Global Energy Transitions

A comparative analysis of key countries and implications for the international energy debate

WORLD ENERGY COUNCIL
Weltenergierat - Deutschland

In cooperation with

ATKearney

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Key messages

1. Fundamental structural changes in the energy sector, also called **energy transitions**, **occur worldwide** and are not an isolated phenomenon. However, energy transitions differ in terms of motivation and objectives, drivers and governance, and also provide a diverse set of challenges and opportunities. This study analyses changes in the energy sectors of six large economies around the globe: Brazil, China, Germany, Saudi Arabia, South Africa and United States.

2. The most important motivation for global energy transitions is to **secure energy supply**, for example, to reduce import dependency as in the United States or to expand supply to meet rising energy demand like in China or South Africa. This is usually combined with the aim to **increase competitiveness by using least-cost approaches for supply expansion**. In Germany, by contrast, environmental concerns and the loss of public acceptance for nuclear energy appear more important core motivations behind the ongoing structural changes. Hence, while Germany is not the only country that is changing the structure of its energy supply base, it is doing so for fundamentally different reasons than the other countries focused on in this article.

3. In all countries analyzed, **government policy making is the main driver of change**. Technical innovation and the business strategies of energy companies were most important in the shale gas revolution of the United States and are key enablers in all countries. However, by and large, it is the politically set framework conditions, such as renewable energy targets and related support schemes or the setting of energy efficiency standards, that determine the rate and direction of each energy transition examined. Regarding the governance structure, the Unites States and Germany follow a more **decentralized** approach, with a significant impact by state-level policy and decision making, whereas the emerging economies like Brazil, China and Saudi Arabia follow highly **centralized approaches**, involving a strong role for government in defining investment priorities.

4. The **main challenges** for industrialized countries are **imbalances in the development path** as well as the **rapid speed of change**. With rapidly increasing shares of volatile renewable energy in the system, for example, technical challenges in the grid have to be overcome. Also, wholesale power markets experience change in the levels and structure of market prices, rendering previous investment in gas power plants, unprofitable. At the same time, **the cost of support schemes** increases the cost burden on end consumers and can pose a political problem for the acceptance of the energy transition. In countries with emerging economies, more direct problems, such as **supply shortages, weak or non-existent grid infrastructure as well as subsidized end-consumer prices**, constitute key challenges that slow down the implementation of structural changes to the energy system.

5. While the challenges of energy transitions often dominate the debate, the opportunities should not be overlooked. Large **shale gas reserves** as well as huge and cost-effective **potentials for renewable energies** provide a significant opportunity for all countries analyzed. Supply challenges can be met long term if the transitory problems of balancing the systems, avoiding stranded cost and keeping end-consumer burdens at economically and politically acceptable levels can be overcome.

6. **The exchange of experiences and the sharing of know-how gained from solving implementation challenges can make an important contribution** toward tackling the challenges of energy transitions world-wide. The countries analyzed can learn from important parallels and differences in terms of **policy making, technology deployment and business-model evolution**. Such a cross-country perspective on energy transitions should have a high priority as it can bring significant benefits to the countries and the businesses engaging in the exchange.

Introduction

The energy transition – the so called „Energiewende" - has been the prominent issue for political discussions in Germany since the beginning of the decade. While the overall political objectives are agreed among a broad societal consensus, the costs and speed of the adjustment to long-term targets are currently subject to significant debate. If the German energy transition is implemented successfully, regulators and industry, both hope to provide solutions of use also for other countries worldwide.

However, the energy world is largely intertwined, incidents and developments in one large economy will have direct or indirect effects on another one. And Germany is not the only energy market facing major changes. Almost all large economies have defined long-term targets and implement strategies to balance their energy needs: providing security of supply, remaining competitive, environmentally sustainable and socially acceptable. Hence, there is a growing body of experiences and solutions that will help to overcome the challenges energy transitions are facing - in Germany and elsewhere. Eventually, every country will benefit from the policy experiences, the innovations in technologies and the new business models devised around the world.

This study sets out to shed some light into a number of global energy transitions to help understand the differences and similarities in these developments, for the benefit of all.

Study objective

An energy transition is defined here as a fundamental structural change in the energy sector of a certain country, like the increasing share of renewable energies and the promotion of energy efficiency combined with phasing out fossil energies. This article provides a comparison of a number of energy transitions as being implemented in some selected countries.

The focus of our comparison will be on selected key themes:

1. **Motivation and objectives**: We would like to understand what motivates changes in the energy sector against the background of the overall energy supply and demand situation of a given country. Possible motivations are supply security, competitiveness, environment and public acceptance. Also, we would like to understand what specific policy targets exist in policy fields such as energy efficiency and renewable energies for each of the countries.
2. **Drivers and governance**: We would like to explore how changes are promoted in the respective energy sectors. Possible drivers are government policies, technical innovation, customer demand and energy player strategies. In addition, we would like to find out how the energy sector is managed by the government for example, whether decisions are made at state or federal level, and if its actions are deemed successful.
3. **Challenges and opportunities**: An understanding of which challenges exist and how they can be overcome might help to generate key take-aways from the comparison that are helpful as lessons for other countries. The same is true for dealing with opportunities.

From the comparison of country case studies, we derive insights with regard to global energy transitions and offer conclusions for the international energy debate.

Scope and key sources

The geographic scope of our analysis aims to cover a range of different examples from various regions while keeping the scope manageable. We chose Brazil, China, Germany, Saudi Arabia, South Africa and the United States as our examples for comparison. Of course, this sample leaves out other highly relevant and equally interesting countries.

Key sources used in the country analyses are official policy documents and energy sector development plans adopted by the national governments, supplemented by country specific statistics and analyses conducted by renowned international organizations. This desk research is supported by a set of background interviews with energy sector representatives and experts in each of the countries analyzed. While the views of the interviewees provided valuable inputs, the analysis and conclusions presented here are those of the authors alone and do not necessarily reflect the views expressed by the interviewees.

Key indicators

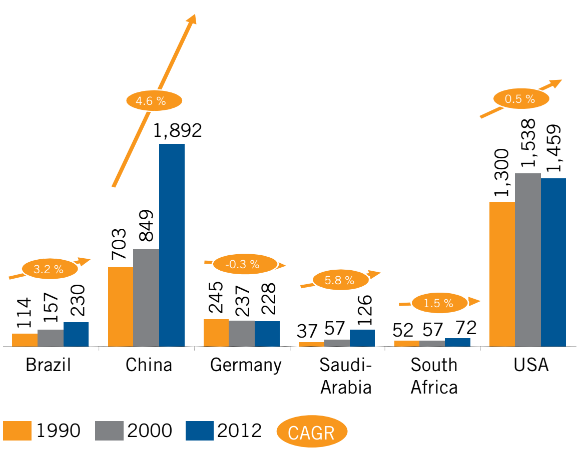
We have selected a number of key energy indicators to illustrate the most important trends regarding energy transitions in the countries of interest. The following analysis provides an overview of past dynamics and a starting point for the country-specific discussions in the section that follows.

Total final energy consumption and final energy intensity

A look at the Total Final Energy Consumption (TFEC) reveals important differences in the sample of countries analyzed. In 2012, China had the largest TFEC with 1.892 Mtoe, and had surpassed the United States during the first decade of this century. In the other countries of interest, namely Brazil, Germany, Saudi Arabia and South Africa, recent TFEC is 6 to 26 times smaller in relation to China and the United States. Due to rapid economic growth, Saudi Arabia and China are characterized by a very high compound annual growth rate (CAGR) of 5.8 % and 4.6 %, respectively, enjoyed between 1990 and 2012. In Brazil and South Africa, dynamic growth ranges from 2-3 % per annum whereas for Germany and the United States, TFEC is decreasing in absolute terms. In Germany, this trend has been stable since 1990, while the United States did not turn the curve until more recently, with only 1.458 Mtoe in 2009, the year after the financial crisis. Due to economic recovery, TFEC has rebounded slightly since then, but is still below 2000 levels.

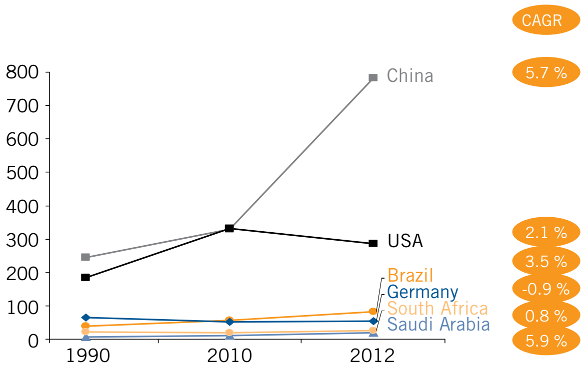
The sectorial breakdown of TFEC allows a more differentiated view of the driving factors and current dynamics. In 2012, China was the largest consumer in terms of total final energy in the industry sector (981 Mtoe) and in the households and services sector (544 Mtoe), whereas the United States was the largest energy consumer in the transport sector (573 Mtoe). Industrial consumption increased most in China with a CAGR of 6.1 % between 1990 and 2012. Saudi Arabia also showed high growth rates for the industry sector with a CAGR of 5.9 %, reflecting the country's strategy to increase domestic production of petrochemical products. In the transport sector, it was China's energy consumption that grew most dynamically at a rate of 8.9 % per annum, followed by Saudi Arabia at 4.2 % and Brazil at 4.1 %. In the households and services sector, Saudi Arabia had by far the highest CAGR at 6.2 %.

