TSURUGA

March 08, 2012

FBR Seminar

Fast Reactor Development in France

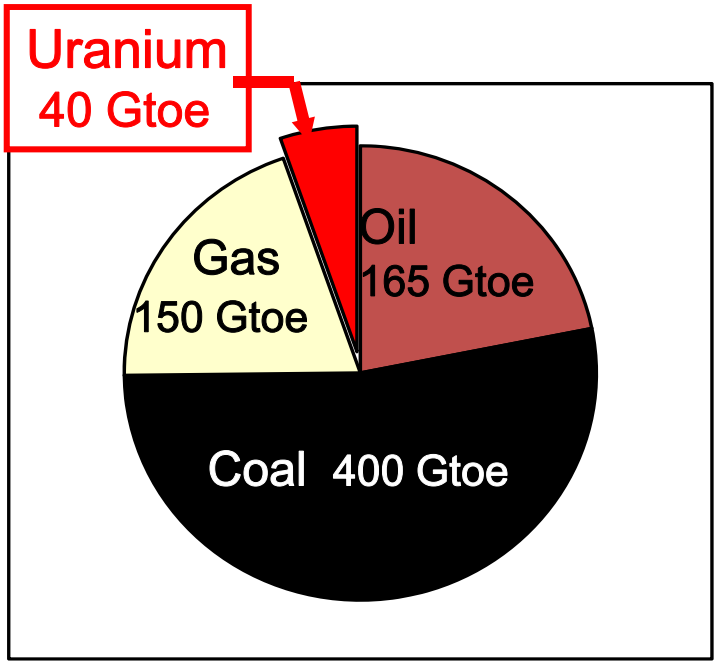
Jacques Bouchard

Fast Reactors : From the Beginning

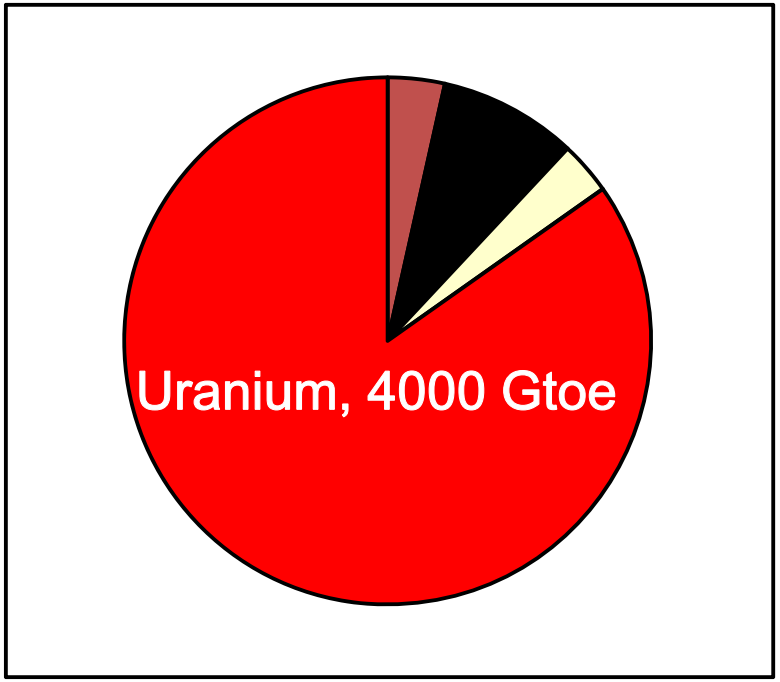
➔ **1951 : the first fast neutron reactor and the first nuclear electricity production**

EBR 1 (USA, Idaho)

