Financing models for nuclear power plants

European Nuclear Power Plant case studies

Ministry of Economic Affairs & Climate Policy
September 2022

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Managementsamenvatting

De Nederlandse regering wil de eerste stappen zetten voor de bouw van twee kerncentrales. In het regeerakkoord wordt de keuze voor kernenergie en de ambities voor twee nieuwe kerncentrales als volgt toegelicht: *"Kernenergie kan in de energiemix een aanvulling zijn op zon, wind en geothermie en kan worden ingezet voor de productie van waterstof. Ook maakt het ons minder afhankelijk van de import van gas."* Dit kabinet zet de benodigde stappen voor de bouw van twee nieuwe kerncentrales. Dat betekent onder andere dat onderzocht wordt hoe de (financiële) bijdrage van de overheid ingevuld zou moeten worden en hoe wet- en regelgeving de nucleaire ambities kan ondersteunen.

Baringa heeft in opdracht van de Directie Kernenergie van het Ministerie van Economische Zaken en Klimaatbeleid case studies uitgevoerd voor Finland, Polen, Frankrijk en het Verenigd Koninkrijk; een viertal Europese landen waar recent kerncentrales gebouwd zijn, nieuwbouwprogramma's zijn gestart of worden voorbereid. Specifiek zijn de volgende programma's en financieringsmodellen onderzocht:

- **Finland** – Finland heeft recent één nieuwe centrale in gebruik genomen, OL3 (1600 MW), en geen concrete plannen voor meer kerncentrales. De bouw van de centrale is gefinancierd door een coöperatieve not-for-profit organisatie waarin grote industriële afnemers participeren. De deelnemers in deze organisatie worden eigenaar van de opgewekte elektriciteit en kunnen deze zelf gebruiken of verkopen. Het project kende een aantal vertragingen door een combinatie van gebrek aan ervaring en onrealistische verwachtingen. De financieringsconstructie vereist commitment van een substantieel aantal grote industriële elektriciteitsverbruikers en lijkt niet kansrijk voor Nederland

- **Polen** – Polen heeft nog geen kerncentrales maar heeft in het Poolse Nucleaire Programma (PNP) een routekaart voor de ontwikkeling van zes kerncentrales in Polen (met een gezamenlijk vermogen van 6 tot 9 GW). De eerste Pools kerncentrale zou volgens deze routekaart in 2033 operationeel moeten worden. Polen richt hiertoe een speciaal bedrijf op waarin de staat een meerderheidsbelang houdt, nadat via een tenderprocedure één technologieleverancier voor het hele programma is geselecteerd, om zo schaalvoordeel te behalen. Bij de keuze van de technologieleverancier spelen onder andere ervaring en daarmee vertrouwen en aantrekkelijkheid voor potentiële investeerders een rol

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- **Frankrijk** – Frankrijk heeft recent de nucleaire ambities flink opgeschroefd en hoopt tot wel 14 nieuwe reactoren te bouwen (met een gezamenlijk vermogen tot 25 GW) om te helpen bij het realiseren van de klimaatambities. De Franse overheid heeft daartoe haar belang in EDF, de aangewezen ontwikkelaar, vergroot tot 100% waarmee het risico voor het nucleaire programma volledig bij de Franse overheid ligt. Frankrijk maakt gebruik van een nieuw reactorontwerp, EPR2, wat nu in de centrale Flamanville voor het eerst wordt toegepast. Dit project wordt geplaagd door ruime vertragingen en kostenoverschrijdingen

- **Verenigd Koninkrijk** – Het Verenigd Koninkrijk wil decennia van onderinvestering in kernenergie terugdraaien en streeft ernaar de kosten te drukken door de komende 30 jaar op grote schaal centrales te bouwen en de nucleaire capaciteit te verdrievoudigen tot 24 GW. De in aanbouw zijnde Hinkley Point C centrale is gefinancierd met een *Contract for Difference* (CfD) waarbij de inkomsten uit de opgewekte elektriciteit voor zeer lange termijn gegarandeerd zijn voor de producent/investeerder. Voor toekomstige centrales wordt het *Regulated Asset Base* (RAB) model overwogen, een model waarbij private investeerders een gereguleerde vergoeding ontvangen van de elektriciteitsleveranciers op basis van de waarde van de asset. Dit model heeft in de afgelopen decennia aangetoond significante investeringen uit de private sector te kunnen ontsluiten maar is nog niet eerder toegepast voor kerncentrales. Recent is het Future Nuclear Enabling Fund opgericht, een fonds van £120m om projectontwikkeling voorafgaand aan een *Financial Investment Decision* (FID) mogelijk te maken

Op basis van deze case studies concludeert Baringa het volgende:

- **Een financieringsmodel waarin verschillende partijen, waaronder het Rijk, bouw- en marktrisico's beheersen en delen** lijkt een randvoorwaarde voor nucleaire nieuwbouwprojecten. Het Poolse model en de Britse RAB-model bieden beide manieren om vertrouwen op te wekken bij beleggers en het risico voor consumenten te beperken, maar moeten zich nog in de praktijk bewijzen

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- Het verdient aanbeveling te **kiezen voor bewezen technologie** en niet voor een *First Of A Kind* (FOAK) ontwerp. De technologische, plannings- en daarmee financiële risico's die een dergelijk ontwerp met zich mee brengen wegen, door de beperkte omvang van de Nederlandse nucleaire ambitie, niet op tegen eventuele voordelen die ermee behaald kunnen worden

- Het aantal leveranciers van nucleaire technologie is beperkt terwijl een aantal Europese landen de nucleaire ambitie flink verhoogt. Nederland begeeft zich daardoor op een *seller's market*. De overheid zou er goed aan doen om pre-FID **structurele relaties aan te gaan met potentiële leveranciers** om zo wederzijds vertrouwen op te bouwen en zicht op passende financiële en technologische kaders te krijgen waarbinnen een eventuele aanbesteding succesvol kan zijn

- De Nederlandse overheid zal een **politiek en reguleringskader moeten creëren dat op het vertrouwen van investeerders kan rekenen**. Dit zal moeten gebeuren door middel van beleid en strategieën gericht op het garanderen van inkomsten voor investeerders, het laag houden van kapitaalkosten en risico's. Daarnaast mogen het beleids- en wetgevingskader geen vertragingen veroorzaken in de totale levenscyclus van het project

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1. Introduction

1.1 Report Objectives

The objective of this ***Financing Models for Nuclear Power Plants*** report is to provide the Ministry of Economic Affairs & Climate ("EZK") relevant insights with respect to the various Nuclear Power Plant (NPP) financing model options and the potential role the Dutch government could play in the view of their nuclear power ambitions.

More specifically, EZK would like to see a reflection on the financing models and approaches used by the governments in several European countries where nuclear power plant projects are under construction and new build programs have started recently.

The reflection should result in an indicative assessment of which of the various government roles and financial models used in these countries would fit well in the Netherlands.

- **What are the current NPP projects under construction across Europe? What are the lessons learnt?**
- **What are the nuclear power new build programs being developed by national governments in order to promote investments in new nuclear power capacity?**
- **Which financing models and approaches are being used?**
- **Which models could be applied by the Dutch government?**

Our Report is based on

*The best available **data sources, insights and learnings** with respect to various recent **NPP new build projects and programs** across several European countries with ambitious nuclear power agendas.*

Four country case studies look into relevant topics related to recent NPP new build construction projects and the implementation of NPP new build programs.

… with the aim to further deepen and broaden EZK's understanding on:

*The potential government role in the **development & realization of new nuclear power plants***	*The various **financing models and approaches** used across Europe*

1.2 Backgrounds

The Dutch Government wants to take the first steps for the construction of two nuclear power plants. The coalition agreement explains the choice for nuclear energy and the ambitions for two new nuclear power plants as follows:

"Nuclear energy can complement the solar, wind and geothermal energy in the energy mix and can be used for the production of hydrogen. It also makes us less dependent on the import of gas. (…) this government is taking the necessary steps for the construction of two new nuclear power plants."

The Ministry of Economic Affairs and Climate ("EZK") is responsible for national and international policy with regard to nuclear energy and the **expansion** of the share of nuclear energy in the Dutch energy mix.

This also involves realising the ambition set out in the government's coalition agreement to take the necessary steps for the **construction of two new nuclear power plants** and to extend the license of the Borssele nuclear power plant.

EZK's nuclear energy programme directorate is now exploring the potential role of the government in order to enable its nuclear ambitions.

