

Time for a new future for nuclear energy

José E. Gutiérrez

The world is rapidly changing – The old one

The world is rapidly changing – The new one

The world is rapidly changing

Information Technologies in general and **Internet** in particular have brought **Globalization** and have exponentially accelerated technological **Innovation**

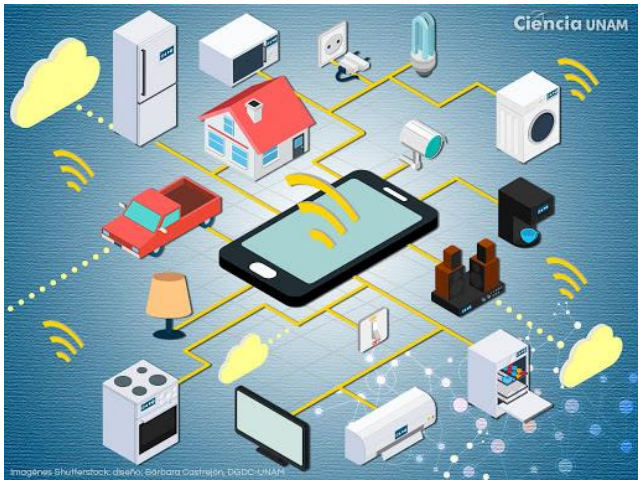
