SMR Deployment and Economics: Viability of Business Case

Aliki I. van Heek
Unit Head 3E Analysis
Planning and Economics Studies Section
Division of Planning, Information and Knowledge Management
Department of Nuclear Energy
International Atomic Energy Agency

TWG SMR
VIC, 8 July 2019

Introduction to PESS

- PESS = Planning and Economics Studies Section

- The Section:
  - assists Member States capacity building, through training, technical assistance and information exchange in energy systems analysis and planning to identify the role of different technologies, including nuclear, in meeting their future energy needs.
  - strengthens Member States' understanding of nuclear technology's compatibility with national sustainable development objectives and its possible contributions to socio-economic development, climate protection and energy security.
  - maintains information references of energy and economic data for IAEA Member States, as well as the world's nuclear power generating capacity projections through 2050.

Two focus areas within PESS

Energy Modelling, Data & Capacity Building

- In-house techno-economic assessments
- **Analytical tools** for energy assessment
- **Support** in using these tools
- Information references of energy and economic data and nuclear power projection
- Capacity building through **training** and technical assistance for national studies

Energy, Environment & Economy (3E) Analysis

- Contribution of nuclear energy & nuclear technologies to
  - Sustainable socio-economic development
  - Climate protection
  - Energy security
- Research and inputs for international negotiations on climate change and sustainable development

Business case definition (1)

business case

noun [C] • UK US

FINANCE, COMMERCE **an explanation or set of reasons describing how a business decision will improve a business, product, etc., and how it will affect costs and profits and attract investments:**

the business case for (doing) sth *The business case for investing in alternative energy is compelling.*

The contest requires contenders to ***make a business case for*** *their invention.*

(Definition of "business case" from the **Cambridge Business English Dictionary** © Cambridge University Press)

Business case definition (2)

- ‘Business model’
  - A business model describes how a project creates, delivers, and captures value.
- ‘Demonstrating the business case’
  - Ability of the project to cover its own fixed and variable costs, to generate acceptable returns for its shareholders, and to induce broad economic, social and environmental impacts that would be beneficial to all stakeholders.

A 5-step process for developing business models for SMRs

1. Determine the requirements in terms of annual revenues

   → The project should cover its own costs and generate returns for its shareholders

2. Conduct a *market research*

   → Market size and needs

3. Analyze the *competitive landscape*

   → Strategic positioning

4. Conduct a *financial analysis* ..

   .. on behalf of the *sponsor of the project*

5. Perform an *economic analysis* ..

   .. from the point of view of *society*

What could make the project economically viable?

How the project should be structured to achieve its objectives?

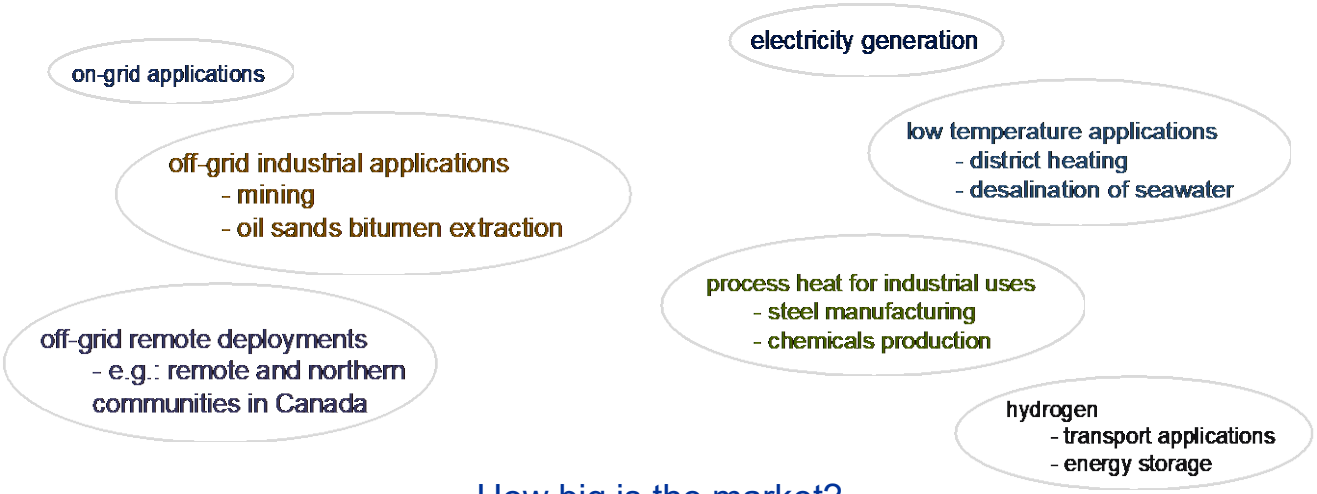
What kind of support governments could provide?

