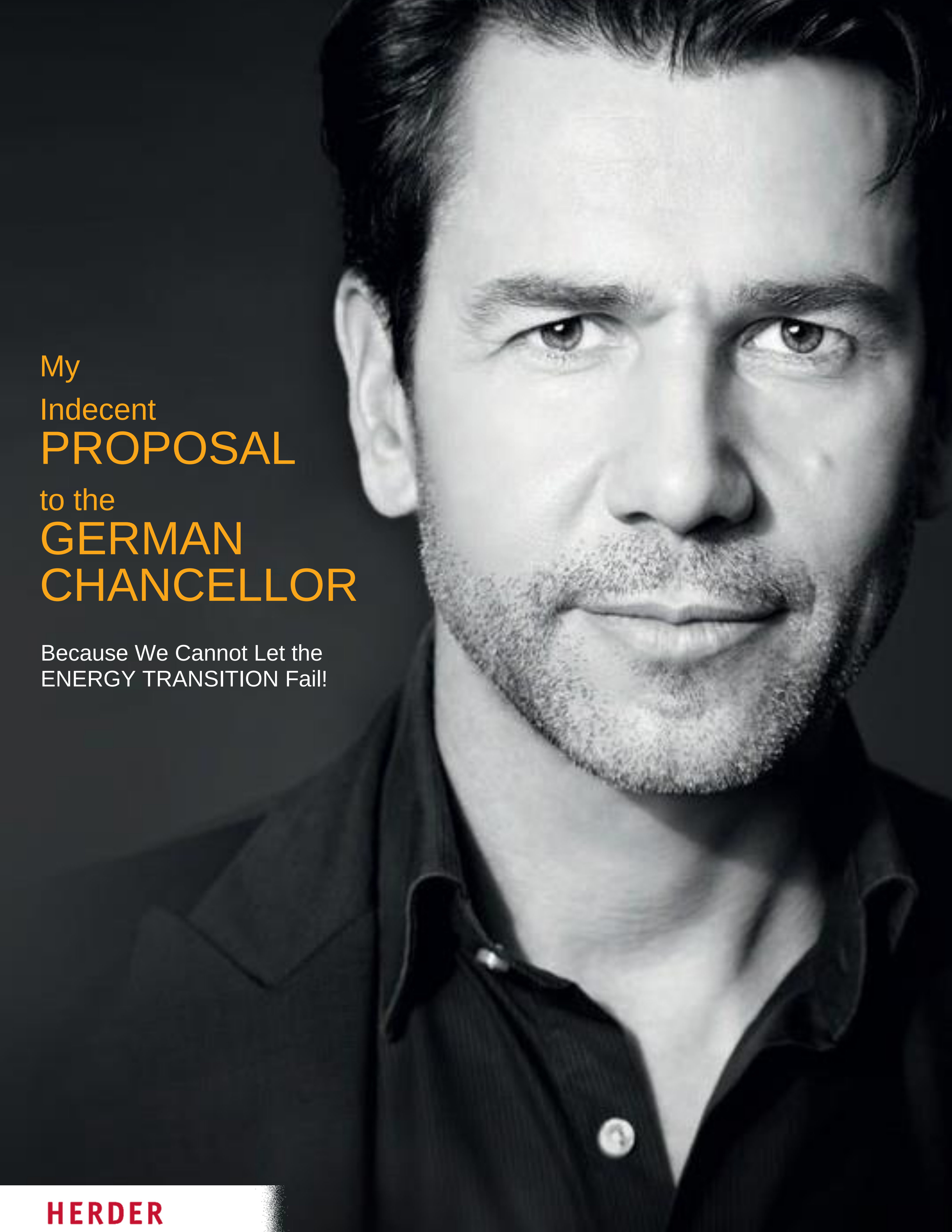


My Indecent PROPOSAL to the GERMAN CHANCELLOR

Because We Cannot Let the ENERGY TRANSITION Fail!

HERDER

The Master Plan

How we can successfully complete the transition to renewable energy as quickly as possible

Introduction: What is the master plan and how does it work?

The thing about the future is that no one can say for sure what will happen. You can, however, do your best to shape it. I find this more useful and more exciting than sitting around and hoping that things will turn out for the best. That is exactly why I'm writing this book – so that as many people as possible can envision a future energy supply from completely renewable energy sources and understand how it would work. This understanding is vital in order to be able to make a decision either for or against it.

It is easy to tell the difference between people who are trying to shape the future and those who are trying to hinder progress: People who want to shape the future set clear goals. People who want to hinder something will look for reasons why it won't work or why it will take longer than expected.

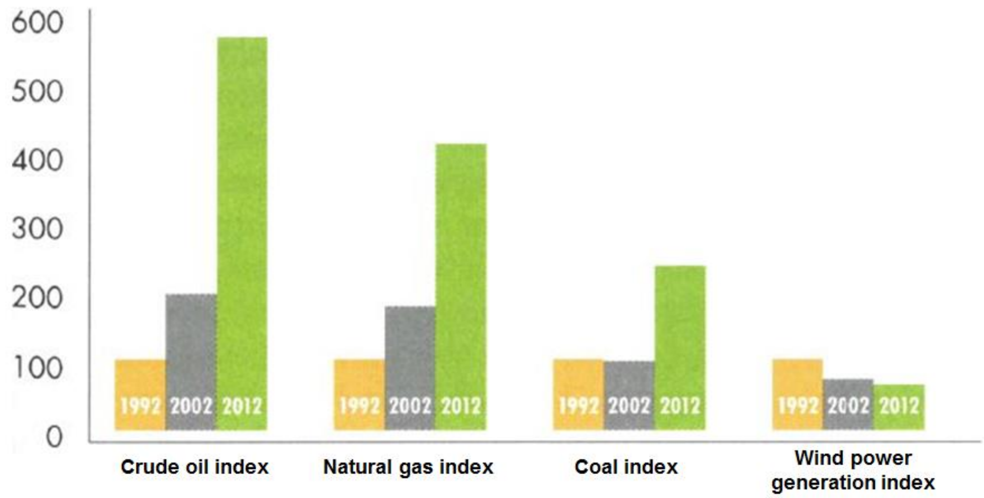
I want to focus on explaining what energy system would be the best and most economic choice for the future. That is why I have developed a master plan. Of course, this plan will have its critics.

