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Joint ICTP-IAEA Advanced School on the Role of Nuclear Technology in Hydrogen-Based Energy Systems

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The Production of Hydrogen with Nuclear Energy
Part 1: Hydrogen Economy and the Role of Nuclear Power

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JÜLICH
FORSCHUNGSZENTRUM

The Production of Hydrogen with Nuclear Energy

Part 1: Hydrogen Economy and the Role of Nuclear Power

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Joint IAEA – ICTP Advanced School on "Development and characterization of materials for hydrogen-based energy systems: Role of nuclear technology"
June 13-18, 2011, Trieste, Italy

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- Energy Situation (world, Europe)
- Demand for Hydrogen
- Drivers for Nuclear Hydrogen
- Examples

Part II

- Hydrogen Production Systems

Part III

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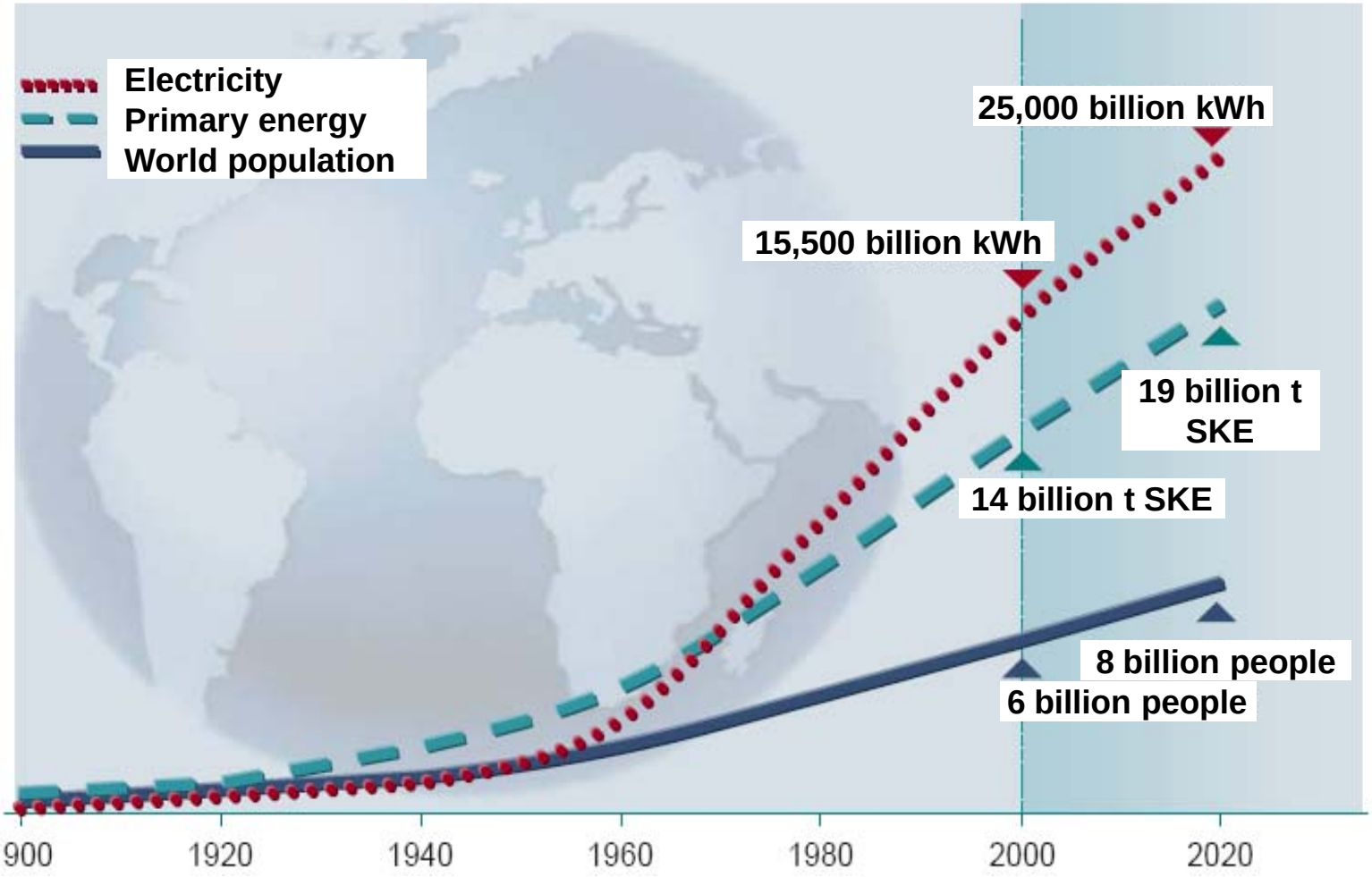
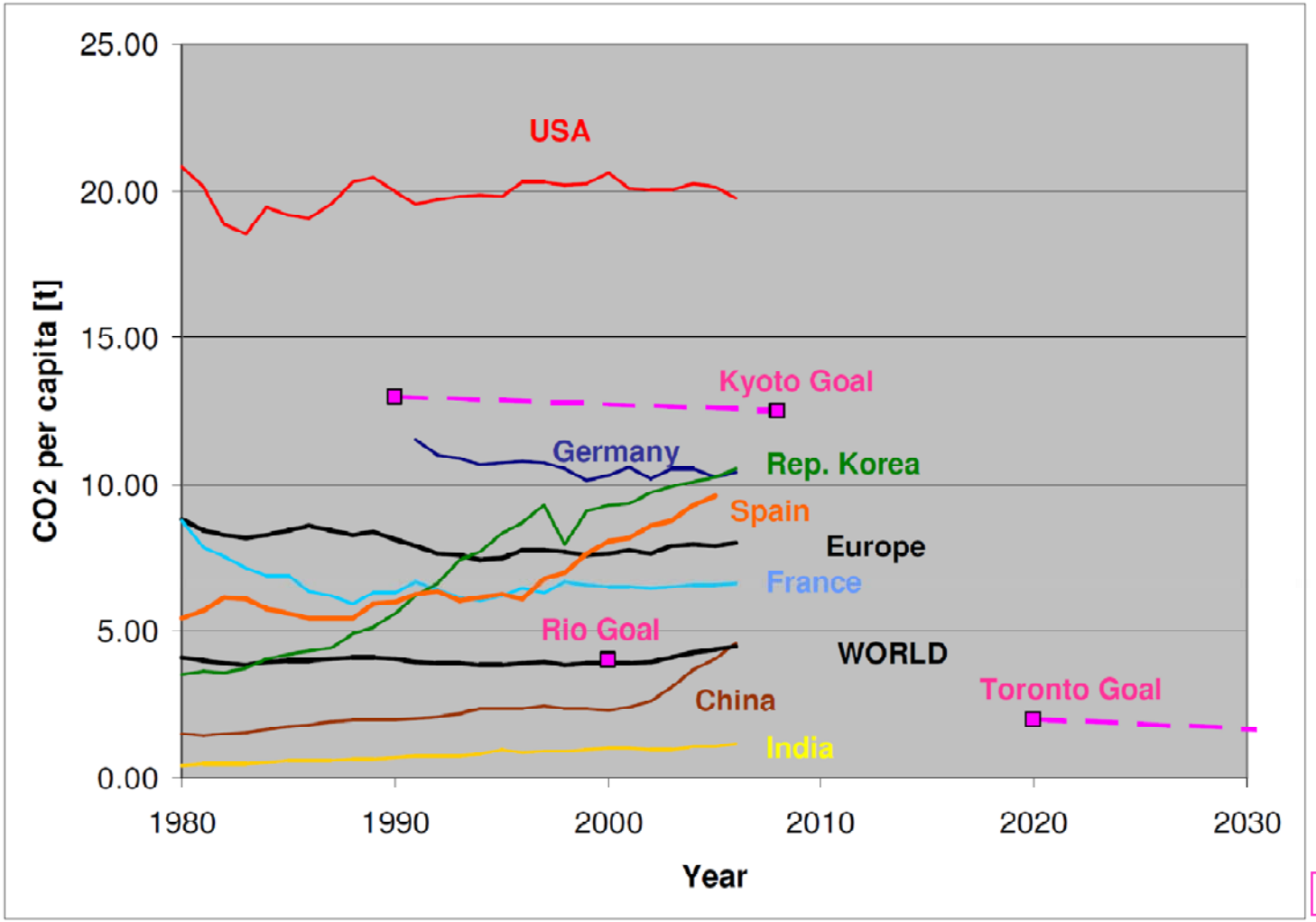
The Global Challenge

