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NUCLEAR ENERGY AGENCY

Minimising the Cost of Capital by Optimising Risk Management in the Financing of New Nuclear Power Plants

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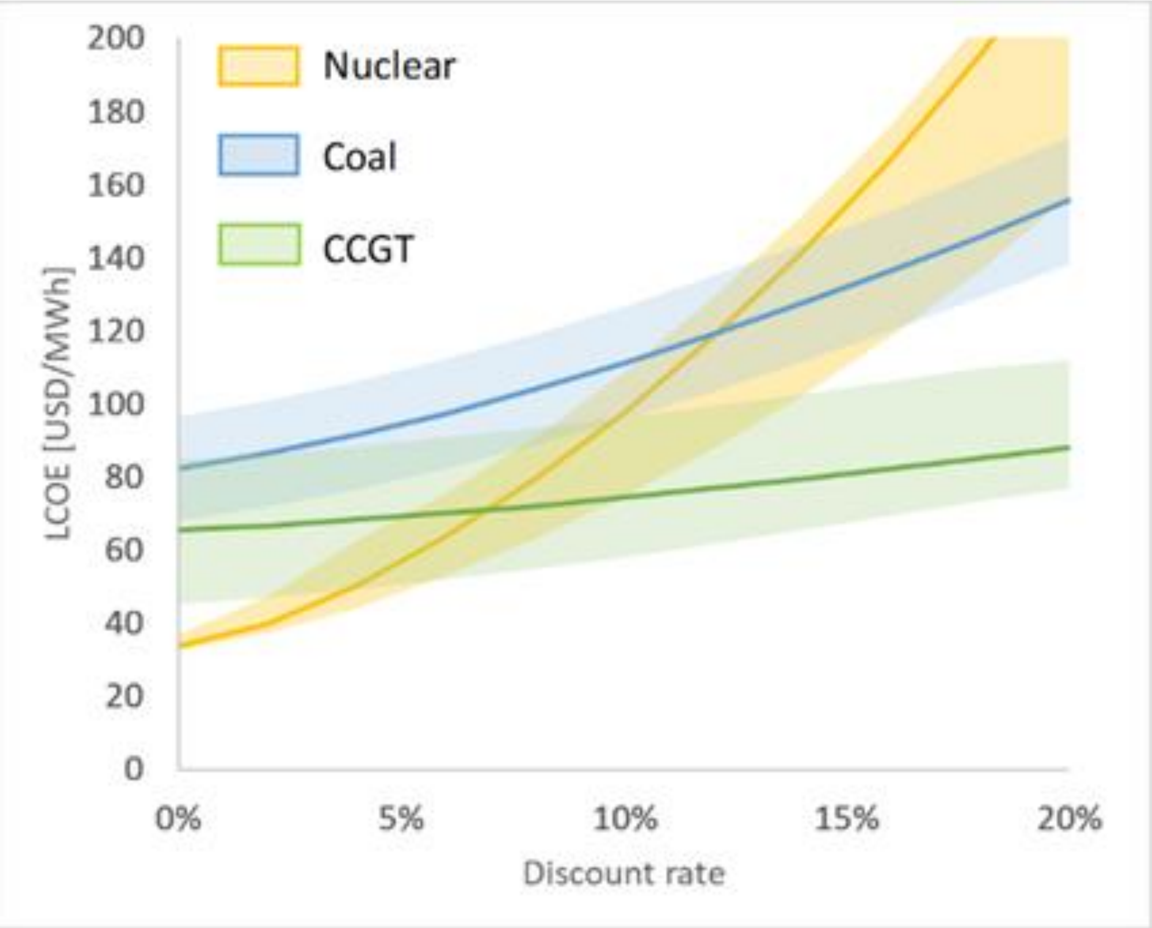
Introduction

- Nuclear energy as a reliable provider of a low carbon electricity provision is an indispensable contributor to reaching net zero carbon emissions by 2050;
- Realising the expected contribution of nuclear requires accelerating the rate of construction of new nuclear power plants;
- The large size and high capital-intensity of nuclear power plants makes minimising financing costs a crucial element in successful nuclear new build;
- Overall, the cost of nuclear new build depends on
    - Overnight costs – previous work in NEA (2020) and NEA (2016)
    - Project structure and efficiency of management – to be developed
    - The different components of the cost of capital (interest rate) – presented today.
- The cost of capital is a function of risk: de-risking the different elements that compose the cost of capital is key to the minimising the costs of financing nuclear power plant.