The assumptions at the heart of this plan are based on the best of my knowledge. I would like to note, however, that this is not a scientific research paper, but rather a concept for the best way to achieve the goal of using 100 percent renewable energy based on my real life experience in the field. I am not offering any specifications for output levels, tariffs, locations for wind turbines or storage capacities that are exact to the decimal. That would not be productive. Instead, I want to take an extremely complex process, which is even more complex when you look at it in detail, and make it comprehensible. It's not about being right about everything. It's about taking our goals for the future and highlighting the most important findings that enable us to act now. What do I want for the future and what do I need to do today to make it a reality? When trying to answer this question, I ask myself: Will the world population continue to grow? Will we require even more energy in the future? And last but not least: How does the shortage of fossil fuels affect the price of energy?

Why is the master plan necessary? Because energy from fossil fuels will no longer be affordable in the future

The price of oil has more than quadrupled over the last ten years. That is a fact. Worldwide energy consumption will double over the next twenty years. That is a very likely prediction. Peak oil, the point at which the maximum rate of petroleum extraction is reached, has already occurred on a global scale. The amount of oil, coal and gas that we burn every day took a million years to develop naturally. We have already used the majority of our resources, which has also polluted the earth's atmosphere and upset the balance of the climate. The path that we are on is not sustainable.

Cost of Energy: Statistics from 1992 to 2012



Sources: German Federal Ministry of Economics and Technology, 2013; Deutsche Windguard, 2013

It's possible that fracking will allow the USA to be less dependent on Russian gas or Saudi Arabian oil for a few more years, but it won't even be enough to sustain one generation, and the USA is no longer the world's greatest energy consumer anyway. China has exceeded the USA in terms of energy consumption, and emerging nations such as India and Brazil are becoming more industrialized and will markedly increase their manufacturing capacities and economic growth, which will also boost their energy consumption.

There are around 80 million people and approximately 50 million cars in Germany. On a global scale, there are over 800 million cars and the world population is around 7 billion, and will soon grow to 9 billion. Can we forbid the rising middle class to consume? Definitely not. So then, let's assume that every one of these people would own a car, as well as a cell phone, laptop, refrigerator and air conditioning.

This would mean that energy consumption in the next fifteen to twenty years would not simply increase by 50 percent, but rather would greatly exceed all of our predictions.

Supplying energy to all of these people using conventional energy sources is absolutely impossible.

It doesn't matter how long we can keep using fossil fuels: It's clear that all of these energy needs cannot be met using cheap oil, and above all, our planet cannot handle additional billions of cars and air conditioning units running on fossil fuels, which will cause the average temperatures to continue to rise. This doesn't just affect polar bears and other animal species; it would result in famine, extreme weather catastrophes, climate refugees and climate wars. Furthermore, petroleum is the “lubricant” that keeps the economy moving and is also needed in a large number of industries for uses other than energy. For example, petroleum is used in the chemicals industry for making plastics and medicine. We can no longer afford to simply burn it up for energy and release it into the atmosphere.

We are confronted with dwindling resources, steadily growing demand, increased production of goods and dramatically accelerating climate change, while on the other hand, the amount of fossil fuels available continues to sink and every liter of oil that is burned is lost forever. You don’t have to be a business economics guru to know that supply and demand determine the price of goods. The less a product is available and the higher the demand, the more expensive it will be. The energy transition does not only have a social and ecological dimension, but is also extremely significant in terms of economics. The Euro Crisis can also be seen as an energy crisis because the EU is forced to spend more and more money on expensive imported fossil fuels. The truth is that Europe can no longer afford its expensive energy and gasoline bills.

This is why my basic thesis for the master plan is: Conventional energy sources will no longer be affordable in the future due to the high cost of fossil fuels.

It follows that, if we continue on the path we are currently on, it is inevitable that fighting and wars will break out over our finite resources. The destruction of our environment will also accelerate at a correspondingly greater rate. Stronger cartels will form and the focus will zero in on a few major global corporations that will hold more and more power over governments. Not to mention civil liberties. Areas will be cleared out, towns and neighborhoods will be dug up and the last drops of oil will be extracted from slate and tar sands, requiring even more energy and releasing even more dangerous greenhouse gases into the atmosphere. This extraction is very expensive, but as prices rise it will become profitable. Even our most prized natural landscapes will no longer be off limits. The same goes for fracking, a method for extracting natural gas from deep underground that uses poisonous chemicals which pollute our drinking water. Fracking is not a real solution, despite claims to the contrary. It is simply a continuation of the problem and postpones any real solution.

What will happen to energy prices in Germany?

The decisive factor will be whether we can assume that the price for fossil fuels will remain stable and whether 100 billion euros annually will be enough, or whether we will see a price increase. In spring 2013, shortly after the Federal Minister for the Environment Peter Altmaier presented his paper about the “Strompreisbremse”, his plan to put a “brake on electricity prices”, I had the opportunity to speak to him at his office in the Federal Ministry for the Environment. Using a pen and paper, he showed me how he came to the figure of one trillion euros, which was what he named as the estimated cost of the energy transition. It is worth noting that he included home renovations in this calculation to arrive at that sum. Of course, existing buildings amount to approximately one third of our CO2 emissions – but this has nothing to do with EEG apportionment. Nevertheless, mathematically speaking, he was correct on a lot of points;

however he calculated this value based on the assumption that the prices for renewables will remain the same, ignoring the innovations and the learning curve of the last few years and the price reductions that have already occurred as a result. More importantly: Altmaier also based his estimation on the assumption that fossil fuel prices will not only stay the same, but actually fall slightly. In my opinion, this is a grave miscalculation.

Minister Altmaier thanking me for the work I've done to promote the energy transition.

When you look at the global parameters mentioned above, it must be assumed that prices in Germany will rise as well. An increase of just a few percent will lead to an increase in the cost of importing fossil fuels from the current cost of 100 billion euros a year to around 250 billion.

That is a difference of billions of euros within two decades. In comparison, the federal budget for Germany in 2013, with all expenses included, is approximately 300 billion euros. Even if you only assume that the cost will double, then the cost for the average household to heat their home with oil will jump from 2,000 euros to 4,000 euros. If the price were to quadruple, many Germans would no longer be able to afford to drive a car or heat their homes.

These calculations must be compared to the 15 or 20billion euros required for the EEG apportionment that we are currently discussing, especially when one takes into consideration that the major energy companies' profits – we're talking about well over 100 billion euros – were always higher than the costs of this apportionment. And that is just the figure from 2012.

