Business Strategy and the Environment Conference, Devonshire Hall, University of Leeds, UK 13th & 14th September 2004

TECHNOLOGICAL INNOVATION AND ECOLOGICAL CONCERN IN THE TURKISH AUTOMOBILE INDUSTRY

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ABSTRACT

The beginning of the 20th century witnessed the birth of mass production and the rapid development of the automobile industry. The ever increasing number of cars mirrors the quality of technology, but the present challenge is to achieve congruence between technology and quality of life. Technology has provided us vast amounts of place utility; however, unregulated technology, while promising comfort and high levels of productivity may create many undesirable environmental effects and social costs. Hence, technology ought to be considered from an environmental perspective.

As societies become more technology and knowledge-based, they should be more capable and willing to manage and monitor pollutants released into air, water, and soil. The time has passed when we used to waste materials. New alternatives orientated to ecological concern have to be included in the automobile production. Reducing the negative impacts of automobiles such as global warming, acid rain, urban smog, land use, and waste disposal can only be achieved by developing cleaner, more efficient automobiles, while at the same time reducing the kilometers traveled by each automobile every year. Thus, the automobile industry has to be the major focus in countries on their way to environmental innovation. The auto industry has to travel farther than any other industry toward a cleaner environment.

The automobile industry plays a vital role in the Turkish economy today. Among the first 20 private firms ranked according to sales, five were automobile firms (ISO, 2004). The industry is defined as the crucial sector of Turkish industrialization, and its contribution to the Turkish economy is as significant as the textile, food and tourism sectors. The Turkish automobile industry is third with respect to turnover after the tourism and textile industries, and also the most rapidly growing sector with an average annual growth rate 13% (AMA, 2004; TAYSAD, 2004).

Turkey has gone through major economic enhancements and significant technical changes in 1990s, and since then, it has faced environmental pressures on swift sectoral growth in energy, textile, ICT, white goods, electronics, and, particularly automobiles. Thus, a number of institutional and legislative elements of environmental reforms have been initiated since 1980s.

However, Turkey has been face-to-face with many marketing challenges about implementing environmental policies, strengthening environmental infrastructure, integrating environmental concerns in economic decisions, and meeting the country's international environmental requirements e.g. EC regulations[1].

This paper is the study of some major automobile companies in Turkey that are investing in technological innovations based on the new environmental demands and requirements. Therefore, the study reveals difficulties, efforts and perspectives for the uses of ecological concepts that Turkey has to face while adapting to the technology of global automobile market.

[1] "*In March 2002, the Commission issued a Communication on "Environmental Technology for Sustainable Development" which argued that environmental technology could contribute to sustainable development by boosting our economies and protecting our environment. However, at present market barriers and a number of other obstacles prevent them from realising their full potential. The Commission therefore proposed to the Barcelona European Council that it develop with stakeholders an action plan to remove the institutional obstacles to the development, take-up and use of environmental technologies. The Barcelona European Council approved this proposal in March 2002, confirming the political importance of environmental technology. In March 2003, the Commission issued a Communication on "Developing an action plan for environmental technology" to follow up to the commitments of the Barcelona Council and to present the process set up for consultation of stakeholders as well as the first findings of the work. The Commission intends to put forward an action plan on environmental technology by the end of 2003 which will include a more comprehensive identification of promising technologies, barriers and action points. The responses of stakeholders to a number of questions in the March 2003 Communication will be taken into account in the preparation of the Action Plan."* Retrieved from http://www.eugris.org/content/pb2policy1.asp

INTRODUCTION

The automobile industry plays a number of significant roles in the industrialization and globalization process of developing countries. These include encouraging the extraction of raw materials, enhancing technology, developing production and operation methods, transferring know-how, and stimulating foreign direct investment. In particular, the automobile industry increases the employment rate and national income, maintains social and economic growth, and value added creating aspects. Therefore, the industry, alone, plays a significant role in the developing stage of countries such as South Korea, Brazil, and Mexico.

