

# **Hydrogen: Facts and fantasy**



# What is hydrogen?

Hydrogen is an element; it exists naturally as a molecule. Each hydrogen molecule is made up of two hydrogen atoms. The chemical formula for hydrogen is H<sub>2</sub>.

Hydrogen can provide energy by being burnt, or by being reacted with oxygen in a fuel cell.

When hydrogen is used, the only exhaust gas produced is water vapour.

In this sense, it is a clean fuel.

**However...**

**Hydrogen is an energy *carrier* - it must be produced from something else.**

**Almost all (99%) hydrogen today is produced from fossil fuels, emitting 830MtCO<sub>2</sub> each year - the same as the entire annual emissions from Indonesia and the UK combined.**

# The Hydrogen Rainbow



## Green hydrogen

Produced through electrolysis using renewable energy. It is the only type of hydrogen with no emissions during its production (except waste heat).

## Grey hydrogen

Produced using natural gas. As natural gas is a fossil fuel, producing grey hydrogen leads to produces climate-damaging carbon emissions.

## Blue hydrogen

Is grey hydrogen, but with Carbon Capture and Storage equipment used during production.

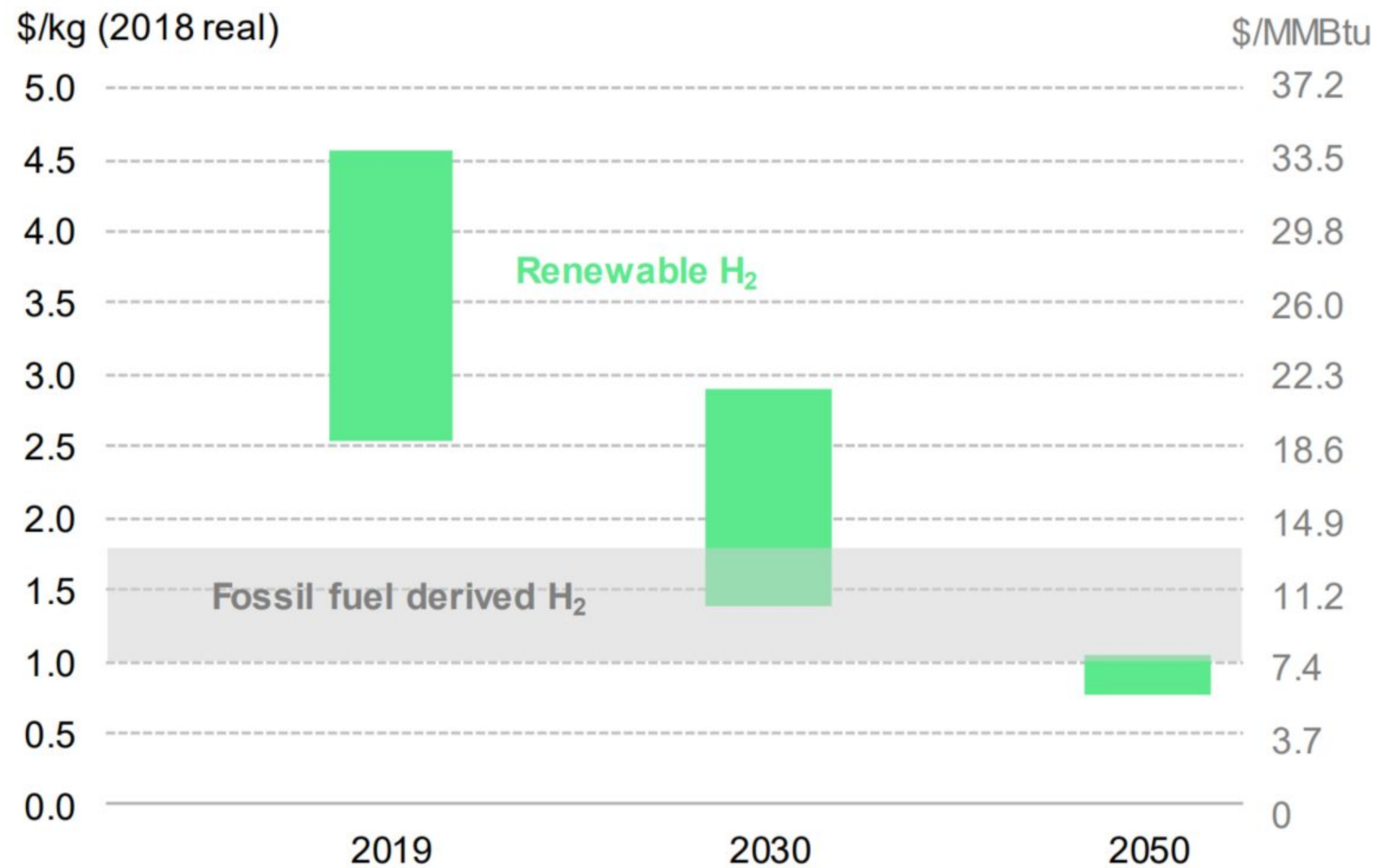
## Turquoise hydrogen

Produced by splitting natural gas into its components, hydrogen and carbon by pyrolysis. This is induced by high temperature obtained from electric heating. Instead of CO<sub>2</sub>, solid carbon is produced, which is then materially bound. This technology is at an early stage and can potentially be coupled with nuclear energy.

## Purple hydrogen

Produced by high temperature steam from nuclear power or via electrolysis from nuclear electricity, therefore with the associated environmental risks linked to nuclear power.

