P. Frankl
TMR Marie Curie Post-Doctoral Research Fellow at CMER

A Success-story of Life Cycle Assessment (LCA) integration in Business Decision Making - The Case of Fiat Auto

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ABSTRACT

The paper reports the results of a case-study about the application of Life Cycle Assessment (LCA) at Fiat Auto. The paper firstly reports the results and implications of a specific LCA-study carried out in the company, i.e. on the comparison of a conventional engine block in cast iron with a possible alternative block in aluminium. Furthermore, it describes the history of LCA introduction and use at Fiat Auto and examines its role in the decision-making context of the company.

Fiat Auto certainly is the firm with the widest experience of use and application of LCA in Italy. To date (1998), it has completed more than 20 LCA studies. Many others are planned for the near-mid future. The interest of the company in LCA is very strong. As a core tool for the wider concept of Life-Cycle Management, LCA is explicitly included in the long-term strategic framework programme called "Project 21", which defines the environmental policy at Fiat Auto.

Moreover, there is a clear commitment to further expand the use of and to integrate it as a routine tool into decision-making processes. LCA is going to be a major supporting tool within the framework of the forthcoming (1998-1999) “Integrated Development Plan of (car) Components”. This plan crosses through several departments, as it is going to involve not only the Department of Environment and Industrial Policies - DAPI - which currently coordinates all LCA activities - but also the Technical, Purchasing, and Production departments. It is going to define the policy of Fiat Auto with respect to material choices and design of car components. It will introduce new specifications for designers, by highlighting the environmental impacts of materials and of project alternatives. It is with this respect that LCA is increasingly going to be used in a systematic way.
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0. SUMMARY

FIAT Auto is the main company of the FIAT Group operating in its “core-business”, that is the production of transportation vehicles\(^1\). It has the largest share of the automotive market in Italy and holds leading position at European level.

The environmental policy at FIAT Auto is defined in a long-term strategic framework program called “Project 21”, which takes its name in reference to the Agenda 21 defined at the Rio Conference. The Project has been developed at the “Direzione Ambiente e Politiche Industriali” - DAPI (“Department of Environment and Industrial Policies”), which was established in 1991. As a core tool for the wider concept of Life-Cycle Management, LCA is explicitly included in the “Project 21”.

Among the many possible LCA studies we selected, together with the interviewees, the one related to the comparison of two equivalent engine blocks, one made from Cast Iron and the other from Aluminium. This has been one of the most significant and instructive studies carried out at FIAT.

In fact, as many other car producers, FIAT has embraced the strategy of reducing the weight of its cars as much as possible with the goal of reducing fuel consumption. A possible way of doing this is by substituting conventional cast iron engine blocks with lighter ones entirely made from aluminium. However, the study demonstrated that the use of aluminium is environmentally positive only under certain conditions. The study concluded that, under the current state (1996) of the F.A.RE. recycling system and of the Italian market of secondary aluminium alloys, the use of aluminium on a large-scale had to be taken into account with great care. This had significant implications on the strategy of the company. In fact, after the study, the decision was taken to slow down the substitution of cast iron engine blocks with aluminium blocks and to apply it only to new models.

In any case, the study did not reject the aluminium solution in general, as it suggested to review conclusions in case of the evolution of external parameters. It is worth highlighting that those decisions clearly have been taken mainly for economic reasons and not only for ecological ones. The environmental analysis further supported this decision. According to the interviewees, a manufacturing extra-cost for the environmental improvement of car and its components is allowed. However, in controversial situations economic arguments would always prevail.

The selected LCA study has been a prospective one, carried out to take decisions out of it and apply

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\(^1\) A few companies of the FIAT group other than FIAT Auto are involved in LCA activities as well. However, until
them on a large-scale. It has been a full LCA study: all product life-cycle stages and LCA phases have been included. Both staff of FIAT Auto (Dept. For Environment and Industrial Policies) and of FIAT Group (Research Center) were involved in the study. There was also a (minor) external support. However, now all LCAs are carried out internally.

FIAT certainly is the company with the widest experience of use and application of LCA in Italy. To date (state as November 1997), the firm has completed 16 LCA studies. Two more are being carried out at present. Many others are planned for the near-mid future.

The interest of the company in LCA is very strong. There is a clear commitment to further expand its use and to integrate it as a routine tool into decision-making processes. LCA will be a major supporting tool within the framework of the forthcoming (1998) “Integrated Development Plan of (car) Components”. This plan, which crosses through several departments (it will involve not only the Department of Environment and Industrial Policies - DAPI but also the Technical, Purchasing, and Production departments), is going to define the policy of FIAT with respect to material choices and design of car components. It will introduce new specifications for designers, that is the environmental impact of materials and of project alternatives. It is with this respect that LCA is increasingly going to be used in a systematic way.

The results of LCA are currently applied only internally. In particular LCA is not perceived as a marketing tool, because of its complex and sometime controversial results. As of other environmental external communication and initiatives, FIAT focuses on target audiences, such as schools, Universities, experts rather than on the general public.

There is clear evidence that LCA activities at FIAT are very well integrated in the process of product innovation. However, the real challenge that FIAT is going to face is the integration of LCA-thinking at all company levels and functions. In fact, on one hand FIAT has developed a significant know-how with respect to “technical” aspects of LCA and the methodology is going to be more and more integrated into design and development choices. This process involves all technical departments, is supported by the top management and will even accelerate through the implementation of the “Integrated Development Plan of car Components”. On the other hand however, the marketing, commercial departments and the network of dealers are excluded from this process yet.

No LCA study has been directly triggered by legislation pressures. However, LCA can be a very
useful tool to anticipate legislation trends, particularly at European level.
1. **INTRODUCTION (BACKGROUND AND COMPANY)**

1.1 **Introduction and overview on the case-study**

This paper reports on the LCA activities carried out at FIAT Auto SpA. Moreover, it focuses on a selected example of application of LCA at FIAT Auto, namely the comparison of two alternative materials – cast iron and aluminium – to be used for building engine blocks. This is one of the most significant LCA studies carried out at FIAT Auto, for various reasons. A main one is that it led to relatively surprising results. On its turn this has led to decisions which slightly changed former strategic decisions of management.

