Small Modular Reactors:
Cornerstone of tomorrow's energy ecosystem?

21 April 2021

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SMRs… a signal that cannot be ignored in OECD anymore

Fortum, Tractebel to assist in Estonian SMR deployment

28 January 2020

Share

Estonia's Fermi Energia has signed Memoranda of Understanding (MoUs) with Finnish power company Fortum and Belgian engineering firm Tractebel to cooperate on studying the deployment of small modular reactors (SMRs) in the Baltic country.

Finnish firm launches SMR district heating project

24 February 2020

Share

VTT Technical Research Centre in Finland has today announced the launch of a project to develop a small modular reactor for district heating. Most of the country's district heating is currently produced by burning coal, natural gas, wood fuels and peat, but it aims to phase out its use of coal in energy production by 2029.

OPG plans SMR construction at Darlington

16 November 2020

Share

Ontario Power Generation (OPG) has announced it is resuming planning activities for building new nuclear generating capacity at its Darlington site in Ontario. However, it is now considering the construction of a small modular reactor (SMR) rather than a large conventional reactor, as previously envisaged.

Why are Small Modular Reactors different?

A business model that starts from the right questions

Recreate public trust in nuclear **safety**?

Expand role in zero-carbon **transition**?

Foster nuclear **investments**?

Alleviate concern of nuclear **waste**?

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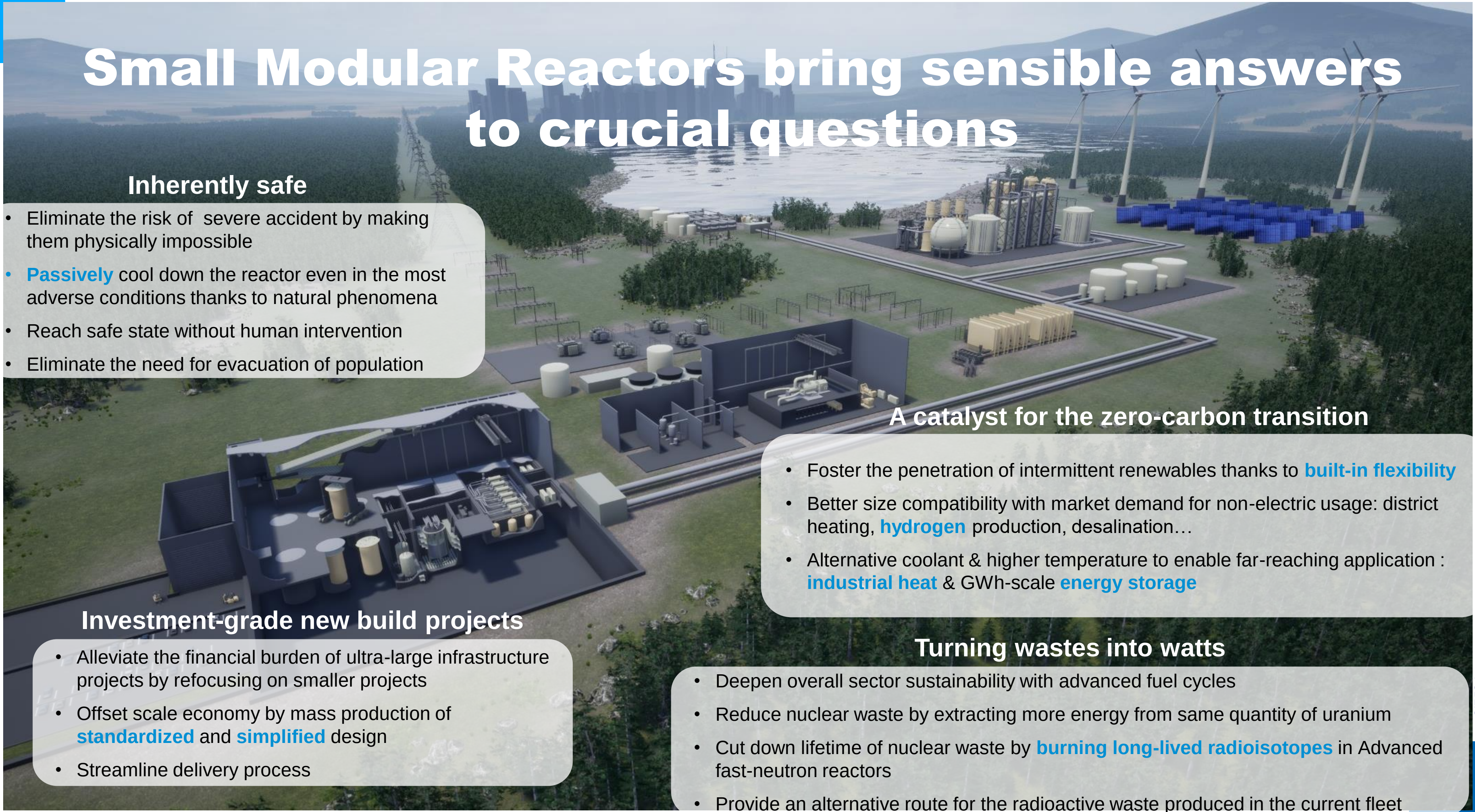

