Ecodesign approaches and Energy Efficiency solutions in the European Chemical Industry

With the contribution of the
LIFE financial instrument
of the European Community

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Energ-Ice Project

Dow Italia, Afros and Crios (Cannon Group), and Federchimica are partners in the Energ-Ice Project co-funded by LIFE, the EU's financial tool supporting environmental and nature conservation projects.

The Energ-Ice Project focuses on reducing the environmental impact of energy using products, such as cold appliances, by taking action at the design stage, where the pollution caused during the product's life cycle can be best prevented.

Additional contributions of the Energ-Ice project are the preparation of two documents:

- "Ecodesign approaches and Energy Efficiency solutions in the European Chemical Industry";
- "Road Map Document for a Sustainable Chemical Industry".

The Documents objectives are mainly two:

- Show the contributions of the Chemical Industry to Sustainable Development, and
- Highlight a roadmap of the Chemical Industry contribution towards a sustainable development of the planet.

"Ecodesign approaches and Energy efficiency Solutions in the European Chemical Industry" is a collection of the most shining examples of the environmental impact of Chemical products and processes along its entire life-cycle, including benefits delivered to downstream users and consumers.

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1. Introduction

The European Union is more and more promoting sustainable production (i.e. development of low polluting and more efficient products, processes and services) and sustainable consumption, patterns and behaviours.

In fact there are many policies and legislative instruments addressing the management of the environmental impact of products:

- the communication from the commission to the European parliament, the council, the European economic and social committee and the committees of the regions. A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy COM (2011) 21;
- the communication from the commission to the European parliament, the council, the economic and social committee and the committee of the regions. Our life insurance, our natural capital: an EU biodiversity strategy to 2020 COM (2011) 244 final;
- the Communication on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan COM (2008) 397/3;
- the Environmental Management and Audit Scheme (Regulation (EC) No 1221/2009) (EMAS III);
- the Ecolabel Regulation (Regulation (EC) No 66/2010);
- the Directive 2009/125/CE on Ecodesign;
- the Communication "Public procurement for a better environment" (COM (2008) 400 how to reduce the environmental impact caused by public sector consumption and how to use GPP (Green Public Procurement) to stimulate innovation in environmental technologies, products and services;
- the REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) Regulation (Regulation (EC) No 1907/2006);
- the Directive 2008/2009/CE on waste;
- the Directive 94/62/CE on packaging;
- the Directive 2011/65/EU ROHS "Restriction of Harzardous Substances in Electrical and Electronic Equipment";
- the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE).

The political program developed, has the intention to strengthen the competitiveness of both process and products also thanks to the improvements to be achieved in the context of sustainable development.

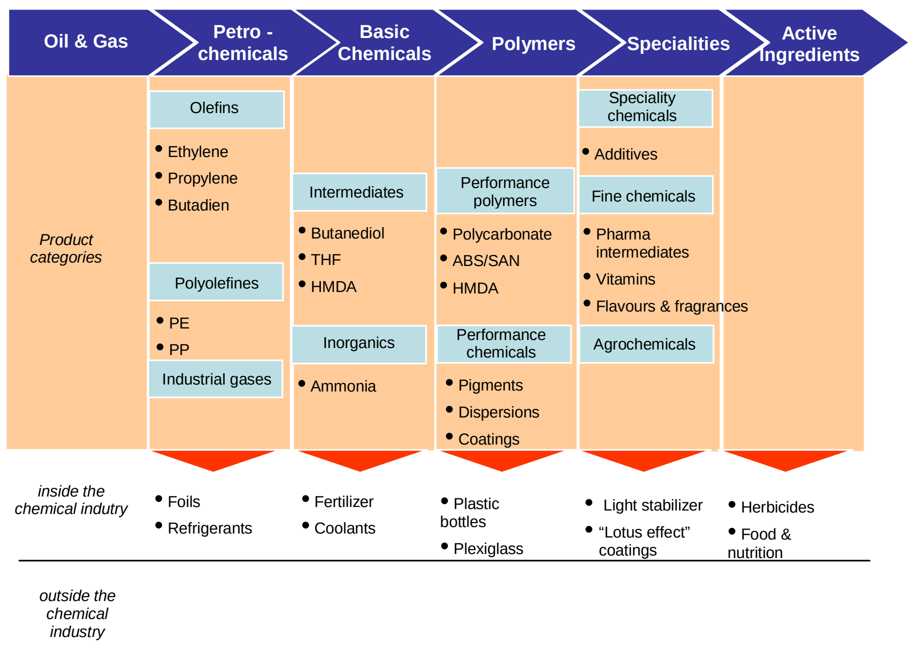
In order to properly evaluate the environmental impact of products and processes, scientific approaches and appropriate tools are needed.
LCA (Life Cycle Assessment) allows to assess the impact of a process or a product associated with all the phases of its life, from "cradle-to-grave" (or better from "cradle to cradle"), i.e. from early design stage till recycling.

LCA provides tools for compiling inventories (energy, material inputs and reuse, environmental emissions and wastes), evaluating the potential impacts associated with identified releases and inputs and interpreting the results for decision making.
The goal of LCA is to compare the full range of environmental effects assignable to products and services in order to improve processes, support policies and provide a sound basis for informed decisions.

The procedures of Life Cycle Assessment (LCA) are part of the ISO 14000 environmental management standards: in ISO 14040:2006 and 14044:2006. (ISO 14044 replaced earlier versions of ISO 14041 to ISO 14043.).
Carbon footprint focused on Greenhouse Gases (GHG) emissions and can be considered as a subset or simplified LCA, as current and future regulations on GHG reduction emission are based on existing LCA methodologies and practises.

The chemical industry is divided into sub-sectors segments very different one to another. We can classify a variety of areas ranging from basic chemicals, which includes petro-chemicals, basic chemicals and polymers, to fine chemistry, including products that can be obtained through subsequent processing of the oil (or by renewable raw materials) and are derived from molecules produced artificially, such as pharmaceutical chemistry and everything that is related to health products, agricultural and food chemistry.

Tab.1: The structure of Chemical Industry



Actually the chemical sector is able to produce useful goods, as raw materials or semi-finished products, to determine, in a substantial manner, the characteristics of many other finished products.

Commonly the chemical industry is represented and perceived as extremely hazardous to healthy for the ecosystem. In reality it continuously seeks new ways to manufacture products in a safer and more convenient way, also offering lower environmental impact.
Moreover, through their use, the chemical products allow to reduce the environmental impact of many other industrial sectors with benefits for the consumers.

With regard to Greenhouse Gases (GHG) emission, for example, a study by the International Council of Chemical Associations (ICCA), “Innovation for Greenhouse Gas Reductions (June 2009)”, found that for every 1 $GtCO_2e$ emitted by chemical industry in 2005, 2.6 $GtCO_2e$ of savings were enabled for other industries and end users.
It can be assumed to reach a model in which it is possible to avoid an emission of carbon dioxide into the atmosphere than 3 times compared to the amount of gas produced by the company itself.

