COP 14 Side Event

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Sustainable Nuclear Contribution to the 21th century Energy Production

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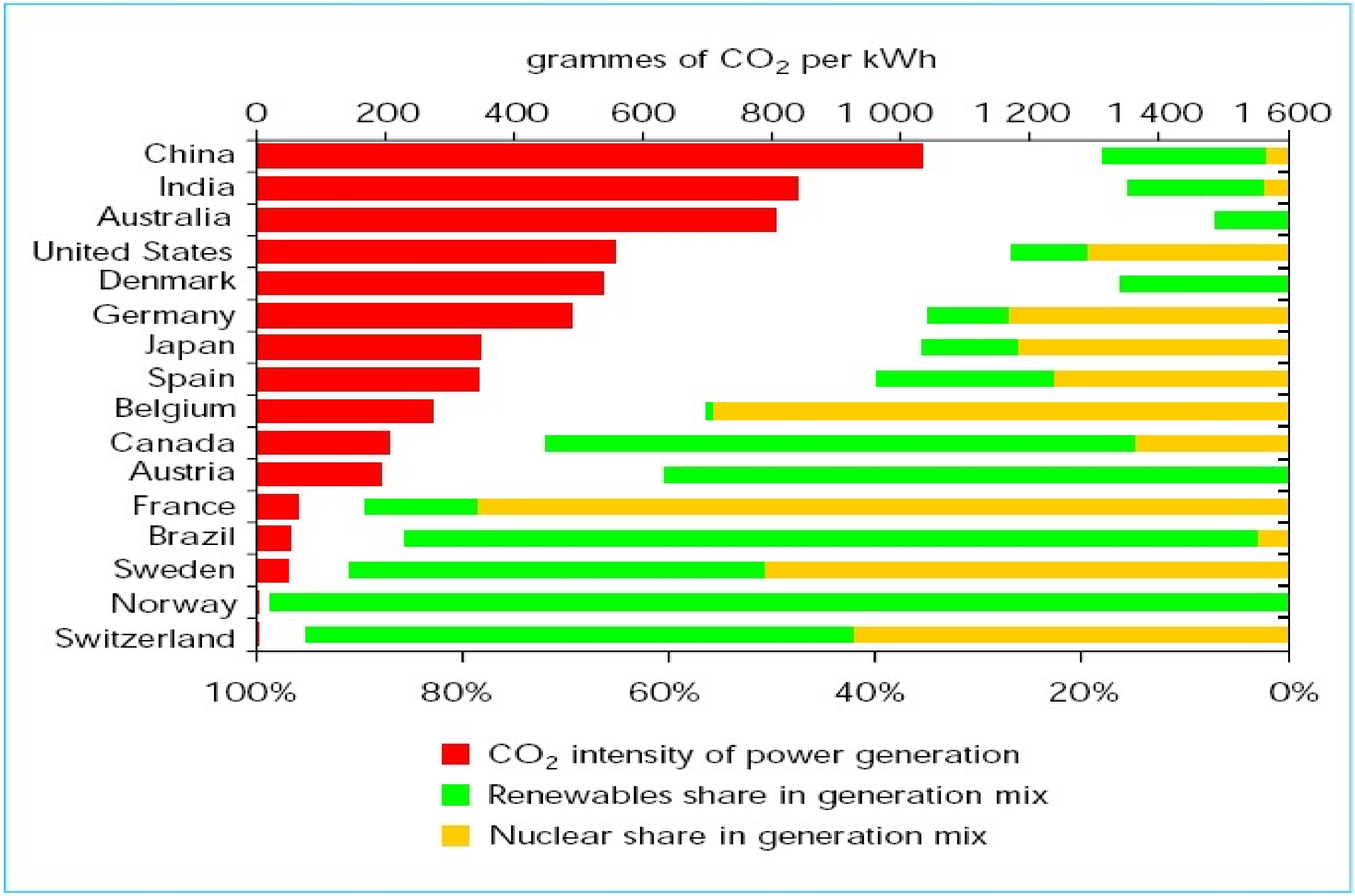
An increasing world energy demand …

