Why CAREM ?

Bias towards smaller sized NPP

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Nuclear Power Plant Design

- Large Scale NPP (PWR, BWR, PHWR, CANDU)
  - Designed in the 50's
  - Optimized for specific environment
  - Improvements made from an existing design
- Changes in environment
  - TMI II (1979) & Chernobyl (1986)
  - Change in Public Perception of Nuclear Energy
  - New Licensing Requirements
  - Technological improvements
  - Market for units of small power output

⇒ New technological optimum = Opportunity for New Entrants

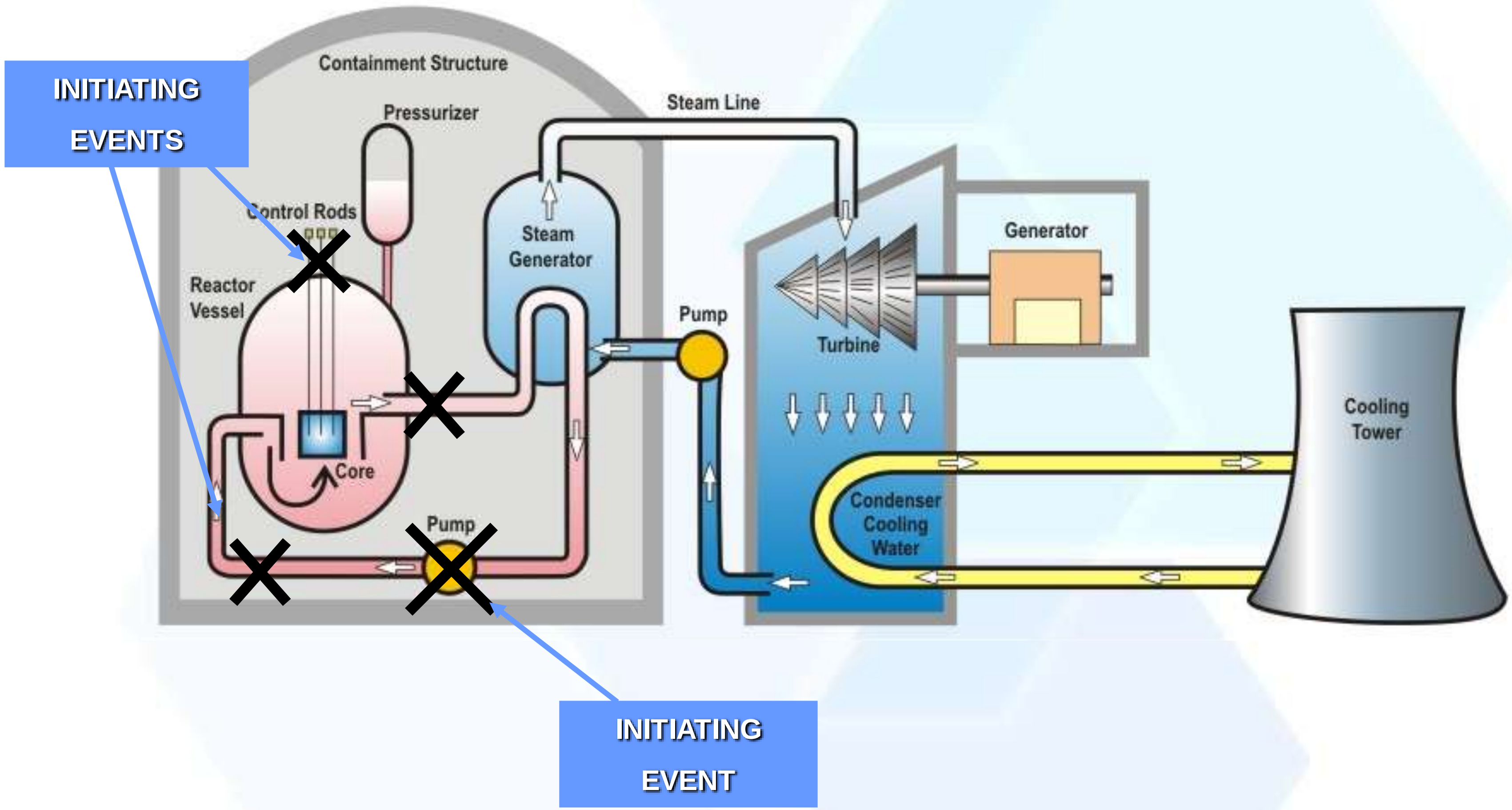
Generation III+ Reactors

- Advanced Boiling Water Reactors
  - • ABWR II (Advanced Boiling Water Reactor II)
  - • ESBWR (European Simplified Boiling Water Reactor)
  - • HC-BWR (High Conversion Boiling Water Reactor)
  - • SWR-1000 (Siedewasser Reactor-1000)
- Advanced Pressure Tube Reactor
  - • ACR-1000 (Advanced CANDU Reactor 1000)
- Advanced Pressurized Water Reactors
  - • AP600 (Advanced Pressurized Water Reactor 600)
  - • AP1000 (Advanced Pressurized Water Reactor 1000)
  - • APR1400 (Advanced Power Reactor 1400)
  - • APWR+ (Advanced Pressurized Water Reactor Plus)
  - • EPR (European Pressurized Water Reactor)
- Integral Primary System Reactors
  - **• CAREM (Central Argentina de Elementos Modulares)**
  - • IMR (International Modular Reactor)
  - • IRIS (International Reactor Innovative and Secure)
  - • SMART (System-Integrated Modular Advanced Reactor)
- Modular High Temperature Gas-Cooled Reactors
  - • GT-MHR (Gas Turbine-Modular High Temperature Reactor)
  - • PBMR (Pebble Bed Modular Reactor)

