Hydrogen Mobility Europe

Well to Wheels Report For H2ME Vehicles D4.19

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Executive Summary (1)
Data Presented in this Report

- This report presents country case studies of well-to-wheel (WTW) emissions from the use of hydrogen vehicles during H2ME:
  - Fuel cell electric vehicles (FCEVs) manufactured by Daimler, Honda and Toyota in **Germany**
  - FCEVs from Hyundai, Honda and Toyota in **Denmark**.
  - Symbio Kangoo ZE H2 fuel cell range-extended electric vehicles (FC REEVs) in **France**
- For the FCEVs, the choice of countries where multiple vehicles operate respects the wish of some project OEMs for anonymisation of individual performance data.
- As Symbio provides the only FC REEV to the project, it is not possible to anonymise its performance data. Symbio has agreed that its data can be presented without anonymisation.
- WTW emissions from project vehicles were compared to those derived from publicly-available real-world driving data from the closest comparable model fuelled by electricity, diesel and gasoline.
- Well-to-tank (WTT) and tank-to-wheel (TTW) reference data for each vehicle fuel was taken from the 2014 JRC report *Well-to-Wheel Analysis of Future Automotive Fuels and Powertrains in the European Context*.
- Where authoritative WTT values are available from country-specific sources, such as national electricity grid mix values, these are used instead.

Executive Summary (2)
WTW Emissions of Hydrogen Vehicles and Comparators

- For the FCEVs in Germany, a mix of 50% steam methane reforming (SMR) and 50% wind electrolysis-derived hydrogen was assumed, which is H2Mobility Germany's ambition for the hydrogen mix at its stations.
- WTW emissions from the FCEVs in Germany were found to be 81 gCO_2e/km, compared to 77 gCO_2e/km for a battery electric saloon, 108 gCO_2e/km for a battery electric sport utility vehicle (SUV) and 220 gCO_2e/km for a diesel-fuelled comparator. Further analysis shows the importance of renewable hydrogen in Germany in achieving comparable or lower WTW emissions than battery electric vehicles (BEVs).
- WTW emissions from the FCEVs in Denmark were found to be 20 gCO_2e/km, compared to 34 gCO_2e/km for a BEV, 47 gCO_2e/km for a battery electric SUV and 217 gCO_2e/km for a diesel comparator. The use of 100% green certified electrolytic hydrogen is key to the low WTW FCEV emissions in Denmark.
- WTW emissions from the FC REEVs in France were found to be 11 gCO_2e/km, compared to 9 gCO_2e/km and 203 gCO_2e/km respectively for a BEV and diesel equivalent. The low carbon footprint of electrolytic hydrogen in France means that the FC REEVs achieve much lower emissions than conventional vehicles whether driven on hydrogen, or electricity, or both.
- It is noted that a full life cycle assessment (LCA) will be necessary to determine the overall emissions impact of vehicles that are fuelled by large amounts of renewable electricity and hydrogen, as the WTW emissions from their fuel usage becomes less significant compared to those from other aspects of their life cycle.

Abbreviations

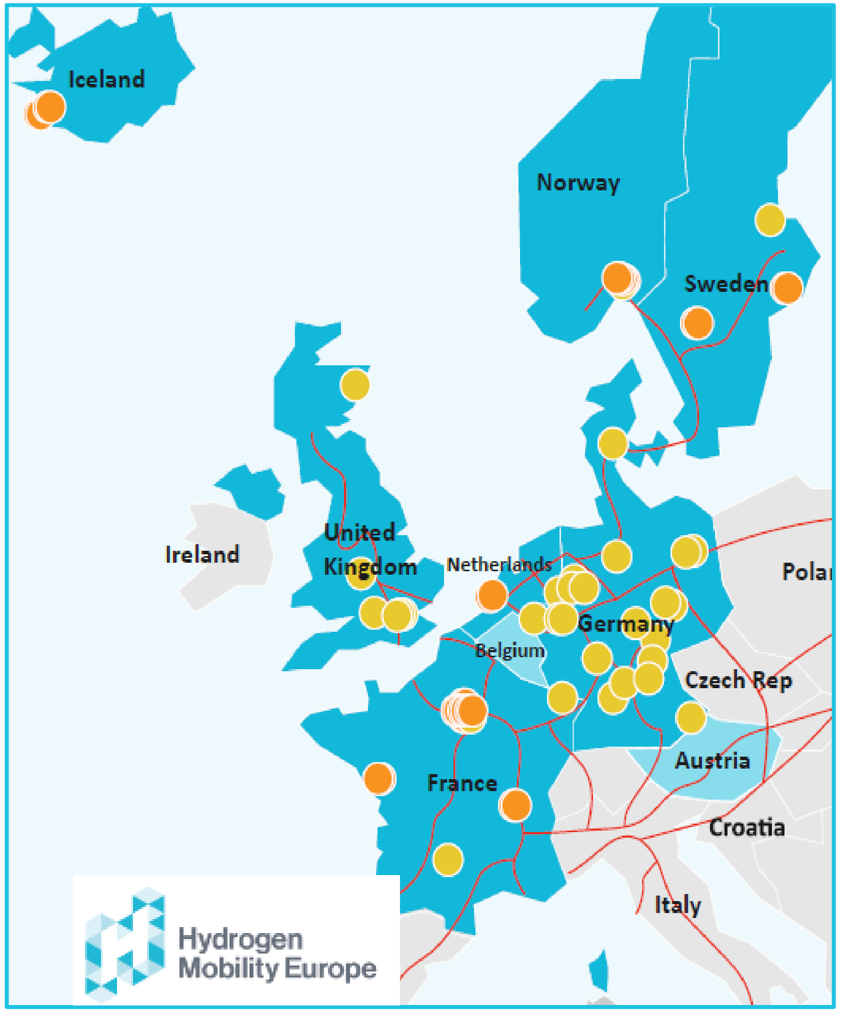
A-M		N-Z	
BEV	Battery Electric Vehicle	OEM	Original Equipment Manufacturer
FCEV	Fuel Cell Electric Vehicle	SMR	Steam Methane Reforming
FCHJU / FCH2JU	Fuel Cells and Hydrogen Joint Undertaking	SUV	Sport Utility Vehicle
FC REEV	Fuel Cell Range Extended Electric Vehicle	TTW	Tank-to-Wheel
H_2	Hydrogen	WTT	Well-to-Tank
H2ME	Hydrogen Mobility Europe	WTW	Well-to-Wheel
HyTEC	Hydrogen Transport in European Cities		
HRS	Hydrogen Refuelling Station		
LCA	Life Cycle Assessment		

Contents

H2ME Initiative (2015 - 2022)
Project Overview

- Hydrogen Mobility Europe (H2ME, https://h2me.eu/, 2015-2022) is the largest passenger and light duty hydrogen vehicle and hydrogen refuelling station (HRS) demonstration initiative co-funded by the Fuel Cells and Hydrogen Joint Initiative (FCH2 JU).
- Supported by €67m of FCH2JU funding, the €170m H2ME project aims to deploy more than 1 400 vehicles and 49 HRS in eight countries by 2022.
- H2ME is formed of the two separate FCH JU-co-sponsored projects, as summarised in the slide overleaf:
  - **H2ME-1** (2015-2020), which aims to deploy 300 fuel cell electric vehicles (FCEVs) and fuel cell range-extended electric vehicles (FC REEVs) and 29 hydrogen refuelling stations (HRS).
  - **H2ME-2** (2016-2022), which aims to deploy 1,100 FCEVs and FC REEVs and 20 HRS.
- This report summarises the comprehensive body of data accumulated on hydrogen vehicle and HRS performance by H2ME from 2015 to the end of September 2019 (i.e., data that was available to Cenex at the time of writing):
  - **310** fuel cell electric vehicles (FCEVs) made by Daimler, Honda, Hyundai and Toyota.
  - **233** fuel cell range-extended electric vehicles (FC REEVs) from Symbio FC
  - **34** hydrogen refuelling stations (HRS) supplied by Air Liquide, ITM Power, Linde (including its subsidiaries AGA and BOC), McPhy and NEL Hydrogen Fueling.

