Zoran V. STOŠIĆ
Vice President Marketing and Sales South–East Europe

Despite Fukushima the Nuclear Perspectives Hold

28 November 2011, Zagreb, CROATIA

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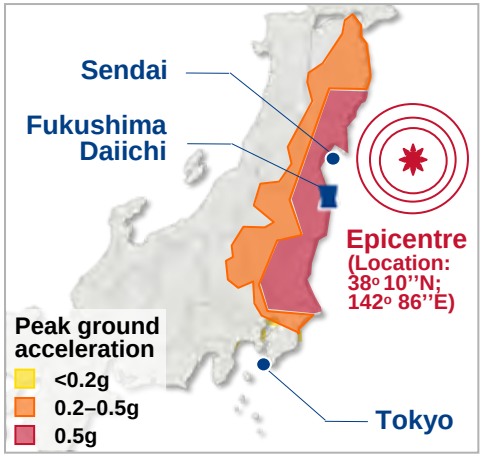
Combination of Natural Hazards of Exceptional Magnitude



Quake

- 2011 Tōhoku earthquake (Great East Japan Earthquake) occurred at 14:46 JST (05:46 GMT) on Friday, March 11th, 2011
  - Magnitude: 9.0 (M_w)
  - Duration: approximately 6 minutes
- Most powerful known earthquake in Japan; 4th largest earthquake in the world since modern record–keeping began in 1900

Global

- Earthquake moved the main island of Japan by 2.4 m, the eastern parts of Japan by 3.65 m closer to North America, speeded up Earth's rotation, cutting day by 1.8 µs due to redistribution of the planet's mass and shifted Earth's figure axis by 25 cm

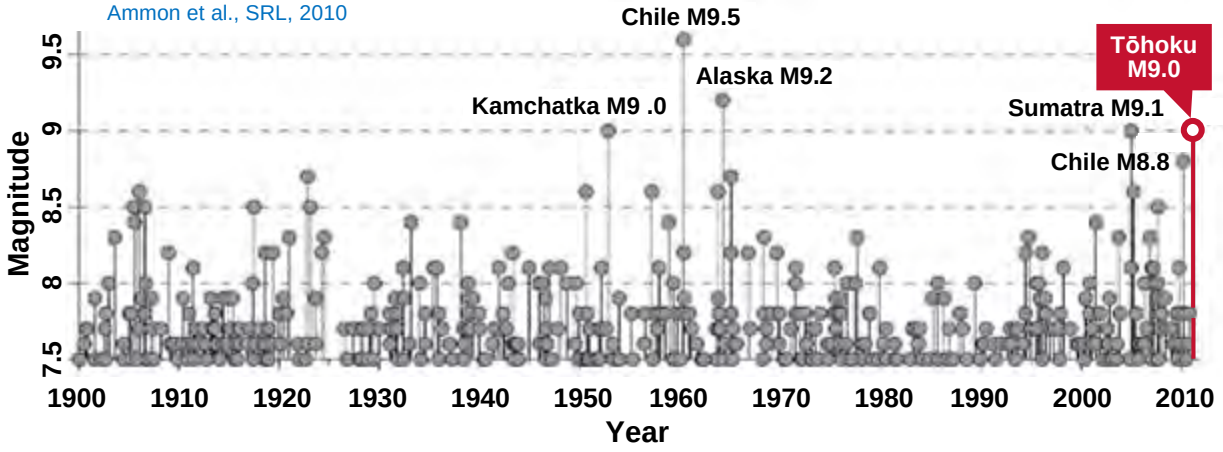
Tsunami

("Harbour Wave" in Japanese)

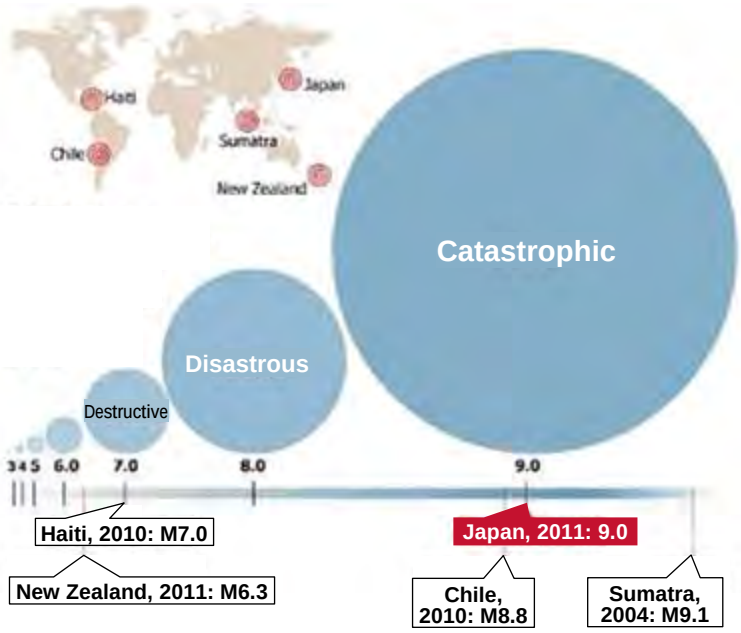
- Tsunami waves, which reached heights of up to 40.5 m in Miyako, travelled up to 10 km inland in the Sendai area. Tsunami wave height estimated at approximately +15 m (Onahama Port base tide level)

A History of Large Earthquakes

Source: USGS PAGERCAT 1900-2008, USGS-NEIC; gCMT 2008-present; Ammon et al., SRL, 2010



Magnitudes of Recent Earthquakes

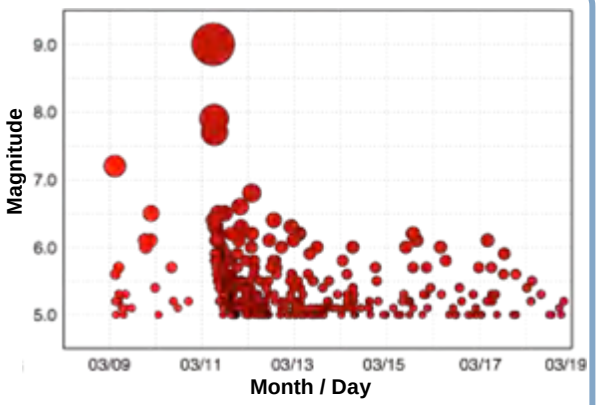


Seismic Energy:
Each step on the magnitude scale is 10 times more powerful than the previous step. Circles represent the seismic energy to scale

Source: USGS, Washington Post; www.OurAmazingPlanet.com

2011 Great Tōhoku Earthquake

Fore– and After–Shocks



- March 11 earthquake was preceded by a series of large foreshocks over the previous two days, beginning on March 9th with a M 7.2 event approximately 40 km from the epicenter of the March 11 earthquake, and continuing with another three earthquakes greater than M 6 on the same day
- Until July 75 aftershocks of magnitude 6.0 or greater have struck the region

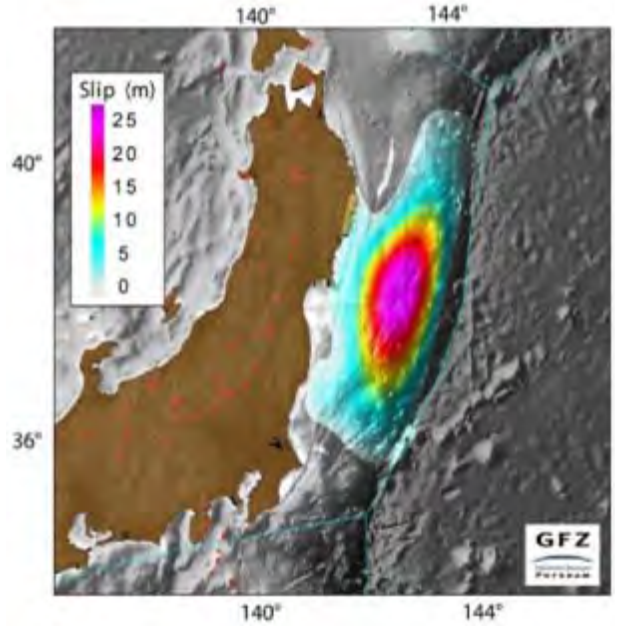
Source:
http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usc0001xgp/#summary

Tectonic Effects

- Water depth: z ≈ 7–8 km
- Hypo centre depth: z_H ≈ 20–25 km
- Peak displacement in the deep underground: D_{max} ≈ 17–25 m
- Crack velocity: v ≈ 2 km/s
- Rupture zone: A ≈ 500 × 100 km
- Vertical displacement: D ≈ 7–10 m
- Rough estimate of water volume involved: V ≈ 125 km^3
- Consequence: Sudden displacement of huge water volume ⇒ Tsunami

Source: Dr. H. Meidow, Cologne, 2011

Topographic Effects

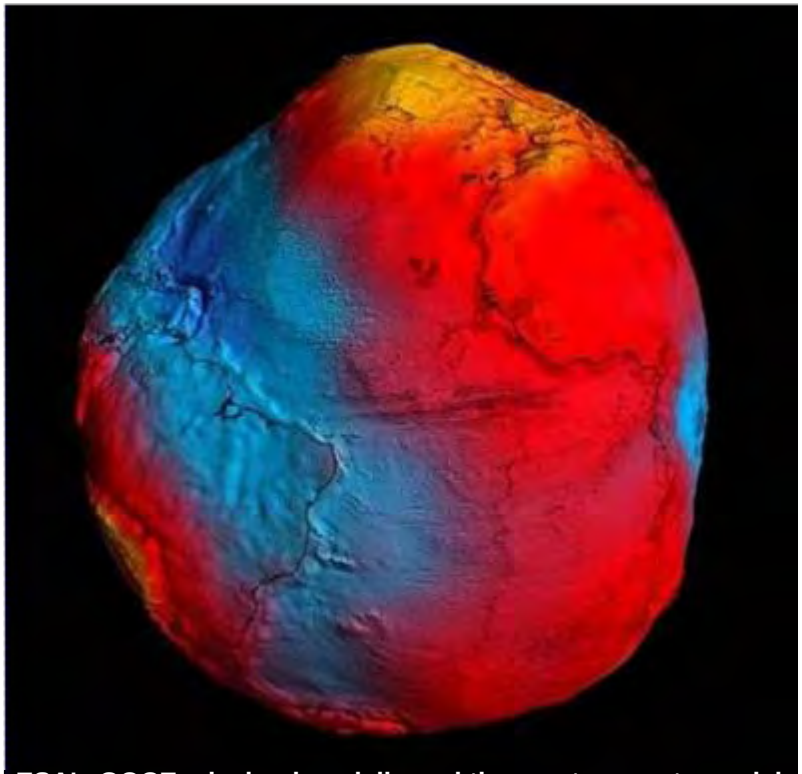


- Relative (maximum) horizontal displacement of Japan, based on GPS data: ≈ 5.2 m
- Displacement on rupture surface: ≈ 25–27 m
- Rupture length (aftershock): ≈ 400 km
- Sea bed lifting: up to 7 m

Source: Dr. H. Meidow, Cologne, GFZ Potsdam, 2011

2011 Great Tōhoku Earthquake

Altered Earth's Gravity



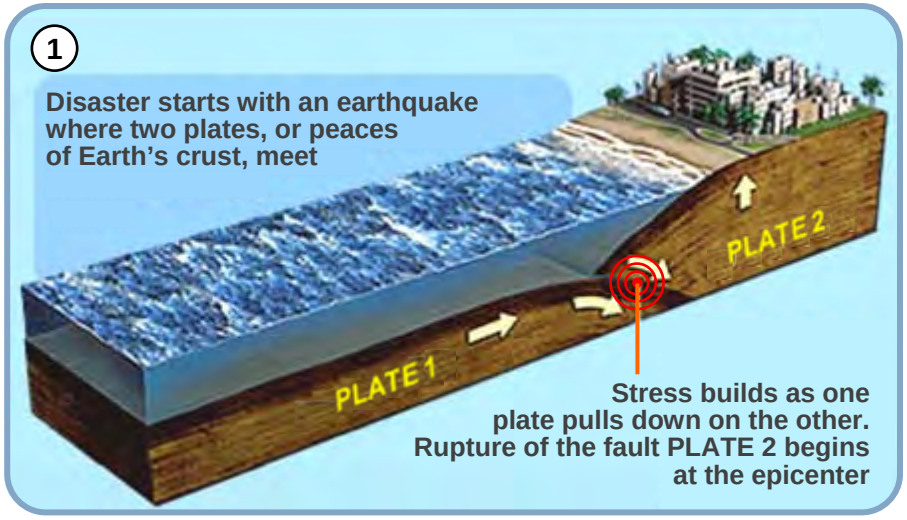
ESA's GOCE mission has delivered the most accurate model of the 'geoid' ever produced. Red corresponds to points with higher gravity, and blue to points with lower gravity

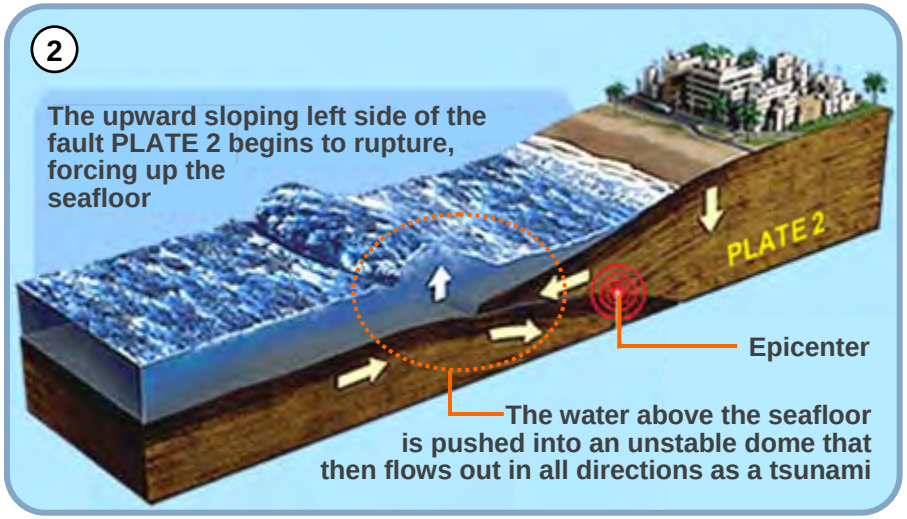
- The devastating earthquake was powerful enough to slightly alter the pull of gravity under the affected area
- To see how the earthquake might have deformed the Earth there, scientists used the Gravity Recovery and Climate Experiment (GRACE) satellites to analyze the area's gravity field before and after the quake
- The researchers found the Tōhoku quake reduced the gravity field there by an average of two–millionths of a Gal by slightly thinning the Earth's crust

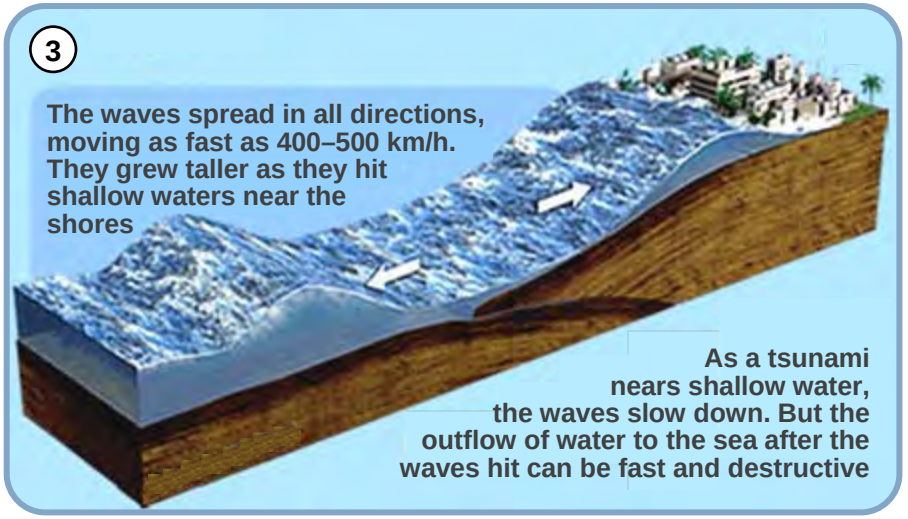
  (In comparison, the strength of the gravitational pull at the Earth's surface is, on average, 980 Gals — the Gal, short for Galileo, is a unit of acceleration; 1 Gal = 1 cm/s^2)
- The most important implication of scientists' findings is that the massive Tōhoku earthquake brings significant changes to not only the ground but also the underground structure of Japan
- The newest data suggests that the ground between the two tectonic plates slipped as much as 50 meters, twice the slip of other giant quakes such as the M 9.1 off Sumatra in 2004 and the M 8.8 in Chile in 2010. This massive movement is one reason why the Japan quake produced such a large and powerful tsunami

Source:
http://www.ouramazingplanet.com/1887-japan-earthquake-altered-earth-gravity.html

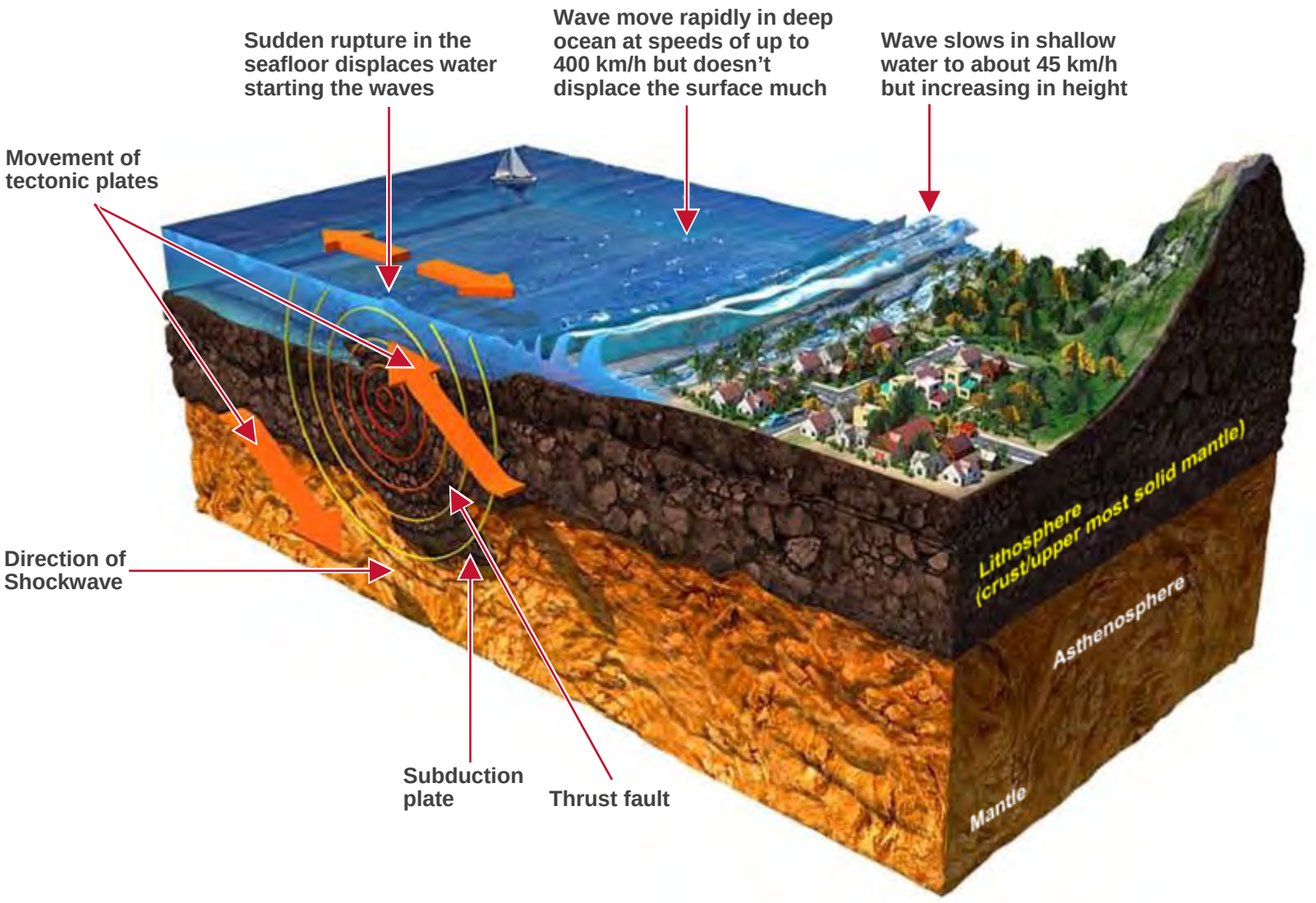
What Causes a Tsunami?