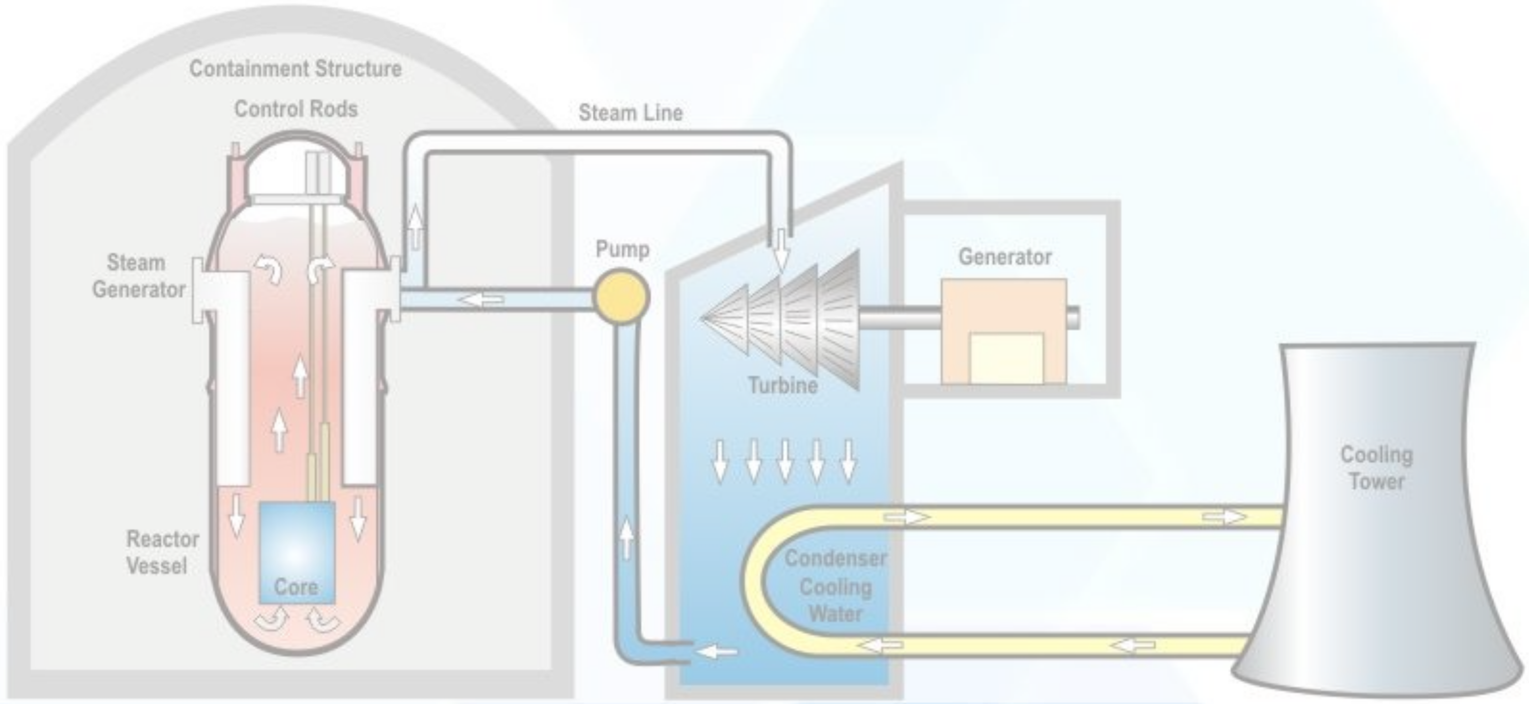
CAREM: Consolidated Trade Mark

- First World Proposal of a Passive Integrated Reactor
- Second World Proposal of a Passive Reactor
- More than 200 presentations in International Forums
- There have been expressions of interest from four countries
- CAREM reviews: **1995: IAEA Test Case for desalination;**
  1999: MOU Mitshubishi Heavy Industries (Japan)
  2000: Three Agency Study (NEA/OECD),IAEA, IEA
  2001: DOE (EEUU)
  2002: Gen IV Forum
- Gen IV Forum 2003:
  "it presents advantages with respect to the Advanced Light Water Reactors and could be deployed by 2015"
- CAREM created a Integrated Reactor :
  - ✓ CAREM Family: NILUS – IRIS; Russian Family: SMART

