Future markets for renewable gases: what would the optimal regulation

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Background and research questions

In order to reduce carbon emissions, fossil fuels have to be replaced by renewable gases

1) What is the potential role of green gases and hydrogen in Europe?

2) Which policy measures are needed to promote renewable gases in an efficient way?

Contents

Renewables gases

1. which types?
2. potential supply?
3. what are costs / break-even prices?

Regulation

4. economic framework
5. recommendations for
   - targets
   - certificates
   - grid access
   - support

Types of gases

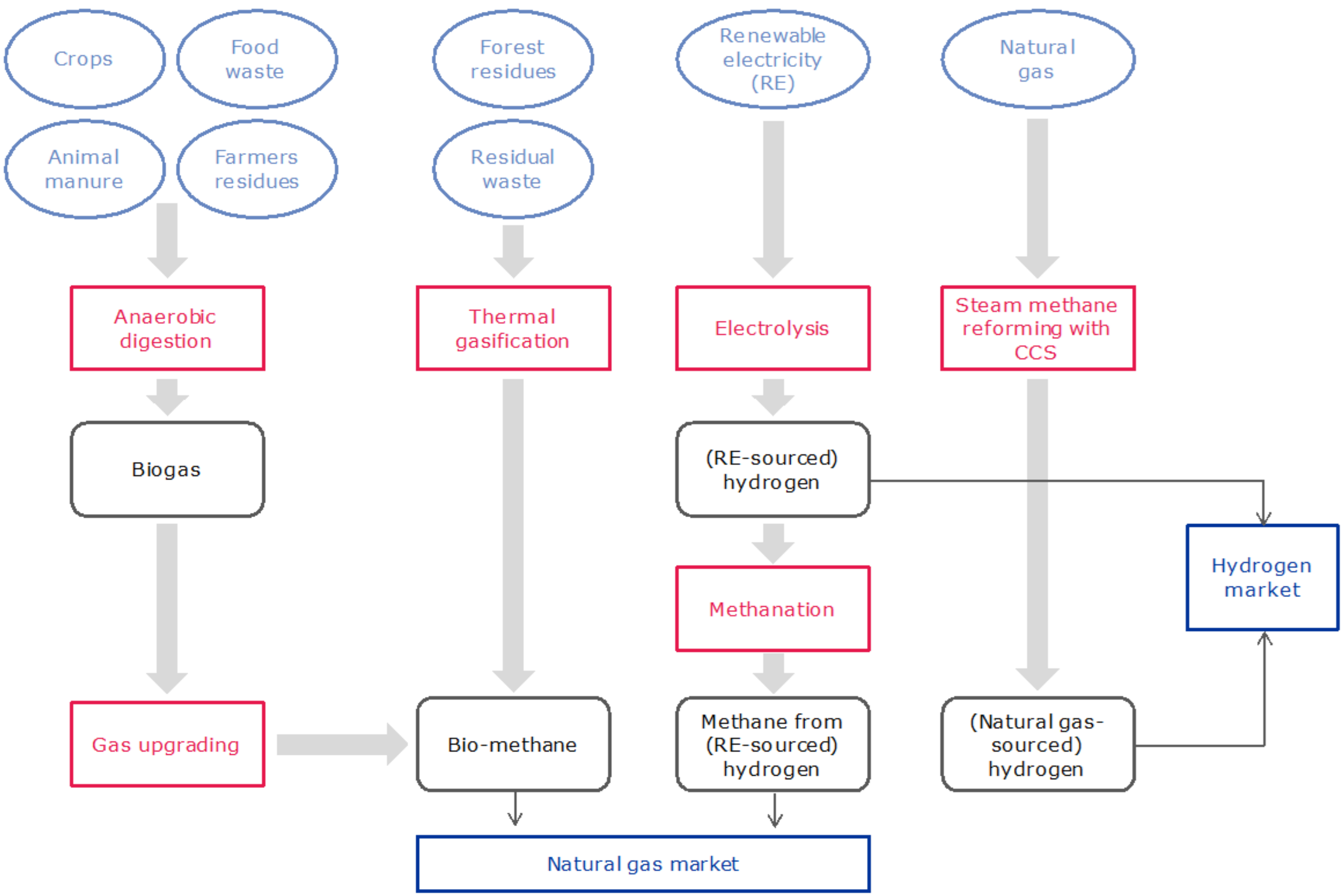
- Biogas
  - produced through anaerobic digestion (AD)

- Bio-methane
  - produced after the purification of biogas
  - or through thermal gasification (SMR)

- Hydrogen
  - produced from natural gas using CCS/CCU (NG-sourced H_2)
  - produced from the electrolysis of water with renewable electricity (RE-sourced H_2)

- Methane from hydrogen
  - produced after methanation of RE-sourced H_2

Schematic overview supply chain renewable gases and hydrogen



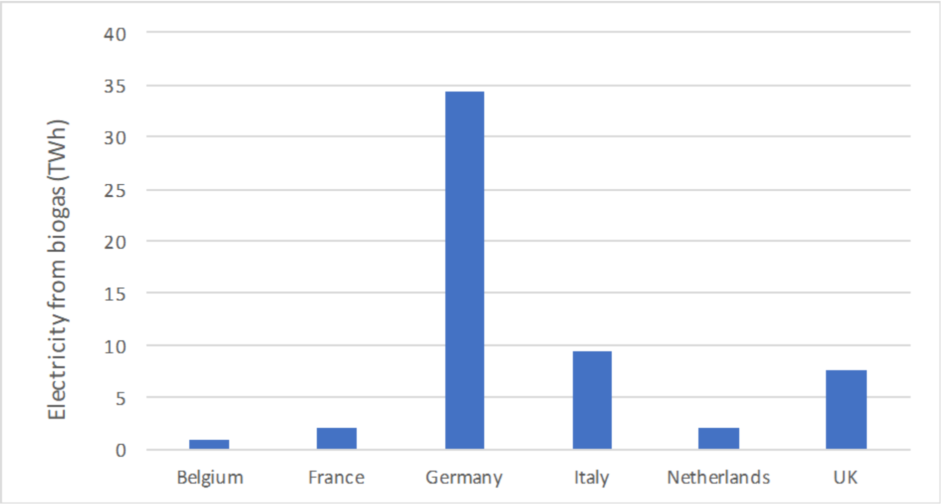
Various markets:

- biomass
- gas
- electricity
- hydrogen

Now: not discussing the interaction between these markets, but just looking at costs, potentials and policies

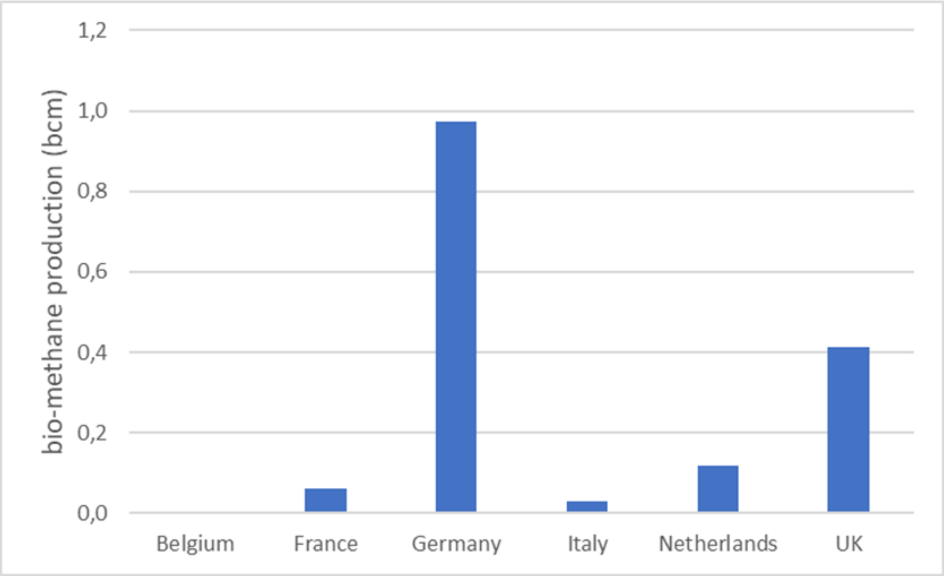
What is potential supply?