FIAT certainly is the company with the widest experience of use and application of LCA in Italy. To date (state as November 1997), the firm has completed 16 LCA studies. Two more are being carried out at present. Many others are planned for the near-mid future. As a core tool for the wider concept of Life-Cycle Management, LCA is explicitly included in the “Project 21”, which defines the environmental policy at FIAT Auto.

This framework programme has been set up by the “Department of Environment and Industrial Policies”, which has been established in 1991 in order to tackle with the complex issue of assessing and reducing the environmental problems of cars. The department has been also established to respond to the emerging and increasing attention of the public in connection of the 1992 Rio Conference on Environment. The “Project 21” takes its name in reference to the Agenda 21 defined at the Conference.

The interest of the company in LCA is very strong. There is a clear commitment to further expand its use and to integrate it as a routine tool into decision-making processes. LCA will be a major tool within the framework of the forthcoming (1998) “Integrated Development Plan of (car) Components”. The plan will define the policy of FIAT with respect to material choices and design of car components. It will involve not only the Department of Environment and Industrial Policies, but also several other departments (Technical, Purchasing, and Production).

The company has expressed a great interest in our research project. We had wide access to data and meetings with both managers and LCA-practitioners. We particularly thank Ing. S. Di Carlo and R.

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2 In fact, this includes all LCA activities carried out in the whole FIAT Group until now. Other people not belonging to FIAT Auto (i.e. CRF and Fisia Italimpianti) are occasionally and/or regularly involved in LCA studies. However, by
Serra and, who organized the meetings.

Participants to the Case Study³:

- Dr. Gian Paolo Massa – DAPI, Responsible for Industrial Policies and Scenarios
- Ing. Salvatore Di Carlo – DAPI. Head, Central Laboratories
- Ing. Rosanna Serra – DAPI, Central Laboratories, coordinator of environmental activities
- Ing. Giancarlo Foglia – DAPI, Central Laboratories, coordinator of LCA activities
- Ing. Davide Diana – DAPI, Central Laboratories, LCA activities
- Ing. Giovanna Loi – DAPI, Central Laboratories, LCA activities
- Ing. Alessandro Levizzari – Centro Ricerche Fiat (CRF - FIAT Group), LCA activities
- Ing. Eugenia Accusani – Centro Ricerche Fiat (CRF - FIAT Group), LCA activities

1.2 Specific techniques for the information and data collection

The case study has been carried out during three meetings. All meetings were held in November at the Department of Environment and Industrial Policies (Direzione Ambiente e Politiche Industriali - DAPI).

The first meeting took place on November, 14th morning at the Central Laboratories, which currently hold the responsibility of coordinating all activities on LCA at FIAT. In this occasion we were presented to the full team of people dealing with LCA. This includes 3 full-time persons at the Central Laboratories of DAPI and two more people working on LCA at the Centro di Ricerche FIAT, which is the Research Center of the corporate group.

After presenting our research project and its goals we were firstly told about the general framework of LCA activities at FIAT, by Ing. Serra, who is the responsible coordinator for environmental activities. Then, we received more detailed information about different LCA studies and their application within decision-making processes.

In the afternoon we met at FIAT headquarters Dr. Massa, responsible for Industrial Policies and Scenarios, Di Carlo Head of Central Laboratories. During this second meeting we were provided with more general information about FIAT’s corporate environmental and industrial policy and about the company’s more strategic point of view about LCA and other environmental management tools and approaches in general⁴.

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³ All participants except the two members of CRF belong to the Department of Environment and Industrial Policies (DAPI).
⁴ The concept of “eco-efficiency” is considered as very important at FIAT/DAPI.
On that day we also collected all the bibliography (reported in § 6).

Finally, we had a third meeting on November, 24\textsuperscript{th}, during which we asked for and received more detailed information and data about the selected case-study.

1.3 **General description of the company**

1.3.1 **Turnover, products, markets, employees**

*FIAT Group*

The FIAT Group is operating in 60 countries with 874 companies. The “core-business” is the production of transportation vehicles - cars, industrial vehicles, tractors, caterpillars, but the group is active in many other different industry sectors.

In 1996, the group had a turnover of 51,3 billion dollars, of which 40,7 were related to the core business\textsuperscript{5}. 37\% of its production was sold in Italy, 40\% in the rest of Europe, and the remaining 23\% outside of Europe. In the same year, FIAT had the 11,3\% market share for cars and 20,0\% for industrial vehicles in Western Europe.

Overall in the world, the FIAT group has 220 production plants and almost 238000 employees (data as of 31/12/96). The investments in R&D activities amounted to 1,4 billion dollars.

All FIAT companies have large management autonomy, within the framework of the strategies established with the corporate head FIAT SpA.

*FIAT Auto*

Fiat Auto is the well-known Italian car producer company operating in the core business of the group. In terms of number of produced cars, it is by far the most important national car manufacturer, as it has acquired the other former independent Italian car producing firms Lancia, Alfa Romeo, Autobianchi, and Ferrari.

FIAT Auto has the largest share of the automotive market in Italy. It has also a leading position at European level.

1.3.2 **Organisation structure of the company**

Figure 1 shows the organization of the different departments at FIAT Auto. It is important to notice that the Department for the Environment and Industrial Policies is well integrated in the decision-
making structure of the company. It is at the same level of other important departments, such as the technical one, purchasing, and production. Its head, Ing. Scolari and it refers directly to the chairman and C.E.O.

According to the interviewees, he is very active and deeply involved in top management decisions at FIAT Auto.

**Figure** - Flow Chart of the different departments at FIAT Auto [source: DAPI - Industrial Policies]

### 1.3.3 Environmental activities and policies

FIAT started to establish Environmental Policies at the corporate level already before the Rio Summit, in 1992. At FIAT Auto, a new department of Environment and Industrial policies (Direzione Ambiente e Politiche Industriali - DAPI) was established in 1991. As already mentioned and as shown in Fig. 1, the department is well integrated in the overall organization of the company.

At the Rio Conference, FIAT signed the International Chamber of Commerce (ICC) Business Chart for Sustainable Development, committing itself to fulfill its requirements. On the basis of the Charter principles, environmental statements have been prepared, to which companies of the Group have been encouraged to agree.

