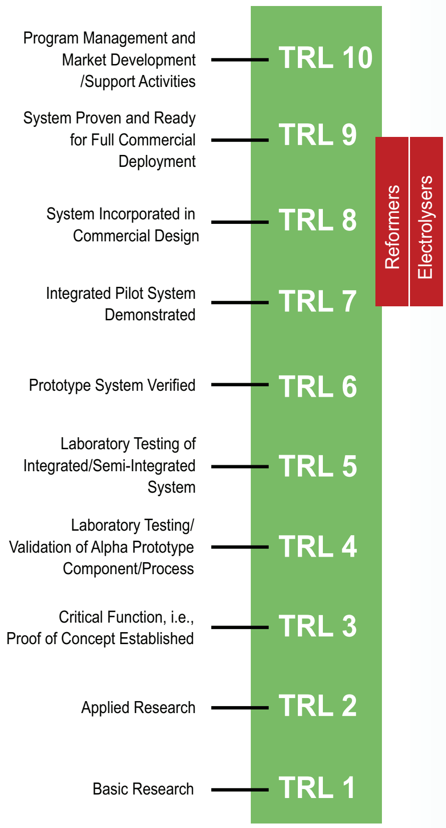
TECHNOLOGY OVERVIEW

STATUS OF THE TECHNOLOGY

Local hydrogen supply systems based on water electrolysis or reforming can be used in various energy applications. These applications include hydrogen refueling stations for fuel cell vehicles (FCVs), production of other alternative fuels and storage of renewable energy. The markets for local hydrogen supply systems are still relatively new. In order to make local hydrogen supply systems commercially viable in existing and future energy markets, standardized system solutions and more efficient key technologies are needed.

TECHNOLOGY READINESS LEVEL (TRL)

On-site small-scale reformers and water electrolyzer systems are modular, and can be developed for many different sizes and capacities. Several international companies supply on-site hydrogen production systems, and the technology readiness level is high (TRL 7–9).



The key technologies are currently commercially available, but significant improvements for energy applications can be made relative to efficiency and costs, especially on a system level. In order to achieve efficiency improvements and cost reduction, it is necessary to further reduce the amount of materials used in the key components (e.g. water electrolyzer stacks) and to develop more efficient balance of plants (e.g., gas clean-up and purification, compression, electrical systems and controls). Standard and more compact designs for containerized local hydrogen production system must be developed to enable mass production of components. This can only be achieved via a close collaboration between suppliers and end-users.

FRAMEWORK SUMMARY

The main purpose of Task 33 is to contribute to the development, evaluation and harmonization of on-site hydrogen production technologies and systems in order to facilitate optimal use of local feedstocks and removal of barriers that delay introduction of these systems in energy markets. This will be achieved by continuing and strengthening an existing IEA network of reformer and electrolyzer technology providers and hydrogen end-users, including gas and car companies (Figure 1). Task 33 – Local Hydrogen Supply for Energy Applications (2013–2015) is a continuation of Task 23 – Small-Scale Reformers for On-Site Hydrogen Supply (2006–2011) and Annex 16 Subtask C – Small Stationary Reformers for Distributed Hydrogen Production (2002–2005).

TASK 33

LOCAL HYDROGEN SUPPLY FOR ENERGY APPLICATIONS

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VITAL STATISTICS

Term

Dates

2013–2016

Members

Belgium, Denmark, France, Germany, Japan, Norway, Sweden, The Netherlands, USA

Expert Participants

17

2014 Meetings

Lenzburg, Switzerland, 20–21 February

Oevel, Belgium, 23–24 September

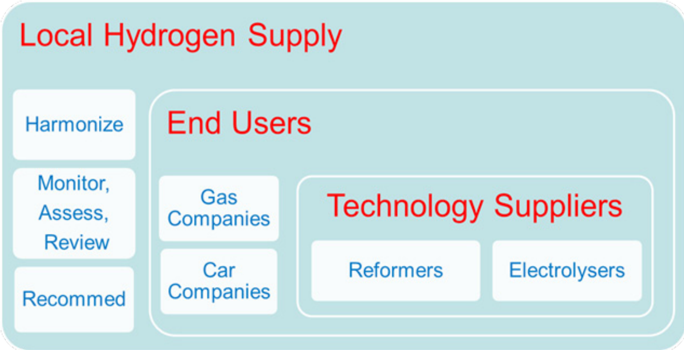

Figure 1 – Overview of Task 33 on local hydrogen production

It therefore follows that the main objective of Task 33 is to provide an unbiased evaluation of various pathways for local hydrogen supply for energy applications. The sub-goals are to:

1. Assess local hydrogen supply systems and on-site hydrogen production technologies.
2. Monitor, review and evaluate new on-site hydrogen production technologies and system concepts.
3. Study barriers and opportunities for local hydrogen energy supply in existing and future energy markets.

