16.10.2023

Waste to Hydrogen

Giacomo Rispoli, CEO MyRechemical

MYRECHEMICAL

MAIRE INTEGRATED ORGANIZATION

SUSTAINABLE TECHNOLOGY SOLUTIONS

- NEXTCHEM NextChem SpA
- NEXTCHEM NextChem Tech SpA
- MYRECHEMICAL
- MYREPLAST Industries
- MYREMONO
- STAMICARBON
- CONSER

PROJECT DEVELOPMENT

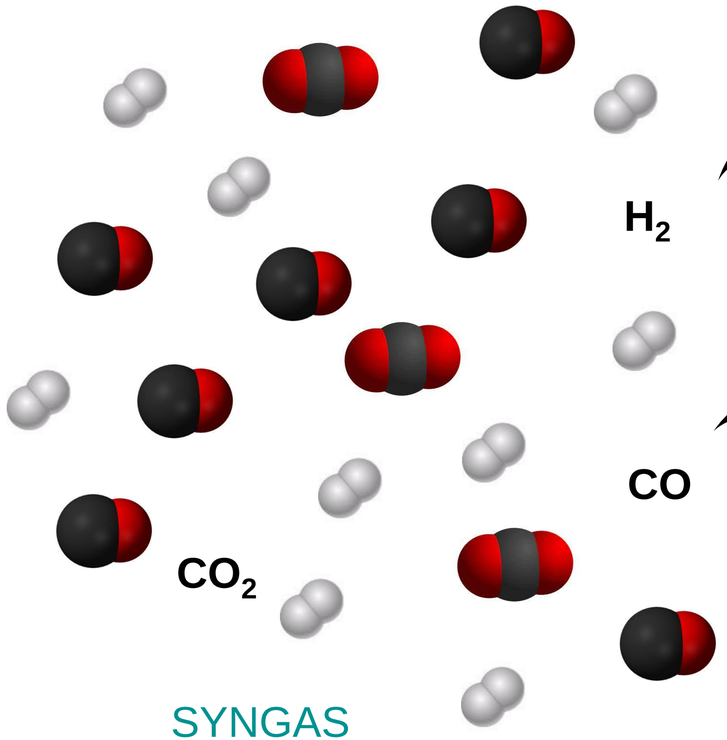
- MET DEVELOPMENT

INTEGRATED E&C SOLUTIONS

- TECNIMONT
- KT
- MST

WASTE TO CHEMICALS CONCEPT

REFUSAL
NOT RECYCLABLE
(I.E. RDF, PLASMIX, SPECIAL WASTE, INDUSTRIAL WASTE)



