

Fuel Cells and Hydrogen for Green Energy in European Cities and Regions

An Initiative by the Fuel Cells and Hydrogen Joint Undertaking



May 2018



Realising the green energy transition with hydrogen and fuel cells in European Regions and Cities – Executive Summary

Fuel cells and hydrogen (FCH) have great potential to be keystones of the green energy transition in European Regions and Cities. Investing in hydrogen and fuel cells now pays off for the following reasons:

- 1 Need for action** – Citizens expect their local governments to become active to reduce harmful emissions, to fight climate change and to improve local air quality

- 2 A green energy solution** – Hydrogen and fuel cells are a viable solution for Regions and Cities to tackle these challenges and to initiate the local green energy transition

- 3 Local benefits** – The use of hydrogen and fuel cells offers enormous benefits for Regions and Cities – For the local environment, for creating an attractive city to live in and for boosting the local economy

- 4 Driving the green energy transition** – Regions and Cities can become active drivers of change on the local level – A European support framework is in place to support them on their way

Pioneering European Regions and Cities have already started making hydrogen their solution for the future – Join now and become part of the green energy revolution!

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- 2 **A green energy solution** – How hydrogen is an answer

- 3 **Local benefits** – What hydrogen can do for your city

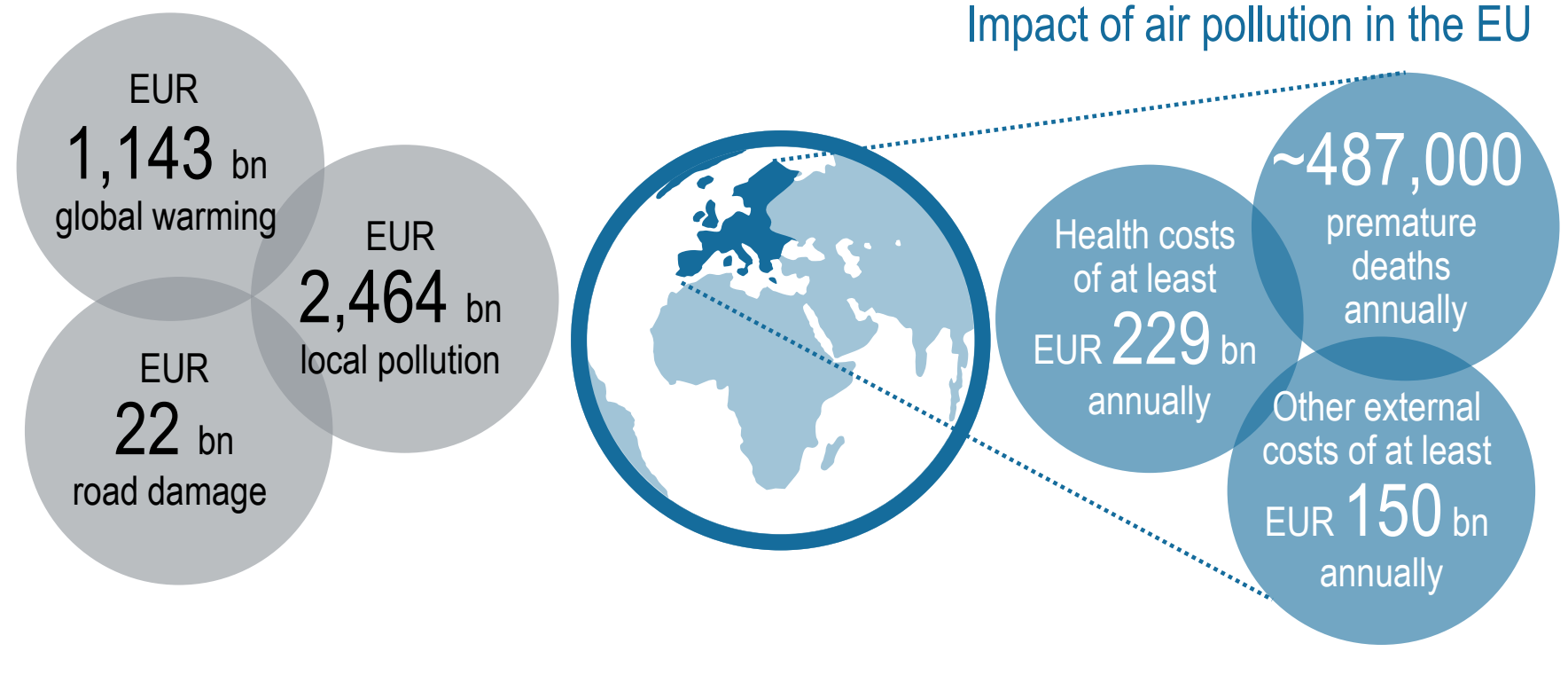
- 4 **Driving the transition** – How you can get involved

- 5 **Contacts** – How to get in touch and join the initiative



The use of fossil fuels causes local air pollution and global warming and leads to immense costs to our societies and our health

Global annual external costs of fossil fuel use



Note: External costs of fossil fuel use are difficult to estimate and different studies have come to a range of external cost estimations, depending also on which external costs are considered. Nevertheless, studies agree that local pollution and climate change cause most external costs and that there is huge potential to reduce these costs by renewable energy use.

