IAEA
International Atomic Energy Agency
Atoms for Peace and Development

The business case for SMR
Challenges and Opportunities for deployment

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The International Atomic Energy Agency

IAEA Quick Facts

Year Founded	1957	Headquarters	Vienna, Austria
Member States	170	Liaison Offices	Geneva, Switzerland New York, USA
Number of Employees	ca. 2,500	Regional Offices	Toronto, Canada Tokyo, Japan
Laboratories	14	Regular Budget	€362.5 million

Publications

Databases

Tools

Services

Our Role

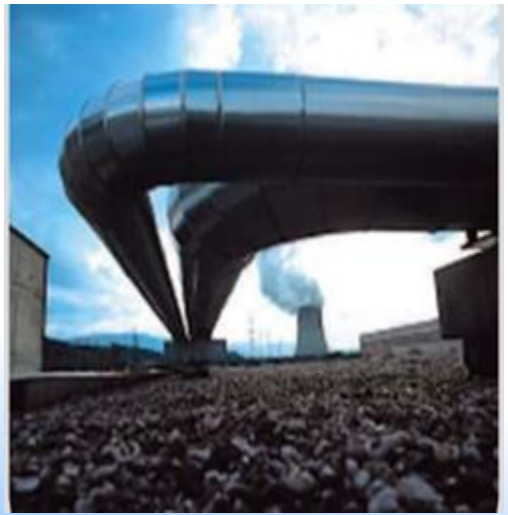
"It is each country's sovereign decision whether to add nuclear power to tis energy mix. For those who choose to do so, the IAEA role is to help them build the expertise to use nuclear power safely, securely and sustainably."
former DG Amano

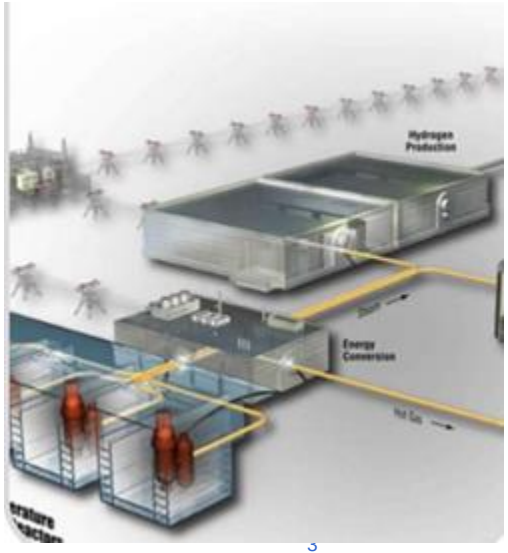
DG Grossi

Nuclear energy products beyond electricity

- .
- Heat
- Cogenerated heat and electricity
- .

- industrial heat
- district heat
- desalinated water
- hydrogen





Nuclear energy products in IAEA PRIS database

- From IAEA PRIS database, in 2020: 71 of 457 nuclear reactors worldwide also used for non-electric energy products
- 55 of these below 2% of their output non-electric

trade-off sales electricity vs. heat

heat cannot be transported as far as electricity

https://pris.iaea.org/PRIS/home.aspx

Power Reactor Information System (PRIS) - Copyright © International Atomic Energy Agency

