Valorization of urban sewage sludge and used cooking oils into bio-H_2 or bio-methane alternative transport fuels for municipal garbage trucks

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Cluster of Bioeconomy and Environment of Western Macedonia

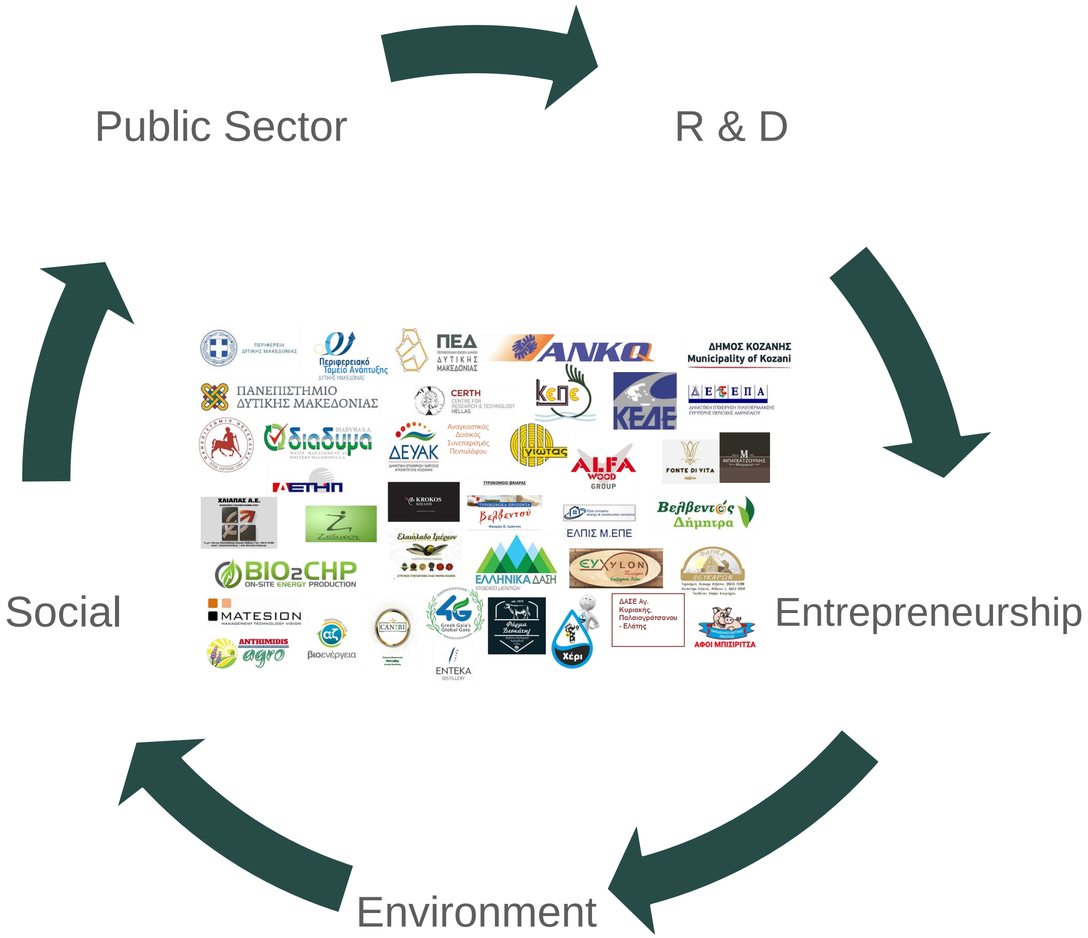
https://clube.gr

- A regional innovation cluster established as a non-profit company on 14th of February 2014
- No member fees
- Funded by strategic consulting services and EU competitive projects

Our vision:

The creation of synergies between R&D and entrepreneurship to increase knowledge and innovation in Western Macedonia

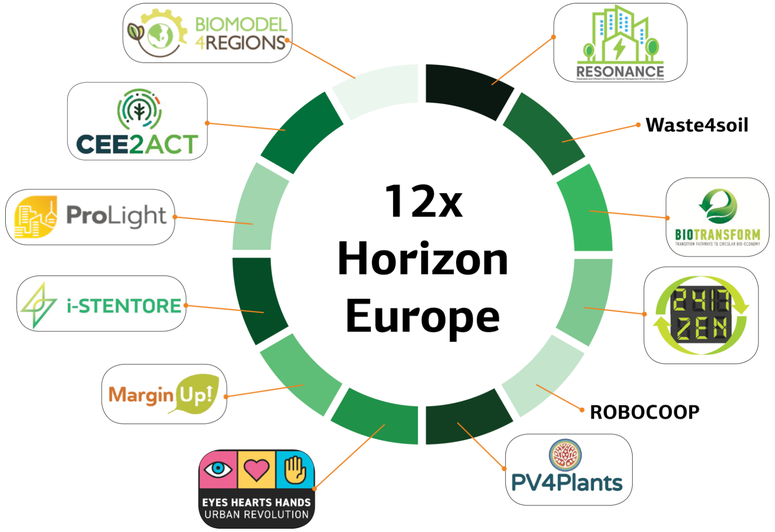
Our Power… Our Members!!!

