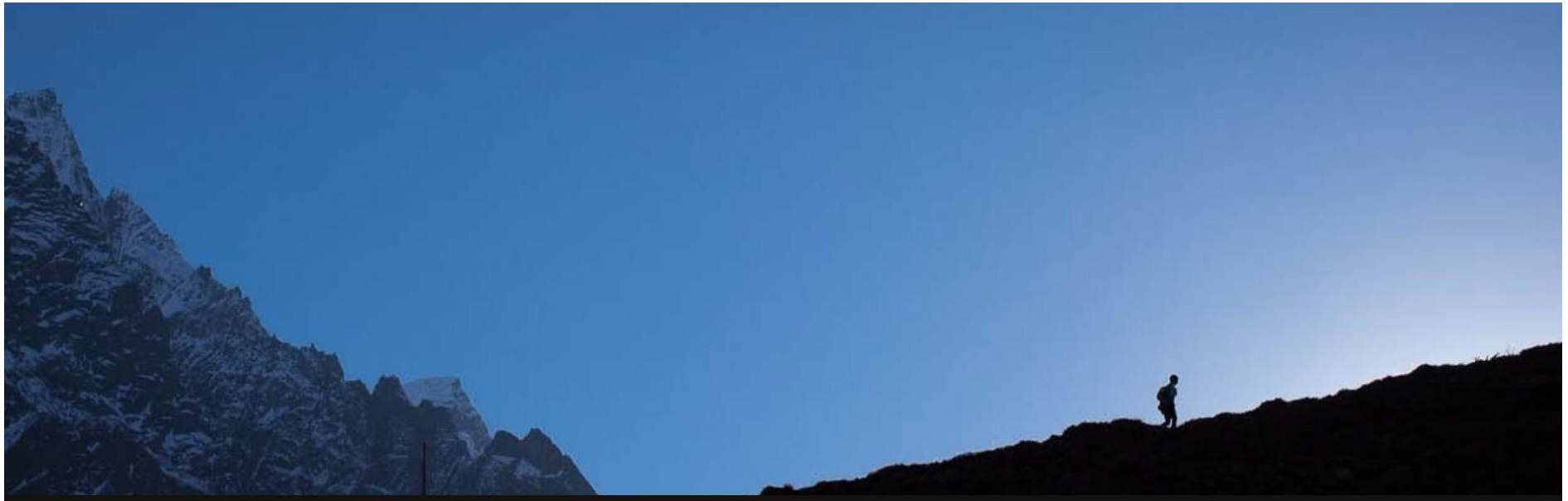
Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável



Class 9 | 6th May 2022 | Global energy and climate

Sofia G. Simoes

SEMINAR ENERGY & CLIMATE CHANGE

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

1	04/03 6ª Feira	16h-18h	Session reserved for students meeting with the Scientific Committee on practical aspects of the PhD Program, and choice of tutors.	Comissão Científica
2	11/03 6ª Feira	16h-18h	ENERGY & CLIMATE CHANGE: A COMPLEX RELATION, PERENE AND INTERDISCIPLINARY. Framework and purpose of the course in the PDACPDS. Practicalities and seminar program. Basic concepts of the energy systems.	J. Seixas, FCT NOVA
3	18/03 6ª Feira	16h-18h	**Current state of the global energy system :** main energy carriers, energy production and consumption regions; energy access; concepts of energy and carbon intensity.	S. Simões
4	25/03 6ª Feira	14h-16h	**Global balance of CO_2 emissions** associated with energy and industrial processes. Estimates of the Global Carbon Budget (http://www.globalcarbonproject.org/) and its relationship to the global energy system and changes in land use. Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways). Global emissions based on consumption vs. production.	S. Simões
5	02/04 Sábado	09h-11h	**Renewables:** Economic, environmental and energy security of endogenous vs. imported resources. Renewable technologies. Sustainability issues related with renewables. Land & water use, critical raw materials. Discussion: Where to place 7GW of solar PV in Portugal till 2030?	S. Simões
6	08/04 6ª Feira	16h-18h	**Energy concepts:** Primary/final energy; Sankey diagrams; energy efficiency; Energy services; Energy carriers; Final energy supply cost curves; learning curves of energy technologies. Definition and usefulness of LCOE. System value of Renewables. Global renewables' market.	S. Simões
7	22/04 6ª Feira	16h-18h	**Drawdown** - Climate Solutions for a New Decade	João P. Gouveia, FCT NOVA
8	30/04 Sábado	09h-11h	**Green hydrogen:** technological options, costs and the role for a carbon neutral energy system	P. Fortes, FCT NOVA
9	06/05 6ª Feira	18h-20h	**CARBON PRICING.** Regulatory framework in the European Union: 2020 - 2030 targets. Fit for 55. European low-carbon Roadmap 2050. Paris Agreement, and its implications.	S. Simões
10	13/05 6ª Feira	16h-18h	**Debate Como perspetivar o futuro da energia e alterações climáticas?** Baseado no artigo *An energy vision: the transformation towards sustainability — interconnected challenges and solution s*	students / S. Simões
11	21/05 Sábado	11h-13h	**Hands-on energy data:** access to energy databases, Portuguese and European (PORDATA, DGEG, EUROSTAT). i) How to find and explore energy statistics and emissions of greenhouse gas (GHG) emissions for Europe and Portugal; ii) How to make energy conversions; iii) How to build indicators and charts with added value; iii) How to analyze economic sectors, and interpret their performance in terms of energy consumption and greenhouse gas emissions.	S. Simões
12	27/05 6ª Feira	16h-18h	**Integrated assessment of energy systems:** The energy system addressed by the systems analysis approach. How to envisage the future energy system? Implications for the decision making in the medium and long term. Concept and formulation of cost-effectiveness within the integrated energy systems. Hands on Climate Mitigation Simulation	S. Simões
13	03/06 6ª Feira	16h-18h	Mentoring with each students' group : discussion on the approach and methods adopted by the students, expected results to be obtained with the final work; assessing preliminary results, if any.	S. Simões
14	17/06 6ª feira	18h-20h	**Smart and Sustainable cities:** concept, components and implications for the energy systems. The concept of Postive Energy Districts, and implications for future planning at the city level.	João P. Gouveia, FCT NOVA
	2 julho, 14h	14h-16h	Avaliações: apresentação dos trabalhos pelos alunos.	S. Simões / J. Seixas

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If you need to discuss topics related to the course, including the assignment, I am available on Fridays 10h-11h – send me an e-mail to book this slot at least 4 days before

Para discussão de assuntos relacionados com o seminário, incluindo o trabalho final, estou disponível às sextas 10h-11h – têm que enviar-me e-mail previamente (pelo menos 4 dias antes)

Às 5as feiras 12h-13h é dada aula complementar em Português (zoom) para quem tem mais dificuldades com o inglês

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PROGRAM & RESOURCES @
https://moodle.fct.unl.pt/course/view.php?id=7450

Climate Change and Sustainable Development Policies

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Assignment

Challenge: Within the scope of your personal interests, select an economic activity:
Fashion | Communication | Food and Beveragel Industry | Health services | Mobility | Other

Assuming your country will be in the midst of a pathway to achieve a carbon neutral economy by 2050 (as stated in the Paris Agreement) or earlier, how do you envisage the selected activity will picture by 2030?

Team work | Think out of the box | Innovate

What is the challenge for the activity? Who are the challenge owners?
What do you envisage the activity must/should deliver in the future?

Climate Change and Sustainable Development Policies

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Assignment | Suggestion of script for development:

- firstly, **formulate (and detail) the problem** as far as you are able;
- characterize the **activity at present** [for example, production / import technologies| type of markets and consumers | competition from other markets? | energy consumption profile | indicators of carbon intensity]
- **envisage the activity up to 2030** [technological options | product change - green| change of consumers | energy consumption profile | indicators of carbon intensity]
- systematize **opportunities for the mitigation** of the selected activities (identify needs of R & D, act on consumption preferences, the product value chain, among others)
- identify and anticipate **constraints and barriers to the desired mitigation**, and explain how to overcome them.

Tips: Start now; try to be objective and quantify what is possible; do not try to be exhaustive (you can not do it within just one course); explore examples that already exist in other countries; be creative.

Climate Change and Sustainable Development Policies

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Assignment | GROUPS?

- Locate yourself in a specific country
- Put yourself in the "shoes" of a **company or public organization (or a group/ association)** – do not leave the topic too wide
- **Groups**: 6 or 7 so far
- **Topics…**
  - Fashion
  - Decentralization of energy/prosumer markets
  - MSW management Portugal
  - MSW management in Brazil
  - Agriculture's carbon neutrality in Portugal
  - Energy supply in megacities (you need to either choose to be an energy company or a municipality)
  - Banking?
  - Water management?

Climate Change and Sustainable Development Policies

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Outline

- H_2 economy wrap-up

CARBON PRICING

- Paris Agreement, and its implications
- Regulatory framework in the European Union: 2020 - 2030 targets.
- European low-carbon Roadmap 2050
- Fit for 55 (FF55) and REPOWEREU
- Prepare the next class: DISCUSSION

Outline

- **H_2 economy wrap-up**

CARBON PRICING

- Paris Agreement, and its implications
- Regulatory framework in the European Union: 2020 - 2030 targets.
- Prepare the next class: DISCUSSION

Climate Change and Sustainable Development Policies

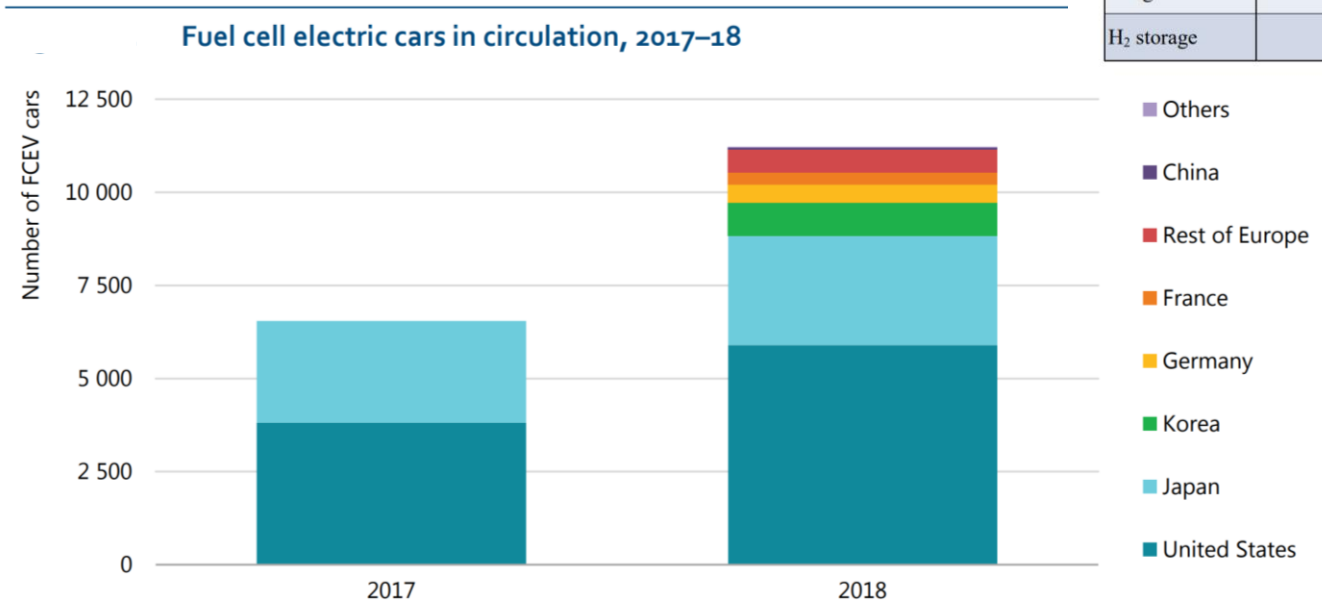
FCEV | Private Cars

FCEV is a type of electric vehicle, but instead of storing electricity, a FCEV stores H_2 and a fuel cell acts as micro power plant to generate electricity on board

Table 1. Fuel cell vehicles available on the automotive market

	Toyota Mirai	Hyundai ix35 Fuel Cell	Honda Clarity Fuel Cell
			
Acceleration 0-60 mph	9.6 s	12.5 s	11 s
Fuel Cell power	113 kW	100 kW	103 kW
Engine power	113 kW	100 kW	130 kW
Top speed	179 km/h	161 km/h	200 km/h
Range	ca. 550 km (NEDC test)	594 km	482 km
H_2 storage	70 MPa	70 MPa	70 MPa

Source: Pielecha et al., 2018



Source: AFC TCP (2019), *AFC TCP Survey on the Number of Fuel Cell Electric Vehicles, Hydrogen Refuelling Stations and Targets.*

