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2013

Bachelor of Commerce Best Business Research Papers

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Original citation:

Macklin, H. (2013). Bluer skies: Germany's path towards a renewable future. *Bachelor of Commerce Best Business Research Papers*, *6*, 39–49.

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Bluer Skies:
Germany's Path Towards a Renewable Future

Hannah Macklin
Fall 2012

ABSTRACT

This research paper's objective is to evaluate Germany's Renewable Energy Sources Act (EEG), and outline how the nation can achieve its goals. It summarizes the changes Germany is making in order to phase out nuclear energy, and what consequences these may have. In addition, this paper evaluates Germany's efforts to shut down nuclear energy while still managing to increase renewable power generation. Focusing on Wind and Solar power generation, this paper describes the initiatives that Germany is taking to successfully reach its goals, and what challenges they are facing. It uses the Natural Step Framework to describe the EEG and outlines three main focus areas that need to be considered when moving forward. These include increasing energy efficiency, reducing carbon emissions in all sectors, and bridging the gap after removing nuclear energy and increasing storage capacity to ensure a stable energy sector using renewable sources. A short survey taken by university students in Cologne indicates a preference towards investing in renewable energies. After reviewing all of these aspects, the results indicate that Germany is currently successful in staying on schedule with their Renewable Energy Sources Act, and will most likely be able to achieve its goals, perhaps even sooner than planned.

INTRODUCTION

Only recently has environmental sustainability become a prominent topic for policy makers in developed countries. It has become clear to the world that our previous methods of conducting business, sourcing energy, and living our daily lives are not feasible options for the future. Sustainability is based upon one simple principle: the limits of our planet's capacity must be recognized in order to guarantee lasting economic prosperity and social well-being, for today and for the future. Each generation takes on the responsibility to solve the problems facing them today, to be aware of the impact they have on our Earth, and which will affect future generations. Sustainability is not confined to national borders, but is a global issue that is linked by business, society, and the environment. For this paper, I have chosen to focus on Germany's initiative towards sustainable energy.

The production and consumption of energy holds a key position in the economic process not only because it is a necessity that is growing in demand, but also because it affects every level of a sustainable society. Energy is used to heat homes, run vehicles, power appliances; almost every aspect of modern society uses some form of energy. However, our current preferred method of fossil energy sources such as gas and oil are in limited supply, and have drastic effects on our planet. After the traumatic effects of Fukushima, nuclear energy, a relatively carbon free source, has also proven to have extreme consequences and limitations. For these reasons, a transition towards changing Germany's fundamental energy consumption infrastructure is being undertaken by the government. The country is phasing out nuclear energy and pushing towards renewable sources derived from natural processes. This paper will focus on wind and solar, primary alternatives to nuclear energy, and how they will

contribute to Germanys Energy Concept. Germany has the chance to become one of the first major industrialized countries to have an efficient energy system, based on renewable sources.

GERMANY'S GREEN PLAN

Germany is perusing a very unique and bold path towards reaching their sustainability goals. The major piece of legislation driving increased renewable energy is Germany's Renewable Energy Sources Act (EEG) and the Electricity Feed-in Law (strEG). This law is a feed-in-tariff that requires utilities to connect renewable sources to the energy grid and reimburse them at a certain rate over a period of time. The EEG provides a fixed rate for producers of green energy (Keppley, 2004).

In September 2010, the government released the Energy Concept, which outlined their plan to reduce carbon emissions using strategic targets unparalleled by the rest of Europe. Using 1990 as the base marker, Germany plans to reduce carbon emissions 40% by 2020, and an astounding 80-95% by 2050. The government aims to reduce primary energy consumption 20% by 2020 and 50% by 2050. In addition, electricity consumption is to fall 10% by 2020 and by 25% by 2050 using 2008 as the benchmark. One of the most pinnacle points is the countries ambition to have renewable energies achieve an 18% share of gross final energy consumption by 2020, 30% by 2030, 45% by 2040, and 60% by 2050 (BMU, 2011).

