The role of nuclear power in Italian future energy scenarios

2nd TANDEM Technical Workshop – Pisa

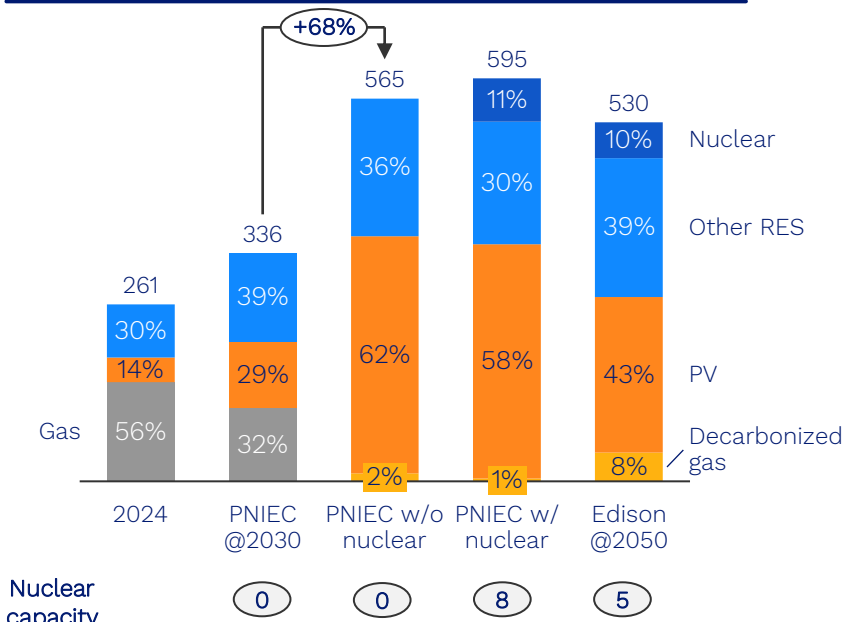
Alberto Pasanisi
Edison - Research, Development and Technological Innovation Director

February 20th 2025

Italian nuclear scenario

Edison & PNIEC scenarios @2050

Italian electricity mix evolution @2050[1] (TWh)

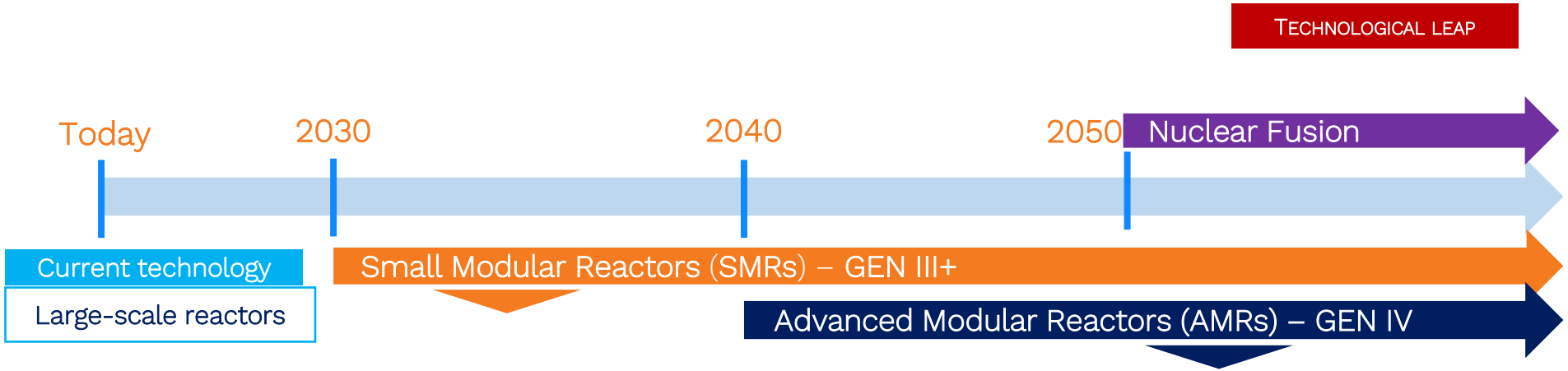


PNIEC scenario July 2024; gas share in PNIEC @2030 is based on Edison elaborations

