

Decarbonising grey hydrogen production in Spain by means of bio-hydrogen with CCS (HyBECCS)

L. Yagüe, Jl. Linares, E. Arenas, J.C. Romero

Rafael Mariño Chair in New Energy Technologies
Repsol Foundation Chair in Energy Transition
Institute for Research in Technology
Comillas Pontifical University

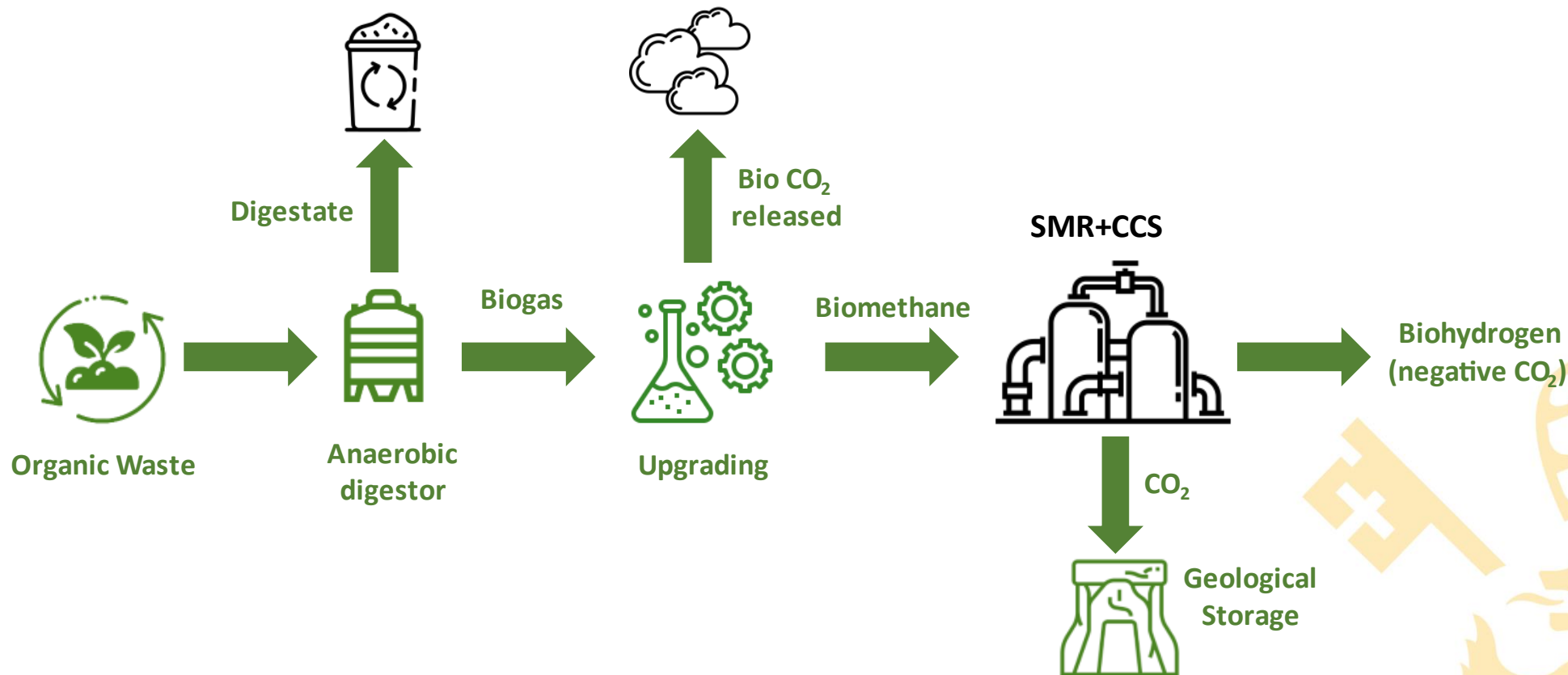
Weight of grey hydrogen

- In 2023 Spain produced 571 kt of grey hydrogen at 15 facilities
- 93% (531 kt) coming from Steam Methane Reforming (SMR) without CO₂ capture (CCS)
- 4.7 Mt CO₂ emitted

