



POLITECNICO  
MILANO 1863

# Problematiche energetiche e ruolo del nucleare futuro (...e presente)

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Nuclear Reactors Group*



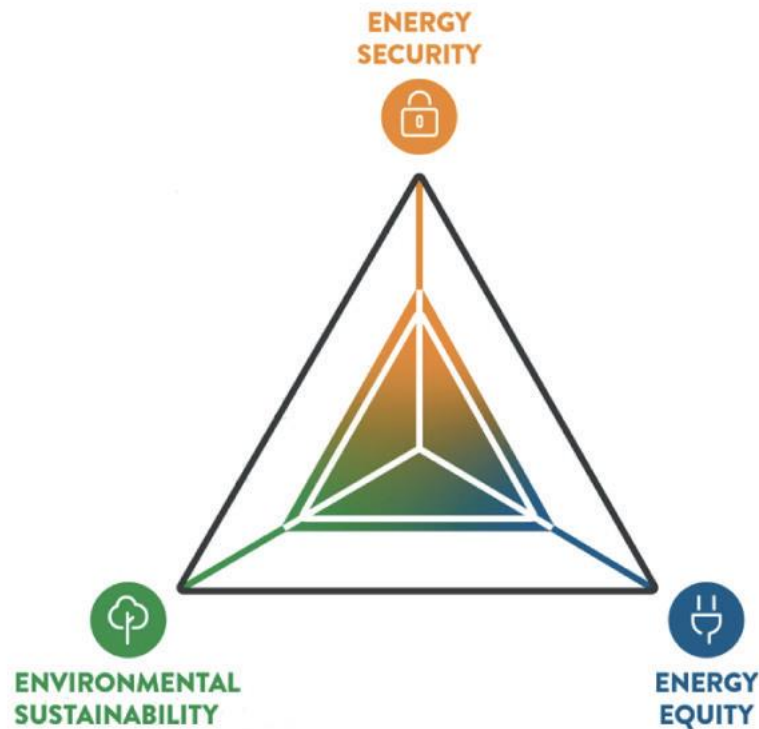
LA TUTELA DELL'AMBIENTE  
Intelligenza Artificiale e nuove tecnologie per  
un futuro ecosostenibile

Milano  
2024 Aprile 13

(I) Global warming

(II) Dipendenza strategica

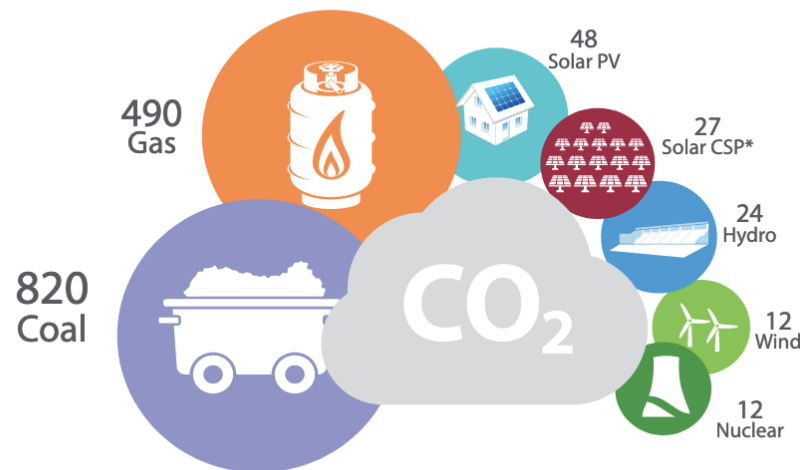
(III) Ricadute socio-economiche



*“ma il Nucleare  
inquina...”*



Comparison of greenhouse gas emissions  
(grammes CO<sub>2</sub> eq/kWh)

