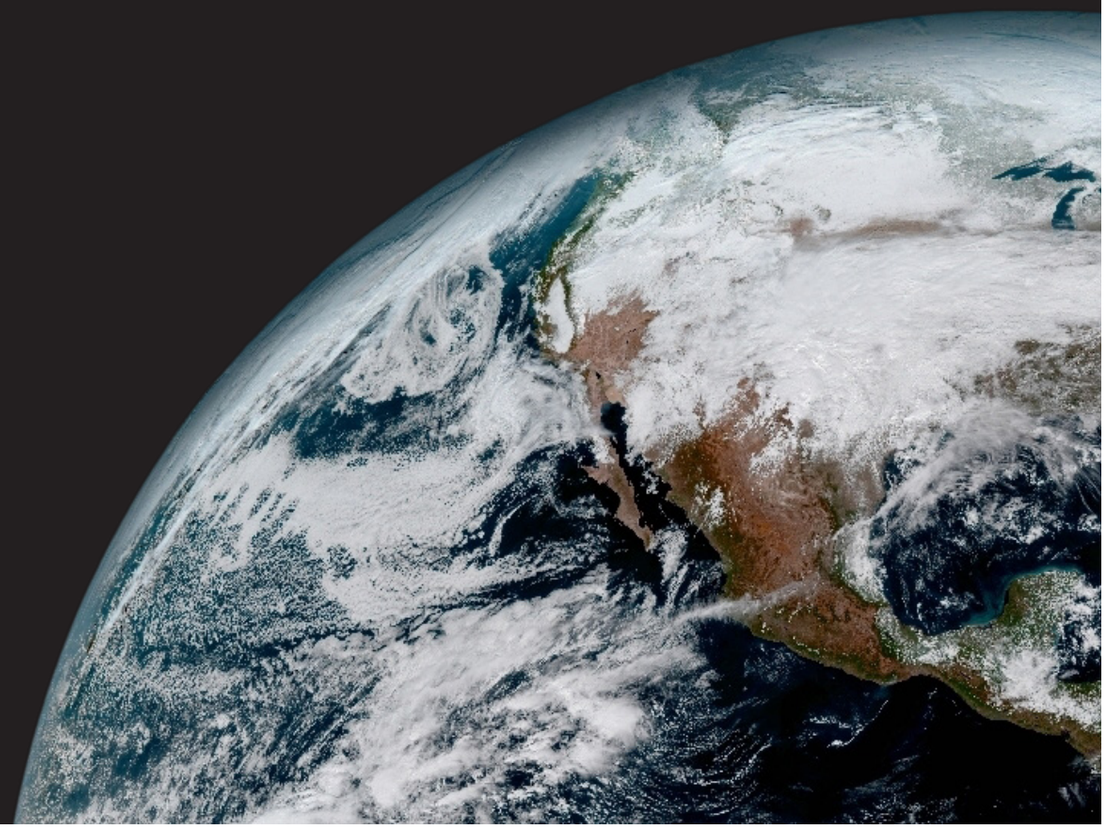
LIGHTYEAR

MISSION

Lightyear

We are Lightyear. We are going to improve the world by making electric driving available to anyone, anywhere in the world. Every year, all the cars in the world together drive one light-year. By doing so, they destroy our world. It is our goal to have the world drive a light-year on solar power by 2035. Our goal is to contribute to a sustainable world.

- Team Lightyear



light-year *[lahyt-yeer, -yeer]*

noun

1. *Astronomy. the distance traversed by light in one mean solar year, about 5.88 trillion mi. (9.46 trillion km): used as a unit in measuring stellar distances.*

Abbreviation: lt-yr.

The Team

Lex Hoefsloot
CEO

Arjo van der Ham
RESEARCH & DEVELOPMENT

Koen van Ham
DESIGN

Qurein Biewenga
FINANCE

Martijn Lammers
STRATEGY

Djanini Markovic
ELECTRICAL ENGINEER

Tessie Hartjes
RELATIONS

Maijke Receveur
BUSINESS & MARKET

Misha Bekker
ELECTRICAL ENGINEER

Mathijs Brands
COMPOSITES

Bas Groenen
ELECTRICAL ENGINEER

Rens Melsen
STRATEGY & FINANCE ADVISOR

Dennis van Iersel
COMPOSITES

Gijs Ramaekers
PROCESS ENGINEER

What is the key to success?

De The 5 founders of Lightyear are alumni of Solar Team Eindhoven. With this student team we built two iterations on solar cars, Stella and Stella Lux. These cars are designed to win the Cruiser Class of the World Solar Challenge, a class that takes in consideration not only speed, but also energy consumption, the amount of people taken on the the ride and how practical the car is. Both times we have achieved our goal there; We became world champion.

Our story began in 2012 with no more than a white sheet of paper: No experience, no network, no money, only 20 young dreamers. Armed with our common sense, a touch of naivety and a healthy dose of enthusiasm, we started a journey that is still continued today. Looking backwards, it's easy to forget about the long hours we made, the heated discussions and stress. For example, a week before departure, our trip to Australia was canceled because the solar car was not allowed to fly. Or the despair after 3 failed attempts and two weeks of lost work to a tightly designed interior part out of the mold.

Those moments are forgotten when you dance on the finish line.

In 13 months, we went from a white sheet of paper to the winning solar car in the World Solar Challenge. I personally think that perhaps the most beautiful during that period might have been the reflection afterwards. How many sponsors, family, friends, TU/E students, citizens of Eindhoven, have not worked on Stella and Stella Lux? One hundred, two hundred, three hundred people? If we can develop a solar car in such a short time, what else can we dream about? What is the key to success? How does the concept actually fit into current trends? When are solar cars ready for the market? After some years, many of these questions are still unanswered and others can be answered with reasonable certainty. The passion has never disappeared, and strengthened with 5 years of experience, wisdom and reflection, we are ready for the next challenge.

We are Lightyear, a group of young dreamers with various skill sets and backgrounds, but with a common mission; Making the world a little better together.

We publish these insights because we strongly believe that we can make the world a bit better by working together. The more people want to contribute, the faster we can get the world off its oil addiction.