# Hydrogen production costs



Source: Bloomberg New Energy Finance, 2020





# Gas v Hydrogen Infrastructure

- **EU gas infrastructure is not ready for hydrogen.**
  - Current pipelines can carry hydrogen 'blended' with natural gas, but no more than 5% hydrogen - huge investments would be needed to retrofit existing infrastructure
- **The EU has overbuilt gas infrastructure:** there is already more capacity to import gas than is needed, and demand for gas is expected to drop drastically (must be phased out by 2050 in EU)
  - So gas companies know they have potentially stranded assets
- Much **less hydrogen infrastructure will be needed**, compared to current gas infrastructure

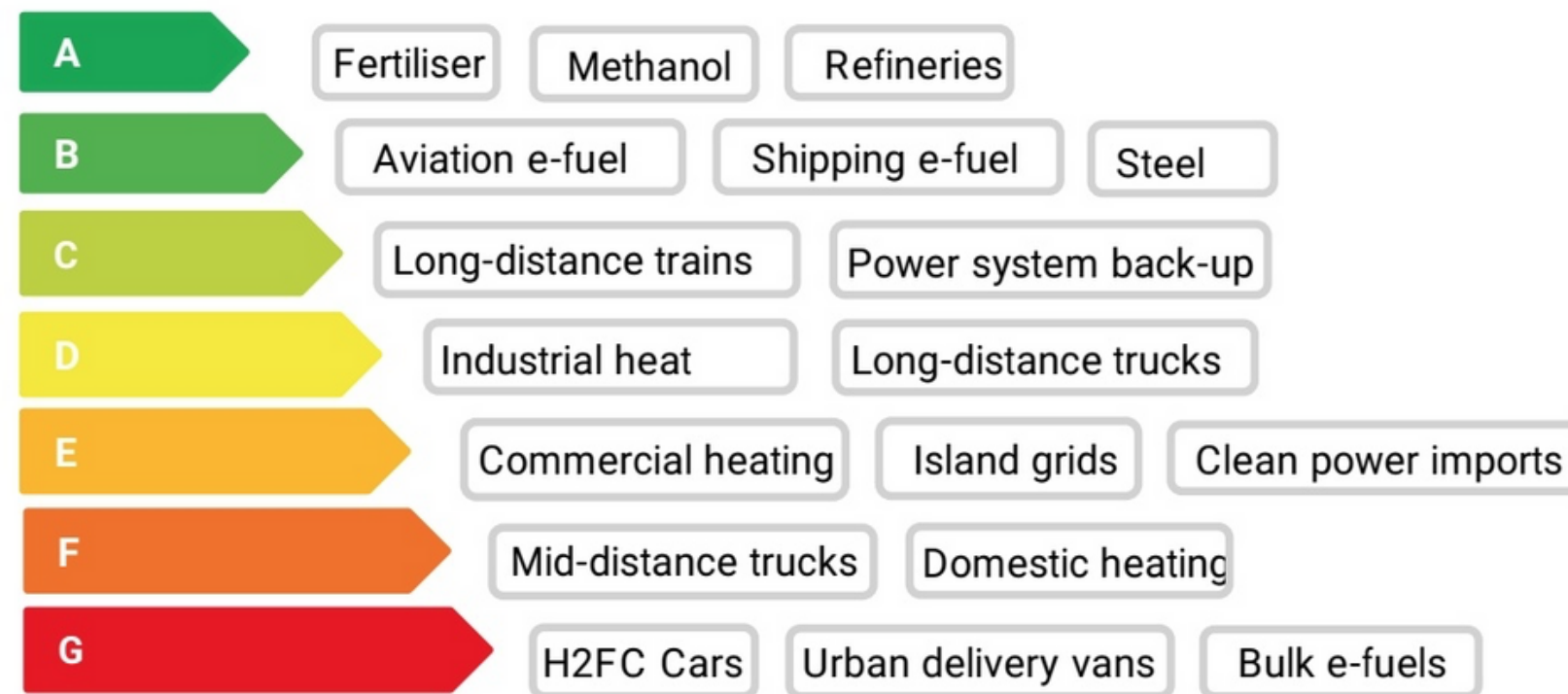
# Hydrogen: The Ladder

## Hydrogen – Demand side sectors

Liebreich  
Associates



### HYDROGEN Use Cases

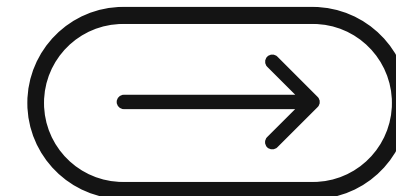


Concept Credit: Adrian Hiel/Energy Cities; Source: Liebreich Associates



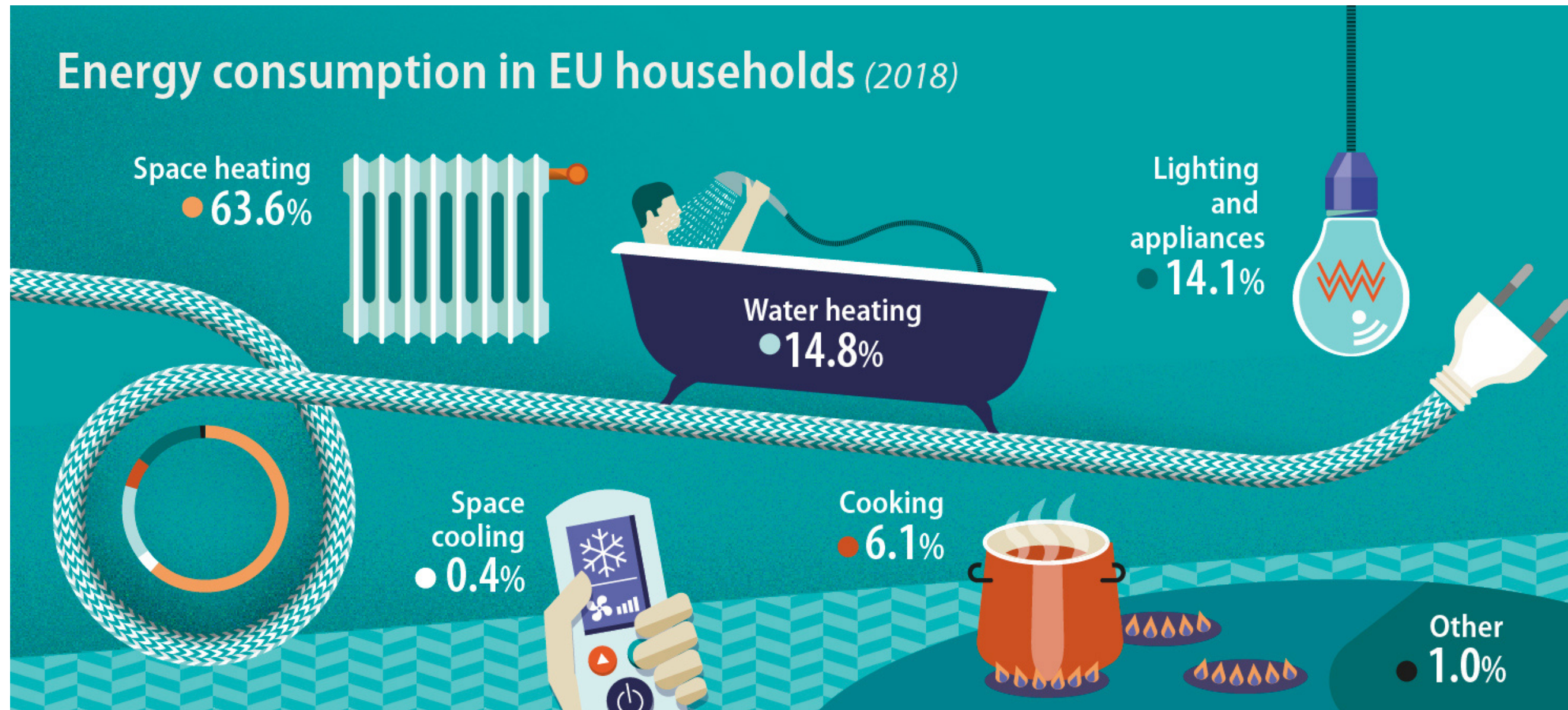
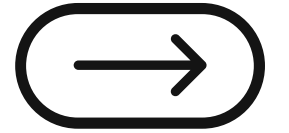
# Is hydrogen the best solution to heat our homes?

Phasing out fossil fuels to win the race to zero-emissions buildings

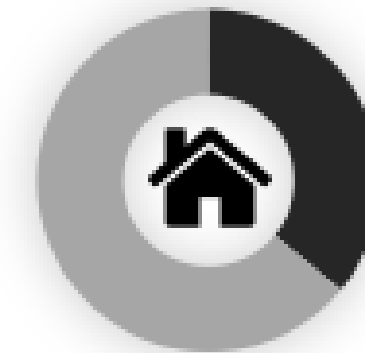




# How much energy do we use at home?



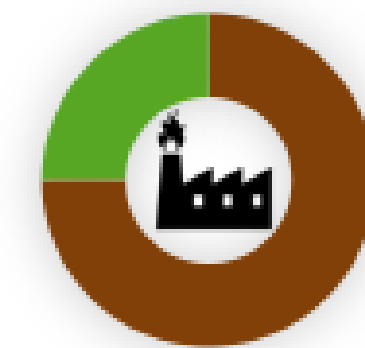
[ec.europa.eu/eurostat](https://ec.europa.eu/eurostat)