Two underway revolutions

- Digital revolution
- Environmental revolution

Two underway revolutions - Digital

The old world

The new world



Two underway revolutions - Environment

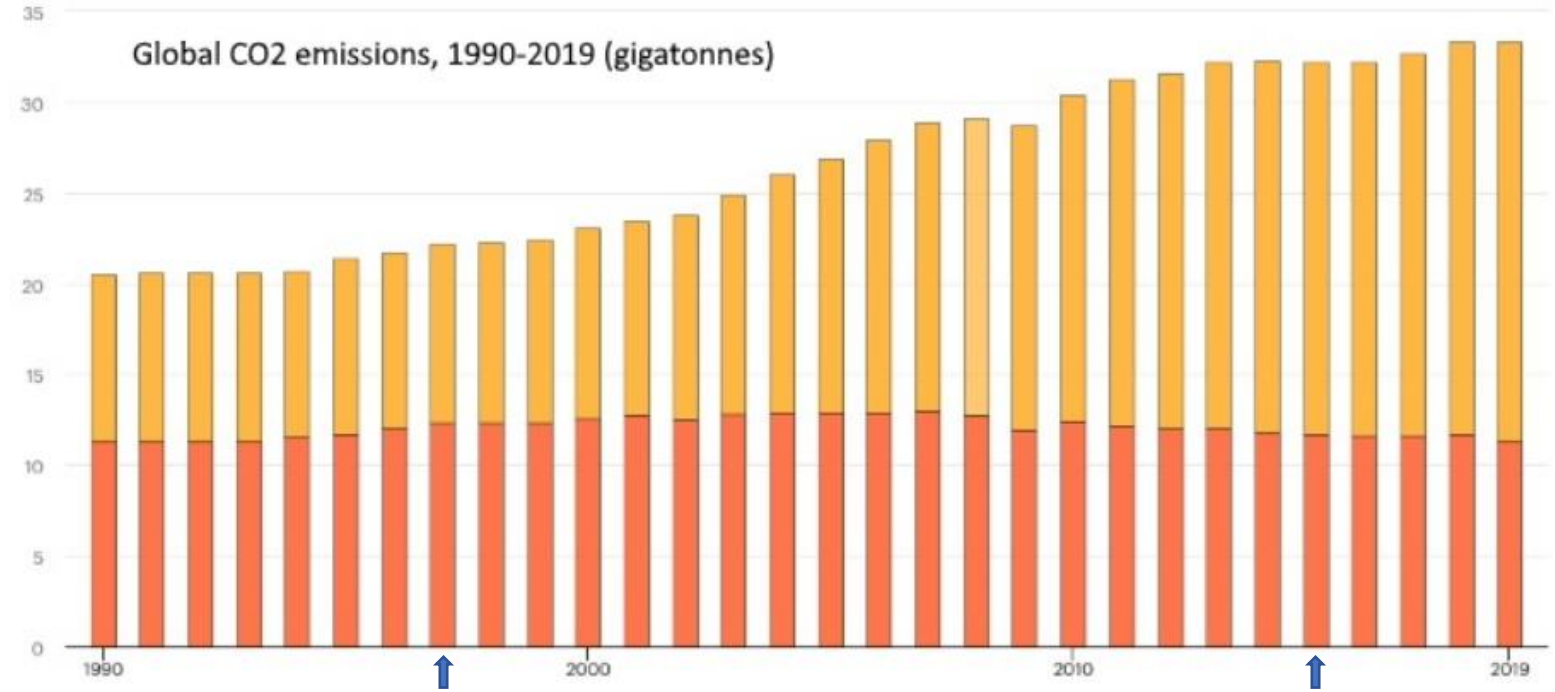








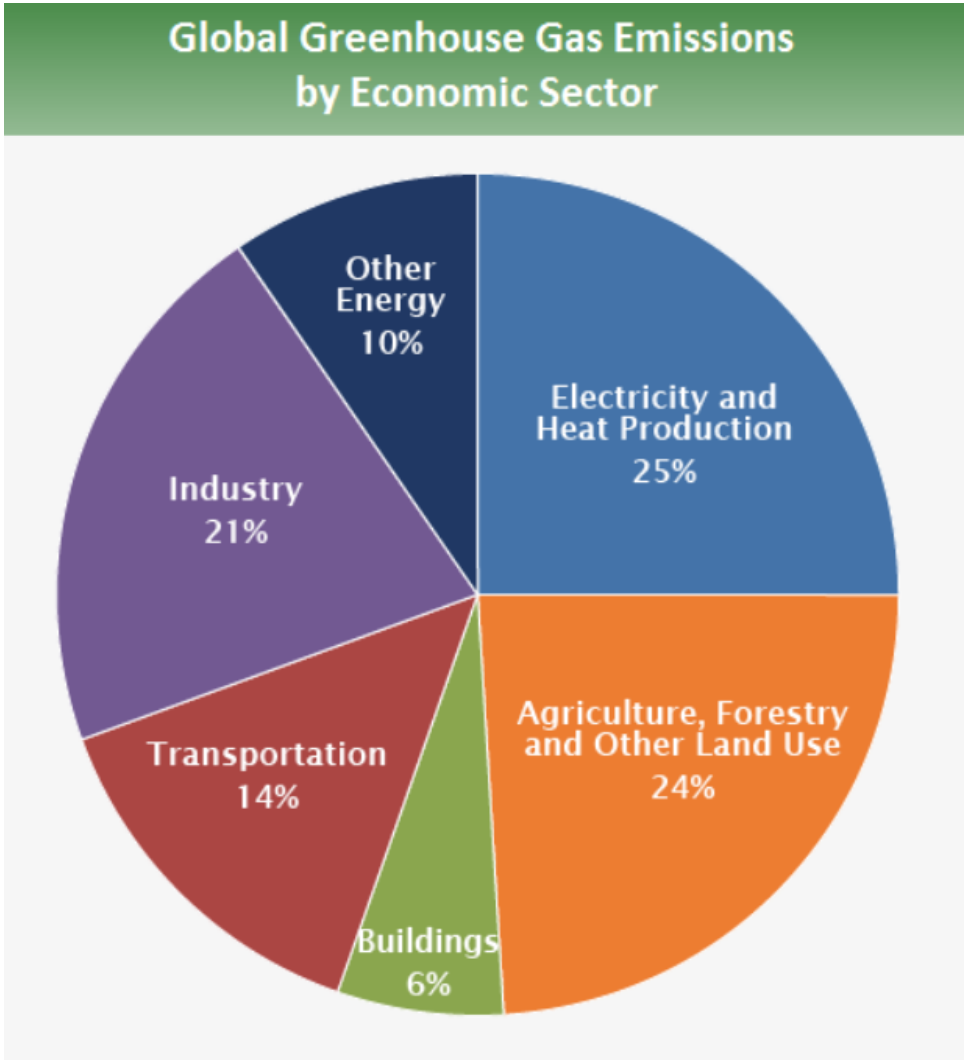

The environmental dilemma



Advanced Economies (orange) versus Rest of the World (yellow) (Image: IEA)

