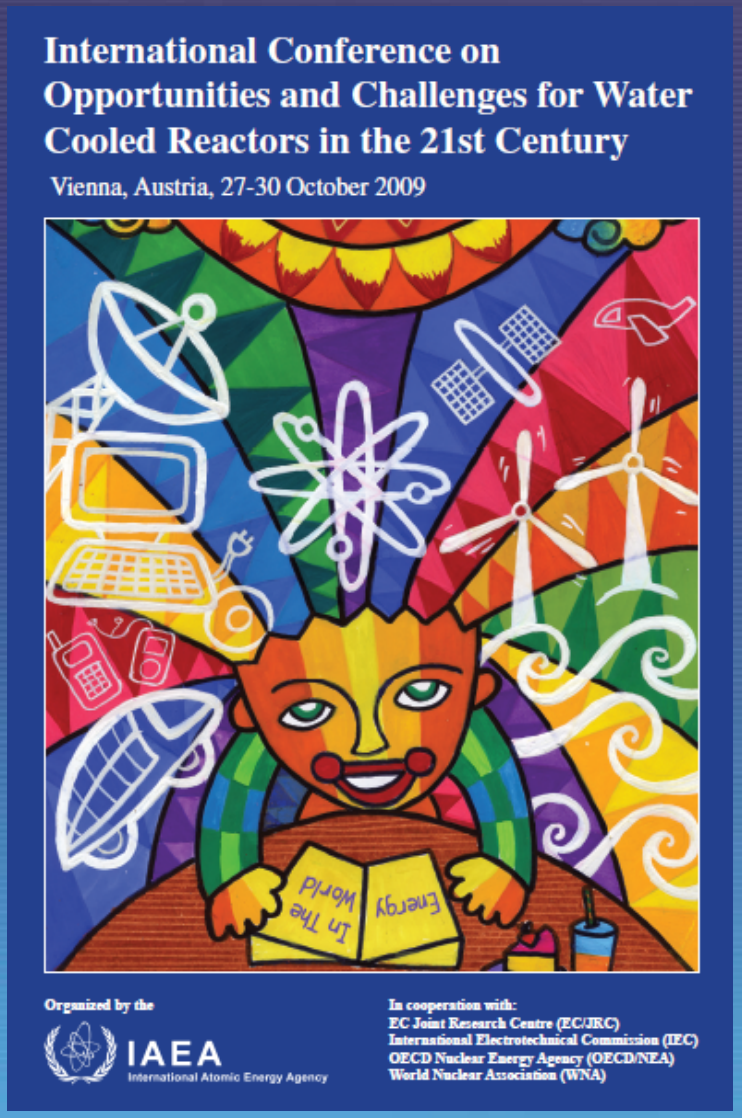


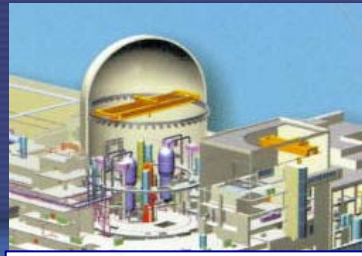
IAEA's Support of Water Cooled Reactors in the 21st Century and Beyond

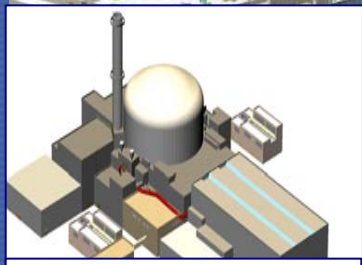
27 October 2009

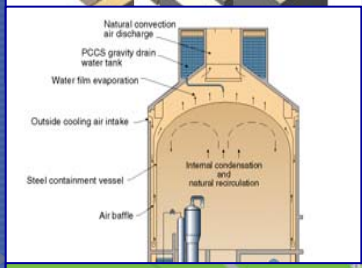
K. S. Kang,
S. Bilbao y León,
O. Glockler

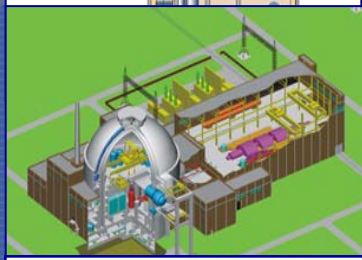
IAEA
International Atomic Energy Agency

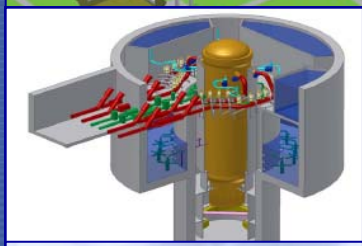
Main Objectives of 2009 Conference

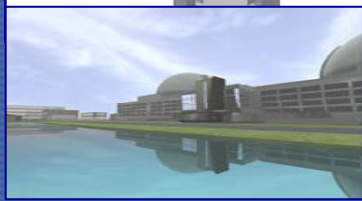






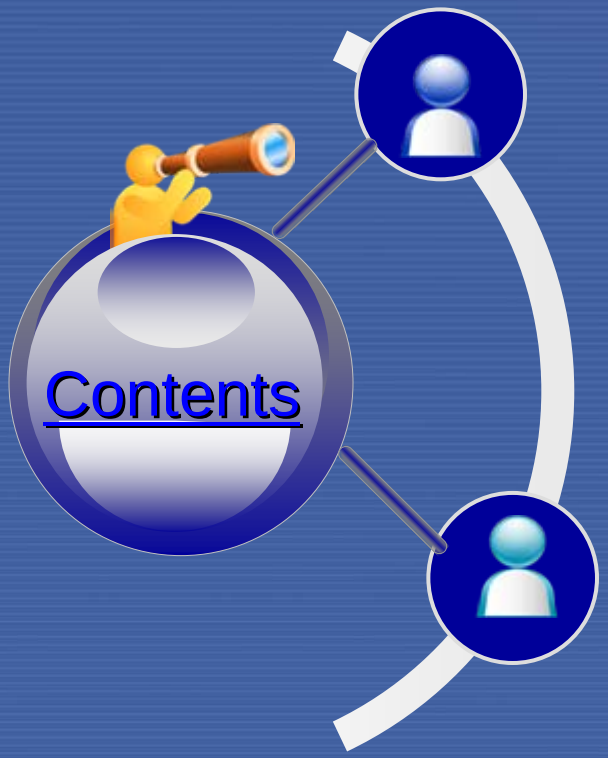






IAEA

IAEA's Support of WCRs in the 21st Century and Beyond



Operating Reactor Excellence

- Global Trends
- Performance Improvement
- Nuclear Energy Series
- Operational Excellence

