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The competitiveness of nuclear

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Defending our industry and our internal market

Claude Fischer
Director of Entretiens Européens

Poverty in the world is a reminder to us that industry and growth are interlinked. No growth without industry, nor qualified jobs! The post-war economy succeeded in marrying energy, innovation and industry, which boosted large-scale development in Western countries. But the industrial innovation back then produced a large amount of CO2, and today human activity and consumption are posing threats to the planet. We have to invent a new kind of growth: develop an industry without C02, clean agriculture, clean transport… Europe wants to make a contribution and has decided to take action on the environment. For energy, it has adopted an ambitious climate package. But by unilaterally focusing on renewables, it has created adverse effects which run counter to the safety and competitiveness objectives it had previously set! The German experience even seems to prove that compensating for the end of nuclear production with renewables is not possible; it simply leads to having to use more fossil fuels! The Commission is currently seeking to adapt the market to produce even more renewables, to the detriment of nuclear, which would only represent 20% of electricity production in 2050 compared to 50% renewables. However, the nuclear industry has managed to create growth and jobs without polluting or emitting greenhouse gases which harm the climate. We know how to manage the risks associated with nuclear and manage the waste it produces, and European directives on safety have made Europe the safest region in the world. Why would we want anything else? Would this mean letting the anti-nuclear ideology win? Those who advocate for this are often the same people preaching about its decline. We have to think 'investment' to invent new development models and not underestimate the problems with jobs and competitiveness. Otherwise we can expect to see greater unemployment and impoverishment.

The competitiveness of nuclear is being questioned. Too expensive? In France, the depreciated Generation 2 could be extended by 10 years, 20 even, with 20% profitability... The challenge is in moving to the 3rd generation. All the studies prove that, in an organised sector, it would be competitive, even when compared to the prices of wind and solar energy which, if we factor in the costs of storage that would be needed to make up for the base reduction, would skyrocket, as explained by Graham Weale in this letter. A European sector would allow for cost-sharing, the creation of a series effect and for European industry to play its rightful role in the world. Several of the world's regions have developed technology to respond to their populations' consumption demands. Africa is also contemplating this and has enormous demographic and industrial challenges to face. It will need Europe in order to grasp fully the technology…

Should Europe become the exception? Stifling its industry? Liberalised nuclear is facing competition from planned nuclear, Xavier Ursat tells us in this issue. What is preventing the European Union from defending its market and its industry? The dogma of liberalisation? But energy, and especially nuclear, is not a commodity like others, it is a public good which has to be defended and regulated! The Commission knows how to find the means when it comes to adapting the market to boost investment in renewables. With the Winter Package, it has proposed price signalling and the modernisation of State aid, but incentives and public guarantees have been refused for nuclear. It needs market reform with long-term contracts but it needs an industrial policy that involves the operators, regulators and regions, allows cooperation as part of internally smart public-private relations, and encourages European and international investment partners alike.

With States having made different energy-mix choices, we have to respect those that want to be able to maintain and develop nuclear. That way the European Union could focus more on its environmental objectives for industry. And during this time of Brexit, it needs to be able to coordinate the internal market's trade and political stance, in keeping with the renewal of European industry.

In summary

Issues of the competitiveness of nuclear energy

Jan Horst Keppler, Jacques Percebois and Graham Weale answer our questions

Is nuclear power essential for a successful energy transition that maintains the basic economic needs and the climate imperative?

Jacques Percebois - One of the main advantages of nuclear is that it emits very little CO2, unlike coal, fuel oil and even gas; this is important considering the priority that must be granted to combating the greenhouse effect. Each French citizen emits on average 4.3 tonnes of CO2 per year (2015 figures), compared to 6.3 in the case of UK citizens and 8.9 for Germans, and this mainly comes from the electricity sector, which emitted 39 million tonnes of CO2 in 2015 compared to 163 in the United Kingdom and 332 in Germany (AIE figures). Nuclear power also allows French domestic consumers to benefit from a kWh price that is significantly lower than the rest of the European Union, especially Germany. Opting for nuclear has enabled France to regain a satisfactory level of energy independence (about 50% of the primary balance sheet). If we remember that France imports all the oil, gas and coal it consumes, nuclear is essential for the energy transition in the world, in Europe and in France, both as a factor in diversifying the energy mix and as a means of combating global warming largely due to the massive use of coal in electricity production.

Graham Weale - A recent report from the Energy Transitions Commission (www.energy-transitions.org) showed that electrification with clean electricity can achieve nearly half of the decarbonisation required in the long-term. Renewable energy is making great progress, with costs falling at a remarkable rate and solutions being found for technical integration problems albeit with the major exception of long-term storage at reasonable costs. In any high electrification scenario, for the last tranche of electricity demand will require either storage of renewables or another form of production. In this respect, nuclear is the only realistic candidate as the prospects for CCS (carbon capture and storage) appear extremely limited. That being said, current nuclear projects in Europe and the US are prohibitively expensive and have a very poor track record in terms of being completed on time and within budget but they could come in line with the costs in Asia. And in the extent that they will be much more acceptable than the alternatives, nuclear energy will be essential for a successful energy transition. The essence of the energy transition is to keep within a limited total carbon budget and independently of previous considerations, all existing nuclear plants ought to be used to produce as much carbon-free power as they can generate safely and economically. Each CO2-free MWh that can be produced from a nuclear reactor instead of fossil fuels is helping to meet that target and reducing the need for future effort.

Jan Horst Keppler - Nuclear is an indispensable part of the solution, but it is not the only one. The outcome depends on the timeframe and on the availability of alternatives. For the time being, nuclear is still the only main source of low-carbon electricity which, unlike hydroelectricity, is not in limited supply. According to publications from the International Energy Agency (IEA) and the OECD Nuclear Energy Agency (NEA), it is also still the most competitive low-carbon technology, both at the plant level and a fortiori at the system level, where it provides round-the-clock electricity in all meteorological conditions. However, and as Graham has just said, recent nuclear projects in OECD countries have been characterised by lengthy delays and budgetary excess, whilst renewable projects, in particular offshore wind and solar PV, are constantly coming down in cost. If the trend persists, the world is unlikely to see countries with a very high share of nuclear power based on newly-built plants. At the same time, it is impossible to achieve total decarbonisation on the basis of variable renewables alone. If we were to design an electricity system from scratch, and hydroelectric resources were limited, a sensible system to look for would be one-third nuclear, one-third renewables (wind and solar PV) and one-third gas. This would ensure substantial CO2 reductions (below 50% of current levels), would be economically sensible and technologically feasible. That said, wherever working nuclear power plants exist, it is obvious that the most economically advantageous and environmentally-friendly solution is to operate them until the end of their technical lives.

In the current calculation method, is nuclear energy competitive with other sources?

Graham - There are two scenarios here – the competitiveness of existing plants on a marginal cost basis against one another and that of new plants on a full cost basis. The current CO2 price of around €5/t is well below the societal cost of emissions, which was estimated by the US Government at €30/t and then by a study from Stanford University at the much higher level of €185/t. If such costs were integrated into fossil fuels then even allowing for decommissioning and storage, existing nuclear power would be competitive with fossil fuels. With respect to new plants even before fully addressing costs of dismantling and storage, nuclear is far too expensive to compete with renewables on a MWh basis, but can become competitive when seasonal storage costs are taken into account.

Jacques - The «cash cost» of nuclear kWh, which currently makes it possible to recover the fixed costs (CAPEX, including the so-called «big refit» costs) and the variable costs (OPEX) of the kWh produced by the working 58 reactors, is of the order of 3.2 to 3.5 euro cents (32 to 35 euros per MWh). We must remember that this figure is lower than the cost of producing all other energies, except hydraulics, and that ARENH, at which EDF sells its nuclear kWh to its competitors, is 4.2 cents. The wholesale price of kWh, on the order of 4 cents on average in the spot market, is largely artificial and does not allow financing for new investments whatever the energy chosen. This low spot price is largely due to the massive injection of non-market financed renewables. The cost of new nuclear power (EPR) is certainly higher (9 to 10 cents), which is higher than the cost of kWh of certain solar or wind farms, but economies of scale are possible. It should be noted that the «long-term average cost» (LCOE) approach does not take into account the «systemic costs» (connection, back-up, storage, balancing) that are low with nuclear power but particularly high with intermittent renewable energy.

Jan Horst - Investments in generation II plants have been economically and financially a very profitable investment but the challenge is to assess investment costs for new plants adequately. The contract-for-difference (CFD) for the Hinkley Point C plant sets the full costs at £92.50 per MWh, which is higher than the costs announced for wind and solar.

The future, however, will bring considerable additional costs to the electricity system as a whole, linked to the flexibility of options and variable demand, of storage, network costs and connection which adds to the final bill for consumers. System costs vary widely depending on the particular situation of a country and the degree of renewable

generation, however at 30% of penetration such costs can add between €20 and €30 per MWh. External costs relating to climate change, air pollution or security of supply are difficult to monetise. Current prices for CO2 emissions of around €6 in the EU and zero in most other areas in the world, however, are nowhere near their marginal damage costs. According to the World Health Organisation (WHO), air pollution, due in part to coal- and biomass-based power generation in non-OECD countries, was responsible for 7 million deaths in 2012.

Is European nuclear power more expensive than in other countries of the world? And why? What is the prospect for the long-term medium for Europe and the world?

Graham - New nuclear plants are demonstrably much more expensive in Europe and the US than in Asia. The reasons for this difference have not yet been adequately documented, but include Europe's lack of experience in building the current generation of reactors. Long-term prospects depend quite simply upon the relative cost developments of nuclear against renewables combined with the storage required to meet the hourly demand pattern over the year.

Jan Horst - Nuclear energy is very capital-intensive, requires long timeframes as well as

a stable and well-functioning institutional framework. As electricity systems in Europe and the United States are becoming more market-oriented this does not facilitate the deployment of nuclear energy. In principle it is still possible to overcome these barriers by providing appropriate guarantees on the level of long-term electricity prices. However, the suppliers of Generation III power plants have yet to show that they are capable of having a genuinely new design supply power to the grid. Other than a small number of BWRs in Japan, which indeed have been built on time and to budget, no Gen III plants have yet been completed in Asia, although there is hope that this will change during the coming year.

