Description of European Legal, Institutional and Political Frameworks

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Executive Summary of D2.4

Renewables policy performance depends on several key factors including financial sustainability, adequate infrastructure, good and competent administration, clear proceedings, standardization and clear interconnection rules. If one is missing, the market might not develop. On the other hand, if support mechanisms like Feed-in-Tariff (FIT) are too high, it has the consequence of very fast development. The downside could be high social costs, due to huge amounts spent on FIT while some needed adaptions of legal requirements might be lagging the development. Therefore, careful balancing of market stimulation mechanisms is necessary.

In this report, conditions of regulatory and financial frameworks are examined in detail for four European countries that are the biggest biogas / biomethane producers in Europe, namely Germany, Italy, France and the United Kingdom. In addition, other European countries are shortly analysed, and important barriers are addressed.

The main findings are that uncertainty and inconsistency about targets and policies, including retroactive changes, significantly hamper renewable energy expansion, as support schemes or procedures that are unclear lower confidence amongst investors. Clear national or regional objectives are decisive. The government must have a vision of its future renewables market in order to know which sectors need to be developed. Clear and long-term goals offer investment security and create stable conditions that are favourable for long-term development of a market. Retroactive changes must be avoided at all circumstances as they undermine trust in the long run.

Which support system is preferable cannot be said without considering the specific situation in a country. Feed-in tariffs bring high investment security but must be well-designed and flexible in order not to induce high costs. Greenhouse gas quotas can help to start the development of the markets. However, it is important to set ambitious quotas and to install high fines if they are not fulfilled.

Another method to support renewables would be a high CO_2 price. The advantage is that it is technology neutral. However, it is necessary to set a floor price in order to avoid a rate too low to induce any investments in renewables.

Auctions, however, are not the most suitable instrument to promote renewable energies - experiences up to now show that it is nearly impossible to set conditions in a way that guarantees the desired outcome.

In addition, it is vital to establish a regulatory framework before implementing the promoting polices. Clear rules for interconnection and cost distribution must be in place and a uniform application of rules must be ensured. It is especially important to give renewables projects priority access to the grid. In addition, it is necessary to have feed-in priority for renewables over fossil fuels in order to guarantee their selling.

Standards, codes of practice and technical specifications for biogas projects must be created and clear rules for emissions and handling of digestate must be made. All in all, the goal of renewables promotion is to reduce GHG emissions and enhance environmentally friendly technologies in order to solve energy problems with fossil fuels and combat climate change. Thus, it is vital to control the plants and their emissions and to ensure a safe and environmentally friendly operation.

Loan guarantees and tax incentives may also be helpful of pushing a market. Loan guarantees can especially address difficulties with the banks. Often, if technologies are new, banks are not keen on financing them without additional securities. However, without access to enough funding, projects will not be realized.

In the long-term, policy makers should make sure that renewable energy technologies can operate in the energy system on a level playing field with other technologies. It is necessary to plan well ahead, and to integrate exit strategies from fossil fuels well in advance. If investment periods of 30-40 years for fossil fuel-based projects are considered, it is vital to stop supporting such projects in time in order to avoid stranded investments. Policies need also to be flexible, to continuously adapt to changing market conditions, to achieve cost-competitiveness and to integrate renewables into the system. There must be enough funding opportunities.

With increasing shares of renewables, grid integration can be challenging. This also must be planned well ahead. The grid infrastructure must be adapted in time or even be upgraded in order to avoid curtailment of renewable energy. In addition, a lack of district heating or adequate cooling infrastructure hinders progress in the heating and cooling sector, and the absence of appropriate engines in vehicle fleets hampers the deployment of biofuels in the transport sector.

At last, public acceptance is very important, plants must run properly and safe in order to reduce noise and door emissions and to avoid accidents – otherwise public acceptance won`t be achieved.

All in all, it is wise to exchange views with countries that successfully promoted renewable energies to avoid their mistakes and to learn from the experiences. It must be examined in what way the own country differs, what are the specific conditions, how the country is structured and what could be transferred.

Summary of the DiBiCoo Project

The **Digital Global Biogas Cooperation (DiBiCoo)** project is part of the EU's Horizon 2020 Societal Challenge 'Secure, clean and efficient energy', under the call 'Market Uptake Support'.

The target importing emerging and developing countries are Argentina, Ethiopia, Ghana, South Africa and Indonesia. Additionally, the project involves partners from Germany, Austria, Belgium and Latvia. The project started in October 2019 with a 33 months-timeline and a budget of 3 Million Euros. It is implemented by the consortium and coordinated by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The overall objective of the project is to prepare markets in developing and emerging countries for the import of sustainable biogas/biomethane technologies from Europe. DiBiCoo aims to mutually benefit importing and exporting countries through facilitating dialogue between European biogas industries and biogas stakeholders or developers from emerging and developing markets. The consortium works to advance knowledge transfer and experience sharing to improve local policies that allow increased market uptake by target countries. This will be facilitated through a digital matchmaking platform and classical capacity development mechanisms for improved networking, information sharing, and technical/financial competences. Furthermore, DiBiCoo will identify five demo cases up to investment stages in the 5 importing countries. Thus, the project will help mitigate GHG emissions and increase the share of global renewable energy generation. The project also contributes to the UN Sustainable Development Goals (SDG 7) for 'Affordable and clean energy", among others.

Further information can be found on the DiBiCoo website: www.dibicoo.org.

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List of Abbreviations

AD	Anaerobic Digestion
BAFA	Federal Office for Economic Affairs and Export Control
BImSchG	*Bundes-Immissionsschutzgesetz* / Federal Emission Control Act
BDR	BIOGAS DONE RIGHT
CIB	*Consortia Italiano Biogas* / Italian Biogas Association
CHP	Combined Heat and Power or Cogeneration
CIC	*Consorzio Italiano Compostatori* / Italian Composting and Biogas Association
	Certificati di Immissione in Consumo di biocarburanti / Certificates of release for consumption for biofuels
CPF	Carbon Price Floor
DVGW	*Deutscher Verein des Gas- und Wasserfachs* / German Technical and Scientific Association for Gas and Water
EEG	*Erneuerbare-Energien-Gesetz* / Renewable Energy Sources Act
EU	European Union
EU ETS	European Union Emission Trading System
FIT	Feed-in-Tariff
FIP	Feed-in Premium
FVB	*Fachverband Biogas* / German Biogas Association
GBA	German Biogas Association
GHG	Greenhouse Gases
GSE	*Gestore dei Servizi Energetici* / Energy Service System Operator
GW_e	Gigawatt electrical
IRENA	International Renewable Energy Agency
KfW	*Kreditanstalt für Wiederaufbau* / German Development Bank
KWKG	*Kraft-Wärme-Kopplungsgesetz* / Combined Heat and Power Generation Act
KOM	Kick-off Meeting
MAP	Market Incentive Programme
MS	Member States
NGV	Natural Gas Vehicle
RED	Renewable Energy Directive
RHI	Renewable Heat Incentive
RO	Renewables Obligation
ROC	Renewables Obligation Certificate
RTFO	Renewable Transport Fuel Obligation
WWTP	Wastewater Treatment Plant

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I. Europe

(1) Introduction

The European Commission is currently discussing the new European Green Deal. A climate law is supposed to be passed in spring 2020 and several legislative acts will be revised in the forthcoming years in order to adapt policies to a – hopefully – more ambitious EU climate policy aiming at carbon neutrality by 2050. In this context, the role of renewable gases will receive special attention. Natural gas will be used as a transitional fuel and is supposed to be replaced step by step by renewable gases. Biogas, biomethane and other renewable gases like synthetic gases will play a key role in helping Europe's transition to a clean energy system with a genuinely resource-efficient and circular economy.

