VGB POWERTECH

Discussion Paper

Investment Requirements in the EU Electricity Sector up to 2050

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Contents

1. Introduction 3
   Impetus of the VGB Scientific Advisory Board 3
   Key findings and implications of the Chalmers study 3
   Additional questions raised by the scientists 4
2. Investment Requirements in the EU Electricity Sector up to 2050 (VGB Project 388) 6
   Executive Summary 6
3. Common statements for politicians and decision makers 9
   Focus on the strategic energy triangle 9
   Need of conventional capacity 9
   System requirements and security of supply 9

1. Introduction

VGB, the European technical association for electricity and heat generation, together with its Scientific Advisory Board (SAB) has recently started a review of the European energy and climate policy. Neither the liberalisation of the electricity markets nor the introduction of the emission trading system has been a success so far. Today it becomes visible in Europe that security of supply is threatened as existing conventional power plants are suffering due to low electricity prices and are going to be shut down, even if they are young and very efficient. There is nearly no new build activity anymore. Some countries are phasing out of nuclear, others are stepping in. Even renewables are living in a phase of political uncertainty, because the future of support systems is under question. Last but not least the whole network infrastructure is under pressure, due to missing political decisions. All countries are individually searching for an adequate market system to keep security of supply on a reliable level, but there is no common European approach in sight at the horizon. There is no common answer to the question, how the energy system should or could look like in 2050. Everybody is talking about the strategic energy triangle, but does everybody mean the same? One major topic on the political agenda seems to be CO_2 reduction and different pathways for this purpose are described, but do they really also take into account the technical feasibility and out of that security of supply?

Impetus of the VGB Scientific Advisory Board

Against this background the VGB Scientific Advisory Board raised serious concern about the future security of electricity energy supply in Europe. Being comprised of about 30 scientists from twelve European countries covering all fields of power production the body is convinced to have a say about this issue. It was therefore agreed to exemplify the complexity of the technical, economic and political challenges related to securing future electricity supply by means of the investment requirements in the EU electricity sector up to 2050.

Key findings and implications of the Chalmers study

On behalf of the VGB Scientific Advisory Board, Dr Mikael Odenberger and Dr Thomas Unger, headed by Professor Filip Johnsson, calculated on the basis of different CO_2 reduction pathways the investment requirements in the electricity sector up to 2050. For this purpose, the Department of Energy and Environment of the Chalmers University of Technology in Goteborg used a database describing the existing power plants across the EU-28, Norway, Iceland and Switzerland.

Key finding of this study is that driven by the two-degree-warming-target, any system transformation to more renewables will require unprecedented, massive investments not only in generation capacity, but also in new grid infrastructure and balancing energy. Such huge investment requirements are not only an unprecedented challenge of the European societies, they are demanding a consistent European energy policy from Poland to Portugal and from Finland to Greece providing a market design able to attract and remunerate these investments.

Professor Johnsson and his team are favourably implying a "stringent European energy and climate policy towards 2050" and are "assuming that policy goals in terms of CO_2 reduction are met". In line with this all four calculated scenarios are based on European publications which have impacted the discourse in Brussels with more or less success:

– "Reference" is based on the reference projection of the EC (2013);
– "Regional policy" is loosely based on the EC Roadmap scenario "Energy efficiency" (EC, 2011);

– "Climate Market" is inspired by, and loosely based on, the EC Roadmap scenario "Diversified supply technologies" (EC, 2011) and the "Power Choices Reloaded" scenario analysis initiated by EURELECTRIC (2013);
– "Green Policy" is loosely based on the EC Roadmap scenario "High RES" (EC, 2011).

Additional questions raised by the scientists

It had been very likely that necessary simplifications of a scenario calculation study would challenge contradiction of a heterogeneous body like the VGB Scientific Advisory Board when the results were discussed for the first time in March 2015. Clear benefit of such discussion is that it reminds of the real complexity of the issue and of the extend of the unknown. Some of the questions raised are highlighted in the following.

The Chalmers study includes variation management by means of import/export of electricity between the regional divisions in the modelling as well as storage in hydro power dams – the study does not reflect new storage options (e.g. batteries, power to gas and compressed air energy storage) which might be serious game changers for the energy system. But while the number of European pump storage plants is known and limited, and public acceptance and market incentives for new built plants are very unlikely, the technical potential of batteries, power to gas or other new technology and its system implications are quite unknown yet.

Biomass is anticipated in this study to become an alternative to fossil fuels, but already today the limited availability of biomass might limit the actual contribution of biomass plant capacity.