H2ME Initiative (2015 - 2022)
Project Overview



Proposed HRS locations under H2ME-1
Proposed HRS locations under H2ME-2

New hydrogen refuelling stations:

- **20** - 700bar HRS in Germany
- **11** - 350bar and 700bar HRS in France
- **11** - 700bar HRS in Scandinavia
- **6** – 350bar and 700bar HRS in the UK
- **1** - 700bar HRS in NL

Fuel cell vehicles:

- **500** OEM (Original Equipment Manufacturer) FCEVs
- **900** fuel cell FC REEV vans

Hydrogen rollout areas:

- Scandinavia, Germany, France, UK, The Netherlands

Observer coalitions:

- Belgium, Luxembourg, and Italy

Industry observer partners:

- Audi, BMW, Nissan, Renault, Renault Trucks, AGA, OMV

H2ME Project Overview
Vehicles Reporting Data to H2ME

	Daimler B-Class F-CELL FCEV	Daimler GLC F-CELL FCEV/PHEV	Honda Clarity FCEV	Hyundai ix35 FCEV	Toyota Mirai FCEV	Symbio ZE H2 FC REEV
						
Dates reporting data to H2ME	2015-2018 (retired)	2019-	2017-	2017-	2017-	2015-
H2ME use-cases	Passenger and fleet car	Passenger and fleet car	Passenger and fleet car	Passenger and fleet car, taxi	Passenger and fleet car, police car, taxi	Light commercial vehicle in company fleets
Tank capacity and pressure	3.7 kg (700 bar)	4.4 kg (700 bar)	5.5 kg (700 bar)	5.6 kg (700 bar)	5.0 kg (700 bar)	1.8 kg (350 bar version)
Battery capacity (kWh)	1.4 kWh	13.5 kWh (9.3kWh usable)	1.7 kWh	0.95 kWh	1.6 kWh	22 kWh

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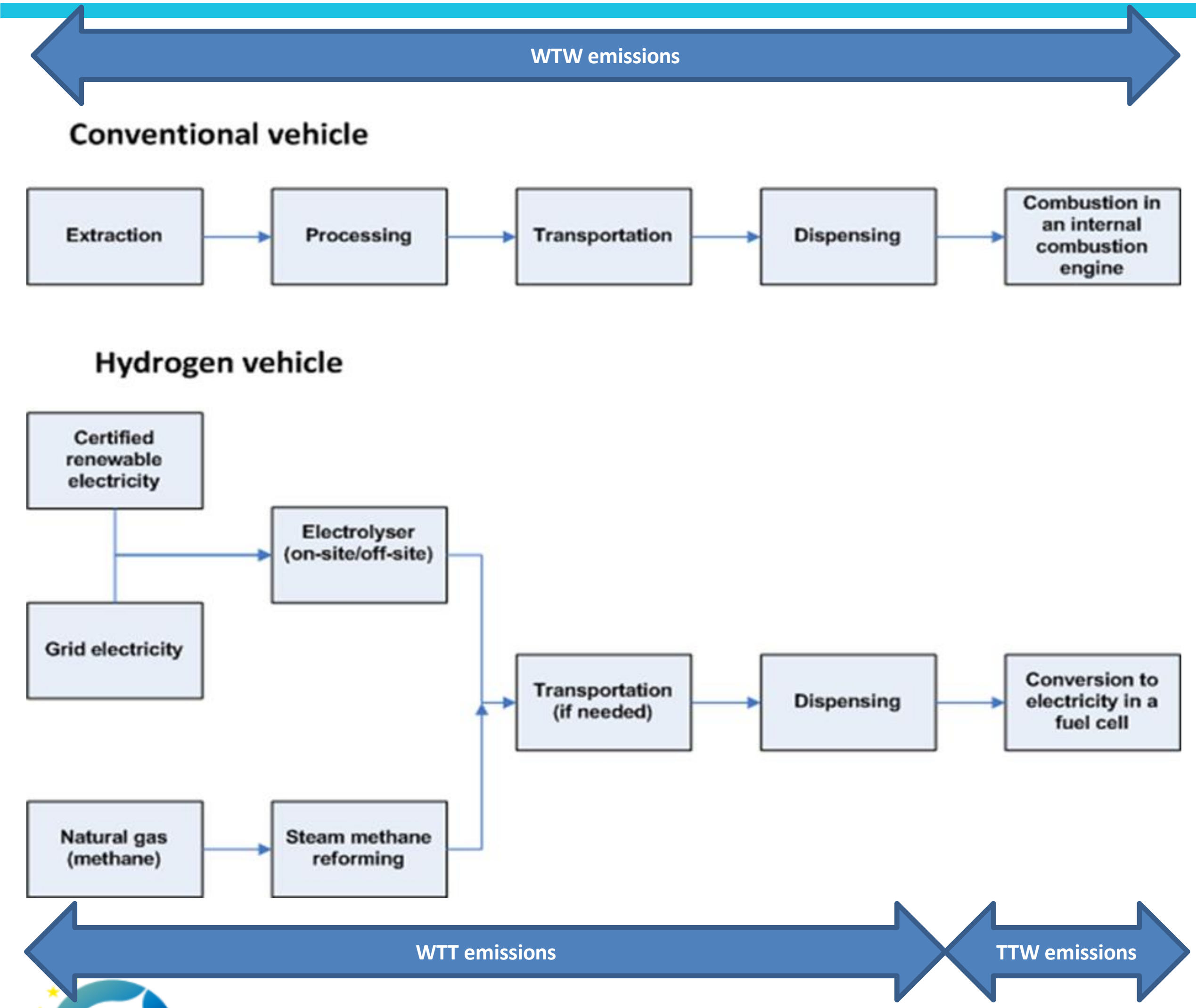
WTW Emissions
Introduction



- Overall well-to-wheel (WTW) vehicle emissions comprise:
  - Well-to-tank (WTT) emissions: from fuel extraction, production and distribution.
  - Tank-to-wheels (TTW or tailpipe) emissions: from fuel combustion.
- The diagram illustrates potential pathways for the production and use of conventional fuels and of hydrogen in H2ME vehicles.
- The emissions implications of the different fuel production and usage pathways for conventional and hydrogen vehicles are discussed later in the report.

WTW Analysis
How Data is Collected and Analysed

- The performance (e.g., distance travelled, fuel consumption) of project vehicles (FCEVs and FC REEVs) is monitored using a variety of methods depending on the data available from each vehicle:
  - Vehicles supplied directly by OEMs that are H2ME project partners (Daimler, Honda, Symbio & Toyota) have loggers attached to a minimum 10% of the deployed fleet. The loggers output daily distance driven and hydrogen consumption data.
  - Other vehicles are fitted with Cenex Clear Capture data loggers which use GPS to analyse vehicle speed and driving behaviour. This is matched with hydrogen refuelling data.
- The distance driven and hydrogen consumed is used by Cenex to calculate the fuel efficiency (the amount of fuel used per unit distance) of each vehicle.
- From this data, WTW emissions are calculated for each project vehicle using the most appropriate fuel production pathway for each location. This is discussed further on subsequent slides.
- The WTW emissions of diesel and electric comparator vehicles are also assessed. The choice of suitable comparator vehicles is discussed in the next slides.

