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BioHydrogen and BioMethane production through two stages AD: A European State of the Art

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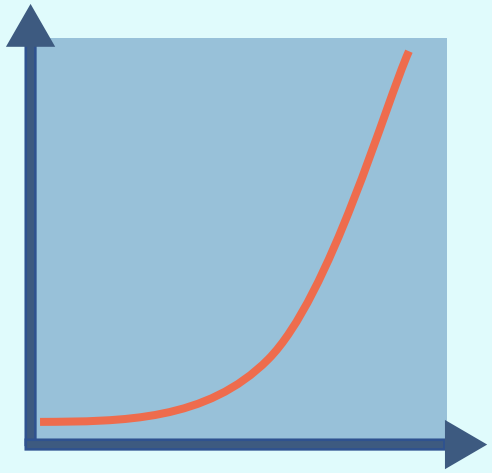
Towards the Green Deal



Global CO2 emissions are above 40 GtCO2/year

The Green Deal (2019) aims to reduce the emissions at least 55% by 2030

EC proposed Hydrogen as a Clean Fuel to achieve this milestone

Hydrogen

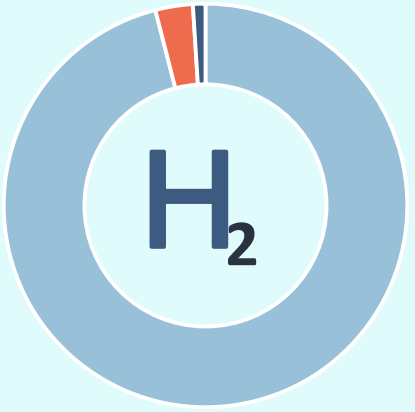
In 2018 total Hydrogen demand was
8.3 Mt

Fossil Hydrogen	1.5 €/kg
Fossil Hydrogen CO_2 captured	2 €/kg
Green Hydrogen	2.5-5 €/kg