Technology Development for WCRs

- Global Trends
- Support to Technology Development
- Technology Training

Opportunities & Challenges

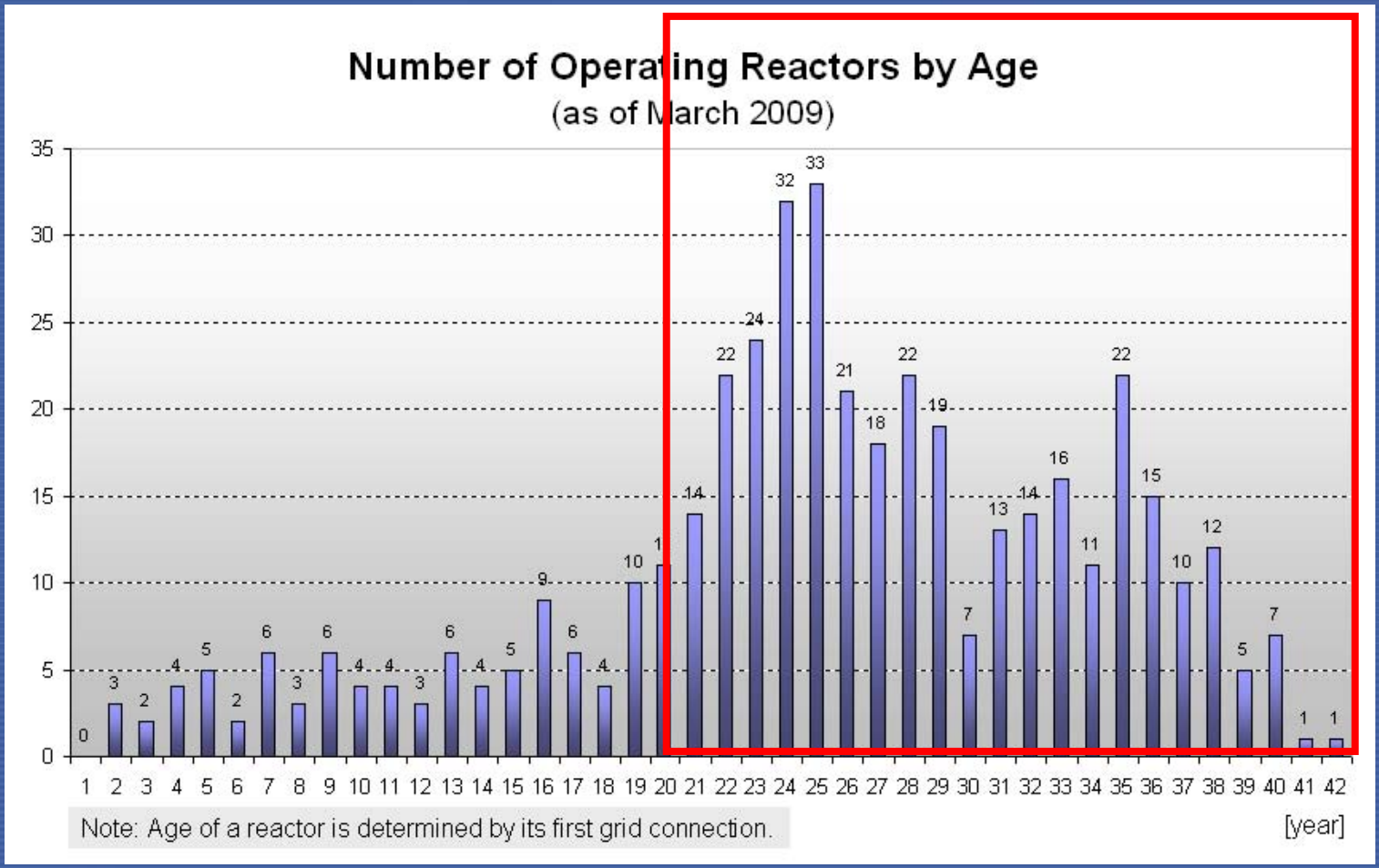
- TC Activities
- Opportunities and Challenges

IAEA

Part 1. Global Trends in Nuclear Power

Long-term operation and power uprating

- Long term operation through continuous monitoring, replacement and regulatory review



Age distribution (327/436 over or equal to 20 years)

Key Successful Trends in Operating NPPs

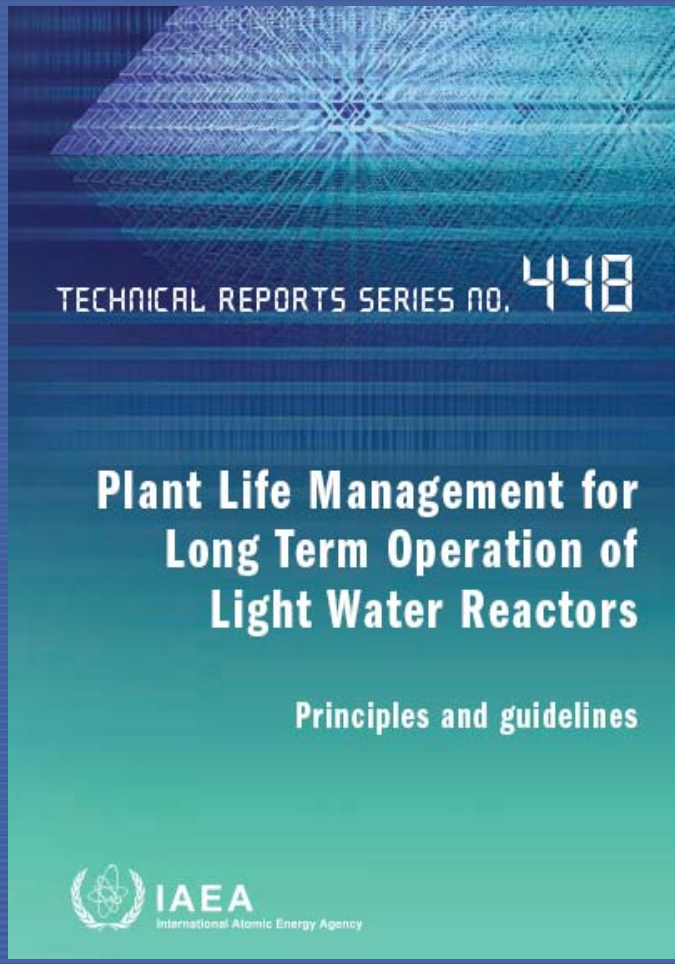
1. Availability factor increase & reduction of unavailability

2. Power upratings :
   - US: 5,695MW(e), Europe :1,212 MW(e), ~1% per year

3. Licensed Life Extension :
   - US: 51 NPPs, 21 application in review
   - Argentina, Czech, France, Hungary, Japan, Korea, Netherlands, RF, Spain, Ukraine