SYNGAS
CIRCOLAR GAS®

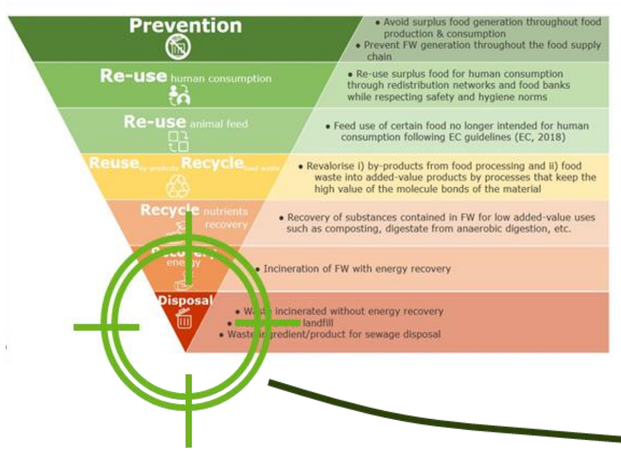
SOSTITUZIONE DEL
GAS NATURALE NEI
PROCESSI INDUSTRIALI

CIRCULAR METHANOL™

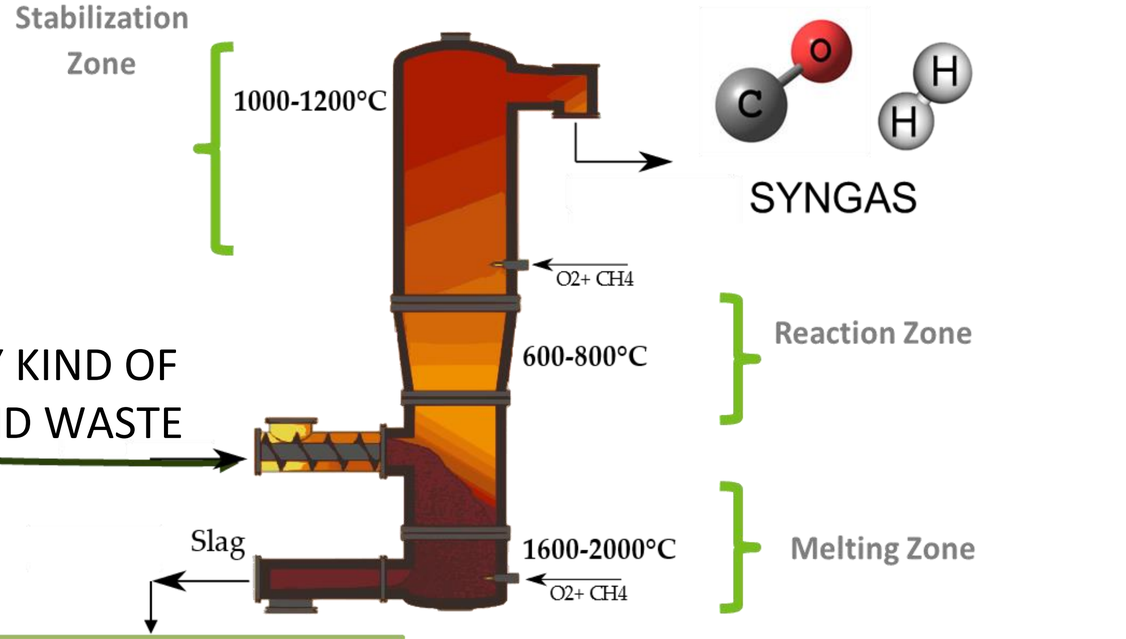
CIRCULAR HYDROGEN®

CIRCULAR ETHANOL™

MYRECHEMICAL - SYNGAS PRODUCTION FROM WASTE



ANY KIND OF SOLID WASTE



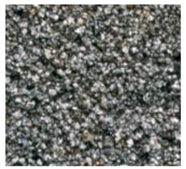
Vetrified inert fraction (granulate)

Ceramic Industry

Rockwool

Civil application

INERTS
≈ 10% in mass
≈ 1% in volume



METALS
≈ 1% in mass
≈ 0,15% in volume

Steel production

EUROPE WASTE

Waste-to-Energy in Europe in 2020

- WtE Plants operating in Europe (not including hazardous waste incineration plants) : **504**
- Waste thermally treated in WtE plants (in million tonnes): **101**

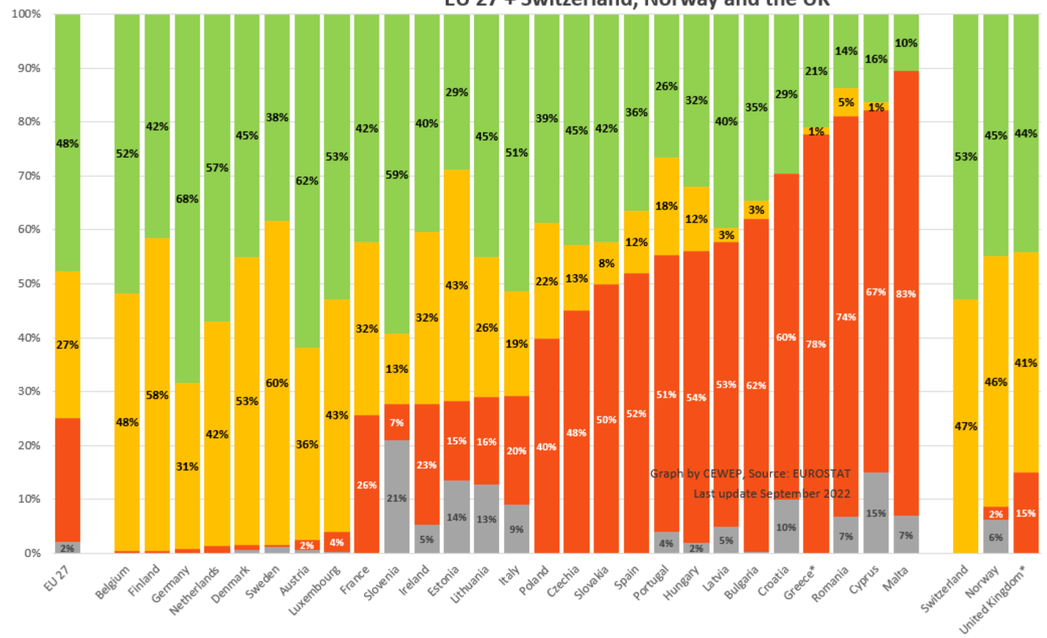
Data supplied by CEWEP members and national sources