There are biogas activities in nearly each European country, see **Fehler! Verweisquelle konnte nicht gefunden werden.**.

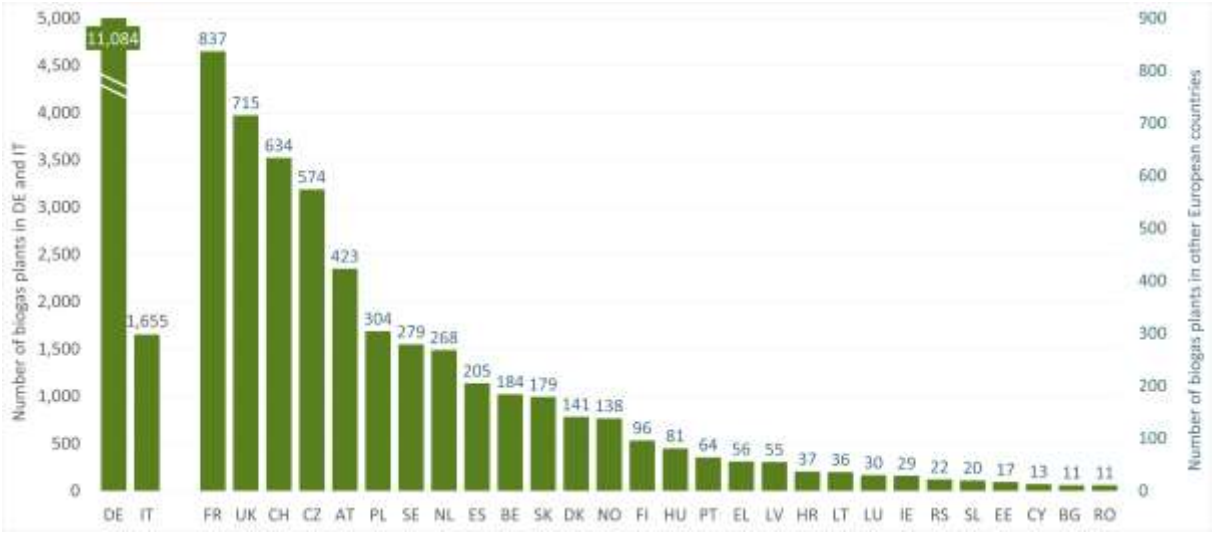

Figure 1: Number of biogas plants in Europe, Source: EBA 2020.

However, there are huge differences in the development of biogas markets in Europe. Within the next chapters the focus will be on the most successful European countries in this respect. By that the reader will get a better understanding of the legal, institutional and political frameworks that enable successful development. Additional barriers and challenges are described.

The conditions for biogas or biomethane vary a great deal from one Member State to another. Within this deliverable, the most decisive legal, institutional and political frameworks from a number of European countries are examined in order to demonstrate the reasons for biogas market development in Europe for stakeholders from the importing countries. The focus will lay on experiences from the following countries: Germany, France, Italy and the United Kingdom. It will be examined how, why and under what conditions these frameworks could act as a barrier or as an enabling element. The countries were chosen due to their significance for the European biogas market development. First of all, there will be a short overview of the relevant European policies and their significance on national policies.

Europe

(2) Development of biogas market in Europe

The number of biogas plants in Europe continued to grow at a steady pace over the course of 2018 to reach 18,202 units by the end of the year.

This represents about a 2% increase compared to 2017, with 419 additional biogas installations (EBA 2020). Most plants per country can be found in Germany (over 9,000), followed by Italy (1,655 plants), France (837 plants) and the United Kingdom (715 plants). The installed electric capacity is roughly 11 GW_e in 2018. The feedstock use for biogas production varies: In Germany, Austria, Latvia, Hungary and Italy, energy crops and agricultural residues make up more than 70% of the overall feedstock used. In Italy, however, the energy crops category includes a significant share of catch and cover crops. Under the slogan “Biogas Done Right”, the biogas market in Italy is being redefined, with the aim of making better use of farmland by double or multiple cropping and using the additional biomass for biogas and biomethane production. In Belgium, Denmark and Poland, in turn , a sizeable share of industrial organic wastes from the food and drink industry goes toward the production of biogas and electricity from biogas. Sewage at wastewater treatment plants is the predominant feedstock for biogas production in Sweden (EBA 2020). Types of feedstock for biomethane production are more heterogenous. Generally speaking, the biomethane sector is less reliant on energy crops than the biogas sector. Although agricultural substrates are used to a certain extent, other feedstock like municipal, organic, industrial or household waste are used in larger volumes. The reason is that the market for biomethane developped later than the market for biogas, after long discussions about sustainability of energy crops. However, the feedstock use for biomethane also varies from country to country.

(3) Regulatory framework

The first regulatory frameworks for biogas or renewable energy started at the end of the 20th century. In several countries support mechanisms for renewables were implemented. Several European countries started first with support of single projects. In the next step support mechanisms for electricity generation were implemented. For example, the German “*Stromeinspeisegesetz*” (Electricity Feed-in Act) which entered into force in 1991 and was the predecessor of the German Renewable Energy Sources Act (*Erneuerbare Energien Gesetz*-EEG) This law initiated the first green electricity feed-in tariff scheme in the world. Additional to the support of electricity production, fuels for transport were supported. Typical instruments were Feed-in-Tariff (FIT) for electricity, quotas (often for fuel) or tax reduction. Probably the most successful instrument for biogas market development were FIT.

With the development of the biogas and bioenergy sector, questions of the sustainability of the feedstock became more relevant. The feedstock use is strongly dependent on European policies. In 2008 discussions on sustainability of biomass started: High prices of agricultural goods induced discussion about food crops vs. fuel crops, about biodiversity and changes in carbon stock in high-diverse regions like rain forests. In addition, the concept of indirect land use change (iLUC) was brought up. These discussions resulted in substantial sustainability requirements for biomass to qualify as renewable fuel in the Renewable Energy Directive (RED I) adopted in 2009.