The aim of this paper is to show some examples of Eco-design approaches and Energy Efficiency solutions offered by the Chemical Industry, by products and applications. The examples show how this approaches helps to improve the sustainability of the different application segment considered.

2. Examples divided for application sector

2.1. Transportation

The transport sector is an important component of the economy impacting directly the development and the welfare of populations.
Modern society dictates a physical distinction between home and work, forcing people to transport themselves to places of work or study, as well as to temporarily relocate for other daily activities.

All trade involves transportation, which is the movement of goods or people from their homes to their jobs or from their homes to the places where they want to go. Nowadays trade is difficult without modern and mechanized transportation.
For this reason transport plays an important role in economic growth and globalization; however, for the intensive use of different modes of travel, we must take into account the effects involving health and environment.

Transport is responsible for about one-fourth of European GHG emissions making it the second biggest GHG emitting sector after energy. Road transport alone contributes about one-fifth of the EU's total emissions of CO_2, the main Greenhouse Gas. Transport accounts for a significant share of the global fossil fuel combustion related to CO_2 emissions. Total fossil fuel related to CO_2 emissions increased from 20.9 Gt in 1990 to 28.8 Gt in 2007, of which transport accounted for 4.58 (1990) and 6.63 (2007) Gt, representing an increase of approximately 45%. According to the World Energy Outlook 2009, global energy related to CO_2 emissions could increase to over 40 Gt by 2030 and transport emissions would make up over 9 Gt of that despite.

2.1.1. Automotive weight reduction

One of the aims of the automotive industry is to decrease the weight of the cars in order to reduce fuel consumption and consequently GHG emissions.

In the past, cars were made above all with steel, but the use of lightweight alternatives has enormously increased in the last couple of decades.

Whereas almost no plastic could be found on a car from the 1950s, today's automobiles have more than 120 kilograms of plastic on board, according to the Transportation Energy Data Book.
Indeed plastics are considered one of the materials to achieve the aim of a weight reduction.

In a car we can find different kind of plastics, such as:

- polyamide;
- acrylnitrile butadiene styrene terpolymer;
- polyethylene terephthalate;
- polyacetate;
- polypropylene;
- acrylic glass;
- polycarbonate/acrylonitrile butadiene styrene polymer;
- polycarbonate.

So, thanks to plastics, it's possible to reduce vehicle weight while guaranteeing the performance required; and every 10% reduction in vehicle weight we can have an improvement (about 5%) in fuel economy.
Furthermore plastic can be easily molded, components can be tailored for more comfortable human ergonomic features, as well as more streamlined, aerodynamic shapes and the durability of plastics results in a longer, more reliable vehicle lifetime.

One example of reducing the automobile weight is cavity-filling foam (e .g. Betamate™ made by Dow) that expands to fill auto body cavities, making cars safer, quieter and more fuel efficient. The main advantages are:

- improved structural safety of vehicles by replacing steel structures;
- in some cases, cavity-filling has enabled more than 36 pounds of net mass reduction per vehicle while maintaining safety performance;
- improved performance with net body structure mass and cost savings;
- more than 40 % more mass efficient compared to steel at equivalent weight.

Companies are also trying to reduce the automotive weight using structural adhesives, replacing welds and mechanical fasteners, helping improve vehicle durability, reducing weight and manufacturing costs.
The advantages of this technology are:

- improve vehicle fuel efficiency;
- conserve raw materials by using plastic molding, instead of mechanical fasteners;
- provide up to 20% weight reduction.

At the International Motor Show in Frankfurt a new concept car, the first automobile with thermoplastic wheel rims was presented. This plastic material rim provides a weight reduction of more than 30% compared to the traditional aluminum rim; indeed the rim weights only 6 kg and it's made in a new polyamide, contributing to a considerable vehicle weight

reduction (12kg less) that translates into a reduction in fuel consumption of a vehicle with a conventional engine.
This polyamide is a composite plastic that can withstand high loads, because it is reinforced with long fibers. The long fiber reinforcement makes it especially strong: it can replace metal wherever energy absorption is a major requirement (e.g. in crash absorbers), seat structures, battery holders, engine mounts and other structural components.

2.1.2. Engine efficiency

The efficiency of an engine is the ratio of the engine's power output to the energy given by the fuel fed into the engine. Hence high engine efficiency is fundamental to low fuel consumption saving costs and emissions.
Sulphur and carbon dioxide emissions, for example, are directly proportional to fuel consumption and to the content of carbon and sulphur in the fuel.
Below we present some procedures used to improve the engine efficiency.

The use of fuel additives such as antioxidants (like phenols), antiknock (like ferrocene or toluene) and alcohol for diesel and for gasoline can, for examples, reduce GHG emission. Indeed using specially formulated diesel additives that remove residues and increase combustion intensity is it possible to maintain a quiet, smooth and efficient engine.

In this situation the fuel consumption of an average car when consuming diesel with fuel additives is 2% less than without additives and from these consumption volumes, annual global net emissions savings are 24 $MtCO_2e$.

Gasoline additives increase gasoline's octane rating (standard measure of the performance of a motor; fuels with a higher octane rating are used in high-compression engines that generally have higher performance) or act as corrosion inhibitors or lubricants, thus allowing the use of higher compression ratios for greater efficiency and power.
The calculation for the savings resulting from gasoline fuel additives is analogous to that of diesel additives and in this case annual global net emissions savings are 28 MtCO2e.

Another example is the use of synthetic lubricants, which consisting of chemical compounds that are artificially made (synthesized).
Synthetic lubricants can be manufactured using chemically modified petroleum components rather than whole crude oil, but can also be synthesized from other raw materials.

Synthetic oil is used as a substitute for lubricant refined from petroleum when operating in extremes temperature environment, because, in general, it provides superior mechanical and chemical properties than those found in traditional mineral oils.
The technical advantages of lubricants are:

- better chemical and shear stability;
- decreased evaporative loss;
- resistance to oxidation, thermal breakdown, and oil sludge problems;
- extended drain intervals with the environmental benefit of less oil waste;
- better lubrication during extreme cold weather starts;
- longer engine life;
- superior protection against "ash" and other deposit formation in engine hot spots for less oil burnoff and reduced chances of damaging oil passageway clogging;
- increase horsepower and torque due to less initial drag on engine.

Synthetic engine oil, compared to mineral lubricating oil, reduces the fuel consumption of an engine by 5%.

2.1.3. Lower frictions – Pneumatics

Low rolling resistance tires minimize wasted energy thereby decreasing required rolling effort, and in the case of automotive applications, improving vehicle fuel efficiency. Approximately 5–15% of the fuel consumed by a typical car may be used to overcome rolling resistance. A 2003 California Energy Commission (CEC) preliminary study estimated that adoption of low-rolling resistance tires could save 1.5–4.5% of all gasoline consumption.

