

Small Modular Reactors

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2016

Next generation
energy company



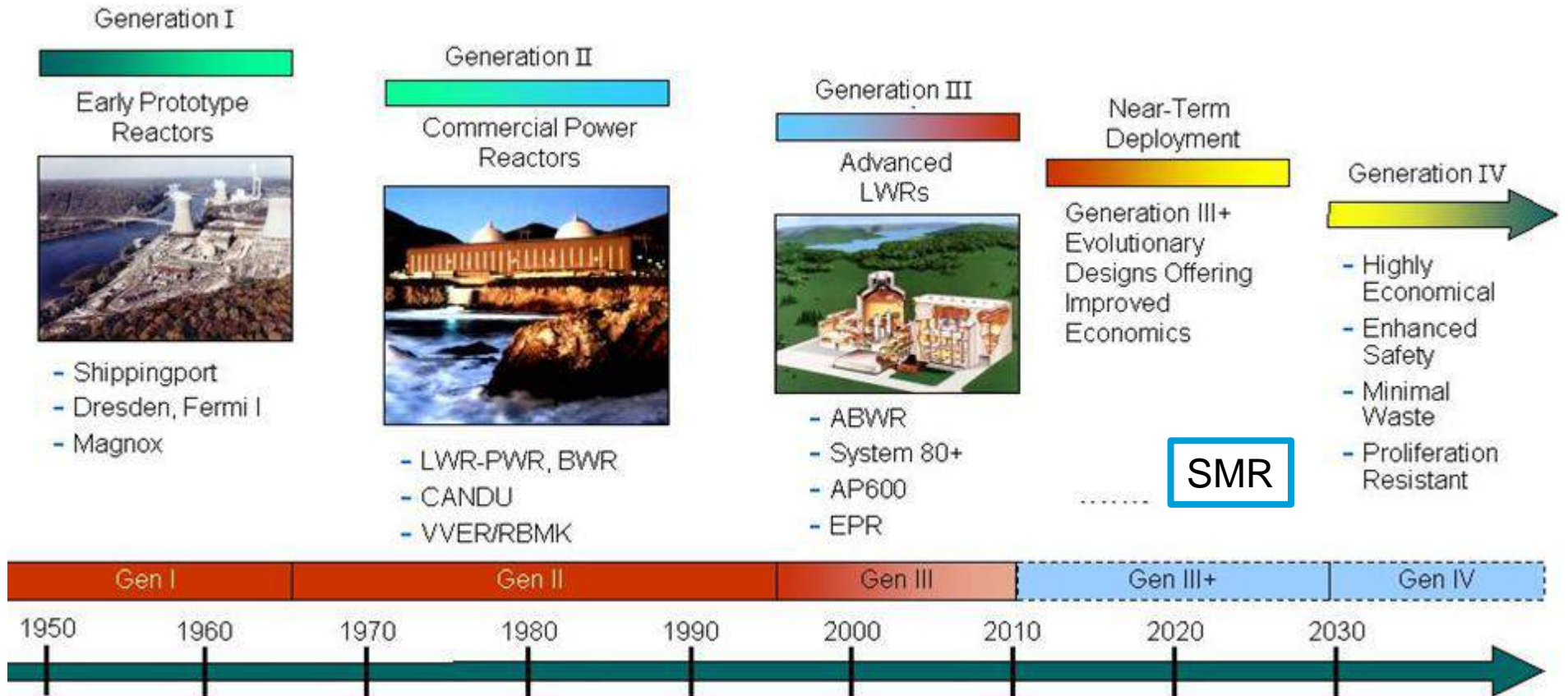
Content

What are SMRs?

What are challenges for SMRs?