Small Modular Reactors bring sensible answers to crucial questions

Inherently safe

- Eliminate the risk of severe accident by making them physically impossible
- **Passively** cool down the reactor even in the most adverse conditions thanks to natural phenomena
- Reach safe state without human intervention
- Eliminate the need for evacuation of population

A catalyst for the zero-carbon transition

- Foster the penetration of intermittent renewables thanks to **built-in flexibility**
- Better size compatibility with market demand for non-electric usage: district heating, **hydrogen** production, desalination…
- Alternative coolant & higher temperature to enable far-reaching application : **industrial heat** & GWh-scale **energy storage**

Investment-grade new build projects

- Alleviate the financial burden of ultra-large infrastructure projects by refocusing on smaller projects
- Offset scale economy by mass production of **standardized** and **simplified** design
- Streamline delivery process

Turning wastes into watts

- Deepen overall sector sustainability with advanced fuel cycles
- Reduce nuclear waste by extracting more energy from same quantity of uranium
- Cut down lifetime of nuclear waste by **burning long-lived radioisotopes** in Advanced fast-neutron reactors
- Provide an alternative route for the radioactive waste produced in the current fleet

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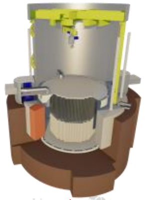
The vibrant international race for Advanced Nuclear

IMSR (Terrestrial) – TRL4
Thermal molten salt reactor

Image source: Terrestrial



SSR-W (Moltex) – TRL3
Waste-burner molten salt reactor

Image source: Rosatom

KLT-40S (Rosatom) – TRL8
Floating nuclear power plant

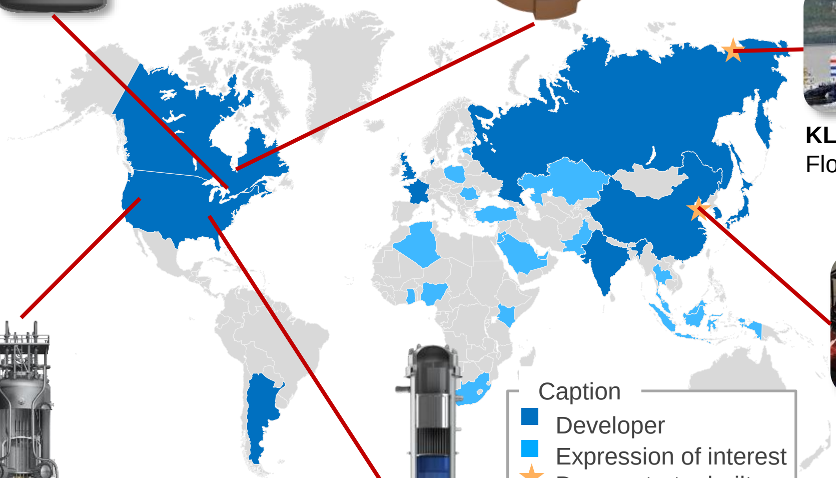


Image source: CGN

HTR-PM (CGN) – TRL7
High temperature gas cooled reactor

NuScale (Fluor) – TRL6
Multi-module Pressurized Water Reactor

Image source: NuScale

BWX-300 (GE-Hitachi) – TRL6
Boiling water reactor

Image source: General Electric - Hitachi

Key figures

- **70+ concepts** under design
- **6+ technology**
- **10 countries** leading development
- **2 FOAK** designs **built**

Our approach to date

- Assessed most **promising technologies**
- Engaged with vendors
- Engaged with utilities and key industry conglomerate
- Investigated promising ‘new’ uses of nuclear energy

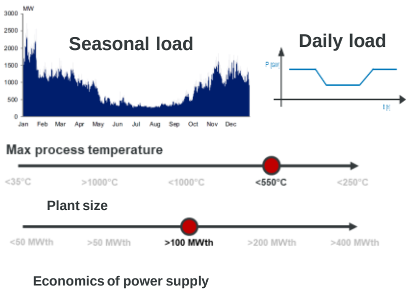
Identifying fitting SMR technologies

70+ SMRs

1 User requirements

- Collect relevant data from user
- Establish assumptions, scenarios and associated list of requirements for SMR selection
- Define exclusion criteria
- Request for Information to Vendors

