D5.2 Identification of potentials and hot-spot regions

Deliverable: *D5.2 Identification of potentials and hot-spot regions*

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Summary and main findings

The REGATRACE Project aims to support the international trade of sustainable renewable gases which can be considered one important element towards long-term strategies for a sustainable energy system. Within REGATRACE, WP5 analyses potential promising technologies for the production of renewable gases and identifies sensitive issues and open questions related to the assessment and sustainability certification of renewable gases. This report is the second of three deliverables from this work package. It includes a discussion of the potentials for biogenic CO_2 from biogas and biomethane production in the EU as well as a discussion of potential hot-spot regions to couple biogenic CO_2 sources with renewable electricity capacities to produce renewable gases in the REGATRACE member states.

The European Union has set ambitious targets for the decarbonisation of its energy system and industrial sectors. Renewable gases are considered to be one of the key components to support this transition towards a climate-neutral economy, which is also compatible with the 1.5 °C goal of the 2015 Paris Agreement. In that sense, renewable gas can play an important role in complementing the efforts of decarbonising the energy system with renewable electricity and support the stabilisation of electricity grids against a growing share of variable renewable generation. Furthermore, renewable gases can directly contribute to the reduction of GHG emissions in hard-to-abate sectors (meaning those sectors where the applications of renewable electrification are limited such as for example the steel industry, various transport sectors, etc.).

Options for the production and supply of renewable gases can for example include biogas and biomethane from anaerobic digestion (AD) plants, Hydrogen (H_2) as well as synthetic methane (e.g., Power-to-Gas (PtG)). While technologies for biogas and biomethane from AD are well developed and production capacities do exist in various EU countries, further capacities for H_2 and synthetic methane production are needed to achieve the GHG reduction targets on EU and member state levels.

The current status of policy framework and the respective markets for biomethane is very divers. Member states are using a wide range of policy instruments and measures (e.g., feed-in tariffs quota systems, etc.) to support the development of biogas and biomethane production. Furthermore, several EU member states implement measures which support a transition of the biogas sector towards the production of more biomethane based on an increasing share of wastes and residues as feedstocks, while the overall importance of energy crops for biogas and biomethane production will further decline.

In the fermentation process of biomass for biogas production, a notable amount of CO_2 is obtained within the raw biogas. When the raw biogas is upgraded to produce biomethane, these CO_2 amounts are separated, leading to a high-quality CO_2 stream as a by-product. This green CO_2 could be used for the production of synthetic methane, for example in combination with renewable electricity in a Power-to-Gas pathway. Next to the availability of CO_2, another advantage of biomethane plants as potential sites for additional PtG installations is that they are already closely connected to feed-in points for the natural gas network. Consequently, this can reduce costs related to the investment in PtG production plants. Thus, biogas production and upgrading sites are often considered as “low hanging fruits” for the integration with power-to-methane technologies. (Schaffert et al. 2020)

Additionally, to conventional biogas facilities which convert organic biomass from agricultural processes, as well as wastes and residues to methane, waste water treatment plants producing sewage gases can be another interesting source for green CO_2. The gas produced in these facilities

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could be directly fed into a methanation process to produce synthetic methane or converted into biomethane.

The regional distribution of the potentials for green CO_2 from AD plants follows the ranking of the primary biogas and biomethane producers in the EU. This report estimates a total theoretical potential of 33,517,367 tonnes of green CO_2 from AD plants in the EU (based on 2019 production figures). A rough estimation based on (Wettstein et al. 2018) has been calculated in order to understand the potential magnitude of synthetic methane to be produced from the amount. Assuming that the total theoretical potential of green CO_2 can be mobilised, together with 6,141,127 tonnes of H_2, a theoretical total of 12,217,840 tonnes of synthetic methane can be calculated. This mass of synthetic methane would correlate to approximately 169,692 GWh of energy of PtG to be produced in the EU based on green CO_2 sourced from AD production units.

Finally, as a third potential element for the development of renewable gas capacities, existing strategies for H_2 supply have been analysed and described briefly in chapter 3.

Considering the very different preconditions, potentials but also the technology and feedstock focus in the various EU member states and the REGATRACE countries, also future production targets and potential hot-spot or preference regions for renewable gases are very divers across the EU. Thus, this report includes short profiles for each REGATRACE partner country, summarising the current situation for RG production. The respective information is included in chapter 5.2.

Hot-spot or preference regions for RG production in the REGATRACE countries could be identified in those areas with close links between green CO_2 potentials (e.g., from AD plants) and renewable electricity production (e.g., in the EU coastal regions). In some countries, these elements are currently decoupled (e.g. Italy with a focus of biogas and biomethane production in the north of the country and hot-spots for renewable electricity production more in the south) leaving future challenges for their combination.

The future transformation of the European gas system and its connection to other energy sectors is a complex and challenging topic with a high number of fundamental legal, technical and administrative barriers in existence. Amongst others, this concerns divergent regulation on technical standards across the EU, contracts and billing arrangements based, safety requirements for the connection and injection of renewable gases into the gas grid infrastructure. Considering the current policy framework, the required “additionality” which is part of the current RED II legislation is considered a significant challenge for the development of new renewable gas production capacities, since it hinders especially the development of economically feasible business concepts.

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Abbreviations

AD	Anaerobic Digestion
CSP	Concentrated Solar Power
DAC	Direct Air Capture
GHG	Greenhouse gas
GWh	Gigawatt hours
ISCC	International Sustainability and Carbon Certification
ISO	International Standard Organisation
LCA	Life Cycle Assessment
MJ	Megajoule
MWh	Megawatt hours
PtG	Power-to-Gas
PtX	Power-to-X
PV	Photovoltaic
RE	Renewable Energy
RED	Renewable Energy Directive 2009/28/EC
RED II	Renewable Energy Directive 2018/2001/EC
RES-E	Renewable energy sources for electricity
RG	Renewable Gas
SDGs	Sustainable Development Goals
SNG	Synthetic Natural Gas
TWh	Terawatt-hour

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REGATRACE in a nutshell

REGATRACE (REnewable GAs TRAde Centre in Europe) aims to create an efficient trade system based on issuing and trading biomethane/renewable gas certificates/Guarantees of Origin (GO) with exclusion of double sale.

This objective will be achieved through the following founding pillars:

- European biomethane/renewable gases GO system
- Set-up of national GO issuing bodies
- Integration of GO from different renewable gas technologies with electric and hydrogen GO systems
- Integrated assessment and sustainable feedstock mobilisation strategies and technology synergies
- Support for biomethane market uptake
- Transferability of results beyond the project's countries

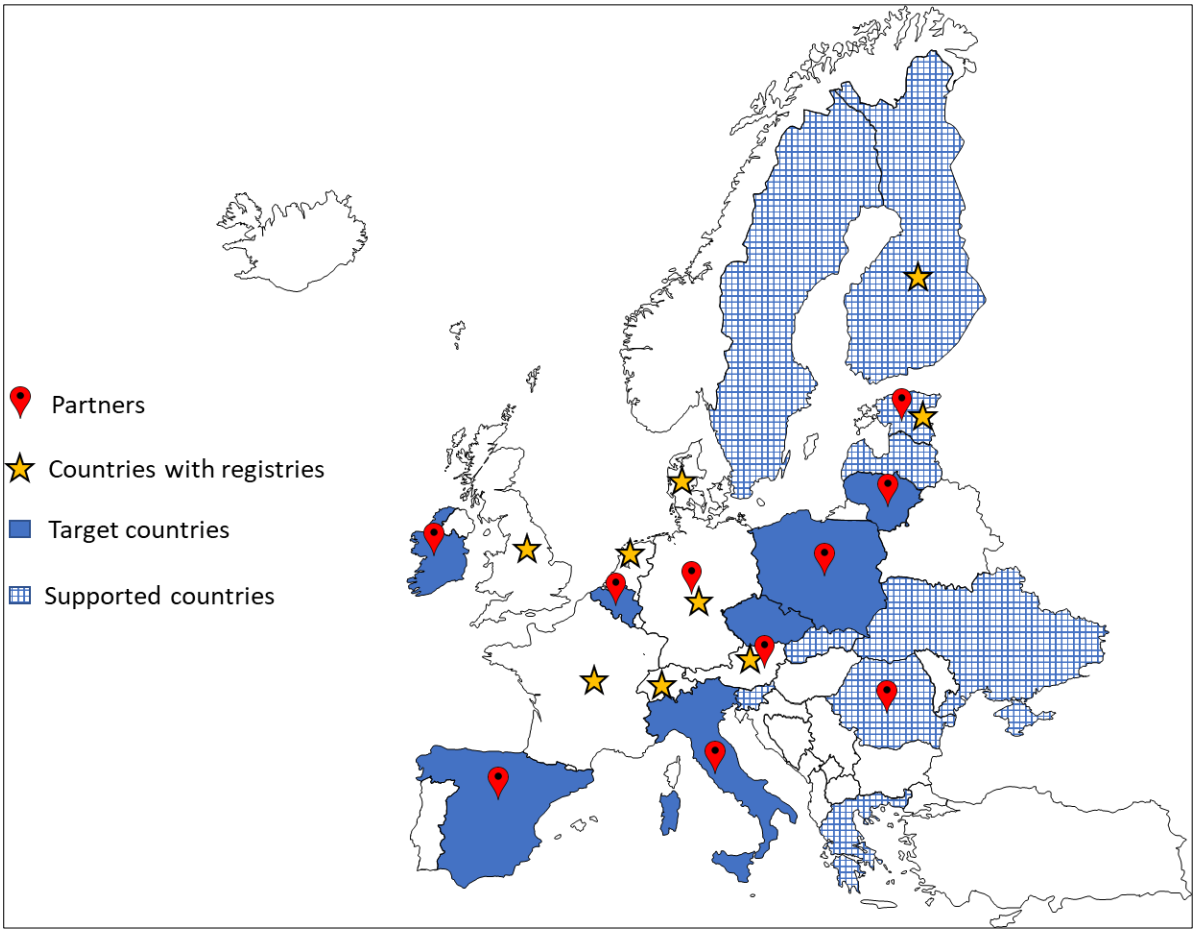

Figure 1: REGATRACE countries and partners

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1 Introduction

Supporting the transformation and conversion of the EU energy system towards using use a sustainable feedstock and technology base, which is in line with international targets for the reduction of GHG emissions and objectives such as the Sustainable Development Goals (SDGs) requires manifold actions from science, policymakers and stakeholders from the industry.

The REGATRACE project is supporting this development by contributing with elements to foster trade of renewable gases amongst EU member states and thus, enabling a more efficient coupling of energy and industry sectors in the EU. However, as recognised by the EU Commission with the introduction of the Renewable Energy Directive, renewable energy technologies are not per se sustainable.

To develop a political framework for the sustainable transformation of the EU Energy system, it is of high importance to understand potential risks and impacts related to the development of renewable gas technologies, as well as to develop associated strategies for risk and impact mitigation. This report is focusing on the potentials to couple technological elements for the production of renewable gases in the EU and more specifically the REGATRACE countries.

1.1 The objectives of WP5 within the REGATRACE project

While REGATRACE in general deals with several topics to support the trade of Renewable Gases in the EU, **REGATRACE WP 5 will address selected aspects related to the sustainability of Renewable Gases.**

These aspects will include:

- **The identification of promising technologies and concepts** for the production of biomethane (both from anaerobic digestion and gasification) and Power-to-Methane. This identification will be based on the potential **GHG intensity** as well as the **costs of renewable gas production**. **D5.1, has been focussing on general trends and lessons learned from literature data and published information.** Also, **key drivers and influencing factors will be discussed**. Main focus of D5.1
- The **identification and discussion of CO_2 potentials from the production of biogas and biomethane in the EU, to produce renewable gas. Potential hot-spot regions for the production of renewable gas in the EU based on the identified CO_2 potentials as well as capacities for the production of renewable electricity. Main focus of D5.2.**
- Finally, **open questions and potential barriers for the sustainability assessment and certification** of Power-to-Methane concepts shall be analysed and appropriate solutions will be developed. **Main focus of D5.3.**

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1.2 Specific objectives of Deliverable 5.2

This Deliverable builds on the findings from D5.1 and aims to continue the work on the above-mentioned targets for WP5.

The core objective of D5.2 is to analyse **potentials for the production of renewable gas** via, i) the bio-chemical conversion to Biogas and the subsequent upgrading to biomethane, ii) hydrogen produced from (renewable) electricity and iii) the combination of biogenic CO_2 from Biogas and Biomethane with electricity from renewable sources to produce synthetic natural gas (Power-to-Gas).

For this purpose, we are building on results from D5.1, which has described indications for costs and impacts related to different technology components for the production of renewable gases. Based on this task, a **pre-selection of relevant technologies** for further assessment has been made. In order to discuss the potentials for renewable gas production on the level of the REGATRACE countries, we developed **compact country reports** to understand country-specific technology foci and regional, as well as temporal perspectives for the production of renewable gases.

Finally, D5.2 aims to combine the findings from the analysis of potentials of CO_2 feedstocks, technology components and their combinations **to potential hot-spot regions** for the production of renewable gas in the REGATRACE countries. This analysis is part of the profiles for the REGATRACE countries.

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1.3 Our approach for the identification of CO_2- potentials and hot-spot regions

To identify potentially competitive technologies for the production of renewable gases in the EU and specifically in the REGATRACE we are considering both, already existing technologies (e.g. Biogas and Biomethane) as well as technologies that are not yet implemented in the market at a large scale (e.g. Bio-SNG), as well as combinations of different technological components (e.g., Power-to-Gas).

Throughout REGATRACE WP5, we are aiming to describe technologies and technology combinations that are feasible for specific countries and regions, based on aspects such as GHG mitigation potentials, costs as well as regional availabilities (e.g., already installed or anticipated production capacities of Biogas/Biomethane or renewable electricity).

The general concept for the production of Power-to-Gas, illustrated in Figure 2 shows our basic framework for the derivation of technologies and technology combinations to be considered. This framework includes the production of electricity based on renewable sources such as wind or solar power, the production of hydrogen from this renewable electricity, the production of biomethane from either Biogas upgrading or the gasification of biomass (Bio-SNG), as well as the combination of hydrogen and carbon dioxide (e.g. from the Biogas process) to produce Power-to-Gas (i.e., methane).

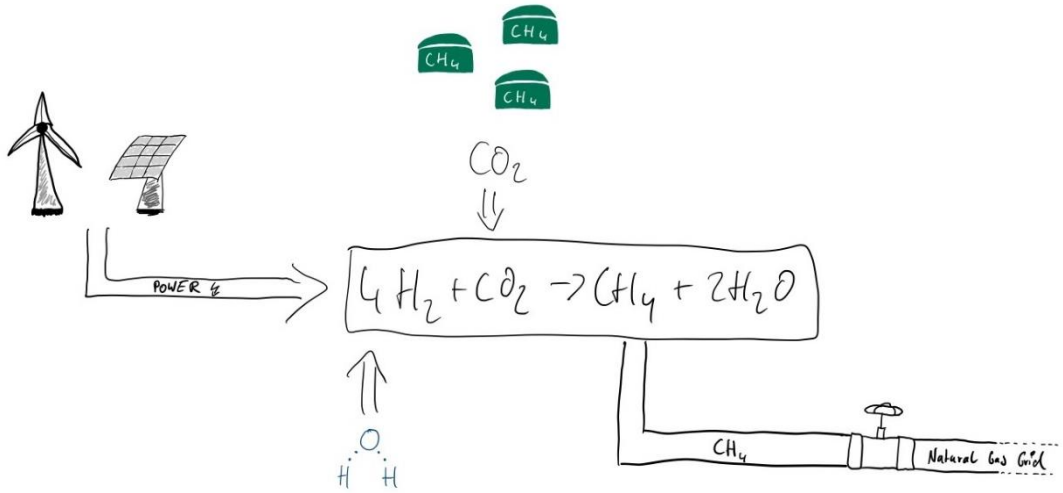

Figure 2 General concept of technology combinations for Power-to-Gas production

Thus, in general, the assessment in WP5 includes three broader groups of technologies, as well as their combinations. These groups include:

- Biogas and Biomethane from biogenic feedstocks and Biomethane from gasification of biomass;
- Hydrogen produced from electricity (via Electrolysis) or gaseous energy carriers (natural gas and Biomethane)
- Power-to-gas from Hydrogen and CO_2.

The identification of potentials of biogenic CO_2 and hot-spot regions for RG production is based on i) a comprehensive review of literature and ii) interviews and input from the different REGATRACE partners. The latter has been coordinated with a harmonised questionnaire (see Chapter 7 with the

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ANNEX) and additional interviews with REGATRACE partners to collect consolidated inputs on current and future RG production in REGATRACE member states.

1.4 Structure of this report

Considering the technologies for RG production described in the previous section and in order to describe the perspectives for RG production in the REGATRACE countries and at EU level, this report starts with an overview on the current production of biogas and biomethane in the EU (Chapter 2). Secondly, CO_2 potentials, as a potential future feedstock for RG production, will be presented with a focus on potentials from biogas and biomethane production (Chapter 4).

Finally, chapter 5 provides an overview of the RG production and production perspectives on EU level and the different REGATRACE member countries.

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2 Biogas and Biomethane production in the EU

To determine the potential for future RG production, we firstly focus on an analysis of existing Biogas and Biomethane production capacities as a source of both, the renewable gas biomethane and CO_2 as a feedstock for the production of synthetic methane (PtG).

2.1 Current primary production

The production capacities for Biogas and Biomethane in the EU have significantly increased over the recent years. Across EU Member states, countries with the biggest production are Germany (10,018 GWh Biomethane in 2018 (International Energy Agency 2021); a total of 87777.4 GWh primary production of biogas in 2019 (Biogas Barometer 2020)), United Kingdom (3,300 GWh in 2018 (Decorte et al. 2020) and 31925.5 GWh of primary Biogas production in 2019 (Biogas Barometer 2020)), the Netherlands (2,226 GWh in 2018 (Decorte et al. 2020) and 4140 GWh of total primary Biogas production (Biogas Barometer 2020)), Denmark (1,425 GWh in 2017 (Decorte et al. 2020) and 4612.5 GWh of primary Biogas production (Biogas Barometer 2020)), Sweden (1,281 GWh (Decorte et al. 2020) in 2018 and 2110.8 GWh of primary Biogas production in 2019 (Biogas Barometer 2020)) and France (1,207 GWh (Decorte et al. 2020) and 11357.9 GWh of primary Biogas production in 2019 (Biogas Barometer 2020)).

Apart from Sweden and Germany, no country reported production of renewable gas via gasification or power-to-methane plants. (Decorte et al. 2020) The following figure from (Decorte et al. 2020) presents the status of Biomethane production in the EU (figures in MWh of Biomethane). Table 1 complements the information on Biomethane production with a status on primary Biogas production from different EU countries.

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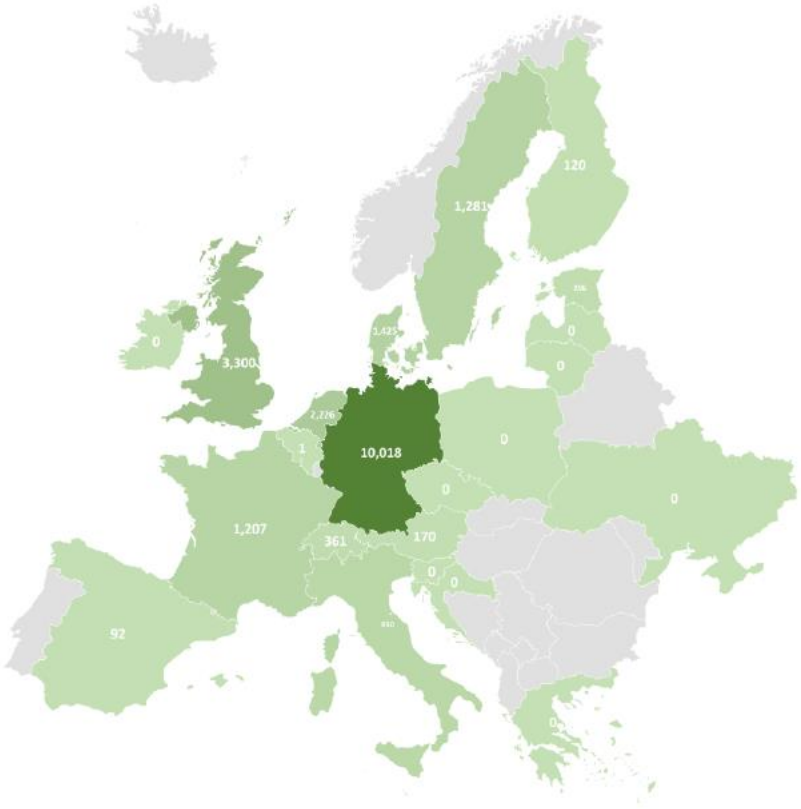

Figure 3 Biomethane production in MWh in the EU (Decorte et al. 2020)

Table 1 Primary biogas production in the EU in 2019 (Biogas Barometer 2020)

Country	Primary Biogas production in 2019 in GWh	Country	Primary Biogas production in 2019 in GWh
Germany	87,777.43	Greece	1,453.75
United Kingdom	31,925.51	Hungary	966.45
Italy	21,259.64	Latvia	937.38
France	11,357.86	Croatia	932.73
Czech Republic	6,759.36	Portugal	931.56
Denmark	4,612.46	Bulgaria	593.13
Netherlands	4,140.28	Ireland	581.50

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Poland	3,471.56	Lithuania	453.57
Spain	3,027.29	Slovenia	258.19
Belgium	2,697.00	Romania	240.74
Austria	2,493.47	Luxembourg	209.34
Finland	2,206.21	Cyprus	162.82
Sweden	2,110.85	Estonia	161.66
Slovakia	1,666.58	Malta	18.61

Over the recent years, EU member states have developed a wide range of supportive elements and measures, resulting in a significant growth of production capacities in the last years in Europe.

While for biogas production the contribution of landfill gas recovery to biogas has been almost constant over the last decade, the major contribution to this growth came from Anaerobic Digestion (AD) plants and, to a lower extent, from sewage gas from wastewater treatment (Biogas Barometer 2020).

Most of the biogas in the EU is used as an energy carrier for electricity generation, by producing electricity only, or in combined heat and power plants aiming to increase the maximum use of heat in order to increase the economic performance of the installation. The general situation of biogas production is very different between EU countries, both in terms of the biogas production technologies and the feedstock focus. However, recent adaptations on EU levels (e.g. the recast of the Renewable Energy Directive, (European Commission 2018) and the corresponding national implementations show a general shift in the feedstock strategies for biomethane and biogas production towards the use of more residues, wastes and by-products, while the general importance of energy crops seems to decline.

Considering the current primary biogas production, Germany (87,777.43 GWh), UK (31,925.51 GWh) and Italy (21,259.64 GWh), followed by France (11,357.86 GWh) showed the highest productions in 2019.

(Decorte et al. 2020) provides a comprehensive overview of existing national policy elements in the EU, with a specific focus on the REGATRACE partner countries.

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2.2 Future targets for Biomethane

While (Decorte et al. 2020) describes the status quo of Biogas and Biomethane production, the following figure provides an overview of existing targets and other, non-binding objectives for the future development of national biomethane targets in different EU countries until 2030.

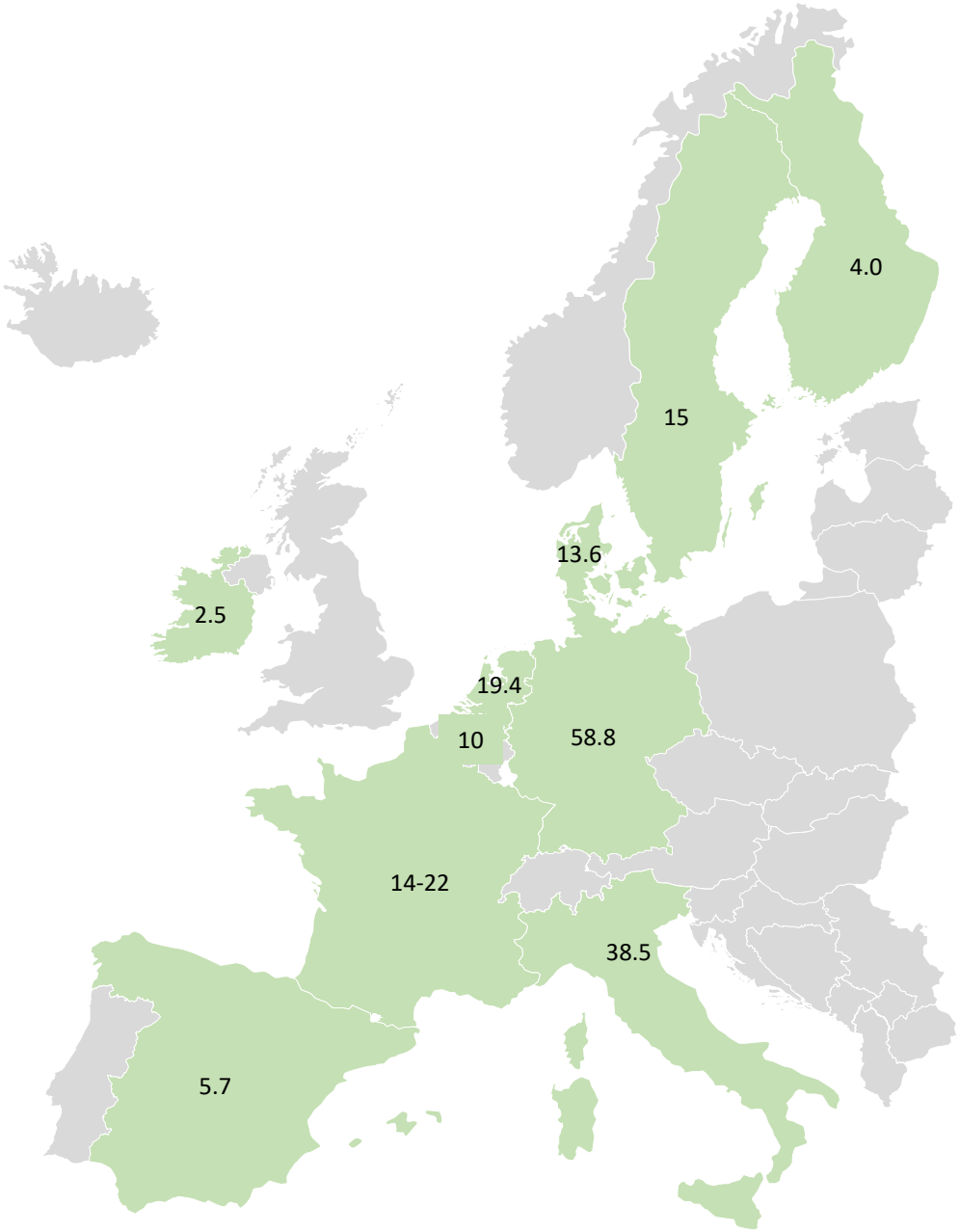

Figure 4 Future biomethane targets in different EU member states until the 2030 timeframe in TWh. Based on (Decorte et al. 2020; Climate Partnership 2020; Ministère de la Transition écologique; then24.com; Sweden 2018; Directoraat generaal Klimaat en Energie 2020)

These respective production targets provide important indications for the future development of biomethane production, which is one of the cornerstones for the future production of renewable gases in the EU. The by-product of green CO_2 as a potential feedstock for the production of PtG is contributing to a second cornerstone.