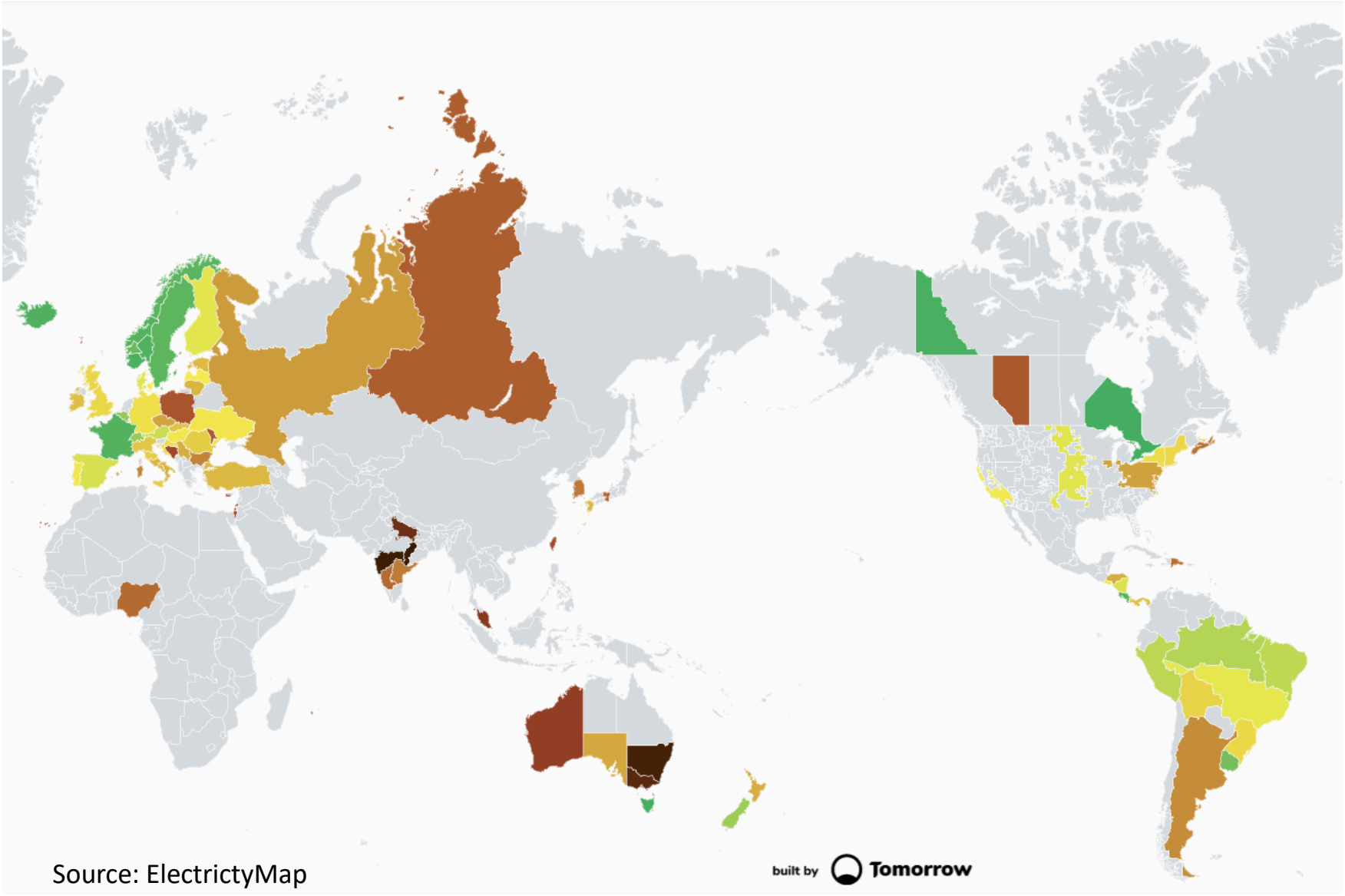
Source: International Energy Agency

The environmental dilemma



Source: EPA

Electricity generation – CO^2 emissions



Source: ElectrictyMap

Electricity generation – Ongoing change

The old world

The new world

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Electricity generation – Ongoing change

- Unequal approximation between countries.
- Continuous widespread growth of solar and wind energy.
- Disappearance of coal and gradual reduction of gas.
- Need to increase energy storage, which will eliminate the need for gas.
- Bet on nuclear energy in the US, China, Russia, UK, Canada, Eastern Europe, Finland and India.

