Safe and Green Energy for Mediterranean Countries: Areva Perspectives

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Sharing Knowledge Across the Miditerranean Conference
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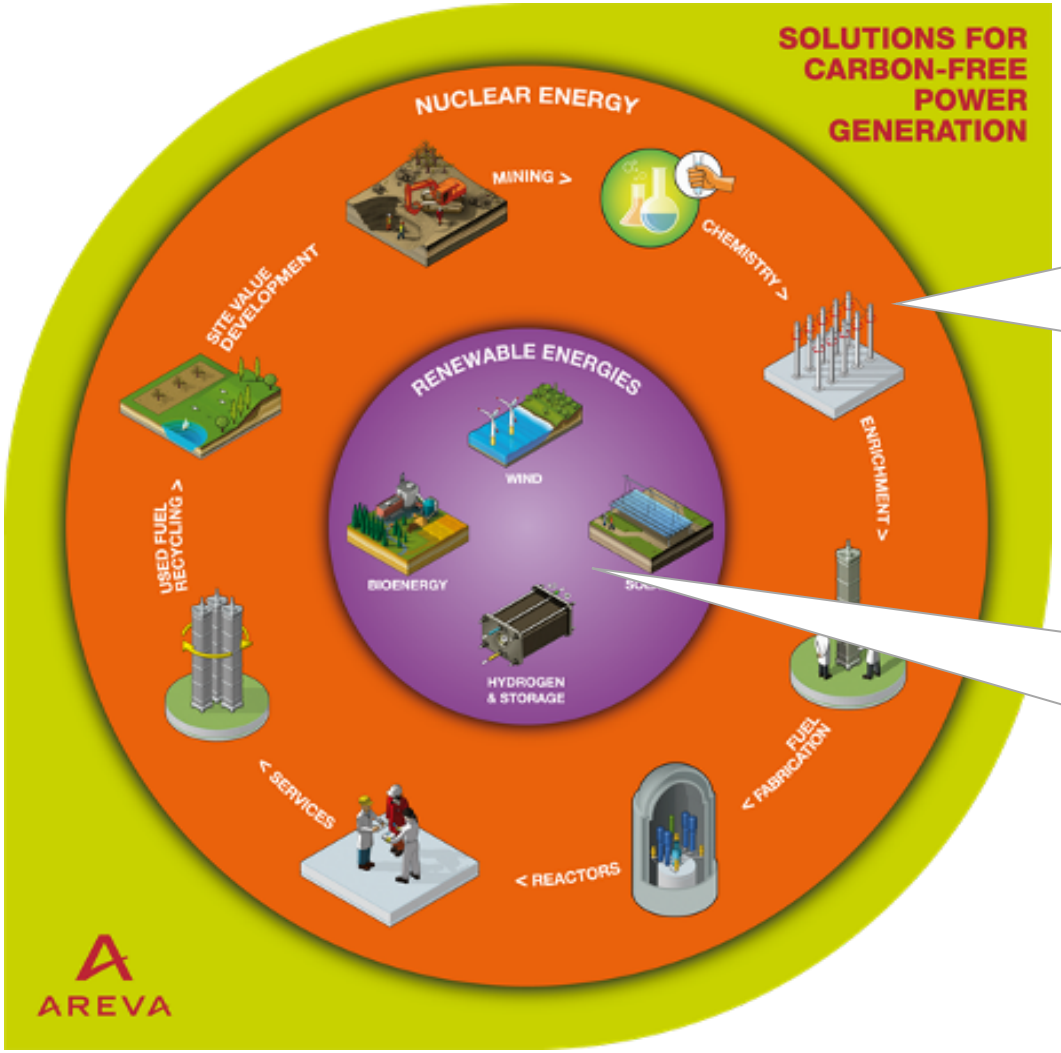
AREVA supplies solutions for power generation with less carbon

- **World leader in nuclear power**
  - **A unique integrated model, from uranium mining to reactor design and related services to used nuclear fuel recycling**
- **A major player in renewable energies**
  - **A portfolio of diversified technologies: offshore wind, concentrated solar power, bioenergies, hydrogen and energy storage**

Nuclear and renewables: contributing synergistically to a reliable, economical and low-carbon energy mix

AREVA offers a wide range of low-CO_2 power generation solutions



Business model based on the **integration in the entire Uranium and Reactor value chains**

Development of a comprehensive portfolio of renewable solutions

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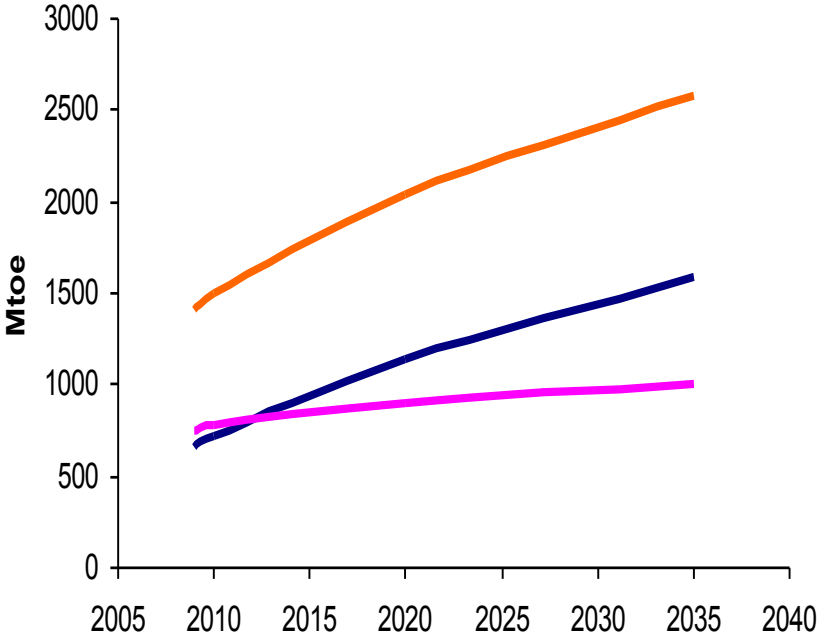
Agenda

