i.e. an increase of nitrogen oxides in the off-gas;
- the insulation of steam pipes and hot water pipes;
- recovery of heat from products, e.g. sinter;
- where steel needs to be cooled, the use of both heat pumps and solar panels;
- the use of flue-gas boilers in furnaces with high temperatures;
- the oxygen evaporation and compressor cooling to exchange energy across standard heat exchangers;
- the use of top recovery turbines to convert the kinetic energy of the gas produced in the blast furnace into electric power.

Material management

3. BAT is to optimise the management and control of internal material flows in order to prevent pollution, prevent deterioration, provide adequate input quality, allow reuse and recycling, and improve the process efficiency and optimisation of the metal yield.

For reduce the emissions, BAT is to select appropriate scrap qualities and the use them; the techniques can be used:

- specification of acceptance criteria suited and having a good knowledge of scrap composition by closely monitoring the origin of the scrap, considering the procedures to exclude scrap that is not suitable;
- having adequate reception facilities and check deliveries and storing the scrap according to different criteria (e.g. size, alloys, degree of cleanliness);
- prompt return of all internally-generated scrap to the scrapyard for recycling;
- having an operation and management plan;

- scrap sorting to minimise the risk of including hazardous or non-ferrous contaminants, particularly polychlorinated biphenyls (PCB) and oil or grease. small quantities of plastic (e.g. as plastic coated components) may be required;
- radioactivity control;
- implementation of the mandatory removal of components which contain mercury from End-of-Life Vehicles and Waste Electrical and Electronic Equipment (WEEE).

Air emissions management

4. BAT is to prevent or reduce diffuse dust emissions from materials storage, handling and transport by using one or a combination of the techniques mentioned below.

If abatement techniques are used, BAT is to optimise the capture efficiency and subsequent cleaning through the setting up of an associated diffuse dust action plan and the monitoring of PM10.

Techniques used are:

- installing wind barriers;
- reduce the handling of materials;
- total enclosure of transfer, unloading and loading points with filtered air extraction for dusty materials;
- implementation of a greening of the site by covering unused areas;
- minimisation of the disturbance of stockpiles;
- storage of powdered carbon, lime and calcium carbide in sealed silo;
- rigorous maintenance standards for equipment;
- dust suppression or dust extraction and the use of a bag filter cleaning plant;

- to the application of emissions-reduced sweeping cars for carrying out the routine cleaning of hard surfaced roads.

Techniques to consider during material transport include:

- the employment of wheel-cleaning equipment to prevent the carryover of mud and dust onto public roads;
- the application of hard surfaces to the transport roads (concrete or asphalt) to minimise the generation of dust clouds during materials transport and the cleaning of roads;
- the damping of dusty routes by water sprays, e.g. at slag-handling operations;
- good practice techniques for molten metal transfer and ladle handling;
- dedusting of conveyor transfer points.

Water and wastewater management

The water management will primarily be constrained by the availability and quality of fresh water and local legal requirements.

5. BAT for wastewater management is to prevent, collect and separate waste water types, maximising internal recycling and using an adequate treatment for each final flow.

This includes techniques utilising, such as oil interceptors, filtration or sedimentation. The techniques are:

- avoiding the use of potable water for production lines;
- increasing the number and/or capacity of water circulating systems when building new plants or modernising/revamping existing plants;
- centralising the distribution of incoming fresh water;
- using the water in cascades until single parameters reach their legal or technical limits;

- using the water in other plants if only single parameters of the water are affected and further usage is possible;
- keeping treated and untreated waste water separated;
- using rainwater whenever possible.

Waste and by products management

6. BAT for solid residues is to use integrated techniques and operational techniques for waste minimisation by internal use or by application of specialised recycling processes (internally or externally). Techniques for the recycling of iron-rich residues include the OxyCup® shaft furnace, the DK process, smelting reduction processes or cold bonded pelleting/briquetting.

7. BAT is to maximise external use or recycling for solid residues which cannot be used or recycled according to waste regulations and to manage in a controlled manner residues which can neither be avoided nor recycled.

8. BAT is to use the best operational and maintenance practices for the collection, handling, storage and transport of all solid residues and for the hooding of transfer points to avoid emissions to air and water.

Monitoring management

Monitoring should be done according to the relevant EN or ISO standards, if these are not available, national or other international standards should be used.

9. BAT is to measure or assess all relevant parameters to steer the processes by means of modern computer-based systems in order to adjust continuously and to optimise the processes online, to ensure stable and smooth processing, thus increasing energy efficiency and maximising the yield and improving maintenance practices.

10. BAT is to measure the stack emissions of pollutants from the main emission sources from all processes.

The continuous measurements are for:

- primary emissions of dust, nitrogen oxides (NO_x) and sulphur dioxide (SO_2) from sinter strands;
- nitrogen oxides (NO_x) and sulphur dioxide (SO_2) emissions from induration strands of palletisation plants;
- dust emissions from blast furnace cast houses;
- secondary emissions of dust from basic oxygen furnaces;
- emissions of nitrogen oxides (NO_x) from power plants;
- dust emissions from large electric arc furnaces.

This includes the discontinuous monitoring of process gases, stack emissions, polychlorinated dibenzodioxins/furans (PCDD/F) and monitoring the discharge of waste water, but excludes diffuse emissions.

The monitoring of process gases provides information about the composition of process gases and about indirect emissions from the combustion of process gases, such as emissions of dust, heavy metals and SO_x .

For monitoring the discharge of wastewater there are standardised procedures for sampling and analysing water and wastewater, such as:

- a random sample;
- a composite sample taken continuously over a given period, or a sample consisting of several samples taken either continuously or discontinuously over a given period and blended;
- a qualified random sample shall refer to a composite sample of at least five random samples taken over a maximum period of two hours at intervals of no less than two minutes, and blended.

11. BAT is to determine the order of magnitude of diffuse emissions from relevant sources. The methods are direct and indirect or evaluations based on calculations with emission factors.

In direct measurement methods emissions are measured at the source itself. Examples are given by measurements in wind tunnels, with hoods or other methods like quasi-emissions measurements on the roof of an industrial installation

In indirect measurement methods where the emission determination takes place at exertion distance from the source. Examples of indirect measurements include the use of tracer gases, reverse dispersion modelling (RDM) methods and the mass balance method applying light detection and ranging (LIDAR).

For calculation of emissions with emission factors, the guidelines using emission factors for the estimation of diffuse dust emissions from storage and handling of bulk materials and for the suspension of dust from roadways due to traffic movements are reported in VDI 3790 Part 3 and in US EPA AP 42.

Noise management

Many processes in the iron and steel production generate significant noise emissions.

12. BAT is to reduce noise emissions from relevant sources in the iron and steel manufacturing processes by using one or more of the following techniques depending on and according to local conditions:

- implementation of a noise-reduction strategy;
- enclosure of the noisy operations/units;
- vibration insulation of operations/units;
- internal and external lining made of impact-absorbent material;
- soundproofing buildings to shelter any noisy operations involving material transformation equipment;
- building noise protection walls, e.g. the construction of buildings or natural barriers, such as growing trees and bushes between the protected area and the noisy activity;
- outlet silencers on exhaust stacks;
- lagging ducts and final blowers which are situated in soundproof buildings;
- closing doors and windows of covered areas.

Decommissioning management

13. BAT is to prevent pollution upon decommissioning.

Design considerations for end-of-life plant decommissioning:

- I. giving consideration to the environmental impact from the eventual decommissioning of the installation at the stage of designing a new plant, as forethought makes decommissioning easier, cleaner and cheaper;
- II. decommissioning poses environmental risks for the contamination of land (and groundwater) and generates large quantities of solid waste; preventive techniques are:
 - i. avoiding underground structures;
 - ii. incorporating features that facilitate dismantling;
 - iii. choosing surface finishes that are easily decontaminated;
 - iv. using an equipment configuration that minimises trapped chemicals and facilitates drain-down or cleaning;
 - v. designing flexible, self-contained units that enable phased closure;
 - vi. using biodegradable and recyclable materials where possible.

B. BAT conclusions for sinter plants

Air emissions

- 1.** BAT for blending/mixing is to prevent or reduce diffuse dust emissions by agglomerating fine materials by adjusting the moisture content.
- 2.** BAT for primary emissions from sinter plants is to reduce dust emissions from the sinter strand waste gas by means of a bag filter or electrostatic precipitators when bag filters are not applicable.
- 3.** BAT for primary emissions from sinter strands is to prevent or reduce mercury emissions by selecting raw materials with a low mercury content or to treat waste gases in combination with activated carbon or activated lignite coke injection.

4. BAT for primary emissions from sinter strands is to reduce sulphur oxide (SO_x) emissions by using the following techniques:

- I. lowering the sulphur input by using coke breeze and iron with a low sulphur content;
- II. lowering the sulphur input by minimisation of coke breeze consumption;
- III. injection of adequate adsorption agents into the waste gas duct of the sinter strand before dedusting by bag filter;
- IV. wet desulphurisation or regenerative activated carbon (RAC) process.

5. BAT for primary emissions from sinter strands is to reduce total nitrogen oxides (NO_x) emissions by using the following techniques:

- I. process integrated measures which can include: waste gas recirculation and other primary measures, such as the use of anthracite or the use of low- NO_x burners for ignition.;
- II. end-of-pipe techniques which are: the regenerative activated carbon (RAC) process and selective catalytic reduction (SCR).

6. BAT for primary emissions from sinter strands is to prevent and/or reduce emissions of polychlorinated dibenzodioxins/furans (PCDD/F) and polychlorinated biphenyls (PCB) by using the following techniques:

- I. avoidance of raw materials which contain polychlorinated dibenzodioxins/furans (PCDD/F) and polychlorinated biphenyls (PCB) or their precursors as much as possible;
- II. suppression of polychlorinated dibenzodioxins/furans (PCDD/F) formation by addition of nitrogen compounds;
- III. waste gas recirculation;
- IV. with the injection of adequate adsorption agents (carbon adsorbs) into the waste gas duct of the sinter strand before dedusting with a bag filter or advanced electrostatic precipitators when bag filters are not applicable.

7. BAT for secondary emissions from sinter strand discharge, sinter crushing, cooling, screening and conveyor transfer points is to prevent dust emissions and/or to achieve an efficient extraction and subsequently to reduce dust emissions by using a combination of the following techniques: hooding and/or enclosure and an electrostatic precipitator or a bag filter.

Water and wastewater

8. BAT is to minimise water consumption in sinter plants by recycling cooling water as much as possible unless once-through cooling systems are used.

9. BAT is to treat the effluent water from sinter plants where rinsing water is used or where a wet waste gas treatment system is applied, with the exception of cooling water prior to discharge by using a combination of the following techniques: heavy metal precipitation, neutralisation and sand filtration.

Production residues

10. BAT is to prevent waste generation within sinter plants with the selective, on-site or external, recycling of residues back to the sinter process by excluding heavy metals, alkali or chloride-enriched fine dust fractions.

11. BAT is to recycle residues that may contain oil, such as dust, sludge and mill scale which contain iron and carbon from the sinter strand and other processes in the integrated steelworks, as much as possible back to the sinter strand, taking into account the respective oil content.

12. BAT is to lower the hydrocarbon content of the sinter feed by appropriate selection and pre-treatment of the recycled process residues.

Energy

13. BAT is to reduce thermal energy consumption within sinter plants by using one or a combination of the following techniques:

- recovering sensible heat from the sinter cooler waste gas;
- recovering sensible heat, if feasible, from the sintering grate waste gas;

- maximising the recirculation of waste gases to use sensible heat.

The sensible heat in the hot air from the sinter cooler can be recovered by one or more of the following ways:

- steam generation in a waste heat boiler for use in the iron and steel works;
- hot water generation for district heating;
- preheating combustion air in the ignition hood of the sinter plant;
- preheating the sinter raw mix;
- use of the sinter cooler gases in a waste gas recirculation system.

C. BAT conclusions for palletisation plants

Air emissions

1. BAT is to reduce the dust emissions in the waste gases from

- the raw materials pre-treatment, drying, grinding, wetting, mixing and balling;
- the induration strand;
- the pellet handling and screening.

by using one or a combination of the following techniques:

- I. an electrostatic precipitator;
- II. a bag filter;
- III. a wet scrubber.

2. BAT is to reduce the sulphur oxides (SO_x), hydrogen chloride (HCl) and hydrogen fluoride (HF) emissions from the induration strand waste gas by using one of the following techniques:

- I. a wet scrubber;
- II. semi-dry absorption with a subsequent dedusting system.

3. BAT is to reduce NO_x emissions from the drying and grinding section and induration strand waste gases by applying process-integrated techniques.

The reduction of the formation of thermal NO_x can be achieved by lowering the (peak) temperature in the burners and reducing the excess oxygen in the combustion air. Additionally, lower NO_x emissions can be achieved by a combination of low energy use and low nitrogen content in the fuel (coal and oil).

4. BAT for existing plants is to reduce NO_x emissions from the drying and grinding section and induration strand waste gases by applying one of the following techniques: selective catalytic reduction (SCR) as an end-of-pipe technique and any other technique with a NO_x reduction efficiency of at least 80 %.

5. BAT for new plants is to reduce NO_x emissions from the drying and grinding section and induration strand waste gases by applying selective catalytic reduction (SCR) as an end-of-pipe technique.

Water and wastewater

6. BAT for palletisation plants is to minimise the water consumption and discharge of scrubbing, wet rinsing and cooling water and reuse it as much as possible.

7. BAT for palletisation plants is to treat the effluent water prior to discharge by using a combination of the following techniques:

- I. neutralisation;
- II. flocculation;
- III. sedimentation;
- IV. sand filtration;
- V. heavy metal precipitation.

Production residues

8. BAT is to prevent waste generation from palletisation plants by effective on-site recycling or the reuse of residues. BAT is to manage in a controlled manner pellet plant process residues, i.e. sludge from waste water treatment, which can neither be avoided nor recycled.

Energy

9. BAT is to reduce/minimise thermal energy consumption in palletisation plants by using one or a combination of the following techniques:

- I. process integrated reuse of sensible heat as far as possible from the different sections of the induration strand;
- II. using surplus waste heat for internal or external heating networks if there is demand from a third party.

Hot air from the primary cooling section can be used as secondary combustion air in the firing section. In turn, the heat from the firing section can be used in the drying section of the induration strand. Heat from the secondary cooling section can also be used in the drying section. Excess heat from the cooling section can be used in the drying chambers of the drying and grinding unit. The hot air is transported through an insulated pipeline called a 'hot air recirculation duct'.

D. BAT conclusions for coke oven plants

Air emissions

1. BAT for coal grinding plants (coal preparation including crushing, grinding, pulverising and screening) is to prevent or reduce dust emissions by using one or a combination of the following techniques:

- I. building and/or device enclosure (crusher, pulveriser, sieves);
- II. efficient extraction and use of a subsequent dry dedusting systems.

2. BAT for storage and handling of pulverised coal is to prevent or reduce diffuse dust emissions by using one or a combination of the following techniques:

- I. storing pulverised materials in bunkers and warehouses;
- II. using closed or enclosed conveyors;
- III. minimising the drop heights depending on the plant size and construction;
- IV. reducing emissions from charging of the coal tower and the charging car;
- V. using efficient extraction and subsequent dedusting.

3. BAT is to charge coke oven chambers with emission-reduced charging systems.

From an integrated point of view, ‘smokeless’ charging or sequential charging with double ascension pipes or jumper pipes are the preferred types, because all gases and dust are treated as part of the coke oven gas treatment.

If, however, the gases are extracted and treated outside the coke oven, charging with a land-based treatment of the extracted gases is the preferred method. Treatment should consist of an efficient extraction of the emissions with subsequent combustion to reduce organic compounds and the use of a bag filter to reduce particulates.

4. BAT for coking is to extract the coke oven gas (COG) during coking as much as possible.

5. BAT for coke plants is to reduce the emissions through achieving continuous uninterrupted coke production by using the following techniques:

- I. extensive maintenance of oven chambers, oven doors and frame seals, ascension pipes, charging holes and other equipment;
- II. avoiding strong temperature fluctuations;
- III. comprehensive observation and monitoring of the coke oven;
- IV. cleaning of doors, frame seals, charging holes, lids and ascension pipes after handling;
- V. maintaining a free gas-flow in the coke ovens;
- VI. adequate pressure regulation during coking and application of spring-loaded flexible sealing doors or knife-edged doors;
- VII. using water-sealed ascension pipes to reduce visible emissions from the whole apparatus which provides a passage from the coke oven battery to the collecting main, gooseneck and stationary jumper pipes;
- VIII. luting charging hole lids with a clay suspension, to reduce visible emissions from all holes;
- IX. ensuring complete coking (avoiding green coke pushes) by application of adequate techniques;
- X. installing larger coke oven chambers;
- XI. where possible, using variable pressure regulation to oven chambers during coking.

6. BAT for the gas treatment plant is to minimise fugitive gaseous emissions by using the following techniques:

- I. minimising the number of flanges by welding piping connections wherever possible;
- II. using appropriate sealing's for flanges and valves; using gas-tight pumps;

- III. avoiding emissions from pressure valves in storage tanks by: connecting the valve outlet to the coke oven gas (COG), collecting main or collecting the gases and subsequent combustion.

7. BAT is to reduce the sulphur content of the coke oven gas (COG) by using one of the following techniques:

- I. desulphurisation by absorption systems;
- II. wet oxidative desulphurisation.

8. BAT for the coke oven under firing is to reduce the emissions by using the following techniques:

- I. preventing leakage between the oven chamber and the heating chamber by means of regular coke oven operation;
- II. repairing leakage between the oven chamber and the heating chamber;
- III. incorporating low-nitrogen oxides (NO_x) techniques in the construction of new batteries, such as staged combustion and the use of thinner bricks and refractory with a better thermal conductivity;
- IV. using desulphurised coke oven gas (COG) process gases.

9. BAT for coke pushing is to reduce dust emissions by using the following techniques:

- I. extraction by means of an integrated coke transfer machine equipped with a hood;
- II. using land-based extraction gas treatment with a bag filter or other abatement systems;
- III. using a one point or a mobile quenching car.

10. BAT for coke quenching is to reduce dust emissions by using one of the following techniques:

- I. using coke dry quenching (CDQ) with the recovery of sensible heat and the removal of dust from charging, handling and screening operations by means of a bag filter;

- II. using emission-minimised conventional wet quenching;
- III. using coke stabilisation quenching (CSQ).

11. BAT for coke grading and handling is to prevent or reduce dust emissions by using the following techniques in combination:

- I. use of building or device enclosures;
- II. efficient extraction and subsequent dry dedusting.

Water and wastewater

12. BAT is to minimise and reuse quenching water as much as possible.

13. BAT is to avoid the reuse of process water with a significant organic load (like raw coke oven waste water, waste water with a high content of hydrocarbons, etc.) as quenching water.

14. BAT is to pre-treat waste water from the coking process and coke oven gas (COG) cleaning prior to discharge to a waste water treatment plant by using one or a combination of the following techniques:

- I. using efficient tar and polycyclic aromatic hydrocarbons (PAH) removal by using flocculation and subsequent flotation, sedimentation and filtration individually or in combination;
- II. using efficient ammonia stripping by using alkaline and steam.

15. BAT for pre-treated waste water from the coking process and coke oven gas (COG) cleaning is to use biological waste water treatment with integrated denitrification/nitrification stages.

Production residues

16. BAT is to recycle production residues such as tar from the coal water and still effluent, and surplus activated sludge from the waste water treatment plant back to the coal feed of the coke oven plant.

Energy

17. BAT is to use the extracted coke oven gas (COG) as a fuel or reducing agent or for the production of chemicals.

E. BAT conclusions for blast furnaces

Air emissions

1. BAT for displaced air during loading from the storage bunkers of the coal injection unit is to capture dust emissions and perform subsequent dry dedusting.

2. BAT for burden preparation (mixing, blending) and conveying is to minimise dust emissions and, where relevant, extraction with subsequent dedusting by means of an electrostatic precipitator or bag filter.

3. BAT for casting house (tap holes, runners, torpedo ladles charging points, skimmers) is to prevent or reduce diffuse dust emissions by using the following techniques:

- I. covering the runners;
- II. optimising the capture efficiency for diffuse dust emissions and fumes with subsequent off-gas cleaning by means of an electrostatic precipitator or bag filter;
- III. fume suppression using nitrogen while tapping, where applicable and where no collecting and dedusting system for tapping emissions is installed.

4. BAT is to use tar-free runner linings.

5. BAT is to minimise the release of blast furnace gas during charging by using one or a combination of the following techniques:

- I. bell-less top with primary and secondary equalising;
- II. gas or ventilation recovery system;
- III. use of blast furnace gas to pressurise the top bunkers.

6. BAT is to reduce dust emissions from the blast furnace gas by using one or a combination of the following techniques:

- I. using dry pre-dedusting devices such as: deflectors; dust catchers; cyclones; electrostatic precipitators.
- II. subsequent dust abatement such as: hurdle-type scrubbers; venturi scrubbers; annular gap scrubbers; wet electrostatic precipitators; disintegrators.

7. BAT for hot blast stoves is to reduce emissions by using desulphurised and dedusted surplus coke oven gas, dedusted blast furnace gas, dedusted basic oxygen furnace gas and natural gas, individually or in combination.

Water and wastewater

8. BAT for water consumption and discharge from blast furnace gas treatment is to minimise and to reuse scrubbing water as much as possible, e.g. for slag granulation, if necessary after treatment with a gravel-bed filter.

9. BAT for treating waste water from blast furnace gas treatment is to use flocculation (coagulation) and sedimentation and the reduction of easily released cyanide, if necessary.

Production residues

10. BAT is to prevent waste generation from blast furnaces by using one or a combination of the following techniques: appropriate collection and storage to facilitate a specific treatment on-site recycling of coarse dust from the blast furnace (BF) gas treatment and dust from the cast house dedusting, with due regard for the effect of emissions from the plant where it is recycled hydrocyclonage of sludge with subsequent on-site recycling of the coarse fraction.

11. BAT for minimising slag treatment emissions is to condense fume if odour reduction is required.

Resource management

12. BAT for resource management of blast furnaces is to reduce coke consumption by directly injected reducing agents, such as pulverised coal, oil, heavy oil, tar, oil residues, coke oven gas (COG), natural gas and wastes such as metallic residues, used oils and emulsions, oily residues, fats and waste plastics individually or in combination.

The methods are:

Coal injection: The method is applicable to all blast furnaces equipped with pulverised coal injection and oxygen enrichment.

Gas injection: Tuyère injection of coke oven gas (COG) is highly dependent upon the availability of the gas that may be effectively used elsewhere in the integrated steelworks.

Plastic injection: it should be noted that this technique is highly dependent on the local circumstances and market conditions. Plastics can contain Cl and heavy metals like Hg, Cd, Pb and Zn. Depending on the composition of the wastes used (e.g. shredder light fraction), the amount of Hg, Cr, Cu, Ni and Mo in the BF gas may increase.

Direct injection of used oils, fats and emulsions as reducing agents and of solid iron residues: the continuous operation of this system is reliant on the logistical concept of delivery and the storage of residues.

Energy

13. BAT is to maintain a smooth, continuous operation of the blast furnace at a steady state to minimise releases and to reduce the likelihood of burden slips.

14. BAT is to use the extracted blast furnace gas as a fuel.

15. BAT is to recover the energy of top blast furnace gas pressure where sufficient top gas pressure and low alkali concentrations are present.

16. BAT is to preheat the hot blast stove fuel gases or combustion air using the waste gas of the hot blast stove and to optimise the hot blast stove combustion process.

For optimisation of the energy efficiency of the hot stove, one or a combination of the following techniques can be applied:

- the use of a computer-aided hot stove operation;
- preheating of the fuel or combustion air in conjunction with insulation of the cold blast line and waste gas flue;
- use of more suitable burners to improve combustion;
- rapid oxygen measurement and subsequent adaptation of combustion conditions.

F. BAT conclusions for basic oxygen steelmaking and casting

Air emissions

1. BAT for basic oxygen furnace (BOF) gas recovery by suppressed combustion is to extract the BOF gas during blowing as much as possible and to clean it by using the following techniques in combination:

- I. use of a suppressed combustion process;
- II. pre-dedusting to remove coarse dust by means of dry separation techniques (e.g. deflector, cyclone) or wet separators;
- III. dust abatement by means of:
 - i. dry dedusting (e.g. electrostatic precipitator) for new and existing plants;
 - ii. wet dedusting (e.g. wet electrostatic precipitator or scrubber) for existing plants.

2. BAT for basic oxygen furnace (BOF) gas recovery during oxygen blowing in the case of full combustion is to reduce dust emissions by using one of the following techniques:

- I. dry dedusting (e.g. ESP or bag filter) for new and existing plants;
- II. wet dedusting (e.g. wet ESP or scrubber) for existing plants.

3. BAT is to minimise dust emissions from the oxygen lance hole by using one or a combination of the following techniques:

- I. covering the lance hole during oxygen blowing;
- II. inert gas or steam injection into the lance hole to dissipate the dust;
- III. use of other alternative sealing designs combined with lance cleaning devices.

4. BAT for secondary dedusting, including the emissions from the following processes:

- reladling of hot metal from the torpedo ladle (or hot metal mixer) to the charging ladle;
- hot metal pretreatment (i.e. the preheating of vessels, desulphurisation, dephosphorisation, deslagging, hot metal transfer processes and weighing);
- BOF-related processes like the preheating of vessels, slopping during oxygen blowing, hot metal and scrap charging, tapping of liquid steel and slag from BOF;
- secondary metallurgy and continuous casting, is to minimise dust emissions by means of process integrated techniques, such as general techniques to prevent or control diffuse or fugitive emissions, and by using appropriate enclosures and hoods with efficient extraction and a subsequent off-gas cleaning by means of a bag filter or an ESP.

General techniques to prevent diffuse and fugitive emissions from the relevant BOF process secondary sources include:

- independent capture and use of dedusting devices for each sub process in the BOF shop;
- correct management of the desulphurisation installation to prevent air emissions;
- total enclosure of the desulphurisation installation;

- maintaining the lid on when the hot metal ladle is not in use and the cleaning of hot metal ladles and removal of skulls on a regular basis or alternatively apply a roof extraction system;
- maintaining the hot metal ladle in front of the converter for approximately two minutes after putting the hot metal into the converter if a roof extraction system is not applied;
- computer control and optimisation of the steelmaking process, e.g. so that slopping (i.e. when the slag foams to such an extent that it flows out of the vessel) is prevented or reduced;
- reduction of slopping during tapping by limiting elements that cause slopping and the use of anti-slopping agents;
- closure of doors from the room around the converter during oxygen blowing;
- continuous camera observation of the roof for visible emission;
- the use of a roof extraction system.

5. BAT for on-site slag processing is to reduce dust emissions by using one or a combination of the following techniques:

- I. efficient extraction of the slag crusher and screening devices with subsequent off-gas cleaning, if relevant;
- II. transport of untreated slag by shovel loaders;
- III. extraction or wetting of conveyor transfer points for broken material;
- IV. wetting of slag storage heaps;
- V. use of water fogs when broken slag is loaded.

Water and wastewater

6. BAT is to prevent or reduce water use and waste water emissions from primary dedusting of basic oxygen furnace (BOF) gas by using one of the following techniques:

- dry dedusting of basic oxygen furnace (BOF) gas;
- minimising scrubbing water and reusing it as much as possible (e.g. for slag granulation) in case wet dedusting is applied.

7. BAT is to minimise the waste water discharge from continuous casting by using the following techniques in combination:

- I. the removal of solids by flocculation, sedimentation and/or filtration;
- II. the removal of oil in skimming tanks or any other effective device;
- III. the recirculation of cooling water and water from vacuum generation as much as possible.

Production residues

8. BAT is to prevent waste generation by using one or a combination of the following techniques:

- I. appropriate collection and storage to facilitate a specific treatment;
- II. on-site recycling of dust from basic oxygen furnace (BOF) gas treatment, dust from secondary dedusting and mill scale from continuous casting back to the steelmaking processes with due regard for the effect of emissions from the plant where they are recycled;
- III. on-site recycling of BOF slag and BOF slag fines in various applications;
- IV. slag treatment where market conditions allow for the external use of slag (e.g. as an aggregate in materials or for construction);
- V. use of filter dusts and sludge for external recovery of iron and non-ferrous metals such as zinc in the non-ferrous metals industry;
- VI. use of a settling tank for sludge with the subsequent recycling of the coarse fraction in the sinter/blast furnace or cement industry when grain size distribution allows for a reasonable separation.

Energy

9. BAT is to collect, clean and buffer BOF gas for subsequent use as a fuel. In some cases, it may not be economically feasible or, with regard to appropriate energy management, not feasible to recover the BOF gas by suppressed combustion. In these cases, the BOF gas may be combusted with the generation of steam.

10. BAT is to reduce energy consumption by using ladle-lid systems.

11. BAT is to optimise the process and reduce energy consumption by using a direct tapping process after blowing.

12. BAT is to reduce energy consumption by using continuous near net shape strip casting, if the quality and the product mix of the produced steel grades justify it.

G. BAT conclusions for electric arc furnace steelmaking and casting

Air emissions

1. BAT for the electric arc furnace (EAF) process is to prevent mercury emissions by avoiding, as much as possible, raw materials and auxiliaries which contain mercury.

2. BAT for the electric arc furnace (EAF) primary and secondary dedusting (including scrap preheating, charging, melting, tapping, ladle furnace and secondary metallurgy) is to achieve an efficient extraction of all emission sources by using one of the techniques listed below and to use subsequent dedusting by means of a bag filter:

- I. a combination of direct off-gas extraction and hood systems;
- II. direct gas extraction and doghouse systems;
- III. direct gas extraction and total building evacuation.

3. BAT for the electric arc furnace (EAF) primary and secondary dedusting (including scrap preheating, charging, melting, tapping, ladle furnace and secondary metallurgy) is to prevent and reduce

polychlorinated dibenzodioxins/furans (PCDD/F) and polychlorinated biphenyls (PCB) emissions by avoiding, as much as possible, raw materials which contain PCDD/F and PCB or their precursors and using one or a combination of the following techniques, in conjunction with an appropriate dust removal system:

- I. appropriate post-combustion;
- II. appropriate rapid quenching;
- III. injection of adequate adsorption agents into the duct before dedusting.

4. BAT for on-site slag processing is to reduce dust emissions by using one or a combination of the following techniques:

- I. efficient extraction of the slag crusher and screening devices with subsequent off- gas cleaning, if relevant;
- II. transport of untreated slag by shovel loaders;
- III. extraction or wetting of conveyor transfer points for broken material;
- IV. wetting of slag storage heaps;
- V. use of water fogs when broken slag is loaded.

Water and wastewater

5. BAT is to minimise the water consumption from the electric arc furnace (EAF) process by the use of closed loop water cooling systems for the cooling of furnace devices as much as possible unless once-through cooling systems are used.

This waste water is treated together with waste water streams from the hot rolling mills. After treatment, the water is recirculated.

6. BAT is to minimise the waste water discharge from continuous casting by using the following techniques in combination:

- I. the removal of solids by flocculation, sedimentation and/or filtration;

- II. the removal of oil in skimming tanks or in any other effective device;
- III. the recirculation of cooling water and water from vacuum generation as much as possible.

Production residues

7. BAT is to prevent waste generation by using one or a combination of the following techniques:

- I. appropriate collection and storage to facilitate a specific treatment;
- II. recovery and on-site recycling of refractory materials from the different processes and use internally, i.e. for the substitution of dolomite, magnesite and lime;
- III. use of filter dusts for the external recovery of non-ferrous metals such as zinc in the non-ferrous metals industry, if necessary, after the enrichment of filter dusts by recirculation to the electric arc furnace (EAF);
- IV. separation of scale from continuous casting in the water treatment process and recovery with subsequent recycling, e.g. in the sinter/blast furnace or cement industry;
- V. external use of refractory materials and slag from the electric arc furnace (EAF) process as a secondary raw material where market conditions allow for it.

Energy

8. BAT is to reduce energy consumption by using continuous near net shape strip casting, if the quality and the product mix of the produced steel grades justify it.

Noise

9. BAT is to reduce noise emissions from electric arc furnace (EAF) installations and processes generating high sound energies by using a combination of the following constructional and operational techniques depending on and according to local conditions:

- I. construct the electric arc furnace (EAF) building in such a way as to absorb noise from mechanical shocks resulting from the operation of the furnace;
- II. construct and install cranes destined to transport the charging baskets to prevent mechanical shocks;
- III. special use of acoustical insulation of the inside walls and roofs to prevent the airborne noise of the electric arc furnace (EAF) building;
- IV. separation of the furnace and the outside wall to reduce the structure-borne noise from the electric arc furnace (EAF) building;
- V. housing of processes generating high sound energies (i.e. electric arc furnace (EAF) and decarburisation units) within the main building.

2.4 New forms of organizing work

Steel is certainly the most recycled material in the world with its 600 million tons per year. In the productive activities carried out in west countries, more than 90% of raw material comes from the iron scrap which is separated and classified in the chain of suppliers, and further treated during the first steps of steel production, before casting.

Italy is the first European country for iron scrap recycling, with an average of about 20 million tons of material per year which is recast in national steel factories. After having completed its structural functions, 100% of demolished steel is recycled (without losing any feature) and 99% of products is recovered because it is easily separable from other materials. In this way, steel directly and indirectly contributes to preserve natural sources.

Increasing the use of scrap instead of ores has allowed a great increase of productive performances in the latest years, along with a reduction of polluting gases and energy demand.

Innovative processes based on compaction of the productive steps have been developed; they are able to better satisfy the requirements of product quality, and above all they have allowed a costs abatement due to a severe reduction of spaces, machineries, electric energy and water.

More and more sophisticated systems have been introduced in order to reduce levels of nitrogen oxide and the quantity of carbon dioxide emitted in the environment. In some geographical areas, several companies are able to reduce CO₂ emissions of 20÷30% through the innovations of the research & development sector. Attention has also been paid to recent applications in the production of electric energy; mostly of them are carried out indoors and guarantee a significant saving of a particularly relevant cost component.

