FORATOM
THE VOICE OF THE EUROPEAN NUCLEAR INDUSTRY

THE IMPORTANCE OF LONG-TERM OPERATION OF THE EXISTING EU NUCLEAR FLEET

HELPING TO ACHIEVE EUROPE'S CLIMATE GOALS AT AN AFFORDABLE COST

NUCLEAR

Is a low-carbon energy source

Ensures security of supply

Is environmentally, economically and socially sustainable

NUCLEAR INDUSTRY IN NUMBERS

Accounts for **26%** of electricity in the EU

Almost **50%** of low-carbon electricity

Supports around **1.1Mn** jobs

Turnover of **102bn** per year

July 2019

EXECUTIVE SUMMARY

An increasing number of experts recognise that decarbonising the power sector cannot be achieved with renewables alone - nuclear will have to play a role if the world is to reach its CO2 reduction targets by 2050. This paper aims to outline the opportunities provided by the long-term operation (LTO) of the existing fleet of nuclear reactors. It furthermore gives an overview of some of the challenges which need to be tackled and provides a series of EU policy recommendations.

The intermediate decarbonisation targets in the transition towards 2050 cannot be achieved without the LTO of existing nuclear power plants (NPPs). In fact, if the EU were to invest in maintaining a fully operational nuclear fleet over this period, then 58% of its electricity would come from low-carbon sources by 2030 – making it the global leader on climate change policy.If not, the share will drop to 38%, increasing cumulative emissions by around 1500 million tonnes of CO2 by 2030.

In a nutshell:

- LTO is unarguably economically advantageous compared to other power sources. It requires a much lower capital investment cost, leading to low investment risks for investors and capital markets, and lower consumer costs.
- From a technical point of view, the LTO of nuclear reactors provides a great advantage thanks to the *"…timely implementation of reasonably practicable safety improvements to existing nuclear installations"* which brings older generation reactors to a level of nuclear safety standards in compliance with the amended Nuclear Safety Directive.
- LTO reduces the EU's energy import dependency – mainly fossil fuels – and provides reliability to the grid.
- Low-carbon nuclear generation provides firm capacity to the electricity system**.**

FORATOM would like to put forward the following policy recommendations:

- Ensure a coherent, consistent and stable EU policy framework (including Euratom).
- Agree an ambitious net-zero CO2 emissions target for the EU in 2050, in line with the European Commission's long-term vision for a climate neutral economy.
- Develop and implement a strong industrial strategy to ensure that Europe maintains its technological leadership.
- Support human competences development.

CONTEXT

The aim of this position paper is to provide more information about the long-term operation (LTO) of the existing fleet of nuclear reactors and its benefits, within the context of the EU's very ambitious target of reducing greenhouse gas emissions by 2050 and ensuring a cost-effective transition.

This strategy, entitled 'A Clean Planet for all', outlines the EU's strategic long-term vision for reaching a climate-neutral economy by 2050 and **confirms that nuclear will form the backbone of a carbon-free European power system, together with renewables.** According to this strategy, in 2050 nuclear capacity will be in the range of 99 to 120 GW (higher than the figures from the 2017 edition of PINC[1] which forecast an installed nuclear capacity of between 95 and 105 GW) and will account for more or less 15% of the EU's electricity mix, depending on which one of the 8 proposed scenarios is followed.

At an international level, the latest Intergovernmental Panel on Climate Change (IPCC) report (Global Warming of 1.5°C, October 2018) recognises that nuclear power is essential if the world is to keep global warming to below 1.5 degrees. According to one of the IPCC scenarios, a six-fold increase in global nuclear capacity is needed if we want to achieve our climate goals. The IEA has recently also made several statements in favour of the nuclear sector in general and LTO in particular. For example, during the 2019 edition of the European Nuclear Energy Forum (ENEF) Dr. Birol indicated that without any policy changes, three-quarters of Europe's nuclear fleet would be decommissioned by 2040. To this, he added that whilst an increase in renewables and a phasing out of coal could reduce emissions by 40%, maintaining nuclear could accelerate CO2 emission reductions.

