



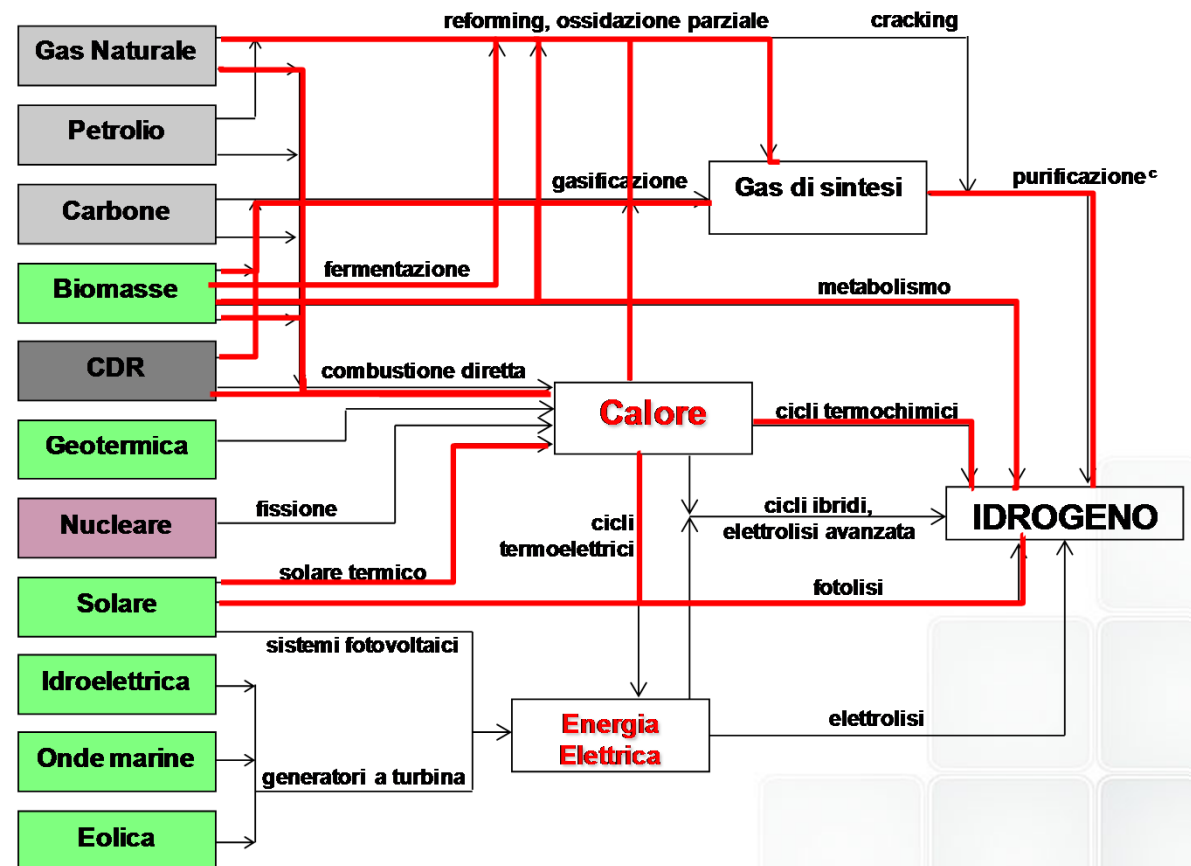
Le Celle a Combustibile e l'Idrogeno in Italia Stato dell'Arte e Sviluppi Futuri

Attività ENEA nel campo della produzione di idrogeno (2)

Alberto Giaconia

R&D projects on Hydrogen production from new and renewable energy sources

- ❑ steam reforming assisted by solar energy (CoMETHy & METISOL projects)
- ❑ water-splitting by thermochemical cycles powered by solar energy (TEPSI & HycleS projects)
- ❑ anaerobic digestion of food and zoo-technical wastes
- ❑ biomass gasification



Hydrogen production processes roadmap

“The pathway to hydrogen generation entirely from renewable energy and material sources probably goes by a transitional period with the utilization of hybrid fossil/renewable integrated systems.”