Ideal portfolio for an efficient transition: nuclear, wind, solar, hydro and storage

Nuclear energy roadmap

- **Safe and efficient operation of the current nuclear fleet**
  - ✓ *Digital transformation*
  - ✓ *Life extensión until at least 60 years of operation*
  - ✓ *Accident Tolerant Fuel*
- **Building new reactors: Gen III/III+ or even better Gen IV**
  - ✓ *Replace capacity*
  - ✓ *Add capacity*
- **Safe and efficient decommissioning of the reactors that are shutting down**
- **Spent Fuel Management**
  - ✓ *Temporary or permanent storage*
  - ✓ *Spent fuel reuse*
  - ✓ *Reduction of the activity of the most active isotopes*
- **Fusion**
  - ✓ *Development of the technology of the future*

All this will only be possible if we invest in innovation and if we are ambitious in our goals. No more delays and excuses

Nuclear energy today – My view

- **Reactors in Operation.** The continuity of the operation of the current reactors in the United States, Canada, Western Europe and Central Europe is the best guarantee of an efficient energy transformation, but not all the countries share that vision. The pressure on costs will intensify, but investments will not be significantly reduced. Increased investment in innovation is required, mainly safety and digital.

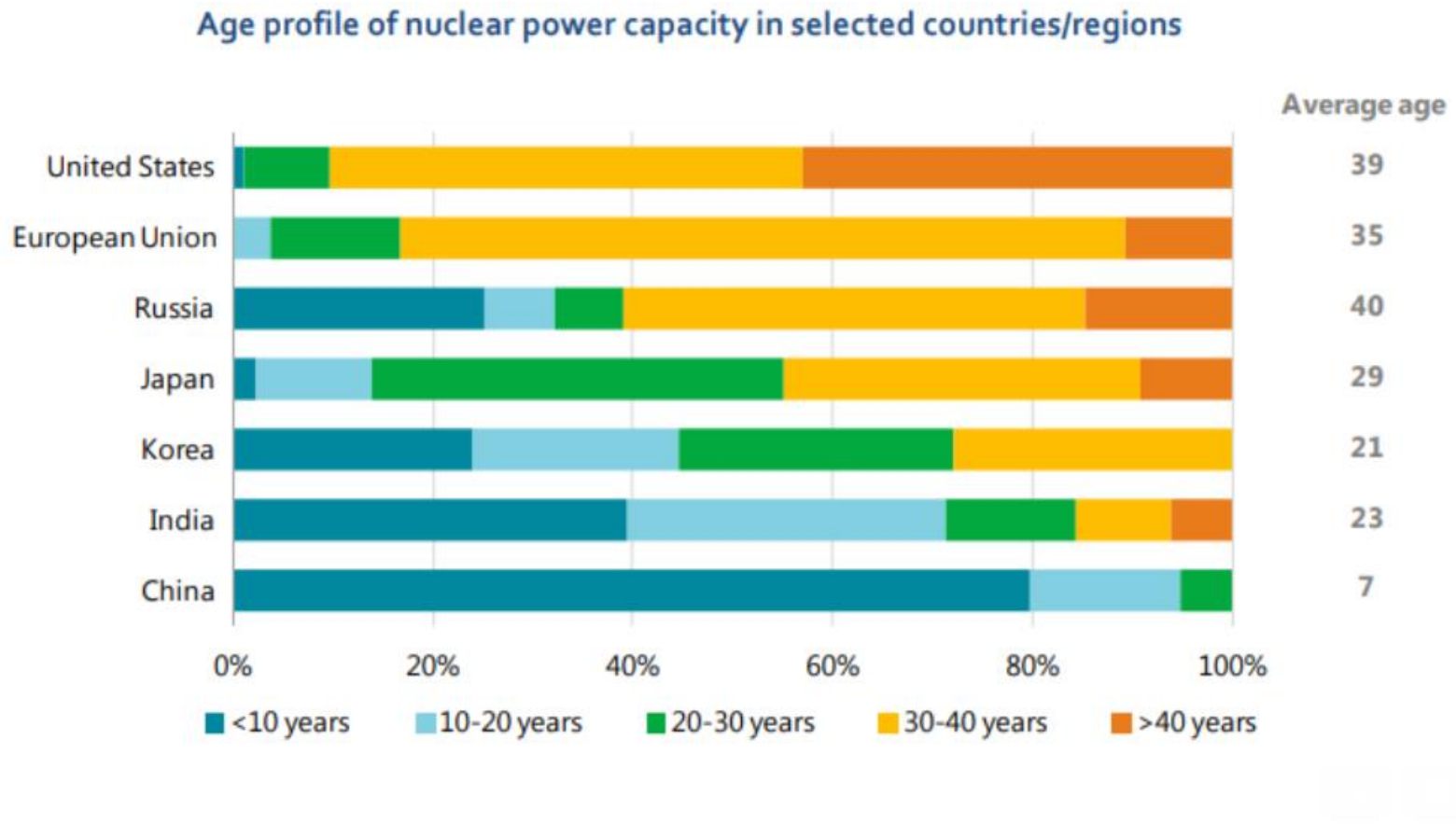
- **New reactors.** The current problem is to be able to build in time and cost plus financing. Large reactors, all of them Gen III and III +, are not the only solution, except in some countries. Western countries must evolve quickly to Gen IV reactors.