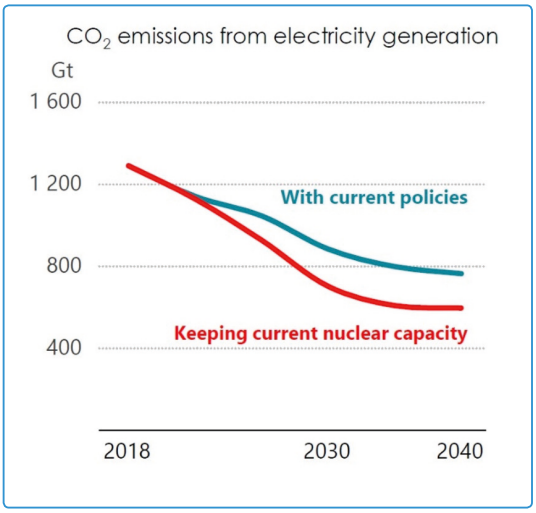

Fig. 1 IEA forecast for the 2040 emission reductions in Europe – presentation delivered by Dr. Birol at ENEF 2019 plenary meeting in Prague

According to its latest report launched in May 2019 - Nuclear Power in a Clean Energy System[2] – the IEA has gone even further by stating that a "steep decline in nuclear power would threaten energy security and climate goals" and "lifetime extensions (of existing nuclear reactors) are crucial to getting the energy transition back on track".

The overall message of all these organisations is that decarbonising the power sector cannot be achieved with renewables alone. Nuclear is the only significant, scalable, low-carbon partner in a future energy mix which is capable of achieving the EU's decarbonisation targets.

FORATOM believes that whilst the European Commission has launched several initiatives to achieve its long-term targets, no efforts are being made to prolong the life of the existing nuclear fleet. As a result, the EU will fail to deliver on its decarbonisation objectives, despite huge investments in renewables and energy efficiency.

[1] SWD (2017) 158 final - Nuclear Illustrative Programme

[2] "Nuclear Power in a Clean Energy System" – IEA, May 2019

Recently, the Commission has published and partly adopted several crucial legal acts which may impact investments in LTO:

- The "Clean Energy for all Europeans" (CEP) legislative package
- "A Clean Planet for all"[3], the EU's strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050
- 4th State of the Energy Union[4]
- A more efficient and democratic decision making in EU energy and climate policy[5]

In FORATOM's opinion, the CEP has failed to incentivise long-term investments in low carbon technologies, as it picks winners – focusing mainly on renewables or energy efficiency policies - and leads to an increase in energy market disruptions without addressing the core issue of decarbonising the sector. This progress was also presented in the last State of Energy Union.

The "A Clean Planet for All" strategic vision does present a more pragmatic approach, foreseeing a 2050 power system which takes advantage of all potential sources of low-carbon energy, focusing primarily on the most mature technologies – renewables and nuclear power.

Currently the 120 GW of installed nuclear capacity in the EU accounts for around one quarter of the electricity generated and almost 50 % of the low-carbon electricity. Nuclear power will clearly play an important role in the 2050 carbon-free power sector. In the run up to 2050, nuclear power will mainly rely on the LTO of its existing fleet. In addition, by 2050 a significant amount of new capacity will need to be built. The aim of this position paper is to provide more information about the importance, opportunities and challenges of the LTO of the EU's current nuclear fleet.

BENEFITS OF LTO

A driver of decarbonisation

The intermediate decarbonisation targets in the transition towards 2050 cannot be achieved without the LTO of existing nuclear power plants (NPPs).

The EU has set a 2030 decarbonisation target of at least a 40% cut in greenhouse gas emissions (from 1990 levels)[6] and is now working on its 2050 targets. But the current 2030 targets are not ambitious enough and will make the 2050 targets very hard to achieve. The European Parliament has expressed its concerns on this point and has called for a more ambitious target[7] of -55%. Indeed, the 2030 emission reduction targets could be revised in order to render them more ambitious. The current path includes the use of fossil fuel sources - extending the lifetime of some existing production facilities as well as building some new ones – and that will lead to an increase in GHG emissions in short and medium term. It will also create a lock-in effect in relation to new fossil fuel production facilities because once built they cannot be phased out after just few years, for obvious financial interests. It will be virtually impossible to achieve the 2030 decarbonisation objectives without LTO given that, even in the case of stagnant electricity demand, the overall share of low-carbon sources will actually decrease (see next page, figure 2).

In fact, if the EU were to invest in maintaining a fully operational nuclear fleet over this period, then 58% of its electricity would come from low-carbon sources by 2030 – making it the global leader on climate change policy. If not, the share will drop to 38%.