Potential of the Main Resource for power Production



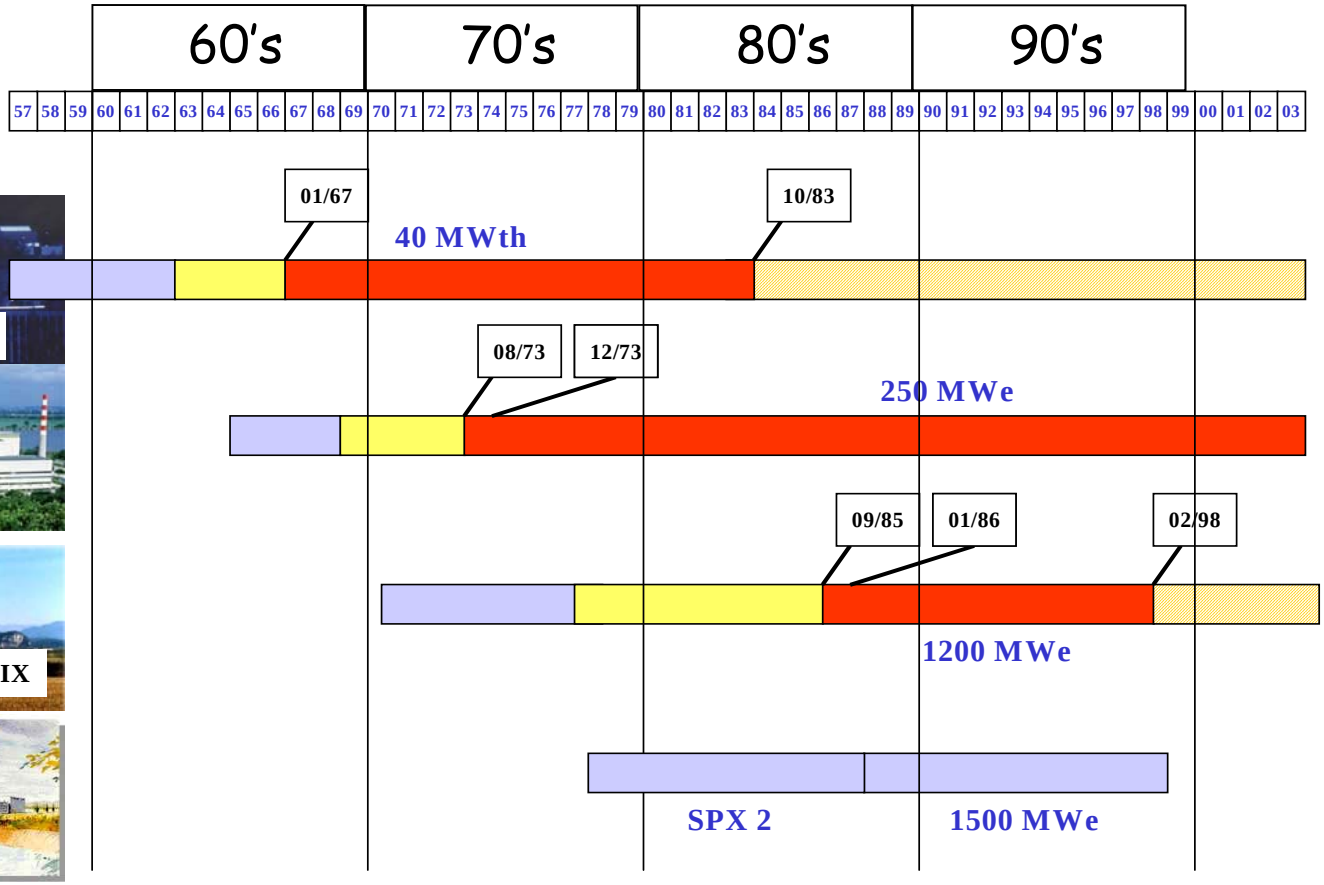
Uranium used in
Light Water Reactors

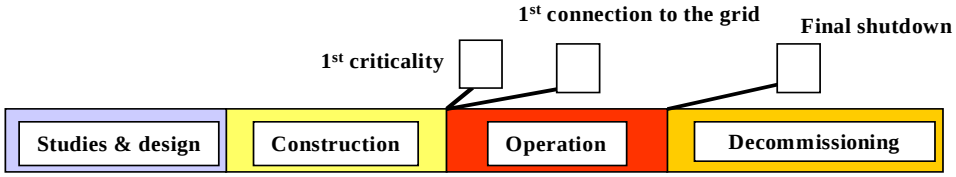


