GEN IV International Forum
Expertise | Collaboration | Excellence

Sustainability a Powerful and Relevant Approach for Defining Future Nuclear Fuel Cycles

Summary / Objectives:

Technically, nuclear energy is anticipated to be one of the most efficient energy source to mitigate the global climate change together with the renewables, due to its low green-house-gases emissions, its reliability and its high base-load capacity. However, public opinion survey and phase-out decision regularly reminds us that political decisions are not only driven by technical criteria. **Beyond the well-known technical and economic optimization, many other criteria are of growing importance such as environmental and social concerns.** This rather recent situation requires changing our rationale technical approach to the wider sustainability approach, which also includes the overall environmental footprint and the more general social acceptability and social impact. This presentation will illustrate how sustainability can help us to identify the most promising trends for future nuclear fuel cycles in order to ensure a long-term future of nuclear energy.

Meet the Presenter:

Christophe POINSSOT has been working at CEA (The French Alternative Energies and Atomic Energy Commission) for more than 25 years in fuel cycle R&D. He is currently heading the Research Department on Mining and Fuel Recycling Processes (DMRC), and is in charge of developing actinides recycling processes and operating the Atalante hot-lab. He is also a CEA international expert in actinides chemistry and professor in nuclear chemistry at INSTN.

He explain the energy transition to the sustainability with environmental drivers, societal drivers, and economic drivers, and show the rationale of future fuel cycles.

The sole technical approach is not sufficient ➔ need for a more global and systemic approach

« Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (…) »
(Bruntland's commission, 1987)

Recent concern
Climate change
Overall Footprint

❶ How to improve environmental footprint?

- *GHG-free energy*
- *Preservation of natural resource*
- *Reduce and manage ultimate waste*
- *Low environmental footprint*

➔ Can nuclear energy be sustainable and how?

Baseline for technology development

❸ How to improve affordability?

- *Predictable, stable and limited energy cost*
- *Economic stability through energetic independence*

Equity, reducing risks, democratic choice

❷ How to improve acceptability?

- *Highest level of safety and reliability*
- *Consensual choice of the society*
- *Promote the international stability*

Main trends will be depicted in the following

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The rationale of future NFC in view of sustainability

1980 — 2050 *Dates are purely indicative* — 2100

TOWARDS INCREASING SUSTAINABILITY

Gen.II & III ***Pu-monorecycling***

Gen.IV ***Pu-multi-recycling***

Gen.IV ***…+ MA recycling***

Pu-mono-recycling
- Twice-Through Cycle
- LWR reactors
- Pu-recycling in MOX fuel

Pu multi-recycling
- Multi-Through Cycle
- Fast-Neutron Reactors (FR)
- Pu multi-recycling

Pu+MA multi-recycling
- Fast Neutrons Reactors (FR)
- Pu multi-recycling
- MA burning

Breakthrough = reactors

Main incentives
- 1st step towards U resource saving
- Efficient waste conditioning

Main incentives
- Major resource saving
- Energetic independence
- Economic stability

Breakthrough = cycles

Main incentives
- Decrease of waste burden,
- Optimisation of the repository
- Public acceptance

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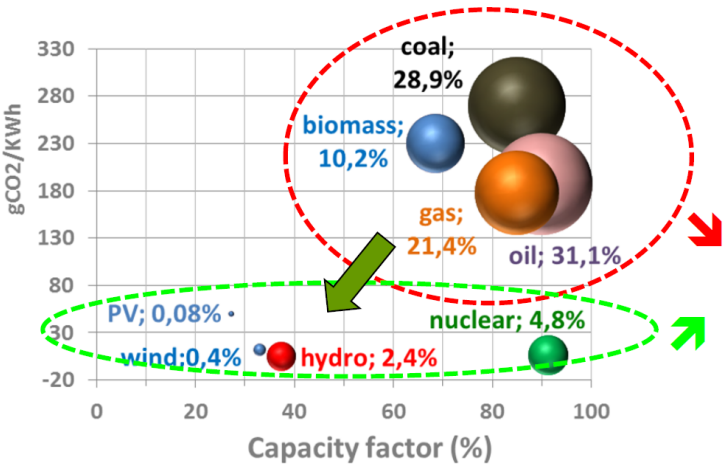
The Energy Transition (3/3)

❶ Increase the energy production

❷ Mitigate the climate change



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Energy transition

❶ ↗ Energy efficienty
❷ ↘ fossil energies ⇔↗ renewable energies + nuclear energy

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Environmental drivers

(1=Reduce GHG missions, 2=Preserve natural resource)

Life cycle assessment of environmental footprint can be performed by simulation tool. Environmental indicators for each energy source on such as GHG emissions, SOx, NOx can be shown by this simulation tool.

Improve the environmental footp

❹ Reduce environmental footprint

❶ Life Cycle Assessment

- From cradle to grave
- A dedicated tool "Nuclear Energy Life Cycle Assessment Simulation" (NELCAS) has been developed *(Poinssot et al., 2014)*

- Design
- Feed-back
- Extrapolation

- Construction
- Deconstruction
- Transport

- Annual TSN reports
- Feedback

- Energy and materials streams
- Release / Withdr.

