



INVESTMENT FRAMEWORK TASK FORCE REPORT

NUCLEAR



Is a low-carbon energy source



Ensures security of supply



Is environmentally, economically and socially sustainable

EU NUCLEAR INDUSTRY IN NUMBERS



Accounts for
26%
of electricity



Almost
50%
of low-carbon electricity



Supports around
1Mn
jobs



Turnover of
100bn
per year

The FORATOM Investment Framework Task Force (TsF) was created with the mission to ensure that past and current practices in the field of nuclear project development and financing can be shared and discussed, and that future policy prospects can be elaborated at a European level.

This work can be seen as a reference to inform policymakers when preparing national or regional low-carbon energy plans in the perspective of the EU Green Deal, that incorporates €1000 Billion of public and private investments planned to 2027. It comes at a time when financial institutions are now being called upon to establish climate lending criteria which will support the financing of EU's industries and infrastructures. While those lending criteria may have major direct and indirect implications for all financing instruments throughout the EU, organisations may wish to refer to the TsF recommendations.

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Executive summary

It is widely recognised that nuclear will play an important role in achieving the decarbonisation & sustainable energy targets. For example, international organizations such as the International Governmental Panel on Climate Change and the International Energy Agency clearly reference nuclear in all their decarbonisation scenarios. Furthermore, the EU's Joint Research Centre recent report: "*Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')*" makes it clear that nuclear is as sustainable as any other power producing technology recognised as complying with the EU's Sustainable Finance Taxonomy.

Nevertheless, to be able to understand the future role of nuclear, investment project specificities need to be assessed together with financing related challenges. The following report provides an overview of how nuclear new build projects can be financed. It aims to provide guidance to **policymakers and investors approaching financing risks for infrastructure under the transition to a net-zero 2050 economy. In a nutshell, public-private financing schemes for low-carbon infrastructure act as the way forward under the EU Green Deal.** In this respect, nuclear projects are similar to infrastructure lending profiles, whilst bearing in mind that other financing instruments may be considered as alternatives (subordinated equity, debt instruments, loans). Overall, the final cost of nuclear based electricity to consumers and capital providers needs to compete on its intrinsic costs and benefits compared to other forms of low-carbon energy sources (renewables, hydro) and vectors (hydrogen), taking into account the value of carbon. It is clear that the cost of financing is a central factor that can drive down final electricity prices over the long term.

A dynamic risk-based approach to financing using contractual incentives may offer innovative solutions in terms of risk mitigation in the future. An investment framework for nuclear also implies that different stakeholders (including regulators, owner-operators, financing parties, main suppliers) provide their endorsement, while a comprehensive safety regulatory framework ensures design continuity.

Governments play a role in financing (either directly or indirectly) as both public and private financial guarantees that cover debt requirements and debt services are considered critical factors in financing arrangements. In addition, certain financing aspects require third party credit support in order to be able to achieve an investment grade.

Key findings and recommendations

1. Both the investment rating and the ability to attract debt for new projects have a central role to play in the financing of new nuclear projects.
2. Multiple financing mechanisms are required to access a variety of sources of capital.
3. A stable and long-term investment policy framework for nuclear optimizes the distribution and allocation of risks for the sake of the community of stakeholders with a view to ensure consumer value for money. Targeted actions may also need to be developed by policymakers so as to enable a comprehensive investment framework.

4. An industrial management framework for nuclear new build projects at the level of project development and ownership level is a key success factor in managing risk.
5. An investment policy planning for low-carbon technologies such as nuclear power is critical in driving investments and achieving the climate neutrality goals as embedded in the EU Green Deal.

Background

The following aspects have been taken into consideration in the formulation of these recommendations:

- Assessment of investment models for nuclear from nine Member States, taking into account electricity market designs, including remuneration schemes and carbon mechanisms.
- Overview of different practical challenges faced by utilities and project developers in recent or on-going new build endeavours when advancing towards the financing close and considering the different phases of financing.
- Evaluation of credit perspectives and assessments, focusing on the underlying nature of the risk related to the financing of nuclear power and the extent to which an investment grade rating can be achieved.

Setting the scene: The role of financing in securing new investments

Over the last decade, new build nuclear projects - in newcomer countries or in countries restarting their nuclear program - have encountered significant delays in delivering on initial plans¹. Design immaturity and design modifications, inflation of Engineering Procurement Construction (EPC) costs, inaccurate initial cost estimates and additional manpower requirements have contributed to large development and construction cost increases compared to those initially budgeted. European Pressurized Reactors in Finland and France and the Westinghouse AP1000 projects in the United States can be cited as examples that have shown significant levels of complexity in certain phases of project execution.

Based upon experience in the field and a review assessment of how low-cost projects compare to high cost plants, the Nuclear Industry Council in the United Kingdom demonstrated that a potential for project cost synergies and reductions of 30% would be achievable relative to high cost² projects.³

Defined as part of the UK's Nuclear Sector Deal, this 30% cost reduction target and the supporting studies show that cost reductions are possible and present recommendations and actions for how to achieve them.⁴

Aside from the issues of design maturity and learning curve effects, the OECD-NEA and the ETI-NDC have also shown that financing costs form a large part of the end cost (also known as the Levelized Cost of Electricity or LCOE) and therefore that **cost reductions which can be obtained at the level of financing provide a large benefit to consumers.**⁵

Recently, there has been growing recognition that the cost of finance (i.e. the Weighted Cost of Capital or WACC) and the role of financing can contribute towards solving some of the competitiveness challenges. Like any large infrastructure project, nuclear new build financing needs to receive the backing of capital providers and lenders over a long-time frame. Considering this dimension is relevant within a context whereby few (if any) utilities would have sufficiently large on-balance sheet capacity for such financing.

This report aims at discussing the financing arrangements of cost competitive new nuclear plants. It will draw attention to the investment context for nuclear, the models that support the financing of new nuclear projects, the interactions between operational factors, as well as market and financing risks. It will present some key takeaways - following a round of discussions with industry experts, and recommendations on key points which require attention and broad principles to be considered when looking at the financing of future nuclear infrastructures.

This paper will also provide guidance to policymakers on how access to capital can be improved for investments in nuclear power plants, a low-carbon technology and key contributor to achieving the 2050 climate net-zero objectives.

¹ MIT (2018), *The Future of Nuclear Energy in a Carbon-Constrained World - An Interdisciplinary MIT Study*

² With reference to the Energy Technology Institute (ETI-NCD) and LucidCatalyst (2018), *The ETI Nuclear Cost Drivers Project: Summary Report*

³ The studies conducted in the United Kingdom refer to documented experiences of different new built units or programs.

⁴ *Ibid.*

⁵ OECD/NEA (2020), *Unlocking Reductions in the Construction costs of Nuclear: A Practical Guide for Stakeholders*

FORATOM five takeaways and recommendations for project financing

Takeaway 1: Investment ratings and the ability to attract debt for new projects have a central role to play

The debt rating is critical because it determines how much debt a project can raise. Debt rating comes from lenders assessment of different scenarios. The rating is assessed in relation to the credit risk assessment that an entity may not meet its financial obligations when they are due and any financial loss which would arise in the event of a default or impairment.