This directive was successfully increasing renewable energy in Europe. It laid down minimum targets for renewables in Europe, namely the 20 % share of renewable energy in gross final energy consumption in Europe in 2020; this European goal was broken down in binding national targets for the Member States (MS). Besides, a target of a 10 % share of renewable fuels in the mobility sector should be reached in each MS. In addition, a mass balance system was introduced, which allowed consignments of raw material or biofuel with differing

sustainability characteristics to be mixed and required information about the sustainability characteristics and sizes of the consignments. Furthermore, it laid down rules for the calculation of greenhouse gas emissions from biofuels and put forward sustainability requirements. The RED I was decisive in bringing renewables in Europe forward.

For Renewables, also soft legislation had its impact: The State Aid Guidelines for environmental protection and energy were adopted in 2014 (EU Commission 2014). Such guidelines primarily serve the EU Commission as a guiding instrument on how certain legislative acts should be interpreted. However, the guidelines introduced hard law through the back door: In it, there were definitions on how renewable energy installations could be supported, for example FIT were only allowed for installations up to 500 kW electric capacity. There was much discussion about the legality of this approach since the guidelines were adopted only by the EU Commission and not in a proper legislative process and were somewhat at odds with contents of RED I.

In 2017-18, the so-called package “Clean Energy for all Europeans” was negotiated (EU Commission -2020). It was a comprehensive update of the EU’s energy policy framework to facilitate the transition from fossil fuels towards cleaner energy sources and to deliver on the EU’s Paris Agreement commitments for reducing greenhouse gas emissions. Based on Commission proposals published in November 2016, the “Clean energy for all Europeans package” consists of eight legislative acts. After political agreement reached by the Council and the European Parliament in 2018 and early 2019, all the new rules could enter into force by mid-2019. The EU countries now have 1-2 years to transpose the new directives into national law. The changes are supposed to bring considerable benefits from a consumer perspective, from an environmental and from an economic perspective. The legislative acts are also supposed to provide an important contribution to the EU’s long-term strategy of achieving carbon neutrality by 2050. The legislative proposals concern the following issues: Energy performance in buildings, Renewable Energy, Energy Efficiency, Governance regulation and Regulation of the electricity market design which consists of four dossiers - a new electricity regulation, an amending electricity directive, risk preparedness and a regulation outlining a stronger role for the Agency for the Cooperation of Energy Regulators (ACER). The issue of renewable energy is tackled in the revised RED, (RED II), that contains a new European goal of 32 % Renewables in 2030, a European goal of 14 % renewable fuels in the mobility sector and a sub quota for advanced renewable fuels of 3.5 % by 2030. In addition, it contains new regulations concerning sustainability: For the first time, not only biofuels for the mobility sector but all renewable fuels for all sectors must prove substantial greenhouse gas reductions (RED II 2018).

A moderate boost for renewable mobility was given through the “Clean Mobility Package” (EU Commission 2019a). The EU's commitments under the Paris Agreement for a binding domestic CO_2 reduction of at least 40% till 2030 forces also legislative measures in the mobility sector. Unfortunately, the current CO_2 standards promote only certain technologies as only tailpipe emissions are calculated. Real life-time emissions have not been considered but the emissions of the whole Life Cycle Assessment (LCA) may be included in the scope when the Regulation is revised in 2021. The “Clean Mobility Package” comprises legislation on the following:

- CO_2 standards: these will help manufacturers to embrace innovation and supply low-emission vehicles, based on the tailpipe approach, to the market. The proposal also includes targets both for 2025 and 2030.
- The “Clean Vehicles Directive” shall promote clean mobility solutions in public procurement tenders.
- The “Combined Transport Directive” promotes the combined use of different modes for freight transport (e.g. lorries and trains) and will make it easier for companies to claim incentives.

- The “Regulation on Passenger Coach Services” is supposed to stimulate the development of bus connections over long distances across Europe and offer alternative options to the use of private cars.
- The battery initiative has strategic importance to the EU's integrated industrial policy.

All these regulations will give incentives to promote alternative fuels in order to reduce emissions according to the Paris agreement. They force Member States to act accordingly.

In December 2019, the EU Commission presented its flagship initiative the “European Green Deal” (EU Commission 2019). The climate law, due in March 2020, will make carbon neutrality by 2050 a binding European target. However, concrete measures and funding is still unclear and will be proposed step by step by summer 2021. Under the Green Deal initiative, the European Commission shall have a look at all legislative acts having impact on climate and align them with each other following the sector integration principle as well as with the new target of zero emissions by 2050.

(4) Evaluation of European Framework

The diverse regulations on European climate and energy policy were essential for the biogas development in Europe. With RED I, there were for the first time reliant and stable framework conditions for the support of renewable energy sources and a common European goal accepted by all MS. In addition, the binding national targets led to consequent legal and political action in each MS. However, the financial crisis has negatively influenced the development in many MS. Savings had to be made which led to retroactive changes in some countries’ support policies for renewable energy. These retroactive changes led to an insecure regulatory environment for further investments. However, these changes were not made on European but on MS level. Even the contentious State Aid Guidelines for environmental protection and energy were in a way favourable for the market development because they brought some clarity and reliability for many open questions. Stable and clear framework conditions can push a market considerably. For investors, even the not very ambitious goals of RED II, adopted now are better than not knowing where the journey will go. RED II sets clear goals until 2030. There are worries within the EU Commission that with the European Green Deal legislative acts like the package “Clean Energy for all Europeans” will be reopened and thus, investments will be endangered, and legal insecurity enhanced.

II. European Member States

The leading biogas producers in Europe are Germany, France, Italy and the United Kingdom. It will be shown in the following in detail for those countries what drivers and barriers there are for the biogas industry and why markets develop differently, depending mostly on the framework conditions. One chapter will follow which deals with the other European countries and possible barriers for biogas development there.

(1) Germany

Germany has the largest biogas market in Europe. With over 9,000 biogas plants and an installed electric capacity of over 5 GW_e the biogas market developed fast in the last 20 years (FvB 2020). The biomethane market developed more slowly, now there are roughly 200 biomethane plants. With around 33 TWh_e produced, biogas (incl. biomethane and biogas from sewage and landfill) accounts for 5.7% of the overall electricity generation in Germany and for around 15% from renewable energy sources (RES) in 2018. The heat supply from biogas amounted to around 18.8 TWh_t in 2018, which corresponds to about 1.6% of the end energy consumption in the heat sector resp. 11% of the energy supply provided by RES (BMWi 2019). In 2017, the German Biomass Research Center (DBFZ) published a study (DBFZ et al. 2017) on the distribution of different substrates. The authors determine a proportion of 49% of energy crops and 45% of slurry and manure as input for the digester based on weight. Only 6% of the inputs are wastes and residues. The share of the digested materials of waste and residues in terms of energy output amounts to 8%. Energy crops supply 77% of biogas energy, slurry and manure only 15% due to the low energy content of the material.

a. Brief description of development of biogas market

Compared to other European countries, Biogas is primarily generated in rural areas and compared to other European countries is produced from a higher share of energy crops. Germany has an extensive regulatory framework for biogas and biomethane.

b. Renewable Energy Sources Act *- Erneuerbare Energien Gesetz (EEG)*

Financial support is provided by different acts, the most important is the Renewable Energy Sources Act (*Erneuerbare Energien Gesetz* - EEG). The EEG played a key role in the success of the German energy transition. Three factors were decisive for the success: There is a right of grid connection for renewable energy facilities, there is the obligation for net operators to preferentially purchase electricity based on renewables and there is a feed-in-tariff to be paid for the generated electricity (ISIC 2019). The first EEG was already published in 2000 and it defined, among others, the non-discriminatory access to the grid and Feed-in Tariffs (FIT) for a fixed period of 20 years. The EEG has been revised five times to correct undesired consequences, the latest version comes from 2017 and it may be reviewed this year for a sixth time.