Current situation – biogas and biomethane



Biogas is mostly used to generate electricity, in particular in Germany (35 TWh)

On EU level: 2% of electricity generation



Biomethane production is quite small

(in Europea: 2 bcm)

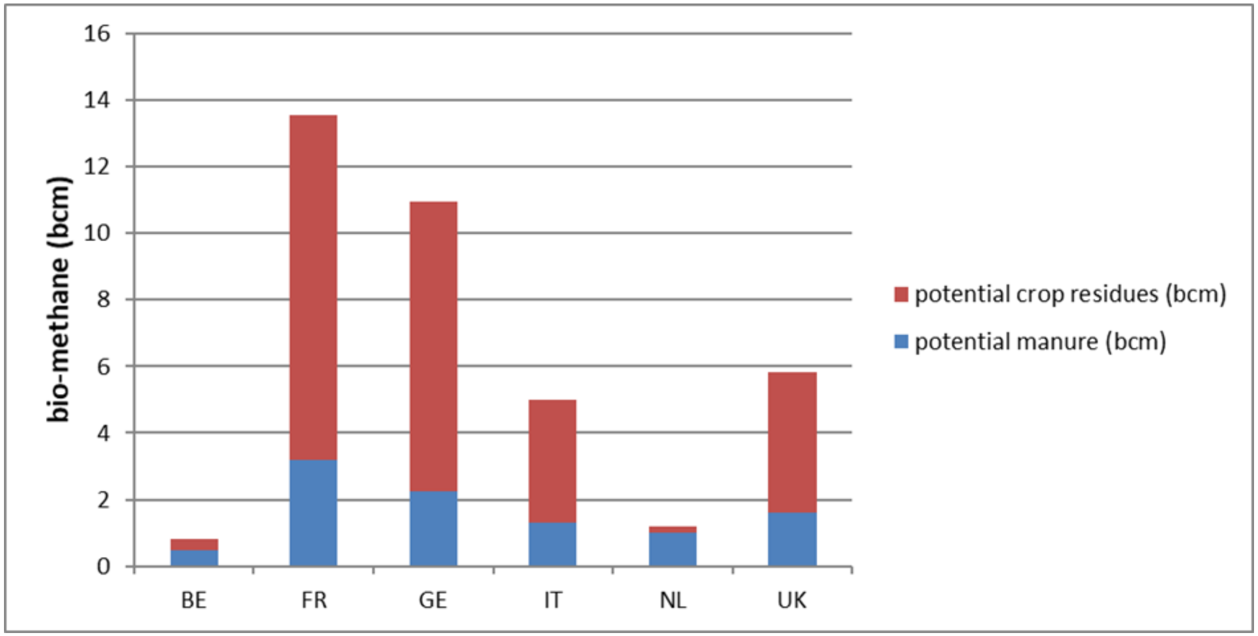
Compare: total gas use in Europe is about 500 bcm

Current situation - hydrogen

INDUSTRY & MARKET SHARE	KEY APPLICATIONS	SUPPLY SYSTEM	H2 DEMAND
General Industry 1%	• Semiconductor • Propellant Fuel • Glass Production • Hydrogenation of Fats • Cooling of electrical Generators	• Small on-site • Tube trailers • Cylinders • Liquid H2	LOW >0.07 Mtons
Metal Working 6%	• Iron Reduction • Blanketing gas • Forming gas	• Cylinders • Tube trailers	MEDIUM 0.41 Mtons
Refining 30%	• Hydrocracking • Hydrotreating	• Pipeline • Large On-site	2.1 Mtons
Chemical 63%	• Ammonia • Methanol • Polymers • Resins	• Pipeline • Large On-site	HIGH 4.3 Mtons

Hydrogen is mainly used as feedstock

Potential supply of renewable gases and hydrogen
Bio-methane from Anaerobic Digestion



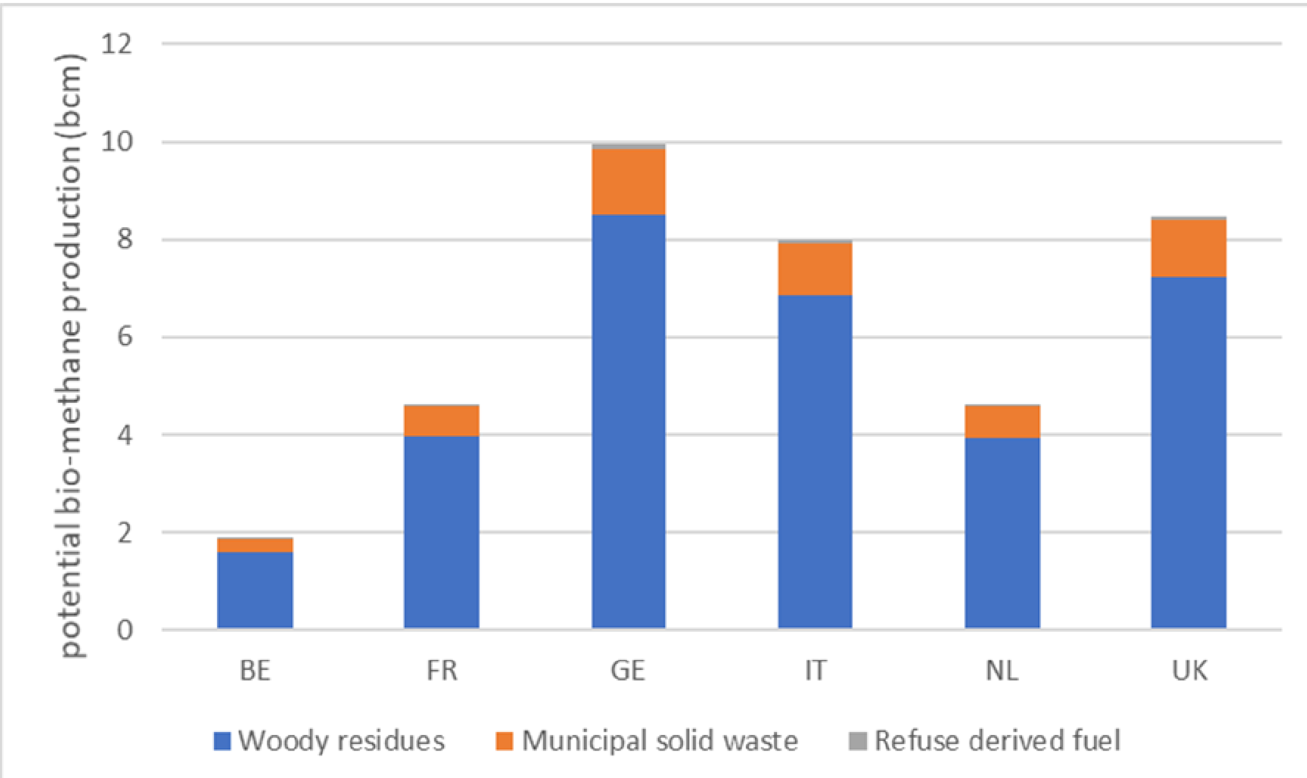
Potential bio-methane from manure constrained by availability of feedstock within 25 km radius.

Potential biomethane from crop residues constrained by amount of residues that can be harvested sustainably.

Combined potential for countries of interest is 37 bcm.

At the EU-28 level, potential is 68 bcm/year

Potential supply of renewable gases and hydrogen
Bio-methane through Thermal Gasification