Product innovations are in continuous development, thus producing improvements in various sectors. For example, the use of new and revolutionary paints allows to avoid the use of particularly pollutant and less long-lasting lube oils in the pipe joints. Moreover, the nanotechnologies employment has allowed the development of very small-sized sensors (essentially self-powered) that are able to measure different chemical and physical parameters by monitoring systems which are located in particularly insidious and hard to reach areas.

Furthermore, non-invasive quality control systems are in continuous increase; they use ultrasounds, electromagnetism and thermography in order to carefully test product features and potential dissimilarities. Moreover, some extremely critical parts of the product are analysed in detail through systems based on 3D laser technology. The online spectroscopic controls allow to considerably reduce wastes.

Complex quenching procedures are widely used in order to create a particularly hard steel, in any case still able to be precisely cut by laser. If compared with conventional types of steel, these steels reach a higher traction resistance. So, it is possible to decrease the thickness of the plate without compromising the solidity of the structure, thus reducing both the weight and the costs of production. There are lots of automotive and part production companies which choose harder steels for the vehicles construction.

Ever more intense is the development of techniques and routine activities able to satisfy customers with the most different needs in very

short times. The great flexibility of the plants, which are able to produce specific lots by responding to very particular orders and commissions, is one of the successful elements of steel factory players, since they're called to solve complex requests in short times too. Push systems are declining also in the sector of steel production. These changes are affecting the production steps more than the casting process. Indeed, production is gaining an ever higher technological level and an ever more flexible organisation, thus increasing its capacity to customize the answers with speed and precision that were unthinkable until some years ago.

Delivery just in time is the rule also for steel factories, different customer sectors and in particular the automotive and mechanical ones. No more storages or big buffers, just tense fluxes in line with the final customer process, as if one could realise a unique productive process without solution of continuity.

By now, work systems are totally integrated. The direct management and control of all the productive steps allow to obtain specific products in detail, also out of standards; moreover, they improve the material traceability and a stable monitoring of its quality.

Also the co-design and the interaction activities between planning and production follow this trend. No one is working stand alone and an ever tighter relationship involving the other sectors of the company, the suppliers and the customers is needed.

Technology and powerful computer calculation systems have increased the knowledge on the chemical aspects of the productive processes, thus enlarging the material offer for the required uses. Moreover, the elasticity guaranteed through the most various combinations of tubulars and cables is able to offer really attractive spaces of architectural creativity, for example in construction sector, both for the aesthetic result and the achievement of levels of eco-friendship and earthquakes resistance certainly better as referred to some years ago.

One of the rails of innovation in the construction sector concerns the dry constructive system which is founded on an approach to the building segment able to satisfy suitable performance standards in terms of safety, eco-friendship and durability. The steel dry system also allows a careful management of realization times, a reduced use of sources with

a consequent severe decrease of waste materials. It is also important the integration of isolating systems and plants, which widely allows to satisfy energetic, acoustic and fire-resistance requirements. The possibility of reusing the components and completely recycling the material is also important, because it leads to increase the competitiveness of steel constructions in terms of environmental sustainability.

Material durability is one of the most technologically developed factors in various sectors. In the world of steel there are lots of technical and engineering solutions which allow an ever more remarkable resistance to biological and environment factors. Refined design approaches make the steel one of the best materials that can stand up to environments containing high concentrations of chlorides (as, for example, heat exchangers where the cooling takes place by means of salt water). The pre-coating guarantees ever-growing quality and durability performances; similarly, solutions which integrate steel with other different materials are more and more interesting.

Growing attention to environmental and social sustainability leads to a growing decrease of the problems which create wasting and pollution. For example, the coating of the boxes for preserving foods has been reduced up to 20 % (up to the 60 % if the improvement of the painting process is taken into account). All of this is achieved without reducing the product shelf-life.

There are several companies which voluntarily undertook a virtuous path by reducing the emissions of their own plants to values lower than the ones imposed by law (for instance, dust concentrations lower than 50 %, organic micro pollutants concentrations lower than 80 %, compared to limit values).

2.5 Case histories

2.5.1. Premise

Because of some significant problematic aspects, as the rising of an international competitive pressure, the rising cost of primary and secondary raw materials (mainly scraps) and a considerable energetic gap, the Italian iron and steel system underlines warnings of highlighted

level of criticalities, especially as for the big companies which marked birth and success of this sector in Italy.

In particular, the industrial future of the ILVA of Taranto, which is tight between total environmental protection and complete safeguard of productive centre, represents a recession area in which the efforts of all Government, local institutions, companies and trade unions must converge.

The ILVA of Taranto is the biggest steel factory in Europe. It produces about one third of the steel production in Italy. At the end of year 2011, the workforce of Taranto plant amounted to 11.533 units.

The different phases of production can be resumed as follows.

Storage and movement of raw materials (basically iron and coal minerals, which are generally unloaded by ships) take place in so-called “ore parks”. Part of the iron minerals accumulated in the parks is sent to the sintering plant, part goes directly to 5 blast furnaces where also fluxes (CaO, obtained from limestone in a plant of the same site) and coke (obtained from coal in a coking plant, composed by 10 arrays of distillation ovens) are sent.

The cast iron obtained in blast furnaces is sent to two converters. The steel firstly goes to the hot-rolling plant and then to the cold-rolling plant. Later, the rolled steel is sent to the plant where the production of metal sheets, tapes, welded pipes and cutting sheets takes place.

2.5.2 Emissions

Productive activities give way to gaseous, solid and liquid emissions.

There are three types of *gaseous emissions*: direct, fugitive and diffuse ones. Direct emissions derive from chimneys and they are due to potential inefficiencies of the abatement equipment. Fugitive emissions are caused by a non-functional machinery. Diffuse emissions originate from storage areas and movement of raw materials, intermediate and solid products.

Solid emissions are made up of residues, by-products and waste. In

particular, the annual amount of waste produced both by ordinary activities and actions of environmental remediation (for example, dusts and sludge's derived from new filtrating systems), are huge (about 3 million tons); at least 10,000 tons are dangerous waste. The creation of two landfills in a suitable location will be provided for the disposal of these wastes. The location is to be chosen in the same factory.

Liquid emissions are made up of drain water coming from the using of process and cooling waters. Both sea water and fresh water (surface waters, groundwaters) are used in the factory. The sea water is taken from the Mar Piccolo and it is moved to the factory, where it is treated by means of coarse/fine screening and addition of antifouling compounds (chlorine dioxide and hydrochloric acid). The sea water is addressed to thermoelectric power station where it is used for indirect cooling; then, it is relaunched to the other Ilva sectors. For some specific processes as coking, it is used sea water coming directly from the water intake plant. Groundwaters from 31 extraction wells located in the factory area, waters from Tara and Sinni rivers (provided by the Authority for irrigation and land transformation of Puglia, Lucania and Irpinia), and drinking water from the Apulian water main are the supply sources of fresh water of the factory. Desalinated water is obtained from the Sinni water through ion exchange. The fresh water is mainly used for gas treatment, direct cooling and/or washing of products (continuous casting, coke quenching), and indirect cooling. The demineralized water is used for steam production, solutions preparation (pickling, rolling mill processes, zinc galvanizing), and indirect cooling. Process/cooling waters coming from producing areas, rainwaters, and streets cleansing waters are collected by two different drainage networks. Process waters are treated before entering the drainage networks. These two networks convey the collected waters in Mar Grande through two separated channels.

2.5.3 Environmental remediation actions

The remediation of Ilva area of Taranto - included in the site of national interest (SNI) – has not yet been effected. This delay has been caused by an administrative contentious procedure which started in 2006 and later in 2012, because the Ministry of Environment asked the Ilva to realize further actions of emergency safety containment of soils, groundwater and landfills, based on a partial characterisation.

As for pollution caused by emissions from production activities of the factory, dusts (derived not only from machinery, but also and above all from accumulation and moving of raw materials in ore parks), dioxins (mainly deriving from the sintering plant), benzopyrene, and benzene (mainly deriving from coking oven) are the most important contaminants. The main actions, aimed at the abatement of these contaminants in various sections of the factory, are described. They have been realized in latest years or planned for the next ones.

Ore parks and conveyor belts

These are the main actions recently carried out for dust abatement in ore parks:

- Realisation of a 80 meters buffer zone between the factory border and the external outline of the nearest accumulation to the same border;
- Installation of mesh barriers in order to limit dust diffusion, above all in the neighbourhood Tamburi;
- Provision of a new hydrants network for accumulations wetting and installation of water nebulisers for the abatement of suspended particulate matter;
- 30% decrease of the annual average stored material by reducing accumulations maximum height;

Next interventions aim to completion of windbreaks, strengthening of the wetting system (by installing humectant wide pipes and a new hydrant network) and total closure (all the 4 sides) of the conveyor belts network (the coverage of 20% of 65 km is currently achieved). In the future, it is expected to realise a total coverage of accumulations so that dust emissions will be reduced of 90%.

Sintering plant

The hot agglomeration of a mixture composed by tiny or dusty material takes place in the plant; in this way, there is the formation of a porous and resistant composite through partial fusion and sintering of particles. Because of high temperature and the presence of organic substances, metals, chlorine and oxygen, the process produces dioxins. The current

emitted-dioxins reduction system consists in an ammonia addition to the mixture fed to the sintering plant (in order to contain dioxins generation), in the injection of coal dust in flue gas upstream the electrostatic precipitators (in order to absorb present dioxins), and in the upgrading of the electrostatic precipitation system before the smokestack (a new advanced device, the Moving Electrode Electrostatic Precipitator, has been added to the existing, traditional one).

In the future, it is expected the realization of a new coal injection system for the dioxins adsorption, the substitution of the electrostatic filters with the more efficient fabric filters, the installation of a non-stop dioxins sampler. It is also expected to carry out actions in order to strengthen the dust abatement system.

Coking

Recently, many interventions in order to limit pollution have been done, as the introduction of new smokeless machinery which allow the massive reduction of emissions of benzopyrene, benzene and dust during the coal loading phase from the hoppers to the furnaces. The de-dusting system has been improved in order to keep the flue gas (generated by taking out carbon coke from the furnaces) under control. A coking gas desulphurization system has been installed in order to reduce emissions of sulphur oxide, deriving from gas combustion. Actions concerning the upgrading of the fire-resistant walls and the metallic structures (to limit fugitive losses between the distillation chamber and the combustion one) have been carried out. In the future, it is expected a complete remake of the loading floor, fire-resistant walls, furnaces regenerators, services fluid networks, kegs, coke extinguishing towers. It is also expected a strengthening of the emissions monitoring system.

Blast furnaces

Decommissioning of one out of 5 blast furnaces has already happened and the adjustment of 4 others has already started (it will require their gradual and temporary shutdown). In order to reduce widespread dust, various interventions are expected on these blast furnaces, as the implementation of a de-dusting system with fabric filters (more efficient of the already-existent wet system) in stock houses, and the improving of dusts interception efficiency in the sector of casting and slag granulation (to be achieved indoor).

Converters

Molten cast iron (it melts when it reaches 1,400°C) is moved to 2 converters by using special railway wagons. Converter n.2 has been equipped with a flue gas aspiration system. This action is going to be realised for converter n.1 too. It is also expected the installation of a flue gas de-dusting system by using fabric filters, which are more efficient.

As for the gathering area for iron scraps, it is expected the realisation of latest generation “haze wide pipes”, particularly efficient for outdoor dust abatement.

Preliminary estimates about actions efficiency

Following the latest years actions in order to improve the environmental performances of the factory, one can notice significant reductions of benzopyrene and dust levels in Machiavelli Station, located near the factory, in Tamburi neighbourhood. As for benzopyrene, the average concentration from January to August 2013 was 0.15 nanogram/m³ (0.10 from June to August); the law's limit for air quality is 1 nanogram/m³. As a reference, the annual averages of 2010 and 2011 were respectively 1.82 and 1.14 nanogram/m³. As for dusts (still in Machiavelli Station), 8 exceedances of law's limit have been measured from January to September 2013 (with only one exceedance from June to September 2013), whereas the law allows up to 35 exceedances referred to a maximum value daily value of 50 µg/m³ (a limit which many Italian cities are unable to respect). In 2011, exceedances have been 38 from June to September and 45 the whole year. Moreover, the average concentration during the first 9 months of 2013 has been 30.7 µg/m³, lower if compared with the annual average (40 µg/m³), as specified in the law in force.

Chapter 3

“The Household Appliances Production”

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3.1 The evolution of the sector

3.1.1 The world-wide scenario

The household appliance market is in a phase of radical transformation of its competitive stance with far-reaching effects both globally and at European level.

Between 2008 and 2012, compared with a 10% decline in mature areas as Europe and North America, the global market for appliances has recorded a growth of 13% which, however, occurred only in so-called emerging countries, and in particularly in the Extreme Orient, and it went to the exclusive benefit of the new Asian and Turkish producers. They are global competitors with a strong presence in Europe, where they offer high-performance products in all segments of the production, with a growing aggressiveness even in the high parts of the market. This stems from their ability to combine research and innovation with production systems at very low cost, based on geographical areas with average levels of labour costs highly competitive (Turkey, Asia, Eastern Europe).

China is by far the biggest global supplier of major household appliances (see Table 3.1). In fact, manufacturing capacity nearly doubled over the last decade.

Table 3.1 Global production of household appliances by country (2012).

RANKING	COUNTRY	VALUE (Million USD)	% SHARE
1	China	147,205	34.3%
2	United States	53,744	12.5%
3	Japan	45,603	10.6%
4	Germany	33,817	7.9%
5	South Korea	16,169	3.8%
6	Italy	14,995	3.5%
7	Turkey	11,232	2.6%
8	Russia	11,218	2.6%
9	Brazil	10,203	2.4%
10	France	84,35	2.0%
	Other	76,618	17.8%
	Total	429,239	100.0%

The Chinese white goods manufacturing industry has benefited from the ongoing trend of multinational firms shifting production to developing nations in an attempt to lower costs. In a similar fashion, countries such as Brazil, India, and Mexico are also sizable producers of white goods.

3.1.2 The European scenario

The home appliance industry in Europe has a proud history in the development of innovative devices that support the lifestyles of consumers, this thanks to research and development activities.

Design for home appliances, eco-design and energy labelling have undergone a revolution in recent decades, leading to a high offering. In the Directive 92/75/EEC, the European Union has established the need to apply an energy label to the main appliances to allow a more rational use and favour saving energy and water, in addition to reducing air pollution. Moreover, in recent years, according to Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), the industry plays a substantial role in recycling each year of 3.2 million tons (about) of obsolete equipment.

It is expected that the European market will have a very moderate growth in the coming years, with a trend to faster growth in Eastern Europe. The average price in these countries is much lower than that of Western Europe, with peaks above 100€ of difference to piece. This trend acts as a strong brake on the penetration of Western Europe productions in the segments of the mass market of Eastern Europe. The market segment most affected by these dynamics is certainly that of the free-standing appliances, always more exposed to international competition than the segment of collection (built in). The free-standing equipment representing more than 80% of the market for refrigerators and washing machines, and today most of the productions in the so-called “free standing” is allocated in low- or very low cost.

In recent years, in fact, the centre of gravity of the European production is drastically migrated towards low-cost countries (LCC), thereby reducing the production quota allocated in Western European countries, namely high-cost countries (HCC) (see Figure 3.1).

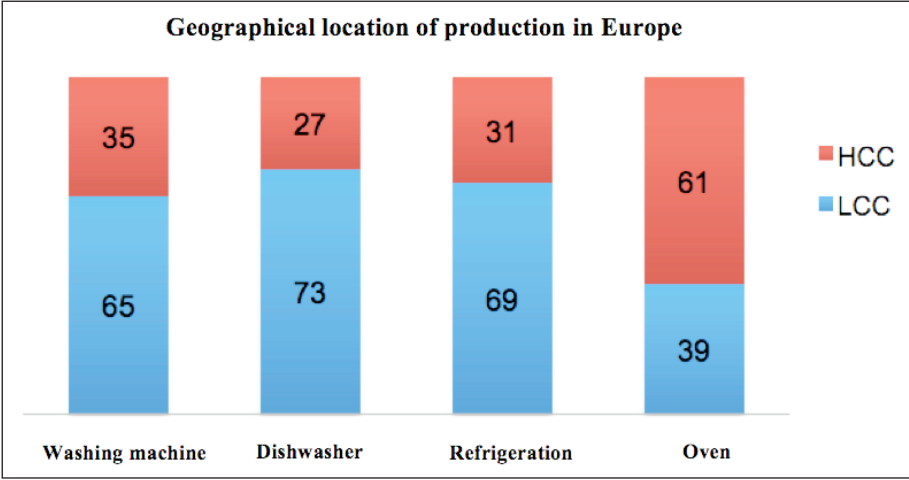


Figure 3.1 Geographical location of production in Europe

3.1.3 The Turkish scenario

The Turkish household appliances sector started production as an assembly industry in the 1950s. The first product was manufactured in 1955 and the first Turkish-made refrigerator was on the market in 1960. The Turkish household appliances industry has achieved tremendous growth since then. Having started out with companies working under licensing agreements and then passed over to know-how usage, the sector today has carved out some major success in world markets with its original design and technology. Now, the household appliances industry is one of the well-established and dynamic sectors in Turkey. The industry is mainly composed of two subsectors; namely, the white goods (durables) which dominates the sector and the small household appliances.

Since the ‘50s, excluding the crisis periods, production realized by the sector continually increased. In fact, the increase in population and living standards has resulted in the need to produce more.

With its production capacity of 25 million units and actual production of 22 million units, the white goods industry has become a significant focus of production in the last 10 years while Turkey has become the leading country in Europe in the white goods sector. Manufacturing

lines are mostly found in the Marmara, Aegean and Central Anatolian regions of Turkey with the major factories located in İstanbul, Manisa, Eskişehir, Bolu, Gebze, Bursa, İzmir, Ankara, Kocaeli, Yalova, Kayseri, Konya and Bilecik. In addition to over 50 medium-scale manufacturing companies and the major producers in the market, there are also around 1,000 supplier companies of parts and components. About 152 of these supplier firms are organized under the “White Goods Parts Suppliers Association of Turkey - BEYSAD” while six major producers are the members of the “White Goods Industrialists Association of Turkey - TURKBESD”. Furthermore, another association called “Small Domestic Appliances Industrialists Association - KESID” has been established in the household appliances sector. Turkish household appliances producers have created their original strong brands, leading to tight consumer-dependence in the domestic market while gaining ground in foreign markets, mainly in the EU countries. Some of the major brands in the domestic market are:

Arçelik, Beko, Altus, Grundig;; Profilo, Bosch, Siemens, Gaggenau; Hotpoint Ariston, Indesit; Vestel, Regal, Seg; Demirdöküm; Candy; Hoover, Süssler etc. © Republic of Turkey - Ministry of Economy, 2014

2 Turkish consumers, who are always after hot new products, prefer to use their own domestic household appliances although the doors of Turkey are wide-open to all world products. This is, in fact, the success of the Turkish household appliances industry which has a wide product range from refrigerators to electrical shavers, microwaves, table-top fridges etc. in various colors, dimensions and designs. Product range is wide enough to supply European markets and satisfy sophisticated European customers. The built-in appliances category is another rapidly developing product range in Turkey. Built-in products are all state-of-the-art products whose target group is the high-income class.

Products are designed for full customer satisfaction. Priorities of the end-users are taken into account in every phase of production and design. Since Turkish manufacturers give high priority to innovation and new product development, research and development activities are carried out consistently. Turkish household appliances manufacturers closely follow international and national developments in environmental issues and comply with environmental legislation and regulations. On the other hand, new generation products are now more efficient and energy-

saving, allowing a reduction in the amount of water, electricity and detergents. Noise emission is another factor taken into account in the manufacturing process. As for consumer services, end-users are well-served by the after-sales services of the appliance manufacturers. The household appliances industry follows strict legislation on after-sales services in Turkey⁽¹⁰⁾.

3.1.4 The Italian scenario

Since 2008, the Italian production of home appliances has dramatically contracted returning to the levels of 1988 (15 million pieces), compared to a peak in 2002 of 30 million units (see Figure 3.2). The crisis has affected all the major producers of large household appliances in Italy; they had to activate many defensive actions aimed at preserving the sustainability of the supply of factories and competitive equilibrium. The cost of labour, and in particular the cost of an hour worked, it is a crucial factor of competitiveness.

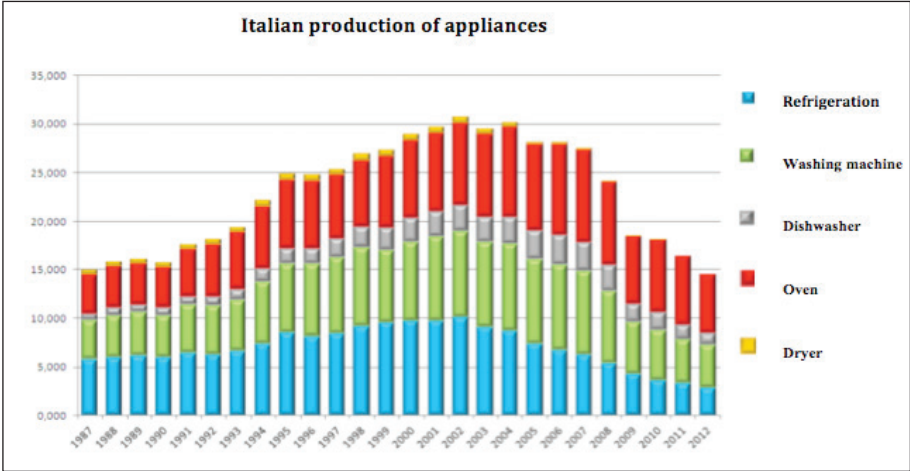


Figure 3.2 Italian production of appliances

According to the data published by the Italian Federation of electro technical and electronic appliances exported from Italy have totalled approximately 9.5 billion Euros in 2012, an increase of 1.1% over the previous year. The top five countries of destination Italian of devices are concentrated in Europe, especially in Germany, with a share of 13.9%, France (13.8%), the UK (7.6%), Russia (4.8%) and Spain (4.5%).

¹⁰ <http://www.economy.gov.tr/portal/content/conn/UCM/uuid/dDocName:EK-021141>

These five countries together account for 44.6% of the made-in-Italy appliances exports.

At the continental level, European member countries absorb 64.4% of Italian products. Other European countries have a share of 11.6%.

Asia has received 10.4% of the Italian appliances, America and Africa absorb a share of 5%, and Australia has a share of 3.5%.

3.2 Processes, technologies and main environmental issues

The paragraph 3.2 describes the main processes and technologies (paragraph 3.2.1 and paragraph 3.2.2) and associated consumption and emission levels (paragraph 3.2.3).

3.2.1. Process overview

Currently, in the worldwide scenario there isn't a traditional route that prevails on the other alternatives. As a matter of fact, the household appliances can be obtained by a lot of different processes and technologies that compete for increasing their market-share.

Materials

Household appliances are fuelled by electricity for domestic use and are commonly divided into:

- white (or large): refrigerator, washing machine, freezer, dishwasher, washer-dryer, ovens, cookers, etc.;
- countertop, kitchen bench, etc.;
- built-in appliance;
- small: blender, fryer, ice cream, etc.;
- brown (electronics): TV, video recorder, etc.

In general, household appliances are built with:

- Metallic parts and components: their manufacturing involves metal-working processes such as die-cutting, stamping and surface treatments, among others;
-

- Plastic parts and components: their manufacturing requires plastic processes such as injection moulding and extrusion;
- Printed circuit assemblies (PCA): electronic assemblies are inside household appliances and are formed by passive components, active components, embedded software, printed circuit boards (PCB) and electric components;
- Electric assemblies: some examples are cabling, fuses, switches, harnesses, etc.;
- Others: printed material, packaging material, glass, etc.;

General plant lay-out

The plant is organized in several production units, where the construction of the individual constituent parts of the appliances takes place. Subsequently, the components are assembled to one another during final assembly (see Figure 3.3).

Each production line consists in a large number of activities arranged sequentially. All lines of metal surface treatment contain more than one treatment or activity type, usually with rinsing vats in between. Some activities are waterless, such as drying, drilling, pressing, forming, bending, crimping, drilling, welding, etc.

The first activity on-site is the delivery and storage of incoming workpieces, substrates and raw materials. The workpieces or substrates are given more than one pre-treatment.

The surface must be clean from dust, swarf and moulding flash, as well as being corrosion- and grease- free to ensure uniform application and permanent adhesion of the surface treatment. Many workpieces or substrates are oiled to prevent corrosion in transit or from a previous operation such as pressing. Usually (but not necessarily) the workpieces will need to be totally smooth to produce a high quality finish.

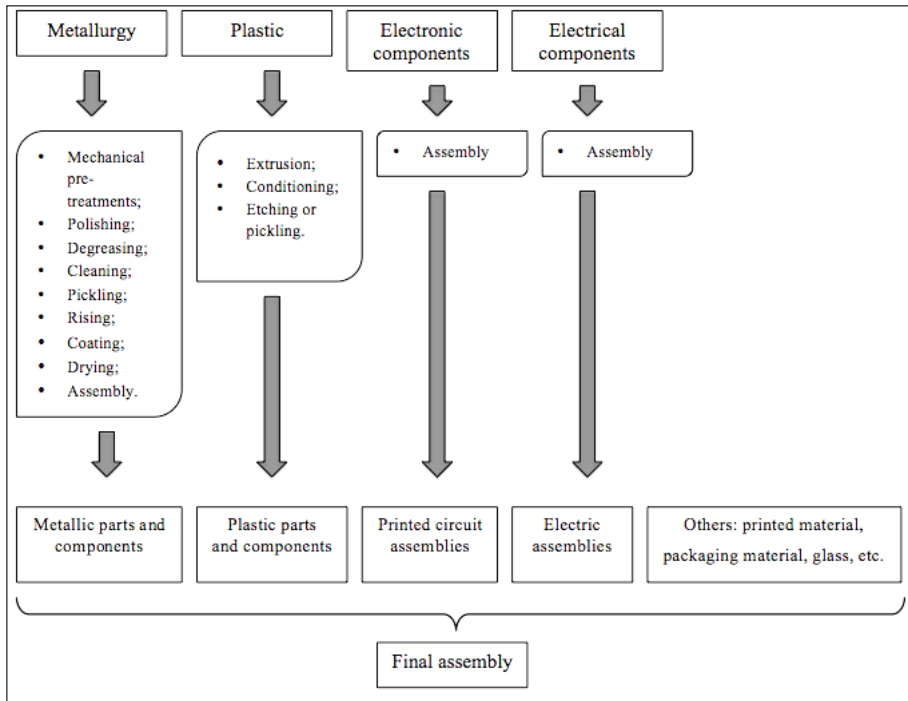


Figure 3.3 Household appliances production methods

Pre-treatment

The pre-treatment steps not only remove greases and oil, but also remove oxides and provide chemically active surfaces for the subsequent treatment.

The pre-treatments can be summarized as follows:

• Mechanical pre-treatments

- i. “Pressing” is used for forming and cutting material, a machine press is a tool used to work metal by changing its shape and internal structure;
- ii. “Bending” is a typical operation performed to the material and forcing it to change shape. A press brake is a typical machine for this operation;
- iii. “Drawing” is a metal-forming operation in which a piece of metal is pulled through a die in order to reduce the cross-section;

- iv. “Stamping” is a manufacturing method that can encompass punching, coining, bending and several ways of modifying the metal, combined with an automatic feeding system;
 - v. “Mechanical polishing” produces an amorphous surface under the influence of pressure and high local temperatures. Individual components are finished using abrasive belts, and then polished with an abrasive paste applied on fabric mops, which removes fine marks and gives a highly polished finish;
 - vi. “Abrasive blasting” traditionally uses sand or grit, but may use softer, finer abrasives such as ground nut shells;
 - vii. In the “deburring and/or tumbling” step, the workpieces are mixed with abrasive stones and tumbled or vibrated for up to several hours.
- Electrolytic and chemical polishing are selective dissolution processes where the high points of the rough surface are dissolved faster than the depressions. Electropolishing removes a fine surface layer electrolytically, and is often used in cases where very smooth and bright finishes are needed. In electropolishing, the workpiece (anode) is immersed in electrolyte and electric current (usually direct current) is connected between the workpiece and the cathode. The workpiece becomes polarised and metal ions start to diffuse to the cathode, and metal is removed from the anode. The reaction can be controlled by adjusting bath and process parameters and by choosing the metal or alloy being electropolished. In these electropolishing processes, different electrolytes are used. Electrolytes are usually mixtures of various acids (sulphuric acid, chromic acid, citric acid, and/or phosphoric acid) and sometimes organic compounds (such as glycerine or diethyleneglycolmonobutylether) are added.
 - Solvent degreasing is usually by means of chlorinated hydrocarbons (CHC), alcohols, terpenes, ketones, mineral spirits or hydrocarbons. CHCs are used because of their good cleaning efficiency and universal applicability, as well as their quick drying and incombustibility, but their use is restricted by environmental and health legislation. The degreasing removes oils, greases, soaps, dirt particles, sanding residues, substances and other contaminants. It is carried out at a temperature of about 50÷60°C using aqueous, alkaline cleaning

agents that may also contain phosphates and surfactants. Phosphating follows, creating a substructure for corrosion protection and adhesion stability of the paint system. A phosphate layer with a thickness of about 1.5 μm is achieved by spraying or by immersion with a water-based solution. It may contain other metals, e.g. widely used tri-metal systems containing zinc, manganese and nickel, as well as calcium, phosphoric acid and oxidants, e.g. nitrite, nitrate, chlorate, hydrogen peroxide, hydroxylamine salt as an accelerator. After another rinsing process, the phosphating layer may be additionally passivated (such as with Cr(VI) or Cr(III) solution). Further rinsing is carried out, finishing with demineralised water. The phosphated body is usually dried, at a temperature of 50÷60 °C, and is immediately transferred to the electrocoating zone.

- Aqueous cleaning is usually a combination of soak and electrolytic activities; the solutions are usually based on sodium hydroxide, phosphate or polyphosphates. Wetting and complexing agents are also added.
- Pickling and descaling are chemical metal-stripping procedures used to brighten and/or remove oxides from the degreased metallic surface prior to other surface treatment processes. In order to remove strong oxide layers effectively, specified acid concentrations, temperature and pickling times must be adhered to. Hydrochloric or sulphuric acids are normally used. In special cases nitric, hydrofluoric or phosphoric acid, or mixtures of acids are used. Solutions containing fluorides are necessary for reliably pickling certain alloys.
- Electrolytically assisted pickling enhances the action of pickling by making the substrate anodic. The non-electrolytic pickling of metals is often followed by electrolytic activation to remove the remains of unwanted residues from the surface, such as oil and dirt, which remain trapped in the micro-roughness of the substrate surface. These are removed by the formation by electrolysis of H_2 at the surface of the cathode and O_2 gas at the surface of the anode. Wetting agents are omitted to prevent foaming; however, cyanides or other complexing agents may be added to improve the activation of steel items. For normal applications, cyanide- and chelating agent-free electrolytes are sufficient.

- Rinsing is usually carried out between processes steps, be they pre-treatments and/or core processing steps.

Coating

The common treatments for coating activities are electroplating and oiling.

The materials commonly used for electroplating steel strip because of their special characteristics are: tin, chromium, zinc, copper and lead.

A wet film of oil is applied to the surface by spray, by wringer rolls or by an electrostatic oiler, for improving protection against white rust corrosion and to facilitate selection and to aid in subsequent lacquering and printing operations.

After all wet processing operations have been completed, the workpieces or substrates need to be quickly and effectively dried in order to avoid staining and corrosion.

The simplest method of drying is by immersing the components in hot water for a few seconds and then allowing them to dry-off in the air. Instead, drying in automated jig plants is most easily accomplished on automatic lines using hot air.

Assembly

In assembling phase all components of metal, plastic and electronic, be they manufacturing internal or external sources, are assembled together to obtain the final product. Assembly lines have been elaborately refined by automatic control systems and transfer machines, which have replaced many manual operations.

The apparatus is packaged and shipped to the warehouse, until you reach the end user through the various distribution channels.

Treatment of plastics

The plastic extrusion process involves melting plastic material, forcing it into a die to shape it into a continuous profile, and then cutting it to length.

Conditioning of plastics provides wet ability of the surface as a prerequisite for subsequent covering and good adhesion of metal layers. The process solution contains sulphuric acid or sodium hydroxide and carbonate, water soluble organic biodegradable solvents (alcohol, glycol derivatives).

Etching or pickling of plastic: it is carried out in an aqueous mixture of chromic acid, sulphuric acid and wetting agent. It is applied to ABS (Acrylonitrile Butadiene Styrene)-type plastic surfaces to oxidise and dissolve the butadiene component, thus generating a micro-rough surface.

3.2.2 Overview of the emerging techniques

An emerging technique is understood in this textbook as a novel technique that has not yet been applied in any industrial sector on a commercial basis. This section contains those techniques that may appear in the near future and that may be applicable to the household appliances production.

Process-integrated automated plating

The process is aimed at integrating the electroplating processes into the production in order to minimise the process costs and environmental impacts.

The technology is particularly suited to uniform cylindrical workpieces manufactured in large numbers. The anode is then shaped to fit around the workpiece (the cathode), leaving a very small space between the cathode and the anode and creating an extremely high field intensity. During plating, the anode is spun rapidly, which creates turbulence in the electrolyte, this increasing mass-transfer rate.

The combination of these two factors allows the electroplating to proceed rapidly, permitting the process to be integrated into a production line.

An automatic sealed system delivers the electrolyte and removes it when it becomes exhausted. A separate central processing system for returned electrolytes keeps the production line waste and wastewater free. Automation of the process means that staff are not exposed to any chemicals.

Advantages of this process are:

- a) waste - and wastewater - free plating on the process line;
- b) no production steps with a pollution load, such as degreasing and pickling.

