
Project Green Boundary

*Replacement of conventional petrol and diesel
vehicles with environmental friendly car sharing
at Chalmers University of Technology*



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Abstract

A serious threat to our quality of life emerges from pollution, especially from road traffic, which is one of the fastest growing pollution. It's worth mentioning that in some countries more people are dying as a result of air pollution as compared to road accidents. Sweden has improved considerably over the last few decades in environmental friendly measures, although there is still a threat to health. There are approximately 100 to 200 cases of lung cancer per year, which are directly linked to air pollutants. The long-term effect of heavy pollution leads to serious damage to the environment. The strategy for reducing pollution level is to reduce the pollutants emitted by transit directly. To get a start in eliminating, or on the least, reducing hazardous emissions from petrol and diesel vehicles we have to work on people's way of thinking towards transportation. A simple solution is a shift from conventional petrol and diesel vehicles to environmental friendly transport. Our starting point is Chalmers University of Technology and the starting people are you, we and I. People traveling from far distances using petrol and diesel vehicle should be convinced of using environmental friendly vehicles including car sharing, public transport and bicycle whereas those living in close premises should be convinced to walk. The task is hard but not impossible. We found that employees and students at Chalmers University of Technology are well aware of the bad consequences of vehicle emission pollution. A considerable number are involved in different pro-environmental groups. However, a complete U-turn from conventional petrol and diesel vehicles to environmental friendly transport may not be expected at an early stage. A gradual process of change through the implementation of a car-sharing program with hybrid electric vehicles as well as a program aimed at increasing the motivation for using public transport, walking, and cycling back and forth to the University might be of great value.

Acknowledgements

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1. Introduction

1.1 Threat to our quality of life

Pollution can be defined as any impact on natural environment that is caused by anthropogenic (that is, human) sources. Its impact is normally assessed in negative sense, by the level of damage: to human health, to quality of life, to the well being of other planetary organisms. Pollution emitted to the atmosphere has the potential to create respiratory health problems, to damage vegetations and buildings and to cause aesthetic unpleasantness. Air pollution has three categories of scale: Global, national/regional and local/regional. Air pollutant influencing the global environment is gases (Carbon dioxide, methane, chlorofluorocarbons and nitrous oxides) that contribute to green house warming and stratospheric ozone depletion. On national/regional scale, air pollutants are transformed from point and area sources over many thousands of kilometers. On the local/regional scale, the most important air pollutants originate from the extensive use of automobiles in the city. In our current thesis work we are dealing with the third scale air pollution category.

Many of our valuable and important natural resources such as forests, rivers, and coral reefs are being destroyed. They provide cleaner air, water, shelter, medicine, and much more. When we taint pollution in our lands, we also harm the animals and plants that live there. Another effect of pollution is the tremendous cost to clean up. Cleaning and preventing pollution adds up in the U.S. to over 100 billion dollars. Social relations are expanding apart due to pollution. Low-income areas do not receive the same protection and benefits from pollution as high-income do. This means a wider gap between the rich and the poor. Nature does not cause pollution; by total recycling, nature makes resources out of all wastes. Our goal should be to learn from nature in this respect.

1.2 Petrol and diesel vehicle emission

The emission from petrol and diesel vehicle, especially the untreated exhaust is a mix of dangerous chemicals. Petrol engine emits Carbon monoxide, Hydrocarbons, Oxides of nitrogen and lead. Diesel vehicle emits oxides of sulfur in addition to other chemicals from petrol engine. The consequences of this are going worse everyday. The two main kind of pollution are clear to us as a brown haze that hangs over cities centers and the whitish haze which can clearly be seen on warm days over the suburb or sea resulting from traffic and industry. But there is a third category the gases, chemicals and vapors, which makes it up.

About 75% of human emissions of Carbon dioxide, the most important man-made greenhouse gas is caused by the use of fossil fuels. Fossil fuel use has caused an imbalance in the earth's normal carbon cycle. Normally, biologic growth absorbs Carbon from the environment and then releases it back into the environment when it decays or is burned. New growth then absorbs the carbon again, and the amount of carbon in the environment remains roughly the same. Since the last ice age, the level of carbon in the atmosphere (in the form of carbon dioxide) has varied only about 5%. However, fossil fuel use has upset the balance.

Global Carbon Cycle (1992-1997) (in GtC)

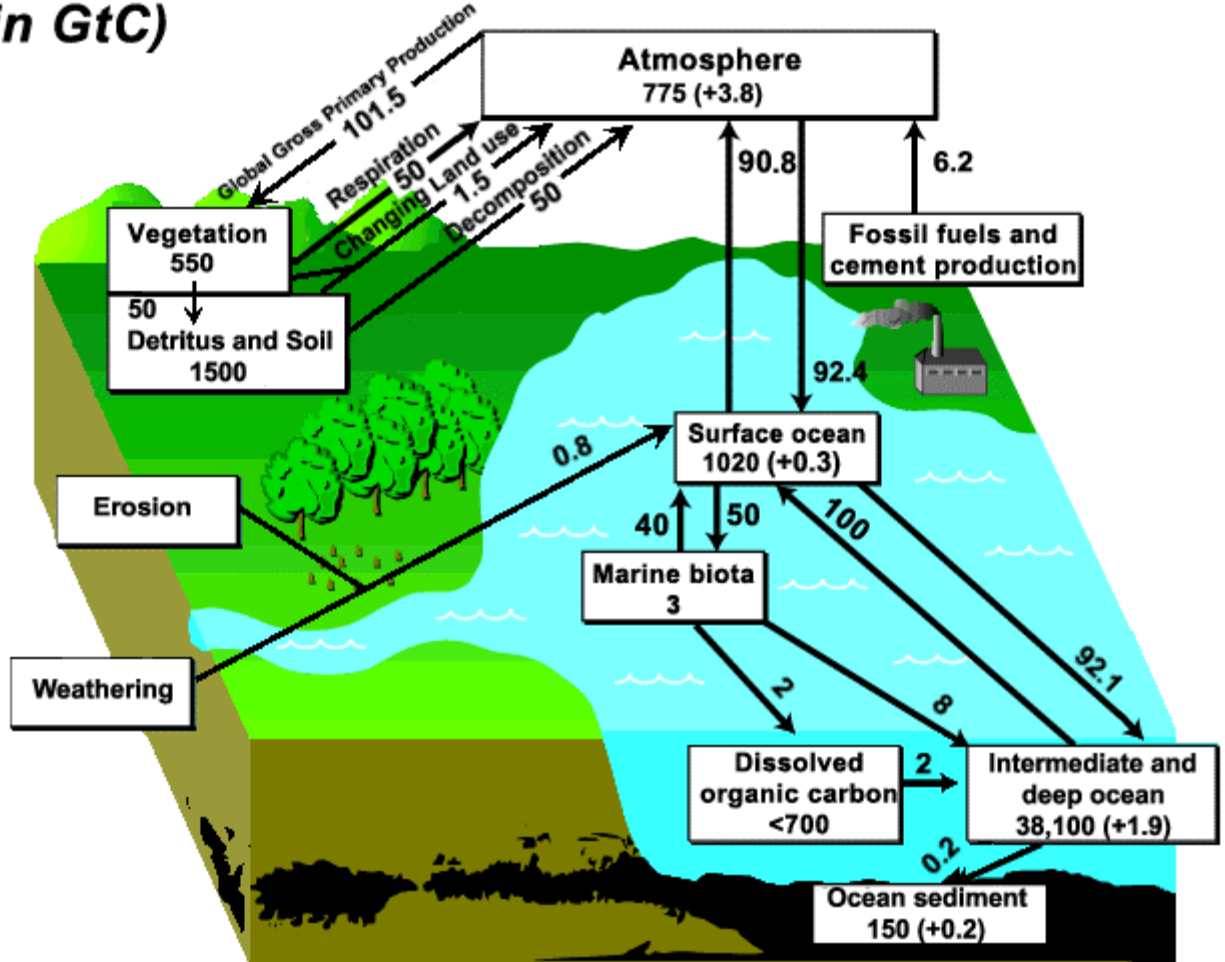


Figure 1: Facts from Carbon Dioxide Information Analysis Center.

Motor vehicle emissions account for 30% to 50% of hydrocarbon, 80% to 90% of carbon monoxide, and 40% to 60% of nitrogen oxide. Cars and light trucks are responsible for about 20% of the nation's carbon dioxide, which is a powerful greenhouse gas. Motor vehicle carbon emissions are essentially proportional to total fuel consumed. Unfortunately, in the coming decades the greatest growth in the automobile population will occur in developing countries which can least afford clean technologies?

In terms of vehicle emission do not necessarily mean that equivalent improvements in air quality will be observed, particularly so for the secondary pollutants NO₂ and Ozone (O₃). The reason is that natural dispersal systems and the chemistry of air pollution are highly complex.

There are signs that European air quality is set to improve; yet very local (every regional) hot spots and exceedances of air quality standards are likely to persist. The US cleaner air act and EU directive 94/12/EEC in Europe make explicit links between air quality objectives and vehicle emission regulation. Air quality has two distinct types of effects on human and ecological health.

