



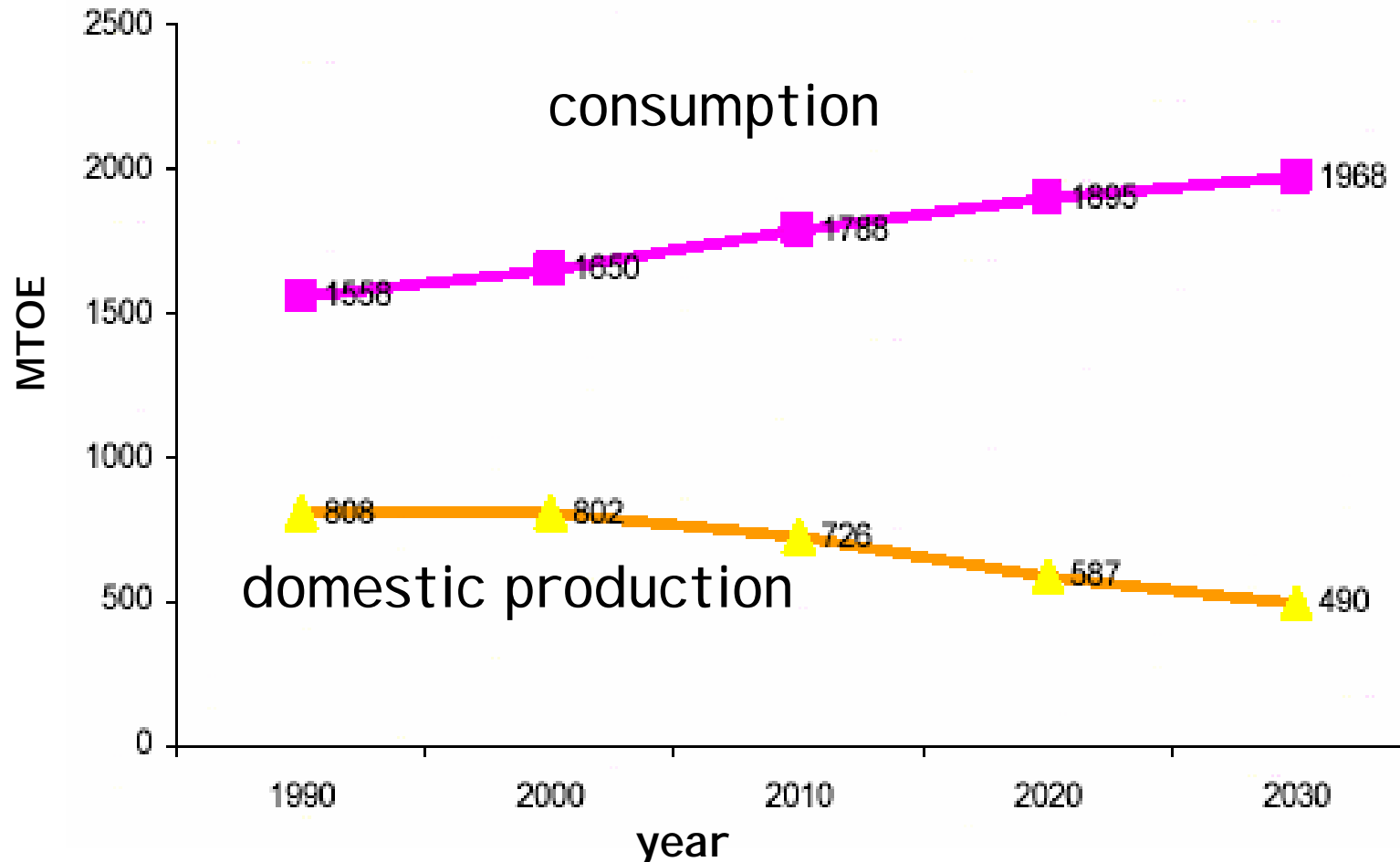
Past and Present Research in Europe on the Production of Nuclear Hydrogen by HTGR

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Energy Situation in the European Union

EU is a net energy importer





Principal Policy Objectives of the EU

- Maintaining security of energy supply
- Reducing the dependence of fossil energy imports
- Meeting Kyoto commitment of an 8% CO₂ reduction by 2008/2012, anticipating the need for much stronger reduction later
- Promoting industrial competitiveness