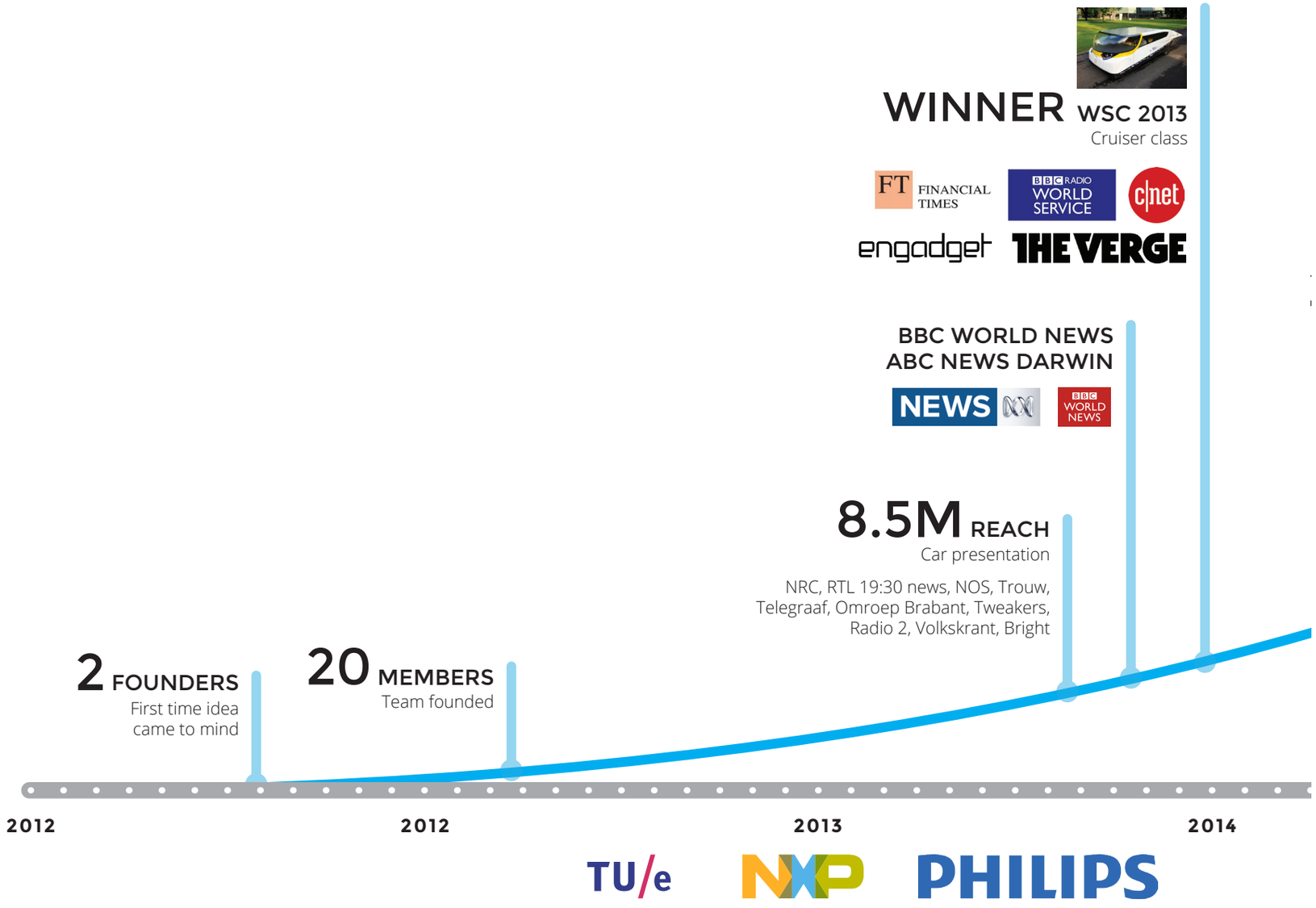
- Lex Hoefsloot, CEO Lightyear

“If I were to point out a group of talents ready and prepared for a mission like this, then it’s Lightyear. The World Solar Challenge was just the beginning, this team is developing itself surprisingly fast.“

Maarten Steinbuch

Professor in Systems- and Control at Eindhoven University of Technology (TU/e)

Figure 1: Our history: The making of family cars powered by solar energy.



ENERGY POSITIVE
FAMILY CAR, STELLA LUX PRESENTED

2ND TEAM STARTED

HIGHWAY 1
CALIFORNIA ROADTRIP

Brabant Development Agency BOM IBM GEFCO

WE BEAT APPLE, SPACEX, ESA, BLOCKCHAIN
CRUNCHIE BEST TECHNOLOGY ACHIEVEMENT

VB TC

WINNER WSC 2015
Fastest qualifying lap time
Cruiser class

SHANGHAI


LIGHTYEAR

FOUNDED
5 ex-Solar Team Members
ready to take the next step

2015 2016 2017 2018

VDL ERICSSON Eneco

*Selection of sponsors

Mobility is a need

No change in the 20th century has transformed the appearance of our streets and cities quite like the car. Streets, parking lots, highways, gas stations, traffic lights, through learning on our feet they have allowed us an easier and more comfortable life. Today the car is our most valuable property after our homes. It is a piece of technology that we trust with our safety, it takes us on holidays to southern Spain.

Research also indicates that mobility is not only a means but also an end in itself. Historically, people have always traveled for an average of 1 hour and 6 minutes (Cloin, 2013). First on foot, after that by horse and now by car or public transport. The duration of our daily mobility needs is not rising, but a faster means of transport gives us a greater reach. That brings more destinations at your fingertips: visiting friends, days out or daily shopping.

Now that in the West almost anyone can benefit from this piece of freedom and comfort, the progress seems to have come to a standstill.

Cars have been roughly the same for almost 50 years, driving still as fast, and are not really cheaper.

Cars have been roughly the same for almost 50 years, driving still as fast, and are not really getting cheaper.

Nevertheless, it seems the once so rigid car industry will soon be reborn. We face huge challenges, but also a world of unlimited possibilities.

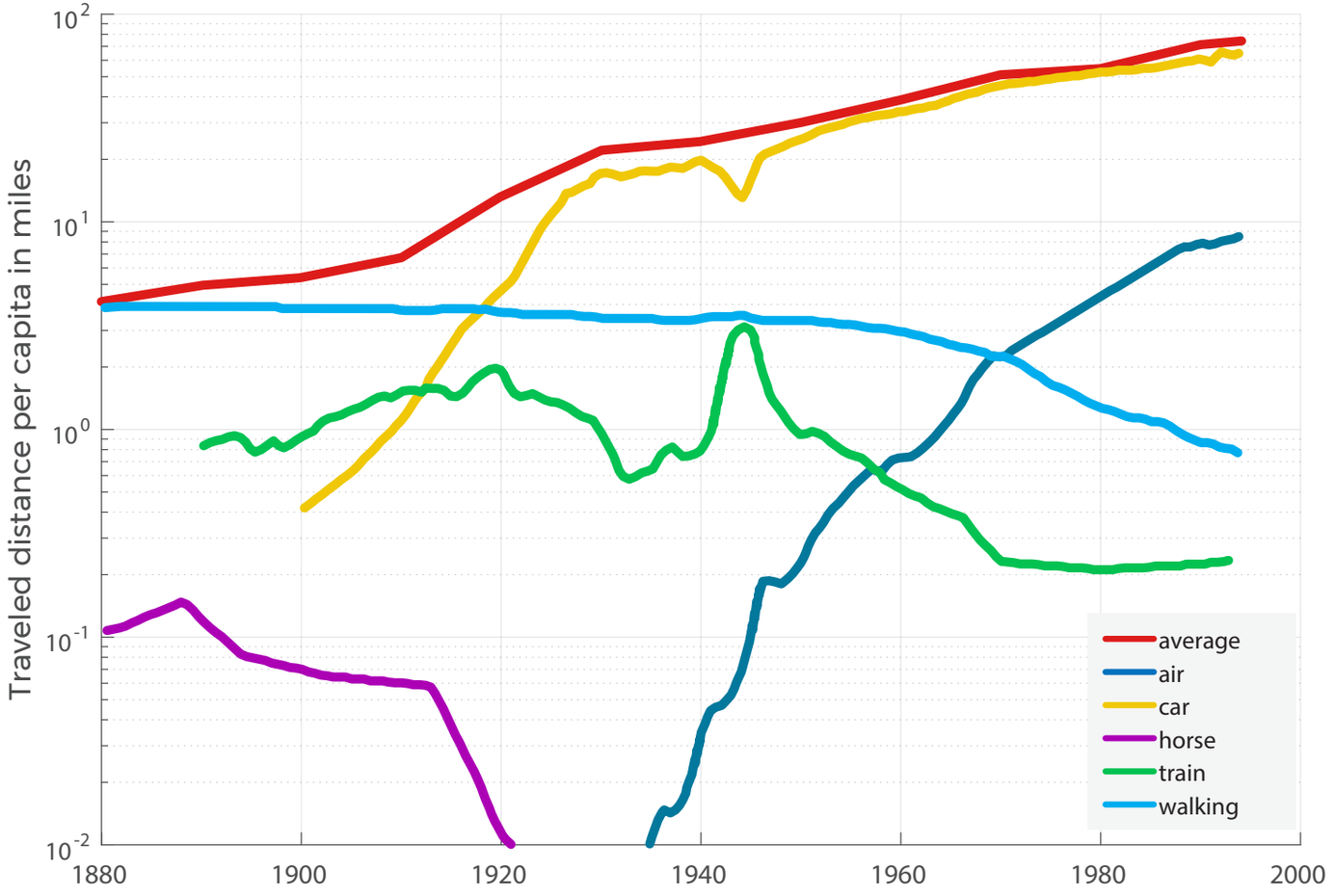


Figure 2: The development of travelling distance in the 20th and 21st century in the USA (Ausubel, 1998)

These three trends are shaking up the automotive industry

In Figure 3, the most important drivers in the automotive industry are named. Those who are currently investigating the car industry come to the conclusion that many of the business models, conventions and power relations in the automotive industry are being overhauled. That creates a turbulent period in which existing structures are broken down and a market where there is room for newcomers. The countless startups that benefit from this develop part-vehicle systems, automobile components, powertrain components for electric cars, as well as completely new car concepts that better fit the requirements of a shared car.