- Vision on the energy mix
- Prerequisites for a nuclear solution
- AREVA technologies

Energy market: continued strong growth

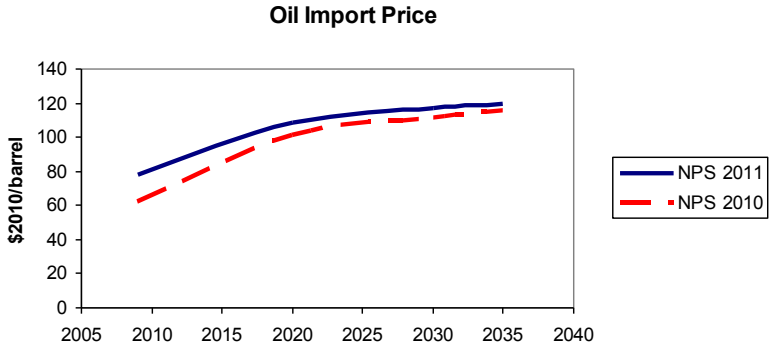


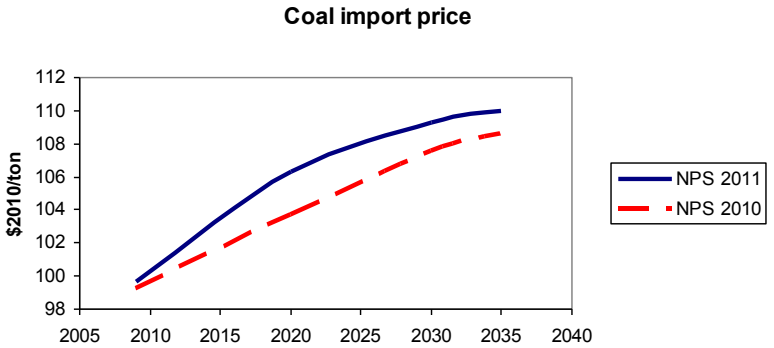
Electricity demand	Energy demand	Per year
3.6%	1.9%	non OECD
1.1%	0.3%	OECD
2.4%	1.3%	World

Energy and Electricity demand are projected to increase drastically over the period 2012-35

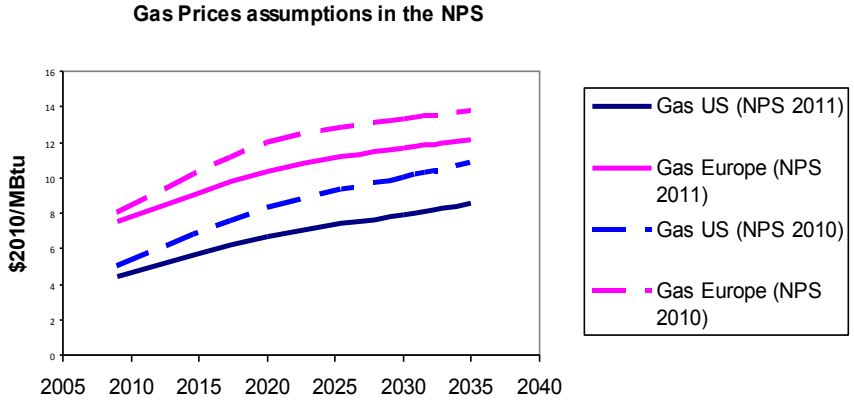
Source: World Energy Outlook (dec. 2011)