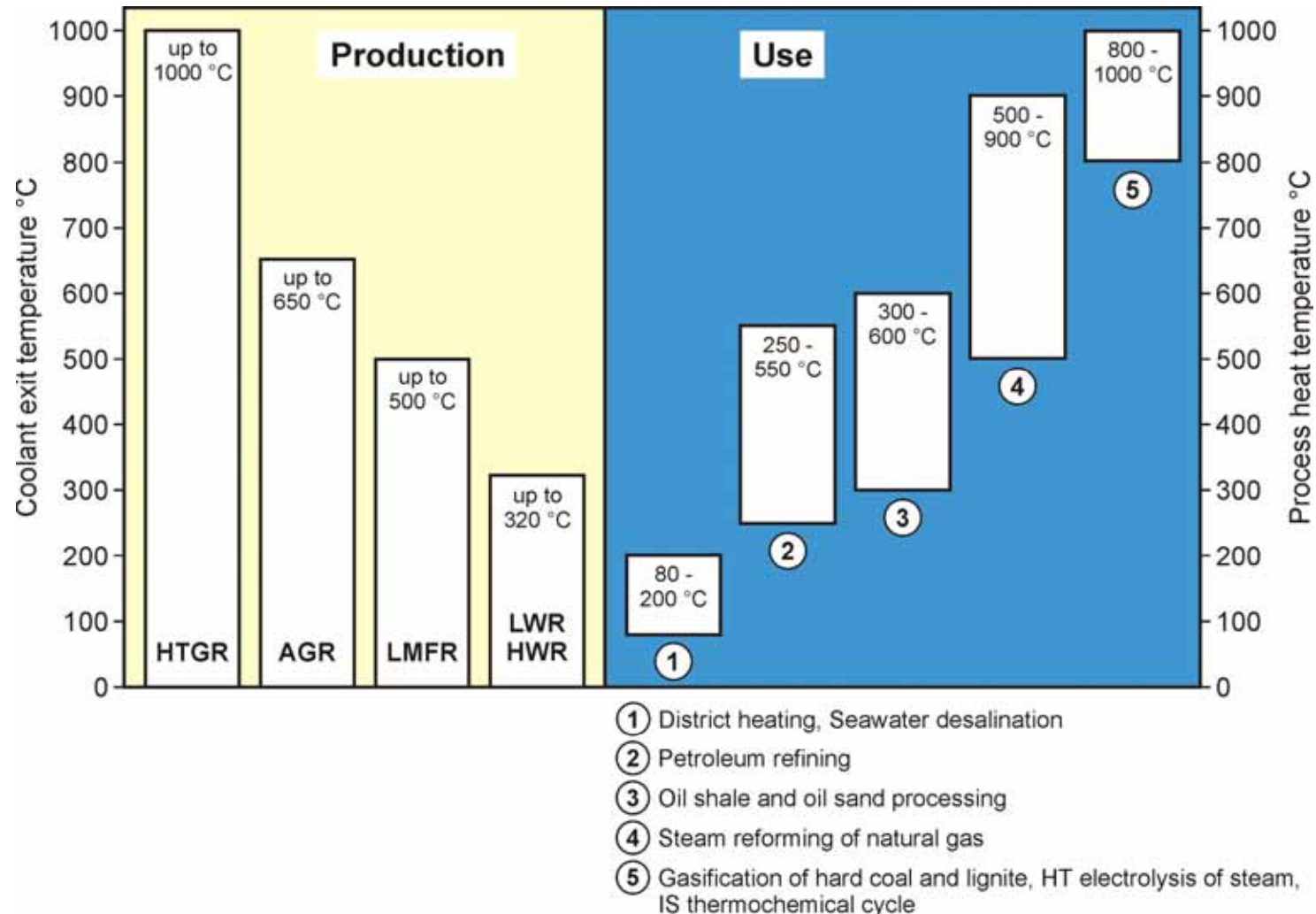


Nuclear Energy in the EU

- 15 of the 25 member states operate NPP, covering more than one third of the total electricity demand, but inhomogeneously distributed;
- Long-term intensive cooperation among nuclear vendors, utilities, research organizations;
- Meeting Kyoto commitments demands for clean fuel and CO₂-free energy sources (renewables, nuclear);
- Water and biomass are the two candidate raw materials for H₂ production on the long run.



