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Cleaner Production (in industry and services) to Mitigate Climate Change

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One of the 17 sustainable development goals (goal 13) adopted by the United Nations on September 25, 2015, is 'climate action', i.e. 'to take urgent action to combat climate change and its impacts'. The major economic sectors contributing to climate change are worldwide: (1) Electricity and heat production (25%), (2) Agriculture and forestry (24%), (3) Industry, and (4) transportation (IPCC, 2014). Cleaner production (or resource efficient and cleaner production), which includes measures to reduce greenhouse gas (mainly CO_2, CH_4, N_2O and fluorinated gases) emissions offers thus in all these sectors the opportunity to combat and mitigate climate change. In this context, emissions over the entire life-cycle of a product or process must be considered.

After a short introduction on targets for the reduction of greenhouse gas emissions, the paper will first give an overview of where, in the practical implementation of cleaner production, measures to reduce greenhouse gas emission can be taken. Burning of fossil fuel for electricity and heat is the largest single source of global greenhouse gas emissions. Greenhouse gas emissions from industry may involve fossil fuels burned on site at facilities for energy generation, but also emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption, as well as emissions from waste management activities. Moreover energy saving measures result in less electricity or heat consumption, thus reducing greenhouse gas emissions related to electricity and heat production. Recycling of input materials often requires a lower energy input than producing these from new resources, so that selection of appropriate input materials, along with on-site reuse and recycling may reduce the emission of CO_2. This aspect of recycling will be discussed in some detail. The possibilities for the reduction of greenhouse gas emissions may thus be summarized as follows:

1. Input material substitution:
   - use less impacting or, preferably, renewable energy or fuels
   - use input materials obtained with lower greenhouse emissions, e.g. by recycling
2. Technology change and process modification:
   - energy use may be decreased and product efficiency increased by the use of optimal process conditions, by improved process control or by designing a completely new process
3. Improved operational practices:
   - energy management
   - maintenance programs
   - proper maintenance

4. Product modification, so that less CO_2 is emitted during the production
5. On site reuse and recycling

All these aspects will be illustrated mainly by case studies by the authors in Belgium, Colombia and Cuba, including production of cement and lime with lower emission of CO_2, forecasting and control of energy consumption in hotels, cleaner production in a fish treatment factory, battery production, pig production etc. These are relatively small projects, in which several of the aspects given above were addressed. The impact of these projects on climate change will be estimated.

In industry, major gains for climate change can also be made by highly integrating industrial production in networks along the lines of industrial ecology. On the one hand in a large industrial complex a material network can be realized, with vertical integration (a large fraction of the base and intermediate products are produced on site, leading to a large range of products). The different vertical production chains may also be interconnected (horizontal integration: by-products or waste from a given vertical production chain are used as base material in other production chains). The material network leads, next to material savings also to energy savings, as e.g. less transport is needed because all the installations are concentrated on the same site, and to reduced emissions of CO_2. In addition, an energy network is possible. In most large industrial complexes both endothermal and exothermal processes take place; some production processes thus require energy, others give energy. The energy can flow from one installation to another under the form of steam. Connecting the energy flows using a heat exchanger network could considerably lower the total energy consumption, as process heat that would otherwise be lost is reused. This will be illustrated by examples from the chemical industry in Flanders, Belgium.

In addition, the production of electricity and heat of course offers also large opportunities to reduce CO_2 emissions, by producing renewable energy (solar thermal energy, solar photovoltaics, bioenergy from (waste) biomass, hydroelectricity, wind energy, …). This will be illustrated by two cases 'Biomass based electricity generation potential of the Province of Cienfuegos, Cuba' and an example from the waste management sector: the 'Ecluse Network of Sleco, Antwerp', which supplies steam produced by combustion of industrial waste, household waste and sewage sludge, directly to several chemical industries requiring energy. This affords a much higher energy efficiency as when the produced steam is used to generate electricity. Moreover the impact of solar and wind energy will be considered.