1. Determine the requirements in terms of annual revenues

2. Conduct a market research

Market segmentation

Dividing a market of potential customers into groups, or segments, based on different characteristics

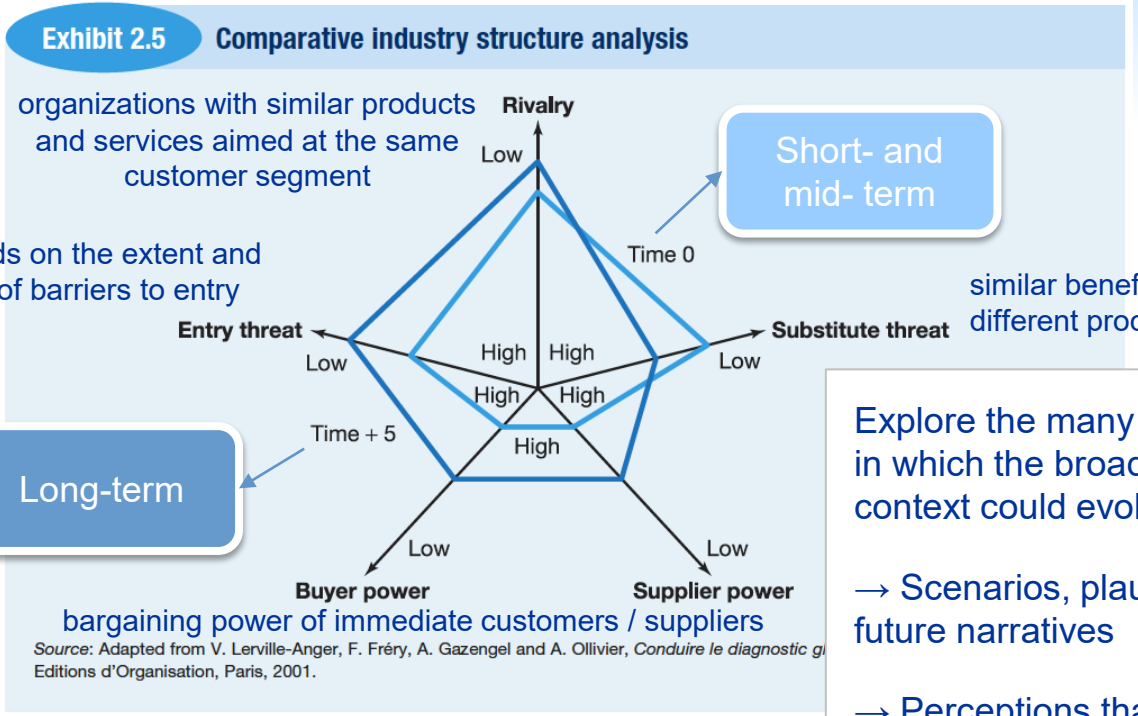


How big is the market?

a projected $400 billion to $600 billion global market for SMRs *

* cf. 'Vision 2050 Canada's Nuclear Advantage'

3. Analyze the competitive landscape



Explore the many ways in which the broader context could evolve

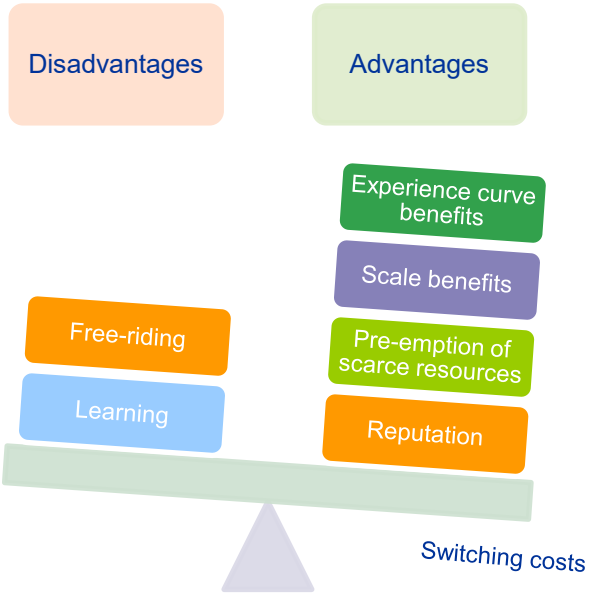
→ Scenarios, plausible future narratives

→ Perceptions that should be challenged

Johnson et al. (2008), Exploring Corporate Strategy.

3. Analyze the competitive landscape

- A first-mover advantage exists where an organisation is better off than its competitors as a result of being first to market with a new product, process or service.
- *Experience curve benefits*, *economies of scale* and the *pre-emption of scarce* resources all confer cost advantages on first-movers.



Johnson et al. (2008), Exploring Corporate Strategy.