Input data



2 Technology selection

1. Preliminary filter through **exclusion** criteria (e.g. no-passive safety…)
2. First pass high-level **multi-criteria** comparative assessment based on public information
3. Second pass detailed comparative assessment based on RFI

Critical Success factors

Caption

- **Safety**
- **Delivery certainty**
- **Public acceptance**
- **Equity & Finance**
- **Cost-competitiveness**
- **Time-to-market**
- **Sustainability**
- **Fit-for-duty**

3 Market Integration

- Comparative analysis of lifecycle benefits (economics, carbon emissions)
- Site survey and selection based on vendor PPE
- Colocalization studies
- Deployment schedule

4-5 top ranked designs

SMR technologies distinguishing features

	Light Water Reactor	Molten Salt Reactor	High Temperature Gas-cooled Reactor	Sodium Fast Reactor
	✔ Mid / late-2020s	✘ Mid 2030s (low TRL)	✔ Under commissioning	? Late-2020s
	✔ Excellent passive safety No backup power	✔ Inherent passive safety High simplicity systems	✔ Excellent passive safety Elimination of core melt	? Excellent passive safety But sodium reactivity & void coefficient
	✔ Possible load-following & desalination	✔ Load-following & heat applications	✔ Load-following & high T° applications	✔ Medium T° applications
	✘ Not a long-term waste solution	✔ Prospects for waste solution	? Higher burn-up Not a long-term solution	✔ Closed fuel cycle and transmutation
	? Good cost-competitiveness: 40 – 90$/MWh	✔ Excellent expected competitiveness: 30 – 65 $/MWh	✘ Lower competitiveness: 80 – 120$/MWh	✘ Operational complexity

Mature SMR technologies starting today…
Game-changing technologies tomorrow

NUSCALE
Power for all humankind
2028

2028

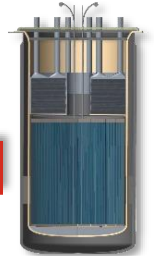
HITACHI
BWRX300

Short-term deployment

- Well-established technologies
- Market initiators before the end of this decade

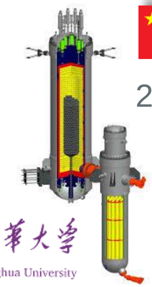
Versatile applications

- Deep decarbonization of energy sector

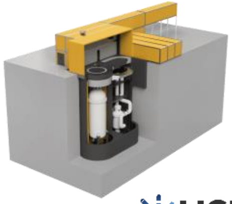


<2030
energy

2029
TERRESTRIAL
ENERGY



2021
清華大学
Tsinghua University



2026
USNC
ULTRA•SAFE•NUCLEAR

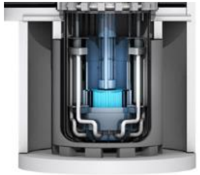
Micro Reactors

- Nuclear batteries
- New business model

Long-term sustainability

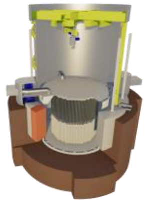
- Reduction of nuclear waste with Advanced Reactors

2027



HITACHI
TerraPower
A Nuclear Innovation Company
NATRIUM

moltex
clean energy
2032



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Known hurdles to SMR market deployment

CHALLENGES	OPPORTUNITIES
Licensing	➢ Regulatory framework simplification and Harmonization ➢ Country of origin approach ➢ Pre-licensing and graded approach
Technology Readiness	➢ Research Labs ➢ Massive government funding
Cost competitiveness	➢ ~1B$ range capital cost ➢ Standardized design ➢ Low footprint and complexity
First Movers for Market deployment	➢ Canada and US ➢ European countries (Northern and Eastern) ➢ China and Russia ➢ Others