- SMRs/AMRs can contribute to decarbonization, alongside RES
  - Installing an average of 1 plant per year from 2035 would bring the number of plants to 15 by **2050** (5 GW), contributing to ~**8% of national production**
  - PNIEC scenario published in July 2024 also envisages the possibility of covering **11% of the production mix by 2050 with nuclear energy**, reaching 24 plants (8 GW)
- Nuclear power would allow the achievement of 2050 decarbonization targets at a **lower cost** than the scenario without nuclear power: **€17 billion in savings,** according to PNIEC
- The **first wave** of plants will be mainly based on **SMRs**, which have a more mature technology (GenIII+), while the **second wave** of plants from 2040 on will see the entry of **AMRs** (GenIV)
  - Some fast neutron AMR technologies will be able to **close the fuel cycle,** by using the waste produced by SMRs as input fuel, thus increasing the energy extracted from uranium and reducing nuclear waste radioactivity

> 5 GW nuclear power expected @2050 (15+ plants)

SMRs, an innovation with benefits that can be amplified through the complementary development of AMRs



Distinctive technological features	Small modular reactors	Advanced modular reactors
	Small size, simplified **modular design** (100-450 MW) and improved **safety**	**Small size**, simplified **modular design** (100-450 MW) complementary to SMR, **closed fuel cycle** and **intrinsic safety**

Source TEHA Group elaboration on various sources, 2024

SMRs features enabling flexible generation for a wider range of applications

Small, modular and safe plants (Small Modular Reactor) available after 2030

Source "Advances in Small Modular Reactor Technology Developments» IAEA Advanced Reactors Information System (ARIS) 2020 Edition

Benefits that new nuclear can enable in Italy – focus on SMRs

Decarbonization and contribution to competitivity (industry and private customers)

- Complementarity with Renewables: programmability and modularity
- Electricity price reduction: minor system costs for energy storage and grid
- Decarbonization of hard to abate sectors: cogenerativity

Contribution to energy security and technologic independence

- Reduction of gas import dependance: lower energy price volatility
- Lower need for critical raw materials
- SMR technology in development in Europe

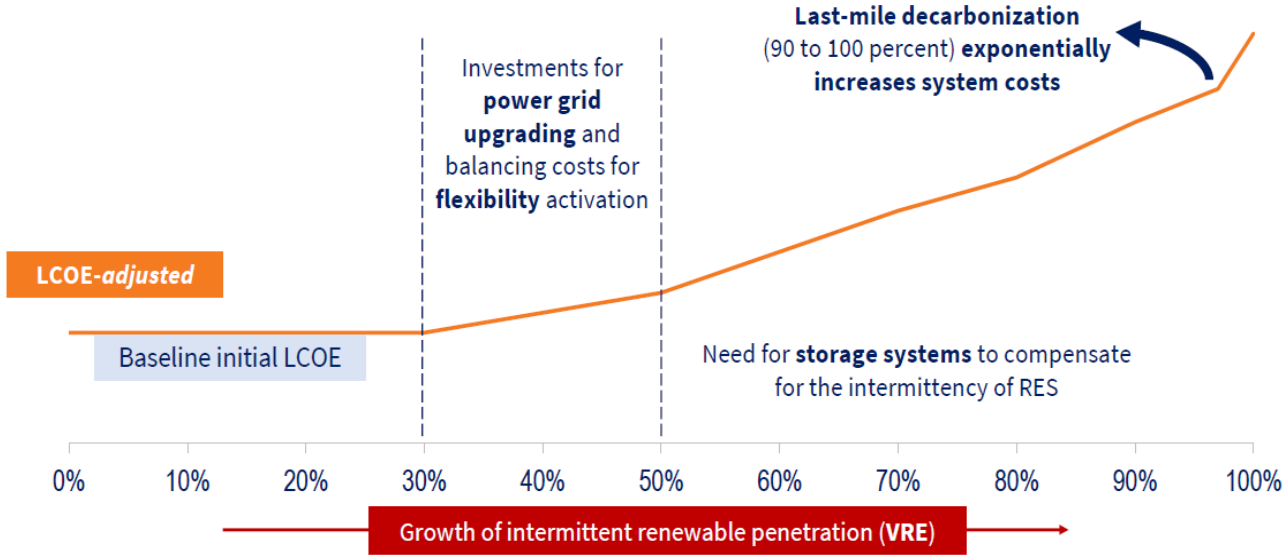
Contribution to the industrial and economic development of the country

