



Nuclear Energy in 15 Minutes

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National Physics Teachers Workshop

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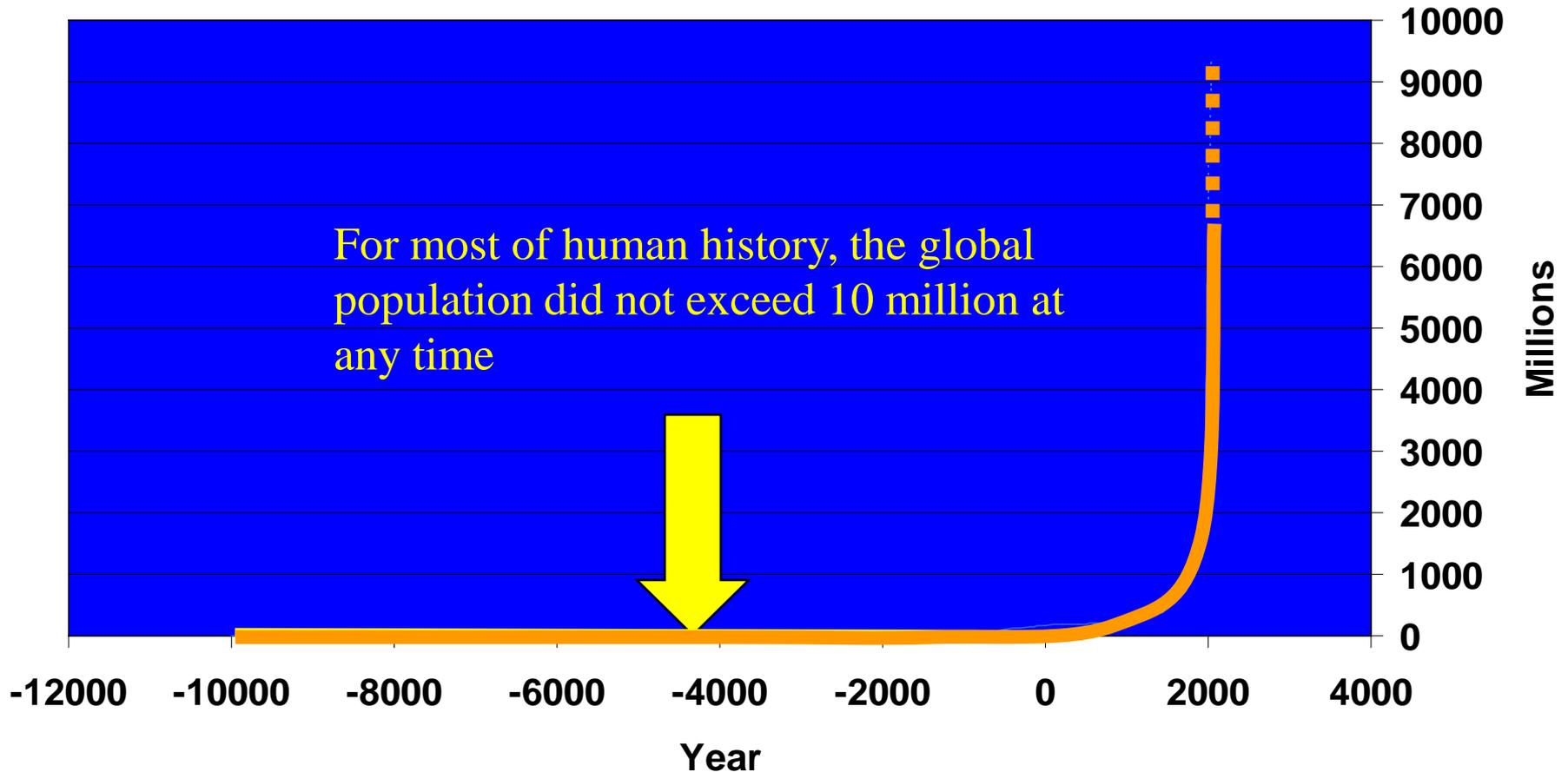






A brief review of the human population

World Population



Population 2000 years ago



The following manner of depicting the growth in population is due to John Ritch, World Nuclear Association