Uranium used in Fast Reactors

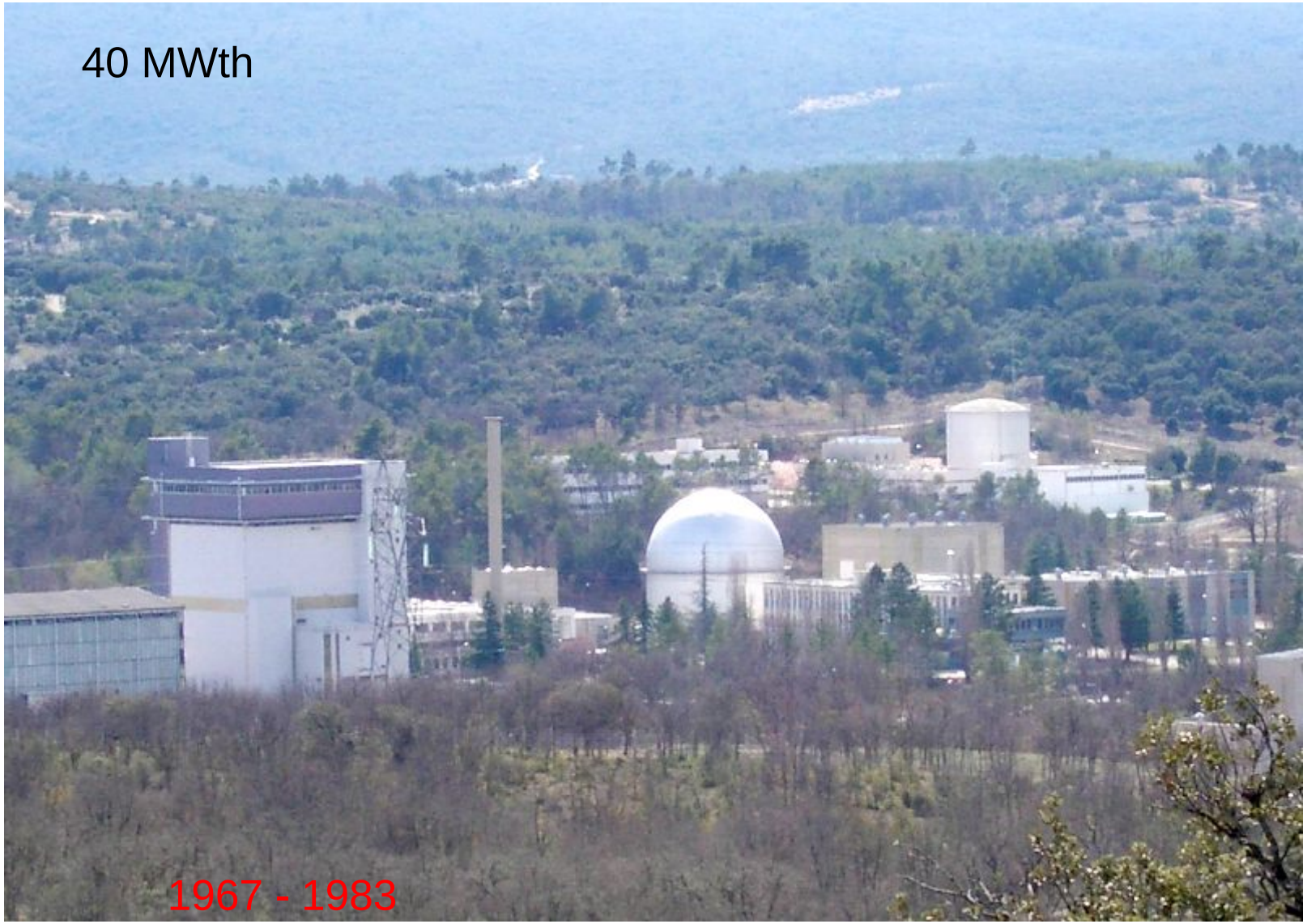
Conventional Identified Resource
(WEC, 2010)

Fast Reactors in France: The First Period





RAPSODIE (Cadarache)



PHENIX (Marcoule)