PWR Traditional Design



CAREM Design

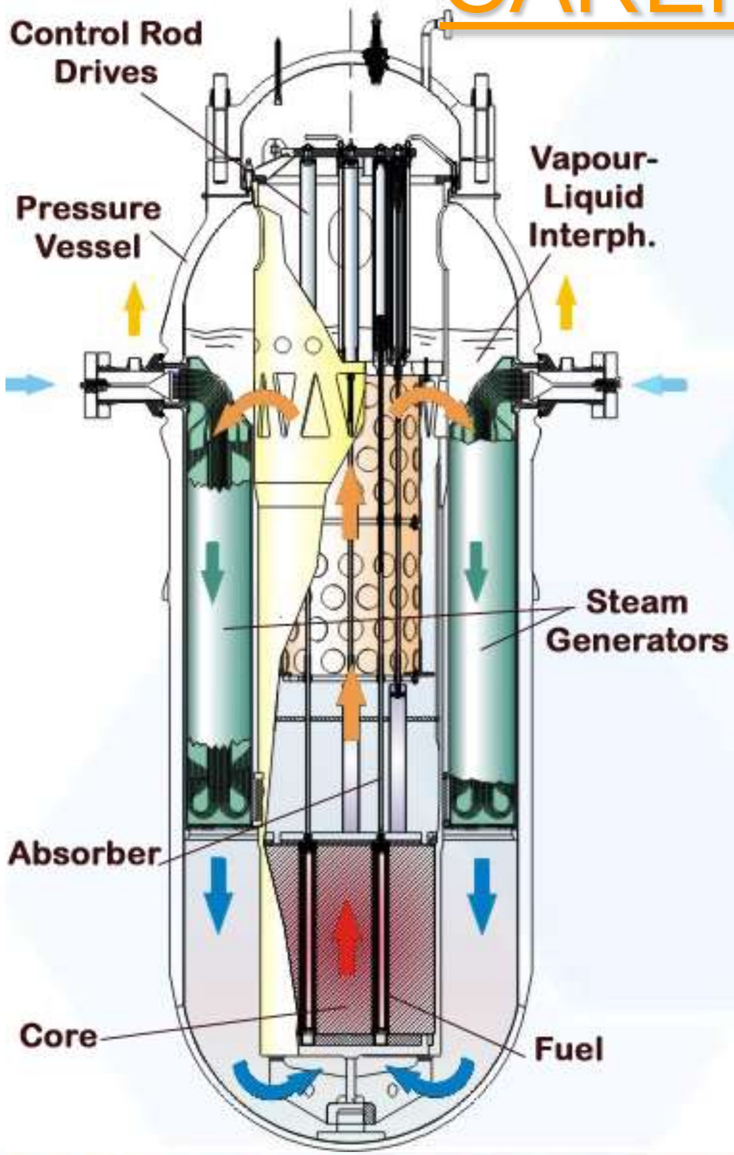


MORE SIMPLE

MORE RELIABLE

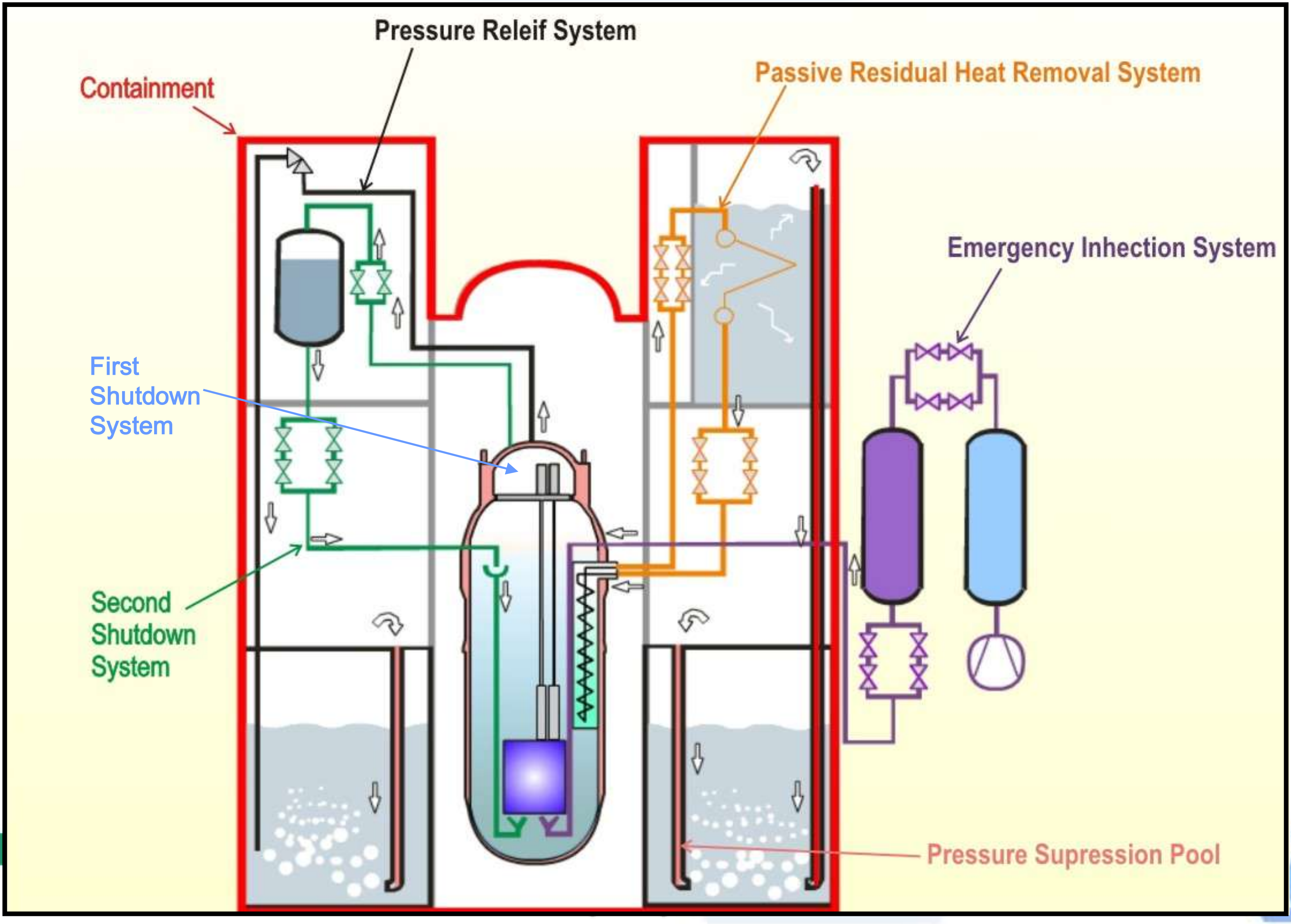
SAFER

CAREM Concept