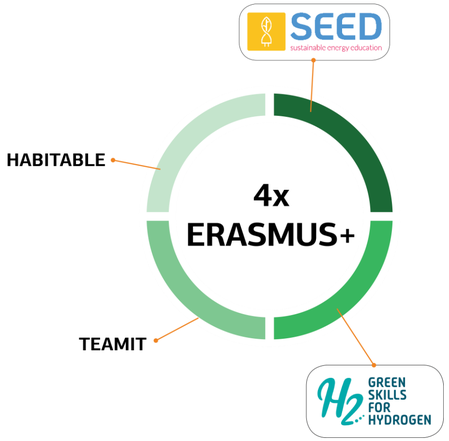


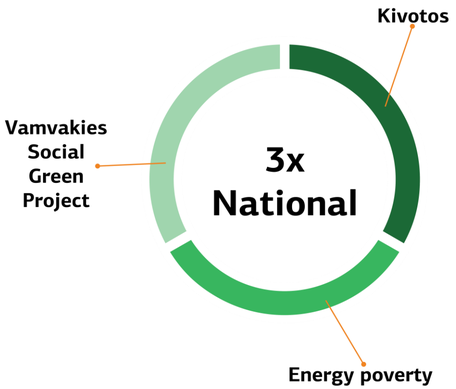
Quintuple Helix

1. Public Sector
2. R&D
3. Entrepreneurship
4. Environment
5. Social

Our Projects

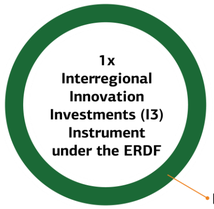




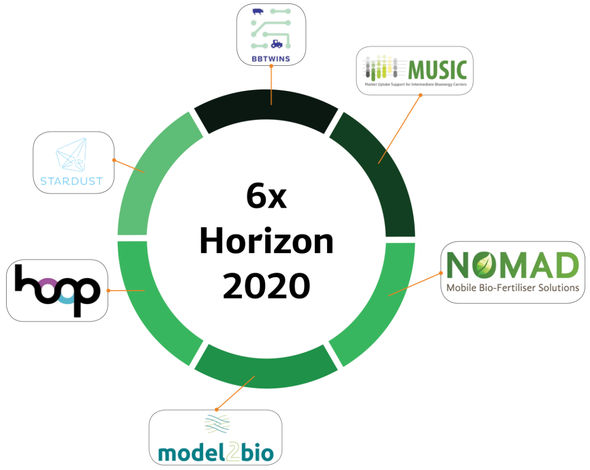


Κοζάνη 2030

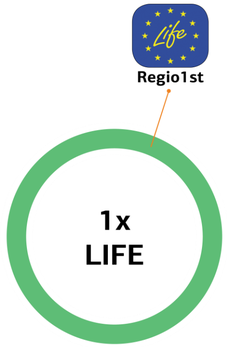
100 Climate Neutral Smart Cities by 2030 – EU Mission



Hy2Market



Agrocircularity: Applications in Agriculture



Project layout

Implementing authority

διαδυμα
ΔΙΑΧΕΙΡΙΣΗ ΑΠΟΡΡΙΜΜΑΤΩΝ
ΔΥΤΙΚΗΣ ΜΑΚΕΔΟΝΙΑΣ Α.Ε.

Technical studies

ΕΠΕΜ

ENVIROPLAN S.A.
Consultants & Engineers

Scientific Partners

UNIVERSITY OF
WESTERN MACEDONIA

CluBE
Bioeconomy & Environmental Cluster
Western Makedonia

Current status

Legislation: The Greek National Plan for Waste Management is addressed with the **JMD 51373/4684/2015**

