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Politecnico di Torino 1859

Towards energy autonomy: meet the challenges ahead.

An Infrastructure on Energy Transition Technologies in Piemonte.

Fabrizio Pirri
Istituto Italiano di Tecnologia e Politecnico di Torino

Cofinanziato dall'Unione europea

REGIONE PIEMONTE

Verso l'autonomia energetica: quali sfide per le Regioni
Towards energy autonomy: meet the challenges ahead
3|10|2022 Torino, Piemonte, Italy

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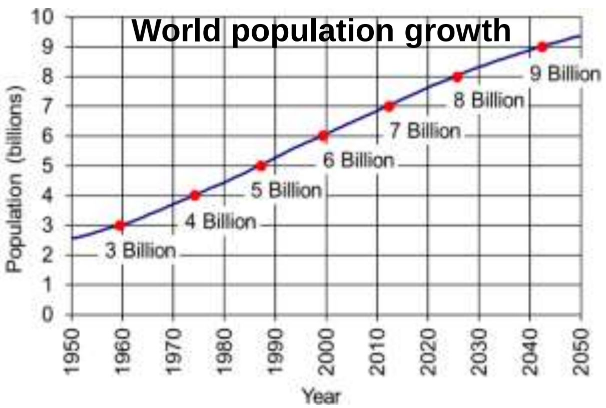
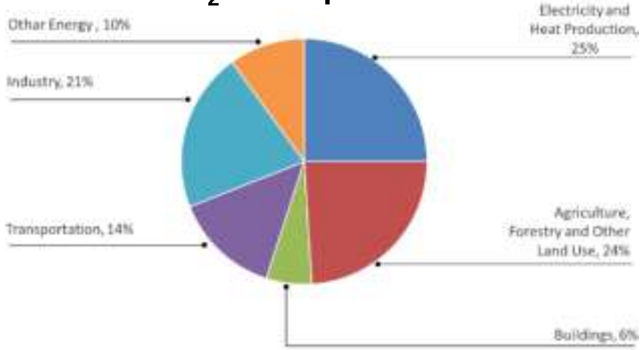
CENTRE FOR SUSTAINABLE FUTURE TECHNOLOGIES