NELCAS

(Poinssot et al., Energy, 2014)

Relevant environmental indicators

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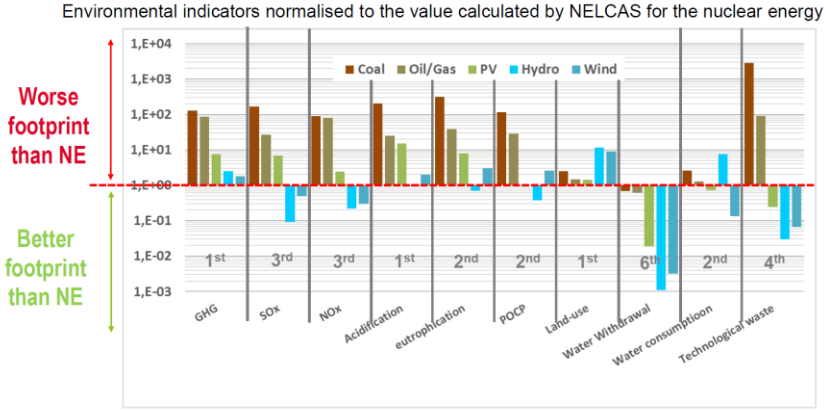
Results for the current fuel cycle

Environmental indicators normalised to the value calculated by NELCAS for the nuclear energy



Nuclear energy is within the top-3 for most of the indicators

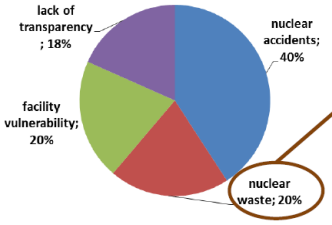
As societal drivers,

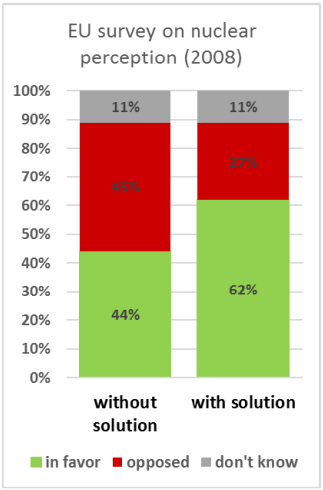
1= Improve safety, 2=Improve waste management.

As economic drivers, 1= Stable & predictable cost,

2= Ensure affordable costs, 3=Towards simpler processes

Improve waste management

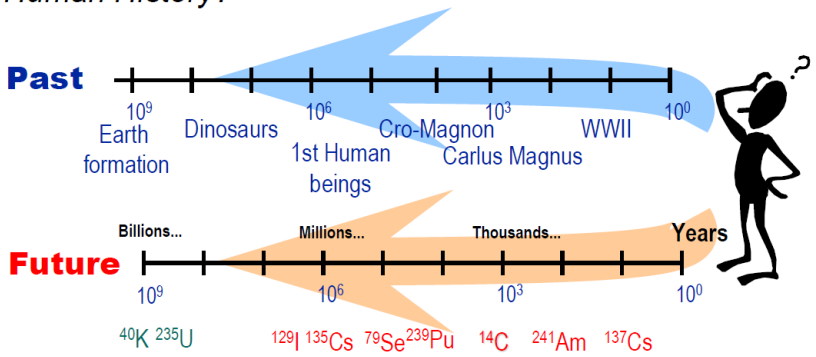




❷ Improve waste management

➢ Waste is severely questioned by public opinion

- Nuclear waste seen as Achille's heel of nuclear energy, mainly due to very long lifetime
- Main concern = waste lifetime. Any reduction could help to improve acceptability. *Could we reduce waste lifetime back within Human History?*



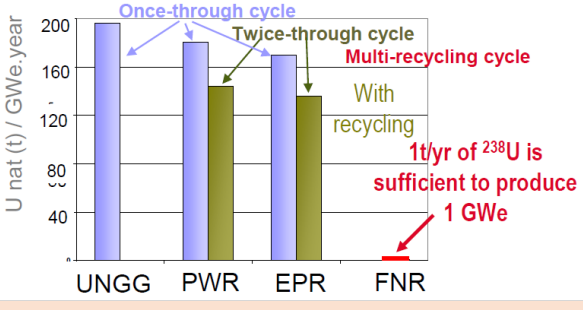
Chap.III: economic drivers

Economic optimization is already at the root of R&D for industry

❶ Stable & predictable cost

➢ Recycling decreases the dependence to U market (price, availability, volatility …)

- Possibility of using U_{rep} and U_{dep} available stockpile with FNR
- Significant extension of U reserve



❷ Ensure affordable costs

➢ Back-end of the fuel cycle has a limited influence on the KWh cost