2018:
FC total stock: 11 200 units
BEV total stock: 5.1 million

Source: IEA, 2019a

FCEV vs other technologies

Hydrogen fuel cell vehicle

Starts at: €60,000

Range: 320-405km/200-250 miles

Time to refuel: 3-4 minutes

Electric vehicle

Starts at: €21,000

Range: 160-500km/100-310 miles

Time to refuel: 30 minutes to 12 hours

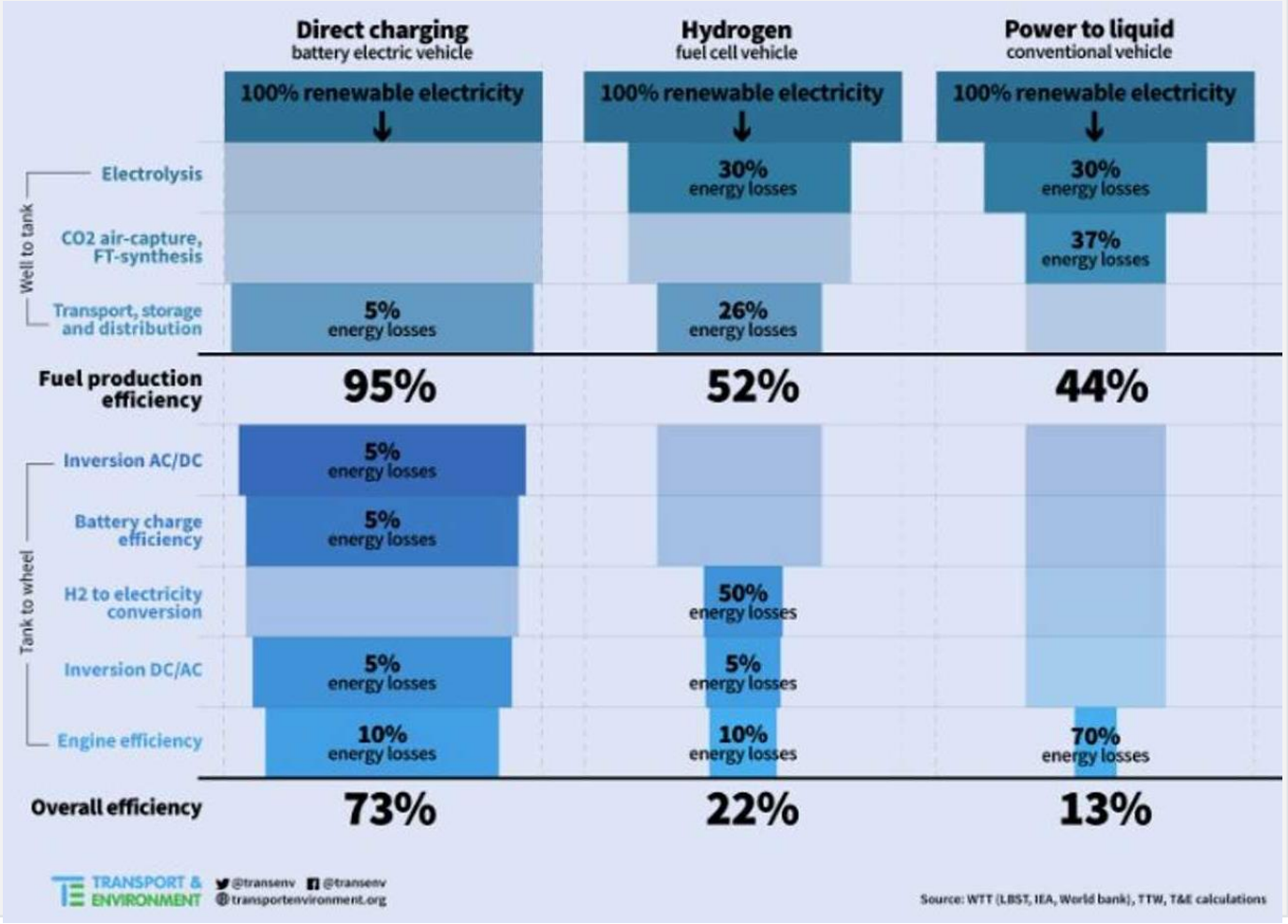
Petrol or diesel vehicle

Starts at: €8,000

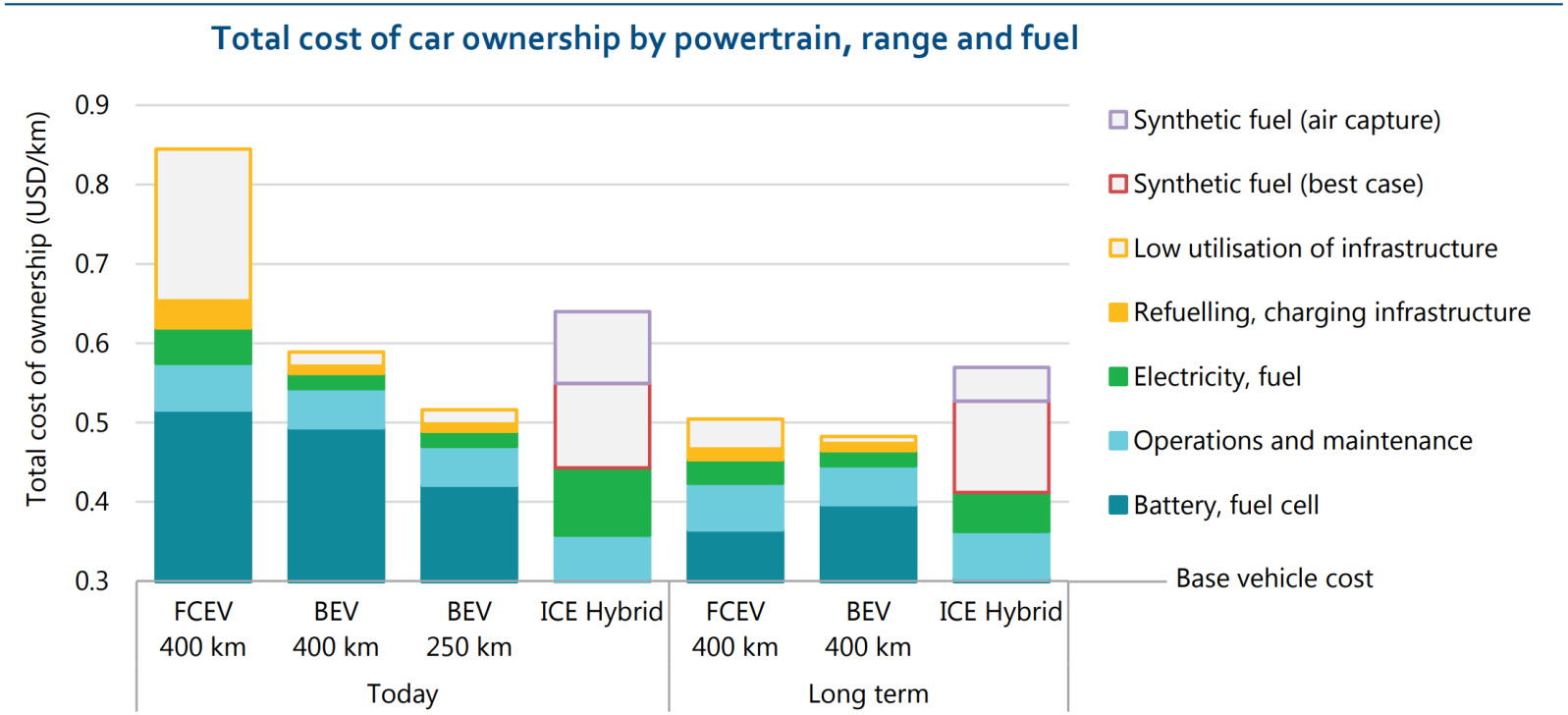
Range: 480-640km/300-400 miles

Time to refuel: 2-3 minutes

Source: https://www.euronews.com/living/2020/02/13/hydrogen-fuel-cell-vs-electric-cars-what-you-need-to-know-but-couldn-t-ask



FCEV vs other technologies



Notes: ICE = internal combustion engine. The y-axis intercept of the figure corresponds to base vehicle "glider" plus minor component costs, which are mostly invariant across powertrains. More information on the assumptions is available at www.iea.org/hydrogen2019.

Source: IEA, 2019a

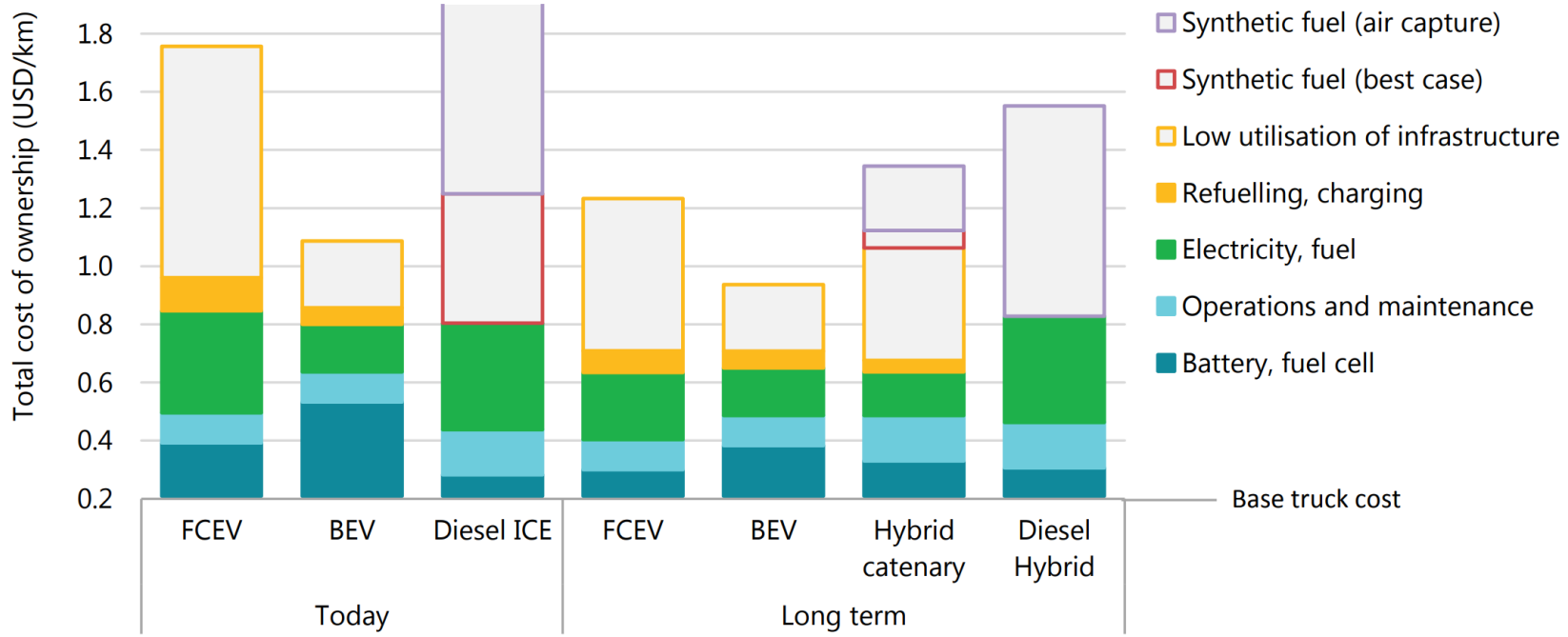
> FCEV costs could break even.

> Cost reductions in fuel cells and storage tanks, together with high utilization of stations, are the keys to achieving competitiveness.

> Refueling infrastructure is determinant of the future competitiveness of FCEVs

Heavy-duty (trucks and intercity buses) FCEVs

Current and future total cost of ownership of fuel/powertrain alternatives in long-haul trucks

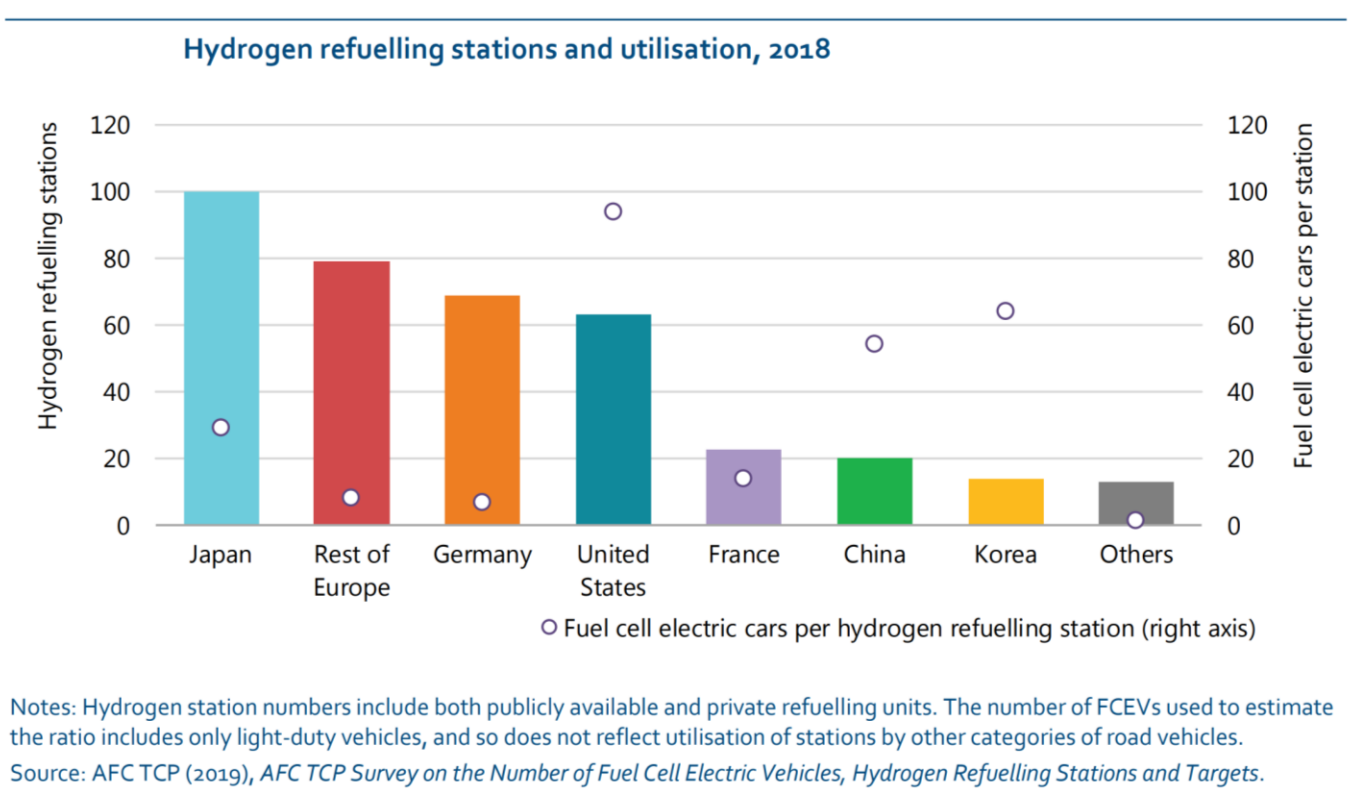


Notes: The y-axis intercept of the figure corresponds to base vehicle "glider" plus minor component costs. Infrastructure covers stations, charging points and catenary lines. More information on the assumptions is available at www.iea.org/hydrogen2019.

- Heavy-duty FCEVs tend to be more immediately competitive against BEVs
- H_2 < USD 7/kgH2 in the long term makes FCEVs competitive in relation with IC
- The limited size of the truck market may limit the fuel cell price reduction (economies of scale). Price will rely on substantial deployment of fuel cells in cars.

Source: IEA, 2019a

H_2 refueling stations



Notes: Hydrogen station numbers include both publicly available and private refuelling units. The number of FCEVs used to estimate the ratio includes only light-duty vehicles, and so does not reflect utilisation of stations by other categories of road vehicles.

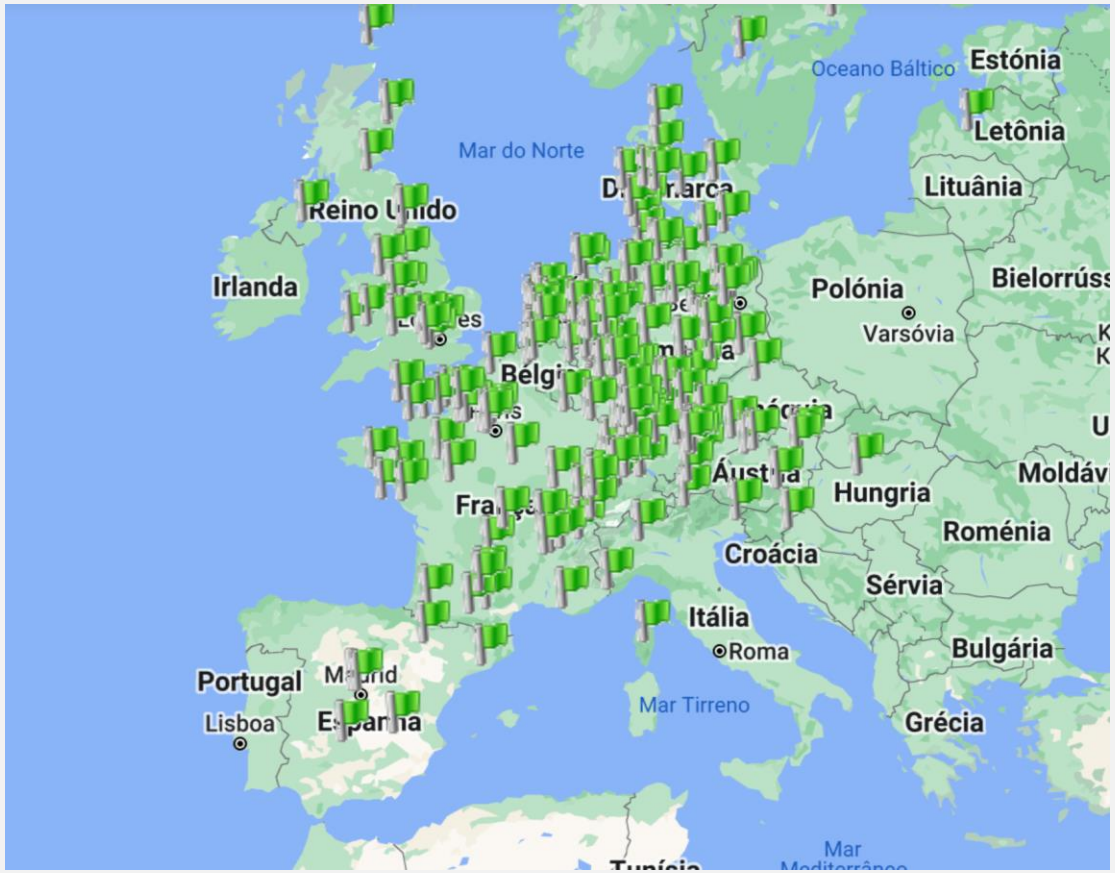
Source: AFC TCP (2019), *AFC TCP Survey on the Number of Fuel Cell Electric Vehicles, Hydrogen Refuelling Stations and Targets.*

Source: http://www.flanderstoday.eu/business/first-public-hydrogen-fuel-station-opens-flanders