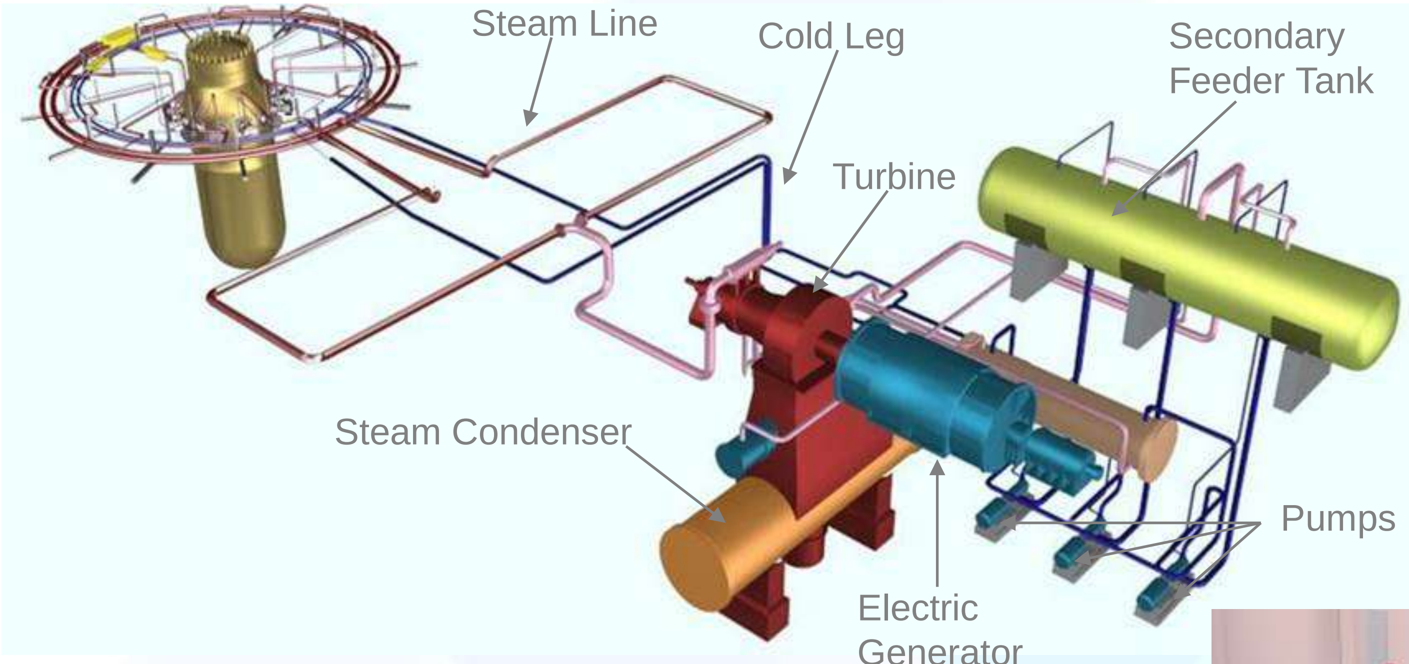


- Innovative features
  - Integrated Primary System
  - Self-pressurised
  - In-vessel CRD
  - Passive Safety Systems