- Valorization of Italian competences and nuclear supply chain, both for Italy and for export
- Contribution to GDP and employment growth

New nuclear role in decarbonizing the last mile

DECARBONIZATION

System costs in a scenario of increasing RES penetration up to 100% of the electricity mix (illustrative)



In this context, "new nuclear" power contributes to:

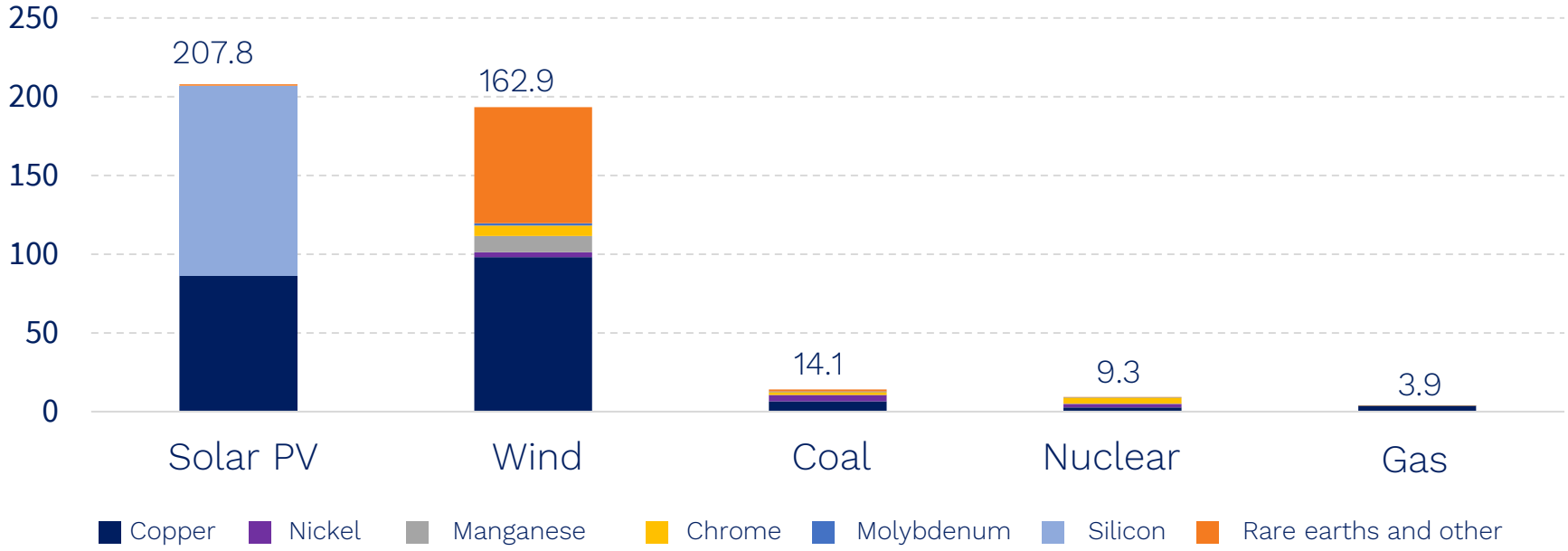
- **Reduced system costs** (lower investment in storage, transmission grids and plants), **enabling the full potential of renewables**
- **Price stabilization** due to greater geopolitical stability of producing countries and low incidence of uranium in the final price

