

HyTEC-DK

»Demonstration of fuel cell vehicles &
hydrogen stations in Copenhagen«

PROJECT END REPORT
DECEMBER 2015

Project No.: 64011-0331



SUPPORTED BY:



Project details

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Project identification	64011-0331
Name of the programme which has funded the project	EUDP-2011-II
Project managing company/institution (name and address)	Copenhagen Hydrogen Network A/S (CHN) Høje Taastrup Vej 42 2630 Taastrup Denmark
Project partners	Foreningen Hydrogen Link Danmark (H2Link) H2 Logic A/S Københavns Kommune Ludwig-Bölkow-Systemtechnik GmbH (Germany)
CVR (central business register)	CHN: 33641389 H2Link: 31321646 H2 Logic: 26933048 Københavns Kommune: 64942212
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Short description of project objective and results

English version

HyTEC-DK has demonstrated a network of 3 hydrogen refueling stations in Copenhagen along with 15 fuel cell electric vehicles (FCEV) from Hyundai. The stations are established in Copenhagen South, Gladsaxe/Herlev and Køge. A total of 4.507kg has been dispensed allocated on 1.362 fuelings and with an average station availability of more than 98%. The FCEVs have driven more than 300.000 km with an average availability of more than 99,5%. The project has catalysed the start of market introduction of hydrogen for transport in Denmark, with several additional stations and vehicle deployments throughout the country.

Dansk version

HyTEC-DK har demonstreret et netværk af 3 brint tankstationer i København sammen med 15 stk. brændselscelle biler fra Hyundai. Brint tankstationerne er etableret i Sydhavnen, Gladsaxe/Herlev samt motorvejssammenfletningen ved Køge. Samlet blev der i projektperioden tanket 4.507 kg brint fordelt på 1.362 tankninger, og med en stations driftsstabilitet på mere end 98%. Brintbilerne har tilbagelagt mere end 300.000 km i løbet af projektet, og med en driftsstabilitet på mere end 99,5%. Projektet har katalyseret en påbegyndelsen af markedsintroduktion af brint til transport i Danmark, med udrulning af adskillige nye stationer og køretøjer på tværs af landet.

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1. Executive summary

HyTEC-DK has been the Danish activities of the HyTEC large scale European demonstration project on hydrogen for transport, supported by the European FCH-JU and Danish EUDP programs, with activities in both London and Denmark.

As part of HyTEC 15 Fuel Cell Electric Vehicles (FCEV) has been procured and demonstrated by the city of Copenhagen. A support network of three Hydrogen Fueling Stations (HRS) has been established and operated in the Greater Copenhagen area. To ensure a continuation beyond the project a FCEV and HRS Expansion study has been developed for Denmark, assessing the potential contribution from hydrogen to the overall Danish goal of achieving fossil independence by 2050.

The HyTEC project has successfully validated the functionality and market readiness of FCEVs and HRS's and has enabled a start of market introduction in Denmark.

Prior to the HyTEC project only one HRS prototype was in operation in Denmark, which was used by various non-automotive FCEV prototypes. With HyTEC a network of HRS's was established and operated in Copenhagen, along with delivery of a fleet of 15 FCEVs from Hyundai to the City of Copenhagen.

The FCEVs have accomplished more than 300.000 km with an availability of more than 99,5% between June 2013 to August 2015 – operation of the vehicles continues beyond the project. End-users have provided only positive feedback on the operation and daily use. Average distance travelled per vehicle per day of operation increased from 36km at the beginning of the project to 50km, indicating that users became increasingly comfortable with the vehicles as they used them.

The average fuel efficiency was 78km/kgH₂. The real-world range of the vehicle is therefore near 450km. The efficiency has varied from a high of 85km/kgH₂ (Jul-13) to a low of 69km/kgH₂ (Jan-14). The deviation from the NEDC rated consumption (105km/kg H₂) is on level with what is seen on conventional gasoline and diesel vehicles.

During the project a total of 4.507kg of hydrogen was dispensed from the three HRS's allocated on 1.362 hydrogen fuelings. Besides the HyTEC FCEV fleet, the station was also used by other FCEVs arriving from other cities in Denmark and Sweden. The HRSs accumulated 36,5 months of operation and will continue operation beyond the HyTEC project.

The HRS's provides 70MPa fueling in accordance with the SAE J2601 standard, and pre-cooling of hydrogen to -40°C enables a fast fuelling of between 3-5 minutes of more than 500+km range. Users however typically fuel when the vehicle tank is 40% empty or when 200km range is left.

The HRS was the first installation of the new H2Station® CAR-100 product where all equipment is integrated into one compact module. This allowed for a very fast installation time of only 48 hours, one of the fastest achieved in the world at the time. The HRSs achieved average availability of more than 98% excluding scheduled maintenance upgrades during the project, validating the readiness for market.

The HyTEC demonstration results have catalysed that three international car manufacturers are now active on market introduction of FCEVs in Denmark – which was one of the project objectives.

In addition public and private investment of more than 90 million DKK is being conducted in the construction of a countrywide network of more than 10 HRS's onwards end of 2016 – also an objective of the HyTEC project.

The commenced market introduction efforts ensures that the phase 1 of a FCEV & HRS Expansion study, developed in the HyTEC project, is on track to be completed.

This enables continuation of a phase 2 where number of FCEVs and HRSs are to be increased onwards 2025, reaching a critical mass and volume for a continued commercial roll-out onwards 2050. If public and private investments can be secured for the phase 2, hydrogen has the potential to contribute to the Danish goal of fossil independence by 2050, by ensuring zero emission in 50% of the entire car fleet in Denmark.

HyTEC has also helped catalyse export of Danish hydrogen technology, with H2 Logic using the project as a platform for sale of products to multiple countries in Europe.

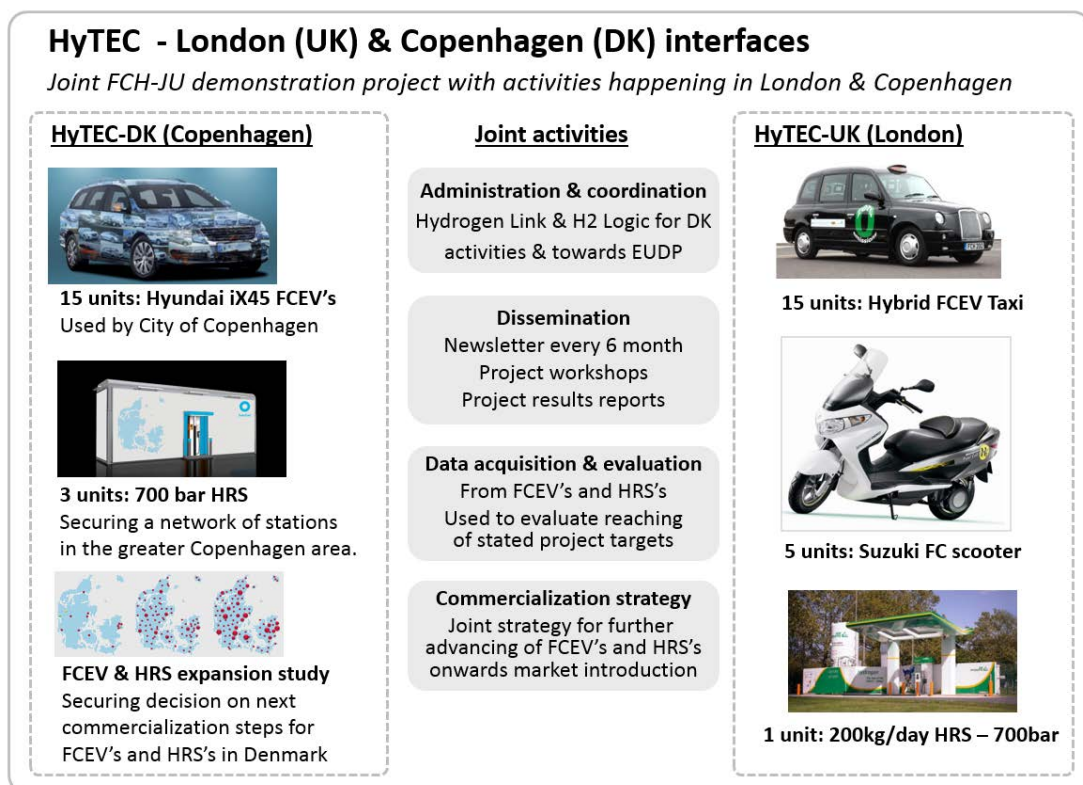
The technical experiences gained from the demonstration in HyTEC has enabled setting up of several new R&D projects on HRSs and supporting hydrogen production, with a total combined budget of more than 200 million DKK.

In conclusion the HyTEC project has met its objectives, ensuring start of market introduction of hydrogen for transport in Denmark and export of Danish technology and with continued R&D efforts.

2. Project objectives

HyTEC has been a joint European large scale demonstration project supported by the Fuel Cells & Hydrogen Joint Undertaking program (FCH-JU) program with activities happening in both London (UK) and Copenhagen (DK). The Danish EUDP program has supported the activities in Denmark.

