The role of H_2 for green methane production

A better integration of RES in the energy system

03/03/2021

IREN at a glance

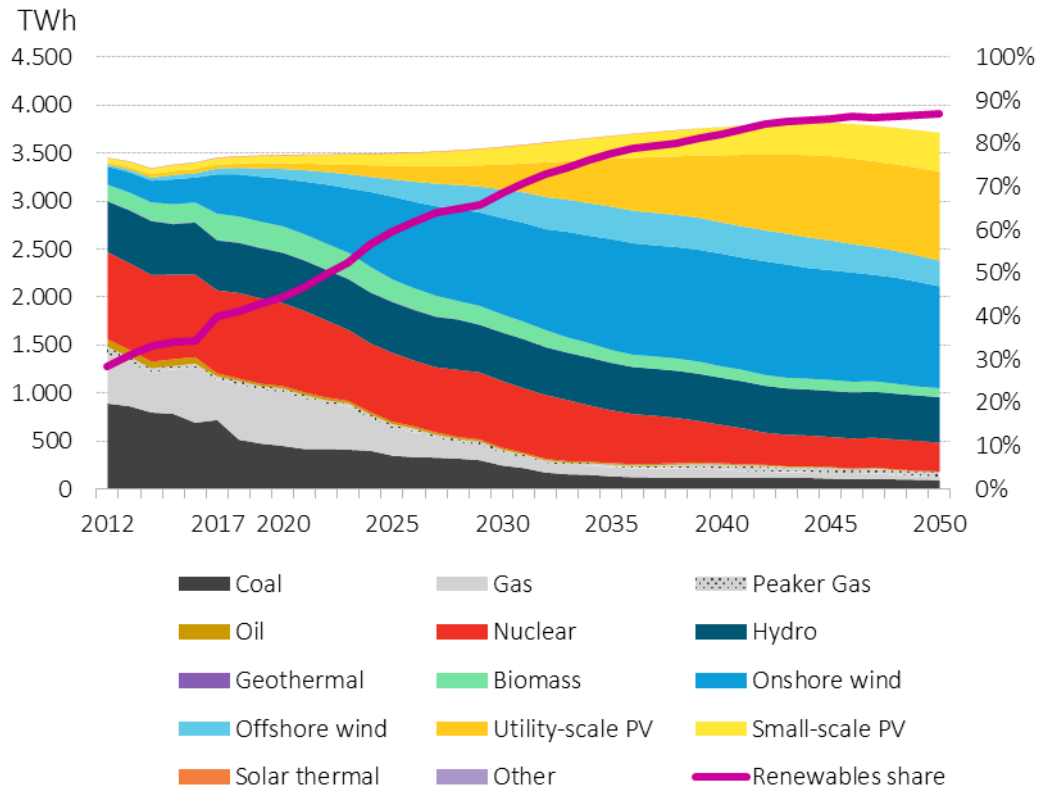
IREN Group

IREN is one of the largest and most dynamic multiutility company on the Italian scene and operates in the following sectors:

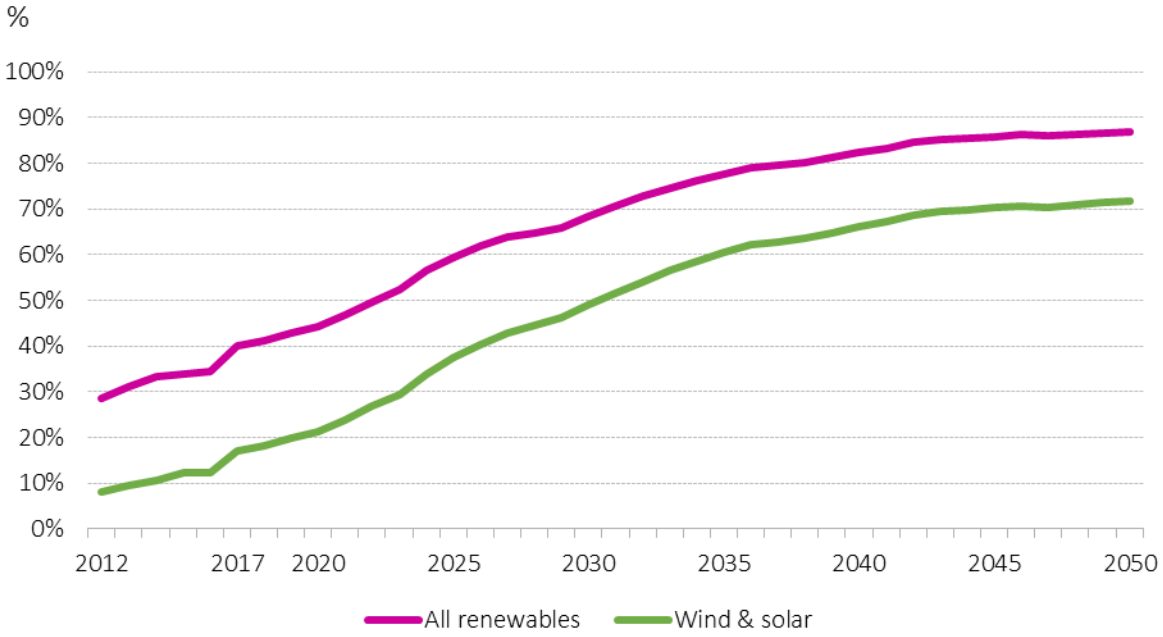
- Electric/thermal energy production
- Electric energy distribution
- Waste management
- Integrated water service
- Gas distribution
- District Heating
- Technological services

