Improving the Knowledge in Hydrogen and Fuel Cell Technology for Technicians and Workers

Grant agreement no.: **621222**

Final Project Report

Project objectives and Achievements (Publishable version)

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Contents

PROJECT FINAL REPORT

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Executive Summary

The KnowHy project aimed at providing to the widest possible audience of technicians specific modules and practical training in an appropriate format and at affordable cost in order to facilitate the deployment of fuel cell and hydrogen (FC&H2) technologies. The partners joined forces to disseminate and communicate at local as well as at international level ensuring the achievement of the KnowHy objectives. The KnowHy program has been disseminated in many events ensuring the high visibility of the project throughout Europe targeting different types of organizations. Website announcements, emails and newsletters have been the preferred method to disseminate project developments.

The consortium was able to meet and exceed several of the important targets set in the KnowHy description of Work (DoW) and also the reviewers of the midterm evaluation. Course contents have been developed and translated into 7 European languages. The online training was offered and the practical sessions were given in different countries and students from the target groups were attracted. However, some targets such as the number of trainees were not met and 852 students had undergone training for the core module and five specialization modules. The number of students that finish the courses and the rate of dedicated hours were less than the targets set.

According to the results of "Second analysis of the feedback" collected from more than 400 surveys, the global satisfaction of the students was very high (3.7/4). Most of the scores were higher than 3.5/4 also in the practical sessions. These results illustrate that the online teaching methodology and the practical courses are appreciated and helpful for trainees to gain knowledge in FC&H2 production. However, there were several comments demanding more practical sessions in the training. Either the training should have been longer itself or should have lasted more than one day. They also found the presence of a teacher very important in practical sessions while, other elements like the Serious Game were slightly less useful. The KnowHy course contents need to be improved mainly focussing on the visual and interactive part of the online platform.

Before starting the KnowHy course, 95% of the students have been already enrolled on other e-learning courses and score them with 7.3/10 and based on the results of satisfaction surveys after participating in KnowHy, the evaluation shows the general satisfaction rate of 9/10. Moreover, students have been asked to evaluate different sections of the KnowHy course such as the Serious Games, online platform and practical session. Developing Serious Games is one of the KnowHy course features. The quality of games has been assessed with a value of 8.6/10 which was higher than the expectation of course developers and teachers (5.5/10). The quality of the KnowHy platform scored similar to quality of Serious Game in students' point of view which was 8.6/10. In comparison to satisfaction value of KnowHy platform and Serious Game, practical session achieved the highest satisfaction value of 9/10 which was in line with teachers' satisfaction.

Feedback from companies that sent students shows a very positive evaluation rating with 8.5/10 and they are willing to introduce KnowHy to other companies. It should be mentioned that only five companies completed the satisfaction survey, on the other hand, we received 38 responses from students sent by the companies. During practical sessions, it was observed that from the teachers' point of view, students' knowledge should have been deeper after passing the e-learning process and it was evaluated by rating of 7.0/10 which is lower than expectations.

The KnowHy course has been disseminated in many events ensuring the high visibility of the project throughout Europe targeting different types of organizations. Every event was carried out with the support of attractive and explicative dissemination material (posters, leaflets and flyers), in order to give the interested persons all the information they needed. Personal talks and presentations

at conferences turned out to be very effective as well. The use of websites to communicate and disseminate turned out to be more of a beaten path by the partners.

The KnowHy SPV (as a non-profit Organization) has been established for the training of technicians and individuals in hydrogen and fuel cell applications post project. This gives an opportunity to the KnowHy consortium to jointly define and allocate the resources required for successful exploitation. For this purpose, the KnowHy business case evaluates a feasible establishment, development and financial exploitation of a joint venture. A financial analysis was done in order to determine various indicators that provide insight into the feasibility of the SPV. This should be considered that investment in this SPV is not only to add value to the business, but it will have a positive impact in the development of the hydrogen and fuel cell industry.

Summary description of project context and objectives

KnowHy aimed to provide the FC&H2 sector with a training offer for technicians and workers featuring quality in contents, accessibility in format and language, practicality for the targeted audience, ease of scalability and update, and at competitive costs which make the training offer economically sustainable after project completion.