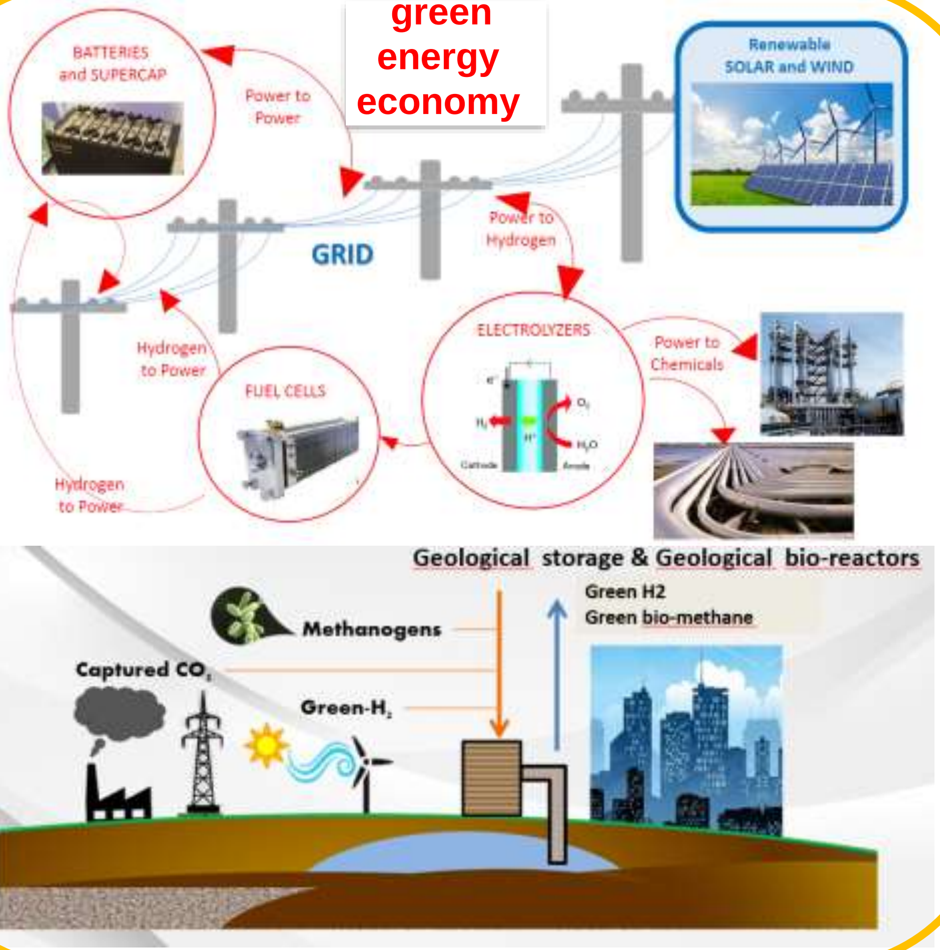
ORIGIN OF THE PROBLEMS



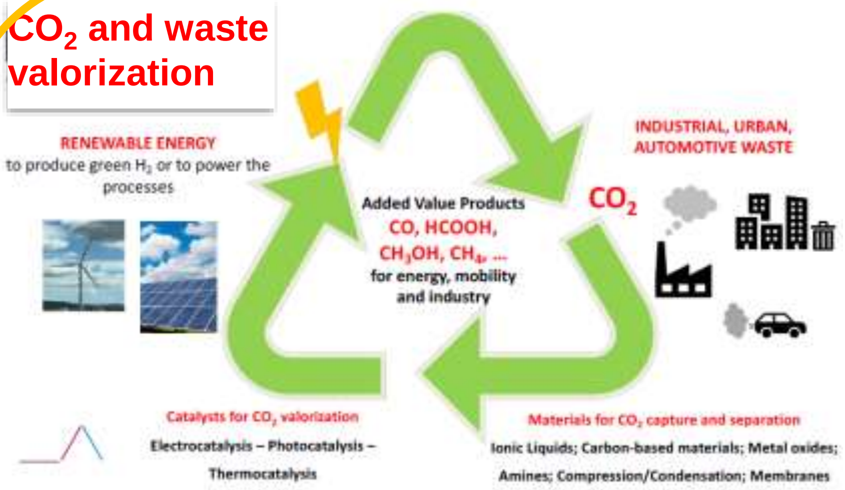
Total world energy consumption: 27 TW y

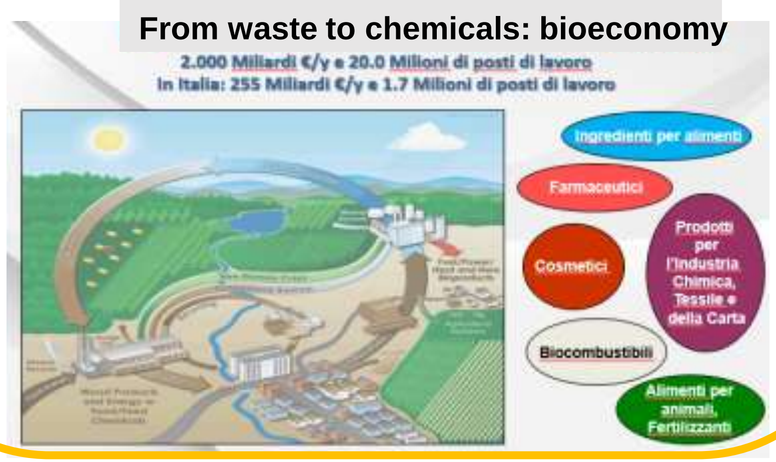
CO_2 world production



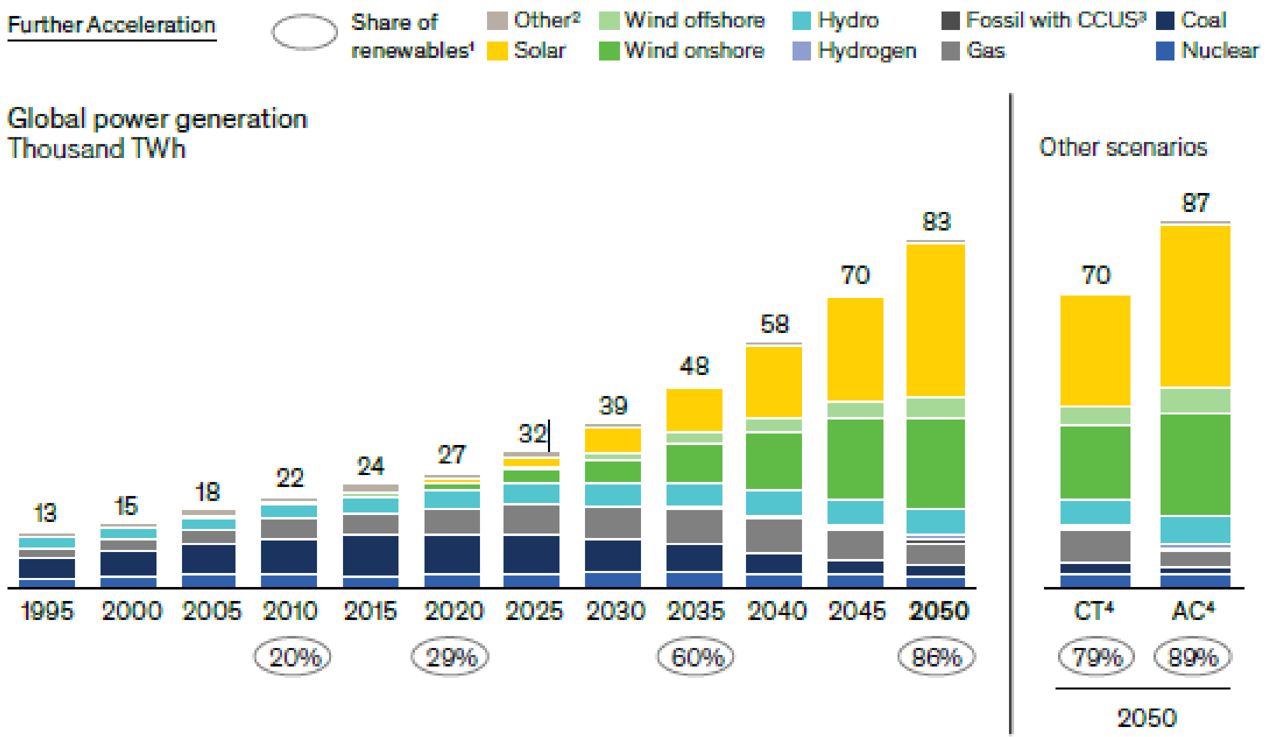


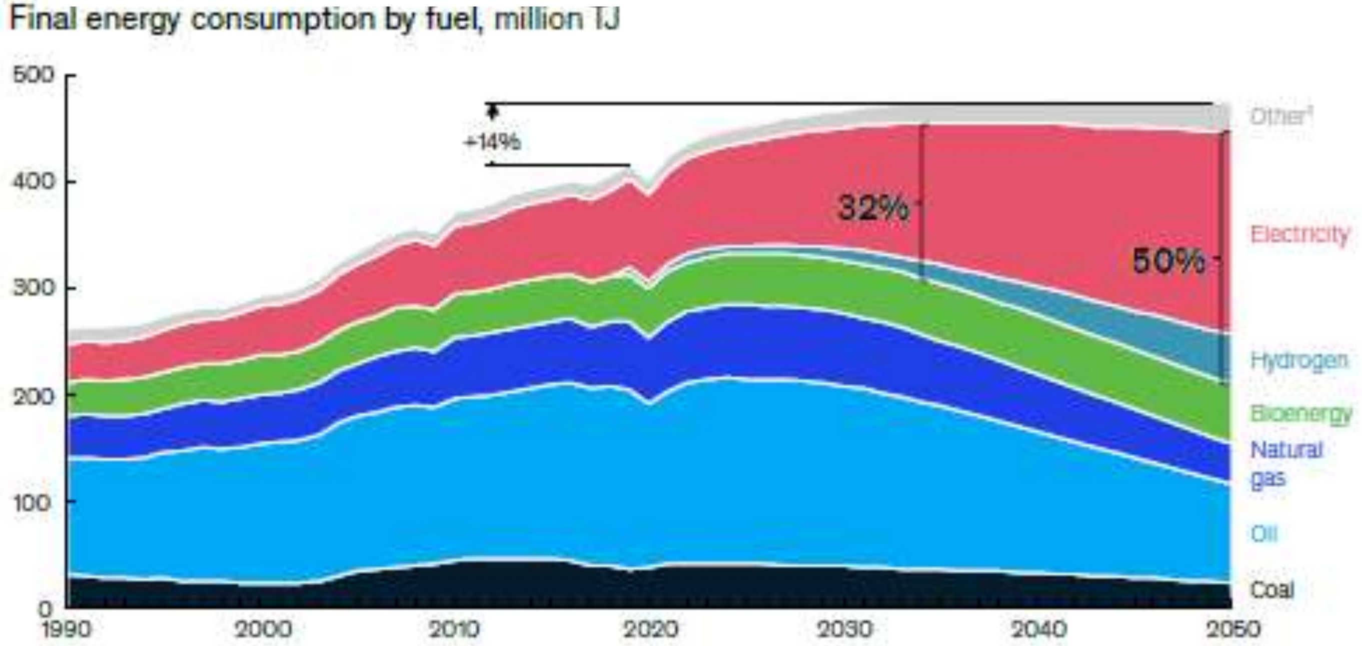
POSSIBLE TECHNOLOGICAL SOLUTIONS





Renewable Energies





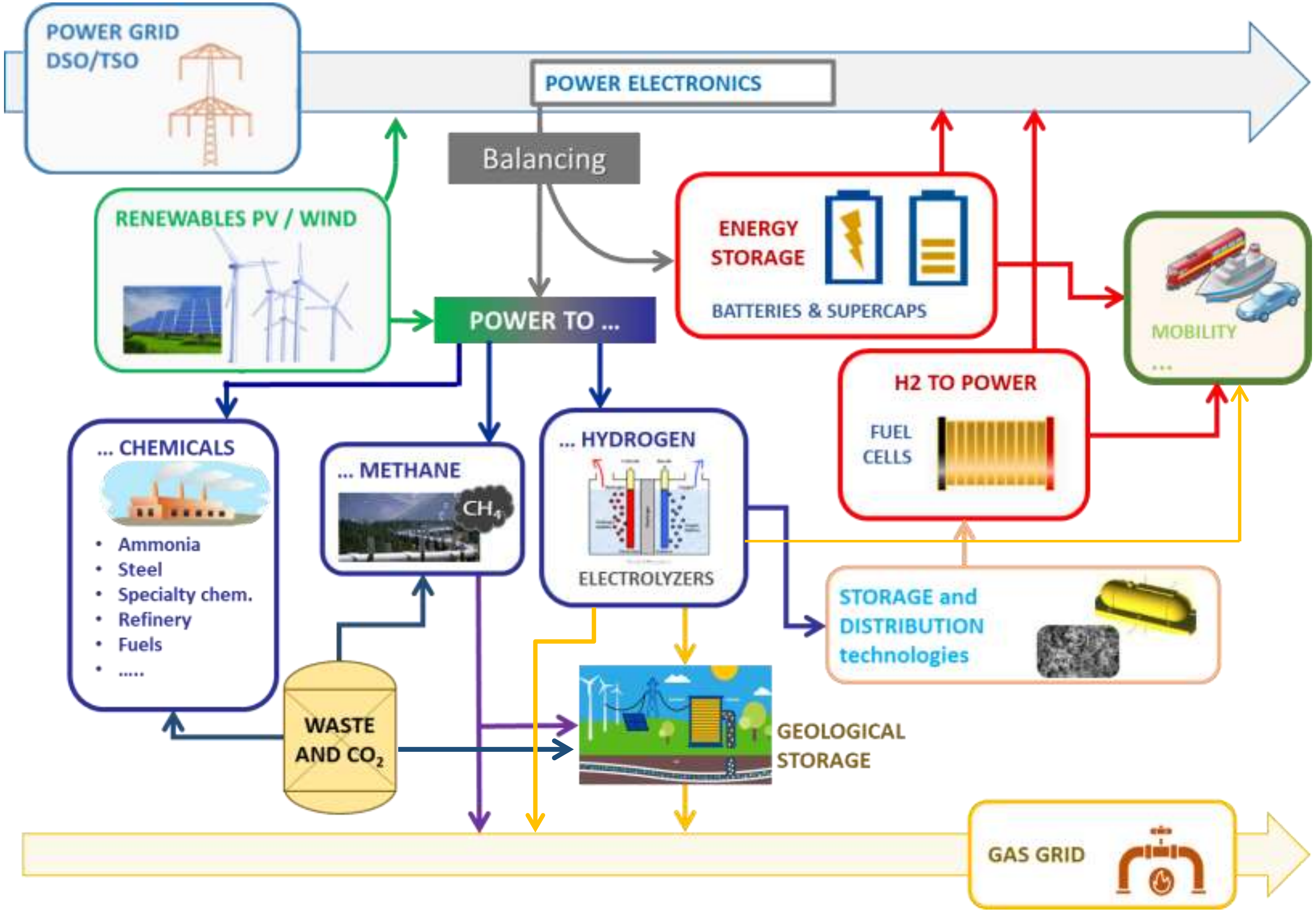
The new energy system

In the future economic and industrial context, r**<u>enewables, green fuels, energy carriers and green feedstocks (in particular hydrogen and e-chemicals) are destined to play a key role in advanced industrial societies</u>**.

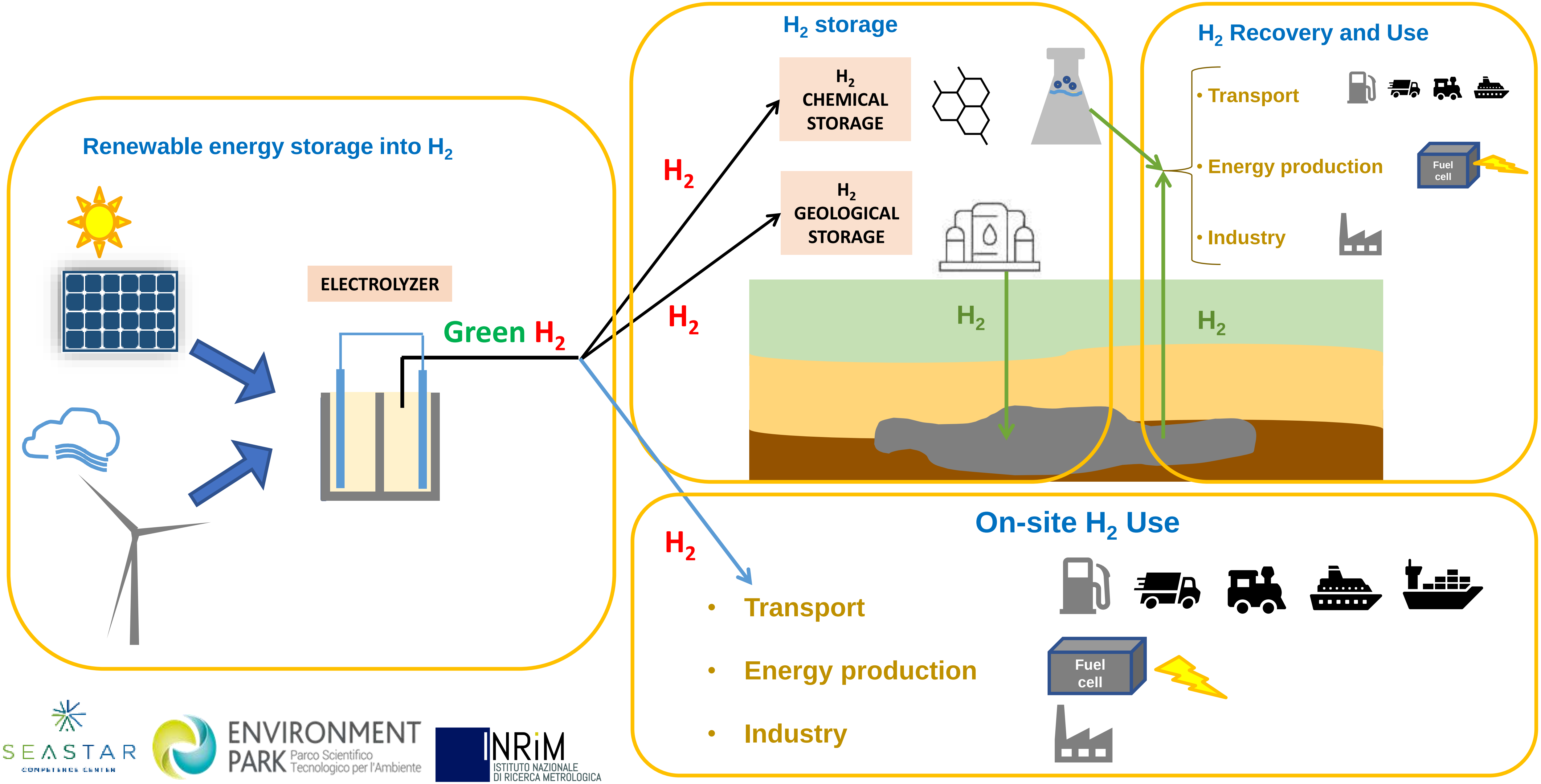
The represents the **interconnection of power & gas networks** new paradigm of energy production and distribution

From the production of **renewable energies and the use of CO2** it will be possible to derive fuels and molecules that can be used both for energy and industrial use.