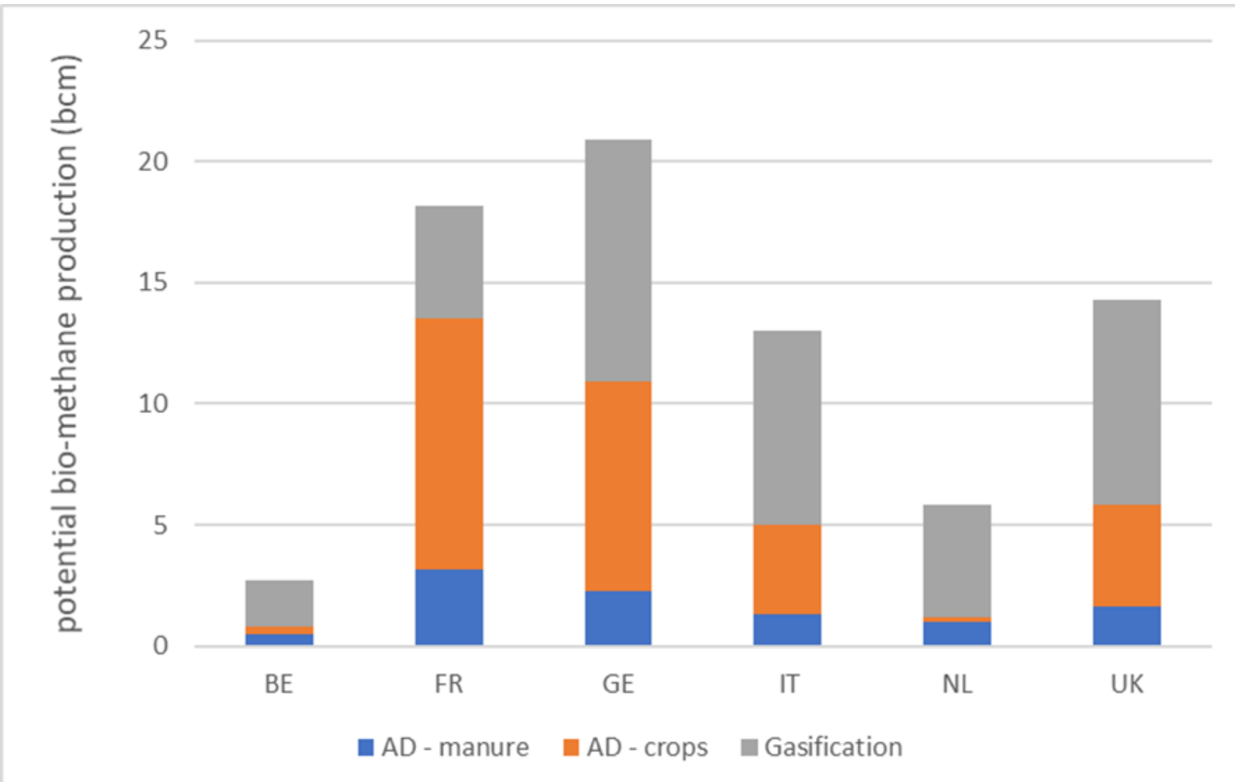


Bio-methane from thermal gasification can be deployed on larger scale as inputs can be transported over large distances.

Combined potential for countries of interest of 38 bcm.

EU-28 potential is 56 bcm.

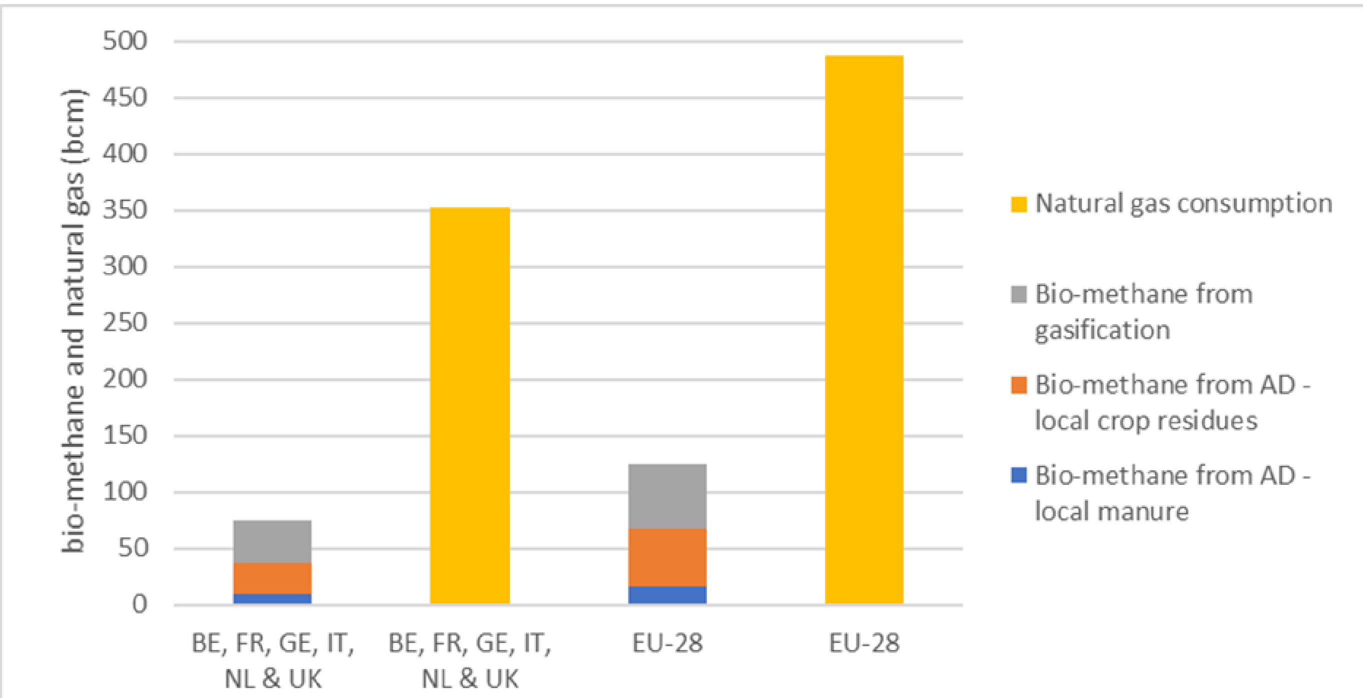
Potential supply of renewable gases and hydrogen
Bio-methane in total



In total, the potential bio-methane for the countries of interests is estimated at 75 bcm

At the EU-28 we come to a large potential: 124 bcm

Potential supply of renewable gases and hydrogen
Bio-methane for countries of interest and EU-28 in total

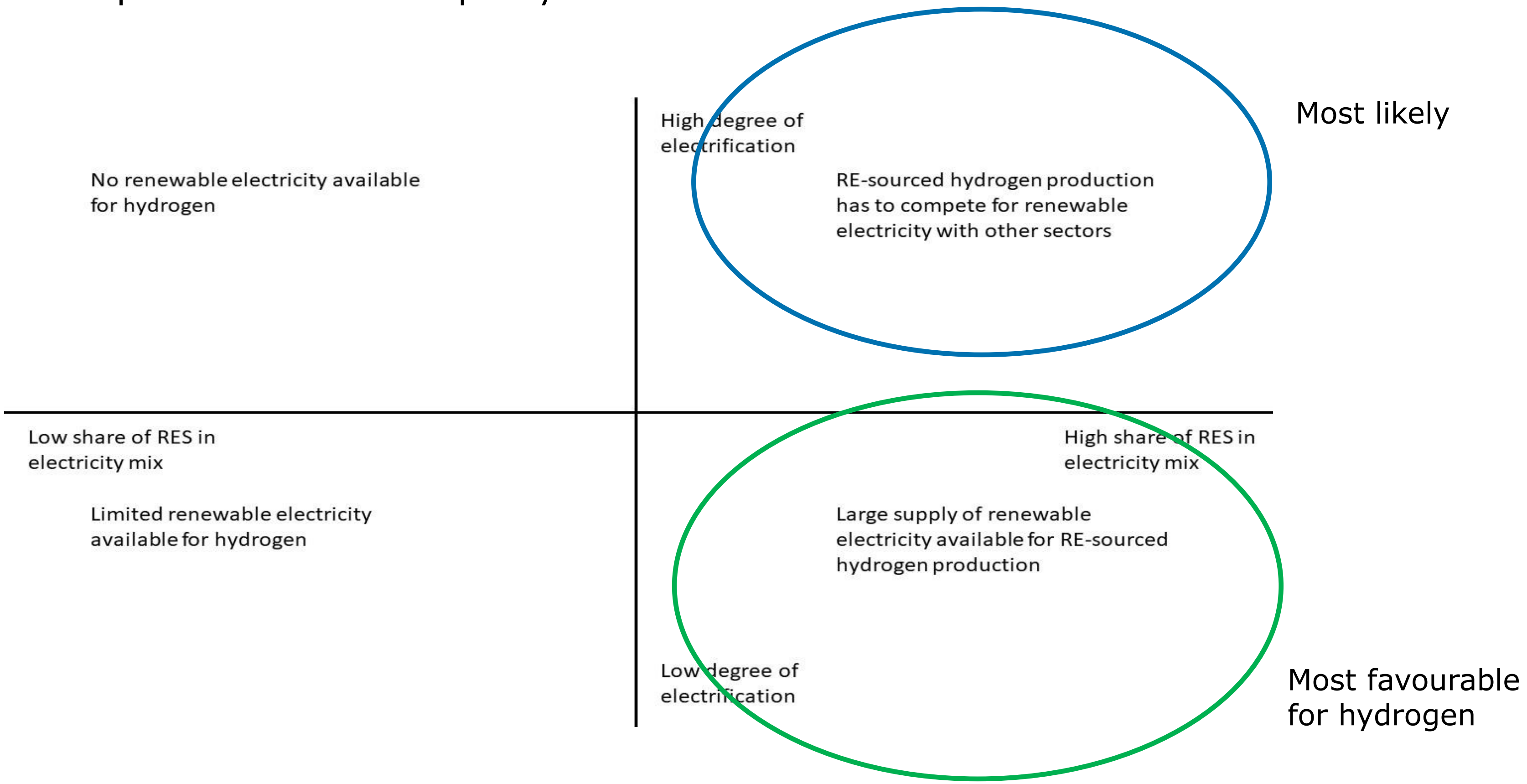


For the countries of interest, the combined potential of bio-methane is equal to roughly 20% of current natural gas consumption.