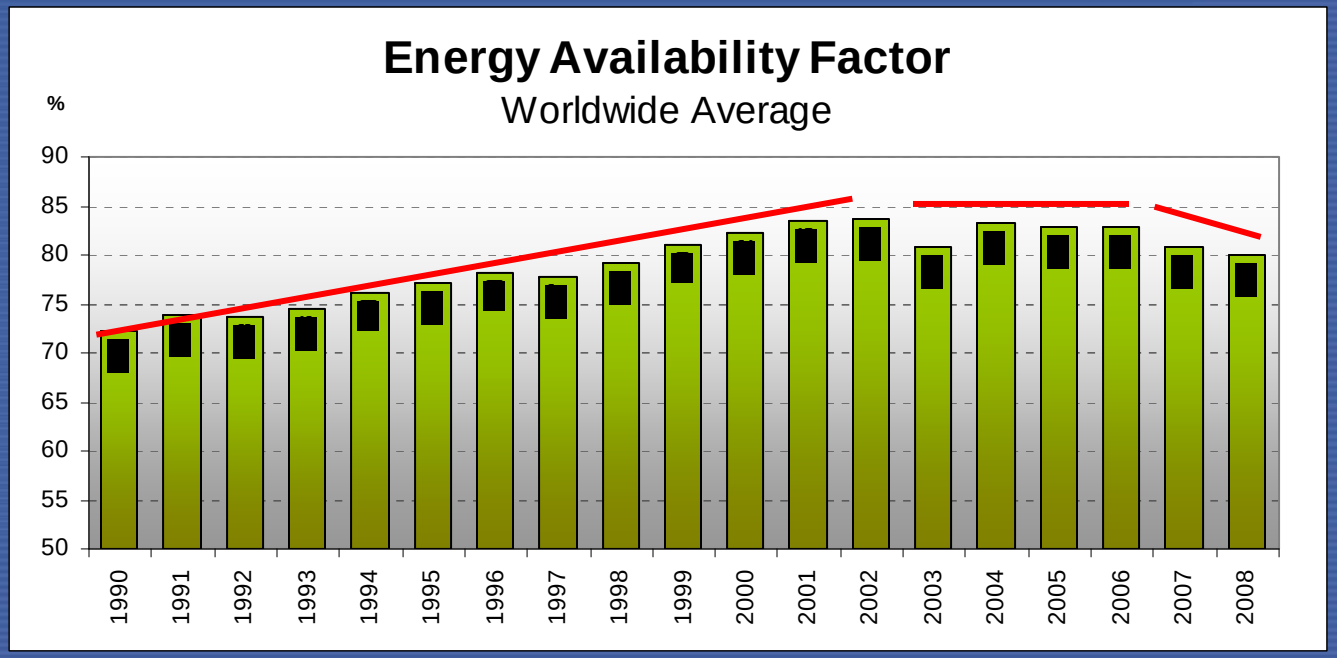
4. High burn-up fuel

5. Success in liberalized markets



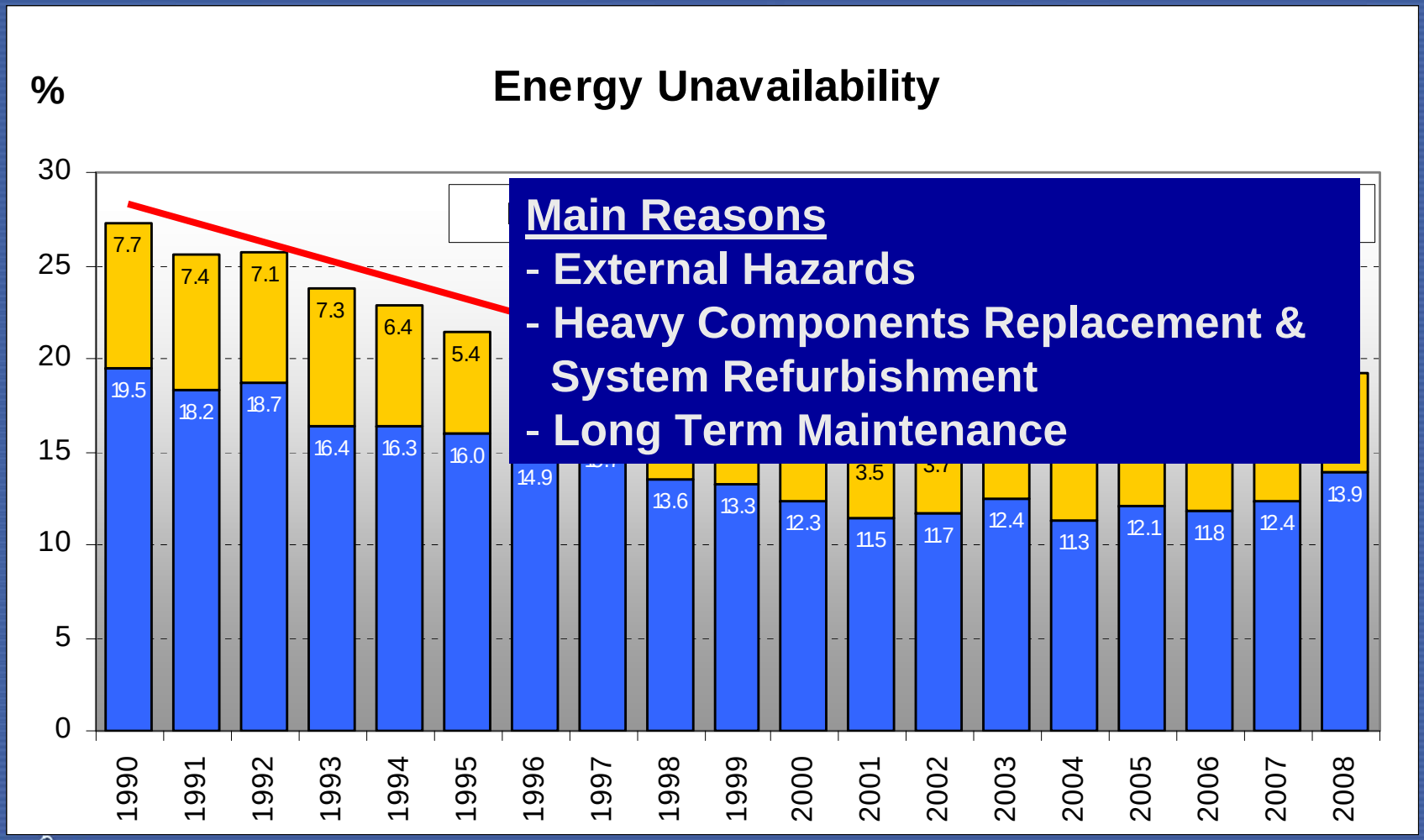
Installed Capacity Utilization

- Continuous increase during last 20 years,
  - Slowed down in recent years
- In 2007 the Energy Availability Factor (EAF) was 81% in average.
  - Half of nuclear reactors operated with EAF above 85%.
- In 1990s an average annual increment was 1% - equivalent to construction of 4 new units every year



