STATUS OF THE ASTRID PROJECT

Advanced Sodium Technological Reactor for Industrial Demonstration

ESNII+ 1ST BIENNAL CONFERENCE, BRUSSELS, MARCH 17, 2015

Nicolas DEVICTOR
Deputy program manager « Generation IV reactors »

nicolas.devictor@cea.fr
The ASTRID objectives

- Technological demonstration reactor (*a step before a First Of A Kind*)
- Integrating French and international SFRs feedback
- A GEN IV system

**Safety**:
- Level at least equivalent to GEN III systems
- Progresses on Na reactors specificities
- Integrating FUKUSHIMA accident feedback
- Robustness of safety demonstration

**Durability**:
- Need of Fast Breeder Reactors and a closed cycle
- Pu multi recycling to preserve natural resources
- The use of natural depleted uranium in France by FBRs allow producing electricity for few thousands of years

**Operability**:
- Load factor of 80% or more after first “learning” years
- Significant progress concerning In Service Inspection & Repair (ISIR)

**Ultimate wastes transmutation**:
- Realization of demonstrations on minor actinides transmutation according to June 28, 2006 French Act on Wastes Management

**A mastered investment cost**

**Non proliferation warranty**

- Irradiation services and options test
The ASTRID program

ASTRID design studies
- Integrated Technology Demonstrator 600 MW(e)
- 4th generation reactor
- Irradiation tool

Core fabrication workshop
- MOX fuel
- A few tons per year

Full scale component testing
- Large test sodium loops
- Refurbishment of zero power reactor MASURCA

Severe accidents experimental program

→ Dedicated talks by JC Garnier and in parallel sessions
ASTRID conceptual design main technical choices

- 1500 thMW - ~600 eMW
- Pool type reactor
- With an intermediate sodium circuit
- CFV core (low sodium void worth)
- Oxide fuel $\text{UO}_2$-$\text{PuO}_2$
- Preliminary strategy for severe accidents (internal core catcher…)
- Diversified decay heat removal systems
- Fuel handling in gas, internal storage
- Conical "redan" inner vessel adopted
- Preferred lay-out:
  - 3 primary pumps
  - 4 intermediate heat exchangers
  - 4 secondary circuits
  - 5 decay heat removal circuits
- Open design option: energy conversion system

Experimental capabilities: to contribute to the qualification of transmutation, fertile or burner subassemblies
**ASTRID main innovations**

**Low void coefficient core with enhanced safety (« CFV »)**

Tertiary circuit filled with nitrogen to prevent any sodium-water reaction

**In-Service Inspection addressed since design phase**

Dispositions for core melt management (no early or important radiactive release)
ASTRID Schedule

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- Preconceptual design
  - Decision to launch the conceptual design
  - Safety orientations file

- Conceptual design
  - Decision to launch the basic design
  - Safety options file

- Basic design
  - Decision to build
  - Preliminary safety report

- Detailed design and Construction
  - First criticality
  - Connection to the grid
  - Tests

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Organisation of the ASTRID project in the AVP2 phase

Contracting authority
Strategic management
ASTRID project team
Operational management
Industrial architect

About 600 people

Reliability, availability, maintainability

European R&D labs
ARDECO

R&D
Innovation, Qualifications, Codes,
Specific developments, Expertises

External assistance

EDF assistance

ASTRID relay team in Marcoule

Search for innovations
TOSHIBA
VELAN
Rolls-Royce

Assistance

Design

Reactors

Nuclear Island

Hot cells

Power conversion systems

Civil engineering

Balance of plant and infrastructures

CEA

R & D

JAA

MFBR

Mitsubishi

/R& D

About 600 people

EDF

Astrid Management

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CEA/Nuclear Energy Division is responsible for the ASTRID project

CEA has concluded bilateral industrial partnerships to cover main design engineering batches

- AREVA NP: nuclear island (core and fuel remains within CEA scope)
- EDF: support to CEA project management
- ALSTOM: turbine island
- BOUYGUES: civil engineering
- COMEX NUCLEAIRE: batches in robotics and mechanics
- TOSHIBA for development of large electromagnetic pumps
- JACOBS for the balance of plant
- ROLLS-ROYCE for innovations in fuel handling and heat exchangers
- AIRBUS D&S for RAMS methodologies
- ALCEN/SEIV for the hot cells
- JAEA/MHI/MFBR for some specific design topics and R&D
- VELAN for large sodium valves
- TECHNETICS GROUP FRANCE for innovative sealing for above core structure and robotics

On-going discussions with other companies
Partnerships around ASTRID

See next slide
European cooperation : 2 pillars

European frameworks provided by EC (FP7, H2020, EERA…)

- Several projects are relevant for SFR R&D and for supporting ASTRID
  - Dedicated to SFR : EISOFAR, CP-ESFR
  - Cross-cutting project for GenIV: ADRIANA, GETMAT, MATTER, SARGEN-IV, SILER, THINS, ANDES…

- New projects with an objective to develop an European roadmap for R&D in support to material development, safety…, and with a cross-cutting analysis on systems selected by ESNII platform
  - ESNII+ (SNETP/ESNII)
  - MATISSE (EERA/JPNM)
  - SESAME
  - SAFEST

ASTRID has several innovations and should meet a more demanding safety requirements

- R&D needs are then large.
- Schedule of European projects are more or less suitable with ASTRID options’ selection and qualification process.
- In addition to European projects and platforms, CEA is then willing to develop bilateral R&D cooperation focused on ASTRID needs.

EDF R&D, PSI, Sweden (KTH, Chalmers, Uppsala), HZDR, KIT, ENEA, JRC/ITU, NNL, CIEMAT, ...
Interactions with nuclear safety authority (ASN)

- ASTRID safety orientations submitted in June 2012
- Review by Expert Committee on Reactor Safety in June 2013
- Letter by ASN in April 2014
  - The safety orientations take into account the SFR feedback of experience in a satisfactory manner
  - No objection to continue the project on the basis of the safety orientations proposed by CEA
  - Safety level at least equivalent to EPR type reactors and taking into account lessons from Fukushima accident

- Review of 6 GIF systems by Expert Committee on Reactor Safety on April 10th, 2014
  - "Among the nuclear systems studied by the GIF, only the SFR presents a sufficient maturity to envisage the realization of a 4th generation industrial prototype in the first half of the 21st century"
Reactor site studies and infrastructures implementation
Conclusion

- With the help of our industrial and international partners, the conceptual design of ASTRID is already well in progress.

- The result of ASTRID safety orientations by the Expert Committee on Reactor Safety and ASN is very satisfactory.

- The current conceptual design phase is the opportunity to further develop our collaborations on design and/or R&D activities.

- **Next important milestones:**
  - Middle of 2015: update of the report on research carried out on the separation and transmutation of long-lived radioactive elements, and on the development of a new generation of nuclear reactors (*French Act of 2006 on waste management*)
  - End of 2015: end of ASTRID conceptual design, Safety Options Report