Fig 1: Borssele nuclear power station in the Netherlands (Link)

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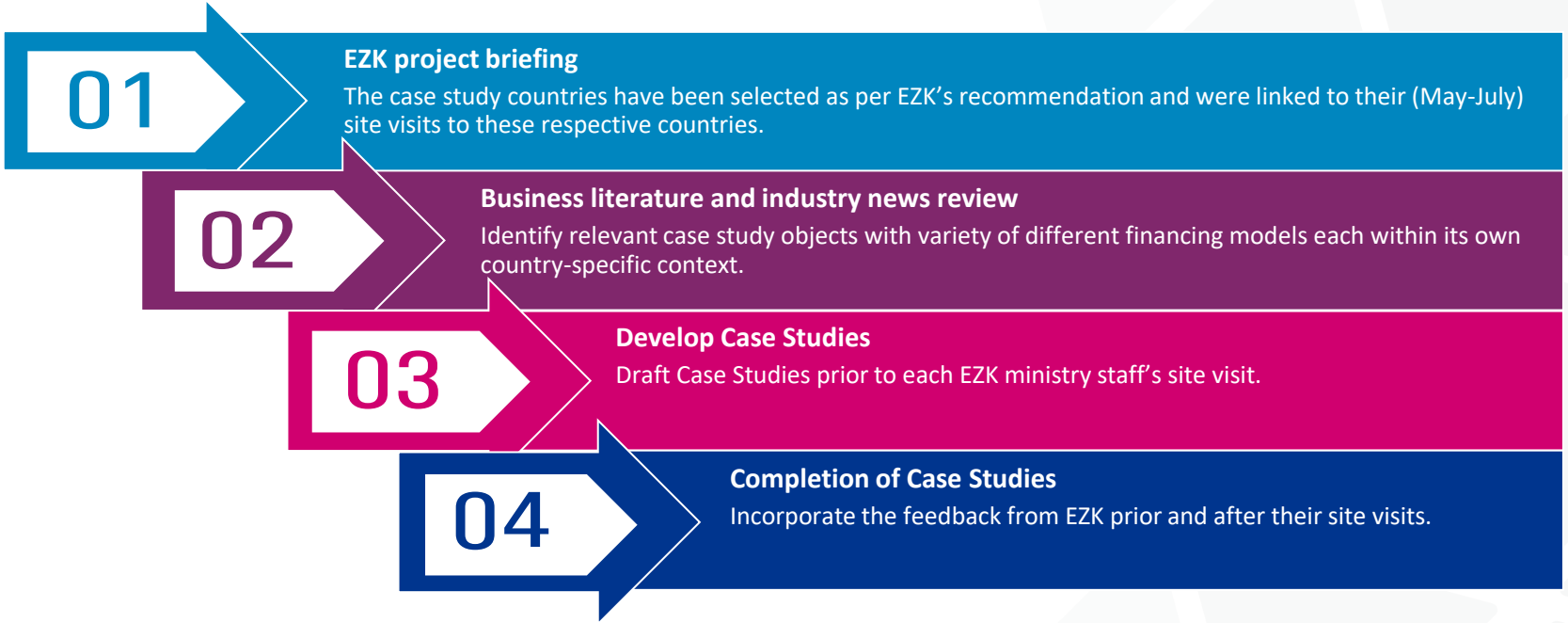
1.3 Our Methodology

We tailored and adapted our approach to meet EZK's requirements

The diagram below illustrates our structured methodology:



This methodology allowed us to include a variety of perspectives, from business literature, EZK's views and the feedback from EZK's counterparts during their respective site visits.

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2. Case studies

2.1 Content and structure of our case studies

We elaborated each country case study within its own specific context.

The following table shows how each case study is elaborated with projects and programs specific to the respective countries.

	 Finland	 Poland	 France	 United Kingdom
EZK visit	30-31 May 2022	6-7 June 2022	19-20 June 2022	11-13 July 2022
Case Study subjects	▲ Olkiluoto 3 (Mankala model)	▲ Polish Nuclear Power Program ▲ SaHo model	▲ Flamanville 3 (EDF) ▲ Macron's nuclear strategy	▲ Hinkley Point C (CfD) ▲ Sizewell C (RAB)
Case study content	An overview of recent NPP projects and NPP new build programs			
	Assessment of the financial model(s) and government roles			
	Reflections and conclusions			

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2.2 Nuclear in numbers

The existing and planned number of NPPs as well as the role of nuclear in the electricity mix varies widely across the researched countries

	Finland	Poland	France	United Kingdom
Number of reactors	5	0	56	9
Total capacity (GW)	4.4	0	61.4	5.9
Generation (TWh)	23.3	0	399	50.3
Share in electricity mix	34%	0%	70%	16%
Reactors under construction	0	0	1 (1650 MW)	2 (3200 MW)
Planned new reactors	0	6 (6-9 GW)	14 (~25 GW)	10 (~15 GW)

Source: World Nuclear Association (link)

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2.3 Finland

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Fig 2: Olkiluoto Nuclear Power Plant Unit 3 Project (link)

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2.3.A Overview of the Olkiluoto 3 (OL3) project

OL3 is the country's first new nuclear reactor in four decades, and Europe's first in nearly 15 years.

Through the commissioning of OL3, approximately 30 percent of Finland's electricity will be generated on the island of Olkiluoto. Subsequently, the share of nuclear power from all electricity consumed in Finland will rise to ca. 40%.

The Olkiluoto 3 NPP project recently exceed 1000 MW output and is expected to reach full capacity by the end of 2022.

NPP	Name	Olkiluoto Unit 3 (OL3)
	Type	European Pressurized Reactor (EPR)
	Capacity	1.600 MWe
Project	Developer/owner	Teollisuuden Voima Oyj (TVO)
	Funding	TVO (25%) + debt (75%)
	Bidding process	2003 Invitation to tender (ITT: 3 bids)
	Vendor/EPC	Areva/Siemens (nowadays Framatome)
	Construction	Started in 2005, Commercial Operation Date (COD) expected in Dec 2022 (originally 2010)
Costs	Turn-key contract size	€3.2 billion
	Estimated Actual costs	~ €11 billion (investment + interest cost)
	Estimated cost per MW	~ €7 million / MW

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2.3.A Overview of the Olkiluoto 3 (OL3) project contd.

Overview of OL3's key milestones and project evaluation

OL3 is built on a turnkey basis by a consortium formed by Areva NP and Siemens. The following diagram gives a snapshot of important dates for OL3 from Development to Operations phase.

Project phases	Development	Construction	Commissioning	Operations
Key milestones	▲ **December 2000:** TVO applies at the government for a "decision in principle" for OL3 ▲ **May 2002:** Parliament approves decision in principle ▲ **January 2004:** TVO submits construction permit application ▲ **February 2005**: Government approves construction permit	▲ **July 2005**: Start of construction ▲ September 2009**:** EPR dome installed ▲ **June 2021:** Installation of reactor pressure vessel ▲ **April 2016:** TVO submits operating license application ▲ **March 2019**: government grants operating license	▲ **December 2021:** Permission for startup granted ▲ **December 2021**: Reactor achieved criticality ▲ **March 2022**: Start power production	▲ COD planned for **December 2022**

Project evaluation

- ▲ The OL3 project encountered a wide variety of issues during the various phases of the project, resulting in significant cost overruns and delays:
  - ▲ TVO's staff did not have hands-on experience of managing a large construction project and did not put in robust processes to qualify vendors and track progress of design
  - ▲ Construction duration targets set in ITT were not realistic
  - ▲ Areva did not have prior experience as a turn-key contractor. It faced significant attrition in staff especially amongst skilled designers and staff with experience in nuclear manufacturing. Alternative subcontractors had limited experience in nuclear projects
- ▲ As a result, the total project costs including capital/interest costs exceeded €11bn (i.e., 3.5 times the original budget of €3.2bn). TVO currently aims for COD in December 2022, which is a 12-year delay from the originally planned COD in 2010

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2.3.B The role of the Government

The future of nuclear energy remains important for Finland. Its industry is highly energy-intensive, and Finland has a target of being carbon neutral by 2035.

Setting the policy & legal framework

- In January 2002, the Finnish Government made a Decision in Principle to construct a new nuclear power plant in Finland for the benefit of the society
- In May 2002, the Government authorised Mankala company TVO to continue preparations for the construction of a new nuclear power plant unit
- The Finnish Government conducted the Environmental Impact Assessment (EIA) while providing the Decision in Principle in 2002. It also considered other factors such as importance of electrical power supply, other societal impact, etc
- The Finnish Government gave the stakeholders an opportunity to present their views on the proposed new NPP before final decision was made. This also included carrying out a poll among the general public

Providing support for financing

- One of the principal barriers to the necessary expansion is the challenge associated with securing competitive financing for new nuclear plants. The Finnish Government have sought to address this with a mechanism called the Mankala model
- The government has facilitated the adoption of the Mankala model, which is an investor/cooperative financing model, where a group of investors raise debt and equity for a project, and share the risk related to doing so
- Even though not funded by the Government, the Finnish Government has provided its full backing for investments in NPP via the Mankala model
- In Finland since the 1970's almost all large power plants have been financed through this financing model, which is covered in more detail in subsequent section

The long-established Mankala operating model has made large-scale power production projects possible and lowered production costs. It has improved Finland's self-sufficiency in energy production.