Source: IMF (2014 and 2015), Health and Environment Alliance (2017), European Environmental Agency (2017), Roland Berger

European citizens are increasingly aware of these challenges and expect their local governments to take action

Europeans perceive major environmental problems...

- > 92% of Europeans see **climate change** as a serious problem
- > 81% say that **air pollution** is an important problem



...caused by fossil fuel use...

- > 63% of Europeans feel that **transport is a main threat to air quality**
- > 78% think **residential energy emissions are negative for air quality**



...and want local authorities to solve them

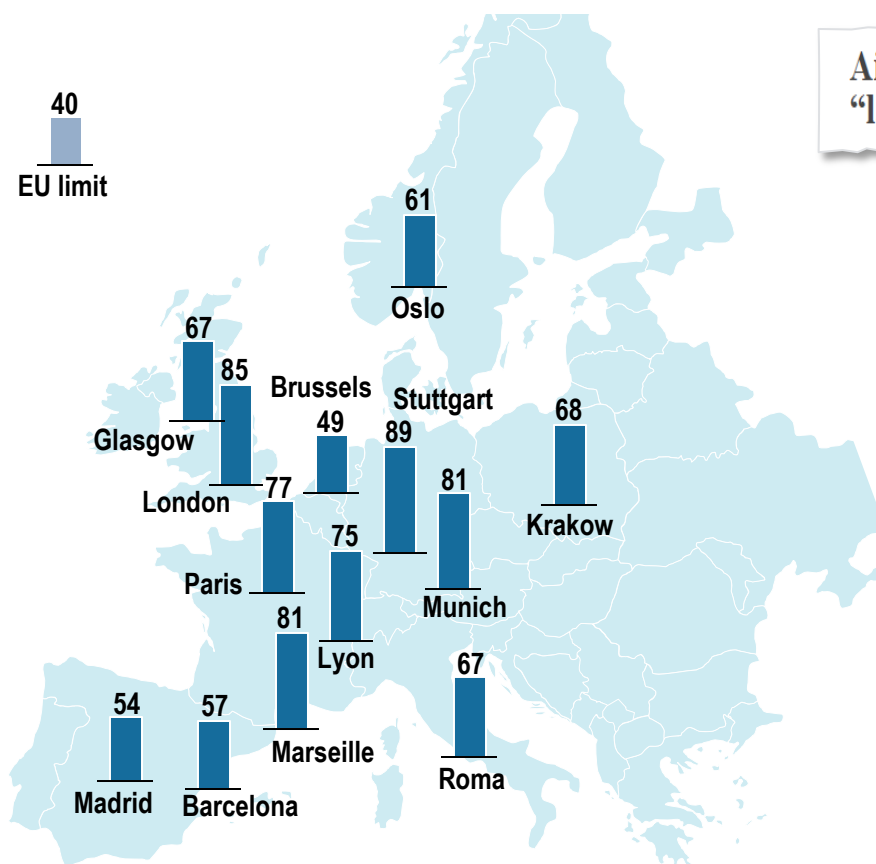
- > 72% of Europeans believe that **public authorities aren't doing enough** for air quality
- > 48% feel that **cities are not doing enough** to protect the environment



Many European cities face serious challenges because they are breaking EU air quality standards and need to take measures now

European cities have high air pollution levels...

