

# Environmental Quality and Sustainable Mobility

## Road towards the circular economy



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*Preface*

This report is the final individual product of the 2<sup>nd</sup> years course; EQSM, Environmental quality and sustainable mobility. It deals with the possibility for a circular economy within the car sector. The report is written by one of the five students of the international Bachelor-degree course 'International Traffic and Transport Management' at the NHTV University of Applied Science in Breda, The Netherlands. The course took place in the last trimester of studyyear 2014-2015, between February and June 2015. The report has been delivered on Wednesday 10 June 2015 by Jelle Mertens.



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## 1. Introduction

For the last decades our way of living has been based on production and consumption by a linear model where raw materials are being used to manufacture goods for consumption. These goods can then be used until the economical or technical value has decreased to a point where the good is not used anymore where it is made for, and the good ends up as waste.

This way of producing and consuming is called the take-make-dispose pattern, which has started its great impact 150 years ago during the industrial revolution. This process leads to an ineffective way of using our raw materials and might lead to risk and the following up consequences for companies and consumers.

The linear economy as we know it, is reaching its limits. First of all the prices of resources get more and more unpredictable and the general resource prices have been rising for the last decade. The McKinsey&Company has created a Commodity Price Index for the last 120 years showing the prices of food, non-food agricultural, metals and energy. Shown in the graph is that since 1900 there is a downward trend in the index value from 180 to 100 in year 2001. From the year 2001 a tipping point can be seen where the prices go up rapidly and are currently at a value of 240 points. This shows the increasing scarcity of these raw materials over the last decade.

Other than the raw material prices there are other signs that the linear economy is at its limits such as the reducing increase in efficiency in factories. The gains made by making a process more efficient are still there but do not create a substantial different anymore. Other limits that can be thought of are the renewal of licences, which can be hard for companies that extensively use the resources of a local market.

In this report the automotive industry as it is at the moment, together with the potential changes will be described. In the second chapter a definition for the circular economy will be given and a comparison between a linear and a circular economy will be made. Also the transition opportunities will be described.

In the third chapter a description will be given on what circumstances have an effect on the circular economy, which might fasten the transition period. In the fourth chapter the circular economy within the automotive industry will be analysed. First a scan is made of the current automotive industry after which the requirements will be described which need to be fulfilled to create a closed circle. The three requirements are based on the energy consumption; return flow of cars and the fuel consumption of motor vehicles.

First of all the basic requirements of the application of the circular economy within the automobile industry will be described in the next chapter. After the requirements are set two scenarios will be described; the automotive circle and the mobility revolution.

At the end the writers opinion about the reachability of the circular concept within the automotive industry will be given followed by the conclusion.



## 2. Towards a Circular Economy

In this chapter the basic principles of the circular economy will be described together with the linear economy. This chapter is mainly based on the publication "RoadTowardsCircularEconomy", published in 2014 as the project Mainstream of the World Economic Forum. The project has been set up in collaboration with the Ellen MacArthur Foundation, a charity aiming to provide information and promote the circular economy and McKinsey & Company, an American policy consultancy company.

### 2.1. Circular economy

"A circular economy is an industrial system that is restorative or regenerative by intention and design." According to the World Economic Forum Publication.

"It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models."

So 4 main topics are mentioned in the definition; the transition towards reusing products, the usage of clean energy, use of non-toxic and therefore environmental friendly material, and the redesign of products.

#### 1.1.1. Biological materials

Within the circular economy, differentiation is made between Biological materials, consumable goods, and technical materials, durable goods. The consumable goods mainly focus on the different use of the material after its first use and the use of non-toxic and environmentally friendly materials, so this process is becoming easier. The concept is made to reduce waste production, or produce waste in such a way that it generates profit for the environment to grow a new product. This way the circle is round and the waste will be processed into a new use. The basic idea is; the product is being produced and used, after which it will be collected and reused. For example a shirt is worn out and recollected and used for pillow filling, after the pillows are at the end of their life cycle the material can be used for isolation. At the end of the isolation materials will have to be replaced, and the material can be extracted and restored into the ground, after which new goods will grow. These materials will then be used to produce new consumable goods. One really important restriction in this process is that all the electricity used, has to be from a renewable origin; such as wind or solar energy.