**36%**  
of energy  
GHG are  
emitted by  
buildings



**80%**  
of these  
emissions  
come from  
heating

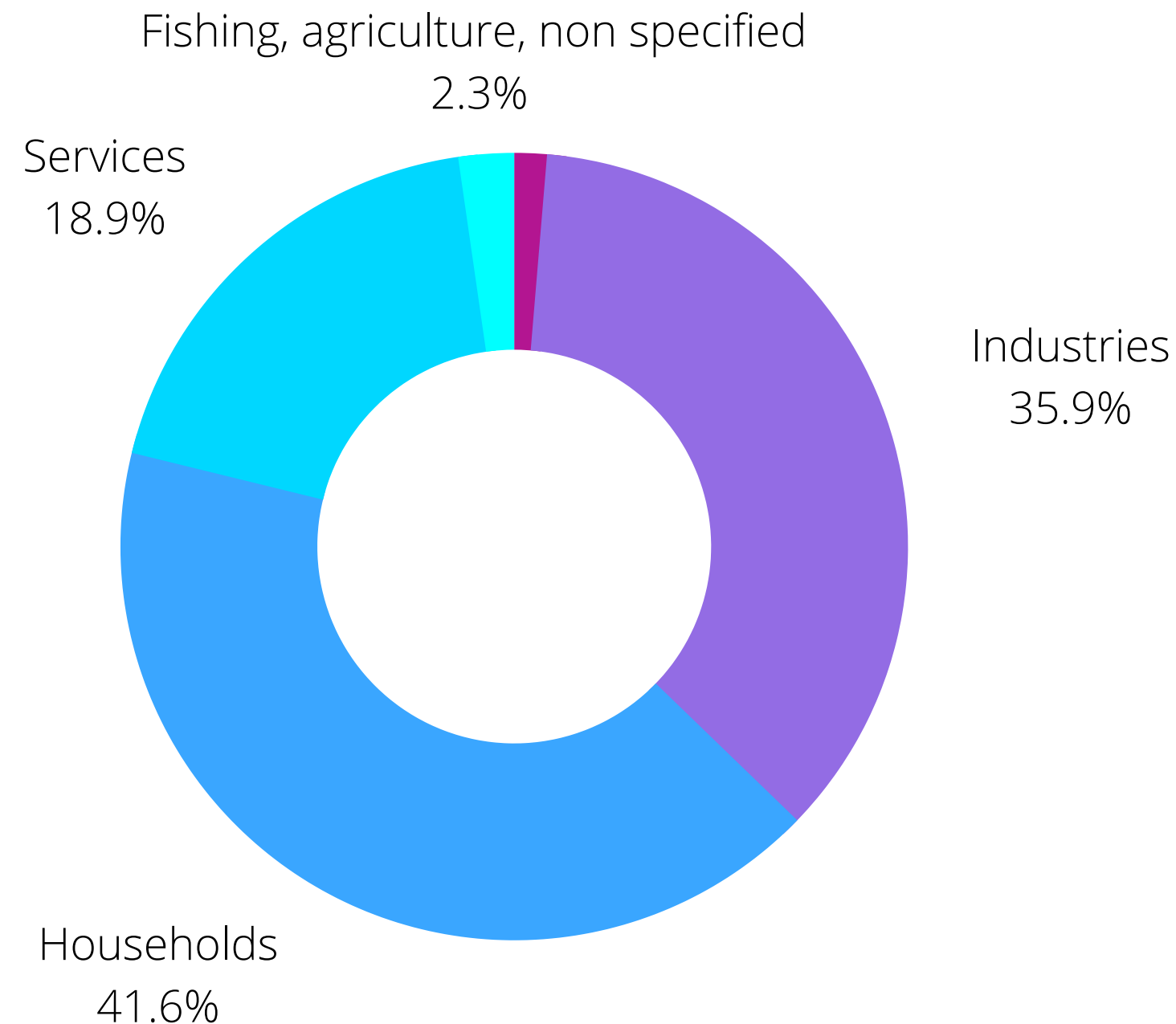


**75%**  
of the heat  
is  
generated  
by fossil  
fuels

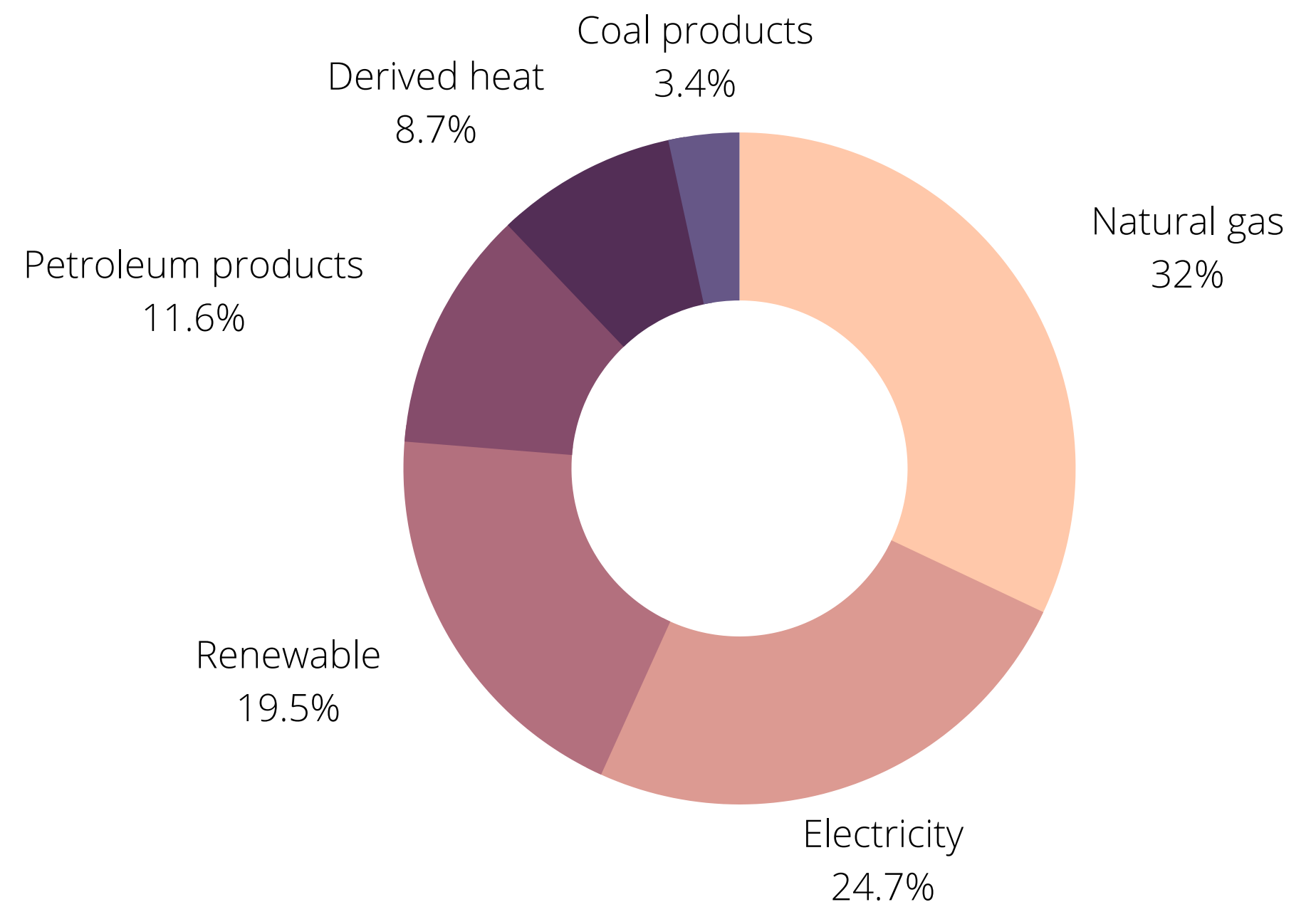


# Which energy do we use in our homes?

## Final energy consumption of natural gas by sector in EU-27 (2014)



## Sources of energy in households in EU-27 (2018)





## Why it matters and what's the urgency?

- If Europe wants more than half its emissions by 2030, it needs to cut emissions from buildings by 60%. (EU own assessment)
- Boilers have on average a life of 22-25 years. If by 2050 Europe wants to be climate neutral, no fossil fuel boilers should be installed after 2025 (ECOS study, IEA net-zero by 2050 report)
- It is not possible to transition to clean energy and end using fossil fuels, if gas use in homes represents a huge portion of the energy needs.