The importance of financing costs



1. Due to their high capital-intensity, the cost of all low carbon power generation technologies (nuclear, wind, solar PV, hydro…) depends heavily on the cost of capital;
2. Among the major dispatchable generation technologies, the LCOE cost of nuclear is the most sensitive to the cost of capital.

Source: IEA/NEA (2020)

Objective and Principal Elements

Objective

Developing a framework for assessing the socially optimal cost of capital for low carbon electricity generation, in particular, nuclear energy, based on **systematic de-risking**.

Principal Considerations and Elements

- Informed by financial economics (capital pricing asset model, CAPM)
- Cost of capital is the cost of risk; optimising risk allocation can (1) reduce the overall economic cost of risk and (2) radically reduce the cost of risk for investors;
- The **real** long-term risk-free rate is at historic lows and likely to stay so
- **Low carbon projects** may be able to **off-set systemic investment risk**;
- Measures exist to de-risk project-specific risks such as (1) policy risk, (2) electricity market price risk and (3) construction risk;

The NEA approach to the cost of capital is based on the standard capital asset pricing model (CAPM) in which the capital costs of a nuclear new build project are the sum of the following components

1. The **real long-term risk-free rate** (inflation protected, long-term high-quality government bonds) plus the country risk premium
2. The **correlation** of the risk of a **nuclear** power project with **systemic** risk and the **systemic risk** itself, which is the **market** risk of a perfectly diversified portfolio
3. The sum of the **project-specific (idiosyncratic)** risks of a new nuclear power project
   a) **policy risk,**
   b) **electricity price risk** and
   c) **construction risk.**

A formal representation of capital cost in the capital asset pricing model (CAPM)

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

r_n	The cost of capital of a **nuclear** power generation project
r_f	The risk-**free** rate (high-quality government bonds)
β_n	The **correlation** of the risk of a **nuclear** power project with **systemic** risk with $\beta_n = \frac{cov\ (r_n, r_s)}{var\ (r_s)}$
r_s	The **systemic** risk, *i.e.*, the **market** risk (r_m or a perfectly diversified portfolio) minus the risk-free rate, that is $r_s = r_m - r_f$.
$\sum_i^n r_{INi}$	The sum of the **project-specific** or "idiosyncratic" risks of a new nuclear power project, typically **(1) policy risk, (2) electricity price risk and (3) construction risk.**

1. The real long-term risk-free rate

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

Real Long-term Rates for Governments with High Credit Ratings Remain Low:

- United States: on 31 August 2022, the **real** yield of 30-year Treasury inflation-protected securities (TIPS) was **0.92%**.
- France: on 8 August 2022, the **nominal** yield (before inflation) on 30-year *obligations assimilables du trésor* (OAT) of France was **2%,** but inflation expectations are **3,5%** for the next five years.
- United Kingdom: on 22 November 2022, the real yield for 50-year **index-linked** gilts was **-0.39%**.
    - For public borrowing, risk-free rates needs to be adjusted further by country risk;
    - For private borrowers, the risk-free rate needs to be adjusted by firm-specific bankruptcy risk (see below).

Despite recent increases in nominal short term rates, the real long-term risk-free rate remains close to zero.

2. Correlation of risks of low carbon projects with systemic risk I

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

1. As climate change and efforts to combat it intensify, implicit and explicit carbon prices will rise.

2. This will *decrease* profitability throughout the economy…

3. …but will *increase* the value of low carbon investments.