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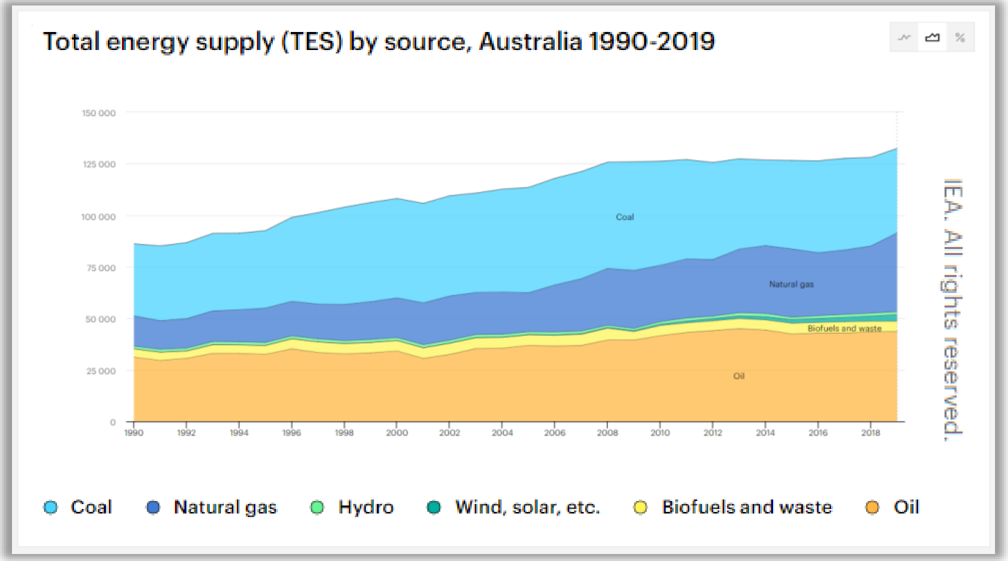
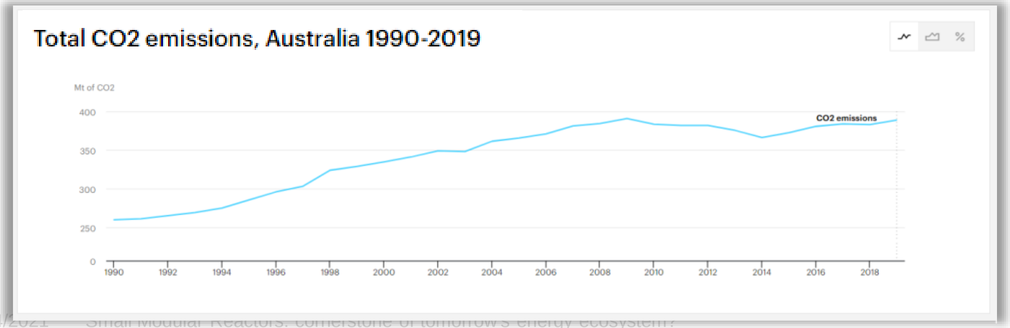
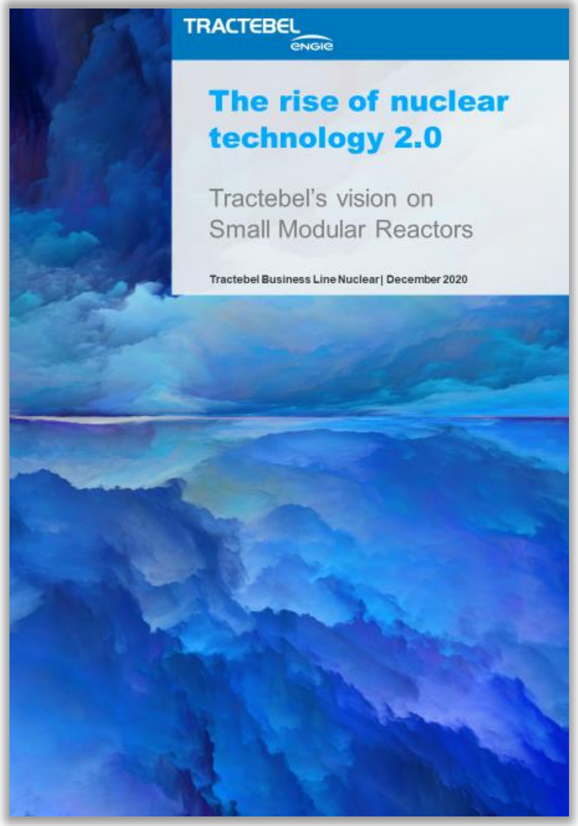
Potential in tomorrow's energy landscape







