



NEW ENERGY & ENVIRONMENTAL
SOLUTIONS AND TECHNOLOGIES

TETHYS WEBINAR - GREEN HYDROGEN PRODUCTION

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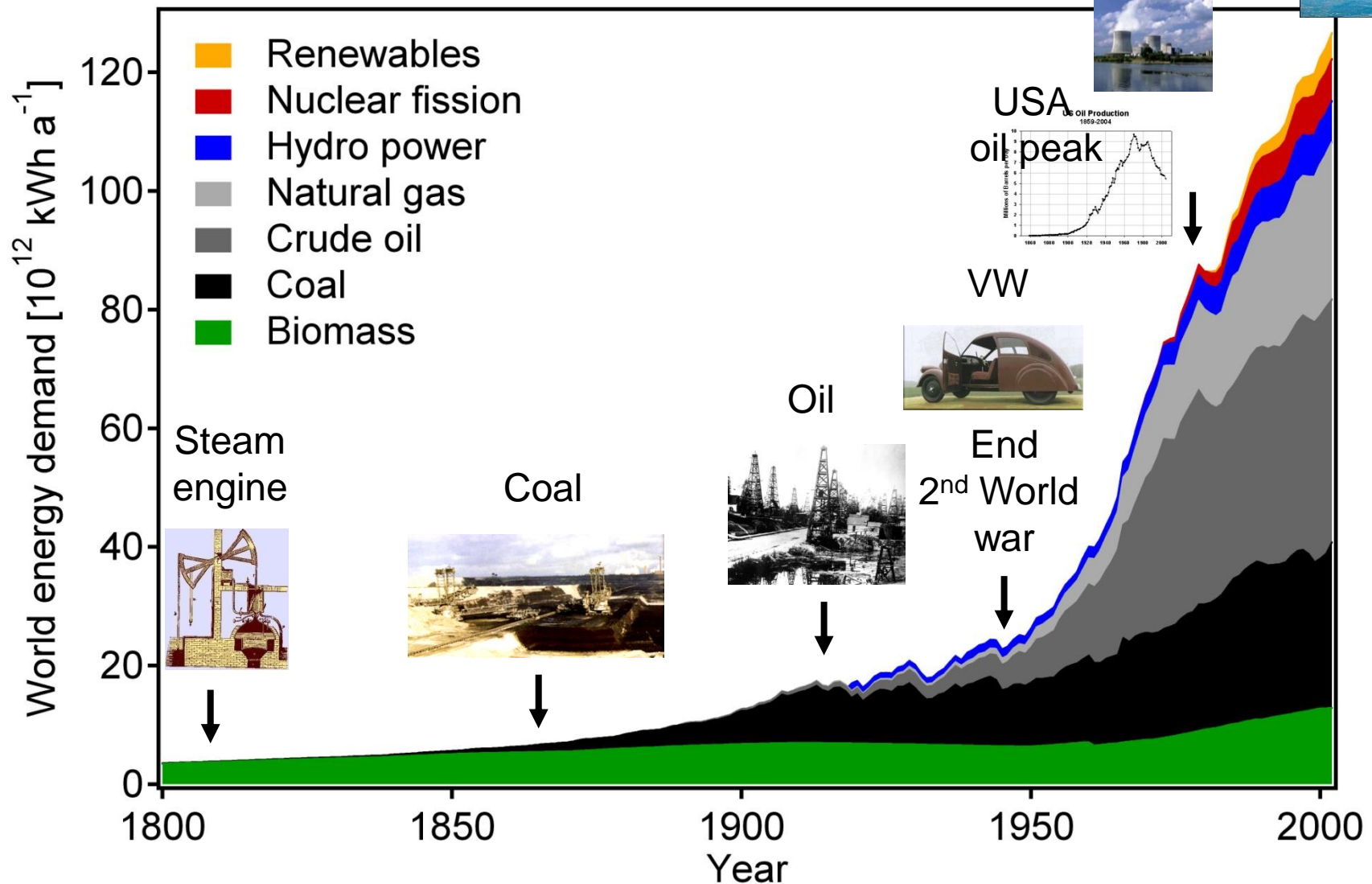
INTRODUCTION

Why hydrogen? Climate change

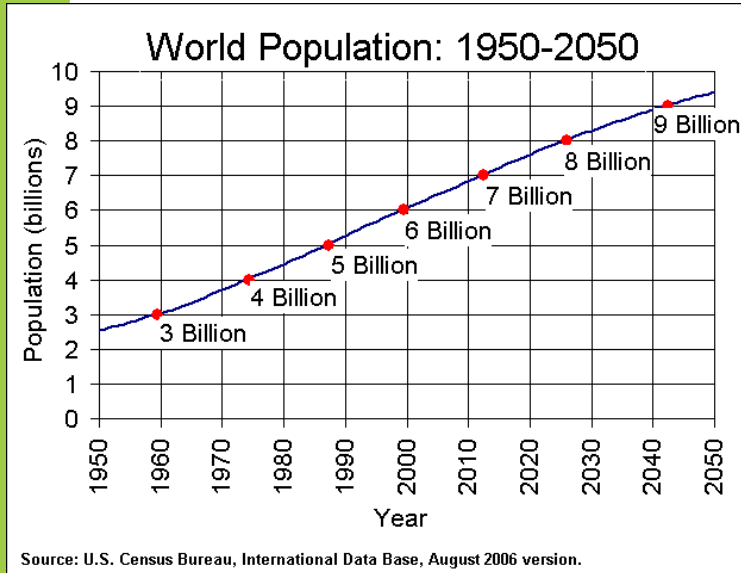
Hydrogen (H₂) as energy carrier

Alternative fuels - European policies

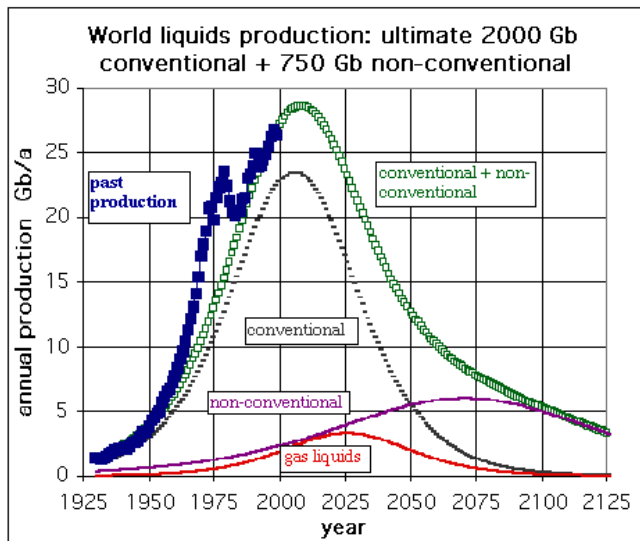
WORLD ENERGY CONSUMPTION



Energy Crisis?