...and face increasing pressure to fight them



Air quality: Commission gives nine countries their “last chance”

Slovakia faces sanctions for polluted air

Norwegian city considers 500 percent toll raise to combat pollution

Milan and Turin ban cars to combat smog and air pollution

German court says cities can ban diesel vehicles

Average annual NOx pollution levels in European cities [µg/m³]

Recent headlines of selected newspaper articles

Therefore, many Regions and Cities in Europe and globally are already taking action to address emission and air quality challenges

Emission reduction targets of European Regions and Cities (selection)

London



Be a zero carbon city by 2050

Torres Vedras



Reduce CO₂ emissions by 29% by 2020

Aberdeen



Reduce carbon emissions by at least 50% by 2030

Riga



Reduce CO₂ emissions by 55% by 2020

C40 Cities



Make major city areas zero emission by 2030

Patras



Reduce CO₂ emissions by 20% by 2020

Oslo



Reduce climate emissions by 95% by 2030

Budapest



Reduce climate emissions by 21% by 2020

Copenhagen



Be carbon neutral by 2025

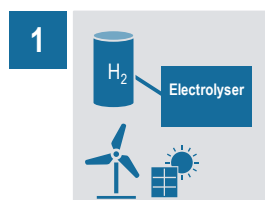
- > Tackling global emission challenges requires **action to be taken on all levels**
- > **Regions and Cities can play a central role** as drivers of change at the local level
- > **Many Regions and Cities globally and in Europe are already pursuing ambitious targets**

Hydrogen and fuel cells can play a key role for Regions and Cities to address the challenges and to realise the green energy transition

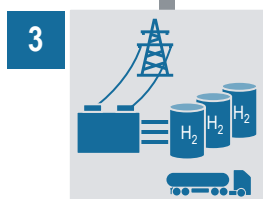
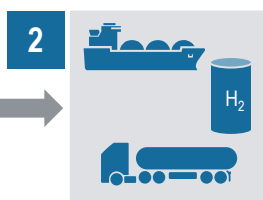
The role of hydrogen in the local energy transition

Enable the renewable energy system

Renewables integration and power generation



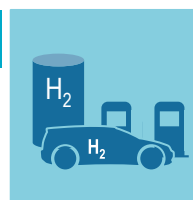
Energy distribution



Buffer for system resilience

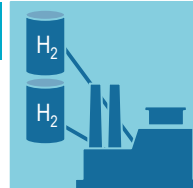
Decarbonise end uses

4



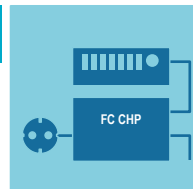
Transportation

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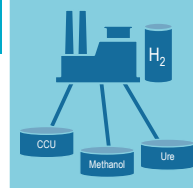
Industrial energy