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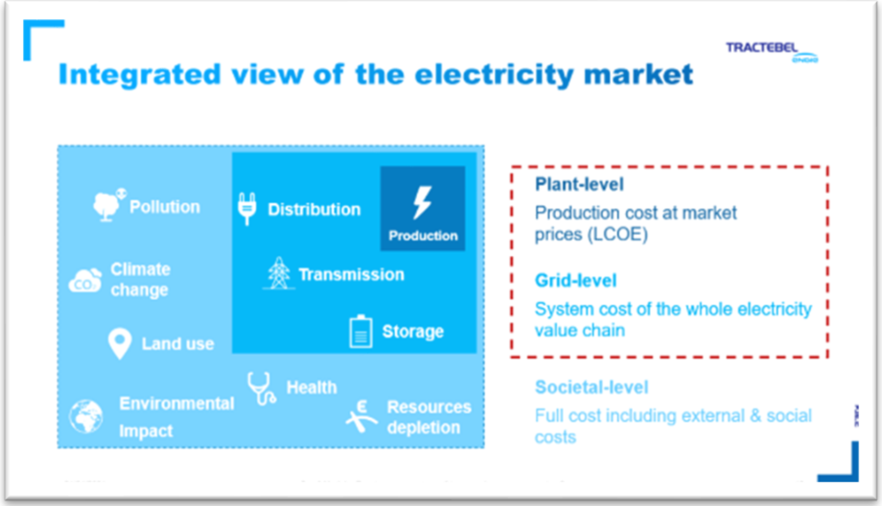
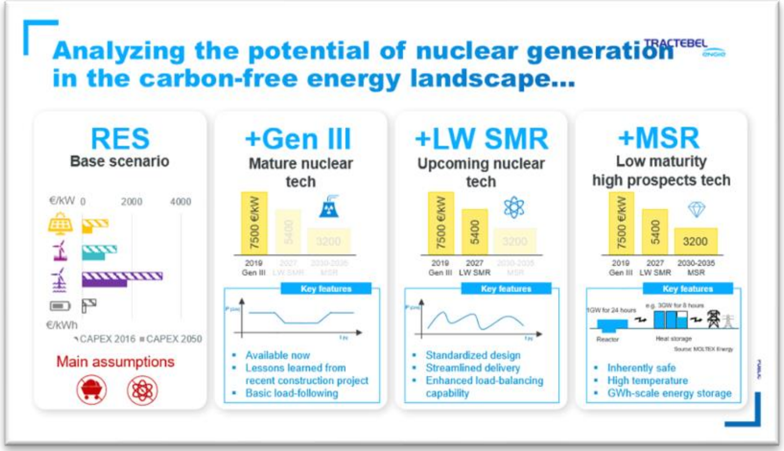
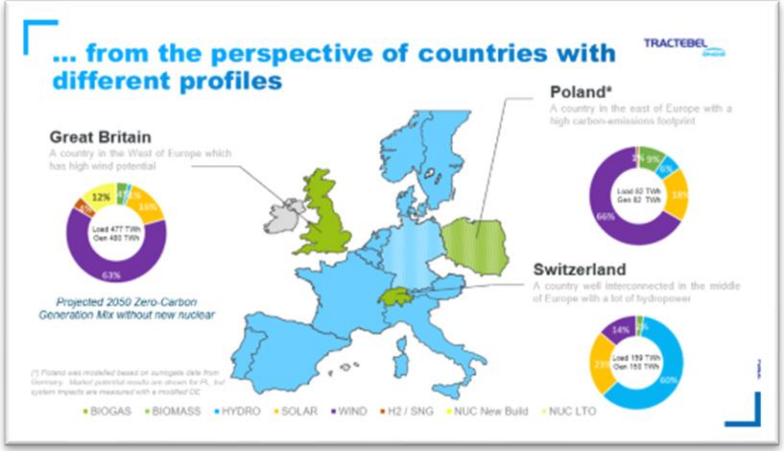
Renewable enablers on the electricity market