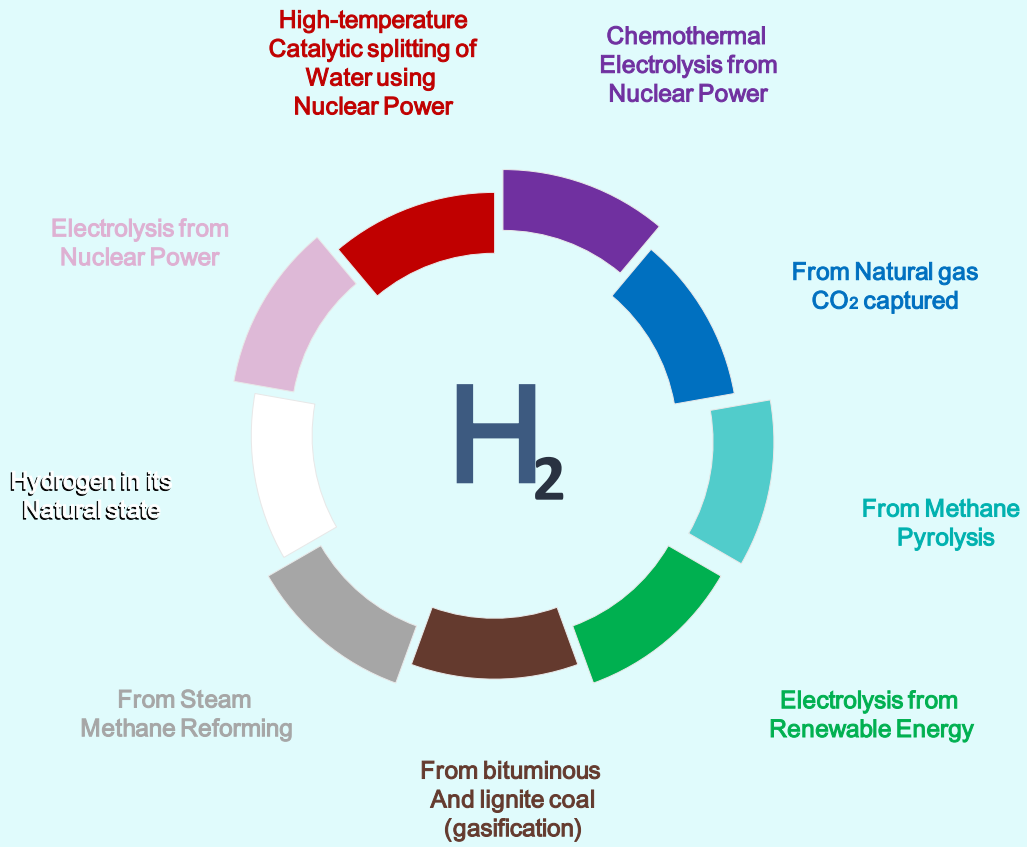
Steam Methane Reforming

Hydrolysis

Other

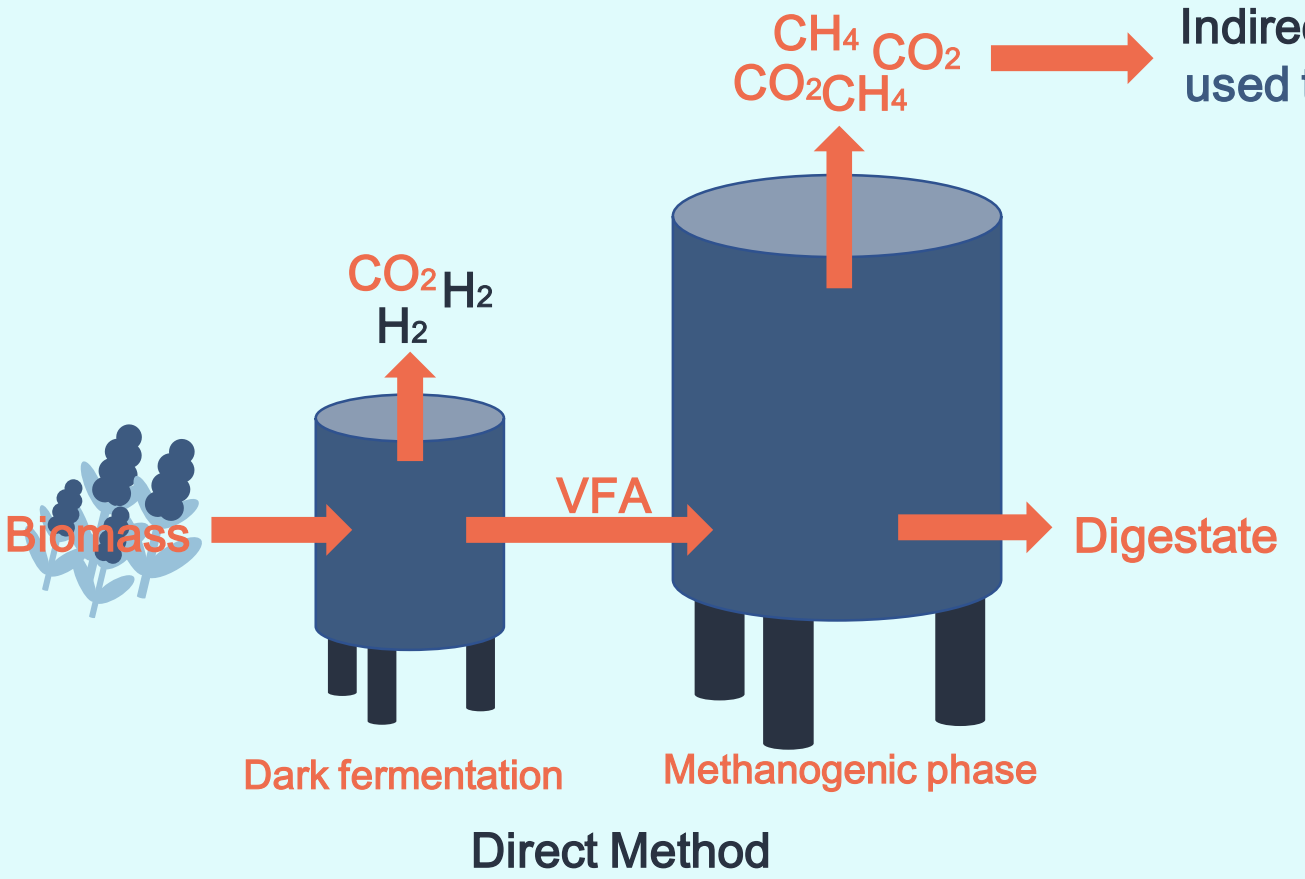


Hydrogen production for EC



Hydrogen can also be produced by the AD process either directly or indirectly

Anaerobic Digestion for Hydrogen production



Direct Method

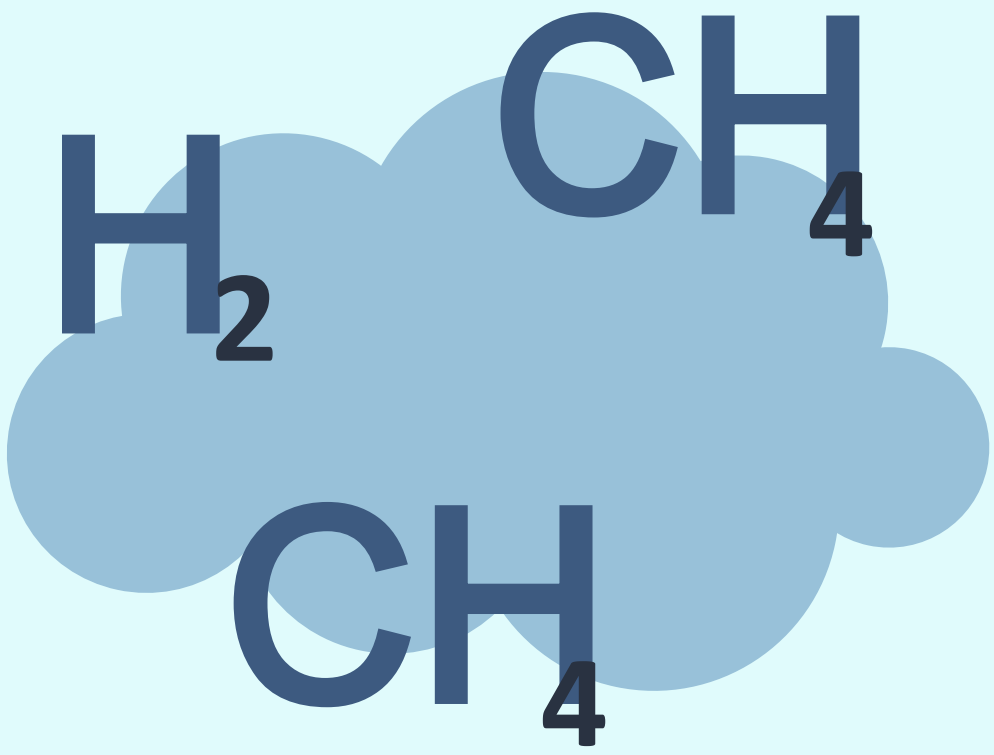
Indirect Method: the CH_4 produced can be used to produce hydrogen through Steam Methane Reforming

Through TSAD different clean fuels can be produced:

- BioHydrogen
- BioMethane
- BioHythane

BioHythane

CH4 (90% v/v) + H2 (10% v/v) = Biohythane



- Avoid the problem of H2 storage

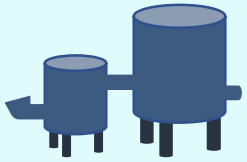
> H2

- It can be injected into the gas grid
- Reduce the Carbon content of natural gas

