CREATETHEFUTURE
ELECTRIC MOBILITY

presenting AMPLIFIED WALKING.

Final report for “Create the Future”, November 2010

CREATETHEFUTURE
ELECTRIC MOBILITY

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Table of contents

1 Introduction

Since the time of the industrial revolution, motorized mobility has been a major aspect of people's lives. The internal combustion engine has had a huge impact on society; determining lay-outs of cities, eating habits of people, people's livelihood, it is even contributed to one of the major causes of death. While the internal combustion engine has lived a very influential life, diagnoses do not guarantee its illustrious position in the future. With fossil fuels slowly being depleted, alternatives for the internal combustion engine are being fervently sought after.

A technology, just as old as the internal combustion engine, may prove to be the successor: the electric motor. The role electric mobility will play in the not so distant future of 2030 is a question many researchers wish they could answer. Since electric mobility could take over the role once held by the internal combustion engine, a clear look into this future is essential for helping shape the society of the future.

2 Trend analysis

An extensive trend analysis can be found in the appendix under chapter 14. The following is a summary of the findings.

The need for mobility will have changed quite a bit by 2030 - a change in family composition and population spread will be the driving factor behind this. There will be more vehicles per household and there will be an increase in average mileage.

Government incentives and regulations regarding 'cleaner' vehicles, such as closing off city centers to polluting vehicles and subsidizing hybrid vehicles, will open doors for cleaner and smaller vehicles in urban(ized) areas.

All this will be made possible through a steady development of technology related to electric mobility: batteries will become cheaper, smaller and have a higher power density per volume, electro motors become cheaper and more efficient, and energy will be used more efficiently and produced in a more sustainable manner.

Lastly, lifestyle also has an impact on electric mobility in the future. Environmental awareness becomes more and more important and showing off your environmental awareness to others is perceived as a status symbol. Having relatively higher incomes gives people that extra bit of spending power, allowing them to make choices that benefit more than just themselves.

All these factors point towards an increase of electric mobility in our near future, most likely in urban(ized) areas in the form of small(er) electric vehicles.

3 Delphi studies

The entire Delphi study can be found in the appendix under chapter 16. The following is a summary of the findings.

We used the Delphi studies to compare our results with the trend analysis. From the trend analysis we saw that there will be more vehicles per person, yet not a large increase in mileage. The Delphi study results predict the same due to better integrated daily activities, such as living, work and leisure.

The government will regulate a cleaner environment by law. Not only by introducing tax based on CO2 emissions, but also by regulating recycling and disposal for the manufacturer. Thus there will be more government influence for a greener environment.

The price of electricity storage will decrease as we can see in both the Delphi studies and the trend analysis. The Delphi results are a lot more optimistic about the use of alternative energy sources than we saw in the trend analysis.

A green lifestyle is in accordance with the Delphi studies already a management standard.

The Delphi studies validate most of our trends. Our assumption, that there will be more electric cars in the urban areas in the near future, is therefore a feasible one.

4 Scenarios

4.1 Focal Issue

In order to create a concrete future scenario, a focal issue must first be assigned. Pertaining to electric mobility, the most logical sector in which to focus is traffic and transport. Once a sector has been found, the most important people or organizations relating to that sector must be identified, known as the actors. (An extensive list is found in chapter 4.2.) The actor on which will be focused here is the electric mobile apparatus manufacturers. With this actor in mind, the key focal issue is to create more electric personal mobility. Seeing as infrastructure and means of transport are present for travelling long distances (trains on railway tracks, automobiles on highways) and electric vehicles are more suited for shorter distances of travel, personal electric mobility should focus on the short distances. Here a gap can be filled; vehicles designed to quickly travel long distances seem cumbersome and excessive in a busy city environment, which will only get busier according to trends. Small electric vehicles fit this environment much better. Also, trends point towards an increase in the banning of large polluting vehicles in city centers.

Personal electric mobility seems therefore a much more logical choice for an urban environment. With this in mind, the central focal issue can be stated: create more electric personal mobility for short distances in a city center.

The focal issue can be categorized in the following way:

- **Sector**
  Traffic and transport

- **Actors**
  Electric mobile apparatus manufacturers

- **Question**
  How can electric vehicle manufacturers bridge the gap between high speed travel (trains, highways) and multiple destinations in city centers?

4.2 Actors

From the trend analysis, actors involved in electric mobility could be pinpointed. There are many actors which play a role in creating more electric personal mobility. Not only the companies which make the apparatuses, but also the consumers themselves of course. (Supply and

demand) Also, the government will play a vital role; ultimately the decisions are in their hands. Further, the existing sector in this focal question; public transportation, will definitely have an influence on the development of this issue. In each of these groups, specific actors are given in the figure below:

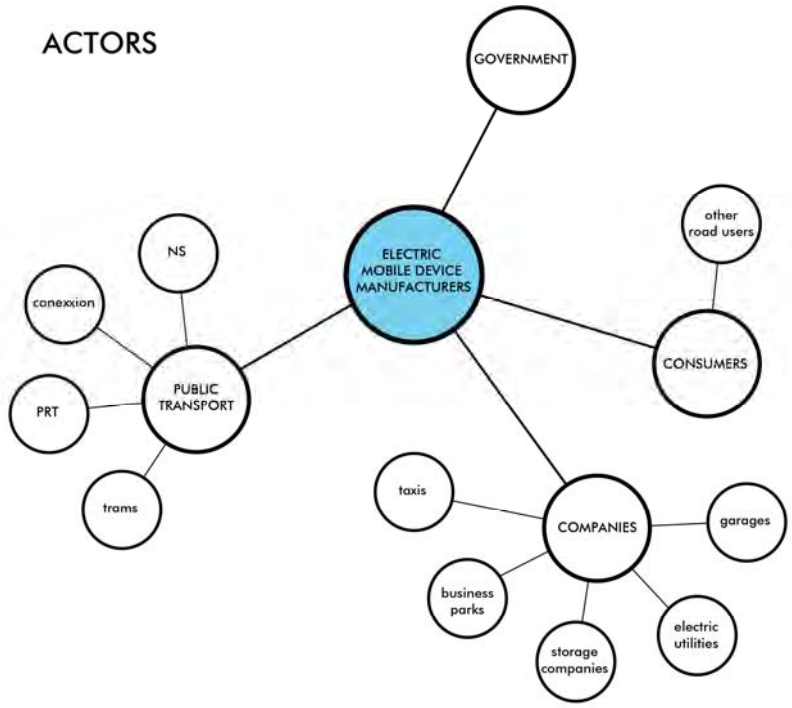


Figure 1: Actors

4.3 Factors

The trend analysis helped determine not only the actors involved in the development of this issue, but also certain factors that play a key role. The adoption and success of electric personal mobility depends on the infrastructure and technology available. Also, the rules and regulation enforced by the government can determine the development. But in the end, people themselves will have to make the choice to either participate or not. This is fully dependent on their lifestyle and whether electric mobility will fit in the equation. For each of these categories specific factors are given in the figure below.

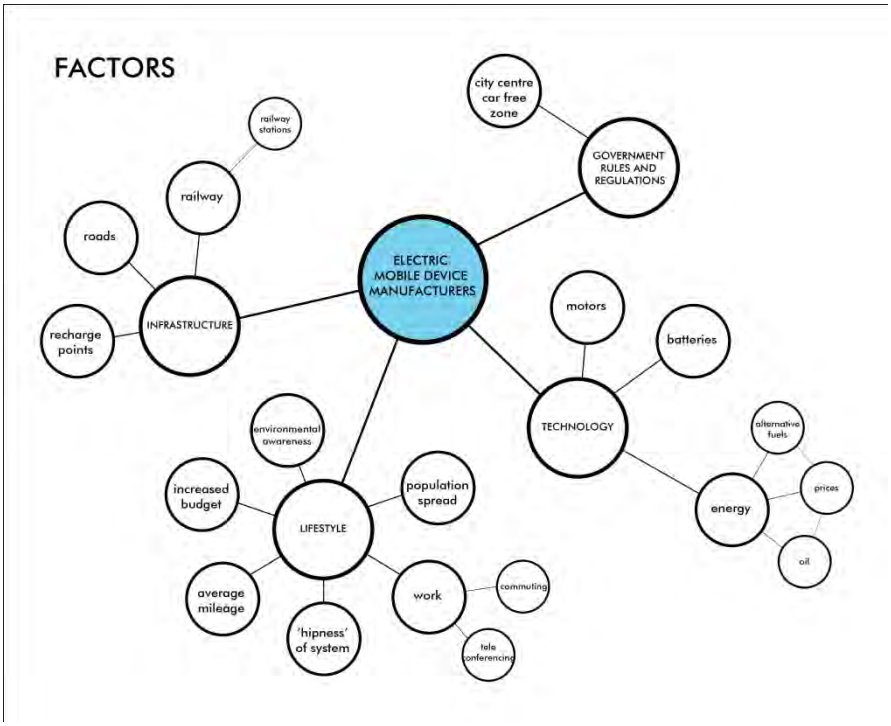


Figure 2: Factors

4.4 Uncertainty and importance matrix

From the trends identified in the appendix chapter 14 and trends pertaining to electric mobility from the “Trends and technology timeline”, a complete list was constructed. After filtering the most closely related trends relevant to electric mobility, a list of 28 trends resulted. The degree of importance each trend has for the future of electric mobility varied from one another. Also, the degree of certainty to which the specific trend will in reality come true differs. A matrix of uncertainty-importance is given in Figure 3.

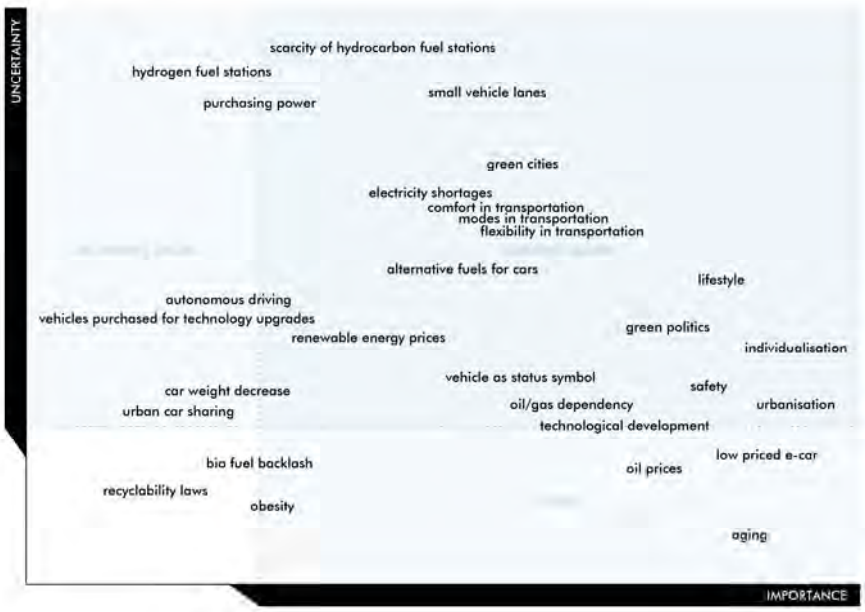


Figure 3: Uncertainty-importance matrix

In the following section an explanation of each term used in the uncertainty-importance matrix will be given.

4.4.1 Short explanation of the trends used U/I matrix.

Car weight decrease

With the current development of lightweight materials like composites the reduction of the weight of the car is reducing fast. This leads to more efficiency and a better performance of the car. Another benefit the car will become more fuel saving.

Vehicles bought for technology upgrades

The Western World exists out of a technology driven society. The need to progress to the next stage is necessary to stay in front of competition. Another key factor, the use of technology makes life easier for example reduce of travel time, less dependency of whether condition etcetera.

Small vehicle lanes

Too make travelling efficient within city borders the infrastructure like roads must be adapted to the growth of the city itself. The current trend of urbanization and individualization leads to more traffic within the city itself. With small vehicle lanes the traffic flow might be more efficient, faster and prevents traffic jams.

Scarcity of hydrocarbon service/fuel stations

The decrease in fuel leads to fewer suppliers and stations. The solution of E-mobility: With the use of power grids the supply of energy is endless, because the grid makes use of energy that elsewhere is unused. This

makes it possible to create charge places anywhere instead of the usual fuel stations.

Recyclability laws

Governments make more stringent requirements for the development of green energy and transport. In the future recyclability and green energy should be developed and supported by grants and legislation to keep progress of society.

Low priced e-car

In the current market there are not yet benefits too drive an electric car due the lack of distance and durability of the battery. But in the future fuel cars will disappear or will be more expensive too drive due the oil decrease/crisis. This will lead relatively cheaper E-cars. (in combination with the purchasing power)

Lifestyle

In the modern life the lifestyle is changing too multitasking. People want to work allot to increase their purchase power and on the other hand keep a social life. Also travelling stays important. Travelling and working might be a new opportunity to combine.

Green cities, Payments to enter most cities by private vehicles

Cities are tending to become and desire to be greener. Green not in the literal sense, but in policies for example removing heavy polluting vehicles from city centres, restricting the number of vehicles in city centres either by private payment or forbidding, using energy efficient means of transportation, in other words; freeing the city centre from smog and stimulating energy efficient activities. This has a direct effect on the type of vehicles allowed in city centres. Clean, electric mobility would fit by a green city.

Bio-fuel backlash

Bio-fuels are currently a method of avoiding refining oil, but rather growing crops to obtain fuel. In this way traditional vehicles can still be used. The problem here is that fact that land used to grow food crops is being replaced to grow fuel crops. It can therefore be expected that this might stimulate food scarcity and thus be a negative backlash and only create another problem. With bio-fuels a problem, electric mobility would gain even more ground.

Electricity shortages

With the population increasing and the demand for electricity also increasing, it is possible that the electricity utilities will not be able to meet the demand, electricity shortages being the result. This obviously would have a negative effect on electric mobility since re-charging the vehicles would sporadically not be possible.

80% of global energy requirements still met by oil/coal/gas

A possible future trend is that renewable sources of energy are not as successful or sought after as once thought. A change in global warming politics or new means of obtaining/using oil, gas or coal could all lead to the situation where the majority of the global energy requirements are still met by oil/coal/gas. Electric mobility could be affected if combustion engines continued to operate, and to a lesser extent if the electricity was produced from oil/coal/gas.

Urban car sharing

The trend that multiple people would share a single vehicle in an urban setting could take off or fail in the future depending on costs related. If this trend were to take off, fewer electric vehicles would be necessary and traffic intensity could decrease. Other factors such as the electricity grid load could also benefit, while the amount of usage of a single vehicle might increase.

Urbanization

The urban areas are growing. There is a movement of people from the rural towards the urban areas. That and with the normal grow of inhabitants the cities will get bigger and more crowdie.

Green politics

The government tries to set up an eco friendly country. Setting up taxes for companies that produce a lot of pollution will reduce the harm of the environment. The government will also use a rewarding system. By an environmental friendly solution people don't have to pay taxes or have to pay less.

Purchasing power

The total amount of goods, or services, which can be purchased with a given amount of money. Do they have in the near future enough money to buy cars? Will it be in the same order as nowadays?

Renewable energy prices

Due to competition between renewable energy sources and decline of fossil fuel, the price of green energy will reduce.

Oil prices

The consumption of energy is growing every day. The world population is growing and people are using more energy. So there is a big need and a decreasing amount of oil resources. That will raise the price of Oil in the next years.

Technology developments

There is a development in the technological products. Newer and better technologies will bring new products and solutions. For the e-mobility market there will be batteries with a longer duration, smart electric systems to make driving safer, Use of strong lightweight materials. And there will be many other technical improvements to make the journey safer, faster and more comfortable.

All vehicles fitted with GPS (autonomous driving, tasks performed during travel)

Autonomous driving replaces the user as a necessary aspect in mobility, the vehicle would drive itself. Electric mobility would be affected as computer driven vehicles would operate more efficient and safer in traffic. Users would therefore be able to do many more activities while in traffic than before.

Hydrogen fuel stations

If hydrogen as a fuel for vehicles would become successful, hydrogen fuel stations would spring up everywhere. This could be in direct competition for electric mobility or result in a fusion between electric/hydrogen filling stations.

Individualization

In our current society personal needs are put ahead of that of the group. It is a trend that finds its origin in changing lifestyles, family composition, consumerism, etc. Individualization of a society has its effect on the way products and services are perceived by the user and is reflected in a higher quality and standard of said products and services. The consumer expects the product to meet their specific set of demands under all circumstances; mobility in all its facets is no different.

80% now obese

Obesity is a growing problem that affects the general population. Trends show that the average body mass index is increasing, which is a worrying statistic. Obesity is accompanied by all sorts of adverse effects on a person's health and well-being, but it also offers design challenges. The next generation of products needs to keep this trend into account in order to prevent problems with the product. A good current example of this is medical facilities such as ambulances or CAT scanners, both are products that are increasingly unable to cater to obese people. The mobility sector will most likely face similar issues in the near future.

Increased comfort in transportation

In line with the trend of individualisation of society, the consumer has higher demands of products and services they use. Transportation or mobility is also subject to this trend. For instance, cars are not just a method of transportation from point A to point B, it tries to do so in the

most comfortable way possible by integrating sound systems, heating/cooling, communicating systems, comfortable seating, etc. Luxury is always on the increase, a trend that does not show any signs of stopping.

Increased flexibility and modes of transportation

Mobility is often put on par with freedom, the freedom to move where and when one desires to. Over the years however, this desire has come with more requirements. For example: public transport is less appealing nowadays due to the lack of choice the consumer has in the exact starting point and destination as well as the route taken. With changing lifestyles and a changing society, old methods of mobility need to be reassessed and adjusted accordingly. The desires of the consumer are pivotal in this process.

Vehicle as status symbol

Cars have always been a status symbol, simply due to their high price and bad investment quality. Nowadays we do not just see this with cars anymore, but also with scooters or other methods of transportation (such as the segway or a bicycle created by a fashion brand). Status is also the reason why hybrid cars sales has taken off the way it did and why sales declined shortly after the crisis (as can be read in part two of the report). When developing a concept for transportation one should not overlook the importance of the status symbol factor.

Aging

The average life expectancy is increasing. People are reaching a higher age in better health. Combined with the change in family composition, namely the fact that the average number of kids per family is considerably lower than it was with the so called ’baby boom generation’, the population is greying. This means old people will make up a relatively bigger part of society and also participate more actively in society; something which also has an impact on their desire for mobility, especially considering the fact that older people have more to spend on average.

Safety

Safety is a big issue in transportation; the car for example has many safety measures to keep the driver and passengers from getting injured in case of an accident. Safety has also affected a basic feature of cars: their size. SUVs are considered to be very safe, but are clearly much larger than required to fulfill their purpose of transporting a person from point A to point B. Safety with any device that transports people is clearly paramount.

4.5 Strategic space

From the 28 terms used in the uncertainty-importance matrix, 20 of these terms fell in the category 'scenario issues', issues with a moderate to high degree of uncertainty and importance. These scenario issues will naturally form the basis of the scenarios later on in this chapter.

These scenario issues were:

- Urbanization
- Green politics
- Safety
- Lifestyle
- Individualization
- Technology development
- Oil/gas dependency
- Vehicle as status symbol
- Renewable energy prices
- Autonomous driving
- Vehicles purchased for technological upgrades
- Alternative fuels for cars
- Flexibility in transportation
- Modes of transportation
- Comfort in transportation
- Electricity shortages
- Green cities
- Small vehicle lanes
- Scarcity of hydrocarbon fuel stations
- Purchasing power

These scenario issues can be translated to a strategic space in which different scenario possibilities can be made. This strategic space is basically a summary of the driving forces behind these issues. The two driving forces consist of dominant actors and dominant topics. This strategic space is shown in Figure 4. The explanation of the driving forces will be given in the next section.

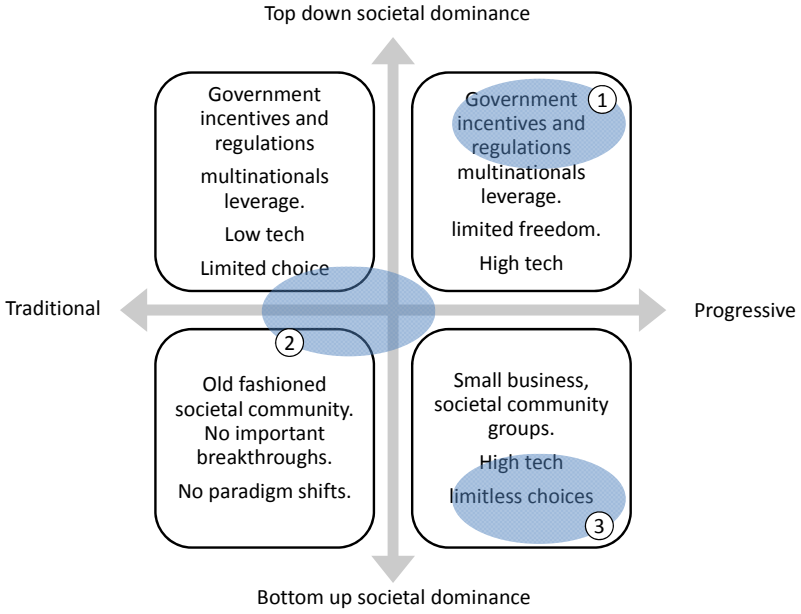


Figure 4: Strategic space

4.5.1 Explanation actors and factors

The dominant actor can be seen in two extremes; the top-down societal dominance being an actor with much power and influence controlling society and determining choices for the lower orders in society and bottom-up societal dominance being a collection of independent grassroots movement communities controlling society. In top-down societal dominance the government and large corporations determine how things will work and basically how people live. People therefore have limited choices as the choices have already been made for them. On the other hand, bottom-up societal dominance can include small groups socially connected internally and externally where an emphasis is laid on a do-it-yourself mindset where anybody can be somebody. In this way, people have a wide range of choices and the freedom to choose whatever they see fit.