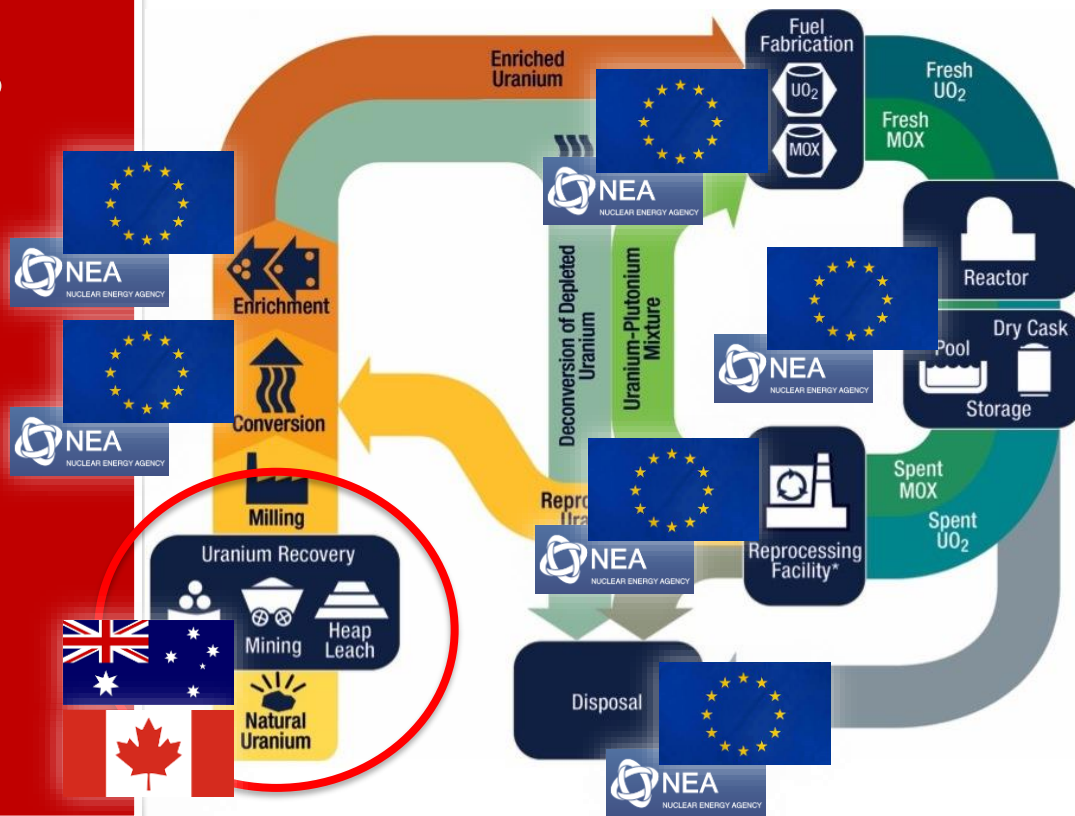


\*Concentrated Solar Power  
© FORATOM - Source: IPCC 2014

# II «Trilemma Energetico» e il nucleare

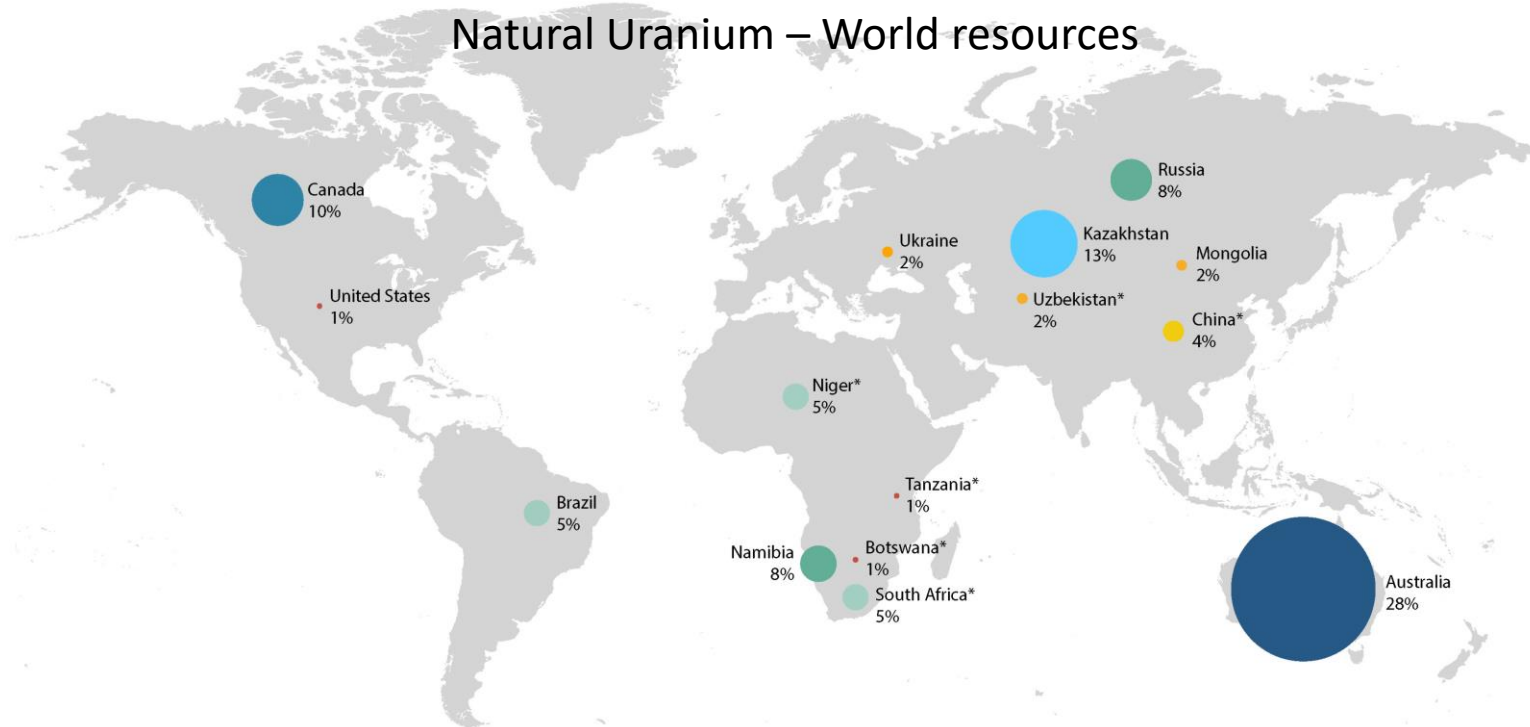
## II. Dipendenza strategica

*“ma il Nucleare è  
rischioso...”*



# II «Trilemma Energetico» e il nucleare

## II. Dipendenza strategica



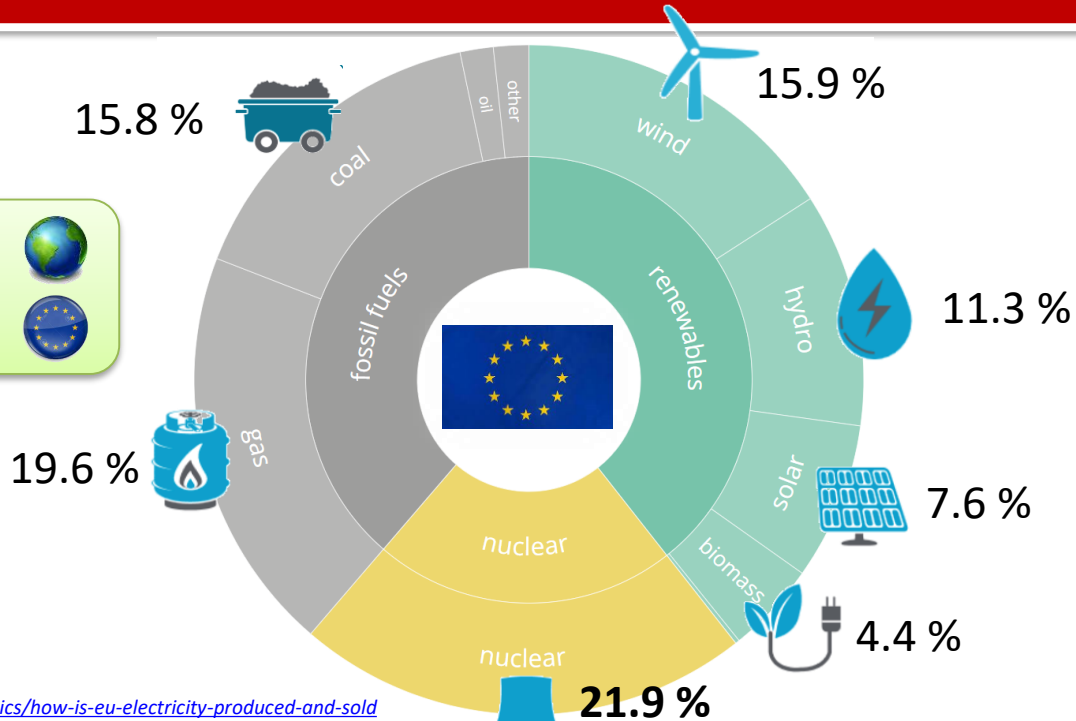
IAEA / NEA, Uranium 2022: Resources, Production and Demand (Red Book), 2022

*“ma il Nucleare non è importante per l’economia...”*



# Il «Trilemma Energetico» e il nucleare Elettricità «green»

*“ma il Nucleare non è importante per l’EU...”*



2023 Eurostat database

<https://www.consilium.europa.eu/en/infographics/how-is-eu-electricity-produced-and-sold>