A practical example

Electricity Generation In Europe
Scenarios To 2050



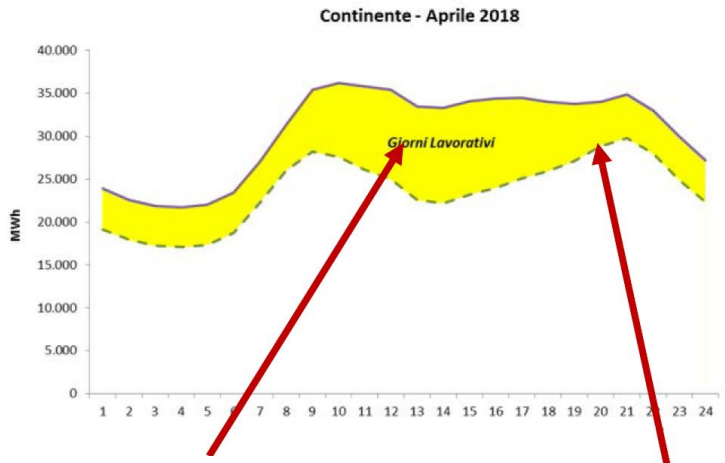
Generation in EU, TWh



Renewables penetration, % of generation

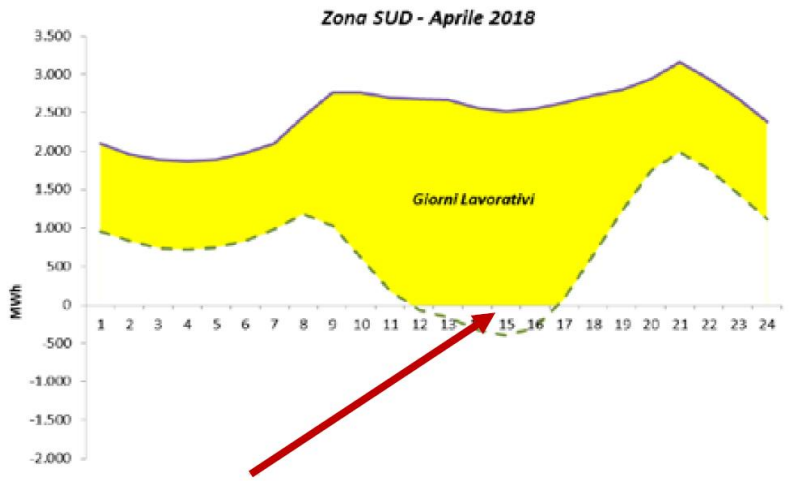
Source: Bloomberg New Energy Finance, New Energy Outlook 2018, June 2018

The Integration Of Renewable Energy Sources



Electricity demand covered by RES (mainly wind and PV)

Ramps



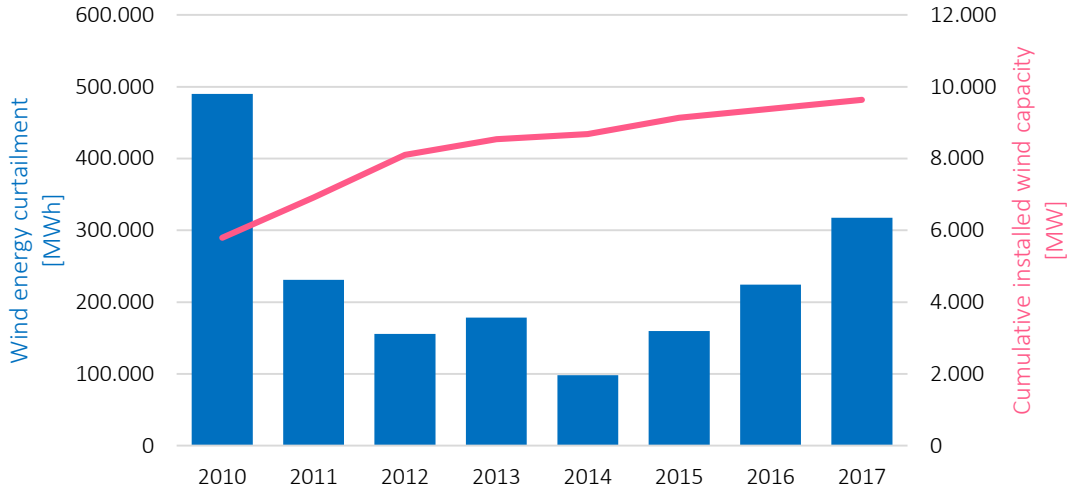
Curtailment

The integration of a high rate of variable renewable energy sources such as wind and solar, means a **deep change in the management** of conventional power plants, which must be more flexible and follow the ramp-up and ramp-down, in order to cover the morning and the evening peaks in particular.

In the *South Area* of Italy (Zona Sud), the production of electricity from wind and solar in some hours of the day is higher than the energy demand: if such surplus cannot be transported to other areas or if conventional power plants cannot reduce their load (when there is no surplus), there is a risk for **curtailment**.

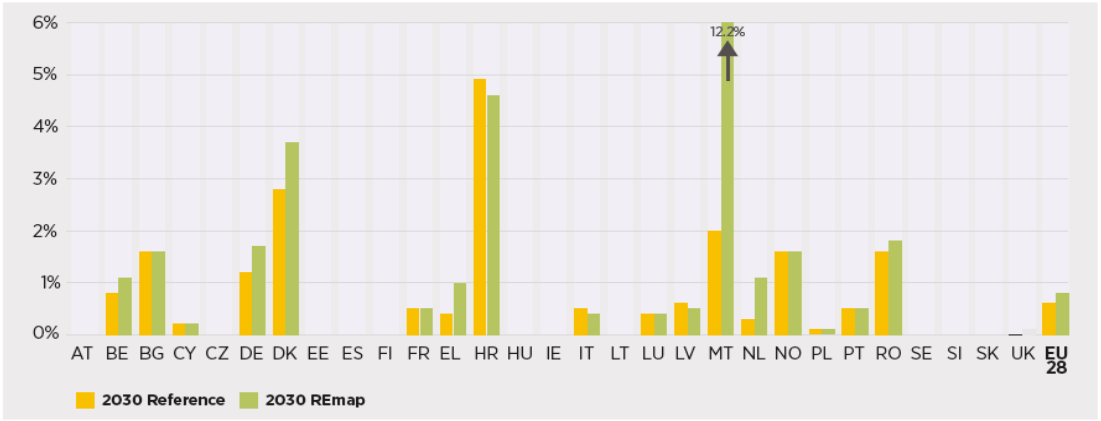
Source: ARERA, Stato di utilizzo e di integrazione degli impianti di produzione alimentati dalle fonti rinnovabili anno 2017, 428/2018/I/EFR.