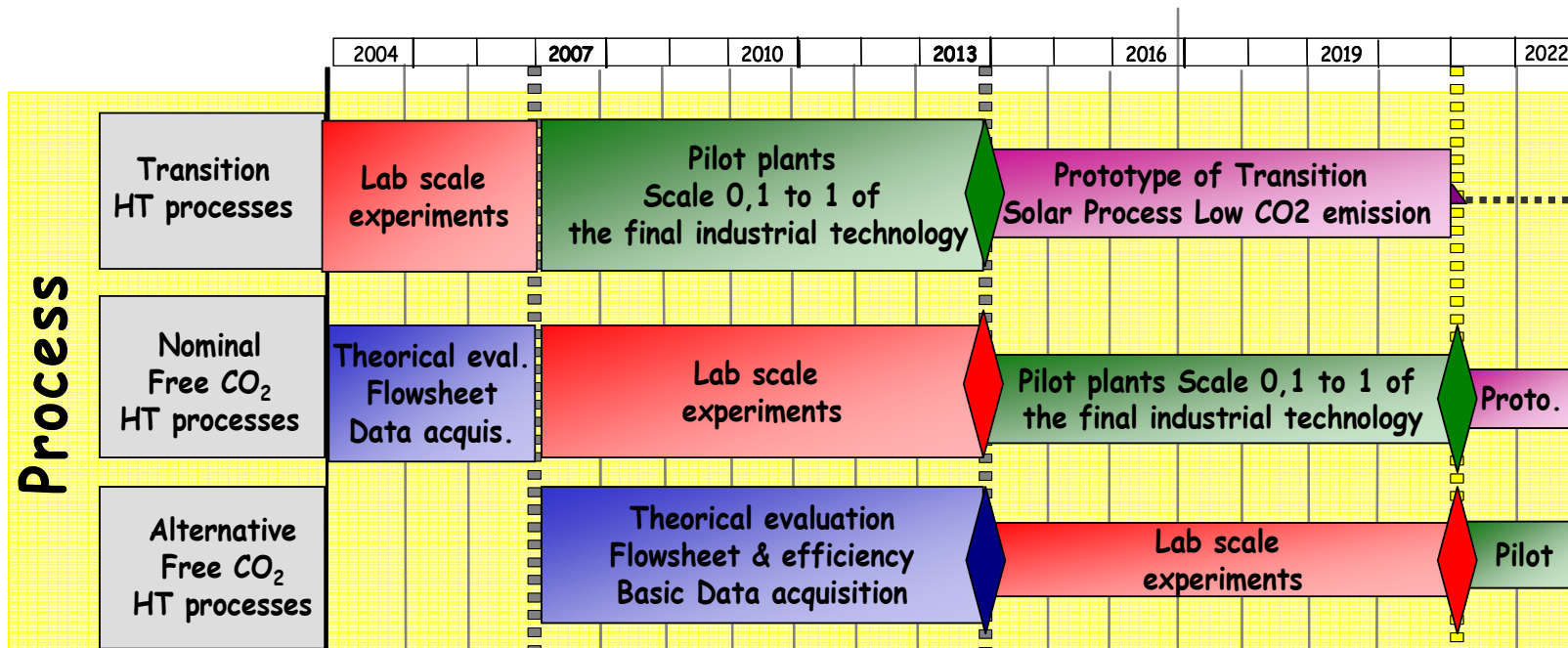