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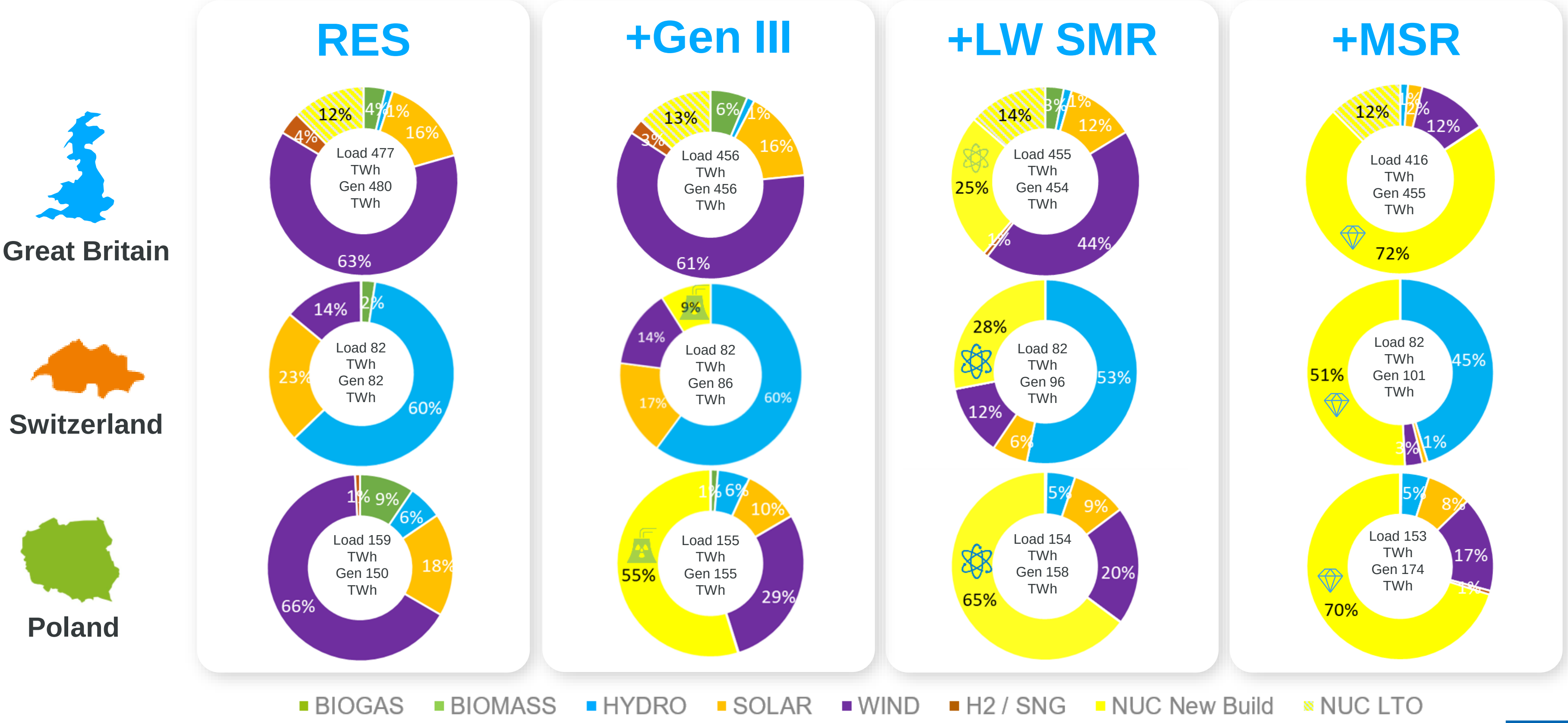
Snapshot of the prospects for Europe 2050



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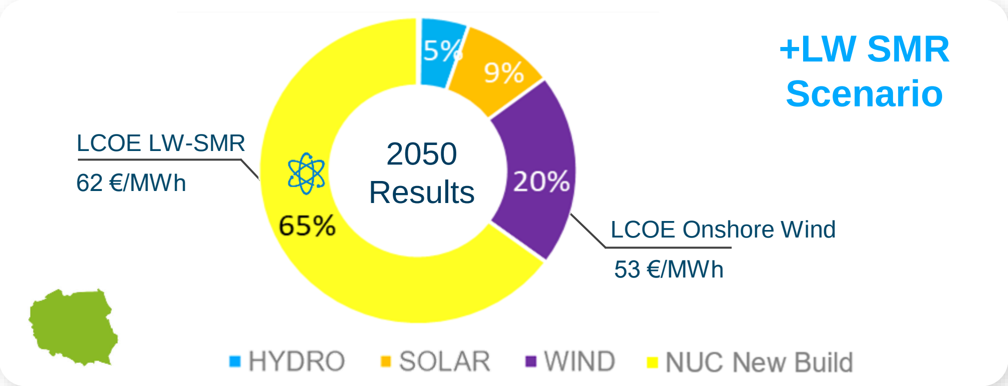
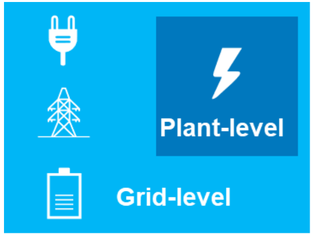
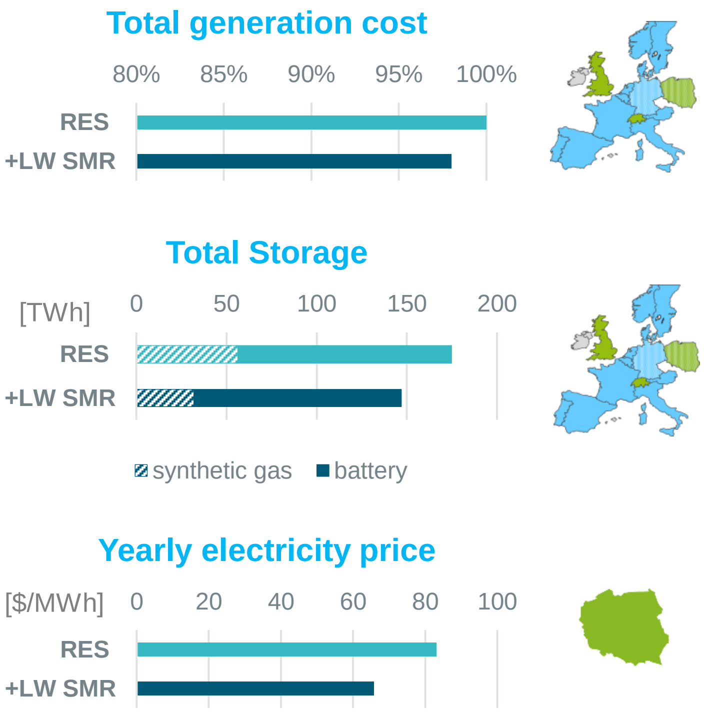
LCOE is not the whole story