The dominant factor is divided in two different directions, namely progressive and traditional. In a traditional mindset people are less prone to advancement and satisfied with the current situation. Technological advancements occur very slowly and are adopted late. A progressive mindset is not satisfied with the current situation and constantly tries to improve on everything and is willing to make changes. Technological advancements occur much quicker in such an environment.

4.5.2 Pinpointing on the strategic space

Once the strategic space was sufficiently constructed, certain points on the strategic space could be pinpointed, forming different scenarios. The

choice of these points was not random. In order to achieve a divers mixture of scenarios, two extremes in the strategic space were pinpointed and one less extreme as a kind of control group.

This led to three different possible scenarios. The following sections will go into detail on each of these scenarios explaining what each scenario entails, give a graphical impression, and give an everyday example of this scenario in a story. In Figure 4, these three pinpoints are shown with the numbers pertaining to the scenario number.

4.6 Scenario 1: 1984

The next scenario is situated in the top right corner of the strategic space. Therefore the scenario is a future which is highly innovative and ruled by a top-down societal dominance. As a result, society is run by the government and large corporations while ‘the little man’ has little to no say. Choices are made from high up and laid on society by government incentives and regulations and large corporation influences. Being an innovative society, technology is very advanced and much is possible. Therefore the sky is the limit in possibilities sense, yet eventual choices are limited for the average person due to the top domination.

Inspired from the book *1984* by George Orwell in which a future advanced society is presented where the government or *big brother*, determines the everyday life of people, this scenario is fitfully named 1984. The scenario does differ from the book with respect to the negative image of the future the book creates. The scenario 1984 is an objective description of a possible scenario of the future.

4.6.1 Scenario issues

Taking into account all of the scenario issues and the result the driving forces create, several key points forming a description of the scenario are given below:

Urbanization

In *1984*, the trend urbanization will develop rapidly. More than 90% of all people will live in cities. Naturally this has a major effect on public transportation as more and more people will need to use its services. The traveled routes will become more focused on traveling within a city (island) and from one island to another. Regional public transportation will therefore become less important. Also, the infrastructure will need to be expanded and be able to handle more traffic as more users need to get from A to B. The government and large corporations will obviously need to make the investments, and are dominant thus will be able to accomplish this. All in all, public transportation will become quicker and easier with increased urbanization.

Green politics and cities

With an innovative and progressive view on green policy, the term green will become even more important in *1984*. This will lead to the total abandonment of exhaust producing cars in city centers. Electrically driven vehicles will be the only allowed source of transportation in cities due to efficiency and pollution laws.

Lifestyle and individualization

The trend urbanization will have a large impact on the lifestyle of people. As people reside more and more in urban areas, their way of getting around and access to work, entertainment, etc will become less something they themselves have to do on their own, but will be arranged for them through public transportation. In mobility sense, people will function far less as individuals and become dependent of a larger system for the masses.

Vehicle as status symbol

The consequence of the former key points is that a vehicle as a status symbol will be something of the past. Personal vehicles with the freedom to travel will be replaced with public transportation.

Safety

In *1984*, the safety of people remains a big issue. In mobility sense, the only way to guarantee the safety of people is to use autonomous driving. Instead of drivers, people will function as security guards in public transportation.

Autonomous driving

As stated earlier, autonomous driving is a logical solution to achieving a safe, efficient, large public transportation system. A strong government and large corporations run this system.

Vehicles purchased for technologic upgrades

This trend will not manifest itself as we know it today; people buying personal vehicles, but will be a key factor in the appreciation of the public transport. People are more likely to use a certain kind of transportation when technological advances increase the comfort, speed and flexibility of the pertaining vehicle. Therefore this will be a driving force in the development of public transportation.

Flexibility and modes of transportation

In *1984*, the majority of the transportation will be public while personal cars disappear. In that sense, flexibility of transportation will be less than currently. However, since an increase in volume and use of public transportation is present, it will be able to serve the needs of many more people quickly and efficiently. The current timetable for example will be much more extensive and waiting on public transportation will be rare.

Also, with a central public system, different modes will be offered to go to any place in the grid.

Comfort in transportation

The trend of people wanting more comfort during travel will continue to increase. Comfort will become a major design criterion when developing public transportation. Since it will need to suite everybody, certain concessions will have to be made.

Small vehicle lanes

As stated earlier, personal vehicles will not be present in city centers thus the trend small vehicles lanes will vanish.

Purchasing power

With ever more jobs becoming redundant and more people living in the same area, jobs will become much more competitive. This will have a negative effect on the purchasing power of individuals as dominant big companies have more workers to choose from and can therefore pay relatively less.

Renewable energy prices

As technology further develops in renewable energy, prices will continue to drop and be at an all time low in *1984*. Almost all of the electricity needed for homes and public transportation will originate from renewable energy production.

Oil/gas dependency

A consequence of the former key point is that people's oil/gas dependency will become obsolete. Vehicles will no longer run on oil products and gas will no longer be needed. Electricity from renewable energy supplies the energy demand in *1984*.

Alternative fuels

An addition to the last key point is the fact that alternative fuels will not survive as replacements for gasoline and diesel. Electricity has taken their place as they were a mere temporary solution between the situation in 2010 and the scenario *1984*.

Electricity shortages

Since electricity is the main power source, electricity shortages would create much havoc. However, the technological breakthroughs making electricity possible from renewable energy and the implementation of a smart grid make these shortages not possible.

Scarcity of hydrocarbon fuel stations

Obviously, hydrocarbon fuel station will be very scarce as hydrocarbon fuel has been replaced.

Technology development

In order for all of the above key point to become reality, technology will remain to develop at a high pace in *1984*, all thanks to the innovative mindset.

4.6.2 Graphical impression

In the figure below, a preview is given for the mood board pertaining to the scenario 1984. In the appendix chapter 16.1 a full screen image is given.

Figure 5: Moodboard 1984

4.6.3 Story

"Should I take the S-line or the B-line? In the S-line I can finish reviewing my report before work, but yeah, the B-line will get me there quicker. Hmmm…",

thought Henk as he lay in bed minutes before the alarm was to go off.

"On the other hand, in the M-line I can tele-conference with Adam about the big merger Tuesday. Actually, I think that…"

BLEEP! BLEEP! BLEEP!

Rang the alarm, interrupting Henk's thought process. As Henk got out of bed he turned off his old fashioned alarm clock, a subject of ridicule from Henk's friends with their fancy REM-pattern-indentifying alarm clocks. Stepping out of the 30 second anti-contaminant shower required by work to take every morning, Henk was fresh and ready to go. Not only did he do his duty for work, but the shower was also a good tax incentive. On the way out the door, after saying goodbye to his wife and kids, he quickly grabbed his breakfast that had been prepared for him once the shower

button was pushed. Only then did Henk realize that he still hadn't made a decision on which line he was going to take.

"Adam.",

said Henk aloud. … After finshed with his call to Adam, Henk made his way to the M-line. It was especially busy this morning. Granted, normally he also didn't have more than 10 centimeters shoulder room, but today was even more crowded than usual. A very common occurrence as basically everyone lived in huge cities nowadays. With the total emergence of renewable energy as *the* energy source, these busy cities *were* cleaner than years ago.

As he took his last step onto the platform from where his train would leave, the train buzzed away right before his eyes. Ah well, the next one was due in 2 minutes anyway. Henk subconsciously rubbed his arm as he waited; it was still sore after a replacement public transportation chip had been implanted after the last one became defect.

The train arrived exactly on time, and Henk stepped in. Once inside he made his way straight towards the tele-conference cells, happy that he could finally use this system again. Without a working chip, he was only allowed to take the A-line; a free line offered to everybody, which consequently meant that it was slow, stinky, uncomfortable and long waits on the platform were expected along with several layovers. Taking the M-line did mean that some funds would automatically be written from his bank account, not something he could do every day, but at least he could teleconference with Adam in peace as he traveled at 350 kilometers per hour towards work. Well pretty much in peace; every five minutes a security guard would check to see if everything was alright, a downfall to the extreme safety measures present nowadays.

After a comfortable train journey and tasty breakfast of bagels made from graseline (a newly invented grain which could grow almost anywhere and required no sunlight), Henk made his way from the train station towards the public electric walkways just outside. Henk took the left fast lane, whizzing past people in the right lane seeing as he was in a hurry. He wanted to be extra early today in order to impress his boss. The competition was fierce on the job market, so he concluded that every little bit should help him in keeping his job. Ever since the world population hit 10 billion, big multinational companies have had their pick of the litter when it came to finding employees. Thankfully, Henk has had the same job for several years now, but he always had to stay on his feet and be productive.

He stepped off the electric walkway at the exit where his work was located as he unclipped his safety tag from the system. Keeping in mind the image he wanted to convene to his boss, Henk decided that chewing gum wasn't professional. Seeing no trash can in sight he spit it out on the ground next to a tree. He should have known better since the new zero tolerance policy towards litter was introduced to not throw his gum away in that way. Sure enough, one of the many surveillance cameras hung in the metropolis

caught him in the act and he could expect a notice of the fine in his mailbox. Stepping through the sliding doors into the office, Henk sighed, preparing himself for another 10 hour work day… (10, if you don't count the hours Henk spends thinking about work)…

4.7 Scenario 2: Steady as she goes

Scenario one is situated in the middle of top down societal dominance and bottom up societal dominance on the traditional side.

In the current situation, the government has a major influence on the progress of green development. Stimulated by rules, incentives and regulations some progress is made. These small achievements will not solve the main issues and are low tech. The public has limited choice in electric mobility related products and the products that are available are limited due to the lack of innovative breakthroughs and the old-fashioned community. Progress is not a must; people accept things as they are.

Combustion vehicles remain an important mode of transportation, if not the most important mode. Development of electric vehicles goes slowly and is still not that attractive to manufacturers. Small groups are trying to speed up the process but are limited by rules and regulations set by the government.

4.7.1 Scenario issues

Urbanisation

The cities will continue to grow in size and population. The city centers are having trouble coping with the large influx of traffic. It is not just a practical problem: the exhaust fumes from the traffic affects the living circumstances in the cities in a very negative way.

Green politics

The awareness of going green can only truly be seen on a small and localized scale: some progressive municipalities and individuals make use of windmills and solar panels, but overall there is little progress on the area of sustainable energy.

Small communities are trying to change the current system but due to the lack of need to change only little progress is made.

Individualization

People form communities with like-minded people, while keeping their individual preferences and opinions. Consumers are allowed to make their own choices with regards to transportation and environmental awareness.

Lifestyle

People have more than one job; travel will become less important because of the internet and being able to work at home. Travelling individually is what most people prefer and the mobility sector has only recently started to try and cater to this need.

Safety

Safety is always an issue in travel and transport; making driving autonomous will make driving safer. The disadvantages and lack of control for the user renders this option not too popular amongst the general population. Only interested individuals and people without a driver's license are interested in such systems.

Scarcity of hydrocarbon fuel stations

Hydrocarbon fuel stations are still common in this scenario due to the continuing dependency on fossil fuels. Most cars are hybrids by now, thus overall the usage of fossil fuels has decreased slightly. Sadly production of fossil fuels has also drastically decreased due to nearing a depletion of natural resources, so there is no real benefit for the consumer – transport is just as expensive as it always has been.

Small vehicle lanes

The infrastructure is adapted to urban traffic in most places; public transport is assigned its own specific lanes. This does give public transport a slight edge over individual traffic, but often the systems are not able to handle the large streams of passengers which nullify most of the benefits of public transport.

Green cities

Regulations and rules are changed to ensure healthy living circumstances in some areas, for instance in some city centers no polluting traffic is allowed.

Electricity shortages

The capacity of the current electricity suppliers is decreasing; a solution could be a new nuclear plant or more wind and solar energy. The growth of the population and the increasing need for electric energy needs to be addressed, especially due to the depletion of natural resources such as oil.

Comfort in transportation

Most people still prefer to use their own transportation because it fits their needs and their individual preferences. With an individual lifestyle the preferences and trends will stay focused on individual aspects in transportation.

Modes in transportation

There are different means of transportation. Individual transportation and public transport still thrive side by side. Individual transportation still has

preference over public transport, mainly due to a lack of investments in the latter option. However, due to the growing crowdedness in traffic and increasing fuel prices people are often forced to make use of public transport.

Flexibility in transportation

Shared transportation is still in practice; carpooling is still practiced when people share a common destination, but it is still not very popular. The government could stimulate this, and force cooperation between public and individual transport. However, like with most changes the government hesitates to push through and the changes happen slowly and sporadically.

Alternative fuels for cars

To power your transport in the future due to the depletion of fossil fuels different means of power supply are needed. The trend leads to combinations of energy types; think of hybrid cars. This will gradually move on to fully electric powered vehicles.

Renewable energy prices

Green energy becomes cheaper and more commercially viable. The use of wind, solar and water power will eventually replace the current energy resources, driven by the depletion of fossil fuel sources. This situation is still some way off though, so while it is still possible the old ways continue.

Vehicle as status symbol

The car remains a status symbol; big fuel guzzling cars will be for the decadent only however. The average consumer owns a hybrid car. Hybrids are still status symbols in a similar fashion to how contemporary cars are status symbols.

Oil/gas dependency

Because the developments stimulated by the government are not progressing fast enough the public will greatly depend on oil based resources. It is expected that cars will become more efficient and eventually turn fully electric once there is no alternative anymore.

Technological development

There is some technological development but it is merely incremental. Small communities are trying to speed up green development but struggle to do so. The government is not stimulating progression to change the technology, the progression is there only because it is needed to keep the economy going.

4.7.2 Graphical impression

In the figure below, a preview is given for the mood board pertaining to the scenario *steady as she goes*. In the appendix chapter 16.2 a full screen image is given.

4.7.3 Story

On a typical drowsy autumn morning, Henk drives to work. Henk lives with his family in a suburban neighborhood and is a business consultant at a big office in the business park just at the edge of the city center. The commute is only 30 minutes if he is lucky enough not to get stuck in city traffic. Sometimes Henk makes use of public transport to cut down on fuel costs what with the high prices nowadays, but today he takes his partly hybrid Alfa 157.

When Henk arrives at the office he plugs in his car in the electric smart grid and leaves it to recharge. The costs are subtracted from his pay check at the end of each month. After entering the office Henk reads the paper and treats himself to a cup of coffee. In today´s newspaper an interesting article is published about electric mobility and what projects the government currently has in development. One of the long term projects is to make public transport within city centers more efficient, green and a closer fit to the individual needs of the public. But Henk has heard it all before, he knows it will take a long time before he will see any major changes. Perhaps his kids might see it become reality one day, but Henk will stick to his trusty hybrid for now. Henk folds up the paper and starts his work; he has a long day ahead of him.

After a long day of work Henk leaves the office and walks to his car. When opening the door Henk spots an oil leak. His car broke down and it will be impossible to get it repaired at this time in the evening, not that trusty after all. Henk is well annoyed; this is the last thing he needed today. The only alternative is to make use of public transport; unfortunately the nearest station is a 15 minute walk from the office, because the business park is a fair distance from the center. Luckily Henk is quite fit. Arriving at the station he notices the metro is delayed by 10minutes and it is pretty

crowded on the platform too. After a 1 hour trip Henk finally arrives at home. He hopes the government fixes the traffic issue within city centers soon; he cannot wait till the government finally initiates their promising electric mobility projects.

4.8 Scenario 3: Get on top

The scenario “get on top” is based on the right below area of the strategic space. The future in this scenario is high tech ruled by the people. Gatherings of grass roots come up with new innovative ideas. Due to the network structure of the society people can easily come in contact with each other. So ideas and technologies can emerge very fast. Sharing all information and helping each other will make the society an innovative and high tech one. The choices are endless because adjustments can be made easily. With the public knowledge everyone can get involved in the designing process. The design and development are done locally.

4.8.1 Scenario issues

Urbanization

In 20 years time, in the year 2030, the number of people in the world is still growing. The trend of migrating from the rural areas towards the city centers will continue as well. The cities will be more crowded and therefore its infrastructure as well. Traffic in the cities will be denser while the infrastructure will remain more or less the same. The infrastructure will be further extended but not sufficiently in order to fulfill the need of the commuter. Smaller and smarter vehicles will be the key to solving this problem.

Green politics and cities

People are becoming increasingly environmentally aware. Setting up local activities will emphasize this trend. In dialogue with local governments city centers will ban high emission cars. As the city becomes more densely populated it becomes paramount to keep living circumstances up to standards.

Lifestyle and individualization

There is a wide variety of lifestyles in 2030. People are more individualistically minded and want to express said individuality. This is revealed in a person´s lifestyle; the way they dress, their job, their online presence and their transport. Products are personalized as to cater to the specific needs of the user.

Multitasking will be a common factor in all lifestyles, as will be sharing experiences and thoughts with similar minded people through social networks.

Vehicle as status symbol

The vehicle will be a way to express one's individuality. It shows to others what kind of person you are, what your moral values are and what you believe in.

Safety

In the "Get on top" scenario, safety is your own responsibility. The government has established ground rules for safety and each vehicle has to meet certain safety criteria. Due to a growing number of manufacturers of electric vehicles a certificate system is introduced. The parts have to be approved individually and the assembled vehicle has to be approved as well.

Autonomous driving

The technology exists and is used for long distance traveling. For urban traffic, people will have to operate the vehicle themselves.

Vehicles purchased for technologic upgrades

In the "Get on top" scenario people are not only buying vehicles for technical upgrades but for esthetic upgrades as well. There is also the possibility to renew some parts of your vehicle, in which case you do not have to purchase a complete vehicle but you can enjoy the benefits of the upgrades.

Flexibility and modes of transportation

Public transport is still in use in 2030, but usage thereof has lightly decreased over the years: less than 5% of the traveled kilometers are by public transport. Most of the transport takes place by small electric vehicles produced by many different manufacturers. The knowledge to make these vehicles is shared on the internet or via social network sites. Due to the variety of manufacturers there is a lot of choice in small electric vehicles.

Comfort in transportation

Everyone can choose what they want in the "Get on top" scenario. If you want a luxurious vehicle with a lot of comfort then that is possible. If you like a sportive, active way of driving you can also fulfill your desire. For every taste and personality there is an option available.

Small vehicle lanes

Closing the inner cities for polluting vehicles comes creates opportunities for smaller electric vehicles. Adjusting the roads to electric vehicles is done slowly. When there is a need for road renewal or newly built roads the size of the lanes is adapted. Because of the variety of vehicles these changes will not be that big.

Purchasing power

Being an innovative country and having an economy based on information the purchasing power will not really differ compared to the purchasing power currently. The local economies will flourish and the influence of multinationals will decline.

Renewable energy prices

Most of the energy in 2030 will be sustainable green energy. Every household has its own energy collectors. Due to the leap in technology there have been substantial innovations that have led to better and more efficient energy collectors. Every household is self-sufficient and therefore costs are not an issue.

Oil/gas dependency

Oil and gas will not influence the energy market. The use of sustainable energy sources has rendered the dependency of oil and gas obsolete.

Alternative fuels

With improvements to batteries in combination with relatively cheap electricity the use of alternative fuels can be neglected.

Electricity shortages

There is no electricity shortage in 2030. Every household has its own smart grid that yields sufficient energy. Due to innovations on the energy market energy is widely available and relatively cheap.

Technology development

Because of an open sourced information network more people are involved with new innovations. Due to a more interdisciplinary approach the rate of these innovations increases as well.

4.8.2 Actors:

Car manufacturers

Multiple small companies are involved in the production of electric vehicles. The knowledge to make these vehicles is shared on the internet or via social network sites, making production of these components open sourced. The companies are housed in small shared workplaces, allowing them to share expensive machinery.

Companies

Companies are working together, (inter)locally based. Due to the shared information companies can come up with better solutions. As a result the manufactured parts are highly compatible.

Government

The government is decreasing their influence. More influence is given to local groups and activities. The solutions for societal problems are tailored to local issues. The local government tries to provide a solid basis for people and companies to develop their ideas.

Consumers

The consumer is more involved in the process of the designing. The sheer amount and variety of electric vehicle manufacturers creates a lot of choice for the consumer, allowing the consumer to create and combine to reflect their identity.

Public transport

Public transport is still in use in 2030, but usage thereof has lightly decreased over the years: less than 5% of the traveled kilometers are by public transport.

4.8.3 Factors

Infrastructure

The infrastructure is more or less the same. Trains are still using conventional rails. The extent of the road network has increased slightly.

Lifestyle

There is a wide variety of lifestyles in 2030. People are more individualistically minded and want to express said individuality. This is revealed in a person´s lifestyle; the way they dress, their job, their online presence and their transport.

Technology

Because of an open sourced information network more people are involved with new innovations. Due to a more interdisciplinary approach the rate of these innovations increases as well.

Government rules and regulations

People are becoming increasingly environmentally aware. Setting up local activities will emphasize this trend. In dialogue with local governments city centers will ban high emission cars. As the city becomes more densely populated it becomes paramount to keep living circumstances up to standards.

4.8.4 Graphical impression

In the figure below, a preview is given for the mood board pertaining to the scenario Get on top. In the appendix chapter 16.3 a full screen image is given.