The relevance of the commitment of the company related to environmental issues has led to the definition of the “Principles of Environmental Policy at FIAT”, which is the implementation guideline for all companies of the group.

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5 Exchange rate as of 31/12/96: 1 US$ = 1519 Lire
6 In our opinion, it is already very important that the environmental issues and the industrial policies are addressed by the company within the very same single department.
To date, FIAT Auto Production sites in Brasil and Poland are certified ISO 14000. The certification of the Italian sites is in program.

*The Project 21*

At the operational level of FIAT Auto, the environmental policy has been defined by the department of Environment and Industrial Policies and has been summarized in a long-term framework project for environmental management. The project is called “Project 21” in reference to the Agenda 21 set forth at the Rio Conference. The project tackles with both short-term and more long-term environmental issues. Figure 2 shows the main features of the project. As shown in the diagram, the Project 21 takes into account all different levels of environmental problems, namely the ones related to products, processes and organization.

![Flow Chart of the “Project 21” Environmental Program at FIAT Auto](source: DAPI - Industrial Policies)

**Figure 1** - Flow Chart of the “Project 21” Environmental Program at FIAT Auto [source: DAPI - Industrial Policies]
1.3.4 LCA activities

Role of LCA in the context of the environmental policy at FIAT Auto

Life Cycle Management is explicitly included in the environmental framework program “Project 21”. Of course, LCA is the basic tool for environmental life-cycle management.

The interest in LCA at FIAT Auto begun in May 1994, when a comparative study between existing impact assessment methods was carried out. The promoter of this interest was directly the director of DAPI, Ing. Scolari. Shortly after this first learning experience to get introductory knowledge about the methodology, two empirical studies begun in September 1994. Since that time 16 LCA studies have been completed (as of November 1997), two are currently being carried out and many others are planned for the near future. All LCAs on materials and/or single car components have been full LCAs; studies on more complex issues (i.e. biodiesel, electric car, etc.) have been screening/streamlined LCAs. Table 1 summarizes all LCA activities at FIAT (updated as of April 1998). It clearly shows the actual commitment towards the use of LCA as a routine tool within the company. As a matter of fact LCA will be systematically used within the framework of the forthcoming (1998) “Integrated Development Plan of (auto) Components” (see §3.2.1).

LCA-capacities (internal/external)

At FIAT Group, LCA studies have historically been carried out both by the Central Laboratories of DAPI (FIAT Auto) and by the FIAT Research Center (FIAT Group). In some cases there has been also some external support, mostly from Universities and/or research institutes. However, the internal capacities and internal resources devoted to LCA have increased over time. At present LCA studies are fully carried out internally.

Three persons from DAPI work presently full-time on LCA. The Central Laboratories DAPI has also the responsibility of coordinating all LCA activities. Moreover, several members of Central Laboratories get involved on-the-spot in LCAs when they have to provide technical and specific information on particular materials and/or components. Finally, other personal of DAPI, belonging to the section “Energy & Ecology” (see Fig. 1) might also be involved in LCA studies.

In addition, two persons are involved in LCA at CRF, the FIAT Research Center.

Another FIAT Group company, namely Fisia Italimpianti SpA, is involved in LCA as well. For example, it has been recently involved in the comparative LCA on CO₂ car paintings vs. conventional solvent painting.

Table 1 shows the list of carried out at FIAT Group as of April 1998.
<table>
<thead>
<tr>
<th>DATE</th>
<th>TITLE OF THE STUDY</th>
<th>TREATED ARGUMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>may-94</td>
<td>STUDY OF DIFFERENT ASSESSMENT METHODS</td>
<td>THEORETICAL STUDY ON DIFFERENT UNIVERSITIES APPROACHES TO THE ASSESSMENT PHASE IN L.C.A. STUDIES</td>
</tr>
<tr>
<td>sept-94</td>
<td>L.C.A. OF RAPESEED METHYLESTHER FUEL</td>
<td>COMPARATIVE STUDY ON METHYLESTHER FUEL WITH NORMAL DIESEL FUEL</td>
</tr>
<tr>
<td>sept-94</td>
<td>L.C.A. APPROACH ON POLYPROPYLENE BUMPER RECYCLING</td>
<td>COMPARATIVE ANALYSIS ON DIFFERENT BUMPER RECYCLING METHODS</td>
</tr>
<tr>
<td>jan-95</td>
<td>LIFE CYCLE STUDY OF BRAVO/BRAVA'S BOOT COLLAR BADGE</td>
<td>LIFE CYCLE STUDY OF THE BRAVO/BRAVA BOOT COLLAR BADGE IN THE CASE OF PLASTIC, ALLUMINIUM OR ZINC ALLOY USE AS RAW MATERIALS</td>
</tr>
<tr>
<td>feb-95</td>
<td>CLUTCH PEDAL LIFE CICLE ASSESSMENT</td>
<td>COMPARATIVE ANALYSIS OF THE BRAVO/BRAVA'S CLUTCH PEDAL IN STEEL OR PLASTIC</td>
</tr>
<tr>
<td>mar-95</td>
<td>ENVIRONMENTAL STUDY ON TYRE FEEDSTOCK ENERGY RECOVERY</td>
<td>COMPARATIVE ANALYSIS OF THREE DIFFERENT WAYS OF TYRE INCINERATION WITH ENERGY RECOVERY</td>
</tr>
<tr>
<td>jun-95</td>
<td>ENVIRONMENTAL IMPACT OF AUTOMOTIVE GLAZING</td>
<td>LIFE CYCLE ASSESSMENT OF GLASS USE IN AUTOMOTIVE GLAZING</td>
</tr>
<tr>
<td>jul-95</td>
<td>LIFE CYCLE IMPACT OF DISK BRAKES</td>
<td>LIFE CYCLE ANALYSIS OF DISK BRAKES IN CAST IRON AND METALLIC COMPOUNDS</td>
</tr>
<tr>
<td>oct-95</td>
<td>L.C.A. OF POLYURETHANE FOAMS IN CAR SEATS</td>
<td>STUDY OF THE ENVIRONMENTAL IMPACT OF POLIURETHANIC FOAMS FOR CAR SEATS</td>
</tr>
<tr>
<td>nov-95</td>
<td>ENVIRONMENTAL IMPACT OF ENGINE BLOCKS</td>
<td>ENVIRONMENTAL ANALYSIS ON ENGINE BLOCKS IN CAST IRON OR ALUMINIUM</td>
</tr>
<tr>
<td>jan-96</td>
<td>L.C.A. STUDY OF VARIOUS MATERIALS FOR CAR BONNETS</td>
<td>COMPARATIVE ANALYSIS OF CAR BONNETS MADE IN STEEL, ALLUMINIUM OR THERMOSETTING COMPOUNDS</td>
</tr>
<tr>
<td>mar-96</td>
<td>LIFE CYCLE ASSESSMENT OF A CAR CONDITIONING EVAPORATOR</td>
<td>LIFE CYCLE IMPACT OF AN AIR CONDITIONING EVAPORATOR UNDER DIFFERENT END OF LIFE RECYCLING HYPOTHESIS</td>
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<tr>
<td>apr-96</td>
<td>LIFE CYCLE STUDY OF THE CAR DASHBOARD</td>
<td>STUDY OF DIFFERENT TYPES OF MATERIALS AND PRODUCTION TECHNIQUES FOR THE CAR DASHBOARD</td>
</tr>
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<td>jul-96</td>
<td>ZERO IMPACT CAR L.C.A. APPROACH</td>
<td>ENVIRONMENTAL IMPACT STUDY OF THE COMPONENTS OF THE ZERO IMPACT CAR</td>
</tr>
<tr>
<td>mar-97</td>
<td>L.C.A. APPROACH TO CAR PAINTING</td>
<td>L.C.A. APPROACH TO WATER PAINTS USE IN ALTERNATIVE TO TRADITIONAL PAINTS</td>
</tr>
<tr>
<td>mar-97</td>
<td>LIFE CYCLE IMPACT OF THE ELECTRICAL CAR</td>
<td>ENVIRONMENTAL IMPACT OF THE ELECTRICAL CAR COMARED TO THE TRADITIONAL FUEL RUNNING CAR</td>
</tr>
<tr>
<td>nov-97</td>
<td>COMPLETE LIFE CYCLE ANALYSIS OF A DIESEL CAR</td>
<td>ENVIRONMENTAL IMPACT OF THE DIESEL RUNNING CAR COMARED TO THE TRADITIONAL FUEL RUNNING CAR</td>
</tr>
</tbody>
</table>
Table 1 - LCA studies carried out at FIAT Group [source: DAPI]