- Cumulative exposure to some pollutants is linked to health and ecological damage. In this case, what matters is high annual averages for such pollutants (e.g. Benzene, benzo, lead, SO₂ and PM)
- Short-term exposure to other pollutants, which act rapidly, is linked to health and ecological damage (e.g. CO, O₃). In this case the length and intensity of pollution episodes is important.

Air quality in Europe is generally good and is possibly improving in relation to some forms of pollution (CO, NO₂) but there is great need to cut air pollution to considerable level. In all cases, the answer is to cut down the pollution at the source. This objective needs the commitment of government, individuals and industries.

Transportation system had undesirable consequences. The strong growth in transportation demand has not only caused rapidly rising levels of congestion and traffic noise, but also severe environmental impacts: the transportation sector is already the major contributor to deteriorating urban air quality and acid rain within the industrialized world and in many developing countries. Oil products fuel the entire transportation sector, and the release of Carbon dioxide associated with the combustion of these fuels adds increasingly to the anthropogenic greenhouse effects. In 1990, humans released 6 billion metric tons of Carbon into the atmosphere, of which the transportation sector accounted for 1.4 billion metric tons, or 23 percent.

1.3 Car sharing concept

To own my own private car means my freedom and privacy. How can share a car with someone? Just think about the following:

Do you want to reduce your expenditure?

- Do you want to help in reducing the demand for parking space?
- Do you want to contribute in the implementation of environmental friendly measures?

If your answer is Yes, then the simple solution is car sharing. Car sharing is a developed form of car rental for a meaningful cause for society and for the environment. Car sharing concept is easy, reliable and practical. It is a change in consumer behavior as a shift from “Individual consumption” to “Organized consumption”. This system is a mean of reducing the number of cars and the use of cars. Car sharing is no longer an idea or a concept, as it has developed into a widespread phenomenon in many European countries.

Car sharing is a concept between cabs and rental cars. We prefer cabs when we have a one-way trip. Rental cars on the other side are available for a minimum period of 24 hours. Rental cars are cost-efficient only for long-distance trips and trips lasting longer than at least one day. In between these two options, there is a demand for short-term within-town-two-way trips. For our target group working inside Chalmers, cabs as well as rental cars are unacceptable. Car sharing, which is already adopted by some individuals working in Chalmers, is the best available alternative after Environmental friendly vehicles for medium and long distance trips.

Operational procedure

All members who wish to use car-sharing facility have to deposit an entry refundable with interest upon exit. Any member who wants to use the car must be able to book it on telephone. They can also arrange for pick-up time, duration and desired pick-up place. Members then pick up and return the car themselves. Each member can be charged with,

- Monthly hours of use.
- Kilometers driven.

Charging rate can vary with the type of the car and the time of the day. The organization working with the implementation of Environmental friendly vehicle will also be able for the implementation and successful operation of this car-sharing scheme.

1.4 Walking and cycling

“The paradox of transportation in the late twentieth century is that while it became possible to travel to the moon, it also became impossible, in many cases to walk across the street.” (Vanderwagen, 1995)

Walking may be regarded as the natural way of transportation. Walking and cycling have a negligible environmental impact. We can simply say that walking and cycling are ideal ways of traveling from the point of view of energy conservation, environmental impact and social equality. The bicycle has an enormous potential for urban transport. Cultural and social conditions are at least as relevant as geographic conditions. Walking is, however, much more than a transport mode. A social aspect and comprehensive experience of the environment are closely connected with walking. Walking on one hand reduces the hazards caused by transport, promotes national health and on the other hand improves more equal moving possibilities among different groups of population and contributes in utilizing more efficiently the present traffic space to create better urban environment.

Discussing all these advantages of walking and cycling there are many obstacles. All these obstacles can be crudely placed into two categories. The first one is that decision makers do not simply perceive walking and cycling as a serious alternative to the car. The second problem is that decision maker concentrate on the building facilities rather than dealing with the increasing dominance of conventional petrol and diesel vehicles. We already have a comprehensive system of cycle routes, covering the whole city and connecting every origin with every destination; the problem is that is full of cars.

The obstacle to the environmental friendly transport is not to be found outside in weather or topography. They are inside us, locked inside our attitudes to our environment, to growth, to consumption and to sustainability. Who will change it? The answer is only and only “**We**”.

2. Theoretical approach

2.1 Different parameters that affect choice of a consumer

In this section we will consider the parameters which will be directly or indirectly influencing the practical implementation of project Green boundary (Figure 2).

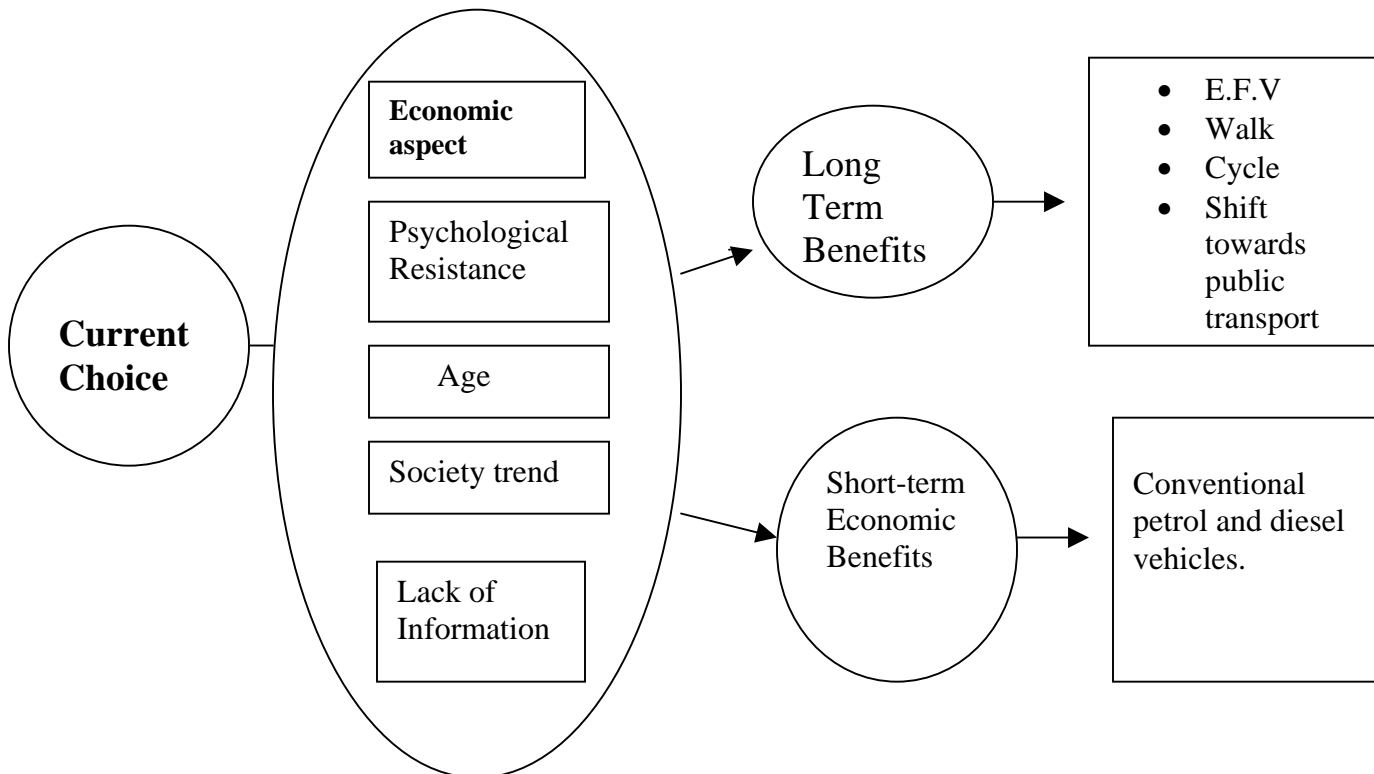


Figure 2: Factors affecting consumer's trend in the short-term and long-term.

2.2 Choice and possible solution

It is quite clear that the individual who is causing pollution in some way, in our case by using petrol and diesel vehicles, have a choice not to do so. The problem is individual whom causes less pollution in the long run has to meet the cost of pollution caused by others. There should be a fair recovery system. The possible solution is the introduction of Green incentives programmed within Project Green boundary. Individuals who are using petrol and diesel vehicles should pay an extra polluter payment each month or half year, which on the other hand be used for the provision of incentives to individuals using environmental friendly way of transportation.

2.3 Economic factor

The ability to freely and inexpensively move goods and people is a fundamental link in the economic chain. It is a fact that consumer income and need for a cleaner environmental transport are inter-related. If we are offering a new choice or trend to a consumer, his mind will immediately start to think about his/her power of buying and his level of income. If the consumer is in the low or moderate-income range it will be hard to adopt a new trend at once.

