Deliverable D7.5

4^{th} Project Meeting and Status Report

Report Status: FINAL

Report Date: 31 August 2021

Authors:

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Confidentiality Level: PU – Public

Acknowledgement:

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under Grant Agreement No 874997. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

R E P O R T

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Note: The 4th project meeting had to be held as a web conference due to the Covid-19 pandemic. It took place on 18th June 2021.

Enclosed is a summary of the meeting including the list of participants, the agenda and excerpts of the Minutes of Meeting (MoM), adapted for publication. In addition, this document includes a summary of project activities and a status report of the different work packages and task.

PRHYDE consortium, Kick-off meeting, 5th February 2020, Paris

CONTENTS

ACRONYMS AND ABBREVIATIONS

CFD	Computational Fluid Dynamics
CHSS	Compressed Hydrogen Storage System
D	Deliverable
FC	Fuel Cell
HD	Heavy Duty (Vehicle)
OTVs	On-Tank Valves
WP	Work Package

1 4TH PROJECT MEETING

Project	PRHYDE – Protocol for heavy duty hydrogen refuelling
Subject	4th General Assembly, 18 June 2021 3-6 pm CET
Place	Web Conference
Date	18 June 2021

1.1 List of Participants

Participants (PRHYDE consortium):

Martin Zerta / LBST, Christopher Kutz / LBST, Susanne Goeritz / LBST (Project Coordinator)

Christian Spitta / ZBT, Alexander Kvasnicka / ZBT, Fouad Ammouri / Air Liquide, Quentin Nouvelot / ENGIE, Vincent Mattelaer / Toyota, Nick Hart / ITM, Claus Due Sinding / Nel, Benoit Poulet / Shell, Stephane Villalonga / CEA, Antonio Ruiz / Nikola, Monterey Gardiner / Nikola

1.2 Agenda

Time	Topic	Responsible
15:00 – 15:40	**Welcome of the coordinator** Approval of agenda	LBST
	General aspects General feedback MTR-meeting; project status & timeline; project extension / contract amendment	
	WP1 / WP7 – Project coordination Annual data reporting	
15:40 – 15:50	**Status report: WP2 – State-of-the-art & specification** Feedback MTR-meeting;	Shell
15:50 – 16:20	**Status report: WP3 – Protocol development** Feedback MTR-meeting; Status of work; Ongoing activities and outlook, timeline	Nel (Shell, Toyota)
16:20 – 16:50	**Status report: WP4 – Simulations** Feedback MTR-meeting; Status of work; Ongoing activities and outlook, timeline	Air Liquide (ENGIE)

Break 10 Minutes until 17:00

Time	Topic	Responsible
17:00 – 17:30	**Status report: WP5 – Experimental validation** Feedback MTR-meeting; Status of work; Ongoing activities and outlook, timeline	Nikola (ZBT, Toyota, CEA)
17:30 – 17:50	**Status report: WP6 – Recommendation and dissemination** Feedback MTR-meeting; Status of work; Ongoing activities and outlook, timeline	ITM
17:50 – 18:20	**Further discussions** SharePoint; Role of experts / partners; external experts – NDAs; Stakeholder involvement; Pictures and figures; Other topics?	ALL
18:20 – 18:30	**Final Remarks and Close of 4th GA**	LBST

1.3 General Topics of the Meetings

- MTR - feedback
- Timeline / extension of timeline
- Contract amendment
- Deliverables / Milestones

1.3.1 MTR Feedback

On Thursday, 17th June 2021, the general mid-term review of the FCHJU-funded project took place. During this meeting, the project coordinator and the WP leaders presented the current status of the project by discussing main results, past, current and planned activities and (expected) delays in the different tasks.

Details on the project progress and delays will also be described in sections 2 and 3 below.

In summary, the PRHYDE consortium has performed high-quality work towards the development of fuelling concepts for heavy-duty hydrogen refuelling. There are, however, significant delays compared to the original schedule, which will require a project extension (see also section 1.3.2). Main delays have been caused (or at least amplified) by the Covid-19 pandemic, which strongly impacted stakeholder interactions and dissemination of first project results. In addition, the original schedule turned out to be too ambitious, especially for an analysis of the state of the art in WP2. As of June 2021, most critical delays have been observed in WP5 (experimental campaign) test sites for protocol and simulation validation could not be commissioned in time and the ambition of the consortium to produce high-quality output led to additional, time-consuming upgrades of test equipment e.g. by installing of additional sensors inside the hydrogen tanks.

While reviewers have confirmed the high-quality output of the project so far, they have at the same time repeatedly stressed the importance of the development of HD refuelling protocols, since these are not only key for a high market penetration of FC trucks but can also serve as important input for European regulation. To ensure a successful project completion in time, several “corrective actions” were recommended, including:

- Additional mitigation measures to handle further potential delays and risks.
- The dissemination plan should be updated to keep stakeholders informed about the progress of the project.
- A project extension is seen as unavoidable and the consortium should develop an efficient and ambitious new timeline, while the quality of the results should not be diluted.
- Project management should be enforced, especially when it comes to the coordination between the different work packages.

Although the delayed start of the experimental campaign in WP5 is seen as key reason – instead of October 2020, first experiments could only take place in June 2021 – the consortium shall try to find possibilities to make up for existing delays by adapting planned activities in WP3 (protocol development) or WP4 (simulations).

1.3.2 Timeline / extension of timeline

The consortium will develop a new timeline for the project, taking the delays and potential further risks into account. Based on the delays with the experimental campaign, the simulation and the protocol development and protocol (draft) development, an extension of additional nine months seems to be necessary. Time should not be recovered on the cost of quality, also the importance of a timely finalization of the project should be considered. To do so:

- The coordinator will, in close cooperation with the WP leaders, prepare and work out a new detailed and realistic timeline. Interrelations and dependencies, especially for outstanding (most critical) deliverables and milestones should be described and pointed out more clearly.
- For the preparation of the new timeline, the update of the description of work and the risk assessment including mitigation strategies, the coordinator will set-up a specific working group.
- The Gantt Chart will be updated summarising the workplan.
- Related risks and mitigation strategies / measures should be identified and described for each outstanding (key) deliverable and milestone, especially in the context of the pandemic.

1.3.3 Contract amendment

The extension of the project will be covered in a second contract amendment to the existing Grant Agreement with the FCHJU. The amendment process will be started as soon as a new timeline has been agreed upon between the partners.

A working group consisting of the WP leaders / Steering Group representatives and the coordinator will immediately start the work for the contract amendment preparation. The contract amendment should be finalised by end of October 2021.

1.3.4 Deliverables / Milestones

Some delays in deliverables and milestones are caused by directly WP-related reasons (e.g. delay in hardware delivery / installations, restrictions for lab / office use or late / limited stakeholder feedbacks and interactions due to COVID-19 restrictions) and indirectly by interdependencies between WPs, tasks, deliverables and milestones (e.g. delay of one deliverable cause a subsequent delay in an upcoming one).

For key deliverables / milestones a special focus has to be set to the interactions and the iterative process between WP3 (protocol development), WP4 (simulation) and WP5 (experimental campaign).

For the outstanding key deliverables and milestones, the coordinator and the work package leaders will work out a realistic and robust timeline.

Outstanding key milestones (MS) are

- MS3: Final fuelling protocol(s) specification (WP3),
- MS8: Tanks and stations ready for testing (WP5), and
- MS9: First set of experimental time series data.