#### 1.1.2. Technical materials

The durable goods have a lot of overlapping characteristics; first of all the durable goods will also be used for their particular purpose. After this first life cycle they will be maintained and, in contradiction of biological materials, reused for the same purpose. This process can be repeated several times until the value is too low to reuse. Then the product can be remanufactured into a new or other product. After this is not possible anymore and all separate parts have reached their technical and economical limits the materials will be separated and recycled.



## 2.2. Opportunities

To make a transition between the make-use-dispose patterns to the circular economy, there must be advantages for both consumers and producers. In other words, there must be a value creation for making the transition. This value creation can be made with different strategies; first one being the inner circle. The inner circle refers to what extend a product has to be maintained or remanufactured to be reused. In this principle counts the tighter the circle, thus the less has to be changes, the more savings can be made and the cheaper the creation of the new product will be. Secondly circling longer, meaning increase the amount of reuses will add value to the products. Moreover the cascade model can be used to increase the effectiveness of the circular model. The cascade model represents the usage of a product after its regular life cycle for another use. So after product has been used for several times for their primary goal, they can be (partly) dismantled and used in other industries. Finally the value creation will be maximized when the inputs are pure, and therefor easy to dismantled and restore in the ground without harming the environment.

So a circular economy could save money for manufacturers, and therefor products could be cheaper and more accessible for all people, without harming the resources of the globe. Apart from this production saving the circular model can have advantages concerning the supply risk for manufacturing companies, product innovation, the labour market and the soil quality.

By reusing and remanufacturing product, a supplier can sell its products several times without having to buy raw material to construct a new product. Instead it can remanufacture or simply resell the original product. When this is not the case anymore the product can be disassembled and recycled and therefor there is no need for new raw material. This has the advantage of reducing risk of supply of resources.

Furthermore innovation can be stimulated by the transition from a one-way production to a circular production, where the value of a used product will be higher, because it can be disassembled and only several parts can be replaced. Now the products are not completely redesigned but only parts are replaced, and ideally only for this would be paid by the consumer. This way the life cycle duration might decrease, but the amount of life cycles can increase, which gives the producer the opportunity in developing and especially implementing innovations faster. For example a car which is used for 25 years after which the value has decrease to only a fraction of the purchase price, only once in 25 years the manufacturer can provide this customer with a new innovation. In the faster lifecycle a consumer can come back with the car after 10 years to remanufacture his engine, with an engine with more efficient technology.

In the recent decennia machines and robots, especially in the production companies, of both raw material and end products, are replacing jobs. In the circular economy, jobs will be created in both the remanufacturing and recycling business to get the most out of the raw materials.

The circular economy first of all aims to decrease the amount of waste, the leakage point, and the waste which is still created will be non-toxic and therefor not harm the environment. These two aspects together make that the method can lead to a more healthy and less polluted soil.

So, the circular economy is subdivided in consumable and durable goods, in which both can



add value by mean of narrowing the inner circle, increasing the amount of circles, the use end-of-life products in another sector and the regulation of the raw materials used in products. With this transition production can become cheaper, while resources are being spared, the risks for companies and consumers decrease, there is more space for innovation, different kind of jobs will be created and the quality of the earths soil can increase.

### 3. Why now?

In this chapter the timing for the transition will be explained, the main goal is to give an insight in the reason why there is a need for the transition towards a circular economy now. Several factors will be mentioned which have an influence in the need and the implementation of the new economical model.

#### 3.1. Limited resources

The world population is growing as never before, before 2025 one billion more people will be living on earth, with a total of 8 billion<sup>1</sup>. This increase in world population will lead to a increase in demand for both consumable and durable goods, but it does not stay with the growth of the population. Especially the middle-class consumer, with a lot of spending power, is increasing due to the upcoming development countries. In these countries citizens become richer and have more spending power, which will also lead to an increase in goods demand. These new costumer groups will start buying more 'high-class' products instead of more natural, self grown products. This might lead to and shift to packages products.