Key insights

- Higher penetration of NUC projected despite WIND lower **LCOE**
- **Grid-level generation cost** is lower with **NUC** than 100% **RES**
  - Lower amount of storage required
  - Lower yearly electricity price
- Lower grid infrastructural transformation (storage, T&D) with flexible nuclear

LCOE ≡ Levelized Cost Of Electricity

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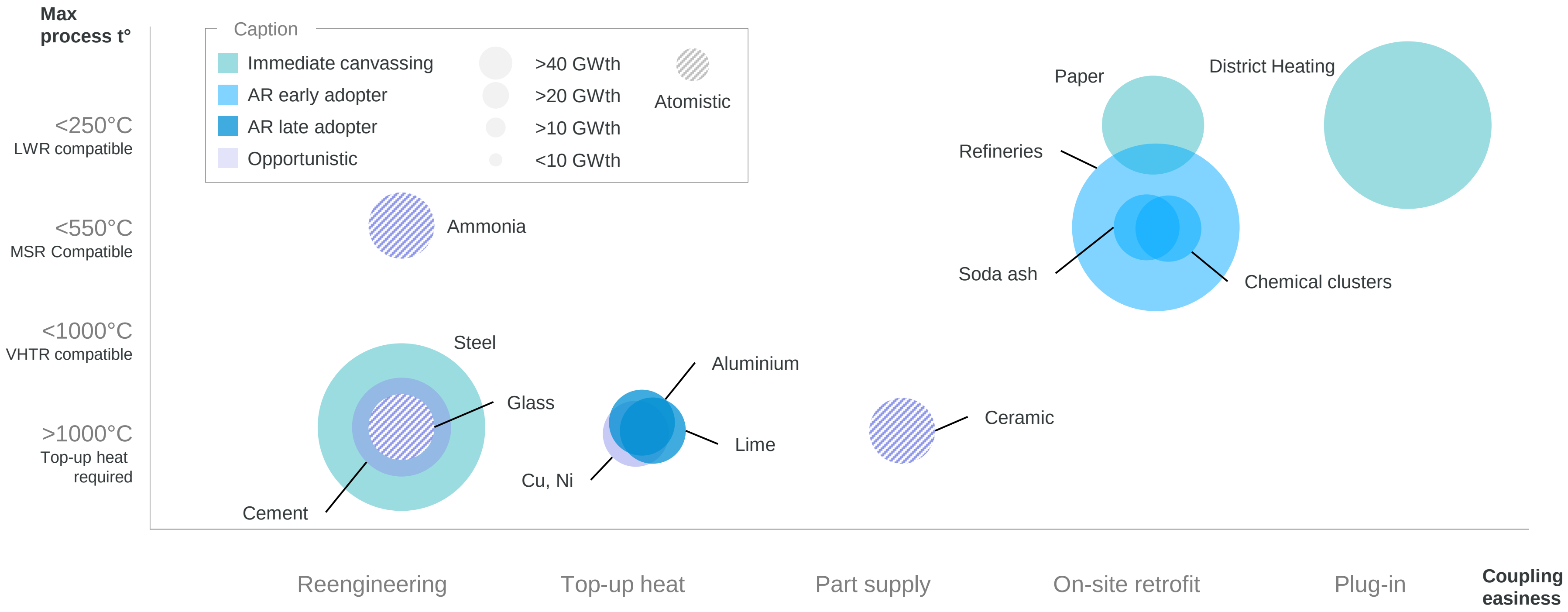
Striving for a deep decarbonization of the economy
Expanding nuclear energy's role for the zero-carbon transition