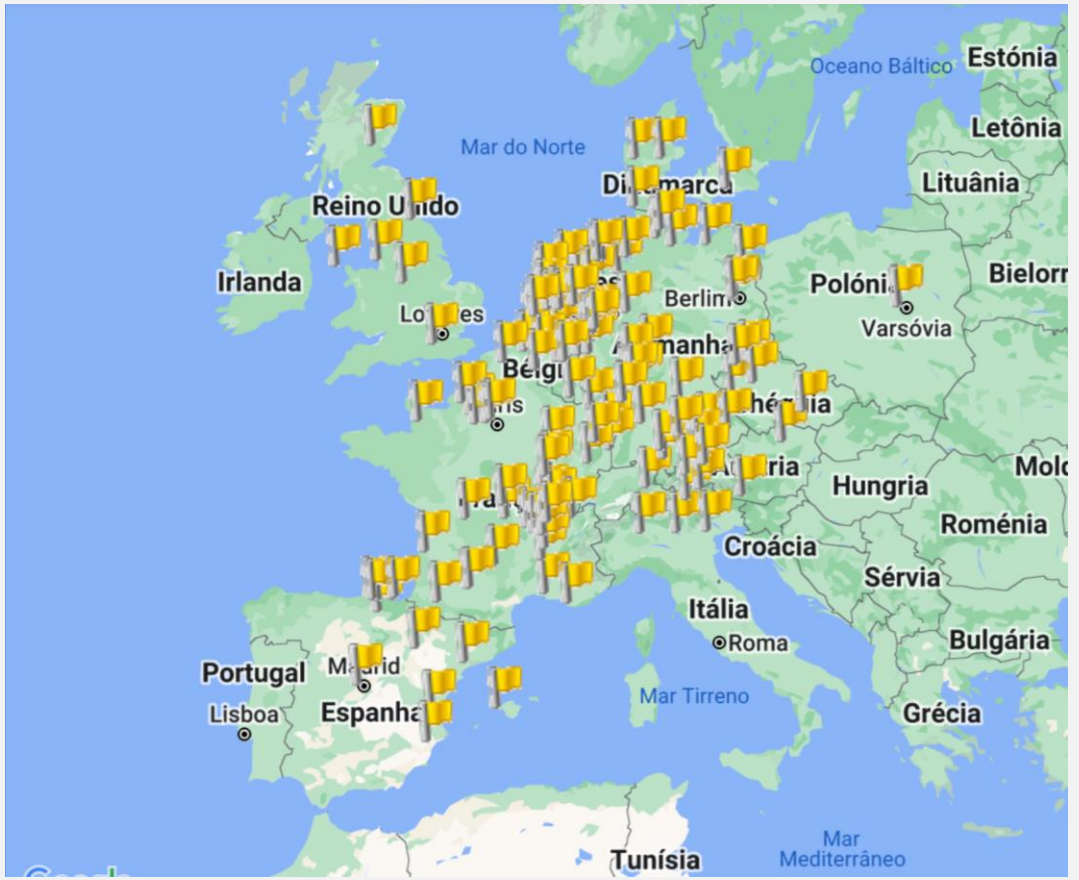
Source: IEA, 2019a

H_2 refueling stations in Europe

> **Existing**



> **Planned**



Source: https://www.h2stations.org/

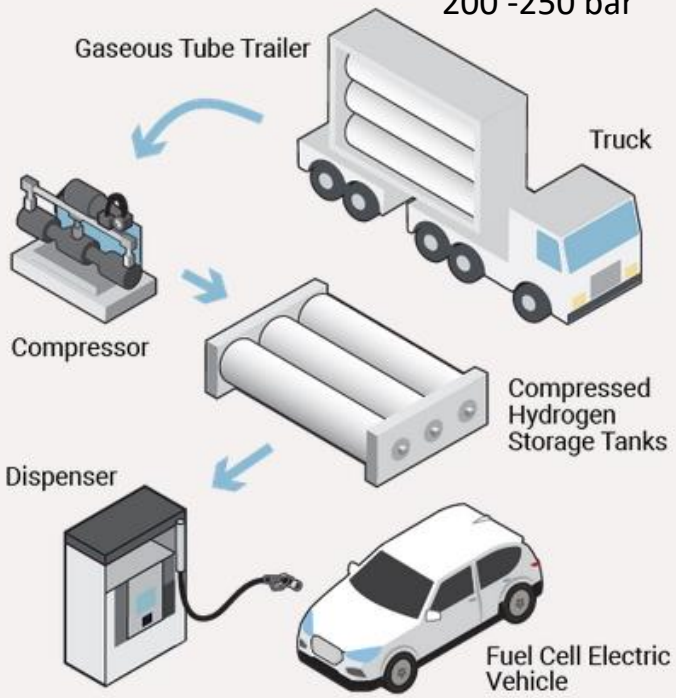
First Mobile Station in Portugal - Cascais

Refueling Stations

Gaseous Delivery

Container Trailer : 500 bar

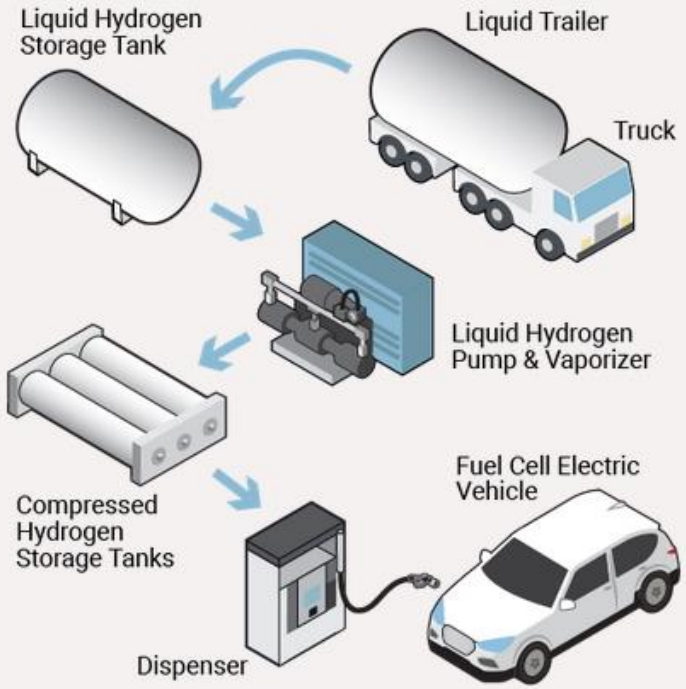
200 -250 bar



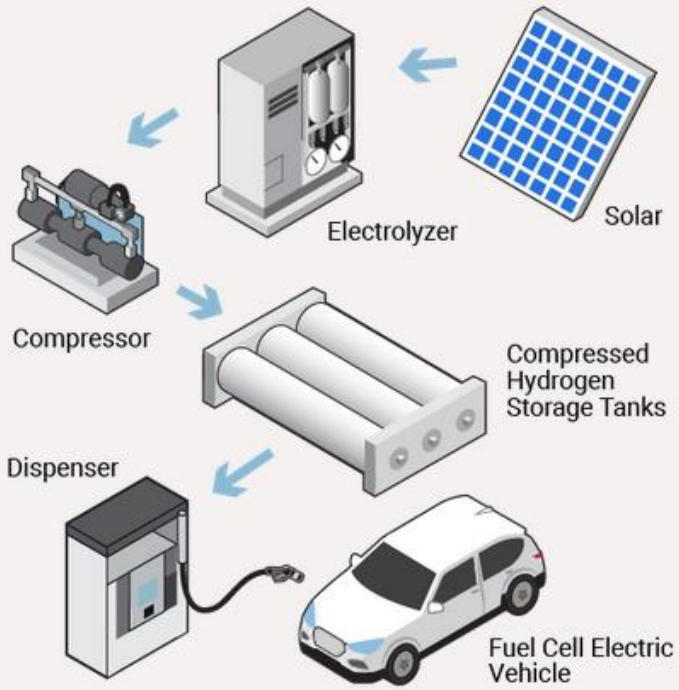
350 bar | 700 bar

Liquid Delivery

4 bar



Onsite Production



Source: https://h2stationmaps.com/

Refueling Stations

Hydrogen refueling is 15 times faster than fast charging

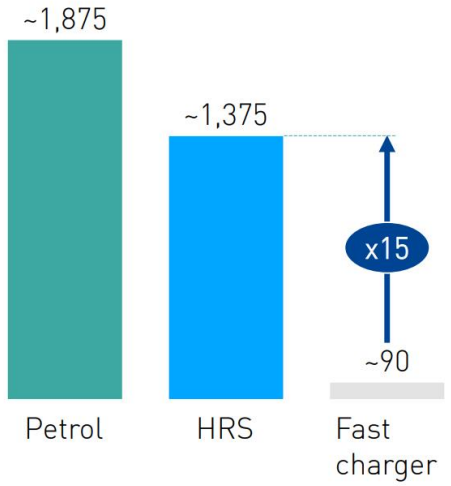
After 10 minutes refueling/recharging time

90% FCEV truck vs. 10% BEV truck of ~1000 km range

Recharging infrastructure ...

requires **10-15x** less space and creates **flexible** instead of peak load

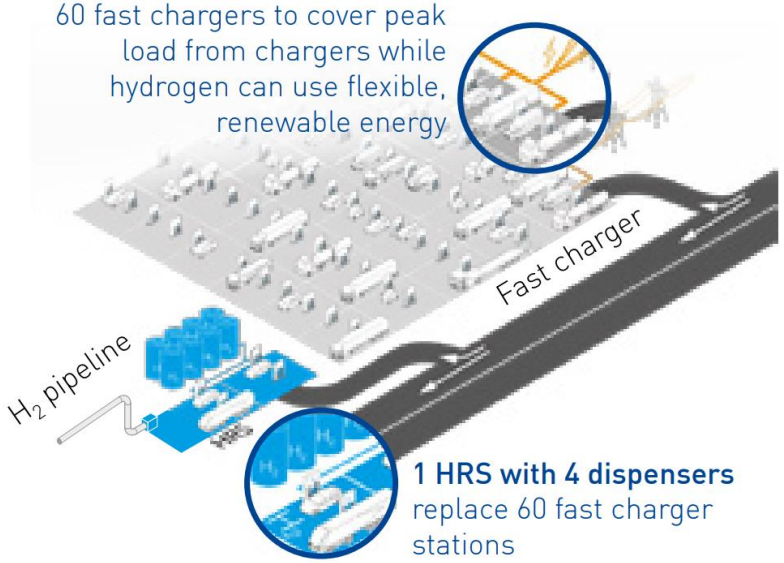
Refueling speed
Km/15 minutes of refueling



Hydrogen refueling is **15x faster** than fast charging

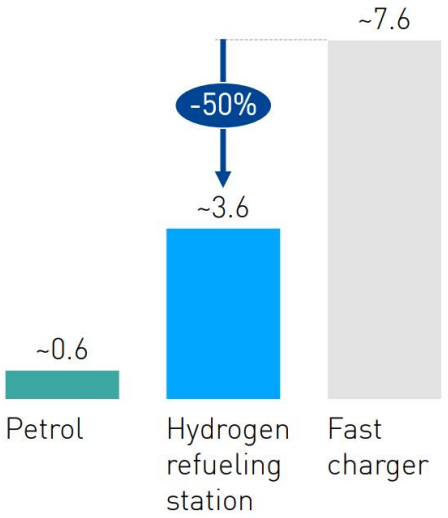
Space requirements

~8 MW powerline required for 60 fast chargers to cover peak load from chargers while hydrogen can use flexible, renewable energy



1 HRS with 4 dispensers replace 60 fast charger stations

Investment costs per refueling
EUR/refueling



Hydrogen refueling is **half as capital-intensive** as fast charging

Assumptions: Average mileage of passenger car = 24,000 km; number of PCs in EU in 2050: ~180 million; ICE: range = 750 km/refueling, refueling time = 3 minutes; FCEV: range: 600 km/refueling, refueling time = 5 minutes, fast charger = 1,080 km²; BEV: range = 470 km/refueling, refueling time = 75 min, gas station = 1,080 m²; WACC 8%; fast charger: hardware = USD 100,000, grid connection = USD 50,000, installation costs = USD 50,000, lifetime = 10 years; HRS: capex (1,000 kg daily) = EUR 2,590,000, lifetime = 20 years, refueling demand/car = 5 kg; gas: capex = EUR 225,750, lifetime = 30 years, 1 pole per station

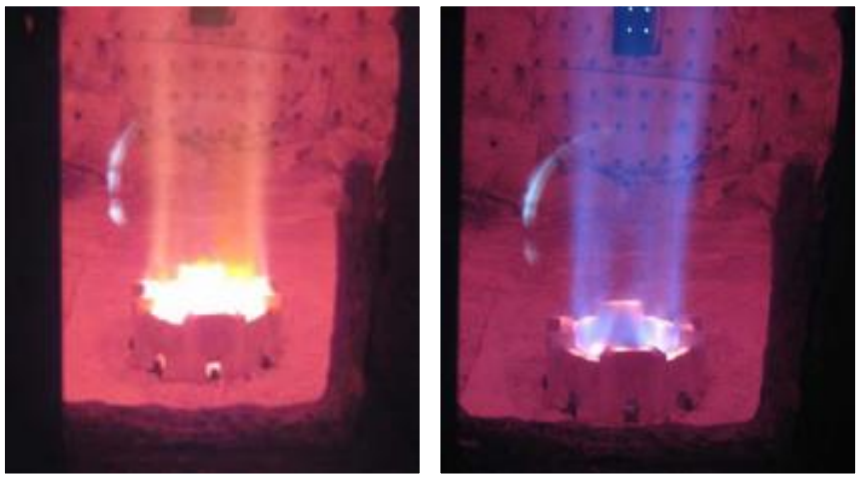
Source: FCH, 2019

H_2 use for heating (Industry and Buildings)

- H_2 can be used in 3 forms:
  - Fuel-cell (H_2 to produce electricity) – lower efficiency than direct use of electricity, higher control of power supply load curves
  - Blended in natural gas (the % of blending depend on the equipment – due to *embrittlement factor*)
  - 100% H_2

- Lower flame brightness affect some industrial sectors – e.g., glass, ceramic
- Higher production of NOX (additional control measures) and H2O steam
- H2 higher volatility and requires additional security measures to detect leakages

with H_2 | without H_2



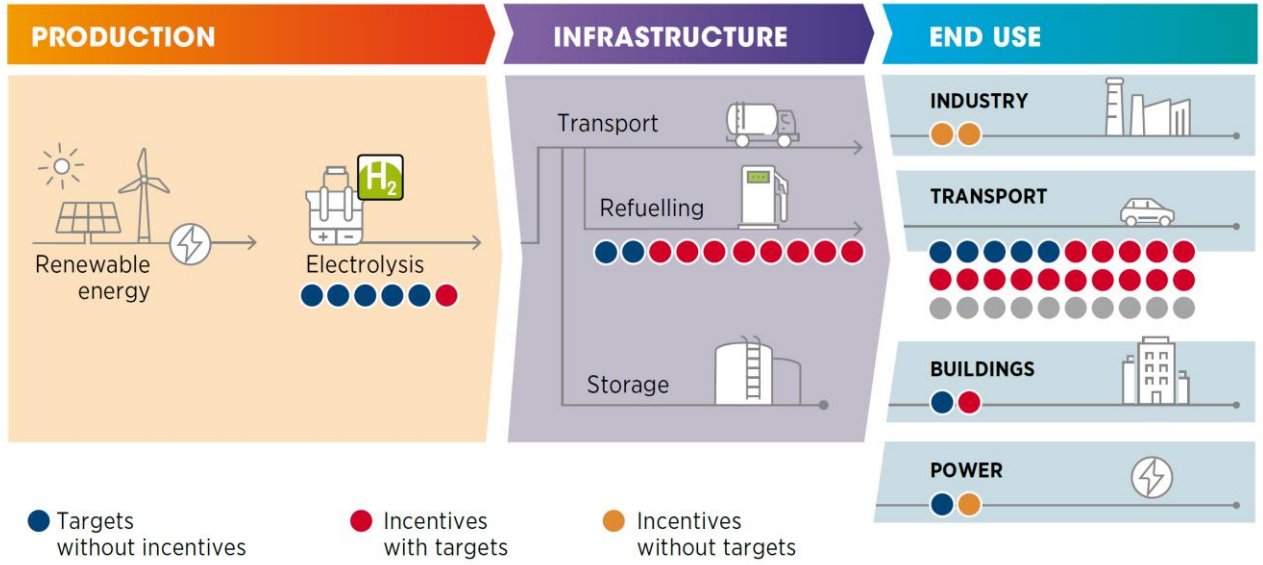
Sources:
"Heat Transfer in Industrial Combustion" , Charles E. Baukal
"Computational modelling of turbulent flow, combustion and heat transfer in glass furnaces", Hoogendoorn et al (1994)
Stig Stenström (2019): Drying of paper: A review 2000–2018, Drying Technology

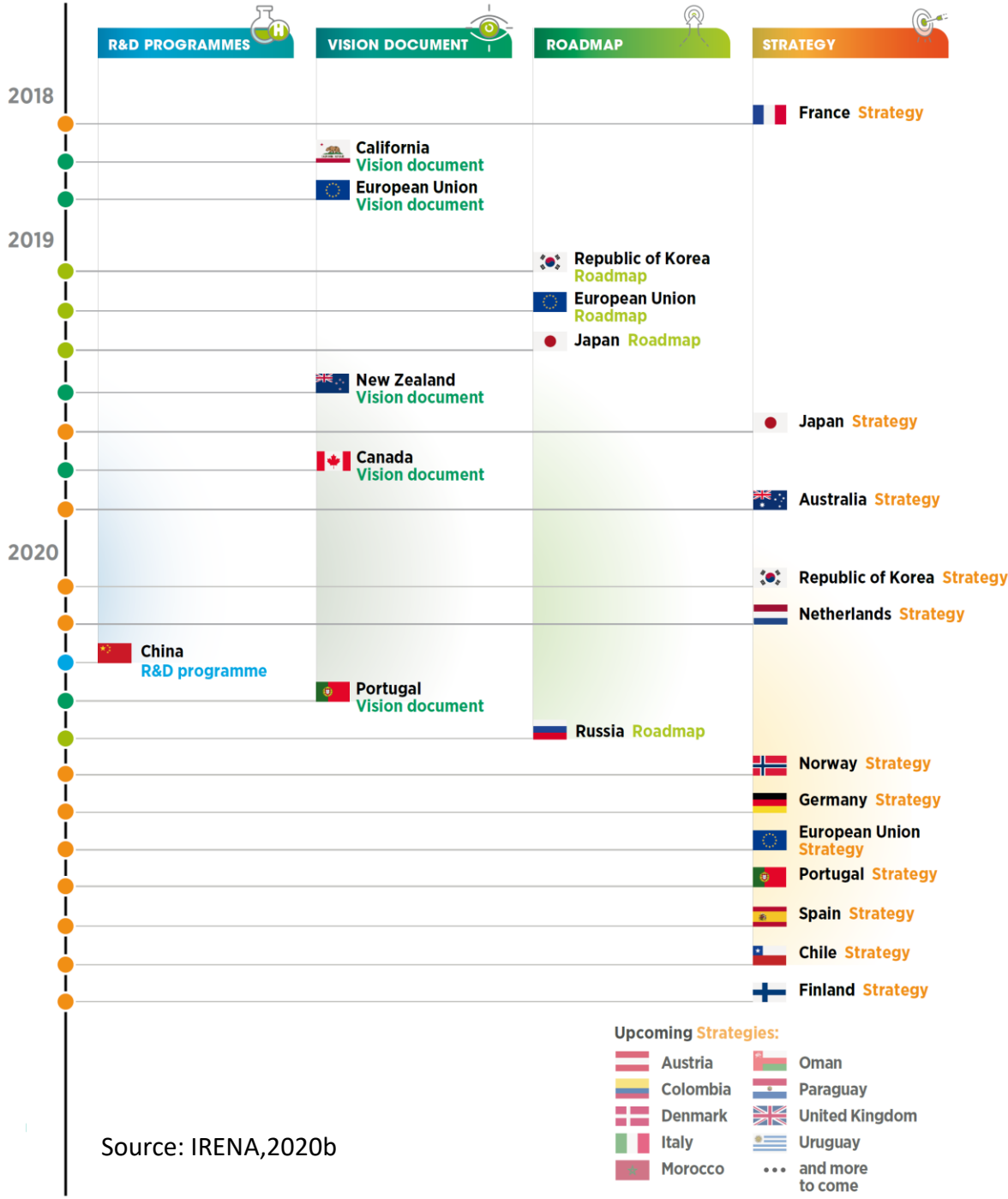
The growing interest on H_2

> The number of countries with polices that directly support investment in hydrogen technologies is increasing