*: Includes plant in Andorra and SAICA plant

CEWEP Confederation of European Waste-to-Energy Plants

Municipal waste treatment in 2020

EU 27 + Switzerland, Norway and the UK



Landfill
Waste-to-Energy
Recycling +Composting
Missing data

About 90 million of tonns are sent to landfill

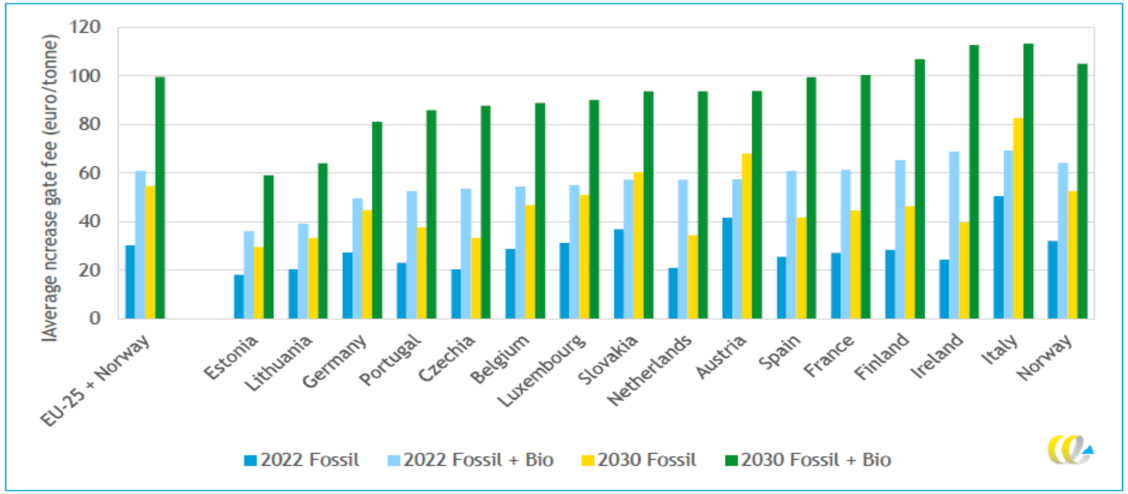
101 million of tonns in Europe are thermally treated in order to be disposed

By Waste to chemical technology roughly 12 million of circular hydrogen could be produced

* Also industrial waste can be fed to WtC, these waste streams roughly account for one third of MSW

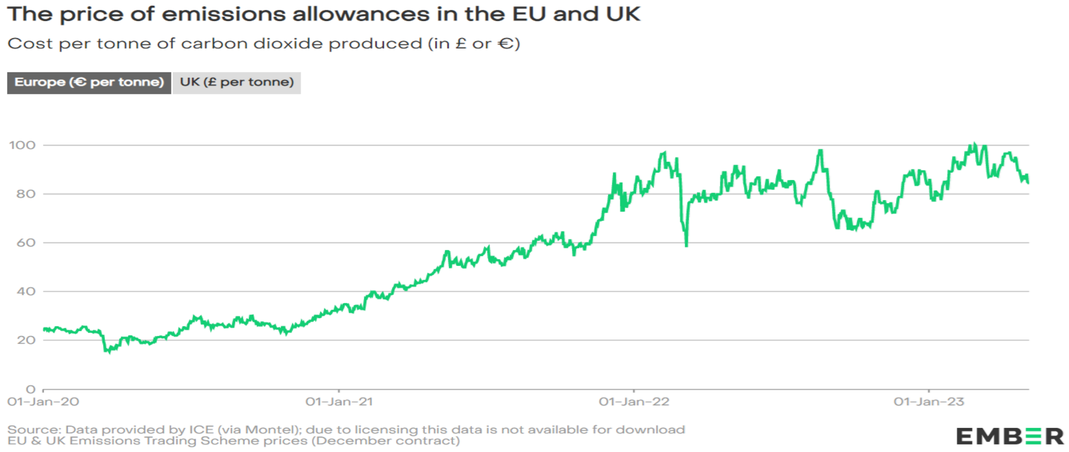
WASTE MANAGEMENT ENTERING IN ETS SCHEME

WTE DELTA GATE FEE BY ENTERING IN ETS SCHEME



ZWE_Delft_Oct21_Waste_Incineration_EUETS_Study.pdf (zerowasteeurope.eu)

EU ETS CO2 PRICES



Carbon Price Viewer - Ember (ember-climate.org)

REVISION OF EU Emission Trading System (EU ETS)

ON 18TH APRIL 2023 THE EUROPEAN PARLIAMENT HAS APPROVED KEY LEGISLATIVE ELEMENTS OF ITS "FIT FOR 55" PACKAGE: EU EMISSION TRADING SYSTEM (EU ETS) REFORM AND THE NEW EU CARBON BORDER ADJUSTMENT MECHANISM (CBAM).

