Nuclear Power Plants – Tackling the Investment Dilemma

A EURELECTRIC contribution to the PINC (Nuclear Illustrative Programme)

September 2015

EURELECTRIC is the voice of the electricity industry in Europe.

We speak for more than 3,500 companies in power generation, distribution, and supply.

We Stand For:

***Carbon-neutral electricity** by 2050*

We have committed to making Europe's electricity cleaner. To deliver, we need to make use of **all low-carbon technologies**: more renewables, but also clean coal and gas, and nuclear. Efficient electric technologies in **transport and buildings**, combined with the development of smart grids and a major push in **energy efficiency** play a key role in reducing fossil fuel consumption and making our electricity more sustainable.

***Competitive** electricity for our customers*

We support well-functioning, distortion-free **energy and carbon markets as** the best way to produce electricity and reduce emissions cost-efficiently. Integrated EU-wide electricity and gas markets are also crucial to offer our customers the **full benefits of liberalisation**: they ensure the best use of generation resources, improve **security of supply**, allow full EU-wide competition, and increase **customer choice**.

***Continent-wide** electricity through a coherent European approach*

Europe's energy and climate challenges can only be solved by **European – or even global – policies,** not incoherent national measures. Such policies should complement, not contradict each other: coherent and integrated approaches reduce costs. This will encourage **effective investment to** ensure a sustainable and reliable electricity supply for Europe's businesses and consumers.

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KEY MESSAGES

Nuclear energy contributes to the three major energy policy objectives of the European Union: security of supply, decarbonisation of the electricity sector and competitive power prices in Europe.

Nevertheless, the sector faces a number of challenges. One of these is to improve the economic operation of existing nuclear power plants. In several European countries distortive national policy measures place economic burdens on nuclear units which are leading to the early shutdown of technically well-functioning nuclear reactors. Another challenge is to enable new market-based investment, which is not viable under the existing energy policy and market framework. To facilitate investment in nuclear and other low-carbon technologies, an improved regulatory framework is needed and in particular, ways must be found of reducing investment risk.

In this respect, the recent Energy Union Communication[1] from the European Commission recognises the need to promote "investor confidence through price signals that reflect long-term needs and policy objectives". This requires a market-based environment and a strengthened, well-functioning ETS system, which are key elements to trigger investments in low-carbon generation technologies, including nuclear power generation.

The legally binding EU wide target of 40% reduction in greenhouse gas emissions by 2030 should remain the centrepiece of the 2030 Climate and Energy Framework and a level playing field should be ensured for all power generation technologies. It is also critical that the internal energy market is completed, and that the market evolves to reflect the new energy mix with increased presence of intermittent energy sources. More specifically, the regulatory framework for nuclear power should ensure that specific tax burdens are reconsidered and that better coordination of national measures is in place. Furthermore, nuclear regulators should promote greater harmonisation and standardisation of nuclear components, which will further improve cost-competitiveness. Finally, European institutions should ensure that funds are made available for low-carbon capital intensive projects.

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[1] European Commission Communication, "A Framework Strategy for a Resilient Energy union with a Forward-Looking Climate Change Policy", 25 February 2015.

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The contribution of nuclear power to the electricity mix in Europe

The European power sector is undergoing radical change. Renewable energy sources (RES), distributed generation and demand response are playing increasing role in the power system. In the meantime, reduced demand due to the economic crisis, coupled with a rapid increase in variable RES with low variable cost, and a drop in the wholesale electricity prices, has seriously affected the business case for power generation, whether new or existing. In this new energy system, decentralised and centralised large-scale systems will depend on each other. Nuclear power can play an important role in solving the challenges of this new, more diverse, energy system, providing the reliable baseload supply necessary to ensure generation adequacy.

Nuclear power today plays a key role in ensuring that Europe's energy needs are met and contributes to the three major energy policy objectives of the European Union: ensuring security of supply, limiting greenhouse gas emissions, and helping to secure competitive power prices in Europe. Some **28%[2] of electricity in Europe** was produced by **nuclear power in 2014**. Nuclear plants thus provide a substantial share of Europe's power generation and are the largest source of low carbon electricity (**54%[3] nuclear share in low carbon electricity generation in 2014**).