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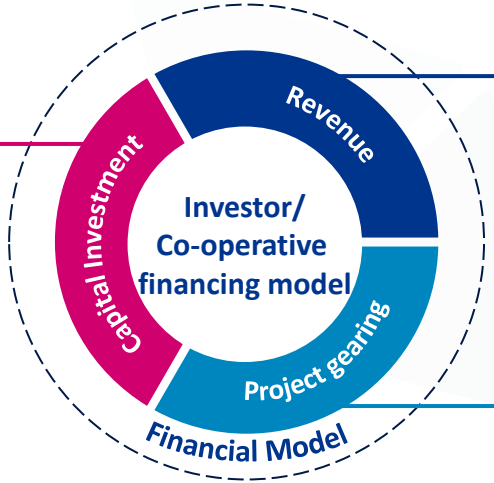
2.3.C The Financial Model

The OL3 project has been funded through the Mankala model.

In Finland, private investment is facilitated through the cooperative “Mankala” investment model, where groups of utilities and industrial power users chose to cooperatively finance a project.

TVO Joint Venture

- Major industrial electricity consumers are jointly investing in the plant through their TVO joint venture
- Each TVO shareholder contributes a proportion of the costs of building and operating the plant, in return for electricity supplies (principally for their own use)



Major industrial electricity consumers

- The Mankala model has been adopted for OL3, which allows the TVO shareholders to benefit from power at cost price during the operational period
- Any surplus is sold through the wholesale market

Equity and debt

- The project is financed by 25% equity and 75% debt, partially with support from the French export credit agency
- This is possible because the plant is being built under a fixed-price turnkey contract with Areva

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2.3.C The Financial Model

The 'Mankala model' is a joint venture model for energy projects which is relatively unique to Finland.

The ***Mankala Model*** is based on the principle of ***a cooperative finance model for large scale energy investments in Finland.*** The model was developed after World War II, when Finland needed more electricity fast and companies were not able to carry out capital-intensive power plant projects alone.

The name originates from a decision from the Finnish Supreme Administrative Court (1963) confirming the legality of the model in relationship to one of the first projects to benefit from it, a hydropower project called *'Mankala'.*

It has been widely and successfully applied in Finland for power and thermal energy production facilities:

- **~ 40%** of electricity generation
- **~ 66%** of nuclear power
- Significant share of **hydro and wind farm investments**

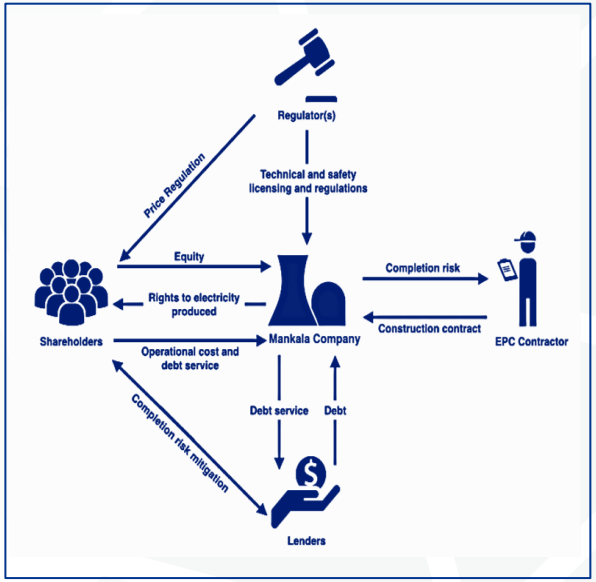

Fig 1: the Mankala model

*In Finland since the 1970s almost all NPP's have been financed by the private sector and through the **Mankala model.***

2.3.C The Financial Model

The OL3 project is financed partly through the balance sheet of Mankala company TVO

How does it work?

- The “Mankala model” is a **traditional and overall successful way of financing generation assets** and a very specific Finnish application of the project financing method in the energy sector
- Within this model, investors, often electro-intensive industrial and municipal power users, establish a limited liability company (LLC), e.g., a Mankala company. The LLC **sells electricity to its shareholders at the cost of production**, since being a co-operative enterprise the LLC does not have to make a profit. The shareholders commit to proportionally paying the power company’s costs. The operating model is included in the companies’ articles of association
- The owners of a Mankala company have the right to get a share of the electricity corresponding to their share of ownership, and at the same time they commit to cover also their pro-rata share of the actual costs of the company. Therefore, the **Mankala company is not exposed to market risks**, as these are taken by the end users
- The lenders do not have recourse to the shareholders’ balance sheet, although in case the Mankala company goes bankrupt the shareholders typically commit to take over the debt. **The Mankala structure is therefore attractive for banks**, as several creditworthy owners will ensure the long-term cash flow, and as a result the project company can be heavily leveraged

What are the benefits?

The Mankala model offers a variety of benefits:

- A **stable long-term price**, not subject to price volatility on the wholesale market, and with security of supply
- **Economies of scale** when constructing new production capacities
- **Sharing of investment risk between several investors-consumers**, which is of particular benefit to small stakeholders
- An **enhanced valuation** by rating agencies which take solidarity among shareholders into account

What are the challenges?

The model has proved successful in Finland in the past, enabling two-thirds of the country’s electricity to be produced at cost price. However, there are some challenges and learnings associated with the Mankala model

- **The application of the Mankala model** depends on whether there are **enough energy-intensive industries** willing and able to participate in a NPP project
- Given the size and risk associated with an NPP project, it is not possible to implement one without a **public-private partnership**

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2.3.D Lessons learnt & reflections

Overall lessons learnt & Baringa's reflections against various perspectives

Viewpoints	Lessons Learnt	Baringa's reflections for Netherlands
Government	▪ In the past, the Mankala model with NPP investments from the private sector has worked well for Finland ▪ With the OL3 project and various NPP project cancellations in mind, the Finnish Government may conclude that the Mankala model no longer works for any future new build NPP projects	▪ Although cooperatives are not uncommon in the Dutch agriculture sector, such collaborations amongst large industrial power consumers in the Netherlands are scarce and quite often not successful, strongly suggesting a successful application of a cooperative model for a NPP project is not likely
Financial Model	▪ In the past the Mankala model seemed like a fit for purpose JV model in which participants could collectively develop NPP projects and benefit from economies of scale ▪ Developing a new NPP seems like a venture with a size and risk profile that does not match with the Mankala model anymore	▪ A 100% utility backed project financing option with an EPC/vendor taking full responsibility for construction risks, does not fit the size, complexity and risks associated with NPP projects ▪ Developing NPP projects in a pubic-private partnership and sharing the risks amongst a range of participants is the most suitable way to avoid financial complications
Implementation	▪ The OL3 project is a "one off" FOAK project, with an eager vendor consortium desperate to launch the first EPR project in Europe and underestimating the risks ▪ The OL3 project led to huge financial losses for vendor/EPC, contributing to near bankruptcy and restructuring of Areva	▪ A robust and proven design should be to avoid changes to designs and regulations and associated cost increases and delays, both of which are more often seen with FOAK designs ▪ Incorporate all relevant and practical lessons learned into the NPP implementation process/program and invest in capacity and capability building to reduce the risk of cost overruns and delays

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2.4 Poland

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Fig 3: SOURCE: SHUTTERSTOCK.COM(link)

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2.4.A Overview of the Polish Nuclear Power (PNP) Programme

The Polish Nuclear Power (PNP) Programme is a roadmap for the development of 6 NPP's in Poland

The PNP Programme includes plans to implement nuclear energy, ensure safe and effective operation of the nuclear power facilities, including decommissioning of the plants after the end of their operational lifetime and the safety of spent fuel and radioactive waste management. The objective of PNP Programme is to build 6-9 GW of installed nuclear capacity based on large, proven pressurized water reactors. Here is a snap-shot of the PNP programme

PNP objectives	Diversification of the Polish electric power sector, replacing ageing fleet of high-emission baseload coal units
	Drastic reduction of greenhouse gas emissions from today's power plants
	Suppress the increase of energy costs for consumers, and even reduce them
PNP's 4 step approach	1. Selecting one common reactor technology for all NPPs, aiming for economies of scale
	2. Selecting one strategic co-investor linked to the technology provider
	3. Acquisition of a 100% share in the SPV implementing nuclear power projects by the State Treasury
	4. After one strategic co-investor is selected, retain at least a 51% stake in the SPV
PNP programme targets	Develop and build 6 GEN III NPP's
	Total generation capacity: 6-9 GW
	Commissioning first NPP in 2033

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2.4.A Overview of the Polish Nuclear Power (PNP) Programme

Overview of planned key milestones from development to operations of the PNP Programme

PNP phases	Development	Construction	Commissioning	Operations
Key milestones	▲ **2009-2014**: first draft of PNP ▲ **2018-2020:** Development of the Polish Nuclear Power programme ▲ **October 2020:** The Polish Government approves the PNP programme ▲ **2018/20:** final site selection process ▲ **2020-2022/23:** Nuclear technology vendor tender process with EDF, Westinghouse, KHNP/KEPCO ▲ **2022-2025:** Licensing and permitting and Site preparations location 1 ▲ **2028-2030:** Site preparations location 2	▲ **2025-2033:** construction and commissioning of first reactor (NPP1) ▲ **2027-2035:** construction and commissioning of NPP2 ▲ **2029-2037:** construction and commissioning of NPP3 ▲ **2031-2093:** construction and commissioning of NPP4 ▲ **20330-2041:** construction and commissioning NPP5 ▲ **2035-2043:** construction and commissioning of NPP6		▲ **2033:** start operations NPP1 ▲ **2035:** start operations NPP2 ▲ **2037:** start operations NPP3 ▲ **2039:** start operations NPP4 ▲ **2041:** start operations NPP5 ▲ **2043:** start operations NPP6

Programme evaluation

- ▲ While the programme is currently ongoing, some quite favourable decisions were taken early on. It was decided to implement all 6 NPP projects with the use of a single technology - Gen III, pressurized reactor. This will provide benefits in economies of scale. A Special Purpose Vehicle was created to manage construction and operation of NPPs
- ▲ The technology vendor was selected as the co-investor with the view of banking their experience to attract investors and provide assurance and expertise to the implementation and investors
- ▲ Coastal location with large baseload was selected as they are attractive for large power generation projects

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2.4.B The role of the Government

Poland plans to have nuclear power from about 2033 as part of a diverse energy portfolio, moving away from heavy dependence on coal.