PHASE OUT OF ETS ALLOWANCES FOR INDUSTRY

FREE ALLOWANCE NEED TO BE REDUCED TO ZERO IN 2034 WITH FOLLOWING PHASE OUT RATE:

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034
Rate	2,5%	5%	10%	22,5%	48,5%	61%	73,5%	86%	100%

WASTE INCINERATION PLANT TO BE INCLUDED IN ETS

The Commission should also assess and report to the European Parliament and the Council by July 2026 on the inclusion of municipal waste incineration plants in the EU ETS, including with a view to their inclusion from 2028 or at the latest 2030.

Source: https://www.europarl.europa.eu/doceo/document/TA-9-2023-0098_EN.html

GERMANY WOULD ALSO ANTICIPATE EU ADDING CO2 FROM WASTE TAX BY 2024

The new, national CO2-tax announced for the German EfW market will come into force from the 1. January 2024. The emissions from waste incineration will be subject to a CO2 tax that amounts to €40/t in 2024, and will increase to €50/t in 2025. The CO2 tax, which is charged to the incinerator, is paid on top of the existing incineration fee.

WASTE MANAGEMENT ENTERING IN ETS SCHEME

WASTE TO ENERGY EMISSIONS VS WASTE TO CHEMICAL

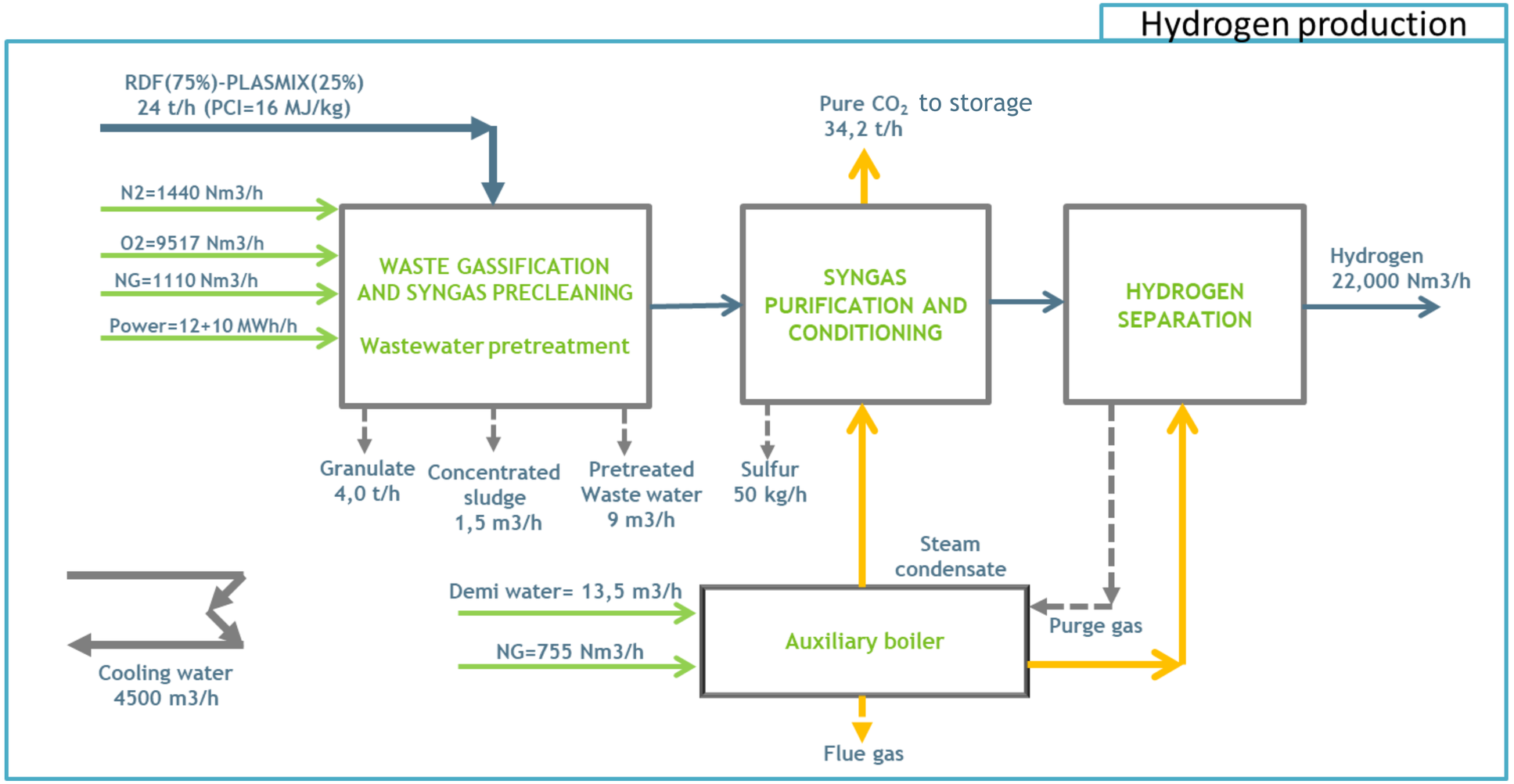
- **WTE**
  ALL CARBON CONTEINED IN THE WASTE IS CONVERTED INTO CO2 AS FLUE GAS AT LOW CONCENTRATION (6-12% mol). THUS IN ORDER TO AVOID EMISSIONS, CO2 CAPTURE SHOULD BE DONE ON FLUE GASES, THEN LIQUEFACTION, TRANSPORT AND STORAGE.
- **WTC**
  THE CARBON OF WASTE IS PARTIALLY CAPTURED BY MOLECULES (IN CASE OF MEOH AND ETOH). IN CASE OF HYDROGEN ALL CARBON IS CONVERTED INTO CO2 BUT AFTER CHEMICAL CONVERSION; THUS, CO2 PRODUCED IS ALREADY COLLECTED INTO A STREAM OF HIGH CONCENTRATION (90-95% mol). DIRECTLY LIQUEFACTION, TRASPORT AND STORAGE HAVE TO BE APPLIED.