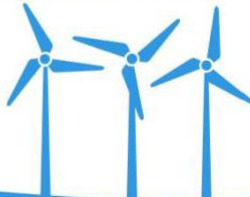
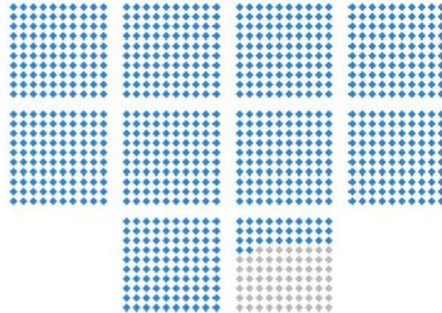
*“ma il Nucleare danneggia l’ambiente...”*

Centrale da  
1000 MWe

673-932 square kilometres

117-194 square kilometres

3.3 square kilometres



Wind  
assuming capacity  
factor 32-47%



Solar  
assuming capacity  
factor 17-28%



Nuclear  
assuming capacity  
factor 90%

**Nota:**

Superficie necessaria per ottenere la STESSA POTENZA INSTALLATA (potenza di picco per le Rinnovabili). Ma produzione di ENERGIA è diversa nella giornata e nelle stagioni.

Per ottenere la STESSA ENERGIA PRODOTTA ALL'ANNO, le Rinnovabili richiedono PIU' POTENZA INSTALLATA + ACCUMULO DI ENERGIA.