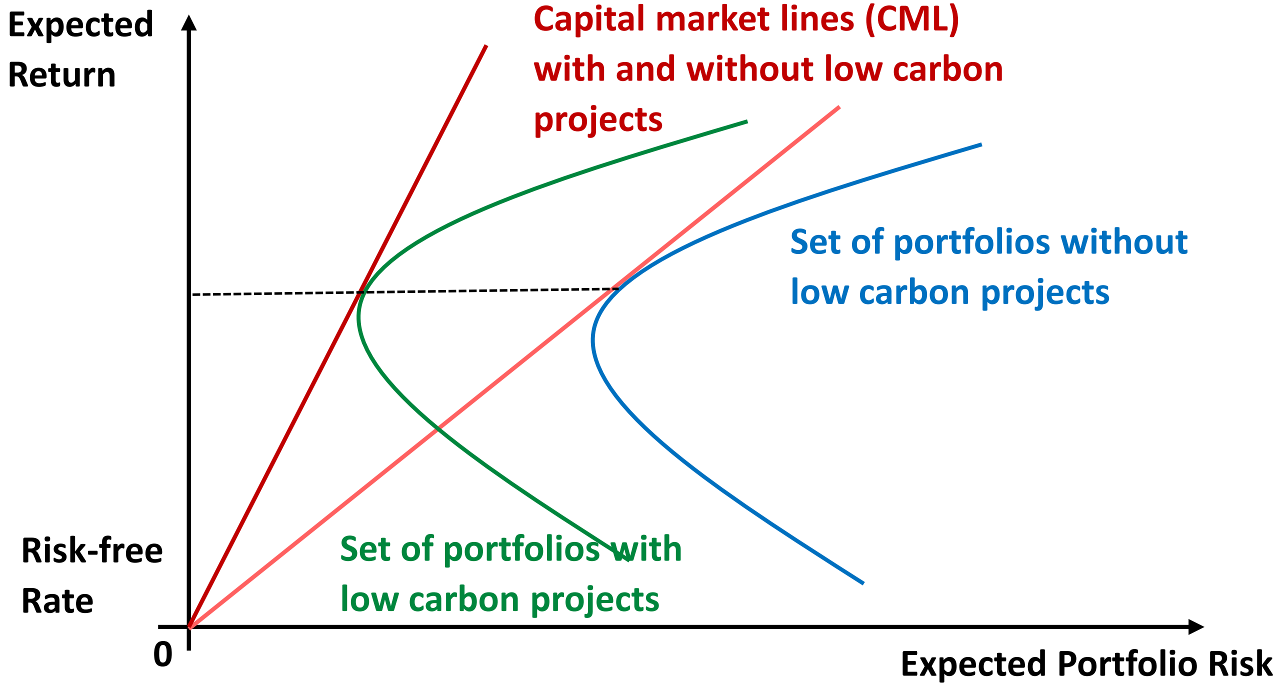
4. If this holds true (1), including a low carbon investment will reduce an investment portfolio's Sharpe ratio (risk-adjusted returns) already with β_n = *0* even more so if β_n < 0 .

5. If this holds true (2), investors will accept very low returns on low carbon investments since they will reduce overall portfolio risk and provide portfolio insurance.

"High-emitting assets are significantly more sensitive to economy-wide fluctuations than low-emitting ones… Our results suggest that carbon emission reduction might serve as valuable risk mitigation strategies (Trinks *et al.*, *Energy Journal*, 2022)."

2. Correlation of risks of low carbon projects with systemic risk II

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$



The slope of the capital market line (CML) for a portfolio *P* with an expected return r_P is the latter's *Sharpe ratio (SR_P)*:

$$SR_P = \frac{r_P - r_f}{\sigma_P}$$

3. De-risking project-specific (idiosyncratic) risks

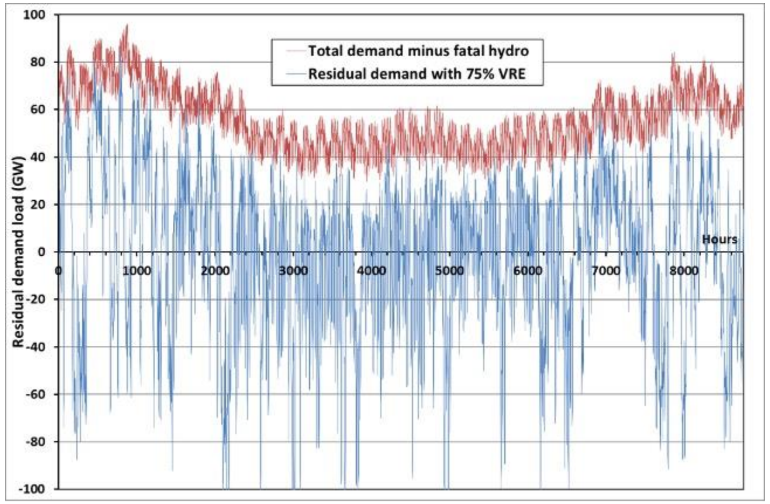
$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

Investing in a new nuclear power plant requires to manage **political risk**, **electricity market price risk** and **construction risk**. There exist effective means to manage each one of the three risks:

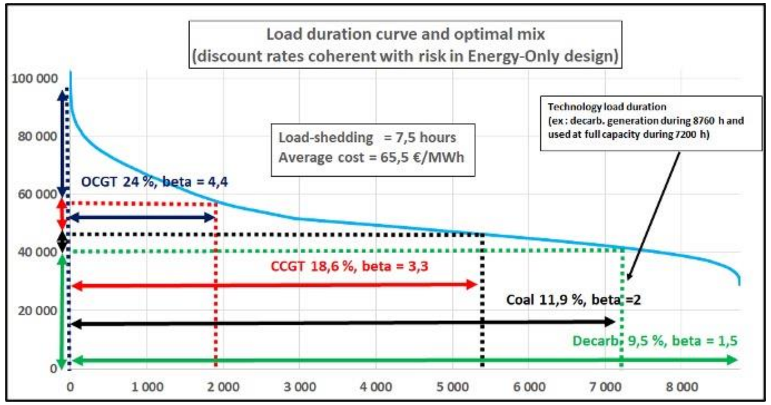
- **Policy risk:** national governments decide on the generation mix and the strategic choice of nuclear power; efficient internalisation implies allocating political risk here.
- **Electricity market price risk:** given the high capital-intensity of all low carbon generation options (nuclear, hydro, VRE, storage…) *net zero* will require to move away from marginal cost pricing in deregulated electricity markets towards long-term pricing arrangements (CFD, FIT, stable tariff…).
- **Construction risk:** risk spreading, *i.e.*, sharing project-specific risks between a large number of individuals such as rate payers or taxpayers reduces the economic costs of such risks; mechanisms such as regulated asset base (RAB), construction work in progress (CWP), loan guarantees or direct public financing advance such risk-spreading.

3.b De-risking electricity market price risk

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$



Source: NEA (2019)



Source: Peluchon (2021)

- A growing share of low carbon-generators with zero short-run variable costs will increase price volatility – markets will alternate between zero prices and the cost of demand response – and thus capital costs.
- A detailed CAPM analysis of the electricity market gives average costs, capital costs for low carbon-generators and load-shedding hours in different market designs:
  - **TODAY's ENERGY ONLY-MARKET with residual carbon emissions:**
    Avg. cost 65.5 €/MWh; capital cost 9.5%; VOLL-hours 7.5;
  - ***NET ZERO* with TODAY'S ENERGY ONLY-MARKET:**
    Avg. cost 118.3 €/MWh; capital cost 22%; VOLL-hours 52;
  - ***NET ZERO* with LONG-TERM CONTRACTS :**
    Avg. cost 82.5 €/MWh; capital cost 3.2%; VOLL-hours 3.

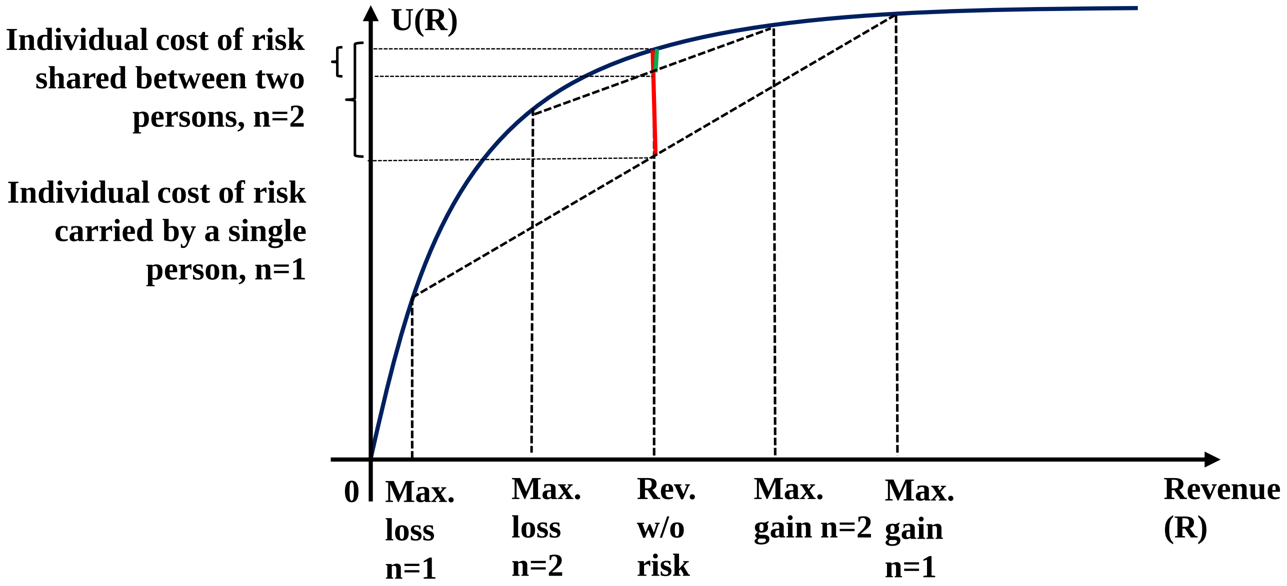
3.c De-risking construction risk

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

Due to their large size, long time frames and complex technical challenges, construction constitutes perhaps the most risk important dimension for new nuclear power projects.