Right to mobility

Together these developments make for easier, cheaper and more comfortable transport. This, in turn, allows for more transport which will be accessible to all. Worrying about the about the costs or the hassle will no longer be necessary, no matter if it is for your trip to the supermarket or your weekend to Paris. However, the demand for mobility is growing not only through technical progress and lower costs. The growth is largely due to the increase in prosperity in the world. Mobility is now at the fingertips of the masses in emerging economies. For example, China has a gigantic middle class that makes that more cars are sold in China today than in Europe or the US. The ability to drive a relatively affordable car gives freedom and security. Research shows that many Chinese buy a car because public transport leaves something to be desired when it comes to safety about late and because a car gives them the freedom to visit their family and friends more often (Ni, 2008).

There is a change happening in the world that the West has only a limited picture of. Over the next 10 years, an unprecedented number of people will achieve the same level of prosperity, in which some countries like India and China will see the number of cars increase from about 200 million to 1.2 billion (Dargay 2007). This unprecedented period of prosperity and growth can completely disrupt the existing automotive industry.

Sharing

REACHES THRESHOLD WHEN

Sharing a car more practical than owning a car
A shared car has to be at walking distance and has to offer a full alternative to owning a car.

Availability can be guaranteed:
The shared car will only be used for daily commute if availability can be guaranteed.

OFFERS OPPORTUNITIES

No purchasing costs
The costs of the car can be shared by a large group of people

More flexible transport
Always everywhere a car available. Way to your work by train, way back by car? No problem.

Autonomous

REACHES THRESHOLD WHEN

Completely autonomous is affordable
Completely autonomous cars are expected by 2020. These cars can move without a driver.

Legislation allows it
There are a few interesting experiments going on in the Netherlands and the Netherlands have the ambition to become one of the first countries in the world to accept fully autonomous cars on her roads.

OFFERS OPPORTUNITIES

Working and meeting up in the car
Doing some work while underway, having a coffee together or catching some sleep while traveling?

Personal taxi
Fully autonomous cars can come fetch you, get the kids to school and drive you home when you have had a drink.

Electric

REACHES THRESHOLD WHEN

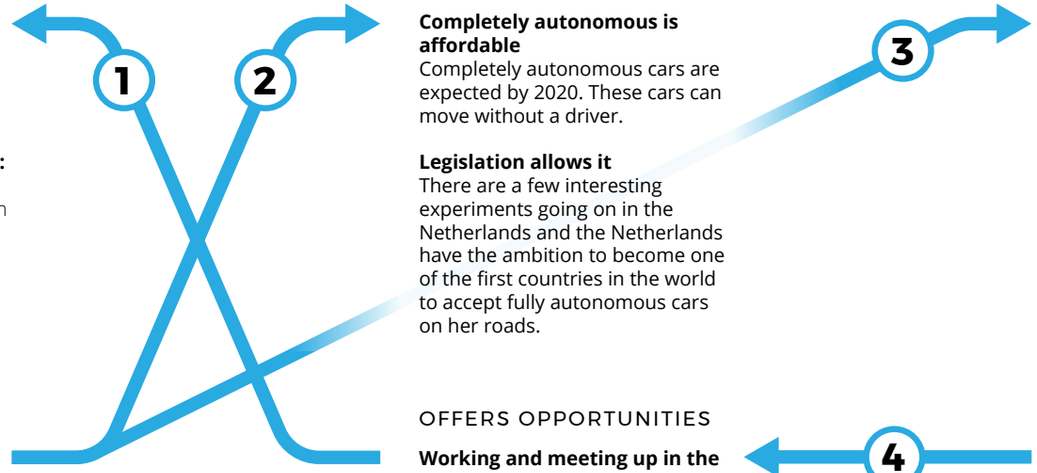
Electrical driving becomes affordable
Batteries are quickly becoming cheaper, by 2018 the first cheap electrical cars with a long range (300+ km) will come to the commercial market.

The charging infrastructure allows it
The Netherlands are a great pioneer. Although the Netherlands have the best charging point coverage in the world, it has been estimated that at least 1 million charging points have to be built.

OFFERS OPPORTUNITIES

Cheap in usage
The energy costs per kilometer are only 2,9 cents compared to 8 cents per kilometer for fossil fuel cars

Clean
Smog and local CO_2 emissions are a thing of the past



1. The car picks you up and drops you off at your front door, which is still closer than the garage where you own your car would be.
2. Expensive autonomous technology becomes affordable by sharing the purchase costs over a large group of people.
3. Electrical cars are expensive but cheap in use. The more you use them, the cheaper they become. Shared cars drive up to 300 kilometers a day.
4. Traveling more often: Traveling is cheap and no longer uses up time.

Figure 3: The three trends revolutionizing the automotive industry

Renewable energy: we can grow again

First of all, let's take a look at current developments in the energy market. It may be said that we live in a unique time, for the first time in the history of the earth (4.5 billion years!), we as Earth's inhabitants have found a way to generate energy with, for example, wind and sun without being dependent of the photosynthesis of plants. However, the switchover to these energy sources is often seen as expensive and as a limitation on the amount of energy we can use. Since these two points are a real concern, the question is: how do we make the energy transition while we also continue to grow?

Wealth has been linked to our energy usage for decades. That's not crazy, because the more work is taken care of, the more energy we use. Think of the car, the washing machine, the fridge and the stove. The use of oil, coal and gas is currently approaching a ceiling due to CO_2 emissions, the finiteness of our fossil fuels and the smog in our atmosphere. In other words, fossil fuels can no longer facilitate our growth and, at the present time, inhibits global growth in prosperity. Chinese people have to leave their car for the day or cannot even buy one, and the same thing is seen in India and even Paris. To help the whole world grow to a higher prosperity level we will have to look for new sources with plenty of energy.

As can be seen in Figure 4, power generation by converting solar radiation to electrical energy, so far, is the most efficient form of energy generation. Sustainable sources are rapidly transforming this image by converting energy directly from natural sources like sun or wind. No other animal species or species of plants converts solar radiation more efficiently into energy than the solar panels on our roofs today. This means that we found our own way of producing energy and are no longer dependent on sources of energy that harm nature. The big advantage: we can continue doing this for millions of years. Sustainable sources are thus the way to re-establish that prosperity growth.