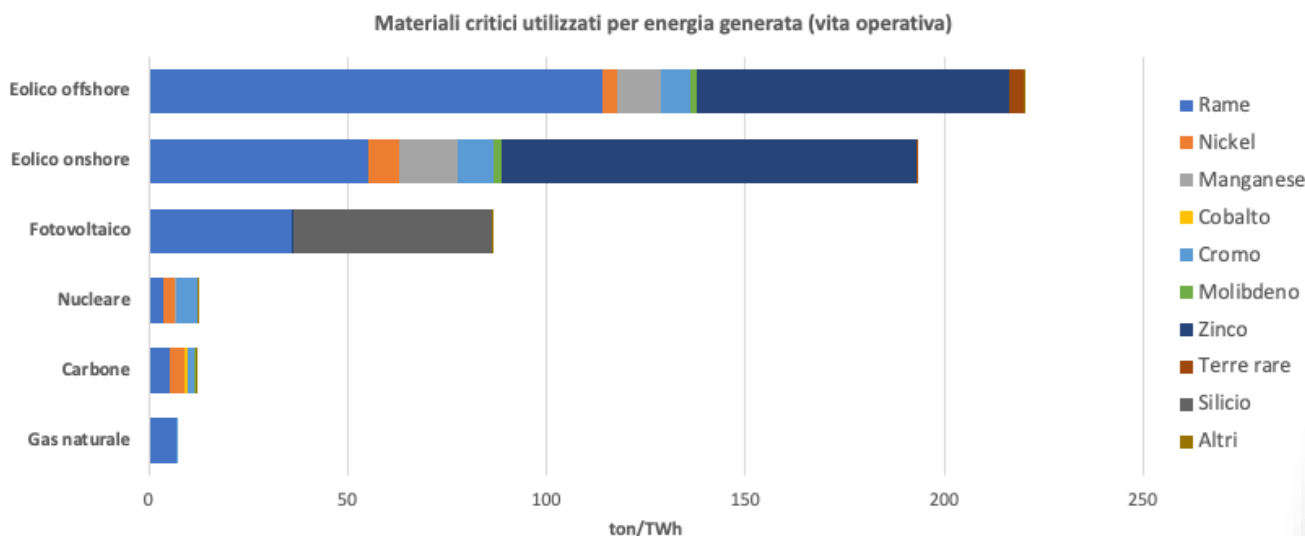
# Il «Trilemma Energetico» e il nucleare

## Uso di materiali critici

Milano  
2024.04.13

9

*“ma il nucleare danneggia l’ambiente...”*



Rielaborazione POLIMI: materiali critici **per elettricità prodotta** (intera vita operativa)



“ma il  
pericol

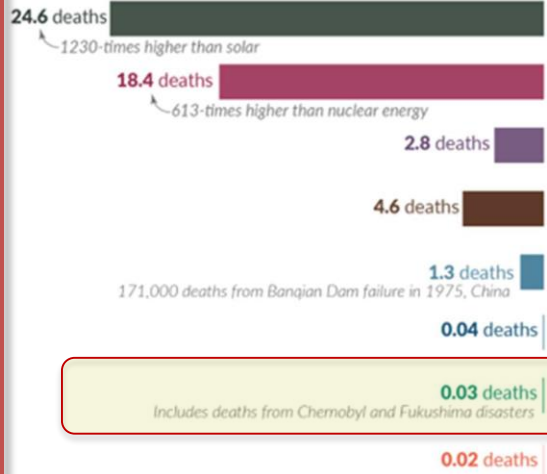


## What are the safest and cleanest sources of energy?

Our World  
in Data

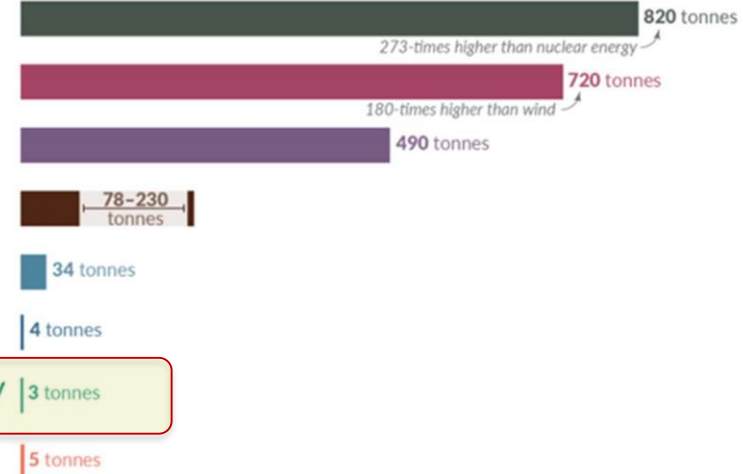
### Death rate from accidents and air pollution

Measured as deaths per terawatt-hour of electricity production.  
1 terawatt-hour is the annual electricity consumption of 150,000 people in the EU.