If politicians would set honest prices for CO2 emissions, they would already be between 30 and 70 euros per metric ton. These costs are accumulating today and will continue to do so in the future; however they don't show up in your energy bill. Instead the state pays for them using tax money. In 2012, power plants in Germany released 317 million tons of CO2 into the atmosphere. At only 30 euros per ton, that would add up to 10 billion euros per year. I only mention this in order to give readers an idea of the figures involved in this debate.

The cost of nuclear power is essentially impossible to accurately calculate or measure: Citizens will have to bear most of the costs for disposal of nuclear waste and for decommissioning nuclear power plants. A beyond design basis accident, like what happened in Fukushima, would be beyond our means. Tax payers have already spent billions of euros on nuclear energy and billions will be accrued in the future as well. We cannot entirely eliminate these costs, even if we immediately switch over to 100 percent renewable energies; however we can limit them and prevent a major nuclear catastrophe from occurring in Germany.

At the same time, we are currently already paying too much for imported resources while losing out on creating our own added value. We subsidize energy for businesses and yet we as a society still pay, because the general public shoulders the cost.

What will result from the fact that the fossil fuels that we use for energy are dwindling while becoming increasingly expensive, will lead to conflicts down the road, and are affecting the global climate in a way that promises to destroy the future of society?

Is there “no alternative”, as we often hear from politicians, or is there a solution that would free us from these costs, which are unstable at the moment and very likely to increase? Can we implement this solution while remaining economically competitive and simultaneously reducing the general public’s dependence on major corporations?

Is there an alternative?

The alternative: Wind power and solar power

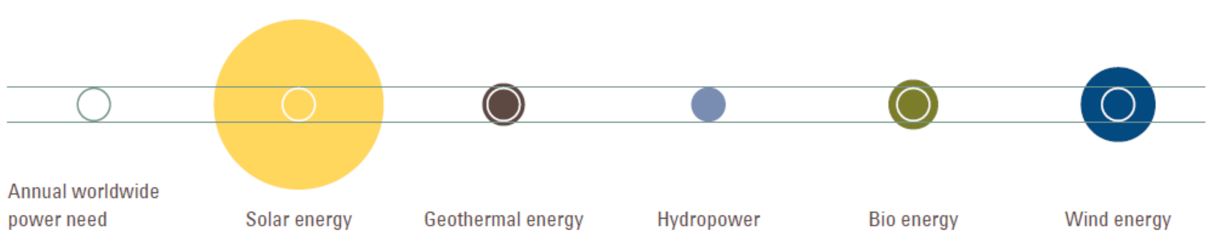
The logical conclusion of the dilemma I just described is simple: We need to free ourselves from the limited market of conventional resources.

Planning a country’s energy supply based on the assumption that the price for raw materials will remain stable is a highly speculative bet for the future and is incredibly risky. If we rely on the sun and the wind to provide us with energy and free ourselves from imports and fossil fuels, we will also no longer rely on dangerous speculation and will benefit from reliable, stable prices. That is a major difference.

How can we do this? By focusing on a combination of unlimited resources that are perfect for Germany – wind and sun.

Hydroelectricity works well in countries like Norway and Costa Rica, for example. In Germany, the best solution is a mix that mainly consists of solar and wind energy. Wind and solar energy, as well as hydroelectricity and geothermal electricity, are unlimited resources and are enough to cover our energy needs. They are free.

There is more than enough available: Every day the sun radiates 15,000 times more energy on the earth than we currently consume. Energy from the wind and the sun can be harvested anywhere. They are therefore not subject to any markets. This means that the price for this energy is almost entirely defined by the amount of the initial investment.



The sun provides many times more energy than we need globally.

Technology continues to evolve and new innovations will make renewables even cheaper; however we need to start now, otherwise our energy supply will become too expensive. These prices are real and include all possible costs. There are no more hidden costs, because wind and solar energy don't create any. That means they don't impact the environment, they don't leave behind any nuclear waste and they don't contribute to climate change. We would no longer depend on imports from unstable countries.

We would no longer rely on major corporations that value profits over citizens and communities.

The master plan – and this is what's most important to me – is not a fictional scenario for saving the world. Its aim is to combine wind and solar power to create a reliable energy source at unbeatably low prices. Wind and solar power are therefore not only more ecologically and socially sound, but also the better economic solution.

Why wind and solar power? The framework of the master plan

The master plan asks the following specific questions: How will we distribute these renewable energy sources? Should all wind turbines be located in northern Germany and all photovoltaic systems be built in the south? Shouldn't we use more hydroelectricity and biomass power plants, since they produce power continuously, which would mean a more constant supply? How much storage capacity do we actually need and is this much storage even possible?

In order to create an optimal energy supply system, the basic framework must first be taken into account. For me, this means storage, transportation, weather, availability, the role of hydroelectricity and the role of bioenergy.

Storage

There are a number of different technologies available for electricity storage; however storing electricity is and will continue to be the most expensive way to use it. Stored energy is two to three times as expensive as energy that is used directly. There are many reasons for this: The investment costs for storage are almost as high as the costs for power generation plants. The storage systems are only used temporarily, which means they have very few operating hours. Storage losses are generally high, except when using modern battery technology.

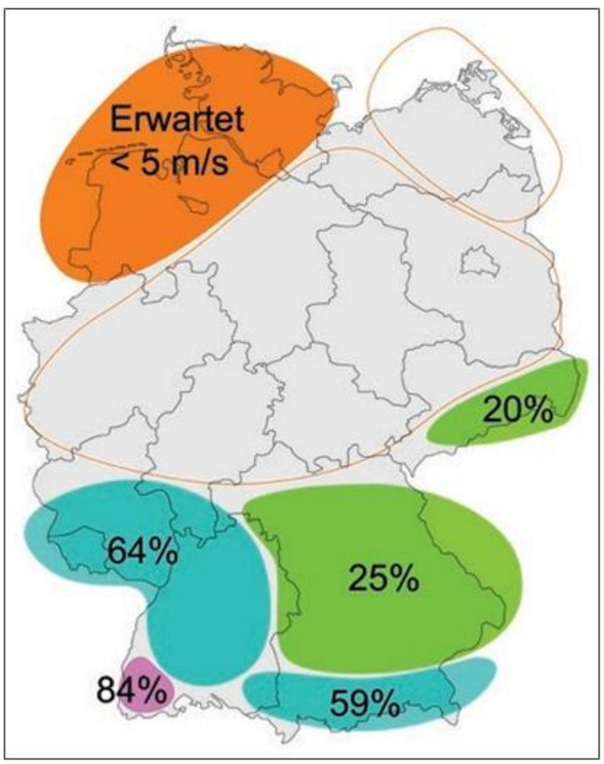
Transportation

Transporting power over long distances via high-voltage networks is expensive. This is particularly true when new and large investments are required. Networks are not storage systems. They can only transport excess power to other regions in the moment that the excess occurs. Networks become even more expensive when they are only used for a few hours every year. Transporting power also involves major losses.