The content and interfaces between the Danish and UK activities in HyTEC is illustrated in the figure below.



Various Fuel Cell Electric Vehicles (FCEV) has been demonstrated in each of the cities of Copenhagen and London as well as a supporting hydrogen refuelling station infrastructure (HRS).

A number of joint activities has been conducted:

- Project administration and coordination
- Dissemination of project results
- Data acquisition from FCEV's and HRS's
- Formulation of a joint commercialization strategy to further advance the demonstrated technologies

The Danish activities in HyTEC has focused on three main tasks.

- **Demonstration of 15 FCEVs in the City of Copenhagen**
Prior to the start of the HyTEC project, only prototype FCEVs from non-automotive companies had been tested in Denmark. The City of Copenhagen therefore conducted a public tender on procuring a fleet of FCEVs from a car manufacturer (Hyundai) for use in the daily transport purposes in the city services. Besides attracting FCEVs from car manufacturers to Denmark, the process has also provided experience in public procurement of FCEVs and daily use hereof across the employees in the city services.
- **Demonstration of 3 HRSs in the Greater Copenhagen Area**
At the start of HyTEC only one HRS was in operation in Denmark in the city of Holstebro. HyTEC where to ensure a network of three HRSs in the great Copenhagen area. Besides providing the fueling for the FCEV fleet in Copenhagen, the stations were also to enable start of market introduction of FCEVs in Copenhagen and pave the way for additional stations throughout the country.
- **FCEV & HRS Expansion study for Denmark**
To support the long term planning an Expansion study was made, modelling potential scenarios for a continued roll-out of FCEVs and HRSs in Denmark onwards 2050. Besides guiding a future roll-out and market incentives, the report also quantifies the potential contribution to reaching the Danish goal of fossil independence by 2050.

The overall objective of the Danish activities were to enable a decision on commencing market introduction of hydrogen for transport in Denmark, by securing:

- **At least two car manufacturers active on FCEV deployment in Denmark**
Availability of FCEVs from the major and established car manufacturers is a key requisite for enabling market introduction. During the HyTEC project three car manufacturers have started FCEV deployment in Denmark or announced plans to do so. Hyundai started the sales of the iX35 FCEV in January 2014 and Toyota launched the Mirai in September 2015. Honda have announced plans to launch their new FCEV in Denmark during 2016.
- **Decision on establishment of a nationwide HRS network across Denmark**
Growing FCEV sales requires an adequate HRS network across the country. During HyTEC several stakeholders have made investments decisions on HRS constructions that will ensure a countrywide network during 2016, covering all the major cities in Denmark.

In summary, the objective has been reached, as the market introduction of hydrogen for transport in Denmark is now ongoing.

3. Project results and dissemination of results

Below is provided a brief summarization of the HyTEC results achieved in Denmark. A more elaborate reporting is provided as part of the European reporting in the overall HyTEC project, consisting of several deliverables reports. A list of these reports is provided in Annex.

3.1 Demonstration of 15 FCEVs in the City of Copenhagen

In January 2012, the City of Copenhagen started activities on the tender and procurement process to deliver the fleet of hydrogen fuel cell cars into the city. The procurement was completed in September 2012 and fifteen ix35 FCEVs from Hyundai were delivered to the city in June 2013. The procurement process was one of the first of its kind for FCEVs and a report on the process has been made as Deliverable D.2.3.1.



Necessary approval of the OEM passenger vehicles for Copenhagen was provided by the OEM as part of the vehicle provision. The OEM was required to provide all necessary documentation to enable homologation in accordance with European legislation and international standards. This included among others the “EIHP2 Draft for Vehicle Approval” and EC REGULATION No. 79/2009 - on type-approval of hydrogen-powered motor vehicles, taking into consideration the time overlap between the two regulation documents. In addition, the base vehicle (e.g. modified gasoline model) required a full European type approval or other sufficient approval. In addition to the European type approval – local Danish approval was required.

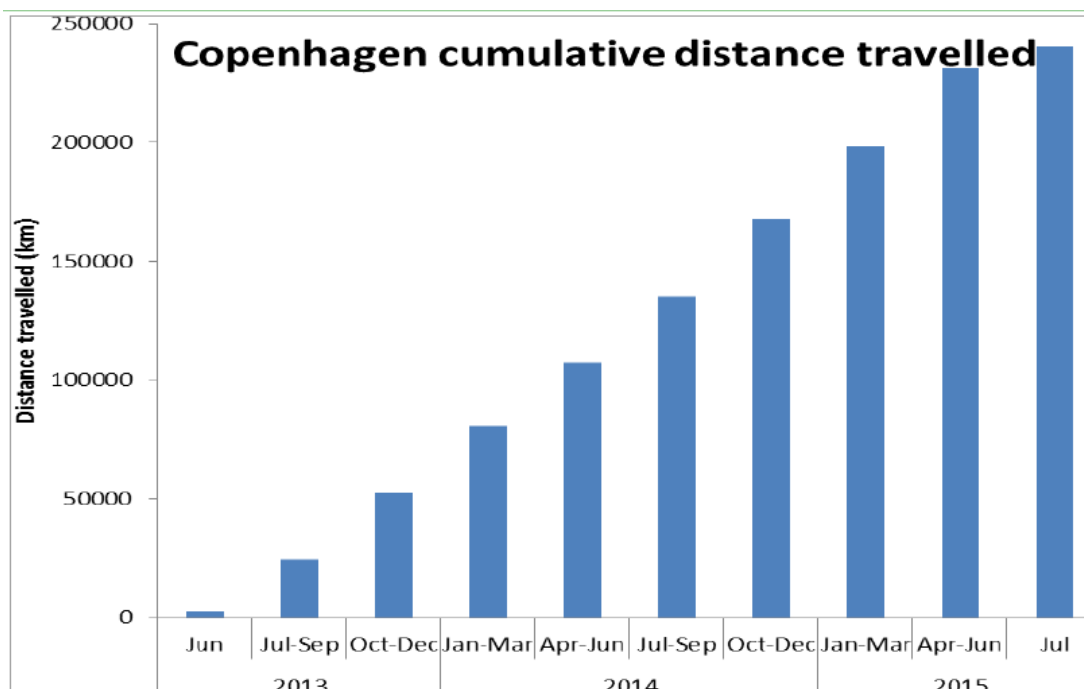
When the fifteen Hyundai ix35 fuel cell vehicles were delivered to the Municipality of Copenhagen, Hyundai Bill Import encountered some issues regarding registration of the vehicles. The Danish registration and taxation systems were not set up to handle hydrogen as a source of power for cars. This had to be created by the Danish

taxation authorities and the Danish Car Importers Association who handle the manufacturers data used for basis of taxation of cars.

Registration of vehicles in Denmark (and other EU countries) is primarily based on data in COC documents (Certificate of Conformity). This data was transferred to the tax authority who through their system allows registration of the particular vehicles. Both the systems that send and receive the data could not use the COC documents data because several figures were left blank, i.e. because the vehicles has no CO2 emission. The systems had to be changed, but also because the cars are tax exempt until 2015 the system also had to be able to allow this, which also required a change. These issues were overcome and as such, the Danish registration of the Hyundai ix35 FCEVs was carried out from April 22nd -29th 2013 and completed so that the cars were ready for deployment in Copenhagen in June 2013.

As a result of this work, the Danish registration of FCEVs can now be completed very quickly. It now only takes 1½ week due to tight corporation between Danish authorities and the Danish Car Importers Association. Deliverable report 5.5 elaborates on the FCEV approval process.

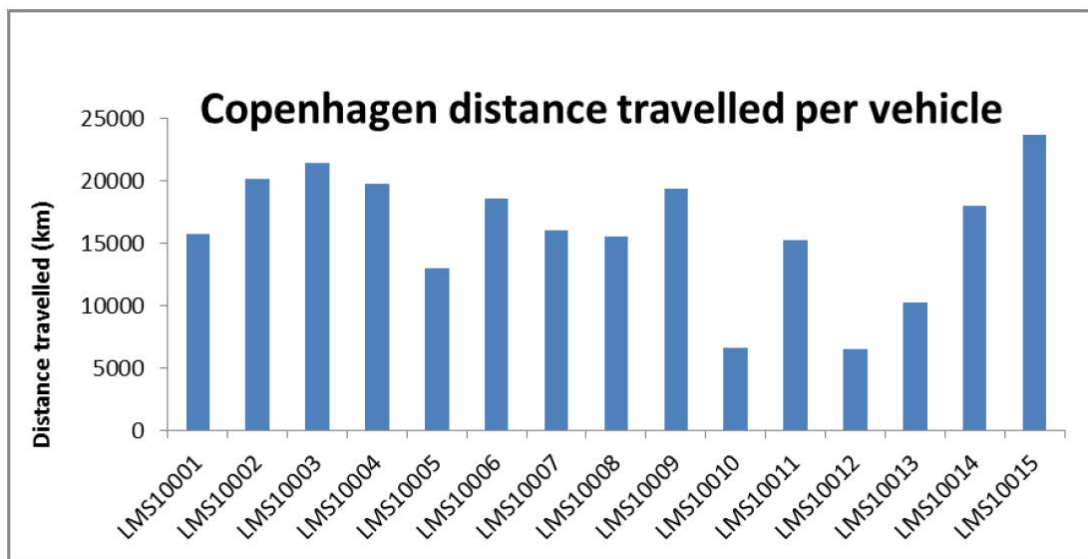
The FCEVs commenced operation in June 2013 and until summer 2015 (end of the project) more than 300.000 km has been driven. The data captured from the vehicle data telemetry only shows 240.000 km, but not all vehicle drive events were analysed and project data captured at the end of the project, thus the mileage measured by on-vehicle odometers was more than 300.000km by the trial end in August 2015.



