The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2141-5

Joint ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced Reactor Technologies

3 - 14 May 2010

Advanced Water Cooled Reactors
Remote Lecture form IAEA Vienna

Bilbao Y Leon S.

IAEA
Vienna
AUSTRIA

Overview of IAEA Project on Technology Advances in Water Cooled Reactors

Sama BILBAO Y LEON
S.Bilbao@iaea.org
Division of Nuclear Power
IAEA

IAEA/ICTP Workshop on Nuclear Reaction Data for Advanced Reactor Technologies
ICTP, Trieste, May 3 – 14, 2010

Water Cooled Reactors Group

The WCR Group monitors worldwide activities taking place in the area of water cooled reactor technology development, facilitates the international exchange and identification of challenges and opportunities in this area, and fosters the international collaboration towards addressing of the challenges and capitalizing on the opportunities

Goals of WCR Technology Development Group

- Continuously monitor worldwide activities on technology development for WCRs
- Facilitate exchange of information among IAEA Member States on technology development for WCRs
- Foster international collaboration on technology development for WCRs
- Support near term deployment of nuclear programs for both emerging and existing countries in WCR technology development
- Provide technology training in WCR technology development

Areas of Interest

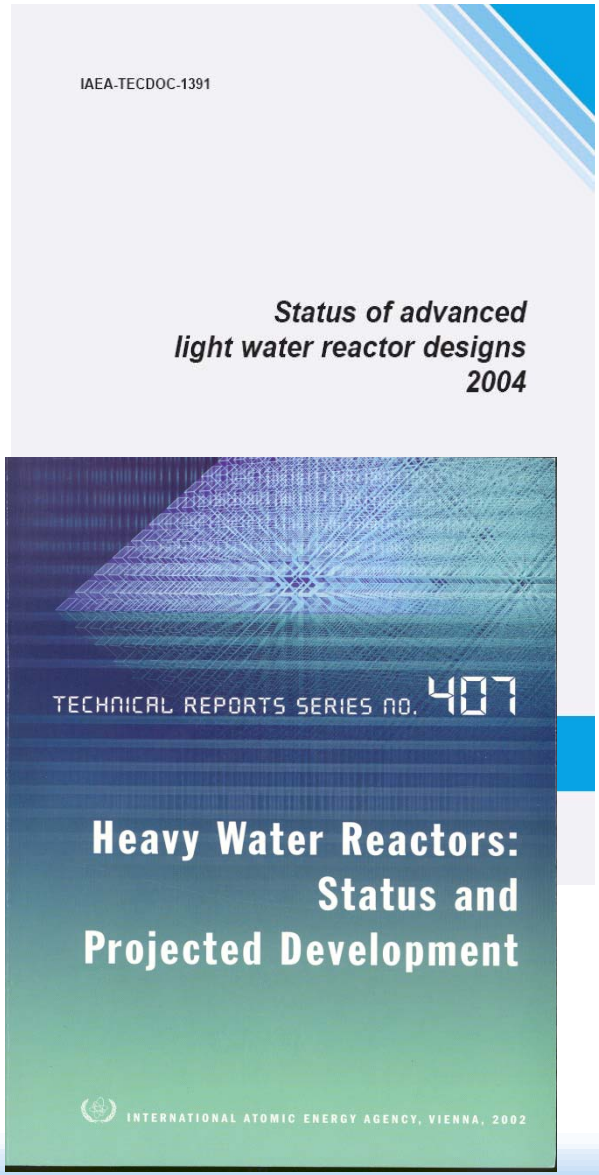
- Design and technologies for current and advanced WCRs;
- Economics, performance and safety for current and advanced WCRs;
- Advanced fuel cycles and fuel options for current and advanced WCRs;
- Infrastructure specific to the development and deployment of WCRs.

Advisory Group

- Two Technical Working Groups (TWG)
  - Advanced Technologies for Light Water Reactors (LWRs)
  - Advanced Technologies for Heavy Water Reactors (HWRs)
- Role: Advise and make recommendations on future activities that will support the advance of WCRs and their development and deployment in the next 50 years.