Figure 6: Moodboard get on top

4.8.5 Story

With a yawn Henk wakes up. His wife next to him is already awake; the empty side of the bed tells him that she is already up and about. He quickly realizes that it must be later then he expected. Looking at the clock he freaks out: it is 10:23 already! Yesterday was a tough day at the office and a real late night to boot. The conference calls he had to make yesterday evening took longer than anticipated and kept him from going to bed. It is also the reason that he does not have to be at his work already. Every day he tries to work for 8 hours, but events like yesterday are compensated with a morning off.

He gets his mobile device and sends a message to his friend Mark. It has been a while since he has been to the gym and he asked if they can meet in the gym that morning. There is also a message from his wife. She says she has already gone to her work and that the kids are at school. His device vibrates again, Mark answered that he can be there at 11. Henk looks at the time on his device and realizes he has to hurry. He grabs his trousers and pants, dresses up and walk downstairs.

He gets a breakfast drink from the fridge and in three big gulps he empties the bottle. He puts on his sneakers and grabs his jacket on the way to the front door. In front of his house his ride awaits him. It is a Schneider based vehicle modified by Gere. He purchased it six months ago and has not regretted it since. He really loves to ride on this vehicle. At the office he can talk for hours on end with Brent who also has a Schneider based one, but Brent has done most of the manufacturing himself. The result is magnificent but it is not as good as the one Henk owns: you can really tell the craftsmanship of someone like Gere. People often tell him that the vehicle fits his personality, and he only can agree. With a full battery he gets on the road. The gym is not that far away but he has to speed up, otherwise Mark will be waiting. The way to the gym has been renovated five years ago but is still crowded, even at this time of day. Most

companies implemented flexible work days and hours, to avoid peak traffic.

Mark is already waiting outside the gym and parked his ride on a hot spot were the battery will be charged. Because of the full battery Henk will park his ride on a regular spot. Mark has a quite stunning ride, he is head of a telecommunications company and the look of his vehicle shows that business is going well. Together they enter the gym for their work out.

Henk wants to work the rest of the day and goes straight from the gym to his office. Taking his own vehicle gives him the freedom to go when and wherever he wants. And with the smaller electric vehicles there is more capacity on the road than before.

Putting his hand up to greet Mark, Henk steers his vehicle to the main road. Off to the office, there is a lot of work to do…

5 Chosen scenario

From the three presented scenarios in the previous chapter, one scenario was chosen in which a product would be developed. The trend analysis and Delphi studies were important factors in the decision in which scenario to design. Eventually a choice was made for the scenario: Get on top. In this chapter, the most important factors which contributed to this choice will be given.

5.1 Individualism

An important trend which was identified was the fact that society is becoming more and more individualistic. People do not want to simply blend into the masses, but want to make their own statement. They have their own needs and consider different aspects of vehicles more important than others. This fits perfectly in a scenario which is based on grassroots movements.

5.2 Small companies

With an individualistic society, people will take things into their own hands and not depend on a few large corporations to develop products to suit their preferences. (This would also be quite impossible) Companies will spring up tailoring the needs of a select few. Therefore the amount of companies will be numerous yet small. Again, a perfect fit for this scenario.

5.3 Open source knowledge

The emergence of open source knowledge such as seen in android based programs currently, will play an important factor in the future. This prediction is another reason why this scenario was a logical choice. Not only that every individual here is important, but also the fact that only a progressive culture would allow this.

5.4 Small communities

With the individualistic flavor this society has and the emergence of open source knowledge, small communities will naturally evolve. People with similar tastes will form small communities where experience and knowledge can be shared. Again, typical grassroots movements with a highly progressive culture.

6 Concept directions

In the previous chapter the choice was made to develop a product that fits the scenario *Get on top*. Based on the trends, ideas were generated that would fit the scenario and address the focal issue. See Figure 7 for an overview of the ideas generated.

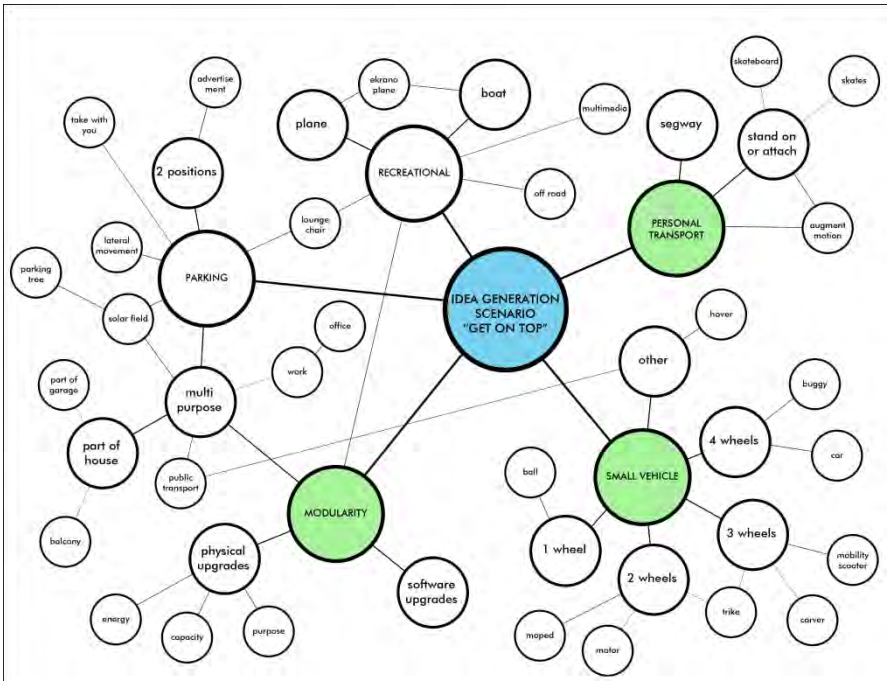


Figure 7: Idea generation

These ideas can be grouped in three different concept possibilities; based on a modularity, personal transport, and small vehicle principle.

6.1 Concept possibilities

6.1.1 Modularity

The modular principle is based on creating a vehicle out of several types of components. The idea behind the concept is that one vehicle is able to fulfill multiple kinds of travel related needs.

An example of this would be: a user is travelling between different cities with the city center as destination. In order to reach their destination they would not be able to take the entire vehicle with them: large vehicles are banned from the center. A solution would be to break off a part of the main vehicle and use that as small lower speed vehicle to reach the city center. The entire vehicle is created from modular parts, basically a platform with detachable parts.

The modularity allows the user to create different kinds of configurations to cater to their specific needs. The consumer is able to choose out of standardized components to create a unique personalized vehicle.

6.1.2 Personal transport

The personal transport idea focuses on individual travel for short range distances. The concept is portable to allow the user to carry it when

travelling on public transport or when entering buildings. This kind of travel is offering a solution to fill the gap between public transport and high-speed travel and is focused on short distances.

6.1.3 Small individual vehicles

The small individual vehicles idea aims to transport people efficiently. The vehicle is able to change its shape depending on its purpose at the time, e.g. the vehicle is more compact when parked to save space and more elongated when moving fast to reduce drag. It is also possible to link up vehicles together to conserve energy, for instance on the highway. Complete autonomous control is compatible with this idea.

6.2 Concept Directions

After investigating the possibilities as shown above, two main directions were concluded. These two directions derived from the three main concept possibilities, keeping the most important trends and focal issue in mind. The focus of this project is to fill in the transportation gap between fast transport and locations in the city center. The concept ideas modularity (also known as building blocks) and amplified walking can both fulfill this focus. A detailed description of what these directions entail is given below.

6.2.1 Amplified walking

This concept direction focuses on the great amount of mobility that can be achieved with this device. It has to be portable so people can take the mobile apparatus along with them while using public transportation or taking the car, and after the journey continue on the small personal transporter.

After multiple brainstorm sessions the idea was born to make use of the movement of the user. By amplifying his movement the user can propel his own vehicle. This amplified walking will go faster than walking and longer distances can therefore be overcome more easily. It will work on a relatively low speed and is for short distances.

This concept direction bridges the gap between fast transport and locations within the city center. An important issue of the get on top scenario is the existence of different lifestyles. There are possibilities to adopt lifestyle elements in this concept. For example a skier or a Nordic walker use the same sort of equipment while their lifestyle is completely different.

6.2.2 Building Blocks

This direction exists out of a modular structure. The vehicle will exist of different technical modules that together will form the vehicle. The blocks that consist of motors, wheels, frames, suspension kits, can be put together to create a personalized vehicle. Doing so will create a whole range of different kinds of vehicles. People can create robust, heavy duty vehicles or light-weight sports cars. The building blocks are sold by small companies and there will be a wide range of product components. There is always the option to integrate personalized components that made the vehicle exactly fit the need of the owner.

This concept direction focuses on the individualistic issue from the get on top scenario. The benefits for the customer are a total freedom to design and create his own vehicle. With the help of the communities and grassroots movements, most of the creating and designing can be done by the owner itself. Creating the vehicle by the user allows the user to build it up to their own requirements, and can let the mobile apparatus fit his identity.

7 Chosen: Amplified walking

7.1.1 Choice

The choice was made to further develop the concept of amplified walking. With the amplified walking concept the movement of the user will be amplified and will directly drive the mobile apparatus. This direction also allows incorporation of the modularity aspect. The device is built up from parts such as wheels, motors, batteries and a frame. Those parts are produced by different small manufacturers and can be combined by the user. With the help of communities, or even without, people can build their own amplified walker that suits their specific needs.

7.1.2 Focal issue

The chosen direction has to fit the focal issue. The question that has to be solved is: “How can electric vehicle manufacturers bridge the gap between high speed travel (trains, highways) and multiple destinations in city centers?” The amplified walker concept combined with modularity in the form of building blocks would address this focal issue the best:

Infrastructure

As an electric mobile apparatus manufacturer the solutions have to be compatible with the existing infrastructure. Creating and implementing a whole new infrastructure is simply not an option.

Small personal transportation

A small and portable device would be able to bridge the gap between high speed travel and destinations in the city.

Especially the portable aspect of the mobile apparatus is important in this concept direction. For instance for commuters a portable apparatus is an advantage and therefore the amplified walking concept direction fits the focal issue better than the stand-alone modularity concept direction.

7.1.3 Scenario

The “Get on top” scenario paints a world mainly driven by the people who are gathered in communities. The individual is important: they want to express themselves and will have personalized lifestyles.

With the use of building blocks the amplified walker can be tailored to the preferences of the owner. It is possible to change the amplified walker by adapting it yourself or with help from small companies. Such a customization makes it possible to adapt the amplified walker to every lifestyle. In the “Get on top” scenario, individualization is paramount. Therefore the building blocks are a good way to emphasize on individual lifestyles.

Another aspect of the scenario is the growing influence of communities. Similar minded people flock together on the internet and are able to share a lot of information, forming an open sourced basis for projects. DIY projects become easier due to a good platform to work from, using forums for instance, and by consulting worldwide experts who are part of the community. In combination with the building blocks and design conventions regarding those blocks it is possible to build your own amplified walker.

The building blocks that provide the user with the ability to customize and personalize their amplified walker cater perfectly to the individualistic nature of the “Get on top” scenario.

8 Principle amplified walking

8.1 The idea

The amplified walker is a new mobility experience. Instead of statically sitting in a car or standing on a segway, users can calmly walk while reaching biking speeds. This is accomplished by means of a small electric apparatus entirely adapted to the walking movement of a person. The amplified walker is designed to work as intuitive as walking itself. Without looking down at the apparatus under the user's feet, it should not be apparent to the user that wheels are in fact touching the ground instead of their own feet. Before such an apparatus could be designed, a brief study in human walking motion was necessary, which is given below. Also, the practical issues that come along with the amplified walker will be discussed. Finally, the technical aspects of the amplified walker will be explained in the following chapter.

8.2 Walking motion analysis

The amplified walker concept takes a movement that is familiar to all of us and amplifies it to keep up with the speed of contemporary life. The concept ensures that the user stays active throughout every stage in their life.

Walking is an interesting periodic motion from a mathematical and biomechanical point of view. Every person walks (slightly) differently and can do this in various ways: normal walking, jogging, running, skipping, etc. Gait analysis deals with the scientific description of human locomotion. Muybridge pioneered in this area back in 1878 already, creating film strips of locomotion of animals and humans (see Figure 8).

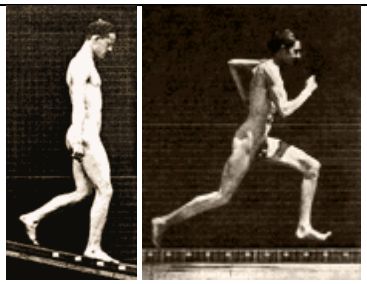


Figure 8: Muybridge film strips

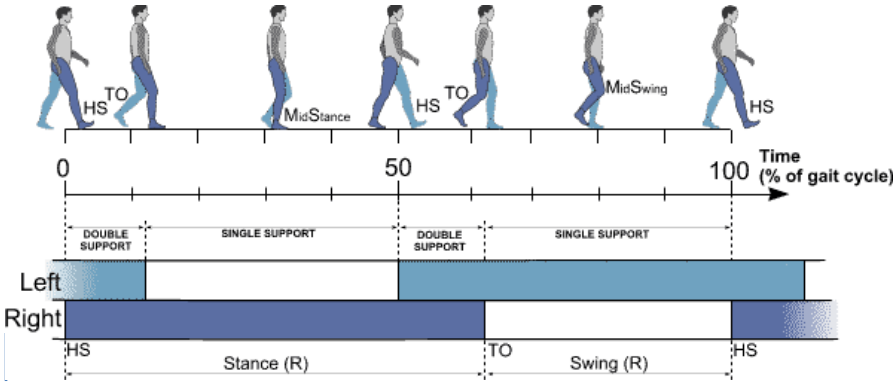


Figure 9: Walking locomotion

The figure above displays the average walking locomotion. It becomes clear that there is a point where both feet are on the ground at the same time. Also, the walker accelerates slightly when initiating the swing and decelerates slightly when ending the swing. When amplifying the walker's movement, this needs to be taken into account as to not create an amplified effect of these variations, creating a jerky ride for the walker. A filter will need to be used to smooth out these variations.

When running there is a moment in time where both feet are off the ground, as opposed to average walking locomotion. Hence, running would require a different amplifying technique compared to walking. The freedom in movement needs to be larger for instance, and the user would have to strap the pedals to their feet in order to keep in contact with the amplified walker.

Turning is done in a subconscious fashion: when one makes a turn, the stance of the feet changes to point to the direction one wishes to move in. This could easily be incorporated into the pedals of the amplified walker; the pedals could adjust according to the user's movements and consequently adjust the direction of movement.

8.2.1 Anthropometric data and ergonomics

The stance, the distance between the user's feet, is mainly determined by a person's hip breadth, measured from the outside of the feet. On the right a table is displayed with relevant data. This will ultimately determine the total width of the amplified walker.

Other factors that play a role are the user's weight, foot length, foot breadth, foot height, and the position of the hands (when applying Nordic walking attachments). Again, all of this data will determine the dimensions of the amplified walker.

measures	24. hip breadth (mm)	
populations	mean	sd
Dutch children 10 to 11 years, female	265	22
Dutch children 12 to 13 years, female	284	24
Dutch children 11 to 12 years, female	272	22
Dutch children 10 to 11 years, male	256	18
Dutch children 11 to 12 years, male	266	21
Dutch children 12 to 13 years, male	272	19
Dutch (18-30 years), mixed	392	38
Dutch (18-30 years), male	375	28
Dutch (31-65 years), male	386	29
Dutch (65-80 years), female	411	35
Dutch (31-65 years), female	420	37
Dutch (18-30 years), female	408	39
Dutch (65-80 years), male	399	25
Dutch elderly (1982), male	331	17
Dutch elderly (1982), female	361	28

Figure 10: anthropometric data

8.3 Practical issues

8.3.1 Stepping on

Getting on the device might seem like a strange experience but is in fact quite simple. An overview of the steps involved after turning on the apparatus is given below:

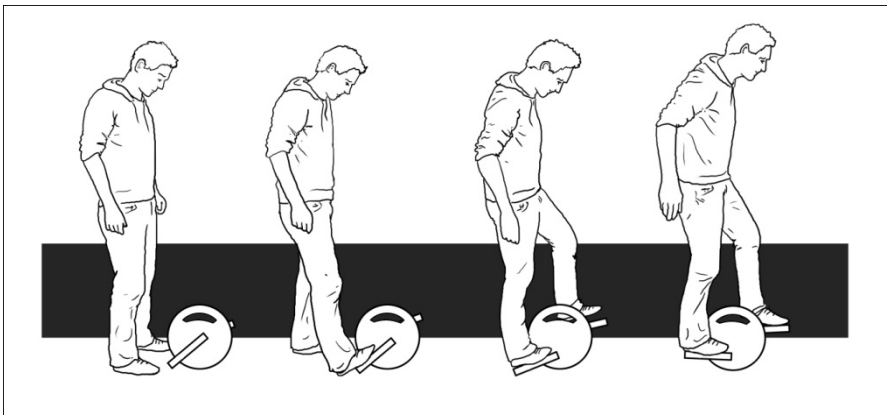


Figure 11: Stepping on procedure

8.3.2 Control

Once the user has stepped onto the amplified walker, the rest of the journey should come naturally to the user. The control of the apparatus during this journey will therefore be completely intuitive – the device follows the user's lead, not the other way around. In order to go forward, one simply walks forward. In order to steer, a foot will need to be rotated while shifting weight to the desired side. All these movements are common natural movements we all do while walking. Braking will also be natural, but slightly to a lesser extent due to the speeds involved. While traveling at biking speeds, users cannot simply stop walking and expect to suddenly stop. Not only will that seem unnatural, but also the user will lose their balance in that short braking distance. Therefore, slight braking will be accomplished by ceasing to walk, and if more aggressive braking is desired, users can lean back on the steps, decelerating the amplified walker quickly.

8.3.3 Weight and dimensions

Seeing as the amplified walker was designed to be taken along in trains or automobiles, the weight is an important factor in its practicality. In order to remain portable, the weight should remain under 10 kilograms. Also, the dimensions of the amplified walker should be as compact as possible. The entire apparatus should only be slightly larger than the wheels propelling the apparatus themselves.

8.3.4 Speed

As will be extensively explained in chapter 10, the speed and pretty much every aspect of the amplified walker can be suited to the user's taste and preferences. Speeds which can be achieved lie around biking speeds (20-30 kilometers per hour). Of course, the question is whether users want to move that fast; therefore the speed will range from 5-30 kilometers per hour depending on the user.

8.3.5 Range

Distances traveled with the amplified walker will not be of long range. Typically the amplified walker will be used for distances from a railway station or city center limit to a destination in the city center. City to city travel will be rare; therefore a logical range for the apparatus will be 25 kilometers. Again, every user is different, thus battery upgrades can suit any range necessary.

8.3.6 Charging

When the batteries are depleted they will need to be recharged. In 2030, the majority of electrical devices will be charged wirelessly, the amplified walker will be no exception. With built in wireless electricity connections and charging regulators, the user will never need to worry about recharging. By simply placing the apparatus within range of the electricity, in less than an hour it will be fully charged once again.

8.3.7 Different ways to propel

The amplified walking movement is the basic concept. The modularity aspect opens up a range of possibilities, part of which is different ways of propelling yourself. This could simply be a different form of the same movement, but it could also be an entirely different movement altogether.

The form of movement depends on age or lifestyle, as illustrated in Figure 12. The main movement would be walking, as it is the basic movement across all lifestyles and age categories. Children may desire a more entertaining method of moving, such as skipping or stepping. Adolescents may want a more extreme method of moving, such as (skate)boarding and carving. Adults may want to work on their health and require a running movement or a full body movement that also involves their arms as well. Elderly would move at a slower pace and might prefer a shuffling movement.

All these movements have in common is that they are natural and can be amplified electrically to act as an effective method of moving around. To support the different movements however, some components would have to be adapted, but this is reflected in the modularity of the concept.

Figure 12: Forms of movement

9 Technical aspects

9.1 Introduction

The basic technical feasibility for the amplified walker is well within reach. The majority of the technology involved is currently available and applied in many products. As the remaining technology necessary for the amplified walker may not currently be applied in such a configuration, developing these technologies will prove difficult, yet definitely not impossible. A comparable product is the segway; the balance and control technologies used in this product remain secret to this date, however prove that an instable machine can be made stable with the right technologies. Therefore, several years will be necessary to achieve a working amplified walker.

9.2 General overview

In this chapter, a technical explanation will be given for one of the many different variations of an amplified walker. This model can be used as a basis for many different kinds of amplified walkers, however it is focused on a walking movement. Adaptations to the manner of 'walking' and purpose of the apparatus will indubitably change the technical layout, however the basic idea behind the technique will remain. See chapter 10 for a complete description of the variation possibilities. In the figures below the total assembly and exploded view of the technical model is shown.

