

CH₂IC



CHIC Final Results

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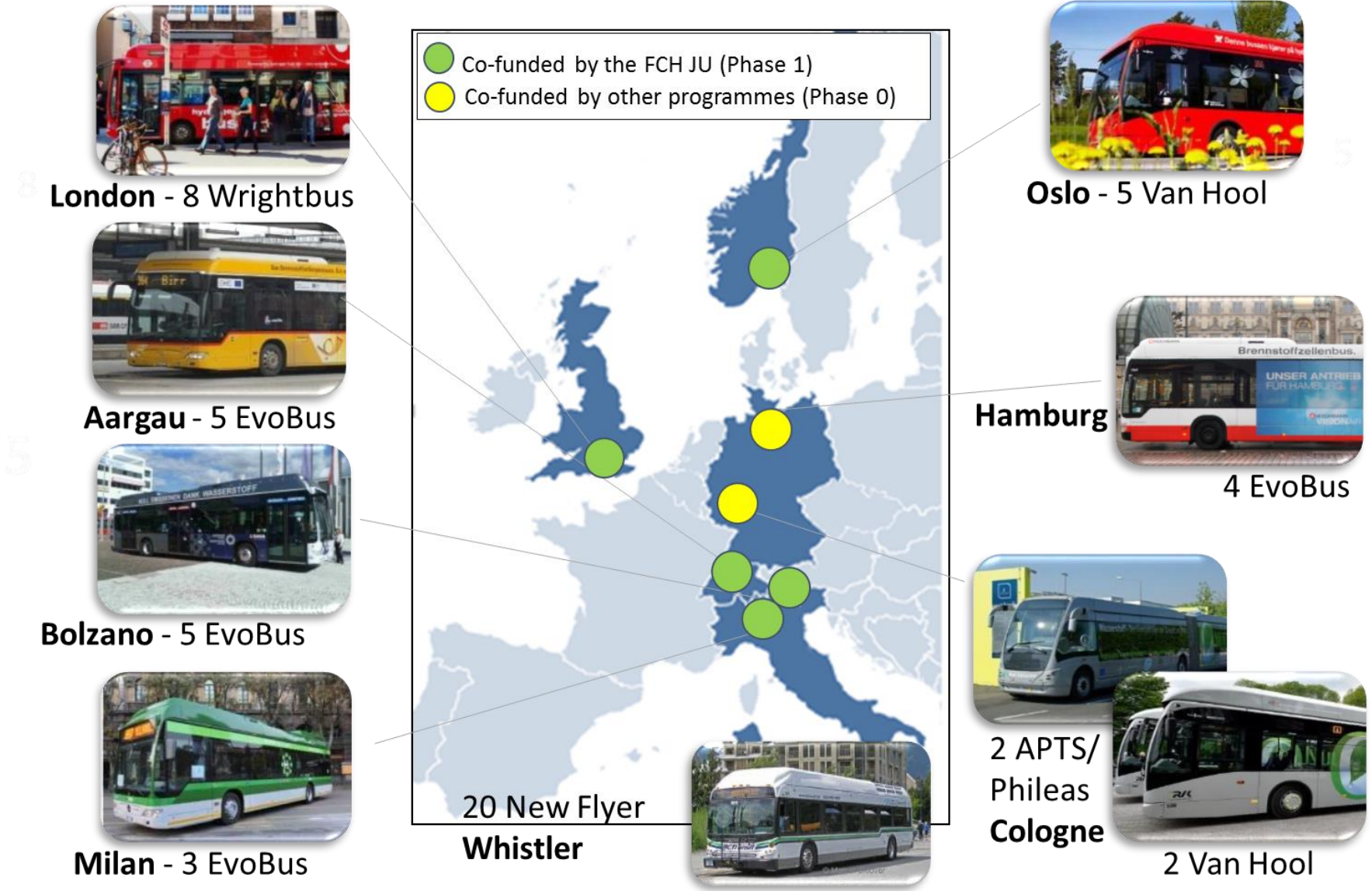
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What?	<ul style="list-style-type: none">• Deployment of 54 fuel cell electric buses and their refuelling infrastructure¹
When?	<ul style="list-style-type: none">• Between 2010 and December 2016
Who?	<ul style="list-style-type: none">• 23 partners from 8 countries• 9 operators/6 bus OEMs involved
How much?	<ul style="list-style-type: none">• €25.88 million European co-financing (FCH JU)• total budget of €81.8 million
FCH JU?	<ul style="list-style-type: none">• Public private partnership between the European Commission, the industry and research promoting the uptake of hydrogen and fuel cell technologies

