Fuel cells and hydrogen
Joint undertaking

CHIC
Clean Hydrogen in European Cities
(256848)

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New Energy World JU
fuel cells & hydrogen for sustainability

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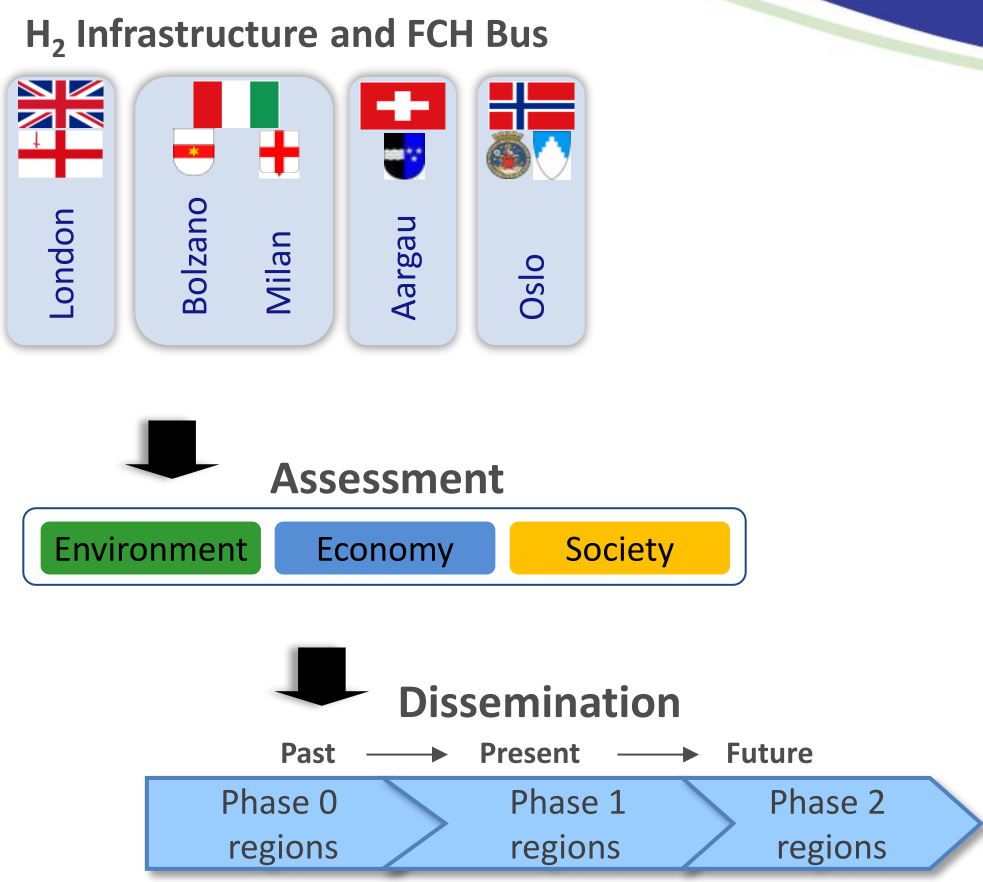
CHIC

http://www.fch-ju.eu/

0. Project and partnership description

The CHIC concept

CHIC



CHIC (Clean Hydrogen in European Cities) in brief

- **25 partners** from **9 countries** worldwide (10 transport companies, 8 industry partners and 7 research/consultants)
- **26 fuel cell buses** operated in 5 Phase 1 cities; together with the Phase 0 cities more than **55 buses in operation**
- **3 different bus manufacturers** in the Phase 1 cities
- **2 filling stations per Phase 1 city** (one existing, one new station)
- Demonstration phase **2010 - 2016**
- **25.83 Mio. EUR funding**, 81.95 Mio EUR costs

1. Project achievements

General goals of CHIC

- **The CHIC project will:** implement clean urban mobility in 5 major European regions through the deployment of 26 hydrogen FC powered buses in medium sized fleets, and the enlargement of the hydrogen infrastructure systems