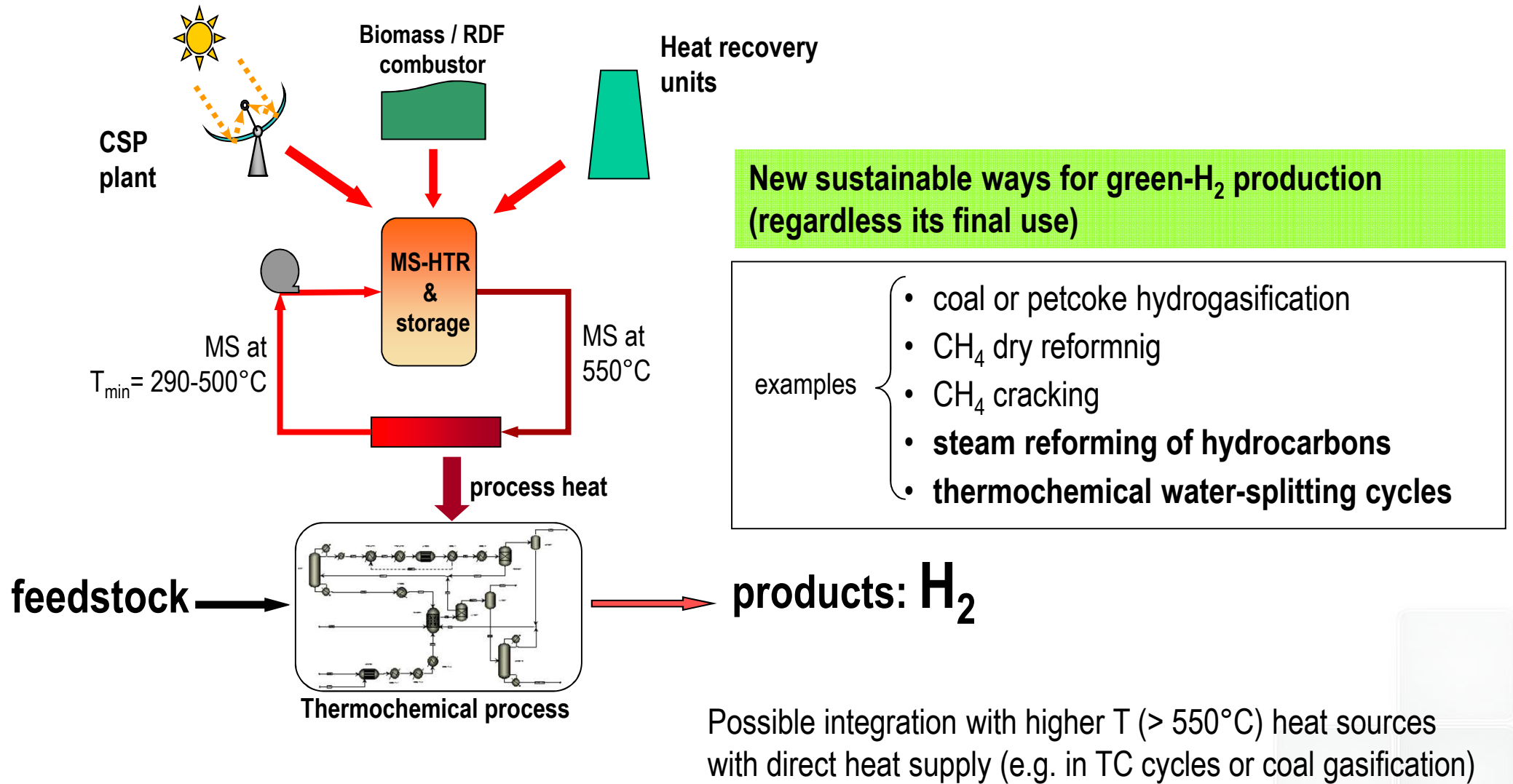