Substitution by trivalent chromium plating for hexavalent chromium in hard chromium applications using modified pulse current

The process uses a simplified trivalent chromium electroplating solution based on chromium sulphate. The current waveform is proprietary (patents pending) and includes pulse-reverse current. Chromium has been deposited at up to 250 μm successfully and could be deposited to any thickness. Hardness, rate of deposition and post-finishing for thick coatings are the same as for hexavalent chromium solutions. Colour for thin layers is the same (chrome-blue) as from hexavalent chromium. The process retains the advantages of Cr III solutions, such as lower concentrations, higher current efficiency and tolerance to sulphate and chloride dragged-in from any previous nickel plating stages. Lack of organic additives will reduce or eliminate solution maintenance with activated carbon.

The process replaces hexavalent chromium solutions, this reducing waste gas and wastewater treatments. Solution concentrations are up to ten times lower than Cr (VI) solutions.

Aluminium and aluminium alloy plating from organic electrolytes

The possibility of production scale plating of aluminium onto steel is attractive because of the high corrosion protection that such a system offers. It would also enable substitution for more toxic metals such as cadmium, zinc and nickel, as well as chromium used in passivation of zinc, etc.

However it is not possible to electroplate pure aluminium onto steel workpieces from an aqueous solution, due to the negative potential of -1.7 V for aluminium in the electromotive series of elements.

A technology electroplating from non- aqueous solvents has been applied for many years on laboratory and pilot scales. In recent years it has been developed in Germany for the first time on an industrial scale

for plating with aluminium or aluminium-magnesium alloys. This has shown the technology to be feasible economically.

After a conventional pre-treatment (degreasing, pickling) the workpieces are dried in a bath with high boiling esters. Because of the high reactivity of the electrolytes with air and water the processing step must take place in a totally enclosed plant. The jigs are placed in the processing vat via an air-lock.

Achieved environmental benefits are:

- substitution by aluminium for more toxic metals such as cadmium, zinc and nickel;
- there is no drag out of electrolyte, rinsing or any subsequent waste water and waste.

3.2.3 Main environmental issues

The main environmental issues arising from the surface treatment of metals relate to energy and water consumption, air emissions, consumption of raw materials, emissions to surface - and ground-water, production of solid and liquid wastes.

Air emissions

Airborne emissions include gases, vapours, mists and particulates. The main sources include pickling, stripping baths, drying, electrolytic degreasing baths, painting, individual treatment processes, as well as some drag-out and rinsing processes (especially where the rinses are heated and/or sprayed). Particulates can derive from mechanical processes such as finishing and polishing, or form from some mists containing chemicals where water vaporises from the droplets leaving airborne chemical particulates. Harmful substances emitted to air are gases from relevant processes, as aerosols loaded with caustic, acids or other chemicals (e.g. caustic soda solution, sulphuric acid, chromium (VI) compounds, cyanide) and as NO_x, HF, HCl.

In the serial varnishing, the group of the volatile organic compounds (VOC) represents the most relevant emission source. They are generated essentially during the application of paint and during the paint drying process. VOC can also originate from the usage of solvents for paint

dilution, for tool cleaning, etc. In the cathodic immersion for the first coating, VOC emissions are generally extracted and eliminated by means of the exhaust gas cleaning installation downstream of the drying installations. In addition to the VOC, during the painting phase alkaline aerosols, NO_x , PM and dusts associated with the metals.

The emissions to air from the assembling phase consist of VOC, PM and welding fumes, as CO_x , NO_x , O_3 and dust.

Wastewater

The main emissions from aqueous degreasing processes are rising waters, separated oil and used degreasing solutions. Important factors for the consumption of chemicals and the generation of wastewater are the degree of pollution of the workpieces, the service lifetime of the degreasing solution and the recycling of rinsing water concentrates into the degreasing tank.

Rinsing waters and used degreasing baths are usually disposed of together through a wastewater treatment system.

Much of the waste produced from process activities is likely to be classified as hazardous. Liquid wastes are spent process solutions that may be stored and disposed of, sent for specialist recycling or recovery or disposed of as hazardous wastes. Solid wastes (dewatering and drying sludges) derive from wastewater treatment and process solutions treatment. Metals (as soluble salts) may be recovered from both solid and liquid wastes. Other wastes include cyanides, surfactants, complexing agents, acids, alkalis and their salts.

The waste produced by consists of special waste, including:

- waste from washing and mechanical processing;
- waste from degreasing operations (as Chemical Surf High Concern (CHCs), that are potentially carcinogenic materials);
- waste from painting operations, waste paint and varnish hardened;
- swarf of ferrous metals and plastics;
- waste from maintenance, cleaning and replacement poly phenylene ether (PPE).

The activities predominantly, such as chemical and electrolytic activities, use aqueous solutions as the medium, therefore the management of water, its pathways and targets are central themes. Process waters are often treated in on-site wastewater treatment plants. The discharge is then usually to municipal wastewater treatment plants, or if the effluent is treated to a suitable standard, directly to surface waters.

The impacts may be due to poor management and maintenance, or lack of investment. Poor housekeeping or accidents in handling and storing solutions, including the failure of storage containers and process tanks, cause acute polluting discharges to surface waters, as well as both chronic and acute pollution events affecting ground waters and soils.

Water usage is also an important issue. The largest proportion of water intake is used in rinsing between process stages to prevent contamination of the next process. In some sites, significant amounts of water are used in cooling.

There may be, also insignificant amounts of water in wastes, compared to those just seen, as some losses in evaporation from drying components, hot solutions in open tanks and from some recovery processes.

Wastewater is contaminated by used reagents and the breakdown products from the processes. The main ingredients of concern are metal ions (cations), which are conservative and toxic anions such as cyanide or chromate.

Waste and by-products

The wastes, hazardous and non-hazardous, must be taken in suitable containers and placed in temporary storage areas, and should be classified.

Dusts are generated from finishing and polishing and they are usually a mixture of particles of abrasives with the abraded substrate. They must be controlled for the law limits on health, safety and environmental impacts, when are extracted in the outside environment. The collected dusts require disposal as wastes, and may be hazardous.

Abrasive blasting creates solid wastes; with non-ferrous metals, these wastes (a mixture of abrasives and abraded material from the metals) may be hazardous.

Energy consumption

Electricity is consumed in electrolytic and other electrochemical reactions (inter alia, electroplating and anodic oxidation). Electricity is also used to operate the process plant and equipment such as pumps, transporter equipment, other motors and compressors. It may also be used for supplementary vat heating (by immersion heaters) as well as heating and lighting of the installations.

Energy is lost, too, as heat when electric current is passed through the treatment solutions: some chemical processes are less energy efficient than others.

Energy is also consumed with raising the temperature of the process baths, for drying components and for other heating activities. Losses occur from evaporation and as radiant heat from equipment. Energy is also used in drying workpieces or substrate and in extracting process fumes.

Cooling can consume significant amounts of water in open flow or some cooling towers, and electricity is consumed by sealed refrigerating systems.

Other issues

Noise: surface treatment is not a major noise emitting industry. However, some activities and associated activities do generate significant noise, such as linishing, polishing, abrasive blasting, deburring and tumbling. These can be as peaks, such as unloading of metal components in stillages, or continuous noise from finishing and polishing or fans and motors sited externally.

Odour: can be associated with some activities, particularly acid fumes and especially when stripping metal layers. The impact will depend on the type and size of activity carried out, the design and operation of any extraction system (e.g. chimney height) and the proximity of receptors, such as housing.

Monitoring

See in the Chapter 6 a general view of the basic principles on monitoring (emissions, process, and impact).

3.3 The Best Available Techniques (BAT)

It is known that in household appliances industry the surface treatments result to be the most critical under an environmental point of view. Consequently, are mainly applied to this sector. The JRC Reference Documents (BREFs) entitled ‘Surface Treatment of Metals and Plastics (STM)’ (2006) and ‘Surface Treatment Using Organic Solvents (STS)’ (2007) reflect an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive).

BAT is to:

- Minimize the energy consumption in the selection and operation of painting, drying/curing and associated waste gas abatement systems;
- Minimize solvent emissions, as well as energy and raw material consumptions, by selecting a paint and drier system;
- Establish and implement plans for existing plants to reduce consumptions and emissions;
- Reduce material consumptions by using high efficiency application techniques;
- Use other paint systems to replace paints based on halogenated solvents.

A. General BAT conclusions

Environmental management system

An environmental management system is a technique allowing operators of installations to address environmental issues in a systematic and demonstrable way. An EMS can take the form of a standardized or non-standardized (‘customized’) system. Implementation and adherence to an internationally accepted standardized system such as EN ISO 14001:2004 can give higher credibility to the EMS, but non-standardized systems can, in principle, be equally effective provided that they are properly designed and implemented.

1. BATs are finalized to implement and adhere to an environmental management system (EMS) that incorporates the following features:

- definition of an environmental policy that includes continuous improvement for the installation;
- planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment;
- implementation of the procedures paying particular attention to: structure and responsibility; training, awareness and competence; communication; employee involvement; documentation; efficient process control; maintenance programmes; emergency preparedness and response; safeguarding compliance with environmental legislation;
- checking performance and taking corrective action, paying particular attention to: monitoring and measurement; corrective and preventive action; maintenance of records; independent internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;
- following the development of cleaner technologies;
- consideration for the environmental impacts from a possible decommissioning, during the design phase of a new technical unit and throughout its operating life;
- periodic application of sectoral benchmarking.

The scope (e.g. level of details) and nature of the EMS (e.g. standardized or non- standardized) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Energy management

2. BAT is to optimise artificial lighting systems, to improve energy efficiency, by using the techniques such as:

- Selection of fixtures and lamps according to specific requirements for the intended use;
- Use of lighting management control systems including occupancy sensors, timers, etc.;
- Identify illumination requirements in terms of both intensity and spectral content required for the intended task.

3. BAT is to optimise heating, ventilation and air conditioning systems, to improve energy efficiency, by using techniques such as:

- Management of airflow, including considering dual flow ventilation;
- Air system design:
 - i. ducts are of a sufficient size ;
 - ii. circular ducts;
 - iii. avoid long runs and obstacles such as bends, narrow sections.
- Use automatic control systems and integrate with centralised technical management systems;
- Improve the efficiency of heating systems through:
 - i. recovery or use of wasted heat;
 - ii. heat pumps;
 - iii. local heating systems coupled with reduced temperature set points in the non-occupied areas of the buildings.
- Stop or reduce ventilation where possible;
- Ensure system is airtight and check joints;
- Optimising of air filtering:
 - i. recycling efficiency;
 - ii. pressure loss;
 - iii. regular filter cleaning/replacement;
 - iv. regular cleaning of system.

4. BAT is to reduce heating losses by:

- seeking opportunities for heat recovery;
- reducing the amount of air extracted across the heated solutions.

Where there is a temperature range for a process, the temperature can be controlled to minimise the energy input:

- i. operating temperature of process solutions that require heating may be reduced;
- ii. processes that require cooling may be operated at temperatures not too low.

Heated process tanks can be insulated to reduce heating losses by:

- i. using double skinned tanks;
 - ii. using pre-insulated tanks;
 - iii. applying insulation.
- optimising the process solution composition and working temperature range;
 - insulating heated solution tanks by one or more of the following techniques:
 - i. using double skinned tanks;
 - ii. using pre-insulated tanks;
 - iii. applying insulation.
 - insulating the surface of heated tanks by using floating insulation sections such as spheres or hexagonals.

5. BAT is to:

- prevent over-cooling by optimising the process solution composition and working temperature range;
- use closed refrigerated cooling system, for new or replacement cooling systems;
- remove excess energy from process solutions by evaporation where:
 - i. there is a need to reduce the solution volume for make-up chemicals;

- ii. installing an evaporator system instead of a cooling system, in which the energy requirement is less.

6. BAT is to design, locate and maintain open cooling systems to prevent the formation and transmission of legionella.

Material management

7. BAT is to minimise water usage by:

- monitoring all points of water and materials usage in an installation, record the information on a regular basis, according to the usage and the control information required. When optimum water usage is established, flow can be maintained at an optimum usage rate level by a variety of measures controlled by an authorised person, such as:
 - i. flow valves - it is good practice to use locking valves;
 - ii. conductivity, pH temperature or other process control measurements.

The information is used for benchmarking and the environmental management system.

- recovering water from rinsing solutions by one of the following techniques:
 - i. filtration;
 - ii. deionisation/demineralisation;
 - iii. reverse osmosis;
 - iv. ion exchange;
 - v. absorption techniques;
 - vi. electrolysis;

and re-use in a process suitable for the quality of the water recovered.

- avoiding the need for rinsing between activities by using compatible chemicals in sequential activities.

Air emissions management

8. BAT is to restrict the use of open topped tanks by:

- a) not allowing direct venting or discharges to air by linking all the

vents to suitable abatement systems when storing materials that can generate emissions to the air (e.g. odours, dust, VOCs);

- b) keeping the waste or raw materials under cover or in waterproof packaging.

9. BAT is to use an enclosed system with extraction, or under depression, to a suitable abatement plant. This technique is especially relevant to processes, which involve the transfer of volatile liquids.

10. BAT is to correctly operate and maintain the abatement equipment.

11. BAT is to have a scrubber system in place for the major inorganic gaseous releases from those unit operations, which have a point discharge for process emissions. Install a secondary scrubber unit to certain pre-treatment systems if the discharge is incompatible, or too concentrated for the main scrubbers.

12. BAT is to have procedures leakage detection and consequently implement the repair.

13. BAT is widespread practice to minimise the amount of humid and/or corrosive fumes. This not only protects employee health, but also:

- protects workpieces or substrates in storage or in the various stages of processing;
- protects the installation infrastructure;
- protects control systems in process control and other sensitive equipment.

14. BAT is to reduce pollutant emissions from sources by using the following measures:

- air agitation of process solutions can be replaced with other methods such as:
 - i. circulating the process solution by pumping;
 - ii. mechanisms to move the jigs.
- baths not in constant use can be kept covered;
- additives can be used to suppress aerosol formation, such as for chromium plating.

15. BAT for waste gas treatments by using the following cleaning systems:

- droplet separators which use a fill material to condense aerosols and droplets. Condensate is usually treated in a wastewater treatment plant;
- exhaust air wet scrubbers.

Water or specific chemical solutions are sprayed into the wet scrubbers usually (but not always) countercurrent to the gas flow.

16. BAT for separated the pollutants emitted to achieve emission standards are used the following exhaust air cleaning devices (see Table 3.2):

- exhaust air scrubbers with fill materials and droplet separators exhaust air scrubbers;
- mist filters used for aerosols and droplets;
- droplet separators for aerosols and droplets, which may be followed by filters;
- cyclones, electrostatic precipitators or filters.

Table 3.2 Devices to reduce emissions

<i>Emissions</i>	<i>BAT to reduce emissions</i>
Sulphur oxide (SO _x)	Countercurrent packed tower with alkali scrubber
Oxides of nitrogen (NO _x)	Scrubbers or adsorption towers
Particulate matter	Wet scrubber, Cyclone, Filter
Ni and its compounds as nickel	Extraction and condense in heat exchanger Water or alkali scrubber, Filter
Cr (VI) and compounds as chromium	Separator, scrubbers or adsorption tower
Hydrogen fluoride	Alkali scrubber
Hydrogen chloride	Water scrubber
Hydrogen cyanide	Non-air agitation
Zinc	Water scrubber

Water and wastewater management

17. BAT is to minimise all water usage in all processes, however, there are local situations where the reduction of water usage may be limited by increasing concentration(s) of anions that are difficult to treat. BAT is to minimise water usage by:

- monitoring all points of water and materials usage in an installation, record the information on a regular basis, according to the usage and the control information required. The information is used for benchmarking and the environmental management system;
- recovering water from rinsing solutions by one of the techniques and re-use in a process suitable for the quality of the water recovered.

Treatment options include:

- i. filtration;
 - ii. deionisation/demineralisation;
 - iii. reverse osmosis;
 - iv. ion exchange;
 - v. electrolysis–oxidation.
- avoiding the need for rinsing between activities by using compatible chemicals in sequential activities.

18. BAT is to monitor and discharge waste water. Discharge may be:

- continuous with:
 - i. continuous online monitoring for key parameters such as pH;
 - ii. frequent manual checking of key parameters, such as pH, metals, cyanide (as appropriate to the installation's activities) ;
 - iii. a combination of both.
- batch discharge with prior checking for key parameters such as pH, metals, cyanide.

19. BAT is when changing types or sources of chemical solutions and prior to their use in production to test for their impact on the existing waste water treatment systems. If the test indicates a potential problem either:

- reject the solution, or
- change the waste water treatment system to deal with the problem.

They are usually either surfactants that interfere with flocculation and/or settlement processes, or complexing agents that prevent metals precipitating.

20. BAT is for new lines or upgrades to reduce drag-in of surplus water from prior rinsing by using an eco-rinse (or pre-dip) tank (see figure 3.4). Build-up of particulates can be controlled to the required quality level by filtering.

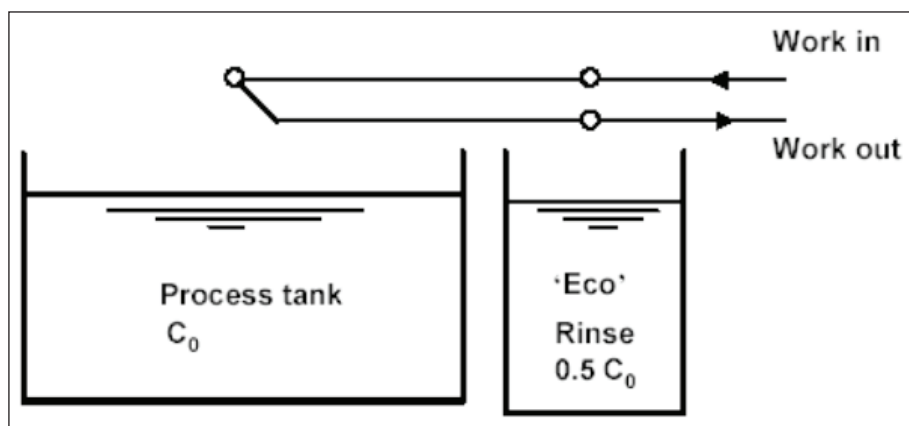


Figure 3.4 Drag-out recovery through eco-rinse

This also assists drag-out reduction, in conjunction with other drag-out and rinsing techniques. A static rinse tank that is used prior to the plating tank and again after the plating tank. It has the effect of reducing drag-out (50% of saving about). Some drag-out from process solutions working at ambient temperature can be recovered through a single rinse station in which the workload is dipped before and after being processed. The eco rinse station (or pre-dip) can be made up with diluted process solution from the very beginning or filled with deionised water only. In

this case it will take some time until the final equilibrium concentration of $0.5 C_0$ (50%) will be reached. The solution only has to be changed when the tank itself and/or the tank walls have to be cleaned. During normal operation, no water has to be added assuming that drag-in is equivalent to drag-out. Drag-out recovery rate (jig and barrel plating) is approximately 50%.

Eco-rinse (pre-dip) cannot be used:

- where problems are caused with subsequent processes (such as partial chemical pre-plating);
- in carousel, coil coating or reel-to-reel lines;
- with etching or degreasing;
- in nickel lines because of increased quality problems;
- in anodising, as material is removed from the substrate (not added).

A reduction of drag-out is an effective primary measure for:

- minimising losses of chemicals in rinses;
- reducing the amount of rinsing required;
- reducing raw material costs;
- reducing quality and maintenance problems with subsequent processes;
- reducing environmental problems associated with rinsing waters.

21. BAT is to reduce the water use and the contamination of water by:

- applying site waterproofing and storage retention methods;
- carrying out regular checks of the tanks and pits especially when they are underground;
- applying separated water drainage according to the pollution load;
- applying a security collection basin;

- performing regular water audits, with the aim of reducing water consumption and preventing water contamination;
- segregating process water from rainwater.

22. BAT is to have a full concrete base in the whole treatment area that falls to internal site drainage systems, which lead to storage tanks or to interceptors that can collect rainwater and any spillage.

23. BAT is to collect the rainwater in a special basin treatment if contaminated and further use.

Waste and by products management

24. BAT for waste minimisation and for materials recovery and waste management. BAT is:

- prevention;
- reduction;
- re-use, recycling and recovery.

Of these, the prevention and reduction of all material losses is the priority. The loss of both metals and non-metallic components together can be prevented or significantly reduced by using BAT in the production processes.

Metals in the sludge may be recovered off-site.

Increasing drag-out recovery and closing the loop require techniques to:

- reduce drag-out;
- reduce rinse-water (such as by cascade rinsing and/or sprays) with drag-out recovery;
- concentrate the returning drag-out or receiving solutions, such as by ion exchange; membrane techniques, or evaporation. The water removed during concentration (such as from evaporation) can often be recycled back into the rinse;

Examples of techniques for this purpose are, for example:

- addition of an eco-rinse tank;

- evaporation using surplus internal energy;
- evaporation using additional energy (and in some cases, low pressure);
- electrodialysis;
- reverse osmosis.

25. BAT is to prevent the loss of materials through overdosing. This is achieved by:

- monitoring the concentration of process chemicals;
- recording and benchmarking usage;
- reporting deviations from benchmarks to the responsible person and making adjustments as required to keep the solution within optimum limit values. This is most consistently achieved by using analytical control and automated dosing.

26. BAT is to recover the metal as anode material using the techniques, as:

- Electrolytic recovery;
- Ion exchange;
- Chromating;
- Precipitation;

and in combination with drag-out recovery. This can greatly assist with reducing water usage and recovery of water for further rinse stages.

27. BAT is to close the materials loop for process chemicals can be achieved by applying a suitable combination of techniques such as: cascade rinsing, ion exchange, membrane techniques, evaporation.

Closed loop is not zero discharge: there may be small discharges from the treatment processes applied to the process solution and process water circuits (such as from ion exchange regeneration). It may not be possible to keep the loop closed during maintenance periods. Wastes and exhaust gases/vapours will also be produced. There may also be discharges from other parts of the process line.

Closing the loop achieves a high raw material utilisation rate and in particular can:

- reduce the use (and therefore cost) of raw materials and water;
- as a point-source treatment technique, achieve low emission limit values;
- reduce the need for end-of-pipe wastewater treatment;
- reduce overall energy usage when used in conjunction with evaporation to replace cooling systems;
- reduce the use of chemicals for treating the recovered materials that would otherwise be discharged in the wastewater;
- reduce the loss of conservative materials such as perfluorooctane sulfuric acid where used.

28. BAT is to keep a monitoring inventory of the waste on-site by using records of the amount of wastes received on-site and records of the wastes processed.

29. BAT is to re-use the waste from one activity/treatment possibly as a feedstock for another.

30. BAT is to identify, separate and treat flows that are known to be problematic when combined with other flows such as: oils and greases, cyanide, nitrite, chromates (CrVI), complexing agents, cadmium.

31. BAT is to eliminate or minimise the use and loss of materials, particularly priority substances. Substitutes for and/or control of certain hazardous substances.

Monitoring management

Monitoring should be done according to the relevant EN or ISO standards, if these are not available, national or other international standards should be used.

32. BAT is to measure or assess all relevant parameters to steer the processes by means of modern computer-based systems in order to adjust continuously and to optimise the processes online, to ensure stable and smooth processing, thus increasing energy efficiency and maximising the yield and improving maintenance practices.

33. BAT is to measure the air emissions of pollutants (NO_x, VOC, PM and welding fumes) from the main emission sources.

For monitoring the discharge of wastewater there are standardised procedures for sampling and analysing water and waste water, such as:

- a random sample;
- a composite sample taken continuously over a given period, or a sample consisting of several samples taken either continuously or discontinuously over a given period and blended;
- a qualified random sample shall refer to a composite sample of at least five random samples taken over a maximum period of two hours at intervals of no less than two minutes, and blended.

34. BAT is to determine the order of magnitude of diffuse emissions from relevant sources.

Noise management

35. BAT is to identify significant noise sources and potential targets in the local community.

36. BAT is to reduce noise where impacts will be significant by using appropriate control measures, such as:

- effective plant operation, for example:
 - i. closure of bay doors;
 - ii. minimising deliveries and adjusting delivery times.
- engineered controls such as installation of silencers to large fans, use of acoustic enclosures where practicable for equipment with high or tonal noise levels, etc.

Decommissioning management

37. BAT is to prevent pollution upon decommissioning.

Design considerations for end-of-life plant decommissioning:

- III. giving consideration to the environmental impact from the eventual decommissioning of the installation at the stage of designing a new plant, as forethought makes decommissioning easier, cleaner and cheaper;
- IV. decommissioning poses environmental risks for the contamination of land (and groundwater) and generates large quantities of solid waste; preventive techniques are:
 - i. avoiding underground structures;
 - ii. incorporating features that facilitate dismantling;
 - iii. choosing surface finishes that are easily decontaminated;
 - iv. using an equipment configuration that minimises trapped chemicals and facilitates drain-down or cleaning;
 - v. designing flexible, self-contained units that enable phased closure;
 - vi. using biodegradable and recyclable materials where possible.

B. BAT conclusions for sheet metal processing

Degreasing

1. BAT is to liaise with the customer or operator of the previous process to:

- minimise the amount of oil or grease;
- select oils, greases or systems that allow the use of the most environmentally friendly-degreasing systems.

2. BAT is where there is excessive oil, to use physical methods to remove the oil, such as centrifuge or air knife.

3. BAT is for reduction of oil and grease applied in the mechanical production areas are included:

- no use of volatile lubricants;
- employment of minimal quantity cool lubrication;
- dripping off and/or centrifuging the workpieces;
- pre-cleaning the workpieces at the point of production;
- shortening the storage time;
- drilling with compressed air cooling;
- use of applied plastic film lubricants in pressing.

4. BAT is to replace cyanide degreasing with other technique(s); but where cyanide solutions have to be used, it is BAT to use closed loop technology with the cyanide processes.

5. BAT is to replace solvent degreasing by other techniques, as treatments to water-based. There may be local reasons at an installation level for using solvent- based systems, such as where:

- a water-based system can damage the surface being treated;
- there a specific quality requirement.

6. BAT is to reduce the use of chemicals and energy in aqueous degreasing systems by using long- life systems with solution regeneration and/or continuous maintenance, off-line or on-line.

Pickling

7. BAT is to extend the life of electrolytic pickling acids by using electrolysis to remove by-metals and oxidise some organic compounds.

Cleaning

8. BAT is to minimise all water usage in all processes, however, there are local situations where the reduction of water usage may be limited by increasing concentration(s) of anions that are difficult to treat.

9. BAT is to minimise water consumption in cleaning plants by recycling water as much as possible.

10. Bat is to separated cleaning solutions from other process effluents to avoid interference with the wastewater treatment plant by excess surfactants.

11. BAT is to treat the effluent water from cleaning plants where rinsing water is used, by using a combination of the following techniques:

- precipitation;
- neutralisation;
- sand filtration to remove residual particulate material;
- activated carbon bed to remove organic material;
- chelating, crown or thiol cation exchange resin bed to selectively remove multivalent ions.

12. BAT is to identify, separate and treat flows that are known to be problematic when combined with other flows such as:

- oils and greases;
- cyanide ;
- nitrite;
- chromates (CrVI);
- complexing agents;
- cadmium.

13. BAT is to extraction fume from the cleaning place for remove water vapour and alkaline or acid fumes.

14. BAT is to conserve raw materials and reduce solvent emissions by minimising colour changes and cleaning, by:

- automated mixing systems;
- re-use of returned inks or coatings;
- re-use of recovered inks or coatings;
- direct piping of inks or coatings from storage;
- direct piping of solvents from storage;
- batch painting/colour grouping.

15. BAT is to minimise the release of solvent, when cleaning spray guns, by collecting, storing and reclaiming for re-use the purge solvent used to clean coating spray guns and/or lines: 80 to 90 % can be re-used.

Drying

16. BAT is to reduce the dust emissions in the waste gases from drying, by using one or a combination of the following techniques:

I. an electrostatic precipitator;

II. a bag filter;

III. a wet scrubber.

17. BAT is to reduce NO_x and VOC emissions from the drying by applying process-integrated techniques, such as lowering the temperature.

18. BAT is to increase the efficiency of treatment by using the following techniques: hot water drying, hot air, air knives.

19. BAT is to reduce energy consumption in drying plants by using the recirculation of hot air.

20. BAT is to optimise drying processes to improve energy efficiency by using techniques such:

- Use of surplus heat from other processes;
- Optimise insulation of the drying system;
- Process automation in thermal drying processes.

C. BAT conclusions for galvanic processing

1. BAT is to reduce accidental spillage by:

- providing plant floors and drainage channels for the removal of pollutants processing and conveying in special tanks;
- drafting of a procedure on handling and storing materials;
- making recognizable by colour and labelling the different pipes to prevent connection errors;
- providing ducts eavesdropping devices and isolation;
- providing the tanks of a gauge with security alarm sound or visual;
- storage in closed containers and placed on a cement or waterproof material.

2. BAT is to reduce emission of toxic vapours with the introduction of suction devices and vapour removal.

3. BAT is to extend the service life of plating baths by using of the following techniques: filtration, activated carbon treatment, crystallisation, selective electrolysis, ion exchange.

4. BAT is to reduce the emissions to air by using treating technologies, such as:

- cyclones and bag filters for particulates;
- vapour incineration, carbon adsorption for VOCs;
- wet chemical scrubbers for Acids, Alkalis, Cyanides.

5. BAT is to reuse the electroplating sludge, from the wastewater treatment, as a secondary raw material, such as, in a pyrometallurgical recycling plant.

D. BAT conclusions for painting

1. BAT is to minimise emissions by using a closed loop for the paint solids, and there is a need for periodic cleaning.
2. BAT is to minimise waste production from painting by:
 - reducing paint overspray generation by optimising transfer efficiency;
 - either dewatering paint sludge before disposal, recycling paint sludge or using the water emulsion technique, such as coagulation of paint solids in wet cleaners, decantation system in wet separation spray booths.
3. BAT for waste gases and fugitive emissions is to both:
 - reduce emissions of VOC by applying extraction and thermal, catalytic, recuperative or regenerative incineration of air from the driers;
 - reduce VOC emissions by applying the maintenance techniques: encapsulation/enclosure, air seals on the entrance and the exit of the ovens/driers, negative pressure in drying, air extraction from coating, drying and cleaning processes.
4. BAT is to reduce emissions of VOC using another technique, instead solvent paint, such as water paint and powder.
5. BAT is to reduce the metals in the water emissions by using the treating technologies, such as: precipitation, reverse osmosis, electrolysis, ion exchange, and ultrafiltration.

E. BAT conclusions for final assembling

1. BAT is for the collection and removal of dust and the maintenance of these limits, using a sleeve dust filter in the welding department.
2. BAT is to reduce noise emissions from relevant sources in the assembly process by using one or more of the following techniques:
 - implementation of a noise-reduction strategy;
 - enclosure of the noisy operations/units;
 - vibration insulation of operations/units.

3. BAT is to control the air emissions from the line assembly by closing the line, providing it with a extraction system

3.4 New forms of organizing work

3.4.1 Introduction

The white goods market has really felt the effect of the recession because of stagnation in construction industry too.

Important operations of purchase, redefinition of business area and processes re-engineering have been actualized on global and European levels. In countries in which the labour cost is higher, the difficulty of maintaining the existent productions showed itself in all its harshness.

Over the years, companies introduced the planning and production system based on platform, by adopting it from the automotive world.

The efficiency of this approach consists in the ability of sharing sub-systems and, at the same time, developing different solutions for all other elements which have to fit the requirements of different markets and individual taste of customers.

One of the implementations has been the “washing platform”, a basic structure which is common to many models of washing machine and it includes:

- a) a mechanical platform made by electro-mechanical components of the machine;
- b) an electronic platform made by electronic components (hardware boards and supervision software).

Now, the most innovation-oriented companies are implementing advanced systems which push the features of the platforms in new directions, by generating further integrations between planning and productive phases and following the inputs coming from the strong push of digitalization.

3.4.2 Lean organization

In the last decades the European companies and organisations have been increasingly studying the innovation practices HPWO (High

Performance Work Organization). In particular, the typical passwords of the “lean system” derived by Toyota got new strength in the manufacturing sector. These practices are spreading in the industrial system, generally along with the choice of streamlining structures, reducing of command line and introducing total quality systems.

The relationship between these practices and the business system of working relationships is not well known, and maybe it is also more controversial, in particular for what concerning unions and workers participations.

There are many business realities which see the lean as a bunch of techniques and methodologies aiming to increase quality and eliminate inefficiencies, but the real quality jump is realized by the ones who match these changing with a high level of organisational participation and workers involvement.

Results can be more significant and long-term only when, in addition to being directly involved in the target of changing, people are also asked to cooperate on the realization of results through some forms of organisational mandate, which gives more autonomy in addition to responsibility.

This causes an increase of the training demand which is related to management competences (team working, communication) against the more traditional technical training demand. In different realities, also the business intranet access, which has got a dedicated software for mapping ideas and projects, evaluating them and collect feedbacks, it has contributed to improve participation and workers’ ability of creating appropriate proposals. Thanks to this, in the latest times workers’ free initiatives are increasing. Before promoting the suggestion to the manager, workers usually test it by involving their co-workers.

The business target of continuously improving production, starting from the gaze of workers, it seems to have necessarily involved lots of aspects of work conditions and relations. If the initial target was facing a globalized competition, which is particularly hard in the white goods sector, by means of obtaining more efficiently products of better quality, the introduced program has strengthened a system of collaborative working relations system and workers involvement, which models business life. Technical information about processes,

production targets and market trends are widespread and precise, feedbacks about innovations and results of improvement process are periodically collected and they are evaluated and propagated through periodical presentations which consider each proposal (and even start the discussion by asking contribution on rejected suggestions).

In some companies, also the communication between single trade union representations and staff management, about both development of improvement systems and markets and employment prospects, is continuous.

Some union agreements are interesting: their target is to defend employment by dealing with courage and innovation the competitiveness problems (unnecessary costs control, better organized continuous improvement systems, schedule flexibility, internal mobility of workers).

Some slogans are significant:

“Being among the best in producing warming products of high technology and being an international company was not sufficient. We wanted to do better and more: that’s why we adopted lean principles as strategic business system, and we used them in all sectors.”

“Lean is creating and improving processes”. “Lean is increasing value”. “Lean is managing the distribution chain better”. “Lean is eliminating wastefulness.” “Lean is believing”. “Lean is always progressing”.