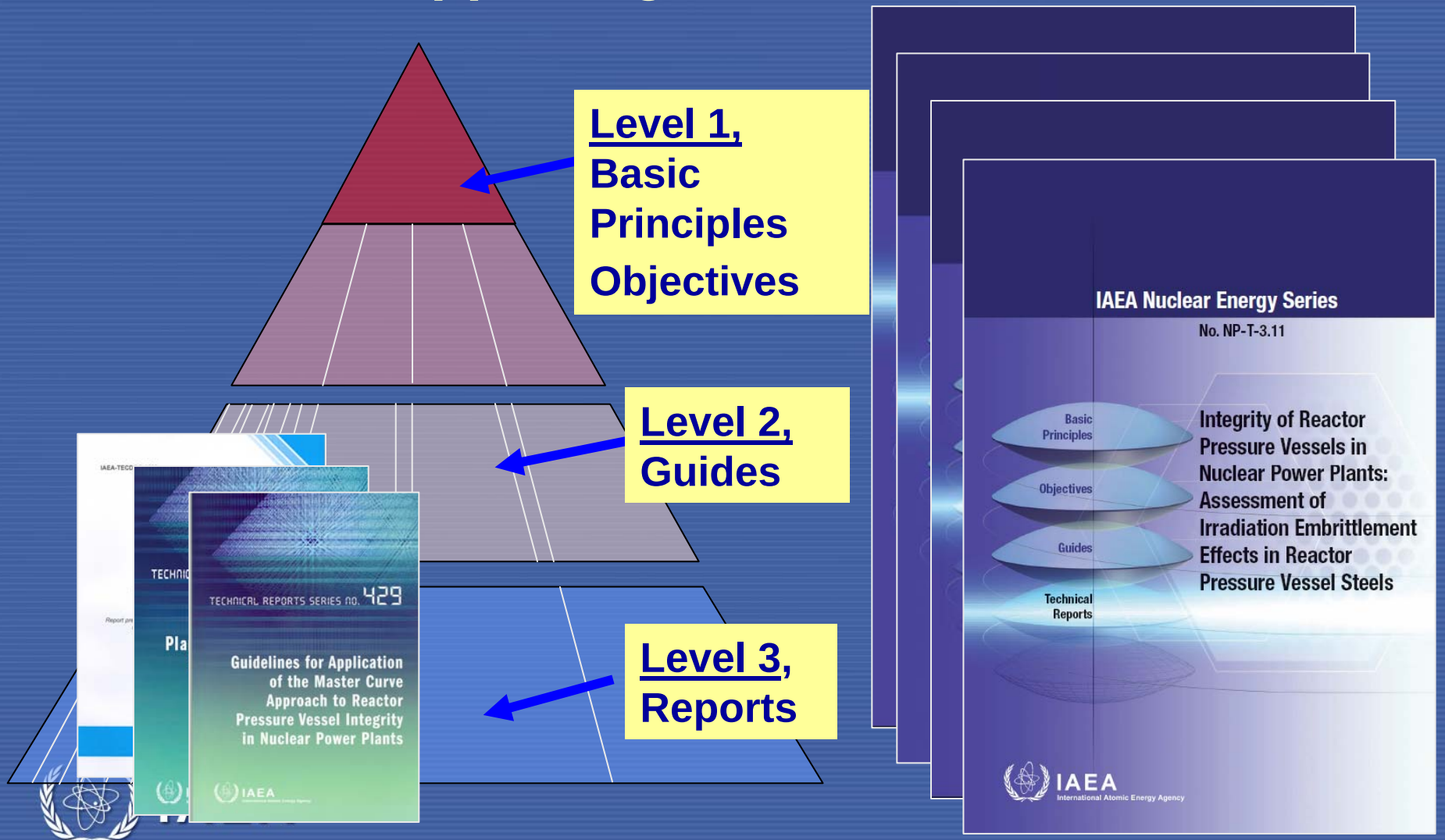
IAEA

Unavailability Trends



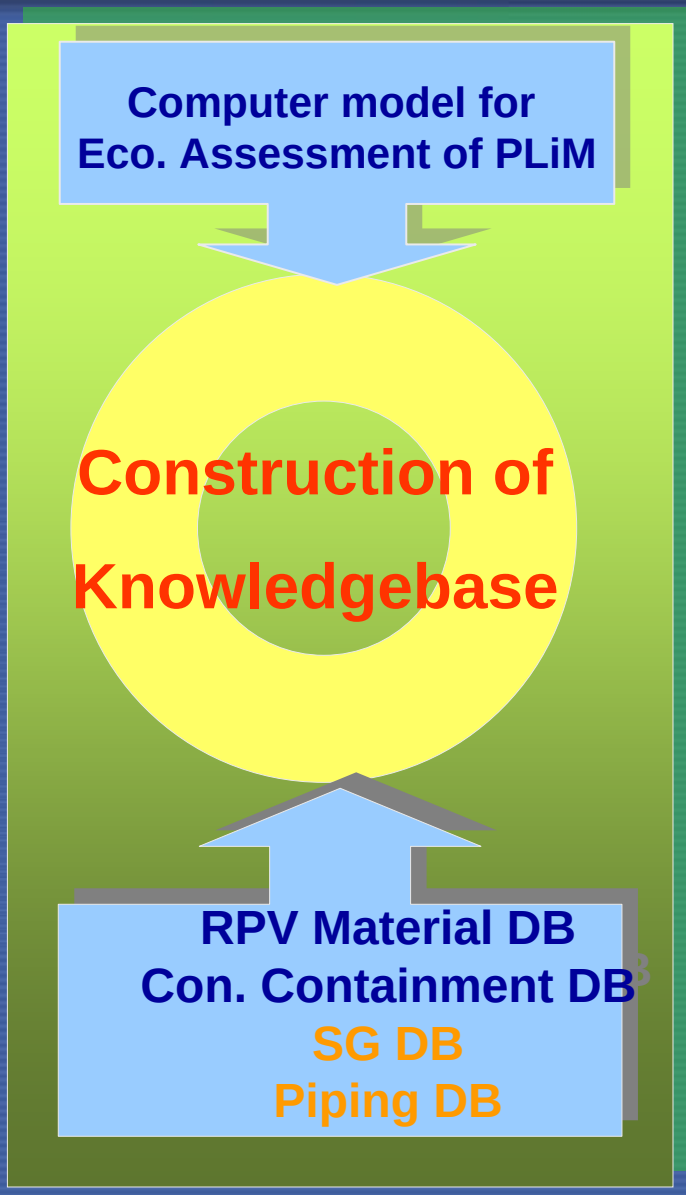
Nuclear Energy Series

Publications supporting the diverse needs of MSs



Basic Structure for Operational Excellence

- **Safety Guidelines**
  - Periodic Safety Review
  - Ageing management
- **Guidelines & Procedures for PLiM**
  - Light Water Reactor
  - Heavy Water Reactor
- **Integrity of System, Structure & Components**
  - RPV, Safety related SSC
- **Ageing Management**
  - Programmatic Guidelines
  - Component specific Guidelines
  - Ageing management review guideline
- **Maintenance and I&C systems**
  - ISI, Reliability Centered Maintenance
  - I&C modernization
  - Condition Based Maintenance



IAEA

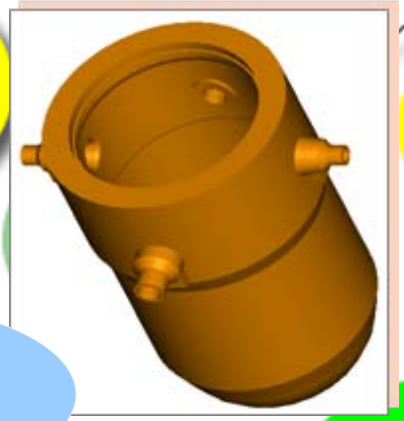
RPV Integrity under Irradiation Damage

Ni/Ni-Mn effect

Cu/P effect with/without Ni

Irradiation damage challenge

Dose rate effects

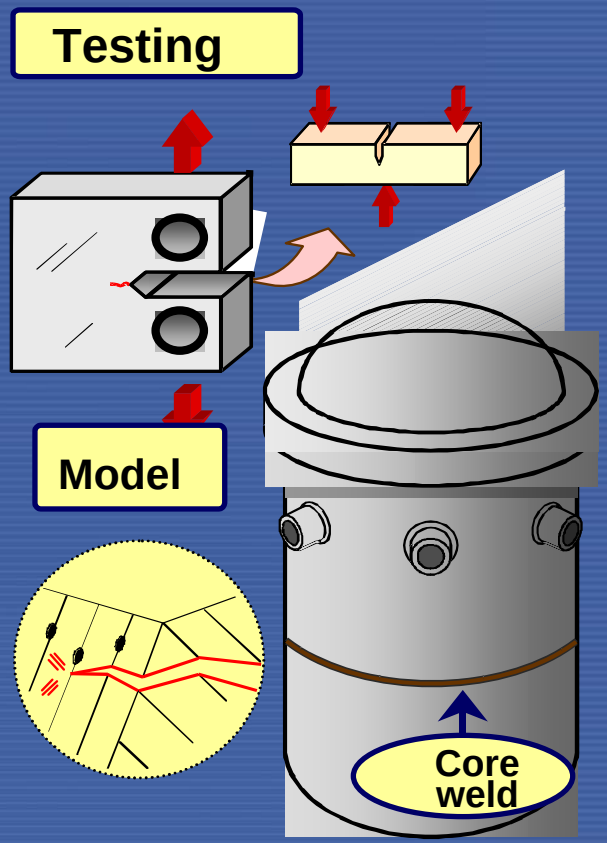


Decrease of USE

Matrix damage

Thermal/Irradiation (C-Mn Effect, Hardening vs non-hardening, etc.)

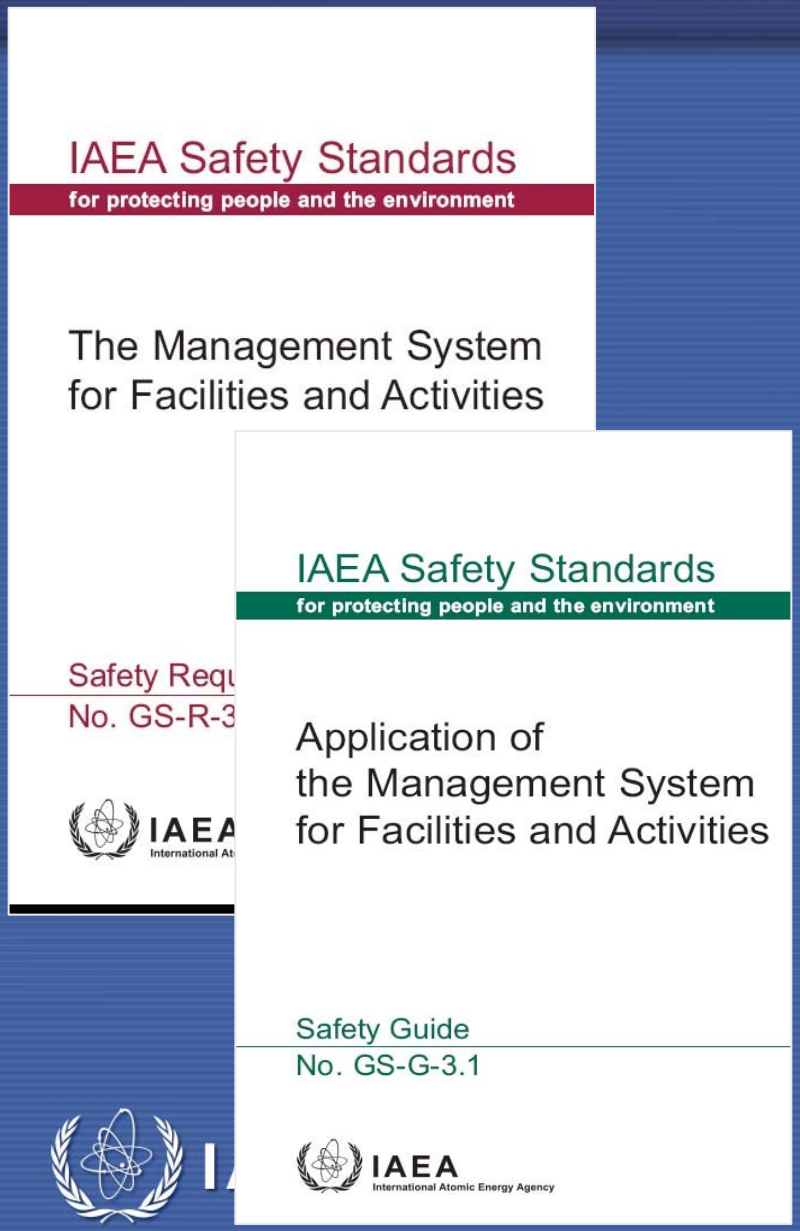
Other V, Mo, Cr, stress cooling rate, etc.

