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Is nuclear safe enough?

Philippe Knoche,
Chief Operating Officer, AREVA
European Energy Forum, March, 2012

Agenda

- **Flashback on Fukushima**
- **European nuclear safety assessments**
- **Reinforcing the nuclear safety framework**

March 11th, 2011: Japan hit by two extreme natural events

Earth-Quake*

- **Tōhoku earthquake (Great East Japan Earthquake) on March 11, 2011 (14:46 JST)**
  - **Magnitude 9.0**
  - **Underwater depth 32km**
  - **177km from Fukushima**
- **Most powerful known earthquake to hit Japan, and 4th largest earthquake in the world since modern record-keeping began in 1900.**

Collapsed tower

Yorunomori line, Cable in substation (subsidence)

Tsunami**

- **Tsunami wave height estimated at approximately +15 meters (O.P)**
- **Fukushima Dai-ichi facilities were designed to withstand maximum waves height of 5.7m high.**

O.P: Onahama Port base tide level

Source: *U.S. Geological Society, **TEPCO

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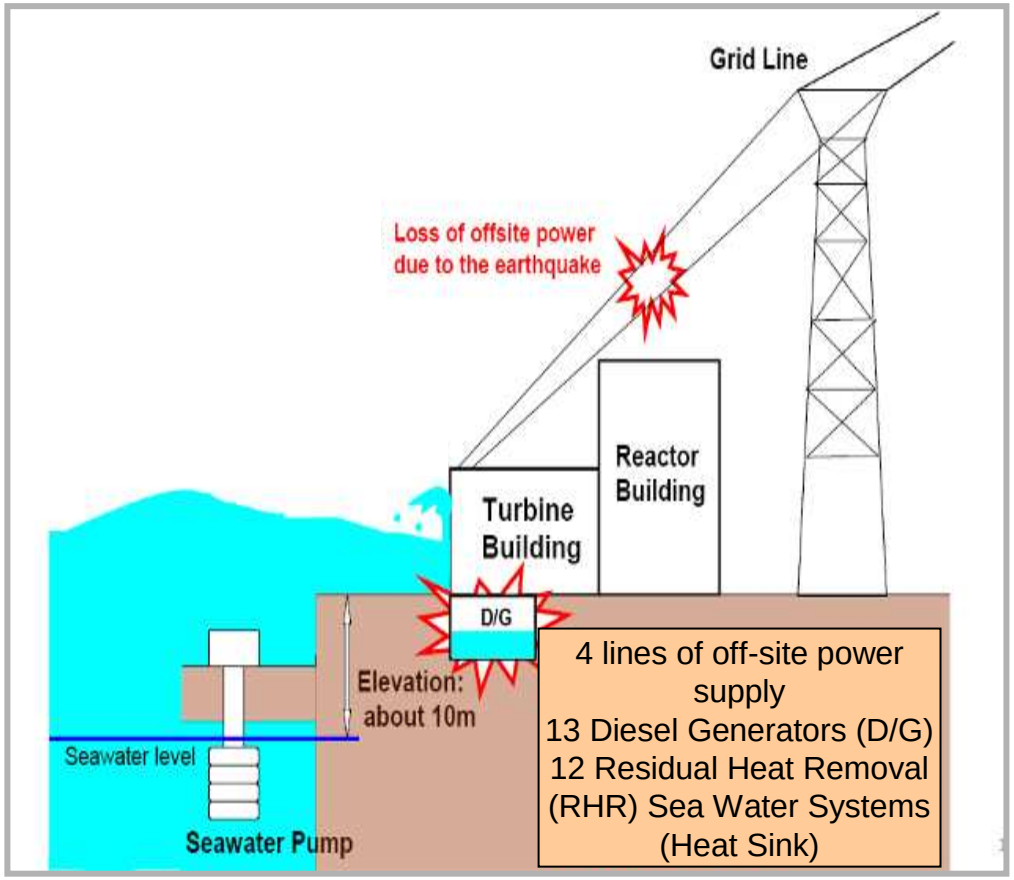
Loss of power and consequential damage to cooling capability



1. **Loss of off-site power due to earthquake**
2. **Emergency Diesel Generators (DGs) started. Cooling systems operate according to the procedures**
3. **Station Blackout : 55 minutes later, tsunami flooded all diesels or their switchgears (except one)**
4. **All motor operated pumps and numerous switchgears became inoperable**
5. **Batteries unavailable on units 1&2 since located under the ground level - Loss of I&C for monitoring functions**
6. **Hydrogen explosions damaged the mobile means set up to inject water in the reactors**