Figure adapted from: Innohyp CA project (EC 6th FP) final report

Thermochemical processes powered by C-free sources

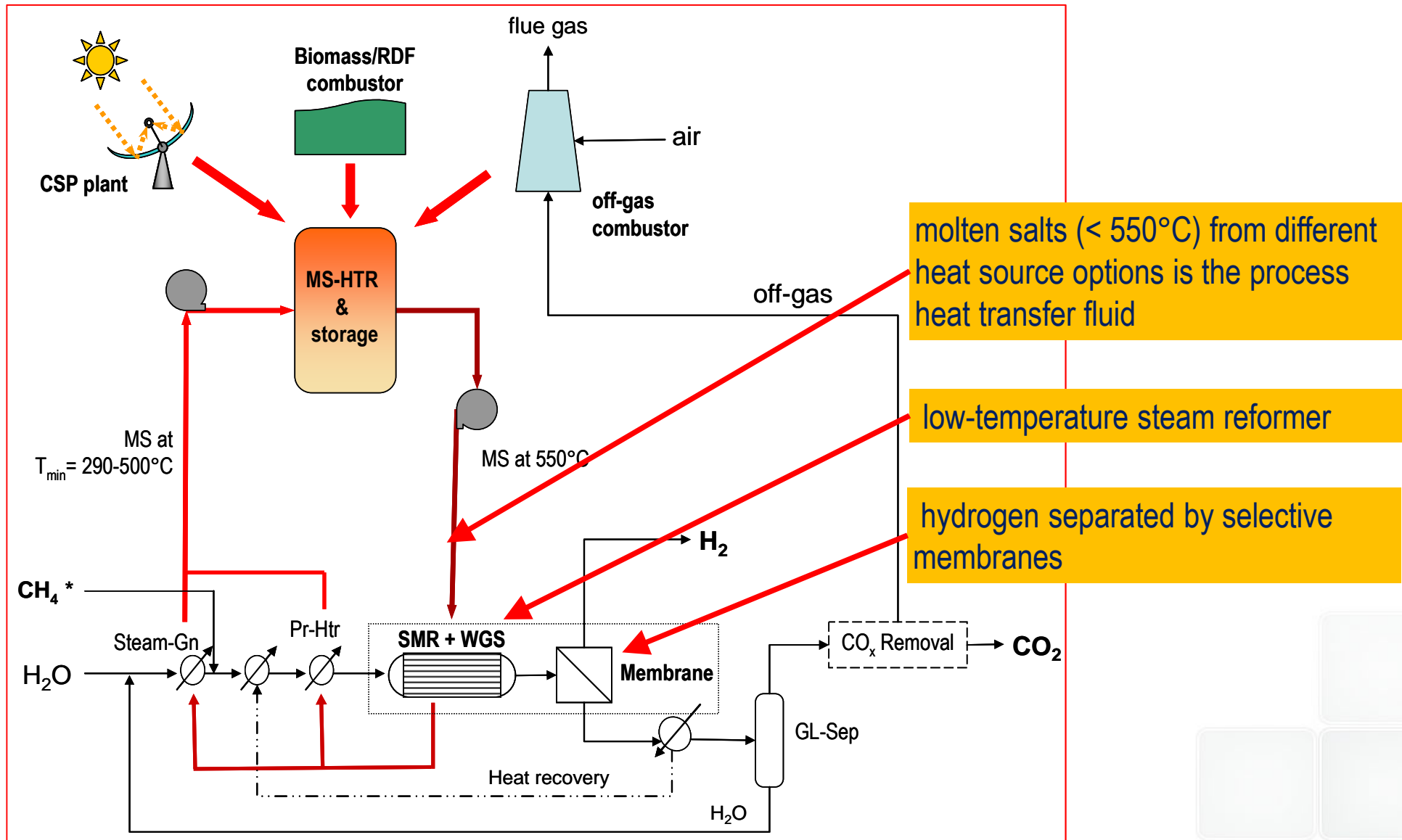


CoMETHy: “**C**ompact **M**ultifuel-**E**nergy **T**o **H**ydrogen converter”

- ✓ Call: FP7-SP1-JTI-FCH.2010.2.2: Development of fuel processing catalyst, modules and systems (Application Area: Hydrogen production & distribution)
- ✓ Duration (3 years): December 2011 → November 2014
- ✓ Budget: ca. 5 M€ (FCH JU contribution: ca. 2,5 M€)
- ✓ 12 partners from Italy, Germany, the Netherlands, Greece, Israel

