NUCLEAR ECONOMICS CONSULTING GROUP

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SMR Projects Financing Options: conditions and possibilities.

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Fabienne's experience in the nuclear power industry business dates from 1990 when she joined Cogema. With AREVA until 2012, she held Senior Management positions in Finance, Strategy, Marketing, Large Projects and Offers, and International Partnerships. She wrote « Financing Nuclear Power Projects: a new paradigm?» (IFRI 2015) and « Conditions and possibilités for Financing New Nuclear Power Plants » (JWELB in 2019). She provides expertise and training to the IAEA, IISS, and teaches the Master's Course "Nuclear Economics" at University Paris Dauphine.

Apart from her activities about nuclear, Fabienne is a Partner with Leaders&Co and Expert « Enterprise Innovation » with the EU Commission ».

Introduction

- Numerous types of SMRs being developed in several countries
- Various technologies
- Wide range of sizes
- Common and specific promises
- Still in development phase, many still in R&D phase
- Commercialization within next ten years (?)
- It is time to explore how SMR projects could be financed

-> conditions and possibilities for financing SMRs

Conditions & possiblities to finance SMRs: outline

- Only projects *considered* viable will be financed and (thus) realized -> Necessary to gain lenders and investors' *confidence* in order to attract them to finance a project.

- Conditions relating to:
  - Energy mix, competing power gen technologies
  - Markets applications
  - specific features of nuclear power plant projects
  - Construction risks
  - (un)certainty of future revenues during operations.

  -> How do SMR projects compare to large NPPs ?

- Financing schemes possibilities for SMRs

- During R&D phase: Public/Government & private funding.
- Government support (strategy, regulation, funding…) is needed for NPPs, even more for SMRs.

There are promising viable business cases for SMRs … and suitable financing schemes.

Basics of financing apply to NPP Projects

- **Energy projects are funded**

through:	by:
DEBT	Lenders
EQUITY	Investors

- **Only projects considered as viable get financed and realized:**
  - **Lenders expect repayment of loans (capital + interest)**
  - **Investors expect participation in the profits**

-> Challenges for financing energy projects relate to risks attached to such projects and perception of those risks by lenders and investors

-> The business case is considered before choosing the financing scheme

Note: Projected financial results highly depend upon hypotheses taken for the business case

Nuclear power share in the energy mix: Government role

- **Government policies**
  - Governments decide of Energy policies and Energy mix
  - They compare available options for the country and decide.
  - Establishment of Integrated Resources Plan (IRP)
  - Two main drivers today: urgency to curb carbon dioxide emissions

    Cost and financing

- **Governmental / political risk:**
  - Stability of governmental choices and policies
  - Government support commitment (R&D, innovation, investment, sustainability)
  - Public acceptance:

- Need to **compare several power generation technologies**: LCOE

Levelized cost of Electricity (LCOE)

- Allows to compare kwh cost from various power generation technologies.

$$\mathrm{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

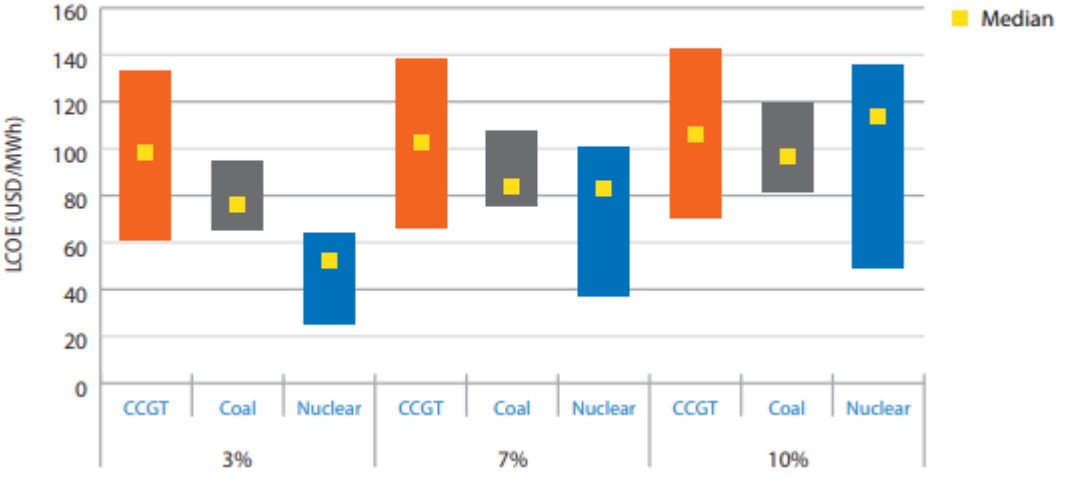
- LEC = coût actualisé de la production d'énergie
- I_t = dépenses d'investissement durant la période t (en année)
- M_t = dépenses d'opération et de maintenance durant la période t (en année)
- F_t = dépenses de combustible durant la période t (en année)
- E_t = électricité produite durant la période t (en année)
- r = taux effectif de réduction annuel
- n = durée de vie du système.

- Most often used at the country level
- LCOE limitations: systems costs, externalities …
- Other Kwh cost definitions relate to profitability of a project or a company:
  - Short term marginal cost
  - Cash cost
  - Accounting cost, from P&L statement

LCOE comparisons for baseload technologies

- OECD/NEA 2015 edition
  - Expected cost of generating electricity from plants commissioned in 2020
  - Expert group of contributors
  - Regional variations especially for construction capital costs
  - Include a carbon cost of USD 30/ton
  - Sensitivity analyses and details by country for data inputs

Figure ES.1: LCOE ranges for baseload technologies (at each discount rate)

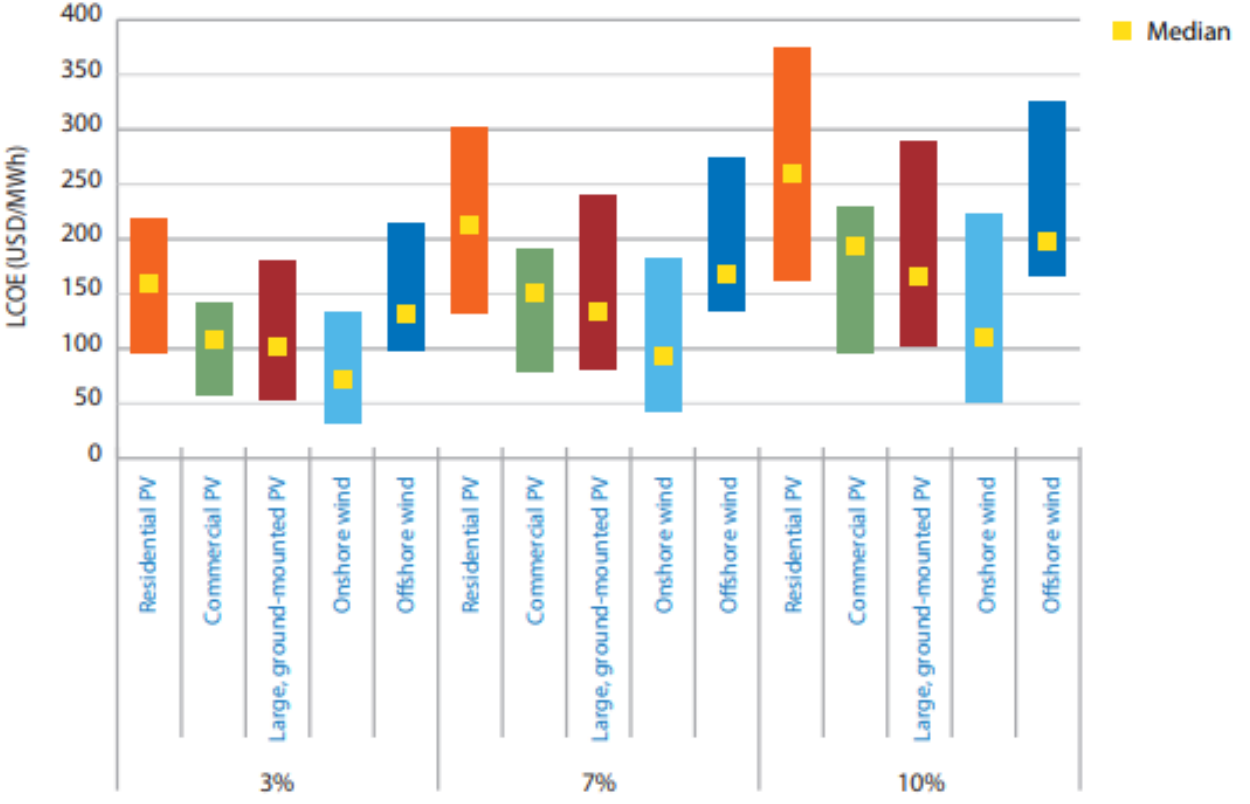


LCOE comparisons for low carbon technologies

- **Projected costs of generating electricity : OECD/NEA 2015 edition**

Ranges close to projections for NOAK SMRs :

Figure ES.2: LCOE ranges for solar PV and wind technologies (at each discount rate)



Viable business case: need for a competitive technology

- **Only projects considered as viable get financed and realized:**
  - **Lenders expect repayment of loans (capital + interest)**
  - **Investors expect participation in the profits**

- Large nuclear reactors are and will remain competitive compared to other technologies. More than 55 plants are in construction phase WW.

- For SMRs, beating **the challenge of size** vs cost Kwe is not obvious
  - Large units are more efficient compared to cost: cost of Kwe decreases with larger sizes.
  - Tendancy to increase size of reactors over time: France: 900 MW, 1300, 1450 MW, 1650 MW
  - « industry economics »: effect on cost per Kwe (about 0,6 size factor)

  -> Large nuclear power units are suitable for power baseload production , with load following…. How do SMRs compare?

Potential viable business cases for SMRs: Markets applications

Business cases can be built for power generation with SMRs:

- **On-grid power when large reactors are not suitable**
  - Size of the economy, electricity needs,
  - What are the other options for baseload kwh production?
  - Security of supply?
  - Are such options CO2-free or low carbon?

  -> terms of the competition is comparison with business case economy of other kwh production costs like small solar, wind, imported gas etc
- **Off- grid power for targeted users or dedicated NPP plants.**
  - Heavy industries such as Mining (Canada) , aluminum producers; Historical examples with large electricity users: Eurodif for gaseous diffusion enrichment(past), paper pulp cies Finland.
  - Remote communities

  -> competition is diesel-fired plants, transported fuel tec.;
- **Other outputs, depending on technologies: process heat ..**

Conditions for attracting financing for NPPs including SMRs: compliance with Int'l rules

- **Country commitment to legal & regulatory rules governing nuclear.**
  - At the international level, rules set by IAEA and several treaties
  - International professional organisations (Wano..)
  - At the national level: individual responsibility of each country to establish
    - Local laws and regulations concerning nuclear power
    - Independent safety authority
    - Nuclear liability regime
    - Nuclear operator etc…
- **Clear SMR and nuclear policy, energy plan, IRP including nuclear power.**

Conditions for financing SMR projects:

Address challenges of specific NPP projects features.

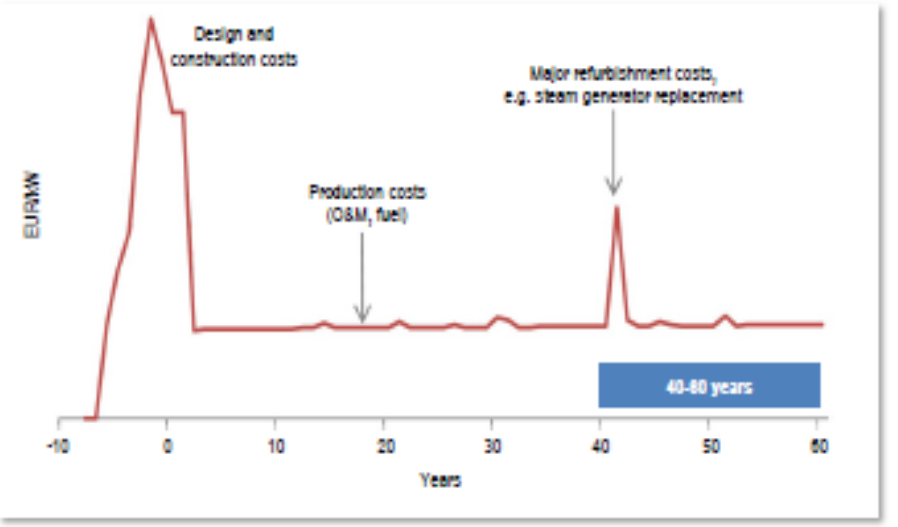
High upfront capital costs

- Funds drawn during construction period
- Loans reimbursed and dividends paid during operations period
- High % of funds committed before Commissioning. High fixed cost ratio, 75 to 80%

-> investment reversibility at high cost

-> high sensitivity to interest rates.

Figure 13: Expenditure profile of a nuclear power plant project



Source: Courtesy of EDF.

For PWR technologies: predictable operational costs

fuel costs are 10% of oper. costs (fossil fuels 60% and volatile

-> Major project risks occur during construction

+ context : poor track record of recent projects.

Conditions for financing SMR projects: Mitigate construction risks

- **Technology risk:**

Most of SMR models are in the development phase

Some are in the pre-licensing phase, for first build 2030 (?)

Some are small models of existing technologies (NuScale PWR),

Some are new versions of technologies that have been built in the past (Sodium),

Some are new technologies (molten salt, variations of HTRs)

Some require new fuel development and supply chain.

- **Some of the technology(ies) promises:**

- Safety features
- Long fuel cycles , no re-loads
- About USD 100/Mwh for a NOAK

-> very few **breakthrough innovative models** regarding cost.

-> Successful licensing process is needed: lengthy and costly

-> **High perceived risk of building a FOAK** , higher than building any of the current Gen3.

Conditions for financing SMR projects: Mitigate construction risks

- **Construction risk is high for reactors units being built today**

- **Challenging construction risks for SMRs :**

-> Overcome the size effect

-> Reap the benefits of innovation and experience in nuclear project management:

- **Factory construction : new for nuclear – logistics & transportation?**
- **Series effect: NOAK after how many?**
- **Safety features : passive safety (already implemented) and technology related features (design)**

-> Construction cost uncertainty

But:

Sizes and budgets range from 1- 4MW to 350 - 600MW, USD 100M USD to USD 1,0bn 2,5bn : closer to other infrastructure and energy projects than large nuclear power units.

-> this should make funding easier.

Conditions for financing SMR projects: Securing future revenues to build confidence.

- Viability of projects depends on costs, and future revenue.
- Business case for SMRs is same as for large NPPs:

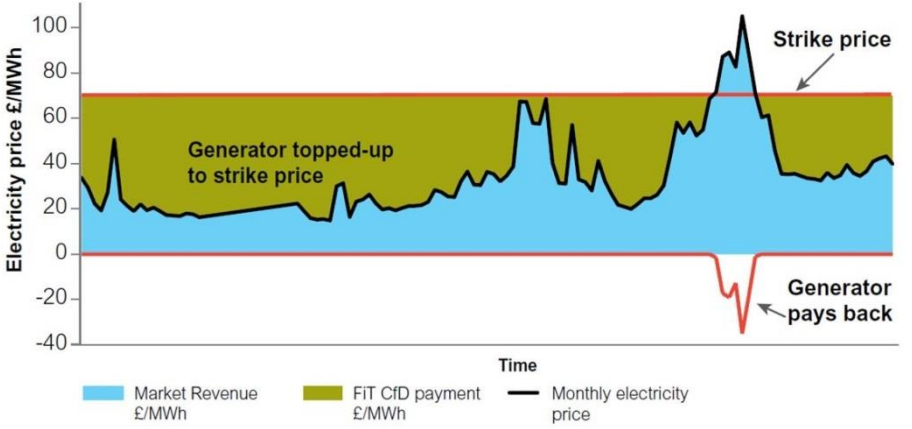
  predictable costs require visibility on revenue.

-> Liberalized and electricity market reforms do not provide revenue predictability.

-> **Find hedging systems**

Long term purchase agreements (PPAs) , off-take arrangements

New tariffs schemes (in the UK, cfd for Hinckley PointC)



Potential for RAB (Regulated Asset Based) model or Capacity markets, to decorrelate financing from kwh market prices. Used in UK for infrastructure financing.

Financing schemes options for SMRs- 1

Historical important role of the International Financing system:

- Commercial banks lending policies towards nuclear projects
- Loans and Bonds with various maturities and amortization schedules , and fixed or variable interest rates
- Creative financial engineering by commercial banks to adapt loan features to the stream of expenditures and revenue of the projects.
- Backing by ECAs, long track record of export financing for NPPs
- After the 2008 crisis, large nuclear projects are not a priority for Banks.
- -> available for SMR projects, smaller deals than large NPPs
- -> But demanding risk reviews …
- -> stringent conditions relating to viability and project governance.

New sources of funds: green bonds, sovereign funds

Financing schemes options for SMRs- 2

SMR projects will not attract private capital without strong incentives:

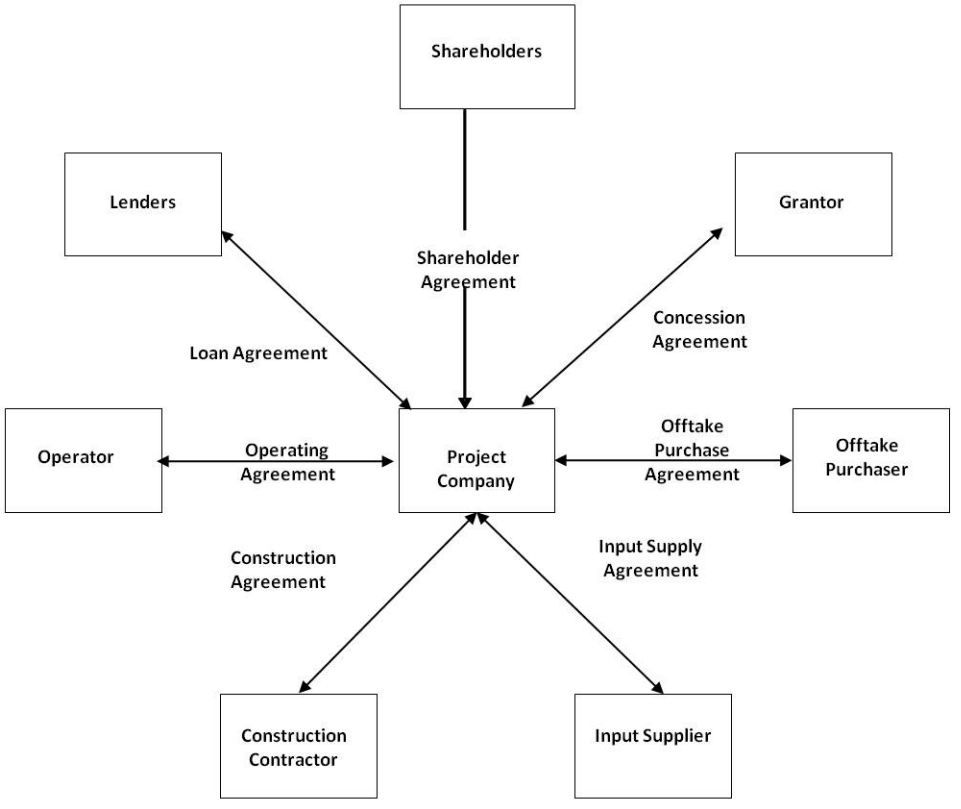
- **Direct and indirect Governments support:**
  - During R&D and Development phase
  - During the licensing phase
  - Support for the FOAK or a number of units
    - Support and incentives to the manufacturing factories,
    - Subsidized loans, equity share through a SOE, production tax credits, siting
  - Sharing construction risk for first units.
  - Provide Future revenue certainty schemes.

- **Start development where a business case is viable:**
  - Size of electricity demand
  - Industrials large electricity users
  - Remote areas

Financing schemes options for SMRs- 3

Project Financing:

A specific project company (SPV) is dedicated to the implementation of a project . Shareholders of the SPV limit their risk (liabilities) to their share in the SPV.



Project Finance fits when:

. Construction risks « controllable and limited

. Technology is well established

. Rate of Return « predictable & motivating »

. Project can be taken over/operated/finished in case of default.

Non- recourse scheme

Not suitable for nuclear power projects

Recent examples: stopped projects in the UK

Financing schemes options for SMRs- 4

On-Balance Sheet Financing:

Corporate Financing is the traditional for private investments, also known as **« Balance Sheet financing » .**

. Description:

Combines borrowing (loans and bonds) and raising equity (invest) against the total assets of the Company.

. **Global recourse on the Company Balance sheet**

The risk of the investment is borne by all shareholders and lenders of the Company. Future global results of the Company are considered to secure sufficient devidends and reimbursement of loans (capital +interest).

. **For financing large NPPs**:

- **Used by large utilities /power plant owners** with strong balance sheets, Exple ,EDF.
- **Often complex**, involving Government support and/or ECAs guarantees + visibility over future revenues . Exple: OL3 Finland.

. Even more suitable for SMR projects if revenue guarantee schemes.

Financing schemes options for SMRs - 5

Industial Electricity user financing scheme:

Complex Corporate Financing, used in Finland for OL3: the Mankala model.

. The shareholders are also customers of the plant, the power off-takers.

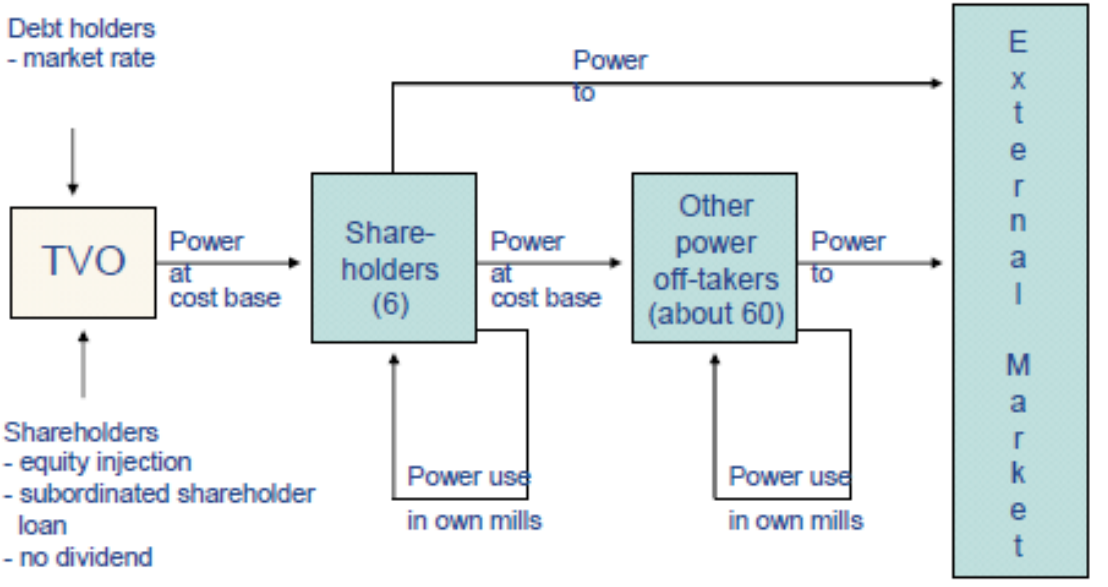
.Equity and debt financing , with ECA involvement in this case.

. Transferred all construction risk

to the vendor AREVA

(high residual risk)

- **Suitable for SMR Projects**



Financing schemes options for SMRs - 6

Public Private Partnerships:

.Definition:

A Long term contract between a Government body and a private entity to provide some public benefit, either an asset or a service.

.PPPs usually combine Developmental and Business Objectives.

-> Can provide access to more sources of funds, including Grants.

-> may lead to complex Project Governance and Management, not favorable to funding from commercial sources.

-> When the PPP is one contract among the large Project, the Project financing schemes prevails over the PPP.

- **Is not used for Nuclear Power Plants as of now.**

Regulated Asset Based financing:

Implemented for infrastructure financing in the UK, explored for NPP financing.

Financing schemes options for SMRs -7

Government financing scheme: suitable for SMRs

Direct or indirect Government support and financing has been the historical approach for developing large domestic nuclear programs: USA, France, Russia, Canada, Belgium, Germany, Japan, Korea, China.

Financing by the host country, ECA available for exports

UAE, Barakah NPP project:

Strong Government involvement &control

4 units planned, Unit 1 completed

84% debt, 16% equity

UAE Govnt provides 78% of the financing

-66% loans, 12% Equity

- Sovereign guarantee for remaining bank loans and for full PPA

Kepco holds 18% equity

Kexim and US ECA (8%)

ENEC, 100% Govt owned holds 82% of the future operator, Nawah.

Concluding remarks:

- Viable business cases exist for SMRs
- On the basis of a proven and licensed technology
- Government financial support is needed during first units' projects
- Private financing will grow as confidence develops
- Business cases drive the financing scheme, not the reverse.

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Financing Nuclear Power Plants Projects: a New Paradigm?

Fabienne PEHUET LUCET 2015

http://www.ifri.org/fr/publications/enotes/notes-de-lifri/financing-nuclear-power-plant-projects-new-paradigm

Conditions and possibilities for financing new nuclear power plants.

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