- **The CHIC project will:** facilitate the development of clean urban public transport systems and mobility action plans into at least 14 new European regions

- **The CHIC project will:** actively collaborate, transfer and secure significant key learning from previous FC projects into the CHIC stakeholders, thereby greatly accelerating the achievement of JTI and EC objectives

- **The CHIC project will:** deliver greater community understanding of ‘green’ hydrogen powered FC buses, leading to increased political acceptance and commitment

1. Project achievements

Alignment to technical targets MAIP/AIP 2009

Technical targets AIP (call 2009)	CHIC targets
Infrastructure: • Capacity of 200 kg/day, upgradable to 100 vehicles per day • Availability of station 98% • OPEX for H2< 10EUR/kg (excl. tax) • Hydrogen purity and vehicle refueling time (according to SAE or analogous specification) • Production efficiency target 50-70%	**Infrastructure**: ✓ Capacity of 200 kg/day, upgradable to 100 vehicles per day ✓ Availability of station of 98% ✓ OPEX for H2< 10EUR/kg (excl. tax) ✓ Hydrogen purity analogous SAE spec, bus refueling time not defined in SAE ✓ Production efficiency between 50-70% ❖ Replacement of 500.000 l diesel fuel
Buses: • >4000h lifetime initially, min 6000 hrs lifetime as program target • Availability >85% with maintenance as for conventional buses • Fuel consumption < 11-13 kg/100km depending on drivecycle	**Buses**: ✓ Fuel cell lifetime > 6000 hrs ✓ Average availability of fuel cell buses > 85% ✓ Average fuel consumption < 13 kg/100km (depending on drive cycle) ❖ Minimum running distance of 2,75 Mio km of fleet ❖ Minimum of 160.000 hrs of operation of fleet

1. Project achievements

Status of bus operation (End September 2013)

Phase	City	No. of buses	Manufacturer	km travelled	FC runtime per Bus [h]	FC runtime total [h]
Phase 0	Cologne	2	APTS	62,047	1,472	2,944
Phase 0	Hamburg	4	EvoBus	103,776	1,573	6,293
Phase 0	Whistler	20	NewFlyer	3,550 250	9,002	180,042
Phase 1	Aargau	5	EvoBus	420,879	3,596	17,978
Phase 1	Bolzano*	5	EvoBus	*Buses are delivered but not yet in operation*		
Phase 1	London**	5 (+3 end 2013)	Wrightbus	391,876	7,061	35,303
Phase 1	Milan	3 (not yet operating)	EvoBus	6,657	N/A	N/A
Phase 1	Oslo	5	VanHool	113,579	964	4,820

* Delay due to changes in national tender law.

**Delay of final 3 buses due to a change of the vehicle and maintenance supplier.

1. Project achievements

Status of infrastructure operation of hydrogen refueling stations of Phase 1 Cities

Phase 1 City	Type of RFS	Manu-facturer	Start of operation	Image	Number of fillings	Kg H_2 refuelled
Aargau	Onsite electrolyser + trailer delivery	Carbagas (Air Liquide)	April 2012		1,954	30,518
Bolzano	Onsite electrolyser	Linde	Summer 2014		N/A	N/A
London	High pressure tube trailer	Air Products	December 2010		2,033	32,037
Milan	Onsite electrolyser	Linde	Summer 2013		9	128
Oslo	Onsite electrolyser	Air Liquide	March 2012		612	12,938

1. Project achievements

Status of infrastructure operation of hydrogen refueling stations of Phase 0 Cities

Phase 0 City	Type of RFS	Manu-facturer	Start of operation	Image	Number of fillings	Kg H_2 refuelled
Berlin	Trailer delivery + on-site LPG reforming	Linde	2005		11,029	182,157
Cologne	Trailer delivery	Air products	2011		569	9,461
Hamburg	Onsite electrolysis + trailer delivery	Linde	2012		475	7,721
Whistler	Delivered liquid	Air Liquide Canada	2009		20,568	515,617