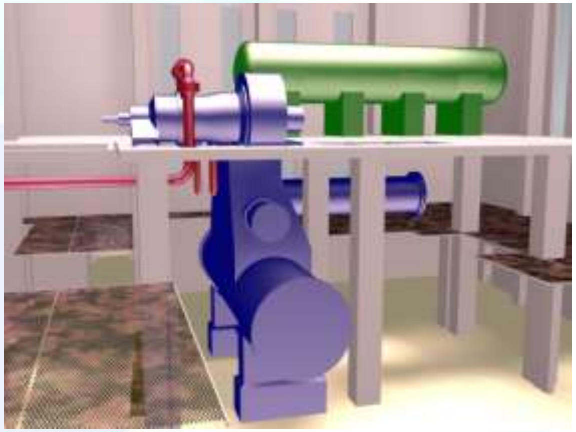
Passive Safety Systems



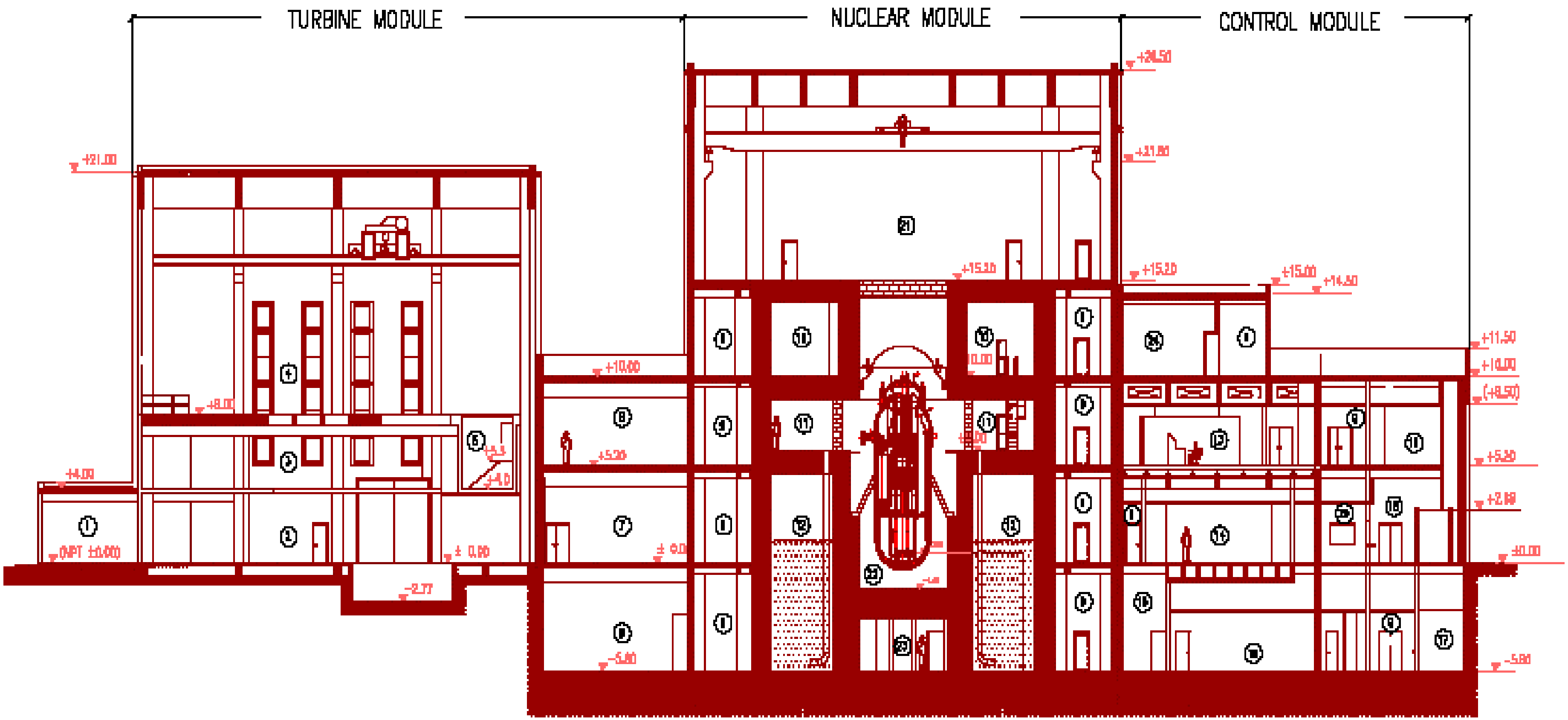
Balance Of Plant



- Operating Conditions
  - Pressure 4,7 MPa
  - Temperature 200/290 ºC



Plant Design



1. MEDIUM VOLTAGE SWITCHBOARD ROOM
2. TURBOGENERATOR
3. TURBINE HALL
4. TURBINE HALL
5. PUMPS ROOM
6. STEAM PIPING VALVES ROOM
7. CLASS II – SWITCH BOARD ROOM
8. WORKSHOP
9. CORRIDOR
10. UPPER DRYWELL
11. PERIPHERIC DRYWELL
12. SUPPRESSION POOL
13. MAIN CONTROL ROOM
14. RACKS ROOM
15. CABLES ROOM
16. LOCKERS
17. STORE ROOM
18. RECEPTION
19. OFFICE
20. GUARD
21. REACTOR HALL
22. CENTRAL DRYWELL
23. LOWER DRYWELL
24. MAIN CONTROL ROOM HVAC SYSTEM

Market target

- Electricity for isolated regions / towns / restricted grid capacity
- Industrial Steam (mining, Oil Sands)
- District Heating
- Desalination
- Shortening the Gap to introduce NE in non Nuclear Countries

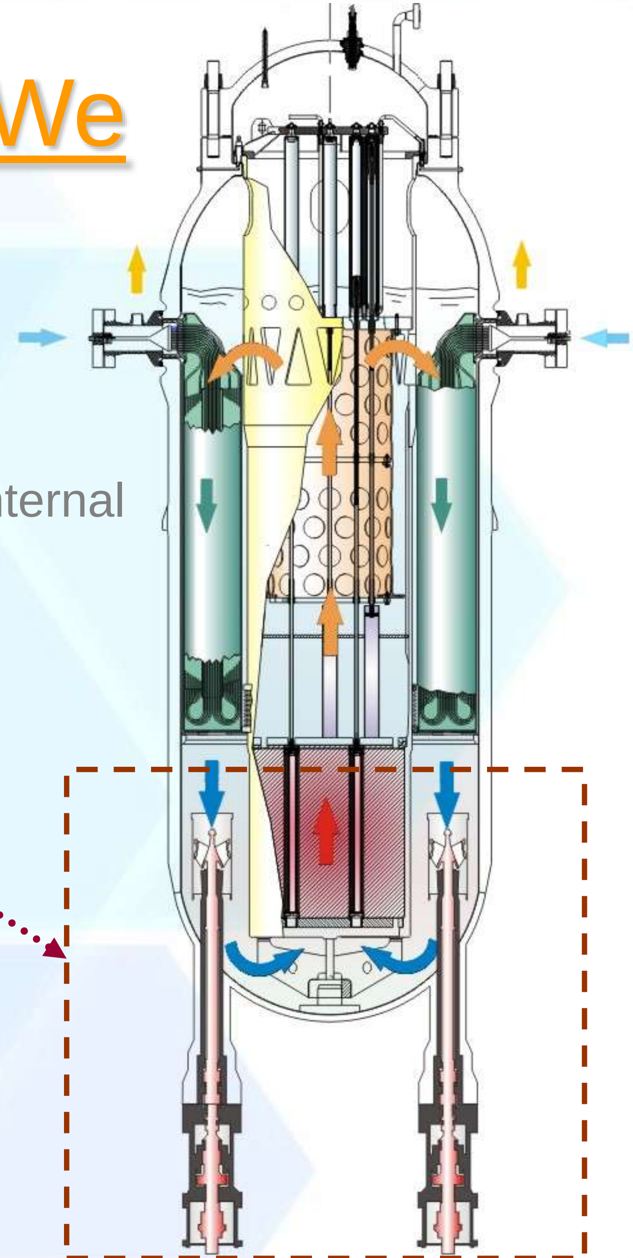
Data Sheet

Thermal Power (MW)	100
Electrical Power (MW)	27
Primary Conditions (MPa, max/min ºC)	12.25, 284/326
Secondary Conditions (MPa, ºC)	4.7, 200/290
RPV (130 Tons) Dimensions (m)	Height 11, Diameter 3.2
Core / Fuel	UO_2 enrich < 3.4%, Zy-4
Reactivity Control	Ag-In-Cd
Burnable Absorber	GdO2
Moderator/Coolant	Light Water
Refuelling Cycle at each batch (FPD)	330 (minimum)
Steam Generators type (12 units)	One Through, RPV-integrated
Turbine System	Condensing type, 175.32Ton/h
Passive Safety Systems	
First Shutdown (control rod)	9 FSS + 19 RCS
Second Shutdown (Boron Injection)	2x100%
RHRS-EC (Steam Condensing)	2x100% (+48hs each one)
Relief Valves	3x100%
Emergency Injection (1.5MPa)	2x100%