The number of biogas plants has increased continuously since the EEG came into force in 2000. Due to dynamic developments over the past few years, biogas technology has been adapted to a changing set of framework conditions. From 2004 to 2011 the EEG promoted the

use of energy crops and animal excrements with very high incentives. A real boom developed – there were up to 1,000 plants installed per year, mostly based on agricultural crops. Thus, most of the existing biogas facilities have been established until the end of 2011.

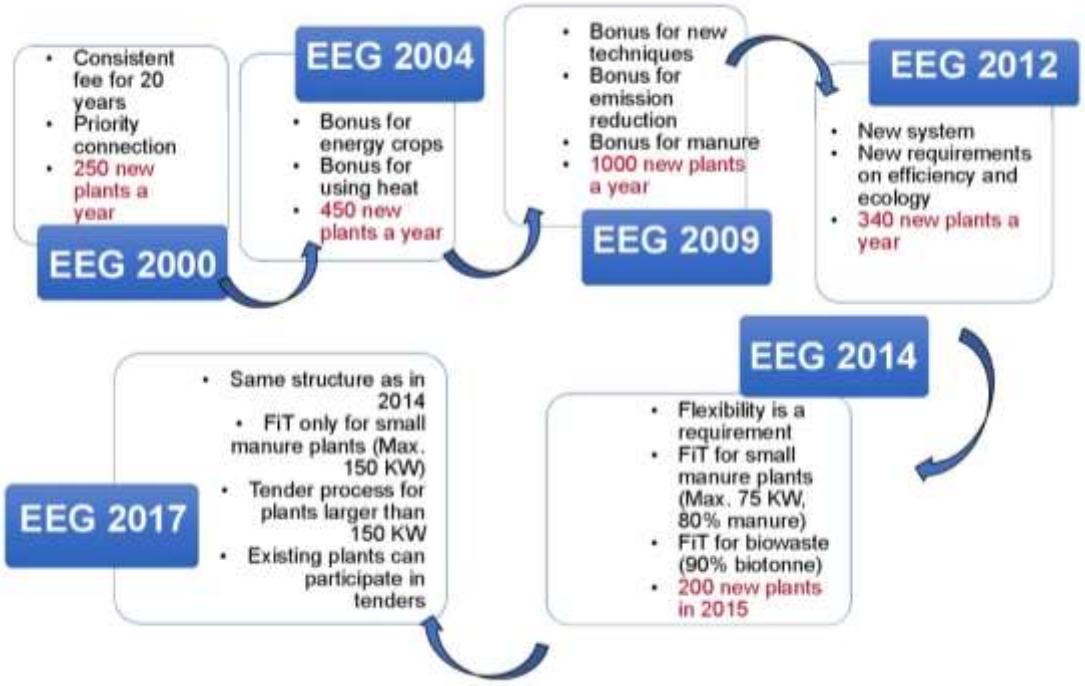

Figure 2: Development of the Renewable Energy Sources Act from 2000-2017, Source FVB 2020.

Since 2012 a new amendment of the EEG came into force. A market and flexibility premium were introduced. The government established a new system with requirements on efficiency and ecology but in total feed-in tariffs were reduced.

With discussions about the sustainability of energy crops the bonuses for the use of crops were abolished in 2014. Instead there were two special tariffs for small scale manure plants and for biogas plants digesting waste. Since the reforms of the Renewable Energy Sources Act (EEG) in 2014 and 2017, the number of newly installed systems has remained constant at a level of about 100 to 150 new plants per year.

In 2017, tenders were introduced due to changing EU legislation: The State Aid Guidelines for environmental protection and energy took effect and had direct impact on German legislation. For biogas plant operators within the EEG there was the possibility to participate in tenders in order to receive further funding after the EEG support would run out after 20 years. Tenders are based on a pay-as-bid model with two auctions already run in 2017 and 2018. Biogas plants to be built with an installed electrical capacity of more than 150 kW_e as well as already existing biogas facilities can participate in the auctions. However, the maximum fee of the tenders was not high enough (14.58 ct/kWh_e) to operate newly built biogas plants in an economical successful way so up to now tenders were not very successful. Plant expansion since 2014 is primarily limited to the extension of existing plants by adding capacity for greater flexibility or by newly installed plants that have mainly been small liquid manure plants with a maximum electrical output of 75 kW which are still covered by a FIT with a sufficient tariff of 22.68 ct/kWh_e.

For the future, it can be assumed that the focus for newly installed biogas plants will be based on animal excrements and waste. Many biogas plants are faced with decisions whether to continue producing biogas when their FIT runs out. In 2024 many plant operators who started their biogas production in 2004 under very favourable conditions have either to take part in auctions in order to get subsidies or to end biogas production if they do not find a possibility to exist without subsidies.

c. Biofuel Quota

Biomethane is mostly used in CHPs in Germany, supported by a FIT for electricity production, because up to now that was the economically most preferential option. Only about 4% of biomethane is currently used as transport fuel.

One limiting factor for the use of biomethane as transport fuel is the - yet - low number of natural gas-fuelled cars in Germany. The annual growth rates of biomethane plants were, however, substantially reduced after the abolishment of the biogas upgrading bonus in 2014. This fact and the often small-structured agricultural area lead to slow development of the biomethane market in Germany. However, due to new legal frameworks and EU regulations biomethane plants offer a promising option within the future German energy system: The EU Renewable Energy Directive gives incentives by the sub-quota for biofuels from e.g. manure and provides high greenhouse gas emission savings that can be interesting for the German biofuel quota. This quota obliges the mineral oil industry to have a certain share of biofuels in their portfolio (6 % in 2020). If they cannot prove that share, they must pay a fine. For biomethane from manure this offers a good opportunity in 2021 when the Renewable Energy Directive is implemented in German law.

d. Other important legislative acts

In addition, the Combined Heat and Power Generation Act provided a feed-in tariff as well, confined to 10 years or 30,000 hours of full utilization (KWKG). Apart from fixed incentives, German regulator gives tax exemptions on biomethane used in CHPs and for electricity. Provisions are stated in the Energy Tax Act and the Electricity Tax Act. Furthermore, there are several programs that support the financing of biogas plants by giving loans or favourable interest rates, like market incentives program (MAP) of the Federal Ministry for Economic Affairs and Energy which are accessible via the support programs of the German Development Bank (KfW) and the Federal Office for Business and Export Control (BAFA).