General objective

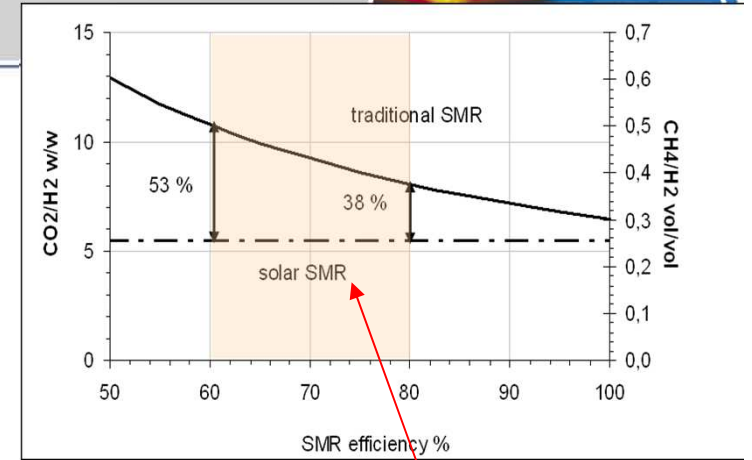
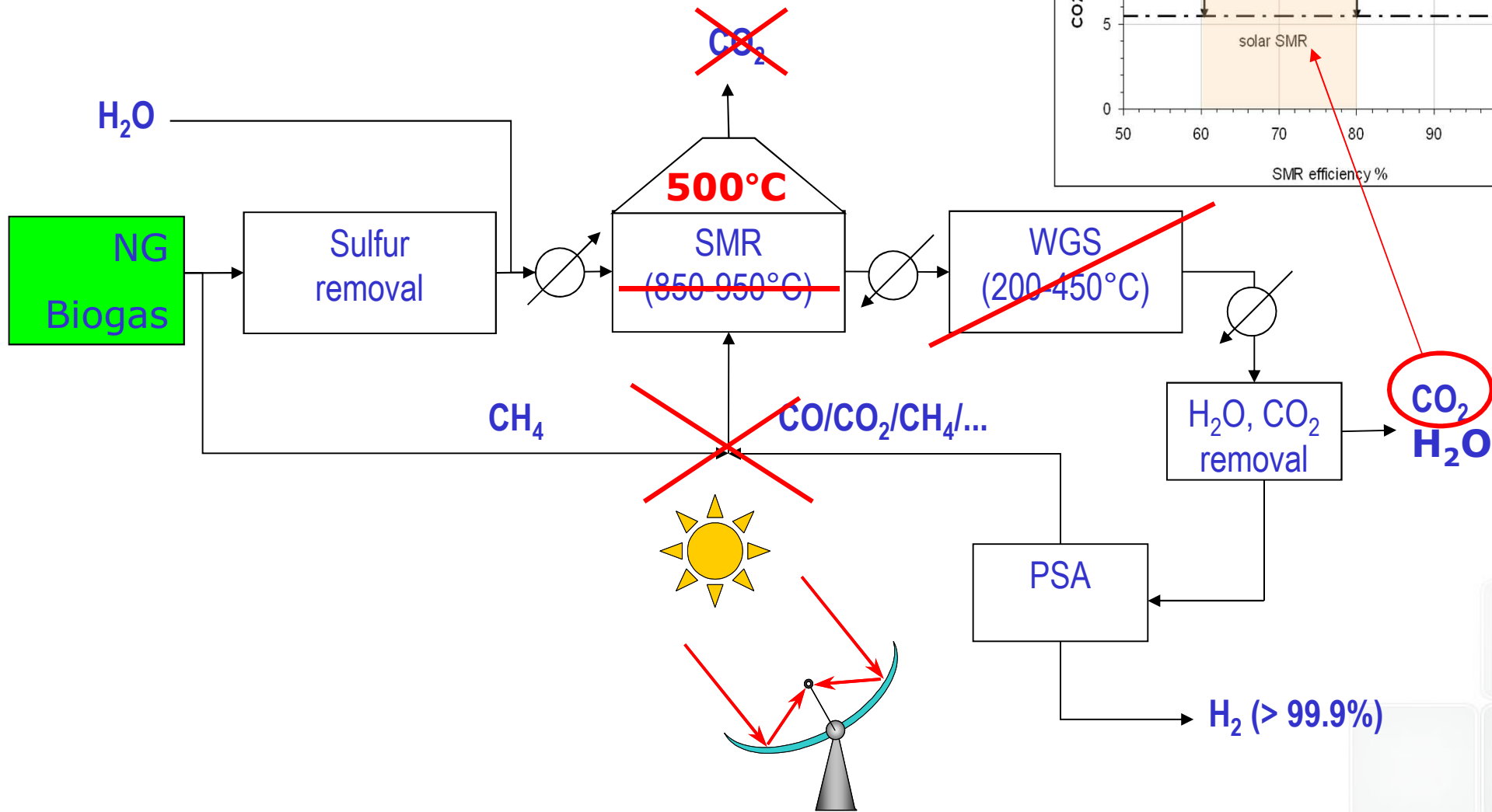
CoMETHy aims at developing an innovative compact and modular steam reformer to convert reformable fuels (methane, ethanol, etc.) to pure hydrogen, adaptable to several heat sources (solar, biomass, fossil, etc.), depending on the locally available energy mix.