Mainly for this reason, the outlook for nuclear as part of the global energy mix is probably stable for the next ten years. After this it depends on the capacity of the new generation of reactors to overcome the current technical and financing challenges. Most scenarios predict a sizeable increase of nuclear energy in order to achieve ambitious climate objectives. However, industry and investors will need to deliver in a market environment, in particular in Europe and the United States.

Jacques - Nuclear technology is not rigid and, beside the EPR programme, there are «new EPR» projects, promising prospects for smaller, less expensive and more reliable reactors (SMR for Small Modular Reactors) and for 4th generation reactors (breeder reactors). It should be noted that the flexibility of nuclear power, which can be controlled by electricity, makes it possible to properly integrate the injection of intermittent electricity generated by wind and photovoltaics until it reaches a certain threshold (30% of electricity production). The world's installed nuclear capacity is expected to increase (especially in Asia), although the share of nuclear power in electricity production is not expected to increase in the near future. One thing is certain: shutting down reactors that work and have been largely depreciated means destroying economic value.

Interview realized by Claude Fischer-Herzog

Debate at ASCPE: the Winter Package and the future of nuclear

On 11 May 2017 at FORATOM, ASCPE welcomed **Massimo Garribba**, Director of Nuclear Energy, Safety and ITER at the European Commission's DG Energy, **Augustijn Van Haasteren**, head of policy at the "Internal Energy Market" directorate, and **Jan Keppler**, chief economist at the OECD, professor at Paris Dauphine University[1]. The meeting, chaired by **Claude Fischer**, took place against the new backdrop of Europe with Brexit, and especially the shifting balance between countries that are pro- and anti-nuclear and the "Winter Package" (Clean Energy for all Europeans) from the European Commission.

Massimo Garribba and **Augustijn Van Haasteren**, stressed the different areas of the electricity market that would be affected by the new package: capacity mechanisms, long-term investment financing… Will these open up new possibilities for nuclear's future? Some of them of course will remain in the mix with the extension of power plants and the building of new capacities, but the reference scenario, published in July 2016, evaluates the share of nuclear in electricity production at 18% in 2030 (20% according to the PINC[2]). How can we retain our industrial capability? For the Commission, operators and regulators need to agree on moving towards standardising methods, and standardisation of the intermediate stages, which have an impact on safety and competitiveness. Does the same apply for the market? The Commission is proposing to adapt its aims to come in line with the 50% RNE by 2050 objective, improving flexibility and energy distribution, whilst offering better pricing signals to attract long-term investments, re-establishing prices with remuneration mechanisms where needed (for cross-border issues, for example). At the same time, the Commission is proposing to improve the framework for multiplying short-term contracts thanks to better consumer information, greater efficiency and more protection for avoiding black-outs and decreasing speculation.

Jan Keppler raised the question of deciding on RNEs whilst having unclear objectives: "what has been done for renewables has not been technologically neutral or independent from the objective of reducing CO2". In other words, the Commission is doing nothing for nuclear whereas the industry is dying a slow death, because of the insistence on an institutional framework (short-term markets, marginal cost pricing) that is incompatible with low carbon technologies. He presented his study on the real costs of nuclear compared to those of other sources and its competitiveness compared to that of other regions in the world[3].

He underlined that with system costs and a

context of very low prices on the electricity market (30€/MWh), there was no incentive to undertake new construction projects. The challenge for the nuclear industry is to move from Generation 2 to G3. Nuclear would remain competitive the moment it entered a liberalised wholesale market. He also proposed long-term contracts for available baseload capacities and re-examining support mechanisms for renewables which would offer incentives for production even when electricity is not needed. A high carbon tax would be an optimal solution and cause less distortion. Finally, he proposed developing flexible resources to allow nuclear and renewables to coexist.

[1] The meeting saw attendance from around forty participants: the meeting minutes can be found on the website www.entretiens-europeens.org

[2] The final PINC was published on 12 May 2017. The in-depth analysis remains the same as that of April 2016.

[3] Cf. Nuclear in low carbon power market. Challenges, incentives, system costs. Pr Jan Horst Keppler. Also see the seminar on the Winter Package with Khristina Yankovitch: http://www.ceem-dauphine.org/agenda/en/59c4077a0a13a0a6d8ba8ea83850190a3f15ce1d

Re-launching the ambition 60 years after the EURATOM Treaty

When the fathers of the European project drafted, sixty years ago, the ECSC Treaty, the Euratom Treaty and the Treaty of Rome, it would mark the central role that energy would play in our modern societies and in States' policy-making.

They founded a European policy for the development of nuclear energy. As the daughter of modern physics, taking advantage of the most powerful forces of nature and the forces inside the nucleus of atoms, the prospects it offered were unrivalled in their effectiveness.

These prospects have since become a reality and we cannot over-emphasize the industrial and economic success of the European nuclear park over the course of several decades.

Europe's nuclear park is a strategic asset; it supports the three pillars of energy policy: competitiveness, the environment and security of supply.

Competitiveness: Nuclear energy derives its economic potential from an unrivalled density of power. After the initial investment, its variable costs are low and predictable. The competitiveness and predictability of energy costs are among the structural factors that determine industrial investment decisions and economic development. The share of imported uranium in the cost of kWh is also very low (a few%) and that of the very high national value added. This greatly assists the trade balance, industrial development and employment. The nuclear industry is thus a source of highly skilled employment, economic development and technological leadership.

Environment: the running of nuclear power plants does not emit CO2 which makes for better air quality. The life cycle of power plants and fuel is extremely low in carbon: nuclear power is a major component of the policy of preventing global warming. It also takes up very little space on our landscapes. A high level of safety is an indisputable prerequisite for its use: Europe possesses the skills, experience, requirements, culture and controls to ensure its long-term viability. The Euratom Treaty helped to build a particularly successful European regulatory framework in this field.

Security of supply: In a world of increasing geopolitical tension and rising instability, where the risks of energy crises are multiplying, energy independence is a factor of stability and peace. Nuclear power is particularly important. Renewable energies are part of this, with nuclear power guaranteeing the indispensable continuity of service, at all times, in any weather.

The ambition expressed by the signing of the Euratom Treaty sixty years ago certainly deserves to be recognised and renewed, because the deep fundamentals that have governed the development of nuclear energy are still relevant, now more than ever.

In order to prepare for the future, in Europe we must focus our energy efforts on security and supply continuity, on how to achieve the Paris climate objectives, electricity markets as well as on the competitiveness of new projects (after the design series).

Markets are now failing and it is crucial to reform them (market design), with regard to the objectives of energy policy and economic, climatic and geopolitical issues, from the perspective of investment and the long-term.

The ultimate goal is to build the framework that supports the operation of existing reactors over time, foster European technological excellence and support investment, new projects and, in due course, the renewal of nuclear power plants.

Bertrand de L'Epinois
President of Foratom

FORATOM
THE VOICE OF THE EUROPEAN NUCLEAR INDUSTRY

Market power issues (market design)

Essentially based on short-term marginal costs, markets do not currently pay or allow for long-term investments.

However, carbon-free production methods require much more substantial investments than fossil-based production methods. Market mechanisms now favour the latter, contrary to the objectives of the Paris Agreement. It is therefore a question of building a market that supports the objective of decarbonising the electricity system.

On the other hand, if the current situation persists, the risks of black-outs or excessive dependence on energy will increase in the medium term. Defining mechanisms, integrating investment costs, system costs and externalities into market prices and ensuring that investors have the necessary visibility is a priority. And all the more so because a significant development of renewable energies presupposes that the market will, because of the variable nature of their production, structurally overcapacity, regardless of the chosen energy mix.

Nuclear power as a factor in security of supply

Nuclear energy consumes very little fuel: 7 g of uranium (a fuel pellet) produces as much energy as 1 t of coal, 3 barrels of oil or 500 m3 of gas. It is thus easy to store the uranium required for several years of consumption (3 years today on average in Europe). The very small share of imported uranium in the cost of production also means that a significant increase in the price of uranium would only result in a small increase in the cost of kWh (let us remember on the other hand the effect of oil shocks on our economy), while significantly increasing mining reserves and sources of supply. Finally, European expertise in the fuel cycle and the prospects of 4th generation reactors are likely to increase our independence in fissile material resources.

[1] the investment represents about 2/3 of the cost of nuclear power (depending on the discount rate)

[2] about 10g/kWh, equivalent to renewable energy emissions, compared to 800 g/kWh emitted from coal-based electrical production and about 500g/kWh emitted by the power stations to gas

Extending the life span of nuclear power plants: profitable for all

EDF has estimated the cost of France's "Grand Carénage" programme of investments over the period 2014-2025, aimed at maintaining and renewing the French nuclear park, increasing the safety of nuclear reactors and extending their life span beyond 40 years, at some 48 billion euros (in current currency). Between 2014-2025, the programme represents on average an investment of 4 billion€/year compared to ongoing investment that is estimated at under 3 billion € for a park such as ours. Factoring this in results in a cash production cost which currently stands at 32€/MWh. We are currently on this plateau of approximately 4 billion euros per year and, progressively, as of 2025 we will observe a slight dip which will reach 30€/MWh.

This cost could be approximated with the production cost of nuclear plants in the United States, estimated by Bloomberg in June 2017 at 35 dollars per MWh. This is the only relevant data to compare with selling costs when it comes to assessing the profitability of extending the life of nuclear plants. Furthermore, the long-term expenditure (dismantling and waste management) is already fully covered at over 100% by dedicated assets which will make it possible to cover the resulting expenditure.

The "cash" production cost of the French nuclear park which comes to 32 €/MWh when taking "Grand Carénage" into account, and progressively drops to under 30 €/MWh following peaks in activity and spending on the programme, is also the one to which we must compare the cost of developing other alternative production means.

This makes it clear that extending the life span of the existing French nuclear park is the most competitive solution all-round. There are no new methods of production with lower cash costs than existing nuclear, even when factoring in all of the investments needed under "Grand Carénage".