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3 Perspectives for H_2 production in the EU and REGATRACE countries

Besides Biogas and Biomethane from AD, and synthetic methane (e.g., via PtG or SNG), Hydrogen is considered as one of the potentially most relevant energy carriers in the future energy system of the EU and several REGATRACE partner countries. Hydrogen can make a necessary contribution to decarbonise the gas sector in the EU and, thus, support the ambition for a climate-neutral energy system (European Commission 2021) and the decarbonisation of hard to abate industrial sectors. Consequently, the EU has published a hydrogen strategy as part of the European Green Deal (EC 2020). The strategy defined an ambitious target for the H_2 supply in the EU by 2030 with a total of 200 TWh of H_2. According to this strategy, the main production routes are electrolysis based on renewable electricity from wind and solar energy.

While there seems to be a common understanding on EU and member state levels regarding the importance of H_2, there are different strategies and prioritised pathways towards 2030 and 2050, especially regarding role of "blue" H_2 from natural gas (with CCS) versus "green" H_2 from renewable energy or the use of H_2 in the heating sector (Lambert und Schulte 2021).

More specifically, existing strategies within the REGATRACE countries can be characterised as follows.

Germany: The current national and climate plan of Germany projects a supply of renewable gases of ~ 21 TWh. Given that the new administration aims to increase the ambition of Germany to reach climate neutrality at an earlier stage, more ambitious targets might also be expected for the future NECPs.

In mid-2020, Germany has published a National Hydrogen Strategy, which recognises the key role of H_2 in the German national energy transition. especially in industry and the transport sector (BMWI 2020). The strategy establishes sets a target for green H_2 target of 14 TWh by 2030.

In order to implement the strategy, Germany has set up a structure for financial support for national projects, including a funding programme for the production and use of sustainable electricity-based fuels for air and sea transport. Furthermore, Germany exempted electricity used directly for H_2 production from the Renewable Energy Sources Act surcharge.

Austria is currently developing its national H_2 strategy. According to (Streitner 2021) the strategy might put a specific focus on the role of H_2 in the chemical and steel industry. In that regard, the recently adjusted target which aims to achieve 100% renewable electricity in Austria by 2030, can provide a promising basis also for the production of green H_2.

Belgium: The Belgian Federal Government issued its Hydrogen Vision, furthermore, the region of Wallonia, supported by an industry initiative developed the Hydrogen Roadmap already in 2018. The strategies highlight the potential of H_2 to contribute to the decarbonisation of the industry. The three regions in Belgium have furthermore started to actively develop H_2 related investments, partly based on EU funds (IEA und CIEP 2021).

The **Czech Republic** has published a national H_2 strategy in mid-2021. This strategy provides the basis to develop the necessary infrastructure for the production and utilisation of sustainable H_2, in the country. The strategy sets a specific focus on the future use of H_2 in the transport sector and heavy industry (CZ 2021).

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Estonia is currently developing a national H_2 roadmap.

Italy presented the first elements for a national hydrogen strategy, indicating a target of 5 GW by 2030 and a number of supportive measures for H_2 projects (IT 2020).

Poland released a draft for the national H_2 strategy until 2030 (with perspectives for 2040) and defines a target of 2 GW for H_2 electrolysis capacity and 2,000 H_2 fuel-cell buses by 2030 (PL 2021).

Spain has developed its H_2 strategy in July 2020, including a production target of 4 GW by 2030 (ES 2020).

Switzerland adopted in June 2021 initiatives of the Swiss parliament for the preparation of a Green hydrogen strategy and an assessment and of potential options for action (CH 2021b, 2021a).

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4 Renewable Gas production based on green CO_2 potentials from AD

For the production of Power-to-Gas or synthetic methane, we consider two main inputs, CO_2, in our case from anaerobic digestion and the subsequent upgrading of biogas to biomethane and hydrogen, produced from renewable electricity. Both can be converted into synthetic methane in a methanation process. For this Deliverable, we will focus on CO_2 from biogas and biomethane production. The overall availability of sustainable CO_2 potentials will be one of the key determinants for the large-scale implementation of methanation capacities in the EU. However, since PtG can be produced from a wide range of CO_2 sources, future activities for the development of RG projects might also include grey, non-bio-CO_2 feedstock sources.

CO_2 from biomass and direct air capture (DAC) are typically being referred to as green CO_2 sources. So-called grey sources refer to industrial emitters.

4.1 Potentials of biogenic CO_2 from biogas and biomethane production in the EU

In the fermentation process of biomass for biogas production, a notable amount of CO_2 is obtained within the raw biogas. When the raw biogas is upgraded to produce biomethane, these CO_2 amounts are separated, leading to a high-quality CO_2 stream as a by-product which could then be used as an input to PtG production.

Next to the availability of CO_2, another advantage of bio-methane plants as potential sites for additional PtG installations is that they are already closely connected to feed-in points for the natural gas network. Consequently, this can reduce costs related to the investment in PtG production plants. Thus, Biogas production and upgrading sites are often considered as “low hanging fruits” for the integration with power-to-methane technologies (Schaffert et al. 2020).

Additionally to conventional biogas facilities which convert organic biomass from agricultural processes as well as wastes and residues to methane, waste water treatment plants producing sewage gases can be another interesting source for green CO_2. The gas produced in these facilities could be directly fed into a methanation process to produce synthetic methane or converted into biomethane.

CO_2 from Biogas and Biomethane production in the EU

Following the discussion of the current production capacities for biogas and biomethane in the EU, this section focuses on the potentials of green CO_2 from the respective AD technologies.

For the calculation of the emitted CO_2 from biogas upgrading, the primary production of biogas is an important basis. (Biogas Barometer 2020) publishes primary biogas production figures for EU countries. According to this reference, biogas production in EU countries is composed mainly of gases from anaerobic digestion and gases from the thermochemical treatment of biomass. Gases from anaerobic digestion mainly include landfill gases, sewage gases and biogases from agricultural holdings. Based on the fact that the biogas consists of 30 – 50 vol.-% of CO_2, the potential of CO_2 is calculated on a theoretical level from the produced amount of biogas.

The spatial distribution of the biogas and biomethane production in the EU is included in Figure 3 (biomethane production) and Table 1 (Biogas production). Based on this information, a theoretical potential of green CO_2 from AD plants in the different EU countries has been calculated. The results are shown in the following Table 2.

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Table 2 Theoretical potential of green CO_2 from AD plants in the EU (on own calculations based on (Biogas Barometer 2020; Decorte et al. 2020)

Country	Green CO_2 from Biogas in m^3/a	Green CO_2 from Biogas in tonnes/a	Total green CO_2 from Biogas and Biomethane in m^3/a	Total green CO_2 from Biogas and Biomethane in tonnes/a
Germany	7,022,194,000	13,763,500	7,750,775,818	15,191,521
United Kingdom	2,554,041,040	5,005,920	2,794,041,040	5,476,320
Italy	1,700,771,200	3,333,512	1,762,589,382	3,454,675
France	908,628,640	1,780,912	996,410,458	1,952,964
Czech Republic	540,748,480	1,059,867	540,748,480	1,059,867
Denmark	368,996,640	723,233	472,633,004	926,361
Netherlands	331,222,400	649,196	493,113,309	966,502
Poland	277,724,400	544,340	277,724,400	544,340
Spain	242,183,120	474,679	248,874,029	487,793
Belgium	215,759,760	422,889	215,832,487	423,032
Austria	199,477,760	390,976	211,841,396	415,209
Finland	176,496,880	345,934	185,224,153	363,039
Sweden	168,867,600	330,980	262,031,236	513,581
Slovakia	133,326,320	261,320	133,326,320	261,320
Greece	116,300,000	227,948	116,300,000	227,948
Hungary	77,316,240	151,540	77,316,240	151,540
Latvia	74,990,240	146,981	7,499,0240	146,981
Croatia	74,618,080	146,251	74,618,080	146,251
Portugal	74,525,040	146,069	74,525,040	146,069
Bulgaria	47,450,400	93,003	140,614,036	275,604

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Ireland	46,520,000	91,179	55,247,273	108,285
Lithuania	36,285,600	71,120	36,285,600	71,120
Slovenia	20,654,880	40,484	20,654,880	40,484
Romania	19,259,280	37,748	19,259,280	37,748
Luxembourg	16,747,200	32,825	16,747,200	32,825
Cyprus	13,025,600	25,530	13,025,600	25,530
Estonia	12932,560	25,348	34,459,833	67,541
Malta	1,488,640	2,918	1,488,640	2,918
Total	**15,472,552.000**	**30,326,202**	**17.100,697,455**	**33,517,367**

The regional distribution of the potentials follows the ranking of the primary biogas and biomethane production in the EU. The total amounts of green CO_2 from AD plants can be read as a theoretical maximum. The question of how much of this potential can be utilised in practice depends on additional technical and economic restrictions.

4.2 Theoretical potential of PtG from green CO_2 from AD

The theoretical potential of green CO_2 from AD plants could be used as a feedstock for the production of synthetic methane. Although the potential of synthetic methane that could be produced from this amount of green CO_2 depends on several technological process parameters, a first rough estimation based on (Wettstein et al. 2018) has been calculated.

Assuming that the total amount of the estimated 33,517,36 tonnes of green CO_2 could be mobilised, together with 6,141,127 tonnes of H_2, a theoretical total of 12,217,839 tonnes of synthetic methane can be calculated. This mass of synthetic methane would correlate to approximately 169,692 GWh of energy of PtG to be produced in the EU based on green CO_2 sourced from AD production units.

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5 Perspectives and Hot-Spots for Renewable Gas production in the REGATRACE partner countries

Based on the various preconditions regarding feedstock potentials, technology development and the existing policy framework, the different EU Member states have implemented a wide range of strategies to develop future capacities for renewable gases. In order to describe the situation in the REGATRACE partner countries, WP5 has developed a questionnaire that was answered by all country partners. The questionnaire was defined in order to understand the specifics of the policy instrument in place to support the development of renewable gas production capacities, to describe country-specific technology or feedstock focus points. The questionnaire that was sent out to and filled in by REGATRACE partners is included in the Annex in chapter 7.

5.1 Brief summary on REGATRACE countries

The specific answers to the questionnaire have been processed and used to produce country-specific profiles for each REGATRACE country. These profiles are included in the next subchapter and provide a more detailed view regarding the specific situation, as well as the perspective for renewable gas production in the REGATRACE countries. This section provides a brief and condensed summary of some answers received for the questionnaire.

As for the specific policy instruments in the REGATRACE countries, the questionnaire results showed that the instruments in place are very diverse regarding their general approach (e.g., feed-in tariffs, quota systems, investment programmes, auctions, etc.) and underlying strategies. Existing specific instruments do mostly focus on AD technologies (mostly with a focus on electricity from biogas). However, many regions are shifting away from the use of cultivated biomass or energy crops towards the use of more waste and residue streams (e.g., focus on the feedstock portfolio of the RED II; Annex IX). Additionally, more and more focus is on biomethane production and subsequent feed into national gas grids.

Contrarily, existing instruments for the development of H_2 and PtG are in most cases on strategy or roadmap level with a more specific implementation to be developed or in preparation.

Focus on specific technologies or feedstock for RG production in the short medium and long term

REGATRACE countries set different focus points regarding their specific strategies and the technologies and feedstocks used for the development of RG production capacities in the short (< 5 years), medium (5-20 years) and long term (>20 years). The following figures provide an overview of the respective technologies and feedstocks that are expected to play an important role in the different countries.

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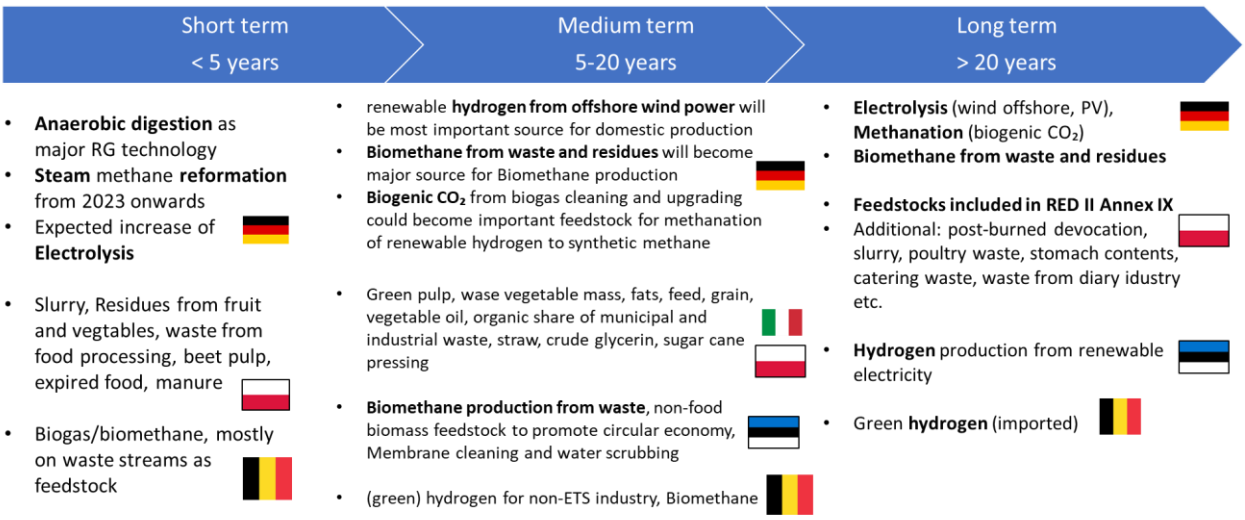

Figure 5 Expected technology and feedstock combinations for RG production in REGATRACE countries in the short, medium and long term. Based on results of the project internal questionnaire

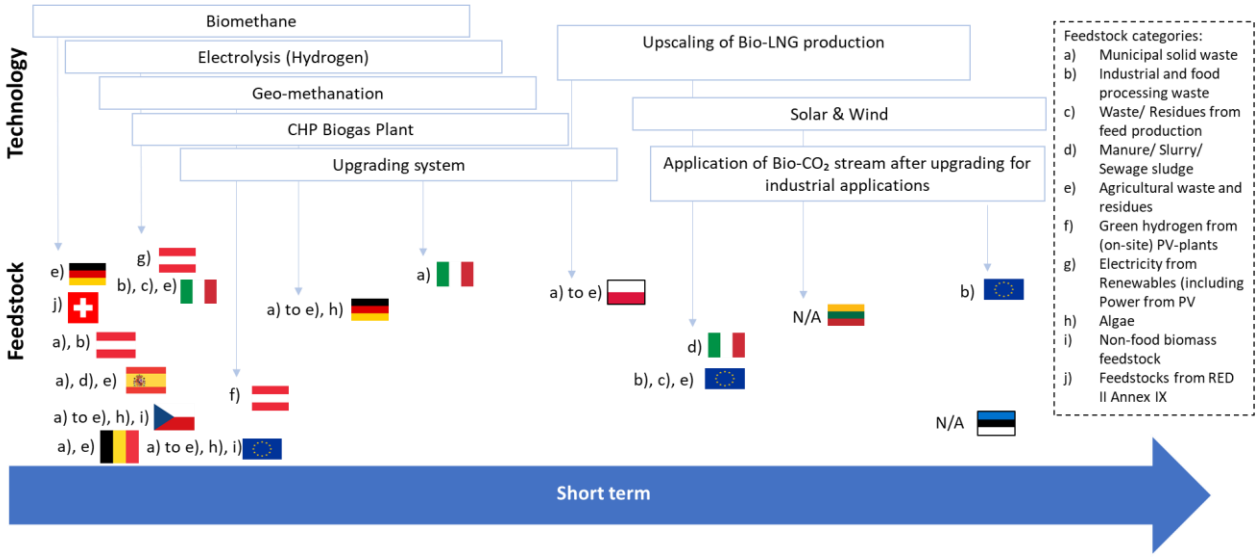

Figure 6 Expected technology and feedstock combinations for RG production in REGATRACE countries in the short term (< 5 years)

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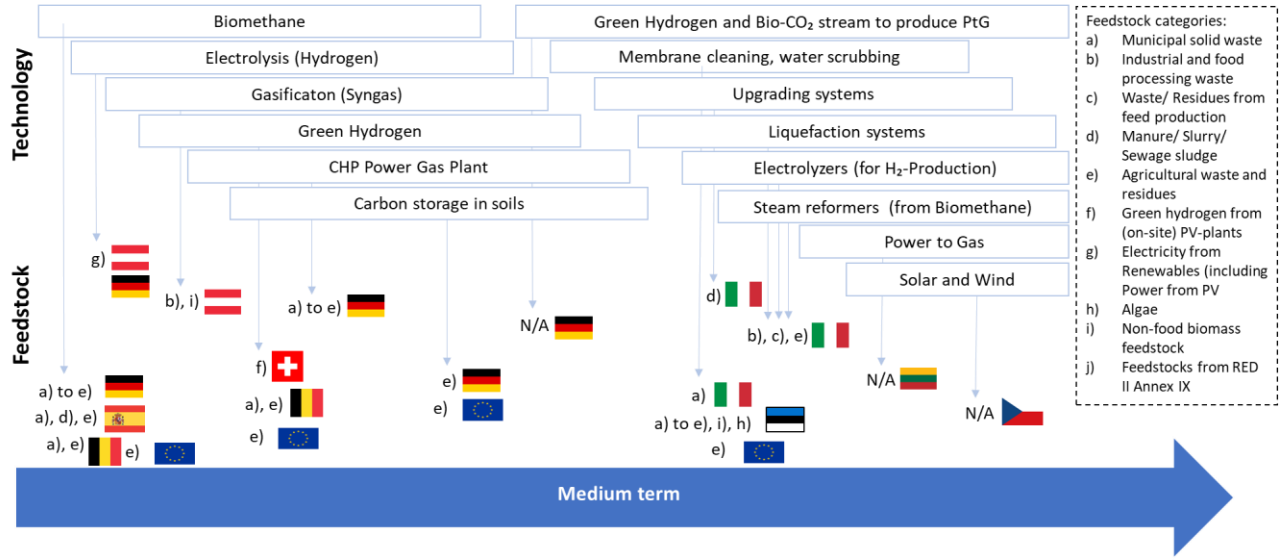

Figure 7 Expected technology and feedstock combinations for RG production in REGATRACE countries in the medium term (5 years)

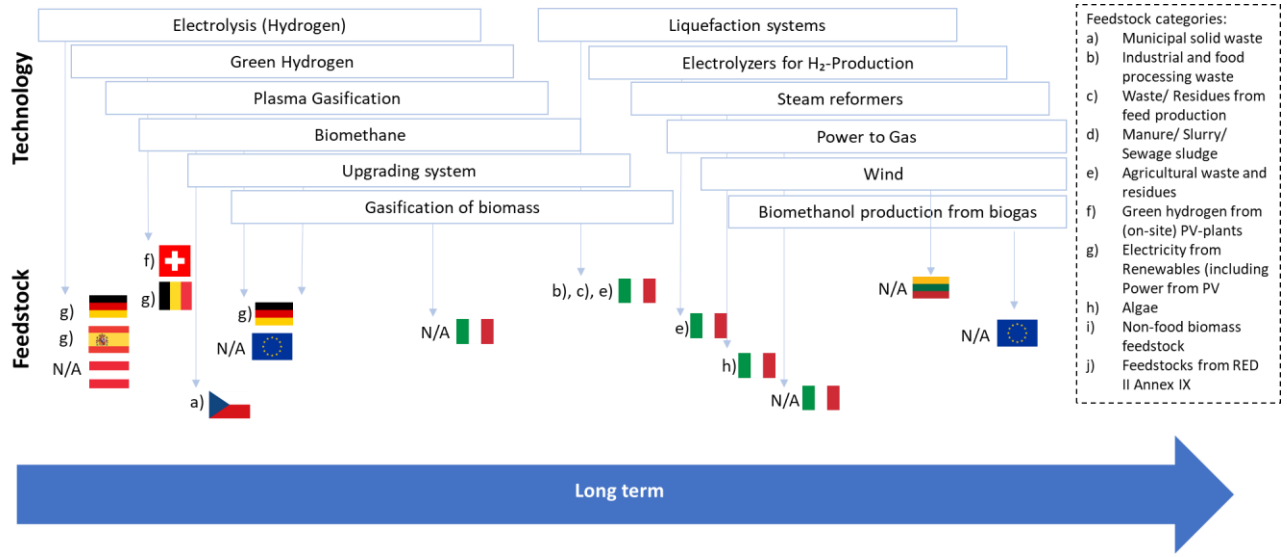

Figure 8 Expected technology and feedstock combinations for RG production in REGATRACE countries in the long term (>20 years)

Interestingly, the questionnaire answers indicated that exiting capacities of AD plants are expected also to play an important role for the future supply with renewable gases in the REGATRACE countries. However, the resource or feedstock base of these installations is expected to change in order to include a greater share of residues and waste materials.

Furthermore, H_2 production based on electrification, using renewable electricity mostly from wind and solar is considered a promising pathway in several countries. Pathways for synthetic methane based on Power-to-Gas are only mentioned rarely (for the long term) by questionnaire answers.

5.2 Specific country profiles for REGATRACE countries

This section includes a profile for the countries of Austria, Belgium, Czech Republic, Estonia, Germany, Ireland, Italy, Lithuania, Poland, Spain and Switzerland. The profiles have been developed based on the answers to the questionnaire, as well as additional input from the country partners and desktop

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research. They are structured into different sections, which aim to provide some brief insights into the status quo of renewable energy and gas production, as well as the respective perspectives in the REGATRACE countries. The sections include:

Current status of renewable energy supply: this section includes information on the share of the different energy carriers in the energy system of the country, the share of renewables used for electricity production and the types and amounts of biofuels used. In order to provide information for all countries in a consistent manner, we used country-specific data from World Energy Statistics and Balances (International Energy Agency 2021) to prepare an overview for each country included.

Policy support for RG technologies: a quick intro to the current policy framework, strategies and targets potentially supporting the development of capacities for renewable gases. This section has been developed based on the questionnaire answers and additional desktop research.

Feedstock and technology focus: this section aims to provide a brief and compact overview on technology and feedstock routes which are either supported by already implemented policies in the country or are expected to become important elements for RG production (in most cases defined based on the judgement of the country partner).

Existing capacities for AD production: short intro to the current state of biogas and biomethane production capacities in the country.

Current CO_2 potentials from AD plants: an estimation of the theoretical potential of green CO_2 from AD production units in the specific country. The estimation has been based on the general approach described under section 4.1. It has to be noted that this potential represents a theoretical maximum, whose exploitation may be limited further by technical or economic restrictions. This potential of green CO_2 can be a relevant element for the development of future PtG capacities in the EU and the REGATRACE countries.

Regional Hot-Spots: this section provides a brief description of potential future Hot-Spots for renewable gas production in the REGATRACE countries, based on the existing preconditions and the countries existing future perspectives.

Existing challenges for RG production: a condensed wrap up of the main challenges and barriers that need to be solved for a successful future development of the renewable gas sector in the country. This section has been developed based on the input from the respective REGATRACE country partners.