CAREM 300 MWe

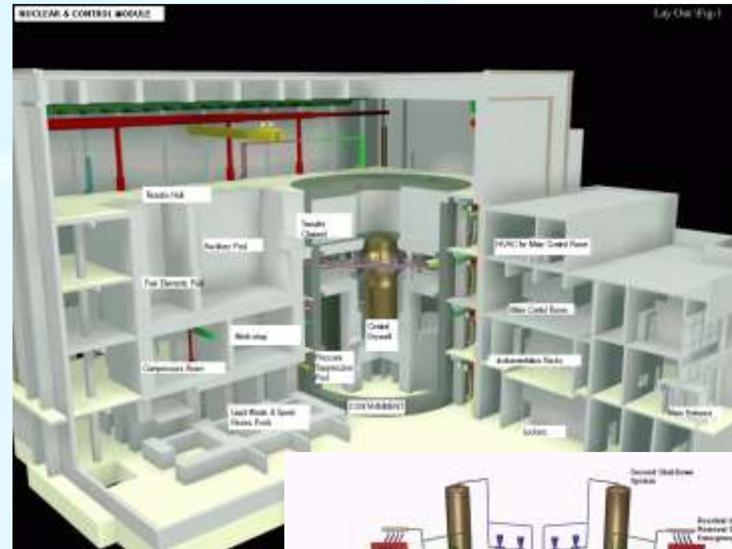
- Goal
  - Competitive Innovative Nuclear Power Plant
- Design Concept: CAREM
  - Integrated Primary Circuit, Self-Pressurized, Internal Control Rod Drives, Passive Safety

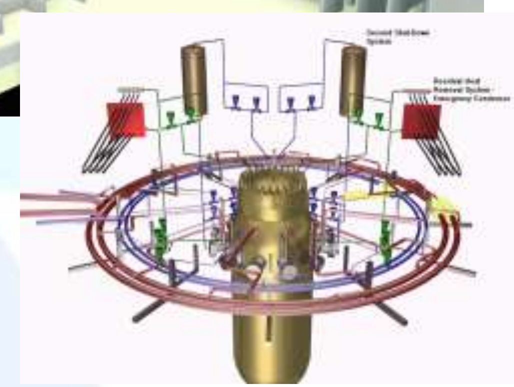
Includes in-Vessel Integrated Pumps



CAREM FAMILY

- CAREM 25
  - Concept feasibility demonstration
  - Budget of the Prototipe:180 Mu$s
  - Estimated Operation by 2014
- CAREM 100
  - Extension of the Basic Concept
  - Improve economy
- CAREM 300
  - FOAK by 2020
  - Preliminary Budget (FOAK) ~900 Mu$s
  - Modular design
  - 20% savings for Follow-up Plants
  - Levelised Generating Cost ~50u$s/MWh



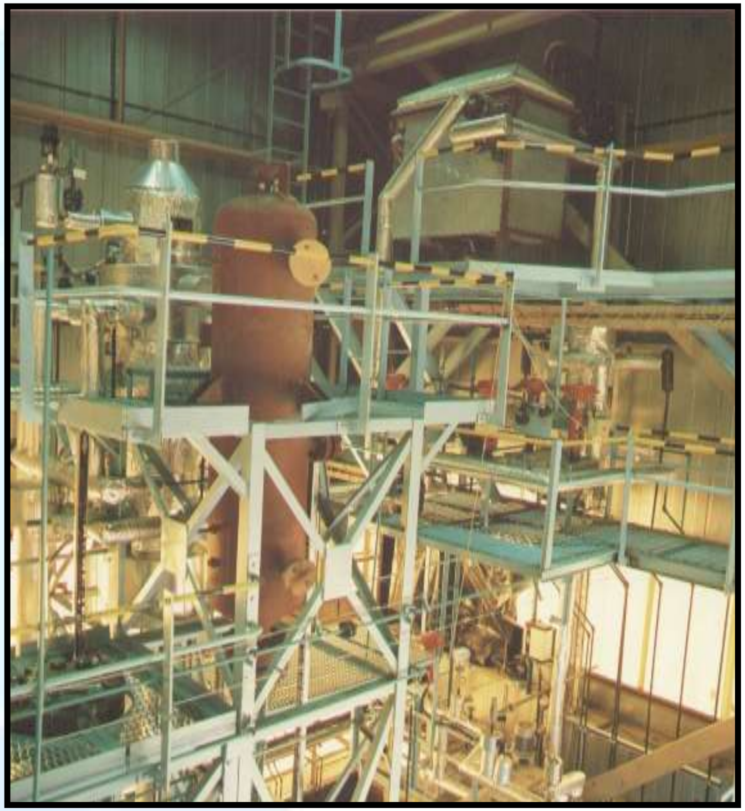


Maturity of the design

- HP test
- In Loop Fuel Test for critical parameters
- Innovative Safety Systems mock-up testing
- Experimental data for validating n- codes
- Endurance and hydraulic test (Fuel)
- Manufacturing Process Challenges

Natural Circulation HP Test LOOP

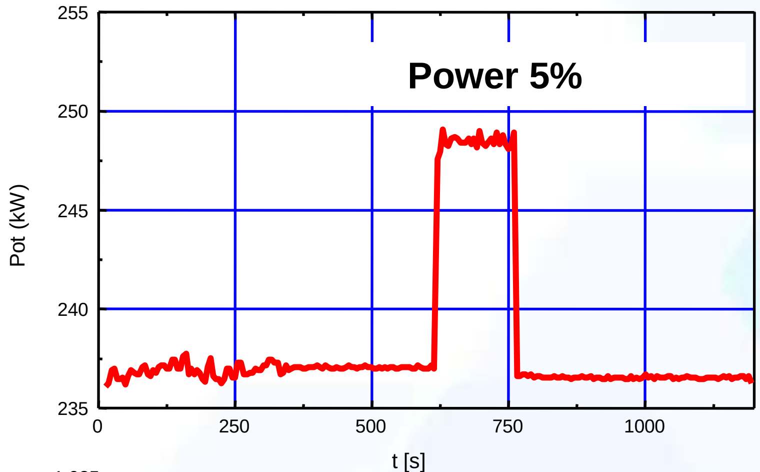
- Main Features
  - One Dimension - Closed loop (1:1 height scale - 3” Pipe diameter)
  - CAREM Operating Conditions (P, T)
  - Control feedback loop
- Typical Tests
  - Response under perturbations in:
    - ✓ Power
    - ✓ Hydraulic Resistance
    - ✓ Pressure
    - ✓ Heat Sink