Figure 1: Total Final Energy Consumption in Mtoe



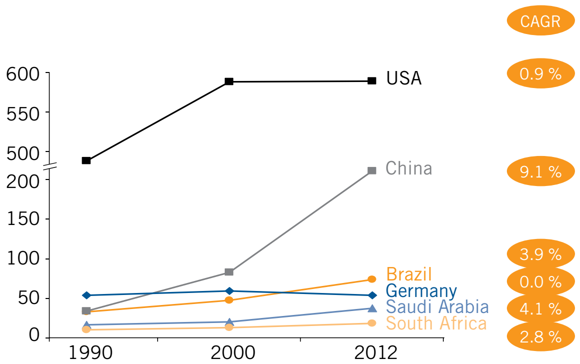
Source: Enerdata

Figure 2: Total Final Energy Consumption – industry in Mtoe



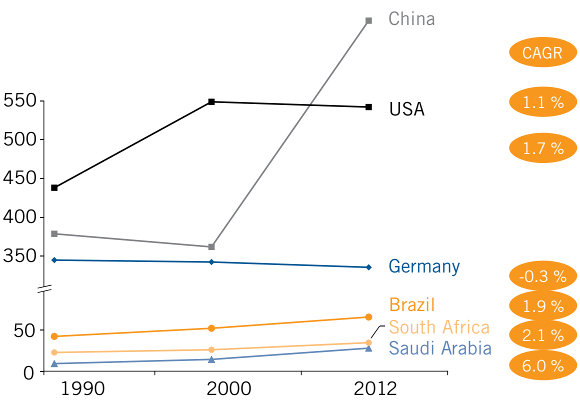
Source: Enerdata

Figure 3: Total Final Energy Consumption – transport in Mtoe



Source: Enerdata

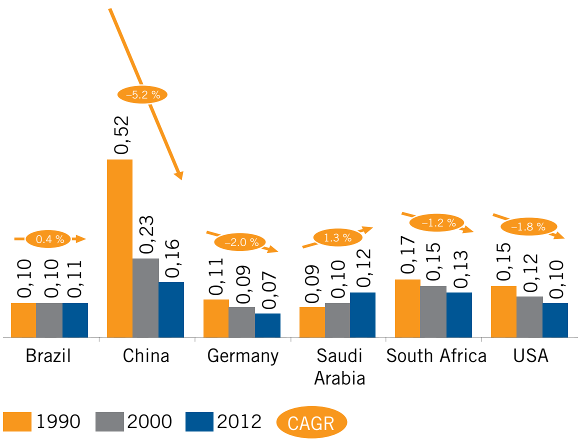
Figure 4: Total Final Energy Consumption – households and services in Mtoe



Source: Enerdata

The development of Final Energy Intensity reveals that the huge growth in demand in China was accompanied by a strong increase in energy efficiency, measured as the amount of energy used per US$ of economic value created. While exchange rate effects are always an issue with such parameters, the trend shows that China achieved significant progress while still not reaching the energy efficiency levels of the other countries in our focus. The developments in Germany, the United States and South Africa imply an improvement in energy efficiency, while Brazil's energy intensity increased slightly, although the level is still comparable with that of the United States. Saudi Arabia represents the striking outlier in this comparison. The country has significantly increased its energy intensity, clearly an indicator of its deliberate strategy to use more energy, for domestic value creation in the petrochemical industry.

Figure 5: Final Energy Intensity in koe/US$05 (at ppp)



Source: Enerdata

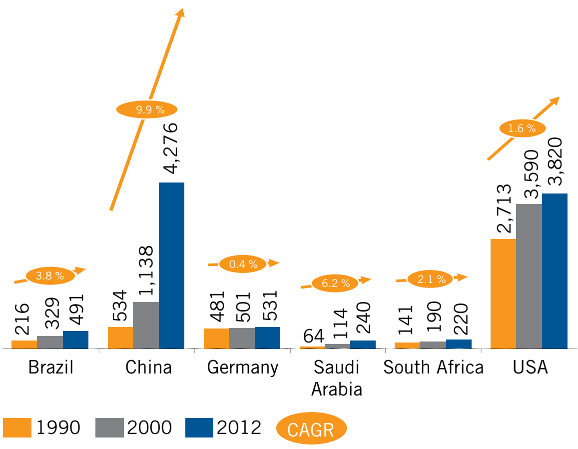
World Energy Council Energy Efficiency Indicators: The Final Energy Intensity is the ratio of final energy consumption over gross domestic product (GDP), here at exchange rate and purchasing power parity (ppp) of the year 2005, and gives a measure of the energy efficiency of a nation's economy. A value given in ppp allows comparing prices internationally, thereby representing the real cost for end consumers. High energy intensities indicate high cost of converting energy into GDP whereas low energy intensities correlate with lower cost.

Electricity consumption

In 1990, the United States was the largest consumer of electricity with 2.924 TWh. By 2012, China (4.276 TWh) consumed more electrical energy than the United States (3.820 TWh). China also had the highest growth rate of electricity consumption at 9.9 % between 1990 and 2012, followed by Saudi Arabia at 6.2 %.

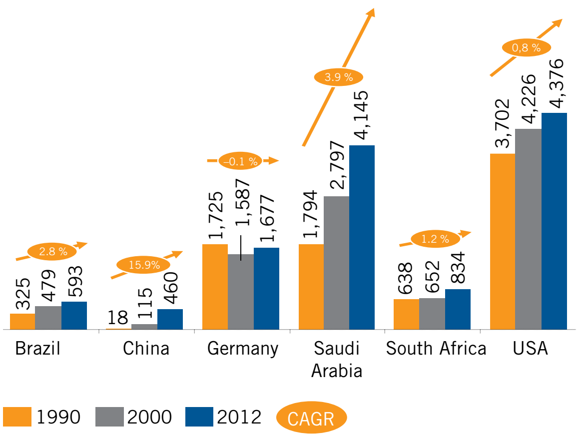
Of the countries in our analysis, the United States had the highest electricity consumption of households 4.376 kWh/cap in 2012, followed by Saudi Arabia and Germany, whereas China's household electricity consumption was the lowest – ten times lower than in the United States. However, due to China's recent industrialization, electricity consumption increased by 15.9 % per annum between 1990 and 2012.

Figure 6: Electricity consumption in TWh



Source: International Energy Agency

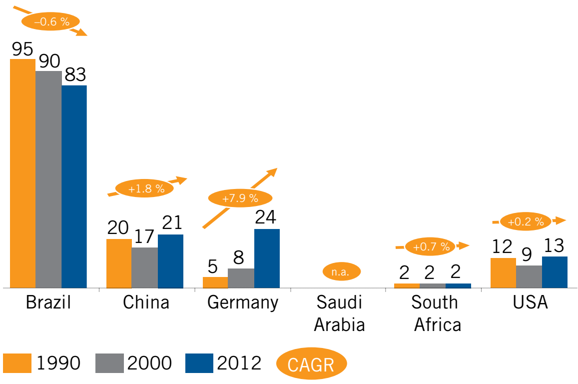
Figure 7: Electricity consumption of households in kWh/cap



Source: Enerdata/World Energy Council Energy Efficiency Indicators

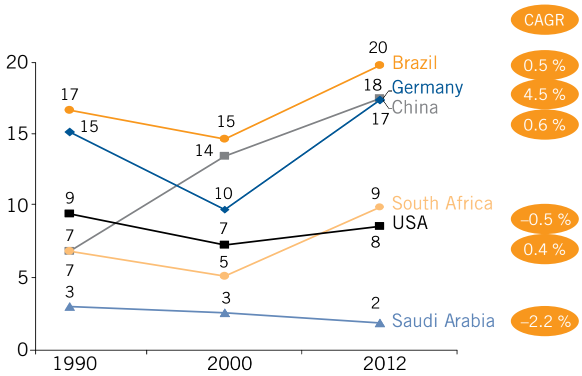
The share of renewable energies in total electricity consumption in 2012 was very high in Brazil at 83 %, due to its traditionally large share of hydropower, followed by Germany at 24 % and China at 21 %. For the other countries in this analysis, renewable energies made up less than 20 % of their total electricity consumption. So far, Saudi Arabia does not use significant amounts of renewable energies for electricity. In Germany, the CAGR between 1990 and 2012 was 7.9 %, by far the highest growth rate among the countries analyzed in this study.

Figure 8: Share of renewable energies in total electricity consumption in %



Source: Enerdata/World Energy Council Energy Efficiency Indicators

Figure 9: Electricity price in USc05/kWh (at ppp)



Data for Saudi Arabia from 2011, as n.a. from 2012

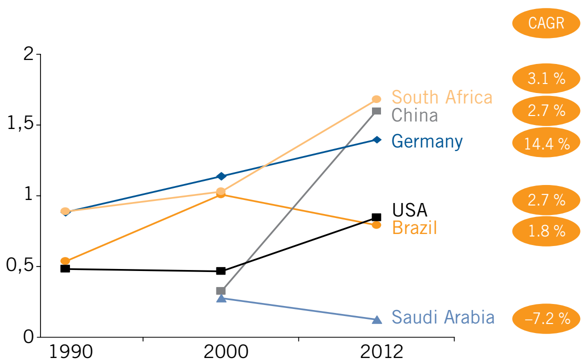
Source: Enerdata/World Energy Council Energy Efficiency Indicators

Electricity and fuel prices

The end consumer price for electricity expressed in purchasing power parities (ppp) of the year 2005 was highest in Brazil, Germany and China at around 17-19 USc05/kWh in 2012, followed by the United States and South Africa at about half that price. The price for motor fuels is relatively high in South Africa, China and Germany at roughly 1.6-1.8 US$05/l. In the United States and Brazil, motor fuels can be purchased for half the price. Due to subsidies, Saudi Arabia has very low prices for electricity (1.90 USc05/kWh) and motor fuels (0.13 US$05/l).

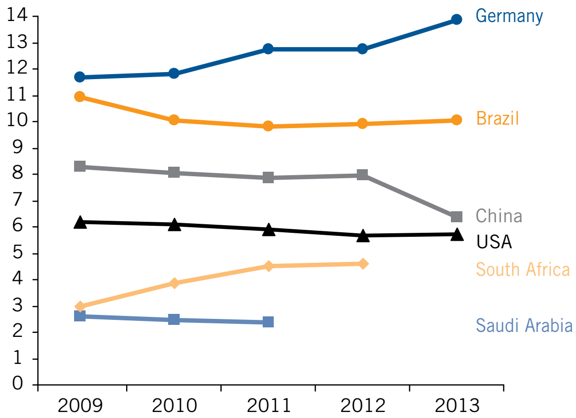
Between 1990 and 2012, prices for electricity and motor fuels in China increased annually by 4.3 % and 15.1 %, respectively. In our other countries of interest, prices for electricity were relatively stable, whereas the price of mo-

Figure 10: Motor fuel price in US$05/l (at ppp)



Source: Enerdata/World Energy Council Energy Efficiency Indicators: The electricity price represents a weighted average price for industry and households.

Figure 11: Electricity price in industry in USc05/kWh



Source: Enerdata/World Energy Council Energy Efficiency Indicators

tor fuels increased by 2-3 % per year, except in Saudi Arabia where the price decreased by 6.1 % per year between 2000 and 2012.

While comparing average prices in ppp terms is useful to get an idea of the costs to end consumers, it tells us nothing about the consequences for industry stakeholders. A comparison of industrial electricity prices showed that the prices are higher in Germany than in the other countries analyzed in this study and that they have even increased in the past few years. In South Africa, prices are increasing as well, however from a lower base, whereas prices are decreasing in China. Noticeably, the price level in Brazil is relatively high, whereas prices in China, the United States and South Africa are clearly lower. Price differences can be compensated by differences in energy intensity; however, a factor of five between prices in Germany and subsidized prices in Saudi Arabia cannot be counterbalanced by different energy intensities.