### Greenhouse gas emissions

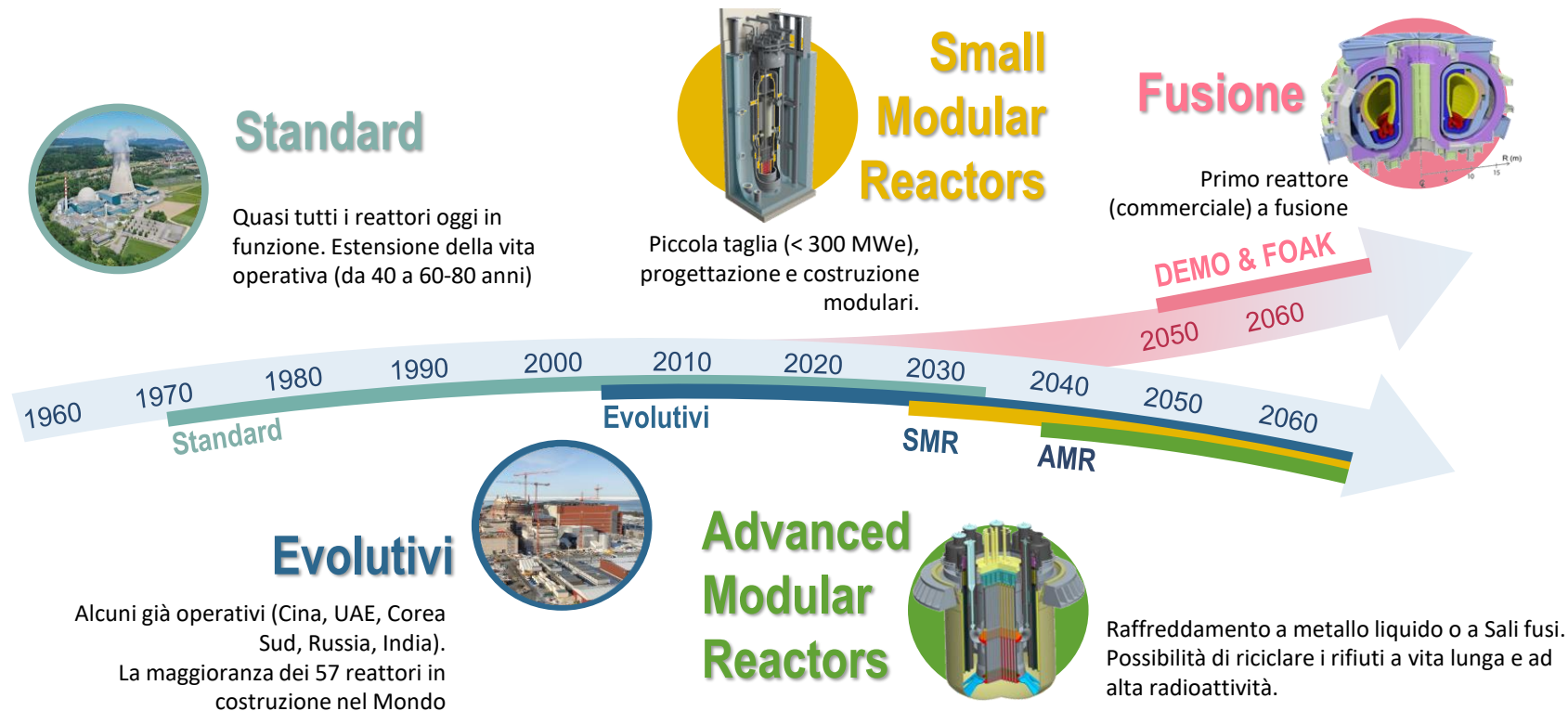
Measured in emissions of CO<sub>2</sub>-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant.  
1 gigawatt-hour is the annual electricity consumption of 150 people in the EU.



Death rates from fossil fuels and biomass are based on state-of-the-art plants with pollution controls in Europe, and are based on older models of the impacts of air pollution on health. This means these death rates are likely to be very conservative. For further discussion, see our article: [OurWorldinData.org/safest-sources-of-energy](https://ourworldindata.org/safest-sources-of-energy). Electricity shares are given for 2021. Data sources: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC AR5 (2014); Pehl et al. (2017); Ember Energy (2021).

OurWorldinData.org - Research and data to make progress against the world's largest problems.

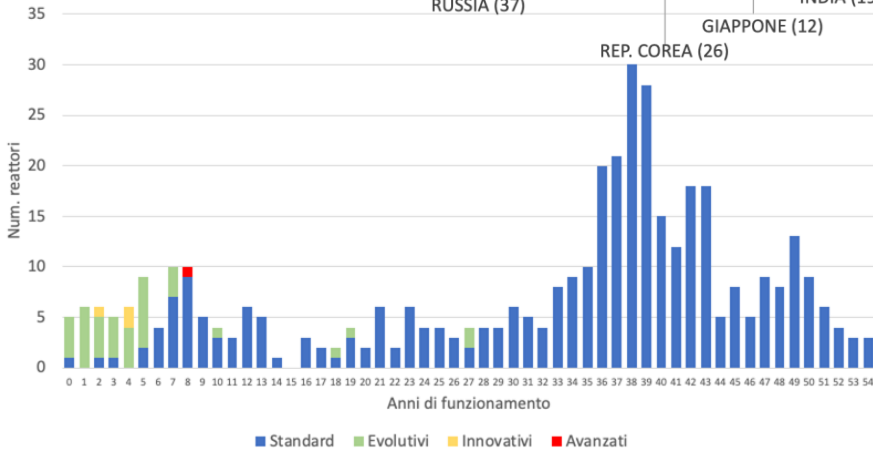
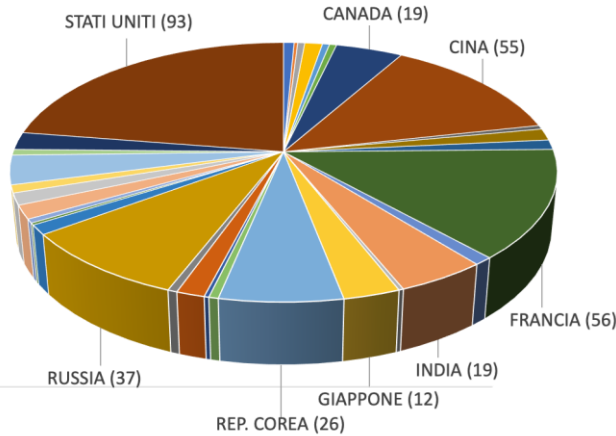
Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.



