THE WORLD NUCLEAR FUTURE

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1 **Energy Market Fundamentals**

2 AREVA Group at a Glance

3 EPR™ Projects Status

AREVA Group
Nuclear & Renewable strategy

The development of Nuclear and Renewable energies is necessary

- Demand Growth: doubling of energy demand by 2050
- Reduction of CO_2 emissions: objective to reduce greenhouse gas emissions by 50% by 2050
- Security of Energy Supply: depletion of fossil resources and geopolitical uncertainties
- Economic Competitiveness: need for energy sources with stable and predictable cost

AREVA's strategy is to consolidate its nuclear power leadership & become a reference player in the Renewable Energies industry

Energy Potential
and Environmental Load of different Energy Sources

For replacing the power of one fossil fuel power plant or one NPP a 1,000 km^2 area is needed for wind farm, and for replacing the energy it produces, several thousands of km^2

For each kW capacity, windmill needs twice as much concrete and 3 times more steel

And for each kWh produced, windmill needs 8 times more concrete and 12 times more steel than for NPP

Average horizontal solar irradiation of Italy < 1,000 kWh/m^2 p.a.

Total surface of Italy ~ 3×10^{11} m^2
Utilizable for solar cells < 10^{10} m^2

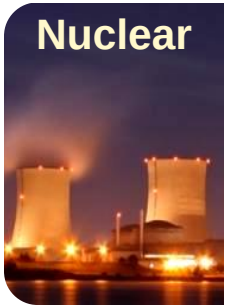
Potential for solar electricity production ~ 10^{12} kWh/Y

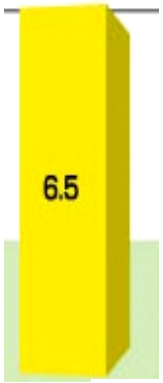
This is approximately equal to the current annual electricity consumption

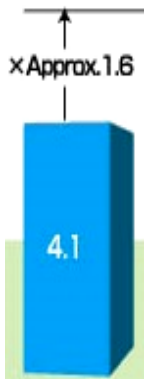
Should Italy be covered by solar cells the production of solar electricity would just suffice for the current Italian demand

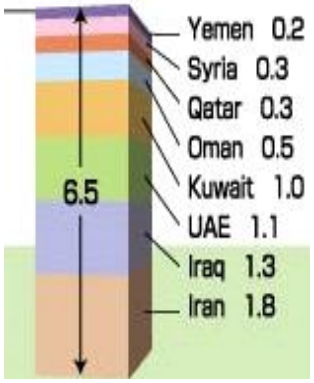
Energy Density and Environmental Load of different Energy Sources

Energy Generated by Nuclear Power and by Oil



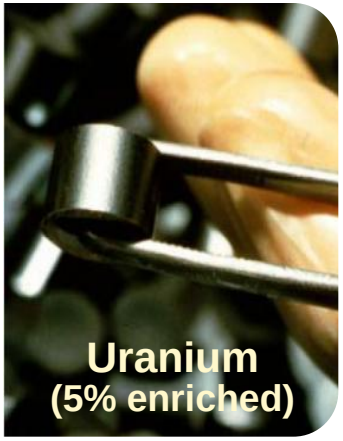






World NUCLEAR power generation (in 100 mill.TOE)	Total OIL production of Saudi Arabia	Total OIL production of other Middle Eastern Countries (in 100 mill. t Oil)

Coal vs Uranium to produce 1 GWh of Electricity



FUEL	400,000 kg (265 m^3)	3 kg (300 cm^3)
WASTE	1,090,000 kg of CO_2 + NOx, SOx, particulates, Arsenic, mercury, etc.	3 kg (w/o reprocessing) 0.1 kg (with reprocessing)

Source:
E. Kee, G. Sachs, 9th Annual Power and Utility Conference, 19 May 2009

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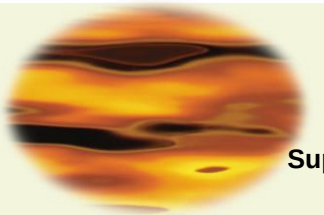
Environmental Load
of some Power Plants generating 1,000 MWe

Source: Gonzalez A., "The Challenge to Nuclear Renaissance: Safety", Int. Conf. Nuclear Energy for New Europe, Portorož, Slovenia, 10–13 September 2007

	Fuel Quantity t/year	Releases	
Oil	 2,000,000 (10 Super tankers / year)		**4 km³** of **oil** is burned worldwide **every day** — equivalent to a cube of **1.6×1.6×1.6 km**
Coal	 2,600,000 (5 trains – 1,400 t/day)	6,000,000 CO_2 44,000 SO_2 22,000 NO_x 320,000 Ash (400 t toxic heavy metals)	
Nuclear	 27 (160 t Nat–U / year)	460 Low–Level* 310 Intermediate 27 High–Level**	**One year** of the global **nuclear** electricity generation produces **1,000 m³** - equivalent to a cube of **10×10×10 m**

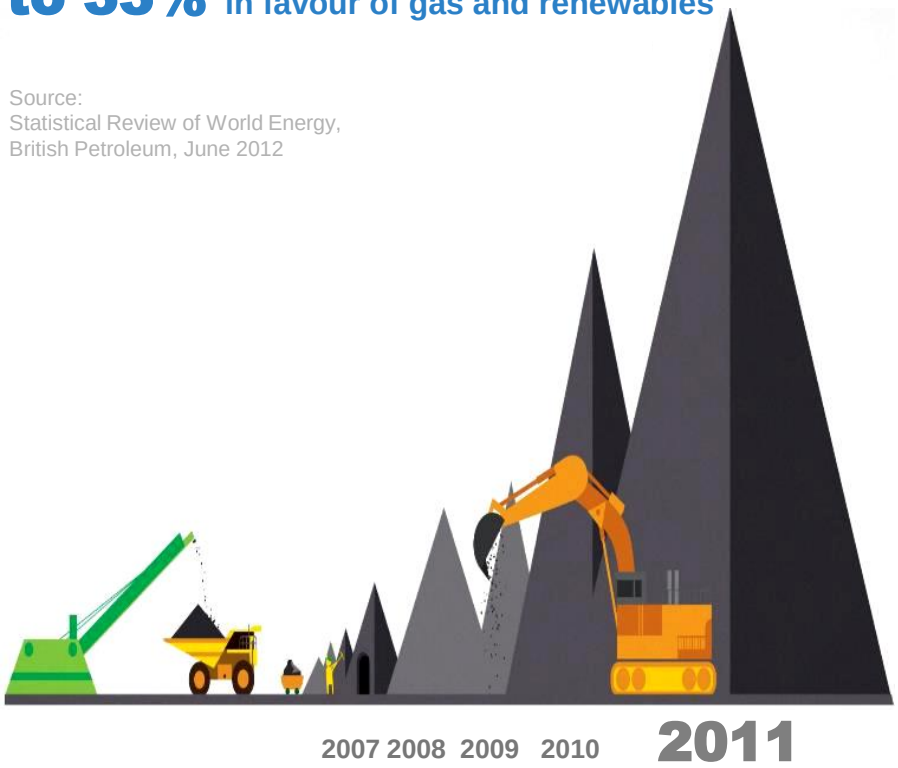
* Activity: 1 to 100 Bq/g (i.e. granite ground activity is 8 Bq/g); Life span (to reach natural radioactivity level) < 30 years

** Activity: about/more than 10,000,000 Bq/g; Life span > 300,000 years

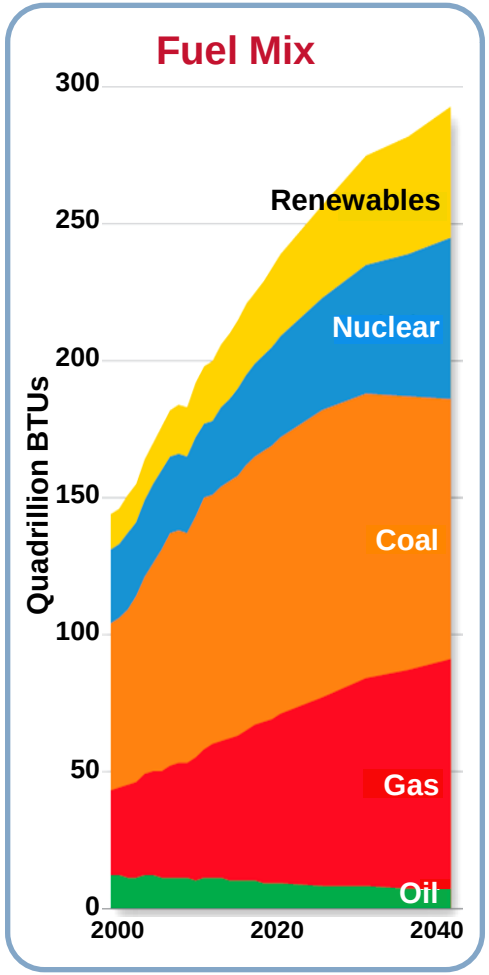
Development of Fuel into Energy/Electricity Generation until 2040

Coal remains the largest source of electricity generation to 2035, but its share drops **from 41% to 33%** in favour of gas and renewables

Source:
Statistical Review of World Energy,
British Petroleum, June 2012



Coal consumption growth **5.4%**



Source: ExxonMobil, "2012 The Outlook for Energy: A View to 2040"

By 2040, **oil and natural gas** will be the world's top 2 energy sources, accounting for about **65%** of global demand, compared to about **55% today**