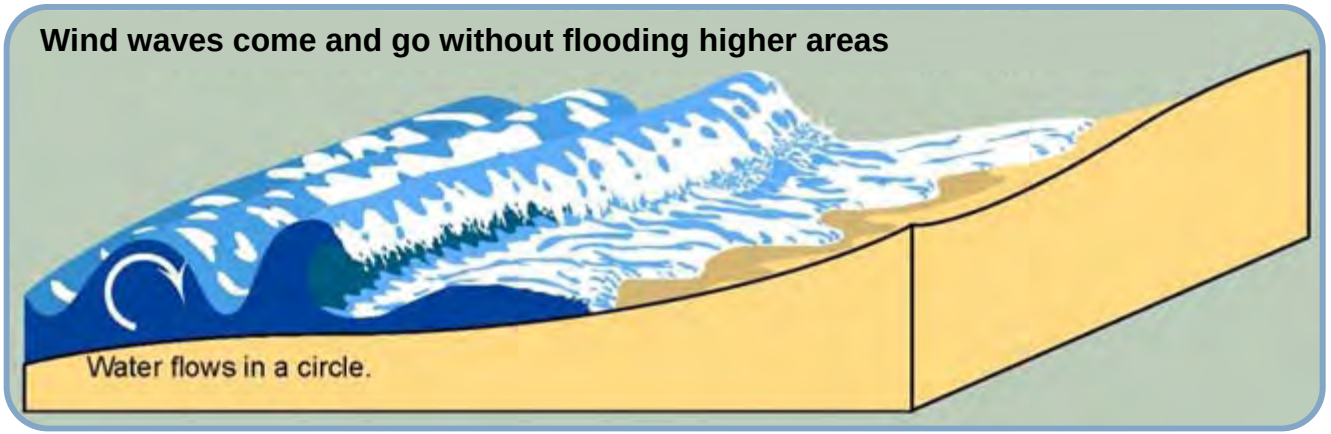


Anatomy of Earthquake / Tsunami

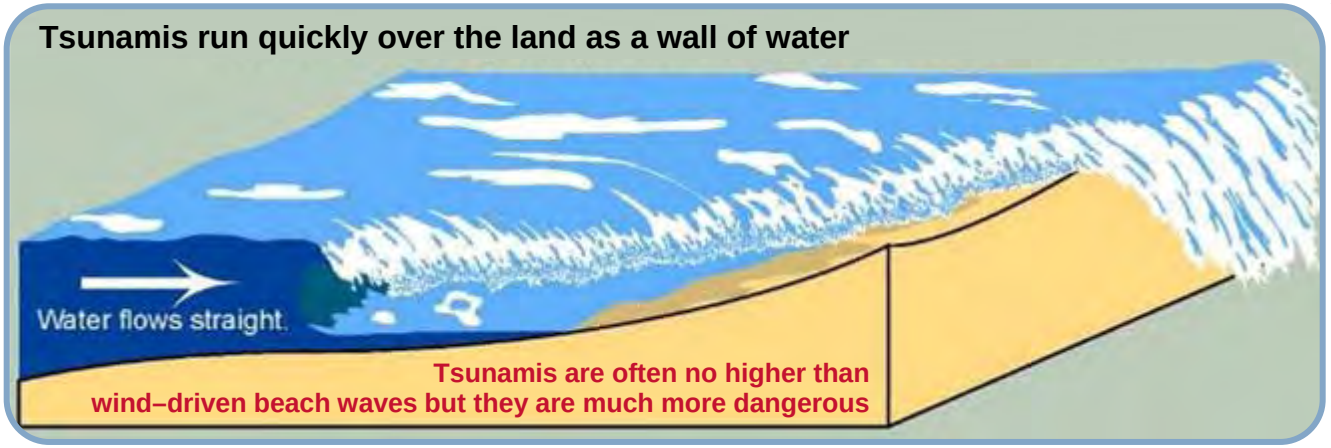


Tsunami versus Wind Wave

Wind Wave



Tsunami



Power of Tōhoku Tsunami










1 Tōhoku Earthquake and Tsunami

2 **Fukushima: Accident due to Natural Disaster**

3 Environmental and Socio–Economic Effects

4 Safety Authorities' Actions Worldwide

5 Impact on Nuclear Power around the Globe

6 AREVA's Positioning

7 Global State of Affairs and Outlook

8 In a Nutshell

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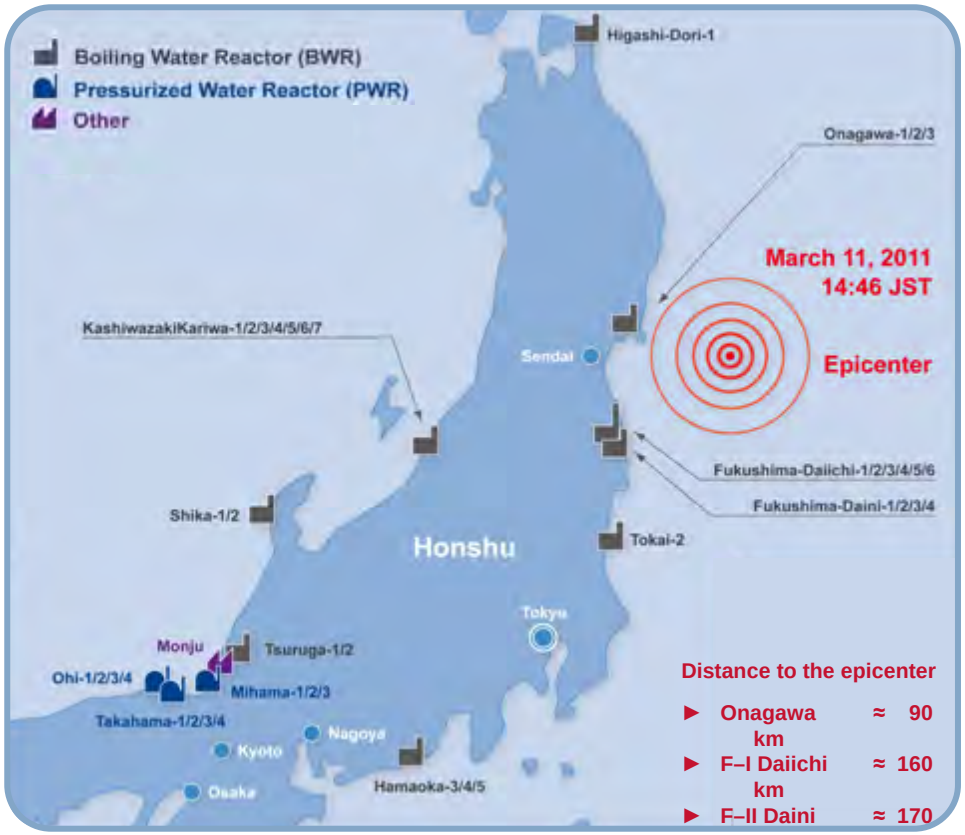
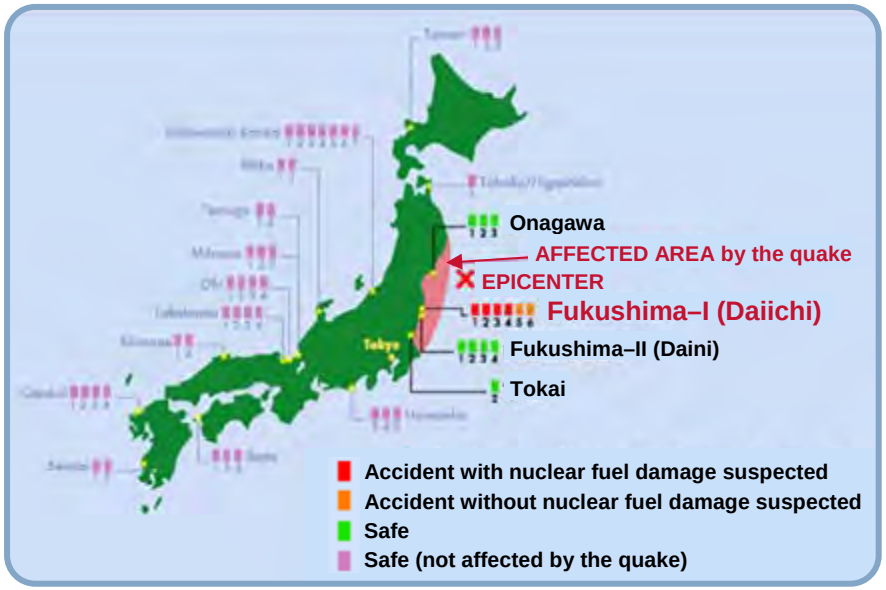
NPPs in Service on March 11th





At time when the earthquake occurred

► **11 reactors under operation automatically shutdown**
- Onagawa 1–3
- Fukushima Daiichi 1, 2, 3
- Fukushima Daini 1–4
- Tokai Daini

► **3 reactors under periodic inspection**
- Fukushima Daiichi 4, 5, 6

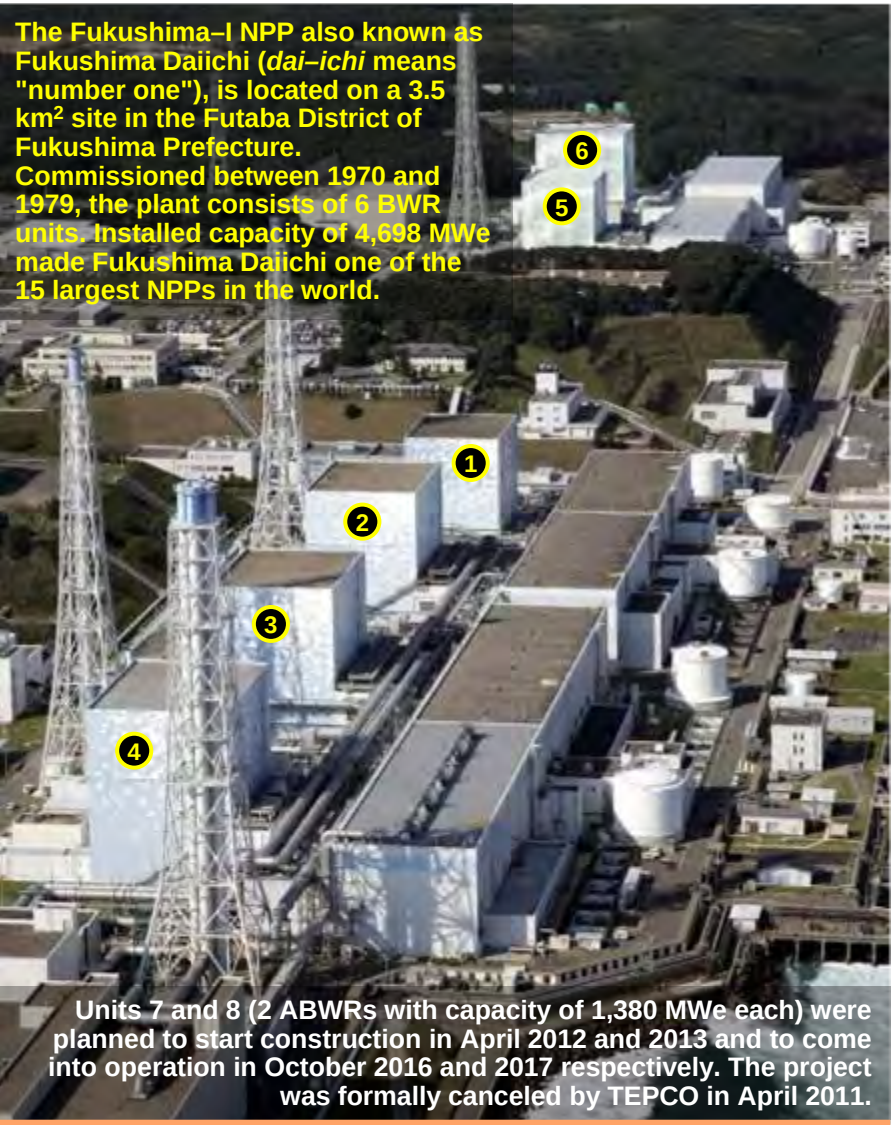
About 55 minutes later, tsunami hit the NPPs

► **Following reactors went to cold shutdown**
- Onagawa 1–3: Offsite power and sea water pumps were available
- Fukushima Daiichi 5, 6: One Emergency DG was available
- Fukushima Daini 1–4: Offsite power was available
- Tokai Daini: Two Emergency DGs were available

► **Problems appear with Fukushima Daiichi 1–4**

NPP Fukushima–I (Daiichi) and –II (Daini)

The Fukushima–I NPP also known as Fukushima Daiichi (*dai–ichi* means "number one"), is located on a 3.5 km² site in the Futaba District of Fukushima Prefecture.
Commissioned between 1970 and 1979, the plant consists of 6 BWR units. Installed capacity of 4,698 MWe made Fukushima Daiichi one of the 15 largest NPPs in the world.



Units 7 and 8 (2 ABWRs with capacity of 1,380 MWe each) were planned to start construction in April 2012 and 2013 and to come into operation in October 2016 and 2017 respectively. The project was formally canceled by TEPCO in April 2011.

Unit	1	2	3	4	5	6
Reactor type & Electric power	BWR–3 460 MW	BWR–4 784 MW	BWR–4 784 MW	BWR–4 784 MW	BWR–4 784 MW	BWR–5 1,100 MW

The Fukushima–II NPP also known as Fukushima Daini (*dai–ni* means "number two"), is located on a 1.5 km² site in the Futaba District of Fukushima Prefecture.
Commissioned between 1981 and 1986, the plant consists of 4 BWR units with total installed capacity of 4,400 MWe.

Unit	1	2	3	4
Reactor type & Electric power	BWR–5 1,100 MW	BWR–5 1,100 MW	BWR–5 1,100 MW	BWR–5 1,100 MW

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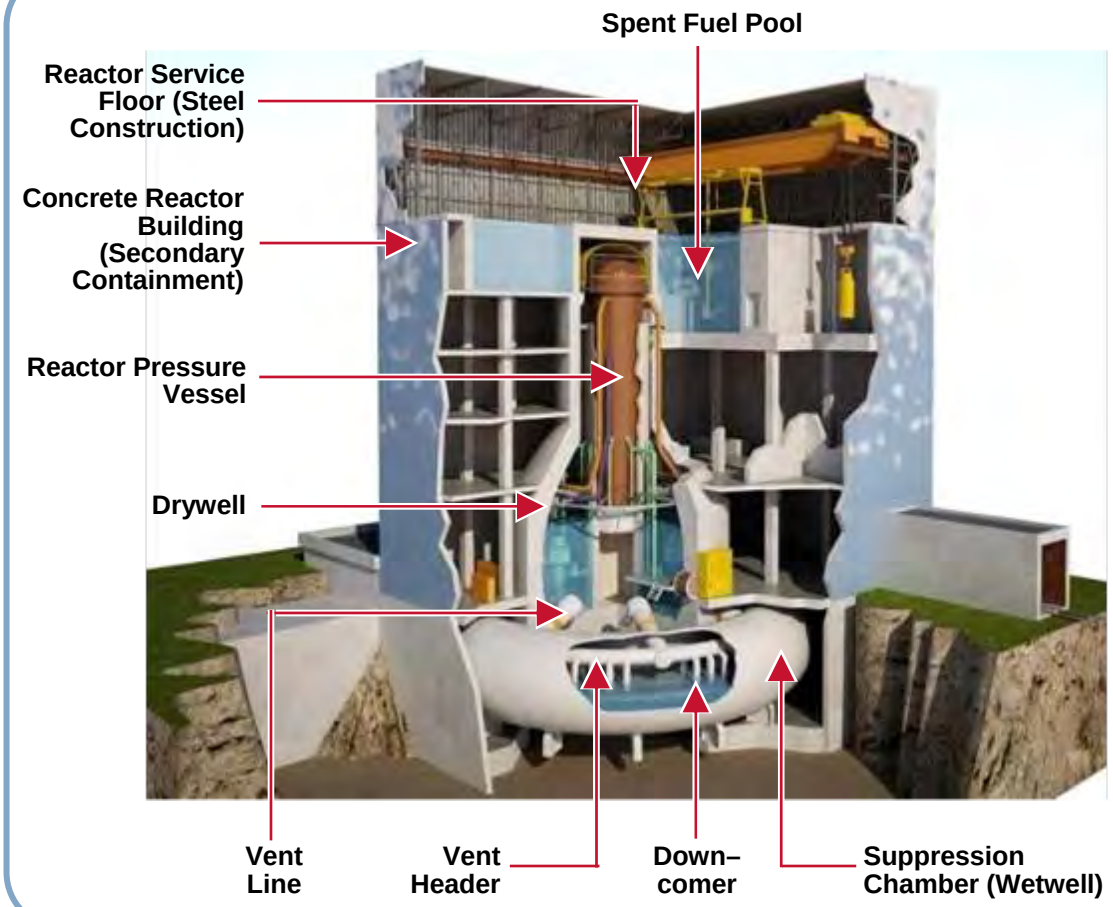
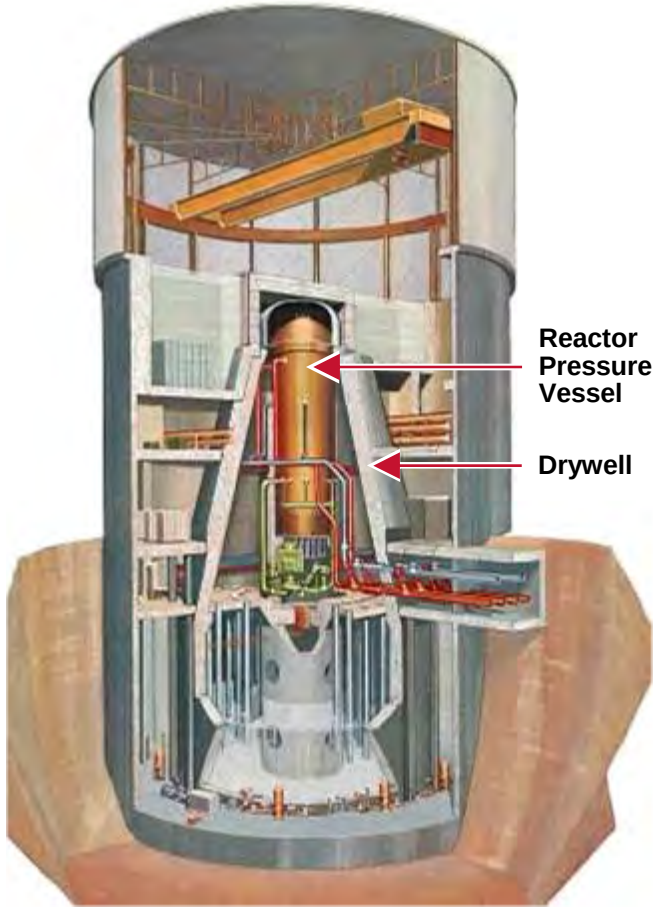
BWRs of Fukushima–I and –II