> These are mainly focus on Transports/Refueling and Electrolysis

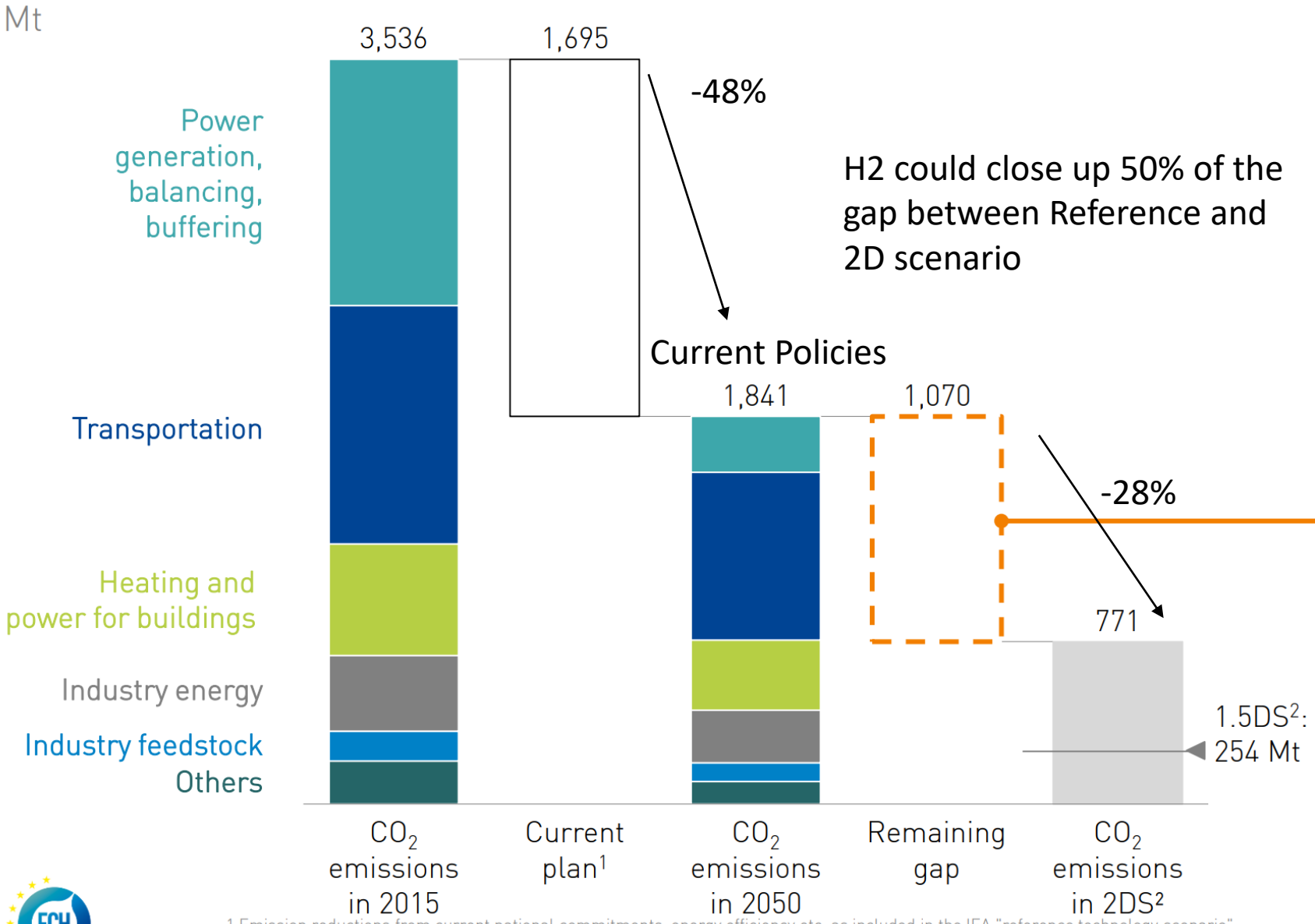
FIGURE 1.4 Number of hydrogen policies at a global level by segment of the value chain





Source: IRENA,2020b

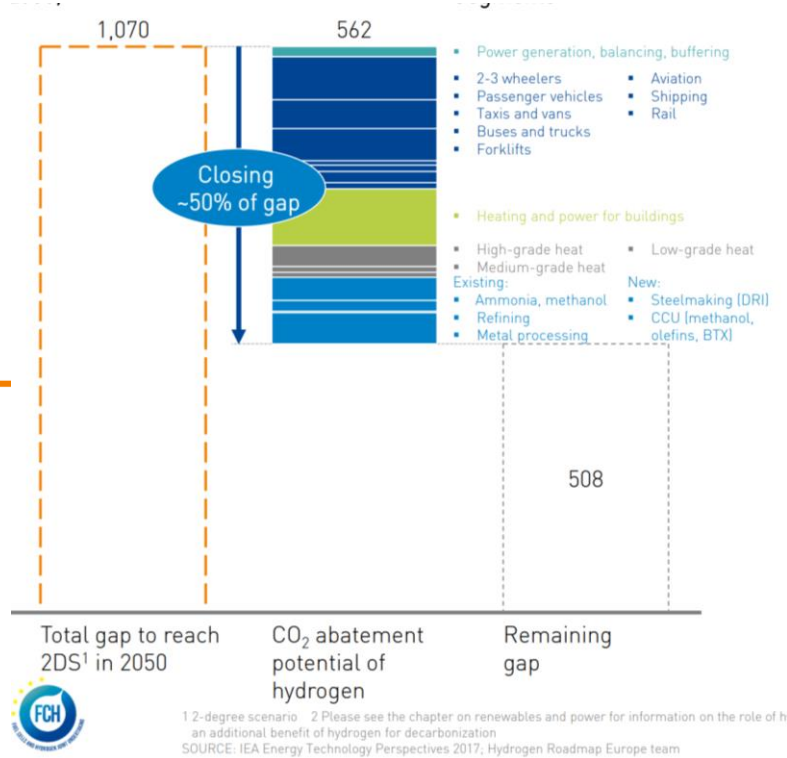
What is H_2 in carbon neutrality?



H2 could close up 50% of the gap between Reference and 2D scenario

1 Emission reductions from current national commitments, energy efficiency etc. as included in the IEA "reference technology scenario"
2 DS = degree scenario
SOURCE: IEA Energy Technology Perspectives 2017; Hydrogen Roadmap Europe team

Hydrogen Roadmap Europe

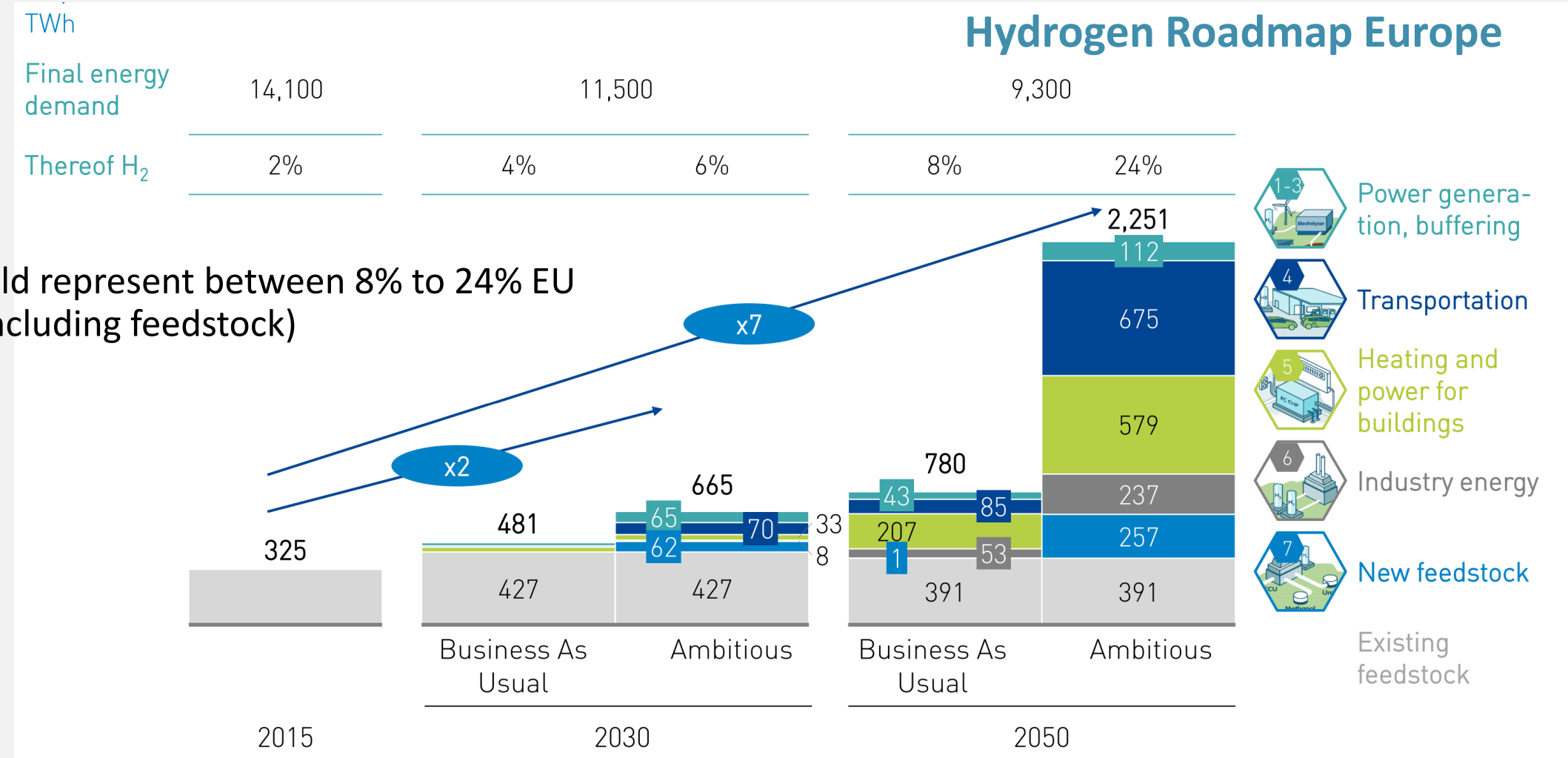


1 2-degree scenario 2 Please see the chapter on renewables and power for information on the role of hy
an additional benefit of hydrogen for decarbonization
SOURCE: IEA Energy Technology Perspectives 2017; Hydrogen Roadmap Europe team

Source: FCH, 2019

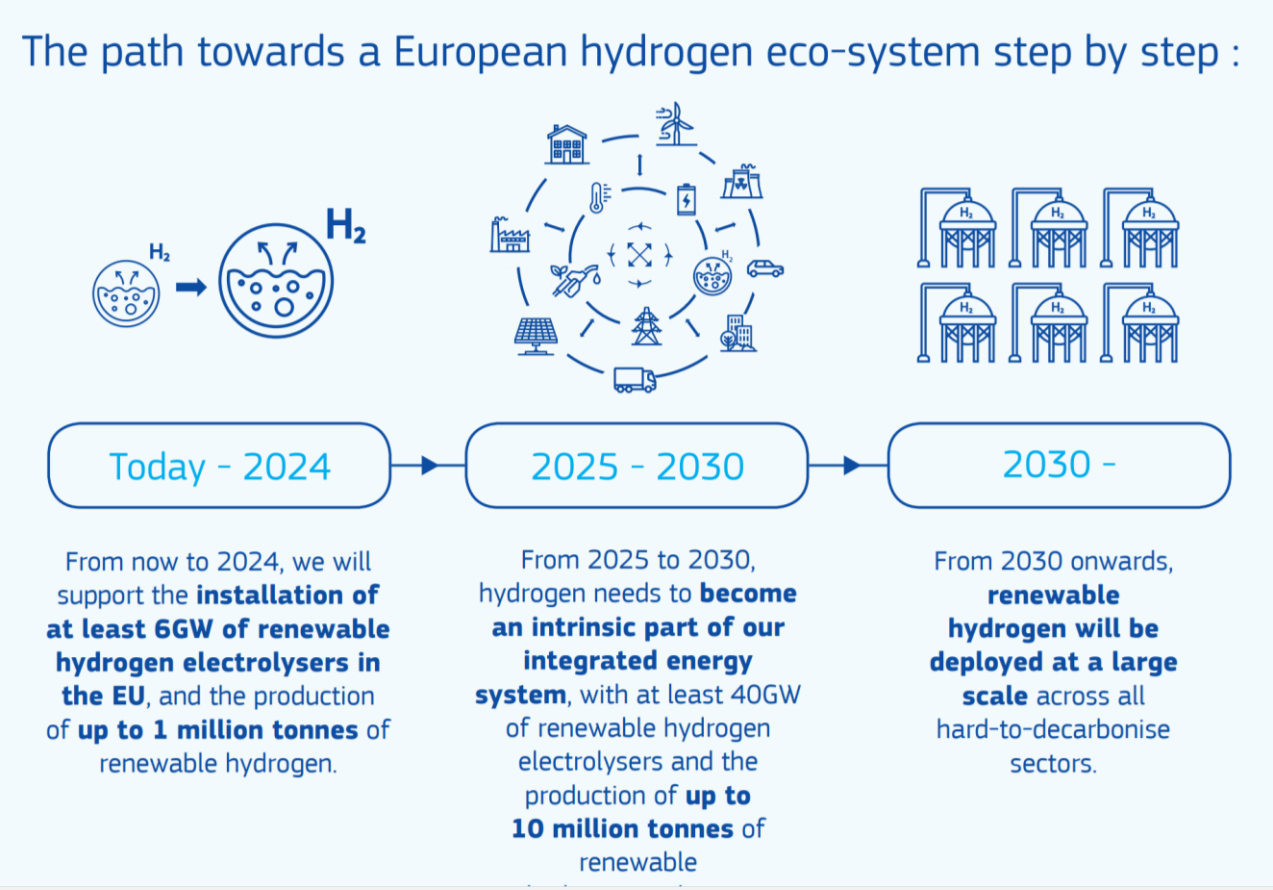
What is the role of H_2 in carbon neutrality?