3.4.3 Attention to people

Spasmodic research of efficiency can lead to mechanisms which border on cynicism and don’t make one think about attention to people. Instead, there are a lot of initiatives by single plants, however inserted in corporate strategies, which consist of involving workers and their relatives into the factory life. A factory which opens the doors to territory and organises moments in order to make people socialise and create a team, it is a form of advanced welfare where working relations mix with familiar and social ones.

All of this seems to take inspiration from the proposed model of business 2.0 of the Humanistic Management against Scientific Management: it is not a new standard or an axiom, but a new type of relation.

A trend which expands to different businesses in different sectors and which demolishes a bit the prototype of a multinational corporation cut off from local contexts. Attempts of communication between work place and life/social worlds which can difficultly be connected to forms of new-paternalism, because they have to be considered as occasion of creative participation through artistic or poetical forms which are generally relished by people, especially children.

3.4.4 Networks and digital innovations

At this point, as it happens in different industrial sectors, the white goods sector too is characterized by mergers and acquisitions which reduce the number of global players. Partnerships and synergies between companies of the same industry, and also complementary sectors, are created at the same time.

There is a very interesting case which arises as a consequence of a profound analysis of the trends which identified the reduction of food wastefulness as a characteristic element of the future. By sharing experiences, the companies created an association with the will of working on the same theme, but with entry points (packaging companies, sensor science, raw material production etc.) different from the white goods sector. Consequently: the collaboration on technological themes is promoted by using everyone's abilities in order to find innovative solutions to the problem of wastefulness, everyone is looking for the right inclination of these technologies for the growth of its business, little and big companies are together in a virtuous ecosystem of transverse innovation.

Generation of "smart white goods", i.e. remotely controlled with a smart phone, tablet or pc, are quickly rising. Optimized Wi-Fi antennas have been developed for the domestic space in order to get a solid connection required for the operation of white goods. All that has promoted a new technology for transferring information between white goods and remote device (above all smart phones and tablets talking about "internet of things", IoT).

We're only at the beginning of the era of connection in the white goods sector; an integration with the food industry is considered, and it is realizable with special RFID labels (Radio Frequency Identification) which allow to mark foods and give information about expiration date,

for example, to the consumer. There will also be the possibility of remotely interacting with the oven for baking on the basis of parameters which will be included in assisted recipes downloadable on smart phones or tablets.

One of the IoT problems are the different protocols and languages, which will create different problems to the final user, because they're created by producers which don't communicate among them. Agreements between global players are underway in order to develop open software platforms for data exchange between domestic "smart" devices.

3.5 Case history: Whirlpool

3.5.1 Premise

Whirlpool is an American multinational company considered one of the main appliance manufacturers in the world, with approximately \$20 billion in annual sales, 100,000 employees and 70 manufacturing and technology research centres throughout the world. Since October 2014 The Italian Company Indesit is part of the Whirlpool Corporation Group. In addition to Indesit, Whirlpool acquired several companies, such as KitchenAid, Maytag, Consul, Brastemp, Amana, Bauknecht, Hotpoint, Jenn-Air, and other major brand names in more than 170 countries. Whirlpool Corporation's European Operations Center is located in Comerio (VA), Italy.

With specific reference to the EMEA region (Europe, Middle East & Africa Region), Whirlpool has a plant in Manisa, located Turkey's Aegean Region. The plant operates mainly in the sector of front-load washers and free-standing refrigerators.

With approximately 26,000 employees, a sales presence in more than 30 countries in Europe, Middle East and Africa and manufacturing sites in nine countries, Whirlpool EMEA is a wholly-owned subsidiary of Whirlpool Corporation.

The monitoring of KPIs on health and environmental safety is reported in the annual report on corporate sustainability, drawn directly by the U.S. main headquarters. In addition, EMEA policies are drawn up in a specific annual report on EEHS issues (Energy, Environmental, Health & Safety)

3.5.2 Emissions

According to the yearly sustainability report, the Whirlpool group has performed the following environmental targets, showing a significant decrease in the emissions during the last years:

ENVIRONMENTAL					
	2011	2012	2013	2014	2015
Energy intensity (megajoules)	215.70	208.90	200.30	194.12	161.40
Water intensity (cubic meters)	0.161	0.150	0.156	0.145	0.107
Greenhouse gas emissions intensity					
Scope 1 and 2 (metric tons) of CO ₂ eq	0.0180	0.0206	0.0170	0.0178	0.0156
Waste intensity (kilograms)	8.37	9.29	9.36	9.19	7.72

Note: Intensity numbers per major appliances
2015 data affected by acquisitions of Hiesel Sanyo and Indesit in 2014. Global goals under review to address these acquisitions.

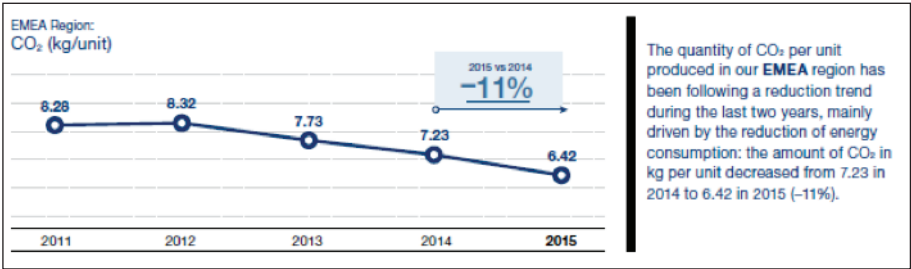
In line with these results, the company also aims to achieve specific goals in terms of environmental impact reduction, by taking into account the following items:

- Full Material Transparency: by 2020 the company will ensure 90% full material transparency on all new products
- Reduction of Energy and Water Use in Manufacturing: the use of energy and water intensity for manufacturing will be reduce by 15%
- Zero landfill waste from manufacturing by 2022 (already reached in Latina America)

The **Energy efficiency** program can count on a pilot investment in wind farms, able to produce renewable energy with zero greenhouse gas emissions. Moreover, the use of photovoltaic plants in Italy and the thermal energy generated by manufacturing processes in Poland, have achieved a significant reduction in energy consumption.

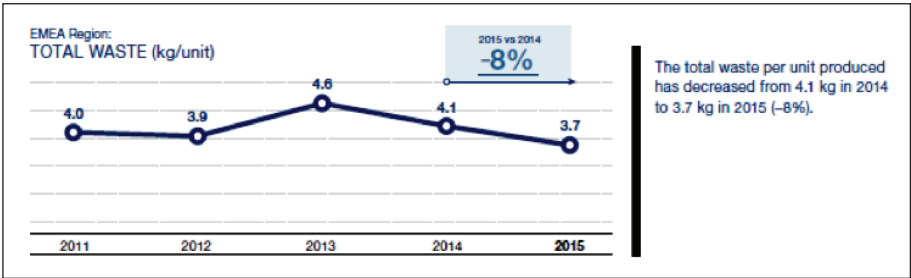
The **Water efficiency** program was increased thanks to the use of recycled and rain water (such as in Latin America). The tracking of water use in Whirlpool processes is ensured by an indicator named *Total Water* (L/unit). This indicator states the amount of total water used to produce one average appliance. According to the company sustainability report, the reduction since 2013 is -57%. The water discharge is carried out based on the local, regional and global regulations. Usually plants are also connected to public sewer systems.

The **Air quality** program is ensured through the certification SmartWay® required to all contracted carriers in order to move goods with lower emissions and less energy (currently covering almost the whole North American shipments). Moreover, the reduction of diesel fuel (by 1.3 million gallons) and total fuel consumption due to the increase in rail use, led to a significant improvement in the air quality.



Source: Whirlpool, 2015 Sustainability Report

The **Material and Wastes** management: in Brazil, through a Zero Waste to Landfill Program, the company was able to achieve a zero waste target from manufacturing and non-manufacturing activities (such as offices, cantinas and toilets). Moreover, the reuse, recover and recycle of materials is usually practiced. When not possible, the disposal of waste is carried out by ensuring the minimum environmental impact.



Source: Whirlpool, 2015 Sustainability Report

With reference to the plant located in **Manisa (Turkey)**, environmental KPIs referring to 2016 targets can be summarised as follows:

Cooling Plant Env KPI's	2013	2014	2015	2016
	Realised	Realised	Realised	Target
Total Energy kWh/pc	24.27	24.30	25.40	25.41
Waste Kg/pc	2.76	2.71	2.60	2.94
Water Lt/pc	168.8	150.0	142.0	147.0
Recycle %	91.6%	92.6%	95.8%	94.8%

Washing Machine Plant Env KPI's	2015	2016
	Realised	Target
Total Energy kWh/pc	17.80	17.04
Waste Kg/pc	3.00	3.03
Water Lt/pc	157.8	187.0
Recycle %	96.9%	95.5%

Following periodic control carried out every two years in the Manisa plant, it has been demonstrated that no parameter has violated the legal limits. Even if measurements were satisfactory, periodical cleaning and maintenance activities of the paint shops in Manisa have been performed. For example, in order to reduce the emissions, a precipitation unit has been inserted in the ventilation system located in the powder paint shop, with the aim to recycle the powder paint and minimise emissions. Another example in this regard is offered by the provision of hot water from Manisa Industrial Zone. It was no longer necessary to use boilers and this helped to eliminated the related emissions.

All types of solid wastes produced in the plant are collected by third party suppliers and recycled by licensed companies. In order to minimise the amount of the waste and to ensure a proper on site segregation, special waste collection points have been developed.

The controls on hazardous chemicals on site are performed with excel sheets. However, it is under discussion whether to develop a web- based chemical tracking and record system for the Manisa local plant. In addition Material Safety Data Sheets (MSDS) controls are performed.



As pointed out by the Manisa Responsible for the Safety and Environmental Management Systems, there is no automated control system but a special storage area for chemicals has been built. It has concrete ground, special drainages. It is completely covered with shelter and can count on a controlled entrance with interlocking system.

Also the training plays a crucial role in ensuring a better environmental safeguard. All workers are trained for around 8 hours every year on the topic of Environment, Health & Safety (EnEHS).

The Manisa plant can also count on a specific energy team established in order to reduce consumption and to increase energy efficiency.

3.5.3 Environmental remediation actions

Whirlpool has set up specific environmental remediation actions in order to achieve its target of reducing emissions by 2020.

Concerning the *main indicators of environmental monitoring*, the Whirlpool company evaluates these indicators on a monthly basis, for the whole EMEA area.

For each plant, the company monitors the following parameters:

- Total water consumption / home appliance product
- Total energy consumed / home appliance product
- Total waste / home appliance product
- % Recycling (waste amount recycled / total waste produced)

With reference to waste management, each of the 22 plants currently active has different procedures. They differ according to the type of waste, divided in macro-categories (based on the quantity):

- Mixed package
- RSU / similar to RSU
- Metal and wood scraps (pallets or containers)
- Sludge from sewage treatment plants, cleaning plants or coating

Normally there is the collection of waste, a later stage of further separation, a volumetric reduction and a subsequent transfer to an external company. In the majority of the plants, these operations are delegated to external firms.

In order to avoid the pollution of the soil, when chemical materials are in storage, the prevention measures adopted by the company involve the setting up of inventory areas conceived in order to prevent spills of substances on the ground (closed and protected areas, catch basins, sealed areas).

Specific procedures are activated in the event of accidental spillage. All these procedures refer to the ISO 14001 management system of each plant.

According to the information provided by Italian and Turkish Environment, Health and Safety experts working in the company, the following actions were pointed out:

- Control daily energy consumption of machines
- Control process periodically for air-oil leakage
- Improve machines and machine's efficiency
- Research new solutions for decrease energy consumption
- Prepare data sheets about energy saving and also publish them
- Decrease breakdown time for energy saving
- Action for efficiency of illumination
- Collect all ideas and discuss them for energy saving
- Decrease the amount of water used for production
- Decrease the amount of water used for domestic purposes and irrigation

- Decrease the amount of the scrap and waste produced
- Meet the targets in E-KPI
- Prepare studies to reuse of water

With reference to some practical examples, it was mentioned that the Line4 pre-assembly illuminations were grouped; 3 pcs. of Mercury vapor lamps cancelled. TH-2 guillotine illuminations were grouped; Purchasing, Planning and H&S office illuminations were grouped; Illigs chiller was closed. Technologic cooling was connected for Illigs and Illig D1&D2 pre-heating group were cancelled. Now, they just used the main heating. 34 pcs. of air leakage points were fixed.

Concerning the next steps to be taken, several priorities were pointed out:

- to produce without pre-heating part on the Illigs& Rotatives;
- To create local teams for control assembly lines;
- To look for low capacity hydraulic motor for TH-1;
- To ensure periodical controls (air & oil leakage);
- To prepare banners about energy saving in order to inform employees;
- To determine the source and the amount of WW in exact. Counters will be placed in different locations of the infrastructure;
- To decrease the irrigation costs and to investigate trickle irrigation;
- To use water saving armature;
- To promote water saving and waste segregation by trainings;
- To reuse RO discharged water.

Chapter 4

“Motor Vehicle Industry”

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4.1 The evolution of the sector

4.1.1 The world-wide scenario

It can be admitted that automobile is among the industries that play major role in the global market, influencing different sectors of the economy worldwide. The automotive industry can be described as a backbone in many developed countries such as Japan, Korea, USA, and Germany, while being an enabler for economic prosperity in developing countries like China, Brazil, Eastern Europe, and Russia at the same time. While the industry in TRIAD countries (USA, Japan, and EU) became a high-tech branch, BRIC countries (Brazil, Russia, India, and China) started with simpler products.

It is expected that the BRICs' share of global vehicle sales will edge towards the 50% mark by 2018 and TRIAD and BRIC markets are expected to converge in terms of customer demands and behaviour within the next 5–6 years. As a matter of fact, China has already become the world's largest automobile producer and market since 2009. The current 5-year plan of the Chinese administration prepares China for a market -share of 30% of all cars in the world and the Chinese government views the development of the new energy vehicle industry as a top priority and has introduced policies and incentives in its favour.

4.1.2 The European scenario

In the European Union, about 16 million units are manufactured, which is about 26% of the world's annual production. Hence, cars are one of the most important products with an annual turnover of about 700 billion Euro. There are about 2 million direct jobs and another 10 million in related manufacturing and other sectors within the automotive industry in the EU (including truck, suppliers, etc.). With its 210 production plants in Europe, the automotive industry exports 75 billion Euro of net trade every year. It is also the largest sector in private research and development (R&D) investments with more than 5,800 patents in 2011. Being the most important player in Europe's automotive industry, Germany has more than 750,000 employees working directly in the automotive sector in more than 45 plants.

The European Union (EU) is the world's leading producer of motor vehicles. The automotive industry is one of the most significant

contributors to the economy of the European Union. The presence of vast base of the automotive industry in the European Union has contributed largely to the prosperity of Europe. The automotive industry in European Union is the largest provider of employment to people in Europe. The industry employs the largest number highly skilled labors and is a key driver of the Europe’s innovation and knowledge. The European automotive industry attracts many foreign investors in R&D (Research and Development). The major highlight of the European Union automotive industry is that, the sector is one of the leading contributors to the GDP (Gross Domestic Product). The industry also accounts for the largest export of Europe; this is one sector where Europe exports more than it imports.

According with the last dates published by the European Automobile Manufacturers’ Association (ACEA), during the last year there has been a steady increase in the number of vehicles produced in EU as is show in the figure 4.1.

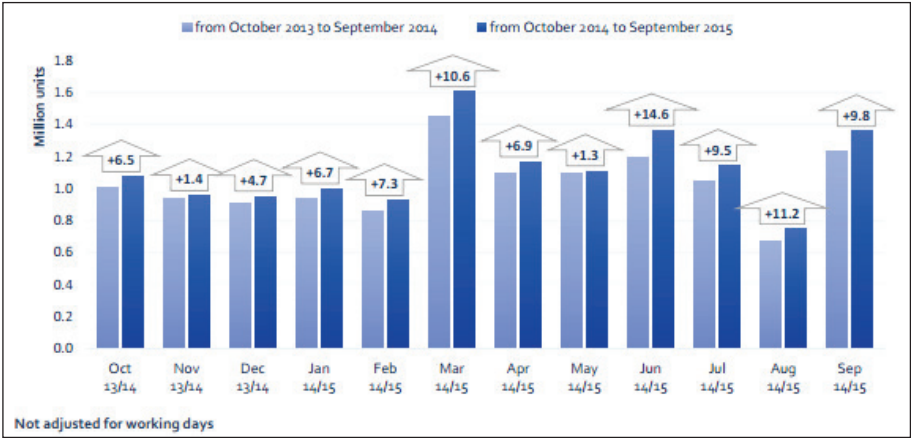


Fig.4.1- New passenger car registrations in the European Union – 12 month trend

In September 2015, the EU passenger car market showed another strong month (+9.8%), marking the 25th consecutive month of growth. Demand for new passenger cars was up in all major markets, driven by ongoing scrappage schemes and by the economic recovery of Southern Europe. Registrations in Spain (+22.5%), Italy (+17.2%), France (+9.1%), the UK (+8.6%) and Germany (+4.8%) increased when compared to September 2014. Across the region, new passenger

car registrations totaled 1,356,868 units. Over the first nine months of 2015, new passenger car registrations increased (+8.8%), surpassing 10 million units (10,413,675).

However, this is still far from the pre-crisis level of almost 12 million units registered during the same period in 2007. All major markets posted growth, contributing to the overall upturn of the EU market over the first three quarters of the year. Spain (+22.4%) and Italy (+15.3%) benefit from strong growth and posted double-digit percentage gains, followed by the UK (+7.1%), France (+6.3%) and Germany (+5.5%).

4.1.3 The Turkish scenario

The foundations of Turkey's automotive industry date back to the early 1960s, when the first efforts to develop and produce a Turkish-made passenger car were undertaken. During a period of rapid industrialization and progress, this key sector transformed itself from assembly-based partnerships to a full-fledged industry with design capability and massive production capacity. Between 2000 and 2014, original equipment manufacturers (OEM) invested more than USD 12 billion in their operations in Turkey. These investments significantly developed their manufacturing capabilities, which in turn led to Turkey becoming an important part of the global value chain of international OEMs. Meeting and exceeding international quality and safety standards, today's Turkish automotive industry is highly efficient and competitive thanks to value-added production.

Significant growth posted by Turkey's automotive sector led to Turkey becoming 15th largest automotive manufacturer in the world and 5th largest in Europe by the end of 2015.

Turkey has already become a center of excellence, particularly with respect to the production of commercial vehicles. By the end of 2015, Turkey was the number one producer of light commercial vehicles (LCV) in Europe.

Proven as a production hub of excellence, the Turkish automotive industry is now aiming at improving its R&D, design, and branding capabilities. As of the end of 2015, 75 R&D centers belonging to automotive manufacturers/suppliers are operational in Turkey.

Notable examples of global brands with product development, design, and engineering activities in Turkey include Ford, Fiat, Daimler, AVL, and Segula. Ford Otosan's R&D center is one of Ford's three largest global R&D centers, while Fiat's R&D center in Bursa is the Italian company's only center serving the European market outside its home country. Meanwhile, Daimler's R&D center in Istanbul complements the German company's truck and bus manufacturing operations in Turkey.

Turkey offers a supportive environment on the supply chain side. There are around 1,100 component suppliers supporting the production of OEMs. With the parts going directly to the production lines of vehicle manufacturers, the localization rate of OEMs varies between 50 and 70 percent.

Turkey is home to many global suppliers. There are more than 250 global suppliers that use Turkey as a production base, with 28 of them ranking among the 50 largest global suppliers.

Auto manufacturers increasingly choose Turkey as a production base for their export sales. This is evidenced by the fact that around 75 percent of production in Turkey is destined for foreign markets. In 2015, more than 900,000 vehicles were exported from Turkey to foreign markets.

While Germany, France, Italy, the UK, and Spain are currently the major export customers of the Turkish automotive industry, there is a trend of diversification in export destinations with companies looking to break into nearby emerging countries where there is considerably more demand potential for new auto sales.

The rise of per capita income from USD 3,000 in the first few years of the 2000s to USD 10,000 in 2015 led to higher sales in the motor vehicles market. While the average annual sale figures in the market were around 360,000 in the early 2000s, the average sales increased to 870,000 by 2015.

Despite the strong growth in the market, the automobile penetration in Turkey -- 165 cars per 1,000 people -- is well behind the European average of 500. This indicates ample opportunities for carmakers in the domestic market. Increased purchasing power combined with a low automobile ownership rate should help drive automobile sales in the coming years⁽¹¹⁾.

¹¹ <http://www.invest.gov.tr/en-us/sectors/Pages/Automotive.aspx>

4.1.4 The Italian scenario

The Italian automotive market has been characterized in the last 36 years by 3 deep crises (1978-2014). The first in 1983, because of economic stagnation and a high rate of inflation. Ten years later, in 1993, there was a crisis even more acute, concurrent with the devaluation of the lira, the forced levy on c / c and the crisis in the service sector, with a market decline of around 29%. This second period of crisis lasted four years and only ended thanks to the scrappage scheme. From that time the market remained stable for 11 years remaining over the 2.25 million vehicles registered, until 2008, year the start of the latest economic crisis. The declines were in a row and particularly heavy, only in 2014 the market turned positive, although the levels reached us back than 35 years to 1979 (Fig. 4.2).

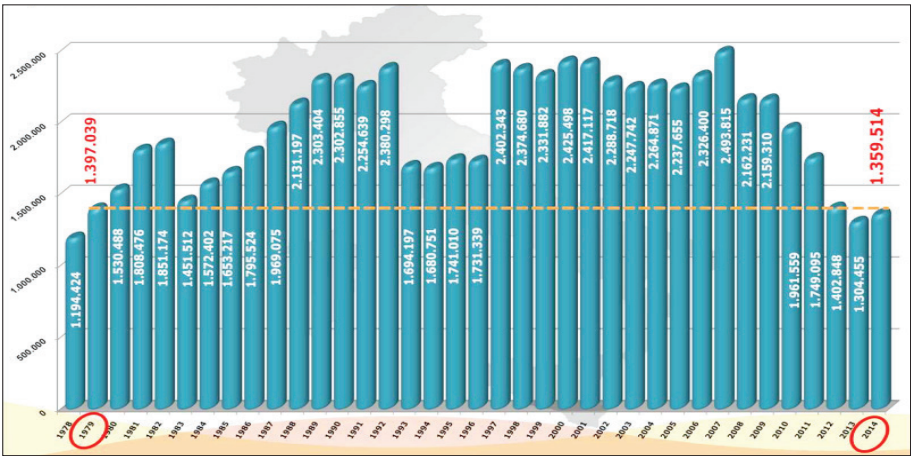


Fig. 4.2- The historical trend of the Italian automotive market

(On the vertical axis the number of registered automobiles is reported)

The economic crisis and the rise in fuel prices has pushed users toward alternative fuels and engines, and consequently the weight of petrol engines has gradually reduced up to more than 30% in 2014.

Cars with LPG fuel, while maintaining a representative around 9% (Fig. 4.3) seem to suffer from the increased product offering with natural gas fuel which, however, (Fig. 4.4) continues in the double-digit growth, thanks to the increase of the range of models offered on the market.

Number of registered cars

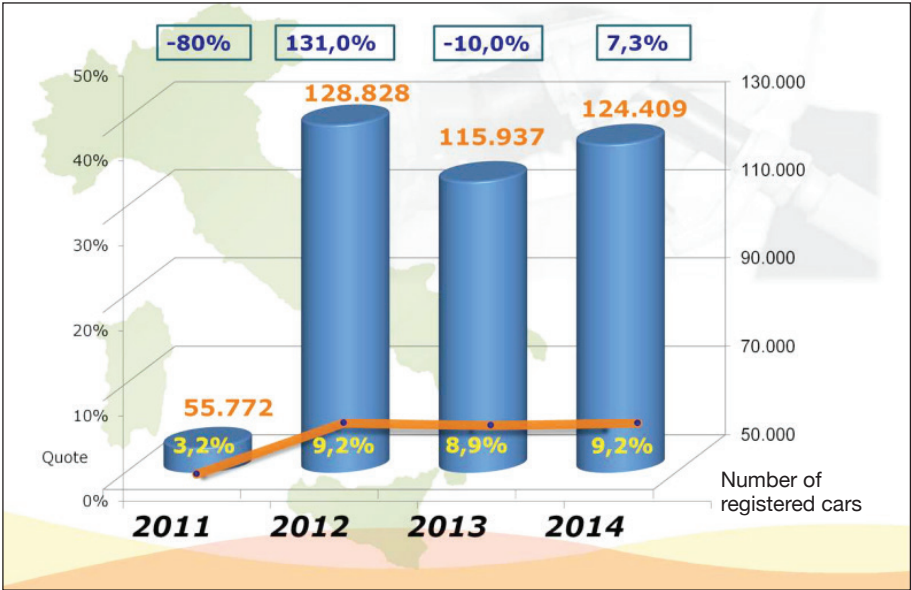


Fig. 4.3- Registrations of vehicles powered with LPG fuel

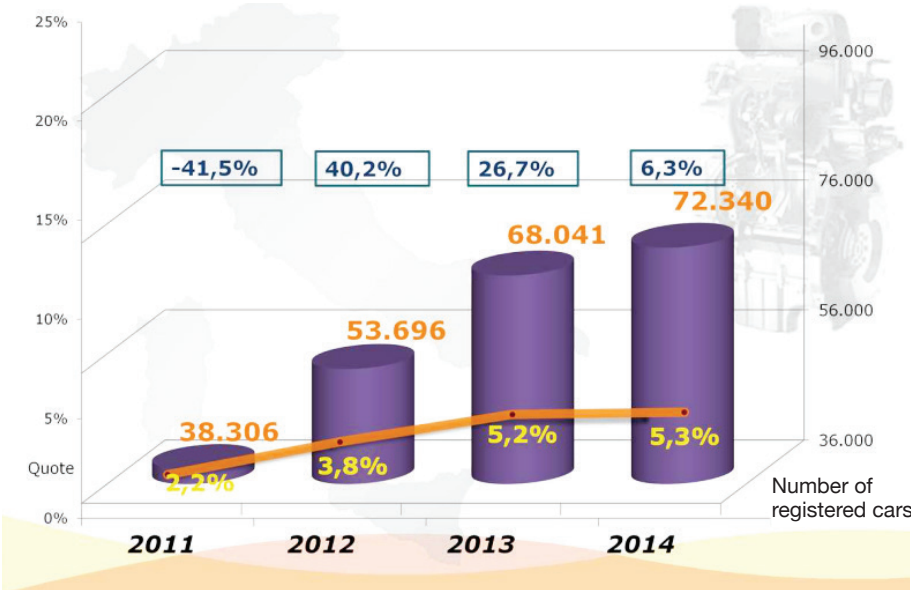


Fig. 4.4- Registrations of vehicles powered with LPG fuel

The natural gas vehicles are those that in 2014 we were able to benefit more for the portion of BEC (Low overall emissions) that were provide. Just over 6,000 cars to natural gas have been registered with incentive.

Hybrid cars continue their rapid rise (Fig. 4.5) thanks to the many innovations product and about 2,800 cars registered with incentives BEC. Their representativeness of the total, in fact, has gone in one year from 1.2% to 1.6%.

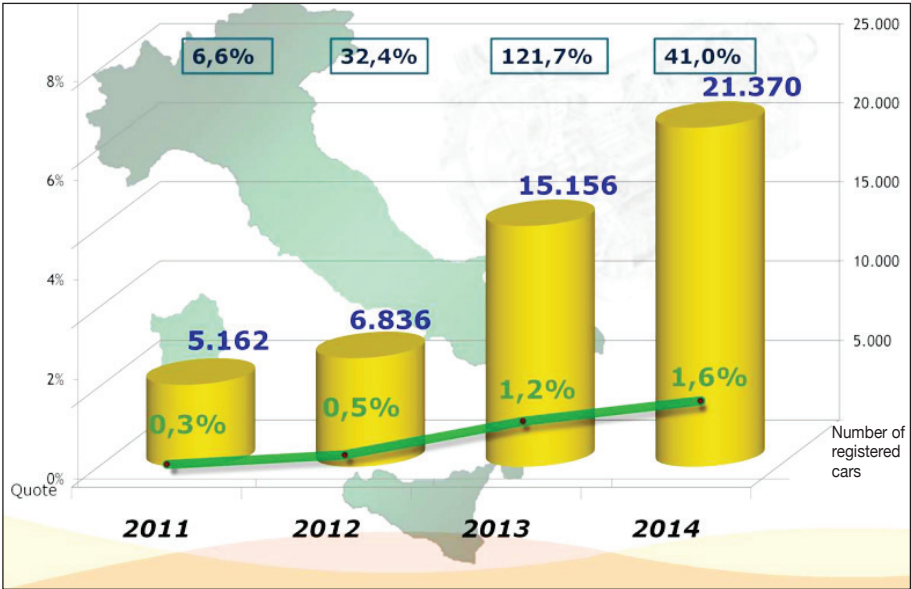


Fig. 4.5- Registrations of hybrid vehicles

4.2 Processes, technologies and main environmental issues

4.2.1 Process overview

Material selection

The manufacture of motor vehicles involves the manufacture and assembly of the final product from a number of metallic, plastic and electrical components.

Motor vehicle part and accessories include both finished and semi-finished components. Lots of parts are bought in an on “just-in-time” basis that means parts arrive only when they needed for assembly; only enough product is sent for a given day’s work. Approximately 8,000 to 10,000 different parts are ultimately assembled into approximately 100 major motor vehicle components, including suspension system, transmissions, and radiators. These parts are eventually transported to an automotive manufacturing plant for assembly. The vehicle industry produces many parts itself (e.g. by subsidiaries), while other parts are purchased; for example engines are cast from aluminium or iron, and further processed in engine plants while vehicle bodies are generally formed out of sheet steel, although there is a trend toward more plastic, reinforced fibreglass and aluminium parts in vehicle bodies directly in assembly plant.

Materials are selected based on factors such as performance (strength vs. Durability, surface finish, corrosion resistance), cost, component manufacturing, consumer preferences and competitive responses. Steel result to be the major automotive component because of its structural integrity and ability to maintain dimensional geometry throughout manufacturing process (Fig. 4.6).

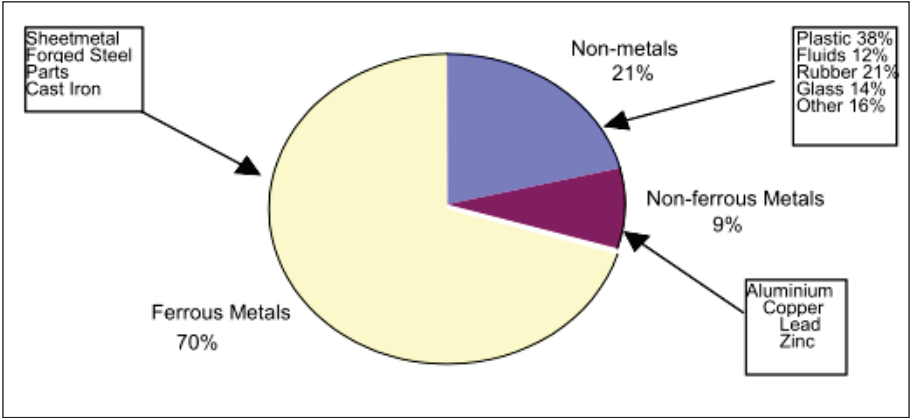


Fig.4.6 - Motor vehicle composition

(Adapted from USEPA Office of Compliance Sector Notebook Project, 1995)

In response to increasing demands for more fuel efficient cars, the composition of materials used in automobiles is changed and iron and steel use has decreased, while plastic and aluminium has increased. Different processes are employed for the production of plastic components.

The following tables (table 4.1) show a list of major automotive parts and the primary materials and production processes used to manufacture them.

Table 4.1- Identification of major Automobile Parts by Material and Process

Automotive Part	Primary Materials	Primary Process
ENGINE		
Block	Iron Aluminum	Casting
Cylinder Head	Iron Aluminum	Casting Machining
Intake Manifold	Plastic Aluminum	Casting Molding Machining
Connecting Rods	Powder Metal Steel	Molding Forging Machining
Pistons	Aluminum	Forging Machining
Camshaft	Iron Steel Powder Metal	Molding Forging Machining
Valves	Steel Magnesium	Stamping Machining
Exhaust Systems	Stainless Steel Aluminum Iron	Extruding Stamping
TRANSAXLE		
Transmission Case	Aluminum Magnesium	Casting Machining
Gear Sets	Steel	Blanking Machining
Torque Converter	Magnesium Steel	Stamping Casting
CV Joint Assemblies	Steel Rubber	Casting Forging Extruding Stamping
BODY STRUCTURE		
Body Panels	Steel Plastic Aluminum	Stamping Molding
Bumper Assemblies	Steel Plastic Aluminum	Stamping Molding

Automotive Part	Primary Materials	Primary Process
CHASSIS/SUSPENSION		
Steering Gear/Column	Steel Magnesium Aluminum	Casting Stamping Forging Machining
Rear Axle Assembly	Steel Plastic	Stamping Molding
Front Suspension	Steel Aluminum	Stamping Forging
Wheels	Steel Aluminum	Stamping Forging
Brakes	Steel Friction Materials	Stamping Forging
SEATS/TRIM		
Seats	Steel Fabric Foam	Molding Stamping
Instrument Panel	Steel Fabric Foam	Molding Stamping
Headliner/Carpeting	Synthetic Fiber	Molding
Exterior Trim	Plastic Aluminum Zinc Die Casting	Molding Casting Stamping
HVAC SYSTEM		
A/C Compressor	Aluminum Steel Plastic	Casting Molding Stamping
Radiator/Heater Core	Copper Aluminum Plastic	Extruding Molding
Engine Fan	Plastic Steel	Stamping Molding

(Source: University of Michigan Transportation Research Institute)

Vehicle manufacturing flow sheet

The vehicle manufacturing process is shown in the Fig.4.7.

There are close linkages with other metal industry sectors, particularly Foundries, Metal Surface Engineering, and Metal, as well as to the manufacture of plastic products, glass and textiles. It is common for the Press Shop and Metal Surface Engineering (Plating Shop) to be located on the same site.