> Natural gas

- Improve combustion stability and flammability range

Anaerobic Digestion for Hydrogen production

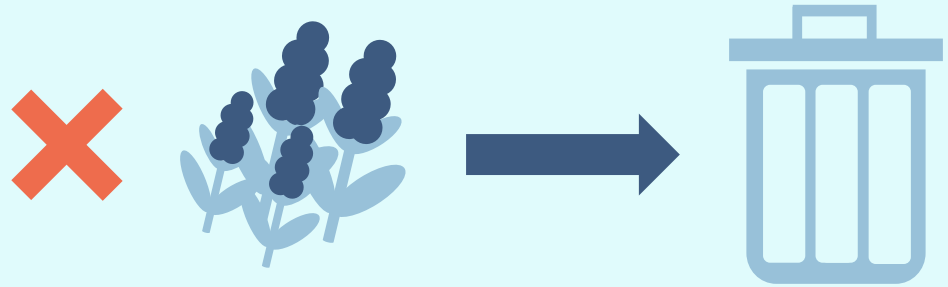


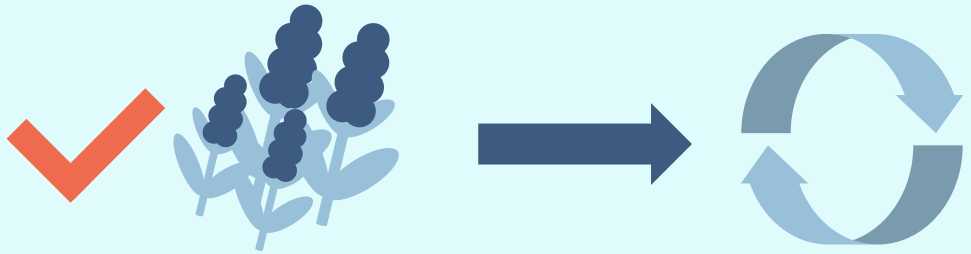
Some values of the main European pilot plants of direct H2 production through TSAD are shown in the table.

	Substrate	Hydrogen Yield	CH4%	H2%
Biohythane production from the organic fraction of municipal solid waste: improving existing anaerobic digestion plants (Cavinato et al.,2012)(Treviso)	OFMSW	74 L/kgTVS	51%	8%
A farm-scale pilot plant for biohydrogen and biomethane production by two-stage fermentation (Oberti et al.,2013)(Milan)	Agricultural residues	99 L/kgTVS	64%	13%
Operation of an innovative pilot plant for the biohythane production from the organic fraction of municipal solid waste (OFMSW) (Trably et al, 2011)(France)	OFMSW	3.8 L/kgTVS	56%	7%

Advantages of TSAD process

- Reduce organic waste
- Continuous production
- Applicable even in small towns
- Does not need of a Renewable Energy Source
- Easily upgradable in 20,000 European biogas plants





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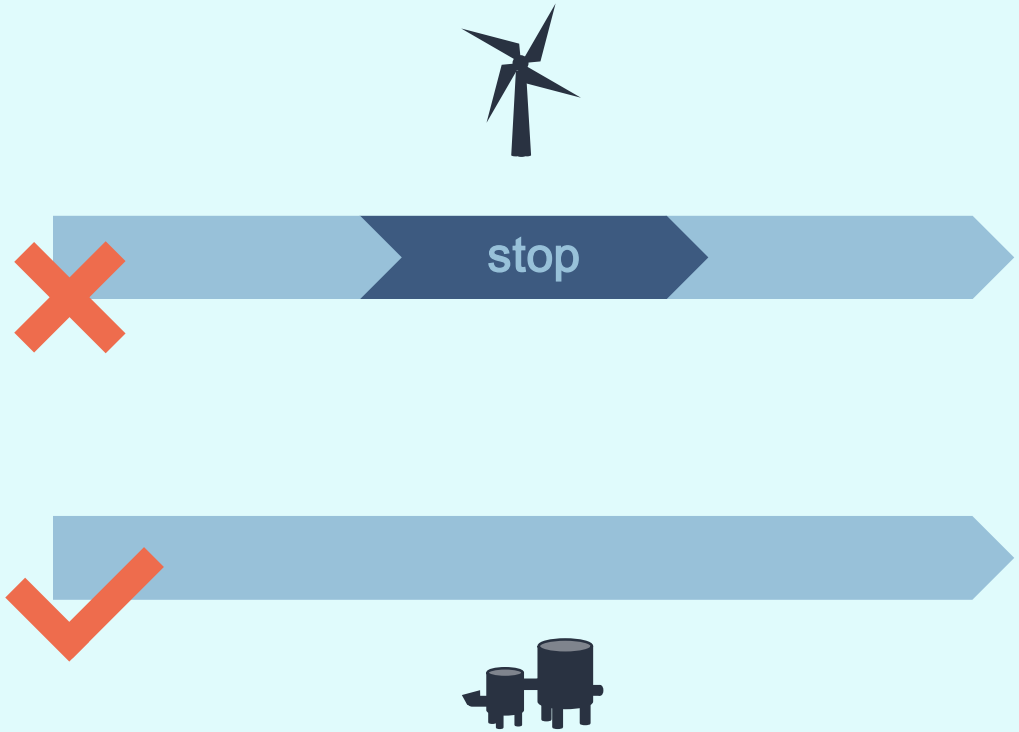