**Does it make sense to use hydrogen boilers to go toward zero-emission heating?**

# Will hydrogen lead to higher energy bills? What's the impact on low-income households?

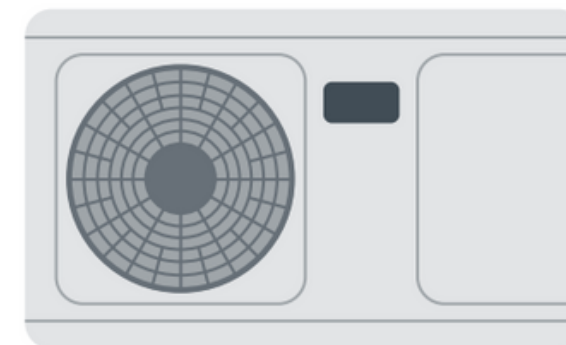
- It will be **twice as expensive** for a **family in 2050** to heat its home with a renewable hydrogen boiler than with a renewable electric heat pump.
- Even with hydrogen produced through gas and CCS (and if gas costs become higher), it would still be cheaper to use a heat pump.
- Even if the cost of a hydrogen boiler could be cheaper, hydrogen production and transportation will make energy bills higher.

December, 2050

Single-family household  
XXXXXX XXX  
XXXXXX EU Member State

## Annual Energy Cost: Heat Pump

Heat Pump Installation (Annuitized).....	€225
Maintenance.....	€12
Cost of Renewable Electricity.....	€342
(Wind and Solar Energy)	
<b>Total .....</b>	<b>€579</b>



December, 2050

Single-family household  
XXXXXXXX XXX  
XXXXXX EU Member State

## Annual Energy Cost: Hydrogen Boiler

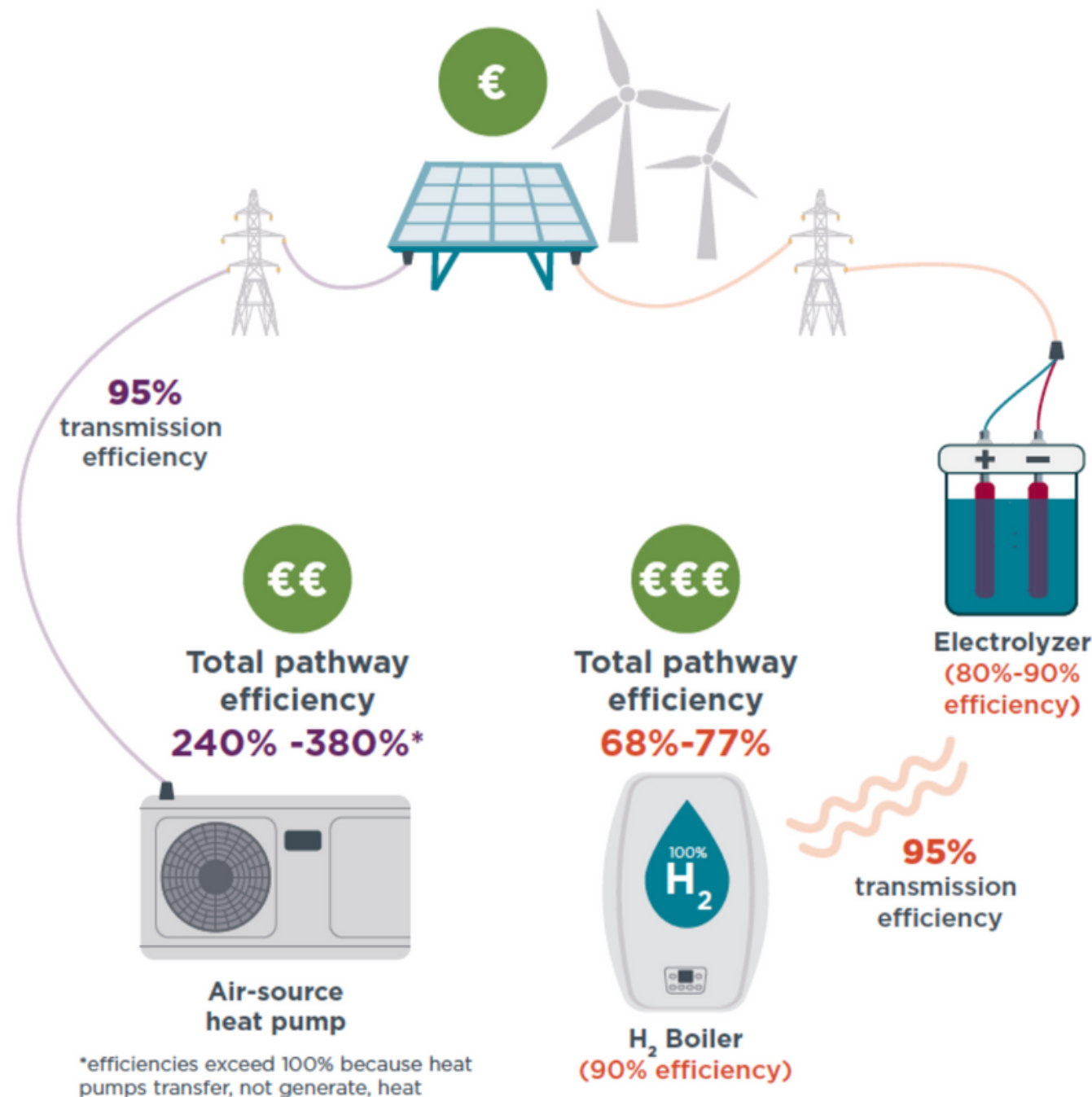
Boiler Installation (Annuitized).....	€49
Maintenance.....	€98
Cost of Renewable Electrolysis .....	€1124
Hydrogen (from Wind and Solar Energy)	
<b>Total .....</b>	<b>€1271</b>