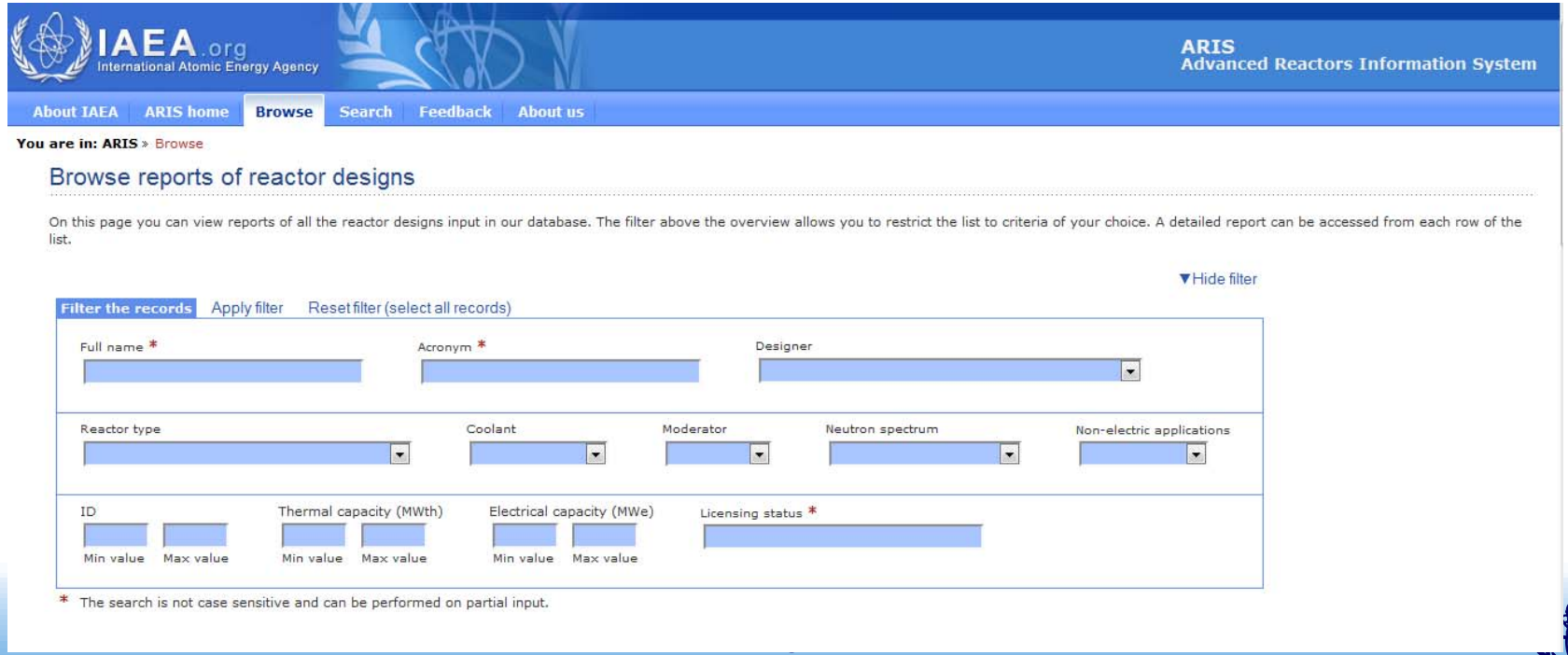
1. Continuously monitor worldwide activities in the area of WCR technology development

IAEA Publications



ARIS: Advanced Reactors Information System

- Goal: Web-accessible database that provides the most up-to-date information about the various nuclear reactor designs
- All reactor designs: LWR, HWR, FR, GCR, SMR



2. Facilitate exchange of information among MSs on technology development for WCRs

3. Foster international collaboration on technology development for WCRs

CRP on Thermo-hydraulic Relationships for Advanced Water-Cooled Reactors

- CRP conducted 1995-1999
- TECDOC-1203, “Thermo-hydraulic Relationships for Advanced Water-Cooled Reactors”, 2001
- Established a consistent set of thermo-hydraulic relationships which are appropriate for use in analyzing the performance and safety of advanced water cooled reactors
  - Critical Heat Flux (CHF)
  - Heat Transfer during Film Boiling
  - Pressure Drop
  - Etc

CRP on Intercomparison of Techniques for Inspection and Diagnostics of HWR Pressure Tubes (1)

- **Phase I : Flaw detection and characterization**
  - Objective:
    - To investigate the capability of different techniques to detect and characterize flaws
    - To inter-compare non-destructive inspection and diagnostic techniques, in use and being developed, for structural integrity of HWR pressure tubes
    - To identify the best NDE methods for detection, location and sizing of various types of flaws in PTs
  - IAEA-TECDOC-1499, Intercomparison of Techniques for Inspection and Diagnostics of Heavy Water Reactor Pressure Tubes: Flaw Detection and Characterization (2006)