1.4 General description of the business external context

1.4.1 The branch/sector context

Markets, technologies and clients
As well known, the car market has become a global market over the last decades. FIAT therefore has to compete on the markets of many different countries all over the world. Most of its competitors are (some are very) active in the environmental field.

It is worth mentioning that car industry of different European countries has realized the need to conduct common research studies on the environmental aspects of their products. This is the case of the EUCAR project, which also includes a part on LCA.

Sector-specific environmental concerns/problems
The largest environmental impacts of the product “car” are very clearly related to its use and to its final phase. The production phase does not have major environmental problems in itself.

As many other car producers, in order to reduce specific fuel consumption rates of its cars, FIAT has embraced the strategy of reducing the weight of cars as much as possible. The selected LCA case-
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study is exactly related to this strategic approach aiming at using lighter materials whenever possible and economically convenient.

As far as the final phase of cars is concerned, materials are recycled as much as possible in the car industry from many years already. Apart from ecological aspects, this is mainly due to pure economic reasons. In fact, a very large majority of car components and materials can be recycled.

All main car producers in Europe have their own strategic approach and their take-back system. The FIAT system is called F.A.RE (Fiat Auto REcycling)7.

The used recycling approach at FIAT is the one of open recycling “in cascade”: the recycled material is used for components with lower quality (technical and structural) requirements than the original ones.

The objective of F.A.RE. is the total recycling of car materials (including energy recovery). The recyclability of materials in itself is not an issue. In principle, metals, plastics and glass are almost fully recoverable. The real issue is the actual number of cars which actually enter the recycling system at the end of their life. To date (15.10.97) 300 Italian car dismantlers are involved in the project and 585000 cars have been taken back from the beginning of the project itself. This corresponds to more than 16000 tons of non-metals recycled (glass, plastics, fluff). Numbers and the market of secondary materials are further increasing. However, the system has been significantly biased by the economic incentives given by the Italian government in 1997 to the people who sold their more-than-10-years old car and bought a new one (385.000 old cars were collected in 1997 only).

According to Dr. Massa, the numbers show a good beginning, but the share of actual recycled cars compared to the new ones sold on the market is still low (the order of magnitude of the Italian market is 2.000.000 cars per year (all marks). In any case, always according to Dr. Massa, the system as it is organized now (voluntary agreement) is expected to recycle, at maximum steady-state, up to 500.000 cars per year. Beyond that number, a dedicated regulation will be needed. As far as this is concerned, it is worth mentioning that the recently introduced Italian law on waste (art. 46 of Decreto Ronchi - January 1997) obliges the owner of a car to take care of its end of life by bringing it back to either to a certified dismantling center or to the manufacturer (either directly or through its network of dealers). In this second case it is the car manufacturer that takes over the responsibility of assuring that the old car is dismissed and materials recycled according to the law prescriptions.

It is worth remarking that FIAT has clearly chosen the approach of Life-Cycle Management (LCM)
to respond to the environmental challenges. Within this strategy it uses a set of tools including LCA, Design for Disassembling, Design for Recycling, etc.).

The main issue for FIAT is to get the thousands of suppliers involved within this LCM system. These are almost all small-medium enterprises which mostly lack of both cultural and technical skill to implement such systems. Most of time they are even not aware of the existence of these tools.

1.4.2 Political and legal context

The Italian political and legal context related to environmental matters is considered very complicated at FIAT (as in any other Italian company subject of our case-studies). A lack of institutional leadership and of a framework law on environmental matters is felt.

No legislation pressure at Italian level triggered any LCA activity at FIAT.

On the other hand however, a policy measure which has had a very significant impact on Life Cycle Management are the above mentioned economic incentives offered by the Italian state in 1997. Incidentally, the economic incentives have been repeated for the first half of 1998. They are even more “ecologically oriented”, as they hold only for buyers of new small cars with low consumption figures.