There should be an introduction of an incentive package to convince the individual to take his/her first step in adopting environmental friendly mean of transportation. There is a need for a basic change in the way of thinking. Every individual thinks and understand the value of “Real costs” but at the same time we have to think about “Social costs”. The problem with the real cost is not that they are not incurred but in a way which associates them with their cause. There is need to combine the two costs.

2.4 Psychological resistance against attempts to reduce conventional vehicle usage

Most individual while changing or thinking to change his/her mode of transportation from conventional to environmental friendly mode of transportation will think about the following important factors

- Positive environmental aspects for the society
- Financial consequences for the individual itself.

Some of the most pressing problems, including environmental pollution resulting from car use, can be characterized as social dilemmas. Each individual receives in short term more advantages from socially defective behavior than from socially cooperative behavior, regardless of what they do. Moreover in the long term all individuals experience more advantages if all defects than if all co-operates. (Dawes 1980).

It's a common human psychology that he/she immediately considers his/her short-term interest instead of long-term interest to the consumer himself/ herself and especially to the society. Every consumer while using conventional petrol and diesel vehicles consider in the short term that it is a cheap mean of transportation used by every one around with easy and cheap maintenance. No one thinks about the long-term effect of heavy pollution leading to serious damage to the environment.

There are two approaches to understand travel behavior. The first is the tracking of behavioral pattern – discovering how people travel. This approach involves documenting travel patterns, determining the characteristics of those travellers and analyzing factors involved in determining those patterns. The second approach is more closely examine the behavior and decision-making process they, in order to understand why people travel the way they do.

The travel behavior of people is affected by the following factors:

1. Decision and networks: Individual travel behavior can be understood within the context of the wider social and economic network.
2. Choices: Choices made by both institutions and individuals can be understood as a hierarchy. The higher level includes those choices that influence many people or many other activities. For example an employer can make decision that influence how all of his/her employees travel to work. Similarly an individual decision to buy his house may affect how all the members of the household travel.
3. The perception of individual: Individual perception of time, environment and alternative modes of travel and travel behavior, determines whether or not they feel they really have a choice in how they travel. For example “ People who have really taken public transport or cycled may not perceive those modes as suited to their life style because of perceived disadvantages which they associate with these modes”. In many cases, individual over-estimate the benefits of their choice and under-estimate the capacity of alternative modes to satisfy their needs.
4. Culture: Culture plays an important role in determining the status, image and acceptability of different types of travel behavior. It's the culture that compels you to the use of car.
5. Education (information and learning): Individuals need targeted, relevant, effective and positive information so as to better understand the consequence of conventional petrol and diesel vehicles on their own and their community quality of life. When people gets information about the scale of the environmental problems and resulting threat can lead people to claim that others are more guilty than they are themselves (self enhancing perception). Therefore they need not to alter their own behavior in a more environmental friendly direction. We will notice it clearly that even if the message is in some way connected so that he/she cannot avoid it's relation to their individual behavior, it still will automatically not change their behavior. This is supported by predictions from (Cooper and Fazio, 1984, Festinger 1957, Golob et al 1979) that if attitudes and behavior are not in line, attitudes are more likely to change. In other way it means that the environment become less important for the person.

Information about the environment will only cause a change in behavior if

- Environmental friendly behavior is not disadvantageous for the individual.
- Valid social norms are positive towards environmentally friendly behavior.
- Sufficient opportunities to demonstrate environmental friendly behavior exist.

Since many causes of environmental problems can be seen as social dilemmas, our original question was: “how can individual be made to forgo their own interests and choose a more environmental friendly option for the general good?” We would learn from previous studies into social dilemmas. These have all been experimental and mainly based on game

theory, for which reason difficulties in extrapolating results to cover real social dilemmas entail obvious problems (see, eg, Dawes, van de Kragt & Orbell, 1988; Vlek & Keren, 1993).

A lack of faith in the willingness of the others is also an obstacle (Messick et al, 1983). When individuals cooperate they do so simply because they have internalized certain values and norms (see Kerr, 1995 for an overview) or because they do not want to contravene cultural imperatives, particularly if their actions will attract the attention of others (Dawes 1980). Moreover it has been shown that individuals differ in their willingness to cooperate (Liebrand, 1986). All in all choices involving environmental implications may be dictated by factors other than concern, or lack of concern, for the environment.

Generally, the acceptance of an improved or new transport mode will be considerable as long as consumers perceive better performances. In this respect public opinions and feelings are important factors to realize a successful introduction of new technologies. The social status of new technologies may be a barrier for their introduction and is often underrated. For example, the electric car initially had better opportunities to become the leading concept for the propulsion of cars. However, the most important reason for its decline has been its inferior image compared to cars with combustion engines (Mom, 1997).

In addition, a barrier might be introduced by inadequate information supply about a new technology and its effects, resulting in a resistance to gain wide acceptance and use it. At this point, an improvement of existing technologies has much better opportunities than the introduction of completely new concepts.

2.5 Process of technological change

There are two approaches, which will be helpful to us in the explanation of technological change process.

1. Wigley et al approach (1996): Wigley argue that technological development will decrease abatement cost in the future. This means, it would be cheaper to reduce pollution from petrol and diesel vehicles emission once alternative technologies have become more cost competitive.
2. Grubb approach. (1997): Grubb argues that specific technical change that will reduce the cost of emission control doesn't occur in vacuum. It is a part of a broader set of issues surrounding the evolution of energy systems and how they respond to different pressures. The following important issues are to be considered
 - Technological change is dependent on policies and market conditions. It is exposed over time to external pressures. Public research and development also plays an important role for technological changes. In our example is the introduction of environmental friendly vehicles, which with the pace of time is increasing its development and effectiveness.

According to Grubb, “ *In order to force technological innovation and diffusion in a specific direction we have to take action to make sure that this thing happens.*”

- One of the biggest hurdles in the way of environmental friendly vehicles is its large initial cost. The already operational conventional vehicle industry work hard to protect their position in the market trying to improve the already developed technology and system instead of introducing environmental friendly vehicles.

We have to see technological changes in the short-term and medium/long term. In the very short term, opportunities for reduction in fuel consumption for all modes of transportation are limited. In the medium term (20 years) and especially in the long term (50 years), enormous technical fuel reduction potentials exist in transportation. This potential can be achieved through a combination of strongly reduced driving resistance and drastic improvement in engine efficiency. But the most effective measures for road vehicles are new types of alternative drive trains: for example, hybrid and fuel cell vehicles with high energy-efficient power storage system.

2.6 Aim

Project Green boundary is a step towards environmental friendly measures, aiming especially for the creation of a zero emission zone inside Chalmers. Our aim is to encircle a green boundary around Chalmers through substitution of private conventional petrol and diesel vehicle with shared environmentally friendly vehicles. This main aim is subdivided into:

- Identification of the problem of vehicle emission.
- Awareness in our target group about the problem.
- Collecting basic data about our target group.
- Knowing the extent of knowledge of our target group about the serious consequences of the problem and their willingness to be a part of the campaign against the problem.
- Presenting and analyzing the obtained data from the questionnaire.
- Pointing the basic hurdles on one hand and possibilities for future work on the other hand.
- Suggestions.

3. Method

3.1 Procedure

To show different steps involved in the planning of an Environmental friendly transportation system inside Chalmers, we have to formulate the problem (Figure 3).