Participants:

Institute	Country	Inspection & Diagnostic Techniques
CNEA	Argentina	UT
AECL	Canada	UT & ET
CNNC	China	
BARC	India	UT & ET
KAERI	Rep. of Korea	ET
KEPRI	Rep. of Korea	ET
NIRDTP	Romania	ET
NNDT	Romania	UT & ET

CRP on Intercomparison of Techniques for Inspection and Diagnostics of HWR Pressure Tubes (2)

- **Phase II : Determination of hydrogen concentration and blister characterization**
  - Objective:
    - Compare different destructive tests for measurement of hydrogen in pressure tube
    - Establish few standardized techniques applicable for PTs
    - Assess the effectiveness of NDE methods for hydrogen measurement
  - IAEA-TECDOC-1609, “Inter-comparison of techniques for inspection and diagnostics of HWR pressure tubes, Determination of hydrogen concentration and blister characterization,” March 2009.
  - Participants:

Institute	Destructive methods				Non-destructive methods		
	IGF	HVEMS	DSC	DTA	Resistivity	UT	ET
CNEA, Argentina	x		x	x		x	x
AECL, Canada		x	x		x		
BARC, India	x	x	x				
KAERI, Korea	x						
NIRDTP, Romania			x			x	x

CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems (1)

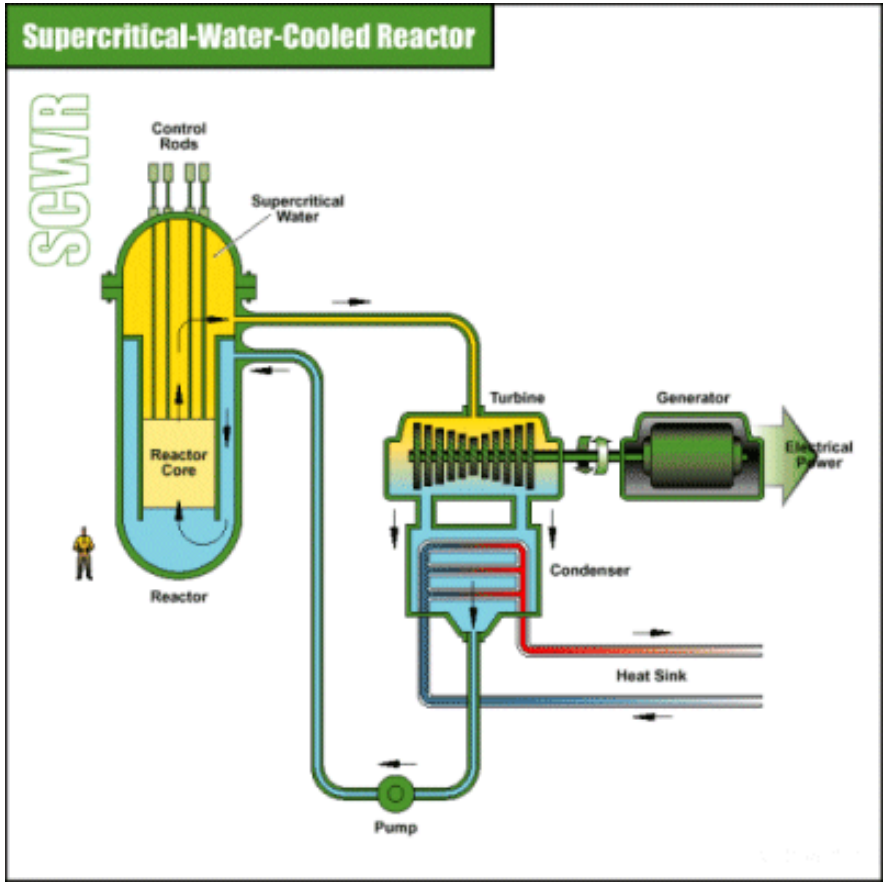
- **Specific Objectives**
  - **establish the status of knowledge: reactor start-up & operation; passive system initiation & operation; flow stability, 3-D effects and scaling laws**
  - **investigate phenomena influencing reliability of passive NC systems**
  - **review experimental databases for the phenomena**
  - **examine the ability of computer codes to predict NC and related phenomena**
  - **apply methodologies for examining the reliability of passive systems**
- **Participants (16)**
  - **CNEA, Bariloche, Argentina**
  - **CEA, France**
  - **FZ Dresden, Germany**
  - **BARC, India**
  - **Univ. of Pisa, Italy**
  - **ENEA, Italy**
  - **IVS, Slovakia**
  - **JAEA, Japan**
  - **KAERI, Rep. of Korea**
  - **Gidropress, Russian Federation**
  - **University of Valencia, Spain**
  - **PSI, Switzerland**
  - **Idaho State University, USA**
  - **Oregon State University, USA**
  - **Purdue University, USA**
  - **European Commission, JRC - Petten**

