A Third electricity scenario

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ABSTRACT

The electricity systems of most European countries still largely rely on conventional base load sources (oil, coal, nuclear) as well as on other fossil fuels for covering peak loads. This is the traditional first scenario developed for decades under complete monopoly conditions

More recently some EU member states such as Spain and Germany have heavily invested in Wind and photovoltaic (PV), two variable sources of electricity. They plan a huge increase supplying up to 50% of their consumption with these two sources. For balancing the grid, gas is planned as back-up. However, such an electricity system also requires additional infrastructure as well as large storage capacities. This new scenario can be seen as the second one.

Geothermal electricity is completely ignored in these two scenarios. With a third scenario, EGEC aims to demonstrate that geothermal electricity is key to reducing the overall system costs of the future electricity systems. Providing a local source of electricity for the base load it will also allow the total energy bill to decrease and make energy more sustainable and affordable.

1. INTRODUCTION

European countries started to develop their electricity mix with fossil fuels (coal, oil, and, since the 1990's, gas). Both base load and peak load were covered by these sources. After some decades, other sources, notably renewables contributed. The largest part came from hydro-electricity but geothermal also started to produce electricity in 1913 (1904 for the first demonstration). The two oil crisis in the 1970s forced nearly all countries to look to alternative sources and to change their electricity mix by decreasing their oil consumption, replacing it in particular with nuclear. It leads to the first electricity mix, the conventional one, with a base load covered by oil-coal-nuclear-hydroelectricity, and the peak load mainly covered by gas.

For the last couple of decades, renewable electricity production has been growing. The largest contribution comes from wind and photovoltaic (PV) which are variable sources of electricity. In some countries (Spain, Germany, Denmark), the contribution of these 2 variable sources can be higher than 50% of the electricity consumption at certain moment of the year. If we aim to use only or mainly these two sources, both storage, new grid infrastructure (smart grid, supergrid) and back-up plants should be built. The back-up will mainly be provided by more flexible gas-fired power plants. Such a scenario is already in development in three EU member states where a base load production is no longer required. So geothermal is in a sense excluded also from this electricity-mix promoted by many studies of institutions and green NGOs. This is what we will call the second scenario.

The third scenario promoted by EGEC is the one where geothermal will play a role because we are convinced geothermal can bring many advantages:
-base load renewable resource (can run 7800h/ year);
-flexibility and scalability (right response for grid stability);
-easily to integrate into existing power systems;
-ideal to limit new infrastructure and to reduce system costs;

Such a scenario proposes a real mix to decarbonise our electricity production with 100% renewables. The only option will be to continue having a minimum share to cover the base load through flexible technologies such as biomass, hydropower, and concentrated solar power and of course geothermal. Variable sources such as wind and PV will cover the peak load. The aim is to have a step between centralised and completely decentralised system with regional security of supply. We also think this third scenario is, when full costs are integrated, the least costly to implement for society.

2. GEOTHERMAL SPECIFICITIES

There are three types of geothermal power plants operating in Europe: Conventional (hydrothermal), Binary and EGS (Enhanced Geothermal Systems). Currently, there are more conventional plants in operation, but with on-going development of the other technologies, as well as the geographical flexibility of EGS plants, there will be an increase in both types in the future. As is demonstrated below, EGS plants will grow strongly in number, from only 3 today, to possibly 50 in a decade's time. Currently, there are many new projects, such as those supported by the NER300 funding programme. Over the last few months we have seen applications coming from very different locations, in addition to "traditional" EGS countries (Germany, France). According to the EGEC Geothermal Market Report 2012 there are 62 geothermal power plants in operation today, 86 plants which are under development (short term: 2016) and the 124 project ideas under investigation (long term: 2019).

Conventional geothermal plants (flash and dry steam turbines) operating with high temperature hydrothermal resources have been in use for 100 years and are fully commercial today with a full cost (integrating systems costs and externalities) of about 7€ct/kWh. Medium and Low temperature/enthalpy (< 180°C) geothermal power plants have been developing for some years and are becoming more and more commercially viable, thanks to the improved efficiency of the binary (ORC and Kalina) turbines with full costs of around 12-18 €ct/kWh. Finally, EGS power plants are still at the pre-commercial stage. Systems need to be replicated, with more projects in different geographical conditions in order to decrease the costs and improve the efficiency of both the turbines and the pumps, and to increase the size of the plants.