For EU-28, the potential is roughly 25% of current natural gas consumption.

Potential supply of renewable gases and hydrogen
Hydrogen

- Potential of natural-gas-sourced hydrogen can be very large conditional on availability of CCS
- Potential of renewable-electricity-sourced hydrogen is very dependent on climate policy and electrification of other sectors



What are break-even prices?

To understand underlying factors, we look at break-even prices

Investment costs

express investments costs in fixed costs per kg. of expected production of hydrogen during life time

→ **CAPEX**

+

Variable costs

express variable costs per kg. of hydrogen

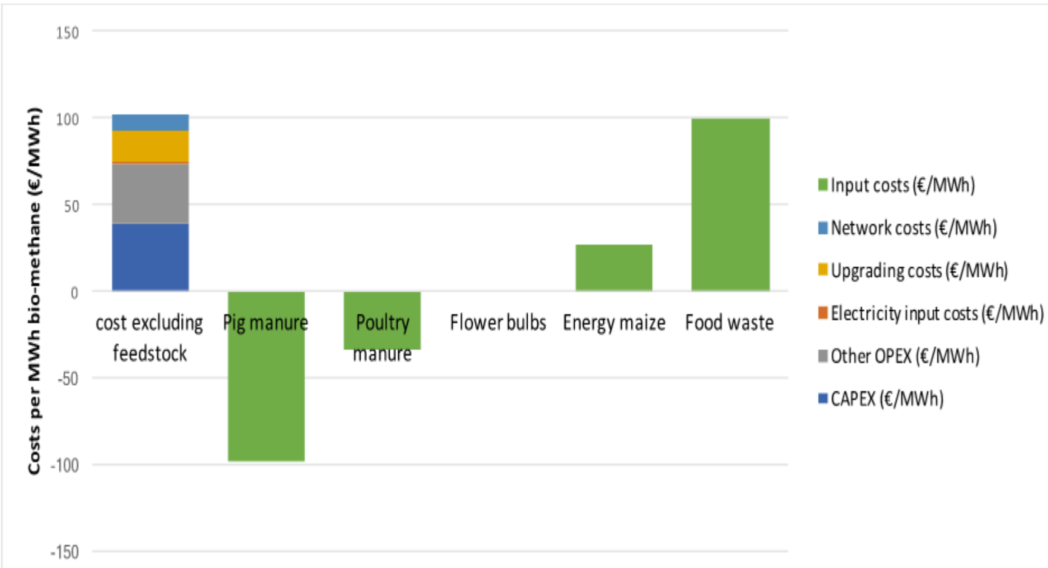
→ **OPEX**

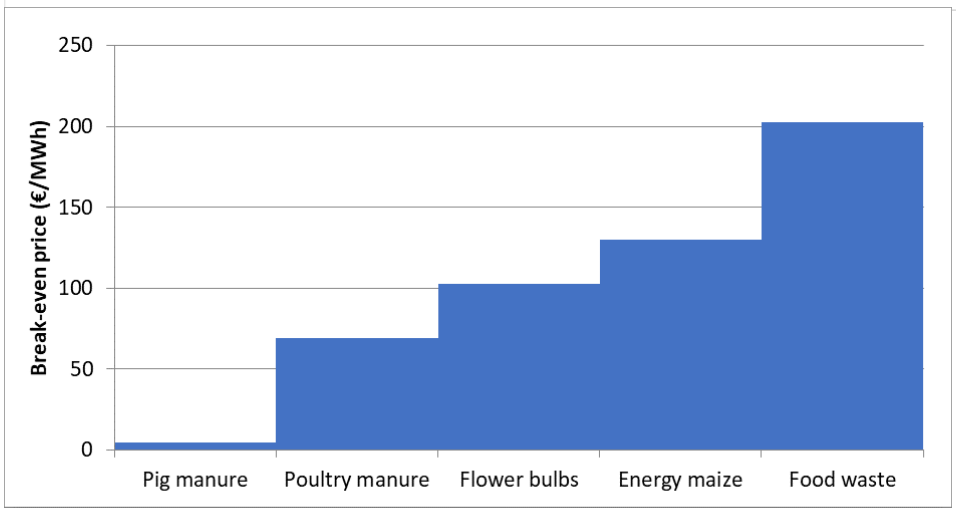
=

Break-even price of hydrogen (euro/kg.)

Anaerobic digestion (AD)

Break-even prices and composition of the costs, per MWh bio-methane





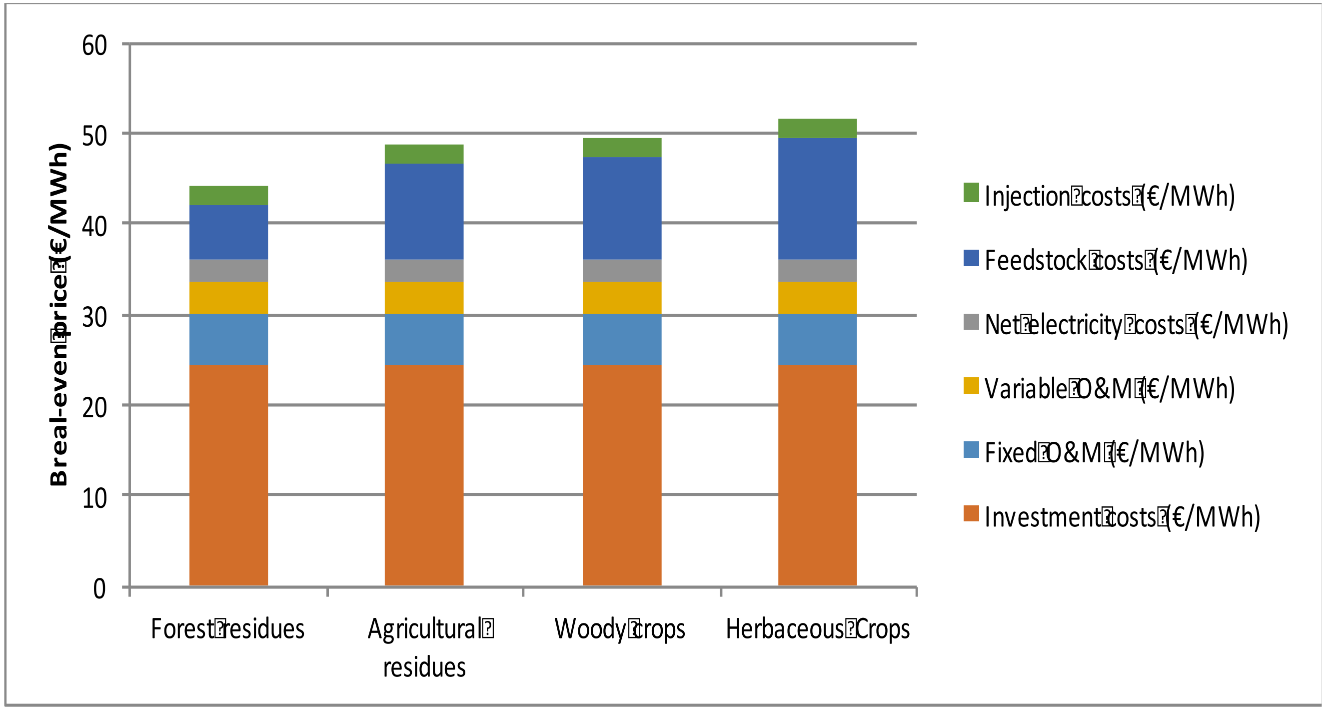
Scale is low (<= 5MW)

The costs of producing biomethane depend heavily on input costs

Break-even prices range from approximately 5 to 200 €/MWh.

Other studies (ENEA, Conzorzio Italiano Biogas, Navigant) find average close to 80 €/MWh.