Outcomes of CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems (2)

- **Document Publication**
  - **TECDOC-1474, "Natural Circulation in Water Cooled Nuclear Power Plants", November 2005**
  - **TECDOC-1624, "Passive Safety Systems in Water Cooled Nuclear Power Plants: The Use of Natural Circulation", November 2009**
  - **TECDOC-XXXX, "Natural Circulation in Water-Cooled Nuclear Power Plants: Phenomena, Modelling, and Reliability of Passive Systems that Utilize Natural Circulation", under preparation**
- **Training Course on Natural Circulation Phenomena and Modeling in Water Cooled NPPs**
- **Last RCM: November 2008**

CRP on Heat Transfer Behaviour and Thermo-hydraulics Code Testing for SCWRs

- **Specific Research Objectives:**
  - to establish a base of accurate data for heat transfer, pressure drop, blowdown, natural circulation and stability for conditions relevant to super-critical fluids,
  - to test analysis methods for SCWR thermo-hydraulic behaviour, and to identify code development needs.
- **Participants (12)**
  - Korea Atomic Energy Research Institute (Korea)
  - University of Wisconsin (USA)
  - China Institute for Atomic Energy (China)
  - Shanghai Jiao Tong University (China)
  - Atomic Energy of Canada, Ltd. (Canada)
  - Bhabha Atomic Research Centre (India)
  - VTT Technical Research Centre (Finland)
  - University of Pisa (Italy)
  - Gidropress (Russia)
  - Institure For Physics and Power Eng. (Russia)
  - Institute for Energy, EC-JRC (Netherlands)
  - University of Manchester (UK)
- 1st RCM – July 2008
- 2nd RCM – August 2009



CRP on Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications (1)

- **Specific Research Objectives:**
  - to improve safety for currently operating HWRs and to facilitate more economic and safe designs for future plants
- **Participating Organizations and Computer Codes to be Used**
  - AECL (Canada), MAAP-CANDU
  - Shanghai Jiao Tong Univ. (SJTU, China), RELAP5/SCDAP
  - BARC (India), RELAP5/MELCOOL
  - NPCIL (India), CONTACT/SEVAX
  - KAERI (Rep. of Korea), ISSAC
  - Politehnica Univ. of Bucharest (PUB, Romania), RELAP5/SCDAP
- **Expected Outcomes**
  - Improved understanding on HWR severe accident phenomena
  - Consensus on HWR severe accident scenario
  - Advanced information on computer code capabilities
  - Recommendations for improvements and subsequent research

CRP on Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications (2)

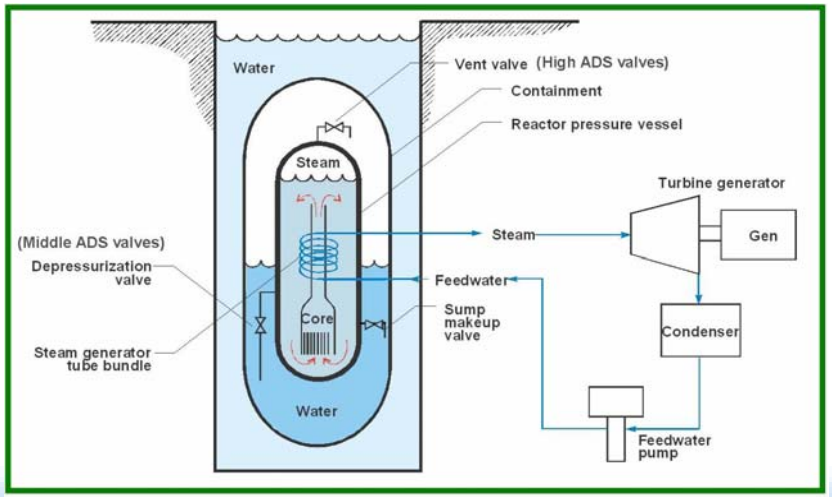
- **CRP Activities:**
  - **Assessment of the existing models, correlations, experiments, and computer codes**
  - **CANDU 6 benchmark analysis**
    - **Establish criteria for fuel failure, fuel channel failure, fuel channel disassembly, core collapse, calandria vessel failure and containment failure, and reactor vault failure.**
    - **Phase 1 : Accident initiation to fuel channel dryout**
    - **Phase 2 : Fuel channel dryout to core collapse**
    - **Phase 3 : Core collapse to calandria vessel failure**
    - **Phase 4 : Calandria vessel failure to containment failure**
  - **New experiment and Benchmark analysis for experiment**
  - **Documentation**
- **The1st RCM:**
  - **IAEA-HQ, Vienna, Austria, February 2009**