Energy produced from Non Electrical Applications

Reactor Group

All Reactors

Filters

Base Year : 2020

Show Reactor Details : Yes

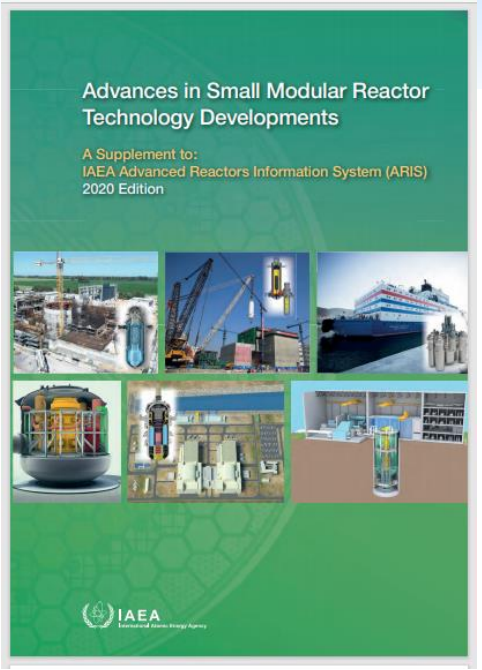
NEA Application type : Process Heating ,District Heating ,Desalination

							Number of Reactors with NEA	RUP [MWe]	Total Heat [GCal]	Electrical equivalent of heat [GWh]	% of NEA
						TOTALS:	71	51181	5986858.83	2189.47	0
ISO Code	Unit	Type	Model	District Heating	Process Heating	Desalination			Total Heat		% of NEA
				PDH Thermal energy [GCal]	PPH Thermal energy [GCal]	PDI Thermal energy [GCal]	Electrical energy for Reverse Osmosis [GWh]	Water production [m3]	Total Heat (PDH + PPH + PDI)	Electrical equivalent of heat [GWh]	
JP	GENKAI-3	PWR	M (4-loop)			11781	0	167552	11781	4.1	0
RO	CERNAVODA-1	PHWR	CANDU 6	45834.37					45834.37	20.94	0.03

Why Small Modular Reactors for non-electric applications?

- SMRs are
  - newer generation reactors
  - designed to generate electric power up to 300 MW
  - components and systems can be shop fabricated
  - transported as modules to the sites for installation

- Instead of concentrating much power generation on one site, SMRs could be distributed over the locations according to heat demand.



https://aris.iaea.org/Publications/SMR_Book_2020.pdf

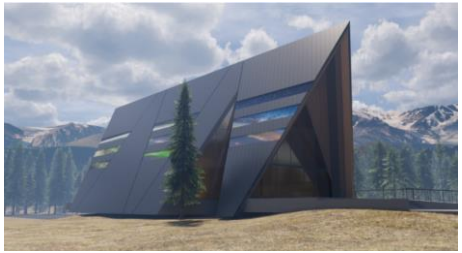
What are Small Modular Reactors?

- SMR is a container term, it is not one particular reactor or plant design, but a group of small-scale designs.
- Not yet commercialized, few are being demonstrated, many not yet.
- Classified along fuel/coolant combination:
  - Based on traditional water-cooled reactor designs
  - Designs featuring:
    - Higher temperatures, better thermal inertia (gas cooled high temperature reactors)
    - Improved fuel/waste economy (fast reactors, molten salt reactors)

recently constructed SMR

From the 72 designs in the IAEA SMR publication:

- 4 built
- 1 under construction
- 67 “on paper” in various stages of design and licensing approval



- 50 by traditional reactor vendors, national laboratories or universities
- 22 by startup companies

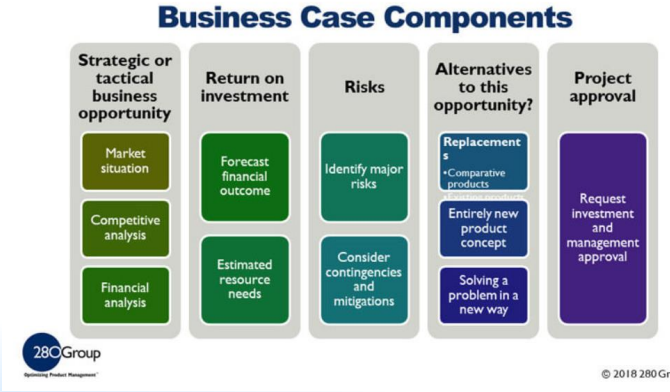
Business Case

- A sound business case is a prerequisite to bringing the SMR technology to fruition.
- Government support can bring it to the market — but to stay there and develop: for this a business case is needed:
  - market needs
  - competitors
  - costs
  - delivery times
  - revenues
  - risks
- Two perspectives:
  - Owner/operator
  - Developer/vendor

What is a business case?