[3] "A Clean Planet for All" communication
[4] 4th report on State of the Energy Union
[5] COM(2019) 177
[6] https://ec.europa.eu/clima/policies/strategies/2030_en
[7] European Parliament resolution of 14 March 2019 on climate change

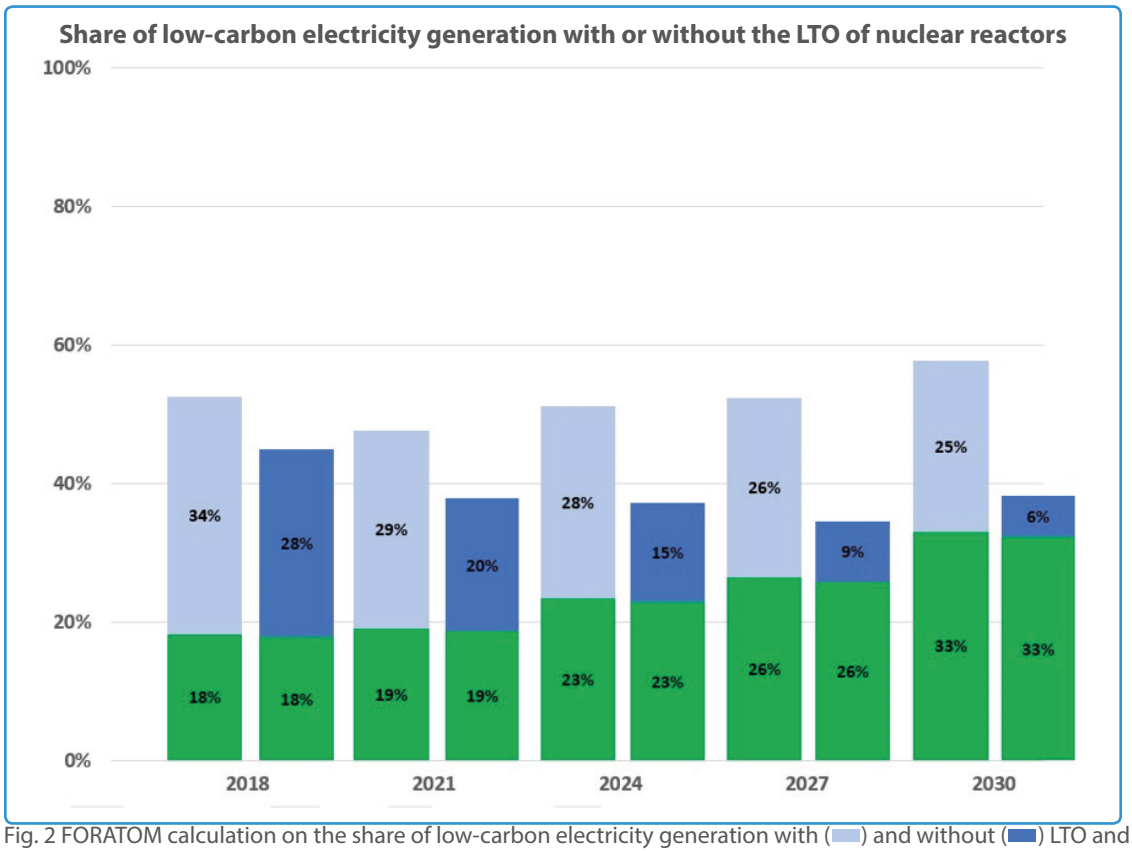

Fig. 2 FORATOM calculation on the share of low-carbon electricity generation with ( ) and without ( ) LTO and renewables ( )
Note 1: the forecast for electricity generation comes from the FTI CL study
Note 2: for the assumptions on LTO it has been taken into consideration the specificity of each country with the different duration of the lifetime extension

This decrease in the share of low-carbon capacity resulting from not investing in the LTO of existing nuclear reactors, will in fact increase emissions in the medium term due to dependence on fossil fuel sources in order to meet back-up needs (highlighted in figure 2). An early nuclear closure scenario (i.e. no LTO of existing nuclear reactors) would increase total emissions over the 2020-2050 period, with the biggest impact in terms of CO2 emissions being recorded in the short and medium term.

