

RENEWABLE ENERGIES IN GERMANY – CHALLENGES AND ADVANTAGES FOR AN EFFICIENT POWER SUPPLY

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Abstract: This paper gives the author's overview of the electrical power supply in Germany in terms of customer expectations, investment in infrastructure in Germany, the use of renewable sources of energy, including solar and wind energy and the influence of taxes on the cost of electrical energy in Germany. The author describes the challenges and advantages of this situation in general.

Introduction

The motivation for efficient power supply is connected with the demand for low cost of the energy and safe supply. That means the supply should be reliable and the grid frequency should be in the required range (Fig. 1). Unfortunately, as the history shows it is very difficult to forecast energy prices (Fig. 2).

Securing a reliable power supply in the time of “Energiewende” in Germany depends on great infrastructure projects like the extension of the national grid. These infrastructure projects are mostly influenced by the national government, the provincial government, the local authorities and the citizens. Coming to a final agreement very often requires a lot of discussions (Fig. 3).

Nevertheless, changes in the power supply have taken place since the beginning of the industrialization and might be seen as an ongoing process (Fig. 4).

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Efficient Power Supply?



Motivation, when an efficient power supply is demanded

- Costs are low
- Supply is safe
 - Grid frequency
 - Reliability

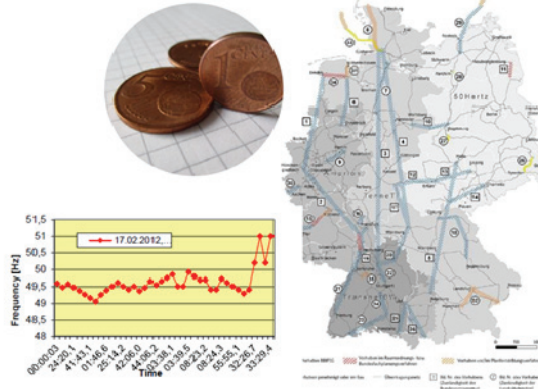


Fig. 1. Efficient power supply

Development of Energy Prices –



Who is able to do a Forecast?