Hydrogen could represent between 8% to 24% EU energy mix (including feedstock)



Source: FCH, 2019

European H_2 Strategy

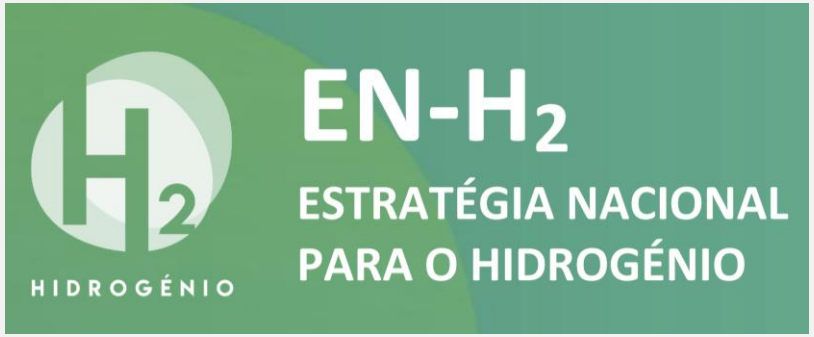


steel-making, trucks, rail and some maritime transport

> ‘share of hydrogen in Europe’s energy mix is projected to grow from the current less than 2% to 13-14% by 2050’

> ‘Assuming current electricity and gas prices, **low-carbon fossil-based hydrogen** is projected to cost in 2030 between **€2-2.5/kg in the EU**, and **renewable hydrogen** are projected to cost between **€1.1-2.4/kg’**

H_2 Strategy for Portugal

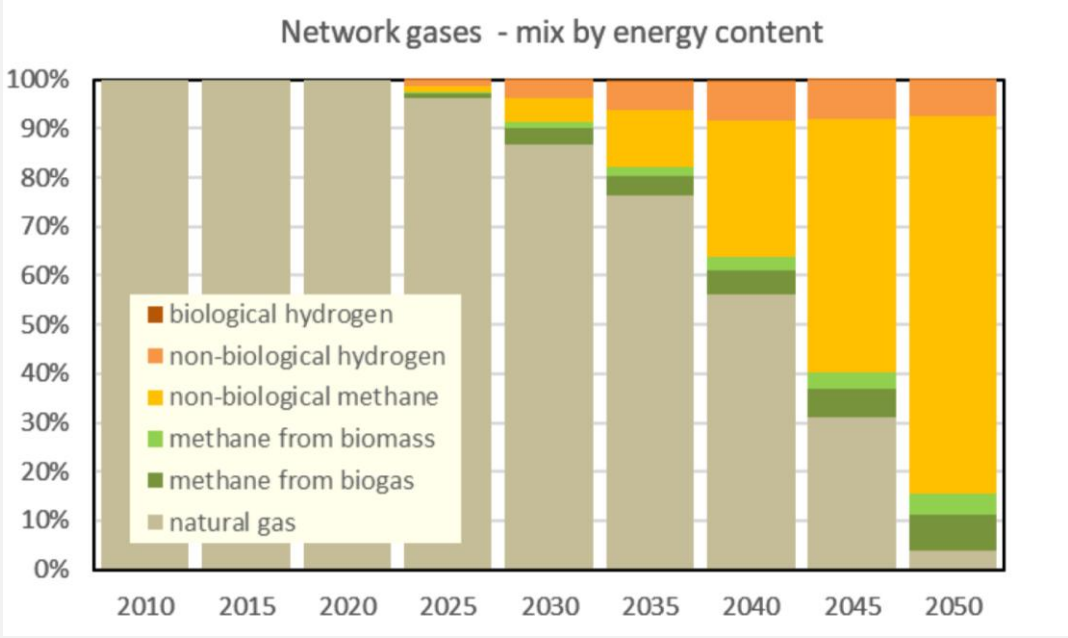


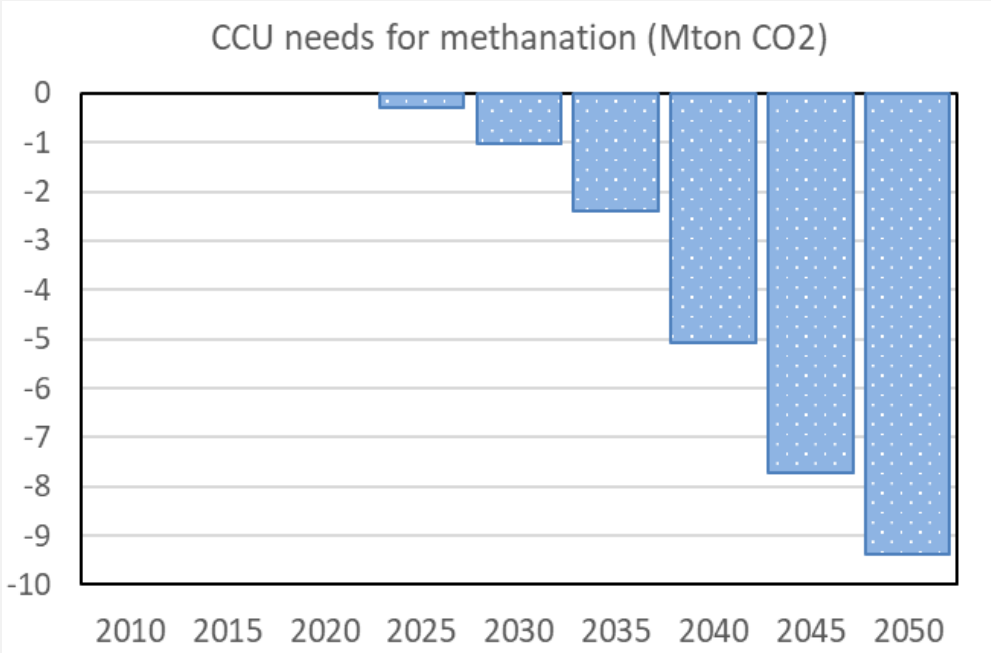
Mostly PV
& Onshore Wind

	2025	2030	2040	2050
H_2 NA REDE DE TRANSPORTE DE GÁS NATURAL[20]	1% - 5%	10% - 15%	40% - 50%	75% - 80%
H_2 NA REDE DE DISTRIBUIÇÃO DE GÁS NATURAL[21]	1% - 5%	10% - 15%	40% - 50%	75% - 80%
H_2 NO CONSUMO DA INDÚSTRIA[22]	0,5% - 1%	2% - 5%	10% - 15%	20% - 25%
H_2 NO CONSUMO DO TRANSPORTE RODOVIÁRIO	0,1% - 0,5%	1% - 5%	5% - 10%	20% - 25%
H_2 NO TRANSPORTE MARITIMO DOMÉSTICO	0%	3% - 5%	10% - 15%	20% - 25%
H_2 NO CONSUMO TOTAL FINAL DE ENERGIA	1% - 2%	2% - 5%	7% - 10%	15% - 20%
H_2 NAS CENTRAIS TERMOELÉTRICAS A GÁS NATURAL	1% - 5%	5% - 15%	40% - 50%	75% - 80%
CAPACIDADE PARA PRODUÇÃO DE H_2	250 - 500 MW	1,75 - 2 GW	3 GW	5 GW
CAPACIDADE PARA PRODUÇÃO DE H_2 UPP[23] (<5 MW)	50 MW	100 MW	250 MW	500 MW

H_2 Strategy for Portugal

According to the National Hydrogen Strategy, CO_2 will be needed to generate synthetic methane, which will be injected in the gas grid



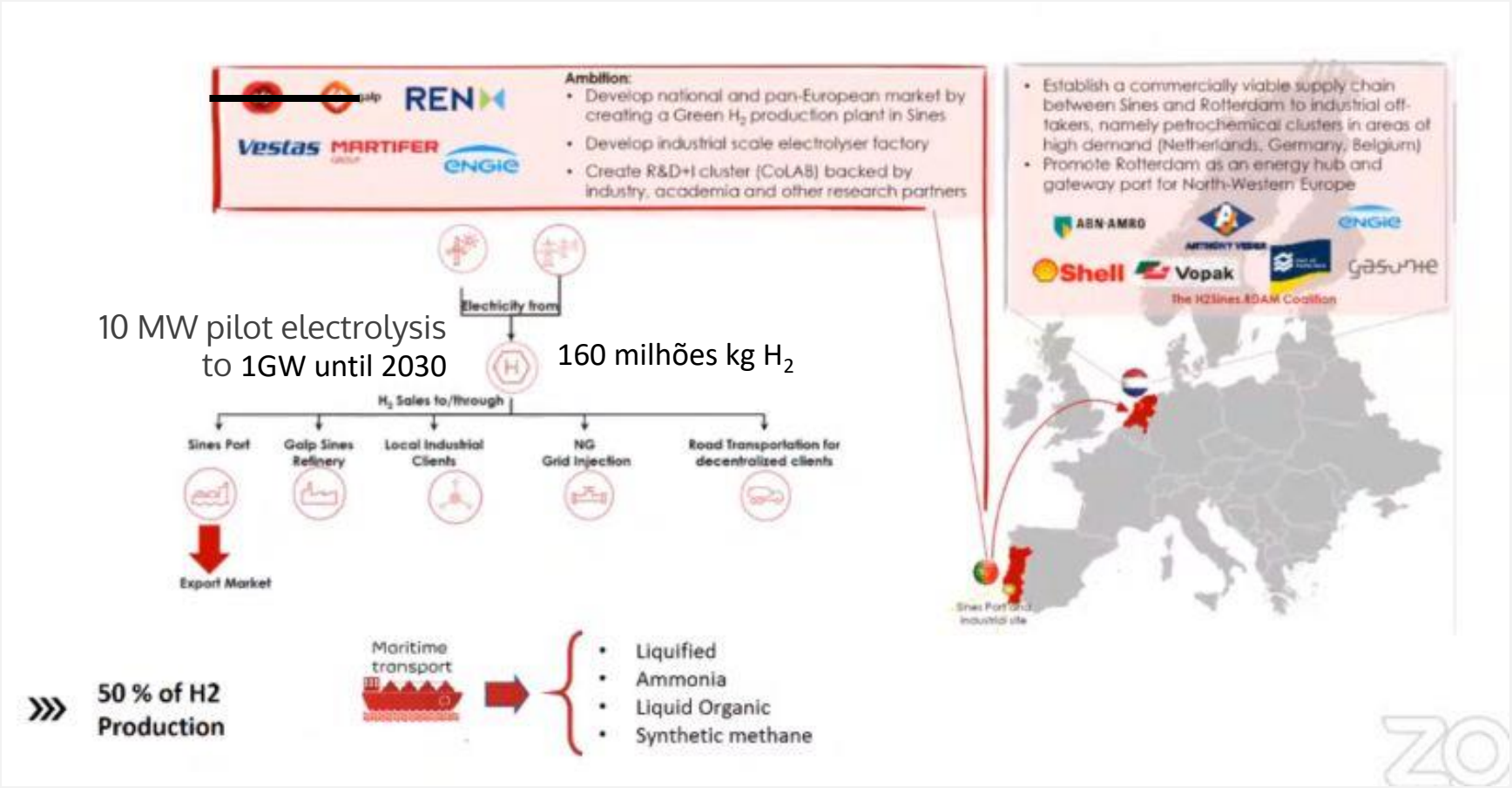


Source: DGEG, 2021

H_2 Strategy for Portugal

Sines Project

GreenH2Atlantic



What is going on with Hydrogen in Portugal

2019

RNC2050 Carbon Neutrality Roadmap

Alternative pathways for all sectors of economy that allow the achievement of net carbon emissions by 2050

2020

PNEC 2030 PLANO NACIONAL ENERGIA E CLIMA

National Energy and Climate Plan (NECP)
[Energy and GHG emission targets for 2030/2040]

74 EoI for **IPCEI call** on Green H_2 → 37projects to 2nd phase

H_2 HIDROGÉNIO

National Strategy for H_2
(August 2020)

2021

PRR Plano de Recuperação e Resiliência

Recovery and Resilience Plan (RRP or PRR)
1st call for projects **on renewable H_2 & other renewable gases 62M€** (30 Set 2021) - total **185M€** for renewable gases in PRR

41 proposals ~380M€
(19th Feb 2022)

2022

PRR Mobilizing and Green Agendas for Business Innovation: H_2 & Lithium pannel with >6 green H_2 proposals
2nd stage proposals to be submitted till 31st March 2022

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H_2 production investment in Portugal (non-exhaustive)

A multitude of different projects with different business models and offtakers is appearing in Portugal

29 H_2 production projects in Portugal registered with European Clean Hydrogen Alliance Project pipeline (Nov 2021) **2981 MW (1500 MW in Sines)**

https://ec.europa.eu/growth/industry/strategy/industrial-alliances/european-clean-hydrogen-alliance/project-pipeline_en

BEHYOND project (EDP, TechnipFMC, CEiiA, …) assessing green H_2 production using offshore energy

GreenVolt aims to produce H_2 at decomissioned Pego coal power plant

Green Pipeline project injecting H_2 into natural gas grid at Seixal

Fusion Fuel uses innovative Hevo-Solar at "H_2 Evora" site near Évora

Keme Energy 1.26 MW green H_2 plant at Sines for an energy community

GreenH2Atlantic funded by H2020 will develop 100 MW electrolyser in Sines (EDP, Galp, Martifer, Efacec, Bondalti, INESC-TEC, …)

Patrícia Fortes

p.fs@fct.unl.pt

Outline

- H_2 economy wrap-up

CARBON PRICING

- **Paris Agreement, and its implications**
- Regulatory framework in the European Union: 2020 - 2030 targets
- Prepare the next class: DISCUSSION

Climate Change and Sustainable Development Policies

United Nations Climate Change Conference – Conference of the Parties

http://emorywheel.com/wp-content/uploads/2015/11/COP21.jpg

What is at stake?

The **tragedy of the commons** is a situation in a shared-resource system where **individual users**, acting independently according to their own self-interest, **behave contrary to the common good of all users by depleting or spoiling the shared resource through their collective action**.

The theory originated in an essay written in 1833 by the British economist William F. Lloyd.

Garrett Hardin (1968), "commons" is taken to mean any shared and unregulated resource such as atmosphere, oceans, rivers, fish stocks, roads and highways.

Climate is a shared common and mitigation is difficult!

Read Garrett's paper: https://www.science.org/doi/10.1126/science.162.3859.1243

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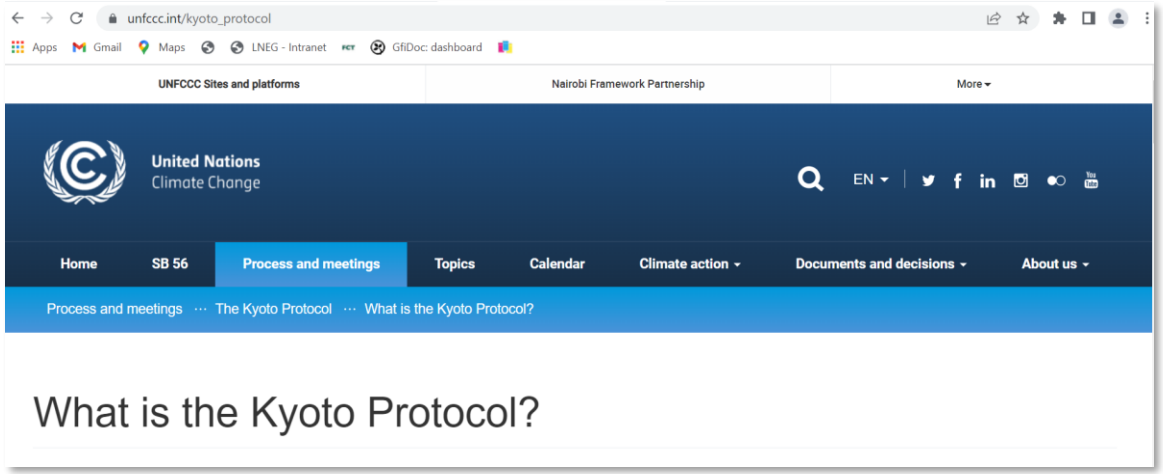
Kyoto Protocol: adopted 1997 and entered in force in 2005)



https://unfccc.int/kyoto_protocol

"the Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The Convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically."

*"It only binds **developed countries**, and places a heavier burden on them under the principle of "**common but differentiated responsibility and respective capabilities**", because it recognizes that they are largely responsible for the current high levels of GHG emissions in the atmosphere.*

*In its **Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union**.*
Overall, these targets add up to an average 5 per cent emission reduction compared to 1990 levels over the five year period 2008–2012 (the first commitment period)."