(Outstanding) Key deliverables (D) include:

- D3.3: Draft fuelling protocol(s) specifications,
- D3.4 Safety and risk assessment of fuelling protocols,
- D3.5 Final fuelling protocol(s) specification
- D6.7 Preparation and publication of results for standardization
- D6.8 Preparation and publication of topics for further work

2 Project Overview

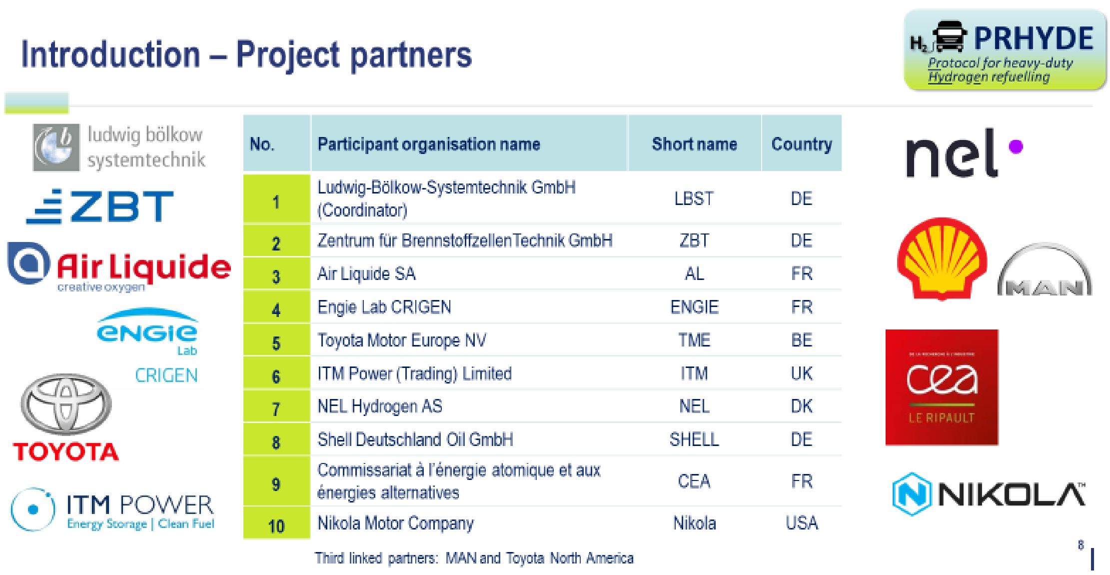
The PRHYDE (Protocol for Heavy Duty Hydrogen Refuelling) project (https://prhyde.eu/) started in January 2020 with an overall project lifetime of two years. Currently, an extension of the project timeline by additional nine month is in preparation.

With funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), the project is aiming to develop recommendations for a non-proprietary HD refuelling protocol used for future standardization activities for trucks and other HD transport systems applying hydrogen technologies.

To do so, the PRHYDE partners will investigate refuelling protocol requirements, and provide data for compressed (gaseous) hydrogen refuelling protocols developed for 35, 50 and 70 MPa nominal working pressures. A broad industry perspective shall be taken into account via appropriate external stakeholder participation throughout the project.

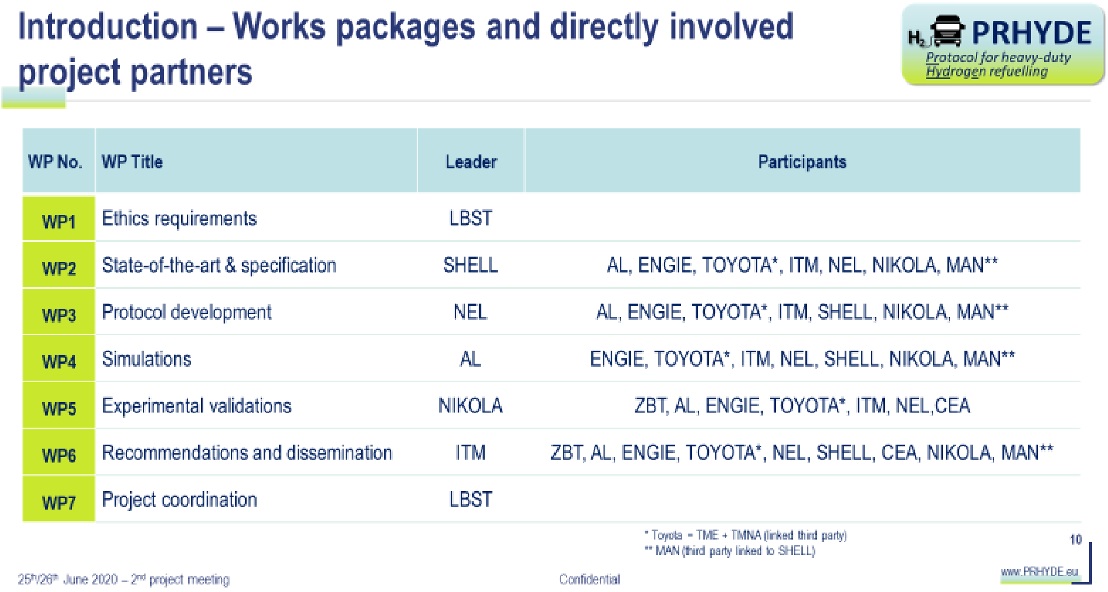
The work will enable widespread deployment of hydrogen for HD applications in road, train, and maritime transport. The results will be a valuable guidance for station design but also the prerequisite for the deployment of a standardized and cost-effective hydrogen infrastructure.

The project is carried out by 10 project partners from 6 countries and two linked third parties, as listed in Figure 1. Figure 2 shows the seven work packages and the contribution of the different partners.



No.	Participant organisation name	Short name	Country
1	Ludwig-Bölkow-Systemtechnik GmbH (Coordinator)	LBST	DE
2	Zentrum für BrennstoffzellenTechnik GmbH	ZBT	DE
3	Air Liquide SA	AL	FR
4	Engie Lab CRIGEN	ENGIE	FR
5	Toyota Motor Europe NV	TME	BE
6	ITM Power (Trading) Limited	ITM	UK
7	NEL Hydrogen AS	NEL	DK
8	Shell Deutschland Oil GmbH	SHELL	DE
9	Commissariat à l'énergie atomique et aux énergies alternatives	CEA	FR
10	Nikola Motor Company	Nikola	USA

Figure 1: Overview of the project partners.



Introduction – Works packages and directly involved project partners

WP No.	WP Title	Leader	Participants
WP1	Ethics requirements	LBST	
WP2	State-of-the-art & specification	SHELL	AL, ENGIE, TOYOTA*, ITM, NEL, NIKOLA, MAN**
WP3	Protocol development	NEL	AL, ENGIE, TOYOTA*, ITM, SHELL, NIKOLA, MAN**
WP4	Simulations	AL	ENGIE, TOYOTA*, ITM, NEL, SHELL, NIKOLA, MAN**
WP5	Experimental validations	NIKOLA	ZBT, AL, ENGIE, TOYOTA*, ITM, NEL,CEA
WP6	Recommendations and dissemination	ITM	ZBT, AL, ENGIE, TOYOTA*, NEL, SHELL, CEA, NIKOLA, MAN**
WP7	Project coordination	LBST	

* Toyota = TME + TMNA (linked third party)
** MAN (third party linked to SHELL)

Figure 2: Responsibilities and participation in the work packages.

A brief overview of the different work packages, a brief description as well as their interdependencies can be found in Figure 3. Accordingly, work package (WP) 1 and WP7 exclusively, cover organizational aspect of the PRHYDE project. Details on the current progress in the different work packages can be found in Section 3.

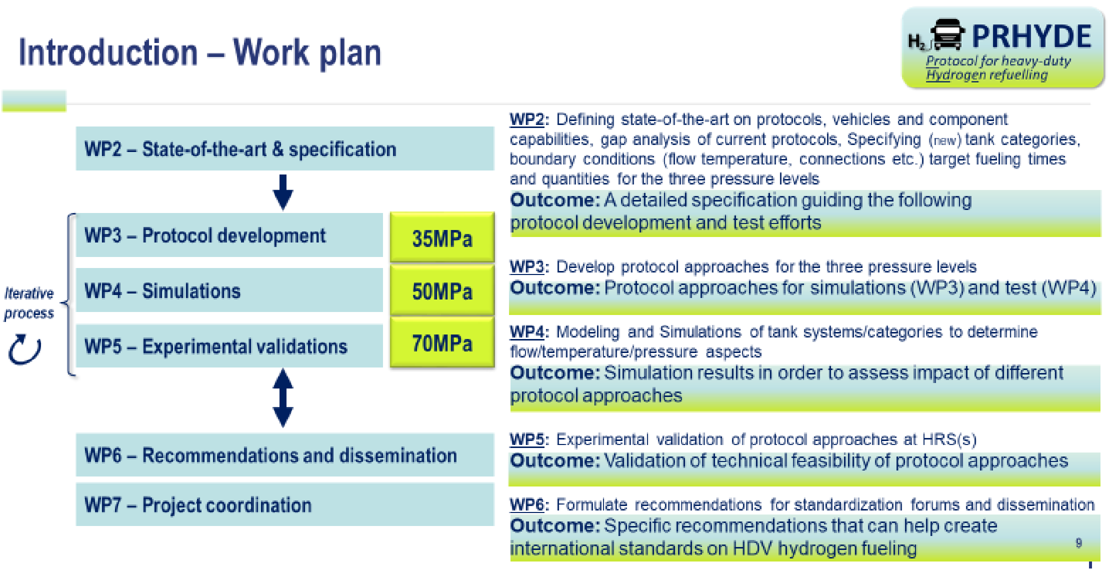


Figure 3: Work Plan of the PRHYDE project.