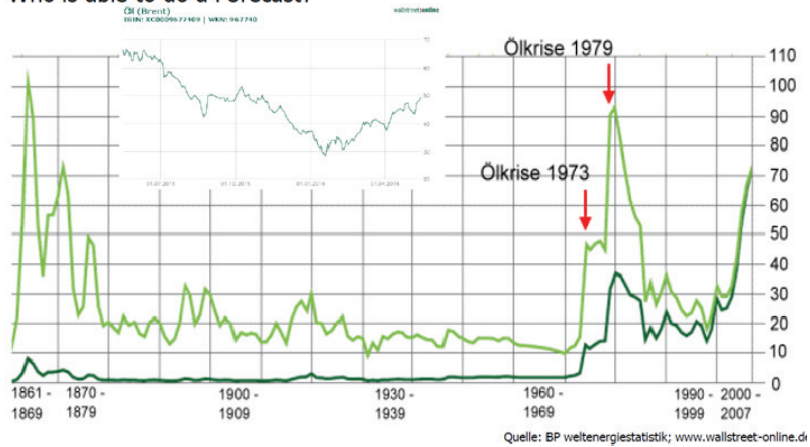


Fig. 2. Development of energy prices

Investment Protection



Infrastructure projects in Germany – influenced by

- National Government
- Provincial Government
- Local Authority
- Citizens

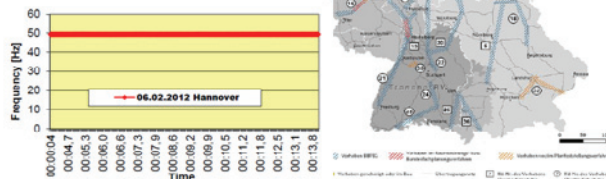


Fig. 3. Investment protection

Investment Protection:
Substitution Effects in the Power Industry

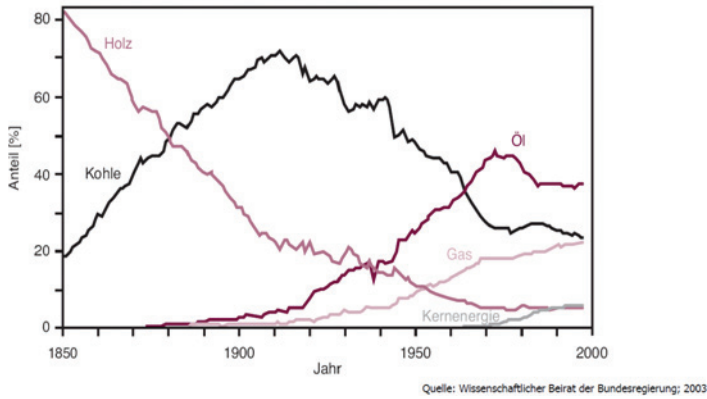


Fig. 4. Substitution effects in the power industry

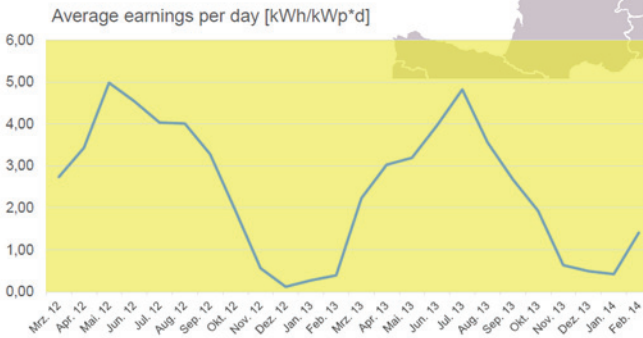
Power Supply by Renewable Energies

Power supply by using conventional sources like coal fired power plants or nuclear power plants is more or less familiar with the customer requirements and covers the demand by operating the power plants on a specific power level. When using renewable energies like the sun radiation or the wind energy you are faced with a strong fluctuating supply that depends at least on the time of the day, the date during the year and the location on the earth. In any case, the earnings from renewable energies for a specific date are hard to predict (Fig. 5 – 7).

Power Supply with Photovoltaics in Germany
Weiden i.d.Opf.



- Specific Earnings with Photovoltaics in Germany
- Average daily earnings



Source: Location OTH-Weiden

Fig. 5. Power supply with photovoltaics in Germany

Power Supply with Photovoltaics in Indonesia
Pekanbaru, Riau Province, Sumatra



- Specific Earnings with Photovoltaics in Indonesia
 - Average daily earnings

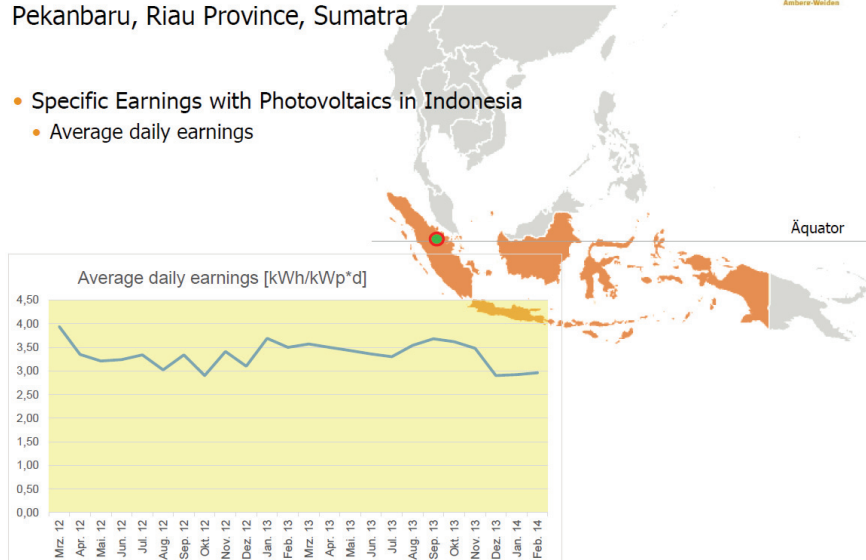
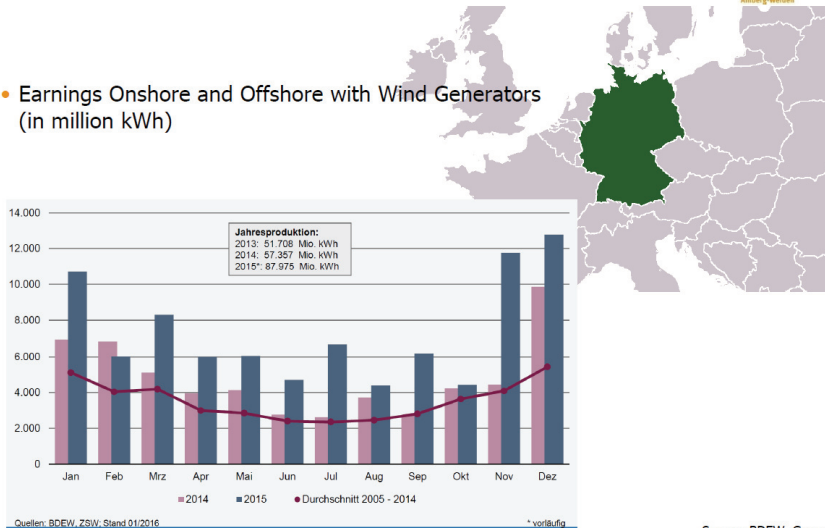