The production units of an integrated motor vehicle assembly process are:

Press shop

Metal fabrication involves the shaping of metal components. Many automotive parts, including fenders, hubcaps, and body parts are manufactured in this sector. A typical large scale production of these

items starts with molten metal (ferrous or not ferrous) containing the correct metallurgical properties. Once the metal has been produced, it is cast into a shape that can enter the rolling process. Sheering and forming operations are performed to cut materials into desired shape and size and bend or form materials into specified shapes.

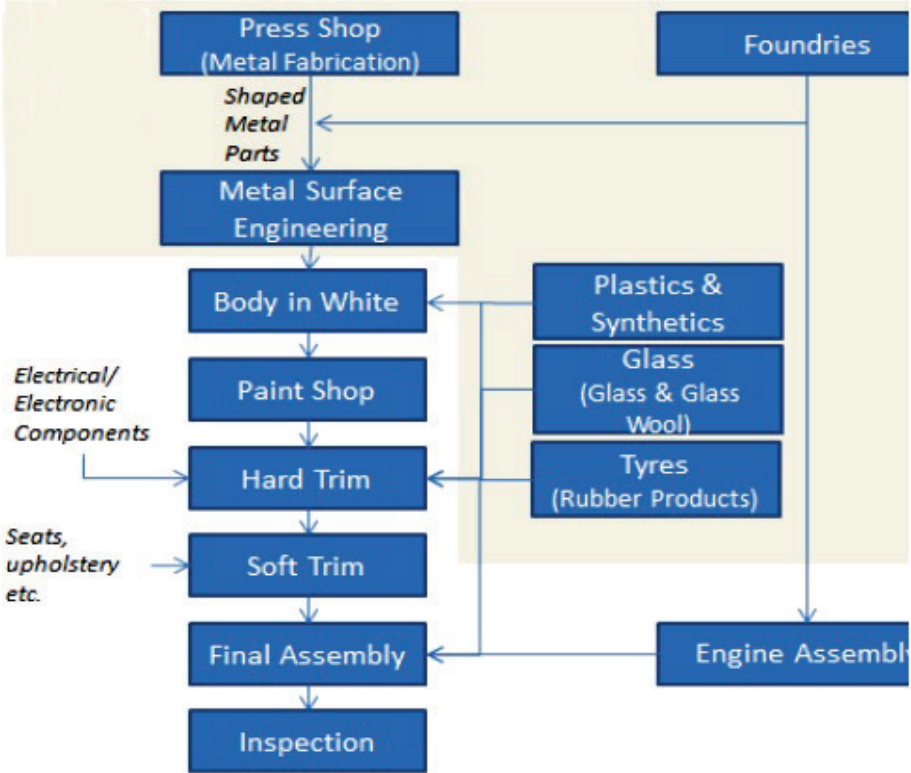


Fig. 4.7 – Manufacturing process diagram

The main processes recognizable at this stage are:

- Shearing (or cutting) operations include punching, piercing, blanking, cut-off, parting, shearing and trimming. Basically these are operations that make holes or openings, or that produces blanks or parts. The most common hole-making operation is punching. Piercing is similar to punching, but produces a raised-edge hole rather than a cut hole. Cut-off, parting and shearing are similar operations with different applications: parting produces both part and scrap pieces, cut-off and shearing produce parts with not scrap; shearing is use where the cut edge is straight; and cut-off produces

an edge shape other than straight. Trimming is performed to shape and remove excess material from the edges of parts.

- Forming operations shape parts by forcing them into a specified configuration, and include bending, drawing and spinning, extruding, rolling, coining, and forging. Bending is the simplest forming operation; the part is simply bent to a specific angle or shape. Bending operations normally produce flat shapes, while forming produces both two- and three- dimensional shapes. Drawing and spinning form sheet stock into three-dimensional shapes. Drawing uses a punch to force the sheet stock into a die, where the desired part shape is formed in the space between the punch and die; in spinning, pressure is applied to the sheet while it spins on a rotating form so that the sheet acquires the shape of the form. Extruding is the process of forming a specific shape from a solid blank by forcing the blank through a die of the desired shape. Complicated and intricate cross-sectional shapes can be produced by extruding. Rolling is a process that passes the material through a set or series of rollers that bend and form the part into a desired shape. Coining is a process that alters the form of the part by changing its thickness; it produces a three-dimensional relief on one or both sides of the part, as found on coins. Forging produce a specific part shape, much like casting. The forging process is used in the automotive industry when manufacturing parts such as pistons, connecting rods, and the aluminium and steel portion of the wheels. Forging uses externally applied pressure that either strikes or squeezes a heated blank into die of the required shape. Forging operations use machines that apply repeated hammer blows to a red-hot blank to force the material to conform to the shape of the die opening. Squeezing acts in much the same way, except it uses pressure to squeeze rather than strike the blank. Forging uses a series of die cavities to change the shape of the blank in increments. The blank is moved from station to station in the die to form the part.

Once shearing and forming a work piece is necessary remove the material from pieces of raw stock with machine tool. The principal processes involved in machining are hole-making, milling, turning, shaping/planning, broaching, sawing, and grinding.

Metal finishing/electroplating (Metal surface engineering)

Numerous methods are used to finish metal products. However, prior to applying the finishing applications, the surface must be prepared. One of the most important aspects of a finished product is the surface cleanliness and quality. Without a properly cleaned surface, even the most expensive coating will fail to adhere or prevent corrosion.

- Pickling and salt bath processes are used to finish metal products by chemically removing oxides and scale from the surface of steel. Steel generally passes from the pickling bath through a series of rinses. Alkaline cleaners are used to remove mineral oils and animal fats from the steel surface and the most common alkaline cleaners are caustic soda, soda ash, alkaline silicates and phosphates. In order to remove surfaces oxides electrolytic cleaning can be also used as well as other abrasive methods such as sand blasting.
- Coating processes are applied to inhibit oxidation and extend the life of the product. Common coating processes include galvanizing, tin coating, chromium coating and terne coating (lead and tin).
- Electroless plating is the chemical deposition of a metal coating onto a metal object, by immersion of the object in an appropriate plating solution.
- Anodizing provides aluminium parts with a hard abrasion- and corrosion- resistant film. This coating is porous, allowing it to be dyed or to absorb lubricants. Anodizing is usually performed using either sulfuric or chromic acid often followed by hot water bath, though nickel acetate or sodium potassium dichromate seal may also be used.

Body-in-white

Once the various automotive parts are produced, they are ready to be brought together for assembly. Although techniques used to assemble an automobile vary from manufacturer to manufacturer, the first major step in assembly is the body shop. At this stage the car begins to take shape as sides are welded together and then attached to the under body of the car.

The unpainted vehicle body (also known as the “body-in-white”) is assembled from formed body panels joined by welding, glue and riveting.

Paint shop

Automotive painting is a multi-step process subdivided into three categories. The stages of the motor vehicle painting process are illustrated in Fig. 4.8.

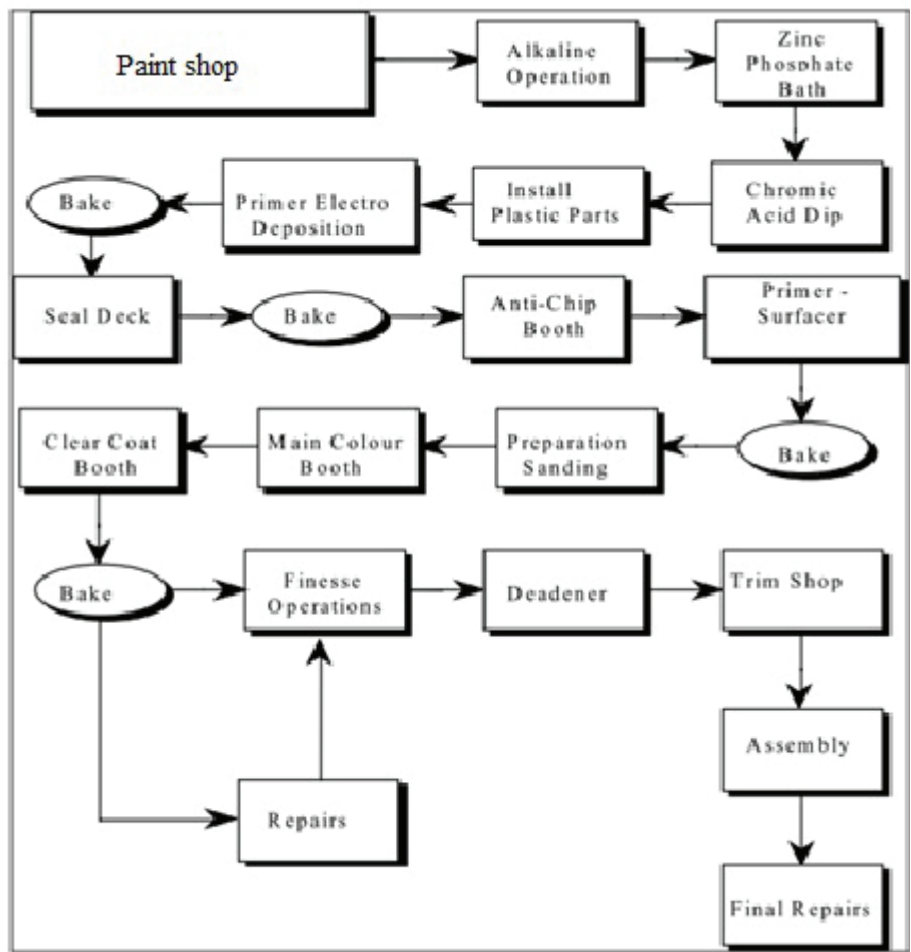


Fig. 4.8 – Schematic of a General Motor Vehicle Painting Process

(Source: Ford Motor Company of Australia 1998)

- Pre-treatment consists in cleaning and anti-corrosion operations in order to prepare the body for the painting and finishing process. Initially, the body is sprayed with and immersed in a cleaning agent, typically consisting of detergents, to remove residual oils and dirt. The body is then dipped into a phosphate bath, typically

zinc phosphate, to prevent corrosion. The phosphate process also improves the adhesion of the primer to the metal. The body is then rinsed with chromic acid, further enhancing the anti-corrosion properties of the zinc phosphate coating. The anti-corrosion operations conclude with another series of rinsing steps.

- Priming operations consist of an electro deposition primer bath, an anti-chip application and a primer surface application. Priming operations further prepare the body for finishing by applying various layers of coatings designed to protect the metal surface from corrosion and assure good adhesion of subsequent coatings. As illustrated in Fig. 9, a primer coating is applied to the body using an electrodeposition method, creating a strong bond between the coating and the body to provide a more durable coating. In electrodeposition, a negatively charged car body is immersed in a positively charged bath of primer for approximately three minutes. The coating particles, insoluble in the liquid and positively charged, migrate toward the body and are, in effect, plated onto the body surface. Prior to baking, excess primer is removed through several rinsing stages. The rinsing operations used various systems to recover excess electrodeposited primer. Once the body is thoroughly rinsed, it is baked for approximately 20 minutes at 130 ° C to 180°C. Next, the body is further water proofed by sealing spot-welded joints of the body.

Water-proofing is accomplished through the application of a paste or putty-like substance. This sealant usually consists of polyvinyl chloride and small amounts of solvents. The body is again baked to ensure that the sealant adheres thoroughly to the spot-welded areas and again emissions of solvents could be expected. Alternatively, this process can be carried out in the primer surface bake oven. After water-proofing, the vehicle body proceeds to the anti-chip booth. Here, a substance usually consisting of a urethane, vinyl plastisol, or an epoxy ester resin, in conjunction with solvents, is applied locally to certain areas along the base of the body, such as the rocker panel or the front of the car. This anti-chip substance protects the lower portions of the body from small objects, such as rocks, which can fly up and damage vehicle finishes. The primer-surfacer coating is applied by spray application in a water-wash spray booth. The primer-surfacer consists primarily of

pigments, polyester or epoxy ester resins, and solvents. Due to the composition of this coating, the primer-surfacer creates a durable finish that can be sanded. The pigments used in this finish provide additional colour layers in case the primary colour coating is damaged. After the primer-surfacer coating is baked, the body is then sanded, if necessary, to remove any dirt or coating flaws. This is accomplished using a dry or moist sanding technique.

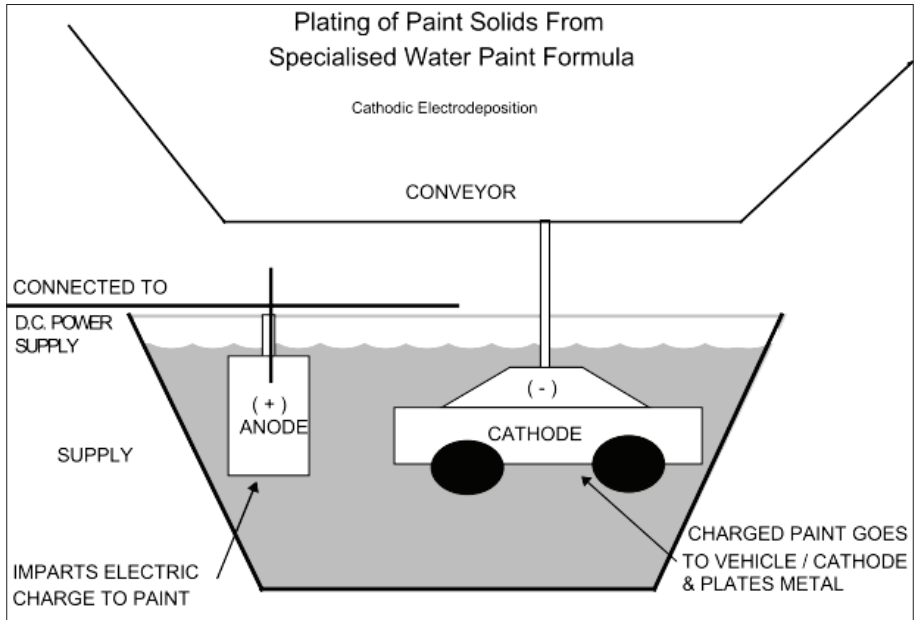


Fig.4.9- Plating of Paint Solids from specialised water paint formula

- Finishing operations consist of a colour coat application, a clear coat application, and any painting necessary for two-tone colour or touch-up applications. In addition to the pigments and solvents, aluminium or mica flakes can be added to the primary colour coating to create a finish with unique reflective qualities. Instead of baking, the primary colour coat is allowed to flash off, or in other words, the solvent evaporates and is emitted to air with the application of heat below the bake temperature. After the primary colour coating is allowed to air-dry briefly, the final coating, a clear coat, is applied. The clear coat adds lustre and durability to the vehicle finish. This coating generally

consists of a modified acrylic or a urethane and is baked for approximately 30 minutes at 140 °C to 150 °C. Once the clear coat is baked, a coating known as deadener is applied to certain areas of the motor vehicle underbody. Deadener, generally a solvent-based resin of tar-like consistency, is applied to areas such as the inside of wheel wells to reduce noise. In addition, anti-corrosion wax is applied to other areas, (e.g. the inside of doors), to further seal the vehicle body and prevent moisture damage. This wax contains aluminium flake pigment and is applied using a spray wand

Trim shop

Hard and soft trim are installed after painting and finishing. Hard trim, such as instrument panels, steering columns, weather stripping, and body glass, is installed first; the car body is then passed through a water test where, by using phosphorus and a black light, leaks are identified. Soft trim including seats, door pads, roof panel insulation, carpeting, and upholstery, is then installed.

Final assembly

Next, the motor vehicle body is fitted with the following: gas tank, catalytic converter, muffler, tail

Pipe, and bumpers. Concurrently, the engine goes through a process known as dressing, which consists of installing the transmission, coolant hoses, the alternator, and other components. The engine and tyres are then attached to the body, completing the assembly process. The finished vehicle is then rigorously inspected to ensure that no damage has occurred as a result of the final assembly stages.

4.2.2. Overview of the emerging techniques

An emerging technique is understood in this document as a novel technique that has not yet been applied in any industrial sector on a commercial basis. This section contains those techniques that may appear in the near future and that may be applicable to the surface treatment using organic solvents sector and to the surface treatment of metals and plastics by electrolytic or chemical processes.

Emerging techniques for electroplating

- Process-integrated automated plating. A project was initiated to integrate the electroplating processes into the production line to minimize the process costs and environmental impacts (it is referred to as FIO in German). The technology is particularly suited to uniform cylindrical workpieces manufactured in large numbers. The anode is then shaped to fit around the workpiece (the cathode), leaving a very small space between the cathode and the anode and creating extremely high field intensity. During plating, the anode is spun rapidly, which creates turbulence in the electrolyte, preventing ion transport in the diffusion layer which is the limiting factor. The combination of these two factors allows the electroplating to proceed rapidly, permitting the process to be integrated into a production line. An automatic sealed system delivers the electrolyte and removes it when it becomes exhausted. A separate central processing system for returned electrolytes keeps the production line waste and waste water free. Automation of the process means that staff are not exposed to any chemicals. At the moment, the FIO technique is not in use. However pilot attempts were promoted by the German Ministry for Science and Technology: a) KVS plastics processing and service GmbH, the developers and manufacturers of the FIO technique, could not establish FIO on the market. The largest problem was the interdependence between the user and the chemicals supplier. For many operators, the level of dependence on the chemical supplier is thought to be too high a risk. b) Siemens Corporation carried out an experimentation based on the integration of the silver plating of copper tubes into the manufacturing process. The promising beginning was not transferred to mass production because of the sales of that production section to another company. c) Bosh carried out a research project that proved to be technically feasible, however for unknown reasons it was not transferred to mass production; partial results of the research project (some recycling technologies) are still in use in the company.
- Substitution by trivalent chromium plating for hexavalent chromium in hard chromium applications using modified pulse current. The process uses a simplified trivalent chromium electroplating solution based on chromium sulphate. The current waveform is proprietary

(patents pending) and includes pulse-reverse current. Chromium has been deposited at up to 250µm successfully and could be deposited to any thickness. Hardness, rate of deposition and post-finishing for thick coatings are the same as for chromium from hexavalent solutions. Color for thin layers is the same (chrome-blue) as from hexavalent chromium. The process retains the advantages of Cr III solutions, such as lower concentrations, higher current efficiency and tolerance to sulphate and chloride dragged-in from any previous nickel plating stages (Table 4.2). Lack of organic additives will reduce or eliminate solution maintenance with activated carbon.

Table 4.2- Comparison of hard chromium plating by traditional Cr(VI) and modified pulse current Cr(III)

	Plating rate µm/min	Current efficiency	Hardness (VHN*) prior to post-hardening	Process sequence
Automotive OEM** Cr(VI)	0.8	24 %	772	<ul style="list-style-type: none"> • 3-step precleaning • Plating • 1-step post-treatment
Cr(III) process	1.2	30 %	777	<ul style="list-style-type: none"> • 3 step precleaning • Plating • 1-step post-treatment
Note: * VHN = Vickers Hardness Number (measurement of hardness) ** OEM = Original Equipment Manufacturer				

The environmental benefits that can be achieved are different:

- a) Replaces hexavalent chromium solutions, with reduced waste gas and waste water treatments. Solution concentrations are the same as existing Cr(III) chemistry and up to ten times lower than Cr(VI) solutions.
- b) Higher current efficiency, therefore less power consumption.
- c) No chloride electrolyte, so no production of chlorine.
- d) Requires no organic additives to suppress chlorine formation, or such as PFOS (Perfluorooctanesulfonic acid) to suppress mist formation or to improve throw.
- e) A further stage of development will confirm if it can be operated as a closed loop system.

Emerging techniques for painting

- Improved water-dilutable 1- and 2-component clear coating. New products in the form of improved water-dilutable 1- and 2-component clear coating systems as well as ‘very high solid’ 2-component clear coating systems (with a solids content of up to 90 wt %) are expected in the future.
- Developments in powder coating. The application of powder topcoating on a larger scale is expected. According to statements from paint producers, a variety of pigmented finish coating systems based on powder are already available; however, these are not yet in serial application. According to industry, this may be due to the difficulty in colour mixing, making recycling impossible. The current powder coats do not meet most European manufacturers requirements for durability and physical and chemical resistance.
- Increased use of pre-coated materials. A further development may be an increasing share of completely finished coil coating parts so that certain painting processes will no longer be performed by the car manufacturer. Because coil coated materials are coated before forming (shaping) and completion of sub-assemblies (e.g doors), the application and extraction techniques enable a lower VOC emission per m² coated than post-forming painting.
- Polyurethane (PU) paint systems. Paint systems based on a polyurethane can be already burned-in at temperatures below 100 °C. This allows the lacquer finish of both metal bodies and plastic mounted parts within a single painting process. A so-called ‘in-line lacquer finish’ would solve the problem of the colour adjustment between the metal body and the coloured plastic parts. The wide range of PU-based paint systems is available for all layers of the paint structure, ranging from the primer to the finish coating as well as for sound absorption and underbody protection. The low burn-in temperatures allow for the use of a wide range of plastics.
- Reduction in paint layers. A reduction in the number of paint layers is to be expected, as primers and base lacquers are united into one material applied in one paint film. Primerless systems using 2-component water-based base coat are being introduced.

Primerless systems reduce application steps from four to three and ovens from three to two. Base coat thickness is slightly increased to cover the underlying electro coat. The most important benefits of this solution are that materials and energy are saved and at the same time the emissions from the painting process decrease.

4.2.3. Main environmental issues

The assembly of motor vehicles can potentially create a number of environmental and health (E&S) risk issues. Most of these risks are associated with harmful substances, which are used during the manufacturing process as well as hazards arising from waste and emissions.

The outputs resulting from the various stages of production, range from air emissions from foundry operations to spent solvents from surface painting and finishing. Many of material inputs and emissions are of NPI-listed substances.

Production processes, the material inputs, the various emissions and wastes resulting from these operations are listed in Table 4.3.

Air Emissions

The emissions are primarily organic solvents, which are used as carriers for the paint and solvents used for cleaning equipment between colour changes and to clean spray booths. The emissions to air are constituted by gas and dust.

- *Press shop (metal shaping)* – Metal shaping operations generate emissions of solvents and metals depending on the type of cleaning operation. Concentrated solvent-bearing wastes and emissions may arise from degreasing operations. Degreasing operations may result in solvent-bearing wastewater, air emissions, and materials in solid form. Air emissions may result through volatilisation during storage, fugitive losses during use, and direct ventilation of fumes.
- *Metal surface engineering (surface preparation)* – Plating operations generate mist due to the evolution of hydrogen and oxygen gas. The gases are formed in the process tanks on the surface of the submerged motor vehicle or on anodes or cathodes. As these gas bubbles rise to the surface, they escape

into the air and may carry considerable liquid with them in the form of a fine mist. The rate of gassing is a function of the chemical or electrochemical activity in the tank and increases with the amount of work in the tank, the strength and temperature of the solution, and the current densities in the plating tanks. Air sparging

Table 4.3- Material inputs and pollutant outputs

Process	Material Input	Emissions to Atmosphere	Emissions to Water or Solid Waste	Emissions via Solid Waste
<i>Metal Shaping</i>				
Metal Cutting and/or Forming	Cutting oils, degreasing and cleaning solvents, acids, and metals	Solvent wastes (acetone, xylene, toluene, etc.)	Acid/alkaline wastes (eg. hydrochloric, sulfuric and nitric acids) and waste oils	Metal wastes (eg. copper, chromium and nickel) and solvent wastes (acetone, xylene, toluene, etc.)
Heat Treating	Acid/alkaline solutions (eg. hydrochloric and sulfuric acid), cyanide salts, and oils		Acid/alkaline wastes, cyanide wastes, and waste oils	Metal wastes (eg. copper, chromium, and nickel)
<i>Surface Preparation</i>				
Solvent Cleaning	Acid/alkaline cleaners and solvents	Solvent wastes (eg. acetone, xylene, toluene, etc.)	Acid/alkaline wastes	Ignitable wastes, solvent wastes, (acetone, xylene, toluene, etc.) and still bottoms
Pickling	Acid/alkaline solutions		Acid/alkaline wastes	Metal wastes
<i>Surface Finishing</i>				
Electroplating	Acid/alkaline solutions, metal bearing and cyanide bearing solutions		Acid/alkaline wastes, cyanide wastes, plating wastes, and wastewater	Metal wastes, reactive wastes, and solvent wastes
Surface Finishing	Solvents	Solvent wastes (acetone, xylene, toluene, etc.)		Metal paint wastes, solvent wastes, ignitable paint wastes, and still bottoms
Facility Clean-up	Solvents	Solvent wastes (acetone, xylene, toluene, etc.)		Solvent wastes and still bottoms

Source: Queensland Department of Environment and Heritage, 1998.

also can result in emissions from the bursting of air bubbles at the surface of the plating tank liquid. Emissions are also generated from surface preparation steps, such as alkaline cleaning, acid dipping, and vapour degreasing. These emissions are in the form of alkaline and acid mists and solvent vapours.

- *Motor Vehicle Assembly* – At this stage are not present significant emissions of pollutant to air, the only factor to be kept under control is the production of fine dust.
- *Paint shop (surface finishing)* – Many of the air emissions of NPI-listed substances generated during motor vehicle production are the result of painting and finishing operations. These operations result in air emissions, as well as the generation of solid and liquid wastes. Air emissions, primarily VOCs, result from the painting and finishing application processes (paint storage, mixing, applications, and drying) as well as cleaning operations. These emissions are composed mainly of organic solvents that are used as carriers for the paint. Solvents are also used during clean-up processes to clean spray equipment between colour changes, and to clean portions of the spray booth. Xylenes and butane are most common along with lesser amounts of butyl acetate and mixed aromatics.
- *Hard and soft trim* – Use of solvent based adhesives during Soft and hard Trim produce air emission of VOC

Wastewater

The production of wastewater is unavoidable and happens in all steps of the assembly process. The wastewater generated contains organic solvents, metals, chemical additives and petroleum-based substances.

- *Press shop (metal shaping)* – In metal shaping operations the wastewater emission are constituted by metalworking fluids that typically become contaminated and spent with extended use and reuse. When disposed, these oils may be contaminated with several NPI-listed substances, including metals (cadmium, chromium, and lead). Many fluids may also contain chemical additives such as chlorine, sulphur, and phosphorus compounds, phenols, cresols, and alkaline.

- *Metal surface engineering (surface preparation)* – Alkaline, acid, mechanical, and abrasive cleaning methods can generate waste streams such as spent cleaning media, wastewater, and rinse waters. Such wastes consist primarily of the metal complexes or particles, the cleaning compound, contaminants from the metal surface, and water. In many cases, chemical treatment operations are used in conjunction with organic solvent cleaning systems. As such, many of these wastes may be cross-contaminated with solvents containing listed organics. Liquid wastes result from workplace rinses and process clean-up waters. Most surface finishing (and many surface preparation) operations result in liquid waste streams.
- *Paint shop (surface finishing)* – Various liquid waste streams may be generated throughout painting operations and are usually the result of the following operations:
 1. *Paint application* - paint over-spray caught by emissions control devices (paint booth collection systems, ventilation filters);
 2. *Paint drying* - ventilated emissions as paint carriers evaporate;
 3. *Clean-up* of equipment and in the paint booth area; and
 4. *Disposal - transfer and recycling* of unused paint as well as containers used to hold paints, paint materials, and over-spray.

Waste and by-products

The creation of waste and by-products is physiological in all industrial cycles for this is important to optimize the use of raw material and to provide for an efficient management system of rejects.

In automotive assembly industry the principal principal residual produced are represented by: scrap metal, wastewater treatment sludge, still bottoms, cleaning tank residues and other solid waste.

- *Press shop (metal shaping)* – In metal shaping operations scrap metal waste are produced. Scrap metal may consist of metals removed from the original piece (e.g. steel or aluminium). Quite often, scrap is reintroduced into the process as a feedstock.
- *Metal surface engineering (surface preparation)* – Any solid

wastes (e.g. wastewater treatment sludges, still bottoms, cleaning tank residues, machining fluid residues, etc.) generated by the operation, may be contaminated with listed solvents and also require inventory. Chemical treatment operations can result in wastes that contain listed metals. In addition to these wastes, spent process solutions and quench bathes are discarded periodically when the concentrations of contaminants inhibit proper function of the solution or bath. When discarded, process bathes usually consist of solid- and liquid-phase wastes that may contain high concentrations of the constituents of concern, especially cyanide (both free and complex).

- *Motor Vehicle Assembly* – The majority of emissions generated during assembly are solid wastes resulting from parts packaging. Advances in packaging design, changes in purchasing, and the elimination of unneeded materials have greatly reduced the amount of expendable waste generated.
 - *Paint shop (surface finishing)* – The principal residual produced in paint shop are represented by:
 - *solvent waste*: the primary source of solvent wastes are recovered solvents, old solvents,
 - *solvent leftovers*, used and contaminated cleaning agents are generated, among other things, by the cleaning and setting up of solvent-based paint systems, by tool, device or spray booth cleaning and possibly by the waste gas cleaning of painting and drying
 - *Paint leftovers and old paints*: due to their changed physical and/or chemical characteristics, paint leftovers and old paints that are no longer usable and have to be disposed of as waste material. Out of specification and/or surplus batches and dried paints are likewise waste.
 - *Paint sludge*: during spray painting, non-separated overspray is captured in water and the coagulated lacquer particles are removed from the water. Coagulation agents are added to the water for separation and for improved cleaning-out processes, hence paint sludge is generated.

Energy consumption

The painting process is one of the most energy intensive steps and is probably the most environmentally significant in vehicle production after considering solvent use and emissions.

Typical values of energy consumption for car paint shops is 38÷ 52 % of the energy consumption for an entire assembly plant (excluding other production activities sometimes located in the same plant, such as foundries, engine block manufacture and production of other component production). Details of the energy consumption for a specific sequence of processes and of individual process steps depend on the type of processes and the individual production line capacities. Because of this, data are often not comparable, even between different production lines within the same site. Detailed data often do not exist or are not published. The following table show a typical energy consumption of car paint shop (Table 4.4).

Table 4.4 - Typical energy consumption of car paint shop

Typical energy consumption of car paintshops	
Production capacity	200000 cars/year
Coating system	Water-based filler and base coat, solvent-based 2K clear coat
Energy consumption of paintshop	Units range
Total energy consumption (plant)	380000 – 580000 MWh
Energy consumption of paintshop (60 % gas)	160000 – 240000 MWh
Paintshop as % of total plant energy	38 – 52 %
Energy consumption of paint processes	Range
Pretreatment	7 – 11 %
E-coating	10 – 15 %
Seam sealing/underbody protection	12 – 18 %
Filler	12 – 18 %
Base coat	15 – 22 %
Clear coat	22 – 33 %
Cavity sealing	2 – 2 %
Total	80 – 120 %
Sources: Ökobilanz Lackierprozess (2003) (Krinke), Pers. Mittl. Hr. Engelmann, Oct 2005, ACEA 2005	

Other issues

Vehicle assembly plants can be noisy work places due to the high level of use of machinery.

Monitoring

See in the Chapter 6 a general view of the basic principles on monitoring (emissions, process, impact).

4.3 The Best Available Techniques (BAT)

It is known that in automotive industry the metal surface treatment results to be the most critical under an environmental point of view and the BAT (Best Available Techniques) mainly are applied to this sector. The BAT Reference Document (BREF) entitled 'Surface Treatment Using Organic Solvents (STS)' edited in August 2007 reflects an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive).

As for the coating of cars BAT is to:

- Minimize the energy consumption in the selection and operation of painting, drying/curing and associated waste gas abatement systems.
- Minimize solvent emissions, as well as energy and raw material consumptions, by selecting a paint and drier system as described. A whole coating system needs to be considered, as individual steps may be incompatible.
- Establish and implement plans for existing plants to reduce consumptions and emissions.
- Achieve the emission values above bearing in mind the cross-media effects and cost benefits analysis.
- Reduce material consumptions by using high efficiency application techniques.
- Use other paint systems to replace paints based on halogenated solvents.

A. General BAT Conclusions

Environmental management system

An environmental management system is a technique allowing operators of installations to address environmental issues in a systematic and demonstrable way. An EMS (Environmental Management System) can take the form of a standardised or non-standardised ('customised') system. Implementation and adherence to an internationally accepted standardised system such as EN ISO 14001:2004 can give higher credibility to the EMS, but, non-standardised systems can, in principle, be equally effective provided that they are properly designed and implemented.

1. BATs are finalized to implement and adhere to an environmental management system (EMS) that incorporates the following features:

- definition of an environmental policy that includes continuous improvement for the installation;
- planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment;
- implementation of the procedures paying particular attention to: structure and responsibility; training, awareness and competence; communication; employee involvement; documentation; efficient process control; maintenance programmes; emergency preparedness and response; safeguarding compliance with environmental legislation;
- checking performance and taking corrective action, paying particular attention to: monitoring and measurement; corrective and preventive action; maintenance of records; independent internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;
- following the development of cleaner technologies;

- consideration for the environmental impacts from a possible decommissioning, during the design phase of a new technical unit and throughout its operating life;
- periodic application of sectoral benchmarking.

The scope (e.g. level of details) and nature of the EMS (e.g. standardised or non- standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

Energy management

Energy management means a systematic advance to efficient use of energy. It includes technical as well as organisational measures. The aim is the minimisation of energy consumption and energy costs. The following elements must be considered:

- energy-specific data must be known,
- efficient energy management (efficient use of energy and cost savings),
- identification of possibilities for energy saving,
- influencing the behaviour of the organisation (the culture) and the employees to save energy.

All energy inputs can be recorded on an actual basis, and split according to type and major end-use on a specified basis, such as monthly, daily, hourly, etc. Inputs can also be benchmarked and optimised against other production measures. The general BAT for energy saving are:

- Improve thermal efficiency of heating equipment to minimise heat loss.
- Implement heat recovery processes, such as steam rising boilers to capture hot gases and re- use elsewhere in operation or for generating energy.
- Monitor and target energy usage and implement behavioural change programmes.

- Consider opportunities to switch to cleaner fuels or renewable energy sources.