Setting the policy & legal framework

- In October 2020, the Polish Council of Ministers adopted the updated Polish Nuclear Power (PNP) Programme. The objective is to construct six nuclear power plants with a total generation capacity of 6-9 GW (between 2033 and 2043) based on proven, large-scale, generation III (+) pressurized water reactors
- Nuclear power has been on the Polish political agenda since 2014, when the first version of the PNP was published. The rationale for nuclear power strategy rests on three pillars: energy security, climate and the environment and economic development
- The assumed investment model provides for the implementation of the project with the use of a single technology, which will produce benefits including economies of scale, a single strategic co-investor linked to the technology provider, and maintaining the State Treasury's control of the implementation of the Programme

Providing support for financing

- The NPP developer and operator is Polskie Elektrownie Jądrowe (PEJ), a company currently 100% owned by the Polish State. PEJ was asked to facilitate the investment process, conduct site investigation as well as obtain all necessary licenses and permits required for the construction of the envisaged NPP's
- The government selected a single vendor as strategic co-investor to help create low-cost project financing options for the NPP programme. The investor will contribute its experience to the construction and/or operation of NPPs and increase the credibility of the project, which will help attract export loans and other sources of capital
- The Polish government decided to retain the majority stake in the SPV set up to deliver the NPP programmes. The retention by the Polish government of control over PEJ will provide direct control over the decision-making process of PNP Programme and will enable effective ownership supervision. It will limit risks affecting the level of financial costs of the nuclear project

The addition of nuclear power plants to the energy mix in Poland will result in the diversification of the directions of supply of primary energy carriers, the replacement of the ageing fleet of coal units with zero-emission units immune to regulatory policies tightening climate requirements.

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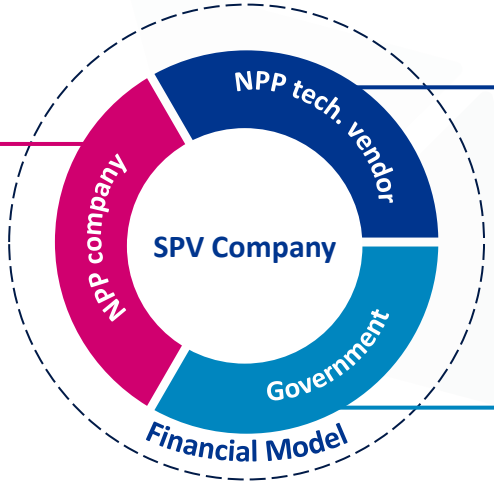
2.4.C The Financial Model

Poland foresees a strategic partnership with the selected NPP technology vendor, to jointly develop, build and operate 6 NPP's.

A Special Purpose Vehicle (SPV) would be created to build, operate and manage the an NPP. While SPV would be 100% state owned to start with, state company will start to divest along different phases of the project, providing certainty to investors albeit at a premium as divestiture options are released closer to COD

PEJ

- Polskie Elektrownie Jądrowe (PEJ) is a company owned by the State Treasury responsible for ensuring the energy security of Poland
- PEJ would facilitate the investment process for NPPs and act as the initial investor in the construction project of the first nuclear power plant in Poland
- It will provide support for the government administration in the implementation of the PNP Programme and build public support for the development of nuclear energy
- Before the COD of the first NPP, PEJ will sell 49% of SPV shares to the strategic investor



NPP technology partner

- A technology vendor selected to become the co-investor providing expertise and assurance to the project
- An early selection of a strategic co-investor will open low-cost NPP project financing options

Government

- The Polish Government aims to ensure energy security and to guarantee that NPPs will bring benefits to the whole economy society, and not only investors

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2.4.C The Financial Model

The Polish co-investment model

How does it work?

- The **first step is to establish a Special Purpose Vehicle (SPV).** Its statutory objective is to build, own, and operate an NPP and sell the electricity produced. The sole owner of the company at the very first stage is the State as the initial investor
- The **State takes over most of the business risk** and facilitates the process of obtaining the lowest-cost financing. It also guarantees efficient project implementation and effective coordination of project tasks
- Then, **a strategic co-investor/technology partner** with proven experience of working in selected nuclear technology is brought on board and the initial investor gradually sells its shares to the co-investor retaining the majority stake in the SPV (i.e., at least 51% of the shares in the SPV). Selling the shares before connection to the grid, the state significantly reduces the financial involvement in the long term

What are the benefits?

The co-investment model offers a variety of benefits:

- The model allows to enhance the competitiveness of the national industry and to increase public acceptance for nuclear power
- A large number of NPP's of the same type will potentially provide the rationale for nuclear fuel fabrication plants in Poland
- Single technology selection will enable economies of scale and lower costs of construction and operation

What are the challenges?

The Polish co-investment model still needs to be practically implemented. Potential drawbacks can be:

- The selection of one single NPP technology vendor and co-investor automatically creates a significant dependency on that particular partner
- With the state being the majority shareholder in the SPV, the state and by extension taxpayers are open to the risk of project failure, should one go down that route
- Selecting a single co-investor for all NPs could increase the risk exposure of the state across the portfolio, should the co-investor go out of business.

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2.4.C The SaHo Model

An alternative to the PNP investment model selected by the Polish Government

- The PNP Programme is based on the establishment of a SPV company that will build, develop and operate NPP using state investment and reduce its stake to at least a 51% before COD
- There is an alternative called the SaHo financial model, proposed by Polish academia wherein it assumes the State will sell **all SPV** shares prior to COD
    - The first step within the SaHo model framework is to establish a SPV. Like the PNP model, its statutory objective is to build, own, and operate an NPP and sell the electricity produced to its owners
    - Then, in the period between the establishment of the project company and connection to the grid, the initial investor gradually sells its shares to electricity consumers (see graph with the basic scheme of shares selling). The sale of shares may be organized in the form of tenders, auctions, or bilaterally negotiated contracts
    - Finally, at the time of grid connection (i.e., the end of construction and start of operation), the initial investor should possess no shares. Here, the SaHo model starts to function in a similar way as the Finnish Mankala co-op model. Furthermore, the SaHo model assumes shares to be predominantly bought by a range of power consumers
- In a variation of the SaHo model, the shares can be bought by the final investor from the State investor at any time between SPV establishment and connection to the grid. The later a final investor buys them, the higher is the price

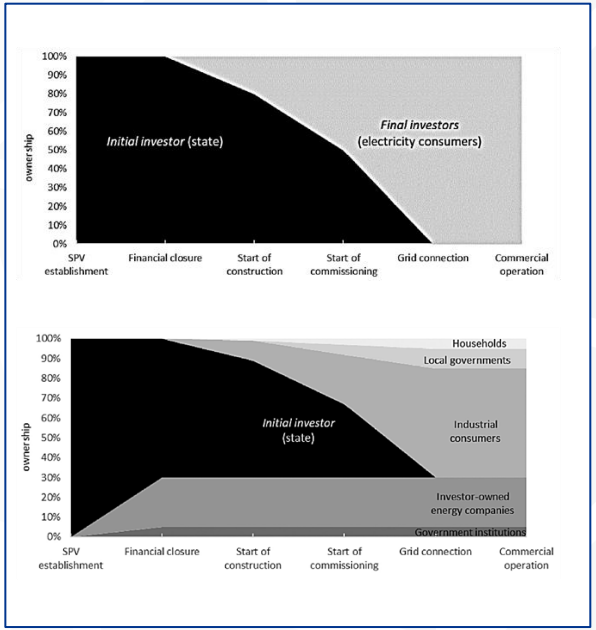

Fig 2: the SaHo model with 2 different divestment options

2.4.D Lessons learnt & reflections

Political will, public-private partnerships with robust technology and vendor/partner assessment will maximise the chance of a successful execution of a nuclear power project