The Integration Of Renewable Energy Sources



2010 – 17 wind curtailment in Italy

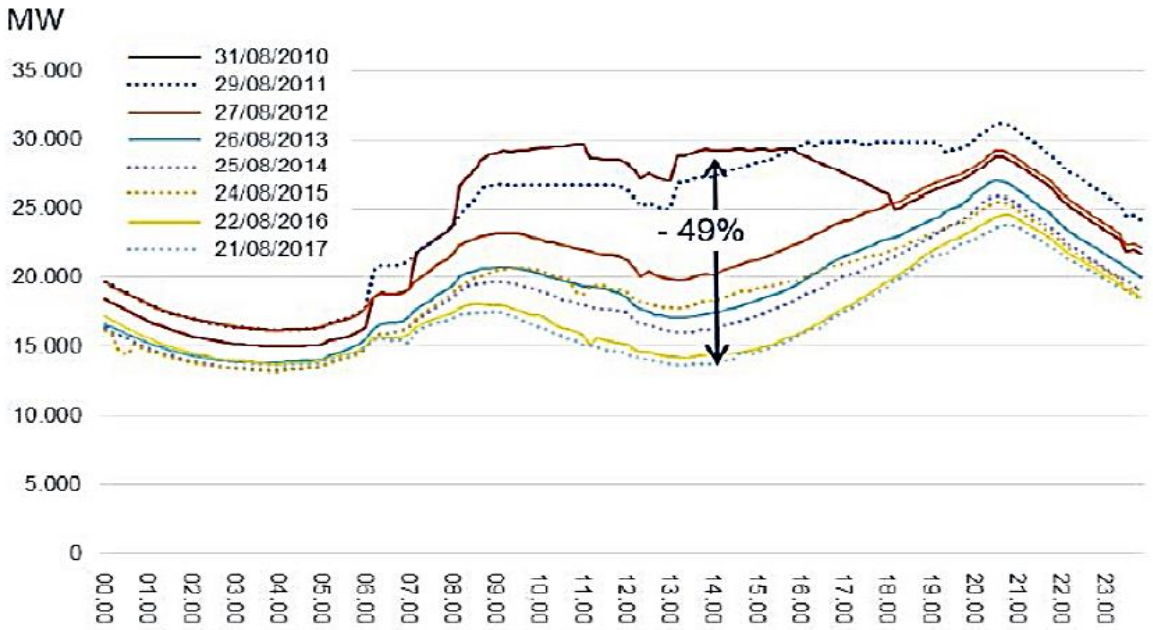
Source: (left axis) GSE, Rapporto delle Attività 2017, 2018
(right axis) IRENA, Renewable capacity stastics 2018

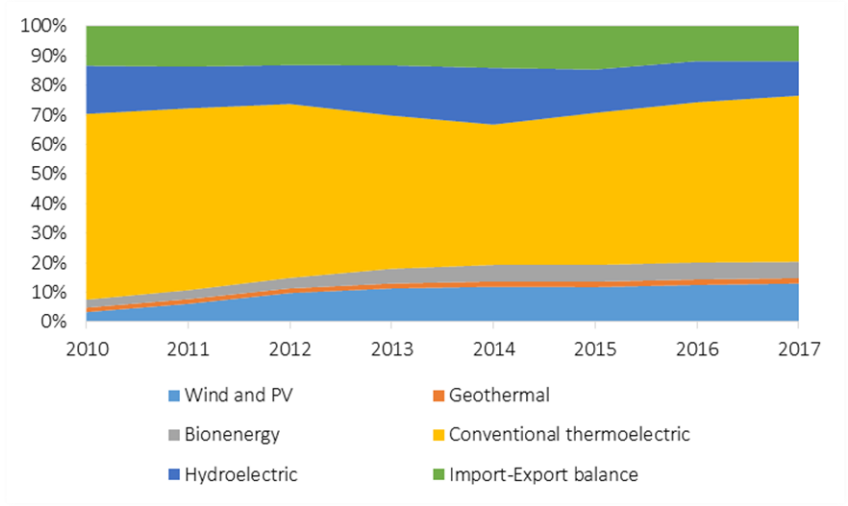


Renewable energy curtailment rate by EU Member State in 2030 (Reference Case versus REmap)

Source: European Union and IRENA, Renewable Energy Prospects for the European Union, 2018.

The Integration Of Renewable Energy Sources





Electricity generation by source, Italy

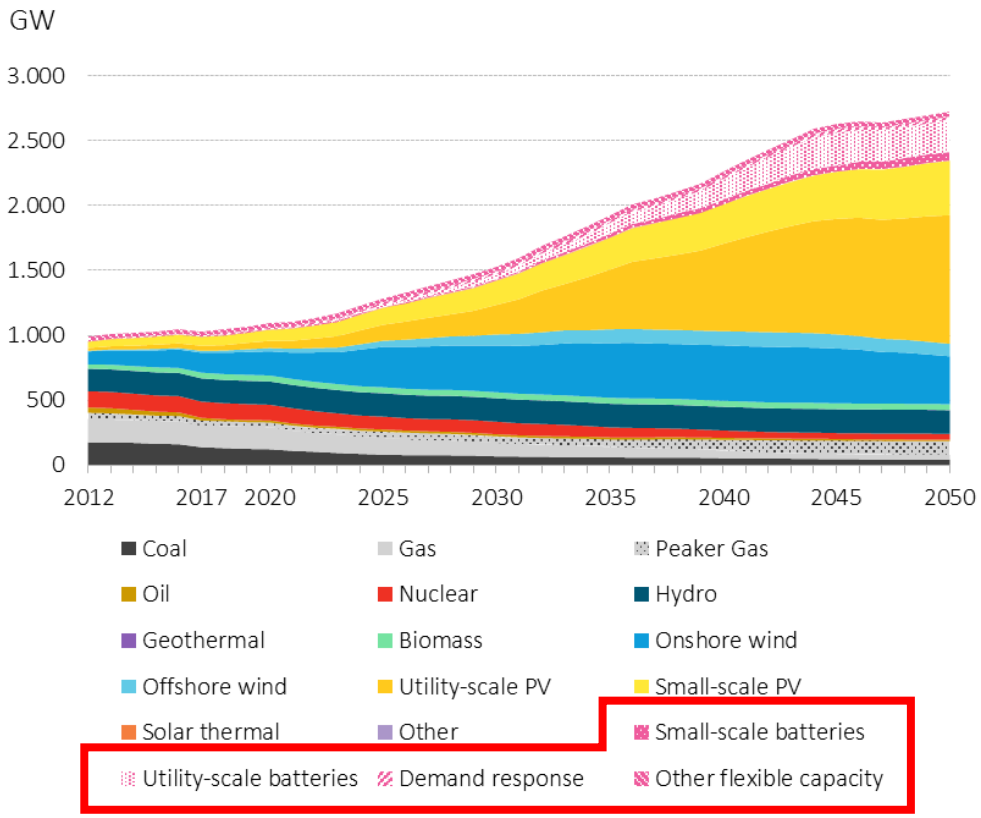
The electricity taken from the national transmission network by the distribution network has clearly diminished in the period 2010-2017. This phenomenon is stronger in the central hours of the day, where about 49% of the peak reduction was achieved due to the increasing diffusion of the distributed generation.

From 2010 to 2017, the installed wind and solar capacity has increased from 9,41 GW (9% of the total capacity) to 29,45 GW (25% of the total capacity).

