Safety, Skills Development and Job creation

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Managing Director
AREVA South Africa
Safety of EPR™
EPR™ safety approach

An accident is a complex series of events:
-> NEED THE MEANS TO REMAIN IN CONTROL OF THE SITUATION, WHATEVER HAPPENS

The EPR™ reactor is designed to resist exceptional events and prevent damage to the surroundings
AREVA Safety Alliance framework

Imperative 1
RESISTANCE TO MAJOR HAZARDS

EVENT:
• External hazard: Earthquake, Flooding, Extreme Temperature
• Internal hazard: examples of broken pipe or valve, fire
• Combination of hazards

OBJECTIVE:
• Preserve Plant Safety

Imperative 2
ROBUSTNESS OF COOLING CAPABILITY

EVENT:
• External hazard beyond worse case scenario

CONSEQUENCE:
• Damage to cooling capability

OBJECTIVES:
• Provide sufficient time to restore cooling capability
• Preserve fuel integrity
• Preserve assets

Imperative 3
PREVENTION OF ENVIRONMENTAL DAMAGE

EVENT:
• Unforeseen event(s) creating extreme conditions

CONSEQUENCE:
• Loss of safety functions, leading to hydrogen production and fuel damage

OBJECTIVES:
• Minimize external radioactive release
EPR™ Safety

- Resistance to external hazards
- Robustness of cooling capabilities
- Prevention of environmental damage

Imperative 1

Resistance to Major Hazards

**EVENT:**
- External hazard: Earthquake, Flooding, Extreme Temperature
- Internal hazard: broken pipe or valve, fire
- Combination of hazards

**OBJECTIVE:**
- Preserve Plant Safety
Resistanc to external hazards

Structural resistance

- Critical buildings
  - APC shell & seism resistance
  - Doors designed to resist external explosions & floods

- Reactor building
  - Pre-stressed concrete containment
  - Steel liner
  - Resistance to external events (impacts) and internal events (leaks, high temperature...)

Design robustness: the EPR™ design can be compliant with a vast variety of sites
Resistance to external hazards: Monitoring and control of the plant

Monitoring systems

- 300+ safety-class monitoring systems in the NSSS:
  - Resistance to extreme conditions: high radiation, temperature and pressure
  - Monitoring still functional in case of an earthquake

Control Room

- Main control room
  - Digital system backed-up by analog instrumentation with qualified displays

- Back-up: Remote Shutdown station
  - Geographical and technological diversity

Design robustness: in case of major hazards, monitoring and control functions of the EPR™ design are preserved
EPR™ Safety

- Resistance to external hazards
- Robustness of cooling capabilities
- Prevention of environmental damage

**Imperative 2**

**ROBUSTNESS OF COOLING CAPABILITY**

**EVENT:**
- External hazard beyond worse case scenario

**CONSEQUENCE:**
- Damage to cooling capability

**OBJECTIVES:**
- Provide sufficient time to restore cooling capability
- Preserve fuel integrity
- Preserve assets
Robustness of cooling systems

1. Emergency feedwater system
   - Cooling through secondary loop with EFWS

2. Safety injection system
   - Cooling through primary loop with safety injection system

Four 100% safety trains

- 4 redundant safety trains...
- ... located in 4 separate buildings
- 2 are further protected by the APC shell
- One train is enough to cool the core (100% train)

Highly redundant cooling systems with two ways to cool down the core
The EPR™ design has multiple redundant and diverse access to water to cool the core.

In case of loss of main heat sink access 1:
- The EPR™ can rely on an alternate heat sink source¹ 2 and a large fire fighting tank 3.
- Additionally, the EPR™ design features significant water reserves in protected buildings (IRWST 4) and four safeguard buildings (four EFWS tanks 5).

1- or geographically diversified access for seaside sites.
Robustness of cooling systems: emergency power

Physical protection

- Diesels & fuel tanks housed in reinforced concrete buildings
  - Seism resistant design
  - Doors designed to resist external explosions & floods

Physical separation

- 2 separate buildings located on each side of the reactor building
  - Deterministically impossible for both of them to be damaged by an external impact hazard (explosion, airplane crash...)