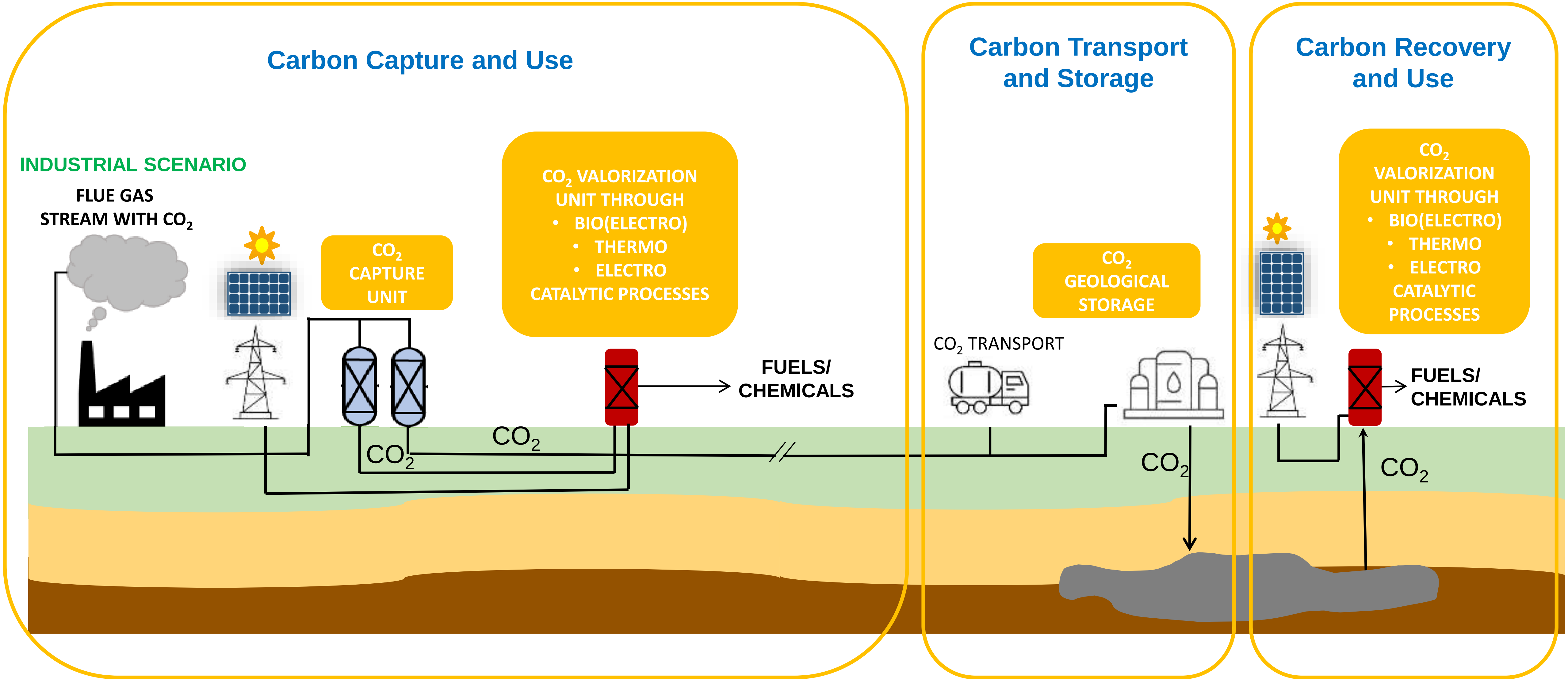
Energy storage is the key element that will maximize the efficiency of energy systems, the use of **clean energy in mobility** and a substantial **reduction of the use of fossil fuels.**



GREEN H_2 VALUE CHAIN



CO_2 VALUE CHAIN



CO_2 CAPTURE AND IMMEDIATE VALORIZATION INTO CHEMICALS AND FUELS

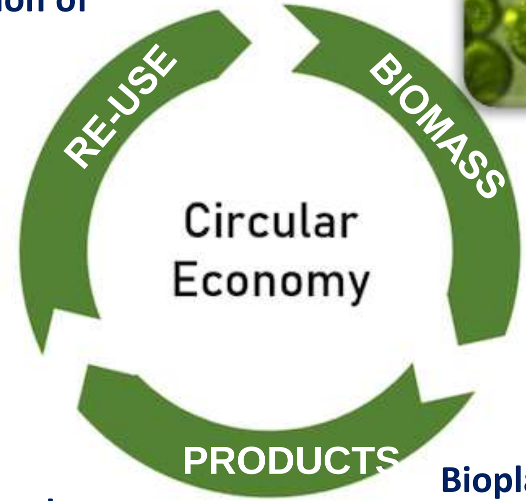
CO_2 TEMPORARY STORAGE

CO_2 VALORIZATION INTO CHEMICALS AND FUELS

Valorization of C-based waste for the production of valuable biomass

Liquid fraction of digestate

Dairy industry waste



Valuable microalgae biomass

High-value products (protein /fatty acids/pigments)

Bioplastic precursors
Biofertilizers
Animal Feeds

Technology Innovation to Accelerate Energy Transitions

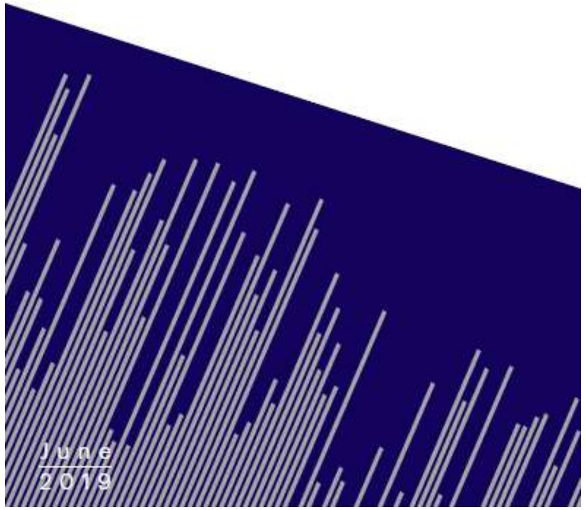


Figure 9. Energy R&D expenditure in the public sector

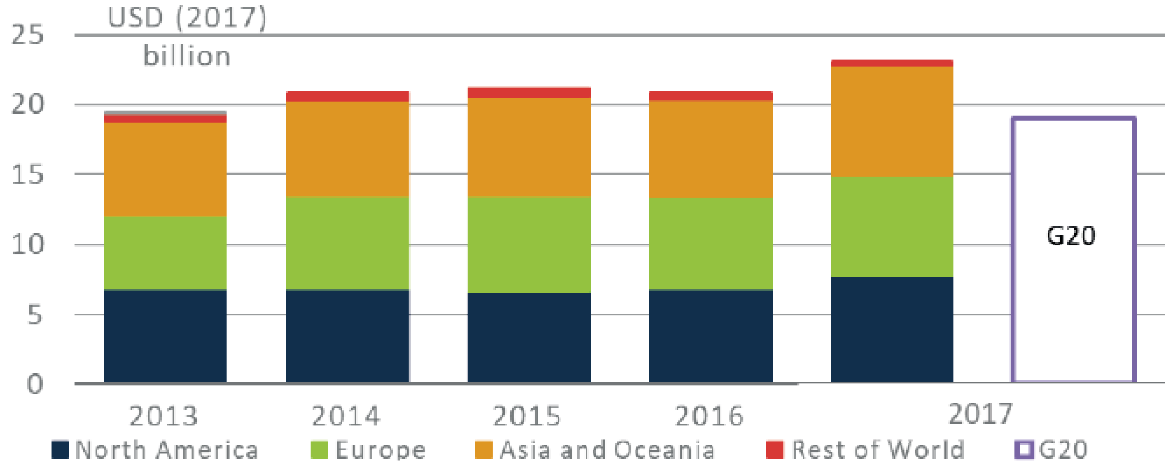
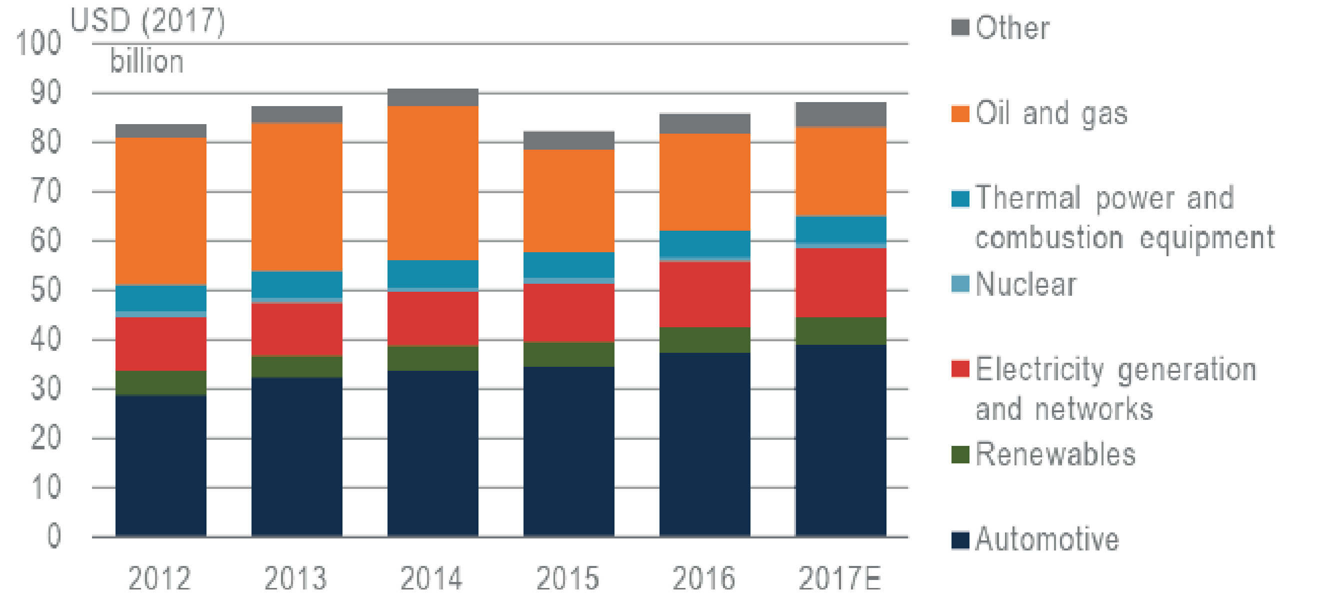


Figure 10. Private-sector investment in energy R&D, by subsector of investing company