To reach this, the consortium has initiated a closely coordinated set of activities with the full involvement of all the partners. The Consortium consisted of partners with experience in FC&H2 technologies and training from European countries covering 7 of the most usual languages, such as English, German, French, Italian, Spanish, Portuguese and Dutch. Customized courses and modules target individual applications as residential combined heat and power (CHP), fuel cell electric vehicle (FCEV), hydrogen refuelling stations (HRS), distributed generation. Six modules comprising of one common core module and five specialisations focused on market roll out applications have been developed.

- Core module: Fuel Cell Basics & Hydrogen Safety
- H2 Fuel Cell for Transport
- Hydrogen Production and Handling
- Micro Fuel Cells
- Combined Heat and Power Generation
- Fuel Cell based Generators (APU and Backup Power)

The target was training 1000 technicians before the end of the project. An online platform for accessing the training contents via the web has been developed for all modules. Moreover, practical sessions have been designed in existing facilities, such as demo projects, or labs adapted to the training. The team was able to run all the courses with several hundred students registered and student evaluations indicated that the courses were of good quality. KnowHy takes into consideration the findings of previous projects such as HyProfessionals, TrainHy and H2-training.

The following actions have been planned:

- Developing an online tool for accessing the training contents via web.
- Developing specific modules adapted them to different applications and translating them into the required languages..
- Carrying out practical seminars in existing facilities, such as demo projects, or labs adapted to the training.
- Dissemination among FCH-JU stakeholders, OEMS, education authorities, and the potential users.

Description of main S & T results / foregrounds

In WP1, the general strategy & expectations have been defined, identifying the target group and profile of technicians to be addressed and defining the modules/courses. The target group were technicians working with installation & maintenance of fuel cell systems. The survey was extended with 99 partners and 9 demonstration projects contacted. The survey was organized ibased on 4 topics:

1. The first section identifies the partner responsible for the interview.
2. The second section collects some essential information about the stakeholder as the name of the contact, the size of the company, the main sector of work.
3. The third section collects information about the sector of interest of the company, focused in terms of training needs.
4. While the last section is dedicated to some specific questions about the training needs.

The core of the elaboration of the materials, in a structured format have been decided based on the survay results during consortium meetings and teleconferences (see Fig.1).. The layout of the contents has been developed with a homogeneous format. The contents of all modules have been translated into the different languages proposed in the project and uploaded onto the online platform. All contents for the core module has been prepared and uploaded onto the platform in the master language (English) (M17). The Dutch version of the core module was available on the platform and appeared complete courtesy of TUD (M17). Translation of the transport module (M14), and hydrogen production (M17) module into the master language has been done and the English has been checked by U'BHAM. The transport module was available on the online platform in both English, French and Dutch. Work continued by U'BHAM to develop contents for the micro fuel cells specialisation module alongside EP.. The CHP and micro-CHP module as well as the FC based generators module was completed after M23. Kiwa has provided guidance and advice on the core module contents which has been implemented for all modules. All project partners were in charge of implementing changes to the specialization modules based on feedback from Kiwa.

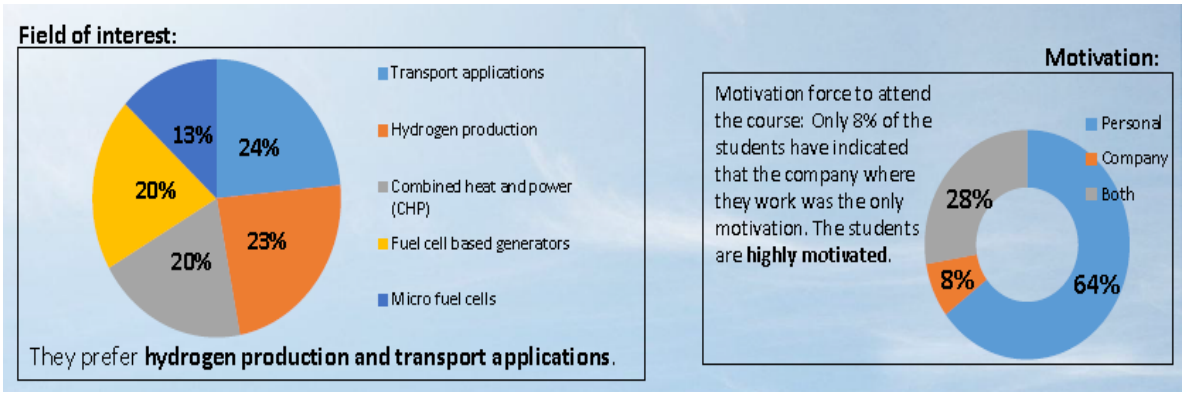

Fig. 1:Students' field of interest in FC & H2 training

An online platform has been developed that can host six modules and allow access to at least 5000 students simultaneously. The online platform provides access virtually from any place worldwide and supports various hardware platforms (see Fig. 2). First, teaching methodology has been defined and specifications of the platform have been defined. The platform has been modified several times in order to facilitate uploading of the course material. additionally, both Android and iOS applications have been developed.