During the whole project lifetime, interaction with key stakeholders is an important aspect of WP6 – Recommendation and dissemination. Originally, five stakeholder workshops were planned to integrate the perspective from outside the consortium and to disseminate results from the different WPs. Although the workshops were meant to cover two different objectives of the project, namely the refuelling protocol and a feasibility study for future protocols, the whole stakeholder process had to be adapted to the Covid-19 situation and the following travel restrictions. Details can be found in Chapter 3.6.

One key measure was to establish an external expert group, which enables the participation of selected companies to contribute to the work in the different work packages. The PRHYDE partners would like to thank the following partners for their contribution (in alphabetical order):

- Daimler,
- LIFTE H2,
- FirstElement Fuel,
- Hexagon purus,
- Luxfer,
- National Renewable Energy Laboratory (NREL),
- National Technology & Engineering Solutions of Sandia, LLC (NTESS),
- RiskTec, and
- Savannah River National Laboratory (SRNL).

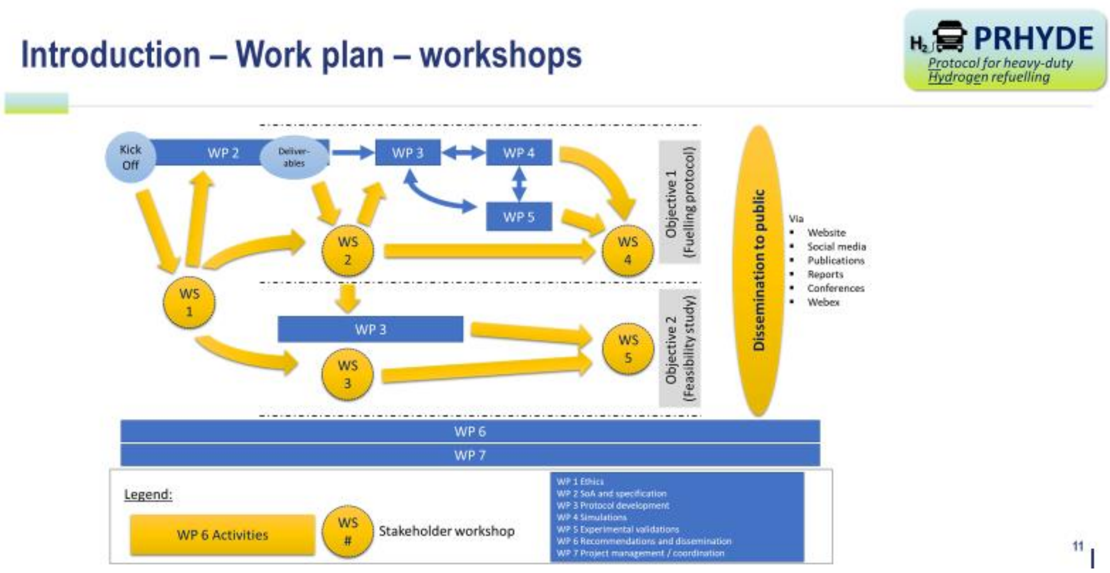


Figure 4: Work plan of PRHYDE workshops.

3 STATUS REPORT

3.1 Summary

After 19 months of the PRHYDE project, WP 1 and WP 2 have been completed while all other work packages are in a progressing state.

- As of August 2021 (month 20), 23 deliverables have been finalized and submitted to the FCHJU.
- All public deliverables are available on the project website, www.prhyde.eu.
- In total, 16 deliverables are still open, 8 of which would have been due by month 20 of the project.
- The consortium is working with much effort to finalize these documents in a reasonable period of time.
- Furthermore, possibilities to extent the project to make up existing delays will be discussed within the consortium and with the FCH JU.

WP 1 (Ethics Requirements) has to ensure and show the compliance of the PRHYDE project activities with the Horizon 2020 ethics rules and in particular, but not limited to Art. 34 of the Grant Agreement.

- Deliverable D1.1 was prepared in cooperation with the project partners from the US, Nikola and Toyota North America. Both US partners have prepared experimental tests and measurements in the US (to be performed in 2021).

WP 2 (State-of-the-Art and Specifications) aims to review the current state-of-the-art, to set targets for future refuelling protocols and to perform a gap analysis between the status quo and the requirements of future refuelling protocols. All WP 2 tasks - were completed in the first project period, although there were significant delays compared to the original project planning (final deliverables D2.5 and D2.6 have been submitted in months 16 and 17).

Main reasons for the delays include:

- A too optimistic planning of the task work, including the establishment of working groups, stakeholder involvement and internal processes in the first months of the project.
- Deliverables 2.1 to 2.5 were originally planned for the same time (due month 3), whereas the parallel work on the different topics did not work as efficient as originally planned.
- With regard to the expert and stakeholder involvement a larger group of participants had participated than originally planned for the WP 2 meetings. - A result was a slower iteration processes between the consortium partners.
- Due to the COVID-19 conditions no face-to-face meetings and workshops for internal project meetings and stakeholder workshops had been possible.

- Stakeholders' input from the first three webinar / web conferences[1] (with the last one taking place between 1st and 3rd of December 2020) and from e-mails & surveys have been relevant for the different deliverables of WP 2 and also for the other WPs.

The WP 2 analyses also served as an important basis for the further development of a HD refuelling protocol in WP 3-5. Therefore, a regular exchange between the work packages has been maintained to provide necessary knowledge, insights and information to each WP task at an early stage, to ensure the continuous project progress.

Regular webcons have been organized by each WP on a weekly / bi-weekly basis and for all consortium partners in a monthly interval. Additional steering group calls with the WP leaders have been organized on demand. For the upcoming project period, the exchange between the WP leaders will be intensified. The project coordinator will organize and manage additional meetings for the inter-WP exchange to ensure the efficient work between the partners, tasks and WPs.

Within **WP 3 (protocol development),** first concepts for refuelling protocols of heavy-duty vehicles have been developed with specifications for the use in the simulation (in WP 4) and experimental validation tests (in WP 5), to perform a safety and risk assessment of the refuelling protocols and to further optimize the developed protocols based on experimental test results.

- In the 19 months period, WP 3 members have set the specifications for preliminary simulations for the three different pressure levels 35, 50 and 70 MPa and both Type III and Type IV tanks. The specification for preliminary simulations has been published as Deliverable D3.1 on the PRHYDE website.
- The formulation of the "Golden Rules" have been started addressing the relationship between vehicle and dispenser and to provide input for D3.2, submitted in May 2021.
- For D3.3 and D3.4 more feedback and inputs have been asked from partners and stakeholders, especially with regard to refuelling concepts to be discussed. D3.3 and D3.4 will be finalized in September/October 2021.

Simulations for different tanks to be used in the WP 5 test campaign have been prepared in **WP 4.**

- Data and information from the WP 5 partners have been delivered but more detailed characteristics on tank walls are to be defined and described.
- The objective of the simulation is to understand what is happening inside the tank.
- Besides preliminary simulations performed in 2020 (see D4.1 and D4.6), additional simulations requested by WP 3 were conducted in the beginning of 2021.

[1] Due to COVID-19 all planned in-person workshops have to conducted as webinars or web conferences in the first 12 months.

- The new information will be integrated in upcoming deliverables. Deliverable D4.7 has been postponed until having more progress on D5.1.
- In January 2021 a meeting with Wenger Engineering was organized to discuss remarks on WP 4 preliminary calculations reported in D3.1. A common conference paper to discuss and benchmark the different models of Air Liquide, Engie and Wenger Engineering has been submitted.

In **WP 5 (Experimental validation)** several tasks and deliverables have been delayed.