Gas is the fastest–growing major fuel source: **1.6%/year** from 2010 to 2040

Nuclear output share drops by 2040 **from 13.5% to 13.1%**

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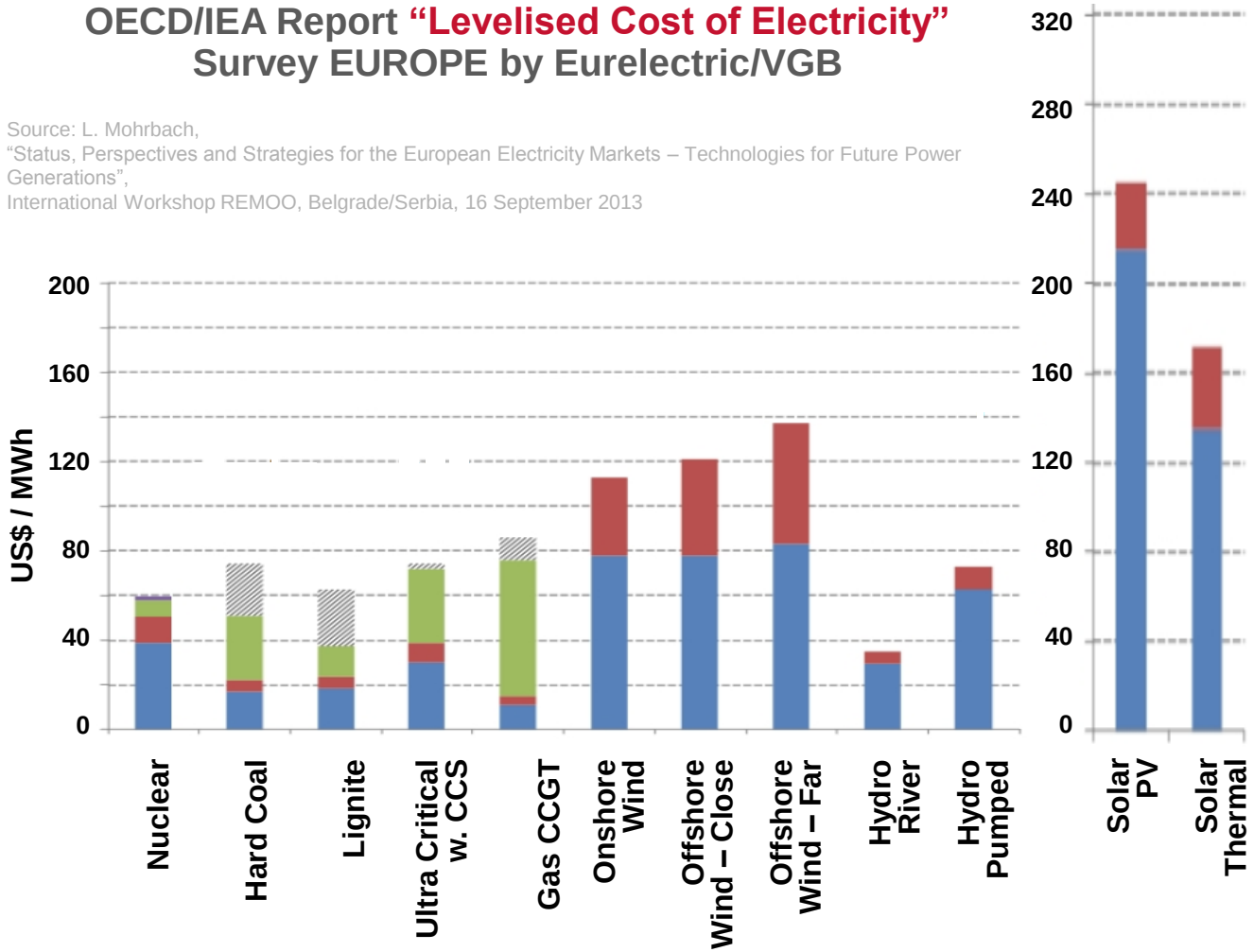
Production Costs of Electricity

OECD/IEA Report "Levelised Cost of Electricity"
Survey EUROPE by Eurelectric/VGB

Source: L. Mohrbach,
"Status, Perspectives and Strategies for the European Electricity Markets – Technologies for Future Power Generations",
International Workshop REMOO, Belgrade/Serbia, 16 September 2013



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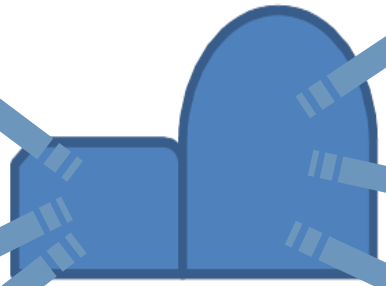
Contributions of Nuclear Energy to Security of Energy Supply

Internal Dimension
(Technical, Financial, Economic Issues)

- Adequacy of generation capacity
- Adequacy of domestic transport infrastructure
- Adequacy of market design and regulation
- Price stability
- Operational reliability

Considers the adequacy of investment in generation capacity and the functioning of infrastructures for the transport, transformation and transmission of energy (ports, high–voltage power lines, distribution systems…)



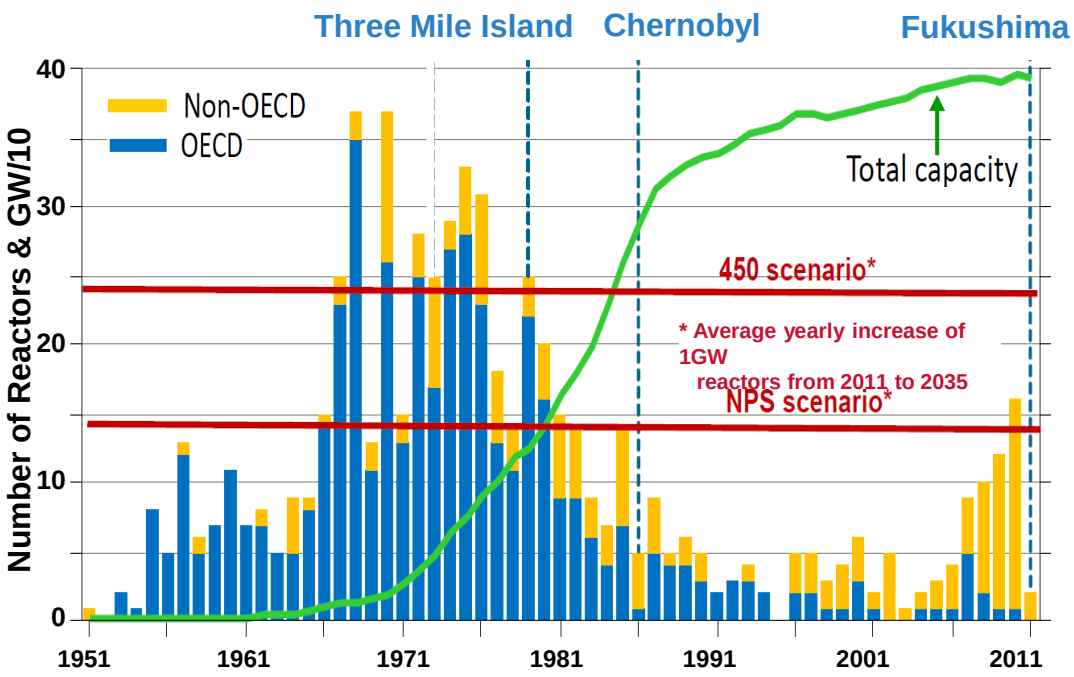
External or Geopolitical Dimension

- Geopolitics, access to primary fuels
- Safety and adequacy of international infrastructures
- Unanticipated resource exhaustion
- Resilience to changes in climate policy

Considers the risks of short-term or long-term interruption of physical energy flows or other deliberate uses of market power for political, military or strategic reasons. It is the aspect of energy supply security uppermost in the minds of policy–makers and the general public alike

History and Current Status of NPPs in the World

Nuclear Reactor Construction Starts 1951–2011 (GW/Y)



In 2010, new construction was consistent with levels needed to achieve the 450 goal

