German energy policy: Its impact nationally and across Europe
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Ladies and Gentlemen,

Thank you very much for the opportunity to put you in the picture as regards the **German energy transition**, its consequences for suppliers and customers and its impact across Europe (Slide 1).

Let me start with a comparison of some **key data** for South Africa and for Germany (Slide 2). South Africa is 3.5 times bigger in size. The number of inhabitants is one-third lower in South Africa. The total energy consumption in Germany is nearly three times higher than in South Africa, while the coal consumption is more or less the same. The total CO_2 emissions are twice as high in Germany compared with South Africa. South Africa's CO_2 emissions per capita are 25% below the German level despite the fact that the share of coal in power generation is twice as high as in Germany.

The map of Germany indicates the **centres of energy production** (Slide 3). Germany is the largest lignite producer worldwide. Lignite is being extracted in ten opencast mines spread over three mining areas. Hard coal is still being extracted in three underground mines. While lignite is a competitive energy source, the mining costs for hard coal in Germany are far above world market prices. Hard coal production will be completely phased out by 2018. In addition, there is some gas and oil production in the northern part of Germany.

Germany is highly dependent on **energy imports**. 70% of the country's energy needs have to be met by imports – mainly of oil, gas and hard coal (Slide 4). The columns indicate the primary energy consumption by fuels. Red stands for imports and blue for domestic production. As you can see, the major part of the consumption of oil, gas and hard coal has to be covered by imports. In the case of lignite and renewable energy we can completely rely on domestic production. Nuclear is shown in a mixed color. The reason is that we import uranium but due to international standards nuclear energy is seen as a domestic fuel even if the uranium is being imported.

This slide gives you an overview of our **main suppliers** for crude oil, natural gas and hard coal (Slide 5). As you can see: Russia is the most important single supplier for oil, gas and hard coal. But South Africa also plays an important role as supplier for hard coal.

Let me now move on to the **electricity sector**. This slide shows the current mix in power generation (Slide 6). In 2014, renewable energy sources – for the first time – were the most important pillar in power generation.

While the **share of renewables in power generation** was 26% in 2014, its share in total generation capacity reached as much as 46% (Slide 7). The reason for this discrepancy is that the operating full-load hours per year are between 1,500 and 2,000 for wind, less than 1,000 for PV, but more than 4,000 for hard coal- and even approximately 7,000 for lignite-based and nuclear power plants.

After giving a brief overview of the basics let us look at Germany's energy transition and its consequences. The German government's energy policy guidelines have undergone a profound change over the past few years. In September 2010, the government enacted a comprehensive **Energy Concept** featuring a large number of policy goals for the decades to come concerning the future energy and electricity consumption, the share of renewable energy and the reduction in greenhouse gas emissions. A central component of this concept was to extend the operation time of nuclear power plants, which were at that time seen as a bridging technology to the era of renewable energy (Slide 8).

Following the **Fukushima nuclear disaster** in March 2011, the German conservative-liberal government coalition made an abrupt U-turn by resolving that 8.5GW of nuclear capacity be shut down immediately and the remainder (12.1GW) be decommisioned between 2015 and 2022 (Slide 9). With the decision to shut down all nuclear capacity by 2022, the government returned to the phase-out schedule decided in 2001 by the then socialist-green government. In the coalition agreement of the new conservative-socialist government, signed in November 2013, the phasing-out decision for nuclear energy was confirmed.

Furthermore, the coalition partners agreed on slightly **modified targets** concerning the reduction in greenhouse gas emissions and the increase in the share of renewables in the electricity supply for 2020, 2025, 2035 and 2050 (Slide 10). The decision to phase-out all nuclear plants is to be seen as final due to the public pressure that has accompanied the nuclear debate over the past few decades.

The envisaged **expansion of renewable energy** is a technological and financial challenge. The core objectives of the Energy Turnaround are the following:

- Transitioning the German power supply from a conventional fuel-based system to one mainly based on renewable energy;
- Keeping power prices at a competitive level for industry and an affordable level for private households;
- Ensuring secure supply at all times.