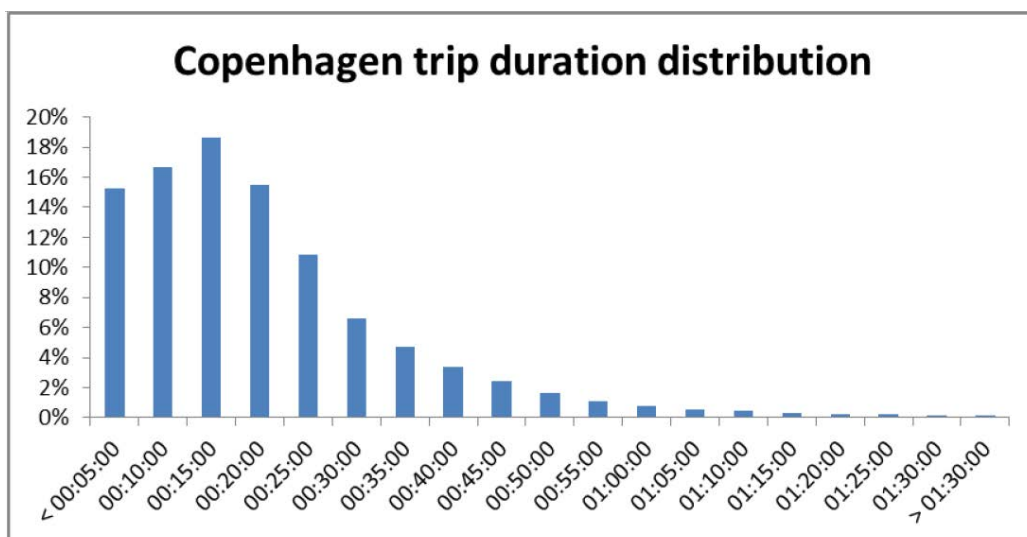
Monthly use of the vehicles increased steadily as they were introduced into fleets, rising from 2.500 km in June 2013 to 13.000km in July 2015.

Average distance travelled per vehicle per day of operation was 50km. This increased from 36km per day at the start of the trial in 2013 showing that the users became increasingly comfortable with the vehicles as they used them.

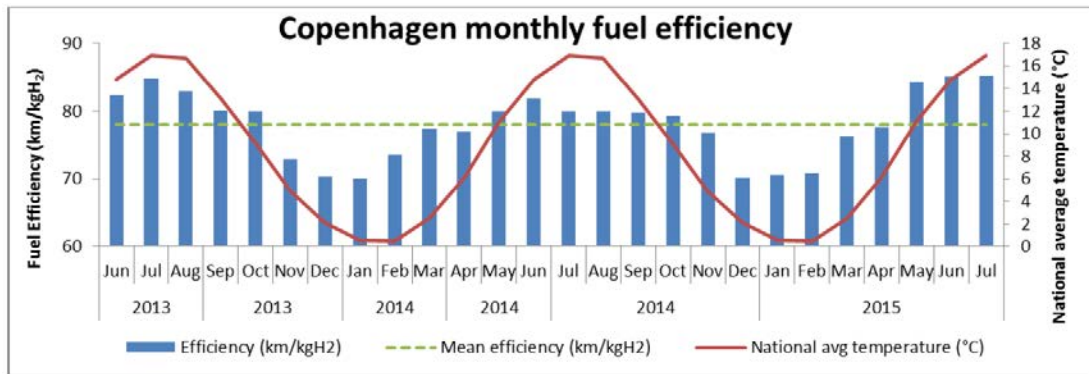
The average distance travelled per vehicle was over 16.000km (~8.000km per year). The furthest travelled by one of the vehicles was 23.600km.



The vehicles were generally used in urban environments for short journeys. The most common trip duration was 10-15 minutes (trip defined as ignition key-on to key off). The longest trip duration was 245 minutes. This use for short trips is not a reflection of the vehicle's range which is much further. The most common trip average speed was 25-30 km/h (excluding time at rest), whereas the average vehicle speed in Copenhagen traffic in general is 27km/h.



The average fuel efficiency June 2013-July 2015 was 78km/kgH₂. The real-world range of the vehicle is therefore near 450km. The efficiency has varied from a high of 85km/kgH₂ (Jul-13) to a low of 69km/kgH₂ (Jan-14). There is no evidence of an efficiency drop off in over two years of operation. Efficiency broadly correlates with average Danish national temperatures. Generally, temperature had a negative correlation with energy consumption due to factors including increased rolling & wind resistance, greater use of on board cabin heating during the winter and reduced battery and mechanical efficiency.

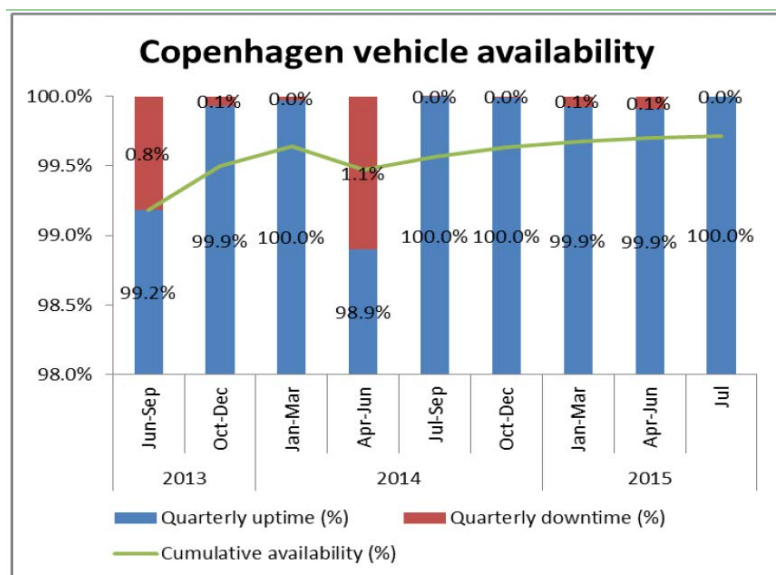


The end users of the vehicles comprise employees of the Copenhagen municipality working in a variety of different administrations.

The users are in general very pleased with the driving abilities and technical performances of the fifteen fuel cell vehicles operating in Copenhagen City. The united response is that the vehicles are very user-friendly, comfortable to drive and technically well-appointed and well-functioning. The challenges have been few and mainly related to user experiences and less to problems of technical character.

The overall vehicle availability was greater than 99,5%. There was very little unscheduled downtime. All vehicles undergo scheduled maintenance every 10.000 km.

Further results are provided in Deliverables reports D6.2.3, D6.5.1 and D6.5.2



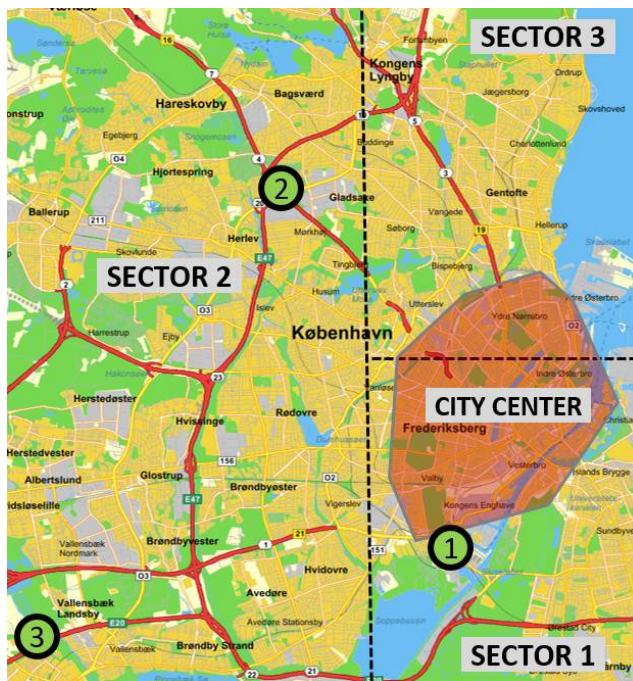
3.2 Demonstration of 3 HRSs in the Greater Copenhagen area

Copenhagen Hydrogen Network A/S (CHN) has constructed and operated three HRSs as part of the HyTEC project. Initially CHN was established by H2 Logic A/S as a dedicated infrastructure company, with the purpose of establishing and operating an early infrastructure of HRSs in Denmark, starting with the HyTEC HRSs. In June 2014 the gas company Air Liquide joined as investor in CHN ensuring a strong set-up for deploying additional stations beyond the HyTEC project.