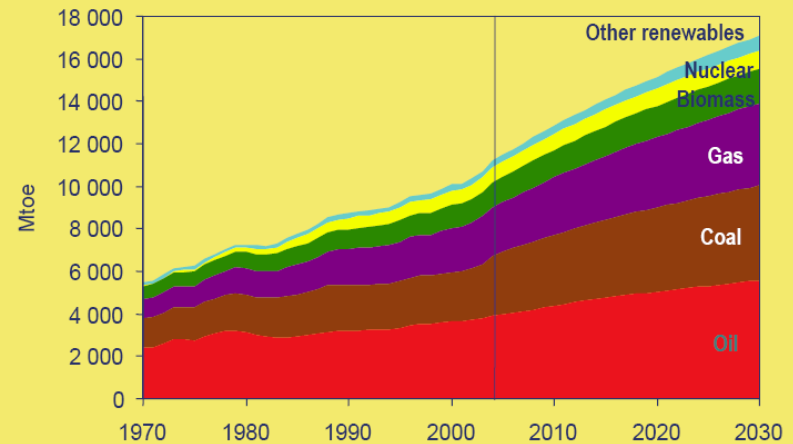


THE HUBBERT CURVE



**World
Energy
Outlook
2006**

The Reference Scenario: World Primary Energy Demand



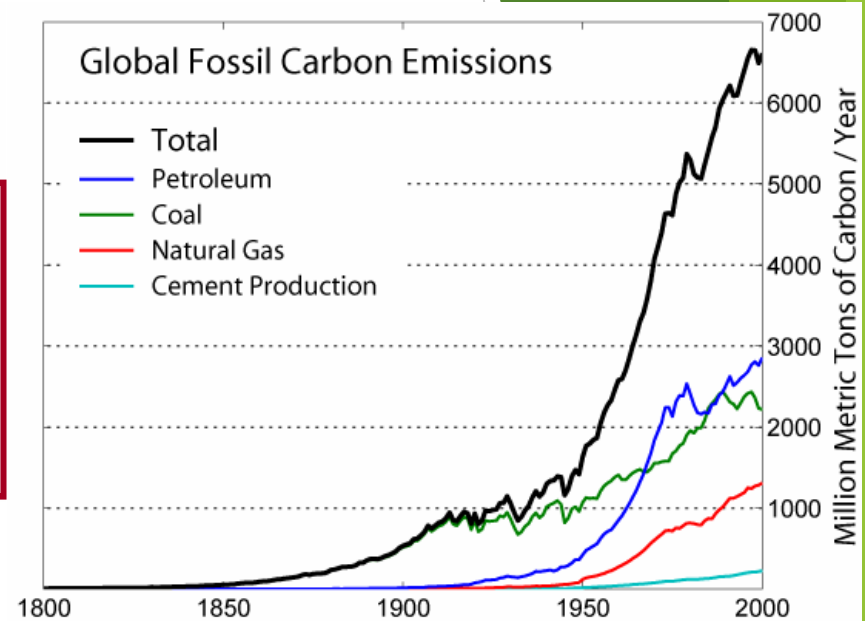
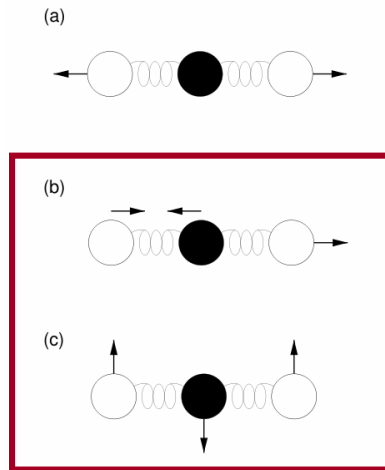
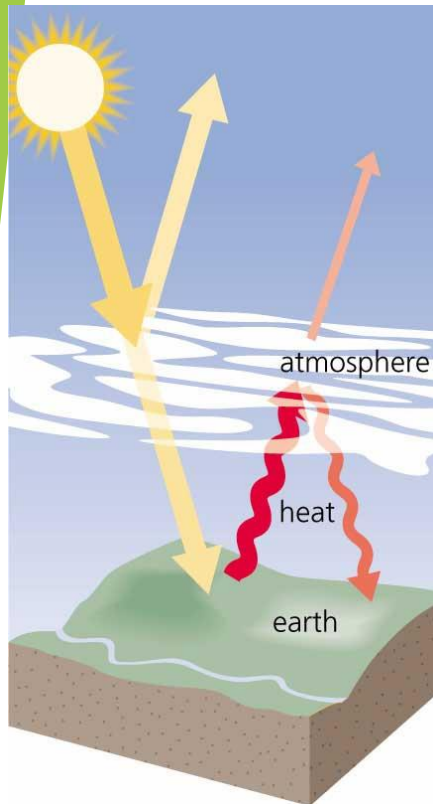
Global demand grows by more than half over the next quarter of a century, with coal demand increasing most in absolute terms

© OECD/IEA - 2006

Environmental Crisis before!



Greenhouse Gas



Svante Arrhenius
(1859-1927)

If the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression.

“On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground”, *Philosophical Magazine* 41 (1896) 237-276

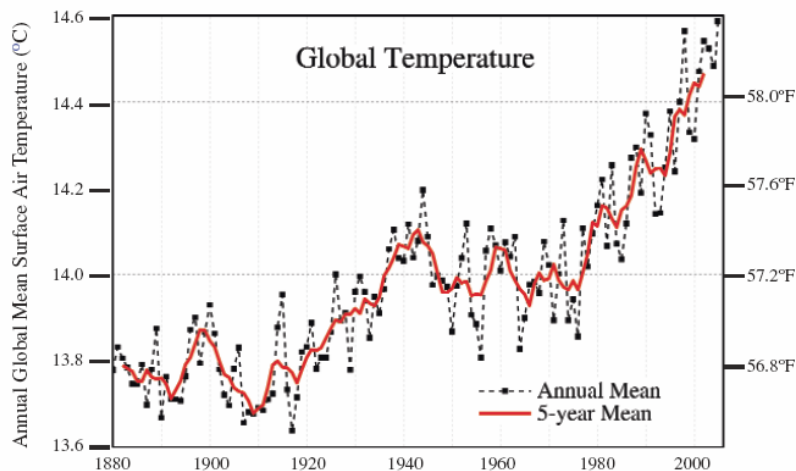
still valid in the simplified expression by Myhre et al. (1998).

Environmental Crisis

The debate on global warming is over.

Intergovernmental Panel on Climate Change, 4th Assessment Report (IPCC - AR4), Paris, Feb. 2007

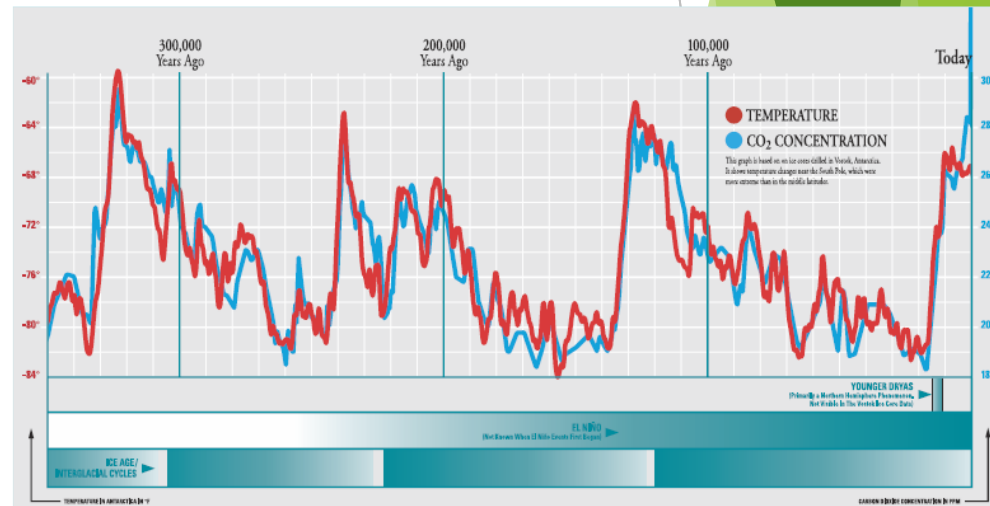
Present levels of carbon dioxide-nearing **400 ppm** in the earth's atmosphere-are higher than they have been at any time in the past 650,000 years and could easily surpass **500 ppm** by the year 2050 without radical intervention.