6



Building heat and power

7

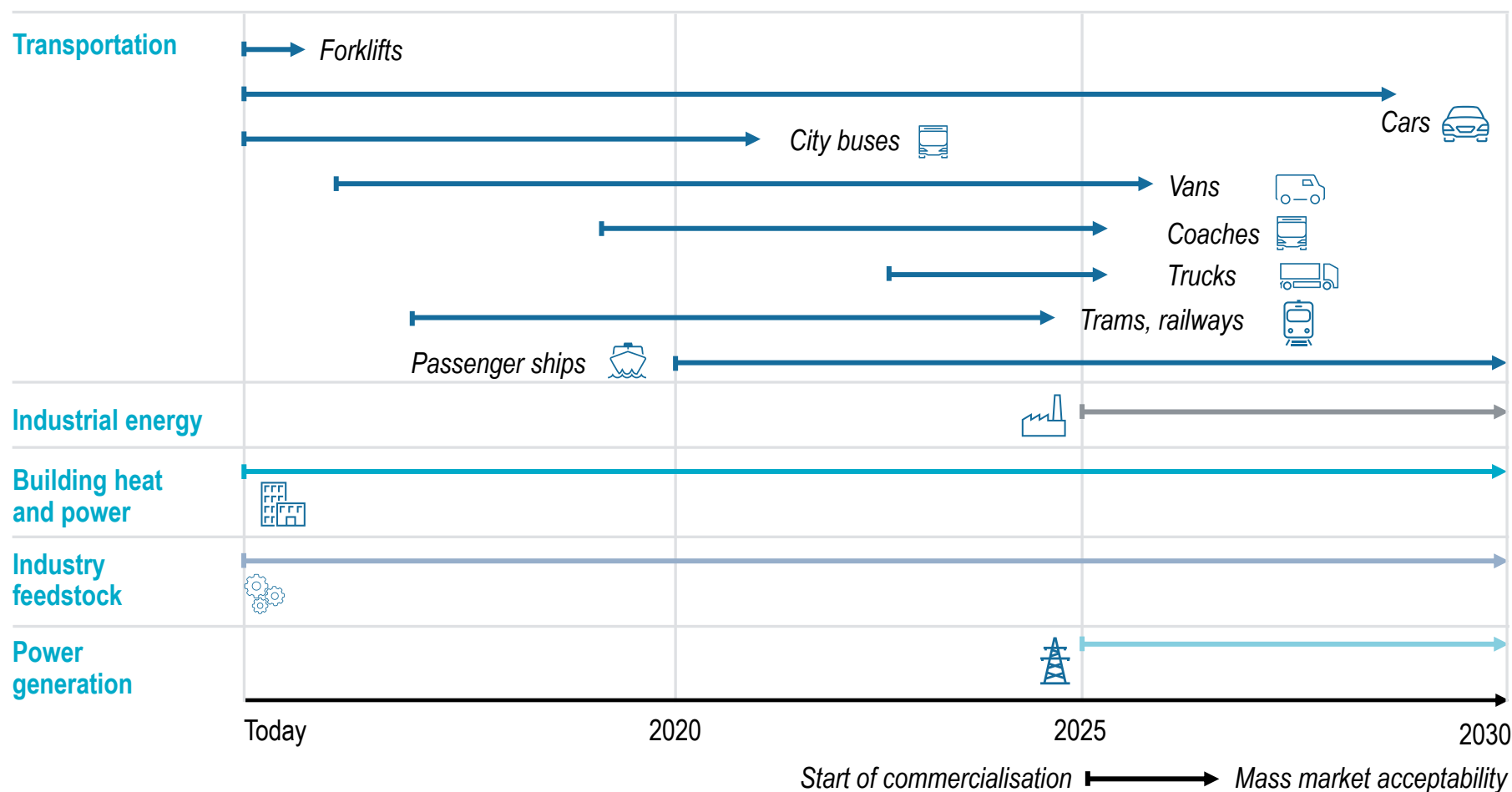


Industry feedstock

Hydrogen is the **most flexible green energy carrier** that can **cater to all energy needs** – It can be produced locally from 100% renewable energy and secures a safe future energy supply

A broad range of hydrogen and fuel cell applications exists for all transport and energy sectors that are ready to be deployed

Overview of selected FCH applications and their road to commercialisation



Numerous successful deployments of these applications show that the technology is a viable solution that works in practice

Experience and achievements in hydrogen and fuel cell technology deployment

FCH experience

	20,000,000+ km travelled globally with fuel cell vehicles
	1,000+ Fuel cell vehicles operating in Europe
	300 new fuel cell buses to be deployed in Europe
	15,000+ Fuel cell forklifts operating globally
	200+ H ₂ refuelling stations installed globally
	120,000+ Fuel cell micro CHP systems installed in Japan

Achievements

	Car driving range improved to 600 km
	Refuelling time for cars reduced to 3 min
	Fuel cell bus costs reduced by about 80%
	Bus fuel cell system lifetime improved by 350%
	50% cost reduction for FC stacks and HRS
	99.4% reliability for stationary FCs achieved

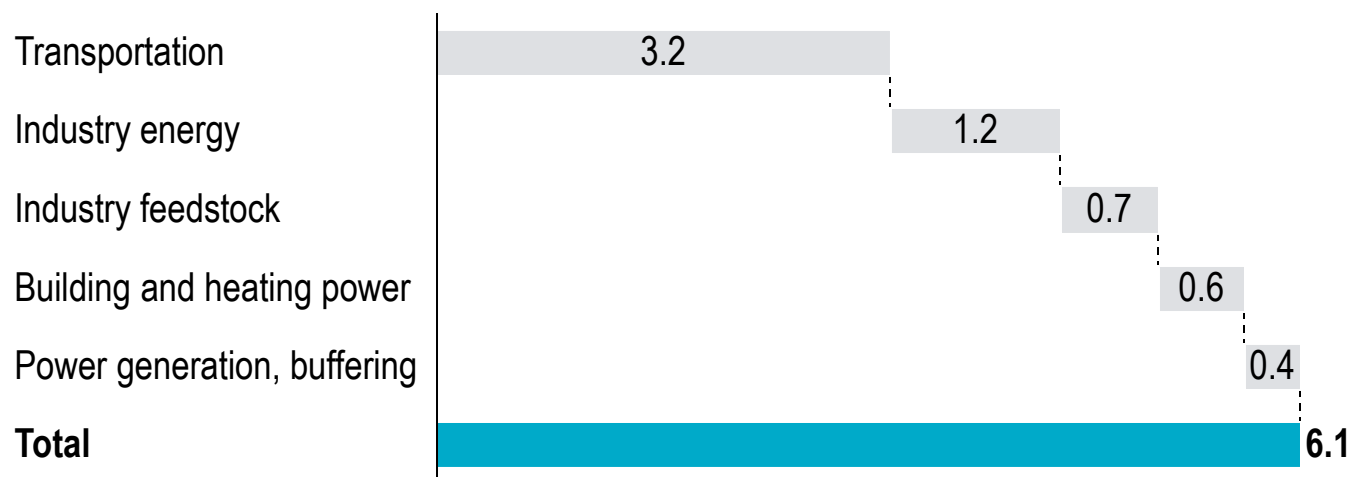
Current status

- > Numerous fuel cell and hydrogen (FCH) **applications are available** today
- > They feature **high technology maturity, safety and reliability** under real life conditions
- > Many FCH applications are **close to commercialisation** – Costs will be reduced with further market uptake

The Hydrogen Council and its industry members see hydrogen as a keystone of a green energy future with enormous potential

Global Hydrogen Vision 2050 – Overview

Potential global annual CO₂ savings in 2050 [Gt]



Realising the Hydrogen Vision for 2050 caters to...