New power highways don’t really result in added value. This can best be explained by comparing them to conventional highways: If all highways were designed so that every truck and every Porsche could drive at full speed on the Friday afternoon before a holiday weekend, then the result would look something like a ten-lane highway. Good for Porsche drivers, bad for the environment and simply unaffordable for the state. Normally we get by with two or three lanes, and that is what we should base our expectations on – not on the idea that everyone can drive at top speeds all the time. Unfortunately, that is exactly what is happening right now in terms of energy policy. The planned network expansion is not focused on the goals of the energy transition, but rather on the goals of energy companies, who want their coal power plants to continue running. The power highways will only be used in the future when renewable energy and excess electricity from coal plants is to be transported to the south of Germany.

Weather

Naturally Germany is sometimes subject to country-wide high-pressure systems and low pressure areas with no sun, but it is extremely rare that the entire country experiences the exact same weather. For example, in the 800 hours per year in which the North Sea winds are calm, up to 80% of the Black Forest region experiences strong winds.



Sub-average winds in the north (under 5 meters per second) can be easily compensated for by good wind conditions in southern Germany.

Availability
Wind and solar power have one-of-a-kind availability. They are available everywhere in Germany and the potential is many times greater than the current demand. In terms of production, wind and solar power is the cheapest option and remains the cheapest option in the long term. That is why I call wind and solar power our base energies.

Hydroelectricity
Large hydroelectricity systems can generate power at the same price as wind and solar power, and sometimes even cheaper, but it can only be used in a limited way in Germany. Hydroelectricity currently accounts for three percent of our power generation. This percentage can be expanded, but only up to about five percent. We don't have the required geological conditions like other countries such as Norway, which can meet nearly all of its energy needs with hydroelectricity.

Organic raw materials
Generating power using biogas is around 50 percent more expensive than power from wind or solar energy. Organic raw materials are limited, must first be grown and have to compete with other crops.

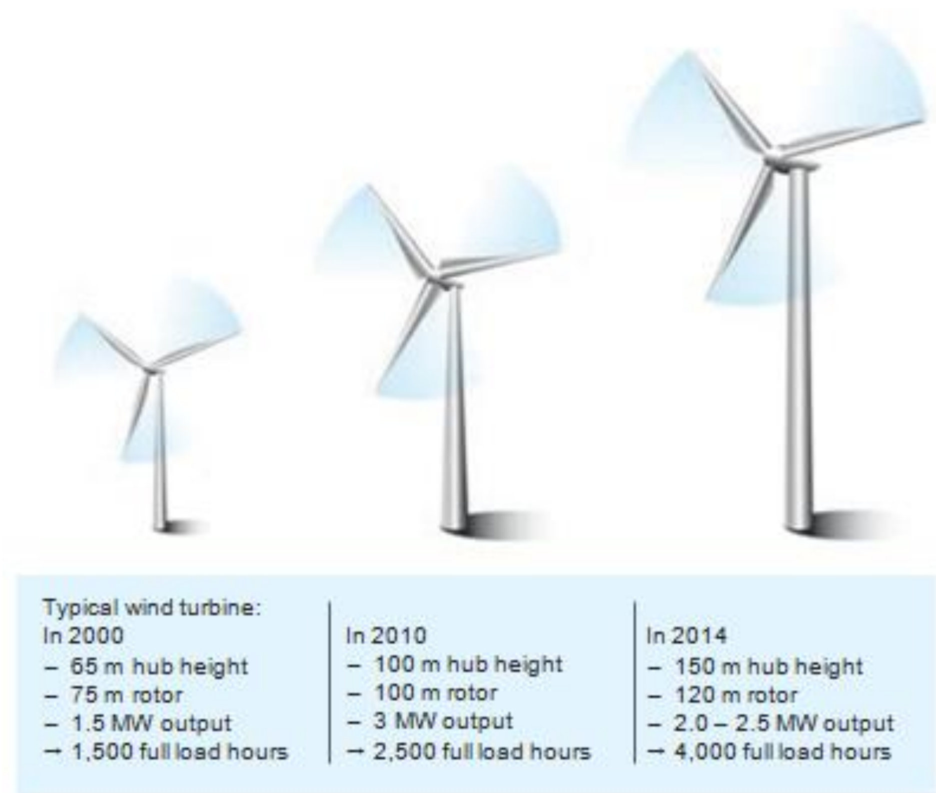
Keeping these aspects in mind, we can create an optimized system for our future energy supply, which is at the heart of my master plan.

The essentials for the most economic energy supply using the wind and the sun
We have a dilemma – fossil energies are limited and lead us to a number of dead ends – and we have a solution – wind and solar energy. Now we need to find the best and most economically sensible form of this solution. How can we combine wind and solar energy in the best possible way so that we don't stifle our economy, but actually boost it while reducing the costs for the government and the general public?

The magic formula:
We need an energy supply that is made up as much as possible of locally generated wind and solar power that is used directly in order to largely avoid having to store and transport this energy and to largely avoid using bioenergy. The motto is:

Be as close to the energy consumers as possible. We can achieve this by distributing wind and solar power systems as evenly as possible throughout Germany and installing them in the best locations for wind and sun hours, provided that this does not take a toll on nature conservation. If we implement the master plan correctly, we won't need any more than the nearly 25,000 wind turbines that are already installed today. We will also need wind and solar systems that feed in energy to the grid as steadily and evenly as possible. Full load hours are an important part of this steady energy supply. For wind systems we need at least 4,000 full load hours rather than an average of 2,000, which we've had so far, and we need more installations at exposed locations and on the coast. For solar power systems, we need 1,500 to 2,000 full load hours instead of the previous 1,000. This is possible.

Development of wind turbines



Source: Calculations and image from the 100% Renewable Foundation

Over the past few years, wind turbines have made a tremendous leap forward and are able to produce more and more power. This trend currently has no end in sight.

What are full load hours and why are 4,000 to 5,000 full load hours for wind turbines the most economic solution?