¹ + 4 internal combustion engine H₂ buses

Buses: 54 fuel cell buses, 6 different bus OEMs, 9 cities of various sizes and climate



Stations: 4 high throughput, 350bar stations over 380 tonnes of H₂ dispensed (to end September 2016)

City	Picture	HRS/H ₂ Producer	Operation start	Type of HRS / source of H ₂	# of fillings	Kg H ₂ refuelled
Aargau		Carbagas (Air Liquide)	2012	Onsite electrolyser (+ trailer delivery as backup)	7,364	103,769
Bozen		Linde	2014	Onsite electrolyser (+ trailer delivery as backup)	2,627	48,027
London		Air Products	2010	Trailer delivery of gaseous H ₂ (SMR)	7,997	133,949
Milan		Linde	2013	Onsite electrolyser (+ trailer delivery as backup)	1,610	20,709
Oslo		Air Liquide	2012	Onsite electrolyser (+ trailer delivery as backup)	3,619	73,715

Overall project snapshot: all technical targets have been achieved (to end September 2016)



Parameter	Project total (incl. ICE buses in Berlin)	Phase 1 cities	Project goal for the Phase 1 cities
Total distance travelled [km]	9,626,116	3,991,056	2,750,000
Total hours of operation [h]	519,498	269,394	160,000
Average FC runtime per bus [h]	6,820	6,690	6,000
Total H ₂ refueled [kg]	1,256,492	380,168	

- **240** times driven around the world in CHIC
- **59** years of bus operation performed in CHIC

¹ This figure does not include the ICE buses in Berlin

Fuel Cell Buses – Achievements (until September 2016)



Programme (FCH JU) objective/target	Project (CHIC) objective/target	Project (CHIC) achievements to-date
>4000h lifetime initially, min.6000h lifetime as program target	Fuel cell lifetime > 6000h	6,820h/bus (excluding ICE buses in Berlin)
Fuel consumption < 11-13kg/100km depending on drive cycle	Average fuel consumption < 13kg depending on drive cycle	12.1 kg/100km (excl. ICE H ₂ & incl. 18m buses) 9.9 kg/100 km Phase 1 cities (12m, 13m in Oslo)
Availability >85%	Average availability of >85% with maintenance as for conventional buses	47 - 89% (availability reduced considerably in Oslo due to refueller contamination issues)
Additional target	Minimum running distance of 2,75 Mio km of fleet	9.63 Million km
Additional target	Minimum of 160.000h of operation of fleet	519,498h

Hydrogen Infrastructure – Achievements (until September 2016)



Programme (FCH JU) objective/target	Project (CHIC) objective/target	Project (CHIC) achievements to-date
Capacity of 200kg/day, upgradable to 100 vehicles per day	Capacity of 200kg/day; upgradable to 100 vehicles per day (400kg)	All Phase 1 cities have installed the required refuelling capacity and ensured 'upgradeability'
Availability of station 98%	Availability of station 98%	> 98% at three sites > 94% at all sites 97% across all sites
Production efficiency target 50- 70%	Production efficiency target 50-70%	> 50% at all sites
Additional target	Replacement of 500.000l diesel fuel	Phase 1 cities: > 1.5 million litres CHIC: > 4.3 million litres

Activity type	Description of activities/achievements
Conferences	<ul style="list-style-type: none"> • Key industrial events engaging the hydrogen community (numerous) e.g. <ul style="list-style-type: none"> ○ Hannover fair each year since 2011 • Public transport events and EU mobility events (numerous) e.g. <ul style="list-style-type: none"> ○ European Electromobility Forum 2016
Workshops	<ul style="list-style-type: none"> • Several workshops held to share lessons learned with potential interested cities <ul style="list-style-type: none"> ○ 2014 Stockholm and Lisbon ○ 2014 Fuel Cell Bus Study and CHIC, in the framework of the FCB commercialization study ○ 2015 dedicated workshop were held in Riga, Paris and London
Publications	<ul style="list-style-type: none"> • Press releases (numerous) e.g. <ul style="list-style-type: none"> ○ COP21 November 2015 contribution of fuel cell buses to de-carbonize transport • Magazines (numerous) e.g. <ul style="list-style-type: none"> ○ Eurotransport Magazine, June 2015 ○ EU Parliament magazine, February 2016 • Regional publications (numerous) e.g. <ul style="list-style-type: none"> ○ Umweltbuch Südtirol, 2014 ○ London’s fuel cell bus takes us on a journey to better air quality in the city, 2016
Awards	<ul style="list-style-type: none"> • Swiss Energy Watt d’Or (2013) • Norwegian Transnova Prize (2014), Ruter was shortlisted

