Electric Power Supply for Road Vehicles, on Road

Project in EIE070

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Contents

Background

There is a huge demand for environmentally friendly cars today. The need is constantly growing as the oil price is increasing. One solution is to use cars that are motorized by electrical power. The main drawback to them is the fact that they can't get very far on a single charge. One way to solve this problem is to increase the efficiency of the cars, but it will be hard since it is almost as high as it can get. Another solution would be to continuously charge the batteries while you drive the car. This would save a lot of time charging the car. If there is a way to realize this problem it would mean a lot to the car industry but mostly the environment.

Requirements and limitations

The need that must be fulfilled in this project is to, in a safe way and with high efficiency, charge the car while it drives. The charge must be done in a very easy way so that any driver, regardless of gender and age, will be able to charge their car. Furthermore there must be a solution so that many cars can be charged at once. This implies high voltage and strong currents, which leads to safety. Safety must be guaranteed to everyone that may be on the road; the charger, the other road users and animals crossing the road. The other road users may be driving a vehicle powered by petrol, that might have a leak, which in case of a spark would lead to an explosion.

Goals and expected results

Find a solution to charge electrical cars on the move, which might work. And present it on a report.

Dissemination of results

The work will be presented in the form of a written report and an oral presentation given at some point later. In the case of issues with immaterial rights we will consult someone more knowledgeable in the area to sort out these issues for us.

Methodology

- Brainstorming.
- Market survey.
- Choosing a couple of ideas that match our criteria's.
- Some calculation on the different ideas.
- Chose the best idea and continue working on that one.
- Compile the results into a report.

Project organization

The persons involved in this project are the mechanical engineering students Kristoffer Bengtsson, Magnus Brange and Viktor Fogelberg and the electrical engineering students Tobias Bonnedahl and Leo Bärring. Mats Alaküla, who will represent Volvo and IEA/LTH in the project, will be able to answer any questions concerning the electrical cars and hopefully more.

Project scheduling

First of all, we must start with some basic background on the electric powered cars of today. We must learn how long time a charge takes today, and in what areas are the research pointing to, what will be the technology of the electric cars of tomorrow. This part can hopefully be done until the start of next study period, when the project really would start. This may be postponed due to exams for some of the project participants.

Criteria

We chose the decision matrices as our method to determine which idea from our brainstorming that is the best one. We will be grading the different ideas with regards to the following criterions. First of all we will look at the criterions in selection 1, where we will make the first product portfolio. The products that will make it to selection 2 will be processed according to selection 2 and give us the final product. The tables can be seen in Attachment 4.

Selection 1

- Safe
- Environmentally friendly(including the appearance of the construction)
- Powerful
- User-friendly
- Efficient
- Realistic
- Demand
- Low competition
- Transition possible
- Reliable
- Applicable on older cars

Safe
The product may not be a hazard or in other ways a danger to the user and non user in the surroundings.

Environmentally friendly
It may not be harmful to the environment like acidify lakes, gain the global warming or in other ways be a hazard to the environment. It should also not be to bad looking.

Powerful
Enough power to drive the vehicle with passengers and the cars total weight.

User-friendly
The product should be easy to understand so everyone can understand it and make no mistakes that may be harmful to the users. Youshouldn't need a large education to use the product.

Efficient
Amount of power generated related to the amount of input power from the power-grid.

Realistic
The product should not be taken from a science fiction movie like Star Wars or something like

that, which mean that it should be possible to make the product today with the knowledge we have today and maybe some research and development in a couple of years ahead. It may not be to futuristic that is impossible to construct we the today's knowledge.

Demand
Is there a demand after this product from different companies that may think the product is interesting and possible to build.

Low competition
Is there a low competition in making this kind of product.

Transition possible
The possibility to make a product that won´t make it impossible for other cars to use the road.

Reliable
The product must work as often as possible without to much disturbance and breakdowns.

Applicable on older cars
Usable during at transition time with both old and new cars

Selection 2

- Price
- Low maintenance
- Development possibilities
- Design
- Usability
- Construction time
- Payment
- Some way to handle intersections
- Available for as many cars as possible
- Disturbance free

Price
A not to expensive product would be good to lower the cost that the costumers will pay to make it more attractive.

Low maintenance
The system must be easy to maintain in order to have a cost efficient solution.