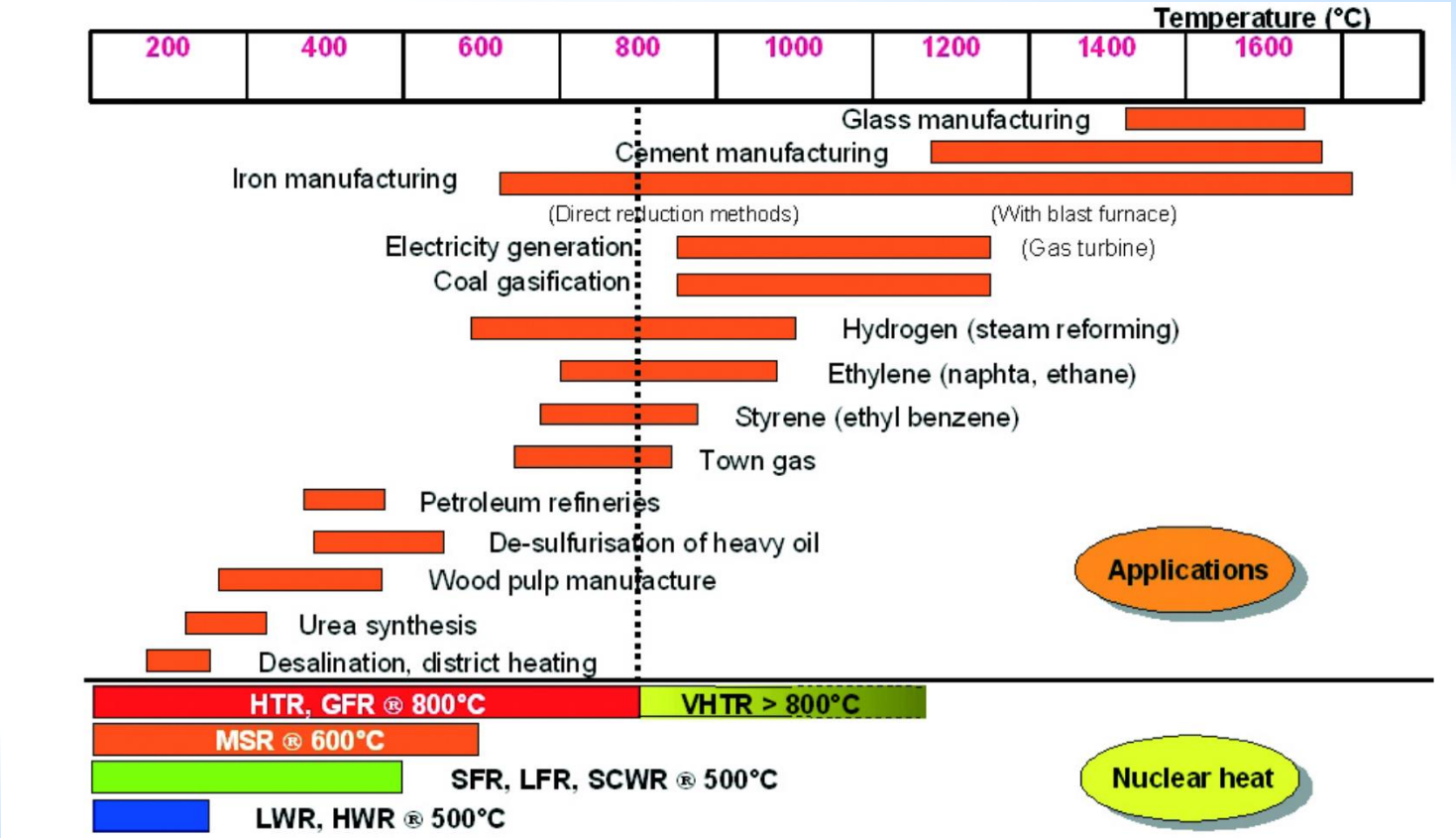
Many definitions, for example:

- The business case is a process to critically examine the opportunities, alternatives, project stages and financial investment in order to make a recommendation for the best course of action that will create business value.