SMR Applications

1. Dispatchable electricity
2. District Heating
3. Desalination
4. H_2 production
5. Process heat

Industrial affinity with SMR-based co-generation - Europe



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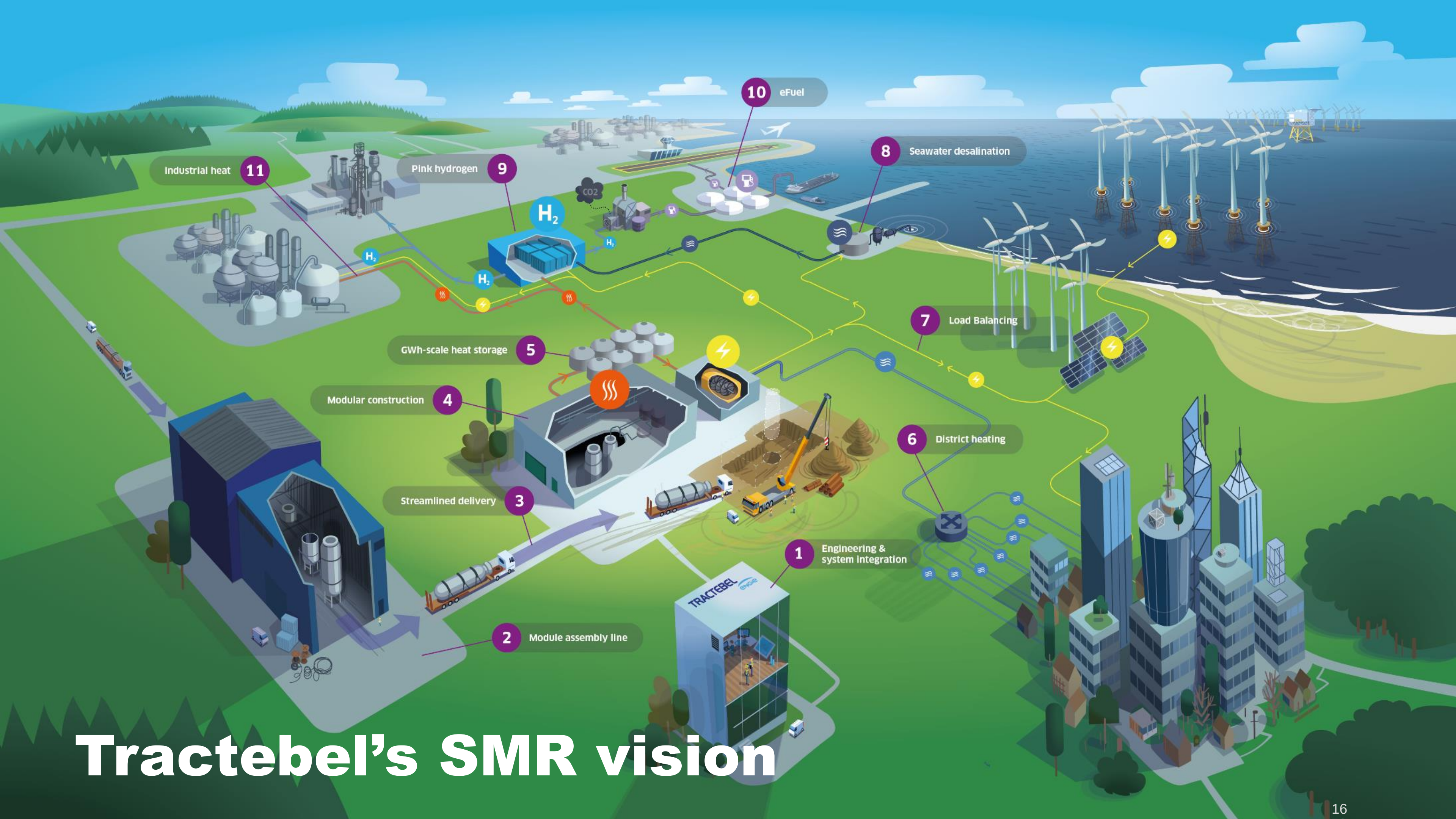

Tractebel’s SMR vision


TRACTEBEL
engie
Engineering
a carbon-neutral
future