IN ORDER TO MAINTAIN THE PROFITABILITY WTE PLANT WOULD INCREASE GATE FEE ASKED BY THEIR PLANT FOR WASTE CONVERSION, BY VARIATING THE STANDARD OF MARKET.

THE ADDITIONAL COST WHICH WTE PLANT HAS TO TURN OVER GATE FEE, FOR WTC CHEMICAL REPRESENT A MUCH LOWER COST BY CREATING AN ADDITIONAL REVENUE ON GATE FEE.

CASE STUDY- CIRCULAR HYDROGEN

CIRCULAR HYDROGEN SCHEME



* CO2 is collected directly pure and sent to geological storage.

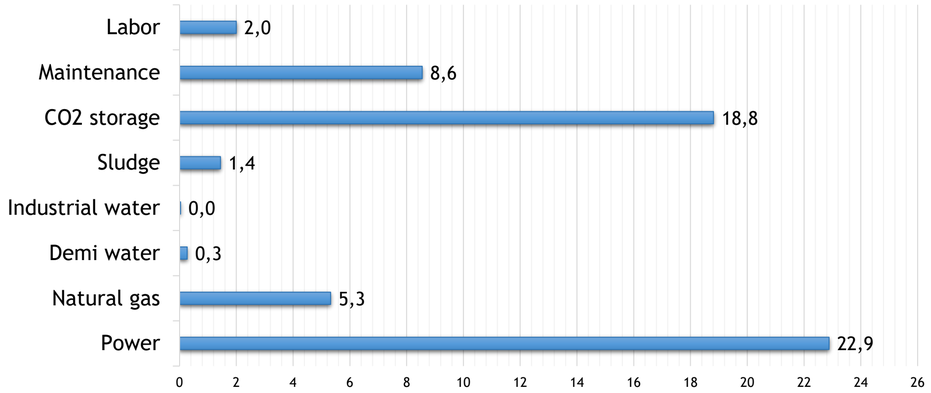
HYDROGEN SCHEME

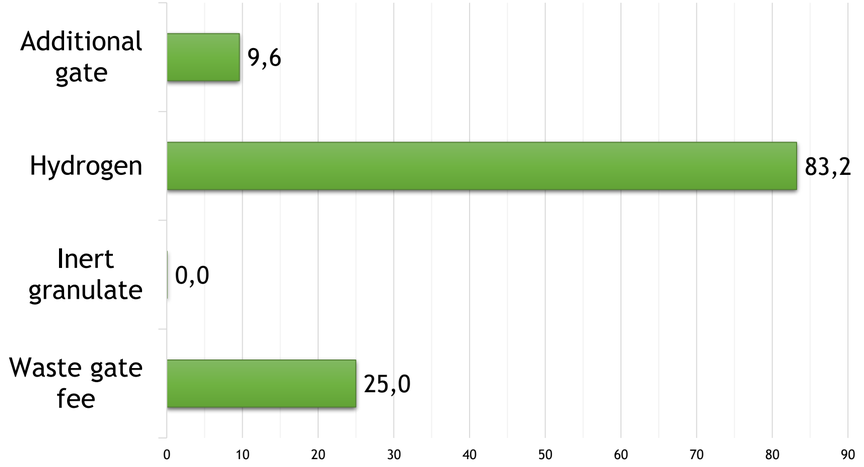
CAPEX (prel.)	570 €M

Power cost	130 €/Mwh
Natural gas	50 c€/kg
Demi water	3 €/m3
CO2 liquefaction, transport and storage	110 €/t