- Deliverable D5.1 (Report on test specification) and D5.2 (Mechanical Measurements Systems) have been delayed due to the ongoing need for discussions with the other WPs. Additional input is needed from WP 3 to define the experimental campaign to calibrate the models and the test protocol. Finalization of D5.1 is expected in Q3 / 2021. D5.2 was internally finalized in December 2020.
- During 2020, CEA has validated at lab scale (CEA-23L-70MPa, CEA-62L-70MPa from the Copernic project) the measurement system to follow the mechanical behavior of a vessel during the fast filling (D5.2). A transportable measurement system was defined and will be provided by a sub-contractor in August-September 2021.
- First fast filling will be performed on the CEA 255L vessel (real scale vessel) and the results will be reported in deliverable D5.3 (to be scheduled in the new timeline). The last step consists in following a ZBT fast filling campaign to monitor the mechanical behavior of a vessel during a H_2 fast filling (D5.4). The date of this campaign needs to be defined between ZBT and CEA (in case of no travel restrictions due to COVID-19).

The WP 5 refuelling test phase activities are delayed by nine months due to unplanned COVID-19 consequences which impacted onsite operations, travel, equipment instrumenttation and component acquisition, and ultimately, testing. Nevertheless, key progress was made and although the restrictions remain in place, a preliminary test of the 70 MPa type IV tank test by Nikola was conducted, ZBT was able to commission their test facility, and plans reflect a nine-month delay

- The build-up of the test installations is expected to be delayed. When the test campaign was originally planned, the plan was to use installed instruments / sensors in the vessel, but now additional thermocouple trees specifically designed for the tanks are needed and have to be retrofitted.
- Commissioning of and preparations at ZBT’s test station was completed in Q2 2021. Tank testing of different vessels (equipped with thermocouple trees) are expected to take place in Q3 2021.
- The preparation of the testing side at Nikola was finalized with last modifications in Q2 2021, including initial calibration and testing with a/the Hydrogen Station Testing apparatus. Preliminary tests have been conducted with a vessel provided by Nikola in Q2/Q3 2021.
- The testing side at TMNA is available for single tank and tank system testing and will be used for real world validation of the fuelling protocol.

- The planned bus refuelling station for the ITM testing side is delayed. Partners have decided to perform 350 bar testing at ZBT's test site and to use an alternative vessel instead. The station may still be used at a later stage in the project.
- Furthermore, a US national laboratory, NREL, has been added to the experimental phase and is to be commissioned in late Summer 2021.

WP 6 (Recommendations and dissemination) has successfully organized three online webinars and web conference. On the webpage (see https://prhyde.eu/progress/) public presentations and project Deliverables have been available for review and comments by stakeholders. For stakeholder information the project has initiated regular newsletters to stakeholders and social media campaigns.

- Originally three face-to-face workshops with stakeholders and experts had been planned for the first year of the project. Due to the Covid-19 virus, all physical meetings and events had to be transferred into an updated format, resulting in online webinars and web conferences (held on 24th March 2020, 23th April 20 and 1st /2nd /3rd December 2020). The results of the online webinars and surveys are published as deliverables D6.3 and D6.4.
- The original dissemination and exploitation plan (D6.2) has been updated in July 2021. A further update is expected in line with the anticipated project extension process (October 2021).
- On the webpage (D6.1) (see https://prhyde.eu/progress/) public presentations and project deliverables have been available for review and comments by stakeholders.
- For stakeholder information the project has initiated newsletters to stakeholders and social media posts. Presentations to standardization organizations were given.

WP 7 (Project management, coordination, and administration)

- The PRHYDE coordinator has set up a regular monthly consortium call to discuss all project-related topics between the consortium partners in addition to the individual calls, implemented on work package level.
- The kick-off meeting took place in Paris on 5th February 2020, the 2nd project meeting was held via web conference on 25th and 26th June 2020, the 3rd project meeting on 17th December 2020 and the 4th project meeting on 18th June 2020 – with participation of the project officer, when available.
- Due to delays in all WPs, specific tasks and deliverables, the coordinator has increased efforts for exchange with WP and task leaders and strengthen the support for the preparation and finalization of the deliverables.
- In the coming months, the coordinator will intensify his management efforts. A new timeline, including an updated Gantt-Chart and an updated risk management, including mitigation strategy will be prepared until October 2021.
- A new contract amendment for the extension of the project timeline will be prepared in close cooperation with the task leaders. The coordinator and the WP leaders have started to work on a more detailed and robust project plan.

3.2 Work Package 2: State-of-the-Art and Specifications

WP leader: Shell

WP 2 has the aim to review the current State-of-the-Art in refuelling technology and existing technology and to set targets for the development of future refuelling protocol. In this WP, six public deliverables have to be created, all available at https://prhyde.eu/progress/.

Task 2.1 Defining fossil parity performance requirements for HDV fuelling

Objectives of the task:

This task aimed at defining performance metrics for heavy duty vehicle refuelling protocols as a benchmark for this project that would allow hydrogen fuel cell vehicle refuelling to compete with current diesel technology in terms of technical performance.

Progress of work:

The task has been completed and conclusion are summarized in deliverable D2.1 (submitted 31st August 2020). Inputs from surveys and workshops (taken place in March and April 2020) are included from different industry stakeholders. Results and deliverables are published on the PRHYDE website.

Main results:

Deliverable D2.1 (Performance metrics for refuelling protocols for heavy duty hydrogen vehicles) defines performance metrics for heavy duty vehicle refuelling protocols as a benchmark for this project that would allow hydrogen fuel cell vehicle refuelling to compete with the current diesel technology as the dominant technology in terms of technical performance.

Accordingly, fossil parity criteria for a range of applications (Trucks, Busses, Coaches, Transport Systems, Inland Ships, etc.) have been established. Outcomes are specifications for H_2 refuelling performances, including hydrogen capacity in kg, H_2 fuelling times in minutes and corresponding max. anticipated average H_2 flow by vehicle segment. The following Table 1 summarized generic use cases and estimations for associated refuelling performance metrics as a benchmark for hydrogen refuelling.

Table 1: Generic use cases and estimations for associated refuelling performance metrics as a benchmark for hydrogen refuelling

Vehicle segment	Compressed hydrogen storage system (CHSS) capacity [kg]	Fuelling time [min]	Corresponding max. anticipated average H_2 flow [kg/min]
N1 commercial vehicle (included for comparative purposes)	2-10	3-5	2
N2 commercial vehicle	10-40	10	4
N3 commercial vehicle	40-80	10	8
M2 passenger carrier	10-40	8	5
M3 passenger carrier	30-100	12	8
Train, low case	150	10	15
Train, high case	500	15	33[1]
Inland ship, bulk carrier	4,500	60	75[2]
Inland ship, push barge	900	60	15
Inland ship, day cruise	300	30	10
Inland ship, river cruise	20,000	120	167[2]
Transport system, low	300	30	10
Transport system, high	1,500	60	25

Note: SOC should approach as much as possible 100%

Task 2.2 Defining requirements for safe HDV fuelling

<u>Objectives of the task:</u>

Discussion and summary of key aspects and gaps identified in risk assessments for the hydrogen refuelling process.

<u>Progress of work:</u>

Completed and published as Deliverable D2.2 in April 2021.

Inputs from survey and workshops are included from industry stakeholders.

<u>Main results:</u>

Overview of the state of the art on refuelling risk assessment, identified gaps to be addressed in new protocols and recommendations for further work.

One of the main conclusions of the risk assessment is that a global system approach to the HRS <u>and</u> the vehicle would provide much better risk reduction than just measures isolated to one of the sides by

a) adding more barriers to prevent unwanted event (excess temperature) due to pressure ramp rate control failure, e.g. advanced communications, triggering termination of the fill and

b) reducing severity/consequences by ensuring the CHSS can withstand the overtemperature resulting from a control failure without catastrophic consequences.

More detailed results are summarised in Deliverable D2.2, which discusses the results of previous risk assessments (e.g. conducted at ISO, EIGA, workshops with the automotive industry and have been presented to GTR) and also provides recommendations and points out open issues as a basis for a specific risk assessment for any new proposed refuelling protocol which will be covered by PRHYDE work package 3.

Task 2.3 Gap analysis of existing gaseous fuelling protocols

<u>Objectives of the task:</u>

Analyses and assesses the existing refuelling protocols in use. Both light-duty and heavy-duty protocols have been assessed, views from wider industry stakeholders have been included in the analysis through the use of surveys and the input from the webinars.

<u>Progress of work:</u>

Completed and published as Deliverable D2.3 in October 2020.

<u>Main results:</u>

In this task, a wide range of refuelling protocols and other relevant documents have been assessed, including SAE J2601, SAE J2601-2, JPEC-S 0003, ISO 19880-1, EN 17127, and SAE J2799. Also, other activities outside of PRHYDE which deal with new refuelling protocols have been mentioned, namely a Korean real time refuelling protocol, HySpeed, and the Clean Energy Partnership (CEP).