The European nuclear industry occupies a leading role across all segments of the nuclear value chain (fuel cycle and reactors), both in terms of technology development and skills. With regard to the security of fuel supply, European companies rank among the world's major producers of nuclear fuel.

Modern nuclear power plants are flexible and can provide load-following properties within the range of 40% to 100% of rated power, although continuous baseload operation continues to be the optimum from both the economic and operational perspective. Their load gradient can be very fast in both directions (up to 5% or 60 MW/min, or even more) - TSOs may require today about 20 MW/min under extreme circumstances. Given that the variable (fuel, operation and maintenance) costs of nuclear generation are low, nuclear plants are well-suited to provide a competitive base load supply of electricity. Different options to further increase the flexibility of nuclear power plants, such as the improved control of nuclear reactors (reactivity control), should be considered.

As regards nuclear safety, the stress tests performed following the Fukushima accident confirmed the high safety standards of European nuclear plants. Additional safety measures adopted as a result of these stress tests will further improve safety standards in relation to very unlikely triggering events. With the amendments made to the Nuclear Safety Directive in 2014, the EU has further strengthened its nuclear safety framework. Continuous improvement of nuclear safety and security in Europe must be tackled not only through national efforts but also at the European and international levels. **EURELECTRIC therefore strongly supports the continuation and enhancement of the current effective cooperation between nuclear safety regulators across Europe.**

EURELECTRIC also underlines the importance of **independent nuclear safety regulators** and stresses that they should have adequate competencies and resources at their disposal. The recent changes to the Nuclear Safety Directive are helpful in reinforcing the independence of nuclear safety regulators.

In addition to the strong focus on **nuclear safety,** the European nuclear power industry continues to work towards even higher standards of environmental protection: reducing the amount of radioactive wastes and spent nuclear fuel, minimising personnel exposure to radiation and contamination, taking responsibility for the safe decommissioning of nuclear power plants, and

[2] Source: Eurostat
[3] Source: Eurostat

increasing the efficiency of nuclear power generation. Moreover, national governments are addressing the framework for long-term waste disposal.

As regards the contribution of the nuclear power industry to growth and jobs, the EU has been a technology leader in the field of nuclear power, and the industry is **estimated to provide currently around 400,000 to 500,000 jobs, directly and indirectly.** The European Commission estimates that additional manpower will be necessary in the future, in the case of lifetime extensions or new-build programmes, but also for decommissioning and waste management[4]**.** Further development in the field of nuclear education and professional training[5] to maintain knowledge and competence in nuclear energy is important.

Public acceptance is also a very important aspect to take into account. In addition to arrangements established at the national level, platforms such as the European Nuclear Energy Forum represent an important forum for an open dialogue with civil society on the use of nuclear, socio-economic aspects, safety and security.

In summary, from the perspective of security of supply, competitiveness and greenhouse gas emission reductions, nuclear energy has the potential to make a valuable contribution to the EU power mix for years to come. The **European Commission's 2050 roadmap confirms that and foresees an important continuing role for nuclear power in the EU**.

Business environment for existing nuclear power plant

Nuclear power plants represent very **substantial capital assets with relatively low operating costs[6],** and therefore nuclear operators have a strong economic incentive to keep existing units running.

Nuclear power plants can, in most cases, be operated for a longer period of time than the original period of licensed operation. Licences are usually subject to periodic review (once every 10 years in most Member States) and are not based on the reactor's design. National Safety Regulators determine whether or not extended operation of the plants can be permitted on the basis of safety requirements. While modern reactor designs are created for a lifetime operation of 60 years, earlier reactors were originally designed for an operating lifetime of 40 years. **The majority of EU nuclear power plants were built in the 1970s and 1980s,** which implies that lifetime extension is already under consideration or will be under consideration in many countries in the near future. Large parts of the current fleet have been modernised and they have 20-30 years of operational lifetime ahead of them, but the economic outlook is uncertain. Further investments in nuclear safety are often required to extend the operating licences, and companies are committed to continuously improve nuclear safety. Investments are being made in existing nuclear plants to improve reliability and resilience, maintain high load factors, increase power output, apply new technologies and assure the safe long-term operation of units.

