NEMESIS 2+ (278138)

Programme Review Days 2012
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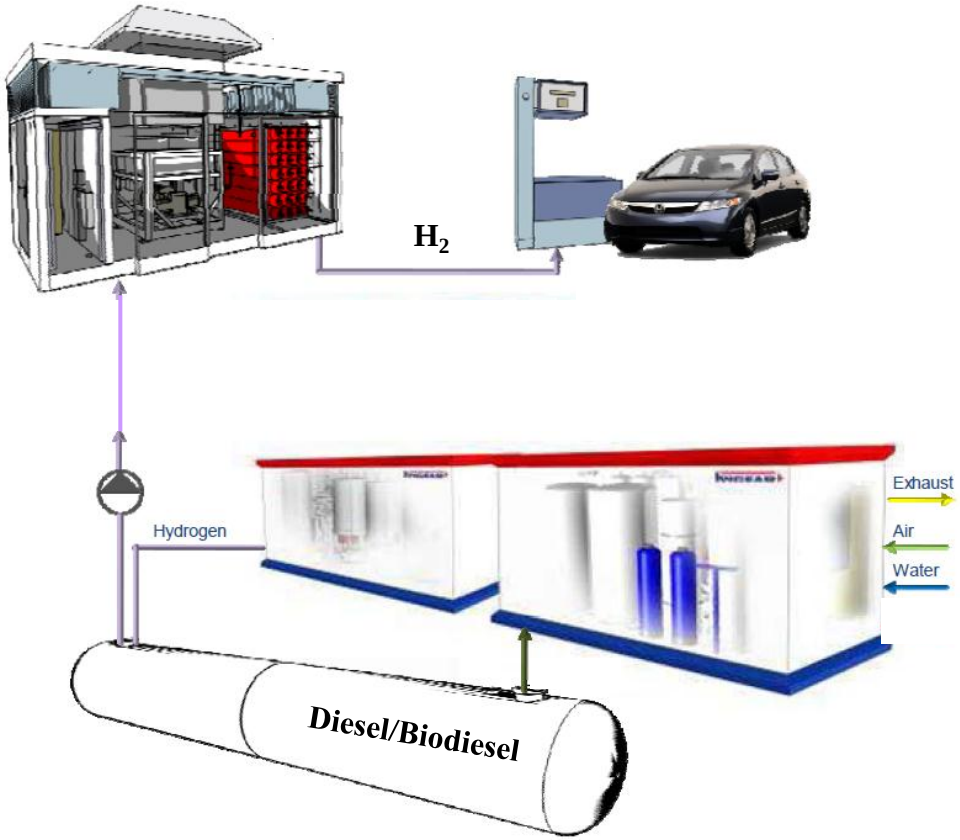
General Overview

- New Method for Superior Integrated Hydrogen Generation System 2+
- Duration: 36 months (01/2012 – 12/2014)
- Total budget: € 3.393.062, FCH contribution: € 1.614.944
- Collaborative project, 7 beneficiaries (3 from industry, 3 from research, 1 SME)

No.	Participant Organisation Name	Short Name	Country
1	Deutsches Zentrum für Luft- und Raumfahrt e.V.	DLR	Germany
2	HyGear B.V.	HYG	The Netherlands
3	Johnson Matthey PLC.	JM	United Kingdom
4	Abengoa Hidrógeno, S.A.	AH	Spain
5	Abengoa Bioenergía San Roque, S.A.	ABSR	Spain
6	Centre for Research and Technology Hellas	APTL	Greece
7	Instituto Superior Técnico	IST	Portugal