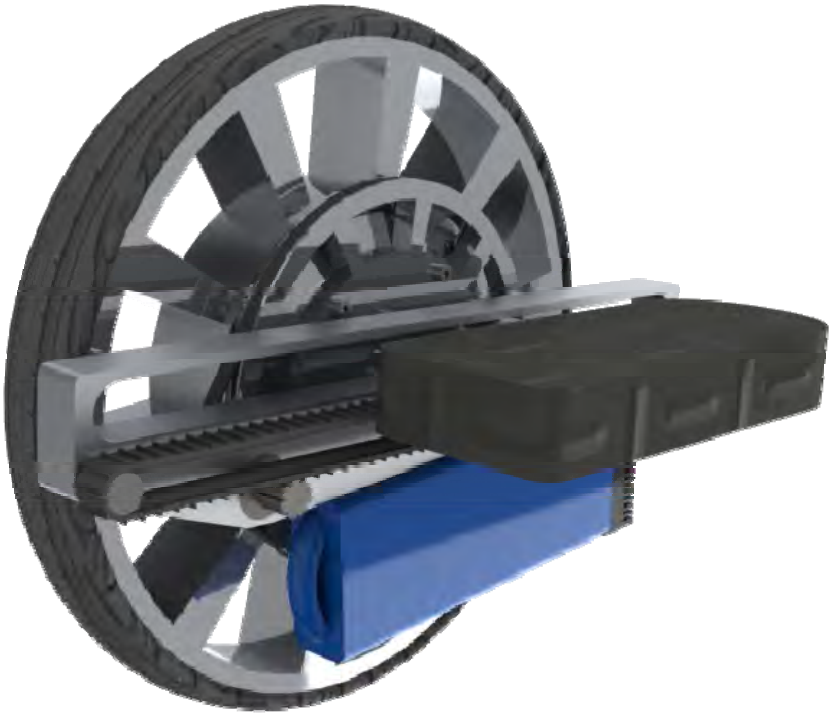


Figure 13: Technical model

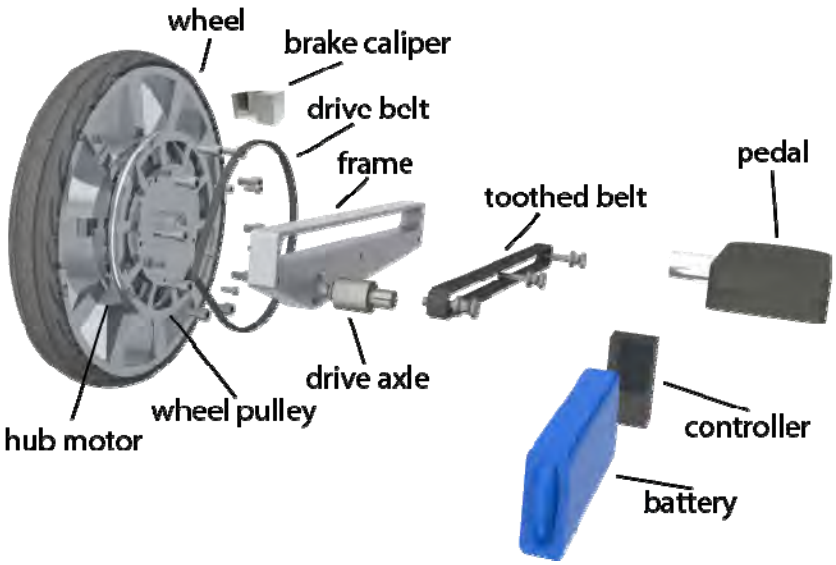


Figure 14: Exploded view technical model

9.3 Operation

As can be seen in Figure 13 and Figure 14, the components comprising the technical model all contribute to propulsion. The user's foot rests on the pedal and is slid backwards in the slot in the frame when taking a step. Suspension (spring and damper) can also be incorporated inside the pedal for light applications. Heavier or off-road applications will require external springs and dampers. A tooth on the pedal slots into the toothed belt, rotating the belt along the pulleys. The toothed belt in turn slots in the toothed pulley of the drive axle, also rotating the drive axle. See Figure 15 for a close-up showing the interaction of these components.

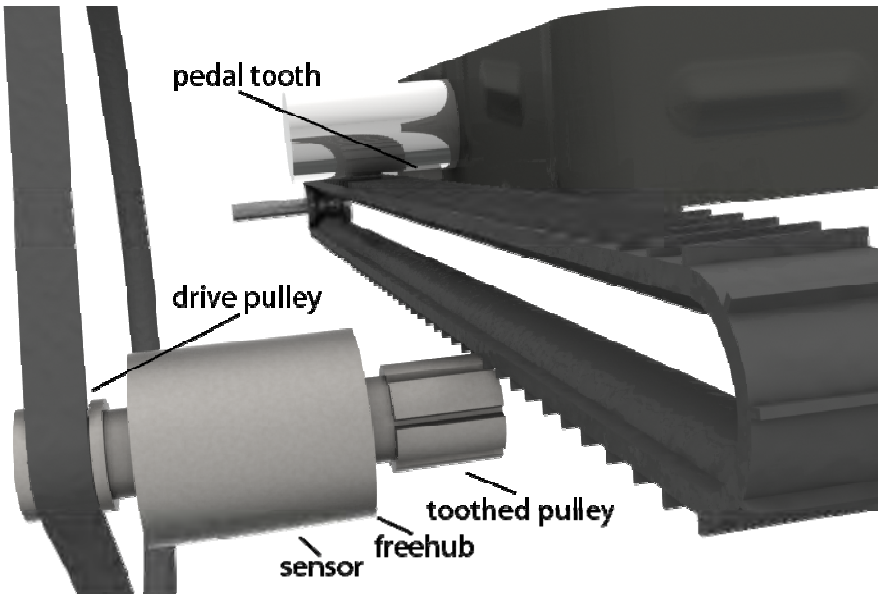


Figure 15: Close-up exploded view

Once the drive axle is engaged, the drive pulley attached to the drive axle rotates, rotating the wheel pulley via a drive belt. Inside the drive axle a free-hub is equipped which only allows the drive pulley to be engaged in a forward rotation, in a backward rotation the toothed pulley rotates freely. The wheel pulley is directly connected to the wheel, creating a forward movement. A sensor in the drive axle determines how much torque is created by the user and sends this information to the motor controller. The controller then uses this reading to determine the suitable amount of power needed from the electro-motor. This signal is sent and the electro-motor and transfers the necessary power directly to the wheel. In this way the user's walking movement is amplified; the amount of amplification can be calibrated according to their own preferences in speed and sensitivity via various filters.

Besides forward acceleration, users will also want to decelerate. In order to decelerate, the majority of braking will come from regenerative braking. In regenerative braking, the electro-motor acts as dynamo which recharges the battery, effectively reversing its role. Not only does this result in deceleration of the amplified walker, this also helps increase the

range that is possible. This regenerative braking is initiated once the user stops walking. If harder braking is necessary, the user can lean back on the pedals, engaging the caliper brakes. The dosage of braking is adjusted when leaning further back.

In addition to movement in a straight line, users will also have to turn. The actions the user will take in turning will be much in the same way as in normal walking. At low speeds, users will rotate their inner foot along the z-axis (from head to toe) towards the direction they want to go. Sensors will send a signal to the left or right electro-motor, (depending on which direction is desired), which will increase the drive in one of the wheels. Also, the height of the pedals on either side will be adjusted, shifting the center of gravity of the user, forcing the entire apparatus a certain direction. These two effects will make the apparatus able to turn on a dime. At higher speeds, the centrifugal force will be the main contributor to turning.

9.4 Additional information components

9.4.1 Hub electro-motor

The electro-motor used in the amplified walker is built into the hub of the wheel, thus directly driving the wheel. This brushless DC motor is completely enclosed, protecting the motor components from the elements. Also, being a brushless motor, the motor is less susceptible to wear, has a better reliability, more power, and better efficiency compared to a brushed DC motor. Besides providing power, the hub-motor also acts as a dynamo, powering the battery and simultaneously braking. Generally, two wheels are used in the amplified walker, each with their own motor. These wheels are placed very close to each other, giving the effect of one wheel. This is necessary for sufficient control of the apparatus. Furthermore, as technology continues to develop, hub-motors will consistently become smaller, more efficient, and more powerful.

Figure 16: Hub electro-motor and battery

9.4.2 Battery

The battery used to power the hub-motor and store excess energy is a LiFePO4 type battery. Currently, this is the best battery for the application due to its performance and safety. In 2030, this will undoubtedly be old-fashioned and replaced with a superior type, increasing power and range while decreasing in size.

9.4.3 Control system

The function of the sensor and controller in the amplified walker is essential to the amplified aspect. Not only is a fast and accurate communication between the two components necessary, but this needs to be fully adjustable. Each user will require a different amount and sensitivity of amplification. Additionally a filter will need to be applied smoothing out the irregularity in walking to a constant speed. Amplifying this motion without a filter would otherwise result in a very jerky ride. Cooling ribs are applied to the front mounted controller in order to provide cooling for the controller.

Figure 17: Controller and sensor

10 Modularity

The amplified walker is created using modular building blocks. The intended use of the amplified walker determines the requirements the different modular blocks have to adhere to. For example an amplified walker aimed at off-road active use would have to meet different requirements than an amplified walker that is used as a small mobile apparatus for children. The walker can be modified with extra blocks that are able to change the appearance and properties of the walker. In this section the possibilities and feasibility of such a system will be explored within the “Get on top” scenario and from the stance of the chosen actor of electric mobile apparatus manufacturers.

10.1 Building blocks and stakeholders

In order to create an efficient system of building blocks for both consumer and electric mobile apparatus manufacturers, the essential components that make up the amplified walker have been listed and analyzed:

- Electromotor
- Wheels
- Batteries
- Steps (also defines movement)
- Suspension
- Frame
- Controls

By splitting up all the components into individual blocks that share similar features the consumer has full control over the amplified walker design. It would also allow electric mobile apparatus manufacturers to focus on a specific component and thus specialize; this would effectively cut their costs and increase their profit making it an appealing choice from their point of view. It would also allow them to offer a wide range of different versions of the component they specialize in. The high level of customization would allow the coexistence of a large number of small companies on the market – each could cater to different lifestyles and specific target groups.

A manufacturer of batteries for instance would be able to offer a large assortment of different batteries: long range, short range, heavy duty, lightweight, etc. The same kind of modularity applies to all but the frame and the controls:

- It is expected that frame production will be a single-item production system rather than a series of items if it wants to allow full control over the shape of the amplified walker. Hence this would require a different production approach compared to the other components.
- The controls require a specific approach as well. The software could be the same for every model, except to unlock certain pieces of the software one must pay for it. Paying for software upgrades is a method that would work well for both the manufacturer and consumer.

Other stakeholders that are involved in the process are garages that provide general maintenance services. They could bridge the gap between customer and the large number of different manufacturers that created the components that make up the user's amplified walker. With a product that carries just one brand the product can be sent back to a store of that specific brand, however if the product is a compilation of a series of smaller brands, this is not so easy. Special garages could provide this

service. Open source production in combination with design conventions regarding all the components should facilitate the maintenance and assembly of the multitude of components.

The garages could also offer assembly and tuning services to those who do not wish to tinker with the amplified walker themselves; they could hire a professional to do it for them.

10.2 Production methods

In order for consumers to have complete control over the shape of the product of their choice, they will need to take on the role of both designer and producer. Of course this needs to be within simplified margins to ensure accessibility of the service.

The most promising results with regards to creating personalized casings of products can be found in the Rapid Prototyping corner. Rapid prototyping defines a group of techniques that allow computer aided rapid construction of a prototype, usually in the form of additive manufacturing. Subtractive manufacturing such as CNC milling is not commonly counted as a rapid prototyping technique.

The rapid prototyping techniques translates a CAD model into a layered model and lays down successive layers of liquid, powder, or sheet material to build up the model. This production technique allows the creation of every shape possible. It would also be possible to create the mould using rapid prototyping techniques and use said mould to cast a model. While the latter is more time consuming, the choice in materials will be less limited.

Rapid prototyping techniques:

- Selective laser sintering (SLS)
- Fused deposition modeling (FDM)
- Stereo lithography (SLA)
- Laminated object manufacturing (LOM)
- 3D printing (3DP)

Selective laser sintering makes use of thermoplastics and metal powders as basis to create the model. Sometimes glass or ceramic based powders are used as well. A thin layer of the material is spread out on the surface of a powder bed after which a high power laser selectively fuses the powder or granules to create one cross-section of the model. After

each layer, the powder bed lowers by one layer thickness and the process is repeated. Eventually a complete model can be retrieved from the powder bed. This technique could be used by manufacturers to create the frame or the casing of the amplified walker.

Fused deposition modeling makes use of thermoplastics and waxes as basis to create the model. An extrusion nozzle extrudes heated material to build up the model, layer by layer. A disadvantage of this method is that depending on the model's build-up, the model may require support in places where no material is applied. This technique could be used by manufacturers to create the casing of the amplified walker.

Stereo lithography is restricted to use with a photopolymer only due to its specialized manufacturing technique. In this process a UV laser vat describes a cross-section of the model on the surface of a vat filled with an UV-curable photopolymer resin. The resin solidifies when exposed to the laser and hardens. Layer after layer can be built up in this manner, creating a model out of the liquid resin. The end result lends itself perfectly for creation of master patterns for injection molding and the likes. This technique could be used to create moulds for single-item production such as the frame.

Laminated object manufacturing is a very low cost rapid prototyping technique; however it is limited to the use of paper only. In this process a sheet of paper is laid out after which a laser traces the cross-section of the model. Another sheet is applied on top of the original layer and the process is repeated until the desired model emerges.

Lastly, **3D printing** uses a technique similarly to that of inkjet printers to create a 3D model. Similar to selective laser sintering a layer of powder is spread out on a powder bed. The jet nozzles of the printer then selectively prints a binder (drops of glue basically) on the powder layer, fusing the powder together to describe the cross-section of the model. It is the only technique that allows you to print the model in full color. 3D printers are already available for the consumer market, be it at a rather high price of about $3,000.-. These printers would allow the consumer to print out their own designs for the product. The size of the components however would be limited initially.

10.2.1 Extrapolation and application

Rapid prototyping techniques will continue to develop. At the moment these techniques are still mostly limited to professional use, but it is expected that in the next decades this product will find its way into our

houses. Costs to acquire and to use 3D printers will decrease drastically over the coming years, making it a technique to keep into account and to exploit for future products.

Manufacturers will be able to use rapid prototyping techniques that allow them to create large objects. This way they can offer a unique service to the consumer who is only able to print small objects using their 3D printers at home. For the frame in particular or parts of the casing manufacturers can use laser cutters as well.

The basis for rapid prototyping techniques is CAD, which in its current form requires a fair bit of know-how. CAD would have to be more accessible to the average consumer if they want to use it to customize their amplified walker all by themselves. One way to achieve this is if the garages create online tools that allow users to be the designer and creator within the confines of an environment created by the garage, only limited by their tools. As example: the fashion sector already offers similar online services; Link [1] in appendix chapter 17.2 allows the user to select the material and composition of their carrier bag and preview it with an online tool.

10.3 Communities

One could also imagine the design aspect is done by an open community, similar to how wallpapers on computers are created. This open community would create a lot of different designs, and the consumer would be able to buy a design (similar to buying an application for a phone for instance) and print it on their 3D printer at home.

As mentioned, CAD requires specific 3D modelling programs that are often not accessible to the average consumer and come with a hefty price tag as well. Therefore it is unlikely 3D modelling will be done by the consumers themselves, but will be limited to manufacturers and certain groups of users.

Much in the same way personalisation of computer environments is achieved nowadays it will be applied to 3D modelling of components for the amplified walker as well. For example, people do not tend to create their own wallpapers for their computers or skins for programs on their computers and phones, but rather find one online they like amongst the millions of images created by art related communities. Most of the time this is free of charge, sometimes a small fee needs to be paid to acquire the desired file.

There are a lot of communities out there offering such services, think of stock photos as basis for art work, applications for phones, wallpapers for computers and phones, skins for programs, etc (see Figure 18). It is expected similar communities will arise to personalise the exterior of the amplified walker. This trend is perfectly in line with an ever more individualistic society.

Figure 18: Communities

10.4 Demonstration of modularity

After having assessed the possibilities and established the feasibility it is time to put it in context and see it in action. Figure 19 shows an overview of the different modular components, as they would be produced by each small manufacturer. The list is intended to give an impression of the variety in components, the list is not complete. By choosing different components the user can create their own amplified walker, tailoring it to their own specific needs.

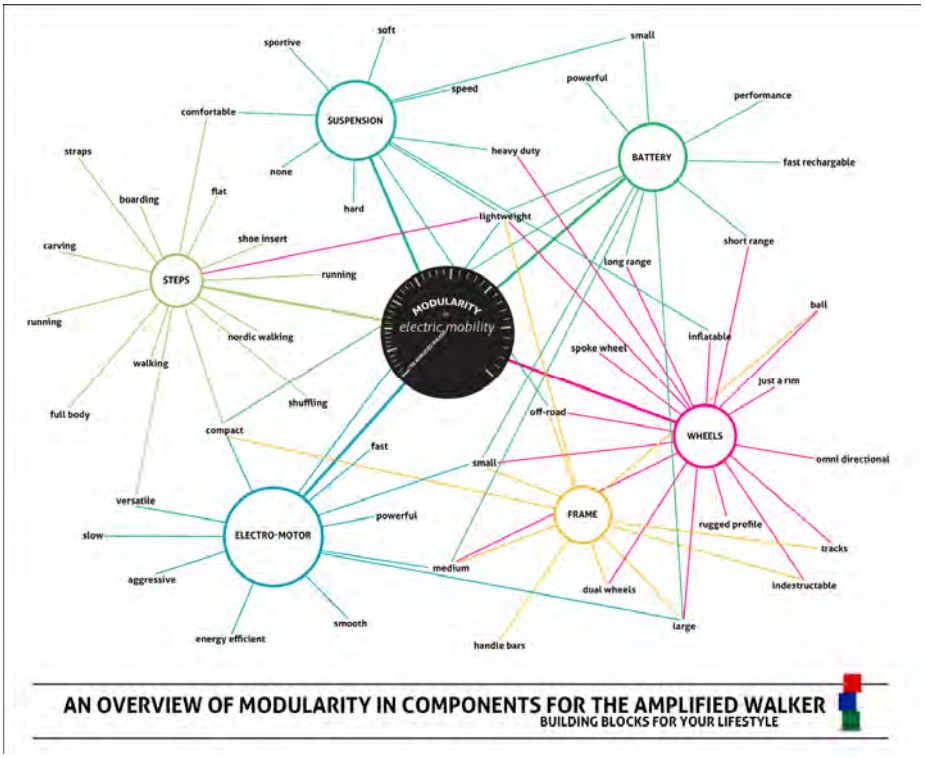


Figure 19: Modularity overview

As a demonstration of this modularity the choice was made to create three different amplified walkers. Creating three different models with different modular components resulted in three vehicles with a very different appearance. The requirements of each group led to a different choice in components to suit their specific needs.

10.4.1 Minimalistic model

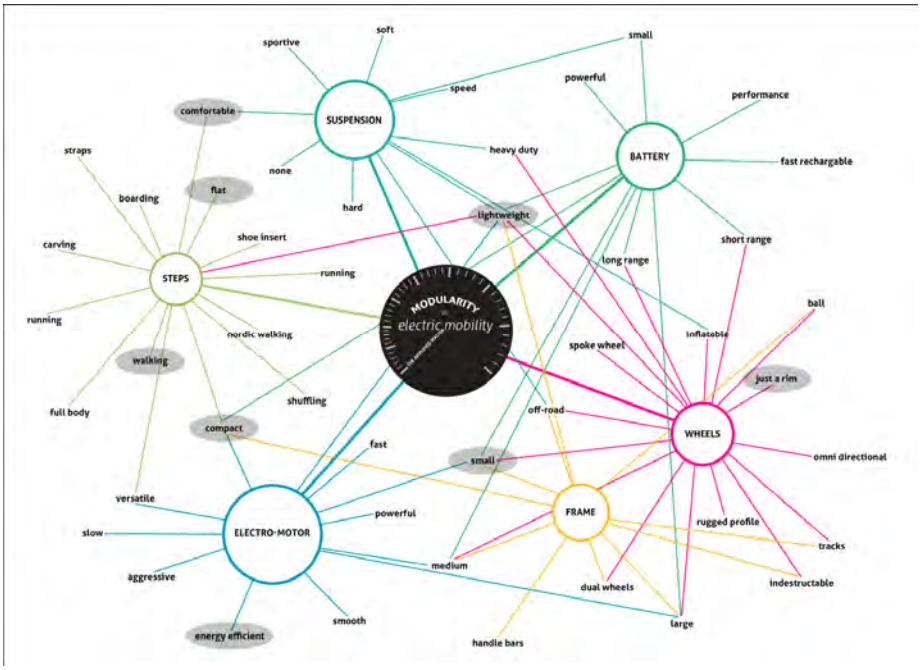


Figure 20: minimalistic model

The first model to be designed is a small minimalistic model for the business market. It is a vehicle for commuters to travel from fast (public) transport systems to the work places in the city. The modularity image as displayed above highlights the keywords the components have to adhere to, which define shape and purpose.

10.4.2 Recreative model

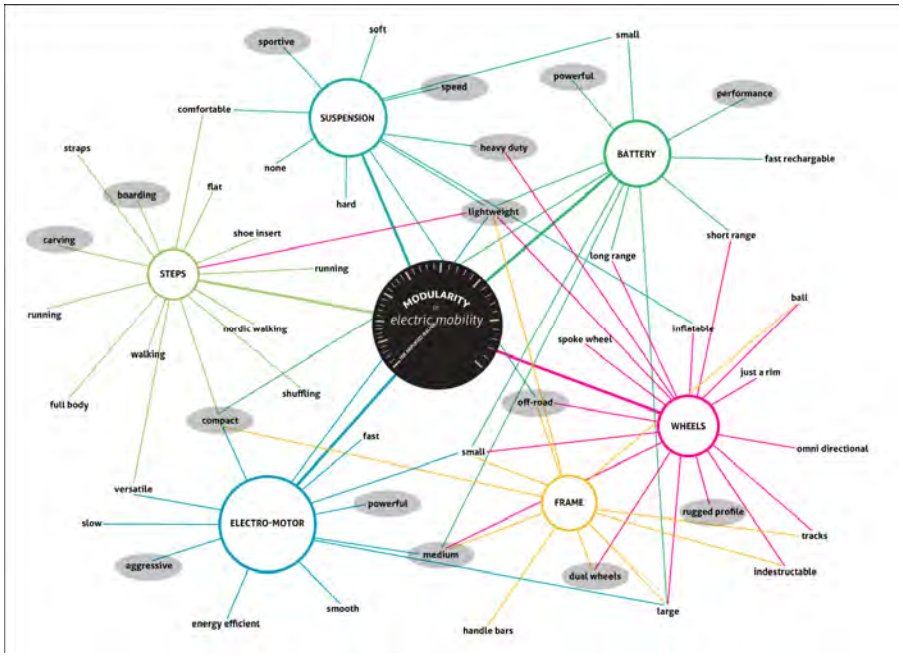


Figure 21: Recreative model

The second model is aimed at the more recreational use of the amplified walker. The amplified movement will be more active and entertaining than walking. Also the components have to be more robust and able to handle bigger forces. Again the keywords are highlighted in the image above.