However, the economics of nuclear power generation is not only dependent on the performance of the technology as such. The current regulatory and business environment may well reduce the

[4] European Commission Staff Working Document, "Second Situation Report on Education and Training in the Nuclear Energy Field in the European Union". (https://ec.europa.eu/energy/sites/ener/files/documents/2ndSituationReportonEducationandTraining.pdf).

[5] For example the development of nuclear training centres such as the VGB's Simulator Centre by KSG|GfS in Essen.

[6] E.g. D'haeseleer, W.: Synthesis on the Economics of Nuclear Energy. Study for the European Commission, DG Energy, 2013.

economic attractiveness of long-term operation, which can lead to premature plant closure. Operators may close plants when the investments required continuing their operation become too large, or operation is not profitable for specific reasons. For instance, the combination of low wholesale electricity prices and nuclear specific taxes is leading to early **closures of technically well-functioning plants in Sweden and Germany** as indicated below:

- Apart from the energy tax, which is levied on the consumption of energy, there is an additional tax on electricity in **Sweden**, which is applied to the production of electricity in a nuclear plant. The duty rate applicable is 12,648 SEK (€1,437) per megawatt (MW) of thermal capacity and calendar month. If a reactor has been out of operation for a continuous period of more than 90 days, a deduction of 415 SEK per MW is permitted for the number of calendar days in excess of 90. The tax was increased by 17% as of 1 August 2015. In order to cover the future costs for final storage of spent fuel and the decommissioning of the nuclear power plants, each plant is charged an individual fee. As a weighted average for the Swedish nuclear the fee in 2014 is 2.2 öre/kWh (€0.0024 per kWh). This fee is increased to 4.0 öre/kWh (€0.0044per kWh) from the year 2015 onwards.

- Shareholders of Oskarshamn's plant are **discussing closing down** the 473MW Oskarshamn-1 (O1) reactor between 2017 and 2019 as well as the 638MW Oskarshamn-2 (O2) reactor. Vattenfall has informed its co-owner E.ON that it plans to close down units 1 and 2 of Ringhals (878 and 807 MW) between 2018 and 2020. These plants have been originally scheduled to shut down in 2025.

- A **German nuclear tax** was introduced in 2010 after negotiation between nuclear utilities and the government to increase the lifetime of reactors and was levied as of 1 January 2011. The tax was designed as a consumption tax on newly installed plutonium and uranium fuel rods. Price: €145 per gram of fissile uranium or plutonium fuel until 2016 (about 1.6c/kWh). The tax was maintained in 2011 when Germany decided a nuclear phase-out.

- E.ON SE decided to **shut down** the 1300MW Grafenrheinfeld plant seven months before its operating licence expired as it was not economical to refuel for a short period of running in an unfavourable market climate.

In other countries also, additional nuclear charges are threatening the profitability of nuclear plants. In **Belgium**, a "nuclear contribution" has been charged to nuclear power plants since 2008, increasing from 0,5 c€/kWh to 1,5 c€/kWh in 2014; this has had a severe impact on the profitability of nuclear plants. In **Spain**, as consequence of the Law 15/2012, two new specific nuclear taxes have been added since January 2013, amounting to 0.53 c€/kWh. In addition, nuclear generation is also subject to an ad-valorem general tax on electricity generation, amounting to 0.35 – 0.4 c€/kWh[7]. Overall, Spanish nuclear power plants (NPPs) face a tax burden on operation in the range of 1-1.05 c€/kWh. In addition, there are also a number of specific regional taxes on NPPs. Finally, and as in some other countries, spent nuclear fuel and radioactive waste disposal and decommissioning of nuclear power plants in Spain is financed by NPPs trough a specific levy, amounting to 0.69 c€/kWh in 2014.