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5.2.1 Austria

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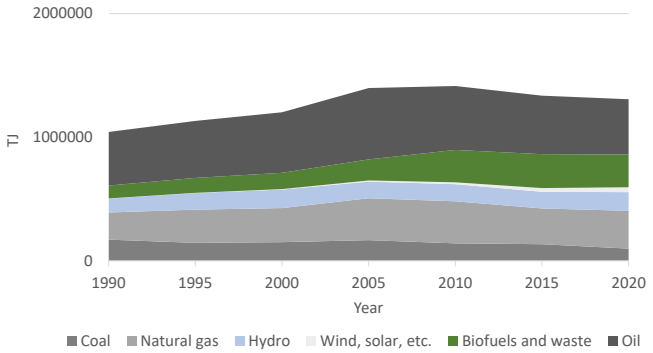
REGATRACE
Renewable Gas Trade Centre in Europe

REGATRACE COUNTRY PROFILE
NOVEMBER 2021

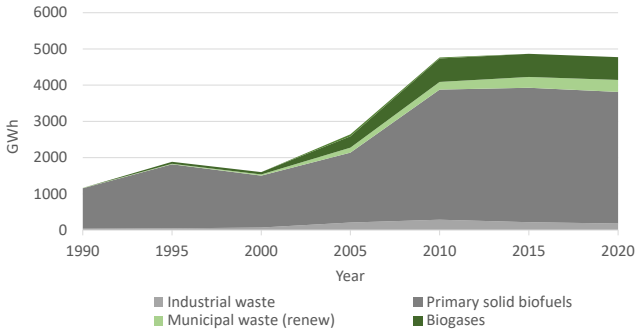
Austria

GENERAL KEY FACTS

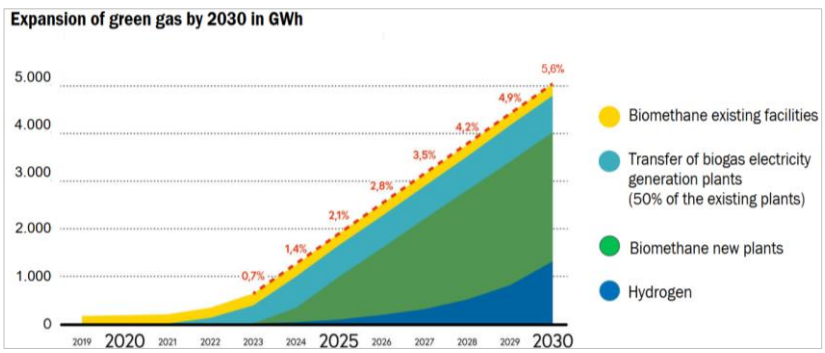
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

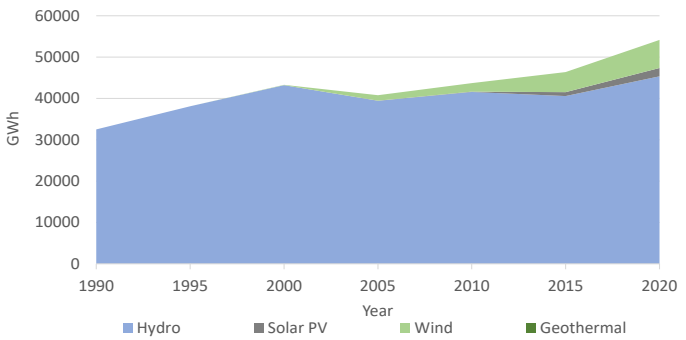


POTENTIALS OF RE IN AUSTRIA



(Maringer 2021)

RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

More than 80% of electricity produced in Austria is based on renewable sources. Renewable electricity may cover up to 70% (in balanced terms) of the total final electricity consumption. Over the recent years, Austria has successfully increased the share of renewables in its total primary energy supply to over 30%. Austria is advancing the transformation of its energy sector in line with commitments under the Paris Agreement and at the European level based on a number of policy measures based on the following targets:

- generating electricity from renewable energy sources to the extent that 100% of total national electricity consumption (in national balance terms) is covered by 2030;
- safeguarding the resilience of the energy system to ensure the security of supply.

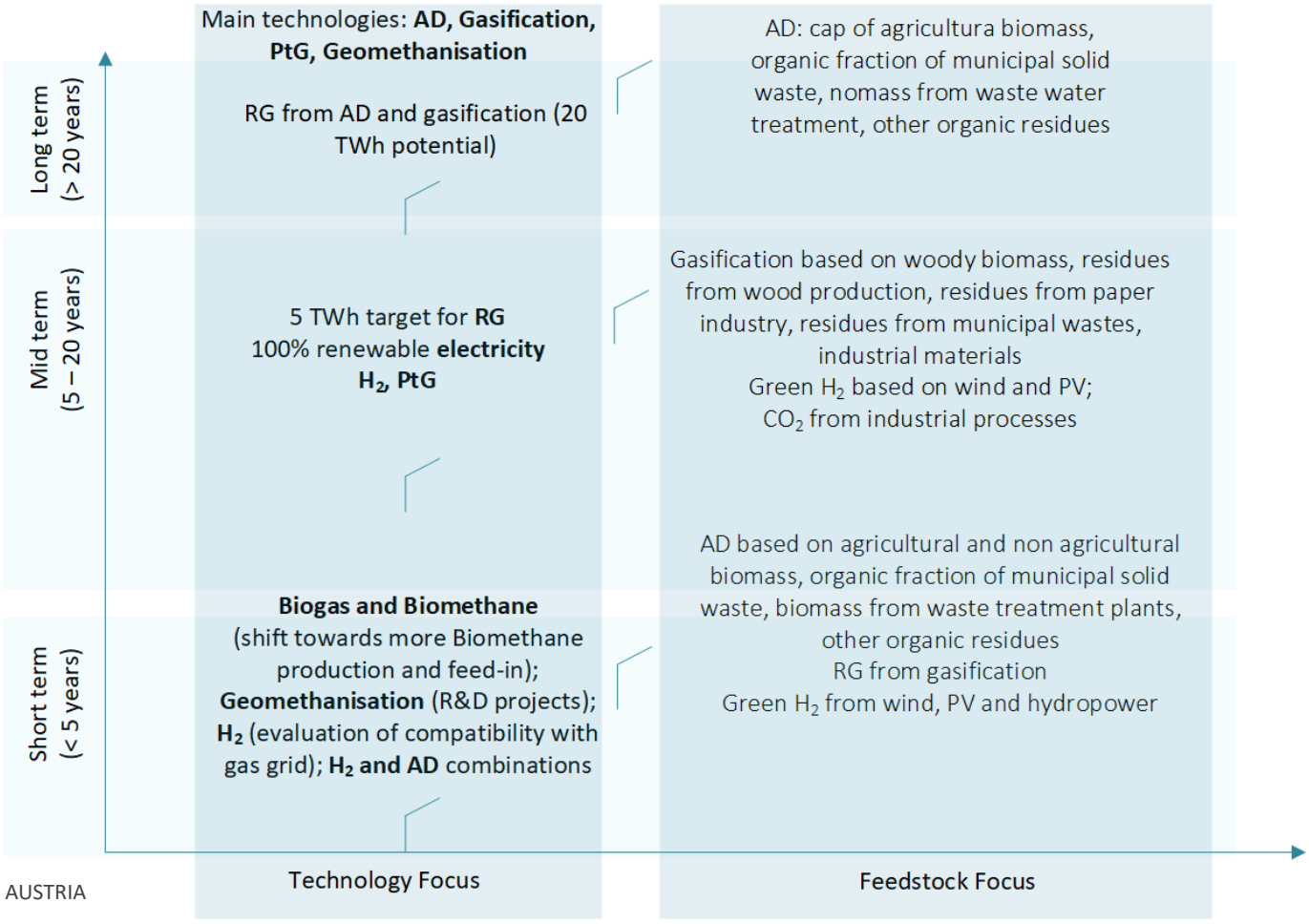
Amongst others, the following policy elements are relevant for the development of RG in Austria:

- #Mission2030: The Federal Government has the goal of generating electricity to the extent that 100 % of total national electricity consumption (in national balance terms) is covered by renewable energy sources by 2030.
- Renewables Expansion Act (Erneuerbaren-Ausbau-Gesetz, EAG 2021) pushing towards a shift from renewable power from biogas towards biomethane grid injection, supported via investment subsidies.

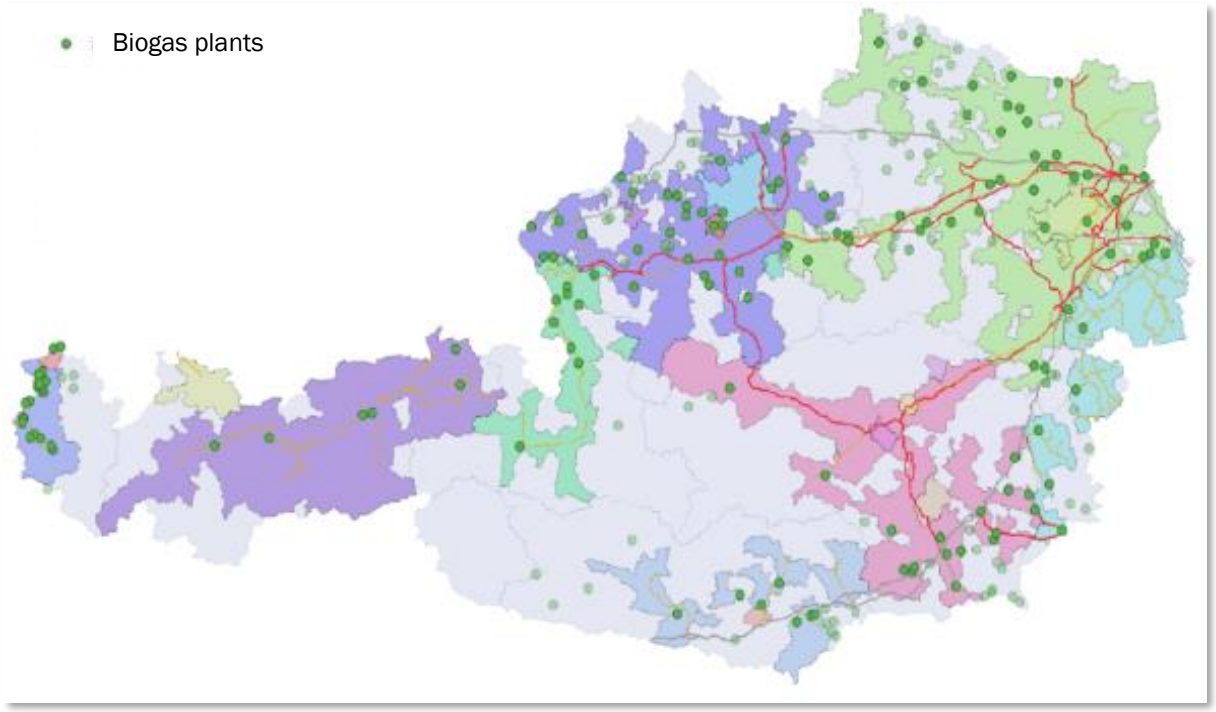
Additional elements under preparation are a national hydrogen strategy and a renewable gas quota for suppliers.

For existing and future biogas and biomethane facilities, support policies aim to shift the resource base towards increasing use of wastes and residues. Additionally, existing investment programmes support the instalment of biogas upgrading and biomethane feed-in technologies for existing biogas plants.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



(AGGM 2019)

- Austria produces an average of approx. 1,700 Nm³/h of biomethane in natural gas quality at 14 production sites that feed into the public gas grid. The substrates used are cultivated biomass, manure from livestock farming and organic residues (including waste from the food industry). The highest level of biomethane injection – approximately 170 GWh – was achieved in 2018. In 2019, injection volumes decreased to a level similar to that reached in 2017, at around 150 GWh. In 2020, 138 GWh of biomethane was injected into the Austrian gas grid.
- In 2020, Austria counted 423 operational biogas plants, with a total reported biogas production of 1,487 GWh converted into electricity and/or heat.

CURRENT CO_2 POTENTIALS FROM AD

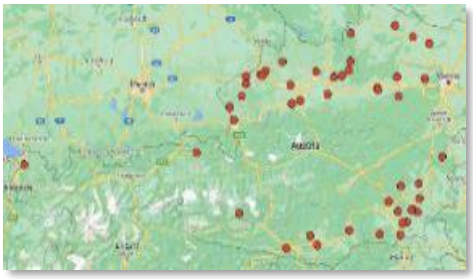
- Based on the existing capacities of biogas facilities in Austria, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane.
- Based on the above-described capacities, we calculated a theoretical potential of 415.209 tonnes (211.841.396 m³) of biogenic CO_2 from existing AD plants.
- The current plans of the Austrian administration towards a shift for more biogas upgrading units would support the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS

ORGANIC RESIDUES FROM DAIRY PRODUCTION

ORGANIC RESIDUES FROM SLAUGHTERHOUSES



ORGANIC RESIDUES FROM SUGAR INDUSTRY

ORGANIC RESIDUES FROM BREWERIES

ORG. RESIDUES FROM DAIRY PRODUCTION

ORGANIC RESIDUES FROM MILLS

(Gabauer & Bochmann 2021)

- Residues from the food and beverage industry and the organic fraction of municipal solid wastes (OFMSW) are to a large extent unavoidable but offer a widely untapped potential for energy production via AD.
- Hot-Spots for RG production are expected in those areas, especially in combination with existing overlaps between the gas grid infrastructure and existing AD plants.

EXISTING CHALLENGES FOR RG PROD.

Existing challenges for the future development of renewable gas capacities in Austria include three main aspects. Firstly there are a number of regulatory challenges due too are missing or unfinished legislation and thus uncertainty for investors/producers and uncertainty for consumers regarding target fulfilment. A green gas quota with substitution obligation for gas suppliers is being considered (§87 EAG 2021), but has been criticised by market participants as it is not an appropriate measure to promote market acceptance, but rather for mature markets. Achieving grid connection is a technical challenge. Remedy is provided by §75 GWG (Gas Economy Act) 2021 referring to grid access fees (*Netzanschlusskosten*) via cost coverage by the network operator for specific components associated with the initial establishment of a grid connection. Another technical aspect is that operators must submit a concept for the provision of raw materials and a concept for the utilisation of biogas fermentation residues in order to receive investment support under the Renewable Energy Sources Act 2021. The third challenge is administration. There are three different certification/registry systems in operation, each for another application purpose of renewable gases, referring to FiT for renewable power, consumer disclosure, biofuels sector. Remedy provided by §81 (7&8) EAG 2021 requesting interfaces between those registry systems to ensure the prevention of multiple counting.

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Compost and Biogas Association Austria: www.kompost-biogas.info European Biomass Assicoation (EBA) (2021) Statistical report; Austrian data submission

www.energymonitor.at

Initiative Future of green gas: www.gruenes-gas.at

Renewable Gas in Austria by 2040: Erneuerbares Gas in Österreich 2040 - Studie zur quantitativen Abschätzung von Nachfrage und Angebot: https://www.bmk.gv.at/themen/energie/publikationen/erneuerbares-gas-2040.html

#Mission2030 Klima- und Energiestrategie Österreich: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi88Pat2q70AhVxiv0HHVBmAPcQFnoECBMQAw&url=https%3A%2F%2Fwww.bundeskanzleramt.gv.at%2Fdam%2Fjcr%3A903d5cf5-c3ac-47b6-871c-c83eae34b273%2F20_18_beilagen_nb.pdf&usg=AOvVaw3QweYOeuNMYMqjVf8MWtpW

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5.2.2 Belgium

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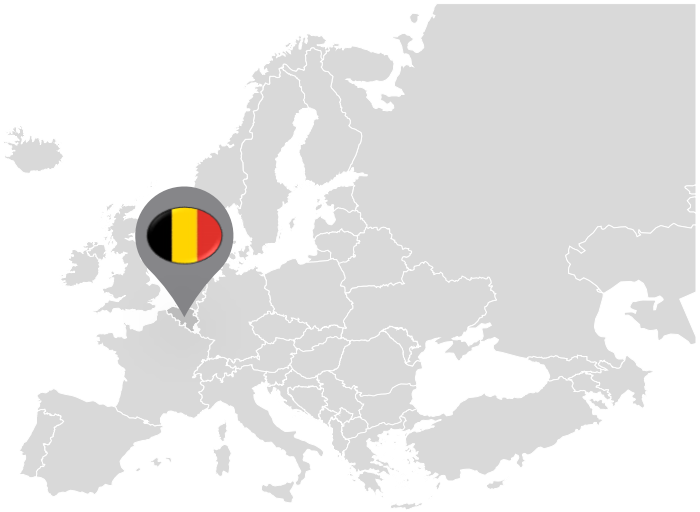
REGATRACE
Renewable Gas Trade Centre in Europe

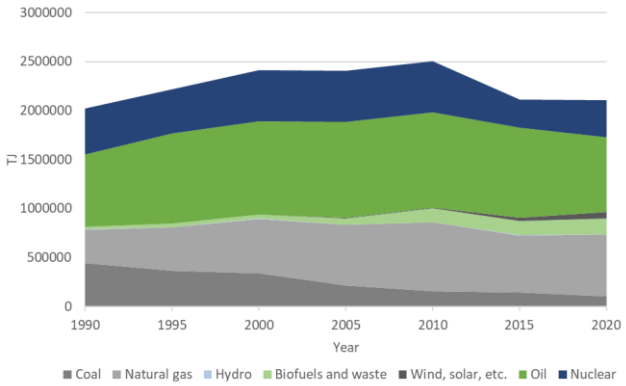
REGATRACE COUNTRY PROFILE
NOVEMBER 2021

BELGIUM

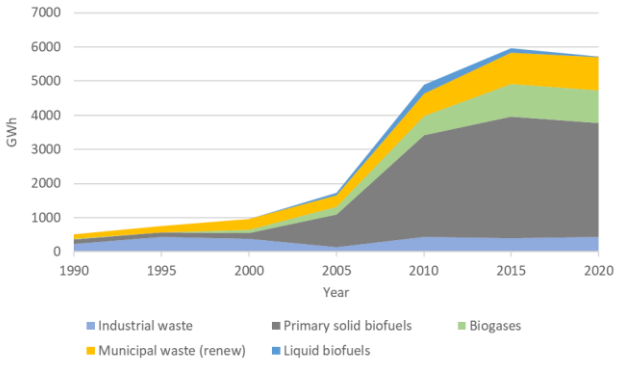
GENERAL KEY FACTS



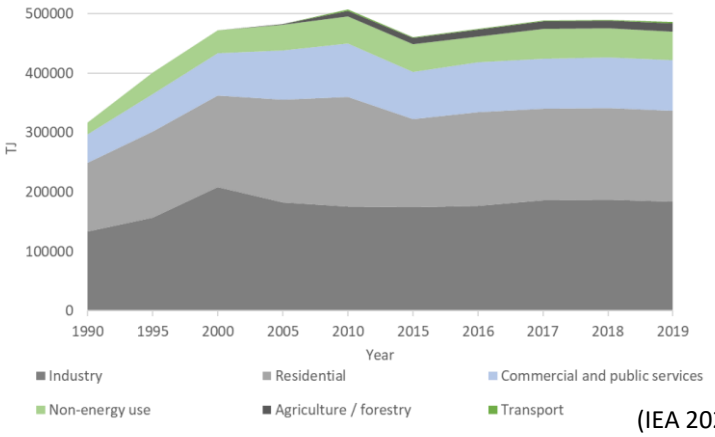
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

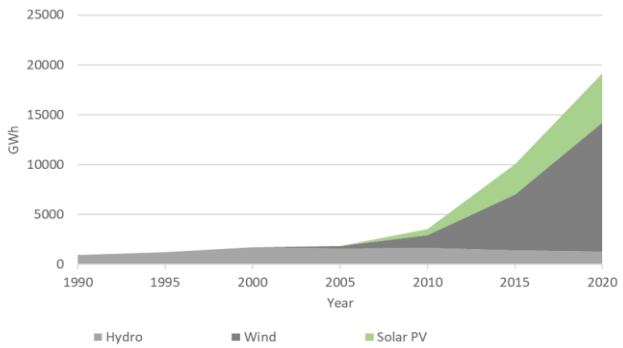


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021)

RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

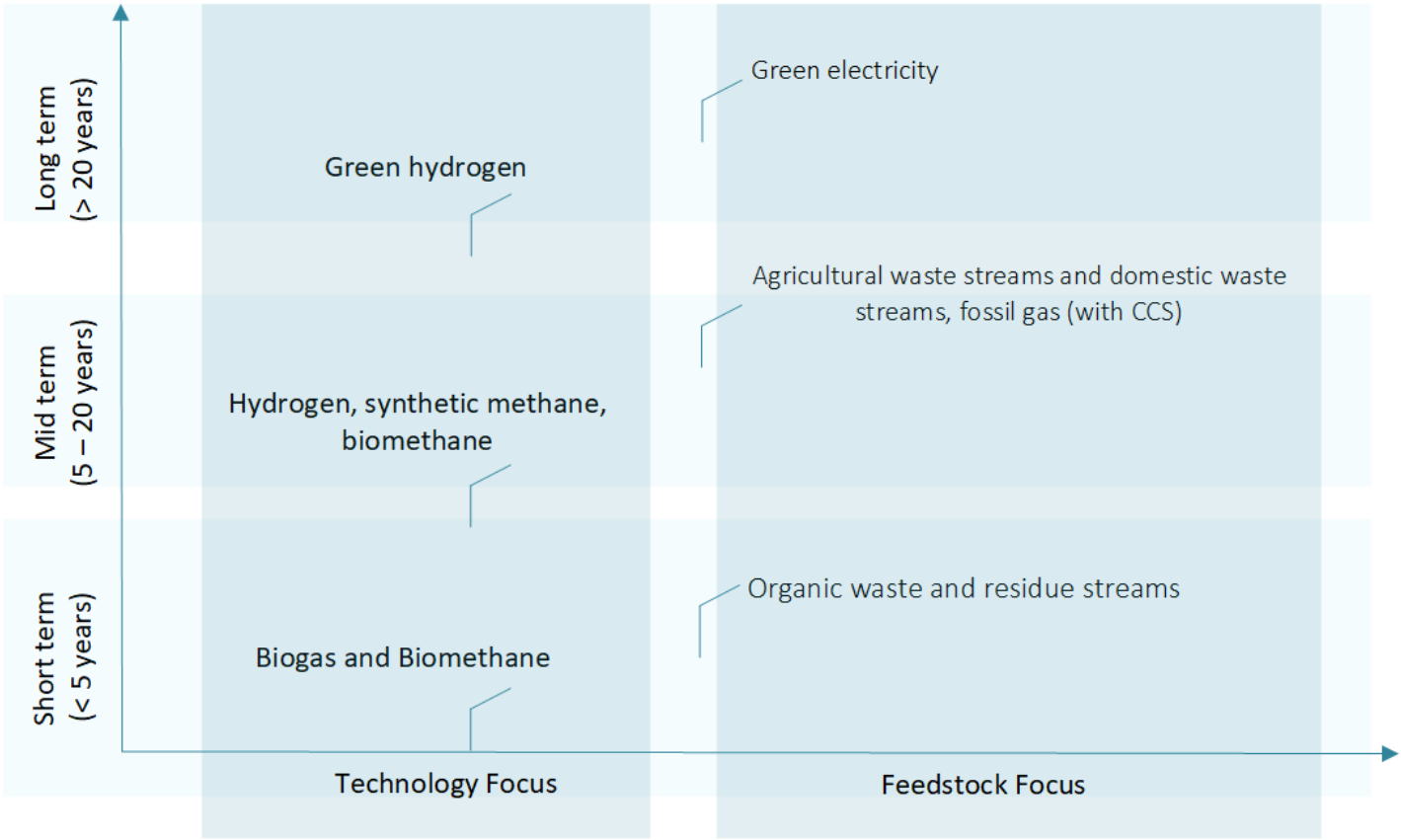
The main strategic policy element for the development of renewable energy in Belgium is the National Climate and Energy Plan 2021 -2030.

Specific measures are defined per region (Flanders, Wallonia, and Brussels) and on the federal level to increase the production of green electricity, green heat and cooling and biofuels. The three regions of Belgium have adopted numerous policies and measures, including regional climate policy plans and strategies and programmes for low-carbon energy supply. Regions support renewable energy technologies through investment subsidies and green certificates. Additionally, the federal government provides tax incentives. In order to foster electricity production from renewable sources, green certificate schemes have been established. Parallel to that, investment subsidy schemes exist in all regions in renewable energy projects. In terms of biofuels, obligatory blending is ruled by the law for the incorporation of biofuels in fossil fuels.