SUBTASK I – TECHNOLOGY ASSESSMENT

Subtask 1 Leader: Everett Anderson, Proton Onsite, USA

The goal of Subtask 1 is to assess the technological and economic level of available on-site hydrogen supply. The sub-goals within Subtask 1 are to evaluate system design (modularization, etc.), operation (compressor challenges etc.), costs (CAPEX and OPEX) and to propose how to reduce costs (standardization, manufacturing, etc.).

SUBTASK 2 – NEW CONCEPTS

Subtask 2 Leader: Christian Hulteberg, Lund University, Sweden

The goal of Subtask 2 is to monitor and review new system concepts and technologies for local hydrogen production. The sub-goals within Subtask 2 are to study fuel feedstock options and available hydrogen production technologies, assess future demands on hydrogen quality and evaluate next generation reformers and electrolyzer technologies and system concepts.

SUBTASK 3 – BARRIERS AND OPPORTUNITIES

Subtask 3 Leader: Magdy Meimari, Air Liquide, France

The goal of Subtask 3 is to develop concepts for harmonization of technologies for local hydrogen supply. The sub-goals within Subtask 3 are to study barriers and opportunities for local hydrogen supply, develop new business cases, study standards and their relevance to the technology and develop technological interfaces to support the social acceptance of local hydrogen production systems.

MEMBERS

TASK MEMBER AND EXPERT TABLE 2013

COUNTRY	ORGANIZATION	EXPERT
Belgium	Hydrogenics	Roel De Maeyer
Belgium	WaterstofNET	Adwin Martens
Denmark	Haldor Topsoe	John Bøgild Hansen
France	GDF Suez	Jacques Saint-Just
France	GDF Suez	Stephane Fortin
France	Air Liquide	Magdy Meimari
France	Nissan Europe	Olivier Paturet
Germany	Mahler AGS	Ralph Stauss
Japan	Mitsubishi Kakoki Kaisha	Retsu Hayashida
Norway	Institute for Energy Technology	Øystein Ulleberg
Norway	NELHydrogen	Bjørn Simonsen
Netherlands	HyGear	Dick Lieftink
Netherlands	Joint Research Centre (JRC)	Georgios Tsotridis
Netherlands	Shell	Andrew Murphy
Sweden	Catator	Fredrik Silversand
Sweden	Lund University	Christian Hulteberg
USA	Proton Onsite	Everett Anderson

COMMENTS ON GROWTH/CHANGES IN MEMBER AND/OR EXPERT PARTICIPANT COMPOSITION

The number of participants (17) in Task 33 is stable and has slightly increased from 2013. A person from WaterstofNET (Belgium) and a new person from GDF Suez (France) joined the group in 2014. There will be a new representative from Air Liquide (France) in 2015.

ACTIVITIES AND RESULTS IN 2011

PROGRESS AND ACCOMPLISHMENTS

Subtask 1 – Technology Assessment of Water Electrolyzers

Small-scale water electrolyzers are typically delivered in modular and containerized systems with a hydrogen production capacity of 30–60 Nm^3/h consisting of several small stacks (10–15 Nm^3/h). New and more efficient water electrolyzer technologies for 1–2 MW systems are under commercial development. Stack costs are still the most dominant cost driver for small water electrolyzers; the stack costs account for about 42–47% of the overall CAPEX. In comparison, large-scale (>1000 Nm^3/h) industrial alkaline water electrolyzer systems have a specific cost around $4000–5000 USD per Nm^3/h. New PEM water electrolyzers capable of operating at high current densities for better integration with fluctuating renewable power system are under development. On a system level there is a focus on reducing the amount of components and materials, and on the development of more efficient balance of plants and power conversion systems.

Subtask 1 – Technology Assessment of Reformers

New and more flexible designs for reformer units with respect to hydrogen production (1–50 Nm^3/h per reformer tube) are under development. As well, highly compact (containerized) reformer systems (250 Nm^3/h) are now being tested and validated. For small-scale reformer systems in the low range (50–100 Nm^3/h), the main cost reductions (CAPEX) can be obtained through scale-up by increasing the sales volume. For small-scale reformers in the high range (250–500 Nm^3/h), the largest cost savings can be achieved by using less materials and making the systems more compact.