At European level, a directive on the recycling of car materials and components is expected in the near future. FIAT feels having anticipated the European legislation by means of its LCA and LCM activities. This will enable the company to promptly comply with the future European directives.

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7 FIAT has an agreement of reciprocity with Renault, BMW & Rover

April 1999
2. THE SELECTED LCA-STUDY

Among the many possible LCA studies we selected, together with the interviewees, the one related to the comparison of two equivalent engine blocks, one made from Cast Iron and the other from Aluminium.

This has been one of the most significant studies carried out at FIAT, for several reasons. Firstly, it is related to a single, but very central car component, that is the engine. Secondly and most interestingly for our case-study, it led to rather surprising results. On their turn, these led to concrete decisions, which changed, at least partially, former company’s strategy with respect to this particular matter.

2.1 The LCA story (chronological)

2.1.1 Motivations and objectives

Generic motivations and objectives

The LCA study on the engine block has been the 9th in order of time carried out at FIAT (see also Table 1). At the time of its beginning, the importance of LCA as environmental impact assessment tool was already recognized within DAPI (but not yet within the whole firm). In particular, some previous LCA had already shown surprising results (i.e. the one on the clutch pedal). This had further led to the conviction that LCA is the right approach to assess the environmental qualities / impacts of materials and components and is a very helpful tool for the design phase of more environmentally benign car components.

Specific motivations and objectives related to the selected product

As many other car producers, FIAT is increasingly striving at reducing fuel car consumption figures. A possible way to achieve this goal is to reduce the weight of the car. At FIAT it has been estimated that a weight reduction of around 10% causes a reduction in consumption of around 4%8.

Therefore, FIAT has embraced the strategy of reducing the weight of its cars as much as possible. A major car component “target” of this strategy is the engine block, as conventional cast iron engine

8 The figures are referred to a medium-big size car weighting around 1100 kg. Within the EUCAR Project, other car producers claim that the reduction of consumption might be around 7%. However, FIAT does not agree with this
blocks can be substituted by lighter ones entirely made from aluminium.

However, as mentioned before, previous LCAs had introduced some doubts about the actual consequences of generic environmental strategies. The LCA comparing two different types of engine blocks has been carried out with the explicit objective of verifying whether the generic strategy of reducing weight was a correct environmental solution under a life-cycle perspective or not.

The specific motivation has been mainly internal to DAPI. The commissioner and promoter of the LCA study was directly Ing. Scolari, head of DAPI. The fact that also competitors were carrying out LCA studies on problems of reducing the weight of cars has been only of marginal importance in triggering this particular study.

The LCA has clearly been a prospective one: the study has been carried out in order to take concrete decisions based (also) on its results.

2.1.2 Chronology and organization of the LCA study

Internal competence and organization

The study started in November 1995. As mentioned before, it was the 9th study from the beginning of LCA activities at FIAT (September 1994). Thus, at that time being, FIAT had already developed a significant experience and internal competence and implemented an internal organization for carrying out LCAs.

Timing, involved people and costs

The study lasted six months. The relatively short time needed has been a consequence of the experience gained and the organization developed (i.e. relating to software, data-bases, etc.) in the occasion of former LCA studies. This LCA analysis has involved one full-time person at DAPI. Moreover, several other persons from the Central Laboratories have been involved on-the-spot, whenever peculiar information on materials was required. The engine blocks are produced internally within the company, therefore no additional information (and consequent resources) was needed from suppliers. No peer review occurred.

In practice, the costs of the selected LCA case-study are the ones related to the manpower of the involved person at DAPI.

result. The figure of 4% has been supported by internal experimentation (by increasing the weight of the car).

9 It is worth recalling that DAPI is responsible both for the environment and for the industrial policies.

10 With this respect, it is worth remembering that FIAT Auto was participating in the EUCAR project at that time.
External support
No external support was needed at the time of the LCA study. However, in a later phase, the same study has been carried out a second time by the FIAT Research Center with the external support of the Politecnico di Torino. This has been done to further check and validate the obtained results, given the importance of their implications. In a certain sense, it has been an internal peer review process.
Interestingly, this second study came to different results. However, discrepancies were clarified after carefully comparing and adapting system boundaries, data-banks, and software.
It is also a consequence of this experience that at FIAT / DAPI it is strongly felt the need for a reliable, shared and public available Italian data-bank on energy systems, transportation, waste and materials.

2.2 Methodological choices

2.2.1 Type of LCA
As already mentioned, the selected LCA study has been a prospective one, carried out to take decisions out of it and apply them on a large-scale.
The conducted study is a full LCA: all product life-cycle stages and LCA phases were included. Several impact assessment methods and software were used for comparison of results.

2.2.2 Detailed description of the products subject of LCA and of their life-cycle
As already mentioned, the study compared two different engine blocks, one made in cast iron, the second one made fully in aluminium. The two engine blocks are both applicable on the same car. An existing car (at that time) was taken as reference model, namely Alfa Romeo 155 Twin Spark 2.0 L. Figure 3 summarizes the main data on the two engine block types.
Figure 2 – Characteristic features and data of the two engine blocks [source: DAPI]

The conventional Cast Iron engine block is the one actually applied on the car. Its life-cycle is shown in Figure 4.

Figure 3 – Life-cycle of the cast iron engine block  [source: DAPI]

On its turn, the life cycle of the aluminium engine block is depicted in Figure 5.
As already mentioned, the LCA has been a full one. Following methodological choices have been taken with respect of the different product life stages (materials, manufacturing, transportation, use, recycling):

**Materials**

The study is somewhat simplified by the fact that engine block are mono-material car components. The Aluminium case obviously takes into account the technical and structural features required for the material. Data on the manufacturing of primary and secondary cast iron and aluminium are a mix of direct data with literature data.

The mining phase has been estimated.

**Manufacturing Process**

The manufacturing of (both) engine blocks occurs internally in the firm. Thus, the related data are direct ones.

**Transport phases**

The actual distances of manufacturing sites were taken into account. All transports occur on trucks.
Use phase

The actual consumption figures of Alfa Romeo 155 T.S 2.0 have been used for the conventional cast iron case. The reduction of consumption in the aluminum case has been estimated by extrapolating the already mentioned empirical relation between weight and consumption reduction (10% of reduction in weight corresponds to 4% reduction in consumption).