18% of final energy demand

20% of required CO₂ abatement

Creation of 30 m jobs globally

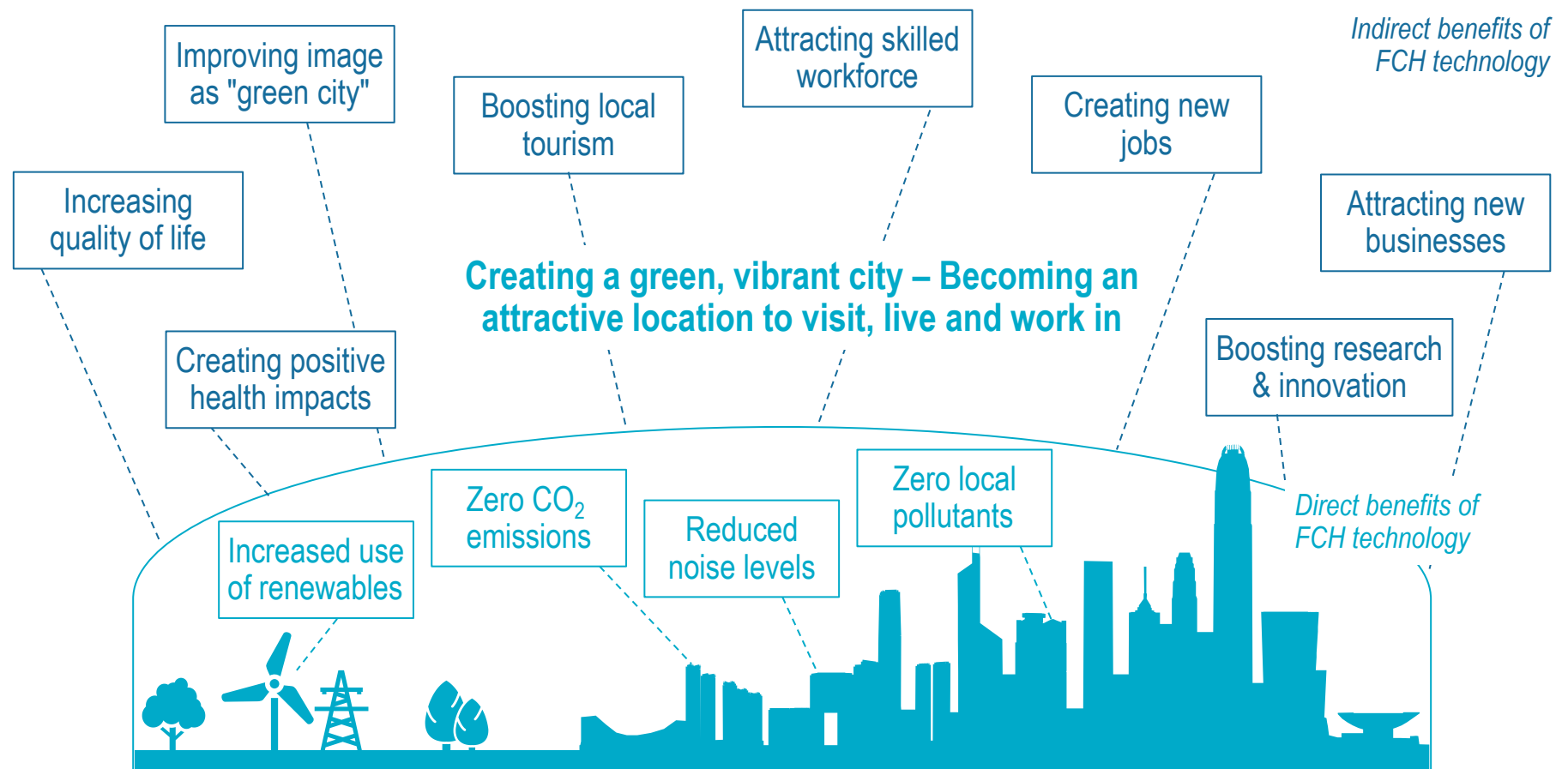
EUR 2,000 bn annual sales

Hydrogen Council



By investing in fuel cells and hydrogen, Regions and Cities can increase quality of living and attract people and businesses