Source: NISA, TEPCO, IAEA

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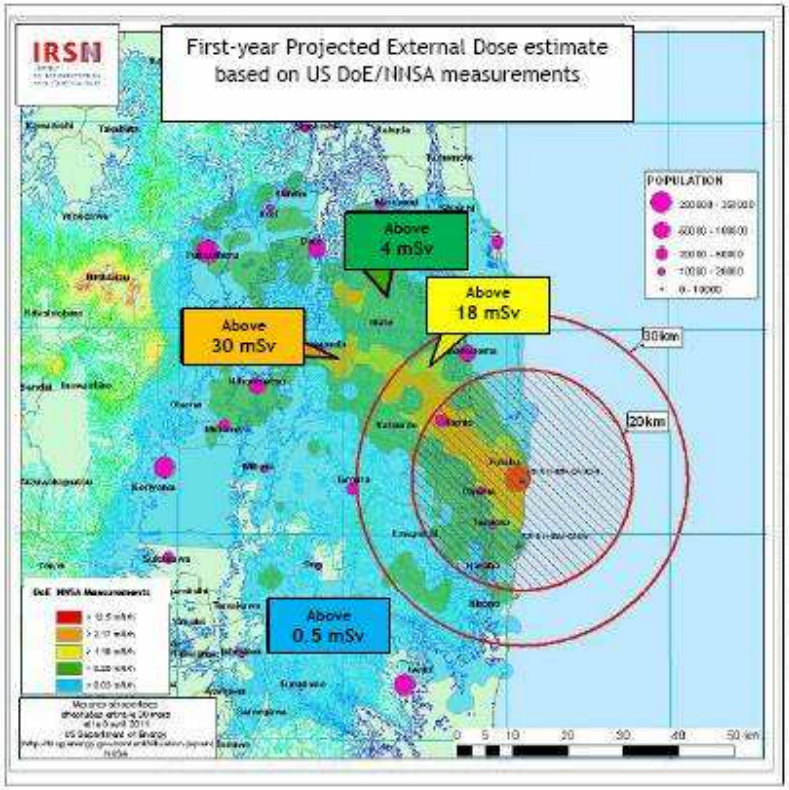
Impact of the nuclear accident on the population

*"The evacuation procedure **was exemplary**"*

IAEA report



- **Around 90,000 people were evacuated and zone restrictions in force**
- **But:**
  - **5 direct casualties on the site unrelated to radiation**
  - **No acute radiation syndrome at all. 6 workers exposed to radiation doses above 250 mSv**
- **Difficult arbitration for Japanese government between clear discomfort and maximum safety**

Note: Natural radiation exposure: 2,5 mSv / y - Maximum radiation exposure in industry: 20 mSv / y
Source: IRSN; Tepco report

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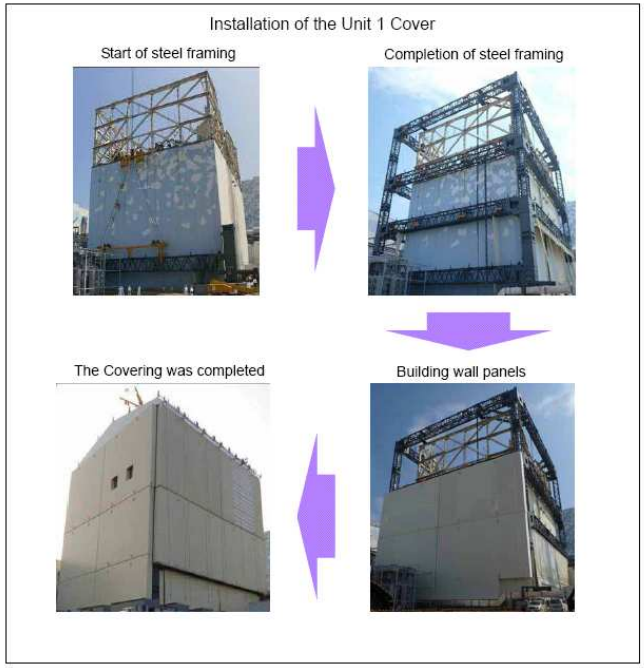
Situation, one year later

> ***Reactors at Fukushima Daiichi Nuclear Power Station have achieved a 'cold shutdown condition' and are in a stable state, and release of radioactive materials is under control.***

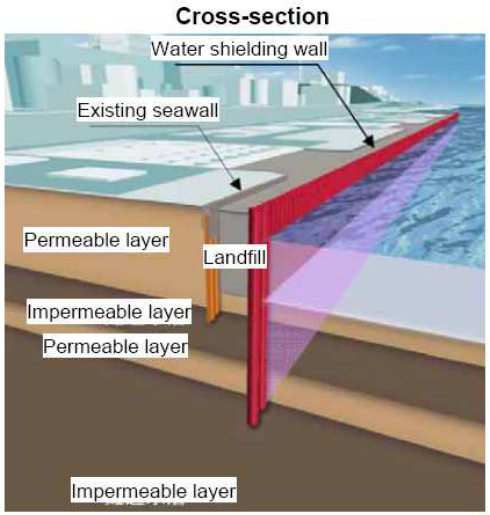
Y. Amano, AIEA, Dec 2011

Mitigation of radioactive release



Mitigation of ground water contamination

Underground tanks for processed water (Highly contaminated water)