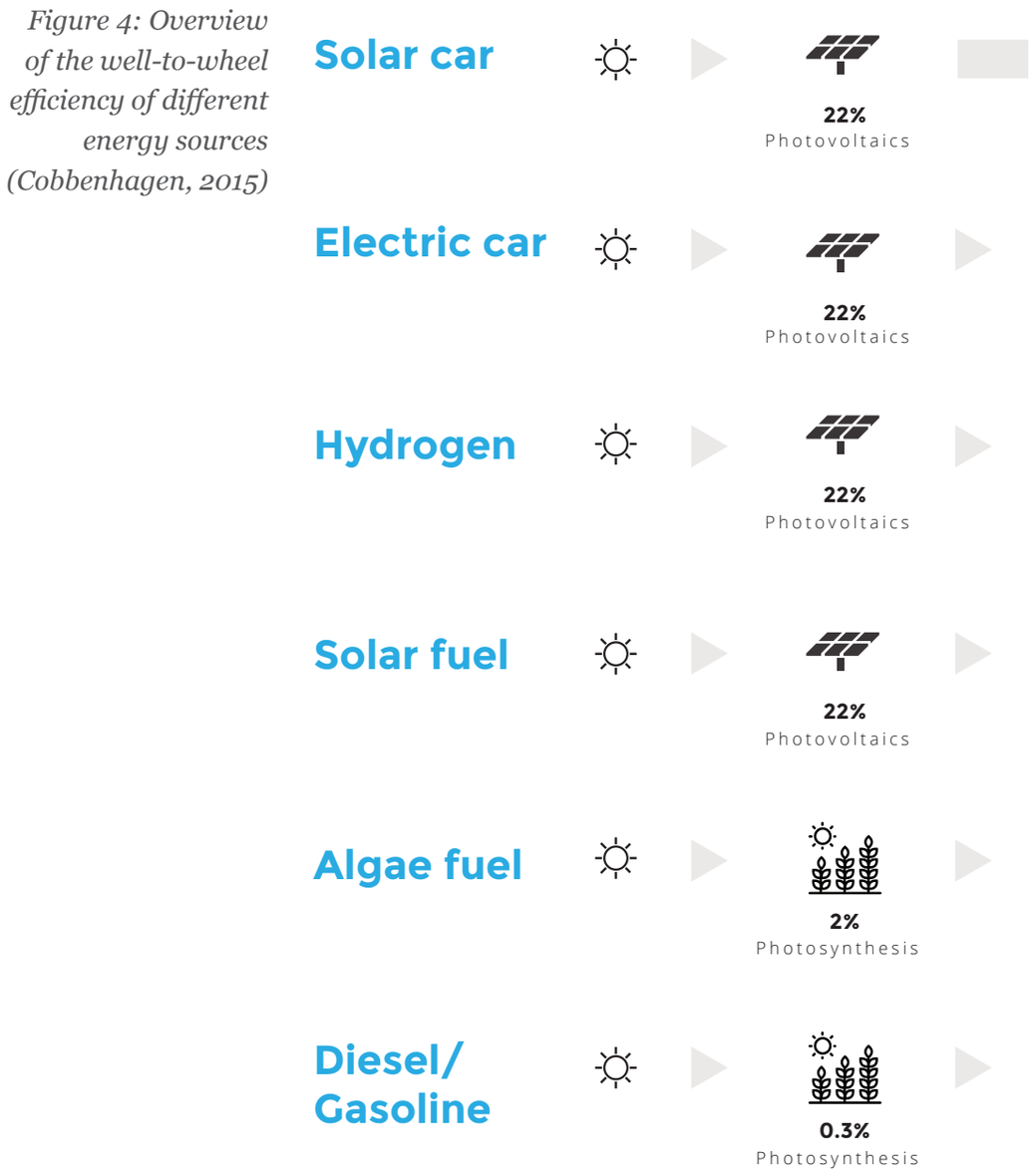
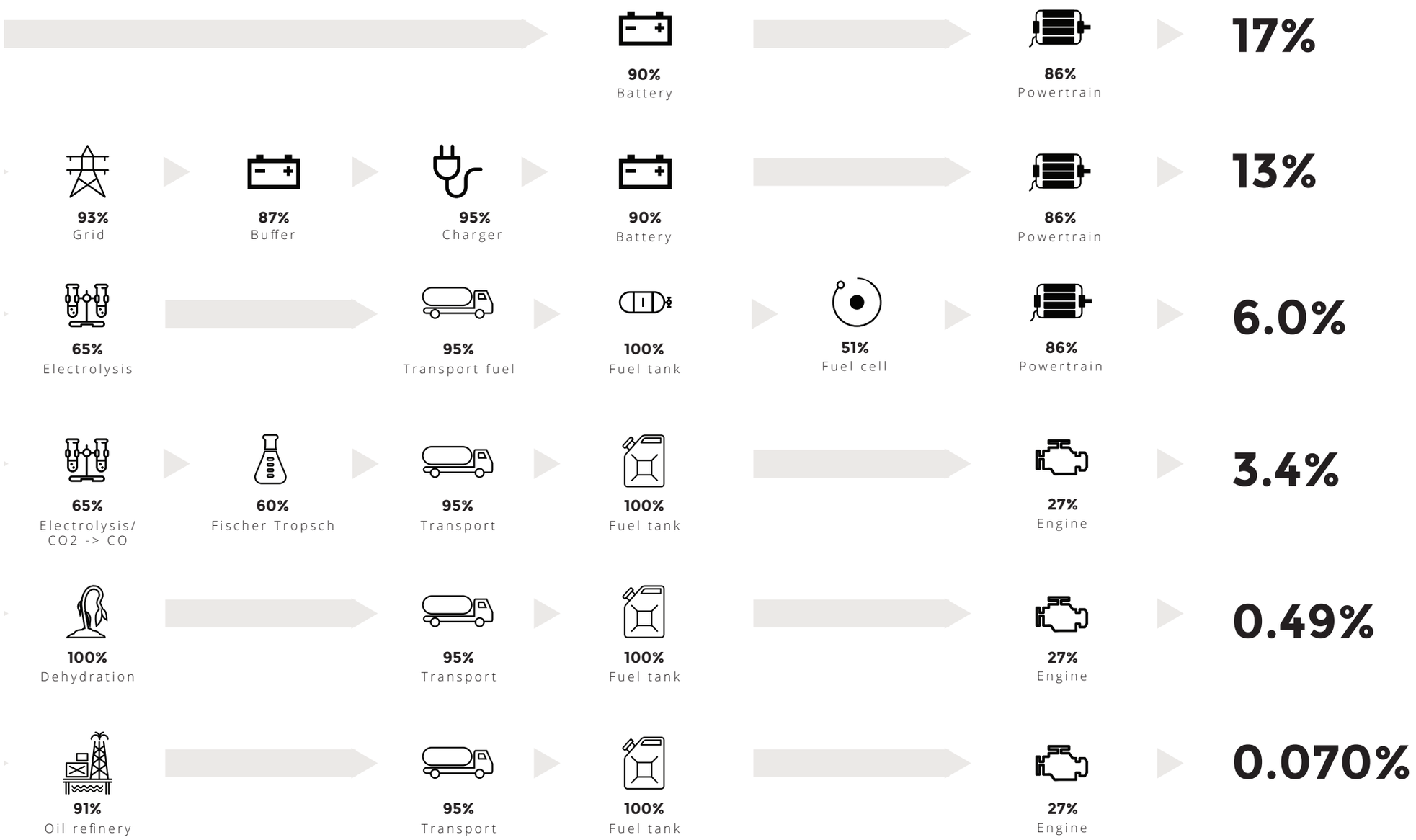


Figure 4: Overview of the well-to-wheel efficiency of different energy sources (Cobbenhagen, 2015)


90%
Battery
86%
Powertrain
17%
93%
Grid
87%
Buffer
95%
Charger
90%
Battery
86%
Powertrain
13%
65%
Electrolysis
95%
Transport fuel
100%
Fuel tank
51%
Fuel cell
86%
Powertrain
6.0%
65%
Electrolysis/
CO2 -> CO
60%
Fischer Tropsch
95%
Transport
100%
Fuel tank
27%
Engine
3.4%
100%
Dehydration
95%
Transport
100%
Fuel tank
27%
Engine
0.49%
91%
Oil refinery
95%
Transport
100%
Fuel tank
27%
Engine
0.070%

The biggest hurdle for mobility: Electric driving for everyone

The previous is just a taste of the good news to come: more prosperity, cheaper mobility, autonomous transport, safer cars. So far nothing but sunshine. In reality, however, it is not that simple because renewable energy has a number of inherent disadvantages.

The question is above all, the techniques are there, how are we going to introduce them everywhere as soon as possible? How do we make fossil fuels superfluous?

Especially the last question is a stubborn one, because unlike traffic jam management it does not always have self-inhibitory effect. But fortunately, there is a solution emerging: electric vehicles and quickly cheapening renewable energy sources. The question at this moment especially is: is the introduction of these techniques fast enough to stave off a climate catastrophe?

Will electric driving be too late?