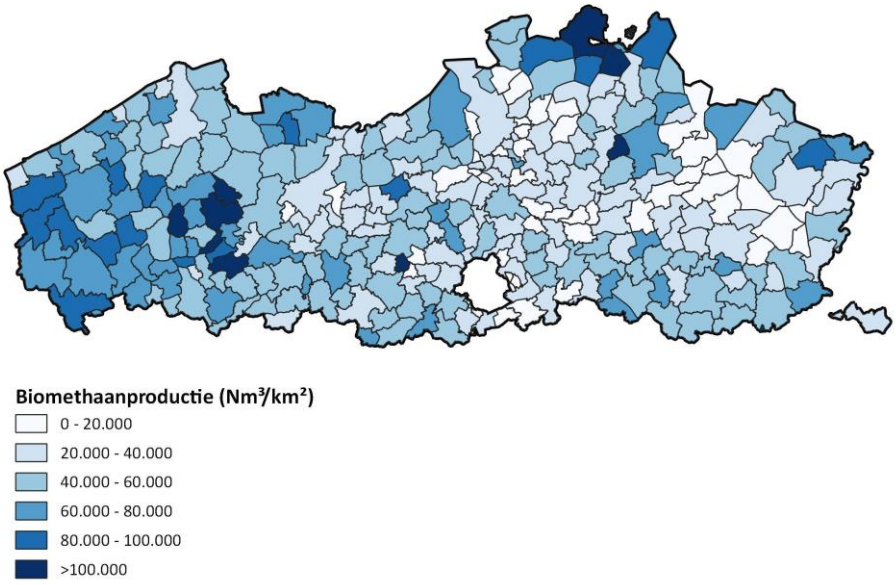
In 2020, the federal government launched a 'hydrogen strategy and vision', preparing the future development of national hydrogen capacities. Specific measures include:

- Development of hydrogen infrastructure hub for import and distribution
- Creation of European certification register
- Development of electrolyser capacity of 150 MW by 2026

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



(Icone 2021)

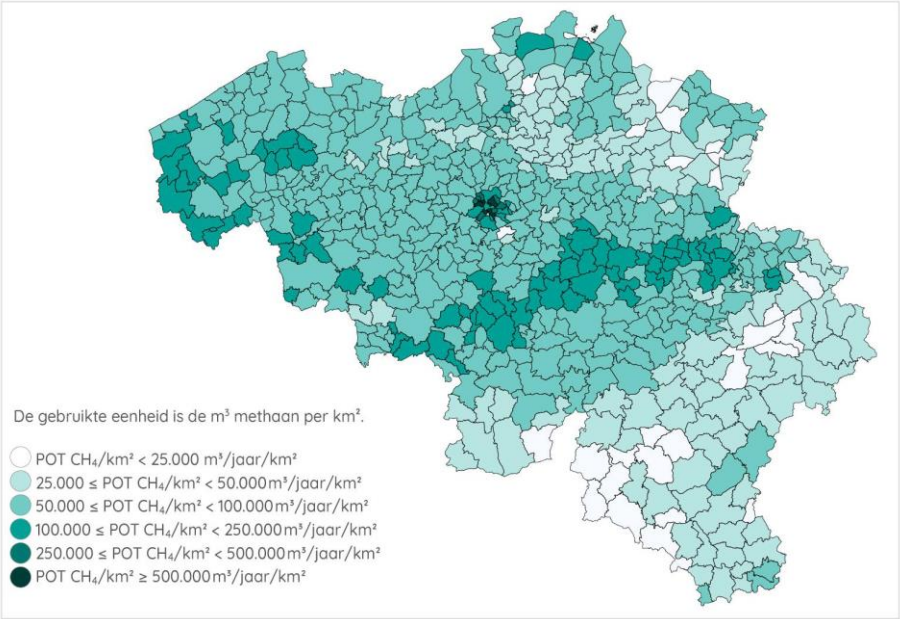
- Currently, Belgium produces ~ 2.5 TWh of Biogas per year (~ 2.0 TWh in Flanders; ~ 0.5 TWh in Wallonia; in total ~60 plants) This biogas is currently used in local CHP to produce green electricity.
- For a large amount of these plants, the support for green electricity ends by 2025. Thus, biogas producers need to find new strategies which would require to rebuild large parts of their plants or to add upgrading units for the production of biomethane for grid injection.
- By end of 2021 in Belgium six biomethane installations will be active, of which five inject in the gas grid.

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Belgium, a theoretical potential of biogenic CO_2 can be calculated [4]. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane.
- Based on the above described capacities, we calculated a theoretical potential of 423.032 tonnes (215.832.487 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Belgian administration towards a shift for more biogas upgrading units and the use of additional potentials of biogenic residues will increase the potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS



(Icone 2021)

Potential future Hot-Spot regions for the production of RG and RG components in Belgium:

- Off shore wind turbines at the coastal area in Belgium. By 2030 all the available developments zones will be operational. The total capacity of off-shore wind energy will increase up to 5.8 GW.
- Hydrogen. Belgium aims to become the import hub for renewable molecules in Europe. It is estimated that the capacity of the hydrogen hub will increase from 3 to 6 GWh in 2030 to 100-160 TWh in 2050.
- Hotspots for additional biogas and biomethane production are closely linked to remaining biomass potentials and the availability of manure of crop residues. Interesting areas in that regard are in the north east and central Belgium.

EXISTING CHALLENGES FOR RG PROD.

Belgium faces several challenges, six of which are mentioned as follows. Firstly, there is a cost difference between natural gas and biomethane. Taxes on natural gas are relatively low in Belgium compared to other Member States, resulting in a competitive price of natural gas. There is a lack of solid support mechanism that offers long-term perspectives to renewable gas producers and creates a level playing field for the different end uses. The public image of renewable gas production needs to be improved. The administrative burden for plant operators is significant, leading to long development times for new projects and higher operating costs. Differences in legislation and policy objectives between the three regions are also significant, making it difficult to introduce new technologies in Belgium. Finally, there is a discrepancy between the production potential of renewable gas and the production targets in the regional and federal energy targets, which underestimates the potential contribution of renewable gas to the energy transition.

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This project receives funding from the European Union's Horizon 2020 Framework Programme Research and Innovation under Grant Agreement no. 857796

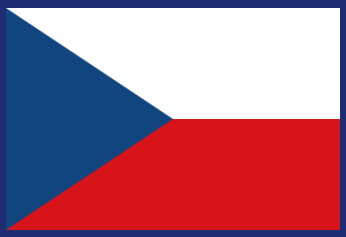
5.2.3 Czech Republic

This project receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 857796

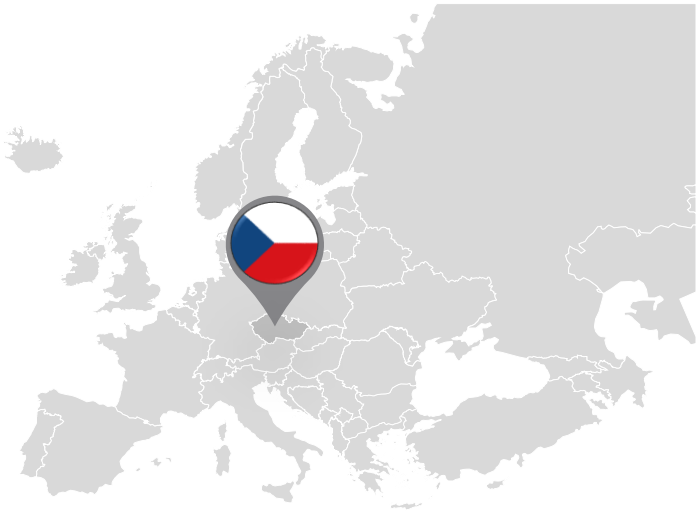
REGATRACE
Renewable Gas Trade Centre in Europe

REGATRACE COUNTRY PROFILE
NOVEMBER 2021

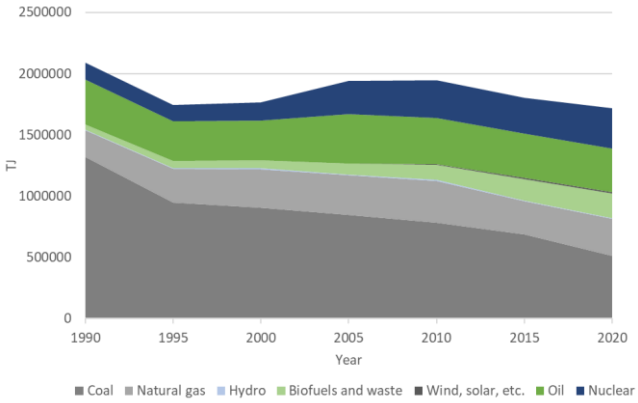
CZECH REPUBLIC



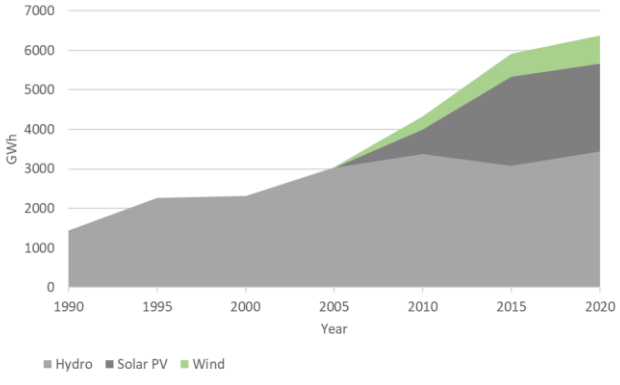
GENERAL KEY FACTS



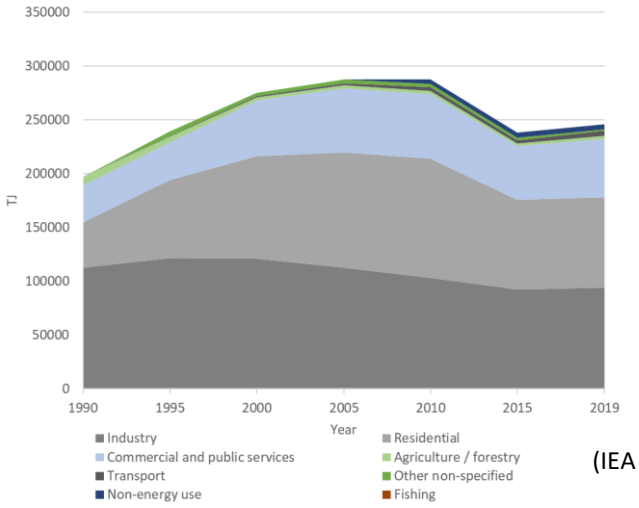
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

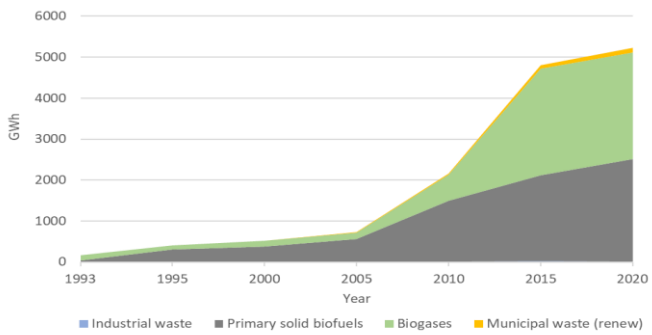


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021a)

RE ELECTRICITY GENERATION

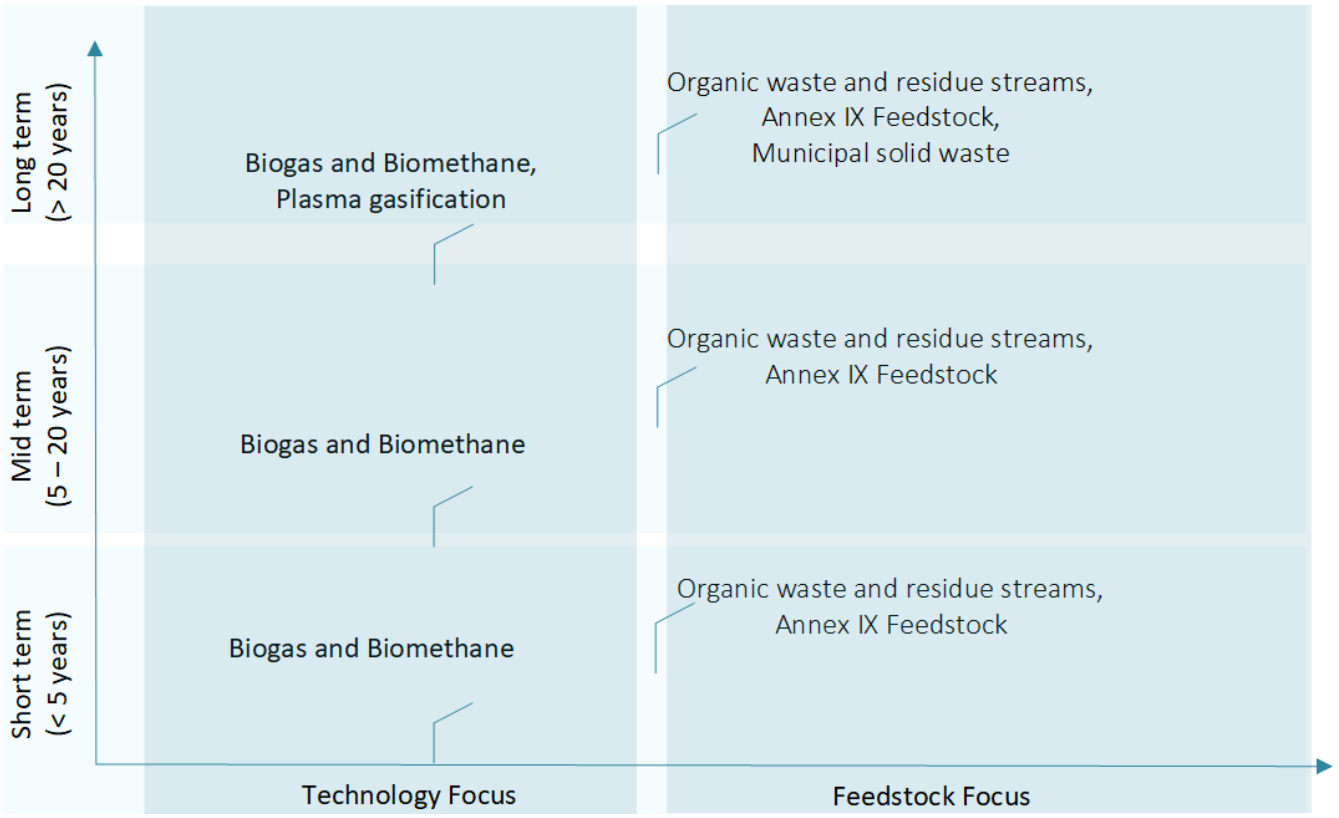


(IEA 2021b)

POLICY SUPPORT FOR RG TECHNOLOGIES

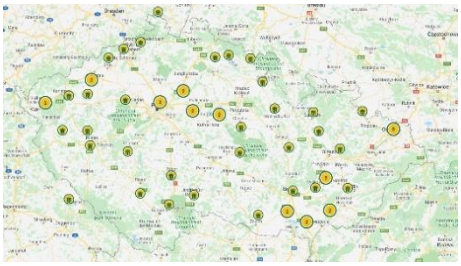
- With its State Energy Policy (SEP), the government of the Czech Republic has formulated a framework for long-term sustainable energy supply (scenarios for the next 25 years (until 2040)). There are several national action plans following the SEP.
- A key challenge of the Czech Republic's energy sector is the phase-out of coal from the energy mix. The coal commission recommends a phase-out by 2038; coal would be replaced largely by natural gas generation, while the share of renewable sources would increase to 25%, largely in line with the SEP of 2015 and the country's National Energy and Climate Plan (NECP) of 2019.
- Renewable energy is supported through either a guaranteed feed-in tariff or a fixed premium tariff (so-called green bonus) paid on top of the market price. For biogas and biomethane, only the fixed premium option applies. For biogas plants: the electricity has to be generated in a CHP plant using biogas from more than 30% of other crops than herbage and crops from targeted growth on arable land, as well as securing the efficient use of at least 50% of the primary energy generated by the biomass from which the biogas is produced (§ 4 par. 5 Letter c Act No. 165/2012).
- Heat from renewable energy sources is mainly supported through subsidies under two Operational Programmes funded by the ERDF.
- Targets for renewable gas production, do relate to biomethane and are oriented according the targets of the RED II (focus on advanced biofuels).

FEEDSTOCK AND TECHNOLOGY FOCUS

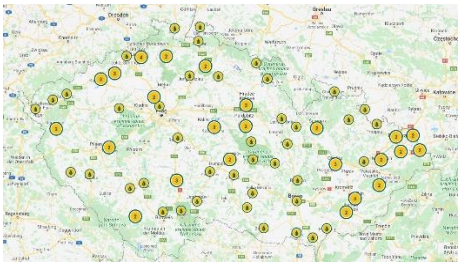


EXISTING CAPACITIES FOR AD PLANTS

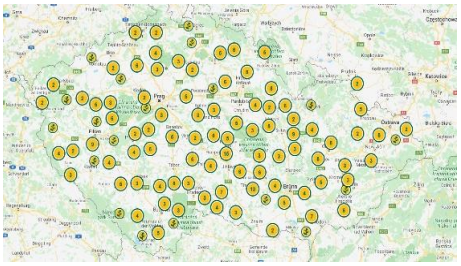
LANDFILL GAS PLANTS



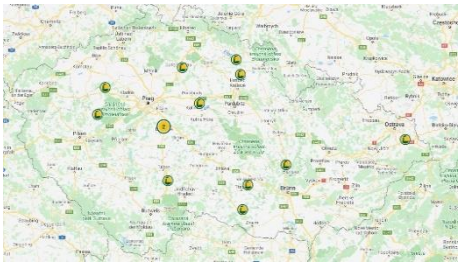
WASTE WATER TREATMENT PLANTS



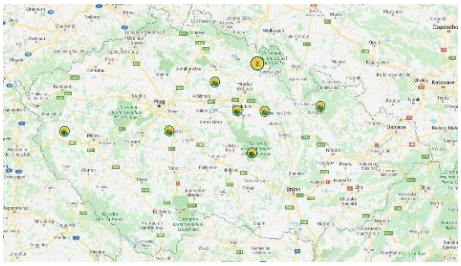
AGRICULTURAL BIOGAS PLANTS



INDUSTRIAL BIOGAS PLANTS



MUNICIPAL WASTE PLANTS



(CZBA 2021)

- Statistics show that end of 2019, the total number of biogas plants was 574 with a total of 367 MW installed capacity. The electricity production per year was 2,526 GWh and the share of biogas in RES is 22.9%.
- Agricultural biogas plants are widespread. An example is the South Bohemia region, where they account for 77%.

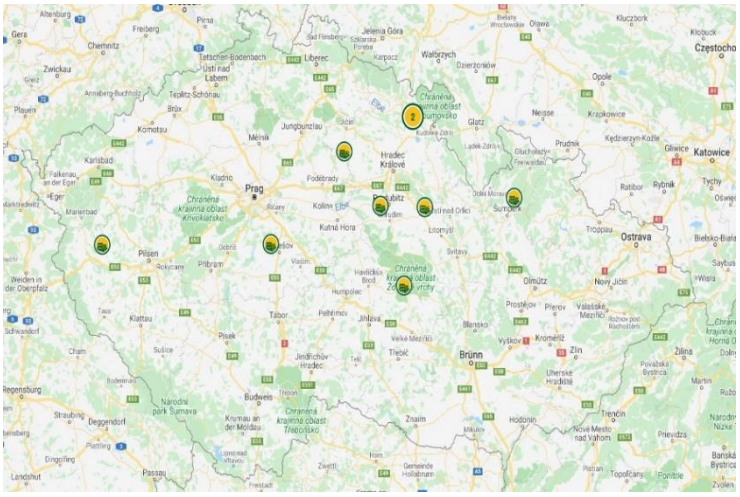
CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in the Czech Republic, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.
- Considering the capacities of AD plants in the Czech Republic as described in the Biogas Barometer of the Erobserver, we calculated a theoretical potential of 1.059.867 tonnes (540.748.480 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Czech Republic administration towards the production of advanced fuels would support the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS OF RG PRODUCTION

MUNICIPAL WASTE BIOGAS PLANTS



(CZBA 2021)

- Future potential pathways for the production of renewable gas in the Czech Republic are plasma gasification, hydrogen and biogas/biomethane. Due to scaling effects, plasma gasification in the Czech Republic might be a viable alternative to waste incineration, which has low energy conversion efficiency.
- Regional hot spots or preferential regions for production do not yet exist, they would rather be defined by large utilities. However, existing facilities for the treatment of municipal waste can be a starting point for the hot-spot development.

- The feasibility of producing hydrogen from renewable sources and the economic viability of such production depends on a number of factors that have been identified in the Hydrogen Strategy of the Czech Republic. One of the points e.g., is a lower RES potential in the CR compared to countries with significantly more hours of sunlight and/or countries with greater wind intensity. For biogas and biomethane, the existing capacities and plants included in the previous page do indicate respective hot spots.

EXISTING CHALLENGES FOR RG PROD.

- Biomethane development is a fairly new type of renewable carrier, introduced into the local legislation for renewable energy in late 2021. This underlines the early stage of development, which is marked by numerous obstacles common for early-stage markets. Despite the fact that technical norms and standards were prepared by the gas industry well ahead, a market is not yet existent.
- The current framework for biofuels in the RED II and its national implementation will not allow for much room to develop biogas and biomethane capacities based on energy crops. The current legislation, which introduces biomethane, starts already with second generation biomethane which is related to a much favourable emission profile. This is beneficial regarding overall emission reduction targets, while at the same time imposing significant challenges for existing facilities (95+% of the existing biogas installations).
- Additionally, the national implementation of the RED II targets in the Czech Republic aims at increasing the share of renewable energy carriers in the transport sector. Thus, operational support will be provided on the basis of purchasing the “green value” of biomethane. In this scenario, potential investors or obliged parties can choose whether to join the state support scheme or to join the EU-wide biomethane market.
- On the other hand, the late introduction of biomethane among RES enabled rigorous preparation of all technical issues beforehand, based on the abroad experience. There are clear and well accepted grid connection rules, and also the much disputed issue on grid connection costs was elegantly solved with mutual agreement of DSOs and biomethane investors.

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https://www.hytep.cz/images/dokumenty-ke-stazeni/Czech_Hydrogen_Strategy_2021.pdf

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https://www.czba.cz/statistiky-vyroby-bioplynu.html

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https://www.mega.cz/gas/

https://www.gasnet.cz/cs/bioplyn/

https://www.cgoa.cz/en/ts.tpp-plan-tvorby-nd/en

https://www.efg-rapotin.cz/

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This project receives funding from the European Union's Horizon 2020 Framework Programme Research and Innovation under Grant Agreement no. 857796

5.2.4 Estonia

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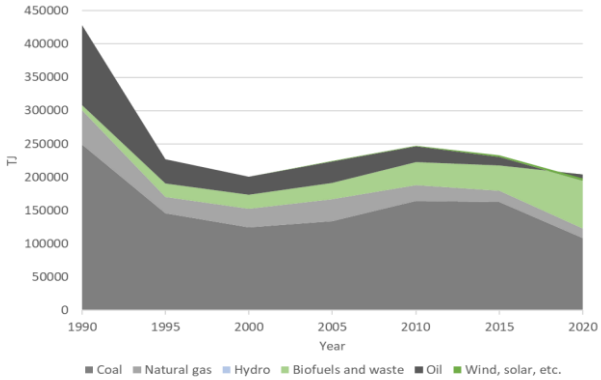
REGATRACE
Renewable Gas Trade Centre in Europe

REGATRACE COUNTRY PROFILE
NOVEMBER 2021

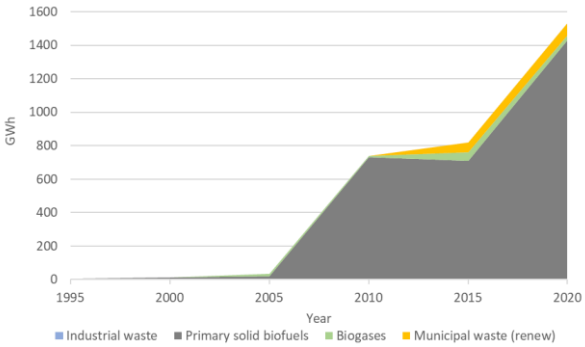
ESTONIA

GENERAL KEY FACTS

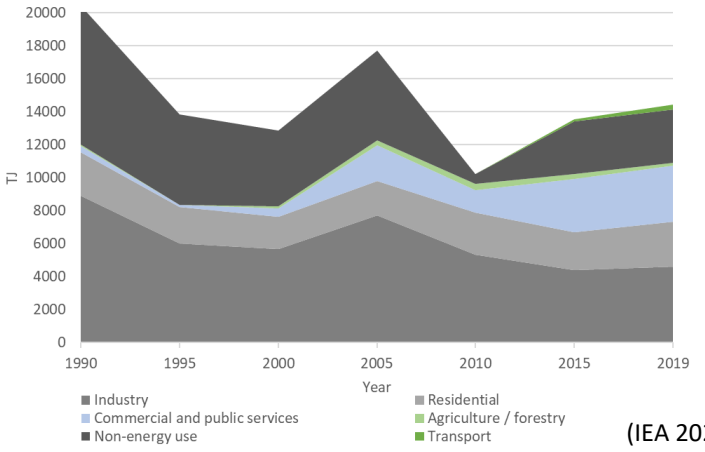
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

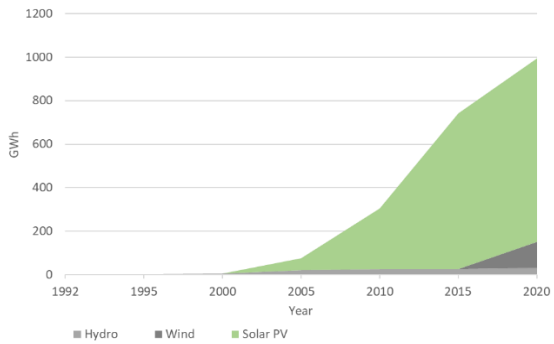


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021)

RE ELECTRICITY GENERATION



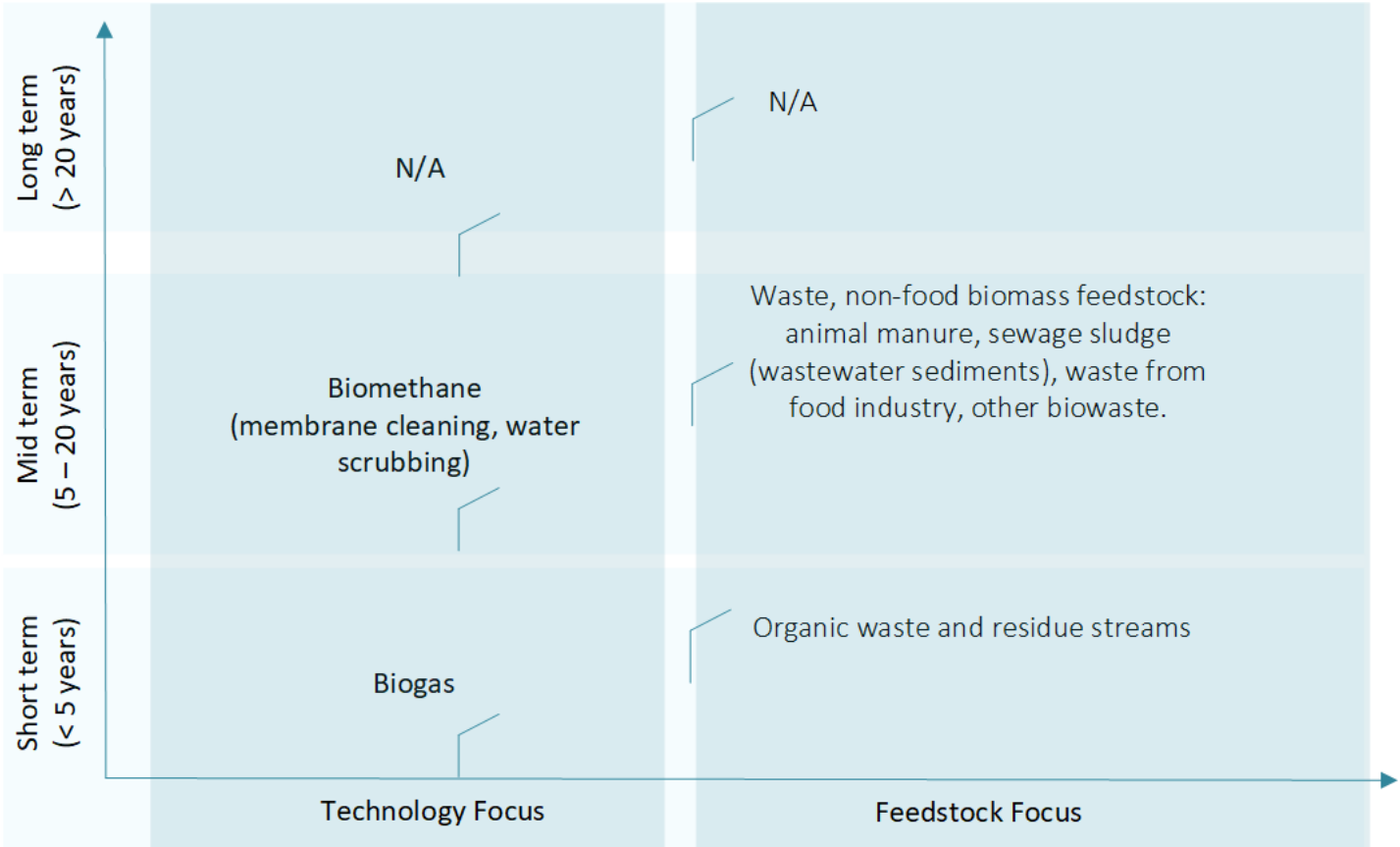
(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

Estonia started to develop its biogas and biomethane sector 10 years ago. The Government of Estonia adopted the Estonian Long-Term Energy Strategy till 2030 in 2018, where biomethane plays an important role in achieving the national target of usage of 10% renewable fuels in transport by 2020. Currently, a regulation is under preparation, which will support the biomethane use is public buses, investment support for building CNG stations with obligation to sell biomethane and feed-in-premium for biomethane producers. Biomethane is also tax-exempted and in long term biomethane certificates are tradeable with biofuel 10% blending obligation of liquid fuels.

