

Nuclear Power in Romania

Selection of lead technical partner(s)

in Romania

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Estonia, Tallinn
October 23, 2009

Contents



- Nuclearelectrica – Basic information
- General (Politics, Trends)
- Status of the Cernavoda Units 3&4 Project
- CANDU Technology
- Conclusions

Nuclearelectrica's Structure



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Shareholders:

- Romanian State – 90.28%
- Property Fund – 9.72%

Main Activity: Electrical Power and Heat Production, NPP Construction and Commissioning and Nuclear Fuel Fabrication

SNN S.A.

Cernavoda NPP – Units 1&2

Nuclear Fuel Plant Pitesti

Safe & Efficient operation of
Units 1&2 – CANDU-6: 700 MWe

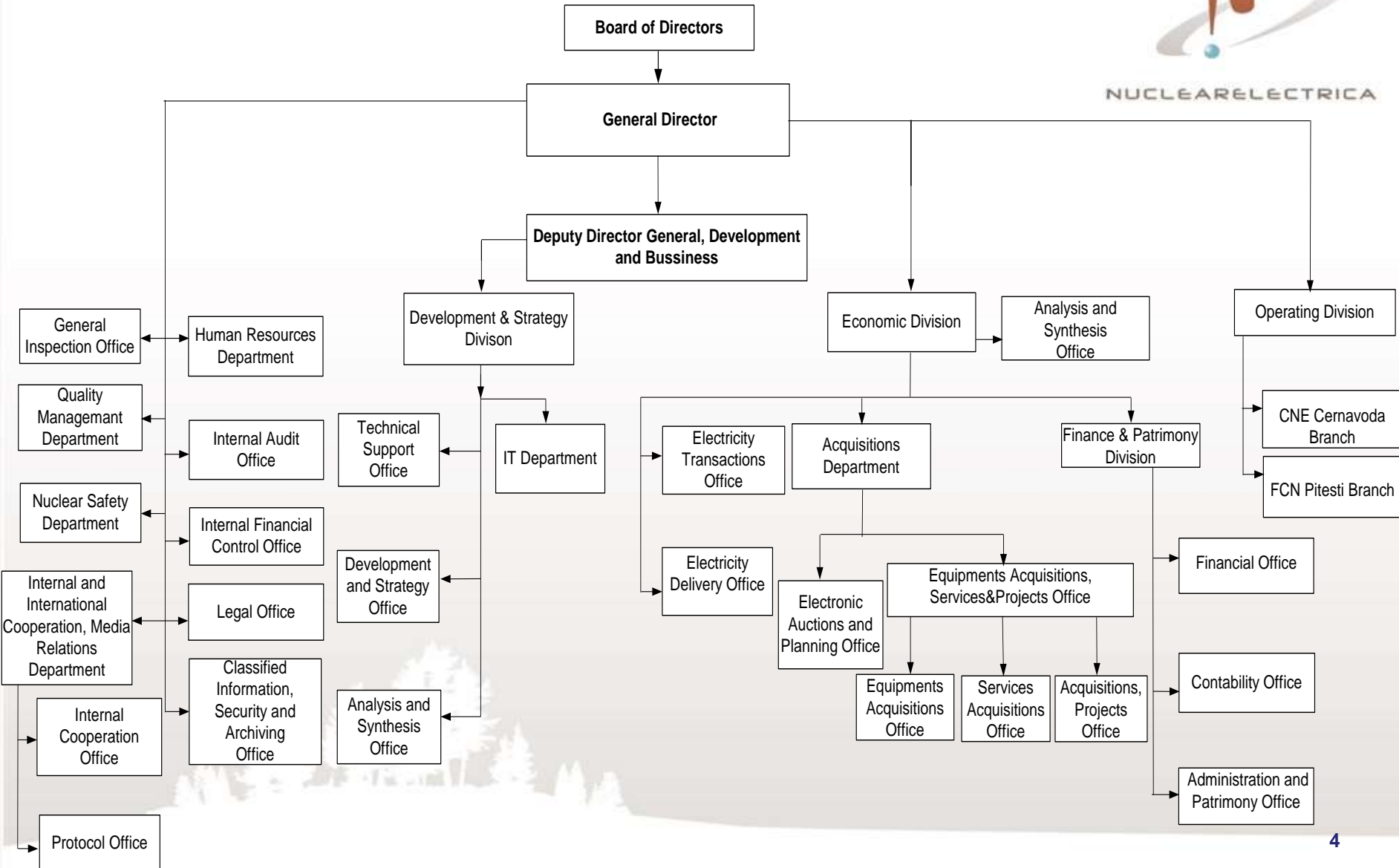
Nuclear fuel fabrication for two units



Nuclearelectrica's Organizational Chart



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The European Climate and Energy Targets



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(7 October 2009 / NucNet News N° 70)

- Today, in the EU, our primary energy supply is 80% dependent on fossil fuels. Reinventing the EU energy system on a low carbon model is one of the critical challenges of the 21st Century.
- The EU has put in place a comprehensive policy framework, including among others: the climate and energy targets for 2020 and a carbon price through the Emissions Trading System.
- It must to deliver, both in terms of the 2020 targets and, in the longer term, aiming for an 80% cut in greenhouse gas emissions by 2050 compared to 1990 levels.
- There are different possible pathways to a low carbon economy. Clearly, no single measure or technology will suffice, and the precise mix in each country will depend on the particular combination of political choices, market forces, resource availability and public acceptance.

An EU Energy Security and Solidarity Action Plan Second Strategic Energy Review



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A five-point EU Energy Security and Solidarity Action Plan (November 2008), focusing on:

- Infrastructure needs and the diversification of energy supplies
- External energy relations
- Oil and gas stocks and crisis response mechanisms
- Energy efficiency
- Making the best use of the EU's indigenous energy resources.

An EU Energy Security and Solidarity Action Plan Second Strategic Energy Review (cont')



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- As a first step, the priorities identified by the Commission as essential for the EU's energy security: the Southern gas corridor, a diverse and adequate LNG supply for Europe, effective interconnection of the Baltic region, the Mediterranean Energy Ring, the need for adequate North-South gas and electricity interconnections within Central and South-East Europe, and the North Sea Offshore Grid.
- As a second step, the Commission's intention to identify and to communicate to the Council and Parliament by 2009/2010, the specific actions necessary to ensure the realization of these projects in practice.
- As a third step, the intention of the Commission to consider tabling on the basis of the response to Green Paper, in 2010, a new EU Energy Security and Infrastructure Instrument, building on the existing TEN-E instrument.

European Parliament adopts energy recommendations

World Nuclear News 04 February 2009



- The EP adopted by a large majority a report drawn up by French Member of the European Parliament (MEP) Anne Laperrouze on the *Second Strategic Energy Review*, which will be discussed at the 19-20 March European Council debate on the EU's future energy strategy.
- Among the main recommendations made in the report for the EU's future energy strategy is a call for the European Commission to draw up a "specific road map for nuclear investments".
- However, the MEPs stressed that nuclear energy is to be used "at the highest technologically possible level of safety." They added that the EU's neighboring countries should also adopt European nuclear safety standards every time a new nuclear plant is planned or an old one is upgraded.

EU adopts binding legal framework for nuclear safety

(FORATOM Flash July 2009)



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- On 25 June, at an Environment Council in Luxembourg, the European Council adopted a Directive establishing a new Community framework for nuclear safety based on the principle of the further harmonization of safety standards at nuclear installations across the EU.
- The objective of the Directive is to ensure the independence of regulators and will contribute to improving public acceptance of nuclear energy by giving EU citizens guarantees regarding safety at nuclear facilities.
- The new Directive on Nuclear Safety will also further emphasize how the safety of workers at nuclear facilities and the protection of the environment remain of paramount importance.
- The Directive, which is legally binding, still needs to be transposed into national legislation by Member States and they have two years to complete transposition. It will enter into force three weeks after its publication in the Official Journal of the European Union. Within the context of global nuclear expansion Europe is a pioneer since the Directive is the first legally-binding framework on nuclear safety to be adopted by any region.

EC Adopts EUR 50 Billion Plan For New Energy Investment

(7 October 2009 / NucNet News N° 70)



- Markets and energy companies acting on their own are unlikely to be able to deliver the needed technological breakthroughs within a sufficiently short time span to meet the EU's energy and climate policy goals.
- The European Commission (EC) has adopted a proposal called 'Investing in the Development of Low-Carbon Energy Technologies', asking for the public and private sectors to help invest an additional 50 billion euro (EUR) over the next 10 years in low carbon technologies including nuclear in order to address climate change, secure European energy supply, and secure the competitiveness of EU economies. This means almost tripling investment in energy technology research in the EU from EUR 3 billion to EUR 8 billion a year.

World Bank - Crisis

(Standard.ro 23 June 2009)



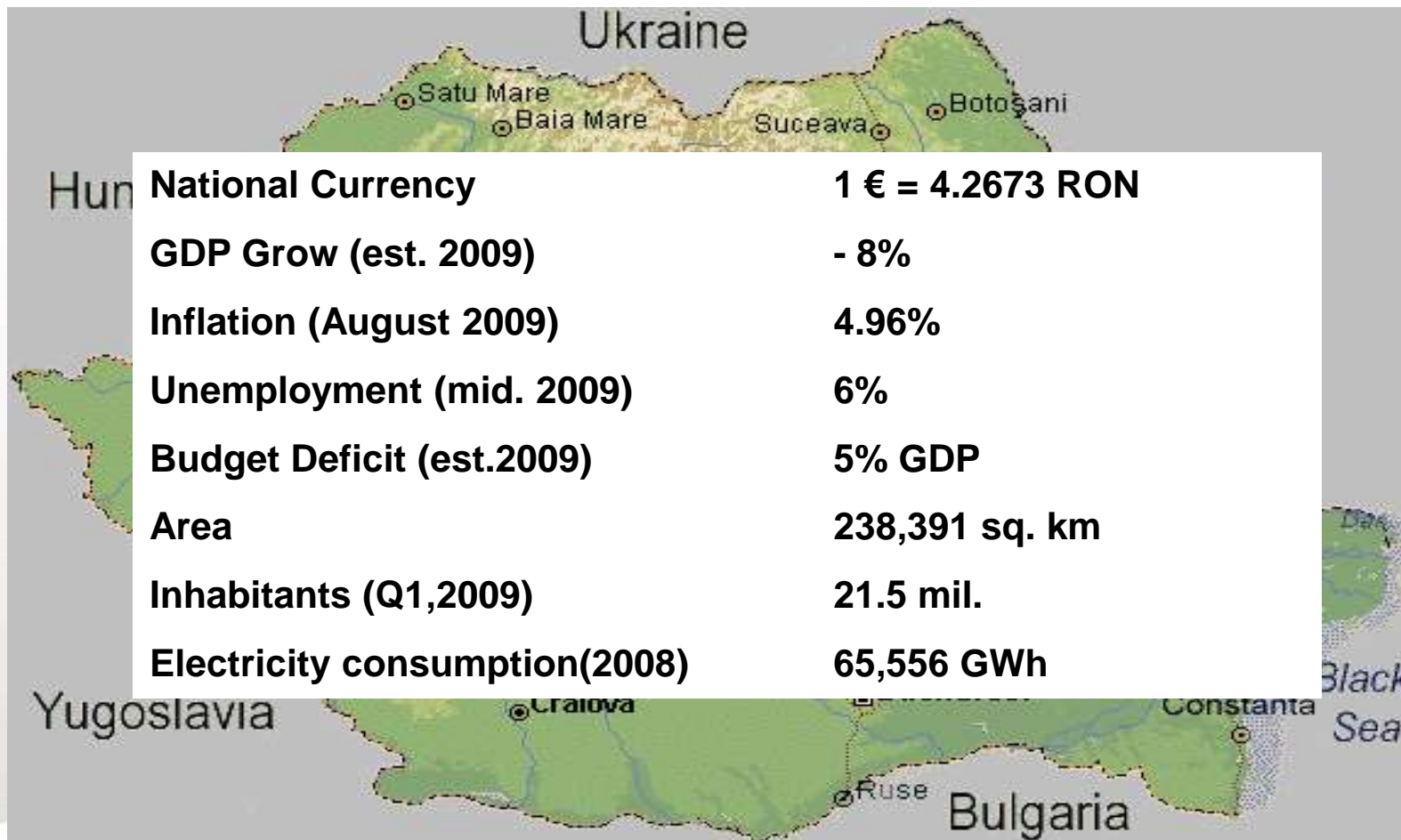
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- Hard Times!
- This year, the world economy is contracting by 2,9%, followed by a growth in 2010 (estimated rate at 2%), according to published report on World Bank website