In particular, an investment debt rating is critical for the construction phase of an infrastructure project. From a credit risk perspective, it is inconceivable that a project would not receive any investment grade rating, otherwise the competitiveness of the project may be affected⁶.

- **Recommendation:** Address the most critical project phase (i.e. construction) with a dedicated enabling framework. The treatment of construction risks under a Regulated Asset Base Model can provide a reference as presented in Appendix 4.

Additional comment: Funding structures based on bond financing would therefore provide some focus on the construction period, which is a delicate phase in the life of a nuclear new build project from a financing perspective. Alternatively, corporate financing (in which debt is raised at the corporate rather than project level) is possible, though one challenge facing this approach is the large volume of investment required for nuclear investments compared to the utility balance sheets (this is considered further below). At the same time, financing may help alleviate some of the concerns raised above.

Takeaway 2: Diversifying financing mechanisms which reflect project attributes enable access to a broader source of capital

Under any new financing model for nuclear new projects, it is important to understand the key role that risk allocation plays between the host country, the developer, the Engineering Procurement Contractor, the utility and the lenders.

- **Recommendation:** Consider a multi-sourcing approach for future projects and, depending on each individual project's specificities, assess the following financing sources:
 1. A commercial offtake agreement that secures offtake conditions from the power plant.
 2. Direct ownership (Investor based model, multi owner model, corporate model).
 3. Refinancing options.
 4. Guarantees (public, export).
 5. Fiscal policies.
 6. Clean energy supports.

Such multi-sourcing approach has been inspired from a number of projects that were reviewed within FORATOM's expert discussion (See Appendix 5).

Ultimately, such an approach will allow a mix of financing solutions to emerge whilst at the same time providing the means to engage with specialised infrastructure financing or in international bond markets. Under such a multi sourcing approach, an Export Credit Agency's financing and export guarantees may act as a central axis to allow other financing sources to be anchored.

⁶ There are three large agencies (S&P, Moody's and Fitch) providing investment rating to corporate issuers. **Example:** Moody's rating system is distributed between different categories (AAA to Ca) and power utilities tend to be recognised as investment grades under the rating methodology 'Unregulated Utilities and Unregulated Power Companies', under which they tend to receive ratings above the BBB+ level.

Takeaway 3: A stable and long-term investment policy framework for nuclear optimizes the distribution and allocation of risks for the sake of the community of stakeholders along with a view to ensure consumer value for money.

As mentioned earlier, risk allocation between players plays a major role for large infrastructures.

- **Recommendation:** Public policies at national and EU level need to identify fundamental principles of economic regulation. Such a framework is to be endorsed by different stakeholders (including regulators, owner-operators, financing parties, main suppliers) based upon a comprehensive safety regulatory framework that ensures design continuity. Under such an approach, some clarification would be provided on who bears the project related risks: vendor (fixed price), operator/investors (merchant model), government (via an equity stake), or consumers (Regulated Asset Base model). Meanwhile, this inclusive decision process shall also factor in the conclusions of public consultations pending approval of the notification of the investment model according to EU State Aid legislation.

Takeaway 4: A management framework for nuclear new build projects at the level of project development and ownership level

A reference framework for monitoring the progress of nuclear projects should not focus entirely on the perception of economic values at completion (based on costs and deadlines). Having projected contractual milestones which need to be reached is very important in monitoring its financing, as seen in the case of the successfully executed CGN-EDF European Pressurized Reactor project in Taishan 1&2. "Milestoning" allows for the sharing of information on concrete elements far before the financing decision and along some short time scales of 1, 2 or 3 years.

- **Recommendation:** In progressing towards achieving low financing costs, corporate and sustainability reporting frameworks can play a major role, as they help to disclose both financial and non-financial information of relevance for investors⁷. As some of this information becomes mandatory for utilities financial and non-financial reports, transparent and harmonized frameworks need to be proposed to investors. This topic is of relevance under the Renewed Sustainable Finance Strategy, as the choice to adopt corporate sustainability reporting also importantly reflects the environmental and social attributes of nuclear when engaging with investors.

Takeaway 5: Reconciliation of investment policy planning exercises and long-term climate goals

The articulation of the EU's climate related goals with energy planning takes place at different institutional levels and extends to the 2030 and 2050 horizon, under the EU's Climate Law's binding objectives relating to net GhG emissions⁸. By 2050, the energy system will deliver a net zero-carbon mix while offering large scale back-up capacities, according to the EU's climate objectives.

In providing visibility to investors, energy and climate planning plays a facilitating role at all levels (EU, regional and national). Policy clarity, coherence and consistency are key building blocks of the policy risk assessment when launching infrastructures projects. Political statements that confirm the important role of nuclear in a country's future energy mix (including the need for nuclear in order to achieve decarbonisation targets) is also an important signal for investors.

⁷ Information that is deemed material to investors is an information of which omission would lead to the investment decision not taking place – The European Commission is working on a double materiality definition.

⁸ European Commission (2020), *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law)*, COM(2020) 80 final

- **Recommendation:** EU's Renewed Sustainable Finance Strategy – as part of the EU Green Deal Action Plan - must facilitate the alignment of nuclear projects with climate goals. A scientific and risk-based approach to investments and to environmental and social externalities under a 'scenario based' and 'technology neutral' approach⁹ would help assess the viability of future nuclear new build¹⁰.
- **Additional recommendation:** More focus should be given to Research & Innovation which has the potential for multiple applications. In order to improve planning and prospective capacities, public authorities have to be made aware of the fact that financing stands as a key success factor in future new build investment decisions.

1. Investment context and challenges

Investments in nuclear are programmed over a longer period with operating lifetimes of 60 years or more as compared to 25-35 years for renewables. Generation II and Generation III Pressurized Water Reactors can be licensed for over 60 years. In the US, nuclear power generators are applying for 80 year licences.

A - Context specific nature of a project-based costs

The economics of nuclear in the four main regions (United States, Europe, Asia and the Middle East) have very distinct characteristics. Those regions (covering OECD and non-OECD) have varying levels of technological maturity and different market regulations and designs. There is also a large difference in investment cost compositions which leads to diverse levels of expected financial flows and returns on a project¹¹. As licensing and design requirements (or design changes to initial requirements) vary between regions, indirect costs allocated to a new build project may also vary.

B - Recent trends in new build developments

Further to a slowing down in the development of new nuclear installations in terms of capacity growth during the 1980s and 1990s, particularly in advanced economies outside Japan and Korea (IEA-2019), a new construction cycle picked up during the 1990s at a global level. Large scale new projects have been launched in several developing economies (with 40 reactors currently under construction), led by the People's Republic of China and India. In the EU and its neighbouring countries, a number of projects are advancing towards construction or evaluation, notably in the United Kingdom with both the Hinkley Point C and the Sizewell-C projects¹².