4. The *financial analysis* is to be conducted on behalf of the *sponsor of the project*

- Elements of a financial analysis:
  - Cash-flows for project costs and revenues
  - Tariff and affordability analysis
  - Financial profitability and sustainability
- Prerequisites:
  - How certain are future revenues
    - Power purchase agreement
  - Ownership structure
    - Risk allocation
  - Project funding strategy

5. The *economic analysis* is to be performed from the point of view of *society*

- The key concept is economic analysis is the use of *shadow prices* to reflect the social opportunity cost of goods and services, instead of prices observed in the market, which may be *distorted*.
- Sources of market distortions are:
  - Non-efficient markets where the public sector and/or operators exercise their power (e.g. subsidies for energy generation from renewable sources);
  - Administered tariffs for utilities may fail to reflect the opportunity cost of inputs due to affordability and equity reasons;
  - Some prices include fiscal requirements (e.g. VAT);
  - For some effects no market (and prices) are available (e.g. reduction of air pollution, time savings).

Economics of Nuclear Power

General Characteristics

- Political component
- Significant government involvement
- Very few utilities own nuclear. These utilities in many countries are partially or wholly owned by state.
- Limited number of vendors.
- Significant safety and non-proliferation issues.
- A source of technological and human resource development.
- Strong public opinion component.
- An accident anywhere is a problem everywhere

Financial Characteristics

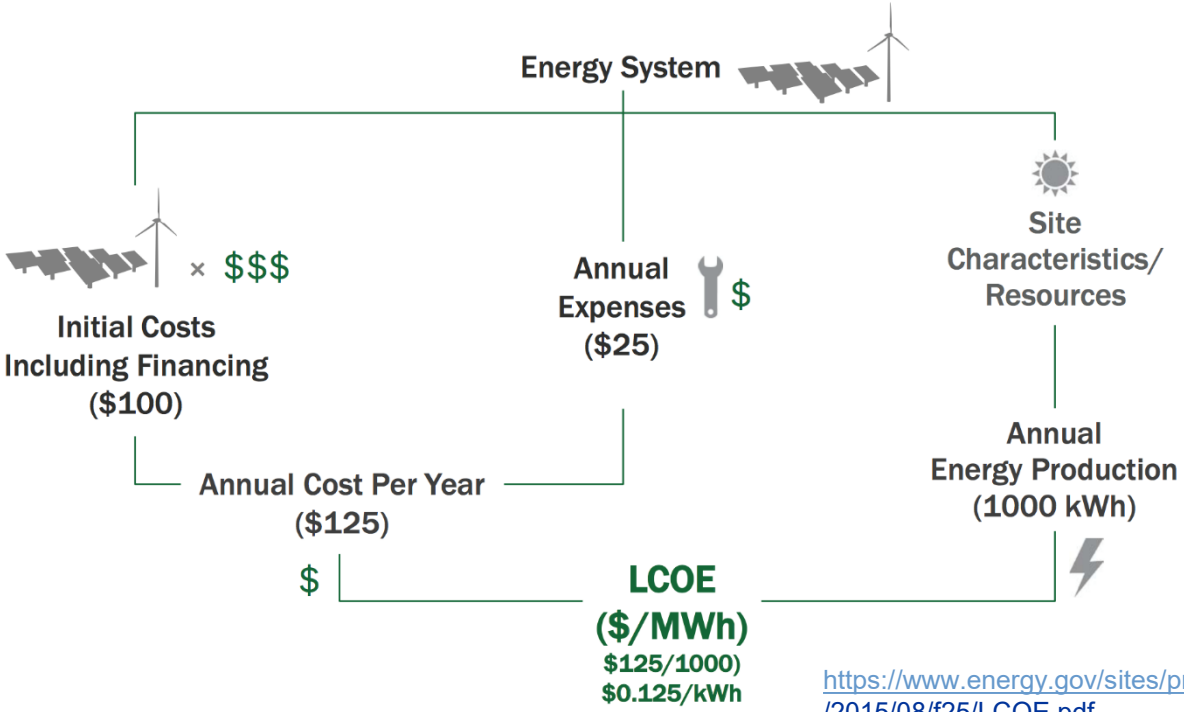
- History of delays and cost overruns (especially for FOAK)
- Nuclear has low OPEX but very high CAPEX
- Very sensitive to discount rate and construction time
- Long lead time (7 years or more); long payback period
- Baseload generation
- Special terms of financing are needed

Costs of Power Generation

- Plant-level costs
  - Pre-project development costs
  - Construction costs
  - O&M and fuel costs (fixed and variable components)
  - Taxes and set-aside provisions
- Grid-level costs
  - Profile (or utilization) costs
  - Balancing costs
  - Grid costs (incl. connection costs)
- Externalities
  - Environmental (for e.g.: emissions of GHG and air pollutants)
  - Socio-economic (for e.g.: impact on security of supply, employment, and the country's economy)