Some members are generally in doubt about the technical feasibility of reaching climate goals and security of supply in parallel without generation from fossil fuels (even if costs are neglected). This especially applies to the "Green policy" scenario calculated by Chalmers.

Doubts in the European energy policy are high. Practical experience with German unilateralism (i.e. nuclear phase-out combined with above-average CO_2-reduction targets) shows that decisions on European level are not necessarily transferred to national levels and vice versa. Also European unilateralism in climate policy neglecting dissenting global trends is seen as critical.

Members insist that not only CO_2 reduction goals, but the triangle of the energy economy - economy, ecology und supply security - must be the parameter of a balanced energy policy and miss this in the actual European energy policy.

Underlining the importance of an appropriate market design, the huge investment need disclosed by the Chalmers study is contrasted to current peak electricity prices of 25-40 €/MWh which do not encourage investments. The Chalmers study is based on a tightening cap on CO_2 (and other policy measures in some scenarios) which, as a result, gives an increase in cost of electricity generation which would result in far higher prices. Thus, in the Climate Market scenario this will correspond to the EU Emission Trading System (EU ETS), being the main driving force for investments. The impact of other market mechanisms on actual investments is not included (e.g. day ahead, intraday prices, capacity markets). Nevertheless, comparing the current market situation including the policy measures available and the Chalmers results, considering that private investments require profitability, there urgently must be strong ideas in politics how to close the gap between low wholesale prices and investment needs.

Certainly the resulting investments in the electricity sector are highly dependent on the cost of the different generation technologies and these may of course change in future in another way than what is assumed in the Chalmers study. In addition, the additional cost imposed by CO_2 pricing and other policy measures (such as the renewables support in the Green Policy scenario) can be

transferred to and divided between the electricity consumers in different ways. This is not included in the study.

To show the full picture of challenges it should be added that electricity accounts for only about 40% of primary energy and 20% of end energy. Therefore carbon replacement will never be achievable with electricity decarbonising only. Replacement of carbon fuels for heating and transport by electricity and/or production of synfuels will therefore require in addition a multiple of the investments calculated in the Chalmers study having its scope in the electricity sector only.

These few examples illustrate the complexity of the energy world, but beyond this complexity the Chalmers study definitely shows that in a real world all well-intended political targets can be missed, if there is no incentive for investors and therefore no one will take care for the necessary assets.

2. Investment Requirements in the EU Electricity Sector up to 2050 (VGB Project 388)

Study carried out by

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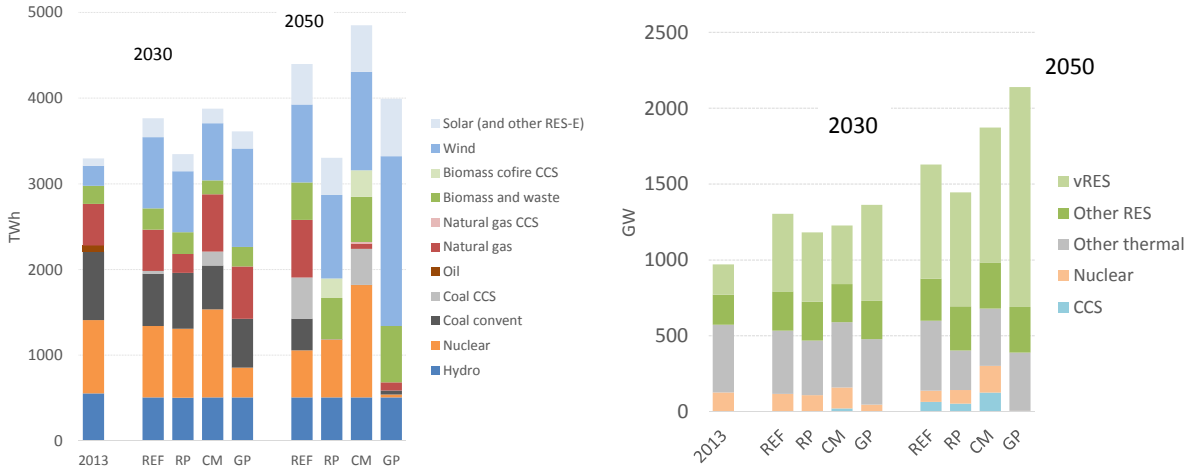
Executive Summary