# Is hydrogen for heating a wasteful use of energy?

**Air-source heat pumps will be more energy efficient and cost effective than using hydrogen boilers to heat single-family homes in the EU in 2050**



- Producing “green hydrogen” from renewables is **extremely wasteful** compared with using renewable power directly to run heat pumps.
- Heat pumps are 3-5 times more energy efficient than hydrogen boilers because instead of losing energy in production, they generate energy by making use of heat in the outside air, water or ground.
- It is highly unlikely that we would be able to build so many wind turbines and solar panels to produce **green hydrogen for heating**, which would require **5X more renewables than what it is needed for heat pumps**.



# Is it that easy and good for climate to use hydrogen for heating?

## A delaying tactic from industry?

100% hydrogen boilers aren't ready yet and the production of green hydrogen is almost inexistent.

Boiler manufacturers and gas companies are developing 'hydrogen-ready' boilers that could run on blended hydrogen and then switch to hydrogen only when available.



The use of hydrogen-mix boilers perpetuates the use of gas for heating. (gas lock-in)

Blending hydrogen with gas won't significantly help meeting the required emission reductions.

It delays the deployment of cheaper, ready-to-use, cleaner alternatives. (Over 16 million heat pump units have been installed. )

## Complex and expensive infrastructure conversion

Going beyond 5% blending would require expensive grid and appliance retrofits, resulting in also the increase of fixed network costs.

Hydrogen is a different gas with different properties and the conversion for domestic use isn't an easy task, with costs falling on consumers.

## What to watch out for...

### Renewable Energy Directive

An EU law that sets targets for the share of renewables in Europe. It addresses also how to increase the uptake of renewables in heating and cooling. (Revised proposal in July, finalised end of 2021)

### National recovery plans and subsidies for home renovation

European leaders will use extra recovery cash provided by the EU for energy infrastructure and building renovation. (on going)

### Ecodesign directive and energy label regulation

The Ecodesign regulation can phase-out the least-efficient heating appliances such as gas boilers. If the Energy label downgrades gas boilers to the lowest energy class (F and G), it would incentivise the uptake of cleaner technologies. (in progress)

### Energy Performance Building Directive

The main EU law to renovate and decarbonise buildings. Among other measures, Member States need to have long term strategy on renovation and buildings should have energy certificates. (EU proposal for revision in the Fall)

# Resources (EU\Europe)

- Think tanks working on buildings and energy efficiency at the EU level, including Building Performance Institute Europe, Regulatory Assistance Project, International Council on Clean Transportation
- Organisations with expertise on appliances standards, also oriented at the impact on consumers: ECOS, European Environmental Bureau, The European Consumer Organisation (and their national members)
- Stakeholders and civil society coalitions focusing on buildings, such as the Right to Energy Coalition, Coalition for Energy Savings and the European Alliance to Save Energy, Renewable Heating and Cooling Alliance. Also environmental civil society organisations at national level
- Other data: Eurostat (energy prices, energy poverty levels), Renovate Europe campaign (socio-economic benefits of renovations), International Energy Agency





# Hydrogen in transport: a game changer?

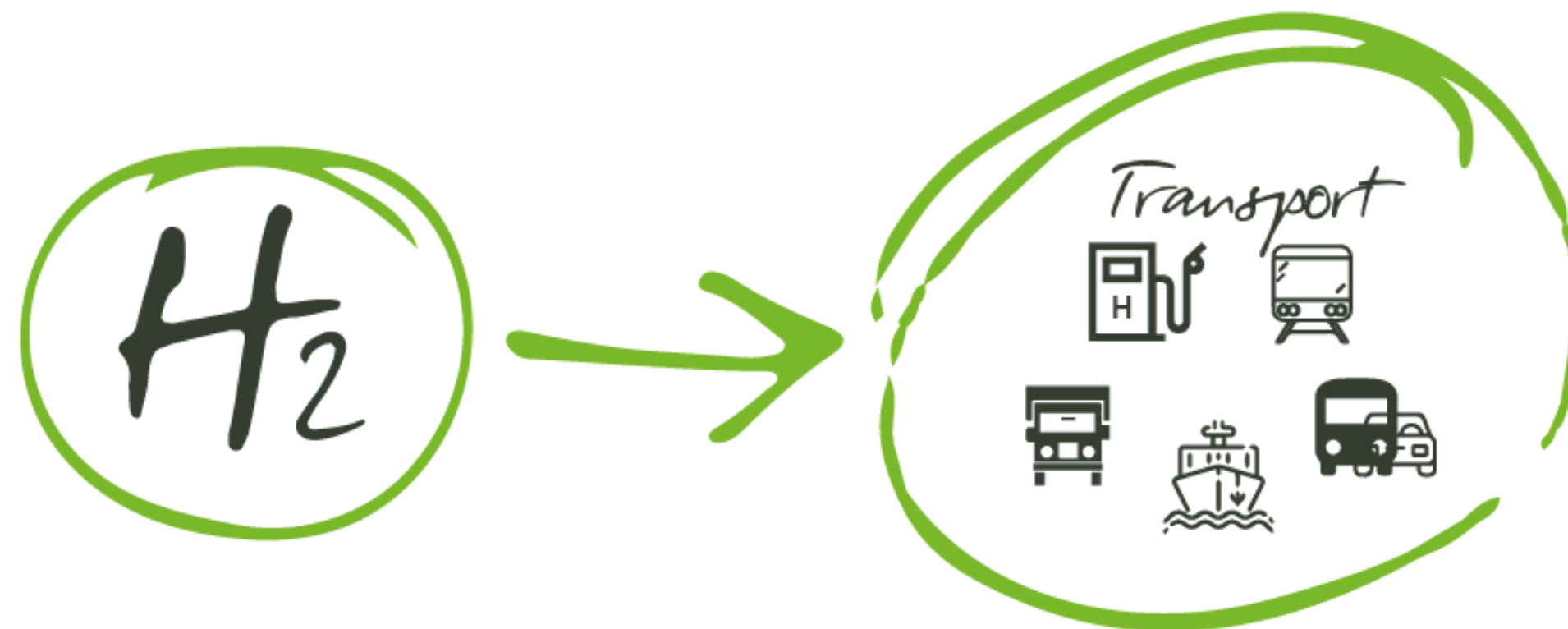
Is it the golden age for hydrogen in transport?