250 MWe

1973 - 2009

Phenix: A Large Experience

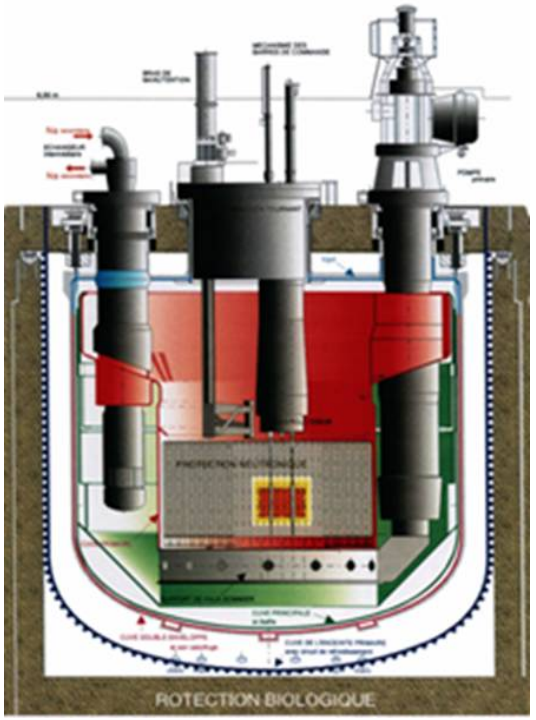
Very good operation

Extensive Feedback Experience:

MOX fuel, closed cycle, technology (SG, IHX)

Demonstration of ISI and reparability

Transmutation of minor actinides

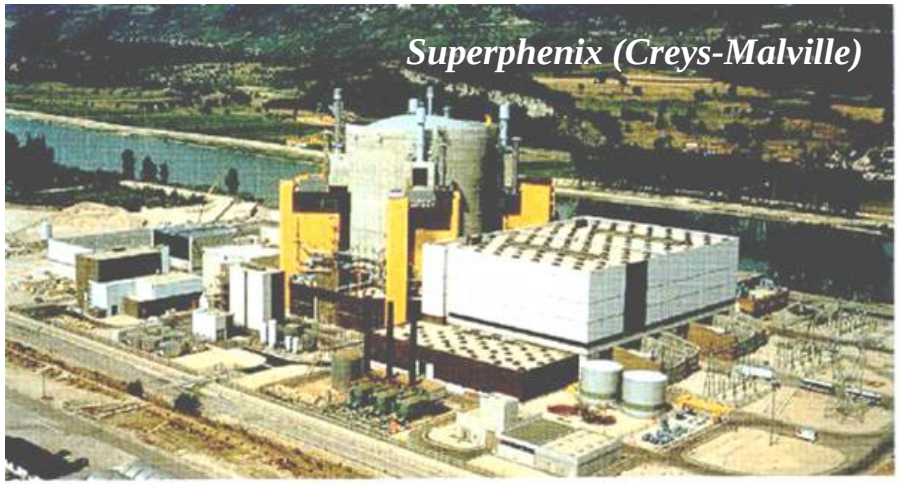


SUPERPHENIX (Creys-Malville)

1200 MWe

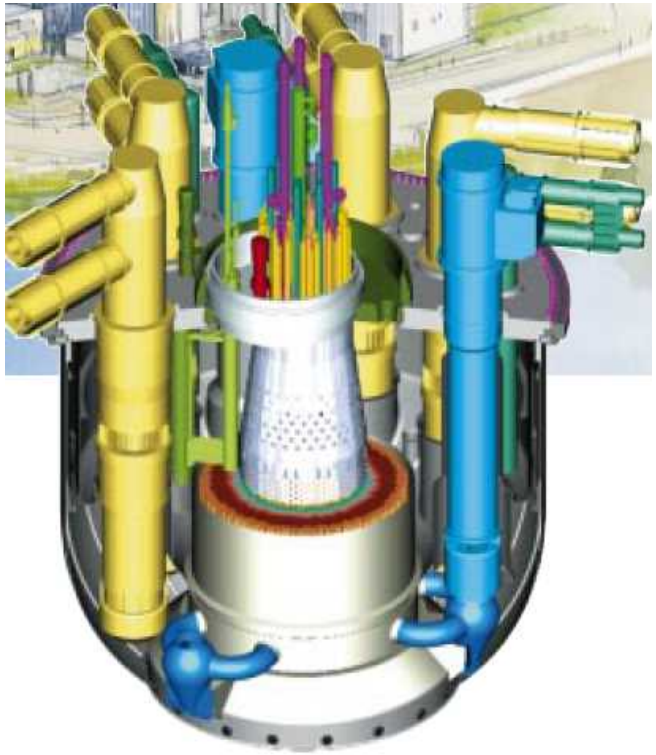
1985 - 1998

Superphenix and the EFR project



Superphenix:

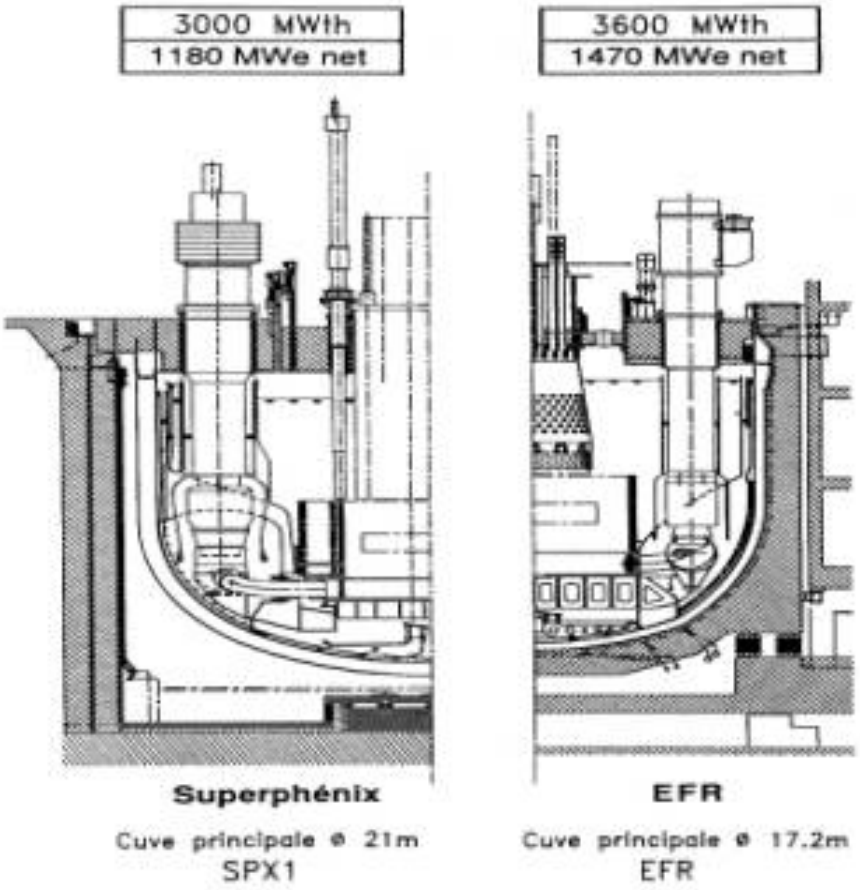
Industrial prototype (1200 MWe),
started in 1985,
shutdown in 1998

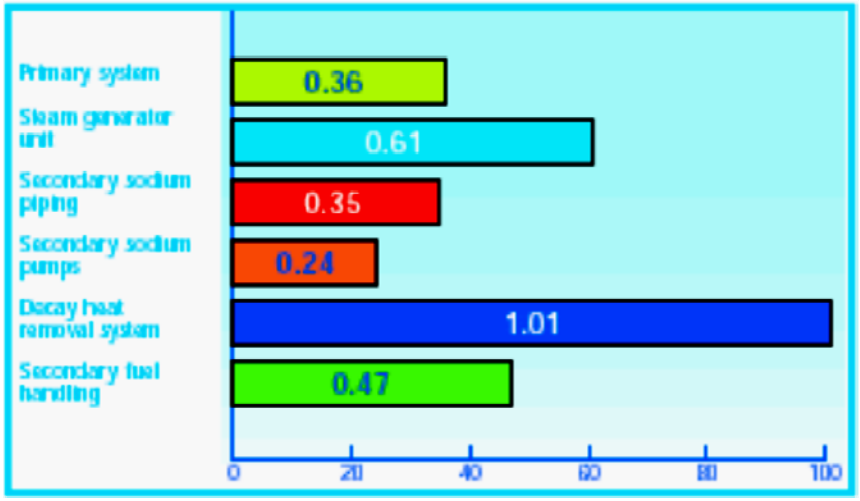


EFR Project
(European Fast Reactor)