Hydrogen as an attractive local proposition



Representatives of pioneering European cities see the local benefits of a green energy transition and reducing emissions with hydrogen

*"Our most **pressing environmental challenge** is cleaning up London's air. [The City of London will] set a target of **only buying clean** electric or **hydrogen buses from 2020**, seeking an agreement across other major European and global cities to do the same."*

Sadiq Khan, Mayor of London



*"The days when gasoline and diesel are the ways to transport yourself are over. It will mean electric and **hydrogen vehicles**"*

Morten Kabell, Mayor of Technical and Environmental Affairs, Copenhagen

*"The City Council recognises that hydrogen can support [the national low carbon] **targets** [and] sees opportunities for **hydrogen to support economic growth in the region** through inward investment, business development and job creation."*

Councilor Jenny Laing, Council Leader, Aberdeen



In principle, there are two ways that cities and regions can benefit locally from investing in the fuel cell and hydrogen sector

Foster local economic development
(strengthen supply side)



Support local R&D activities and build-up of a local FCH industry

Strengthen local economy

Attract new businesses

Create local jobs

Benefit locally from
investing in the FCH
sector

**Seize environmental benefits by
deploying applications**
(strengthen demand side)



Realise or support local FCH application deployments and build-up of infrastructure

Improve local air quality

Reduce CO₂ emissions

Increase quality of living



Developing both the supply and the demand side of the FCH sector in parallel is needed –
Cities and regions can seize local benefits from investing in both sides

Supporting local economic development in the FCH sector induces local economic growth and creates new jobs and innovation

Potential for innovation, economic growth and job creation



Growing sector – Already today, the European fuel cell and hydrogen (FCH) sector is **developing quickly with large growth potential for local businesses** in the sector



Market potential – A large international hydrogen market **offering business opportunities for local SMEs and global players along the entire value chain** is evolving



Local employment opportunities – Developing the FCH sector is expected to **create more local employment** (up to 15 jobs per EUR 1 m revenues)¹⁾ **and domestic value**



Competitiveness through innovation – Investing in innovative technologies can **secure local economic competitiveness** when conventional technologies will be faded out