The specific costs (CAPEX) for small-scale reformers is around $5000–12000 USD per Nm^3/h, depending on the capacity (50–500 Nm^3/h). In comparison, large-scale (>1000 Nm^3/h) reformers have a specific cost around $1000–3000 USD per Nm^3/h. These results indicate that compact local small-scale reformers with a large hydrogen capacity (500 Nm^3/h) may be competitive with more traditional centralized large-scale reformers with a low hydrogen production capacity (1000 Nm^3/h), depending on the local situation with respect to fuel supply and hydrogen distribution.

Subtask 2 – New Concepts

New concepts for local hydrogen production have been analysed, with a focus on concepts that address the following two major future energy challenges:

1. Uptake of the increased amount of variable renewable energy
2. Large scale storage of renewable energy

Different Power-to-Gas (PtG) concepts have been studied. This research utilizes renewable energy based hydrogen (produced via water electrolysis) for CO_2 methanation that increases the yield from the same amount of substrate (e.g. biogas). Water electrolyzer companies are mainly focusing on low-temperature water electrolysis, which requires separate handling of H_2 and CO_2 before the gases are combined in a methanator.

The two main challenges with the PtG-concept based on low-temperature water electrolysis are the low overall energy efficiency and high cost. An alternative PtG-concept is to use high-temperature solid oxide electrolysis (SOECs). However, the product gas is a syngas (SNG or upgraded biogas) and hydrogen is only used internally in the process. The high-temperature SOEC option has the best potential for a high energy conversion efficiency (up to 80% overall energy efficiency).

New sorption enhanced reforming (SER) concepts are also under development. SER has the potential for high overall conversion efficiency (up to 95% hydrogen yield) combined with CO_2-capture. Local hydrogen production via reforming of biogas from waste water treatment plants has been identified as a near-term application for small-scale reformers.

There are several economic and financial issues related to the PtG-concept. Today, it is possible to monetize the energy content of an RE-based gas, but it is not possible to monetize the value of the climate benefit. Barriers for energy storage assets must be removed, markets for load-based ancillary services must be created and the climate value must be monetized. Today there exist few tariffs for biogas and renewable SNG. In the future it will be necessary to value the renewable H_2 or SNG for decarbonizing the gas grid, heat sector and transportation sector.

Subtask 3 – Opportunities and Barriers

There are several opportunities for and barriers to local hydrogen supply systems. A comparison between on-site hydrogen production and bulk hydrogen delivered by trucks is summarized in the table below. Specific opportunities and challenges relating to hydrogen refuelling stations (HRS) have been studied. The growing market for HRS for fuel cell electric vehicles (FCEVs) is one of the main opportunities for local hydrogen supply systems. However, one of the major challenges with this market is the strict standard on hydrogen quality for FCEVs (SAE 2719), which requires a hydrogen quality of 9.995% and < 0.2 ppm CO, among others. Small-scale hydrogen production systems can meet these technical requirements at nominal operating conditions, but there are challenges with energy efficiency for systems with frequent start/stops, particularly for reformer based systems. Furthermore, the FCEV standard also makes it necessary to install sophisticated and expensive gas monitoring systems.

SUPPLY MODE	BULK	ON-SITE
Description	• Tube trailer swap • Ground tubes	• Electrolyser • SMR • Bulk back-up
Technical / operational barriers	• Location • Access • Safety • Regulatory codes	• Same as bulk delivery • Indoor / outdoor • Duty cycle / operating profile • Sizing vs. backup • Access to utilities/feedstock
Financial barriers	• Capital investment • Profitability - Market price - Cost of molecules - Distribution cost	• Capital investment • Profitability - Low bulk market price - Contractual commitment
Economic barriers	• Traffic • Safety • Carbon footprint	• CO_2 emissions (SMR)
Opportunities	• High storage pressure • Standard docking station design • Harmonized regulatory standards • Use up excess bulk	• Cost reduction (SMR) • Electrical efficiency (electrolyser) • On-site / filling station model

FUTURE WORK

Two expert meetings with workshops are planned, along with participation in WHTC2015 in Sydney.

A possible follow-up of Task 33 (from 2016) will be discussed at meetings in 2015.

REFERENCES

Task 33 was presented at the WHEC 2014 conference in Gwangju, South Korea.

Task 33 Operating Agent Dr. Ulleberg contributed to *"FCH JU – Fuel Cell Distributed Generation Commercialisation Study"* by Roland Berger