When I was writing this book, people warned me repeatedly not to get too technical with my arguments and discussions. I'll try my best. I know that, being a physicist, it's easier for me to understand certain technical concepts than it is for other people. On the other hand, I'm no good at learning foreign languages and have no musical talent. Interestingly enough, when I say that I'm a physicist, the most common reaction I get is: "Oh I stopped studying physics in 10th grade!"

Nonetheless, I would like to provide an in-depth explanation of the term “full load hours” because once a person has fully understood this term, they can understand many other concepts. Furthermore, I’ve noticed that this term is being used frequently by a lot of people, but I often have the feeling that some of these people have no idea what they’re actually talking about. When I explain this concept, it’s also partly in the hope that many people who are already talking about full load hours will then really understand what it means – in particular, those who make the decisions regarding our future energy supply.

Okay, so what are these ominous full load hours, exactly?

I will try to explain it using a farming analogy, which should be easier for everyone to understand. I also chose this analogy to explain the difference between energy and output. Let’s assume that a farmer has a horse, a plow and a large field. If the horse works at its full capacity, this would be equal to one horsepower (1 hp ≈ 0.74 kilowatts). With his horse working at full capacity, the farmer needs around 10 hours to plow the large field. The output (of the horse) is then 1 hp (0.74 kW), the work performed (= energy) is 10 hph (10 hours x 1 hp). The number of full load hours (of the power plant “horse”) is therefore calculated by dividing the amount of energy by the output of the horse – in this case 10 hph divided by 1 hp. In this case, it’s ten hours.

Now let’s assume that the horse only works at half of its total capacity because it also has to carry extra weight. Then, the amount of output that the horse uses to plow the field would be 0.5 horsepower (hp). In ten hours, the amount of work (= energy) would only be 5 hph. That means that the horse would plow half of the field. And the number full load hours? It would be 5 hph (amount of energy) divided by 1 hp (maximum output) – that would be five full load hours, even though the horse worked for ten hours.

I hope that the term “full load hours” has become a bit clearer. In terms of power plant and energy technology, the number of full load hours has become a parameter for comparing technologies and locations. For years I have heard the argument that wind power is not efficient enough because the full load hours are significantly lower than with conventional power plants.

This comparison is not valid: Full load hours are not a valid unit for comparing the yield of wind turbines with conventional power plants. The number of full load hours for coal power plants is generally very high and is nearly the same as the hours of use because you can always add more coal for fuel. This is different for wind energy and solar power systems, because the “fuel” is wind and sunshine, which is variable, but free. That’s why the main issue is how economic we can make this switch to renewables and not how “well” the generator is being utilized. In specific terms, the main point is to find a number of full load hours that is ideal for our future system.

But is it even possible to always or nearly always use the generator at full capacity?

YES, it is possible – from a technological standpoint, it’s rather easy and it’s also possible at average inland wind locations:

In terms of wind energy, this is possible if we combine a very small generator (for example one with 100 hp, or 74 kW, which is approximately the output of a car motor) with a very large rotor with a diameter of 120 meters, for example. Even a slight breeze will have the power to run the generator at full capacity. And that would be the case for around 7,500 to 8,000 hours of the 8,760 hours in a year.

From an engineering standpoint, it would be ideal if the wind turbine could produce the same output reliably nearly every day, just like a conventional power plant.

So what's the problem?

The amount of power that a wind turbine produces in one year first depends on the wind speed, and then on the size of the surface that catches the wind, the rotor diameter. It is much less dependent on the generator output. If the generator constantly operated at maximum capacity, we wouldn't be able to use the amount of energy produced by a slightly higher wind speed because we'd have to cap everything above the generator's capacity. This would waste too much energy and the price for a kilowatt hour of energy would become too expensive because the amount of usable power generated would not be proportional to the construction costs of the wind turbine.

It is therefore possible to produce much more power when you combine a rotor with the same diameter with a large generator, which also allows for much greater energy yields at greater wind speeds. However, this would reduce the number of full load hours. Previously, this was the standard setup, which is why we have an average number of full load hours between 2,000 and 2,500 at many locations.

At very high wind speeds, this produces yields so high that they can no longer be transported. This means we'd have to massively expand the electricity grid or create enormous storage units for the amount of electricity produced. What could prove to be the most economical solution for the individual turbines is not the best solution for the entire system when you take into account all of the costs.

The goal: Determining the right relationship between maximum yield and maximum utilization.

This means we need to find the ideal balance between the technical goal of consistent power generation and the economic goal of creating a system that produces the most power possible while taking into account the acquisition costs. The optimal number of full load hours for the future power supply is a compromise between the efficiency of individual turbines and the technology. The ideal compromise is around 4,000 to 5,000 full load hours – 4,000 at average inland locations and 5,000 at locations with higher wind speeds overall.

Why is that the ideal? At 7,000 to 8,000 full load hours, the wind power would cost many times as much. In the range between 4,000 and 5,000, the costs only increase by a few percent because, on the one hand, you can save money by not requiring a larger generator, a more powerful turbine and connection to the grid, and on the other hand you only cap off a few hundred hours of increased power generation a year.

Until now, wind turbines were only viewed individually and the overall relationship between them was not taken into consideration because they did not play a role in the initial phase of the energy transition. Now, however, we are focusing on wind and solar power to supply all of our electricity needs and we must take into account the sum of all of the wind turbines and not just focus on the individual installations.

Making these changes to the system will mean that we can cover around 60 percent of Germany’s energy needs using wind energy without having to significantly increase the number of turbines. At the same time this means the overall yield would not have to be increased to exceed demand when the wind speeds are very high. This allows us to generate six times as much power using nearly the same number of turbines.

This is also important when you consider preserving the natural beauty of the landscape and protecting the environment.

There is enough potential and space available to make a major impact on the energy transition.

	End of 2012	Future (based on previous assumptions)	Future (intelligent solution)
Number of turbines	23,000	**40,000**	25,000
Total output	31,000 MW	160,000 MW	80,000 MW
Average size	1,350 kW	3 – 5,000 kW	2 – 4,000 kW
Full load hours	2,000 h	2,000 h	4,000 h
Energy yield (in an average year)	62 TWh	320 TWh	320 TWh
Percentage of energy needs met (540 TWh)	10%	60%	60%

Development of wind turbines: today vs. the future as currently anticipated vs. an intelligent future solution

The number of full load hours for solar modules can also be increased from 1,000 to between 1,500 and 2,000. In order to do this, the relationship between module size and inverter size must be adjusted.