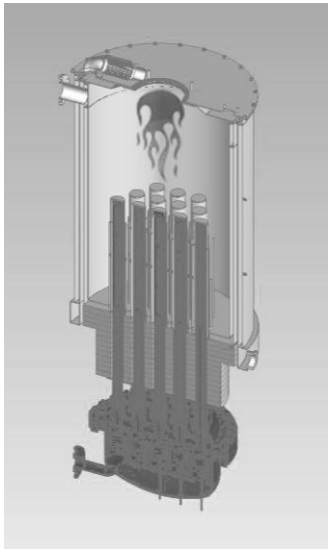
☛ Project Concept

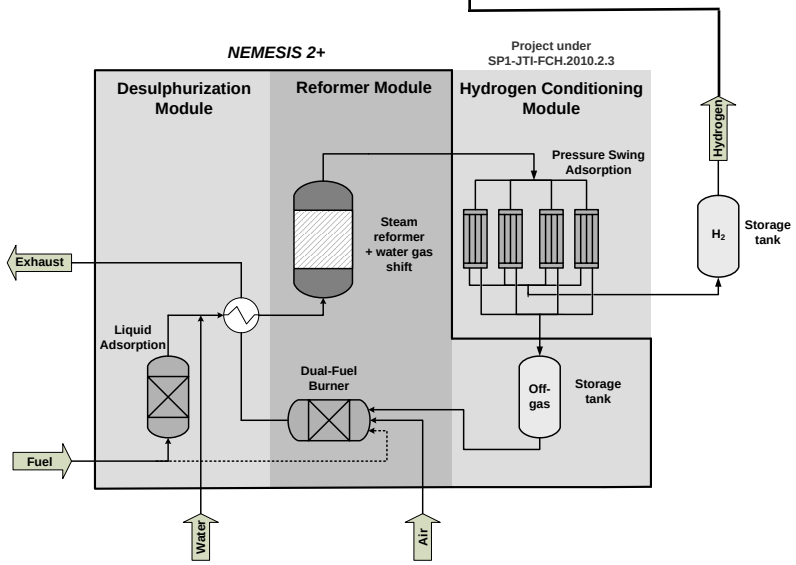
On-site hydrogen production at refuelling stations from diesel and biodiesel



☛ Project Targets

- Development of a pre-commercial hydrogen generator (50 Nm^3/h)
- Feedstock: diesel and biodiesel; steam reforming technology
- High overall system efficiency (> 70 %), stable long-term operation (1000 h), H_2-purity 5.0
- Reduction of hydrogen production costs (< 4 € per kg)





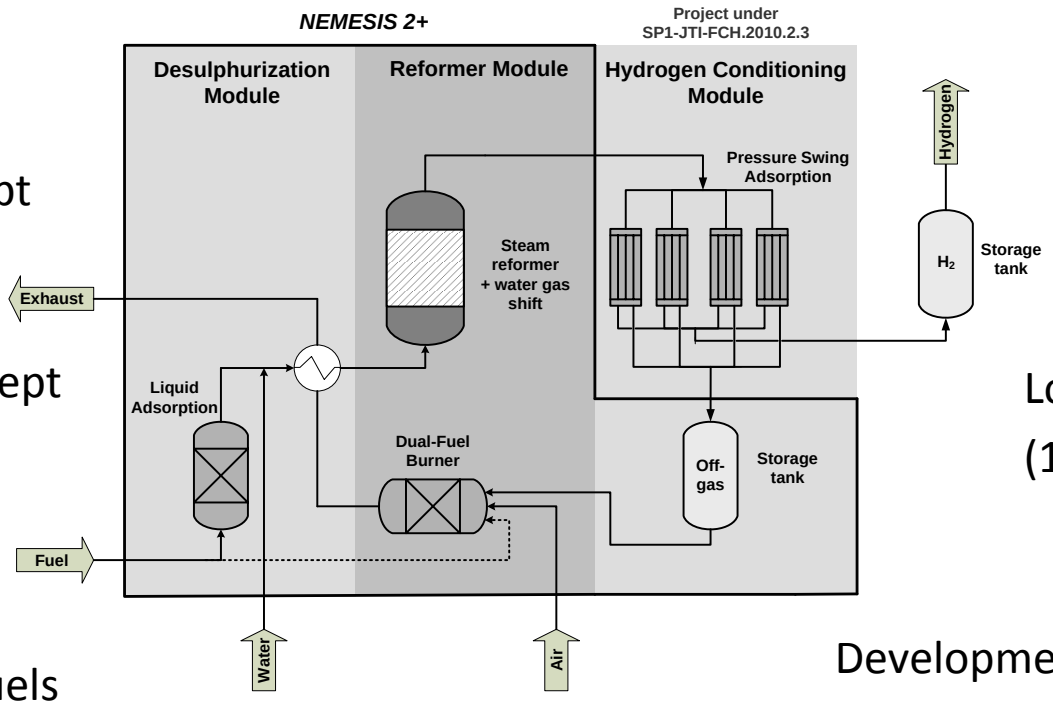
☛ Approach

Pressurized steam reforming (12 bar)