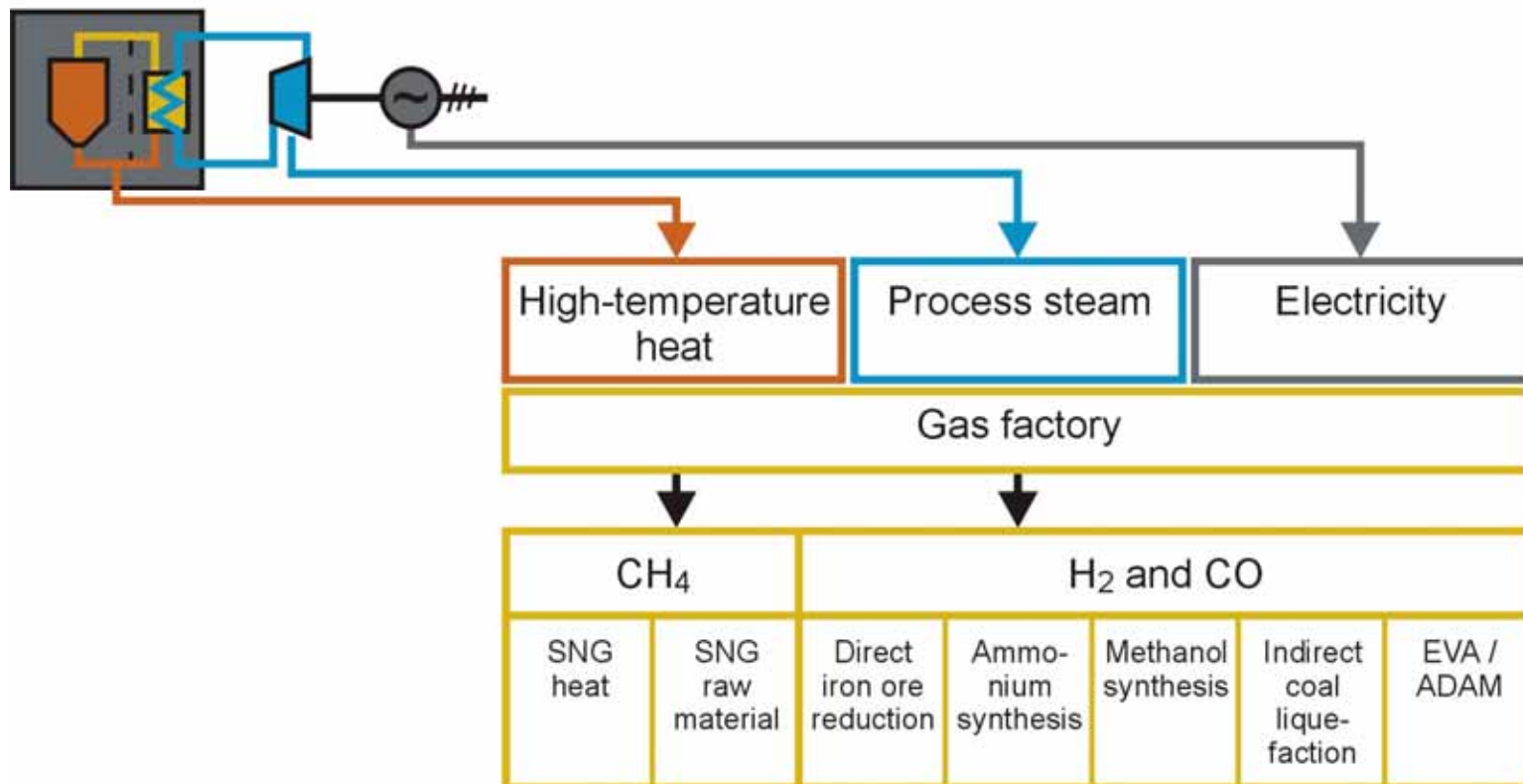
Nuclear Process Heat Temperatures





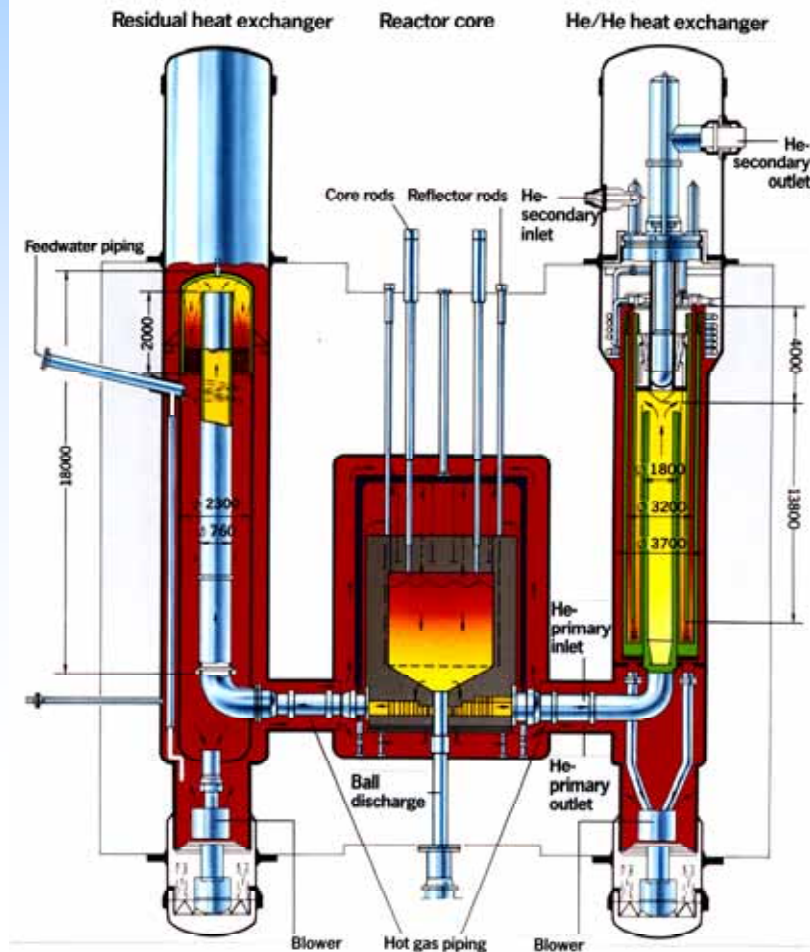
Nuclear Process Heat Applications

Nuclear process heat
(PNP)