Current refuelling protocols are insufficient for use in heavy duty applications, as they do not support:

- Fills to the required amount of hydrogen – most refuelling protocols are limited to 10 kg or 30 kg (technically it is possible to fill larger CHSS, but above 30 kg operating issues cannot be excluded).
- Fills in the required speed / at high transfer rates of hydrogen adequate to the respective applications (max. 120 g/s) – the required flow rates for HD applications are just not supported by current protocols.
- Meeting the cost targets for hydrogen – current refuelling protocols do not support the required cost decrease path to diesel parity by forcing the station operators to over-design refuelling systems.
- Clear but flexible criteria on how to fill an application with hydrogen – either the protocols are too prescriptive or non-informative, such as with SAE J2601-2.
- Interoperability between all heavy-duty vehicle types on the roads – many stations have been programmed to only service e.g. buses with type 3 CHSSs only – now posing a possible safety threat, as in many cases the number of vehicles coming to a certain station cannot be exactly controlled. This is especially true for publicly accessible stations.

Since in most cases a conservative scenario is considered (due to the absence of advanced communication between the station and a vehicle), the precooling temperature can be relaxed and the State-of-Charge (SoC) should be improved in the upcoming heavy duty protocols.

To take existing shortcomings and gas into account, a large number of requirements for protocol development has been formulated, which served as Input for Task 2.6 – specification of HDV fuelling protocols.

Task 2.4 Gap analysis of hardware used with existing gaseous fuelling protocols

Objectives of the task:

Analyse performance capability of current state-of-the-art hardware used with existing gaseous fuelling protocols. Capture lessons learned from their use and implementation and identify gaps in relation to potential addressing of HDV requirements and other issues, such as reliability and customer problems.

Progress of work:

Completed and published as Deliverable D2.4 in November 2020

Inputs from survey and workshops from industry stakeholders are included and explicitly mentioned as an annex to the document.

Main results:

Summary and discussion of the current status for nozzles and receptacles, tanks, on-tank valves, and other elements in the refuelling line.

Deliverable D2.4 identifies some of the critical aspects including

- the connection devices, enabling vehicles to connect to dispensers, but also to enable control of what vehicles are able to fuel at certain dispensers, based on the flow rate, or pressure level, or information communicated from the vehicle to the station (as discussed in Deliverable D2.3), and
- components on the vehicle that may lead to differing levels of heating within the vehicle tank, and therefore that must be accounted for in the design of a refuelling protocol.

Besides an overview of the state-of-the-art hardware also an analysis and discussions about anticipated and required developments is given.

Task 2.5 Analysis of existing non-gaseous refuelling protocols or applications

Objectives of the task:

Review and discussion of existing approaches of non-gaseous storage onboard of applications, such as liquid (cryogenic) hydrogen, cryo-compressed storage, liquid organic hydrogen carriers (LOHC), hydrides and chemical storage, and benchmarking them by listing their advantages and disadvantages and current technology readiness level (TRL). New forms of storage will need to exceed compressed gas hydrogen storage (CGH2) metrics including volume for packaging, technical operating parameters, and customer requirements for cost, efficiency, and refuelling time.

Progress of work:

Completed and published as Deliverable D2.5 in April 2021.

Inputs from survey and workshops are included from industry stakeholders.

Main results:

It appears that the refuelling of hydrogen applications with gaseous hydrogen is the most relevant and most mature of the refuelling methods (see Table 2). Some applications may be explored with alternative storage and refuelling methods, such as LH2 or CcH2 storage, though both will need significant work to reach higher TRLs and be adopted by the market. Other alternative technologies, such as LOHCs, hydrides, Ammonia and local generation from aluminium still have severe technical challenges to overcome, such that a widespread application in nearby future is very unlikely. Bundle swap only moves the point at which the hydrogen is transferred into its primary containment, therefore it is closely related to refuelling with CGH2.

Table 2: Summary of different H_2 storage and refuelling options

Technology	Advantage	Disadvantage	TLR
CGH2	Mature, well understood, commercially deployed, suitable for decentralized use and application. refuelling rates higher than J2601 developed in this project	Requires a good understanding of the involved thermodynamics,	8-9
LH2	High storage densities. refuelling rates equal or higher than J2601 possible	Requires centralized liquefaction, lack of standardization	7-8
CcH2	Very high storage densities, refuelling rates equal or higher than J2601 possible	Requires centralized liquefaction, lack of standardization	7
Ammonia	High storage densities. refuelling rates equal or higher than J2601 possible, but additional severe safety precautions needed.	Poisonous, lack of standardization	5-6
Hydride storage	Relatively low pressures involved.	Relatively low storage densities, complex heat management, long loading times, currently not competitive with SAE J2601	5-6
LOHC	Moderate storage density, easy to handle most LOHCs. High transfer rates possible, equal or higher than J2601 possible	Unsolved dehydrogenation issues, unattractive energy balance due to high amount of energy for dehydrogenation. Lack of standardization, unsolved issues on LOHC quality control and ageing throughout the lifetime, unsolved issues around determining the degree of hydrogenation,	4-5

Technology	Advantage	Disadvantage	TLR
		different and incompatible LOHCs on the market	
Bundle Swap	Fast transfer of large amount of hydrogen to the application, potentially use of intermodal transport for supply chain	Lack of standardization, does not immediately resolve the issue of filling vessels	6-7
Local generation from Al	Hydrogen generation on demand	Reaction kinetics not well enough understood, Al2O3 as waste (not harmful, but unsolved concept of what to do with it),	3-4

Task 2.6 Specification of HDV fuelling protocol(s)

Objectives of the task:

Summary and combination of the results of task 2.1-2.4 into a specification for the HDV fuelling protocol(s) to be developed in WP 3. This covers an outline on how the protocol should work and which parameters are to be tested on being influential on the fuelling performance: tank type and its size, number of vessels, including volume, initial pressure and temperature, final pressure levels, fuelling times, precooling or not, refuelling piping characteristics, station characteristics, communication requirements and other relevant boundary conditions such as ambient temperature ranges.

Progress of work:

Completed and published as Deliverable D2.6 in May 2021.

Inputs from survey and workshops are included from industry stakeholders.

Main results:

Deliverable D2.6 provides and summarises engineering requirements for the protocol to meet (mandatory requirements) and recommendations (considerations, targets), and is based on the scope of the project, external input from the surveys and an analysis of D2.1-D2.5 conducted by the PRHYDE consortium. Also, previous experience in developing refuelling protocols, brought in by the consortium members, has provided valuable input into the requirements.

The report also contains a description of the envisioned scope and output of this project, and includes a delimitation of where the project will not work?, in order to clearly focus and deliver useable results.

The Requirements have been put into following categories:

- Safety Requirements
- Scope Requirements
- Performance Requirements

Additionally, a section on requirements towards the standardization was added, as it was noticed that a number of practical issues can only be addressed at the standardization level that will require harmonization with a number of existing or yet-to-be-developed standards. It is the intent to disseminate these additional requirements to the public, with specially targeting the standards development organization that will carry the results of this project further, most likely ISO.

3.3 Work Package 3: Protocol development

WP leader: NEL

The four tasks of WP 3 are to develop concepts for future HD refuelling protocols, lay out specifications for the use in the simulation and experimental validation tests, to perform a safety and risk assessment of the refuelling protocols and to further optimize the developed protocols based on the validation test results.

Task 3.1 Develop technical approach(es) for fuelling protocol(s)

Objectives of the task:

Develop concept(s) for heavy duty vehicle (HDV) fuelling protocol(s) that addresses the specifications from WP2 (state-of-the-art of existing fuelling protocols and gap analysis). This requires diligent considerations, development efforts and weighing of multiple aspects that in some cases may be conflicting:

- The HDV performance requirements (tank size, fuelling pressures and times) may vary greatly across the different vehicle and market segments. It may therefore be necessary to develop multiple protocols to sufficiently address the specific requirements for each segment.
- Fuelling has to avoid overheating and overfilling in any instance based upon vehicle and station conditions. The protocol(s) to be developed will in parallel undergo safety and risk assessment.
- The WP2 analysis of the current state-of-the-art-nozzle, the receptacle and communication hardware on both station and vehicle side shows a significant capability gap with regards to meeting the HDV performance requirements. It may be required to define new components different from what is on the market today in order to achieve sufficiently fast fuelling and to meet the target.