Thermal gasification
Break-even prices and composition of the costs, per MWh bio-methane



Scale is bigger (1 GW)

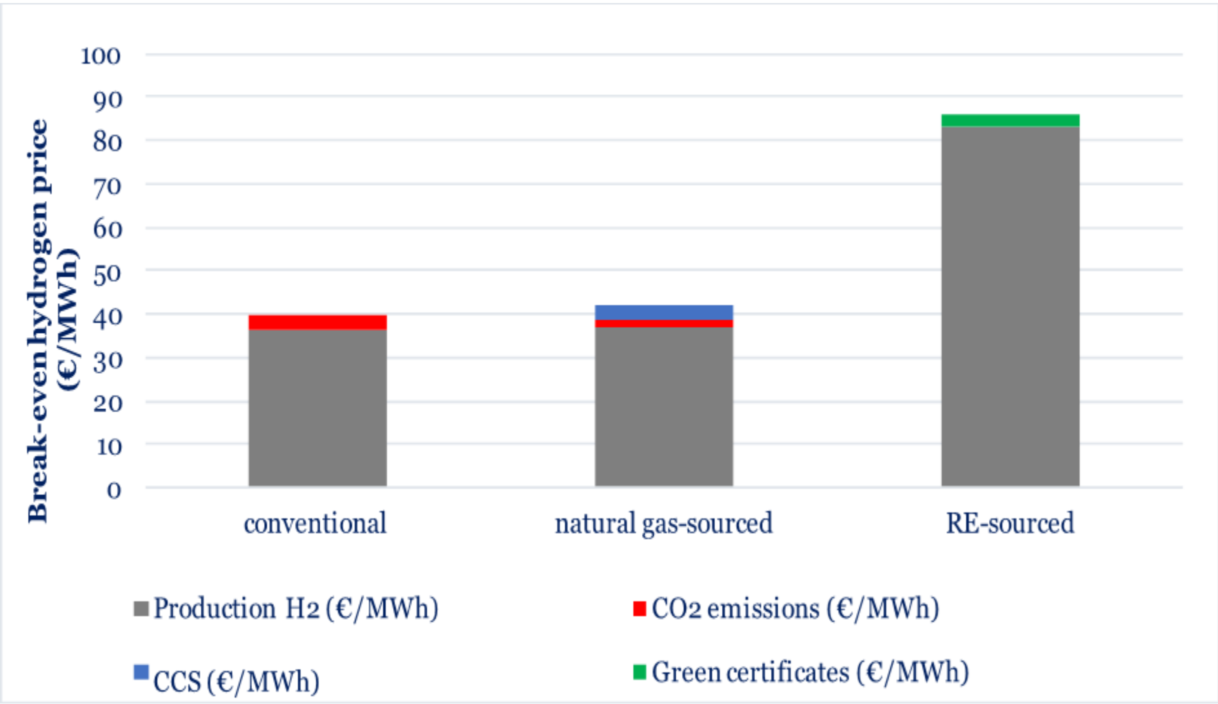
Costs are less dependent on feedstock.

Costs range from approximately 44 to 52 €/MWh.

Project demonstrations (Gaya, GoBiGas) show higher costs but break-even prices come down to 60 €/MWh.

Hydrogen

Composition of the costs different production techniques, per MWh H_2



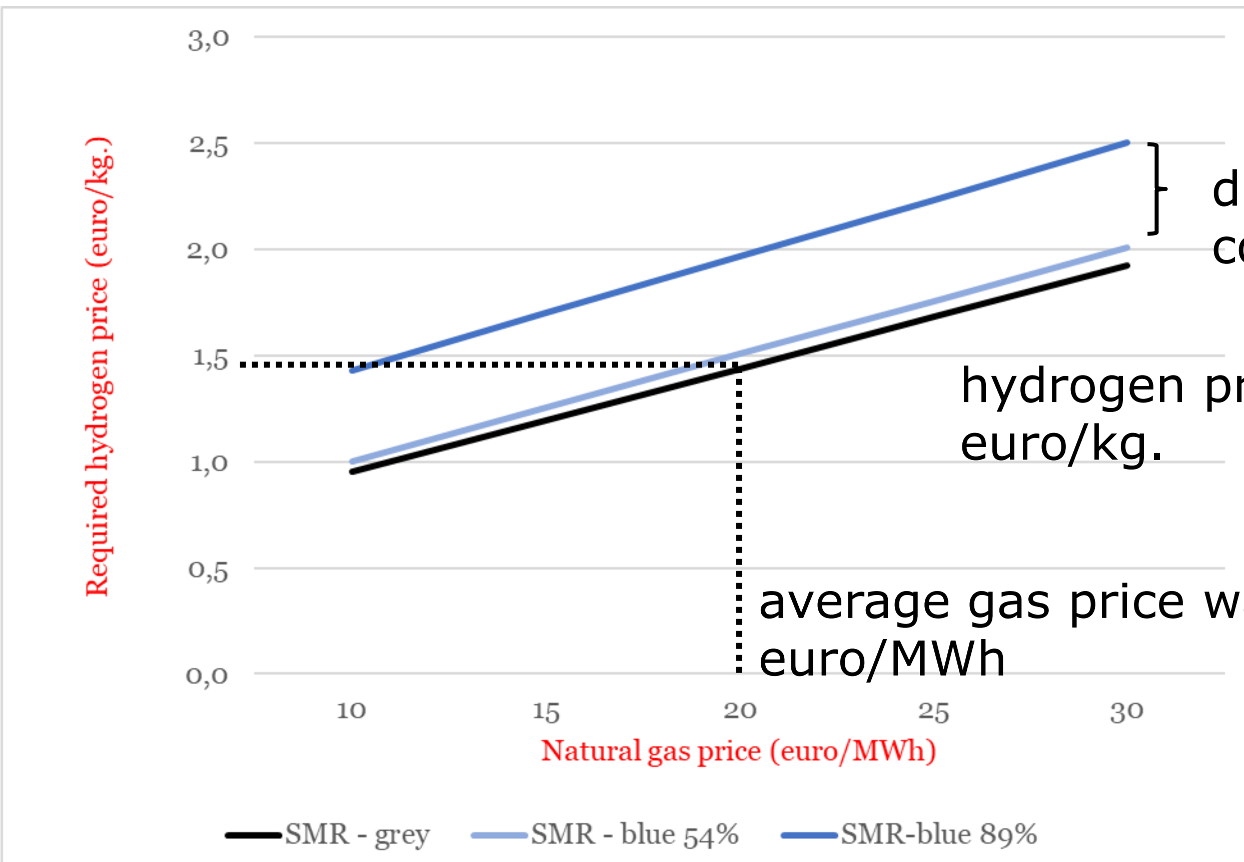
Costs of H2 production depend on natural gas or electricity price

With current prices, costs for natural gas-sourced H2 (with CCS) are around 40 €/MWh and for renewable-electricity-sourced H2 are 85 €/MWh

SMR: required hydrogen price depends on prices of gas and CO_2

when price of gas is 15 euro/MWh and price of CO_2 is 15/euro, price of grey hydrogen needs to be 1.2 euro/kg

blue hydrogen needs price of 1.60 – 2.00 euro/kg.