Romania



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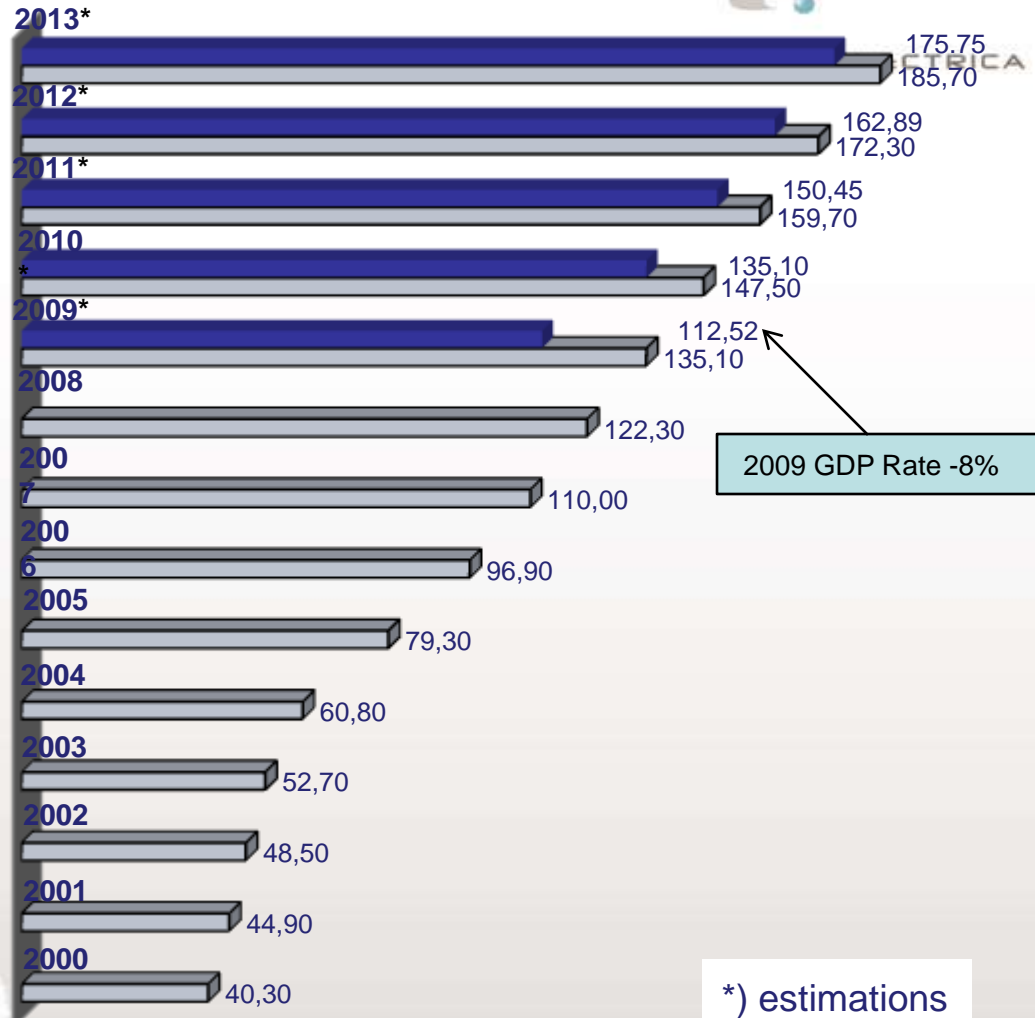


EURO versus RON

1st Jan 2008 – 1st Oct 2009



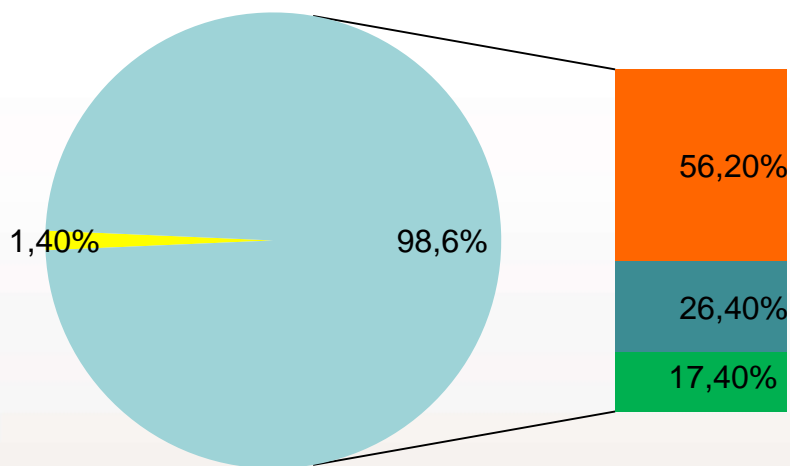
Crisis – Romania's GDP



*) estimations

2008 Electricity in Romania

Total resources – 65,556.8 mill. kWh



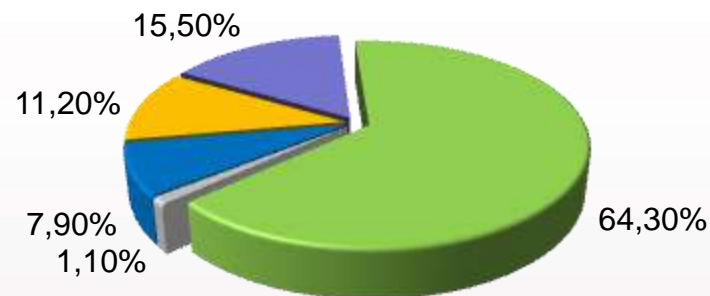
- Thermal Power stations
- Hydro Power Stations
- Nuclear Power Stations
- Import

Consumption by Destination



NUCLEARELECTRICA

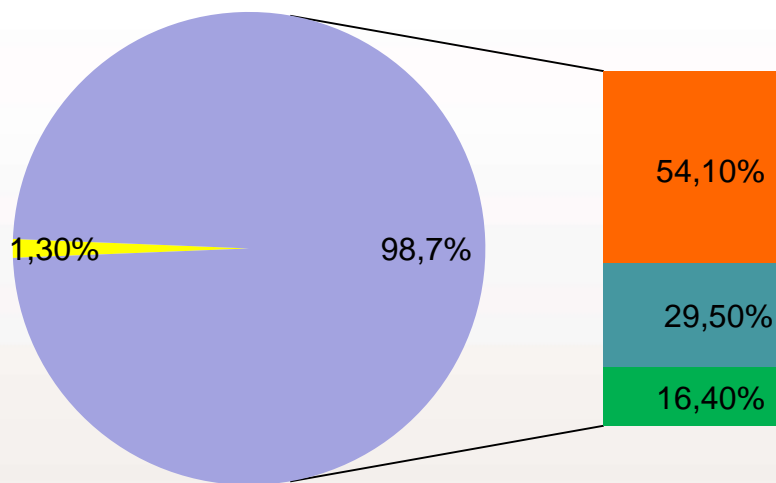
Total destinations – 65,556.8 mill. kWh



- Technological own consumption in networks and power station
- Population consumption
- Consumption in economy
- Public illumination
- Export

January – August 2008 Electricity in Romania

Total resources – 43,894.7 mill. kWh



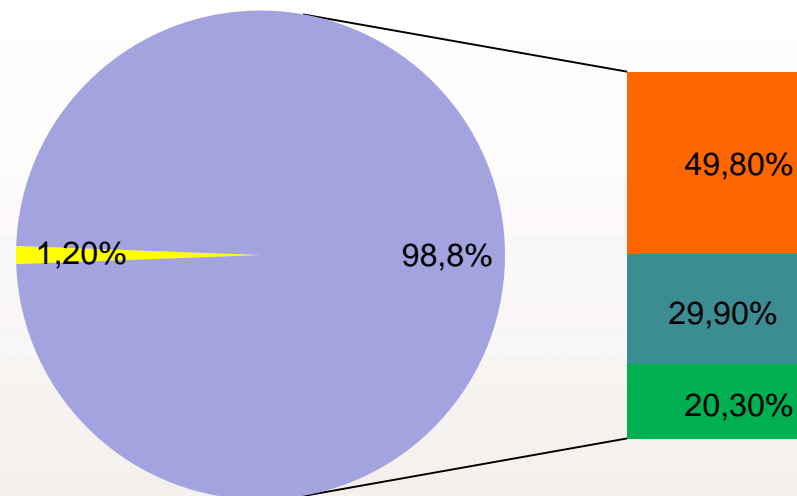
■ Thermal Power stations ■ Hydro Power Stations
■ Nuclear Power Stations ■ Import

January – August 2009 Electricity in Romania



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Total resources – 38,468.6 mill. kWh



■ Thermal Power stations ■ Hydro Power Stations
■ Nuclear Power Stations ■ Import

Europe feels a certain chill

WNN 13 May 2009



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- Major utilities in Europe have weathered the economic storm, with meteorological conditions mitigating a general drop of about 6% in electricity use across Europe.

However,

Global Demand For Nuclear Will Continue To Rise

(NUCNET News in Brief / No. 45 / 21 April 2009)



- Global Demand For Nuclear Will Continue To Rise, Says ElBaradei
- The economic crisis could delay the implementation or expansion of nuclear power programmes in some countries for a limited period, but in the medium and long term global demand for energy will continue to increase significantly as countries everywhere seek to improve living standards, the director-general of the International Atomic Energy Agency (IAEA) has said.
- Mohamed ElBaradei told the International Ministerial Conference on Nuclear Energy in Beijing that although nuclear power is not a panacea for all the world's energy problems, it will continue to play an important role in the global energy mix. The OECD Nuclear Energy Agency's (NEA) high projection is for global nuclear power capacity to grow by around 66 percent by 2030, he said.