To produce tires and for their reliability, chemicals are essential.
Tire reliability comes from styrene-butadiene rubber with added stabilizers and antioxidants such as phenolic resins.
Strength and elasticity are the benefit of sulfur compounds added during the vulcanization process; carbon black and silica make tires abrasion resistant, while whitewalls get that extra good look from titanium dioxide pigments; finally UV coatings make the tires last longer.

Research and development of innovative materials is the key for the design and fabrication of even more sustainable tires guaranteeing reduced environmental impact, greater driving safety and improved production efficiency.

For this purpose, many Companies are studying of new polymers for rolling resistance, performance in low temperature conditions, durability and grip.
Companies are working with universities to develop a natural rubber, obtained from sources other than the rubber tree. Research is aimed at diversifying the potential supply sources, thereby reducing pressure on the biodiversity of producer countries while allowing the Company to manage the potential lack of raw materials more flexibly.
Studies are also underway on a new technology for selective de-vulcanization to recycle the materials resulting from discarded tires. This would significantly reduce tire production costs and environmental impact.
Moreover research and development, in Companies, is also focused on:

- biomaterials, such as silica from renewable sources;
- high-dispersion silica for wet grip, rolling resistance and durability;
- high-performance carbon black derived from racing competition applications for extreme grip;
- nano-fillers for more stable compounds, lighter structures and highly impermeable liners.

2.1.4. Lithium-ion batteries for electric cars

An electric car is a plug-in battery powered automobile which is propelled by electric engines.
Although electric cars often give good acceleration and have generally acceptable top speed, the lower specific energy of production batteries (available in 2010), compared with carbon based fuels, means that electric cars need batteries that are fairly large fraction of the vehicle mass but still often give relatively low range between charges. Recharging can also take significant lengths of time. For shorter range commuter type journeys, rather than long journeys, electric cars are practical forms of transportation and can be recharged overnight. Longer range journey options are currently being pursued by installing battery swapping station infrastructure throughout several pilot cities such as Tokyo.

A great innovation created to avoid the emissions of dangerous gases has been the lithium-ion battery. It is a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge, and back when charging.

The most important advantages of lithium batteries are:

- wide variety of shapes and sizes efficiently fitting the devices they power;

- much lighter than other energy-equivalent secondary batteries;
- high open circuit voltage in comparison to aqueous batteries (such as lead acid, nickel-metal hydride and nickel-cadmium);
- increased amount of power that can be transferred at lower current;
- no memory effect;
- self-discharge rate of approximately 10% per month, compared to over 30% per month in common nickel metal hydride batteries, approximately 1.25% per month for low self-discharge NiMH and 10% per month in nickel-cadmium batteries;
- components are environmentally safe as there is no free lithium metal.

The lithium-ion car battery is under rapid development and improvement; for example an American start-up has identified a material with a novel microscopic structure that could help to improve the storage capacity of one of the battery electrodes.

Also lithium-air batteries are becoming more attractive for automotive industry. Lithium-air is a metal-air battery that uses the oxidation of lithium at the anode and reduction of oxygen at the cathode to induce a current flow. The major appeal of the Li-air battery is the extremely high energy density, a measure of the amount of energy a battery can store for a given volume, which rivals that of traditional gasoline powered engines. Lithium-air batteries gain this advantage in energy density since they use oxygen from the air instead of storing an oxidizer internally.
Nowadays, the performance of such batteries has been limited to only a few charge–discharge cycles with low rate capability; however, scientists and industry alike see potential in its development.

Electric cars are expected to have a major impact in the auto industry giving advantages in reducing city pollution, and offering less dependence on oil mitigating the expected rise in gasoline prices. World governments are pledging billions to fund development of electric vehicles and their components. CEOs of the most important auto industries have said that one in 10 cars globally will run on battery power alone by 2020 and that the companies believe that both fuel cell vehicles and battery electric vehicles are needed for reduction of greenhouse gases emissions and reliance on oil.
Additionally a recent report claims that by 2020 electric cars and other "green" cars will take a third of the total of global car sales.

2.1.5. Marine antifouling coatings

Marine fouling on the bottom of ships is a real problem from both cost and performance standpoint. The increased friction caused by growth of marine fouling organisms reduces the speed of a vessel and causes an increase in fuel consumption.

Antifouling paint or bottom paint is a specific coating applied to the hull of a ship or boat in order to slow the growth of organisms aggressive to the hull which can affect a vessel's performance.
Hull coatings may have other functions in addition to their anti-fouling properties, such as acting as a barrier against corrosion on metal hulls, or improving the flow of water past the hull of a fishing vessel or high-performance racing yacht.

The fuel consumed by the marine shipping industry is reduced significantly through the use of coatings. It was estimated that the average fuel consumption of ships without antifouling coatings would be 29% higher. With a yearly fuel consumption of 220 Mt of fuel in the marine shipping industry, this translates into fuel savings of 63 Mt, which corresponds to gross savings of 200 $MtCO_2e$ per year. After taking into consideration the production footprint of the coatings and average coating lifetime of 12 years, the net abatement volume is about 190 $MtCO_2e$.

2.2. Insulation

2.2.1. Building Insulation

Energy efficiency has become the main requirement in the construction sector; in view of that approximately 40% of world energy consumption is used for heating and/or cool houses and plastic is becoming the most used material for thermal insulation.
As reported in the ICCA study, insulation of buildings is, at 2.4 GtCO2e, the largest contributor to the net emissions savings. Insulation greatly reduces the heat lost by buildings, and so significantly decreases the need for energy used for heating. If cooling savings were to be included the net GHG abatement would further increase.

Thermal insulation in buildings is an important factor to achieve thermal comfort for its occupants. Insulation reduces unwanted heat loss or gain and can decrease the energy demands of heating and cooling systems.
In this application different materials plastics are used: EPS - expanded polystyrene foam, XPS - extruded polystyrene foam, and PU - rigid polyurethane foam.

The performance efficiency of thermal insulation made of plastics is such that make their use highly advantageous not only in terms of savings energy and reduction of greenhouse gas emissions, but also in terms of reduced impact on environment.

The plastics in the form of high pressure laminates (HPL - High Pressure Laminates) can also be used for the exterior of buildings (e.g. facades, balconies), where HPL are a good alternative to traditional materials.

In addition, a coating insulation system - which consists of several elements including an adhesive layer - is an effective response for the insulation because:

- is applied outside the walls of the building through which is estimated that occurs more than 50% of energy losses;
- improves the comfort even during the summer;
- is the only practically feasible solution for the energy adaptation of the existing buildings.

Some Companies are also developing new innovative latent heat storage material, which makes the construction industry sustainable in the area of air conditioning. Indeed is it possible to use a phase change material (substance with a high heat of fusion which, melting and solidifying at a certain temperature, capable of storing and releasing large amounts of

energy), which completes a phase change from solid to liquid within the indoor temperature and human comfort range and in doing so can store a large quantity of heat.
An example of this material is a special microsphere with a latent heat storage material (made from a special wax mixture) inside. Thank this microencapsulation technology, phase change materials can be integrated invisibly into the most diverse of construction materials.
The passive climate control made by this provides you with air conditioned premises for a large part of the year, with a reduction in the use of energy.