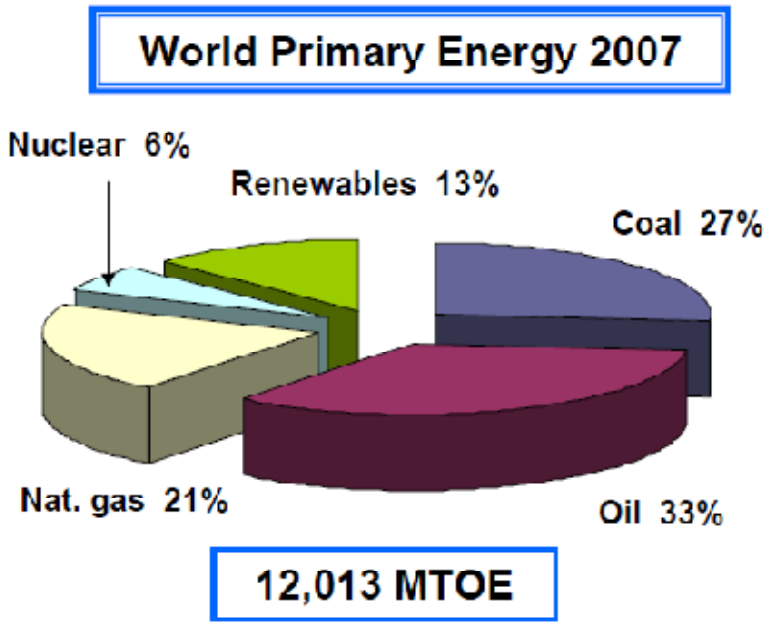


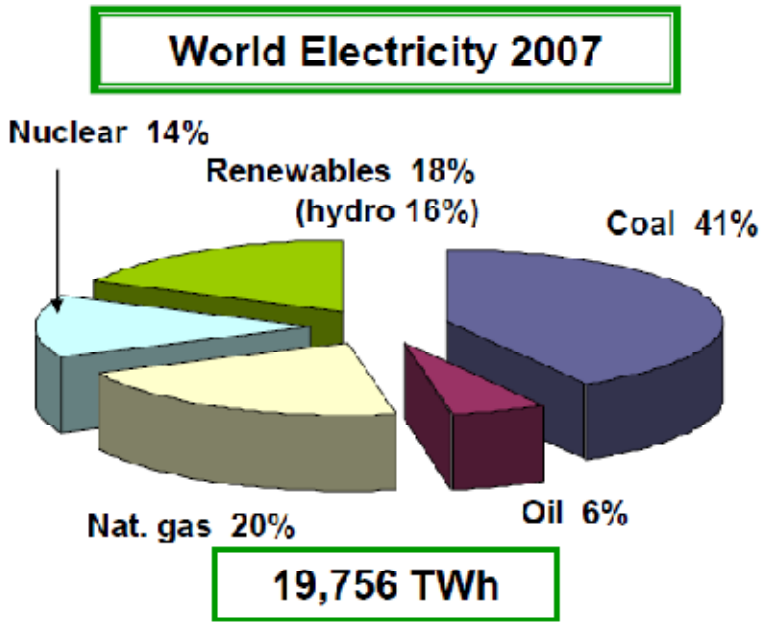
Energy-Related CO_2 Emission per Capita



EIA

Key World Energy Statistics 2007



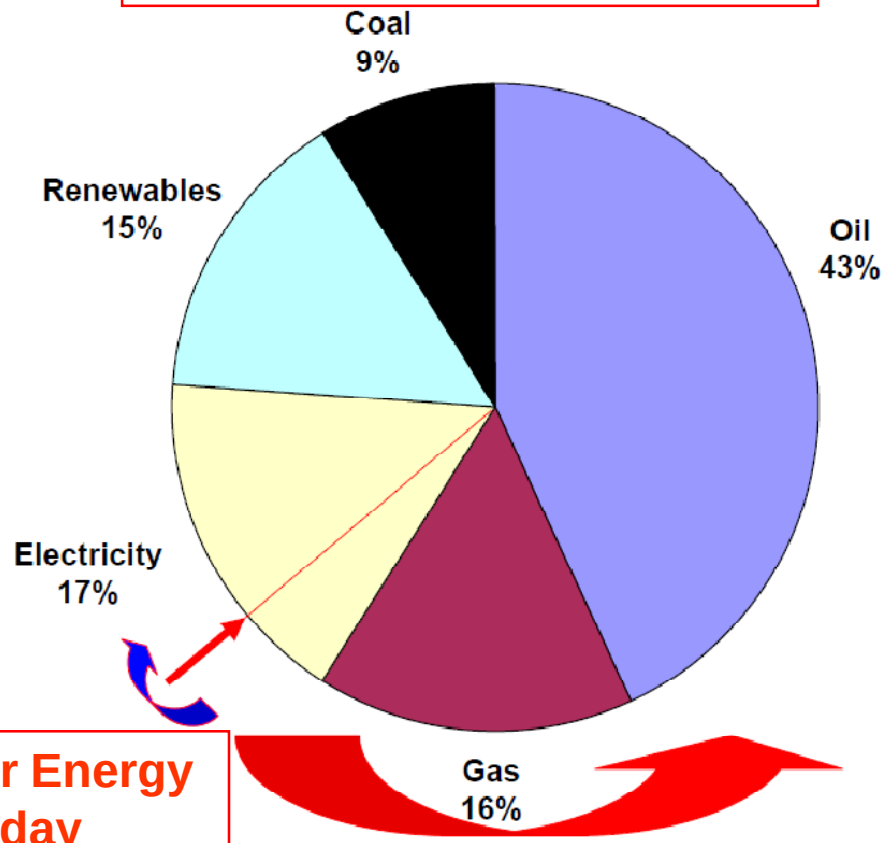


IEA 2008

Forms of Energy Utilization

- Final Energy Market dominated by fossil fuels
- Electricity is 17% of final energy
- Nuclear only for electricity
- Penetration of nuclear into two directions or combined
- Nuclear process heat has a huge potential in the energy sector !!!
- Combined Heat & Power saves resources & reduces GHG emissions

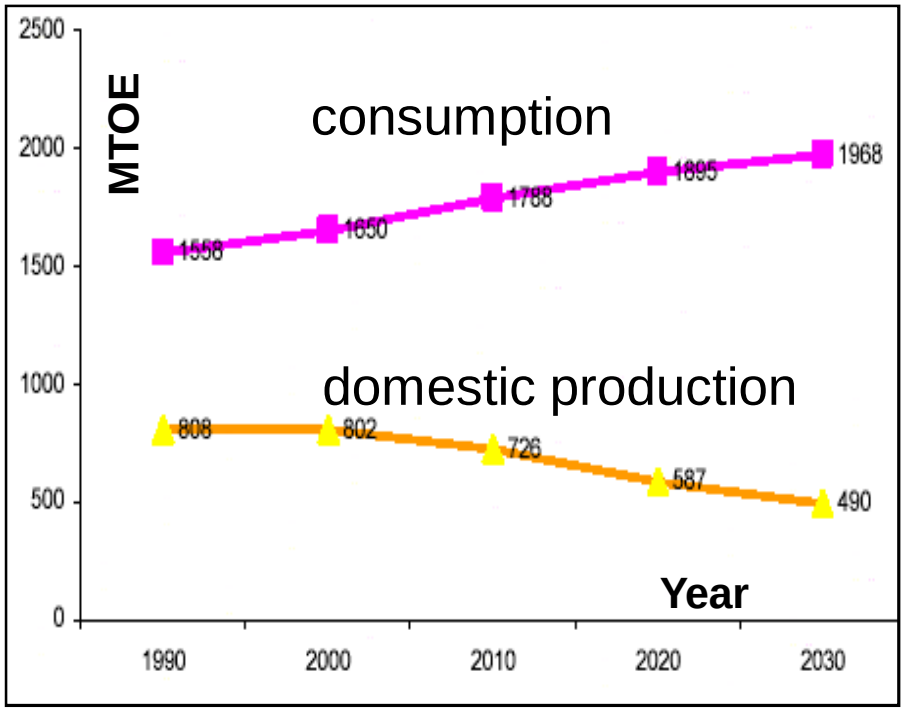
Final Energy Consumption (~8500 MTOE in 2007)