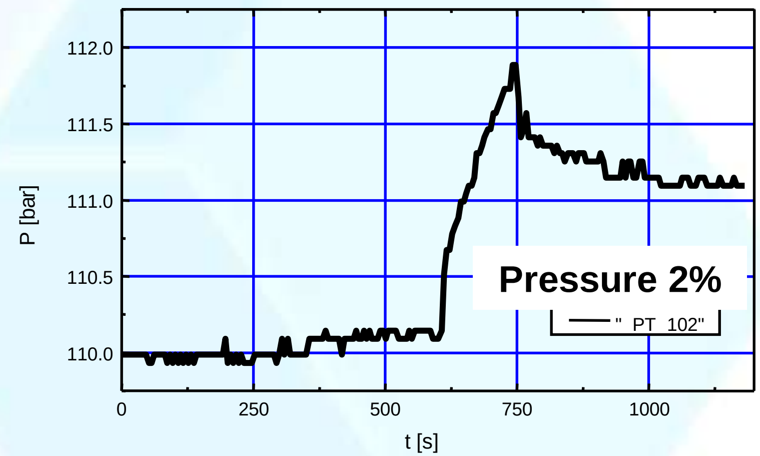


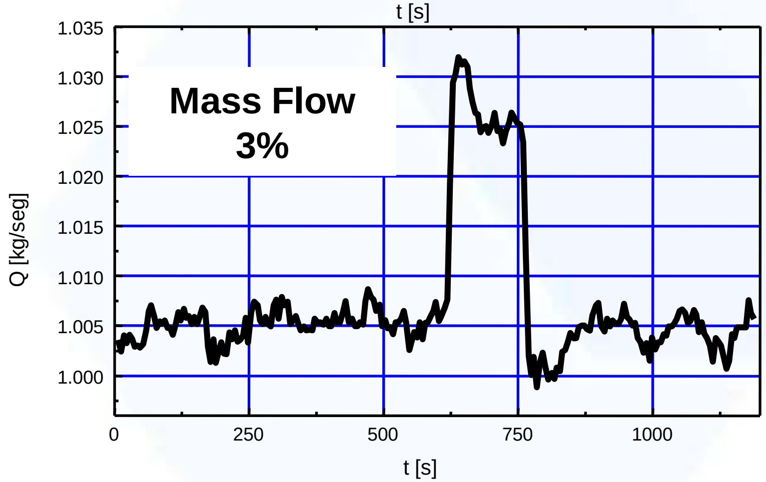
Confirmation of High Stability of the Primary System (Self Pressurized-Natural Circulation)

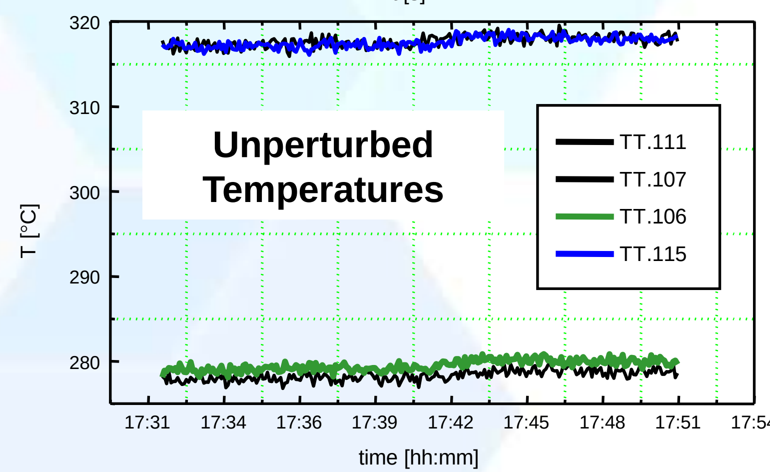
Dynamic Response

PERTURBATION on POWER, Time = 150 sec



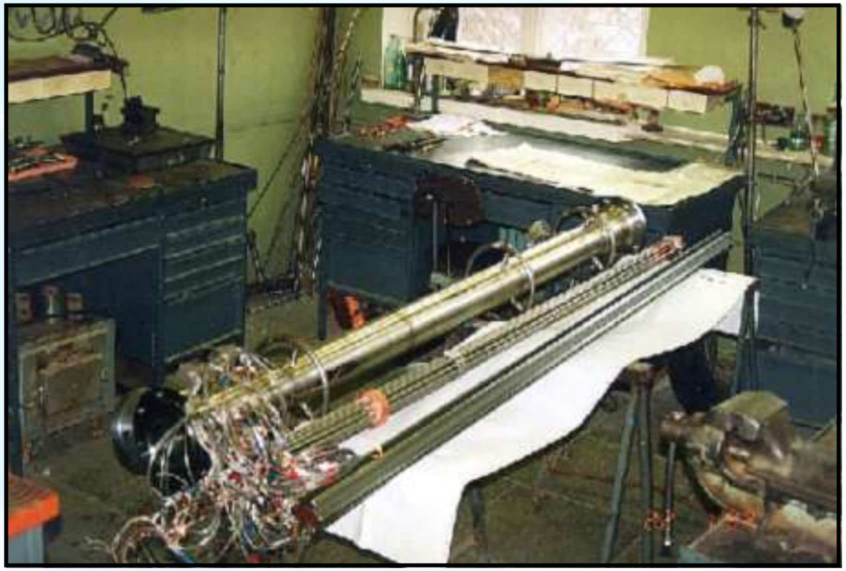






Core Design - CHF Tests

- Facility - Termohydraulic Lab IPPE (Obninsk-Russia)
  - LP Freon Loop Test
  - HP Water Loop Test



- Screening Points

	Test range	CAREM	units
Pressure	10 - 13	12.2	MPa
Mass Flux	200-700	410	kg/m²/s
Quality	-0.15 to 0.15	< 0.10	-

More than 250 experimental points under different conditions were obtained in the Freon loop and more than 25 point in the water loop