Daiichi Unit 1–5 / Mark–I

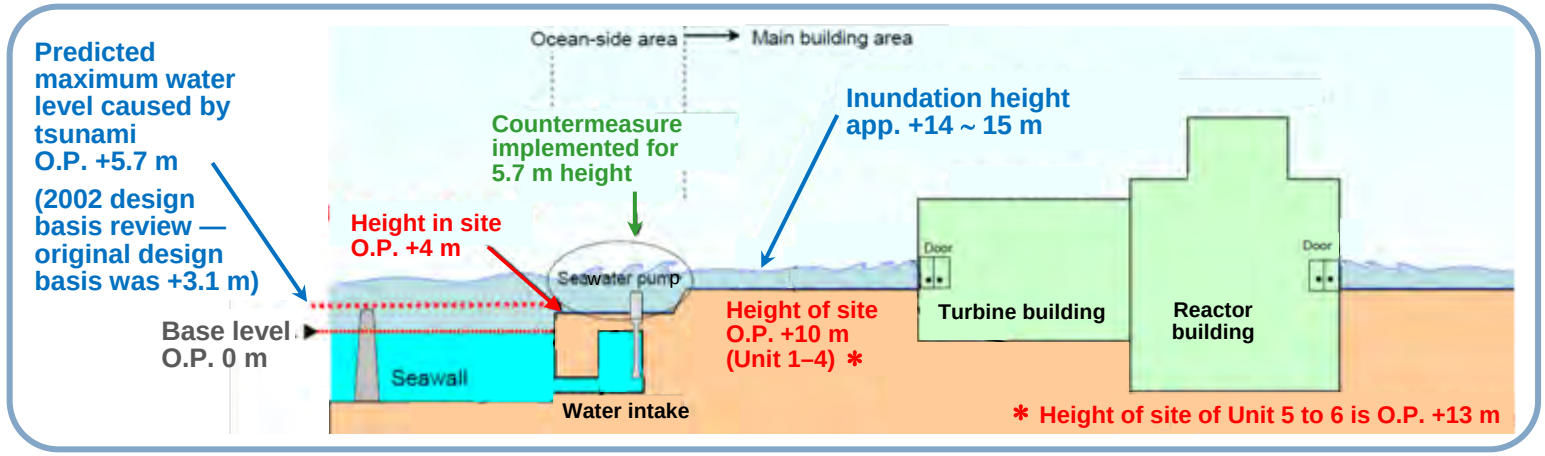


Daiichi Unit 6 & Daini / Mark–II

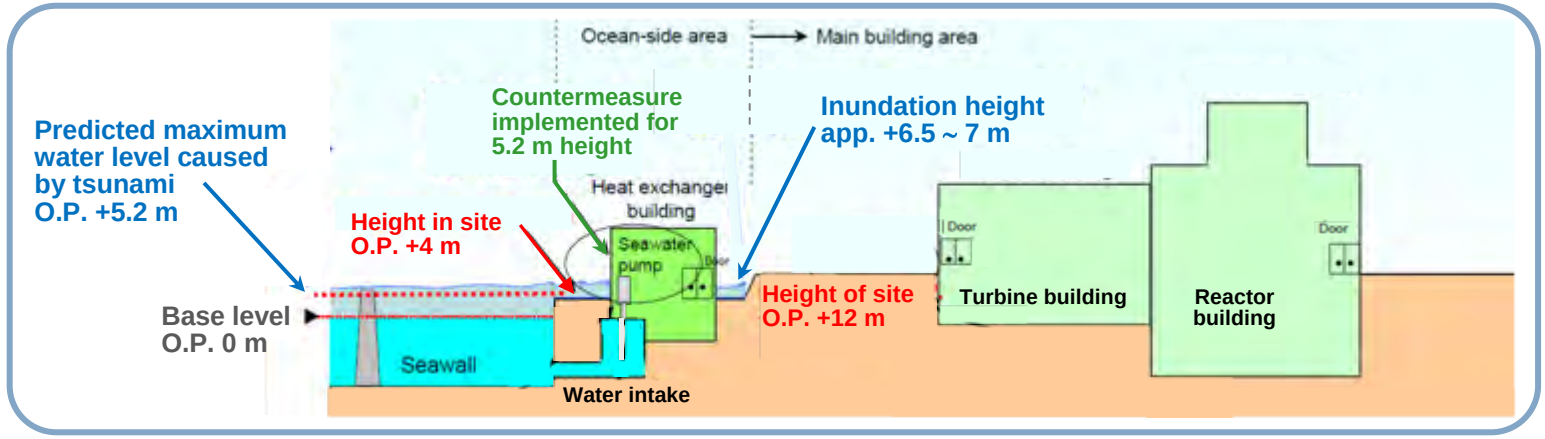


Tsunami Impact on Fukushima–I and –II

Daiichi

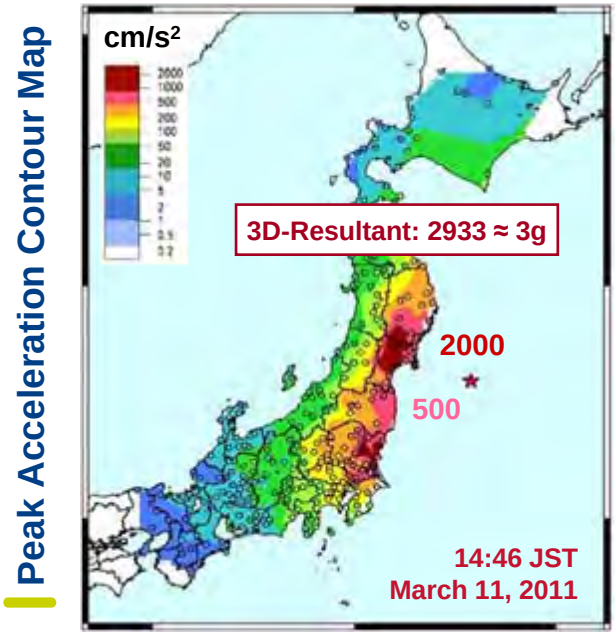


Daini



- Based on the evaluation method by the Japan Society Civil Engineers revised on 2002, we assumed the highest water level of Tsunami as O.P. +5.7m at Fukushima Daiichi and O.P. +5.2m at Fukushima Daini
- Inundation height was approximately O.P. +15m at Fukushima Daiichi and approximately O.P. +7m at Fukushima Daini
- Accordingly, we have confirmed that the impact of Tsunami (water level and inundated area) was relatively larger in Fukushima Daiichi NPS than Fukushima Daini NPS

Fukushima Daiichi: Beyond Design Basis Earthquake

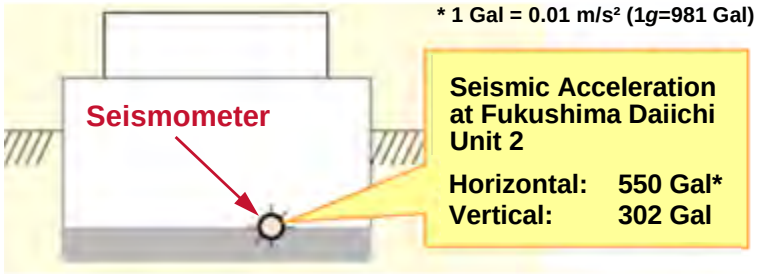


Source: NISA, JNES, TEPCO

Fukushima Daiichi	Acceleration[1] in cm/s²		
	Horizontal		Vertical
	N–S	E–W	
Unit 1	460	447	258
Unit 2	348	550	302
Unit 3	322	507	231
Unit 4	281	319	200
Unit 5	311	548	256
Unit 6	298	444	244
Design Basis	441	438	412
Shutdown[2]	135 – 150		100

E-W: East-West N-S: North-South
[1] maximum response, preliminary data [2] threshold for reactor scram

Source: Nied, WANO Tokyo, TEPCO, 2011



- The earthquake moment–magnitude was M_w=9.0 and Fukushima design basis value was M_w=8.2. So the moment–magnitude was by a factor of $10^{(9.0-8.2)} \approx 6.3$ higher
- The measured accelerations was up to 26% higher than quake design basis values
- Despite, automatic shutdown of all operating reactors (units 1–3) occurred within seconds — Units 4–6 shutdown for outage at the time of the earthquake

Fukushima Daiichi: Beyond Design Basis Tsunami

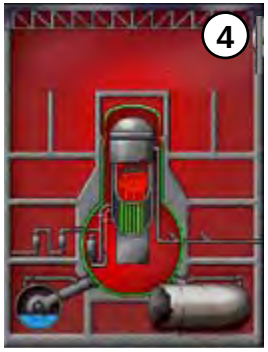
Fukushima Daiichi: A Multi–Unit Accident

Units 1, 2 and 3 until Hydrogen Explosion and Explosions at Units 1 and 3

Core damaged but retained in vessel

Some portions of core melt into lower RPV head

Containment pressurizes. Likely leakage at drywell

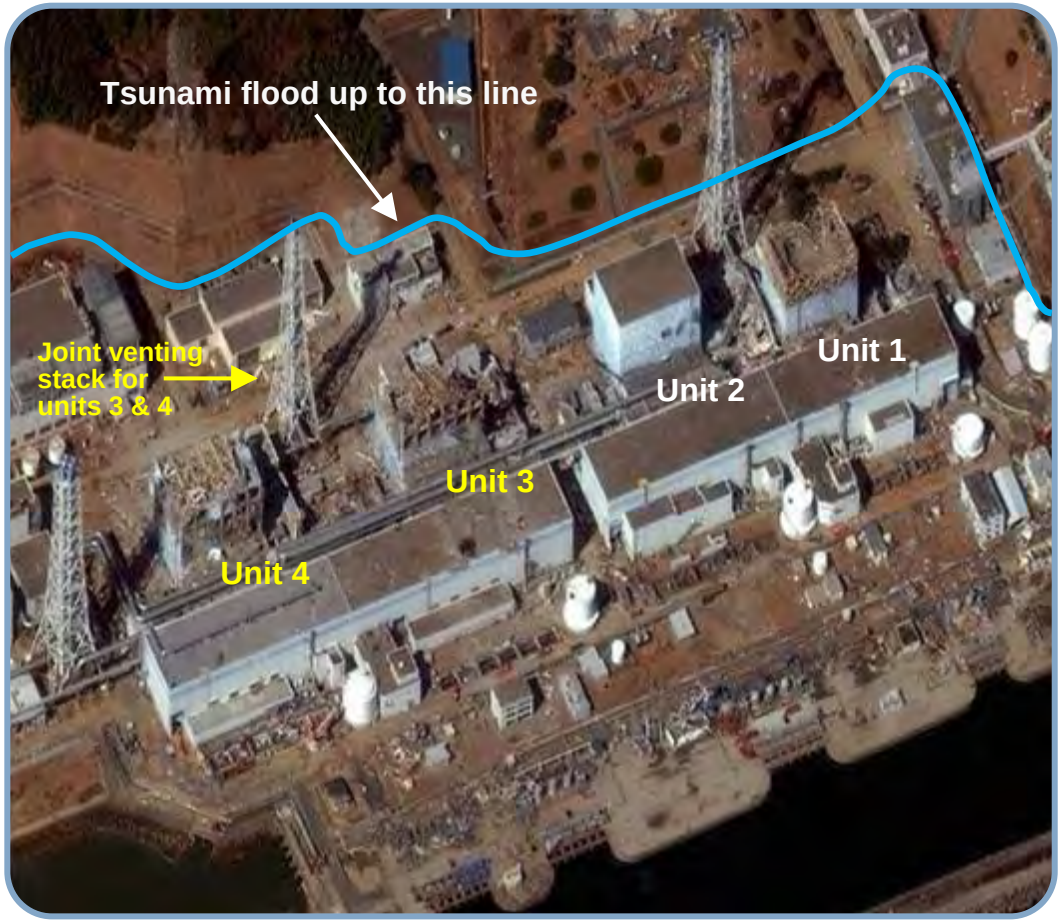


Releases of hydrogen into secondary containment

Unit 1 explosion (March 12th at 15:36)

Unit 3 explosion (March 14th at 11:01

Aerial View After Explosions



Source: Janti, Digital Globe, 2011

October 18th — Fukushima Daiichi on Target for Cold Shutdown

- **Units 1 to 3 are all on track to be declared in cold shutdown by the end of the year, in line with the schedule set in the restoration roadmap, according to TEPCO**
- **Cold shutdown would be declared once the temperature at the bottom of the RPV of each reactor is being effectively maintained at below 100ºC and the release of radioactive materials from the units is "under control and public radiation exposure by additional release is being significantly held down“**
- **These conditions — the goal of the second phase of TEPCO's roadmap for stabilisation — have now almost been met**

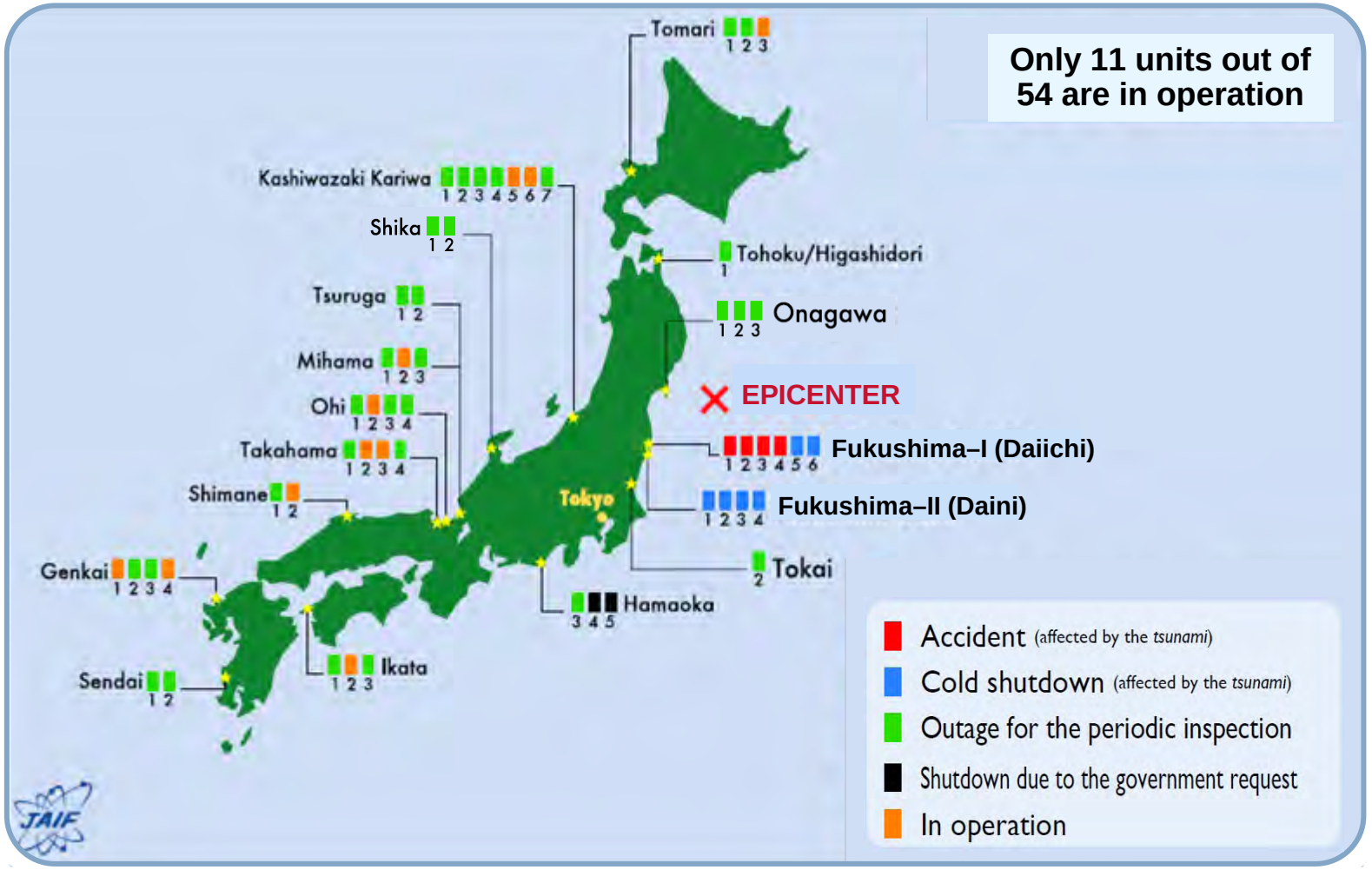
The reactor building cover in place at Unit 1

November 17th — Driving on with Fukushima Daiichi Roadmap

- **6 of 10 stabilisation goals at Fukushima Daiichi are completed, with official recognition of cold shutdown still outstanding despite low core temperatures**
  - **Temperatures recorded at the bottoms of the RPVs for Units 2 and 3 are below 70ºC, while Unit 1 is cooler still at 37ºC**
  - **Being below the landmark 100ºC, these basically fulfil the conditions for the declaration of cold shutdown although this has not been officially recognised by the government**
  - **A complicating factor is the uncertainty over the melted core. Water leaking from holes in the bottoms of the RPVs, has lead to concerns that corium may have followed. Drywells contain large pools of water at below 50ºC**
- **The latest update on roadmap activities from TEPCO and the Ministry of Economy, Trade and Industry detailed the tasks completed as well as those that lie ahead for the ruined plant**
- **Stable cooling of damaged reactors has been improved and the release of radioactivity further reduced. The accumulation of water used for cooling is being managed and the site has improving margins to avoid this water overflowing, in case of typhoon for example**
- **The rate of emission of radioactivity is around 13 million times less than at the height of the accident on March 15**

Source: http://www.world-nuclear-news.org

Status of the NPPs in Japan as of November 2nd



Source: JAIF, 2 November 2011

Why have Other Plants in affected Area survived?