10.4.3 Comfort model

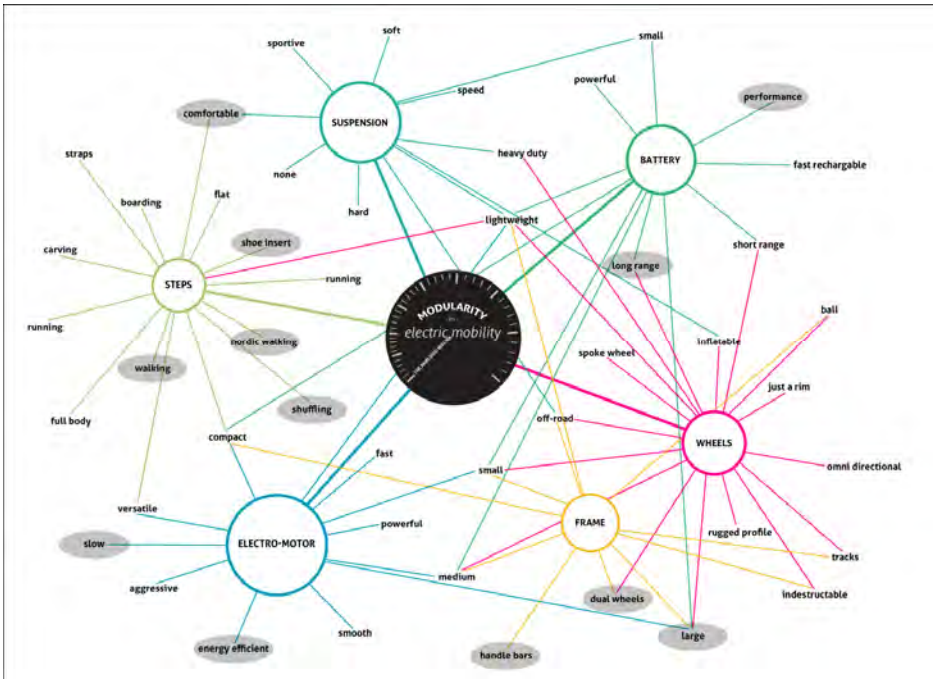


Figure 22: Comfort model

The third model is equipped with three wheels to give the amplified walker a more visible sense of stability. This model will be heavier and features different ways of movement, ranging from walking to shuffling, with handles as additional feature.

10.5 Taxonomy

Combining different parts result in a whole range of product families. As can be seen already with the three models it is possible to create completely different models based on the same principle. If the idea of the building components begins to live its own life, a whole range of products will be created. The amplified walker principle will be available in many different forms and ways of movement.

In Figure 23 a basic overview is made of a possible taxonomy of the product once communities get to play around with all the possibilities. A natural evolution of the product will be possible, with the requirements originating from the community – the user gets to decide what functionality their amplified walker needs to have. This functionality would not be limited to transport alone, it could extend to fulfill tasks related to the user's lifestyle and identity (such as using the business model as a docking station for cell phones or laptops, or sharing walking routes with peers if using the comfort model). The components can be combined to create an infinite amount of possibilities.

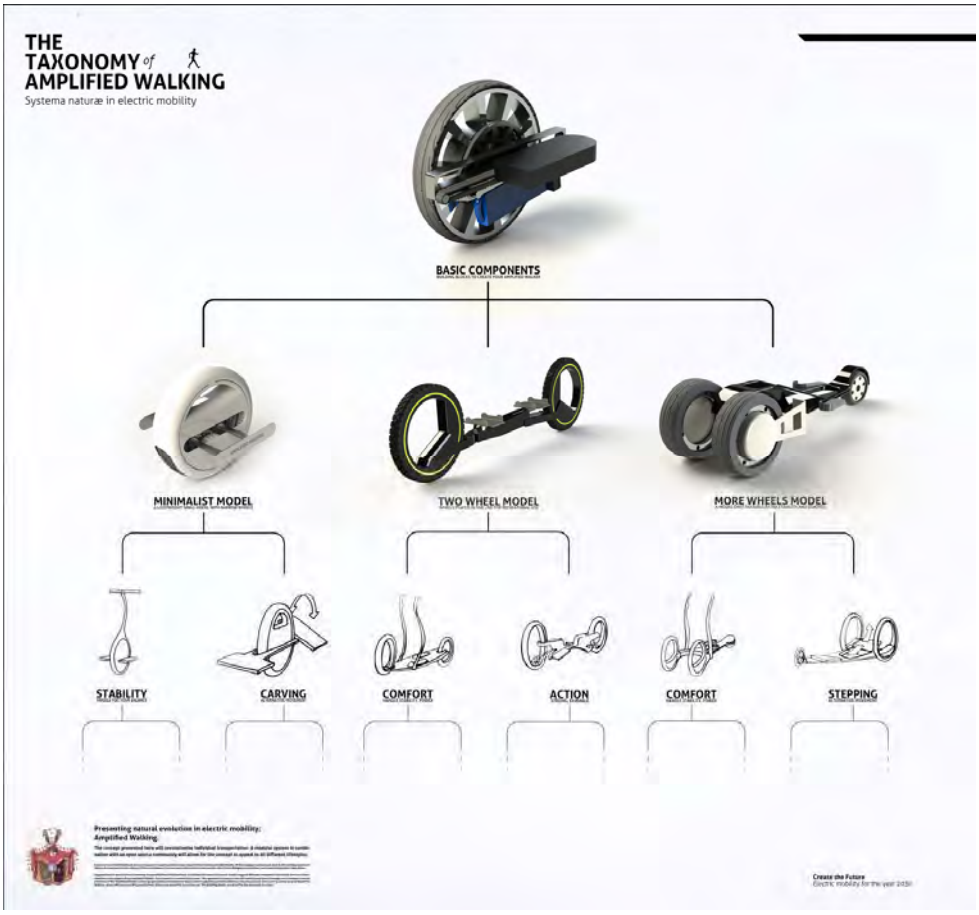


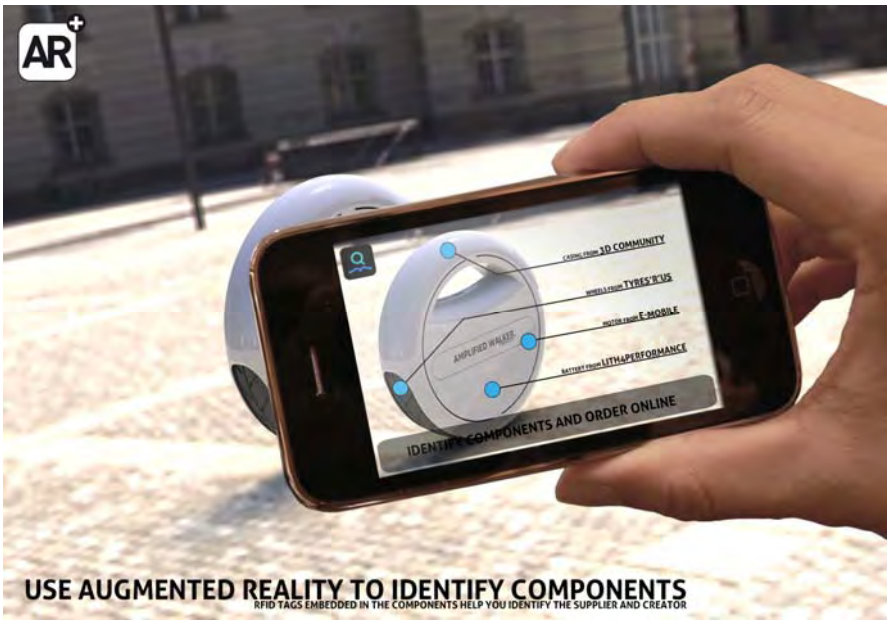
Figure 23: Taxonomy

10.6 Other features - Identifying components

Due to the specialised division of component fabrication the resulting vehicles will not carry a specific brand anymore, which exacerbates advertisement for manufacturers. This is especially a problem for components that are not visible from the outside of the vehicle; hence this issue requires a different approach in order for manufacturers and communities to get their product out there.

A solution can be found in RFID tags in combination with mobile phone applications. By embedding all of the components with a small RFID tag, an augmented reality (AR) application on a mobile phone will be able to detect the specific components (plus their origin) that make up a certain amplified walker model. The user will see the components and what company has produced/created it, and will also be able to immediately go online and order their own components.

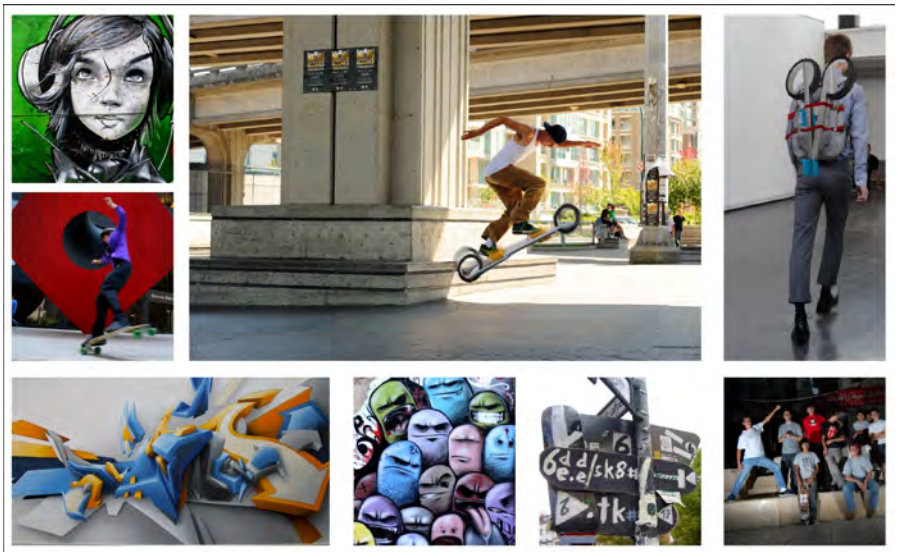
RFID tags are already available in many different sizes and shapes, yet are not widely embedded in products yet. RFID tag readers however are still somewhat limited with regards to the distance between reader and tag and are also still rather large in size, but attempts are made to incorporate it into mobile phones (see link [2] in appendix chapter 17.2). It is expected that the RFID reader technology will sufficiently develop by 2030 for it to be widely available to all consumers in an efficient form.



11 Concepts

11.1 Recreational model

The active amplified walker targets the active segment of users. The lifestyle according to the users is active, adventurous and playful. The streets of the city are not only just meant for transport but are also a playfield where you can have fun with your mobile apparatus.



To fulfill the demands of the active lifestyle the components of the mobile device have to be strong, lightweight and robust. The tires of the mobile apparatus have to be equipped with a strong profile to have a good grip on the road or even off-road. Operating the recreational model is a little different than the standard amplified walker. With the rear foot a carving movement is made which is then amplified and drives the electrical devices.

An overview for the recreational model:

- The electromotor in the rims gives the device a sportive look.
- Lightweight materials allow for more control.
- A robust frame is required to handle the forces of extreme use.
- It is foldable for easy transportation.
- Steering is done by pitching the front foot step.
- The carving movement of the foot will be amplified and drive the device.
- A spring system will take care of suspension.

Optional:

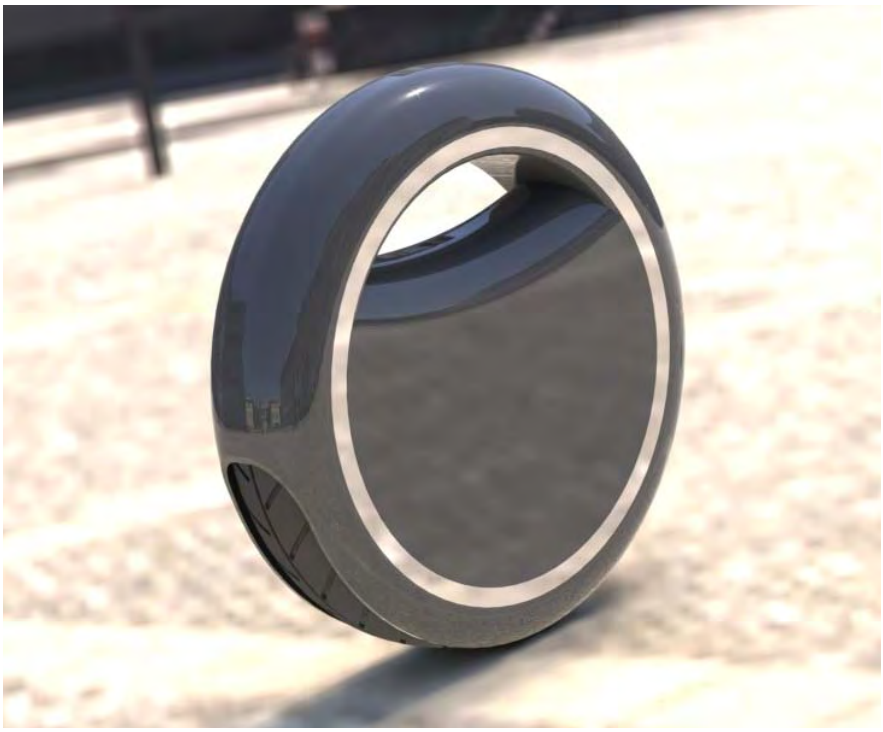
- Grind plates for extreme use.
- Textures and patterns can be used to customize the look and create extra grip.

The active walker, much like every other amplified walker, is fully adjustable to the demands of the owner. If desired, components can be changed to suit one's specific needs, for instance: one could install bigger tires, a more powerful motor, higher capacity batteries or one could change the shape of the frame.

11.2 Business model

The business model is a variation of amplified walker that is aimed specifically at the commuter. The commuter has a unique set of demands, like every lifestyle in an individualised society.

To meet the demands of commuters the product should be small, lightweight and easy to carry on public transport for instance. The product should also be able to cope with curbs and should be able to function under less ideal weather circumstances. The above requirements translate into design specifications. As amplified movement a regular walking pace is used.



An overview for the business model:

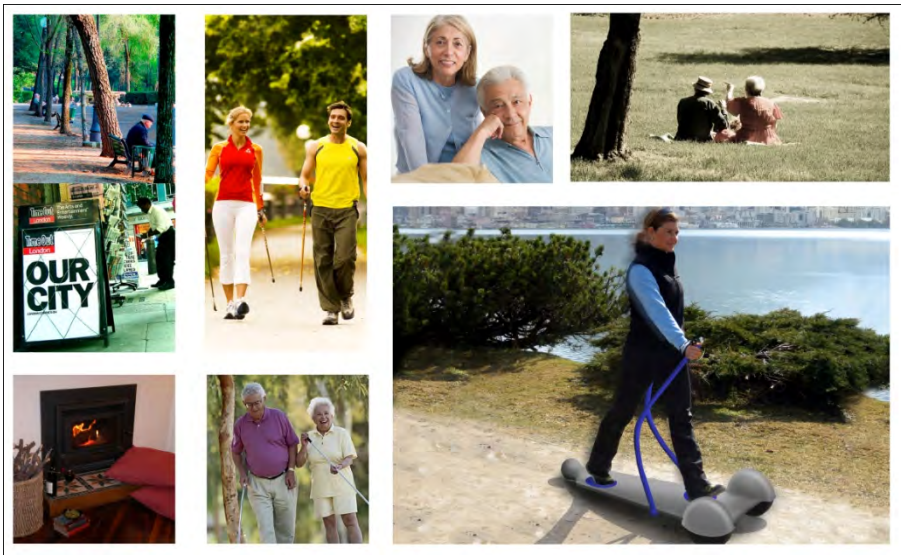
- The model is as small and lightweight as possible, the materials and structure reflect that.
- The hollow wheel allows the user to carry the product without adding a handle to the exterior. It also ensures optimum use is made of the available space.
- The casing protects against dirt and water puddles, but still allows the user to scale curbs.
- Two narrow tires in combination with gyroscopes create stability and maneuverability.
- The steps can be folded to fit inside the wheel to make the model more compact.
- As material ABS with a high quality finish would fit the lifestyle of the business man/woman.
- The rubber wheels acts as suspension.

Optional:

- The model can be painted with solar paint or could be created using solar polymers so the device could generate energy while not in use (such as while working).
- The device could act as a recharge point for the user's devices, such as phone, laptop, or variations/combinations thereof.

11.3 Comfort model

The comfort model aims to reach and provide transport mainly to the elderly in the city, but it also addresses recreational needs for walking enthusiasts.



To meet the requirements of this specific target group it is important that the walker is easy and comfortable to use. If desired by the user, handlebars could be attached that offer extra support and ability for the user. The frame has 3 tires to offer the extra support required by the user. The kind of movement used to power the comfort model depends on the wishes of the specific group: e.g. elderly people shuffle and average people can walk or Nordic walk. The speed of the vehicle is slow as to not impose too much on the sensory input of the user. There is no need for high-end performance because the comfort model is designed for normal use and not for extreme use situations.

The comfort model, just like all the amplified walkers, can be personalized. Patterns and colors can be changed, handlebars can be attached or detached, tires can be bigger or smaller, etc.

An overview for the comfort model:

- The model is large and has 3 tires for stability.
- Different kinds of movement are possible (walking, Nordic walking, shuffling).
- The model is energy efficient and usable for longer distances.
- The handle bars are foldable as well as detachable.
- The model is very reliable and moves at a slow to average speed.

Optional:

- The model is able to transform into a chair to offer support when the user stops.
- A navigation system can be added to supply walking routes (for Nordic walking for instance).
- The comfort model is able to pull a shopping cart.
- The comfort model can be stored easily in a closet to conserve space when parked.

12 Energy

In line with the scenario “Get on top”, households in 2030 will be more or less self-sufficient with regards to their energy production and consumption. According to trends, electric devices will continue to become more efficient and thus use relatively less energy. Trends also show that environmental awareness is on the rise and will continue to rise, resulting in more energy produced in a sustainable manner.

12.1 Sustainable energy

Amongst the sustainable methods of energy production is, divided per generation:

- First-generation technologies
  - Biomass combustion
  - Geothermal
  - Hydroelectric
- Second-generation technologies
  - Biomass energy extraction (bio fuels)
  - Solar heating and photovoltaics
  - Wind power
  - Hydrogen and fuel cells
- Third-generation technologies
  - Biomass gasification
  - Solar thermal energy
  - Tidal energy

First-generation technologies are the result of the industrial revolution at the end of the 19th century and have been on the market for a long time. These technologies are still widely used but are limited to specific locations because they depend on geographical characteristics.

Second-generation technologies have been developed since the 1980s as a response to the oil crisis of 1973 and 1979, but still go strong due to an ever increasing environmental awareness. Second-generation technologies are already commercially viable and applicable to individual products and circumstances. These technologies are expected to show a big increase in efficiency due to upcoming technologies such as nanotechnology. Second-generation locally based renewable energy system would fit the individualistic “Get on top” scenario very well.

Third-generation technologies still require a lot of research and development in order to be an effective competitor on the market. It is

expected that nanotechnology amongst others will increase the efficiency of both second- and third-generation technologies substantially. Third-generation technologies mostly aim to provide power to a large group of people and thus would be a better fit for a more government controlled scenario - it also has to be kept in mind that investments have to be immense for third-generation technologies to be a viable alternative energy source.

12.2 Solar technology

Of the second-generation technologies solar cell technology looks most promising and offers a wide variety of methods and types. As displayed in Figure 24 solar voltaic technologies still have a lot of unfulfilled potential regarding their efficiency, which is expected to be improved drastically over the coming years along with a drastic decrease in costs. China's decision to subsidize utility scale solar power projects will also have a big impact on solar energy development.

A list of the main current and future solar cell technologies (and materials), each with their own advantages, disadvantages and potential:

- Silicon solar cells
- Thin-film solar cells
- (Organic) polymer solar cells
- Photo electrochemical cells (PECs)

The energy produced with the above technologies can be stored in batteries or converted into other sustainable energy carriers, such as hydrogen, and used when required.