PNP-500 Process Heat HTGR



Status of Project (~1990):

- 500 MW Prototype designed (950°C)
- Coal gasification processes demonstrated (1-10 MW)
- Main components tested in 10 MW scale
- Materials lifetime ~ 120000h
- Licensing assured (e.g. tritium / gas explosions)
- Economics under elevated oil prices

Coal Gasification Demonstration in Pilot Plants



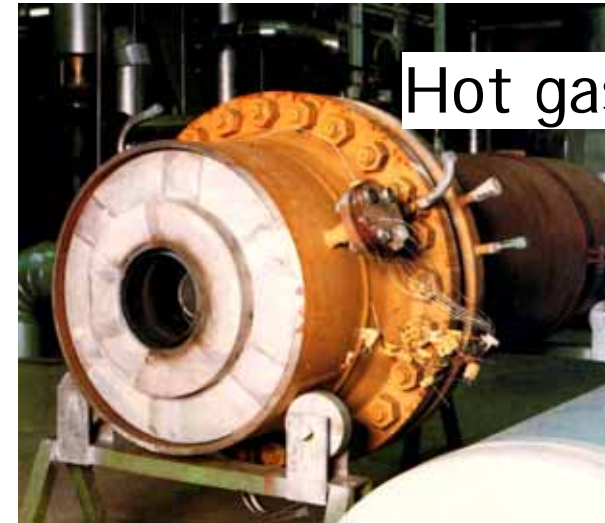
Hydro
←

Steam
→





Component Test Loop (KVK)