Fig. 2: KnowHy website, registration page

All six KnowHy modules have been running during M25 and M26 (in Belgium, Spain, The Netherlands, Italy and the United Kingdom). All modules in different languages have been uploaded onto the platform by M30 of project. Six modules including one common core module and five specialisation have been developed and uploaded onto this platform.

Table1. Operating platform with contents.

	en	nl	es	it	pt	fr	de
Teasers	24.10.16	01.02.17	12.12.16	08.03.17	23.02.17	22.12.16	29.12.16
Contents	07.10.16	07.02.17	12.12.16	22.12.16	17.01.17	21.12.16	23.12.16
Tests	14.02.17	14.02.17	12.12.16	17.01.17	03.02.17	30.01.17	27.12.16
SG	14.11.16	07.03.17	12.12.16	17.01.17	07.03.17	22.12.16	21.12.16

Each module consists of several units. At the end of each unit there was a multiple-choice quiz (MCQ) consisting of 10 questions. The trainees needed to obtain 75% or above in order to advance onto the next unit. Trainees were encouraged to retry the unit quiz if a mark of less than 75% was attained. There were no limitations on the number of attempts. The unit quizzes contained questions with three different difficulties levels: easy, intermediate and hard. The unit quizzes were randomly selected from the question bank including 4 easy, 4 intermediate and 2 hard questions. Points awarded for correctly answering the easy, intermediate and hard questions were 1, 1.5 and 2, respectively. The penultimate unit involved a recap test containing 10 MCQs from each preceding unit.. The pass mark for the recap test was 75%.

WP4 was planning and organizing the practical training sessions and attracts students from the target groups.

Table 2. Practical sessions planed until the end of the project

	Module	SPECIALISATION MODULES				
	CORE MODULE	transport	H2 production	FCBG	CHP	microFC
ITALY	4	2		2	1	
The Netherland	4	4	3	3	4	3
Spain	4	2	2			
Portugal	2	2	2			
Germany	3		1	1	2	
Belgium	2	4				
United Kingdon	4	1	1	1	1	2
France*	1	1				

Aims of this WP were to create the practical training sessions for each module and provide training facilities from partners' own facilities or available demo projects (Fig.3). Training programs were organized in the different countries. Besides, this WP involved giving support to the students (tutorials, mentoring, follow-up). During the running of the training, the feedback from end-users were collected via a questionnaire, the results were analysed and this feedback was incorporated into the training modules for fine tuning.

Fig. 3: KnowHy test practical session in Belgium with local available facilities.

In many cases the equipment available in the partner's facilities, taken separately, have not been enough to provide practical training with the quality that is required. During the discussions to identify available demo sites, it was found that hands-on practical training is not easy at demonstration facilities as these facilities were often rather expensive and it was not easy to get permissions for their use. Therefore, training kits have been prepared/bought and shared by the partners during the practical sessions (Fig. 4).

In order to test the KnowHy concept, one full training cycle using the KnowHy curriculum has been performed. During the trial, students have received questionnaires and were to evaluate the contents and methods.

1. Transportation module in Belgium (February 2016)
2. Core module started in Delft (March 2016) (Fig.4)
3. Transport module organized in Delft (August 2016)

Fig. 4:KnowHy test practical session in the Netherlands

More courses with different specialisations have been offered in 2017. In total, about 560 students have taken part in the practical training sessions, with more than 35 practical sessions and an average of 15-20 students per session (Fig. 5). After each practical session surveys have been collected (160 surveys), first and second analysis on feedback have been performed and reported in deliverables of WP5.