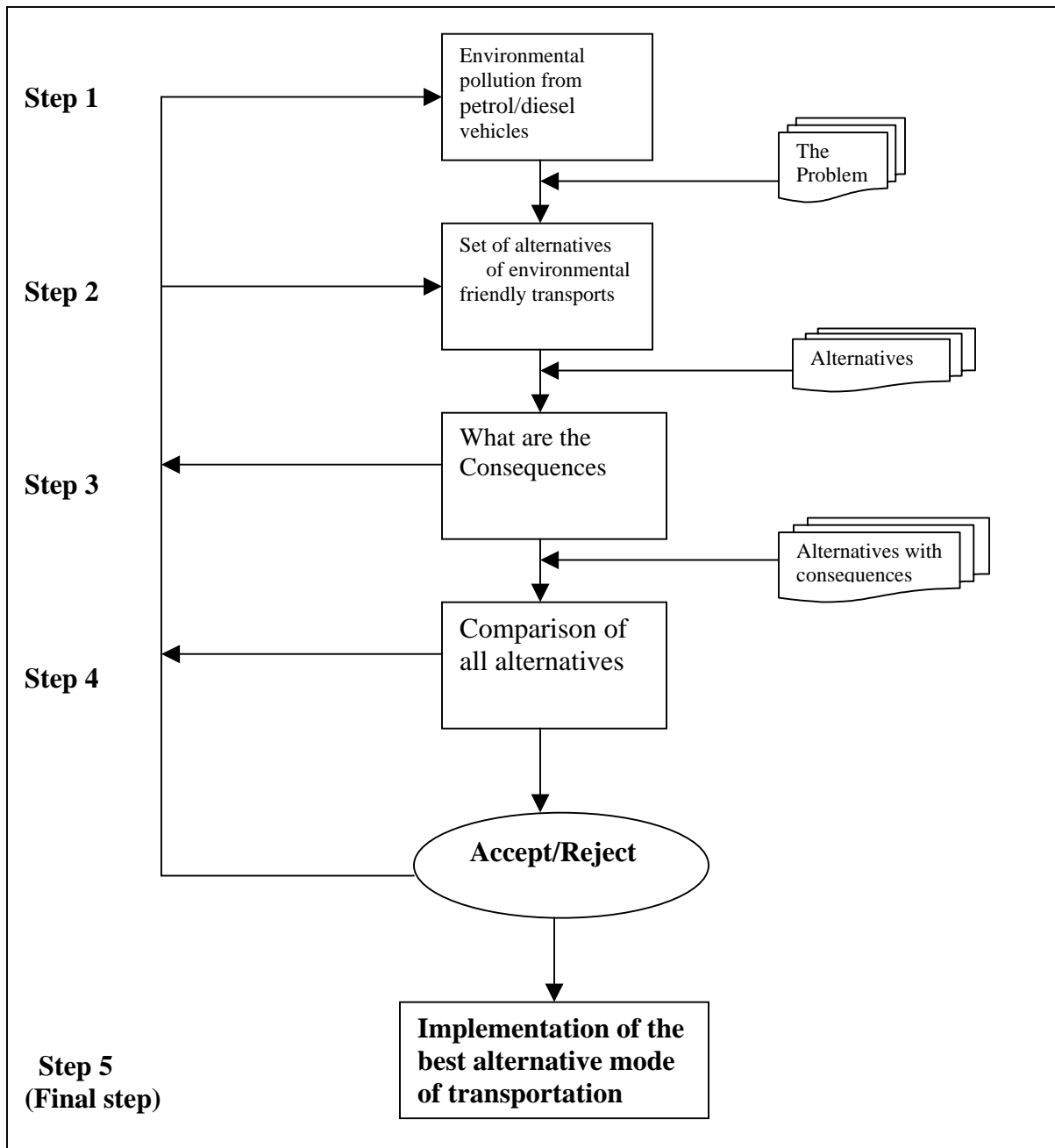


Figure 3. Flow chart for a decision making process

In first step the specified problem of environmental pollution from emission of petrol and diesel vehicle is sorted out. Step 2 and 3 are the search phases, we identified the different alternatives and their specific consequences are determined. Moreover the different alternatives determined in step 2 and 3 are compared with each other in step 4. Finally in step 5, which comprises the factual decision, a choice of best environmental friendly transportation system is made. In the start of the decision making process, decision maker is uncommitted and can search freely among a vast number of alternatives. Throughout the process the number of relevant alternatives is reduced, consequently a decision is made in connection with the final choice of an alternative. But as clear from the Figure the decision making process is iterative and a number of returns to previous steps is to be expected with the aim of adjusting the setting of objectives.

The main idea for Project Green boundary came from the **RESTOF** group at Chalmers. The idea was the replacement of private conventional petrol and diesel vehicles to shared Environmentally friendly vehicles. All employees, who travel with their own petrol and diesel vehicle was our target group. After fixing our line of action, we concentrated our attention towards collecting information. An introductory E-mail was already forwarded by **RESTOF** group informing all Chalmers employees about the growing consequences of petrol and diesel vehicle emission and the start of the project. The target group was also requested for comments and suggestions about the problem.

Our aim is to replace partially or as a whole the present pollution concern transport system with the environmental friendly transport. Our choice will depend on the most practical and conveniently adoptive transport system. We have a set of alternative environmental friendly transport system available, out of which we will pick the most feasible one. Depending on the conditions available we can implement a single transport system as a whole or we can implement a combination of the best feasible possibilities.

- Electric vehicles
- Biogas vehicles.
- Ethanol vehicles.
- Natural gas vehicles.
- Hybrid-petrol vehicles.
- Bicycle.
- Walk.
- Public transport.

In the beginning we were having a number of alternative, which we expected to be reduced to a few in number.

- Group 1 includes hybrid and electric vehicles.
- Group 2 includes ethanol, natural gas and biogas vehicles.
- Group 3 includes bicycle, walk and public transport.

3.2 Environmental friendly vehicles

What is, in this thesis, considered as an environmental friendly vehicle (EFV)? Simply it means a vehicle, which is cleaner than the Swedish environmental class 1 vehicle but still fully suitable for daily use in the city in terms of safety and user-friendliness.

3.2.a): Electric vehicles

This new technological dream is now changing into a reality. People who are concerned about pollution problem are to a greater extent shifting towards electric vehicles. Today's electric vehicles provides performance, very low operating cost and is emission free. Electric vehicles produce much lower emission than even the cleanest internal combustion engine, even when emission associated with electricity production is taken into account. As electric vehicle are turned by electric motors rather than mechanical gasoline powered, there is a significant reduction in green house emission. Unlike conventional vehicles, which tend to pollute much more as they get older, electric vehicles maintain their negligible emission rates over time.

People are conscious about the long charging duration of EV. There is good news, currently under development "quick charge system" could cut the time to 15 minutes or less. With existing charging technology time limitations, charging at nights will always be the more cost-effective and convenient. There are currently three types of charging systems:

- Charging can be done from standard, grounded 230V, 3-prong outlet available in every home.
- Charging is at 240V 40 amp charging station with special consumer features to make it easy and convenient to plug in and charge EV at home or at EV charging station.
- A high-powered charging "quick charge system" currently under development that will provide a charge in less than 15 min.

Looking into the design efficiency, we have to make it clear that electric motors are not just cars powered by batteries charged with household current but also vehicles that generate electricity or store it in devices other than batteries. The main plus point in electric vehicle function is the provision to the electric motor that drives the wheel in motion, but when the car is slowing down the same motor extracts all energy from the car's motion (Figure 4). If we look into functional system of a conventional internal combustion engine, there is a common running engine whose power is diverted through a series of gears and clutches to drive the wheel and to turn a generator for various electrically powered accessories in the car.

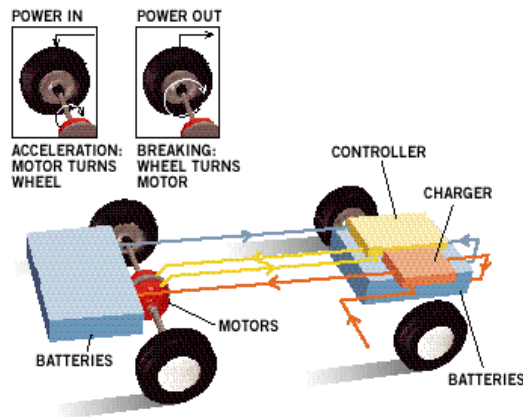


Figure 4: Major components of the electric vehicle.

There are a lot of reasons for electric vehicle efficiency and environmental friendly nature. Some of which are:

- The electric motor is directly connected to the wheels; no energy is consumed while the car is at rest increasing the efficiency to approximately one fifth.
- The vehicle converts more than 90% of the energy in its storage cell to motive force, whereas internal combustion engine utilize less than 25% of energy in a liter of gasoline.
- Battery powered electric vehicles would practically eliminate emission of carbon monoxide and volatile unburned hydrocarbons and would greatly diminish nitrogen oxide emission.
- With the introduction of ultra capacitors, which stores large amounts of electricity and can charge and discharge quickly, there seems to be a considerable increase in electric vehicle efficiency.

3.2.b): Hybrid electric vehicles

A vehicle that uses a gasoline engine in combination with batteries and an electric motor is a hybrid electric vehicle (HEV). This vehicle maximizes energy efficiency and reduces emissions. Energy-saving features include automatic engine shutdown when the vehicle is stopped and regenerative brakes that converts kinetic energy into electricity to charge the battery. Previous hybrid vehicles were generally classified as either parallel or series type, but now with the latest development there are HEV vehicles in the markets based on parallel type but to optimize the engines operation, it includes a system that enables series like operation through the use of a generator and a motor that are independent of each other.

HEV's are often configured with its batteries in the rear and its electric motor, gasoline engine and electronic control circuitry under the hood (Figure 5). A highly aerodynamic body improves overall fuel efficiency and ensures that the vehicle can travel as far as possible under battery power alone

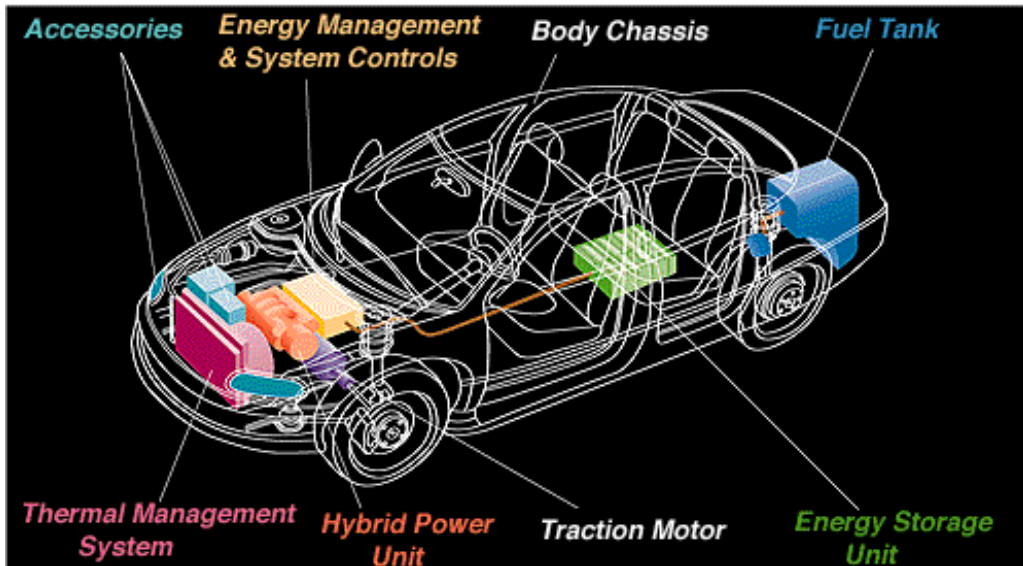


Figure 5: Major components of a hybrid electric vehicle.