Fukushima Daiichi Unit 5 & 6

- Elevation of the ground level is 13 m (Unit 1–4: 10 m)
- One air cooled EDG of Unit 6 which is located on the ground level and Metal Clad Switchgear (M/C) were not lost
- Temporary sea water pump installed after the earthquake was operable, making use of power source from survived EDG

Fukushima Daini NPS

- Offsite Power was not lost
- RHR function of Unit 3 survived
- Motors of sea water pumps for Unit 1, 2 and 4 were replaced on March 14th, followed by re–activation of core cooling function

Onagawa NPS

- Elevation of the ground level 14.8 m was higher than Tsunami wave height

Tokai Daini NPS

- Although off site power was lost until May 13th, 2 out of 3 DGs were available thanks to the recently installed barrage to one of 2 seawater pump area to protect pumps from tsunami

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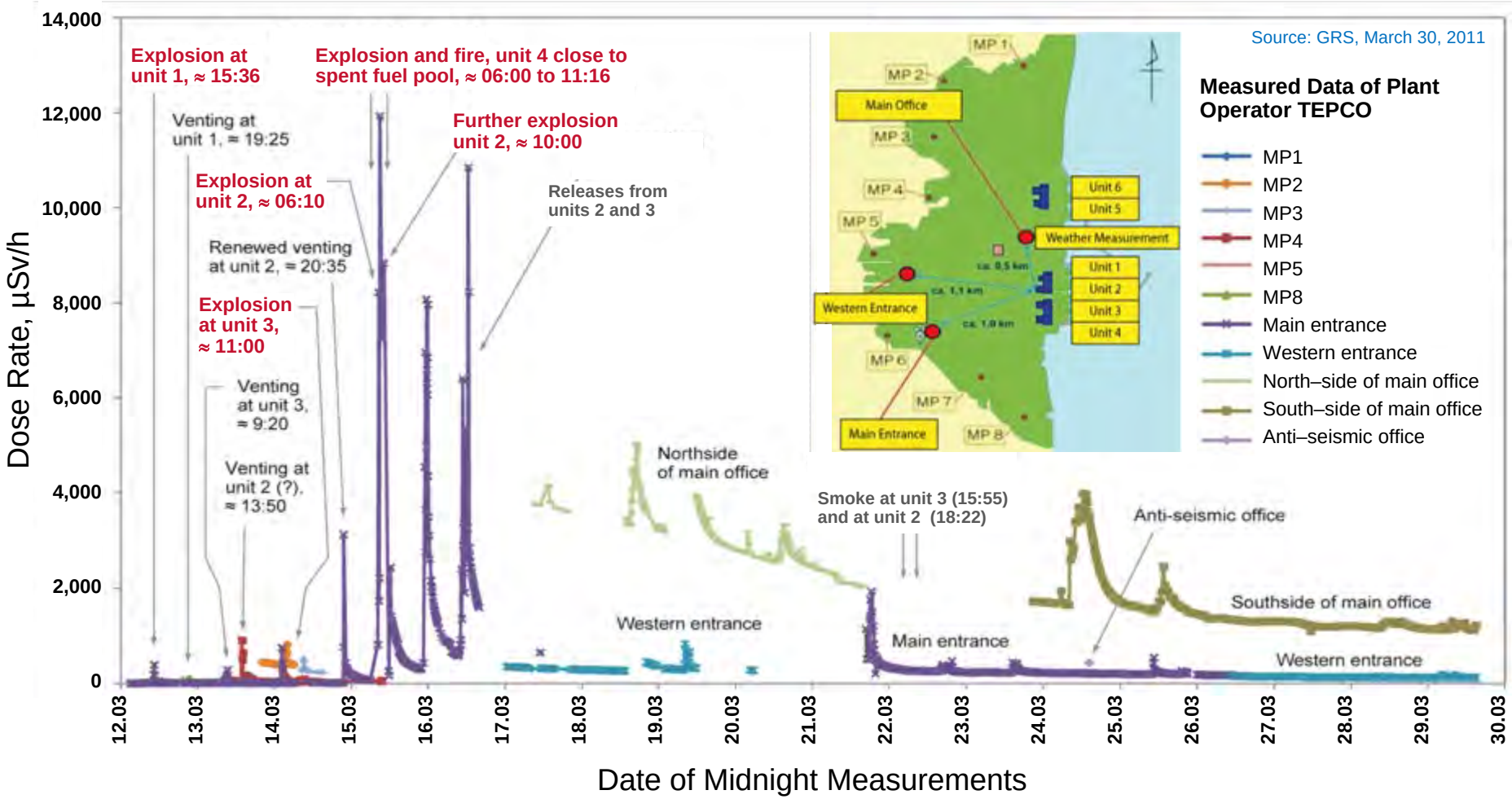
On–Site Radioactive Release

Dose Rates at Fukushima Daiichi



Environmental Damage: Off–Site Radioactive Release

- **April 12: Fukushima Daiichi NPPs revised to Level 7 (INES scale) based on the "People and Environment" criteria, as a result of radioactivity release estimation**

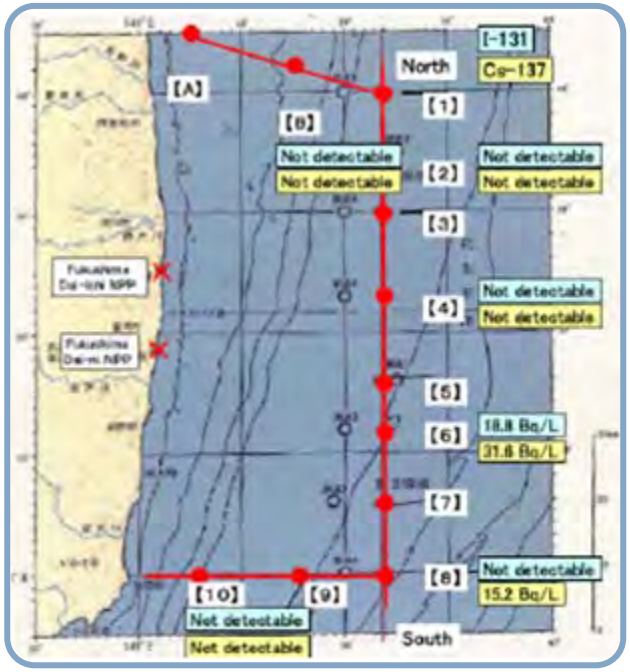
- **Total release of radioactive material: 0.3–0.6×10^{18} Bq ($I_{131,eq}$) (1/10 of the case of the Chernobyl accident)** Source: JAIF

- **Estimations about Water Volume:**
  - Total about **110,000 m^3**
  - Most **contamination coming from Unit 2** (20 MBq/cm^3) vs. Unit 1 and 3 (about 0,4 MBq/cm^3)

Radioactive Release in the Air

Source IRSN

Radioactive Release in the Sea



Source NISA

Radiation Dose: Reference and Comparisons

Effective dose equivalent (mSv)

Radiation exposure in daily life

10000

(Whole body exposure)
99% mortality 7,000~10,000

Death dose of staff working in Chernobyl reactor (in one month) 6,000

(Whole body exposure)
50% mortality 3,000~5,000

Maximum measured dose in Fukushima Daiichi reactor No. 3 (per hour) 450

1000

(Whole body exposure)
decrease of lymphocyte 500

Maximum permitted for staff working in emergency cases (only Fukushima Daiichi case) 250

Maximum permitted for staff working in emergency cases (ordinary) 100

100

Maximum permitted for radiation workers in one year 50

Natural radiation at Guarapari Beach, Brazil (per year) 10

10

Chest X–Ray computed tomography (one time) 6.9

Natural radiation per person (per year, world average) 2.4

1

Regular public space (except medical area) 1.0

Abdominal X–Ray for health check up (one time) 0.6

Tokyo – New York flight (round trip) 0.19

(radiation varies depending on the flight altitude)

0.1

The target figure around Nuclear Power Plant (per year) 0.05

Source: TEPCO; AP, Spiegel Online, 19 April 2011
(Note) The amount of natural radiation is including the effect of inhalation of Radon.
(source) UNSCEAR 2000 Report, "Sources and Effects of Ionizing Radiation" etc.

Earthquake Impact Scale Alert Levels

The alert levels are based on the range of most likely losses; the uncertainty in the alert level can be gauged by the histogram, depicting the percent likelihood that adjacent alert levels (or fatality/loss ranges) occur.

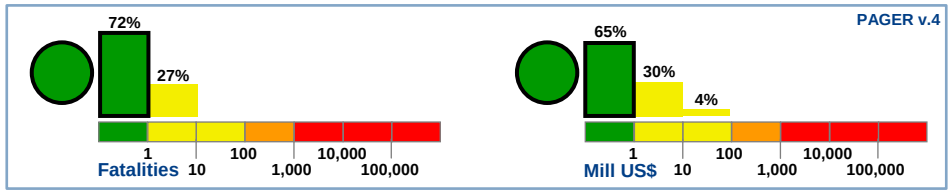
Accompanying text clarifies the nature of the alert based on experience from past earthquakes. If the economic alert is yellow or greater, the text will also give a range of economic losses in terms of the country's GDP.

The higher level of the two alerts is shown as the summary alert.

Fore–shock

9.03 2011, 02:45:20 GMT

M 7.2 — 21 hours, 44 minutes after earthquake



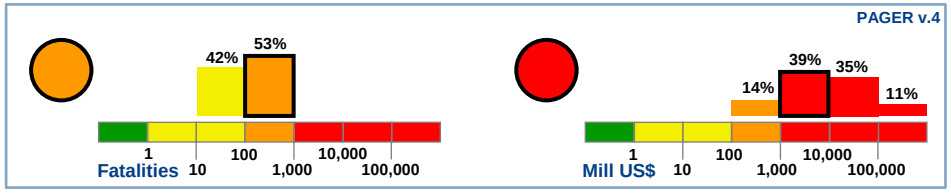
Estimated Fatalities — Estimated Economic Losses

Green alert level for shaking–related facilities and economic losses. There is a low likelihood of causalities and damage.

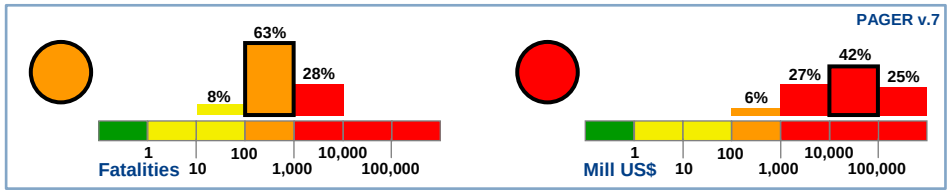
Great Tōhoku Earthquake

11.03.2011, 05:46:23 GMT

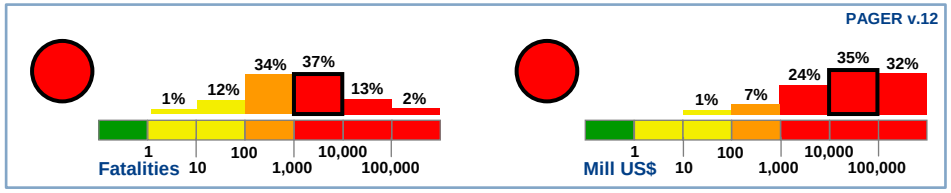
M 8.9 — 2 hours, 6 minutes after earthquake



M 9.0 — 4 days, 9 hours after earthquake



M 9.0 — 15 days after earthquake



Estimated Fatalities — Estimated Economic Losses

Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are less than 1% GDP of Japan. Past events with this alert level have required a national or international level response.

Orange alert level for shaking–related facilities. Significant causalities are likely.

Source: David Applegate, "The Great Tohoku Earthquake", USGS, 21 March 2011
Gavin Hayes & David Wald: U.S. Geological Survey, National Earthquake Information Center

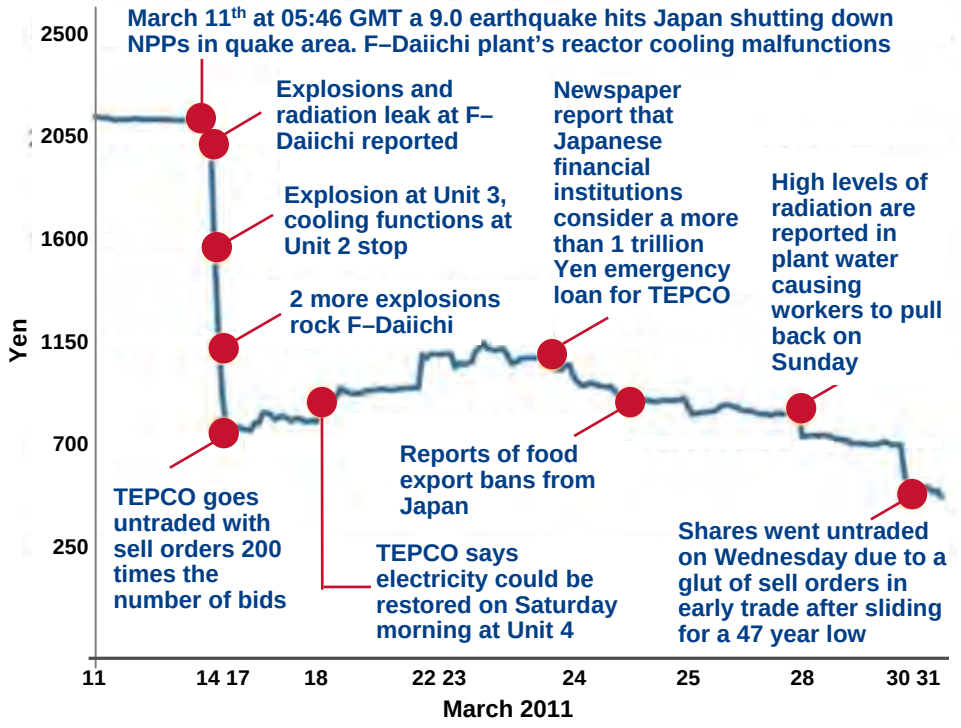
Socio–Economic Effects: Loss Estimates

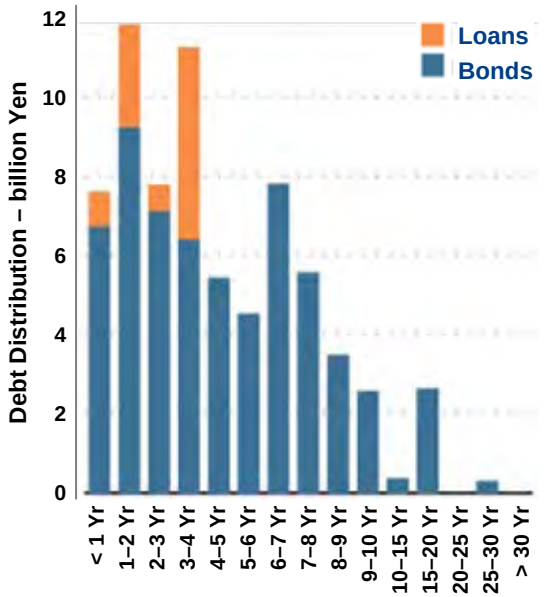
Source	Time since event	Magnitude	Estimate NB: PAGER = Shaking losses only to structures
CATDAT EQLIPSE–Q v2	70 min	Mw 8.8, Tsu.	925 (291–1340) shaking related deaths + 10,000–20,000 tsunami deaths (using a 90–95% assumption); 125–480 billion US$ (70% tsunami), 259 billion US$ median total loss
Credit Suisse	1 day	Mw 9.0	10–50 billion US$
Some Analysts	1.2–2 days	Mw 9.0	122 billion US$
CATDAT EQLIPSE–R v1	2 days	Mw 9.0	520 shaking deaths; 159 billion US$ direct losses, 144 billion US$ indirect losses (5–yr)
Credit Suisse	2.5 days	Mw 9.0	171–183 billion US$
EQECAT	3 days	Mw 9.0	> 100 billion US$ (20 billion US$ homes, 40 billion US$ infrastructure)
RMS	3 days	Mw 9.0	200–300 billion US$
CATDAT EQLIPSE–R v2	8 days	Mw 9.0	257 billion US$ direct losses
HIS Global Insight	13 days	Mw 9.0	250 billion US$ direct losses
Japanese Government	14 days	Mw 9.0	197–308 billion US$ direct losses (social capital, housing, private plants & equipment)
CATDAT EQLIPSE–R v4	42 days	Mw 9.0	281 billion US$ (195–320 billion US$) direct losses, 70–175 billion US$ indirect losses (2–yr), 147–286 billion US$ indirect losses (5–yr)
Japanese Cabinet Office	3 months	Mw 9.0	208 billion US$ direct losses for the 4 largest prefectures (51% infrastructure, 15% homes, 10% manufacturing, 24% other)

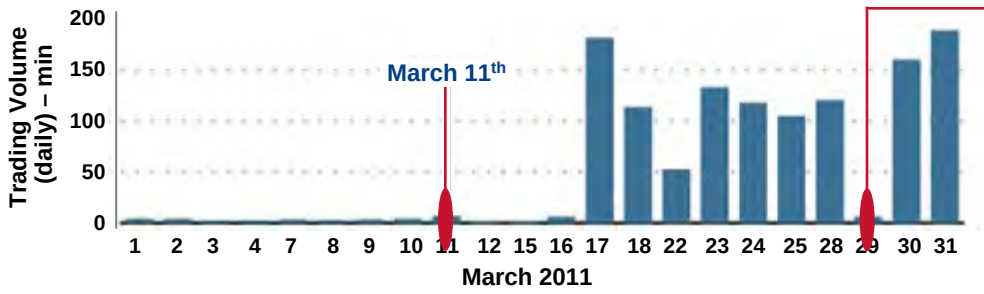
- The 2011 Tōhoku earthquake has caused the largest economic loss ever from an earthquake, surpassing the 1923 Great Kanto earthquake. 6 out of the top 20 economic losses due to earthquakes since 1900 are from Japan
- In terms of fatalities, the expected total of around 27,500 deaths for Tōhoku earthquake, is the highest by over 4 times for a country with HDI (Human Development Index) of over 0.8. The previous highest was Kobe, with around 6,434 deaths
- Once the magnitude was raised to M8.9–M9.0 and the JMA (Japan Meteorological Agency) and USGS (US Geological Survey) intensities were audited, a loss estimate of between $100–$500 billion USD loss was released. Some models with high indirect effects even predicted up to $1.1 trillion USD loss
- Estimates created using CATDAT (Integrated Global CATastrophe DATabases) give a total of between $125 and $480 billion USD loss with a median of $259 billion USD loss. The difference came about due to the uncertainties in structural losses in Miyagi prefecture and also different business interruption and other component models
- The third round of estimates take into account the net effects of extra business interruption models for the automotive industry, and also additional losses due to updated damage figures. This estimate has a median of $304 billion USD with the range from $187 billion to $512 billion USD loss

Source: Daniell, J.E., Vervaeck, A., Wenzel, F. "A timeline of the Socio-economic effects of the 2011 Tohoku Earthquake with emphasis on the development of a new worldwide rapid earthquake loss estimation procedure", Australian Earthquake Engineering Society 2011 Conference, Barossa Valley, South Australia, 18-20 November 2011

Falling TEPCO Shares







A flood of sell orders temporarily halted trading in shares of TEPCO as speculation grew about a possible government takeover of the company, which faces multibillion $ losses from its nuclear disaster. TEPCO shares plunged March 28th to their lowest level in 3 decades, falling by the maximum daily limit. The shares have lost more than 2/3 of their value since March 11th

9 August 2011

TEPCO reported a US$ 7.4 billion quarterly loss due to a massive provision to compensate victims of the nuclear disaster, soaring fuel costs and a dive in sales.