Development possibilities
The possibility to make more developments in the future and large developments which may increase the efficiency or maybe lower the construction cost etc.

Design
How the product looks and pleases the users and other people around.

Usability
Is it possible to use the product on different roads. In other words can you use it in the city also or just on the motorways.

Construction time
How long is the construction time. The lower construction time the better.

Payment
The possibility to charge the users for the electricity they use.

Available for as many cars as possible
The product shouldn’t concentrate on one type of car or one kind of model and brand. It should be available to as many cars as possible.

Disturbance free
It shouldn’t disturb radio-frequencies or cell phones or other equipments.

Brainstorming

Here are a few ideas of how to solve this problem presented.

- Solar panels on the roof.
- Power-rail
    - in the road.
    - in the air above the car.
    - on the side of the road.

- Some kind of "magnetic-field to speed" thingy.

Solar panels

If solar panel were mounted on the car the energy emitted from the sun could be used to charge, and drive, the car. This would be very environmentally friendly, since this energy otherwise is wasted. A few attempts of this has been done; these cars are very wide and flat. The reason for this is to maximize the area where the solar panels can be placed, and minimize aerodynamic resistance. A typical design of a solar panel powered car can be seen in Figure 1.

Figure 1; Nuna 3 built by Delft University of Technology, Netherlands
(Source: http://forum.avtoindex.com/foto/data/media/5/nuna_3_solar_car_1.jpg)

The Nuna 3 has more than eight square-meters of solar panels, 5 kWh battery capacity and a total efficiency of 97 %. The car is worth a more than 1 million Euros.

Pros:

- Efficient on sunny days and in sunny countries.
- Safe for co road users and animals.
- Free power.
- Environmentally friendly.

Cons:

- Won't work at night or very cloudy days.

Power-rail over the car

Some kind of power-rail that are connected to the power-grid above the car. This will give high voltage/current to the car.

One idea is to put power-rails for a couple of kilometers and under those kilometers power up and (re)charge the car. When there aren't power-rails the car can run on battery for a couple of kilometers, and then repeat the procedure. It require a lot of planning so nobody will run out of electricity. But it's much better than having to build a power-grid over all the roads in Sweden/the world.

Pros:

- Direct contact with the power-grid (Unlimited electricity directly to the car).
- Enough electricity to power the car and recharge the battery at the same time.

Cons:

- High power electricity in/near the road, dangerous for animals and humans that crosses the road.
- Work badly when it's snowy or very could.
- Bad looking for the environment.
- Expensive to build.

Figure 2; Trolleybus(Trådbuss) in Landskrona, powered by a power-rail in the air.
(Source: http://upload.wikimedia.org/wikipedia/commons/8/8d/Tr%C3%A5dbuss_Landskrona.JPG)

Power-rails in the road

Similar suggestion to power-rails over the car is to have them under the car which also will give high voltage/current to the car.

Pros:

- Direct contact with the power-grid (Unlimited electricity directly to the car).
- Enough electricity to power the car and recharge the battery at the same time.
- Not as bad looking over the car since you can´t see it as much.

Cons:

- High power electricity in/near the road, dangerous for animals and humans that crosses the road.
- Can collect dirt in the glitches were you charge your car.
- Expensive to build.