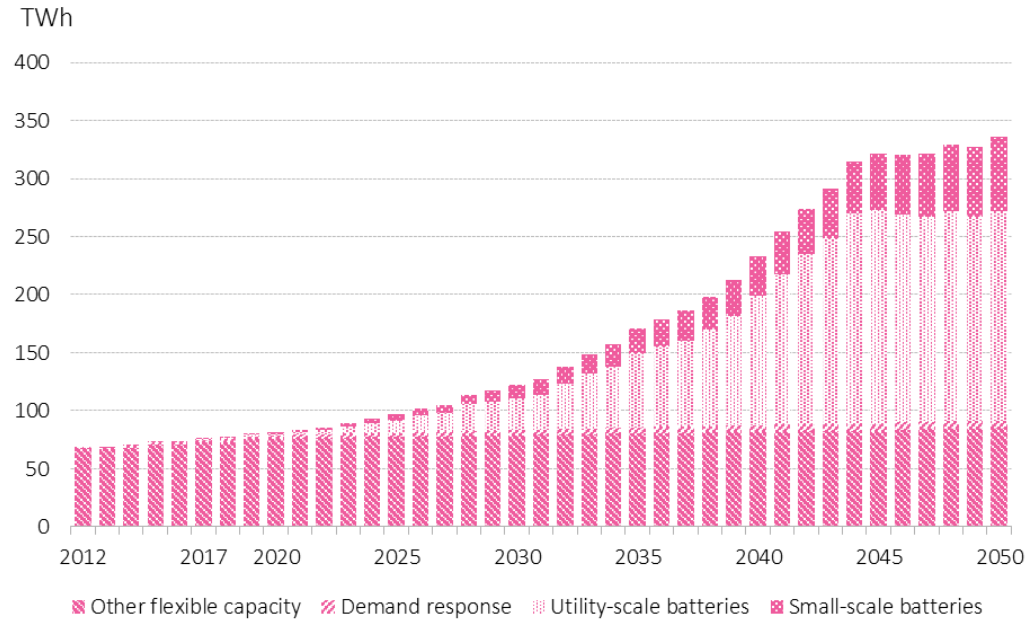
Source: (left graph) ARERA, Stato di utilizzo e di integrazione degli impianti di produzione alimentati dalle fonti rinnovabili anno 2017, 428/2018/I/EFR.
(right graph) Terna, L'evoluzione del mercato elettrico: tutti i dati

Electricity Generation in Europe in 2050

New Energy 'Sources'



Cumulative installed capacity in EU, GW

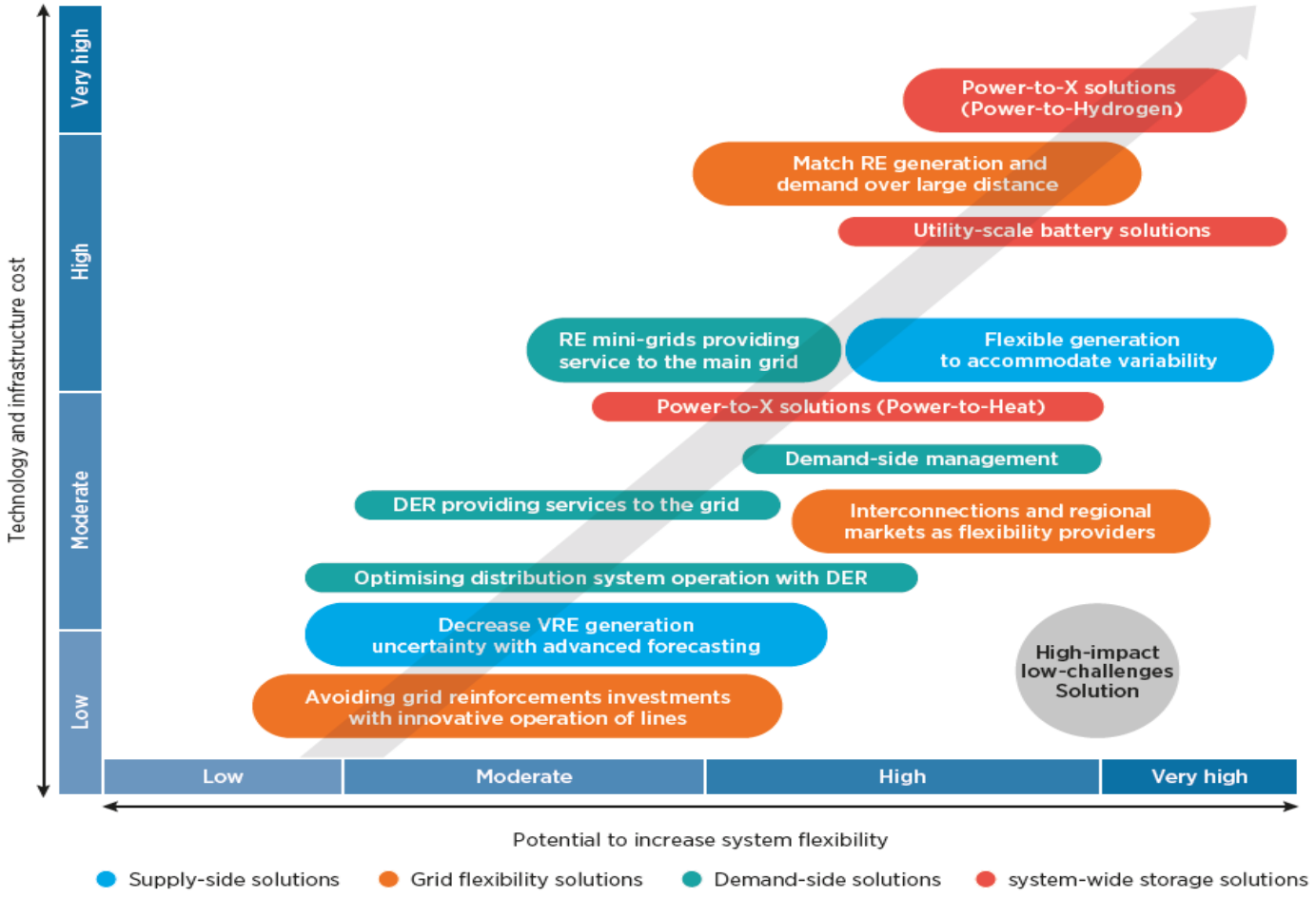


Energy shifted by storage in EU, TWh

It is expected that about 7% of the electricity generated in Europe in 2050 (3.711 TWh – slide 3) will be stored in batteries.

Source: Bloomberg New Energy Finance, New Energy Outlook 2018, June 2018

Flexible Solutions to Support RES
The Power-To-X



Source: IRENA, Innovation landscape for a renewable-powered future: solutions to integrate variable renewables, 2019

Green methane: hydrogen and what else?