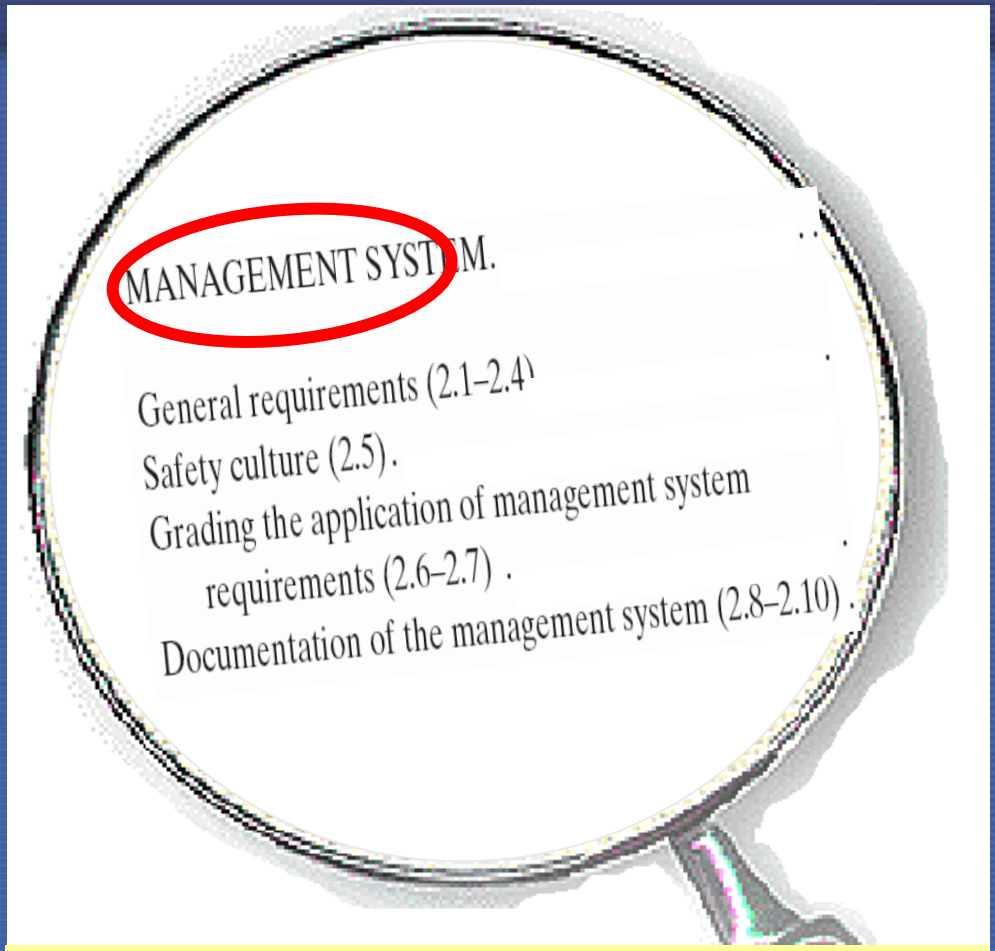


Coordinated Research Projects

After I&C Modernization (Oskarshamn 1 NPP)

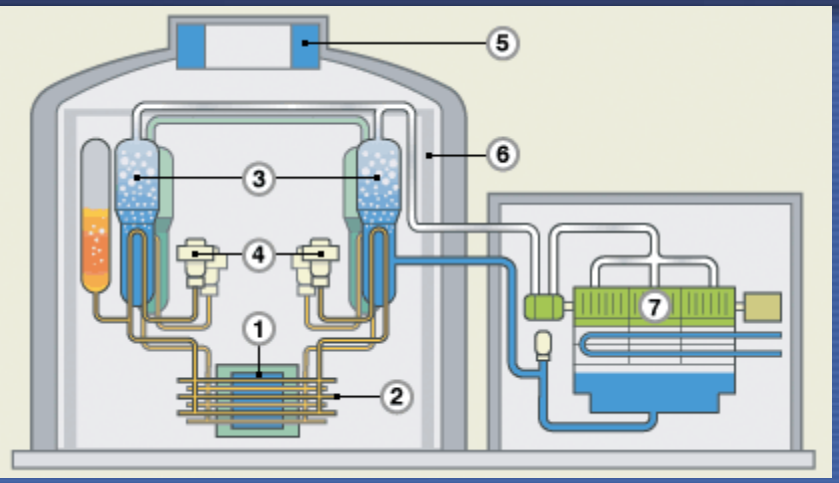
Management System for Nuclear Facilities



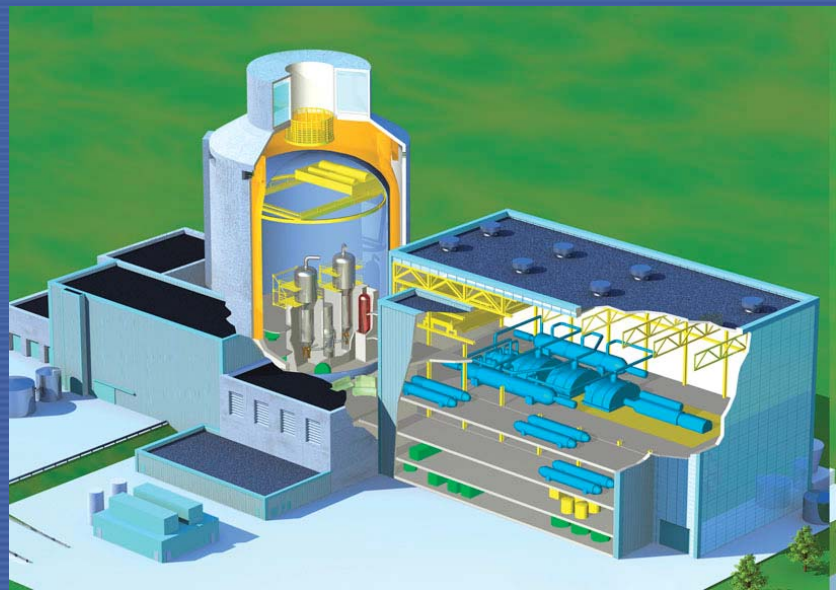


- **Management of resources**
- **Process implementation**
- **Measurement, assessment & improvement**