Today, only 1.1% of newly sold cars in Europe are electric. Research shows that the biggest reservation for the purchase of an electric car are the limited reach and the high purchase price (Bessenbach 2013). The underlying cause of the fear for the reach is that it is uncertain whether the car can be charged when the battery is empty, in other words, whether there will be charging infrastructure in the vicinity. The electric cars currently on the market are seen by the US Environmental Authority EPA as interesting for only 2-4% of the population (Kodjak, 2015). The same research shows that there is a big gap between the expectations and actual performance of electric cars, which also indicates the car's charging time and range as the biggest reservation. Reason enough for car manufacturers to work on these issues.

What obstacles are there on the road to large scale introduction?

Electric cars have the potential to be cheaper than the cars we drive with conventional drive trains. Although looking at the current price of electric cars one would not suspect it. That advantage is roughly in two factors.

First of, electric cars are more efficient with energy than cars

with internal combustion engines, thus reducing the need for energy. Because electricity per unit of energy is roughly as expensive as gasoline, you will ultimately save a lot on energy costs.

The second advantage of electric drivetrains is the simplicity of electric motors, especially if you compare this to the complexity of the current fuel engines. The fuel engine has been around for almost 100 years and was transformed from that awkward, inefficient and filthy braking engine to the powerful, economical, quiet and relatively clean fuel engine. To achieve that, the engine of an average Toyota sedan today consists of 254 parts, as much as 16% of all parts of the whole car (Andresen, 2012). Electric motors have the advantage of needing much less adjustments to be useful: a set of coils, magnets and the right electronics, and you have an extremely suitable and powerful propulsion source.

But that raises the question: what makes current electric cars relatively expensive?? A quick answer to this question is: the batteries and charging infrastructure (McKinsey, 2016). What's up with that?

Batteries

To begin with, unlike electric motors, batteries are very complex. Like fuel engines, 40 years ago batteries were very dirty, hefty, graceless and could save little energy. Today, batteries have become better due to the high demand for batteries for laptops and smartphones. These compact lithium-ion battery cells can save more than 6 times the energy the lead batteries at the time could. The chemistry of these battery cells is so complicated that a kilowatt of capacity still costs $227 (McKinsey, 2016). For a full battery pack for an electric car with 300 kilometers of action radius, this amounts to between $11250 and $15000.

The improvements in battery technology do not follow Moore's law, and scientists therefore expect that batteries will only get cheaper gradually over the past 40 years. McKinsey predicts that batteries will cost $150 / kWh in 2030, GTM Research indicates that $217 is achievable by 2020 (Cobbenhagen, 2015). The batteries will therefore remain the most expensive component of electric cars for a long time.

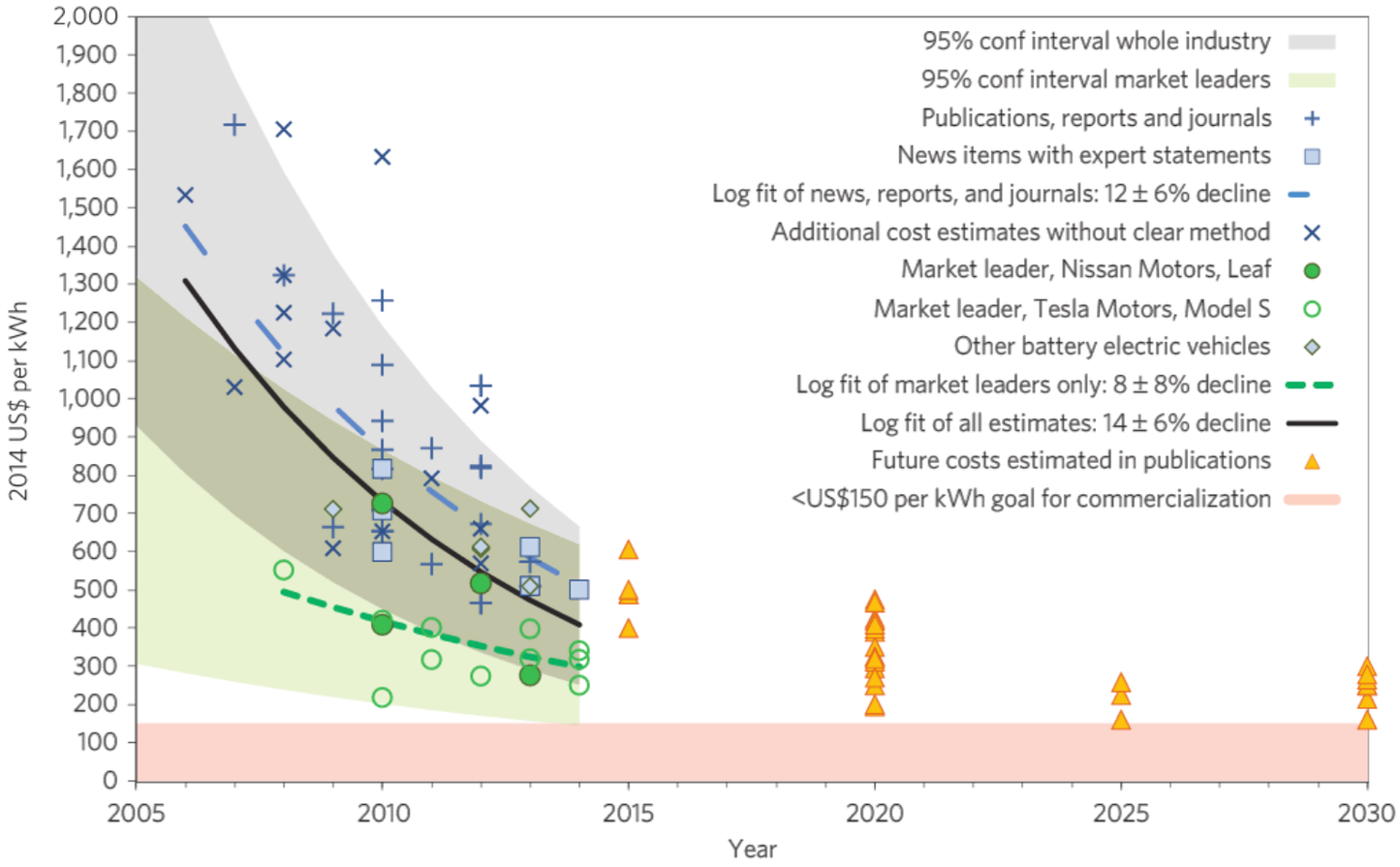


Figure 5: Trends in battery prices (Nykvist, 2015)

Charging Infrastructure

Electricity is a wonderful form of energy that is easily turned into other forms of energy such as heat, motion and chemical bonds (batteries). The major disadvantage of electricity, however, is that it is a “thin” energy carrier: storing and transporting it requires a lot of large infrastructure. For example, batteries store up to 30 times less energy per kilogram than gasoline.

That makes the infrastructure to transport and buffer energy pricey. Fast charging (the way electric cars these days are charged) is still expensive due to the high peak currents and infrastructure required today: € 0,59 per kilowatt hour along the highway at Fastned (a Dutch charging service). In comparison, when you drive electric you pay € 11 for 100 kilometers when using fast charging, while driving a diesel fuel costs € 7.50 for the same 100 kilometers. The motto is thus: Charging at home is cheaper because that infrastructure is already there.

A look into the future teaches us that with the arrival of electric driving and renewable energy the electricity networks will have to process more peaks and shortages. Ecofys calculated that the peak demand for neighborhoods will grow from 0.9 kW per household to 4.4 kW per household, partly due to electric cars. The costs associated with such intensification for the medium-voltage grid in the areas surveyed are roughly € 750 to € 2700 per household, and the costs for the high-voltage grids and low-voltage networks will have to be added to that (Ecofys, 2014).

Also, the whimsical demand and supply of energy in the future will create large differences in day/night and summer/winter consumption and yield. The differences between those must be supported with energy storage in the form of batteries and fluids. The costs of batteries are about € 0.10 per kWh of stored energy (Register, 2015) now, which increases the electricity price to € 0.30 per kWh.

Lastly, charging points are still a major issue, especially for the 70% of Dutch people who do not own a driveway (Nature & Environment, 2016) and are therefore reliant on public charging infrastructure. It is expected that approximately 53,000 additional charging stations will be needed in the Netherlands by 2020, the cost of these charging stations is estimated at around 25 million euros, almost € 500 per pallet (Autoweek, 2016).