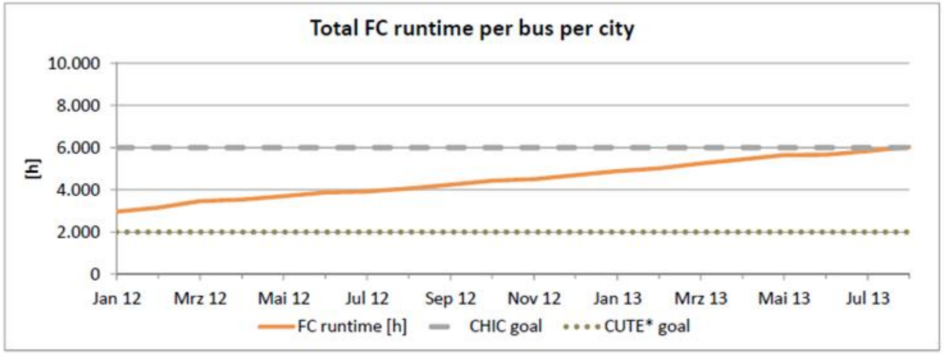
1. Project achievements

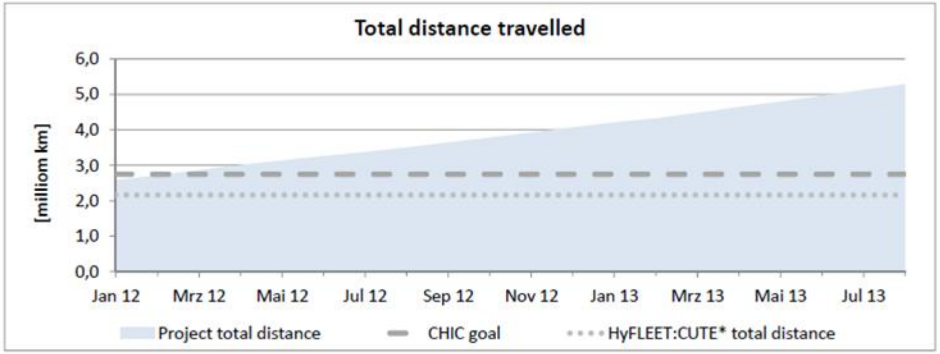
Technical target improvements

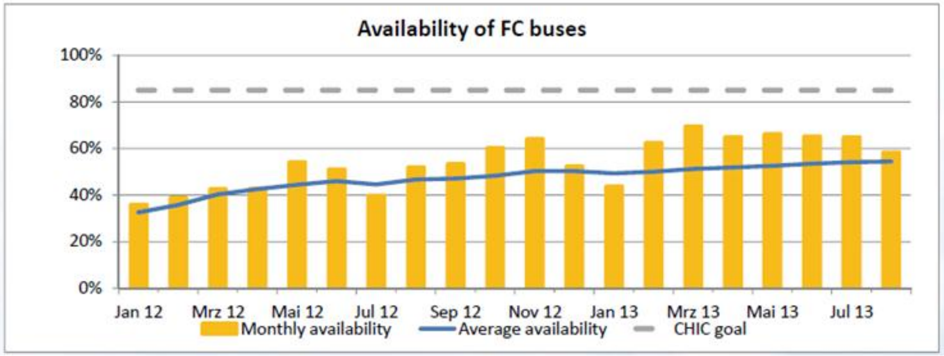
Data as of 31.08.2013

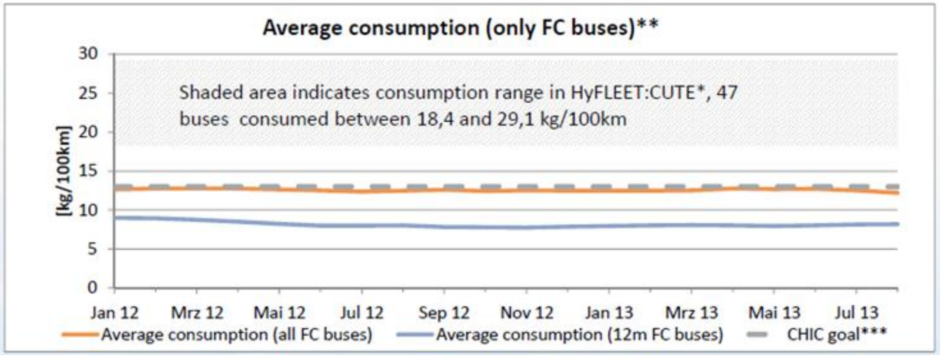
	Current Month	Project to Date	Project Goal
Total distance [km]	152.277	5.288.888	2.750.000
Total hours on FC system [h]	7.916	245.361	160.000
Average FC lifetime [h]	184	6.033	6.000
Total H_2 refuelled [kg]	18.780	790.326	-
Replacement of diesel fuel [liters]	133.109	2.919.699	500.000