End-of-life phase

The actual data of the F.A.RE. system have been used. Real data on secondary aluminium producers have been used as well.

2.2.3 LCA-steps

Here is a description of steps and methodology used for the LCA study.

Goal definition

The goal of the analysis was a prospective one (DAPI’s position), that is to compare the environmental impact of a conventional cast iron engine block with the one of a new aluminium engine block. Given the relevance of the implications of the study, we may define it as “strategic” (it was not likely planned as a strategic study, however it become significant).

Boundaries and Functional Units for Data Selection

The functional unit used is the entire engine block, as it provides the same service in the car.

As already mentioned, real data about material suppliers were used. Both aluminium and cast iron are produced in Italy.

The mining phases have been estimated.

The Italian electricity production mix was considered for all electricity consumption phases. However, also possible alternative scenarios have been taken into account.

The end-of-life phase was evaluated making different possible scenarios of aluminum recycling possibilities.

Data Acquisition

The information for the raw material processing were taken from literature, interviews and internal
FIAT databases, compiled during earlier studies.

For the use phase and the end-of-life, FIAT based its assumptions on the performance tests and on the experience of designers.

The quality of direct process data is obviously very good. The average quality of data might be considered as good. However, according to the author of the study, better data related to energy systems and transports would be needed.

Impact Assessment

Several assessment methods and software have been used for comparison (basically for learning purposes). Incidentally, FIAT is trying to establish its own weighted indicator, for internal purposes. According to the people at DAPI, the basic idea behind this approach is that only eco-inventories are “objective” (if coherent system boundaries and assumptions are employed). The impact assessment is always a rather subjective and sometimes “political” process. Therefore, in principle, any company should be free to set-up its own most appropriate indicators (as long as this is done for internal purposes).

In this particular case, results and recommendations derived directly from eco-inventory results.

2.3 Results and recommendations

2.3.1 Comparison between the two engine blocks

The characteristics of the two compared engine blocks are the one already summarized in Fig. 3. In the case of aluminium, a sensitivity analysis with respect to the level of use of secondary aluminium instead of primary aluminium has been carried out. On its hand, cast iron is always obtained from scraps.

Main conclusions

The main outcome of the LCA study is that the use of aluminium is environmentally benign only under specific conditions, namely:

- a significant weight reduction (at least 40%)
- a large use of secondary aluminium alloys derived from recycled scraps.

The study also suggests that, under current Italian market situation, in case of a sudden and
significant large use of aluminium in cars, there could be availability problems for suitable secondary alloys.

As said before, the results are strongly dependent on the percentage of recycled aluminium used. Results also depend on other parameters, such as the actually obtainable weight reduction, the specific fuel saving, the hypothesis made on the electricity production mix, etc.. Figure 5 summarizes the dependence of results on those parameters as far as energy consumption is concerned. Similar results are obtained with respect to CO₂ and other air emissions [source: DAPI, [1].

The study recommends to consider these results in the design of new models, not only for crankcases but also for other components, especially those made of rolled and forged aluminium.

**Figure 5** - Comparison of energy consumption of the two engine blocks (Aluminium - cast iron) depending on various analysis parameters [source: DAPI], [1].

*Surprising results*
The results were surprising, at least to management people not used to consider the whole life-cycle of materials. In fact, before this study, it was generally thought that any car weight reduction is environmentally friendly. The company strategies with respect to car consumption reduction had been tuned according to this “generic principle”.

The study demonstrated that the use of aluminium is environmentally positive, but only under certain conditions. The study concluded that, under the current state (1996) of the F.A.RE. recycling system and of the Italian market of secondary aluminium alloys, the use of aluminium on a large-scale had to be taken into account with great care. This had significant implications on the strategy of the company.

In any case, the study recommended that conclusions to be reviewed in case of change of external parameters (amount of suitable recycled aluminium on the market, amount of actually recycled cars, etc.).

### 2.3.2 Organisation, difficulties and challenges

The study had no major difficulties, as an internal organization was already established at that time. However, the author stressed the need to have a public data-bank at Italian level on energy system, transportation, waste management and materials.

In this specific case there has not been any particular problem with suppliers. However it is worth mentioning that in other cases of more complex car components, FIAT has had major problems with the collection of data from suppliers. In fact, FIAT people directly went to suppliers to get the data together with them. This is a general problem for carrying out LCA in the car industry (see also § 3.1.2.)

### Controversial results

Results of the LCA can be significantly different according to different impact assessment methodologies. Moreover, they can substantially change depending on the chosen system boundaries, electricity production mix scenarios, etc.. As mentioned before, this particular study was done again by the Fiat Research Center, obtaining controversial results. However, differences have been clarified after a careful analysis of the above mentioned analysis parameters.

No external peer review has taken place.

*Need for a simplified methodology for a wider use of LCA*
The selected case-study has been a full LCA. This is also the case of other LCA on single car components. However, the need for a simplified methodology in the case of LCA of a more complex object (i.e. the whole car) was stressed. In fact other LCAs in which the functional unit is the whole car (see Table 1), have been simplified LCA studies.

2.4 Decisions and Application

2.4.1 Decisions related to products

Large-scale substitution of cast iron engine blocks with aluminum engine blocks

After the study, the decision was taken to slow down the substitution of cast iron engine blocks with aluminium blocks. It is worth highlighting that this clearly has been done not only for ecological reasons but also for economic ones. The full substitution of cast iron engine blocks on all existing models would have implied major production changes and consequent investments. However, the environmental analysis further supported this decision.

Review of the application over time

The selected LCA did not reject the aluminium solution in general. As mentioned before, the study itself suggested to review conclusions in case of the evolution of external parameters, such as actual number of recycled cars and availability of suitable secondary aluminium alloys on the Italian market. It is also in this perspective that aluminium engine blocks are actually applied in a new car model (Alfa Romeo 156). To date however, this is still a niche market application.

2.4.2 Decisions related to the internal organization

A certain organization was already established when this case-study has been carried out. This organization has further evolved with time, as the importance of LCA has been recognized. Today, three full-time persons are involved in LCA activities at DAPI. Other persons are involved at the FIAT Research Center and at FISIA.