Global Demand For Nuclear Will Continue To Rise (cont')

(NUCNET News in Brief / No. 45 / 21 April 2009)

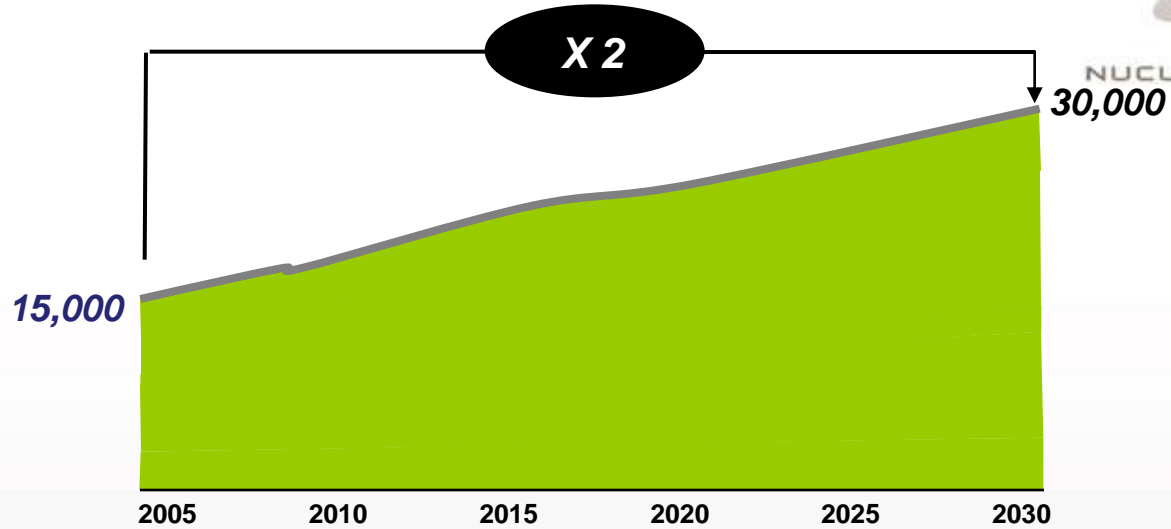


- “There are now 436 nuclear power reactors in operation in 30 countries. Growth targets have been raised significantly here in China, in India and in the Russian Federation. Asia remains the focus of growth in nuclear power.”
- The attraction of nuclear energy is supported by the improved performance of the nuclear energy industry since the 1980s. The world has now accumulated more than 13,000 reactor-years of experience, Mr ElBaradei said.
- “Improvements in safety have been matched by improvements in efficiency. Nuclear plants are more economical to run, availability and productivity have increased and there is less down-time for maintenance.”

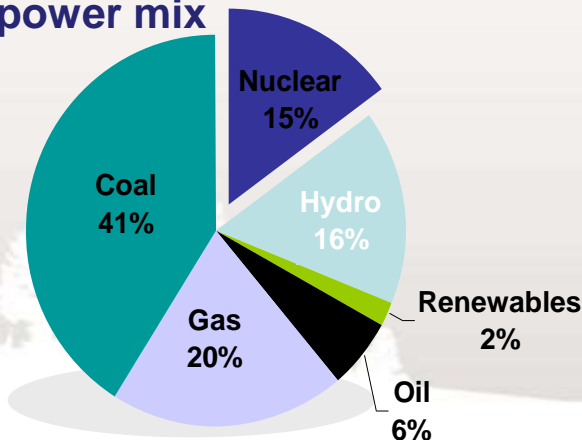
Global Demand For Nuclear Will Continue To Rise (cont')



- ▶ Worldwide electric power generation (in TWh)



- ▶ 2008 – Worldwide distribution of electric power mix

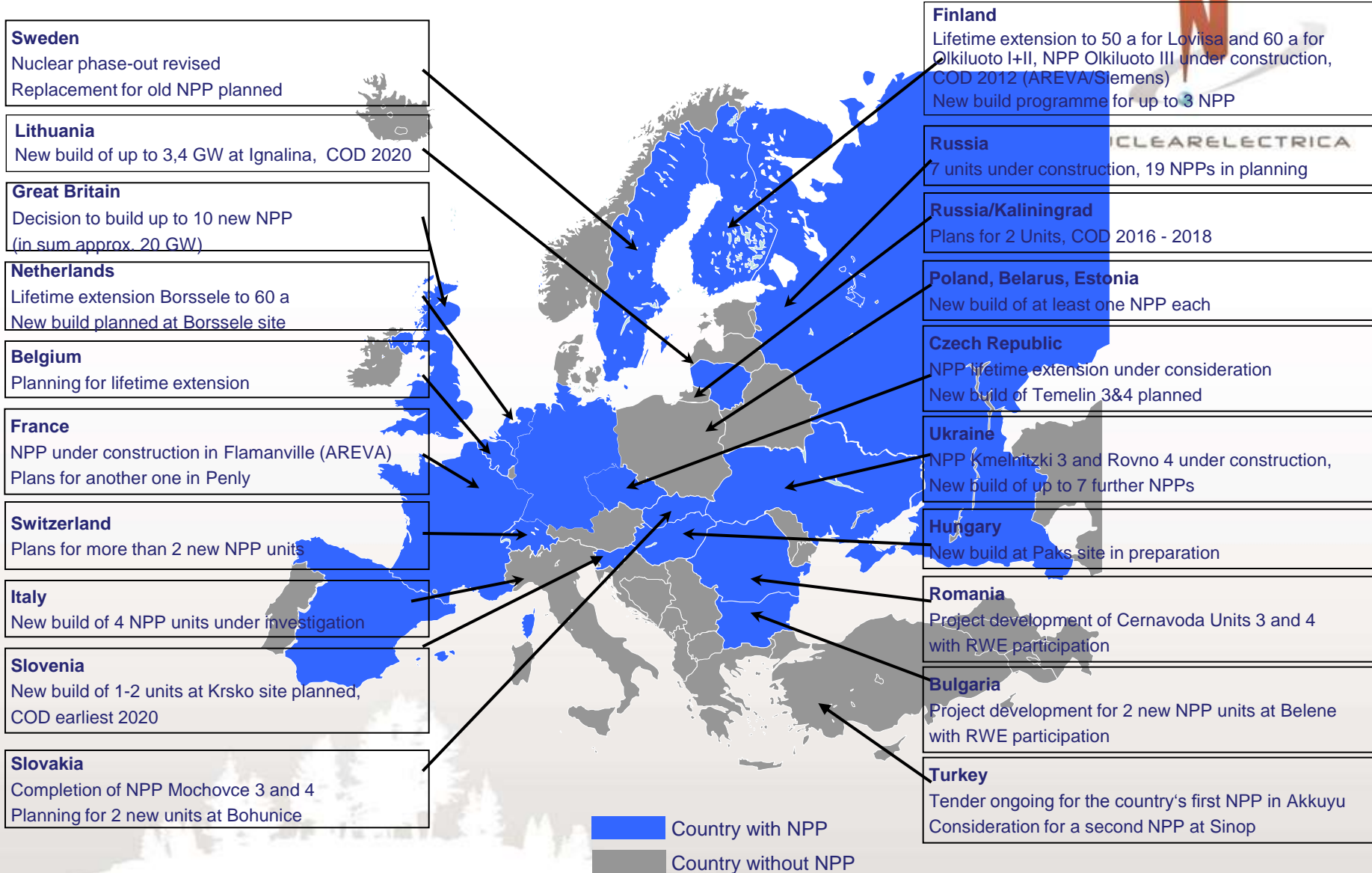


- ▶ Capex in the Power sector expected to reach \$13.8 trillion²⁰⁰⁷

- ◆ \$6.8 trillion in T&D
- ◆ \$6.8 trillion in generating capacity

Sources: World Energy Association (March 2009), IEA-World Energy Outlook (2008)

Nuclear new build in Europe



Sweden
Nuclear phase-out revised
Replacement for old NPP planned

Lithuania
New build of up to 3,4 GW at Ignalina, COD 2020

Great Britain
Decision to build up to 10 new NPP
(in sum approx. 20 GW)

Netherlands
Lifetime extension Borssele to 60 a
New build planned at Borssele site

Belgium
Planning for lifetime extension

France
NPP under construction in Flamanville (AREVA)
Plans for another one in Penly

Switzerland
Plans for more than 2 new NPP units

Italy
New build of 4 NPP units under investigation

Slovenia
New build of 1-2 units at Krsko site planned,
COD earliest 2020

Slovakia
Completion of NPP Mochovce 3 and 4
Planning for 2 new units at Bohunice

Finland
Lifetime extension to 50 a for Loviisa and 60 a for
Olkiluoto I+II, NPP Olkiluoto III under construction,
COD 2012 (AREVA/Siemens)
New build programme for up to 3 NPP

Russia
7 units under construction, 19 NPPs in planning

Russia/Kaliningrad
Plans for 2 Units, COD 2016 - 2018

Poland, Belarus, Estonia
New build of at least one NPP each

Czech Republic
NPP lifetime extension under consideration
New build of Temelin 3&4 planned

Ukraine
NPP Kmelnitzki 3 and Rovno 4 under construction,
New build of up to 7 further NPPs

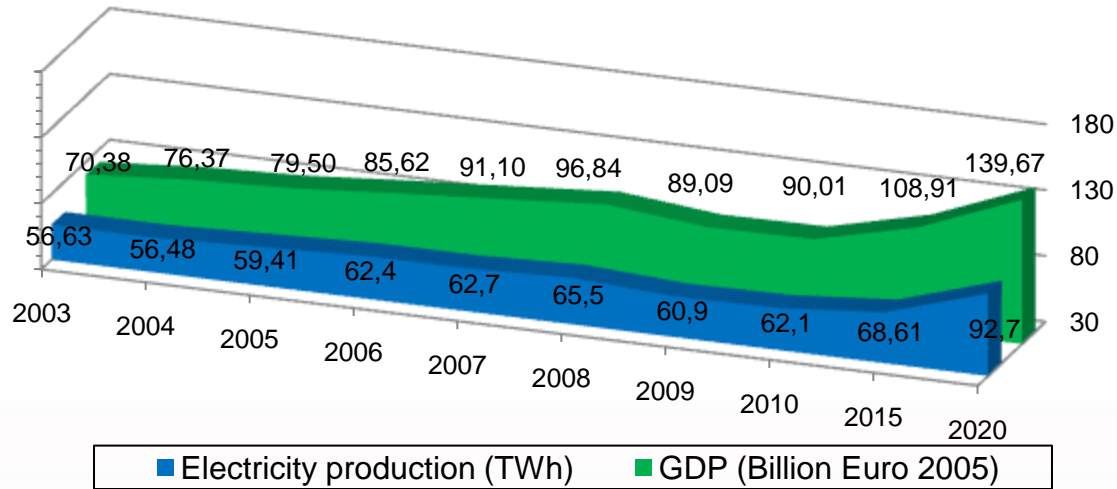
Hungary
New build at Paks site in preparation

Romania
Project development of Cernavoda Units 3 and 4
with RWE participation

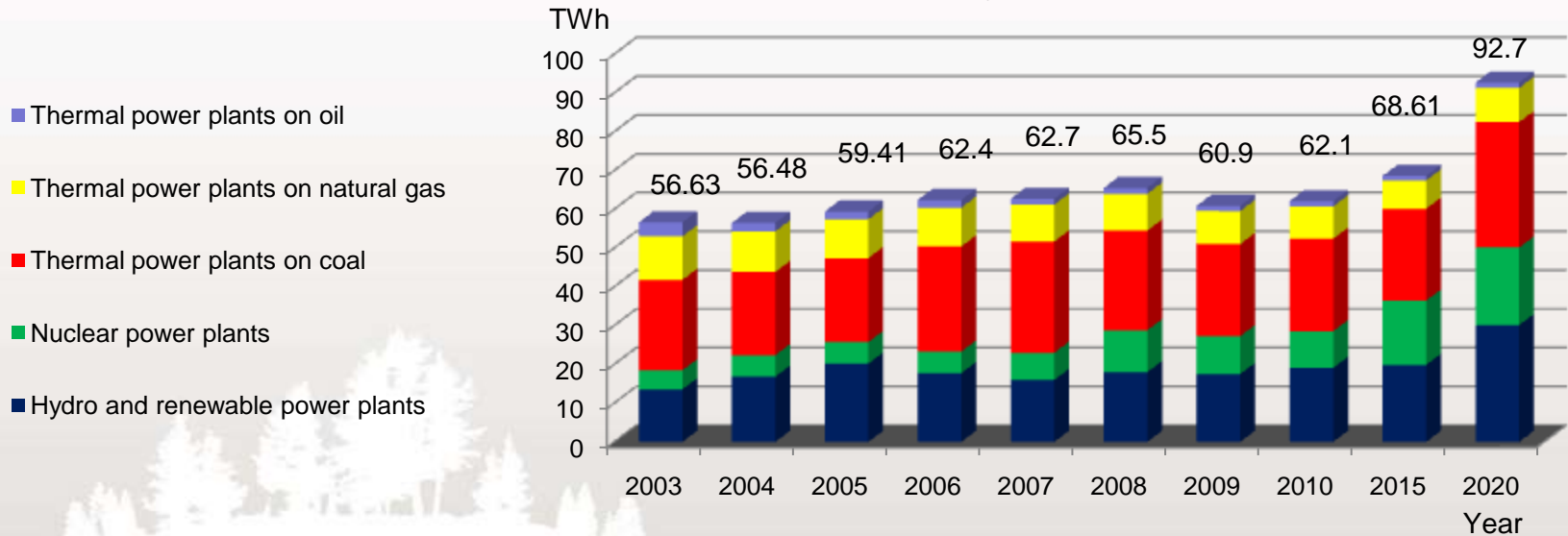
Bulgaria
Project development for 2 new NPP units at Belene
with RWE participation