Example of business case structuring

Markets for SMR



Economies of scale - demand

- Demand needs to be sufficient – multiple units
- Not only nuclear, also for example airplanes:

> Airbus needs a minimum of six to eight orders a year to keep production alive at the A380's final assembly plant near Toulouse.
>
> https://www.nytimes.com/2018/01/15/business/airbus-a380-emirates.html

The New York Times

Airbus A380, Once the Future of Aviation, May Cease Production

An A380 operated by Malaysia Airlines passing over London. The European aerospace company said on Monday the A380 was at risk of being discontinued. Matthew Childs/Reuters

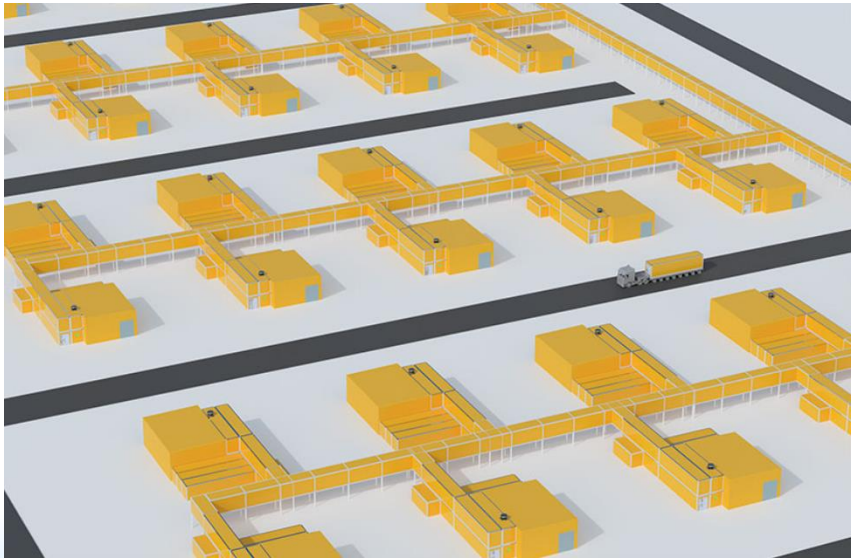
By Jack Ewing

Jan. 15, 2018

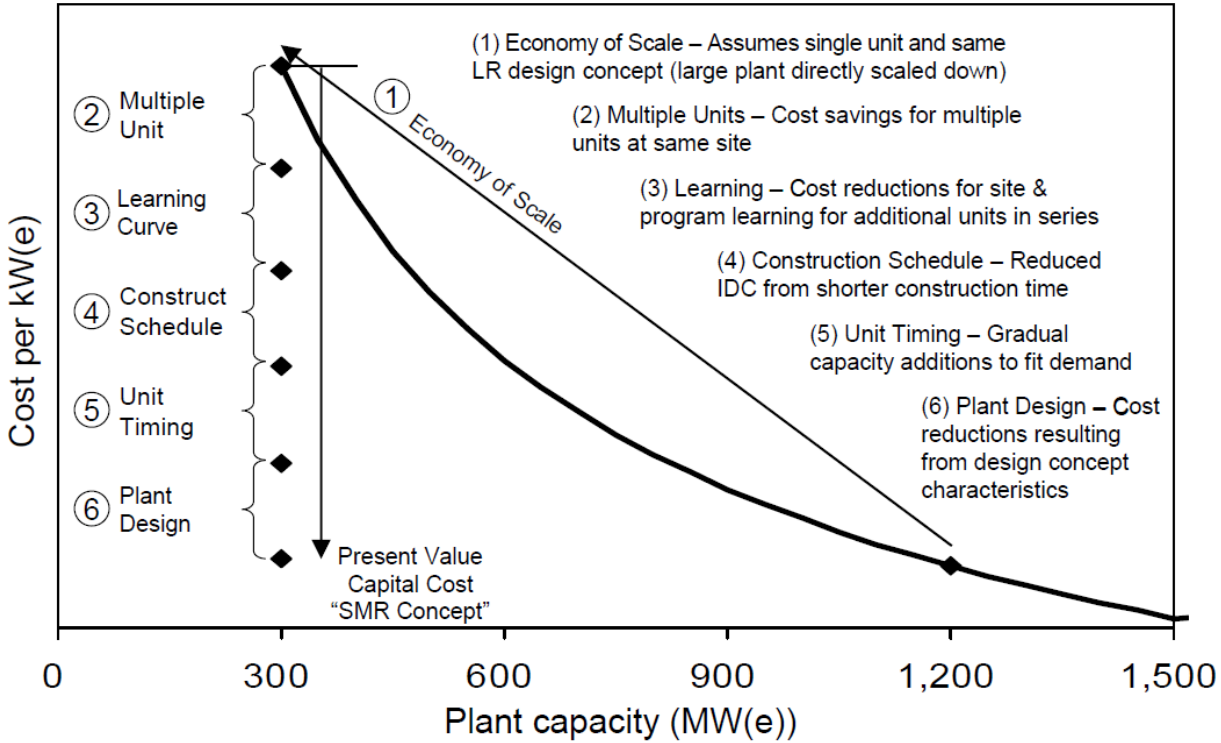
Competitiveness

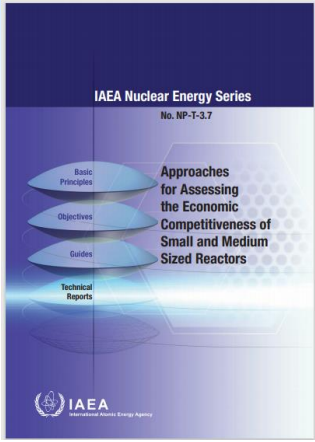
- Competitive: with respect to whom?
  - On specific locations
  - Also to traditional large-scale nuclear power?