Nuclear Energy today

Heat Market

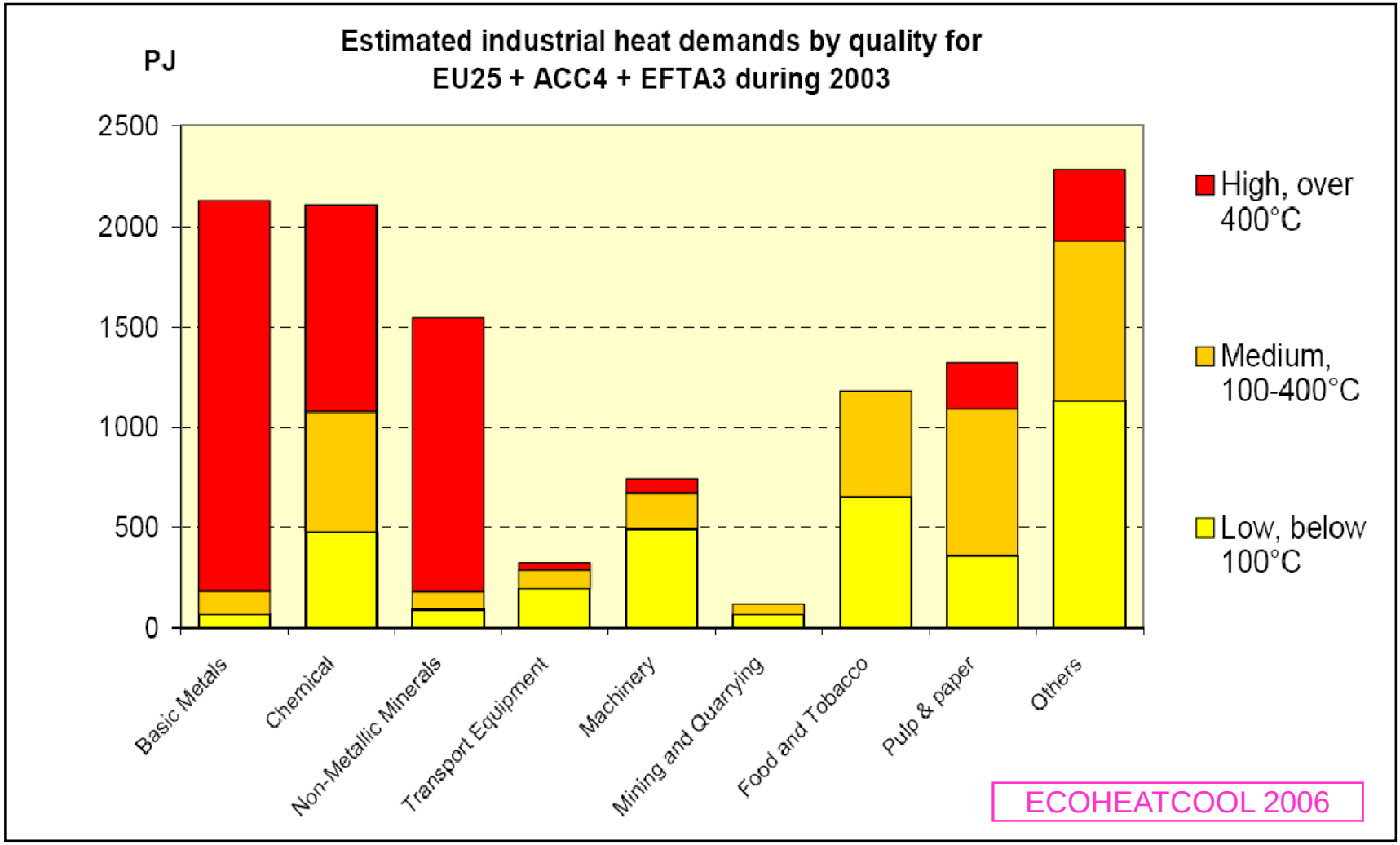
Energy Situation in the European Union



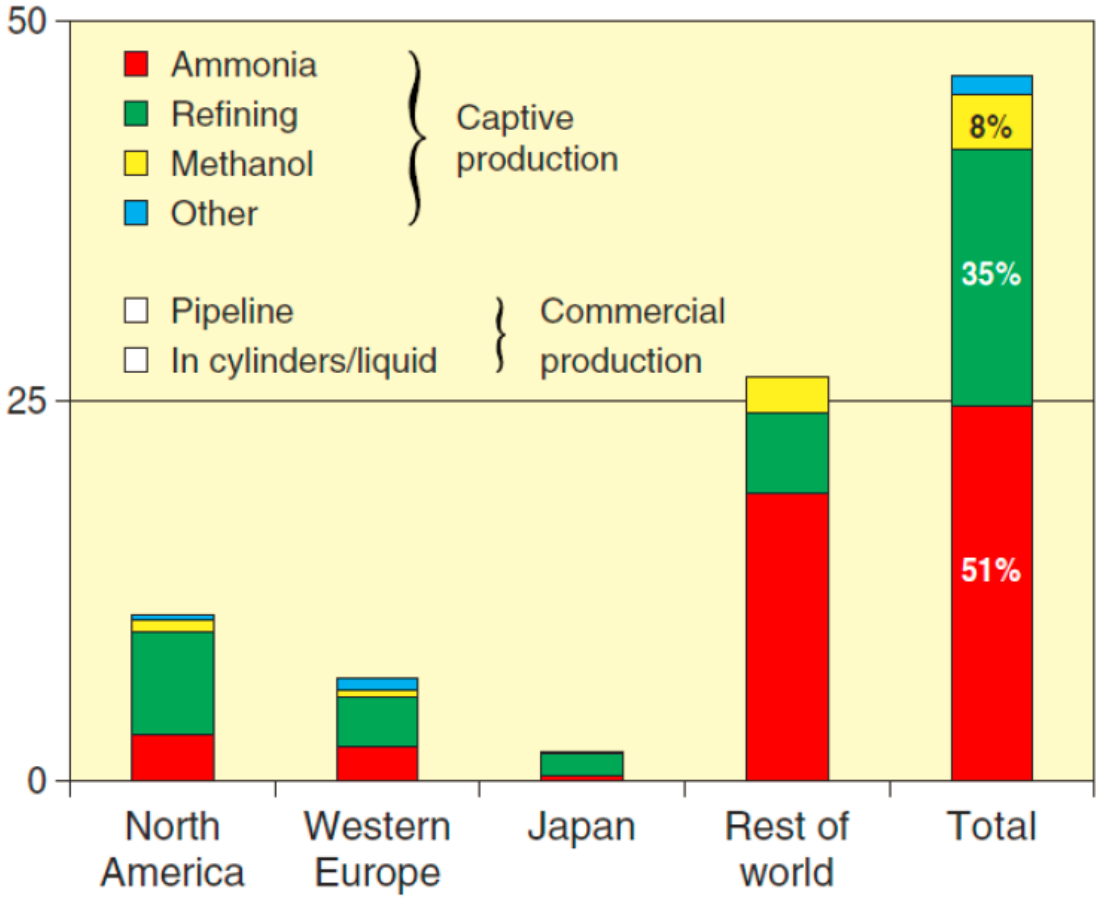
EU is a net energy importer

- **Primary energy consumption of EU-27: 1757 MTOE (as of 2007)**
- **15% of world energy consumption**
- **18% of world electricity consumption (or 3325 TWh)**
- **Growing energy demand 2 %/yr**
- **Would lead to +14% of CO_2 (1990) instead of promised -8%**
- **Decreasing domestic production**
- **143 NPP (131 GW) in 14 of EU27**
- **National energy policies (diverse, fragmented, isolated)**

Demand for Industrial Heat (Example: Europe)