The sector is also the backbone of the Turkish economy, and is vitally important for Turkish manufacturing industry. There are about 17 automobile firms in Turkey, producing different vehicles including truck, bus, minibus, commercial vehicles, and passenger cars. According to ISO (2004) data, in the first 20 private firms ranked according to sales volume, two were automobile manufacturers. Thus, the industry is defined as the locomotive sector of Turkish industrialization and its contribution to the Turkish economy is as significant as the textile, food and tourism industries. The Turkish automobile industry has also positively affected a number of small and medium enterprises (SMEs) for a long time, because the industry needs a variety of components through suppliers.

The Turkish automobile industry started with the industrialization progress in 1950s. Under the import substitution (ISI) and export-led growth strategies (ELG), Turkish automobile industry took the route of forming different strategic alliances. The liberalization policy and the ELG strategy opened up a new horizon for the Turkish automobile industry and international trade since 1980s. Thus, many global automobile giants have established factories via this kind of formation, and have stimulated a number of automobile manufacturers to make investments since 1950s. Ford, Honda and Hyundai, for instance, have introduced initiatives for new investments through alliances producing passenger cars and minibuses. Thus, the production capacity of Turkish automobile industry has increased gradually, with the exception of the two economic recessions. During the period from 1960 to 2003, production increased from 1,161 units to 562.000 units. The export rate of the automobile industry also increased gradually from $2 million in 1963, to $6 billion in 2003.

ECOLOGICAL CONCEPTS AND ENVIRONMENTAL DEMANDS FOR AUTOMOBILE PRODUCTIONS: A Technological Perspective

Today, energy and environmental issues, influencing innovative processes and product design in business, have an increasing significance in economies (Clark, Paolucci, and Cooper, 2002). The innovation in modern industrial economies is a difficult and expensive process of throwing out the old to get the new (Schumpeter, 1935; Hall and Kerr, 2003). Along with technological advances, innovations are a way to human progress but does not have the same perspective for economies, sectors and industries and suggest for irreversible and irresistible changes (Schumpeter, 1935; Nelson and Winter, 2002; Hall and Kerr, 2003).

Effective technological advances come through the underlying technologies, demand and characteristics of the organizations all that operate in a complex environment. Moreover, these technological advances face with difficulties in research and development, decision making process, consumer valuations etc. Therefore innovation has double glided; it is a difficult mission to handle, on the other hand, it is the path that leads the organization to get competitive advantages in international markets (Hall and Kerr, 2003; Clark, Paolucci, Cooper, 2003). Also, environmental technical change is the master way; organizations can reduce their environmental impacts without producing negative economic impacts (Cairncross, 1991; Green et al., 1994; Hall and Kerr, 2003).

However, as the standard of living and economic well-being increases, technical change has brought about undesirable social and environmental side effects, and environmental issues appear as a main anxiety for both academics and policy makers (Grubler, 1994; Hall and Kerr, 2003).

Today, radical technological advances in environmental impacts are not only related with company's sustainable competitive advantage, but also related with corporate social responsibility and social concerns. Here, the major players of social environment of the firm can either be a barrier or a catalyst for the technological innovation (Hall and Kerr 2003).

Also, old technologies hamper new and alternative technologies, which have less environmental impacts (Hall and Kerr, 2003). There are many handicaps in the acceptance of environmental innovations inside and outside the organization that are related to each other (Kemp and Schot, 1998; Hall and Kerr, 2003). For instance, there are alternative fuel transport systems; however, because of those handicaps that halt organization on the way to innovation, most of those organizations prefer to give up technological innovations regarding environmental concerns.

As a result, insufficient personnel and capital resources, awareness, and technical competence, organizational resistance, expensive production, uncertain regulation activities, and marketplace restrictions slow down, somehow hinder, radical technological innovations in ecological concept (Baral and Engelken, 2002).

Environmental Impacts of the Automobile Sector

Today, the world's numbers of automobiles grow faster than the population. In 1950 there were approximately 50 millions of vehicles while this number increases to 600 million by 1994. It is expected to be 3 billions of vehicles on the road by 2050 (Sperling, 1995; Garling and Thogersen, 2001). As the usage of automobiles increase, the amounts of carbon-dioxide and other climate-altering greenhouse gases increased those were released by the internal combustion vehicles (ICVs) (Garling and Thogersen, 2001). The release of waste emissions into air produces great deal of environmental deterioration and reveals as a huge barrier for quality of life and sustainable development (Daniel and Rosen, 2002). As mentioned, the air pollution as a result of engine exhaust emissions is only a part of the iceberg, environmental concern is also subject to materials and energy used in manufacturing and servicing automobiles, energy and emissions coming from the production of fossil fuels to power those automobiles, fluids to lubricate and cool them also to wash them, sprays and paints to coat them and materials used at the end of the vehicle's life (Maclean and Lave, 2003).