Viewpoints	Lessons Learnt	Baringa's reflections for Netherlands
Government	▪ The Polish PNP Programme is a very useful instrument in order to structure a national nuclear power strategy and associated nuclear policies ▪ State involvement reduces risks such as political risk, legal risk, and regulatory risk	▪ The Polish nuclear ambitions and time path are generally similar to those of the Dutch government ▪ Dutch government would have to wait and see whether any private utility and/or vendor would take the initiative and lead the NPP new build development process
Financial Model	▪ State involvement encourages private financial institutions to provide financing at the lowest possible interest rate. This enables better NPV generation ▪ It can be considered a breakthrough concept, changing the way of thinking about nuclear power and bringing it closer to citizens	▪ Considering that the chances that NPP's will be initiated by the market are extremely low, a State-owned SPV model could be a viable option for the Netherlands to promote the timely construction of NPP's in the Netherlands, given the NPP project (monetary) size and risk profile
Implementation	▪ The number of potential nuclear technology providers is rather limited. EDF, Westinghouse and KHNP/KEPCO are the only vendors which are involved in the pending tender process	▪ The limited number of vendors in the PNP suggests it is important to start building strong vendor relations early in the process to build trust and align on expectations and avoid undesirable outcomes of possible tenders

Baringa

2.5 France

Contents

Fig 4: The Flamanville nuclear power plant in France(link)

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2.5.A Overview of the Flamanville 3 project

EDF builds a new type of EPR on the site of Flamanville

The Flamanville 3 NPP project is still under construction after various delays. The following table gives a high-level snapshot of the project.

NPP	Name	Flamanville 3
	Type	European Pressurized Reactor (EPR)
	Capacity	1.650 MWe
Project	Developer/owner	EDF
	Funding	EDF (100%)
	Vendor/EPC	Framatome (EDF)
	Construction	Start in 2007, original COD planned for 2012, but delayed till the end of 2023
Costs	Estimated Actual costs	~ €15-20 billion euro (investment + interest cost)
	Estimated cost per MW	~ €11 million euro / MW

2.5.A The Flamanville 3 project

Overview of planned key milestones from development to COD

Project phases	Development	Construction	Commissioning	Operations
Key milestones	▲ **2006:** EDF takes FID, after successful public consultation and approval from the French Government	▲ **2007**: start of construction, ▲ **July 2013:** EPR dome installed ▲ **September 2014:** installation of reactor pressure vessel ▲ **April 2015:** Installation of the 3 steam generators ▲ **April 2016**: Control rod drive mechanisms installation ▲ **March 2017:** System performance tests start-up	▲ **June 2017:** the French regulator issued a provisional ruling that Flamanville 3 is safe to start ▲ **July 2018**: discovery of quality deviations in the welding. Fuel loading was delayed until the end of 2019. ▲ **October 2019**: EDF announced that fuel loading would be delayed until the end of 2022	▲ COD planned for **late 2023**

Project evaluation

- ▲ The initial estimates for construction time and costs for the Flamanville 3 project were unrealistic. While the historical average NPP construction time worldwide was 121 months, the initial construction time scheduled for the Flamanville 3 project was 54 months. This underestimation created huge pressure to try to keep to the very tight delivery times. The multiple design modifications led to frequent suspension of the project
- ▲ The deviations from the initial budget and schedule related also to a lack of governance on EDF's part and by the supervisory authorities. The Board of Directors did not hold regular meetings to discuss this strategic project, nor did they respond to the alert messages from the audit committee
- ▲ The total actual project costs (including capital/interest costs) is currently estimated at around €20bn (i.e., more than 6 times the original budget of €3.3bn). The project currently aims for COD by the end of 2023, which is a massive delay from the originally planned COD in 2012

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2.5.B The role of the Government

The French government has recently announced a “renaissance” for the nuclear industry and build as many as 14 new reactors, arguing that it would help to make France carbon neutral by 2050.

Setting the policy & legal framework

- In February 2022 President Macron set out his plan for a (new) French nuclear renaissance: *"Key to producing electricity in the most carbon-free, safest and most sovereign way is precisely to have a plural strategy, to develop both renewable and nuclear energies. The time is right for a nuclear renaissance in France.”*
- This new strategy means both the lifetime extension of existing NPP’s as well as the launch of a programme for new reactors. The Macron government announced to implement a new regulation of nuclear electricity that will replace the existing ARENH mechanism. The new system would enable households and businesses to benefit from stable prices, close to electricity production costs in France
- A broad public consultation would take place in the second half of 2022 on energy, with parliamentary discussions to followin 2023 to revise the multi-annual energy programme. The new programme could lead to the commissioning of 25 GW of new nuclear capacity by 2050

Providing support for financing

- From a financial and regulatory perspective, government announced massive public funding to the tune of several tens of billions of euros to be committed to financing this new programme, which will make it possible to preserve EDF's financial situation and develop the entire sector
- As EDF is designated to build and operate the new EPRs, the French Government State will secure EDF's financial situation and its financing capacity in the short and medium-term. EDF is actively preparing, along with the entire nuclear industry, the construction of new EPR2 reactors in France. Since the beginning of 2022, the engineering teams, together with those of the main French suppliers, have been busy developing the detailed design and the licensing of the reactor
- In a move to blunt the impact of soaring energy prices exacerbated by the prospect of an abrupt halt to Russian gas supplies, the French government has announced full nationalization of EDF to provide impetus to debt-laden nuclear programme in France

The deeper push into nuclear marks a policy reversal for Macron, who promised earlier (2018) to close 12 nuclear reactors as part of a move away from nuclear.

Baringa

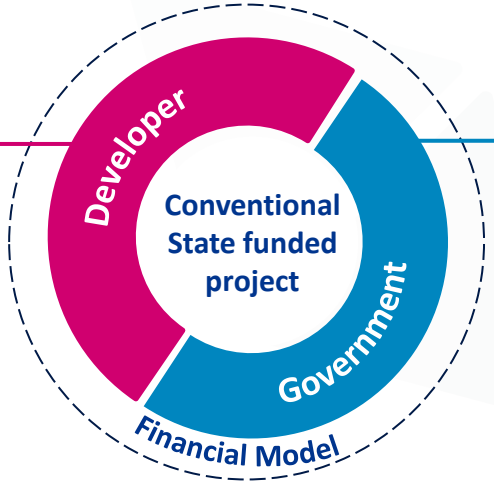
2.5.C The Financial Model

A State funded model for development of NPP using state owned company as the delivery arm. The French State recently announced full nationalization and control of EDF.

The Nuclear renaissance in France is fully state funded with no public private partnership. The government is providing public backed guarantees to EDF as there is no guarantee over the income it will receive from the operation of its reactors.

EDF as sole developer

- EDF historically has been state-owned with the government owning 84% of the stake in it
- EDF has been designated by the French Government to build six EPR2s and to launch studies on the construction of eight additional EPR2s
- They financed the development phase and associated overruns with the construction of an FOAK, as well as the restarting of the French nuclear industrial process, after a standstill of fifteen years
- The risk in development of the NPP is owned by EDF and indirectly by the government and French citizens



French Government

- The State assumes its responsibilities to secure EDF's financial situation through providing public backed guarantees and its financing capacity in the short and medium-term
- It will enable it to pursue its profitable development strategy within the framework of the energy transition
- **In July, the French government announced increasing the stake in EDF from 84% to 100% to help support the nuclear programme**

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2.5.C The Financial Model

A state funded model for development of NPP using state owned utility as the delivery arm

How does it work?

- The **French Nuclear Renaissance programme is a classic state funded programme** delivered through a state-owned utility
- The French **government is ensuring provision of funds and guarantees** to secure the financial state of the developer while **making policy changes to provide income security** to the utility company
- The government increases its stake in the developer and assumes the responsibility and risk of delivery of the programme completely

What are the benefits?

The French Nuclear Renaissance programme model offers the following benefits:

- **low-cost power**, as the state can set the price per unit energy from the NPP, providing low-cost/affordable power to its citizens
- **Resilience:** Being state owned improves energy security of the country and reduces dependency on foreign energy in the future
- Opportunity to divest once operational and proven to create value for its shareholders

What are the challenges?