To keep up with this rising demand a lot of natural resources are needed. With the current consumption and recycling rate several of these raw materials are expected to run out within the next 50 years. A circular economy will release some of the pressure of these natural resources and therefor prolong the availability of the resources.

Apart from the need to shift away from the linear economy there are several favourable social and geographical changes, which allow the transition towards a circular economy. One of these is that in several countries the preferences are shifting away from ownership. More people than before are open for sharing and therefor do not have to posses certain items. This non-owning principle means that one object can be used for several personas and will therefore be more used. For example car sharing can prevent cars to idle for 23 hours a day, instead several persons per day can use these cars. This asset productivity can lead again to a lower demand; which means that fewer cars have to be produced for the same amount of people and providing still the same service. Because the maintenance is in this model spread over a bigger group of people, the usage cost of the service can decrease. This concept is also possible for other markets, such as lighting. Philips is currently offering the 'light service', which means that Philips will install lights, but will keep being the owner. If the lights are broken they will replace it, and will take the old light with them, so they have a 100% return flow. Also this is an example of the shift away from ownership.

The earth wide level of urbanisation leads to a more effective opportunity to centralize the reverse flow and to reach the costumer easier. Because of the shorter distances and the high

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<sup>1</sup> (Population pyramid, no date)



density, reverse flows from for example waste will become cheaper and therefore more accessible.

Also different kind of technological developments will accelerate the development. The Internet and the presence of the smart phones and applications allow the share economy to develop. For example finding a shared car is really easy and fast, but other than that, the car can be opened and started via the mobile application. Also developments like reverse treatment technologies, which help to recycle used products, are beneficial for this transition.

Finally the regulations from governments in the recent years have rewarded steps towards a circular business model. For example the European Union aims in the White book for 20% less energy usage by 2020.

## 4. Mobility revolution

In this chapter the applicability of the Circular economy into the automobile industry will be described. In this report not only the production, reuse and recycling of this industry will be considered, but also the usage of the automobile. In order to achieve a fully circular situation also the consumption within this particular market needs to be taken into account. The information in this chapter is based on; “the Circle scan analysis” by the CircleEconomy to the Automotive sector and “the mobility revolution” by Lukas Neckermann.

### 4.1. Current Automotive Industry

The challenge is to not only make the production, but also the usage and end-of-life phase of the automotive circular. Looking at the current production of cars, noticed is that most cars are produced using raw material, these materials are bought by the car manufacturer. After the raw materials are produced and bought the manufacturing process can begin. All the completed cars are then sold to individuals or companies, in the Netherlands still 80 per cent of all the households own at least one car,<sup>2</sup> in total this is about 8 million cars only within the Netherlands.<sup>3</sup>

Most of the cars on the road are driving on fossil fuels, which are not only not renewable, but also produce emissions. In European perspective 73 per cent of all mobility is done via the car, where train and bicycle are both only 8 per cent and metro and walking only 2 per cent.<sup>4</sup>

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<sup>2</sup> CBS

<sup>3</sup> (Automotive Circle Scan, 2014)

<sup>4</sup> (Automotive Circle Scan, 2014)





Transportation by car with fossil fuels is, from these alternatives, the most polluting and environmentally unfriendly mean. These combustion engines create CO<sub>2</sub>, that much CO<sub>2</sub> that the whole car branch is good for 18 per cent of the total CO<sub>2</sub> pollution within the Netherlands.<sup>5</sup> After the car has been used for an amount of time by its first owner it will be directly sold to the next user, or will be redistributed via a third party company or the manufacturing company. At a certain time the car has lost its economical or technical where it is not profitable anymore using it for what it is made for. This can be because the maintenance costs are getting to high, but also because after an amount of time regulations regarding to taxes change. This can lead to a situation where buying a new, more fuel efficient car, will have the effect of saving money, because of the tax advantaged. At the moment that the owner cannot find a new owner anymore for the car it will be trashed, most likely brought to a car dump. Here it will be partly disassembled for the parts where the car dump can make money with, the rest will be partly harvested and recovered and partly used for landfill.