Population 1000 years ago



1800: Beginning of the industrial age



1927 Global Population



1960



1974



1987



1999

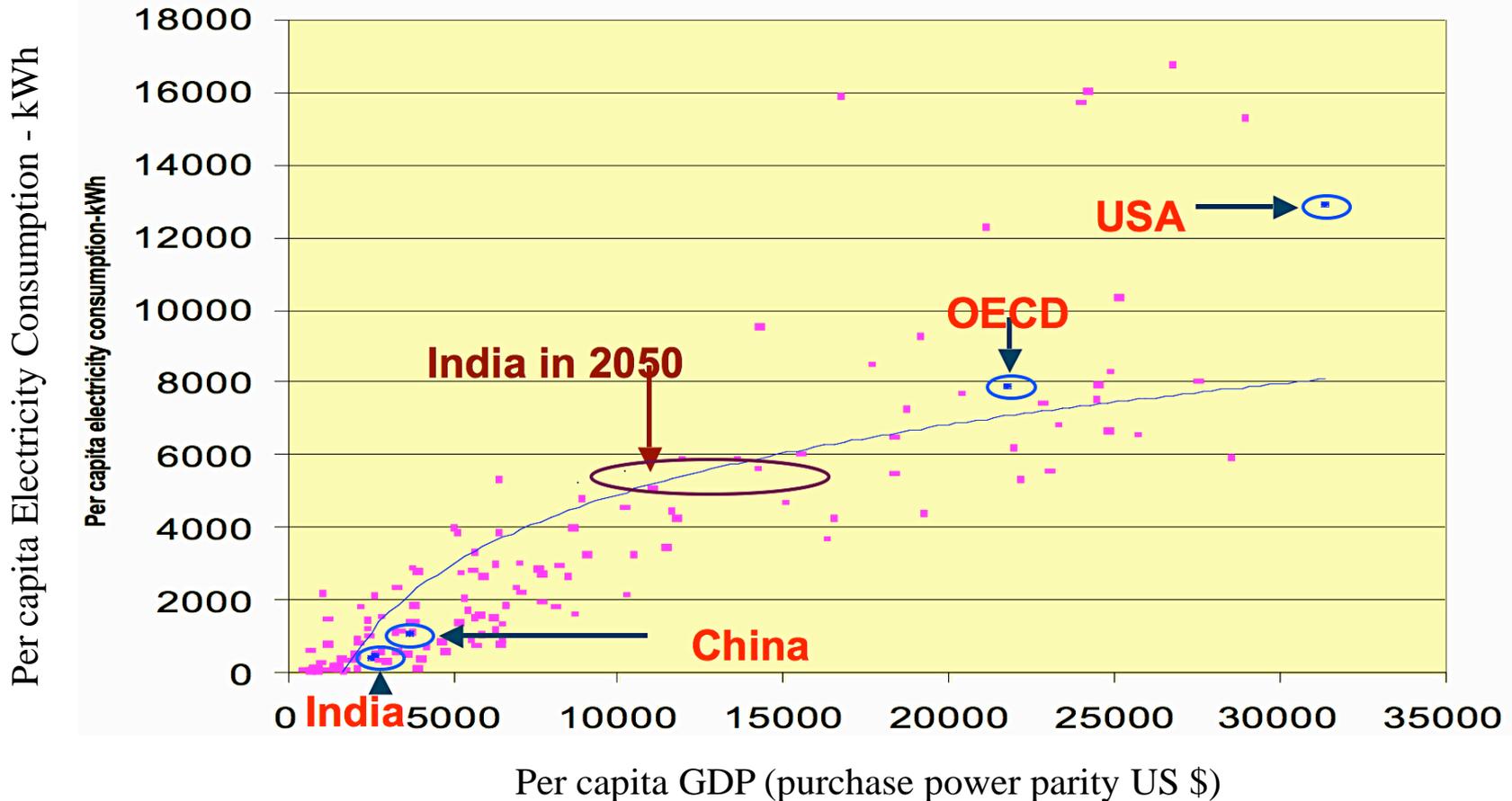


2050 Estimated Population

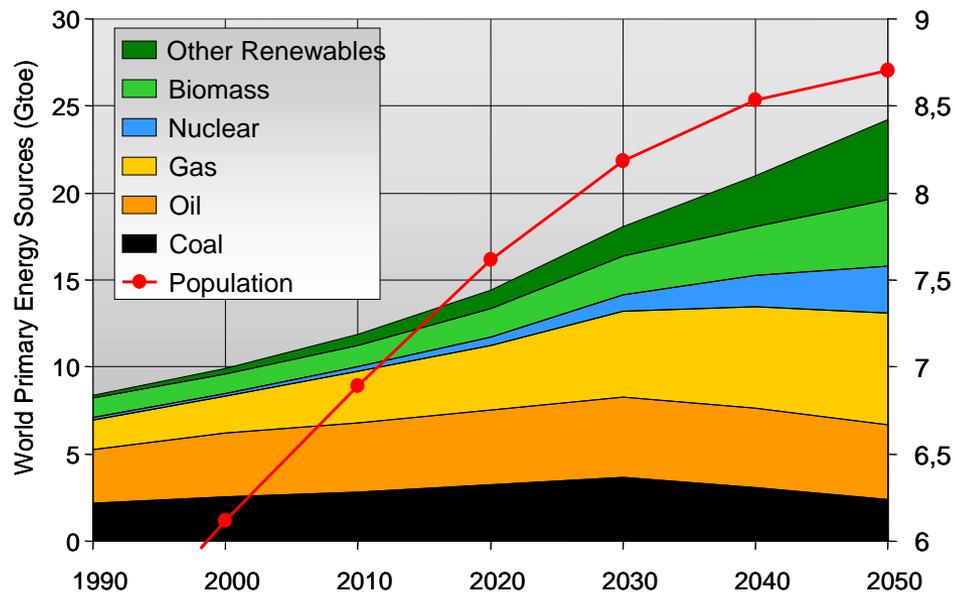
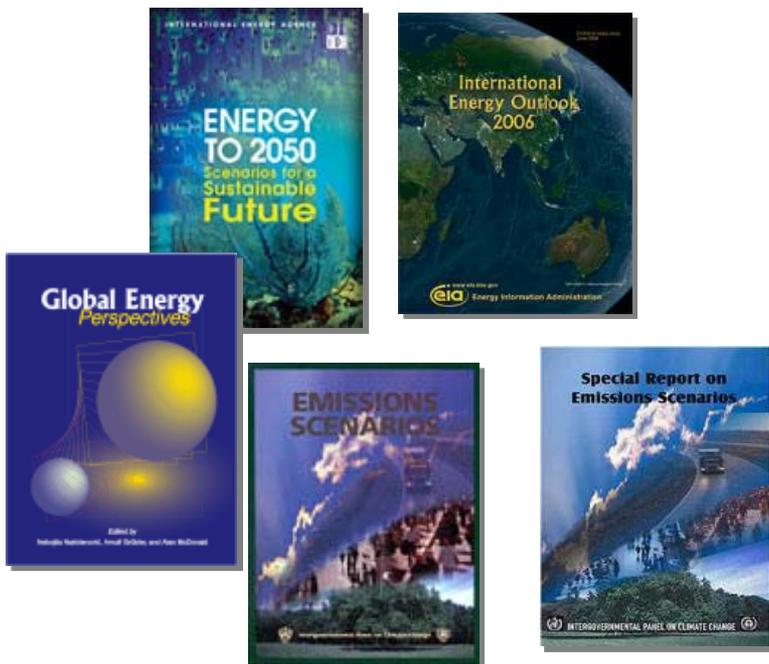


Correlation Between Electricity Consumption & GDP

Per capita Electricity Consumption vs. Per capita GDP for various nations of the world



Energy Supply Will Increase to Meet Demand



Source IEA : Energy to 2050 - Scenarios for a Sustainable Future

The additional needs will mainly come from large developing Countries: China, India, Brazil...

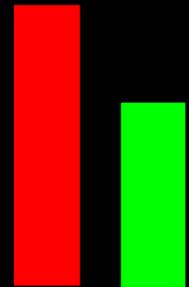
Jacques Bouchard,
GLOBAL 2007

Technical basis for energy policy

- Highly recommended reading
- Very useful rule-of-thumb numbers
- No advocacy
- Free download or \$0.99 on Kindle
- Looks at both supply and demand