Source TEHA Group elaboration on NEA, DoE data and various sources, 2024

Nuclear power has a low supply risk

STRATEGIC AUTONOMY

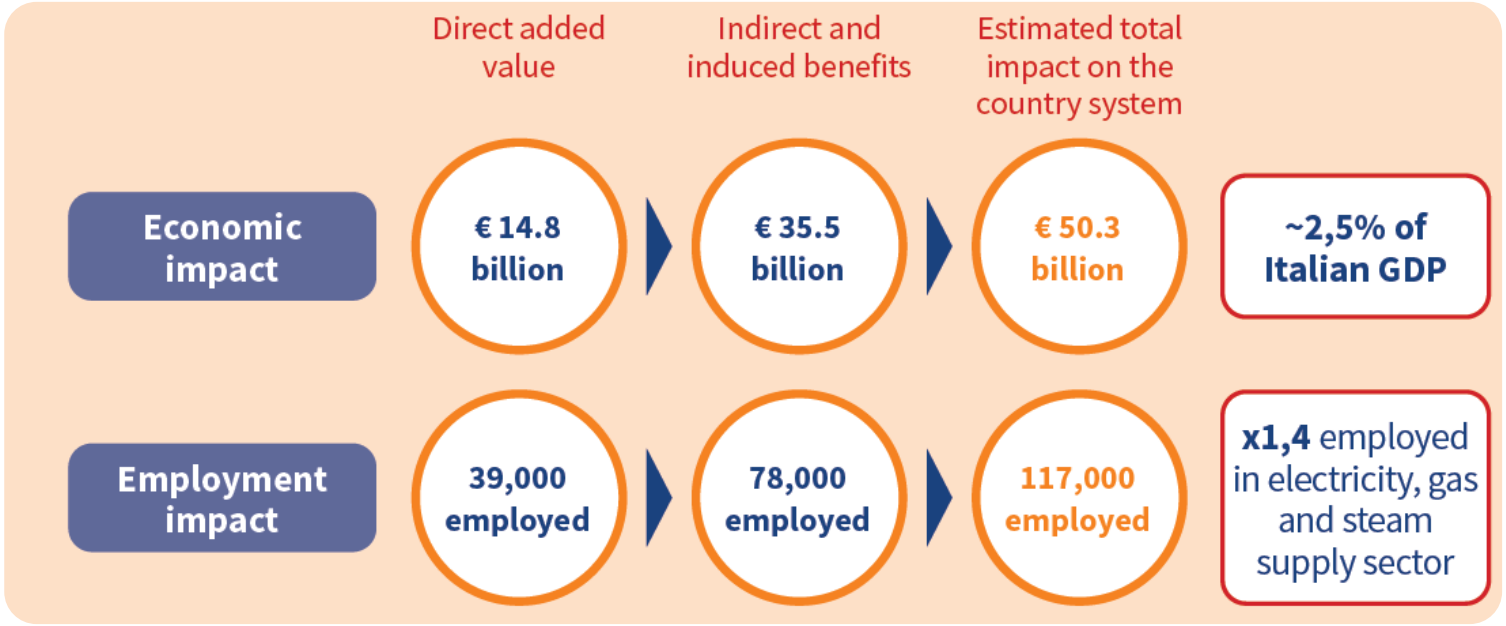
Critical raw materials by type of energy source (kg per GWh), 2021



According to the European Commission, 97.1% of critical nuclear raw materials have a low supply risk