FCH and FP projects	Nature of interaction and joint activities
3Emotion High V.LO-City HyTransit	<ul style="list-style-type: none"> • Sister Projects <ul style="list-style-type: none"> ○ CHIC lessons learned shared ○ Joint workshops vis versa ○ Participation in project meetings
Fuel Cell bus commercialization study / strategy	<ul style="list-style-type: none"> • CHIC workshop held at the study general assembly in Dec. 2014 <ul style="list-style-type: none"> ○ CHIC partners participated in the study ○ CHIC partners where involved in the set-up of city clusters ○ Additional CHIC workshops where organized at the national clusters meetings
North America	<ul style="list-style-type: none"> • 20 fuel cell buses in public service in Whistler until March 2014 • BC Transit is a “Phase 0 city” within the project, exchanging data and knowledge • International Fuel Cell Bus Workshops <ul style="list-style-type: none"> ○ Held concurrently with Bi-Annual meeting in Hamburg 2013 ○ International Fuel Cell Bus Workshop in California 2015 ○ International Zero Emission Bus Conference and Fuel Cell Bus Workshop in London 2016

Activity type	Description of activities/achievements
Training /Education	<ul style="list-style-type: none"> • Special training for bus drivers, technicians and emergency personnel has taken place in each participating city; refresher courses are also taking place regularly
Safety, Regulations, Codes and Standards	<ul style="list-style-type: none"> • Public report on the procurement of HRS has been completed (ref. CHIC deliverable D3.7 Experiences with the implementation of infrastructures for hydrogen refuelling and lessons for future installations) • Public report on the certification of fuel cell buses and refuelling infrastructure sharing the experience of CHIC cities has been completed (ref. CHIC deliverable D4.3b Report collecting the experience from the Phase 0 and Phase 1 cities with respect to certification of the buses & H₂ refuelling infrastructure)
Public awareness	<ul style="list-style-type: none"> • Study on acceptance of hydrogen buses and hydrogen technologies (ref. CHIC deliverable D3.5 Study on the influencing factors for fuel cell and hydrogen technologies in public transport) • Interviews with 50+ individuals within organisations external to the hydrogen world in Europe and in North America (ref. CHIC deliverable D3.8 Issues of concerns for external stakeholders and critics and pathways to their resolution; Phase 1: June 2013; Phase 2: September 2015) • Sustainability assessment of fuel cell buses and related infrastructure (ref. CHIC deliverable D3.15) • Awareness raising among the public is mainly taking place in the cities operating the buses or in the surrounding region <ul style="list-style-type: none"> ○ School visits, participation in fairs or city’s festivals, bus shuttle service at public events, Radio and TV interviews, articles in the local press

Stations

- Inability of stations to **meter hydrogen supply** accurately enough
- **Delay** in start of operation (procurement, permitting, shipment of equipment)

Buses

- **Availability** has not yet consistently met CHIC target (85% availability), **range between 47 - 89%**.
Reasons include:
 - Immature supply chains → Improvement with increased experience
 - Component failures → Implementation of technical solutions
 - Limited pool of maintenance staff → will probably be resolved by larger scale deployment

Stations

- Routes to **affordable hydrogen** from **green sources** need to be demonstrated
- **Regulations on hydrogen refueling stations construction and safety** need to be further harmonized at EU and international level
- Stations fitted for a **larger number of buses**: 50-200 buses – 1,000-5000kg hydrogen/day
→ EU project NewBusFuel in 12 locations across Europe

Buses

- **Bus availability needs to improve** over 85% - expected to be resolved by
 - a) resolving the teething issues
 - b) scale in the supply chain → new trial with >100 buses starting
 - c) **Prices need further reduction to enable genuine market traction**
- **Longer warranties of fuel cells for buses** up to 35-40,000 hrs to be consistent with conventional bus overhauls (20,000+ hrs best in class)
- **Expand the FC bus platform choice** (e.g. 18 m or large capacity buses)

- **CHIC highlighted:**

Key challenges that will need to be solved
to unlock the market potential

- **CHIC demonstrated:**

**Fuel cell buses have the potential
to provide the same operational flexibility
as conventional diesel buses
for a wide range of public transport routes.**

CH₂IC



Thank you for your attention



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