Accordingly, environmental issues on vehicles emerge in two main headlines. First, it is near term-local pollution that consists of ozone, air toxics, PM and fuel cycle emissions. Secondly, it comes the long term that consists of global warming and fossil fuel consumption.

Moreover, local emissions are formed by carbon monoxide (CO), nitrogen oxides (NOX), volatile organic compounds (VOC), sulfur dioxide (SO2), particular matter (PM), and lead. These emissions are detrimental for the environment. CO, NO_X, and VOC (or hydrocarbons (HC), react with the atmosphere and form ozone Recent models of light-duty gasoline vehicles form less ozone therefore they seem to be cleaner than older vehicles. Today some of the alternative fuels form smaller amount of ozone than gasoline does. Toxic air pollutants are known as pollutants that cause serious health problems. Motor vehicles release several pollutants in every step of their life cycle however the master effect is due to the exhaust emissions. Some of the alternative fuels are cleaner than gasoline and diesel since they form less toxic pollutants. Long term environmental concern is about climate change and global warming. Water vapor, CO_2, methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and other gases including halocarbons, per-halocarbons are called greenhouse gases. When they accumulate in the atmosphere for years they block the sunlight and cause temperatures to increase, sea level rise, loss of biodiversity, and many diseases (MacLean and Lave, 2003).

Alternative Vehicles of Future

Since road transportation is liberally dependent on fossil fuels, a large amount of GHG is released into air. During fossil based fuel usage almost most of the carbon is converted to CO_2. Separating carbon from fossil fuels would lessen CO_2 emission. This technology is not appropriate for fossil fuels however fossil fuels can be converted to hydrogen with separated carbon as a motor vehicle fuel (MacLean and Lave, 2003).Also, since crude oil is used as the master energy source, important amounts of CO2 are released into air. At this point, alternative fuels such as hydrogen emerge as a response to climate change (Lenssen and Flavin, 1996; Ogden, 1999; Farrell et al., 2003). Vehicles that run on hydrogen have a low emission, which is almost zero for fuel-cell-powered vehicles (Farrell et al., 2003).

Fuel cells, which do not include harmful processes like combustion, produce electricity through chemical reactions. They can be called as an electrochemical engine for electric/hybrid vehicles, which consist of positive and negative electrodes with an electrolyte in between. In this process hydrogen is passed over the negative electrode while oxygen is passed over the positive electrode. A hydrogen ion passes through the electrolyte and the electron that emerged from the ionization of the hydrogen passes through a circuit and produces power. Then the hydrogen ions and electrons meet the oxygen in the positive electrode and release water. This process is continuous as long as hydrogen and oxygen supplies exist. Fuel cells are classified with respect to their electrolytes. Some fuel cell types are Proton Exchange Membrane (PEM), Phosphoric Acid models (PAFC) with acidic electrolyte, Alkaline (AFC), Molten Carbonate fuel cells (MCFC) with an alkaline elctrolyte, Solid Oxide model (SOFC) with solid-state ceramic electrolyte (Hall and Kerr, 2003). Fuel-cell vehicles (FCV) can both by pure hydrogen gas and hydrogen-rich fuels like methanol, natural gas or gasoline but these fuels are converted to hydrogen by an onboard device called reformer. FCVs, working with pure hydrogen, produce merely water and heat, no pollutants but hydrogen-rich fuels and reformer can release a small amount of air pollutants at least less than conventional vehicles (EERE and EPA, 2004).

Another alternative system is electric motors with battery power which use the electrical energy that is stored in the battery. Electrical energy that is stored in battery is converted to mechanical energy by electric motors. (MacLean and Lave, 2003). The need to prevent air pollution, electric vehicles came back to market with more powerful batteries. Although this technology is much more efficient than internal combustion engines, there are insufficient numbers of recharging sites (EERE-EPA, 2004).