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Immediate reaction of the international community

- **At European level, high level conference held by Commissioner Oettinger as soon as March 15th and European Council conclusions adopted on March 25th.**
- **A G8 / G20 level – NEA ministerial seminar on Fukushima nuclear accident and nuclear safety on 7 June; Forum for Heads of Nuclear Safety Authorities on 8 June**
- **IAEA Ministerial meeting on 20-24 June set out basis of action plan on global safety standards, stronger peer review and better accident management. Action plan was endorsed at General Conference on September 13.**

» **Strong political impetus to improve nuclear safety at global level**

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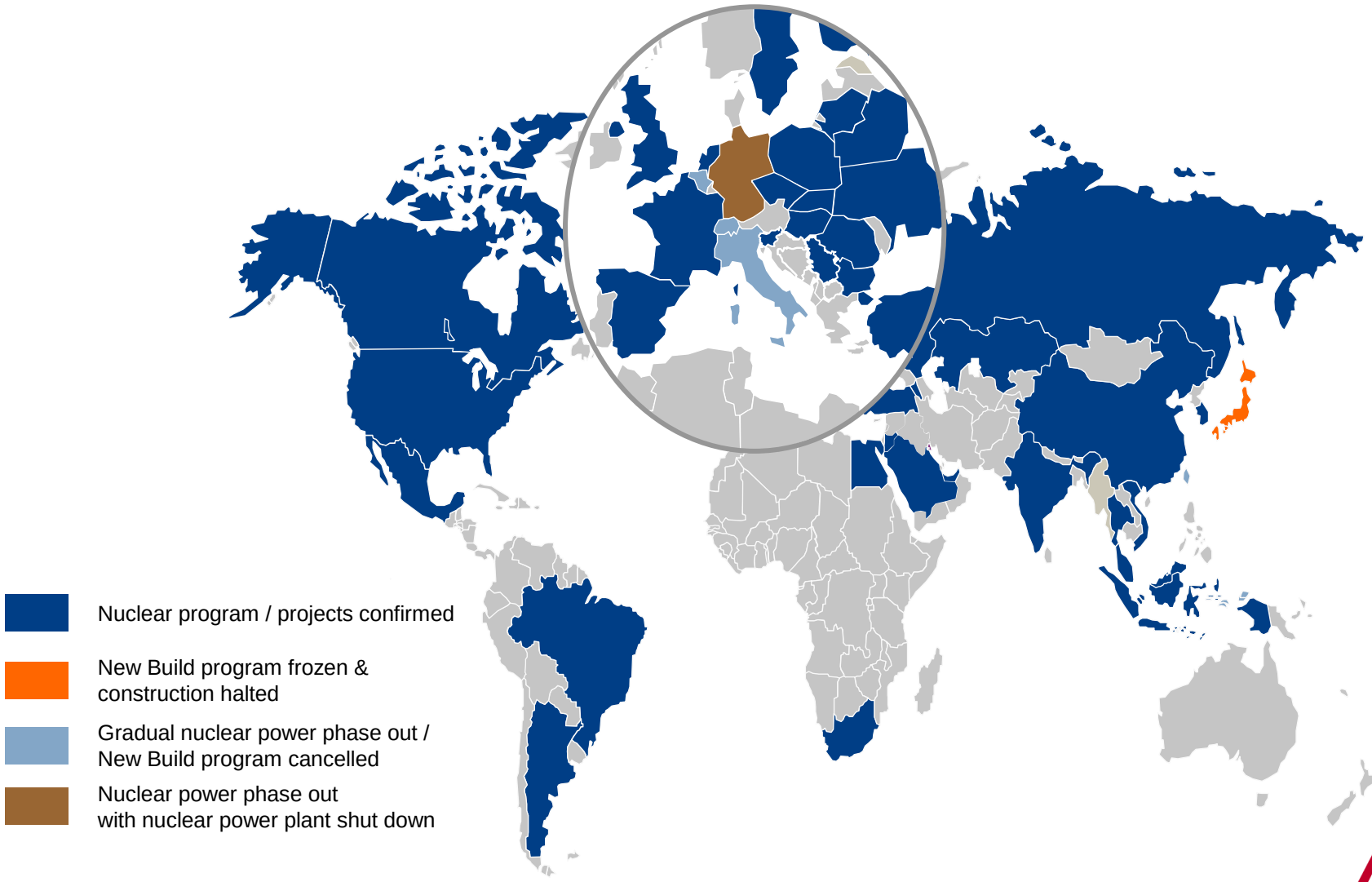
Most countries have not rushed decisions