2.2.2. Fridge and heat Insulation

The household sector is one of the largest users of electrical energy in the European Union, consuming 29% of total electrical energy.
Cold appliances account for about 20% of household energy consumption.
The Directive 2012/27/UE on energy efficiency establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's 2020 20% headline target on energy efficiency and to pave the way for further energy efficiency improvements beyond that date.
It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of indicative national energy efficiency targets for 2020.

The good practice in this area is the Energy-Ice Project, developed by Dow and Cannon and co-financed by the European Commission program LIFE.
The Energy-Ice Project focuses on reducing the environmental impact of energy-using products, such as cold appliances, by taking action at the design stage, where the pollution caused during the product's life cycle can be best prevented.
The project is expected to showcase an innovative Polyurethane (PU) foaming technology to insulate cold appliances (refrigerators and freezers) offering enhanced insulation while using blowing agents having very low GWP (e.g. cyclopentane).

The overall objectives of this project are to demonstrate that:

- a new technology employing a hydrocarbons blowing agents can be used in Europe to improve the insulation properties of PU foams for cold appliances in a more cost-efficient way;
- the manufacturing of cold appliances, including the impact of end-use disposal on the environment can be much more environmentally friendly and sustainable than standard processes;

- the new technology will give a new approach for defining new standards for hydrocarbon blown foams with improved insulation properties superior to those employed today allowing current A/A+/AA+ labeling;
- energy consumption of cold appliances in Europe can be reduced up to 10% with respect to the best-available appliances produced today with a positive impact on the European and worldwide market.

Energy-Ice provides:

- energy efficiency;
- cost efficiency, quality and productivity;
- sustainability and GHGs reduction.

All of these can be achieved with high-performing insulation PU foam using the low GWP and ZERO-ODP Cyclopentane blowing agent. The foam thermal conductivity target of the cyclopentane blown Energ-Ice foam is as low as 0.018 W/(m • K) measured at 10°C, against the average reference value of 0.020 W/(m • K).

Plastics are useful also in insulation of hot water boilers.
These are applications in which the characteristics of thermal insulation are essential.
In fact more and more often the melamine resin foam is chosen for external insulation of the water tanks made of stainless steel.

A key factor in this application is the thermal conductivity of the foam, less than 0.035 W/(m • K) and then with a high thermal insulation. This reduces energy losses in the production of hot water.
An example of a specific application of plastic materials for use in water tanks is the collaboration between BASF Polyurethanes GmbH and the company Stiebel Eltron, a manufacturer of major home appliances.
Using an analysis of eco-efficiency, the two companies have developed a water prototype cylinder based on a product of Stiebel Eltron, with the intention of reducing the consumption of energy to heat water.
After the heating of buildings, in fact, the water heating is the second largest application for energy consumption in a private home.
The amount of energy consumed to maintain temperatures in the water depends on the model of the cylinder and the type of insulation.
The analysis of eco-efficiency has shown that the performance of this cylinder can be further improved with the use of more suitable isolation, in the way to guarantee boiler able to reach the same performance as those installed on wall. The prototype is able to save 30% of energy.

The project involves an initial phase of analysis of the performance of existing water boiler, depending on the type of model used and isolation.

Then it was examined whether further opportunities to optimize performance remained.

Finally, the prototype named "Small Cylinder of the Future" was created.
In the analysis of eco-efficiency of this prototype also the ecological impact of the production process, the steps of the product recycling and service life, estimated at 15-20 years, were considered.
The polyurethane system insulation thickness is greater in some specific areas, while the rigid polyurethane foam has been improved to provide greater insulating performance. The behavior of these polyurethane foams in such application is important, because during the water heating, the gas within the cells expands, contrary to what happens in a refrigerator.
This behavior has to be considered when configuring the insulation of the cylinder.
The insulating layer is characterized by a considerable flexibility and, at the same time, for the ability to retain shape and dimension when exposed to heat.
The development of this prototype enables the two companies to anticipate part of the new legislation being developed in the European Community with regard to the labeling of the boiler, which will be similar to that used for refrigerators.

2.3. Building

The chemical industry is heavily engaged in research and development of technological solutions to promote sustainable development in buildings. In this context, the role of chemistry is:

- offer affordable innovative products that reduce the environmental impact of processing throughout the supply chain of construction industry;
- allow the reduction of energy consumption and CO_2 emissions in daily use of housing and nonresidential buildings, contributing decisively to manage climate change (think that 40% of world energy consumption is used for heating and/or cool houses); see chapter "2.2.1. Building Insulation" for in depth details.

2.3.1. Construction materials and paints

"Sustainable building" (also known as "sustainable construction") refers to a structure and using process environmentally responsible and resource efficient throughout the whole building's life cycle: from initial design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the design teams, the architects, the engineers and the client at all project stages. The sustainable building practice expands and complements the classical building design concern of economy, utility, durability, and comfort. Although new technologies are constantly being developed to complement current practices in creating more sustainable structures, the common objective is that sustainable buildings are designed to reduce the overall impact of the built structure on human health and on environment by:

- efficiently use of energy, water, and other resources;
- improved occupant health and improving employee productivity;
- reduce waste, pollution and environmental degradation.

An example of Sustainable Building is "NET ZERO" Energy Home realized by Dow and Cobblestone Homes. Michigan's first affordable net-zero energy home utilizes readily-available energy efficiency technologies from Dow.

This technology's advantages are:

- use 60-70 % less energy than conventional homes;
- save $3,500 in annual energy costs;
- save more energy than it consumes–averting over 44,000 lbs of CO_2 annually.

The International Energy Agency released a publication that estimated that existing buildings are responsible for more than 40% of the world's total primary energy consumption and for 24% of global carbon dioxide emissions.

In addition to the CO_2 emission problem, it is also necessary to resolve the water problem. For this reason Dow launched the Global Water Challenge (GWC), an organization dedicated to building awareness and promoting scalable actions in expanding coverage for clean water and sanitation worldwide.
Dow funded the GWC to generate a global movement meeting the urgent need for safe water and sanitation while also providing innovative solutions:

- lower cost desalination technologies;
- effective ultra-filtration systems;
- materials to improve sustainability of water;
- sustainable business models for water systems;
- innovative ways to increase awareness like the Dow Live Earth Run for Water.