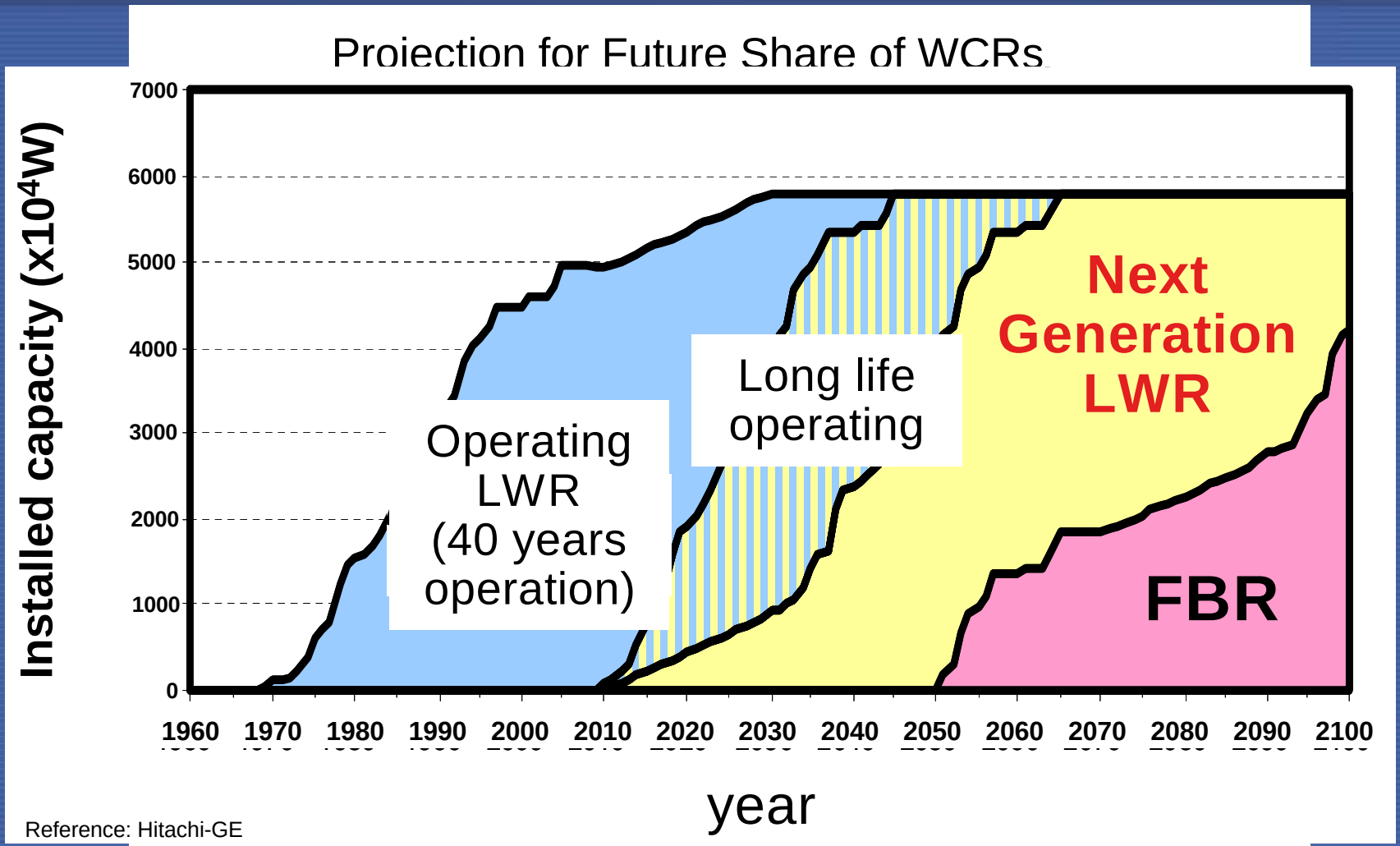
Part 2 : Technology Development for Water Cooled Reactors



http://www.iaea.org/NuclearPower/Technology/WRC/



Projection of WCR Technology



Reference: Hitachi-GE

Reference: MIT

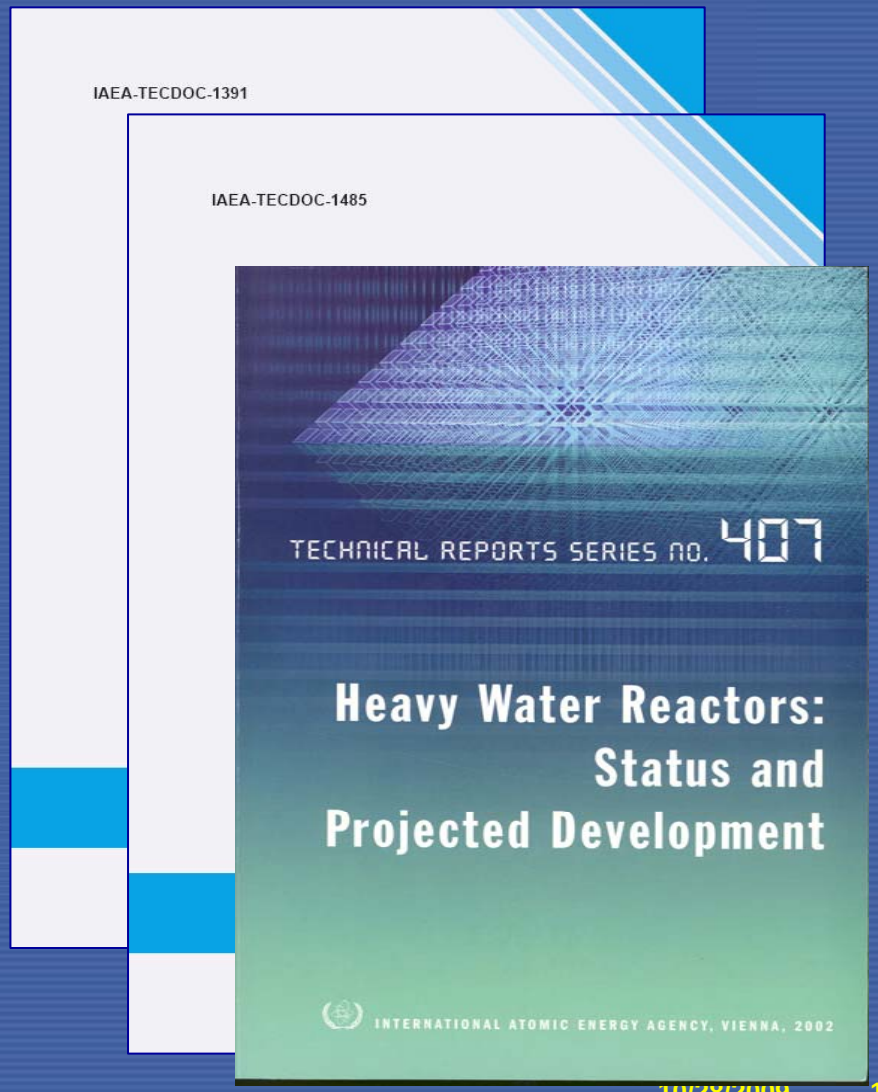
Global Trends in WCR Technology

- **Cost Reduction**
  - Improving construction methods to shorten schedule
  - Modularization and factory fabrication
  - Standardization and series construction
  - Economy of scale → larger reactors
  - Design features for longer lifetime
- **Performance Improvement**
  - Establishment of user design requirements
  - Development of highly reliable components and systems, including “smart” components
  - Improving the technology base for reducing over-design
  - Further development of PSA methods and databases to support
  - Development of passive safety systems
  - Improved corrosion resistant materials
  - Development of computer based techniques
  - Development of systems with higher thermal efficiency and expanded applications

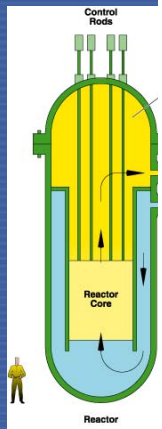
Technical Descriptions of WCRs

- Development goals & safety objectives
- Evolutionary and innovative
- Electricity or co-generation
  - Descriptions – each design:
    - Systems
      - Nuclear
      - Power conversion
      - I&C
      - Electrical
      - Safety
    - Summary level technical data
    - Design measures to enhance economy and reliability

Under Development web-based Status Reports including all reactor lines



Support to Technology Development



:: IAEA THERPRO - Thermo-Physical Materials Properties Database :: - Windows Internet Explorer

http://therpro.hanyang.ac.kr/

:: IAEA THERPRO - Thermo-Physical Materi...