Project status	47 buses in operation		

	Average Monthly Data (per bus)					
	Total distance [km]	Total hours on FC system [h]	Consumption [kg H_2/100 km]	H_2 refuelled [kg]	Number of fillings	Bus availability
Min	646	30	7,9	113	6	43%
Average	**3.240**	**184**	**11,8**	**400**	**22**	**58%**
Max	5.495	303	21,8	558	29	91%









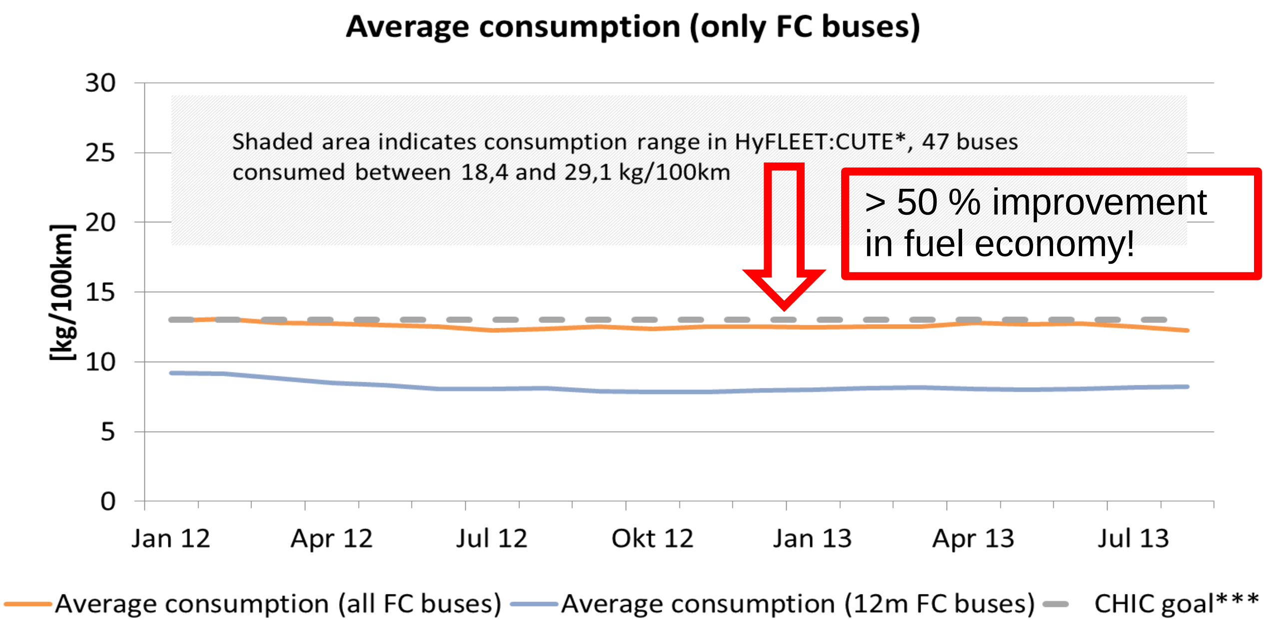
1. Project achievements

Technical target improvements

One of the **most significant results** of the trial program is the **improvement in fuel economy** which has been observed.