Estonia has introduced a support scheme for biomethane producers, following the conditions and rules for using aid granted as support for the development of the biomethane market. The aim of the support scheme is to increase the local production of biomethane and enhance the consumption of locally produced biomethane in the transport sector in order to fulfill the national transport sector targets.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS

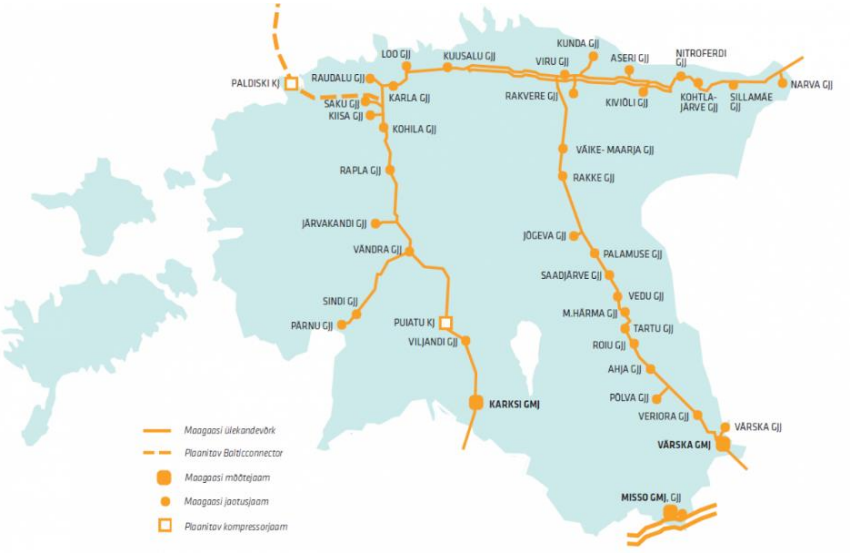
- Since 2018 two Biomethane plants in Estonia are under operation of which one is using agriculture residues and one pulp wastewater.
- All of the biomethane produced is used in the Estonian transport sector. Currently, there are 16 CNG stations in Estonia. 70% of CNG consumption in transport is biomethane.
- Additionally, Estonia has capacities for biogas production based on landfill gas and sewage sludge gas with an annual primary production of 161.6 GWh in 2019.

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas and biomethane facilities in Estonia, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process, can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.
- Considering the capacities of AD plants in Estonia as described above and in the Biogas Barometer of the Erobserver, we calculated a theoretical potential of 67.541 tonnes (34.459.833 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Estonian administration towards the production of biomethane fuels for the transport sector would support and expand the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS



(MKM EE 2021)

Potential regional hot-spots in for future RG production in Estonia are especially in close connection to and along the gas pipelines in the country.

The biogas potential for Estonia is estimated to 633 million Nm^3, of which 21 million Nm^3 would be from landfills. This includes a potential production of 450 million Nm^3 biomethane.

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IEA International Energy Agency. Countries and Regions. https://www.iea.org/countries (Accessed December 6, 2021).

ISI Fraunhofer-Institut für System- und Innovationsforschung. Biogas Barometer. https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2020/2020-EurObserv_ER-biogas-barometer-GB-20201215.pdf (Accessed December 6, 2021).

MKM EE Ministry of Economic Affairs and Communication. National gas grid map. https://www-mkm-ee.translate.goog/et/tegevused-eesmargid/energeetika/gaasiturg?_x_tr_sl=et&_x_tr_tl=en&_x_tr_hl=de&_x_tr_pto=nui (Accessed December 6, 2021).

INTERESTING LINKS/ LITERATURE

Regatrace doc D6.1: Mapping the state of play of renewable gases in Europe (2020); https://www.regatrace.eu/wp-content/uploads/2020/04/REGATRACE-D6.1.pdf

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This project receives funding from the European Union's Horizon 2020 Framework Programme Research and Innovation under Grant Agreement no. 857796

5.2.5 Germany

This project receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 857796

REGATRACE
Renewable Gas Trade Centre in Europe

REGATRACE COUNTRY PROFILE
NOVEMBER 2021

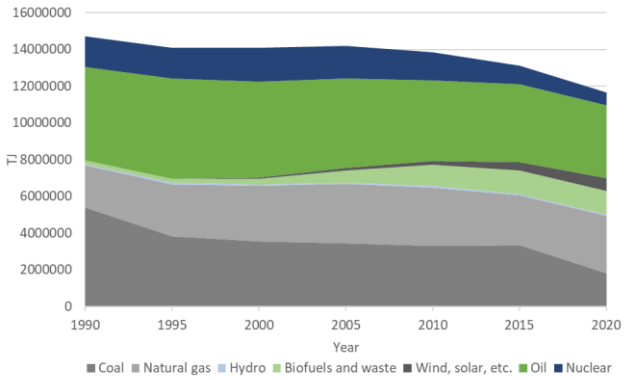
GERMANY

GENERAL KEY FACTS

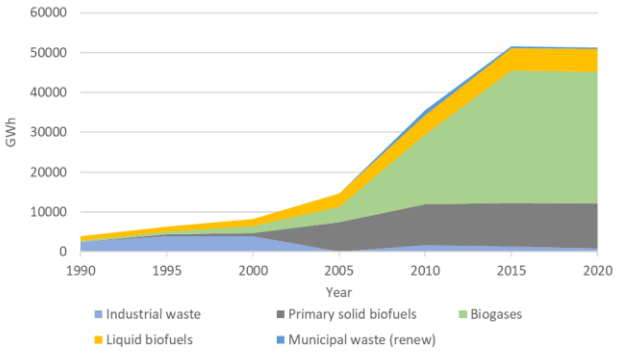
POTENTIALS OF RE IN GERMANY

SCAN ME

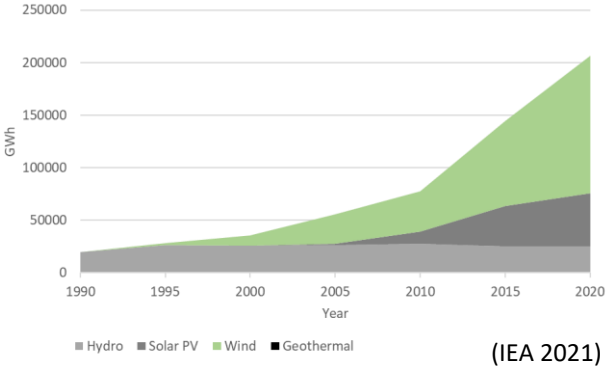
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS



RE ELECTRICITY GENERATION



(DBFZ 2021a)

(IEA 2021)

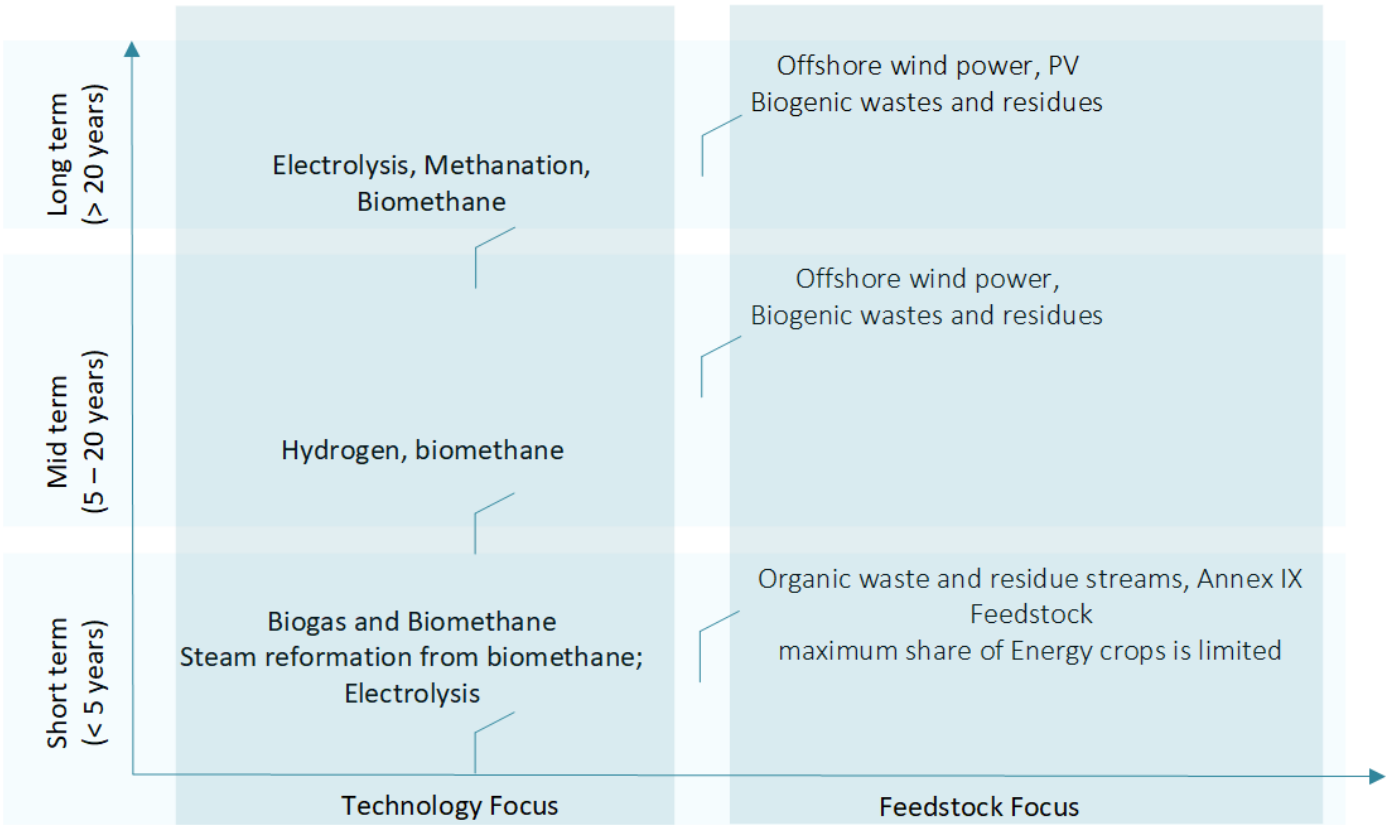
POLICY SUPPORT FOR RG TECHNOLOGIES

Over the last 30 years, Germany has developed a significant amount of biogas production capacities, mainly for the production of heat and electricity. Currently, the production of electricity from renewable sources is mainly supported through a market premium scheme. The German government aims at increasing the share of renewable electricity up to 65 percent of gross domestic electricity consumption in 2030. The share of renewable energies in electricity consumption was 45 percent in 2020. A combination of tenders for renewable electricity production capacity and feed-in premiums for renewable electricity shall facilitate this development. One tender is dedicated to the electricity production from biomethane. The yearly tender volume is 150 MW.

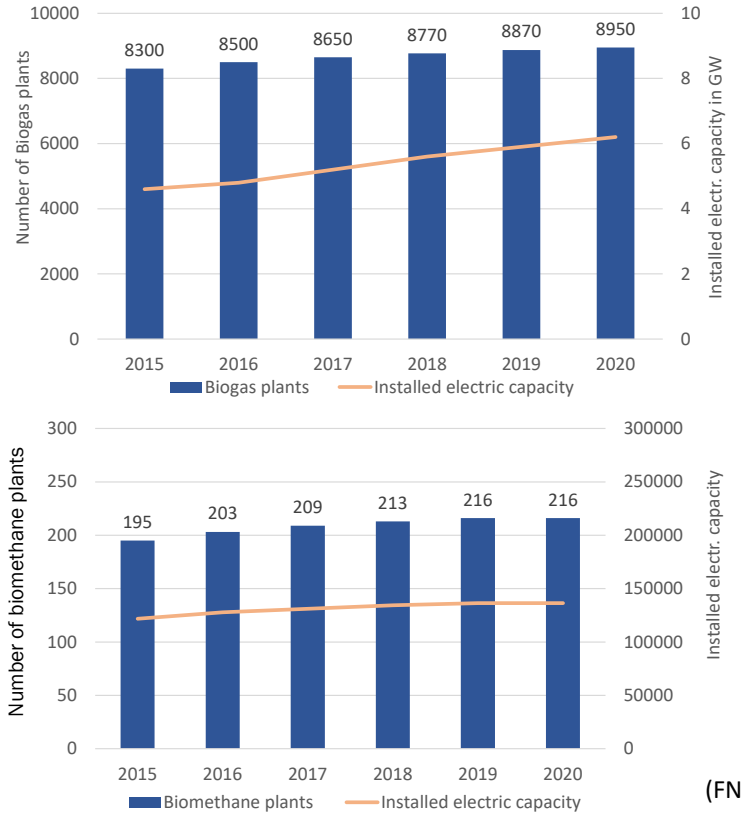
Different mechanisms shall facilitate the market uptake of renewable energy sources in the transport sector. Fuel suppliers are obliged to reduce the greenhouse gas emissions from their fuel deliveries by 25% in 2030, which can be fulfilled by the usage of biofuels and other alternative fuels. This so-called greenhouse gas quota is combined with a sub-quota for advanced biofuels. Furthermore, it includes a quota for jet fuels from renewable fuels of non-biological origin. The quota will be introduced in 2026 starting with 0.5% of the jet fuel consumption and increasing up to 2% in 2030. A new element in the GHG quota is hydrogen from biogenic sources, which can be counted towards the overall GHG quota.

Following the national German hydrogen strategy, which was published in June 2020, the national demand for hydrogen is expected to increase from 55 TWh to an amount of 90 to 110 TWh in 2030. Part of this demand will be met by domestic production of renewable hydrogen. In order to achieve this target, up to 5GW [the new, yet to be published federal government agreement foresees to increase this target to 10 GW, to be achieved through offshore wind and international cooperation], production capacity for renewable hydrogen shall be developed by 2030 and an additional 5GW by 2033/40.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



- At the end of 2019, around 8,800 biogas production plants were in operation in Germany. Most of them are in operation with an on-site electricity conversion of biogas and satellite CHP-units. In addition, approx. 200 plants include upgrading units for the production of biomethane to be fed into the national gas grids.
- The installed electrical capacity in Germany in 2019 was approx. 6 GW

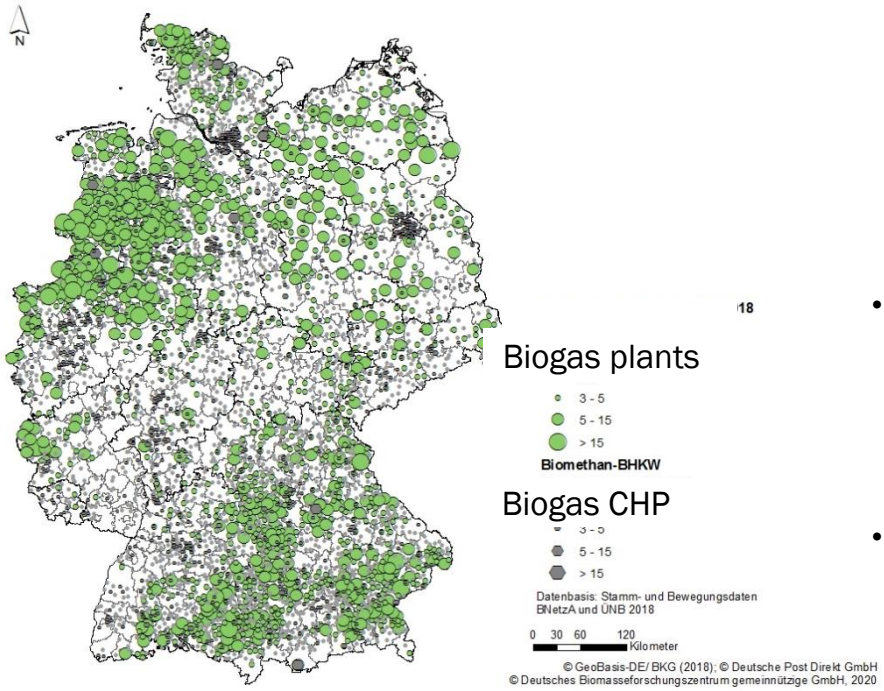
(FNR 2021, Appunn 2020)

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of AD facilities in Germany, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane.
- Based on the described capacities in the Biogas Barometer, we calculated a theoretical potential of 15.191.521 tonnes (7.750.775.818 m^3) of biogenic CO_2 from existing biogas production.
- The current plans of the German administration towards a shift for more biogas upgrading units would support the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS



(DBFZ 2021b)

- Future regional hot-spots for the production of renewable gases of non-biological origin will depend on capacities for eligible carbon sources and/or renewable electricity (in case of hydrogen, CO_2 is not needed).
- For AD plants, Lower Saxony and Southern Germany are potential hot spots regarding the anaerobic digestion from manure.
- Growing capacities of wind power installations in the coastal area of Germany can be the basis of future hot spots for hydrogen production

EXISTING CHALLENGES FOR RG PROD.

- Availability of sufficient production infrastructure for meeting the national demand, especially of hydrogen and biomethane (as a substitute for natural gas) for industrial processes.
- Production costs are still high compared to their fossil counterparts. This prevents end users from changing their supply if there is no economic incentive or benefit.
- Certification and verification of the origin and sustainability of the renewable gases. This is a key element to be addressed to guarantee consumer trust and marketability of the renewable gases. Since the legislation is still pending, no certification schemes can apply to be officially recognized by the EU in order to conduct hydrogen certification. Furthermore, it is also unclear how certain (leaked) criteria are to be verified and what sort of proof needs to be provided.
- The renewable electricity criteria for the production of RFNBOs are quite complex. Producers would face high transaction costs by searching for electricity suppliers whose renewable electricity comply with the EU criteria on renewability, temporal correlation, geographical correlation, additionality and system serviceability. Thus trading platforms are needed for Art 27. RD II compliant electricity.

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5.2.6 Ireland

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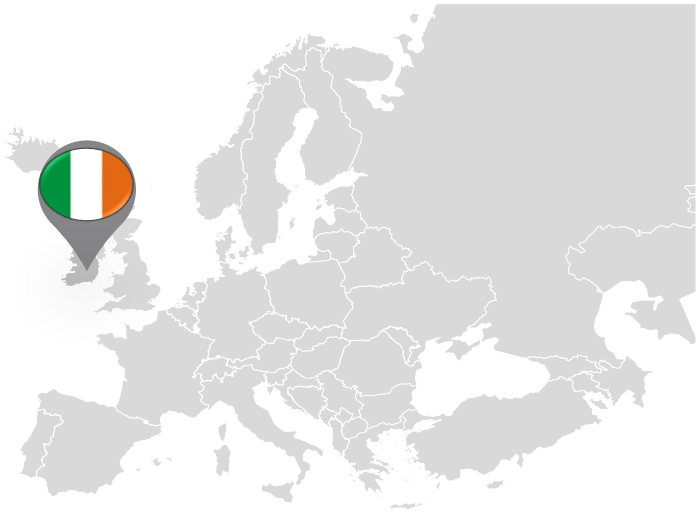
REGATRACE
Renewable Gas Trade Centre in Europe

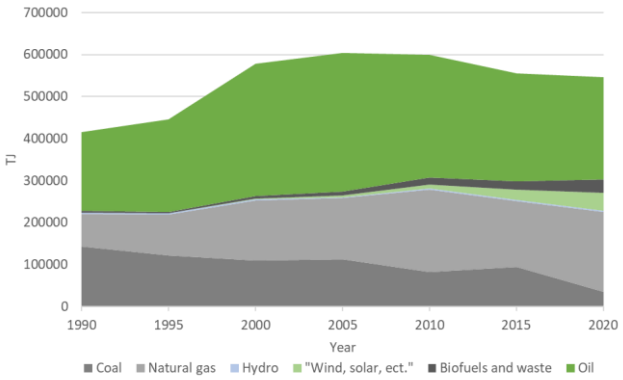
REGATRACE COUNTRY PROFILE
NOVEMBER 2021

IRELAND

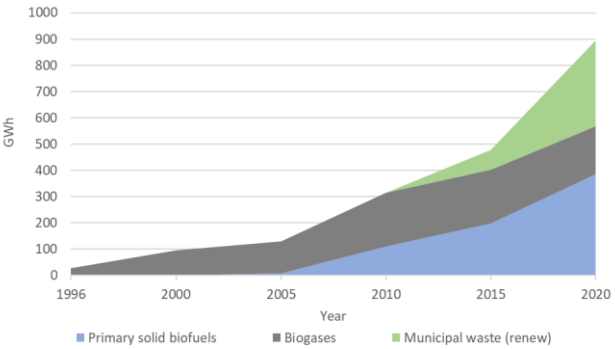
GENERAL KEY FACTS



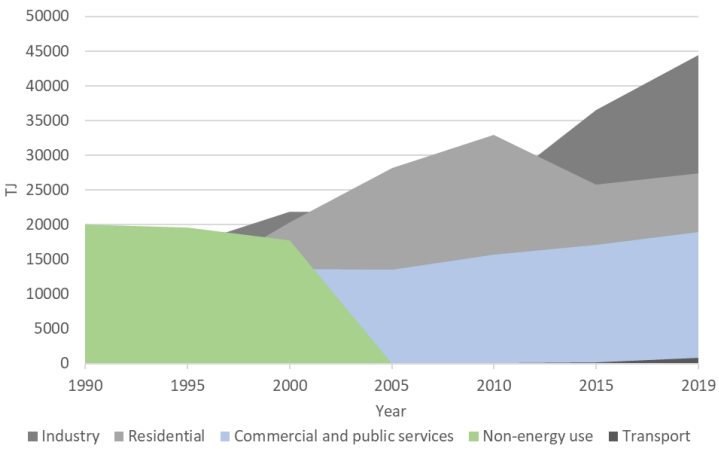
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

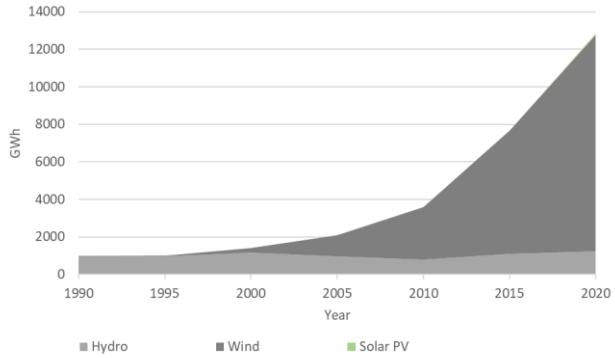


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021)

RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

The **Climate Action and Low Carbon Development (Amendment) Bill 2021** is focused on reducing economy-wide GHG emissions by 51% by 2030 and reaching economy-wide carbon neutrality by 2050. A new **National Energy and Climate Plan 2021-2030** (NECP) was published 2021 with the following targets:

- Complete the phase-out of coal and peat-fired electricity generation
- Increase renewable electricity – wind and solar up to 80% by 2030
- Produce 1.6 TWh of indigenous, sustainably produced biomethane per year
- Increase the use of biofuels in transport; roll out up to 2.7 TWh of district heating

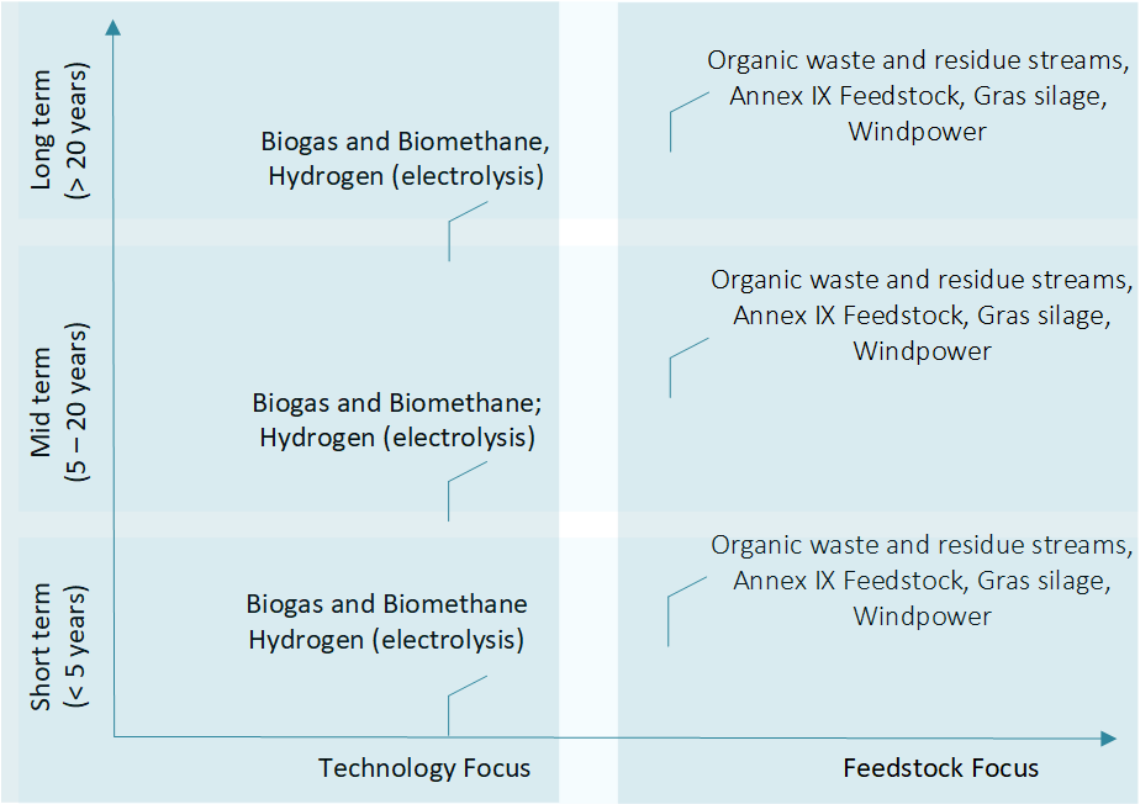
The Renewable Energy Ireland (REI) **Renewable Heat Plan 40by30**, a roadmap to an Ireland where 40% of our heat can come from renewables by 2030, has been published 6th May 2021.

