Reversibility Options for Cigéo during its life time

- **Retrievability** - Ability to retrieve (remove) waste packages at different stages of the DGR life
- **Reversibility** - A broader meaning: Decision-making process adopted during the Project life; it involves decisions like: "Pursuing, Modifying, Retrieving".

Retrievability Scale as defined by OECD/NEA

**Test bench created for a retrieval test campaign in 2014-2015:**
- Devices installed to provide heat and humidity:
  - Temperature maintained at 90°C inside the steel liner.
  - Salt spray (generating a flow of condensed water running on the liner bottom intrusion).
- Environmental conditions created considered as a very penalizing situation:
  - In the real underground environment the thermal peak should be reached after some 10 years.
  - While water inlet peak may be somehow deferred in time by comparison to the one created on the test bench.
- Need to address the technical difficulties for Retrieval Robot:
  - Temperature tough on Robot actuators (change from electric to pneumatic);
  - Creation of corrosion products on steel casing intrados and container wall;
  - Some 10 years;
  - Corrosion inside the casing, following activation.
- Need for tangible Retrievability Demonstrations:
  - Practical trials of prototypes;
  - Integration of solutions in the Cigéo design;
  - Planning of Retrieval tests during the Cigéo "Pilot Phase".

Retrieval Test Objectives & Milestones

- Overall view of test bench with heating and saltwater spraying systems
- Overall view of cleaning robot
- The disposal container is removed by a pulling robot (before heating and corrosion phases)
- Corrosion inside the casing, following activation by heat and saltwater spraying
- Overall view of cleaning robot
- Cleaning robot at work
- Collection of corrosion flakes in dedicated box
- The disposal container is emplaced inside a steel cased horizontal borehole (the disposal cell) by a "pushing robot"
- The disposal container is removed from the disposal cell by a "pushing robot"
- The disposal container is removed from the disposal cell with a significant corrosion product build up
- The vitrified (HL) primary waste package (from COGEMA) is encapsulated in a steel overpack (90mm thick), forming the disposal container.
- Andra acknowledges the technical contribution of CEGELEC CEM in the implementation of the prototype development & the retrieval tests campaign.

**Retrievability in Cigéo Design**

- Develop mechanical systems for retrieval:
  - Robust sensors and data transmission devices.
  - Optimize operational conditions (ventilation, flushing).
- Develop monitoring tools:
  - Minimize effects of corrosion.
- Need for tangible Retrievability Demonstrations:
  - Practical trials of prototypes;
  - Integration of solutions in the Cigéo design;
  - Planning of Retrieval tests during the Cigéo "Pilot Phase".
- Tests of Industrial Prototypes:
  - Develop mechanical systems for retrieval:
    - Robust sensors and data transmission devices.
    - Optimize operational conditions (ventilation, flushing).

Overall view of CIGEO FACILITIES

- OVERVIEW OF CIGEO FACILITIES
- CIGEO UNDERGROUND FACILITIES
- Deep Reversible Geological Repository (aka DGR or Cigéo) is the reference solution for HLW & IL-
- Temperature maintained at 90°C inside the steel liner.
- Salt spray (generating a flow of condensed water running on the liner bottom intrusion).
- Design, fabrication and test of a cleaning robot in 2016,
- Devices installed to provide heat and humidity:
  - Temperature maintained at 90°C inside the steel liner.
  - Salt spray (generating a flow of condensed water running on the liner bottom intrusion).
- Need for tangible Retrievability Demonstrations:
  - Practical trials of prototypes;
  - Integration of solutions in the Cigéo design;
  - Planning of Retrieval tests during the Cigéo "Pilot Phase".
  - Work on cell design and package design:
    - Cell structure must resist rock creeping over 150 years.
  - Temperature maintained at 90°C inside the steel liner;
    - What is the state of the disposal cell / of the package at time of retrieval?
  - Work on phenomenology:
    - Minimize effects of corrosion.
  - Optimize operational conditions (ventilation, flushing).
- Need for tangible Retrievability Demonstrations:
  - Practical trials of prototypes;
  - Integration of solutions in the Cigéo design;
  - Planning of Retrieval tests during the Cigéo "Pilot Phase".
- Tests of Industrial Prototypes:
  - Develop mechanical systems for retrieval:
    - Robust sensors and data transmission devices.
    - Optimize operational conditions (ventilation, flushing).

Reversibility Conditions*:

- Andra first issued its "Statement of opinion" used as a basis for discussion with the French Parliament (OPEFCT);
- Its "Statement of opinion" used as a basis for discussion with the French Parliament (OPEFCT);
- The disposal container is removed by a pulling robot (before heating and corrosion phases);
- Work on cell design and package design:
  - Cell structure must resist rock creeping over 150 years.
  - Temperature maintained at 90°C inside the steel liner;
- Reversibility Conditions:
  - What is the state of the disposal cell / of the package at time of retrieval?
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