- SMR needs economy of numbers
  - Identical units on multiple locations
  - Multiple identical modules on few locations



SMR competitiveness w.r.t. large reactors





Generic view of factors affecting comparative costs of small and medium sized reactors (SMRs) and large reactor (LRs). IDC: interest during construction.

SMR economic principles

- SMR economics are based on economies of numbers, modularity and standardization for commercial deployment
- This could allow the nuclear industry to be more like the airline or shipbuilding industry in terms of deployment model
- A fleet approach would see SMR designs built in factories promoting standardization and learning-by-doing through the building of subsequent, identical units

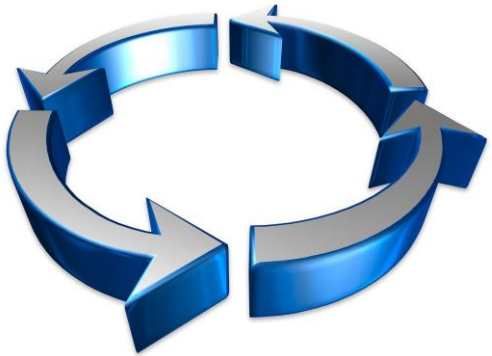
M. Caplan, MZ Consulting. Regional Meeting on the Role of Small Modular Reactors in Future Energy Markets: The Business Case, IAEA, 15 to 19 February 2021