New nuclear power enabler of economic impact by 2050

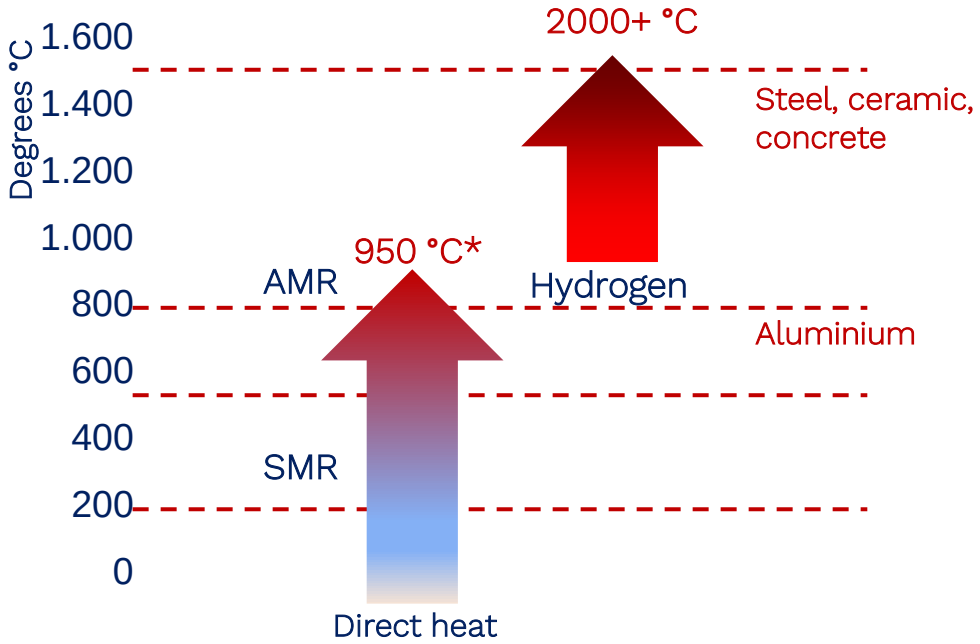
INCREASED COMPETITIVENESS



Estimate of the total economic and employment impact by 2050 for the country system through investments in the construction of "new nuclear" power in Europe and Italy (billions of euros and numbers of jobs). Source TEHA Group elaboration based on data from AIDA, ISTAT and various sources, 2024.

New nuclear enabling the production of industrial heat and hydrogen for industries

DECARBONIZATION



- Although it does **not reach the 1,500°C** needed for some industries (steel, ceramics and cement), nuclear power can **produce hydrogen to decarbonize** the processes of those industries
- The EU has established that nuclear-produced hydrogen can be considered "**low-carbon hydrogen**"

N.B. "New nuclear" power can produce heat to be used for electrolysis, and the hydrogen thereby produced - more efficiently than with other energy sources - can be used for industrial processes of energy-intensive companies. (*) The figure refers to the temperature reached by some AMR models.

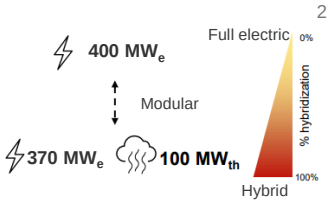
Source: TEHA Group elaboration on NEA, DoE data and various sources, 2024

Hybridization of electricity and heat

Possibility of mixing electricity & heat for DH[1], H_2, desalination and high-temp. Industrial uses

Energy for electrification

SMRs and AMRs are **modular and flexible** for different applications. Based on heat requirements, from a potential use for 100% electricity production, part of the power can be dedicated to heat production



SMRs/AMRs with size of 100-450 MWe, 90% load factor and lifetime of at least 60 years could support a boost to electrification of Italy

Heat for industrial uses and district heating

AMRs can dedicate part of their heat for industrial applications with medium-high temperatures (e.g. **chemical and refining ind.**). **District heating networks** require low temperature heat, that can be extracted downstream of the steam turbine in SMRs

District heating 90-110°C → SMR

Industrial uses 300-500°C → AMR

3% of one SMR provides thermal consumption of the 14 largest Italian DH networks (~500 GWhth/y)
12% of one AMR provides thermal consumption of a refining industrial hub (~500 GWhth/y)