Source: D. Houssin, IEA, "World Nuclear Fuel Cycle", Helsinki, 18 April 2012

Current Status

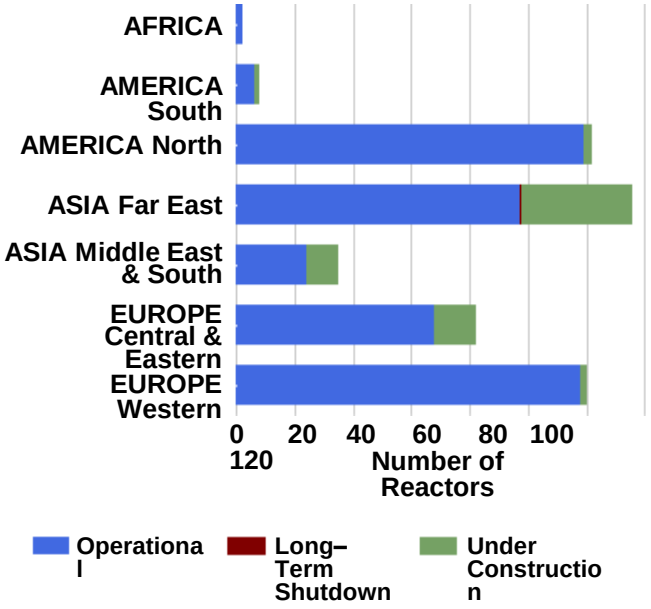
434 Nuclear Power Reactors in Operation

370.5 GW_e Total Net Installed Capacity

1 Power Reactors in Long Term Shut–Down

70 Reactors Under Construction

Regional Distribution



Source: IAEA PRIS data base. 4 October 2013

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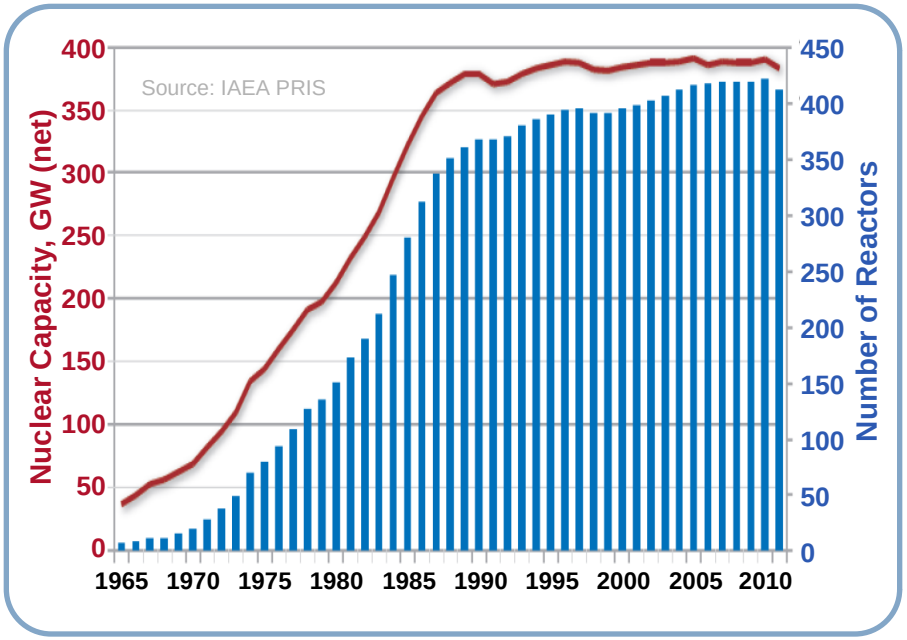
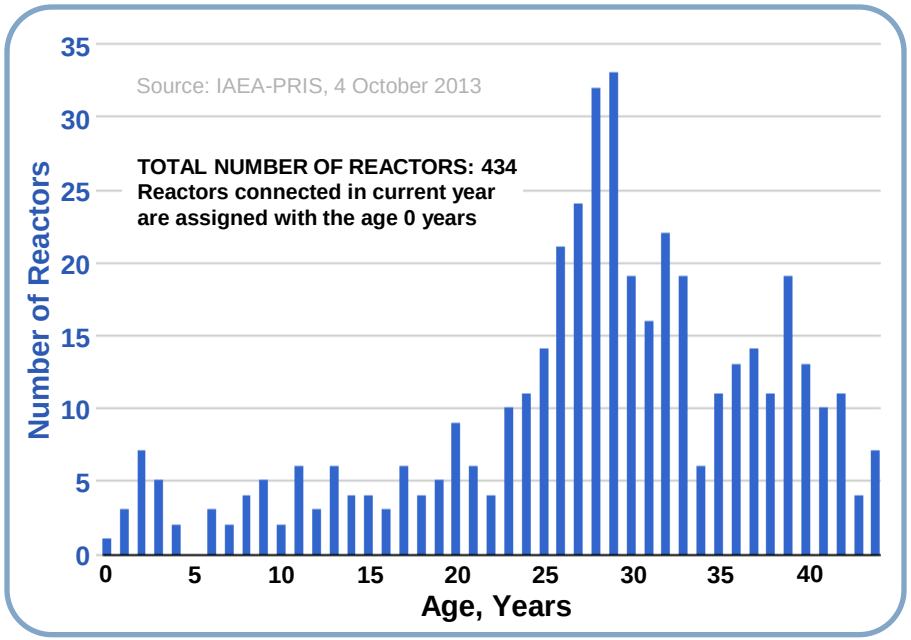
Reactors in Operation and their Age Worldwide





- Between **1995** and **2013**, the **number of reactors** remained virtually **unchanged** (**434 → 437**), but the installed capacity grew by more than **9%** (**341 GWe → 372 GWe**) due to (1) "Small" reactors being decommissioned and "Large" ones being connected (2) Power uprates
- As of March 2013, the **Mean Age** of the 437 reactors operating in the world is **28 Years**
- By **2030, 72%** (or 267 GW) of nuclear generating capacity will be more than **40 years old**
- All nuclear capacity to be retired by 2030 has to be replaced by new capacity

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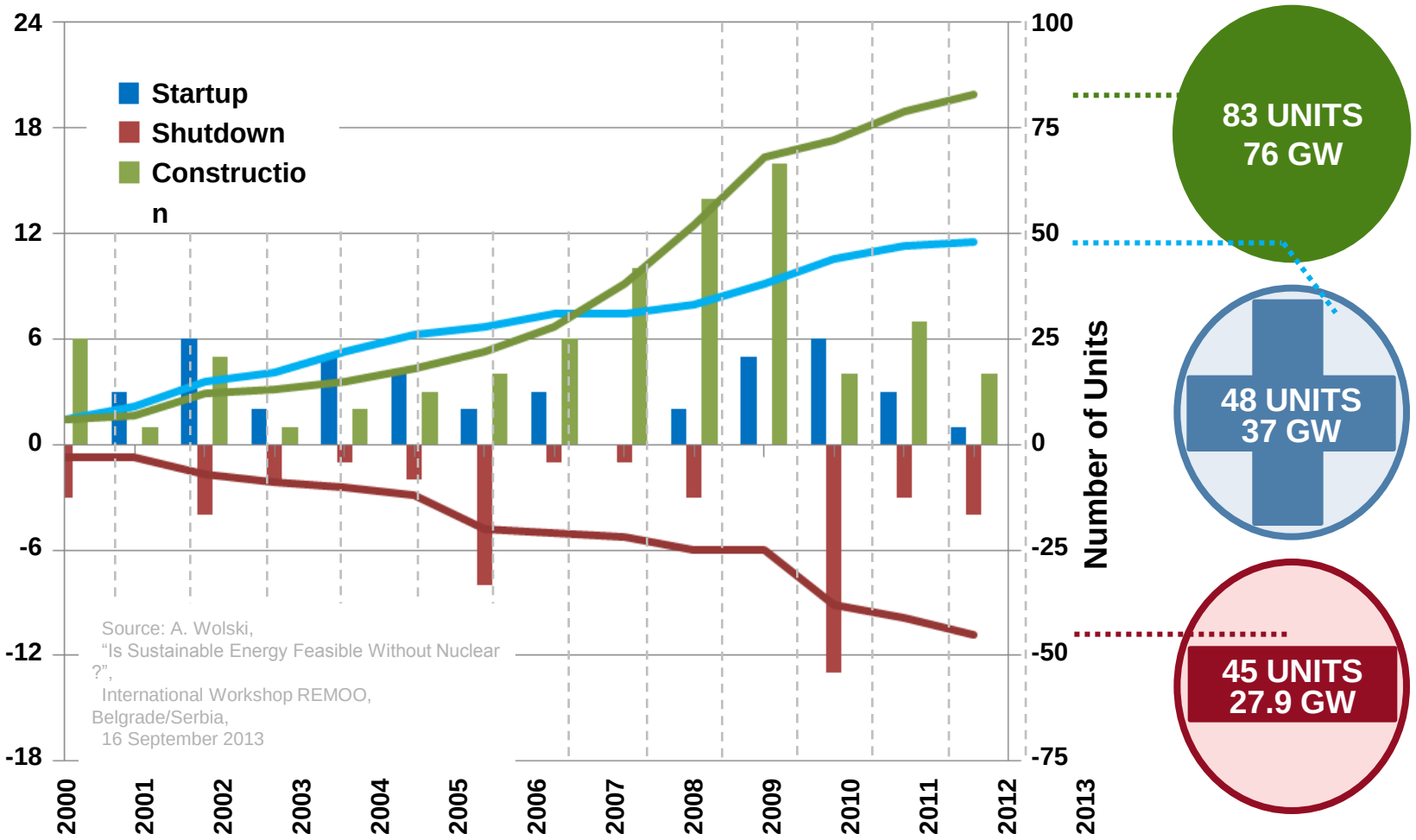
Nuclear Recent Development