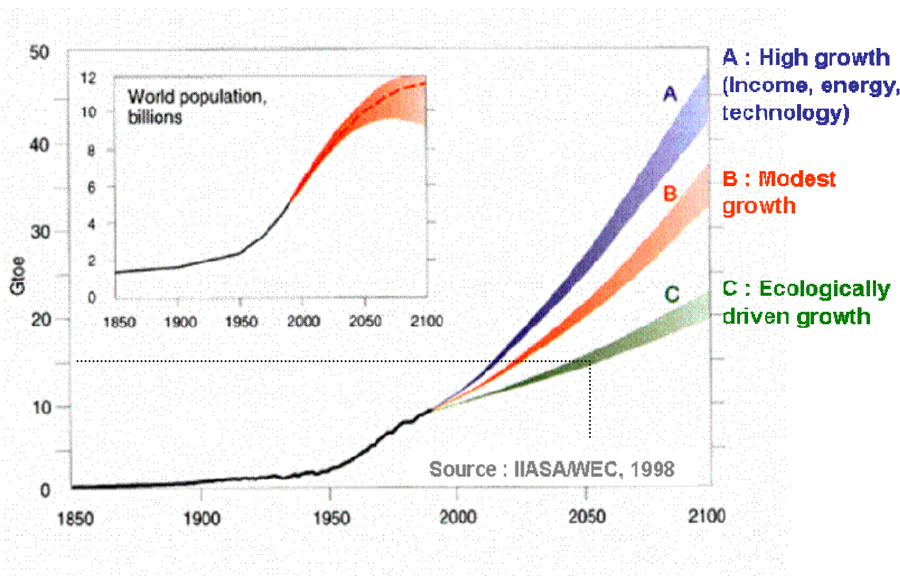
… and various answers

Figure 13.1: **Power Sector CO_2 Emissions per kWh and Shares of Nuclear Power and Renewables in Selected Countries, 2004**



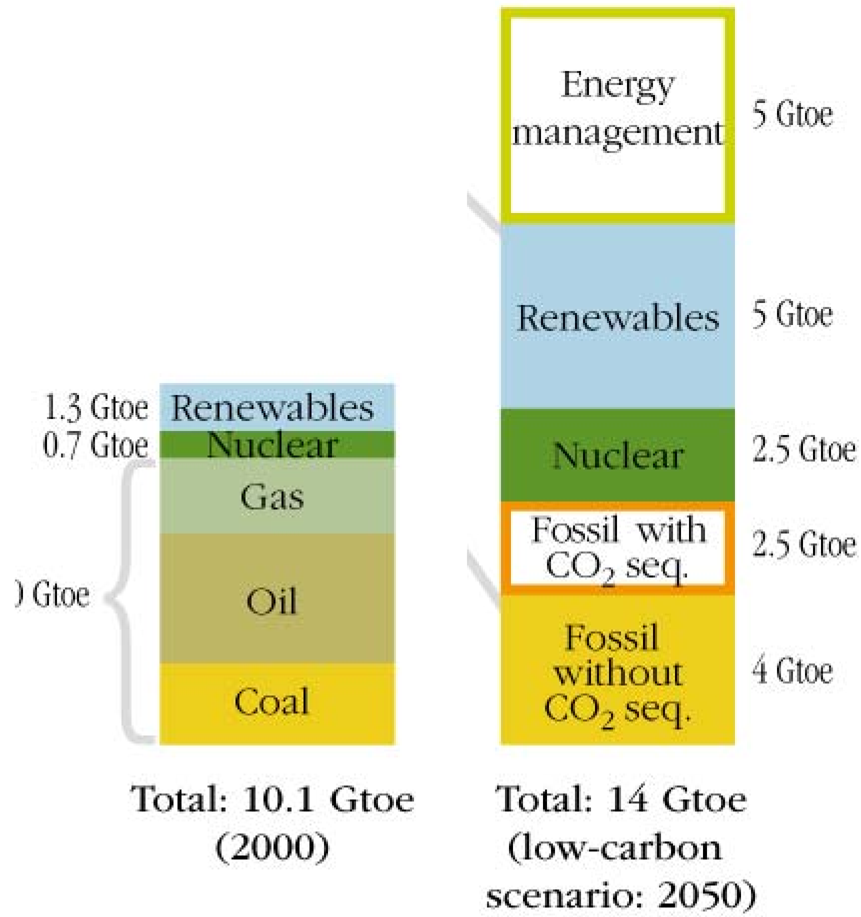
Source AIE 2006

Low carbon energy scenario for 2050



Today, nearly 2 billion people without electricity (30%)

- Energy demand will increase
  approx. double if no strong energy management / saving policy is implemented
- Nuclear power will play an important role among other sources of energy