2.1 Local renewable energy

The main advantages of geothermal electricity are:

- Renewable Base Load: the unique role of geothermal in providing 'base load' amongst renewable energies should be highlighted, and should be considered by policymakers as an additional benefit (grid stability). It should therefore receive a premium compared with weather dependant energies. A geothermal plant has very limited operation and maintenance costs, and companies can be organised for running these facilities in a remote manner, with optimal predictive maintenance to keep the capacity factor as high as possible.

-Resource Location: A standard geothermal project does not exist. Every power plant has some peculiarity, especially from the resource point of view; policies should address particular measures for each specific case or group of similar situations. Geothermal is a local resource for a country, a region, a county; and local companies should be present in the market, directly or through Joint Ventures with major multinationals, in particular in the cascade development of thermal energy usage.

-Large variety of scale: It is possible to have a very small geothermal project owned and run by a municipality or even a hotel, so it is necessary to have scale specific policies in place. In the meantime the high upfront cost of exploration is a good argument for for the development of larger projects or by the consolidation of multiple projects with common exploration.

2.2 A flexible base load source

Geothermal plants are characterized by a high capacity factor, typically in excess of 70%.

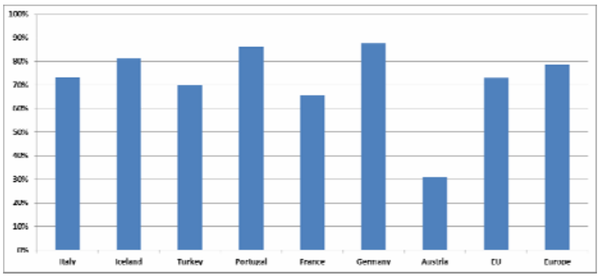

Fig.1: Installed Capacity Factor of Geothermal Electricity Plants in Europe.

The largest source of flexibility in power systems is the ability of dispatchable power plants such as geothermal plants to ramp output up and down on demand. Geothermal plants are dispatchable as they are able to respond to commands from a system operator, at any time, within certain availability parameters, and to increase or decrease output over a defined period. Geothermal is 'base load' so it has been designed to run 24h per day throughout the year. It is also flexible because plants should be ready to respond with at least six-hours' notice.

3. THE CONVENTIONAL FIRST SCENARIO

The electricity grid started to be developed in 1907 with the creation and installation of the first transmission lines without important losses. But the main development of a European electricity grid was after World War II.

3.1 Energy mix

The current electricity mix in the EU is composed of conventional base load (nuclear, coal and oil) and large renewable electricity sources.

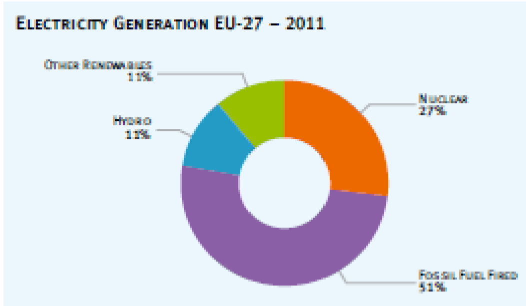

Fig.2: Electricity generation in the EU-27 in 2011.

Base load production varies country by country from around 20% (nuclear, oil, coal, hydropower) to more than 70% (mainly nuclear and hydropower).

Geothermal produces only 7 TWh which represents less than 0,02% of the total EU electricity consumption.

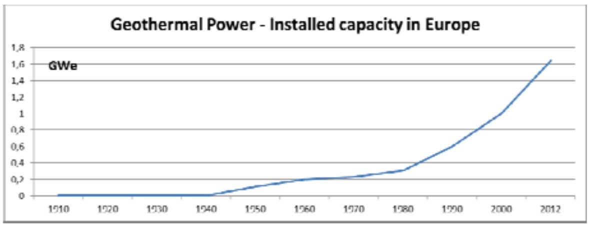

Fig.3: Geothermal power, installed capacity in Europe 1913-2013, in GWe.

3.2 Trends

The trends come from a study published by the European Commission in 2009: the energy trends 2030.