# What is the role of hydrogen in transport?

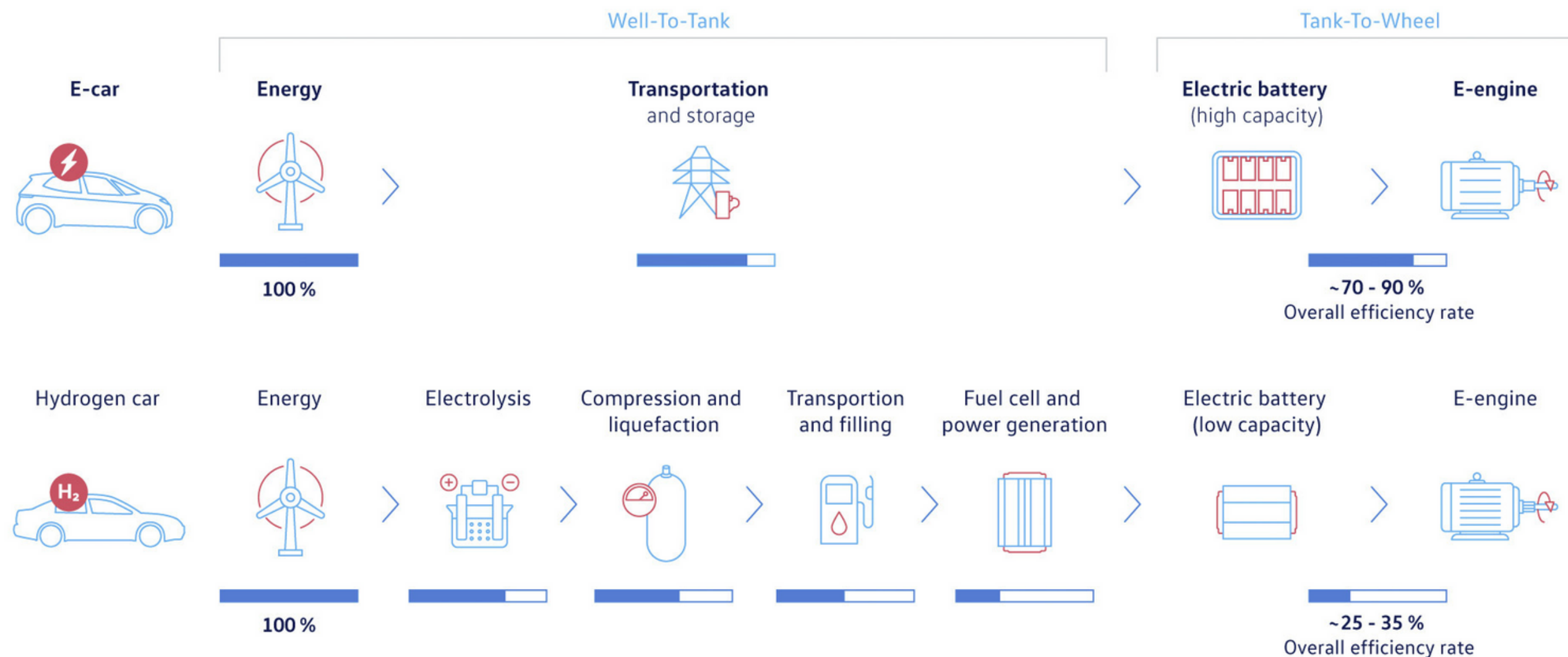
Mobility is currently the smallest component in the entire hydrogen market, representing less than 0.1% of global demand.



# For cars and vans: other solutions exist

## Hydrogen and electric drive

Efficiency rates in comparison using eco-friendly energy



Source Volkswagen

Battery electric cars and vans are a much more efficient use of energy and hydrogen powered ones should not be the priority.



# For trucks: only for long distance

For trucks doing urban and regional deliveries, battery electric lorries are more efficient and cheaper to run.