Decision to remove nuclear energy

After the disaster in Fukushima, the German government deemed nuclear power an unsafe means of electricity. Germany decided to phase out their reliance on nuclear electricity (which was about 30% of the national supply in 1999) (Bundesregierung, 2011). Seven nuclear plants were shut down permanently within three months following the accident (Bundesregierung, 2011). Germany was able to avoid blackouts and meet energy demands by reducing surplus electricity exports, by temporarily importing electricity from neighbouring countries, and by using the reserve capacity of traditional back-up power plants (Jungiohn & Rickerson, 2011). The remaining nine plants will be shut down completely by 2022 at the latest and perhaps even sooner (Bundesregierung, 2011). This phase out of nuclear power has opened up doors for investment in renewable energy and high-efficiency natural gas plants instead, which reduces the cost for these technologies and creates a less costly adaptation for the economy.

Not all countries in the European Union (EU) feel the same way. French Prime Minister Francois Fillon, whose country operates more than one-third of the nuclear reactors in the EU and uses 80% nuclear energy to power the country believes this plan is unrealistic. Fillon respects the decision, but believes there is no way for the European Union to meet its emission-cutting targets without some nuclear power (WRI, 2011). However, Germany has already transformed the way it produced energy; from 2000 to 2010 Germany managed to transform its use of renewable electricity from 5% to 17%. Andreas Carlgren, Sweden's Environment Minister, also criticized the German decision, saying it could result in higher electricity prices across Europe (WRI, 2011). However, Germans have been willing to tolerate slightly higher energy prices if it means the promotion of a domestic renewable energy industry (Keppley, 2012).

One way Germany was able to avoid blackouts was by temporarily importing electricity from neighbouring countries. In 2011 Germany was increasingly importing energy from France and the Czech Republic (Gitschier & Neubecker, 2011). Since France produces mainly nuclear energy, Germany appeared to be replacing nuclear with nuclear, and outsourcing the risk to neighbouring countries. However this apparent hypocrisy will be short lived as the country builds gas plants and invests in solar

and wind power to make up for the loss in energy production. Germany certainly does not plan to rely on other countries for energy sources on a long-term basis.

Without nuclear energy, Germany will need to develop more efficient power grids. In May 2012, the country announced that over the next decade they would expand their energy grid to help renewable power fill the gap. At the request of the government, the four major grid operators drew up a strategy for the essential grid expansions. This included upgrading 4400 km of existing transmission lines and adding some 3800 km of new high-voltage lines over the next ten years. The cost of this investment would reach up to 20 billion by 2022 (World Nuclear, 2012). However, without the proper investment and upgrades, Germany could experience higher costs elsewhere. For example, it could lead to shutdowns of regional energy producers because the proper infrastructure is not available, resulting in higher prices nationally and perhaps the need to import energy as a price-taker (World Nuclear, 2012). Currently, power stations are located relatively close to where electricity is consumed. However, in the future, power generation at sea and in coastal areas will increase significantly. This means power can be fed into the grid from many different generation systems, like photovolics, wind, or biomass.

The costs of the phase-out policies depend on the number of available substitutes and their capabilities. Germany is already one of the world leaders in wind and solar energy production, and has taken action to increase their investment.

A MOVEMENT TOWARDS GREEN ENERGY

Planning

Any transition like the one Germany has undertaken requires a significant amount of planning. For this reason, I have decided to use the Natural Step Framework: the A-B-C-D process to outline Germany's progression.

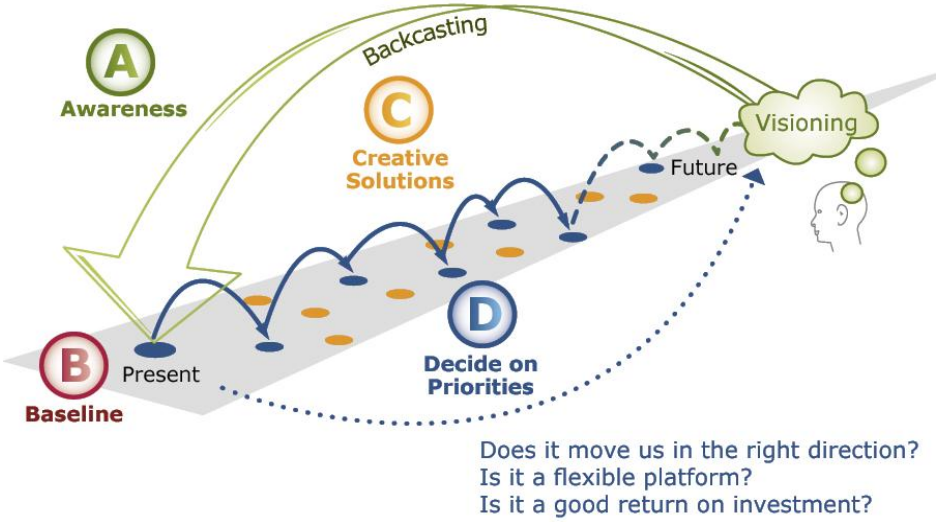
As outlined in The Natural Step, there are four key principles in moving towards a sustainable society:

1. Eliminate our contribution to the progressive build-up of substances extracted from the Earth's crust
2. Eliminate our contribution to the progressive build-up of chemicals and compounds produced by society
3. Eliminate our contribution to the progressive physical degradation and destruction of nature and natural processes
4. Eliminate our contribution to conditions that undermine people's capacity to meet their basic human needs (Natural Step, 2012)

In addition to these four principles, the Natural Step also offers the A-B-C-D framework, standing for Awareness, Baseline, Clear and compelling, and Down to action.

The first step in the ABCD model is creating awareness about the problem in order to find a solution. After the tragic effects of Chernobyl, and then again in Fukushima, Germany became well aware that using nuclear energy can have disastrous after effects. Not only that, but the nation is making sustainability its main target for coming years. During this stage, ambitious goals are to be set, which may require radical changes and innovation to overcome limitations. This can be seen in Germany's Renewable Energy Sources Act (EEG), which outlines many drastic goals that will be discussed throughout this paper.

Figure 1: The ABCD model for planning in complex systems (Natural Step, 2012)



The next step of the framework is Baseline mapping. This step uses the four sustainability principles mentioned earlier to establish the sustainability 'gap' and to evaluate the country's industries in terms of sustainability from 'cradle-to-cradle'. Inside Germany's EEG act, 1990 was used as the baseline in many cases to determine the improvement ratios and goals. This allowed the nation to identify target areas, like carbon emissions, and percentage of renewable energy production, and create policies that utilize any assets Germany has in order to overcome obstacles.

The third step of the ABCD process is finding creative solutions to overcome these obstacles and establishing a clear vision. The goals and procedures for achieving sustainability must be clear and compelling when motivating a nation to strive for success. This also can be seen in the Renewable Energy Sources Act, which compares Germany's current status, and where they could be by 2050. The EEG Act educates the public on all the benefits of using renewable energy, backed up with investments in research projects. In addition, the government outlines their incentive plans to help people not only understand the necessity to changing their ways, but why they would want to.

The final stage, and most important of the four, is Deciding on priorities and getting down to action. Germany has been in this stage since 2009, working to achieve the goals set out by the EEG that year. Due to the continual updating of targets and evaluating their progress, Germany has been able to stay on track. One example being the fact that Germany has already transformed the way it produced energy; from 2000 to 2010 the nation managed to transform its use of renewable electricity from 5% to 17% (WRI, 2011).

THE MAIN FOCUS: INVESTING IN WIND AND SOLAR

This section will briefly discuss the backgrounds of both types of energy generation, and the benefits/challenges that they offer Germany.

Wind

Wind energy plays a key role in the reduction of CO_2 emissions and clean energy generation worldwide. Due to its low environmental impact and wide availability, offshore and onshore wind energy is the fastest growing energy resource today (Dincer, 2011). Wind turbines use kinetic energy created through changes in atmospheric pressure close to the Earth's surface to rotate the blades. In Germany, modern turbines use the lift principle; the blades do not offer any resistance to the wind, but turn as the wind flows past causing them to rotate and generate energy. This energy source is carbon free and is an important aspect in climate protection.

In Germany, the technology is pivotal to the Renewable Energy Sources Act, the replacement of nuclear power, and reducing their carbon emissions. In 2009, 952 new wind turbines were installed in Germany, reaching a total of 21,164 and an energy generation capacity of 25,777 MW. Wind energy saved about 20 million tonnes of CO_2, and wind power generation is expected to increase 25% by 2025 (BMU, 2011). This shows how crucial wind energy is for Germany to becoming carbon neutral while still meeting electricity demand.