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Main commercial prospects and new construction programmes

Finalising the negotiations	Bidding process (ongoing / upcoming)	Preparing the ground
NPCIL	FVO	Delta
CGNPC	CEZ	MVM
EDF	JAEC	TVO
HNP (techno.)	Eskom	
EDF	PGE	
TVA		
Eletronuclear		

Completion

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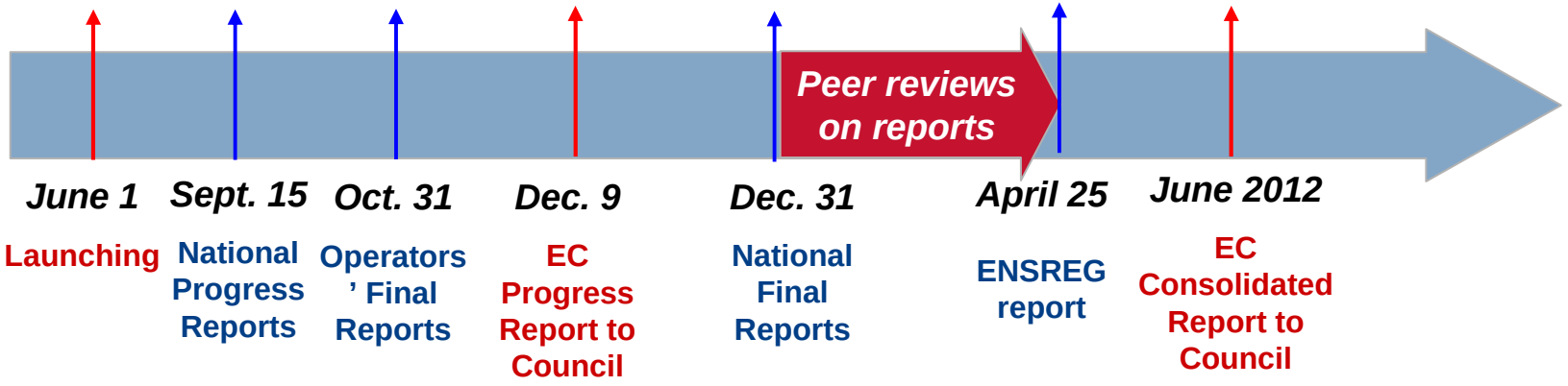
Agenda

- Flashback on Fukushima
- European nuclear safety assessments
- Reinforcing the nuclear safety framework

EU agreement on safety checks



- **Requested by the European Council, lead by national safety authorities within ENSREG and based on WENRA proposals**
- **The EU process concerns 14 countries and 143 reactors**
- **Several third countries (Ukraine, Switzerland, Japan, Canada, UAE…) are involved or are observers**
- **Tens of thousands of pages of technical reports published on line**

❑ *WENRA: Association of Chief Regulators of EU nuclear countries*

❑ *ENSREG: safety authorities of EU27 + European Commission*

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ENSREG / WENRA framework

- **Extreme natural hazards**
  - **earthquake, flood, extreme weather conditions…**
  - **Check installation conformity with referential**
  - **examine combination of hazards & hazards exceeding the referential**
- **Loss of safety functions (whatever the cause)**
  - **loss of power supply**
  - **loss of ultimate heat sink (LUHS)**
  - **assess robustness of defense in depth, examine cliff edge effects**
- **crisis management**

Assess the robustness and defense in depth of the installations in extreme situations