Long-haul, heavy-payload trucks will be cheaper to run using hydrogen fuel cells than diesel engines by 2031.  
source: Bloomberg NEF

## Hydrogen vs battery electric trucks - Long distance

Trips up to 400 km represent 62% of EU truck activity

Parameters	Fuel cell electric truck	Battery electric truck
		
	2030	
Total cost of ownership over first 5-year user period (based on France)	€ 459 k	€ 393 k
Vehicle purchase costs	€ 139 k	€ 167 k
Annual renewable fuel costs <sup>1</sup>	€ 38 k	€ 22 k
Cost parity with diesel without subsidies	Mid 2040s	Early 2030s
Economies of scale with cars	Low	High
Max range without refuelling / recharging	1200 km	800 km
Refuelling / recharging time (full)	10-20 minutes	8 hours (overnight) 60 minutes (opportunity)
Net payload loss (weight) <sup>2</sup>	None	None

1: Renewable fuel costs are incl. taxes, levies and charges, transport and distribution costs for electricity and fuel; assuming renewable hydrogen cost for the end user of € 5.40/kg (2030) and renewable electricity cost for the end user of €-cent 15.26/kWh (2030).

2: Additional weight from the onboard battery pack (assumed energy density of 318 Wh/kg in 2030) of 4.2 t is compensated for by the additional ZEV weight allowance (2 t) under the EU Weights & Dimensions Directive and net savings from replacing a conventional with an electric drivetrain (2.4 t).



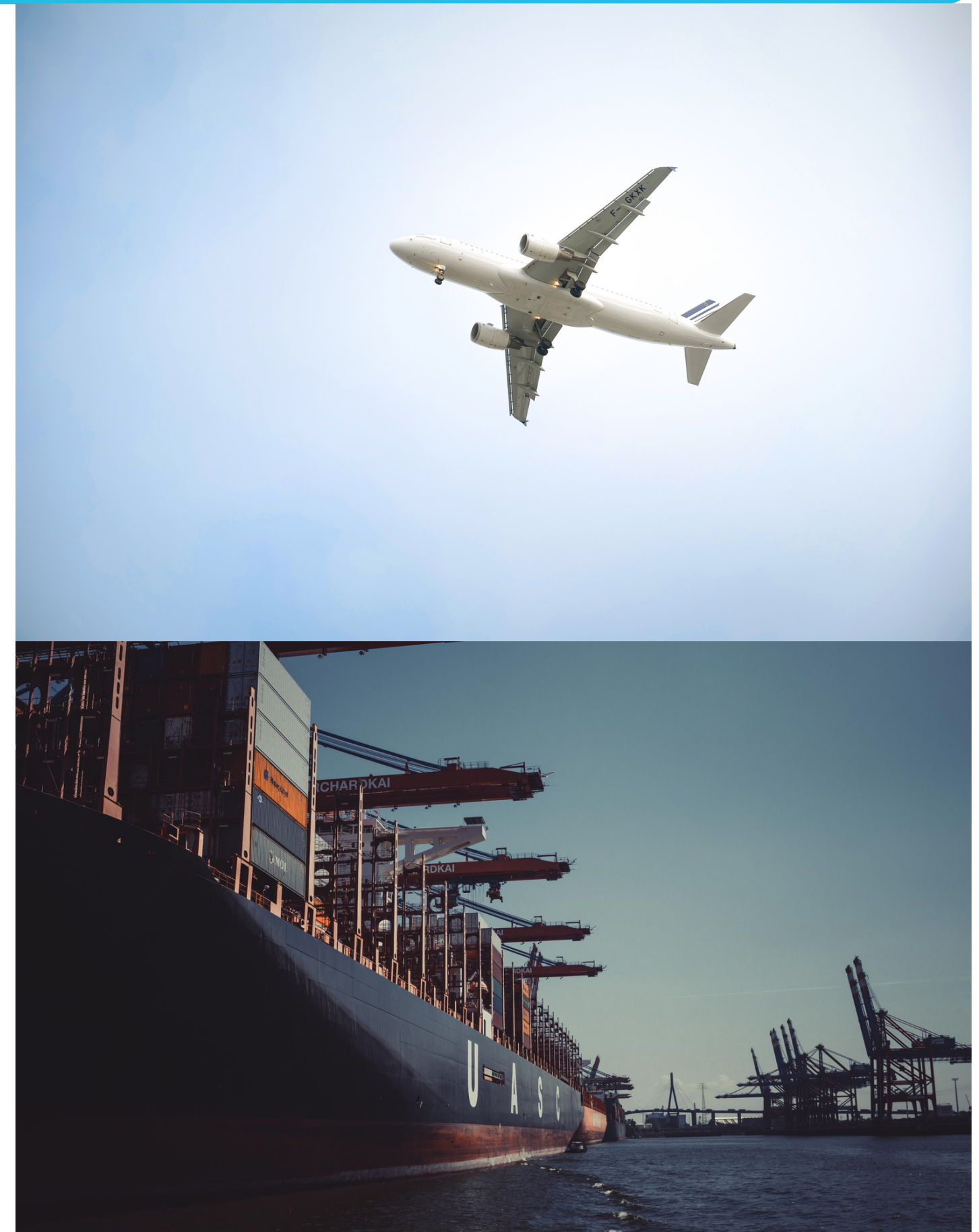


# For aviation and shipping: how close are we?

Hydrogen is the missing link in Europe's strategy to decarbonise planes and ships where electrification is not an option.



Need to boost the production and supply of sustainable alternative fuels for aviation and shipping.





## The Revision of the Alternative Fuels Infrastructure Directive -July

AFID will set national targets to deploy infrastructure across Europe.  
-focus on electricity and green hydrogen infrastructure to be coherent with the EU Green Deal's climate ambitions.

## The Revision of the Trans-European Transport Network (TEN-T) -Q3

Opportunity to identify road freight urban nodes, hotspots of freight activity in Europe with refuelling infrastructure.

## What to watch out for