Levelized cost of electricity (LCOE) -

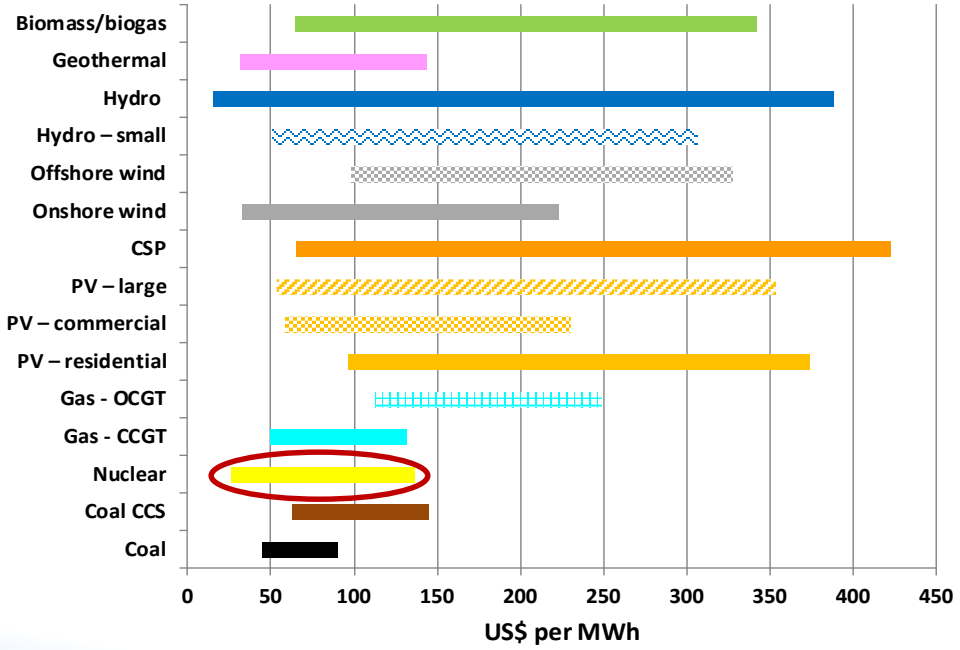
LCOE = the total cost of power plant construction and operation per unit of power production



https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf

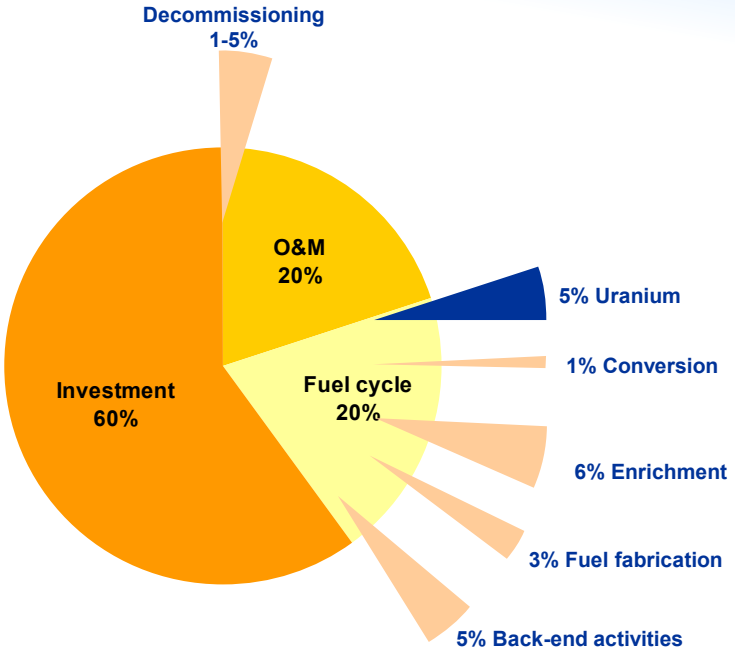
Adapted from European Wind Energy Association, "Economics of Wind Energy," http://www.ewea.org/fileadmin/ewea_documents/documents/00_POLICY_document/Economics_of_Wind_Energy__March_2009_.pdf