As a consequence of stringent European energy and climate policy towards 2050, the impact of the European electricity-supply system is likely to be very significant. Assuming that policy goals are met, the European electricity-supply system will emit only a marginal fraction of the greenhouse gases emitted today and the share of renewable electricity may amount to at least half of gross electricity consumption. However, depending on the setup and degree of European harmonization of policy instruments, and depending on technological development and availability of some technologies, e.g. nuclear power, carbon capture and storage, and renewable electricity generation, we find that the pathways towards very low emissions may differ significantly. This impacts the balance between different technologies, the total consumption of electricity, the electricity-price formation and the pace and magnitude of capacity investments over time. Nevertheless, all pathways which fulfil the 2050 climate policy goals will consist of large amounts - yet at different levels - of renewable electricity such as wind and solar power. In this study, we elaborate on these issues based on extensive and detailed modelling of the entire European electricity-supply system from today and until 2050. The most important findings and conclusions of this study include:

- Renewable electricity generation (RES-E) will grow substantially in all investigated scenarios. The difference across the scenarios lies in the investment pace. Assuming less stringent climate-policy goals will reduce the need for new renewable electricity somewhat.
- Since variable renewable electricity generation (vRES-E), with inherent lower annual capacity utilization compared to traditional thermal power plants, grows substantially in all investigated scenarios, overall installed capacity will grow much faster than demand for electricity on an energy basis (this development has already been a fact during the last years after a long period since 1990 when capacity grew equally fast as demand in Europe as a whole). In this study, we estimate the electricity gross consumption to grow between roughly zero and 50% by 2050, depending on scenario, compared with 2013, while the installed capacity grows between 50% and more than 100%, depending on scenario, during the same period of time.
- The transition towards more vRES capacity will involve increased demands for regulating capacity. This includes supply options in the form of back-up during times with low availability of wind and solar irradiation, such as gas turbines, but also end-use options such as increased flexibility in electricity use.
- The transition of the European electricity-supply system may also involve new investments in conventional high-efficient fossil-fuel based generation (e.g. natural gas power), new nuclear power (if politically acceptable) and carbon capture and storage, CCS (if commercially available). Common to these non-renewable, yet CO_2-lean, alternatives is that price signals in the wholesale market must be sufficient and reach levels that deviate substantially from what currently is seen in the European wholesale electricity markets.

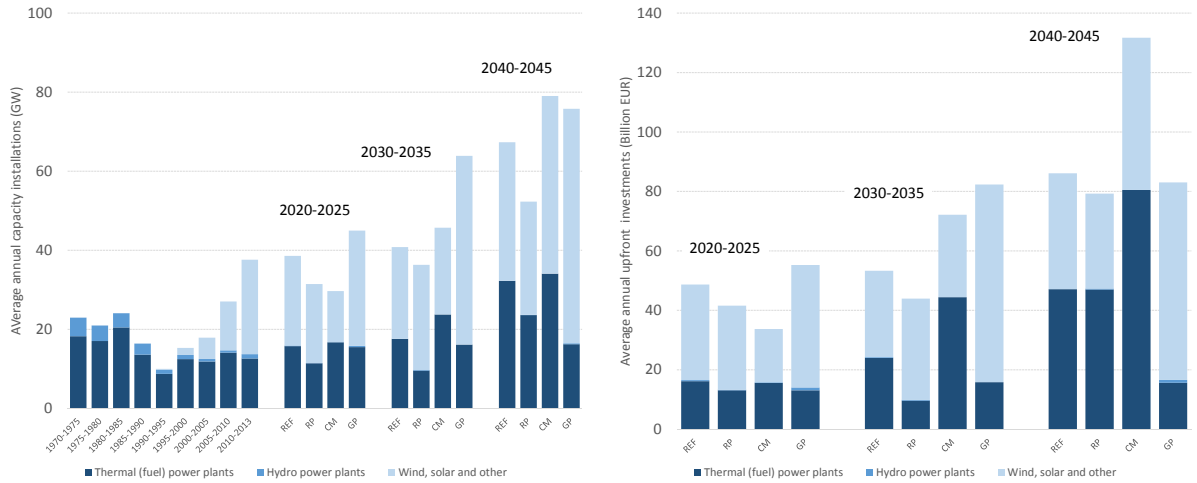
A summary of electricity generation and installed capacity is shown in the two panels below for the four scenarios investigated in this work.



Electricity generation (left panel) and electricity-generation capacity (right panel) in Europe in 2030 and 2050, respectively, for the four investigated scenarios (vRES=variable renewable electricity generation). REF= Reference, RP=Regional Policy, CM=Climate Market and GP=Green Policy.