Results give some improvement in some aspects:

- ☐ The teaching methodology is appreciated;
- ☐ The platform needs to be finalised and enhanced;
- ☐ The practical courses are essential;
- ☐ The trainer presence is considered essential;
- ☐ The future scenario for the practical session in two days needs to be considered.
- ☐ The handouts needs to be considered because studying everything online was found difficult

Fig. 5: KnowHy practical session (core module) in the Netherlands

The surveys (444) were collected from the second phase of the project (after M26) and showed improvement of course quality in such a way that the overall satisfaction of 3,7/4 can be considered as a great success. Monitoring and improving the quality of the outcomes of the project and effective implementation were the leitmotivs of WP5. This consisted of monitoring the general progress, balance and perception of quality, and is focused on:

- Monitoring the progress of the training as in order to detect early possible pitfalls.
- Defining and implementing corrective actions in order to improve the quality of the training and get effectiveness back on track.

Establishment of indicators and protocols was finished on time and the deliverable associated was submitted in the corresponding period. However, several questions were modified to clarify the group to be surveyed and the questions of the satisfaction questionnaire have been reformulated so as to better identify the reasons of the failure, if any. General indicators have been defined so as to evaluate the surveys carried out to students, teachers, industries and students during the practical sessions.

The evolution of number of students enrolled in KnowHy courses was highly satisfactory with 705 students by M32 (See Fig. 6). The number of practical sessions has reached the number of 37. Transport applications module was the most demanded. At the end of the courses, teachers believe that students reach a level of knowledge of 7.9/10, which again is slightly above from what students anticipated (7.2/10). The companies that have participated in the project sending students have shown a very positive evaluation of the course. Satisfaction with the courses was high, valuing with 8.5/ 10. Serious Game, platform and other materials were highly valued for their usability and quality.

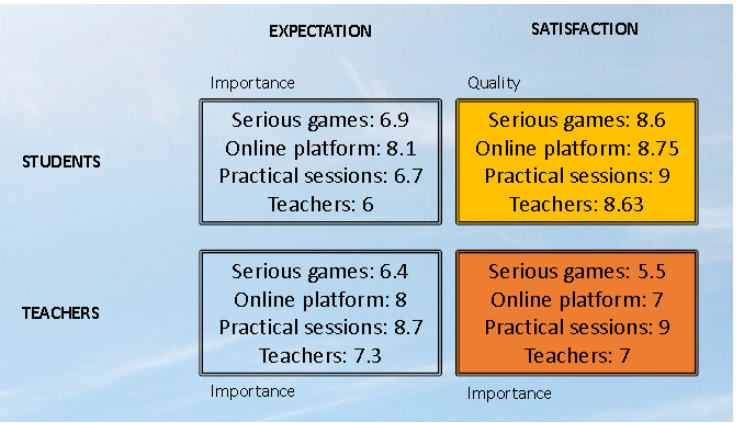

Fig. 6:Expectation and satisfaction of students and teachers

Additionally, a verification process has been carried out by USJ in collaboration with the course developers in which the quality of the courses has been demonstrated and verified. It has been agreed by the consortium that the courses are accredited by USJ and KnowHy consortium. It is advised that the contents of the courses are really technical for people that have no previous knowledge on this field. In some cases, for general public, the material is hard to follow.

A comprehensive dissemination plan has been developed to ensure the visibility of the project and dissemination trough the stakeholders and the general public in WP6. The objectives of this WP were seeking possible trainees in Europe and to design and develop a comprehensive dissemination and communication strategy. The first draft of the dissemination plan has been elaborated in 2014. The stakeholders identified have been contacted to support the identification of training needs and content during the survey implementation (See Fig.7). The dissemination plan described the

strategic approach to identify the target groups and the communication channels and how to mobilize those to promote and disseminate the project outcomes in a timely manner. The second version has been updated and improved in 2015. After the midterm review project meeting, the 3rd version was prepared by November 2016.