CRP on Development of Advanced Methodologies for Substantiation of Passive System Performance in Innovative Reactor Designs

- Objectives
  - Identify requirements for a method of reliability assessment of passive safety systems for future advanced NPPs
  - Establish a set of definitions for reliability assessment of passive safety systems
  - Identify a benchmark problem for comparison and validation of methodologies for reliability assessment of passive safety system performance
  - Benchmark select reliability assessment methodologies against selected benchmark problem
  - Compare the results and prepare recommendations
- Participants (8)
  - CNEA, Argentina
  - CEA, France
  - BARC, India
  - IGCAR, India
  - ENEA, Italy
  - University of Pisa, Italy
  - Gidropress, Russian Federation
  - Idaho State University, USA
- 1st RCM – April 2009

ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents

- Objectives
  - To compare the best-estimate computer code calculations to the experimental data obtained from the integral test facility representing an integral type reactor
  - To improve the understanding of thermal-hydraulic phenomena expected to occur in normal operation and transients in an integral reactor
  - To evaluate the capability of computer codes to adequately predict the occurrence of important phenomena, and the corresponding behaviour of nuclear systems during operating, upset and accident conditions, which are represented in experiments
- Scope
  - A. NC with stepwise decrease in primary inventory – investigating stability with increasing 2-phase conditions (limit: liquid level at top of core)
  - B. Coupled primary system – containment response with LOFW + opening of ADS valves
- Host: Oregon State Univ. (OSU) of USA
- Experimental facility description report and ICSP plan were issued
- Participants (9)
  - USNRC (USA)
  - OSU (USA)
  - Univ. of Pisa (Italy)
  - KAERI (Korea)
  - KINS (Korea)
  - Serco (UK)
  - SJTU (China)
  - CIAE (China)
  - BARC (India)
- First Workshop
  - March 2010 at OSU, USA



ICSP on Comparison of HWR Thermal-hydraulic Code Predictions with SBLOCA Experimental Data

- **Purpose of the ICSP**
  - Improve understanding of important phenomena expected to occur in SBLOCA transients
  - Evaluate code capabilities to predict these important phenomena, their practicality and efficiency, by simulating an integrated experiment
  - Suggest necessary code improvements or new experiments to reduce uncertainties
- **Participating Organizations and Computer Codes (8)**
  - CNEA (Argentina), CATHENA
  - AECL (Canada), CATHENA
  - Tsinghua Univ. (China), CATHENA
  - AERB (India), RELAP5
  - NPCIL (India), ATMIKA
  - KINS (Rep. of Korea), MARS-KINS
  - KAERI (Rep. of Korea), CATHENA
  - CNE PROD (Romania), CATHENA
- **Selection of Experimental Cases**
  - Tests B9006 and B9802 of RD-14M SBLOCA experiments (will be provided by AECL)
- **3rd Meeting: 26-28 August 2009 at IAEA-HQ**

4. Support near term deployment of nuclear programs for both emerging and existing countries in WCR technology development

Nuclear Reactor Technology Assessment

- Provide practical guidance and a design-neutral systematic approach to the evaluation of available nuclear reactor designs against user's needs
- Provide tools to enable informed decision making
- 2nd draft under preparation – 2010
- Workshop 2Q 2010