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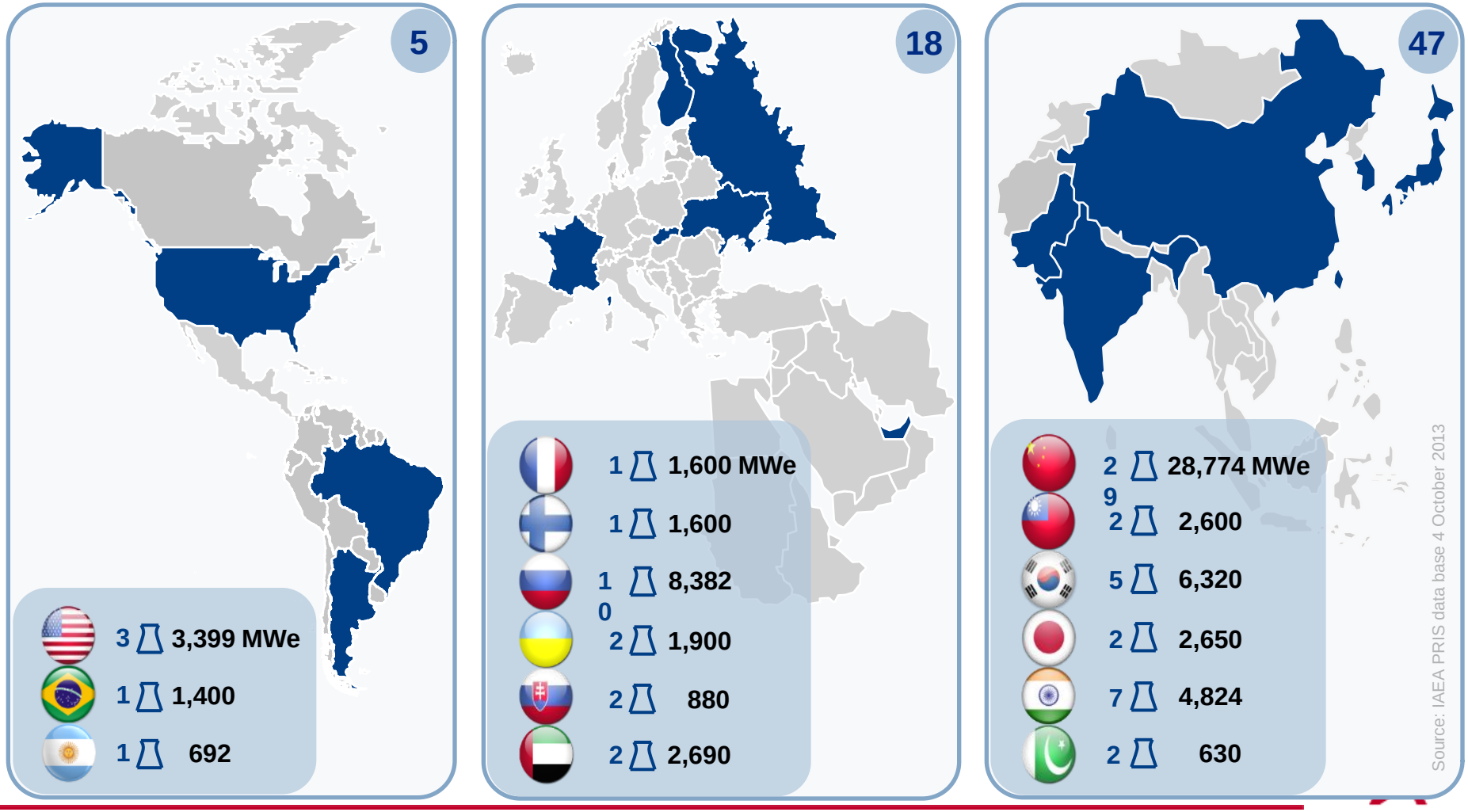
70 Nuclear Power Plants are under Construction Worldwide

Post Fukushima:
Most countries have confirmed the importance of nuclear in their energy mix



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Nuclear New Build Perspectives

New plants to come in near future

Fennovoima
Pyhäjoki

TVO
OL4

JAEC

EDF
Hinkley Point C
Units 1-2

NPCIL
Jaitapur 1-2

CEZ *Temelin 3-4*

Turkey
Sinop Project,
4 units

CGNPC
Taishan 3-4

New plants to come

Argentina - NA-SA

Malaysia - MNPC

UAE - ENEC

USA - EDF / PPL / Duke Energy

Hungary

Canada

Saudi Arabia

Poland - PGE

UK - GDF Suez – Iberdrola

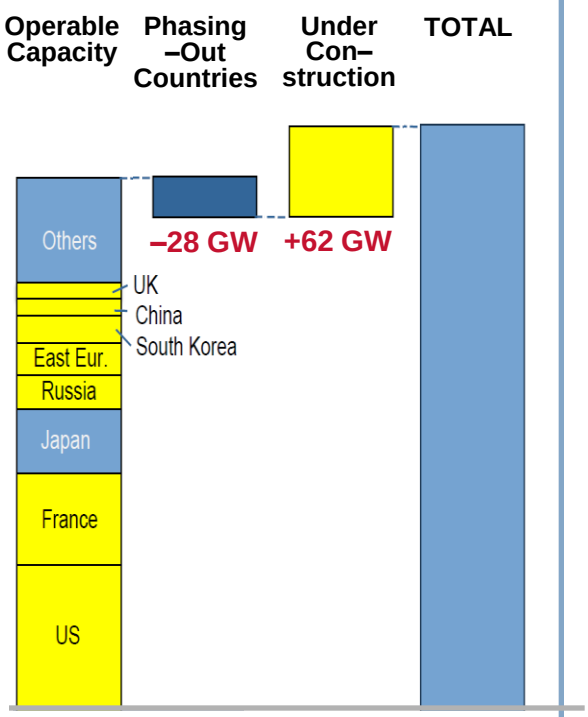
South Africa - ESKOM

Sweden - Vattenfall

Vietnam - EVN

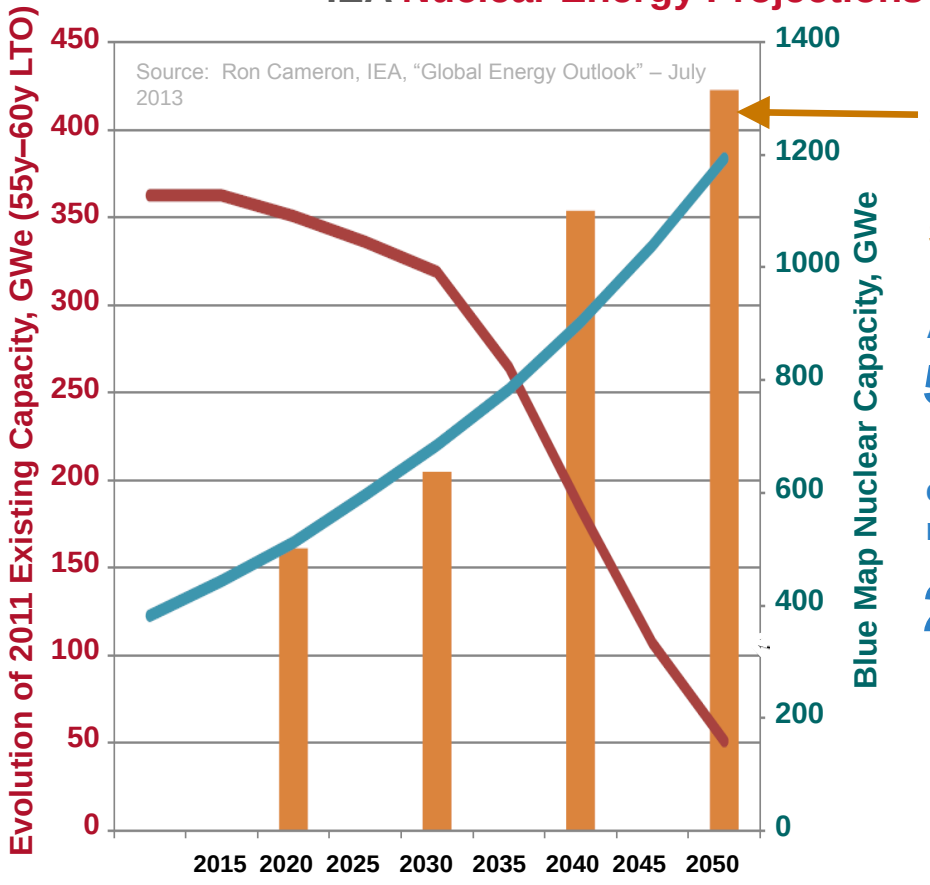
Effect of Fukushima might be quite Modest at Global Level

Evolution of Nuclear Capacity a Year after Fukushima



Source: D. Houssin, IEA, "World Nuclear Fuel Cycle", Helsinki, 18 April 2012

IEA Nuclear Energy Projections



New Build needs to reach **Blue Map** Scenario

About **50 GWe** capacity remaining by **2050**

Despite phase–out in certain European countries, nuclear capacity will continue to grow in China, India, Russia, South Korea and other countries

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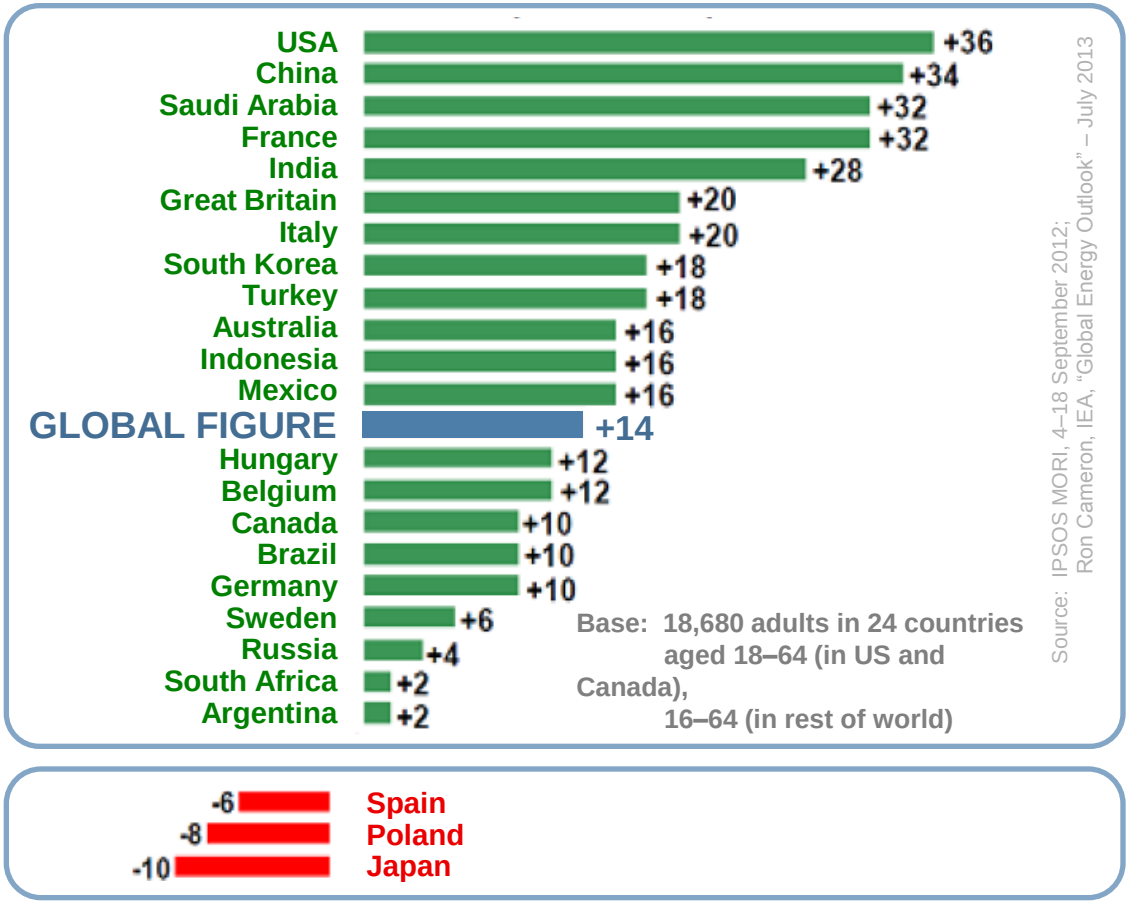
Public Support growing again
in most Countries after post–Fukushima Low