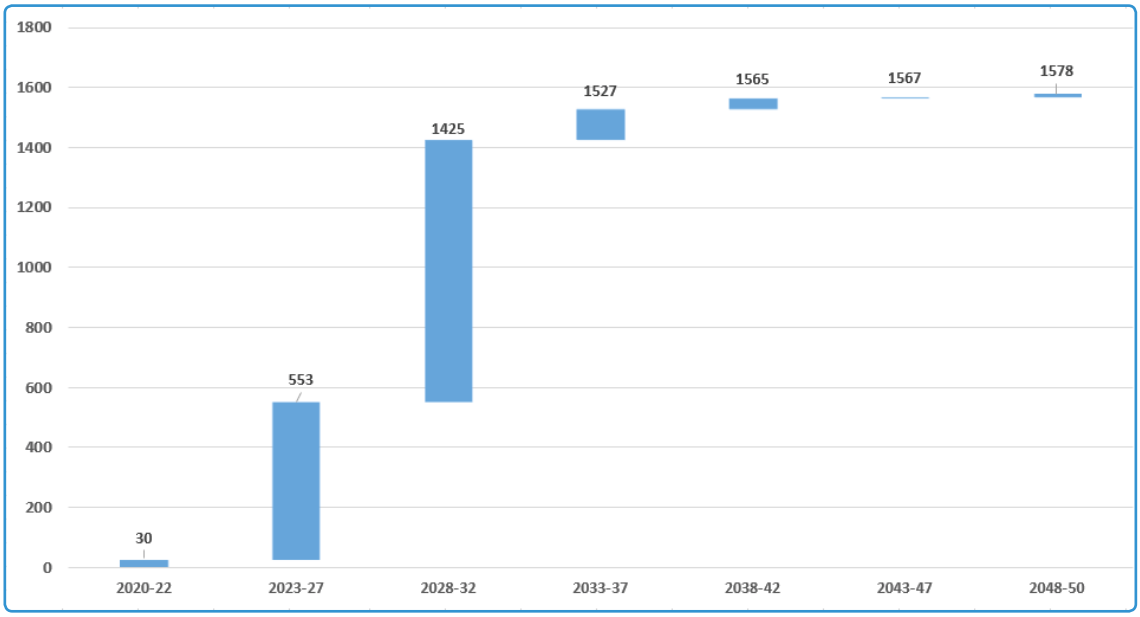

Fig. 3 CO2 emissions (MtCO2) added to the overall budget in the case of an early closure of the nuclear reactors – FORATOM calculations based on FTI-CL Energy results

In FORATOM's opinion, the EU's Emission Trading System (EU-ETS) should be the main tool to reduce industrial greenhouse gas emissions, but it is still far from achieving its objective as it does not incentivise long-term investments in low-carbon technologies. FORATOM has frequently expressed its concerns[8] about the failure of the current EU-ETS to incentivise the continued operation of existing low-carbon technologies and the fact that it does not encourage a switch from fossil fuels.

Economic aspects

Key message: LTO is unarguably economically advantageous compared to other power sources. It requires a much lower capital investment cost, leading to low investment risks for investors and capital markets, and lower consumer costs.

Capital costs

According to PINC, the average LTO investments between 2000 and 2025 are around 630 EUR/kWe, representing the lowest capital cost of all low-carbon technologies. PINC also estimates a total LTO investment need of around EUR 46,9 billion during the period 2015-2050.

Generation prices

According to Commission's PRIMES model figure[9] forecasts for 2030, the levelized costs of electricity (LCOE) for installed capacities (LTO) will be the lowest among all technologies:

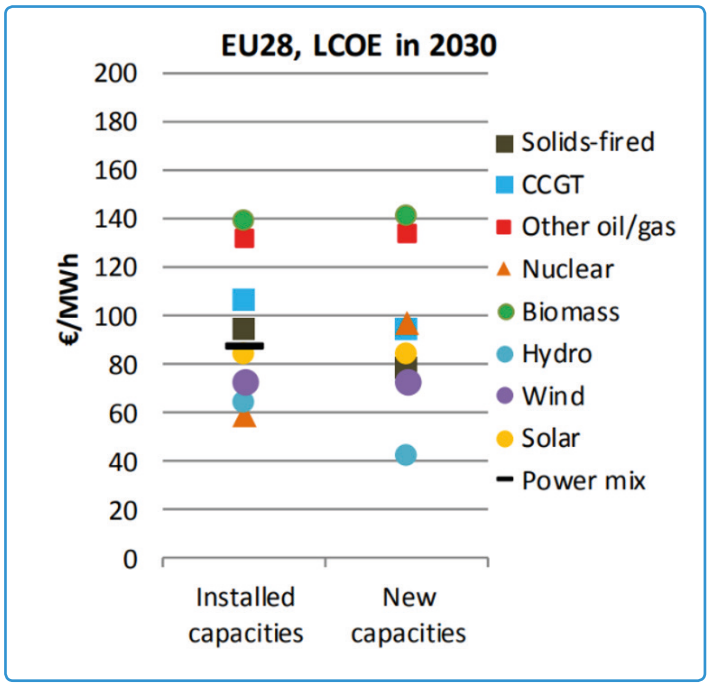

Fig. 5 EU 28 - comparison of forecast (2030) electricity prices and cost produced by different technologies

[8] FORATOM's position papers
[9] Energy prices and costs in Europe - COM(2019) 1 final

Consumer costs

An early closure of nuclear capacity would impact the undiscounted Consumer cost by more than €200 billion by mid-century. Consumer would benefit from the savings in the short to medium term (before 2035), further strengthening the contribution of nuclear generation in the transition to a decarbonised economy.

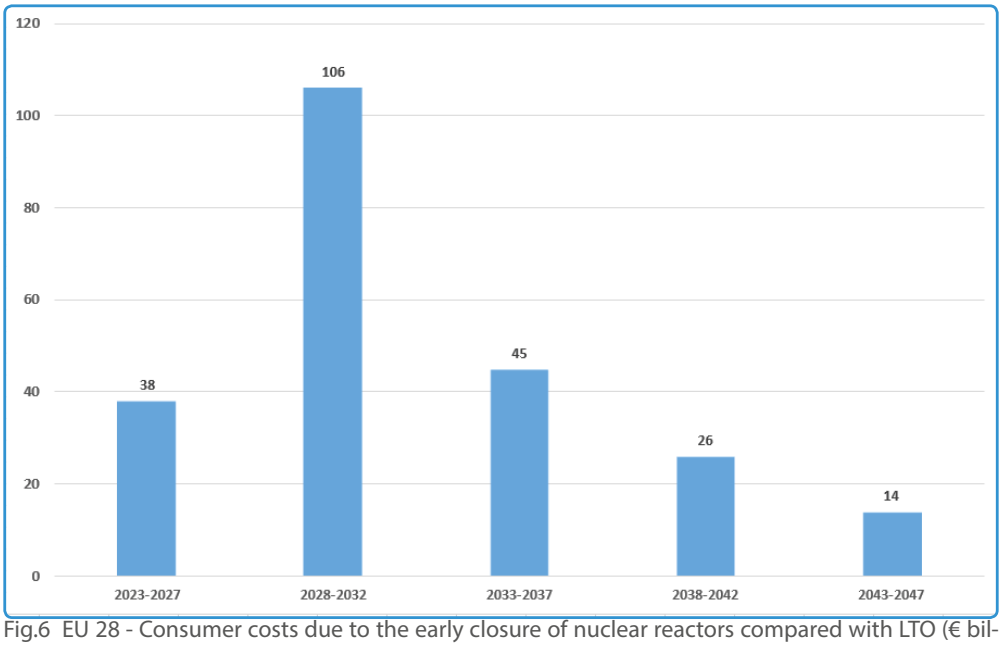

Fig.6 EU 28 - Consumer costs due to the early closure of nuclear reactors compared with LTO (€ billion) – FORATOM calculations based on FTI-CL Energy results

Regulatory aspects

From a technical point of view, the LTO of nuclear reactors provides a great advantage thanks to the "…timely implementation of reasonably practicable safety improvements to existing nuclear installations"[10] which brings older generation reactors to a level of nuclear safety standards in compliance with the amended Nuclear Safety Directive.

The technical lifetime of NPPs is limited by the economic rational of investments and the ongoing licensing procedure or framework which aims to achieve the highest European and international nuclear safety standards. The decision authorising the operation does not distinguish between "before LTO" and "after LTO" as the licensing conditions remain the same.

