Design of SMART Car

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Abstract The purpose of this research is to try getting use of each possible power source to get a car moving with the minimum running cost and minimum damage to the environment.

Keywords smart , car, energy, new generation

1. Introduction

1.1. Our Vision

We are planning to make a car that opens the doors for new generation of cars

1.2. Our Mission

Using the pervious experiences to have a new Engineering Icon

- Our scope of work
- Energy used to move the car
- Reliability
- Features

1.3. What is meant by Smart?

Smart means that the car is too smart to understand the ongoing events and to keep up with our daily lives.

S.M.A.R.T. also means

Sound: as we need the design of the car without any errors so we can have sound design for the car

Material: Using the green materials is also taken into consideration in our smart car

Achievable: Making sure that this Smart car can be done is also meant by our project

Realistic: Real world makes us sure that we have to search for what the society needs so we can't exceed a specific cost or require a very hard mean of production

Tolerance: We have also to take into consideration the tolerance of the calculations we can't depend on that the world is ideal

1.4. The Design

According to the pervious experiences in this field we

would go for a weight of the car 860 kg (including the battery and the motor)

As the simulation in Solid-Works® makes us see we have a frontal area of 1.7 m²Energy used to move the car. Due to our mission we were looking for a previous car to start where others finished not starting over also in the energy used we were looking for the perfect solution that would provide:

1. Sustainable source
2. Relatively cheap

1.5. Reliable

We are also looking for new resources that would fulfill these conditions. A lot of wasted energy could be used as we can do some energy harvesting to the interior design as well as the exterior one. The Energy would be divided into two sections inside the car and outside the car. The energy harvesting would also depend on the main source of energy as we can gain much energy from the heat loss if we are using I.C.E. (Internal Combustion Engine) or we gain use regenerators if we are using a B.E.V. (Battery Electric Vehicle). Later on in this report we will choose which kind of cars to develop

1.6. Reliability

You can't ask a customer that just bought a car not to use his car daily or to ask him to wait for couple of hours to make sure that the car is ready to use. It is so important to make sure that the car is ready at any time no matter it is a shiny day or a hard raining day. Also the maintenance is a very important factor. Most of car users would consider their car is "in a good shape" for at least 5 years of normal usage. We have to make sure that our design could be used for 5 years without needing to replace any important parts.

1.7. Features

Nowadays the customers are looking for his comfort if you have a very good car without any features you can't have a successful car in the market. We see the Chinese experience in the cars. With very low price you are now able to have a car full of features like a parking sensor and automatic transmission. Maybe it is something very easy but

it is very important to a daily customer. Also it should be considered from the begging to calculate the power needed for these features. It is also unbelievable that we found that can generate energy from these features. We can't depend on our low price or that the car is green or the low running cost only. We have to do it the smart® way.

1.8. What do we want from our car?

We are looking for a car without any running cost maybe it's a dream but we have to think big then we can achieve it later. We will start by getting a previous experience and then modifying it to cost us no running cost at all or very low running cost.

We are also looking for a green car low emissions an environmental friendly car would be very acceptable now a days.

How can we achieve our purpose and the market purpose at the same time?

We all to have to admit that the main motive for any product is the customer desire but there are 4 other impacting factors that have (almost) the same effect on any product. Science has this big effect on the product. The technology factors can change a lot nowadays. No one could have every imagined that we need a mobile phone. No one could think that a "smart" phone is now a need. It is all about science that now we have can have micro processors so you can have a small computer as you used to call or a smart phone as we can say. And this is our gate to a new smart environmental friendly car. We have to take into consideration what we should afford for customer satisfaction without giving up the new concept we are looking after.

1.9. About the market

When you look at the numbers it is too easy to know how you can sell a car. You could even ask yourself when I am going to buy a car what do I think about?

Your answer would be:

1. The cost (fixed and running)
2. The look
3. The features
4. Previous experiences

Of course you can't make sure that everyone is happy but you have to take into consideration the popular demands.

2. The Investment Climate

It is a gear thing to know that a lot of brands nowadays are looking for some green projects we can see Toyota® and Nissan® are already heading for this new market. The electric & the hyper cars are already doing a great job worldwide. The capital is controlled not only by the customer needs or the near profit smart business men look for a way long profit and sustainable products only have the ability to do that. Politics also can do magic. It is totally obvious that normal finite resources are located in the Middle East area. Capital doesn't like wars getting away from this are of the world is now possible they just want to make sure that they don't want to get back there.