Sustainable
Energy-
without the hot

David JC MacKay

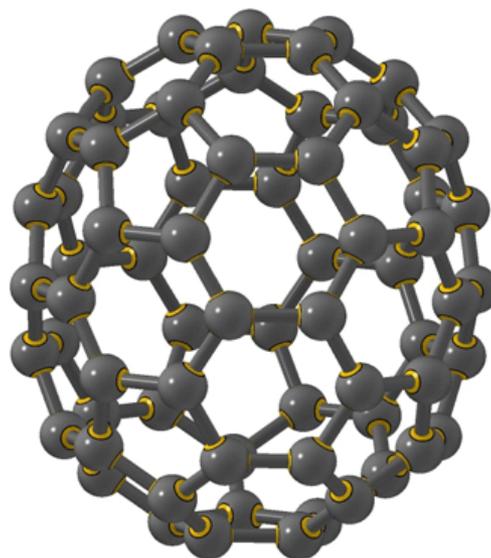


Energy: from the cosmos to electricity

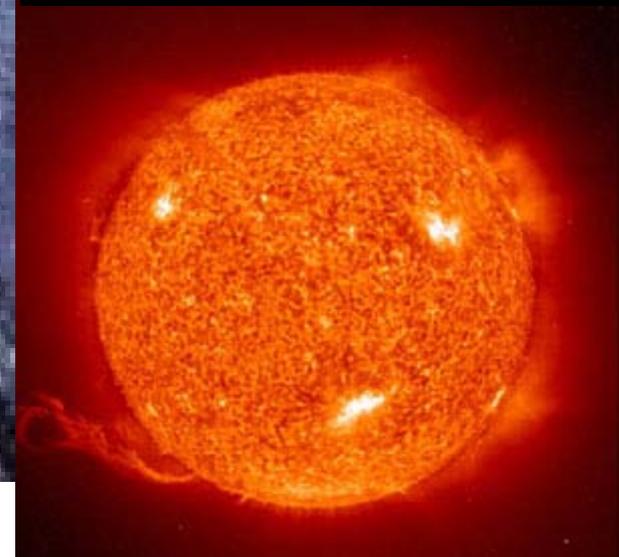
Fission



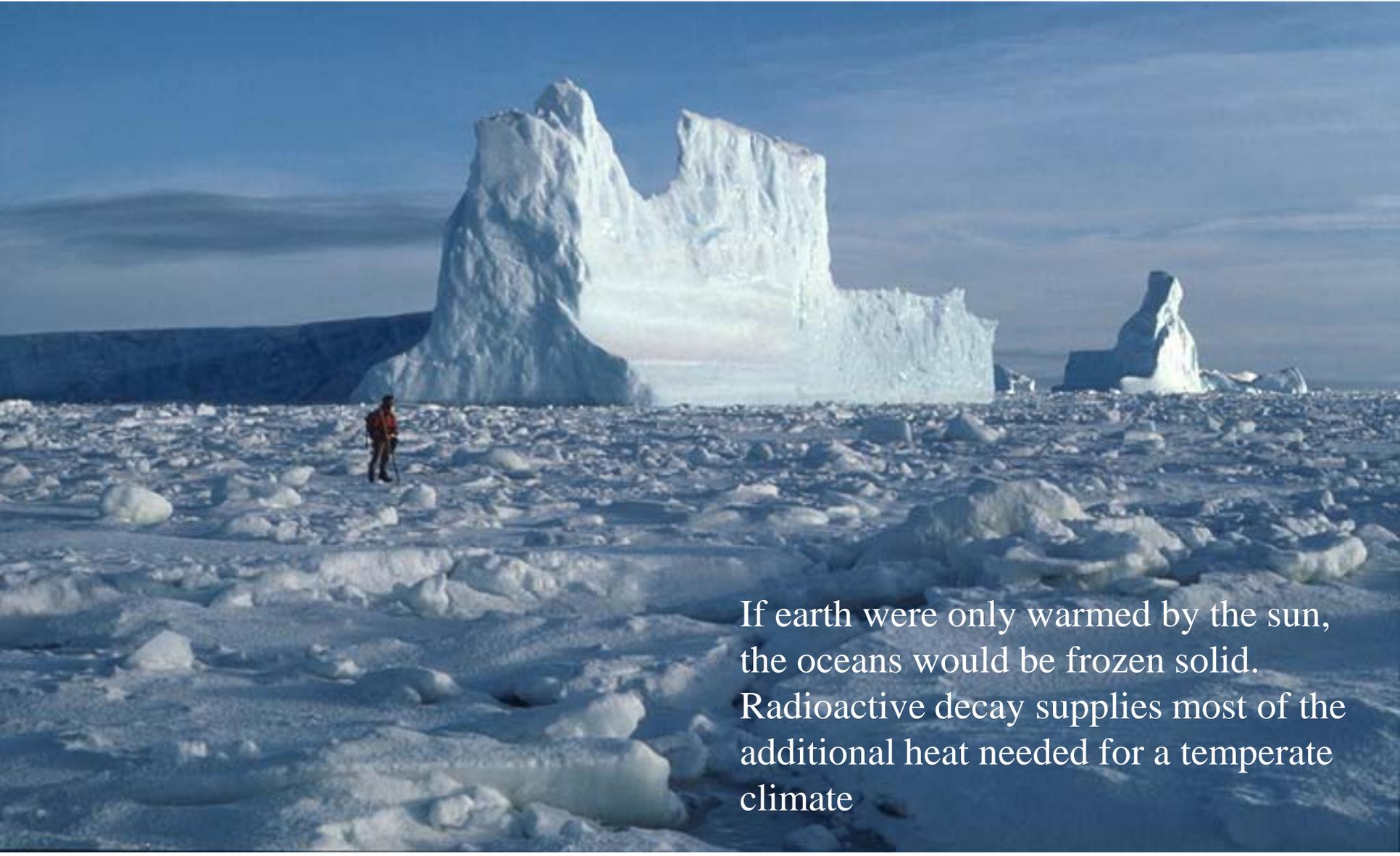
Carbon Bonds



Fusion

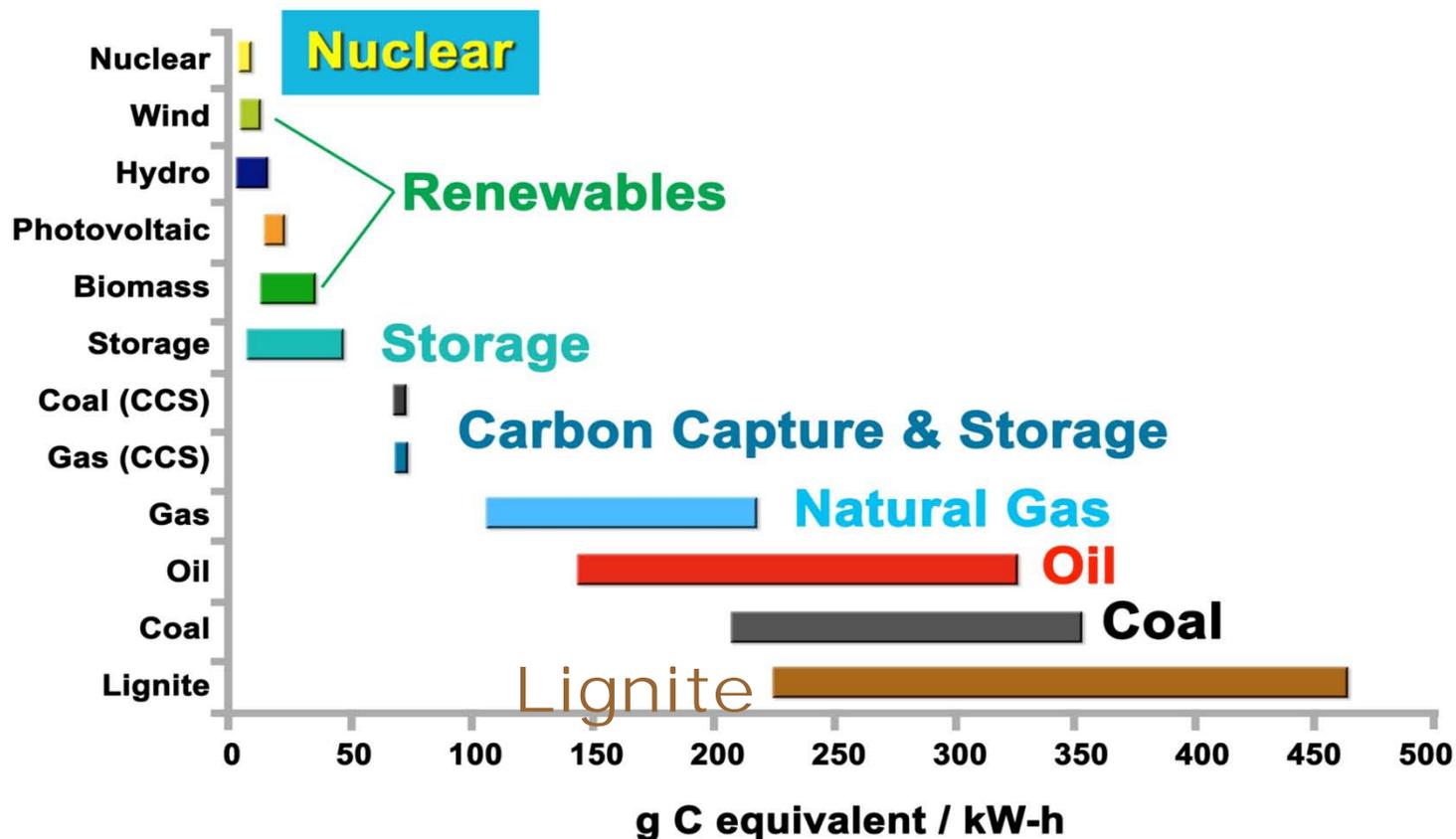


Radiation enables life on earth



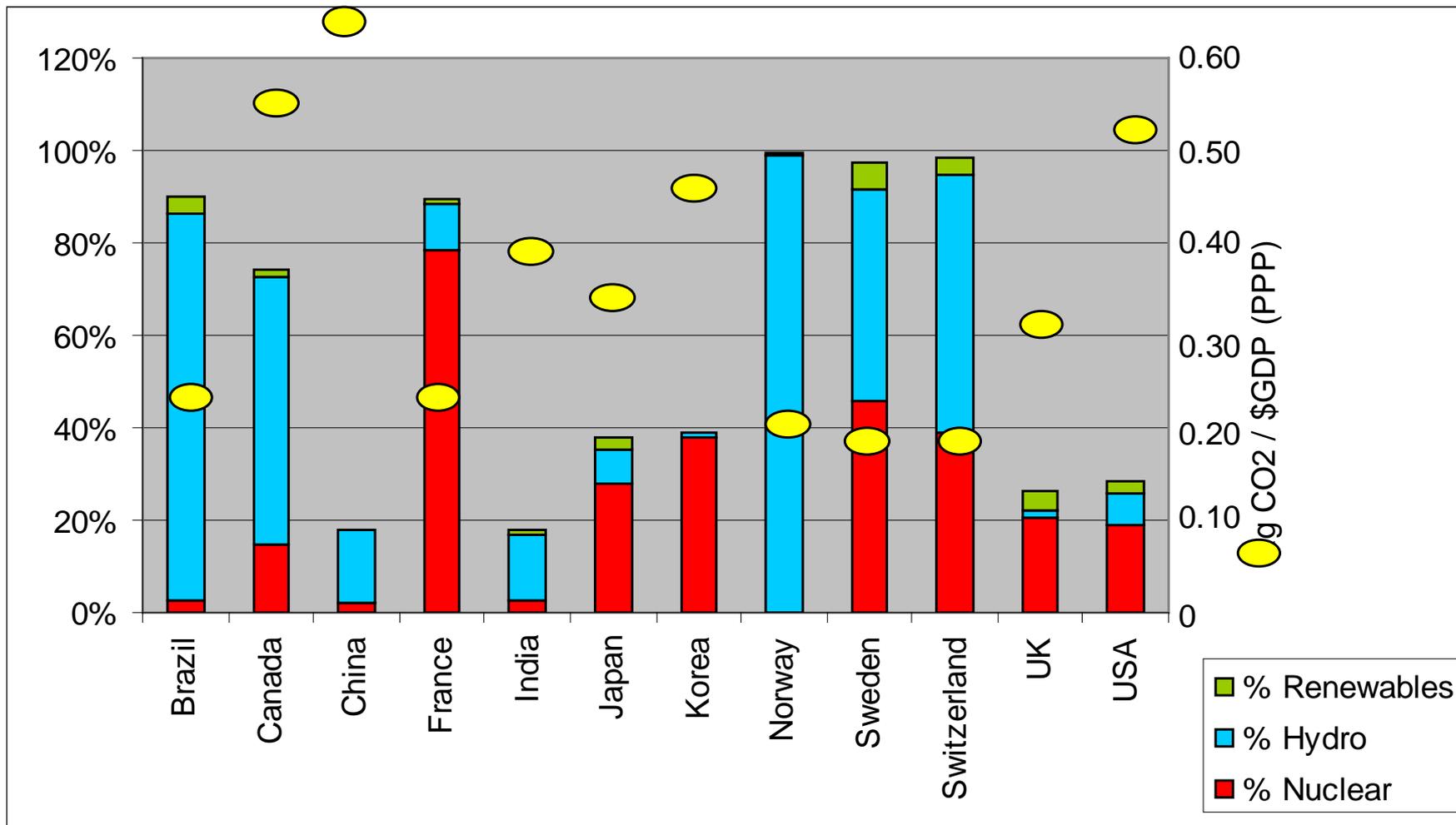
If earth were only warmed by the sun,
the oceans would be frozen solid.
Radioactive decay supplies most of the
additional heat needed for a temperate
climate