Western Macedonia

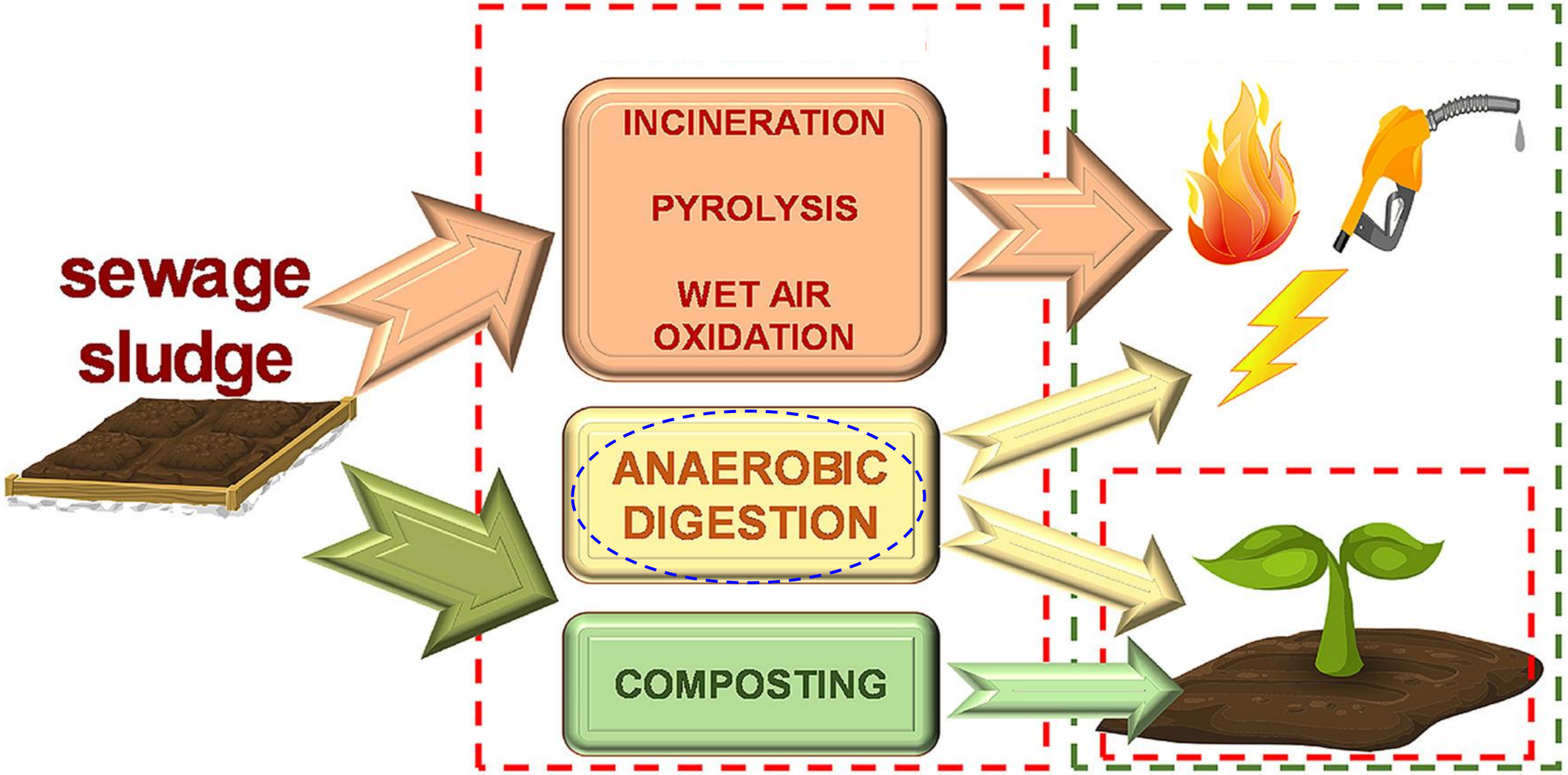
WWTPs in Western Macedonia

1) Florina
2) Amyntaio
3) Ptolemaida
4) Koila
5) Kozani
6) Lefkopigi
7) Servia
8) Velvendos
9) Askio
10) Neapoli
11) Kastoria
12) Deskati
13) Grevena

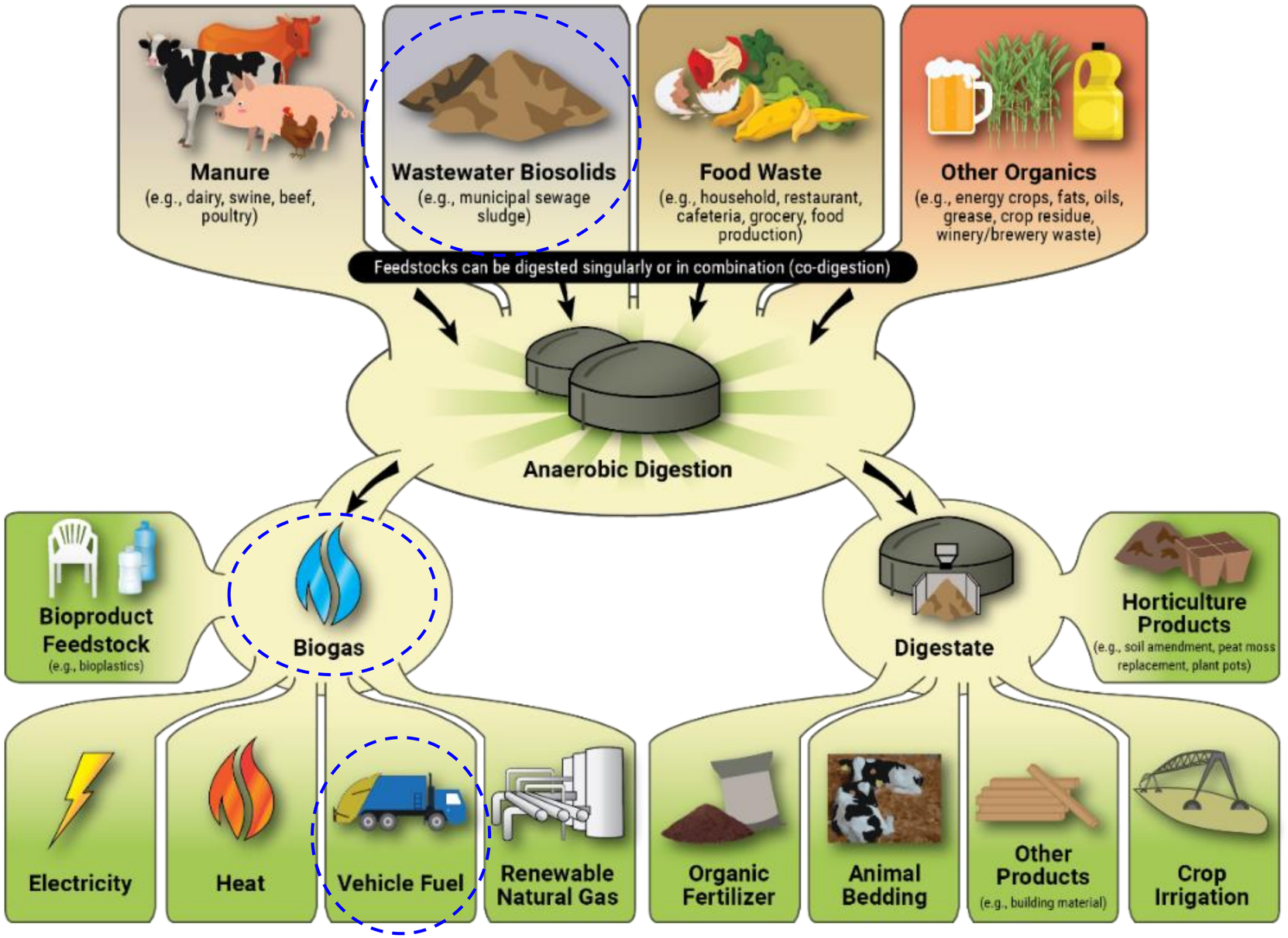
Sewage sludge production:

8,900 tn/year

Sewage sludge management pathways



Anaerobic digestion process



Proposed alternative routes

8.900 t/year

Sewage sludge

50 t/year

UCOs

Anaerobic digestion

Digestate

Biogas

462,700 m³/year

Cleaning and Reforming
Water Gas Shift
Pressure Swing Adsorption

Bio-H_2

582,000 m³/year

H_2 Refueling Station
Fuel Cell Garbage Trucks

Biogas upgrading

Bio-CH_4

246,000 m³/year

CNG Refueling Station
and Garbage Trucks

*Operation = 360 d/yr

Feedstock and Biogas Production

Sewage sludge
8,900 tons/yr

UCOs
50 tons/yr

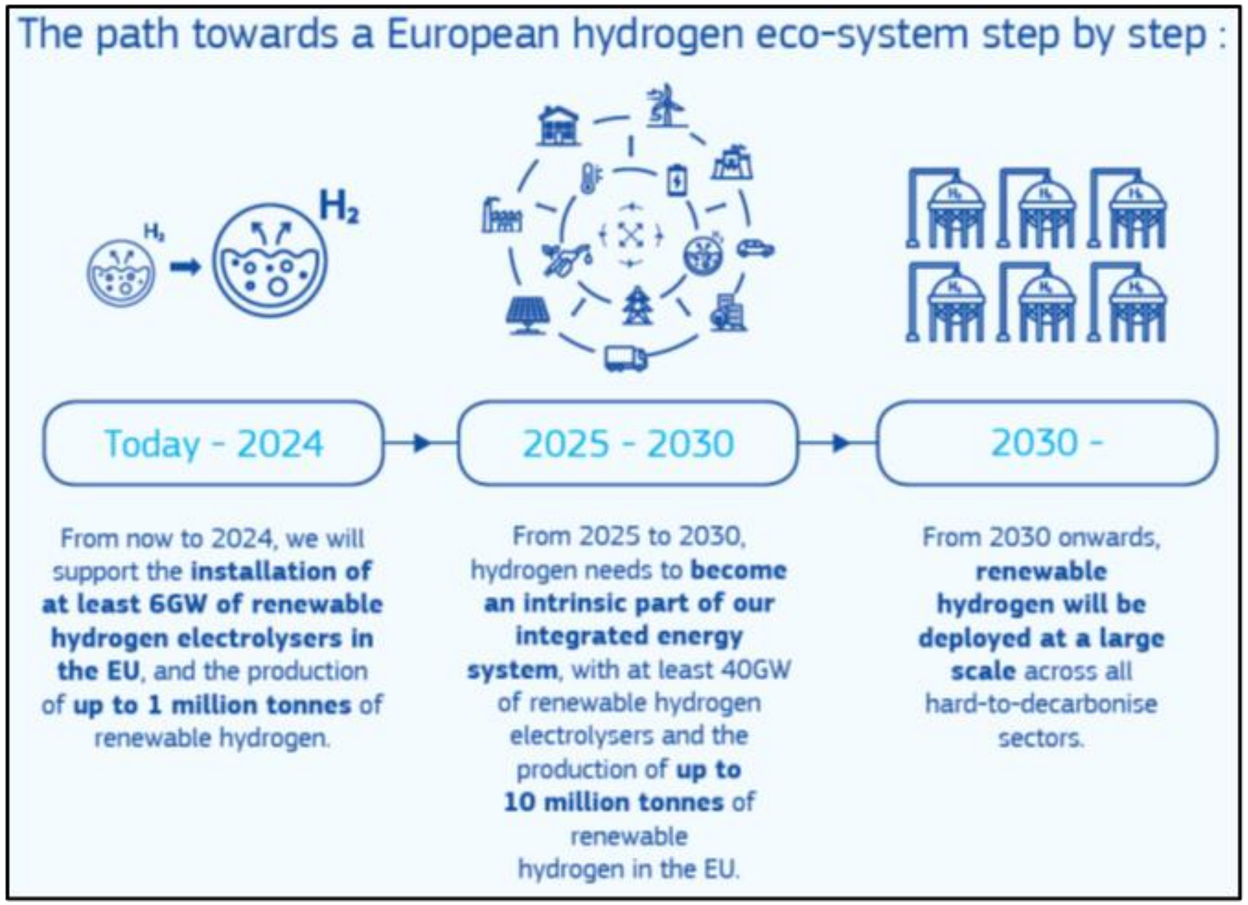
Anaerobic Digestion

Biogas
470,000 m^3/yr