It was later extended to 2020 (Doha Amendment)

Kyoto Protocol created a carbon market

1 tCO_2 = economic value in the market

- Major invention in international environmental diplomacy
- Emissions Trading
  - Cap-and-trade between industralised countries
  - Traded unit Assigned Amount Units (AAU)
- Joint Implementation (JI)
  - Emission reduction projects in industralised countries
  - Traded unit Emission Reduction Unit (ERU)
- Clean Development Mechanism (CDM)
  - Emission reduction projects in developing countries
  - Traded unit Certified Emission Reductions (CER)

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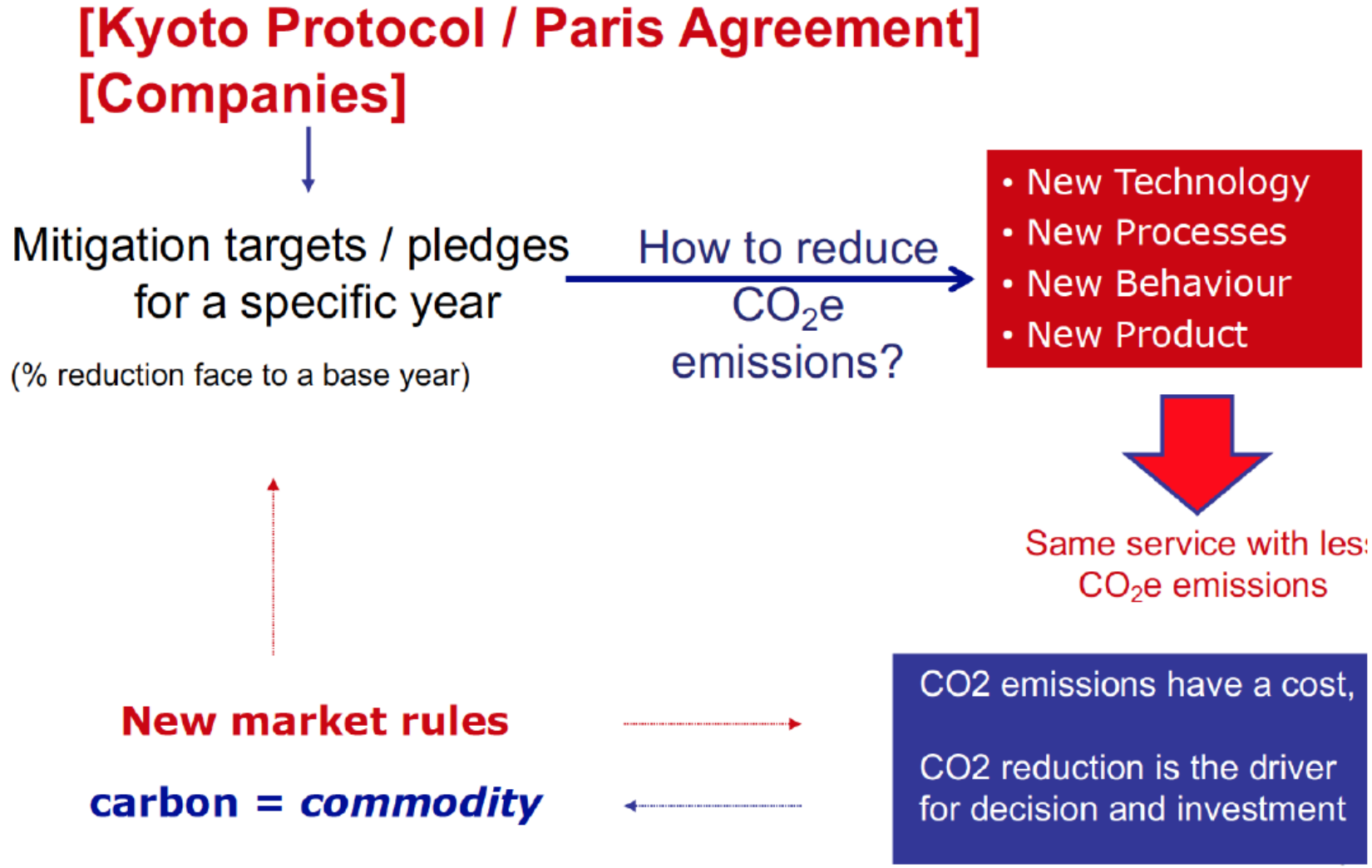
Kyoto Protocol created a carbon market



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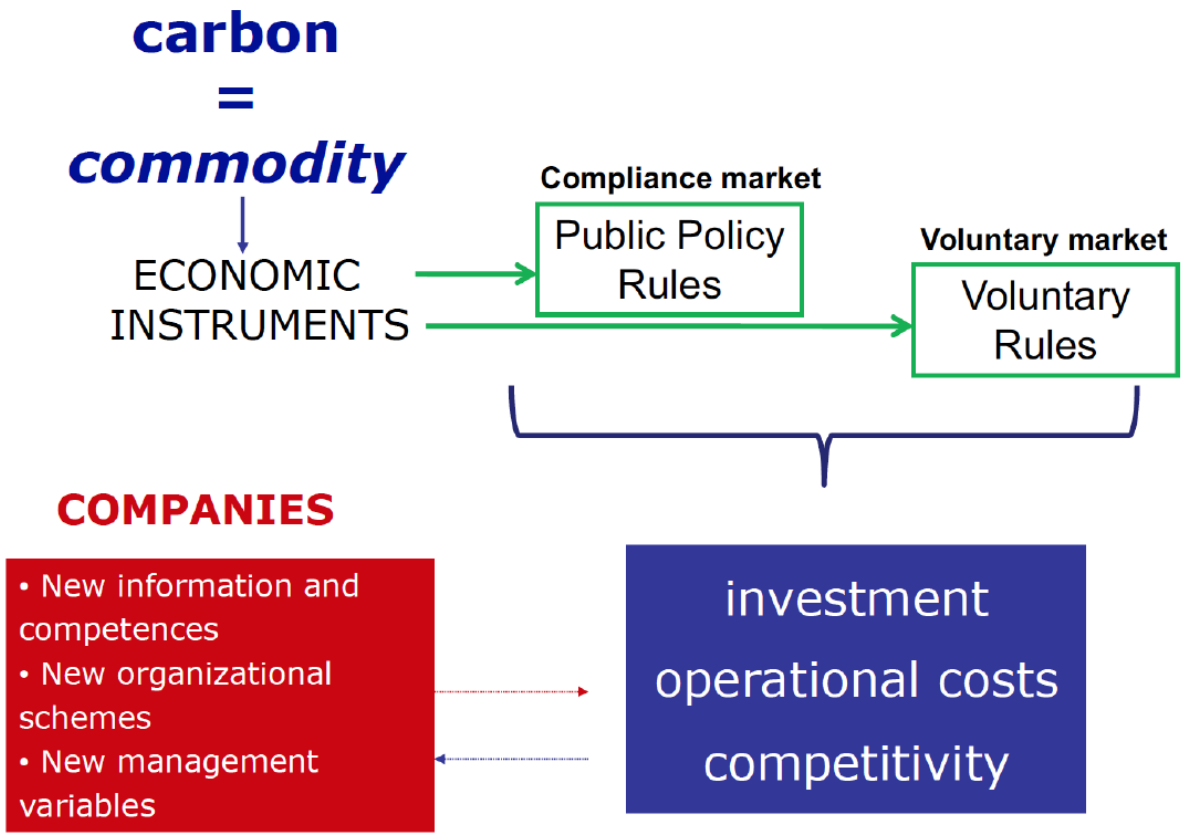
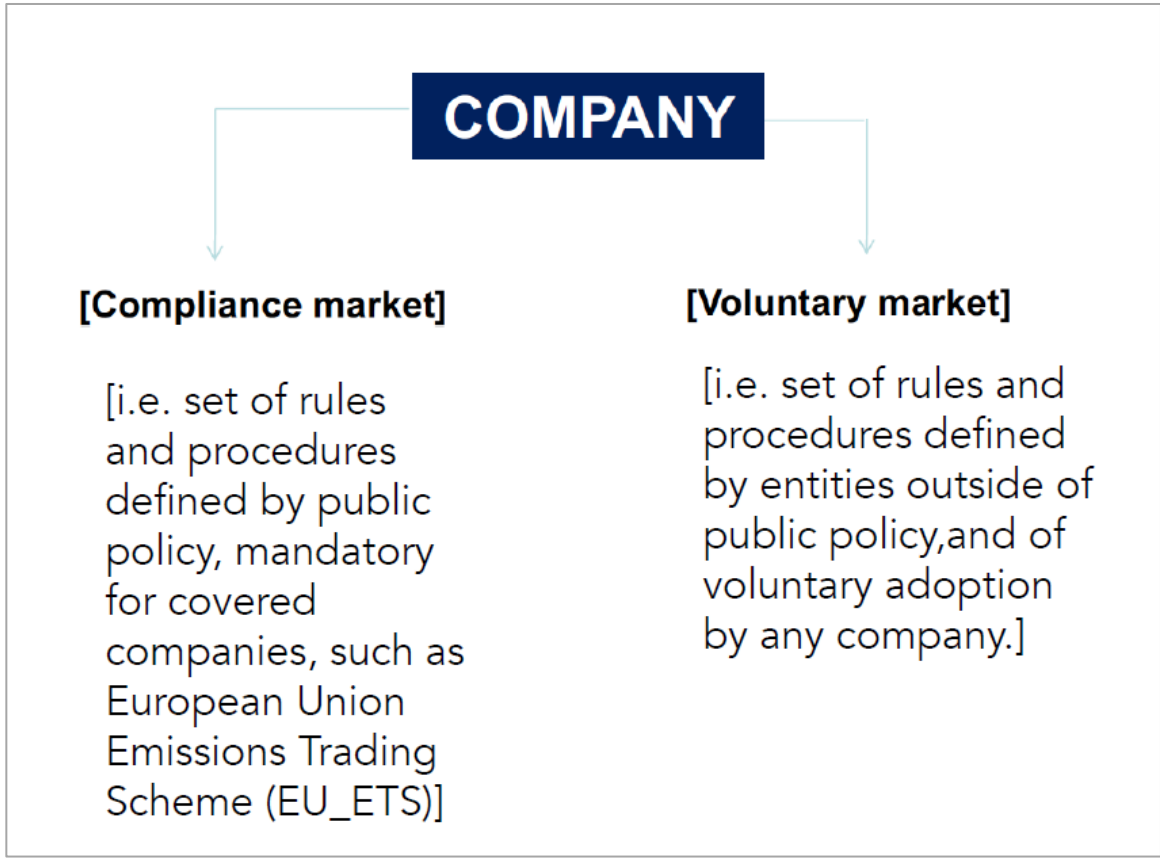
Public policies and private action





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The Paris Agreement challenge

Huge difference to the pathway towards 2ºC, based on current NDCs (Nationally Determined Contributions)

The COVID-19 crisis offered only a short-term reduction in global emissions and will not contribute significantly to emissions reductions by 2030 unless countries pursue
an economic recovery that incorporates strong decarbonization.

Unconditional targets are considered voluntary and implementable without outside support.
Conditional on either financial support from a "high-ambition" bloc of countries, or conditional on supportive climate-related policies pursued by other countries

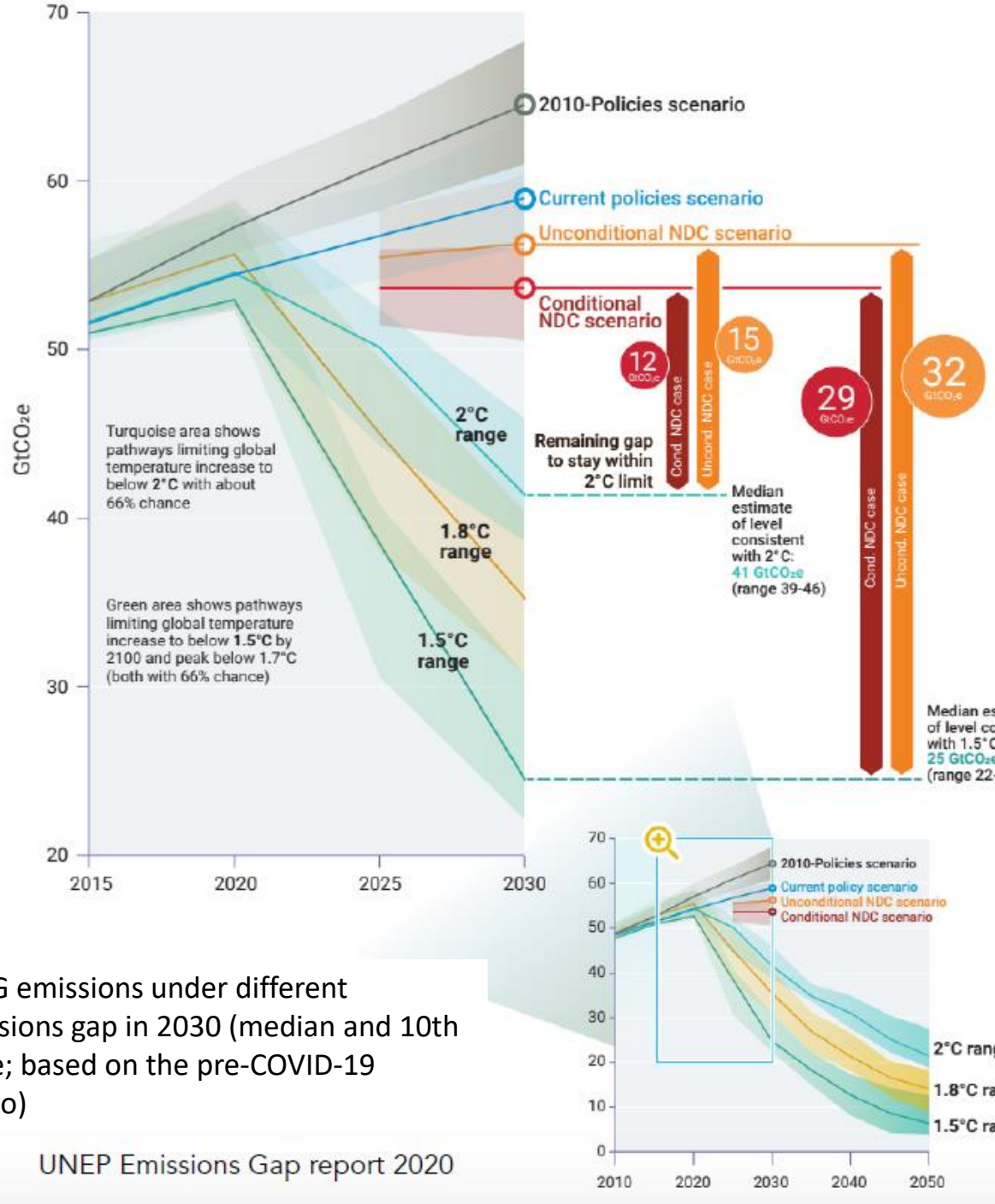

Figure ES.5. Global GHG emissions under different scenarios and the emissions gap in 2030 (median and 10th to 90th percentile range; based on the pre-COVID-19 current policies scenario)

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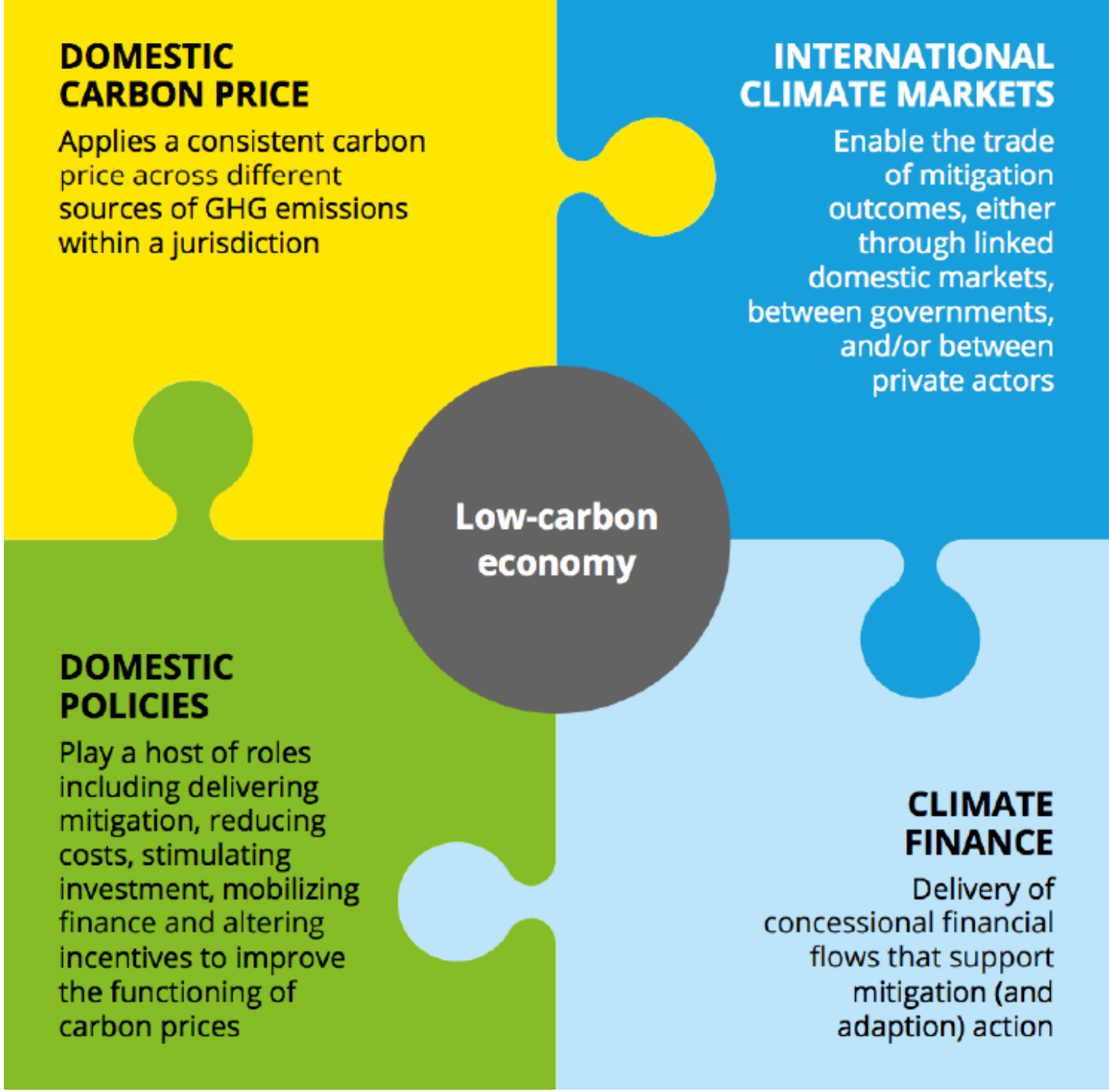
How to ensure mitigation?