The state backed funding has the following challenges and disadvantages:

- Several state backed companies and projects across the world have earned the reputation of being inefficient. Hence, **good organisation structure and controls** are needed to ensure company and operations will not turn into a tax payer money guzzler.
- **Recruiting the right people** to right areas could be challenging
- **Avoiding political interference** in company operations

2.5.D Lessons learnt & reflections

Large scale nuclear projects and programmes are difficult to set up without government backing and sharing of risks between taxpayers and investors

Viewpoints	Lessons Learnt	Baringa's reflections for Netherlands
Government	▪ The nuclear renaissance programme shows that the state plays a very important role in designing policies and legislations that will provide some form of income security to these large projects ▪ Stable government and political will are extremely important to provide these long term guarantees to the project developer	▪ The Dutch Government will have to consider bringing in political and legislative changes to provide some form of income protection to the developers ▪ They may need to play an active role in brokering these deals amongst private players or public-private partnerships to unlock investment
Financial Model	▪ The recent NPP new build projects in Europe, including Flamanville 3, proved that the conventional developer-led approach (utility carrying all the construction and market risks) is no longer a realistic option ▪ There is government backing needed to provide guarantees for income, securing funding for projects of this size	▪ It is difficult to launch new projects without any form of public guarantee, irrespective of financial model adopted. Hence, a model, in which various parties, including the State manage and share both construction and market risks, seems like a pre-requisite for any NPP new build projects
Implementation	▪ The nuclear renaissance project shows that a project of this size and complexity cannot be executed without a robust and mature technical design and a capable industrial supply chain ▪ Realistic budgeting and scheduling, together with proper project management, cost controlling, and governance structures are key principles for successful project implementation	▪ The Dutch Government will have to play an important role in the further NPP project development and execution process. It will need to build up a fit for purpose programme management organization with the right competencies and capabilities in order to successfully steer the process throughout all the different stages

Baringa

2.6 United Kingdom

Contents

Fig 5: Hinkley Point C construction of the second reactor (link)

Baringa

2.6.A Overview of the UK nuclear new build programme

The UK Government targets a total nuclear power capacity of 24 GW by 2050, representing up to 25% of the electricity demand.

UK is making a big call to reverse decades of underinvestment in nuclear power and aims to drive down costs by building at scale over the next 30 years.

UK's nuclear power strategy	Short term goals	The Government intends to take 3 projects to FID in this and the next Parliament.
	Mid term ambitions	These ambitions could see the nuclear sector progressing up to 10 more reactors.
	2050 target	The UK aims for nuclear power capacity to up to 24 GW by 2050 (3 times more than today).
NPP projects and support	Available NPP sites	The UK has 8 sites designated as potentially suitable for new nuclear: Hinkley, Sizewell, Heysham, Hartlepool, Bradwell, Wylfa, Oldbury and Moorside. The Government is also planning to develop an overall siting strategy for the long term.
	Funding	The UK is considering the role government financing can play in supporting new projects. Final contracts and construction would commence when any outstanding conditions are satisfied, and projects are sufficiently mature.
New nuclear technology	SMRs and AMRs	The Government wishes to accelerate work on advanced nuclear technologies, including both Small Modular Reactors and Advanced Modular Reactors.

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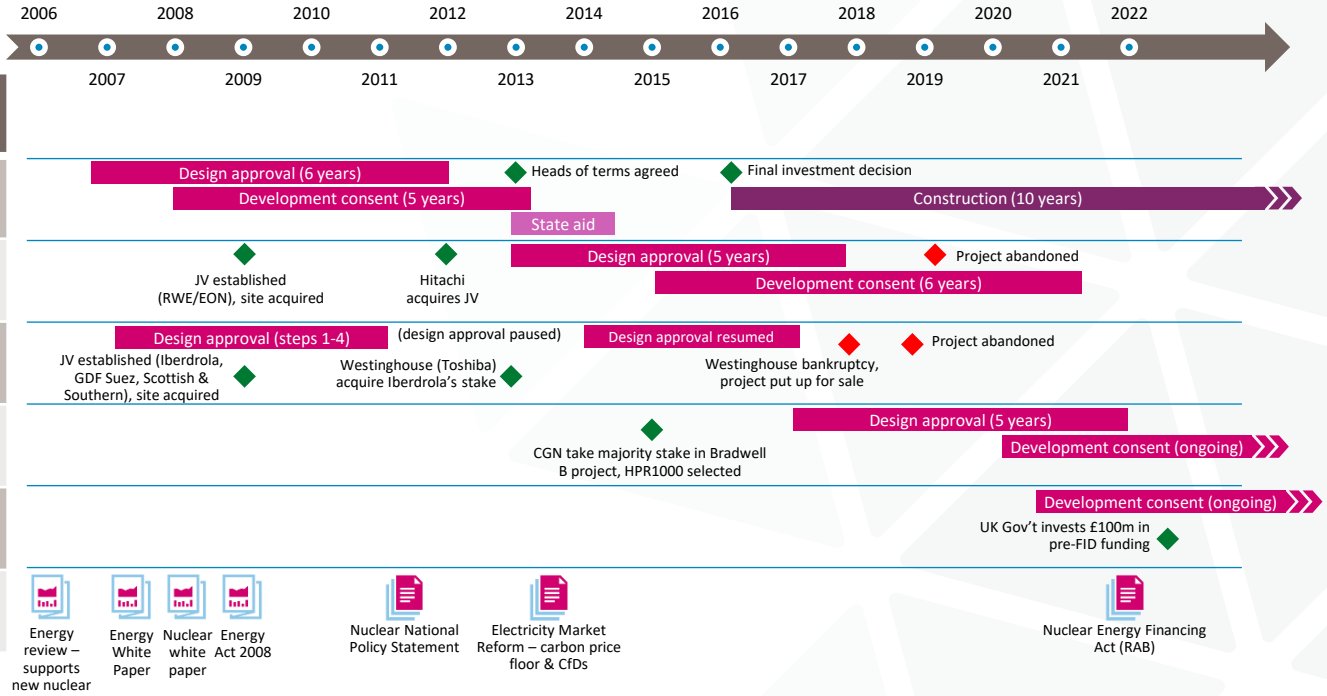
2.6.A Overview of the UK nuclear new build programme

Timeline for UK's nuclear programme

Project	Technology vendor
Hinkley Point C	EDF (EPR)
Wylfa	Hitachi (ABWR)
Moorside	Westinghouse (AP1000)
Bradwell	CGN (HPR1000)
Sizewell C	EDF (EPR)
Legislation	Government



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2.6.B The role of the Government

The UK Government is putting nuclear at the center of its strategy to reach net zero carbon emissions by 2050, alongside renewables

Setting the policy & legal framework

The UK Government has put in place a number of regulatory, policy, and legislative measures intended to facilitate new nuclear development, including:

- The 'Generic Design Assessment' (GDA) process carried out by the independent Office for Nuclear Regulation to assess new nuclear reactor designs ahead of site-specific approvals
- National Policy Statements (NPS) setting out the needs case for large energy infrastructure for planning purposes, including the nuclear NPS which designated 8 sites as potentially suitable for new nuclear power stations
- The Funded Decommissioning Programme, which puts in place the legal framework for decommissioning plans for new nuclear generators
- The Electricity Market Reform (EMR) programme (launched in 2011), which introduced the carbon price floor, Contracts for Difference (CfD) and Capacity Market (CM) schemes to incentivise investment in new generation in GB
- The CfD scheme provides long-term price stability for generators, including renewables and nuclear (see slides 39-40). CfD are administered by a Government-owned counterparty, the Low Carbon Contracts Company (LCCC), which is funded by a levy on electricity suppliers

Providing support for financing

- The CfD scheme was used for Hinkley Point C (HPC), enabling the project to be financed without direct Government funding. However, under this model investors bear all construction risks, and escalating costs and delays have meant that no developers were able or willing to finance projects after HPC
- In response, in 2022 the government introduced primary legislation to introduce a 'Regulated Asset Base' (RAB) model for new nuclear and appoint Ofgem as the economic regulator for nuclear RAB. (See slides 41-42)
- Under the RAB model, projects start receiving regulated revenues based on an agreed rate of return from the start of construction, and risks are shared between investors and consumers. Government can also provide a 'backstop' support package for investors and customers in the event of severe cost-overruns during construction
- The Government is providing funding to Sizewell C in advance of FID (£100m in January 2022, and £700m committed in early September 2022), and may take a 20% equity stake in its construction alongside EDF
- The Government is also establishing a new body ('Great British Nuclear') to bring forward new projects, and a £120m 'Future Nuclear Enabling Fund' that applicants can apply to for funding to help develop projects pre-FID

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2.6.C The Contract for Difference (CfD) model (1/2)

The CfD scheme is designed to incentivise new low carbon electricity generation, including nuclear

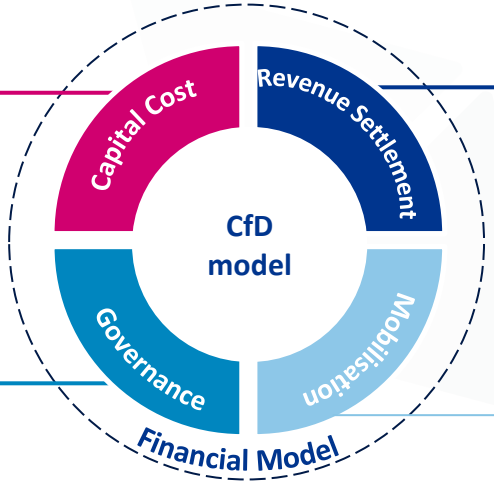
A CfD is a long-term contractual agreement between a low carbon electricity generator and Low Carbon Contracts Company (LCCC), designed to provide the generator with price certainty over the lifetime of the contract.