Fig. 6. Power supply with photovoltaics in Indonesia

Power Supply by Wind Generators in Germany



- Earnings Onshore and Offshore with Wind Generators (in million kWh)



Source: BDEW, German

Fig. 7. Power supply by wind generation in Germany

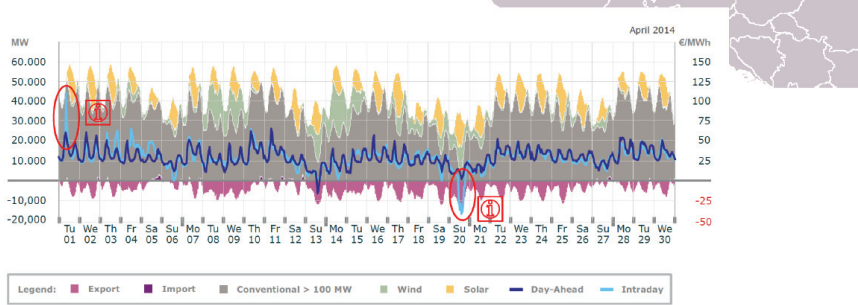
This unpredictable situation in power supply and power demand by using renewable energies like solar radiation or wind energy leads to a situation where the cost for electrical energy on the spot market is negative (Fig. 8).

This negative price happens when the production of electrical energy is higher than the demand in the grid in Germany. In this case, power producers that are not able to shut down their plant are going to pay money for getting rid of the produced power.

Power Supply in Germany



- Electricity Production and Spot-Prices: April 2014



Source: Fraunhofer Institut, German

Fig. 8. Electricity production and spot-prices: April 2014

In 1998, the German government forced the extension of renewable energies. The targets were set on how much of electrical energy has to be covered by renewable energies. Finally, that leads to a complex taxation system for the electrical energy that, on the one hand, should help to cover the cost for financing the extension of the renewable energies and, on the other hand, it has to consider the total cost for the customer. The customer expects moderate increase in the cost of energy. These targets were met very well during the last years (Fig. 9 – 11).