A plentiful low-carbon source

When moving towards a low-carbon future, France is starting from a remarkable position, compared with its larger neighbours. In 2015, the French EDF park emitted 17 gCO2/KWh, in other words almost 20 times less than the European average of approximately 300g; one of the biggest emitters being Germany with 505g CO2/KWh. To recall, the Germany/EDF ratio was 11 in 2010 (with the French park emitting 11 times fewer grams of Co^2/Kwh in 2010; this ratio was 30 in 2015). A quick comparison shows an increase in emission rates of grams of CO^2/Kwh, in Germany, between 2010 and 2014, from 449 to 502 grams of CO^2/KWh. This represents an increase of just over 10%.

At the same time, EDF stopped using its 250 MW coal-fired thermal power stations and improved the use of its nuclear park instead. This resulted in a decrease in emissions of CO^2 grams per KW/h, in actual fact falling from 40 to 17. Furthermore, it should be noted that German private customers pay between 80% and 100% more for their electricity than their French counterparts, the difference in price being mainly attributable to subsidised renewable energy.

Finally, nuclear and renewables are complementary: taking into account their fluctuations, renewable energy sources, wind and photovoltaic, need to resort to other basic production methods. Together with hydraulic, nuclear is the only production method that can meet the availability requirements, and it is decarbonised too.

This fits right into the decarbonisation objectives set during the COP21.

Dominique Minière

Director of the Nuclear and Thermal Power Stations, EDF

A nuclear market facing competition from planned and serial nuclear

A product's competitiveness is often measured by the life cycle of the product and the market on which it is sold. In the nuclear sector, the costs of developing the Generation 2 technology (GEN2) are presented as being lower than those of Generation 3 (GEN3), a comparison which seems starker in Europe than in the rest of the world. This gap can be partially explained by the three phases of electricity markets in Europe:

- The development phase of nuclear driven by increasing demand for electricity, against a backdrop of tensions on oil prices, with dynamics underpinned by the construction of standardised reactors, resulting from national policies procuring sufficient price visibility.
- The phase of balance between supply and demand in electricity, in a context of low fossil fuel prices, with the introduction of subsidies to promote the development of small series of renewable energy sources. Optimising nuclear parks combined with robust market prices allowed electricians to make a profit which was then partially reinvested in renewable production.
- The phase of over-capacity in means of producing electricity triggering the collapse in wholesale prices, stripping electricians of their own investment capabilities. Only the UK, limited in terms of electric interconnection and having put in place a guaranteed price mechanism, had the means to add to their nuclear capacity, adding to the GEN 3 units launched by two European electricians during the balance phase.

A lack of energy policy is harming Europe

We must also remember that Europe, in addition to having wholesale markets which only give reliable price signals after three years at best, is hampered by the lack of a common energy policy and imposes restrictive policies upon its member countries on their respective borders, effectively reducing the effects and opportunities of scale for nuclear. This trajectory shows the difficulty in putting in place the right instruments to respond to the objectives of an energy policy, of finding the balance between subsidies and the series effect.

In comparison, other regions which have put in place robust nuclear programmes such as Korea, China and Russia have been able to make an industrial transition between their GEN2 and their GEN3, preserving the series effect and limiting the increase in costs to changes in design to cope with the more pressing needs. Furthermore, these countries put in place the associated planning and financing according to a national scheme close to phase 1 of nuclear development in Europe.

Costs shouldered by industry

As is the case for major infrastructure projects, what are the costs attached to nuclear projects? Here too, the distribution pattern differs depending on the vision of accounting in question. In Europe, with countries being rather indebted, so as to have a good local footing, the project has to create value for all and this means investing in industry, education, logistics, etc. In other countries seeing growth, the expenditure that is deemed vital for economic development is still supported by the States and/or regions, freeing up industry from financing, which may appear almost like a type of subsidy. Offset principles may also be implemented. In reality, the costs of a nuclear project may face very different realities in the total or partial distribution of costs associated with several factors: predevelopment, more or less existing infrastructure; financing, periodically accrued interest, guarantees; R&D; how the project is organised according to fixed objectives; levels of provisions to be allocated; distribution of contracts between the construction phases and the operational phases.

Let us bear in mind, however, that a nuclear project has a long time span. Because of this, the French regions were able to withstand a wave of deindustrialisation, thanks to the plants they have, in which EDF has constantly optimised reactors so as to make them as profitable as possible and so that all the lessons from building Flamanville 3 have been learned, equipping the nuclear sector with tools for competitiveness. Drawing economic comparisons between energy systems remains an extremely complex exercise in terms of the project's externalities, its methods of financing and the market dynamics which can influence the scenario that is ultimately chosen. This applies to nuclear but also to renewables.

Xavier Ursat

Director of New Nuclear Projects and Engineering, EDF

Can solar photovoltaic become competitive?

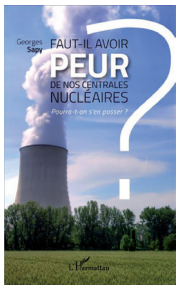
Light energy received locally on earth depends on three main factors: the latitude of the location, the season and the cloudiness of the sky (rain, dense cloud cover or thick fog can reduce light energy to practically zero, and it is the most important factor in running photovoltaic panels). The combination of these three factors determines what is known as the charge factor (time equivalent to running on full power) of a PV installation, which influences how much electricity it can produce each year. This makes it a major parameter in competitiveness, the other determining parameter being the cost of investment per kW installed.

This means that the location of a PV installation on the planet plays a crucial role in its competitiveness. The differences are substantial between an installation situated in the enlarged zone of the tropics and another in a moderate zone. The zone of intertropical latitudes (from ± 23° extended to ± 30 to 35°) has two major plus points: maximum light energy received outside of cloudy periods and only a small gap between day-night all year round (lack of distinct seasons). This small gap results in PV production which fluctuates only slightly all year round, which contributes to a high charge factor and makes it competitive, and also stores enough energy throughout the day to produce affordable electricity at night. By way of example, a PV installation recently installed on the ground in Chile, located at altitude in the Atacama Desert, at the latitude of the Tropic of Capricorn and under a sky with very little cloud cover (ideal conditions), reaches an average charge factor of 2,730 hours per year.

The conditions in the temperate zone, for example, in Europe on the 50th parallel, the same latitude as Paris, are much less favourable: the annual average of light energy is twice as low there, and twice as low again in winter than in summer. If we add a daily duration that is twice as low in winter than it is in summer, the combination of these two effects leads to production that is 4 times lower in winter than in summer and a charge factor in the range of 950 hours per year, i.e. three times lower than in the tropics. All things being equal, this makes PV production there three times more expensive.

These inherent characteristics of temperate Europe have another major drawback: PV production there is constantly at odds with its needs: it is minimal in winter when consumption is higher, and at a maximum in summer when consumption is lowest (which then creates unnecessary surpluses which destabilise the networks and markets). Furthermore, the intermittent nature of PV production throughout the year means having to have additional/emergency ("back-up") means available to make up for the shortages. These means come at a high cost, which is then added to the already-high cost of PV production.

To sum up, the competitiveness of PV production which is already intrinsically low in our middle latitudes, is even lower when the costs of compensating for its intermittent nature are taken into account. It is logical therefore to use this form of production exclusively for regions towards the South of Europe (South of France at a push, Spain, Portugal, Italy, Greece) but appears aberrant in higher latitudes (for example, the average charge factor in Germany does not exceed approximately 870 hours…). This means the costs have to be very high, much higher than new nuclear…



Georges Sapy

Engineer, member of "Sauvons Le Climat"

Author of «Should we be afraid of our nuclear Power Plants?»

The Efficiency-N Scenario

Nuclear energy and carbon capture and storage through biomass: a solution for limiting the increase in average surface temperature to 1.5 °C

A study realized by:

Berger, A., Blees, T., Bréon, F-M., Brook, B.W., Deffrennes, M, Durand, B., Hansen, P., Huffer.E., Grover, R.B., Guet, C., Liu, W., Livet, F., Nifenecker, H., Petit, M., Pierre, G., Prévot, H., Richet, S., Safa, H., Salvatores, M., Schneeberger, M. and Zhou, S. (2017)

Collaboration from GISOC (Global Initiative to Save Our Climate)

Following COP21, the stakeholders (countries signing the final declaration) asked the GIEC to study the possibility of limiting the increase of the surface temperature compared to the pre-industrial era to 1.5 rather than 2 degrees. In association with the international cooperation "Global Initiative for Saving Our Climate (GISOC)" which it created, the association "Sauvons Le Climat" (SLC) proposed a scenario enabling this limit to be respected. To that end, the accumulation of anthropogenic CO2 emissions does not exceed 600 Gt until 2100.

This result was possible by completely replacing fossil fuels with a mix of approximately equal shares of nuclear and renewables as of 2060. CO2 neutrality is reached in 2060. After 2060 it is possible to continue the growth of nuclear production to the extent that it is essentially produced by breeder reactors.

The alternative scenarios put to the GIEC require mass-scale use of CSC (CO2 capture and storage). The MESSAGE Efficiency scenario by the IIASA which is the most energy-efficient and involves a shift away from nuclear, contemplates storage of 1300 Gt of CO2 in 2100, whilst limiting the increase in energy consumption to 40% between now and 2100. In the case of our Efficiency-N scenario, the quantity of CO2 stored (thanks to biomass) is limited to 275 Gt and energy consumption may increase by 150% at the end of the century. Nuclear power would reach 20000 GWe, essentially in the form of fast breeder reactors. The possibility of seeing such developments in nuclear power have been demonstrated in a previous article (Int. J. Global Energy Issues, Vol. 40, Nos. 1/2, pp.43–78).

Sauvons Le Climat

Nuclear : the foundation of a decarbonised economy
Nuclear strategy in Finland

The role of the private sector is decisive

Finland does not per se have an official nuclear strategy; all of the currently operating plants as well as new build projects are private investments and done without political subsidies. At the same time, nuclear plays a decisive role in Finlands power system; currently, about 25% of consumed electricity is generated with the 4 operating units. Built in late 70s and early 80s, there are two 500MW VVER-440 plants as well as two 880MW BWRs in Finland. These will be supplemented by two new build projects, OL3 (1600MW EPR) and Fennovoima plant (1200MW VVER). In short, the initiative to build new units always comes from within the industry; the government merely reacts to it but does not proactively plan to build units. As expected, the government's new climate and energy strategy did not focus on nuclear. According to the ministry, this is because there are already two projects going ahead as previously planned, and no further governmental actions are needed to secure the use of nuclear power in the future since it's clear that Finland will continue to have nuclear in the electricity mix with an estimated 40-45% share by 2030.