WTW Analysis
Comparator Vehicles (1)

- The previous version of this report (D4.17) featured the Daimler B-Class F-CELL and the Symbio Kangoo ZE H2.
- Both vehicles had electric, diesel and gasoline variants for which real-world comparator data was available.
- This report features data from four FCEVs that have been introduced to the project since 2015:
    - Daimler GLC F-CELL
    - Honda Clarity
    - Hyundai ix35
    - Toyota Mirai
- It also includes the Symbio ZE H2 as an example of a FC REEV.

WTW Analysis
Comparator Vehicles (2)

- Not all of the FCEVs (e.g., the Mirai) are based on existing platforms, and for larger SUV-type vehicles there are few pure electric variants where sufficient real-world data yet exists.
- Also, not all vehicles operate in all project countries.
- This report features data from four FCEVs that operate in two H2ME countries to allow for anonymisation of results from project OEMs:
  - Daimler GLC F-CELL (diesel comparator data available)
  - Honda Clarity (diesel comparator data available for the Honda Accord)
  - Hyundai ix35 (diesel comparator data available)
  - Toyota Mirai (diesel comparator data taken from the Toyota Camry)
- The following vehicles were chosen as battery electric vehicle (BEV) comparators for all FCEVs:
  - The Nissan Leaf as a BEV saloon (it is acknowledged that the kerb weight of the Leaf at ~ 1 600 kg is lower than the FCEVs)
  - The Tesla Model X as a BEV SUV
- For the Symbio FC REEV, comparator data is available for the diesel and electric Kangoo.

WTW Emissions
H2ME Vehicles and Comparator Vehicles

Hydrogen Mobility Europe

WTT emissions

- *For all vehicles:* WTT emissions depend on
  I. the amount of fuel used per unit distance (i.e., the fuel efficiency) and
  II. the source of the fuel.

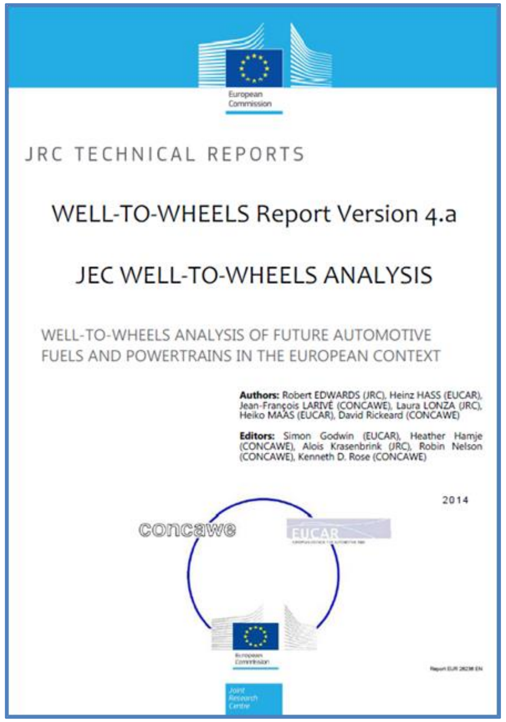
TTW emissions

- *For FCEVs:* use of hydrogen in a fuel cell to generate electricity to power the vehicle produces no tailpipe emissions other than water, i.e., TTW emissions are zero.
- *For range-extended fuel cell vehicles (FC REEVs):* operation on electricity provided by the battery, or the fuel cell, or a combination of both, produces no tailpipe emissions (other than water in the case of the fuel cell), i.e., TTW emissions are also zero.
- *For electric comparators:* TTW emissions are zero.
- *For diesel/gasoline comparators:* emissions again depend on
  I. the amount of fuel used per unit distance (i.e., the fuel efficiency) and
  II. the source of the fuel.





WTW Emissions
Sources of WTT and TTW Data


JRC TECHNICAL REPORTS

WELL-TO-WHEELS Report Version 4.a

JEC WELL-TO-WHEELS ANALYSIS

WELL-TO-WHEELS ANALYSIS OF FUTURE AUTOMOTIVE FUELS AND POWERTRAINS IN THE EUROPEAN CONTEXT

Authors: Robert EDWARDS (JRC), Heinz HASS (EUCAR), Jean-François LARIVÉ (CONCAWE), Laura LONZA (JRC), Heiko MAAS (EUCAR), David Rickeard (CONCAWE)

Editors: Simon Godwin (EUCAR), Heather Hamje (CONCAWE), Alois Krasenbrink (JRC), Robin Nelson (CONCAWE), Kenneth D. Rose (CONCAWE)

2014

- The JRC (a collaboration between the EU, EUCAR and Concawe) produces the report *Well-to-Wheel Analysis of Future Automotive Fuels and Powertrains in the European Context*.
- The JRC report provides authoritative EU-average values for WTT and TTW emissions from various production pathways for electricity, hydrogen and diesel/gasoline fuels.
- This deliverable uses the latest available WTW values from Version 4.a (2014) of the report.
- Where authoritative WTT values are available from country-specific sources, such as national electricity grid mix values, these are used instead.

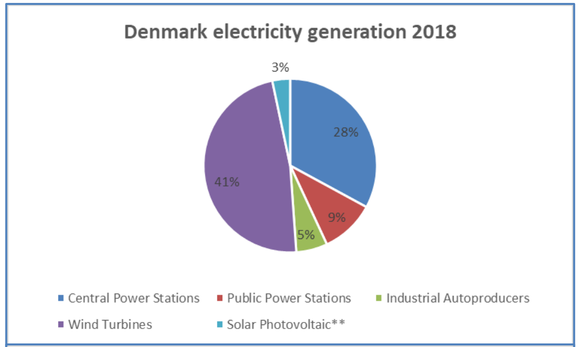
WTW Emissions
WTT and TTW Fuel Data Used in this Report. 1. Oil-Derived

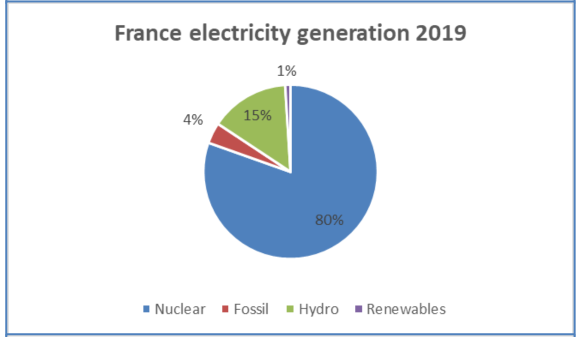
Pathway	Fuel	WTT (gCO_2e/MJ)	TTW (gCO_2e/MJ)	Source
COD1, typical EU supply and refining	Diesel	15.4	72.2	JRC WTW 4.a
COG1, typical EU supply and refining	Gasoline	13.8	73.4	JRC WTW 4.a

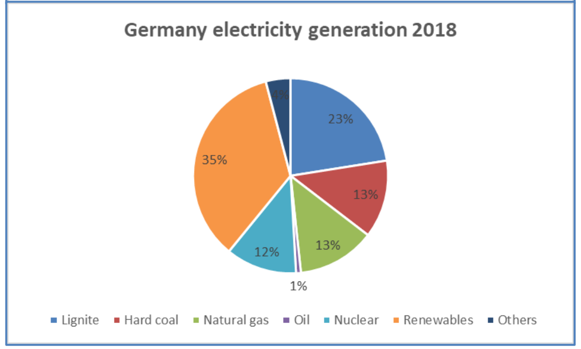
WTW Emissions
WTT and TTW Fuel Data Used in this Report. 2. Hydrogen