Life Cycle Greenhouse Gas Emissions

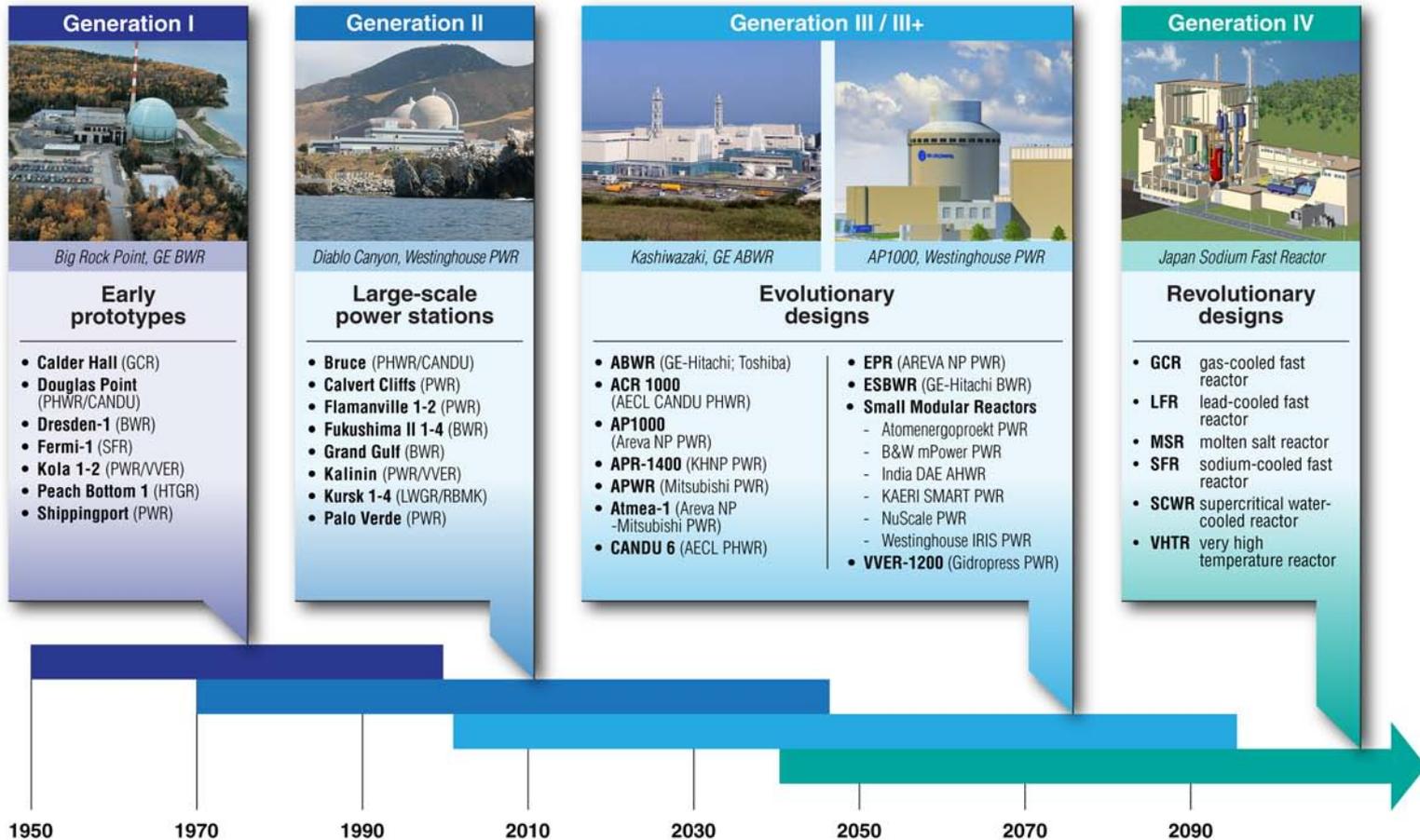


CO₂ emission rates for electricity generating alternatives (storage: batteries, pumped hydro, compressed air storage; CCS Carbon Capture and Storage) (Weisser 2007)

Productivity and CO₂ intensity



The Nuclear Future (and Past)



US Nuclear by the numbers

10

- Percentage of US electricity **capacity**

20

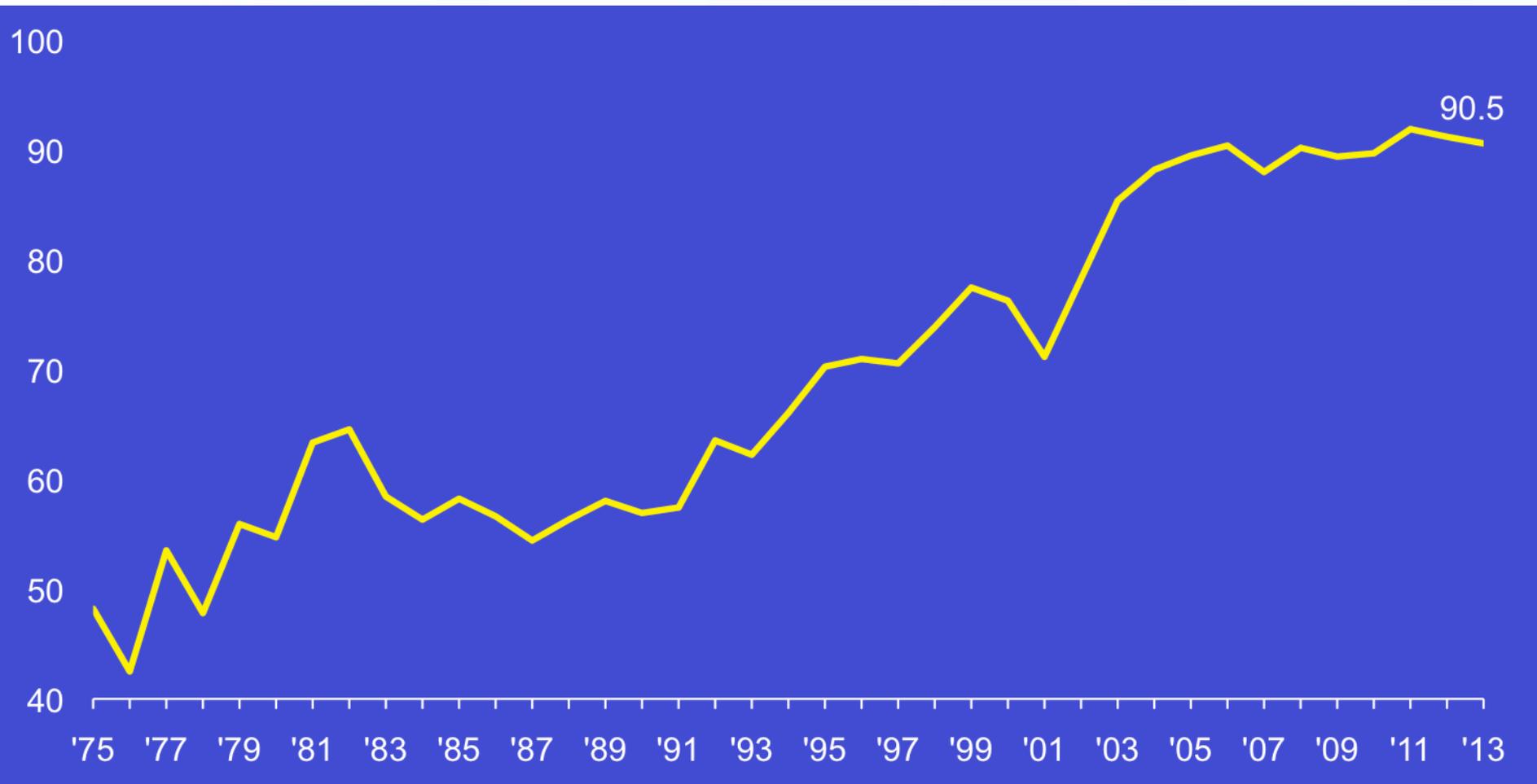
- Percentage of US electricity **production**

70

- Percentage of US electricity **emission free generation**

700,000,000 tons of CO₂ emissions avoided annually by US nuclear energy production

