A Co-Operation Between China and Europe in The Field of Sustainable Development: Main Results and Planned Activities

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Abstract

The Project "*Eco-Compatibility of Industrial Processes for the Production of Primary Goods*" (an INCO Project, n° IC18-CT96-0095, financed by the European Community for the period 1997-1999)[1] was a good experience for establishing a co-operation between China and Europe in the field of sustainable development, with special regard to environmental impact assessment of industrial processes.
The overall objective of this project is to propose guidelines useful to re-define development policies in China in the field of sustainable production of primary goods: all the activities performed in this Project are planned to increase the environmental consciousness of industrial manufacturers both in China and in Europe throughout the application of life-cycle concept to the automotive sector. Car is just the final product of many production chains: starting from raw material mining and energy production and delivery systems and tracing all the processes until the final destination of materials at the end of the car useful life, it is possible to identify a great variety of industrial sectors and, as a consequence, to adapt design to an overall eco-efficiency objective.
During the three years of the Project, the Life Cycle Assessment (LCA) of two small size cars produced in China and in Europe was completed and different scenarios for the recycling of cars at the end of their life were studied with a re-Design For Environment (DFE) approach.
One interesting application of the study is a recycling system that is now planned to be organised in China: the goal is to build a consortium among dismantling plant and to stimulate the use of materials from vehicles at the end of their useful life to produce new car components.

Key words Sustainable development, Life Cycle Assessment, EC-China co-operation

1 The co-operation

The Consortium is made by seven Universities and research centres, two Italian, two German, one Danish and two Chinese. The common goal is to determine and to test new guidelines useful to re-define development policies in China in the field of sustainable production of primary goods. The most important innovative tools adopted by the Consortium belong to environmental impact assessment methodologies and are Life Cycle Assessment (LCA) and Design For Environment (DFE).

2 The analysed system and the methodological approach

The choice of the car as the particular good to be investigated under an environmental impact point of view derives by the fact that the Chinese market is involved by a big expansion of the automotive sector (at an average annual rate of about 13% since 1980, especially of little size cars) [6] and the possible consequences of a such development lead to the necessity to perform a study about its energy and environmental aspects.
Life Cycle Assessment (LCA) is the innovative tool adopted to identify and assess under an energetic and environmental point of view all primary industrial sectors involved in the system under study.
The LCA framework is organised in an Inventory stage (LCI), where the aim is to provide a detailed description of the inputs of raw materials and fuel into the system and the outputs of solid, liquid and gaseous wastes from the system, an Impact Assessment stage (LCIA), where the LCI results are linked to identifiable environmental problems and an Interpretation and Improvement stage, in which the system is modified in an attempt to reduce environmental impact.
LCA and Design For Environment (DFE) are then linked and used to simulate the improvements suggested or implemented in order to see if the expected changes have occurred but also to avoid the introduction of any unwanted side effect.

[1] For more information, please visit the site: www.diget.polito.it\incoproject\inco_page.htm.

The result is the availability of an eco-design tool, in which the traditional approach to design is integrated by environmental consideration on processes and materials used in all unit processes included into the system, from raw materials extraction to final destination of components after the disassembling phase at the end of car useful life.

Life Cycle Inventory (LCI) of a small size car produced in China and in Europe is the first important result of the co-operation activity that was characterised by a complete overview of all unit processes and how they are inter-related within the plants and the operations considered (De Benedetti et al., 1998).
The two selected cars adopted for the analysis are Fiat Panda and Xialy, respectively made by the Fiat Group in Italy and the Tianjin Automotive Industrial Group in China.

3 Some results of the inventory analysis

The gross energy consumption (GER)[2] [1] is quite different in the two cases: about 140 GJ for the Chinese car and about 35 GJ for the European car.
In the case of China, the influence of national energy mix on the gross energy consumption is very high: the Chinese energy system is based on coal (China is the largest consumer of coal in the world) and the production of electricity from this primary fuel is highly inefficient.
As well as GER, Global Warming Potential (GWP) of the production systems represents another interesting parameter to evaluate their environmental burdens: the GWP of the Chinese car is about 8.300 kg CO_2-equivalent, while the GWP of the European car is about 2.000 kg CO_2-equivalent[3] [2].