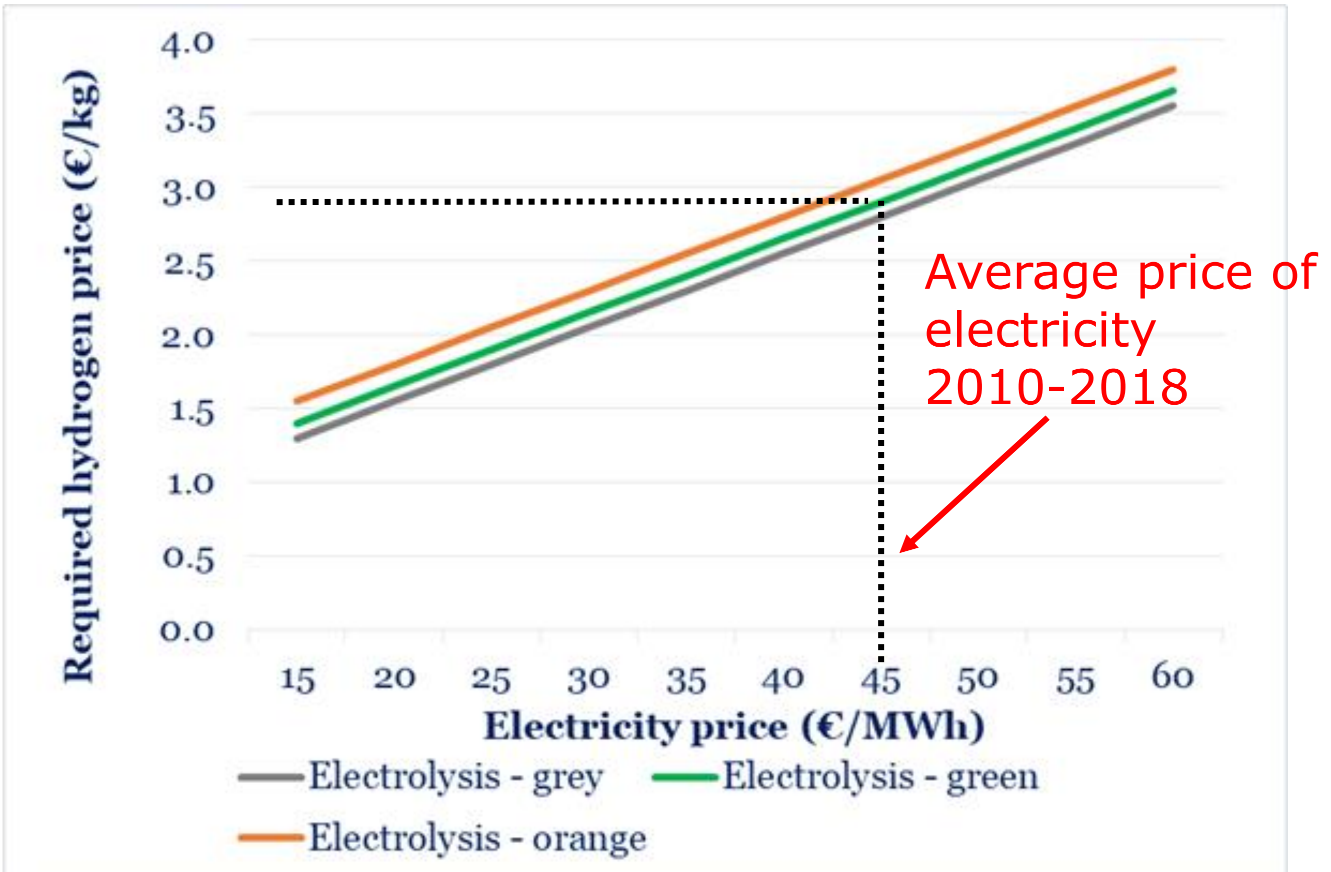
due to spread in costs of CCS

hydrogen price was about 1.5 euro/kg.

average gas price was about 20 euro/MWh

Electrolysis: required price of hydrogen depends on prices of electricity and green certificates

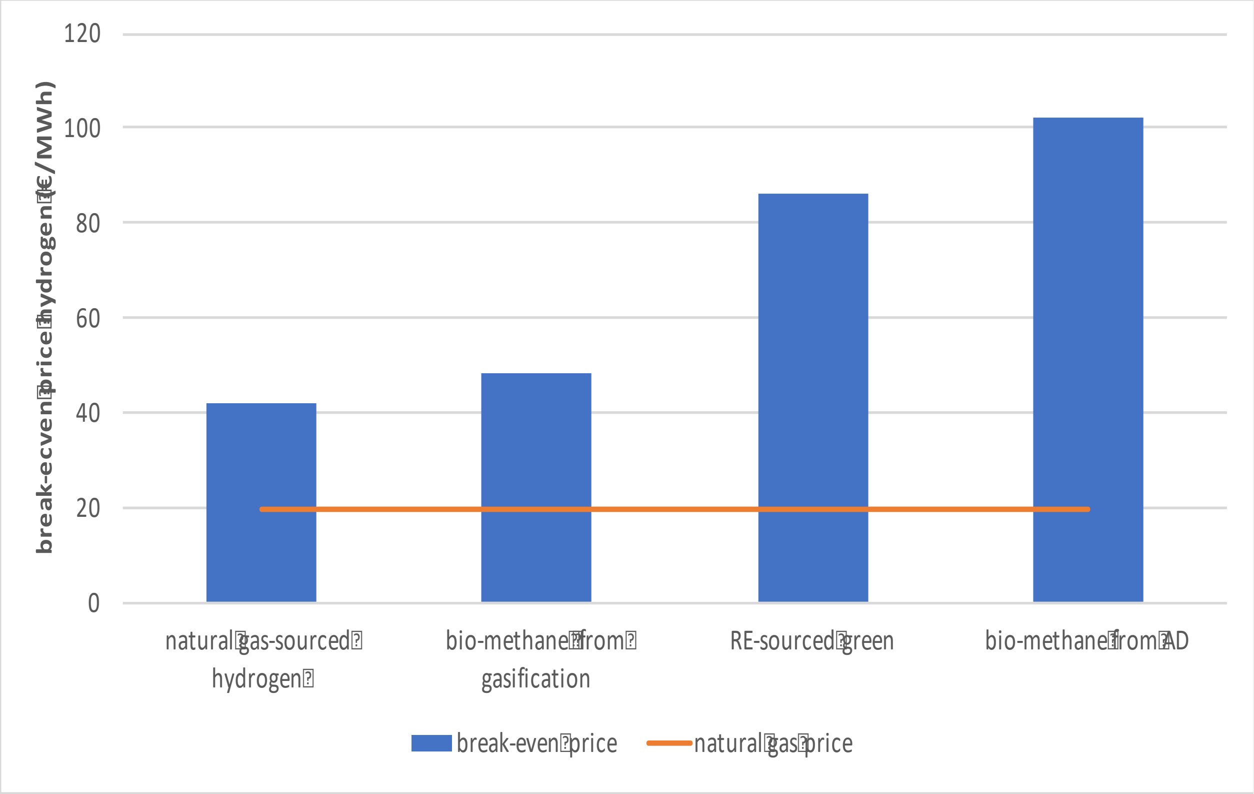
when electricity price is 45 euro/MWh and CO_2 price is 15/euro, the price of hydrogen should be 3.0 euro/kg