According to the IAEA's definition[11], LTO is a continuous operation beyond a framework defined by the technical project or licence, after an assessment and if regulatory conditions are met. LTO is neither a major nor a minor change because it does not alter the physical aspects of the project[12] and it is important to keep in mind that the safety requirements for NPPs "before long-term operation" are the same or higher as those "during long-term operation". The nuclear reactors will operate under the same conditions based on normal operation such as after a planned outage.

The nuclear industry has been a precursor in applying the highest and most stringent quality assurance principles. Over time, it has developed a comprehensive safety culture encompassing both design and human aspects. Based on this, the industry has been able to fully analyse and learn lessons from any incidents and accidents that occurred during its 18000 reactor-years of operation in the world[13]. As a result, the plants currently operating today in Europe benefit fully from these improvements, rendering them much safer than when they were commissioned.

It should be noted that there is no real cliff edge effect in either the level of safety or technical degradation due to ageing when reaching the original design lifetime.

[10] Nuclear Safety Directive 2014/87 – article 8.a.
[11] IAEA (2017): Handbook on Ageing Management for Nuclear Power Plants
[12] Case C-275/09 Brussels Hoofdstedelijk Gewest v. Vlaamse Gewest ECJ "the extension of the licence in the absence of any work or interventions involving alteration to the physical aspect of the site is not a project under EIA directive"
[13] IAEA Power Reactor Operation Years (PRIS)

Security of supply

LTO reduces the EU's energy import dependency – mainly fossil fuels – and provides reliability to the grid

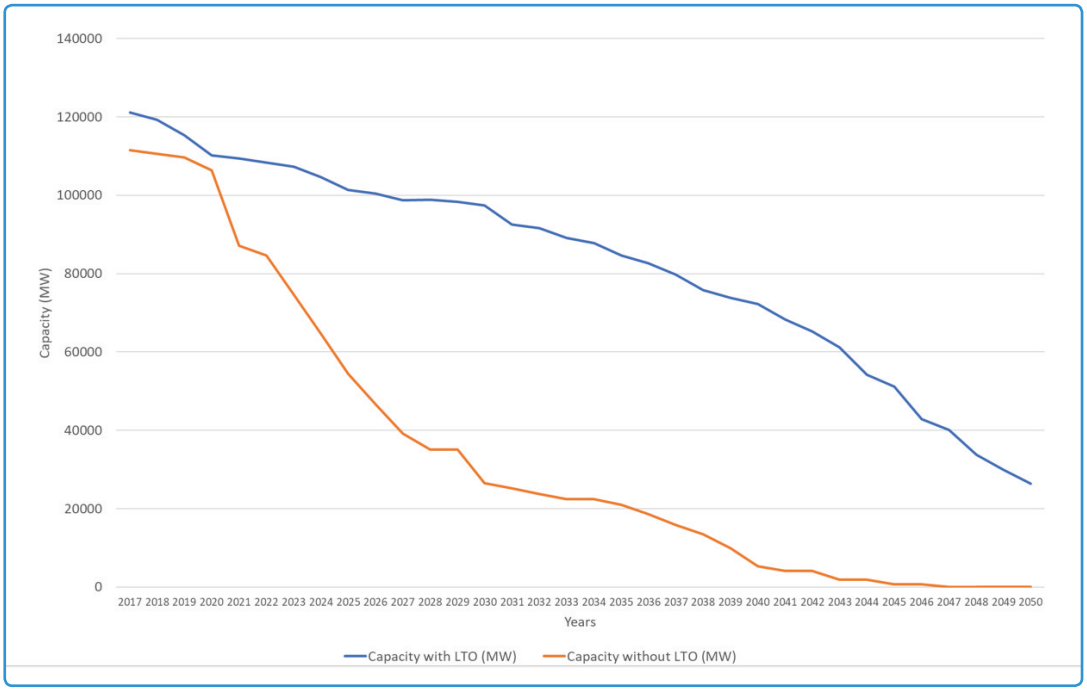

Fig. 7 EU-28 existing nuclear capacity projections with and without LTO (FORATOM own calculation).
Note 1: No new builds taken into account.
Note 2: For the assumptions on LTO the specificity of each country with the different duration of the lifetime extension has been taken into consideration

As shown in figure 7, nuclear capacity trends with or without LTO show a progressive decrease from 2017 to 2050. According to national agendas, LTO nuclear capacity will reach approximately 25 GW by 2050 whereas without LTO, it will decrease to 0 GW by 2046. The gap between these 2 scenarios increases up to a level of almost 71 GW in 2030 and will have to be filled mostly with additional thermal fossil fuel capacity.