Turkey
Tender ongoing for the country's first NPP in Akkuyu
Consideration for a second NPP at Sinop

Romanian Electricity Production Forecast



Gross Electricity Production Structure



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Project Cernavoda Units 3 and 4: Overview



Description

- Construction of two nuclear power plant units 3 and 4 (Canadian CANDU technology 2x720 MW) on existing nuclear power plant site Cernavoda, Romania
- RWE, Enel, GDF Suez, CEZ, Iberdrola and Arcelor Mittal together with Romanian SNN have established the SC Energonuclear project company for development, construction and operation
- Turn-key contract (EPC) approach is base for negotiations
- Operation of nuclear power plant units 3 and 4 by O&M company with Romanian operator SNN.
- Expected electricity from units 3 and 4 ca. 10-11 TWh/a; 12% from overall country production; investors receive part of it according to their share of the PCO



Timeline

- Aug 2007 Approval of Strategy for Investors Selection
- Oct 2007 Binding offers
- Nov 2007 Selection of the preferred investors
- Dec 2007 Start of the negotiations
- Dec 2008 Concluding of the Investors Agreement (IA)
- Mar 2009 Registration of PCO
- End 2010 Start of the Project Phase
- 2016/2017 Connection to the grid

The investors selection process



Negotiation Commission

Stakeholders representatives

- Nuclear Agency
- Ministry of Economy
- Ministry of Foreign Affairs
- Nuclearelectrica

BIS – Evaluation criteria

Profile of investors

- Committed to invest at least 50,000,000 EUR
- Experience in power generation or as large power consumers

Specific criteria for power generation companies

- Installed capacity (MW) of nuclear reactors currently in operation or in operation in the last ten years
- Installed capacity (MW) of non-nuclear plants currently in operation or in operation in the last ten years
- Experience of managing the construction of nuclear power plants in last twenty years (MW)
- Number and classification of reported nuclear incidents in the last ten years

Specific criteria for large power consumers

- Average annual electricity demand over the last five years
- Electricity demand in the next ten years

Investment grade rating

- BBB or better under the (Standard and Poor) or Baa or better (Moody's)

Equity commitment

Commitment to fund pre-project activities

Adherence to the project model and the investor agreement

Cernavoda Units 3 and 4 from an Investors prospective



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Safe

- **Newest regulatory requirements** are considered by CNCAN
- Comprehensive EIA under ESPO convention including public hearings
- SNN is an experienced operator with an internationally proven reputation (WANO)
- CANDU6 is a safe technology with a successful track-record over the last decades
- **Usability of existing structures** must be proven and guaranteed

Reliable

- Romanian nuclear infrastructure is well developed through the last 20 years
- **Broad support** from politics and most of the population
- **Risks are shared** among several experienced investors
- Mitigating measures to be implemented for smooth execution
- Project structure suitable, but state majority causes **unforeseen challenges**

Viable

- For business development **CSEE is a key region**
- Strong presence of **private companies** creates interest on financial market
- **Economic viability** based on 2006 feasibility assumptions – to be updated for FID

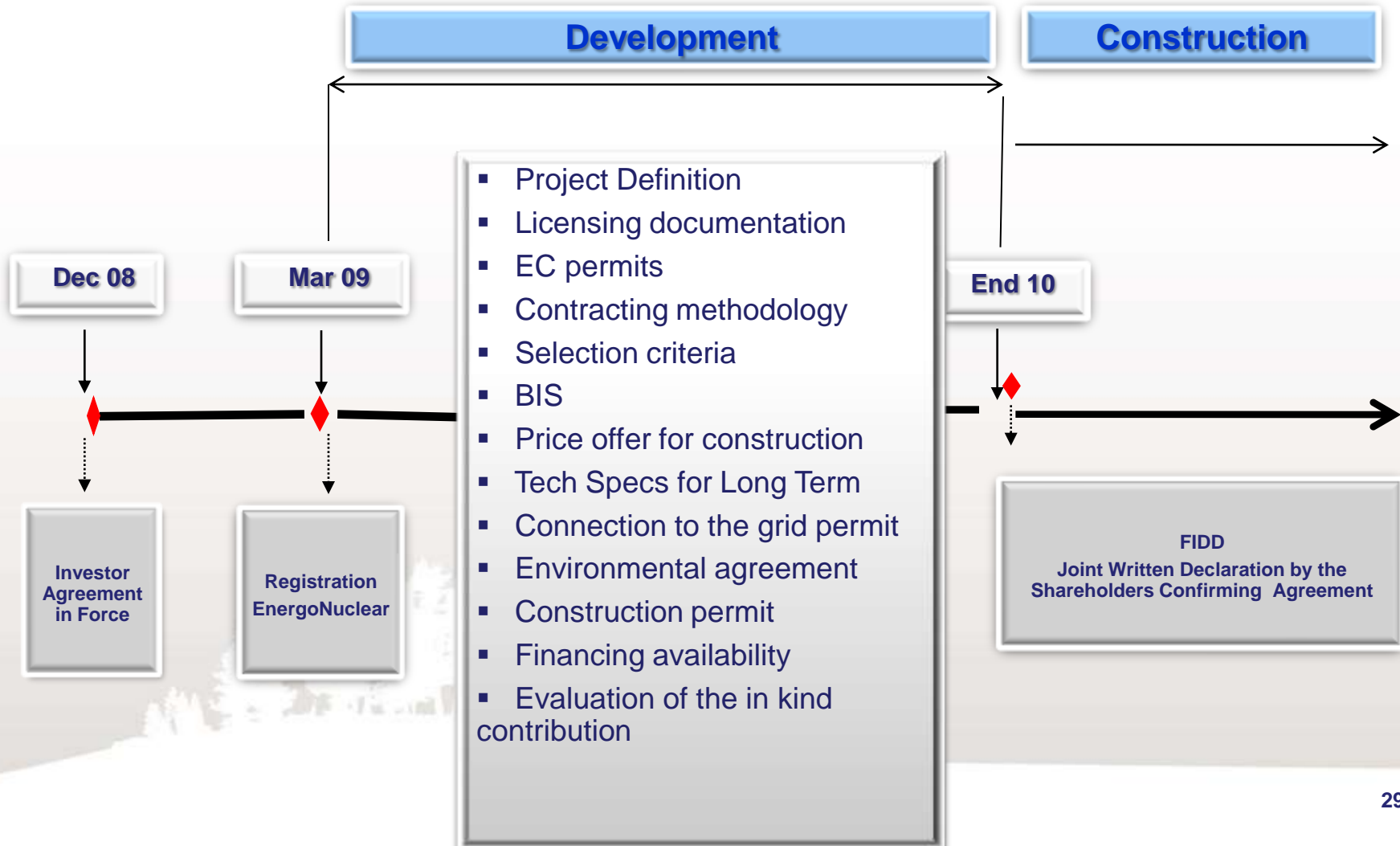
Sustainable

- **Sustainability of environment** for an investment into nuclear has to be proven during pre-project phase
- **Maximum professionalism** is needed, because time is money
- A nuclear project is a long term partnership of all shareholders – we show and expect clear **commitment**

Cernavoda Units 3 and 4 - Project Milestones



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Pre - project approach



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TEAM

One representative
from each investor

Sub -TEAMS

- EPC
- Off-Take
- Supply
- O&M
- Financing
- RDW

EnergóNuclear

Consultants

Potential
contractors

- Prime contractor
- Sub-contractors

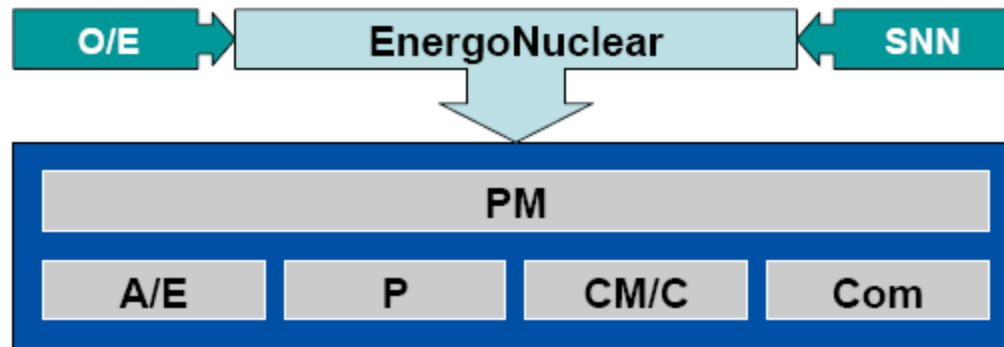
Objectives of the Project Model



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- Single point of responsibility for a turnkey-type EPC contract.
- Obtaining overall performance guarantees for the units.
- Limit risk for the owner by obtaining assurances regarding on-time and on-budget execution of the works.
- Conscious risk allocation to the party which can manage it best.
- Understand cost driver and control of the project costs.
- Ensure bankability of the resulting contract.

Project Model for Public Procurement Procedure



- EnergoNuclear wants to sign one contract for a full scope plant delivery: turnkey handover at 100% full-power
- Owners obligations are fulfilled together with O/E and SNN (e.g.QA/QS, Com staff and materials, ...)
- PPP starts with an Invitation for Participation with preference for a prime contractor (Consortia allowed)

Scope	Description
PM	Overall Project Management with responsibility for budget and schedule for the plant delivery
A/E	Architect Engineering for the whole plant (NSP+BOP) with responsibility for safety and performance of the design
P	Procurement of all goods and services necessary to erect the plant with responsibility for QA/QS
CM / C	Construction Management and Construction of the whole plant with responsibility to involve local subcontractors
Com	Commissioning until handover at 100% power with responsibility for appropriate involvement of owners staff

Why CANDU for Romania?