IAEA THERPRO
Thermo-Physical Materials Properties Database

Home | Search | Index | Link | BBS | DB Library | Help | Contact Us
[User Stat.] [Data Upload System] [WorkGroup Member Forum] [WG-Mail]

Manager | MY INFO | LOGOUT | ADMIN | Level : Administrator

Resources for : Home ▸ Search

Compound | Property | -- Select Property -- | Search | Power Search

1 / I A	2 / II A	3 / III B	4 / IV B	5 / V B	6 / VI B	7 / VII B	8 / VIII B	9 / VIII B	10 / VIII B	11 / I B	12 / II B	13 / III A	14 / IV AA	15 / V A	16 / VI A	17 / VII A	18 / VIII A
1 H Hydrogen 1.00794																	2 He Helium 4.002602
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.8457	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (262)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Uun Ununnilium (269)	111 Uuu Unununium (272)	112 Uub Ununbium (277)	113 Uut	114 Uuq Ununquadium (289)	115 Uup	116 Uuh Ununhexium (289)	117 Uus	118 Uuo Ununoctium (293)

*Lanthanides	57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
*Actinides	89 Ac Actinium (227)	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

A : Solid | A : Gas | A : Liquid | A : Synthetic | : Alkali metals | : Alkali earth metals | : Transition metals | : Rare earth metals | : Other metals | : Nonmetals | : Halogens | : Noble gases

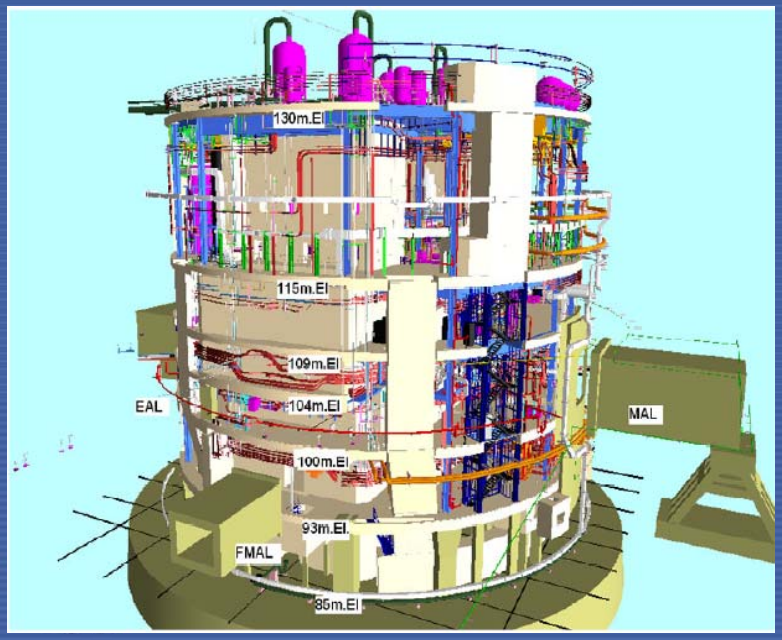
IAEA Designated Center for Nuclear Materials Properties Database Management

TOP

Internet | 100%

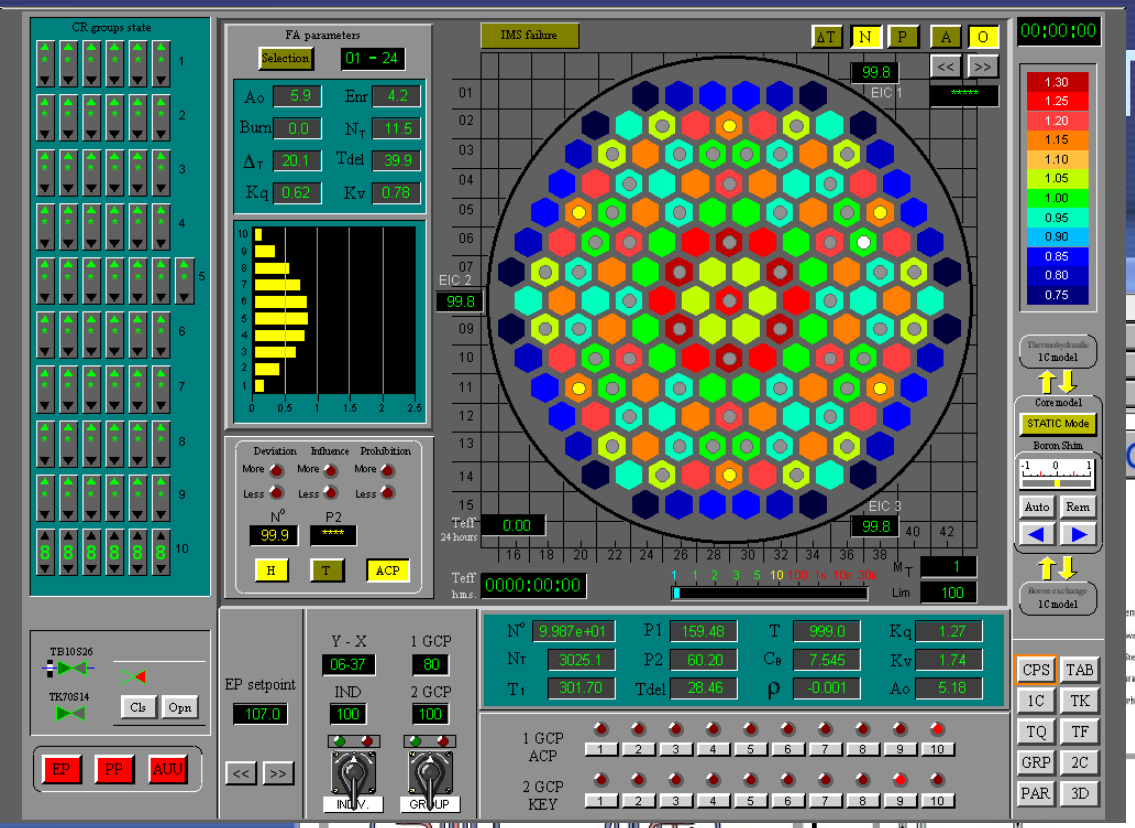
Support to Near-Term Deployment

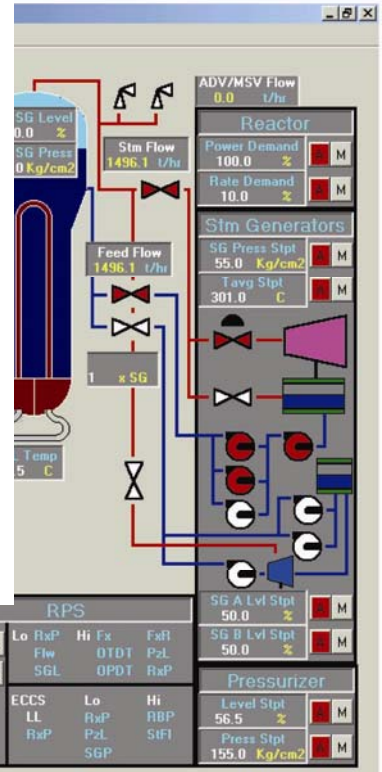
- Advanced Construction Technologies
- Modularization
- Technology Assessment
- Feasibility Studies
- Efficient Use of Water Resources