A positive law for industry

Furthermore, the renewal of the Nuclear Energy Act is being processed by the ministry of employment and economy. Next phase will be a parliamentary review after the revealing of the suggestion for the new act in late August. There are likely to be some changes to the current situation, especially a new licence for decommissioning a nuclear power plant, but in general the renewal is not revolutionary. Moreover, the ministry has taken into account many of the industry's concerns and the new act is generally seen as positive by the industry.

A competitiveness challenge for the sector

Traditionally, nuclear power has been competitive in Finland as well as in the Nordic market, because the plants have been constructed some time ago and the operating costs as usual for nuclear, are not very high. In recent years, the situation has changed and the nuclear sector faces a challenge in competitiveness. There are numerous reasons for the development, as both the wholesale prices of electricity have come down as well as the costs risen. A brief summary of both:

Electricity prices - The whole market in Europe is facing difficulties due to increased supply of electricity that has near-zero marginal cost. In the Nordic market, this is due especially due to increased supply of wind power; however, this is only half the truth. During the past 10 years, roughly 18 terawatt hours of demand has vanished from the market due to industrial restructuring in Finland and Sweden. These changes in supply and demand, together with very low ETS prices, has led to a situation where almost no new investments are made in the power sector without subsidies. The market has recovered slightly but the competitiveness challenge remains.

Costs - There have been numerous increases in the costs and taxes laid for the nuclear power industry in Finland at the same time with the challenging market situation. Aside rising taxes, the main problem is the cost of licencing and approving components to be used in nuclear power plants. The lack of standardisation as well as the tailor made nature of the industry has created a situation where a few bolts can cost as much as a new car.

What needs to be done

The power sector should have a healthy, subsidy-free structure and a price level in which the ETS system would work as the sole driver for investments in emissions-free production. This would be both the most economical as well as the fastest way of achieving substantial reductions in carbon emissions of the whole power sector. Aside from the market side, the industry need to work together with the regulator, ministries as well as the supply chain to achieve a more reasonable cost level. Technically there shouldn't be a problem; the similarly safety first -aviation sector was able to standardise and harmonise itself, why shouldn't the nuclear sector be able to do the same? The main challenge is not technical but political. There are already some good signs; the European Commission is aware of the problem and the need for standardisation, and the Finnish regulator has already started to use a graded approach -method in reviewing of the different supply chains. However, a lot remains to be done on the EU level with different stakeholders.

Tuomo Huttunen
Nuclear Senior Advisor, Finnish Energy

News on nuclear facilities in Finland

Olkiluoto 3 EPR project achieved yet another milestone: commencing cold testing of the primary circuit, consisting of tens of tests at different pressure levels, as well as engaging the main circulation pumps.

Further tests are expected, including hot testing in the fall of 2017, as well as the delivery of nuclear fuel to the site, which is to be loaded in spring 2018 after the Operation Licence has been granted. TVO has informed the Nordic electricity markets that according to the plant supplier´s test program the OL3 EPR plant unit will produce between 2 and 4 TWh of electricity during the second half of 2018. The project is proceeding towards the scheduled start of the regular electricity production at the end of 2018.

Hanhikivi 1 is in the infrastructure-building & licencing phase. The delivery of technical documentation to the regulator continues but there have been some delays from the plant supplier and hence Fennovoima announced in September that they expect to be granted the construction licence in 2019 instead of 2018, followed by first concrete. The plant should be operational in the end of 2024.

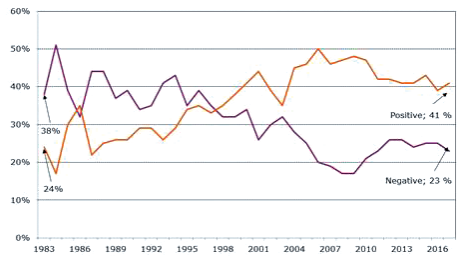
Loviisa NPP (2x VVER 440) were upgraded from 496MW to 503 and 502MW, making the total output more than 1000 megawatts for the first time. The units have operation licences until 2027 and 2030, there have been no announcements of applying for a lifetime extension or for a new power plant.

POSIVA: The Radiation and Nuclear Safety Authority in Finland (STUK) issued a decision on November 25, 2016 that Posiva can start the construction works of the final disposal facility in Olkiluoto. Posiva has now started the first licensed work phases as referred to in the construction licence granted in November 2015.

Public opinion toward nuclear power

The latest results from a poll held late March 2017 show promising signs of an increase in the number of people supporting nuclear, and a decrease in the number against it.

Development of the acceptance of nuclear power 1983 - 2017
1983-2004 Gallup omnibus, 2006- telephone interview



ENGIE : its role in the energy transition with nuclear power

As a low-carbon electricity source, nuclear power is an indispensable contributor to the energy transition and COP21 objectives. The most straightforward and economical way of maximising this contribution is to operate the existing power stations as long as they can be operated safely in order to minimise total CO_2 emissions.

A nuclear expertise of more than 50 years

ENGIE is one of the few European groups having more than 50 years of nuclear-related expertise all along the nuclear value chain. ENGIE is a major European nuclear operator with 7 PWR units in Belgium, with a total capacity of 5800 MW. As of today, ENGIE has clear visibility for continued operations until 2025 and is ready to continue operating its fleet beyond that date in compliance with the highest safety standards if the technical, economical and legal conditions permit.

In addition to its extensive operating experience, numerous entities of the ENGIE Group are strategically positioned in nuclear engineering and design, construction, fuel management, maintenance, radwaste management and decommissioning & dismantling services. There is considerable potential for growth of these services in the coming decades as the nuclear fleets are aging, numerous plants undergo lifetime extensions prior to progressive shutdown and decommissioning.

Considerable potential for growth exists also in nuclear new build. There are around 60 new reactors under construction and some 150 projects under different stages of development in the world. Twelve out of 15 of the world's largest economies made the choice of nuclear power in their current and future energy mix (the 3 exceptions being Germany, Australia and Italy) and numerous smaller countries, both developed and emerging, made policy decisions in favour of nuclear power.

A sector facing its competitiveness

However, new nuclear power is increasingly facing a competitiveness problem due to a combination of factors, including cost overruns of the latest generation of reactors, stringent safety regulations, dysfunctional electricity markets and the absence of meaningful carbon pricing. In such context it is unlikely that nuclear new build will occur in countries and markets that cannot offer long term stability of electricity prices and adequate guarantees to investors. The reality is that most of the new reactors are built by vertically integrated state-backed companies and in countries offering the necessary regulatory framework. Countries with limited access to gas and to renewable resources will be more likely to establish pro-nuclear policies. The numerous innovative designs currently under development, inherently safe and smaller reactors may be another enabler of new nuclear construction in the medium term, offering lower costs, shorter construction times and increased flexibility to act as a convenient low-carbon complement to intermittent renewables.

Promising technological advances

The current context makes the case for private investment in new nuclear extremely challenging. Despite this, ENGIE remains committed to the development of the nuclear industry and capitalises on its experience in nuclear project development and in nuclear operation to act as a provider of services related to nuclear projects worldwide, working with developers, vendors, state-owned or private utilities, regulators or governments, and complementing the broad range of engineering, installation, operation and maintenance services it offers.

Nuclear Power Plants in Tihange in Belgium ENFIE - ELECTRABEL

Forward multi-stakeholders cooperation and partnerships

The nuclear industry needs close international cooperation of all actors – operators, investors, regulators, equipment manufacturers and service providers in order to maintain their high level of excellence in support of the safety of the installations. ENGIE develops partnerships with large companies that have nuclear technologies as part of their core business, that have ambitious programs in developing new technologies for the energy transition and with whom ENGIE and its affiliates (Tractebel, Endel, INEO, Axima, Cofely, etc.) have multiple complementarities of expertise and skills.

Develop a long-term investment framework

The numerous countries which recognize the global contribution of nuclear as a secure, reliable, dispatchable source of carbon-free electricity need to develop an adequate investment and market framework. On its side the nuclear industry needs to tackle the challenge of competitiveness without any compromise on safety. These are the conditions to allow the nuclear energy which has demonstrated its ability to reduce CO2 emissions quickly and efficiently to play its role in the energy transition.

Jan Bartak
Director Nuclear Development, ENGIE

ENGIE

The German model: costly for both Germany and Europe

Only a few months after having agreed to extend the lifespan of nuclear power plants from 8 to 10 years, Angela Merkel made the decision in March 2011 to close 8 of them immediately and the other 9 in 2022. She was forced to reopen the coal and lignite mines to compensate for the loss of nuclear production: from 17.8%, this fell to 13% in 2016, compared with 29% for renewables… 27% for coal!

According to the economics institute of the University of Düsseldorf, this decision has already cost her 150 billion euros and could run to 370 billion by 2025. Companies have posted record losses of 16 billion for E.ON, 5.7 billion for RWE, and they will have to put up a fund specifically dedicated to managing nuclear waste consisting of 24 billion. The Karlsruhe Court agreed to compensation proceedings and sentenced the State to pay back 7 billion in compensation from the special tax in 2010 in exchange for extending the plants' lifespans. An additional cost for taxpayers who are paying excessive prices for electricity, and which 6.9 million of them can no longer afford.

Will this decision be an opportunity for the German economy? Nothing could be less sure: the public subsidies required to encourage investors, the problems of compatibility with high-tension lines, the costs of storing the electricity needed to compensate for the intermittent nature of renewables and the threat of 100,000 job losses in coal are all slowing down the ecological transition. Germany is seeking to impose its model upon Europe which would allow it to make its markets more flexible thanks to European interconnections and cross-border use of capacities. It is uncertain that this model would harbour advantages for Europeans who would like to be able to decide on their own energy mix and in certain cases maintain their nuclear production. ***C.F***

Russia - Europe: an essential cooperation

A difficult year for the nuclear industry

Uncertainties around the bankruptcy of Westinghouse and plans to cut back nuclear in France and South Korea led many to argue the sector has run out of steam. Tumbling prices for solar and wind energy and delays and cost overruns in new build nuclear projects reinforced the nonsense claim for the viability of 100% renewables.

