International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)

IAEA Programs on SMRs with specific update on Transportable Nuclear Power Plants (TNPP)

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Regulatory Information Conference
Nuclear Regulatory Commission
March 8-10, 2011 Bethesda MD USA

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Outline

- Roles of IAEA on SMRs
- IAEA Programmes on SMR in 2011
- IAEA Programmes on SMR for 2012 – 2013
- INPRO TNPP Study on legal and institutional issues
- Key Issues in Design Certification and Licensing of SMRs
- Status of Russian TNPP: Floating Nuclear Co-generation Plant (FNCP)
- Summary

Definition and SMR Developments in Member States

- Small-sized reactors: < 300 MW(e)
- Medium-sized reactors: < 700 MW(e)
  - Upper power limit reflects current Large-sized units which can be up to 1700 MW(e)
  - Includes modular or non-modular (built in situ)
- Design Concepts of SMRs have been developed in Argentina, China, India, Japan, the Republic of Korea, Russian Federation, South Africa, USA, France, and several other IAEA Member States
- US and developed countries adopted the term: Small Modular Reactors not IAEA SMR

Roles of IAEA on SMRs

- Coordinate efforts of Member States to facilitate the development of SMRs
- Systematic approach to identify key enabling technologies necessary to achieve competitiveness and reliable performance of SMRs, and by addressing common issues
- Establish and maintain international network with international organizations involved in SMR activities
- Coordination with Member States experts by planning and implementing workshops/training and by facilitating the sharing of information/experience, transfer of knowledge
- Develop international recommendations and guidance on SMRs which address specific needs of developing countries

IAEA Programmes on SMRs in 2011

- Consultancy Meeting on "Status of Innovative SMR Designs with a Potential of Being Deployed by 2020"
  - April 2011 in IAEA - Vienna
- Research Coordination Meeting for the CRP on "Development of Advanced Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors (I31018)"
  - 26 - 28 April 2011 in IAEA – Vienna
- The 3rd Technical Meeting on "Options to Incorporate Intrinsic Proliferation Resistance Features to NPPs with Innovative SMRs"
  - 14 - 17 June 2011 in IAEA – Vienna
- Workshop on Advanced Nuclear Reactor Technology for Near Term Deployment
  - 4-8 July 2011 in IAEA – Vienna
- CM on "Options to Enhance Energy Supply Security with NPPs based on SMRs"
  - 3 -6 October 2011 in IAEA – Vienna
- Workshop on "Technology Assessment of SMR deployable by 2020"
  - 5 – 9 December 2011 in IAEA - Vienna

IAEA Programmes on SMR for 2012 - 2013

- Develop roadmap for technology development, assessment and deployment - including MS requirements, regulatory and business issues
- Define operability, performance, maintainability and constructability indicators to assist countries in assessing advanced SMR technologies
- Develop Guidance and Tool to Facilitate MSs with Planning for SMR Technology Development and Deployment
- Application of CFD Codes for the Design of Advanced Water Cooled Reactors - to prepare for an NE series report on Development Status and Prospects for Advanced Computation Methodologies
- Coordinate a CRP on development of methodologies for the assessment of passive safety system performance in advanced
- Provide education and training on various aspects of SMR technology development and assessment and SMR applications
- Improve economic competitiveness evaluation methodology for SMR

Where to Learn More?

- IAEA-TECDOCs 1451and 1536, IAEA Nuclear Energy Series NP-T-2.2, and IAEA Advanced Reactor Information System (ARIS)
  - Presents many of the available technological options for TNPP and also addresses issues with their deployment

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Transportable NPPs (TNPP)

- TNPP is defined as a transportable and re-locatable nuclear power plant, which is capable of producing final energy products like electricity or heat (e.g., for district heating, process heat, or seawater desalination)
- A TNPP includes the nuclear reactor (with or without fuel) and the balance of the plant (e.g. steam generator, turbine, etc.) and fuel storage facilities, if necessary
- A TNPP is physically transportable, but is designed neither to produce energy during transportation nor to provide energy for transportation