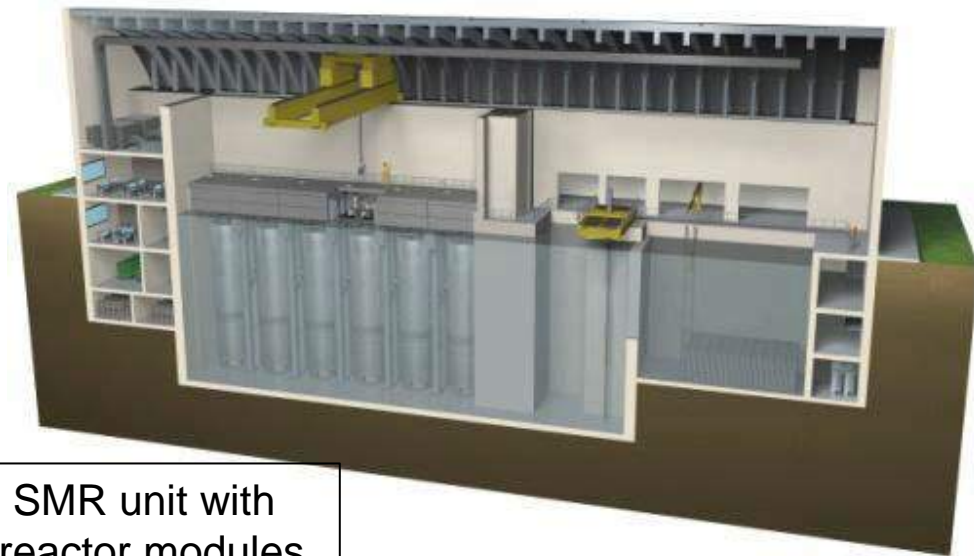
Why do SMRs play a role in the future?

What are Small Modular Reactors ?



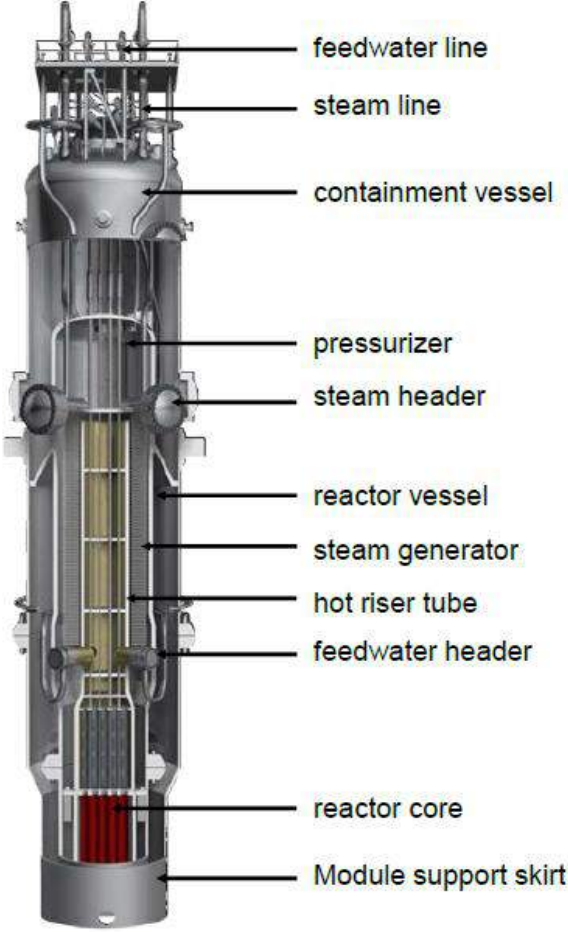
Advantages of SMRs and financing

- Modularity, serial production, factory fabricated
- Simple design, often passive safety systems
- Lower initial investment, (“buy one module and add others later...”)
- Shorter construction time (~3 years)
- Redundancy of production units; flexibility of outages
- **Flexibility!**



NuScale SMR unit with multiple reactor modules

Example: NuScale



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 Fig. 1. Schematic of a NuScale power module.