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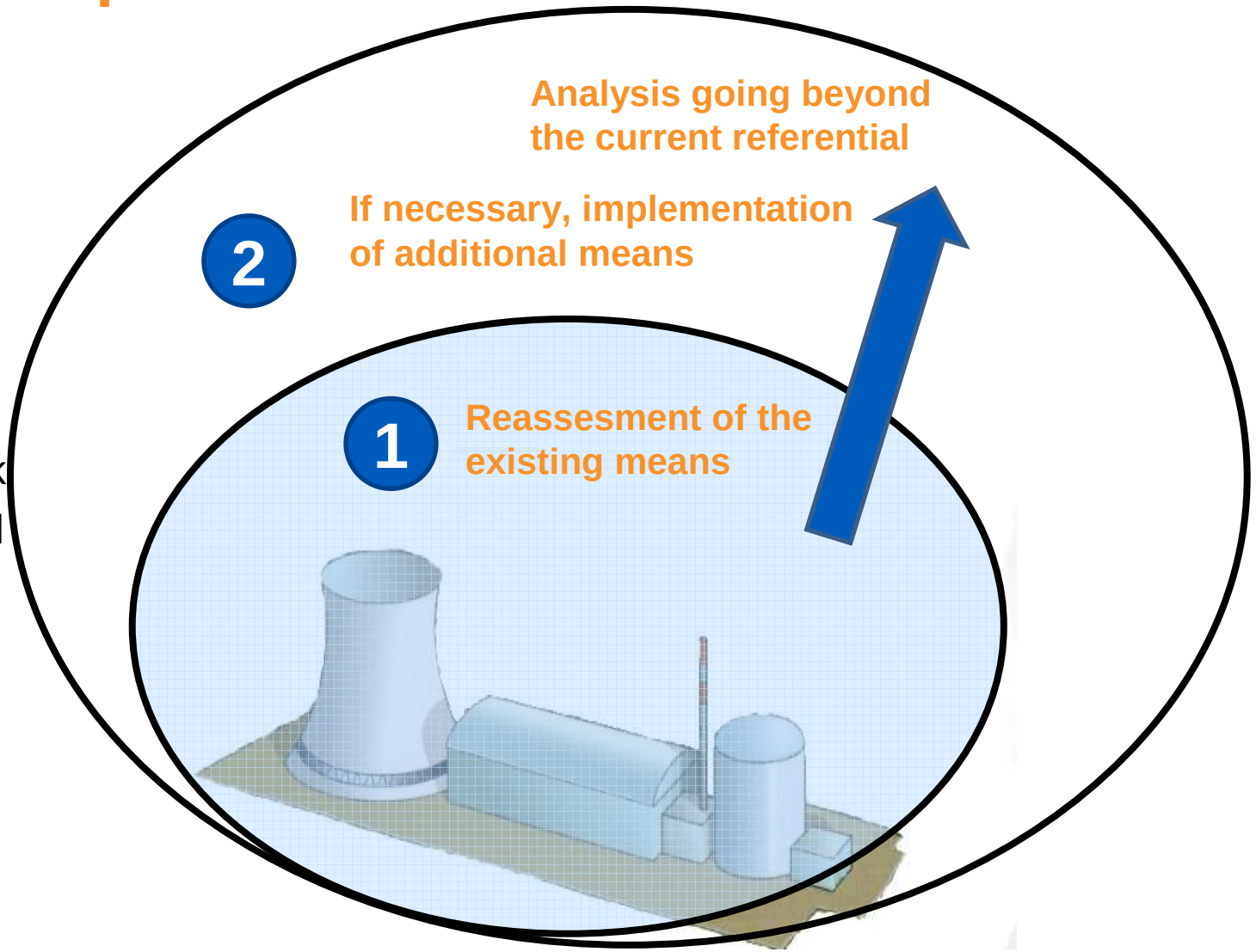
How did EDF proceed?

The 6 fields assessed :

- Earthquake
- Flooding
- Loss of heat sink
- Loss of electrical supply
- Severe accident
- Subcontracting management



EDF CSA main conclusions : the fundamentals

- **Initial design** (PWR) - good intrinsic robustness
- **Continued improvement of safety**: periodic safety assessments
- **Standardization of the EDF fleet:** homogeneity of the improvements; operating feedback of more than 1,000 reactor x years
- **Quality of plant operations**: operation, maintenance, emergency preparedness- local + national, transparency
- **Industrial organization and resources**: mastering the design and improvement of plants by the integration of engineering and R&D resources
- **General industrial context** and selection process, qualification and monitoring **of suppliers and service providers** = allows EDF to benefit from the contributions of the best companies in the world which are specialists in their field

EDF CSA main conclusions

- EDF, acting as architect-engineer and operator of its fleet, issued the Complementary Safety Analyses in a very tight schedule
- Following those CSA, EDF confirms **the present good level of safety** for all its nuclear facilities
- Following the **CSA new analyses,** EDF proposes **supplementary measures**, taking into account **potential extreme situations** further than the previous design assumptions did
- These analyses and modifications will continue **to improve even more the good level of safety** of **EDF's nuclear fleet**

Actions proposed following the Complementary Safety Assessments

Five fields of analyses - three objectives:

Earthquake

Flood and other hazard

Loss of Heat Sink/ Station Blackout (Reactor and Spent Fuel Pool)

Severe accidents

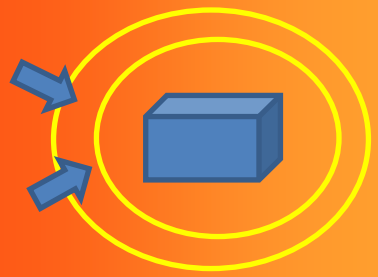
Protect the key safety functions

Avoid fuel meltdown (reactor) or fuel uncover (Spent Fuel)