Location of the current facilities in Spain producing grey hydrogen by SMR



Biohydrogen with negative emissions (HyBECCS)



Biohydrogen with negative emissions (HyBECCS)

Biomethane resources

- Diverse estimations:
- 44 TWh/year
- 60 – 90 TWh/year
- 163 TWh/year

Repsol construirá el primer almacenamiento de
CO₂ marino en la costa de Tarragona

- El Gobierno da dos meses para presentar ofertas competidoras
- La petrolera cuenta ya con proyectos en EEUU, Indonesia, Brasil y Francia

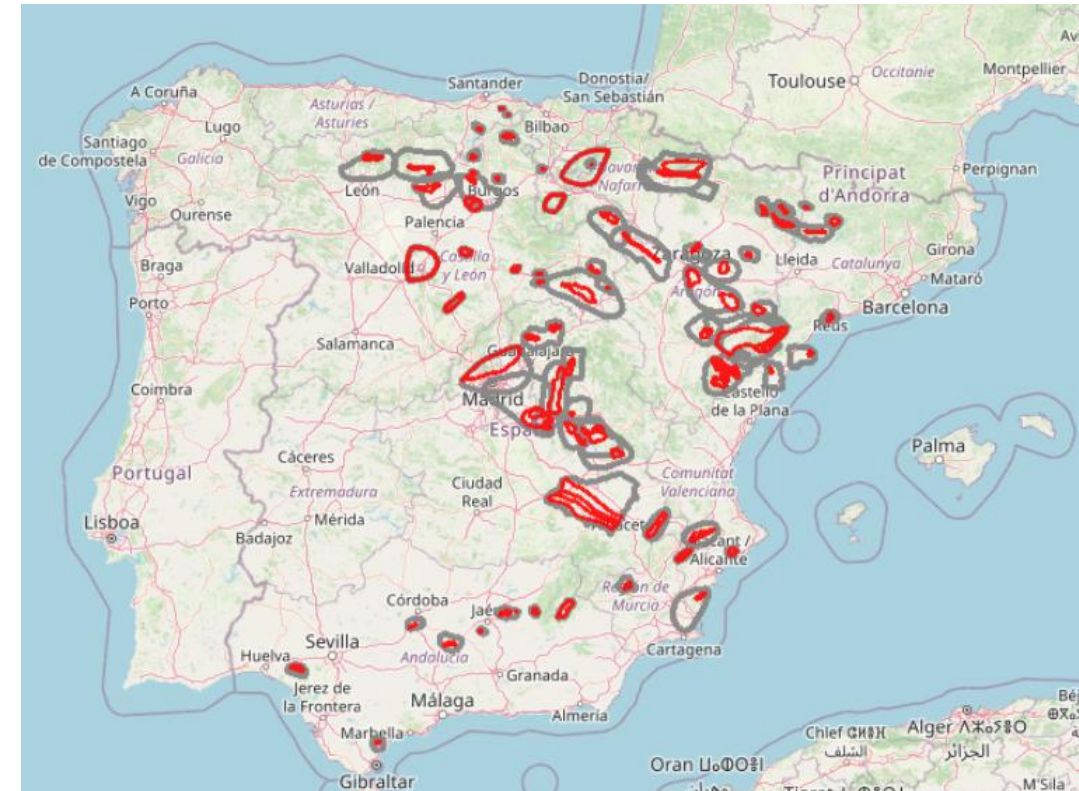


Josu Jon Imaz, consejero delegado de Repsol

[[El economista, 25/11/2023](#)]

Geological sites (CCS)