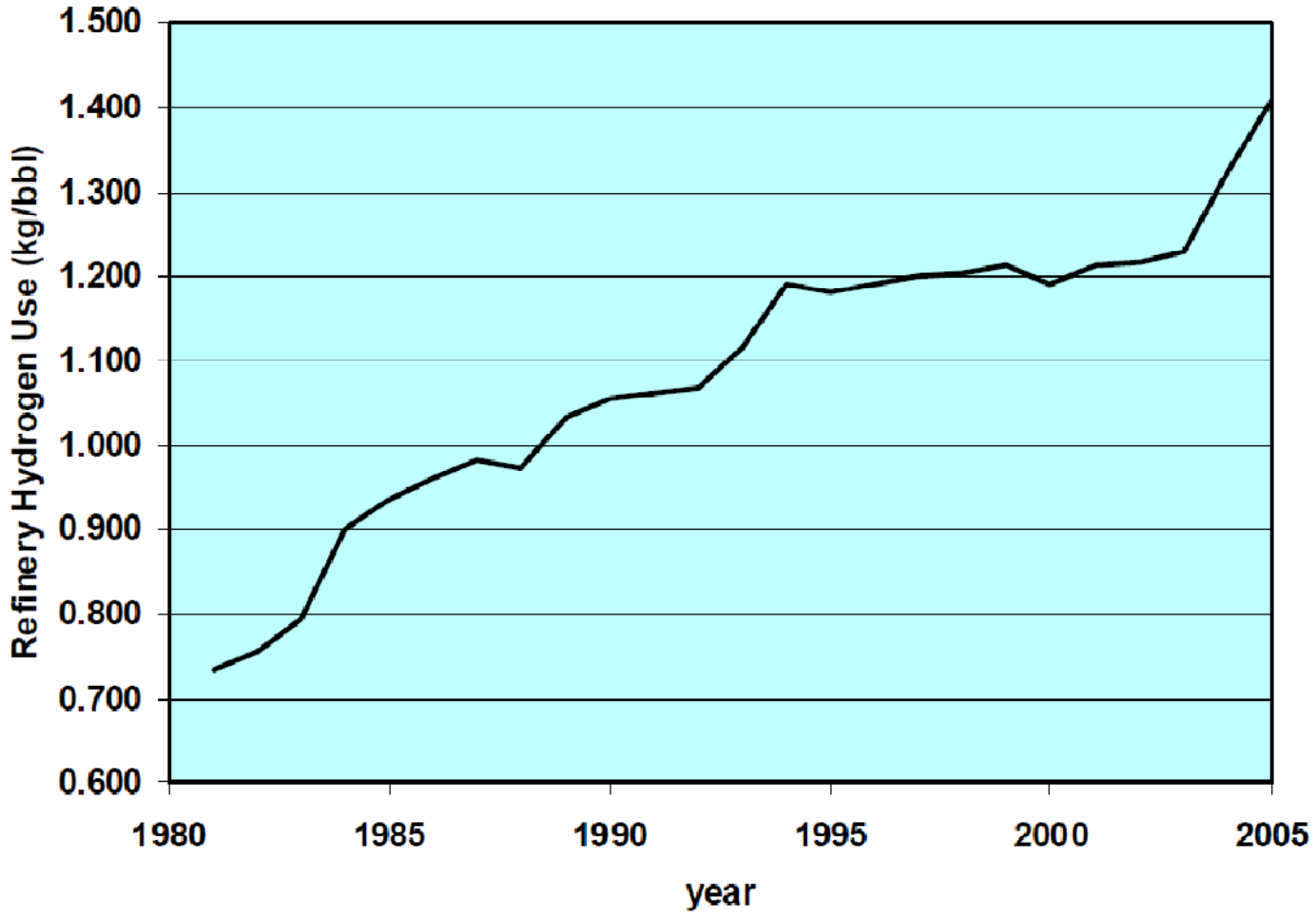
Current Use of Hydrogen



His 2004

Annual production (2006): ~53 Mt or ~630 billion Nm^3 or ~8 EJ or ~190 MTOE

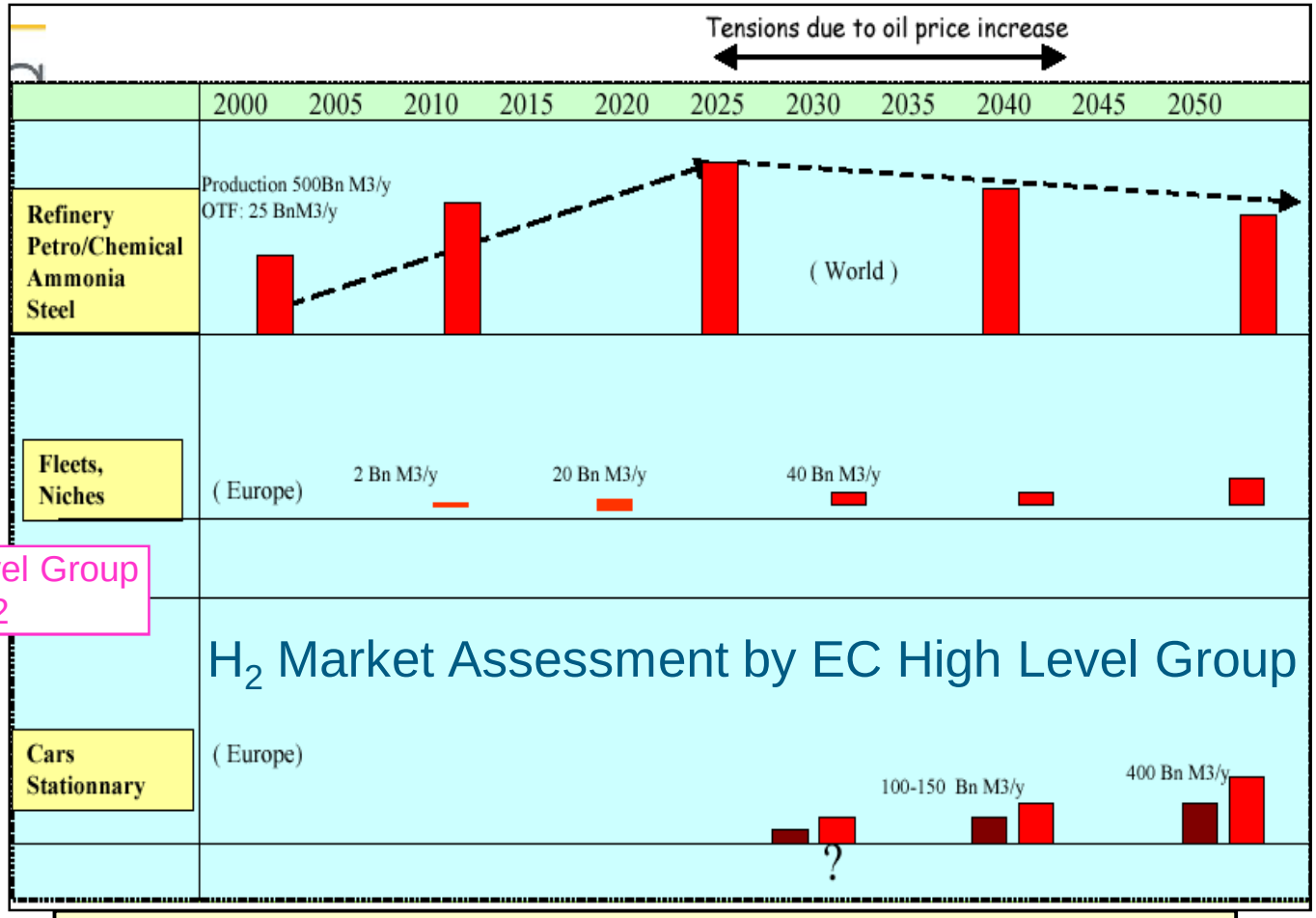
Hydrogen Consumption in US Refineries



~25,000 t of H_2 per day

Herring 2008

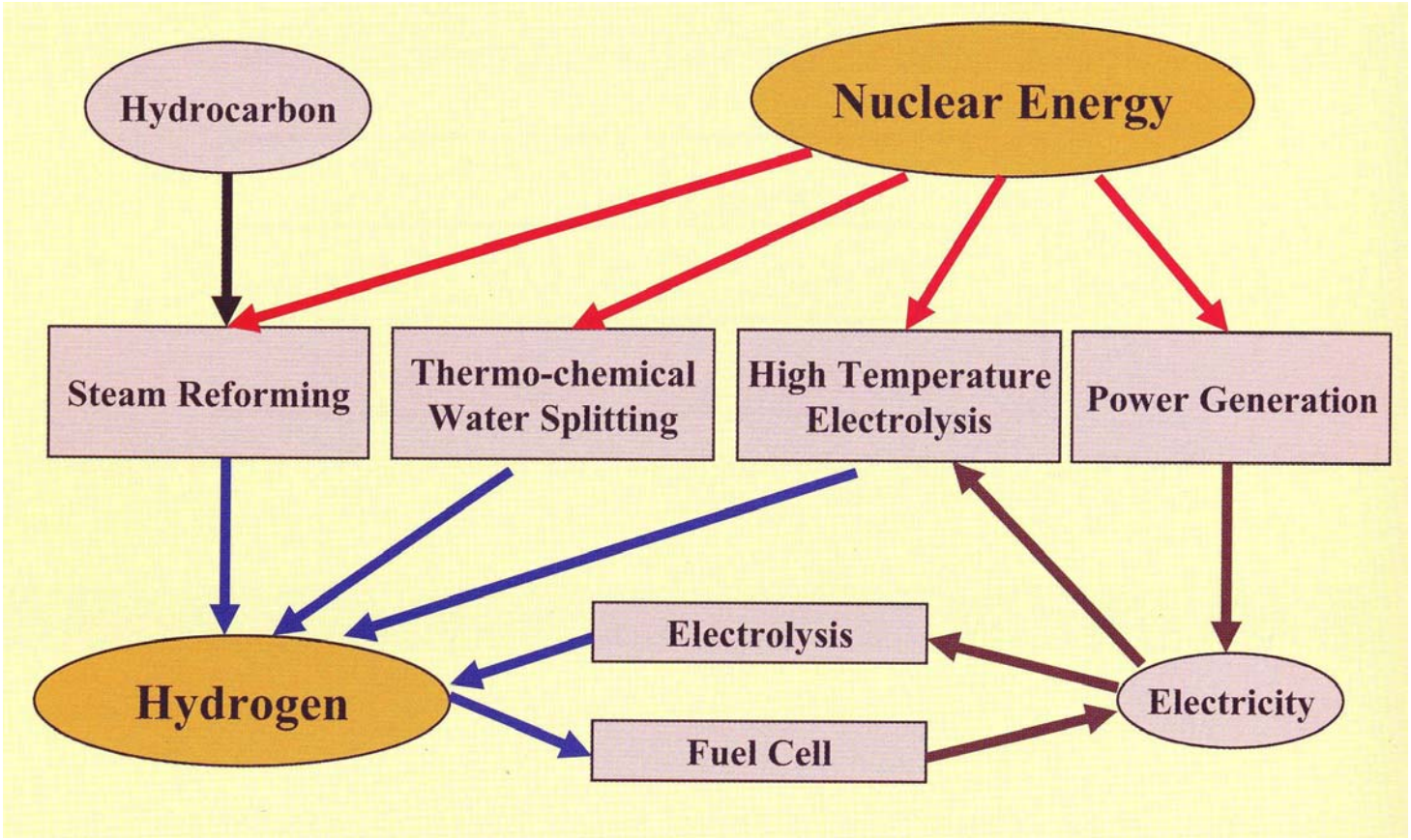
Future Demand for Hydrogen



EC High Level Group 2002

Tremendous need for hydrogen in future

Routes for Nuclear-Assisted H_2 Production



Tsukada 2005

H_2 as energy storage

Driving Forces for Nuclear Hydrogen