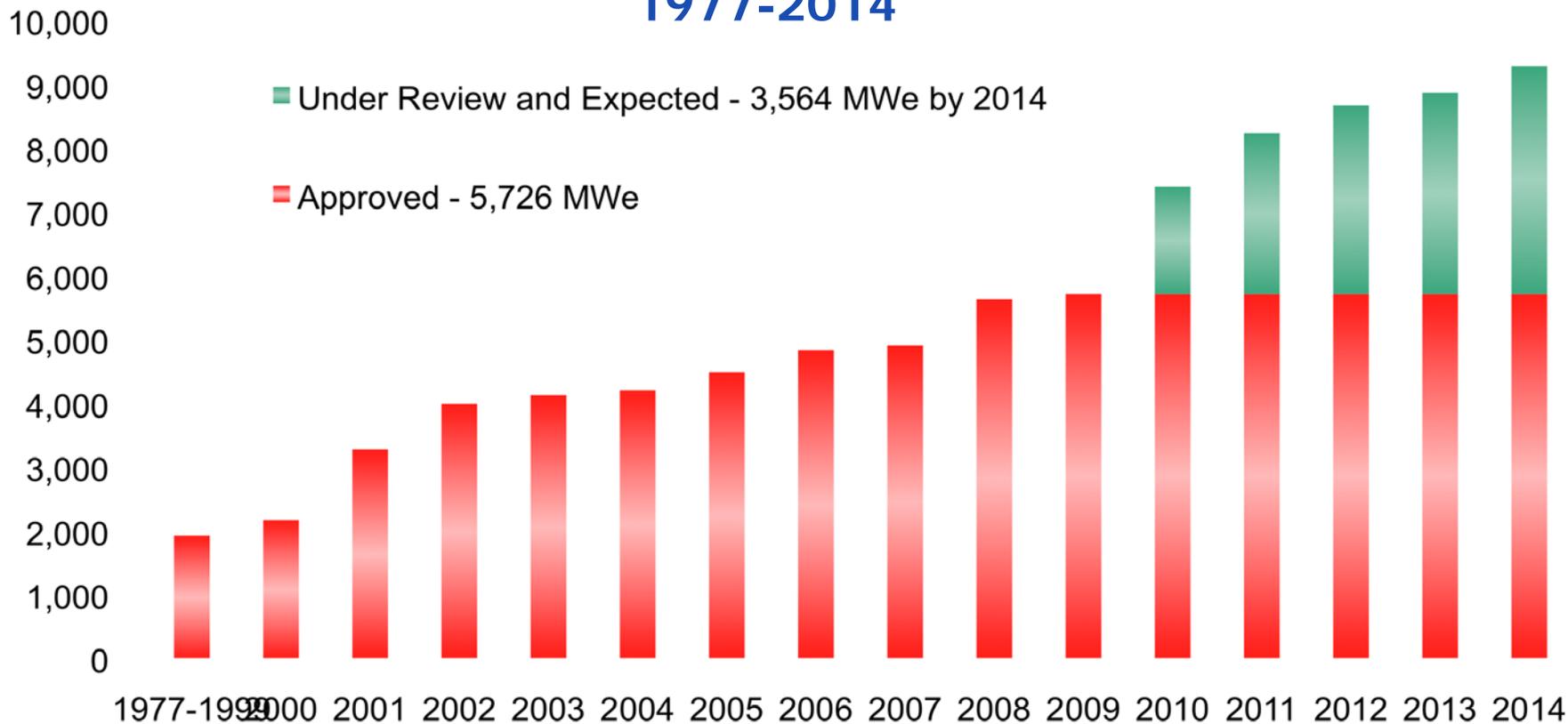
Nuclear capacity factors 1971-2009



Source: Energy Information Administration

Updated:5/10

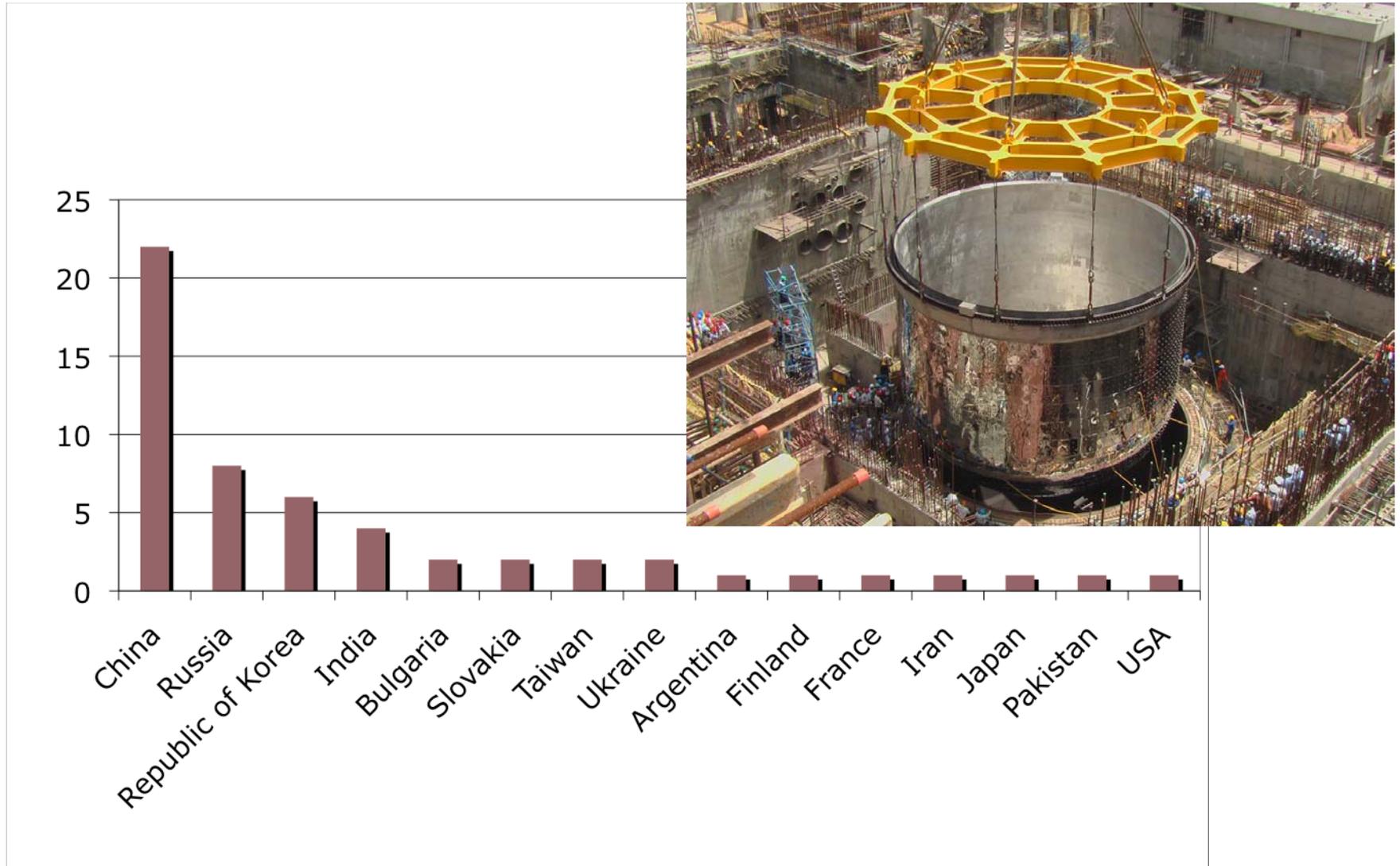
Cumulative Capacity Additions at U.S. Nuclear Facilities 1977-2014