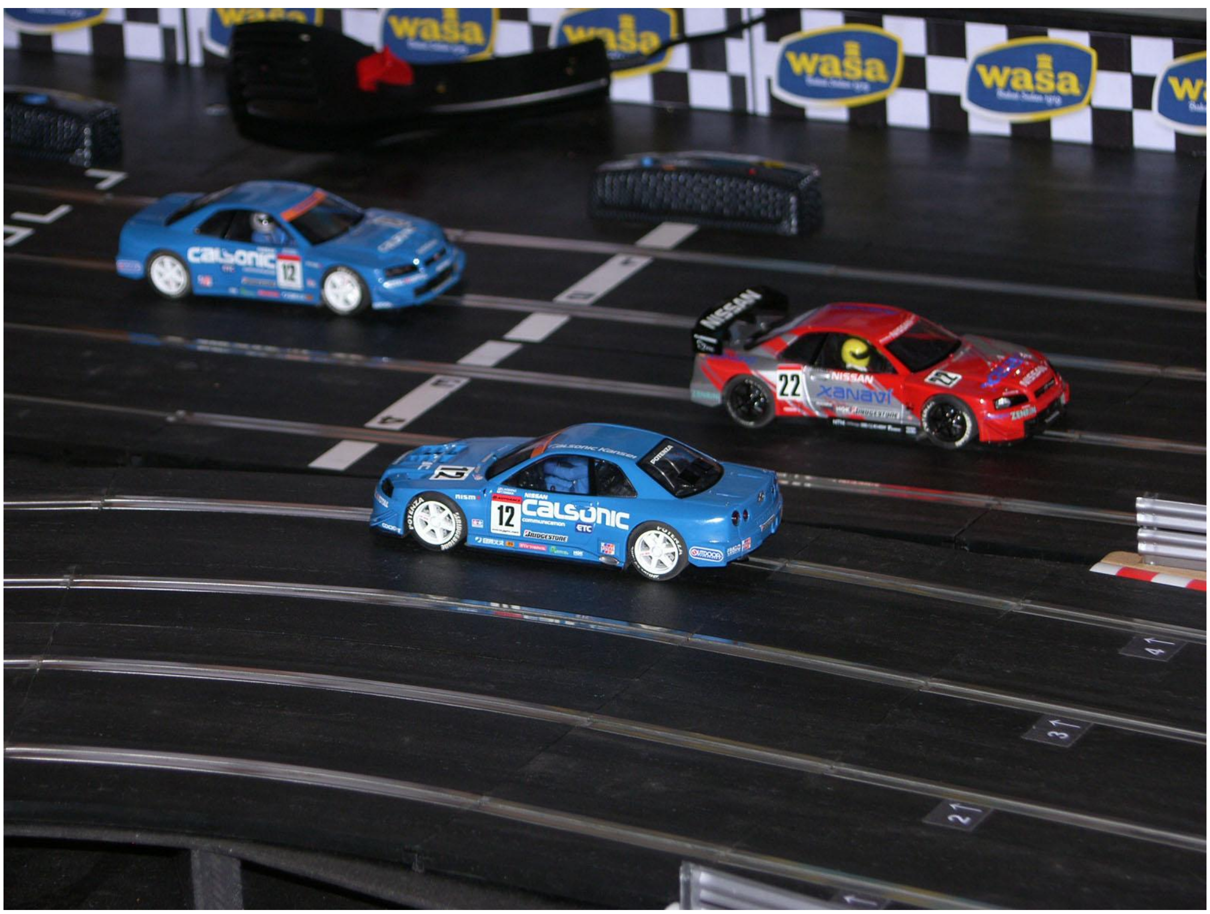

Figure 3; Power-rail in the road.
(Source: http://www.sweclockers.com/imagebank/30fa4/5Wezi0.jpg)

Power-rails on the side of the road

Also similar to the suggestions above but having the power-rails on the side of the road instead which won´t destroy the road and not be as bad looking as having rails over the car.

Pros:

- Direct contact with the power-grid (Unlimited electricity directly to the car).
- Enough electricity to power the car and recharge the battery at the same time.

Cons:

- High power electricity near the road, dangerous for animals and humans that crosses the road.
- Work badly when it's snowy or very could.
- Can´t charge constantly when making an overtaking.
- Still bad looking

Some kind of "magnetic-field to speed" thingy.

Just a dopey idea. We were thinking about building a really big linear motor with the cars and the road. But that isn't really what we're looking for.

Final design

Design choice

After having made our evaluation in the view of our criterions we can see that power-rails under the car is the best choice of design since it got the highest score. The conductors under the car are going to slide on a stick letting the driver move a little bit to left and right. Could have used some kind of suspension also but that could have made it wobble. The rail have to be in the road and not on the road which would destroy the tires and be very dangerous for a motorcyclist if he would pass the rails.

How it works

The rail under the car is going to be milled down in the road which contain two conductors that transfer the electricity. When the rail is somewhere in the middle of the car, the car 'sees' the rail with help of a camera and sends down the other conductors to the rails and start the transfer of electricity using brushes (see attachment 3). Since drivers won´t be able to keep the car completely steady the conductors on the car are going to slide on a stick letting the driver move a little bit left or right when charging. If the driver want to make a overtaking the moving conductor is going to come to it´s maximum limit and turn on a switch that will rise the conductors from the rails. They will then come down again in the same way as mention before with the camera.

The conducting wires in the road should be divided into sections that are about 1km long. So they could be turned off in case of emergency and to get down the current in every wire.