Emerging economies: challenges squared

Fortunately, despite the above-mentioned challenges, the Netherlands are a world leader when it comes to electric driving. So much for the Netherlands, what is the situation in the rest of the world? The same two challenges make for even greater barriers in emerging economies. There are still additional challenges in these markets: 'normal' cars and fuel are significantly cheaper in emerging economies.

How do we make electric cars competitive in emerging economies?

In Western Europe, the electric car has already reached an attractive price level due to the high fuel excise. Over the lifetime of the car, it can already be beneficial (in conjunction with subsidies) to drive electrically. Figure 6 quickly makes it clear that these excise taxes are mostly found in western European countries. Electric cars are still economically unattractive in countries without artificially high gasoline prices.

The average price of a VW-Golf equivalent in these countries is also significantly lower. Together, these two give an indication of the Total Cost of Ownership (TCO) of these cars.

This TCO can also be used to estimate the price point at which electric cars can be sold financially attractively. The € 30,000 introductory price of current electric cars is well above the prices you can ask in emerging economies for such a car.

Good news, however, is the bars are high when it comes to the objectives: India has set itself the goal of driving 100% electrically by 2030. That is not so surprising: the cities of India are suffering from heavy smog. Figure 7 shows that air quality in India is one of the worst in the world.

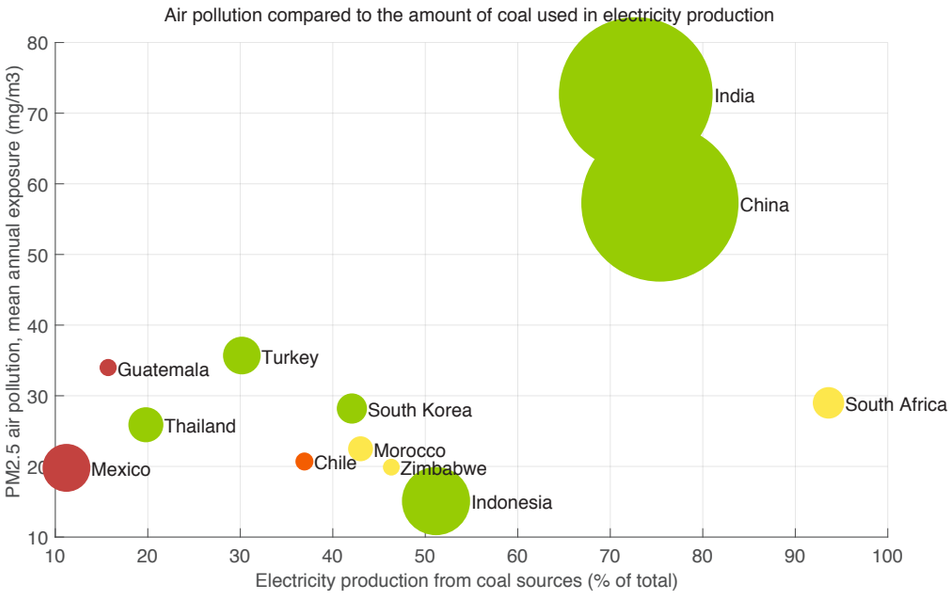
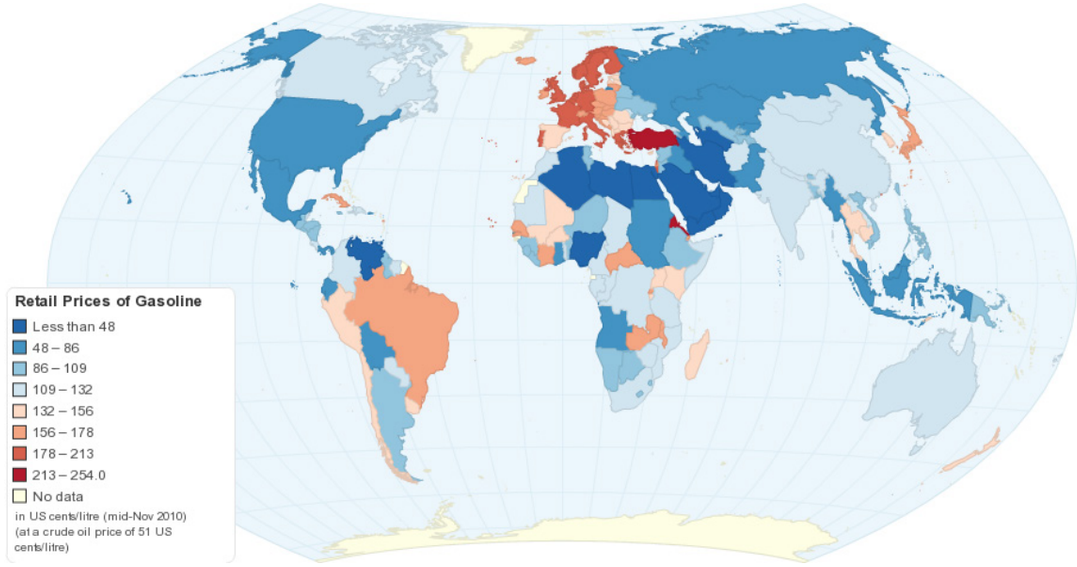


Figure 7: Air quality vs electricity production



Figuur 6: Retail prices of gasoline (Chartsbin, 2010)

Infrastructure

A sustainable charging infrastructure consists of three major components that must undergo three major changes during the energy transition.

The first step is energy production. In many emerging economies, coal is by far the cheapest source of energy and therefore supplies most of the energy. Investments in coal generated electricity are still high, even in India only, $ 50 billion is being spent in the construction of new coal plants (D'Monte, 2016). This development is not only worrying in regard to global CO2 emissions, but also with an eye on the smog in many Asian cities. It is therefore important that the extra energy production capacity for electric cars is not supplied by coal plants, but is sustainably generated. Generating with coal electricity would only mean a shift of the emissions problem from cars to coal power plants.

During a recent coal-buying visit to Australia mr Goyal was clear on his point of view, saying that a modern lifestyle in India will require a "very large amount of baseload power and this can only come from coal."

— Piyush Goyal is the Minister of State for Energy (Brent, 2016)

The second step is distribution. In many emerging economies, the electricity network has grown organically and capacity is limited. The new infrastructure needed for the construction of solar power plants must be able to move the peaks in solar power to the places where energy is needed. Electricity grids must be able to supply the peak currents that electric cars require when charging.

In India, it is expected that in the coming years, about $ 50 billion (John, 2013) should be invested in the energy grid to meet the demanding growth. As a result, the distribution costs for solar energy sources are expected to rise to about $7.30 per kWh, compared with the average electricity price of $10 per kWh, which means that the costs will almost be doubled.

The third step is charging the car itself. Due to the compact construction of many Asian cities, people generally do not have their own garage or driveway. Electric cars can thus almost exclusively be charged at public charging stations. Given the small number of charging stations in India, there are therefore only a handful of people driving electrically in India and countries like India. Due to the small amount of electric cars sold, the government is not in a hurry to build charging stations.

Are infrastructure independent cars feasible?