No **end-of-pipe technology to reduce enough** greenhouse gas emissions in industrial units or thermal power plants

- How to induce mitigation in **nations**?
- How to make **companies** reducing their greenhouse gas emissions?
- How to press **families and individuals** reducing emissions?



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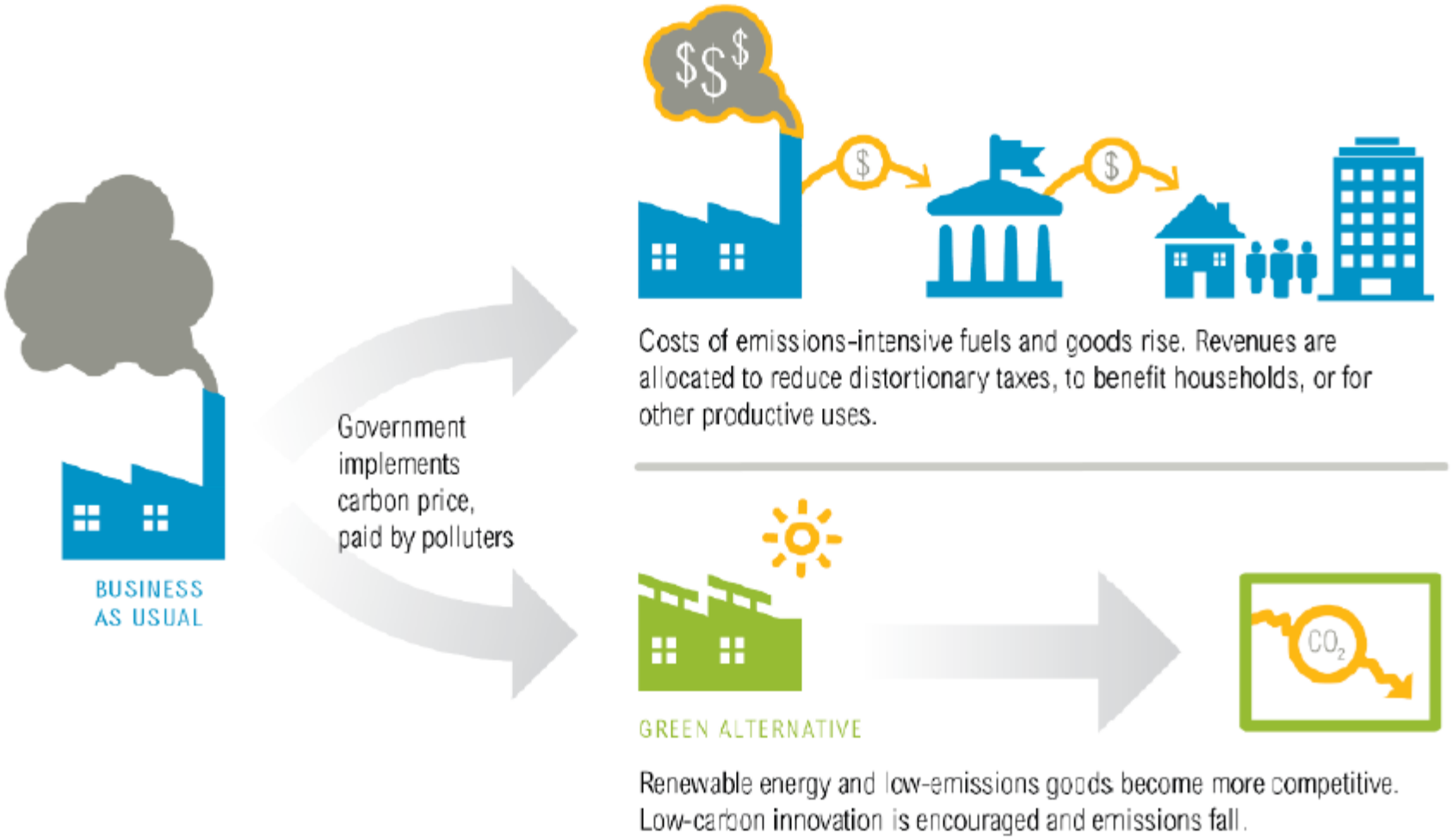
What happens if we put a price on carbon?



www.wri.org/carbonpricing

WORLD RESOURCES INSTITUTE

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Climate Change and Sustainable Development Policies

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There is currently a market distortion in favor of fossil fuels

Post-tax energy subsidies were estimated at $4.7 trillion (6.3 percent of global GDP) in 2015 and at $5.2 trillion (6.5 percent of global GDP) in 2017.

In dollar terms, Emerging and Developing Asia accounts for about 40% of global post-tax subsidies with advanced economies accounting for about one quarter.

Post-tax consumer subsidies exist if consumer prices for energy are below supply costs plus the efficient levels of taxation. The efficient level of taxation includes two components. First, energy should be taxed the same way as any other consumer product. Second, some energy products contribute to local pollution, traffic congestion and accidents, and global warming—efficient taxation requires that the price of energy should reflect these adverse effects on society. In most countries, taxes on energy fall far short of the efficient levels.

Producer subsidies exist when producers receive either direct or indirect support that increases their profitability above what it otherwise would be. This support can take many forms, including receiving a price for the output above the supply cost, paying a price for inputs below supply costs, or receiving a direct transfer from the budget.

Getting Energy Prices Right (IMF) 3:45min

https://www.youtube.com/watch?v=nCCkKu09CJE

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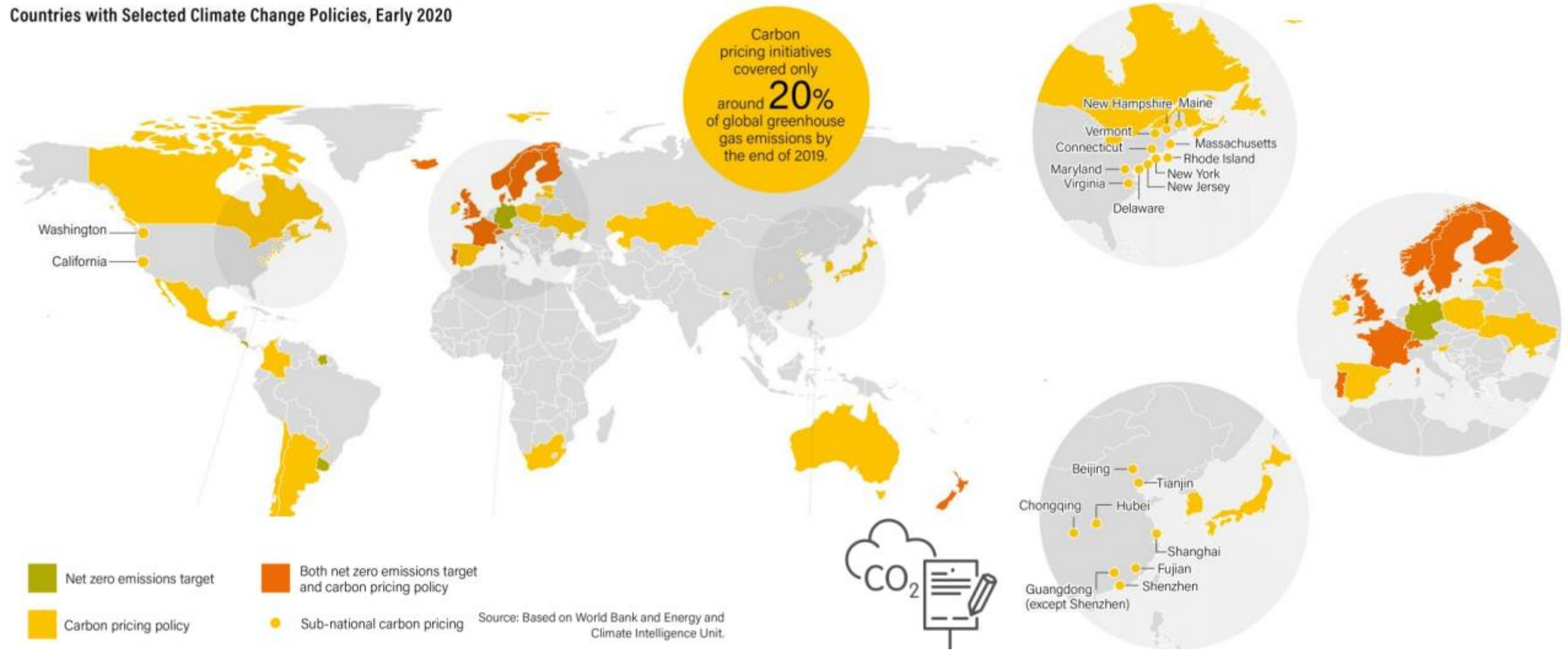
CARBON PRICING SLOWLY EXPANDING



https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_presentation.pdf

Carbon Pricing instruments

Compliance instruments (rules settled by public policies):

- **Emissions Trading Schemes (ETS):** instrument based on a cap (over a industrial unit) and trade between two industrial units)
- **Carbon Tax:** on producers, like coal power plants over the coal consumed, or on consumers, like over gasoline or diesel consumption

PURPOSE: CHANGE BEHAVIOR AND DECISION!

https://openknowledge.worldbank.org/handle/10986/35620

There are also Voluntary instrument (no rules from governments): voluntary carbon market

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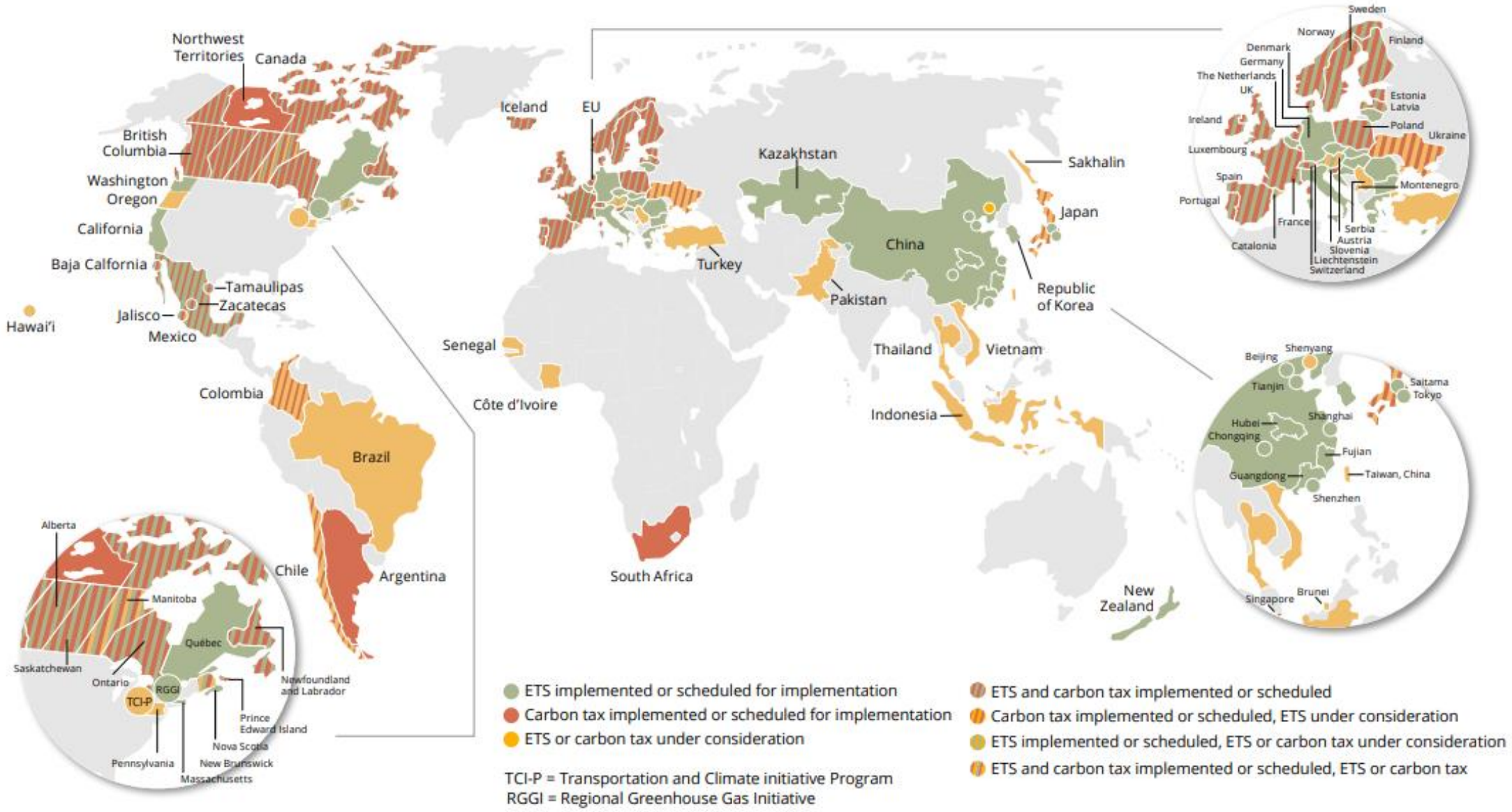
CARBON PRICING MAP (2021)



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Climate Change and Sustainable Development Policies

Carbon Pricing enough?

CARBON PRICING – A NECESSARY BUT NOT SUFFICIENT POLICY

- Carbon pricing can play a role in incentivizing low-carbon action by internalizing the cost of greenhouse gas emissions
- However, for it to work, several things are needed:
  - It must be sufficiently **AMBITIOUS**. Experts say prices of USD 40-80/tCO_2e are needed to meet the 2°C goal.
  - It must be **WELL DESIGNED AND ADAPTED** to the jurisdictional context.
  - It must **FORM PART OF A SUPPORTIVE POLICY PACKAGE** – other policies are needed to drive research and development, unlock non-economic barriers to mitigation and to target emissions reductions with very high abatement costs

https://openknowledge.worldbank.org/handle/10986/35620

Climate Change and Sustainable Development Policies

Carbon Pricing enough?

SOME EARLY SIGNS OF MORE AMBITIOUS CARBON PRICING POLICIES

- More governments are adopting net zero targets and we are beginning to see **MORE AMBITIOUS CARBON PRICING INSTRUMENTS**:
  - In the EU, allowance prices have hit all-time highs as the bloc steps up both long and short term climate ambition and the market foresees caps tightening following the announcement of the Green Deal.
  - Prices are increasing in countries like Canada, Germany and Ireland
  - New Zealand's Climate Change Act sets out changes to its ETS and outlines a national mitigation framework in line with a 2050 net zero target
- Greater ambition is also leading more governments to consider **CARBON BORDER ADJUSTMENTS**. These may in turn may spur more climate ambition (but are also facing opposition)

NEW CARBON PRICING INSTRUMENTS LAUNCHED

- China's emissions trading system came online – the **LARGEST CARBON MARKET IN THE WORLD**, initially covering around 4,000 $MtCO_2$ or 30% of its national GHG emissions.
- The UK and Germany both launched national carbon markets and carbon taxes in the Netherlands and Luxembourg came into operation.

https://openknowledge.worldbank.org/handle/10986/35620

Outline

- H_2 economy wrap-up

CARBON PRICING

- Paris Agreement, and its implications
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Climate Change and Sustainable Development Policies

European Climate Regulatory Framework

- **2020 climate & energy package**

  https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2020-climate-energy-package_en

- **2030 climate & energy framework** [part of the Green Deal], updated to a more ambitious emissions reduction target (-55%)

  https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

- **2050 long-term strategy** (based on *A Clean Planet for all- A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*)

  https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN

- **National plans and strategies** (and several national regulations and laws):
  - National energy and climate plans (NECPs 2030)

  https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en
  - National long-term strategies (2050)

  https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en

The European Green Deal

https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

https://audiovisual.ec.europa.eu/en/video/I-199819?lg=EN

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European Climate Regulatory Framework (II)

https://ec.europa.eu/clima/policies/strategies_en

2020

- 20% cut in **greenhouse gas** emissions (from 1990 levels)
- 20% of EU energy from **renewables**
- 20% improvement in **energy efficiency**

2030

55%

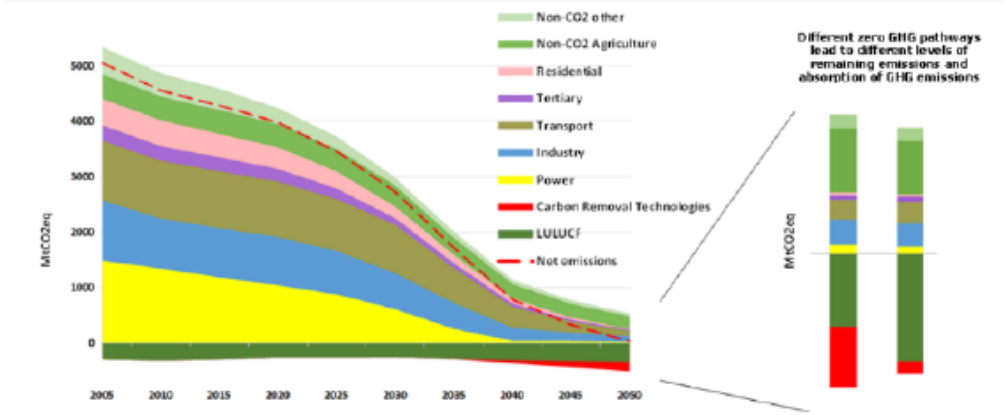
- 40% cut in **greenhouse gas** emissions (from 1990 levels)
- 32% of EU energy from **renewables**
- 32,5% improvement in **energy efficiency**

2050

The European Parliament endorsed the net-zero greenhouse gas emissions objective in its resolution on climate change in Mar 2019 and resolution on the European Green Deal in Jan 2020.