Global investments in nuclear - including investments in the existing fleet of nuclear reactors (Long Term Operations LTOs) - are currently estimated at 35 Billion USD (IEA,2020)¹³. The size of annual investments in nuclear is therefore much lower when compared to renewable-based technologies (wind, solar, biomass, hydro) that represent an amount of 235 Billion USD (IEA, 2020).

⁹ FORATOM (September 2019), Position Paper: *Sustainable Finance: FORATOM calls for equal treatment of all low-carbon technologies*

¹⁰ European Commission Joint Research Centre (2021), *Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')*, Petten, JRC124193.

¹¹ OECD/NEA (2012), *The economics of long-term operation of nuclear power plants*, p.44

¹² Equivalent to 59 GW of new capacities

¹³ Long Term Operations or LTOs refer to the operation of nuclear beyond an established timeframe (an operating life defined by safety licensing)

C - Investment cost drivers in nuclear and other low-carbon sources

This section dives into industry cost trends and explains to what extent the cost of financing is an important driver of total unit costs. In addition, it reflects upon the benefits and limitations of Levelized Cost of Electricity (LCOE) when comparing different generation technologies.

- **LCOE definitions and limitations**

Definition: The Levelized Cost of Electricity (LCOE) metric indicates the average revenue per unit of electricity generated that is required to cover the costs of building, operating and financing a power plant during an assumed operating life. According to LCOE, costs and revenues are discounted back to today's value using the Net Present Value methodology. Therefore, unit electricity costs measured as LCOEs provide an output based assessment of how investments will economically perform over time in a system, under a set of operational factors: load output and remuneration structure (merchant, capacity based, grid fee, carbon content) and based upon an assumed cost of capital and plant based performance (plant load factor).

- **What information needs to be factored in to achieve a technology neutral stance in policy decisions?**

As the Lazard studies show since 2009, LCOE's historic trends may be helpful for investors in tracking both market and financing dynamics within and between regions, as they provide an indication of the relative costs of different technologies and how these are changing over time. As LCOE provides an assessment of the revenue required to cover a project's costs, they can also be one indicator considered in policy decisions, although there are limitations which means it should not be relied upon in isolation¹⁴.

Policymakers considering the benefits of nuclear relative to other low-carbon technologies (under a technology neutral approach) should ensure that their analysis also incorporates externalities relating to system integration (capacity value and grid related costs) and environmental impacts (contribution to a system carbon mitigation and adaptation). The International Energy Agency provides estimates for LCOE under the horizon of 2040¹⁵.

Enhancements to LCOE are being proposed as additional elements under Appendix 5 regarding the advantages and limitations of LCOE for investors.

- **What factors drive nuclear LCOE in comparison to other technologies?**

Given the long operating life of nuclear and the level of capital intensity (6900 USD/KW – 12000 USD/KW according to Lazard-2019), profitability assessments show a large range of sensitivities to the average Weighted Cost of Capital. Out of all technologies, **nuclear stands as the most sensitive to a change in capital costs and to factors used when assessing the financial benefits of an investment and comparing those benefits to alternative low-carbon opportunities**¹⁶.

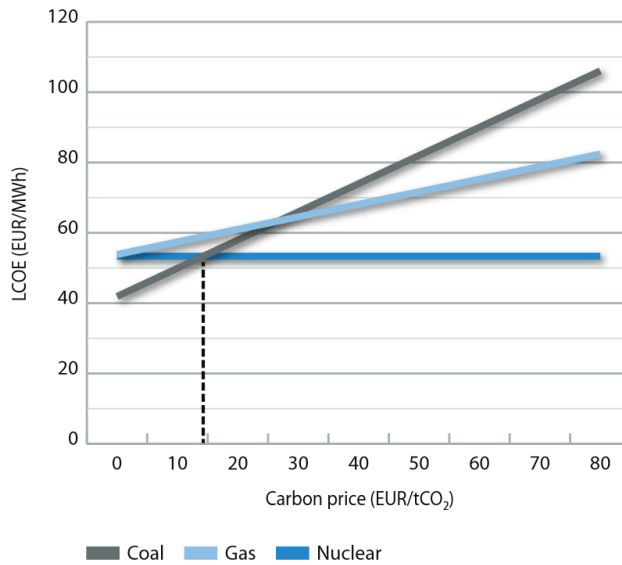
When comparing the opportunity of an investment in nuclear with coal and gas power generation in Europe, nuclear positions itself as a low-carbon and cost competitive alternative to fossil-based generation as long as the cost of capital stays below the level of 7%, as illustrated in Graph 1. Above such a nominal cost of capital threshold, total financing costs grow to levels that may breach what governments, regulators and consumers consider as affordable.

¹⁴ Timilsina, G. R. (2020). *Demystifying the Costs of Electricity Generation Technologies*. The World Bank.

¹⁵ IEA (2019), *Nuclear Power in a Clean Energy System*, IEA, Paris

¹⁶ Cameron, R., Marcantonini, C., & Keppler, J. H. (2011). *Carbon Pricing, Power Markets and the Competitiveness of Nuclear Power*. Paris Dauphine University.

LCOE of different power generation technologies at a 7% discount rate



Graph 1 - Carbon Pricing and LCOE sensitivity¹⁷

While LCOE reflects the competitive positions of projects or/and technologies in different regions of the world, they are also largely dependent on other factors such as capital market liquidity, and the ability to identify alternative opportunities for investors. Regulatory stability and visibility plays a major role in attracting investors and therefore they indirectly affect LCOE developments, because they are affected by the cost of finance¹⁸.

D - The role of carbon markets for nuclear – Impact of the EU reform

For nuclear power generators, carbon prices provide an additional remuneration for electricity which reflects the fact that nuclear emits less greenhouse gases (mainly carbon) than the average power system and therefore directly contributes to carbon abatement with a life cycle emission of 12 g CO₂/kWh¹⁹. The carbon component is not always perceived as directly financeable because it has a system value more than a project value and can be affected by political risk.

Carbon pricing should take the form of a financial incentive. In the EU, there are various exchange systems and mechanisms relating to carbon certificates and schemes (European Trading Schemes, green certificates, carbon floors). Investors, policymakers and other parties believe that carbon pricing will be an important driver for investments in low-carbon technologies under climate mitigation and adaptation objectives²⁰.

Reminder: Greenhouse gases exchanges in the United States, EU and China, the abatement price is driven by the marginal cost of a tonne of GhG reduction (either via trading or auctioning). The European Emission Trading Scheme (ETS) monetizes the carbon value from all power generation plants (EU Allowance Unit price). Prices tend to reflect arbitration from high emission sources to lower emission sources²¹. Outside of the ETS, carbon abatement prices can also be calculated for new technologies such as carbon capture and storage or hydrogen-based technologies, that will provide additional large-scale carbon mitigation options to 2050.