Acoording to EERE and EPA (2004) in 1970s and 1980s the attention was paid to battery powered vehicles. But the real revivals of electric vehicles were experienced during 1990s when the energy conservation and environmental protection was brought to scene throughout the world. Despite electric vehicles had high efficiency and zero local and minimum global exhaust emission, short driving range and short initial cost could not stop hybrid electric vehicles to emerge (Chau and Wong, 2002). Hybrid electric vehicles are a combination of an energy transformation and one or more energy storage systems. One type is an internal combustion engine (gasoline) and a battery. An internal combustion engine can run on any fuel other than gasoline, a fuel cell or gas tribune and the battery can be replaced by an ultra capacitor or flywheel (MacLean and Lave, 2003).

Alternative Fuels of Future

Today mobile sources in every kind of transportation form approximately 60% of the total nitrogen oxide (NO_X) emission, 35 % of the non-methane organic compound emission (NMVOCs) and 17 % of the carbon dioxide (CO_2) emission in Europe countries (EUROSTAT, 1995; Johansson, 1999). In 1990, 25% of the world's energy use, and 22% of the global CO_2 emissions were constituted by the transportation sector (IPCC, 1996; Azar et al., 2003). Thus, alternative fuels emerge for environmental protection although they are most costly to produce than diesel and petrol, a non-renewable resource (Johansson, 1999). Price, availability, ease of use, and high energy density provide these two fuels more popularity (MacLean and Lave, 2003). Road transportation is mostly based on fossil fuel crude oil and since fossil fuels are the master source of greenhouse gases, technology presents us fuels such as hydrogen, reformulated gasoline, natural gas, biomass, ethanol, methanol, propane (liquefied petroleum gas), P-series, solar and wind energy.

Firstly, hydrogen which has a vital role in developing sustainable transportation is not an energy source; it is an energy carrier, a renewable resource which has limited onboard storage and low energy content (MacLean and Lave, 2003). However it can be used effectively in internal combustion engine vehicles with natural gas (Hythane) and in fuel-cell vehicles without releasing any harmful emissions (Johnston et al., 2004). On the other hand when hydrogen is used to create electricity, because of the high temperature of the combustion engines, small amount of NO_x emissions may be released (Schulte et al., 2004).

Secondly, renewable alternative automobile fuel is biomass which is safe and which reduces serious air pollutants such as particulates, carbon monoxide, hydrocarbons, and air toxics. However because of high costs of total fuel supply chains, it becomes difficult to use biomass for large-scale operations (Faaij and Hamelinck, 2002; Hekkert et al., 2003). Biomass can also be converted to many fuel types such as bio-diesel, ethanol, methanol and hydrogen (Hekkert et al., 2003).

Another alternative, natural gas (NG), forms naturally from fossil energy therefore it is not renewable (MacLean and Lave, 2003). There is a large-scale of resources of natural gas than oil resources and they are more evenly distributed over the world (Amoco-BP, 1999; Hekkert et al., 2003). A transition from crude oil to natural gas is a good way to reduce the carbon emission per unit combustion energy. Moreover it can easily be converted to many other energy carriers such as biomass-based synthetic NG or hydrogen. It also contains less local pollutants; aromatics and impurities than crude oil. It is the cleanest and most acceptable fossil fuel today. (Dicks, 1996; Hekkert et al., 2003) NG is not used in a large scale; however, it can be stored on board a vehicle as compressed natural gas (CNG) or as liquefied natural gas (LNG) (Johnston et al., 2004). Many developed countries (the US, Japan, The Netherlands, the UK, and German) have a NG transmitting infrastructure, and transfer of NG is achieved by large pipeline systems (Dicks, 1996; Hekkert et al., 2003).