Progress of work:

Completed in May 2021.

D3.1 public report on the characteristics of the cases to be studied in the preliminary simulations (month 5) is available on the PRHYDE website.

D3.2 confidential report on selected fuelling protocol approach(es) was delayed and submitted in May 2021.

Inputs from survey and workshops are included from industry stakeholders.

Main results:

The outcome of this task and the objective of the corresponding deliverable D3.1 is to define characteristics for WP 4 efforts on preliminary computations on single tank refuelling in order to give an order of magnitude of temperature increase during refuelling of large tanks for different cases which are considered as representative. The results of these simulations are anticipated to be published during a later stage of the project by the PRHYDE consortium as deliverable D4.1.

It should be noted that the selected scenarios and cases do not reflect the future refuelling protocol approach. Instead, they will help to support the future work of the project such as protocol development and experimental campaign in WP 5.

In deliverable D3.2 seven new concepts for fuelling control have been proposed. The concepts are variations of advanced MC Formula framework with incremental improvements or philosophy changes for dramatic improvements.

The concepts are summarised in deliverable D3.2.

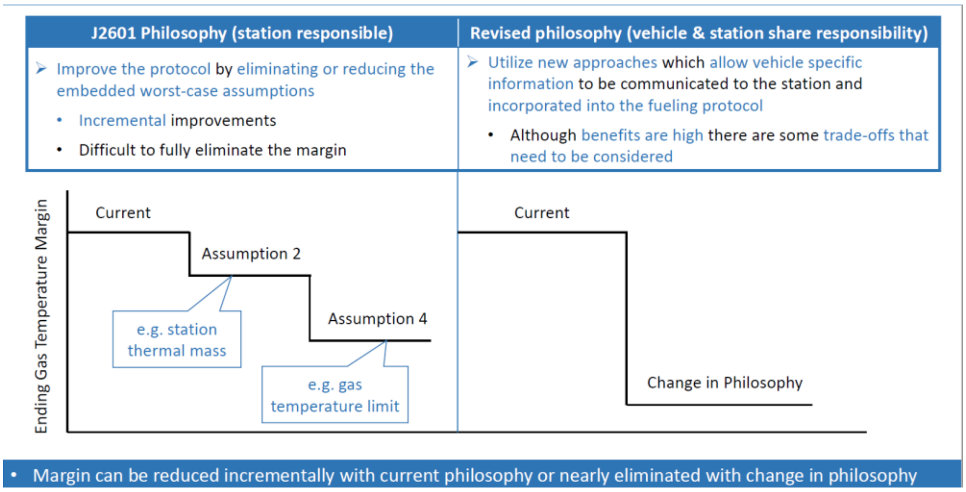


Figure 5: Philosophy of refuelling concepts

Task 3.2 Specifying fuelling protocol(s) for use in validation tests

Objectives of the task:

Task 3.2 specifies in more detail the selected protocol concepts developed in task 3.1. For validation tests in WP 4 and WP 5 specific parameters have to be defined for the fuelling protocol, including

- tank parameters: type, size categories, number of tanks, temperature and pressure limits etc.;
- fuelling performance: fuelling time, initial pressure, temperature, target SoC;
- fuelling approach: open or closed loop or other;
- fuelling communication: data to be collected initially and during fuelling and safety level/means and
- component capabilities: flow and pressure drop for nozzle and receptacle.

Progress of work:

Ongoing.

Deliverable D3.3 is scheduled for September 2021.

Main results:

Ongoing.

Anticipated results of D3.3 (confidential report):

- Quantitative performance study of fuelling concepts
- Sequence Diagrams for understanding the concepts
- Instructions to simulate and field test the concepts

Task 3.3 Safety and risk assessment of fuelling protocol(s)

<u>Objectives of the task:</u>

To assess new threats introduced by heavy duty fuelling and in particular by the new fuelling concepts.

This task provides the analysis of new threats and provides recommendations / requirements for instrumentation on Station- and/or Vehicle-side for safe implementation of the respective new fuelling concepts.

<u>Progress of work:</u>

Ongoing

<u>Main results:</u>

Work in progress

D3.4 (confidential document)

Task 3.4 Optimization of fuelling protocol(s) based on validation test results

<u>Objectives of the task:</u>

Validate the fuelling concepts which until this point is mere theory. Slight adjustments or revised control philosophy may be an outcome of this task.

<u>Progress of work:</u>

Not started.

Waiting for validation test results.

A new timeline for tasks 3.4 and D3.5 is under development.

<u>Main results:</u>

Not available.

In D3.5 (confidential document) key results of the project will be summarised. The final fuelling protocol will we based on D3.3 and validation test results from WP 4 and WP 5.

D3.5 will serve as input for the public deliverables D6.7 and D6.8.

3.4 Work Package 4: Simulations

WP leader: Air Liquide

In WP4 CFD simulations for different tanks to be used in the WP 5 test campaign have been prepared. Data and information from the WP 5 partners have been delivered but more detailed characteristics on tank walls to be defined and described. The objective of the simulation is to understand what is happening inside the tank.

Task 4.1 Preliminary calculations

Objectives of the task:

Understand basic interrogations regarding the parameters influencing the fillings in the HD setup.

Several parameters influence the fillings, overheating and/or overfilling can occur. The preliminary simulations run by WP 4 quantifies these effects in the configurations chosen by WP 3.

Progress of work:

Completed.

Preliminary calculations have been run and analysed in Deliverables D4.1 (public) and D4.6 (confidential). In D4.1, after defining parameters jointly, Air Liquide and ENGIE ran benchmark cases to compare their simulation codes. After that, simulations for H35 and H70 were run by Air Liquide, simulations for H50 by ENGIE.

Deliverable D4.6 detailed insights gained by those simulations, concerning the pressure drop coefficient and specific conclusions for each pressure level.

Main results:

The main results are listed below:

- Results for H35 show that there is no need for pre-cooling with an ambient temperature of 15°C to avoid overheating, but 10 minutes fillings are too short to lead to a SoC of 100%. This consideration on limited SoC is dependent on the kv value chosen and it may be worth to further refine these simulations in the project when pressure drop and kv value have been adjusted based on operational feedbacks. Simulations with an ambient temperature of 40°C show that it should be possible to develop a refuelling protocol without pre-cooling, as the 50 L configurations do not cause any overheating, even with type IV tanks. For the 350 L configurations, the preliminary calculations show overheating in the situation with a high ambient temperature of 40°C.
- Results for H50 show that there is no overheating with an ambient temperature of 15°C. In case of 10 minutes fillings, it is not possible to reach a SoC of 100%, in contrast to 15 minutes. As one configuration (type IV 350 L tanks) leads to temperatures approaching 85°C, a large increase of ambient temperature above 15°C will result in overheating. It may therefore be necessary to install pre-cooling hardware in H50 stations.
- For H70 simulations, the results indicate overheating in several cases, especially for 350 L tank configurations. As these simulations were run with an

ambient temperature of 15 °C, which could easily be higher in reality, pre-cooling will be necessary for a H70 protocol. 10 minutes fillings lead to a relatively high SoC (above 93%), and 15 minutes fillings with the same conditions allow to reach an almost complete fill, of at least 97.6 %. Simulations were run with type III tanks as well as with type IV tanks, even if there is currently no H70 type III tank: the simulations are meant to be informative.

Task 4.2 Definition of measurement conditions

Objectives of the task:

- Identifying the list of physical parameters that need to be measured and characteristics of the experimental set up that need to be known in order to perform model calibration and validation in further work of WP 4. This also includes recommendations on test rig specifications and sensor positions.
- Defining some recommendations for the experimental campaign regarding the conditions in which tests will be performed (pressure ramp rate, target pressure, injection temperature, etc.).

Progress of work:

Completed in October 2020.

Main results:

D4.2 (confidential report).

A list of physical parameters to be measured and characteristics of the experimental set up (to perform model calibration and validation in further work of WP 4) were identified.

Recommendations were drawn on test rig specifications and sensor positions.

Recommendations for the experimental campaign were defined regarding the conditions in which tests will be performed (pressure ramp rate, target pressure, injection temperature, etc.). These recommendations are based on relevant experimental cases for model calibration and on preliminary simulation results from D4.1.