Nuclear energy will play an important role in the future

Renaissance

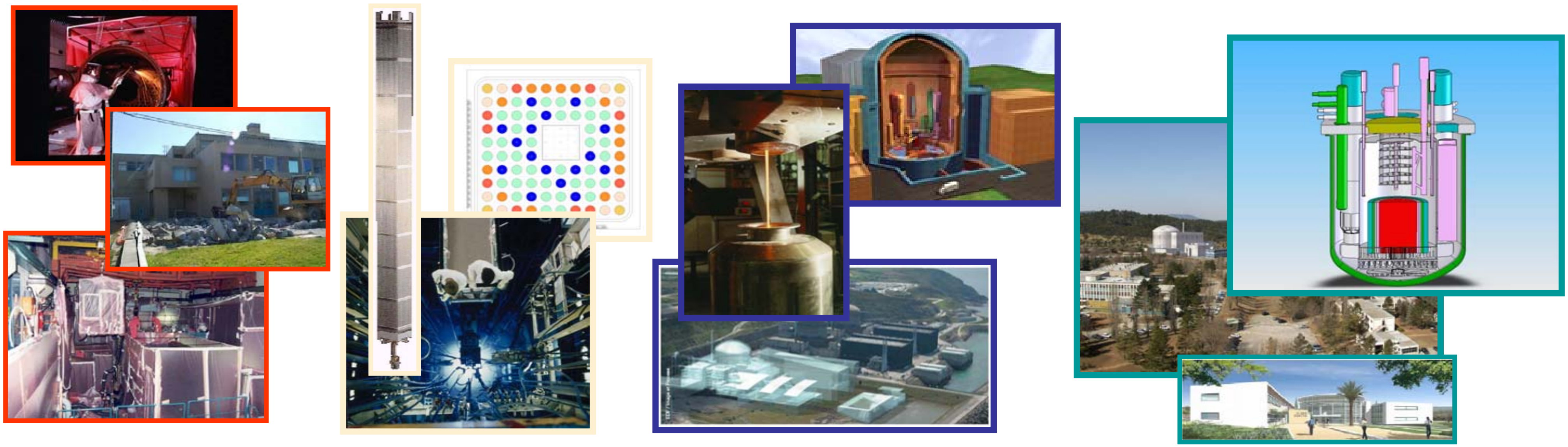
- No CO_2 emissions
- Security of energy supply
- Competitiveness
- Improved safety

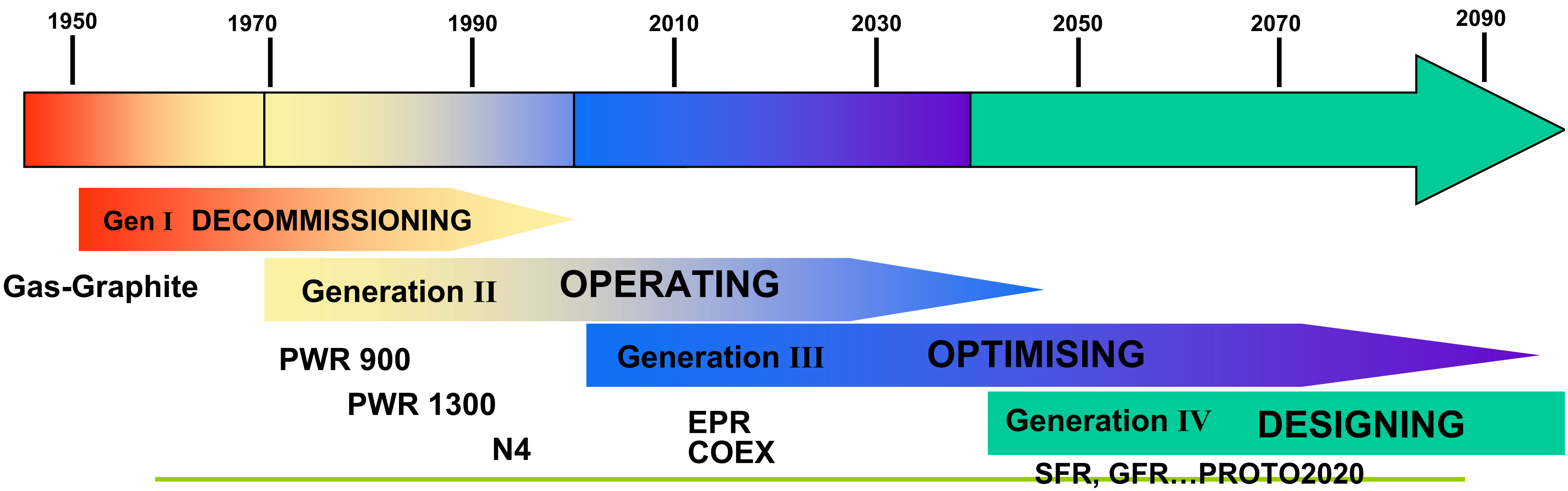
Sustainability

- Waste management
- Resources preservation
- New issues (hydrogen production, water desalination, industrial heating …)