To ensure the carbon neutrality/negativity of the whole Power-to-Gas chain (with green methane as the main output), also the feedstock/platform molecules should be "green":

- **Hydrogen** should be "*produced through the electrolysis of water and with the electricity stemming from renewable sources (…) or through the reforming of biogas (instead of natural gas) or biochemical conversion of biomass*". (1)
- Reused **carbon dioxide** should lead to a neutral (or even negative) carbon balance. To this aim, CO_2 should be removed from:
  - combustion processes (e.g., fossil-fueled power plants, waste-to-energy plants etc.) via post-/pre-/oxy-combustion carbon capture technologies;
  - atmosphere through low-/high-T direct air capture;
  - biogenic sources (e.g., biogas upgrading process).

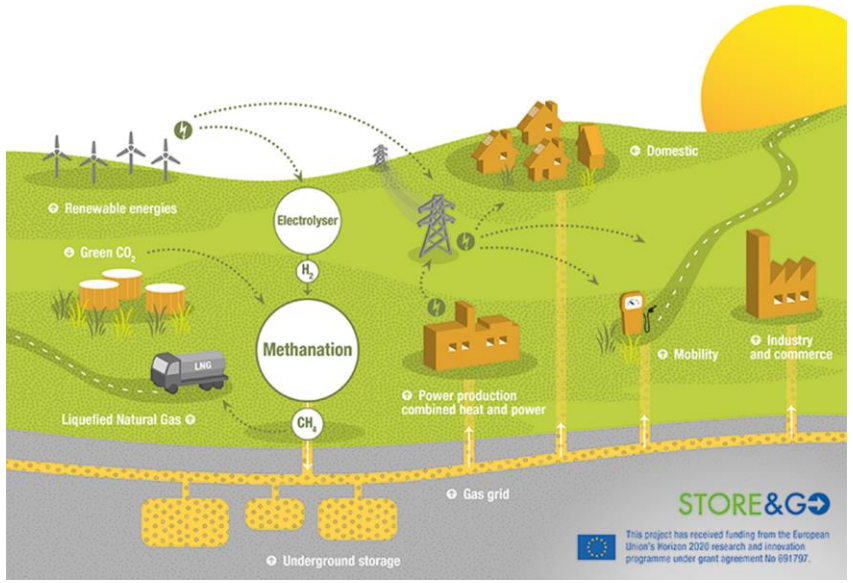
Methane can be synthetized following different technological chains:

- Thermocatalytic conversion;
- Biologic conversion (driven by micro-organisms);
- Electrochemical reduction of CO_2;
- Gasification of solid biomass.

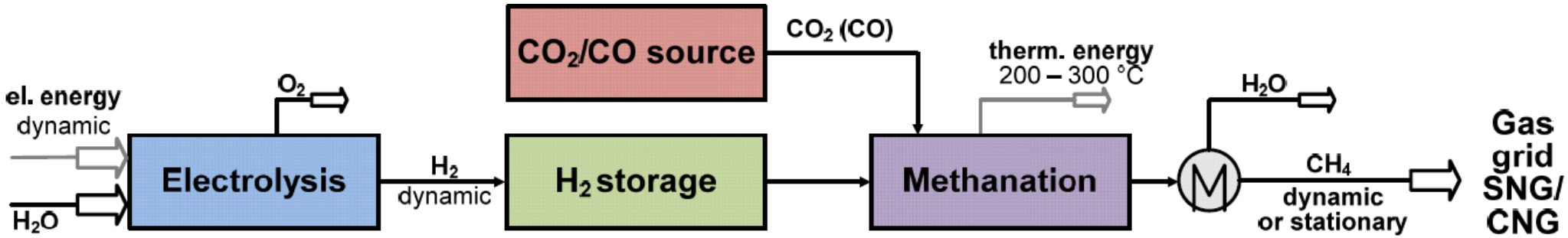
(1) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS - A hydrogen strategy for a climate-neutral Europe

Power-to-Gas

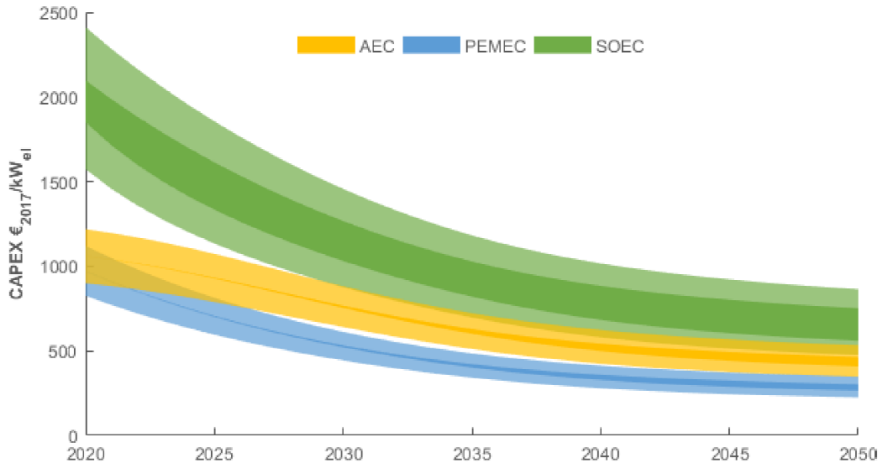
From Green Electrons To Molecules, The STORE&GO Project



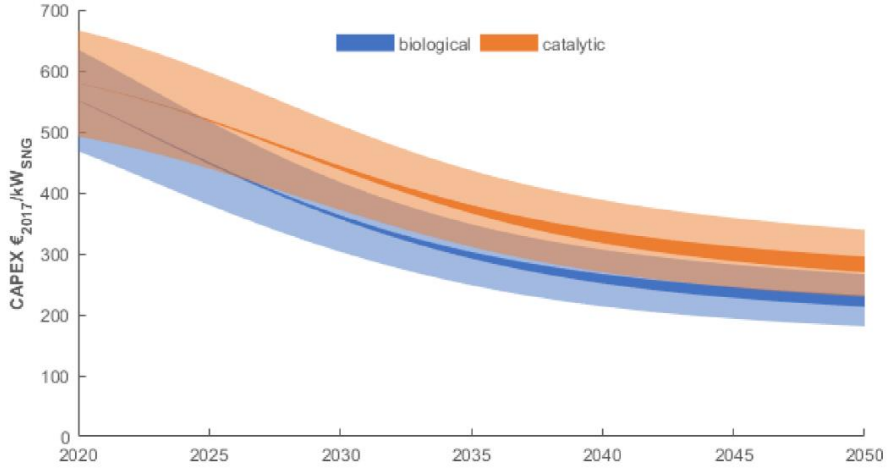
The STORE&GO Project will demonstrate 3 innovative **Power to Gas (PtG)** systems located in Germany, Switzerland and Italy. The project aims to validate the **technical and economical feasibility** of integrating the PtG technology with innovative systems of energy generation and distribution.