The results of a recent study[14] undertaken by FTI-CL Energy Consulting demonstrate that an early closure of nuclear capacity would increase fossil fuel consumption (gas and coal) by 6500TWh. This would in turn increase Europe's fossil fuel dependency as follows:

- 36% increase in power sector consumption of gas between 2020-2050
- 18% increase in power sector consumption of coal between 2020-2050.

If coal is imported in smaller amounts, the dependency on imported gas will become very high (2017 natural gas dependency in the EU-28 attained 74.4%[15]).

[14] Pathways to 2050: role of nuclear in a low-carbon Europe – FTI-CL Energy study, November 2018
[15] Natural gas supply statistics - Eurostat

System reliability

Low-carbon nuclear generation provides firm capacity to the electricity system

It is important to highlight that the decarbonisation of the electricity sector should not jeopardize security of supply. National Energy and Climate Plans so far lack an in-depth analysis of security of supply.

Many Member States are considering the replacement of thermal generation with a massive amount of intermittent renewables in their decarbonization trajectories. Coal generation will be phased-out by 2030 in France, Spain, Italy, Portugal, the Netherlands, Demark, Sweden, the UK, Finland and Austria. Meanwhile Germany has proposed to more than halve coal capacity by 2030 and to phase-out nuclear by 2022. France will cap nuclear generation at 50% by 2035, after delaying it's previous goal of 2025.

Intermittent renewables cannot replace firm thermal capacity in terms of security of supply. For example, wind generation provides a firm capacity equivalent of less than 10% of its installed capacity. Photovoltaic generation provides zero MW of firm capacity. In contrast, thermal and, in particular, nuclear generation provides a firm capacity of more than 90% of its installed capacity. Firm capacity is the minimum capacity available for the system in a worst-case scenario (ie a day of maximum demand and less supply).

In addition, interconnections cannot provide any firm capacity in the event of a generalized issue with security of supply in Europe. Indeed, it seems difficult to justify that all countries can simultaneously depend on their neighbours to ensure security of supply, without any of them being able to even ensure their own.

As a result, the European Commission should urge Member States to include an in-depth analysis of security of supply in their National Energy and Climate Plans. Member States should phase out thermal generation at the pace that minimizes emissions whilst guarantying security of supply. The role which nuclear capacity can play in this scenario is key in terms of ensuring security of supply during the energy transition due to the high availability which this technology guarantees.

Additional benefits

Circular economy

The LTO of nuclear reactors will save raw materials, as the electricity will be produced with existing facilities and far fewer raw materials will be required during their extended operation. It will also reduce the amount of radioactive waste produced (quantity of waste / TWh), as the amount of waste or so called waste intensity resulting from decommissioning will be divided by a larger amount of TWh produced. The waste intensity statement doesn't apply to nuclear fuel which remains at the same level for as long the nuclear reactor operates.

Competitiveness

Choosing the life-time extension option will maintain and develop the European nuclear supply chain, rendering it competitive both locally as well as globally. According to a study undertaken by Deloitte[16], thanks to a combination of LTO and new nuclear reactors, the EU-28 trade surplus (difference between exports and imports) will increase from a current value of 18.1 billion Euros to 33.5 billion Euros in 2050. This increase will be mainly because the supply chain development will not only cover the EU-28 market, leading to a decrease in imports but will also increase the export of local components and potential new reactor designs. The conclusion is that, in addition to covering the EU-28 market, the supply chain will be able to increase exports outside Europe.

Maintaining workforce competences

By choosing LTO, the nuclear industry will benefit from maintaining and upgrading the competences of operators and suppliers as well as providing an additional 350,000 jobs according to the same Deloitte study.

Economic and Social Impact report – Deloitte, April 2019

CHALLENGES

LTO will reduce the EU's energy import dependency – mainly fossil fuels – and will also provide reliability to the grid

Regulatory aspects

As already indicated, even if from a technical point of view LTO cannot be considered as a change in the way the reactor operates, there are still discussions regarding the applicability of certain requirements stemming from the ESPOO and AARHUS conventions regarding the lifetime extension of nuclear reactors.