[7] The precise figure depends on the electricity market price.

New Investments in Nuclear power

The European Commission's 2050 Roadmap foresees an increasing role for electricity (doubling its share in final energy demand up to 36-39% in 2050) and a continuing role for nuclear power in the EU in three out of five of its decarbonisation scenarios: the two scenarios with the highest share of nuclear power foresee respectively between 15 and 18% of primary energy for nuclear power. These scenarios would require new investments in long-term operation and new build after 2020.

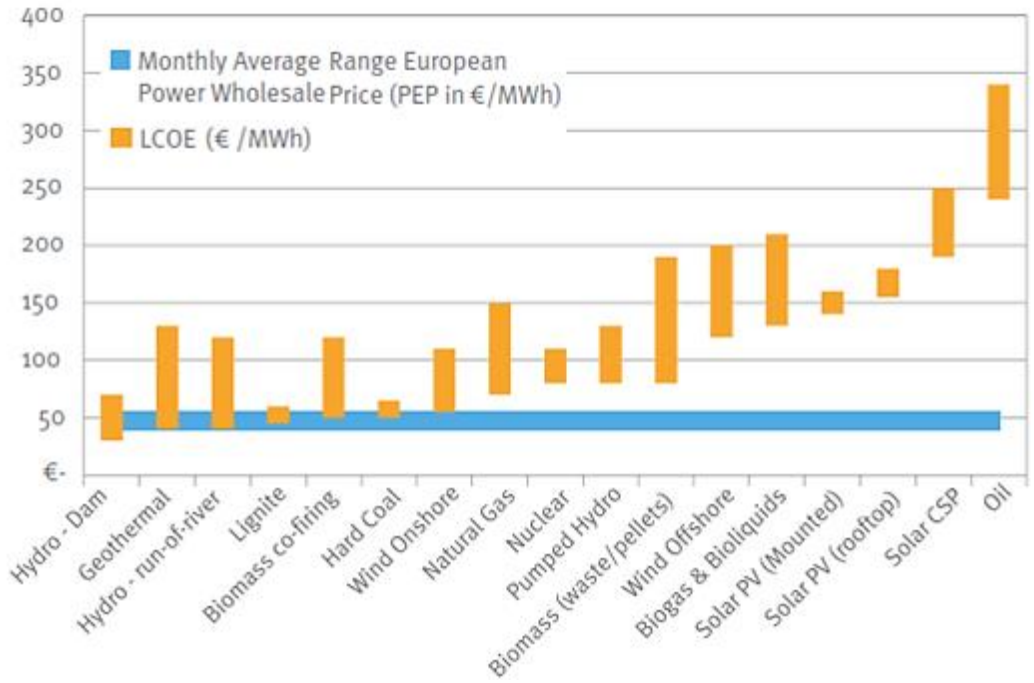
New nuclear plants are currently under construction in France, Finland and Slovakia, and are at the planning stage in the United Kingdom, Hungary and Romania. However, several other European countries wishing to develop nuclear plant on security of supply and decarbonisation grounds have faced delays in launching new projects. Given the depressed level of electricity wholesale prices and the trend to lower load factors, the business case for market-based investment in power generation in Europe is generally very challenging, whatever the technology (see Figure 1 below). In particular, the carbon price does not yet provide an adequate signal for investors to move towards low-carbon technologies. This illustrates the **investment dilemma** currently faced by power companies and the difficulties in meeting Europe's decarbonisation ambitions in the current energy policy and market framework.

The European Commission's recent report on Investment Perspectives[8] recognises this situation. It notes that an **annual investment in generation capacity of some €50bn will be needed for the period up to 2030**. However the report expresses concern that "under current market arrangements and without further integrating existing markets, wholesale market prices may prove too low to trigger the necessary investments in generation capacity. In such a situation generators would require some additional forms of remuneration which would have to be borne by consumers or tax payers."