Hot gas valve



Hot gas duct

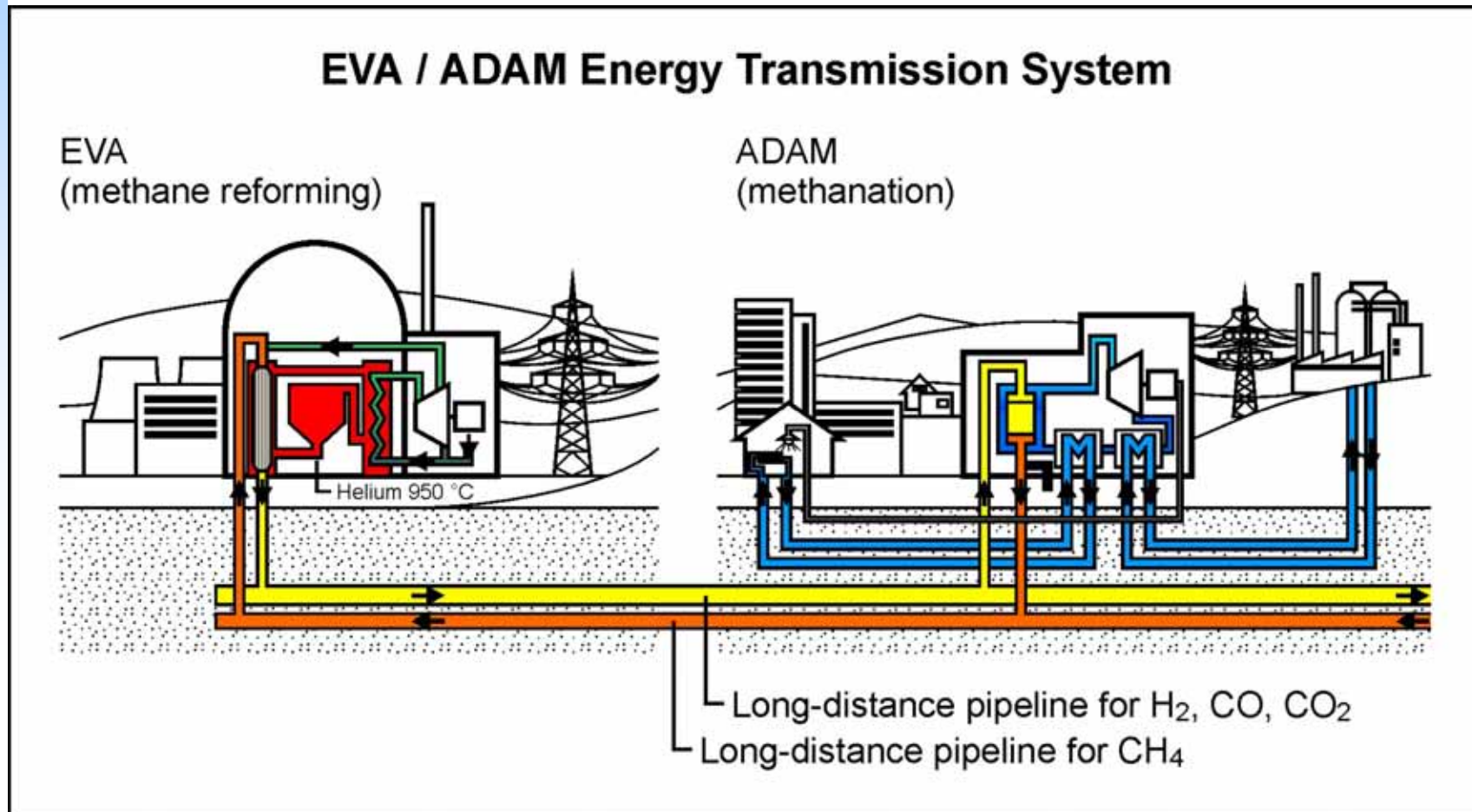


He-He-I HX Manufacture by Steinmueller





Long-Distance Energy Transportation System





Long-Distance Energy Transportation System

EVA

steam reforming

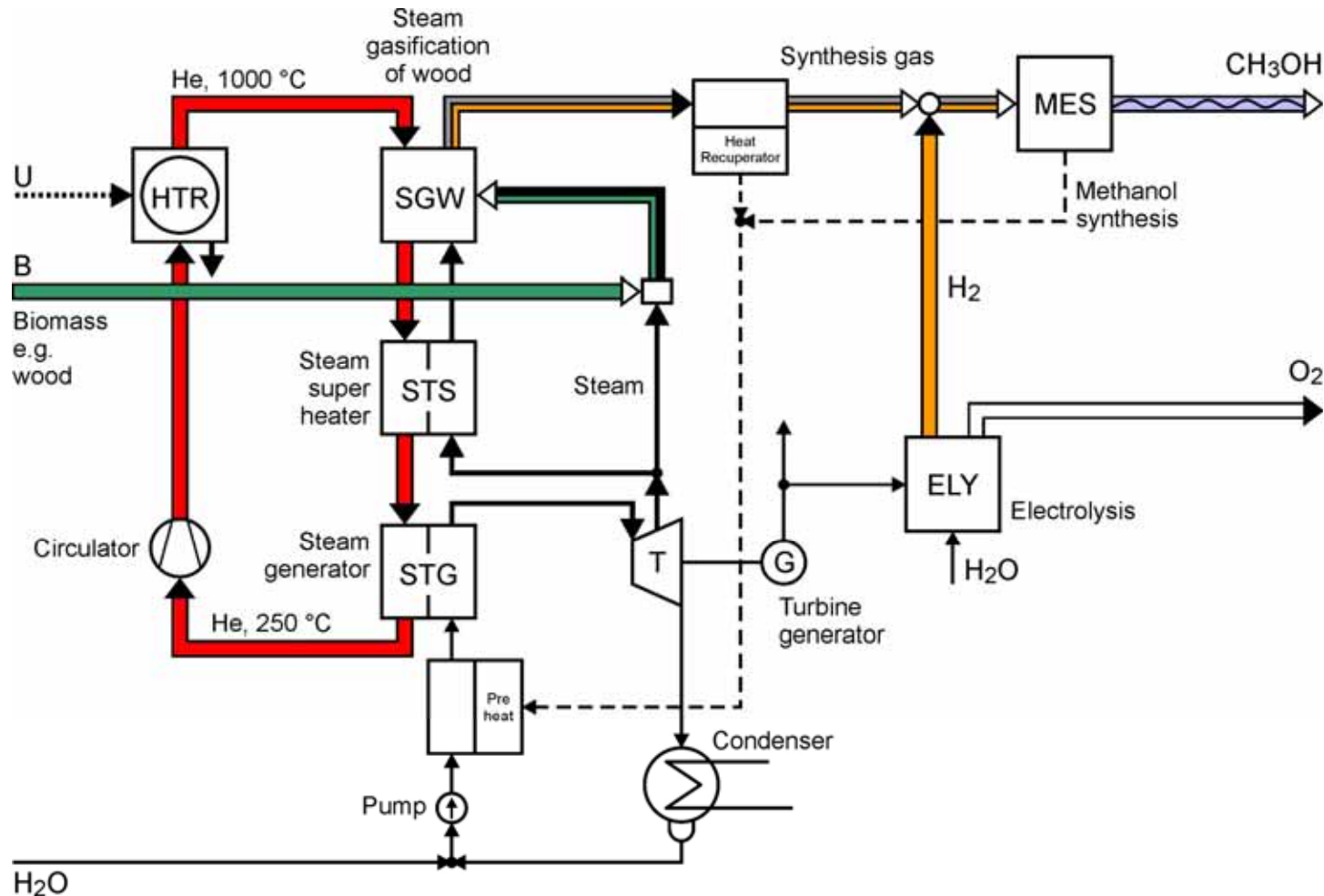


ADAM

methanation

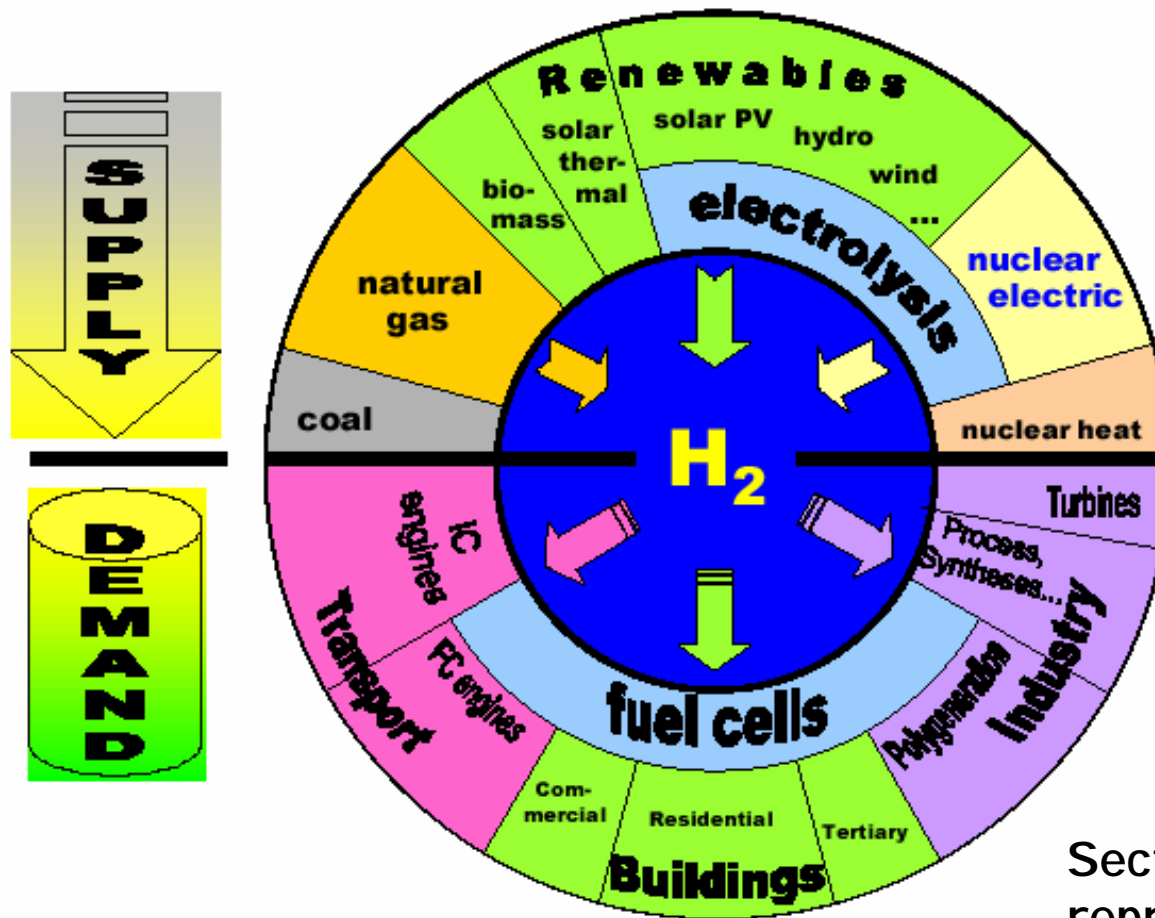


Energy Alcohol Production from Biomass





Hydrogen Supply Options and Demand



Sector sizes do not
represent current
or future markets

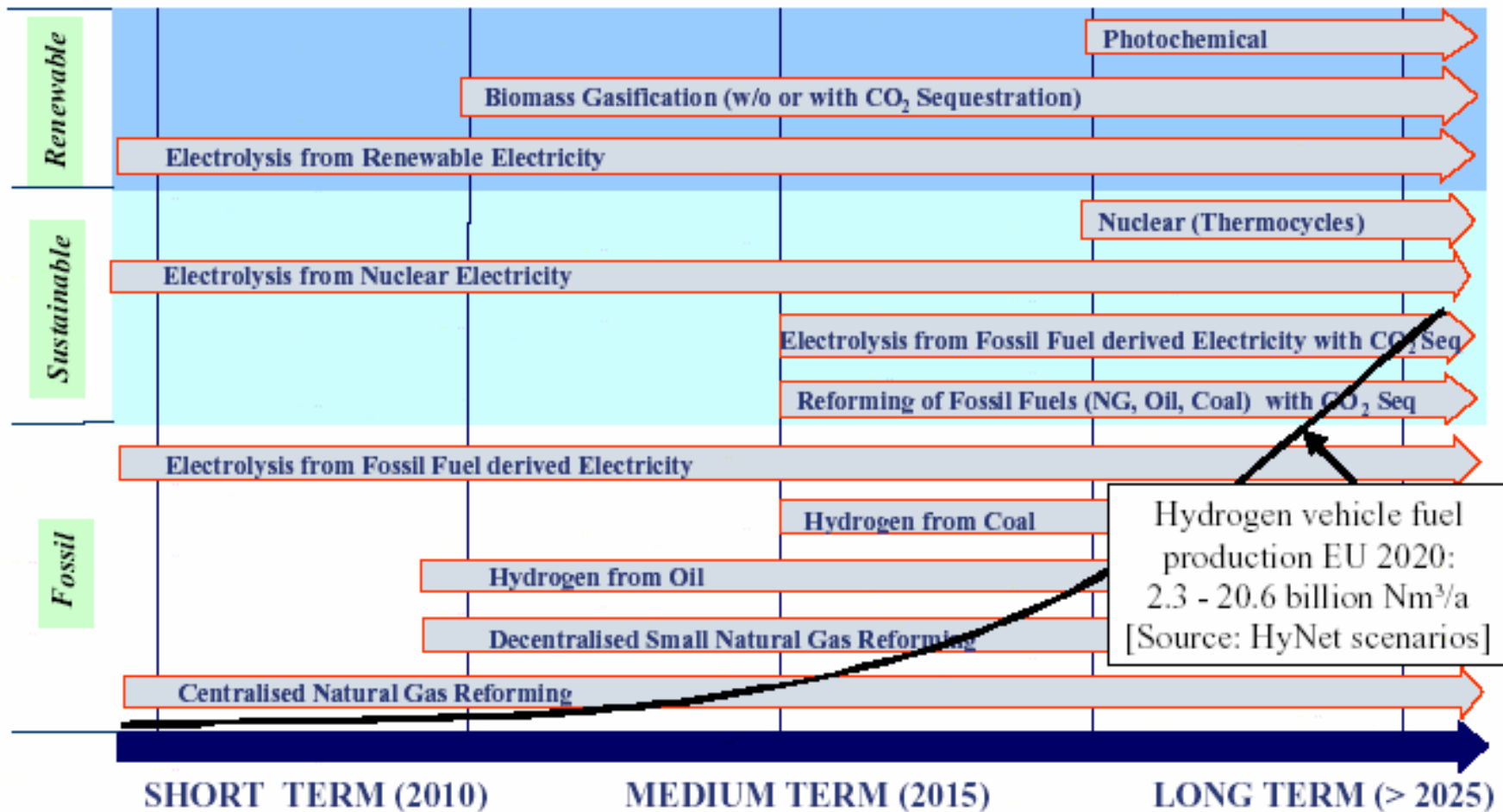


Creation of Policy Groups

- High Level Group on Hydrogen and Fuel Cells (HLG)
to develop European consensus on the introduction of hydrogen energy