- **SMR.** Important support from the United States, United Kingdom and Canada to its development. More than 30 projects under development, who will win?. However, almost all projects are in the technology development phase. Not all the SMR projects are Gen IV. Integration with other industrial uses: energy storage, hydrogen production, district heating, etc. Leap in innovation, which is late.

- **Decommissioning and dismantling.** D&D will continue to be an expanding market due to the commitments already made and new ones that will come. However, some projects may be delayed in favor of other priorities. New technologies are required to increase the efficiency of work and improve the safety and security of the public.

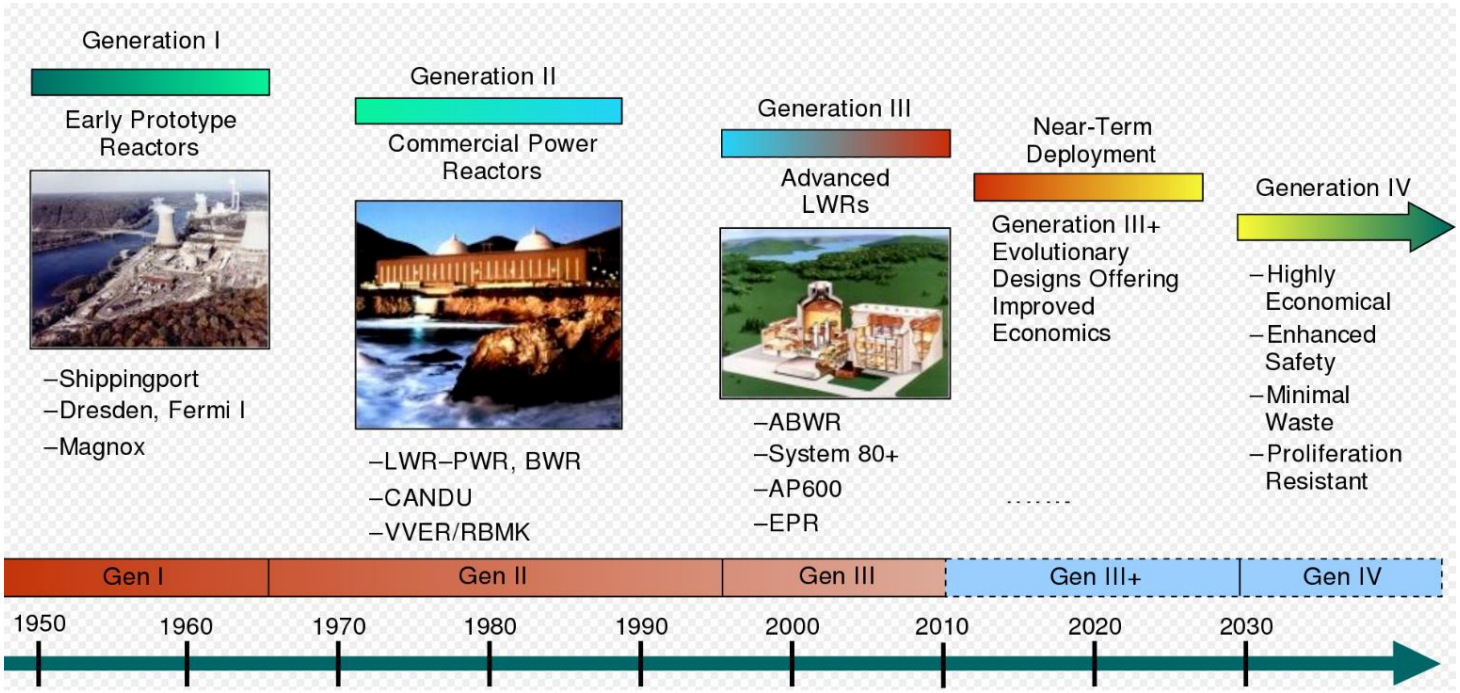
- **Spent Fuel management.** Even though there are viable technical solutions, this is an issue that is not yet resolved and that governments do not know how to tackle. Storing spent fuel and then burying it is not