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Technology Options

TRANSPORTATION

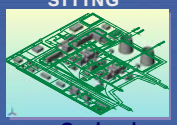
Barge

Railway

Truck

SITING

Barge mounted



On-land

Underwater

REFUELLING

On-site refuelling **Factory refuelling**

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INPRO TNPP Study / Options

- Study underway by INPRO (Institutional and legal issues with TNPP) considers two Options and two Scenarios
- Option 1 (more challenging)
  - TNPP is factory assembled, supplier fuels and nuclear tests TNPP and ships with fuel, supplier maintains and refuels and then decommissions the TNPP
- Option 2
  - TNPP is factory assembled, factory pre-tested (non-nuclear), maintained, then fuelled and refuelled onsite

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INPRO TNPP Study / Scenarios

- Scenario 1
  - The supplier provides, operates and takes back the whole TNPP, including the spent fuel. The TNPP is operated by the supplier. The TNPP is regulated and licensed by the host state.
- Scenario 2
  - The supplier provides and takes back the whole TNPP, including the spent fuel. The TNPP is operated by an entity established and staffed by the host country. The TNPP is regulated and licensed by the host state.

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Specific issues

Legal and Regulatory

- national nuclear legislation of vendor and recipient countries
- legal implications in case the plant is not solely transported through national territories waters
- sharing responsibility for liability and security
- compatibility of regulations in the supplier and host states
- new regulatory and licensing approaches
- responsibility for operation and supervision
- transport of a fuelled reactor
- emergency planning
- waste management
- applicability and adequacy of existing IAEA Safety Standards

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Specific Issues

Security and physical protection

- malevolent attack to the reactor or to fuel during transport (sea or river)
- stealing or hijacking of fuel or reactor during transport
- malevolent collisions
- physical protection of the plant during operation
- coordination of security arrangements by the operator with the national security organisation
- applicability and adequacy of existing IAEA Security Series

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Specific Issues

Transport

- transport on national territorial water
- transport on international water
- transport on rivers
- transport of a reactor with fresh fuel
- transport of a reactor with irradiated fuel
- transport of a contaminated reactor vessel without fuel
- transport of activated parts
- transport of radioactive waste
- compliance with current package requirements
- package or reactor vessel as a package testing
- approval by multiple national competent authorities
- applicability and adequacy of existing IAEA Safety Standards

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Specific Issues

Environmental protection

- large contamination of sea water or river water during transport
- large contamination of sea water or river water during operation
- effect on the environment
- applicability and adequacy of existing IAEA Safety Standards

Siting

- effects of external events associated to with the location of the plant (tides, waves, wind)
- response to earthquakes and tsunami
- impact of other floating ships
- possible fire due to dispersion of oil by tanks or other accidents
- diffusion of radioactive substances released directly in the water
- applicability and adequacy of existing IAEA Safety Standards

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Specific Issues

Design

- definition of the design basis associated with the site and special condition of operation
- implication of the design basis on the actual design of TNPPs
- anchoring systems, recipient structures
- connection to a very small and unstable grid (or no grid at all)
- emergency energy supply (current designs claim complete independence from the land supply)
- protection against flooding
- modality and equipment for refuelling
- sinking of the floating reactor
- applicability and adequacy of existing IAEA Safety Standards

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Possible Benefits of TNPPs

- Reduced requirements for infrastructure, reduced associated costs
- The host states may need only limited facilities for the storage and management of fresh and spent nuclear fuel
- The TNPP site can be easily restored to a non-nuclear condition
- The investment cycle length and construction costs can be lower than for a land based NPP of the same capacity
- Regional service centres may help with maintenance (and refuelling)
- National or regional centres may provide training to host state staff
- Decommissioning of TNPPs is provided by the supplier
- Availability of a TNPP could allow some countries to make a decision to introduce nuclear power earlier according to supply requirements

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Identified Challenges

Option 1 – factory fuelled reactors

- Factory fuelling and zero-power testing with subsequent delivery of the assembled reactor to the user
- Transportation issues of a TNPP (safety, security, environmental impacts) for the case when the TNPP is shipped with fuel in the reactor core
- Nuclear liability with specific reference to liability during TNPP transportation (a TNPP with fuel in the core may need international liability coverage)
- Safeguards issues for TNPP fuelled in the supplier state and exported: How will host state fulfill safeguards obligations with no access to fuel on the site?
- Shipment of the whole reactor at end of life with used fuel back to the factory for refurbishment, repair and/or refuelling

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Preliminary Conclusions of the INPRO TNPP Study