As a first exercise in the project, a site analysis was conducted in the greater Copenhagen area, with the purpose of identifying and selecting three HRS sites. Together the HRS's were to provide a sufficient fuelling coverage for the city.

The first site was selected in early 2012 covering the area south of the city centre (Sector 1). Sites for the remaining two HRS's were also identified during 2012 – ensuring coverage of sector 2 as shown on map.

Sector 3 may be a target area for future HRS's outside the project.



Building permit for the first HRS in Copenhagen was secured in late 2012. Building permit for HRS Copenhagen Ring/Gladsaxe was secured during fall 2014 and for the third HRS Copenhagen West/Køge in early 2015. The permits are documented in Deliverables reports D.3.3.2.a and D.3.3.2.b.

The HRS technology demonstrated in the three HRSs is developed and delivered by H2 Logic. The HyTEC project was the first demonstration for H2 Logic of the H2Station® CAR-100 product, that since then has been deployed in several other countries in Europe.

The stations provides 70MPa fueling in accordance with the SAE J2601 standard, and pre-cooling of hydrogen to -40°C enables a fast fuelling of between 3-5 minutes of more than 500+km range. Each station has a capacity of up to 75kg/day and is based on a combination of partial onsite electrolysis and trucked-in hydrogen supply.

Locations	3 HRSs in the Greater Copenhagen area
Daily capacity (per station)	Up to 75 kg/day (depending on inlet pressure)
H2 Supply	Partial onsite
Refuelling pressure	70MPa
SAE J2601/SAE J2799 level	A-level -40°C with IR
Owner & Operator	Copenhagen Hydrogen Network A/S
HRS Technology provider	H2 Logic A/S



The technical specifications are further elaborated in Deliverables reports D3.2.2a and D3.2.2b.

The first HyTEC HRS was opened in June 2013 in Copenhagen South (Sydhavnen) located at an existing gasoline station. The location is close to the city centre and the major highway entering the city from the south.

The HRS was the first installation of the new H2Station® CAR-100 product where all equipment is integrated into one compact module. This allowed for a very fast installation time of only 48 hours, one of the fastest achieved in the world at the time.

A time-lapse video of the installation was made and published online:

<https://www.youtube.com/watch?v=kjGaNGhz1pE>

Below is shown a picture of the installation HRS in Sydhavnen. Hydrogen production is integrated into the station module, that also includes a build-in dispenser. Trucked-in supplemental supply of hydrogen is placed to the back of the station behind the fencing.



The second HRS in Copenhagen (Copenhagen Ring/Gladsaxe) was successfully put into operation in December 2014. The HRS is located at a conventional fuelling station right next to a major highway ring around Copenhagen to the North/West. The HRS was open for fuelling in December 2014, whereas the official opening event was conducted in April 2015. Below is shown a picture of the HRS installed at site.



In July 2015 the third HRS commenced operation at the Copenhagen West/Köge site completing the network. The HRS is located at an old battery swapping station (Better Place) and right next to a BEV fast charging facility. The location is next to the major highway intersection at the outer skirts of Copenhagen, connecting to Germany and West Denmark. Below are shown a picture of the installed HRS at site.

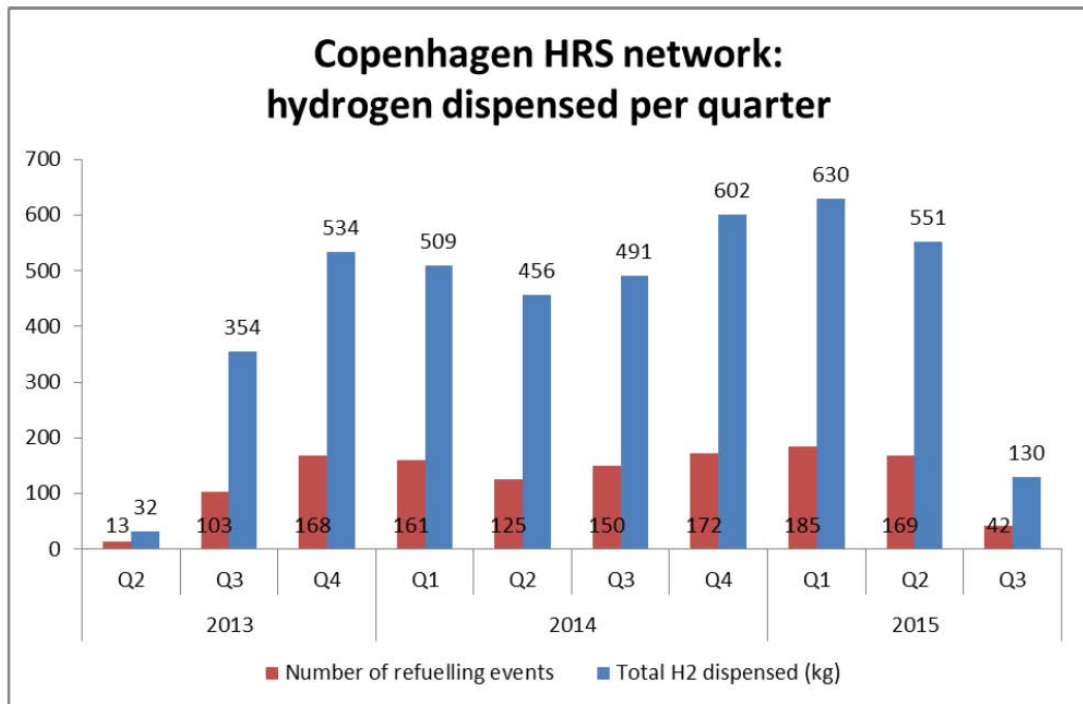


Completion of the three HRSs is reported in Deliverables Reports D3.4.2.a and D.3.4.2b.

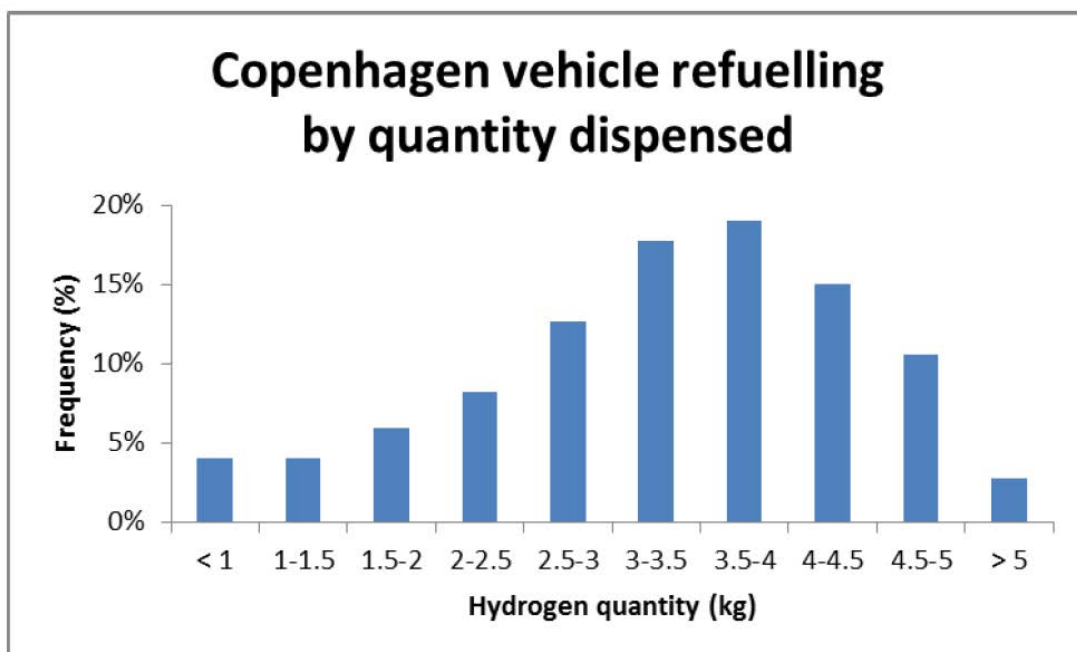
The HRS's in Copenhagen has been in continuous operation since the starting date of each HRS. By end of the HyTEC project, a total of 36.5 months of HRS operation was achieved. All three HRS's will continue operation beyond the project period.

Operation results is reported in Deliverable report D6.2.3 and a brief summary is provided below.