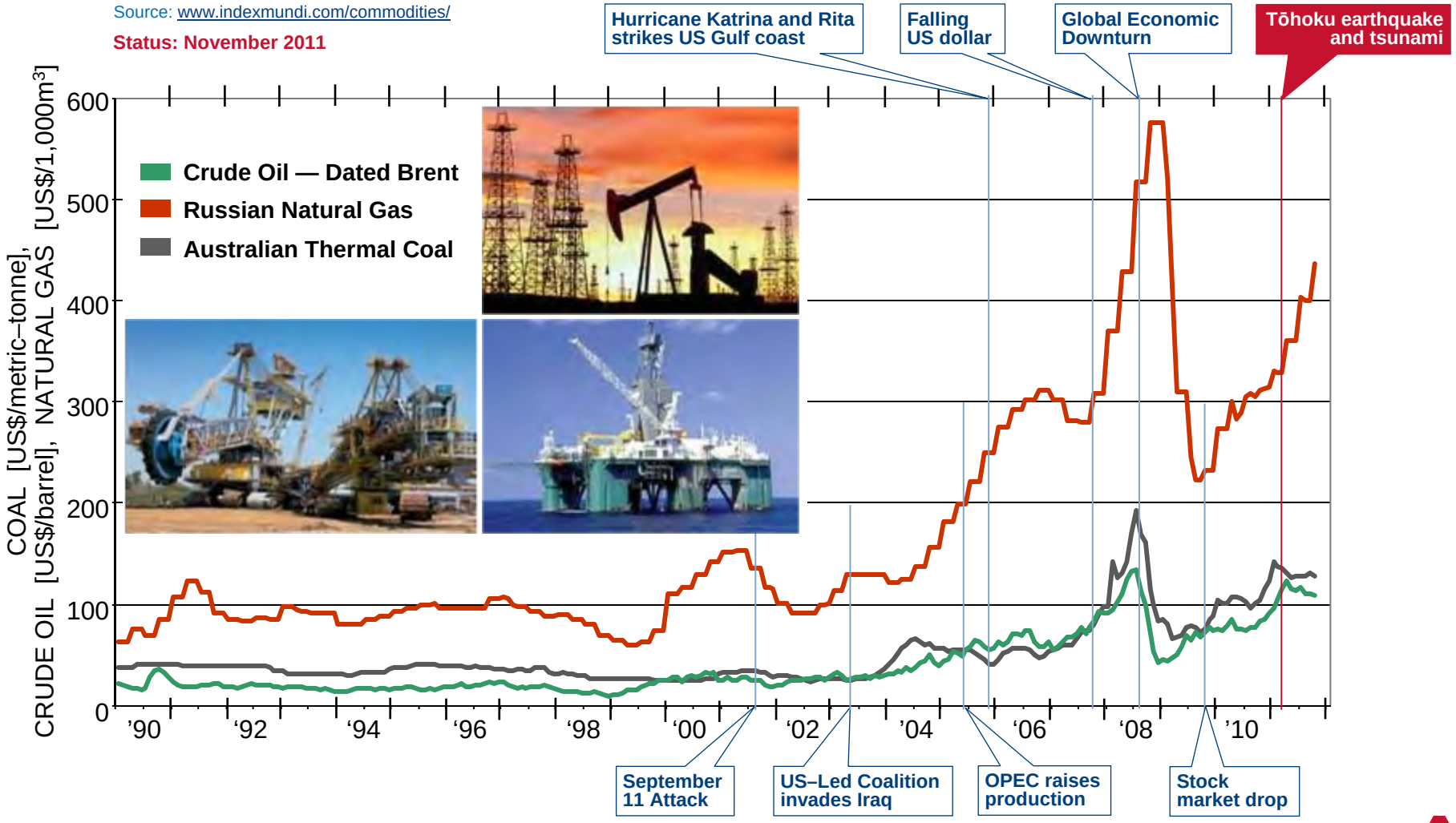
TEPCO's chances of survival improved after Japan's parliament early August passed a bailout scheme backed by taxpayer funds and contributions from other utilities to help shoulder a compensation bill analysts estimate could climb as high as US$ 130 billion.

Shares of TEPCO have lost more than 80% since the disaster. The stock had tumbled as much as 14% in morning trade following media reports it would book a massive quarterly loss.

Impact on World Non–Renewable Fuel Spot Prices

Source: www.indexmundi.com/commodities/

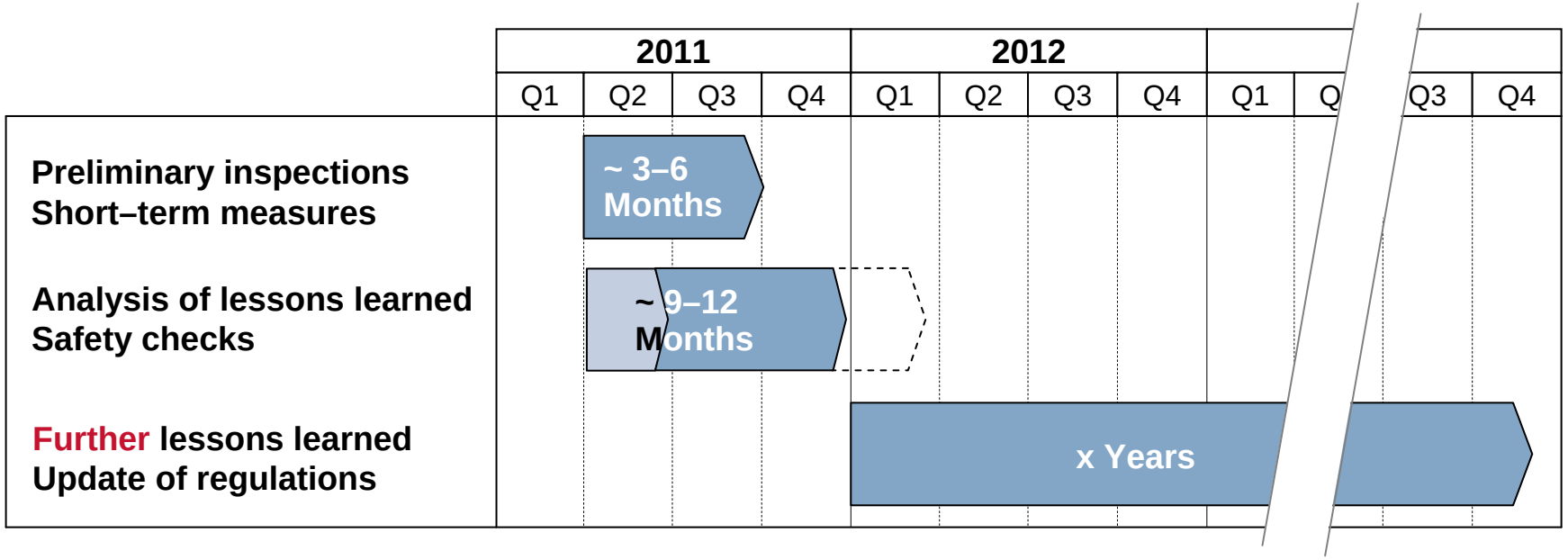
Status: November 2011



AREVA

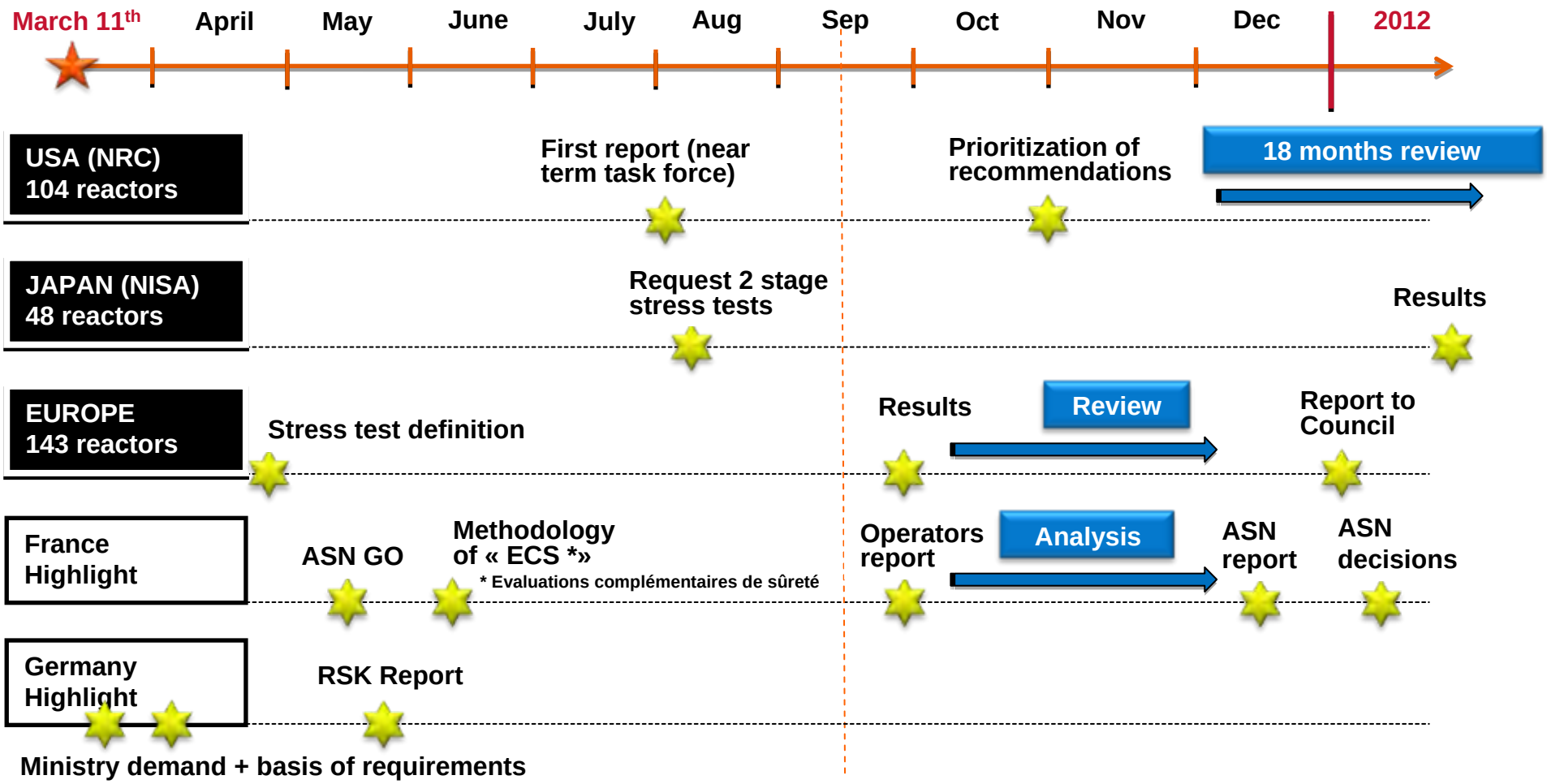
Regulatory Authorities Worldwide Launched 3 Types of Measures

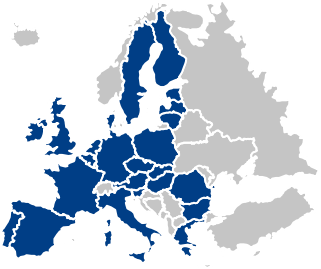
Typical schedule



Short–term measures necessary … but lessons learned process may be lasting 10 YEARS OR MORE!

Safety Authorities Timeline (2011)

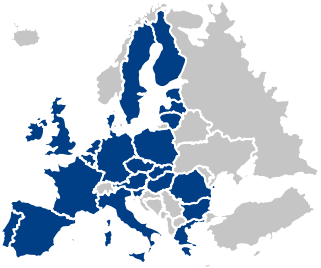




EU Safety Checks: A Difficult Initial Process

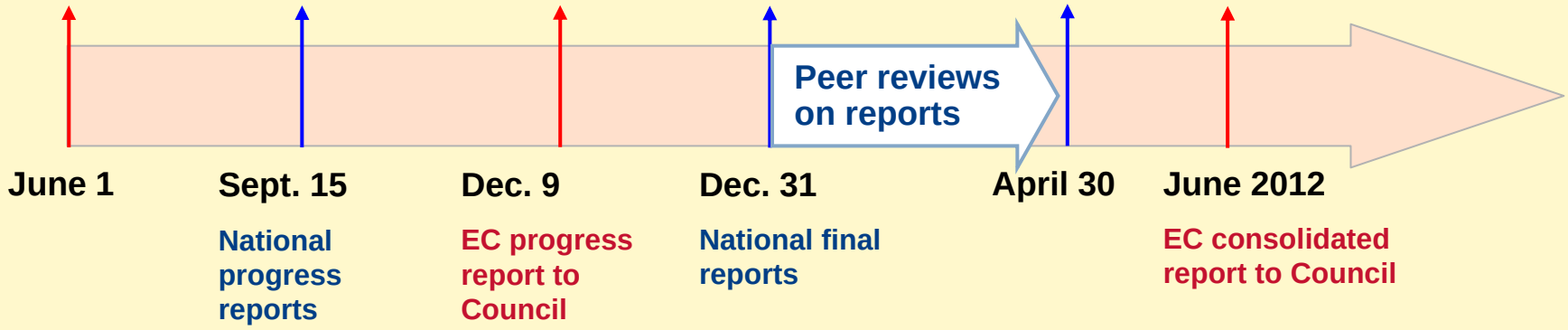
EC WENRA ENSREG

- Considering the accident at the Fukushima NPPs the Council of the EU declared that "*the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment ("stress tests"); … the assessments will be conducted by independent national authorities and through peer review; … the EC (European Council) will assess initial findings by the end of 2011, on the basis of a report from the Commission*"
- March 22nd and 23rd: WENRA (Western European Nuclear Regulators Association) members decided to provide "*an independent regulatory technical definition of a "stress test" and how it should be applied to nuclear facilities across Europe*"
- March 25th: EU Energy Council asked that "voluntary tests based on common standards" be prepared by the Commission, Member States and National Regulators
- April 21st: WENRA Task Force proposed the "stress tests" specifications. A "stress test" is defined as "*a targeted reassessment of the safety margins of NPPs in the light of the events which occurred at Fukushima: extreme natural events challenging plant safety functions and leading to a severe accident*"
- May 13th: Based on April 21st WENRA proposal, ENSREG (European Nuclear Safety Regulators Group) and Commission agreed on the scope and methodology for "*risk and safety assessments*" of NPPs in the EU
- May 24th: The ENSREG and EC agreed on the scope and methodology for planned "*comprehensive risk and safety assessments*" of power reactors in the EU
- June 24th: Armenia, Belarus, Croatia, Russia, Switzerland, Turkey and Ukraine expressed their willingness to undertake checks following the "*EU model*"
- In addition, actions needed for: Access to earthquake–/flood–proof external storage; Externally accessible connections for mobile equipment; Segregated leads to feed fuel–pool from outside



The European Agreement on Safety Checks

Timing: assessments undertaken by European operators before June 1st, 2011



- This process concerns 14 countries and 143 NPPs
- Scope: extreme natural hazards (earthquakes, flooding …) and their consequences
- Out of scope at this first step: security threats ➔ second step

An European framework …
but safety remains a national prerogative !

Safety Checks in European Countries

France — **ASN**

- Complementary safety evaluations (ECS) concern all large operators (EDF, CEA, AREVA,…). Results sent to ASN Sept.15, for report to Government Nov 15. All reports were made public.
- The ECS scope has been reinforced on some aspects for specific sites, such as floods resulting from the rupture of dykes
- As part of its prerogatives, ASN also conducts regular inspections to audit existing safety measures in a Fukushima like situation

UK — **HSE / ONR**

- ONR (Office for National Regulation) published interim report on May 18, seeing “no reasons for curtailing operations” and making 26 recommendations
- National progress report issued in September: “none of the review work (…) has indicated any fundamental weaknesses »
- Final reports are due in December

Finland — **STUK**

- STUK Preliminary Report issued May 16: **No new threats nor gaps needing immediate upgrades**
- Some issues requiring further surveys are identified, like effects of high sea level in Loviisa, or the impact of great cold, increase in the fuel storage tanks capacity…
- **Final report issued end of June** not public (for security reasons)

Germany — **BMU / RSK**

- Report issued on May 18: **Germany’s nuclear power plants have a “high degree of robustness”** although 4 units have a weak physical protection if they are hit by airplane
- **But political decision** yet taken to phase out all nuclear by 2022

Safety Checks in European Countries

Czech Republic — SÚJB

- **Short–term and medium–term plans**: Performance of ENSREG–EU Stress–Tests is expected
- **Long–term plans**: Licensees will continue realisation of long–term corrective actions based on recent Periodic Safety Reviews and technical measures based on recent SAMG (Severe Accident Management Guidelines) programme
- No important Lessons Learned identified so far

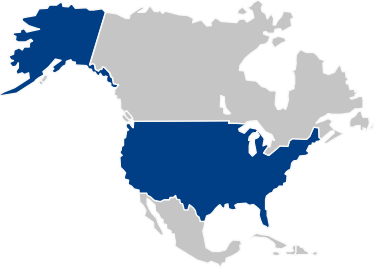
Switzerland — ENSI

- **Stress–Tests** (fuel–pool increased protection against seismic & flooding, extended emergency guidance) — result: **no immediate threat to the population** — and **team–inspections of all NPPs on fuel–pool–cooling and emergency guidance as well as of the external storage** (access to earthquake– /flood–proof extended storage) started in May
- **Guidelines on procedure for the reassessment of earthquake/flooding hazard**
- **Actions**: Reassessment of earthquake/flooding

Spain — CSN

- On May 25th the CSN sent a Complementary Technical Instruction to each Spanish NPP. NPPs sent on August 15th a preliminary report to the CSN. **Further actions**:
  - **DBE (Design Basis Earthquake)** has to be reviewed and using PSA ruling out **other external events** whose likelihood is lower than once in 100,000 years
  - Complete long–term loss of AC power is the most restrictive **loss-of-safety-function scenarios** comprising other events
  - Concerning Severe Accident Management, licensees to reinforce their current measures and organization to respond to **BDA (Beyond Design Accidents)**
  - Improvements for diversifying options regarding **loss of spent fuel–pool–cooling systems**
- Between October and December 2011 CSN will carry out inspections to all NPPs

- **National safety studies launched independently from the European framework**
- **Safety assessment: site-specific, extreme natural hazards ➔ new margins to be taken**
- **And what happens if margins are overridden?**



Safety Checks in the USA

U.S.A.