Limitation of radioactive releases

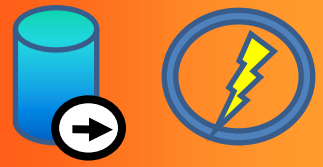
Four fields for actions

1. Reinforcement of protections against hazards



2. Additional electricity source

Additional water reserves



3. Protective measures in case of core meltdown

Studies / knowledge of phenomena

4. Optimisation of organisation

Reinforcement of crisis management

(resources and equipment)

French ASN CSA main conclusions

- On january 3rd, 2012, ASN presented its main conclusions, as requested by the French government.
- the ASN considers that the plants show a level of safety sufficient that enables her not to ask the immediate shutdown of any of them.
- At the same time, the ASN considers that it is necessary to increase, in a time as short as possible, beyond the safety margins already in place, the robustness of the plants to cope with extreme situations. The concept of “hardened core” (noyau dur) proposed by EDF answers to this requirement.
- Technical Requirement under discussion with ASN: approval on April 2012. “Hardened core” to be defined at the end of June 2012.

EPR safety at the light of Fukushima

- **EPR design incorporates :**
  - **the lessons learnt from Three Mile Island**
  - **the probabilistic safety assessments performed in the 1980s**
  - **the operational feedback from the operating fleet**
  - **the outputs of large R&D programmes on severe accidents**
- **EPR safety objectives :**
  - **set by French and German safety authorities**
  - **gain an order of magnitude on severe accident probability**
  - **include severe accident mitigation in the design**
  - **in case of core melt, only very limited protection measures, in space and time, would be requested**
  - **reinforce the design towards external hazards and terrorism**

EPR is an evolutionary design including major innovations and achieving the highest safety standards

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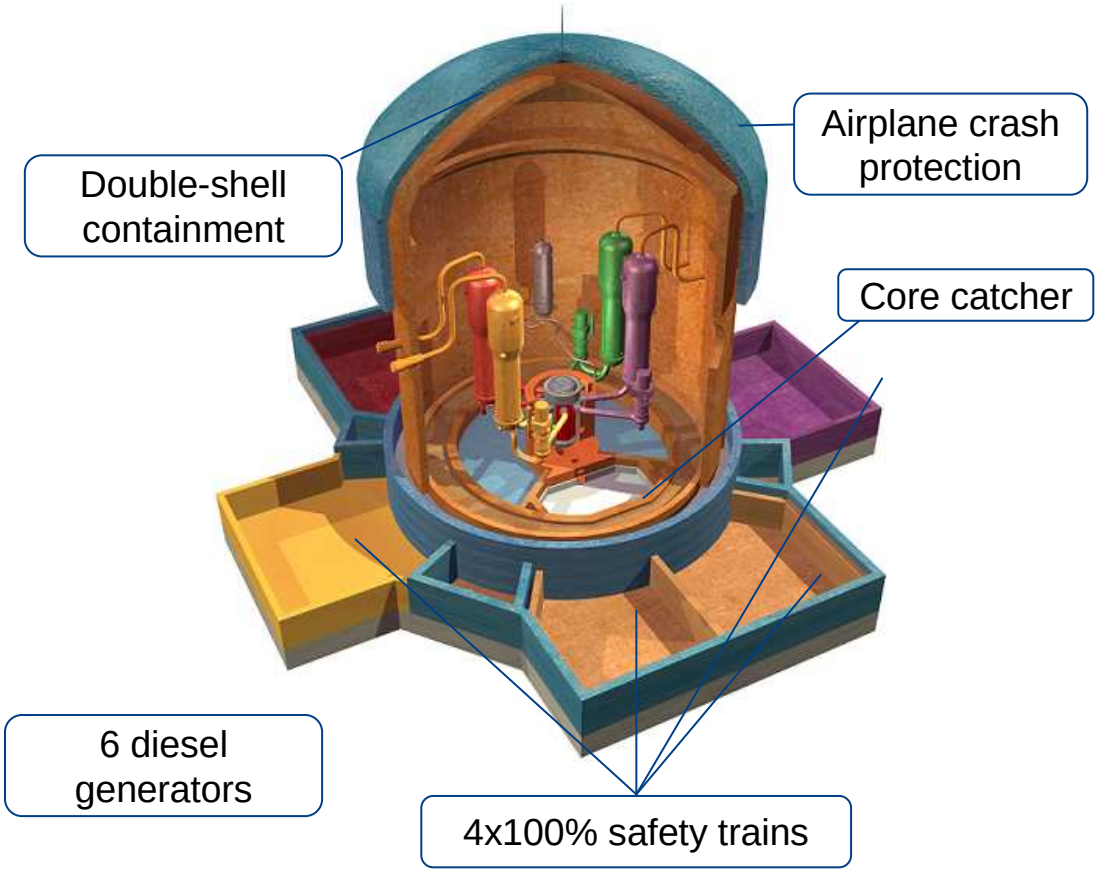
Some EPR safety features