Solar modules produce direct current, which means they need an inverter that can turn the direct current into alternating current. The alternating current is the decisive factor. Today, the modules and inverters in a solar power system generally have the same output. As with current wind turbine technology, solar power systems only reach maximum capacity when the conditions are ideal, which is only for a limited number of hours a year.

For this reason, inverters can be designed to be much smaller in the future. At the same time, module yield will increase. Increasing the surface area that takes in the sunlight also increases the inverter utilization. This significantly increases the yield on cloudy days and also in the winter, and when more solar energy is collected than the inverter can process, the excess energy is stored in the form of batteries. When the batteries are full, the energy is turned into heat (primarily warm water) using buffer storage.

What do we do if there is no wind or if the wind is too strong?
For nearly two decades, skeptics have asked me this question: What do we do if there is no wind and the sun isn't shining? More recently, another question has come up: What do we do if the wind is too strong and if there's too much sun?

These are important questions, and below I will give you the answers. The two basic steps are combining the three major aspects of energy – electricity, heat and mobility – and using energy more efficiently than we currently do today.

What do we do if there is too much wind?
The simplest and most cost-effective answer to the question of what we should do if there is too much wind or too much sun: **We adjust our usage to match the amount generated.**

That means that when we generate more electricity, we use more electricity than we normally would. We won't waste electricity, however. We'll use it to prepare for phases in which we generate less energy. In specific terms, this means that on hot summer days with lots of sun we could use the electricity for cooling purposes.

Adjusting our usage when there is too much wind generally means no additional costs, or only minor costs. One inexpensive solution is to turn this electricity into heat using the power-to-heat system. Heat storage systems (generally water tanks) cost very little and many of these are already installed in district heating networks and in private households. In times when we have excess electricity, it can be easily and quickly turned into heat using a simple heating element (immersion heater). Periods when this excess power is turned into heat allow consumers to save on heating fuels. Currently, these fuels are oil or natural gas, but in the future these will be biogas or wood fuels. Oil currently costs just under 10 cents per kilowatt hour, which means wind power is already cheaper. **The second possibility is storage.** This combines the solutions for "too much" and "too little" electricity.

What do we do if there is too little wind?
By producing electricity in the way described above, we will always have a mix of wind, solar and hydroelectricity in Germany; however there will be times when these are not enough. For these phases, we need combined heat and power plants and batteries or pumped-storage power plants. These are the most important components for a need-based supply.

Pumped-storage power plants and batteries are important, but due to their low storage capacities they can only be used for small power supply gaps because they can only store small quantities of energy. They are ideal for using solar energy at night or when, for example, everyone opens their refrigerator at the same time during the halftime of a national soccer game.

Pumped-storage power plants are mainly of interest to us because there are already a number of them installed in Germany with a capacity of nearly 8,000 megawatts, which is equivalent to about ten percent of the maximum power consumption at any one time. It's possible that more of these systems will be built in the future, however they will have to compete with future battery capacities which will be located closer to the consumer and will be able to put out nearly 100 percent of the energy that they take in.

Battery storage units will also be used in private households, but will be primarily used in the industrial sector. This technology can be combined with today's "uninterrupted power supply" (UPS) technology to form synergies, such as battery backup systems for supercomputers. In the future, car batteries will be available in such great quantities that only a small percentage of those available will be used.

When we have less wind and solar power in the winter, we will need a storage unit that will provide us with energy for this time period. At these times, we will primarily rely on biomass or green hydrogen in **combined heat and power plants**.

Green hydrogen is hydrogen that is generated by electrolysis and can be stored in the existing infrastructure the same way biogas is stored. The storage capacity is immense. Underground gas caverns can store enough to supply all of Germany with power for over 100 days. Gas can be transported over long distances cheaply using the existing infrastructure. The disadvantage: Only one third of the stored amount can be turned back into electricity. The rest must be used as heat. It also makes sense to use this technology in the industrial sector so that the systems can be used most efficiently.

In order to ensure that there is enough electricity available at all times, the capacities of combined heat and power plants must be significantly increased. These combined heat and power plants (CHPs) are primarily used in the industrial sector and by public utility companies.

They have proven their operational reliability over numerous decades. The CHP is essentially a motor that drives an electric generator which produces electricity. It can be used flexibly, in any magnitude and at any time, and it is highly efficient.

Energy efficiency as an essential component of the future of energy

In order for this solution to be economical, all of the raw materials and nearly all of the stored energy must be used. At the moment, much of our technology is extremely inefficient, for example car motors, power plants and many biogas plants. Around 60 to 70 percent of our energy is being released into the atmosphere without being used. Efficient combined heat and power plants are located close to the consumers and have virtually no power or heat loss and they are highly cost effective. **If we took the money that is supposed to be invested into the large overland grid – 20 billion euros – we could finance all of the combined heat and power plants we would need for the future with a total output of 40,000 to 50,000 megawatts. If the German government would take this money and, instead of investing it in a grid system, use it to subsidize combined heat and power plants for companies, the savings in terms of energy costs would result in a major competitive advantage.**

If combined heat and power plants are so simple and reliable, why don't we use them on a large scale? Because the electricity, as opposed to solar, wind and hydroelectricity, is based on burning raw materials, which cost money. Even if we use raw materials at maximum efficiency in CHPs, they are still expensive. That is why we only use this electricity in a targeted way to fill gaps.

The wrong solution

In their plan for the energy transition, the coalition of the CDU and the FDP, which currently makes up the majority of the German federal government, included night storage heating as a form of energy storage for wind and solar energy. In doing so, they did away with the ban on night storage heating from the previous administration, which was to go into effect in 2019. The ideas behind both of these moves are correct: to shift energy consumption when there is too much electricity in the grid, and to view heat as a form of consumption and treat it as such. Night storage heating was originally encouraged in order to store as much energy from nuclear power plants in the grid as possible. This would mean that the nuclear power plants could run through the night. Isn't it a good thing, then, that these electric heaters would be operated in the future using excess renewable energies?

It sounds good, but in fact it's quite the opposite.

Purely electric heating – even heating pumps – are counterproductive because they don't help to use up excess renewable energy, but rather create a major need for additional backup capacities at the wrong time – namely, in winter. Ten million electric heating systems would require an additional backup capacity of 200,000 megawatts. This is equal to two to three times the capacity required today, and therefore is not possible. The time of year when people need to heat their homes coincides with time when less solar and wind energy is available in most parts of Germany. This is when we need to use CHPs at full capacity to meet our energy needs.