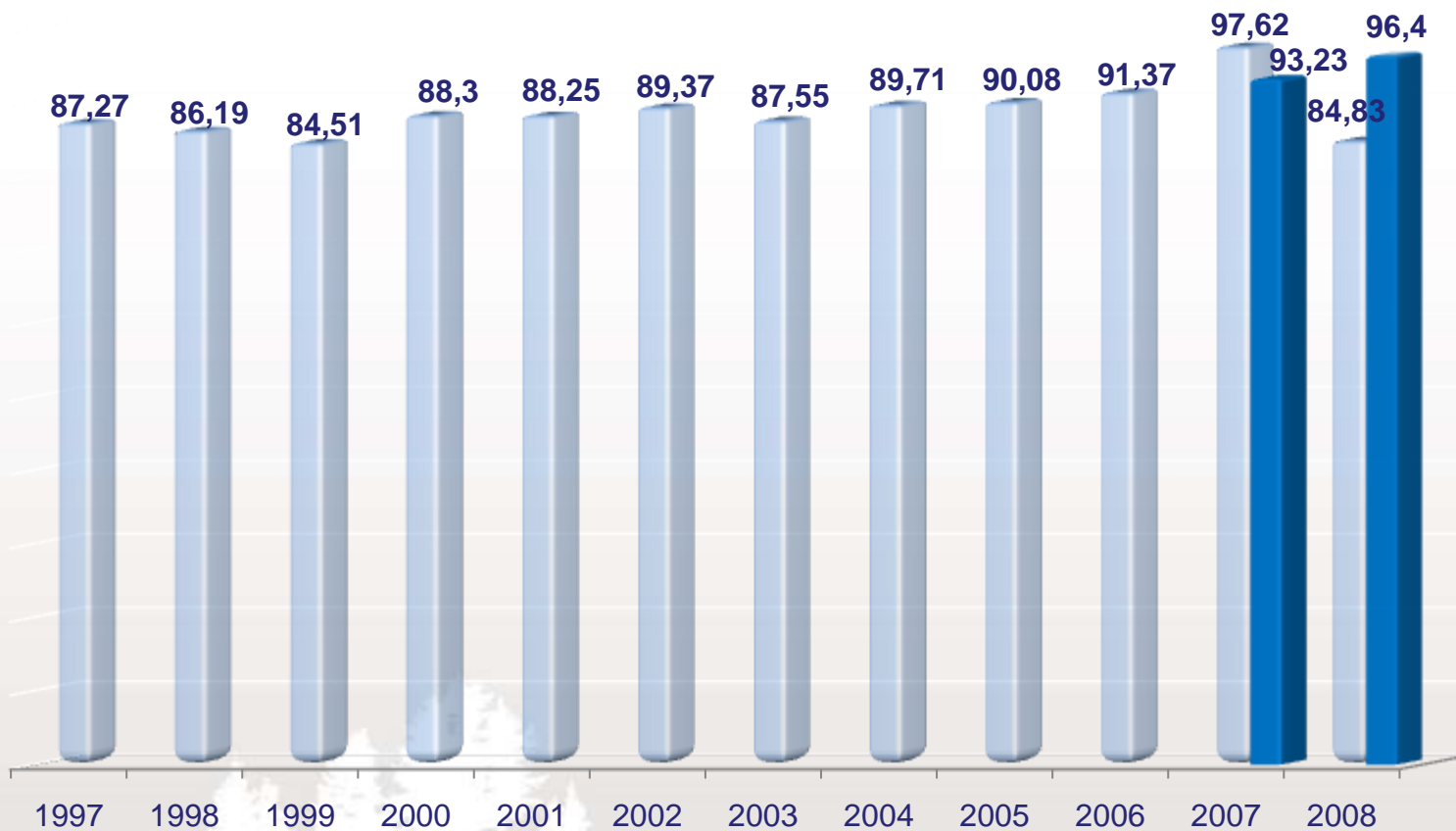
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- Historically point of view- 70's
 - Political decision – energy independency of the country
 - Internal resources of natural uranium
 - Appropriate size of the unit (700 MW) for Romanian grid
 - Knowledge about heavy water and fuel fabrication process
 - Licenses for NSP (AECL) and BOP (ANSALDO) and TG (GE)
 - Technology transfer for equipment materials fabrication
- Today- Cernavoda 3 and 4 Units
 - Cernavoda site designed for 5 units
 - Existing infrastructure in design, engineering, nuclear fuel, heavy water equipment and materials
 - Expertise in operation and maintenance the units
 - Availability of skilled staff

Gross Capacity Factor for Units 1&2



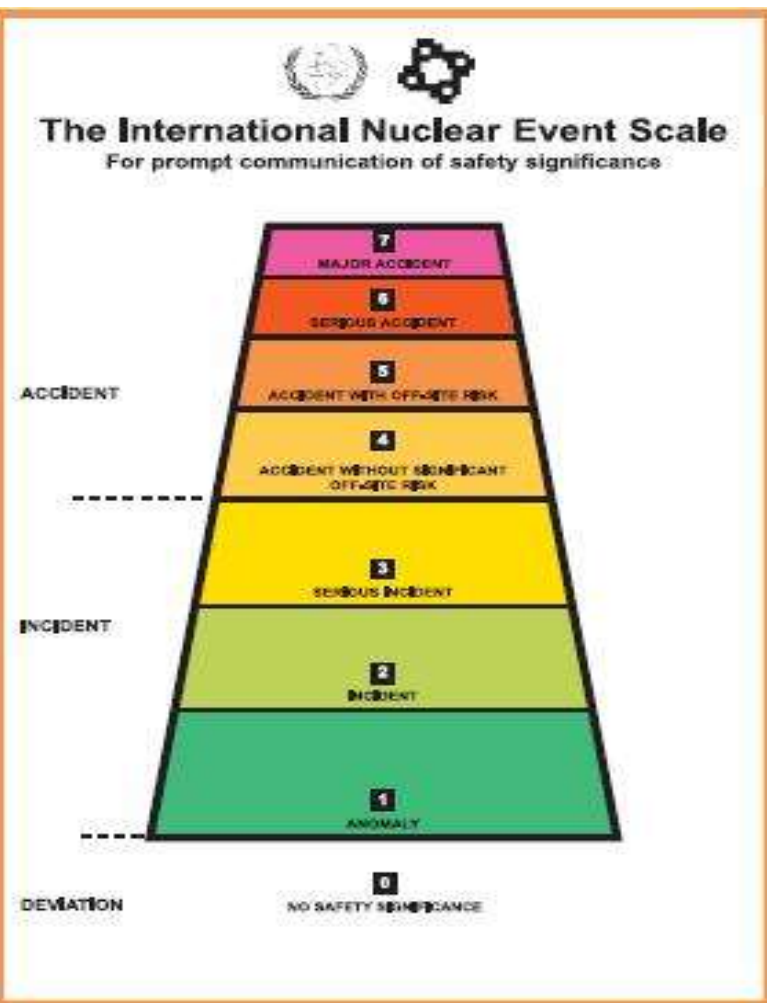
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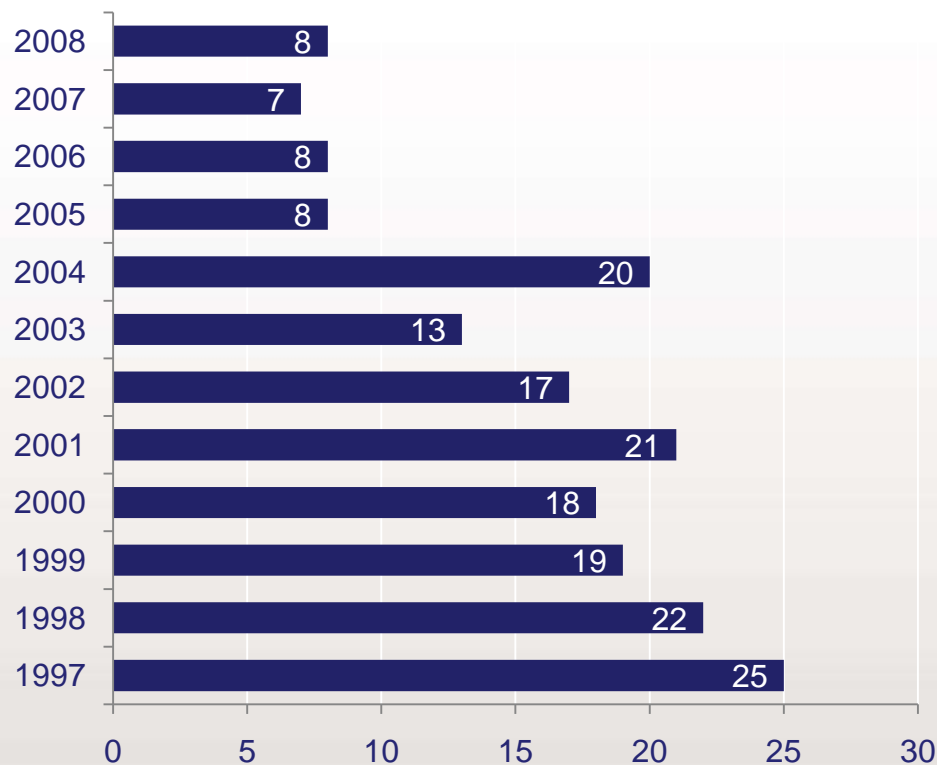
Cernavoda NPP Safe Operation Experience



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Reportable events to nuclear regulatory authority (CNCAN)



No events with dose limits violation or environmental impact occurred since in service (1997 ÷ 2008)

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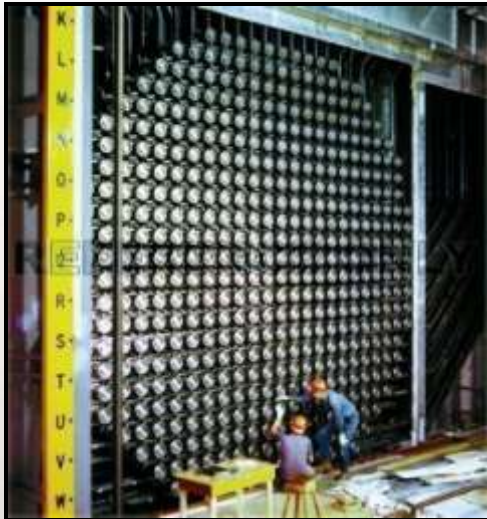
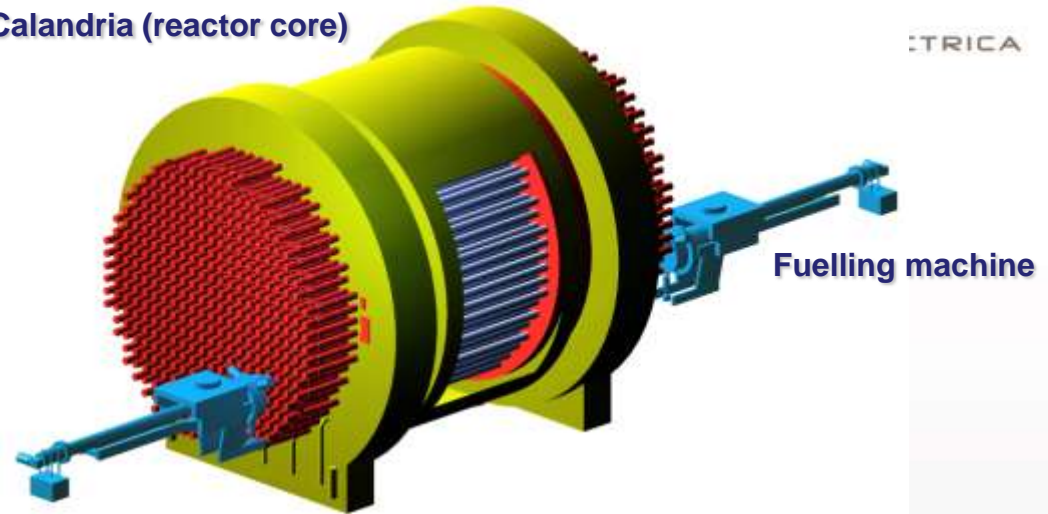
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CANDU Design Fundamentals



- Natural uranium fuel
- Heavy water moderator
- Channel-type reactor
- On-power refuelling
- Fully automated operation
- Computer controlled

Calandria (reactor core)