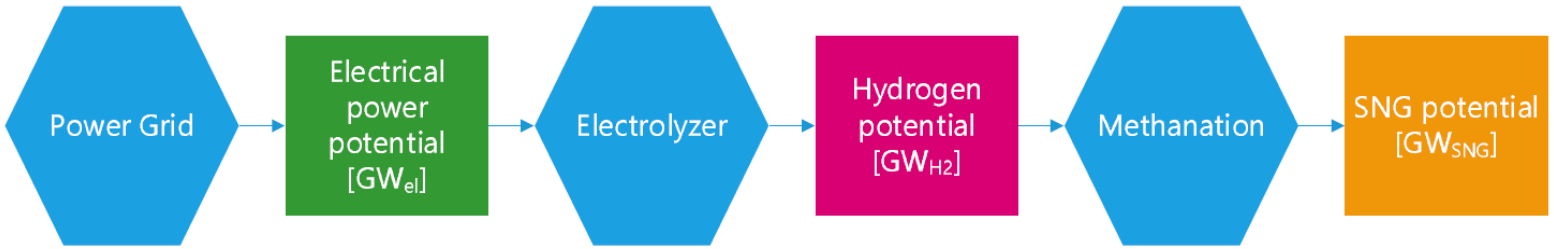
Market scenarios and price evolution
Store&Go project



Learning curves for electrolysis systems



Learning curves for methanation systems

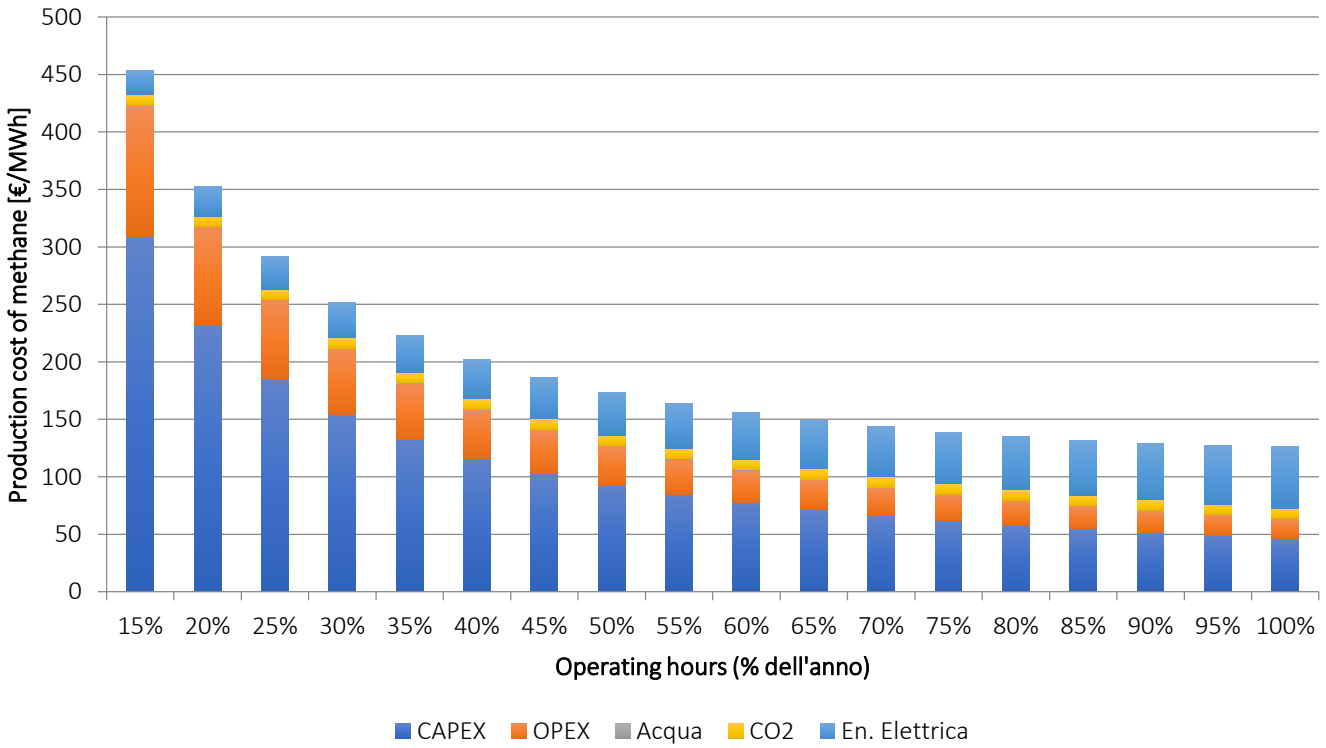


Efficiency 59÷77 %

Efficiency ≈75÷80%

Source: Project EU H2020 Store&Go, Energieinstitut, D7.5 – Report on experience curves and economies of scale, 2018

Market scenarios and price evolution
Store&Go project



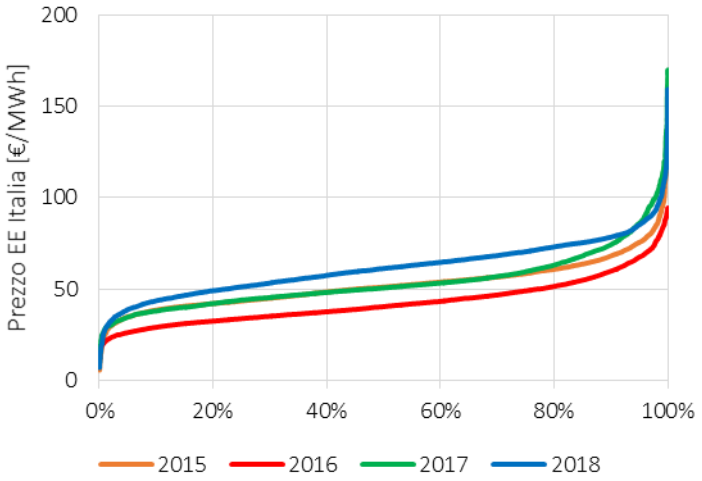
Production cost of methane as a function of the annual operating hours.
Price of electrivity in Germany (2016): 29 €/MWh

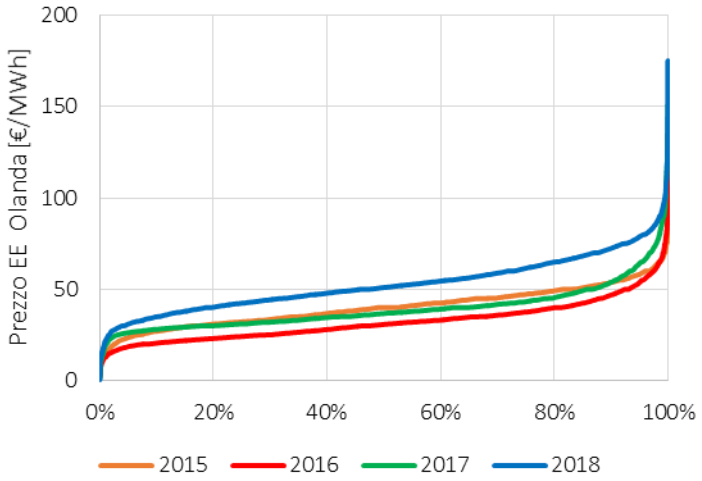
The production cost of methane through a Power-to-Gas system is in the range 120-190 €/MWh in case of more than 4.000 operating hours per year.
In 2016, the average price of natural gas in the main EU markets was 15 €/MWh.