# 1. Standard: Estensione di Vita



N. Reattori in funzione nel mondo (Gen. 2024, Tot. 413)



40 anni



Reattori:

417



100



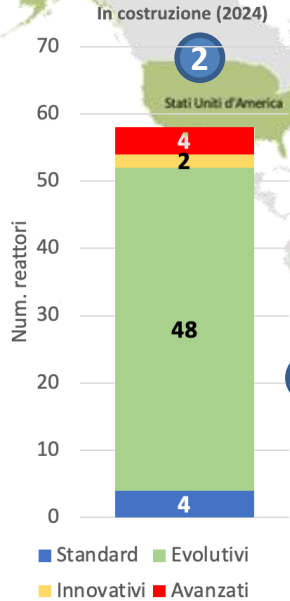
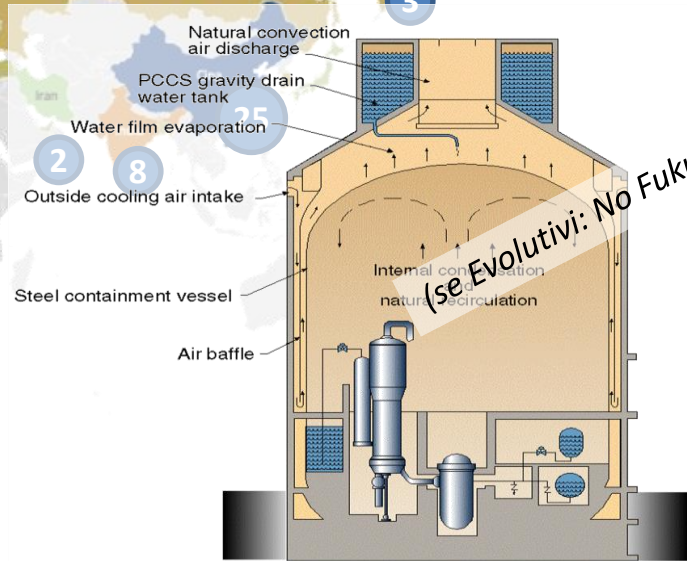
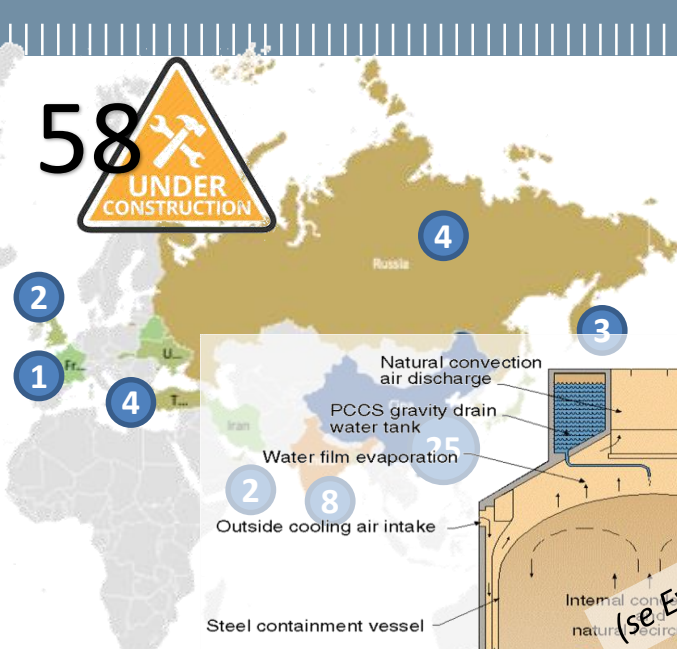
Anni di esperienza:

19 200

Funzionamento:

60+ anni

# 2. Evolutivi: In costruzione & Operativi



# 3. Small Modular Reactors: cambio di paradigma



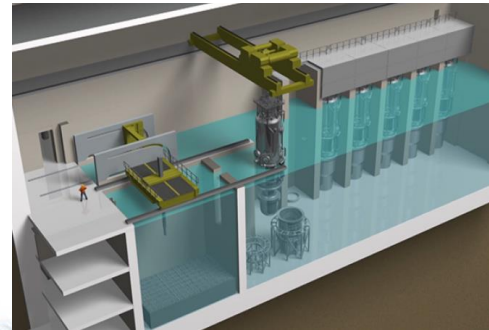
Reattori nucleari di taglia limitata (< 300 MWe)