a solution according to the technological level of the 21st century. New technologies must be developed that reduce the activity of the longest-lived isotopes or their volume. Again the solution is innovation.

Nuclear energy today – Reactors in operation



Fuente: IAEA

Evolution of the nuclear technologies

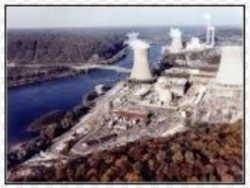


Evolution of the nuclear technologies

GEN IV International Forum℠

Generation I

Early Prototype Reactors



–Shippingport
–Dresden, Fermi I
–Magnox

Generation II

Commercial Power Reactors

–LWR–PWR, BWR
–CANDU
–VVER/RBMK

Generation III

Advanced LWRs

–ABWR
–System 80+
–AP600
–EPR

Near-Term Deployment

Generation III+ Evolutionary Designs Offering Improved Economics

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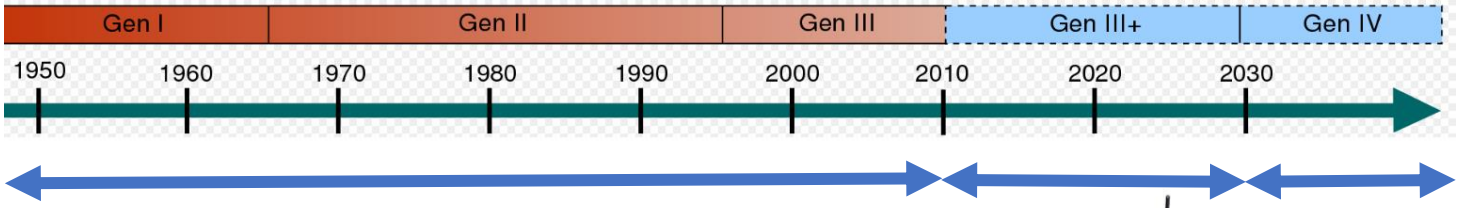
Generation IV

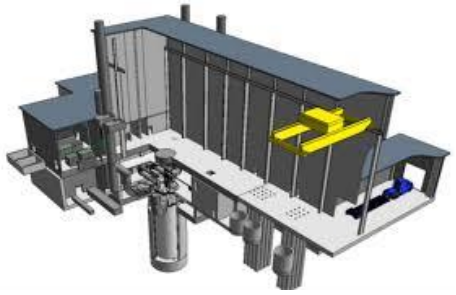
– Highly Economical
– Enhanced Safety
– Minimal Waste
– Proliferation Resistant



SMR – who will win?