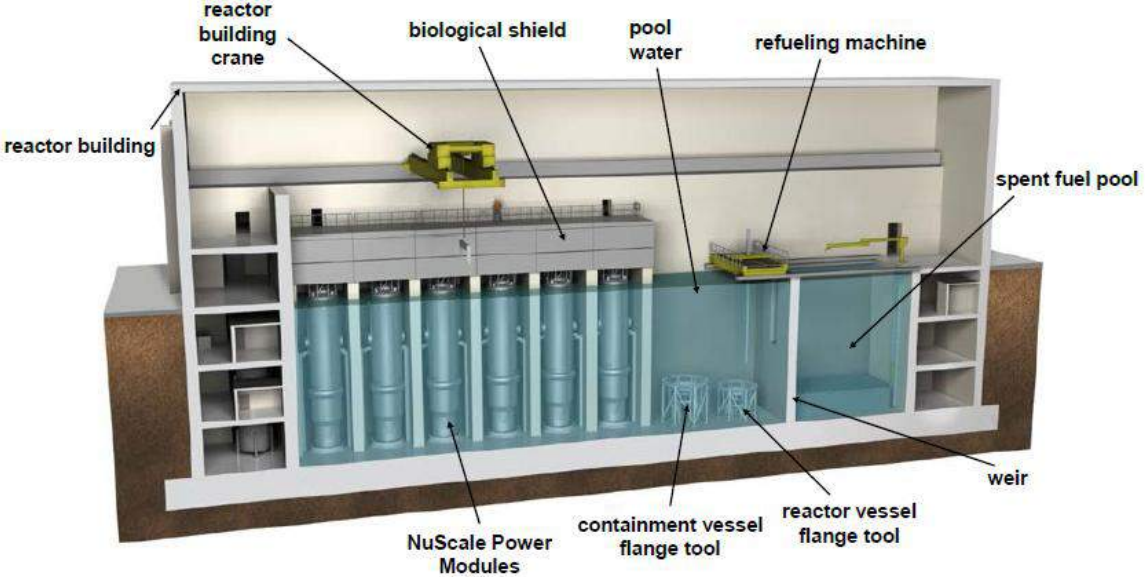
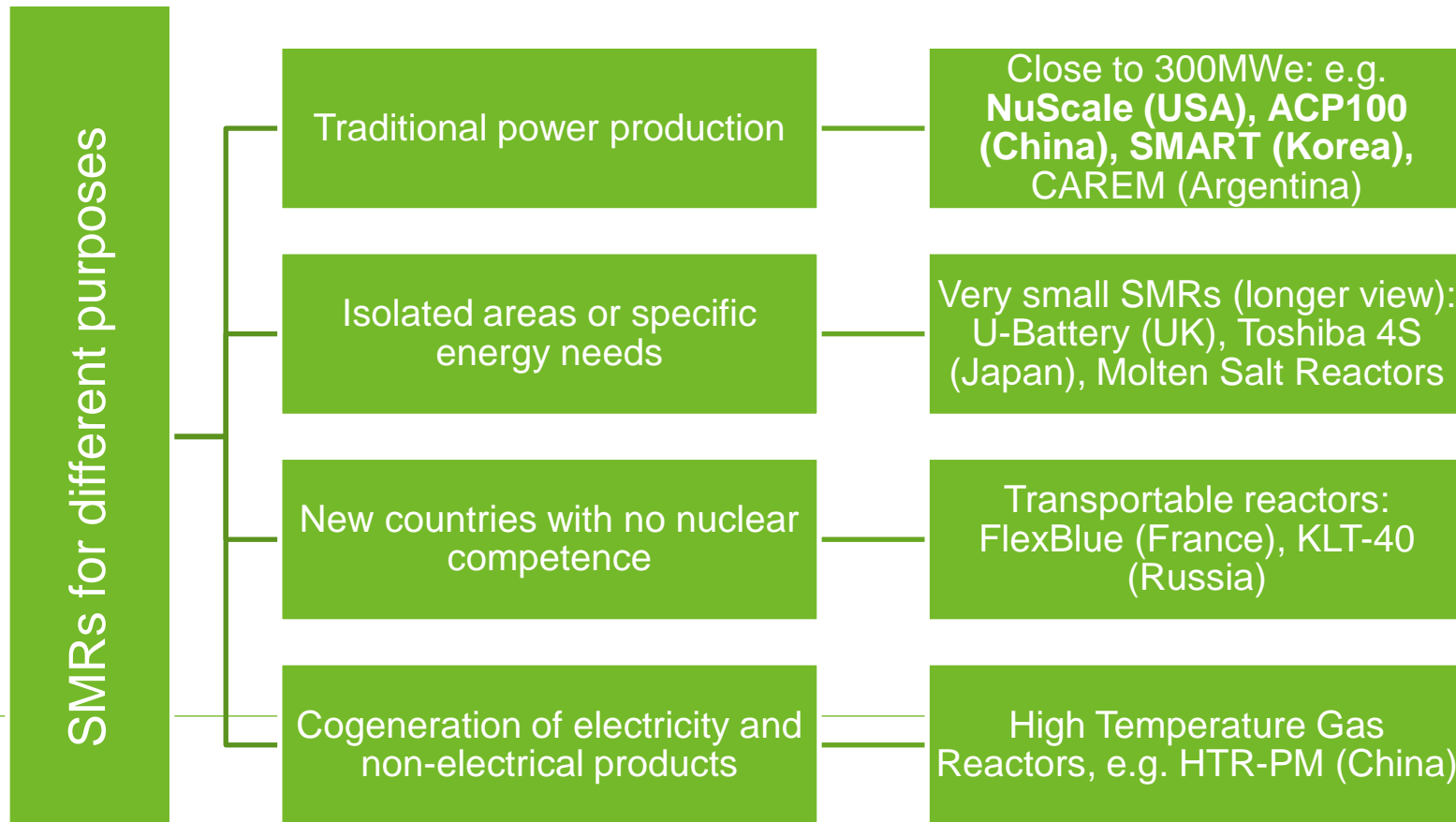