Another important topic to analyze is about painting materials; nowadays, for example, there is a big interest in photo-catalytic paint.
Titanium dioxide (TiO2) is the most used material for this application; it acts as a catalyst in the presence of ultraviolet light which initiates the reaction with atmospheric pollutants.
There are two types of photochemical reaction proceeding on a TiO2 surface when irradiated with ultraviolet light. One includes the photo-induced red-ox reactions of adsorbed substances, and the other is the photo-induced hydrophilic conversion of TiO2 itself. The combination of these two functions has opened up various novel applications of TiO2, particularly in the field of building materials.
TiO2 is a material used as a photocatalyst or photopromoter for the degradation of organic or inorganic compounds in solution or gas phase under radiation. The ability to promote these chemical changes makes it very interesting for applications in the environmental clean-up to improve the quality of air or water.
TiO2 is able to absorb solar energy making it available to decompose pollutants through chemical reactions. This property is due to the fact that such oxide is a semiconductor.

Researchers have calculated that, in a large city, if 15% of visible urban surfaces is covered with photo-catalytic products, the air pollution is reduced by approximately 50%.

2.3.2. Piping

Use of plastic pipes has been an extraordinary development. Compared to tubes made of other materials, plastic ones present an high energy efficiency due to low temperature of processing and production of the raw material. The reduced weight also allows a considerable saving of fuel during the transport and eases the handling. An analysis of the entire life cycle of product shows that:

- the only greenhouse gas emissions arising from the production of the tubes are those related to the energy consumption in production phase; from LCA (Life Cycle Analysis) it results that producing 1 km of pipes in plastic material allows to avoid CO_2 emissions by a minimum of 33 to a maximum of 249 tons (depending on the diameter);
- in the final stage of the life cycle, i.e. at the time of disposal, plastic tubes have a positive energy balance because the energy contained in the plastic - being derived from oil, gas or coal - can be recovered both with recycling and using it as fuel in waste recovery energy.

Systems based on plastic pipes combine the benefits of longevity and durability with those of ease of installation and handling. Therefore, they offer an economic and cost effective long lasting solution.
Further advantages are the robustness, flexibility, immunity to corrosion. The tubes can also be insulated, helping to reduce heat loss and further improving energy efficiency in the construction system.

PVC has become the leading material for large diameter buried pipelines installed by both water and wastewater utilities as well as for smaller diameter drain waste and vent (DWV) piping.
PVC pipe manufacturing is an energy efficient process, so consuming less Joule (J) than alternative materials made with equal length of pipe. A survey has indicated that the manufacture of pressure piping used in the building, construction and transportation industries required 56,497 trillion fewer Joule than iron and concrete/aggregate alternatives would require if they were substituted for all PVC pipe. PVC pipe and fittings also weight less than alternative piping materials allowing for significant energy savings in their transportation. Furthermore, their lighter weight enables them to be installed more easily and efficiently than the above-mentioned alternatives.

PVC pipe durability results in resource conservation. When properly designed and installed, PVC pipe has an estimated life span well beyond 100 years, with little or no loss of strength.

Other advantages in using PVC in pipe are:

- Reliability: PVC pipe resists scale build up, pitting and tuberculation. Its internal surface remains smooth and deposit-free from corrosive or hard water. As a result, PVC pipe resists bacteria build up and maintains high flow efficiency which reduces pumping requirements and virtually eliminates the need for disassembly or cleaning it for the life of the system;
- Water quality: Increasing public attention to water quality and health are additional factors in favour of using PVC in piping applications. PVC pipe delivers water as clean and pure as it receives. It imparts no taste or odour to the water it transports. And PVC pipe helps to maintain uniform water temperature due to its low thermal conductivity;
- Fire performance: While some construction materials ignite easily and burn rapidly, PVC does not. PVC piping products meet or exceed all applicable building code requirements for installation in fire-resistive construction;
- Expansion and contraction: PVC pipe has higher expansion and contraction rates than metallic pipe;
- Cost: PVC piping is attractive from a cost standpoint not only because its initial cost can be less than the cost of other materials but also because its light weight means reduced transport costs. Additionally, it lasts longer and requires less maintenance than competitive materials, thus reducing repair and replacement costs.

2.3.3. Windows

PVC windows are emerging as a way to isolate the interior of the house from cold, rain, humidity and wind while keeping the heat longer.
Moreover doors and windows can repair from acoustic pollution, isolating noise in town. We have also to remember that the considerations related to winter season could also apply to summer cooling.
Furthermore, PVC has a durable maintenance and it is easily recyclable.
PVC windows perform extremely well in comparison to alternative framing materials in energy and thermal efficiency ratings. Energy efficient windows mean lower heating and cooling costs for a home or building owner, as well as environmental benefits. PVC as a material is not a conductor of heat and cold, and hollow chambers within the frame provide thermal barriers that further block heat transfer.
The installed costs and lifecycle costs of PVC windows are competitive with those of other framing materials, and in most cases PVC is the most affordable alternative. The average lifespan of PVC windows varies widely according to the intended application and other factors, but most PVC window manufactured offer warranties of 20 to 30 years.

Like all vinyl products, PVC windows profiles are recyclable, both pre use (e.g., manufacturing off-cuttings and construction site waste) and post use (e.g., removal at end of useful life).

2.4. Agriculture

The primary agricultural fonts of pollutants are nutrients (particularly nitrogen and phosphorus), sediment, animal wastes and pesticides.
Agriculture is also an important source of two strong greenhouse gases, nitrous oxide (N2O), resulting from the microbic transformation of nitrogen fertilizers, and methane (CH4), produced by the digestive processes of ruminants.
Indeed, nitrous oxide pollution from agriculture mainly comes from using inorganic nitrogen fertilisers and from storing manures, while direct losses of methane from animals are due to fermentation caused by bacteria in their stomach.

Cows produce the most methane per animal - followed by horses, sheeps, goats and pigs. Emissions from lactating dairy cows are particularly high.
Poultry don't produce any methane directly, but a small amount is released from their excreta. However, intensive poultry farms and poultry production facilities - ie those with a capacity exceeding 40,000 birds - must have an environmental permit to operate and show compliance with the proper removal, disposal and/or treatment of waste matter. For more information, see the guide on minimising farm waste, composting and recycling.

So is it possible to reduce agricultural methane emissions by:

- reducing livestock numbers;
- improving productivity and fertility;
- modifying the diets of livestock.

Instead is it possible to reduce nitrous oxide emissions by taking the following steps to ensure your fertilizer use is efficient and nitrogen losses are minimised:

- regularly testing your fertilizers spreader to ensure accurate application;
- ensuring that any staff applying fertilizers are well trained and only use the minimum amount necessary;
- crop nutrient management planning;
- carrying out soil analysis to establish how much fertilizer is needed;
- using technology to target nutrient use and cut machinery use;
- incorporating manures to reduce the need for inorganic fertilizer;
- improving slurry handling.

You can also reduce levels of nitrogen in your livestock's excreta by matching the nitrogen in their diet to their specific needs.

2.4.1. Fertilizer & crop protection

Crop protection technology, which includes all pesticides, herbicides, insecticides, fungicides, as well as biotechnology products, helps to control the weed species, harmful insects and numerous plant diseases that afflict crops.
Agrochemicals are the second largest contributor to emissions savings. Indeed the use of fertilizers and modern crop protection has helped to increase yield enormously over the past few decades.