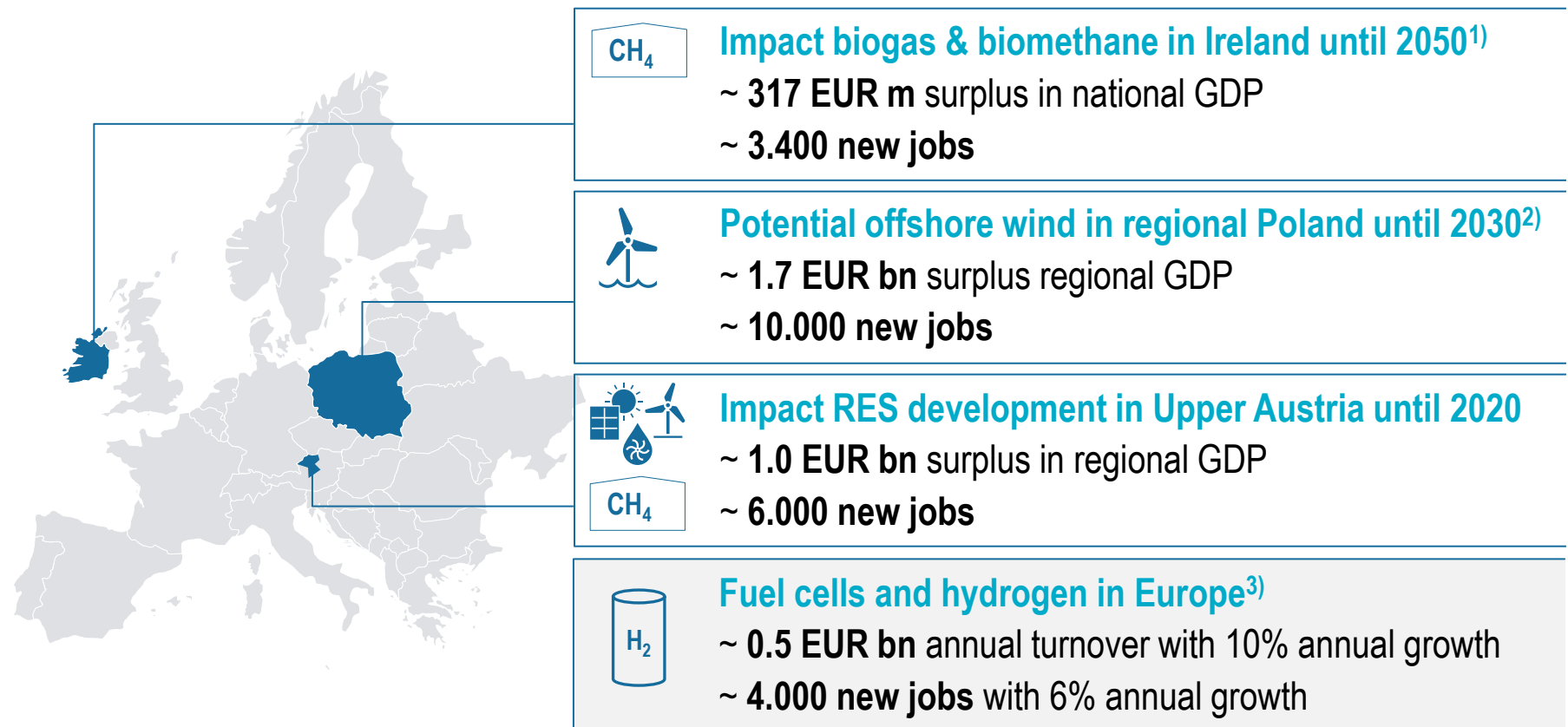


Shaping local transformation – Investing in FCH technologies will **support local economic transformation** as a basis for future growth

1) Compared to fossil fuel value chains; current estimates assume roughly 12 jobs created directly and indirectly per USD 1 m of revenues in advanced industries

Promoting and supporting investments in renewable energy technology fosters local economic growth and job creation

Selected examples of green technology impact on domestic economic value creation



1) Only impact of operation, excl. construction; impact on gross value added
 GDP = Gross domestic product; RES = renewable energy sources

The development of the Ruhr area is an example of how to spark local innovation and create employment in the FCH sector

Overview of H₂ Region Emscher-Lippe*

Large H₂ offtake in chemical industry with own pipeline network and local maintenance competence centre



Concord Blue project plans to produce local H₂ from syngas

Public transport plans to introduce FCH trains



FCH manufacturer decided to settle in the region, creating 20 jobs



Research-focused waste water treatment facility reforms green H₂ for local HRS

Region Emscher-Lippe

North Rhine-Westphalia

Communal waste company tests two FCH garbage trucks



H₂ Technology Center Herten supports local SMEs in the sector creating 50 jobs so far



Energy Institute at the University of Applied Sciences "Westfälische Hochschule" acts as FCH knowledge hub with 20 professors and several spin-offs in the FCH sector



*) In the wider regional context, the hydrogen and fuel cell center ZBT GmbH in Duisburg should also be mentioned as an important knowledge and technology hub

FCH mobility applications are particularly advantageous – They feature environmental benefits with full operational flexibility

Main advantages of FCH mobility applications



No NO_x or other pollutants impacting local air quality



Same performance and flexibility as conventional solutions



No CO₂ emissions if hydrogen is produced from renewables



Long runtimes and ranges without need for refuelling



Low environmental impacts due to low noise and vibrations



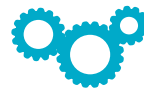
Short refuelling cycles, e.g. only 3 mins for cars

FCH applications are the most flexible zero emission solution – This is one reason why 78% of automotive executives say that they will **be the real breakthrough for electric mobility**

Regions and Cities can take an active role in shaping the local green energy transition and supporting local FCH adoption

Roles for Regions and Cities in developing the sector

Enabler



- > Support build-up of a local H₂ economy
- > Develop and implement local incentives
- > Facilitate and support local FCH adoption through...
 - Stakeholder engagement
 - Awareness raising/ marketing
 - Financial support schemes
 - Advisory services
 - Training and education

Driver



- > Transform local public transport systems by deploying FC buses, trains or taxis
- > Transform municipal fleets by deploying FC cars, vans, garbage trucks, etc.
- > Green public buildings by equipping them with FC CHP systems
- > Invest in local build up of HRS and H₂ production infrastructure to create the basis for private sector FCH use



Both roles – **DRIVER** and **ENABLER** – are needed to develop the sector – Regions and Cities can **lead by example** and kick-start the development by **realising first deployment projects**

Pioneering Regions and Cities take action to kick-start local transformation by investing in fuel cell and hydrogen technology (1/2)