The main instrument used to make renewable energy the backbone of power supply is the **Renewable Energy Sources Act**. This law provides guaranteed feed-in tariffs for green electricity for 20 years after commissioning the plant concerned. Grid operators are obliged to purchase the entire quantity of green electricity with priority. The trading companies pass on the deficit – feed-in tariff minus market price – to customers by imposing a re-allocation charge (Slide 11).

The **renewable capacity** for power generation increased from 12GW in the year 2000 to 40GW until the end of 2008 and to 90GW until the end of 2014. The total number of renewable energy capacity can be broken down as shown in the slide (Slide 12). Especially the capacity of solar PV exploded after 2008 because the costs were below the guaranteed feed-in tariff. Investors could be sure to get a guaranteed margin for the next 20 years which is quite attractive compared with alternative capital investments (Slide 13).

Within the last six years (**between 2008 and the end of 2014**) the increase was 32GW for solar PV and 15GW for wind energy. That means that the funding system for renewable energy sources was quite effective. The share of renewables in total power demand has increased from less than 7% in 2000 to nearly 28% in 2014 (Slide 14).

However, this development has its price. In Germany, total feed-in based on subsidised renewables amounted to 150TWh in 2014. The remuneration paid to plant operators and premium **payments totalled €24bn** in 2014. After deducting income from marketing, on balance, we obtain net subsidy payments of nearly €20bn for 2014.

The subsidies are financed via a **re-allocation charge** that is paid by electricity consumers through a mark-up on the grid-access fee. Starting on 1 January 2014, this re-allocation charge has been increased to €62,40/MWh. The red line indicates how wholesale electricity prices have developed between 2000 and 2014. The blue columns show the development of the re-allocation charge. The re-allocation charge has reached a level which is twice as high as the wholesale price for electricity (Slide 15).

Depending on the amount of electricity consumed and on the share of the electricity costs in the gross value added, industry pays a much lower re-allocation charge. For an average household with an annual consumption of 3,500kWh, the re-allocation charge – including the value-added tax levied on it – is equivalent to some €260 per year. Another aspect is that the subsidy system leads to a **redistribution in favour of relatively well-to-do population groups** who have solar panels installed on the roofs of their homes, at the expense of lower-income households.

A **comparison between electricity prices** reveals the dilemma (Slide 16). Power prices for industry are at the same level as in Japan and three times higher than in countries like Norway or the USA. Private customers in Germany pay even more for electricity than private consumers in Japan. The level in Germany is more than double that of the OECD average and three times as high as in Norway and the United States.

Power producers, too, have to face **new challenges**. These include:

- Reduced duration of the utilisation of conventional power plants;
- Dropping prices on the wholesale market per kilowatthour;
- Providing conventional power plants with the required flexibility to meet not only fluctuations in demand but in addition fluctuations in the feed-in of renewable-based electricity.

Since the power demand in Germany has been more or less stable since 2000, the increased feed-in of renewable based electricity has led to a **decrease in the operating hours** of conventional power plants.

This occurred in connection with **falling wholesale prices** for power. The price decline in electricity wholesaling affects all conventional power plants. Compared with the highest prices, which were reached in 2008, wholesale power prices have halved (Slide 17). The main reasons are the following: increased feed-in of renewables and decreased fuel and CO_2 prices, the latter also caused by the high feed-in of renewables.

The increased use of renewable energy has had the so-called **merit-order effect** (Slide 18). The expansion of renewables shifted the supply curve, which is determined by the variable costs of the different power plants, to the right – with the result that power plants with lower marginal costs are price-setting. While gas-fired plants predominantly set the prices in most hours in the past, the increase in renewables has changed this such that the marginal price setting power plant is a hard coal-fired one in most hours.

This results in a declining margin for all conventional power plants. The **margins** of gas-fired power plants are below zero. They are either not operating or operating only in a few peak hours (Slide 19).

But in many cases hours with peak prices on the wholesale market are also decreasing. This can be demonstrated by the **M-shaped elctricity price curve,** which is typical for sunny days (Slide 20). There is a steep rise in PV production from 8 o'clock onwards, and from 1 o'clock onwards it goes down. The blue line shows the effect on wholesale power prices. They go down at midday. That cuts revenues of power producers who operate conventional plants.