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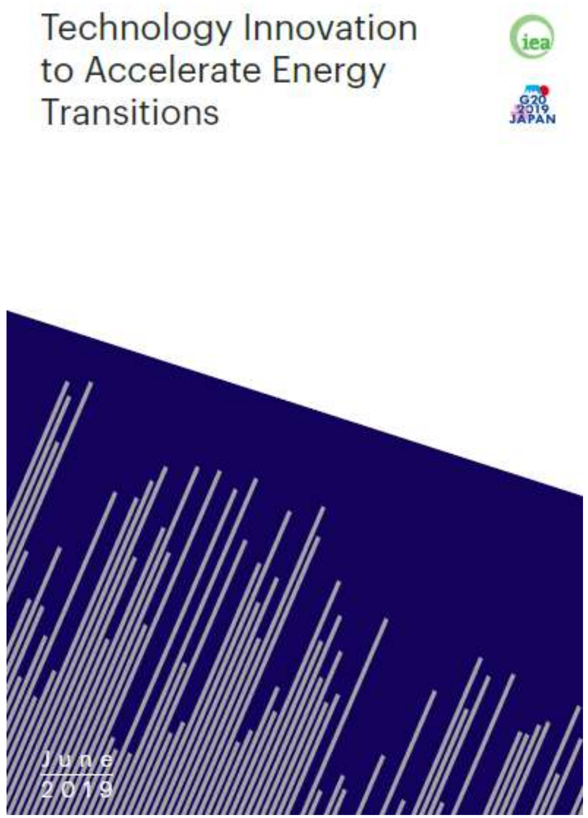

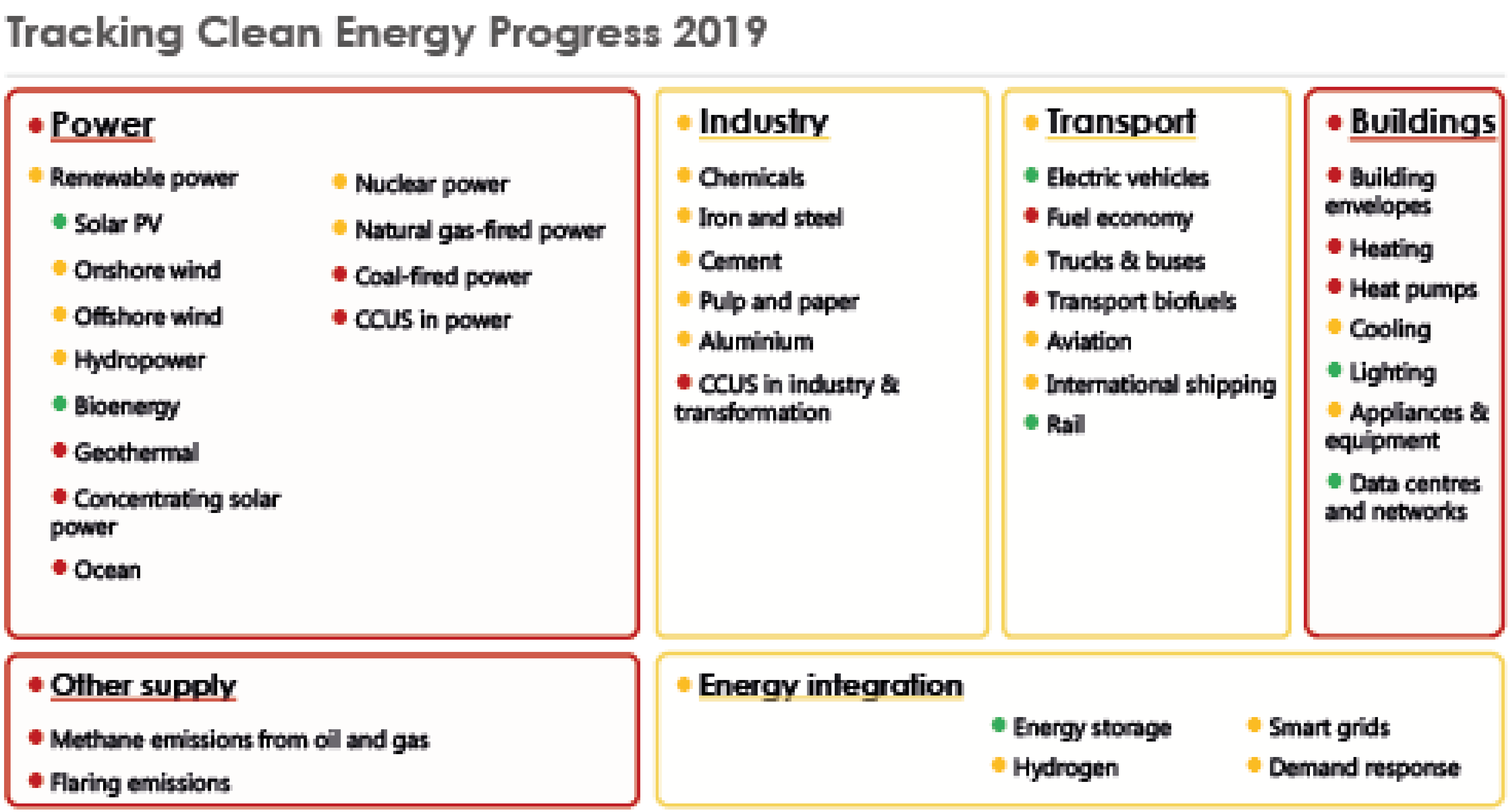

The online IEA publication, *Tracking Clean Energy Progress* (*TCEP*), assesses policy, investment, deployment and innovation progress in 43 sectors and technologies, rating them green if on track with the transition, yellow if further efforts are needed and red if fully not on track.

<u>GREEN POWERED FUTURE</u> The Challenge: Variable renewable energy, such as solar and wind, is already the lowest-emission and lowest-cost form of electricity generation in many regions, but its inherent intermittency limits the potential for electricity systems to integrate very high levels of renewable power. The Goal: ***<u>To demonstrate that by 2030 power systems in different geographies and climates are able to effectively integrate up to 100% variable renewable energies in their generation mix and maintain a cost-efficient, secure and resilient system</u>***. The Mission: Through large-scale demonstrations and enhanced investments in research and development, we will develop a toolbox of innovative solutions to provide confidence that all countries can build a renewable-powered future and realise an affordable clean energy transition.

<u>CLEAN HYDROGEN</u> The Challenge: Clean hydrogen has the potential to decarbonise hard to reach sectors, such as industry and heat, which are responsible for two thirds of global emissions and help unlock the full potential of renewable energy. However, today it is up to three times more expensive than hydrogen produced from fossil fuels. The Goal: ***<u>To make clean hydrogen cost competitive by reducing the cost to end users to USD $2 per kilogram by 2030</u>***. The Mission: We will catalyse cost reductions by increasing research and development in hydrogen technologies and industrial processes and delivering at least 100 hydrogen valleys across production, storage and end-use worldwide by 2030, to unleash a global clean hydrogen economy.

<u>ZERO-EMISSIONS SHIPPING</u> The Challenge: International shipping transports 90% of the world's goods and is responsible for 3% of global emissions, potentially increasing by half by 2050 on its current trajectory. To set international shipping on an ambitious zero emission trajectory, we need commercially viable, zero-emission ocean-going vessels in the global fleet by 2030. The Goal: For ships capable of running on zero-emission fuels to make up at least 5% of the global deep-sea fleet by 2030. The Mission: We will crystalize an ambitious alliance between countries, the private sector, research institutes and civil society to develop, demonstrate, and deploy zeroemission fuels, ships, and fuel infrastructure together by 2030 and make zero-emission ocean going shipping the natural choice for ship owners.

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Energy Technology Perspectives 2020

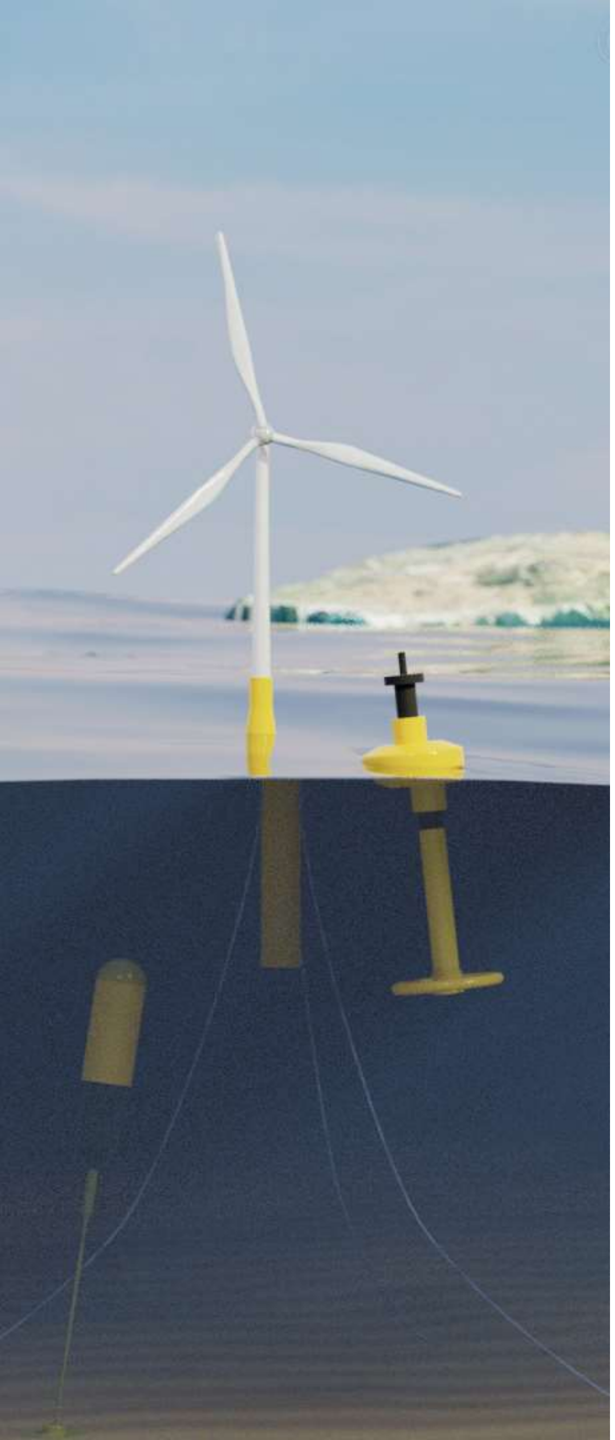
Spreading the use of electricity into more parts of the economy is a contributor to reaching net-zero emissions. In the Sustainable Development Scenario, final electricity demand more than doubles. This growth is driven by using electricity to power cars, buses and trucks; to produce recycled metals and provide heat for industry; and to supply the energy needed for heating, cooking and other appliances in buildings.

Carbon capture and bioenergy play multifaceted roles. Capturing CO2 emissions in order to use them sustainably or store them is a crucial technology for reaching net-zero emissions. In the Sustainable Development Scenario, CCUS is employed in the production of synthetic low carbon fuels and to remove CO2 from the atmosphere. At the same time, the use of modern bioenergy triples from today's levels. It is used to directly replace fossil fuels (e.g. biofuels for transport) or to offset emissions indirectly through its combined use with CCUS.