EU long term strategy submitted to UNFCCC (2019) aligned to Paris Agreement goal

Figure 4: GHG emissions under the scenario of a global temperature increase of 1.5°C[1]



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Climate Change and Sustainable Development Policies

European Green Deal

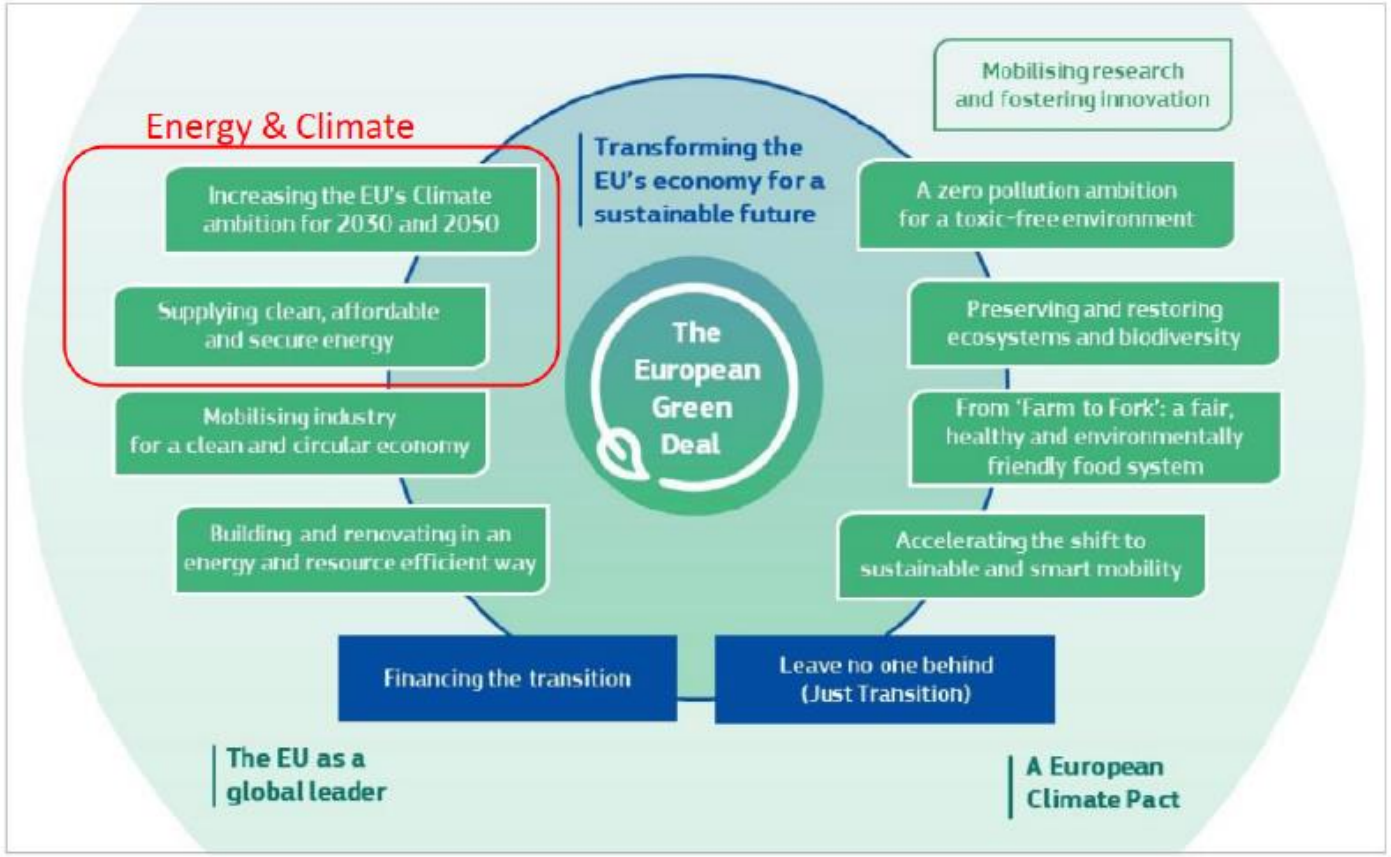

Figure 1: The European Green Deal

Between 1990 and 2018, EU reduced greenhouse gas emissions by 23%, while the economy grew by 61%. However, current policies will only reduce greenhouse gas emissions by 60% by 2050.

(...)

By summer 2020, the Commission will present an impact assessed plan to increase the EU's greenhouse gas emission reductions target for 2030 to at least 50% and towards 55% compared with 1990 levels in a responsible way.

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STEPPING UP EUROPE'S 2030 CLIMATE AMBITION - INVESTING **IN A CLIMATE-NEUTRAL FUTURE FOR THE BENEFIT OF OUR PEOPLE**

Brussels, 17.9.2020
COM(2020) 562 final

Communication from the Commission to the European Parliament, the Council, The European Economic and Social Committee and the Committee of the Regions

EUROPEAN COMMISSION

Climate Change and Sustainable Development Policies

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1990-2019

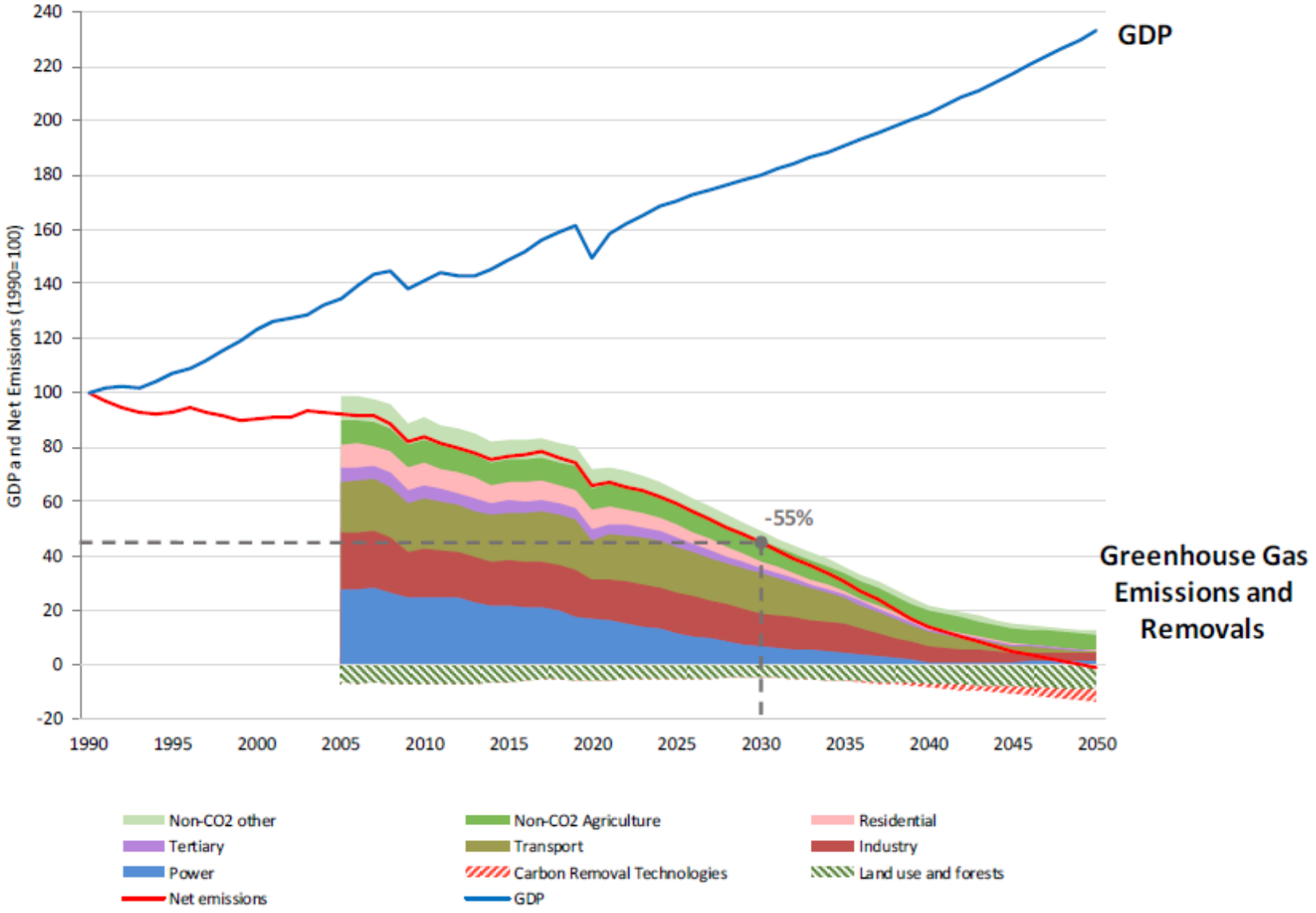
EU GHG (with removals) -25%

EU economy +62%

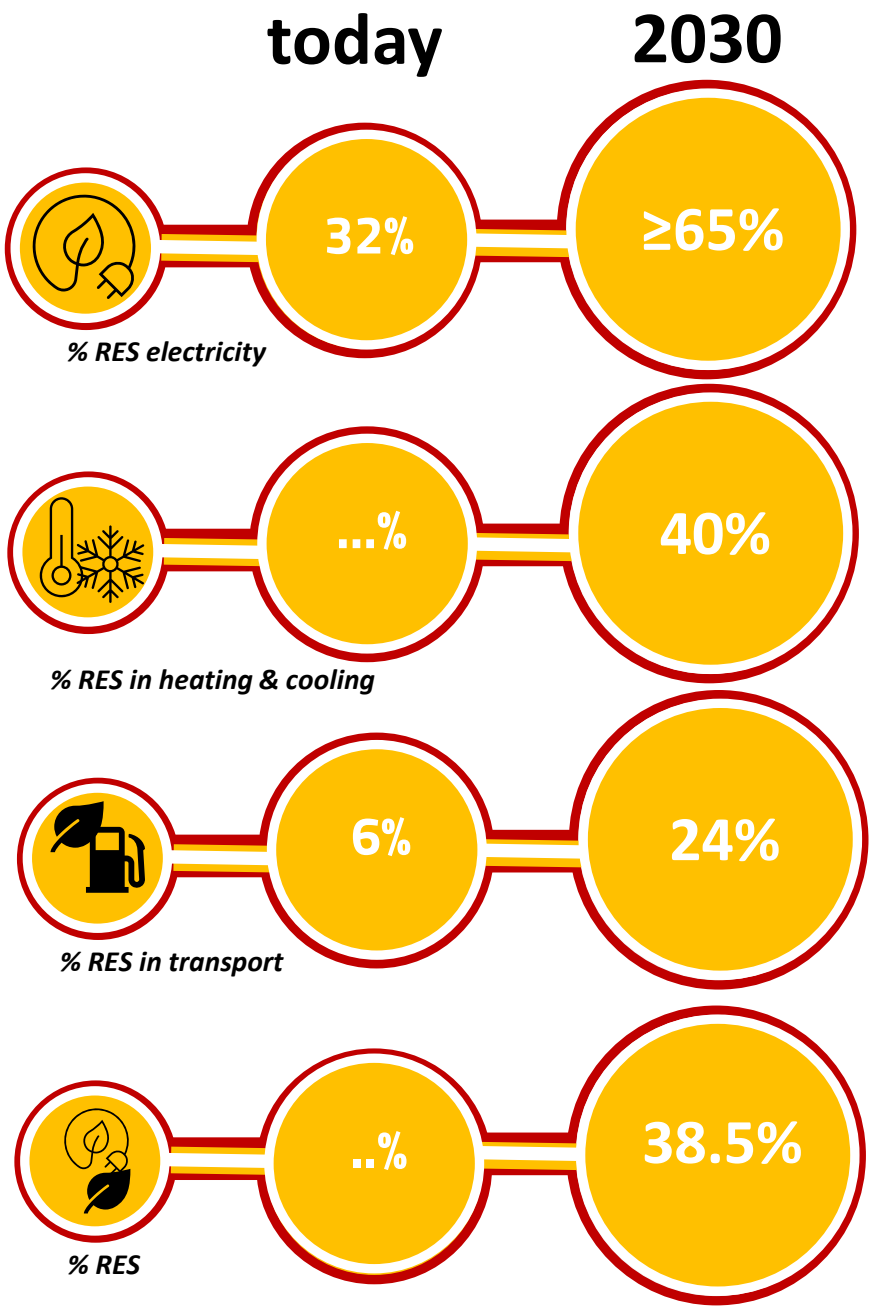
Current EU GHG emission pathway leads -60% GHG_{1990} by 2050

2030

-55% GHG_{1990}



Climate Change and Sustainable Development Policies



regulate at least intra-EU aviation emissions in the EU ETS and include at least intra-EU maritime transport in the EU ETS

Fossil fuels consumption

coal -70% $_{2015}$

oil -30% $_{2015}$

gas -25% $_{2015}$

savings of 36-37% for final energy consumption and 39-41% for primary energy

2030 GHG emissions reduction

-20% $_{2015}$

-25% $_{2015}$

CH_4, N_2O, F-gases -35% $_{2015}$

Climate Change and Sustainable Development Policies

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Outline

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CARBON PRICING

- Regulatory framework in the European Union: 2020 - 2030 targets.
- Paris Agreement, and its implications
- **Prepare the next class: DISCUSSION**

Climate Change and Sustainable Development Policies

A vision towards sustainable and carbon neutral energy system: is it possible for everyone?

13th May 16h30-18h

All students **must read the 4 papers below carefully,** to inform your vision (positive prospects vs. bottlenecks and barriers) and do the homework to be well prepared (ideas + arguments + some statistics as necessary to support your perspective) to contribute to the debate. Each student may choose its own perspective, for example developing country or very rich country, global company or small company, NGO or other organization, or any other. **The students should organize themselves in groups of 3 representing the same perspective,** to prepare jointly the positions in the debate.

There is the need to have **two volunteers** (one male + one female) to make a short presentation (10 min at the maximum total) based on the paper 'Energy Vision (van Vuuren, 2012)' to organize key challenges to address during the debate (among others).

READ (available in MOODLE):

- A roadmap for rapid decarbonization https://www.science.org/doi/10.1126/science.aah3443
- Net-zero emissions energy systems https://www.science.org/doi/10.1126/science.aas9793
- Towards demand-side solutions for mitigating climate change https://www.nature.com/articles/s41558-018-0121-1
- An energy vision: the transformation towards sustainability - interconnected challenges and solutions https://doi.org/10.1016/j.cosust.2012.01.004

A vision towards sustainable and carbon neutral energy system: is it possible for everyone?

16h30 (10 min): Initial presentation by the two volunteers.

16h40 (20 min): Tour de table, each group of students presents who they represent in the debate (i.e. developing country or very rich country, global company or small company, NGO or other organization, or any other), and makes a single statement (1-2 phrases) about its expectation regarding the key question of the debate (see the title). Each group should previously decide who will address the first intervention.

17h00 (45 min): Debate will evolve around the following guiding questions: (1) what are the (different and diverse) opportunities to achieve a sustainable and neutral carbon energy system to provide the energy services for the economy and consumers? (2) what barriers exist for such transformation? (3) what are the key factors to invest in? (4) what aspects should be avoided? [you may cover all aspects, from technology to financing, education or policy instruments, among others]. Each group's member need to raise hand to call for intervention!

17h45 (15 min): Final remarks from each group about the achievement regarding the debate's question (1-2 phrases). Each group should previously decide who will address the final intervention.

18h00 Close

As the debate will run in English, students not fluent in English (in groups of 3) should write an essay (pdf) of 5 pages maximum, (1) taking the perspective of a specific stakeholder (i.e. developing country or very rich country, global company or small company, NGO or other organization, or any other); (2) elaborating at least on the 4 previous questions, and (3) commenting on the key question (see the title).

Deadline: May 13th to my email.

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Key information you should have apprehended after the class

- Why do we need carbon pricing context of Kyoto Protocol and the Paris Agreement
- Different instruments used for carbon pricing (emission trading, carbon taxes)
- Existence of compulsory and voluntary carbon markets
- Limitations and need for complementary approaches besides carbon pricing
- Existence of subsidies on fossil fuels and difficulties removing them
- Global overview of carbon pricing instruments across regions and countries
- European Union climate mitigation regulatory framework (2020 and 2030)