Hydrogen production

Hard-to-abate sectors (high-temperature applications as **ceramic, glass, metallic, cement**) could be decarbonized with **H2**. SMRs could provide heat and electricity to produce H2 using high temperature electrolysers SOE[3]

150-200°C → SMR

18% of one SMR produces H2 to decarbonize one ceramic industrial hub (up to ~700 GWhth/y).
Otherwise, using green H2 would require ~1100MW of dedicated PV[4]

Sea water desalination

Sea water thermal desalination requires low-temperature heat that can be extracted downstream of the steam turbine in SMRs, thus slightly impacting their electrical efficiency

90-110°C → SMR

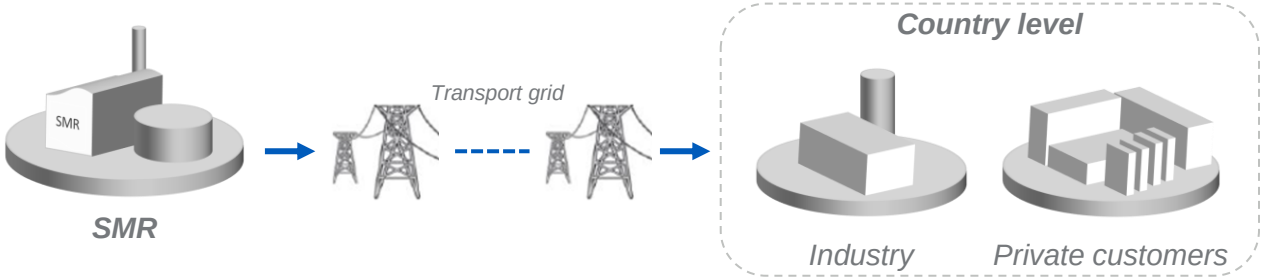
10% of a SMR/AMR plant would provide for drinking water needs of a town like Modena or an area like Elba Island

Sizing of the power impact considering an SMR / AMR plant of 400 MWe
1) DH District heating 2) Source "Nuward SMR's opportunities and socio-economic & environmental features" report published in June 2023, figure referred to SMR Nuward case
3) SOE Solid Oxide Electrolyser 4) Combustion efficiency H2 90%, electrolysers efficiency 65%, equivalent hours PV 1100 h/year

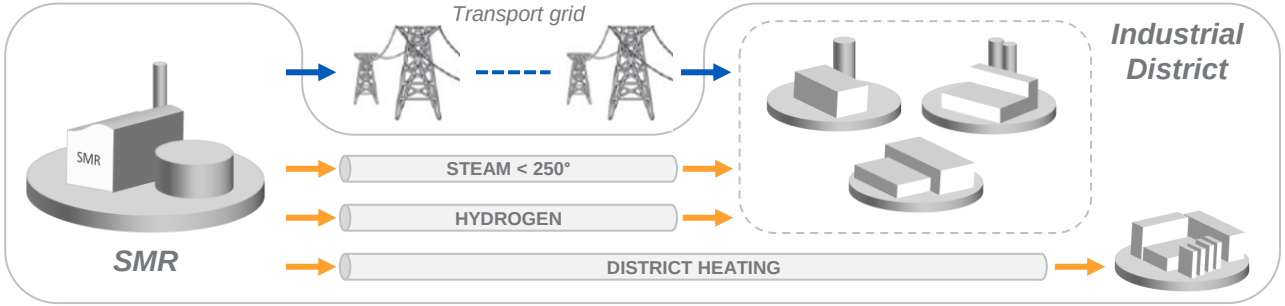
Decarbonized electricity & heat: potential SMR applications

Applications

Electricity only



Cogeneration



Impact on territories

- SMR requirements:
  - Water (little)
  - Seismicity
  - Transport grid
- Possibility to reuse existing nuclear sites