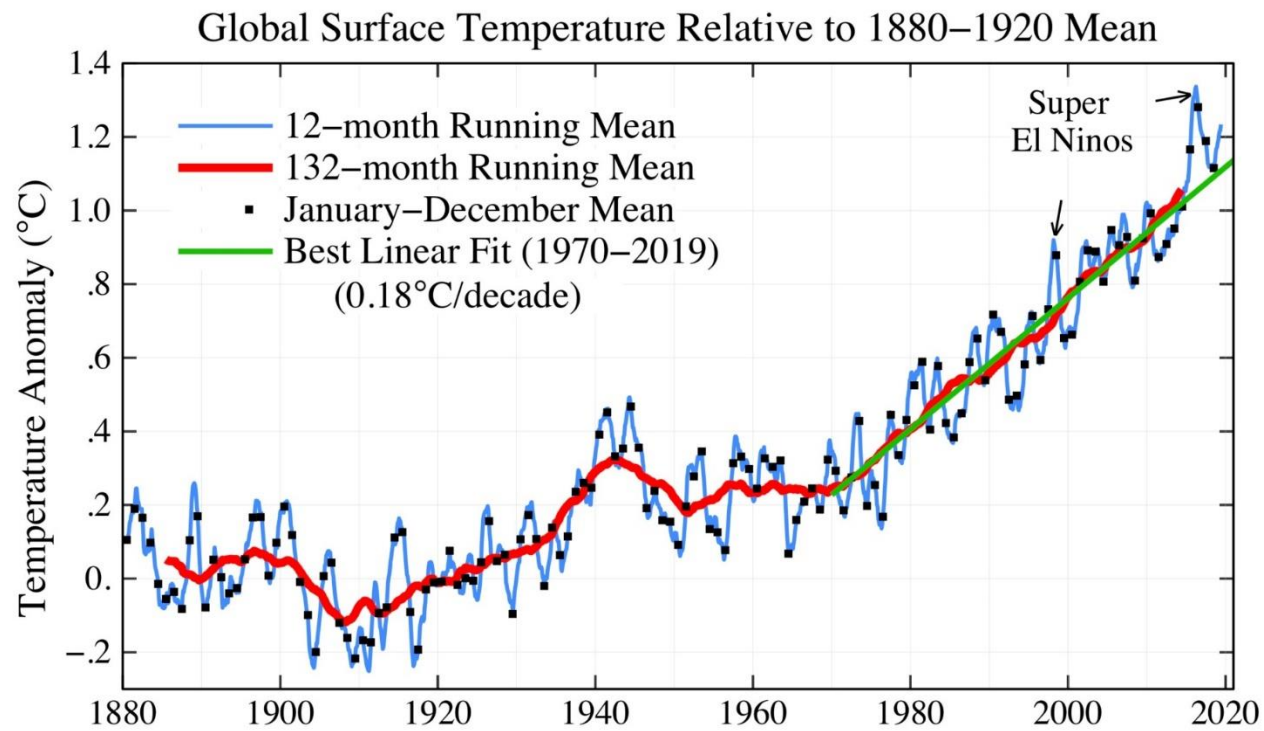


Measurements at meteorological stations
Goddard Institute for Space Studies

Understanding and responding to climate change
MARCH 2006 NATIONAL ACADEMY OF SCIENCES

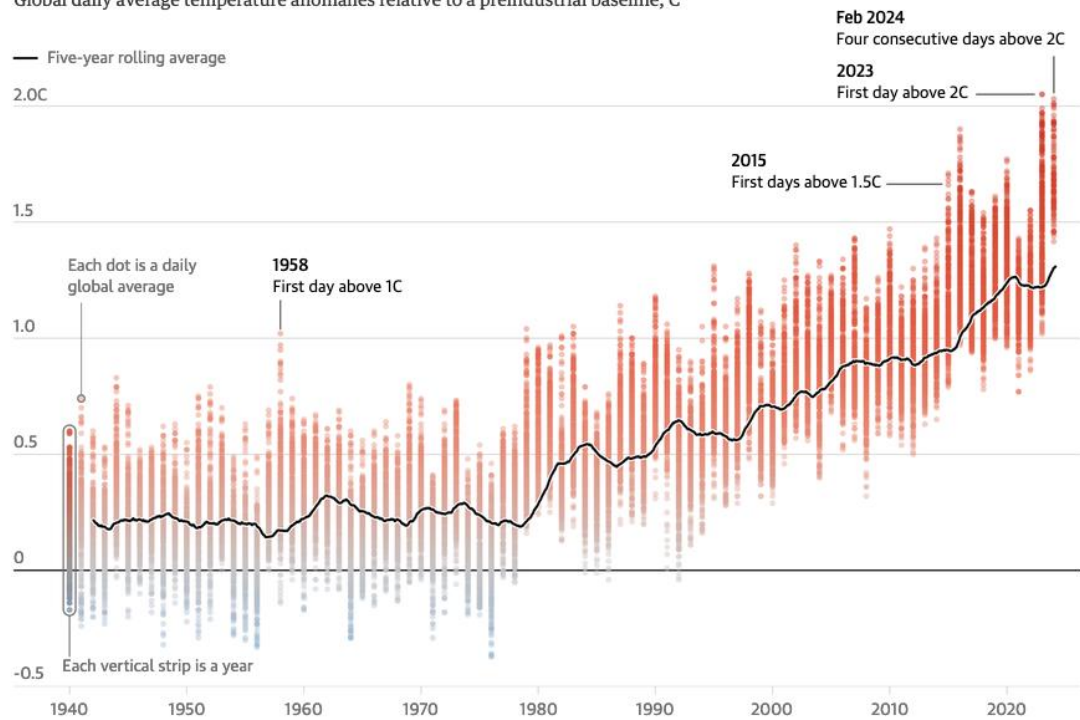
Recorded in ice cores from Vostok, Antarctica
Understanding and responding to climate change
MARCH 2006 NATIONAL ACADEMY OF SCIENCES





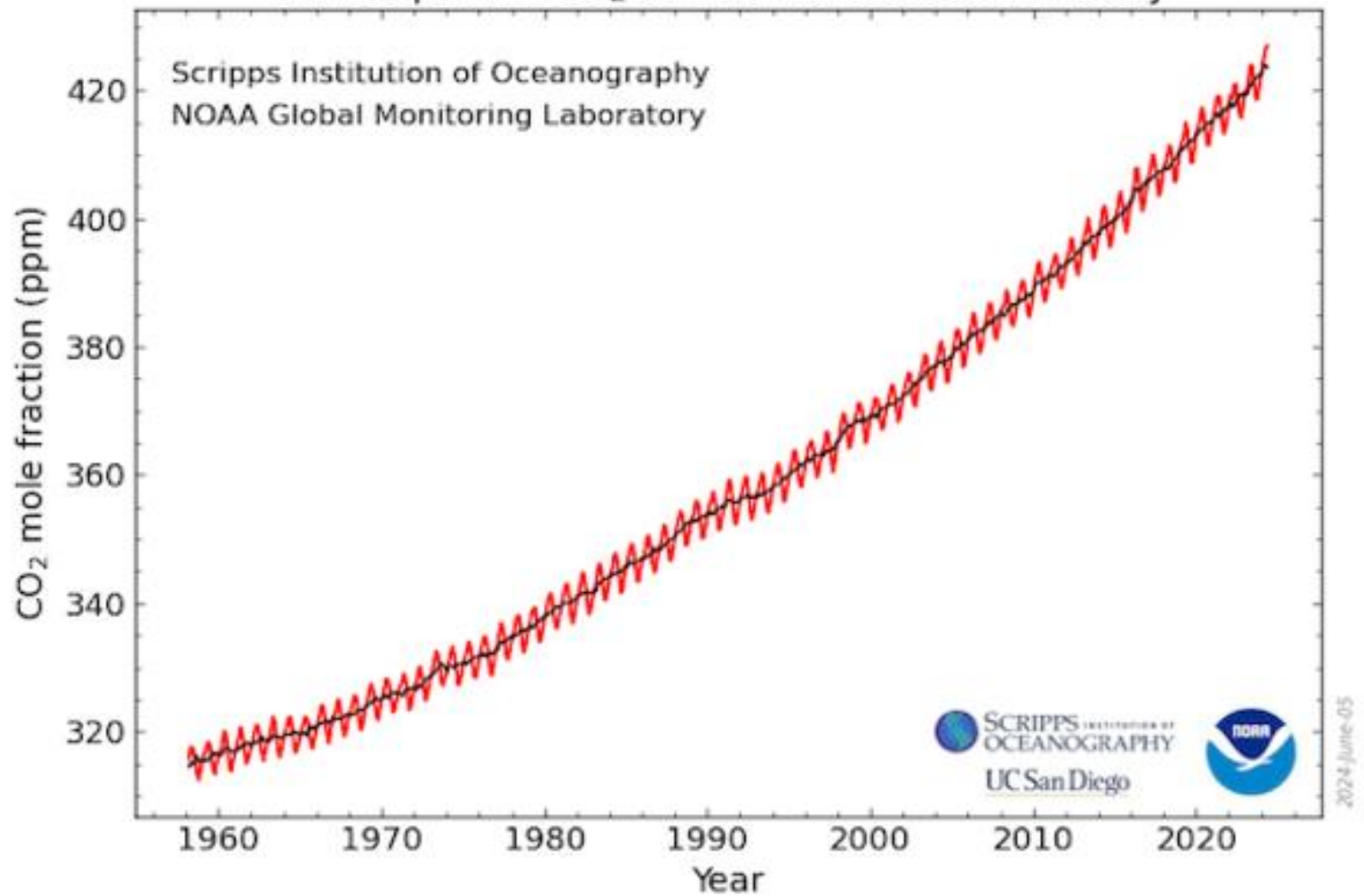
Daily temperature anomalies

Global daily average temperature anomalies relative to a preindustrial baseline, C