Country-specific energy transitions

In the following analyses, we have looked at the countries' specific motivations and aims for energy transition, their key drivers and governance structures as well as key challenges and opportunities.

Brazil

Brazil is the largest energy consumer in South America and its total final energy consumption increased by 3.2 % per year between 1990 and 2012 thanks to sustained economic growth[1]. In 2011, the largest share of Brazil's energy consumption was powered by oil and other liquid fuels (47 %), followed by hydroelectricity (35 %)[2]. The recent discovery of some of the world's largest oil reserves, located offshore in very deep water, could transform Brazil into one of the major oil producers of the world. Furthermore, these reserves are expected to contain sizable volumes of natural gas.

In the 1970s, the government had implemented policies to encourage domestic ethanol production and consumption in an effort to address the country's dependence on oil imports and its surplus of sugar cane. Today, Brazil is the second largest consumer of ethanol in the world after the United States, but production has fallen and the country now to some extent imports ethanol from the United States.

Brazil also has the largest electricity sector in South America with almost 120 GW of installed generating capacity in 2012, with hydropower generation accounting for 80 %. Many of Brazil's hydropower dams are located far away from the main demand centers, which means that high-voltage transmission lines are needed to avoid distribution losses. Also, hydropower suffers from supply shortages during periods of dry weather, but such periods can be compensated by the use of costly fossil fuel-based standby capacities. Moreover, according to official energy scenarios, the government expects demand for electricity to grow by 4.7 % per annum[3].

Motivation and objectives

According to government documents, supply security and environmental protection are the key objectives of Brazil's energy policies[4]. Additionally, the government regulates end consumer prices for electricity by directly intervening to control inflation, another high political priority.

With regard to energy sector development, the government releases a 10-year Energy Expansion Plan every year[5]. In recent years, these plans have focused on diversifying renewable energies and on slowly phasing out fossil power. Until 2022, it is expected to increase the total generation capacity by more than 50 % to 183 GW, including hydro from 79 to 114 GW, wind from 2 to 17 GW, biomass from 9 to 14 GW, gas from 10 to 14 GW, and coal and nuclear from 2 to 3 GW each (other energies from 15 to 18 GW). However, this scenario does not represent an investment plan, rather it serves as a guideline for auctions, for which the government announces capacities and awards contracts depending on the costs of generation. To further stimulate the market for renewable energies, mandatory biodiesel blending was increased to 5 % in 2010[6].

In the Copenhagen Accord pledge of 2010, Brazil pledged a voluntary target was to reduce its greenhouse gas emissions (GHG) by 36 – 39 % compared to projected emissions in a baseline scenario by 2020[7]. To achieve this aim, the National Climate Change Plan largely focuses on reducing GHG emissions from deforestation[8]. Overall, given the hydro and ethanol focus of its energy supply, energy-related emissions play a significantly smaller role in Brazil than in any of the other countries covered by our study.

Drivers and governance

Key drivers of change are investment decisions, or the lack thereof, by large nationally owned energy players as well as selected policies of the Brazilian government that mainly encourage investment in renewable energies. Energy efficiency standards appear to be less of a focus than in other countries in the study. However, Brazil already uses a net-metering scheme for decentralized supply, such as for small photovoltaic sites[9]. This scheme compares the demand and supply of each end consumer

1 Enerdata
2 U.S. Energy Information Administration: Brazil Overview, October 1, 2013
3 Brazilian Ministry of Mines and Energy: Plano Decenal de Expansão de Energia 2022, December 2013
4 International Energy Agency: Policies and Measures for Brazil
5 Brazilian Ministry of Mines and Energy: Plano Decenal de Expansão de Energia 2022, December 2013
6 International Energy Agency: Policies and Measures for Brazil
7 Government of Brazil: Copenhagen Accord pledge, January 29, 2010
8 Government of Brazil: Plano National Sobre Mudança do Clima, Decreto nº 6.263, November 21, 2007
9 DENA, Market Study Brazil, 2013

involved on a yearly basis and aims to provide favorable conditions for residential systems. Nevertheless, it is not as yet attractive due to the low electricity prices for end consumers. In the future, the large solar potential combined with increased electricity prices and the reduced costs for photovoltaic systems could lead to solar power experiencing a dynamic development.

Policies are sometimes implemented without looking at long-term effects. In particular, the regulation of energy prices to control inflation led to counterproductive effects. For example, ethanol producers were promoted with government support in order to reduce import dependency and then went bankrupt when the government introduced end consumer price caps while prices for sugar were increasing on the world market[10]. Moreover, potential investors in oil and gas reserves cannot be sure about the profitability of large potential investments due to the government-mandated reduction of end consumer prices. Lack of investment in new, efficient capacities will, however, lead to costly backup capacities that in turn will drive inflation.

The main instrument used to control the energy sector is the organization of auctions for new capacities[11]. The first auctions held were limited to certain technologies, for example, the first biomass-only reserve energy auction in 2008 during which the government auctioned 2,379 MW of power, followed by the first wind auction in 2009 with a total of 1,805 MW. Recently, the government started to open the auctions for other technologies, resulting in highly competitive prices for wind power. However, those prices were too low to pay off investments in solar energy. As a result, the first solar energy auction in the State of Pernambuco, which led to contracts for 122 MWp of solar power installations, was held in 2013[12]. This auction represents the first significant addition of solar power to the Brazilian energy landscape, where thus far, despite the high solar irradiation in some areas of the country, no significant solar generation plants have been built. Overall, Brazil has a lot of experience in how to use auctions to promote development of the energy sector while ensuring cost reductions and the implementation of contracts. One thing learnt, for example, is that prices can be too competitive as this often lead to financing and investment approval problems.

10 Bloomberg: Brazil Crushing Sugar to Ethanol With Caps on Fuel Prices, December 19, 2013, www.bloomberg.com
11 International Energy Agency: Policies and Measures for Brazil
12 greentechsolar: Brazilian State Auction Clears 122 Megawatts of Solar PV, January 2, 2014, www.greentechmedia.com

The key institutions that govern the energy sector are as follows:

- CNPE: National Council for Energy Policy, responsible for advising the Presidency of the Republic and elaborating energy policies[13]
- MME: Ministry of Mines and Energy (under the Brazilian government), responsible for all energy-related topics, and EPE, the government's Energy Research Agency, responsible for providing input for the planning and implementation of actions by the Ministry of Mines and Energy[14]
- ANP: National Agency of Petroleum, Natural Gas and Biofuels, responsible for regulating the oil sector and linked to the Ministry of Mines and Energy[15]
- ANEEL: Brazilian Electricity Regulatory Agency, responsible for establishing electricity tariffs and linked to the Ministry of Mines and Energy[16]

Responsibilities for electricity on the one hand and oil and gas on the other, are split between different institutions, both subordinate to the Ministry of Mines and Energy. This leads to coordination problems that regularly need to be resolved within the Ministry.

What appears to be more problematic, however, is the fact that energy is subject to contradictory regulation philosophies: While the investment in new generation capacity follows a competitive least cost approach, end-consumer price levels are determined by an interventionist policy oriented at fiscal or monetary policy objectives. Energy is thus not regulated holistically, but is strongly affected by other political issues in the country.

Challenges and opportunities

In 2013, Brazil was under a real threat of blackouts when the country's reservoirs dropped to dangerously low levels after years of drought. As the drought continued in early 2014 and water was preserved for the FIFA World Cup being held during the summer, energy supply conditions deteriorated further. As a result, thermal backup capacities were brought on line. The scarcity of supply combined with the use of more expensive thermal capacities

13 Ministry of Mines and Energy: www.mme.gov.br
14 Ministry of Mines and Energy: www.mme.gov.br
15 National Agency of Petroleum, Natural Gas and Biofuels: www.anp.gov.br
16 Brazilian Electricity Regulatory Agency: www.aneel.gov.br

Figure 12: Main characteristics of Brazil's energy sector

Selected indicators

Parameter	2012	CAGR 1990 – 2012	Out-look
Total Final Energy Consumption	**230 Mtoe**	3.2 %	↗
Final Energy Intensity	**0.11 koe/US$05[1]**	0.4 %	→
Electricity consumption of households	**593 kWh/cap**	2.8 %	↗
Share of renewables in electricity	**83 %**	–0.6 %	→
Electricity price	**19.84 USc05/kWh[1]**	0.8 %	↗
Motor fuel price	**0.76 US$05/l[1]**	1.6 %	↗

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives

- Brazil's chief motivation is to **secure supply** by installing new capacities and diversifying the energy mix
- Another key objective is **inflation control,** leading to end consumer price caps and a decline in investments

Drivers & Governance

- Key drivers of change are **government policies and investments in renewable energy auctions** made by large energy companies and international investors
- Governance is **highly centralized**

Challenges & Opportunities

- Brazil has a large hydropower share but suffers from **supply shortages** brought about by dry climate
- **Large oil reserves and a huge renewables potential** could transform Brazil into an exporter of energy

has caused a strong increase in costs, which were passed on to end consumers in the form of government taxes rather than electricity price hikes for fear of inflation reaching even more damaging levels than the current 5-6 % annually.

Given the dry weather and the expected demand growth, Brazil's main challenge is to ensure the security of supply by diversifying new capacities while keeping the cost of these structural changes as low as possible[17]. The auctions for new capacities have paved the way here, but they need to be flanked by favorable conditions in other politically charged areas to allow the implementation of low-cost projects. Most important are political certainty and reduced tax levels, as these factors directly impact the cost of financing investment projects.

If Brazil meets these challenges successfully, notable shale gas energy resources and the large potential for renewable energies can be utilized in the long term. So far, decentralized energy efficiency and production potentials are going unutilized and these could lead to cost reductions for end consumers in the medium and long term.

17 Global Energy Network Institute: Renewable energy potential of Brazil, September 2010

China

China is the largest energy producer in the world, mostly driven by steadily rising coal production[18]. Due to its rapid industrialization, China is now also the largest energy consumer worldwide and between 1990 and 2012 increased its total final energy consumption by an average of about 4.6 % per annum[19]. China's rapidly increasing demand for energy has a great influence on the world's energy markets, but it has also led to very significant challenges in terms of local air pollution. In 2013, the mean urban particulate matter concentration was 50 % higher than the maximum value recommended by the World Health Organization, with particularly harmful values in winter and spring[20,21].