Calculations

One liter gasoline contains approximate 43 MJ energy.
A gasoline engine have about 30% efficiency.
When driving on the motorway a car consume about one liter gasoline per 10 km.
10 km takes about 6 min (360 sec) to drive.
An electric car has an efficiency of about 90 % that we approximate to 100 %.
So we get:
43 MJ / 3 = 14.3 MJ
14.3/360 = 40 kW

A car needs about 40 kW to drive on the motorway. If we want to charge the car at the same time we need about 100 kW.

Electric power

If only electrical characteristics have to be taken in consideration, ideally the power rails would supply power in form of high voltage and low current, since P=RI^2, however, that is unsuitable if not for direct safety reasons, then for that the possible isolation distance is much less for a car than for e.g. a train.

With that said, when looking past the connection route and filters (which will be much needed, it will, no doubt, be a noisy environment) the power needs to be converted to a suitable voltage and current level to supply the motors and charging electronics with power. This can be achieved with a switching transformer which has the added benefit of being able to be built very flexible with regards to different types of input.

Control electronics

The real challenge is controlling the whole system. In the centre is maintaining smooth contact with the power rails for as long as possible even when the car isn't moving in exactly the same direction as the rails. Also initiating and ending contact when a road segment with rails is passed is needed. For this at least two communication systems are needed. The first one is detail oriented with the task of helping identifying the direction of the rails. As many different methods possible is preferred in order to increase the robustness of the system, along with cameras with image interpretation software, painted symbols using a one or two dimensional bar code system could be added to increase fault tolerance. In addition to this, Beacons of infra red light could be used as another fail-safe, with the added possibility of modulating the light in order to transfer data.
The other one is relatively large scale and communicates the presence of a rail system is close. Other data as voltage levels, payment details, traffic information et cetera could be handled through this channel. A wireless LAN could be used for this task, and would be fairly easy to extend if and when the need to communicate other types of information arises.
software being able to identify moving objects and differentiate between vehicles and other objects. This would also be combined with data supplied by the vehicles themselves. Since image recognition can only do so much, quite a lot of information would be needed to be supplied by the vehicles, data about vehicle hull integrity could be transmitted in order to detect A control system would also be needed, with non isolated high power conductors in open air the severity of an accident would increase. Thus a monitoring system that is able to swiftly shut down sections should the need arise, is required. This would consist of camera system with collitions. Another example would be shutting down the rail if a vehicle seems to be stopping; speed below 40km/h and slowing down.

Materials

Materials for the road.

For the wires we going to use some kind of copper-steel alloy that are harder than copper but still conduct electricity very good. The protective bumbs (see attachment 1) should be made out of some kind of rubber so they bend when you drive on them and don´t have such a high conductivity.

Materials for the car.

The construction should be made out of stainless steel.
For the brushes we're thinking of some kind of copper-steel alloy. The brushes should be softer than the power-rail because they're easier to replace than the power-rail.

Sensors

The camera under the car is used to locate the power-rail.
Two sensors for knowing when the car has turn right or left to much, so the power-rail is to far away from the middle of car.

More ideas

- Cover the power-rail-hole with some kind of rubber-fly that bends down when the conducting-thingy from the car goes down.

References

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http://www.nuonsolarteam.nl/