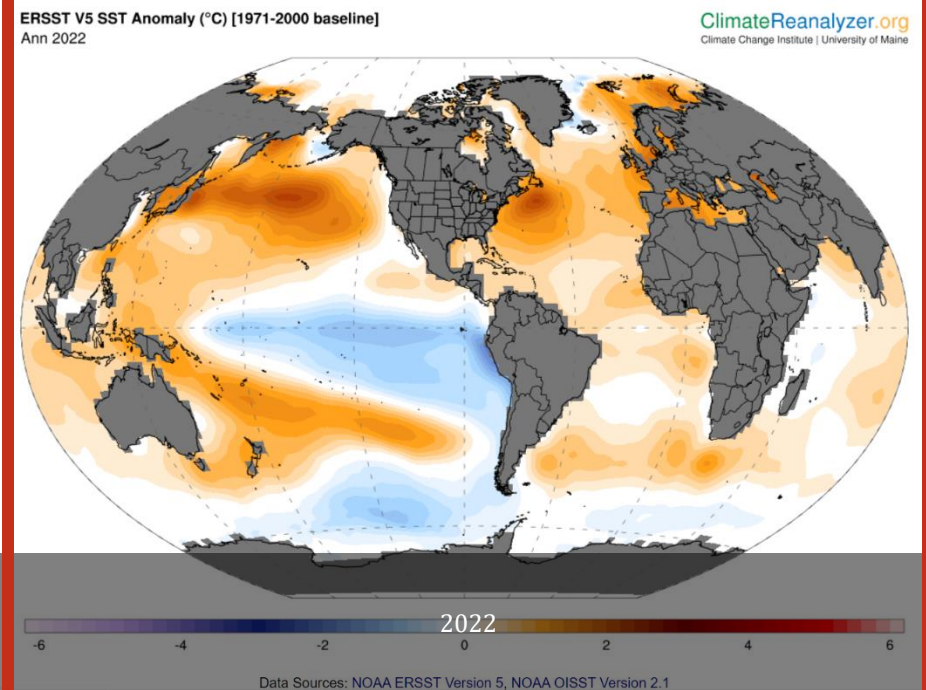
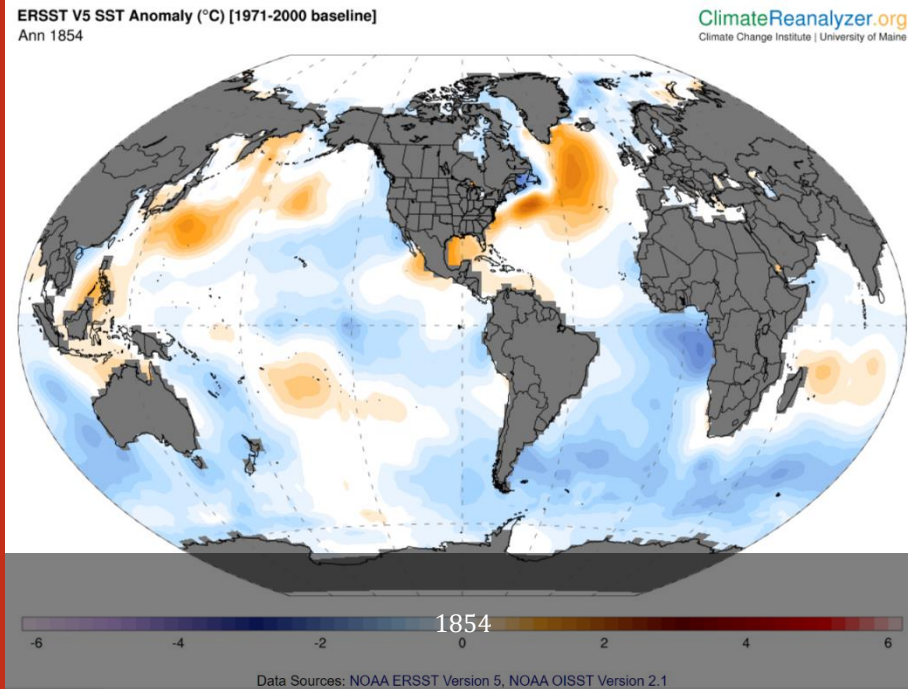


Guardian graphic. Source: Copernicus C3S/ECMWF Era5. Note: Preindustrial baseline = 1850-1900

Atmospheric CO₂ at Mauna Loa Observatory



Sea Surface Temperature

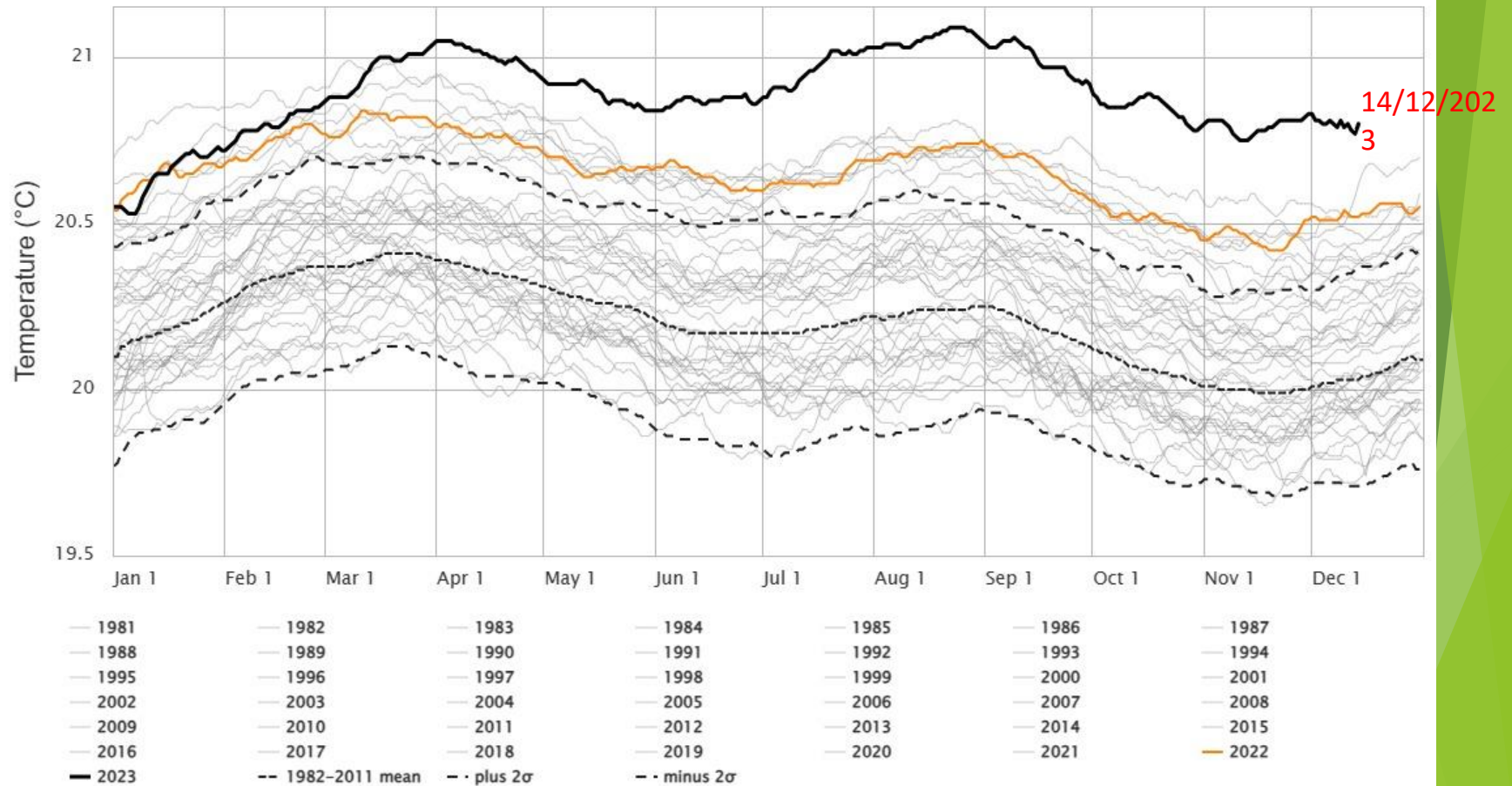


https://climatereanalyzer.org/clim/sst_monthly/

Daily / annual sea surface temperature variation

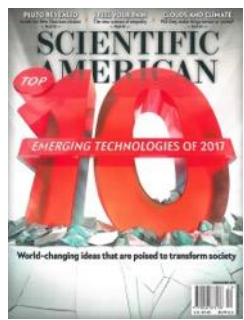
https://climaterenalyzer.org/clim/sst_daily/