¹⁷ *Ibid.*

¹⁸ Prudential Capital Requirements - Basel Capital Regulation - have been cited as obstacles for large banking institutions.

¹⁹ Bruckner, T. et al (2014). *Technology-specific Cost and Performance Parameters* [Annex III]. In *Climate Change 2014: Mitigation of Climate Change* (pp. 1329-1356). Cambridge University Press.

²⁰ Edenhofer, O. et al (2019). *Options for a carbon pricing reform.*

²¹ See European Electricity Exchange – Emission Unit Allowances (EUA), Spot, Futures, Options

Carbon market failures may materialize at different levels within the mechanisms that underpin the exchange of carbon allowances.

For instance, the carbon market may fail in delivering liquidity to operators and investors. Meanwhile, there may also be a failure to provide an efficient price formation and forward price visibility. In some regions, a situation marked by a structural oversupply and low-carbon prices (below €40/tonne) has recently proven detrimental to governments, market actors and investors. Carbon price floors have been proposed in some countries (e.g. Sweden and France) to tackle and clear some of the uncertainty faced in the market.

Carbon pricing mechanisms are also subject to significant political risk (particularly for an asset with as long an operational life as a nuclear power plant). For example, in the UK a carbon price floor (which was applied to fossil fuel generators in addition to the ETS) was introduced in 2013 at €9/tonne and intended to follow an increasing trajectory to €30/tonne in 2020. However, in 2015 the UK Government froze the carbon price at €18/tonne until 2021. The arrangements for carbon pricing following the UK’s exit from the EU are still being confirmed.

Under the EU ETS, a Market Stability Reserve (MSR) for the phase covering 2021 – 2030 has been put in place and carbon prices are expected to adjust upward as the reserve grows and reduces the amount of allowances in circulation.

Even if the EU carbon price has risen significantly since the MSR was announced (from €5 to €25-30/tonne CO₂), the carbon emission price (€25/tonne CO₂ on 20/10/2020) is still far from a level that would provide any policy certainty. According to the Nuclear Illustrative Programme - PINC 2017 – a carbon price in the range of 43 to €72/tonne of CO₂²² is needed for investors in order to act as a long-term financial incentive to nuclear new build.

		BSL	MIX-50	REG	MIX	MIX-non CO ₂	CPRICE	ALLBNK
Carbon Price in €15/tCO ₂	2030	32	36	32	44	44	60	65

Table 1 - The carbon price level under the Commission’s 2030 scenario analysis²³

- **Over recent years, carbon pricing has been highlighted by many governments and institutions as the most important climate policy signal that can result in effective carbon abatement and mitigation trajectories. Yet, it does not constitute a clear investment signal for large-scale capital projects with a long operating lifetime. Any failure to deliver on a liquid, efficient and visible carbon price needs to be fixed through additional measures to offer more certain remuneration to low-carbon power generators.**

In Europe, the EU Green Deal adopted at the end of December 2019 and its commitment to reach carbon neutrality by 2050 strengthens the case for more ambitious climate action and a wider application of carbon pricing, to be complemented by a Carbon Border Adjustment mechanism, that would ensure that the price of imports of goods and services reflect more accurately their carbon content thus reducing the risk of carbon leakage. Furthermore, a carbon border tax adjustment would need to be designed so that the benefits of low-cost nuclear electricity to final consumers remains unaffected.

In this context, construction cost reductions will have to be taken into account in nuclear investments with regards to achieving climate ambitions.

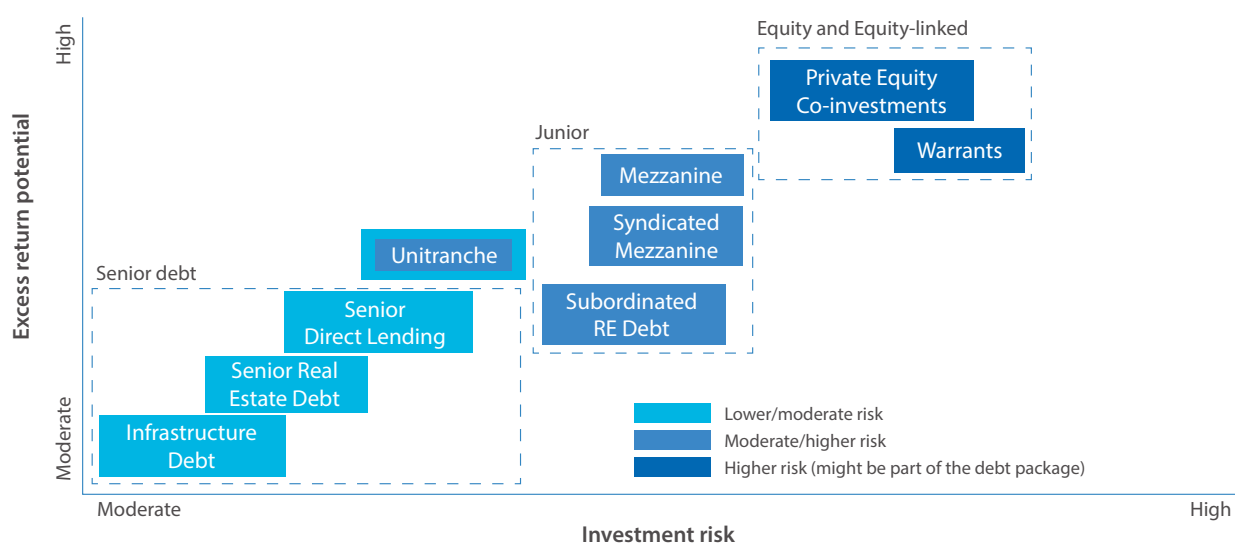
²² European Commission (2017), *COMMUNICATION FROM THE COMMISSION Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty -Final (after opinion of EESC)*, COM(2017) 237 final

²³ European Commission (2020), *Impact assessment - Accompanying the document COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Stepping up Europe’s 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people*, (SWD(2020) 176 final)

E – What are the critical phases to attract financial investors?

This section discusses issues that may occur when a project is being proposed to a set of financial institutions before financial close. It is based on the exchanges conducted within amongst the industry (Best Practice Assessment of Projects) and indicates how risk gaps may occur depending on a different set of financing models. To this extent, it explains where and how the industry would foresee the most critical phases related to financing risk.

Risk perceptions drive capital costs and the possibility to fund investment vehicles which support new build construction and operations²⁴. Risk can only be appreciated depending on “who takes the risk”. For corporate banks, the financing proposition will go through various bankability assessments, while equity shareholders will be attracted by the capacity of an asset to yield dividend over the equity asset value.