Renaissance

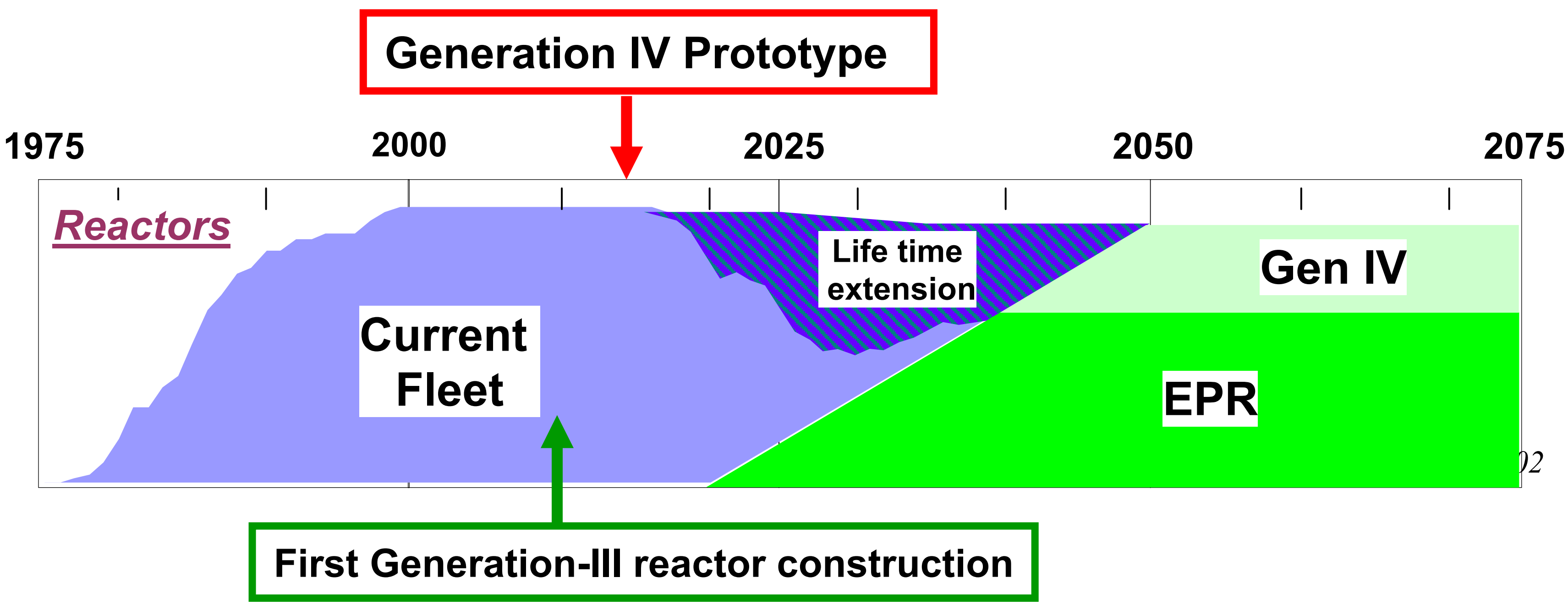
Evolution of nuclear power in France





Transition scenarios between generations

- **Major role of Light Water Reactors (LWR) in the 21st century**
  - Current LWRs (Gen II): life time extension (> 40 years)
  - Gen III/III+ LWRs : current LWRs replacement around 2015 – in operation during 21st century
- **A transition scenario between LWRs and Fast Neutrons Systems**
- **2040: - Deployment of Fast neutron systems (SFR or GFR)**
  according to the market request