Data Source: NOAA OISST V2.1 | Image Credit: ClimateReanalyzer.org, Climate Change Institute, University of Maine



Hydrogen as Energy Carrier





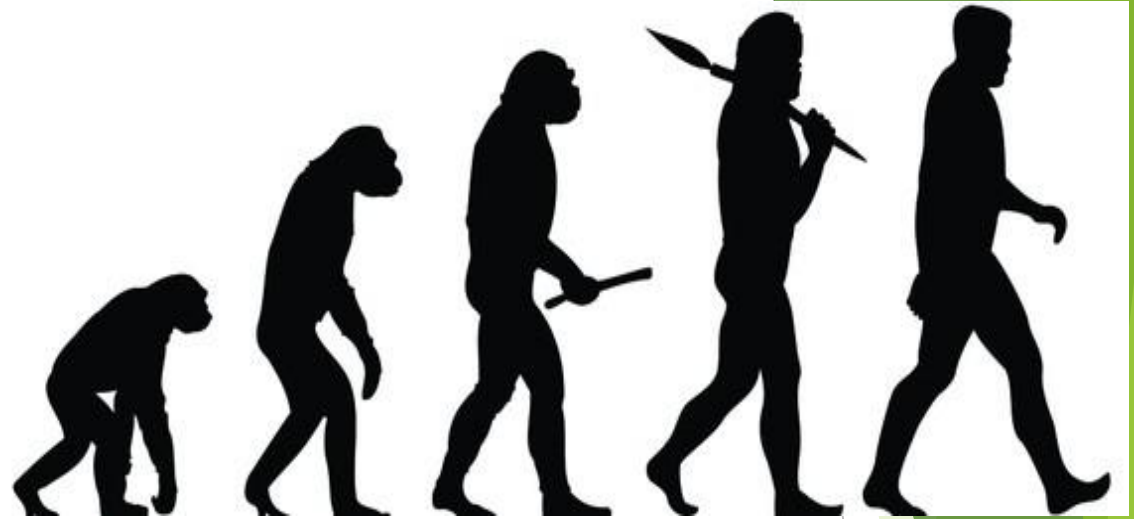
TOP 10 EMERGING TECHNOLOGIES OF 2017

*a collaboration between Scientific American and
the World Economic Forum*



1. Water Made by the Sun - Technologies that pull moisture from the air are now solar-powered
2. Fuel from an Artificial Leaf - Technology that mimics photosynthesis converts carbon dioxide to fuels in a sustainable way
3. AI that sees like humans - A deep-learning tool for visual tasks is changing medicine, security and more
4. Precision Farming - Sensors, imaging and real-time data analytics improve farm outputs and reduce waste
5. Mapping Every Cell - A global project aims to understand how all human cell types function
6. Liquid Biopsies – Ultrasensitive blood tests promise to improve cancer diagnosis and care
7. Hydrogen Cars for the Masses - Reducing precious metals makes fuel-cell catalysts affordable
8. Genomic Vaccines - Vaccines composed of DNA or RNA could enable rapid development of preventives for infectious diseases
9. Sustainable Communities – Instead of “Greening” individual houses, entire blocks of homes are retrofit into a single efficient unit
10. Quantum Computing - New algorithms and Techniques open the door to innovative applications

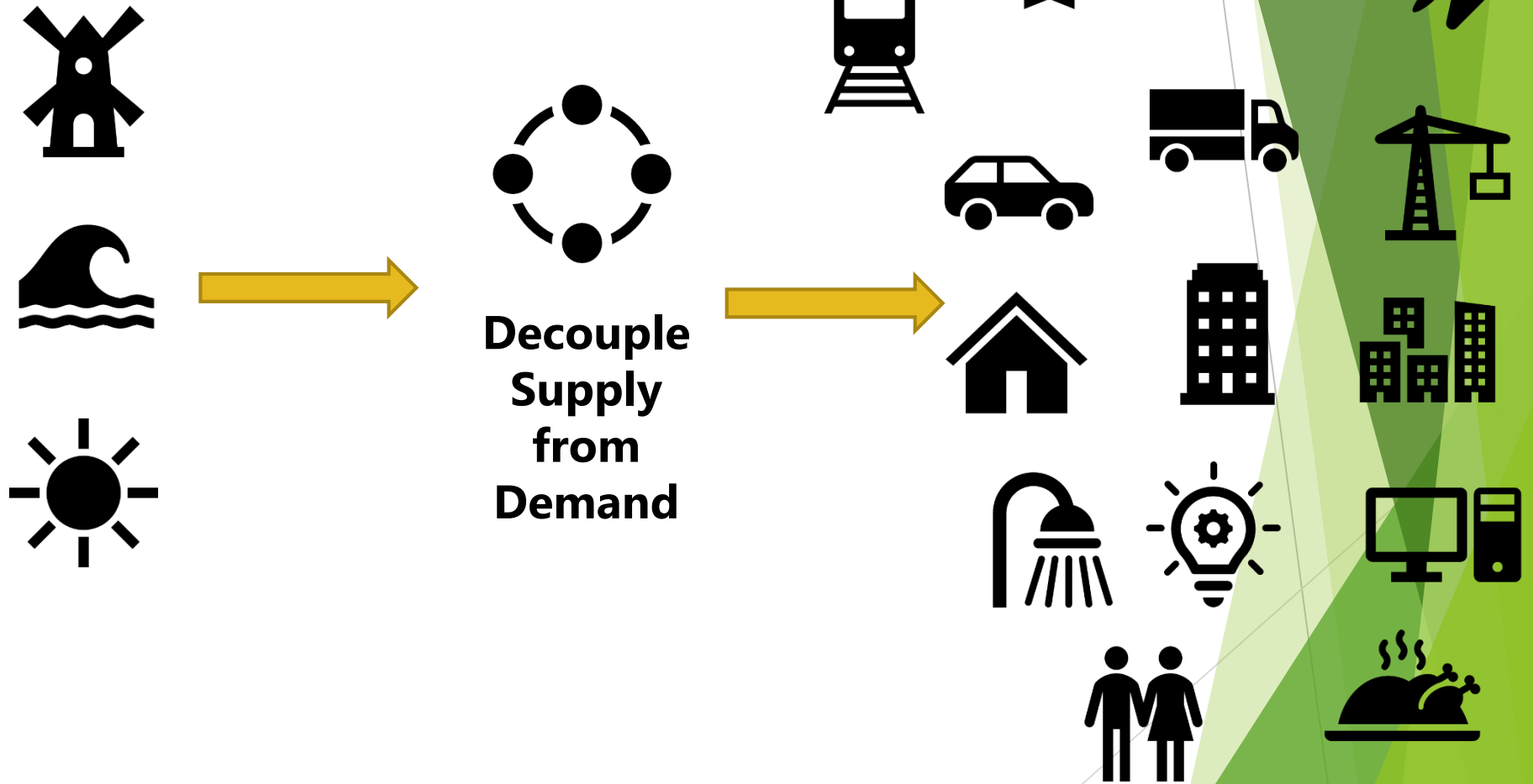
- Age of coal.
 - CCCCCC
- Age of oil.
 - CHCHCHCH
- Age of gas.
 - CH₄
- Age of hydrogen ?



AS WE MOVE TO A 100% RENEWABLE ENERGY LANDSCAPE, A KEY CHALLENGE IS TO DECOUPLE SUPPLY FROM DEMAND IN RENEWABLE ENERGY IN ORDER TO ACHIEVE ENERGY BALANCE.

THIS BECOMES IMPOSSIBLE TO MANAGE WITHOUT SIGNIFICANT STORAGE CAPACITY.