52-53 v/v % CH_4

ANAEROBIC DIGESTION PARAMETERS

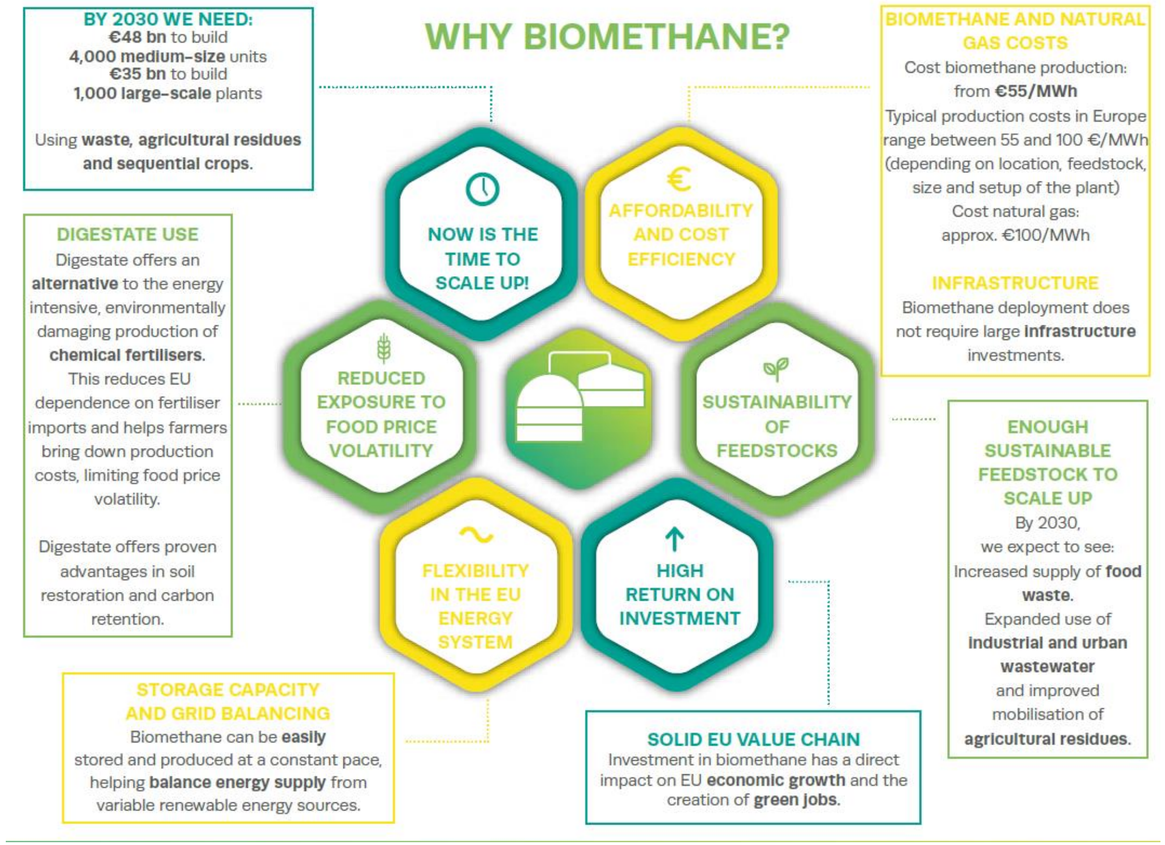
- ✓ Mesophilic temperature range (28 – 38 °C)
- ✓ Hydraulic Retention Time (HRT = 26 days)

The role of biohydrogen

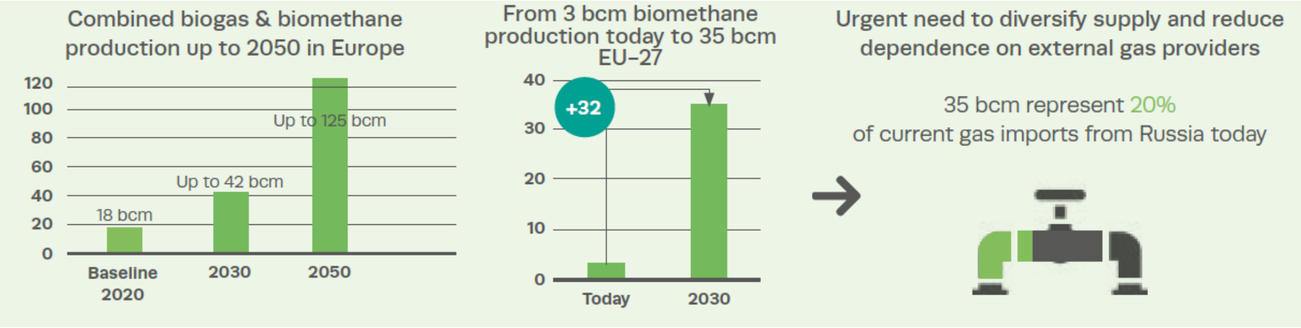


- ✓ **The REPoweEU plan aims to produce 10 million tons of renewable hydrogen until 2030 via funding of clean hydrogen initiatives**
- ✓ **Total investment of 335-470 bn € are required, including 200-300 bn € for H_2 production through renewable energy sources**
- ✓ **The European Hydrogen Bank will create a full hydrogen value chain in the EU, in accordance with the Net-Zero Industry Act**