Pathway	Fuel	WTT (gCO_2e/MJ)	TTW (gCO_2e/MJ)	Source
GPCH3b: centralised reforming, road transport @50MPa	Hydrogen	150.1	-	JRC WTW 4.a
EMEL2/CH1: onsite electrolysis, grid electricity	Hydrogen	232.5	-	JRC WTW 4.a
EMEL1/CH2: central electrolysis, grid electricity	Hydrogen	226.3	-	JRC WTW 4.a
NUEL1/CH1: onsite electrolysis, nuclear electricity	Hydrogen	8	-	JRC WTW 4.a
WDEL1/CH2: central electrolysis, wind electricity (assumed pipeline delivery)	Hydrogen	13	-	JRC WTW 4.a

WTW Emissions
WTT and TTW Fuel Data Used in this Report. 3. Electricity (1)







- There are different electricity generating mixes in the three countries that will be used as case studies in this report.
- CO_2 emissions from electricity generation in each country are dependent on amount of renewables/low carbon generation employed:**
  - Denmark: 206 gCO_2e/kWh*
  - France: 60 gCO_2e/kWh*
  - Germany: 474 gCO_2e/kWh*.

* Sources:
- Denmark: **https://ens.dk/sites/ens.dk/files/Statistik/el-maanedsstatistik.xls**
- France: https://www.rte-france.com/en/article/major-electricity-trends-month
- Germany: **https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20181214_brd_stromerzeugung1990-2018.xlsx**

(accessed 24/11/19).

** These values may not include losses from the transmission and distribution of electricity. According to the JRC, this can add ~ 10% to the gCO_2e/kWh values (http://publications.jrc.ec.europa.eu/repository/bitstream/JRC85326/wtt_report_v4a_april2014_pubsy.pdf, accessed 08/04/20).

WTT and TTW Fuel Data Used in this Report. 3. Electricity (2)

Pathway	Fuel	WTT (gCO_2e/MJ)	TTW (gCO_2e/MJ)	Source
EMEL3, Grid electricity, LV supply	Electricity	150.1	-	JRC WTW 4.a
NUEL, Nuclear electricity	Electricity	5	-	JRC WTW 4.a
WDEL, Wind electricity	Electricity	0	-	JRC WTW 4.a
Denmark, grid average, 2017	Electricity	57.2		ENS*
France, grid average 2018	Electricity	16.7	-	RTE*
Germany, grid average 2018	Electricity	131.7	-	UBA*

* Sources:
- Denmark: **https://ens.dk/sites/ens.dk/files/Statistik/el-maanedsstatistik.xls**
- France: https://www.rte-france.com/en/article/major-electricity-trends-month
- Germany**: https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20181214_brd_stromerzeugung1990-2018.xlsx**

(accessed 24/11/19).

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- Calculation of WTW emissions for H2ME vehicles
- **H2ME WTW emission country case studies**
  - FCEVs in Germany
  - FCEVs in Denmark
  - FC REEVs in France
- Conclusions of the H2ME WTW emissions analysis
- Caveats to the H2ME WTW emissions analysis

Introduction to H2ME WTW Case Studies
Choice of Vehicles and Locations

- H2ME project vehicles operate in a variety of roles (e.g., fleet and passenger cars, police vehicles, taxis) in each participating country.
- The remainder of this report presents three country operation case studies where the project has accumulated significant amounts of operational data:
  - Germany (Daimler, Honda, Toyota)
  - Denmark (Hyundai, Honda, Toyota)
  - France (Symbio)
- For the FCEVs, the choice of countries where multiple vehicles operate respects the wish of some project OEMs for anonymisation of individual performance data.
- As Symbio provides the only FC REEV to the project, it is not possible to anonymise its performance data. Symbio has agreed that its data can be presented without anonymisation.

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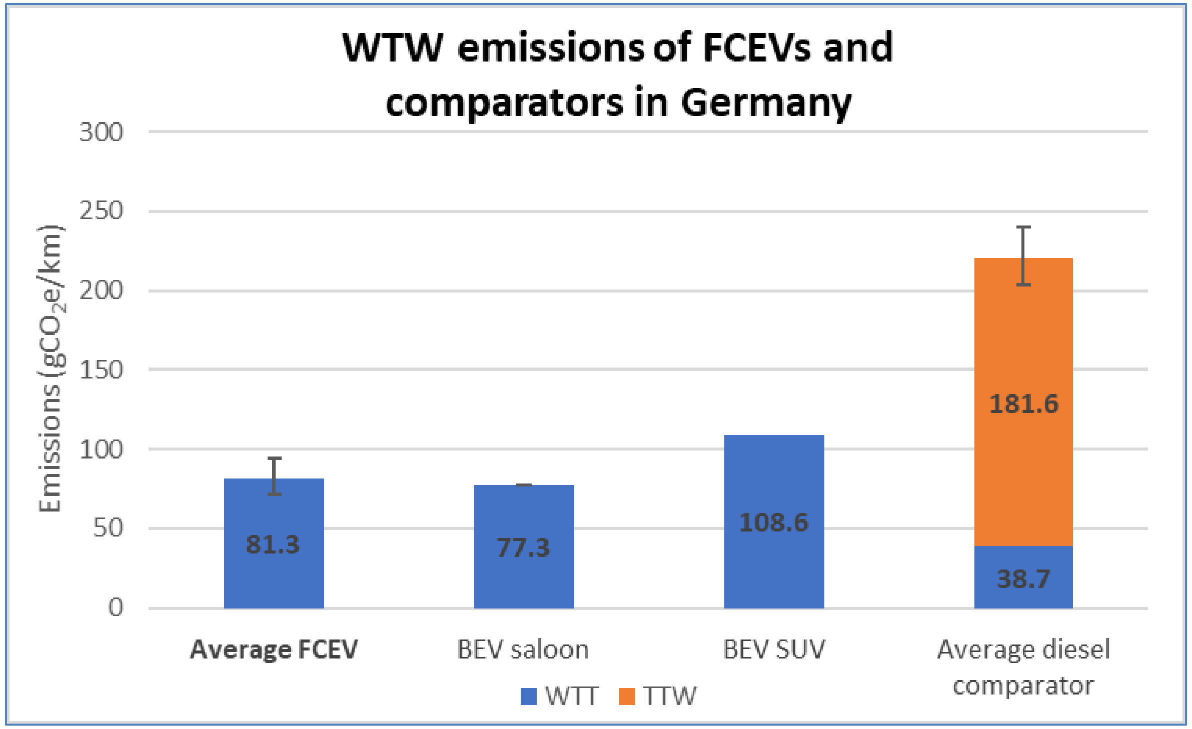
H2ME WTW Case Studies
FCEVs in Germany

- Vehicles operating in Germany since 2017 for which detailed data is available include:
  - Daimler GLC F-CELL
  - Honda Clarity
  - Toyota Mirai
- Vehicles subject to detailed monitoring have driven 516 000 km and consumed 5 770 kg H_2.
- Other vehicles operated by end-users such as CleverShuttle and Alphabet have covered considerably more distance.