Today, FIAT is well organized and equipped to carry out any kind of LCA fully internally within the firm.

2.4.3 Implications for further applications of LCA

Following main implications / requirements for a wider use of LCA have been identified at DAPI:

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The use of full LCA for the analysis of single components, and the use of simplified LCA in the case of the whole car. The need for agreed simplification rules.

The need of a public data-bank on energy systems, transportation, waste systems and materials, in order to be able to compare results and data coming from different sources.

An increased commitment towards a careful supply-chain management. The collection and quality of data from suppliers is still a problem. The issue is how to involve and motivate them.

### 2.4.4 External actors involved in the decision-process

No external actors were involved in the decision-process.

### 2.5 INFORMATION AND COMMUNICATION

**Internal communication**

As it usually happens with all kind of information about materials, LCA results have been communicated from the Central Laboratories of DAPI to the other departments (Technical, Purchasing, and Production). After a series of common meeting, results have been communicated to the Head of the Product line, who has the responsibility for the final decision.

The level of internal communication and training is high. However, feedbacks are quite different. In general, there is a high level of involvement among the departments involved in the design, while the involvement it is very low in the marketing and commercial department. This also holds for this particular case.

**External communication**

The results of the LCA have not used externally as a marketing instrument.

The full selected case-study has been never published. However, some results have been have presented in specific occasions (i.e. SAE scientific meetings - [1]).

In general FIAT does not invest a lot in spreading out information on its environmental activities. As for the commercial- marketing side, there is the conviction that green marketing in Italy does not (yet) pay back in terms of company's image or customer's satisfaction when choosing a car. The only "ecological" campaign carried out by the company, advertising the F.A.RE. system, partly confirmed this opinion; but it has to be said that FIAT's "ecological" message could hardly be retained by consumers, being mentioned just in one campaign.

In particular LCA is not perceived as a marketing tool, because of the complexity and
controversiality of results.
As for other environmental external communications and initiatives, FIAT focuses on target audiences, such as schools and Universities rather than on the general public.
3. ROLE OF LCA IN THE DECISION MAKING CONTEXT

3.1 The decision-making culture

3.1.1 Internal decision-making culture

There are substantially two large ways of communication and decision-making processes at FIAT Auto. The first one is an “horizontal” way of communication between the departments. Each department analyses all products according to its own tasks and responsibility (see also Figure 1). Then, there is a second, “vertical” way of communication and decision-making which is directly connected to the single product (a car model) and crosses the different departments. In practice, there is a responsible person for the single car project, who coordinates the activities of all departments related to that particular car. This person has the responsibility of taking the final decisions. He directly refers to the Chairman and C.E.O.

3.1.2 Country and industry sector-specific “culture”

The Italian car sector

The Italian car sector is practically made exclusively by FIAT. However, this is true at the level of production of the whole car. At level of single component producer, the situation is radically different.

FIAT Auto has thousands of suppliers. Most of them are small-medium enterprises. This has very important implications as far LCA and LCM activities are concerned. In fact, most of these companies are not able, due to limited internal capacities or resources, to implement environmental management systems or LCA activities. Most of the time they are not even aware of the existence of these tools. As a matter of fact, FIAT people had to go directly to the suppliers in order to directly have access to LCA data.

It is a major issue for FIAT how to spread out the environmental culture among these SME’s. FIAT has spread out questionnaires among its suppliers to get feedback from them. It is constantly spreading out information. The general sensation at DAPI is that a larger pressure by FIAT is needed to get suppliers more involved in environmental issues. However, at least until now, the attitude has been rather prudent in order not to “frighten” them too hardly.
3.2 THE PRODUCT INNOVATION PROCESS AND THE INTEGRATION OF LCA IN THIS CONTEXT

3.2.1 The “typical way” of product innovation within the firm

Product innovation is driven by the market. As mentioned before, FIAT mainly responds to this challenge with a “vertical” organization, which crosses the different departments and is coordinated by a single Product Head. The major implication of this is twofold: firstly, there is a high level of collaboration and integration of activities between different departments. Secondly, the Environmental Department DAPI, which has the responsibility of the Central Laboratories is deeply integrated in the Product Innovation process.

Very recently (in 1998), this integration process has further increased, exactly as far as components and materials are concerned. In fact, in future all decisions about components and materials will be commonly taken by the different departments (DAPI, Technical, Purchasing and Production) within the “Integrated Development Plan of (auto) Components”.

3.2.2 The integration of LCA within the process of product innovations

As a consequence of the above mentioned internal organization and process of decision-making, LCA activities at FIAT are very well integrated in the process of product innovation. There are several good reasons for this:

- The Environmental Department DAPI is responsible at the same time of FIAT Industrial and Environmental Policies and is well integrated in the over-all organization scheme of the company.
- Apart from LCA and environmental matters, there is a high level of integration of the different departments because of a “vertical”, product-oriented organization.
- LCA activities are coordinated by the Central Laboratories of DAPI, which have the responsibility to communicate and discuss the results with the other departments. This is a key-point, since the Central Laboratories have always been responsible for providing data on materials to the other departments and to the management. This has the major implication that the other departments (Technical, Purchasing, Production, etc.) receive all information, including the environmental data and LCA results, from the very same officers from which they were used to receive basic data on materials. This is a very different situation from receiving LCA data by an environmental dept. far away from the traditional decision-making process.
• LCA activities will further increase and be integrated within the “Integrated Development Plan of car Components”. In this Plan a new specification has been introduced for designers, that is the environmental impact of materials and of project alternatives. It is with this regard that environmental matters and LCA results will become an everyday tool for designers and people involved in technical choices regarding materials and car components.

• LCA “culture” is now spread out in all design departments. DAPI has received good feedback from all of them.

3.2.3 The future use of LCA within the company

There is a clear commitment at FIAT towards the use of LCA as a routine management supporting tool. LCA activities will be further expanded. Several other LCA studies are foreseen. LCA will be systematically employed within the “Integrated Development Plan of car Components”. The application of LCA is already and will increasingly be a prospective one.

At least for the near future, LCA will basically employed as internal tool for research, development and design activities. It is not expected to be used as a marketing tool.