A secure and sustainable energy system with net-zero emissions results in a new generation of major fuels. The security of today's global energy system is underpinned in large part by mature global markets in three key fuels – coal, oil and natural gas – which together account for about 70% of global final energy demand. Electricity, hydrogen, synthetic fuels and bioenergy end up accounting for a similar share of demand in the Sustainable Development Scenario as fossil fuels do today.

Quicker progress towards net-zero emissions will depend on faster innovation in electrification, hydrogen, bioenergy and CCUS. Just over one-third of the cumulative emissions reductions in the Sustainable Development Scenario stem from technologies that are not commercially available today. In the Faster Innovation Case, this share rises to half. Thirty-five percent of the additional decarbonisation efforts in the Faster Innovation Case come from increased electrification, with around 25% coming from CCUS, around 20% from bioenergy, and around 5% from hydrogen.

Long-distance transport and heavy industry are home to the hardest emissions to reduce. Energy efficiency, material efficiency and avoided transportation demand (e.g. substituting personal car travel with walking or cycling) all play an important role in reducing emissions in long-distance transport and heavy industries. But nearly 60% of cumulative emissions reductions for these sectors in the Sustainable Development Scenario come from technologies that are only at demonstration and prototype stages today. Hydrogen and CCUS account for around half of cumulative emissions reductions in the steel, cement and chemicals sectors. In the trucking, shipping and aviation sectors, the use of alternative fuels – hydrogen, synthetic fuels and biofuels – ranges between 55% and 80%. Fortunately, the engineering skills and knowledge these sectors possess today are an excellent starting point for commercialising the technologies required for tackling these challenges.

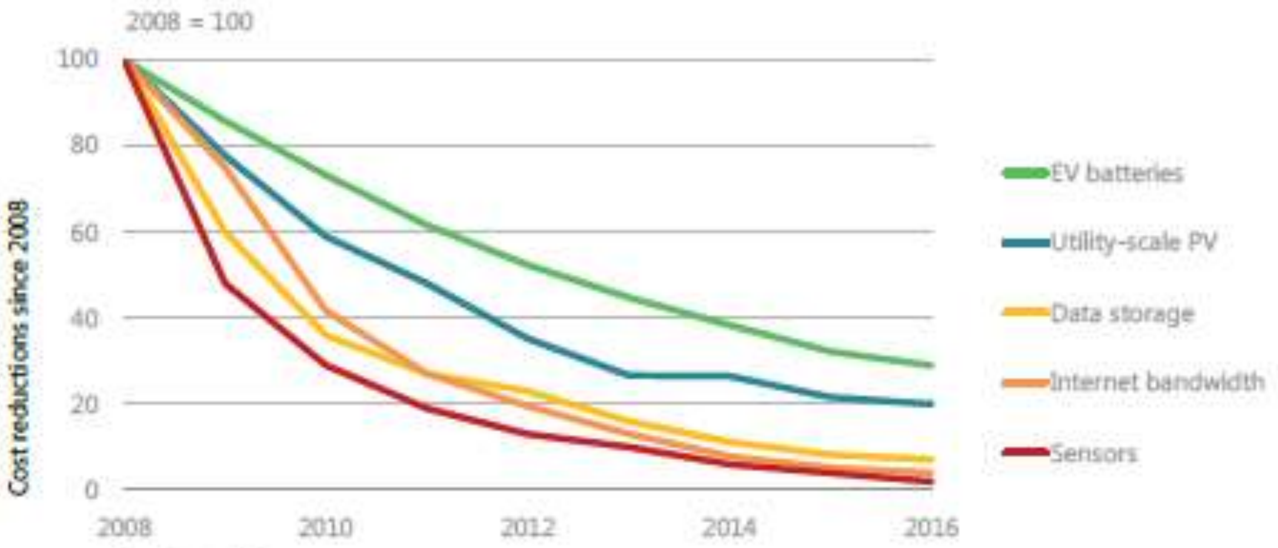


Renewables

Renewable energy is considered the cornerstone for the energy transition to a sustainable economy and climate protection. According to the European Union, **renewable energy penetration is expected to reach 32% by 2030**. The International Energy Agency reports that renewable energy was the only source that saw **growth in demand in 2020**, despite the COVID-19 pandemic inducing a macroeconomic shock. Based on modern trends and market studies, **renewable technologies represent promising path to full decarbonization and to energy autonomy.**

Research and experimentation infrastructures for the above mentioned technologies are essential to offer advanced technological tools and services to the academic and business world aimed at accelerating the industrialization of these devices and subsystems.

Figure 6. **Speed of cost reductions in key energy sector technologies, against those in the digital sector**



Note: EV = electric vehicle.

Source: Based on BNEF (2017), *Utilities, Smart Thermostats ans the Connected Home Opportunity*; Holdowsky et al. (2015), *Inside the Internet of Things*; IEA (2017), *Renewables*; *Tracking Clean Energy Progress*; *World Energy Investment*, Navigant Research (2017), *Market Data: Demand response*. Global Capacity, Sites, Spending and Revenue Forecasts.

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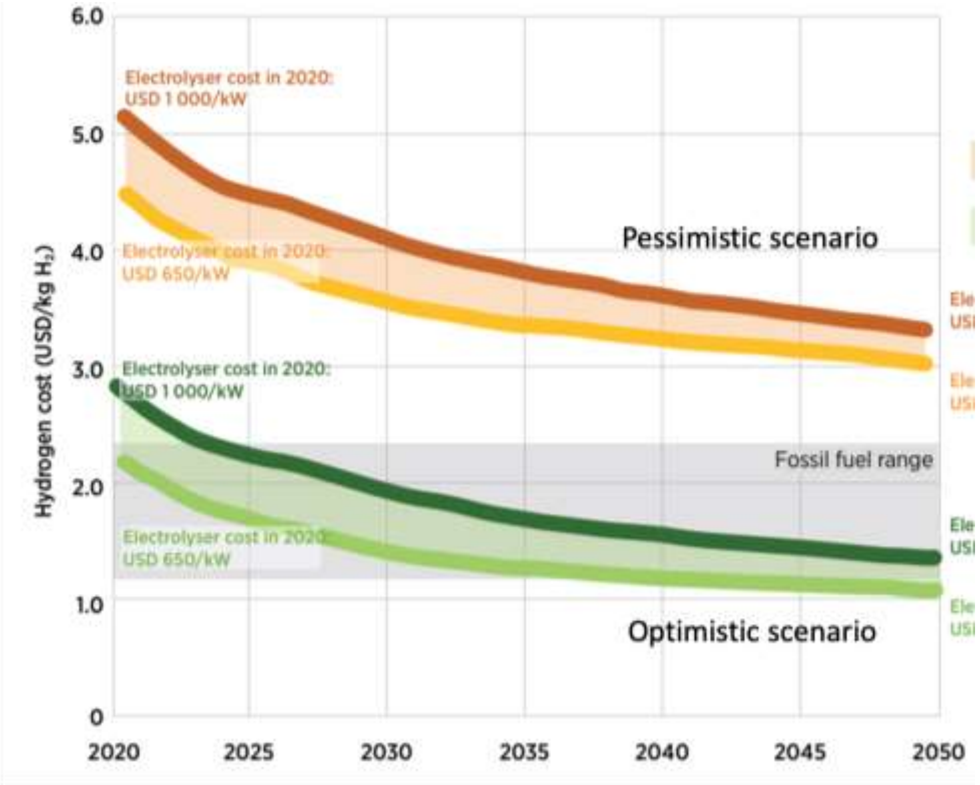
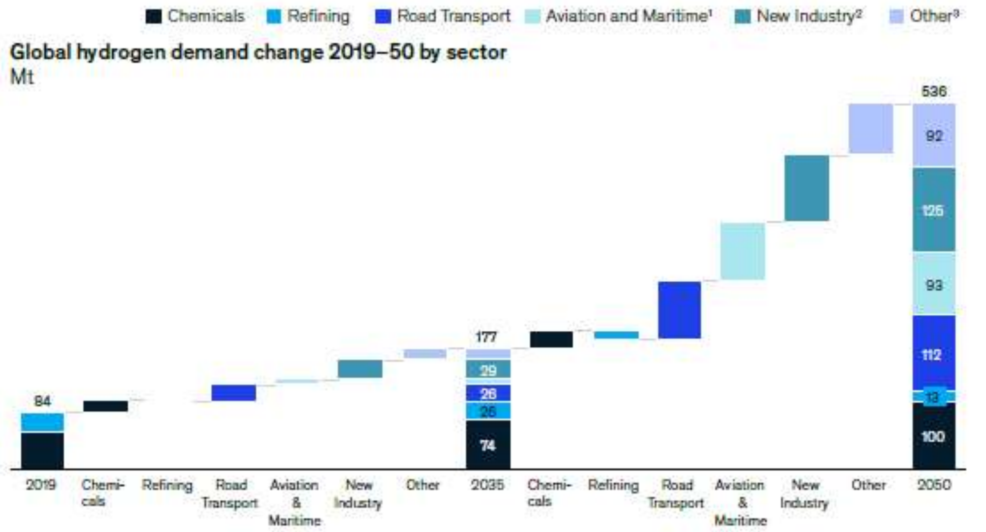
Hydrogen

The EU Hydrogen Strategy has set a renewable hydrogen **<u>production target for 2030 at 10 million tons/year.</u>** This is almost equivalent to the current total hydrogen production capacity of 10.5 Mt/year that has been developed over several decades. Total hydrogen demand in industry (steel mills, chemicals, fuels) **will reach 5.2 Mt H2/year** in the EU by 2030. In addition mobility (starting from heavy duty applications) and energy uses will express an increasing demand for green hydrogen. Besides production, technologies for hydrogen to energy conversion (**in particular fuel cells**), will see a very strong growth in terms of demand and will form the basis of new production chains.