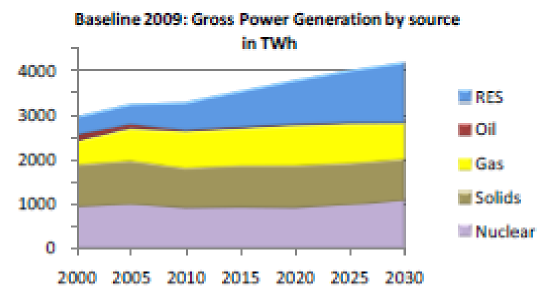

Fig.4: Structure of power generation in 2030. EC: EU energy Trends to 2030, update 2009, European Commission, Brussels, 2010

4. THE NEW SECOND SCENARIO

With an EU commitment to decarbonise the economy and especially the energy sector, several Member States have intensively deployed wind and PV. In Spain, Germany and Denmark on some days, these two sources cover more than 50% of the demand. But they are variable, which means that other sources have to cover the rest of the production and also balance the grid.

4.1 Energy mix

In such an evolving scenario, there is still a 'base load' component, with a growing share of variable renewable sources which under certain circumstances can stress the grid and put the adequacy of the system at risk. Figure 5 gives an idea of the electricity mix in Denmark, a country which has heavily invested in wind energy. In 2010, the overall share of electricity from wind already represented more than a fifth of the total electricity consumption of the country.

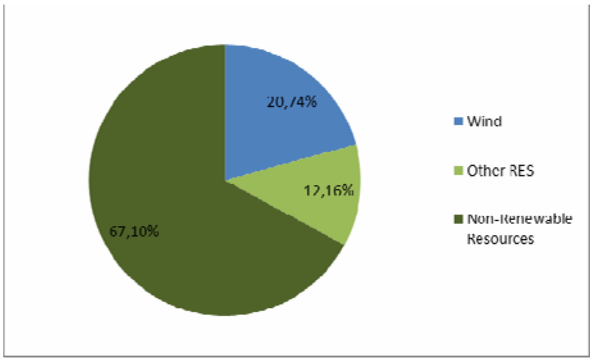

Fig.5: Electricity mix in Denmark in Denmark in 2010 (Source: Eurostat SHARES Result 2010).

4.2 Perspectives

In order to illustrate how the second electricity scenario can develop up to 2050, we use data from the European Commission's Energy Roadmap 2050 which was developed by using the PRIMES EU-wide energy model. PRIMES is owned by the National Technical University of Athens.

In the Energy Roadmap 2050, all decarbonisation scenarios would be dominated by variable renewable energy sources. The share of other sources such as nuclear and gas fluctuate from scenario to scenario (European Commission, 2011).

In 2050 in the 5 decarbonisation scenarios:

- Hydropower would provide between 7.7% and 9.2% of electricity production
- Wind energy would provide between 31.6% and 48.7% of electricity production
- Solar energy would provide between 9.9% and 16.4% of electricity production
- Hydro power would provide between 7.7% and 9.2% of electricity production
- Biomass would provide between 9.3% and 10.9% of electricity production
- Geothermal would provide between 0.3% and 0.6% of electricity production
- Nuclear would provide between 2.5% and 19.2% of electricity production
- Coal and lignite will provide between 2.1% and 13.1% of electricity production
- Gas would provide between 7.5% and 19.5% of electricity production
- Oil-fired would provide between 0% and 0.1% of electricity production

In the second electricity scenario the development of renewable energy appears to be limited to a massive concentration of wind in the Northern Seas and solar in the Mediterranean countries. The analysis of the Impact Assessment of the Roadmap, shows, however, that cumulative grid investment costs alone could be €1.5 to €2.2 trillion between 2011 and 2050, with the higher range reflecting greater investment in support the above-mentioned concentrated approach to the development of renewable electricity.