- Nuclear energy to produce hydrogen at a large scale to replace CO_2 emitting fossil fuels;
- Fossil reserves saved for later use in environmentally friendly applications, resource savings 30-40%
- Energy security from extended fuel reserves and independence of foreign oil uncertainties
- Help to meet growth rates in energy consumption and substitute for expensive electricity production with fossil fuels (if cost of nuclear heat is sufficiently low)

Introduction of Nuclear Hydrogen to Market

- Will start by present uses and production methods;
- Will be determined by
  - economics of production and end use,
  - consumer‘s perception of availability and convenience,
  - convincing safety concept of the combined system;
- Synthesis of liquid fuels (e.g., methanol) in transition phase

Arguments against Nuclear

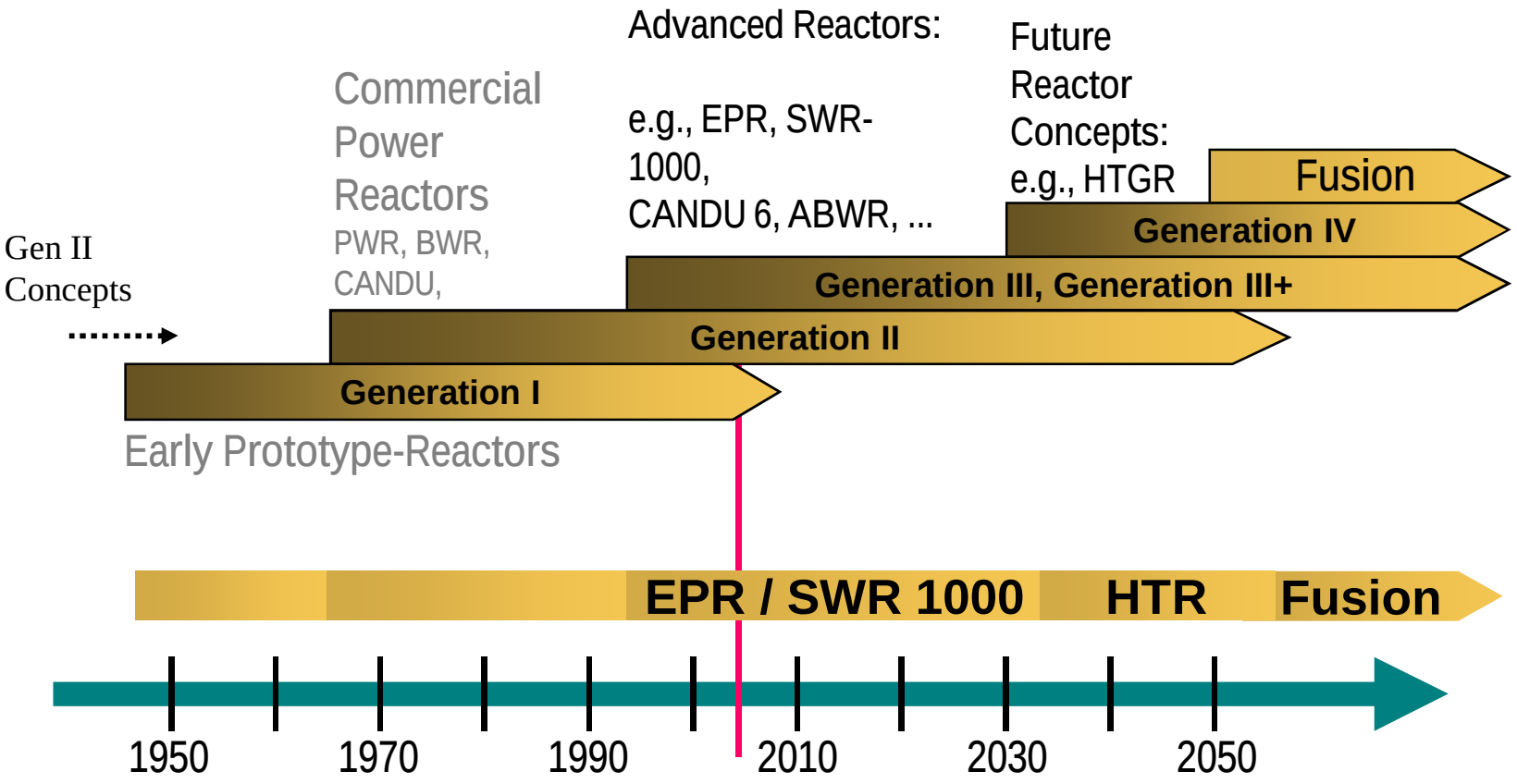
- **Limited Uranium Resources**
- **Long-Term Threat by Radioactive Waste**
- **Radioactive Emissions / Catastrophic Accidents**
- **Additional Danger by War / Sabotage Impact**
- **Abstract Risk Formula**