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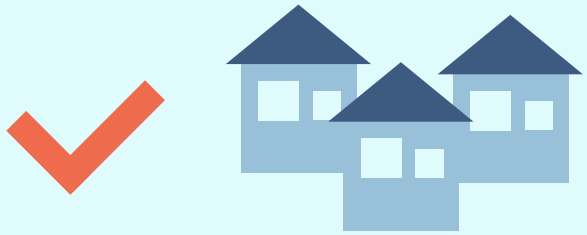

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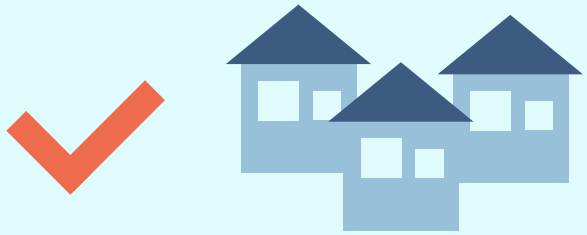

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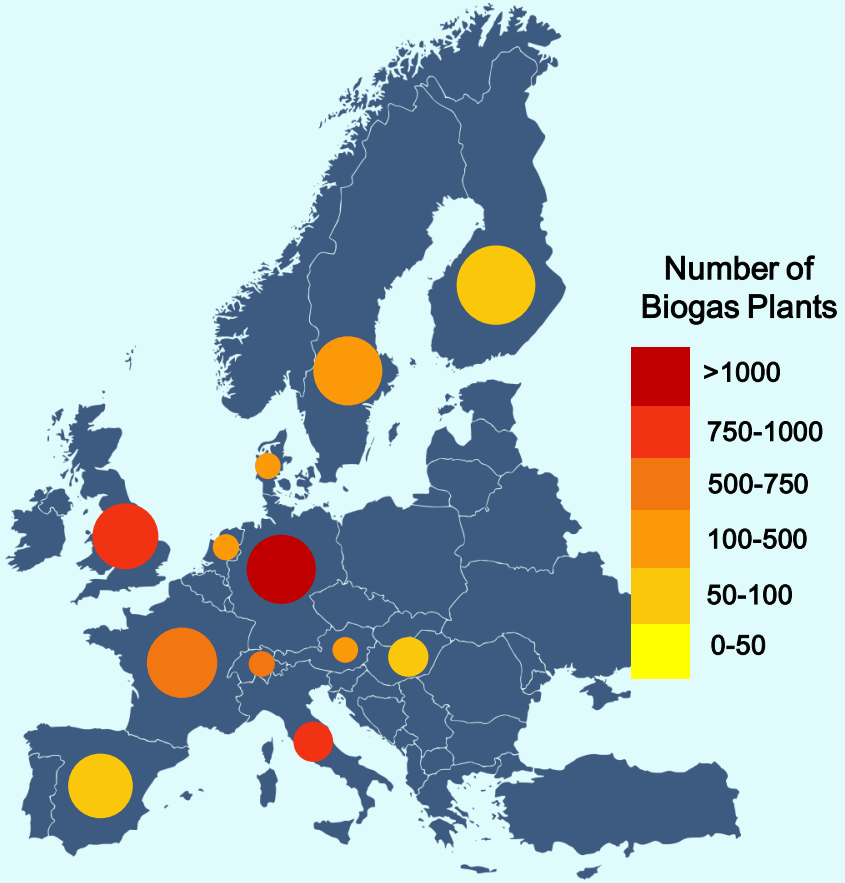
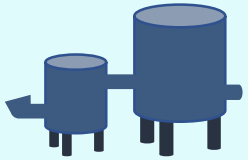


Currently, industrial-scale plants using TSAD are few and do not use a specific treatment for hydrogen, but it is directly consumed along with methane.