Task 4.3 Preparation of CFD cases

Objectives of the task:

The first objective of this part is to collect the different geometrical characteristics of the tanks and the injection system of the gas inside that will be used for testing. The purpose is to prepare all the meshing needed to perform 3D CFD calculations for the three selected tanks for testing.

Progress of work:

Completed in May 2021.

Main results:

D4.3 (confidential report) describes and summarises

- the characteristics and hypotheses of tank cases that will be simulated,

- description of tools and modelling choices made,
- confirmation that results are consistent between Air Liquide and ENGIE despite potential different modelling choices, and
- final estimation of the simulation times required for such long hydrogen tank filling.

The various tests carried out have shown the similarity of the results between AL and Engie on type 4 tanks (50 and 70 MPa). The different simulations on a half tank have shown long and costly simulation times (20 to 45 days of calculation for one refuelling) showing that CFD simulation must be reserved for the most critical cases.

All geometrical characteristics for the three tanks and the related injection system were finally obtained. The tank and injection system mesh were realized for the three selected tanks.

A first benchmark for the CFD was carried out successfully between Air Liquide and Engie for the different type 4 tanks.

Task 4.4 Complementary calculations

Objectives of the task:

Support WP 3 and WP 5 in their arising interrogations during their work concerning the estimation of gas and wall temperatures in the different refuelling conditions based on numerical modelling.

Progress of work:

Ongoing, in parallel to WP 3 and WP 5.

Main results:

Work in progress.

D4.6 (confidential report) submitted July 2020 (see also D4.1).

D4.4 (confidential report) scheduled for March 2022*. The different experimental conditions set by WP 5 are being analysed to support the actual experimentations: points of attention, end-of-fill criteria, customized temperature and pressure profiles. Delayed due to late start of experimental tests

D4.5 (confidential report) scheduled for May 2022*.

D4.7 (confidential report) is open and postponed until October 2021* due to the delay to start the experiments in June 2021 instead of September 2020.

D4.8 (public report) scheduled for July 2022*.

* Dates based on updated timeline.

3.5 Work Package 5: Experimental validation

WP leader: Nikola Corporation

The WP 5 test phase activities are delayed by nine months due to unplanned COVID-19 consequences which impacted onsite operations, travel, equipment instrumentation and component acquisition, and ultimately, testing. Nevertheless, key progress was made and although the restrictions remain in place, a preliminary test of the 70 MPa type IV tank test by Nikola was conducted, ZBT was able to commission their test facility, and plans reflect a nine-month delay.

Task 5.1: Definition of the test specifications

Objectives of the task:

The first objective of this task is to precisely define the characteristics of the test rigs that will be used in PRHYDE experimental campaign: the tanks specifications, the instrumentation of tanks and test facilities, the potential of CHSS multi-tank configuration and instrumentation, the fuelling boundary conditions, the P&ID of the test rig, and apply to the fuelling protocol to be developed under WP 3.

The second objective of this task is to define test matrix that detail the number of tests and the condition in which they will be performed (dispenser pressure profile, dispenser precooling profile, end of fill target etc.).

Progress of work:

Ongoing.

Most of the characteristics of the ZBT test rig have been collected but some elements are still missing due to the commissioning phase.

The collection of the Nikola test rig characteristic was provided and an initial test sequence to validate WP 4 fuelling model was conducted.

Main results:

In progress.

D5.1 (confidential report) is scheduled for September 2021. The current version of D5.1 contains tables with detailed information on ZBT test rigs (tank system details, HRS details) and some test matrix proposal under discussion with WP 4.

Task 5.2: Tank selection and purchasing

Objectives of the task:

ZBT: Procurement of two single hydrogen storage tanks one for 50 and one for 70 MPa in close consultation with the project consortium.

ITM: Unable to secure a 35 MPa bar type III tank for testing as planned. However, Engie arranged with ZBT to provide an instrumented substitute type III tank for the 35 MPa bar test sequence to be conducted in the last quarter of CY21.

Progress of work:

Ongoing.

Main results:

In progress.

50 and 70 MPa tanks have been purchased for tests at ZBT.

70 MPa tank was precured by Nikola for a single tank testing and validation.

Toyota full system available to be scheduled for testing after initial iterations and results from single tank testing by ZBT and Nikola.

Task 5.3: Station and tank adaptation

Objectives of the task:

Equipping the single tanks for 50 and 70 MPa with additional instrumentation and OTVs. Expansion of the data acquisition system to handle the additional instrumentation. Adapt and fit the HRS to the required high flow requirements of the PRHYDE measurements.

Progress of work:

Ongoing.

At ZBT the commissioning of the hydrogen test field has been completed and the expansion for the data acquisition for the PRHYDE project has been implemented. The following figure shows the commissioning phase and the first delivery of a/the hydrogen trailer to the ZBT hydrogen test field.

Figure 6: Commissioning of ZBT hydrogen test field (Source: ZBT)

ZBT tanks are actual being instrumented with thermocouple trees. The delivery of the instrumented tanks back to ZBT was delayed. For both tanks OTVs were procured and the information regarding the tanks, OTVs and thermocouple trees were shared with the PRHYDE consortium. In particular, the positioning of the individual temperature measuring points in the gas space of the tanks was a long, iterative process.

Independently of this, tests with actual available tanks were already carried out, the data acquisition system was tested and the data export from the PLC was implemented. The following figure shows a preliminary test with a 50 MPa type IV NPROXX tank with a volume of 215 l. The tests served to verify the functionality of the test system.

High flow tests with a small available tank system consisting out of three 50 MPa 215 l NPROXX tanks will follow in a short time.

Nikola contracted an external testing facility to perform the single 70 MPa tank testing for PRHYDE. The external testing facility features a climate chamber, whereby the test article can be conditioned to varying ambient conditions.

In addition to an array of internal thermocouples, the exterior surface of the tank was also instrumented with thermocouples, secured to the exterior or ‘surface’ of the tank.

Main results:

In progress.

D5.2 (confidential report) was submitted in March 2021.

The adaption of the ZBT test facility is ongoing to realize the PRHYDE tests by the delivery of the instrumented tanks. So, the programming of the refuelling procedure to achieve the required mass flow rates and cooling for high flow filling were implemented and the safety adaption of the 700 bar line of the test station for the 500 bar tests were initiated. Tests are to take place Q3 2021.

Task 5.4: Test phase

Objectives of the task:

Series of refuelling will be performed following the defined test specification of deliverable D5.1.

All results will be shared with WP 3, WP 4 and WP 6. Experimental time series data set collected for all tanks (35, 50 and 70 MPa) will be provided to Air Liquide, ENGIE and SHELL for simple and CFD model calibration.

These measurements will provide important data to assess the compatibility of actual tanks with new protocols and prepare for future tank conception challenges.

Feedback will be provided toward tank manufacturers during workshops (WP 6)

Progress of work:

Ongoing.

D5.3 (public report) is scheduled for Dec 2021*

D5.4 (public report) is scheduled for Dec 2021*

D5.5 (confidential report) is scheduled for June 2022*.

*Dates based on updated timeline.

Nikola’s initial test sequence for validation of the WP 4 models was conducted in June 2021. The results were shared and analysed on a daily basis by the WP 4 and WP 5 teams to ensure any necessary correction. Modifications were implemented during the initial test sequence.

Testing at ZBT will commence in later Summer 2021.

Main results:

In progress.

Nikola's testing campaign on a single heavy-duty, H70 tank was a success. 18 fuelling tests were conducted in accordance with the test matrix as defined by colleagues from WP 4 and WP 5. The testing set-up and all data (mass flow rate, pressures, temperatures) have been shared with the PRHYDE consortium via the shared drive.

WP 4 has since utilized the data for verification of 0D/1D models and will be conducting CFD simulations to further study the stratification phenomena during fuelling. The data from the testing campaign can also be used to infer performance on some of the protocol options currently under analysis.

3.6 Work Package 6: Recommendations and dissemination

WP leader: ITM Power

- Originally within the first 12 months, three face-to-face workshops with stakeholders and experts had been planned.
- Due to the Covid-19 virus, all physical meetings and events had to be transferred into an updated format, resulting in online webinars and web conferences (held on 24th March 20, 23th April 20 and 1st/2nd/3rd December 20).
- The results of the online webinars and surveys are published as deliverables D6.3 and D6.4.
- Further dissemination activities in Q3 2021 include another workshop to take place on 20th September 2021 (Details to be shared via the PRHYDE newsletter and on the website). Furthermore, two publications will be presented during the international Conference on Hydrogen Safety (ICHS) 2021[2].
- Final workshops are planned in Q3 2022 to disseminate and discuss preliminary / final results of the project.
- With D6.2 the PRHYDE Dissemination and exploration plan was prepared in August 2020 and revised in July 2021. This plan will be updated in October 2021, taking a proposed project extension into account.
- On the webpage (D6.1) (see https://prhyde.eu/progress/) public presentations and project Deliverables have been available for review and comments by stakeholders.