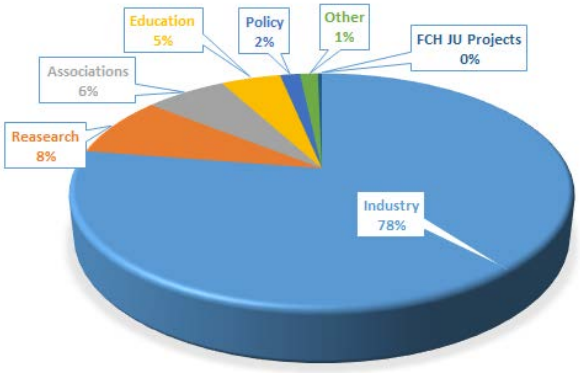

Fig. 7: Stakeholders per organization type

All partners were responsible for the local implementation of this task. The presentation, flyers and posters were shared within the dissemination events. Most of the partners already displayed some level of practical means at their facilities, but real life working hardware can be of special interest for the target groups. It is found that hands-on practical training is not easy at demonstration facilities as demonstration facilities were often rather expensive and it was not possible to get permissions for their usage. However, Campus Automobile is equipped with small-scale didactic equipment tailored for awareness and first handling of hydrogen experiments. TU Delft organized visits to the Power plant Warmiekrachtcentrale, they could take advantage of the Fuel Cell car (Hyundai) from the Green Village and also they have FC labs available. A strategy for seeking trainees has been outlined with the aim of involving 1000 participants in the training. A database of the stakeholders was created by FAST, including industrial and research institution partners. All of the partners regularly drafted articles providing detailed information about the project developments and results. During the development of the project, almost 40 announcements have been done both in general press and in Specialist journals. (For more details please see D6.7)

The site to date had 48497 views, 5390 visits in October 2016 in correspondence with the courses in 2016 and the promotion of the ones in 2017. In following figure shows the statistics of the website from October 2015 to March 2018.

Fig. 8: Statistics of the website [Google analytics]

Two annual workshops have been organized during the project. One workshop was organised in conjunction with a technical event in Birmingham on the 26th of May 2016. The second KnowHy workshop was organized at CTC Bonn on 20th of October 2017 (Fig. 9). 21 stakeholders and

experts from industry, KnowHy consortium, certification and education institutions. Entrepreneurs and representatives of the UN Climate Secretariat Bonn attended the KnowHy workshop in Bonn.

Fig. 9: KnowHy annual workshop in Germany

The KnowHy Business Case is divided into five sections that describe the project itself, the marketing strategy used, the services provided, the competition faced within the market and a brief financial outlook. The market research confirms the ever growing demand for hydrogen and fuel cell related products and services as well as the rapid increase of the need of technicians ..

The non-profit SPV allows and encourages present day KnowHy partners and others, to offer the courses in different countries on appropriate financial conditions that fit to the organizations involved. The SPV concept was developed with the direct involvement from the partners who have shown interest (KIWA and TU Delft) and additionally PNO involved in discussions. Other partners need not necessarily join the SPV to get the benefits. Every 2 years new partners can join the SPV. The KnowHy SPV management structure is based on that of a partner royalty model. In this model, KnowHy partners and new (associate) partners must pay a royalty fee to teach these courses. The royalty fee will be a fixed amount for each student participating per module. The royalties will then be collected by the KnowHy SPV who then uses it for maintaining and updating the course material and distributes a part of the cash flows accordingly. This will be done by giving each KnowHy partner a percentage of the royalties. On top of that, a KnowHy partner can receive a bigger share if this partner updates the content regularly. These KnowHy partners then receive a part of the cash inflow whenever they update the materials or support the KnowHy SPV in updating the materials. The SPV is maintained by the willing parties of the KnowHy consortium and will continue to update the course material . The royalty fee will be the same for all KnowHy partners. However, this fee will be higher for new (associate) partners. KnowHy partners are free to offer the course with different tuition fees.

In order to determine the feasibility and the profitability of KnowHy SPV, the financial flows and indicators were calculated and provided and the Partner Royalty Model's cash flows is described clearly. It is assumed that for the first year of the KnowHy SPV 200 students participate in the core module and 200 enrol on the specialization modules and only 25% of them can attend the practical sessions. The KnowHy SPV's income will be spent in three ways:

a) Royalty to developers
b) Cost of online platform

c) Rest, which consist of updating material, maintenance, salary for part-time workers and unexpected expenditures

The management of this joint venture potentially guarantees benefits both in the form of financial gains as well as positive externalities arising from the development and investment in the training of hydrogen technology expertise.

The KnowHy Foundation is a non-profit organization, which enables its partners to provide affordable training in hydrogen and fuel cell application technologies. The KnowHy Foundation starts as a small, independent and flexible organization with low up-front costs. The board members (see Fig. 10) are all employed by TU Delft. Also from a wider picture the choice of seat in The Netherlands is sensible as the current demand in the Netherlands for the KnowHy Training (with fees paid) exceeds that of other European regions and countries. Internal organization is not fixed, it can be adapted subject to the growth of the KnowHy activities. The governing body exists of an Executive Board, with a chairman, a secretary and a treasurer. This Executive Board is responsible for making the day-to-day decisions and for the overall management of the Foundation. The Council of Participants has a formal status in the organizational structure of the KnowHy Foundation. The Council is an advisory body to promote the cooperation between the Foundation and the partners and to advise the Foundation on strategy, policy and new opportunities.