However, wind energy does have it challenges. Wind turbines are useless without a strong wind resource, thus the correct location of each individual turbine is significant for any wind energy project. A reduction of wind resources by just 10% can increase the generation cost by 8.5% (Blanco, 2009). Wind turbines should therefore be dispersed over a large geographical area to ensure a more reliable energy supply. If the wind speed in one is incorrectly calculated, generation in different regions can compensate for the loss. If wind turbines are situated in remote locations far from cities there is greater necessity for costly transmission lines. In addition, wind turbines may be renowned for their low impact on the environment compared to other technologies, however there is concern about the visual impacts, depletion of bird populations who are killed by the blades, as well as the noise produced by the rotor blades. Expansion of offshore wind power production faces challenges due to environmental protection acts along the shores. In addition, Germany's offshore projects face deeper waters (30-40m) close to shore, as compared to offshore wind projects elsewhere (Busgen & Durrschmidt, 2009). This brings about higher costs for base re-enforcement and maintenance. Other issues include a high investment cost with only a turbine lifetime of around 20 years (Blanco, 2009).

Despite these challenges, wind energy is still the most promising form of renewable energy available. Wind turbines have the capability to produce large amounts of power, enough to meet Germany's growing demand. For example, in 2009, 12 wind turbines were placed offshore, a relatively new technology, but these 12 generators alone can power the electricity demand of 50,000 households. The German government plans to grow offshore wind energy and feed up to 25,000 MW of energy into the grid by 2025, increasing its share of electricity generation to 15% (FME, 2010). Moreover, due to the high proportion of wind-generated electricity, especially in northern and eastern Germany, onshore wind systems should be able to contribute to grid stability. Wind energy is currently the largest portion of Germany's renewable electricity generation, and both on- and offshore turbine farms offer good potential for expansion, strengthening Germany's ability to reach their EEG goals (Busgen & Durrschmidt, 2009).

Solar

Solar is another crucial technology for Germany's renewable energy plan. Solar panels work using the photovoltaic process (PV) where radiation energy is absorbed and generates electricity. This radiation energy is absorbed into semi conductor cells and changed from photo (light) energy into an electrical current. The electrical current is created when the sun's radiation hits a silicon atom (from the semi-

conductor) and knocks off an electron (Whitburn, 2012). Two types of solar panels exist, the first being Crystalline silicon technology that has been used for almost 50 years. This type of solar panel was used for powering satellites in space. It has the ability, or photovoltaic efficiency, of converting up to 18% of solar radiation exposure into useable electricity.

The Renewable Energies Act entered an obligation for all new buildings to use renewable energies as the source for heat supply. Solar energy is one example of how buildings are becoming more carbon neutral. Germany will achieve its targets for expanding renewable energies given plants can be built without excessive red tape or resistance. The new Planning Acceleration Act will make it easier to build solar plants beside and on buildings (Bundesregierung, 2011). In addition to this and a recent boom in PV panel installations, German utilities claimed solar power production to be more than 50% of what it was in 2010 (USA Today, 2012). The PV capacity rose from 32 MW in 1999 to nearly 17,320 MW in 2010, which made Germany the largest market for solar cells (Huentelera, Schmidt & Kanieb, 2012).

One issue with solar energy, the same as with wind, is its unreliability. Solar panels are dispersed all over the country, and when the sun shines, they act as one plant, pushing electricity into the grid. However, this can cause problems when the grid receives too much energy than is required. For this reason, Germany must invest in better energy storage plants and find a way for the inconsistency of solar energy to be less harmful. One might think that having too much energy than expected would be a good thing! However, the rapid expansion in solar panels is increasing the costs for consumers significantly. As solar expanded from 1 percent of energy in 2009 to 3.5 percent in 2011, the costs for subsidies, largely paid for out of consumers' pockets, are quickly rising (Dowling, 2012). In addition, cheaper production costs in Asia are causing domestic companies to go bankrupt. Almost half of the panels being installed in Germany are imported from China, an issue that must be addressed by the German government (Dowling, 2012).