Sustainability of biomass is covered by the Biofuel Quota Act, the Biofuel Sustainability Ordinance and the Biomass Ordinance. These apply only to biomethane that is used for transport purposes, which is credited for achieving the biofuel quota. However, in 2021 also biogas and biomethane produced in newly built plants and used in CHPs must fulfil the sustainability requirements (according to EU legislation RED II). For biomethane, special regulations have been foreseen for biomethane injection to the grid to ensure safe, efficient and environmentally friendly grid-bound supply. This includes, among others, the Act on the Supply of Electricity and Gas, the Gas network Access Ordinance and the Gas network charges ordinance on conditions to access gas grid.

Biogas and biomethane in Germany fall also under emissions regulatory frameworks, describing specific technical requirements and safety examinations of plants. The most important is the Federal Emission Control Act (BImSchG), which is supplemented by several work sheets from the German Technical and Scientific Association for Gas and Water (DVGW). The production and use of a by-product of anaerobic digestion, the digestate, is also regulated by several documents: The Fertilizing Act, the Fertilizing Ordinance, the Biowaste Ordinance and the Biomass Ordinance. In addition, plant operators struggle with new requirements for biogas plants in order to increase safety and to prevent hazardous incidents. The demanding EU fertilizer regulation puts an additional burden on farmers who produce too much digestate and either must build more storage room or to process the digestate further in order to be able to export it. Also new regulations about maximum emission values of methane lead to further pressure on biogas plant operators.

In principle biogas plant must be operated environmentally friendly and safe in order to qualify for financial support but stronger regulations on emission control and safety often lead to high investment costs and give additional burden, especially on the economy of the biogas plant operation.

e. Local / regional initiatives

In Germany, the federal principle allows the regions to develop their own plans regarding promotions. For example, Bavaria as one of the federal states in Germany gives subsidies for natural gas public transportation buses in cities in order to reduce CO_2 emissions. Since 2018, bus companies get up to 30% of the cost reimbursed if they buy a natural gas bus for their fleet (STMB 2018).

f. Success factors

The major driver for the expansion of biomethane in Germany were the ambitious goals of the German government and, more specifically, the introduction of the bonuses within the amendments of the EEG in 2004 and 2009. However, the boom with 1,000 plants per year was not a really “healthy” development because it led to cost explosion. In retrospect, tariffs for that period were most likely too high.

Thanks to the focus of the EEG on the electricity sector, nearly all biogas and biomethane in Germany is used for cogeneration of heat and power (DBFZ et al. 2019). Thus, the government decides with its instruments which utilization is promoted and in which direction a market will develop.

In 2018, biomethane accounted for only 1.1% of the end energy consumption of renewable energies in the transport sector even though biomethane produced from organic waste, manure or dung can be double counted for the national biofuel target (BMU 2016). The design of the supporting instrument, the EEG, is directly linked to the outcome. Therefore, it is important to design such an instrument wisely, to avoid promoting undesirable outcomes. It is also important to find the right tariffs. However, to start biogas production, a FIT is a very successful instrument since investment security is high and the income can be calculated in a reliable way. One very decisive success factor in the German biogas industry history was the long-term investment security FIT bring with them. The FIT created a secure environment. Investors knew how to plan, and the 20 year-period of fixed income rates made the investments worthwhile. Even if conditions changed with each revision of the EEG, the changes only applied to new plants, there were no retroactive changes. In addition, administrative competence is high in Germany - even if application for permits may take a while all is regulated in detail and legal rights can be claimed because legal certainty is given. Legal and administrative certainty are also important factors for success.

g. Barriers

Now, the decisive barrier for biogas production in Germany is clearly the lacking political will or vision. Years of uncertainty lead to unfavourable investment conditions. For years there was a discussion ongoing that focused only on costs without any vision for the future or a plan for the necessities of the energy transition. The central question for the German biogas market is still which economically viable options exist for the continued operation of existing biogas plants. If there is no chance for an economic operation of existing biogas plants after the expiry of the feed-in tariff according to EEG, the required investments and maintenance of these plants will be put off, and - with the expiry of the EEG tariff - the available plant capacity will

decrease (DBFZ et al. 2019). The current scenarios for bioenergy that are discussed by the government are not consistent and do not set the right conditions to ensure the long-term development of this technology. Many plants were even willing to adapt to stricter legal requirements and sustainability proofs. However, there must be an economically viable and profitable perspective.

Thus, it is necessary to examine whether there are alternative plant concepts which are economically viable by using acts like the biofuel quota and switching to biomethane production or by producing electricity in times of high prices. However, the electricity market still does not give the right signals for the latter. Besides, the RED II offers favourable GHG savings for biogas from manure which may lead to investment in manure plants for biofuel use in the transport sector. But this is not implemented until June 2021 the earliest. In combination with a higher national greenhouse savings quota, it would offer some economic perspectives. Although, the transportation sector for gaseous fuel is not well-established in Germany and would need more political support and improved legal framework. Currently, the missing market perspective is the main problem for promoting biomethane in Germany. Signals for a new framework combined with better economic conditions for biogas/biomethane in Germany are urgently required if the number of biogas plants in Germany shall be maintained.

Above, in the chapter success factors, it is described that the legal structure in Germany is quite elaborated. The downside is that there are many laws, regulations and standards to be fulfilled by the biogas plant operators. The German Biogas Association (GBA) (*Fachverband Biogas* (FVB)) counts above 300 regulations/laws/standards that must be followed. There is probably nobody in Germany who understands all regulations and implications of amendments. This makes the operation of plants very challenging and puts a heavy administrative burden on plant operators.

(2) France

At the end of June 2019, 708 biogas plants with a total installed capacity of 470 MW were connected to the grid in France. Biogas plants are divided into three categories in France: methanisation plants, household waste treatment plants (Installation de stockage de déchets non dangereux, ISDND) and sewage gas plants (Station d'épuration des eaux usées, STEP). More than two thirds of the biogas plants are methanisation plants (DFBEW 2019b). The feed-in of biomethane into the natural gas grid, which is given priority by the French government over electricity generation, is steadily increasing in France. At the end of March 2019, the biomethane injection capacity was around 1.36 TWh/year, produced by 88 units. The governmental objective of the sector is 6 TWh/year in 2023, and 14 to 22 TWh/year in 2028 (DFBEW 2020). In comparison: In 2015 only 18 GWh of biomethane were produced. Agricultural biogas units in France can be split in two categories: centralized territorial projects, bringing together several actors, mixing animal manure with wastes from industries and local authorities and projects led by farmers, utilizing mainly animal waste, supplemented with external waste, crop residues and energy crops. Mid 2018, there were 305 agricultural biogas units, and 43 territorial projects running. But biogas isn't restricted to the agricultural sector: Mid 2018, there were also 150 biogas units in landfills, 15 in domestic waste facilities, 73 in Wastewater Treatment Plants (WWTPs) and 104 in water treatment units for industries or agroindustry. How did the French biomethane market develop?

a. Brief description of development of biogas market

With the Law on Energy Transition for Green Growth (Loi relative à la transition énergétique pour la croissance verte - LTECV 2015) passed in 2015, two planning instruments for national energy and climate policy were created in France. The national decarbonisation strategy (Stratégie nationale bas carbone, SNBC) sets the reduction path for greenhouse gas emitting sectors while the multiannual energy programming (Programmation pluriannuelle de l'énergie, PPE) translates these targets into concrete milestones for the energy mix (DFBEW 2019a). France has now set itself the target of increasing the share of renewable energies in gross final energy consumption to 33% by 2030 (previously 32%). The share of renewable energies in electricity generation is to be 40 % by that date, as already defined in the LTECV.