Reason for the >50% improvement:

- use of fully hybridized powertrains
- smaller and better optimized FC systems



High station availability

- The availability of stations in the CHIC project has been consistently high.
- Average station availability (excluding Hamburg[1]) is over 98% for the stations in the trial
- This compares favorably with the HyFLEET:CUTE project, where problems with on-site production, compression and dispensers affected the trial. This lead to an average availability of 89.8% for the whole trial.

Phase	City	Availability to date
1	London	*>99%*
1	Aarau	98%
1	Oslo	~99%
0	Cologne	*90% - 95%*
0	Hamburg	Feb 12 - Jul 13: 81,3%[1]
0	Whistler	99%
0	Berlin	*N.A.*

[1] The average station availability in Hamburg has ben affected by a breakdown (end of 2012).

2. Bottlenecks

Delays in project start times

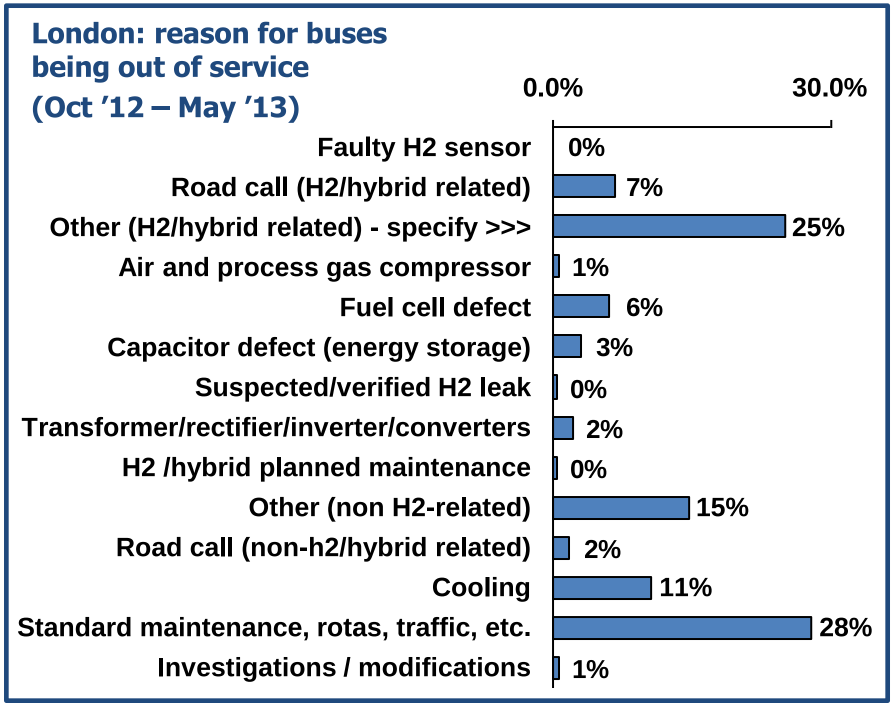
- The start date of all of the projects has been later than originally envisaged.
- There are numerous reasons for this:
  - Delays in permitting for stations and maintenance facilities (London, Milan)
  - Delays in construction of the refueling facilities (Milan[1])
  - Delays in procurement processes (Oslo, Bolzano[2])
  - Delays in manufacture/shipment of buses (Oslo, London)
  - Poor availability of the buses in the commissioning phase (Oslo)
- These delays suggest a **need to improve awareness of the technology and associated issues amongst decision makers and regulators** in member states.
- Recommendations have been developed in a **"Guidance Document for delivering fuel cell buses"**

[1] Due to a transport incident during the delivery of key infrastructure components.