Aesthetics and Internal design combination

The second factor is the look we have to agree that it has a great affect (of course the price is the most important factor). The designers can do great work to have a good looking product but our job is to make sure that this "magic" could be done. To make this clear let's take a journey in Korea. Two years ago Hyundai® had a vision "New thinking new possibilities". Back then Hyundai was just a normal automotive industry company that makes economic cars and some heavy weight industries. The company CEO decided to change the way it works. He asked for whole new designs but not only from the designers but also with the engineers. The look of the Hyundai was acceptable enough to sell the car check fig 1 it is the Hyundai coupe it is good looking enough to have good selling numbers but the new vision didn't mean just to sell

Figure 1. Hyundai Coupe

The revolution that took place in the design is very obvious in the model "Elantra™". This model is the upper intermediate class in the chain of the cars (the targeted group already by Hyundai). I.e. the most important car for Hyundai Let's have a quick comparison between Hyundai Elantra™ 2010 and Hyundai Elantra™ 2012 (after the implementation of the new vision was completely done (U.S.) numbers.

Table 1. comparison between Elantra 2010 and Elantra 2012

Elantra 2010™	Elantra 2012™
Sold around 39,904 cars	87,304 and the numbers are jumping
A normal car in the company	Opened the doors for whole new generation
Was made by only engineers	Combination between the designers and engineers
Was bought by only intermediate marketing class	Everybody likes it and wants to have one!!!

We can now start the journey the designers went so crazy by themselves then later met the engineers to get back to reality as most of their sweet dreams met the aerodynamics laws and drag power requirements then designers went back to do their homework later on they met for the final concept drawing (fig 2) then it turned from the concept into outlook dimensions then went back again to designers to make sure that these dimensions won't ruin their look (fig 3) then it went back to the engineers to build up a 3D model (fig 4) then there they go they have now the body shape.

Figure 2. The concept idea for Elantra™

Now talking about our product we have to combine the look and the engineering concepts. The effect of this is great. We could see the change happened in Hyundai brand during the last two years because applying some aerodynamics and principles of the exterior design.

3. Types of Vehicles

3.1. Introduction

An electric vehicle (EV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. There are three main types of electrical vehicles that exist, those that are directly powered from external power source, those that are powered by stored electricity originally from an external power source, and those that are powered by an on-board electrical generator, such as an internal combustion engine (a hybrid electric vehicle) or a hydrogen fuel cell.

3.2. History

Electric motive power started with a small drifter operated by a miniature electric motor, built by Thomas Davenport in 1835. In 1838, a Scotsman named Robert Davidson built an electric locomotive that attained a speed of four miles per hour (6 km/h). In England a patent was granted in 1840 for the use of rails as conductors of electric current, and similar American patents were issued to Lilley and Colten in 1847.

Between 1832 and 1839, Robert Anderson of Scotland invented the first crude electric carriage, powered by non-rechargeable primary cells. By the 20th century, electric cars and rail transport were commonplace, with commercial electric automobiles having the majority of the market. Over time their general-purpose commercial use reduced to specialist roles, as platform trucks, forklift trucks,

ambulances, tow tractors and urban delivery vehicles, such as the iconic British milk float; for most of the 20th century, the UK was the world's largest user of electric road vehicles. Electrified trains were used for coal transport, as the motors did not use precious oxygen in the mines. Switzerland's lack of natural fossil resources forced the rapid electrification of their rail network. One of the earliest rechargeable batteries - the nickel-iron battery - was favored by Edison for use in electric cars. EVs were among the earliest automobiles, and before the preeminence of light, powerful internal combustion engines, electric automobiles held many vehicle land speed and distance records in the early 1900s. They were produced by Baker Electric, Columbia Electric, Detroit Electric, and others, and at one point in history out-sold gasoline-powered vehicles. In fact, in 1900, 28 percent of the cars on the road in the USA were electric. EVs were so popular that even President Woodrow Wilson and his secret service agents toured Washington DC in their Milburn Electrics, which covered 60–70 miles per charge. In the 1930s, National City Lines, which was a partnership of General Motors, Firestone, and Standard Oil of California purchased many electric tram networks across the country to dismantle them and replace them with GM buses. The partnership was convicted of conspiring to monopolize the sale of equipment and supplies to their subsidiary companies conspiracy, but was acquitted of conspiring to monopolize the provision of transportation services. Electric tram line technologies could be used to recharge BEVs and PHEVs on the highway while the user drives, providing virtually unrestricted driving range. The technology is old and well established.

3.3. Electric vehicle glossary

Table 2 shows the full description and explanation for EV, Pure-EV / Pure-Electric Car, PHEV and Hybrid.