## Vantaggi:

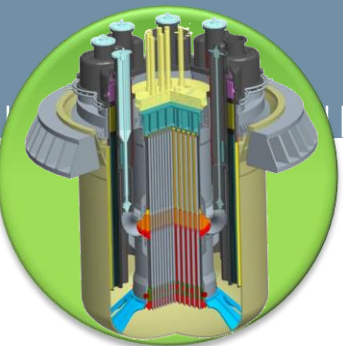
- Design **semplificato**
- Strategia di sicurezza a «**sistemi passivi**» (circolazione naturale: no Fukushima)
- Progettazione e costruzione **modulare**, in officina
- **Cogenerazione** (idrogeno, accumulo termico, teleriscaldamento, desalazione, biofuel)

## Sfide:

- Mercato internazionale, costruzione in serie
- Dimostratori: tempi e costi



# 4. Advanced Modular Reactors: opzione riduzione rifiuti



Reattori raffreddati a:  
piombo liquido, sodio liquido,  
sali fusi

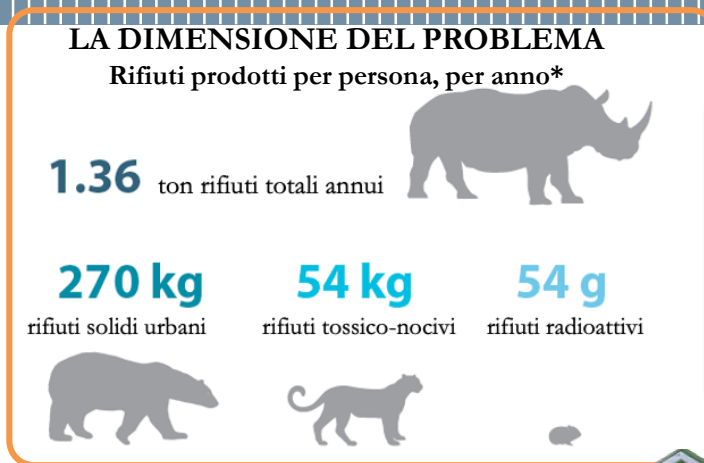
«fisica differente»: eccesso di neutroni

### Vantaggi:

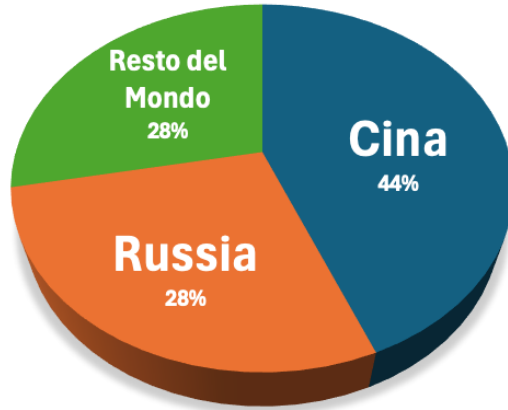
- Gli stessi degli SMR (molti GenIV sono SMR)
- Miglior **rendimento**
- Possibilità di **separare e «bruciare» i rifiuti** ad alta radiotossicità

### Sfide:

- Economicità
- Integrazione con impianti del ciclo del combustibile (proliferazione)



## Reattori in costruzione



### Francia:

- LTO (>30 NPPs),
- 6 EPR2 (+8),
- SMR Nuward (500M€ finanz., atteso annuncio sito FOAK),
- Iniziativa AMR (finanz. Bpifrance): NAAREA-MSR, Newcleo-LFR, Jimmy Energy-HTR, Renaissance Fusion-Stellarator, Calogéna-LWR, Hexana-SFR, Otrera Nuclear Energy-SFR, Blue Capsule-SFR

**Svezia, Belgio:** phase-out abbandonato,

**Finlandia:** grandi reattori e SMR,

**Ungheria:** 2 VVER da costruire,

**Bulgaria:** 2 AP1000 da costruire (aziende coreane), MoU con FRA,

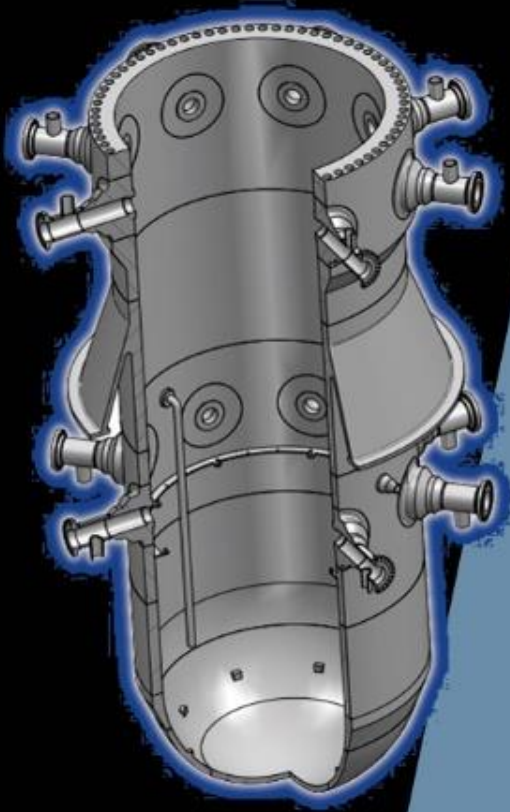
**Rep. Ceca:** gara per 4 LR, EdF vs. KHNP,