Graph 2 - Relationship between return and investment risk²⁵

Risks are assessed and quantified differently depending on the form of the financing source that is included within a funding instrument. Equity investors (shareholders) are willing to accept a higher risk level compared to debt holders with an expectation of higher returns. At the level of bondholders, minimum credit and cash flow-based coverage indicators (debt / interest, cash flows / interests, cash flows / debt) and liquidity levels need to be sustained overtime otherwise an investment may encounter financial distress and cash flow imbalances, and could ultimately face a number of rating downgrades and potentially lead to a default.²⁶

Different approaches may be conducted in order to assess financing and progress along financing objectives. Gap analysis may be conducted at the level of investments (investment gap) or cost of capital (risk-based gap assessment). In instances where risk gaps and aversions are not fully addressed by other measures (for example, a Credit Guarantee), a residual market failure may be identified.

More broadly, the fact that a number of residual market failures may not be sufficiently addressed by existing regulatory frameworks at EU level – notably with the EU Emission Trading Scheme or at the level of national capacity markets - may push investors to request some form of public investment support (revenue supports, risk mitigation supports).

²⁴ Investors’ risk perception can be defined as the level of cash generation and of real long-term growth generated by 1 Dollar of Investment.

²⁵ *An overview of private debt* (2019, 11 February), Principle for Responsible Investments

²⁶ Moody's (2019) *Construction Risk in Privately Financed Public Infrastructure (PFI/PPP/P3) Projects*

2. Competitiveness of nuclear financing

A nuclear new build project spans over long lifetimes and involves many industrial activities from uranium supply to plant decommissioning, waste treatment and recycling²⁷. These activities develop over time depending on industrial partnerships, with some important differences between countries and regions, where governments, plant owners/operators, contractors and developers, vendors, and services providers may have different roles, positions and ambitions.

The development of new nuclear installations in terms of capacity growth slowed in the 1980s and 1990s, particularly in advanced economies outside Japan and Korea (IEA-2019). Construction has picked up since then, with most new projects located in developing economies, led by the People's Republic of China and India. According to the International Energy Agency, there are currently 54 reactors under construction, of which 40 are in the developing economies²⁸. In the EU and its neighbouring countries, the Investment Framework Task Force reviewed seven projects under construction or evaluation (See IFTF table).

Barriers to entry are elevated and this is partly related to the licensing cycle of nuclear technologies and the underlying and increasing safety dimensions. Export specificities and restrictions have emerged, and this implies that the nuclear equipment market cannot strictly be compared with other energy industries²⁹. For a company wishing to enter a country as a prime contractor, public support in the form of a governmental agreement is a prerequisite.

A - Cost of financing and nuclear new build costs

Investments in nuclear projects are characterized by a high proportion of capital costs during the construction period (construction lead time) leading to large financing costs. While leveled capital costs typically account for around 70% of total production costs for a new build plant, costs are largely fixed in their nature³⁰. Variable expenses are associated with the fuel cycle costs (estimated on average at 12% of total costs) and the plant's power generation output³¹.

Fixed and variable investment costs can be divided into Overnight Construction Costs (OCC) and capitalized financial costs³². The project construction lead-time directly impacts total capitalized financial costs and forms a very large component of total production costs. Mechanisms to reduce the cost of financing can reduce these costs significantly.

B - Capital funding instruments in a nuclear new build plant

Financing costs include cost of debt and cost of equity. The cost of debt depends on different factors like credit rate, interest rates, location, risk premium, guarantees, access to "green bonds" and other forms of green or infrastructure labels.

²⁷ With the current fleet having an operating lifetime of 60 years similar to new designs life.

²⁸ Equivalent to 59 GW of new capacities

²⁹ Lévêque, F. (2014). *The international trade of nuclear power plants: the supply side*. Revue d'économie industrielle, (148), p.64.

³⁰ Likhov, A. (2012), *The economics of long-term operation of nuclear power plants*, OECD/NEA. These values have been computed for an OCC of USD4500/kWe, a load factor of 85%, 60 years lifetime and 7 years of construction time at a real discount rate of 9%

³¹ *Ibid*. These values have been computed for an OCC of USD4500/kWe, a load factor of 85%, 60 years lifetime and 7 years of construction time at a real discount rate of 9%

³² Capitalized investment costs derive from future capital expenses being discounted to today's value in using a discount factor.

Long-term financing may be sourced from the debt capital market where lenders require an interest charge over an amount of net debt (interest rate) to be repaid according to a debt schedule repayment.

Capital providers (pension funds, sovereign funds, private banks, etc.) originate capital from various sources (for example pensions) and then provide equity and debt to capital markets. The level of engagement and guarantees mobilized, notably when it comes to securing Export Credit Guarantees or to provisioning long-term engagements, contribute to attracting capital.

- Debt capital can be provided under different forms. Export credit agencies (see the Barakah United Arab Emirates), government to government loans (government backed financing to a state-run NPP technology vendor), bond issuances or host government debt coupled with a cooperative funding mechanism (See Appendix 3 - Mankala financing model)³³.
- Equity capital can be provided under the form of a liability on a utility's balance sheet, host government investment (See Appendix 4 - UK projects - Sizewell C) or vendor equity commitment.

Among the debt funding sources, Export Credit Agencies (ECAs) have been playing a key role for many years with the provision of insurance products and/or long-term financing instruments. Both ECA's financing and export guarantees shall be considered as an important lever to the financing model.

Given the long construction and operating lead horizons, equity commitments need to be aligned for a relatively long period of time by all kind of investors. This case has been illustrated by the Belene Nuclear Power Plant project in Bulgaria³⁴.

3. Ownership models associated to the financing of nuclear projects

There is no single approach to the financing of a nuclear project and ownership is no longer the single determinant to a financing model. Financing models vary depending on the location and maturity of the project: in advanced or in developing economies, the associated level of maturity and track-record of a technology also has an impact.

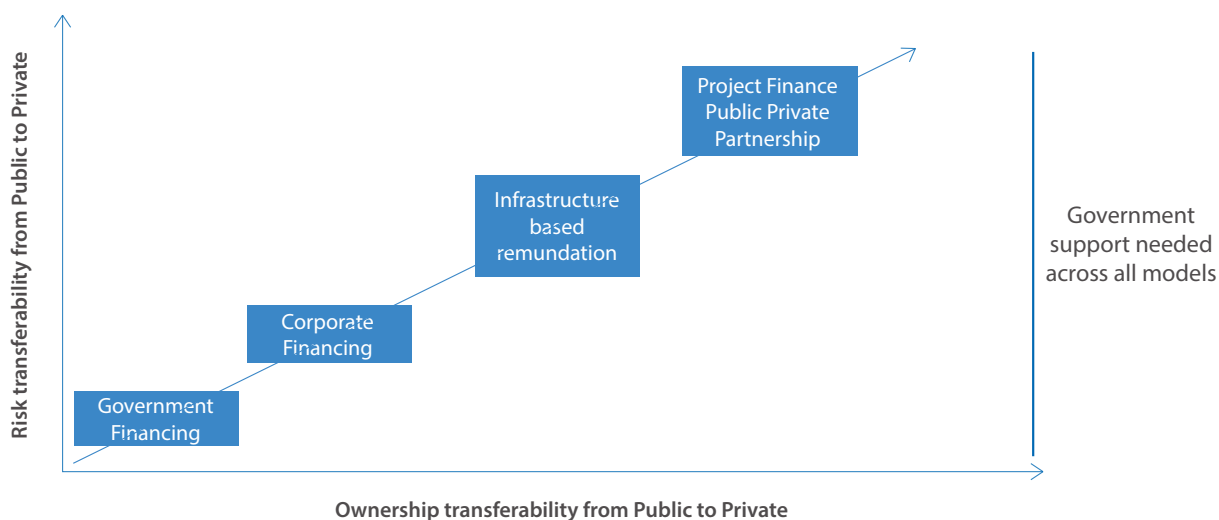
OECD-NEA (2020) distinguishes between three models:

- Government financing model (Sovereign model): The project can be funded directly through the state budget or via indirect forms of public borrowing (e.g. government owned development bank). This model implies that taxpayers would carry a number of project risks. Countries with low sovereign risks (above BBB-rating) would be able to provide advantageous financial conditions, including for international projects, as the project will benefit from the state's credit rating.
- (Private) corporate model: Utilities with a strong balance sheet can finance large projects by raising equity and borrowing money (debt). Creditors may claim their loan against the company's assets as a whole³⁵.
- (Private) project finance model: A project company is created which establishes a legal separation between the project and the sponsors' other assets. Hence, lenders have limited recourse beyond the revenues and/or assets of the project. As the debt remains in a project company, it is accounted in the form of an "off the balance sheet" engagement.

³³ "UAE's nuclear power project achieves \$24.4 bln financing close" (2016, 20 October) *Reuters*

³⁴ "Bulgaria unveils wide interest in belene project" (2019, 20 August) *World Nuclear News*, New Nuclear

³⁵ *EIB energy lending policy : Supporting the energy transformation* (2019, 14 November). *European Investment Bank*. and FORATOM's response to the EIB consultation in "FORATOM highlights need for investment in all low-carbon technologies to meet climate challenges" (2019, 2 April) FORATOM.



Graph 3 - Ownership models and risk transfer dynamic³⁶

A. Comparison with renewable-based financed models

The International Energy Agency has recently provided detailed information on the various finance techniques used by project developers, when it comes to financing new build renewable energy generation projects³⁷.

The financing of renewable-based projects broadly covers two forms:

1. The balance sheets of the project owners.
2. Financing mechanisms such as syndicated equity from institutional or sovereign investors and debt from banks.

Under all financing schemes, fixed returns provided through stable remuneration schemes (Power Purchase Agreements [PPAs], Feed In Tariffs) coupled with a lowering of manufacturing costs and efficiency gains have proved attractive for investors in certain regions of the world.

- For instance, RES project finance based on a PPA has grown significantly in the United States³⁸. In 2019 alone, global renewable capacity jumped by an estimated 184 GW to 1 627 GW, which resulted in an average growth in installed capacity of 14% per annum when observed over a 10 year period.

Renewable project finance can be described as a homogenous asset class in terms of the technique it uses, and the risk-return components of projects vary between the different regions of the world and largely depend on support schemes (Renewables Portfolio Standards-RPS in the United States and Clean Energy Standards)³⁹.

Utilities and some financial investors have been constantly growing their renewable portfolios since the early 2000's. The start of 2020, however, marked a sharp slowdown in the growth of asset finance, with a lower amount of project finance being compiled after the Covid-19 crisis.

³⁶ Adapted from Barkatullah, N., & Ahmad, A. (2017). *Current status and emerging trends in financing nuclear power projects*. *Energy strategy reviews*, 18, 127-140.

³⁷ With the publication of the World Investment Outlook

³⁸ United Nations Environment Programme and Frankfurt School-UNEP Centre (2019), *Global trends in renewable energy investment 2019*

³⁹ IEA (2020), *Energy Investing: Exploring Risk and Return in the Capital Markets*, Joint Report by the International Energy Agency and the Centre for Climate Finance & Investment, Paris

B. Ownership and financing models

There is no single approach to the financing of a nuclear project and ownership is no longer the single determinant of a financing model. Financing models vary depending on the location and maturity of the project: in advanced or in developing economies, the associated level of maturity and track-record of a technology also has an impact.

From an ownership perspective, two main models have been used in past nuclear project financing: a government financing model (or sovereign model) and a corporate financing model. In both of those models, governments play different roles either as 'investors' or as technology 'providers' to a state-owned company. Under corporate financing models, governments co-invest with corporates.

- A state-owned operatorship model is largely developed in developing economies while a private operatorship model is largely developed in advanced economies⁴⁰.
- Private models (corporate model, project finance, co-financing) imply that financial risk is being transferred from the public sector to the private sector.

Financing models may also combine governmental support and a private financing source within a diversified pool of financing sources. Some recent interest in project finance results from the fact that due to its legal dimensions (lenders have a recourse on the project asset), project finance makes it relatively easy to establish risk sharing mechanisms between the different parties. Whilst project financing can be considered as a reference model in large energy and commodity infrastructures such as Liquefied Natural Gas, large-scale renewables or hydro, it has been rarely used in nuclear projects. Although nuclear-based project finance remains limited, a recent deal in the United Arab Emirates⁴¹ has taken this approach⁴².

C. Key success factors for financing a nuclear project

A set of different factors have been discussed in expert roundtables (which included a number of observers). These factors are deemed to constitute a key strength for the success of projects.

While the key fundamental objectives of financing are to secure finance at an efficient and low cost of finance, those objectives shall also be set up to make sure that there is a mechanism and discipline in terms of frameworks and state aid compliance.

1. Governmental support for nuclear should come first. In terms of government support, different agreements may be elaborated between the government and the nuclear industry. For instance, financial support for front-end spending would help advance the project towards the construction phase. During the development phase, government support shall be envisaged with a view to reduce the development period risk. During financing, governments may be involved in the risk allocation through the provision of explicit government guarantee.
2. Market-based frameworks need to strengthen the competitive proof testing and improve the acceptability of investment in nuclear at the levels of off-takers and investors. Recent projects experiences in the United Kingdom (Sizewell-C Second of a Kind [SOAK], building upon the experience of Hinckley Point C) and Romania (Cernavoda units 3&4) show to what extent revenue mechanisms need to be established as backbones of electricity markets and alongside state aid rules. In designing a revenue model, price and volume limitations (cap and/or floors) act as key risk mitigation factors. As proposed in Dukovany II (Czech Republic), the scheme consists of a combination of a repayable loan and an off-take contract for the entirety of the power generated between CEZ and the Czech Government.

⁴⁰ IEA (2019), *Nuclear Power in a Clean Energy System*, IEA, Paris

⁴¹ Turak, N. (2020, février 17). "The UAE gets green light to operate the Arab world's first nuclear power plant". *CNBC*.

⁴² Ray, S. (2015), *Infrastructure Finance and Financial Sector Development*. ADBI Working Paper 522. Tokyo: Asian Development Bank Institute.

3. Reliable and proven designs do mitigate the technological design risk and they have been assumed as a key prerequisite of any investment decision on new nuclear.