H2ME WTW Case Studies
Fuel Consumption of FCEVs and Comparators in Germany

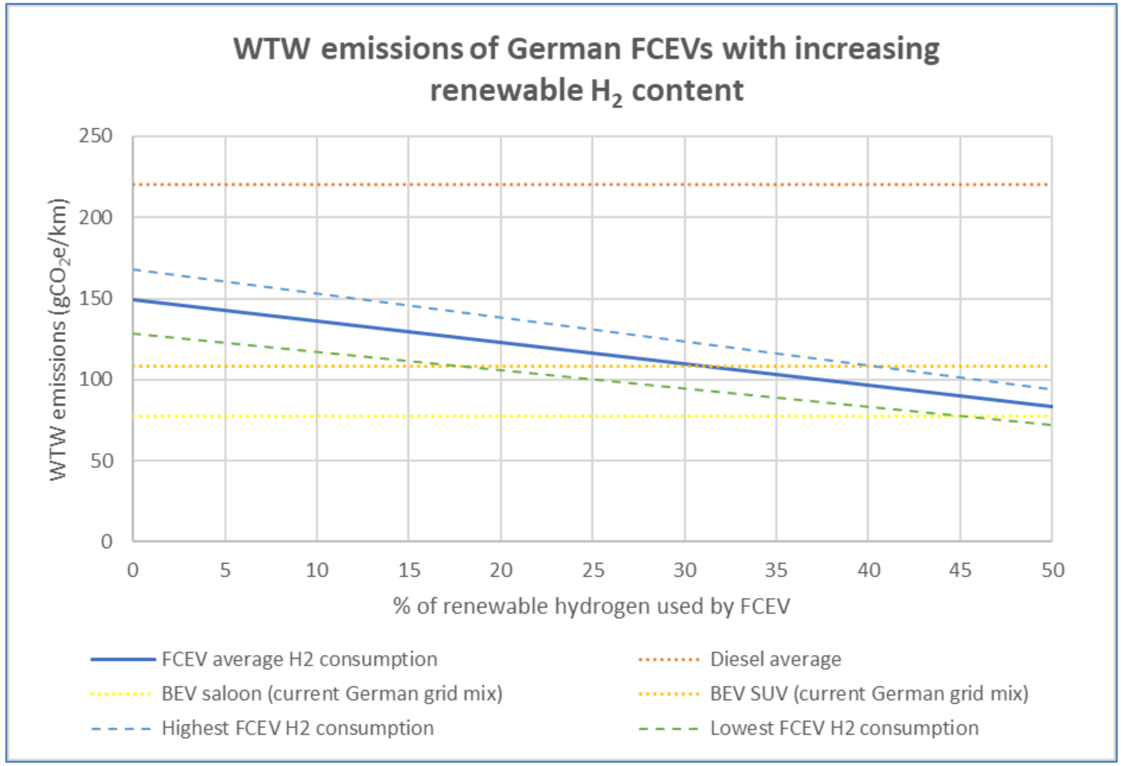
Vehicle	Fuel efficiency/ consumption	Units	Energy usage (MJ/km)	Source
Average of FCEVs in Germany	1.11	kgH_2/100km	1.34	H2ME project 2017-2019
BEV saloon	16.3	kWh/100km	0.59	Spritmonitor.de
BEV SUV	22.9	kWh/100km	0.82	Spritmonitor.de
Average of diesel comparators	7	l/100km	2.52	Spritmonitor.de

H2ME WTW Case Studies
WTW Emissions of FCEVs and Comparators in Germany



- The graph shows the WTW emissions from project FCEVs and comparators (the black bars represent the highest and lowest fuel consumption of each vehicle type).
- For the FCEVs, the WTW emissions are calculated using a 50:50 mix of hydrogen derived from steam methane reforming (SMR) and wind electrolysis. This is the ambition for the hydrogen generation mix to be used by H2Mobility Germany.
- The following page shows the effect of varying the amount of renewable hydrogen used by the FCEVs on the WTW emissions from the vehicles.

H2ME WTW Case Studies
WTW Emissions of FCEVs and Comparators in Germany
The Influence of Renewable Hydrogen



- The graph shows the effect of increasing the amount of renewable hydrogen used by the FCEV on its emissions, compared to current WTW emissions from diesel and battery electric comparators.
- While the emissions of the FCEV are always lower than those of the diesel comparator, the graph demonstrates the importance of renewable hydrogen in achieving similar or lower WTW emissions than electric vehicles.
- In the longer term, Germany's *Climate Action Plan 2050* aims for a 95% cut in GHG emissions compared to 1990 levels, and the complete or near-complete decarbonisation of electricity generation. This will reduce WTW emissions from BEVs to near-zero.
- There will be a need for 100% green hydrogen for transport to reduce FCEV emissions to near-zero.

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- Conclusions of the H2ME WTW emissions analysis
- Caveats to the H2ME WTW emissions analysis

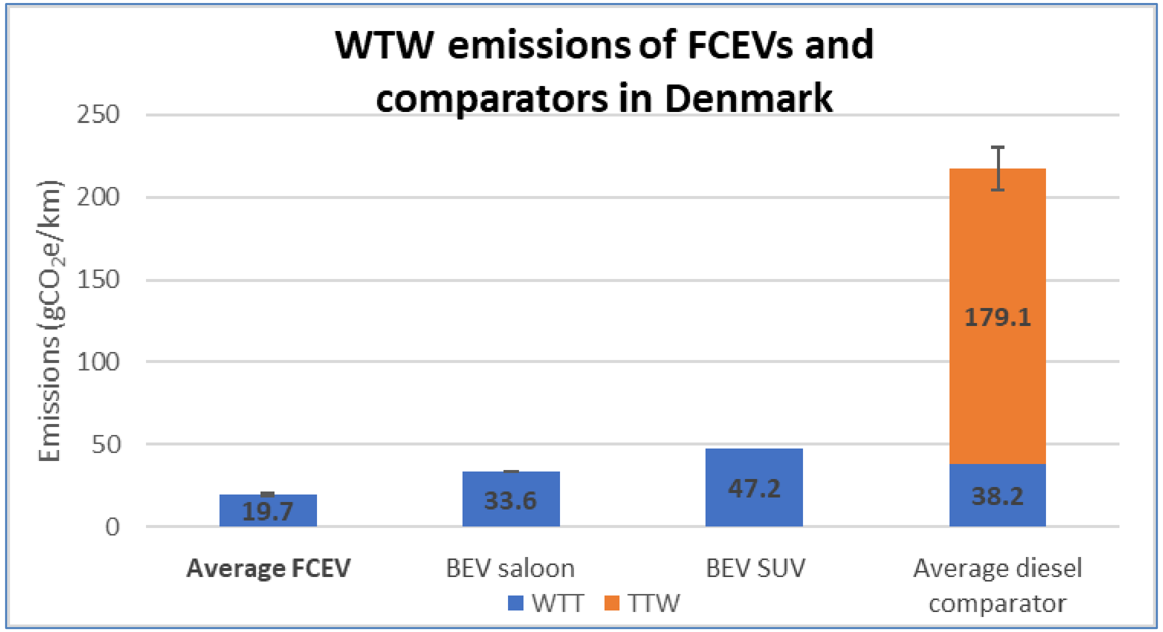
H2ME WTW Case Studies
FCEVs in Denmark

- Vehicles operating in Denmark since 2017 for which detailed data is available include:
  - Honda Clarity
  - Hyundai ix35
  - Toyota Mirai
- Vehicles subject to detailed monitoring have driven 152 000 km and consumed 1 918 kg H_2.