The Irish Government introduced the **Biofuels Obligation Scheme** in 2010 to ensure that a proportion of the transport fuel used in the State consists of environmentally sustainable biofuels. The excise rate for natural gas and biogas used in transport has been set at the EU minimum rate of EUR 2.60 per gigajoule since 2015 (until the end of 2022) to make natural gas and CNG more competitive in relation to diesel, the dominant transport fuel in the freight sector. Also a Green Public Transport Fund since 2017 supports the uptake of low-carbon, energy-efficient technologies within the public transport sector.

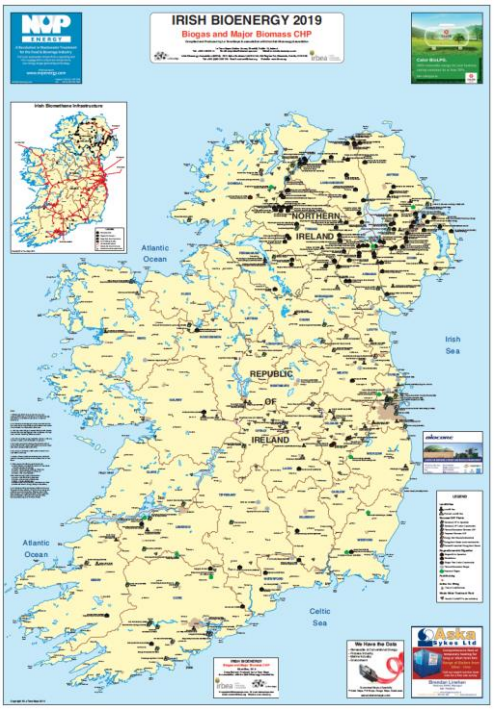
Ireland will develop its hydrogen technology, green hydrogen in particular will be used at its maximum potential, as a fuel for power generation, in manufacturing, energy storage and transport.

Ireland is one of a few countries globally where all fossil fuels are subject to a carbon tax. The tax applies to all non-ETS fuel combustion except for certain small exemptions (e.g., high-efficiency co-generation of heat and power).

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



(Gov.Ie 2021)

Many of the existing biogas plants in the Republic of Ireland are privately owned. Statistics from IEA Bioenergy count approximately 59 plants and 22 plants under construction, as of 2018. The main use of biogas produced in wastewater treatment plants (WWTP) (15) is the production of heat and electricity in onsite CHP units and to thermally dry dewatered digestate to produce a high-quality biofertiliser. In addition, there are 3 biowaste plants, 12 agricultural, 4 industrial, 22 landfill and 3 biomethane plants with an installed capacity of more than 86 MW (excluding WWTP).

The development of a sector focused on the use of food waste and animal manure can increase biomethane and biogas production to a scale of approximately 12 PJ by 2050. Maximising the use of grass silage delivers a net benefit under favourable conditions. The equivalent of 28% (~34 PJ) of Ireland's current gas demand could come from biogas and biomethane by 2050.

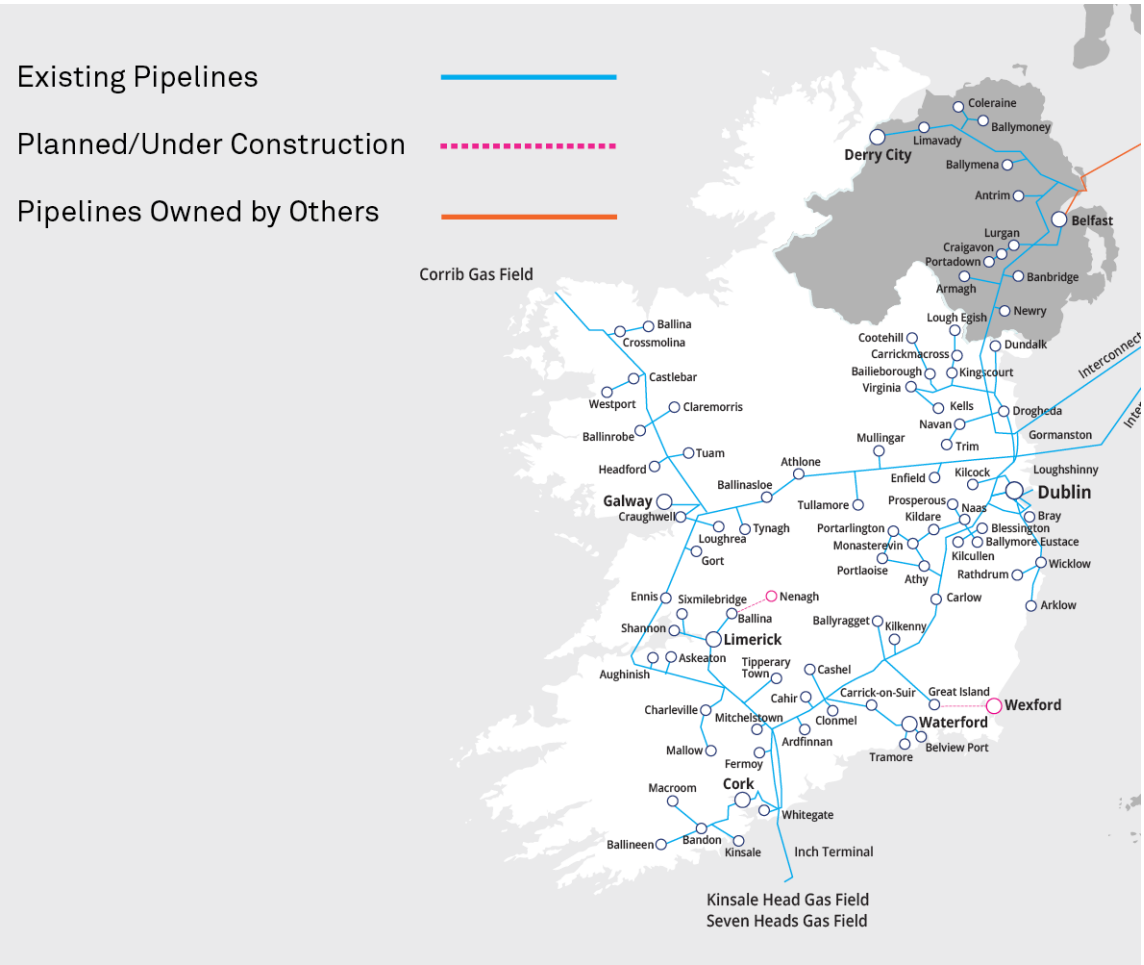
CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Ireland, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process, can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.

- Considering the capacities of AD plants in Ireland, as described in the Biogas Barometer of the Erobserver, we calculated a theoretical potential of 108.285 tonnes (55.247.273 m^3) of biogenic CO_2 from existing AD plants.

(ISI 2021)

REGIONAL HOT-SPOTS



(Ireland2050 2021)

Ireland has the highest potential for Renewable Gas production per capita in Europe with a potential of 13 TWh achievable by 2030, an EU Commissioned report has found. A forecast shows that up to 9.8 TWh per annum of renewable gas can be delivered from the agriculture sector in Ireland by 2030. Potential Hot-Spot regions for RE production are the coastal areas (off-shore wind) as well as biogas and biomethane hot-spots as indicated in the map.

Central Grid Injection (CGI) facilities are designed to operate as gas Entry Points on the network where Gas Shippers can register capacity and transact gas into the system for delivery to their gas customers in the heat, power and transport sectors.

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5.2.7 Italy

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REGATRACE
Renewable Gas Trade Centre in Europe

REGATRACE COUNTRY PROFILE
NOVEMBER 2021

ITALY

GENERAL KEY FACTS

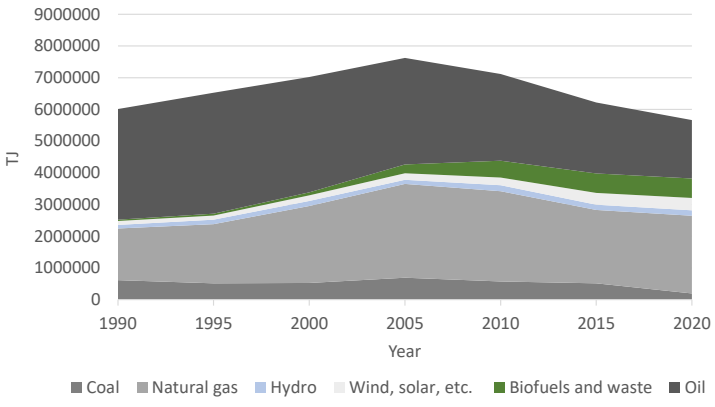
POTENTIALS OF RE IN ITALY

RES target for the electricity sector (TWh)

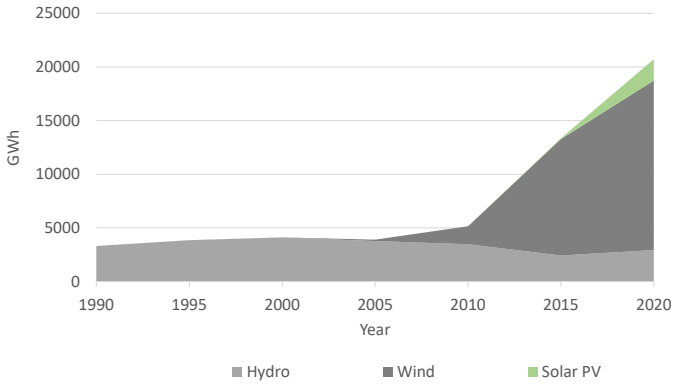
	2012	2013	2014	2015	2016	2017
Numerator – Gross electricity production from RES	**93.3**	**103.3**	**107.6**	**109.7**	**110.5**	**113.1**
Hydro (normalised)	44.1	45.0	45.8	45.9	46.2	46.0
Wind (normalised)	12.4	14.1	14.9	15.3	16.5	17.2
Geothermal	5.6	5.7	5.9	6.2	6.3	6.2
Bioenergies	12.3	17.0	18.7	19.4	19.4	19.3
Solar	18.9	21.6	22.3	22.9	22.1	24.4
Denominator – Gross inland electricity consumption	**340.4**	**330.0**	**321.8**	**327.9**	**325.0**	**331.8**
RES-E share (%)	**27.4%**	**31.3%**	**33.4%**	**33.5%**	**34.0%**	**34.1%**

(Ministry of Economic Development 2021a)

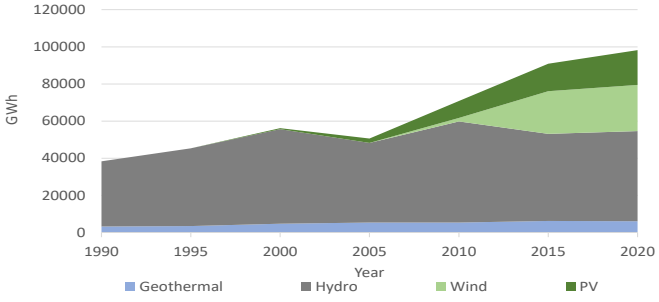
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS



RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

In Italy, the growth of RES has been supported by different mechanisms and significant revisions occurred over time, in particular in the electricity sector. Over the recent years, Italy has developed a significant amount of agricultural biogas facilities, mostly with a focus on electricity production. For the development of the electricity sector, different policy instruments have been introduced, including:

- a feed-in premium scheme, (changed to a feed-in tariff scheme/sliding FIP) for PV installations (over 20 years) and CSP (over 25 years);
- a green certificate scheme for all RES different from PV (over 15 years);
- a feed in tariff scheme for all RES different from PV with a capacity up to 1 MW (over 15 years);

Currently, for new biogas plants dedicated to electricity production, policy support is limited to agricultural plants below 300 KWel and with maximum annual production quotas (Italian Law n. 145/2018).

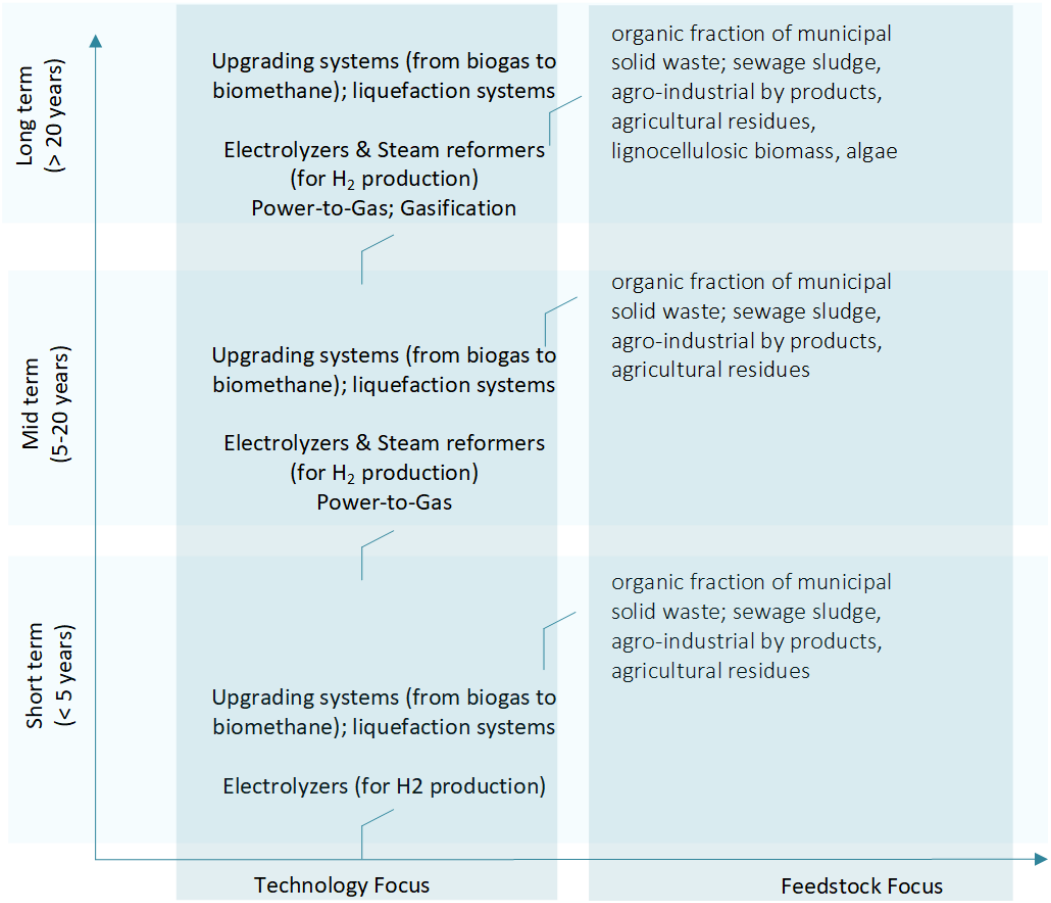
In March 2018 a decree was published introducing incentives for the production of biomethane. The decree remains in force until the end of 2022 and gives incentives only if a biofuel is produced for the transport sector. Target: 1.1 billion m^3 by the end of 2022.

Recent policy strategies aim to transform existing agricultural biogas facilities into Biomethane units also thanks to the Italian PNRR (1.91 billion euros available for conversions from biogas into biomethane.)

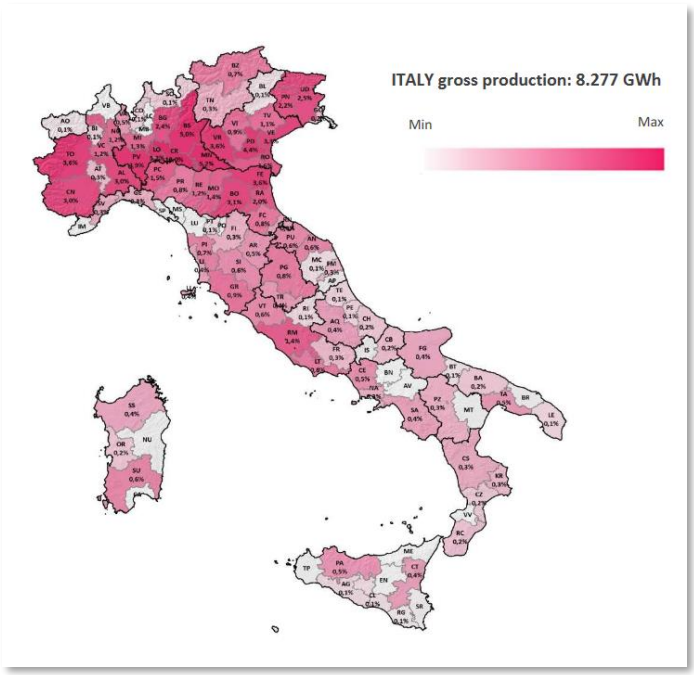
A new biomethane subsidy scheme (biomethane not only as a biofuel but also for other end uses) is expected in early 2022.

To achieve the existing targets for RE in transport, Italy has introduced a Biofuel blending obligation quota, including a target for advanced fuels. The measure specifies that the mandatory quota for advanced biofuels must be fulfilled for 75% by biomethane and for 25% by other advanced biofuels. The respective shares will be reviewed every two years.

FEEDSTOCK AND TECHNOLOGY FOCUS

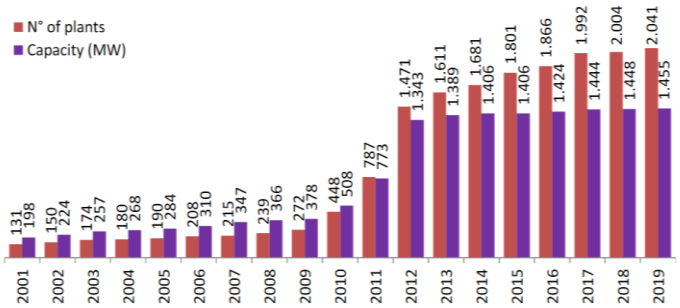


EXISTING CAPACITIES FOR AD PLANTS



(Ministry of Economic Development 2021b)

Currently, in Italy there are about ~2.000 biogas plants with a capacity of ~ 1.500 MW that produce renewable electricity. Most of the plants are concentrated in 4 regions of northern Italy (Lombardia, Veneto, Emilia Romagna, Piemonte).



(EBA 2021)

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Italy, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane.
- Based on the above described capacities, we calculated a theoretical potential of 3.454.675 tonnes (1.762.589.382 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Italian Administration to expand these existing capacities in the coming years would also significantly increase this potential of CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS

(GSE 2021)

Italy is one of the leading European countries in terms of both the number of identified biogas plants and wind turbines. However, while regional hot-spots for biogas and biomethane are in the northern regions (Northern Italy gives the major contribution, 83.4% of the national total, with the Lombardy as most important region), renewable electricity production from wind turbines is located mostly in the southern areas. Consequently, additional grid infrastructure connections might be necessary to couple CO2 sources with wind electricity for Power-to-Methane production.

EXISTING CHALLENGES FOR RG PROD.

In order to achieve the Italian goal of 1.1 billion cubic meters of biomethane destined for the transport sector, further initiatives and measures are necessary. The Italian Biogas Consortium as REGATRACE partner is promoting the introduction of the following measures, both at the national and European level:

- allow a greater use of agro-industrial by-products (e.g. pomace) for the production of advanced biomethane;
- increase the advanced biomethane quotas foreseen for the years 2021, 2022 and subsequent years;
- broaden the biomethane incentive also to maritime shipping;
- continue to encourage the purchase of heavy vehicles powered by liquefied methane and introduce a reduction in motorway tolls for heavy vehicles powered by bioGNL;
- recognise biomethane in the European strategy for sustainable mobility;
- set, at European level, objectives for the use of biomethane in transport by 2030;
- promote biomethane as green fuel in the Directive on Alternative Fuels Infrastructure (DAFI);
- encourage EU car manufacturers to develop and produce the required clean fuel gas engines that will enable the scale-up of biomethane in the transport sector and hence a faster decarbonization.