An economic theorem (Arrow and Lind , 1970) states that **investments can be evaluated at the risk-free rate if their risks are spread over a sufficiently large number of individuals**. This is due to the fact that the *total economic costs of the risk* decline as the share of the costs of risk as a share of total income decline (see graphic).

- In the case of new nuclear projects, this is done by mechanisms such as **regulated asset base (RAB)** or **construction work in progress (CWP),** which allocate part or all of construction risk to **rate payers**.
- Public participation in project companies allocate part of construction risk to **tax payers.**
- The counter-argument "risk spreading can be done through financial markets" is not applicable here due to complexity, transaction costs and informational asymmetries.



Putting it all together

$$r_n = r_f + \beta_n * r_s + \sum_i^n r_{INi}$$

r_f The real long-term **risk-free** rate is below 1% but needs to be adjusted by relevant country risk premium.

$\beta_n * r_s$ If returns of nuclear power projects are uncorrelated or negatively correlated with returns of other assets, its correlation with system risk becomes zero or negative. Current working assumption is that correlation is zero.

$\sum_i^n r_{INi}$

(1) Policy risk: can be internalised through indemnification clauses;

(2) Electricity price risk: long-term contracts providing predictable prices at average costs eliminate price risk;

(3) Construction risk: economic costs can be minimised through risk spreading over rate payers or taxpayers.

r_n **The cost of capital of a fully de-risked new nuclear power generation project is equal to the real long-term risk-free rate plus the appropriate country risk premium.**

Public and private investments

- **Do the preceding results also pertain to privately funded projects? Yes.** If low carbon generation projects do reduce portfolio risk with $\boldsymbol{\beta_n = 0}$ then also private investors will accept very low rates for such projects as they improve the performance of their portfolios.
    - Myopia or herd behaviour may delay full realisation of this effect by private parties; this would constitute a market failure and could, with appropriate cost-benefit analysis, grounds for government intervention;
    - Private investors will be highly interested to participate in fully de-risked low carbon projects.
- What does the term "***risk free rate plus country risk premium***" mean in the case of a private entities? It means "***risk free rate plus firm-specific bankruptcy risk premium***".
    - This is akin to the equity premium in Newbery (2021) minus the systemic risk;
    - For a project company with a fully de-risked low carbon project investment, the firm-specific bankruptcy premium should be equal to the risk-free rate.
- Arguments make no use of exogenously set **social discount rate (SDR)** or **social time preference rate (STPR)**. These concepts have been introduced in the 1970s to ensure that the **well-being of future generations is adequately taken into account**. With real private long-term rates close *below* the SDR, they no longer provide guidance for decision-making.

Policy Implications

The results of the report apply equally to private and public investments. However, there remain **important and specific roles for governments:**

- First and foremost, ensure credible and effective commitments to reach *net zero* carbon emissions by 2050.
- Implement the frameworks for measures to reduce the economic costs of
  - Policy risk
  - Price risk
  - Construction risk
- Participate directly in projects in case of market failures when private actors do not realise the true economic value of projects, especially with respect to their ability to off-set long-term systemic risk.
- Organise efficient and sustainable projet management structures over the long-term.
  - Advance agreements of transfer of ownership from public to private investors at commissioning as key option.
  - Make sure that questions of distribution and fairness are adequately addressed.
- Safeguard macroeconomic stability to minimize country risk premiums.

Concluding Remarks

- The approach is less radical than it looks. Historically, all forms of low carbon generation, including nuclear power, have always benefitted from de-risking.
- This report provides a **framework** to discuss and plan de-risking to lower the cost of capital of new nuclear projects in a **transparent and systematic** manner.
- The final allocation of risks is not only an economic efficiency issue but also an issue of fairness and distribution. Different countries will implement different solutions.
- **Key Point 1:** Climate change and net zero policies will profoundly change the impact of systemic financial risk on different assets, in particular on low carbon generation.
- **Key Point 2:** Fully de-carbonising electricity generation (*net zero*) will require systematic de-risking of low carbon new build projects, including construction risk.
- **Key Point 3:** Taking Points 1 and 2 into account, the financing costs of fully de-risked new nuclear power projects can be far lower than commonly assumed. Private investors looking to offset systemic risks will offer very competitive rates for fully de-risked nuclear power project producing reliably large amounts of low carbon electricity.