The French biomethane sector has grown considerably since it was launched in 2011 with the introduction of feed-in tariffs over a period of 10 to 20 years (depending on the technology). In 2015, it began operating under the Guarantee of Origin system, which ensures the traceability of renewable gas, with approximately 80% of the resource being used as vehicle fuel and 20% for heating. Article 104 of the LTECV creates the legal basis for the introduction of direct marketing with a sliding market premium (complément de rémunération) for new, market-ready large-scale plants (DFBEW 2019a). Plant operators or direct marketers sell generated electricity quantities directly on the electricity market. In addition to the income from the direct marketing of the electricity on the market, they receive a so-called "current" market premium, which corresponds to the delta between the technology-specific reference value and an average reference exchange price determined subsequently. The market premium model offers operators the opportunity to maximize income by means of targeted sales tactics compared to the feed-in tariff. Revenues from the capacity market will be deducted from the market premium.

As off 2016, the support mechanism for biogas changed and primarily depends on the proportion of sludge from wastewater treatment (below 50% and above 50%). The specifications of the proportions of wastewater sludge, agricultural effluents and cultures

(dedicated, intermediate or “stolen”) are defined in the preparation texts. The LTECV introduced the possibility of using dedicated crops for energy purposes if the prevalence of the use of food crops for human and animal consumption is ensured. Installations using dedicated energy crops can be excluded from receiving public grants, depending on the criteria set by the region. There is a political and societal consensus on the principle of non-competition between food & energy crops. The dedicated energy crops are understood as crops mainly used for energy production, planted in substitution to food crops or animal feed crops. The agricultural by-products such as straw, chaff, but also catch crops that are cultivated for energy purposes (CIVE) are not regarded as dedicated energy crops. Today, about 3% of dedicated energy crops are used for biogas production.

The LTECV regulates and further reduces their use in biogas plants, while supporting the use of agricultural by-products, intermediate/ catch crops for energy purposes. The aim is to further develop and enforce biogas production and anaerobic digestion while avoiding an adverse development regarding sustainability aspects of the process (e.g. imports of biomass, competition for land and with food and feed supply).

Biogas plants with an installed capacity of more than 500 kW were able to obtain a market premium contract by successfully participating in a tendering procedure launched in February 2016. The third bidding period ended in April 2019. 60 MW were put out to tender in each case. Bids could be submitted in two categories, 50 MW for wood energy (already from 300 kW) and 10 MW for mechanization plants. In addition, there was a system with a power purchase agreement and fixed feed-in tariff for electricity production from biogas. This was laid down in a tariff decree dated 13 December 2016 which is degressive. Besides, the feed-in tariff decreases with increasing installed capacity. In addition, a premium could be paid for the use of liquid manure.

Furthermore, the LTECV extends the right laid down in the Agriculture and Food Act (EGAlim) to feed all types of renewable gas, or gases produced from recovered energy, into the grid. In addition, a reform of the system of biogas guarantees of origin is planned: following EU legislation (RED II) guarantees of origin from other countries within the European Union will be recognized in France from 30 June 2021 onwards.

There is also other funding available for biomethane used in district heating networks, as it is for other renewable energies used for heating. Users of a heating gas that is certified as renewable by the Guarantee of Origin system and used in district heating networks contributes to attaining the figure of 50% renewable and recovered energy in the mix enjoy a reduced VAT rate of 5.5%.

b. Success factors

France is another example of how fast a market can develop if the political will is adequately transferred in a well-designed legislative framework. As in Germany, the FIT proved vital in helping the market to grow. Other incentives like reduced tax also showed its effects. France developed its market later than Germany, thus incorporating already the sustainability in its design: Energy crop use was discouraged the focus is on waste utilization. However, despite the good market development there are still some barriers to address.

c. Barriers

One difficulty is to ensure a reliable and constant supply of feedstock in terms of both quantity and quality. In addition, as it is mostly the case with biogas plants, large areas of land are required to spread the digestate. If these areas are not close-by, you either need large storage

rooms or must find possibilities to treat the digestate accordingly and sell it. In both cases, higher investment is needed.

Besides, administrative procedures in France take some time: it can take between 18 months and 6 years to set up a project, due to the complexity of the administrative procedures involved. Administrative procedures also induce further costs.

Another barrier may be the lack of social acceptability of biogas plants. People often fear odour, noise pollution and increased traffic.

Finally, there is the financing: Banks are often very cautious when it comes to funding anaerobic digestion projects. Even if they agree on financing a project their financing criteria are extremely strict. Before financing an anaerobic digestion project, a bank is looking closely at the potential to generate revenue in the future. The main indicator used is the so-called DCR (Debt Coverage Ratio) which must be over 140%. Investment funds, however, display little interest in the biomethane industry, given the smallness of projects (ENEA 2017).

(3) Italy

Italy had 1,655 biogas plants in 2018 (EBA 2020). In terms of number of plants, it is the second biggest biogas market in Europe after Germany, and the third one in terms of biogas production. Most biogas plants are on-farm, using animal manure and forestry-agricultural by-products. More than 80% of biogas plants use biomass of agricultural origin, 12% landfill waste, 3% organic fractions of municipal solid waste (OFMSW) and 5% biomass-derived water treatment. Italy is accounting for three quarters of the European natural gas vehicle (NGV) fleet, with around 1 million light compressed natural gas (CNG) vehicles, and a fleet of about 3,300 methane-fuelled buses (Ifri 2017) as well as more than 1,200 fuel stations. Roughly 31% of all natural gas refuelling stations in Europe are in Italy (WBA 2017).

Biogas was almost exclusively used to produce electricity and heat as biogas upgrading into biomethane has just started in Italy in 2018. At the end of 2017, biogas power plants had an installed electricity capacity of 1,400 MW, of which under 1,000 MW is in the agricultural sector.

a. Brief description of development of biogas market

Biogas development expanded considerably from 2008 to 2012, thanks to a Feed-in Tariff (tariffa onnicomprensiva) that guaranteed the highest European FIT for small biogas electricity plants from agricultural feedstock (EUR 280/MWh_e for plants <1 MW), including energy crops. This allowed the great expansion of the biogas sector in Italy, reaching more than 1,000 biogas plants in five years. The number of biogas plants rose considerably. Electricity generation from biogas (all biogas, including landfill gas) increased from 1.6 TWh generated in 2008 to 7.4 TWh in 2013 (Ifri 2017).