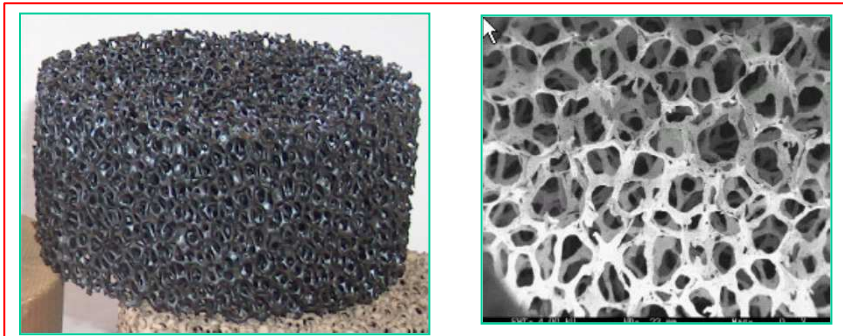
Low-temperature SMR powered by C-free sources



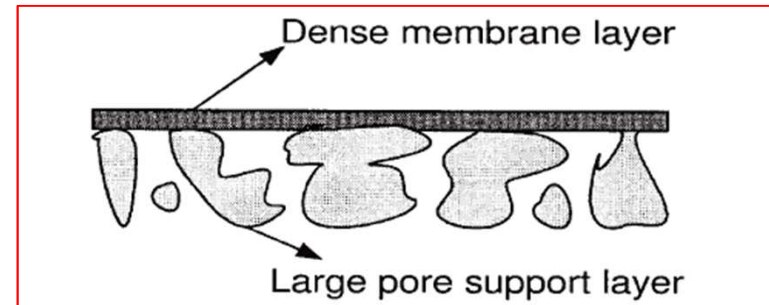
Conventional vs. Solar SMR Route:



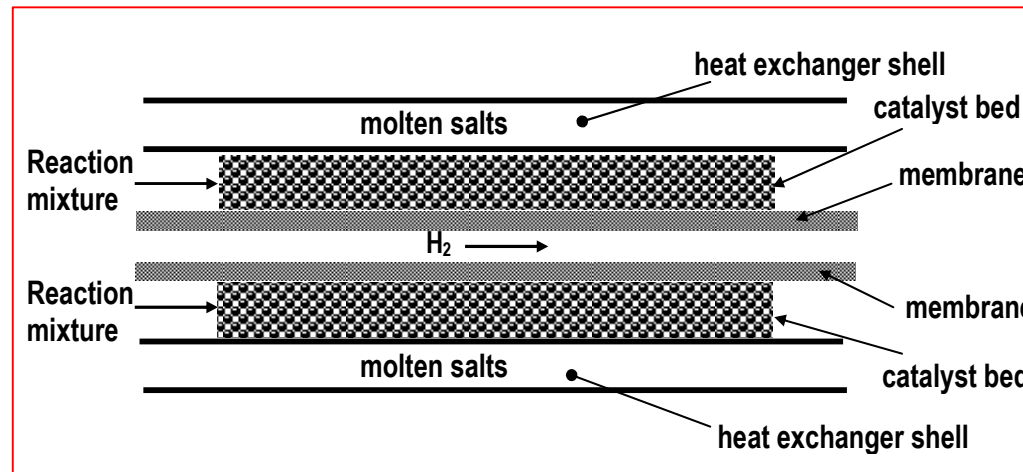
Advanced catalysts for low-temperature steam reforming (NG, biogas, ethanol)



Selective membranes for hydrogen separation



Membrane reactor design



ENEA's experience in molten salts and CSP technology

Solar Thermodynamic Laboratory in Casaccia RC



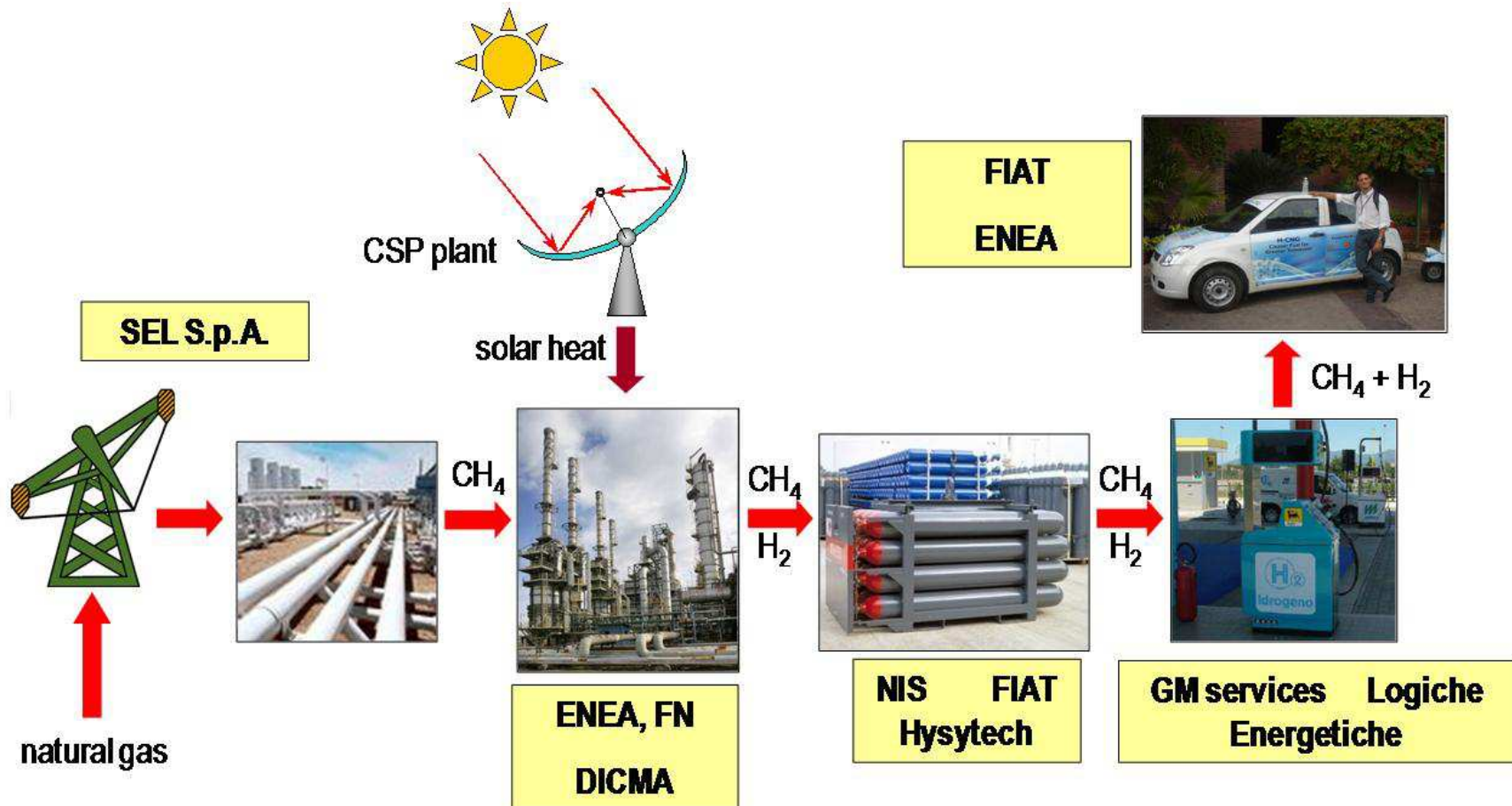
ENEL plant in Priolo Gargallo (Sicily)