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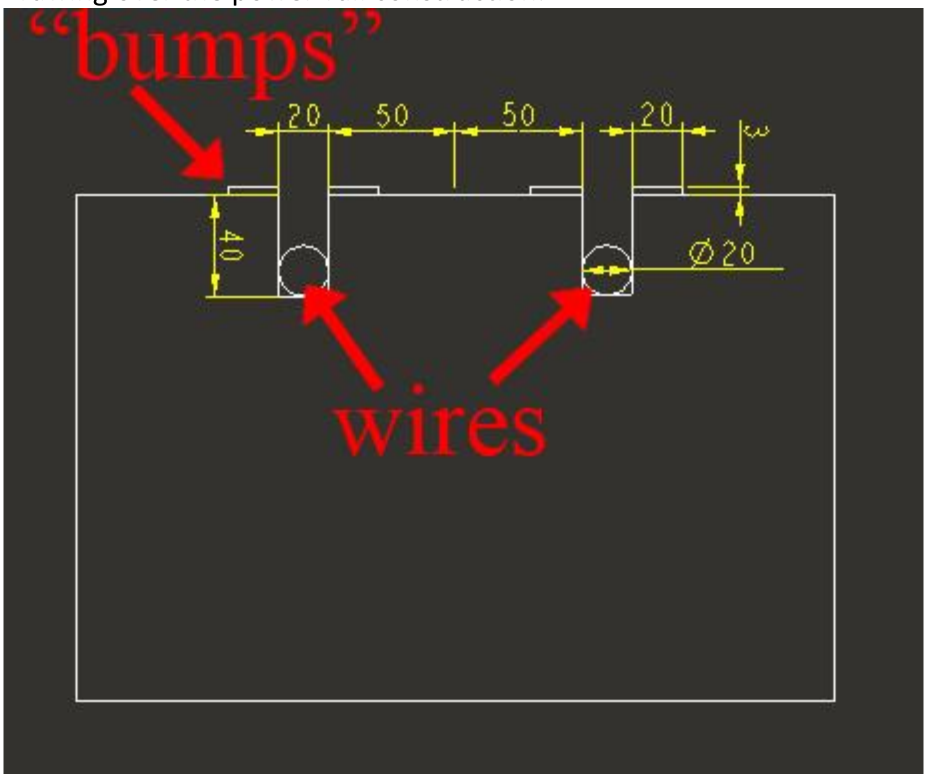
Attachments

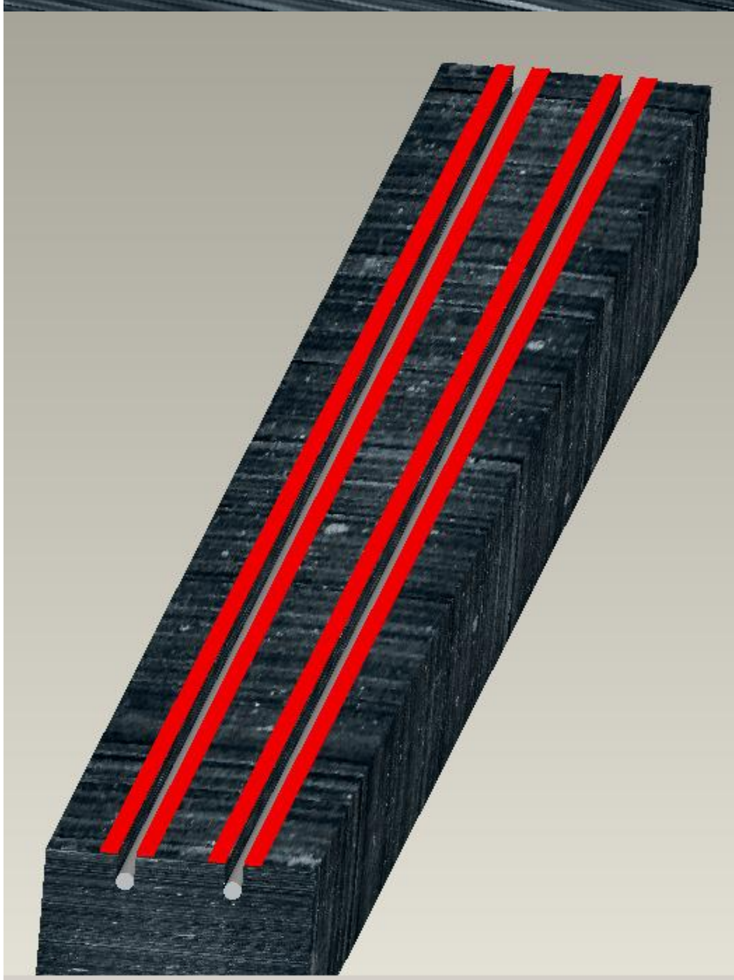
Attachment 1

Drawing over the power-rail construction.