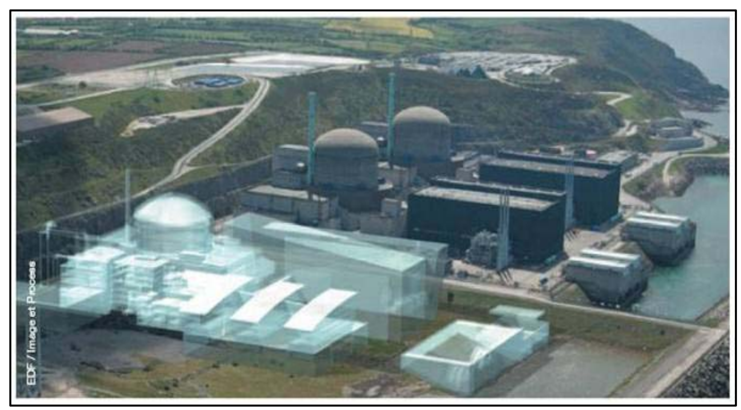


Europe: Gen III on the tracks with EPR…

- A 1600 MWe reactor, lifetime 60 years
- A mature concept, based on current PWRs' experience
- Significant improvements in safety and economy

→ Under construction in Finland at Olkiluoto (TVO) in operation by 2011

- **July 05**: French Energy Policy Act
  → A Gen III plant by 2012
- **Oct 05 – Feb 06**: Public debate to build an EPR in Flamanville
- **Dec. 07**: First concrete of EPR unit
- **2012** : Connection to the grid

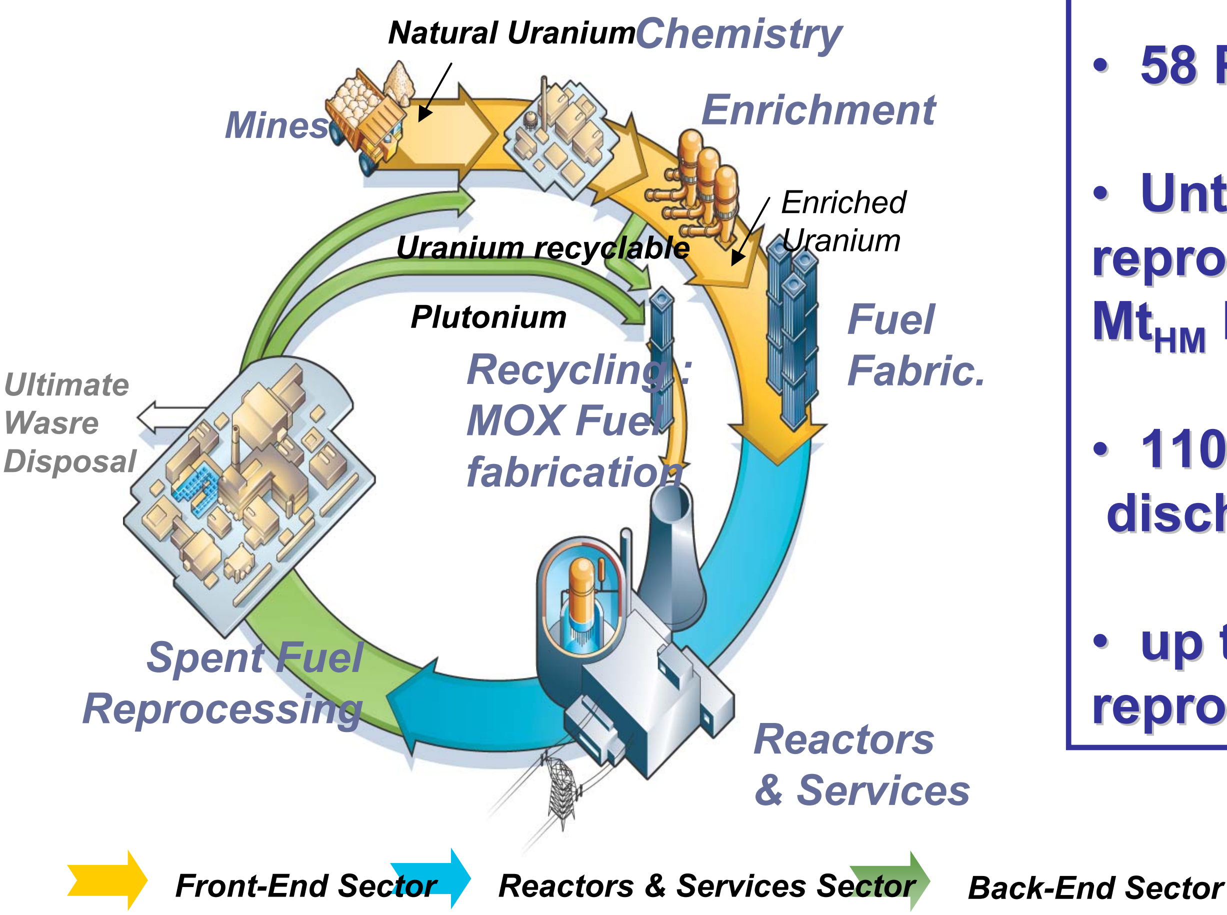


Sustainability:

→Waste management

→Resource preservation

Closing the Fuel cycle: an industrial reality



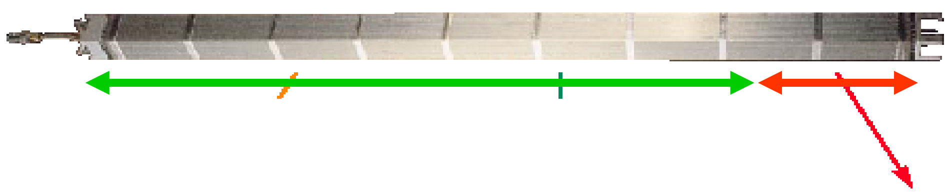
- since 25 years in France :
- 58 PWRs → 415 TWh in 2004
- Until now: ~ 20 000 Mt_{HM} spent fuel reprocessed and more than 1200 Mt_{HM} MOX fuel recycled
- 1100 Mt_{HM} /yr of spent fuel discharged from the French PWRs
- up to 1 600 Mt_{HM} /yr of spent fuel reprocessed (domestic + foreign)

Objectives of spent fuel treatment and recycling

Efficient use of natural resources

1 LWR fuel assembly = 500 kg uranium before irradiation in the reactor

➢ **Extract the maximum energy from the fuel**



Valuable materials (96%)

Uranium (94 to 96 %)

Plutonium (1 %)

Reprocessing & Recycling

Wastes (4%)

Fission Products (3 to 5 %)

Minor Actinides (0,1 %)

A responsible management of nuclear spent fuel :

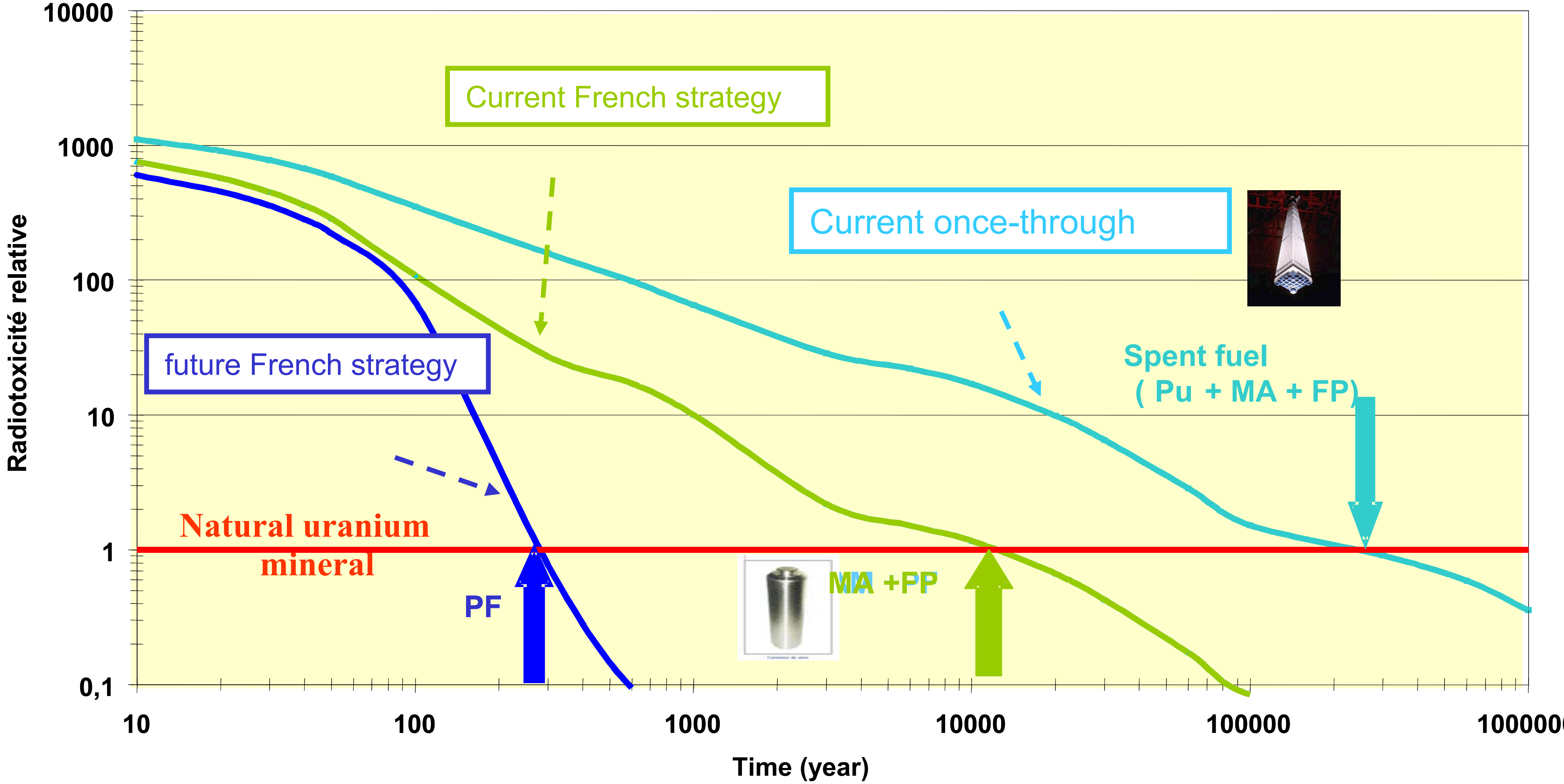
- Recycles 96% of spent fuel materials
- Saves 30% of natural resources
- Costs less than 6% of the kWh total cost
- Reduces by factor 5 the amount of wastes
- Reduces by factor 10 the waste radio-toxicity
- Adapted technologies allow a safe conditioning of wastes to guarantee their long term confinement and stability, during dozens of thousands of years