Universal Energy Vector





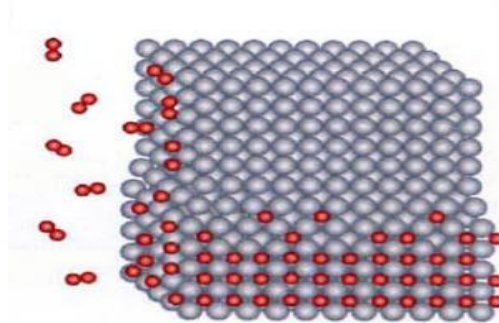
- ✓ By far the most abundant element in the universe (75%). However, on earth, it is not found practically free (but in compounds like water, hydrocarbons, etc.)
- ✓ The highest energy content per unit mass compared to any other known fuel (120.7 kJ/g, almost three times larger than gasoline).
- ✓ Clean combustion, produces water and electricity / heat.
- ✓ **Safety compared to gasoline**, diesel or natural gas.
- ✓ Decentralized energy production systems (can be produced in many ways anywhere).

The Hydrogen Economy

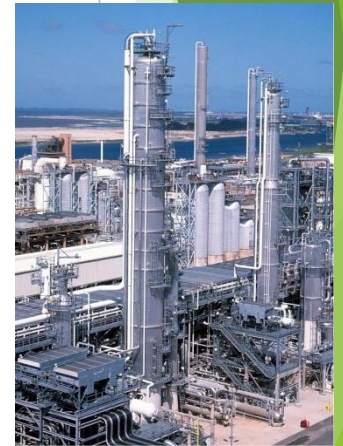
• PRODUCTION



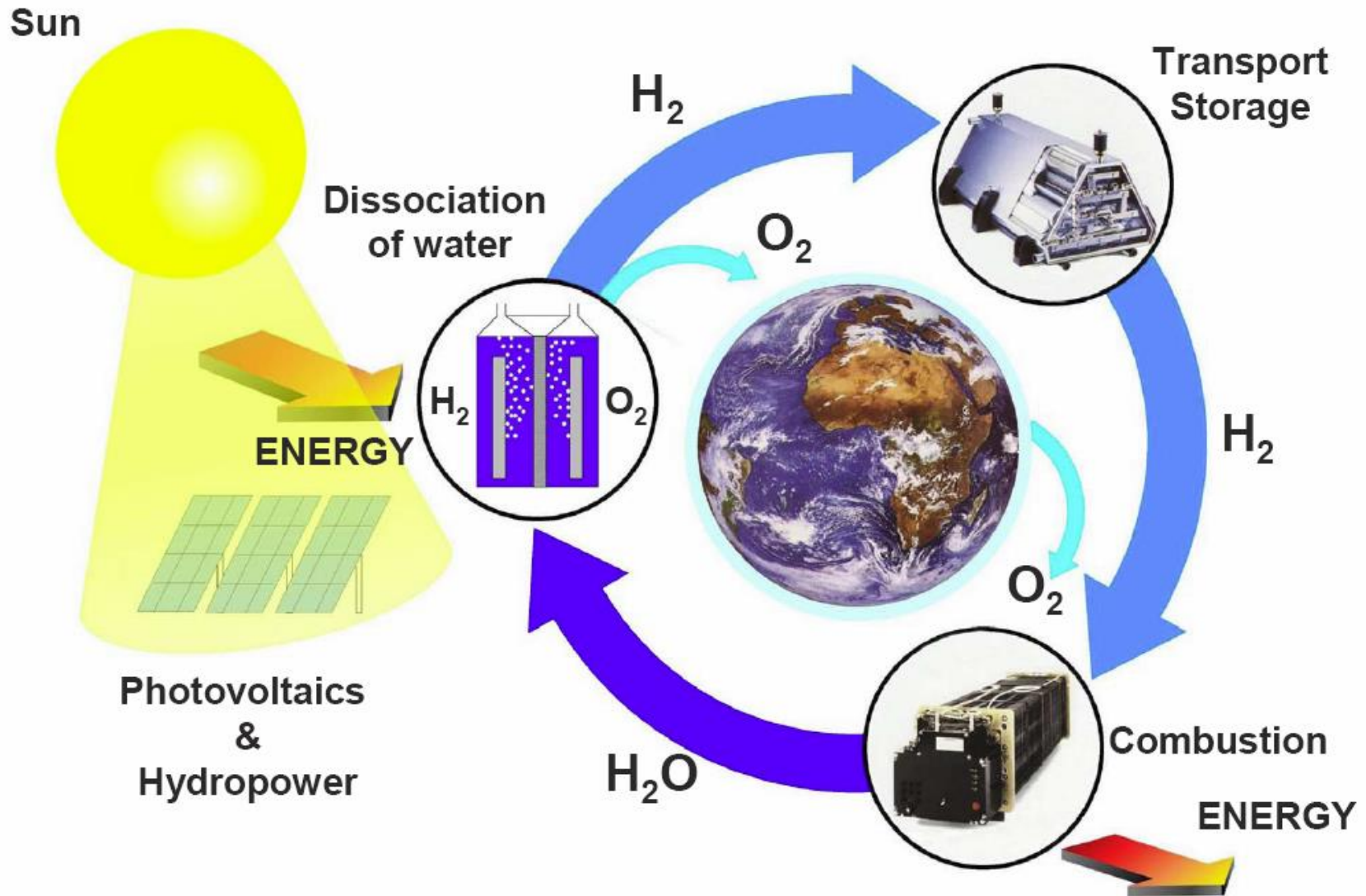
• STORAGE



• USE



The Hydrogen Cycle



EU Policies



EU Regulatory Framework: Fit for 55

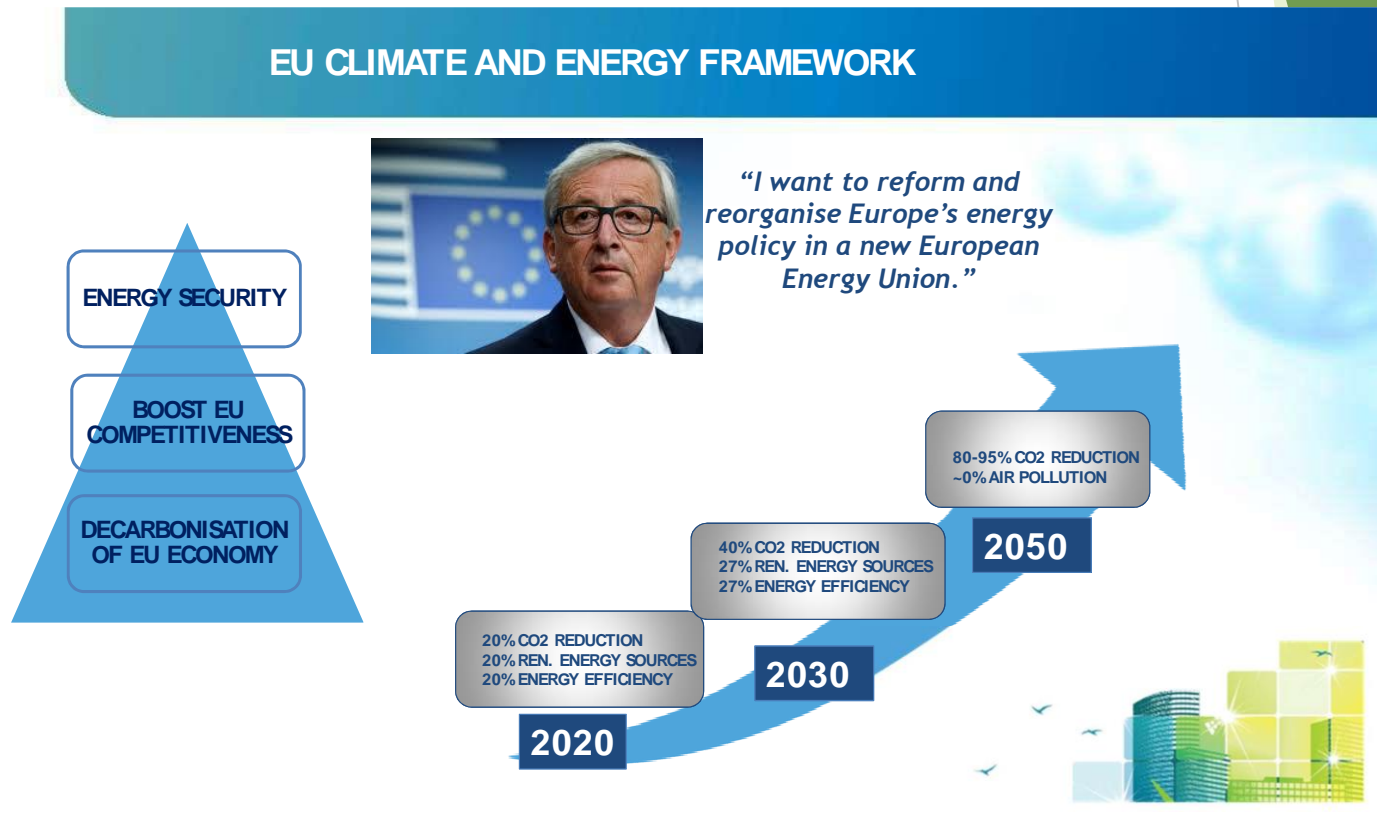
European climate law sets the reduction targets for net greenhouse gas emissions