Price green certificates

- *EU:* *2 euro/MWh*
- *Dutch: ("orange" 5 euro/MWh*

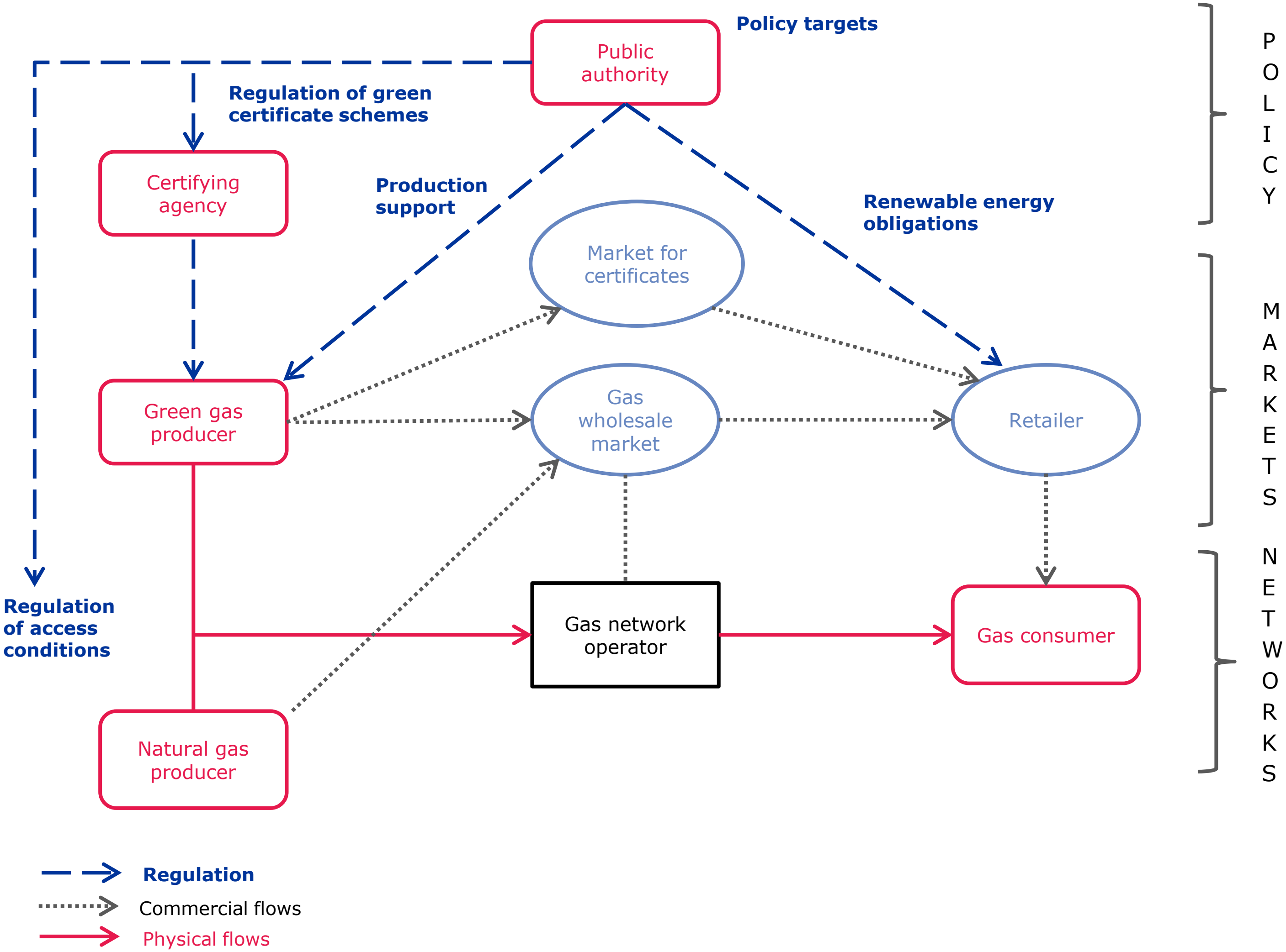
Comparison of break-even prices



Cost vary significantly across technologies, but on average costs of bio-methane and H2 are quite high compared to the natural gas price (2 to 5 times as high).

How to foster renewable gases?

Policy Framework



Economic principles to define optimal regulation

Economic criteria	Categories of regulation				
	Policy targets	Certificates schemes	Access to the grid	Support schemes Production support	Renewable energy obligations
Allocative efficiency: price=MC			Tariffs per unit should be equal to marginal costs	Support = value of externality – value of other regulatory measures to internalise (e.g. carbon tax)	Imposed cost = value of externality – value of other regulatory measures to internalise
Dynamic efficiency: sufficient return on investments	Long-term policy commitments	Long-term transparency on certificate scheme	Total regulated revenues should cover fixed costs of grid	Long-term certainty on support schemes	Long-term policy view on obligations
No market power			Third-party access, unbundling	In case of competitive tendering: many producers required	Retailers should have a choice among producers to buy renewable gas from
No information asymmetry		Increase trust of consumers by standardisation & public certifier	Capacity and tariffs should be clear to (potential) network users	Competitive tenders in case of many producers; otherwise smart incentive mechanisms, like menus, price caps	Traceability of green gas
No hold-up			Certainty for network operators about compensation of costs of connecting renewable gas	Governments should not be held-up after the support decision has been made	
Fair distribution			Fees related to actual costs producers cause + actual usage of the network_+ common costs fairly allocated among network users	Support <= actual costs – other revenues	Price certificates <= actual costs – other revenues
Cost-effective	Choose first lowest-cost options	Information about production characteristics	No discrimination among production technologies; only based on costs	Lowest-cost options should be chosen first	Lowest-cost options should be chosen first

Current situation regarding targets

CURRENT ENERGY POLICY

Main goals for 2020

	Italy	France	Germany	Belgium	Netherlands	UK	**EU**
% renewable heat in total heat	17,1	33	15,5	11,9	8,7	12	-
% renewables in final electricity	26,4	27	38,6	20,9	37	31	-
% renewable in transport	10,1	10,5	13,2	10,1	10,3	10,3	10
% overall RES in final energy consumption	17	23	19,6	13	14,5	15	20

Source: Renewable Energy Action Plans of the European Member States

Main goals beyond 2020

		Italy	France	Germany	Belgium	Netherlands	UK	**EU**
2030	% renewables in final electricity	55	40	40-60*	17**	-	-	-
	% overall RES in final energy cons.	30	32	30	20**	27-35	32	32
	% renewable gas in gas consumption	-	10	-	-	-	-	-
2050	% renewables in final electricity	-	-	80	-	-	-	-
	% overall RES in final energy cons.	-	-	-	-	100	-	100

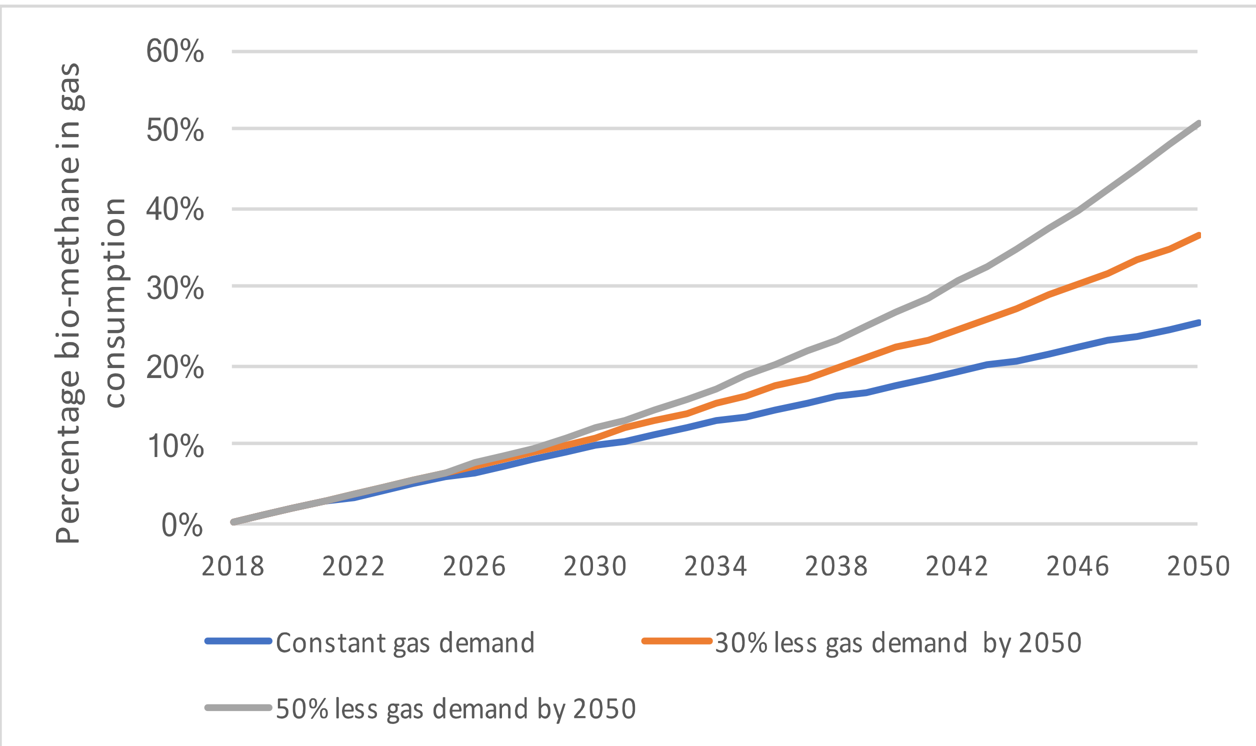
Source: CEER Status Review of Renewable Support Schemes in Europe

*: 2025: 40 - 45% (gross electricity consumed); 2035: 55 - 60%.

**: 17% is off-shore wind; 20% excludes off-shore wind

Only France has a target for renewable gas

Bio-methane targets can be based on a) potential and b) expected gas demand



Assuming constant gas demand:
targets: 10% by 2030 and 25% by 2050

If gas demand declines by 30% by 2050, target could be 35% by 2050

If gas demand declines by 50% by 2050, target could be 50% by 2050

Hydrogen targets

- If there is a strong electrification, electricity prices will be high in many hours….
- so there are maybe not many hours of low prices to produce RE-sourced hydrogen
- the bulk of hydrogen will be produced from natural gas (blue SMR)
- Conditional on this we recommend that 100% of the hydrogen produced by 2050 should be carbon-free

Certification

Market failure

- information asymmetry: users cannot see how the gas is produced
- Result without regulation
  adverse selection: users will not be prepared to pay extra for products of higher quality (e.g. more renewable)