Fig. 2. Cut-away view of reactor building for 12-module NuScale plant.



SMRs for various purposes

1. Traditional deployment for energy production
2. Niche applications (remote locations, non-electrical products, e.g. water desalination, process heat)



Schedule of SMRs around the World (LWR technology)

USA

- Plan is to have FOAC SMRs operational around 2020 (this was target in 2012)
- National Funding (mPower and NuScale)

China

- CNNC design ACP100 – in operation 2022
- CGN floating ACPR50S – in operation 2020

Russia

- floating KLT-40S reactor has been constructed – in operation?

Argentina

- CAREM25 demonstration plant under construction – first criticality 2018

Korea

- SMART licensed in Korea – under development in Saudi Arabia (desalination focus)

UK

- No specific design selected, feasibility study done
- National funding competition ongoing

Content

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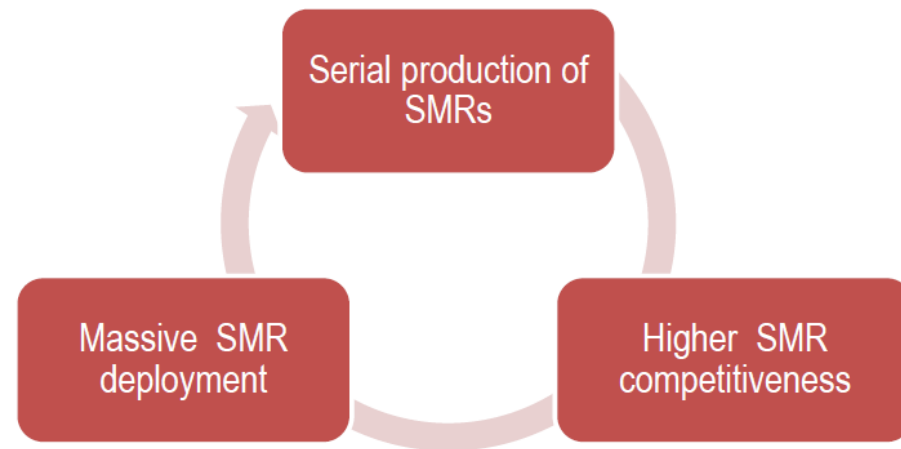
What are challenges for SMRs?

Why do SMRs play a role in the future?

Challenges for SMRs

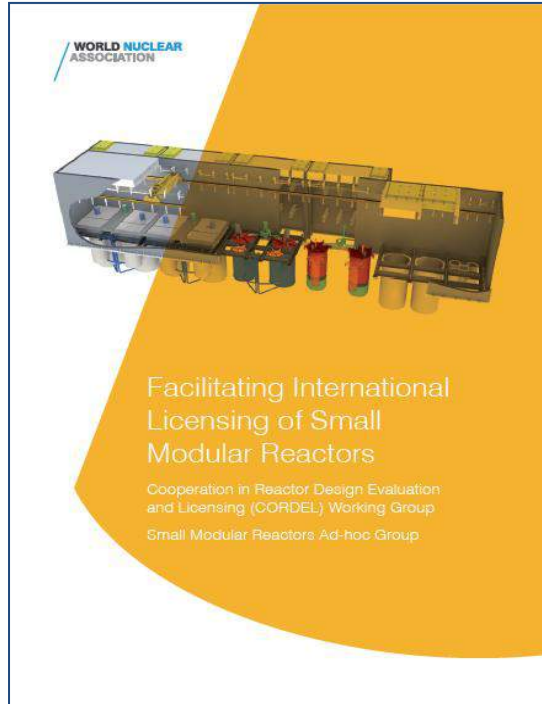
- **Licensing** process currently not supporting SMRs
 - International deployment
 - Licensing process development and commonly accepted safety requirements
 - **CULTURAL CHANGE NEEDED IN THE INDUSTRY AND THE REGULATOR**