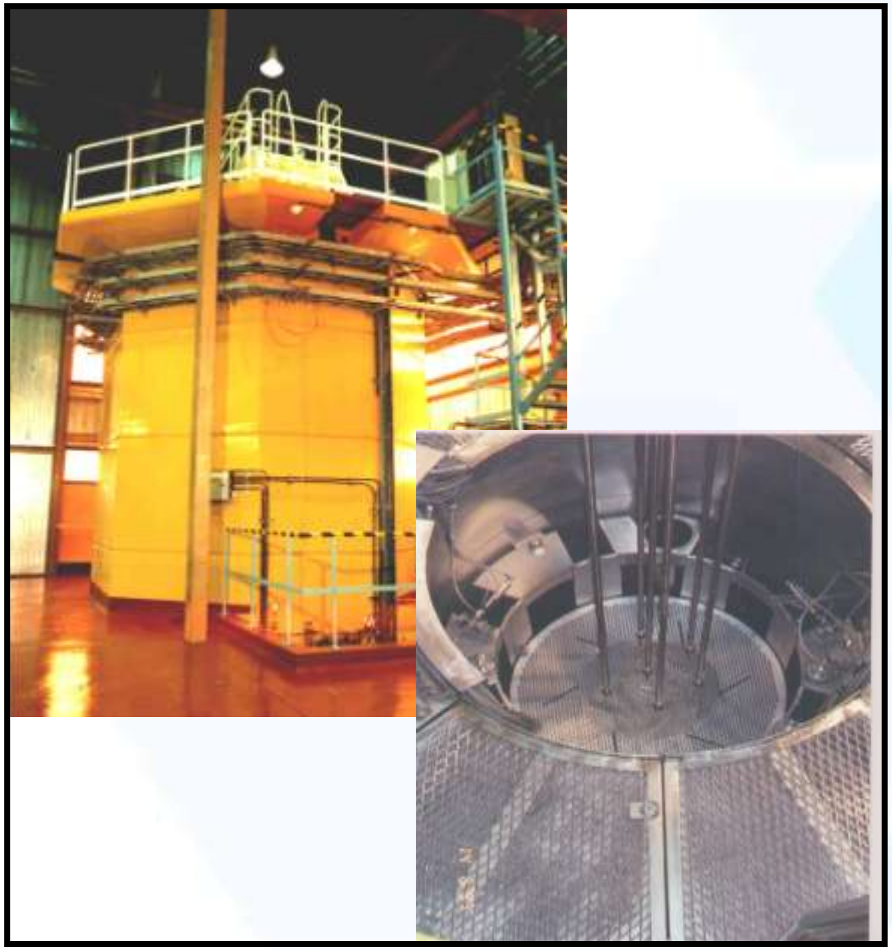
First Shutdown System

Hydraulic CRDM Test Rig

- Rig Features
  - 1 mechanism Full-scale
  - Test conditions: atm P, T< 90ºC
  - Feeding Pipe resembles layout
  - Flow regime allows scalability of the Results at HP conditions

- Output
  - Feasibility of the design
  - Design & Operating Data for HP Test

Core Design - Neutron Physics



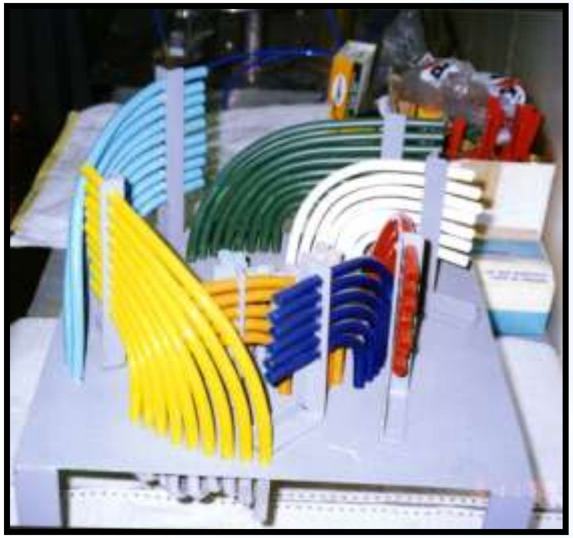
- Modelling
  - Nuclear Data:
    - ✓ HELIOS library
  - Cell Code CONDOR:
    - ✓ CP in 2-D cylindrical geometry
    - ✓ VAL: PWR critical pin cell & VVER-cells Test
  - Core Code CITVAP
    - ✓ 3D geometry
    - ✓ Follow up capability
    - ✓ VAL: MTR and VVER Tests
- Critical Facility (RA-8)
  - Experiments for each configuration of the CAREM core

Fuel Assembly Mechanical Design

- Fuel Assembly Prototype: allowances and manufacturing techniques
- Low Pressure Loop: Hydraulic Resistance & Flow induced vibration
- High Pressure Loop: Endurance test, wear-out and fretting

Reactor Pressure Vessel Internals

- Mock ups for evaluation of mechanical design parameters and manufacturing process
  - Steam Generator Lay Out
  - Fuel Maneuvering Device (Refueling)
  - Pass Through for Instrumentation



Why CAREM ?

- Innovative Small Nuclear Power Plant with Passive Safety Systems.
- Simple and Reliable Design.
- High positive impact on Licensing, Operation and Maintainability
- Maturity: Mockup and loop Tested, Code Validated and Internationally reviewed
- Market opportunity for special applications
- Green Light to Prototype (Atucha Site) op. by 2014
- Concept able to be extended to 300 MWe: competitive for electricity generation markets

THANK YOU

Market Opportunity

- Very Small Nuclear Power Plant (27 MWe)
  - Bridge Nuclear Power Plant
  - Isolated Places
  - Nuclear Desalination and Cogeneration
  - Industrial Steam, i.e. Mining and Oil Sand

- Small Nuclear Power Plant (300 MWe)
  - Competitive Electricity Generation
  - More Economical & Larger Power in Multi-units