4 Recycling of materials

The most important task of the last year of the co-operation is the evaluation of disassembling opportunities for the recycling of materials which constitute the examined cars.
This properly constitutes the beginning of the Interpretation and Improvement stage.

A comparative LCA of re-use of materials originated by a selective dismantling of Fiat Panda and Xialy was therefore examined and a completely new scenario for car dismantling and recycling in China was studied. The main goal of these last activities of the project was to provide useful information for the Project Consortium partners in charge of the design for disassembling and recycling tasks.
The investigated processes mainly refer to a system called “F.A.Re” (Fiat Auto Recycling) that is organised by Fiat Auto and operates in Italy since 1992. In particular, it is finalised to add recovery of non-metallic parts to traditional recovery of metals.
A similar system is now under consideration by Chinese operators in Beijing and Shanghai metropolitan areas with the goal to reproduce the organisation of recycling activities that operate in Europe.

Once the car arrives to the dismantling plant, which is part of the organisation, firstly all the fluids are extracted and sent to specific treatments. Successively, the vehicle is subjected to selective dismantling operations to recover those components that are rich of recyclable materials, such as bumpers, glasses, dashboards, seat foams, chassis and engine. These parts are addressed to specific treatments and re-use circuits: for instance, polypropylene bumpers are extruded into pellets and used for the production of air ducts for car industry, seat foams are used for the production of under-carpets and so on.
In the case of Fiat Panda, it is possible to recuperate 7,9 kg of polypropylene. Because of mechanical resistance constraint, it is not possible to use more than 30% of recycled polypropylene to produce new bumpers. On the other hand, recycled polypropylene can be used 100% for the production of air ducts.

The car is then shredded and crushed and three fluxes are speared: ferrous metals (steel and cast iron), light alloys, and fluff.
Fluff, that is formed by all organic residues can be destined to incineration or alternatively sent to landfill.

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[2] The forms of energy associated with a production system are direct energy (energy directly consumed in materials processing and handling), indirect energy (energy used by the fuel producing industries in supplying the direct and feedstock energies) and feedstock energy (when a raw material, which can act as a fuel, is taken into a system and used as a material rather than a fuel). The sum of these three terms is the gross energy requirement (GER).
[3] The adopted conversion factors for GWP calculation come from United Nations Working Groups and refer to current state of the art.

Ferrous alloys are used for the production of steel and aluminium alloys are reused in metallurgical industry too.
In the example of Figure 1, steel, polypropylene and aluminium are addressed into a closed loop recycling for the production of new car components in appropriate percentages, while car glasses are ground and used for the production of bottles into an open loop recycling.