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5.2.8 Lithuania

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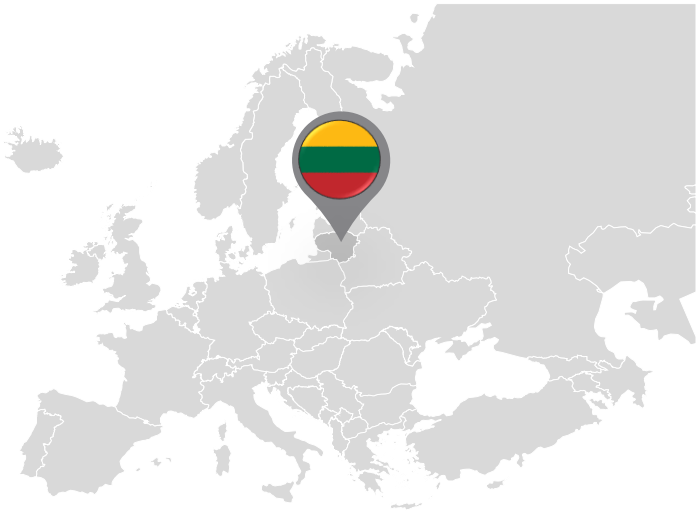
REGATRACE
Renewable Gas Trade Centre in Europe

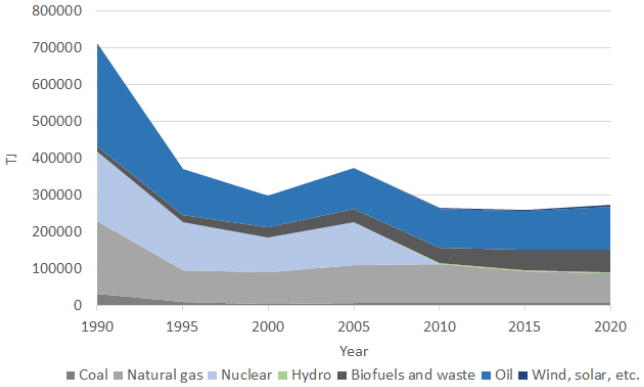
REGATRACE COUNTRY PROFILE
NOVEMBER 2021

LITHUANIA

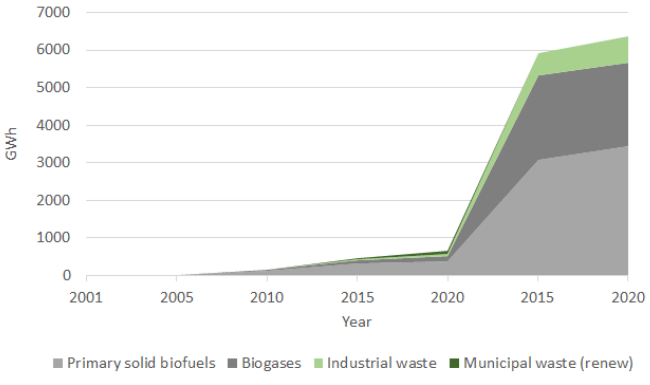
GENERAL KEY FACTS



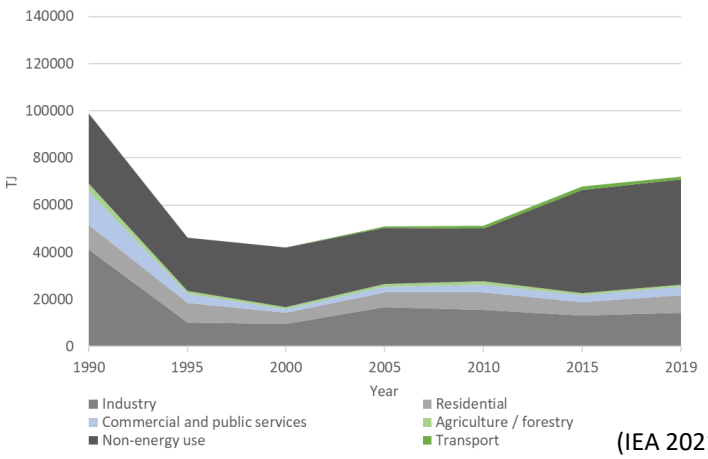
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

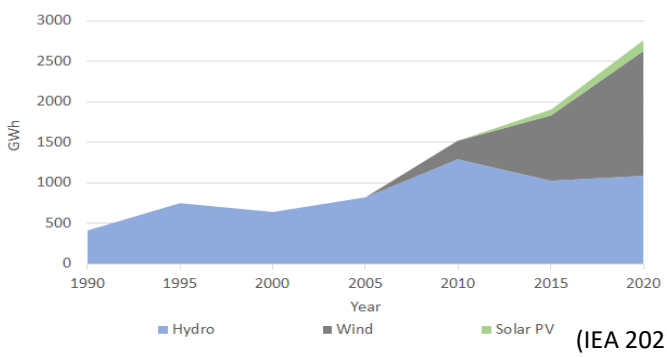


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021)

RE ELECTRICITY GENERATION



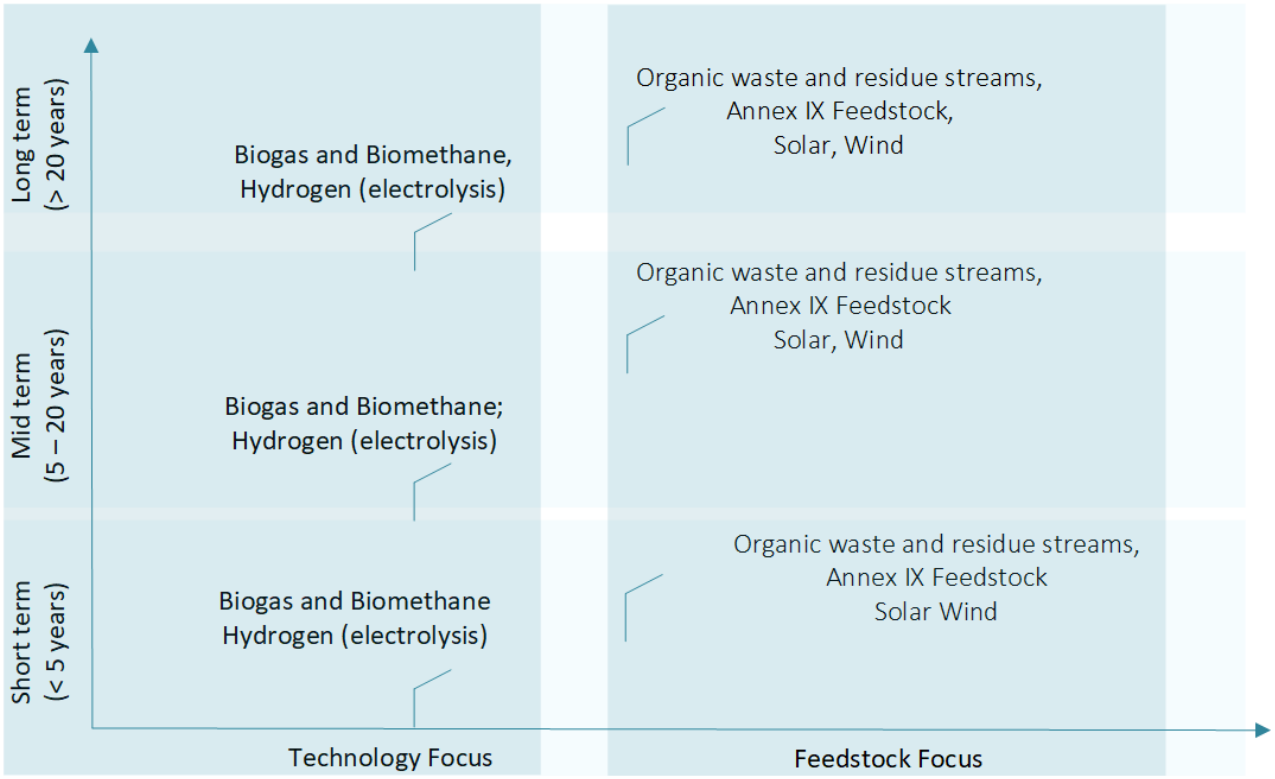
(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

Lithuania has several support schemes for the development of renewable energy carriers, that have been adjusted over time. In 2018 and 2020, parliament approved amendments to the Law of the Republic of Lithuania on Energy from Renewable Sources, moving to a sliding feed-in premium for renewable electricity (regulated by the National Energy Regulatory Council [NERC] and allocated through auctions), as well as provisions for renewable energy communities (Republic of Lithuania, 2020). The Alternative Fuels Law was adopted in March 2021. It will form the basis for new support measures for biofuels and alternative fuels, including renewable electricity, hydrogen and biomethane gases (Republic of Lithuania, 2021).

Following Lithuania's national targets, Biomethane, hydrogen and syngas should make up at least 5% of TFEC in the transport sector in 2030. Government plans to shift existing biogas production subsidies (with feed-in tariffs set by NERC) to biomethane production and create a new investment support scheme for biomethane production facilities, using feedstock from wastes and residues. Biomethane production should reach 92 million cubic metres by 2030 (Republic of Lithuania, 2019). In 2020, Lithuania introduced guarantees of origin of gas from renewable sources and a national registry. The government adapted the natural gas quality requirements to ensure their applicability to injected hydrogen gas in December 2020. A new biofuel blending scheme will be introduced under the Alternative Fuel Law which will raise the blending obligation for fuel suppliers up to 16.8% in 2030 (15% plus the sub-target for advanced biofuel components). There is no domestic second-generation biofuel production in Lithuania. Given the limit on the use of first-generation biofuels for sustainability at 7%, Lithuania needs to invest in supplies of second-generation biodiesel, such as hydrogenation-derived renewable diesel.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS

- Statistics show that Lithuania has approximately 40 operating Biogas plants with a total installed capacity of ~90 MW
- The future sees an expansion of Biogas and Biomethane production as well as a shift towards more upgrading of Biogas to Biomethane.

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Lithuania, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.
- Considering the capacities of AD plants in Lithuania as described in the Biogas Barometer of the Erobserver [2], we calculated a theoretical potential of 71.120 tonnes (36.285.600 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Lithuanian administration towards the production of advanced fuels would support the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

REGIONAL HOT-SPOTS

- Lithuania has a significant potential for offshore wind in the Baltic sea in the medium term. Thus, future hot-spots for RG production are partly expected in the coastal region to the Baltic sea.

(ISI 2021)

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5.2.9 Poland

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REGATRACE
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REGATRACE COUNTRY PROFILE
NOVEMBER 2021

POLAND

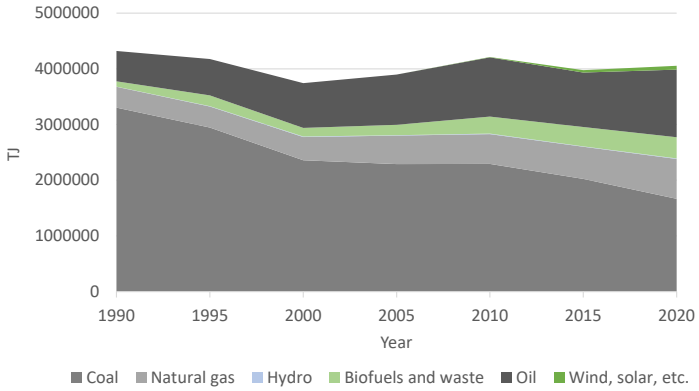
GENERAL KEY FACTS

POTENTIALS OF RE IN POLAND

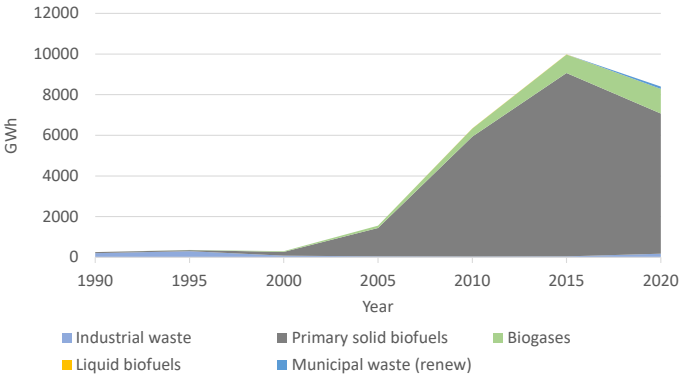
	Gross final consumption from RES	
All	376,060 TJ	
Solid biofuels		65,56 %
Wind		13,72 %
Liquid biofuels		10,36 %

(IEO 2021)

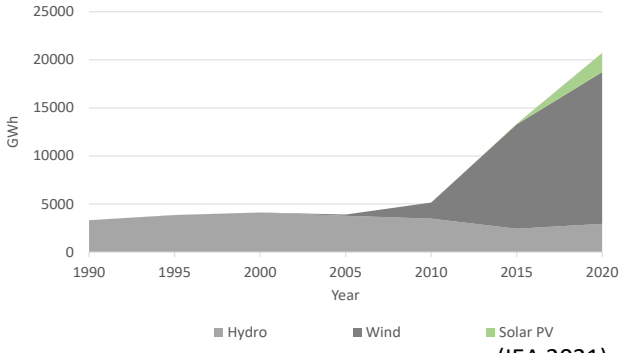
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS



RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

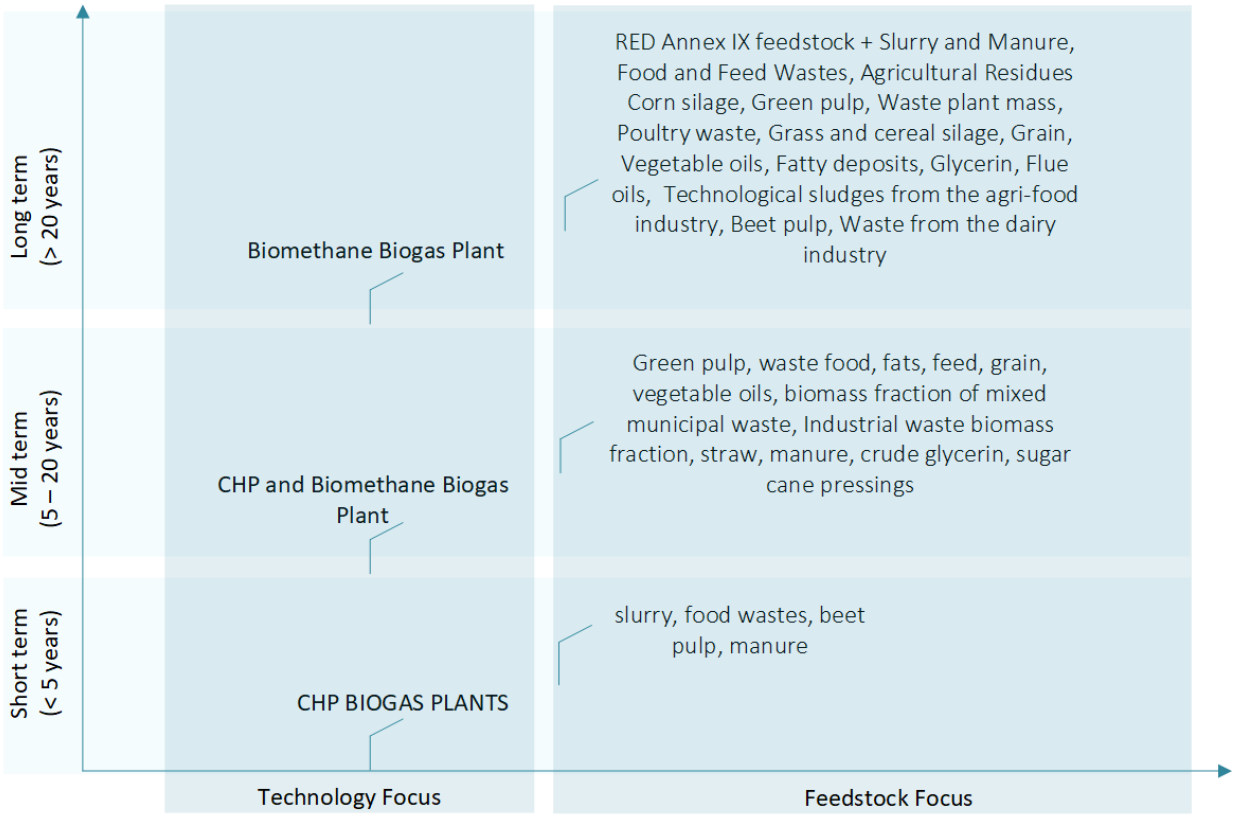
On the 2nd of February 2021, the Ministry of Climate and Environment of Poland officially announced the ratification of the Energy Policy of Poland until 2040 (PEP2040). This policy is a response to the key challenges faced by the Polish energy sector and sets the strategic directions for the energy sector. The main aspects addressed by this policy are:

- The **rapid diversification and growth of energy generation from low-carbon sources**, which shall lead to more than a 50% reduction of CO_2 emissions in the electricity sector by 2040.
- The decreased share of coal in electricity production to fall below 56% in 2030.
- The **growth of RES** share in gross final energy consumption **to at least 23%.**
- The **growth of RES to 32% in electricity production in 2030, and in 2040 – 40%.** The full realisation of offshore wind and PV potential can provide up to 30 GW of new power generation capacity in total by 2040.

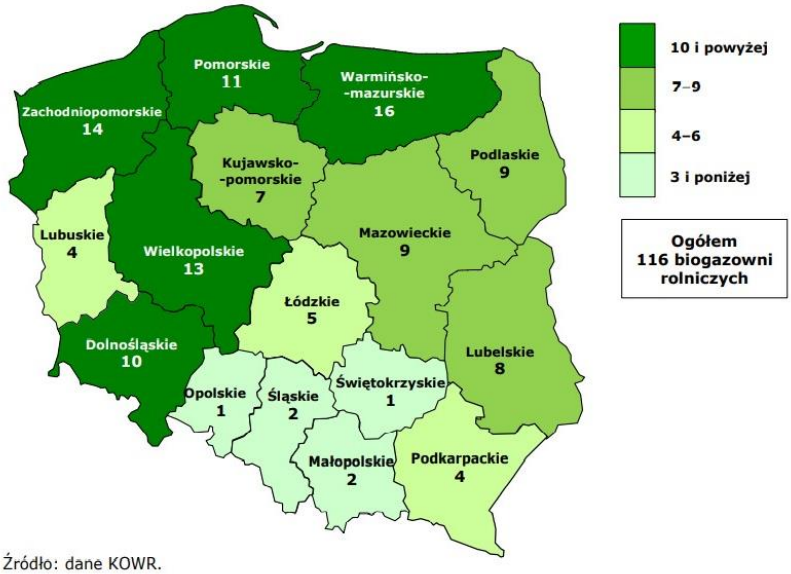
Besides, the most important policy instruments for the development of Renewable Gas technologies in Poland are:

- The **Renewable Energy Sources Act** where it is presented that 1 m^3 of biogas is processed in CHP engines into about 2.2 kWh of energy and about 8 MJ of heat.
- **Act on Bio-components and Liquid Biofuels** in which biomethane was recognized as fuel to fill the RCW.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



Źródło: dane KOWR.

- Statistics show that Poland has 301 biogas plants with a total of 231 MW of capacity. 116 of these Biogas plants are agricultural plants, the remaining plants are landfill gas and sewage gas facilities (each ~1 quarter of the total capacity).

- Poland's Renewables Act 2015 introduced a new feed-in tariff support mechanism which will include separate auctions for different technologies, including one for agricultural biogas.
- The future sees an expansion of 100-120 MW of new biogas capacity per year. This would mean adding up to 800 new biogas plants by 2025.

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Poland, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane.
- Based on the above-described capacities, we calculated a theoretical potential of 544.340 tonnes (277.724.400 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Polish Administration to expand these existing capacities in the coming years would also significantly increase this potential of CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

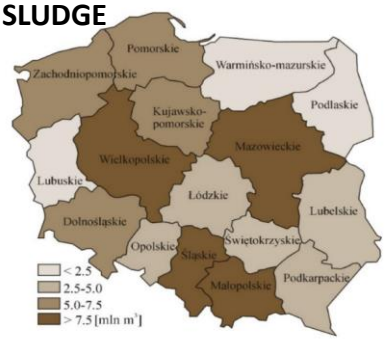
REGIONAL HOT-SPOTS

BIOMASS FROM SLURRY/MANURE

BIOMASS FROM BIODEGRADABLE WASTE

BIOMASS FROM SEWAGE SLUDGE

BIOMASS FROM SEWAGE SLUDGE



BIOMASS FROM MUNICIPAL WASTE

Based on these potentials, one interesting hotspot is the northern part of mazowieckie voivodship. 1/3 of the poultry and egg production is based in that area.

EXISTING CHALLENGES FOR RG PROD.

Considering the future development of RG production capacities in Poland, existing barriers can be structured into three main categories.

Existing technical barriers include problems with the existing Infrastructure (e.g., limited access to the network, underdeveloped market of NGVs and vehicle charging infrastructure, lack of proper waste segregation, limited access to connect to the power grid, which is a prerequisite for installation and the availability of substrates for RG production).

Secondly, the current market and legislative framework imposes a number of economic barriers such as high investment costs (especially for the upgrading of biogas to biomethane), high costs for the connection to the gas grid along with the necessary infrastructure for gas analysis and a lack of an appropriate system of guarantees of origin for biomethane in Poland.

Finally, a number of potential social barriers do already or can hinder the future development of RGF technologies. Amongst others, this includes a lack of social acceptance for biogas and biomethane plant projects. Reluctance regarding the willingness to cooperate with local authorities, companies distributing gas.

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5.2.10 Spain

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REGATRACE
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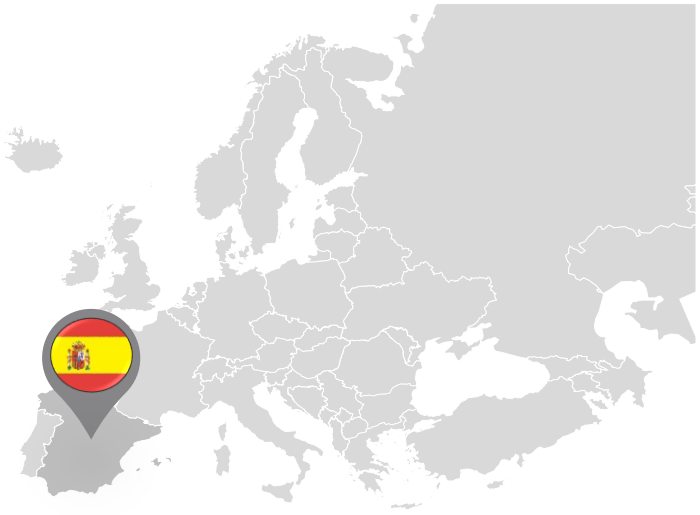
REGATRACE COUNTRY PROFILE
NOVEMBER 2021

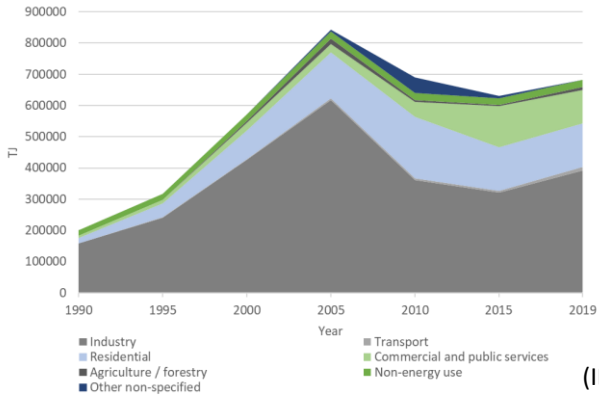
SPAIN

GENERAL KEY FACTS



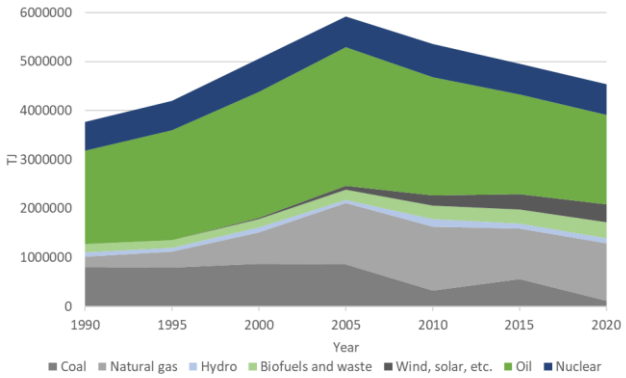
NATIONAL NATURAL GAS CONSUMPTION

The Spanish biomethane potential reaches 120 TWh and renewable electricity potential reaches 3.300 TWh.