Fossil fuel growth limited by price increases



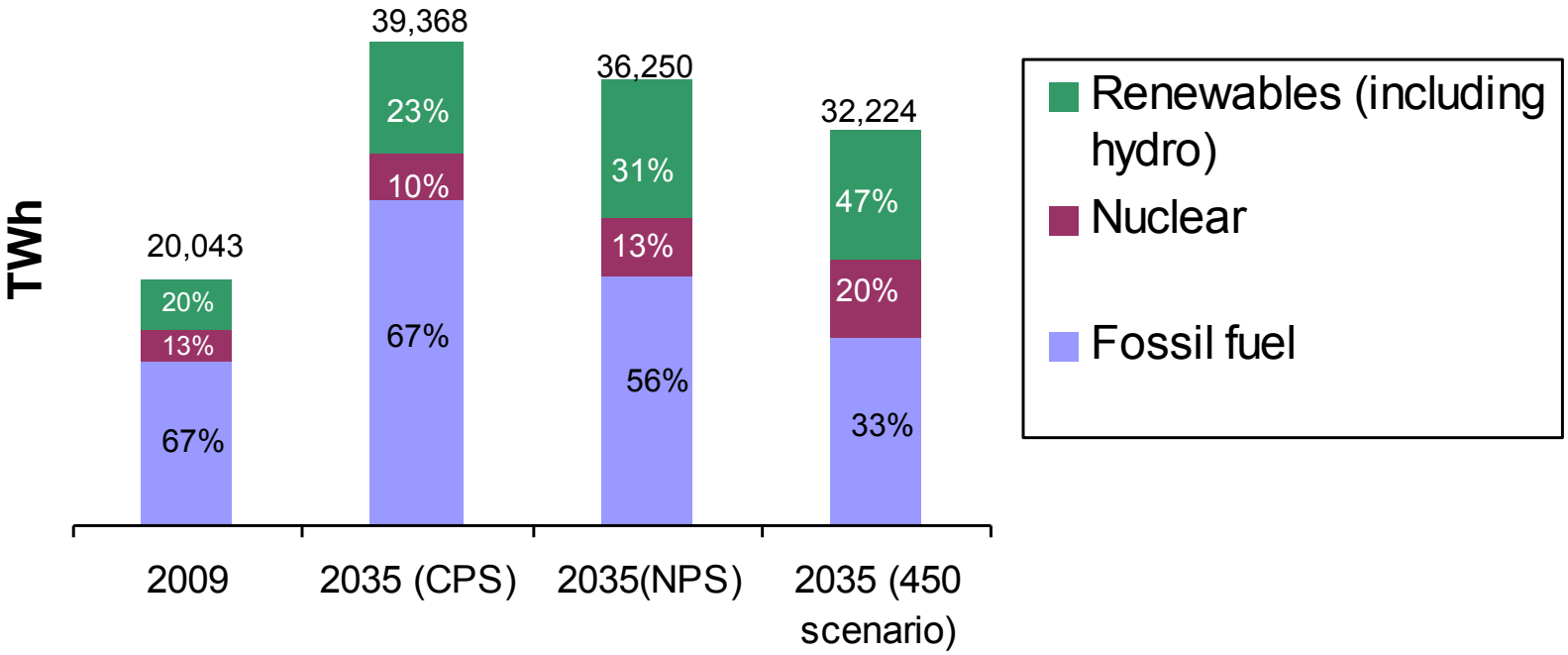


Fossil fuel prices are expected to rise steadily, reflecting increasing energy demand & ever more constraining environmental pressure



Source: World Energy Outlook (dec. 2011)

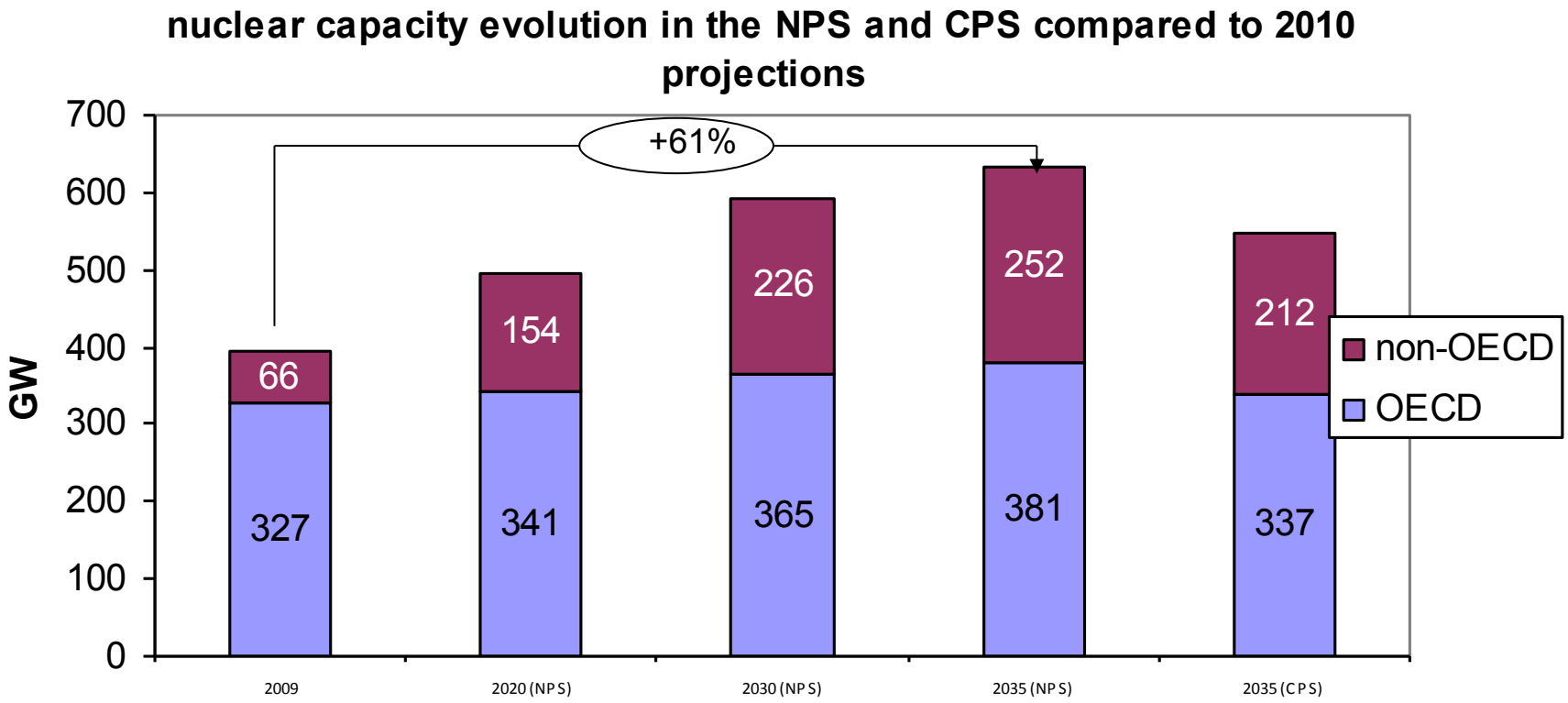
World electricity generation mix in 2035