NRC

- **First U.S. inspections of 104 operating plants issued May 20**
  - "Every plant has the capability" to respond to severe accidents
  - **Less than 1/3 of 104 U.S. reactors found to have some vulnerabilities to extreme emergencies**
- **Near-term review (90 days) to check the safety level of the U.S. fleet**
  - Near-term NRC Task Force report issued July 13
  - **12 "overarching" recommendations** and 35 detailed recommendations for near-term and longer-term actions, associated with seismic and flooding events, station black out, beyond-design basis events
  - Sept 8 : NRC Chairman G. Jaczko proposed that plant owners should review **earthquake hazards at least once a decade**
  - NRC staff prioritization and recommendations provided for Commission review and approval in October
- **18–month review to be undertaken on NRC staff's first recommendations**
  - Until end 2012 (originally expected for end 2011)
  - For development of a new regulatory framework
- **Recent natural disasters led to successful real-scale exercises**
  - Fort Calhoun (flood), Brown Ferry (tornado) & North Anna (earthquake)

Safety Checks in Asia and Russia

Japan — NISA

- **Merging of NISA with NSC** announced beg August ; it **should be effective in April 2012.**
- Plan for **new "comprehensive safety assessments"** issued on July 15, to be achieved by end 2011;
- Based on a **two-step** methodology and on **European safety checks.**
- The new Government wants the IAEA to assess the safety of shut down NPP's before they restart

China — NNSA

- **Initial survey** of NPPs (in operation and under construction) completed **August 5**
- Details on the results and proposed improvements to be made public by mid 2012

India — AERB

- Creation of an **independent Safety Authority** decided
- Plans to increase plant defense and preparedness revealed by operator NPCIL on July 26, incl. **building of sea protection barriers** at Tarapur and Madras
- **High level committee report** submitted to AERB on August 31: limited recommendations for improvement
- To be reviewed by AERB then implemented by NPCIL

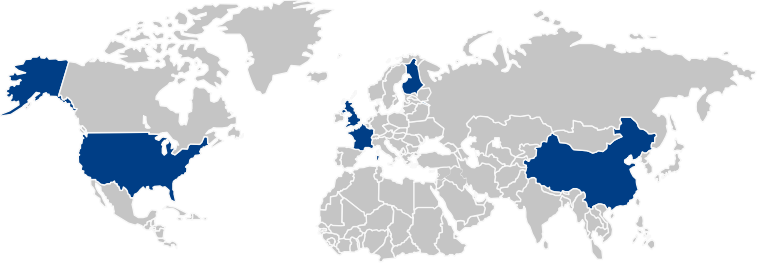
Russia — Rosteh-nadzor

- Declared the **absence of gaps** following the audit of the Russian fleet on April 18
- Call for international Safety Standards

Trends:
More Cooperation, More Independence

- **Safety checks methodology adopted in various parts of the world**
  - EU approach (WENRA) adopted by 7 neighboring countries + Japan, Brazil…
  - The action plan, adopted by the IAEA board in September 2011, asks for a methodology to be developed
- **International harmonization to be enhanced**
  - IAEA's role on harmonization of safety standards, transparency and emergency support coordination stressed (June 2011 conference). Russia wants IAEA safety standards to be compulsory
  - IAEA call all nuclear countries to implement safety tests and present national reports at an extraordinary CSN meeting in August 2012
- **Inspection missions & peer reviews will be further developed**
  - European Council in March: safety checks to be analyzed by "independent national authorities and through peer reviews"
  - IAEA action plan asks for voluntary OSART peer-review of at least one reactor / country in the next 3 years, "with initial focus on older nuclear power plants"
  - WANO wants to conduct peer reviews of safety in all NPPs in less than three years. Main evolutions:
    - Better define WANO role in case of emergency (add emergency preparedness to peer reviews)
    - Will look more closely at fuel storage, and at some aspects of the design
- **A growing independence of safety authorities**
  - Asked for by IAEA, EU Council, European Commission, Governments…
  - Positive evolution in Japan, South Korea, India ….

But IAEA's action depends on resources and political will: strengthened international oversight REFUSED BY ITS BOARD



Position of Safety Authorities on EPR™ by AREVA Design and New Build

France	**ASN**	▶ FA3 EPR™ submitted to same safety checks as operating plants, EDF proposed limited design and site modifications **=> Conclusions from ASN end 2011** ▶ **Construction ongoing during safety check** ▶ **On July 18, ASN asked for improvement for concrete in FA3 construction**
UK	**HSE / ONR**	▶ ONR final report published October 11 confirms: **no need to change siting strategies for new NPPs** ▶ GDA applicants requested to consider implications for generic designs ▶ GDA process delayed, and **final design acceptance for UK EPR now December 2012**
Finland	**STUK**	▶ **STUK has not identified any shortcomings** on the OL3 resistance to extreme external hazards ▶ Construction is proceeding normally on the OL3 site ▶ **TVO stress tests report** end October: **"*no modification needs were identified in the applied design bases*"**
U.S.A.	**NRC**	▶ **U.S. EPR™ design certification ongoing** ▶ In its July 12 report, the NRC 90-day task force **issued some recommendations on new build**, including SBO mitigation capabilities, spent fuel pool make up capability, instrumentation, ... ▶ NRC's Gregory Jaczko on October 4: **"*new reactor licensing is working well*"**
China	**NNSA**	▶ **Approval of new reactor projects suspended since March** ▶ **Safety review** of NPPs under construction **completed in August**, but safety plan would be issued by the Government in 2012 ▶ **Taishan 1&2 construction ongoing**

1 Tōhoku Earthquake and Tsunami

2 Fukushima: Accident due to Natural Disaster

3 Environmental and Socio–Economic Effects

4 Safety Authorities' Actions Worldwide

5 Impact on Nuclear Power around the Globe

6 AREVA's Positioning

7 Global State of Affairs and Outlook

8 In a Nutshell

AREVA

Governments take Pragmatic Approach — Public Confidence to be Regained

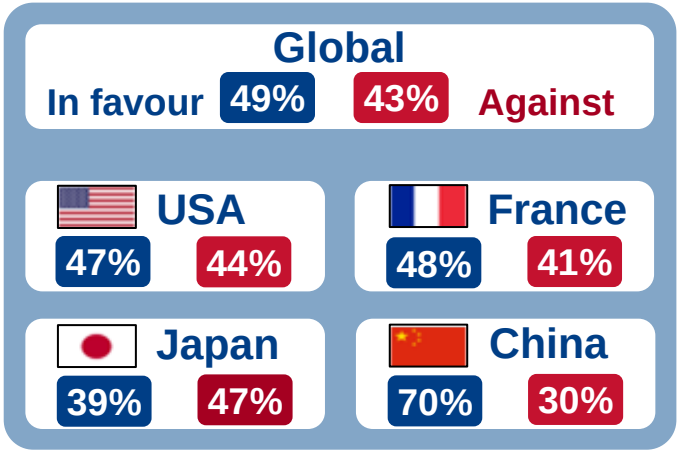
Governments

- Safety checks of nuclear plants (existing and planned) launched
- New Build programs:
  - UK, Czech Republic, Poland, China, India, Finland, South Africa… confirmed their New Build programs. Some short–term delays as part of the safety check process
  - Italy cancelled its new build program by referendum
  - No ongoing construction is stopped, except Japan
- Germany and Switzerland decide to gradually phase–out nuclear

Public Opinion

- Worldwide WIN–Gallup[1] poll shows majority still favours nuclear, even with Fukushima still fresh in their minds
- In Japan, the majority turned against nuclear but a majority still favours the nuclear option in the U.S., France or China
- A second worldwide poll by IPSOS[2] has shown an opposite result. Nonetheless, a sizeable share of the "against" are not in favour of closing existing plants, their confidence must be regained

[1] Poll in 47 countries published on April 19, 2011
[2] Poll in 24 countries made mid of April 2011



Public confidence is not a given
To earn it and keep it: No compromise on safety, continuous improvement

Public Opinion Polls on New Builds

Favorable opinions on continued nuclear constructions
IPSOS, June 2011, 24 countries – Sample

Above 40%

Poland	52%	USA	44%
India	49%	UK	43%

Below 20%

Argentina	18%
Brazil	11%

In between

China	38%	France	23%	South Africa	31%
Japan	37%	S. Korea	32%	Saudi Arabia	30%

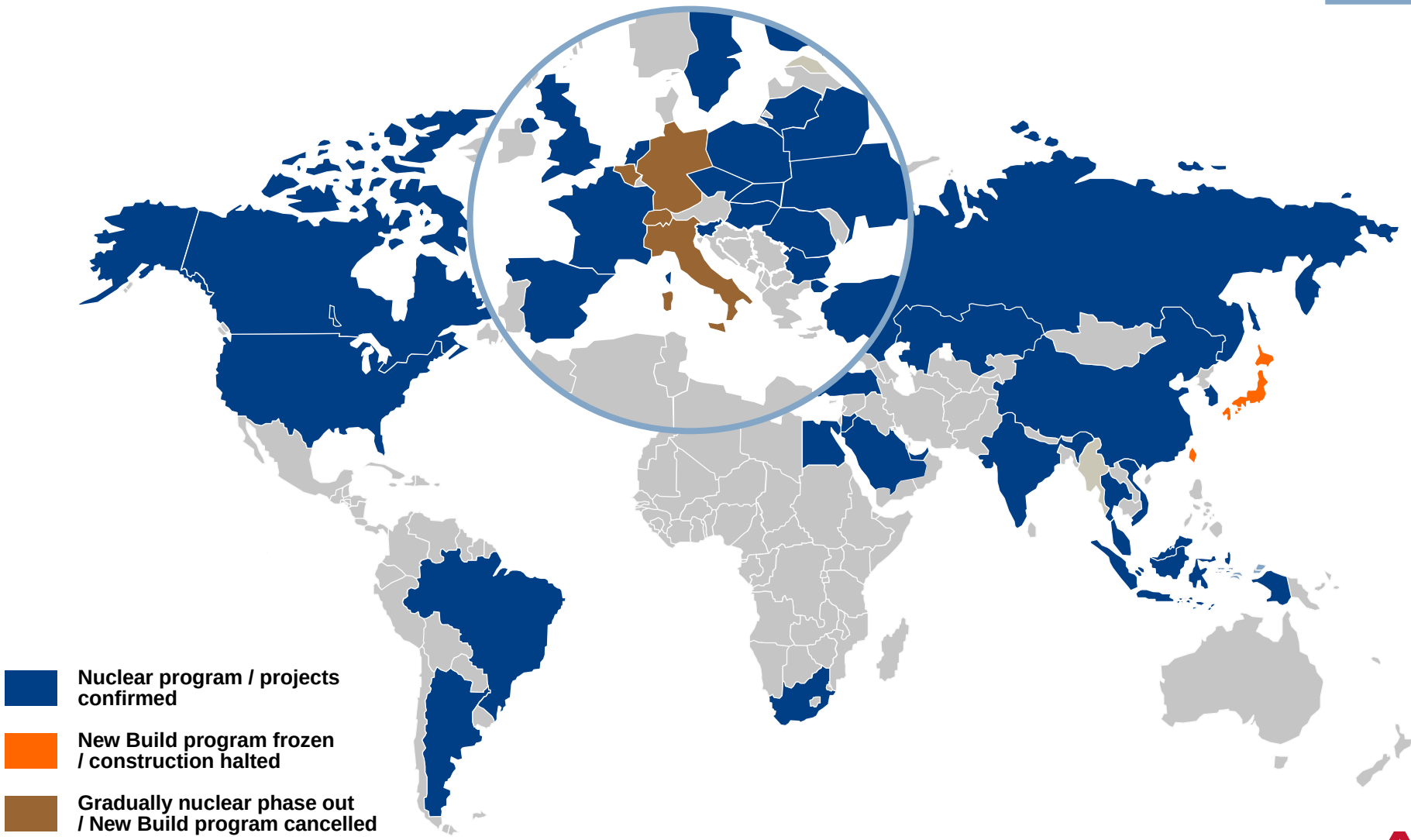
Global 31%

Two recent polls

54% accept new nuclear if it helps tackle climate change
(source Populus, September 2011)

62% in favor of the use of nuclear energy
(source NEI, October 2011)

Most Countries have confirmed the Importance of Nuclear in their Energy Mix ...



... and Carry on Supporting Nuclear Energy

« I see no reason why we should not proceed with our current policy: namely that nuclear should be part of the future energy mix… »

– UK Secretary of State – May 18, 2011

« The schedule that foresees the selection of the winner by 2013 remains valid. Development of nuclear energy is the country's absolute priority even after the March 11 accident at Japan's Fukushima Daiichi atomic plant »

– Czech Republic Prime Minister – March 29, 2011

« Fukushima accident will not affect China's long term strategy and commitment to develop safe and efficient nuclear power [...] China remains totally committed to the peaceful use of nuclear power »

– Secretary General of CNEA (China Nuclear Energy Association)

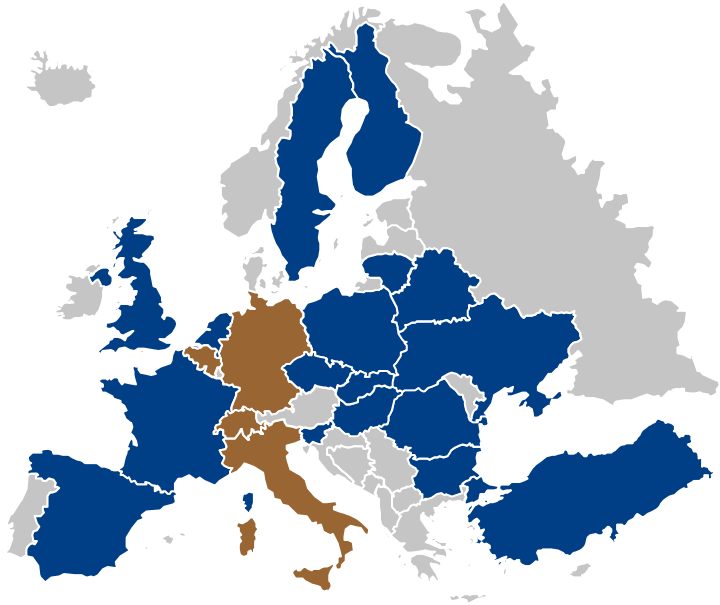
In presence of Angela Merkel, Prime Minister Manmohan Singh reasserted that India needs nuclear energy to meet its emission targets. He confirmed the 20GW in 2020 generation target

– Indian Ministry of External Affairs **–** May 31, 2011

Focus on Europe

- **UK, France, Czech Republic, Poland, Finland & Netherlands share close position**
  - Do not surf on the wave of emotion: Nuclear energy is still necessary
  - Lessons must be learned from Fukushima event and may affect technical requirements for New Build programs
- **New Build programs – especially with the closest CODs – may be delayed**
- BUT **no question to cancel or stop current construction**
- **Safety checks** will be conducted on existing fleet by **end of year**

- **Four countries: Germany, Switzerland, Belgium and Italy decided to take more stringent measures. Each case is very different**
  - **Germany**: 7 (+1) oldest plants shut down though first reports of safety checks issued by RSK state that plants are safe. Decision to close NPPs by 2022
  - **Switzerland**: federal government opted for a gradual phase–out by 2034 which marks the start of a long legislative process before a definitive decision is taken
  - **Belgium**: political parties reached an agreement to shutdown the 3 oldest reactors by 2015 and on a complete exit by 2025 **conditionally** on finding enough energy from alternative sources to prevent any shortages
  - **Italy**: referendum led to cancellation of return to nuclear power



Focus on Middle East and Africa

- **Saudi Arabia**: New Build program further confirmed, **goal of 16 units by 2030**
- **UAE, Jordan, Egypt:** New Build program confirmed
- **Republic of South Africa:** Integrated Resource Plan including nuclear confirmed

Focus on Asia

- **Chinese State Council**
  - Temporarily suspended approval of new nuclear plants
  - Safety review of operating and plants under construction completed
- **The launch of new Generation II projects is debated.** Projects which have not reached first concrete yet might be shifted to Generation III
- **<u>BUT Indian and Chinese administrations and utilities confirm their will to continue nuclear New Build programs</u>** relying on most advanced standards
- **India**
  - Government decides to set up an independent safety authority
  - **Federal and Maharashtra governments support Jaitapur** project
- **South Korea:** made preliminary check of existing plants and plans to improve safety authorities' organization
- **South–East Asia:** all with New Build programs confirmed long–term nuclear power choice

- **Japan:** Government continues to consider nuclear power as essential, priority is to restart NPPs currently in outage, 2–step safety checks in progress
  - New Build constructions halted
  - One plant (Hamaoka) halted by government until proper anti–earthquake / tsunami measures are in place
  - Safety authority to be moved from Ministry of Industry to Ministry of Environment
- **Taiwan: Lungmen construction continues, but older NPPs will not be granted life–time extension licenses**

Focus on Americas

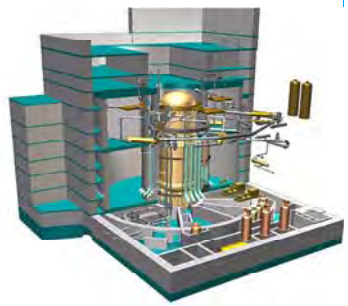
- **Canada**
  - Most **provinces** involved in a New Build program **confirmed their commitment** despite Japan nuclear crisis
  - Safety inspection of all operating plants and potential improvements of current safety frameworks and standards have been discussed
- **U.S.**
  - In general, **reactions by political leaders are rational**
  - **Administration is supportive of nuclear**, Federal Loan Guarantee program reconfirmed
  - Some opinion leaders calling for **much stricter safety**, which would impact New Build
  - NRC Task Force issued 12 recommendations and near term recommendations
  - Utilities with new build plans have **reaffirmed their commitment**. Only NRG (ABWR) has suspended their projects
- **Mexico**: commitment to nuclear energy reaffirmed
- **Brazil**: No change to New Build program (currently re–assessed by the Government)
- **Argentina**: New Build program confirmed

AREVA

AREVA's Positioning on the New Build Market is Reinforced after the Fukushima Events

- **Design and licensing of nuclear reactors**
- **Prepare and execute new NPP large projects**
- **Range of Generation III reactors**
  - EPR by AREVA (PWR: 1,650 MWe)
  - ATMEA1 (PWR: 1,100 MWe)
  - KERENA by AREVA (BWR: 1,250 MWe)





- **New build addressable market: 196 GW over 304 GW of New Builds**
  - Excluding ongoing constructions
  - Excluding inaccessible market (Russia, Korea, Japan)

EPR™ Safety Approach

An accident is a complex series of events:
➔ NEED THE MEANS IN CONTROL OF THE SITUATION, WHATEVER HAPPENS

Emergency power sources

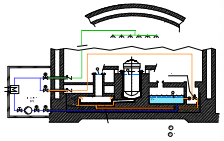
Diversity

(against common cause)

Redundancy

(against single failure)

Four safeguard divisions



Core catcher & Containment spray

Complementarity

(between active and passive systems)

The EPR™ reactor is designed to resist exceptional events and prevent damage to the surroundings