Moreover, P-series is a mixture of natural gas liquids (pentanes plus), ethanol, and a biomass-derived co-solvent (MTHF), formed from renewable resources and has many emissions benefits for reformulated gasoline (Johnston, 2004). Reformulated gasoline (RFG) known as clean gasoline, achieves significant exhaust (VOC, NO_X and air toxics) and evaporative emissions of VOC, benzene from vehicles. However, according to EPA, the sulfur content of gasoline poisons catalysts. EPA remarked that sulfur interferes the oxygen on the catalyst surface. To minimize the NO_X emission this must be taken under control, and vehicles should be less sensitive to sulfur. Gasoline sulfur removal is significant especially for new technology vehicles such as fuel-cell and DI (MacLean and Lave, 2003).

Finally, electricity is another alternative fuel which can be used in power battery and fuel-cell vehicles known as zero emission vehicles (Johnston et al., 2004; MacLean and Lave, 2003). However, the energy source for electricity is a significant matter since if electricity is produced by nuclear, wind or hydro power no air pollution occurs. On the other, hand if it is produced by use of coal or wood, it causes significant amount of upstream emissions (MacLean and Lave, 2003).

Some Toxic Heavy Metals Used in Automobile Sector and Their Alternatives

The main use area of electricity, current batteries have low energy density and a large battery mass to provide a desirable range to the vehicle. Today, nearly all battery materials contain toxic heavy metals and they make unwanted environmental effects from mining and smelting the metal, producing, recycling batteries (Lave et al., 1995; MacLean and Lave, 2003). These batteries contain large amount of toxic heavy metals such as lead and mercury:

- **Lead**

Today, in every car manufactured contains very nearly 27 pounds of lead in many vehicle components. Lead acid battery is the master component that uses lead. Lead was phased out of consumer products like gasoline and paint. However, the main source of lead pollution- auto batteries has been overlooked. It is common that auto batteries are recycled. On the other hand most of the lead release during vehicle manufacture, use, and disposal is overlooked.

Lead-acid, starting-lighting-ignition (SLI) batteries use %90 of the lead in vehicles. Other automobile applications of lead are Wheel balance weights, alloys and protective coatings, vibration dampers, solders in electronics and stabilizers in polyvinyl chloride (PVC) and other plastics.

Lead releases and transfers from lead production and automobile –related manufacturing processes were 71,000 metric tons in 2002, according to Federal Toxic Release Inventory data (Gearhart et al, 2003). Other lead releases occur during vehicle use and disposal. They happen because of inadequate vehicle dismantling and recycling processes. Most of the leads are lost to landfills. Lave et al, expressed for the effects of the current technology of battery powered vehicles on ozone and lead discharges as a result of lead-based battery powered vehicles. By 1998 it was remarked that lead-acid battery powered vehicles were a great burden for the environment when compared with new ultra-low emission of gasoline powered vehicles (Daniel et al., 2003).

- **Mercury**

Automakers use mercury switches in many applications although many other cost-effective solutions exist. Moreover the industry has no suspicion about introducing new applications of mercury (e.g., mercury-vapor headlamps). Mercury is a permanent and bio-accumulative chemical pollutant (PBT) whose usage should be terminated. When it is released, mercury does not leave the environment for years and expand to a wide area. It may cause serious health problems especially on children even if they are used in small quantities. Being subject to mercury may cause mental retardation, cerebral palsy, deafness, and blindness, impaired sensory and cognitive ability tremors, and the inability to walk. Since 1995 automakers have pledged to stop using mercury switches in new cars and trucks but by 1996 international automakers Toyota and Honda had entirely halted using mercury switches in lighting and antilock brake. After Sweden's ban on mercury, members of the Association of International Automobile Manufacturers, Inc., completely eliminated the use of mercury switches. Antilock brakes, convenience lighting, active ride control, speedometer systems, headlamps, remote transmitters and radios are some of the automobile applications of mercury. When the life of a vehicle is over, it is usually recycled. During the process of separating old vehicles into metal and non-metal fractions, mercury switches are not removed or recovered. While grinding process switches may rupture and mercury expands and pollutes the soils and water. Moreover during the steel-recycling process some of this mercury may vaporize and pollute the air. Thus, automakers all over the world are introducing new alternatives such as active-ride control, back-lit instrument panels, and mercury-vapor headlamps which use less mercury than mercury switches do (Menke, 2001).

METHODOLOGY OF RESEARCH

This paper is the study of some major automobile companies in Turkey that are investing in technological innovations based on the new environmental demands and requirements. Therefore, the study reveals difficulties, efforts and perspectives for the uses of ecological concepts that Turkey has to face while adapting to the technology of global automobile market.

This study was completed within a six-week time scale. In view of the limited time available all interviews were conducted by telephone. Further data on the background information of firms was obtained from company records, bulletins, and archives, annual and internal reports. During the secondary and in-depth telephone interview research process the authors collect a wide range of information for each automobile firm. The completed interview lasted approximately 20 to 25 minutes.

TECHNOLOGICAL INNOVATIONS and ENVIRONMENTAL DEMANDS

Today the Turkish automobile industry is one of the main locomotive industries in Turkish economy. The sector has achieved a major development in a short period by becoming the third biggest sector after textiles and tourism industries. Turkey is one of those countries that possess environmental issues directly in its constitution. However, all activities about the environment have been controlled by the Environment Act and relevant regulations; there are more than one foundations or institutions that hold the authority to act. Therefore, authority confusion occurs. Moreover, there are problems that emerge because of mingled responsibilities. On the international basis Turkey has signed 41 contracts and accepted many declarations and protocols. Developments in the international platform indicate that those responsibilities about the environment will increase soon. It has not been constituted an emission inventory for conventional pollutants which mostly come from the industry. Although concentrations of all those conventional air polluters are strictly monitored in developed countries, in Turkey only particulates and sulfur dioxide measurements are implemented in 117 stations cited in 48 cities and 6 counties. In 1995, Turkish Automobile Industry has put in action a study targeted to new technological evolutions that automobile industry suffered for and to production of motor vehicles that are up to EU Standards (EURO-93 Norms). Moreover investment plans and programs dated to 2005 have been prepared for oil refineries to provide all automobile users to meet the requirement of benzene with unleaded gasoline.

In Turkey, major automobile manufacturers can only implement a small part of the technology that is designed for the good of the environment in developed countries. The main reason here is that the government does not encourage enough. Newly developed technologies in developed countries feel the support of the government. Moreover technologies which manufacturers, such as Toyota, Honda, and Ford are working on, cannot easily be implemented in Turkey, since infrastructure related to those stations that sell hydrogen does not exist.

In addition to the station problem, there is not enough demand from customers since relevant to their standard of living the first point they need to ask for is how much fuel the vehicle consumes and what its total cost is. For instance hybrid vehicles possess two engines so naturally have a higher price than others therefore, the percentage of costumers who seek for environmental concern does not exceed 1%.

The research found similar result of Hall and Kerr (2003) that there are many factors which hinder these technical innovations to come to Turkish automobile market. In Turkey, transition from the old system to the new system seems to be too risky for automobile companies. The introduction of a new system may lead to sunk investments. For instance the introduction of battery-fed electric vehicles needs variety at the infrastructure level for charging batteries. Automobile companies resolve the core competence with combustion engines so they prefer to wait for the market to enlarge and to have sufficient market demand, to introduce new alternative vehicles. Although governments seem to support these innovations, they sometimes do not stimulate enterprises. Automobiles are not only used for transportation anymore. As more powerful automobiles emerged in the marketplace, they started to be seen as an indicator of status. The new technology is compared with the dominant technology. Consumers would not prefer to pay more for less powerful engines to lessen environmental effects. Since new technologies require infrastructural basis for new developments (e.g. new distribution systems for hydrogen technology and new arrangements of charging batteries for battery-fed vehicles) and permanence of these systems should be sustainable and maintenance skills should be adequate. Turkey needs more skilled personnel for these new developed technologies. On the other hand major automobile manufacturers in Turkey such as Renault-Oyak and Ford have environment-friendly plants where all environmental requirements are satisfied. For instance in the plant of Renault-Oyak, action about air has been taken in a number of areas to reduce VOCs emissions; recovery of automatic purges from application machines, increased responsibility placed on cleaning firms when solvents are used, introduction of technologies improving the efficiency of paint application and the use of a distillation column to recycle spent solvents. By improving the paint application process, the plant has reached its objective of cutting VOCs in 2003. Moreover the plant of Ford-Otosan was rewarded as the best of Europe.

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