Material management

Materials management is concerned with management functions supporting the complete cycle of material flow, from the purchase and internal control of production materials to planning and control of work in process, to warehousing, shipping and distribution of the finished product. An effective materials management process ensures that the right kinds of materials are at the right place whenever needed.

BAT is to optimize the management and control of internal material flows in order to prevent pollution, prevent deterioration, provide adequate input quality, and allow reuse and recycling and to improve the process efficiency and optimization of the metal yield. In particular :

- *Just-in-time management* : applying a just-in-time management system will ensure that the ordered amount of materials, e.g. paint or ink, which are to be used for a specific job, matches the volume that is needed. Less waste materials will arise and fewer raw materials are used.
- *Quality assurance of paints and solvents* : systematic evaluation and reduction of adverse environmental impacts to air and water. Paints and solvents are usually approved by competent experts (in-house or external) before use in paintshops.
- *Minimisation of raw material consumption* : reducing amounts of hazardous waste and consumptions of fresh solvents. By re-using the hazardous waste (in this case solvent), its life cycle is expanded.
- *Re-use of returned paints or inks* : permit a lower consumption of fresh paint or ink and less waste to be disposed of. Solvent- and water-based returned paints or inks can be re-used if they are not diluted too much and are not contaminated with cleaning agents where these differ from the solvent used as thinner.
- *Pig-clearing systems* : this method only fills as much paint into the system as necessary for the coating processes. The advantages are the lower use of cleaning agents, the reduction of paint and solvent losses as well as the decrease of the manual processes with the color change.

Air emissions management

BAT is to prevent or reduce diffuse dust emissions from materials storage, handling and transport. It is necessary capture and clean dust emitted and sequentially monitoring PM10 levels.

The techniques used are:

- Venturi particle separation ;
- Dry filter systems;
- Electrostatic filters (precipitators);
- Scrubber.

Techniques to consider during material transport include:

- the employment of wheel-cleaning equipment to prevent the carryover of mud and dust onto public roads;
- the application of hard surfaces to the transport roads (concrete or asphalt) to minimize the generation of dust clouds during materials transport and the cleaning of roads;
- the damping of dusty routes by water sprays, e.g. at slag-handling operations.

Water and wastewater management

Under normal conditions, there should be no emissions to sewer or waters from vehicle coating and refinishing operations using solvent coatings.

The new trend towards use of waterborne paints may result in some discharge to sewer, but pretreatment will be required and authorization to discharge to sewer or waters must be obtained in advance from regulating authorities. The source of such emissions would be waterborne paint gun washes and spray booth wash waters. Emerging treatment for such waste water is chemical flocculation followed by filtration or sedimentation.

The general purpose of the measures described in the following sections is to avoid material losses and emissions to water, reduce water usage

and consequently reduce the need for wastewater treatment. To do this, several well known unit operations for phase and material separation are applied.

- Minimize the consumption of water used in production processes and equipment cleaning.
- Consider upgrades to wastewater treatment facilities.
- Recycle wastewater where possible, e.g. certain solvent wastes such as gun wash can be sent for recovery and reuse in another application where these facilities are available.
- Ensure untreated wastewater does not discharge to watercourses through use of wastewater treatment facilities and monitoring of wastewater discharges.

Wastes and by-products management

BAT for solid residues is to use integrated techniques and operational techniques for waste minimization by internal use or by application of specialized recycling processes (internally or externally).

Solid wastes may arise from several sources during assembly and the majority of wastes by volume result from packaging - reusable or disposable. Reusable packaging covers metal racks, bins and containers and disposable packaging covers wood pallets, cardboard, plastic, polystyrene and polythene film. Other solid wastes include:

- Scrap metal from the press shop, which is normally recycled off-site.
- Metal-rich dust generated by the abrasive disc smoothing of welds and soldered joints.
- Sludge generated by wastewater treatment facilities of equipped vehicle manufacturing plants.
- Additional wastes arise from general operations, cleaning and maintenance and the disposal of faulty equipment and parts.

Improperly disposed of waste can lead to pollution and ground contamination.

BAT is to maximize external use or recycling for solid residues and to manage in controlled manner residues which can neither be avoided or recycled; in particular:

- Return packaging of hazardous and non-hazardous materials (wherever possible), such as empty drums, to supplier for reuse.
- Recycle packaging wherever possible.
- Develop and implement a waste management plan covering all aspects of waste treatment on site. Wherever possible, priority should be given to reduction of wastes generated, and recovery and re-use of raw materials.

Monitoring management

BAT is to monitor VOC emissions in order to be able to minimise them. A solvent management plan is the key technique to understand the consumption, use and emission of solvents, especially fugitive VOC emissions.

When considering monitoring, the monitoring JCR Reference report on Monitoring emissions from IED- installations (2013) gives guidance and lists appropriate sources of standards procedures to use for issues including:

- direct monitoring, accounting for total emissions including monitoring of fugitive and diffuse emissions, surrogate parameters and mass balances;
- timing of sampling;
- how to deal with uncertainties.

BAT is to measure the stack emissions of pollutants from the main emission sources from all processes.

Monitoring techniques are:

- Mass balances for solvents in order to evaluate the outputs of organic solvents in the waste gas and as fugitive emissions.
- Direct measurement of solvents and emissions to air. Direct measurement can simply be the measuring by volume or by weight of solvent or materials containing solvent.

- Monitoring levels of solvent in sewers and avoid contact with water or steam in the process, or unplanned discharges (leakage, spills, etc.).
- Monitoring and controlling aquatic toxicity where materials with known aquatic toxicity are discharged at quantities that may have an environmental impact, then the discharge should be monitored according to the type of material and a frequency necessary to enable control of the discharge.

BAT is to identify significant noise sources and any potential sensitive receptors in the vicinity. Where noise may have an impact, BAT is to use good practice techniques such as:

- Conduct a noise survey and mark out dedicated areas with signage where there are elevated noise levels and PPE is required.
- Enclose noisy machines to isolate people from the noise where practicable.
- Reduce vibration exposure times and provide PPE where people may be exposed to vibration.
- Limit scrap handling and transport during unsocial hours to reduce noise.

Noise management

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- Enclose noisy machines to isolate people from the noise where practicable.
- Reduce vibration exposure times and provide PPE where people may be exposed to vibration.
- Limit scrap handling and transport during unsocial hours to reduce noise.

Decommissioning management

BAT is to minimise consumptions and emissions also in case of decommissioning by reducing unplanned emissions, recording the history of usage of priority and hazardous chemicals and dealing promptly with potential contamination.

Design considerations for end-of-life plant decommissioning are:

- giving consideration to the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant, as forethought makes decommissioning easier, cleaner and cheaper
- decommissioning poses environmental risks for the contamination of land (and groundwater) and generates large quantities of solid waste. Preventive techniques are process-specific but general considerations may include:
 - I. avoiding underground structures*
 - II. incorporating features that facilitate dismantling*
 - III. choosing surface finishes that are easily decontaminated*
 - IV. using an equipment configuration that minimises trapped chemicals and facilitates drain-down or cleaning*
 - V. designing flexible, self-contained units that enable phased closure*
 - VI. Using biodegradable and recyclable materials where possible.*

B. BAT conclusions for Press shop and surface preparation

Air emissions

1. BAT for degreasing operations is for use of *water-based degreasing* which remove Oil, grease and dirt from metal or plastic substrates with water-based detergent solutions. A reduction of solvent emissions, particularly halogenated solvents, is obtained.
2. BAT for volatilisation during storage, fugitive losses during use, and direct ventilation of fumes provides :
 - *Encapsulation/enclosure*: reduction of fugitive emission. Part of the machinery or whole lines to avoid the release of fugitive emissions make the workplace more health and safety, reduce the risk of injuries from machinery and reduce noise. Enclosure or encapsulation reduces the volumes of air to be extracted, and therefore reduces the size of extraction fan motors and waste gas treatment where applied.
 - *Air extraction*: reduction of solvent emissions.
 - *Dust abatement* throughout pre-treatment, filtration and scrubbing including:
 - I. Increasing the external air concentration using a plenum: reduction of the net air volume to be treated by the abatement techniques.
 - II. Venturi particle separation;
 - III. Scrubber

Water and wastewater

1. The BAT for reduce waste water and for treatment of waste water in degreasing operations are:
 - *Multiple (cascade) rinsing* for minimize the consumption of water.
 - *Use of ion exchanger* (Figure 4.10) for bath maintenance and water saving in the phosphating step.

- *Membrane filtration* for reduction of water consumption (contaminants are more concentrated).
- *Bath desludging* for bath maintenance operation in the body shop .

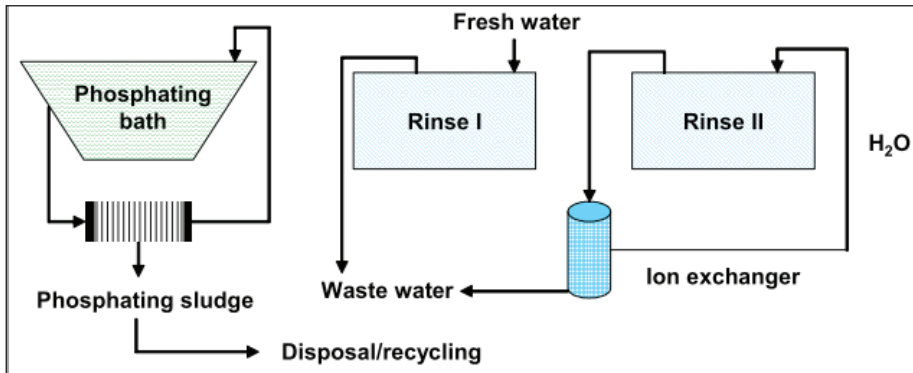


Figure 4.10- Schematic of a phosphating unit with an ion exchanger

2. BAT is to treat the effluent water from press shop where rinsing water is used or where a wet waste gas treatment system is applied.

Production residues

1. BAT is to prevent waste generation within press shop with the selective recycling of metal wastes (eg. copper, chromium and nickel) back to the process.
2. BAT is to reuse cutting oils and metal working fluids regenerating them after process by filtration.
3. BAT is to minimizing the possible release of oil to soil, surface water, groundwater and topsoil. A possible technique is the use of *oil tight trays* that permit to collect the losses of oil from hydraulic systems in a sort of tank and avoid the leakage of oil.

Energy

1. BAT is to reduce/minimise thermal energy consumption in stamping plants by using one or a combination of the following techniques:

- Stamping presses can utilize variable voltage controls (VVCs) to avoid voltage unbalance which can degrade the performance and shortens the life of three-phase motors.
- Air actuators die cushions on large stamping presses are used to support inserts in the lower die. These units, after only 3 months of use on a “moderately sized” stamping press, will often produce leaks of 100 ft³/min. In a large stamping plant with 200 presses, this translates to 4 MW of electricity. Air actuators that have replaced the pistons on die cushions have shown little or no leakage for over five years. One stamping plant in Michigan reported 25% reduction in compressed air by converting half of its presses. In addition to energy savings, replacing pistons with air actuators produces a more consistent product and greatly reduced maintenance, with maintenance savings comparable to the energy savings.

C. BAT conclusions for metal finishing and electroplating

Air emissions

1. BAT is to reduce the gas emissions from :
 - plating operations that generate mists due to the evolution of hydrogen and oxygen gas;
 - air sparking process that can result in emissions from the bursting of air bubbles at the surface of the plating tank liquid;
 - surface preparation steps that generate emissions (such as alkaline cleaning, acid dipping, vapour degreasing); these emissions are in the form of alkaline and acid mists and solvent vapours.
2. BAT is to reduce fugitive air emissions in the installation. High process control reduces chemical and water usage by using one of the following techniques:
 1. *Encapsulation* of integrated surface treatment line with extraction system;

II. Exhaust air *wet scrubbers* where water or specific chemical solutions are sprayed into the wet scrubbers usually (but not always) counter current to the gas flow.

3. BAT is to reduce NO_x emissions from the surface preparation section by applying process-integrated techniques, such as :

- Reduction of NO_x could be achieved by selective reduction using $(\text{NH}_2)\text{-X}$ compounds (with $\text{X} = \text{H}, \text{CN}$ or CONH_2) injected into the gas stream. The most common reducing agent is ammonia. Both non-catalytic (SNCR) and catalytic (SCR) techniques exist.
- Wet scrubbing

Water and wastewater

1. BAT for metal finishing and electroplating plants is to minimise the water consumption and discharge of scrubbing, wet rinsing and cooling water and reuse it as much as possible by:

- monitoring all points of water and materials usage in an installation, record the information on a regular basis, according to the usage and the control information required;
- recovering water from rinsing solutions and after treatment recycling/re-use;
- avoiding the need for rinsing between activities by using compatible chemicals in sequential activities.

2. BAT for metal finishing and electroplating plants is to treat the effluent water prior to discharge. The techniques commonly used to treat waste water are:

- I. Flocculation
- II. Electro flocculation
- III. Vacuum distillation
- IV. Biological treatment
- V. Ultra and Nano filtration and reverse osmosis

Production residues

1. BAT is to prevent waste generation from surface treatment. There are four key factors for the avoidance and minimisation of waste in surface treatment processes, and they are described in the appropriate sections:
 - reducing the amount of hazardous material in the waste,
 - extension of the service lifetime of the process solutions,
 - decrease of the drag-out of process solutions,
 - feedback of the dragged-out process solutions into the process tanks.
2. BAT is to re-use and recycling of waste. The following are examples of external valorisation:
 - Hydro and pyrometallurgical companies engaged in non-ferrous metal refining. Part of the electroplating sludge may have a high value material content and recycling by third parties can be arranged in many cases. Recycling includes refining of the metals copper, nickel, chromium and zinc from suitable electroplating sludge as metals or metal compounds.
 - Manufacture of usable metal concentrates.
 - Reuse of phosphoric and chromic acids, spent etching solutions, etc.
 - Aluminium hydroxide from anodising can be precipitated and recycled, for example as a coagulant for sewage treatment (the rinsing waters from colouring and sealing processes may contain heavy metals and it is advisable to collect sludge separately from these waste water streams if re-use is required).
 - Inorganic chemical companies and the glass and ceramics industry which use metals or metal compounds intentionally in the manufacture of products.

Energy

1. BAT is to reduce/minimise thermal energy consumption in metal finishing and electroplating plants by using one or a combination of the following techniques:

- I. Improve thermal efficiency of heating equipment to minimise heat loss.
 - II. Implement heat recovery processes, such as steam rising boilers to capture hot gases and re-use elsewhere in operation or for generating energy.
 - III. Monitor and target energy usage and implement behavioural change programmes.
2. BAT is to reduce heating losses from process solutions but actual techniques used may depend on the options to re-use heat, the availability of renewable energy supplies and local climatic conditions.
 3. It is good practice for process solutions to be agitated to keep a consistent solution concentration throughout the vat. Agitation of anodising solutions is essential to maintain a constant temperature in the bath and remove heat from the surface of the aluminium.

The energy saving options are:

- compressed air through nozzles
- low pressure air
- hydraulic turbulence
- Agitation of the work pieces by moving the flight bars or rods by cams or motors

The use of compressed air gives high evaporative heat losses, especially when used in conjunction with air extraction as well as energy consumption by the compressor. However, the energy losses may be negligible when used in very small tanks.

D. BAT conclusions for paint shop

Air emissions

The paint process in the vehicle manufacturing industry is a highly complex and fully integrated operation consisting of many interdependent steps.

1. BAT is to use coatings and paints with low concentrations of organic solvents by choosing one of the following options:
 - *Water-based paints* normally have a water content of 10÷65% and often also contain <3÷18% organic solvents as a solubiliser and for an improvement of the properties of the wet film layer.
 - *Radiation curing paints* that has a particularly chemical group that can be activated by UV light or fast electrons. It is possible to produce liquid coating systems that cure and harden without heat and without any emission of VOCs.
 - *Powder coatings conventionally cured* are solvent-free materials that consist of powder with a particle size in the range 25÷60 µm.
 - *Powder slurry* are powders dispersed and stabilised in water and are applied using conventional equipment for liquid paints.
2. BAT is to reduce VOC emissions and increase the possibility for recycling of the paint in use in certain applications, by using one or a combination of the following techniques:
 - *Hot spraying of paint material*: reduction of the amount thinners and, consequentially, obtaining lower VOC emissions.
 - *CO₂ atomisation (the unicarb system)*: the organic compounds are replaced by CO₂, which is fed to the high viscous paint material.
 - *Electrostatic atomising processes*: paint material is atomised via an electric field.
 - *Electrostatically assisted compressed air, airless and air assisted spraying*: the atomization is realized via hydrostatic pressure of material.

3. BAT is to use techniques to manage overspray that have to be caught using one or a combination of following techniques:
 - *Wet separation spray booth* where overspray in a spray booth is intercepted by applying a water curtain.
 - *Paint-in-paint spray booth* where overspray in a paint spraying process is partly collected by a screen made of Teflon.
 - *Water emulsion techniques* permit a particle separation of over 99 % and achieve a remaining particle content of $<3 \text{ mg/m}^3$ in the exhaust airflow.
 - *Cold plate spray booths*.
4. BAT are to abate dust and particle contained in gas waste by using one or a combination of the following techniques:
 - *Membrane filtration* where the VOC rich gas is passed through an organic selective membrane module.
 - *Venturi particle separation*.
 - *Scrubber* where waste gas are separated in air flowed scrubber collectors by intensive mixing of waste air with water.
 - *Oxidation*.
5. BAT is to avoid air emission from paint shop capturing and treat waste gas by air extraction. Air may be extracted from the application machinery used in the main process. The application equipment may be open (in reality, extraction is from the whole room: this is used in some industries for health and safety reasons) or partially or wholly enclosed.

Water and wastewater

1. BAT is to avoid material losses and emissions to water, to reduce water usage and consequently reduce the need for waste water treatment by means of the following operations :
 - *Continuous discharge of paint sludge*: in wet separation spray booths the service life of the water can be increased up to one year by the continuous discharge of paint sludge.

- *Decantation system.*
 - *Coagulation of paint solids in wet cleaner* for reducing the consumption of water (commonly applied in the automotive industry).
2. BAT is to apply wastewater treatment that could be on-site or off-site. Techniques to reduce waste water include treating waste water from paint spray booths (Figure 4.11) and the aim is to reach the values show in Table 4.5:

Table 4.5 Contaminants and law limits

Contaminants	Limit value (mg/l)
BOD₅ (where discharged to a river or controlled water)	100
COD (where discharged to a municipal waste water treatment plant)	2500
Suspended solid (where discharged to a municipal waste water treatment plant)	1000

The techniques commonly uses to treat wastewater are:

- VI. Flocculation
- VII. Electro flocculation
- VIII. Vacuum distillation
- IX. Biological treatment
- X. Ultra and Nano filtration and reverse osmosis

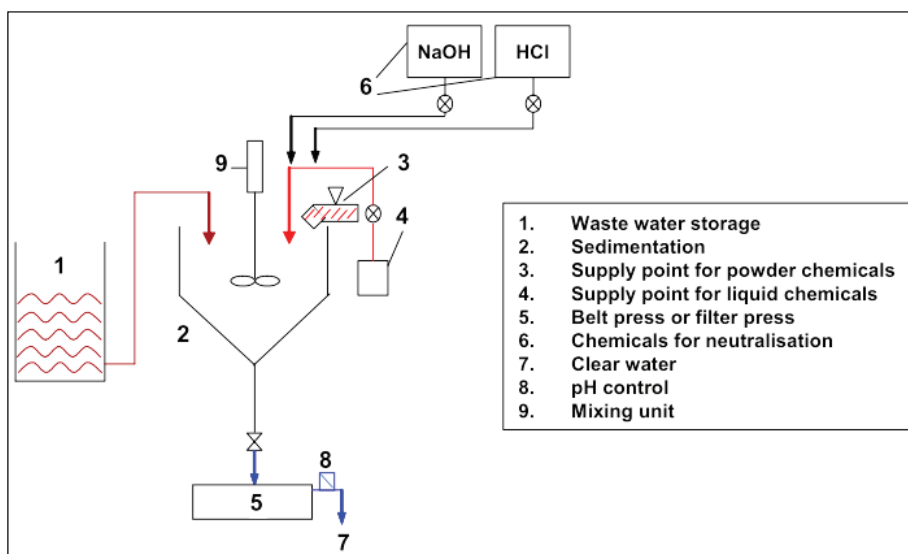


Figure 4.11 Scheme of waste water treatment applied in a wet separation spray booth

(with reference to Kluthe Benelux BV)

Production residues

1. BAT is to minimise waste containing solvent through recovery and re-use :
 - *Recovery of used solvents from the process*: used solvents, e.g. used for cleaning, can be treated for re-use, e.g. by filtration or distillation.
 - *Treatment of used solvents for re-use* by distillation and filtration.

2. BAT is to treat of activated carbon used to treat waste gases. When the surface of the adsorbent has adsorbed nearly as much as it can, the efficiency of adsorption decreases. The adsorbent is then usually regenerated by desorbing the retained solvents by one of the following process:
 - *On-site recovery of the used activated carbon* and other adsorbents by heat treatment.

- *Off-site regeneration/solvent removal of the used activated carbon* and other adsorbents.
 - *Incineration of the used activated carbon* or other adsorbents.
3. BAT is to manage wastewater sludges produced in paint shop by one of the following process:
- *Centrifuges*: for dewatering waste (paint sludges, phosphate sludge) and reducing waste volume and weight.
 - *Filter press*

Transfer efficiency of coatings

1. It is BAT to optimise transfer efficiency of coatings. The following techniques have the highest transfer efficiencies:
- robot application
 - dipping instead of spraying
 - electrostatic application
 - HVLP (high volume low pressure) guns
 - booth optimisation

Energy

- I. BAT is to maximise energy efficiency and minimise energy losses. In paint shop drying of paint is one of the most energy consuming processes and it can be actuated through evaporation process that are :
- *Induction drying*,
 - *Radiation drying (microwave and high frequency drying)*.
 - *Infrared radiation curing*

E. BAT conclusions for Assembly

Production residues

The main impact produced in assembly plants come from packaging that result in solid waste. BAT is to develop an advances packaging design, changes in purchasing, and eliminate the unneeded materials. These actions can have greatly reduced the amount of expendable waste generated.

4.4 New forms of organizing work

4.4.1 Introduction

Automotive sector is suffering a huge problem of productive overcapacity for several years. The huge parking lots of unsold or waiting-for-sale cars in different parts of the world are an example.

Competition between producers became more and more ruthless: everyone is looking for ways to reduce costs and offer innovative products with the attempt of tearing market shares off from competitors.

Along with mergers and joint ventures, collaborations and synergies are growing in sectors of specific products, following strategic lines of product specialisation from the one part, and extension of productive volume from the other part.

The automotive sector, among series or lots productive typologies, is certainly the one which is characterized by complexity and demanded for continuous innovations. One has to deal with the managing of basic itemized lists which include hundreds of thousands part numbers, trimmings and variations among the most eccentric. A middle-sector car can include more than 50 electrical boxes which manage 2000 software parameters and it is offered with about 200 options and a range of combinations which overcomes 2000.

From the one part, the offer is in continuous growth since it is more and more customized for what concerns the demands of single customer, according to a pull logic which borders on artisanal design. From the other part, industrial strategies for cost reduction are strengthened through product architectures which are applied on greater volumes.

Benchmarking level really impresses if we think it developed among different plants of various global builders, a sort of manufacturing Olympic Games. Of course, putting various productive processes and competitiveness data under the incisive microscope of experts is not uncommon; Harbour Report, JD Power, Agamas are all structures which evaluate and correlate productivity data and quality of various automotive productive processes.

Automotive manufacturing today it is an interesting place for different aspects: industrial, environmental, sociological, psychological and aesthetical.

This new organisational dynamics gives new dignity to manufacturing, which consequently expands itself to its main performers: labourers. Innovation hasn't got just a direction anymore (top-down), but it grows through technical-experiential knowledge (bottom-up) which have been increased by protagonists of the production line. Proficiencies of an engineer complete (but don't "trample on") the ones of technicians and shop floor operators: an equal level relation is generated, a virtuous cycle which is fed by fieldwork in addition to theoretical contribution.

4.4.2 World Class Manufacturing, a successful model

The definition of World Class Manufacturing (WCM) was born in the mid 80s and indicates the set of methods and procedures developed to improve production and working conditions in companies.

Richard J. Schonberger, professor at the University of Nebraska and president of Schonberger & Associates, is considered the creator of the World Class Manufacturing (WCM) for his contribute in the field of Production, Logistics, Maintenance, Quality, Planning and Control.

Schonberger was inspired by what is seen in Japan during his travels among the best companies of the Rising Sun, including the automotive giant Toyota. In Toyota is applied an innovative model defined precisely Toyotism - also known as lean system - based on how to make the products simultaneously, as quickly as possible, economic and high quality.

This philosophy is summed up in two Japanese terms: "muda" and "kaizen" translatable with the elimination of waste and continuous

improvement. The WCM is an industrial approach, in which all the players are involved: from workers to top management. Rigorous methodological approach, field testing, continuing education, fight against waste, attention to safety and working conditions are the foundations of this new model. The continuous improvement of performance is measured through a series of periodic evaluations at the end of which is assigned a score that leads to the recognition of awards that depart from bronze and then became silver, gold and world class. Not just a symbolic statement but also a cash prize for the employees.

The WCM structure is summarized in the fig. 4.12.

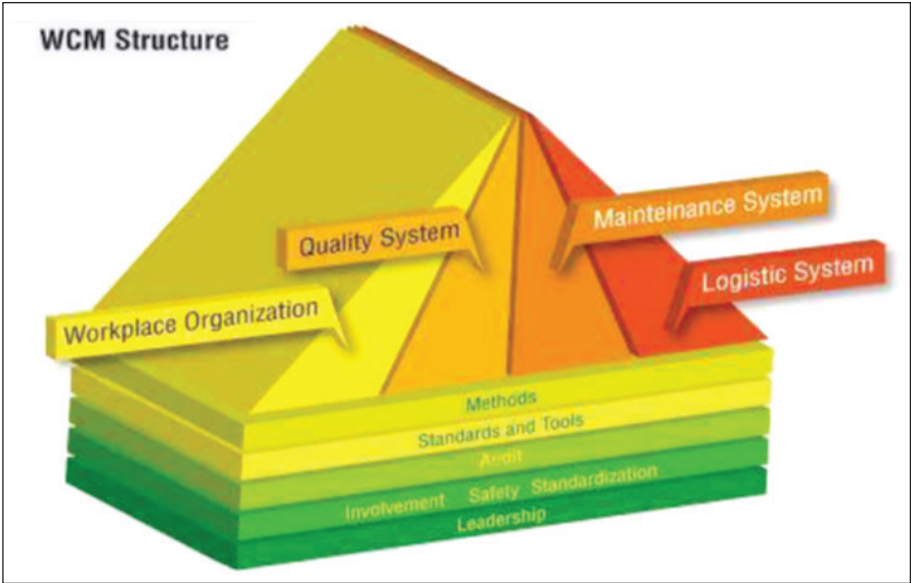


Figure 4.12 WCM structure

As for the automobile sector, finally abandoned the assembly line designed by Henry Ford, the work takes place in a clean, low-noise, ergonomics, supported by high technology, participating and improving the production processes without accumulation of goods in stock.

4.4.3. Evolution of the assembly line

An assembly line is a manufacturing process in which interchangeable parts are added to a product in a sequential manner to create an end product. In most cases, a manufacturing assembly line is a system through which a product moves. At each station along the line some

part of the production process takes place. While assembly line methods apply primarily to manufacturing processes, business experts have also been known to apply these principles to other areas of business, from product development to management.

The passage of years has brought numerous variations in assembly line methodologies. These new variations can be traced back not only to general improvements in technology and planning, but to factors that are unique to each company or industry. Following are brief descriptions of assembly line methods that are currently enjoying some degree of popularity in the manufacturing world.

- *Modular Assembly*—This is an advanced assembly line method that is designed to improve throughput by increasing the efficiency of parallel subassembly lines feeding into the final assembly line. As applied to automobile manufacturing, modular assembly would involve assembling separate modules (chassis, interior, body) on their own assembly lines, then joining them together on a final assembly line.
- *Cell Manufacturing*. This production method has evolved out of increased ability of machines to perform multiple tasks. Cell operators can handle three or four tasks, and robots are used for such operations as materials handling and welding. Cells of machines can be run by one operator or a multi-person work cell. In these machine cells it is possible to link older machines with newer ones, thus reducing the amount of investment required for new machinery.
- *Team Production*. Team-oriented production is another development in assembly line methods. Where workers used to work at one- or two-person work stations and perform repetitive tasks, now teams of workers can follow a job down the assembly line through its final quality checks. The team production approach has been hailed by supporters as one that creates greater worker involvement in the manufacturing process and knowledge of the system.
- *U-shaped assembly “line”*. A line may not be the most efficient shape in which to organize an assembly line. On a U-shaped line, or curve, workers are collected on the inside of the curve and communication is easier than along the length of a straight line. Assemblers can see each process; what is coming and how fast; and one person can

perform multiple operations. Also, workstations along the “line” are able to produce multiple product designs simultaneously, making the facility as a whole more flexible. Changeovers are easier in a U-shaped line as well and, with better communication between workers, cross-training is also simplified. The benefits of the U-shaped line have served to increase their use widely.

Moreover, computer power has made it possible to reduce the costs associated with holding inventories. Just-in-time (JIT) manufacturing methods have been developed to reduce the cost of carrying parts and supplies as inventory. Under a JIT system, manufacturing plants carry only one or a few days’ worth of inventory in the plant, relying on suppliers to provide parts and materials on an “as needed” basis. Future developments in this area may include suppliers establishing operations within the manufacturing facility itself or increased electronic links between manufacturers and suppliers to provide for a more efficient supply of materials and parts.

4.4.4 Advanced Lean Systems

In the 90’s, there have been different occidental attempts which tried to best emulate Toyota intuitions and practices. After that, different automotive players developed more surely well-structured and efficient methodologies.

If we exclude excessively easy emulations - unfortunately still current – from the refined Toyota architecture, we can see a significant growth of lean business structures of good level in the latest years, especially in Europe. The breakthrough happened when companies decided not to conceive the lean organisation as a group of practical tools for reducing costs and increase efficiency anymore, but as a new organisational philosophy.

Without trivializing the topic of costs, inefficiencies and the huge range of experimented best practices for reducing them, advanced lean systems are based on new paradigms, where the most important plus are: team working, growth of proficiencies and autonomy, early work place planning, environment and energy as strategic “partners”, obsessive evaluation of each specifics, continuous development of good ideas.

In the world, there is the common and historical idea that machines and automation will save us, but it is widely proved that people make the difference. Of course, we have to consider the precious contribution of technological innovation that is going to develop more and more, but we must remind that manual skills contribution and people's organised intellect are decisive factors in manufacturing complex objects as cars.

Basically, advanced lean systems try to use everything in a smart way, without hyperbolic leaks. Technology and telecommunications will be surely essential in the future, but nothing will ever replace people's ability and creativity.

It doesn't convince the risk of automaton drift, which exalts the role of robots and telecommunications routine as they were the world's panacea. Real innovation must be evaluated with growth or decrease criteria of collective wealth, that's why people and relations between them will always have an incisive role in the cyber-physical society too.

4.4.5 Digital Factory

Some researchers connect latest discoveries and the future ones to the terrible secular stagnation phenomena. In their opinion, future inventions won't have enough potential of production transformation as the previous technological revolutions. There would be great innovations in consumption, but they wouldn't be able to deeply affect society, whereas demographic changes which generate shattering social impacts are usually considered deep innovations. Therefore, we would be in front of a continuity of innovations, not a revolution proper.

Among the digitalization forms of processes of automotive sector, we can already find new generation robots which are characterized by artificial intelligence and deep learning. Advanced configurations of 3D simulation are very suggestive and useful for the right ergonomic design of workplaces, or border line touch screens through which an operator constantly speaks with a well-structured net: team leader, supervisor, supply chain, quality, and best practices network. In prototype phase, the use of exoskeletons – which could further reduce peoples' biomechanical load – just like semi-automatic partners and weight cancellers are already doing. In the next years, the IoT will replace advanced IT and RFID systems and it will allow an immediate

production management (synchronous use). 3D printers are already used for the production of small lots or specific details and they are going to have a considerable development and spreading of use. The idea of each physical worker having its own “digital” replicated image aside is futuristic, but maybe not so much.

Also with the perspective of a new industrial configuration, it is useful to take into account a suggestion coming from Japanese wisdom and which recommends to keep together: Monozukuri (art of doing things well) and Hitozukuri (art of making people grow).

4.4.6 Reinventing training processes

The risk of automaton drift will remain widely present, the winning challenge won't be trying to obstruct innovation, but trying to guide it for a society advantage. One of the most important things for this purpose is investing on training and, above all, reinventing modalities whereby one experiments efficient learning processes.

Car producers are proposing Academies again as continuous training structures and innovation. There is a recurrent reference between head quarter and suburbs, plant and innovation centre, in a hermeneutic circle which generates renovation, best practices, patents.

Classroom traditional training is more and more improper; even if it has been called into question since a lot of time, it is still practiced. Without belittling traditional frontal lessons, it is also necessary to review the model in order to make it more interactive and shared.

Labs, learn by doing experiences, informal focus groups, relationships between theory and practice, knowledge and experience.

If it's true, as smart organisations discovered, that everyone can contribute with intellect and create value and renovation, one-directional systems, where someone knows and teaches and others learn, cannot work anymore.

Equal exchange experiences are interesting, maybe of different competences, but with the same dignity. This kind of mutual engagement which is generated, it stimulates people to feel enhanced and the organisation to continuously improve, which is an indispensable factor for the third millennium.

4.5 Case history: Fiat Chrysler Automobiles (FCA)

4.5.1 Premise

Fiat Chrysler Automobiles is a Italian-American multinational company leader in the automobiles sector. FCA was born from the merger of two historic automobile groups: Fiat, founded in 1899, and Chrysler, founded in 1925. The seventh automaker in the world, it designs, develops, manufactures and it is involve in the trades market of cars, commercial vehicles, components and production systems around the world. Actually FIAT, Alfa Romeo, Maserati, Lancia, Fiat Professional, Abarth, Jeep, Chrysler, Dodge, Ram Trucks, Mopar, SRT brands are part of the Group.