The hybrid propulsion concept combines the advantages of electric driving (efficiency, smoothness, elegance) with the vast operating range of combustion engines (Figure 6). For short distances, the electric motors get the propulsion energy entirely from the batteries (thus having zero emission in short range traffic). For longer distances, the hybrid module (combustion engine coupled with a generator) is producing the average of the required driving power, while the batteries support peak power requirements. As the combustion engine runs in its optimal rotational speed range, the energy consumption is significantly lower than with conventional propulsion.

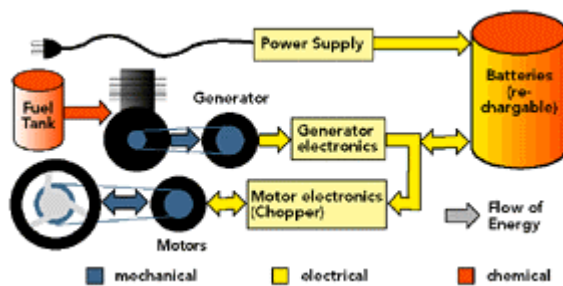


Figure 6: The hybrid propulsion concept.

According to www.innovation.copper.org/global/ev_hybrid.html, HEV's has several advantages over traditional internal combustion engine vehicles:

- Fuel efficiency is greatly increased, while emissions are greatly decreased.
- Engine is sized to average load, not peak load, which reduces the weight of the engine.
- Regenerative braking can be used, which help minimize the energy lost when driving.
- HEV can be operated using alternative fuels.

3.3 The questionnaire

We prepared our questionnaire in English as well as in Swedish. The questionnaire was designed in such away that we got adequate information about our target group. We also prepared our questionnaire in English for employees and students from non-Swedish speaking countries. For all other in our target group we distributed the general Swedish language questionnaire.

The cover page of our questionnaire contained introduction of the project and information about the contact persons. Similarly second page was a glimpse of the problem and it's possible solution whereas from page 3 to 6, we tried to gather all related information about consumer approach, opinion and suggestion. The obtained information were about:

- Present mode of transportation.
- Person filling in the questionnaire has got adequate knowledge and information about environmental pollution.
- Is he/she willing to adopt environmental friendly mode of transport.
- How much our target group is willing to pay more for environmental friendly mode of transport.
- Is he/she willing to hire E.F.V from Miljöbilpoolen.
- His/her preference and rank for different environmental friendly mode of transport available.

In the last two pages we aimed to collect general information without mentioning of name or designation

3.4 Distribution of the questionnaire

After preparation of the questionnaire, the next and most important stage was its distribution among our target group. Our target group includes employees at Chalmers University of Technology (150) and Chalmers Lindholmen (30) as well as the Student Union (6) and those having a vehicle sponsored by the University (11).

Results

4.1 The subjects

Of the 150 distributed questionnaires at Chalmers University of Technology (Cth), 43 were returned completely filled out; of the 30 distributed at Chalmers Lindholmen (CL) 12 were received back, of the 6 distributed to the Student Union, there was no response back, and of the 11 distributed to those having a vehicle sponsored by the University (SP) 4 questionnaires were returned, resulting in a response rates of 28.7 %, 24.0 %, 0 %, and 36.4 %, respectively.

Out of **43** completely filled out returned questionnaire in Cth, CL and SP group, the proportion of male was 65%, 63.6% and 75% respectively, whereas 35%, 36.4% and 25.0% respectively for female.

The mean age at CTH is 42.6 years, 47.2% in CL and 61.2% for SP group. Looking at the level of education of our target group we observe that 85% of our target group in Cth, 100% in CL and 100% of SP group have University level education. During our quantitative data analysis, we found that annual income level for 2.5% of our target group from Cth lies below the range of Kr 75,000, for 5% of our target group in Cth annual income level lies in the range between Kr 75,000 to Kr 140,000. Similarly for 25% of our target group from Cth and 9.1% from CL, the annual income ranges between Kr 150,000 to Kr 224,000. Moreover for 20% of our target group from Cth and 27.3% from CL, the income level ranges between Kr 225,000 to Kr 299,000. Finally a total proportion of 47.5% of our target group from Cth, 63.6% from CL and 100% of SP group has got an annual income level above Kr 300,000.

Concerning mean of transportation to Cth and CL, 7% of our target group from Cth, 16.7% from CL travels by trams, 4.7% of our target group from Cth travels by train, 14% from Cth and 8.3% from CL use bicycle. Similarly 48.8% of our target group from Cth, 58.3% from CL and 75% of SP group travels alone in their private cars. Moreover a total of 11.6% of our target group from Cth and 25% of SP group walks. Moreover the distance to work (Km) is 11.6, 15.2 and 31.0 for Cth, CL and SP group.

Almost 80.6% of our target group from Cth, 100% from CL and 100% of SP group showed their interest in environmental issues. When asked about their intention to work in a pro-environmental organization, we got a satisfactory response. Results shows that 32.4% of our target group in Cth, 36.4% in CL and 66.7% of SP group are active in different pro-environmental organizations.

Table 1. Sociodemographic.

	<i>Cth</i> (n=43)	<i>CL</i> (n=12)	<i>SP</i> (n=4)
Men (%)	65.0	63.6	75.0
Women (%)	35.0	36.4	25.0
Age (M)	42.6	47.2	61.2
University degree	85.0	100.0	100.0
Income (%)			
Less than 75,000	2.5	-	-
75,000-140,000	5.0	-	-
150,000-224,000	25.0	9.1	-
225,000-299,000	20.0	27.3	-
More than 300,000	47.5	63.6	100.0
Mean of transportation (%)			
Tram	7.0	16.7	-
Train	4.7	-	-
Bus	14.0	8.3	-
Bike	23.3	8.3	-
Car, alone	48.8	58.3	75.0
Car, shared	25.6	16.7	-
Walking	11.6	-	25.0
Distance to work (km)	11.6	15.2	31.0
Interested in environmental issues (%)	80.6	100.0	100.0
Active in a pro-environmental group	32.4	36.4	66.7

Table 1 shows data concerning our target group personal vehicle usage. Result shows that 59.3% of our target group from Cth, 87.5% from CL and 83.4% of SP (individual using sponsored vehicle by the University) travel daily with their own car.

The trip time (in minutes) by car for our target group in Cth is 18.7, 23.0 in CL and 30.5 for SP group. Parking location details shows that 96.2% of target group from Cth, 100% from CL and 100% SP group parks their vehicles inside Cth premises. Looking into the details about the parking payment types, we found that 18.5% of our target group in Cth paid daily for parking, while 7.4% from Cth, 12.5% from CL and 33.3% of SP group paid on half-year basis. Moreover 74.1% from Cth, 75% from CL and 33.3% of SP group buy annual parking cards. Concerning available parking options 12.5% of our target group from CL and 33.3% from SP Group adopts hourly paid parking. A total of 59.3% of our target group from Cth, 42.9% from CL and 66.7% of SP group mentioned comfort, time saving and freedom of travel as their main reason for usage of private cars.

4.2 Preferences of environmentally friendly vehicle alternatives

In this section we will have a look on the preference results for different kinds of environmental friendly vehicle for car sharing. Looking at the overall preference, it is clear from Figure 7 that majority of our target group preferred Hybrid electric vehicle as their firsthand choice for car sharing. But the main advantage of Hybrid electric vehicle is its dual mode operation.

The main reasons behind their decision were

- Fuel cost saving.
- Fewer trips to the gas station.
- Environmental attributes.