Change in Net Support for Nuclear Energy
April 2011 — September 2012



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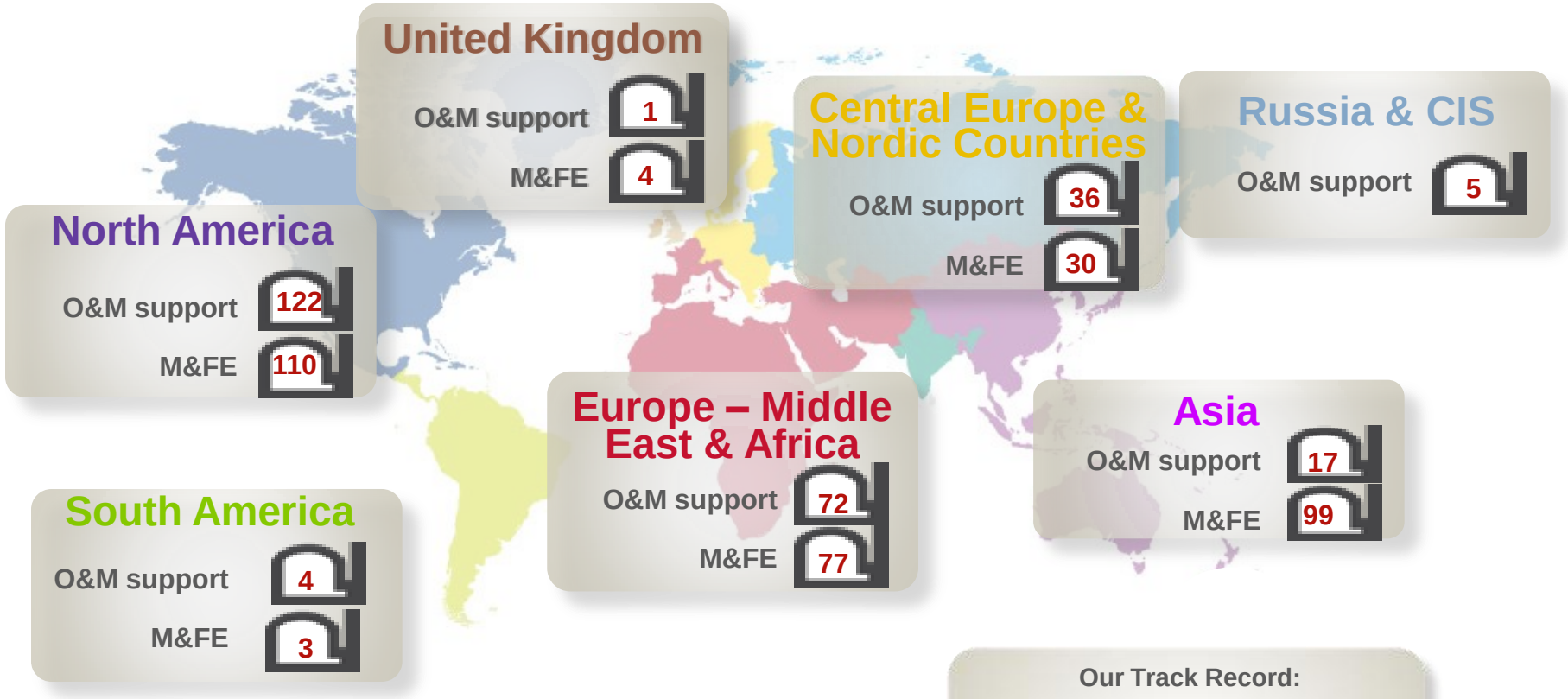
AREVA World in nuclear energy



360/440 reactors served by AREVA in the World

Our Track Record:
100+ nuclear reactors delivered

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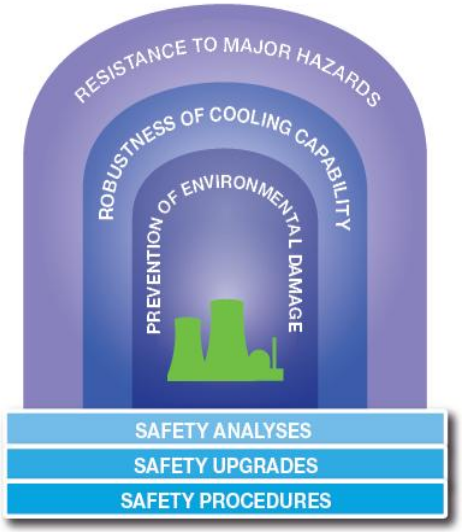
Safety Alliance

AREVA's Safety Alliance

- **Engaging with utilities to help them meet ever-increasing safety requirements**
  - **Safety analyses**
  - **Safety upgrades**
  - **Safety procedures**

- **A safety framework structured around three imperatives:**
  - **Resistance to Major Hazards**
  - **Robustness of Cooling Capability**
  - **Prevention of Environmental Damage**



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Forward Alliance

Forward Alliance: the launch of a new program

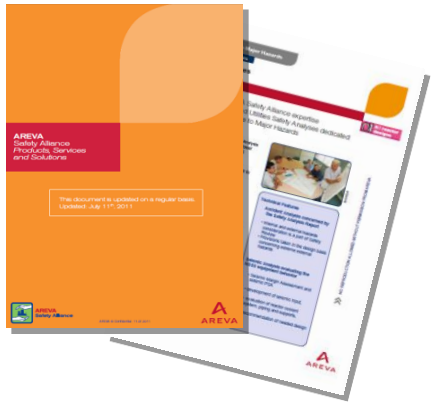
Helping utilities extend the operation (LTO) of their reactors

- **Providing personalized assistance to our customers to ensure the long-term operating safety of their nuclear fleets in accordance with international regulations**
- **Three priorities:**
  - **Support provided during the license renewal process recommended by the IAEA**
  - **Assistance for safety reviews of major components**
  - **Products and solutions meeting project requirements**
- **Offering integrated solutions based on AREVA's "aging management" activities**
- **Forward Alliance catalog: more than 25 products, services and solutions for extended operations**

AREVA Safety and Forward Alliance Catalogues

AREVA Safety Alliance

- **AREVA Safety Alliance catalogue (35+ products)**
  - **Support to meet ever-increasing safety requirements**



AREVA Forward Alliance

- **Forward Alliance catalogue (25+ products)**
  - **Services and Solutions for Long-Term Operation**

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1 Energy Market

2 AREVA Positionning

3 EPR™ Projects Status

State of Affairs and Prospects

EPR™ Projects Status

The Value of Experience
In a Nutshell

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4 EPR™ Reactor Units under Construction

Olkiluoto 3

Taishan 1&2

Flamanville 3

The World's First Advanced Fleet to be deployed

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State of Affairs and Prospects

EPR™ Projects Status

The Value of Experience

In a Nutshell

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The Value of Experience: LICENSING

Reviewed by reference Safety Authorities

- The EPR™ reactor:
  - Construction license granted by Finnish, French and Chinese Safety Authorities
  - Final Design Acceptance confirmation issued by the O
  - Desig
    end o
- The only Ge
  Fukushima
- The EPR™ Reactor fully complies with WENRA objectives for New Power Reactors and is ready to comply with post–Fukushima requirements
- This unique breadth and depth of design review strongly mitigates the licensing risk related to nuclear new build

LICENSING


2005 STUK


2007 asn AUTORITÉ DE SÛRETÉ NUCLÉAIRE


2009 NNSA 国家核安全局

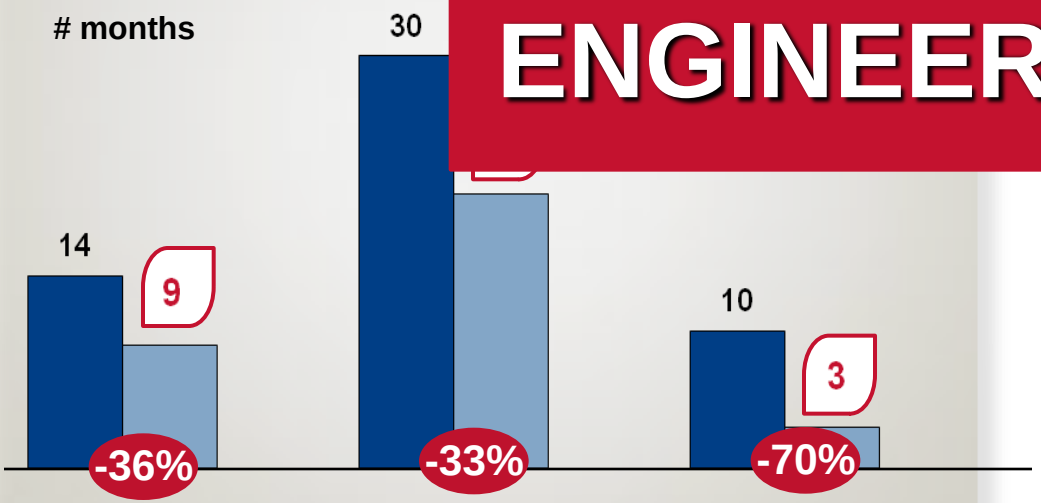

2012 HSE Health & Safety Executive


2014 U.S. Nuclear Regulatory Commission

The Value of Experience: ENGINEERING
Standardisation on Early Engineering Activities