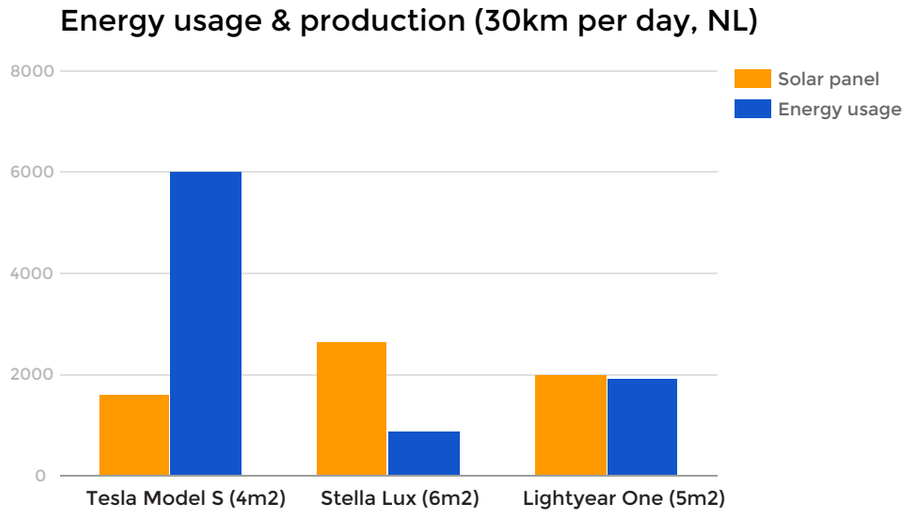


Figure 8: Energy usage & production in Wh

The challenges are clear, so now the question is: what options do we have to help electric cars become the standard worldwide as soon as possible? An obvious solution for rolling out an infrastructure is the development of a vehicle that requires as few modifications as possible to the infrastructure. For a long time, the development of such a vehicle was unfeasible. However, recent technical progress and cost reductions have changed this. Nevertheless nuances and other constraints might still ruin the ambitious plans. The key question Lightyear has been trying to answer as of late: is such a vehicle technically possible and can such a concept be cost competitive?

Technical

Stella was a first start in 2012, a first prototype to test the concept of infrastructure-independent vehicle, such as a solar car. In order to better visualize what is achievable technically, a clear distinction must be made between the energy output from the solar panel and the energy consumption of the car while driving. In short, those two should be as balanced as possible. That's also the reason why adding a solar cells to current electric cars futile: the roof only accommodates a modest solar panel and the car itself uses too much energy.

Therefore we are looking for an opportunity to increase the solar panel yield and reduce the car's consumption.

Reducing energy usage

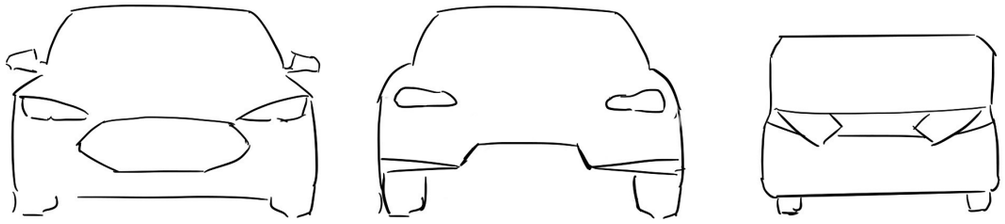
The energy use of an electric car is built up out of the following components; rolling resistance, aerodynamic drag, drivetrain efficiency and the auxiliary power usage. The drivetrain efficiency is the amount of energy that is transformed into a forwards motion. Electric cars are already quite efficient, transforming up to 90% of energy into motion. Internal combustion engine cars, however, only reach up to 30% efficiency (Cobbenhagen, 2015). Even for electric drivetrains, there is still a lot of room for improvement but for simplicity reasons, we are going to leave that out of this equation as well as auxiliary power. So what remains?

Aerodynamic drag

Aerodynamic drag is caused by air molecules 'colliding' with the front of a vehicle while driving. De force required to move these molecules out of the way is seen as energy loss. The more air needs to be moved, the more energy is required to move the car forwards.

Energy use can be reduced by moving less air. There are two ways of achieving that, reducing the frontal area the air collides with or making sure the air flows around the car neatly so that it moves as little as possible. In scientific terms, this comes back in frontal area A and drag coefficient Cd. The frontal area can be reduced in a number of ways. The most obvious is to reduce the width or height of the car but replacing the wing mirrors with cameras or adding a tunnel through which air can flow is also an option. Reducing the drag coefficient can be done by choosing the car's shape in such a way that air flows neatly along its surface. The ideal shape is the shape of a water drop, this shows that it is important to shape the car in such a way that all airflow around the car is brought back together at the car's tail..

Figure 9: Frontal surface area. From left to right: Tesla Model S, Lightyear One and Stella



Rolling resistance: Tyres and weight

Rolling resistance is mainly caused by the deformation of the car's tyres on the road. The total rolling resistance is made up of two factors; the car's weight and the type of tyres used. Cars have been getting heavier and heavier over the past years. A Citroen AX from 1990 weighs in at 640 kg while a modern Citroen C-zero comes in at 1080 kg. This is causing an upward weight spiral, a heavier car needs heavier suspension, heavier brakes and a heavier chassis. In electric cars, this also means a heavier battery.

The good news is that this spiral can also be reversed. (Luedeke, 2014). This can be done by improving the aerodynamic performance and the use of lightweight materials such as carbon fibre. A lighter car results in lower energy usage which, in turn, results in a smaller (and thus lighter) battery and lower specced motors.

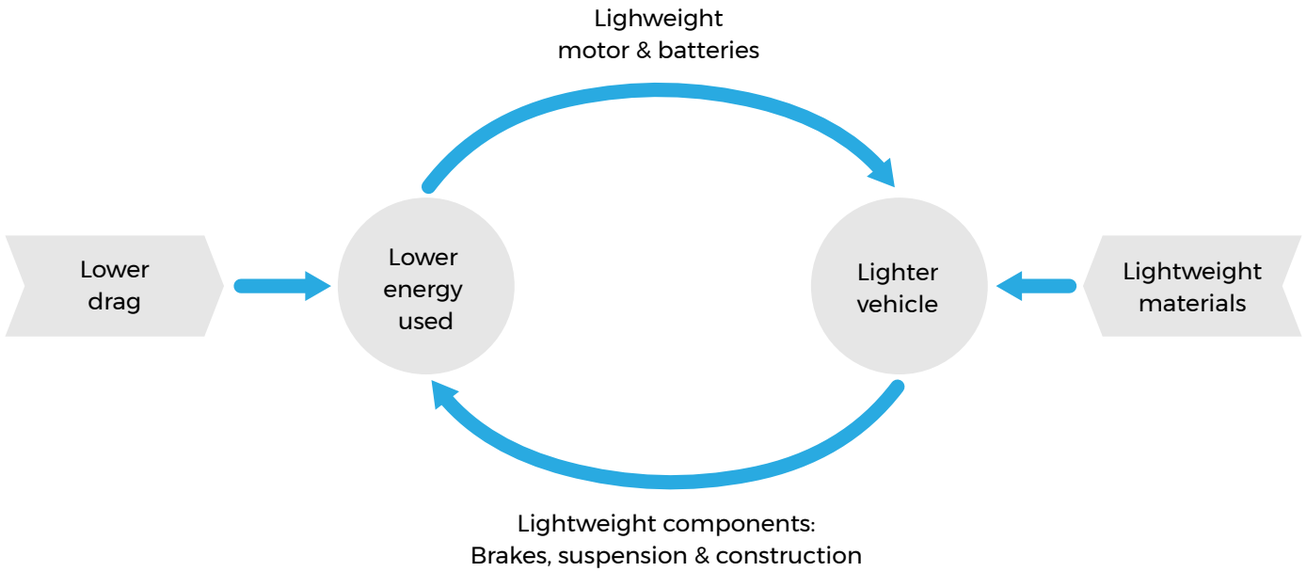


Figure 10: Secondary weight spiral

Increase the yield of the solar roof

Solar cells also have two factors of importance, surface and efficiency. The return is important for a vehicle because the available surface area is limited. At best, affordable solar cells today convert 24% of the sunlight into electricity (Kanellos, 2016). In addition, it is especially important for the surface area of the solar roof to be able to curve neatly with the front of the car. With some modifications to the shape of the car, it is possible to place 4 to 6 square meters of solar cells. Subsequently, sophisticated electronics are used to effectively harvest the energy captured by the solar cells, reducing the influence of shading and curvature of the roof.

How fast does the solar car advance in performance?

When making the first plans for participation in the World Solar Challenge, we made some rough estimates of the performance of a car that could win the competition with 4 people on board. The sum consists of only a few important numbers: the weight of the car, the size of the car and the potential output of the solar roof. These are exactly the numbers that are important for the future of the solar car.