Waste gate fee	130 €/t
Additional Gate fee	50 €/t*

Circular H2 COP for 10% IRR~ 5,3 €/kg





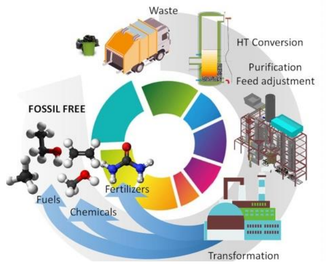
* delta efficiency for CO2 storage vs WTE CO2 storage

LCA POINT OF VIEW

COMPARING WITH H2 COMING FROM STEAM REFORMING AND WASTE DISPOSAL WITH INCINERATOR SCHEME

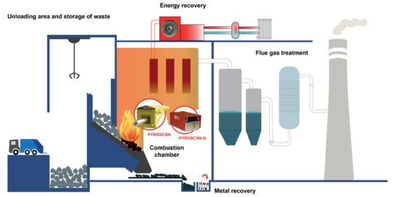
CONVENTIONAL METHANE STEAM REFORMING

VS



WASTE TO HYDROGEN

Minus



WASTE INCINERATOR

Plus

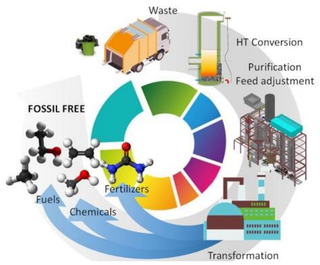
POWER NOT GENERATED BY INCINERATOR

LCA POINT OF VIEW

COMPARING WITH H2 COMING FROM STEAM REFORMING AND WASTE DISPOSAL WITH LANDFILL SCHEME

CONVENTIONAL METHANE STEAM REFORMING

vs



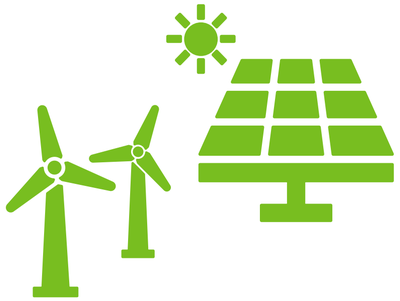
WASTE TO HYDROGEN

Minus

WASTE LANDFILL

CASE STUDY- ELECTROLYTIC HYDROGEN

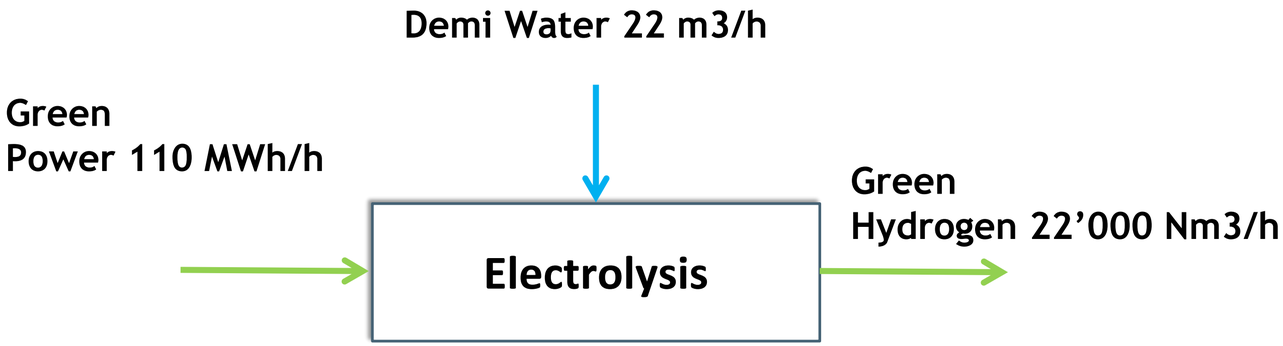
ELECTROLYTIC HYDROGEN SCHEME



*in order to have no indirect emisison power should come from renewable energy other wise should be taken into consideration that power from grid generates about 11 kgCO2 per KgH2.