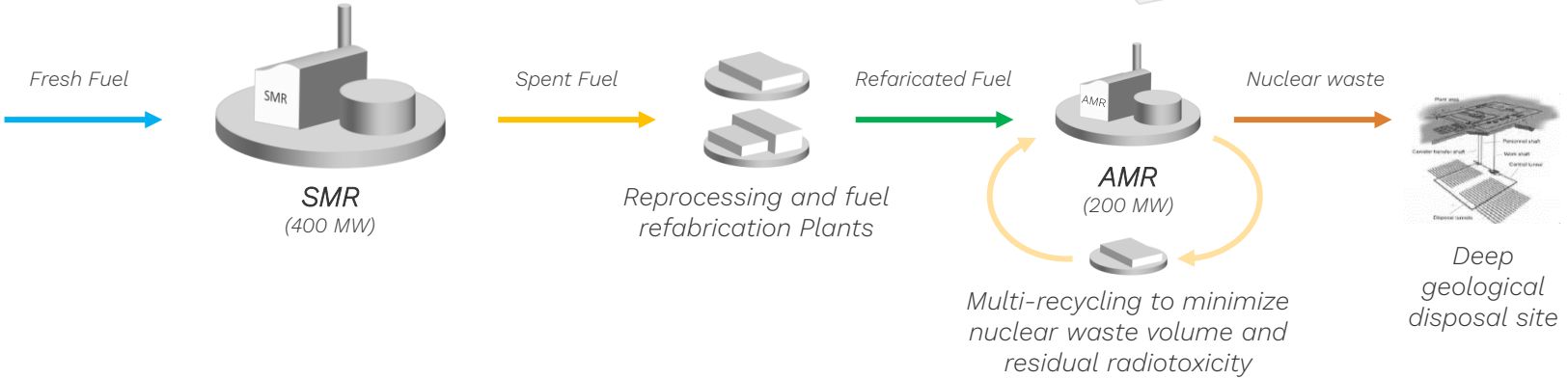
- SMR requirements:
- Industrial requirements and thermal needs temp:
  - Steam for temp < 250°
  - Hydrogen for temp > 250°
- Installation inside industrial districts

Installing SMRs close to industrial districts is an opportunity for energy intensive industries' decarbonization

Note: High temperature steam electrolysis requires 25% less electricity than low temperature water electrolysis

Closing nuclear fuel cycle: SMRs-AMRs complementarity

AMRs (ex. Lead Fast Reactors – LFRs) can reuse spent fuel from Gen3 reactors



Closing the fuel cycle allows to minimize volume and residual radioactivity of nuclear fuel waste (<300 years)

Need to act at EU scale to allow for competitiveness, not reachable at National level due to limited numbers (5 AMRs for a 15 SMR fleet)[1]

An EU partnership is to be seeked for, starting from SMR technology of choice

1. *Preliminary estimations for AMRs focused on closing the fuel cycle in Italy: around 5 AMRs (200MW class) for a 15 SMR fleet (400MW class) – power ratio around 6:1*

Edison engagement for the development of new nuclear in Italy

LOI Edison, EDF, Ansaldo Energia and Ansaldo Nucleare
- Industrial cooperation for the development of new nuclear in Italy and abroad

MOU Edison, EDF, Ansaldo Nucleare and Federacciai
- Collaboration for the development of SMRs to address industry energy needs
- Assessment of possibile supply of steelmakers' facilities with French nuclear energy for the transition period

MOU Edison, EDF, Enea
- Studies on passive safety systems and SMRs in cogeneration mode

Cooperation Agreements among Edison, Framatome and Politecnico di Milano
- Training and research joint programs for the development of new nuclear in Italy

Active participation in platforms for new nuclear
- Piattaforma Nazionale per il Nucleare Sostenibile
- EU SMR Industrial Alliance
- Progetto Nucleare Confindustria

Edison ambition is to build 2 SMRs in Italy by 2040

Thank you for your attention