Some 20 to 40 per cent of the world's potential crop production is already lost annually because of the effects of weeds, pests and diseases (according to FAO - Food and Agriculture Organization of the United Nations). These crop losses would be doubled if existing pesticide uses were abandoned, significantly raising food prices.

To summarize agrochemicals have a lot of advantages, like:

- Increase food production: crop protection technologies allow producers to increase crop yields and efficiency of food production processes;
- Decrease the cost of food: crop protection technologies also impact the cost of food. Without it, food production would decline, many fruits and vegetables would be in short supply and prices would rise;
- Consumer benefits: pesticides allow consumers to consume high-quality produce free of insect blemishes and insect contamination. Crop protection chemicals that reduce and, in some cases, eliminate, insect damage allow the consumer to purchase high-quality produce free of insect fragments.
- Monetary advantage in the use of pesticides; indeed, every dollar that is spent on pesticides for crops yields four dollars in crops saved.

Generally speaking, farmers benefit from having an increase crop yield and from being able to grow a variety of crops throughout the year. Consumers of agricultural products also benefit from being able to afford the vast quantities of produce available year round.

However we have to remember that agrochemicals could have also negative aspect; nowadays farmers use pesticides in a more safety way than in the past, for example they choose less toxic pesticides and they spread it only in a limited zone, reducing the contamination of nearest land.

Agriculture creates emissions in two ways, from the farming activity itself, and from converting land to agricultural use (using machines to make land usable for agriculture).
Indeed the farming emissions of conventional farming with fertilizers and crop protection were found to be close to those of organic farming. This can be explained by the fact that the CO_2e saving in organic farming due

to avoided use of fertilizer and crop protection is largely compensated by organic farming’s considerable yield loss.

2.4.2. Feed supplements

Ammonia is a major pollutant and contributes to an acidification of soils, as well as to respiratory problems in animals and in humans living close to farming operations.
Ammonia is formed by the breakdown of urea in animal manures and slurries, or uric acid in poultry manures. Most of the available nitrogen in manures is in the form of ammonium-nitrogen, which can be used as a direct substitute for inorganic fertilizer.

However, ammonia can easily escape as a gas and cause significant environmental damage when it’s re-deposited, by:

- upsetting the balance for vegetation that relies on low levels of nitrogen in the soil or water;
- causing excess soil acidity, which can damage certain types of vegetation.

Ammonia can also have a direct toxic effect on trees or other vegetation, for example lichens and mosses, if they grow close to a source of high emissions, as it can damage foliage and slow growth.

There are many proposed actions and strategies to reduce livestock-related ammonia emissions, such as ventilation, nutrition and manure treatment. Nutritional strategies include diet formulation as close as possible to the animal’s actual requirement based on digestible amino acids. Another option that has recently gained increasing importance is the inclusion of phytogenic feed additives in the animal diet.

In particular, the first step to reduce levels of ammonia is to ensure that animals are not fed more protein than is necessary. This will reduce the amount of nitrogen excreted.

Also some feed additives have the potential to reduce the amount of ammonia found in the manure of the animals or in the barn air.
A feed additive is a vitamin for farm animals that can't get enough nutrients from regular meals that the farmers provide. In some cases if an animal does not have some type of feed in its diet it may not grow properly.

2.5. Packaging

Sustainable packaging is the development and use of packaging with improved sustainability.
To achieve a sustainable packaging we have to remember that packaging should be used only where it is necessary; the mass and volume of packaging (per unit of contents) can be measured and used as one of the criteria to minimize during the package design process. Usually "reduced" packaging also helps minimize costs.
Finally also recycling could have an important role to reduce GHG emission and waste of energy; for example for a good packaging can be chosen small components which are not difficult to separate and do not contaminate recycling operations.

Packaging is one of the major applications of plastics. Compared to alternative materials, a plastic package has significantly lower weight. This advantage results in a lower overall carbon footprint, despite a higher production footprint per kilogram of material (about 2-4 kgCO_2e per kg plastic versus 0.7 kgCO_2e per kg for glass and paper, 3 kgCO_2e per kg for thin steel and 8 kgCO_2e per kg for aluminium).

Plastic is often used for packaging because it is very light in weight and can be shaped into many forms. Plastic is also resistant to water and extreme temperatures, making it able to withstand almost any type of environment. In addition lighter packaging means less fuel used in transportation.

2.5.1. Bioplastics

The usage of renewable sources for the bioplastics production is a reality that is going to develop so much in any country of the world.
Bioplastics are composed by vegetable components, such as corn starch, and biodegradable polymers obtained both from raw materials of renewable origin and from raw materials of fossil origin.
Bioplastics can be processed according to the most common plastics processing technologies to create products with similar or better characteristics than traditional plastics, but fully biodegradable and compostable.
Several biopolymers are produced and marketed (thermoplastic polymer materials, biodegradable and compostable) for different application technologies.

The advantages of bioplastics are:

- biodegradability in various environments, such as in composting and soil (in accordance with the European standard EN 13432 and certification programs released by leading international certification bodies);
- workability with the same technology of traditional plastics and similar productivity;
- printability with standard inks and printing technologies;
- colorability mass with biodegradable master-batch;
- intrinsic antistatic;
- sterilizable by gamma rays.

Some examples of bioplastics are shopper, disposable tableware, accessories, packaging, toys, healthcare, etc.
But bioplastic can also be used in thermoforming and injection molding.
For example, capsules for coffee were produced with this technology. These articles of very common use have a significant environmental impact which may be reduced with the use of biodegradable plastic.
In addition, bioplastics require lower temperatures process, resulting in significant savings of energy (about 35%).

Today there are different types of bioplastics able to replace traditional plastic materials, in many applications. For other types of applications, instead, bioplastics require improvements either about performances or about related productive processes. In those cases the benefits, coming replacing the traditional plastic materials with bioplastics, are only at the environmental level.
However, it‘s expected that in the near future an economic benefit may arise, especially considering the increasing price of oil and its derivatives, which constitute the basis for the production of traditional plastic materials.
Ultimately, in the coming years the bioplastics success could be a new concrete developing path for the entire plastics industry.

Bioplastic can also help to improve the process of composting: since it can be composted, it’s easy to separate waste collection for organic recovery. In the case of products made from bioplastics such as cutlery, tableware and food packaging, their compostability enables organic recycling of mixed waste, since both parts (objects made from bioplastic and food waste) are biodegradable and compostable. This characteristic is important for any situation where there is a risk that organic waste will become contaminated by plastic products, thereby making it hard to recycle. Separate collection and recycling of organic waste in compost is highly advantageous for the environment as compost traps carbon in the soil and maintains its fertility.