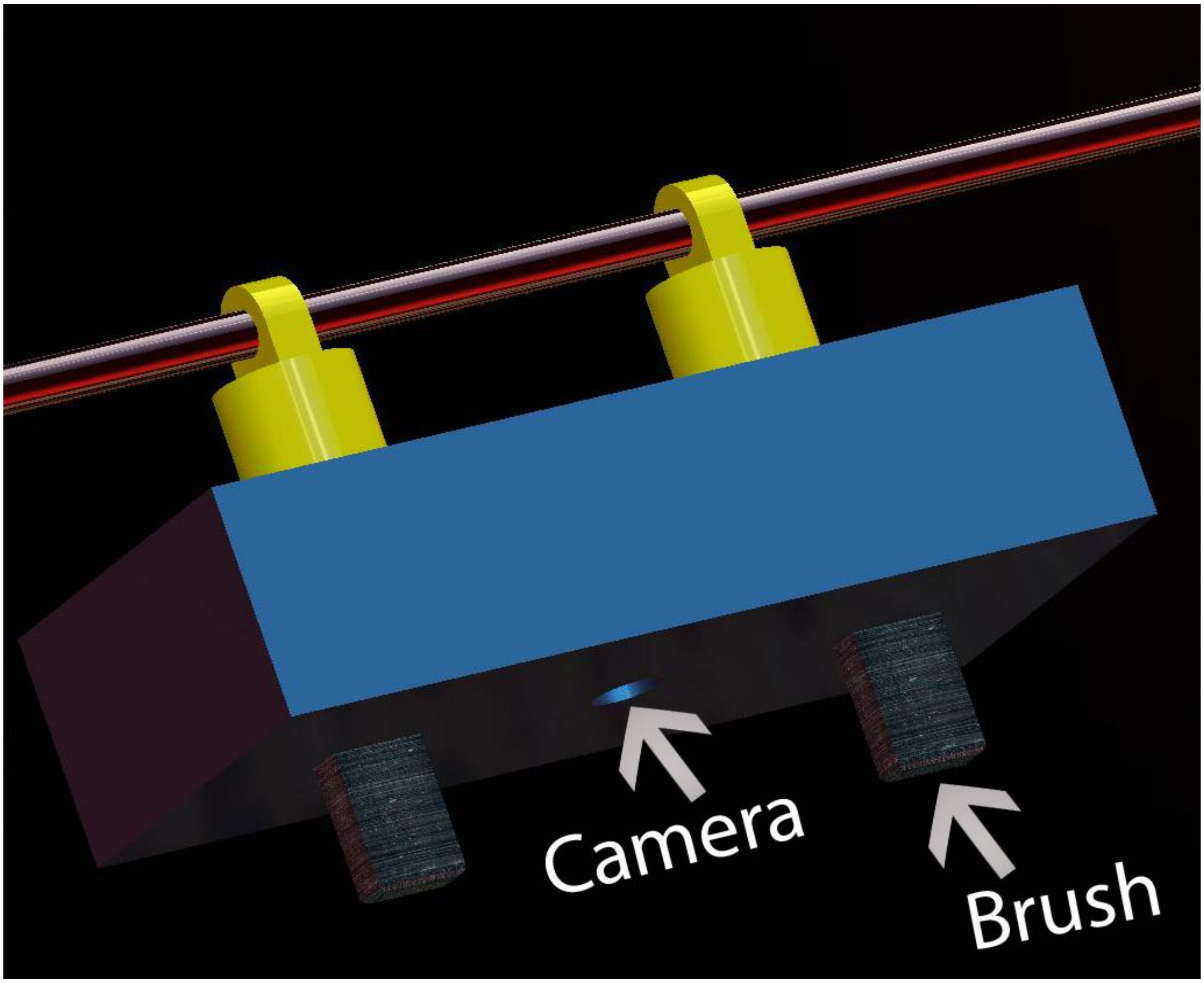
Attachment 2

Pictures over the power-rail.



Attachment 3

Power rail connector



Attachment 4

Selection matrix 1

Criterions	Solar panels	PR - above	PR - under	PR - on the side
Safe	5	3	1	1
Environmentally friendly	4	3	4	4
Powerful	1	5	5	5
User-friendly	5	4	4	4
Efficient	1	5	5	5
Realistic technology	1	5	5	4
Demand	5	3	4	3
Low competition	2	4	4	4
Transition possible	5	2	4	4
Reliable	2	3	1	3
Applicable on older cars	4	2	2	1
Sum selection 1	**35**	**39**	**39**	**38**

Selection matrix 2

Criterions	PR - above	PR - under
Price	2	2
Low maintenance	2	3
Development possibilities	3	3
Design	1	5
Usability	3	1
Construction time	3	2
Payment	5	5
Available for as many cars as possible	3	4
Disturbance free	4	4
Sum selection 2	**26**	**29**