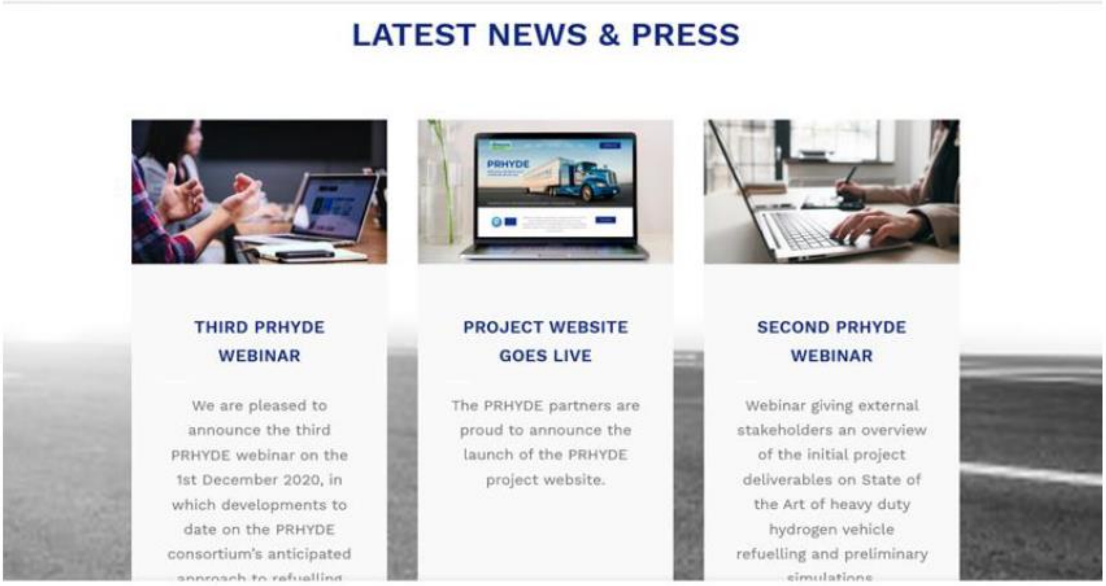


Figure 7: PRHYDE website, Latest News and Press (www.prhyde.eu)

[2] For details see https://hysafe.info/ichs2021/.

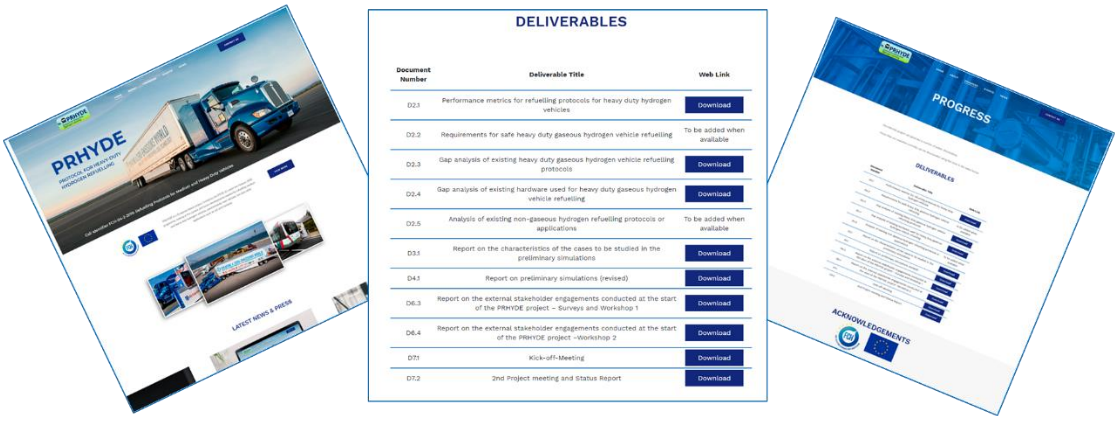


Figure 8: PRHYDE published deliverables on the website https://prhyde.eu/progress/

- For stakeholder information the project has initiated regular newsletters to stakeholders and social media campaigns. To be added to the mailing list, please subscribe via info@prhyde.eu.

Figure 9: Example for PRHYDE announcements under LinkedIn https://www.linkedin.com/posts/ludwig-boelkow-systemtechnik-gmbh_greenhydrogen-h2-hydrogen-activity-6673624098200940544-9JOp

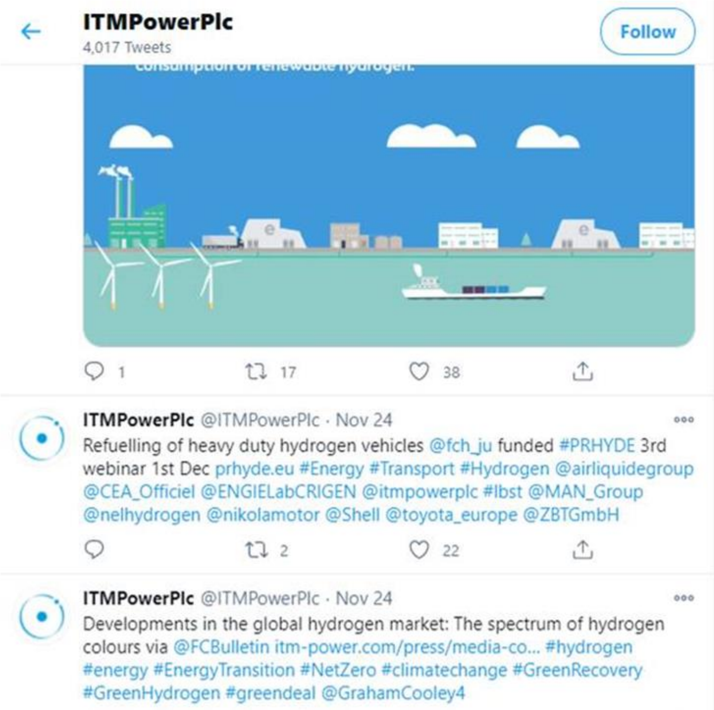


Figure 10: Example for PRHYDE announcements by ITM on twitter, #PRHYDE

3.7 Work Package 7: Project management, coordination, and administration

WP leader: LBST

For the general project management and the exchange with the project partners regular web meetings with the project consortium have been established. Between January 2020 and July 2021 18 regular web conferences for consortium members only were organised.

In addition, meetings with WP leaders / Steering Group members on specific topics were conducted.

After 19 months four general meetings have been organised. (D 7.1, 7.2, 7.3 and this D7.5). The kick-off meeting took place in Paris on 5th February 2020. Due to COVID-19 restrictions the 2nd, 3rd and 4th project meetings were held via web conference in June 20, December 20 and June 21.

Figure 11: PRHYDE consortium at Kick-off meeting in Paris, 5th February 2020.

For the efficient administrative and content related work, an internal SharePoint and a central e-mail to reach the project coordinator (coordinator@prhyde.eu) was established.

In December 2020 a first contract amendment had been successfully prepared and approved by the consortium and the FCH JU.

What is PRHYDE?

With funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), the PRHYDE project is aiming to develop recommendations for a non-proprietary heavy duty refuelling protocol used for future standardization activities for trucks and other heavy duty transport systems applying hydrogen technologies.

Based on existing fuelling protocols and current state of the art for compressed (gaseous) hydrogen fuelling, different hydrogen fuelling protocols are to be developed for large tank systems with 35, 50, and 70 MPa nominal working pressures using simulations as well as experimental verification. A broad industry perspective is captured via an intense stakeholder participation process throughout the project.

The work will enable the widespread deployment of hydrogen for heavy duty applications in road, train, and maritime transport. The results will be a valuable guidance for station design but also the prerequisite for the deployment of a standardized, cost-effective hydrogen infrastructure.

Further information can be found under https://www.prhyde.eu. For feedback on the PRHYDE project or the published deliverables, please contact info@prhyde.eu.

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With contributions by: