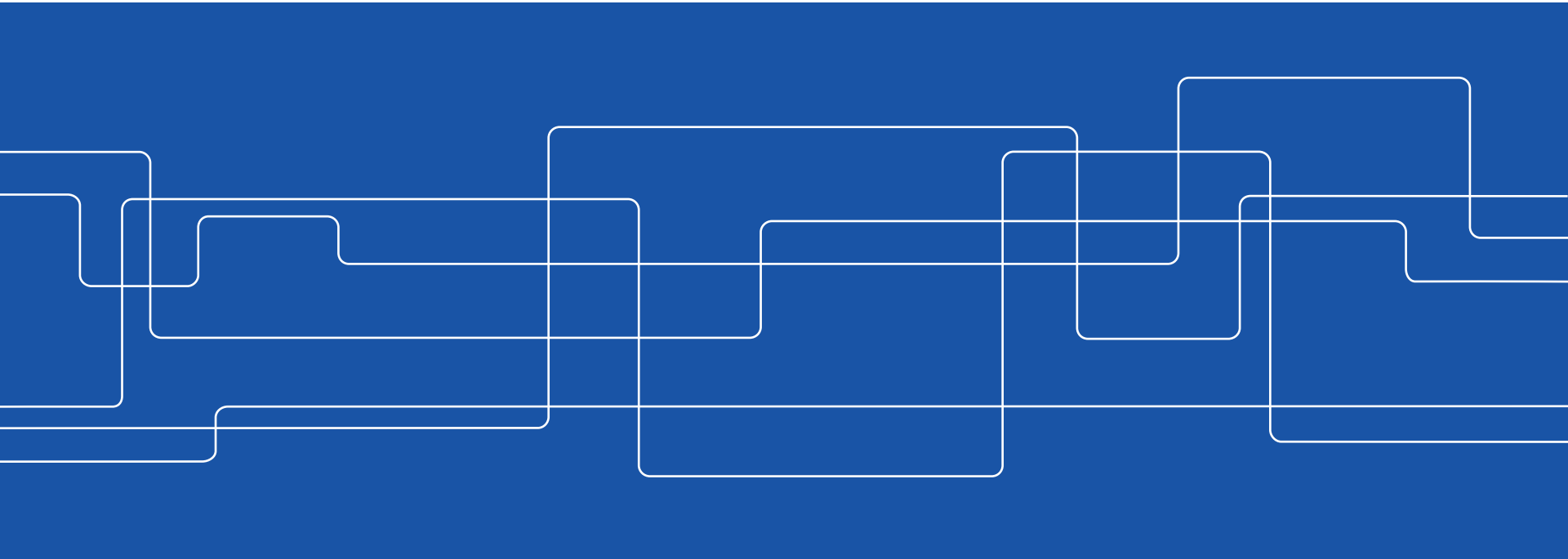




# **Status of global sodium fast reactor activities**

Energiforsk seminar, Jan 24-25 2017, Stockholm