Figure 1 below indicates that the majority of power generation technologies in Europe have a levelised cost of electricity (LCOE) higher than the current depressed wholesale price. Nuclear generation is one of the generation technologies whose LCOE is the closest to the average range of European wholesale price.

[8] European Commission, "Energy Economic Developments – Investment perspectives in electricity markets", 3 July 2015.

Figure 1: Levelised Cost of Electricity (€/MWh) at realised full load hours in 2013 compared with Average Range of European Electricity Wholesale Price in 2013[9]



Source:

- *Alberici, S. et al. (2014). Subsidies and Costs of EU energy: An Interim Report. (DESNL14583). Utrecht, the Netherlands: Ecofys.*
- *Kost, C. et al. (2013). Levelized Cost of Electricity Renewable Energy Technologies - Study - Edition: November 2013. Freiburg, Germany: Fraunhofer Institute for Solar Energy Systems ISE.*
- *World Energy Council, & Bloomberg New Energy Finance. (2013). World Energy Perspective: Cost of Energy Technologies. London, UK: World Energy Council.*
- *Department of Energy & Climate Change. (2013). Electricity Generation Costs (December 2013). London, UK: Department of Energy & Climate Change.*
- *International Energy Agency. (2014). World Energy Outlook 2014. Paris, France: International Energy Agency.*

According to the recent OECD/IEA/NEA report[10] on the Projected Costs for Generating Electricity nuclear energy is among the most competitive options for generation plants built up to 2020 on a levelised lifetime cost basis. However, in the case of nuclear power, the **risk of specific policy measures** (e.g. taxes in SE, BE, ES and DE as outlined above) and the high level of capital costs must also be considered. The high capital costs are compensated by the long lifetime of nuclear assets, but in an uncertain policy environment and relatively short-term energy markets, they can represent a particular challenge. Market and regulatory uncertainty influences especially large scale, long-term projects. Changes in regulation may cause delays, including budget and time overruns. Regulatory stability for nuclear power is therefore of great importance.

In the light of the above, Europe needs to consider **ways of reducing the investment risks** associated with capital-intensive low-carbon energy projects, including nuclear power plants. A variety of policy

[9] *As these LCOE numbers are based on public studies (which take different realised full load hours (FLH) for all technologies in the different EU countries), EURELECTRIC assumes 'average European' FLH.*
EURELECTRIC acknowledges the drawbacks of LCOE comparisons. While they can provide a reflection of total costs, given high-quality assumptions, the broad set of technologies play such different roles in the power system that they provide equally wide-ranging benefits or value to the energy system and investors.

[10] https://www.iea.org/bookshop/711-Projected_Costs_of_Generating_Electricity

measures could be used to achieve this. Such measures should be market-based and not driven by regulation, thereby ensuring that they become an integral part of a competitive market while also having the benefit of stabilising revenues for generators, thus reducing risks. Long-term contracts between market participants, which include the predicted full cost of the service of energy and capacity, are one of the tools to give sufficient incentives to investors. Long-term contracts allow reducing the risks faced by investors and therefore lower the risk premium (required by the capital market) and the capital costs. This helps to drive down costs for customers.

The European Investment Bank and the European Commission's new **Investment Plan** also has an important role to play in facilitating investment in low carbon capital intensive projects.

Improving cost efficiency of nuclear power plants

EURELECTRIC supports the **Multinational Design Evaluation Programme** (MDEP), with the objective of enhancing multilateral co-operation within the existing regulatory framework, to encourage multinational convergence of codes, standards and safety goals and to implement the MDEP products in order to facilitate the licensing of new reactors. National regulators should retain sovereign authority for all licensing and regulatory decisions, but EURELECTRIC believes that further efforts should be made to harmonise standards, so that ultimately design approvals are valid across the EU.

Efforts in **research and development** should also be stepped up. Key areas include design improvements to reduce costs and improve constructability, as well as innovative technologies for example those relating to Generation IV and small modular reactors. The potential for a more efficient use of nuclear fuel should also be exploited and the disposal of spent nuclear fuel and radioactive wastes should continue to be a priority area.