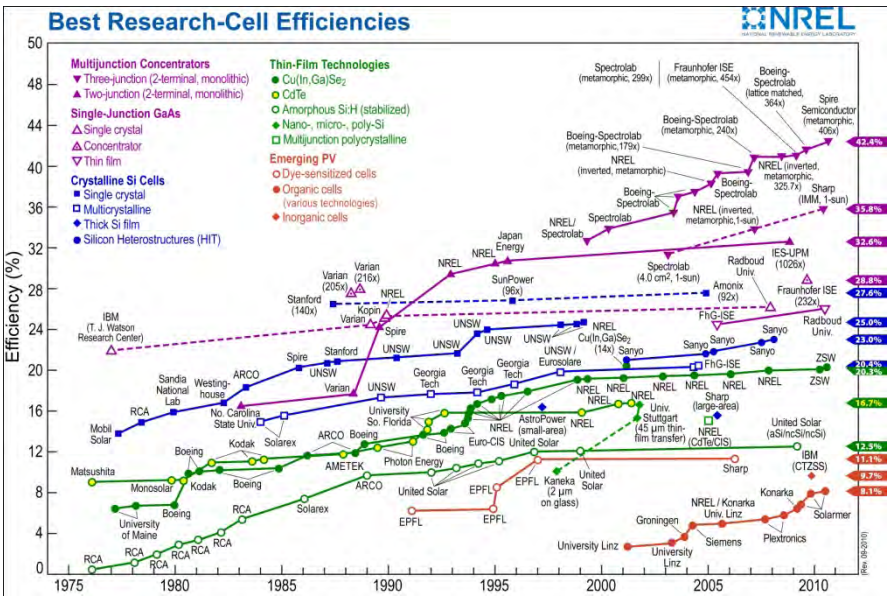


Figure 24: Solar energy efficiencies

12.3 In context

It is expected that households in 2030 will make extensive use of solar energy to meet their energy needs. New developments such as solar paint and solar polymers mean that products and property can be painted or coated with materials that produce energy, fitting the self-sufficient desires of the individualized society.

Users can ‘plug in’ their amplified walkers at home or at the office to recharge. It would also be possible for companies to create a parking place for amplified walkers that are coated with solar paint or polymers, effectively creating a solar panel field that can be connected to the power grid. Such a ‘field’ would give the amplified walker an additional purpose while it is not actively in use. The latter is merely an example: the applications of the new solar energy developments are endless.

13 Robustness

The amplified walker is designed for the get on top scenario. With the building blocks it is possible to customize it to the preferences of the owner. Information is shared through online communities, allowing people to personalize their amplified walker to fit their identity. The amplified walking principle is a good solution for the commuter issue, a solution aimed at short distance travel. Overall the amplified walker concept is a perfect fit for the get on top scenario.

By placing the product in the other scenarios one can assess its robustness and determine whether or not it is a viable concept in those settings as well. If so, the product is robust and widely accepted and therefore will have a stronger market potential.

13.1 1984:

The 1984 scenario features state of the art technologies controlled by the government and will result in limited freedom. The entire scenario is explained in chapter 4.6.

- Choices will be more limited: large corporations and the government run the market.
- Modularity will be toned down a lot: large corporations determine the few available models.

- Environmental awareness is an important vanguard of the government, as such energy consumption will be low, and energy production will be done in a sustainable manner.
- Transport is focused within the city, small clean vehicles are encouraged.
- Public transport takes precedence over other forms of transport.
- Government will make large investments in any new sustainable transport system.
- Distances become less important: work and recreation will be localized.

Consequences for the concept:

- Modularity is determined entirely by the companies, resulting in only a few basic models with no extra choices for the consumer.
- The concept can be implemented by the government to provide a solution for short distances as addition to the public transport system.
- The vehicle will not be a status symbol at all; there is no need for customization.
- Driving has to be safe or the government will not approve. This would mean some safety factors have to be improved; autonomous driving could be a solution.

The concept of the amplified walker also fits in the 1984 scenario. There are some restrictions but also some great opportunities. The addition of the building blocks is in the 1984 scenario of no real use: it is in the large manufacturers' best interest to produce only a couple of models. Safety is also an important factor that will be of great influence on the application and form giving of the amplified walker. The principle of amplified walking is beneficial in the 1984 scenario too; it is healthier for the user and uses less energy, two arguments in favor of the government's stance.

13.2 Steady as she goes:

The steady as she goes scenario is a more 'easy going' scenario. It is similar to the current situation: the government has a rather big influence but small groups can still force changes if they are persistent. The complete scenario is explained in chapter 4.7.

- Technological progress is limited.
- Reliance on fossil fuels is still substantial, electric vehicles are still uncommon.
- The communities are trying to combine knowledge to get ahead, but major breakthroughs stay away.
- The government will set rules regarding electric vehicles.

Consequences for the concept:

- As a result of the lagging communities, the technology is not ready for DIY.
- There will be less choice regarding the modularity due to a limited technological progress.
- Due to government regulations there will be less freedom regarding vehicle design, which means there will be less different vehicles available to the consumer.
- It will be difficult for the consumer to create a vehicle and be allowed to use it on the road.
- Creation and assembly are mostly left to companies.
- Customization will occur, but not in the extreme way as it is possible in the get on top scenario.

In this scenario the amplified walker will still thrive. Due to the lagging communities the big manufacturers will find applications for the new technique first. Customization through the different building blocks will therefore remain limited. However, because the individual is still of some importance in the steady as she goes scenario, companies will eventually offer customization options.

13.3 Conclusion

The concept of the amplified walker is quite robust. The technical principle of the amplified movement is in all three scenarios a solid concept and can survive all the three scenarios effortlessly. Customizing the design of the amplified walker using the building blocks is in the 1984 scenario not viable, but even without this modularity the amplified walker is still a very useful mobile apparatus and will flourish in all three scenarios.

Appendix

14 Trend analysis

The main trend for electrical mobility is: “There will be an increase in small(er) electric vehicles aimed at travel in the city”. This main trend will be substantiated with the use of local trends which will form factors for the main trend. These local trends are divided into the following five categories:

- Social
- Political
- Economical
- Technical
- Lifestyle

14.1 Social

The population of a country is not a passive given. The number of people in a country is growing or decreasing. The inhabitants are moving towards big cities or to more rural areas of the land. The trends in the social category are the following:

- Urbanization
- Increase in number of cars per household

14.1.1 Urbanization

People´s need for more mobility will influence the method of travelling. As can be seen in the following graph, population growth will decrease in the least populated areas and increase in the already densely populated areas. An increase in prosperity will result in an increase in car ownership and an increase in average travelled distance. Other factors such as changes in family composition, the position of the woman (more women work nowadays, creating an increase in commuter traffic), education levels, etc also influence the need for mobility (Harms, 2008).

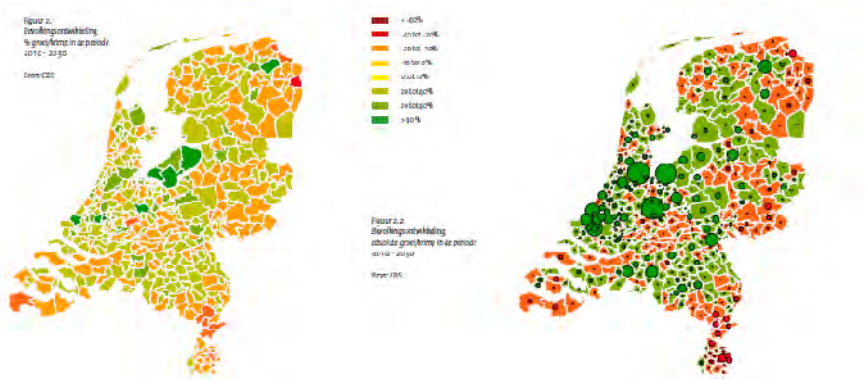


Figure 25: Increase of urban areas

We can also see this in the travel distance factor. As can be seen in the graph below, 91% of all drivers travel less than 150 kilometers per day. Combined with the change in population spread the urbanization will only increase in the upcoming years.

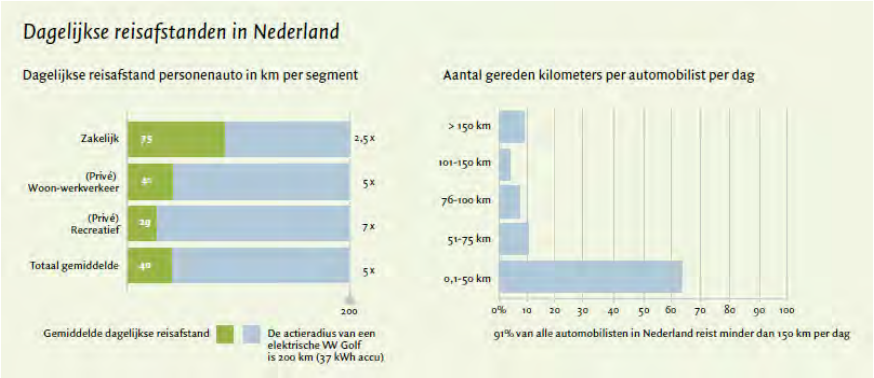


Figure 26: Travel distances

14.1.2 Increase in number of cars per household

In the graph below it can be seen that in the previous years there was an increase in both number of cars and driven kilometers per person. The line describing the amount of cars per household is linear and will grow in the coming years. The line describing the amount of driven kilometers will flatten out at the end of the graph, yet still remain to slightly increase.

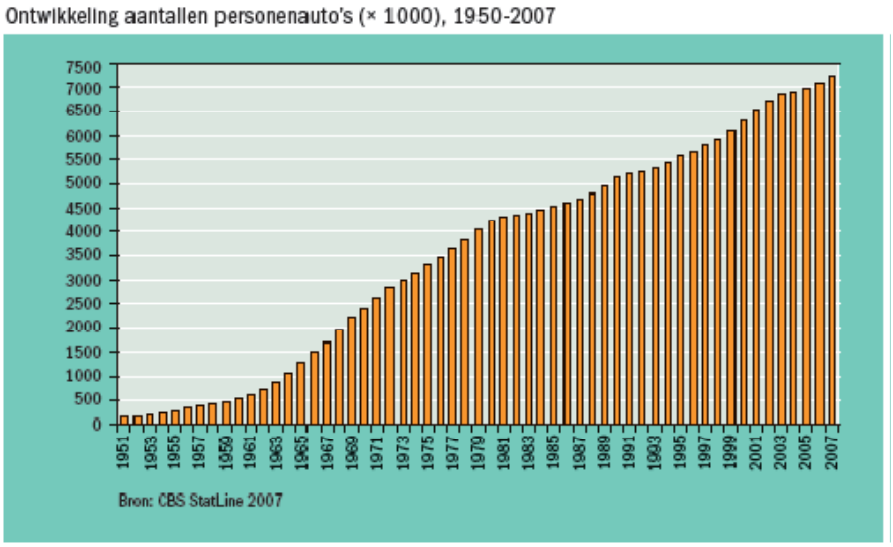


Figure 27: cars per person

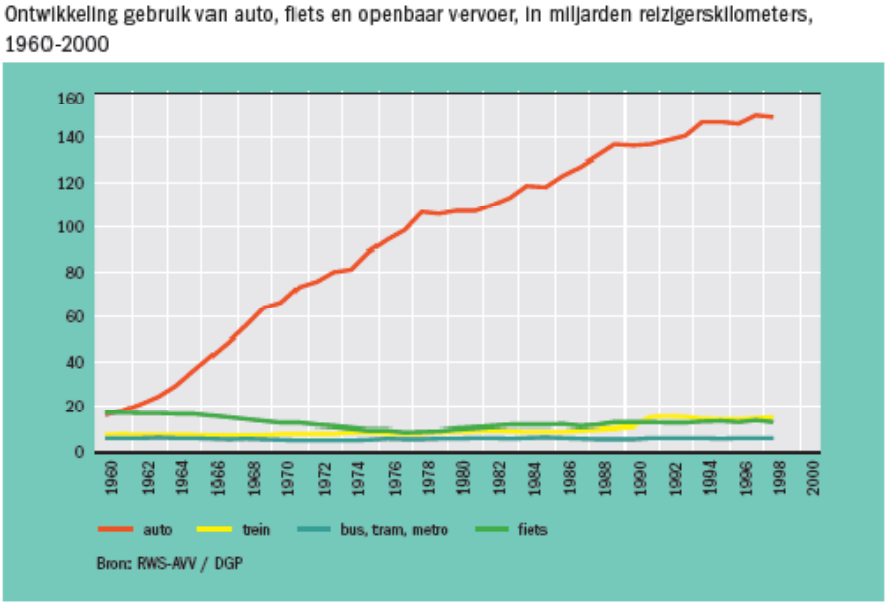


Figure 28: Use of alternative transportation

A change in family composition and the fact that the average maximum age is still increasing means there will either be more (especially elderly) drivers or that they are seeking mobility in another form. This has an effect on the purchased vehicles as can be seen below, simply because elderly have relatively more to spend. This can be witnessed with hybrid cars already, as is displayed in the graph below.

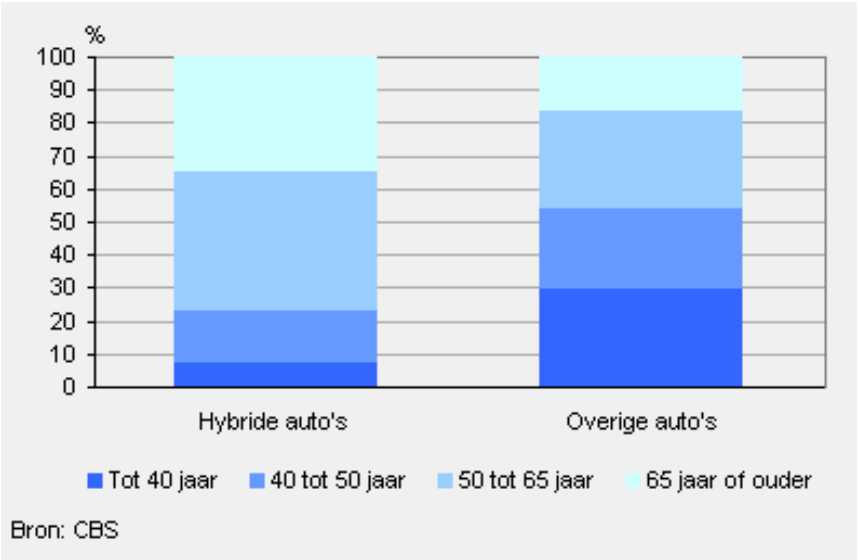


Figure 29: Age and hybrid

14.2 Political

The following political trends can be identified:

- Government spending
- Government subsidized policies
- Other policies (i.e. banning polluting cars from city centers)

14.2.1 Government spending

In the following graph the investments that governments of countries with emerging economies make on renewable energy is shown. A drastic increase since 2001 is seen, with an exception in 2008. This possibly is due to the economic crisis at the time.

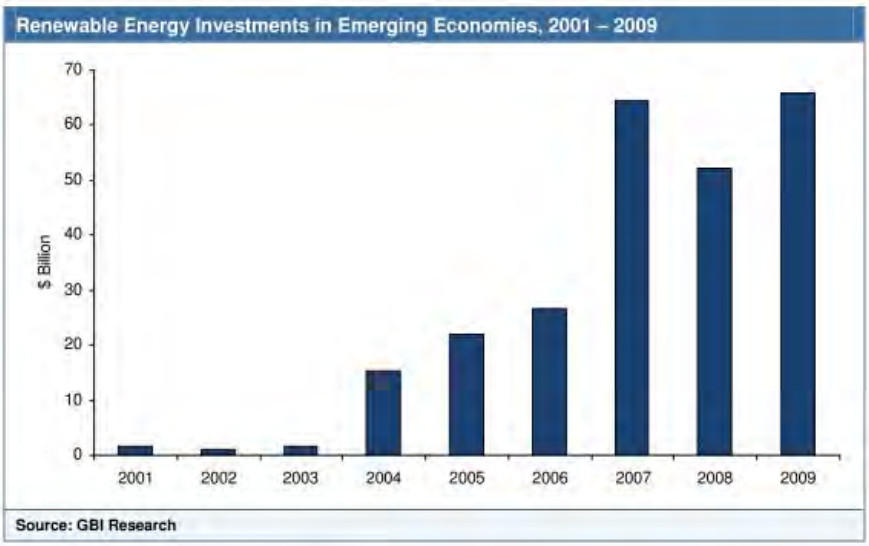


Figure 30: Renewable energy investments

It can be seen that the investments are every year increasing. For the coming years the investments will continue to rise. Till 2030 this growth will not continuing to be linear but still increasing.

14.2.2 Government subsidized policies

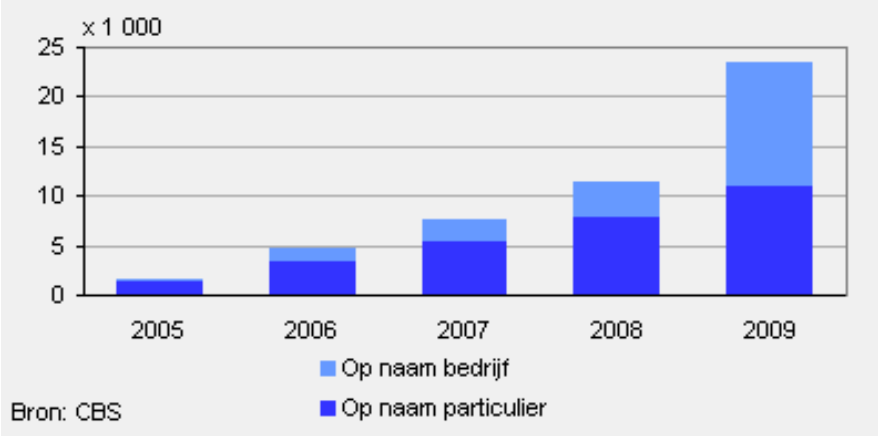


Figure 31: Dutch government inventives

The government can force technological advances that are otherwise not seen due to the profit reasons. These advances normally have a highly social impact. An example of this can be seen in the graph above – in January 2008 the Dutch government introduced a fiscal addition of 14% for fuel efficient cars, as opposed to the 25% that applies to other cars. From the graph it is clear that measure has had a big influence on fuel efficient cars used by businesses.

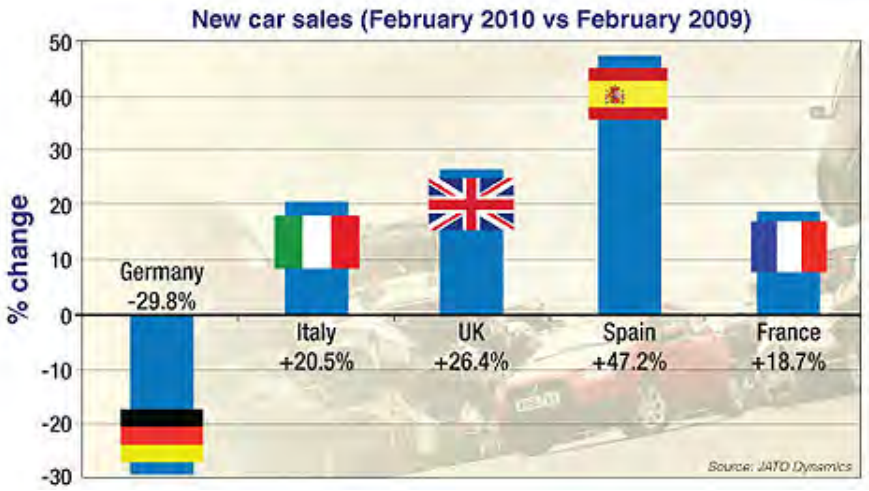


Figure 32: Influence government incentives

Government incentives such as a cash rebate for purchasing a new car when an old car is traded in led to a boost in new car sales. When Germany ended its program, the result is seen in the above figure. The other countries continued with their programs.

Nowadays there is a fiscal addition on green cars in the Netherlands. This incentive influences the sale of green cars. This trend may be not valid anymore in 2030. The government wants to promote new technologies, as soon as they can stand on their own feet a fiscal addition is not needed anymore.

14.2.3 Other policies

Since the 1960's, city centers have introduced car-free areas banning polluting cars in an effort to increase the quality of the air. An example of one of these cities is given in the figure below. It shows that since 1962 the amount of car-free areas in Stockholm has only increased over time. Similar developments are seen all over the world.

Figure 33: Car-free Stockholm

The trend for car free city zones will continue. Due to urbanization and green mobility solutions, emission cars will be banned from the centers.

14.3 Economical

The following economical trends can be identified:

- Purchasing power
- Energy prices
- (Hybrid) car sales

14.3.1 Purchasing power

Since the early nineties, the purchasing power of Dutch citizens has steadily increased. A peak is seen in 2001. After the peak, the purchasing power decreases drastically until around 2008-2009 a slight increase is seen. Seeing as purchasing power generally remains constant over the years and fluctuates in a certain pattern, not much change is expected until 2030 and is inspected to increase the coming years, respectively.

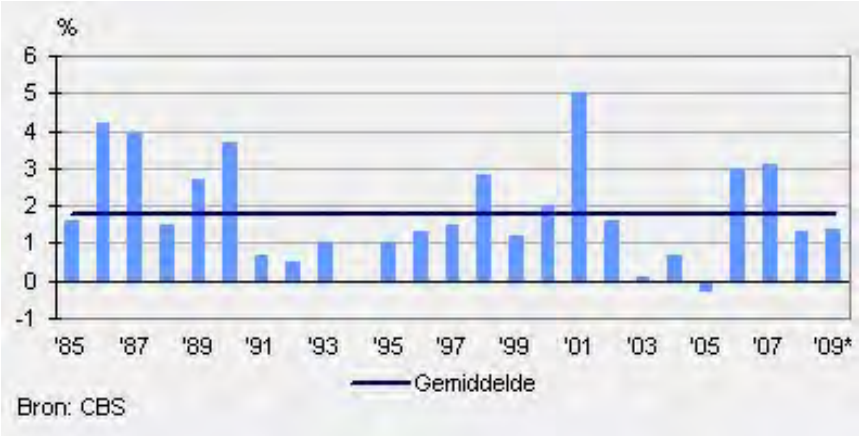


Figure 34: Purchasing power

This is supported by the following graphs which show the income of people from 1996 to 2005. Here again a peak is seen in 2001, followed with a decrease.