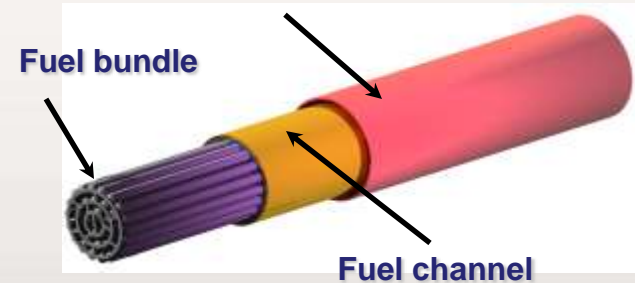


CANDU 6
Reactor Face

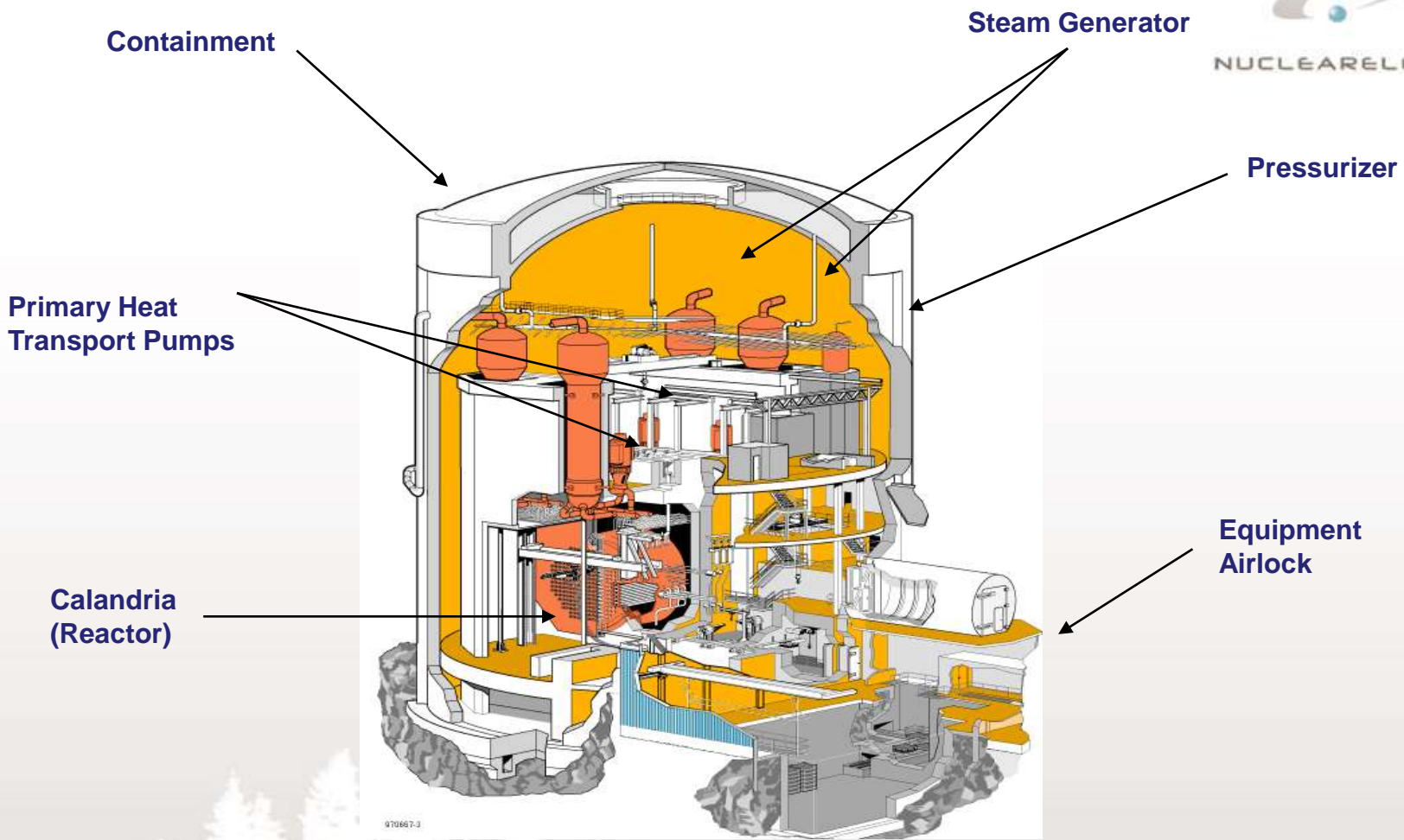


37-element bundle
(20kg / 50cm)

Calandria tube



CANDU 6 Reactor



The Design Philosophy



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- The defence-in-depth philosophy of the CANDU 6 reactor recognizes that even if the unexpected events occur, they are effectively countered.
- There are four key elements:
 - Prevention - Fundamental in the CANDU approach to safety is good design and the application of strict quality control during the design, manufacturing and construction phases of the plant. Equipment failure and human error are anticipated and addressed.
 - Protection - Protection aims at stopping an accident before it can do much damage to the reactor. Redundant systems are provided to shut down the reactor and remove decay heat.
 - Mitigation – Restoring heat removal capability of the systems if it is lost, in order to prevent, or limit the extent, of fuel damage.
 - Accommodation - Its purpose is to contain the release of radioactive materials to the environment by the physical barriers.

The Design Philosophy (cont')



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- Many physical barriers were implemented for the purpose of avoiding the release of radioactivity:
 - The ceramic fuel, uranium dioxide (UO_2) which contains more than 90% of radioactive fission products is solid.
 - The ceramic fuel resides sealed in a leak-tight, metal sheath.
 - The fuel is inside a sealed heat transport cooling system.
 - A massive concrete containment building surrounds the cooling system.

Nuclear Safety



- Grouping and separation of safety systems and safety support systems to increase reliability: diverse and independent

Safety Function	Group 1 Systems	Group 2 Systems
Shutdown	Reactor Control System Shutdown System 1	Shutdown System 2
Heat Removal From Fuel	Heat Transport System Steam and Feedwater Systems Shutdown Cooling System Emergency Core Cooling Syst Moderator System	Emergency Water System
Contain Radioactivity	Reactor building air coolers	Containment & containment subsystems
Monitoring & Control	Main Control Centre	Secondary Control Area

Nuclear Safety – Special Safety systems



- The CANDU reactor is designed with special safety systems:

Shutdown System Number 1 (SDS1)

Shutdown System Number 2 (SDS2)

Emergency Core Cooling (ECC) System

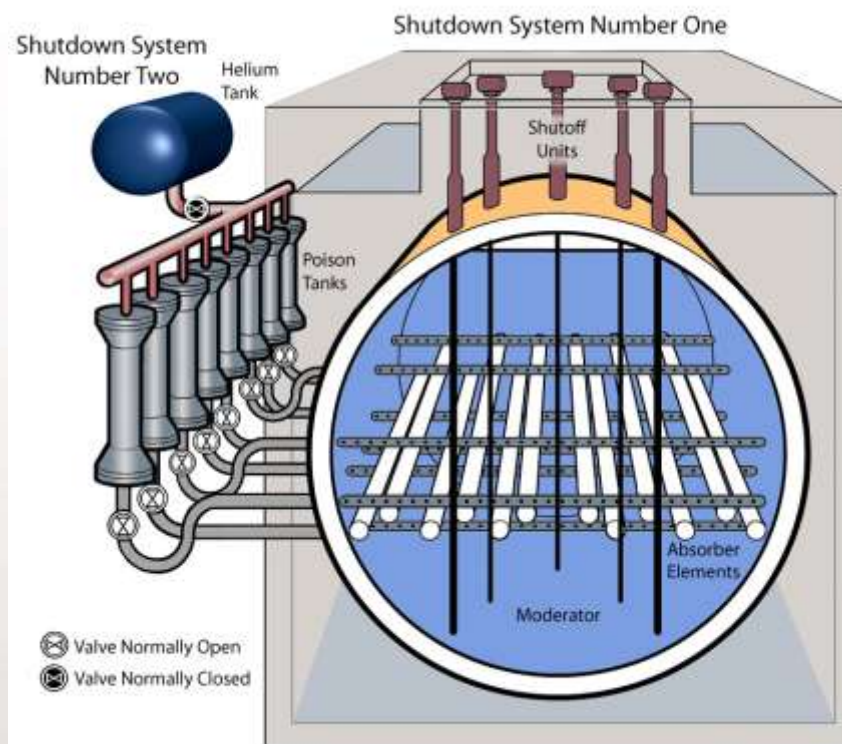
Containment Building

Nuclear Safety



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- **Dual, independent, fast-acting safety shutdown systems**
 - Fully automated (with hardware interlocks), fully capable
 - Trip on short time-scale neutron kinetics
 - Passive operation
 - Proven design concepts
- **SDS1**
 - Vertical absorber cadmium rods
 - Improved response time
 - No rod ejection scenario
- **SDS2**
 - High-pressure poison injection
 - Using gadolinium nitrate



Reactor Regulating System

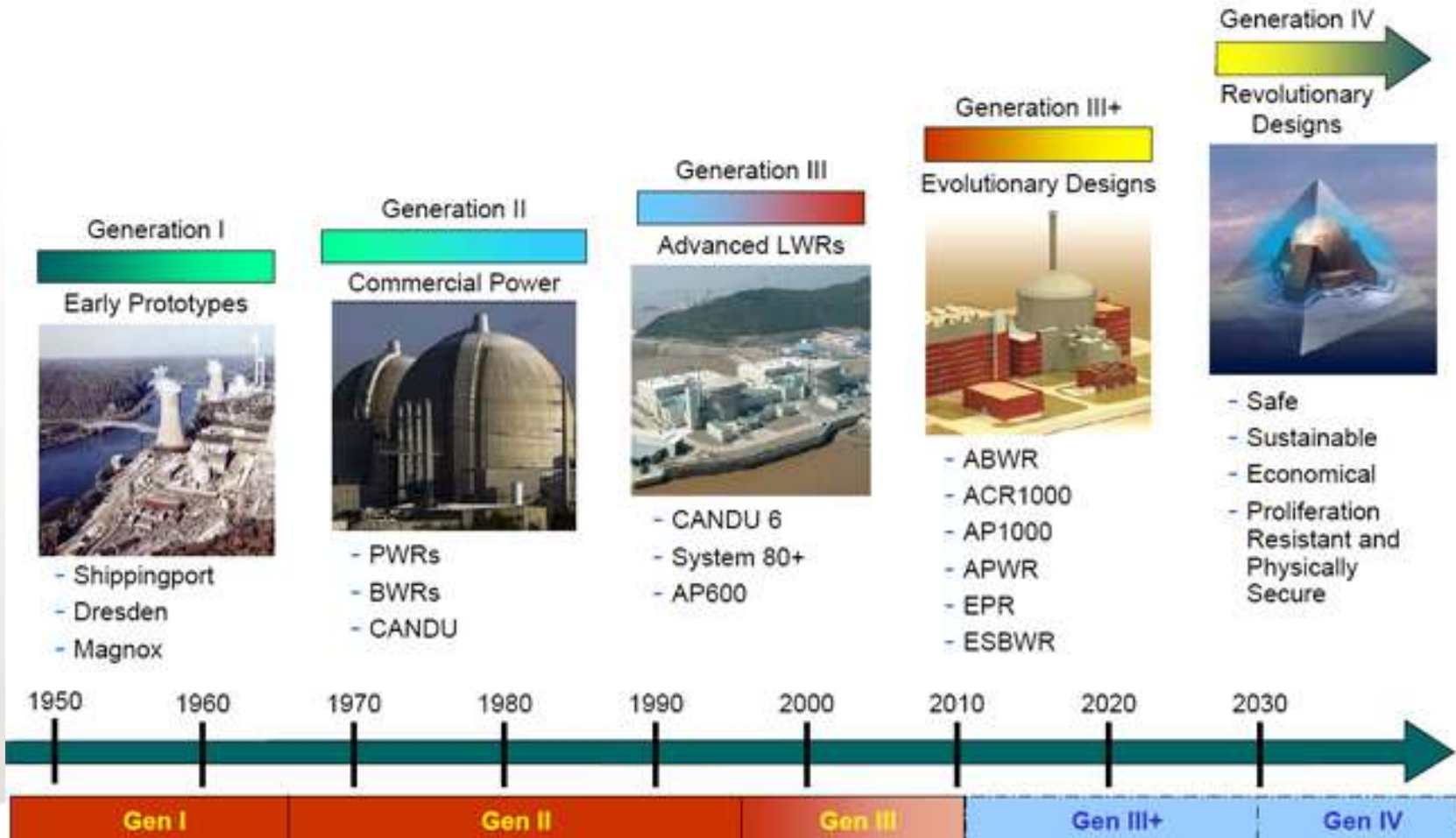


- Reactivity control devices
 - 6 liquid zone control absorbers (light water)
 - 4 mechanical control absorbers (cadmium)
 - 21 adjuster rods (stainless steel or cobalt)
 - Soluble poison addition into moderator*
- Instrumentation
(Start-up instrumentation, Fission chambers, Ion chamber system, Self-powered in-core flux detectors)
- Digital control programs
(Power measurement & calibration, The demand power routine, Enhanced load following capabilities, Reactivity control and flux shaping, Flux mapping routine, Setback & stepback routines)