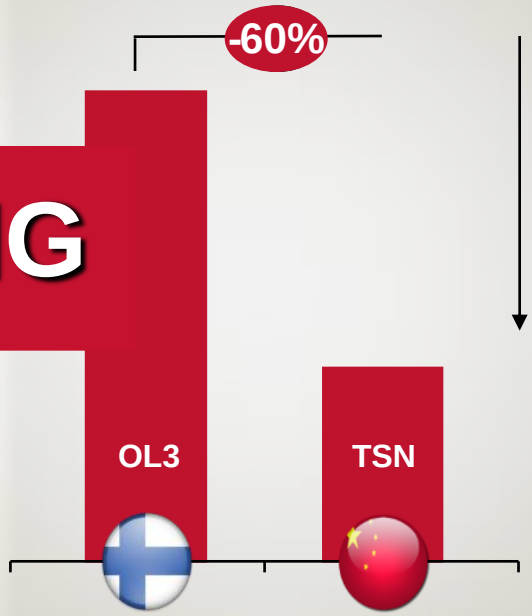
System activities:
Input data for other disciplines ready earlier and better defined

- **P&ID: Important input for layout in order to validate Civil Works (CW) interfaces**
- **DSE stage 2: Important input for I&C**



ENGINEERING

NSSS engineering standardized and streamlined



Number of engineering hours for NSSS completion (for Taishan: estimate)

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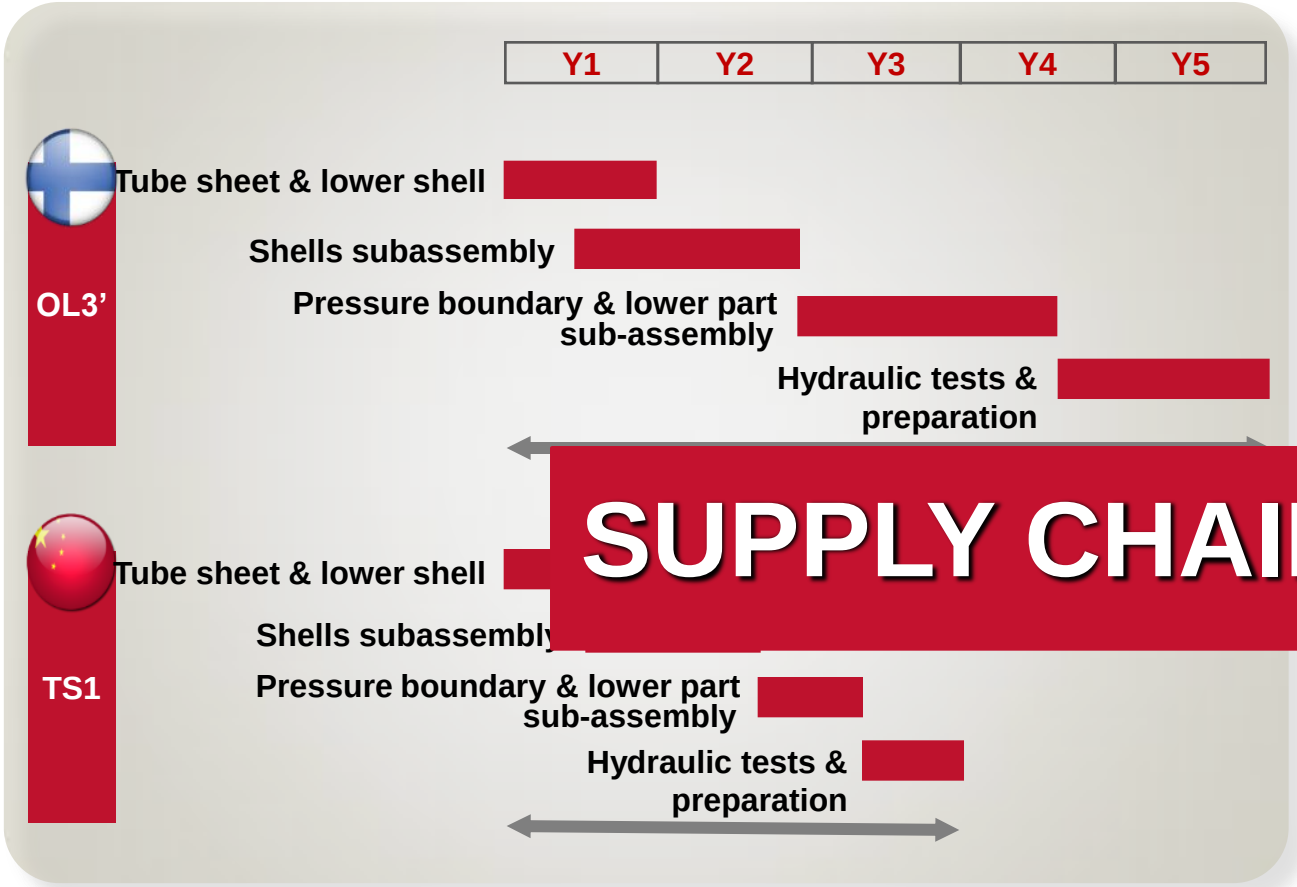
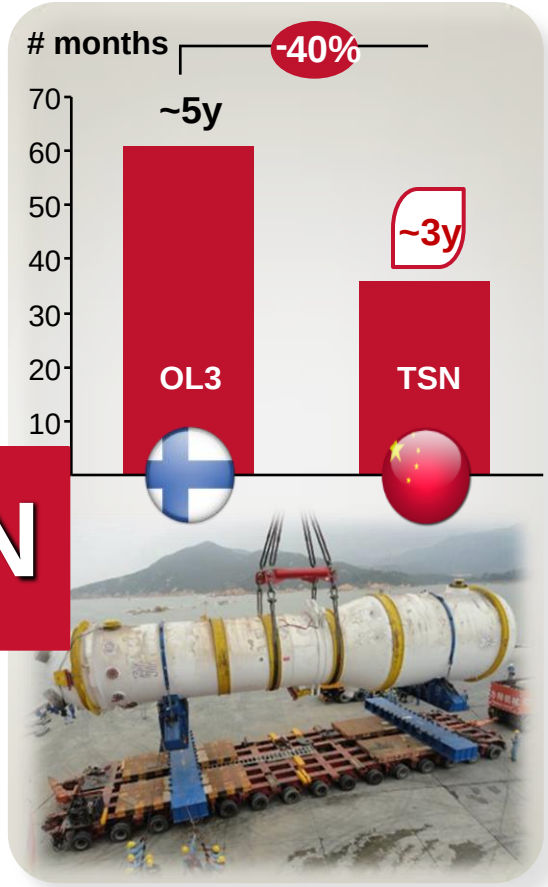
The Value of Experience: SUPPLY CHAIN
Manufacturing of Heavy Components