Redundancy & diversification

- Four main 100% redundant diesels
  - Each with 72 hours autonomy at full load
- Two additional station blackout diesel generators (SBO)
  - Fully diversified (no common cause failure)
  - 24 hours additional autonomy each

6 emergency diesels: redundant, diversified and protected
Further backed-up by safety-class batteries with a 12h autonomy
Robustness of cooling systems:
The core can be cooled down using only one diesel generator and without any heat sink.

- **Multiple cooling systems**
- **Multiple water supply sources**
- **Multiple emergency power sources**

High robustness of cooling systems: redundancy, diversity, complementarity and geographical separation.

4 safety trains
IRWST (1800 m³)
EFWS tanks (4x400 m³)
Alternate heat sink source
2 x 3 emergency diesels
Reactor fuel pool robustness

- Dedicated fuel building
  - Reinforced concrete wall
  - Additional protection layer by the APC shell

- Cooling systems
  - Redundancy of the main system: two independent, physically separated cooling systems
  - Diversity: additional back-up cooling system

High robustness of cooling systems: also for the reactor fuel pool
Increased safety margins are needed for potential **cliff edge effects** (events beyond safety limits with non-linear consequences).

This means an **NPP must not enter into a severe accident sequence as soon as the site worse case scenario is exceeded** and have safety margins/cooling robustness providing a “grace period” to prevent the cliff-edge effect.
The EPR is licensed to resist to a 0.25g-0.3g peak ground acceleration.

Seismic Margin Assessments performed for safety authorities in the UK and US lead show that even a 0.6g peak ground acceleration seism would not have significantly impacted the EPR capabilities to mitigate the risk of severe accident.

In similar seismic conditions as of Fukushima earthquake, the EPR would not have endured damages impairing the adequate operations of its safety systems.

EPR is certified to resist to a large spectrum of peak ground acceleration levels.

Seism resistance requirements of safety authorities per project.

1. Construction license
2. Safety demonstration adjusted to Finnish requirements, however most equipments in line with EPR standard seism resistance.

Source: Project construction licenses and ongoing certification processes.
Robustness:
Provide grace period to mobilize emergency means

- The significant grace period provides more time to bring mobile emergency means and prevent cliff-edge effect.

- The robustness of the cooling chain means less decay heat to manage and enables to manage the situation even with limited mobile means.

- For water, the mobile means can refill either the IRWST, EFWS and fire fighting tank.

Cliff edge effect illustration
A firefighting truck is enough for water supply from t+24h on.
EPR™ Safety

- Resistance to external hazards
- Robustness of cooling capabilities
- Prevention of environmental damage

Imperative 3

PREVENTION OF ENVIRONMENTAL DAMAGE

EVENT:
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CONSEQUENCE:
- Loss of safety functions, leading to hydrogen production and fuel damage

OBJECTIVES:
- Minimize external radioactive release
However low the probability of severe accident for the EPR™ design might be, the consequences around the site are too severe to be ignored. As such, keeping control of releases is accounted for in a deterministic way during a severe accident.

To prevent containment breach and subsequent environmental damage means:

First, to prevent highly energetic events,
  - No high pressure core melt
  - No H2 explosion
  - No steam explosion

Second, to achieve long-term core melt stabilization
Prevention of environmental damage
No high pressure core melt

Core melting at high system pressure can potentially lead to:

- Steam generator tube rupture with containment bypass
- Major melt dispersal

The EPR™ design includes additional dedicated primary depressurization valves

Primary loop depressurization

Pressurizer safety valves

Dedicated severe accident depressurization valves (2 x 2 valves)
Prevention of environmental damage
No H2 explosion

► Minimize H2 concentration:
Large reactor building with interlinked compartments

► Reduce H2 quantity:
*Passive Autocatalytic Recombiners*
Ex-vessel steam explosions can occur when
- Melt pours into a water pool
- Melt is flooded with water