- **First deployment**
 - First customer not easily found
 - Consortium of utilities and developers?
 - Or national activity?



World Nuclear Association

SMR Task Force – activities to support SMR licensing



- Report on '*Facilitating International Licensing of Small Modular Reactors*' just issued – available [online](#)
- Main recommendation: **New approach to licensing justified given the design characteristics of an SMR.**

Content

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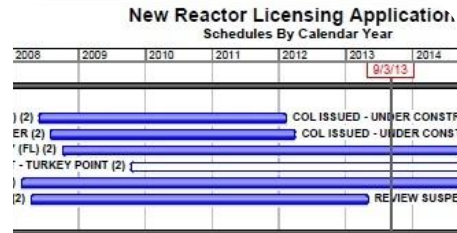
Why do SMRs play a role in the future?

Nuclear projects are too long



Design certification of AP1000

- 2002 – 2006



Combined Construction and Operating license

- Summer and Vogtle NPPs
- 2008 – 2012



Construction

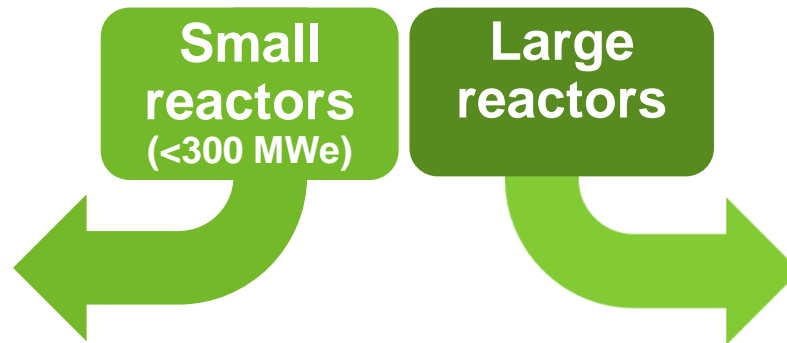
- 2013 – 2017/19

Not the case in Asia or Middle East (e.g. in China 25 under construction)

Alternative trends in nuclear

Nuclear technology trends:

- large vs. small, active vs. passive, complex vs. simplified
 - different technologies selected according to the local market needs (newcomer countries vs. established nuclear users; power market size)