LCOE generating costs: technologies compared



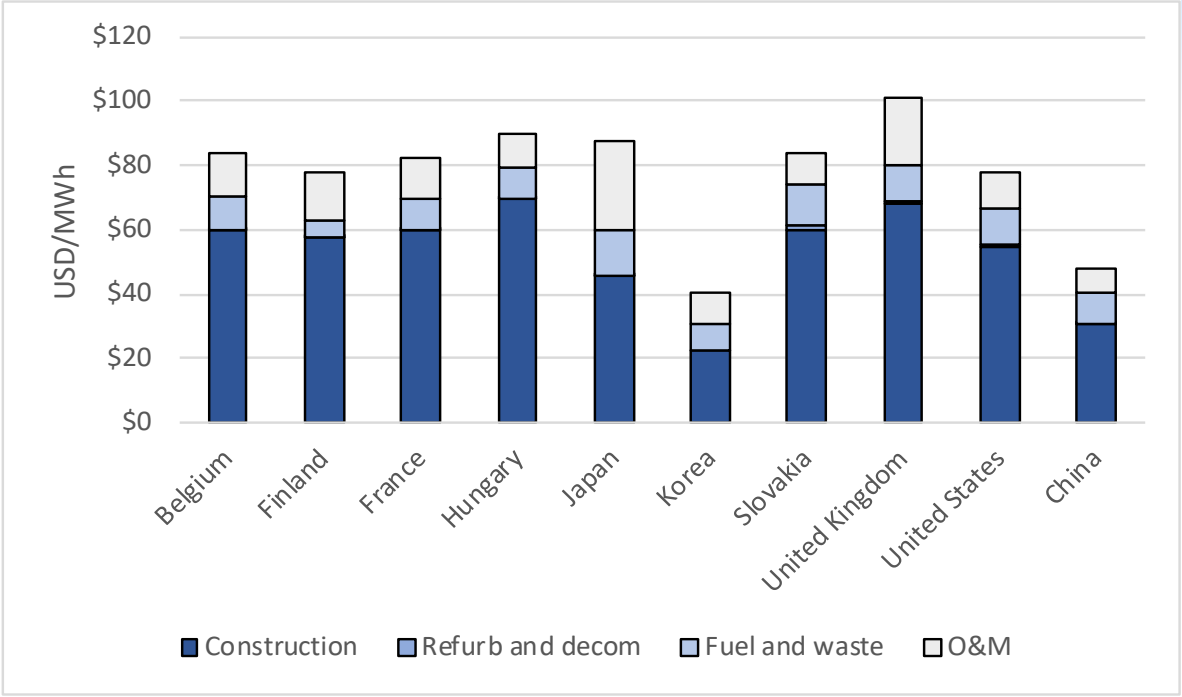
Source: NEA/IEA, 2015

Typical Nuclear Electricity Generation Cost Breakdown



Source: NEA

History of nuclear power LCOE



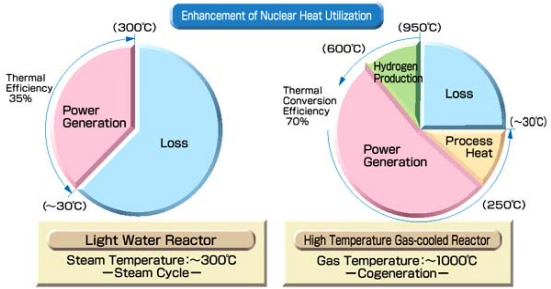
Source: IEA, Projected Costs of Generating Electricity 2015

Development potential: opportunities for SMR

Nuclear power still has a significant development potential:

- Up to 60% higher fuel efficiency (and correspondingly less waste)
- Significantly lower off-site effects in case of an accident

- Markets beyond electricity, e.g.:
  - Hydrogen production from electrolysis
  - Drinking water production by desalination



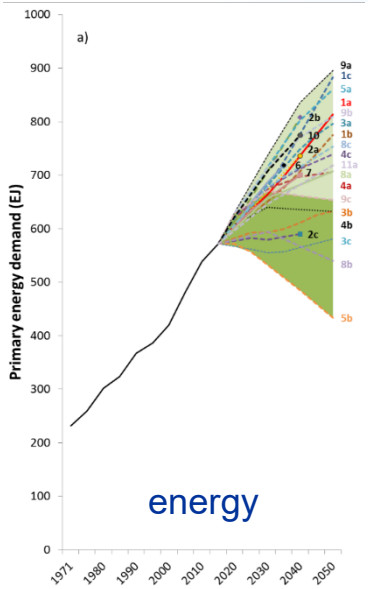
Development potential: opportunities for SMR

The challenge for SMR: lack of economy of scale

Potential remedies:

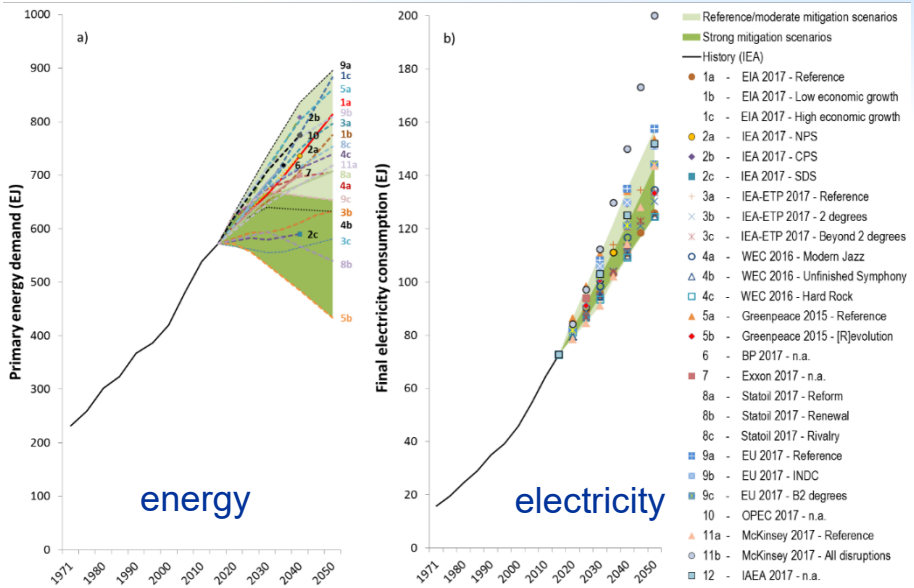
- Series production
- Factory (shop) fabrication

Demand challenge



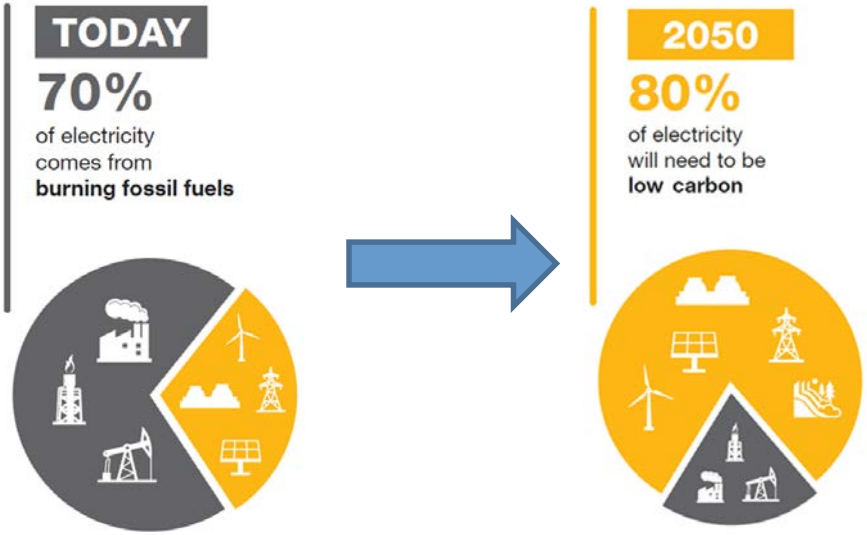
Reference/moderate mitigation scenarios
Strong mitigation scenarios
History (IEA)
1a - EIA 2017 - Reference
1b - EIA 2017 - Low economic growth
1c - EIA 2017 - High economic growth
2a - IEA 2017 - NPS
2b - IEA 2017 - CPS
2c - IEA 2017 - SDS
3a - IEA-ETP 2017 - Reference
3b - IEA-ETP 2017 - 2 degrees
3c - IEA-ETP 2017 - Beyond 2 degrees
4a - WEC 2016 - Modern Jazz
4b - WEC 2016 - Unfinished Symphony
4c - WEC 2016 - Hard Rock
5a - Greenpeace 2015 - Reference
5b - Greenpeace 2015 - [R]evolution
6 - BP 2017 - n.a.
7 - Exxon 2017 - n.a.
8a - Statoil 2017 - Reform
8b - Statoil 2017 - Renewal
8c - Statoil 2017 - Rivalry
9a - EU 2017 - Reference
9b - EU 2017 - INDC
9c - EU 2017 - B2 degrees
10 - OPEC 2017 - n.a.
11a - McKinsey 2017 - Reference
11b - McKinsey 2017 - All disruptions
12 - IAEA 2017 - n.a.

Demand challenge



The Climate Change Challenge

(when limiting temperature rise to 2° C above pre-industrial levels)