<u>These data underline the importance of acting in support of the national industry to develop "Made in Italy" solutions for the production and conversion of Green H2, bridging the current industrial gap that our country suffers against its main competitors.</u>





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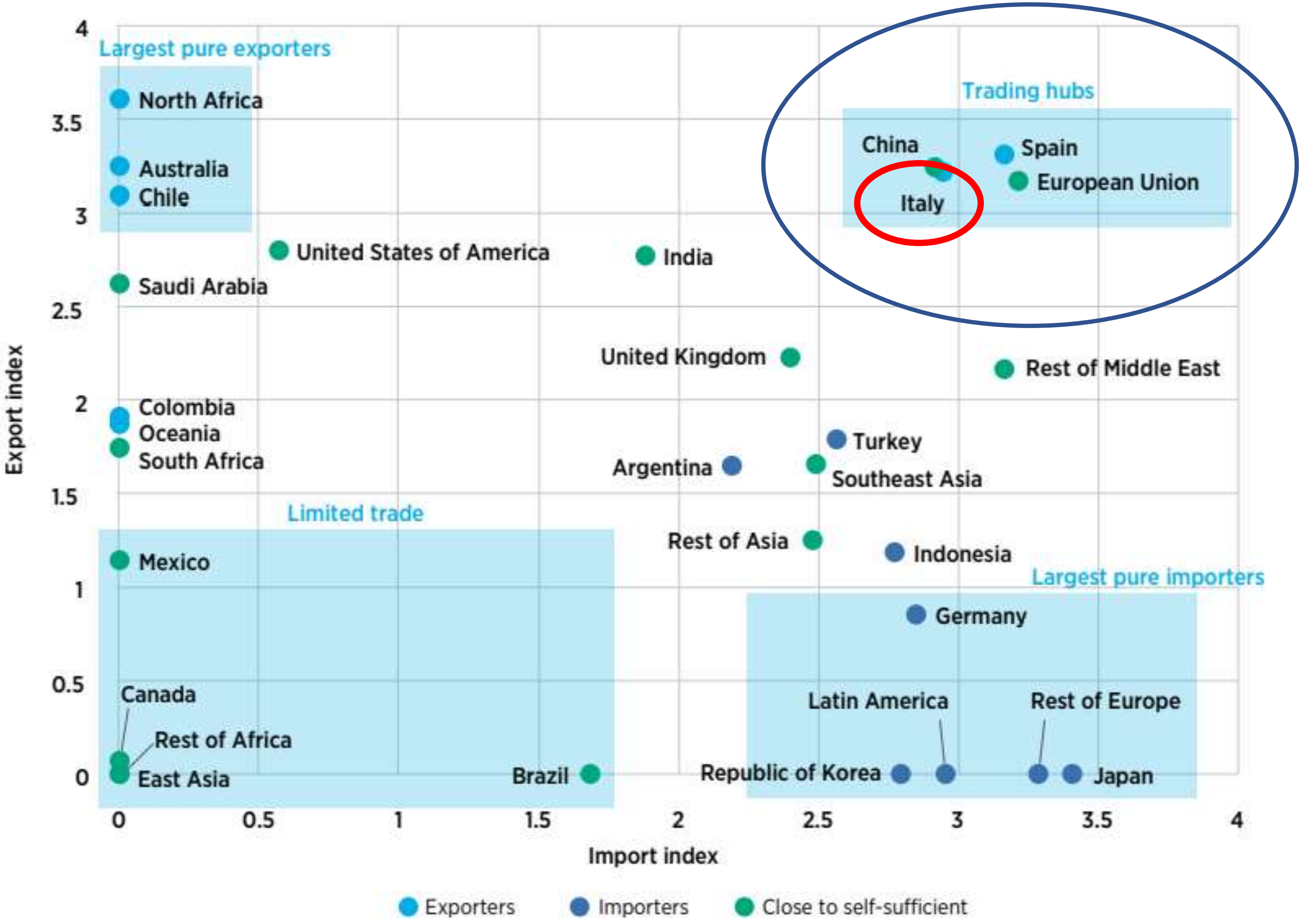
VOLUMES OF HYDROGEN EXPORT AND IMPORT AROUND THE WORLD IN 2050 WITH OPTIMISTIC TECHNOLOGY ASSUMPTIONS



Source: IRENA – International Renewable Energy Agency 2021/2022

Fuels from CO2 and waste

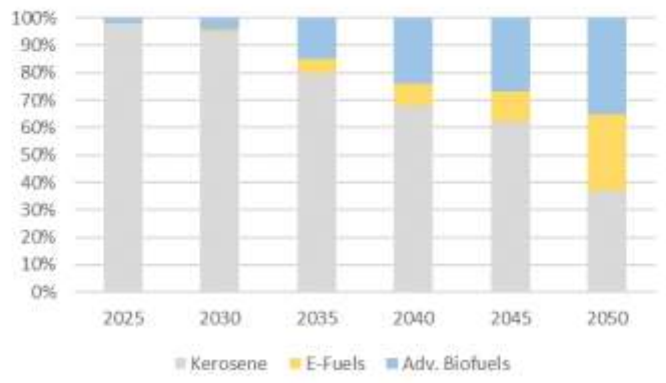
Achieving the EU's CO_2 emission reduction targets requires the use of "new" fuels of non-fossil origin. For example, in the aviation sector alone, the new EU regulation "Re-Fuel Aviation" requires that by 2050 63% of fuels used in aviation will be "sustainable" (SAF - Sustainable Aviation Fuels), i.e. **conventional biofuels and synthetic fuels** (**advanced biofuel** and **e-fuel**), with an estimated production capacity of **26 Mt/y by 2050 and a planned investment of 88 billion Euros**.

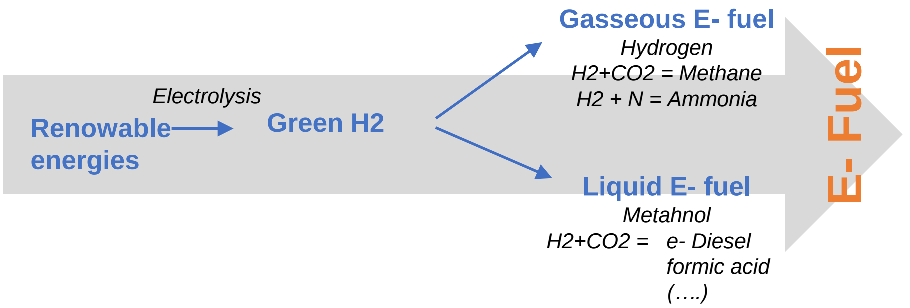
The activities of the research infrastructure will accompany fuel companies in the **development of technological solutions for the production of SAF**, both derived from organic wastes and synthesized from anthropogenic CO_2 and green hydrogen.

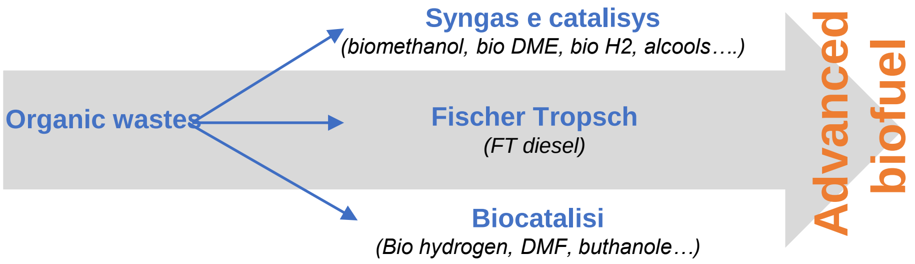
Therefore, the importance of acting in support of the national industry to **develop "Made in Italy" solutions for the capture and valorization of CO2/waste represents a fundamental step that can ensure in the near future to Italy a role of European and global leadership in the sector**.

Regulation of ReFuelEU Aviation

Mandatory adoption of sustainable aviation fuels (SAF) - % of EU internal consumption







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' TRANSACTION RELEASES

21 June 2022

First flight in history with 100% sustainable aviation fuel on a regional commercial aircraft

Published in Releases and news under Renewable solutions, Aviation
Neste MY Sustainable Aviation Fuel

Neste Corporation, Press Release, 21 June 2022 at 2.00 p.m. (EET)

CCU or CO_2 conversion technologies require two essential inputs: CO_2 and Energy:

A) CO_2

Carbon dioxide is currently emitted from various industries, such as the power, chemicals, cement and steel sectors but also from biological fermentation processes such as biogas facilities. All existing sources can be used to capture and provide the CO_2 as long as it is ecologically reasonable. Longer term innovations include the capture of CO_2 directly from the atmosphere (direct air capture).

B) Energy

Technologies that convert CO_2 into fuels or chemicals typically require energy input in the form of either:

- heat
- electricity to power the process or produce hydrogen via electrolysis from water, or
- solar radiation (e.g. to grow algae)

Such energy should be produced from renewable sources or at least have the lowest environmental footprint (e.g. waste heat that is currently being dumped).

For technologies that convert CO_2 into mineral materials, only very small amounts of energy input are required, because the chemical reaction that transforms CO_2 into carbonates is naturally exothermic (i.e. it generates heat).

C) Water

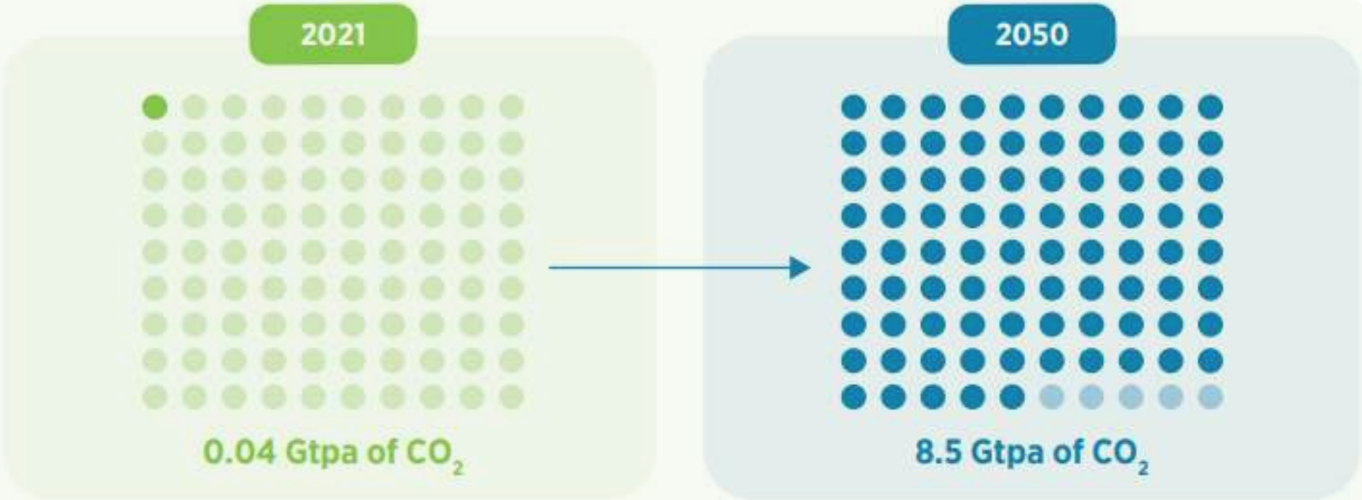
For the production of fuels and chemicals, water is also required.