Nuclear power is projected to represent between 10% to 20% of power generation by 2035

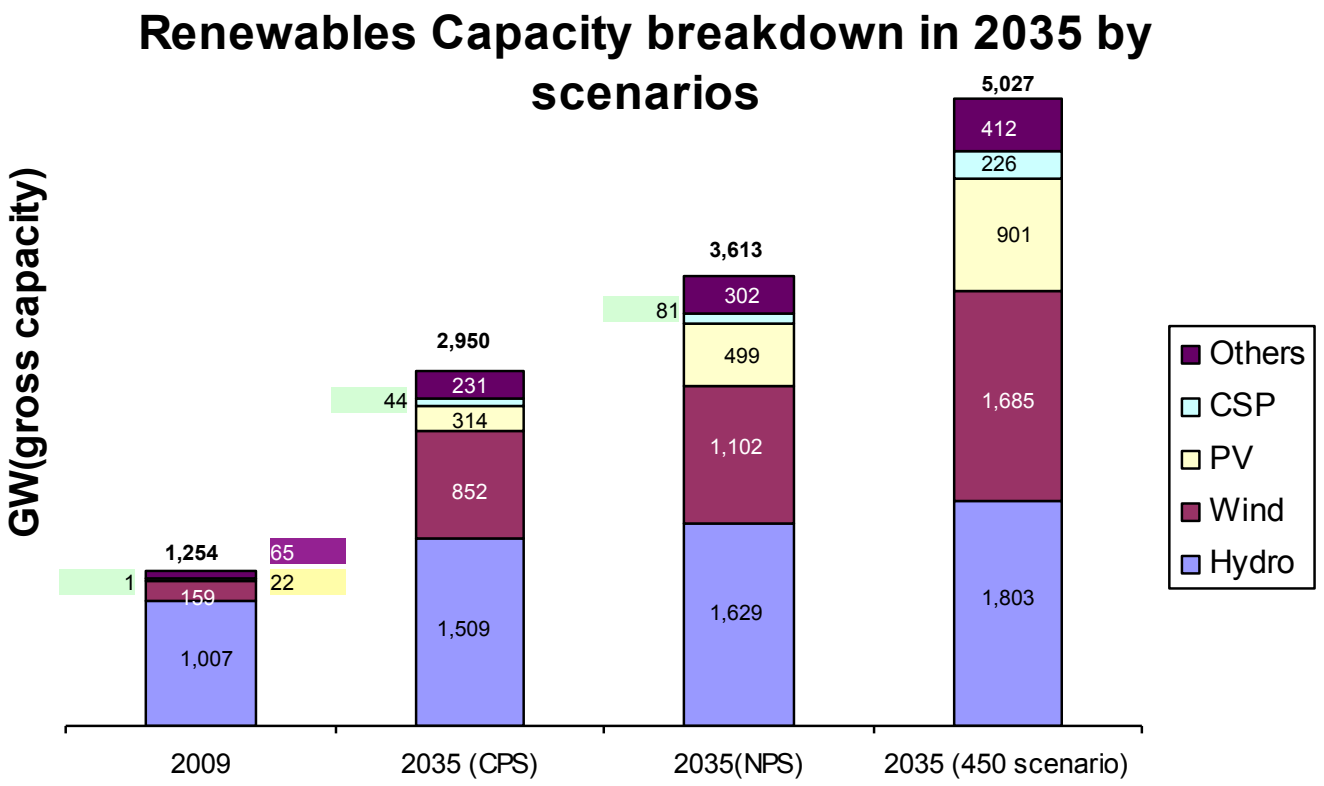
Source: World Energy Outlook (dec. 2011)

Nuclear capacity increase



Source: World Energy Outlook (dec. 2011)

Accelerated growth in renewable energies



By 2035, the share of renewables in the generation mix will increase from 20% to today to 31% in the NPS and 47% in the 450 scenario.

Source: World Energy Outlook (dec. 2011)

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Important Preliminary Remarks

Not all « newcomers » to nuclear energy are alike :

- **Demography, geography, financial resources, degree of Industrialization, maturity of regulatory framework do differ**
- **Some countries have started the Process for many years, others are true newcomers**

The steps described hereafter can have overlaps

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1. Before the decision

Preliminary studies are necessary:

- **Forecast of future energy/electricity needs**
- **Forecast of electric grid development**
- **Preliminary survey of potential sites (seismicity, cooling water availability, population density, grid, etc.)**
- **General infrastructure survey (industrial capability, trained human resources availability, public acceptance…)**

Help is available : IAEA, AFNI, Consulting firms

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2. Necessary Conditions (1/2)

In advance of constructing first nuclear reactors, countries must establish:

- **Training of specialists** (basic scientific + nuclear engineering disciplines: reactor physics, thermal hydraulics, radiation protection, I&C, safety analysis, nuclear law…). First abroad and then in national universities, private engineers but also public regulators.
- **Radiation Protection Authority** (usually exists but often must be reinforced)
- **Legal Framework** (safety, security, radiation protection, materials accounting & safeguards, waste management, public information, authorization process…)

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2. Necessary Conditions(2/2)

- **Nuclear safety authority : competent, independent from operators, with teeth + technical support organism (possibly external)**
- **International commitments (NPT, safeguards agreement, additional protocol, conventions…)**
- **A nuclear research center**

Help available

Areva competency building offer - Overview

- **Level A Courses: Introduction and Popularization of NPP Technologies**
  - Overview Nuclear Fuel Cycle (1 Day)
  - Basics of Nuclear Safety within GEN III+ Reactors (1 Day)
  - Overview of GEN III+ Reactors (1 Day)
  - Nuclear Power Plant (NPP) Basics (1 Day)
  - Plant Life Cycle - Modern Tools used in Design, Construction and Commissioning of GEN III NPP Plants - Module A (3 h)
  - Plant Life Cycle - Construction and Commissioning of GEN III Reactors in 100 Pictures Module B (3 h)

- **Level B Courses: Specific Technology Courses for Bachelor Level**
  - Basics of GEN II PWR, BWR (5 Days)
  - Short Introduction to GEN III+ PWR (5 Days)
  - Short Introduction to GEN III+ BWR (5 Days)

- **Level C Courses: Courses dedicated to professionals taking into account subjects of interest at Master and PhD Level, Postdoctoral Studies**
  - Core Physics and Nuclear Operation Practice (3 Days)
  - Digital Instrumentation and Control Systems in NPP (5 Days)
  - Thermodynamics and Thermohydraulics in a Pressurized Water Reactor (5 Days)
  - Advanced Design Features of GEN III+ NPP (10 Days)
  - Codes and their application on GEN III+ NPP (duration determined by topics to be covered)
  - Know How Knowledge from an Experimental Test Facility of PWR Primary Circuit (duration determined by topics to be covered)
  - PWR Nuclear Instrumentation (2 Days)
  - Severe Accident Management (1 Day)

- **LEVEL X: Courses by request**

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3. Implementation Studies

To be carried out in parallel, by the Operator :

- **Site selection and qualification (environmental impact Assessment). The more thorough, the lesser risk of delay during construction**
- **Grid reassessment (and often upgrading) : this may determine the Unit size of the NPP**
- **Selection of a reactor type & size**
- **Financing scheme for NPP & Fuel (equity, Loans, long term contracts, State guarantee if any)**
- **Evaluation of the potential for « localization » (notably civil works, heavy equipments…)**

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4. Plant Construction

Construction can begin only after authorization from the Safety & Licensing Authority

- In Industrialized countries, construction time would range from 4 to 7 years (notably according to plant size)
- Local conditions may increase this duration
- After completion of construction, a series of « cold » and « hot » tests, then criticality, rise to power, connection to the grid (~30% nominal) and full power operation (6 months to one year)
- Industrial operation (as defined contractually)

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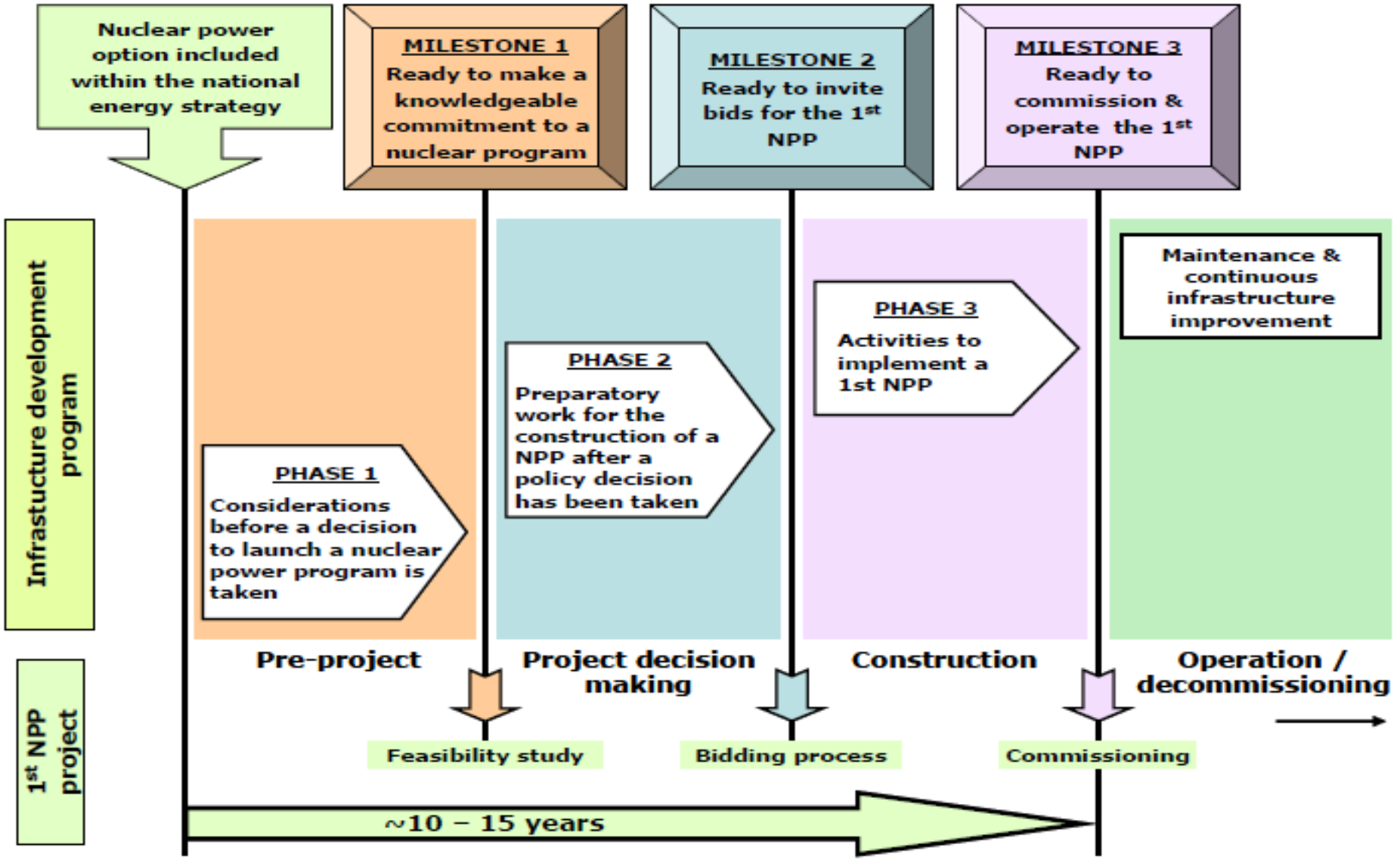
Infrastructure Development Program