Source: AREVA, average of the four Steam Generators for each unit

Apr '12
First two steam generators delivered on Taishan site

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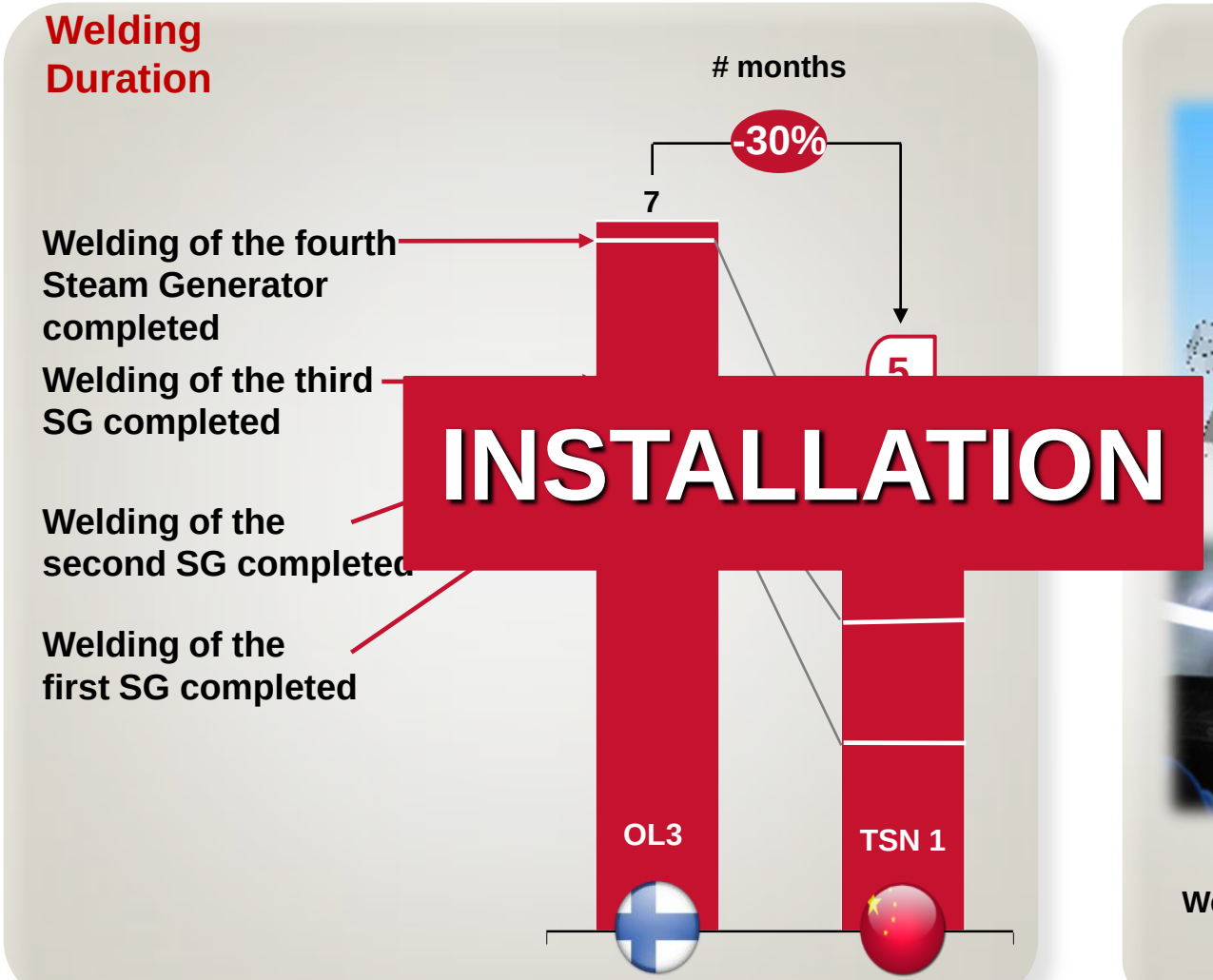
The Value of Experience: INSTALLATION
Welding of Primary Loop

Welding Duration



Welding of SG1, Taishan

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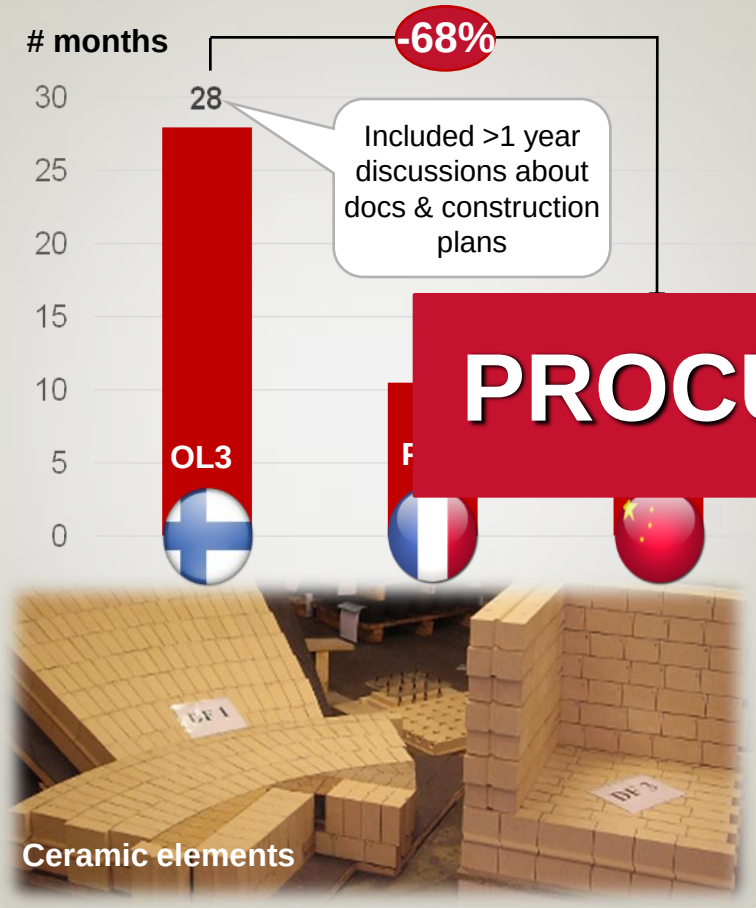
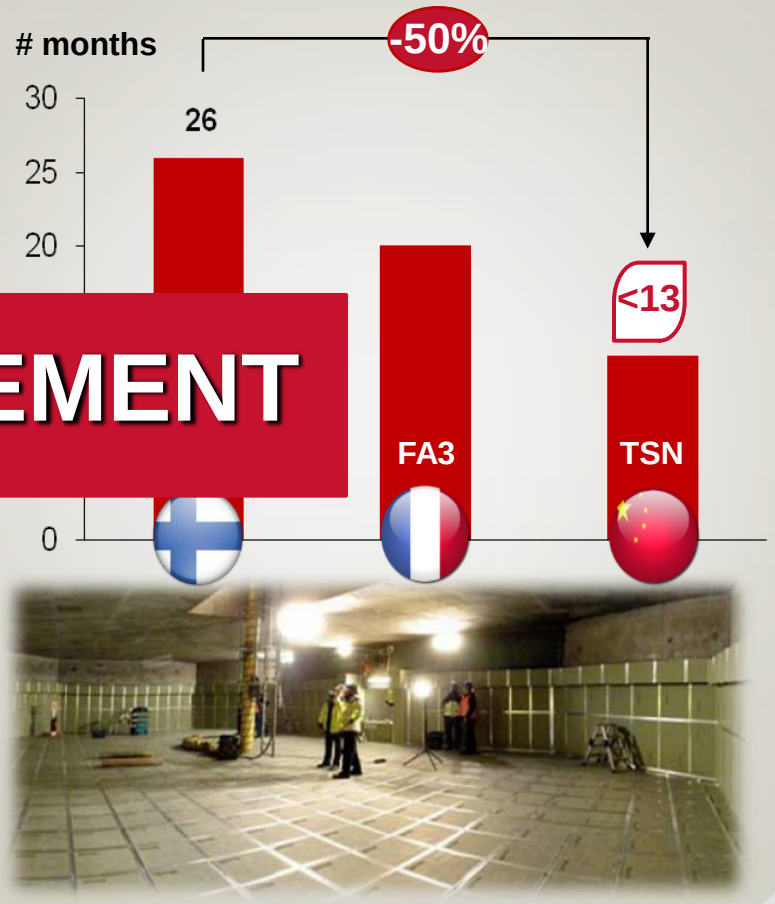
The Value of Experience: PROCUREMENT
Illustration on the Core Catcher

Delivery time core catcher protection layer[1]



Delivery time core catcher cooling structure[1]



PROCUREMENT

1- Delivery time: from contract to delivery

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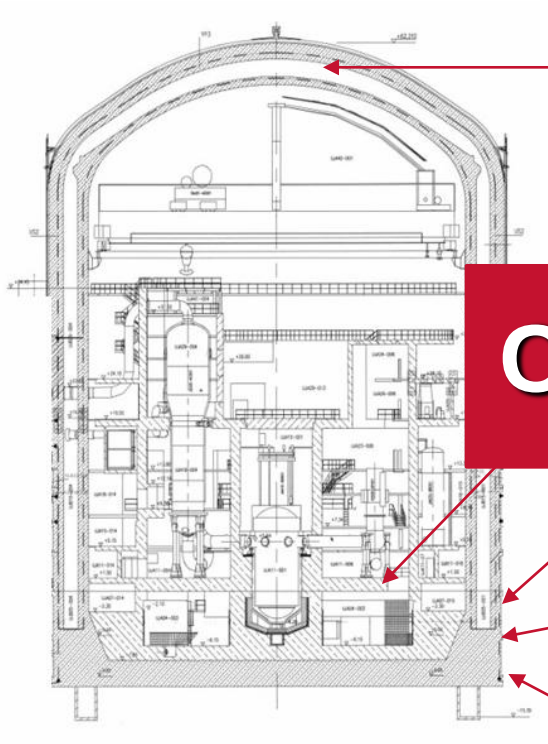
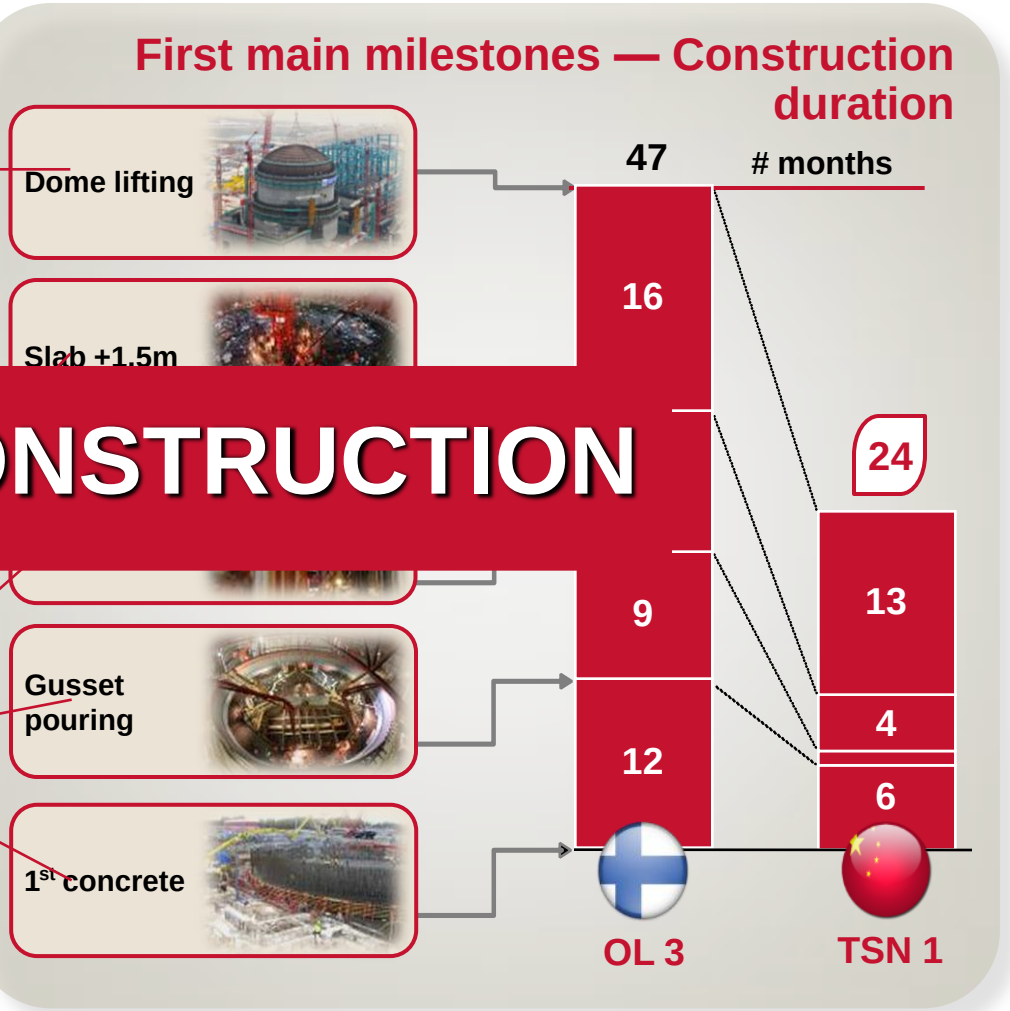
The Value of Experience: CONSTRUCTION