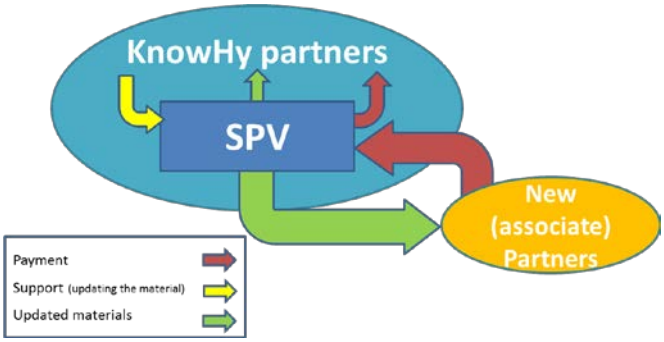

Fig. 10: SPV future activities and relation with the partners

Potential impact and main dissemination activities and exploitation results

The dissemination activities were under WP6 led by FAST and each partner was responsible for the local implementation of the dissemination activities. FAST regularly drafted articles providing detailed information about the project developments and results, with input from partners. All partners translated the article in their own language, if necessary, and publish/send it to the general press and specialised journals and magazines identified in the dissemination plan and other possible publications.

The publication included articles in International journals, press releases, structural page and announcements in the websites of the partners (Fig.11). However, announcements on websites were the preferred way to inform about Project developments.

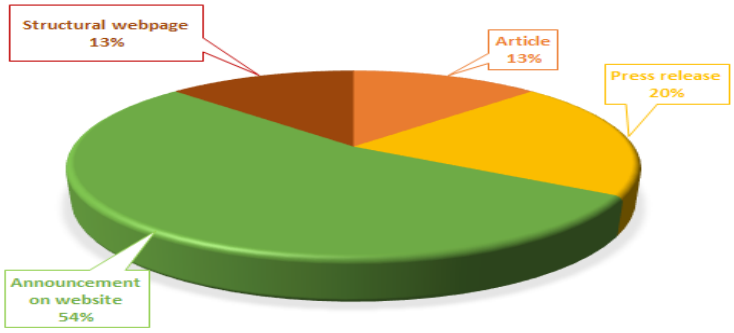

Fig. 11: Publications during the project period

The partners have participated in several events for project was dissemination. Each partner identified the types of events (such as fairs, conferences, seminars, workshops) where they could promote the project.

Table 3. List of events

TYPE OF ACTIVITIES	MAIN LEADER	TITLE	DATE	PLACE	TYPE OF AUDIENCE	SIZE OF AUDIENCE	COUNTRIES ADDRESSED
Presentation, Poster, flyers	FAST	European Fuel Cell - Piero Lunghi Conference 2015	18/12/2015	Napoli (Italy)	academia, research, industry, policy	More than 250	INT
Presentation, Flyer, poster	FAST, TUD	Knowhy	13-17/4/2015	HANNOVER MESSE 2015	industry –research and development - industrial automation, IT, industrial supply, policy	220.000	INT
Flyers	FAST	KnowHy	30/10/2015	Smart Mobility World Conference, Monza (Italy)	Academia, industry, decision makers, general public	1600	INT
Flyers	FAST	KnowHy	22-26/6/2015	H2FC European technical school workshop, Greece	Academia, industry	95	INT
Conference	Campus	event related to the Fuel Cell & Hydrogen in the Automotive	02/10/2015	Campus Spa-Francorchamps	Industry, research	more than 50	BE (mainly)
Flyers	TUM	KnowHy (+Workshop Birmingham announcement)	10/02/2016	Symposium Energieinnovation Graz	Industry, research, policy	500	EU (mostly German speaking)