This means that in the current automotive industry raw materials are being used for producing the cars, energy is used to produce the parts and assemble the car, after which it goes into the usage phase. In this phase it is most likely to idle most of the day, and run on fossil fuels the rest of the day. After its life cycle it will either find a new owner or being partly disassembled and partly used for landfill. This method is highly polluting and requires a big amount of raw materials to be produced per car.

## 4.2. Circular automotive industry

For the creation of a circular transportation market based on cars there are several requirement and scenarios, which are possible. The requirements are points, which in any case need to be taken into consideration to create the circular system, based on the in chapter two mentioned characteristics of a circular economy. Rabobank and the book “the mobility revolution” by Lukas Neckermann base the scenarios on the “automotive Circle Scan”.

## 4.3. Requirements

Within the automotive industry several phases consume energy, such as the manufacturing, assembling, recycling and potentially the usage. To close the circle and therefore the leakage points, all this energy which is being used has to be produced on a green and renewable way. Let this be solar energy, wind energy or another kind of renewable energy. Secondly the car manufacturing process needs to be changed in a circular way. The situation where cars are being produced by raw materials on the one side, but on the other side of the chain cars nearly the same raw material are being used for landfill is not sustainable and requires the use of new raw materials for the same product. Car manufacturers therefore need to arrange to get the full backflow of their sold fleet, after the cars arrive back at the factory, usable parts out of the old car can be used in a new car, other materials can be recycled and used in the manufacturing of the new fleet as well.

To allow this process to go smoothly and cheap, the cars and other motor vehicles need to be designed on such a way, that they are easily dismantled. If the parts can be separated easily from each other, it is more efficient to reuse products out of the end-of-life cycle cars. For the third requirement it is necessary that all cars are driving on a renewable, green fuel. To make sure there is a zero emission, cars need to drive without a regular combustion engine. This

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<sup>5</sup>(Automotive Circle Scan, 2014)



alternative fuel can vary between multiple options, most important is that also the energy needed to produce this alternative fuel needs to be produced by a renewable source.

#### 4.4. Scenario 1; automotive circle

From the total travelled distance in Europe per year, almost three quarters is travel by car. Apart from this the car ownership is in our culture, it is a status symbol which needs to stand in front of your house, or which you take to work or leisure. At the same time walking, taking the bike, taking the train or the bus are still used a lot less. For many trips, long and short the car is being preferred. Because of this high split of the car within the mobility market and the regular working hours within most companies, there is a high peak in traffic. This high peak in traffic leads to congestion for commuting traffic, a full working week per year in congestion on average in Netherlands. After the trip has been completed these cars need to be parked, these same cities are getting more full every year due to the urbanisation in Europe. These cars are than being parked for 22 to 23 hours a day, not allowing space for public space or infrastructure for alternative transport modes.

So the problem in short, nowadays more cars drive on alternative fuels, so they do not solely have combustion engine, but this percentage is still really small. By far the biggest group within these alternatively fuelled cars is a hybrid, which are still able to drive on its combustion engine. Part of the reason why travelling by car is not a fuel efficient way of travelling is that with moving a car, not only the person, but also the +/- 1.400 kg of the car itself is being brought to every destination.

So, to allow a completely circular and emission free transportation market, the percentage of car usage needs to decline from 73 per cent to less than one quarter, according to Automotive circle scan by Rabobank.

Half of the travelled Kilometres can be done by mean of public transport, by providing good transport connection on both short and middle long distance, the bus and train can become more attractive than taking the car. The bus can make short distances within cities, it is able to run fast connection, and in some situation have a shorter route than the car. For the middle long distance the train can be faster than the car, if there is a good connection between the station of arrival and the end destination. This can be in walking distance, reachable by bike or by public transport.

The advantage of bus connection above private cars is that the amount of persons within one vehicle increases, and therefore the m<sup>2</sup> per person on the road. These busses, depending on the size, can take up to 148 passengers.<sup>6</sup> Because a public transport company owns these busses, the type of engine is easier to regulate than for private vehicles. A governmental organisation can change the concession process in such a way, that from the next concession

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<sup>6</sup> (Noord, no date)



period only applications with alternatively fuelled busses will be accepted. In this last case the cost for the transport organisation might rise, which should not be calculated through in the ticketing price, since this should be competing to car usage. To overcome this price difference governmental organisation can, at least in the first year where the technology is very expensive, subsidize these public transport companies.

For the longer distance the train, with a capacity of one up to two thousand passengers<sup>7</sup>, is a very good option. Trains are one of the safest and efficient ways of transport. They make use of own infrastructure, which means they will not cause extra congestion on the roads. More than half, 52 per cent, of the rail road kilometres within Europe are electrified.<sup>8</sup> These travellers kilometres can therefore simply be made green, by changing the power which goes into the rail network with power from a renewable source and no changes have to be made on the consumer side.

By providing dedicated infrastructure also the bike can become an important stakeholder in the mobility market. With providing cycle lanes the safety and the speed can be guaranteed for cyclist, which will make the mean a lot more attractive. In situations where geographical challenges do not allow normal city bikes, electric bikes can be a solution to overcome this height difference.

The leftover 25 per cent of transportation kilometres can still be transported by car. Because of the decrease in car usage, expected is that the roads will be less congested, so that travellers have less delay. To optimise the multi modality where travellers can chose out of, it is important to not get stuck to daily behaviour. When all modalities are equality accessible and a fair price comparison can be made for every trip, travellers will be more flexible in their mode choice. To get to this situation the transition from ownership to on-demand, semi-public transportation is introduced. This semi-public transport principle where cars are not owned, but used as a service, will allow travellers to make a comparison between time and cost of both car usage and public transport, this can make the other means more attractive. This will increase the use of the assets and therefor reduce the idle time, when cars are more in use for driving they are less parked. Which means there is more space on the street available for other purposes.

These companies owned cars would be fuelled by a renewable source, so it shifts away from fossil fuels. For the system in general it does not matter which fuel this is, as long as it is completely renewable. Depending on the technological developments determined could be which source will be the most suitable for this transportation system.

With the transition from ownership to semi-public transport several travellers can use one vehicle, even on one day. Because the vehicle is used for many kilometres, efficiency

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<sup>7</sup> (VIRM | Treinen van NS, no date)

<sup>8</sup> (EU Transport in Figures 2012 - European Commission, p33)



improvements and innovations will have a big effect. For example a car used for 200.000 kilometres per year saving 1 kWh per 100 kilometres has more effect on cost savings than a car which drives 20.000 kilometres per year. Therefore the improvements to vehicles will become more profitable.

To allow this process to be more efficient and to maximize reuse of parts instead of recycling, the cars used for this system will have to be produced in such a way that they are easily disassembled, so that parts can be replaced or reused into other vehicles. When the car is completely at the end of its life, it will be returned to the company where it is produced. Because the vehicles are used more effectively there is less demand for cars, which means that also the production will decrease. This decrease in new car production can be won back at the increase of car improvements and to the recycling of old vehicles into new vehicles, creating a complete closed loop. Whether the owners of the shared cars are car manufactories, public transport companies or third parties is not defined yet, and depends on how the market grows.

To conclude, the first scenario would lead in decrease in car usage. Mainly the public transport sector would gain a lot of travel kilometres, but also the slow means as walking and cycling will increase. These can become more efficient and require less assets per person for transportation and are safer than using the car. Necessary for this is a good public transport network and safe pedestrian and cycle facilities. The car user ship in the first scenario is decreased to 25 per cent and the vehicles are owned by a company, making car usage a service. This will lead to faster innovations, 100 per cent return flow of the vehicles and a fair competition between the modes.

#### 4.5. Scenario 2; the three Zeros

In the Automotive circle scan the main focus is laid on the change of the modal split, and therefor make it possible to close the circle. At the three zeros mainly focus on; Zero emission, zero accidents and zero ownership. These three principles should make the transportation of people emission free, but will also improve the quality of life by the introduction of autonomous vehicles.



The car industry as is seen with the three zeros principle does not have private ownership of cars, but moreover does not have manually driven cars anymore. Technologies by Google, but also by other car manufacturing and technology companies have developed systems which allow cars to drive them selves. In several countries in the world the autonomous car is allowed to make test runs, and Google is expecting to reach the 10 million kilometres very soon. Expected is that by 2020 autonomous cars are available for the market. The autonomous car on itself already brings some advantages; cars do not get tired, can steer more straight and have a better feeling for keeping the speed and releasing the throttle before intersections. Furthermore autonomous cars can detect object which people cannot see, such as a kid behind a car or a cyclist in the blind spot. These first principles count for the situation where there are both autonomous and self driven cars on the road.

In the situation where there is dedicated infrastructure for the self driving cars, the whole situation changes beyond limits. Imagine, a road where every car knows all the details such as direction, destination, speed, etc, about every other car. Not only that, but the car also knows the road, the regulations and when the traffic light will be green again. This allows cars to communicate with each other about speed or distances between each other. Than can adapt their speed when driving towards a traffic light so no unnecessary acceleration is needed and the flow of traffic is better regulated. Also distances between cars can be reduced, so that capacities on motor ways can increase.

Taking into account that more than 90 per cent<sup>9</sup> of the total road accidents are being caused by human failure the amount of accidents is expected to drop. But not only in this 90 per cent can be reduced, also the remaining 10 per cent is expected to become nihil. These accident free roads will allow even a better throughput of traffic, making traffic congestions phenomena from the past.

The self driving vehicle have got another advantage, just like in scenario 1 the vehicles will be owned by a company and will become a semi-public transport. The advantage of the self driving car is that they can reposition them themselves. Now there is no need anymore to walk a couple of metres to a available car, but a car can be ready in front of your door. This will lead to both a advantage to the rural areas, which are now also connected to the network with the same service level, but also for the cities. Because all search traffic in cities will be gone, the car knows where there is space; there will be less traffic in the city. Going a step further, cars that can drive themselves do not have to park in the centre of a city but can wait for a suitable time to move out of the city and park on a more appropriate place.

Bottlenecks for the autonomous car are the big stakeholders in the current car industry. Not only oil companies will lose, but also car manufacturing companies will sell less cars, construction companies will have less roads to construct and even car insurance companies will be harmed. Some of these stakeholders are very powerful and will have a big influence on politics and the acceptance of the system

Apart from the legal boundaries there is also a social issue, most people nowadays are aware of the fact that driving a car yourself is less safe than letting a computer drive a car. Even

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<sup>9</sup> (Volvo truck, European accident reseach and safety report, 2013)



though this is generally known and believed, there is a resistance against self-driving cars, simply because people do not want to be killed by a computer.

Coming back to the concepts;

Zero emission. This is rather straight forward, the need and the technology is there to shift away from fossil fuels towards renewable fuels. This is one of the main factors how Zero emission will be reached. Looking at the overall concept of the three zeros, more factors are influencing the total emissions positively. The other influence will be mentioned in the next parts.

Zero accidents. The autonomous car will be able to reduce car accidents and might be able to get rid of car accidents all together. The feeling of safety in the car is not always fair, approximately 1,2 million people are dying because of car usage every year. For air traffic to become as unsafe as car traffic, 20 big airplanes will have to crash every single day.<sup>10</sup> Nevertheless there are still thousands of people killed all over the world because of cars. The reduction of this number will lead to a better living condition.