Aberdeen – Developing a leading early deployment and hydrogen technology hub



- > Aberdeen currently has Europe's largest hydrogen bus fleet, a hydrogen sweeper, and a hydrogen car fleet incl. a taxi and is testing light-duty hydrogen vehicles
- > Two refuelling stations with local H₂ production have been established
- > Ambitious plans exist to expand the local hydrogen vehicle fleet and to develop a local H₂ economy



Hype Project Paris – Implementing the world's first hydrogen taxi fleet



- > In 2015, the world's first hydrogen taxi fleet was launched in Paris
- > By the end of 2017, 40 hydrogen taxis were in operation – 75 more will be deployed in early 2018
- > By the end of 2020, 600 vehicles are planned to be on the road
- > To support the hydrogen car fleet, a network of hydrogen refuelling stations is gradually being installed



Flanders and Southern Netherlands – Developing a cross-border hydrogen region



- > The regions are jointly developing hydrogen projects ranging from Power-to-Gas to transportation
- > 4 HRS, 2 garbage trucks, 7 buses, 30 cars, 75 forklifts and a mobile refueller are in operation; 2 trucks will join in 2018
- > An H₂ Roadmap exists to boost FCH uptake in the region with 10 buses, 15 garbage trucks, 4 HRS and 25 MW PtG coming soon



Pioneering Regions and Cities take action to kick-start local transformation by investing in fuel cell and hydrogen technology (2/2)

Energiepark Mainz – Developing local hydrogen infrastructure



- > In 2015, the local utility company installed the first PEM electrolyser at MW-scale
- > The system is currently one of the world's largest that delivers clean hydrogen from renewable electricity
- > Produced H₂ is used locally as fuel, tested in re-electrification and injected into the gas grid



H₂ South Tyrol – Enabling the green mobility shift with hydrogen



- > The South Tyrol region currently runs hydrogen buses and cars as well as a refuelling station (2 bus nozzles, 1 car nozzle) and a local H₂ production facility
- > A Hydrogen Centre has been established to coordinate local activities
- > Ambitious plans exist to upscale hydrogen use in regional mobility



Oslo and Akershus Region – Fostering the use of hydrogen in transport



- > The region currently runs hydrogen buses in public transport and cars for public fleets, taxis and in private use
- > A refuelling station network is being built up with five stations already in operation and three under construction or in planning
- > The region aims to be among the leading regions in Europe for early use of hydrogen in transport



The FCH JU supports European Regions and Cities in implementing local fuel cells and hydrogen technology deployments

JIVE 1/2 – Joint initiative for hydrogen vehicles across Europe

- > Both projects will further advance the commercialisation of hydrogen buses in local public transport
- > In total, 294 hydrogen buses will be deployed in 20 European cities and regions
- > Project duration is from 2017 to 2023 with a total budget of EUR 211.9 m (~27% FCH JU funding)



HyFIVE – Hydrogen for innovative vehicles HYFIVE HYDROGEN FOR INNOVATIVE VEHICLES

- > The project will contribute to the commercial roll-out of FCH vehicles and refuelling infrastructure across Europe
- > The 15 project partners will deploy 110 fuel cell cars and 6 new refuelling stations linked with 12 existing stations
- > Project duration is from 2014 to 2018 with a total budget of EUR 39.1 m (~46% FCH JU funding)



REVIVE – Refuse vehicle innovation and validation in Europe

- > The project will advance the development of fuel cell refuse trucks for municipal services
- > 15 fuel cell powered vehicles will be deployed in total in 8 locations across Europe
- > Project duration is from 2018 to 2021 with a total budget of EUR 8.7 m (~57% FCH JU funding)



The FCH JU supports Regions and Cities in taking the next steps – Join and become part of the green energy revolution!

The FCH JU's Regions & Cities Initiative

Regions and Cities Initiative Coalition



88 European Regions and Cities from 22 countries representing approx. one quarter of Europe's population and GDP



Hydrogen Europe representing more than **100 companies from the fuel cell and hydrogen industry** providing a broad range of products and solutions



The Fuel Cells and Hydrogen Joint Undertaking – A unique public-private partnership between the European Commission, Industry and Research

Benefits from participating

- 1 Deepen your knowledge and exchange experience** with different FCH applications
- 2 Establish contacts in the industry** which can be useful for own FCH project developments
- 3 Access detailed cost data** and tools to **develop a high-level cost analysis** for your location
- 4 Receive support in identifying funding and financing options** for your projects
- 5 Get support in identifying and addressing local stakeholders** to support your projects

Find detailed information and analyses on
<http://www.fch.europa.eu/page/about-initiative>

For further information or joining the initiative, please do not hesitate to get in touch with us

Relevant contact information

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