The role of bioCH_4



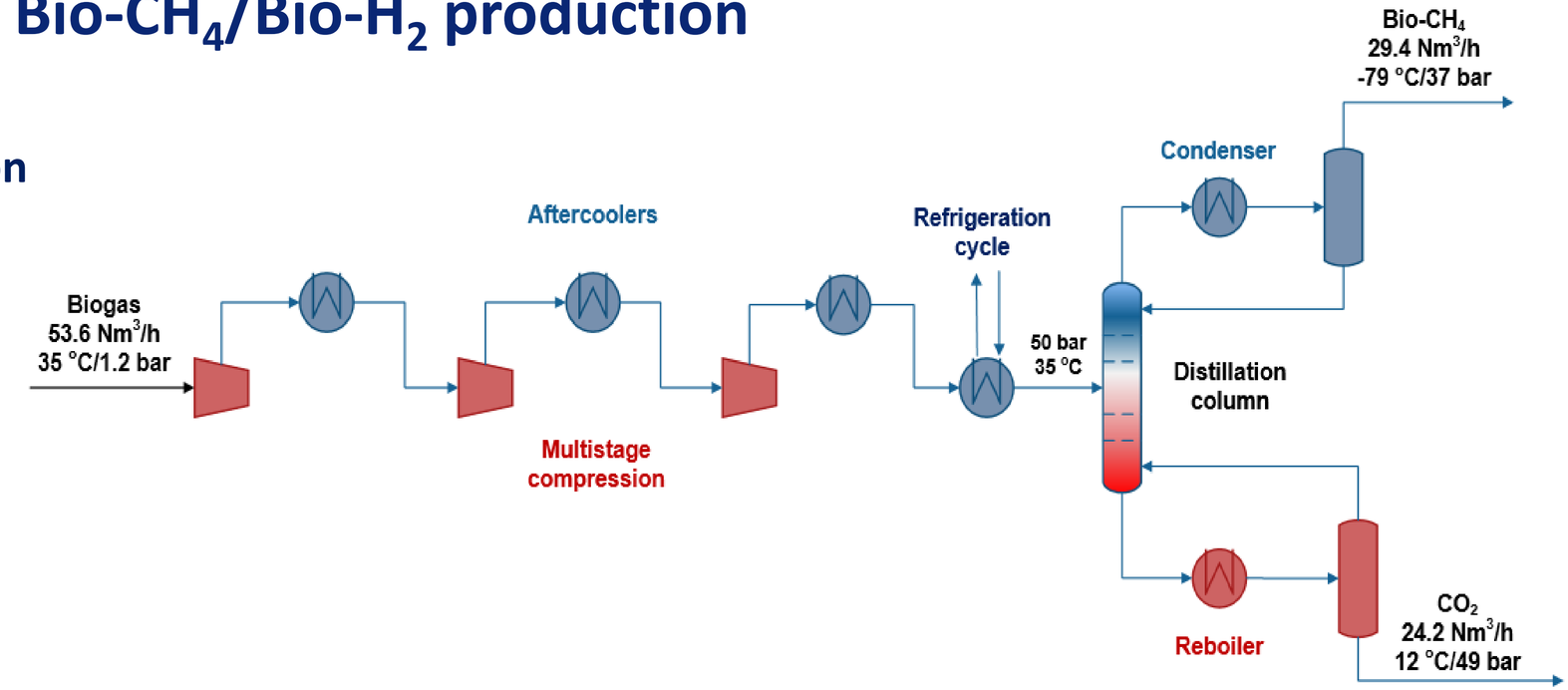
- ✓ **The European biogas/biomethane sectors are committed to delivering 35 bcm of biomethane by 2030**
- ✓ **In 2020, 18 bcm of biogas/biomethane were produced in the EU**
- ✓ **Upgrading existing biogas facilities to produce more biomethane and expanding production capacity will provide the EU with a more resilient and sustainable energy system**



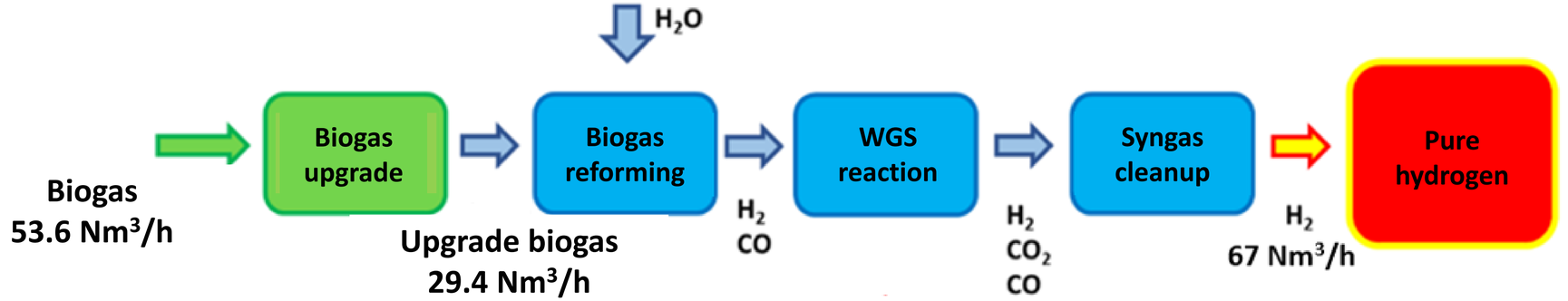
Bio-CH_4/Bio-H_2 production

Cryogenic distillation for bio-CH_4 production

- ✗ Energy consumption
- ✗ Cost
- ✓ High product purity (99.99 %)
- ✓ Liquid bio-CH_4 (easy to transfer)