Table 2. Full description and explanation for EV, Pure-EV / Pure-Electric Car, PHEV and Hybrid

Abbreviation	Full Description	Explanation
EV	Electric Vehicle/Electric Car	A vehicle powered, in part or in full, by a battery that can be directly plugged into the mains. In short any vehicle that can be plugged in.
Pure-EV / Pure-Electric Car	Pure-Electric Vehicle Alternative descriptions: Electric All Electric Battery Electric Vehicle (BEV) Fully Electric	A vehicle powered solely by a battery charged from mains electricity. Currently, typical pure-electric cars have a range of approximately 100 miles.
PHEV	Plug-In Hybrid Electric Vehicle Alternative descriptions: Plug-In Hybrid Vehicle (PHV)	A vehicle with a plug-in battery and an internal combustion engine (ICE). Typical PHEVs will have a pure-electric range of over 10 miles. After the pure-electric range is utilized, the vehicle reverts to the benefits of full hybrid capability (utilizing both battery power and ICE) without range compromise.
E-REV	Extended-Range Electric Vehicle Alternative descriptions: Range Extended Electric Vehicle (RE-EV) Series hybrid	A vehicle powered by a battery with an ICE powered generator on board. E-REVs are like pure-EVs but with a shorter battery range of around 40 miles. Range is extended by an on board generator providing many additional miles of mobility. With an E-REV the vehicle is still always electrically driven.
Hybrid	Hybrid Alternative descriptions: Hybrid Electric Vehicles (HEV) Normal Hybrid Parallel Hybrid Standard Hybrid	A hybrid vehicle is powered by, either or both, a battery and an ICE. The power source is selected automatically by the vehicle, depending on speed, engine load and battery charge level. This battery cannot be plugged in; charge is maintained by regenerative braking supplemented by ICE generated power. A number of fuels can power hybrid ICEs, including petrol, diesel, Compressed Natural Gas, Liquid Petroleum Gas and other alternative fuels.

3.4. Electric vehicle performance

The term ‘electric vehicle’ (EV) refers to any vehicle powered, in part or in full, by a battery that can be directly plugged into the mains. Performance will depend on the type of EV.

All pure-electric cars qualifying for the Plug-In Car Grant must be able to travel at least 70 miles on a single charge and many are capable of 100 miles.

Plug-in hybrid cars qualifying for the Plug-In Car Grant must be able to travel in excess of 10 miles on battery power, although many are able to travel further, before reverting to the benefits of full hybrid capability (utilizing both battery power and ICE) without range compromise.

Extended-range electric cars qualifying for the Plug-In Car Grant must meet requirements relating to Plug-in hybrids, but are typically able to travel in excess of 40 miles on battery power with hundreds of miles of additional range via the on-board generator. The average individual journey length is about 13 Kilometers and the average total daily distance travelled is 40 Kilometers. These distances can be comfortably achieved using pure-electric cars and many journeys can be made with plug-in hybrid or extended-range electric cars using only battery power.

3.5. Vehicle experience, range, speed, suitability

3.5.1. What are EVs like to drive?

EVs are easy and fun to drive. Smooth, swift acceleration and light handling make the driving experience very enjoyable. Also, electric motors are very quiet, which means the driver is in a quiet, calm environment. Finally, similar to automatic cars, there is no gearbox in a pure-EV, which is particularly useful in built-up areas or heavy traffic. Electric cars require the same driving license as traditional cars and pure-electric cars can be driven on an automatic-only driving license.

3.5.2. What are the benefits of EVs?

Electricity is one of a number of options which has great potential as an alternative to oil. It can be produced from sustainable sources, it can be readily supplied, and it produces no emissions at the point of use. This means EVs can offer significant environmental benefits when used as urban commuter transport. Here are some of the benefits of EVs when operating solely on battery power:

- no emissions at the point of use
- a quiet driving experience
- fun to drive
- easy to use infrastructure
- practical and easy to drive, particularly in urban stop-start traffic
- home charging is convenient and avoids queuing at petrol stations

3.5.3. What is the top speed and acceleration of an EV?

Electric vehicle specifications indicate that EVs are able to achieve similar speeds to their ICE counterparts during every day driving. All EVs which are qualified must be capable of reaching speeds of 60mph or more. Some pure-electric cars can reach speeds up to 125mph where permitted.

Power is delivered by the electric motor as soon as the vehicle begins to move which gives smooth and swift acceleration.

3.5.4. Does an EV have adequate range for all my needs?

Range depends on the type of EV and how it is driven. Currently, most pure-electric cars offer a range up to 100 miles and are ideal for short to medium length journeys. If you are likely to be regularly driving short to medium range journeys and over 100 miles then an E-REV, PHEV or alternative fuel/ low carbon ICE may be more suitable.

The average individual journey length is 8.6 miles and the average total daily distance travelled is 25 miles. In Europe, more than 80% of Europeans drive less than 63 miles in a typical day. This shows that a significant number of journeys could easily be made using an EV.

3.5.5. Will EVs suit everyone?

Not all vehicles in the market are suitable for all drivers but EVs match the transport needs of a great proportion of the population very well.

The intended use will determine what type of EV is most suitable. Manufacturers are introducing more car models, which will satisfy the demand for vehicles of different size and capacity. Whilst the majority of EVs on the market are likely to be city-sized vehicles, research is also being carried out on cars in the super luxury market.

Until recently, pure-electric cars have been used mainly in commercial and urban environments.

3.6. Charging

3.6.1. How long does it take to charge an EV?

How long it takes to charge an EV depends on the type of vehicle, how depleted the battery is and the type of charge point used. Typically, pure-electric cars using standard charging will take between six and eight hours to charge fully and can be 'opportunity charged' whenever possible to keep the battery topped up.