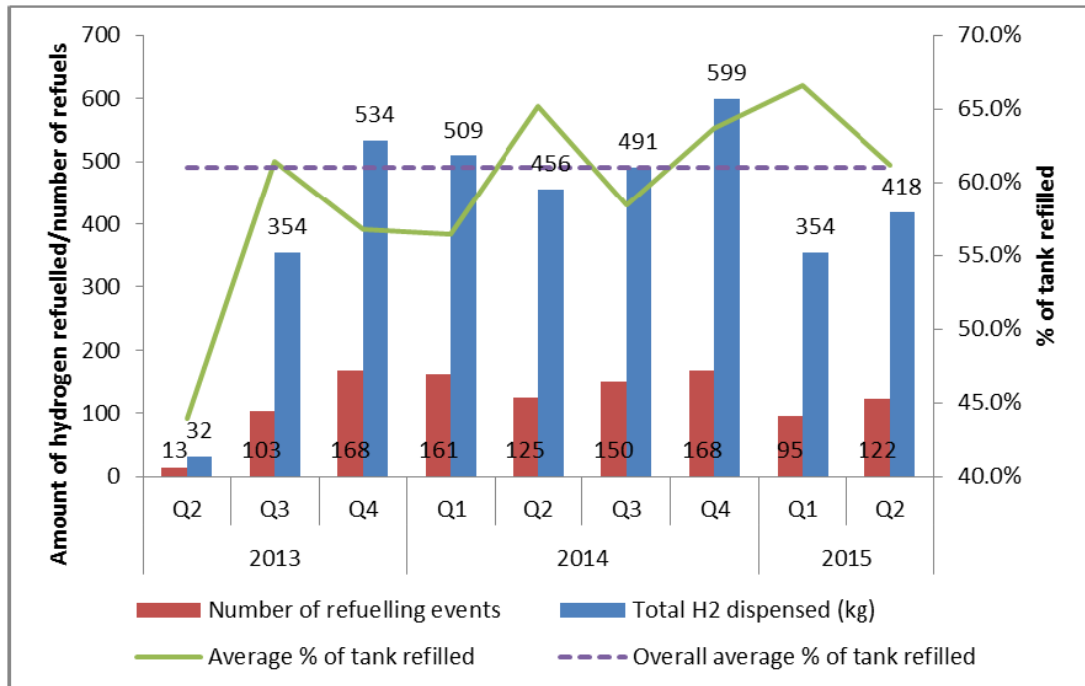
For the three HRS in Copenhagen, a total of 4.507kg has been dispensed allocated on 1.362 fuelings.



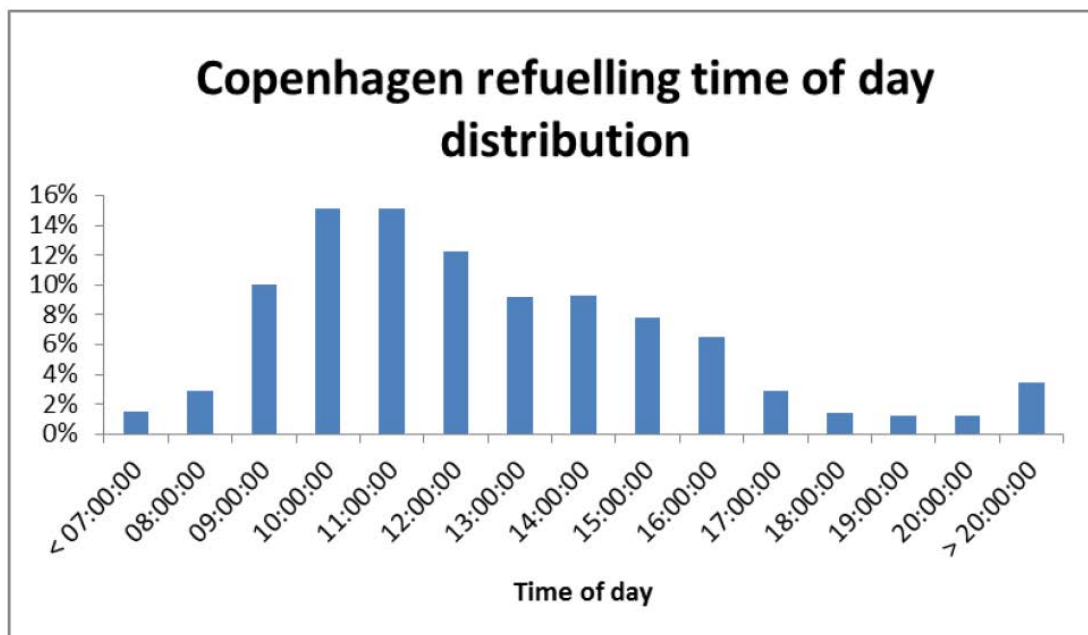
The modal (most popular) refuelling amount per refuelling event is 3-4kg, or ca. 60% of the vehicle tank capacity of 5,6kg. There is no evidence that this has changed since the start of the vehicle deployment.



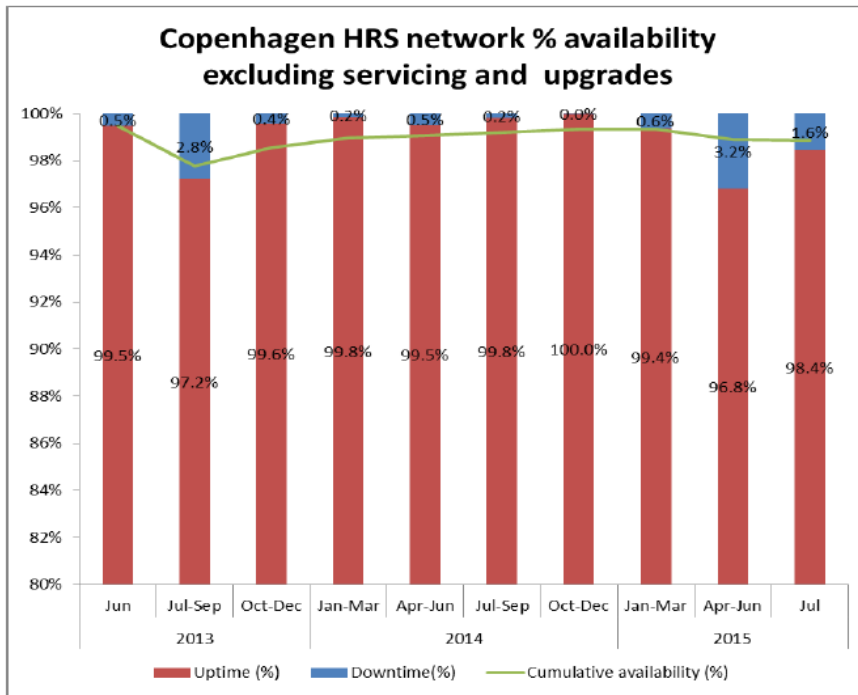
Users almost always complete refill the vehicle hydrogen tanks when refuelling. On average users add around 3,4kgH₂ per fill, or ~60% of the tank's capacity of 5,6kg. The average amount filled has remained at or near 60% since mid-2014, showing that any range anxiety effects that may have existed at the start of the trial have diminished.



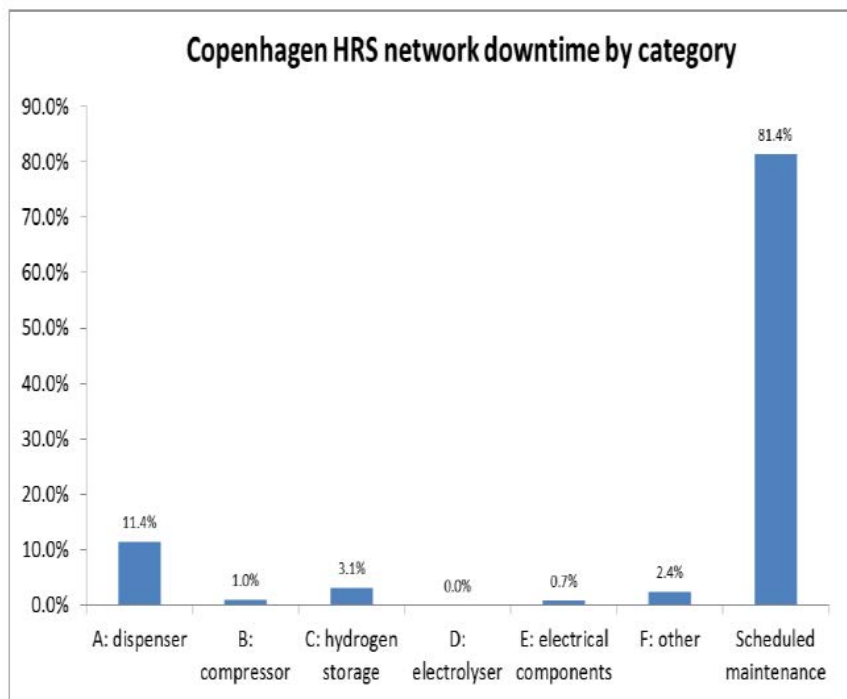
The great majority of refuellings were carried out during the working day which demonstrates the vehicle's duties as part of working public fleets. There is evidence of a morning peak between 10 am and 12pm. There are comparatively fewer refuelling events at the end of the working day showing that the drivers do not in general refuel the vehicles to be ready for the next user on the next working day.



The three HRSs combined achieved an average availability of more than 98% excluding scheduled maintenance upgrades during the project.