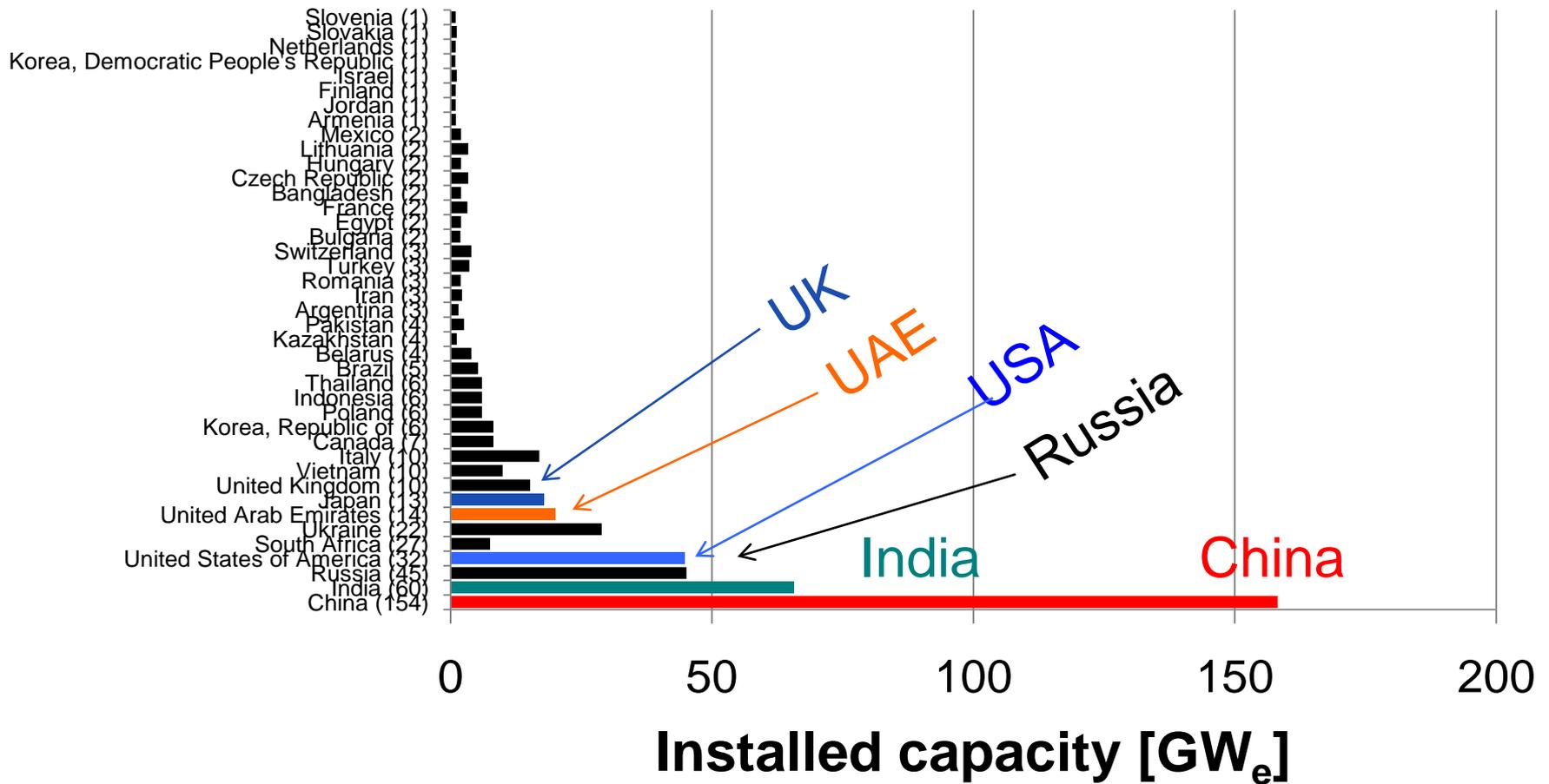
Source: Nuclear Regulatory Commission

Updated: 6/2010

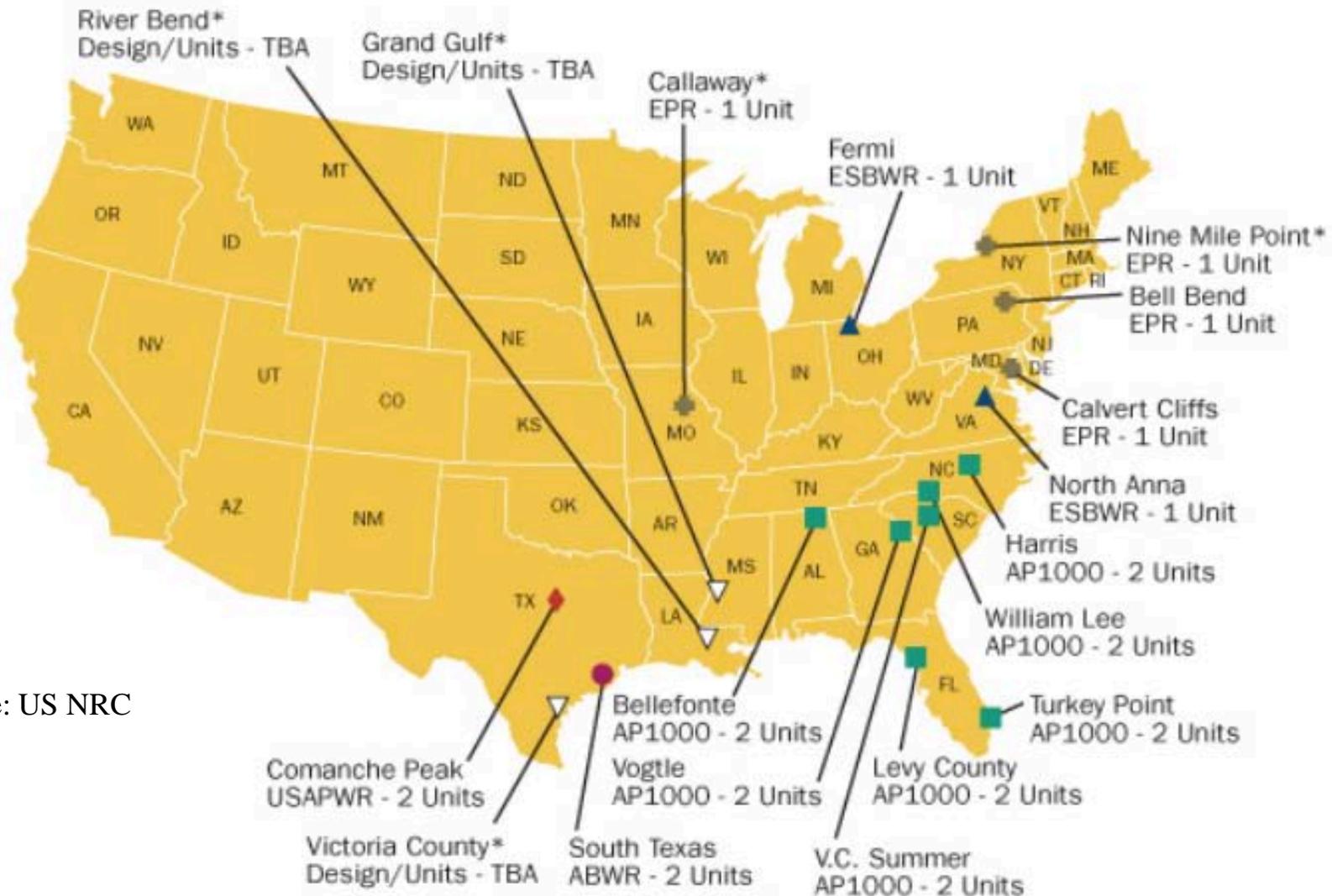
Plants under construction by country



Nuclear reactors planned & proposed by 2030



New nuclear plant applications in US



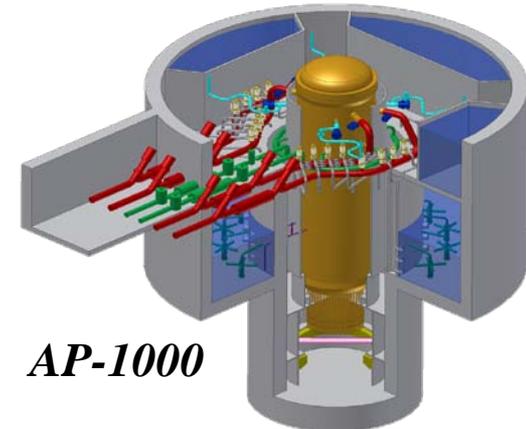
Source: US NRC

Designs Competing for US Market: Generation III

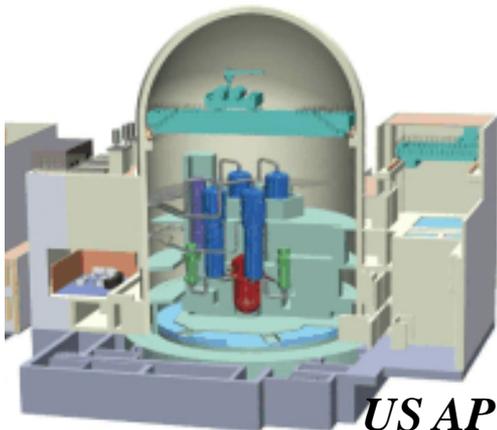
- Standardized designs based on modularization producing shorter construction schedules
- Passive or redundant systems to enhance safety
- Easier to protect from terrorist attacks



