A brief review of Renewable Energies in Germany

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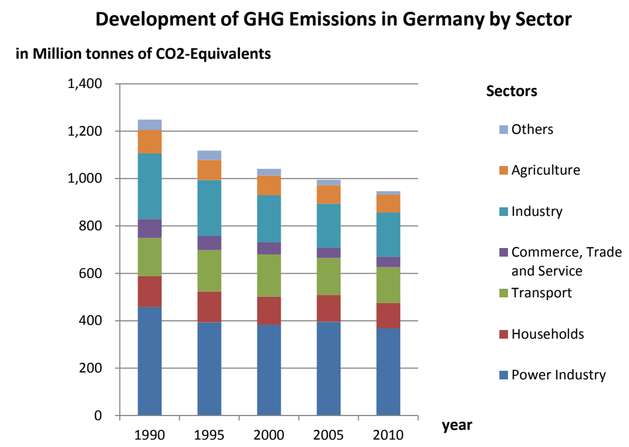

Figure 1: Own Illustration based on Umweltbundesamt (2014)

Introduction

Due to climate change and shortages of fossil fuels a transition to clean-green energies becomes crucial. By 2020 Germany wants to reduce its greenhouse gas (GHG) emissions by at least 80% compared to 1990 (Henning & Palzer, 2013). Germany is currently running its energy transition (*Energiewende*) and the primary focus seems to be on electricity generation (Smith Stegen & Seel, 2013). Taking under consideration that electricity approximately accounts for half of all GHG emissions from the German power industry (Henning & Palzer, 2013), this development is sensible. Major aims of the German Government are to phase out nuclear power by 2022 (Dehmer, 2013) and to increase the share of renewable energy sources (RES) in electricity supply to minimum 35% by 2020 and minimum 80% by 2050 (Pegels & Lütkenhorst, 2014).

This poster aims to give a brief introduction into the German *Enegiewende*, to give an overview of different renewable energy sources (RES) in Germany and to show impacts and challenges of the *Energiewende.*

The German *Energiewende*

In general, the *Energiewende* is driven by the following laws: The Renewable Energy Act (EEG), the Renewable Energy Heat Act, the Grid Expansion Acceleration Act and the Energy Economy Law (Smith Stegen & Seel, 2013). The EEG was established in 2000 (Mabee, Mannion, & Carpenter, 2012) and guarantees a privileged feed in of renewable electricity and a fixed feed in tariff (FIT) for 20 years (Kirsten, 2014). The renewable electricity consumption increased from 3% in 1990 to 23% in 2012.

Renewable Electricity Supply in 2013 by Source

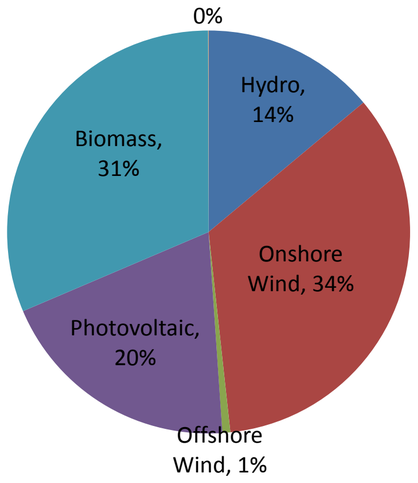

Figure 2: Own Illustration based on Bundesministerium für Wirtschaft und Energie (2014)

Renewable Energy Sources

The uptake of renewable energies is increasing in Germany. In 2013 RES accounted for 25.4% of the total electricity supply (Bundesministerium für Wirtschaft und Energie, 2014). For the electricity generation will be concentrated on wind energy, photovoltaic (PV) and biomass (see Fig 2) as hydro sources have already reached their limitations in Germany and there is little potential for geothermal (Scholz, Beckmann, Pieper, Muster, & Weber, 2014).

Wind

Figure 3: Wind power plant, *Retrieved from:* http://www.br.de/themen/wissen/energie-windkraftanlagen-holztuerme100.html

Wind energy has almost quintulpted since early 2000s (Smith Stegen & Seel, 2013).

In 2012 the onshore and offshore wind energy capacity was 31,156MW. Germany aims to have a growth in wind energy generation to 85,000MW by 2050 which would account for half of Germany`s electricity demand (Smith Stegen & Seel, 2013).