H2ME WTW Case Studies
Fuel Consumption (TTW) of FCEVs and Comparators in Denmark

Vehicle	Fuel efficiency/ consumption	Units	Energy usage (MJ/km)	Source
Average of FCEVs in Denmark	1.26	kgH_2/100km	1.51	H2ME project 2017-2019
BEV saloon	16.3	kWh/100km	0.59	Spritmonitor.de
BEV SUV	22.9	kWh/100km	0.82	Spritmonitor.de
Average of diesel comparators	6.9	l/100km	2.48	Spritmonitor.de

H2ME WTW Case Studies
WTW Emissions of FCEVs and Comparators in Denmark



- The graph shows the WTW emissions from project FCEVs and comparators (the black bars represent the highest and lowest fuel consumption of each vehicle type).
- For the FCEVs, the WTW emissions are calculated using 100% hydrogen derived from wind electrolysis as project HRS are served by 100% green-certified hydrogen.
- Under this assumption, FCEVs in Denmark have lower emissions than BEVs and conventional comparators.
- Emissions from BEVs will decrease in future years as the Danish electricity grid is progressively decarbonised.

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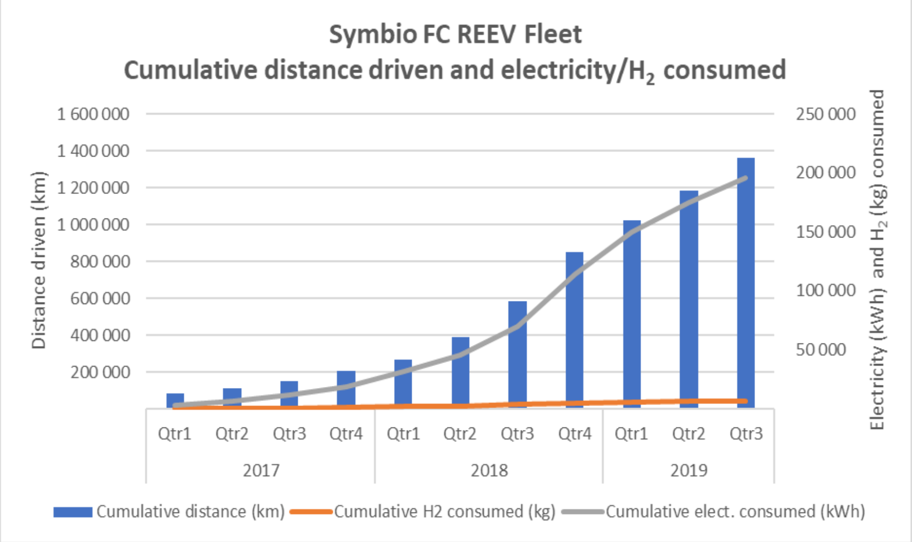
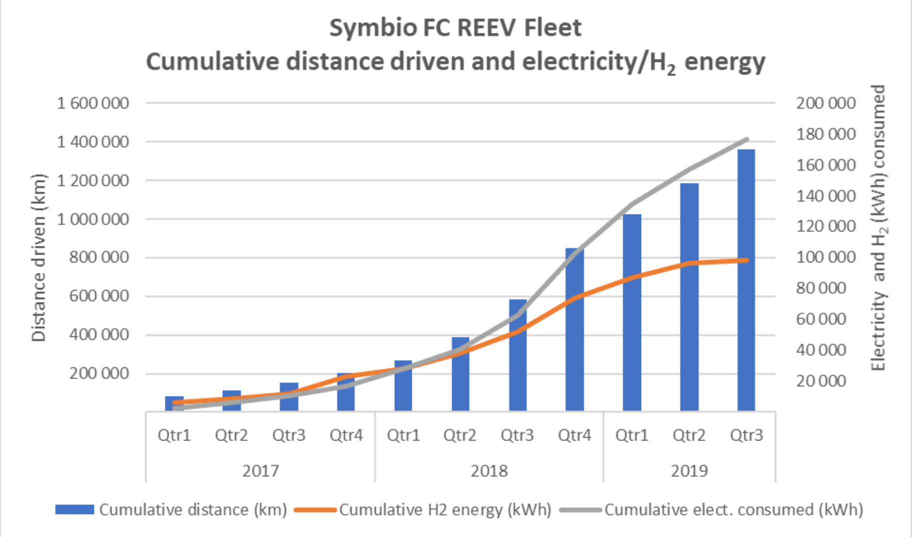
H2ME WTW Case Studies
Fuel Consumption of FC REEVs and Comparators in France

Vehicle	Fuel efficiency/ consumption	Units	Energy usage (MJ/km)	Source
Symbio ZE H2	17	kWh/100km	0.62	Average value for vehicles subject to detailed monitoring, H2ME project
Kangoo ZE (BEV comparator)	15.6	kWh/100km	0.56	Honestjohn.co.uk
Kangoo diesel	6.11	l/100km	2.32	Spritmonitor.de
Kangoo gasoline	7.8	l/100km	2.56	Spritmonitor.de

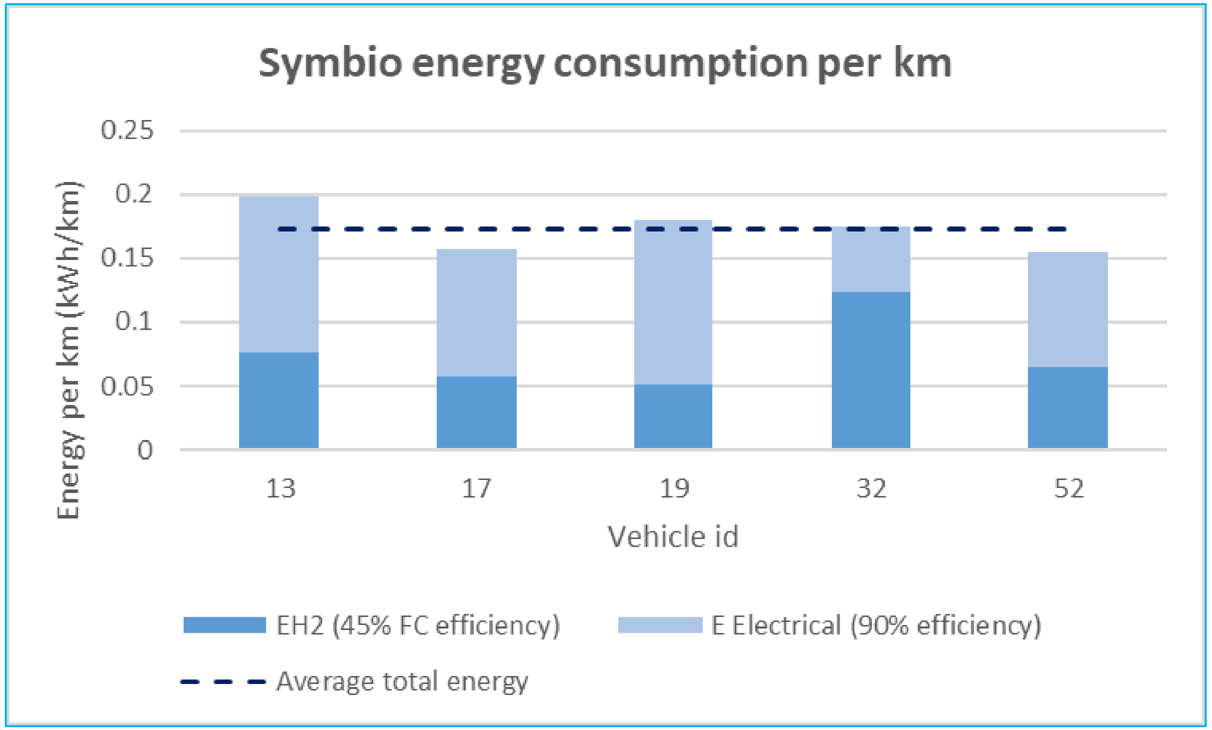
H2ME WTW Case Studies
Light Commercial Vehicles in France: Fleet Overall Fuel Use