First main milestones — Construction duration



CONSTRUCTION

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State of Affairs and Prospects

EPR™ Projects Status

The Value of Experience

In a Nutshell

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General Remarks

- Nuclear power has advantages in an energy mix.

  For developed countries, it contributes to security of supply, reduction of GHG and provide stability of electricity prices over long periods.

  For many developing countries, it meets the demand for energy

- As such, despite the Fukushima effect, many countries are recognising a need for more nuclear — Canada, Poland, Czech Republic, UAE, Turkey, Vietnam, China, India, Korea, Russia, UK etc.

  Least cost models to reach carbon targets all include increasing nuclear shares

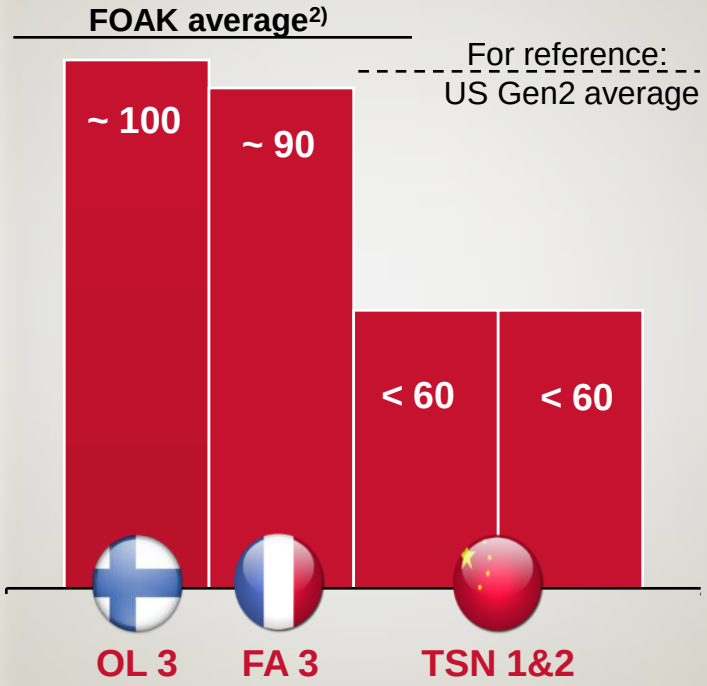
- In terms of costs, LCOE calculations confirm the overall lifetime competitiveness of nuclear but construction times need to be reduced for new designs.

  This is being achieved in China

- If system costs were internalised, this would create a more level playing field and nuclear power would be increasingly competitive in comparison to intermittent renewables

The EPR™ Reactor Series Effect:
On–Budget & Faster Project Delivery

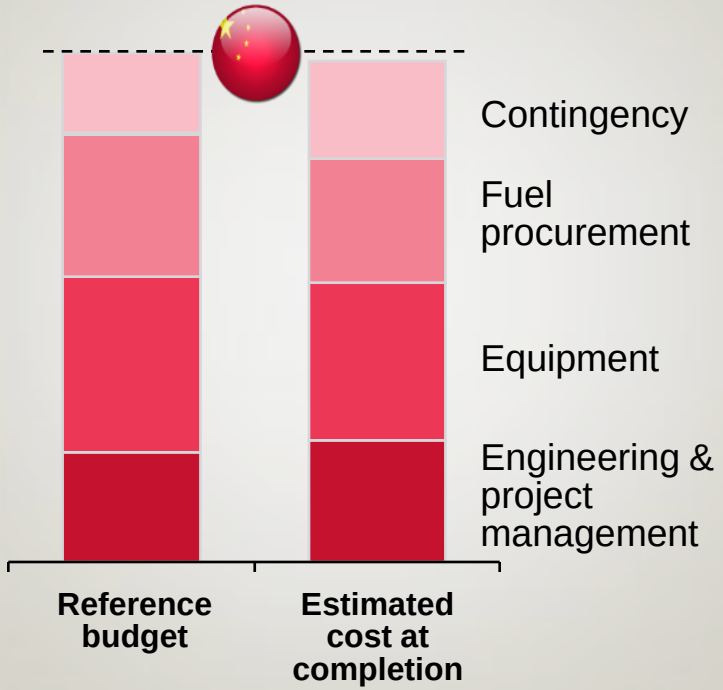
Planned construction time[1] has been reduced significantly…



1) 1st concrete to start of nuclear operation **(# months)**

2) FOAK average duration for AREVA reactor series

…and costs are well under control: Taishan on budget with already more than 85% costs committed on AREVA's scope



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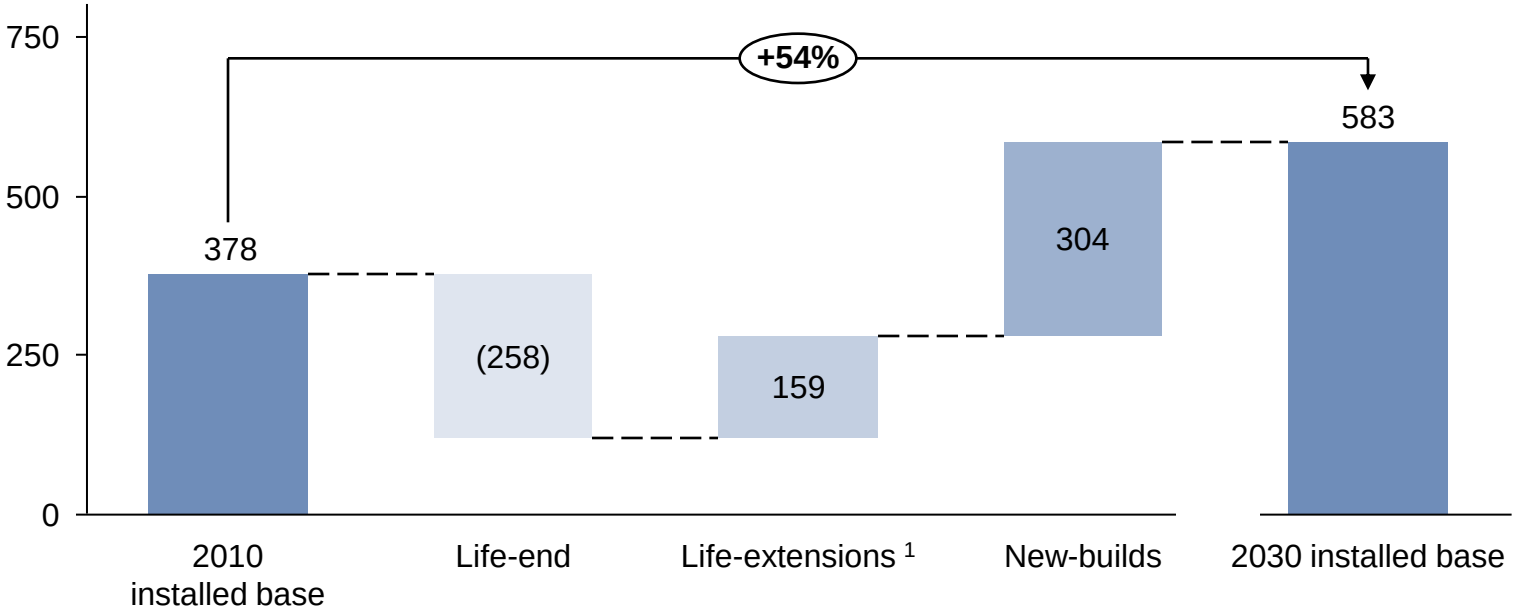
Muito Obrigado!

Global nuclear capacity is projected to increase by 54% by 2030

AREVA forecast of 2010-2030 evolution of the global nuclear installed base

(Net output, GW)



1. Including power uprates

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