FCA operates through companies located in 40 countries and has commercial relationships with customers in approximately 150 countries. It counts 235,000 employees.

The Group's operating activities are organized on a regional basis and assigned to four areas representing four geographic regions: NAFTA (United States, Canada and Mexico), LATAM (South America and Central America excluding Mexico), APAC (Asia and Pacific) and EMEA (Europe, Russia, Middle East and Africa).

FCA is one of the most sustainable automotive companies in the world. Every day is actively contributing to the transition towards a circular economy. With the circular economy products and their components are designed to be recovered or recycled to prolong their life cycle to the benefit of the environment. The transition towards a circular economy offers significant benefits from the point of view of economic sustainability.

4.5.2 Environment and climate change

Central to FCA's approach is the belief that effective, lasting solutions to climate change and other pressing environmental issues can only be achieved through an integrated approach that combines individual and collective commitment; an effective multi-stakeholder strategy; investment in enabling premium processes and technologies; and the incorporation of circular economy principles in operations. All

of these elements are an integral part of FCA's model of operating responsibility⁽¹²⁾.

This means designing and making vehicles more environmentally friendly, but also minimize emissions of establishments and optimize production processes for a more efficient management of natural resources. The Environmental Guidelines defines the best practices in terms of environmental protection, waste reduction, optimizing water and energy consumption.

In line with these results, the company also aims to achieve specific goals in terms of environmental impact reduction, by taking into account the following items:

- reduce energy consumption through more efficient production processes and products;
- limit emissions of greenhouse gases and other pollutants through the implementation of innovative technical solutions and promotion of safe and economical renewable energy sources;
- minimize consumption of raw materials by promoting the use of renewable and recycled materials in the production processes;
- minimize waste, in particular hazardous waste, or encouraging the use of reusable and environmentally-friendly packaging and containers in order to increase material savings and reduce waste;
- reduce consumption of fresh water, increase its reuse and recycling, and prevent to any possible extent emissions of hazardous substances to water from manufacturing⁽¹³⁾.

In all establishments of the world they have introduced an Environmental Management System based on methods and procedures to optimize the environmental performance. The application of World Class

¹² FCA, 2015 Sustainability Report,
http://reports.fcagroup.com/sustainability/2015/sites/fcacsrl5/files/download_center/2015_sustainability_report.pdf

¹³ FCA, 2015 Environmental Guidelines,
https://www.fcagroup.com/en-US/sustainability/FiatDocuments/LG_Environmental.pdf.

Manufacturing⁽¹⁴⁾ to all establishments, a methodology that seeks the continuous improvement of the performance of production processes, contributed to the development of instruments and methods that provide support in reaching targets to curb the environmental impact of plants while aiming to cut waste and optimize energy use.

4.5.3 Emissions

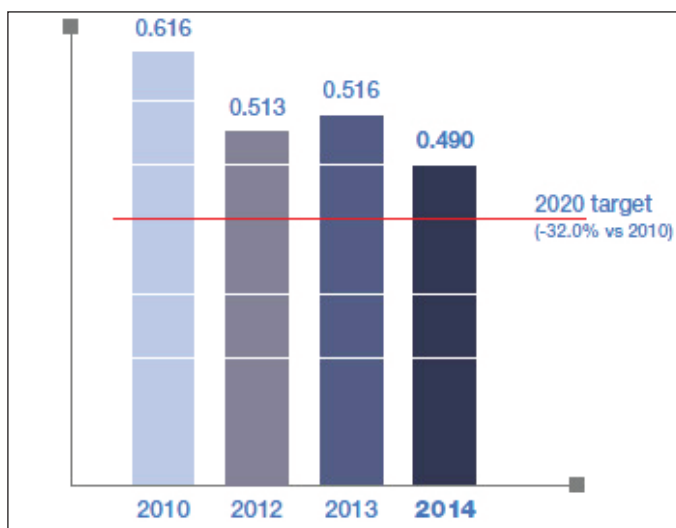
With the inclusion in the “A” List in the Climate Change CDP⁽¹⁵⁾ 2016 initiative, the FCA Group was again recognized among the global leaders for his commitment and the significant results achieved in the fight against climate change. FCA recognizes its role in addressing climate change effects along its value chain and aims to reduce the CO2 emissions of its products and processes from design, production, distribution, use and the end-of-life phase. The Company has established long-term targets aimed at reducing the environmental footprint.

In 2014, total CO2 emissions were roughly in line with the amount reported in 2013, for a total of about 4 million tons aided by the 2,700 energy projects that were launched in 2014, which saved €44 million. Emissions of CO2 per vehicle produced at Mass-Market Brand assembly and stamping plants decreased 20.5% in the last five years, falling from 0.616 tons per vehicle produced in 2010 to 0.490 tons per vehicle produced.

Numerous best practices have been introduced at the Melfi plant. For example, heat from operation of a trigenerator plant is reused to heat and cool fluids and mini wind/photovoltaic hybrid generators have been installed to meet a portion of the offices’ energy requirements. These measures, in addition to efficient energy management practices at the plant (ISO 14001 certified since 2001; ISO 50001 certified since 2011) have resulted in a 37% reduction in CO2 emitted per vehicle produced (2014 vs 2009).

¹⁴ WCM is an integral part of the Group’s Environmental Management System (EMS). This pillar is dedicated through the achievement of four key goals: zero accidents, zero waste, zero breakdowns and zero inventory

¹⁵ CDP is an international non-profit organization that provides companies and the only city global system for measurement, publishing, managing and sharing the most important environmental information on carbon emissions, water consumption and conservation of stocks natural woodland. CDP works on behalf of 822 institutional investors managing more than a third of the Capital invested in the world.



Source: FCA, 2014 Sustainability Report

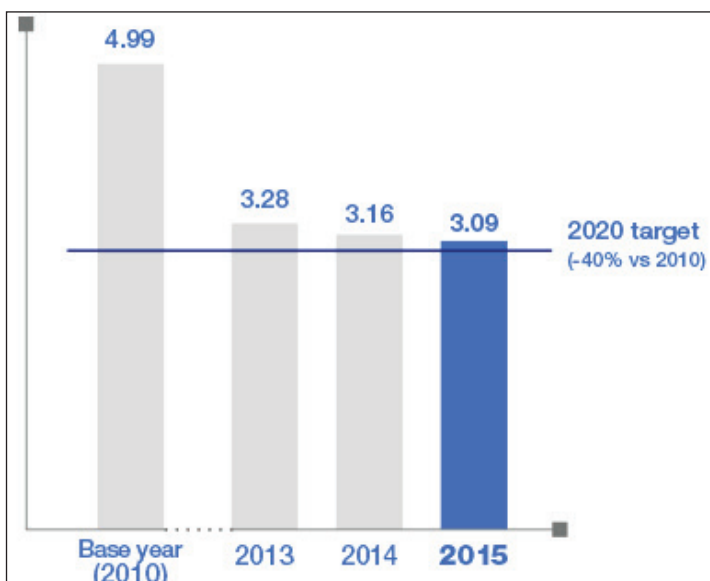
4.5.4 Water Management

FCA sees water as one of the most important natural resources to be protected. With this aim, they have drawn up the Water Management Guidelines to apply to all Group companies. These provide the principles for sustainable management of the entire water cycle and place greater emphasis on reducing consumption of water resources, especially in water-stressed regions where water is a limited resource and its availability is critical to the surrounding environment and population.

As a result of improvements in water cycle management and measures taken to reuse water in industrial processes, in 2015 FCA reduced overall water consumption by 1.4% compared with 2014 (from 25.3 to 24.9 million m³) and by 27.1% compared with 2010 (from 34.2 to 24.9 million m³). Projects to cut the quantity of water consumed led to an overall savings of about €2.7 million in 2015¹⁶.

In 2015, the water consumption per vehicle produced is reduced by 2.2% and the recycling within FCA plants in about 98%.

¹⁶ FCA, 2015 Sustainability Report, http://reports.fcagroup.com/sustainability/2015/sites/fcacr15/files/download_center/2015_sustainability_report.pdf



Source: FCA, 2015 Sustainability Report

At the Melfi Plant Water consumption per vehicle produced was down 43% compared with 2009 as a result of measures that enable regular monitoring of the water network to prevent leakage and a decrease in the amount of water used in painting processes..

4.5.5 Waste Management

FCA has implemented procedures to ensure maximum recovery and reuse of materials and minimum waste. In all industrial processes the objective is to recover, recycle and reuse raw materials. Anything that cannot be reused is recycled. Where waste cannot be recycled or reused, it is often dismantled using technologies with a lower environmental impact as possible, with sending to landfill only as a last choice⁽¹⁷⁾. These principles are applied in all plants worldwide. Waste management initiatives were implemented at Melfi plant to improve and standardize the waste separation process, resulting in 93.5% of waste being recovered and zero waste to landfill in 2014.

¹⁷ FCA, 2012 Waste Management Guidelines.



Source: FCA, 2015 Sustainability Report

Thanks to the waste separated process implemented at Melfi, there are two results: the volume of by-products has been reduced by 65%, and all materials are now reusable, meaning zero waste. These results, also due by the recent improvements in the technologies and processes employed in the paint shop, together with the technological improvements introduced for production of the new SUVs, have enabled FCA Melfi to register its best ever performance in environmental terms.

4.5.6 Environmental Remediation Actions

The strong employee engagement and continuous improvements in environmental performance at the plant level is an essential part of FCA's strategy to generate sustainable, long-term value for stakeholders. Energy managers at each company within the Group are responsible for overseeing facility environmental activities and directing capital investments dedicated to specific action plans. They monitor developments with national and local laws and regulations related to the environment and they conduct periodic compliance audits. At the end of 2015, 146 Group plants were ISO 14001 certified; the plants without that certification are audited by the central Environment Health and Safety Unit (EHS). About Energy Management System, at December 2015 the majority of Group plants were ISO 50001 certified representing approximately 94% of the Group's total energy

consumption. The Group EMS and EnMS, with WCM methodologies and tools, they contribute to reduction in the impact of manufacturing processes and to achievement of environmental objectives. To manage and minimize environmental and safety risks, a preventive and proactive approach is employed. Participation of employees and targeted training programs are the key of WCM's success. Exceeding the most effective processes to all plants is enable to reduce the environmental footprint: action plants aimed at reducing the environmental footprint and ensuring financial sustainability are in place at all plants.

Chapter 5

“The Treatment and Valorization of Materials at the End of the Cycle of Life”

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5.2.2 The life cycle of an automobile

This chapter takes into account the treatment and valorization of the household appliances (see paragraph 5.1) and the motor vehicles (see paragraph 5.2) at the end of the cycle of life. It is worthwhile noticing that the processes and technologies described in this chapter are similar to those usable at the end of the cycle of life of a lot of electrical and electronic equipment, such as computers, TVs, hairdryers, digital watches, electronic toys, medical devices, etc.

As for the iron & steel industry, this sector is essentially aimed at producing the basic feedstock for other productions. Moreover, steelworks release large amounts of solid residues that are recycled in the steelmaking plant itself or reutilized in other factories. Consequently, this chapter doesn't deal specifically with the iron & steel industry too.

5.1 Recycling applied to the household appliances production

5.1.1 Extraction of reusable and recyclable materials

Premise

Large household appliances are an essential part (40%) of the industrial sector producing Electrical and Electronic Equipments (EEEs). Other significant EEEs are IT equipments (mainly computers), TVs, small household appliances (e.g. kettles and hairdryers), electrical tools, digital watches, electronics toys and medical devices. The new Directive 2012/19/EU on the Waste Electrical and Electronic Equipment (WEEE), which recasts the previous Directive 2002/96/EC, contributes to the sustainable production and consumption of EEEs by, as a first priority, the prevention of WEEE and, in addition, by the reuse, recycling and other form of recovery of such wastes.

As a result of this complex mix of product types and materials, some of which are hazardous (including arsenic, cadmium, lead and mercury and certain flame retardants), WEEE recycling poses a number of health risks that need to be adequately managed.

The exact treatment of WEEE can vary enormously according to the category of WEEE and technology that is used. Some treatment

facilities utilise large-scale shredding technologies, whilst others use a disassembly process, which can be manual, automated or a combination of both.

Once abandoned, a device can be recycled in three ways:

- a) The re-use of equipment. If the equipment disposed still works, you can extend the life cycle, postponing the actual treatment process. In this case it is not correct to speak of WEEE. Reuse is possible only for those products that do not contain mercury or substances harmful to the ozone.
- b) Re-use of components. You can reuse some parts still in perfect working of equipment abandoned, using them on new equipment or component parts.
- c) Recovery and recycling of materials. You can reuse materials contained in WEEE as secondary raw material in the production process of other goods.

Main steps of waste management

Reception and collection represent a very delicate phase that must be performed to ensure the integrity of the asset disposed during collection and transportation. In doing this the incoming wastes to the recycling centre are subjected, as required by law, to radiometric control, to verify the presence of radioactive substances.

Pre-treatment and safety take out preliminary processing of moving parts and the removal of any hazardous materials, such as chlorofluorocarbons, used oils, cathode ray tubes, electronic boards, flammable substances.

Removing and recovery of components include a series of operations, mainly manual, involving the dismantling of the apparatus in its individual components, to facilitate the processes of recovery and reuse as secondary raw materials.

Crushing and screening materials are phases of high automation, to select the materials for the recovery of materials and energy. At this stage the selected materials are reintroduced into the production cycle. For materials whose reuse is not possible, the law provides for the recovery of energy through incineration.

Disposal concerns the portion of waste that neither can be reused nor sent to the incinerator before disposal, hazardous substances are first made inert.

As can be seen in the Figures 5.1, 5.2, 5.3, and 5.4, the first mechanical operation on waste takes place in a plant of grinding, comprising a series of crusher mills in cascade.

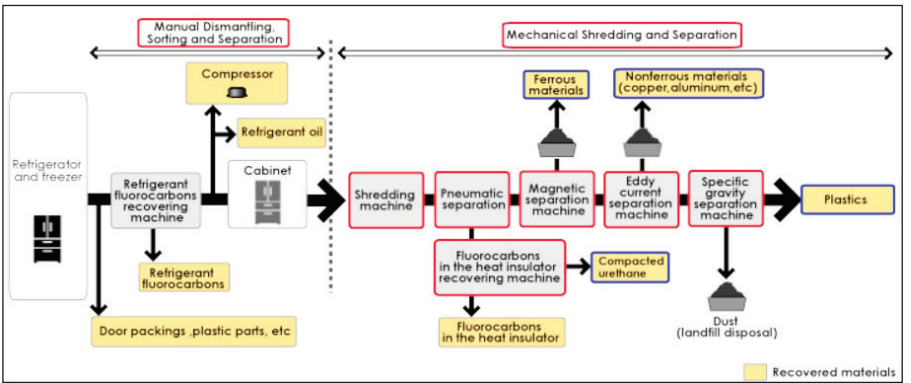


Figure 5.1 Recycle of refrigerator and freezer

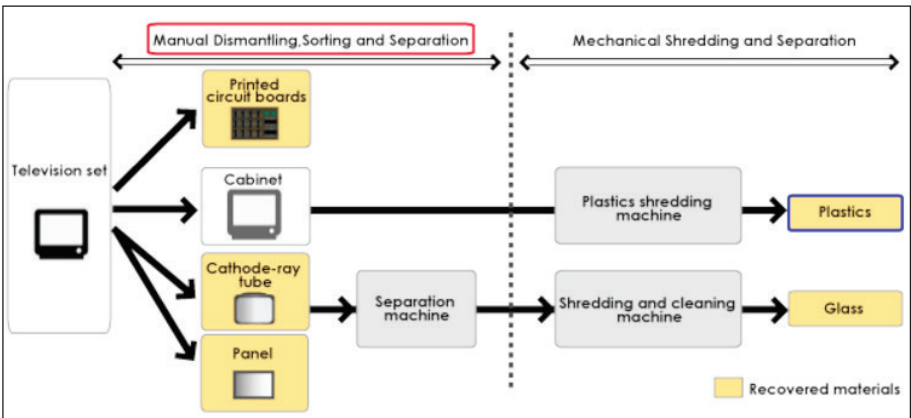


Figure 5.2 Recycle of television set

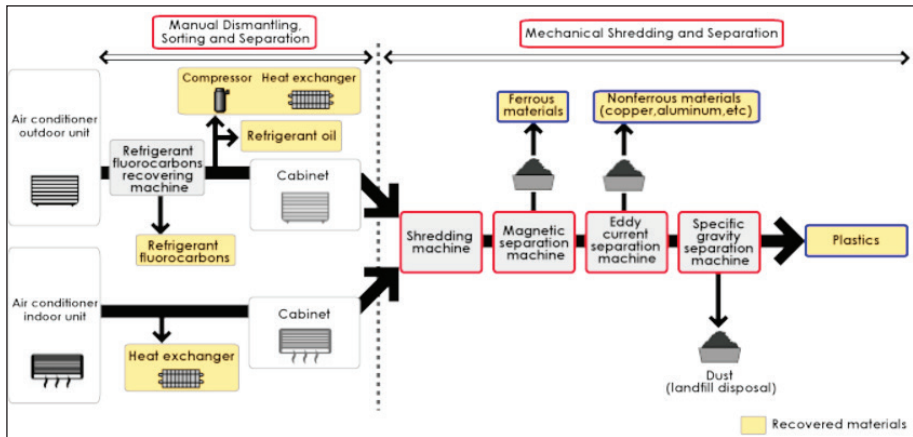


Figure 5.3 Recycle of air conditioner

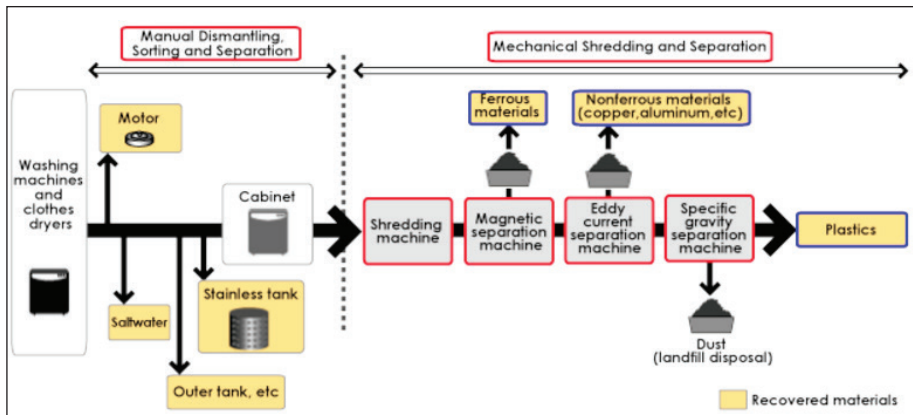


Figure 5.4 Recycle of washing machines

At the end of this process, waste is reduced to a size smaller. The ground materials are sent to a separation plant where the following operations can be carried out.

- **Pneumatic separation:** the separation takes place by density and aerodynamic characteristics (size and shape). The separation occurs through the combined action of a jet of air, which can lift the lighter material, and oscillatory movements capable of separating the material with lower specific gravity from the rest. In a first phase

the plastic is separated from aluminium and copper. The plastic by means of a pneumatic transport system is sent in containers, while copper and aluminium are sent to a second machine that with the same procedure subdivides them and discharges them in special bins. All the air used for pneumatic conveying and separation of materials is then sent to stations that provide filtering to reduce dust before entry into the atmosphere.

- Magnetic separation: this process is used for magnetically susceptible material that are extracted from a mixture using a magnetic force; the process is applied for the recovery of ferromagnetic metals from non-ferrous metals and other non-magnetic waste.
- Eddy current separation: this process is used for separate non-ferrous metals. Material is fed onto the conveyor belt of the eddy current separator, which moves it across the magnetic rotor where separation occurs. The two streams of material discharge into a housing. The housing has a splitter to divide the non-ferrous metal from the non-metallic material, such as paper, plastic, wood or fluff.

The key component of the eddy current separator is the magnetic rotor, which has a series of permanent rare earth magnets mounted on a support plate attached to a shaft. The magnetic rotor is surrounded by (but not attached to) a wear shell which supports the conveyor belt. This allows the rotor to spin independently and at a much higher speed than the wear shell and belt.

When a piece of non-ferrous metal, such as aluminium, passes over the separator, the magnets inside the rotor rotate past the aluminium at high speed. This forms eddy currents in the aluminium which in turn create a magnetic field around the piece of aluminium. The polarity of that magnetic field is the same as the rotating magnet, causing the aluminium to be repelled away from the magnet. This repulsion makes the trajectory of the aluminium greater than that of the non-metallic material, allowing the two material streams to be separated (see Figure 5.5).

- Specific gravity separation: this method is of common practise when the two components, in form of either a suspension or a dry granular mixture, can be easily separated as their specific weight are significantly different.

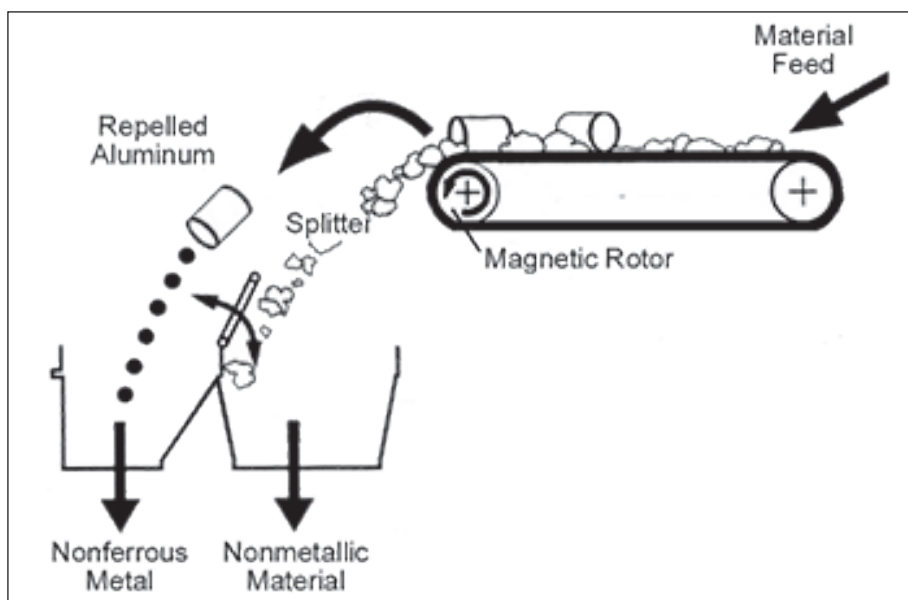


Figure 5.5 Eddy current separation machine

5.1.2 Harmful substances treatment

Certain types of equipment may contain substances harmful to human beings and environment. These substances must be removed before recycling. The most frequent harmful substances are:

Chlorofluorocarbons (CFCs) and Hydro chlorofluorocarbons (HCFCs): they are the top leaders amongst the substances responsible of the ozonosphere depletion. Once used as a propellant in aerosol sprays, they may be present in the cooling circuits of freezers and air conditioners of older generation or in polyurethane foam coatings.

Lead: contained in batteries, cathode ray tubes and solder, is highly toxic. It damages seriously the nervous system and the vasculature.

Cadmium: it is found in semiconductors, cathode ray tubes. Carcinogen, it can cause irreversible damage to the kidneys and bones.

Mercury: present in thermostats, medical equipment, telecommunications devices and especially in discharge light sources, it causes serious damage to the brain and, in children, because the inhibition of mental development.

5.1.2.1 CFCs/HCFCs

According to the environmental policies in the fight against the ozone hole and the greenhouse effect, protocols and international guidelines were issued to encourage research and development in the refrigeration sector.

The Vienna Convention was signed in 1984 and Montreal Protocol in 1987. This is the first example of a legally binding international agreement that established the reduction of the use of CFCs to a 50% decrease in production and consumption by 1999. In 1992, in Copenhagen, there was the meeting of the Parties according to the Montreal Protocol, where the ban of CFCs was anticipated by 1 January 1996. Amongst the ozone-depleting substances the HCFCs were also indicated.

As an example, the difluoromonochloromethane (R22) is a hydro chlorofluorocarbon (HCFC) commonly used in air conditioning systems. Once released into the air, the ultraviolet rays of the sun cause the decomposition of R-22 and the release of chlorine in the stratosphere. The chlorine reacts with ozone, thus depleting the ozonosphere. Due to the reduction of the ozone layer, harmful ultraviolet rays reach the earth's surface, causing a number of environmental and health problems. The HCFCs were banned by 2030, anticipated by 2015 in the European Community.

The impact of refrigerants on the environment can be summarized in the following points:

- toxicity for humanity and animals;
- biological and genetic influences;
- smell;
- flammability and explosiveness;
- direct impact on global warming;
- energy consumption during production and the utilization, with consequent impact on the production of CO₂;
- potential influence on ozone layer.

The available alternatives to CFCs and HCFCs are always substances of synthetic nature (see Table 5.1), such as HFCs that are chlorine-free, with ozone depletion potential (ODP) zero, but which have a high Global Warming Potential (GWP).

Table 5.1. Refrigerant class and replaces

Refrigerant Number	Name	Composition or chemical formula	Replaces
R-22	Difluoromonochloromethane	HCFC-22	
R-115	Chloropentafluoroethane	C ₂ ClF ₅	
Inorganic Compound			
R-717	Ammonia	NH ₃	
R-718	Water	H ₂ O	
R-744	Carbon dioxide	CO ₂	
Organic Compound			
R-290	Propane	CH ₃ CH ₂ CH ₃	
R-600	Butane	CH ₃ CH ₂ CH ₂ CH ₃	
R-600a	Isobutene	CH(CH ₃) ₂ CH ₃	Replacement for R-12 (CCl ₂ F ₂)
R-1270	Propylene	CH ₃ CH=CH ₂	
R-32	CH ₂ F ₂		
R-125	Pentafluoroethane	CHF ₂ CF ₃	
R-134a	1,1,1,2-tetrafluoroethane	CH ₂ FCF ₃	Replacement for R-12 (CCl ₂ F ₂)
R-143a	1,1,1-trifluoroethane	CH ₃ CF ₃	
R-152a	1,1-difluoroethane	CH ₃ CHF ₂	
Azeotropic mixtures			
R-502		R22/R115 (48.8/51.2)	
R-507		R125/R143a (50/50)	Replacement for R-502 in refrigerated transport; replacement for R-502; retrofit of existing R-502-installations.
Zeotropic mixtures			
R-404A		R125/R143a/R134a (44/52/4)	Replacement for R-502 in transport refrigeration. Close replacement of R-22 in commercial refrigeration applications. Possible replacement for R-404A in supermarket chill and low temperature systems.
R-407C		R32/R125/R134a (23/25/52)	Replacement for R-22 in existing installations; close replacement of R-22 in commercial refrigeration applications. Possible replacement for R-404A in supermarket medium and low temperature systems.
R-410A		R32/R125 (50/50)	Substitute for R-22. Substitution of R-13B1 in low temperature application.

To limit the impact of HFCs on the environment, the European Union gave off the Regulation n.842/2006 on certain fluorinated greenhouse gases that require periodic monitoring of systems using HFCs to limit the risk of escape. Alternatively, there are the natural fluids, such as ammonia (R717), hydrocarbons (R290, R1270, R600a), water (R718) and CO₂ (R744). The criteria for selecting the refrigerant of the future are based on parameters such as energy efficiency, safety and environmental sustainability.

Chlorine-free synthetic alternatives

Chemical alternatives, chlorine-free, offered by manufacturers of HFC refrigerants are: R134a, R32, R143a, R152a and R125 (cloropentafluoroetano). R32, R143a and R152 are flammable, do not meet the standards on “safety refrigerants”, and the R125 cannot be used as a pure refrigerant because of its poor thermodynamic properties. The solution to this problem is provided by the use of mixtures, the most common of which are non-azeotrope, where the flammability of good working fluids such as R32 has been neutralized by the use dell’R125 and / or R134a.

Natural fluids

A further alternative is the return to the use of natural refrigerants such as ammonia (R717); hydrocarbons such as propane (R290), propylene (R1270), isobutene (R600); water (R718); carbon dioxide (R744). The ammonia and hydrocarbons do not meet the safety requirements of refrigerants due to their toxicity and / or flammability; water and carbon dioxide, however, meet these standards.

Ammonia (R717): it is one of the first refrigerants used in refrigeration. Especially in plants of major powers, ammonia has always been the preferred fluid, given its thermodynamic characteristics, its low cost compared to (H) CFC and its low impact on the environment. However, it has drawbacks: it is toxic and has a characteristic odour. The technology of ammonia systems is different from that of the plants to fluorocarbons: copper is not compatible with ammonia; this fluid requires usually open compressors (although it is available a particular type of hermetic compressor useable with ammonia). However, the use of ammonia is increasing in new plant. A change is the transition from the use of wet evaporators to dry evaporators; a second variation

concerns the transition from the use of insoluble oils with ammonia to soluble oils, especially in small plants. The use of heat exchangers plates reduces significantly the refrigerant charge. Advantages related to the use of ammonia are:

- it is excellent from the thermodynamic perspective, offering a good efficiency of the refrigerating cycle;
- it has an extensive field of application and it is normal to use it down to - 45 ° C evaporation temperature;
- it is biodegradable and absorbable in water;
- it is easily available at low cost.

The disadvantages are:

- it is flammable and explosive;
- it is an irritant and blistering in some cases;
- it corrodes copper.

To overcome the disadvantages it is advisable the use of safety devices, such as:

- leak detectors;
- abatement in water tanks where the discharges of the safety valve are conveyed;
- forced ventilation apparatuses.

Hydrocarbons: isobutene and mixtures of propane and isobutene are used successfully used as refrigerants in coolers and freezers.

Propane can replace R22 in an efficient manner, using one internal heat exchanger. Propane, when compared with R22, shows the follows advantages:

- no changes respect to the current technology;
- better efficiency of the plant;
- reduction of the refrigerant fluid of the plant by about 50%;
- scarce solubility with water as the (H)CFCs and HFC.

The only problems of propane are that it is inflammable and the limitations posed by compressor manufacturers.

Carbon dioxide (R744): it is a natural fluid, which in the thirties was used in refrigeration ships and for the cooling of buildings. Carbon dioxide was used primarily for its negligible environmental pollution and its energy efficiency. In addition, the CO₂ is preferred in those applications in which the losses cannot be avoided and in applications with higher energy efficiency, which can be reached precisely through the use of this fluid and its cycle characteristic.

In conclusion, the main advantages related with the use of carbon dioxide are:

- environmental compatibility, non-flammability and absence of toxicity;
- limited cost and high availability with the usual lubricants and with common materials of construction.

Water (R718): the water was used, and still is, in Mechanical Vapour Recompression (MVR) systems; also it is used in chillers where performs both the function of cooling fluid and thermovector fluid. The water requires the use of centrifugal compressors.

5.1.2.2 Lead

Lead is always among one of the most recycled materials in terms of recovery rate. Lead can be remitted infinitely to remove impurities. It is cost-effective to collect and recycle. More than 50 % of lead used in the production of brand new lead products around the world is obtained by recycled lead.

Recovering and recycling lead has great environmental advantages. Lead recycling reduces disposal of lead to environment and conserves natural resources.

Use of recycled lead in the production of brand-new products is highly energy efficient. Recycled lead production takes only 35 to 40 % of the energy necessary to produce primary lead from ore.

5.1.2.3 Cadmium

Cadmium will be always present in human society, either in useful products or in controlled wastes. Today, its health effects are well understood and well-regulated so that there is no need to restrict or ban cadmium products which, in any event, contribute so little to human cadmium exposure as to be virtually insignificant.

Nickel-cadmium batteries are essential and irreplaceable in many industrial and consumer applications, particularly those requiring high power, long cycle lives, and good high or low temperature performance. Rechargeable Ni-Cd batteries can replace thousands of primary non-rechargeable batteries, and thus significantly reduce the total amount of waste. The materials in recyclable Ni-Cd batteries can be more than 99% recovered for reuse in the production of new Ni-Cd batteries.

Cadmium pigments and stabilisers are important additives in certain specialised plastics, glasses, ceramics and enamels to achieve bright colours along with long service lives, even in very demanding applications. From an ecological point of view, it is important to develop and maintain functional products with long service lives, once again to minimise the input into the world's waste stream. Inferior substitutes characterized by shortened service lives will ultimately only increase the volume of the world's waste. It should also be emphasised that cadmium in these applications presents high chemical stability and insolubility, and it is embedded in the product's matrix.

Cadmium coated components, likewise, provide outstanding corrosion resistance along with low friction coefficient, low electrical resistivity, good galvanic comparability, good plating coverage, ability to coat a wide variety of surfaces, and good braze ability and solder ability. In addition, cadmium coating wastes and products are easily recycled.

The recovery of cadmium from cadmium products through recycling programs not only ensures that cadmium will be kept out of the waste stream and out of the environment, but it also conserves valuable natural resources as well.

5.1.2.4 Mercury

Since 2009, the United Nations Environment Programme UNEP has developed a program for the incremental avoidance of mercury emissions and the elimination of mercury-containing products and wastes. Since 2013, the so-called Minamata Convention is ready for ratification and will expectedly come into effect in 2016.

Accordingly, the demand and need for state of the art technologies and systems for the treatment and removal of mercury-containing products and wastes will increase significantly.

The mercury-containing wastes and products are mainly treated by means of thermal desorption. Technically, thermal desorption is a solid-liquid separation in which mercury, as a volatile component, is removed from a solid or sludge-like matrix under the impact of heat. Thermal desorption separates the waste into a solid mercury-free residue and a liquid phase that consists of water, mercury and other pollutants that might be existing in the waste or product and that evaporate in the accordant temperature range.

Depending on the waste characteristics, the solid residue usually achieves all criteria for a disposal on a Class I or Class II landfill for non-hazardous waste. In some special cases, the treated solid residues can be stabilised chemically or physically in a separate process step prior to disposal.