www.co2value.eu

Source: IRENA – International Renewable Energy Agency 2021

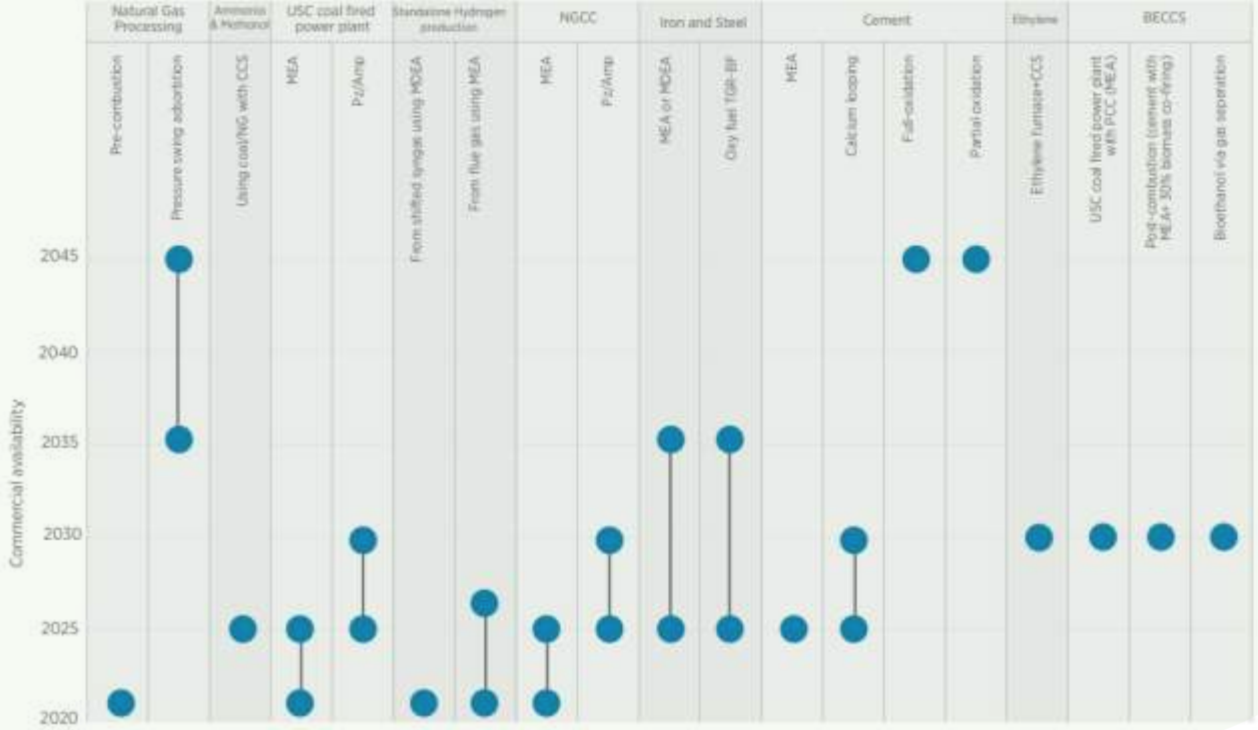
CO_2 CAPTURE

GLOBAL CARBON CAPTURE INSTALLED CAPACITY



FORECAST INVESTMENTS: 2 TRILLIONS USD

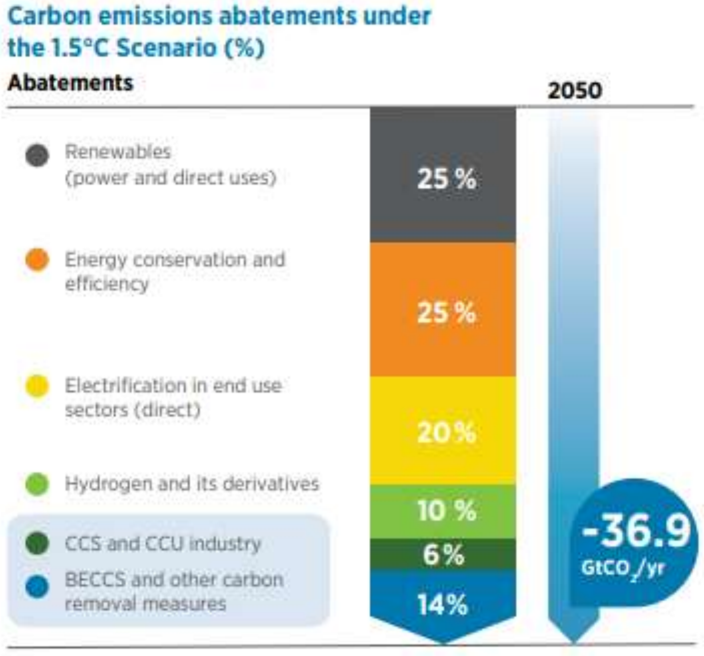
Commercial availability of CO_2 capture technologies



CO_2 STORAGE

Cost estimates for onshore and offshore storage

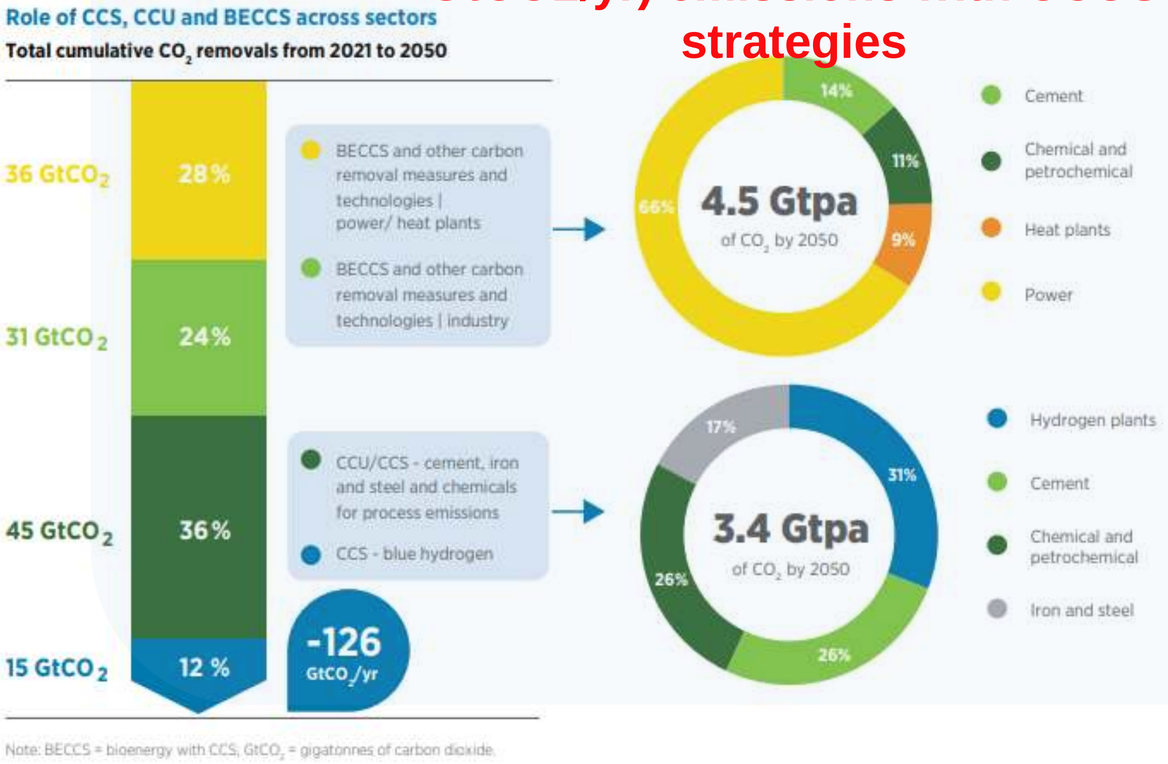
In 2050 forecast abatement of 20% of CO2 (-36.0 GtCO2/yr) emissions thanks to CCUS strategies



CO_2 VALORIZATION

CCU: carbon capture and use
CCS: carbon capture and storage
BECCS: bio energy with CCS

Forecast cumulative (2021-2050) removals of CO2 (-126.0 GtCO2/yr) emissions with CCUS strategies



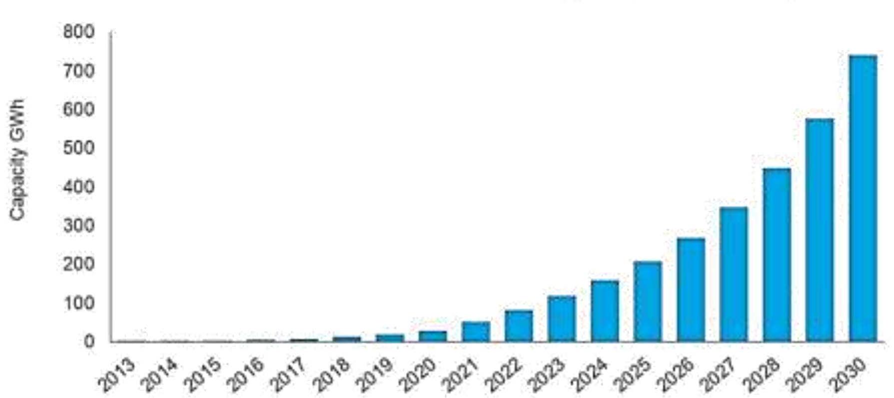
Energy Storage

A sustainable energy transition inevitably passes through the possibility of making the production of energy storage systems as eco-compatible as possible.

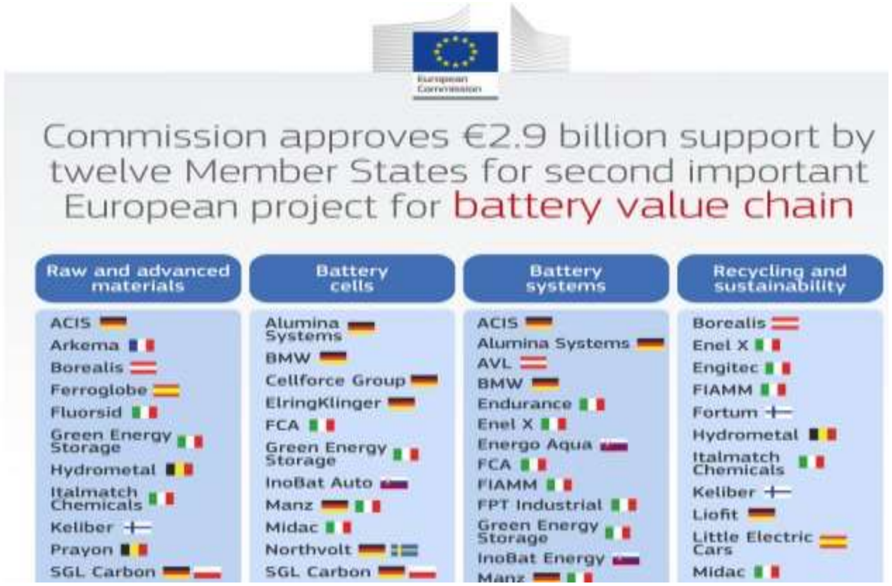
Rechargeable batteries and supercapacitors represent the two most promising technologies to meet these needs due to the balance of performance between energy density and power. The EU Commission estimates that meeting the EU's demand for electrochemical storage devices alone would require **at least 10 to 20 large-scale battery and supercapacitor production plants**, i.e. "gigafactories", capable of producing about 200 GWh of batteries and supercapacitors per year, **with a mobilized investment volume of 20 billion Euros**.