Bio-H_2 production integrated system



Multi-criteria analysis

Five broad categories of criteria:

1. Environmental
2. Technical
3. Financial
4. Legislational
5. Social

Quality characteristics of the final product (energy density)
Emissions from fuel production and use
Effects on soil and aquatic environment
Aesthetic and noise disturbance
Fire and explosion hazard

Technologies based on their level of the maturity
Degree of innovation
Collection, storage and transport
System energy efficiency
Dependence on raw materials

Investment and reinvestment costs
Operational and maintenance costs
Ability to find subsidies/grants
Payback period of the investment
Oil usage cost

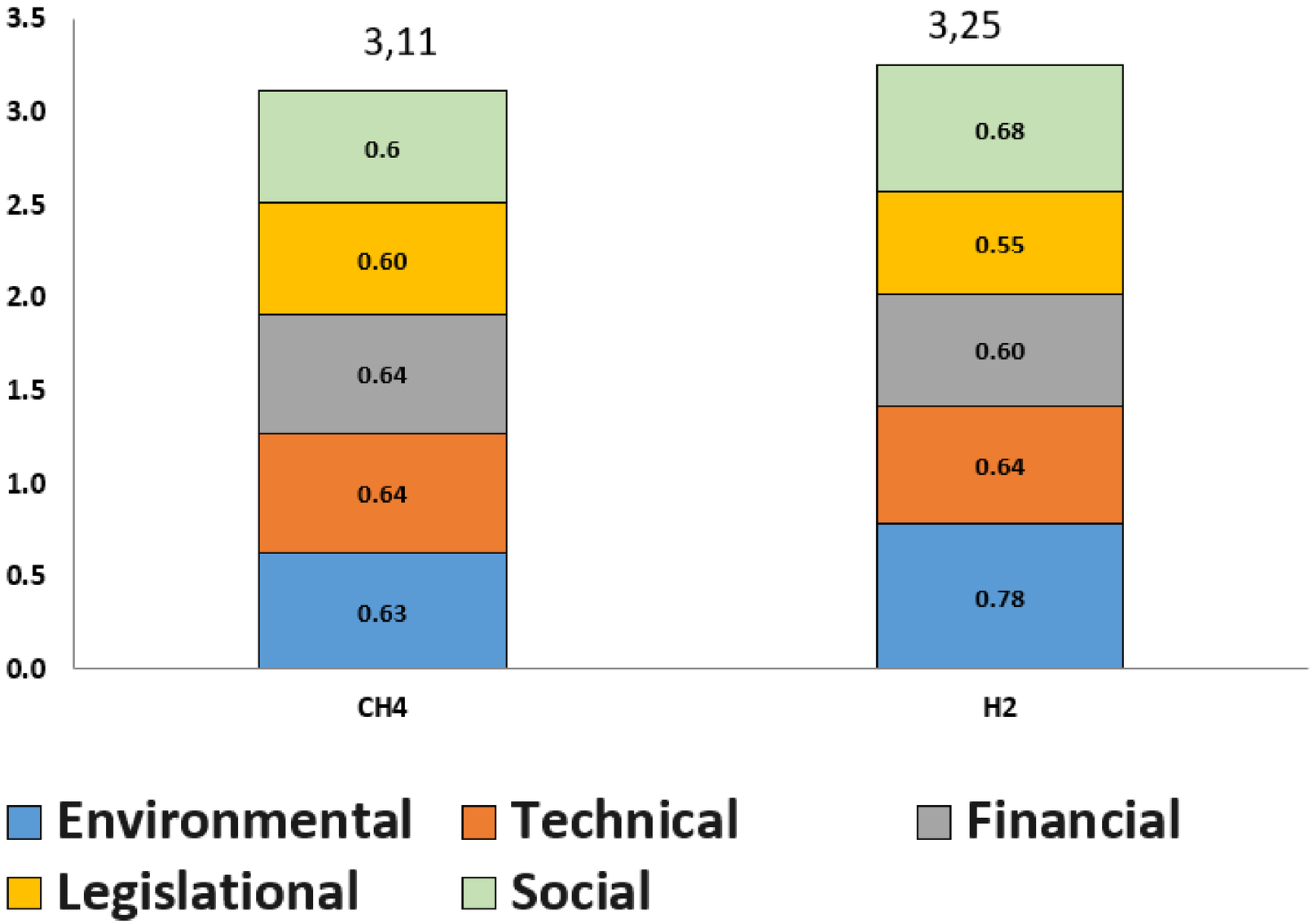
Land use restrictions
Legal and institutional framework
Flexibility to future changes in the legislative framework

Land use restrictions
Legal and institutional framework
Flexibility to future changes in the legislative framework

Each category includes several sub-criteria (with specific weights that add up to 20%):

Note: all the scenarios are relatively ranked, for each sub-criterion, between a scale of 1 (worst) to 5 (best)