Notwithstanding the need of proven track records, Small Modular Reactors may provide new heat applications, and that potentially would unlock some of the challenges related to financing. The primary potential benefit for financing SMRs is that they have a lower capital requirement and shorter construction time.

Project remuneration scheme and design	Example of support to Low-Carbon Energy Financing	Impact on nuclear risk acceptability for shareholders
Pure merchant Model	Wind Onshore	Financing not possible under current merchant conditions ⁴³
Power Purchase Agreement (PPA) in an unregulated market	Renewables (Wind Offshore – Solar CSP)	Mitigation of market price risk does benefit shareholders
Offtake agreement under a cooperative model	Nuclear New Build – Mankala Finland	Elimination of the market price risk positive for shareholders
Purchasing Power Agreement (PPA) with a central buyer	Nuclear New Build - Romania	Direct benefit – Counterparty guarantee required

Table 2 - Examples of Low-Carbon Project funding schemes and impact on project risk acceptability⁴⁴

D. Understanding credit risk in light of political risks

As credit risk tends to be relatively high at the inception of the project, financing needs to drive credit risks down over the project life-cycle, assuming the project does not face any unplanned cost overruns⁴⁵. Under any financing structure, the financing model can be adapted to different degrees of market liberalization and can be combined with an export credit guarantee in some regions.

There are two implications from such an approach. The first one is that the ex-ante credit worthiness of the project becomes public before financial close, as third parties conduct due diligence on the project before its sanctioning.

Secondly, an assessment of the political context (and construction risk) needs to take place when the financing is being arranged. Often, political risk guarantees are required to attract both commercial lenders and institutional investors, while this implication is also relevant under a corporate finance model.

In financing a new nuclear project, credit risk protections and political risk understanding therefore become equally important considerations to both industrial and financial investors as well as for institutional stakeholders.

Regulated asset base structures, similar to the experience in the United Kingdom (with the regulated infrastructure model used for the Thames Tideway Tunnel and where the financing model was allowed to extract a nominal WACC of 5.5%⁴⁶) can be used to secure a credit rating .

Political risk - assessed as any change in framework conditions that puts the economics of an investment into imbalance and affects a project’s financial continuity - has been mentioned by the industry as a concern that investors need to consider carefully. Past project experiences have shown that political risk and change in law risks have manifested not only when the nuclear industry acts as a private investor in a foreign country, but also within the EU’s jurisdiction (see nuclear phase out decisions in Germany and Belgium).

⁴³ Electricity prices, wholesale market liquidity and forward visibility have been assessed as too low by experts of the FORATOM Investment Framework Task Force

⁴⁴ Source: Investment Framework Task Force - FORATOM

⁴⁵ Along the lifetime of the project, decision gates can provide options to exit the project in the event that it does not comply with contractual milestones as illustrated in the United Kingdom Moorside project.

⁴⁶ Zhivov, N. (2018). *The Thames Tideway Tunnel: a hybrid approach to infrastructure delivery*.

Policy risks cover a set of different risks such as:

- Project cost increases due to changes in licencing policies (Licensing and Completion Risk).
- Loss incurred due to political changes that affect completion (Licensing and Completion Risk).
- Variations in fiscal law.
- Economic losses due to delayed approvals.

For the incumbent utilities that are listed on the stock market, the decision of Germany to phase out its nuclear capacities has exposed equity and debt investors to a de-facto decision. This decision had numerous consequences on the balance sheet of the utilities exposed to this risk and this resulted in a restructuring of the utilities sector⁴⁷. Legal claims were brought by some utilities under Energy Charter rules and state aid principles were also challenged.

The OECD Principles for Public Governance of Public-Private Partnerships highlight the need for governments to establish clear, predictable and legitimate institutional frameworks for infrastructure investments⁴⁸. By establishing strong legal conditions and frameworks, governments have a central role to play in improving the perception of investment risks.

⁴⁷ With implications on the long term financing of nuclear waste management.

⁴⁸ OECD (2012) *OECD principles for public governance of public-private partnerships*

Appendix 1. Examples of Low-Carbon Project funding schemes and impact on project risk acceptability

	Global market size (Nominal Value) bn USD	Scale / Market dynamic	Final Investment Decisions Min-Max levels (Volumes) GW/year	Capital providers
Nuclear	35	Large scale to mid-scale Base Load	5-18 GW / year	State Owned Enterprise (SOE), Public
Utility Scale Renewables Wind and Solar ⁴⁹	234	Small – mid scale Mid-merit and Peak Load	60-165 GW / year	Private, Public
Hydro	54	Large scale to mid-scale Base load – Peak load	9-37 GW / year	SOE, Public, Private

Source: FORATOM Investment Framework Task Force (IFTF) - IEA (2020), *World Energy Investment 2020*, IEA, Paris

⁴⁹ Utility scale refers to photovoltaic or wind plants that are aggregated and connected to the grid.

Appendix 2. Proposed enhancement to LCOE analysis for nuclear

Assessing ex ante on the ground of the individual design and technology characteristics, what would have to return in the form of revenues (electricity and capacity). To this extent, LCOEs can be very valuable in providing a comparative assessment between different technologies. However, the LCOE methodology remains theoretical and does not provide true information about the level of profitability obtained once observed electricity prices exceed the calculated break-even level and they are not suitable when it comes to system costs (balancing costs) and dealing with volatility assessment of power market trends.

What is relevant to consider is the probability that the LCOE does not deviate from real time market price observations and expectations. For instance, in case of a deviation of the construction lead time, the patterns of overnight cost overruns can be evaluated under different scenarios, cost curve assumptions and market assumptions.⁵⁰

Proposed enhancements of LCOE

In 2018, the International Energy Agency introduced a **Value Adjusted LOCE - VALCOE** measure. The value-adjusted LCOE (VALCOE) incorporates information on both costs and the value provided to the system. Based on the LCOE, estimates of energy, capacity and flexibility value are incorporated to provide a more complete metric of competitiveness for power generation technologies.

A selection of authors from other institutes is proposed. Those have suggested enhancements, where the benefits which nuclear brings to system costs (firm capacity and inertia provisions) are quantified.

- Boston Andy, Energy Research Partnership, United Kingdom **System Cost of Replacement Energy – SCORE**, 2019⁵¹
- Haslett Andrew, Energy Technologies Institute: **Average Cost of Energy – ACOE** also known as **Effective LCOE**, 2018⁵²
- Australian National University, **Levelised Cost of Balancing – LCOB**, 2017⁵³
- US Energy Information Administration: **Levelized Avoided Cost of Electricity – LACE**, 2013⁵⁴

⁵⁰ Portugal-Pereira, J., Ferreira, P., Cunha, J., Szklo, A., Schaeffer, R., & Araújo, M. (2018). [Better late than never, but never late is better: Risk assessment of nuclear power construction projects](#). *Energy Policy*, 120, 158-166.