- > Ultimate goal: climate-neutrality by 2050
- > Intermediate goal: reduce net GHG emissions by at least 55% by 2030, compared to 1990 levels

Fit for 55

- > Proposals to revise and update EU legislation
- > Framework for achieving the climate targets
 - New cars and vans on the market as of 2035 should have zero-emissions. Creation of a new, separate emissions trading system for road transport and building sectors
 - Hydrogen filling stations on main roads at least every 200 km (end of 2030) – denser network expected in urban areas

Decarbonisation - EU level



GLOBAL CO2 EMISSIONS BY SECTOR

Key targets for 2030 in the E.U.:

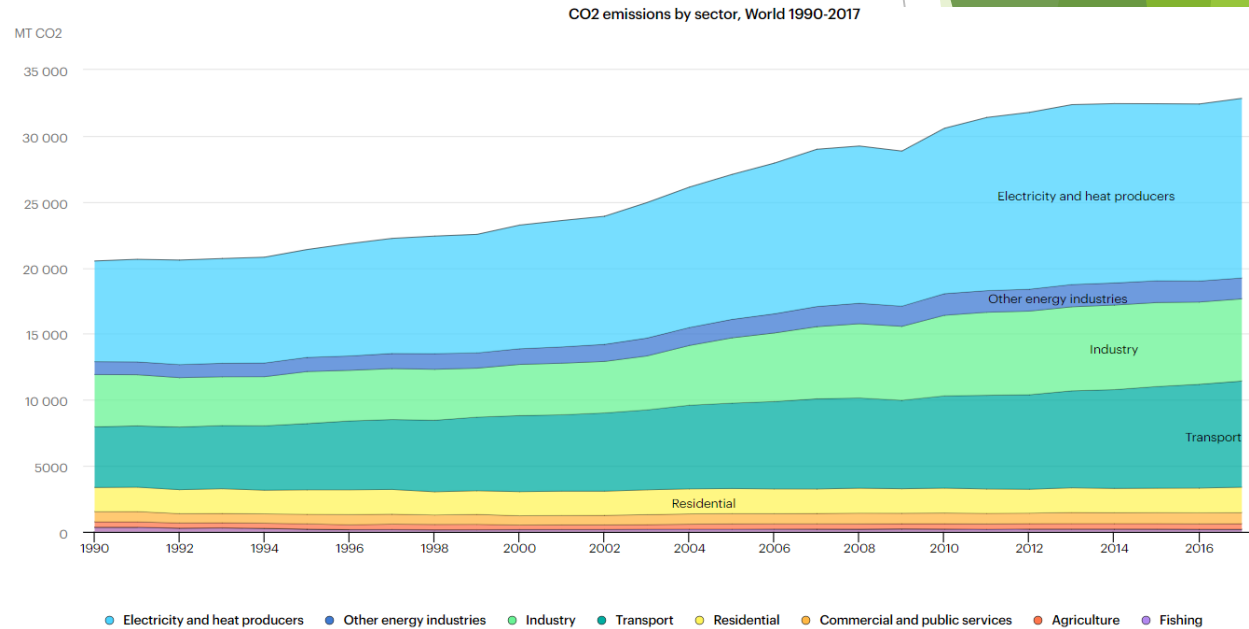
At least 40% cuts in **greenhouse gas emissions** (from 1990 levels)

At least 32% share for **renewable energy**

At least 32.5% improvement in **energy efficiency**

E.U. targets for Transportation Sector

- **30%** decrease of CO2 emissions by 2030
- **60%** decrease of CO2 emissions by 2050



“Water will be the coal of the future” - Cyrus Harding, 1874 - *hero of Jules Verne’s novel*
«*The Mysterious Island*»

150 years later, hydrogen economy is about to become a reality...



“... In developing and deploying a clean hydrogen value chain, Europe will become a global frontrunner and retain its leadership in clean tech.”

Executive Vice-President for the Green Deal, Frans Timmermans
8 July 2020

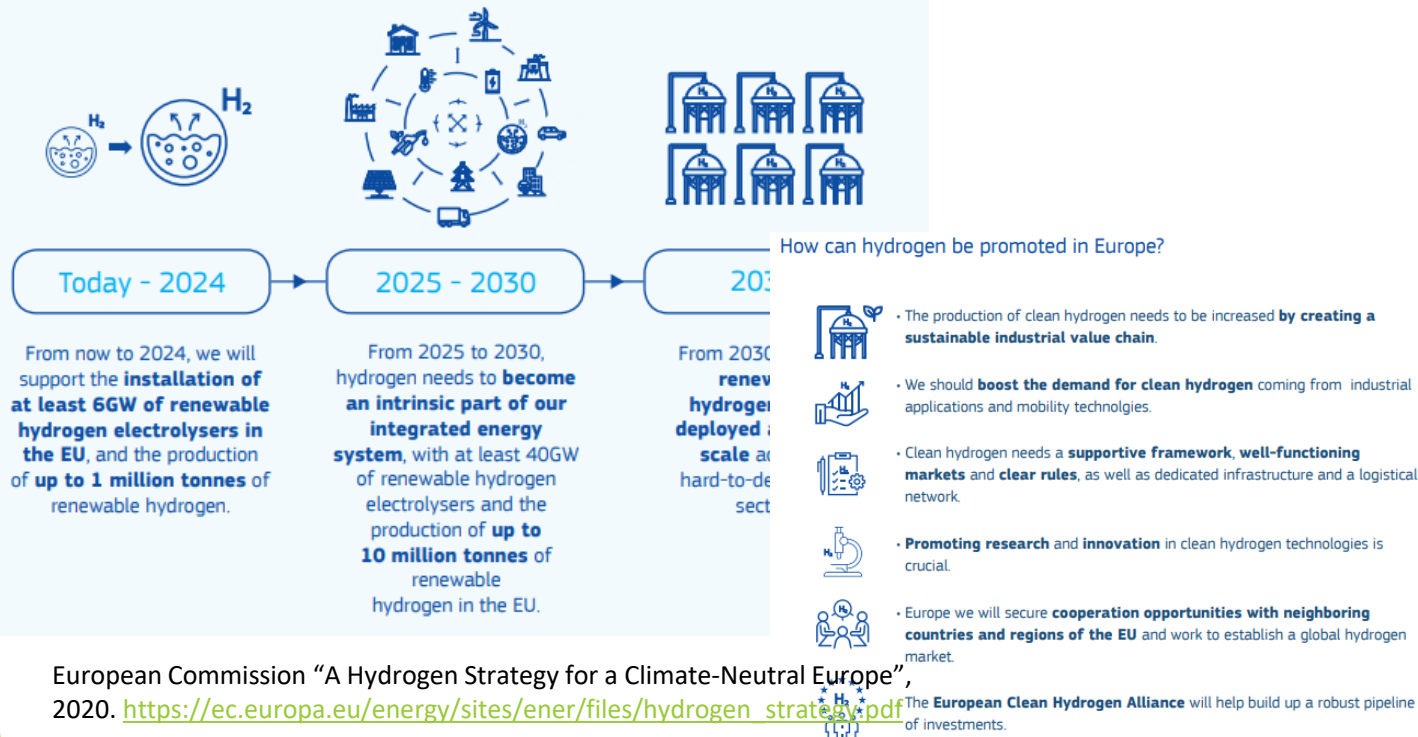
STATE OF THE UNION 2020

“I want Next Generation EU to create new European hydrogen valleys, to modernise our industries, to power our vehicles, and to bring new life to our rural areas”
EC President Ursula von der Leyen, 16 September 2020

The President further announced that 30% of the €750 billion #NextGenerationEU budget will be raised through green bonds. And 37% funding will be invested in European Green Deal objectives, including 'lighthouse' European projects – hydrogen, green building and 1 million electric charging points.