(from IAEA)

It's a marathon: plan and prepare well and start early !

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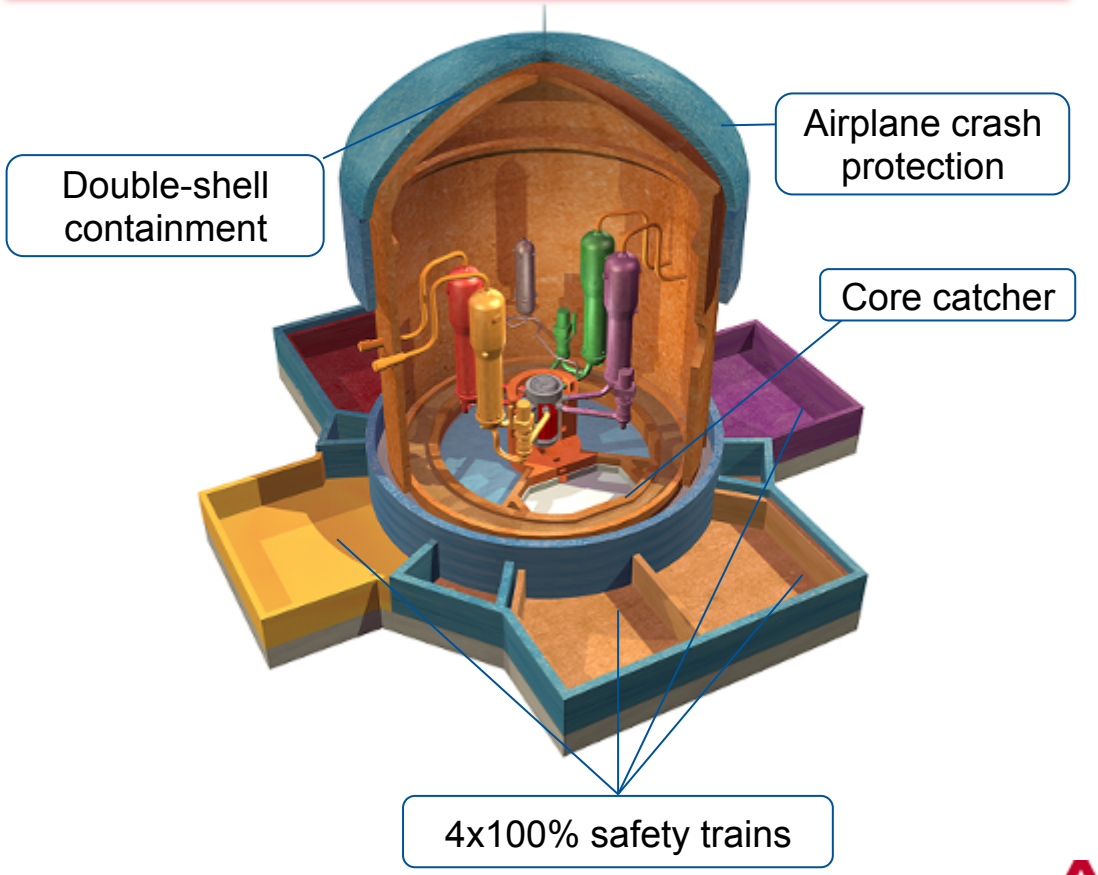
EPR™ and ATMEA1: designed to meet the most demanding safety standards

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

EPR™ example – Main safety features



Assessment 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**

EPR™

- The most advanced New Generation Reactor
- Four EPR reactors are already under construction
  - Olkiluoto, Finland (1)
  - Flamanville, France (1)
  - Taishan, China (2)
- Licensing or pre-licensing underway in
  - United States
  - United Kingdom
  - India