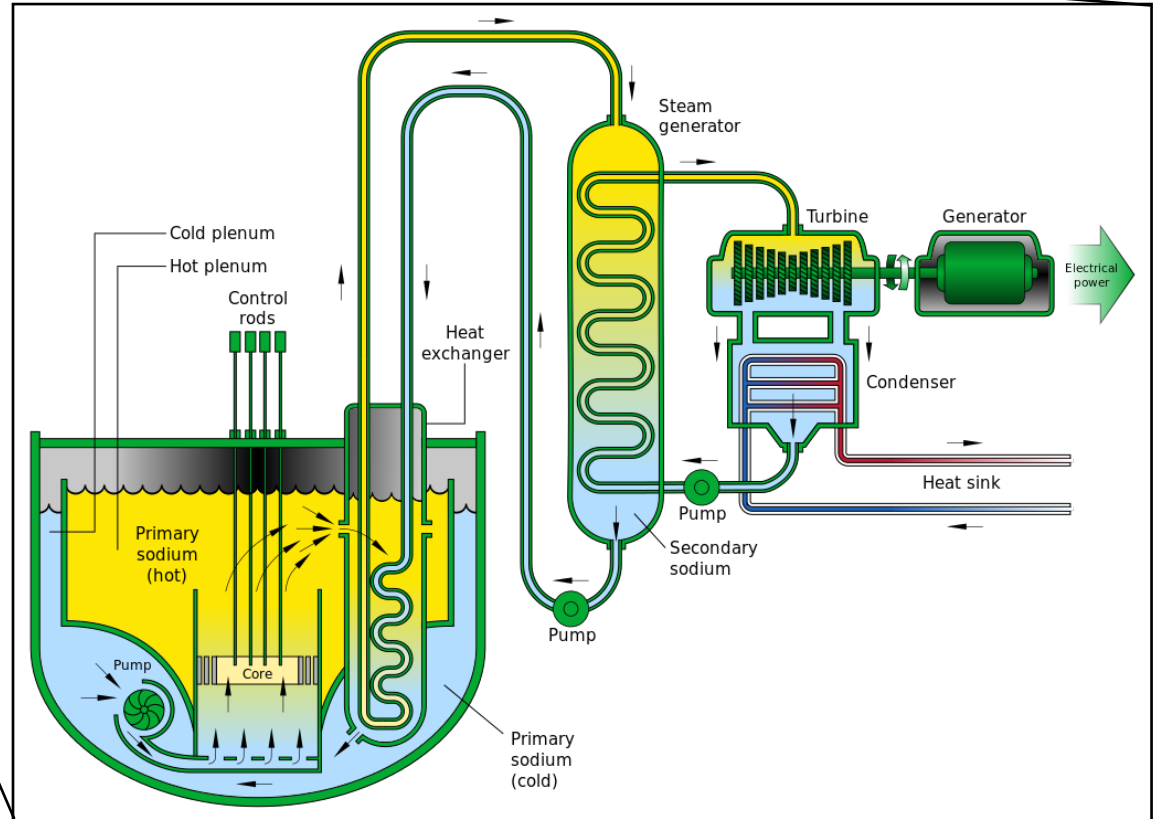
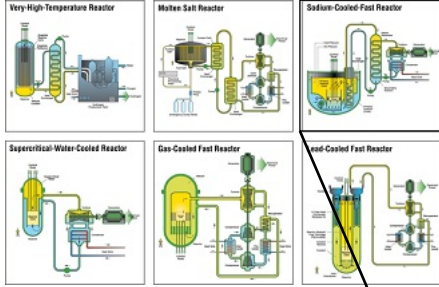
Anders Riber Marklund – KTH (CEA), Lloyds Register