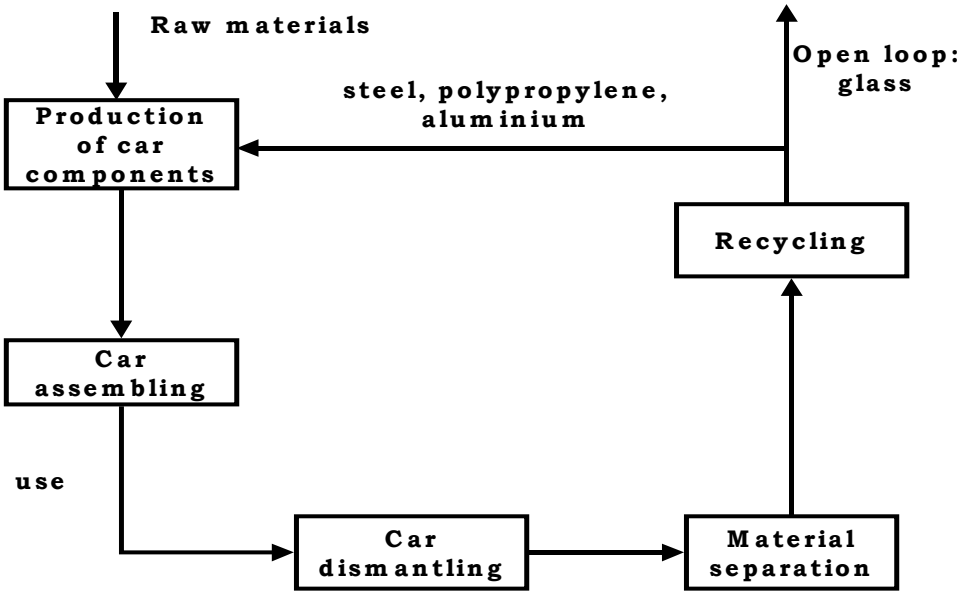

Figure 1. The materials flow in the Fiat Panda production system: the closed loop recycling includes steel, polypropylene and aluminium. Car glasses are addressed to an open loop recycling.

Again, in the Fiat Panda case, at the end of the dismantling process about 490 kg of steel and cast iron are available. F.A.Re. system subjects ferrous scraps to a selection process and to a steel production in electric arc furnace (EAF).
The re-calculation of the environmental burdens of production processes taking into account the recycling processes, including transports and materials treatments leads to new results.

Figure 2 shows the comparison between the original situation, in which the components are produced from primary materials, and the recycling scenario, in which the same components are realised using an appropriate percentage of recycled material.
In Table 1 is shown the comparison of Global Warming Potentials in the two cases.
These two parameters show an improvement in the case of use of secondary processes. Other impact categories parameters, such as acidification and photosmog, increase in the case of use of secondary processes due to a larger use of transports. In any case, the Chinese Authorities can evaluate the possibility to organise a secondary materials market for the automotive industry and the re-Design For Environment activities can start adopting these results as an objective base.
Taking into account the foreign availability to invest in the whole sector, a first result is the project of some dismantling plants in Beijing and Shanghai metropolitan areas to provide secondary materials.

5 Planned activities

The co-operation with Chinese researchers and authorities is going on for the continuos improvement of the automotive system here presented.
Taking into account the high coal dependence of the Chinese energy system, a new project was recently submitted to EC to go on with the co-operation with China. This new project deals with the environmentally friendly development of an ultra-clean micronized coal slurry fuel to be used in diesel engine. This project represents the natural follow-up of the INCO project because the fuel under study is expected to be used in

different sectors, from transportation to agriculture and it can be also useful to implement the use of LCA and DFE in industrial operations that are close to the automotive one.

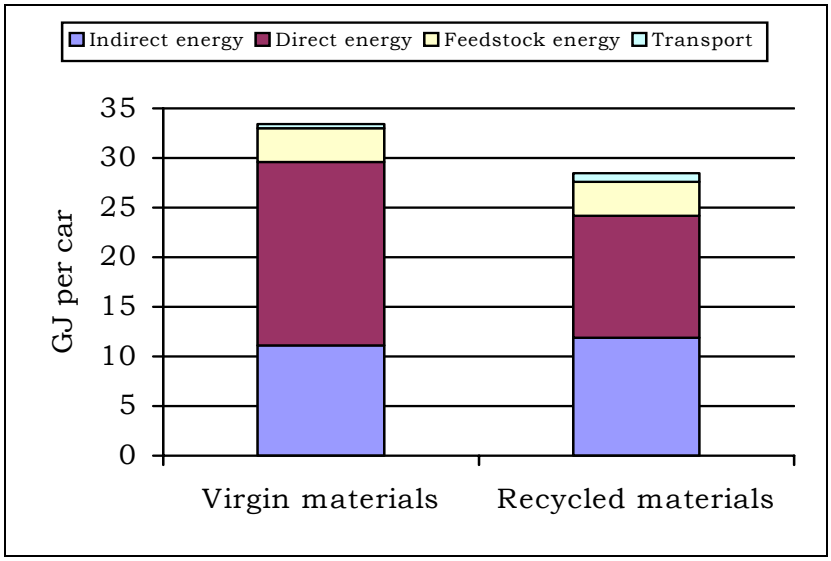

Figure 2. Gross energy requirement for Fiat Panda production using primary and secondary materials.

Table 1. GWP for Panda production in the two cases of materials use.

Impact category	Virgin materials	Recycled materials
GWP (t CO2 equivalent per car)	2.060	1.580

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