Pure-EVs capable of using rapid charge points could be fully charged in around 30 minutes and can be 'topped up' in around 20 minutes, depending on the type of charge point and available power. PHEVs take approximately one and a half hours to charge from a standard electricity supply. E-REVs take approximately four hours to charge from a standard electricity supply. PHEVs and E-REVs require less time to charge as their batteries are smaller.

3.6.2. Why does standard charging take this long?

Charging a battery is not the same process as replacing fuel in a tank. Current battery technology means that it takes longer to charge an EV than it would to refuel a conventional car with petrol or diesel. However, if you have access to off-street parking at home, the process of charging is potentially very simple. You just plug in your EV when you get home and leave it to charge.

3.7. Batteries

3.7.1. How long will the battery last in my EV?

Battery manufacturers usually consider the end of life for a battery to be when its capacity drops to 80% of its rated capacity. This means that if your original battery has a range of 100 miles on a full charge, after eight to 10 years (depending on how much the vehicle has been driven) this may have reduced to 80 miles. However, batteries can still deliver usable power below 80% charge capacity, although this will produce shorter range. Whether you want to exchange it at that stage for a newer battery will partly depend on your driving habits. A number of vehicle manufacturers have designed the battery to last the lifetime of the car.

3.7.2. What is the cost of a replacement battery?

That depends on the size and type of the battery, which are determined partly by the vehicle. Batteries are relatively expensive at the moment but it is likely that prices will come down, as technology improves and volumes increase.

3.8. Servicing, repair and breakdown

3.8.1. Where will I be able to get an EV repaired or serviced?

Manufacturers will ensure that service technicians are provided with detailed service instructions and training, just as they do for ICE vehicles. In addition, industry training programs are being developed to ensure dealers, technicians, manufacturing staff, emergency services and breakdown assistance staff can become qualified to handle EVs.

3.8.2. What will it cost to service a Pure-EV?

There are fewer moving parts in a Pure-EV, which should reduce servicing costs and downtime. When the Pure-EV does require servicing it will be similar to an ICE service. Although the power train is different, many of the service actions for Pure-EVs are similar to ICEs.

3.8.3. What warranty can I expect?

The warranty of an EV will be in line with current warranties on ICE vehicles. All manufacturers who utilize the Plug-In Car Grant must offer a minimum three year battery warranty on the car as standard, as well as an option for the consumer to purchase a further two year warranty extension.

3.8.4. Do EVs work in cold weather?

Yes. As with any newly developed vehicle, manufacturers have carried out extensive testing in extreme weather conditions. In addition, there have been a number of 'real life' trials of EVs since 2009. During February 2010 everyday users drove their EVs in the worst winter weather conditions for 30 years. The range of EVs may be affected by cold weather; the use of heating and other items is likely to increase the load on the vehicle system and reduce the range, particularly of pure-EVs, in cold weather. Control systems can be used in EVs to minimize the amount of

energy used by additional items, such as air conditioning and heating. Finally, it is worth knowing that EVs don't need a warm up period like many conventional ICE vehicles in the winter.

4. The selection of the car

In this section we will choose the car that we will make the improvements on. From the previous section we knew that the selection would be a hybrid-car as it allows us too much of the development. From the hybrid cars we picked up the ultra-commuter that drives us into the next question "Why the ultra-commuter?" but before that we have to be introduced to "what is the ultra-commuter?"

4.1. What is the ultra-commuter

Ultra-Commuter is a hybrid electric concept car first designed by the University of Queensland Sustainable Energy Group and unveiled in 2005. In 2007 the project was transferred to the Waikato University School of Engineering and further developed in conjunction with Hybrid Auto Pty. The Ultra-Commuter project commenced in 2000 out of the University of Queensland's award winning solar car project, the Sun Shark. Dr Geoff Walker said the aim was to make a car that people could register and drive from the knowledge gained making the Sun Shark. The car body toured Queensland in 2005 and 2006 as part of RACQ's road show on the history of Queensland motoring called Bull dust to Bitumen and Beyond. In 2007 Matthew Greaves, Ben Guymmer, and Bernie Walsh who started the Ultra-Commuter project formed Hybrid Auto and passed development on to a Waikato University School of Engineering team lead by Dr Mike Duke. The Ultra-Commuter was described as a long range two seated electric vehicle. It ran on either a single 150 kg lithium battery pack which gave it a range of about 200 km. With two battery packs installed the range is doubled to 400 km. The car could attain speeds of between 120kmh and 170kmh. The cars aluminum honeycomb chassis was about one third the weight of a similar sized production car, and two engines are situated in the rear wheels. Hybrid Auto (now Ultramotive Technologies) and Page MacRae, a Mount Maunganui engineering firm, funded the initial development cost of about NZ\$150,000, with the intention of making it road legal as a research tool for investigating introducing battery electric cars into New Zealand. Ultramotive provided the electric motors. In 2007 Dr Duke of Waikato University stated that it would take at least 18 months and cost at least \$10 million to market and produce between 100 and 2000 electric cars a year. Development work continued at Waikato University with another solar powered car being certified as roadworthy in 2011. This second car was driven from Auckland to Bluff between 24 November and 6 December 2011. They were joined on the journey by Bochum University's solar round the world car.