Industrial challenges

Without LTO it will be difficult to maintain a competitive and skilled supply chain. Without a well maintained and developed supply chain there will be issues when it comes to modernising the existing fleet (digitalisation of instrumentation and control full analogic systems, full scale simulators, 3D models, etc…)

Jobs

According to the Deloitte[19] study, the impact of LTO on jobs is around 350000 direct and indirect jobs. These jobs will be lost without the LTO of the current fleet. Not going ahead with LTO could also pose several other challenges: attracting talent, adapting the workforce to new technologies, ensuring new employees to replace those who retire, maintaining a high level of skills and so on. According to the same Deloitte study, currently around 47% of nuclear industry employees in the EU are highly skilled, therefore making the transition to a new generation of workers will be even more challenging and dependent on access to a well-developed high education system.

Industrial and Energy Sovereignty

With the 3 main economic powers strengthening their position in energy matters by setting export and cooperation limiting regulations (export control for the USA, export control from China, gas and oil tap control from Russia), LTO is a way for Europe to maintain a strong industrial asset capable of feeding the European electrical network for a long period and physically independent from limiting regulations set by other economic powers. Furthermore, the nuclear industry and the R&D programs directly or indirectly related to LTO are important and critical to many industries (medical, food and agricultural, sensor development, space and aerospace, and physics and material physics research). LTO would support European energy and industrial sovereignty.

Specific taxes for the nuclear sector

The decision on whether to go ahead with LTO is an economic one. In some countries this decision is very much affected by the existence of taxes which apply only to the nuclear sector (i.e. Spain, France, Belgium).

Public acceptance

Whilst in some cases public opinion may not always be favourable towards nuclear, this is often due to the lack of information relating mainly to technical aspects. But as explained earlier on, LTO is an opportunity to align existing nuclear reactors to the latest nuclear safety standards. In addition, LTO can be considered as an opportunity as public acceptance in some countries is more favourable towards existing installations than new ones.

Stakeholders awareness

More broadly speaking, one important challenge is to raise awareness amongst a broad range of stakeholders (politicians, media, decision makers, influencers and the public) about the potential consequences of not going ahead with LTO, particularly in relation to climate change. The focus should be on the different benefits offered by all currently available low-carbon technologies as well as providing reliable information about breakthrough technologies which could become commercially viable in the future.

Market failure

More needs to be done to tackle market failures, particularly the issue of wholesale prices being too low and becoming more and more unpredictable due to the expansion of renewables and a carbon price which is not high enough to trigger a switch away from fossil fuels in favour of low-carbon energy.

POLICY RECOMMENDATIONS

Considering the above challenges, FORATOM would like to put forward the following policy recommendations:

- Ensure a coherent, consistent and stable EU policy framework (including Euratom).
    - Fully integrate nuclear power into all energy policy discussions, particularly those relating to the EU's decarbonization goals and security of supply.
    - Ensure coherence between policies – for example, policies aimed at achieving climate goals should support all low-carbon technologies recognised in the EU's "A Clean Planet for All" communication.
    - Ensure technological neutrality.
    - Readdress market failures.
- Agree an ambitious net-zero CO2 emissions target for the EU in 2050, in line with the European Commission's long-term vision for a climate neutral economy.
    - Increase the EU's mid-term (2030) CO2 reduction target to ensure the EU is on track to achieve climate neutrality by 2050 and decarbonize the electricity sector by 2040.
    - Allow equal market access and support for all forms of low-carbon generation. This will enable a more sustainable and cost-effective energy mix and reduce the need for non-market support schemes.
- Develop and implement a strong industrial strategy to ensure that Europe maintains its technological leadership.
    - Support supply chain optimization efforts.
    - Promote, together with regulators, a better alignment of licensing and regulatory processes, and contribute to more harmonization across the EU nuclear sector.
- Support human competences development.
    - Assist in attracting young people to this industry. To do this, and in line with other international organisations, the EU should be more vocal on the fact that nuclear power has a future in the 2050 low-carbon economy.
    - Policymakers, educational systems and industry should work together to ensure generation transition and competence transfer, as well as to help the workforce adapt to new technologies (digitalization, industry 4.0).

About us

The European Atomic Forum (FORATOM) is the Brussels-based trade association for the nuclear energy industry in Europe. The membership of FORATOM is made up of 15 national nuclear associations and through these associations, FORATOM represents nearly 3,000 European companies working in the industry and supporting around 1.1 million jobs.

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