TSAD Pilot Plants



In fact, there are several pilot scale plants, that using the TSAD process to produce hydrogen.
Some European Examples:

- Biohythane production from the organic fraction of municipal solid waste: improving existing anaerobic digestion plants (Cavinato et al.,2012)(Treviso)
- A farm-scale pilot plant for biohydrogen and biomethane production by two-stage fermentation (Oberti et al.,2013)(Milan)
- Operation of an innovative pilot plant for the biohythane production from the organic fraction of municipal solid waste (OFMSW) (Trably et al,2011)(France)
- Organosolv pretreated birch sawdust for the production of green hydrogen and renewable chemicals in an integrated biorefinery approach) (Sarker et al., 2022)(Sweden)

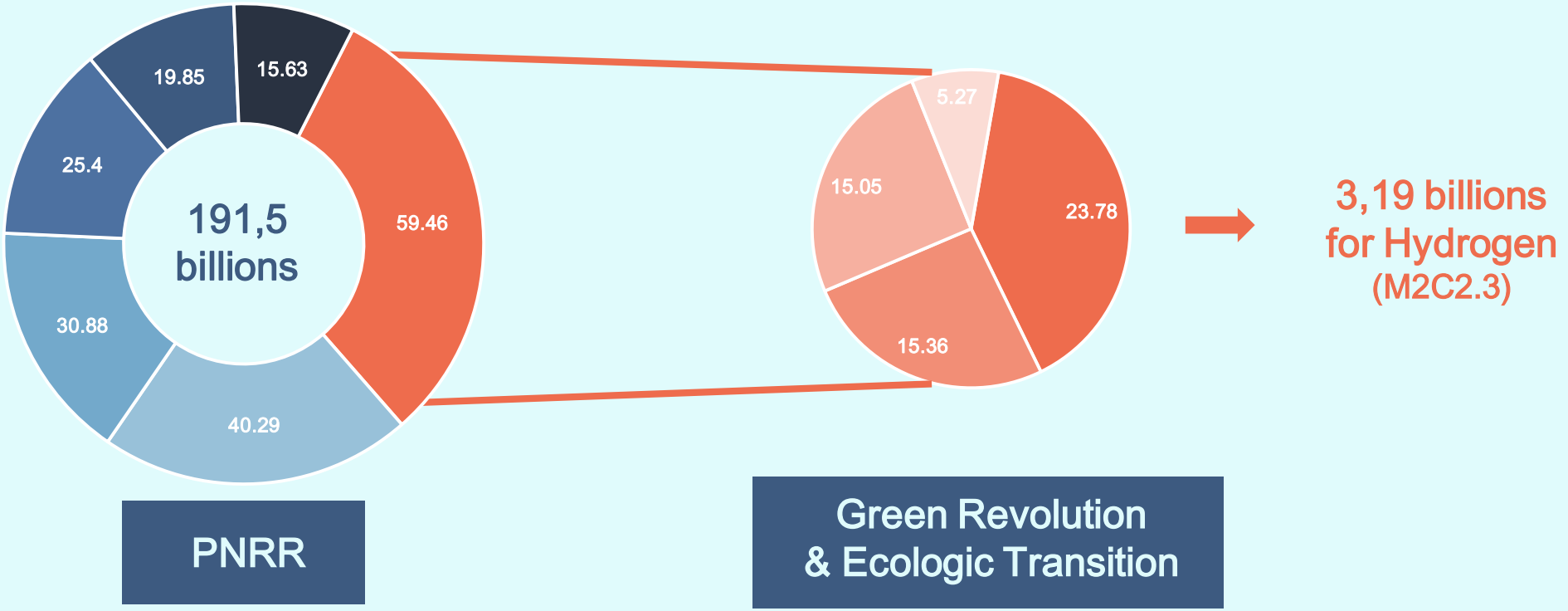
Process Optimization

TSAD pilot plants currently focus research and process optimization on:

- Combination of different pre-treatments
- Recirculation of second stage's digestate to keep under optimal value the pH of the first reactor
- Combination of different substrates

Future Prospects

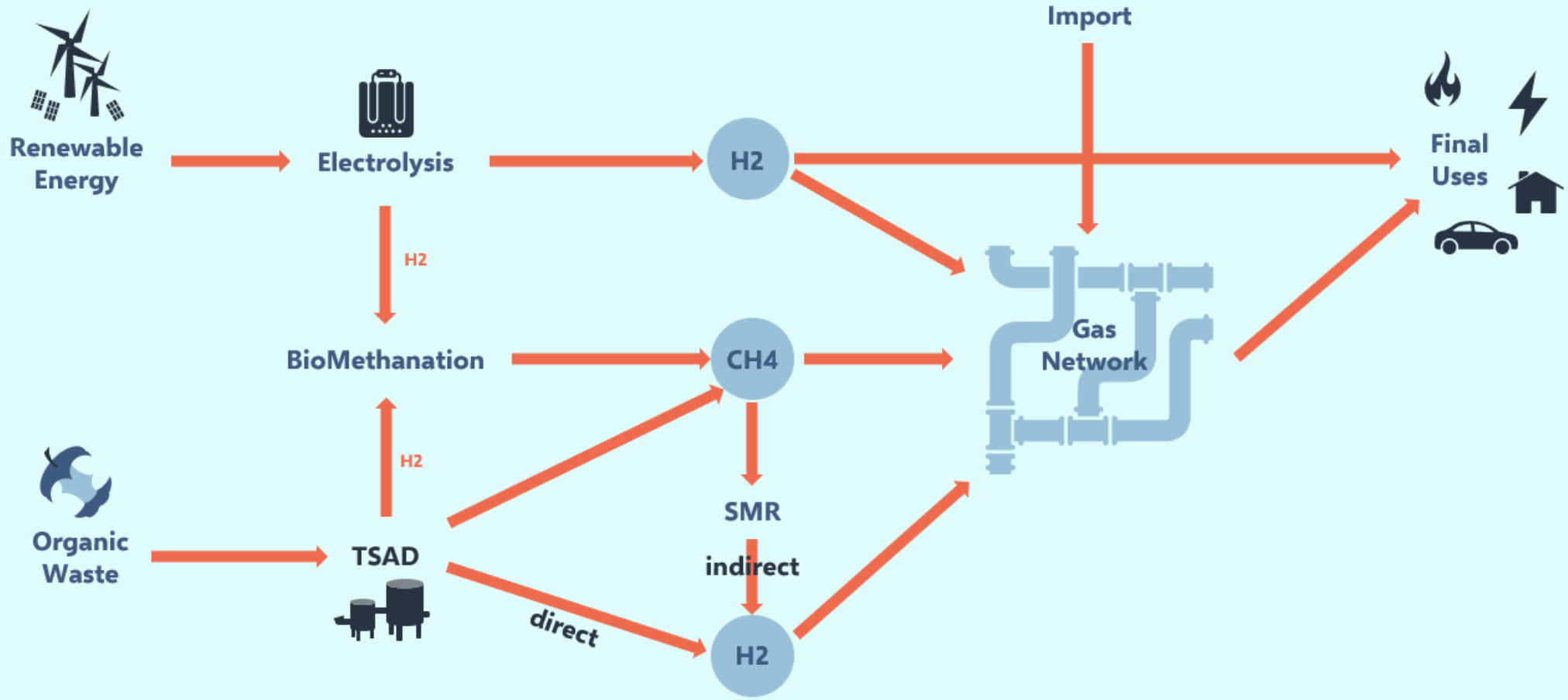
Hydrogen could be the key for the EU to the decarbonization by 2030-2050.
In particular, the italian PNRR allocated 3,19 billions to Hydrogen production and utilization



https://italiadomani.gov.it/it/home.html

Future Prospects

The TSAD process, even on the large scale, and the biohythane production could be an important help in achieving this goal.



Thank you for the attention