Zero ownership. To reduce the amount of cars needed to reach the needed service level for cars the ownership needs to be replaced by a sharing system in the form of semi-public transport. Not only the fleet size will be reduced but also the return flow of cars to the manufactory can be maximized and the innovation can be stimulated.

Furthermore for the mobility revolution the vehicles and the factories need to be run a renewable energy source. Also the cars need to be made from previously collected and reused or recycled cars. The three zeros are not based on changing the behaviour of users of the automotive industry but on changing the system in such a way that that it can be optimally used. It will get safer and faster on the road and quieter in the streets.

## 5. My opinion

Before the economical crisis of 2008 the environment and the effect we as earth inhabitants have on the globe was a big topic. Almost every night new discussions and arrangements were made. In the crisis this was more of secondary importance, but now in 2015 it is coming back. Recently the G7 has made the announcement in Bayern, Germany, to take measures to not exceed 2 degrees global temperature increase. These are signs that the environment and the dangers of this are an important topic of conversation and are more and more taken seriously.

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<sup>10</sup> (Neckermann, 2015)



Even though the problems and the possible solution are known behaviour of people does not change. Driving an electrical car changes the technology and not the way of transporting. This is in my opinion the big challenge nowadays, we have become so used to technology that we think it will solve problems for us. Making use of governmental regulations I think that the fossil fuels will be changed by a renewable energy source over time. Also the return flow of vehicles can be improved.

The society change will, especially within the new generation, shift more towards a sharing system in which cars can be rented and not owned. But even these services are not nation wide yet, especially not Europe wide. Which means that also this process will take several generations to fully develop.

In my opinion, I believe that the whole automotive industry will change towards a circular standard very gradually, until a point where the need for change is that clear, and the environmental impact of our behaviour is already that far developed, that we can simply not do different than change our behaviour, to safe the world and to increase world population health and standard of living.



## 6. Conclusion

The impact of the linear economy is clearly visible, raw material prices are instable and risk for both consumers and companies are rising. A shift towards a circular economy, where there are no raw materials needed and there are no emissions, is becoming more realistic. The circular economy is subdivided into two categories; the consumable and the durable goods. Looking at the car industry mainly the durable, technical circular economy is applicable.

The limits in resources make the need to shift towards a circular economy needed in the time where we live now. Not only the limited resources, but also the worldwide urbanisation makes the circular economy a favourable solution. Due to the urbanisation backflows will have a shorter distance and are therefore more effective. Apart from that the circular economy can create jobs in recycling and remanufacturing. Lastly the current governmental goals and regulations stimulate and reward green and circular initiatives.

At the current state energy is being used to create, use and to dispose cars at the end of their life cycle. The energy used in this process is just partly from a renewable source and therefore very polluting. The alternative, the circular economy can be the solution.

To create a circular economy within the car industry all the energy needed to produce and to reuse and recycle the cars need to be produced via a renewable source. Furthermore the backflow of the cars needs to be arranged so that all the produced cars can be reused or recycled. Also the fuel used for the car needs to be renewable and not a fossil fuel.

In this report two scenarios are described, the first is the automotive circle. A principle which focuses on the change of the model shift. More kilometres can be travelled by foot, bike and public transport and therefore reduce the car kilometres. The cars would be owned by companies and used as a semi-public transport and therefore be more competing against other modes. Another advantage of the company owned vehicle is that the backflow is better controlled and that it can stimulate innovation, due to high asset utilization.

The second scenario, the mobility revolution, focuses more on the technical rather than the behavioural change and describes the automotive industry as an automated industry. The three zeros; zero emission, zero accidents and zero ownership represent the characteristics of the method. The autonomous cars could communicate with each other to achieve capacity goals for the roads and reduce traffic accidents. A major advantage of the self-driving cars is that they can reposition themselves and can therefore be used more effectively and consumer oriented.

To conclude, there is a need for a shift from the current automobile industry towards a greener and renewable method. There are a lot of technologies ready, but eventually behaviour and policy need to change before anything will happen. When this will be... Hopefully in the near future.





### Sources

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