A serious comparison of the Levelized Cost of Electricity (LCOE[1]) from different types of plant paints a very different picture.

For nuclear LCOE, assumptions about cost of capital are crucial[2]. Nuclear plants are infrastructure, comparable with power grid, railways or airports, with regulated cost of capital typically below 4%. Yet, recent studies assuming a cost of capital to be as high as 10-12% overestimate the cost of nuclear by 25-30%.

In addition, the system and balancing costs associated with smoothing the intermittency of renewables could cost as much as the generation itself. Backing renewables with gas comes at an even higher price[3]. On top of that, it exposes the market to volatility of gas prices as the share of fuel cost in gas power generation is about 70% compared to that of uranium which represents 10% in the production of nuclear energy, a benefit that could be worth as much as US$ 25/MWh.

When hidden costs are taken into account, including carbon price, nuclear is the best value for money.

The misunderstanding on costs has led to some governments backing away from nuclear, markets shrinking and nuclear vendors losing capability. In many countries the supply chain could not benefit from an economy of scale. Risks, delays and cost over-runs became inevitable.

A different approach

Russia developed an efficient, manageable nuclear supply chain when it created Rosatom, a vertically integrated corporation in charge of design, build and operation of nuclear power stations, uranium mining, conversion and enrichment, the supply of nuclear fuel and backend decommissioning.

It then embarked on a US$40-billion national new build program to make nuclear the backbone of its electricity infrastructure. Boosting domestic demand, it helped reduce supply chain risks and accelerated learning.

Ten years on, Rosatom's VVER-1000/1200 series is the only generation III pressurized water design which is "tried and tested" with reference units in India, China, Iran and Russia. In 2016, VVER-1200 was the first generation III+ nuclear reactor in the world to be completed. By the end of the year the second VVER-1200 is expected to go on-line marking the start of a series. With over 40 power units to be completed by 2030 in 14 countries, this economy of scale enables us to reduce construction costs by over 30%.

Opportunities for Europe

This pipeline also creates enormous opportunity for international cooperation, with Europe being a strategic partner for Rosatom. We have a joint fuel fabrication plant with Areva NP which supplies 11 nuclear plants in Europe, we use the Arabelle turbine for VVERs; EDF, Rolls-Royce and Schneider Electric take part in VVER new build and LTO projects. We are developing a state of the art Multi-D PLM construction management solution with Dassault System. The share of European high-tech vendors in each Rosatom power unit is already around €1 billion.

Each VVER reactor avoids up to 9 million tonnes of CO2 per annum. It creates thousands of jobs, boosts economic growth in the countries of our suppliers as well as the countries where projects are located.

Andrey Rozhdestvin
CEO of Rosatom Western Europe Sarl, France

ROSATOM

[1] The «LCOE» for a given energy production facility is the sum of the discounted energy production costs divided by the amount of energy produced, which is also discounted.

[2] For nuclear LCOE, assumptions about cost of capital are crucial. A recent study by IEA and NEA OECD found that for plants scheduled to be commissioned in 2020, assuming cost of capital at 3% and carbon at US$30/tonne, nuclear is the lowest cost for all countries, with a median of US$50-55 /MWh, lower than coal (US$70-75 /MWh) and onshore wind (US$65-70 /MWh). But this changes dramatically when cost of capital is increased. At 7%, price per MWh for nuclear, leaps to over US$80 and at 10% it soars to US$110, becoming the most expensive baseload source.

[3] According to Lazard, the low capacity factor for back up gas generation means it would cost US$165-217 /MWh assuming a gas price of US3.45$/MMBtu.

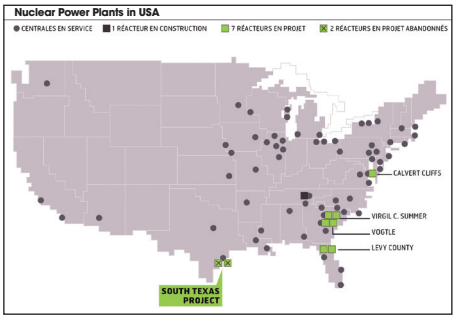
Brexatom: into bilateral renegotiations.

With the United Kingdom's departure from Euratom, the nuclear States are losing a powerful ally in the face of Germany which is pushing for all Euratom funds to be directed into decommissioning programmes rather than production and research. Should it renounce the cooperation mechanisms created by Euratom for research, safety and radioprotection? We may well ponder the future of the partnership concerning the merger with the JET (Joint European Torus), the laboratory located close to Oxford which Euratom finances to the tune of 50%, or that of the construction of Iter at Cadaraches with a budget of 18 billion euros.

Naturally, as with Brexit, the negotiations will involve the Member States of Euratom, because the decision to leave the treaty does not mean the United Kingdom turning its back on nuclear energy and there may well be bilateral agreements to be signed. Foratom even pleaded at the beginning of April for the UK to benefit from the Euratom provisions if new agreements had not been concluded within the two-year withdrawal period, which for some British MPs could take 10 years. For France, the challenge is sizeable. Almost the whole park is operated by EDF Energy. The group is committed to building two EPRs at Hinkley Point, a 21 billion euros project which is due to start in 2019 and will eventually supply 7% of the United Kingdom's electricity. It is important for both sides to recreate the political and legal conditions necessary for trade and bilateral cooperation to consolidate the Franco-British partnership.

In addition, the United Kingdom is a leading partner for France in the domestic electricity market. Indeed, it has 3GW of interconnection capacity with continental Europe, and could reach 9.8 GW by 2022 if all approved projects are implemented. The cessation of funding dedicated to these projects of common interests (PIC) or Connecting Europe Facility (CEF) could jeopardize these investments necessary to guarantee security of supply to the European Union (and vice versa in the United Kingdom), and would seriously strike commercial relations with France.

United States Putting regulation back into nuclear



New York, Illinois, Connecticut, Ohio, New Jersey… States are reaching out to operators to save their nuclear power plants: all are advocating putting in place mechanisms to preserve nuclear, which is essential in reducing greenhouse gas emissions[1].

Whilst producing 20% nuclear electricity, the United States is facing some major challenges in competition which are posing a threat to their nuclear park. The market is deregulated, and the abundance of shale gas, the low prices of fossil fuels, the decrease of consumption and the development of renewables have all driven sales prices downwards, competing with nuclear which is seeing the profitability of its plants being eroded and forcing it to reduce its capacity accordingly: with about a hundred reactors, the American nuclear park is still the largest in the world, but several dozen plants could be forced to close in the deregulated ("merchant") States…

The closures (if they do go ahead) will bring heavy consequences for the regions' economies but also for consumers' electricity bills, without mentioning the greenhouse gas emissions of several million tonnes of CO2/year.

Re-regulate: nuclear operators are looking to save their economic model and are looking at a wide range of proposals, ranging from granting "zero emission credits" to negotiating long-term contracts.

Upon seeing measures adopted in the states of New-York and Illinois, with the introduction of a *Zero Emission Credit* (ZEC) system which mainly aims to support nuclear plants[2], Connecticut is working on drafting a law that would allow Millstone, the State's only plant (2335 MW) operated by Dominion, to sign a long-term contract to supply electricity to the State which is causing outrage among the other electricity producers (despite the fact it already exists for solar and wind energy). Coming under pressure from FirstEnergy which has decided to withdraw from nuclear production, the State of Ohio is attempting to impose a *Zero Emission Credit* (ZEC), which would allow the two plants threatened with closure to remain operational, preserving their competitiveness, but also employment and economic activity. New Jersey is in discussions with PSEG which would like to get ahead of competitiveness problems and introduce financial aid, drawing inspiration from ZEC, for its two plants.

Whilst awaiting these new regulations, the American nuclear industry has no choice but to lower its production costs, and is even discussing investment demands with the Nuclear Safety Authority. It has obtained the authorisation for the reactors to run for a period of 60 to 80 years. Under these conditions, the reactors from the 70s will still be in use in 2050, allowing them to go back to exceptional profitability levels. The current situation, however, with oil and gas prices at their lowest, is doing nothing to help the development of new capacities. The new plant Watts Bar 2 in Tennessee, the "first 21st century nuclear power plant in the United States" opening twenty years after the last unit was connected to the American network, is an outlier.

Claude Fischer

[1] This article is based on a note from the SFEN based on information provided by the French Embassy in the United States - April 25, 2017

[2] cA legal battle is being waged by various producers and associations of taxpayers accusing the States of market distortion and violation of the Constitution.

When China invests

China has fully understood that, in the same way as renewable energy sources, nuclear represents a solution for doing away with its ultra-polluting dependency on coal, and is a response to the increasing demand for electricity among its population.

Comprising 36 functional reactors in 2017 and 21 reactors under construction, its nuclear park represents an installed capacity of over 28200 MWe. And no doubt this is just the beginning. The country's 13th five-year plan, approved in March 2016, plans for the doubling of nuclear energy production in particular. The Chinese State Council is therefore set to approve plans to build between six to eight new nuclear reactors per year, which could take the country's installed nuclear capacity to 58 GW between now and 2020 (over 30 GW under construction), 150 to 200 GW in 2030 and even 500 GW in 2050.

The European nuclear sector has a card to play. This is reflected in the construction of two EPR reactors each with a power of 1600 MW by EDF and its ally CGN in Taishan, all for an investment of 1 billion euros.

After South Africa, could Kenya now be a new African atomic powerhouse?

Kenya, a country which imports electricity from Ethiopia (major producer of hydraulic power), is facing strong domestic demand for energy, accelerated by the country's large-scale and fast industrialisation, but production using hydraulic, wind and even geothermic resources as planned for 2025 will not be enough to meet their needs.

Kenya proposes to incorporate nuclear energy into its energy mix to reach 1000 MW in 2017 and 4000 MW ten years later.