- **Ability to withstand exceptional accidents and natural events**
- **Reducing the risk of a serious accident with core melt**
- **No significant impact on local populations near the site in the event of a serious accident**
- **Ability to withstand a commercial airplane crash**



EPR is characterized by its robustness towards external hazards and the strength of its defense in depth

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Position of safety authorities on EPR™ design and new build

France

- *"the enhanced design ensures already an improved robustness"*

Finland

- *STUK report on OL3, Dec 2011: "External events are comprehensively taken into account in the design [of the EPR reactor] and the adequacy of the design has been demonstrated"*

UK

- **Interim Design Acceptance Confirmation for UK EPR issued on Dec. 14, and final design acceptance now December 2012**

Lessons learnt

- **The EPR safety principles are confirmed after Fukushima**
- **Some modifications to further improve the robustness :**
  - **water-tightness (eg ultimate back-up diesel building and pumping station)**
  - **autonomy of the site (eg fuel for diesels)**
  - **mobile means (generators, pumps)**
- **The return on experience analysis will be based on a continuous improvement approach**



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AREVA's comments on the European safety review

- **The European complementary safety assessments could become an international best-practice in terms of thoroughness and transparency.**
- **National reports and conclusions highlight that nuclear safety is not fundamentally called into question, that no nuclear plants need to be closed but that some technical improvements are to be implemented to increase robustness of existing installations.**
- **Once the assessments are concluded, an additional follow-up phase could be agreed to exchange on the measures to be implemented.**
- **It is too early to anticipate any conclusion from this process but it is likely that some areas of convergence could be identified at European level.**

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- Flashback on Fukushima
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- Reinforcing the nuclear safety framework

Topics currently discussed at EU level

- After Fukushima, the Council tasked the European Commission to evaluate if the nuclear safety framework should be reinforced.
- Last December, twelve Member States* had not yet transposed the 2009 directive.
- A public consultation has been launched which covers:
  - Competence and independence of nuclear safety authorities
  - Basic principles and requirements on the siting, design & construction and operation of nuclear installations
  - Scope of peer reviews
  - Transparency obligations
  - Emergency response processes
  - Communication tools

* Austria, Belgium, Cyprus, Denmark, Estonia, Greece, Italy, Latvia, Poland, Portugal, Slovakia and the UK

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Enhancing cooperation among national safety authorities

- **Nuclear safety is a national prerogative.**

- **Nuclear safety relies on the very high level of technical expertise and processes within Safety Authorities.**

→ **harmonisation of nuclear safety in Europe is to be achieved through enhanced cooperation among European regulators.**

- **Safety authorities could be tasked to define roadmaps towards:**
  - **Nuclear safety standards for new builds**
  - **Harmonization of licensing through cross-recognition of safety assessments.**

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WENRA[1] members

Nuclear safety agencies of countries operating nuclear power plants…

Germany	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	Hungary	OAH	United Kingdom	HSE	Austria	lebensministerium.at
Belgium	AFCN agence fédérale de contrôle nucléaire	Lithuania	State Nuclear Power Safety Inspectorate (VATESI)	Slovakia		Ireland	Radiological Protection Institute of Ireland
Bulgaria		Netherlands	Rijksoverheid	Slovenia		Italy	MINISTERO DELLO SVILUPPO ECONOMICO
Spain	CSN CONSEJO DE SEGURIDAD NUCLEAR	Czech Rep.	SÚJB	Sweden	Strål säkerhets myndigheten Swedish Radiation Safety Authority	Luxembourg	Ministère de la Santé DIRECTION DE LA SANTÉ GRAND-DUCHÉ DE LUXEMBOURG
Finland	STUK	Romania	IFIN-HH	Switzerland	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra	Norway	Statens strålevern Norwegian Radiation Protection Authority
France	asn					Poland	PAA

Note: L'Arménie, la Russie et l'Ukraine participent également à WENRA avec un statut d'observateur
1. Western Europe Nuclear Regulators Association
Source: www.wenra.org

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WENRA's objectives for new builds

1. Normal operation, abnormal events and prevention of accidents
2. Accidents without core melt
3. Accidents with core melt
4. Independence between all levels of defence-in-depth
5. Safety and security interfaces
6. Radiation protection and waste management
7. Leadership and management for safety

« Reducing, as far as reasonably achievable, the core damage frequency taking into account all types of credible hazards and failures and credible combinations of events »

Qualitative in nature but sufficiently prescriptive to set the reference for new builds in a non-binding proposal