The University of Queensland Ultra-Commuter project is the demonstration of an ultra-light weight, low drag, energy efficient and low polluting, electric commuter vehicle equipped with a 2.2 m² onboard solar array. A key goal of the project is to make the vehicle predominantly self-sufficient from solar power for normal driving purposes, so that it does not require charging or refueling from off board sources. This paper examines the technical feasibility of the solar-powered commuter vehicle concept, as it applies the Ultra-Commuter project. A parametric description of a solar-powered commuter vehicle is presented. Real solar insolation data is then used to predict the solar driving range for the Ultra-Commuter and this is compared to typical urban usage patterns for commuter vehicles in Queensland. A comparative analysis of annual greenhouse gas emissions from the vehicle is also presented. The results show that the Ultra-Commuter's on-board solar array can provide substantial supplementation of the energy required for normal driving, powering 87% of annual travel needs for an average Queensland passenger vehicle. The vehicle also has excellent potential to reduce annual greenhouse gas emissions from the private transport sector, achieving a 97% reduction in CO₂ emissions when compared to the average Queensland passenger vehicle. Lastly, the vehicle battery pack provides for tolerance to consecutive days of poor weather without resorting to grid charging, giving uninterrupted functionality to the user. These results hold great promise for the technical feasibility of the solar-powered commuter vehicle concept and the Ultra-Commuter project.

4.2. Why the ultra-commuter

The ultra –commuter would be selected because of the following:

- 1- Based on academic search so information could be collected easily
- 2- One of the best results in drag force tests
- 3- Big space for improvements
- 4- Looks good and can fill the market needs
- 5- The cost is reasonable as from the study it's price could be under 20,000\$

4.3. What are the technical specifications of the ultra-commuter

As shown in Figure 3 these are the way the car looks like.

The specifications of the car are:

- 1- 2 doors 2 seat coupe car
- 2- Body: fiber composite panel
- 3- Chassis: hydro formed/bonded aluminum
- 4- Size L/W/H: 3800/1600/1300 mm
- 5- Mass: 640 Kg
- 6- Layout: rear wheel drive
- 7- Motors: 2*75Kw 1500 r.p.m 500 N.m. each
- 8- Transmission: none
- 9- Power source: Battery & solar cells
- 10- Batteries: Li-ion 75 kg 60 kW peak power
- 11- Solar panel: roof mounted 2.2 m² 12% efficiency
- 12- Internal combustion engine: 800 cc motor
- 13- Gear box: 4 gears gear box
- 14- Fuel storage: 36 liter of fuel
- 15- Tires: 175/55 R17 low rolling resistance
- 16- Braking: regenerative and emergency disc break
- 17- Acceleration time from 0 to 60 Km/h: 8 seconds
- 18- Top speed: 180 Km/h
- 19- Maximum pure electric drive: 170 Km
- 20- Solar only: 50 Km per day (depends also on the conditions)
- 21- Maximum range with the usage of the internal combustion engine: 500 Km
- 22- Steering: rack and pinion
- 23- Suspension: wishbone

5. Improvements Ideas

The ultra-commuter uses 2.7L of gas every 100 Km as it was mentioned in the introduction we are looking for decreasing this 2.7L or even canceling it depending on renewable energy.

In this section we will show some of the ideas that might help us to do so. These ideas will be followed by calculations to make sure that these improvements are applicable and will compensate the usage of the fuel

1. Better solar cells efficiency
2. Enlarging the power bank
3. Lowing the speed (using less power consumption motors)
4. Using the wind energy
5. Lighter weight
6. Using the surrounding environment (Piezo material)
7. Expected problem

Figure 3. Ultra commuter model in the reality and in Solid-works® model

5.1. Better Solar cells efficiency

As it was mentioned in section 3 the ultra-commuter has 2.2 m² solar cells surface array with efficiency of 12.6%. Using a better solar cells might make the efficiency go up to 15.6%.

5.1.1. The type of the new solar cells

We would recommend using the mono-crystalline as it's:

1- Mono-crystalline solar panels have the highest efficiency rates since they are made out of the highest-grade silicon.

2- Mono-crystalline silicon solar panels are space-efficient. Since these solar panels yield the highest power outputs, they also require the least amount of compared to any other types. Mono-crystalline solar panels produce up to four times the amount of electricity as thin-film solar panels.

3- Mono-crystalline solar panels live the longest. Most solar panel manufacturers put a 25-year warranty on their mono-crystalline solar panels.