International partnerships

The Kenya Nuclear Electricity Board (KNEB) is expanding the number of partnerships it has at international level to benefit from experience and expertise with nuclear when deciding on sites and feasibility studies. "*We have already signed agreements with the International Atomic Energy Agency (IAEA), as well as the Chinese Government, to speed up the development of nuclear energy in Kenya. Nevertheless, due to the many challenges such as the need to put in place the essential infrastructure, the electric power plant will only be operational after 2027*", revealed Collins Juma, CEO of the KNEB1. The costs of the project are estimated at 9 billion dollars and countries such as Slovakia, South Korea, China and France have already positioned themselves.

The future of energy in Africa

The whole of Africa is currently contemplating the role of nuclear in the energy mix. It will need to supply electricity to over 2 billion inhabitants. It possesses almost 20% of the world's uranium resources in 34 countries. Morocco, Ghana, Niger, Tunisia, Egypt and even Uganda are ambitiously

working to take their place alongside South Africa on the list of nuclear countries. The emergence of an African nuclear park, a symbol of economic vitality and power on the international stage, will radically change the economic order on the continent. For western countries, the stakes are twofold. On the one hand they need to occupy a central place in the construction and operation of the future plants and, on the other hand, they need to ensure access to African uranium to keep their plants running.

A debate with Les Entretiens Eurafricains

What could the cooperation between Europe and Africa look like? Nuclear requires political stability and African countries must be able to take ownership of nuclear, develop expertise and build a nuclear that is safe and sustainable. Together with Entretiens Eurafricains[1], we are ready and willing to open the debate and get the ball rolling.

C.F.

[1] The Entretiens Eurafricains were created by ASCPE in 2014

Belgium's decision and its consequences
for security of supply, prices and the climate

Almost fifteen years have elapsed since the Belgian Government decided to shut down the country's nuclear power plants after being operational for 40 years. This decision, which was to come into effect after 2015, was made amid almost widespread indifference; it also seemed to be broadly reversible in a context of "nuclear revival". In the meantime, the Fukushima accident fundamentally changed the energy policies of several countries in Europe and massive subsidies for renewable energy sources were introduced, completely disrupting the electricity market. Nevertheless, in the run-up to the first nuclear closures planned in 2015 (Doel 1-2 and Tihange 1), the Belgian Government found itself forced to backtrack because the country's security of supply was about to run into serious problems. Why? This is because all too often, the problem of the energy mix is presented in black and white terms: end nuclear and replace it completely over time with renewables.

The Belgian Nuclear Forum, in association with PWC, recently studied how complementary these two energy sources were and the consequences on Belgium's supply, prices and the climate. Firstly, the study shows that the potential growth in renewable energy sources and maintaining the nuclear park at its current capacity will not even meet the country's needs in the long term without making heavy use of fossil fuels (principally gas) or imports. It then shows that the complementary nature of nuclear energy and renewables would keep prices and energy levels low. Finally it shows that the coexistence of nuclear and renewable sources would mean producing more decarbonised electricity over the long term.

This would appear to be broadly in line with the opinion held for a long time by the Belgian Nuclear Forum: the energy mix of the future will be achieved by allowing nuclear and renewables to complement each other, not by forcing them to go head to head.

NUCLEAIR FORUM NUCLEAIRE

Robert Leclere
President of the Nuclear Forum

Standardisation: the key to linking safety and competitiveness

During the debate organised by the ENEF on 23 May in Prague, a unanimous opinion was reached: standardisation of equipment would save on costs and time. If other industries have achieved standardisation, nuclear ought to be able to as well: its competitiveness depends on it. **Jarmo Tanhua**, from TVO, added that the standardisation of procedures must not be overlooked as it would achieve better safety and better transparency. Standardisation, however, will only be achieved if the regulating authorities and European institutions play their part. As **Matheus Abbt** confirmed, standardisation will improve the perception of risk and get rid of uncertainties if supported by a European framework. **Jan Haverkamp**, Vice President of Nuclear Transparency Watch, recognised that after Fukushima, standards were raised. But he also affirmed that if costs were the driving force behind harmonisation, then it would drive them downwards. How can safety and competitiveness be linked? **Massimo Garribba** acknowledged that there may be a contradiction, but that a process has been set in motion with the legal framework and the first instruments provided by the Commission. **Andrew Wasylyk**, project leader at the World Nuclear Association, recalls that the demand for electricity is expected to have doubled by 2050. Nuclear will have a key role to play: it will have to cover 25% of the demand for electricity. But to achieve this, there must be no barriers to new construction projects. He urged consistency across authorisation systems, cooperation with the regulatory authorities (independence does not mean isolation) and businesses, and a swift pace of construction. The association promotes the idea of international consistency and predictible authorisation systems. **Massimo Garribba** underlined the tensions between national responsibility and supranational responsibility, and invited the regulators and the States to cooperate more effectively and progress towards consolidated standardisation.

Manon Tanguy
Head of mission at ASCPE

independent · international · incisive energy post

Interview of Claude Fischer Herzog : "EU needs a nuclear industrial policy"

September 26, 2017 by Clare Taylor

Europe is in danger of losing its leading position in nuclear power, warns Claude Fischer Herzog, Director of ASCPE-Les Entretiens Européens et Eurafricains, she calls on the EU to develop an industrial policy of which nuclear power will form an integral part. …

[Read more... http://energypost.eu/15754-2/]

Erratum : a translation error has been made in the answer on the safety « But if safety does not become a dimension of nuclear competitiveness in Europe, it will be counterproductive! » and not « But if safety becomes... »

Article available in French on www.entretiens.europeens.org

Nuclear safety in Europe
4th Regulatory conference

ENSREG planned its first regulatory conference on nuclear safety on 2011, the second on 2013 and the third on 2015. The fourth was held on 28th and 29th June 2017.

These events provide ENSREG representatives and stakeholders around the world to share experiences and point of view on the challenges faced and the realizations regarding nuclear safety in the EU and worldwide.

The 2017's Conference was broadcasted on the Internet on the ENSREG' web site an the audiovisual recordings were available :

first day : https://webcast.ec.europa.eu/4th-european-nuclear-safety-conference-ensreg-gasp-1

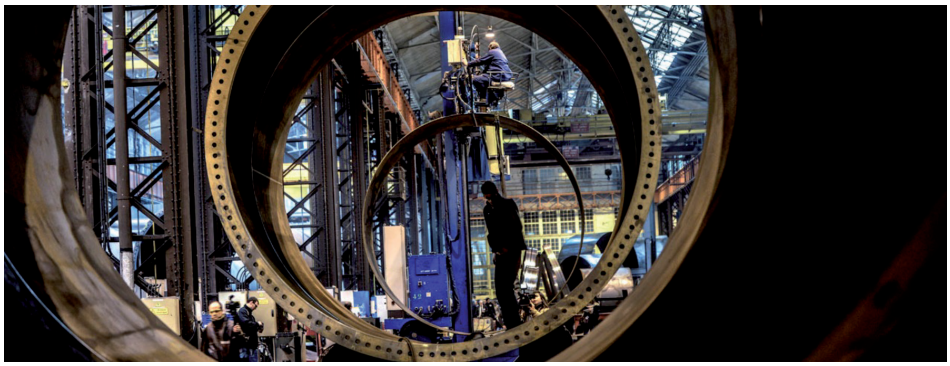
press conference : https://webcast.ec.europa.eu/4th-european-nuclear-safety-conference-ensreg-mans

Second day : https://webcast.ec.europa.eu/4th-european-nuclear-safety-conference-ensreg-gasp-2

Nuclear energy: a committed player in driving local economies

In the space of half a century, factories, power plants and research centres have all played their part in structuring the lives and identities of local communities. The third industrial sector, nuclear, comprises 220,000 professionals and 2,500 businesses with state of the art installations scattered all over France, in domains ranging from energy to healthcare.

From now until 2020, the sector is set to recruit almost 8,000 professionals each year. Twice as qualified as what industry requires on average, the sector's jobs are sustainable and the vast majority of them cannot be outsourced. Furthermore, by controlling the whole value chain in nuclear production, the French sector absorbs a larger proportion of the jobs and is not dependent on having to import technological or industrial expertise from abroad.



The factory at Creusot

An industry with a high level of added value and very highly-qualified jobs

To ensure that its skills are being renewed, the industry is more focused than ever on the quality of training. Against this backdrop, the support of local government, especially regional authorities, is essential in reinforcing training which will make it possible to create a talent pool of top-level engineers and technicians. French nuclear training is one of the most respected in the world and consequently it attracts students from all four corners of the globe.

In addition to direct and indirect jobs, the nuclear industry is generating 190,000 brand new jobs and is bringing vitality to local areas, particularly in rural locations or areas affected by deindustrialisation. With purchasing power that is above the French average, the sector's professionals are breathing new life into the local economic fabric. On the industrial front, the sector is investing more than ever before in the areas where plants are located by ordering from local businesses and modernising its facilities.

A sector that supports local SMEs

To give an example, in 2014 the nuclear power plants at Penly and Paluel (Normandy) gave a third of their contracts to local businesses. In turn, the La Hague fuel processing facility carries out three-quarters of its procurement within the region. (Photo)

Construction sites also generate a large number of qualified and sustainable jobs. When the EPR was being built at Flamanville, it created over 4,000 positions and half of these went to the local workforce. To achieve this, a far-reaching partnership was created with the employment agencies and the region of Normandy to train 1,061 jobseekers, who then joined the site.

United Kingdom: a win-win partnership

On the other side of the Channel, the building of two EPR reactors at Hinkley Point will create several jobs in the United Kingdom but in France too where the engineering and manufacturing of certain components will be taking place. This site will benefit the whole French industrial fabric: from major groups to medium-sized enterprises. Out of the 21.6 billion euros needed for the project's completion, 40% of the contracts will benefit French industry. According to a PWC study from 2011, a European EPR generates almost 3,750 jobs per year in France during the construction phase. This means that the Hinkley Point project could create over 7000 jobs in industry in France.