SMR specific challenges and opportunities

- Standardization
- Collaborative deployment model including
  - financing
  - demonstration
- Communication/promotion of SMR

Standardization: more than technology

- Often standardization is focused on repeating the same plant design
- True standardization is much more, includes repeating the same:
  - Supply chains
  - Construction methods
  - Licensing models
  - Project structures
  - Training
  - Operating models
- The more that can be repeated, the lower and the more certain the cost



Developing a collaborative deployment model

Potential customers should come together to develop the SMR market

- Each customer's project depends upon successful fleet deployment by the vendor
- Working together creates the fleet required and reduces the risk of vendor failure
- Assessing vendors together creates the market pull to support the vendor developing a viable fleet model
- Development costs are shared and standardized
- Sufficient user base to maintain the technology going forward

SMR project structure and financing

- A common project structure to manage risks and reduce the cost of capital should be developed
- Fleet economics to increase confidence in program success should be used
- Good project structures will attract favourable financing → financing should be treated as an outcome rather than a problem

M. Caplan, MZ Consulting. Regional Meeting on the Role of Small Modular Reactors in Future Energy Markets: The Business Case, IAEA, 15 to 19 February 2021[19]

SMR demonstration: who will build the first?

+ government funding possible

- more expensive than series model

HTR-PM, China

AVR, Germany

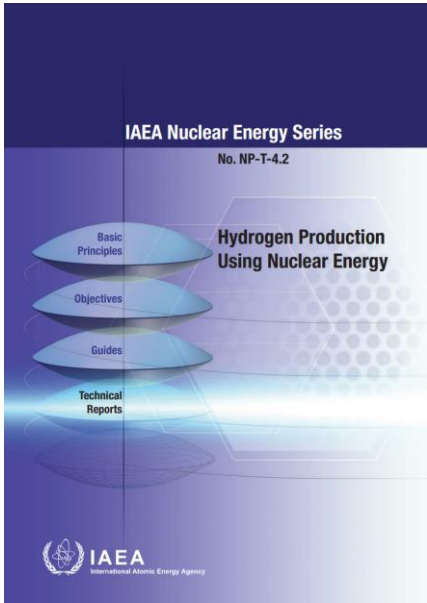
Promoting and communicating on SMR

- New markets
- Improvement on fuel and waste performance
- Be careful on safety
- Be aware of the political and institutional aspects
- Interest of the media

SMR business case related activities of IAEA

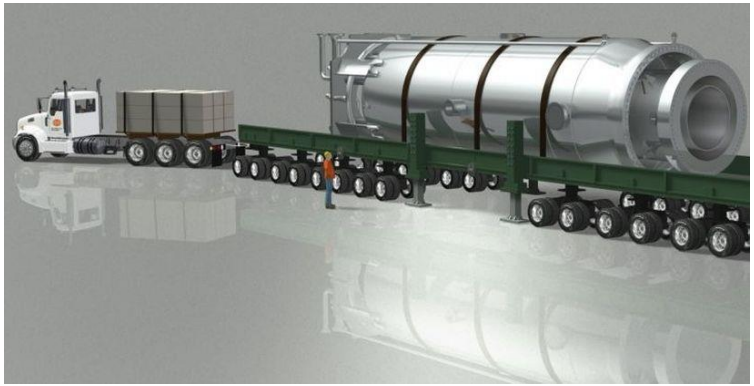
- Coordinated Research Project 2020-2023:
  - Economic Appraisal of Small Modular Reactors Projects: Methodologies and Applications
- Regional Meeting on the Role of Small Modular Reactors in Future Energy Markets: The Business Case

- Nuclear Hydrogen Business Case



Takeaways

- Instead of concentrating much power generation on one site, SMRs could be distributed over the locations according to heat demand.
- A business case includes the market situation, competitive landscape, return on investment and risks.
- A fleet approach would see SMR designs built in factories promoting standardization through the building of subsequent, identical units.



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Thank you for your attention!