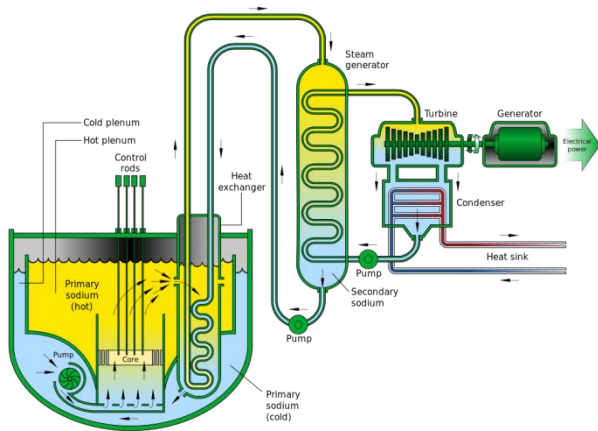
# Concept New Plants Development

# The Sodium Fast Reactor (SFR)



# The Sodium Fast Reactor (SFR)

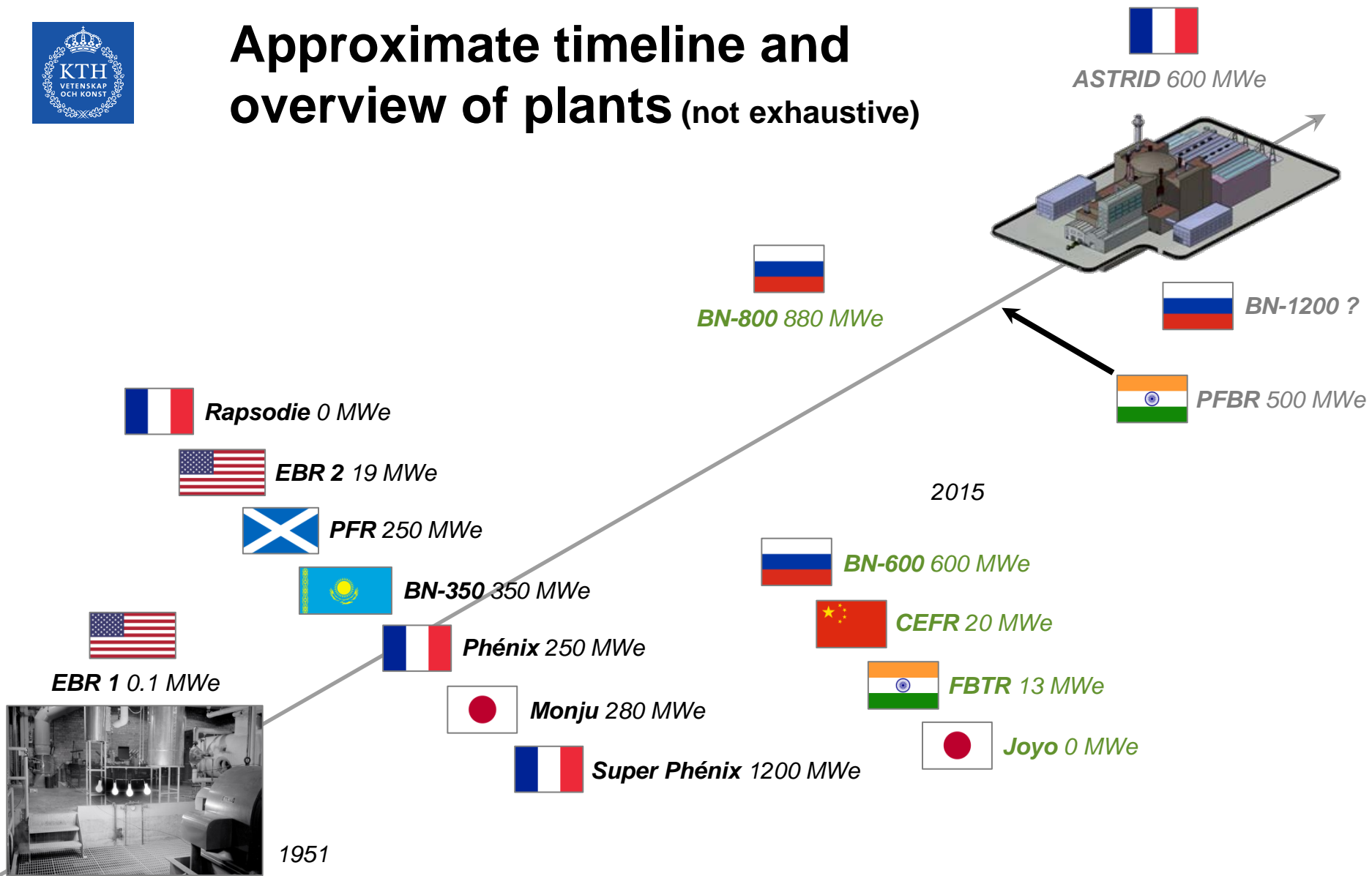
## Some notable differences to LWR systems



- Fast neutron spectrum → Breeding and transmutation capabilities.
- Opaque, reactive and light coolant in closed and (almost) non-pressurized system without chemical auxiliary process.
- Primary vessel without penetrations below free coolant level.
- Fuel assemblies made of steel.
- Containment design basis based on fire instead of pressure.
- Three circuit design → No radioactive coolant in steam generator, however chemical reaction risk.



# Approximate timeline and overview of plants (not exhaustive)





# A comparison

## Generation IV Forum Goals

- Increased resource utilization
- Excellent plant safety
- Transmutation
- Economic competitiveness
  
- Least attractive route of proliferation

## Demonstrated

- Breeding
- Passive shutdown
- Transmutation
- High availability
- High burnup



*EBR 2*



*Phénix*



*BN-600*



*FBTR*



# Concept **New Plants** Development



# CEFR

China Experimental Fast Reactor

20 MW<sub>e</sub> pool type SFR located at the China Institute of Atomic Energy, Beijing.

Developed by Afrikantov OKBM for the China Institute of Atomic Energy.

Full power test runs performed in 2014.