General principles for regulation

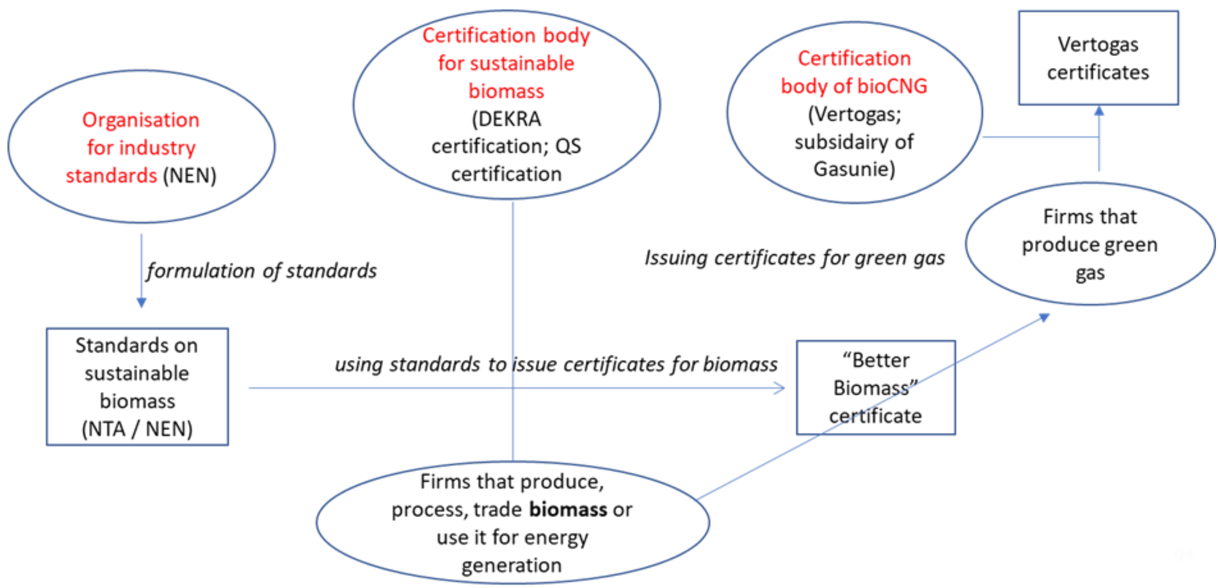
- users need to trust the whole process of certification
- certification need to give all relevant information on product characteristics
- long-term certainty about organization of system

Certification

Current situation

- Various national systems
- restricted international trade
- international trade based on mass-balancing

Dutch system



Certification

Recommendations

- improve international standardization of renewable gas
- make certificates internationally interchangeable
- make certificates interchangeable with ETS and electricity
- process of certification should be done by public agencies
- reconsider need for mass balancing in international trade (book-and-claim?)

Access to the grid

Market failure

- grid is natural monopoly
- result without regulation:
  monopolistic behavior, high tariffs, lower quality of network services

General principles for regulation

- variable tariffs equal to marginal costs
- total network revenues sufficient to cover total network costs
- ‘fair’ distribution of fixed/common costs
- equal treatment of various technologies
- independent network operator (i.e. unbundling)

Access to the grid

Current situation

- general EU principles regarding cost recovery and reasonable tariffs
- incentive/tariff regulation implemented on national scale
- European regulation does not allow TSO’s to charge different tariffs for renewable gases, due to non-discriminatory issues.

Recommendations

- same principles for renewable and natural gas
- but two exceptions possible
  - renewable gas producers could be given discount in fixed fees because of negative externality of natural gas
  - priority access in case of congestion

Support schemes

Market failure

- negative environmental externality: greenhouse gas emissions of natural gas
- result without regulation:
  To much use of natural gas / to less of renewable gas

General principles for regulation

- support for renewable gas should be equal to (marginal) value of negative externality
- support should not be higher than surplus costs of renewable gas (compared to natural gas) minus support through other mechanisms (e.g. tax exemption)
- support scheme should give incentives for innovation, cost reduction
- lowest-cost options should be chosen first

Support schemes

Current situation

- various designs in Member States
  - production support: feed-in-tariff, feed-in-premium,
  - renewable energy obligations
  - investment aids

		Italy	France	Germany	Belgium	Netherlands	UK
Supply							
	Feed-in tariffs (FITs)	yes	yes	yes	-	-	yes
	Feed-in premiums (FIPs)	yes	yes	yes	yes*	yes	-
	Investment grants	-	yes	yes	yes	-	-
Demand							
	Tax exemptions	-	-	-	-	yes	yes
	Obligations	-	yes	yes	yes	-	-

*: because certificates have fixed prices, de facto similar to FIPs

Source: CEER Status Review of Renewable Support Schemes in Europe

Support schemes

Current situation

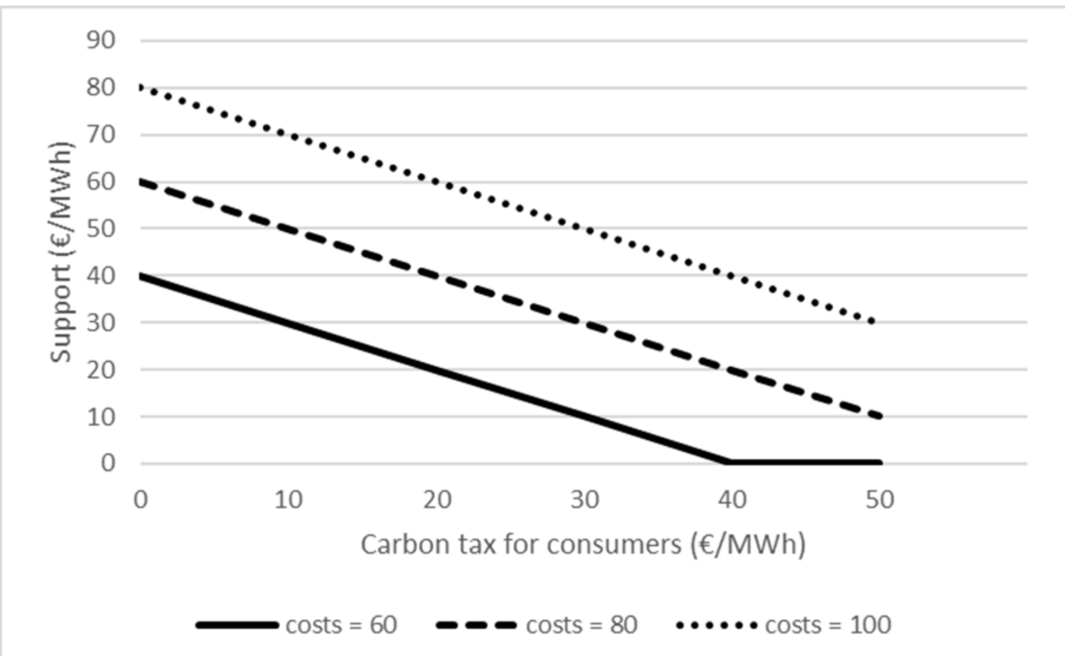
- various support levels

	FITs	FIPs	Duration support
UK	5.50 €ct/MWh if V<40 GWh		20 years
	3.24 €ct/MWh if 40<V<80 GWh		
	2.50 €ct/MWh if V>80 GWh		
NLs		4.5 €ct/kWh	12
BE		9,3 €ct/kWh***	10
FR	9.5 €ct/kWh for K<500 kW		10-20 years
	4.5 €ct/kWh for K>3.5 MW		
DE*	7.44 €ct/kWh for K<500kW		20 years
	6.5 €ct/kWh for 500kW<K<20 MW		
IT		6,46 €ct/kWh***	

Support schemes

What should be maximum support level?

- maximum support levels based on the break-even constraint, for various levels of production costs and in relation to the value of carbon taxes to be paid by consumers



Gas price was 20 euro/MWh over past 10 years

If carbon tax is 10 euro/MWh, consumer price is 30 euro/MWh

If costs are 60 euro/MWh, 30 euro/MWh subsidy required

Support schemes

Recommendation on design

- Incentives for efficiency by for instance
  - competitive tendering (offshore wind)
  - degression mechanism (UK)
  - budget constraints (NED)
  - declining reserve bids (FR)

Summarizing main recommendations

Targets

- Renewable gases:
  10% in 2030 and 20-40% in 2050
- Hydrogen:
  - no target for RES hydrogen
  - Natural-gas-hydrogen: 100% based on CCS

Certificates

- EU standards for renewable gas
- international interchangable
- compatible with ETS and electricity
- operated by public agencies
- reconsider need for mass-balancing

Grid access

- same economic principles for renewable gas as for natural gas
- 2 exceptions conceivable:
  - discount on contribution to fixed network costs
  - priority access in case of congestion

Support schemes

- based on value negative externality
- controlling for all kinds of support and break-even constraint
- estimate: 40-50 euro/MWh
- no support for RES hydrogen if renewable electricity is supported
- design: incentives for dynamic efficiency

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