- Annual investments will be of significant size during the entire period until 2050 (and probably beyond, yet not studied here). Investments will increase as existing capacity is phased out due to aging or due to unprofitability following e.g. increased penalty from increased costs to emit CO_2, which in turn gradually increases costs of electricity generation. Historically, annual capacity investments have been typically around 20 GW across the EU. During last years, this figure has approached 40 GW due to massive investments in wind and solar power. During the coming decades, we estimate that the corresponding annual capacity investments will increase further, typically to between 40 and 80 GW per year, depending on scenario and year. This is indeed, in a historical perspective, a large figure and further underlines the challenges associated with a sufficient need for capital, manufacturing capacity, engineering labour skills and, of course, electricity-grid infrastructure.
- The potentially lower electricity demand in the future, which may be a consequence of the third policy goal of the EU, the energy-efficiency goal, may present an option to somewhat reduce the immense investments in supply capacity and, thus, reduce the pressure on the manufacturing industry and the large infrastructural and engineering challenges associated with the significant transition at the supply side.

The average annual capacity investments in GW and associated investment costs as obtained in this report are summarized in the two panels below.



Investments in new capacity in the four scenarios in five-year periods as obtained in this work; RP=Regional Policy, CM=Climate Market and GP=Green Policy <u>Left panel:</u> Average annual capacity investments (commissions in GW) in five-year periods for different means of electricity generation and for all scenarios (Source for 1970-2013: Chalmers Power Plant Database). <u>Right panel</u>: Average annual upfront investments (in Billion EUR) in five-year periods for different means of electricity generation and for all scenarios.

- Investments in new electricity-generation installations are often faced with public resistance from near-by residents. In this study, we find that investments in new non-renewable thermal generation are limited in such a way that existing power plant sites would be sufficient to use also for new installations. Thus, as existing power plants are phased out, they may leave space for new units that possibly are of larger capacity size, as generally in the case of new nuclear power. The need for greenfield sites is, hence, only marginal. However, in the case of RES-E technologies the picture is completely different. This is especially true for wind power and for biomass power, both of which will require a substantial number of greenfield sites across the EU. This is also an important factor that potentially may dampen the transition pace of the electricity-supply system. For solar power, however, such conflicts are less likely to occur since the majority of installations are likely to be on roof tops.

3. Common statements for politicians and decision makers

The VGB Scientific Advisory Board is of the opinion that the Chalmers study is an excellent basis for the discussion of the societal impact of the current policy of the European Union and its member states for the electricity sector.

Key finding of the study is that the targeted large decarbonisation of the electricity sector will require unprecedented, massive investments not only in generation capacity, but also in new grid infrastructure and balancing energy. Such huge investment requirements are not only an unprecedented challenge of the European societies, they are demanding a consistent European energy policy from Poland to Portugal and from Finland to Greece providing a market design able to attract and remunerate these investments.

Focus on the strategic energy triangle

Other than done in the study, which in line with current political priorities focus on CO_2 reduction targets, it is necessary for the European Union and its member states to address the entire triangle of the energy economy – economy, ecology und security. The other two cornerstones of the triangle, i.e. security of supply and economic feasibility and competitiveness, cannot be neglected without serious consequences for the European societies.

Low wholesale prices for conventional electricity generation forcing to shut-down even newest plants, in combination with high end user electricity bills suffering from renewables' subsidies, cannot be an everlasting basis of the electricity market.

It will be a political question, how and whether the European societies can motivate and afford such market distortions in the future.

Need of conventional capacity

There is an ongoing need of conventional capacity, at least to stabilize the electricity supply system. From a technical point of view, the European societies are currently building a second generation portfolio of renewables in parallel. But this costly additional portfolio will not and cannot substitute the secured capacity of conventional generation, at least as long as novel storage technologies are not available at large scale.

CCS plants are already today proven technology. Yet, in order for CCS to be implemented there must be a sufficient policy measure pricing the CO_2 emissions. CCS will increase the generation cost by around 4-5 cent/kWh, which is below of the German renewable levy.

System requirements and security of supply

The transition of the European energy system towards renewables is also limited by the electrical net (cross border interconnections, domestic transmission and distribution systems) as well as by missing storage capacities. Necessary investments in this infrastructure will increase the required investments in the electricity sectors beyond generation plants. If the infrastructure will not be significantly developed with regard to the new challenges imposed by intermitting renewables, these limitations will endanger the security of supply.

VGB PowerTech e.V. is the European technical association for electricity and heat generation. Our currently 480 member companies are operators, manufacturers and institutions involved in the field of power industry. Members from 34 countries represent an installed capacity of 458,000 MW, mainly located in Europe.

This paper was developed by the VGB Scientific Advisory Board. The VGB Scientific Advisory Board is an independent body, which supports the association in all matters of research, development and education. It is comprised of about 30 experts from twelve European countries; they represent all fields of power production and cover all topics from basic research to applications.

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