Two years later we did this calculation again, and we were pleasantly surprised. Pure technological advances gave an improvement of 26.4% compared to Stella. What technological improvements form the foundations for this?

Car weight drops by improving battery technology and using lighter materials

The batteries in electric cars make the car relatively heavy. Certainly, as batteries gradually become cheaper, you see that cars are gaining ever-increasing reach by adding additional battery capacity, but with that also more weight.

Yet another trend is also visible. German car manufacturers (led by BMW) see great potential in the use of lightweight materials like carbon fiber to reduce the consumption of electric cars. This allows for a larger range without requiring more batteries.

Where Tesla clearly chooses to add additional battery capacity, BMW chooses another way: invest in lightweight technology.

At the same time, another factor also plays an important role: the amount of energy that can be stored per kilogram in batteries. This contributes perhaps even more to the trend of lower the weight of the car.

Where Tesla clearly chooses to add additional battery capacity, BMW chooses another way: invest in lightweight technology.

Solar cell technology is getting cheaper and more efficient

For a solar car, relatively standard commonplace solar cells would already provide enough energy for average trips in the Netherlands. The cost of these cells is so low by now that all cells can be bought for € 500 and have a return of about 18 to 20%. Developments in solar cells also cause steady growth in yield, which for the current top monocrystalline silicon cells is approximately 26% (Green, 2016).

An exciting development in the solar cell world is the advance of perovskite solar cells, which can already reach 22% efficiency. It is expected that tandem cells, a combination of a silicon cell and a perovskite cell reach efficiencies up to 30% at an affordable price. Meanwhile the solar prices are going through a small revolution, as in Chile an offer has been made for a solar farm that supplies power for € 0,025 per kWh (Saurabh, 2016). That is more affordable than nuclear power, gas stations and many coal plants. This revolution could spark because of the nature of solar power. Where fossil fuels will remain a raw material to be mined, solar panels require very little initial raw materials and continue producing for 20 years. It is a technology rather than a raw material.

Conclusion

Mobility is a need for mankind, and in the last decades the car has become an essential part of it. We have taken a look at the trends in the automotive industry and the energy sector. Electric cars, shared cars and self-driving cars will change existing structures and business models. The rise of renewable energy is accelerating and we can continue to grow in our energy needs. From government and the population, acceptance increases and demand for clean and affordable solutions such as electric cars increases. A challenge is the development of the electricity grid and the roll-out of charging infrastructure; especially in developing areas where demand for cars will increase sharply over the next decade.

The solution can be found in infrastructure-independent cars, for example solar cars. The key to a solar car is to maximize solar yield and minimize consumption, which can make the car lighter and gives it less aerodynamic drag. Rapid technological developments in mainly battery and solar cell technology ensure that a solar car is already possible, and in the years to come will only get better.


NXP
WEIMO
TNT
SEGULA
ANSYS
Altium

Join us!

To reach the goal of our mission, we are currently developing our first car. With our mission, we not only ensure a better future but we also build a company with a lot of potential. It is therefore interesting to be involved with Lightyear as an investor and or partner.

For more information about either, please contact Qurein Biewenga at qurein.biewenga@lightyear.one.


LIGHTYEA

References

Andresen, C. (2012, September).Biobased Automobile Parts Investigation - USDA. Retrieved February 7, 2017, from https://www.usda.gov/oce/reports/energy/Biobased%20Automobile%20Parts%20Investigation%20Report.pdf

Ausubel, J. H., Marchetti, C., & Meyer, P. S. (1998). Toward green mobility: the evolution of transport. European Review, 6(2), 137–156. doi:10.1017/S1062798700003185

Autoweek (2016, February 12). 'Meer laadpunten nodig voor elektrische auto' Retrieved February 07, 2017, from http://www.autoweek.nl/nieuws/meer-laadpunten-nodig-voor-elektrische-auto/

Bessenbach, N., & Wallrapp, S. (2013). Why do Consumers resist buying Electric Vehicles? (Publication). Copenhagen: Copenhagen Business school.

Brent, W. (2016, March 4). India: All Homes Electrified by 2019. Retrieved February 07, 2017, from http://www.powerforall.org/blog/2016/2/28/infographic-indias-247-power-for-all-progam

Chartsbin. (2010). Worldwide Retail Prices of Gasoline (US cents per litre). Retrieved February 08, 2017, from http://chartsbin.com/view/1115

Cleantechnica (2016, May 15). EV Battery Prices: Looking Back A Few Years, & Forward Yet Again. Retrieved February 07, 2017, from https://cleantechnica.com/2016/05/15/ev-battery-prices-looking-back-years-forward-yet/

Cobbenhagen, R., & Hoefsloot, L. (2015, June 30). The car of the future (Publication). Eindhoven university of technology.

Cloïn, M. (2013). Met het oog op de tijd (pp. 141-148,ISBN. 978 90 377 0670 3). Den Haag : Sociaal en Cultureel planbureau.

D'Monte, D. (2016, October 22). With its continued investments in power plants, India may soon produce more coal than it consumes. Retrieved February 07, 2017, from https://scroll.in/article/819445/with-its-continued-investments-in-power-plants-india-may-soon-produce-more-coal-than-it-consumes

Dargay, J., Gately, D., & Sommer, M. (2007). Vehicle ownership and income growth, worldwide: 1960-2030. The Energy Journal, 143-170. http://www.canadasexcellentfuture.com/sites/default/files/Car%20Ownership%201960-2050.pdf

Ecofys Consultancy. (2014, November 7). Waarde van slimme netten. Retrieved February 7, 2017, from http://www.ecofys.com/files/files/ecofys-2014-the-value-of-smart-grids-dutch.pdf

Green, M. A., Emery, K., Hishikawa, Y., Warta, W., & Dunlop, E. D. (2016). Solar cell efficiency tables (Version 49). Progress in photovoltaics: research and applications, 25:3–13

John, J. S. (2013, October 23). India's $10B Roadmap for Smart Grid Transformation. Retrieved February 07, 2017, from https://www.greentechmedia.com/articles/read/indias-10b-roadmap-for-smart-grid-transformation

Kanellos, M. (2016, June 28). SunPower's 24.1% Efficiency Record: Are We Near The Ceiling? Retrieved February 07, 2017, from http://www.forbes.com/sites/michaelkanellos/2016/06/27/sunpowers-24-1-efficiency-mark-are-we-near-the-ceiling/

Kodjak, D. (2012). Consumer Acceptance of Electric Vehicles in the US (Presentation).

Luedeke, T., & Vielhaber, M. (2014). Holistic Approach for Secondary Weight Improvements. Procedia CIRP, 21, 218-223.

McKinsey (2016, January). Automotive Revolution - Perspective Towards 2030. Retrieved February 7, 2017, from https://www.mckinsey.de/files/automotive_revolution_perspective_towards_2030.pdf

Natuur & Milieu. (2016, May 09). Laadpalenschaarste - hoe staat jouw gemeente ervoor?. Retrieved February 07, 2017, from https://www.natuurenmilieu.nl/blog/laadpalen-schaarste-of-niet/

Ni, M. C. J. (2008). Motorization, vehicle purchase and use behavior in China: A Shanghai survey (Vol. 69, No. 11).

Nykvist, B., & Nilsson, M. (2015, March 23). Rapidly falling costs of battery packs for electric vehicles. Nature Climate Change, 5(4), 329-332. doi:10.1038/nclimate2564

Register, C. (2015, January 13). The Battery Revolution: A Technology Disruption, Economics and Grid Level Application Discussion with Eos Energy Storage. Retrieved February 07, 2017, from http://www.forbes.com/sites/chipregister1/2015/01/13/the-battery-revolution-a-technology-disruption-economics-and-grid-level-application-discussion-with-eos-energy-storage/

Saurabh. (2016, September 20). Wind Energy Scores Big In Chile's Electricity Auction. Retrieved February 08, 2017, from http://cleantechies.com/2016/08/18/wind-energy-scores-big-in-chiles-electricity-auction/