IEA HIA Task 33

Local Hydrogen Supply for Energy Applications

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Objective & Goals

**Objective**
- Provide an unbiased evaluation of various pathways for local hydrogen supply

**Goals (Subtasks)**
1. **Assess local H2 supply systems and on-site H2-production technologies**
2. **Monitor, review, and evaluate** new on-site H2-production technologies & system concepts
3. **Study barriers & opportunities** for local H2 energy supply in existing & future markets
Scope of Work

Task 33 – Local H2 supply

Local Hydrogen Supply

End Users

Harmonize

Monitor

Assess

Review

Recommnd

Gas Companies

Car Companies

Technology Suppliers

Reformers

Electrolysers
Participants

Task 33 – Local H2 supply

16 members from 15 organizations in 11 countries
Subtasks

1. **Technology Assessment**
   - Technology Readyness Level; TRL = 7-9

2. **New Concepts**
   - Demonstration projects; TRL = 5-7

3. **Barriers & Opportunities**
Subtask 1
Technology Assessment

- **Alkaline Water Electrolysis**
  - Standard robust 60, 150, 300, 500 Nm³/h systems commercially available

Source: Hydrogenics

Source: NEL Hydrogen
Subtask 1
Technology Assessment

- **Alkaline Water Electrolysis (Industrial)**
  - MW-scale & durable commercial systems available
  - Technology not suitable for dynamic load following operation (<1 sec response)
  - Quick ramp-up (<10 min) to rated power possible

Source: NEL Hydrogen
Subtask 1  
Technology Assessment

- **PEM Water Electrolysis**
  - Compact, efficient, pressurized (30 bar)
  - 30-60 Nm³/h systems commercially available
  - 300 Nm³/h systems (MW) under development

Source: Proton Onsite
Subtask 1
Technology Assessment

Task 33 – Local H2 supply

Water Electrolyzers Costs (CAPEX)

Specific Cost [kUSD per Nm³/h]

Small-scale water electrolysis

Large scale water electrolysis

Hydrogen Production Capacity [Nm³/h]
Subtask 1  
Technology Assessment

Water Electrolyzer Costs

- **CAPEX:**
  - 5000-12000 USD per Nm³/h (50-500 Nm³/h)
  - **Stack costs 42-47%** of overall system costs
  - Reduce use of precious materials
  - Simplify balance of plant

- **OPEX**
  - Develop more efficient balance of plants
  - Operate at higher current densities

Task 33 – Local H2 supply
Subtask 1
Technology Assessment

- **Reformers**
  - Compact systems → Standard & Modular Systems
  - 10-300 Nm³/h systems commercially available

Task 33 – Local H₂ supply

Source: MKK  Source: HyGear
Subtask 1
Technology Assessment

Task 33 – Local H2 supply

Reformers Costs (CAPEX)

Specific Cost [kUSD per Nm³/h]

Hydrogen Production Capacity [Nm³/h]

Small-scale (on-site) reformers

Large scale (centralized) reformers
Subtask 1
Technology Assessment

Task 33 – Local H2 supply

Electrolyzer & Reformers Costs (CAPEX)

Specific Cost ($US*1000/Nm3/hr)

H2 Production Capacity (Nm3/hr)

PEM Electrolysis

Small-scale reformers

Large-scale reformers

PEMWE Cost Projection
Subtask 2
New Concepts

**Goal**
- Monitor and review new system concepts and technologies

**Activities:**
- Study fuel feedstock options and hydrogen production technologies
- Assess future demands on hydrogen quality
- Evaluate next generation technologies
Subtask 2
New Concepts

- **Renewable energy based systems:**

- **Power-to-Gas**
  - Power-to-hydrogen (H₂)
  - Power-to-methane (CH₄)

- **Biogas-to-Hydrogen**
  - CO₂-capture
  - Methanation
Subtask 2
New Concepts

Task 33 – Local H2 supply
Power-to-Gas, Hamburg, Germany

PEW Water Electrolyzer

\[ P_{\text{rated}} = 1 \text{ MW} \]
\[ P_{\text{max}} = 1.5 \text{ MW} \]
\[ \text{H}_2 = \text{ca. 200 Nm}^3/\text{h} \]

Source: Hydrogenics
Subtask 2
New Concepts

Task 33 – Local H₂ supply
Biogas to Hydrogen, Fukuoka, Japan

Source: MKK
## Subtask 2  
**New Concepts**  

**Task 33 – Local H2 supply**  

### Biogas to Hydrogen, Fukuoka, Japan

<table>
<thead>
<tr>
<th>Sub-system</th>
<th>Target Value</th>
<th>Experimental Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Biogas pretreatment facility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Biogas flow rate</td>
<td>$\geq 2,400 \text{Nm}^3/\text{day}$</td>
<td>$2,400 \text{Nm}^3/\text{day}$</td>
</tr>
<tr>
<td>(2) Siloxane</td>
<td>$\leq 0.265 \text{mg/Nm}^3$</td>
<td>$0.250 \text{mg/Nm}^3$</td>
</tr>
<tr>
<td>(3) Methane purity</td>
<td>$\geq 92%$</td>
<td>$93.7%$</td>
</tr>
<tr>
<td>(4) Recovery rate (Methane)</td>
<td>$\geq 90%$</td>
<td>$92.6%$</td>
</tr>
<tr>
<td><strong>2. H$_2$ production unit (Reformer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Hydrogen production</td>
<td>$\geq 3,302 \text{Nm}^3/\text{day}$</td>
<td>$3,311 \text{Nm}^3/\text{day}$</td>
</tr>
<tr>
<td><strong>3. High pressure H$_2$ supply system (HRS)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Pressure</td>
<td>82 MPa</td>
<td>82 MPa</td>
</tr>
<tr>
<td>(2) Loading speed</td>
<td>$\leq 5 \text{kg per 3 min}$</td>
<td>5.3 kg per 3 min</td>
</tr>
<tr>
<td><strong>4. CO$_2$ recovery unit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) CO$_2$ Concentration</td>
<td>$\geq 99%$</td>
<td>99.52%</td>
</tr>
<tr>
<td>(2) CO$_2$ Recovery rate</td>
<td>700 kg/day</td>
<td>765.6 kg/day</td>
</tr>
</tbody>
</table>