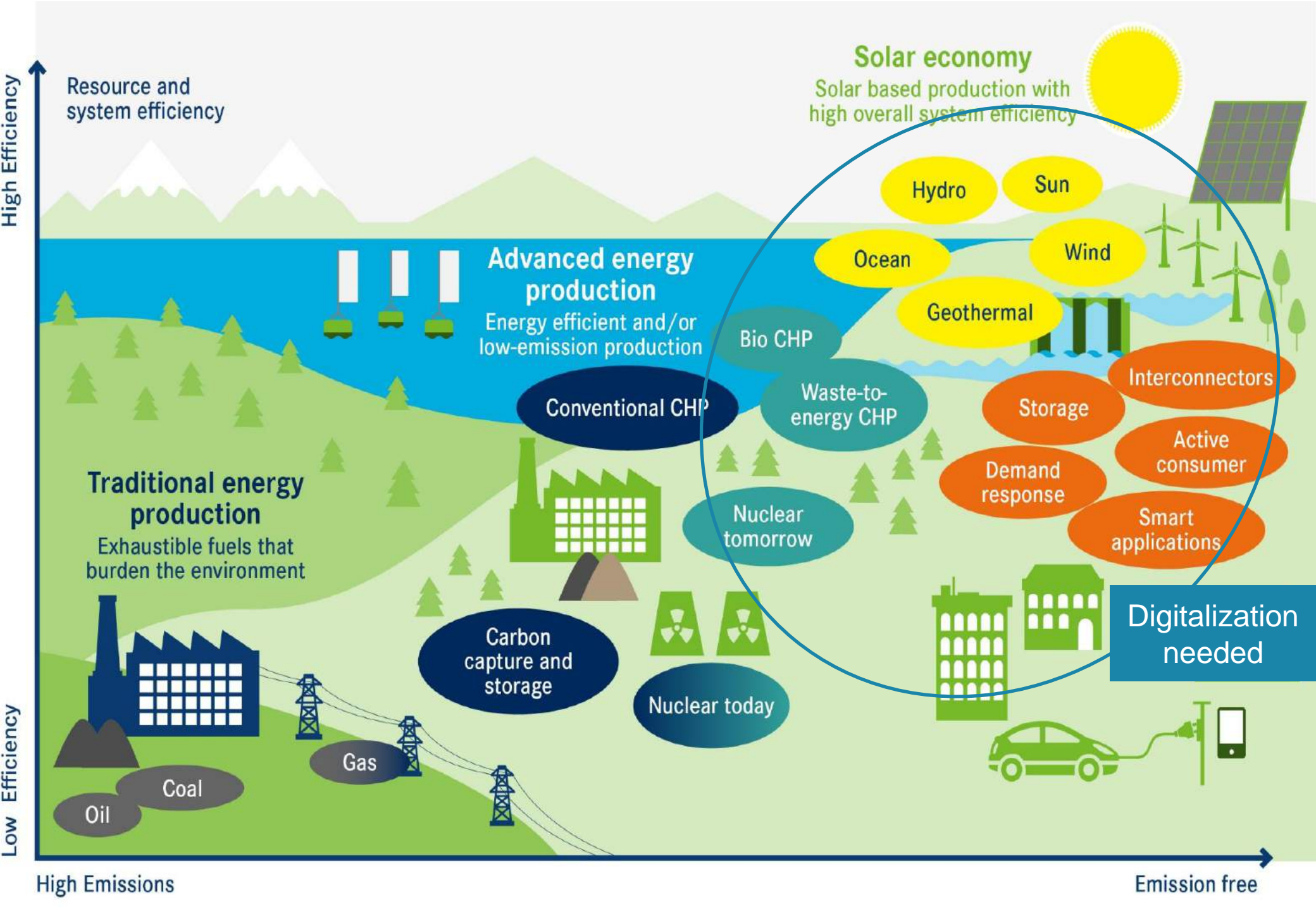


Economy of serial production

Manageable projects, stepwise investments
Simplified, standardized concepts

Economy of scale

Complex projects, large investments
Beneficial when large amount of power needed

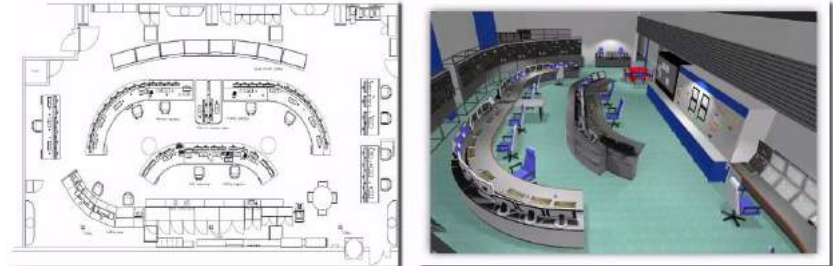


Nuclear industry is moving forward in many areas

Digitalization in the industry

- New tools and technologies to nuclear industry
- Example: Control room can be further developed and tested (validated) in virtual reality (VR) using:
 - 3D models
 - 360 videos – immersive training
 - Process simulation in Virtual Reality
 - And much more...