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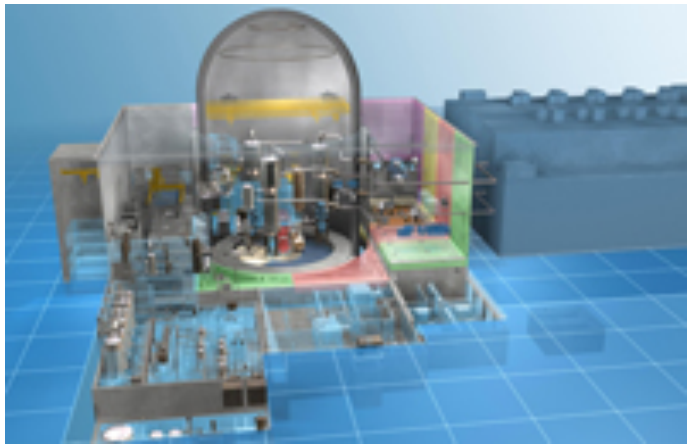

ATMEA1

- **Mid-sized PWR with Generation III+ safety features, well suited to medium power grids.**
- **Designed using innovative, proven nuclear technologies from AREVA and MHI, ATMEA's parent companies.**
- **Short-listed by JAEC (Jordon Atomic Energy Commission) in May, 2012 – *"..well fitting Jordan energy needs and requirements, both in technical and economical terms, and is ensuring the highest possible safety levels to the Jordan public."***

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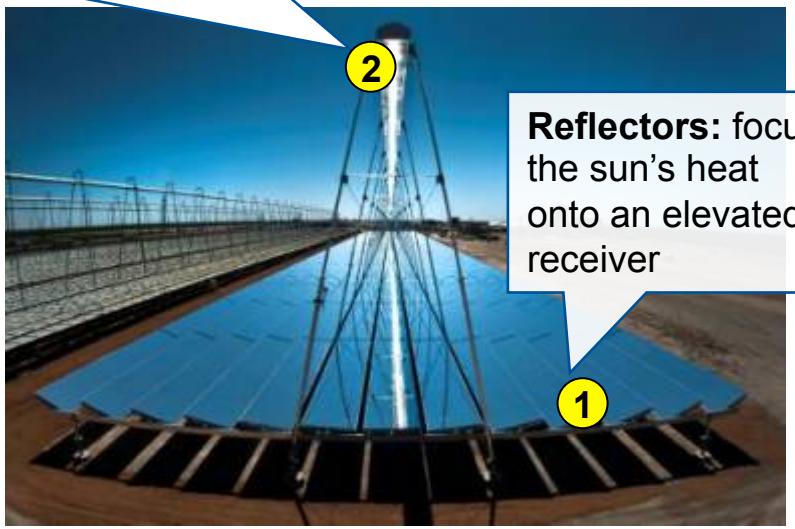
A unique offshore wind offer
Significant Track-record

- The most powerful offshore turbine currently in operation (5 MW)
- A wind turbine designed specifically for harsh sea conditions with a light weight structure
- A leading European player in offshore wind:
  - EU grant for Alpha Ventus project
  - EIB loan for Borkum West II
  - AREVA will build 100 turbines of 5 MW each for St Brieuc wind farm

AREVA Concentrated Solar: an innovative technology

Working principles of AREVA Solar's technology

Receivers: contains tubes filled with water. Concentrated sunlight boils the water, generating superheated steam.



An array of optically shaped reflector mirrors concentrate up to 50 "suns" of energy on a set of thermal receiver tubes to create high pressure steam

▶ Projects in Australia and US:

- **CS Energy (Queensland, Australia) – solar booster for Kogan Creek 750 MW coal-fired power station. Solar Dawn will combine AREVA Solar steam generators with a gas boiler back-up system, boosting plant outpur by 45 MW (and avoiding 35 Mt of GHG emissions/year)**
- **Tucson Electric & Power (Arizona, US) – solar booster (5 MW) for TEP coal-fired power plant. Enough power to service 600 homes, with no additional GHG emissions.**