External communication is and will continue to be fairly restricted to expert meetings and conferences. To date, there has been only one publicity campaign on the FARE (Fiat Auto Recycling) system, explaining the open recycling (cascade) approach at FIAT. Other LCA results have not been communicated to the market. However, LCA is (shortly) explicitly mentioned in the annual environmental report. The limited communication is the consequence of two main reasons. The first one is that the (Italian) market is considered not yet sufficiently sensitive to environmental concerns. The second one is that companies generally think that (at least at present) results of LCA are too complex (and often disputable) to be communicated to the public.

According to Dr. Massa, the real challenge that FIAT is going to face is the integration of LCA-thinking at all company levels and functions. In fact, on one hand FIAT has developed a significant know-how with respect to “technical” aspects of LCA and the methodology is going to be more and more integrated into design and development choices. This process involves all technical departments, is supported by the top management and will even accelerate through the implementation of the “Integrated Development Plan of car Components”. On the other hand however, the marketing, commercial departments and the network of dealers are excluded from this process yet. The implementation of the plan might help to foster communication (the environmental data will systematically presented together with all other technical and economic data). However,
there is still the feeling that more effort will be needed to fill the communication and cultural gap.
4. CONCLUSIONS

FIAT Auto is certainly the most advanced company with respect of LCA use and application in Italy. The firm has already conducted 16 LCAs until now (Nov. 1997). The use of LCA will be further systematically expanded within the “Integrated Development Plan of (auto) Components”. The most important thing is that the role of the "Dept. For the Environment and Industrial Policies " and the use of LCA are deeply integrated at a very high level in the decision-making structure of the firm. As far as this is concerned, to our opinion, FIAT Auto seems to be a pioneer even compared with some other competing European car companies.

LCA is explicitly mentioned as a tool for Life Cycle Management in the “Project 21”, which is the operative framework of environmental policy at FIAT Auto. The motivation was clearly an internal / strategic one. Of course the company was aware that competitors also used LCA, but according to the interviewees, this was not a major pushing factor.

LCA activities at FIAT begun in 1994. Short time after, the objectives of (all) LCAs become prospective ones, that is studies were commissioned in order to take real decisions and not only for learning / confirmation purposes.

The selected case-study has been a complete LCA. Both staff of FIAT Auto (Dept. For Environment and Industrial Policies) and of FIAT Group (Research Center) were involved in the study. There was also a (minor) external support. However, now all LCAs are carried out internally.

The main critical issue encountered has been the collection of data and the involvement of (the thousands of) suppliers. In this and other cases, FIAT officers had to directly visit suppliers to gather their data. FIAT is also in great favor of the establishment of a public, reliable and commonly shared data-bank.

LCA results have been immediately applied to existing cars, that is on a large-scale. However, it is important to notice that decisions were mainly taken on the basis of economic trade-offs. LCA results just agreed with the economic analysis results. According to the interviewees, a manufacturing extra-cost for the environmental improvement of car and its components is allowed. However, in messy situations, economic arguments would always prevail.
From an operational point of view, the key point at FIAT is that all LCA activities are now co-ordinated by the Central Laboratories of the Dept. for Environment and Industrial Policies. The Central Laboratories have always been responsible for providing data on materials to the other departments and to the management. This has the major implication that now the other departments (Technical, Purchasing, Production, etc.) receive all information, including the environmental data and LCA results, from the very same officers from which they were used to receive basic data on materials. This is a much more favorable situation than receiving LCA data by an environmental department far away from the traditional decision-making process.

The level of internal communication and training is high. However, feedbacks are quite different. There is a high level of involvement among the departments involved in the design, it is very low in the marketing and commercial department.

On the contrary external communication is fairly restricted to expert meetings and conferences. To date, there has been only one publicity campaign on the FARE (Fiat Auto Recycling) system, explaining the open recycling (cascade) approach at FIAT. Other LCA results have not been communicated to the market. However, LCA is (briefly) explicitly mentioned in the annual environmental report. The limited communication is the consequence of two main reasons. The first one is that the (Italian) market is considered not yet sufficiently sensitive to environmental concerns. The second one is that companies generally think that (at least at present) results of LCA are too complex (and often disputable) to be communicated to the public.

There is a clear full commitment at FIAT Auto towards an extended use of LCA as a routine tool. As a matter of fact, an inter-departmental committee has been established at the beginning of 1998 that has the task to provide all data about car components within the “Piano integrato di sviluppo dei componenti – Integrated Development Plan of Components”. This includes the environmental data which are to be systematically provided by means of LCA.

In general, the use of full LCAs is expected for materials and car components, whereas streamlined LCAs are and will be used for more complex issues (i.e. electric car, biofuels, etc.)

No LCA study has been directly triggered by legislation pressures. However, LCA can be a very useful tool to anticipate legislation trends, particularly at European level. For instance, the application of LCA will help the company to respond to the forthcoming European Directive on the Recycling of car materials and components.
At Italian level, the company complains the lack of an environmental framework law and the confusion of rules, roles and actors.

FIAT strongly supports the creation of a public shared data-base on energy, transports and waste systems.

To our opinion, there is clear evidence that LCA activities at FIAT are very well integrated in the process of product innovation. There are several good reasons for this:

- The Environmental Department DAPI is responsible at the same time of FIAT Industrial and Environmental Policies and is well integrated in the over-all organization scheme of the company.
- Apart from LCA and environmental matters, there is a high level of integration of the different departments because of a “vertical”, product-oriented organization.
- LCA activities are coordinated by the Central Laboratories of DAPI, which have the responsibility to communicate and discuss the results with the other departments. For the communication process, this is a crucial-point, since the Central Laboratories have always been responsible for providing data on materials to the other departments and to the management.
- LCA activities will further increase and be integrated within the “Integrated Development Plan of car Components”.
- LCA “culture” is now spread out in all Design & Development departments.

We share the opinion of Dr. Massa, that the real challenge that FIAT is going to face is the integration of LCA-thinking at all company levels and functions. On one hand FIAT has developed a significant know-how with respect to “technical” aspects of LCA and the methodology is going to be increasingly integrated into design and development choices. On the other hand however, the marketing, commercial departments and the network of dealers still need to be integrated in this process.
5. REFERENCES