In 2012, with effect on January 2013, the government adjusted its incentives downwards and moved to a Feed-in-Premium, except for small plants (Ministerial Decree of 6 July 2012). The new policy gave preference to the use of by-products and farming waste over energy crops and encouraged the development of small plants (up to 600 kW_e). The initial effects of this new policy were felt from 2013, when the number of newly installed biogas plant dropped (only 140 plants in 2013 compared with 684 in 2012). Since then, the number of biogas plants and their electricity generation have stagnated (8.3 TWh in 2017). Heat generation from biogas totalled 3.1 TWh in 2017 from 2.1 TWh in 2012. In 2013, the government also re-oriented its biogas policy from electricity generation (except for small plants) to biomethane production and set up a FIT for biomethane production for natural gas vehicles (NGVs), high-efficiency cogeneration and grid injection (Ministerial Decree of 5 December 2013 for the promotion of biomethane, hereafter 2013 Biomethane Decree).

In March 2018, the Italian government adopted the “Ministerial Decree on the promotion of biomethane and advanced biofuels in transport for the period 2018-2022. The Decree has given a strong boost to the sector (DECRETO 2 matzo 2018).

The decree aims at promoting the production of biomethane and advanced biofuels to increase the share of renewable fuels in the transport sector. With this decree, Italy aims at achieving an overall 9% renewable target in the transport sector by 2020, and a secondary target for advanced biofuels starting at 0.6% in 2018 and rising to 1.85% in 2022. The decree introduces a support scheme for advanced biofuels, biomethane and advanced biomethane injected into the natural gas grids to be used in the transport sector. The decree allocates EUR 4.7 billion of funds between 2018 and 2022 and covers a maximum amount of 1.1 bcm (billion cubic meters) of biomethane production per year.

The scheme is fully financed by transport fuel suppliers under their biofuel blending obligation. Contrary to the 2013 Biomethane Decree, only biomethane injected into the natural gas grids to be used in the transport sector can have access to the support mechanisms. Background is that Italy must catch up in the mobility sector with renewable energies in order to reach its goals. The biomethane promotion scheme is based on the allocation of certificates of release for consumption for biofuels (Certificati di Immissione in Consumo di biocarburanti, better known as “CIC”). These CIC are allocated to biomethane producers by GSE (Gestore dei Servizi Energetici, the National Agency in charge of managing all the support schemes for renewables deployment) to be sold to fuel suppliers subjected to a mandatory blending quota like Germany. The number of CIC that these suppliers are obliged to hold is determined every year. A mandatory quota for advanced biofuels has been introduced (1.85% in 2022). The Decree specifies that 75% of the sub-target for advanced biofuels must be met with biomethane and the remaining 25% with must be met with other advanced biofuels (Ifri 2017). Biomethane counted as “advanced” if feedstock is used that is specified with look at European legislation, especially as laid down in ANNEX IX of the RED II. There is a specific favourable tariff for advanced biomethane in the Decree. The Decree applies to production plants starting operations between 2018 and 2022, and to plants already supported under the 2013 Biomethane Decree, that opt for the provisions of the new Decree. The scheme is also open to existing plants to produce biogas, which is converted, partially or totally, in plants to produce biomethane between 2018 and 2022. The Decree thus opens the possibility of a progressive shift from electricity production to the biomethane sector (with some specific rules for biogas plants continuing to produce renewable electricity).

Generally, the strong use of natural gas in the mobility sector in Italy was induced by policy and financial measures focused on vehicle and infrastructure as well as a large tax advantage of natural gas over diesel and petrol. The infrastructure network is well-developed with more than 1,300 CNG refuelling stations and is constantly increasing. Italy consumes 1.1 Gm^3/a of natural gas in road transport (Ifri 2017) This is a good precondition for biomethane use in the mobility sector.

In terms of sustainability, the Italian biogas association (*Consorzio Italiano Biogas* - CIB) in association with Italian farmers has developed a unique model for producing sustainable biogas/biomethane from agriculture, called BiogasDoneRight (BDR). BDR is a sustainable and proven model to produce food, fodder and renewable energy while allows the decarbonization of the agricultural sector (Dale et al. 2016). The BDR model is based on innovative agricultural technologies integrating biogas/biomethane production, sequential cropping and precision farming, to ensure a carbon negative agriculture, capable of emitting less GHG, while capturing and sequestering carbon and generating positive environmental externalities, such as increased carbon content of soils, increased soil fertility and lower input of chemical fertilizers, thanks to the efficient use of digestate (bio-fertilizer). With the BDR model, agriculture becomes a circular economic model with a strategic role in the fight against climate change. The model also increases economic and environmental resilience of agriculture. The BDR model has been demonstrated by Italian farmers in the Po Valley and recent works with international partners have shown that the concept is scalable and exportable (Ifri 2017).

b. Success factors

Due to its extensive network of natural gas fuel stations Italy has a huge potential for using biomethane in the mobility sector. The biogas market in Italy was - like in Germany and France – promoted by the introduction of a FIT. Biomethane is getting started due to the newly adapted tariffs. Italy also proves with its BiogasDoneRight (BDR) model that it is wise to proactively suggest new ways of handling sustainability problems.

c. Barriers

The regulatory framework for biomethane has been a long process in Italy. Bureaucratic-administrative procedures of authorization are different from region to region, many administrations display scarce knowledge of the legislation. There are different interpretations of the law, especially related to agricultural feedstocks or for the use of digestate.

Another problem in Italy are non-technical barriers: The NIMBY syndrome (Not in My Back Yard) is the most difficult barrier to overcome in Italy. Despite the positive effect on local areas due to reduction of pollution and emission of CO_2, the social acceptability of biogas plants is controversial as local communities are afraid of potential local negative externalities including smell, heavy traffic and congestion, noise, badly managed fertilizer, damage to health and visual disamenities (Ifri 2017).

(4) United Kingdom

The United Kingdom has the climate target of delivering 15% of all energy from renewable sources by 2020 and to reduce greenhouse gas emissions by 80% by 2050. There are now 486 operational anaerobic digestion plants in the UK, including 84 biomethane-to-grid plants, and a further 343 anaerobic digestion projects under development. Most plants use predominantly agricultural substrates such as manures, slurries and crops, and only about a quarter use food and industrial wastes.

a. Brief description of development of biogas market

In 1989, electricity generation in the UK was privatized. Within the so-called Electricity Act the Non-Fossil Fuel Obligation (NFFO) was introduced in order to support nuclear power generators, which were state owned. However, in 1990 it expanded to include the first renewable generation.

Several subsidies for renewables were introduced in the following years:

The Renewable Heat Incentive (RHI) provides a fixed income (per kWh) to generators of renewable heat, and producers of renewable biogas and biomethane. AD facilities completed after 15 July 2009 are eligible for the RHI. The lifetime of the tariff is 20 years.