- Deep saline aquifer
- 103 sites
- Overall capacity: 21 Gt CO₂



Geological storage

$$\text{Transportation cost} \left[\frac{\text{€}}{t \text{ CO}_2} \right] = 0,2675 \times d[\text{km}]^{0,5979}$$

$$\text{Storage cost} \left[\frac{\text{€}}{t \text{ CO}_2} \right] = 655,93 \times Q[\text{MtCO}_2]^{-1,107}$$

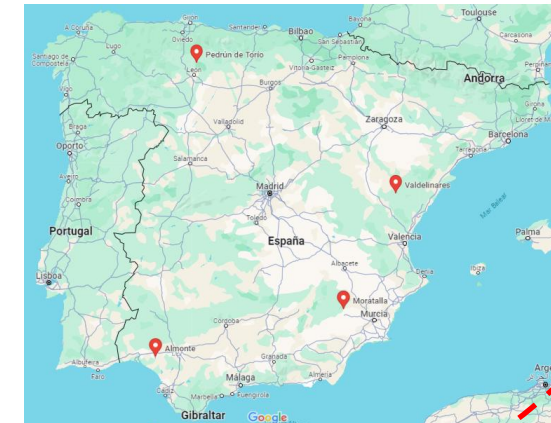
Prioritising distance to the storage:

- 9 sites
- transport & storage cost: 9.9 €/t CO₂



Prioritising storage capacity:

- 4 sites
- transport & storage cost: 5.5 €/t CO₂



Scenario A

- Total replacement of natural gas by biomethane
- Negative emissions are generated, available to be sold

Scenario B

- Partial replacement of natural gas by biomethane
- Net-zero is pursued (negative emissions self-consumed)

- Natural gas: 25 €/MWh-HHV
- Biomethane: 68.7 €/MWh-HHV
- CO₂ tax: 80 €/t CO₂ (nominal escalation rate of 3.5%)
- Investment according to size of the facility
- Transportation and storage according to actual location of facilities and sites



Results: Scenario A

Scenario A

- Total replacement of natural gas by biomethane
- CCS is added in all the facilities
- 28.7 TWh of biomethane are required
- 4,65 Mt CO₂ are converted in -4,59 Mt CO₂
- Current LCOH: 2.61 €/kg
- LCOH in Scenario A : 3.45 €/kg
- Δ LCOH = 0.83 €/kg

Facility	H ₂ production [t]	Fossil hydrogen (current situation)			HyBECCS (Scenario A)		
		Natural gas [GWh-HHV]	CO ₂ emissions [kt]	Cost [M€]	Biomethane [GWh-HHV]	CO ₂ emissions [kt]	Cost [M€]
San Roque/Algeciras CEPSE	13,688	672	119.63	37.27	738	-118.26	49.32
Huelva Fertiberia	47,584	2,335	415.88	125.26	2,565	-411.13	165.30
Huelva/La Rabida CEPSE	67,393	3,308	589.01	173.30	3,633	-582.28	227.30
Cartagena Repsol	122,506	6,012	1070.70	308.63	6,604	-1058.45	403.14
Puertollano Fertiberia	21,343	1,048	186.54	58.66	1,151	-184.40	78.38
Puertollano Air Liquide	29,976	1,471	261.99	79.79	1,616	-259	105.91
Puertollano Repsol	11,450	562	100.07	31.98	617	-98.93	42.53
Castellon de la Plana BP	63,989	3,141	559.27	164.80	3,450	-552.87	216.03
Tarragona Air Products	41,231	2,024	360.36	107.65	2,223	-356.23	142.05
Tarragona Repsol	18,479	907	161.50	50.18	996	-159.66	66.45
Sabinanigo ENERG.IND.ARAGON	1,071	53	9.36	3.50	58	-9.25	4.62
,Muskiz Repsol	50,645	2,486	442.64	132.17	2,730	-437.57	176.24
La Coruña Air Liquide	19,163	941	167.48	51.45	1,033	-165.57	68.57
La Coruña Repsol	17,110	840	149.54	46.60	922	-147.83	62.29
Aviles Nippon Gases Europe	5,870	288	51.30	16.76	316	-50.72	22.16
TOTAL	531,497	26,085	4,645	1,388	28,652	-4,592	1,830