*Source: MKK*
Subtask 3
Barriers and Opportunities

Goal:
- Develop concepts for harmonization of technologies for local H2-supply

Activities:
- Study barriers & opportunities
- Develop new business cases
- Study standards and their relevance to technology
Subtask 3
Barriers and Opportunities

- **Technical factors**
  - Utilization profile, operation strategy, utilities, capacities, pressure, H₂ quality, etc.

- **Economic & External factors**
  - Gas company presence, environmental impact, regulatory codes & standards, safety, utilization rate, etc.
Subtask 3
Barriers and Opportunities

Task 33 – Local H₂ supply
Example: HRS for FC EVs

- 100 JPY/Nm³ = 10 EUR/kg
- Number of FCV Refuelings per day
  - On-site
  - Off-site JPY80/Nm³
  - Off-site JPY40/Nm³

Graph showing H₂ production cost [JPY/Nm³] vs. number of FCV refuelings per day: 14h/day vs. 24h/day.
Subtask 3
Barriers and Opportunities

Task 33 – Local H2 supply
Example: HRS for FC EVs

Source: Hydrogenics
Subtask 3
Barriers and Opportunities

Task 33 – Local H2 supply
Example: H₂ Comp. Costs

Input pressure: 5-15 bar
Output pressure: 200-300 bar

Graph showing relative capital cost of compressor (EUR/flow) versus kg/h.
Subtask 3
Barriers and Opportunities

Hydrogen quality & purification
- HRS for FC EVs have other requirements than industrial hydrogen applications
- Strict for some contaminants, but not so strict on others e.g., $\text{H}_2 > 99.97\%$; 0.2 ppm CO (SAE J 2716)
Subtask 3
Barriers and Opportunities

Task 33 – Local H2 supply
Example: HRS for FC EVs

- **Fueling Protocols**
  - High pressure & fast refueling requires pre-cooling

- **Hydrogen Quality**
  - Existing fuel standards for FC EVs are strict on impurities, particularly CO (0.2 ppm)

- **Conclusion** (Key Message):
  - The existing HRS fueling protocols and hydrogen quality standard for FC EVs are strict and lead to extra costs, but are not technical barriers
Summary

1. Technology Assessments
2. New Concepts
3. Barriers

Local Hydrogen Supply

- Harmonize
- Monitor
- Assess
- Review

End Users
- Gas Companies
- Car Companies

Technology Suppliers
- Reformers
- Electrolysers
## Participants

**Task 33 – Local H2 supply**

16 members from 15 organizations in 11 countries

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<tr>
<th>Name</th>
<th>Organization</th>
<th>Country</th>
<th>Category</th>
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<tbody>
<tr>
<td>Andrzej Chmura</td>
<td>Nissan EU Car Company</td>
<td>EU</td>
<td>Car Company</td>
</tr>
<tr>
<td>Andrew Murphy</td>
<td>Shell Netherlands End User (Gas)</td>
<td>Netherlands</td>
<td>End User (Gas)</td>
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<tr>
<td>Bjørn Simonsen</td>
<td>NEL Hydrogen Norway Electrolyzers</td>
<td>Norway</td>
<td>Electrolyzers</td>
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<tr>
<td>Christian Hulteberg</td>
<td>Lund University Sweden Research</td>
<td>Sweden</td>
<td>Research</td>
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<tr>
<td>Dick Lieftink</td>
<td>HyGear Netherlands Reformers</td>
<td>Netherlands</td>
<td>Reformers</td>
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<tr>
<td>Everett Anderson</td>
<td>Proton Onsite USA Electrolyzers</td>
<td>USA</td>
<td>Electrolyzers</td>
</tr>
<tr>
<td>Fredrik Silversand</td>
<td>Catator AB Sweden Reformers</td>
<td>Sweden</td>
<td>Reformers</td>
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<tr>
<td>Georgios Tsotridis</td>
<td>Joint Research Centre EU Research</td>
<td>EU</td>
<td>Research</td>
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<tr>
<td>Jacques Saint-Just</td>
<td>GDF SUEZ France End User (Energy)</td>
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<tr>
<td>John Bøgild Hansen</td>
<td>Haldor Topsö Denmark Reformers</td>
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<td>Ralph Staß</td>
<td>Mahler AGS Germany Reformers</td>
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<tr>
<td>Retsu Hayashida</td>
<td>Mitsubishi Kakoki Kaisha Japan Reformers</td>
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<td>Roel De Maeyer</td>
<td>Hydrogenics Belgium Electrolyzers</td>
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<tr>
<td>Stefan Neis</td>
<td>WaterstofNet Belgium Hydrogen Stations</td>
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<tr>
<td>Stéphane Fortin</td>
<td>ENGIE (former GDF SUEZ) France End User (Energy)</td>
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<tr>
<td>Øystein Ulleberg</td>
<td>Institute for Energy Technology Norway</td>
<td>Norway</td>
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Thank you for your attention!

IEA HIA Task 33 – Local Hydrogen Supply

A premier global resource for technical expertise in H2 RD&D

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