These effects can be seen from the beginning of spring as the daily level of solar radiation increases (Slide 21). The **timing of the increase in solar radiation** in the morning does not coincide with the increase in power consumption. While electricity demand increases between 4 and 8 a.m., the increase in PV feed-in occurs between 8 a.m. and 1 p.m. Similarly, PV feed-in decreases in the evening, a few hours before the decline in power consumption. This means that conventional plants have to kick in at short notice twice – in the morning and in the evening. In order to integrate the high PV feed-in at midday, and afterwards provide full load to cover the evening peak, the coal- and gas-fired power plants are intermittently reduced to part-load operation.

This demonstrates that power producers have to face another new challenge. What mattered in the past was offsetting fluctuations in consumption between day and night, workdays and weekends, summer and winter. Now **feed-in intermittency** has been added, and this has at least the same magnitude as the fluctuations in consumption.

Let me give you **two examples**. The 21st of March 2013 was a day with nearly zero feed-in of wind and PV (Slide 22). The lowest feed-in occurred when the demand was very high. On the 24th of March 2013 the opposite happened. The demand was low and at midday more than two-thirds of the total demand could be covered by wind and PV with the result that we obtained negative prices on the wholesale market.

The conventional power plants have to compensate for the described fluctuations in demand and in renewable feed-in. The technical challenge consists in designing conventional power plants with the required **flexibility**. In new coal- and gas-fired power stations, this is achieved in the course of plant construction. In the case of existing systems, it has in the meantime become possible to take flexibilisation measures with considerable success, so that coal-fired power plants in Germany can technically adapt to growing demand by short-term load adjustments in the same way as gas power stations can. Pure base-load power plants without flexible operation hardly exist anymore in the German market.

In the regular configuration of two gas turbines and one steam turbine, the minimum load of a new **NGCC plant** is typically around 60% of its installed capacity. An even lower minimum load is achievable by switching off one gas turbine, but since this causes a substantial loss in efficiency this mode of operation is rarely used (Slide 23).

By contrast, a **new coal-fuelled power plant** has a lower minimum load of approximately 40%, with further potential to reduce this to 20 to 25%. The reason for this is that the output of the coal boiler is controlled via direct fuel combustion and not, as in the case of an NGCC power plant, via a HRSG with an upstream gas turbine. It was possible to reduce the minimum load at existing power plants in Germany by optimising the boiler-turbine system using modern control systems. Optimised power plants are now able to achieve a part-load level of less than 20%.

The **change between part load and full load** in power plants involves load changes of approximately 3 percentage points per minute; the change in operating mode can therefore be achieved at all plants in less than half an hour (Figure 24).

Slide 25 shows the course of adjusted operation of hard coal-fired power plants in **November 2014**, following changes in demand and available generation from renewable energy sources. Gas-fired power plants operated at a low and stable level without contributing to load adjustments.

The situation is this (Slide 26): At times, wind and solar power almost meet the total electricity demand, while at others there is nearly no contribution from these sources. Therefore, **conventional power plants are needed to ensure security of supply**. But the expansion of renewables leads to conventional power plants becoming increasingly unprofitable. That makes it necessary to add a capacity mechanism to the energy-only market. There is a proposal of the utilities on the table to launch a decentralised market for the product of firm capacity, supplementing the income earned from the sale of electricity on wholesale markets. Appropriate capacity mechanisms should be a suitable instrument to provide protection against power failures. Guaranteed capacity has a value comparable with an insurance and therefore it should be given a price, which could be determined by auctioning.

Another problem is grid expansion. True, there is no general capacity problem in Germany so far, even with eight nuclear-power station units being switched off in 2011 and in spite of the decision to successively shut down the remaining nine nuclear units until the end of 2022. However, the decommissioned nuclear-power station capacity seriously affects the south of Germany, whereas wind power is increased in the north (offshore and onshore) in particular. This makes a substantial **expansion of the transmission grids** necessary. In reality, the extensions to the grids – this also applies to the necessary expansion of the distribution networks – are not keeping pace with the increase in the power generation capacity of wind and PV systems. The reasons for this include long approval prcedures, some of which are prolonged further by a lack of local acceptance of line construction and by financing problems.

Further increases in the installed capacity of renewable energy are expected, mainly on the basis of PV and wind. As early as 2034 we expect a renewable capacity that is twice as high as the maximum annual load (Slide 27).