Results: Scenario B

Scenario B

- In only 6 facilities:
 - NG replaced by biomethane
 - CCS is added
 - 2 sites required (1.6 Gt CO₂)
- 14.4 TWh of biomethane are required
- 4,65 Mt CO₂ are converted in -8 kt CO₂
- Current LCOH: 2.61 €/kg
- LCOH in Scenario B : 3.02 €/kg
- Δ LCOH = 0.41 €/kg

Facility	H ₂ production [t]	Natural gas [GWh-HHV]	Biomethane [GWh-HHV]	CO ₂ emissions [kt]	Cost [M€]
San Roque/Algeciras CEPSA	13.688	672		119,63	37,27
Huelva Fertilberia	47.584	2.335		415,88	125,26
Huelva/La Rabida CEPSA	67.393	3.308		589,01	173,30
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Muskiz Repsol	50.645	2.486		442,64	132,17
La Coruña Air Liquide	19.163	941		167,48	51,45
La Coruña Repsol	17.110	840		149,54	46,60
Aviles Nippon Gases Europe	5.870	288		51,30	16,76
TOTAL	531.497	12.945	14.434	-8	1.606

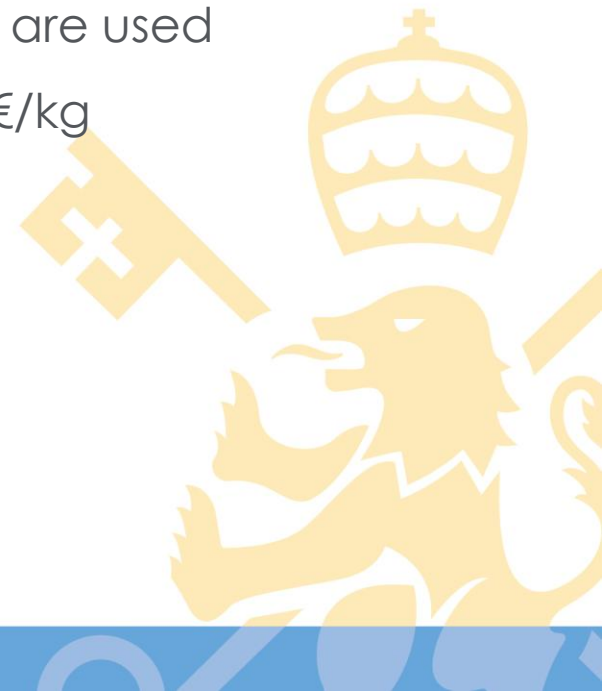
Summary of outcomes

- **Scenario A:**

- All facilities (15) involved
- 28.7 TWh of biomethane < expected potential
- Management of 4.59 Mt CO₂ is required
- 4 geological sites are used
- Extra cost of 0.83 €/kg

- **Scenario B:**

- Only 6 facilities involved
- 14.4 TWh of biomethane < Scenario A
- Management of 2.31 Mt CO₂ is required
- 2 geological sites are used
- Extra cost of 0.41 €/kg



Conclusions

- Resources required: enough biomethane and CCS sites
- Extra costs: lower than 0.5 €/kg in net-zero scenario, taking 25 €/MWh-HHV as natural gas cost (conservative hypothesis)
- Moderate infrastructure changes are required in Net-zero scenario
- In A scenario -4.6 Mt CO₂ can be leveraged to compensate 90 Mt of transport
- Regulation should be adapted to cover these technologies:
 - Transport and storage of CO₂, along with pipelines net
 - Negative emissions trading



THANKS FOR YOUR ATTENTION

Questions?



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comillas.edu

linares@comillas.edu