[2] Due to changes in the national tender rules during the procurement process.

2. Bottlenecks
Bus reliability

- The reliability of fuel cell buses on the project has not yet consistently met the CHIC target (85% availability) and has until now been lower than HyFLEET:CUTE (average >92%, please note that buses were operated via *single* shifts) and the diesel industry standard (95% availability).
- The range of monthly availabilities on the CHIC project has been between 40 and 80%.
- Reasons for poor availability include:
  - Immature supply chains
  - Problems with management of maintenance contracts
  - Component failures – air compressors, inverters etc. have caused considerable issues on some of the trials – replacements are being implemented.



The qualitative research:

- Approx. 185 face-to-face interviews in 5 of the CHIC regions (Aargau, Bolzano, Cologne, Hamburg & Oslo) between August 2011 & March 2013
- Interview partners: Bus drivers, Citizens/Passengers, Regional Stakeholders, CHIC partners

Main findings:

- **Generally positive attitude** towards hydrogen technologies amongst the **general public, bus drivers etc.**
- The **electric drive trains significantly improve the work environment** for bus drivers
- **Very few interviewees questioned the project idea and technology concept**, the majority of interviewees supported it
- A majority of interviewees addressed or **questioned hydrogen origin**, and related their acceptance to the use of renewable energies for hydrogen production
- **Safety issues were not a topic in the general public -** people trust in authorities and expect technologies be safe before brought to market
- **Additional work to convince sceptical decision** makers and opinion formers of the role of hydrogen buses in the transport mix and as wider **part of the low carbon energy system**

CHIC Highlights

World Economic Forum 2013 Davos

- 2 CHIC Fuel Cell Buses transported for one week (22-27 January 2013) on a 20-minute route particpants as well as inhabitants
- The technology is mature and efficient even in cold climates and in high altitude areas
- Passengers appreciated the presence of greener technology on the Davos streets during the WEF

Swiss energy Watt d'Or award

- PostAuto awarded with Swiss energy "Watt d'Or" award from the Federal Office for Energy on the 10th January 2013 in Bern

4. Project Report

Dissemination activities

Latest international events presenting CHIC

- EUSEW: HyER European Parliament Event and General Assembly, 25-26 June 2013, Brussels
- Mobility Week, Brussels, 16-22 September 2013
- KlimaMobility Fair, Bolzano, 19-21 September 2013
- Metrex Conference, Oslo, 20 September 2013
- F-Cell, Stuttgart, 1 October 2013
- Franche Comté Region Meeting, 2 October 2013
- Remini Bus Expo, 7 October, Milan
- CHIC Intermediate Conference @ Open Days on Electromobility, 8 October, Brussels
- UK Forum, New Castle, 11 October 2013

Opportunities and next steps

- The CHIC project is demonstrating that fuel cell buses have the potential to provide the same operational flexibility as conventional diesel buses for a wide range of different route types.
- This is achieved with considerably improved efficiency of fuel use and without harmful emissions.
- The CHIC project has highlighted a series of key challenges which will need to be addressed by the next generation of fuel cell buses:
  - Availability of the buses needs to improve over 90% - much of this is expected to be demonstrated under CHIC, as teething issues are resolved

Key challenges

Improvements	Future steps
Warranties of fuel cells on the vehicles have increased to 15,000 hours *(best in class)*	Even longer warranties (35-40,000 hours) will be needed
	Expand the FC bus platform choice (e.g. 18 m or large capacity buses)
Prices of buses have fallen considerably during the CHIC project	However, these prices need considerable further reduction to enable genuine market traction
CHIC has demonstrated fuelling station designs which are appropriate for 10 buses/day	To service a full depot designs for 100 buses/day will be needed
Results from discussions with policy makers and opinion formers	Clear routes to affordable hydrogen from green sources to be demonstrated and well articulated

Thank you!

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