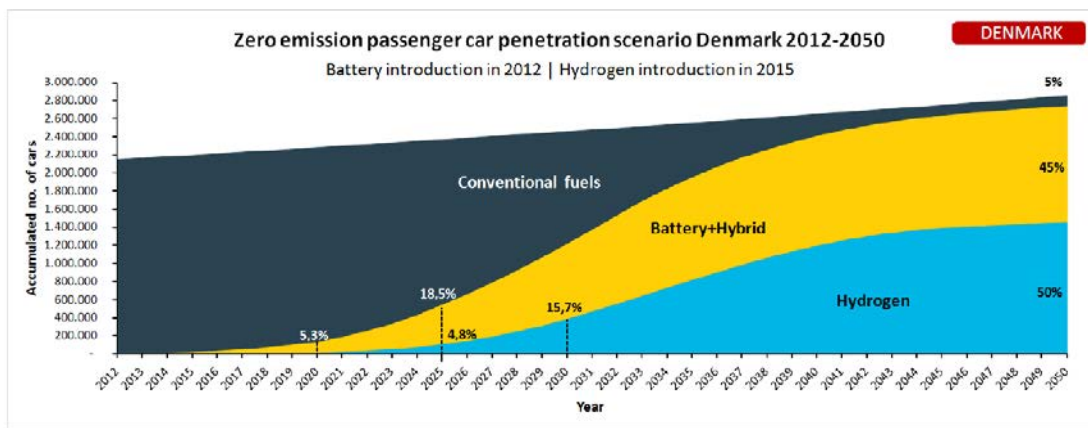
Over 80% of HRS downtime was due to scheduled maintenance and upgrades.



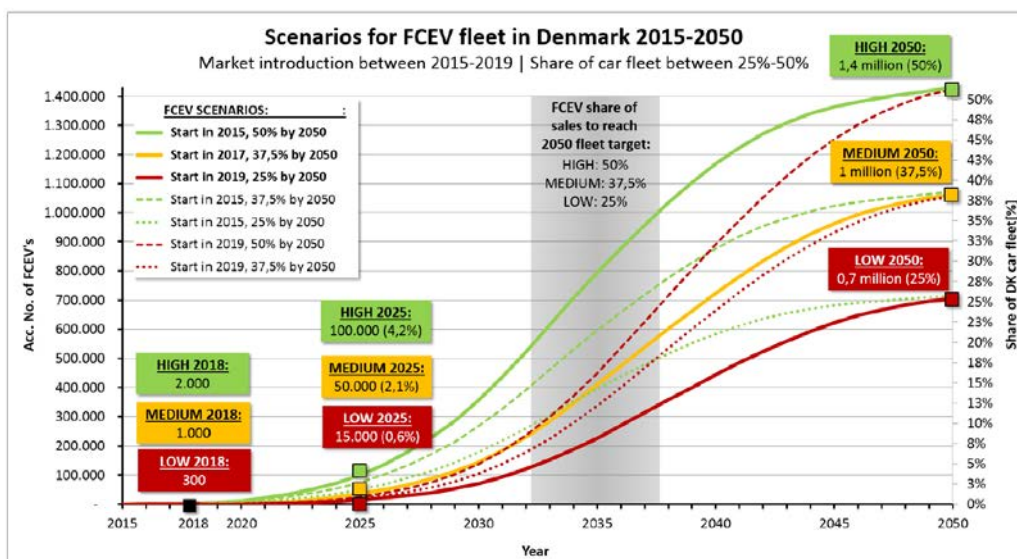
3.3 FCEV & HRS Expansion study for Denmark

A detailed FCEV & HRS Expansion study for Denmark has been conducted as part of the HyTEC project. The study has analysed scenarios for deployment of FCEVs and HRSs in Denmark onwards to 2050, with the aim to contribute to the overall Danish goal of 100% fossil independence by 2050.

Reaching fossil independence by 2050, requires that almost the entire car fleet by 2050 becomes zero emission. Whereas biofuels can be expected to be prioritized for heavy duty transport in the long term, the majority of passenger vehicles will need use of electricity through batteries and hydrogen. Battery Electric Vehicles (BEV) are expected to target the smaller car segments where with short range is acceptable, whereas FCEVs are targeting the normal sized cars, where long range and fast fueling is needed. The overall assumption for the study has therefore been a 50/50 split between BEVs/Hybrids and FCEVs in the Danish car fleet by 2050.

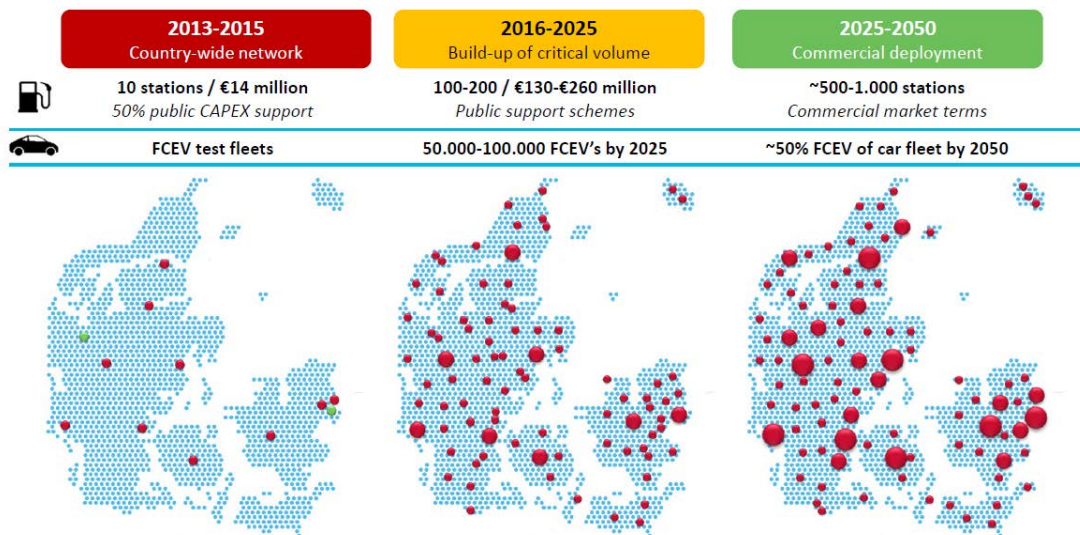


Reaching 50% FCEVs by 2050 in Denmark requires reaching of 100.000 vehicles (4,2%) by 2025 and 1,4 million by 2050 (50%). If less vehicles are actually deployed during the early years, the share by 2050 may drop to between 25-37,5%.



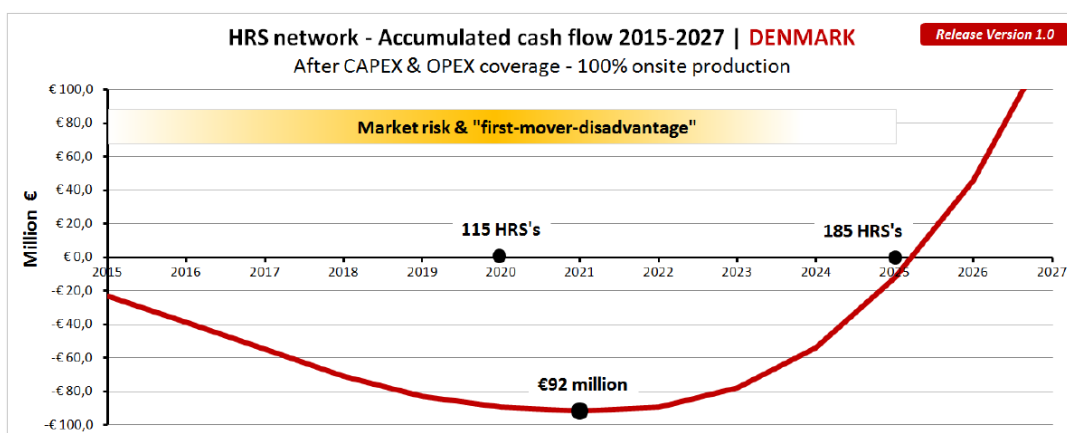
The detailed HRS roll-out study has focused on the high scenario where 50% FCEVs are achieved, ensuring the contribution to the Danish goal of fossil independence.

Three roll-out phases has been modelled, as outlined in the figure below.



In a phase 1 onwards 2015 a countrywide network is to be established ensuring at least 10 stations in the major cities across Denmark. Also FCEVs from the major car manufacturers are to become available.