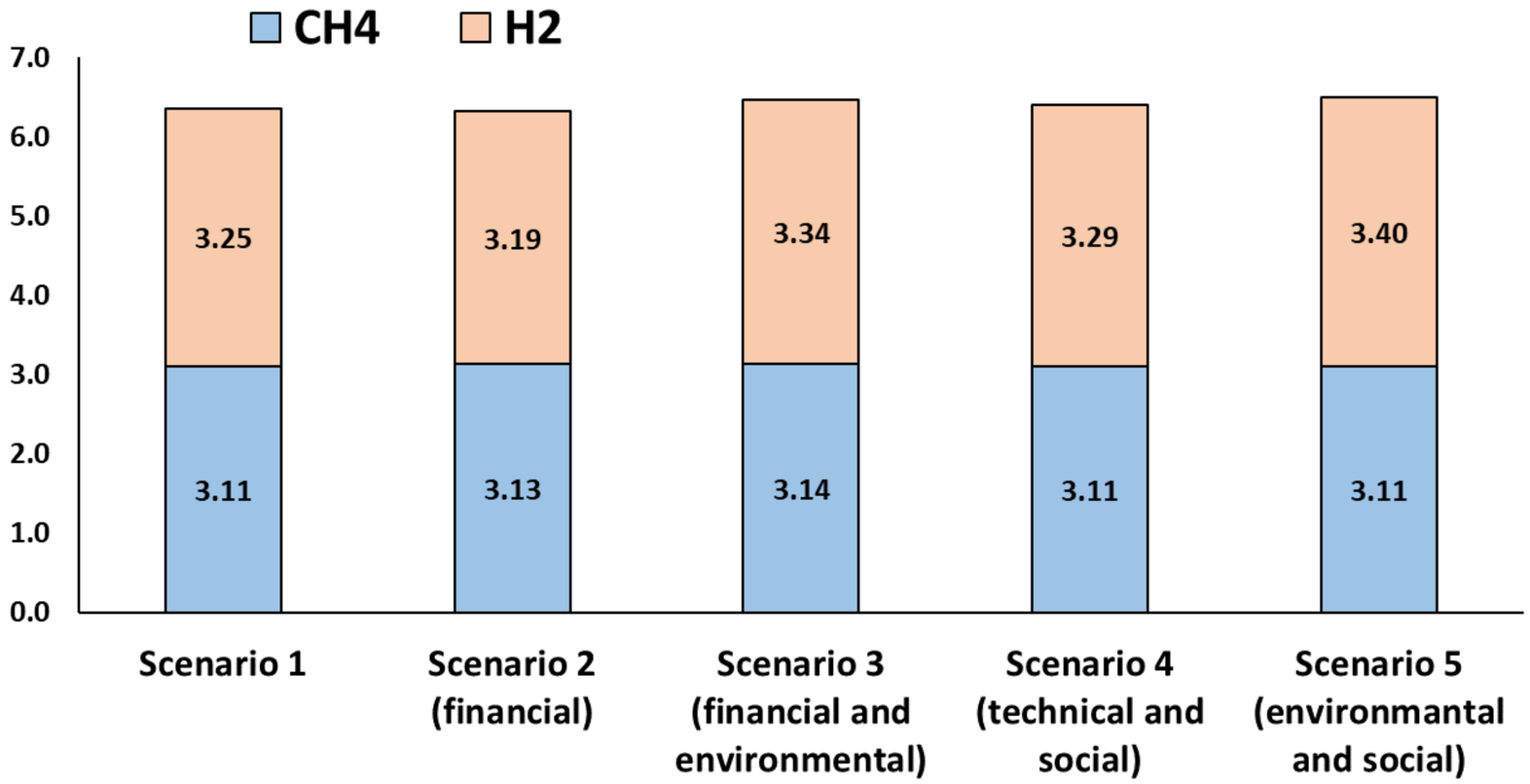
Multi-criteria analysis



Sensitivity analysis

Five scenarios:

1. Each category contributes equally (20%) in the result
2. Environmental: 15% Technical: 15% **Financial: 40%** Legislational: 15% Social: 15%
3. **Environmental: 30%** Technical: 15% **Financial: 30%** Legislational: 10% Social: 15%
4. Environmental: 15% **Technical: 30%** Financial: 15% Legislational: 10% **Social: 30%**
5. **Environmental: 30%** Technical: 15% Financial: 15% Legislational: 10% **Social: 30%**



1 m^3 H_2 ⟶ 0,083 kg H_2

Annual production H_2: 582,000 m^3H_2/yr x 0,083 kg/m^3 H_2= 48,300 kg/year H_2

(130-135 kg/day H_2)

H_2 garbage trucks

H_2 130 kg/day → H_2 Refueling Station → 10-12 zero emission garbage trucks

H_2 Consumption = 10 – 14 kg /100 km
Mean Distance = **110 km/day**

✓ **Cost for each garbage track ~700,000 – 1,000,000 €**

OEMs & vehicle integrators	E-Trucks Europe, FAUN Kirchhoff, ULEMCo, Navistar, Heliocentrics

Fuel cell garbage trucks

Next steps

- Detailed technoeconomic analysis of the integrated system
- Implementation of RES to cover the thermal and/or electrical demands of the system units
- Management of the excess electricity from the RES system via hybrid configurations with heat pumps, electric boilers and thermal storage

Thank you for your attention!

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