Flyer	FAST	Knowhy	25-29/4/2016	HANNOVER MESSE 2016	industry –research and development - industrial automation, IT, industrial supply, policy	220.000	INT
Flyers	TUM	KnowHy (+Workshop Birmingham announcement)	09/05/2016	Regatec	Industry, research, policy	165	EU
Workshop	FAST, TUD, TUM, CAMPUS, UBHAM	KnowHy	25/05/2016	FCH2 Technical Conference 2016, Birmingham	Industry, research, poilcy	114	EU
Presentation	FHA	Online training methodology in Fuel Cell and Hydrogen technologies for Europe	13-16/06/2016	Zaragoza (Spain) WHEC 2016	FCH industries, research institutions, decision makers	900	INT(50 Countries)
Presentation	KIWA	Standardization of hydrogen systems	26/09/2016	Dutch Committee of CEN-CENELEC/TC 6 on Hydrogen first meeting	Industry, policy makers, research institutions		NL
Flyers	TUM	FDFC Stuttgart	31/1-2/2/2017	Stuttgart	Industry, research, policy	more than 150	EU (mostly German speaking)
Presentation	KIWA	Introduction KnowHy courses	01/03/2017	Noorderpoort College Groningen	Teachers automotive and automotive mechanics	35	NL
Flyers	FAST	KnowHy	15 - 17/3/2017	Aberdeen Hydrogen Transport Summit 2017	Local authorities, bus manufacturers, bus operators and other key stakeholders from transport sector	150	EU
Flyers, Poster, EHA Stand	FAST	KnowHy	24 - 28/4/2017	HANNOVER MESSE 2017	industry –research and development - industrial automation, IT, industrial supply, policy	220000	INT
Presentation	TUD	KnowHy Workshop CTC Bonn	20/10/2017	CTC Bonn	academia, research, industry, policy	more than 20	NL
Presentation	KIWA	summary experiences with KnowHy courses	20/10/2017	CTC Bonn	Mostly people already involved in KnowHy	± 18	NL, GE
Presentation	FHA	TRAINING OF TECHNICAL STAFF AND EMPLOYEES IN H2 AND FUEL CELL	17-20/10/2017	IBERCONAPPICE 2017	FCH industries, research institutions, decision makers	45	ES
Presentation	KIWA	Introduction KnowHy courses	22/11/2017	Kiwa Apeldoorn	Technicians and decision makers	60	NL
Oral and poster presentation	TUD	FCH JU annual review day of 2017	23-24/11/2017	Brussels	industry –research and development - energy and mobility technologies, policy	more than 100	BE

Many activities were performed for project promotion during the project, and were carried out through different channels in order to have maximum impact (Fig. 12). The utilization factor of

dissemination channels used by partners during the development of the project has been shown in following Figure.

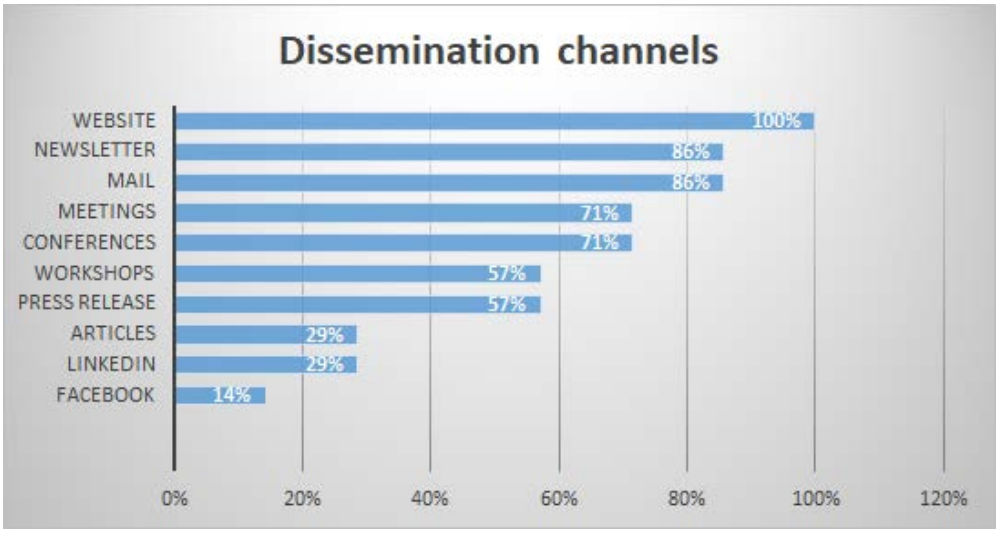

Fig. 12: Percentage of the partners that used a certain dissemination channel

Website announcements, emails and newsletters have been the preferred method to disseminate project developments. Managing social networks though, was more difficult than expected. To ensure high level of activity on the social networks and consequently many views and followers, the pages were constantly updated. For LinkedIn, besides the page, information on the page reposted by people with a lot of connections is considered an effective way to keep the page alive.

Address or project public website and relevant contact details

https: // Knowhy.eu/