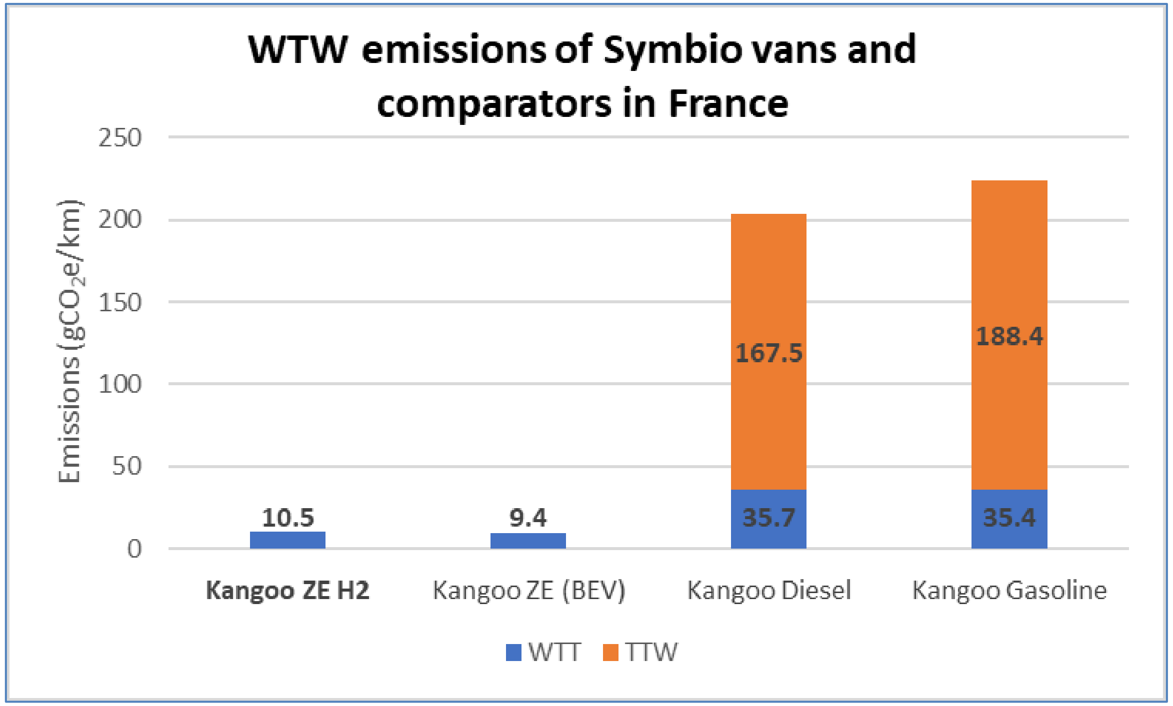
- The Symbio ZE H2 is a fuel cell range-extended electric vehicle (FC REEV) – i.e., it can be fuelled by hydrogen, electricity or a combination of both.
- The top graph shows a simple comparison of hydrogen and electricity fuelled to the vehicles. Hydrogen has a higher energy content per unit (kg) than electricity (kWh).
- Comparing energy consumption is therefore more informative. The bottom graph assumes:
  - H_2 conversion via the FC to electricity is 45% efficient (value provided by Symbio).
  - The efficiency of energy transfer from the battery & FC to the wheel is 90%.
- Under this (very simplified) assumption around 50% of the fleet's kilometrage was fuelled by H_2 in 2018. This value is used in subsequent slides.

H2ME WTW Case Studies
Light Commercial Vehicles in France: Fleet Energy Use



- The graph shows the energy consumption of five of the Symbio vans in France that are subject to detailed monitoring by the project.
- Although the vehicles use different amounts of hydrogen and electricity, under the assumptions described in the previous slide the graph shows that the overall vehicle energy consumption (i.e., hydrogen plus electricity) per km is approximately the same for the vehicles.
- In practice, this means that to the driver the vehicle drives as an electric vehicle irrespective of whether the fuel is hydrogen, electricity, or a combination of both.

H2ME WTW Case Studies
WTW Emissions of FCEVs and Comparators in France



- The graph shows the WTW emissions from the project FC REEVs and comparators.
- For the FC REEVs, the WTW emissions are calculated using a 50:50 mix of hydrogen derived from nuclear-powered electrolysis and French grid electricity.
- Since French grid electricity has very low carbon footprint compared to the EU average, fuelling the vehicle with electrolysis-derived hydrogen or electricity makes little difference to the WTW emissions, which are significantly lower than those of a diesel or gasoline-fuelled vehicle.

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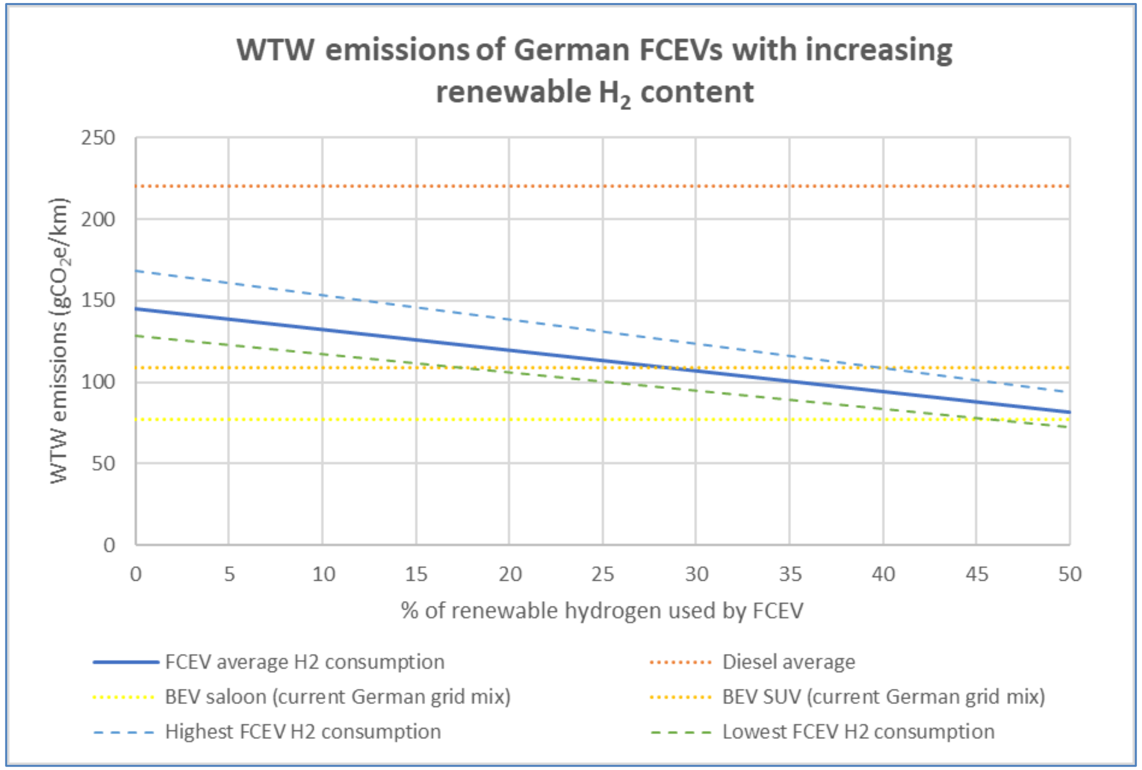
Conclusions from the H2ME WTW Emissions Analysis
Low Carbon Hydrogen is Key to WTW Emissions Savings



- The analysis has shown that project hydrogen vehicles achieve lower WTW emissions than diesel or gasoline vehicles even if using fossil (SMR)-derived hydrogen.
- Emission savings compared to diesel or gasoline vehicles are increased significantly when low carbon or renewable (wind- or nuclear electrolysis-derived) hydrogen is used.
- Significant low carbon hydrogen content is essential to achieve WTW emissions that are comparable to, or better than, those from battery electric vehicles.
- As emissions from BEVs fall in line with electricity grid decarbonisation plans across Europe, so the importance of increasing the use of renewable hydrogen in transport will grow.