Motivation and objectives

As a dynamically growing economy, China's key objective was and continues to be to ensure supply[22]. Increasingly, however, China's motivation for a transition toward a larger share of renewable energies is also being driven by

18 U.S. Energy Information Administration: China Overview, February 4, 2014
19 Enerdata (www.enerdata.net)
20 China's Ministry of Environmental Protection: Pollution statistics
21 World Health Organization: China statistics
22 China's State Council: White paper on energy 2007

environmental issues, with a particular focus on local air pollution[23,24,25]. The most important official targets according to the 12th Five-Year Plan, which defined objectives for 2015 in relation to 2010, are as follows:

- 16 % decrease in energy consumption relative to GDP
- Increase of non-fossil fuel usage in primary energy consumption from 8.3 to 11.4 %
- Increase of renewable energy usage in primary energy consumption to 9.5%[26], up from a reported base of 7.6%[27] in 2010
- Construction of 120 GW hydro, 70 GW wind and 5 GW solar power plants
- Construction of 40 GW nuclear power plants

One of the most dynamic developments China has recently experienced is a boom in solar power installations. The original target of the 12th Five-Year Plan was already surpassed in 2013, when some 11-12 GW of solar power plants were installed. Estimates suggest that China might reach in excess of 35 GW by 2015[28]. This explosive growth is similar to the development of wind power installations that added 16 GW to the Chinese power production capacity in 2013, representing 45 % of newly installed wind capacity worldwide[29]. These developments reflect the increase in the renewable energy share in primary energy consumption to 9.8 % in 2013, also indicating that China is on target to fulfill the goals of the Five-Year Plan[30]. Delays in grid connection have hindered the full deployment of these generation capacities for power supply, but the government has great ambitions to address these issues and launch a more distributed approach for wind and solar deployment. Overall, China still needs to securing additional energy supplies to support its economic growth, but a transition to a more efficient and less fossil-dependent supply base is on its way.

23 China's State Council: 11th Five-Year Plan (2006 – 2010)
24 China's State Council: 12th Five-Year Plan (2011 – 2015)
25 China's State Council: White paper on energy 2012
26 China's State Council: The 12th Five-Year Plan for Renewable Energy (2011 – 2015)
27 BP: Statistical Review of World Energy, June 2013
28 European Photovoltaic Industry Association: 9th Member Workshop, Brussels, March 6, 2014
29 Global Wind Energy Council: Global Wind Statistics 2013
30 China's National Energy Administration: Statistics

Drivers and governance

In the last couple of years, China has set several standards for energy efficiency, like the National Building Energy Standard, which demands a 50 % reduction of a building's total operation load and the Aluminum Industry Permitting Standards, which puts limitations on energy consumption and demands increases in electrical efficiency[31]. China's government also uses incentives, such as the vehicle excise tax rates, which reduce tax on small-engined cars down to 1 % while increasing taxation on large-engined cars up to 40 % of the selling price, and the Renewable Electricity Generation Bonus, an increase of the bonus for renewable electricity by almost 100 %.

Support for renewable energy electricity generation is among the key policies that are driving the significant installations of solar and wind capacities in China. This is often supplemented by support from regional and local authorities, which can take the form of favorable access to land. China is expected to play a leadership role in deploying energy-efficient and alternative fuel vehicles in its dynamically growing automotive sector[32]. The target of 5 million such vehicles by 2020 and the production of cars that consume < 5 l/100 km of fossil fuel would, if achieved, likely give China a leading position for alternative fuel vehicles worldwide. Hong Kong's Environment Bureau is currently monitoring the development in China and discussing the future fuel mix in terms of self-sufficient generation versus imports from China's mainland[33]. By 2050, the floor area of residential and service buildings is expected to increase by 27 % and 47 %, respectively. Setting the National Building Energy Standard and reducing energy demand for space heating and cooling are therefore central to restricting the level of growth in buildings energy consumption.

The focus of energy transition appears to be on electricity. Here, China is combining the industrial policy objective of manufacturing technologies with export potential for installations such as solar, wind or nuclear power plants, with the added benefit of a large domestic market for these technologies. The automotive sector appears to be the second priority as here, too, China is striving to gain an increased share of the manufacturing market, with new drive trains such as those of electric vehicles as the accelerator. Independent of huge energy saving potentials, building efficiency is only the third priority for active

31 International Energy Agency: Policies and Measures for China
32 International Energy Agency: Energy Technology Perspectives 2012
33 Hong Kong's Environment Bureau: Financial Monitoring of Electricity Companies, Towngas Company and Retail Prices of Auto-fuel, www.enb.gov.hk/en

policy making. This prioritization is a big issue in a fast-growing building market and it should be addressed urgently as significant infrastructure investments today will determine energy demand levels for decades to come.

China's energy transition is governed by the National Energy Commission, a 'mini-cabinet' under the State Council with 21 members led by the Premier[34]. The commission was established in 2010 as the successor to the National Energy Administration and is responsible for all energy-related topics, implicating centralized management and stressing the high priority the Chinese government is giving to this issue. In 2013, a National Energy Bureau was founded as yet another attempt to effectively coordinate the large and highly complex business of energy policy and business. At the same time, the role of regional and local authorities should not be underestimated.

Challenges and opportunities

China's energy transition is taking place under the double pressure of needing to enhance the energy supply for its growing economy while changing to more sustainable, less polluting sources. Key challenges lie in the infrastructure already installed: While it is comparatively simple to install new wind and solar power plants, it is more difficult to integrate them into existing grid structures or to decommission older, dirty power plants, given the overall need for fresh capacity. Moreover, China's target to roll out 40 GW of nuclear capacity seems to be very ambitious.

The key opportunity in China's energy transition certainly lies in the dual use with which China can realize its return on investment in new energy technologies, both as the largest energy consumer in the world as well as an increasingly strong exporter of affordable technologies for an emerging global energy transition market.

34 U.S. Energy Information Administration: Background Brief No. 504, February 5, 2010

Germany

Germany is Europe's largest economy and consumed 228 Mtoe of energy in 2012, roughly the same level as Brazil and equivalent to 16 % and 12 % of US and Chinese energy consumption, respectively. Germany's energy consumption has already exhibited a slightly downward trend over the past 22 years despite continuing economic growth, indicating both improving energy efficiency as well as a stagnating population.

Figure 13: Main characteristics of China's energy sector

Selected indicators

Parameter	2012	CAGR 1990 – 2012	Outlook
Total Final Energy Consumption	**1892 Mtoe**	**4.6 %**	↗
Final Energy Intensity	**0,16 koe/US$05[1]**	**–5.2 %**	↘
Electricity consumption of households	**460 kWh/cap**	**15.9 %**	↗
Share of renewables in electricity	**21 %**	**–0.0 %**	→
Electricity price	**17.49 USc05/kWh[1]**	**4.3 %**	↗
Motor fuel price	**1.76 US$05/l[1]**	**15.1 %**	↗

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives
- China's chief motivation is to **secure supply** while energy demand is steadily rising
- Another key objective are **environmental topics**

Drivers & Governance
- Key drivers are **government policies**, mainly standards and incentives for technology production and roll out
- Governance is **highly centralized**

Challenges & Opportunities
- Heavy coal use causes serious **local air pollution**
- As the largest energy producer and consumer, China has **significant influence on the world's energy market**

Electricity consumption, which reached 531 TWh in 2012, reveals a slight long-term growth trend of 0.4 %, which is by far the least dynamic growth rate among all of the countries analyzed in this study. Furthermore, recent years have seen a slight absolute reduction in power consumption from a peak of 542 TWh in 2008[35]. This downward trend is despite the fact that Germany was impacted to a far lesser extent by the global economic downturn following the credit crunch and despite the fact that Germany has maintained a significant industrial base, including energy intensive chemicals and manufacturing sectors. Germany has therefore succeeded in decoupling economic growth from energy consumption and its comparatively high energy prices have fostered significant increases in energy efficiency in the past.

Motivation and objectives

The energy transition in Germany is characterized by two key developments: A rapid buildup of renewable energy sources supported by the country's feed-in tariffs and the decision to decommission nuclear power stations entirely by 2022. The coalition government of the Social Democratic Party and the Green Party, which significantly boosted the feed-in tariff scheme already in existence and pushed through the initial decision to decommission nuclear power plants, was mostly driven by an environmental agenda to curb greenhouse gas emissions and also by a desire to reduce the risks of nuclear accidents and waste disposal. A significant additional objective was to build up an industrial base in renewable energies to ensure Germany's industry a leading position in a global growth sector.

With regard to its exit from nuclear energy, Germany experienced something of a roller coaster ride. As the key political demand of the Green Party, the coalition government negotiated a phase-out plan for nuclear power plants with the country's nuclear utilities in 2000 and the agreement was enacted in 2002. However, when the election of 2009 brought about a change of government, with a conservative-liberal coalition coming to power, this phase-out plan was reversed in October 2010, prolonging the life-time of nuclear reactors significantly[36], only then to be reversed again by the same government following the disastrous consequences of the tsunami in Japan in March 2011. In the aftermath, the German parliament decided to shut down eight nuclear power plants by August 2011, with a full nuclear exit to be implemented by 2022[37]. The vast majority of Germans supported this move and an ethics commission headed by elder statesmen and well respected representatives from German society recommended in May 2011 that this decision be taken[38].

Ethical and environmental concerns have also impacted other technologies, such as biofuels. Here, concerns regarding large-scale monocultures have led to diminishing support for biofuels, which are seen as either leading to a loss of biodiversity in Germany or as encroaching on pristine nature in biomass exporting regions of the world[39].

The full set of long-term national objectives of the German energy transition was agreed upon in 2010 and 2011. The aim is to reduce greenhouse gas emissions by 80 to 95 % by 2050, compared with 1990 levels. Primary energy consumption is targeted to be reduced by 50 % by 2050 compared with 2008 levels, while renewable energy is to provide 60 % of gross energy consumption and 80 % of gross electricity consumption by 2050[40].

For the shorter time frame, for the period up to 2020, key quantitative objectives of the German environmental and energy policy[41] reflect the 20/20/20 targets agreed at EU level, such as achieving an 18 % share of renewable energy in overall final energy consumption by 2020. This official target is a binding commitment in the framework of the EU's Renewable Energy Directive, Directive 2009/28/EC. For 2030, Germany aims to achieve a 30 % share of renewable energy, although this is not a binding target at the European level.