„One-reformer“-concept

Innovative desulph. concept (liquid phase adsorption)

Focus on liquid fuels (diesel, biodiesel)



Scale up from 5 to 50 Nm^3/h

Long-term testing (1000 h)

Development of S-tolerant and coke-resistant catalysts

Elaborated heat management

☛ Testing procedures

Fuel characterization

- Diesel analysis according to EN 590
- Biodiesel analysis according to EN 14214
- Sulphur analysis of liquid fuels according to ASTM D5453 (ISO 20846)

Catalyst characterization

- Characterization of catalyst surface using in-house test procedure
- Analysis of coke and sulphur deposits on catalyst surface (in-house procedure)

Techno-economic Evaluation

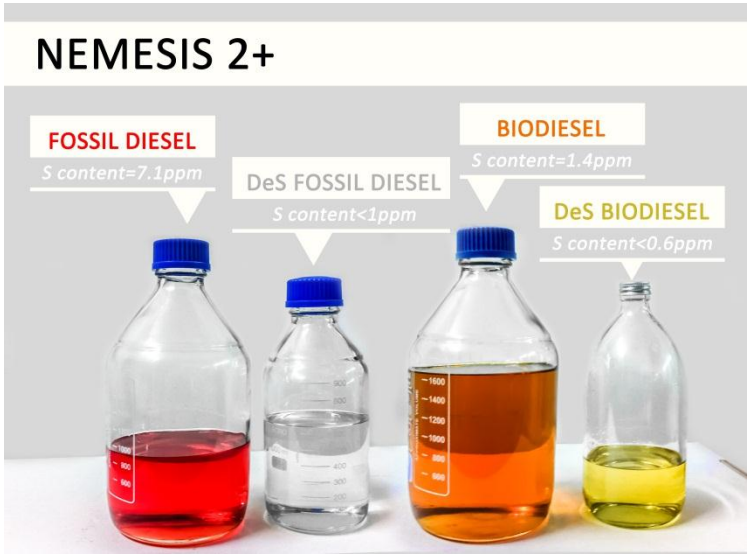
- Life cycle assessment of S-reduced biodiesel according to ISO 14040 and directive 2009/28/EC

☛ Technical Accomplishments and Progress towards overall SoA

- **WP 1 "Definition Phase":** Fuels (diesel, biodiesel) characterized and supplied to partners, System Specification document agreed between partners. ✓
- **WP 2 "System simulation":** Existing 50 Nm^3/h system of HyGear based on natural gas implemented into Aspen Plus and validated with experimental data, Preliminary calculations carried out using diesel and biodiesel→ results provided to partners ✓
- **WP 3 "Liquid Desulphurization"**: ✓

Promising regenerable sorbent material identified:

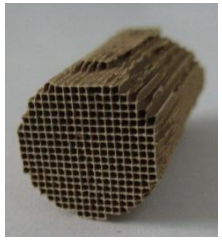
- Sulphur content < 2 ppm (<1 ppm) can be achieved for diesel (biodiesel)
- DeS process has no or negligible effect on the (bio)diesel properties of interest
- A relevant prototype will be designed and implemented



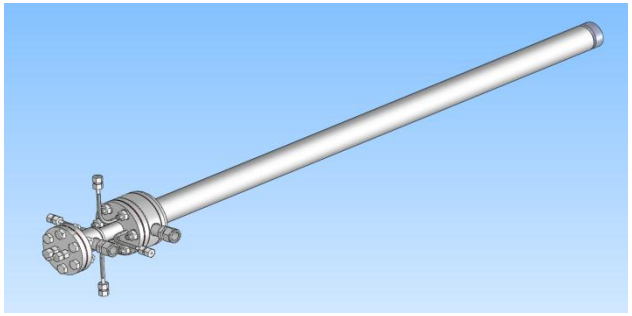
☛ Technical Accomplishments and Progress towards overall SoA II

* *www.nemesis-project.eu*

- **WP 4 "Catalyst Development":** JM: Initial performance screening → Pt-group reforming catalysts identified with increased activity;
  IST: Construction and commissioning of WGS test-rig
  DLR: Test campaign with biodiesel finished→ Optimum operating conditions identified.
  Next: Evaluate influence of sulphur on reforming and WGS + long-term testing (100 h).