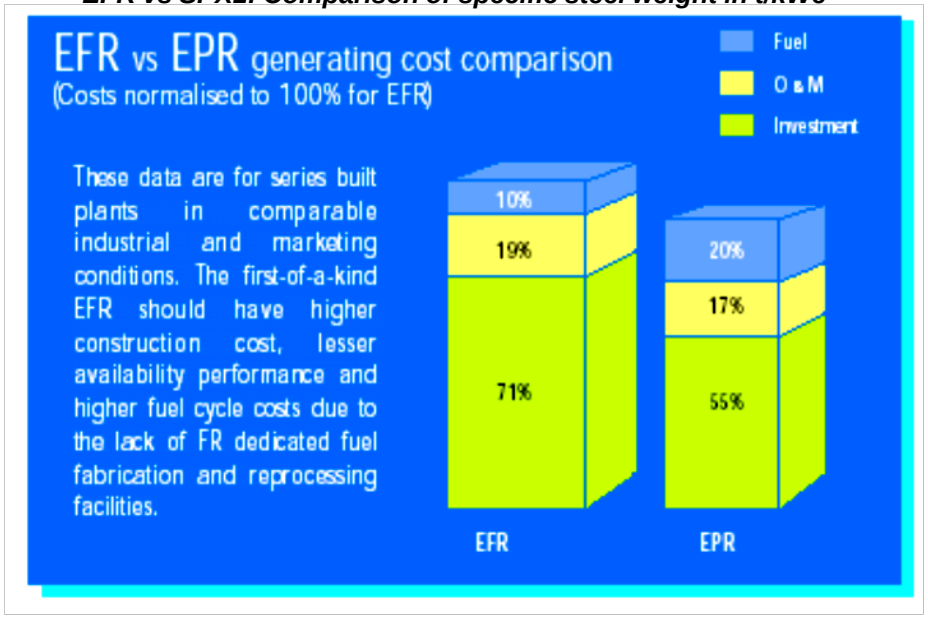
1500 MWe

EFR Economic evaluations (1998)





EFR vs SPX1: Comparison of specific steel weight in t/kWe



Fast Reactors in France: The Next Step

- **To reach Generation IV criteria**
- **To continue the R&D on sodium cooled and gas cooled fast reactors.**
- **To build a new SFR prototype, ASTRID, by 2020 with the aim to confirm new Gen IV developments and to demonstrate the feasibility of actinide burning.**
- **The French industry, EDF and AREVA, is involved in the project which is open for international collaborations.**

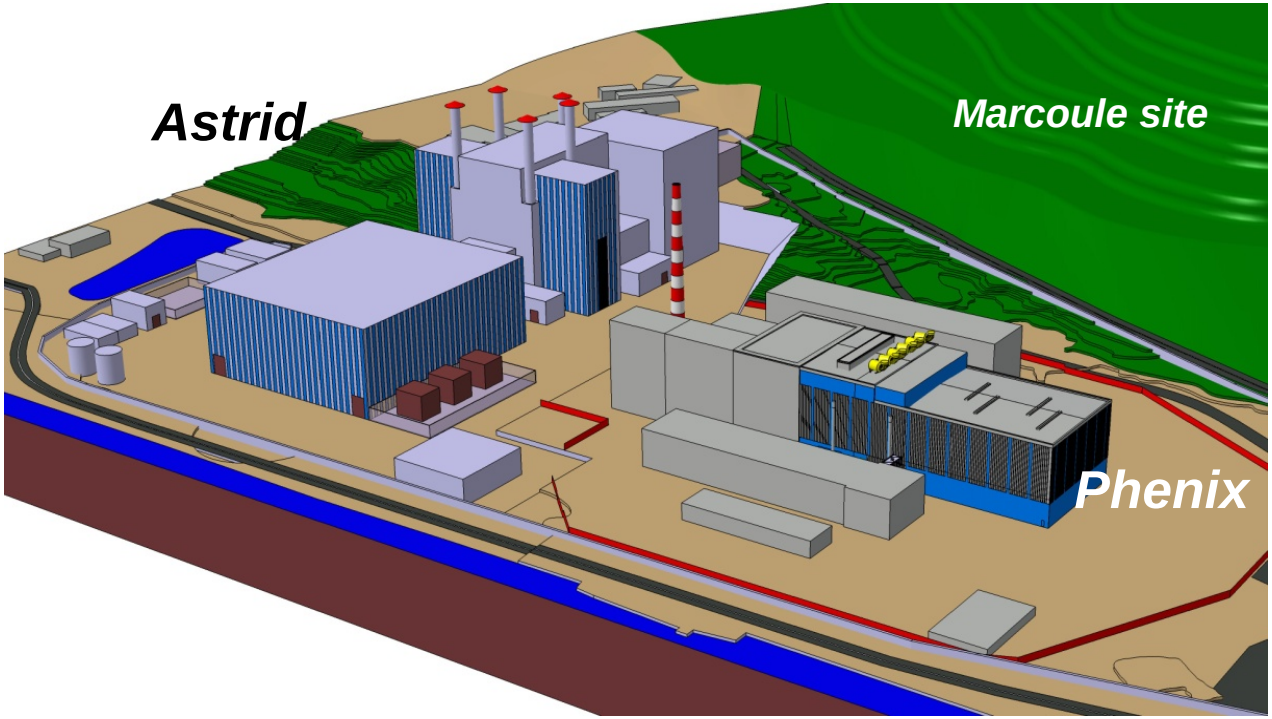
Sodium Fast Reactors : A New Prototype ASTRID