These targets are translated by the German government into indicative targets for specific sectors. With regard to electricity, the objective is to generate a share of at least 35 % of gross power consumption from renewable energy sources by 2020 (up from 25.3 % in 2013). For 2030, a target share of at least 50 % of renewable energy in gross electricity consumption has been defined. Regarding energy efficiency, an absolute reduction of power consumption by 10 % by 2020 constitutes a very ambi-

35 Statista 2014: Nettostromverbrauch in Deutschland (Net Power Consumption in Germany), www.de.statista.com

36 Deutscher Bundestag: Atompolitik

37 Deutscher Bundestag: 13. Gesetz zur Änderung des Atomgesetzes, Bundesgesetzblatt, July 31, 2011

38 Ethik-Kommission Sichere Energieversorgung: Deutschlands Energiewende – Ein Gemeinschaftswerk für die Zukunft. May 30, 2011

39 Deutsche Akademie der Naturforscher Leopoldina: Bioenergie: Möglichkeiten und Grenzen, October 2012

40 German Ministry for Economic Affairs and Energy: Second Monitoring Report, 2014

41 See German Ministry for Economic Affairs and Energy: Second Monitoring Report, 2014 for a comprehensive overview

tious target, which is unlikely to be met given the trends to self-generated power and e-mobility.

The objectives to increase renewable energy use in heat generation and transportation are less specific by comparison and focus mostly on efficiency increases. As regards heat consumption, a decrease in energy demand of 20 % is targeted by 2020, driving standard setting as well as low interest loans for the renovation of buildings. In transportation, an explicit target regarding the mandatory addition of ethanol to gasoline provoked significant public resistance. Instead, a reduction of the overall energy consumption in transportation and a volume target of 1 million electric vehicles by 2020 are driving government policies in the sector.

Drivers and governance

The key driver of the energy transition is clearly government policy making, as illustrated by the key role political support had in renewable energy deployment and by the political decision to exit nuclear energy as described above. The overall objectives are agreed among a broad political consensus and are thus unlikely to be subject to sudden changes brought about by election outcomes. That said, of course, the detailed regulation and, in particular, the costs and speed of the adjustment to long-term targets are subject to significant political debate in Germany.

Regarding cost developments, several important reforms of the country's feed-in tariff system for renewable energies have been instituted, strongly reducing specific levels of support. For example, feed-in tariffs for solar power generated by photovoltaic modules declined in Germany from 46-56 cents/kWh in 2004 to 9-12 cents/kWh in 2014[42]. However, in retrospect these reductions came late and the cumulative effect of the very rapid deployment of installations led to immense financial commitments for the next 20 years. The annual bill for renewable energy support, which was passed on to end consumers via a surcharge, amounted to €19bn in 2013 alone. In 2014, the most recent reform of the country's "feed-in law" prescribes a transition to an auctioning system for renewable energy support hoped to reduce the cost of further additions to the renewable energy base already installed. Governance of energy has seen significant changes in recent years. While core responsibility for energy was always with the Federal Ministry for Economic Affairs, climate protection and renewable energy policies where under the auspices of the Ministry for the Environment (now the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety). Additionally, the Federal Ministry of Agriculture played an important role with regard to biomass utilization. Consequently, while issues of energy sector performance and renewables were inherently interlinked, the multiple responsibilities and particularly the split between renewables and overall energy responsibility led to a situation that was characterized more by rivalries than by cooperation, coordination and alignment between the different government authorities in charge.

But as renewable energies rapidly penetrated Germany's power sector, it became increasingly apparent that more coordination was needed to ensure a smooth transition of the overall system. Hence, in fall 2013, governance of energy, including renewable energies, was changed and it is now located entirely in the newly labeled Ministry for Economic Affairs and Energy, headed by the Vice Chancellor, and has thus significant weight in the ruling coalition government.

To further increase the level of coordination regarding the energy transition, the government has devised a "10-point-agenda"[43] that comprises the key policy actions to secure successful implementation of the transition. These policy priorities illustrate that there is a strong intention not only to fix and modernize instruments such as renewable support and energy efficiency policies, but also to think more holistically about the design of the entire energy market and to increase European collaboration.

With this shift towards more centralized governance that allows a holistic policy making approach to the energy system, Germany mirrors the thinking of the European Union with regards to energy. The EU's "policy framework for climate and energy in the period from 2020 to 2030" was proposed in January 2014 and is planned to be adopted by October 2014[44]. It underlines the need to move from a set of parallel policy initiatives toward a more holistic framework that actively manages the interdependencies between the various policy fields.

42 Fraunhofer ISE: Aktuelle Fakten zur Photovoltaik in Deutschland, July 28, 2014

43 German Ministry for Economic Affairs and Energy: Zentrale Vorhaben Energiewende für die 18. Legislaturperiode, www.bmwi.de

44 European Commission: COM(2014) 15 final, January 22, 2014

Challenges and opportunities

The high dynamics of additions to the country's renewable energy capacity, with a focus on wind and solar, are causing deep structural changes in the German energy market. This change is being felt in the wholesale market where large volumes of volatile feed-in have a disruptive potential for conventional power plants. But traditional, commodity-focused sales organizations in the retail markets for gas and electricity are also affected very significantly.

On the wholesale power market, the impact of more than 84 GW of installed renewable power generation capacity – more than half of it installed since 2008[45] – has translated into a price drop from 2008 levels of around €60-70/MWh to about €30-40/MWh in 2013[46]. This price level renders many conventional power plants unprofitable and provides no incentives for investments in modern, highly efficient power plants[47]. As Germany is at the same time also fading out its nuclear power plants by 2022 and is in the process of retiring many ageing conventional power plants, the question of how to finance new, assured power generation capacity remains unresolved.

Consequently, a lively discussion regarding the design of the electricity market and the possible introduction of a capacity market is ongoing[48]. This debate is highly complex as the issue is found to be deeply interdependent with other policy-driven developments, such as the speed of expansion of renewable energy systems in Europe as well as the setting of quotas for the European Union's emissions allowance trading system. These issues transcend the realm of national energy politics and force Germany and its neighboring countries to collaborate more intensively in energy policy and market design.

For transmission and distribution grid operators, the greatly increased share of volatile renewable energy fed into the grid has necessitated significant change in the way grids are managed as well as substantial investment in grid and transformer capacities. Regarding grid investment, rural grids with a very high wind or solar energy share are particularly in need of strengthening in key regions of capacity growth. Overall, Germany needs to strengthen its North-South transmission capacities in order to deal with the structural mismatch of high (and continually increasing) wind-power production in the North and key demand centers in the South and West of the country. A national grid development plan has confirmed the need for four major "transmission corridors" that should be developed with a mix of projects, including the strengthening of existing lines and the construction of new ones.[49] However, these projects have met with significant resistance in the regions affected by the new powerlines and it remains to be seen if the officially desired acceleration of grid infrastructure projects will be achieved in practice.

For energy retailers, the fact that German retail electricity prices for households and commercial users are now 2-3 times higher than the long-term generation costs of small-scale PV systems and onshore wind turbines makes self-consumption business models increasingly relevant. With customers finding it financially and physiologically attractive to produce an increasing share of their energy needs themselves, grid operators and energy suppliers alike need to rethink their product portfolio and long-term perspectives.

The trend to self-consumption also affects the heating segment: Small-scale CHP applications and PV-powered heat pumps are putting demand for gas and heating oil under increasing competitive pressure. This development further augments a trend to improving energy efficiency in new buildings as well as existing building stock, which is a declared priority area of energy policy making in Germany for the coming years[50] .

In the case of liquid fuels, the dynamic growth trend that had led to an increase in the share of renewables from less than 0.5 % in 2000 to a peak of 7.4 % in 2007 has been reversed since and reached 5.3 % in 2013. This trend reversal was initially due to the fading-out of imported biofuel oils between 2008 and 2010 and more recently due to a decline in biodiesel use and stagnating demand for bioethanol[51]. Here, the political discussion regarding the sustainability of biofuel usage and the impact on biodiversity has rendered business models that were apparently thriving only a few years earlier, obsolete.

45 German Ministry for Economic Affairs and Energy: Erneuerbare Energie im Jahr 2013, Februar 2014, www.erneuerbare-energien.de
46 German Ministry for Economic Affairs and Energy: Energiedaten, ausgewählte Grafiken, www.bmwi.de
47 Hauff et. al: Ausgestaltung und Koordination von Kapazitätsmechanismen im europäischen Strommarkt. A.T. Kearney study commissioned by EnbW, April 2014
48 Agora Energiewende: Strommarktdesign im Vergleich, Juni 2013

49 Bundesnetzagentur: Bestätigung Netzentwicklungsplan Strom 2013
50 German Ministry for Economic Affairs and Energy: Zentrale Vorhaben Energiewende für die 18. Legislaturperiode, www.bmwi.de
51 German Ministry for Economic Affairs and Energy: Erneuerbare Energie im Jahr 2013, Februar 2014, www.erneuerbare-energien.de

Figure 14: Main characteristics of Germany's energy sector

Selected indicators

Parameter	2012	CAGR 1990 – 2012	Outlook
Total Final Energy Consumption	**227 Mtoe**	**–0.3 %**	→
Final Energy Intensity	**0,07 koe/US$05[1]**	**–2.0 %**	↘
Electricity consumption of households	**1677 kWh/cap**	**–0.1 %**	→
Share of renewables in electricity	**24 %**	**7.9 %**	↗
Electricity price	**17.59 USc05/kWh[1]**	**0.7 %**	↗
Motor fuel price	**1.59 US$05/l[1]**	**2.7 %**	↗

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives

- **Climate protection** and the **loss of public acceptance of nuclear** are chief motivations
- Focus on achieving **renewables targets** is shifting to system stabilization and cost control

Drivers & Governance

- **Government incentive schemes** were the key enabler of very significant private investment in renewables
- **Centralization of responsibilities** to improve agility to ensure system stability

Challenges & Opportunities

- High penetration of volatile renewables poses significant **challenge to investment** in assured power supply
- **Technical solutions and new business models** are pioneered in Germany and have global potential

Overall, the key challenges for Germany are not primarily the technical issues surrounding system integration. They key challenges lie in the adaptation of market designs and business models so that they are capable of dealing with the increasing complexities and uncertainties of the energy market. If successfully implemented in Germany, solutions and companies involved in this "pilot energy transition" will have significant opportunities abroad, too. Due to its advanced stage of renewable penetration, high levels of energy efficiency and several policy attempts regarding the heat and mobility sectors, the country is a "laboratory" for energy transitions worldwide.