4- Tend to perform better than similarly rated polycrystalline solar panels at low-light conditions.

5.1.2. Maintenance

The way to raise the efficiency of the solar cell is to keep it clean and in a good position. Here in our application we can add to the scheduled maintenance (daily) that the vehicle owner should keep the array clean. One of the best solutions also is to add sun tracking system so the array is always positioned in the best position facing the sun. The good maintenance can always keep the array efficiency and in sometimes helping the solar cells to have better efficiency even if the maintenance is simple it has a big impact.

5.1.3. Egypt conditions

Allah has given Egypt very good resources and one of them is the Sun. The ultra-commuter was launched already in Europe. All of the calculations are calculated according to the conditions over there the difference in the solar radiation would make a great impact on the usage of the fuel.

5.2. Enlarging the battery bank

The ultra-commuter already has a good battery bank but erasing the fuel storage and the internal combustion engine would make us able to enlarge the battery bank. The ultra-commuter is already using 75 Kg of batteries li-ion 100 cells. We would recommend use the weight that is erased to add new batteries that might help to extend the range. The calculation section might make us have a better view.

5.3. Lowing the power consumption

The ultra-commuter uses 2 motors each motor is 75Kw as it was mentioned before. The ultra-commuter has some specifications that might not be needed as a car moving in

Cairo. The car has too much torque and can do very high speed which something good but not needed. Something was noticeable also there is no transmission the car. There is no gear box as the motors are powerful enough to move the light-weighted car. In the next section we will calculate if we can use another motor hat consumes less power.

5.4. Using wind energy

One of the most important factors that might be an obstacle while designing a car is the air resistance. Using the wind in our favor might be a good point as it might help generating the needed power. The aerodynamics of the car might help by providing some cavities that we can add wind turbines to generate some electrical power

5.5. Lighter weight

The weight is a very important factor the mass of the car is around 600 Kg (more details is provided at section 3) so while choosing the best improvement option the weight factor might be considered as one of the important factors also erasing all the unnecessary weight might make it easier to move the car and to consume less power. The weight might be saved by erasing 120 Kg of the internal combustion engine and about 36 liter of the fuel. Detailed calculations will be provided in the next section

5.6. Using the surroundings

One of the ideas was using the surrounding environment like the Piezo material or putting some solar cells in the back lights to get use of the other cars lights. The Piezo material might be also placed under the seat or under the gas pedal that might provide some electrical power. It was considered very little power but we thought about it. More details will be provided in the next section.

5.7. Expected problems

5.7.1. Stability of the car

The improvements should be equally distributed in the body of the car as the stability of the car might be affected.

5.7.2. Aerodynamics

Some of the suggested improvements require adding some movable parts like moving the array to track the sun.

5.7.3. Safety of the car

Some of the improvements might affect the safety of the car like the weight of the car. The safety of the car might be considered.

5.7.4. Solutions

Strict calculations should be provided also simulation of the improvements should be available. We used

Solid-works® software for the aerodynamics calculations, stability and the weight. We used fluent® software for the calculations of the solar cells.

6. Validity and simulations

This section is named validity and simulation because of this section is about making sure that the improvements are valid and applicable also the simulation is very important to us. It's known to us that the car is already using 2.7L of fuel every 100 Km and all of the calculations are made at average speed 50 Km/h without repetitive stops. In this section we will not calculate all the power consumption we will just calculate the power that compensate the 2.7 L of fuel.

6.1. The mass of the car

The ultra-commuter weights already 640 Kg

So

$Mass\ of\ the\ car = m_{total} = 640\ Kg$

$Mass\ of\ internal\ combustion\ engine = m_{I.C.E.}$
 $= 130\ Kg$

The fuel storage is 36 L

$Mass\ of\ fuel = \rho * v$

As ρ = Density of the fuel = 0.97 L/kg

& V = volume of fuel = 36 L

$Mass\ of\ fuel = 0.97 * 36 = 34.92\ Kg$

So

$Mass\ of\ the\ car\ after\ removal\ of\ the\ fuel\ system =$

$m_{new} = m_{total} - (m_{I.C.E.} + m_{fuel})$

$m_{new} = 640 - (130 + 34.92) = 640 - 164.92$
 $= 475.08\ Kg$

6.2. The motor

The ultra-commuter uses 2 Dc motors 75 Kw with torque 500 N.m. each and maximum revolution per minute 1500 r.p.m. each The ultra-commuter is capable of achieving 150 Km/h but the needed speed isn't 150 Km/h we just need to go average speed at 50 km/h we would recommend changing the motor. So we need to have a new motor that can provide the same torque. We might sacrifice the revolution per minute which means technically the maximum speed that the car can achieve as we are designing the car to be economical

not for sport usages.

6.2.1. The new motor selection specifications are

- Power: 50Kw - Maximum r.p.m.: 1000 r.p.m. - Torque: 500 N.m.