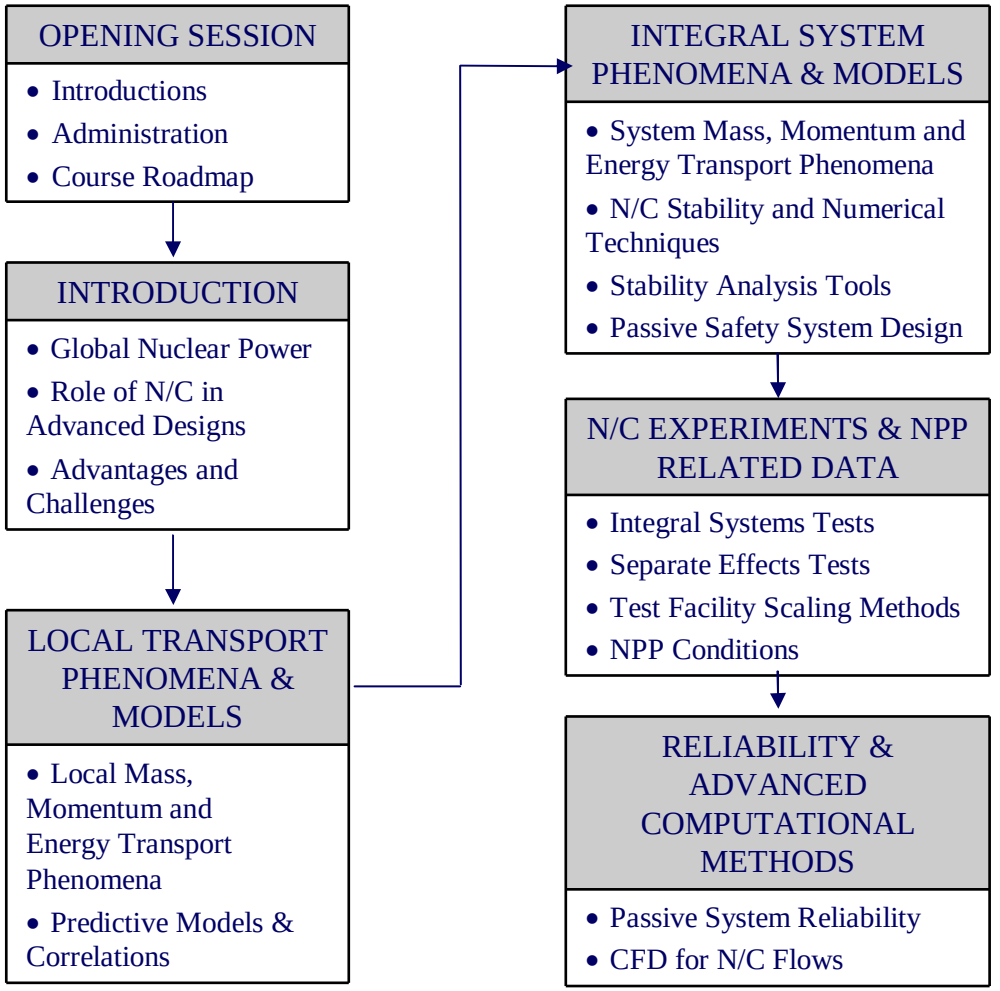
Construction Technologies for Nuclear Power Plants

- NE Series Report “Construction Technologies for Nuclear Power Plants”
  - To be completed in less than one year
  - Two consultancies + One Technical Meeting
  - Goal: Assimilating global experience from a variety of recent large construction projects to provide good insight into the means of achieving a short and efficient construction schedule for future NPP construction projects.
  - Contents:
    - Comprehensive descriptions of all construction methods (conventional and advanced)
    - Advantages and disadvantages of each
    - Best practices and lessons learned
- Follow-up NE Series Report: “Localization and Industrial Infrastructure Development in Support of the Construction of Nuclear Power Plants”
  - Content
    - Identify activities which could be conducted by the local labour force and the domestic industry
    - Identify trade-offs in schedule-cost considerations when using local capabilities
    - Plan the development of industrial infrastructure
    - Plan the development of human resources
- Workshops on Construction Technology

5. Provide technology training in WCR technology development

Training Course on Natural Circulation Phenomena and Modelling in Water Cooled NPPs

- **ICTP Trieste, Italy, June 2004**
- **ICTP Trieste, Italy, June 2007**
- **INL, USA, May 2008**
- **ICTP Trieste, Italy, June 2008**
- **Univ. of Pisa, Italy, June 2009**
- **ICTP Trieste, May 2010**



PC-Based Simulators

- Simulators provided free of charge to MSs – Educational purposes
- Collection of 7 simulators
  - BWR → Enhanced in 2008
  - Passive BWR → Developed in 2008-2009
  - PWR
  - Passive PWR
  - PHWR
  - Advanced PHWR
  - WWER → Manual enhanced in 2009
- 2-week workshop at ICTP, Trieste – October 12-23, 2009
- Future plans
  - Maintain and enhance the IAEA collection of simulators
  - Periodic workshops geared to University Professors
  - Workshops within the framework of TC/Infrastructure development


Thank you!