2.6. Consumer goods-low temperature detergents

Innovative detergents, with non-ionic surfactants, complexing agents (phosphonates or laminated silicas), bleach (hydrogen peroxide or per-carbonate) and enzymes, have change the way to wash.
These low-temperature detergents show the combined CO_2e impact of modern surfactants and laundry enzymes. Modern washing agents have contributed to modernize washing technologies, leading to excellent results at much lower temperatures than in the past and therefore reduced energy consumption and CO_2e emissions. Compared to soap based systems for which the washing temperature is typically 60°C or higher, the temperature can be reduced to 30°C if modern washing agents are applied. In this way we can actually save about 50 million tons of CO_2 a year.
Apart from the in-use phase, modern detergents also have a lower CO_2e footprint than soaps. For modern detergent systems, life cycle emissions of 65 gCO_2e/dosing were estimated, compared to 309 gCO_2e/dosing for soap. This difference is largely driven by the fact that modern detergents are more efficient and require only one third of the amount of soap.

2.7. Power

2.7.1. Solar power

Solar energy is the energy derived from the sun through the form of solar radiation.
A solar cell (also called a photovoltaic cell) is a device that converts the energy of light directly into electricity by the photovoltaic effect.
Traditional photovoltaic cell technologies are mainly based on silicon, a semiconductor that generates an electric current when illuminated, thanks to the photovoltaic effect. Even if consolidated, this technology has also some drawbacks:

- high energy consumption to obtain a silicon purity sufficient for cell production;
- the electricity produced is still relatively expensive when compared to that from fossil fuels;
- silicon modules are difficult to fit inside buildings, transport and portable electronic devices, because of the material rigidity and fragility.

For this reason some Industries are interested to replace this solar cell with organic solar cells, built from thin films (typically 100 nm) of organic semiconductors, including polymers.
The new technologies can produce lightweight and flexible devices for consumer electronics, easily fitting in buildings and vehicles, also exploiting curved or complex surfaces.
The manufacturing processes of organic cells do not require extreme environmental conditions and are already used for conventional printing (for example ink-jet printing and gravure); consequently production costs, including energy consumption, are significantly lower than those of traditional silicon cells. As a final result, better environmental compatibility is achieved.
The main advantages of this technology are:

- use of areas and surfaces not accessible to traditional PV devices, thanks to architectural and structural integration;
- technological integration in devices that cannot use traditional solar cells, such as portable electronics, transportation and applications requiring energy but far from power grids;
- manufacturing processes that are widely available, relatively inexpensive and not requiring extreme production environments (e.g. high vacuum or high temperatures).

Nowadays the energy efficiency of these organic cells is lower than the silicon cells, but further improvements are planned in efficiency and durability.

2.7.2. Wind power

Wind power is the conversion of wind energy into a useful form of energy, such as using: wind turbines to make electricity, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships. A large wind farm may consist of several hundred individual wind turbines which are connected to the electric power transmission network. Offshore wind farms can harness more frequent and powerful winds than are available to land based installations and have less visual impact on the landscape but construction costs are considerably higher. Small onshore wind facilities are used to provide electricity to isolated locations and utility companies increasingly buy surplus electricity produced by small domestic wind turbines.
Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land.
Any effects on the environment are generally less problematic than those from other power sources. As of 2011, 83 countries around the world are using wind power on a commercial basis. As of 2010 wind energy was over 2.5% of total worldwide electricity usage, growing at more than 25% per annum. The monetary cost per unit of energy produced is similar to the cost for new coal and natural gas installations.

Wind turbines require high performance lubricants for proper operation. The role of lubricants is widely underestimated in the wind energy sector, although it has a decisive influence on the performance, efficiency, maintenance requirements, and service life of the equipment, indeed by selecting advanced oils and greases, and adopting a proactive approach to maintenance, wind farm operators can significantly improve the productivity of their operations and reduce costs.
The industry essentially needs three types of lubricants: gear lubricants, hydraulic fluids, and greases. The lubricants protect against micro-pitting and wear even in tough conditions.
Some synthetic oil, compared with conventional, mineral based oils permit to extend the interval between oil changes from 18 months to three years or more.
So by introducing technologically advanced synthetic lubricants alongside an effective oil equipment condition monitoring programme, wind farm operators can look to reduce costs and maximise the productivity of wind turbines, including those operating in remote, offshore locations.

Some Industries produce also high-performance grouting materials, adhesives and sealants. Grouting materials must be able to absorb the enormous vibrations, wave actions, torque and wind power during the lifetime of the wind turbine.

Some benefits for the customers are:

- proven fatigue resistance ensuring long durability;
- zero autogenous shrinkage;
- fast and cost effective installation;
- rapid strength build-up, even at very low temperatures;
- applicable at temperatures down to +2°C, allowing for longer weather windows;
- installation cost considerably reduced due to fast overall installation;
- earlier operation of the wind farm and return on investment;
- high early and final strengths.

2.7.4. Biomass & biofuels

The term "bio-refinery" does not mean an ecological refinery but a refinery that produces biofuels.
The use of biofuels offers environmental benefits related to the absence of pollutant emissions (sulfur and polyaromatic hydrocarbons) and lower Greenhouse Gases emissions according to LCA (Life Cycle Analysis), although the energy efficiency is lower than fossil fuels.

Dow formed a joint venture with Mitsui & Co. in Brazil to create the world's largest integrated facility for the production of biopolymers made from renewable, sugar cane derived ethanol.
Companies plan to produce sugar cane derived ethanol for use as a renewable feedstock source out of Dow's Brazil facility.

Addition of new biomass-based feedstock will diversify Dow's raw material streams from traditional fossil fuels and:

- save equivalent of 3.3 million barrels of oil per year;
- reduce approximately 1.2 million metric tons of CO_2 emissions per year.

Some Industries are developing new high performance bio-fuels (e.g. high quality biodiesel) and are producing bio-energy through the conversion of non edible biomass.

We have to remember that first generation biofuels are made from the sugars and vegetable oils found in arable crops, which can be easily extracted using conventional technology. In this case there is a threshold above which Industries cannot produce enough biofuel without threatening food supplies and biodiversity.

A solution is the development of second generation biofuels, which are mainly made from non-edible feedstocks as lignocellulosic materials like wood and straw. Using these raw materials there's no competition with food industry.

For example it is possible to produce bio-fuels through the gasification of biomass and the following liquefaction of such syn-gas or through the cultivation of microalgae that are able to proliferate on industrial waste water or on saline water, metabolizing the nitrogen and phosphorus compounds contained in them, and to absorb the CO_2 in the industrial off gas to obtain biomass with high content of removable lipids, convertible into diesel fuel.

In particular, the biomass produced by microalgae can be advantageously exploited for energy purposes: once separated from the growth media by gravity separation and filtration, it can be used to extract vegetable oil convertible into fuels.

The advantages of the use of microalgae are also:

- higher biomass yields per acre of cultivation than traditional biofuels;
- may minimize or avoid competition for arable land used for conventional agriculture and food production;
- may be grown using waste water, and saline water, which may reduce competition for limited freshwater supplies;

In addition, producing biofuels from algae may have similar benefits as traditional biofuel production including increasing energy security and decreasing the dependence on imported fossil fuels.