- European Hydrogen and Fuel Cell Technology Platform (Jan. 2004)
to develop coherent hydrogen research and deployment strategy for Europe



Timeline for H₂ Production Technologies





„Quick Start“ Initiative by EC

➤ First call for proposals of FP6 (March 2004)

EC awarded 10 contracts in H₂ with 62 M E

EC awarded 6 contracts in FC with 30 M E

(to be matched by private funding)



EU Contracts on Hydrogen in FP-6

Project	Topic	Coordinator	EU Funding [M E]
HYTHEC -STREP	Thermochemical cycles	CEA (F)	1.9
CHRI SGAS -IP	H ₂ rich gas from biomass	Växjö Uni (S)	9.5
Hi2H2 -STREP	HT electrolysis	EDF (F)	0.9
HYWAYS -IP	European hydrogen roadmap	LBST (G)	4.0
NATURALHY -IP	Infrastructure H ₂ -Nat. Gas mixes	Gasunie (NL)	11.0
STORHY -IP	Storage for on-board applications	Magna Steyr (A)	10.0
HYSAFE -NE	Research in safety issues	FZK (G)	7.0
ZEROREGIO -IP	H ₂ fuel cell fleet demonstration	Infraserv (G)	7.5
PREMI A -SSA	Effectiveness of demo initiatives	VITO (B)	1.0
HYICE -IP	Internal combustion engines	BMW (G)	9.0



INNOCENT-IP (March 2003)

- 30 M Euro IP on innovative hydrogen production processes (incl. nuclear)
- Evaluate and compare different processes of H₂ production with focus on thermochemical cycles, but includes also steam reforming as well as “very innovative” ways
- Not accepted (July 2003)
Modified version to be relaunched as CA