This means the government has passed a law that doesn't take advantage of the times when there is an excess amount of wind and solar power, but rather creates a new, completely unnecessary power gap in the winter. Why would they do that? Let's rephrase this question: Who benefits from this law and who petitioned for this law in the first place? The answer: RWE, a major electricity and gas company. Why? Because this would mean that they could sell their coal-based electricity, even though consumers don't need it. This in turn would mean that the CO2 emissions would be ten times as high as that from normal condensing boilers.

The energy transition is not about increasing the maximum amount of energy required by expanding inefficient systems, but it is rather about reducing energy needs as much as possible. If we want to make the energy transition as inexpensive as possible, we need to ban all electric heating immediately and reduce the required backup capacities by between 10,000 and 20,000 megawatts.

How should we use bioenergy?

When we talk about the alleged problem with bioenergy – that it feeds cars instead of people – then it's important to know that only around 20 percent of arable farmland in Germany is used to grow renewable raw materials. In 2001, 1.15 million hectares of plants were grown for biodiesel – mainly rapeseed – and another 0.9 million hectares were grown for biogas – primarily maize. I am generally in favor of using different kinds of plants so that we diversify our raw materials instead of creating a monoculture crop; however the primary problem in terms of world hunger is meat production. That is because it is a major waste of calories, water, and energy as well as arable land that is used to grow feed for pigs and cows. Numerous kilograms of feed are required to bring one kilogram of meat onto the market. If we used this land to feed people instead of animals, we could really do something to end world hunger. I don't want to try to convince everyone to become a vegetarian, but I think it's reasonable to ask that people become more conscious of their meat consumption and strive to eat it less frequently.

Bioenergy will no longer be used to power automobiles

In the future, bioenergy should be used in the most logical way. Rather than burning it as fuel in conventional cars, which is highly inefficient, it makes more sense that it should be used in combined heat and power plants to simultaneously generate electricity and heat. The CHPs are located in public utility companies, in industrial plants and businesses that require both electricity and heat. Mini CHPs are installed in private households. They are highly efficient, have low transport losses and require little storage. We have a lot of capacity: At over one million hectares, the amount of space that we currently require for biofuel is much more than would be required for growing crops for biogas.

Biogas will be burned more quickly and more efficiently

Bioenergy plants currently run almost 24 hours a day, which gives them around 8,000 full load hours. That is comparable to brown coal power plants. But when wind and solar energy is available, we won't need expensive bioenergy. That is why, rather than producing and using bioenergy at a constant rate throughout the year, it makes more sense to use it in the future as a backup for the phases when wind and solar energy are not available. We need 2,000 full last hours instead of 8,000.

Biogas can be stored in caverns. If the gas is used up in a short period of time instead of bit by bit, it's possible to quadruple the output. The amount of bioenergy that we generate from the cultivated area of just over two million hectares is enough to fill in the gaps for the times when wind and solar energy aren't enough. This backup will mostly be required in winter, when, for example, only 15 percent of the total wind power output is available on the grid.

We don’t need to use any additional space for bioenergy
More efficient energy usage will allow us to switch to 100 percent renewable energy without requiring more land devoted to bioenergy. On the contrary, an increase in efficiency in biogas plants has not even been taken into account yet in our calculations. More in-depth research will allow us to harvest more raw materials for energy from the same amount of space, and improvements in the biological transformation process will mean that we can extract 50 to 100 percent more energy from the raw materials. In the end, bioenergy is still in competition with green hydrogen. Whatever is less expensive in the end will establish itself as the standard.

The formula for the master plan: 60+25+5
It is technically and actually possible to achieve a highly consistent energy supply using wind and solar energy. To achieve this, we need systems that can collect a lot of wind and a lot of sun, while at the same time being equipped with small generators or small inverters. These systems must be distributed optimally throughout Germany and be able to produce energy close to the consumer.

We can cover around 60 percent of our energy needs with wind power, and around 25 percent with solar power. If we add 5 percent from hydroelectricity, then up to 90 percent of our energy needs can be covered using wind, solar and hydroelectricity as direct sources. The rest will be supplied from combined heat and power plants that are run using bioenergy.

On a warm summer day, Germans consume 40,000 megawatts of energy; at peak times, for example a cold winter afternoon, they use up to 80,000 megawatts of energy. These 80,000 megawatts are also the maximum amount that the grid can hold. That is the basis for my calculations. 80,000 megawatts of wind power can be integrated into the power grid today in a way that is evenly distributed and close to the consumer.

Once wind turbines are optimized to run with 4,000 full load hours, they will be able to provide up to 320 terawatt hours. The net energy consumption in Germany is currently approximately 540 terawatt hours. This means that using 25,000 modern wind turbines, we can generate 60 percent of the net energy requirement in the future. How can we achieve 25 percent solar power?

By optimizing our use of solar energy by increasing the number of full load hours to between 1,500 and 2,000 and increasing the yield from rooftop systems. This will also significantly increase the yield on cloudy days and in the winter in particular. The excess power will be stored (primarily in batteries) and turned into heat (mainly into warm water). In total, in comparison to all of the scenarios that have been suggested today, we will need less long-term storage of power if we can generate the majority of this energy directly using wind and the sun and have it located close to the consumer.

The second formula of the master plan is: Energy + Heating + Mobility + Efficiency
The master plan considers and brings together all three submarkets of energy consumption. Energy is one of them, heating is the second and fuel for mobility is the third. When you take into account the rising price of oil and the dwindling resources, it's clear that we have to act quickly to move the market of motors and mobility to renewables. The additional electricity required for electro mobility will be made possible by saving energy (for example by placing a ban on standby functions for electronic devices) and increasing efficiency elsewhere, so that the overall energy requirement remains the same. An ideal combination of all three energy markets and efficient energy usage are the two major factors for creating an optimal economic solution for the energy industry of the future.

The combination of wind and solar power with a high number of full load hours and a combined heat and power plant that is run on bioenergy will make energy self-sufficiency a real possibility across all levels – from private residences to the industrial sector.

If the master plan is correctly implemented, we can reduce our primary energy consumption by 25 percent compared to today simply by increasing efficiency. Primary energy is the energy that must be used (i.e. coal) in order to generate end energy (i.e. electricity). With my concept, we would never pay more than 10 cents per kilowatt hour of electricity. That means we'd spend less money on the whole than we spend today just on imported raw materials. With the money we save we could easily introduce electro mobility and adequately insulate our houses.