STRATEGIES

This section describes three strategies that Germany will need to work towards if they wish to succeed in becoming powered mainly by renewable sources.

Strategy 1: Energy Efficiency

In order to run a country with primarily renewable energy successfully, the industries that require large amounts of power must also be transformed. This means improving energy efficiency in all sectors. Germany has placed a strong focus on improving the building sector. This can be seen in the European Union's instruction in the Energy Performance of Buildings, which outlined that all new buildings must consume close to zero energy from 2020 onwards. Germany has put in place a very successful incentive scheme (KfW-scheme) which supports ambitious renovation that goes far beyond the minimum requirements set by the EU. The KfW-scheme impact includes:

- 1.65 million buildings and building units constructed and/or renovated
- 7.5 billion Euro funded between 2006 and 2010 by special tax reductions, renovation programs, etc. to go towards lower energy consumptions and modernizing the building sector
- Greenhouse gas emissions reduced by 4.2 million tons per year (Drybol, Thomsen & Danfoss, 2010).

In addition to more strict building standards, inefficient appliances must be replaced in the market by highly efficient ones. Consumers should be able to more easily identify how much energy each product consumes. This means the government should push for more ambitious standards on energy consuming appliances and labels should be more transparent.

Strategy 2: Carbon Free Energy in all Sectors

In order for Germany to meet their long-term de-carbonization goals, all sectors must be transformed. This is being done in the power sector by focusing on renewable energies like wind and solar. However, the success of their efforts highly depends on having the proper infrastructure. For example, the transportation and automobile sector produces large amounts of carbon emissions each year. The automobile industry in Germany is one of its largest, and a transformation towards electric/more sustainable cars would have a great impact. If the German government implemented stronger efficiency standards for companies like BMW, VW, and others, efforts to cut long-term emissions could be more effective. This can be seen in their efforts to have a minimum of one million electric cars on German roads by 2020 (Bundesregierung, 2011). If this nation of car-lovers became the leading producer as well as the leading market of electric vehicles, their influence would hopefully carry over into other countries. Germany hopes to encourage the purchase of electric vehicles by providing ten years free of vehicle tax, designated electric vehicle parking spaces equipped with charging stations, and permission to use bus lanes (Bundesregierung, 2011).

Strategy 3: Bridging the Gap and Power Storage

Solar and wind power are not exactly reliable sources of energy. If Germany wishes to provide a constant and dependable supply of energy, they must be able to store energy in case it is needed. This requires modern storage options that will allow electricity to be fed into the national grid as required. The federal government has acknowledged this issue, and will be providing up to 200 million Euros for research and development in this area as an initial phase, scheduled to run until 2014 (Bundesregierung, 2011).

Transforming the energy sector toward renewable sources while phasing out nuclear power requires other fuels to fill the gap to ensure a stable power network. Germany has begun the development of highly efficient gas- and coal-fired power stations to create a swifter turnover and help balance fluctuations from wind and solar plants (Bundesregierung, 2011).

ASSESSMENT

Table 1 compares annual renewable electricity generation predictions of two studies commissioned by the federal ministries of environment (BMU) and economy (BMWi) accompanied with mid-term projections for the electricity system operators (TSOs). Included in the table are the goals set by Germany's National Renewable Energy Action Plan submitted to the European Commission in 2010 and the expected political targets set by the German federal states (Länder).

Table 1. Gross electricity generation from domestic renewable energy sources (Lechtenböhmer & Samadi, 2013).

Table 1. Gross electricity generation (in TWh) from domestic renewable energy sources; comparison of scenarios and political ambitions (2010–2025).

		2010	2011	2015	2020	2025	2025 vs. 2010
Actual	[a]	103	122	–	–	–	–
Scenarios/projections	TSOs[b]	–	122	174	–	–	–
	BMU[c]	103	116	166	234	283	+180
	BMWi[d]	–	–	161	199	231	+128
Political targets/expectations	NREAP[e]	105	116	168	217	–	–
	Länder[f]	–	–	–	315	–	–

a AG Energiebilanzen (2012).

b IE (2011).

c BMU (2012).

d BMWi (2011).

e National Renewable Energy Action Plan (German Government, 2010).

f Sum of individual targets of German federal states (dena, 2011).