Arguments in Favor of Nuclear

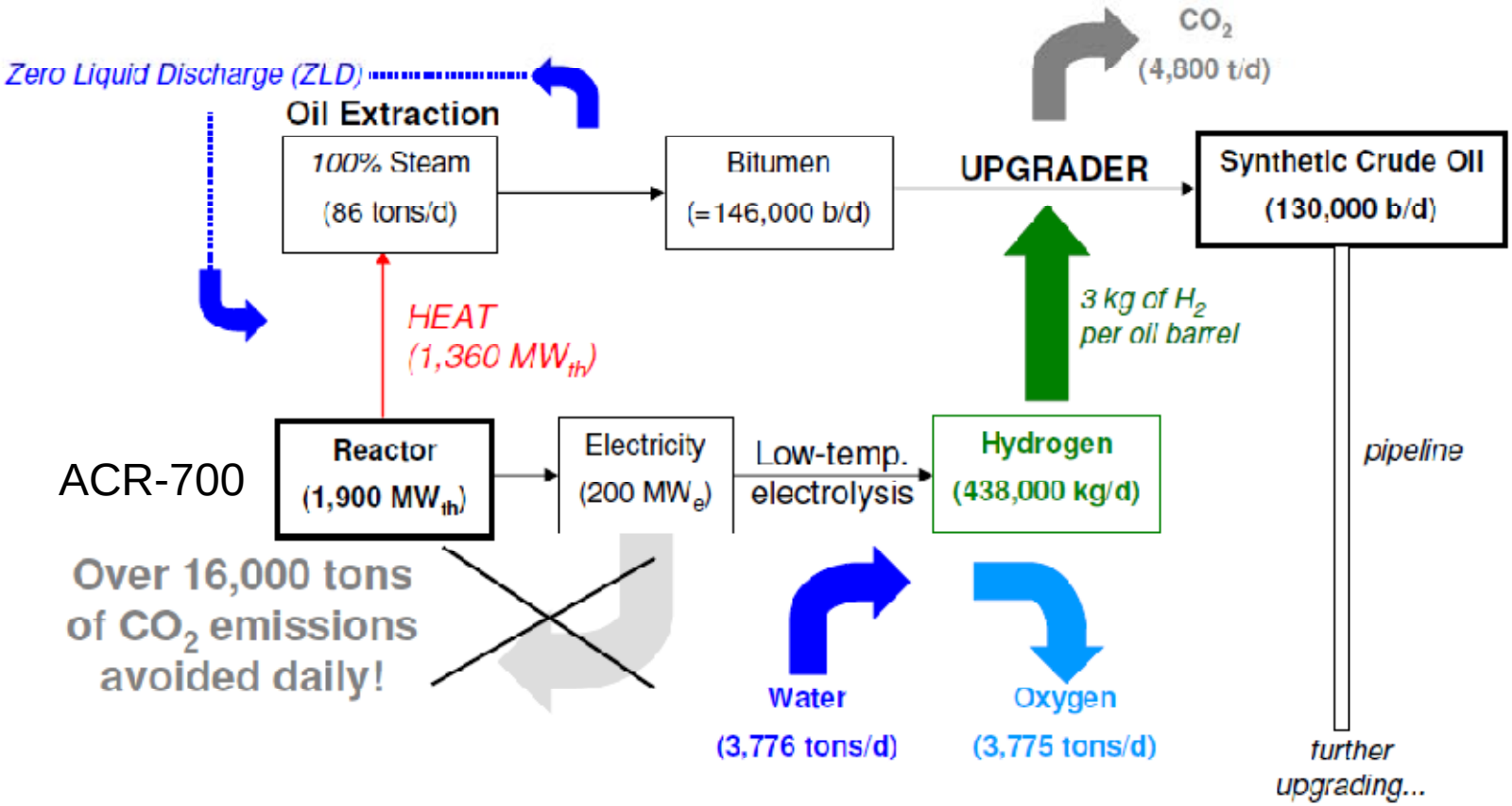
- **CO_2 emission-free production of energy**
- **Competitiveness vs. gas and coal**
- **Low impact of fuel cost**
- **Stabilization of electricity price within the mix**
- **Saving of fossil fuel resources**

Nuclear energy contributes to climate protection and energy supply security (Target "Sustainable Development")