Figure 35: Income

14.3.2 Energy prices

In the following graph, it is clearly shown that oil prices have only increased over the past decade. Since demand remains to increase while reserves decrease, the price of oil is expected to grow even larger in 2030.

Figure 36: Oil barrel price

Alternative energy sources, as a new technology, began as very costly means of energy. As can be seen in the following graphs, the cost per kWh produced by these alternative sources had significantly decreased

since its initiation. As the technology continues to develop, the price should continue to decrease in 2030.

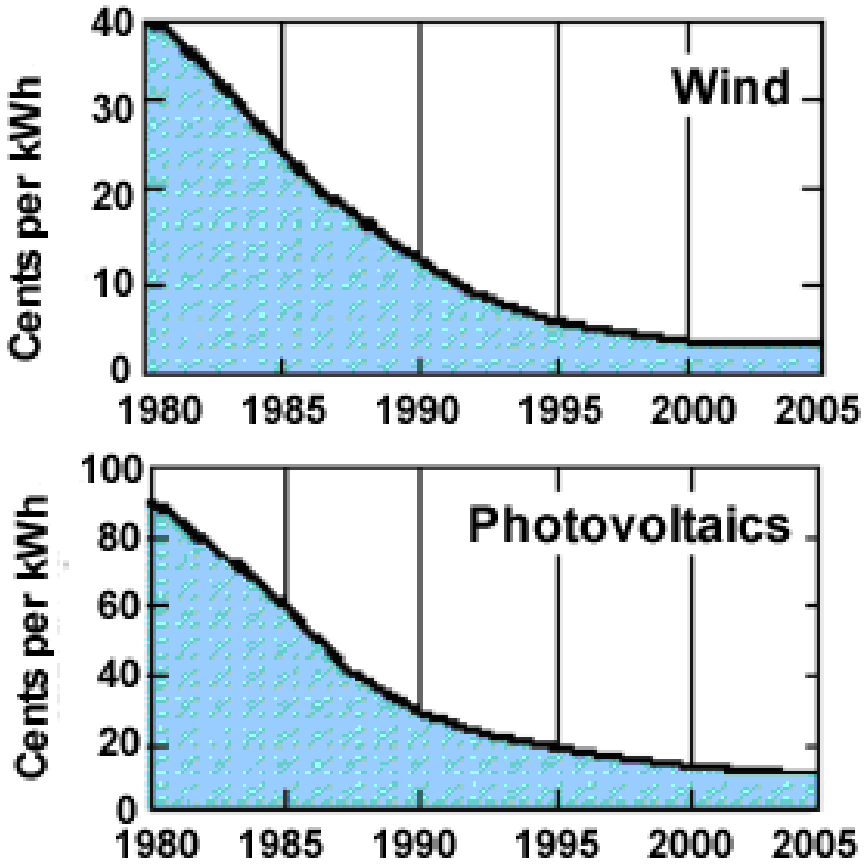


Figure 37: Costs alternative energy

With a lower price in alternative energy sources, it can be expected that these sources will contribute more to the total energy production, as can be seen in the following graph. An 8% increase is in comparison with the other sources significant.

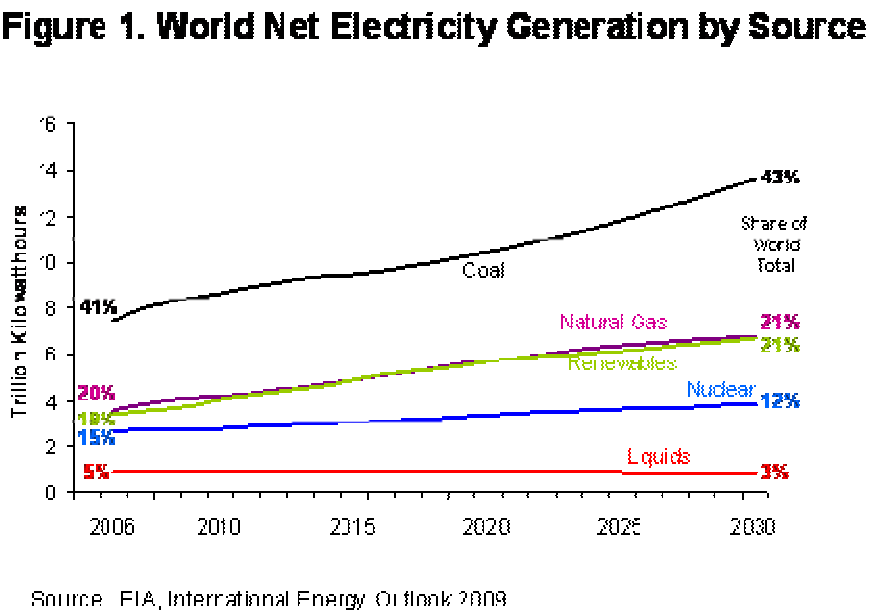


Figure 38: Electricity generation

14.3.3 (Hybrid) cars sales

Cars sales have steadily increased over the years, the figure below supports this statement for the years 2004-2009.

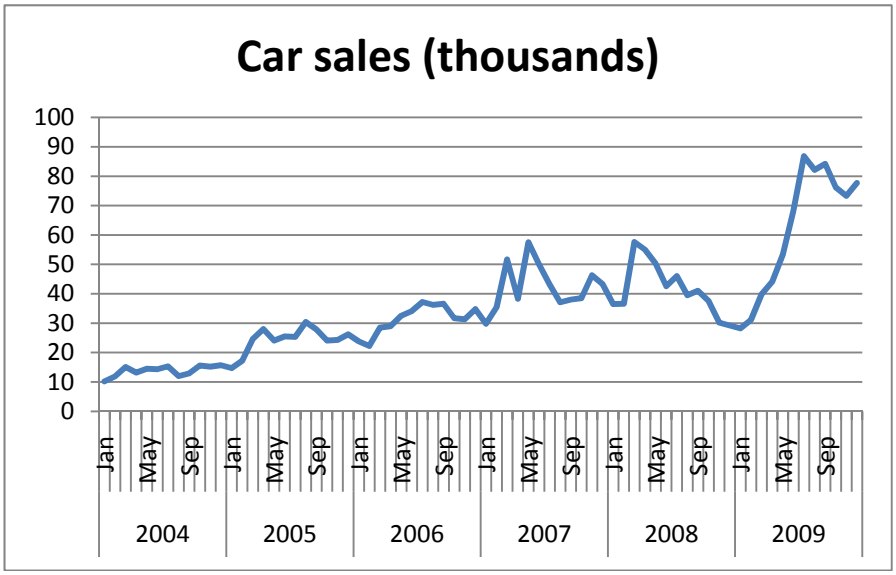


Figure 39: Car sales

This has many different reasons and a closer look focusing on hybrids reveals that the same is the case for hybrid car sales. Not only have more been sold, but a greater model variety is present each year. (See the figure below)

The trend will carry on for the next years. In the chart it can be seen that the growth is almost linear. Until 2030 the growth will increase but will not grow linear (due to market saturation).

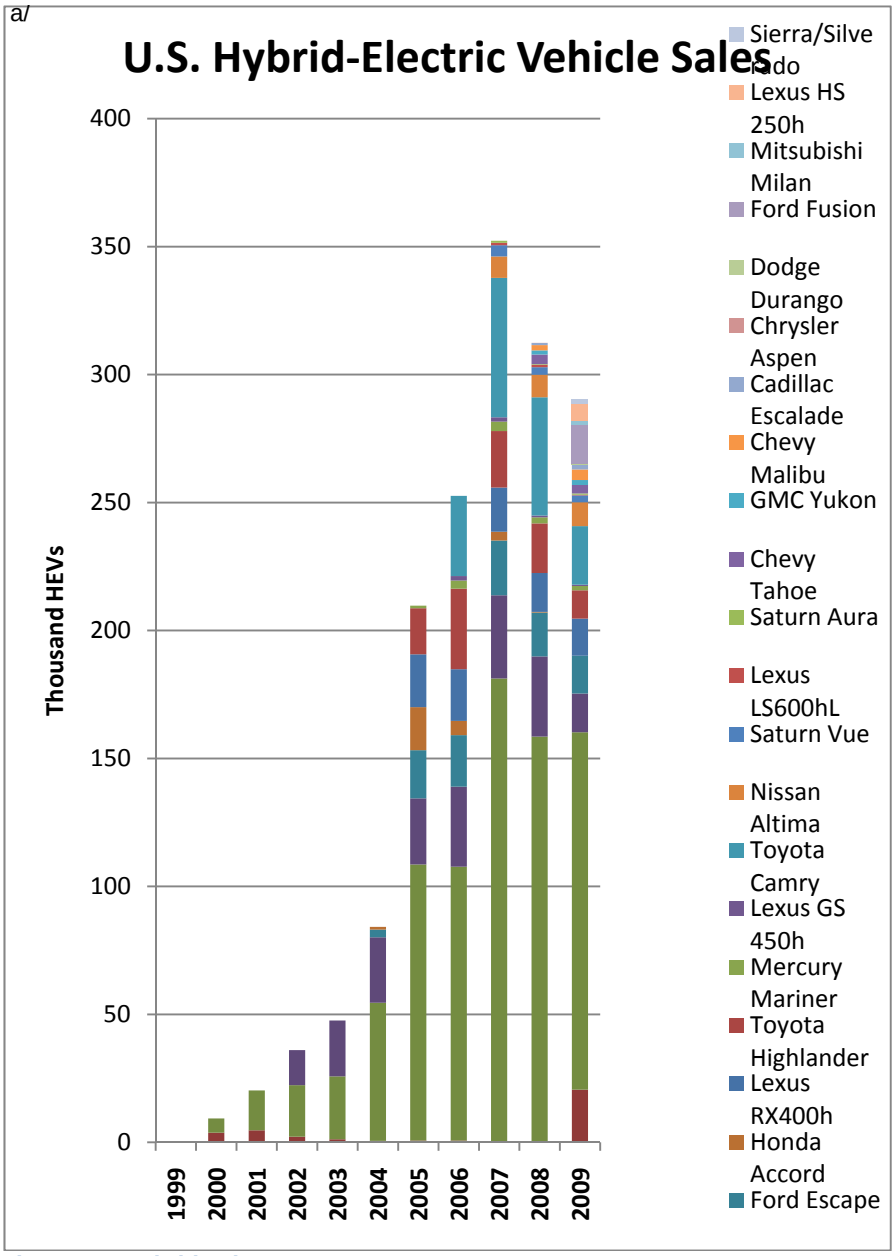


Figure 40: Hybrid sales

14.4 Technical

The following technical trends can be identified:

- Alternative fuels
- Battery development
- (Electro)motor development

14.4.1 Alternative fuels

The following graph displays the amount of certain fuel models offered over the years. Models with alternative fuels show a gradual incline: more and more models of cars are available as hybrids and ethanol. This incline is predicted to continue on the same path in the future.

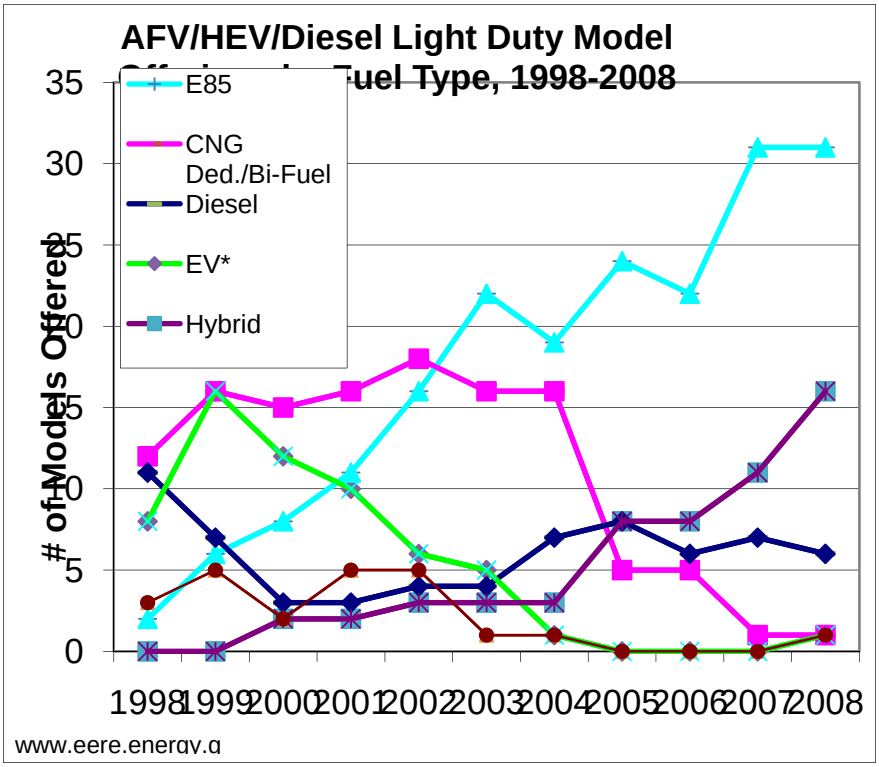


Figure 41: Alternative sales

* EVs do not include Neighbourhood Electric Vehicles, Low Speed Electric Vehicles, or two-wheeled electric vehicles.

14.4.2 Battery development

The technology of batteries is constantly improving to increase the energy density of the material. This has led to interesting developments, of which the lithium-ion battery technology is the most promising.

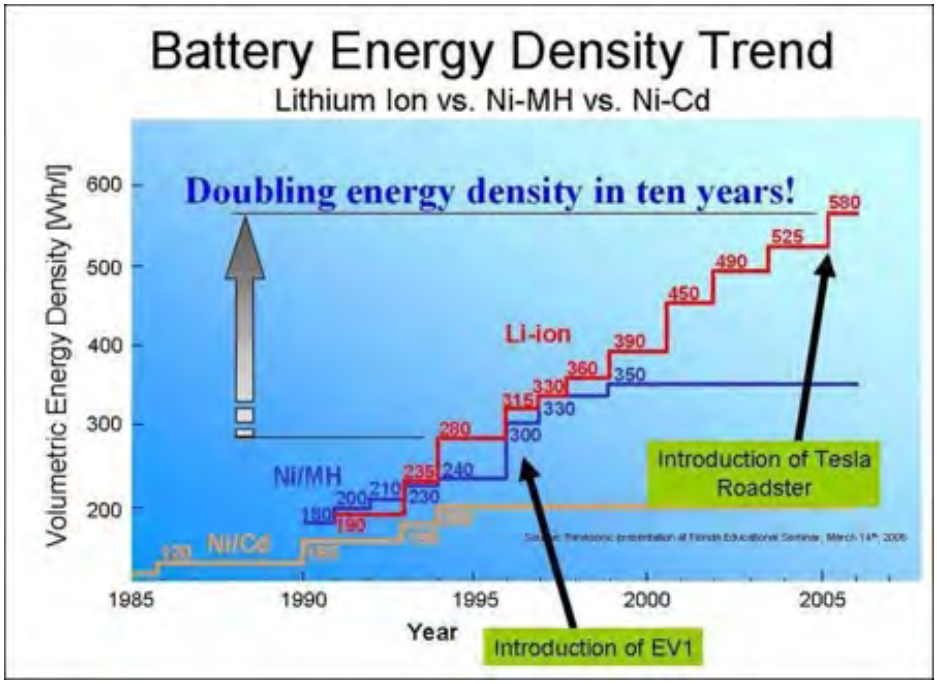


Figure 42: Battery energy density

The potential of this technology is reflected in the sales figures since its introduction: the market value figuratively skyrockets. It is also reflected in the changes in market demand for lithium cobaltite, a shift that could spark pivotal political changes.

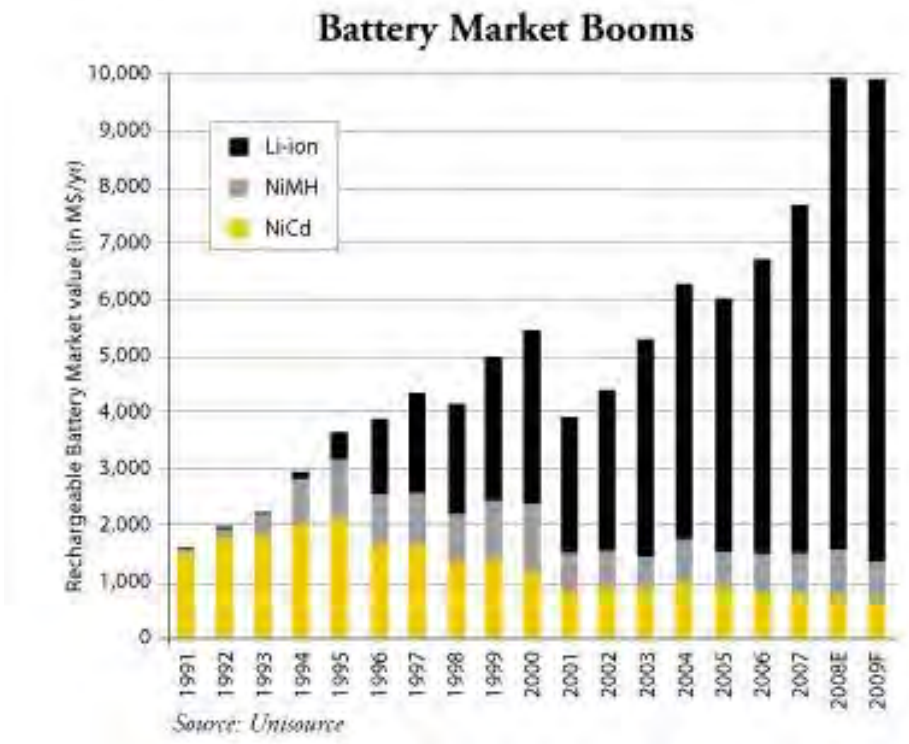


Figure 43: Battery market

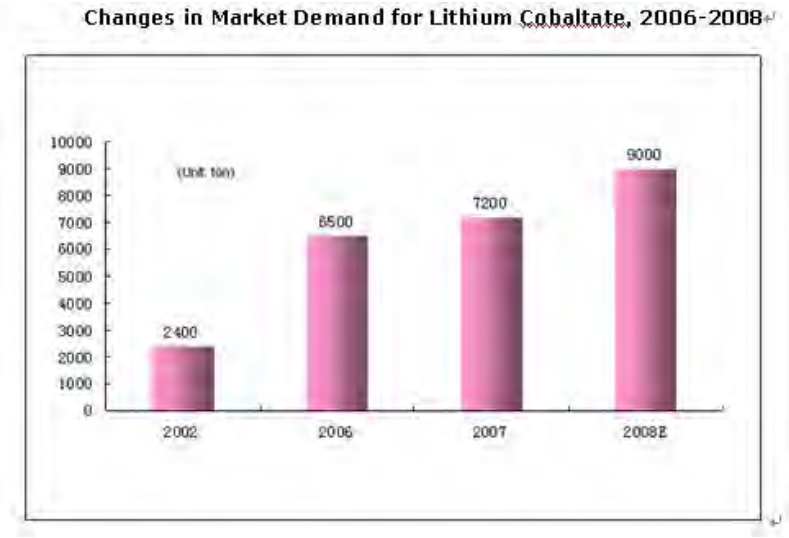


Figure 44: Demand lithium cobaltate

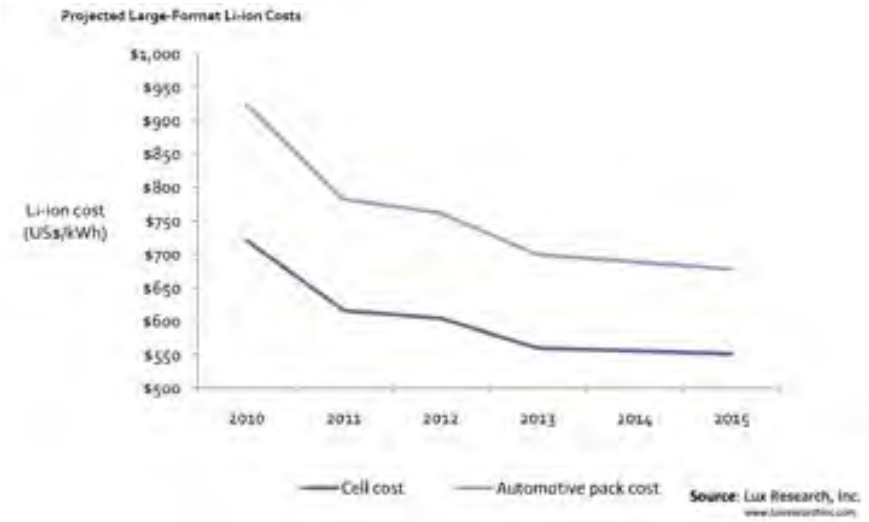


Figure 45: Li-ion costs

Costs of lithium-ion batteries are decreasing as well, which has a direct effect on the price of electric (hybrid) vehicles and investments made in the product.

14.4.3 Electro-motor development

Electro-motors are currently very efficient (above 90%) when used for high power applications. See the figure below. Smaller motors are less efficient (under 70%), thus there is definite room for improvement and development of smaller application motors. In 2030, it is predicted that these developments will create a much more efficient small electro-motor. These are factors which will facilitate the introduction of small electric vehicles.