Investor(s)

- Private Investors fund development of the project.
- Project plan to meet delivery window for development as there are strong disincentives for non-delivery
- Generate energy after commissioning and sell at the wholesale price dictated by the market

Government

- Create a counterparty – the Low Carbon Contracts company (LCCC)
- Government runs competitive auctions to award contracts to private investors/ generators based on the 'strike price' they bid
- Generators receive long term income security and helps secure lower cost of capital
- LCCC sets the amount of levy on suppliers to fund payments to generators



Central Counterparty

- Government-owned central counterparty (LCCC) channels cash flows to/from retailers and generators.
- Contract terms for renewables is 15 years and for nuclear 35 years. Merchant operation after contract expiry provides incentive for power upgrades, life extension etc

National Grid ESO

- Runs competitive competitions to award contracts to private investors/ generators

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2.6.C The Contract for Difference (CfD) model (2/2)

Contracts for Difference is a private law contract between a generator and the Low Carbon Contracts Company (LCCC), which is owned by Government, under which the generator's income per unit of electricity is fixed.

- Difference payment is calculated by comparing a reference price, which is a measure of the market price for electricity, and the generator's strike price, which was set for most projects by an auction and varies project to project. If the reference price is below the strike price, LCCC pays the generator the difference, with the money coming from a levy placed on electricity suppliers. When the strike price is below the reference price, the generator pays LCCC the difference and the money is channeled back to suppliers
- Contract provides real-terms price stability during operation for a contract term. The same form of contract is used for renewables (intermittent and baseload) and nuclear with some differences in terms
- Contract allocation can be by competitive auction or bilateral negotiation, with signature after project pre-development conditions met – though for nuclear only bilateral negotiations have been tried
- Contract sets out milestone delivery dates and final delivery window for development: it is not intended to be an 'option' for the developer and there are disincentives for non-delivery
- Price stability leaves project exposed to volume risk and cost-base risk (including construction cost). The contract provides some protection from qualifying changes in law and regulation
- Contract terms for renewables is 15 years and for nuclear 35 years. Merchant operation after contract expiry provides incentive for power upgrades, life extension etc.

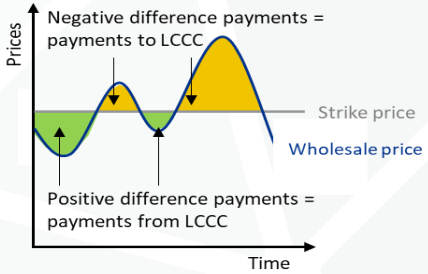

Fig 6: CfD model (link)

Low Carbon Contracts Company (LCCC) is the government-owned counterparty to generators, with an obligation to raise revenue by levy on electricity retailers to pay difference payments, or to return difference payments received from generators to retailers.

In the crisis due to the Russian invasion of Ukraine, the two-way difference payments are, as intended, recovering hundreds of millions of pounds from generators to benefit consumers each quarter.

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2.6.D The Financial Model for RAB

The primary objective of a nuclear RAB model would be to enable the delivery of new nuclear projects and reduce the cost of this additional nuclear capacity.

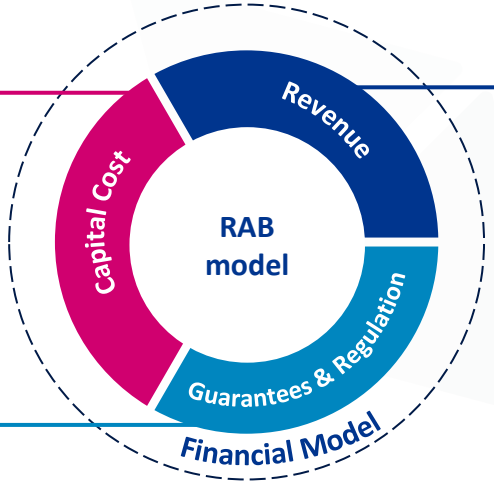
The nuclear RAB model is a robust revenue stream that ensures a secure and consistent flow of revenues between electricity suppliers and nuclear companies benefiting from the RAB model for the duration of their nuclear project's regulatory period.

Investor(s)

- Private Investors fund pre-development to designation (site selection, design approval, development consent)
- Competitive allocation of shares minimises cost of capital
- Government can provide funding from designation onwards to attract private capital for the final investment decision

Government & Regulator

- Government can provide support package as a backstop for investors and customers in the event of severe cost-overruns during construction within the RAB model
- Ofgem (regulator) would appoint a nuclear RAB administrator, whose objective would be to complete construction and/or keep the plant running



Taxpayers/Consumers

- The license determines the revenue stream based on agreed rate of return on funds committed
- The revenue stream is raised during construction by a levy on electricity suppliers. This helps reduce the overall cost of capital, by providing a supplier funded allowed revenue during construction thereby avoiding compound interest and financing costs during a lengthy construction period for a nuclear project
- The revenue stream is paid during operation by a price stabilization mechanism with a variable levy, reflecting the regulated allowed revenue, which will be re-calculated each period to deliver the agreed revenue stream for the period.
- This includes outturn construction and operational costs, so consumers and investors share construction cost risk

Baringa

2.6.D The Financial Model for RAB

A RAB model is a type of economic regulation typically used in the UK for monopoly infrastructure assets such as water, gas and electricity networks.

- The Regulated Asset Base model was originally developed by facilitate privatization of ‘natural monopolies’ including electricity, gas and water networks
- Value of assets is augmented by investment and diminished by depreciation with an agreed rate of return on current value determines allowed revenue stream. The price charged for network access is set to recover the allowed revenue
- There is a large body of academic literature debating the pros, cons and nuances of the model, but it is generally held to be credible by investors
- Model extended to single-largest new investment in water network, the Thames Tideway Tunnel. This is the first use of the model to support the financing of a single asset
- Extending the model to an asset that operates in competitive markets requires the use of an instrument equivalent to the Contract-for-Difference to raise the required revenue

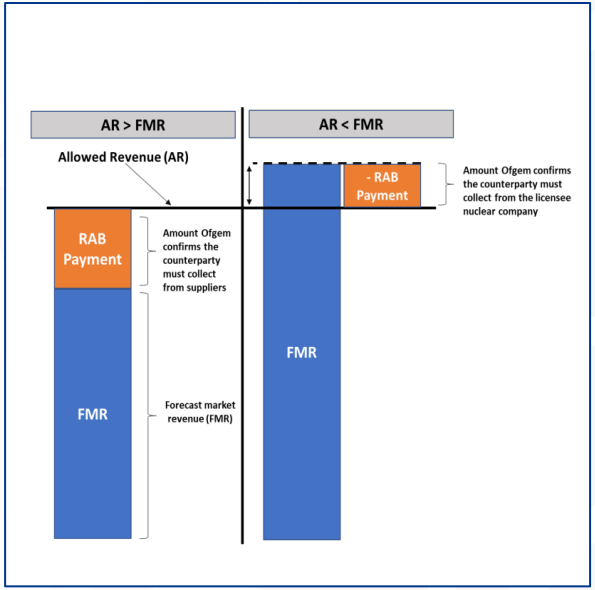


Fig 7: RAB model revenue adjustment mechanism (link)

RAB-funded infrastructure has received significant quantities of investment from private sector players over the last 20-30 years.

Baringa

2.6.D The Financial Model for RAB

How will the proposed RAB model work for nuclear projects in UK?

How does it work?

- The government introduced primary legislation to appoint an economic regulator to implement the RAB model for new nuclear (Nuclear Financing Act 2022). Ofgem will undertake this role. Sizewell C has been designated as the first project to proceed towards RAB licencing
- Private investors fund pre-development to designation (site selection, design approval, development consent). Government can provide funding from designation onwards to attract private capital for the final investment decision. The RAB licence lasts for the entire economic life of the power station. The licence determines the revenue stream due to investors based on agreed rate of return. Competitive allocation of RAB company shares minimises cost of capital
- The regulated return to investors is raised by a levy on electricity suppliers, based on the value of the RAB (the value of the NPP investment on which the return is made) and WACC with legitimate operating costs for e.g. maintenance being recouped on a pay-as-you-go basis. This revenue stream allows investors to start recovering their costs before plant completion and avoids the build-up of interest on loans, which would ultimately lead to higher costs to consumers once the NPP is operational
- Defuelling and decommissioning is funded from revenue set aside during operation, in the same way as was done for Hinkley Point C. Government support package provides a backstop for investors and customers in the event of severe cost-overruns during construction

What are the benefits?

The RAB model offers a variety of benefits:

- **Reducing risk and hence cost of capital** - Transferring risk from a project will, if all other factors are held constant, lower the cost of capital investors will accept to fund the delivery of that project
- **Stable long-term revenues** due to long license terms. 35 years for nuclear
- **sharing of investment risk between several investors-consumers**, which is of particular benefit to small stakeholders
- an **enhanced valuation** by rating agencies which take solidarity among shareholders into account

What are the Challenges?