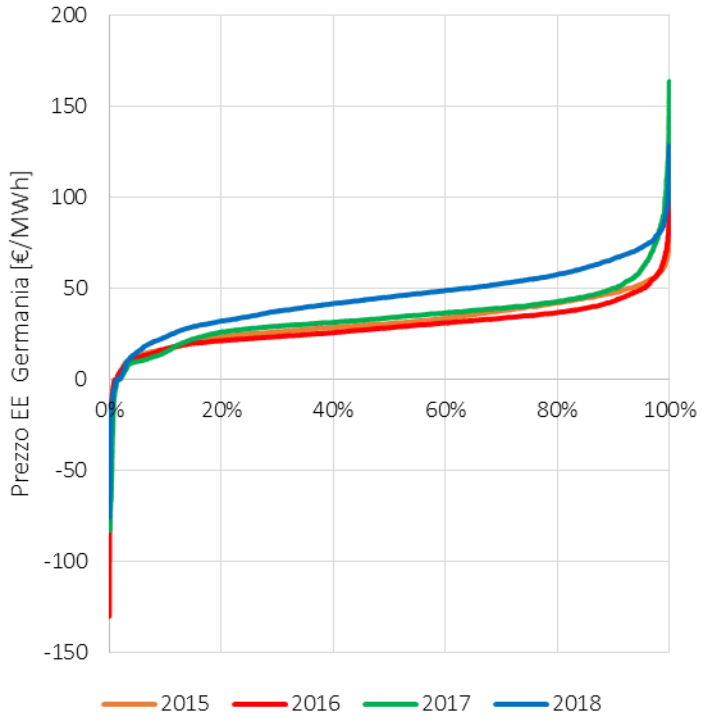
The price of electric energy has a heavy influence on methane production cost: its share is in the range 22-43%.
In 2016, the average price of electricity was 29 €/MWh in Germany and 43 €/MWh in Italy (+50%).

Source: Project EU H2020 Store&Go, Energieinstitut, D7.5 – Report on experience curves and economies of scale, 2018

Market scenarios and price evolution
Store&Go project



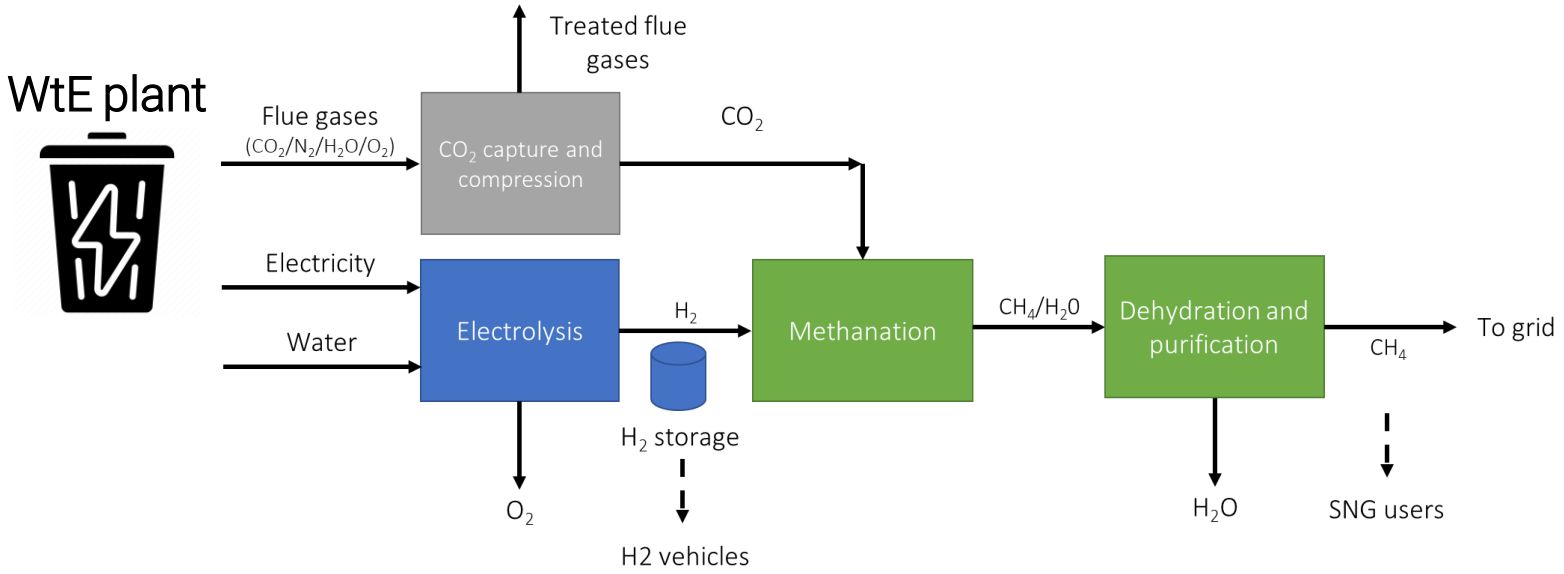




Trend of electric energy price in Italy, the Netherlands and Germany

Source: GME, EPEX Netherland, EPEX SPOT.