A power plant prototype (500-600 MWe)

Demonstration of technology and design innovations

Resource saving: fuel recycling with enhanced safety and proliferation resistance

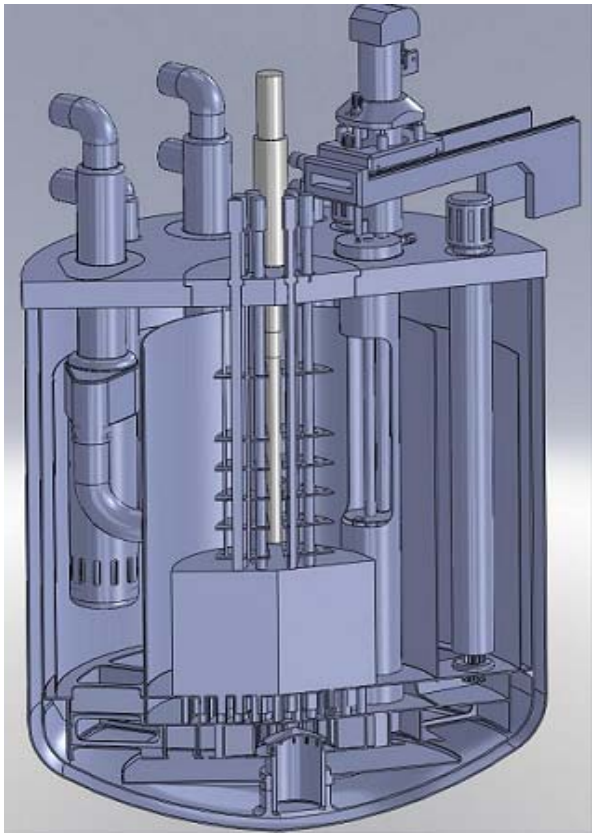
Waste management: step by step demonstration of actinide burning



ASTRID: Design Features

Basic Options:

- Power: # 600 MWe
- Pool type design with Na intermediate circuit
- Oxide fuel
- Core catcher
- Potential for actinide burning



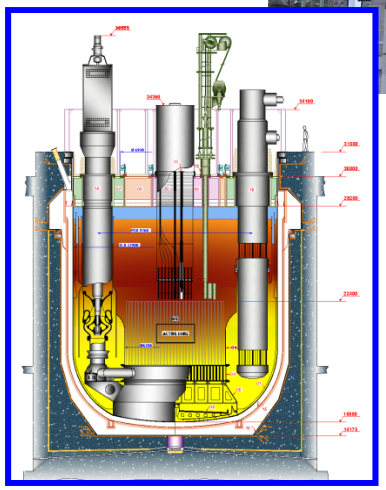
Still open:

- Energy conversion
- Number of loops
- Catcher technology
- Materials and design of the steam generators (or exchangers)
- ….