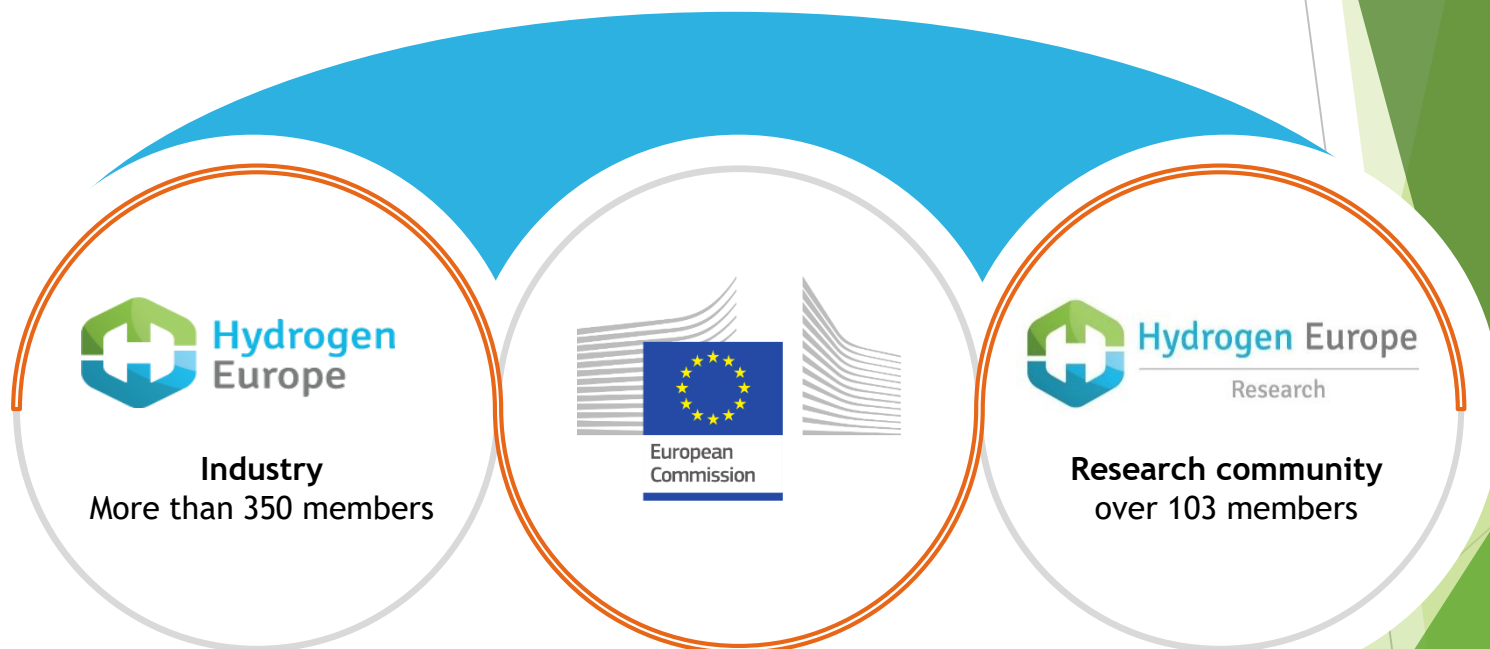
EU Position on Hydrogen

The path towards a European hydrogen eco-system step by step :



Clean Hydrogen Joint Undertaking

EU Institutional Public-Private Partnership (IPPP)



To facilitate the transition to a greener EU society through the development of hydrogen technologies



European Union represented by the
European Commission




**A portfolio of
clean, efficient and
competitive
solutions based on
fuel cells and
hydrogen
technologies in
energy and
transport**




Clean Hydrogen JU Objectives

Support a sustainable hydrogen economy, contributing to EU's climate goals




Support the implementation of the Commission's Hydrogen Strategy



Stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications



Strengthen the competitiveness of the EU clean hydrogen value chain



Contribute to the EU ambitious 2030 and 2050 climate ambition

EU Hydrogen Strategy launched on 8th July 2020

Objectives in 3 phases with the Hydrogen Alliance to support the investment agenda

Phase 1: 2020-2024

- 6GW of renewable H₂ electrolyser
- 1 million tonnes renewable H₂
- Replace existing H₂ production
- Regulation for liquid H₂ markets
- Planning H₂ infrastructure

Phase 2: 2025-2030

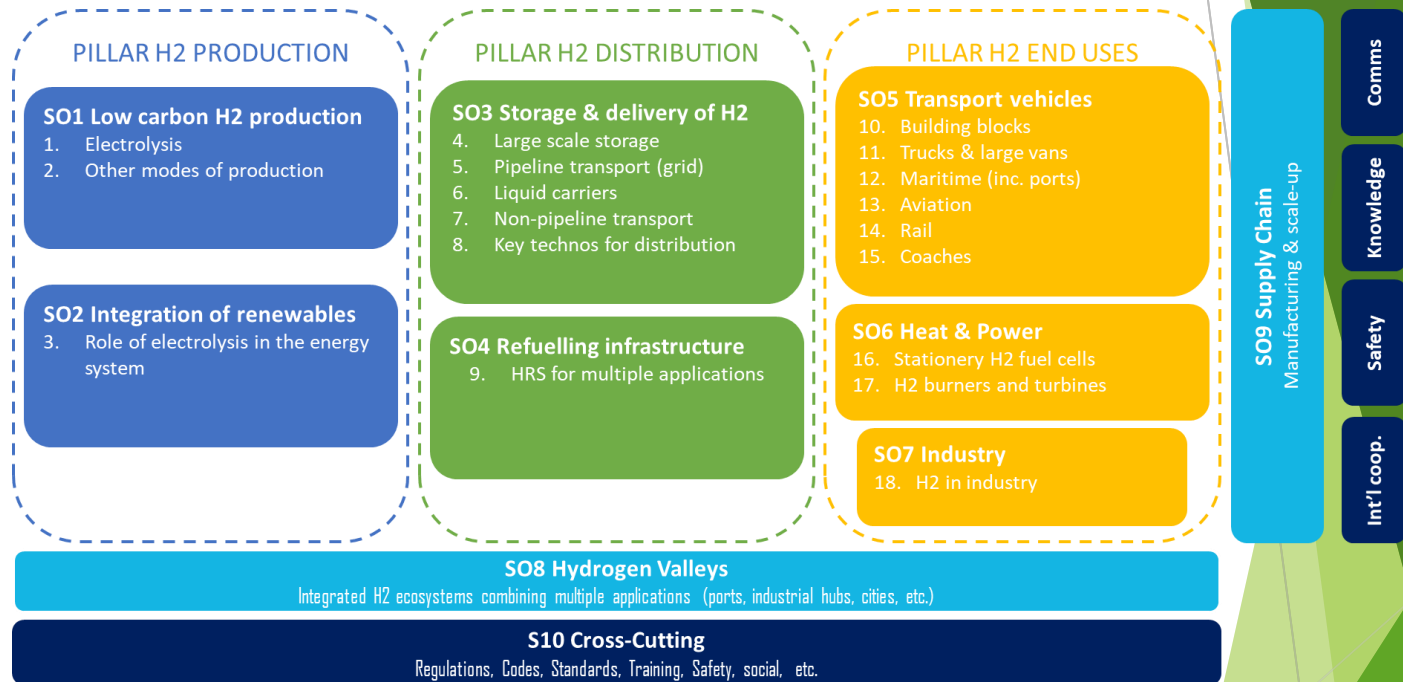
- 40GW renewable H₂ electrolyser
- 10 million tonnes renewable H₂
- New applications in steel & transport
- H₂ for electricity balancing purposes
- Creation of "Hydrogen Valleys"
- Cross-border logistical infrastructure

Phase 3: 2030-2050

- H₂ technologies matured and deployed at large scale in hard to abate sectors.
- Expansion of hydrogen-derived synthetic fuels
- EU-wide infrastructure network
- An open international market

Clean Hydrogen Alliance to support the EU investment agenda

Research and Innovation priorities in Clean Hydrogen JU



Co-funded by
the European Union

Research & Innovation Activities