Fortum - Efficiency through latest technologies



Control room layout design has evolved from 2D into 3D and immersive 3D

Fortum - Efficiency through latest technologies



Next natural step can be combining the control room visualization with dynamic process simulation



APROS[®]
Process
simulation
software

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purification
system

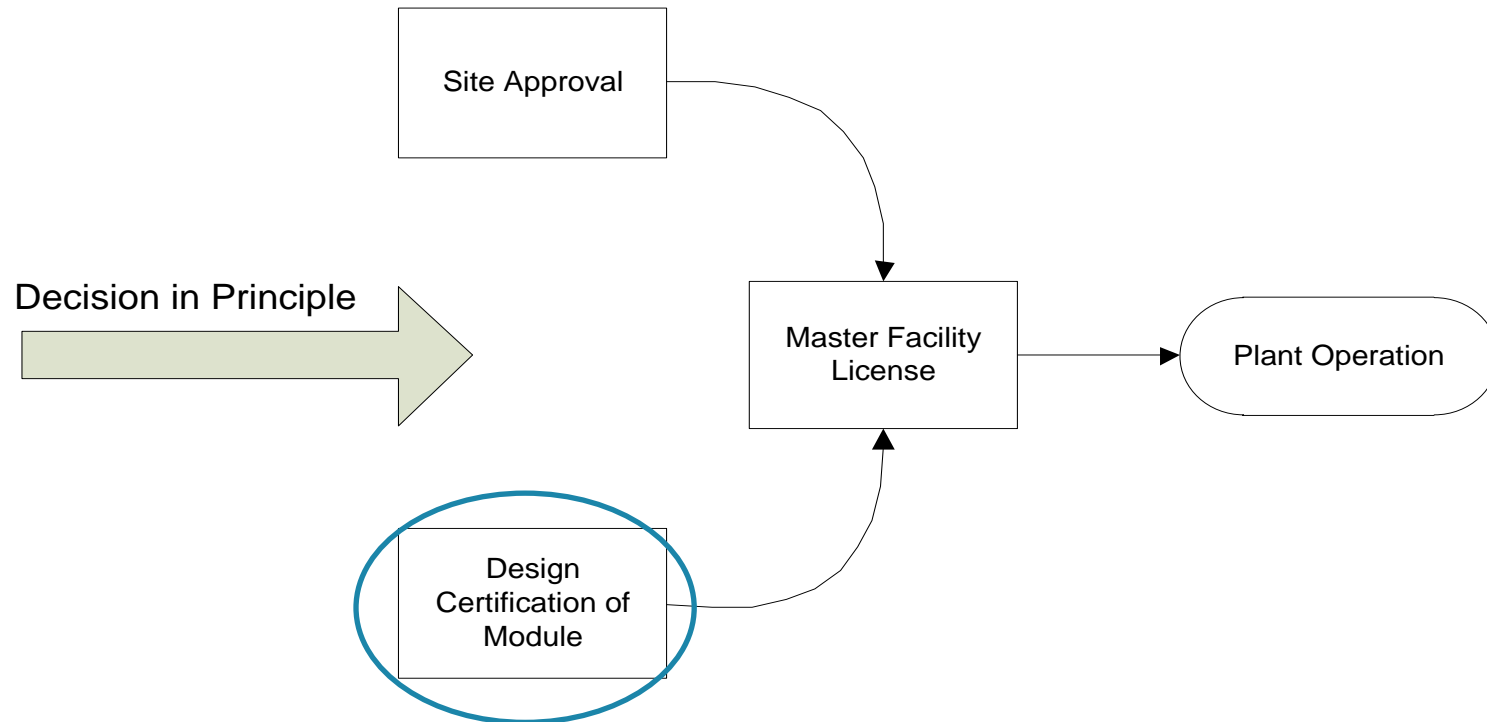
ADLAS[®]
Advanced
licensing
and safety
concept

PATI
Nuclear
material
management
system

ReMaint[®]
Nuclear
maintenance
concept

Backup slides

International approval needed for SMR designs



- Optimized licensing process for SMRs, if no licensing process exists in a country
- Main output of the SMR licensing study is the **module design certification**

This kind of approach could be a first step towards international design certification/acceptance!

Why do we need to rethink in the future ??

**Even nuclear industry is changing!
Digital solutions are one part of the change.**



*We need new approaches to keep
nuclear in future energy system!*

*We need to unlearn our old
habits!*



Licensing challenge: What is a safe nuclear design?

- Is the same design safe e.g. in USA and in Finland?
- Focusing on the design (not site or organization)



Currently all the designs are modified for licensing. In SMR designs the reactor module and main safety systems should be standardized.