**Romania, Slovacchia, Slovenia, Olanda, Polonia (newcomer country):** piani per LR e SMR (mercato potenziale SMR: circa 10 entro il 2035, poi 10 SMR/anno fino al 2050)





Sett. 2023



**How many**  
**Reactor Pressure**  
**Vessel for SMRs,**  
**the Italian nuclear**  
**supply chain is ready**  
**to produce every year ?**

Mar. 2024

lancio della EU SMR Industrial Alliance

# 25 aziende pronte ad avviare la Supply Chain Nucleare Italiana degli Small Modular Reactors

Milano  
2024.04.13

ansaldo | energia

AGRA AIR COM  
COINOX  
Baglioni

ATB RIVA CALZONI

E&R BREMBANA&ROLLE



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CAEN Sys  
Systems & Spectroscopy Division

CECOM  
HIGH PRECISION SOLUTIONS

CESTARO ROSSI  
CONTRATTI PER LA MANUTENZIONE DI REATTORI PLANTAS SIND 1971 - ITALY

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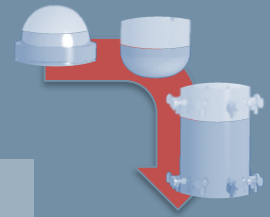
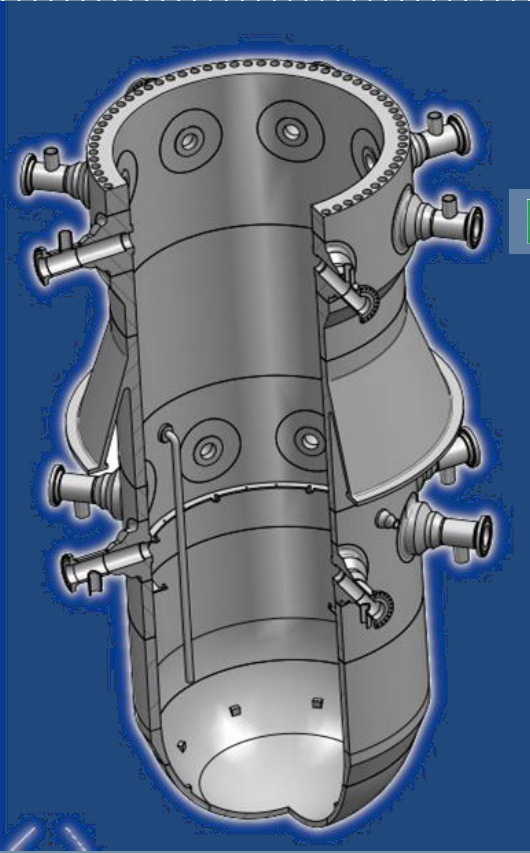
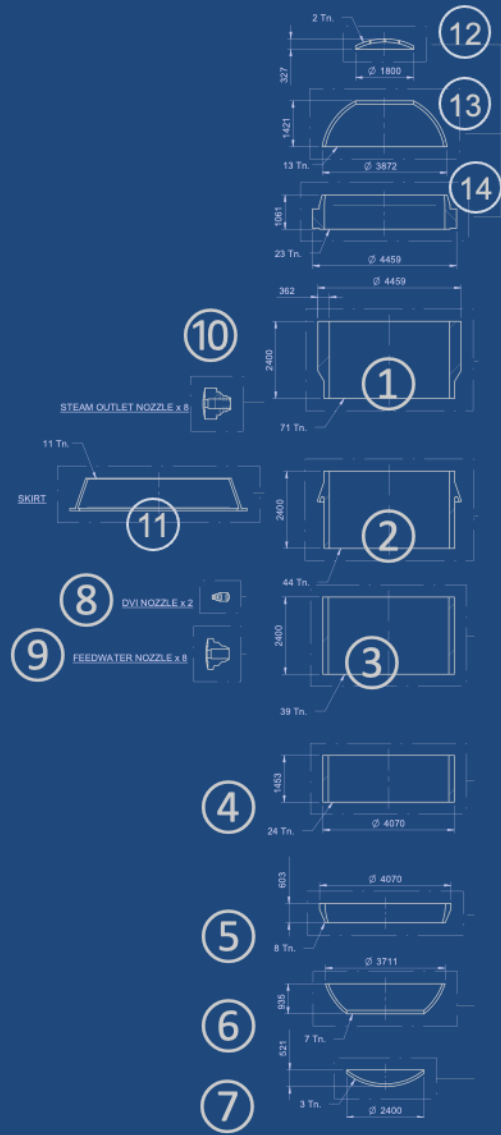
SIET  
sperimentiamo le tue idee

SIMAC  
since 1975  
A PASSION FOR CHALLENGES

walter tosto



# Reactor Pressure Vessel per SMR fabbricabili in Italia, all'anno



 **FORGING COMPANIES**



 **MANUFACTURING COMPANIES**



**+**  
**8**  
SMR/anno

**download  
the brochure  
HERE**



## ITALIAN NUCLEAR SUPPLY CHAIN FOR SMALL MODULAR REACTORS

Preliminary investigation and Case Study on Large Components manufacturing  
(Case #1: Reactor Pressure Vessel)

# I tre «paradossi italiani»

Milano  
2024.04.13



prof. Marco E. Ricotti



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