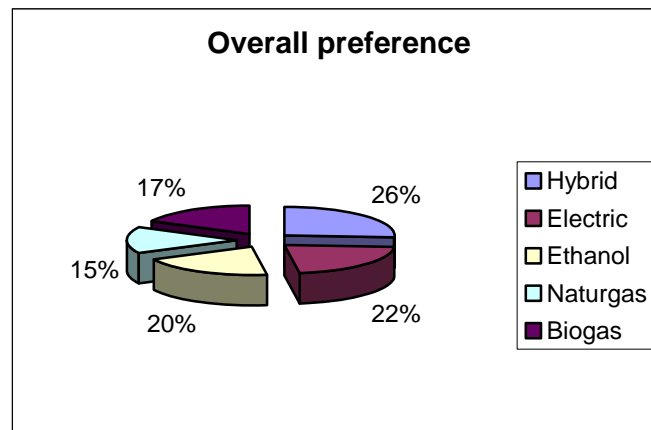


Figure 7: Overall preferences of alternative vehicles.

To get a clear result from our analysis and ease in successful implementation of our project we precede with our analysis on the basis of three different groups described earlier. Here we start with our analysis for the first two groups.

Fig 7a and 7b represents the preference results for group 1 whereas fig 7c, 7d, and 7e represents the preference results for group 2. For group 1, results from Fig 7a shows that 44% of our target group preferred hybrid electric vehicle as their first preference, 19% ranked it as "Preference no 2", 11% as "Preference no 3" and nearly 22% replied that hybrid electric vehicle will be their last preference whereas results from Fig 7b shows that 41% of our target group preferred it on the first place, 20% on the second and 13% each assigned preference no 3rd, 4th and 5th respectively for electric vehicle.

Group 1

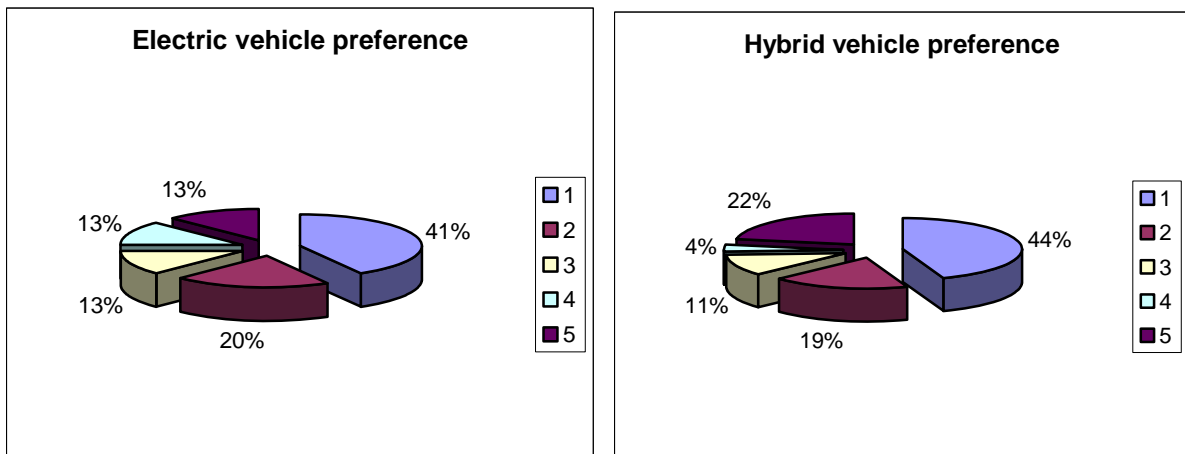


Figure 7a: Preference for electric vehicle.

Figure 7b: Preference for hybrid vehicle

Looking for the preference results for group 2, results from Fig 7c shows that 33% of our target group preferred biogas vehicle on the second place, 25% preferred on the first place and 21% referred it as “Preference number 4”. Similarly for ethanol vehicle 36% replied they will rank it as “Preference number 3” 28% as “Preference number 2” and 20% preferred it on the 4th place. Looking at preference results for natural gas vehicles we found that 28% of our target group ranked it as “Preference no 4th and 5th respectively, 16% as “Preference number 2 and 3” and 12% ranked it as their “Preference number1”.

Group 2

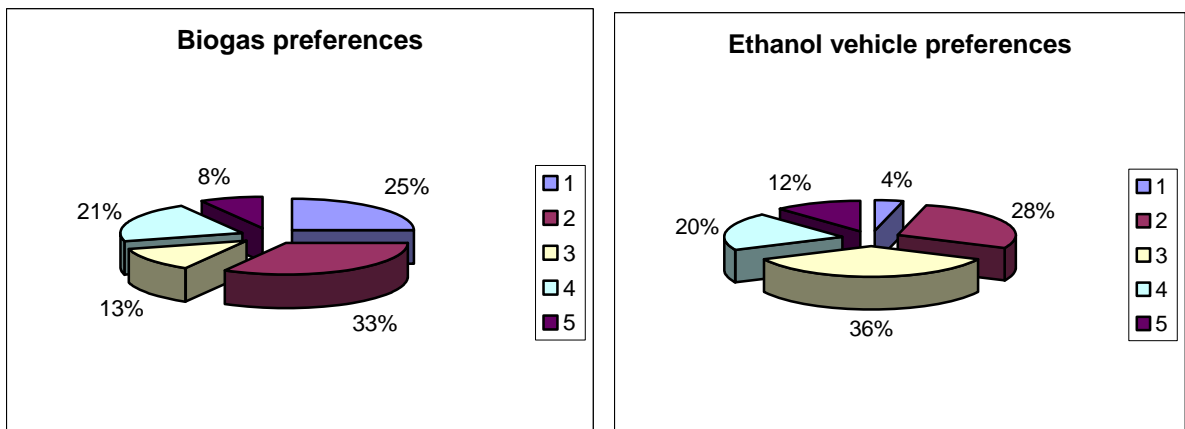


Fig 7c: Preference for biogas vehicle.

Fig 7d: Preference for ethanol vehicle.

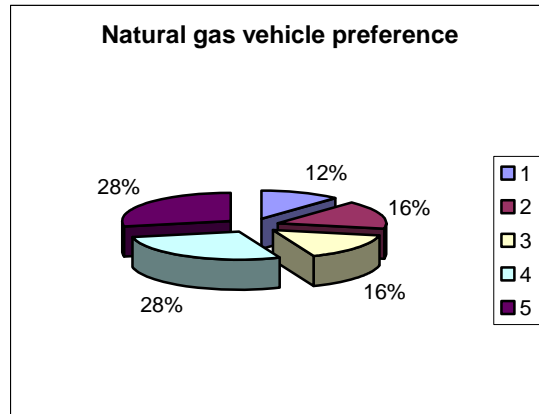


Fig 7e: Preference for natural gas vehicle.

In addition to choosing between different alternatives of environmentally friendly vehicles the subjects also had to give reasons for their choices (Table 3).

Table 3: Reason for choice of vehicle.

Reason	Men (n=36)	Women (n=19)
Quiet/no smell	1	2
Distance/speed	6	1
Clean	13	1
Flexible	1	1
Ease of use/effectiveness	2	4
Recharging/refueling possibilities	5	0
Do not know	3	6
Missing	5	4

Table 3 shows that 25% of our target group considered environmental cleanliness as a reason for their first-hand choice of EFV's. Similarly 13% thinks that distance covered by the vehicle and its speed is important for first hand choice consideration. Moreover a total of 11% choose the ease of use and effectiveness as a reason for their choice whereas 9% choose recharging and refueling possibilities of the vehicle and 16.3% of total mentioned that they don't know the reason for their first hand choice. Moreover 16.3% of the subjects did not state any reason for their choice of environmentally friendly vehicle. Gender differences also affect first hand choice of vehicle type. Male concentrated on recharging and refueling possibilities, cleanliness and distance/speed of the vehicle whereas for female main reasons for first hand choice of a vehicle was ease of use and effectiveness, quietness and absence of smell. They didn't care too much about the recharging/refueling facilities, distance/speed and flexibility of the vehicle.

4.4 Willingness to pay

The results shows that 59.6% of our respondent replied that they are willing to pay the same amount of money as for a conventional vehicle, 20.4% mentioned that they were willing to pay more whereas 22.2% were willing to pay less (Figure 8a-c). Moreover 5.6% replied “they didn’t know” and 6.9% didn’t replied at all.

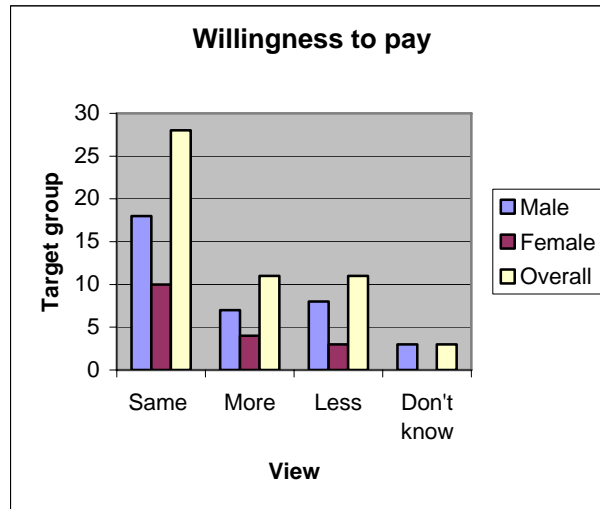


Figure 8a. Willingness to pay distributed over gender.