Valérie Faudon,
General Delegate of the SFEN

Find studies of the SFEN (in French)

A new ambition for nuclear power

Nuclear power in the service of the territories

France, a political signal which could cost the country dearly

Restoring the share of nuclear in electricity production to 50% by 2025 would cost France 17 reactors. That, anyway, is the figure that has been suggested by Nicolas Hulot, Minister for Ecological Transition. **A roadmap that will be difficult to adhere to given such a surreal objective!**

Renewables versus nuclear: the government is prepared to spend 15 billion euros to invest in nuclear and simplify approval procedures for new wind or solar power projects (the speed of implementation is far from being able to cover the losses of nuclear electricity production). While our nuclear park still supplies 72% of electricity production, while the majority of plants have been depreciated, while they could still produce for 10 or even 20 years, **this decision, if it does indeed go ahead, would be a huge economic and climatic waste!** Nuclear is what allows France to emit less greenhouse gas than any other country in Europe and it provides us with a secure supply and energy independence. In Germany, the shutting down of power plants has led to the reopening of coal mines; we would have to import more fossil fuels!

What industrial strategy is this proposal part of? Without even mentioning how much such a decision would cost , has the government really decided to weaken France and destabilise its sector - at the very moment that the world is entering into a new nuclear era with increasing numbers of countries adopting nuclear (the number is set to stand at 36 in 2025 compared to 31 at present), and the "new nuclear" which is going to be revolutionary in bringing electricity to all - and to decarbonise our economy? Clean driving by 2040, another of the government's objectives, will eat up 20% of electricity production and will need to double peak demand in the absence of staggered charging.

Suffice to say this commitment cannot be met! **But the mere facts of even announcing it is devastating!** This is undoubtedly the biggest hurdle standing in the way of the sector's future. ***C.F.***

[1] The figures mentioned for EDF are 5.7 billion fewer revenues per year and an operating deficit of 1.8 billion; and the compensation that the government will have to pay for the loss of profits associated with "Le Grand Carénage" and the life extension of the power stations. Cf. Les Echos of July 11, 2017.

Innovation, a challenge of competitiveness

As with any industry, innovation is a competitiveness issue for nuclear power. In an interview with SFEN, François Gauché raises three key challenges to move towards an ever safer, more competitive and sustainable nuclear: technological, scientific and digital. For the director of the DEN (Directorate of Nuclear Energy) to the CEA, the projects need political and budgetary support to assemble the best skills and new solutions and develop modeling and simulation tools, coupled with experimental platforms adapted. Cooperation between principals, research actors and industrialists (SMEs and large groups) is essential for the emergence of cooperative projects.

Partnerships for mutualisation

The CEA works with major groups such as EDF, AREVA and ANDRA, which pool their resources and skills. It also collaborates with other industry players, such as SMEs / SMIs in the framework of the Strategic Committee of the nuclear industry (CSFN) to develop new technologies and help bring innovations themselves, or integrate them into consortia meeting calls for tenders from financing windows. Thus the project of ASTRID reactor brings together a plurality of actors. Airbus Safran Launchers, Alcen, Areva NP, Bouygues, CNIM, EDF, General Electric, JAEA, MHI and MFBR, NOX, Onet Technologies, Rolls-Royce, TOSHIBA, Velan and Technetics. This fourth-generation reactor project is not to commercialize the reactor, but to use it as a «technological demonstrator», breaking with Phénix and Superphénix, meeting high requirements in terms of safety.

A sector in full evolution

Fifty start-ups imagine new nuclear systems and China is investing heavily in a wide range of technologies. France and CEA are involved to maintain skills and excellence throughout the fuel cycle. Prepare future generations so that they are always safer and more competitive through better resource management.

Electricity consumers demand more stability and competitive prices

Climate policy and energy independency are the main drivers for the energy transition Europe is currently going through. For electricity generation, renewable energy sources (essentially solar and wind power, but also other technologies) are to become the future substitutes for the "old" thermal plants, particularly the ones based on fossil fuels. Industrial consumers throughout Europe are aware of the importance of the challenges, and are supportive of this transition, unavoidable indeed in the medium turn.

Need security

At the same time, however, industrial electricity consumers also need a minimum level of security of supply in order to guarantee the integrity, safety and efficiency of their processes, and competitive power costs and prices in order to be able to cope with international competition. The technologies of today for renewable power generation have made substantial progress in the last decade on both these counts, but are, at the same time, still cause of concern for both aspects.

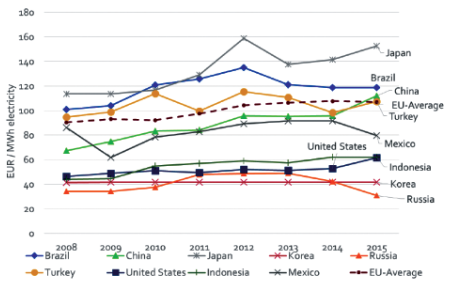
A diversified mix is needed

As for security of supply, solar panels as well as windmills have benefitted from massive support in Europe and have known an explosive growth in the last 15 years. In some EU countries, they have already become the most important generation capacity source. However, their availability is function of weather conditions, and unfortunately, in most parts of Europe, these are far from being optimal. Other sources of capacity therefore need to supply electricity when the sun doesn't shine and/or the wind doesn't blow. With power storage still being too expensive and grid capacities for EU-wide energy exchanges still too limited to allow unconstrained exchanges (a solution that would in any case also come with a high cost), thermal plants are still needed to guarantee security of supply. Gas, coal and nuclear plants have clearly proven their effectiveness in the past decades.

It is always the final consumer who pays

As for competitive prices, and notwithstanding the enormous progress made

Figure 8: Average industry electricity prices in the EU and major trading partners



Source: Brazilian Ministry of Mining and Energy, Chinese Price Monitoring Centre, NDRC, Indonesian State Electricity Company, Russian Federal State Statistics Service; EIA data for Turkey, S Korea, Japan, USA and Mexico.

in recent years, current technologies of renewable energy sources still need subsidies of some kind in order to find their way into the electricity market. These extra costs are generally charged through to end consumers through higher grid tariffs or surcharges, adding to the competitive handicap of industrial consumers in Europe compared to selected industrial areas in the rest of the world (see graph)

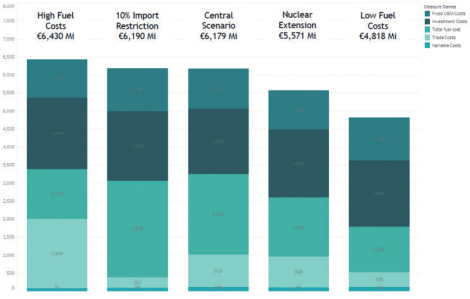


Figure 4-20 - Scenario comparison: annual energy system cost in 2030 (million Euros)

Industrial consumers in Europe recognise the need for the EU to evolve towards low carbon electricity generation technologies in Europe, but at the same time need reliable and competitively priced electricity in order to maintain their activities on the continent. Technological breakthroughs are therefore needed to reach both the climate and energy policies in Europe, a target only to be achieved through continuous efforts in research and development. In the meantime, efficient and (where possible) low-carbon thermal plants will continue to be needed to bridge the gap. A recent study by EnergyVille shows that, in Belgium, the energy transition will be substantially more expensive if all nuclear plans are closed by 2025 as planned by the government.

Peter Claes

Director – Federation of Belgian Industrial Energy Consumers

Vice-President – International Federation of Industrial Energy Consumers

Nuclear energy and Renewables : which complementarity?

In October 2014, the European Council agreed on a 2030 climate and energy policy framework for the EU, setting an ambitious economy-wide domestic target of an at least 40% reduction in greenhouse gas emissions for 2030. The Paris Agreement has vindicated the EU's approach. Implementing the 2030 energy and climate framework as agreed by the European Council is a priority in following up the Paris Agreement.

Characteristics in common

The main sources of low-carbon energy, nuclear and renewables, already provide more than half of the electricity needed in the EU. These sources have several characteristics in common. While having low operating costs, both face high initial capital costs. In the current low wholesale price environment with high volatility of electricity prices, this represents a significant challenge in securing the necessary investment on the capital markets with a view to building future generation capacity. A solution to this challenge lies in making sure that the market gives the right investment signals and, to the extent necessary, in intervening by correcting any market inefficiencies. However, any correction mechanism must fully comply with EU state aid rules. The EU's ambition is that investments in low carbon technologies be spurred by the market and, once these technologies become mature, market-friendly support schemes gradually disappear. Renewable sources have already become more competitive and the need to subsidize them is less pressing. The nuclear sector should go in the same direction, notably through standardisation, more efficient licencing, better control of the supply chain and other means.

From the base load to the point: need for reliable sources

Both nuclear and renewables can, under some circumstances, serve as baseload sources or as flexible ones. Dispatchable renewable sources, such as hydroelectric power plants (on rivers with reservoirs, where available) and biofuels already provide a reliable source of baseload electricity. Nuclear energy, when operating in a base load mode, is the best known source of dispatchable baseload power.