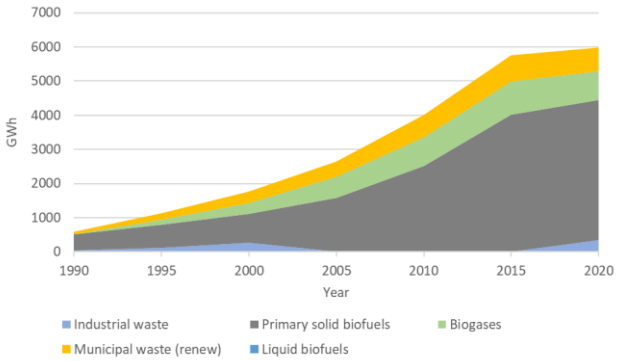


(IEA 2021)

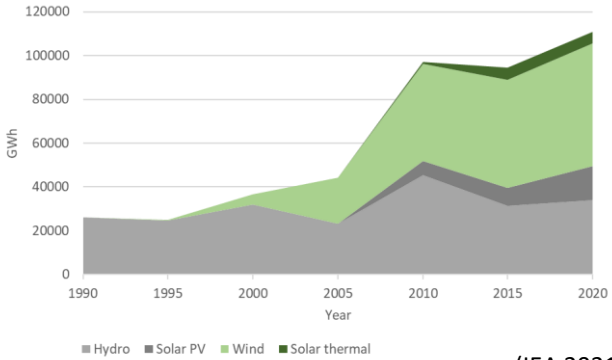
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS



RE ELECTRICITY GENERATION

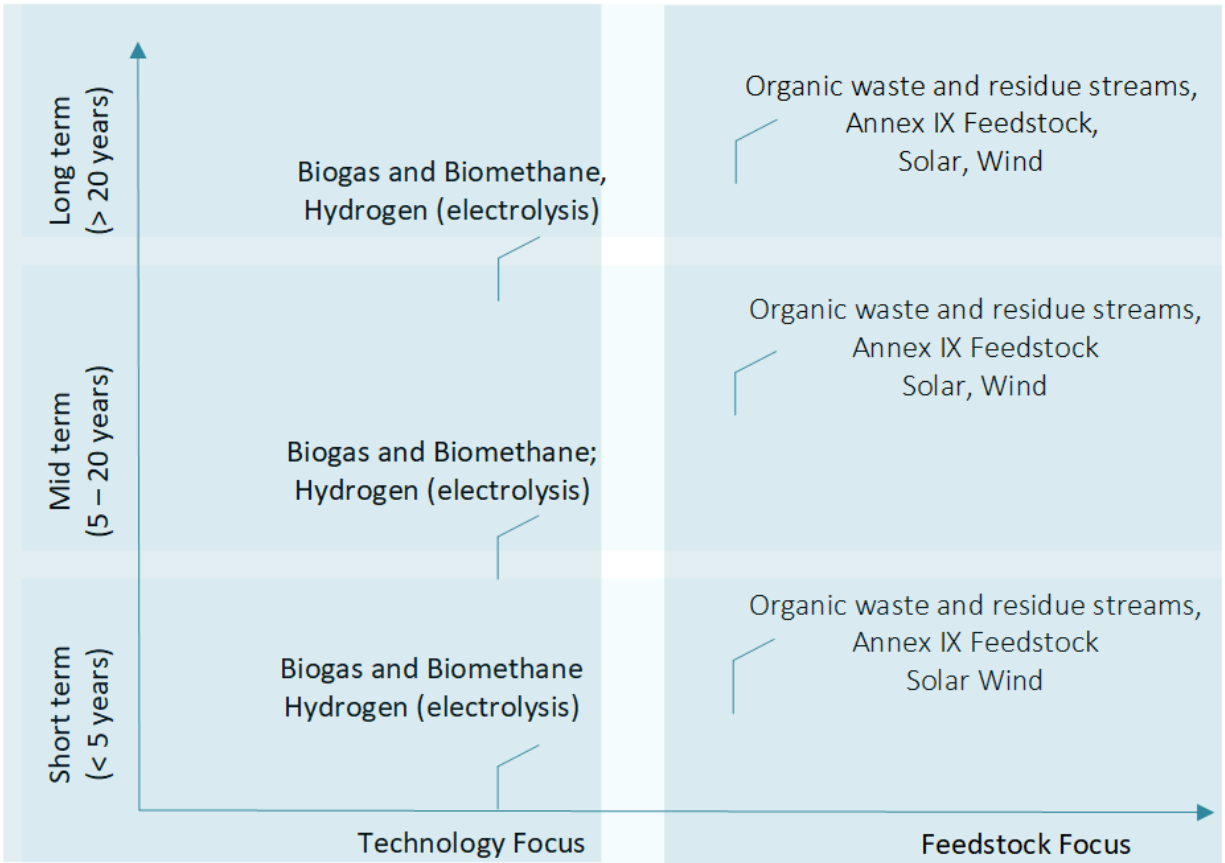


(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

- Spain has great potential and large industries in agriculture, livestock, agri-food and waste management which could support the development of a biogas and biomethane market. In July 2021 the Ministry (MITECO) has published a draft of Biogas Roadmap to increase the sustainable production of this renewable gas by 3.8 times by 2030 (increasing to over 10.4 TWh). This is in line with the National Integrated Energy and Climate Plan (PNIEC) 2021-2030, the long-term strategy for a modern, competitive and carbon neutral Spanish economy in 2050, as well as with Law 7/2021 of 20 May on Climate Change and Energy Transition. This first drafting version of the Biogas Roadmap is a necessary first step, but is not very ambitious in its goals, it needs to be developed in a more demanding and more ambitious way. The roadmap focuses on waste recovery (agricultural and municipal waste and sewage sludge) and promotes the use of biogas in two ways: the production of electricity and useful heat - especially for industry - and the conversion of biogas into biomethane for heavy-duty transport and as a substitute for fossil natural gas. It foresees five lines of action with 43 specific measures, most notably: the creation of a system of guarantees of origin, similar to that for electricity from renewable sources, so that consumers can distinguish biogas from conventional fossil gas and its sustainable origin is highlighted; and the possible setting of penetration targets, similar to those already in place for the promotion of biofuels.
- The newly drafted Royal Decree on a system of guarantees of origin for renewable gases from October 2021 also sets targets and calculation standards for the integration of renewable energies in transmission. In this area, the limit for the penetration of biofuels from food and feed crops from 2023 stands out, set at 7% of final energy consumption in rail and road transport. It also introduces contributions from advanced biofuels and biogas in transport, which will be at least 0.2% in 2022, 1% in 2025 and 3.5% in 2030. This first drafting version of the Royal Decree Project for the partial transposition of RED II can be a first document for this Legal and Regulatory framework development, in the same way the Biogas Roadmap is a necessary first step. The final Royal Decree will approve the urgent development and operationalization of Guarantees of Origin for renewable gas.
- There is also a Biofuel quota (support mechanism for the use of biofuels and other renewable fuels in transport) to regulate the sale and consumption of biomass-based fuels. This also includes biohydrogen.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS

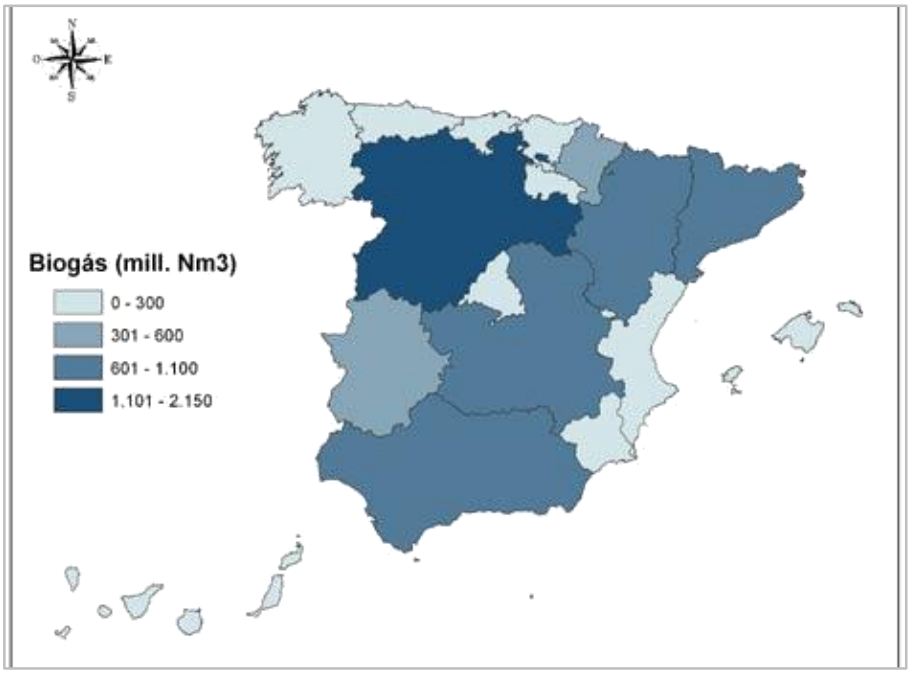
- In Spain, there are currently 210 active biogas plants in Spain. Spain's total biogas production in 2020 amounted to 8,079 GWh. Of the plants in operation, 38% are linked to wastewater treatment plants, 24% to agricultural sector, 21% to landfills and the rest to other sectors.
- The coming years will be important for the development of the Spanish biomethane sector; there is a growing trend towards biomethane in Spain as a result of the construction of new plants.
- At the end of 2020, there were 2 active biomethane plants in Spain. And by the end of the year, 5 plants in total are expected to be operational.

CURRENT CO_2 POTENTIALS FROM AD

- Based on the existing capacities of biogas facilities in Spain, a theoretical potential of biogenic CO_2 can be calculated. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.
- Considering the capacities of AD plants in Spain as described in the Biogas Barometer of the Erobserver, we calculated a theoretical potential of 487.793 tonnes (248.874.029 m^3) of biogenic CO_2 from existing AD plants.
- The current plans of the Spanish administration towards the production of advanced fuels would support the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS



(PSE 2021)

- The Spanish biomethane potential reaches 120 TWh.
- Almost the 50% of current domestic and commercial and industrial natural gas consumption in Spain.
- The coming years will be important for the development of the Spanish biomethane sector.

EXISTING CHALLENGES FOR RG PROD.

Existing challenges for the future development of renewable gas capacities in Spain include three main aspects. Firstly, stable regulatory framework and long term foresight are needed in order to attract investments and foster both the supply and demand side. One way to achieve this would be the introduction of mandatory and increasing annual biomethane consumption targets backed by Guarantees of Origin. Economic and financial mechanisms formulated in a specific and dedicated programme to support and promote renewable gas production projects could help to develop the market. This could include Feed-in-Tariffs and Premiums, tax incentives, direct subsidies, investment leverage through soft credits, tax exemptions. In the framework of recovery, transformation and resilience mechanisms, biogas could be given greater importance.

Secondly, technical challenges including feasible management concepts for digestates are needed in order to develop sustainable concepts with closed loops between energy production and agriculture. For greater legal certainty, the legal end-of-waste status of digestate should be clarified in the existing legislation and roadmaps.

Thirdly, administrative challenges, concerning mostly the streamlining and reduction of response times by the Administration in the processing of authorizations and permits.

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ISI Fraunhofer-Institut für System- und Innovationsforschung. Biogas Barometer. https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2020/2020-EurObserv_ER-biogas-barometer-GB-20201215.pdf (Accessed December 6, 2021).

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5.2.11 Switzerland

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REGATRACE
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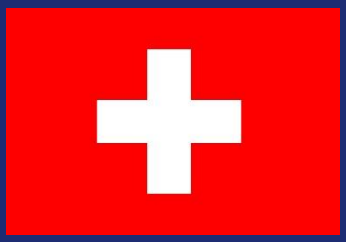
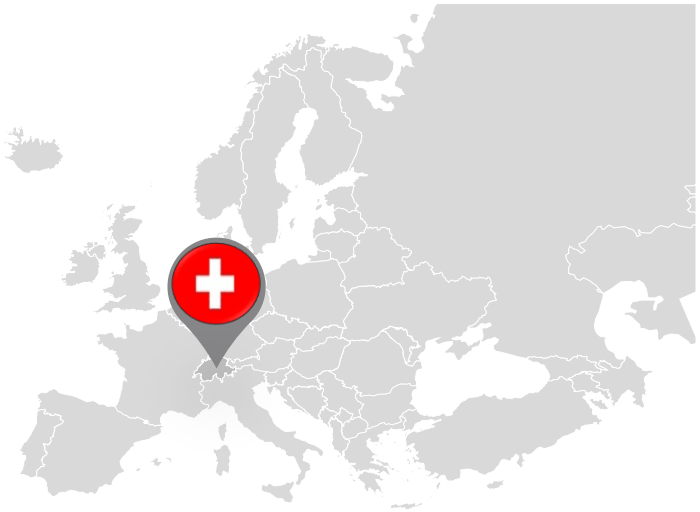
REGATRACE COUNTRY PROFILE
NOVEMBER 2021

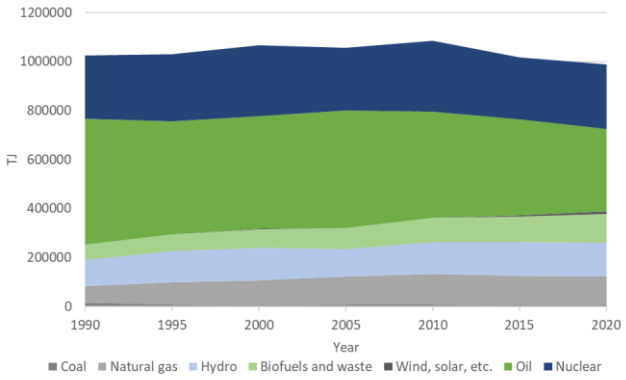
SWITZERLAND



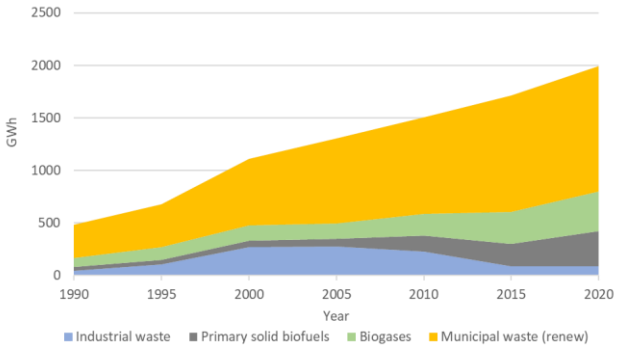
GENERAL KEY FACTS



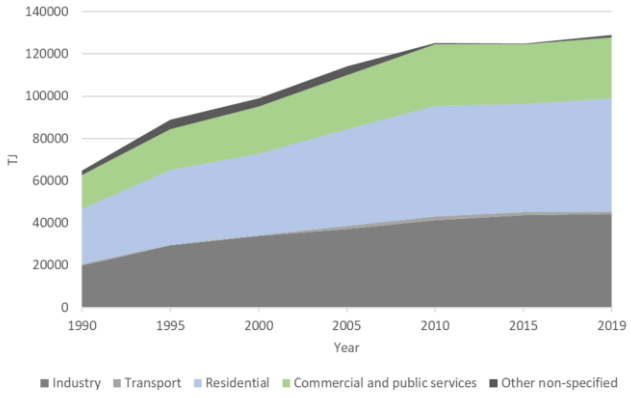
CURRENT ENERGY SUPPLY



ELECTRICITY FROM BIOFUELS

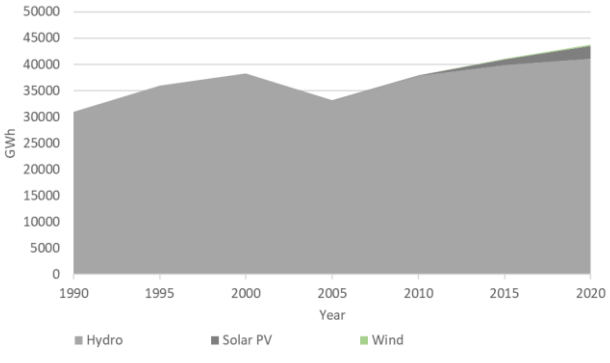


NATIONAL NATURAL GAS CONSUMPTION



(IEA 2021)

RE ELECTRICITY GENERATION



(IEA 2021)

POLICY SUPPORT FOR RG TECHNOLOGIES

Switzerland is supporting the production of biogas and biomethane, with a strong focus on the sustainability of the used feedstock. With the Federal Electricity Act and the Federal Electricity Supply Act, a federal subsidy scheme is applicable for biogas used to produce electricity. The tariff varies according to the used renewable energy source. Current legislation does not give specific targets for the development of biomethane, but Swiss gas distributors, have set a target for a share of 30 % of biomethane for gas consumed in the heating market (excluding industry) by 2030. The Swiss association of the Gas Industry has set up a fund to support new or adapted biomethane plants. The support scheme includes three elements:

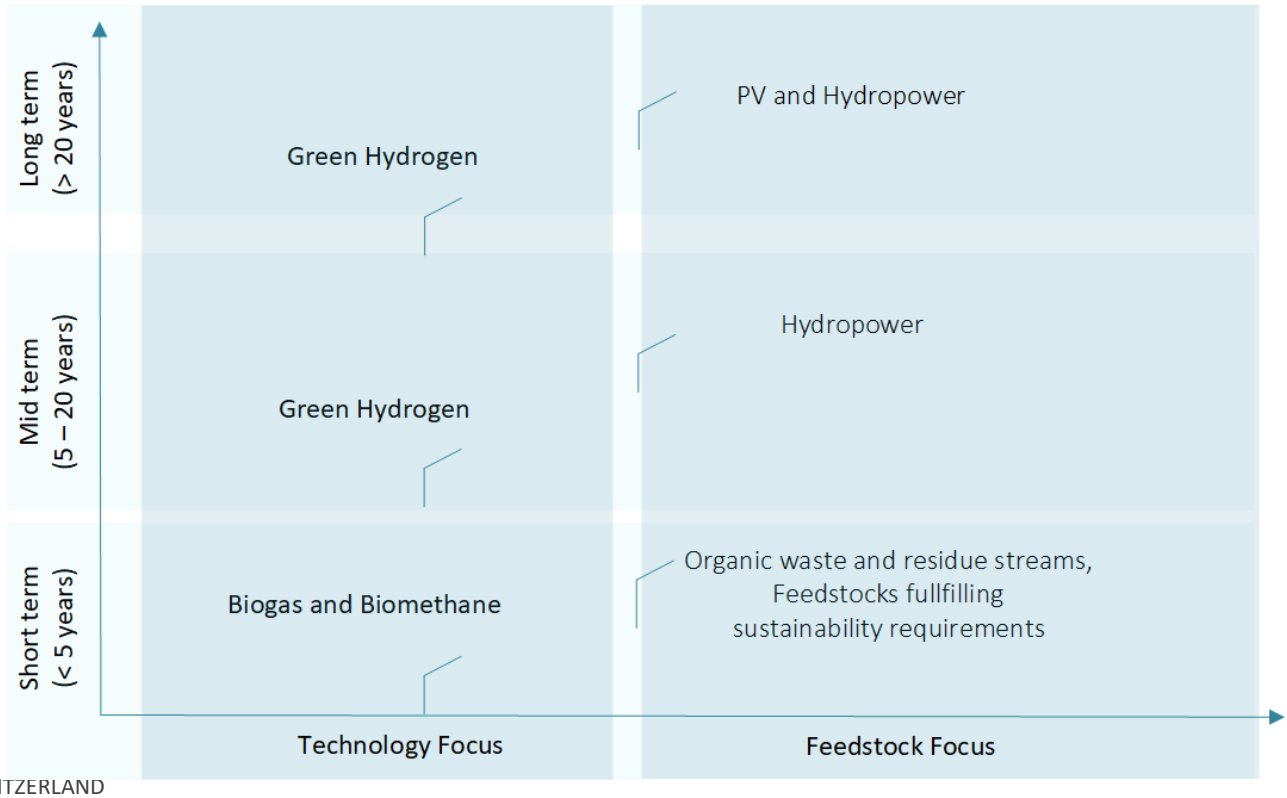
- An investment grant per Nm^3/h
- An injection support for the first 36 months per kWh
- A grid operator support for the first 36 months per kWh.

Additionally, there is an exemption from the following taxes for biomethane:

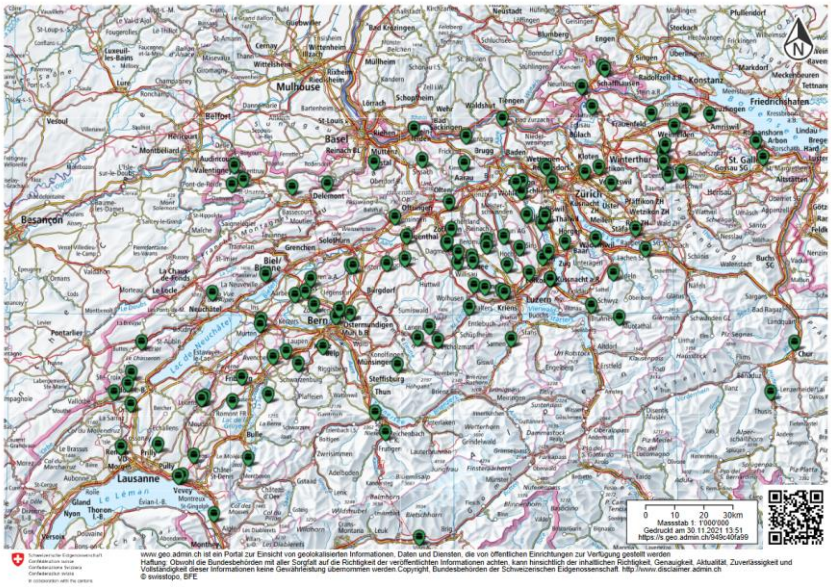
- CO_2-levy on fossil fuels (currently at CHF 96/tonne of CO_2, equaling CHF 0.017/kWh)
- Mineral-oil-tax: If used as motor fuel, biomethane receives an exempt which provides a benefit compared to CNG. Further examination of the tax regime is ongoing in the context of the future legislation regulating greenhouse gas emissions ("CO_2-Gesetz"), (120/tonne of CO2, as of 1.1.2022, equaling CHF 0.022/kWh)
- Currently, no grid use fee is due for the injection of biomethane. The specifics of grid connections for biomethane plants are subject to negotiation.

Additionally, the National Council adopted in June 2021 initiatives of the Swiss parliament to prepare a Green hydrogen strategy for Switzerland, and an assessment and options for action.

FEEDSTOCK AND TECHNOLOGY FOCUS



EXISTING CAPACITIES FOR AD PLANTS



(BFE 2021)

Statistics show that in 2018 Switzerland had 634 biogas plants with a total annual biogas production of approx. 1,450 GWh in 2018. With 473 plants, waste-water treatment plants are the biggest contributors followed by 111 agricultural plants, 38 bio-waste plants and 20 industrial, landfill gas only 2.

By 2020 37 plants upgraded biogas to biomethane for grid injection (total production in 2020: around 400 GWh).

There are currently around 150 filling stations for 14,00 gas vehicles, most of which offer a standard blend of bio-CNG and natural gas, which can be upgraded to up to 100% at some stations.

CURRENT CO_2 POTENTIALS FROM AD

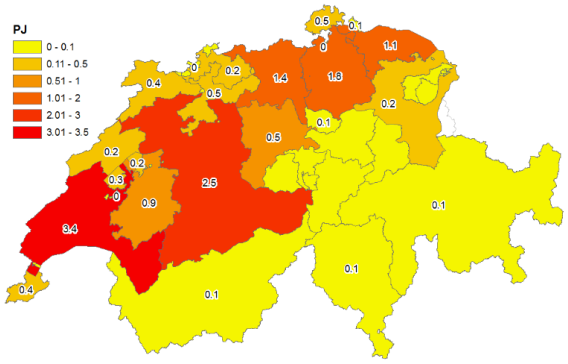
- Based on the existing capacities of biogas facilities in Switzerland, a theoretical potential of biogenic, green CO_2 can be calculated [3]. This CO_2, which is a component of the Biogas product from the AD process can be extracted in case the Biogas is upgraded to Biomethane. The CO_2 can be used as a feedstock for the production of synthetic methane.

- Considering the capacities of AD plants in Switzerland as described above, we calculated a theoretical potential of 25,301.76 tonnes (12,800,000 m^3) of biogenic CO_2 from existing AD plants.

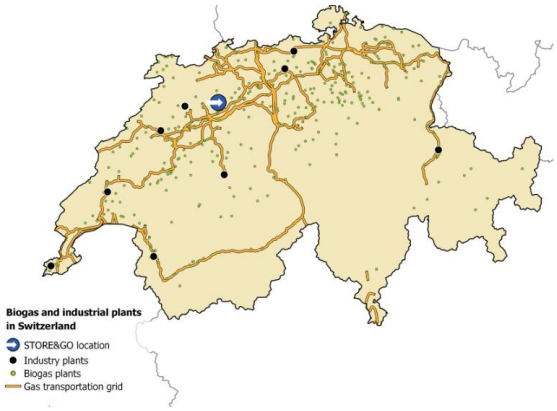
- The current plans of the Swizz industry towards the production of more biogas and biomethane until 2030 would support and expand the availabilities of these potentials of biogenic CO_2 which could be used for the production of renewable gases such as Power-to-Gas.

(ISI 2021)

REGIONAL HOT-SPOTS



Theoretical potential (in PJ) of agricultural residues



Biogas, industrial plants, gas transportation grid in Switzerland

- Existing potentials for biogas and biomethane feedstock as well as the main gas pipelines as feed-in points are important preconditions for the identification of potential future hot-spots for renewable gas production.
- The main hot-spots for both elements are located mostly in the northern and western part of Switzerland.
- This region shows favourable preconditions and potentials for a potential coupling of technologies for the production of synthetic methane.

(Thees et al. 2017)

EXISTING CHALLENGES FOR RG PROD.

- The current legal framework consists of many inconsistencies and uncertainties, as renewable gas is subsidized on the national level only when it is used for direct electricty production.
- A new CO_2-law as well as legislation on the market framework for both electricity and gas are in various stages of the political process, it is currently still unclear, whether conditions for injection of renewable gas into the grid, as well as incentives for their use (in the sectors of industry, transportation as well as households) will become more attractive.
- Gas infrastructure is faced with tough political challenges on the distribution level and it remains to be seen what part it may play in the future energy system on the local level. However, dilligent local planning, as well as favoured treatment for renewable gases may play an important part both for security of supply and a climate neutral energy system.

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INTERESTING LINKS/ LITERATURE

https://www.sccer-biosweet.ch/wp-content/uploads/Biomass-Potentials.pdf

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7 Annex I – Questionnaire template

REGATRACE Survey for consortium members.

Internal Questionnaire

WP5

T5.2

23/09/2021

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7.1 Introduction

REGATRACE WP5 aims to assess different technologies to produce renewable gases in the EU and more specifically in the REGATRACE countries.

We are kindly asking for your support by answering this questionnaire which will hopefully allow us to add a more regionalised approach and perspective to the previous assessment task in WP5.

Thank you for your support!

In case there are any questions regarding the questionnaire please contact stefan.majer@dbfz.de or Josephin.helka@dbfz.de

Kind regards,

Stefan Majer and Josephin Helka

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7.2 Section 1 – Personal Background

1. Your name:

2. Your affiliation:

3. Your country/region:

7.3 Section 2 – Identification of relevant technology elements for the identification of RG hot-spots

4. Do your country/region have strategies for the development of renewable gas (RG) [1]and/or renewable electricity [2]capacities?

Yes/No/Planned. If yes, please give references.

5. If you answered "Yes" or "Planned" to Question 4, do these strategies focus on specific technologies and/or feedstocks?

Yes/No

6. If you answered "Yes" to Question 5, what are these specific technologies/feedstocks in the short (< 5 years), medium (5-20 years) and long terms (> 20 years)?

Short term technologies/feedstocks
Medium term technologies/feedstocks
Long term technologies/feedstocks

[1] For this project we decided to focus on Biomethane (from both, anaerobic digestion and gasification of biomass), Hydrogen (electrolysis and steam reformation, Power-to-Gas)
[2] e.g. from solar, wind or hydropower

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7. In your opinion, what are the most relevant RG technologies and feedstocks for your country/region?

	Technologies	Feedstocks
Short term		
Medium term		
Long term		

8. Are there any combinations of technologies you listed in Question 7 that you think are particularly promising? If yes, please elaborate.

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7.4 Section 3 – Data input to WP5

1. Can you provide us with references or specific information on the costs of the technologies for the production of RG and renewable electricity based on the technologies that you have identified in the previous questions? If yes, please elaborate for short (< 5 years), medium (5-20 years) and long terms (> 20 years)?

2. Do you see regional Hot-Spots or preference regions for the production of RG and/or renewable electricity based on the technologies that you have identified in the previous questions? If yes, please elaborate for short (< 5 years), medium (5-20 years) and long terms (> 20 years)?

7.5 Section 4 – AOB

3. Is there anything else to consider for WP5? Did we miss something? Please let us know:

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