MET.I.SOL. Project

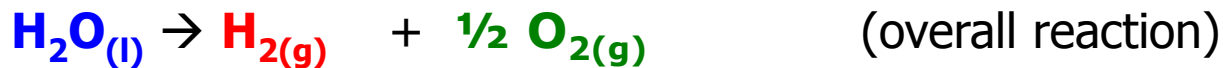
METISOL: “Produzione di miscele **MET**ano-Idrogeno con cicli termochimici alimentati da energia **SOL**are e sistemi di stoccaggio a bordo veicolo”

- ✓ Funded by: Ministero dell’Ambiente e della Tutela del Territorio e del Mare
- ✓ Call: Bando per il finanziamento di progetti di ricerca finalizzati ad interventi di efficienza energetica e all’utilizzo delle fonti di energia rinnovabile in aree urbane
- ✓ Duration (2 years): February 2010 → February 2012; Budget: ca. 3 M€



Sulfur-Iodine (S-I) cycle

- 1) $2\text{H}_2\text{O}_{(l)} + \text{I}_2 + \text{SO}_2 \rightarrow 2\text{HI}_{(l)} + \text{H}_2\text{SO}_{4(l)}$ (Bunsen reaction, 25-120°C)
- 2) $2\text{HI}_{(g)} \rightarrow \text{H}_{2(g)} + \text{I}_{2(g)}$ (350-550°C)
- 3) $\text{H}_2\text{SO}_{4(g)} \rightarrow \text{H}_2\text{O}_{(g)} + \text{SO}_{2(g)} + \frac{1}{2} \text{O}_{2(g)}$ (800-1000°C)



R&D activities are carried out in the framework of 2 projects:

→ HycycleS EC-funded project (2008-10)



→ TEPSI national project (2005-10)



Scientific feasibility demonstrated at the bench scale (10 NI/h hydrogen production)

Syngas production from biomass

Some biomass gasification activities carried out at the ENEA-Trisaia research center in the framework of National and European programs.

500 kW_{th} Circulating fluid bed



ENEA Trisaia Research Centre

1 MW_{th} Fluidized bed



ENEA Trisaia Research Centre

Anaerobic digestion of food and zoo-technical wastes

Energetic valorisation of zoo-technical industry wastes.



Biomasse

**Riduzione dei costi
di smaltimento
dei rifiuti
Riciclo dei materiali**

Anaerobic
digestion

Biogas (H_2 , CH_4)

Thank you for your attention!