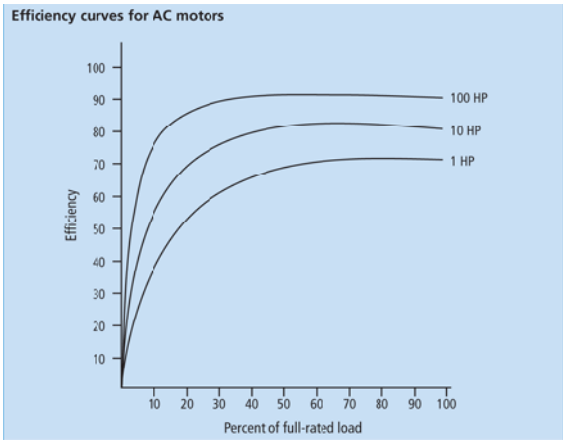


Figure 46: Efficiency electro-motors

14.5 Lifestyle

The following lifestyle trends can be identified:

- Status in environmental awareness
- Effect of the media

14.5.1 Status in environmental awareness

As green products have gone mainstream, their quality should be up to standard and should continue to improve as well. Consumers will not buy green products if it means less comfort and less quality to the consumer. According to Sofia Ribeiro, marketing expert from Kiwano marketing: “Green products can be a status symbol only if that means that green products provide, at the very least, the basic experience consumers would have with the non-green version. [..] So green products that compare equally to their non-eco counterparts will sell well; green products that miss the quality mark won't enjoy mass adoption”.

Green products as a status symbol can also be seen in the article “going green to be seen” (2). People do not go green out of altruistic reasons: they do it because it is a status symbol. However, because it is a status symbol, it is one of the first things to get rid of in time of crisis.

Another major shift of going green is rules and regulations set by the government. A lot of companies are already willing to create green products that have green labels and this number will continue to increase in the future. In 2030, people will care even more about green development and the environment than in our current society.

14.5.2 Effect of the media

The media has a strong social and cultural impact upon society. This is predicated due to their ability to reach a wide audience with a strong and influential message. The media constantly reports about the environment and climate changes. This makes it impossible for consumers to avoid being confronted with their behavior and this has an effect on the sales of green products. In the media, companies advertising with green labels and why they are contributing to a better environment. Another impact of the media is the attention on pollution and environmental pollution. This will affect the trend of going green and being aware of your own environment.

Manners to provide this information is e.g. television broadcasting. Television broadcasting has a large amount of control over the content that the society watches and how often it is viewed. Also, newspapers play a role in spreading information and being critical. A fairly new phenomenon is the Internet. The internet provides information which people can research and debate in topics and articles. This creates space for more diverse political opinions, social and cultural viewpoints and a heightened level of consumer participation.

15 Delphi studies

In this section interesting items will be selected that are relevant to the trend analysis earlier in this report. Any mutual coherence will be analyzed to detect differences or similarities with the trends found. For a clear overview, the results of the Delphi studies are categorized in the same manner as the trends.

15.1 Social

In the trend analysis it came feasible that more people will use a car. More people will move to more urban areas of the country. Therefore the infrastructure will need to expand in the bigger cities.

From the Delphi studies we can see that, with a probability of 58%, transportation will decrease (point 5 in the graph below). In the trend analysis we saw stagnation in the increase of the amount of driven kilometers per person. Our assumption that the amount of driven kilometers will not grow is feasible compared to the Delphi study.

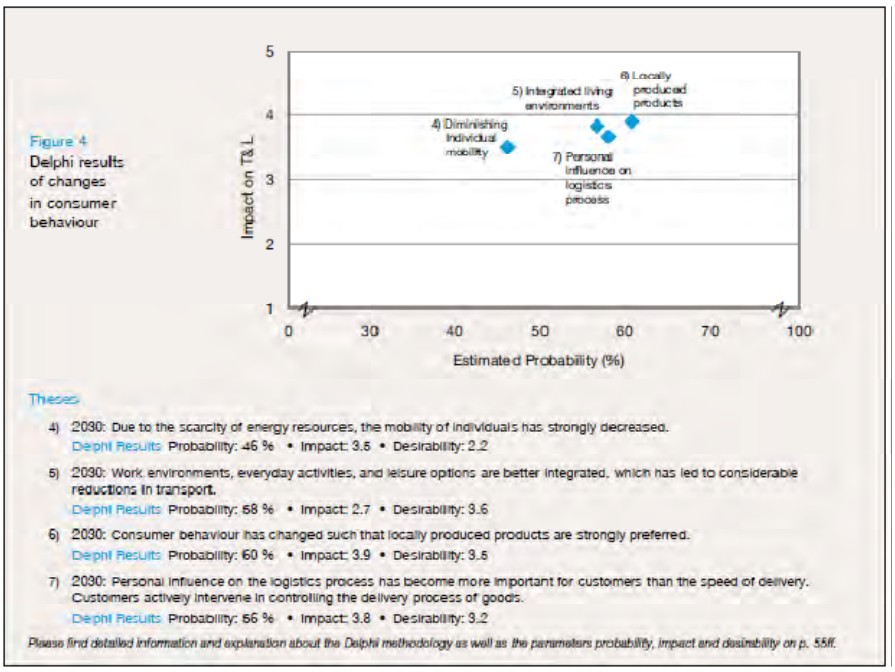


Figure 47: Consumer behavior

15.2 Political

Taxes and other government issued policies will ensure that technological advances will have social benefits – without such interference the chances of implementation are slim at best, simply due to costs. This matches the trend analysis which clearly shows how government issued policies can effectively influence consumer behavior. It will also greatly benefit environmental awareness and products linked to that topic.

The most important 10 topics

	Topic	Index	Year T*	Year S*
1	45: Technology for forecasting abnormal weather disasters resulting from climate change.	94	2015	2023
2	34: Technology for predicting and assessing global depletion of the resources that are used in Japan.	93	2012	2018
3	40: Energy consumption per capita in Japan reduces by half.	92	-	2031
4	44: Technology for minimizing the impacts of and restoring damage from large-scale industrial accidents.	90	2012	2017
5	42: Introduction of an automobile tax based on CO_2 emissions.	90	-	2013
6	14: Clean fuel (other than hydrogen) that does not emit particulates, NOx, etc.	90	2014	2021
7	09: Discovery of the seeds of new practical technologies for the safe disposal of CO_2 with long-term stability.	87	2017	-
8	01: Elucidation of the emission, absorption and fixation mechanism of greenhouse gases in a natural system as a result of climate change.	87	2014	-
9	50: Meso-scale (about 10-km mesh) precipitation simulation.	85	2011	2018
10	07: Development of a global monitoring system for marine pollution.	83	2014	2022

5	28: Manufacturers' responsibility for collecting and disposing of discarded products is defined by law, and recycling systems in which more than 90% of used material is thermal- or material-recycled become widespread. Design for recycle/disassemble technology, easy assemble & disassemble production technology , selective collection system technology etc. enable it to achieve.	91	2013	2021

Figure 48: Important topics

15.3 Economical

From the trend analysis we saw that the oil price will increase. From the Delphi study we get the same prognosis. The question is whether the price will double (compared with the 2008 price). Most of the participants agree with the thesis.

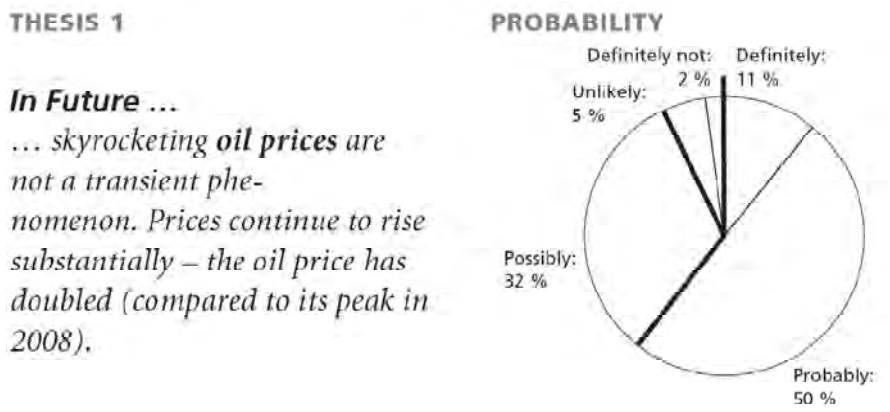


Figure 49: Thesis

15.4 Technical

The figures below are taken from Delphi studies regarding batteries. They forecast the expected decrease in costs and increase in power density of different types of battery technology. The figures quantify the trends already witnessed in the analysis.

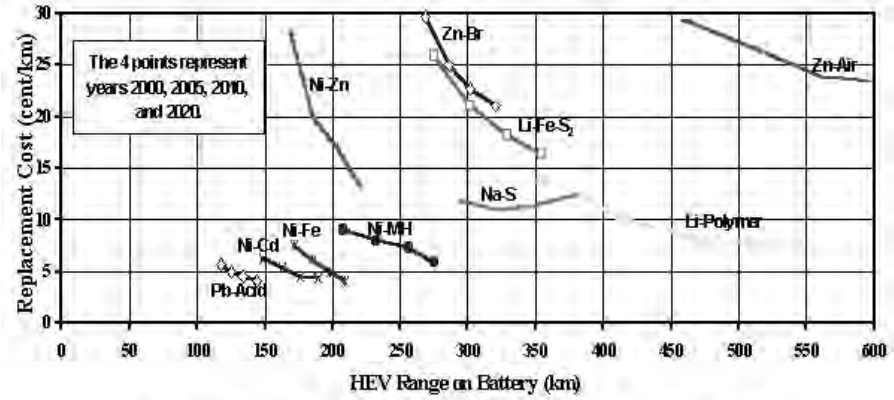


FIGURE 3. HEV Battery Replacement Cost and Range Associated with the Mean Power Requirements

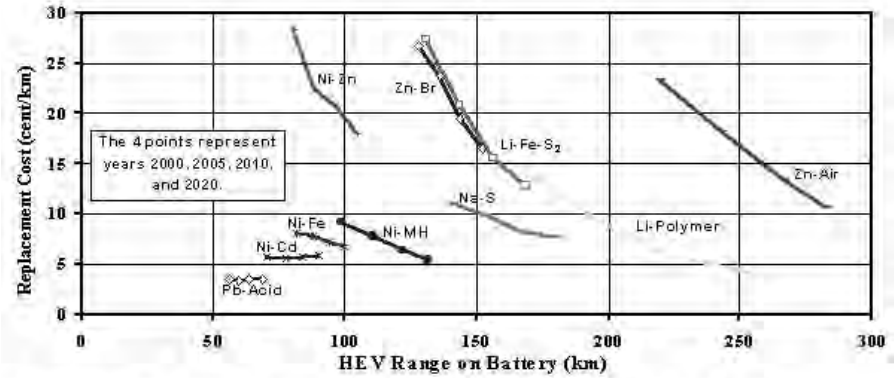


FIGURE 4. HEV Battery Replacement Cost and Range Associated with Half the Mean Power Requirements

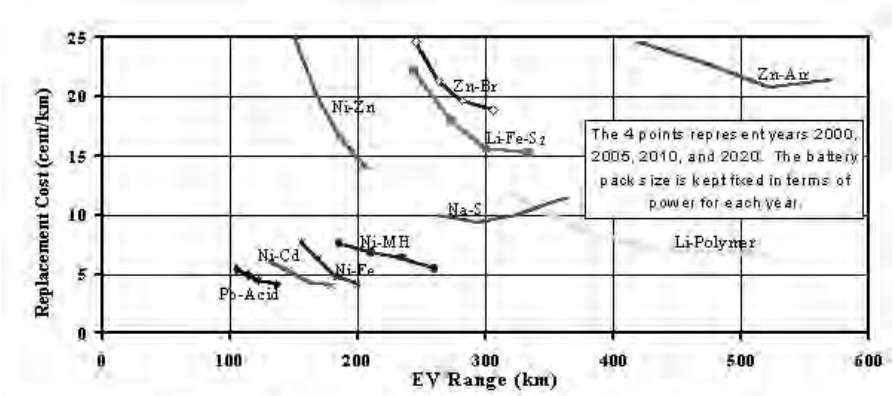


FIGURE 1. EV Battery Replacement Cost and Range Associated with the Mean Power Requirements

Figure 50: Battery replacement

Another development shown by Delphi studies is that in 2014 electric cars will be equipped with fuel cells – this deviates from the analysis. The analysis shows that the prices of fuel cells and investments thereof are much higher compared to battery technology.

50	Development of an energy-efficient and extended-service-life large passenger transport using composite materials in main structural elements.	1	85	13	22	65	54	22	51	27	0	78	35	15	9
		2	82	10	21	70	51	12	68	20	0	79	30	12	5
		X	8	100	0	0	75	50	50	0	0	75	50	38	13

		1	8	16	91	39	0	8	28	45	49	67	8	5	2	1	7	28	2	0
		0	2	12	91	40	0	5	26	48	50	73	2	1	4	1	4	32	1	1
		0	0	13	100	63	0	0	63	63	75	100	13	0	0	0	13	13	0	0

Topic	Importance index	Forecasted realization time
29:Widespread use of technology to reduce the harmful components of exhaust gas from large trucks to 1/10 of present levels, such as diesel exhaust catalysts, particulate traps, lean-burn NOx catalysts and high precision combustion technology.	88	2011
26:Widespread use of electric cars equipped with fuel cells.	83	2014
27:Reduction of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	67	2014

Figure 51: Topic

Delphi studies also show that non-fossil energy will be abundantly present in our near future, facilitating the development of electric vehicles. The analysis is less optimistic than the results of the Delphi studies, though costs are not mentioned in the Delphi results.

The most important 10 topics

	Topic	Index	Year T*	Year S*
1	27: Widespread use of production processes using low CO_2 emitting energy sources such as non-fossil energy (wind, geothermal, photovoltaic, solar heat, waste heat, etc.), cogeneration systems, stationary fuel-cell systems etc..	95	2014	2023

Figure 52: CO2

The decrease in energy consumption by 50% per capita in Japan is an interesting point. The ranalysis only shows an increase in energy consumption per capita, not a decrease.

15.5 Lifestyle

The Delphi studies show that it becomes increasingly important for companies related to product development to be aware of the environment, to the extent that it becomes a management standard.

05:Environment-friendly product development practices such as the introduction of "eco-design" or "green procurement" becomes a management standard.	80	2008

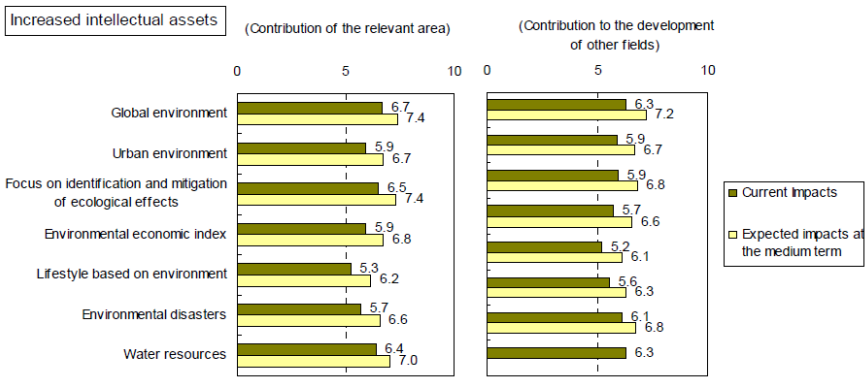
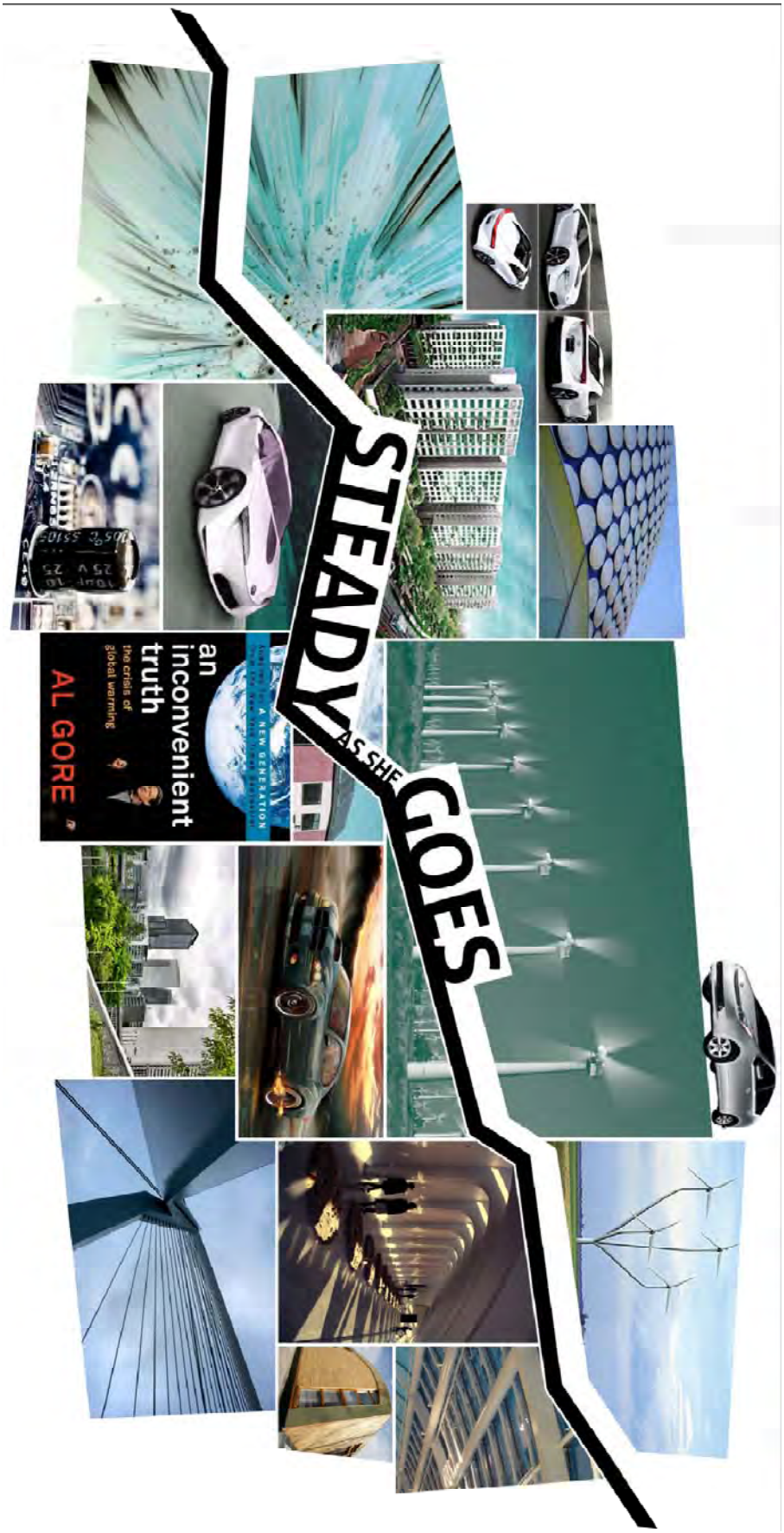


Figure 53: Impacts

16 Mood boards

16.1 1984

16.2 Steady as she goes



16.3 Get on top

17 References

17.1 References figures trend analysis

Figure 25

Krimp en Mobiliteit: Gevolgen van demografische veranderingen voor mobiliteit door Kennisinstituut voor mobiliteitsbeleid Maart 2010.

Figure 26

Nederland gaat elektrisch rijden. Bron CBS 2004

Figure 27

Overwegend onderweg, De leefsituatie en de mobiliteit van Nederlanders, Lucas Harms Juli 2008

Figure 28

Weblink CBS: http://www.cbs.nl/nl-NL/menu/themas/verkeer-vervoer/publicaties/artikelen/archief/2009/2009-2813-wm.htm

Figure 29

Weblink: http://www.gbiresearch.com/

Figure 30

Weblink CBS: http://www.cbs.nl/nl-NL/menu/themas/verkeer-vervoer/publicaties/artikelen/archief/2009/2009-2813-wm.htm

Figure 31

Weblink: http://qualityautosearch.blogspot.com/2010_03_01_archive.html

Figure 32

Weblink: http://www.metropolismag.com/html/content_0802/ped/index.html

Figure 33

Weblink: http://www.rtl.nl/%28/financien/rtlz/nieuws/%29/components/financien/rtlz/2010/weken_2010/28/0714_1030_Koopkracht-steeg-in-2009-met-1komma4-procent.xml

Figure 34

Weblink: http://www.nrc.nl/economie/article1711009.ece/Koopkracht_huishoudens_daalt_opnieuw

Figure 35

Weblink: http://priceofoil.org/2008/06/11/how-about-250-a-barrel/

Figure 37

Weblink: http://lib.wmrc.uiuc.edu/enb/2009/05/28/world-energy-use-projected-to-grow-44-percent-between-2006-and-2030/

Figure 38

Weblink: http://www.marklines.com/en/numproduct/index.jsp#hybrid

Figure 39

Weblink:
http://www.afdc.energy.gov/afdc/data/#www.afdc.energy.gov/afdc/data/

Figure 40

Weblink: www.eere.energy.gov/afdc/data/index.html

Figure 41

Weblink:
http://www.kk.org/thetechnium/archives/2009/07/was_moores_law.php

Figure 42

Weblink: http://www.crwenews.com/?p=22112

Figure 44

Weblink: http://www.luxresearchinc.com/

Figure 45

Weblink: http://www.appliancedesign.com/Articles/Motors/BNP_GUID_9-5-2006_A_10000000000000077613

17.2 Links

[1] "FREITAG–F-CUT", http://www.freitag.ch/shop/FREITAG/page/fcut_page/detail.jsf, last accessed 31st of October 2010.

[2] "SECTION9: iPhone RFID Reader", http://blog.section9.co.uk/2010/03/iphone-rfid-reader.html, last accessed 29th of October 2010.