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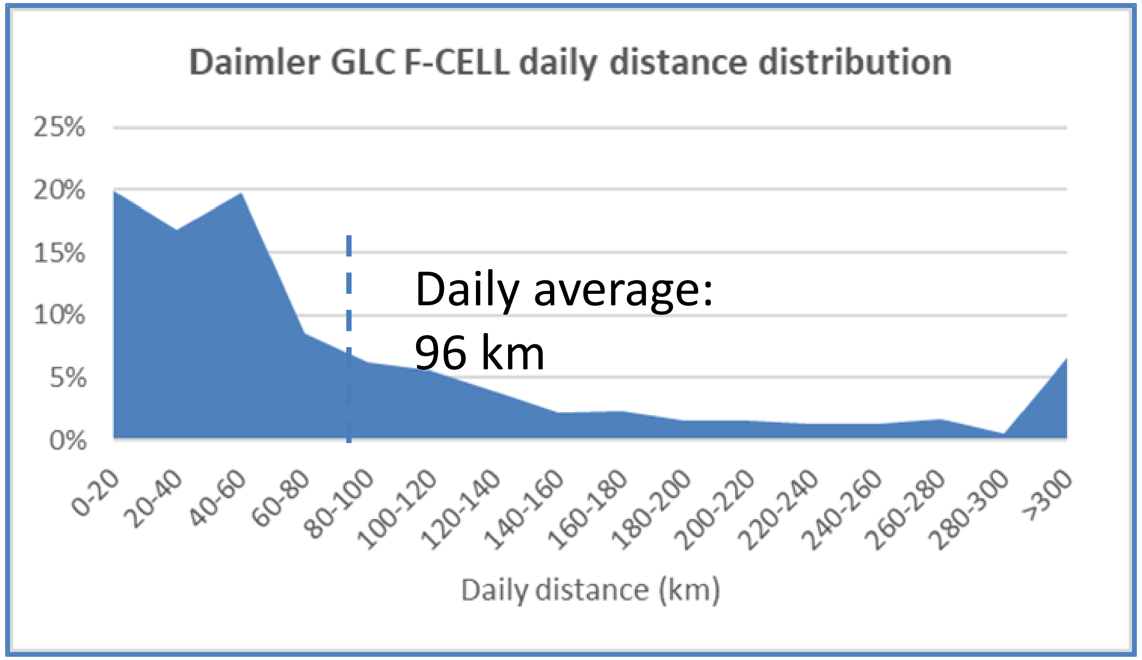
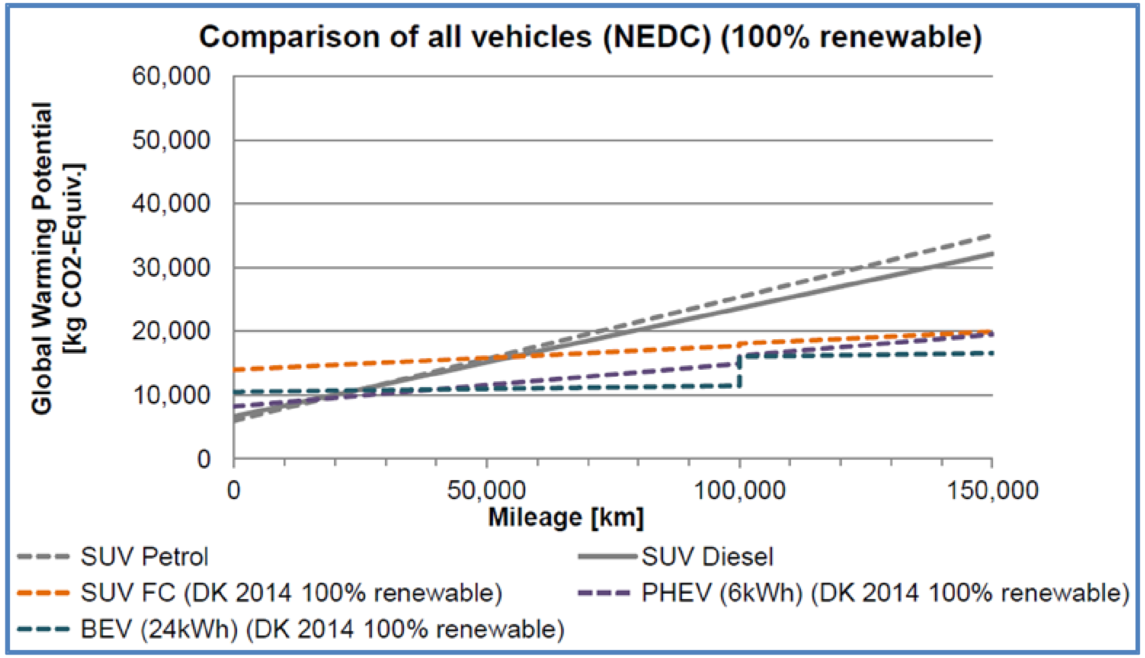
Caveats to the H2ME WTW Emissions Analysis
1. Hydrogen Vehicles and Comparators are Different



- The FCEVs and FC REEVs investigated in this study travel on average 60 – 100km km a day, a range which should be well within the capability of all the vehicles (conventional, electric and hydrogen) considered in this analysis.
- The FCEVs have been shown to travel over 1 000 km in a given day, and FC REEVs 300km+.
- It is recognised that focusing on WTW emissions does not account for all of the different characteristics, and operational advantages and disadvantages, of hydrogen vehicles and comparators. In making a vehicle purchasing decision, users will consider a range of factors including:
  - Total cost of ownership
  - Refuelling time
  - Range
  - Reliability
  - Flexibility
  - Air quality emissions

Caveats to the H2ME WTW Emissions Analysis
2. This is *Not* a Full Life Cycle Assessment



*Source: *HyTEC Final Life Cycle Assessment Report (2015)*, Aleksandar Lozanovski and Michael Baumann (Fraunhofer), Lourdes F. Vega, Gabriel Blejman and Patricia Ruiz (MATGAS)

- Life Cycle Assessment (LCA) considers all aspects of vehicle production, usage and disposal.
- This WTW analysis is *not* a full LCA. It simply considers fuel production, delivery and use, rather than the production and disposal of vehicles, etc.
- The HyTEC project (2011-2015)* conducted a full LCA of a FCEV (Hyundai ix35) compared to conventional and plug-in electric equivalents.
- Points revealed by the full LCA included:
  - Low carbon/renewable hydrogen is essential to achieve life cycle emission savings for hydrogen vehicles over conventionally-fuelled equivalents.
  - The use of renewable fuels increases the significance of non-usage-related life cycle emissions, such as fuel cell production and disposal, as the WTW emissions from the fuel become much smaller.

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