MONJU (Tsuruga, Japan)

300 MWe Prototype, Na-FBR

Other Fast Reactors around the World



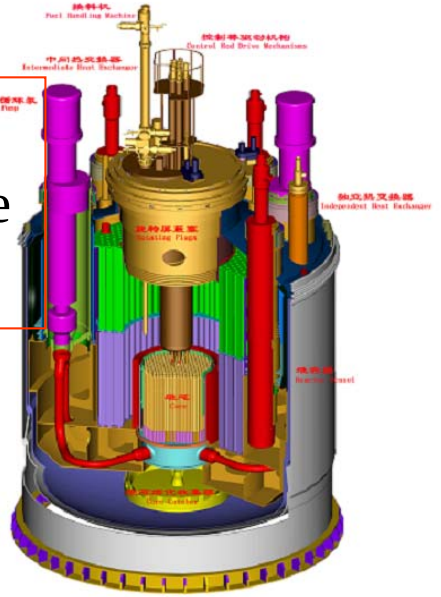
PBFR (India)

500 MWe, 2014

CEFR (China)

65 MWth, 20 MWe

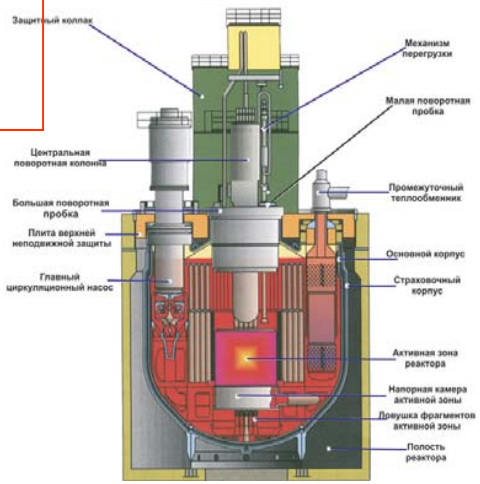
2011



BN600, 1980

BN800, 2014

(Russia)



The Russian Reactor BN 600

Beloyarsk Plant,
600 MWe Reactor, integrated concept, sodium-cooled
Started in 1980, still operating

Fast Reactors in Russia

- **A long story of developing SFR with many steps, BOR60, BN350, BN600…**
- **A specific experience with lead cooled fast reactors used for naval applications.**
- **A new construction, BN800, started near twenty years ago, delayed for economic reasons and now in completion.**
- **Original developments on fuel fabrication technology (vibropak) but not yet industrial experience with MOX.**
- **Many studies of future projects: BN1200, BREST…**

And the USA?

- **EBR1 (the first nuclear electricity) was followed by an experimental reactor EBR2 operated for more than 40 years.**

- **The program was intensive with a large industrial project, Clinch River, when at the end of the 70s, the US administration decided to stop all developments related to the use of plutonium.**

- **In the 80s, Argonne developed the Integral Fast Reactor (IFR) concept based upon the use of metallic fuel and pyroprocessing. EBR2 was intensively used for demonstrations. The program was stopped ten years ago.**

- **The Blue Ribbon Commission in its recent report still recommends to work on the concept of fast reactors for the long term.**

- **US Laboratories are actively participating in GIF and other cooperation.**

Japan-France: A long collaboration in F.R.

- **The two countries have long expressed the need of saving resources and minimizing waste.**

- **They have started early the development of fast reactors and built many facilities including experimental and demonstration reactors.**

- **Reprocessing spent fuel and recycling valuable materials is strategic policy and industry business in both countries.**

- **Within the Generation IV International Forum, Japan and France have a major role in the development of the SFR program.**

Learning Together

Collaboration started in the 60s before the construction of the experimental fast reactor JOYO

Sharing Experience

Prototype FBR Monju

And for the future?

- **Our two countries have the most advanced technology, with industrial experience, and we share the same views on the criteria for Gen IV systems.**

- **Phenix has been the main tool during the last two decades and now this essential role should be played by Monju, later relying on new prototypes such as Astrid.**

- **Both CEA and JAEA have valuable R&D facilities and we should share their use to bring the necessary demonstrations while limiting the expenses.**

- **In short, it's time for an enhanced collaboration.**

Conclusion

- **Fast Reactors remain a key step for sustainability of nuclear energy production. Uranium at low price will not be for ever and burying the plutonium is not a good prospect.**

- **R&D and technology developments are subject to efficient bilateral and multilateral collaborations which can still be improved. The industry should be more and more involved.**

- **Reaching the criteria of Gen IV, in particular for safety, should be a common objective.**

- **Japan has made a large investment in the development of F.R. Monju and many R&D facilities are unique tools. The French and the international community hopes this country will continue to contribute to the common goal of future nuclear energy.**