2.7.5. CO_2 capture and storage

Carbon capture and storage (CCS) or carbon capture and sequestration, is the process of capturing waste carbon dioxide (CO_2) from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. The aim is to prevent the release of large quantities of CO_2 into the atmosphere.

For CO_2 capture, the challenge is to separate CO or CO_2 from synthetic fuels from those derived from fossil fuels, or to separate CO_2 from the flue gas. This is respectively pre- and post-combustion capture. There are also alternative ways, like for instance having the combustion in almost pure oxygen (oxyfuel combustion), which produces a stream of highly concentrated CO_2, but requires the separation of oxygen from the air.

For storage, the major challenge is to ascertain the safety and reliability of storage of CO_2 in geological formations at all timescales. Only geological storage of CO_2 is considered to be environmentally acceptable in the EU. Ocean storage above the seabed, for instance, is not considered acceptable. Several geological settings are envisaged as potential storage sites, oil and gas reservoirs, in exploitation or depleted, non mineable coal seems, and deep saline aquifers.

A very important example to reduce the problem of CO_2 is the "CO_2 capture and storage technology" developed by Dow Oil & Gas and Alstom Power. The project's objective is to make possible the capture and geological storage of 10% of European CO_2 emissions, or 30% of the emissions of large industrial facilities (mainly conventional power stations).
To accomplish this, two types of approach must be validated and developed: new technologies for the capture and separation of CO_2 from flue gases and its geological storage, and tools and methods to quantify and minimise the uncertainties and risks linked to the storage of CO_2.

Dow Oil & Gas and Alstom Power are jointly developing advanced amine process technology that utilizes an advanced amine solvent from Dow, in combination with advanced flow schemes to provide a cost-effective post-combustion, carbon capture technology for application in power plants worldwide.
This advanced amine process is degradation-resistant and extremely energy efficient when it comes to capturing CO_2, while helping control emissions.

The most important advantages given by this product are the following:

- carbon capture and sequestration reduces GHG emissions from coal combustion – which represents 40% of world's power generation;
- Dow and Alstom's Advanced Amine Process leads the industry in carbon capture;
- pilot plant in West Virginia designed to capture 1,800 tons/year of $CO_{2;}$
- large-scale facility in Poland being constructed to capture 1.8 million tons/year of CO_2.

2.8. Lightning

The primary strategy in energy efficient lighting lies in a design that recognizes what will occur in the area to be lit and sizes the lighting to that task.
One of the most efficient energy saving light bulbs used in homes is LED (light emitting diode).

2.8.1. LED lightning

A LED lamp (or LED light bulb) is a solid-state lamp that uses light-emitting diodes (LEDs) as the source of light. LED lamps offer long service life and high energy efficiency, but initial costs are higher than those of fluorescent and incandescent lamps. Chemical decomposition of LED chips reduces luminous flux over life cycle as with conventional lamps.

The environmental impact of LED lighting is small because, unlike fluorescent lamps which contain mercury, it does not contain substances that can harm the environment after disposal.
Furthermore, thanks to its high light emission efficiency (the efficiency of converting electricity to light), LED lighting holds the future promise of reducing energy consumption compared to current mainstream fluorescent light sources. Society has high expectations for the practical application of LED lighting as a technology of low environmental impact.

Indeed we have to remember that conventional light bulbs waste most of their energy as heat; for example, an incandescent bulb gives off 90 percent of its energy as heat, while LEDs remain cool.

LED bulbs are now one of the most cost-effective ways to save energy and money, because they use 50% to 80% less power. Many of the latest LEDs are also dimmable, with outstanding colour temperature choices and longevity that extends over decades. So, you maintain excellent light quality and save on the cost of ongoing operation, replacement, and labor.

LEDs continue to get brighter, more efficient and cheaper. Some predict a 2 or 3 times improvement in efficiency and brightness before the decade is over with significant price decreases.

2.8.2. OLED lightning

In recent years new technologies are starting to use in lightning; for example the organic light emitting diode (OLED). The structure consists of a stack of fluorescent organic layers sandwiched between a transparent

conducting anode and metallic cathode. When an appropriate bias is applied to the device, holes are injected from the anode and electrons from the cathode; some of the recombination events between the holes and electrons result in electroluminescence (EL).
In these materials the emissive electroluminescent layer is a film of organic compound which emits light in response to an electric current. This layer of organic semiconductor is situated between two electrodes. Generally, at least one of these electrodes is transparent.

While LEDs use tiny inorganic crystals based, for example, on gallium nitride, OLEDs are made from pigment-like organic compounds. Companies are working on these organic molecules to improve the efficiency and the duration of the devices.

OLEDs are used to create digital displays in devices such as television screens, computer monitors, portable systems such as mobile phones, handheld games consoles and PDAs.

An OLED display works without a backlight. Thus, it can display deep black levels and can be thinner and lighter than a liquid crystal display (LCD). In low ambient light conditions such as a dark room an OLED screen can achieve a higher contrast ratio than an LCD, whether the LCD uses cold cathode fluorescent lamps or LED backlight.

2.9. Plant’s emissions reduction

Dow’s Stade site produces approximately 2.2 million tons of products per year and is one of the world’s first large chemical sites almost entirely independent from external disposal facilities.
The site operates one of the largest industrial biological sewage plants in Europe and creates an innovative bio-sludge recycling technology that reduces solid wastes with thermal treatment, using chemolysis technology.
The site has:

- recycled 100 percent of bio-sludge for 20 years;
- reduced carbon dioxide emissions;
- extended the recycling process.

2.9.1. Catalyst

Catalyst could help to reduce a plant’s emission. A catalyst is a chemical substance that affects the rate of a chemical reaction by altering the activation energy required for the reaction to proceed.
A catalyst may allow a reaction to proceed at a lower temperature or increase the reaction rate or selectivity. Catalysts often react with reactants to form intermediates that eventually yield the same reaction products and regenerate the catalyst. Note that the catalyst may be consumed during one of the intermediate steps, but it will be created again before the reaction is completed.
In the chemical industry and the industrial research, catalysis plays an important role. The different catalysts are in constant development to fulfill economic, political and environmental demands. If you use a catalyst it is possible to replace a polluting chemical reaction with a more environmental friendly alternative.
Because of its ability to speed up some reactions and not others, a catalyst enables a chemical process to work more efficiently and often with less waste. Hence, catalysts are important in industrial chemistry.
Catalytic chemistry is used in many different ways to minimize the impact of industry on the environment. Catalysts are often used to treat hazardous materials. When materials passed over the appropriate catalyst, toxic elements can be filtered out.
Also in automotive industry catalysts are used to reduce emissions from gasoline and diesel engines by using automotive catalytic converters. Using an active metal in a device that provides a large surface area for metal dispersion and intimate contact between exhaust gas and the metal catalyst, a catalytic converter promotes chemical reactions for the conversion of the pollutants into carbon dioxide, water, and nitrogen.

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