Nervetheless continous (at least 8000 h/year) renewable power would required relevant storages system.

Actually green hydrogen is not a cheap solution (unless for exceptional cases where contest could be favorable to solve mentioned issue)

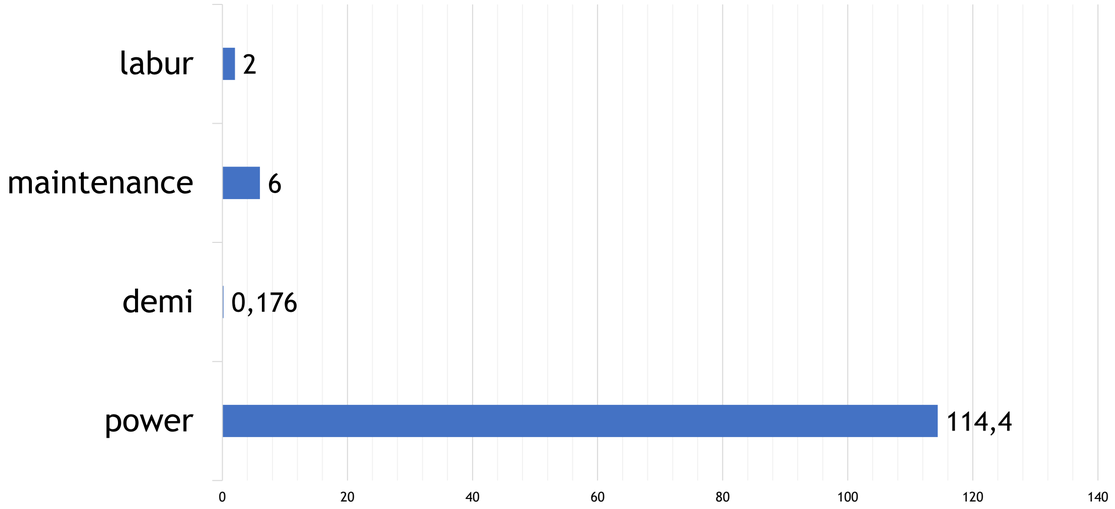


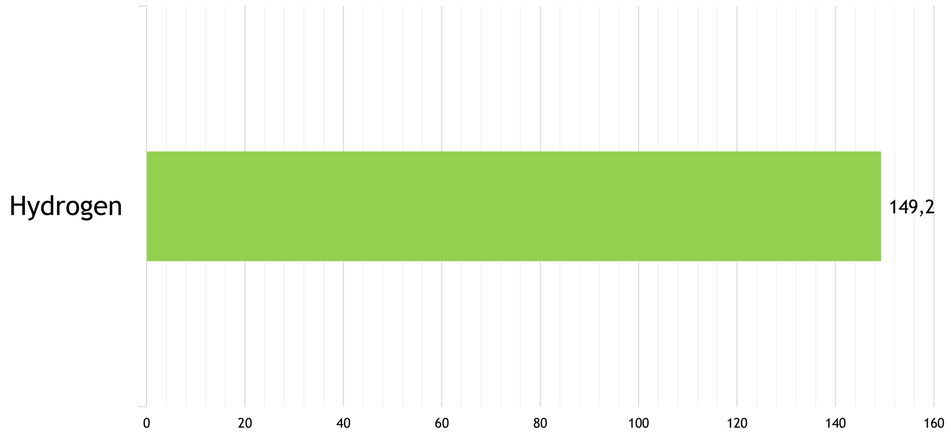
HYDROGEN SCHEME – electrolysis comparison for 22.000 N3/h