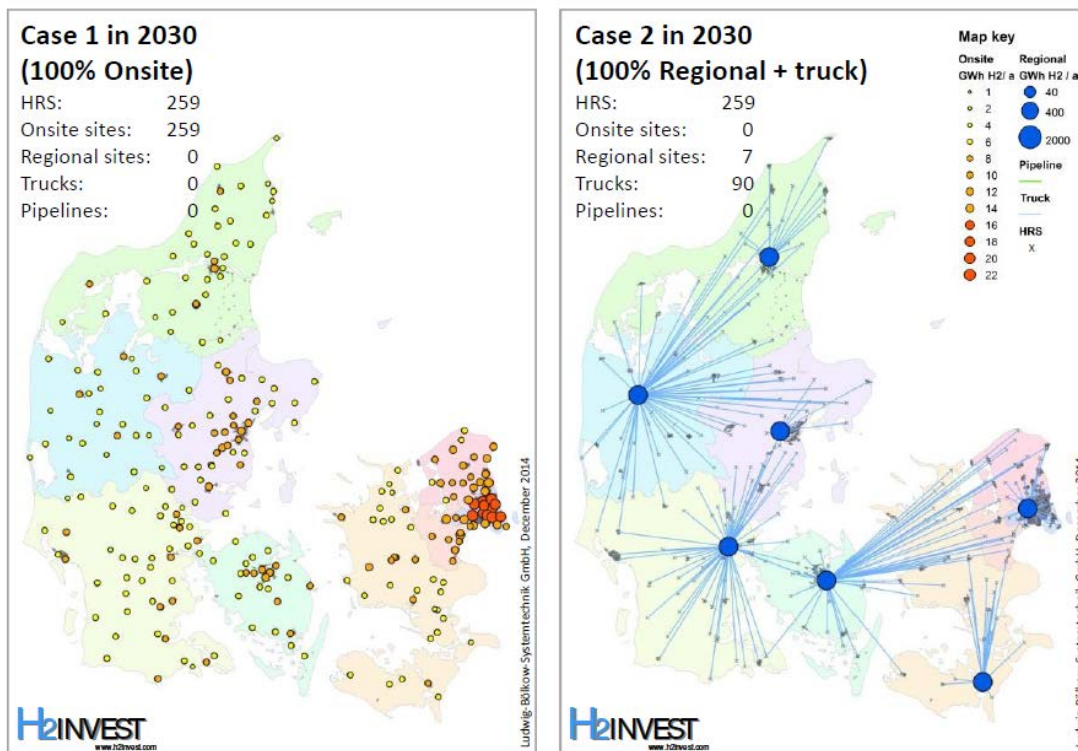
In a phase 2 onwards 2025 the HRS network and FCEV fleet is gradually to grow, reaching between 100-200 stations and 50.000-100.000 FCEVs. Accomplishing this will require a combination of public and private investments. The public investments can be done as market support mechanisms as has been in place for other renewable energy technologies in Denmark in the past. The public support is to address the investment risk during the first 10 years, where HRS utilization is expected to be low, as HRS roll-out will happen faster than the FCEV deployment. Building 185 stations onward 2025 will result in a peak cash flow of minus €92 million. The public funding can help reduce the cash flow and thus risk for private investors.



Reaching the critical volume during phase 2, may enable a continued commercial deployment onwards 2050 (phase 3), reaching 50% of the car fleet and between 500-1.000 stations.

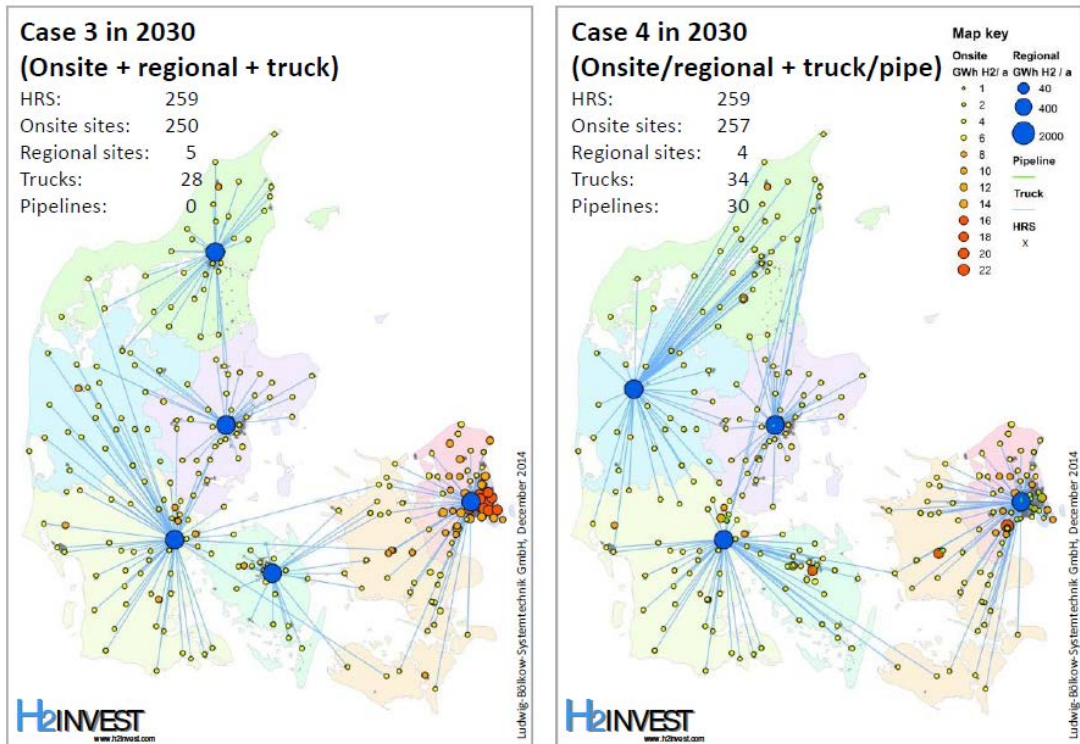
The hydrogen supply in Denmark is assumed to be based on use of renewable electricity and electrolysis production of hydrogen. As the share of renewable electricity in the Danish grid increases, so does the CO2 emission reduction from FCEVs. From 2025-2050 FCEVs would decrease CO2 emissions with accumulated 33,6 million tons.

Detailed assessments has been conducted on various hydrogen supply cases, e.g. onsite production or central production with distribution and combinations hereof. Below are shown 4 cases analysed for 2030 in the HyTEC project.

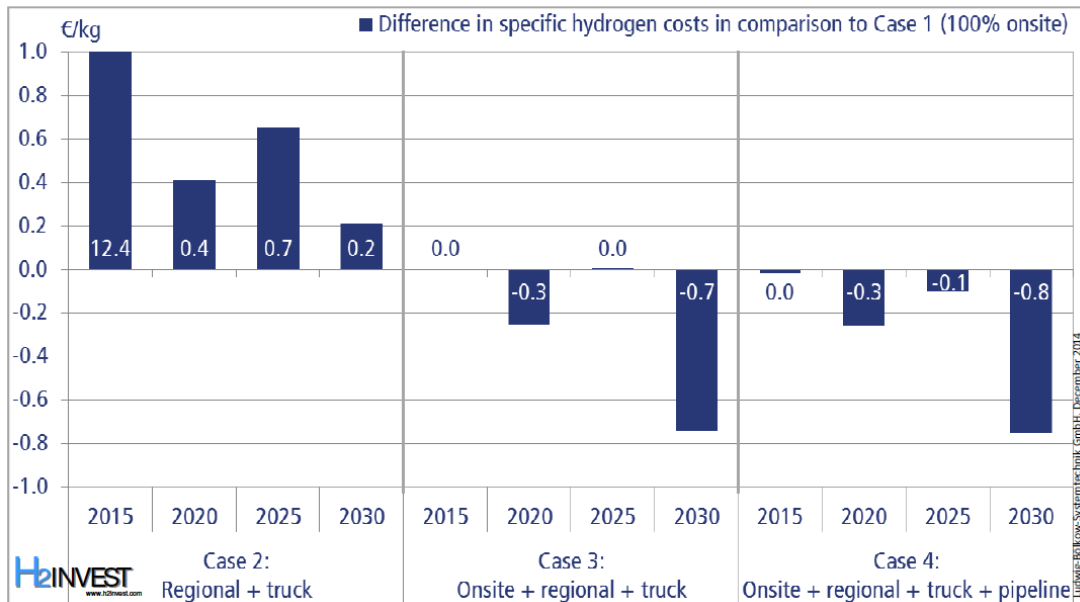


In case 1 hydrogen production is done onsite at the HRS, whereas in Case 2 all production is done at seven regional (central) sites with trucking of hydrogen to the station.

Case 3 (next page) combines onsite and central production reducing the number of regional production sites to 5. In case 4 use of hydrogen distribution via pipeline is also introduced in the most densely populated areas.



For each case the specific hydrogen costs has been calculated and compared, as shown in figure below. By 2030 the case 4 provides the lowest hydrogen price, shown as the difference to the price case 1, which is the most costly supply set-up.



The complete FCEV & HRS Expansion study is reported as Deliverable D8.2.2.

3.4 Dissemination of results

Progress and results has been disseminated throughout the project period.

The overall HyTEC EU project has operated the website www.hy-tec.eu where project news, progress and results has been published on a continuous basis.

The Danish activities (HyTEC-DK) and general news on hydrogen for transport has been disseminated by Hydrogen Link via the website www.hydrogenlink.net. During the project the news dissemination has been moved to a new platform www.brintbiler.dk that going forward is to act as a public portal for hydrogen vehicles and stations in Denmark. News on hydrogen for transport in Denmark and abroad is being published on the website on a regular basis. In addition the website features latest publications, map of fuelling stations and available FCEVs.

Two major HRS opening events were held during the project.

The first event was held in in June 2013, where the 15 FCEVs was delivered for the City of Copenhagen and where the first HRS was opened in Copenhagen South (Sydhavnen). The opening was attended by President and CEO, Byung Kwon Rhim, Hyundai Motor Europe, Director, Niels Rønnebech, Hyundai Bil Import A/S, Deputy Mayor of London, Kit Malthouse, Technical and Environmental Mayor, City of Copenhagen Ayfer Baykal and Danish Minister for Climate, Energy and Building, Martin Lidegaard (shown in picture below).