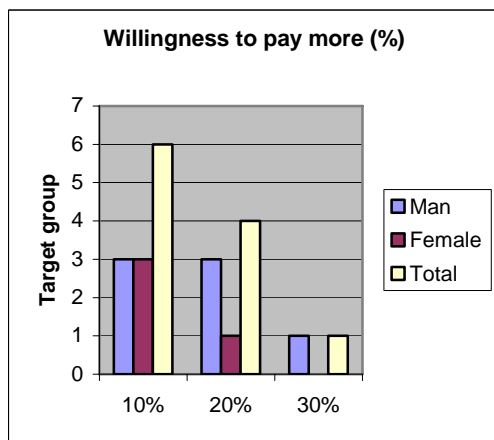


Fig 8b: Willingness to pay more.

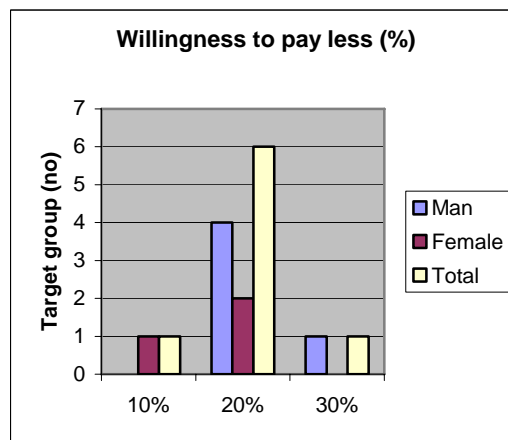


Fig 8c: Willingness to pay less.

Among the target group which expressed their willingness to pay more:

- 54.5% were willing to pay 10% more.
- 36.3% were willing to pay 20 more.
- 9.0 % were willing to pay 30% more.

Similarly among the target group which expressed their willing to pay less:

- 12.5% are willing to pay 10% less
- 75% are willing to pay 20% less.
- 12.5% are willing to pay 50% less.

4.4 Willingness to join car sharing

At this stage we offered a new option to our target group. We asked them whether they would like to join car sharing, if they were offered at Cth. Lets check our results. Our target group was provided with two clear options for car sharing.

- Leasing for work trips.
- Leasing for work trips back and forth.

For the option of leasing a car for work trip 52% of our target group replied, "No trips involved in their work trips", 26% of our target group travels with their own car whereas 8.7% replied, "they travel with Cth cars" and again a proportion of 8.7% replied, "Its difficult to plan trips beforehand". Similarly 4.3% prefer to walk, use bicycle or public transport for their work trips (Figure 9 and Table 4).

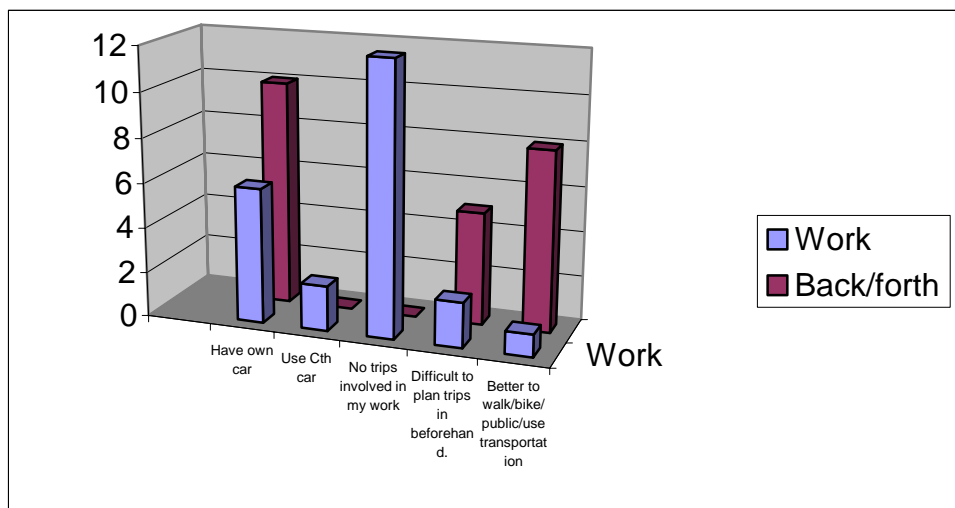


Fig 9: Reasons for joining car sharing for work and back and forth to work.

Table 4: Reason for not leasing for work trips.

Reason	Work	Back/forth
Have own car	6	10
Use Cth car	2	0
No trips involved in my work	12	0
Difficult to plan trips in beforehand.	2	5
Better to walk/bike/public/use transportation	1	8

The subject was also targeted with other option of leasing a car for their personal trips. Table 5 shows that regarding the option for leasing a car for personal trips in evening time, 58.7% replied “No” to the idea, 19.5% replied, “they will lease the car for some days per month”, 10.9% replied to lease the car on daily basis and again 10.9% of our target group gave a simple answer “they don’t know” (Figure 10 and Table 5).

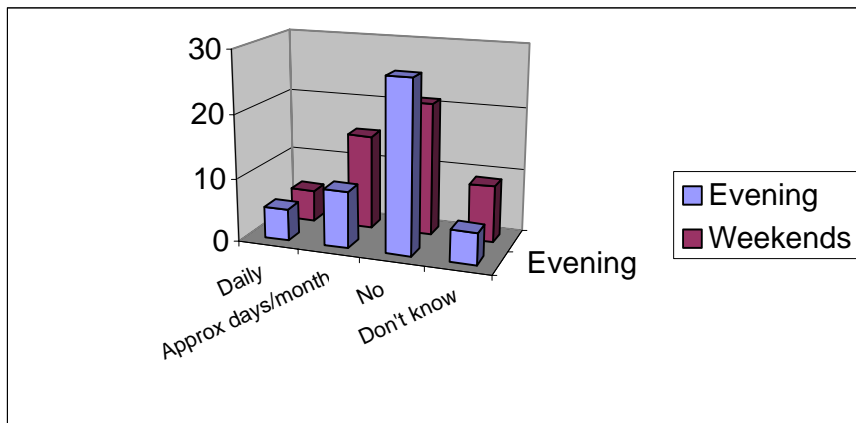


Fig 10: Reasons for joining car sharing for evening and weekend trips

Table 5. Stated leasing evenings and weekends.

	Evenings	Weekends
Daily	5	5
Approx days/month	9	15
No	27	21
Don't know	5	9

Similarly regarding the option for leasing a car on weekends, 42% replied “No”, 30% expressed their willingness to lease the car for some days per month, 18% replied, “they don’t know” whereas 10% of our target group expressed their willingness to lease the car on weekend on daily basis.

4.5 Should CTH take an environment initiative?

Cth has got a good reputation in working for pro-environmental tasks. The subjects were asked about their opinion for an initiative step by Cth in combating environmental pollution. Results from Figure 11 shows that 87% of our target group expressed their willingness that Cth should take an initiative whereas only 12.9% replied “they don’t know”, From Fig 8 it is clear that majority of males as well as females in our target group are in favor of Cth initiative.

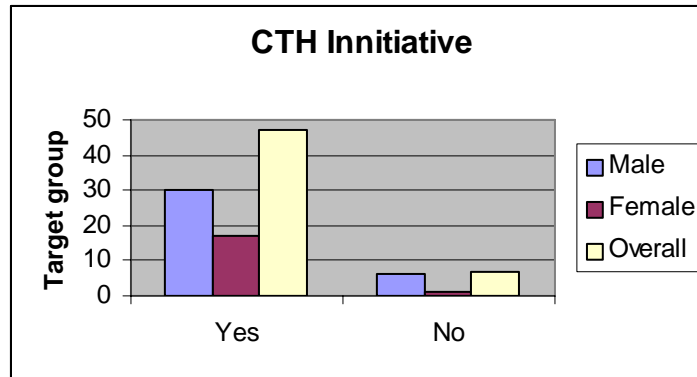


Figure 11. Females and males opinions about whether Cth should take an environmental Initiative, or not.

Moreover, the subjects stated that the reason why they thought that Cth should take such an initiative (Figure 12). Results show that almost 40% of all subjects suggested that Cth should be in the front line, 28.5% replied that Cth has got competence and knowledge whereas 19% stated that everyone is responsible for environment including Cth. A total of approximately 20% mentioned this initiation is a part of the policy claimed by Cth; and 7% thought it would bring goodwill to Cth.

Code	Means
1	Not initiate car share
2	Have competence and knowledge
3	To be in the front line
4	Everyone is responsible for environment
5	Part of Cth policy
6	Give Cth a good will

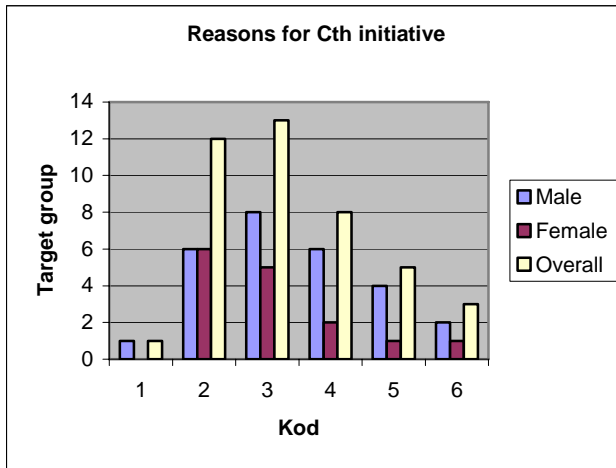


Figure 12. Reasons why Cth should take an environmental initiative distributed over gender.

5. Discussion

The successful implementation of project Green boundary is expected to be a starting step towards the creation of a green zone. Every individual is certain that vehicle emission is a threat to our green future and something has to be done even if there are areas of uncertainty and disagreement. A majority of subject in this study were university graduates, which most certainly means that they are well aware of the consequences of pollution from vehicle emission. Furthermore, they were well paid and the correlation between the level of income and adoption of environmental friendly measures is strong. A majority of the subjects were also interested in environmental issues and a considerable number was involved in some kind of environmental organization. Despite that a majority of all subjects traveled alone with their own car back and forth to their workplace. What is the main reason for this? The simple answer was that it is comfortable, saves time, and gives a sense of freedom. For individuals living within a distance of 5 Km from Cth, the modes of transport available in Group 3 are the best alternatives. A considerable number of our target group is already in use of cycling, walking and public transport, however there is need for efforts in changing this considerable number into majority.

Fortunately, at least some of the subjects perceived the car-sharing program as an interesting alternative to reduce vehicle emission within the area of Cth. For that program the hybrid electric vehicle was thought to be the best choice. Since a consumer's willingness to pay could be regarded as a simple measure of the importance he/she puts on, in this case the environment, it is a positive sign for an implementation of a car sharing program at Cth that a considerable proportion of all subjects are willing to pay 10% more for an environmental friendly car.

However, before offering a car-sharing program, at for instance, Cth the following has to be considered

- No individual wants to lose his/her freedom, control and accessibility.
- By leasing a car trips have to be planned in beforehand.
- Leasing should not be more expensive.

It should me made crystal clear that leasing a car from a car-sharing program at Cth is different from renting of an ordinary car. Therefore, a car-sharing program at Cth should have cars that are at the leaser disposal, like their own private car, and nobody should have to lose his/her freedom of travel, accessibility and privacy, and it should not be more expensive to use than their private vehicle.

Implementation of a car-sharing scheme will not be an easy task but Cth is committed to issues of sustainability and has recently made a strategic investment in environmental research, the Chalmers Environmental initiative (CEI), so it should not be an impossible task.

6. *Future Recommendations*

The use of walking and cycling cannot be expanded without diminishing unwanted use of conventional petrol and diesel vehicles. As we have a considerable proportion of our target group who already adopted walking and cycling as their mode of travel, its time to convince our target group who are living in a circle of **5 Km** for cycling and **1 Km** for walking, resulting a minimum usage of conventional petrol and diesel vehicles. Campaigns and smaller, practical measures like cycling maps, safe paths, and bicycle parking racks create a better climate for cycling and gradually make cycling socially acceptable in cities without a cycling tradition. Availability of bicycle parking facilities throughout the cities, especially at railway station and bus terminal and provision of bicycle caring facilities on buses and trains, will help in establishing inter-modal alternatives to the car for long and short distances

As discussed earlier there should be implementation of regulation and provision of attractive incentive packages to convince individuals for a shift towards environmental mode of transport. Incentives should be put in place before charges are implemented. Incentives that decrease dependability on private cars will on the other hand increase the potential for car sharing. Measure that enhances the financial benefits of car sharing can raise the potential for car sharing. General subsidies or tax regulations/exemptions are just some of the possibilities. Other option includes road pricing or measures that increases the marginal costs of private car ownerships. There should be priority car parking facility for all car-sharing vehicles and dedicated car share spaces.

Implementation of a successful car-sharing scheme requires basic awareness programs explaining operational procedure, related information, differentiating between car rental and car sharing, and visits tours to environmental friendly vehicles show rooms. There is a primary obstacle for the provision of infrastructure facilities including access to proper parking facilities in the city and lack of collective traffic alternatives. The integration of car sharing in local traffic planning and close cooperation with the already existing traffic system is necessary initiatives if the use of car sharing is going to increase in future.

In addition to these concerns there should be an effective electronic car sharing booking and accounting system, accurate transferring of trip data from car sharing vehicle to the a booking center. Moreover better communication system between car and operating system should include GSM-based on board computer for highly flexible car sharing location for each car-sharing vehicle.

The most important current research questions evolve around the following points.

- How can the shortcomings of common ownerships, such as reduced care for the material product, be counterbalanced by incentive or group structure?
- How large need the group size to be and what is the best network density in terms of membership and spatial area?

- What are the relevant public regulation settings fostering this system of mode of transport adequately?
- To what extent the to-be implemented car-sharing scheme flexible for accommodation of other kinds of alternative vehicles like electric, biogas and ethanol vehicles in the future.
- How to assure easy access, simple operation and privacy assurance of individual in addition to smooth operation of the scheme?

Moreover there should be guaranteed access of disabled with space for two wheel chair in some cars. The behavioral obstacle also play a crucial role in relation to car sharing, but further studies are needed to identify the character of these obstacles and provide the means to remove them. Intensified information efforts will probably be of some help in removing the obstacles.

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Mr Kenhira Maruo from "Machine and vehicle design system department".

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Appendix

Questionnaire (English)

Below are presented different means of transportation that are thought to be environmental friendly. Think that you will rent a car from the environmental friendly car pool. Your job is to assign preference No 1 for your first-hand choice, preference No 2 for your second choice and so on.

- Biogas
- Ethanol
- EL
- Natural gas
- Benzine

We also want your motivation for your first choice

.....

Normally someone will pay a constant price per hour, per day and per week plus a fixed mile price when you rent a car. What will be your preference for payment to rent a car from environmental friendly car pool?

- Same as name and model for driven mileage.
- More for name and model for driven mileage.
- Less for name and model for driven mileage.
- Don't know.

If you mark that you will prefer to pay more in the question mentioned above, we are wondering how much more you will prefer to pay in total (constant+miles driven price) to rent a car from environmental friendly car pool?

- 10% more.
- 20% more.
- 30% more.
- 40% more.
- 50% more.

If you mark that you will prefer to pay less, we are wondering how much less you will prefer to pay in total (constant+miles driven price) to rent a car from environmental friendly car pool?

- 10% less.
- 20% less.
- 30% less.
- 40% less.
- 50% less.

Think that you have the opportunity to rent a car from environmental friendly car pool for your travelling during daytime, for your travel to and from your work place, for private travel during weekdays between 18:00 and 8:00 in the morning and for your private travel during the end of the week and weekend.

Would you be interested to rent a car from environmental friendly car pool for your travelling during daytime?

- Yes, daily.
- Yes, some time a week.
- Yes, some time per month.
- No.
- Don't know.

If your answer for the above mentioned question is "No" we would like to know the reason.

.....

Are you interested to rent a car from environmental friendly car pool for your travel to and from your work place?

- Yes, daily.
- Yes, some times a week.
- Yes, some times per month.
- No.
- Don't know.

If your answer for the above mentioned question is "No" we would like to know the reason.

.....

Are you interested to rent a car from environmental friendly car pool for your private traveling between 18:00 and 8:00 in the morning?

- Yes, daily.
- Yes, some times a week.
- Yes, some times per month.
- No.
- Don't know.

If your answer for the above mentioned question is "No" we would like to know the reason.

.....

Would you like to rent a car from environmental friendly car pool for your private travel at the end of the week and weekend?

- Yes, daily.
- Yes, some times a week.
- Yes, some times per month.
- No.
- Don't know.

If your answer for the above mentioned question is "No" we would like to know the reason

.....
.....

Do you think that Chalmers should take an initiative step towards the start of an environmental friendly work?

Yes, because.....

No, because.....

Don't know.....

Other points and ideas.....

.....
.....
.....

SOME GENERAL QUESTIONS

I am

- Male
- Female

My age.....years.

My level of education is

- Gymnasium
- University

My annual income is

- Less than 75,000.
- Kr 75,000 to Kr 149,000.
- Kr 150,000 to Kr 224,000.
- Kr 225,000 to Kr 299,000.
- More than 300,000.

My work place is

- Chalmers.
- Chalmers Lindholm

I am interested in environmental friendly work

- Yes
- No

I work for an environmental friendly.

- Yes, personally
- Yes, in an organization.
- No.
-

Reason for No.....

There is Km distance between my home and my work place.

I travel to my work place with

- Tram
- Bus
- Cycle
- Car private
- Car shared
- Walk

What is your car type?

Company name.....

Model.....

I drive by car to my work place,

- Daily.
- Some days per week.

I drive by car because.....

.....

I park my car

- Inside Chalmers
- Outside Chalmers.

I pay parking fee

- Per day withKr.
- With monthly card.
- With half year card.
- With year card.
- Other.....

Thanks for your co-operation