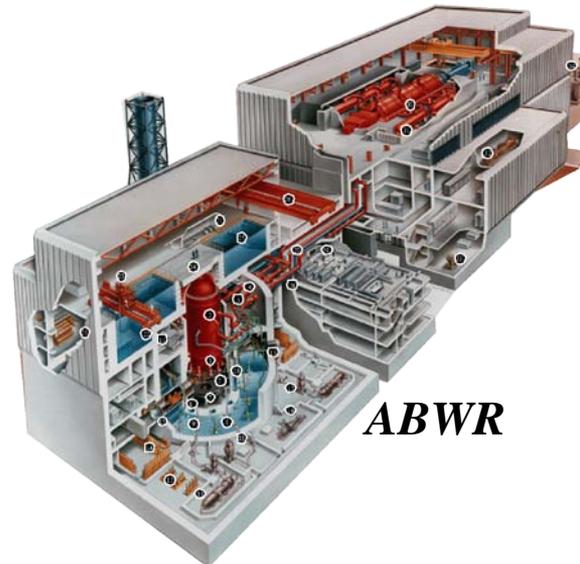
ESBWR



AP-1000



US APWR

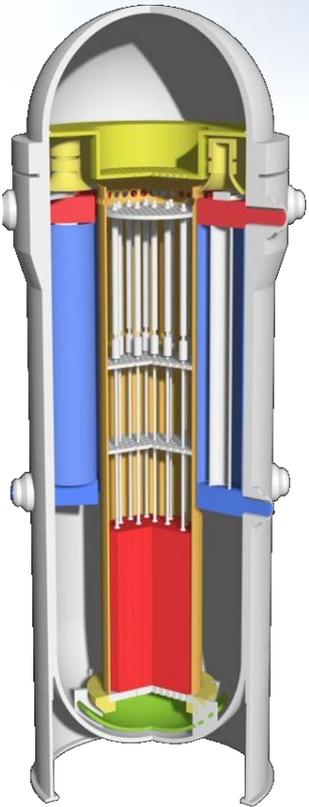


ABWR

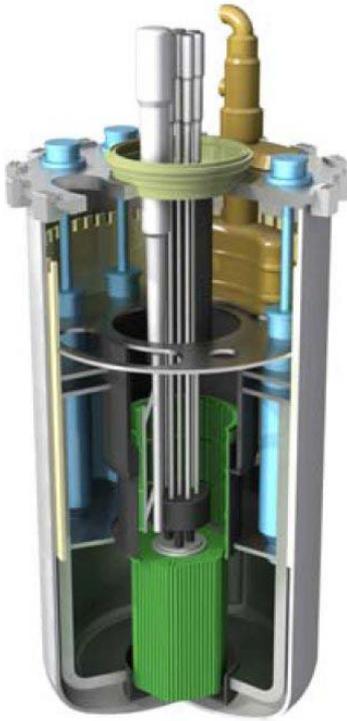


EPR

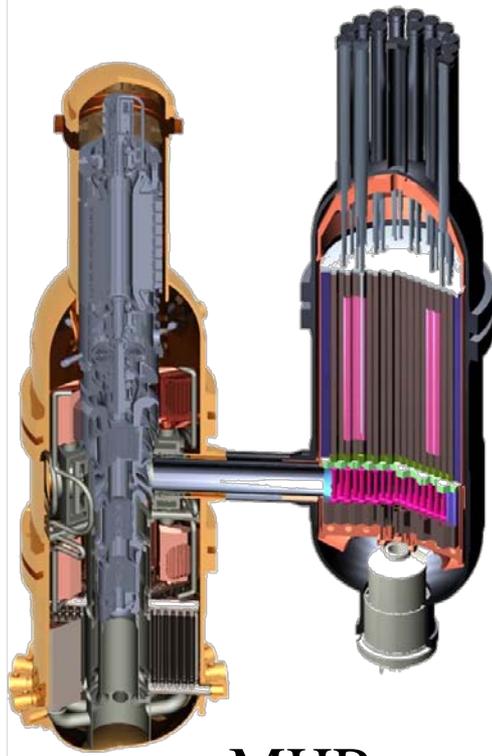
Small Modular Reactors (SMR) address financing and infrastructure issues