Saudi Arabia

Saudi Arabia has almost one-fifth of the world's proven oil reserves, is the largest producer and exporter of petroleum liquids in the world, and maintains the world's largest oil production capacity[52]. Saudi Arabia also has large natural gas reserves, although production remains limited so far. As the country does not import or export natural gas, all consumption must be met by domestic production. In 2012, almost 60 % of total primary energy was oil-based, with natural gas accounting for most of the rest[53]. Currently, Saudi Arabia consumes 30 % of its own oil production; however, this is forecast to rise to 80 % in 2032 owing to increased value creation in the country[54]. As Saudi Arabia wants to reduce oil usage for electricity generation, the country is seeking alternative energy sources such as renewables and nuclear power. So far, Saudi Arabia's share of renewable energies is very low, and despite its high potential for solar power, only 12 MW of capacity are installed[55]. In terms of nuclear energy, Saudi Arabia aims to have its first reactor operational by 2020 and wants to build 16 reactors by 2030, which would then cover 20 % of the country's electricity needs.

Motivation and objectives

Saudi Arabia's final energy consumption has increased by 5.8 % per annum between 1990 and 2012[56], mainly due to population growth, industrial development and a subsidy regime encouraging wasteful consumption[57]. In

52 U.S. Energy Information Administration: Saudi Arabia Overview, February 26, 2013

53 BP: Statistical Review of World Energy, June 2013

54 K.A.CARE: Solar Energy: The Sustainable Energy Mix – Cornerstone for Saudi Arabia

55 Eckart Woertz, Norwegian Peacebuilding Resource Center: The domestic challenges in the Saudi energy market and their regional and geopolitical implications, November 2013

56 Enerdata (www.enerdata.net)

57 Eckart Woertz, Norwegian Peacebuilding Resource Center: The domestic challenges in the Saudi energy market and their regional and geopolitical implications, November 2013

Figure 15: Main characteristics of Saudi Arabia's energy sector

Selected indicators

Parameter	2012	CAGR 1990 – 2012	Outlook
Total Final Energy Consumption	**126 Mtoe**	**5.8 %**	↗
Final Energy Intensity	**0,12 koe/US$05[1]**	**1.3 %**	↘
Electricity consumption of households	**593 kWh/cap**	**3.9 %**	↗
Share of renewables in electricity	**negligible**	**n.a.**	**n.a.**
Electricity price	**1.90 USc05/kWh[1]**	**–2.1 %**	↘
Motor fuel price	**0.13 US$05/l[1]**	**–6.1 %**	↘

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives

- Saudi Arabia's chief motivation is to enhance **local value creation**
- **Energy efficiency, renewables and nuclear power** are scheduled to play a role, but implementation is slow

Drivers & Governance

- Key drivers are two programs, the Saudi Energy Efficiency Center **(SEEC)** and the King Abdullah City for Atomic and Renewable Energies **(K.A.CARE)**
- Governance is **highly centralized**

Challenges & Opportunities

- The long-standing practice of **subsidized prices** for electricity and fuel needs to be addressed
- Saudi Arabia has a **very high solar power potential** that it is currently not being exploited

order to meet the rapidly growing demand for energy, the country's chief motivation for energy transition is to ensure the security of supply[58]. Moreover, Saudi Arabia wants to diversify its energy production by expanding its natural gas, refining, petrochemicals, and electric power industries. In addition, subsidized electricity and motor fuel prices may be removed to limit demand growth.

According to the Energy Efficiency Report of 2005, the government is targeting a 30 % reduction in electricity intensity by 2030 and a 50 % reduction in peak demand growth by 2015 compared with the increase between 2000 and 2005[59]. Despite these targets, energy intensity actually increased between 1990 and 2012 by 7.8 % per annum[60]. As a result, the government set up the Saudi Energy Efficiency Center (SEEC) in 2010, which is mainly responsible for the development of energy efficient technologies[61]. The main short-term target of this center is to raise the minimum energy efficiency ratio for windows and air conditioners. In the long term, their vision is to match the global average energy intensity by 2020. As a consequence, some initiatives have been put in place, like the Saudi Energy Efficiency Workshop in 2012 or efficiency audits on commercial and public buildings. Furthermore, energy efficiency can also be increased by encouraging the use of smart metering to create awareness about energy consumption and efficiency among the population.

Another motivation for energy transition is an increasing awareness of environmental issues. A Royal Decree of April 2010 founded the King Abdullah City for Atomic and Renewable Energy (K.A.CARE) in Riyadh and could prove to be the most groundbreaking step toward a more sustainable energy sector[62]. The City is fully funded by Saudi Arabia's government and in charge of drafting policies for renewable and nuclear energy deployment plans. K.A.CARE has recently set a total target capacity of 54 GW by 2032: 41 GW of solar, 9 GW of wind, 2 GW of biomass, 2 GW of geothermal, and 17 GW of nuclear power [63].

Drivers and governance

In Saudi Arabia, two ministries share responsibility for the energy sector, the Ministry of Water and Electricity[64] and the Ministry of Petroleum and Mineral Resources[65], both

58 U.S. Energy Information Administration: Saudi Arabia Overview, February 26, 2013
59 ABB group: Saudi Arabia Energy Efficiency Report, March 2013
60 Enerdata (www.enerdata.net) World Energy Council: Energy Efficiency Indicators
61 ABB Group: Saudi Arabia Energy Efficiency Report 2012
62 International Energy Agency: Policies and Measures for Saudi Arabia
63 K.A.CARE: Solar Energy: The Sustainable Energy Mix – Cornerstone for Saudi Arabia
64 Ministry of Water and Electricity: www.mowe.gov.sa
65 Ministry of Petroleum and Mineral Resources: www.mopm.gov.sa

organized under the Kingdom of Saudi Arabia. The SEEC and K.A.CARE programs mentioned above could become the main drivers of change in Saudi Arabia's energy transition. Moreover, the economic development of the country's petrochemical industry represents another important factor.

Challenges and opportunities

One of the major challenges Saudi Arabia faces is to reverse the long period of low prices and vested interests and to manage the transition to higher prices[66]. In addition, energy policies must become more coherent and effective, a challenging goal under the current bureaucratic structure with little connection between ministries, agencies and the business sector. Finally, awareness of the impacts of energy consumption must be raised among the public, which is mainly concerned about local air pollution but not about GHG emissions.

A key opportunity is the energy efficiency and renewable energy potential that provides Saudi Arabia with the possibility to free up significant amounts of its domestic oil and gas use for exports or as feedstock for the country's growing petrochemical industry. The current system of artificially low energy prices that do not reflect the true costs needs to be changed in order to spark private investment in energy efficiency as well as solar and wind-based power generation. Solar power, in particular, offers a huge opportunity given the significant irradiation and availability of space in the country.

South Africa

South Africa has a large coal mining industry and uses its sizeable coal deposits to meet most of its domestic energy needs, leading to a 70 % share of coal in the total primary energy supply and a share of more than 93 % in electricity generation in 2011[67]. To close the current capacity gap, two very large-scale coal-fired power plants with a total capacity of almost 10 GW are under construction[68]. In addition, large industrial companies were asked in late 2013 to cut their energy consumption by 10 % during periods of peak demand in order to avoid blackouts. Nevertheless, "rolling blackouts" still happen, with the last one being in March 2014[69].

South Africa imports about two thirds of its oil and natural gas consumption and also has a sophisticated synthetic fuels industry producing fuels from coal-to-liquids and gas-to-liquids plants to meet rising oil demand[70,71]. The potential discovery of notable shale gas resources represents an opportunity to become self-sufficient, but the discoveries also led to an intense discussion between industry stakeholders and non-governmental organizations about the environmental impact of unconventional gas exploration and hydraulic fracturing[72,73]. In early 2014, the government released new regulations governing the exploration of shale resources[74]. However, industry stakeholders greeted these regulations with some reservation because the government has reserved significant proceeds for itself. It will remain to be seen if incentives are sufficient enough for investors to commence exploration.

Motivation and objectives

South Africa's energy strategy includes the following key objectives[75,76]:

- Security of supply to ensure that the energy supply is secure and demand is well managed
- Infrastructure to facilitate an efficient, competitive and responsive energy infrastructure network
- Regulation and competition to ensure that there is improved energy regulation and competition
- Universal access and transformation to ensure that there is an efficient and diverse energy mix for universal access within a transformed energy sector

66 Glada Lahn and Paul Stevens: Burning Oil to Keep Cool, December 2011
67 International Energy Agency: Statistics for South Africa
68 U.S. Energy Information Administration: South Africa Overview, February 28, 2014
69 Agence France-Presse: South Africa hit by intensive blackouts amid power shortages, March 6, 2014
70 International Energy Agency: Statistics for South Africa
71 U.S. Energy Information Administration: South Africa Overview, February 28, 2014
72 The Treasure Karoo Action Group: www.treasurethekaroo.co.za
73 Greenpeace Africa: Say ‚No' to Fracking in the Karoo, March 9, 2011, www.greenpeace.org/africa/en/
74 Mining Weekly: CoM welcomes, supports passing of MPRDA Amendment Bill, www.miningweekly.com
75 South Africa's Department of Energy: Revised Strategic Plan 2011/12-2015/16
76 South Africa's Department of Energy: Annual Performance Plan 2014/15

- Environmental policies to ensure that environmental assets and natural resources are protected and continually enhanced by cleaner energy technologies

- To implement policies that adapt to and mitigate the effects of climate change

- To implement good corporate governance for effective and efficient service delivery

An additional key objective which is not explicitly mentioned in the strategic energy plan is very simple: Jobs. With an unemployment rate of 25 %, South Africa needs to create jobs for its steadily growing population[77]. Job potential and local value creation thus impact all policy fields, including energy. Import substitution, for example, by promoting biofuels production, as well as the refurbishment of old power plants are both driven by this key objective.

Another political priority is electrification: In 1994, only 36 % of households were electrified. Over the past twenty years, close to 6 million new households were connected, so that by now over 80 % of households have access to electricity[78]. As from an economic perspective, micro grids often offer a better opportunity for remote areas than conventional grids do, the feasibility and cost-effectiveness of 100 % grid connectivity is questionable[79]. Moreover, demand growth has previously been overestimated, now putting into question the government's plan to install additional nuclear power capacities.

Vision 2025 released by the South African government points out the intent to alter the energy mix by having 30 % of clean energy by 2025. Also, the Copenhagen Accord pledge of 2010 states that South Africa will take nationally appropriate emission mitigation action to enable a 34 % reduction compared to the 'business-as-usual' emissions growth trajectory by 2020 and a 42 % reduction by 2025[80]. To achieve these aims, the government successfully implemented auctions for renewable energy projects under the Renewable Energy Independent Power Producer Procurement Programme (REIPPP) to better use South Africa's high potentials[81]. The government's commitment to nuclear energy is also strong, with firm plans for expanding the capacity by almost 10 GW in the next decade, despite severe financial constraints[82].