The EPR™ manages core melt with the core catcher
As a result, the presence of water is excluded by design
- In the reactor pit
- In the core catcher before spreading
  ➔ No steam explosion possibility
Prevention of environmental damage
Long-term core melt stabilization

Core catcher cooling

The Core catcher protects the integrity of the containment basemat. It is designed to passively stabilize molten core:

- In the core catcher the melt triggers the opening of (redundant) flooding valves
- Gravity-driven overflow of water comes from the IRWST through an embedded steel channel

Long-term core cooling is provided by the containment spray

Complementarity of active and passive systems for severe accident management
Safety of Technology:
It is the first choice to do
Generation III safety improvements over Gen 2 include feedback from 3 major events:

- **Three Miles Island** (1979): accident with core melt
  - Reduce Core Damage Frequency

- **Chernobyl** (1986): radioactive material dispersion
  - Reduce environmental impact even in case of a severe accident

- **9/11** (2001): terrorist attack by large plane
  - Reinforce protection and resistance against external hazards, including large commercial airplane

Each key event is an opportunity to assess/improve safety standards.
Risk of core melt down accident divided by over 10 with Gen III reactors

Frequency of severe accidents resulting in core damage per year per reactor

- GEN II
- GEN III

Minimum safety level for Gen III: Less than one per 100,000 years
The EPR has been designed to minimize its environmental footprint.

Comparison of environmental footprints
EPR™ reactor versus Gen II reactors

<table>
<thead>
<tr>
<th>Category</th>
<th>EPR™</th>
<th>Gen II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>-25%</td>
<td></td>
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<tr>
<td>Thermal release</td>
<td>-12%</td>
<td></td>
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<tr>
<td>Uranium consumption</td>
<td>-15%</td>
<td></td>
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<tr>
<td>Final waste</td>
<td>-10%</td>
<td></td>
</tr>
<tr>
<td>Used fuel</td>
<td>-23%</td>
<td></td>
</tr>
<tr>
<td>Collective radioactivity dose*</td>
<td>-60%</td>
<td></td>
</tr>
</tbody>
</table>

Methodology
- Typical environmental criteria have been selected.
- For each criteria, the performances of both the EPR and a typical Gen II* reactor have been computed. The relative EPR performance is then displayed.
- To avoid discrepancies, all values are expressed per MWh (except for the collective radioactivity dose).

Source: AREVA
* 900 MW, CPR reactor; ** per reactor x year for operating and maintenance workers.
Localization, Partnership, Technology Transfer: AREVA long track record
AREVA Track Record in Technology Transfer and Localization worldwide

Real life experience

- **South Korea**: a relationship that began over 30 years ago

- **China**: a total cooperation for nuclear energy self-reliance

- **Brazil**: Renewing a long-standing partnership for greater self-reliance

- **Japan**: La Hague to Rokkasho-Mura reprocessing plant, from knowledge to self-confidence

- **South Africa**: a fuel technology transfer that resulted in indigenous fabrication of fuel reloads for Koeberg NPP

- **USA**: moving the nuclear revival forward with the construction of new manufacturing facility.

"and more to come in India, United kingdom, South Africa, ..."
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Nuclear Industry Localization Conference, Cape Town June 1st to 3rd, 2011
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Renewing a long-standing partnership for greater self-reliance

and more to come in India, United kingdom, South Africa, ...
AREVA Track Record in Technology Transfer and Localization worldwide

Real life experience

"From knowledge to self-confidence"

- At first (1976), Japan sent 3 000 tons of spent fuel for reprocessing to La Hague
- Then, beginning in 1987, they engaged in the development of domestic reprocessing capabilities
  - Technology transfer
  - Technical assistance for start-up and plant operations
  - Tailor-made, hands-on training in the La Hague sister plant

and more to come in India, United kingdom, South Africa, ...
AREVA Track Record in Technology Transfer and Localization worldwide