Electrical Power – the Highest Form of Energy Costs for Industrial Enterprises

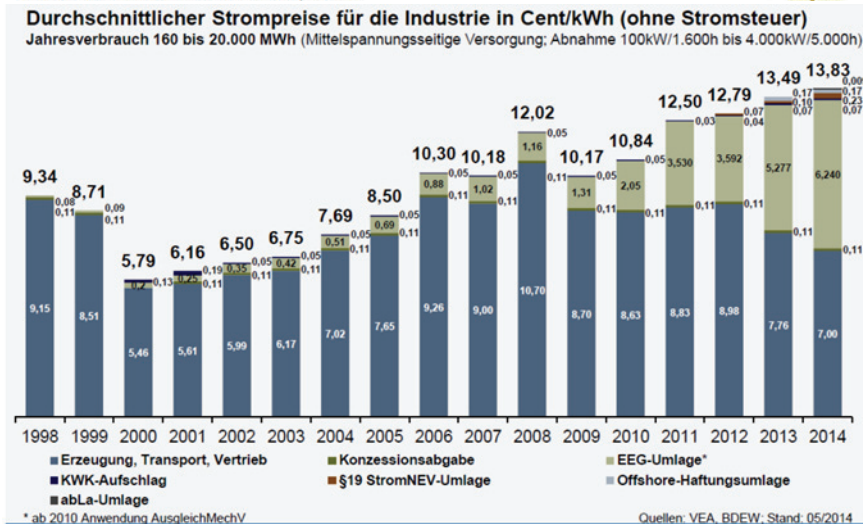


Fig. 9. Costs for industrial enterprises

Electrical Power – the Highest Form of Energy



Private Households

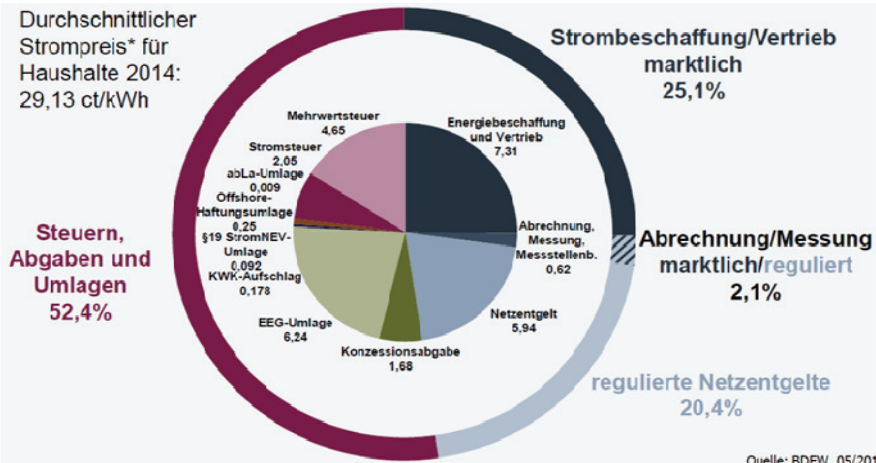


Fig. 10. Private households

Electrical Power – Cost Structure



Average Household in DE: 3.500 kWh_{el}/year

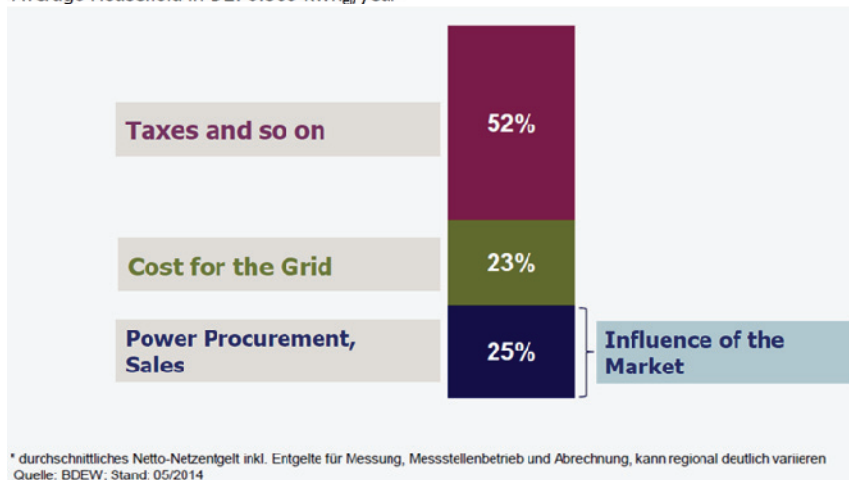


Fig. 11. Cost Structure of electrical power

From 2010 up to 2014 the extension of renewable energies in Germany became partly an exponential rate of growth. Such an exponential growth might lead to more undesirable effects, including negative prices on the spot market. By adopting the financial parameters for the power producer of renewable energies the rate of growth was reduced and it is expected to be on the track again. The German government expects a target of 80 % of the electrical power in Germany produced by renewable energies for the year 2050 (Fig. 12).

This process is called “Energiewende”, since the nuclear power plants in Fukushima became unsafe in 2011 and the German government decided to stop the production of electrical energy by nuclear fuels by 2022.

Targets for the Gross Electrical Power Consumption in Germany

Based on the Renewable Energy Law 2014 (BMWI)

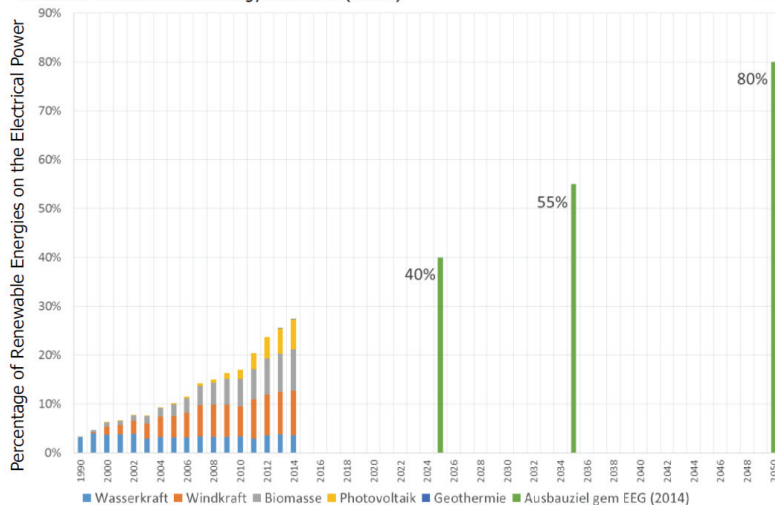


Fig. 12. Targets for the gross electrical power consumption in Germany

Production Costs for Energy

The knowledge of developing and using renewable energies for more than 20 years in Germany has resulted in different studies about the current production cost for the renewable energies and the production cost expected in the future. The comparison of the conventional power production using the fossil fuels and/or nuclear fuels is of special interest. The Fraunhofer research center concluded that the production cost for electrical energy, when using wind energy onshore, has already undercut the production cost for electrical energy compared when using fossil fuels and nuclear fuel in Germany (Fig. 13, 14).