In summary, South Africa clearly plans to implement an "energy transition" towards a less carbon-intensive energy system. However, pressing short-term energy supply needs and a delay in decision making in terms of project implementations are putting this transition on hold. In the short to medium term, renewable energies will increase in absolute volume, driven by governmental auction schemes. However, they are unlikely to gain any significant share of power generation output as demand growth outstrips additional renewable capacity and large-scale coal plants will come on line.

Drivers and governance

The key driver of change is the shortage of supply, flanked by centralized government planning and supported by a number of regulatory instruments[83]. The 2013 update of the Integrated Resource Plan highlights the significant uncertainties that accompany South Africa's ongoing transition from a low-cost and energy-intensive industry base to a more efficient yet more energy cost-intensive industry structure[84]. The plan points out that some of the planned investments in additional coal and nuclear capacities have been put into question, and describes a clear long-term trend towards a larger share of renewable energies. More specifically, the plan targets a more than 100 % increase in total capacity by 2030, with an additional 22 GW of renewable, 16 GW of coal, 10 GW of nuclear, 6 GW of gas and 4 GW of other power.

One example of government policy is the SANS 204 policy, which specifies standards for energy efficiency in buildings[85]. Also, in the area of automotive fuels, the Energy Efficient Motor Programme subsidizes the purchase cost of new, highly efficient motors[86]. Overall, the government is targeting reducing energy intensity by 12 % between 2005 and 2015, as defined in the National Energy Efficiency Strategy[87]. Between 2009 and 2014 electricity prices rose by 18 % per year, thereby driving real changes in energy efficiency for the first time[88]. In addition, the

77 Economic Co-operation and Development: Statistics for South Africa
78 South Africa's Department of Energy: Annual Performance Plan 2014/15
79 The South African National Energy Association
80 South Africa's Department of Environmental Affairs: Copenhagen Accord, January 29, 2010
81 Renewable Energy Independent Power Producer Procurement Programme
82 World Nuclear Association: Nuclear Power in South Africa
83 International Energy Agency: Policies of Measures for South Africa
84 South Africa's Department of Energy: Integrated Resource Plan for Electricity 2010-2030, November 21, 2013
85 SABS Standards Division: SANS 204:2011 – Energy efficiency in buildings, August 2011
86 ESKOM: Energy Efficient Motor Programme, October 2009
87 South Africa's Department of Energy: National Energy Efficiency Strategy, September 26, 2013
88 A.T. Kearney analysis

Figure 16: Main characteristics of South Africa's energy sector

Selected indicators			
Parameter	2012	CAGR 1990 – 2012	Outlook
Total Final Energy Consumption	**72 Mtoe**	1.5 %	↗
Final Energy Intensity	**0.13 koe/US$05[1]**	−1.2 %	↘
Electricity consumption of households	**834 kWh/cap**	1.2 %	↗
Share of renewables in electricity	**2 %**	0.7 %	↗
Electricity price	**9.47 USc05/kWh[1]**	1.4 %	↗
Motor fuel price	**1.84 US$05/l[1]**	3.4 %	↗

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives
- South Africa's chief motivation is to **secure supply** after a period of underinvestment
- Additional key objectives are the **creation of jobs** and **electrification of households**

Drivers & Governance
- Key drivers are **investments** by state-owned utilities and industrial companies
- Governance is **highly centralized**

Challenges & Opportunities
- South Africa's government has to provide **more regulatory clarity** to increase investments
- **Large shale gas reserves** provide the opportunity for self-sufficiency

government released the Electricity Pricing Policy to provide direction and principles for the formulation of electricity prices[89]. They also introduced mandatory biofuel blending, requiring 5 % biodiesel blending by 2015[90], and the Clean Fuels Two (CF2) initiative limiting the levels of harmful compounds in fuel[91].

The Department of Energy was established in 2009 and is responsible for all energy-related issues, including renewable energies, energy efficiency and technology investments and research[92],[93]. It collaborates with the Department of Trade and Industry with regard to incentive schemes for renewable energies[94]. NERSA, the National Energy Regulator of South Africa, was established in 2004 to govern all forms of energy from oil and gas pipelines to electricity[95]. The planned energy transition is thus managed centrally, with regional governments having very limited influence. At the same time, ESKOM, the national power company, has a dominant position in the coal and power sector and is a key player in all aspects of market evolution[96].

Challenges and opportunities

South Africa's main challenge is to overcome supply shortages while diversifying the energy mix. Providing regulatory clarity to increase investments, replacing fossil fuels with shale gas and renewable energy systems and improving coordination among government agencies are most important to achieving this aim.

In electricity, the development of renewable energy capacities will require the construction of additional transmission infrastructure as the current grid connections are primarily fed from large coal plants in the mining areas, while wind and solar resources are in other parts of the country[97]. In addition, the self-generation of solar power and the operation of fuel-saving solar installations instead of diesel aggregates will require regulatory backing as part of the power sector reform.

With regard to oil and gas, the future policy for shale gas use will fundamentally impact the prospects and poten-

89 South Africa's Department of Minerals and Energy: Electricity Pricing Policy, December 19, 2008
90 South Africa Info: SA to blend biofuels from 2015, www.southafrica.info
91 South Africa Info: South Africa eyes cleaner fuels by 2013, www.southafrica.info
92 Government of South Africa: www.gov.za
93 South Africa's Department of Energy: www.energy.gov.za
94 South Africa's Department of Trade and Industry: www.thedti.gov.za
95 National Energy Regulator of South Africa: www.nersa.org.za
96 ESKOM: www.eskom.co.za
97 A.T. Kearney analysis using Solar and Wind Energy Resource Assessment

tially require very significant investments. If this policy is pursued, South Africa could greatly reduce its dependence on imports and even become an exporter of natural gas while reducing GHG emissions at the same time.

United States

The United States is the second largest consumer of energy in the world[98]. However, the country's total final energy consumption did not increase significantly in the last two decades. In 2011, the primary energy mix consisted of 36 % oil, 26 % gas, 20 % coal, 9 % nuclear and 9 % renewable power[99]. The majority of energy is hence derived from fossil fuels. Due to increased shale gas exploration, net imports declined to 19 % of primary energy in 2011[100]. Over the last years, the plan to build liquefied natural gas terminals to diversify sources of import has led to a discussion about enabling the export of natural gas. Moreover, as the largest provider of funds worldwide, the United States plays a leading role in the research into and the development of new energy technologies[101].

Since the late 1990s, the government has supported the development of nuclear capacity as part of a long-term energy strategy. However, so far, nuclear capacity has not been expanded for economic reasons[102]. In contrast, renewable energy sources are growing dynamically because of a large natural potential combined with significant federal and state level support[103]. This recent development has put the United States among the market leaders for renewable energy capacity. In 2013, 1.1 GW of wind[104] and 4.8 GW of solar power were installed, the latter representing an increase of 41 % over 2012[105]. This development indicates that the Solar Investment Tax Credit, a tax privilege for investments in solar energy, has been very effective.

The discovery of large shale gas reserves over the last decade has profound implications for enhancing energy security, cost reduction and climate protection policy[106]. Although concerns of non-governmental organizations have emerged about the environmental sustainability of shale gas exploration[107,108], the current course of intensive exploration is bound to be continued. Companies are therefore striving to improve public acceptance, for example, by disclosing the components of all fracking fluids and by conducting high-standard water-quality tests[109].

Motivation and objectives

The key objective of the United States' energy transition is to increase supply security by reducing its dependence on imports. To increase the competitiveness of domestic industry, the country also aims to reduce the cost of energy supply by developing new technologies. Moreover, to promote a transition away from oil in the transport sector, the government is targeting the introduction of one million plug-in hybrid and electric vehicles by 2015[110].

Over the last years, control of local air pollution by the Environmental Protection Agency and by emission trading in sulfur dioxide has led to reduced emissions of small particulates, especially from coal plants. By contrast, regulation of greenhouse gas (GHG) emissions still represents a political battleground. Like other countries, the United States signed the Copenhagen Accord pledge in 2009 and agreed to reduce GHG emissions by around 17 % by 2020 relative to its 2005 emissions levels[111]. Although this commitment was not ratified and therefore does not have any legal standing, the government released a policy with respect to the mandatory reporting of GHG emissions, covering approximately 85 % of the country's emissions[112].

Recent extreme weather events and advances in the exploration of shale gas – which enables the substitution of coal-fired power plants with gas-fired capacities – have, however, rendered the most recent push by the Obama administration to address climate change politically feasible: In June 2013, the United States Environmental Protection Agency was directed by President Obama to define State-level reduction targets for "carbon pollution" by June 2015. A first draft of the Carbon Pollution Emission Guidelines was proposed by the EPA in June 2014 and

98 International Energy Agency: United States
99 U.S. Energy Information Administration: Annual Energy Review 2011, Figure 1.0
100 The World Bank: Energy imports, net (% of energy use)
101 International Energy Agency: The United States Review 2007
102 World Nuclear Association: US Nuclear Power Policy, March 2014
103 U.S. Department of Energy: Strategic Plan 2014-2018
104 Global Wind Energy Council: Global Wind Statistics 2013
105 Solar Energy Industry Association: Solar Market Insight Report 2013
106 International Energy Agency: Energy Technology Perspectives 2012
107 Sierra Club: Marcellus Shale Gas Campaign, www.sierraclub.org
108 The Nature Conservancy: Marcellus Shale 101, www.nature.org
109 ExxonMobil: Shale Gas: An American Success Story, www.corporate.exxonmobil.com
110 The White House: A Secure Energy Future, March 2012
111 U.S: Government: Copenhagen Accord, January 28, 2010
112 U.S. Environmental Protection Agency: Greenhouse Gas Reporting Program

Figure 17: Main characteristics of the United States' energy sector

Selected indicators			
Parameter	2012	CAGR 1990 – 2012	Out-look
Total Final Energy Consumption	**1459 Mtoe**	**0.5 %**	↗
Final Energy Intensity	**0.10 koe/US$05**[1]	**–1.8 %**	↘
Electricity consumption of households	**4376 kWh/cap**	**0.8 %**	↗
Share of renewables in electricity	**13 %**	**0.2 %**	↗
Electricity price	**8.37 USc05/kWh**[1]	**–0.6 %**	↘
Motor fuel price	**0.86 US$05/l**[1]	**2.7 %**	↗

1. at ppp
Source: Enerdata, A.T. Kearney Analysis

Motivation & Objectives

- The United States' chief motivation is to secure supply in order to **reduce import dependency**
- Other key objectives are **cost reduction** and **local job creation.** A new **"carbon pollution"** reduction plan is currently under development

Drivers & Governance

- Key drivers are **entrepreneurial investments** in new technologies and government policies
- Governance is **decentralized**

Challenges & Opportunities

- **Coordination problems between federal and state level institutions** need to be resolved
- **Large shale gas reserves** offer a reliable, long-term energy source and complement a shift to renewables

opened to public scrutiny and comment[113]. The new quality of this initiative is illustrated by the fact that GHG emissions are now defined as "pollutants" and can therefore be regulated under the existing Clean Air Act. This limits congressional influence on the policy and might thus provide a stable legal framework for climate protection in the US. However, given the emerging nature of the policy and considering the significant skepticism regarding climate change-related policies still prevalent in much of the US' political environment, it remains to be seen if climate protection truly becomes a cornerstone of US energy & environmental policy.