The German Government wants to achieve an onshore capacity of 30,000MW by 2030 and an offshore capacity of 10,000MW by 2020 (Smith Stegen & Seel, 2013).

PV

Figure 4: Photovoltaic, *Retrieved from :* http://www.jahrstorfer-solartechnik.de/?Leistungen:Photovoltaik

Photovoltaic (PV) is the most supported renewable energy source in Germany (Kirsten, 2014). Since 2008 solar panel prices have been falling rapidly and through the financial crisis bank interests were near zero so the investment in solar panels became a popular fund in Germany (Dehmer, 2013).

Through this development there was a yearly increase of PV which was twice as much as expected in 2009, 2010 and 2011 (Dehmer, 2013). The capacity increased by 7,000MW per year. It is aimed that PV supplies by 2050 15% of 764 TWh end-user electricity supply (Scholz, Beckmann, Pieper, Muster, & Weber, 2014).

Biomass

Figure 5: Biomass, *Retrieved from:* http://www.carbon-terra.eu/de/schottdorf-meiler/input

Almost one third of all generated renewable electricity is generated from biomass, which makes it to one of the most important energy sourcesin Germany (Sauter, Witt, Billig, & Thrän, 2013).

Furthermore, the Renewable Energy Heat Act aims a share of 14% of renewable heat by 2020 (Deutsche Energie-Agentur, 2010). Therefore Biomass will play an important part, as it is often used in combined heat power (CHP). Moreover, Scholz and other authors (2014) point out, that by 2050 around 7% of all electricity demand will be fed by biomass and SNG produced from biomass.

Biomass has the advantage, that it is storable and the already existing infrastructure can be used.

Impacts of the *Energiewende*

GHG Certificate Glut

There is a European-wide trade of CO_2 certificates, which is supposed to set incentives for investments into CO_2 reducing improvements (Kirsten, 2014). The amount of certificates is fixed by political arrangements and their prices are determined by market processes.

Through the *Energiewende,* the European certificate market became crowded because Germany has less CO_2 emissions and needs less certificates. This means, the supply of certificates rose while the demand decreased, which reduced certificate prices and involved a slackening of incentives.

Electricity Price

The extra costs of renewable electricity generation is paid by a "EEG-Umlage", which is a surcharge on the electricity price. A study of the Fraunhofer Institut für Solare Energiesysteme ISE says that the EEG distribution increased from 0.19 c/kWh in 2000 to 6.24 c/kWh (European cents; 1.00€=1.4557AUD [29.09.2014]) in 2014 (Mayer & Burger, 2014).

The "EEG-Umlage" is defined by the difference of the compensation payment (FIT), which an operator of a renewable power plant receives and the electricity price at the electricity exchange market (Kirsten, 2014). The electricity price at the electricity exchange market is defined by the highest marginal cost which arise for electricity generation.

Simplified the following formula can be derived:

$$EEG\text{-}Umlage = FIT - C_{max.\ marginal}$$

Through the GHG certificate glut, marginal costs decreased and as the marginal costs for renewable electricity generation is nearly zero, the "EEG-Umlage" increased.

Since supplier of electric energy rarely decrease their general electricity prices, the reduced electricity exchange market price was not forwarded to customers. Therefore, the electricity price increased, as the "EEG-Umlage" increased and is added to the general electricity price. Furthermore, the number of industries which are excepted from renewable energy transfer to keep them international compatible is increasing, which again leads to a rising "EEG-Umlage" and to rising electricity prices. This leads to criticism in the German society as mainly private customer pay the *Energiewende.*

Major Challenges of the *Energiewende*

The storage of renewable energies and peak demand management are seen as challenges. The Deutsche Energie-Agentur (2010) says, that many industries can contribute to this by running energy intensive processes during times of high electricity supply.

Furthermore the grid expansion is a challenge. Smith Stegen and Seel (2013) point out that the Deutsche Energie-Agentur published a report in 2012 which presents how Germany can meet a share of more than 60% of renewable energies in electricity consumption by 2030. Their least expensive scenario would cost 11.1billion and would require 11,200 km of new high and extra-high-voltage lines.

Conclusion

The uptake of clean green energy in Germany benefits strongly from the EEG and the most important RES in Germany are wind, PV and Biomass. Nevertheless, the *Energiewende* has negative impacts on the GHG emission certificate trading and the electricity price has strongly increased. The major challenges are seen in grid extension, storage technologies and peak demand management.

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