Training

- Hydro

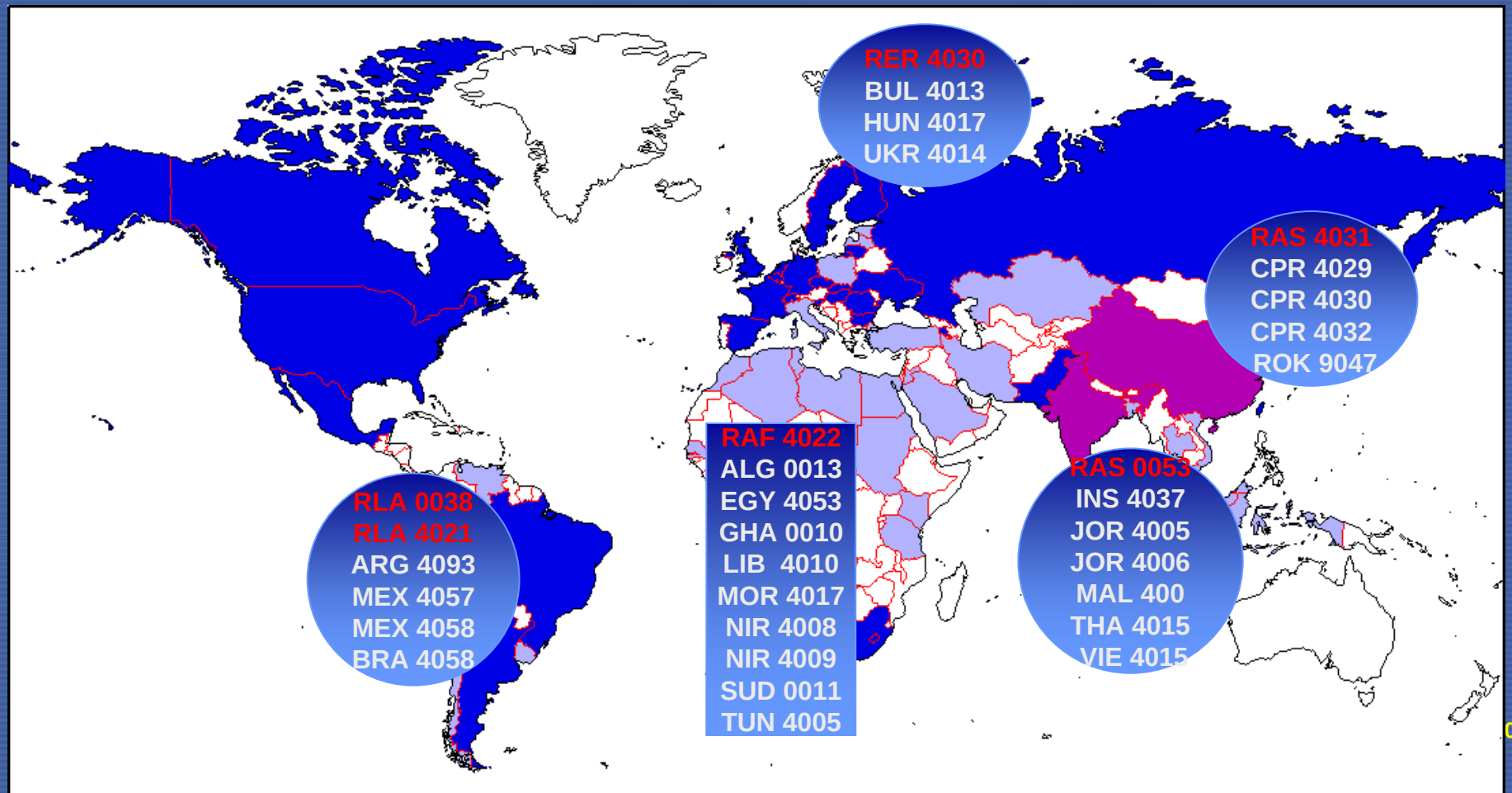




IAEA

Technical Cooperation Activities in 2009~2011

- Enhancing Research Reactor Utilization and Safety (AFRA)
- Sustainable Energy Development and Preparation for Nuclear Power
- Introduction of Nuclear Power for Electricity Generation
- Developing and Implementing PLiM and PLeX Programmes in NPPs
- Establishing a Structural Integrity Assessment Procedure for NPP Components

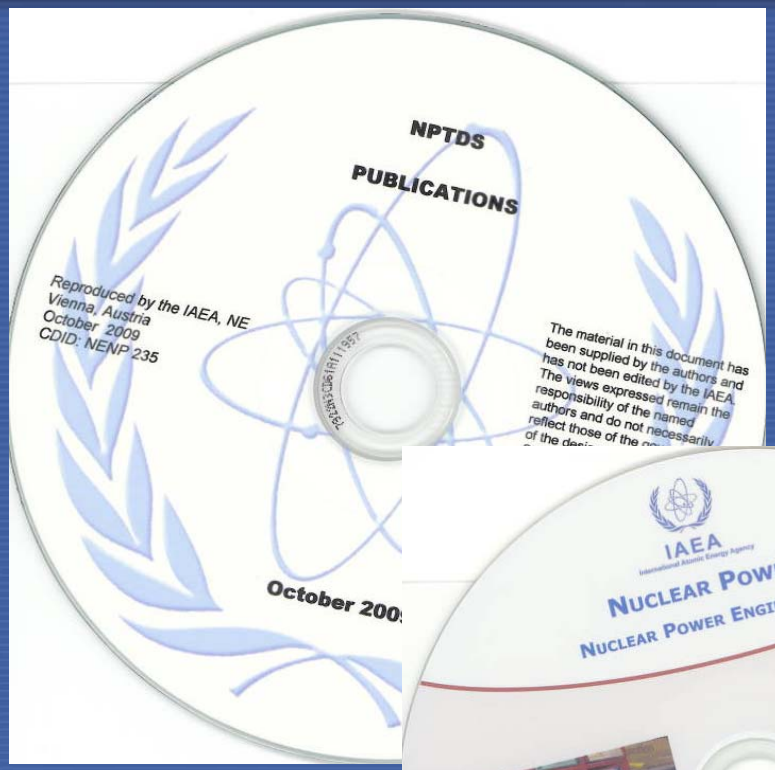


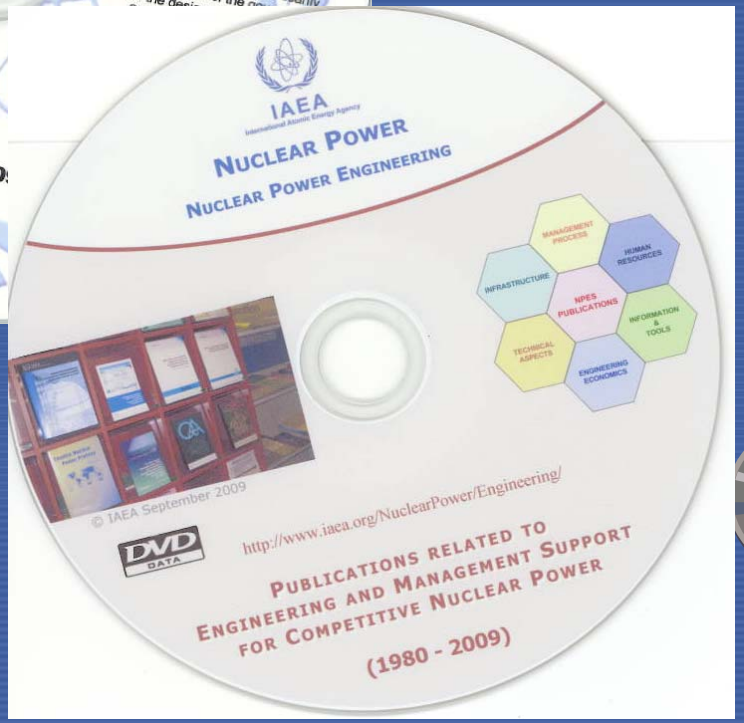
Support to Newcomers in 2010 under Inter-regional TC Projects

- **Promoting Technology Development and Application of Future Nuclear Energy Systems**
  - **Long-range Nuclear Programme Planning and Strategy Development (June, Vienna)**
  - **Project Management for New Nuclear Power Projects (May, Korea)**
  - **INPRO Dialogue Forum on Nuclear Energy Innovations (October, Vienna)**

Main Achievements

Publications on Best Practices & Lessons Learned





IAEA

New Opportunities & Challenges

- **Maintaining efficient & safe operation of existing reactors and research facilities**
  - Aged Nuclear Power Plans and Workforce
  - Decline of government support in some Member States
- **Provide confidence on proliferation and security concerns**
  - Avoid diversion or misuse of nuclear material
  - Technology development on evolutionary/innovative designs
- **Harmonization of safety standards and regulatory requirements**
  - Promote the deployment of internationally standardized reactor designs
- **Facilitating continuous improvement of management system**
  - Support of change management in deregulation and aging plant/personnel
  - Development of leadership and effective management skill
- **Cost Uncertainty and Supply Chain**
- **Support the success of the nuclear renaissance and beyond**
  - Advanced technologies and advanced materials
- **Effective use of fissionable resources**
  - Availability of uranium and minimization of spent fuel