Three myths that the master plan disproves

Myth 1: Wind and solar power won't work because of a lack of frequency and voltage stability
Wrong. In order for grid operation to be stable, the voltage may not fluctuate and the grid frequency must remain constant at 50 Hz. In this regard, modern wind and solar power systems have all of the characteristics of conventional power plants. Combined heat and power plants can be connected or disconnected, turned up or turned down as needed in order to ensure stability.

The storage capacity of batteries in the future will cover many times our current maximum energy requirement. The one million electric cars, which the German government would like to have on our roads by 2020, would be sufficient for this purpose.

They won't all be connected to the grid at the same time, will they? No, they won't; however, in the future, if there are between 30 and 40 million electric cars and an average usage time of a half an hour per day, there will always be enough vehicles connected to the grid.

Myth 2: We need offshore wind turbines in order to have enough full load hours and to create jobs
Wrong. The master plan makes it very clear: We absolutely cannot afford offshore wind energy. The arguments for offshore wind power were always the number of full load hours, the lack of space inland and the lower price. All of these have been disproved. Wind turbines in the North Sea and the Baltic Sea would be much too far away from the consumers. This system would require vast transport grids, an expensive grid expansion, increased storage capacities and all of the value created on-site would be lost. It's true that offshore wind turbines have a high number of full load hours, but significantly more full load hours are possible than was previously assumed by using the right technology for inland wind turbines along with solar power installations.

Once solar energy becomes far cheaper than offshore wind due to innovations and mass production of solar modules, offshore will become the most expensive way to produce electricity. It is already more than two to three times more expensive than wind energy on land.

I've talked about this with a number of politicians – with the Federal Minister for the Environment Peter Altmaier, as well as with members of the SPD and the Green Party, and they all said: Yes, offshore energy is expensive, but it creates a lot of jobs. Last year, however, the solar industry created six times as many jobs and politicians still drastically cut the feed-in tariff. The only reason: The electricity was too expensive.

It doesn't make sense that this argument doesn't apply to the most expensive method of generating electricity. It only starts to make sense when you learn that the producers of offshore electricity are not the public, but rather major corporations. Once you know that, it becomes clear why the Bundestag decided to subsidize offshore wind energy now, at the height of the debate over electricity prices, even when there is no grid for this power.

Myth 3: We need to expand the grid
Wrong. All of the studies that have been used to justify grid expansion are based on the erroneous claim that wind turbines will only achieve between 2,000 and 2,500 full load hours in the future. Either the people who conducted these studies didn't know that the full load hours can be easily adjusted, or they were pursuing the objective of feeding as much wind and solar power into the grid as possible, but also feeding in coal power at the same time.

I've said it before: Expanding the grid is following the same logic as creating a ten-lane highway in order to allow every Porsche driver to drive as fast as they want any time they want, without taking into account the economical and ecological costs.

It's possible that coal power is of great interest for these major corporations. For Philipp Rösler, the Federal Minister of Economics and Technology, it's possible that he wants to support these corporations and he simply doesn't know better. At any rate, he has consistently been a prominent supporter of a quick and extensive grid expansion. By passing laws that move to quickly implement this plan, he wants the Green Party to get caught between their two main interests – the energy transition and environmental conservation.

Since we don't need offshore energy, as was shown earlier, but instead need wind energy distributed throughout the country and close to the consumer, we also don't need to expand the grid to the highest possible voltage level. There are simple ways to transfer loads. We can turn electricity into heat or gas and store it, which would require an even lower investment than the proposed grid expansion. What we need is repowering. Old wind turbines with less full load hours must be replaced by new ones with more full load hours.

What does the master plan mean for everyday people?

In my master plan, electricity is not considered on its own, but rather as part of an overall system of energy supply – in combination with heating and mobility. The average German household spends

5,000 euros annually for this energy package. Politicians are debating the 200 euro EEG apportionment, but not the other 4,800

euros of that package, and they are ignoring the price increases that are going to affect us in the future if we don't rid ourselves of our dependence on conventional fuels, especially oil.

That is why it's time that we finally start to name the people who are truly driving up energy costs and to push back against them. Everyone together, and ideally with an honest Minister for the Environment leading the forefront. That is why I'd like to now address Peter Altmaier directly and tell him: Dear Minister Altmaier: We don't need a "brake on electricity prices" to slow down the rising energy costs if it will only amount to an eventual rapid increase in these prices.

What we need is a special tariff for low-income citizens who can't afford the EEG apportionment.

What we need is an end to the subsidization of conventional energy sources.

What we need is to slow the increase in the price of oil and gasoline.

What we need is to slow down the growth of the electricity and oil cartels.

Every year we spend 200 billion euros on energy, and this upward trend is accelerating.

We need to hit the brakes on all of this, Minister Altmaier. Because, compared to this, even the trillion euros you calculated is minor.

And we need to start by immediately switching over to 100 percent renewable energies.

If anyone is able to do this, then as the Federal Minister for the Environment, it's you.

This became clear to me as we traveled together from Berlin towards southwest Germany.

Our government must now identify the best locations for wind turbines, while at the same time protecting the environment, and they must revise the EEG so that the solution it presents can be implemented quickly.

Minister for the Environment Peter Altmaier visiting the juwi headquarters in summer 2012.

The master plan for energy, heat and mobility
This is how we can quickly achieve an energy supply made up entirely of renewable energies:

1. The formula of the master plan is: 60 percent wind power, 25 percent solar power, 5 percent hydroelectricity. The rest will be supplied from combined heat and power plants that are run using bioenergy.

2. We will primarily use wind and solar energy because wind and sunshine are unlimited and free. This will end our dependence on expensive imports and rising prices for the limited quantities of raw materials such as oil, coal and gas.

3. Wind and solar energy can provide a reliable electricity supply around the clock. Power gaps in the winter can be covered using bioenergy and stored electricity.

4. The systems will be designed so that they provide as much electricity as consistently as possible. We will distribute the energy systems as evenly as possible throughout Germany. In the individual regions we will select the best technology for the locations with the greatest possible yields.

5. We don’t need any more wind turbines than we already have or any additional land for bioenergy. We will not use high-voltage lines or expensive electricity production in offshore systems, and we will make it easier to store electricity for later use.

6. Our energy supply will not only be completely clean and sustainable, but will also be reliable and affordable in the long term.

7. By using electricity, heat and mobility more efficiently, we would be able to produce energy at lower prices than we are currently paying for imported raw materials today, not just in the future. With the money we save, we can switch to electric cars and insulate our homes.