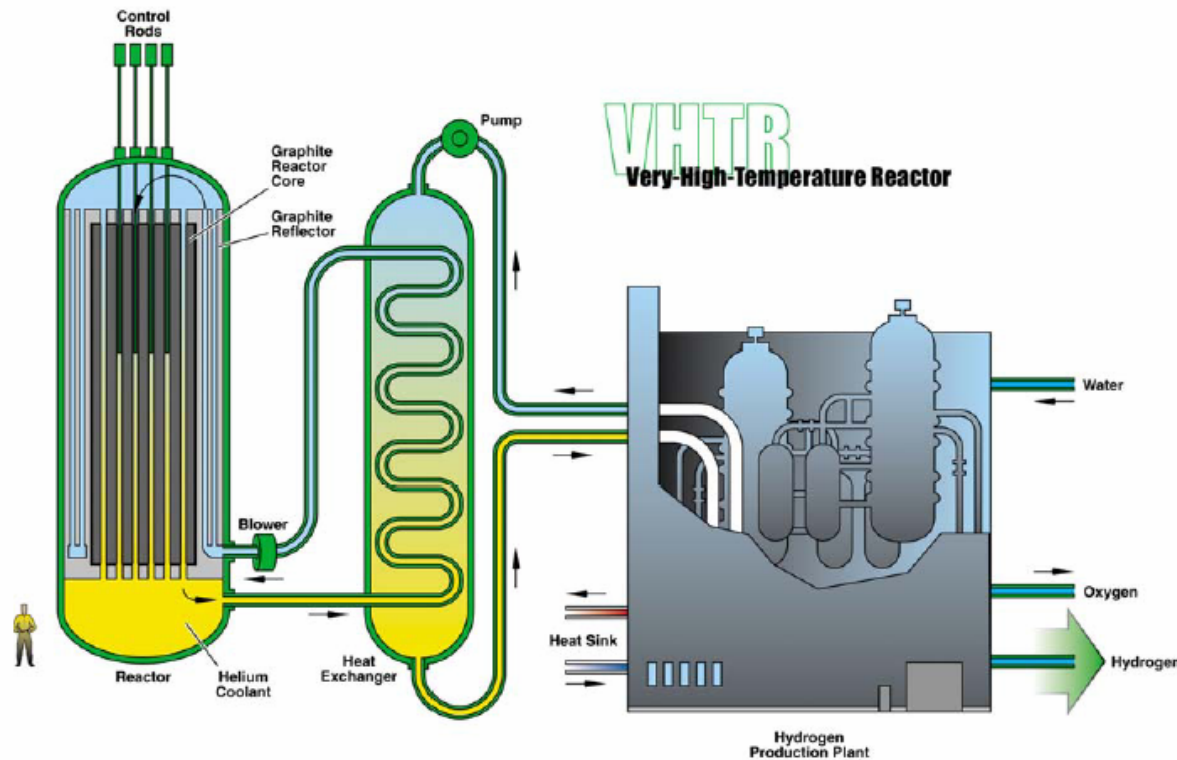


HYSAFE-NE (March 2004)

- EU Network of Excellence
- Strengthening capacities to implement new technological solutions for H₂ as energy carrier
- Harmonize methodologies for safety assessment
- Focus on studies of fire and explosion safety, mitigation techniques, detection devices
- Promote use of H₂
- Establish a European Hydrogen Safety Center



Gen I V nuclear reactor: VHTR



- 400-600 MW(th) for electricity and process heat production;
- Helium-cooled, graphite-moderated, thermal neutron spectrum;
- Gas outlet temperature of 900-1000 °C;
- IHX for heat transfer to H₂ production plant or gas turbine.



Program Plan for VHTR by 2010

- Long-term technology improvement by making use of knowhow from HTGR development;
- HTTR and HTR-10 to demonstrate VHTR capabilities in pilot scale and in near term;
- I NEEL co-generation project as full-scale demonstration of VHTR objectives with H₂ production system.



VHTR Hydrogen R&D program

- Developing and optimizing thermo-chemical water splitting processes of the sulfur family (reference: S/I , special focus on HT step);
- Evaluating alternatives;
- Advancing the high temperature electrolysis process.



V/HTR-Integrated Project in FP6

- 35 partners, coordinated by Framatome-ANP
- Facilitates and supports the EURATOM contribution to the Gen IV International Forum (GIF)
[at present technically represented by MICANET]
- Complements national efforts on HTR/VHTR
- Connected to hydrogen activities in FP6 by sub-projects „System Integration“ and „Safety“
- Currently under negotiation with EC
[evaluation process: 26.5 out of 30 points]



V/HTR-IP Overall Objectives

- Study 1st generation of advanced gas reactor technologies with R&D support to existing demonstrator projects;
- Explore options for 2nd generation by developing systems for very high temperature (950 - 1000 °C) applications.



V/HTR-IP Breakdown Structure

1. Coupled Reactor Physics and Core Fluid Dyn.
2. Fuel Technology
3. Back-End of the Fuel Cycle
4. Materials Development
5. Component Development
6. Safety
7. System Integration
8. Education & Training



Recommendations for an R&D Strategy on Hydrogen Production Processes

- Address present hydrogen market and transition phase
- Include HYDRI CITY (exchangeability of H₂ and electr.)
- Extend R&D to alternatives (e.g. thermochem. cycles)
- Take benefit from non-nuclear H₂ process developments (e.g. solar steam reforming)
- Prepare „lighthouse“ demonstration projects (HTTR, NGNP)
- Establish international R&D programs (e.g. GIF)



**Thank You
for Your Attention**

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