The biggest drawback of renewables is that their availability is not in our hands. Therefore, almost the **same conventional power plant capacity as today will be needed** in the years to come to cover peak demand and, even as renewables grow further, would be continued to be required to ensure security of supply. But, as mentioned before, the expansion of renewables leads to conventional power plants becoming increasingly unprofitable.

Another effect of the renewable expansion in Germany is that it has a significant **influence on the neighbouring countries** that are connected to the German grid network. The expansion of renewables in Germany provokes increasing electricity exports. In 2014, we achieved a new record of 74TWh in power exports. The export/import balance was 35TWh. A further increase in the German export surplus is expected (Slide 28).

Several of **Germany's European neighbours have complained** about the impact of the intermittent generation and the unbalanced supply-demand situation within Germany on the power system. Polish and Czech grid operators in particluar have voiced concern over unscheduled loop flows that occur when electricity flows from the northern areas of Germany through eastern European markets back into southern Germany. They have begun to install phase shifters on German borders that enable TSO to physically push back electricity flows if necessary. This approach contradicts the principle of the European internal energy market.

Besides these effects the increased feed-in of renewables-based electricity has **effects on the wholesale prices and revenues of power companies in Germany's neighbouring countries** (Slides 29 and 30).

The German market is integrated into the European market and we have a **European energy and climate policy**. In October 2014, the European Council endorsed a binding EU target of at least 40% domestic reduction in greenhouse gas emissions by 2030 compared with 1990 emission levels. Further decided targets for 2030 include (Slide 31):

- To double the share of renewable energy in total energy consumption to 27% and
- To increase energy effiency by at least 27%. This indicative target at the EU level has been set to improve energy efficiency by 2030 compared with projections of future energy consumption based on current criteria.

The sectors which are covered by the European Emission Trading scheme, such as power generation and industry, have to achieve an even more ambitious target: a 43% reduction in CO_2 emissions by 2030 but compared with 2005, while the target for the non-ETS sector is limited to 30% compared with 2005 (Slide 32). The 2050 target for the power sector is even more ambitious: a reduction in CO_2 emissions by at least 80% compared with 1990.

Let me now move on to my **conclusions** (Slide 33)

- The **central targets of energy policy** are security of supply, competitive and affordable prices and environmental protection.
- These targets have the same rank.
- There should be **one instrument for each target**. The adequate instrument for climate protection is pricing CO_2 – either via a tax or via a cap and trade system.

- To keep energy affordable and competitve we should support renewables via **auctioning systems** and give them market responsibility. In this respect, South Africa is ahead of Germany.
- As far as conventional energy sources are concerned, we should rely on **least cost solutions**, for instance in countries that don't have sufficient low-cost gas resources, coal or nuclear energy.
- Whether preference is given to coal or to nuclear energy should be a **rational decision**. Some cost calculations show that coal combined with CCS even has cost advantages over nuclear energy. South Africa has storage capacity for CO_2 – mainly offshore.
- **CCS is technically feasible** and possibly has lower risks than nuclear energy.
- A further advantage of CCS is that it guarantees **more employment within the country.**
- For **energy security**: discrimination of cost-efficient domestic energy sources is to be avoided.

The **main messages** are the following:

- The **three energy policy targets** of energy equity, energy security and environmental sustainability, which address the "energy trilemma," should be given the **same rank**.
- **Instruments** that assure rational and cost-efficient solutions should be given priority. Energy policy should ensure that energy and carbon markets deliver.
- **A low-carbon future** is not only linked to renewables; carbon capture, utilisation and storage is important and consumer behaviour needs changing.
- Functioning energy markets require investments and **regional integration** to deliver benefits to all consumers.
- **Regional priorities differ: there is no "one-size-fits-all" solution to the energy trilemma.** Energy transition also takes place in many other countries. The difference between Germany and most other countries is that in Germany climate issues are given priority while in most other countries, especially those outside of Western Europe, priority is given to providing all people with access to electricity, to improving the industry's competitiveness and to improving security of supply.

The new brochure, published by the German Member Committee of the World Energy Council (Slide 34), demonstrates this for selected countries including South Africa.