Research into **innovative nuclear technologies** should be supported at the EU level, building on the strengths of the existing capabilities at the Joint Research Centre and within national organisations, universities and commercial entities.

Nuclear Waste

Through the implementation of the 2011 EU Directive on Radioactive Waste and Spent Fuel Management, EU Member States are developing solutions in nuclear waste, including in R&D. For instance, MYRRHA, a research reactor aiming, among other objectives, at reducing waste, is internationally recognised and was listed by the European Commission in 2010 as one of 50 projects to make Europe the leader in high-tech research in the next 20 years. Locations for deep geological disposal are also being selected in several countries.

Conclusions and Recommendations

Nuclear power plants currently make an important **contribution to the three main objectives of EU energy policy**. A continuing contribution of nuclear power will be needed as Europe undertakes the low-carbon energy transition, but a more positive EU policy framework is needed if this is to be achieved.

Regulatory Framework for Power Generation

- A **stable and predictable regulatory framework** is crucial for the transition towards a low-carbon economy. To maintain investor confidence, governments should avoid retrospective or arbitrary changes to the regulatory regime.
- The **internal electricity market should be completed.** Energy-only markets remain the reference for the completion of the internal electricity market. However, as in many markets the introduction of a capacity element is becoming increasingly important, EURELECTRIC recognises that properly designed capacity markets are an integral part of a future market design. Capacity markets should be technology neutral.
- The legally binding EU wide target of 40% reduction in greenhouse gas emissions by 2030 should remain the centrepiece of the 2030 Climate and Energy Framework. A level playing field must be ensured between different technologies. A **robust EU ETS is key** for triggering investments in low carbon generation.
- Market-based solutions should be found to **reduce the investment risks** associated with capital-intensive low-carbon energy projects.
- European institutions should ensure that the **funds are made available** for low carbon capital intensive projects.

Framework for Nuclear Power

- The average age of nuclear power plants in Europe is around 30 years, and decisions need to be taken on long-term operation, new-build and decommissioning. EURELECTRIC would welcome an **EU wide assessment of the current situation and proposals** at the EU level regarding the role of nuclear power, alongside other power generation technologies within the energy mix, as the European Commission plans to do so in the upcoming PINC document.

- Specific **tax burdens** that distort the economics of long-term operation of nuclear facilities and which distort the wholesale electricity market should be **avoided.**

- In order to improve cost efficiency in the nuclear sector, EURELECTRIC would welcome the continuation of efforts from national regulators to develop **harmonisation and standardisation**.

- Continuous improvement of nuclear safety and security in Europe must be tackled not only through national efforts but also at the European and international levels. EURELECTRIC supports the continuation and enhancement of the current effective **cooperation between nuclear safety regulators and the sharing of best-practice among** nuclear **operators.**

- Post-Fukushima **safety upgrades** should be implemented for existing reactors in a timely manner, with the EU established stress test process helping to ensure this.

- **The independence** of national safety regulators and adequate **competencies and resources** must be ensured.

- **R&D efforts should be stepped** up with a view to promoting improved cost-effectiveness both in nuclear power generation and in waste management.

- **Research into innovative nuclear technologies** should be supported at the EU level, building on the strengths of existing capabilities at the Joint Research Centre and within national organisations, universities and commercial companies.

- Any **barriers to cooperation between EU Member States** (e.g. in the construction of new nuclear power plants[11]) **should be removed.**

- Public authorities, including the European Commission, should **promote a facts-based dialogue** on nuclear power.

[11] For example the Visaginas nuclear power plant project in Lithuania, a joint project of three Baltic States.

EURELECTRIC pursues in all its activities the application of the following sustainable development values:

Economic Development

- Growth, added-value, efficiency

Environmental Leadership

- Commitment, innovation, pro-activeness

Social Responsibility

- Transparency, ethics, accountability

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