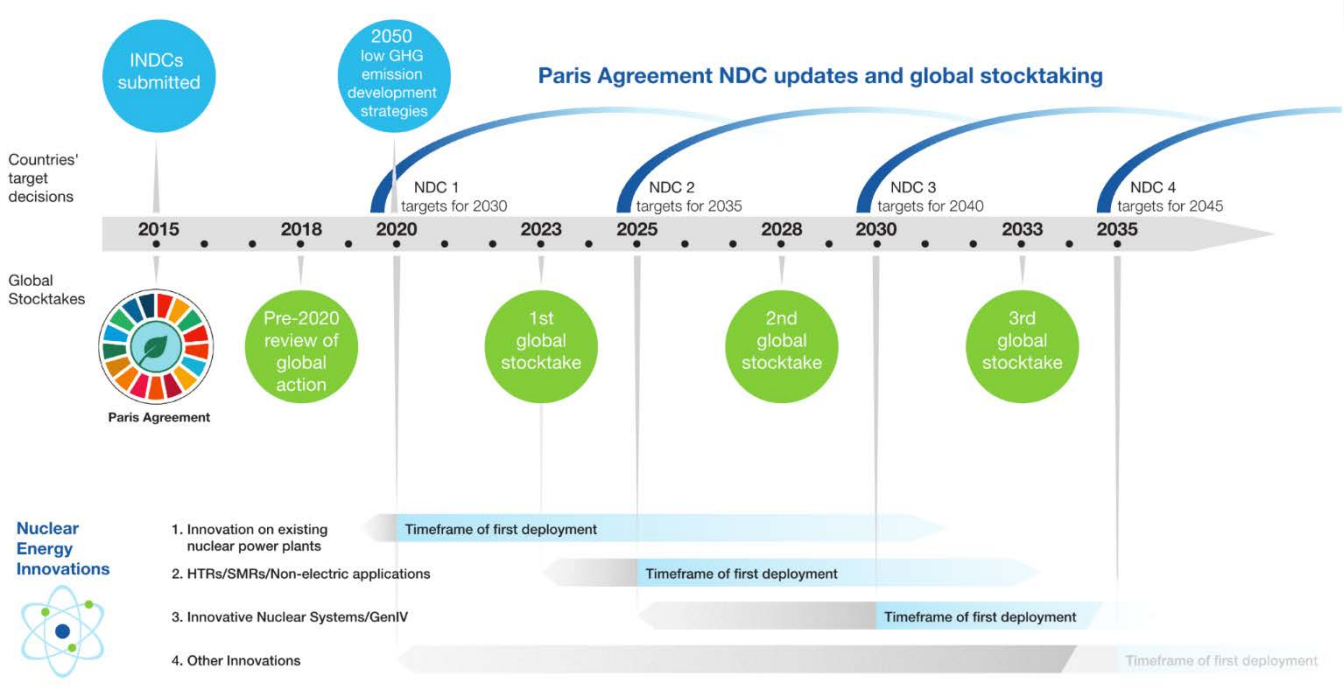
Today, nuclear energy represents one of the largest contributors to low carbon energy, supplying 1/3 of available low carbon electricity.

Decarbonization of the electricity sector is a double challenge:

1. a large fossil share to be replaced by low-carbon technologies, and
2. a fast growth in the coming decades

The Paris Agreement: an opportunity for innovative nuclear power

NDC = Nationally Determined Contribution



The recurring character of the Paris Agreement offers an opportunity for innovative nuclear power: the dynamic mechanism to strengthen mitigation ambition over time

The role of nuclear energy in evolving electricity markets

- Looking inward:
  - LWR remained dominant
  - Innovative concepts (HTR, FR), are being built but only very few, one-of-a-kind, electricity-only
- Looking outward: electricity markets changed
  - Deregulation
  - Integration of larger shares of intermittent renewables in the electricity systems

Source of image: N. Enbar, EPRI, Enabling Greater Grid Flexibility, NREL Workshop on Pathways to Decarbonization, Golden CA, USA, 9-10 June 2016

Electricity generating assets in the "Old World" vs. the "New World":

Old world

- 8000 hours with less than 15 starts annually
- 15 year time horizon
- Long-term power purchase agreement and certain capacity payments
- Predictable regulatory landscape
- Predictable O&M cost

New world

- 2000 hours with more than 100 starts annually
- 3 year time horizon
- Uncertain capacity payments, ancillaries, and energy prices
- Dynamic regulatory landscape
- Unpredictable O&M cost

Source: K. Spengler, GE, Connecting the Physics and the Financials, APPF, IEA, Paris, France, 18 September 2017.

Electricity generating business cases in the “Old World” vs. the “New World”:

Old world

- Straightforward business case and investment decisions
- Deterministic financial value models
- Physics of solution is primarily hardware

New world

- Probabilistic business case with scenarios complicating investment decisions
- Stochastic financial value models with market and regulatory uncertainty
- Physics of solution is hardware, advanced controls, and optimization software

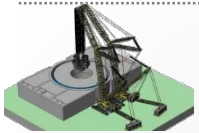
Source: K. Spengler, GE, Connecting the Physics and the Financials, APPF, IEA, Paris, France, 18 September 2017.