AREVA

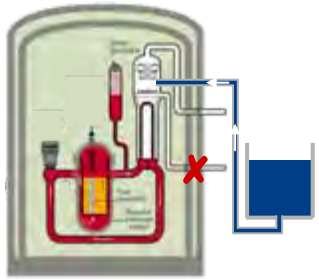
The EPR™ Reactor would have Resisted Fukushima Events

The EPR™ reactor is designed to resist extreme hazards: resistance of structure and equipment

- **Nuclear island stands on a single reinforced concrete basement**
- **Containment building comprises 2 walls:**
  - Inner pre–stressed concrete housing with steel liner
  - Outer reinforced concrete shell (1.86m thick) protecting inner walls and structures from direct impacts and resulting vibrations
- **Equipment tested on vibrating tables and through modelling**

Availability of the cooling systems

- **Water supplies**
  - 1 tank (1,800m^3)
  - 4 backup systems (4x400m^3)



- **Cooling equipment**
  - 4 cooling systems located in 4 separate buildings

- **Generators**
  - 6 backup diesel generators

The EPR™ Reactor would have Resisted Fukushima Events

Pool located in a sturdy fuel building & multiple safety–class cooling

- **Sturdy fuel building**
  - Concrete containment building, designed to withstand the crash of a commercial airplane
- **Multiple safety-class cooling systems**
  - 2 main independent cooling systems, located in different parts of the building
  - A third diversified cooling system

Explosion risk prevented

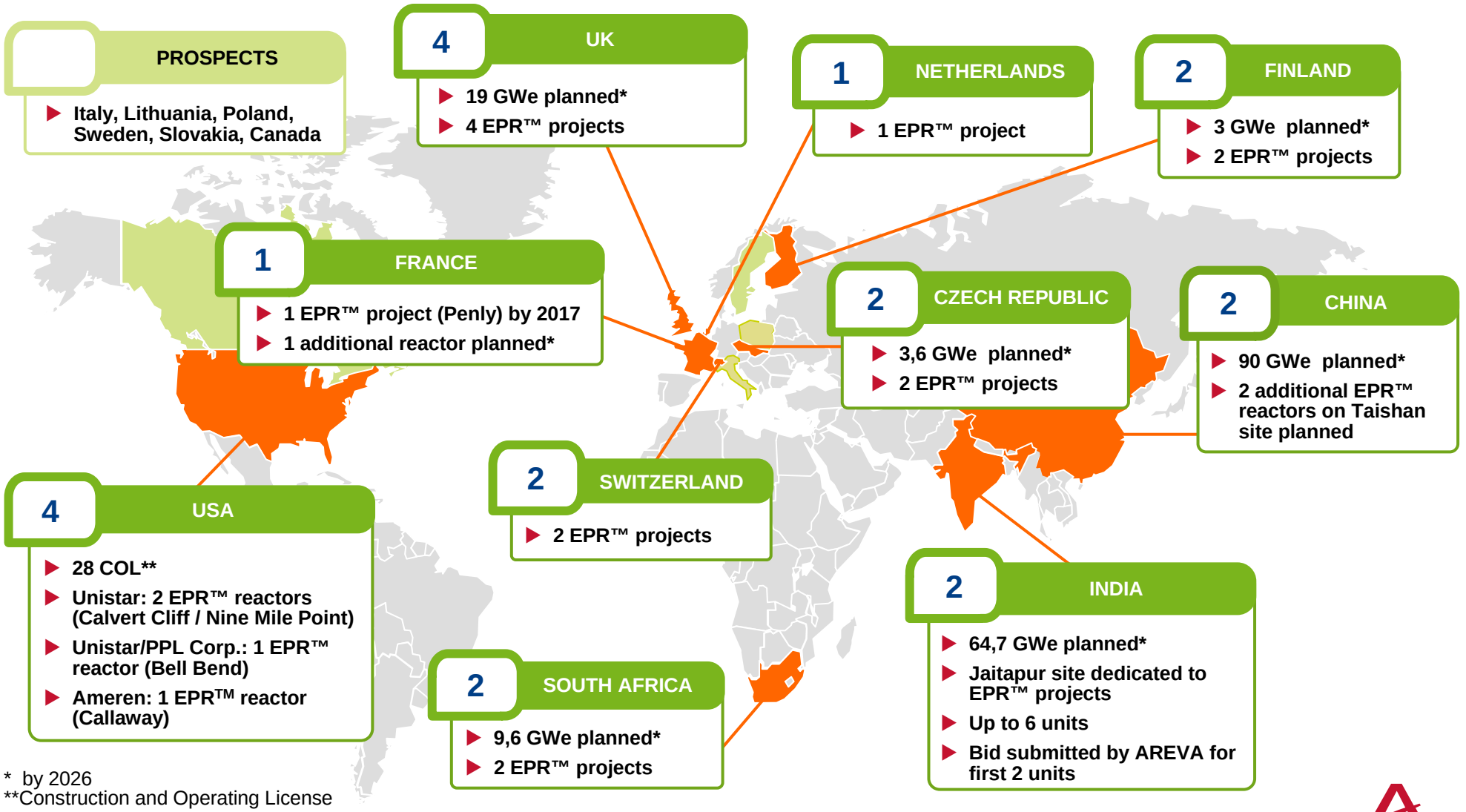
- **Limiting hydrogen concentration**
  - Reactor building designed with important volumes and communicating compartments
- **Reducing hydrogen quantity**
  - Use of hydrogen recombiners

Limited contamination of the site and protection of populations

- **Double containment reactor building**
  - No impact outside the building
- **Core catcher** to confine the molten core

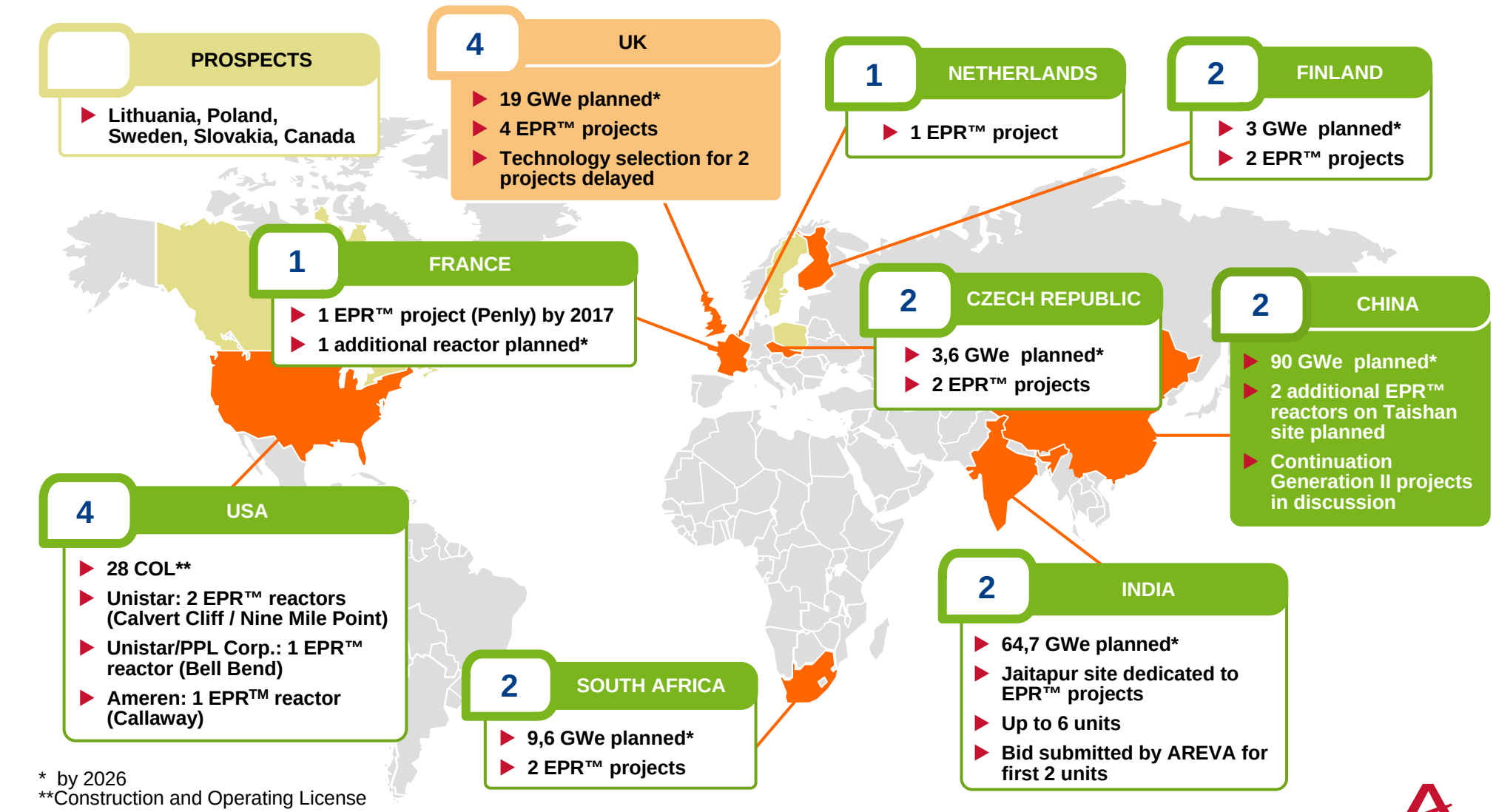
The EPR™ reactor has a strong competitive edge for new build projects

AREVA EPR™ Fleet is Being Deployed in Exclusive Negotiations — Before Fukushima



* by 2026
**Construction and Operating License

AREVA EPR™ Fleet is Being Deployed in Exclusive Negotiations — After Fukushima



* by 2026
**Construction and Operating License

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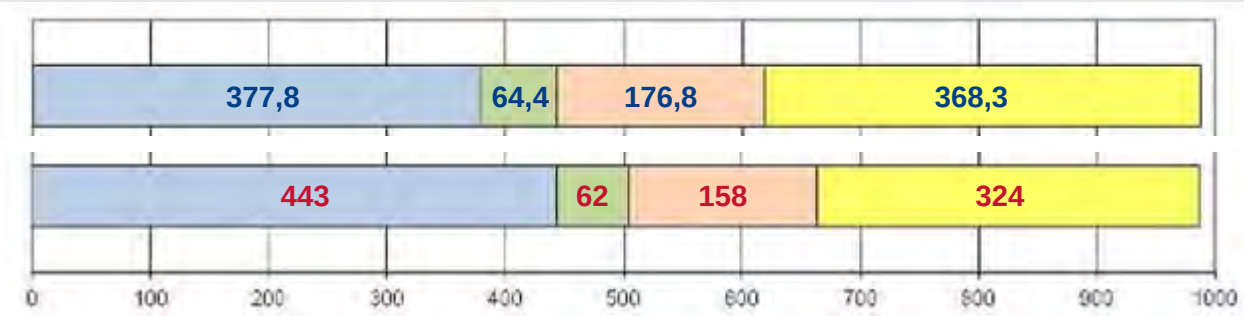
World Installed Nuclear Capacity

OPERATING	**Connected to the grid**
BUILDING / CONSTRUCTION	**First concrete for reactor poured, or major refurbishment under way**
PLANNED	**Approvals, funding or major commitment in place, mostly expected in operation within 8–10 years**
PROPOSED	**Specific program or site proposals, expected operation within 15 years**

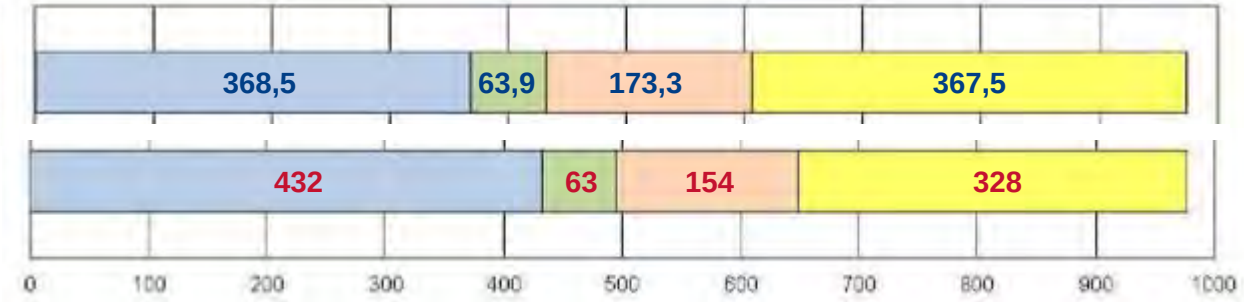
BEFORE Fukushima

2 March '11



AFTER Fukushima

8 October '11



Source: WNA, October 2011

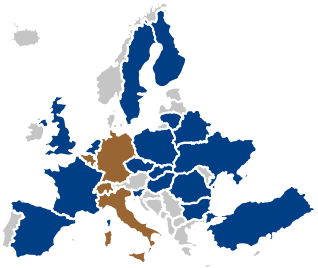
New plants coming on line are balanced by old plants being retired. Over 1996–2009, 43 reactors were retired as 49 started. WNA estimates that at least 60 of those now operating will close by 2030, most being small plants. The 2009 WNA Market Report reference case has 143 reactors closing by 2030

NPPs under Construction as of November 17th

Source: PRIS database: Last updated on 2011/11/17

	N° of Units	Total (MWe net)
Argentina	1	692
Brazil	1	1,245*
Bulgaria	2	1,906*
China	27	27,230
Finland	1	1,600
France	1	1,600
India	6	4,194
Japan	2	2,650
Pakistan	1	315
Russia	11	9,153**
South Korea	5	5,560
Slovakia	2	782*
Taiwan	2	2,600
Ukraine	2	1,900*
USA	1	1,165*
TOTAL	65	62,592

* Completion
** Out of the 11, only 4 are “Gen–3” reactors

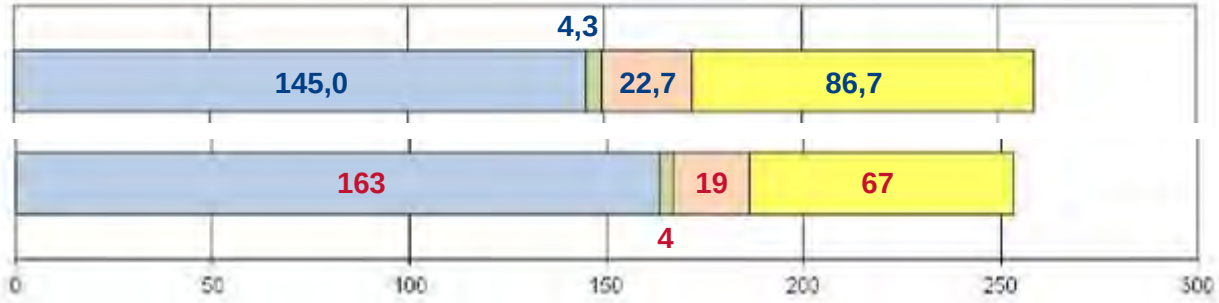


Installed Nuclear Capacity in Europe

OPERATING	**Connected to the grid**
BUILDING / CONSTRUCTION	**First concrete for reactor poured, or major refurbishment under way**
PLANNED	**Approvals, funding or major commitment in place, mostly expected in operation within 8–10 years**
PROPOSED	**Specific program or site proposals, expected operation within 15 years**

BEFORE Fukushima

2 March '11



AFTER Fukushima

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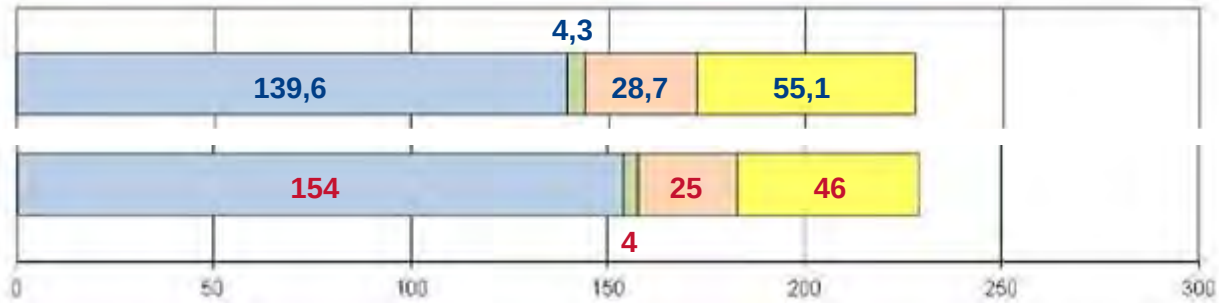
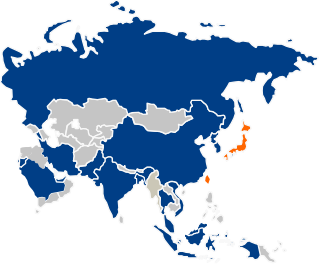


Source: WNA, October 2011

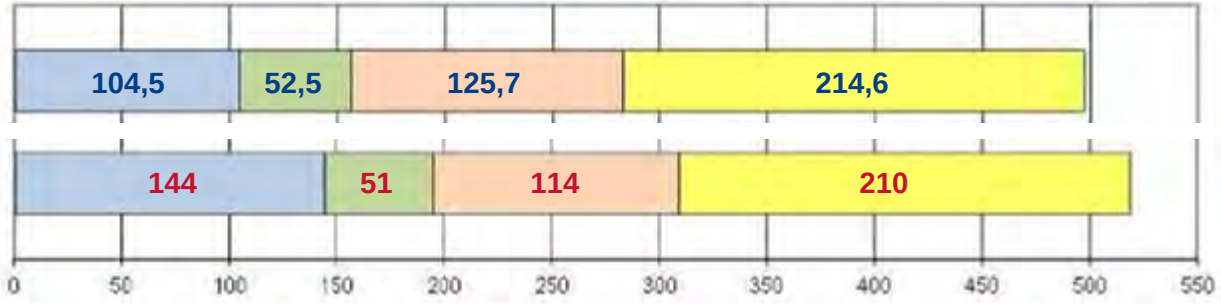


Installed Nuclear Capacity in Asia

OPERATING	**Connected to the grid**
BUILDING / CONSTRUCTION	**First concrete for reactor poured, or major refurbishment under way**
PLANNED	**Approvals, funding or major commitment in place, mostly expected in operation within 8–10 years**
PROPOSED	**Specific program or site proposals, expected operation within 15 years**