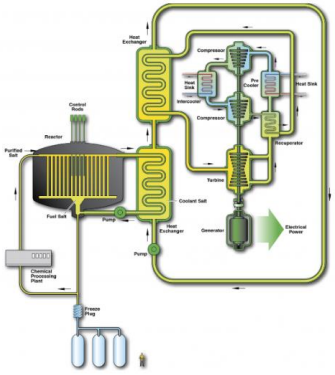
Small/Modular LWR

Simplified Small Reactors

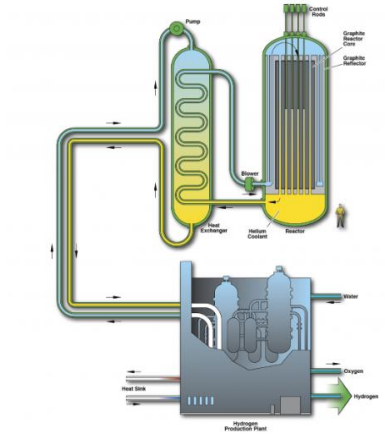


Micro Nuclear Reactor

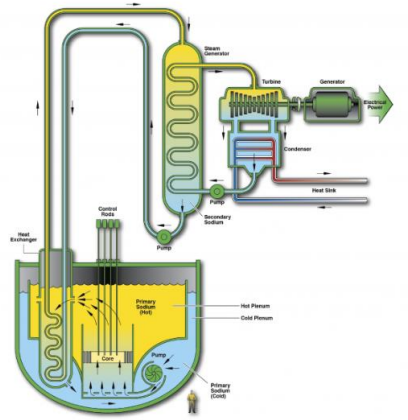
Molten Salt Fast Reactor



Very High Temperature Reactor



Sodium-Cooled Fast Reactor



SMR – who will win?

Small/Modular LWR

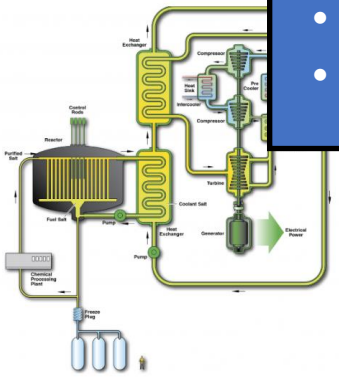
Simplified Small Reactors

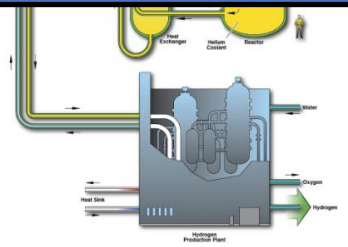
Micro Nuclear Reactor

Requirements for the new reactors:

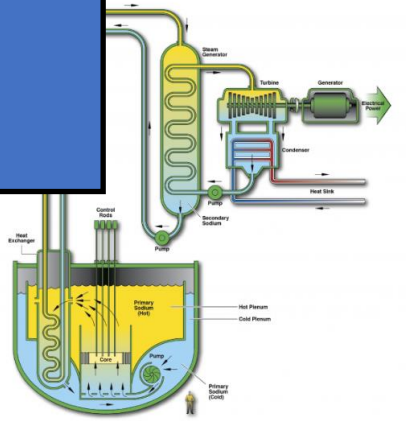
- Inherent safety
- Competitive
- 100% flexible
- 100% Digital
- Dismantlable off-site
- Help manage spent fuel
- Alternative industrial uses