- Power consumption at 50 Km/h: 35 Kw (Drag force is considered)

We might also use the same theory of the gas cars (one motor to move the two wheels) we can reduce the power and the weight which will save a lot but re-designing the car might require changing the shape of the car to erase the cavity of the two motors and have one cavity for one motor.

That would change the shape of aerodynamics which is something away from our scope of research. So reducing the motors Kw to 50 Kw with the same torque and less r.p.m. would do the job. The calculations for the power saved. The two motors consume around 60 Kw at average speed. So the motor 50 Kw might need about 35 Kw at the same average speed

Power saved = Consumption of 75 Kw motor
 - Consumption of 50 Kw

Power saved = 50 - 35 = 15KwBut

We would need to recalculate the mass of the car as we removed an electric motor

So the new mass is

$m_{new\ final} = m_{n1} - m_{motor}$

As $m_{motor} = m_{old\ motor} - m_{new\ motor} = 4\ Kg$

This is negligible amount so we will remain the mass at its old value.

6.3. The power needed

Now we would calculate the power needed .The motor 50 Kw motor generates maximum r.p.m. of 1200 r.p.m. if the motor runs at lower revolution per minute it would consume 20 Kw per hour. All of the calculations were made assuming that the car moves at 50 Km/h . The distance we need to compensate the power used in it is 100 Km which makes the time two hours

$Power\ needed = 2 * Consumption\ of\ one\ hour = 2 * 20$
 $= 40Kw$

So we would need to have about 40 Kw→(1)

But we already saved 15 Kw

So the actual power need is

$Power\ needed = 40 - 15 = 25Kw→(2)$

Figure 4. solid-works® model before aerodynamics test

6.4. The solar cells

It was mentioned before that the usage of solar cells can be improved by several ways

6.4.1. Solar tracking

One of the ways to get higher efficiency of the solar cells is to track the sun the tracking. Simply the figure 3 shows it as the solar mechanism is responsible of moving the solar panel to face the arrays of the sun at a particular angel. It could be also defined as a solar tracker is a device that orients various payloads toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices. But since it's a moving car we need to make sure that it won't increase the resistance of the air to the car. Also that it won't affect the stability of the car. That would happen through the simulation.

Figure 5. Sun tracking mechanism

As it appears in the aerodynamics analysis the resistance at the top is very high so moving the panel would generate a massive resistance to the car even if it would increase the efficiency but it would require a way more power to move the car. The draw was made by solid-works® software.

6.4.2. Egypt Conditions & The efficiency of the solar cells

The car is designed primary to be in Europe & America but there are differences between the radiation rate between Egypt (Africa) and Europe. In Egypt more solar radiation will be so it might make us save more energy but we should consider that when the car was under test it was only gaining solar energy there so we will calculate the energy generated here and the energy was generated there and the difference between the two values will make us now the saved power by running the car in Egypt and not in Europe. First of all we should know the solar radiation both in Egypt and in Europe.

By looking at the Egyptian solar radiation map we get that the solar radiation equals average of 6.7 Kwh/day/m².

$$P = I * A$$

As P is the power provided by the Solar cell

I is the solar radiation

A is the area of the panel

Let's name the power in Egypt Power Egypt
So

$$P_{Egypt} = I * A$$

$$P_{Egypt} = 6.7 * 2.2 = 14.74 \text{ Kwh per day}$$

The solar radiation in Europe and America is 4.5 Kwh/m²/day

So Power Europe is calculated as below

$$P_{Europe} = I * A = 4.5 * 2.2 = 9.9 \text{ Kwh per day}$$

So the Power saved by the solar energy is

$$P_{Solar \text{ Energy}} = P_{Egypt} - P_{Europe} = 14.74 - 9.9 = 4.84 \text{ Kwh per day}$$

The total power saved will be

$$P_{Solar \text{ Energy}} = 4.84 * \text{No. of hours} = 4.84 * 2 = 9.68 \text{ Kwh}$$

Those calculations neglected the efficiency of the solar cells. The efficiency of the solar cells that were used in the original car (without improvements) were around 13%. The type was polycrystalline solar cells. The recommended new type of the solar cells is the mono-crystalline the new efficiency would be 15.6% (Overall average efficiency). We would need to recalculate the Power without neglecting the efficiency of the solar cells.

$$P_{Egypt \text{ final}} = P_{Egypt} * \mu = 14.74 * \frac{15.6}{100} = 2.29944 \text{ Kwh per day}$$

$$P_{Europe \text{ final}} = P_{Europe} * \mu = 9.9 * \frac{13}{100} = 1.287 \text{ Kwh per day}$$

$$P_{Solar \text{ Final}} = P_{Egypt \text{ Final}} - P_{Europe \text{ Final}} = 2.29944 - 1.287 = 1.01244 \text{ Kwh per day}$$

$$P_{Solar \text{ Final}} = 1.01244 * \text{No. of hours} = 1.01244 * 2 = 2.02488 \text{ Kw per day}$$

$$2.02488 \text{ Kw per day} \rightarrow (3)$$

Figure 6. Aerodynamic test result

6.5. Wind energy

By reviewing the figure4 (the aerodynamics analysis) we got that the best spot to place the wind turbine is 1 & 2

6.5.1. Choosing the wind turbine

As we already have erased the internal combustion engine we have some space to add some weight but we are pretty limited due to the space that could be afforded by the design.