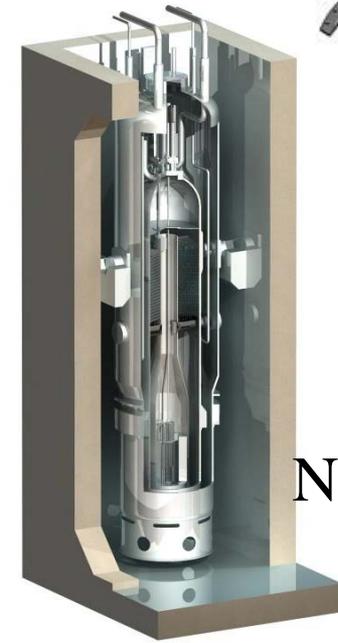
IRIS



PRISM



MHR

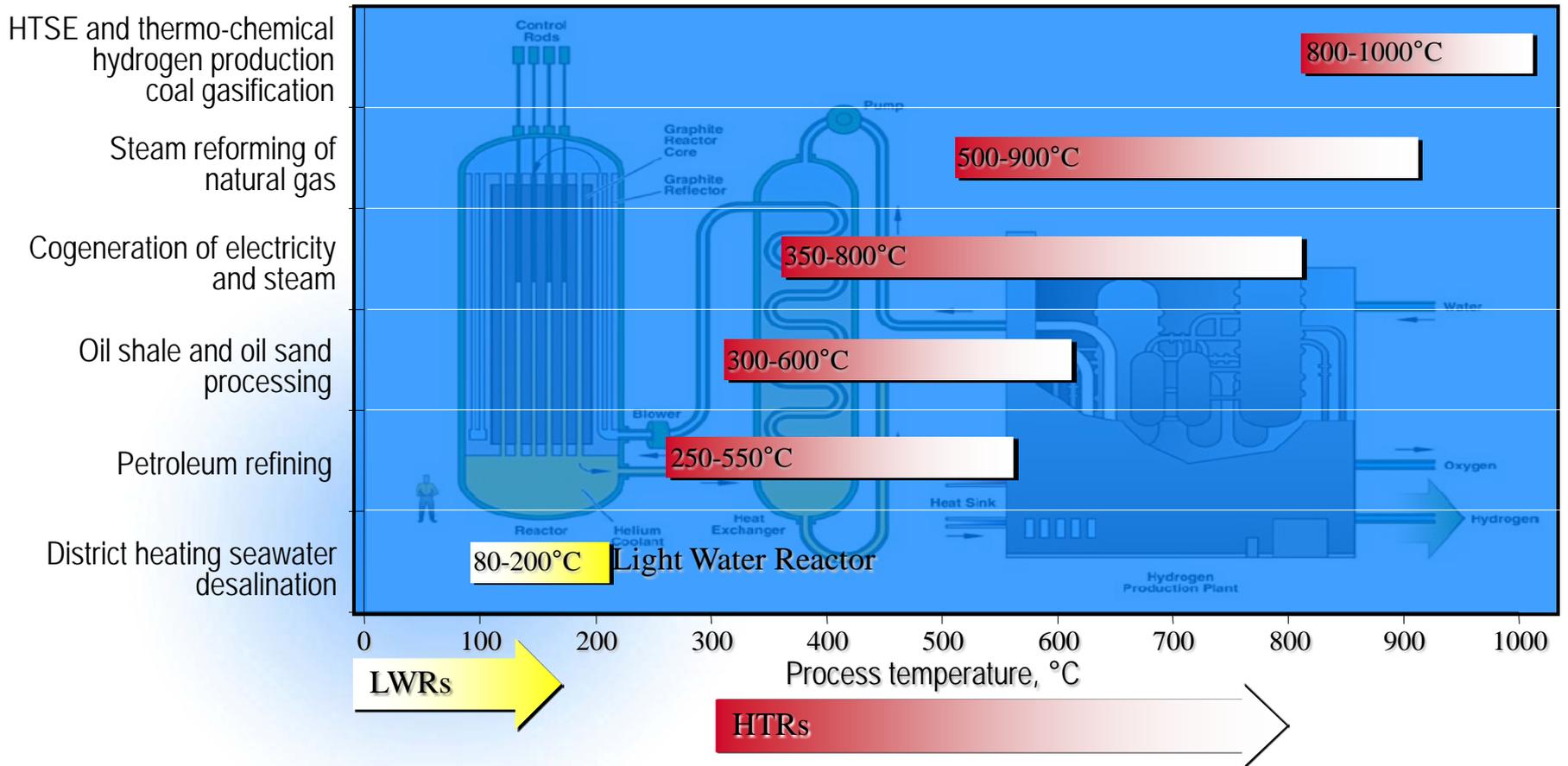


NuScale



mPower

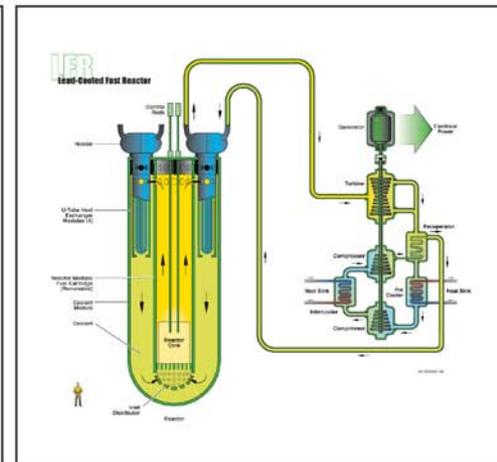
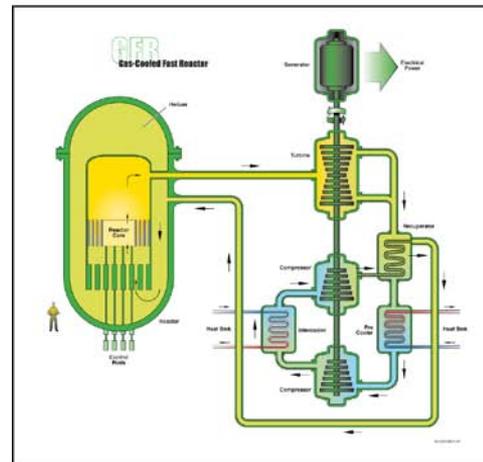
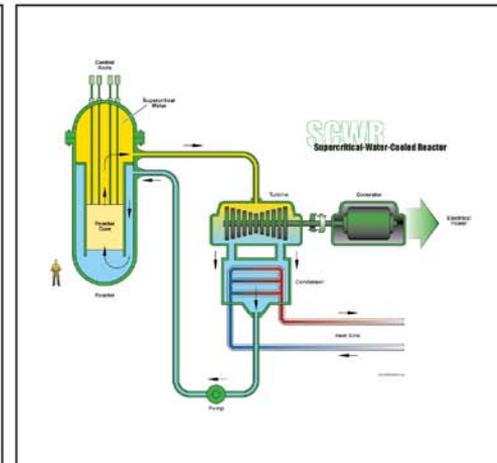
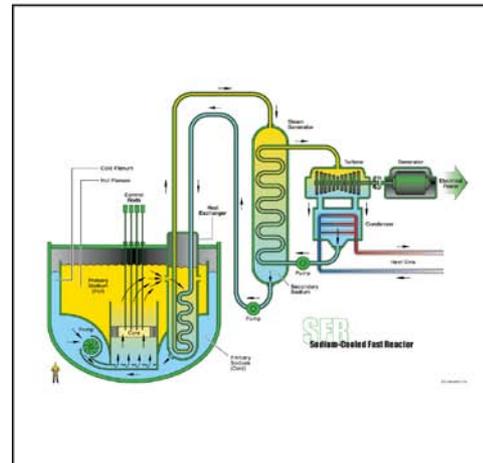
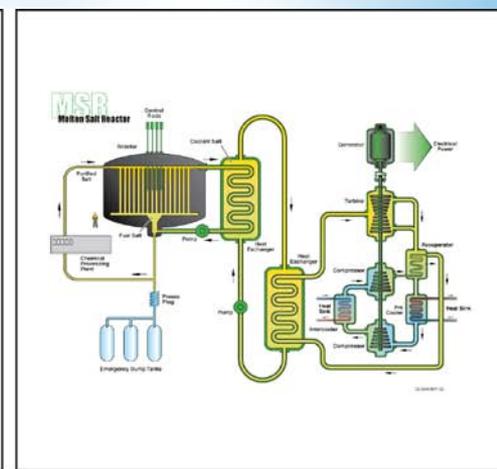
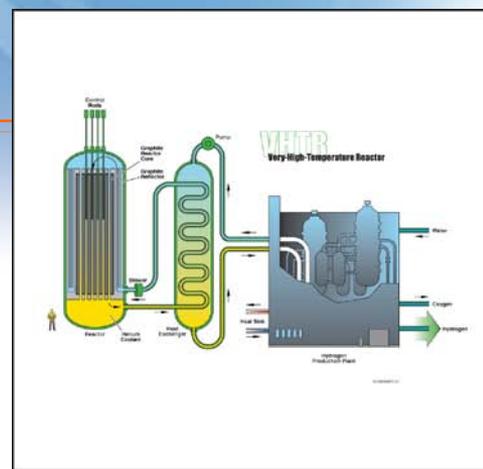
Higher temperature expands the range of applications



There is a role for existing LWRs, advanced LWRs, and small reactors...

Generation-IV Challenges

- High temperature
- Exotic materials
- Helium
- Liquid metals
- Supercritical water
- Supercritical CO₂
- Minor actinides
- Major actinides
- High burnup cores
- Nonproliferation



The Nuclear Renaissance is upon us...

- Increased public understanding & acceptance of nuclear energy's role
- License extensions
- Enabling new reactor construction
- Exploring advanced reactor concepts and fuel cycles
- Growing enrollments in nuclear science and engineering at universities

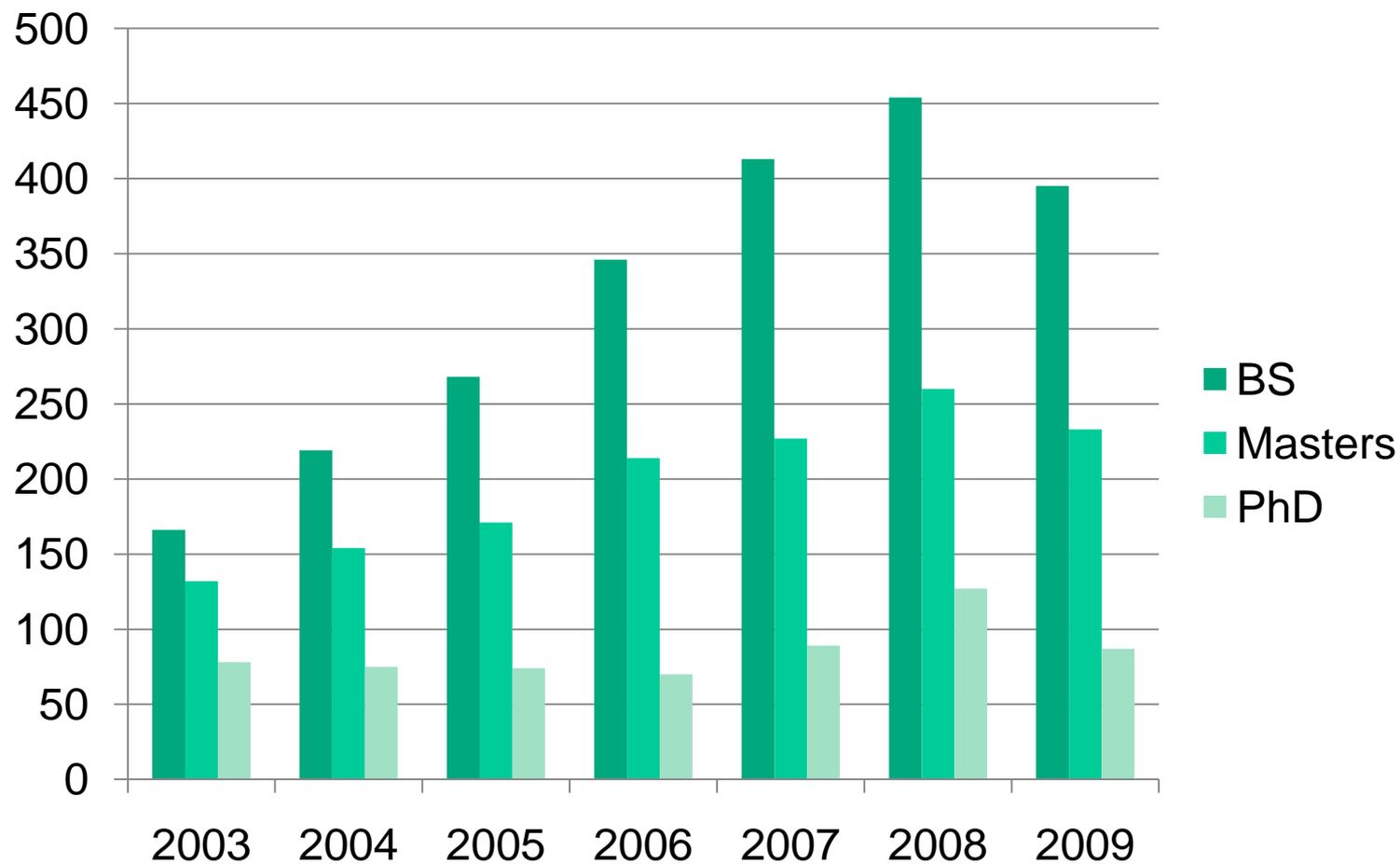


Workforce is a major issue



World Nuclear University Summer Institute
Oxford

Nuclear Engineering degree trend



***DOE has a new
R&D roadmap***



NUCLEAR ENERGY RESEARCH AND DEVELOPMENT ROADMAP

REPORT TO CONGRESS

April 2010



U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

Summary Status of Nuclear Energy

- Globally embarking on construction of Generation-III reactors
 - China will overtake the US in installed capacity by mid-century
 - Countries with more government control over implementation of energy policy have more success with nuclear construction
 - Cost of a new 2-unit plant is more than the total market capitalization of most US utilities
- Majority of future action will be in developing countries
- No longer a US-owned domestic NPP supplier
- Fuel cycle decisions deferred
- R&D trending toward more diffuse—no project focus
- Small is beautiful?
- Fusion is 20 years away just like it was in 1963
- Everyone has a reactor concept in his hip pocket
- Cheap natural gas due to new technology has softened the market
- Scenarios of extensive nuclear build out assume a carbon policy