- Legal instruments covering, in particular, nuclear material and issues of security and physical protection are, in general, applicable to innovative nuclear installations such as TNPP
- IAEA safety standards and security recommendations would be applicable to the different phases and options of TNPP transportation, siting, commissioning and operation

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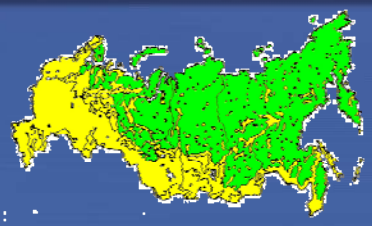
Small power systems – key to energy security for Russia



Vast territory (2/3 with decentralized power supply), low population density, significant length of Arctic and Far Eastern borders and rigorous climate require robust sources of electric power and thermal energy

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Prospective Sites of Floating Nuclear Co-Generation Plants (FNCPs)

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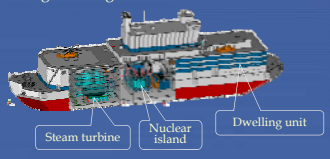
FNCP – Main Features

Floating power unit (FPU) – nuclear facility designed as a rack-mount type vessel; regulated by Russian Maritime Navigation Register.



Length, m	140,0
Width, m	30,0
Hull height, m	10,0
Draught, m	5,6
Displacement, t	21 000
Installed capacity	
• Electrical, MW	70 / 38
• Thermal, Gcal/h	50 / 146,8
Construction period	4 years
Output	
• Electric power, mln.kW.h/y	455 / 210
• Thermal, th.Gcal/y	350 / 900

Coastal and hydraulic facilities (CHF)
– basic civilian construction and regulation

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Floating Power Unit Safety Approach

1 – FUEL
2 – FUEL ROD COVER and ASSEMBLY
3 – PRIMARY LOOP
4 – NUCLEAR ISLAND CONTAINMENT
5 – CENTRAL MODULE CONTAINMENT

- Radiation impact on population and environment in normal operation and in case of any emergency situation should not exceed natural radiation background.
- Non-radiation impact comprises heat pollution and water muddied by hydraulic facilities construction. This impact remains within acceptance limits.

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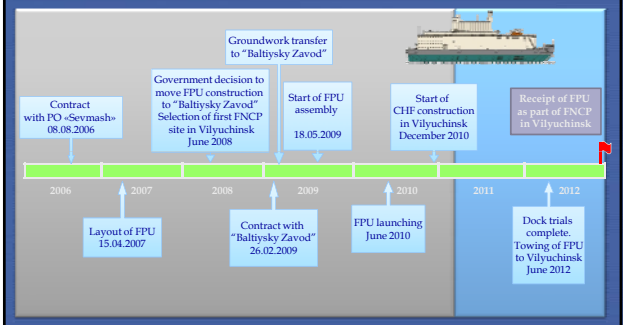
Milestones of the First FNCP Construction



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Floating Power Unit at Baltiysky Zavod's berth

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FPU Hull Construction at "Baltiysky Zavod"

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TNPP "Akademik Lomonosov" (mid-2010)

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Two KLT-40S reactors of "Akademik Lomonosov"

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Vilyuchinsk site where "Akademik Lomonosov" will start operation in 2013

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Engineered structures in support of "Akademik Lomonosov"

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FlexBlue (DCNS, AREVA-TA, CEA France) A factory built; underwater TNPP

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FlexBlue

- FlexBlue is a cylindrical unit 100 metres in length and 12 to 15 metres in diameter. Inside is a small nuclear power reactor and steam generators and turbines necessary to produce 50 to 250 MWe.
- Over the next 2 years DCNS, AREVA-TA, EDF and CEA will perform detailed reviews of:
  - technical and production options;
  - market potential;
  - comparison with other sources of Energy
  - nuclear proliferation issues; and
  - safety and security aspects of seafloor power plants

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Implications on IAEA future activity

- The Agency needs to be prepared to provide assistance to Member States interested in TNPP reactors
- Necessary actions:
  - acquire available knowledge
  - assess the adequacy of the current legal instruments
  - detailed check of applicability and completeness of current Safety Standards
  - identify existing gaps
  - prepare appropriate documents to provide guidance and assistance

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THANKS

FOR

YOUR ATTENTION

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