- **WP 5 "Reformer Module**": HYG: Preliminary design studies based on current natural gas system, Single reformer tube sent to DLR → Mapping of operational window
  IST: CFD-modeling of burner and combustion chamber, preliminary testing of dual fuel burner (atomization tests, spray characterization)



- **WP 6 "Prototype"** and **7 "Techno-economic evaluation "**: → Start in month 19
- **WP 8 "Coordination":** Public website*, 3 page-article in Nov. Issue of "*International Innovation Report*"

Correlation of the project with the corresponding Application Area (as mentioned in MAIP/AIP documents):

- Area addressed: **"Hydrogen Production & Distribution"**

- Aim: Develop a portfolio of sustainable hydrogen production, storage and distribution processes which can meet 10 % - 20 % of the hydrogen demand for energy applications from carbon-free or lean energy sources by 2015.
- Approach: Demonstrate various sustainable hydrogen production and supply chains (ready for commercialization by 2013) + exploit synergies with Area "Transportation & Refuelling Infrastructure"
- Improve hydrogen production efficiency
- Enhance cost competiveness of renewable hydrogen production

Detailed project activities & results/achievements versus MAIP/AIP document targets

Expected output AIP Topic: "Development of fuel processing catalyst, modules and systems" Call: 2010	Objectives NEMESIS2+	Status at 30% of the project	Expected revised objectives
System efficiency (%): > 80 conversion efficiency (HHV H_2 (5.0)/HHV fuel) *Electrical consumption < 0,1 kWh/(Nm^3 H_2, 10 bar)*	*> 80* *< 0,1*	N/A (tests not finalized)	*> 70* *< 0,1*
System cost after 6 years (€): < 5.000 /(Nm^3 H_2)	*< 5.000*	N/A (prototype not yet built)	*< 5.000*
Scalability (Nm^3/h): 2 - 750	*5-750*	N/A (tests not finalized)	> 1.000 Nm^3/h possible
Catalyst durability: Adding 5 ppm of H_2S to the feed results in a < 20 % decrease in hydrogen production + long-term catalyst stability	*< 20 % decrease*	< 2 % decrease over 12 hours	< 2 % proof long-term stability (1000 h)
Availability/Recyclability: Catalyst Replaceable within 4 hours, active metal recovery > 85 %	*< 4 hours* *> 85 %*	< 4 hours Recyclability to be determined	*< 4 hours* *> 85 %*

Identify and comment on gaps/bottlenecks in RTD&D proposed by MAIP/AIP documents:

- Consider food-fuel competition
- Consider availability of different feedstock (biodiesel, bioethanol etc.) and regulatory framework

Comments on priorities and topics possibly under/over-estimated in the AIPs in terms of technical challenge

- Over-estimated: Conversion efficiency targets (→ Focus on H_2-production costs!)
- Under-estimated: Development of S-tolerant catalysts (→ more systematic approach! + use synergies between projects)

How project addresses and contributes to:

- Training and Education: Dissemination plan will be established at midterm including training and education events. Final workshop will be held at the end of the project → Present results to stakeholders and industry.
- Safety, Regulations, Codes and Standards: Improve in-house test procedures
- Dissemination & public awareness: 3-page article appeared in November Issue of "*International Innovation Report*", public project website (www.nemesis-project.eu) has been launched in October
- Information on publications: Master thesis "biodiesel reforming at elevated pressures", poster presentation on national conference.

- Technology Transfer / Collaborations
  - Synergy effect with Area “Transportation & Refuelling Infrastructure”: Hydrogen conditioning module developed under topic SP1-JTI-FCH.2010.2.3 by partner HyGear will be integrated into the NEMESIS2+ prototype in the last six month of the project.

- Project Future Perspectives
  - Proposed future research approach and relevance
    - Decision on final process setup will be taken at midterm, Strategy of Risk sharing between different routes (i.e. development of liquid desulphurization and S-tolerant catalysts). So far no deviations from work plan.
    - Possible contribution to the future FCH JU Programme: HyGear is in close contact with Dutch Ministery of Infrastructure & Environment (in collaboration with the French, German, Swedish and Danish governments) of Ten-T hydrogen roll-out project

Thank you for your attention!

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