⇨ **Recycling, such as implemented today, gives time and opens a large range of options for the best management of nuclear wastes**

⇨ **more sustainable policy**

Long Term Radio-toxicity of Spent Fuel

Comparison with natural uranium



→ Fission products radio-toxicity decreases down to natural uranium radio-toxicity in <u>300</u> years ! ←

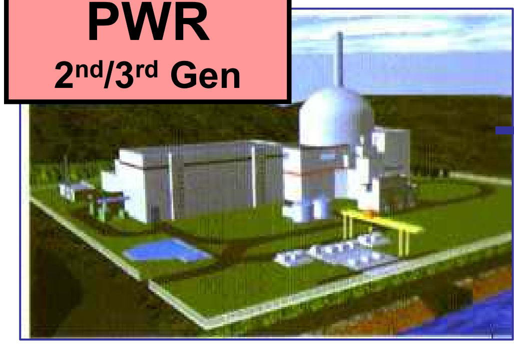
Next generation fuel management strategy

The recycling plant

new fuel (MOX)

new fuel

PWR
$2^{nd}/3^{rd}$ Gen

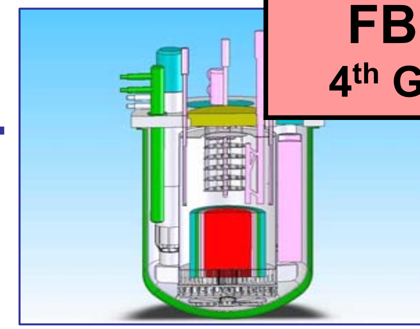


Spent fuel

Recycling
Treatment &
re-fabrication

Spent fuel

FBR
4^{th} Gen



Universal canister
➔ ready for disposal

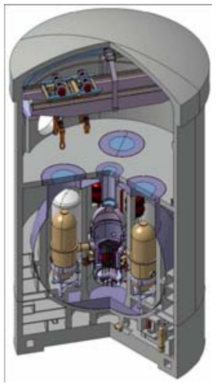
Consistency with Generation III/III+ reactors
Full U & Pu recycling (sharply decrease the repository impact)

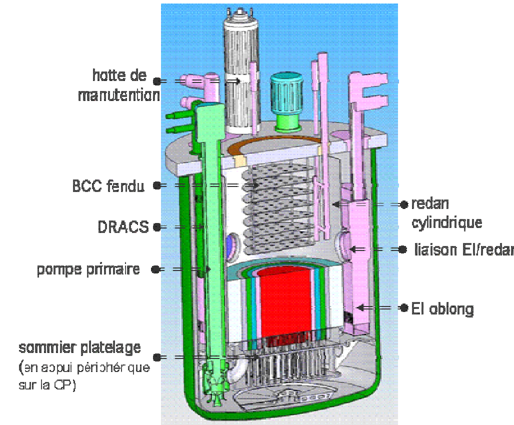
Treatment & Recycling competitiveness

Resistance to Proliferation (Integrated Plant, no Pu alone)