# PFBR

## Prototype Fast Breeder Reactor

500 MW<sub>e</sub> pool type SFR, currently being finalized at Madras atomic power station, Kalpakkam, India.

Developed by the Indira Ghandi Centre for Atomic Research and to be operated by BHAVINI Ltd under the Department of Atomic Energy.

First criticality is expected in 2017. Construction costs are estimated at 750 M€ with a construction time of 12 years.

Successor of FBTR (Fast Breeder Test Reactor)



# BN-800

Beloyarsk unit 4

880 MW<sub>e</sub> pool type SFR at the Beloyarsk power station in Zarechny, Sverdlovsk Oblast, Russia.

Developed by Afrikantov OKBM and operated by Rosenergoatom.

Full power production and commercial operation was started during autumn of 2016.

Successor of BN-600, another SFR at Beloyarsk power station.



Concept  
New Plants  
**Development**



# ASTRID

Advanced Sodium Technological Reactor for Industrial Demonstration

A reactor project run by CEA with partners (Areva NP, EDF, Alstom, Bouygues, Jacobs, Rolls Royce, Toshiba etc.)

Aiming towards a new SFR pool-type plant of Generation IV standard generating about 600 MW<sub>e</sub>

## Objectives

- Technological demonstration reactor
- Integration of french and international SFR feedback
- Gen IV system:
  - Safety, durability, operability, ultimate waste transmutation, mastered investment cost and non-proliferation warranty.
- Irradiation services and option testing



# ASTRID

Advanced Sodium Technological Reactor for Industrial Demonstration

## Specific innovations/improvements studied

- Low sodium void effect core
- Diversified decay heat removal
- Internal core catcher
- Electromagnetic secondary sodium pumps
- Na-N<sub>2</sub> Brayton cycle energy conversion system
- Instrumentation, inspection & repair novelties

## Schedule

- First criticality planned ~2025

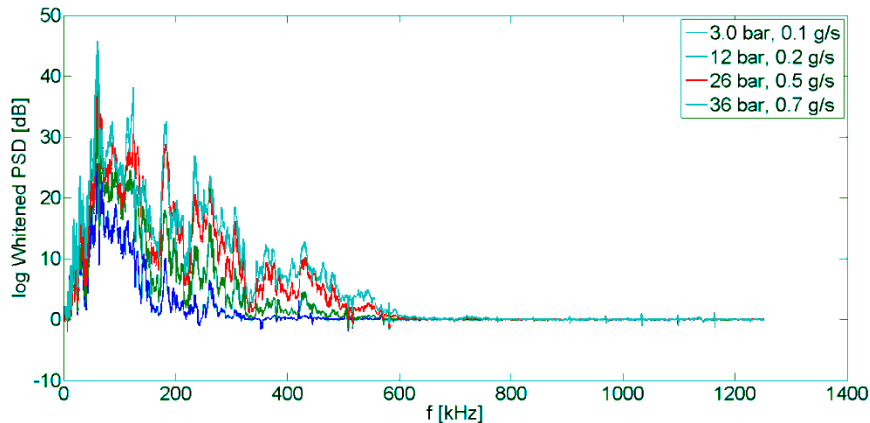


# ASTRID

The sodium-nitrogen energy conversion system

Innovative sodium-nitrogen energy conversion system, eliminating the risk of sodium-water reaction.

A passive acoustic leak detection system is featured among the instrumentation options for this component.





# Other projects

Other organizations with ongoing SFR R&D projects:

- DOE (USA)
- KAERI (South Korea)
- JAEA (Japan)

A deal was signed in 2009 to sell two BN-800 units to China.

BN-1200?

E.g. GE and Toshiba have fairly detailed SFR design concepts in their portfolio.



# Thank you

Contact:

**Anders Riber Marklund**

Senior Consultant

Lloyd's Register

Email: [anders.ribermarklund@lr.org](mailto:anders.ribermarklund@lr.org)

Phone: +46 (0)8 445 21 00

Cell: +46 (0)70 230 41 14

Lloyd's Register Consulting - Energy AB

Visit: Landsvägen 50A, 172 63 Sundbyberg,

Post: PO. Box 1288, 172 25 Sundbyberg, Sweden

Visit [www.lr.org](http://www.lr.org) or follow us on [twitter.com/lrenergy](https://twitter.com/lrenergy)