6.5.2. The aero dynamics analysis and how the drag power is affected

By reviewing solid-works® simulation we find that we have about 150 cm free space as it is shown in fig 5.5. We can put two standard wind-turbines each one of them can afford 1 Kwh per day. This wind-turbine has a safety lock that it would shut down if it exceeded a certain velocity also it won't start working only after minimum velocity (helping not to require more drag force to make the car achieve the same velocity). The solid-work® simulation showed us that adding the two objects (it wasn't defined as wind-turbine) in the cavity in the frontal and the back it would increase the Cd to make it 0.33. That would make us need 0.5 Kwh from the motor to retain the same velocity (It is also noticeable that the standard wind-turbine would generate 1 Kwh per day as it's the neat value) .That would make the calculations as below

$$P_{wind\ turbines} = 4 * 1 = 4Kwh\ per\ day$$

$$P_{motor} = 0.5\ Kwh$$

$$P_{wind} = P_{wind\ turbines} - P_{motor} = 4 - 0.5 = 3.5\ Kwh$$

$$P_{wind\ final} = P_{wind} * No.\ of\ hours = 3.5 * 2 = 7\ Kw \rightarrow (4)$$

6.6. The final calculations

By summing the equations we will get the following

By reviewing equation 2, 3 & 4

$$P_{solar\ final} + P_{wind\ final} = 2.02488 + 7 = 9.02488\ Kw$$

But we already have from equation 2

That the Power needed is

$$Power\ needed = 25\ Kw$$

$$Power\ needed\ (final)$$

$$= Power\ needed - P_{solar\ final}$$

$$- P_{wind\ final}$$

$$Power\ needed\ (final) = 25 - 9.02488 = 15.97512\ Kw$$

To overcome the shortage of the power we would need some charged batteries to help us extend the range of the running Kilo meters. But we already saved a mass of 164.92 Kg of the car. The battery bank already weights 75 Kg

providing 180 Km range (Regeneration mood is considered in these calculations). If we can add another battery bank that might weight another 75 Kg so the final weight of the car might be as below

$$m_{car\ (final)} = 475.08 + 75 = 550.08\ Kg.$$

This is still below the original mass of the car. The new battery pack will provide peak power of 60 Kw but it still needs to be recharged before taking off.

6.7. Final saying

From mathematical calculation and simulation software we can say that the reliability of our calculations is about 40%, most of our results were taken at intermediate conditions. Facing a cloudy day or a day without any wind would make a great problem for the car driver. That's pretty obvious that the conditions can affect deeply on any renewable power resource. That might lead us to three solutions we might have the ability to do some comparisons between them.

1- Keeping the I.C.E.

2- Replacing the I.C.E. with generator

3- Add more battery pack and provide recharging stations

6.7.1. Keeping the I.C.E.

No matter what happens an internal combustion engine with volume of 800 cc will never be a bad choice. It has some advantages:

- Very high reliability
- Average noise level
- Not very high fixed cost

6.7.2 Replacing the I.C.E. with generator

If we have some electric motors what about using a generator to generate power to the electric motors. By consulting some electrical engineers and according to the free mass we have. We can have a generator with peak power of 70Kw that can provide 30Kw with only 0.8L of fuel. The advantages:

- Good reliability
- Low emissions
- Low running cost

6.7.3 Add more battery bank and provide recharging stations

The parking lot might make us able to use the solar power by both providing cool place to park the car and to generate electrical power that might recharge the car while parking it.

The advantages:

- Zero running cost
- No noise at all
- Totally green

Table 3. Comparison between I.C.E, Electrical generator and solar cell station

	I.C.E	Electrical generator	Solar cell stations
Reliability	Very High	Good	Low
Noise	Moderate	Moderate	Low
Green	No	Semi-green	100% green
Fixed cost	Low	Moderate	Very High
Running cost	High	Moderate	Zero
Performance	Very High	Low	Very Low

From the comparison above we can see that we can't get everything but we have to prioritize the things we need and according to our purpose of this research we need to get:

- 1- Renewable & Green source of energy
- 2- Good Reliability
- 3- Not very high cost

So, that drives us to select the second choice which might provide Green source of energy and also renewable.

Figure 7. Relation between Original Working theory and the new modification

7. Conclusions

- We can lose some speed and performance in order to keep our environment.
- Semi-green car can give us the benefit of green energy with a Moderate running.
- Third World countries should work to get the benefits from its natural resources in order to improve its economy.
- Renewable energy will not run out ever. Other sources of energy are finite and will someday be depleted.

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