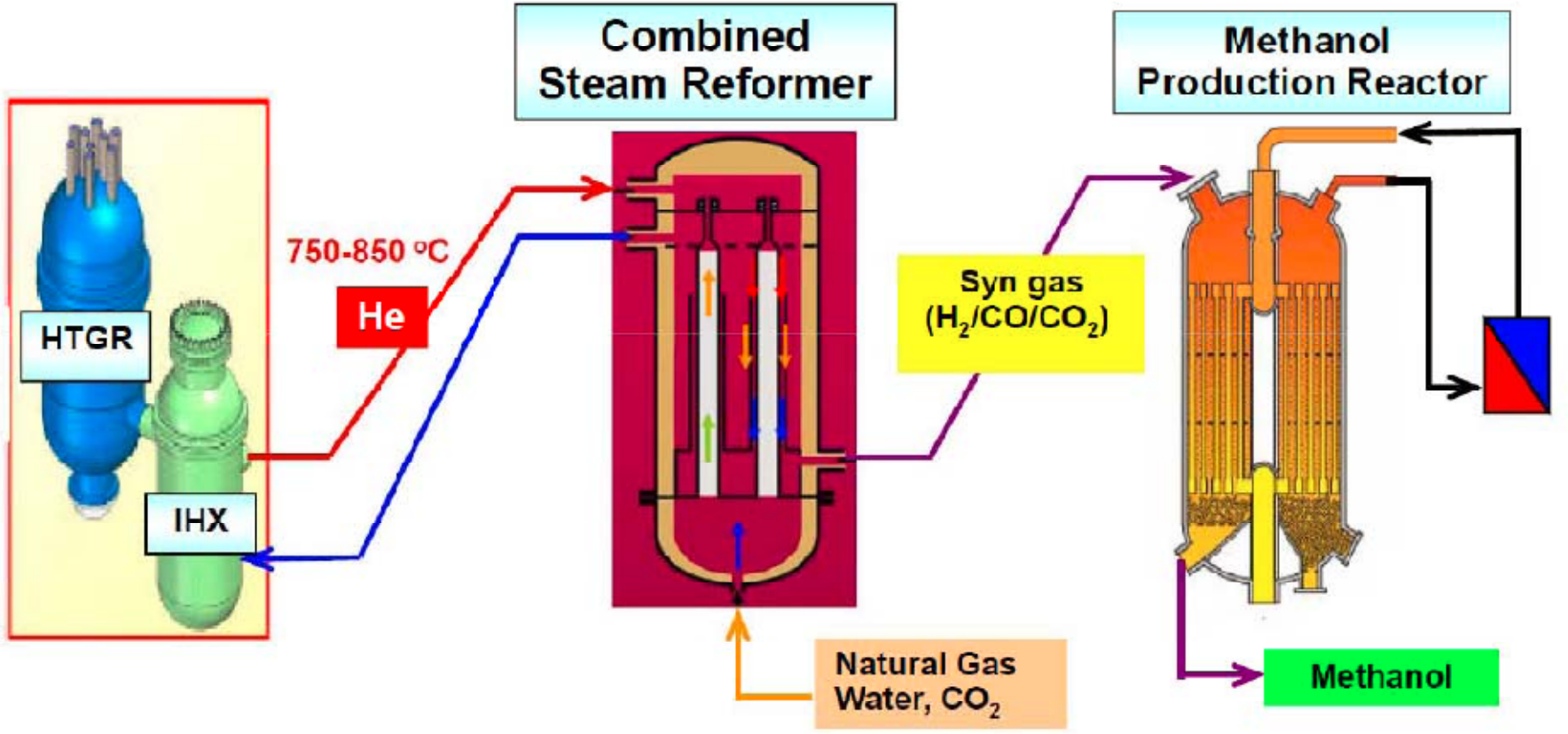
Nuclear Power Plant Generations



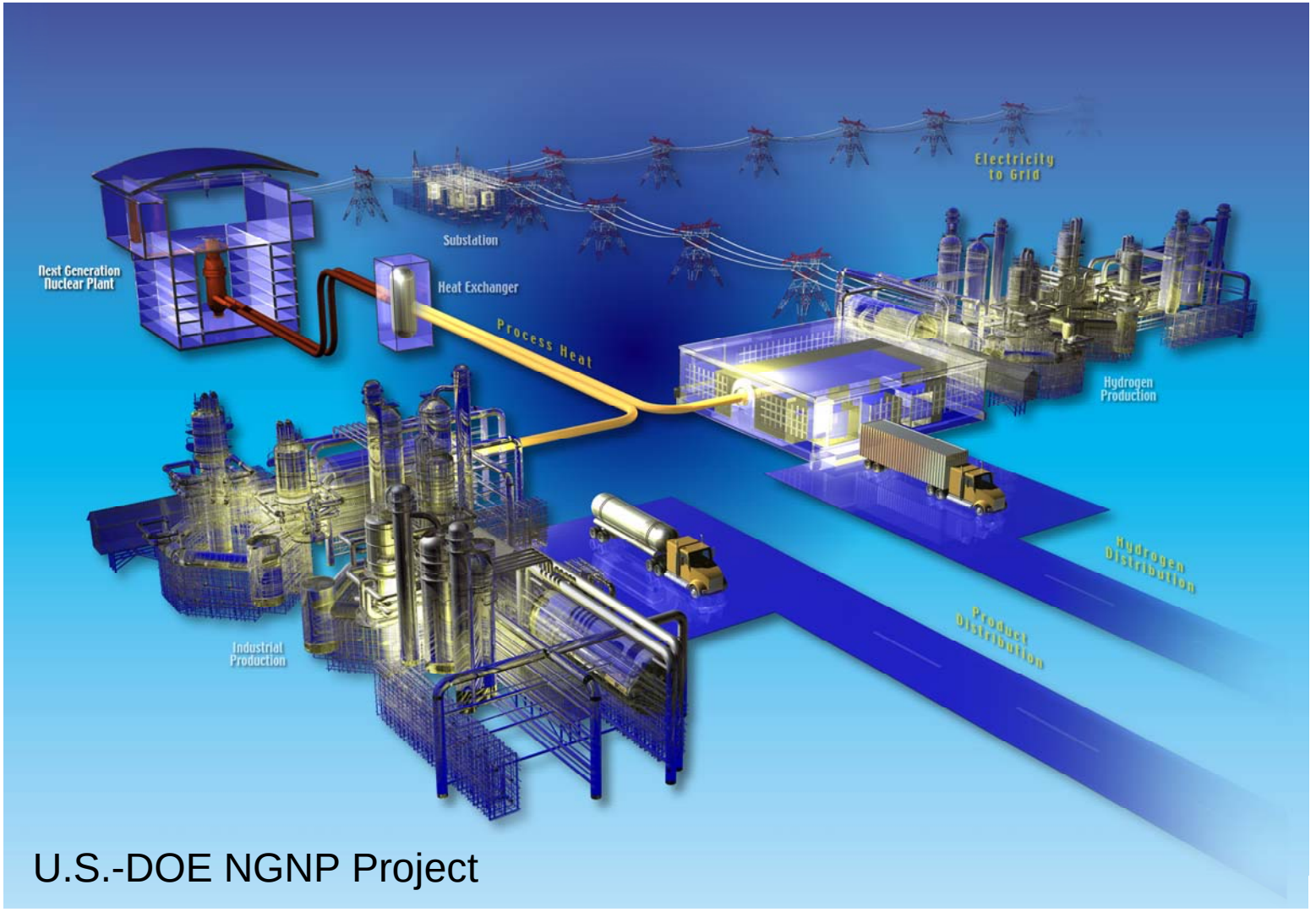
Nuclear Syncrude Production (Canada)



Nuclear Methanol Production (Rep. of Korea)



Nuclear Hydrogen Production (USA)



U.S.-DOE NGNP Project

Thank you
for your kind attention !

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