Production Costs: Renewable Energies

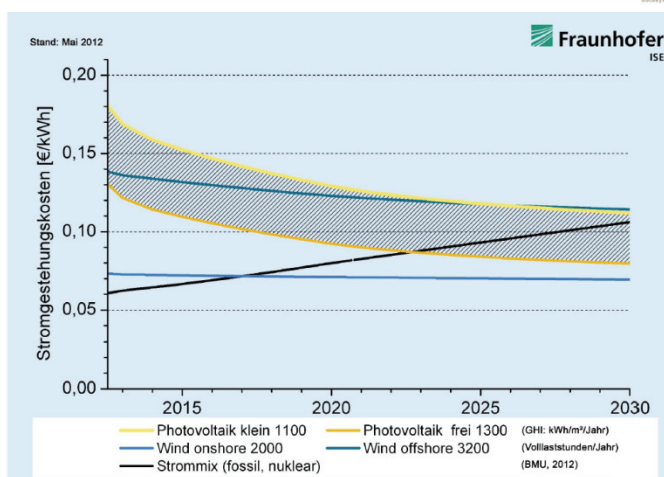


Fig. 13. Production costs: renewable energies

- System Expansion
- Smart Grid Systems
- Controlling Power Range
- Power Storage

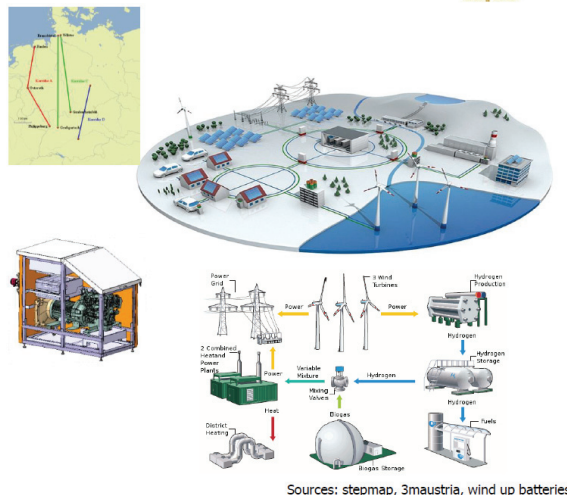


Fig. 14. Challenges/advantages of renewable energies in DE

In terms of study it can be expected by end of 2020s the production of electrical energy in Germany by renewable energies will be almost much cheaper than using fossil fuels or nuclear energy.

Conclusion

An important aspect of utilizing renewable energies in Germany is the international commitment to the Kyoto protocol. The reduction in CO₂-emissions by producing electrical energy has been the main target. Nowadays, nearly 20 years after the signing of the Kyoto protocol, Germany is well on the way and reaching all the targets from international agreements referring to the reduction in CO₂-emissions.

Currently, the challenges and advantages of the “Energiewende” are of interest. One big topic is the extension of infrastructure, e.g. guiding the energy from wind power plants in the north to the more industrialized centers in the south of Germany. The industry and policy makers are discussing the final agreements. In the result, Germany will get a high-end transmission system for electrical energy that will be a blueprint for transmission lines in the 21-st century.

Another very big topic is the integration of the fluctuating renewable energies in a grid system of the highly industrialized country like Germany that needs a reliable power supply system, especially when 80 % of the electrical energy is procured by renewable energies, and thousands of small power producers are in the grid. Under these circumstances, a smart grid system and suitable energy storage systems are necessary. At the moment, a wide range of solutions are discussed. It is interesting from the engineers’ perspective that not only the electrical power supply is discussed, but the integration of the mobility sector. It can be expected that solutions for this wide range of challenges will be

cutting-edge technologies that will bring more advantages than disadvantages. The energy supply system in Germany will become almost fully sustainable by the end of this century.

Возобновляемая энергия в Германии – проблемы и преимущества эффективного электроснабжения

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Ключевые слова: возобновляемые источники энергии; солнечная энергия; устойчивость; энергия ветра; энергоэффективность.

Аннотация: Представлена авторская точка зрения на тему электроснабжения в Германии в соответствии с ожиданиями клиентов, влияния на инвестиции в инфраструктуру федеральной системы, энергоснабжения с использованием возобновляемых источников энергии солнца и ветра и влияния налогов на стоимость электрической энергии. Дано описание проблем и преимущества данного вопроса в целом.

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