The thermal treatment of mercury waste is typically performed at temperatures between 350°C and 800°C, depending on the chemical composition of the mercury. Under vacuum, free, metallic mercury can evaporate already at a temperature around 350°C. If the mercury is present in batteries or it is chemically bound, for example as mercury salt, higher treatment temperatures are required up to around 800°C. In individual cases the temperature needed might be even higher.

5.2 Recycling applied to the motor vehicle industry

5.2.1 Premise

The overall results show that the greatest environmental challenge for the automobile sector is the depletion of non-renewable resources and in particular crude oil. Oil is mostly used during the utilization phase of the car to cover the energy demand during the whole lifetime. In addition, a variety of air pollutants such as carbon monoxide, nitrogen oxides, hydrocarbons but mainly carbon dioxide are emitted to the environment through the combustion of gasoline or diesel fuel contributing to significant impacts such as climate change, acidification, eutrophication etc. but also to respiratory and other effects on human health. Raw material acquisition and processing is the second most important contributor to the impacts mentioned above.

However, in terms of material efficiency it is shown that the sector has a reduced environmental impact in particular when it comes to the recycling of metals. Greater efforts should be made for special plastic and other newly materials developed to be more efficiently recyclable than the traditional polymers in order to reduce the waste stream. Consequently, there are different improvement options for the automobile industry that can compensate the environmental challenges.

Alternative fuel options can lead to energy and resource savings as well as emission reductions during the use phase. Substitution of heavier materials with lighter ones can improve fuel and material economy. And finally, increased recycling possibilities can lead to material and energy recovery but also to waste reduction. However, all alternatives should be further evaluated in a sustainability and life cycle perspective to measure the overall savings and also ensure that they are not introducing new problems for the sector.

5.2.2 The life cycle of an automobile

The life cycle of an automobile begins with minerals extraction and processing in order to produce the materials and the components needed for the final product. An automobile consists of approximately 15.000 to 20.000 parts, which makes a detailed analysis of all material flows very difficult. Steel, aluminium and polymers are the dominating components

with a total share of more than 80% by vehicle. Consequently, natural resources like coal, iron, bauxite, petroleum and natural gas are broadly used as necessary raw materials for the production of those components.

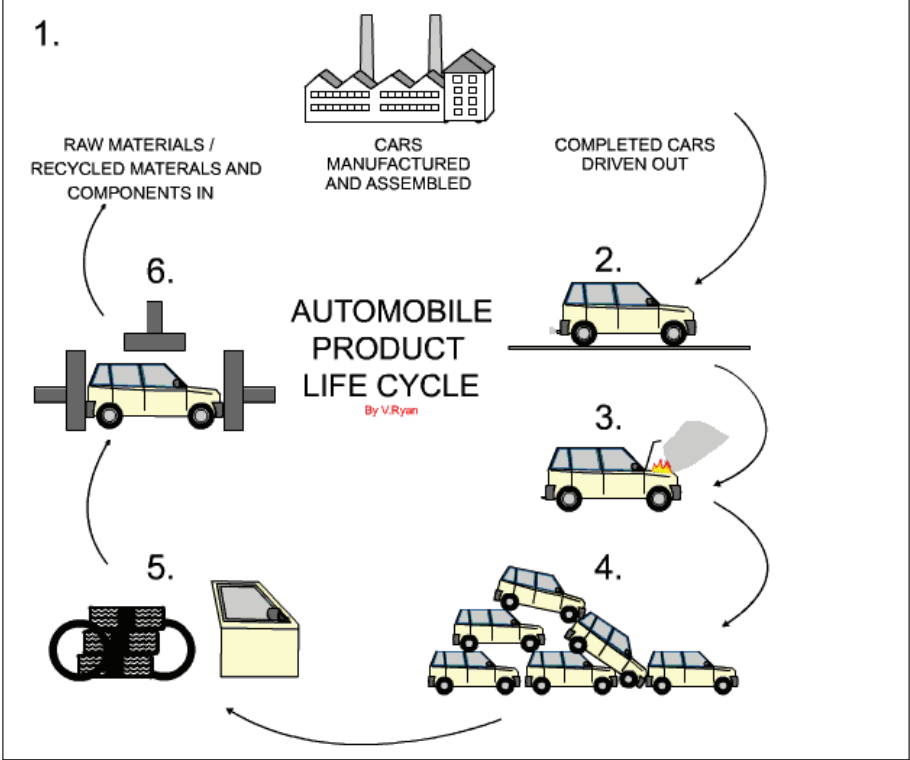


Figure 5.6 Automobile product life cycle

As is shown in figure 5.6 the automobile product life cycle can be summarized in 6 steps :

1. *Raw materials, recycled materials and components enter the factory.* Completed cars are driven out of the opposite end and transported to their owners. The vehicle manufacturing and assembly, as is explained in chapter 4, consists of a set of different processes representing different kinds of activities and complex supply chains that have a great geographical distribution. In summary, the major stages that can be recognized during the manufacturing phase are the fabrication of the different components, the assembly and painting processes and several finishing activities.

2. *The car is driven throughout its useful lifetime.* During this step the car may be used for work, business and pleasure. It consumes petrol or diesel and pollutes the atmosphere. From time to time it needs servicing and repairing. The average utilization time of an automobile is around 10 to 15 years. However, this can vary according to the model, drivers behavior and other unpredictable reasons like car accidents. During that average lifetime a passenger car covers a distance of 150.000 to 200.000 km. Even though new technologies for automobile operation have started to evolve, like for example electric and fuel cell vehicles, the most common process remains the internal engine. The majority of vehicles today use gasoline or diesel.
3. *After the utilization step the vehicle becomes waste as every other product.* It cannot be repaired any further and it breaks down for the last time. This may be after ten years or more.
4. *The car is taken to the scrap yard.* Once upon a time this would have been the final resting place of most cars but today more than 90% of end-of-life vehicles are collected and treated, as recent regulation measures impose. A set of processes follow in order to extract reusable and recyclable parts and materials and also reduce the volume of the waste.
5. *A vehicle today is reused and recycled at an average rate of 80% by weight.* This may include a wide range of materials and components. Around 65% to 70% of this rate corresponds to its metallic components while the rest (around 10%) corresponds to the parts as wheels, recyclable rubber, plastics and metals. These parts/ materials are sold to companies that can reclaim the materials for further use. For example, the rubber from the old types can be turned into granules and reused. Many of the plastics used in modern cars can be recycled in a similar way, turning old plastic into granules that can be used to manufacture many modern products. The steps carried out at the end of life by the treatment facilities are the following :
 - Pre-treatment (or de-pollution) where vehicle components that contain dangerous and toxic substances are removed. Examples of such components are the operating fluids like different oils

and fuels, the battery, the oil filters, components containing mercury and devices like the airbags which contain explosive substances. Most parts removed in this stage are recycled or further treated and disposed according to regulation.

- Dismantling where the vehicle is disassembled to its major components and the individual parts that can be recycled or reused directly are removed. Parts that have an economic value like the engine or other parts of the body could be directly recovered and reused after some repairing processes. Parts are divided according to different material and components fractions and then recycling takes place. Examples of most commonly found components of this fraction include tires, parts made of glass, catalytic converters, etc.
 - Shredding is the final step during the end-of-life treatment process. The goal of shredding is to reduce the volume of the remaining waste and at the same time separate the materials in more homogenous fractions in order to make their recycling easier. The vehicle parts are shredded into smaller pieces and then mechanical and physical processes like magnetic separation, eddy current belt and sink-floating methods are used in order to separate further the different materials according to their type and properties. After these processes the materials are divided to three general categories: ferrous metals (iron, steel), non-ferrous metals (aluminum, copper) and shredder residues. Ferrous and non-ferrous materials are directly recycled as scrap metals. Shredder residues (SR) (light and heavy fraction) constitute the remaining 25% by weight of the vehicle that is not recycled. Materials from the SR fraction are more complicated to be extracted since it is a mixture of substances with different properties. Extraction and recycling of those substances is possible but most of the times it is not economically feasible. The majority of the SR fraction ends up in landfills after some last treatment process.
6. *The remainder of the car is crushed into blocks.* Post shredding processes are aiming to achieve higher separation and recycling levels by extracting the remaining metals and other parts like plastics and minerals from the SR. Again mechanical and physical

separation methods are used. The remaining residues highly consistent of polymers are disposed in landfills in most of the countries worldwide. The total amount of waste end up in landfills from end of life vehicles in Europe is estimated to be around 2 million tons per year. Taking also into account the fact that concentration of plastics and composites in new vehicles is increasing, the SR treatment would become much more efficient. Increasing the possibilities for SR utilization and higher recovery rates is therefore becoming urgent.

Chapter 6

“Monitoring”

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- 6.1 Establishing monitoring conditions**
- 6.2 Data production chain**
- 6.3 Monitoring approaches**
- 6.4 Reliability and comparability**
- 6.5 Total emissions evaluation**
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- 6.7 Compliances assessments and reporting**

The aim of this chapter is to provide information to guide operators in meeting their obligations with regard to the monitoring requirements of industrial emissions at source. This also helps promote comparability and reliability of monitoring data.

Given that there are three main types of industrial monitoring:

- Emission monitoring: monitoring of industrial emissions at source, i.e. monitoring releases from the plant to the environment.
- Process monitoring: monitoring the physical and chemical parameters (e.g. pressure, temperature, stream flow rate) of the process in order to confirm, using process control and optimization techniques that the plant performance is within the range considered appropriate for its correct operation.
- Impact monitoring: monitoring pollutant levels within the environs of the plant and its area of influence, and the effects on ecosystems.

This document focuses only on the monitoring of industrial emissions at source.

6.1 Establishing monitoring conditions

The following seven considerations must be taken into account when establishing monitoring conditions:

1. **“Why” monitor?** There are two main reasons: (1) for compliance assessment, and (2) for the environmental reporting of industrial emissions. However, monitoring data can often be used for many other reasons and objectives and indeed it is often more cost effective when monitoring data obtained for one purpose can serve other purposes.
2. **“Who” carries out the monitoring?** The responsibility for monitoring is generally divided between the competent authorities and the operators, although competent authorities usually rely to a large extent on “self-monitoring” by the operator, and/or third party contractors. It is highly important that monitoring responsibilities are clearly assigned to all relevant parties (operators, authorities, third party contractors).

3. **“What” and “How” to monitor.** The parameters to be monitored depend on the production processes, raw materials and chemicals used in the installation. It is advantageous if the parameters chosen to be monitored also serve the plant operation control needs.
4. **How to express ELVs and monitoring results.** The way the emission limit values (ELVs), or equivalent parameters, are expressed depends on the objective for monitoring these emissions. Different types of units can be applied: concentration units, units of load over time, specific units and emission factors, etc. In all cases, the units to be used for compliance monitoring purposes should be clearly stated, they should preferably be internationally recognized and they should match the relevant parameter, application and context.
5. **Monitoring timing considerations.** Several timing considerations are relevant for setting monitoring requirements, including the time when samples and/or measurements are taken, the averaging time, and the frequency. The determination of monitoring timing requirements depend on the type of process and more specifically on the emission patterns and should be such that the data obtained are representative of what is intended to be monitored and comparable with data from other plants.
6. **How to deal with uncertainties.** When monitoring is applied for compliance checking it is particularly important to be aware of measurement uncertainties during the whole monitoring process. Uncertainties need to be estimated and reported together with the result so that compliance assessment can be carried out thoroughly.

6.2 Data production chain

Generally, for the majority of situations the production of data can be broken down into seven consecutive steps.

1. Flow/amount measurement
2. Sampling
3. Sample storage, transport and preservation
4. Sample treatment

5. Sample analysis
6. Data processing
7. Data reporting
8. Sample storage, transport and preservation

Since the results are as inaccurate as the most inaccurate step of the chain, knowledge of the uncertainty of each step of the data production chain leads to a knowledge of the uncertainty of the whole production chain. This also means that care must be taken with every step of the chain as it is worthless having an extremely accurate analysis of the sample if the sample itself is not representative of what is to be monitored or if it was badly preserved.

In order to improve the comparability and reliability of the monitoring data, all the information from one step that could be relevant for the other steps (e.g. information on the timing considerations, sampling arrangements, handling, etc.) should be clearly indicated when passing the sample to the following steps.

Flow/amount measurement

The accuracy of the flow measurement has a major impact on the total load emission results. The determination of concentrations in a sample can be very accurate, however accuracy of the determination of the flow at the time of sampling may vary widely. Small fluctuations in flow measurements can potentially lead to large differences in load calculations.

In some situations flow can, more easily and accurately, be calculated instead of measured.

Sampling

Sampling is a complex operation consisting of two main steps: establishment of a sampling plan and taking of the sample. The latter may influence (e.g. by lack of cleanliness) the analytical results. Both steps strongly affect the measurement results and the conclusions derived from them. It is therefore necessary that sampling is representative and properly performed; this means that both sampling steps are carried out according to relevant standards or agreed procedures. Generally, sampling should comply with two requirements:

1. The sample must be representative in time and space. This means that when monitoring the releases from an industry, the sample taken to the laboratory should represent all that it is discharged during the period of interest, for example, a working day (time representativeness).

Equally, when monitoring a substance, the sample should represent the whole amount being released from the plant (space representativeness). If the material is homogeneous, sampling at a single point may be enough, however for heterogeneous materials several samples from different points may be required in order to have a spatially representative sample.

2. The sampling should be carried out with no change in the composition of the sample, or to an intended and more stable form. In fact, there are parameters in a sample that should be determined, or somehow preserved, in situ as their value may change with time, for example the pH and the oxygen content of a waste water sample.

Generally samples are labelled and identified with a sample code number. This should be a unique sample identification number assigned from a sequentially numbered register. Further information necessary for defining the sampling plan and further interpretation of the results should consider the following items (which may be indicated in a label attached to the sample):

- The location at which the samples are taken. The location should be such that the material is well mixed and sufficiently far away from the mixing points to be representative of the overall emission. It is important to select a sampling point that is practical to reach and where the flow can also be measured or is known. The samples should always be taken from the same defined locations. Appropriate safeguards should be considered with regard to the sampling point (e.g. good access, clear procedures and instructions, work permits, sampling loops, interlocks, use of protective equipment) in order to ensure that any risk for sampling personnel and the environment are minimized.

- The frequency at which the samples are taken and other timing considerations, such as the averaging time and the duration of sampling. The frequency is usually decided on a risk basis, taking into account the variability of the flow, its composition, and the magnitude of the variability with respect to unacceptable limit values.
- The sampling method and/or equipment.
- The type of sampling, e.g. automatic (time or flow proportional), manual spot, etc.
- The size of individual samples and bulking arrangements to provide composite samples.
- The type of sample, e.g. a sample for a single or multiple parameters analysis.
- The personnel in charge of taking the samples; they should have appropriate skills.

To improve reliability and traceability of the sampling, a number of parameters may be included on the label with the sample code number, for example:

- date and time of sampling;
- sample preservation details (if applicable);
- process relevant details;
- references to measurements made at the time when the sample was taken.

Most of these details are already considered in standards or norms.

Sample storage, transport and preservation

In order to preserve the parameters that are to be measured during any storage and transporting of the sample, a time-proof pretreatment will generally be needed. Any pretreatment of the sample should be carried out according to the measurement program.

For waste water, this pretreatment generally consists of keeping the sample in the darkness, at a suitable temperature, typically 4 °C, adding certain chemicals to fix the composition of the parameters of interest, and not exceeding a maximum time before analysis.

Any arrangement for chemically preserving, storing and transporting the samples should be clearly documented, and indicated, when possible, on the sample label.

Sample treatment

Before analyzing the laboratory sample, some specific treatment may be needed. This treatment strongly depends on the analysis method being used and the component being analyzed. Any treatment of the sample should be carried out according to the analysis program.

Any specific treatments applied to the samples should be clearly documented when reporting, and indicated, when possible, on the sample label.

Sample analysis

There are many analysis methods that are available for many determinations. The complexity of the methods may range from those requiring only basic laboratory apparatus or analytical instruments commonly found in laboratories, to methods requiring advanced analytical instruments.

There will normally be several analytical methods available to determine a parameter. Selection of the appropriate method is always made in accordance with the specific needs of the sampling (i.e. the specified performance criteria) and depends on a number of factors, including the suitability, availability and the cost.

As different methods can give variable results from the same sample it is important to indicate with the results the method used. In addition, the accuracy of the methods and matters affecting the results, such as interferences, should be known and indicated together with the results.

When an external laboratory is used for the analysis of the samples, it is very important that the selection of the sampling and analytical methods are carried out in close co-operation with the external laboratory. This

ensures that all relevant aspects such as method specificity and other limitations are considered before the sampling is performed.

Data processing

Once measurements' results are produced, the data generated need to be processed and evaluated. All data handling and reporting procedures should be determined and agreed by the operators and authorities before the testing begins.

Part of the data processing involves the validation of emission data. This is usually done by skilled personnel in the laboratory, who check that all the procedures have been properly followed.

Validation may include the use of a thorough knowledge of monitoring methods and national and international (CEN, ISO) standardization procedures, and may also involve quality guarantees for certification methods and procedures. An effective system of controls and supervision, in which calibration of equipment and intra- and inter-laboratory checks are involved, may also be a standard requirement in the validation process.

A considerable amount of data may be generated when carrying out monitoring, particularly when continuous monitors are applied.

Data reduction is often necessary in order to produce the information in a format suitable for reporting. Data handling systems, mostly electronic devices, are available which can be configured to provide information in a variety of forms and which take a variety of inputs.

Statistical reductions may include calculations from the data of means, maxima, minima and standard deviations over appropriate intervals. When data are from continuous monitoring, they can be reduced to 10-second, 3-minute, hourly, or other relevant intervals, as means, maxima and minima, standard deviations or variances.

Data loggers, chart recorders, or both, are used to record continuous data. Sometimes an integrator is used to average the data as it is collected and the time-weighted average (e.g. hourly) is recorded. Minimum data requirements may include taking a value every minute by recording the measured value or updating the rolling average (e.g. a one-minute rolling hourly average). The recording system can also be capable of

storing other values that may be of interest, such as the minima and maxima.

Data reporting

From the large amount of data generated when a parameter is monitored, a summary of the results over a certain period of time is usually generated and presented to the relevant stakeholders (authorities, operators, public, etc.). Standardization of reporting formats facilitates the electronic transfer and subsequent use of data and reports.

Depending on the medium and the monitoring method, the report may include averages (e.g. hourly, calendar day, monthly or annual averages), peaks or values at a specific time or at times when the ELVs are exceeded.

Card - The data production chain for different media

For air emissions, wastewater and wastes, some relevant issues such as volume measurements, sampling issues, data handling and processing, etc., are presented.

Air emissions

ELVs for air are generally laid down as a mass concentration (e.g. mg/m³) or, together with the volumetric flow emitted, as a mass flow (e.g. kg/h), although specific emission limits are also sometimes used (e.g. kg/t of product). The mass concentration of an emission is the concentration of the measured component averaged, if necessary, over the cross-section of the waste gas channel of the emission source over a defined averaging time.

For spot-checking or for compliance verification by external parties, for facilities with operating conditions that primarily remain constant with time, a number of individual measurements (e.g. three) are made during undisturbed continuous operation at periods of representative level of emissions. In facilities whose operating conditions vary with time, measurements are made in sufficient number (e.g. a minimum of six) at periods of representative level of emissions.

The duration of individual measurements depends on several factors, e.g. on gathering enough material to be able to give it a weighting,

whether it is a batch process, etc. The results of individual measurements are assessed and indicated as mean values. Usually it is necessary to determine a minimum number of individual values (e.g. 3 half-hour values) to calculate a daily mean.

The sampling of particles in a flowing exhaust gas must take place isokinetically (i.e. at the same velocity as that of the gas) to prevent segregation or disturbance of the particle-size distribution due to inertia of the particles, which can lead to a false analysis of the measured solids content. If the sampling rate is too high, the measured dust content will be too low, and vice versa. This mechanism depends on the particle size distribution. For particles of aerodynamic diameter $<5\div10\text{ }\mu\text{m}$, the effect of this inertia is practically negligible. Applicable standards require isokinetic particle sampling.

Continuous monitoring is a legal requirement in several Member States of European Union for processes whose emissions exceed a certain threshold value. Parallel continuous determination of operational parameters, e.g. waste gas temperature, waste gas volume flow, moisture content, pressure, or oxygen content, allows the evaluation and assessment of continuous measurements. The continuous measurement of these parameters may sometimes be waived if these, from experience, show only slight deviations which are negligible for emission assessment or if they can be determined by other methods with sufficient certainty.

Conversion to reference standard conditions

Monitoring data for air emissions are typically presented in terms of either actual flow or a 'normalized' flow.

Actual conditions, which refer to actual temperature and pressure at the source, are ambiguous and should be avoided in permits.

Normalized data are standardized to a particular temperature and pressure, typically 0 °C and 1 atm respectively, although sometimes they may be referenced to 25 °C and 1 atm.

Conversion to Reference Oxygen Concentration

In combustion processes, the emission data are generally expressed at a given percentage of oxygen. The oxygen content is an important reference value from which the measured concentrations can be calculated according to the equation:

$$E_B = \frac{21 - O_B}{21 - O_M} * E_M$$

Where:

E_B = emission expressed at reference oxygen content

E_M = measured emission

O_B = reference oxygen content (expressed in percentage)

O_M = measured oxygen content (expressed in percentage)

Wastewater

There are basically two sampling methods for wastewater: composite sampling and spot sampling.

(a) Composite sampling. There are two types of composite samples: flow-proportional and time-proportional. For the flow-proportional sample, a fixed amount of sample is taken for each pre-defined volume (e.g. every 10 m³). For time-proportional samples, a fixed amount of sample is taken for each time unit (e.g. every 5 minutes). Because of the desired representatively, flow-proportional samples are generally preferred.

The analysis of a composite sample gives an average value of the parameter during the period over which the sample has been collected. It is normal to collect composite samples over 24 hours to give a daily mean value. Shorter times are also used, for example 2 hours, or half an hour. Composite sampling is usually automatic;

instruments automatically withdraw a portion of sample at the appropriate volume discharged or time.

Duplicates of composite samples can be kept frozen, and then mixed together to calculate the weekly, monthly or annual mean concentration, although this may cause a change of the composition and lead to the storage of large amounts.

For annual load calculations, composite samples are generally preferred.

(b) Spot sampling. These are taken at random moments and are not related to the volume discharged. Spot samples are used, for example, in the following situations:

- if the composition of the waste water is constant;
- when a daily sample is not suitable (for example, when the water contains mineral oil or volatile substances, or when, due to decomposition, evaporation or coagulation, lower percentages were measured in daily samples than are actually discharged);
- to check the quality of the discharged waste water at a particular moment, normally to assess compliance with the discharge conditions;
- for inspection purposes;
- when separate phases are present (for example an oil layer floating on water).

If there are enough composite samples, they can be used to determine a representative annual load. Spot samples can then be used to support and/or verify the results. If not enough composite samples have been determined, the results of the spot samples can be included.

In principle, separate annual loads are calculated for both the composite samples and the spot samples. Only then are the annual loads compared with each other and, if necessary, corrected.

Wastes

Because of the heterogeneous nature of solid wastes, determination of the composition is not an easy task. If statistical procedures are difficult to implement, a more generalized field procedure can be adopted, based on common sense and random sampling techniques.

For the waste received at or produced by the permitted installation, the operators should record, and retain the following records for an appropriate period:

- a) its composition;
- b) the best estimate of the quantity produced;
- c) its disposal routes;
- d) a best estimate of the amount sent to recovery;
- e) registration/licenses for carriers and waste disposal sites.

6.3 Monitoring approaches

There are several approaches to monitoring a parameter. These include:

- direct measurements;
- surrogate parameters;
- how to express monitoring results (mass balances, emission factors, calculations).

However, some of these possibilities may not be available for the parameter of interest. The choice depends on several factors, including the likelihood of exceeding the ELV, the consequences of exceeding the ELV, the required accuracy, costs, simplicity, rapidity, reliability, etc., and should also be suited to the form in which the components may be emitted.

In principle, it is more straightforward, but not necessarily more accurate, to use direct measurements (specific quantitative determination of

the emitted compounds at the source). However, in cases where this method is complex, costly and/or impractical other methods should be assessed to find the best option. For instance, in those cases in which the use of surrogate parameters provides an equally good description of the actual emission as a direct emission measurement, these methods may be preferred for their simplicity and economy. In each situation the necessity for, and the added value of, direct measurements should be weighed against the possibility of simpler verification using surrogate parameters.

Whenever direct measurements are not used, the relationship between the method used and the parameter of interest should be demonstrated and well documented.

National and international regulations often impose requirements on the approach that can be used for a particular application, e.g. EC Directive 94/67/EC on the incineration of hazardous waste requires the use of relevant CEN (Comité Européenne de Normalization) standard methods. The choice may also be indicated or recommended in published technical guidance, e.g. the Reference Documents on Best Available Techniques.

The monitoring approach to be adopted in a compliance monitoring program may be chosen, proposed or specified for use by:

- the competent authority - the usual procedure
- the operators –usually a proposal which still needs approval by the authority
- an expert –usually an independent consultant who may propose on behalf of the operators; this proposal still needs approval by the authority.

When deciding whether to approve the use of an approach in a relevant regulatory situation the competent authority is generally responsible for deciding whether the method is acceptable, based on the following considerations:

- fitness for purpose, i.e. is the method suited to the original reason for monitoring as shown, for example, by the limits and performance criteria for an installation?

- legal requirements, i.e. is the method in line with EU or national law?
- facilities and expertise, i.e. are the facilities and expertise available for monitoring adequate for the proposed method, e.g. technical equipment, staff experience?

The use of surrogate parameters, mass balances and emission factors transfer the burden of uncertainty and traceability (to the specified reference) to the measurement of several other parameters and to the validation of a model. This model could be a simple linear relationship, similar to that used with mass balances or emission factors.

Direct measurements

Monitoring techniques for direct measurements (specific quantitative determination of the emitted compounds at the source) vary with the applications and can be divided mainly into two types:

(a) continuous monitoring

(b) discontinuous monitoring.

(a) Two types of continuous monitoring techniques can be considered:

- fixed in-situ (or in-line) continuous reading instruments. Here the measuring cell is placed in the duct, pipe or stream itself. These instruments do not need to withdraw any sample to analyze it and are usually based on optical properties. Regular maintenance and calibration of these instruments is essential.
- fixed on-line (or extractive) continuous reading instruments. This type of instrumentation continuously extracts samples of the emission along a sampling line, transport them to an on-line measurement station, where the samples are analyzed continuously. The measurement station may be remote from the duct, and therefore care must be taken so that the sample integrity is maintained along the line. This type of equipment often requires certain pretreatment of the sample.

(b) The following types of discontinuous monitoring techniques can be considered:

- instruments used for periodic campaigns. These instruments are portable and are carried to and set up at the measurement location. Normally a probe is introduced at an appropriate measurement port to sample the stream and analyze it in situ. They are appropriate for checking and also for calibration.
- laboratory analysis of samples taken by fixed, in-situ, on-line samplers. These samplers withdraw the sample continuously and collect it in a container. From this container a portion is then analyzed, giving a mean concentration over the total volume accumulated in the container. The amount of sample withdrawn can be proportional to time or to flow.
- laboratory analysis of spot samples. A spot sample is an instantaneous sample taken from the sampling point, the quantity of sample taken must be enough to provide a detectable amount of the emission parameter. The sample is then analyzed in the laboratory providing a spot result, which is representative only of the time at which the sample was taken.

Surrogate parameters

Surrogate parameters are measurable or calculable quantities which can be closely related, directly or indirectly, to conventional direct measurements of pollutants, and which may therefore be monitored and used instead of the direct pollutant values for some practical purposes. The use of surrogates, used either individually or in combination with other surrogates, may provide a sufficiently reliable picture of the nature and proportions of the emission.

The surrogate is normally an easily and reliably measured or calculated parameter that indicates various aspects of operation such as throughput, energy production, temperatures, residue volumes or continuous gas concentration data. The surrogate may provide an indication of whether the ELV can be satisfied if the surrogate parameter is maintained within a certain range.

Whenever a surrogate parameter is proposed to determine the value of another parameter of interest, the relationship between the surrogate and the parameter of interest must be demonstrated, clearly identified and documented. In addition, traceability of the parameter's evaluation on the basis of the surrogate is needed.

How to express monitoring results

Mass balances consist of accounting for inputs, accumulations, outputs and the generation or destruction of the substance of interest, and account for the difference by classifying it as a release to the environment. The result of a mass balance is usually a small difference between a large input and a large output, also taking into account the uncertainties involved. Therefore, mass balances are only applicable in practice when accurate input, output and uncertainties quantities can be determined. *Emission factors* are based on the unit of product, for example kg/t of product, (or unit of input, for example g/GJ thermal input, for combustion processes) and can be used to compare different processes to each other independently of actual production, thus also allowing the opportunity to evaluate trends; the value thereby acting as a benchmark, which can be used to select the best technique. The use of *calculations* to estimate emissions requires detailed inputs and is a more complex and more time consuming process than emission factors. On the other hand they provide a more accurate estimate given that they are based on specific conditions of the facility. In any emission estimation calculations, the emission factors need reviewing and prior approval by the authorities.

6.4 Reliability and comparability

The practical value of the measurements and the monitoring data depends on the degree of confidence, i.e. reliability that can be placed on the results, and their validity when compared to other results from other plants, i.e. comparability. Therefore, it is important to ensure the appropriate *reliability* and *comparability* of the data. In order to allow a proper comparison of the data, it should be ensured that all relevant information is indicated together with the data. Data that have been derived under different conditions should not be directly compared, in these cases a more elaborate consideration may be necessary.

A good understanding of the process to be monitored is essential for obtaining results that are reliable and comparable. Given the complexity, cost, and subsequent decisions based on the monitoring data, an effort should be made to ensure that the data obtained are appropriately reliable and comparable.

Reliability of the data may be defined as the correctness, or the closeness, of the data to the true value, and should be appropriate for the intended use of the data. Certain applications need extremely accurate data, i.e. very close to the true value, however, in other situations, rough or estimated data may suffice.

To assure the quality of the whole data production chain, attention should be paid at every step to all quality aspects. Information about the uncertainty associated with the data, the accuracy of the systems, the errors, the validation of the data, etc. should be available together with the data.

The sampling stage is very important, and should ensure that measurands subjected to analysis are fully representative of the substance of interest. It is thought that the largest part of the uncertainty of a measurement is due to this stage.

Situations where the reliability is poor and the results are far from the true value can mislead important decisions, such as penalties, fines, prosecutions or legal actions. Therefore it is important that the results have the appropriate level of reliability.

Comparability is a measure of the confidence with which one data set can be compared to another. When the results are to be compared with other results from different plants and/or different sectors, they need to have been obtained in a way that enables them to be compared so as to avoid wrong decisions.

Data that have been derived under different conditions should not be directly compared and a more differentiated consideration may be necessary. The following measures can be taken to ensure the comparability of the data:

- use of standard written sampling and analysis procedures, preferably European CEN standards when available;

- use of standard handling and shipping procedures for all collected samples;
- use of skilled personnel throughout the program;
- use of consistent units when reporting the results.

The availability of relevant information concerning the production of the monitoring data is important in order to allow a fair comparison of the data. For that reason it should be assured that the following information, when relevant, is indicated together with the data:

- method of measurement, including sampling;
- uncertainty;
- averaging time;
- frequency;
- calculation of the average;
- units (e.g. mg/m³);
- source that has been measured;
- prevailing process conditions during the acquisition of the data;
- auxiliary measures.

6.5 Total emissions evaluation

The *total emissions* of an installation, or unit, are given not only by the normal emissions arising from the stacks and pipes, but also by taking into account diffuse, fugitive and exceptional emissions. It is therefore recommended that IPPC permits, where appropriate and reasonable, include provisions to properly monitor these emissions.

As progress has been made in reducing channeled emissions then the relative importance of other emissions becomes increasingly important, for instance more attention is now paid to the relative importance of *diffuse and fugitive emissions*. It is recognized that these emissions

can potentially cause damage to health or the environment, and that sometimes their losses may also have economic significance for a plant. Similarly, the relative importance of *exceptional emissions* has also increased. These are classed as occurring under foreseeable conditions or unforeseeable conditions.

6.6 Values under limit of deception

Measuring methods normally have limitations with regard to the lowest concentration that can be detected. Clarity on the handling and reporting of these situations is essential. In many cases the problem can be minimized by using a more sensitive measuring method. Therefore, a proper monitoring strategy should attempt to avoid results under the limit of detection, so that only for less interesting low concentrations do values under the limit of detection occur.

In general, it is good practice to use a measurement method with detection limits of not more than 10 % of the ELV set for the process. Therefore, when setting ELVs, the limits of detection of the available measurement methods need to be taken into account.

It is important to distinguish between the limit of detection (LOD - the lowest detectable amount of a compound) and the limit of quantification (LOQ - the lowest quantifiable amount of a compound). The LOQ is usually significantly larger than the LOD (2 - 4 times). The LOQ is sometimes used to assign a numeric value when handling values under the limit of detection, however the use of the LOD as a reference value is widely spread.

6.7 Compliance assessments and reporting

Compliance assessments and reporting

Compliance assessments generally involve a statistical comparison between the measurements, or a summary statistics estimated from the measurements, the uncertainty of the measurements and the emission

limit value or equivalent requirements. Some assessments may not involve a numerical comparison, for example they may just involve a check of whether a condition is complied with. The measured value can be compared with the limit, taking account of the associated uncertainty in measurements, and determined as belonging in one of three zones: (a) compliant, (b) borderline or (c) non-compliant.

Reporting involves summarizing and presenting monitoring results, related information and compliance findings in an effective way. Good practice is based on consideration of: the requirements and audiences for reports, responsibilities for producing reports, the categories of reports, scope of reports, good reporting practices, legal aspects of reporting and quality considerations.

In carrying out the monitoring, optimization of the *monitoring costs* should be undertaken whenever possible, but always without losing sight of the monitoring objectives. Cost-effectiveness of the monitoring may be improved by applying some actions including: selecting appropriate quality performance requirements, optimizing the number of parameters and the monitoring frequency, complementing routine monitoring by special studies, etc.

Textbook For Capacity Building of Environmental Management Units in Metal Sector

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