This table shows the range of expectations regarding electricity generation from renewables held by the BMU, 2012 and BMWi, 2011. The ministry of environment expects renewable electricity generation to reach 283 TWh/a[1] by 2025. In comparison, the scenario for the ministry of economy (BMWi, 2011) predicts 18% less at 231 TWh/a. Projections by the TSOs state that growth in renewable electricity generation might actually exceed expectations in both scenarios. This could be due to the rapid growth in the solar PV industry. In between the predictions by both ministries lay the goals set out by Germany in their National Renewable Energy Action Plan.

The differences between the government agency scenarios and the political targets of the Länder for 2020 are due to differing expectations for the growth in onshore wind capacity (Lechtenböhmer & Samadi, 2013). The technology is already relatively competitive within the market, but the success of wind energy is highly dependent on the states and municipalities who are responsible for planning the sites of wind power plants.

This table indicates how renewable electricity generation will continue to grow in the coming future, and how realistic the goals set by the German government can be. Renewable energy does have the

[1] TWh: The kilowatt-hour (symbolized kWh) is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time. Major energy production or consumption is often expressed as terawatt hours (TWh) for a given period that is often a calendar year. One terawatt hour is equal to a sustained power of approximately 114 megawatts for a period of one year (Wikipedia, 2013).

capability to meet the country's energy needs, given, of course, that Germany is able to manage all of the respective challenges, for example the adaptation/expansion of electricity grids.

THE NEW GENERATION

In order to gain insight into how students feel about the EEG act, I conducted a short survey in front of the University of Cologne Library. I quickly asked 25 students questions and asked them to rank their answers from 1 to 3, 1 being no, 2 being maybe, 3 being yes.

Questionnaire

1. Would you be willing to pay slightly more for electricity if you knew it came from a renewable source?

   Results: 1: 6 responses
   2: 5 responses
   3: 14 responses

2. Do you think the removal of nuclear power in Germany is a good idea?

   Results: 1: 6 responses
   2: 7 responses
   3: 12 responses

3. How important is renewable energy to you? 1 being not very, 2 being kind of, and 3 being very.

   Results: 1: 3 responses
   2: 9 responses
   3: 13 responses

Results and conclusions

The survey I conducted does not determine how the rest of the nation feels, as this is a small sample group of a specific population. However, these students will become the future of Germany, and do hold relevance in that they are all voters. The responses to question 3 indicate that even at an age around 20-26, renewable energy is important. This may be an indication of why the Renewable Energies Act has such momentum and the wind and solar industries have exploded. The general trend from this survey shows a generation more concerned about the well-being of their planet, and that they are willing to invest.

CONCLUSION

Environmental health directly affects all fields of life and should become a serious concern in the global society. Given recent tragedies including but not limited to, Fukushima and the BP oil spill, from mine collapses in China, West Virginia, Russia, to natural gas explosions in San Bruno, California, how we source our energy can have detrimental impacts on human life and the environment (Madrigal, 2011). These catastrophes show that steps must be taken to create more sustainable and safe power sectors that are based on renewable energies. Germany has taken action to transform their power market by moving it to the center of the country's political agenda and creating the EEG clean-energy law.

By focusing on renewable energies, mainly solar and wind, the country will cut their CO2 emissions in the long run, creating a climate-friendly, sustainable, and secure energy supply for Germany. To ensure their EEG plan is successful the country must conquer the challenges ahead. Germany must find a way to expand the national energy grid and make it better suited for renewable energies. There must be investment in R&D for developing better energy storage plants to help deal with the unreliability of wind and solar generation. The nation must also change the demand on energy by creating more efficient industries, for example the building and automobile sectors. If these obstacles as well as others are met with innovation and support by the country, Germany will be one of the first industrialized nations to be powered primarily by renewable energy.

Lesson for other countries

Germany's combination of sustainable policies, emissions trading, standards, regulations, and incentive programs has allowed this country to completely overhaul their energy industry. By focusing on long-term infrastructure, and rigorous planning and investment into their EEG act, the nation has been able to transition to an economically strong, low carbon economy. While this mix may not work in every country, other nations can learn from Germany's efforts, and take pieces from the German package to change their own country, and help the world work towards a more sustainable future.

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