The model has highlighted some challenges as well:

- The **taxpayer takes on a share of the risk** of high impact events such as delays and exceeding construction costs
- **Consumers pay** from the start of construction which is years **before they receive the benefits** of the power generated from the plant. There is therefore a cost to consumers as they do not receive any interest on these payments over the construction period

Baringa

2.6.E Lessons learnt & reflections

New nuclear power plants will not be built by the private sector without some form of government support

Viewpoints	Lessons Learnt	Baringa's reflections for Netherlands
Government	▪ The original UK nuclear model attracted very substantial (£bns) of investment at risk by developers ahead of legally-binding support. ▪ The current view in the UK is that some level of pre-FID financing is needed to help develop new projects	▪ The Dutch authorities will need to consider if Netherlands can provide confidence to attract vendors and investors to a smaller-scale market (2 units). ▪ Some degree of pre-FID financial support or guarantees may be required
Financial Model	▪ The UK CfD model where all construction cost and duration risk is taken by developers (investors) is unlikely to achieve the value for money for high-risk nuclear projects ▪ The RAB model is new but promising for nuclear power plants ▪ Some degree of risk sharing between consumers, taxpayers and investors is likely to be required	▪ It is difficult to launch new projects without any form of public guarantee, irrespective of financial model adopted. Hence, a model, in which various parties, including the State manage and share both construction and market risks, seems like a pre-requisite for any NPP new build projects
Implementation	▪ The UK regulatory regime resulted in very long periods of time to secure planning consent and design approval and required numerous changes to the NPP designs, even when already approved by other regulators (European, US, Japan). This has driven (a) extended durations of project pre-development and construction, (b) increased project costs, and (c) increased project risk, all of which have resulted in higher consumer costs	▪ The Dutch Government will have to ensure the regulation and regulatory processes do not become barriers in development of nuclear projects thereby adding delays and cost overruns to already complex projects

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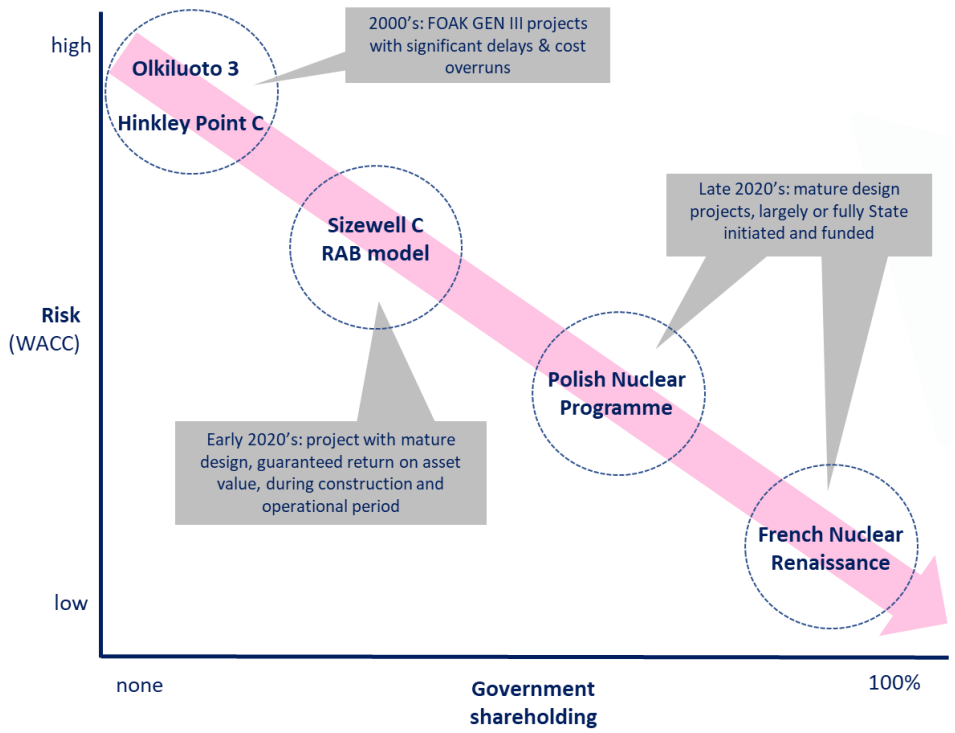
3. Conclusions

3.2 Conclusion

Case studies in perspective



Observations

The various case studies addressed a range of NPP new build projects and programmes in Europe, each with their own specific context and backgrounds. When these projects and programmes were plotted against their (indicative) risk profile and the level of government support, some interesting trends can be observed since the start of this millennium:

- For a variety of reasons, many traditional utilities **have moved away from nuclear** and preferred to **invest in relatively smaller and less risky generation technologies**.
- Governments with nuclear power ambitions need to **trigger NPP new build projects with risk reducing incentive schemes** like the UK government did with the **CfD mechanism for HPC** and the envisaged **RAB model for SZC**.
- Now it looks like we have arrived at the next stage in which the development of NPP new build projects (or rather programmes) are **initiated and (largely) funded by governments.**

Baringa

3.1 Baringa reflections and recommendation

Baringa's reflection and recommendation across the four cases considered for this report

Focus Area	Reflection	Recommendation
Investment and Finance	▲ The cases present an interesting spectrum of financial models ranging from the non-for-profit Mankala model one with assured return to the investors to completely state owned as the French nuclear renaissance to UK's CfD for Hinkley point and yet to be proven RAB model for new NPPs ▲ The point that comes out from all of the above case studies is that some degree of risk sharing between consumers, taxpayers and investors is likely to be required	▲ The Dutch government should consider launching new projects with some form of public guarantee – assured revenue or backstop guarantee for investors. This should be done irrespective of financial model adopted ▲ A model, in which various parties, including the state, manage and share both construction and market risks, seems like a pre-requisite for all NPP new build projects. The Polish model and UK's RAB suggest the best ways to build investor confidence while reducing public exposure
Implementation	▲ It is critically important to have a mature technical design and a capable industrial supply chain. ▲ Realistic budgeting and scheduling, together with proper project management, cost controlling, and governance structures are key principles for successful project implementation	▲ Use a robust and proven NPP design as the Dutch nuclear programme is too small to carry the risks of a FOAK project ▲ Ensure access to high quality technical expertise and assurance support available for the project ▲ Incorporate all relevant and practical lessons learnt internationally into the NPP implementation programme
Government and Regulation	▲ The case studies have highlighted a range of models with varying levels of involvement from different governments. But across all case studies, it is abundantly clear that some form government support is a must, and that a classic developer led model does not work due to the size and complexity of the NPPs	▲ The Dutch government will need to create a political and regulatory framework that will build investor confidence. This would need to be done through policies and strategies that i. provide assured revenue to investors ii. reduce risk and provide low cost of capital ▲ At the same time the policy and legislative framework should not add delays to the overall project lifecycle

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Appendix

Further reading

Relevant links

- Nuclear-Designing-a-financing-model-that-guarantees-competitively-Sfen.pdf
- La construction de l"EPR de Flamanville (J-M Folz, 2019)
- The-cost-of-new-nuclear-power-plants-in-France.pdf (sfen.org)
- Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide
- EDF announces new delay and higher costs for Flamanville 3 reactor | Reuters
- Looking back to see the future: Building Nuclear Power Plants in Europe
- la filiere epr cour des comptes | vie-publique.fr
- International Journal of Management and Economics 2021; 57(4): 343–359
- www.vie-publique.fr/rapport/271429-la-construction-de-lepr-de-flamanville
- SG-1999-08469-01-00-FR-TRA-00 (EN) (europa.eu)
- Korea's KHNP keen on clean energy, nuclear in Poland
- Korea offers six reactors to Poland
- South Korean KHNP offers co-financing of Polish nuclear project – The First News
- Nuclear Project will benefit Poland beyond energy and carbon neutrality
- Westinghouse Milestone Advances Nuclear in Poland
- Agreement between the United States and Poland
- EDF submits a non-binding preliminary offer to the Polish Government
- Poland / EDF Signs Key Agreements With Potential New-Build Suppliers
- EDF prepares to support Poland's nuclear program
- Study on business and financing models for carbon neutral energy supply in Finland.
- The Mankala cost-price model
- Mankala principle: A concept to finance large clean energy investments in Finland
- The Financing of Nuclear Power Plants
- Current status and emerging trends in financing nuclear power projects
- Mankala Chronicles: Nuclear Energy Financing and Cooperative Corporate Form in Finland
- Financing Nuclear Power

Abbreviations

Abbreviation	Meaning
AMR	Advanced Modular Reactor
CFD	Contract For Difference
COD	Commercial Operation Date
EC	European Commission
ECA	Export Credit Agency
EZK	Economische Zaken en Klimaat
FOAK	First Of A Kind
GW	Gigawatt
ITT	Invitation To Tender
LCOE	Levelised Cost Of Energy
LCC	Limited Liability Company
NPP	Nuclear Power Plant
Ofgem	Office of Gas and Electricity Markets
PNP	Polish Nuclear Programme
PWR	Pressurized Water Reactor
RAB	Regulated Asset Base

Abbreviation	Meaning
SMR	Small Modular Reactor
SPV	Special Purpose Vehicle
UK	United Kingdom
WACC	Weighted Average Cost of Capital

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