Drivers and governance

The Department of Energy is responsible for all energy-related issues, including science and innovation programs, and is supervised by the Secretary of Energy, a political appointee of the President[114]. In addition, each state has its own energy department that releases further policies and has its own budget. As a consequence, energy policies are determined by federal and state institutions. Drivers of change are, as described above, regulations and incentives but also sizeable investments in new technologies.

In addition to standards for local air pollution, the Environmental Protection Agency is also in charge of setting energy and fuel efficiency standards[115]. Recently, the first-ever fuel economy standards for heavy-duty trucks were put in place, and the toughest standards for passenger vehicles in the history of the United States were proposed, requiring an average performance equivalent of 23 km/l by 2025[116]. Moreover, due to numerous policies and measures in the building sector[117], energy consumption per housing unit has declined more than 20 % over the last three decades based on the Residential Consumption Energy Survey from 2009[118]. Recently, the Environmental Protection Agency even extended its use of standards to GHG emissions, when releasing limits for carbon dioxide for the first time[119].

113 U.S. Environmental Protection Agency: Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule, June 18, 2014
114 U.S. Department of Energy: Organization Chart, January 17, 2014
115 Environmental Protection Agency: National Ambient Air Quality Standards
116 U.S. Environmental Protection Agency: Regulations & Standards for Light- and Heavy-Duty Engines and Vehicles
117 International Energy Agency: Policies and Measures for the United States
118 U.S. Energy Information Administration: Residential Consumption Energy Survey 2009
119 ClimateProgress: EPA Publishes First Rule Limiting Carbon Pollution From New Power Plants, www.thinkprogress.org

In 2013, the government released the Climate Action Plan, the latest key policy consisting of the following three pillars: (i) cut carbon pollution; (ii) prepare for the impacts of climate change; and (iii) lead international efforts to combat global climate change[120]. To promote renewable energies, the Department of Energy issued the Business Energy Investment Tax Credit rebating 30 % of solar, wind and fuel cells as well as 10 % of geothermal, microturbines and combined heat and power technology investments[121]. In addition to this federal incentive, many states have their own Renewable Portfolio Standard requiring utilities to provide a defined energy share from renewable energy sources[122].

Challenges and opportunities

One of the main challenges for the United States is to coordinate state and federal regulations in order to achieve a high level of consistency across policies and programs. To address environmental concerns regarding shale gas exploration, a key challenge for policy makers is to develop a regulatory framework that is effective in ensuring safe production and that will also ensure acceptance of the technology. As shale gas represents a comparatively cheap and reliable energy source, it is seen as an opportunity for re-industrialization in the United States as well as as a cost-effective combination with volatile renewable energy sources. Given its abundance, shale gas might even open an opportunity for the US to reverse its position and to become an exporter of energy on the global energy market. For this reason, shale gas enjoys significant political support and is likely to remain a cornerstone of the US energy transition for the foreseeable future.

120 U.S. Government: The President's Climate Action Plan, June 2013
121 Database of State Incentives for Renewables and Efficiencies: Business Energy Investment Tax Credit
122 Database of State Incentives for Renewables and Efficiencies: DSIRE's Quantitative RPS Data Project

Key observations and implications

Based on the results of this comparative analysis, we believe there is sufficient reason to speak of a „global energy transition“, as fundamental structural changes are ongoing in a number of key energy markets. However, this change differs very significantly between countries in terms of motivation and objectives, drivers and governance as well as challenges and opportunities. At the same time, a number of characteristics and processes appear to be strikingly similar among the countries analyzed in this study.

Motivation and objectives

Supply security is the single most important motivation for energy transitions worldwide. However, the reasons why the countries in this study want to enhance access to their own domestic energy sources vary substantially. While the United States primarily aims to reduce its import dependence, South Africa's key objective is to create jobs by enhancing local value creation. China, in turn, is pulling all levers in order to meet its steeply rising energy demand, whereas Saudi Arabia aims to preserve its high level of supply security by diversifying energy resources and to increase local value creation.

Another crucial motivation is to reduce the cost of energy supply. This objective primarily drives end consumer price caps and auctions for renewable energies in Brazil. Environmental protection and public acceptance appear to play a less important role in a global comparison, with Germany as the most prominent example in this regard. Nevertheless, the objectives of climate protection are a fixture of most energy policy documents around the world and serve as an important argument in the public and political debate for pressing for structural change. Of course, all countries follow a certain combination of targets, so that the focus pointed out here rather represents a dominant motivation than an exclusive focus.

Drivers and governance

The key driver of change in the energy sector is government policy making. This is true not only in cases of successful policy implementation but also in the absence of clear policies or a failure to implement them. In all of the countries analyzed here, government policies impact the energy sector very substantially and there is no country where one could speak of pure "market evolution" regarding sector development. Unfortunately, framework conditions appear to be often set with limited attention to and understanding of the long-term effects and interdependencies between the various policy fields.

For example, price caps on gas in Brazil to control inflation have led to the bankruptcy of ethanol producers that were built up with government support in the decades before. The Brazilian government has also enforced price reductions for electricity, leading to reduced investments that, in turn, have resulted in brownouts and the reactivation of old backup capacities. Another example is Germany, where renewable energy support has been successful in spurring very dynamic growth of renewable energy capacities but has also stranded investment in conventional power plants. On the other hand, in some countries, plans released by the government are regularly adapted and thereby serve as an early warning system. For example, in South Africa, demand growth was previously overestimated, which is now putting into question the government plan to install additional capacities.

To summarize, most countries covered by this study have defined long-term national targets for particular technologies. But some are also relying on an evolving planning horizon and adjust their outlook and respective policy priorities when conditions change. While this approach introduces some uncertainties in its own course, it does reflect the fact that the overall system balance and viability need to be adjusted and calibrated if previously adopted planning assumptions, for example, with regard to consumption growth or the cost of technologies, prove to be outdated.

With regard to the mechanisms of the policies, a broad range of approaches is employed. Here, market elements in certain areas of policy making are often combined with interventionist policy making in other areas of the framework. Key examples are listed below:

- Renewable energies ramp-up is supported in all countries in this study, but with widely different policy tools and limited traction of some of them. Auction schemes in Brazil and South Africa and feed-in tariffs in Germany are just some examples of the highly differentiated policy portfolio. In the latter case, the success of low-cost provision of renewable energy in the auction systems is, of course, the result of a learning curve the technology providers bidding and the project developers enjoyed during times of high feed-in tariffs in Germany.

- Energy efficiency policies can be standards-driven as in the United States or price-driven as in South Africa, where end consumer prices were regulated upward to reflect true costs and to relieve pressure on the state budget. This development in South Africa has led to significant investments in industrial energy efficiency and, in turn, planning assumptions regarding demand growth needed to be corrected.

- Biofuel production in Brazil, South Africa and the United States supports job creation in the agricultural sector but suffers from a continued dependence on mandated demand due to relatively high production costs. In the case of Brazil, the production of biofuels was rendered obsolete when prices for sugar increased but end consumer price caps for biofuels were introduced.
- The ongoing shale gas boom in the United States was largely a technology-driven phenomenon, which requires further elaboration of the policy framework by mitigating environmental and social impacts to ensure sustained production. Shale gas also has significant potential in South Africa and, to a lesser degree, in Germany; however, public acceptance issues play an important role in both countries, stressing the need for a holistic policy plan.

With regard to governance, countries like Brazil, China, Saudi Arabia and South Africa have a more centralist approach than Germany and the United States, where state-level policies are partly at odds with federal-level policies. Also, the often observed overlap of economic and environmental policy priorities and responsibilities is a recurrent theme in all countries. Overall, there is a general perception that holistic governance is absent and that the energy sectors are subject to significant short-term thinking despite their predominantly long investment cycles.

Challenges and opportunities

In countries with an emerging economy, the key challenge is the dual pressure between meeting demand while keeping costs low and improving environmental performance. By contrast, navigating structural change with stranded assets and multiple policy priorities, including a strong focus on meeting environmental objectives, represents the main challenge in industrialized countries.

As change in a complex, interconnected energy system needs to be introduced in a balanced manner, the lack of holistic policy making is a key challenge for those making investment decisions. The lack of harmonization between state and federal levels is another recurrent theme, especially in the United States and Germany, leading to complicated regulatory frameworks and high implementation costs. Of course, this challenge is less pronounced in a more centralized decision-making system like China. Nevertheless, project implementation always requires the alignment of national objectives and local realities. Another challenge is the tension between different interests and the lack of a broad-based societal consensus regarding the way forward for a country's energy transition, leading to uncertainty and consequently to less investment.

We see the following key opportunities:

1. **Global resource abundance**, meaning that energy efficiency potentials combined with renewable energy sources and shale gas potentials provide an abundance of energy that can be made accessible with currently available technologies.
2. **Global learning curves in technology development**, which can significantly lower the cost of the energy supply. The fact that many countries have embarked on a similar journey at the same time provides a global market for technologies and know-how that is necessary to enable a global energy transition. The rollout of renewable energy technologies such as wind and solar power has provided confirmation of the enormous cost reduction potentials that global demand can unleash. Shale gas and biofuel technologies are further examples of where companies can leverage global markets to improve quality and reduce costs.
3. **Maturing policy making based on global experience**, so that countries can also learn from each other in terms of policy making as previous and current policies appear largely dominated by national or, at best, regional debates. Extending these national debates with in-depth views from global policy experience can bring about an opportunity to actually get things right.
4. **A global business opportunity for companies that provide relevant technologies, services and know-how to implement energy transitions successfully.** Such "energy transition business models" can profit long term from the ongoing fundamental change, if they prove agile enough to navigate the significant uncertainties that will prevail in global energy sectors for years to come.

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