Research intends to accompany companies producing storage devices in the development of **technological solutions for the production of more efficient and sustainable devices and to amplify the economic impact of this industrial sector in Italy**.

Global behaviour of energy storage up to 2030



Source: Wood Mackenzie



Power Electronics: from network to BEV

Vehicle electrification is one of the most impactful responses in the automotive industry in achieving CO2 emission reduction targets.

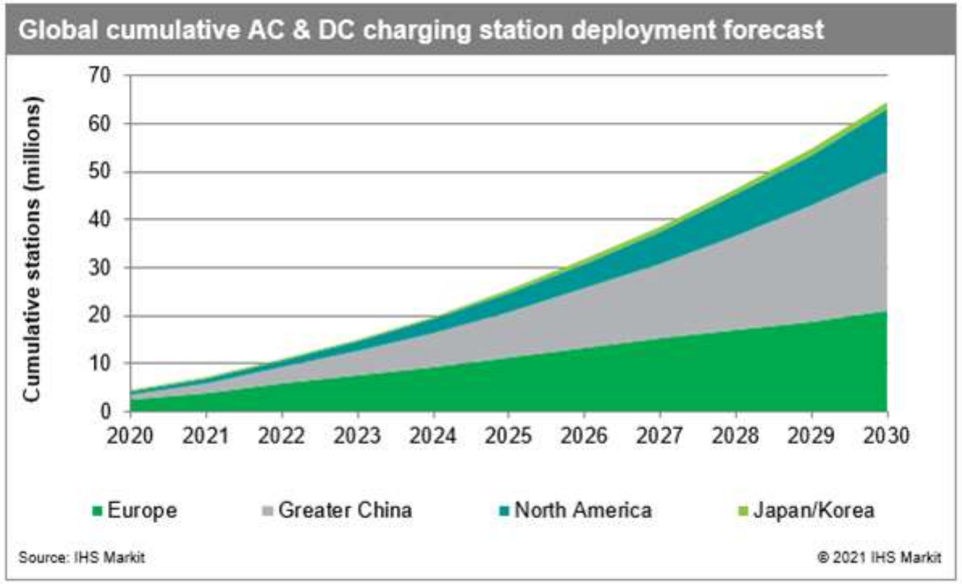
The automotive industry is in the process of transitioning away from conventional propulsion, with the long-term goal of fully decarbonizing vehicles on the road.

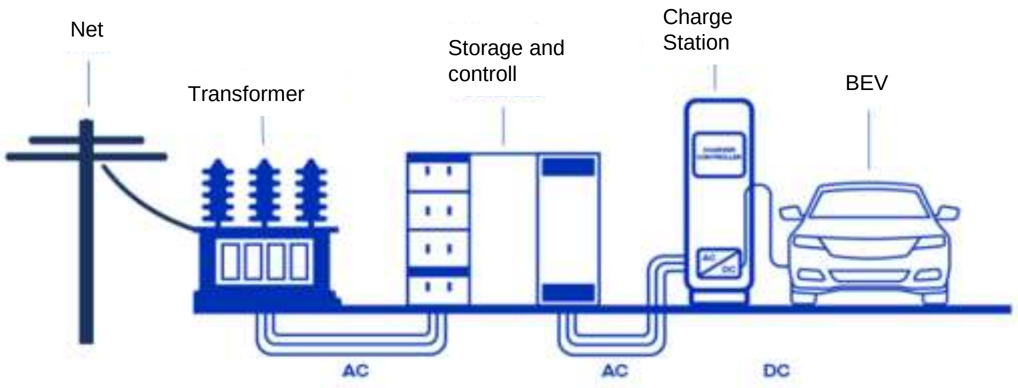
Based on market studies, the next two years will be crucial for **Europe** to secure its leading status. An initial target of **14 million electric vehicles is expected to be reached by 2025**.

Subsequently, minimum estimates mention **33 million EVs by 2030**, when maximum estimates speak of 40 million EVs.

Power semiconductors are an essential part of storage and control systems and grid-connected charging stations.

In addition to these, on-board Power Factor Corrector (**PFC**) devices must also be taken into account for the **traction** of new **BEV/HEV** vehicles.





Piemonte : a clean energy vocated territory

The Piedmont region is among the few in Italy to have built and supported **the creation of a energy transition supply chain**.

Starting in 2003, the Piedmont region supported the creation in Environment Park of the HYSYLAB laboratory and, over the years, several research programs dedicated to hydrogen.

The regional support has contributed to the growth and **strengthening of companies and research centers** in the area with a National and European dimension.

Thanks to this continuity, **today Piedmont is a Hydrogen European-level territory of excellence,** its companies and research centers are able to respond to the new challenges on hydrogen technologies launched by international markets.

2003 – HYSYLAB
First PPP Hydrogen «Open lab» in Italy

2008 – HYDROGEN EUROPE
POLITO e UNITO among founding members

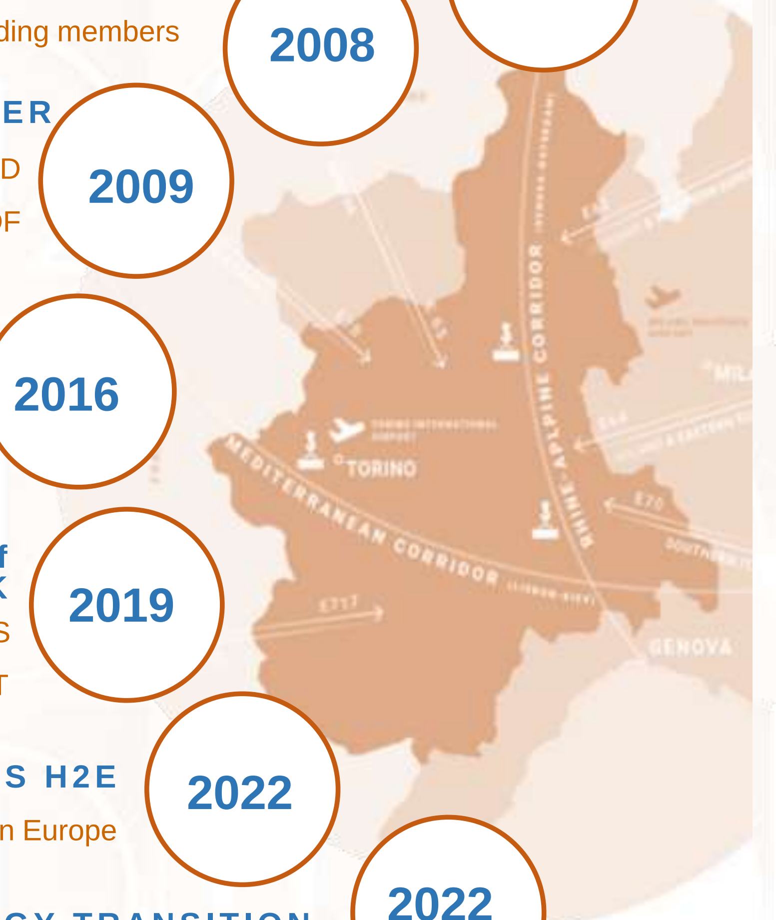
2009 – H2 REGIONAL CLUSTER
Establishment of the cluster and initiation of R&D programs funded by ERDF

2016 – LAUNCH OF CSTF - IIT
Italian Institute of Technology- IIT launches the Centre for Sustainable Technology Future

2019 – COMPETENCE CENTER of MISE in ENVIPARK
Integration through MISE Competence Center of LABS of Envipark, Polytechnic of Turin and IIT

2022 – REGION PIEMONTE JOINS H2E
First Italian region having join Hydrogen Europe

2022 – INFRASTRUCTURES FOR ENERGY TRANSITION
EU Recovery Funds MUR approval for the creation of two infrastructures for applied research on technologies for energy transition



OBJECTIVE

Supporting industrial development and competitiveness in the energy transition

The project aims to create a Technological Infrastructure for the **<u>development of components and systems in some important sectors of the energy transition</u>**.

<u>IIT, POLITO and INRIM</u> want to contribute to complete the supply chain of the research and innovation process, strengthening the mechanisms of **knowledge transfer** by encouraging the **systemic use of research results** by the industrial sector.

This objective is pursued through a **transformative approach to innovation**, with the mobilization of **private skills and capital** as well as the introduction of innovative management models.

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Energy Transition @ Torino

100+

Progetti di ricerca

200+

Ricercatori

6000 mq

laboratori

Politecnico di Torino

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“Components and Systems for Energy Transition” (CoSyET)

The Project objectives are in line with the global response to the threat of climate change and related socio/economic challenges:

REGIONAL LEVEL	NATIONAL LEVEL	EUROPEAN LEVEL	INTERNATIONAL LEVEL
CoSyET is the natural evolution of the project “CCL - CO2 Circle Lab” funded in the framework of the Programma Operativo Regionale “Investimenti per la crescita e l’occupazione” F.E.S.R. 2014/2020 Action I.1a.5.1 of Regione Piemonte, focused on the development of innovative biotechnological, electrochemical and thermochemical processes for products with high added value from renewable raw materials.	**CoSyET** will accomplish the tasks of the Mission 2 of National Recovery and Resilience Plan PNRR - Green revolution and ecological transition, "Innovative energy, hydrogen and sustainable mobility", which aims to increase the share of energy produced from renewable sources and the development of an industrial chain in this area, including H_2, and the PNIEC Integrated National Energy and Climate Plan objectives for obtaining renewable H_2 for the decarbonisation of energy-intensive industrial sectors and long-haul commercial transport.	**CoSyET** is directly contributing towards the achievement of targets set forth by the European Green Deal (EGD) and a series of policies and strategies connected to and supported by EGD (e.g., the new Industrial Strategy, SET-Plan and more specifically Action 9 on CCUS, the Renewable Energy Directive, the Circular Economy Action Plan, the Hydrogen strategy etc.). Primary contribution will be provided towards EU climate neutrality objectives for 2030 (55% reduction of GGE compared to 1990 level) and 2050 (net zero GGE), in the context of a resource-efficient and globally competitive European economy.	**CoSyET** will contribute to priorities in the context of energy transition processes set by the Paris Agreement, the 2030 UN Agenda for Sustainable Development, as also reflected by the COP26 UN Climate Conference. As for the contribution towards UNSDG, it will provide a direct contribution to “Affordable and Clean Energy for All”; SDG8 “Decent work and economic growth”; SDG 9 “Industry, Innovation and Infrastructure”; SDG 13 “Climate Action”.

ISTITUTO ITALIANO DI TECNOLOGIA

ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

SEASTAR COMPETENCE CENTER

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

Politecnico di Torino

Fabrizio Pirri

fabrizio.pirri@polito.it

fabrizio.pirri@iit.it

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