The Evolution of Nuclear Power



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Enhanced CANDU - Comparison of Select Enhancements



	CANDU 6*	EC6
Electrical & Wiring	Extensive connections to central DCCs	>75% less wiring & electrical
Containment	1.07m epoxy-lined prestressed concrete	1.8m steel-lined with stronger concrete
Control Systems	DCC & traditional control layout	DCS with human factors engineering
Computer Maintenance	Specialized to DCCs	60% cost reduction
Pressure Tubes	4.2mm	~12.5% Thicker
Feeders	Carbon Steel	Improved corrosion resistance (> Cr %)
Performance Factor	89% LCF fleet average	Over 90% annually
Power	680 MWe	Up to 750 MWe**

*Based on CANDU 6 at Point Lepreau

**Dependant on site conditions

EC 6 Load Following Capability For Grid Stability



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- Capable of continuous operation in reactor following turbine mode
- Capable of daily load cycles from 100% to 60% FP
- Can compensate for grid frequency fluctuations of 2.5% between 90% to 100% FP
- Proven at Pickering, Bruce and Gentilly 2 reactors in Canada and in Embalsy in Argentina as well as in the Wolsong C6 plant in Korea
- NPP can continue operating with loss of line to grid

CNSC to assess AECL reactor design

(WNN 13 May 2009)



NUCLEARELECTRICA

- Atomic Energy of Canada Ltd (AECL) has signed a service agreement with the Canadian nuclear regulator to conduct a design compliance review of the Enhanced Candu 6 (EC6) nuclear reactor.

CANDU & PWR - Similarities



- UO₂ fuel in zirconium-clad elements
- Similar steam generators
- Large concrete reactor containment
- Turbine - generator plant
- Condenser water system and pump-house, etc.

CANDU vs. PWR

different design philosophy



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CANDU

Natural uranium fuel
Separated heavy water (D₂O)
coolant and moderator
Distributed core (fuel channels)

Pressurized Water Reactor

²³⁵U enriched fuel
Combined light water coolant and
moderator
Integrated core (single pressure
vessel)

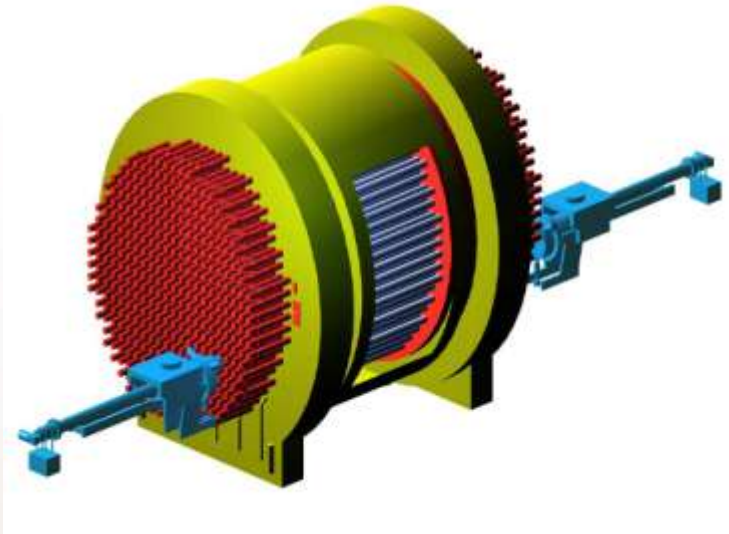


CANDU vs. PWR

different design philosophy

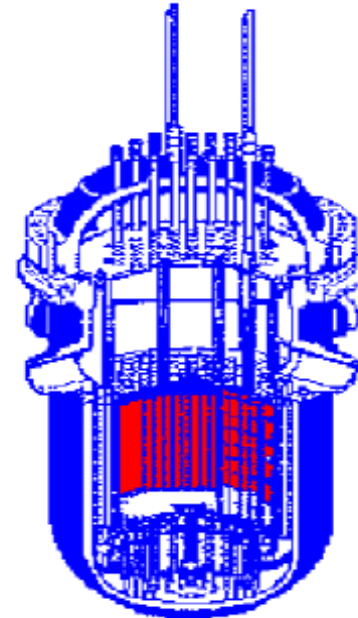


CANDU 6



380 small diameter channels
Heavy water
Two separate systems (coolant & moderator) (no Boron)

PWR NUCLEARELECTRICA



One large diameter vessel
Light water
One system (coolant = moderator)
(Boron Present)

Fuel comparison



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CANDU



natural uranium
short bundles (0.5 metres)
on-power refuelling
remove defected fuel during operation

PWR



enriched uranium
long bundles (3.8 metres)
shut down to refuel
remove defective fuel only when shutdown to refuel

CANDU - More Features



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- Very simple fuel bundle design
- Excellent neutronic economy
- Fuelling on-line at full power
- Can undergo an outage at convenient time
- Can locate failed fuel and immediately remove it without shutting down the reactor
- Fuel fresh or spent does not pose any criticality concern
- Maintained steady and a very small core reactivity excess
- Systems can be maintained and tested while reactor is at full power in Reactor Building
- Contains all reactor control, shutdown systems and nuclear measuring devices in cool, low pressure moderator (no-pressure driven ejection possible)
- Is capable of load following as proven in several C6 plants

Contents



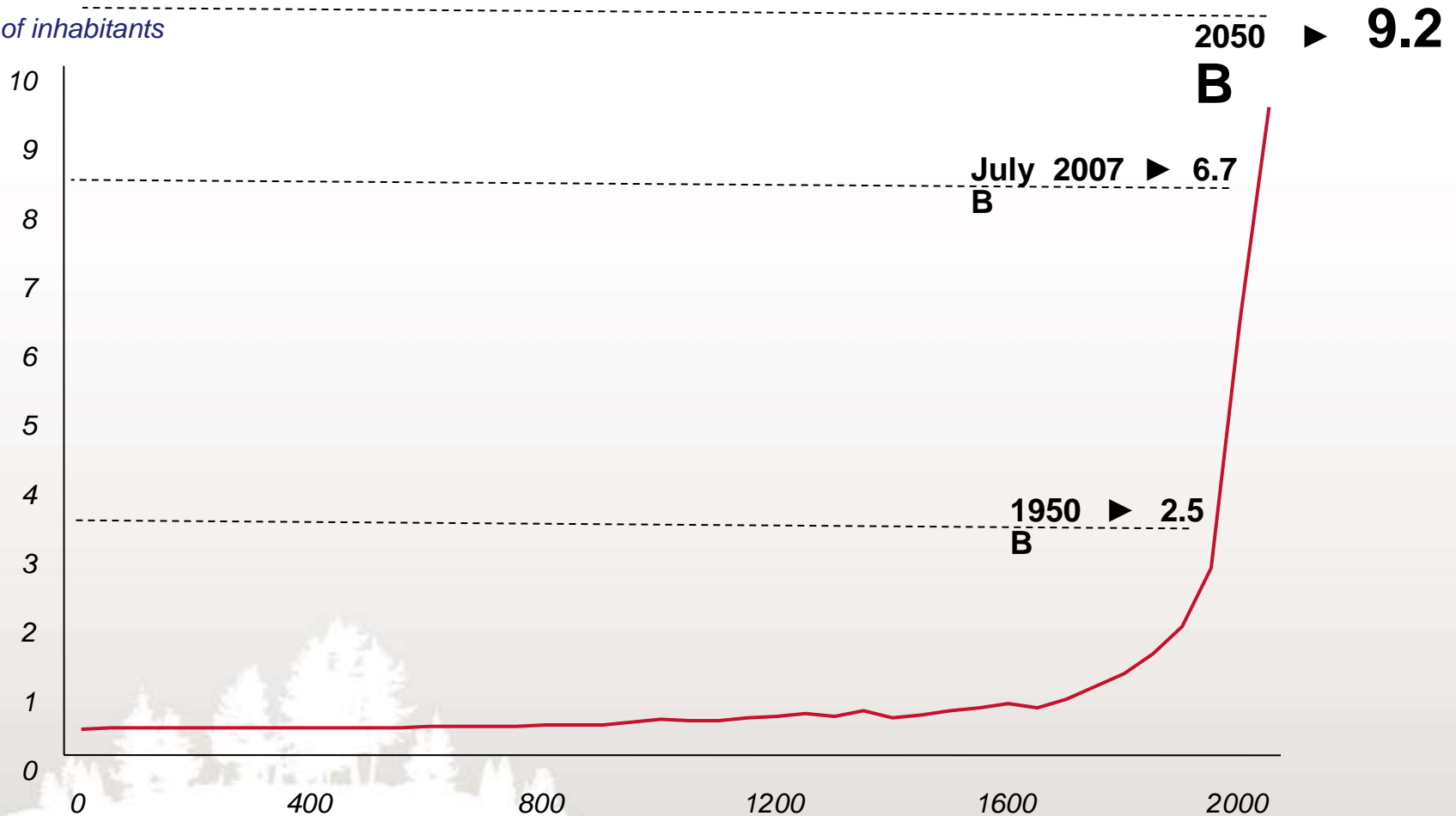
- Nuclearelectrica – Basic information
- General (Politics, Trends)
- Status of the Cernavoda Units 3&4 Project
- CANDU Technology
- Conclusions