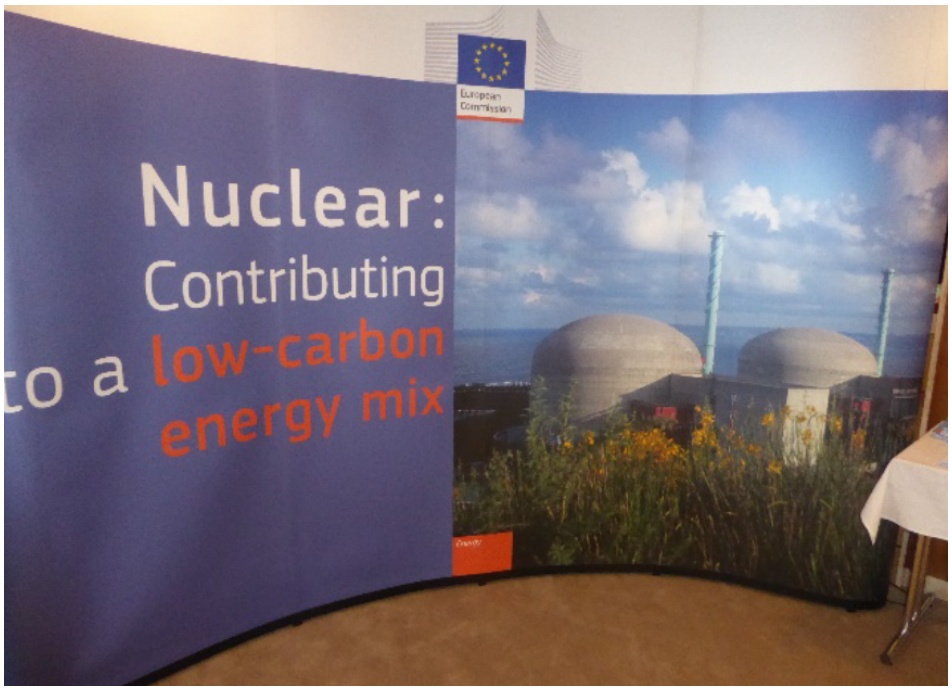
On the scale from base load to flexible sources, nuclear energy can also be used under the so-called 'load following mode', when it becomes a more flexible source. This flexibility can be in the form of frequency control – i.e. increasing or decreasing operating power in response to the needs of the grid. These are usually relatively small changes (2-5% of their output within a few seconds to a few minutes, depending on the size of the grid). The other form of flexibility is daily or weekly planned load following, which adapts supply to cyclical variations of demand, such as decreases during nights or weekends, or more subtle changes in response to grid needs.

Another flexible but also relatively unpredictable energy source are the so-called intermittent sources. These are the variable renewable power sources such as wind power and solar power. The main advantage of these sources, besides their low-carbon characteristics, is that once built they have a very low, even zero marginal cost.

Additional uses

In theory, it is possible to cover all the electricity needs of Member States from low-carbon sources, provided that all possible sources of flexibility in the energy system are deployed. This includes flexible, dispatchable renewable generation, but also interconnections, storage and demand response, as well as cross-sectoral integration (for example, power to gas). Accordingly, the Commission welcomes the determination of EU industry and the Member States to establish a full value chain of batteries in Europe, with large-scale battery cells production and recycling.

Decisions on whether to use non-low-carbon sources, such as coal and gas, are legally within the competence of the Member States. At the same times, Member States have agreed and committed to contributing to the EU's climate targets. In the context of the governance part of the 'Clean Energy for All Europeans' proposals in their current form (under consideration by Council and EP), Member States will prepare, in close cooperation with their neighbours and the Commission, national climate and energy plans laying down their trajectories towards these common climate and energy objectives. The Clean Energy package also includes steps towards a level playing field in the energy market, ensuring that the market will give the right signals for investment into future sustainable energy sources. Furthermore, as announced in the May mobility package «Europe on the Move», the Commission will soon table a proposal setting revised CO2 standards for cars and vans for the



post-2020 period. We want these targets to be ambitious but realistic. We will not propose a quota for e-cars. EU legislation has always been technology-neutral, and this will continue in future.

Creating a low-carbon value chain from Production to Interconnection

Experience already exists in countries like Germany and France on the technical feasibility of using renewable energy sources and nuclear energy in a complementary manner. Germany in particular has successfully operated its nuclear power plants in the load following mode for the last 30 years, and has thus vast experience with the advantages and challenges of such a system. The most well-known challenges, which are longer outages due to replacements of parts of nuclear power plants that wear out faster in this mode, as well as the economic consequences of revenues foregone during the reduced output, are at least in part mediated by the stabilizing effect on the market price, when nuclear power plants reduce output during low demand periods (and thus prices are not pushed down any further).

Moreover, the newest models of nuclear power plants, such as the Advanced Boiling Water Reactor (ABWR) and the European Pressurized Reactor (EPR), have been developed specifically with load following capacities, reinforcing those parts of the power plant that are known to wear out faster in such a mode. Decisions on allowing a load following mode or not are, however, up to national safety regulators, and thus cannot be made by the Commission.

In addition, the final choice of which energy source to use or not in a national energy mix remains with Member States. However, Member States have to take into account other considerations, as outlined in the Commission's Energy Union strategy, in particular security of supply and the affordability of energy for all citizens. Therefore decisions on the use of specific energy sources should be made after due consideration of the global picture.

State and EU commitments for climate targets

Finally, and probably most critically, the future development of energy demand needs to be taken into account in the strategic direction of our energy policy. Cross-border interconnectivity, already today one of the key goals of the Energy Union, would help eliminate duplication of supply, but often faces national supply security consideration in Member States, which would like to ensure energy for their own citizens without relying on other countries. Moreover, improvements in energy efficiency will of course lead to significant reduction in demand, while the potential electrification of transport (especially electric vehicles) may result in total demand increasing.

In this context, Member States should work together with the Commission and with each other, to use the optimum energy mix for a low-carbon future of all. The choice of whether or not to use renewable sources and nuclear energy in their complementarity, and to what extent, is up to each Member State. The EU is consolidating the enabling environment for the transition to a low-carbon economy through a wide range of interacting policies and instruments reflected under the Energy Union Strategy, one of the ten priorities of the Juncker Commission.

Massimo Garribba
Director for Nuclear energy, Safety and ITER
European Commission

ITER, an international organization

The ITER project represents the culmination of 40 years of scientific experiments conducted simultaneously throughout the world. Its ambition: to reproduce an energy that resembles that created naturally in the heart of the sun. Europe has taken the lead in this project, with a 45% share of construction costs (34% during the operating phase), financed 80% of the EU budget and 20% France, the host country of ITER (the other ITER members each having a share of about 9%).

Unique in the world, the project brings together 34 countries that have established agencies. In Europe, the joint venture «Fusion for Energy», located in Barcelona, is responsible for delivering Euratom's contribution to ITER.

The organization, led by Osamu Motojima and the ITER Council, is governed by an international treaty that sets out the rights and obligations of each partner.

It is responsible for the design of the research facility, its construction, its operation (planned for 20 years) and its shutdown. In June 2016 the ITER Council approved ad referendum an updated schedule and associated cost estimates for the completion of the ITER construction up to the first plasma stage, which is expected to be in December 2025, and operating at full power, extend to 2035.

A dynamic project for growth and local employment in France

France is the host country for the project. The Iter mission is placed with the Prefect of the Provence-Alpes-Côte d'Azur region, in charge of the realization of regional facilities (such as the international school provided by the regional council) or the ITER route transport of exceptional components (financed by the Bouches-du-Rhône General Council). The organization of convoys of exceptional components will be ensured by a coordination unit set up within the Iter France Agency.

Created within the CEA, it is made up of around twenty employees, and is responsible for the reception of ITER employees and their families and the site servicing work.

By 2030, nearly 58,000 jobs are expected to be created in the region, according to INSEE's latest study, particularly in the fields of science, technology and business support. Large research facilities such as those located in Cadarache, the research technopole (approximately 1,300 people, including nearly 500 employees directly by ITER) and the CEA (6,000 people) contribute to the economic vitality of this employment area.

The Entretiens Européens on investment

Creating the conditions for nuclear renewal in Europe

In 2016, stakeholders sounded the alarm bell: we will no longer be leaders if we do not invest more! The world is entering a new nuclear era and Europe has to invest in training, in new technologies, in renewing nuclear parks to keep its place in the world. What we are missing is an industrial policy and an incentive market framework. "We do not have sufficiently strong political consensus and the Commission is bound by the decisions of Member States," underlined **Gerassimos Thomas**, Deputy Director General at the European Commission's DG ENER.

That being said, do all States not benefit from nuclear energy when there is intermittence on the networks? So how can we allow the States that want to produce nuclear electricity to go ahead and do so? Shouldn't we be thinking in terms of the general interest rather than national interests? With EURATOM in 1957, a decision was made: we must let that decision stand. What is the priority today? How can we re-create the conditions for investment and go back to the policy on industry and services which made the Union strong?

Arbitration in favour of renewables

"Certain aspects play in our favour: the COP 21 and the COP 22," responded Gerassimos Thomas. But will climate change provide a sufficient framework? With regard to the safety directive which obliges practically all Member States to have a transparent roadmap, and clearly expose their financing methods: this does not constitute an industrial strategy. Of course the Commission is not doing nothing: research, support for new technologies, pan-European training… But the funding is scarce and it is the market framework that industry has spoken out against: impossible to invest without correct price signals and without long-term contracts. This is a debate which also concerns renewables. How to combine

Gerassimos Thomas and Claude Fischer during the conclusions to the Entretiens Européens of 2016

a certain percentage of intermittent energy in the mix with base energy? The responses provided by the "Winter Package" in order to give positive investment signals, may allow for arbitration between objectives, but they do not come out fighting in favour of nuclear .

Proposals for building a market framework for project viability and financing.

1. Invest in human capital and create pan-European training centres. There can be no nuclear industry and no safety without people and skills.

2. Foster cooperation in new technologies for adding value to European projects on the market. These new technologies such as SMRs exist, they just don't make it to market.

3. Multiply the CO2 floor price by 3 or 4.

4. Modernise State aid, and create long-term contracts, in parallel to the spot market and capacity market. Shouldn't the CfD signed in the United Kingdom become a model?

5. Promote stronger cooperation between nuclear States to progressively build a nuclear market that is open to our neighbours, and make them associated States. The UK, but Russia too, which is present in all European countries.

6. Foster investor partnerships. The UK does this with the French and Chinese. What better than sharing safety and security? When moving to a global market?

8. Develop cooperation with all. Involving stakeholders is a must: we have to learn from one another – including from accidents. This cooperation can have varying geometry.

Les Entretiens Européens & Eurafricains

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Les Entretiens Européens

19th October - Brussels

Hearings:

- The European ambition, 60 years after the EURATOM Treaty
- Nuclear generation - The potential to play a central role in a low-carbon future
- Supporting the nuclear power plants in the United States for sustainable development

4 Round-Tables:

- Transparency, an issue for competitiveness. The truth on costs and prices.
- Prosperity of territories: the impact of nuclear power on growth and employment
- Safety, an asset for competitiveness –Safety costs : how to reduce them without reducing safety
- Solidarity as an aspect of competitiveness

Provisional findings

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