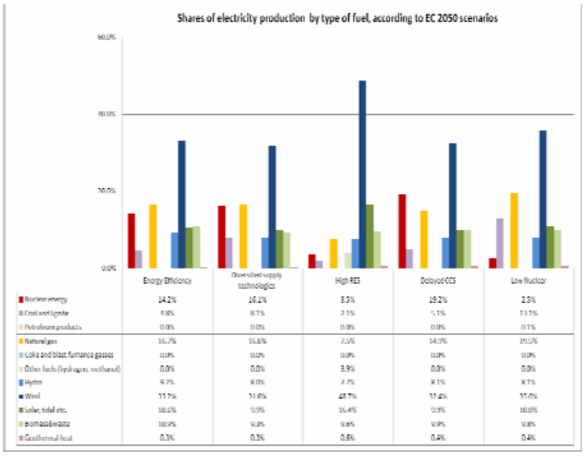

Fig.6: Shares of electricity production by fuel according to the EC 2050 scenarios

5. THE FUTURE THIRD SCENARIO

The two scenarios presented in the foregoing chapters undoubtedly present some advantages but also serious drawbacks. The first ensures stability to the grid and predictability for market operators. However, this kind of scenario appears to be incompatible with the current energy challenges. To begin with, climate mitigation policies as confirmed by the International Energy Agency's World Energy Outlook 2011. This has warned that four-fifths of the total energy-related CO2 emissions permissible by 2035 are already "locked-in" by our existing capital stock (IEA, 2011b). Secondly, this system is not compatible with the need for more flexibility as, for instance, carbon capture and storage (if proven to be technically and economically viable) applied to gas significantly decreases its capacity to ramp up and down quickly. Thirdly, when it comes to nuclear for instance, this scenario simply becomes non-compatible with a market-based system. Indeed new nuclear build appears to be too politically risky and costly to attract investors unless the market is altered and a tariff is guaranteed for 40 years as the recent reform of the electricity market in the UK has shown.

The second scenario is compatible with the EU's objective of decarbonising the electricity system in Europe. However, as outlined in the EC Energy Roadmap 2050, it would imply a disproportionately high concentration of capital investments in a small number of countries. This issue, furthermore, risks turning into a real challenge if the public antipathy for new transmission corridors and major upgrades to existing lines (including bigger sub-stations and towers) are taken into serious consideration.

In contrast, a more balanced concentration would share and reduce the investment requirements among the Member States, significantly reduce the need for additional grid infrastructure, not to mention the benefits in terms of local competitiveness and growth in employment.

5.1 Energy mix

In the third electricity scenario long-term benefits prevail over short-term considerations and external costs are fully internalised into energy prices. In this scenario European countries roll out a higher number of renewable energy sources to develop the most cost-effective energy system and guarantee a truly secure security of supply.

EGEC aims to demonstrate that geothermal electricity is key to reducing the overall system costs of future electricity systems. Providing a local source of electricity for the 'base load' it will also allow the total energy bill to decrease and make energy more sustainable and affordable.

Such a scenario relies on a higher number of technologies and proposes to continue having a minimum share to cover the base load through flexible technologies such as geothermal, biomass, hydropower, and concentrated solar power. Variable sources such as wind and PV will cover the peak load.

Geothermal will be a key technology and a geothermal power plant should be installed in each region of Europe as

-There is the potential to install anywhere in Europe: high-medium-low enthalpy plants or EGS.
-It will balance the grid locally and regionally
-It will decrease the total costs for the society with no need for storage and large infrastructure
-It will decrease GHG emissions

5.2 Perspectives

The decarbonisation of the electricity sector will only be possible with a large additional contribution from the flexible renewable energy sources in order to replace base load production from coal, gas and nuclear.

Geothermal and other flexible RES do not have external costs associated with traditional fossil fuels such as storage, grid and supply infrastructures or waste management (CO2, nuclear). These technologies do not need costly storage systems. Neither is there a need for supply infrastructures from external countries when using flexible RES. These flexible RES technologies are present in Europe and they are complementary.

In addition, these technologies can provide peak load and the necessary grid regulation services to ensure system stability by compensating highly variable production patterns of variable RES technologies. Moreover, being complementary with variable RES-E technologies, their integration will promote synergies in the grid infrastructure development across Europe.

By including all external costs, we can see that geothermal and other flexible RES technologies are by far the most competitive ones. External costs include carbon capture and storage for coal and gas and underground nuclear waste management, but also infrastructure costs should be taken into account. External costs must be included in order to have a fair and transparent competition in the energy mix costs analysis up to 2050. This scenario can therefore be the most economic scenario for the 2050 electricity mix. In the mid to the long-term, this scenario can increasingly provide affordable, indigenous and sustainable energy to European people.

6. CONCLUSIONS

The electricity systems of most European countries still largely rely on conventional base load sources (oil, coal, nuclear). This is the traditional first scenario developed for decades under complete monopoly conditions. However, such a scenario seems to be no longer compatible with environmental objectives as well as with the internal energy market.