Molten Salt Fast



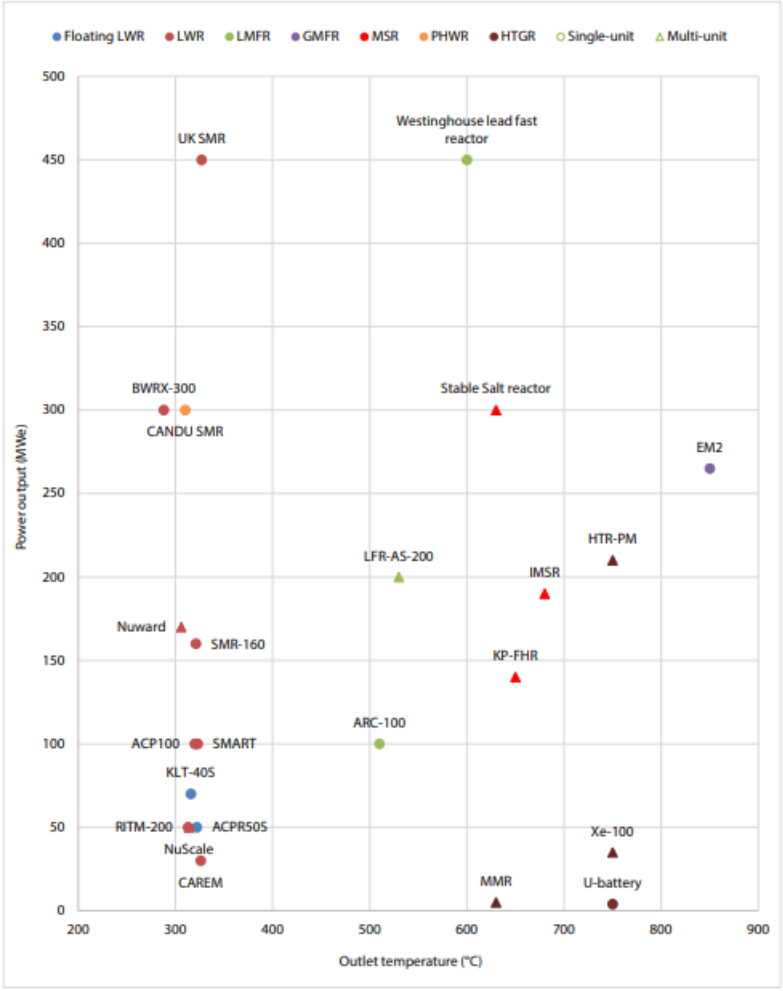


Cooled Fast Reactor



SMR – who will win?

Figure 1: Selected reactor designs as a function of power output, core outlet temperature and deployment configuration



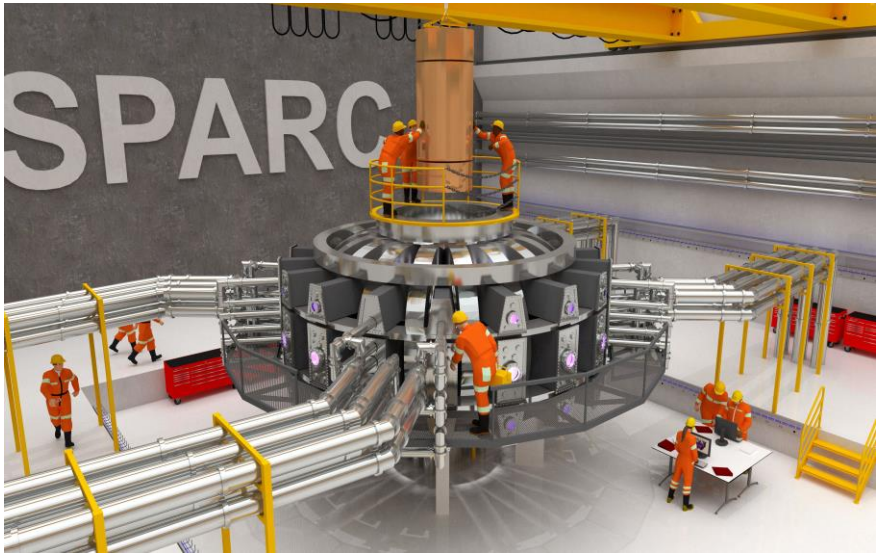
Notes: LMFR = Liquid metal fast reactor; GMFR = Gas modular fast reactor; HTGR = High temperature gas reactor.

Source: IAEA (2020).

Fusion ?

NUCLEAR FUSION ENERGY IS 30 YEARS AWAY…AND ALWAYS WILL BE

ITER



MIT

Nuclear energy for a new world



Time for a new future for nuclear energy

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