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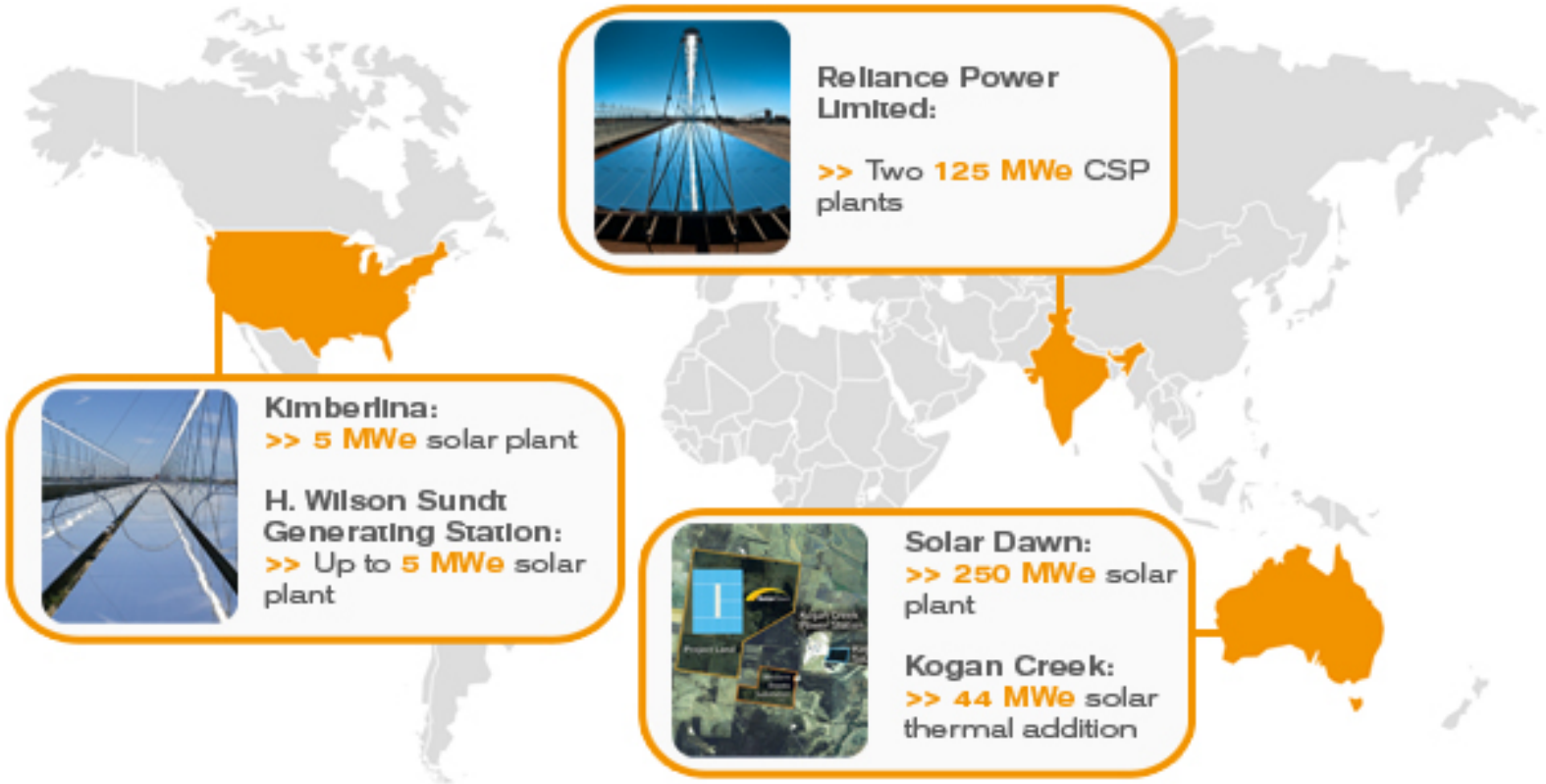
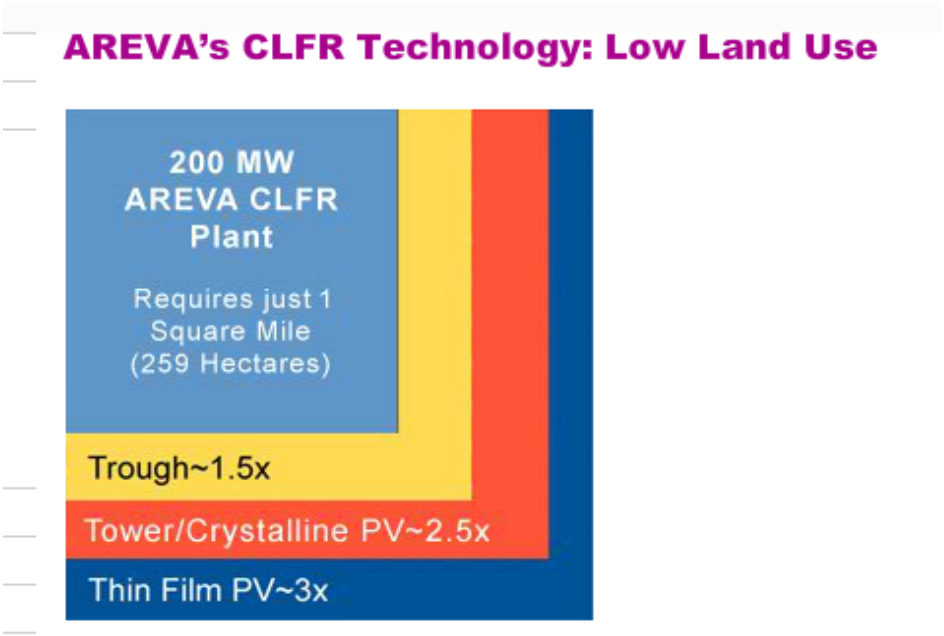
Other CSP projects



A low footprint



- **Benefits of efficient land use:**
  - **Lower natural habitat mitigation costs**
  - **Less time-intensive permitting process as a result of smaller footprint**
  - **Lower land and grading costs**
  - **Lower ongoing operation and maintenance costs**
  - **Easier access to contiguous, flat land (requires a grade less than 3%)**
  - **Easier to site at existing power plant and industrial sites**

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Conclusion

- **AREVA**
  - **provides safe solutions for green energy production for the short, mid and long term**
  - **Provides insights, experience, and technical expertise in a range of low CO2 electricity generation technologies**
  - **Shares its knowledge (training and education) and accompanies countries during the knowledge and competency development phases**
- **Nuclear power and renewables are complimentary**
  - **Both needed to fight climate change**
  - **Both will grow in emerging countries**
  - **We may help you to choose what will be the best solution for your country and for our future**


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