Real life experience

1972: Uranium Conversion - Industrial cooperation

1976-1985: Koeberg Nuclear Power Plant Construction

1980: Fuel Fabrication Technology Transfer

Services & Maintenance - LESEDI

“A fuel Technology Transfer that resulted in indigenous fabrication of fuel reloads for Koeberg Nuclear Plant”

and more to come in India, United kingdom, South Africa, ...
AREVA Track Record in Technology Transfer and Localization worldwide

Real life experience

Fuel fabrication plants
Enrichment
Design & Construction of nuclear reactors
Services & Maintenance
Pump & motor maintenance workshop
Heavy component manufacturing plant
Used fuel treatment facility development study

“Moving the nuclear revival forward with the construction of a new manufacturing facility”

and more to come in India, United kingdom, South Africa, ...
Jobs creation and Skill Development in RSA
IRP2010 Nuclear Power Generation

MWe

2020 2021 2022 2023 2024 2025 2026 2027 2028

Total new MWe
Many people will be required to build the nuclear power plants included in the IRP2010 (9600MWe).

Many of these people will not have experience of working on a major industrial project like this.

As a result, we all must work together to ensure that the proper level of safety training is available and that all employees are introduced to and understand these requirements.
What jobs?

- New build construction
- Manufacturing for new build
- Nuclear plant operations & maintenance
- Nuclear Safety Authority
- Nuclear fuel cycle program
- Induced
- Transition from import to local manufacturing for other industries
- International Nuclear Training Centre
- Nuclear export market

Jobs for South Africans
What types of jobs?

NPP Construction Craft Distribution

- Boiler makers: 4%
- Painters: 2%
- Pipefitters: 17%
- Teamsters: 3%
- Operating engineers: 8%
- Millwrights: 3%
- Masons: 2%
- Insulators: 2%
- Laborers: 10%
- Iron workers: 18%
- Electricians/Instrument fitters: 18%
- Carpenters: 10%
- Sheetmetal workers: 3%
### Transition from New Build Construction

#### Typical qualification time frame for suppliers of nuclear equipment

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<thead>
<tr>
<th>Years</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
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<td>Issue Invitation to Tender</td>
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<td>Bidding, negotiation period</td>
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<td>Award NPP contract</td>
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<td><strong>AREVA Activities</strong></td>
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<td>Preliminary evaluation of local suppliers</td>
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<td>Request budget pricing from local suppliers</td>
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<td>NPP bidding period</td>
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<td>Prepare procurement specs, documents</td>
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<td>Prepare final qualified supplier list</td>
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<td>Issue RFQs for equipment &amp; materials</td>
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<td>Award Purchase Orders</td>
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<td>Supplier decision to be involved in NPP program</td>
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<td>Qualification period (assume 2 years)</td>
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<td>Fabrication period</td>
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**Start of NPP Contract**

Supplier qualification to be complete to be included on approved suppliers list
Timing of Skills Development

The Challenge: Manufacturing companies must be ready to bid – they must be qualified.
Total Rand potential spend for nuclear fleet

Total ZAR for IRP 2010 Nuclear (9600 MWe)

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We must keep our eye on this curve.

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Nuclear Industry Localization Conference, Cape Town June 1st to 3rd, 2011
Conditions to restart a Nuclear fleet in RSA
◆ RSA Nuclear case

◆ Selection process

◆ Technology selection to follow the safety selection criteria (never forget that we are building for – up to 60 years operation).
◆ Tendering process need to be an EPC
◆ Proposition of a Strategic/ Investor partner linked to the selected technology
◆ Availability to finance a fleet project (Commitment of the Vendor State and Banks)
◆ Technology transfer, skills development and localization
◆ Selection of a Preferred Vendor
◆ Contract award

◆ Electricity Tariff

◆ Eskom Electricity tariff is almost in place to finance IRP forecast of 9600 MWe without investors
◆ Waiting for next NERSA decision in June for 2013 and 2014

◆ Strategic Partner / Equity Investors

◆ Foreign investor with strong experience in Nuclear project would assist Eskom in optimizing the financing structuration and obtain better conditions
◆ Discussion on expected ROE to be opened with equity investors.
Thank you,
Any good questions!