The second event was held in April 2015 where the second HRS was opened in Gladsaxe/Herlev. The opening was conducted by the Danish Minister for Climate, Energy and Building, Rasmus Helveg Petersen (shown in picture below).



Efforts have also been conducted during the project on dissemination and outreach with the aim to share the experiences from using FCEVs and catalyze further users in the greater Copenhagen area. More than 35 activities has been conducted, covering strategic meetings, conference attendances and test rides with potential users.

A full list of the events is available in the Deliverables Report D7.1.4.

4. Utilization of project results

The results of the HyTEC project has been utilized by the participating companies and for Denmark as a whole in several aspect.

Foremost the objective of HyTEC to catalyse a start of market introduction of hydrogen for transport in Denmark has been achieved.

During the project period several car manufacturers have commenced or announced plans to market introduce FCEVs in Denmark. Hyundai started sales of the iX35 FCEV in January 2014 and Toyota started sales of the Mirai in September 2015. Honda have announced plans to commence sales of their new FCEV model in 2016.

The arrival of FCEVs to Denmark has also helped catalyse public and private investments in additional HRSs in Denmark, than the three HRSs in the HyTEC project.

New demonstration project of total ~90 million DKK has been initiated in Denmark during the HyTEC project period, ensuring an additional of up to seven HRS's during 2016 (total 11). The project also includes additional roll-out of FCEVs.

New hydrogen transport demonstration projects in Denmark

Project	Scope	Budget	Support program
HIT	Two HRS's in Aalborg & Vejle	24 million DKK	TEN-T / Danish Ministry of Transport
Bridge2H	15 FCEVs across Denmark	7 million DKK	Danish Transport Agency
HyFIVE	Two HRS's in Korsør & Aarhus. 20+ FCEV's from Hyundai, Honda & Toyota	~30 million DKK	FCH-JU
H2ME-1	1 HRS in Kolding 20+ FCEV's from car manufacturers	~19 million DKK	FCH-JU
H2DK	4 HRS's in multiple cities	10 million DKK	Danish Energy Agency
		~90 million DKK	

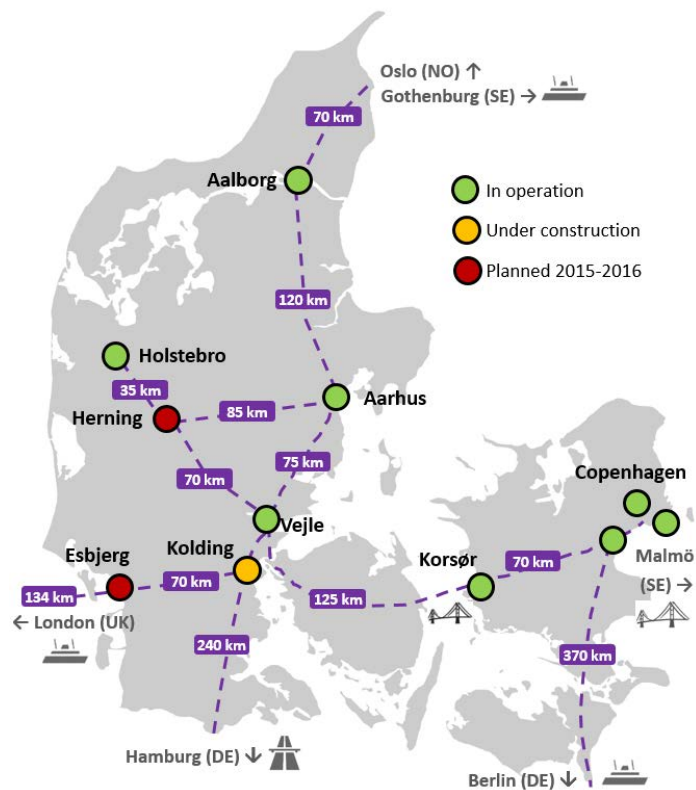
Public funding of average 50% has been secured from various national and European programs, whereas the remainder 50% is financed by private companies. The private investments are done by two HRS infrastructure entities that was established during the HyTEC project.

Copenhagen Hydrogen Network A/S that operates the three HRS's in the HyTEC project, was further expanded during the project with the arrival of Air Liquide as investor, and has built additional two HRS's in respectively Aalborg and Vejle.

In January 2015 a new infrastructure entity named Danish Hydrogen Fuel (DHF) was established as joint venture between OK (oil company), Strandmøllen (gas company) and H2 Logic. DHF has already built two HRS's in Denmark with plans for additional up to three HRS's during 2016.

By December 2015 a total of nine HRSs are in operation throughout Denmark, whereas at the time of the HyTEC project start, there was only one HRS.

With the public and private investments, the phase 1 of the HyTEC expansion plan for Denmark will also be reached during 2016 – as Denmark then will have a fully country-wide HRS network covering all the major cities.



The HRS technology demonstrated in HyTEC was developed by H2 Logic and the project was used as the first showcase and demonstration of the H2Station® CAR-100 product. The results and experience from the project has enabled H2 Logic to achieve sale of multiple H2Station® products for several countries in Europe.

In addition the results of HyTEC have also helped to initiate new R&D projects in Denmark on HRS's and supporting hydrogen production with a combined budget of more than 200 million DKK. The projects are supported by various national and European programs.

5. Project conclusion and perspective

The HyTEC project has validated the functionality and market readiness of FCEVs and HRS's and enabled a start of market introduction in Denmark.

Prior to the HyTEC project only one HRS prototype was in operation in Denmark, which was used by various non-automotive FCEV prototypes. With HyTEC a network of HRS's was established and operated in Copenhagen, along with delivery of a fleet of 15 FCEVs from Hyundai to the City of Copenhagen.

The more than 300.000 km driven in Copenhagen with positive end-user feedbacks and 1.362 hydrogen fuelings with an availability of more than 98% have validated that the technology is ready for market introduction.

The results have catalysed that three international car manufacturers are now active on market introduction of FCEVs in Denmark – which was one of the project objectives.

In addition public and private investment of more than 90 million DKK is being conducted in the construction of a countrywide network of more than 10 HRS's onwards end of 2016 – also an objective of the HyTEC project.

The commenced market introduction efforts ensures that the phase 1 of the FCEV & HRS Expansion study developed in the HyTEC project is on track to be completed.

This enables continuation of a phase 2 where number of FCEVs and HRSs are to be increased onwards 2025, reaching a critical mass and volume for a continued commercial roll-out onwards 2050. If public and private investments can be secured for the phase 2, hydrogen has the potential to contribute to the Danish goal of fossil independence by 2050, by ensuring zero emission in 50% of the entire car fleet in Denmark.

HyTEC has also helped catalyse export of Danish hydrogen technology, with H2 Logic using the project as a platform for sale of products to multiple countries in Europe.

The technical experiences gained from the demonstration in HyTEC has enabled setting up of several new R&D projects on HRSs and supporting hydrogen production, with a total combined budget of more than 200 million DKK.

In conclusion the HyTEC project has met its objectives, ensuring start of market introduction of hydrogen for transport in Denmark and export of Danish technology and with continued R&D efforts.

Annex – list of HyTEC deliverables reports

As part of the HyTEC project extensive deliverables reporting has been conducted towards the FCH-JU Program. The table below lists the deliverables relevant for the Danish activities in the HyTEC project. Some deliverables are project internal, whereas public deliverable reports are made available from the FCH-JU Program website www.fch.europa.eu . Please note that not all reports may not yet be online at the time of publication of this report – Dec. 2015.

HyTEC-DK deliverables reports

No.	Title	Publication level
D2.3.1 / 2.2	Procurement process report Copenhagen	Public
D2.3.2 / 2.5	Delivery of OEM passenger cars Copenhagen	Public
D3.2.2a / 3.2	Final design specification of first Copenhagen refuelling station	Project internal
D3.2.2b / 3.3	Final design specification for remaining Copenhagen refuelling stations	Project internal
D3.3.2a / 3.6	Necessary building and operation permission secured for first Copenhagen HRS	Public
D3.3.2b / 3.7	Building and operation permit for remaining Copenhagen refuelling stations	Public
D3.4.2a / 3.9	Completion of a first HRS in Copenhagen	Public
D3.4.2b / 3.10	Completion of remaining HRS's in Copenhagen	Public
D5.3 / 5.5	Approval of OEM vehicles (Hyundai ix35FCEV) for use by Municipality	Public
D6.2.3 / 6.6	Final technical report	Public
D6.5.1 / 6.10	Analysis of driver and fleet decision maker attitudes in 'before' survey report	Public
D6.5.2 / 6.11	Final driver and fleet decision maker attitudes report	Public
D7.1.2 / 7.2	First local dissemination event to launch the project to the public – Copenhagen	Public
D7.1.4 / 7.4	30th local dissemination event – Copenhagen	Public
D8.2.2 / 8.6	Report on expansion of Danish hydrogen infrastructure	Project internal