SMR: already more market-oriented

Economic

- Lower Upfront capital cost
- Economy of serial production

Better Affordability



Modularization

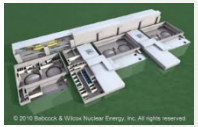
- Multi-module
- Modular Construction

Shorter construction time

Flexible Application

- Remote regions
- Small grids

Wider range of Users



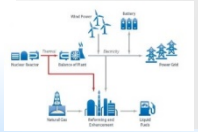
Smaller footprint

- Reduced Emergency planning zone

Site flexibility

Replacement for aging fossil-fired plants

Reduced CO_2 production



Potential Hybrid Energy System

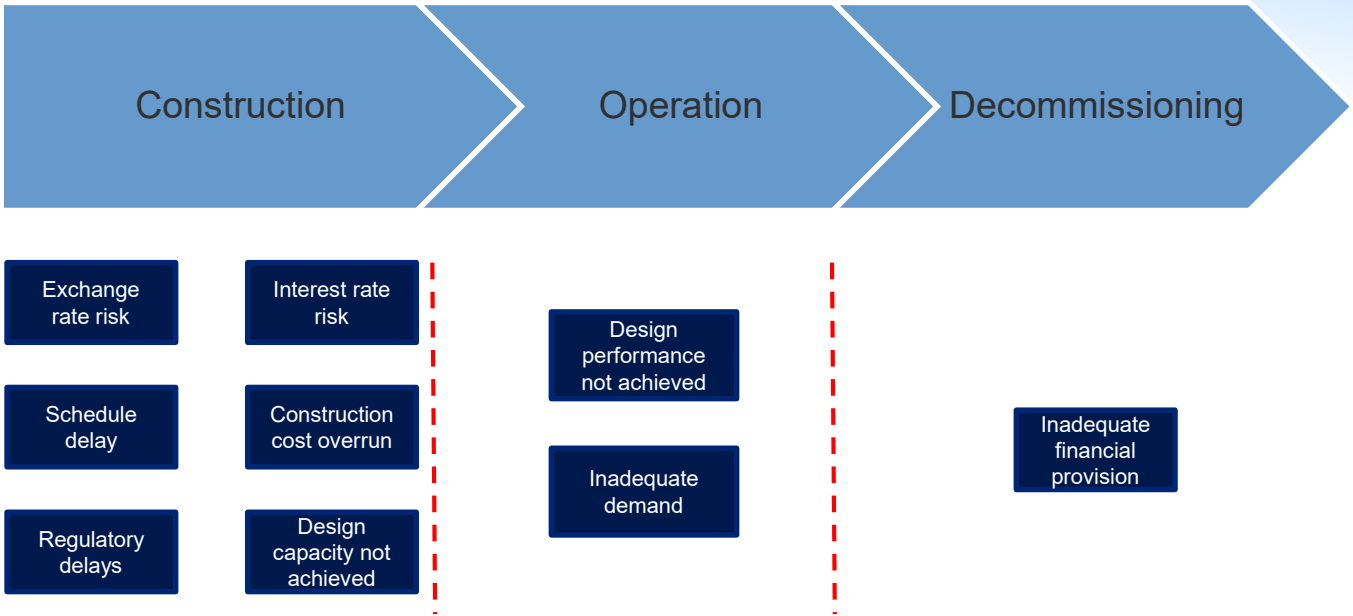
Integration with Renewables

Economics of Nuclear Power: Risks

- **Risk allocation** – key factor for investors:

- Capital exposure (not unique for nuclear)
- Completion risk
- Regulatory risk
- Operating risk
- Market risks – demand & revenues
- Political risk
- Technology risk
- External disasters

Risks over the nuclear project lifecycle



All these risks will potentially impact the return received by funders
All these risks are ***financial*** risks!

Innovative nuclear construction projects today

- Advanced reactor construction projects are
  - in regulated environments
  - technologically closely related to prototypes built previously
- Key to a viable SMR business case:
  - perceived market risk
  - limited technological risk
  - supportive government attitude

Research: respond to the electricity market

Nuclear engineering research:

- Drive capital costs down (clever construction, generic license?)
- Drive energy costs down (pooling systems, automation in O&M and security?)
- Design nuclear power concepts that operate flexibly (fast-ramping)
- Invent tricks (e.g. energy storage in order to run full power all the time)

Other:

- Help with repairing the electricity market (define kWh pricing models where nuclear would fit in better)
- What role will energy storage play? (to back up for variable renewables, therefore shrinking the market for nuclear)

To summarize

- Business case for SMR can be viable when the risks can be limited enough for the investments needed
- Research: respond to the electricity market!

IAEA
International Atomic Energy Agency

Thank you
for your attention!

Dr. Aliki I. van Heek
Unit Head 3E Analysis
Planning and Economic Studies Section (PESS)
Division of Planning, Information and Knowledge Management
Department of Nuclear Energy
Tel. +43 (1) 2600-26942
Mobile +43 (699) 165 26942
Email: a.vanheek@iaea.org
Internet: www.iaea.org