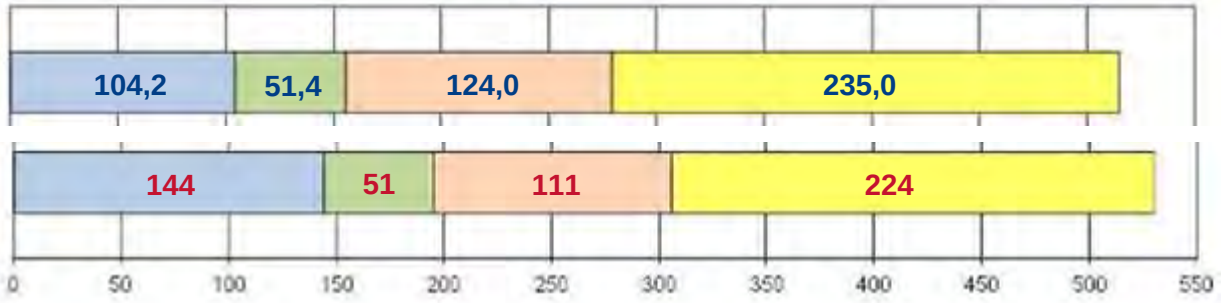
BEFORE Fukushima

2 March '11

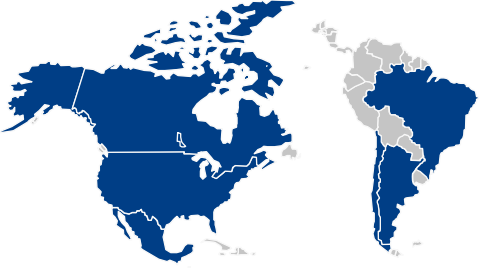


AFTER Fukushima

8 October '11



Source: WNA, October 2011

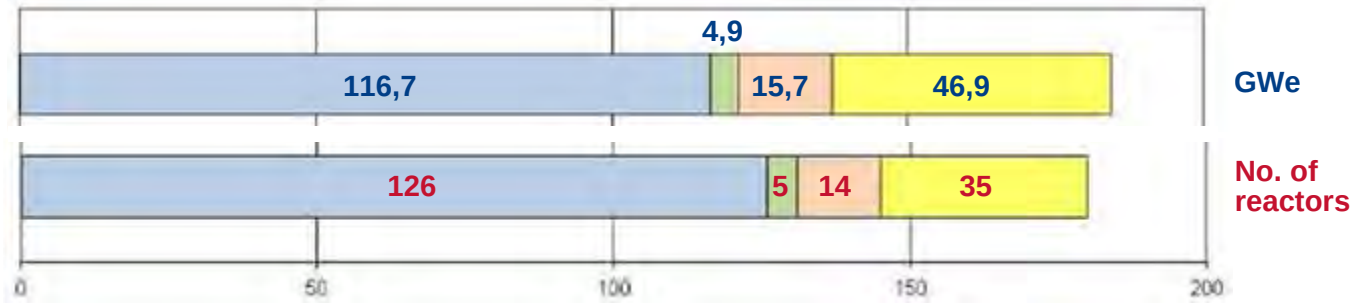


Installed Nuclear Capacity in Americas

OPERATING		Connected to the grid
BUILDING / CONSTRUCTION		First concrete for reactor poured, or major refurbishment under way
PLANNED		Approvals, funding or major commitment in place, mostly expected in operation within 8–10 years
PROPOSED		Specific program or site proposals, expected operation within 15 years

BEFORE Fukushima

2 March '11



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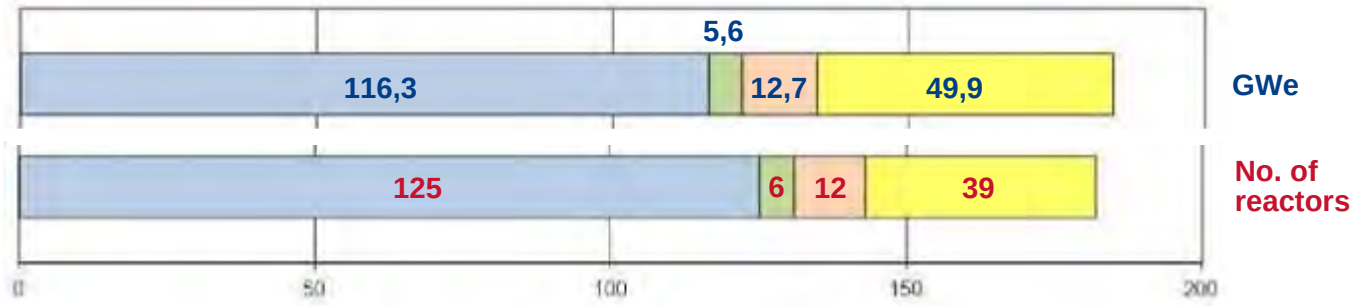
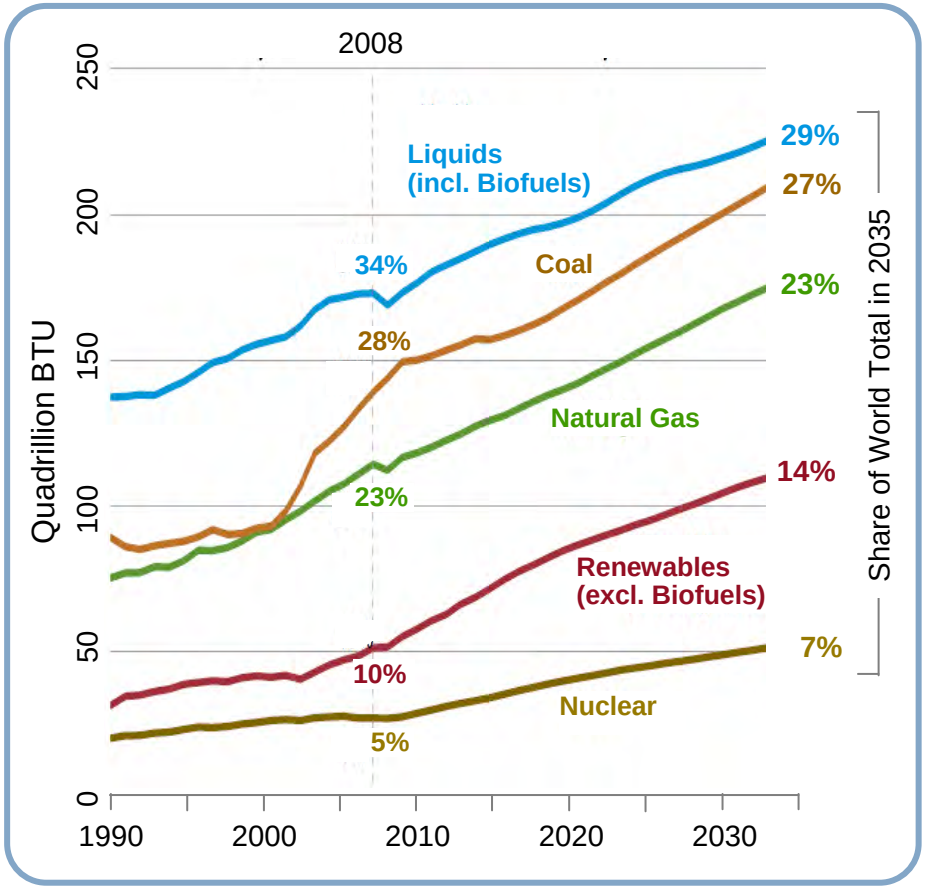


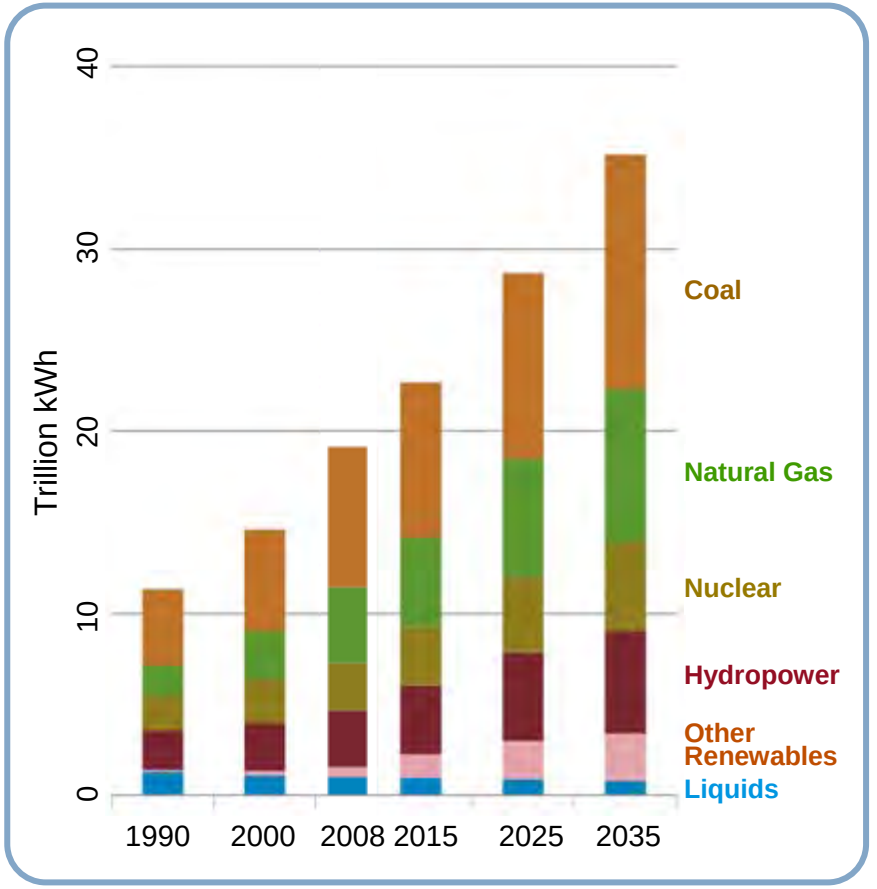
Source: WNA, October 2011

World Energy Mix Projections until 2035

Energy Consumption by Fuel



Net Electricity Generation by Fuel

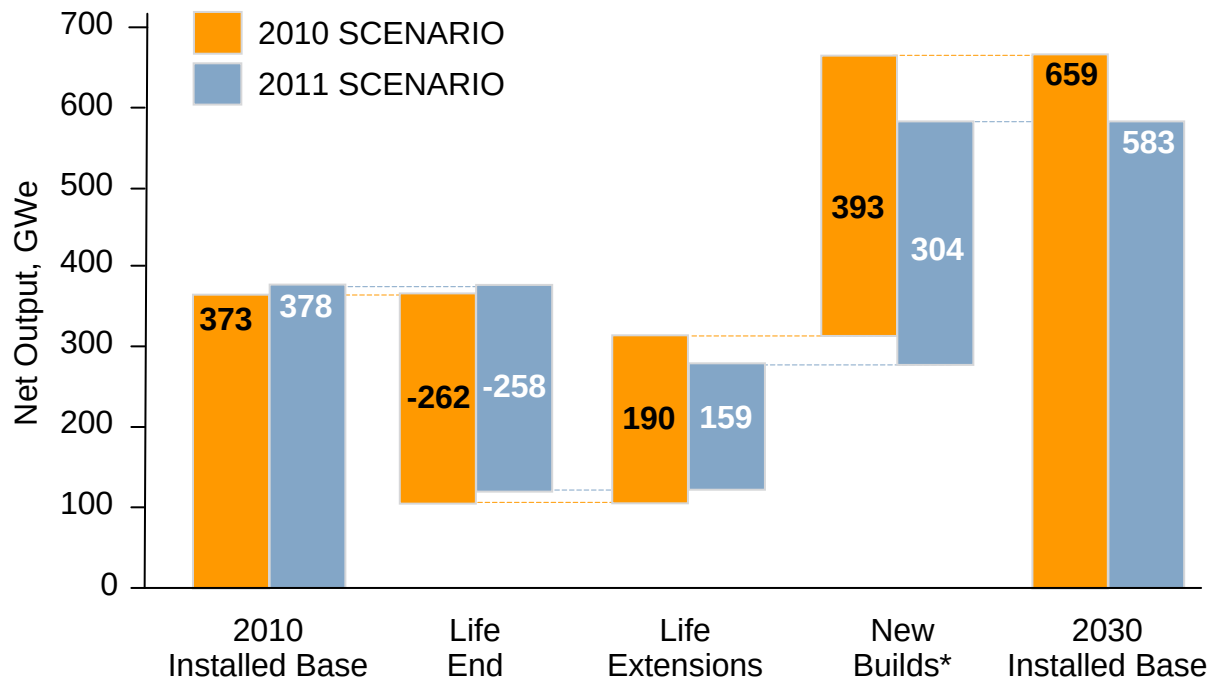


Source: EIA, International Energy Outlook 2011, September 2011

Expected Worldwide Growth in Installed Capacity: +2.2% p.a. by 2030

AREVA 2011 Forecast

Evolution of the Global Nuclear Installed Base



Nuclear fleet growth

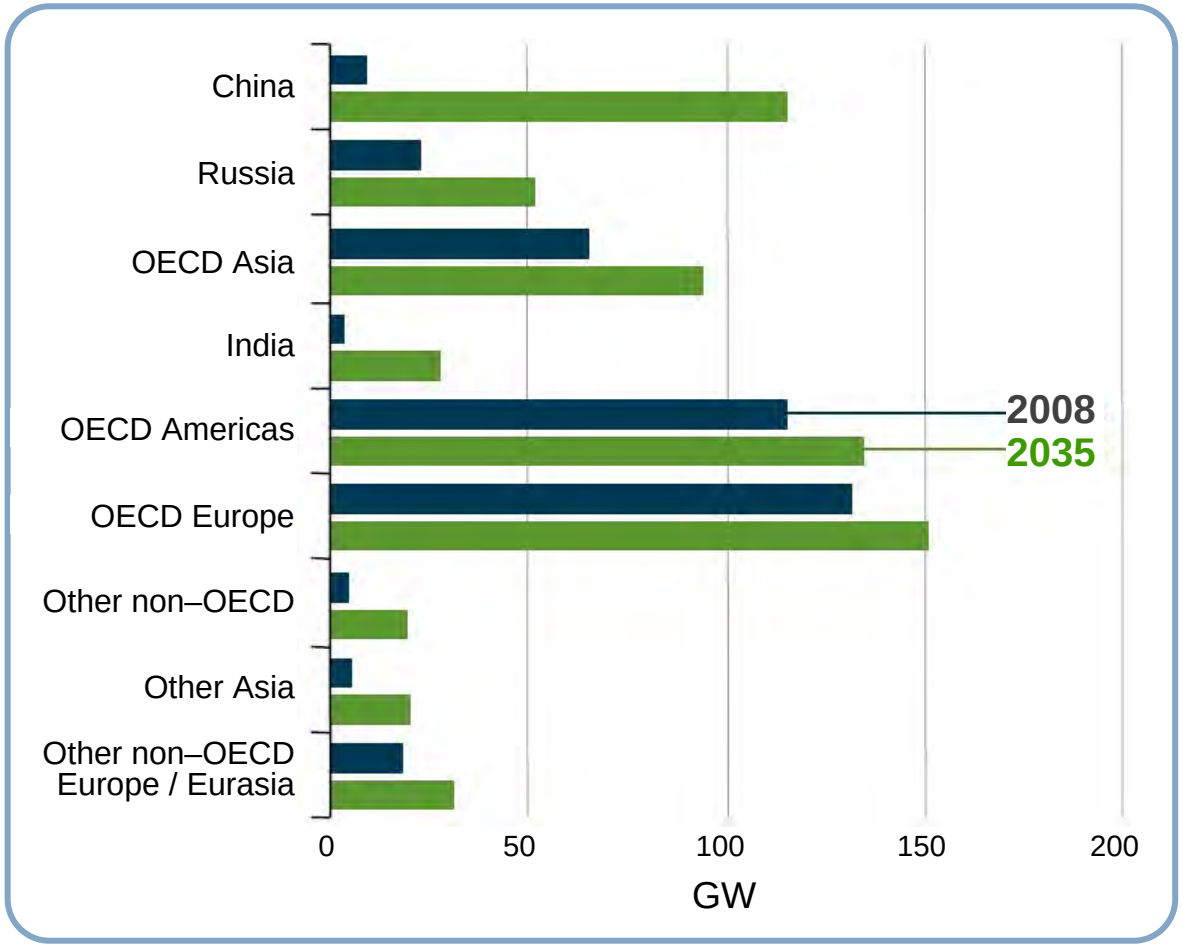
2010–2030: 2,2% CAGR
1990–2010: 0,7% CAGR

* New orders considered until 2023 are commissioned by 2030 (assumption of 7 years between project launch and reactor commissioning)

On 27th July 2011 the IAEA Director–General Yukiya Amano said:

"Despite Fukushima Daiichi, global use of nuclear power will continue to grow in the coming decades and will remain an important option for many countries"

Nuclear Generating Capacity by Region in 2008 and 2035



Source: EIA, International Energy Outlook 2011, September 2011

AREVA

In a Nutshell — 1

- **Fukushima accident: Earthquake and tsunami on March 11th 2011**
- **Status of Japanese nuclear fleet:**
  Only 11 units out of 54 were in September 2011 in operation
  - Automatic shut down of 14 reactors following earthquake (including 6 Fukushima Daiichi reactors)
  - 13 reactors were in outage phase or extended break at the time of the accident, 16 more have entered programmed outage phase since then
- **Immediate governments reactions**
  - Most governments confirmed their nuclear programs
  - Safety checks were announced in most countries
  - Decision from Germany to shut down 8 reactors (built before 1980) and to phase out nuclear by 2022; Switzerland announcement of nuclear phase out by 2032; Italian referendum cancelling New Build program
  - Japan is restructuring the organisation of safety authority
- **Front–end marginally affected**
- **Impact on nuclear power:**
  Compared to status on March 2nd 2011, in October 2011 there were
  - 11 reactors (9.29 GWe, i.e. 2.46% of installed capacity) less connected on grid
  - 1 reactor more under construction
  - 4 reactors less on order/planned and 4 reactors more proposed

In a Nutshell — 2

- **US DOE's (Department of Energy) EIA (Energy Information Administration) releases on September 15th 2011 "International Energy Outlook 2011" stating that**
  - **Global nuclear energy generating capacity projected to rise from current 368 GWe to 644 GWe by 2035**
  - **Electricity generation from nuclear power projected to increase from current 2.63 GWh to 4.9 GWh in 2035**
- **World Energy Council on November 15th 2011: "Nuclear has role in sustainable mix"**
  - **A new report released November 15th 2011 "Policies for the future: *2011 Assessment of country energy and climate policies*" has determined that a mixture of generating technologies and strategies is best for ensuring sustainable energy production**
  - **The report ranks country performance according to an energy sustainability index – how well they perform in the 3 pillars of energy policy: (i) Energy security, (ii) Environment and (iii) Affordability**
  - **The best performers are those which have the most coherent and robust energy polices and which most successfully manage the trade–offs between the 3 pillars. They all have diversified energy portfolios and promote energy efficiency. Notably, no country leads in all three areas**
  - **It is clear that nuclear energy plays a prominent role in the electricity generation mix of all countries highlighted and that moving away from nuclear could impact their performance**
  - **To note is that focusing solely on reducing greenhouse gas emissions and relying only on market mechanisms is not enough to achieve sustainability**
  - **The aftermath of Fukushima is causing a great deal of turbulence for the future of nuclear power. Looking to phase out nuclear technology must address the issue of how to do so without negatively impacting existing energy sustainability – local and regional**

Zoran V. STOŠIĆ
Vice President Marketing and Sales South–East Europe

Despite Fukushima the Nuclear Perspectives Hold

28 November 2011, Zagreb, CROATIA

AREVA