French Strategy for Fast Neutrons Systems

In consistency with French priorities in GEN IV, development of Fast Reactors with closed fuel cycles, along 2 tracks:





- **Sodium Fast Reactor (SFR):**

  the most mature of fast reactor in the world,
  but significant improvements with respect to SPX & BN600

- **Gas Fast Reactor (GFR):**

  interesting features for the coolant (inert, no void effect) and capability to reach high temperatures,
  but needs technological breakthroughs (fuel concept)

- **New processes for spent fuel reprocessing and recycling**

  U-Pu: MOX fuel manufacturing facility (t/y)
  Minor actinides fuel manufacturing (kg/y)

La Hague Reprocessing Plant

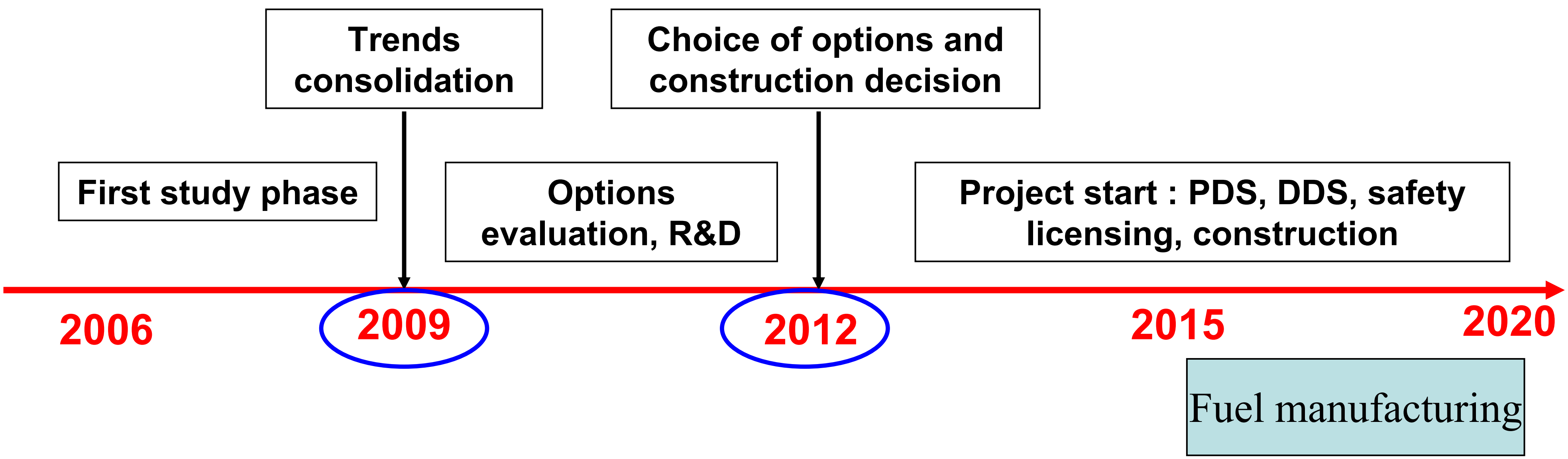
→ **Industrial deployment around 2040**

SFR / MOX FUEL FABRICATION

MINOR ACTINIDES PILOT

Fast Neutrons Reactors: a common schedule for the two options

➔A 6 year period for R&D to **gather technical elements necessary to decide the next step and propose the specifications for the prototype**



➔This does not mean that all the options for the Gen-IV nuclear systems have to be decided before 2020

GEN IV : an opportunity to strengthen R&D for future systems

→ New goals for sustainable nuclear energy

Continuous progress :

- Economically competitive
- Safe and reliable
- Industrial deployment ~2040

Key points :

- Waste minimization
- Natural resources conservation
- Proliferation resistance

Multilateral cooperation with 3 levels of agreements:

1. Intergovernmental
2. Systems (x 6)
3. R&D Projects (3 à 6 / System)

New issues for

1. hydrogen production
2. water desalination
3. heat production

The vision for future nuclear energy

Nuclear energy for the 21^{st} century

Renaissance

3^{rd} generation reactors with best available technologies for recycling

Sustainability

4^{th} generation fast Reactors with advanced technologies for recycling