For this reason, some countries have heavily invested in variable renewable sources. However, such an electricity system, that we have dubbed as second electricity scenario, requires enormous additional infrastructure as well as large storage capacities. It would imply a disproportionately high concentration of capital investments into a small number of countries and make public acceptance more problematic.

In this paper we have therefore proposed a third scenario where all renewable technologies are deployed. In this scenario geothermal plays an important role, not least for its base load and sizeable features.

This third electricity scenario can guarantee security of supply, system adequacy and stability to grid. If all external costs, including infrastructure are taken into account, it also appears to be the most compatible the environmental and competitiveness objectives of the EU energy policy.

The investments we choose today will bind us for decades to come. If the EU is to live up to its ambitious decarbonisation commitments, there is no room left for false moves. The third electricity scenario has not been truly investigated in recent analyses, including in the recent EC Energy Roadmap 2050. Isn't the time to remedy this deficiency?

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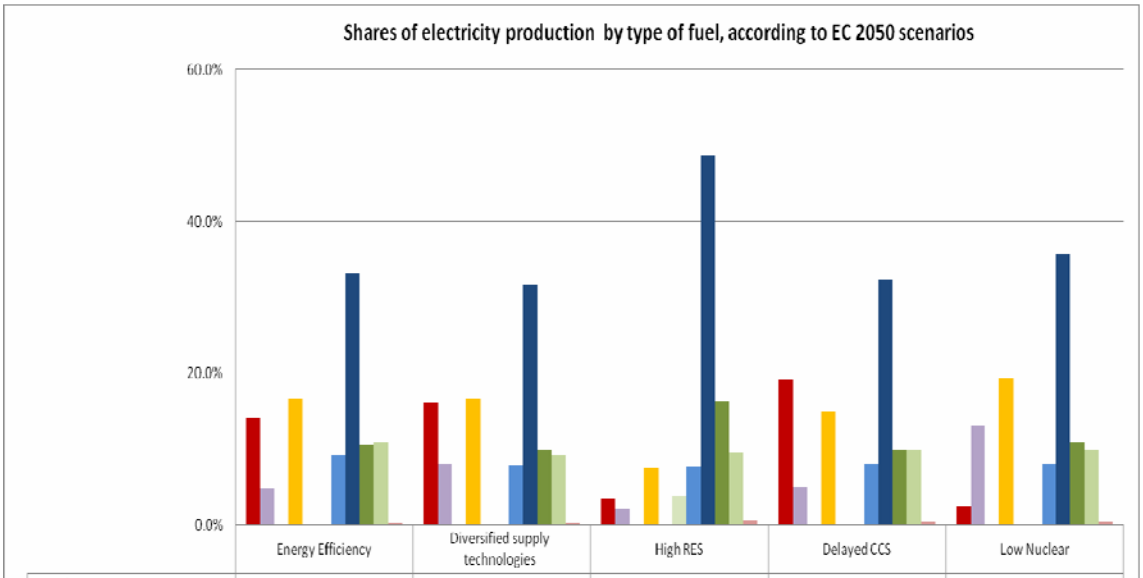

	Energy Efficiency	Diversified supply technologies	High RES	Delayed CCS	Low Nuclear
Nuclear energy	14.2%	16.1%	3.5%	19.2%	2.5%
Coal and lignite	4.8%	8.1%	2.1%	5.1%	13.1%
Petroleum products	0.0%	0.0%	0.0%	0.0%	0.1%
Natural gas	16.7%	16.6%	7.5%	14.9%	19.5%
Coke and blast furnance gasses	0.0%	0.0%	0.0%	0.0%	0.0%
Other fuels (hydrogen, methanol)	0.0%	0.0%	3.9%	0.0%	0.0%
Hydro	9.2%	8.0%	7.7%	8.1%	8.1%
Wind	33.2%	31.6%	48.7%	32.4%	35.6%
Solar, tidal etc.	10.6%	9.9%	16.4%	9.9%	10.8%
Biomass&waste	10.9%	9.3%	9.6%	9.9%	9.8%
Geothermal heat	0.3%	0.3%	0.6%	0.4%	0.4%

Fig.6: Shares of electricity production by fuel according to the EC 2050 scenarios