From waste-to-energy (WtE) to waste-to-gas



Electrolysis section

Carbon Capture section:

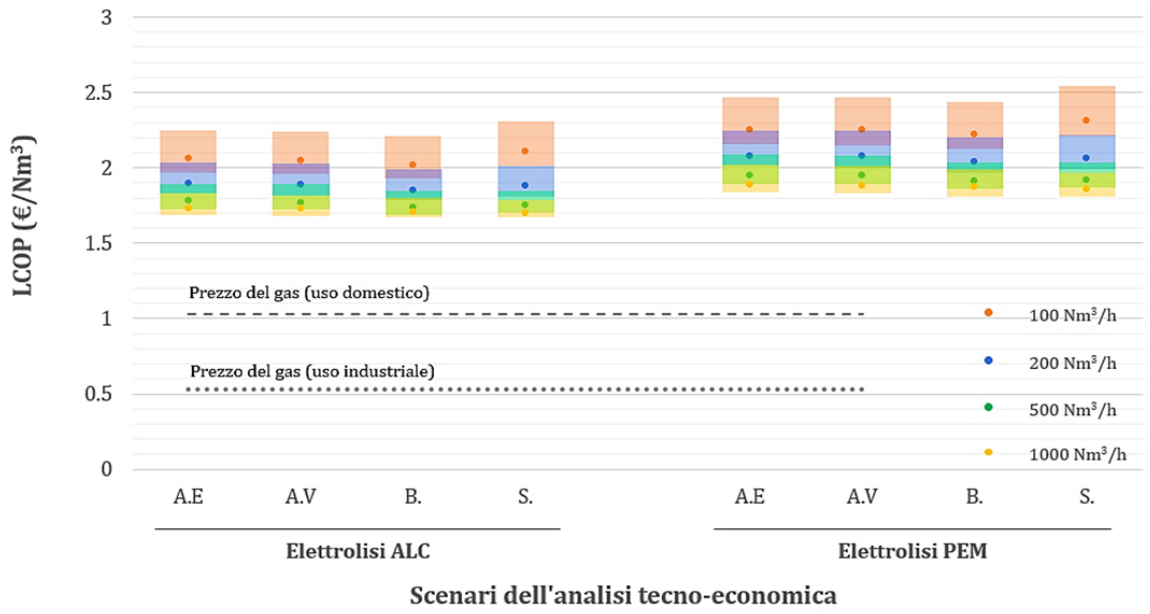
- Option A. An absorption process based on aqueous solution of MEA in a two-column scheme.
- Option B. An absorption process based on MEA blended with ionic liquids in a two-column scheme.
- Option S. Two fixed-bed reactors equipped with solid sorbents based on PEI/silica.

Methanation section:

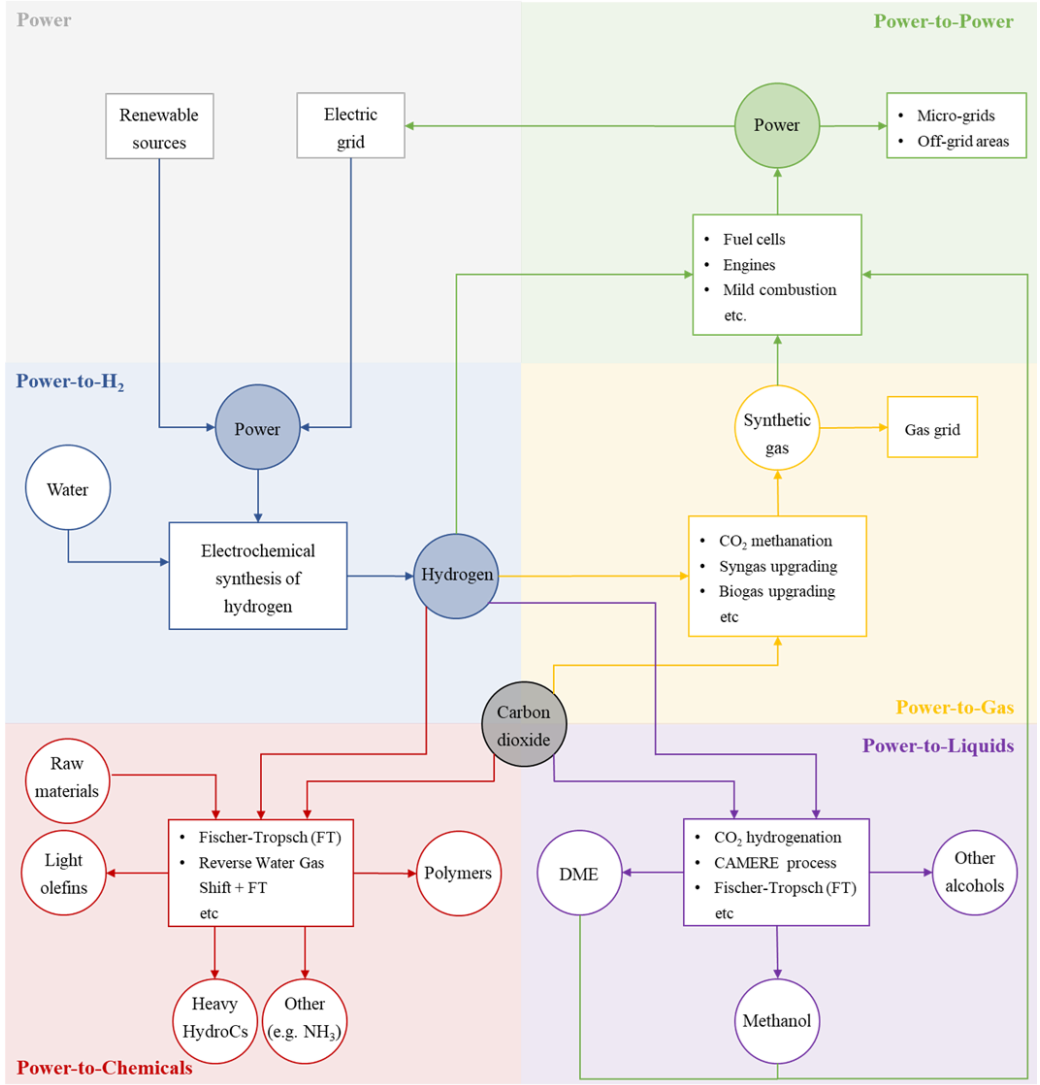
- three cooled fixed-bed reactors equipped with Ni/γ-Al2O3 catalyst showing high selectivity, activity and stability. Produced SNG is finally dehydrated and purified in order to achieve the specifications for the injection in the natural gas network.

From waste-to-energy (WtE) to waste-to-gas

Scenario	Nm^3/h SNG	100	200	500	1000
Electric consumption	GWh/y	16.4 – 16.9	32.9 – 33.1	82.4 – 86.3	165 – 168.3
Water consumption	m^3/y	4800 - 5300	9500 - 10600	23700 - 26100	47400 - 52200
Thermal integration	MWh/y	0 – 420	0 – 790	0 – 1730	0 – 3200
SPECCA	MWh/t_{SNG}	30.7 – 32.4	30.8 – 31.7	30.9 – 33.0	30.9 – 32.1
Global efficiency	**% (LHV basis)**	**42.45 – 44.84**	**43.40 – 44.70**	**41.76 – 44.62**	**42.87 – 44.56**



The role of H_2: final product and platform molecule



Source: G. Buffo, P. Marocco, D. Ferrero, A. Lanzini, and M. Santarelli, "Power-to-X and Power-to-Power routes," in Solar Hydrogen Production: Processes, Systems and Technologies, Elsevier, 2019, pp. 530–575.

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