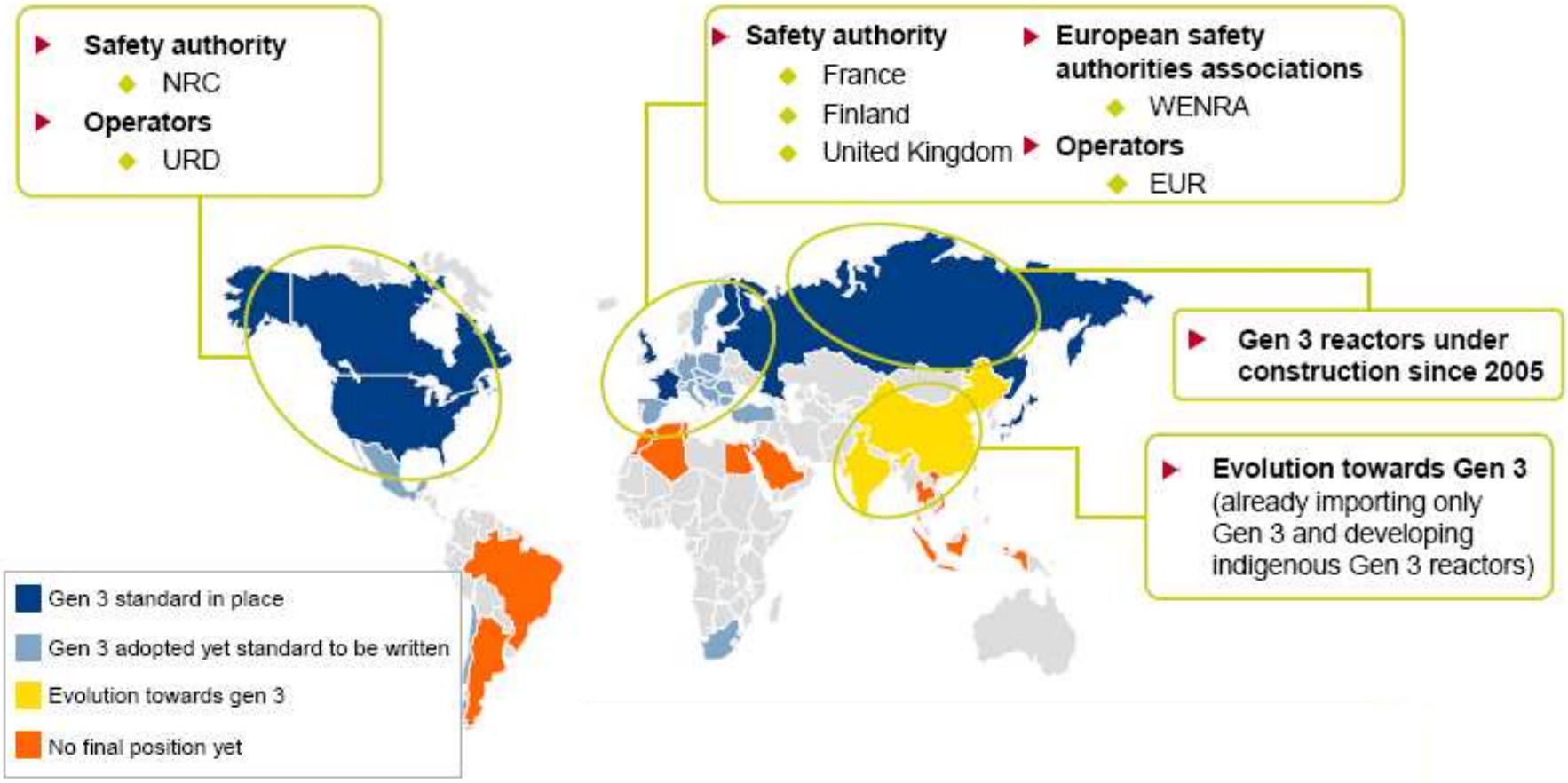
Endorsement of WENRA safety objectives

- **In February 2011, the European Council called "*to maintain and promote the highest nuclear safety standards internationally*".**

- **Heads of state now need to politically endorse WENRA safety objectives so they are used as a reference in the EU and beyond.**

- **Nuclear safety regulators should be tasked to agree on a roadmap towards common technical safety standards for new build, taking due account of WENRA "position papers".**

Importance to promote GEN 3 safety standards



Source: AREVA analysis

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Wrap-up

- **The Fukushima accident has not halted the development of nuclear but safety is reaffirmed as a non negotiable priority.**
- **The industry is committed to take stock of all the lessons from the Fukushima accident.**
- **The European complementary safety assessments could become an international best-practice in terms of thoroughness and transparency.**
  - **National reports and conclusions highlight that nuclear safety is not fundamentally called into question**
  - **Technical improvements are to be implemented to increase robustness of existing installations in extreme and beyond design situations.**
- **Harmonisation of nuclear safety in Europe is to be achieved through enhanced cooperation among European regulators.**
- **Heads of state now need to politically endorse WENRA safety objectives for new builds so they are used as a reference in the EU and beyond.**

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