CAPEX (prel.)	250 €M

Power cost	130 €/Mwh
Demi water	3 €/m3

Electrolytic H2 COP for 10% IRR ~ 9,5 €/kg





Hy2Rome

WASTE TO ETHANOL & HYDROGEN

ETHANOL from 55.000 to 62.000 tons

HYDROGEN from 0 to 1.500 tons

LIQUID CO2 for industrial uses 20.000 tons

ARTIFICIAL SAND for civil application
30.000 tons

TOTAL INVEST.COST ~ 600 millions €

ENGINEERING & CONSTRUCTION - 4 years

EXPECTED LIFE - 20 years

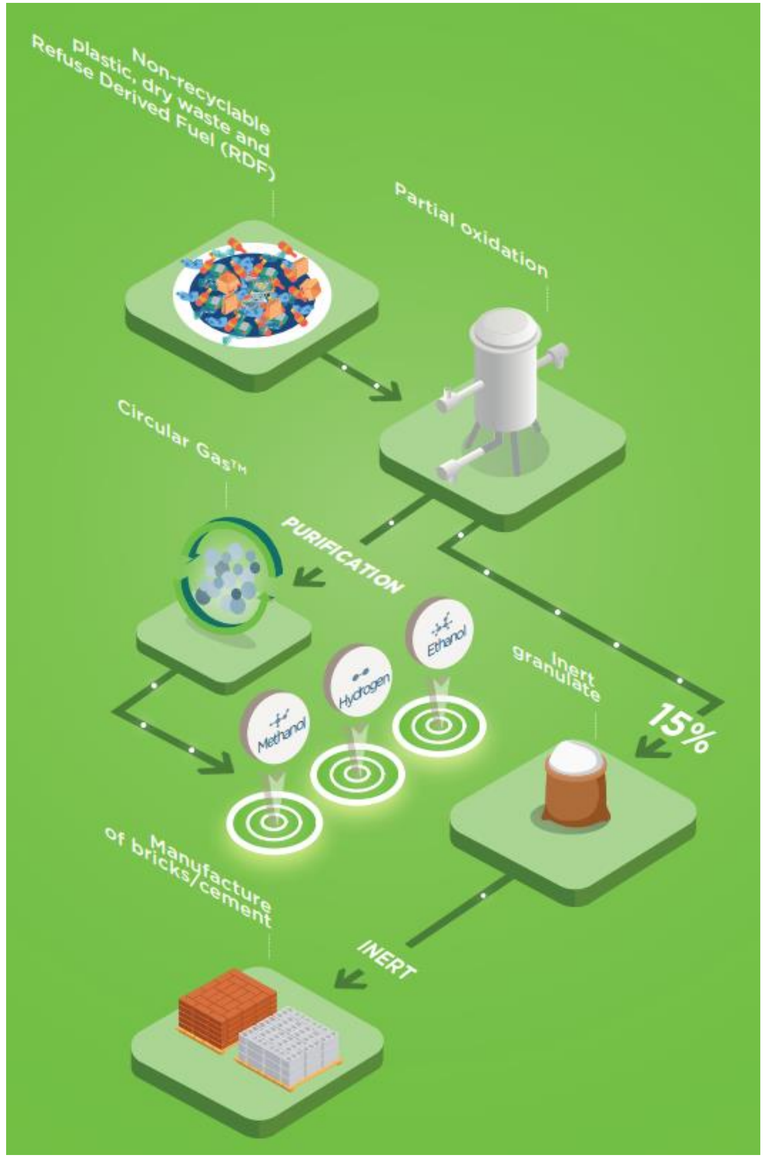
Hy2Rome – WASTE TO ETHANOL & HYDROGEN

GRANT OF **€194 MILLION** ASSIGNED TO NEXTCHEM AS PART OF THE “IPCEI Hy2USE” EU PROJECT FOR THE DEVELOPMENT OF THE FIRST WASTE TO HYDROGEN PLANT IN THE WORLD

NextChem's Waste to Chemicals technology, commercialized through MyRechemical, represents the state of the art for the recover of non-recyclable waste.

The European Commission has decreed that Waste to Chemicals and the H2 produced through this technology are perfectly compatible with European decarbonization policies and therefore considered Taxonomy Compliant.

MECHANICAL COMPLETION WITHIN Q4 2026



HYDROGEN VALLEY

H2 can always be produced at competitive prices with a W2C plant in parallel with a liquid fuel or a chemical product (methanol, ethanol, ammonia, SAF). This flexibility allows you to follow step by step the growing demand for H2 without risking not fully exploiting the production facilities

CO2 HUB

The W2C process does not emit CO2 diluted in exhaust gases like WTE plants. The residual CO2, not converted into a precious molecule, is pure CO2 thanks to the intrinsic architecture of the process and can be easily liquefied or compressed to be deposited at industrial, agricultural and geological levels.

The circular hydrogen produced by the plant will be distributed by the first service station designed for Rome.
It will allow the destruction of hydrogen for

- Mobility heavy transport vehicles
- Internal port mobility
- Bus Transportation Services
- Mobility for waste collection services

CONCLUSIONS

- Hydrogen plays an essential role in European decarbonization policies.
- Waste to hydrogen combined with CO2 storage allows the production of low carbon hydrogen at low cost.
- Incineration units can be converted into Waste to chemical ones.
  For each new WtH2 unit an hydrogen valley can be created.
- About 12 million of ton of H2 per year could be produced in Europe by converting all waste usually incinerated or sent to landfill (even more by accounting of industrial waste).
- Waste to hydrogen unit can also replace in refinery steam reforming unit fed by methane for hydrogen internal use, and can be used for decarbonization of steel factories.