



## **Integrated design for demonstration of efficient liquefaction of hydrogen (IDEALHY)**

### **Fuel Cells and Hydrogen Joint Undertaking (FCH JU)**

Grant Agreement Number 278177

Title: Report on Efficiency and Cost Calculations

Authors /  
Project Partner: David Berstad, Petter Nekså,  
Harald T. Walnum / SINTEF Energi AS  
Lutz Decker / Linde Kryotechnik AG  
Alice Elliott / Shell Global Solutions  
International B.V.  
Hans Quack / Technische Universität Dresden

Work Package: Component Assessment and Optimisation of  
Feasible Large-Scale Liquefaction Process

Deliverable Number: D2.7

Date: 11 November 2013

Report Classification: Restricted (here: *Publishable Summary*)



<b>Approvals</b>	
<b>WP Leader</b>	✓
<b>Coordinator</b>	✓
<b>FCH JU</b>	<b>pending</b>
<b>Contacts</b>	
<b>david.berstad@sintef.no</b>  <b>info@idealhy.eu</b>	

## **Acknowledgements**

The research leading to these results has received funding from the European Union's Seventh Framework Program (FP7/2007–2013) for the Fuel Cells and Hydrogen Joint Technology Initiative, under grant agreement number 278177.

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## Publishable summary

In the now concluded process selection phase (Work Package 1, WP1) of IDEALHY the most promising hydrogen liquefaction concept was selected for further development in the succeeding Work Package 2 (WP2). The selected liquefier concept was described by a set of process characteristics with respect to: hydrogen pressure level and process pathway; refrigeration cycle types and refrigerants for precooling and cryogenic cooling; and expansion devices for final expansion and liquefaction.

This report describes the final energy optimization of the selected IDEALHY liquefaction process, and the energy, footprint and cost estimates made thereof. The main focus of the optimization was to locate the optimum temperature split between the mixed refrigerant (MR) precooling cycle and the cryogenic Neliium (helium/neon mixture) Brayton cooling cycle. Several cases for the MR cycle, for instance with/without pre-chilling or with/without two-phase flow at the MR heat exchanger inlet, have been optimized, and a final optimum split temperature has been identified.

The MR cycle was optimized for several cases and boundary conditions. For each case, the optimum MR composition, pressure levels and flow rate were found. The performance of the MR cycle was compared to that of the Brayton cycle, and an optimum split temperature was found by first plotting the aggregate power consumption of the two cycles. In addition, it was found advantageous to use a pre-chilling utility also for the MR cycle, as this stabilizes the operating conditions.

With this result it was possible to predict the overall power consumption of a 50 tpd plant. At full capacity the required power is 13.33 MW. This corresponds to a specific power requirement of 6.4 kWh/kg and a thermodynamic (exergetic) efficiency of 42 %. This is based on realistic assumptions of the efficiencies of the main components, which were obtained through inquiries to potential component suppliers.

With this result the main goal of the IDEALHY project has been reached.

The size and cost of a 50 tpd plant has also been briefly discussed, showing a draft layout of the plant and estimated pipe diameters for the main pipelines. Cost estimates suggest that the novelty of the processes results in a high initial CAPEX for the very first plant, which means that a demo plant able to demonstrate the technology is unlikely to be economically sustainable in the absence of additional funding (e.g. subsidies).

It should however be noted that the very high efficiency of the IDEALHY process will in principle lead to a relatively low ultimate cost of the compressors and other ambient temperature installations like motors, transformers, cooling water system. It is therefore expected that for later series IDEALHY plants the CAPEX will be lower than for plants built with any alternative process.

## Key words

Hydrogen  
Liquefaction  
Optimisation of free parameters  
Optimum precooling temperature  
Overall power needs of total plant  
Plant footprint  
Pipe dimensions

## Table of Contents

Acknowledgements .....	i
Disclaimer.....	ii
Publishable summary.....	ii
Key words.....	ii
Table of Contents.....	iii
<b>1 Introduction.....</b>	<b>1</b>
<b>2 Final Process Optimization and Feasibility Evaluation .....</b>	<b>2</b>
2.1 Optimum Pre-cooling Temperature .....	2
2.1.1 Specification for the MR Section of the IDEALHY Hydrogen Liquefier.....	4
2.1.2 Influence of the pre-cooling temperature on MR cycle process design.....	4
2.1.3 Optimization of the MR pre-cooling for different temperatures.....	5
2.1.4 Results from optimization .....	6
2.1.5 MR with Chiller .....	8
2.1.6 Effect on pre-cooling temperature for the Helium Brayton cycle .....	11
2.1.7 Final pre-cooling process .....	12
2.1.8 Further Details of the Chiller and the MR refrigerant.....	12
2.2 Optimization of Brayton cycle .....	13
2.3 Layout and energy efficiency of the final system design .....	14
<b>3 Size and cost evaluation .....</b>	<b>17</b>
3.1 Plant footprint .....	17
3.2 Pipe Diameters .....	18
3.3 Cost .....	20
<b>4 Conclusions .....</b>	<b>22</b>