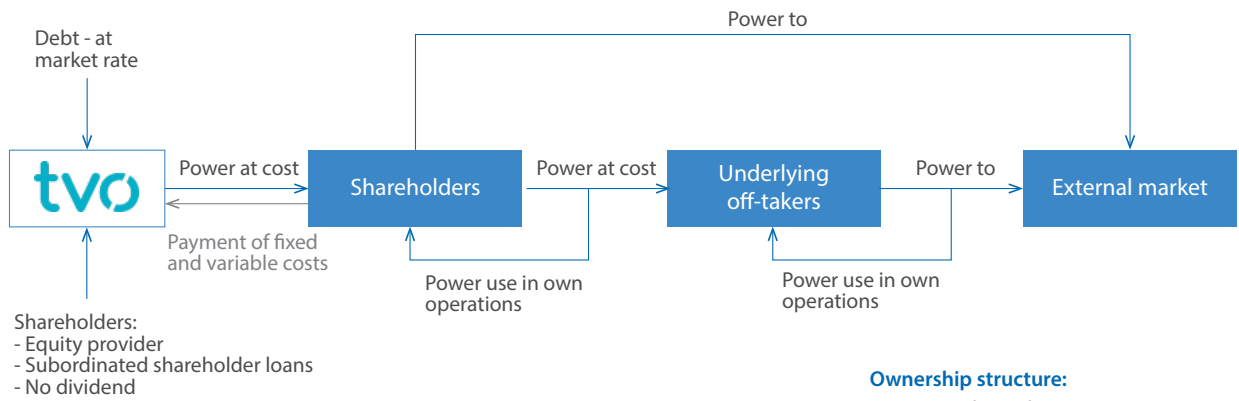
⁵¹ Boston, A., & Thomas, H. K. (2015). ["Managing flexibility whilst decarbonising the GB electricity system"](#). *Energy Research Partnership*.

⁵² Energy Technologies Institute (2018), [Comparing generating technologies](#)

⁵³ Blakers, A., Lu, B., & Stocks, M. (2017). [100% renewable electricity in Australia](#). *Energy*, 133, 471-482.

⁵⁴ EIA Energy Conference (2013), [Assessing the Economic Value of New Utility-Scale Renewable Generation Projects Using Levelized Cost of Electricity and Levelized Avoided Cost of Electricity](#)

Appendix 3. Financing Model - Example of Mankala in Finland



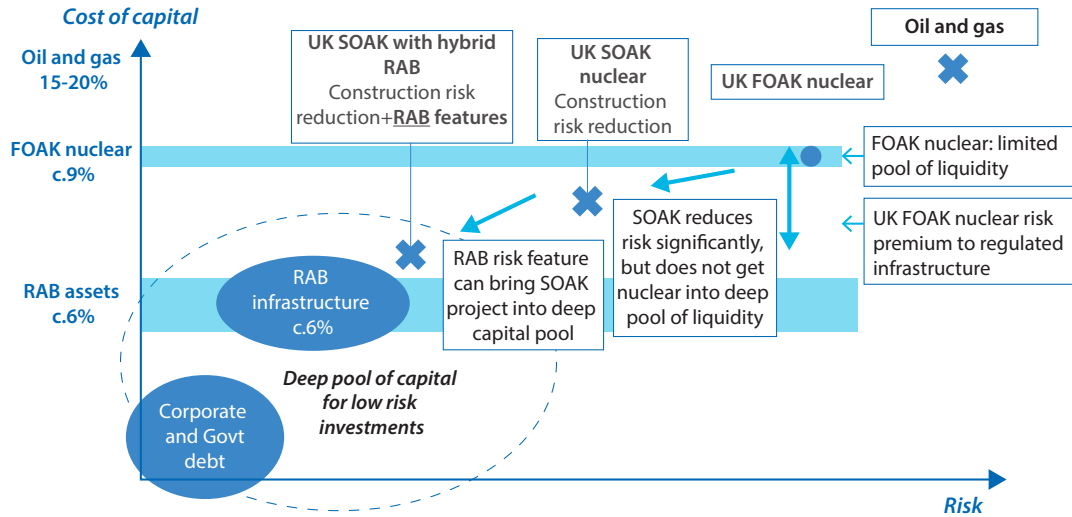
Ownership structure:

- Industrial companies 44%
- Energy companies 31%*
- Fortum 26%

*50 companies owned by 132 municipalities

Source: Fortum

Appendix 4. RAB based Financing Model - Example of Sizewell C in the United Kingdom



Source: Sizewell C – EDF Energy

Appendix 5. List of Projects reviewed within the Investment Framework Task Force

Country	Technology	Power Plant	Estimated Capacity (MW)	Commercial Start Up	Owner / Operator	Estimated New Build Cost (Date of Estimate)	Funding Model	Funding Status
Finland	European Pressurised Reactor	Olkiluoto 3 (OL3)	1600	2022	Teollisuuden Voima Oyj (TVO), a non-listed public limited company	€8.5 bn (Sept 2019)	Mankala	Funding closed
Finland	WVER 1200	Hanhikivi 1	1200	2027	Fennovoima	€6.7 bn - NEI	Fennovoima, Rosatom, Project Finance	Funding closed
United Kingdom	UK European Pressurised Reactor	Hinkley Point C	2 x 1630	2026-2027	EDF Energy/CGN	£22-23 bn (£2015, Jan 2021)	Contract for Difference	Funding closed
United Kingdom	UK European Pressurised Reactor	Sizewell C	2 x 1630	2032-2033	Sizewell C	TBC	TBC - Regulated Asset Base under consideration	Funding not opened yet
Romania	CANDU	Cernavoda Nuclear Power Plant expansion Units 3-4	2 x 724	2030-2031	SN Nuclearelectrica	€6 bn	Undecided	Funding not opened yet
Bulgaria	AP 1000 WVER 1000	Kozloduy NPP Unit 7	1000	Not communicated	Kozloduy Nuclear Power Plant	€3.8 bn (2014)	Strategic Investor model	Waiting governmental decision
Bulgaria	WVER 1000	Belene NPP 2 Units	2000	Not communicated		No more than €10 bn	Tender ongoing	Waiting governmental decision
Czech Republic	Licensing ongoing	Dukovany (+ Temelin)	Not communicated	2034/2035	ČEZ Group	Not communicated	Undecided	Funding not opened yet

Source: Investment Framework Task Force – FORATOM

Appendix 6: Euratom Loan instruments

The European Commission is empowered to lend money - on behalf of Euratom – for the financing of investment projects related to nuclear power generation and the nuclear fuel cycle in EU countries, and to help finance safety improvements or the decommissioning of nuclear installations in certain neighbouring countries.

Euratom has its own credit ratings, identical to those of the EU.

- FitchRatings AAA / Outlook stable
- Moody's Aaa / Outlook stable
- Standard&Poors AA / Outlook stable

But given the limited budget and also the unwillingness of the Commission, most of the loans are allocated to safety improvements or decommissioning projects

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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