World Population Trend



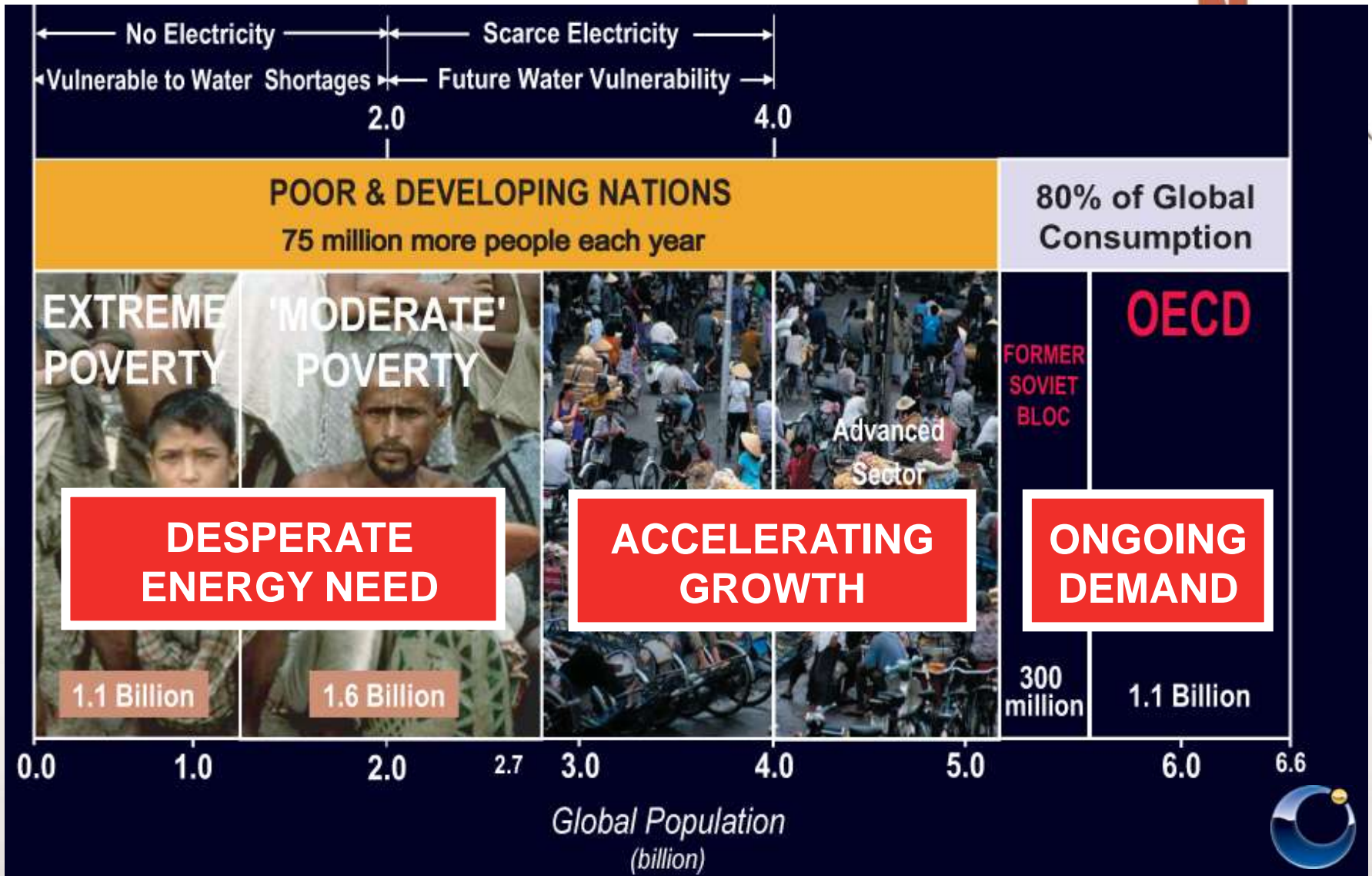
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Billions of inhabitants



Source: U.N. demographic projections – 2006 edition

A World of Extremes



Nuclear new build challenges



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The Basics

- Cost ➔ on budget
- Schedule ➔ in time
- Quality ➔ best quality

Owner

- Efficient project management
- Qualified human resources
- Reasonable project plans and suitable contract models

Supply Chain

- Global and localized manufacturing capacities
- Qualified human resources (engineering, construction, etc.)
- Financial industry (besides utility balance sheets)

Regulator & Politics

- Efficient processes, sustainable support, solution oriented decision making
- Standardized/harmonized requirements, international development
- Qualified human resources

Nuclear Infrastructure



Existing and Planned Reactors



439 now operating*

40+ more under construction*

70+ new plants projected in next 15 years**

Plus, numerous up-rates and license extensions

=

Growing Demand for Highly Skilled Workers!

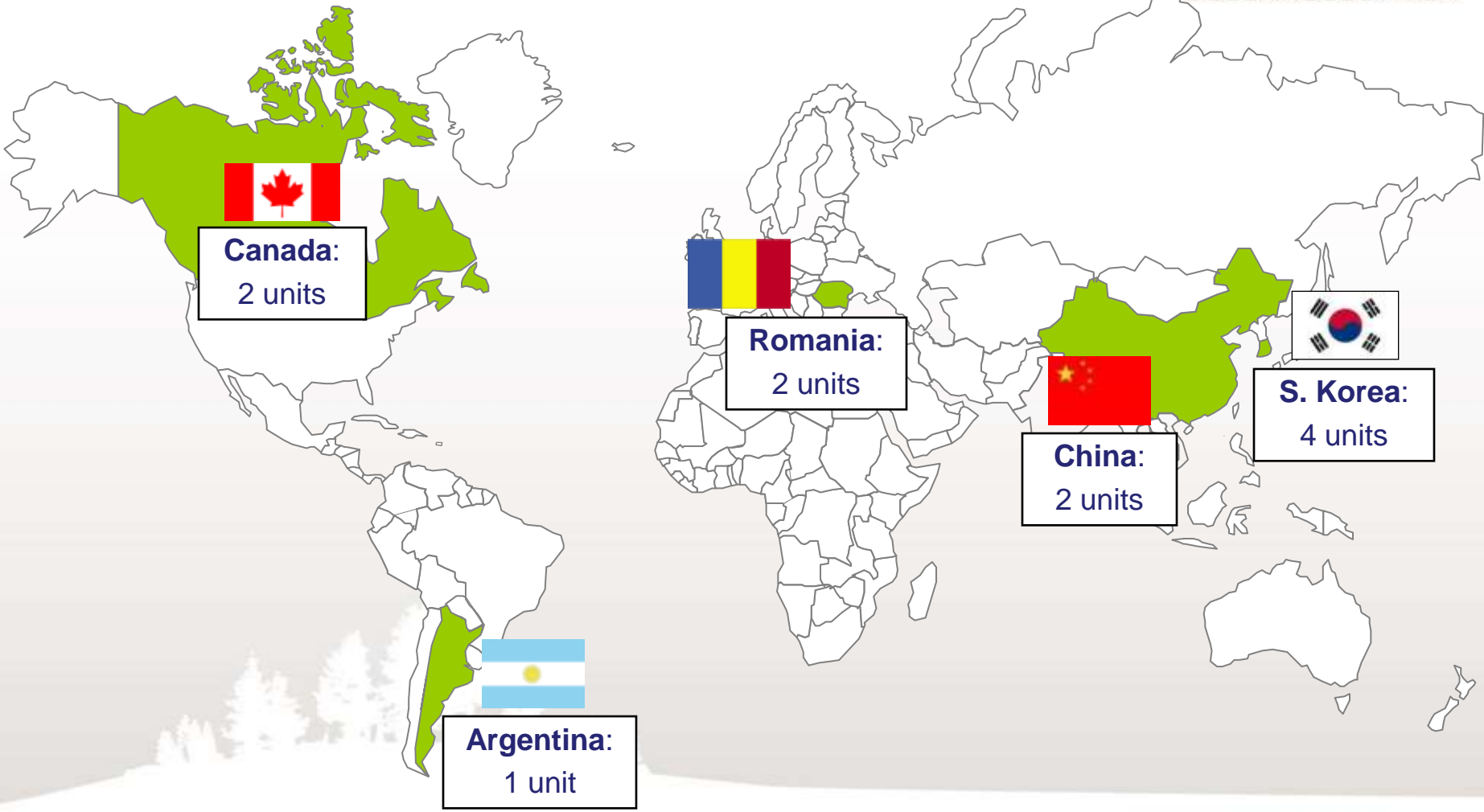
*Sources: *WNA, **IAEA*

CANDU 6 Operators Around the Globe



EC6 is based on AECL's extremely successful CANDU 6 design

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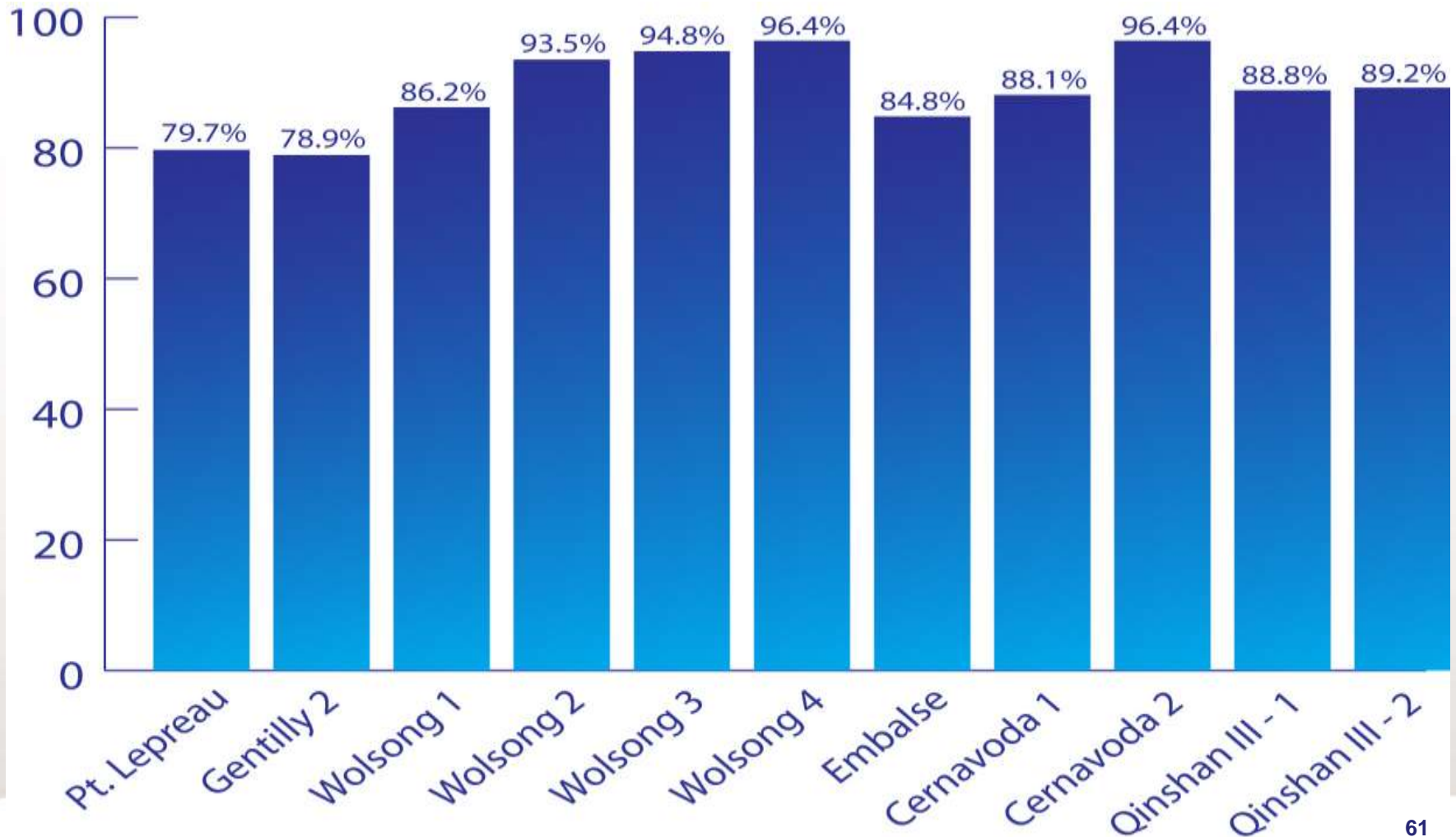


CANDU 6 Performance Excellence



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- The average lifetime capacity factor is 89%



Conclusions



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- CANDU 6 product has continued to improve since the initial deployment in early 80's

- AECL has reviewed the requirements for advanced reactors and assessed the enhancements that have been incorporated in Gen III designs such as:
 - Improved design margins for safety and operations
 - Design with lower core damage frequency
 - Simplification and standardization of designs including the use of passive features
 - Design considerations include human factors, maintainability, constructability and sabotage protection

Conclusions (cont')



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The CANDU 6 reactor fleet with over 125 reactor years of operation has an excellent safety record attesting to its superior safety features

- CANDU 6 reactors are being life extended in Canada and abroad (Bruce, Lepreau, Gentilly 2, Wolsong 1, Embalse) - Life extension is confirmation of economics and safety
- AECL with its proven record to deliver the project on budget and schedule is offering EC6 as ready for near term deployment



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Thank you !