In 2002 it was superseded by the Renewables Obligation (RO) in England and Wales and in different forms in Scotland (2002) and in Northern Ireland (2005). The Renewables Obligation (RO) was the main support scheme for large-scale (> 5MW) renewable electricity projects in the UK. A Renewables Obligation Certificate (ROC) was a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. Anaerobic digestion was among the technologies that received additional support in the form of multiple ROCs. In England, Scotland and Wales an anaerobic digester could receive 2 ROCs/MWh until April 2015, reducing to 1.9 ROCs/MWh for 2015/16 and 1.8 ROCs/MWh in 2016/17. The value of ROCs varied (NNFCC 2020).

From 2010 to 2019, Feed-in Tariffs (FITs) provided a guaranteed price for a fixed period to small-scale electricity generators in England, Scotland and Wales. FITs were intended to encourage the provision of small-scale low carbon electricity. Only AD facilities with less than 5MW capacity, completed after 15 July 2009, were eligible for FITs. The Government offered preliminary accreditation for AD, with a guarantee that the project would be eligible for the tariff payable at the time of accreditation. Each tariff runs for 20 years. There were two elements to the scheme; the generation tariff for every kWh of electricity generated, and the export tariff for every kWh of electricity exported to the national transmission network. From April 2014, a flexible degression mechanism was introduced to control costs; this is set at a baseline of 5% per year but can accelerate (to 20%) or decelerate (to 0%) based on annual accredited and pre-accredited capacity.

The Renewable Heat Incentive (RHI) was introduced in 2011 and provides a fixed income (per kWh) to generators of renewable heat, and producers of renewable biogas and biomethane. AD facilities completed after 15 July 2009 are eligible for the RHI. The lifetime of the tariff is 20 years. The level of tariff depends on the technology in use, and the date of accreditation. In April 2013 DECC implemented a transparent budget management mechanism in the non-domestic RHI scheme, called degression.

The budget for RHI has been confirmed up to 2020, but with a substantial reduction in the budget which is intended to restrict its growth.

From April 2013, Carbon Price Floor (CPF) was introduced in Great Britain. The tax applies to fossil fuels used for electricity generation. Renewable electricity is exempt from paying this tax.

In 2014, the Contracts for Difference (CfD) scheme was introduced for generators of 5MWe and above in England, Scotland and Wales as part of the Electricity Market Reform; new generators have the option to claim the RO or the CfD. After 2017 the RO closed to all new generators.

From October 2015, Sustainability reporting for solid and gaseous biomass plants is mandatory.

The Renewable Transport Fuel Obligation (RTFO) requires suppliers of fossil fuels to ensure that a specified percentage of the road fuels they supply in the UK is made up of renewable fuels. Biomethane is eligible for Renewable Transport Fuel Certificates if it is dutiable and produced wholly from biomass. Until recently there have been poor incentives for gas to transport, and this sector has only developed in transport fleets, however these is supposed to improve under the RTFO scheme, and some expansion is expected.

The Environment Agency enforces regulatory standards including digestate spreading, handling of wastes, emissions and safety.

There are still organic waste volumes remaining for AD use in the UK, however, feedstock accessibility (especially for household waste) remains a major barrier to further industry development. Some progress has been made over recent years to improve access to food waste. Source segregation of food waste became mandatory for many businesses in Scotland under The Waste (Scotland) Regulations 2012. Meanwhile, Northern Ireland banned food waste from entering landfill in April 2015, with separate collections mandatory for Councils from April 2017. However, despite these developments only around half of all UK District Councils currently provide a food collection service for households, with England Councils especially low at below 30% (NNFCC 2020). With current austerity measures enforcing Council cuts to be made across the board, it appears unlikely that further improvements in food waste collection will be made in England for the foreseeable future.

b. Success factors

In the United Kingdom there are several financial support measures for biogas / biomethane. As in all other countries, the level of remuneration is decisive for the success. It must be chosen in a way that it is possible for the government to finance it over a long period of time, it should be high enough to induce a market development but also not overcompensate.

c. Barriers

However, barriers to grid connections for biomethane plants are significant. Access to gas and electricity grids continues to be hampered because of capacity restrictions, technical issues and high costs with little incentive for network operators to improve conditions. Renewable energy sources are not given priority. Using biomethane as a transport fuel represents the most carbon effective use of biogas, according to studies, but government policy is not currently effectively supporting this use through the RTFO.

High costs and regulatory complexity have made grid connection difficult for many plants. Although injection to the gas grid is one of the most efficient uses of biogas, only two plants are currently connected. Amendments to the gas regulations – already being contemplated – such as increasing the volume of oxygen biomethane may contain and relaxing inappropriate requirements on calorific value measurement would make a major difference, as would

introducing functional specifications for grid connections to standardize connection requirements and open them up to competition.

Putting the RTFO on parity with the RHI will mean that biomethane producers will be better incentivized to go down the transport route where this is viable rather than choosing grid injection, which is the most logical option at present. Government should also give a clear steer to local authorities to encourage them to use biomethane vehicles in bus fleets and refuse collection vehicles.

In addition, there is much food waste available but no uniform system of its collection throughout the country.

III. Other European countries

The report on the four countries above described in some detail the building of a biogas / biomethane market. However, there are other countries in Europe that did not develop such markets and some that developed smaller but successful markets. Why is that so?

There are different reasons for this. Some European countries were hit so hard by the economic crisis in 2008 that they made retroactive changes in biogas support systems or stopped promotion of renewables altogether, for example Greece and Spain. Others feared for their energy security and continued using fossil fuels like Poland. In many countries, there is much food waste available but no uniform system of its collection throughout the country – so it cannot be used for biogas production. In the following, there are some details about the situation in different EU countries. Since naming all countries would exceed the dimension of this report, only examples will be named.

(1) Brief description of biogas market development

Greece was hit very hard by the economic crisis in 2011. As a result, financing and investments, including those into renewable energies, have suffered. As of late 2017, 37 biogas plants are running in Greece of which 30 are landfill or sewage gas treatment plants. Since 2016, there is a FIT in Greece. The 20 years state-fixed feed-in tariffs are anchored in law 4414/2016. There are two different tariffs according to installed capacity of the power plant and its substrate. For fermentable waste and organic sewage sludge from wastewater treatment, the tariff is between 10.60 - 12.29 cents per kWh. The other tariff is for organic residues and wastes from livestock and agriculture, the FIT is between 20.40-22.50 cents per kWh. However, social acceptance is sometimes low. (IBBK 2019). Until now, the biogas sector is still in its infancy.

Spain has only one renewable gas injection plant in the network, and one in planning. This is due to the inefficiency and high cost of this type of service. While Spain had very generous regulations on incentives for wind and photovoltaic energy, biogas was discriminated, where public incentives for electricity production were 35% lower than in other European countries. This, together with the difficulties of developing profitable energy crops due to the scarce rainfall in the country, led to the slow development of the sector, with only 50 anaerobic digestion plants. As the economic crisis hit Spain also hard, the authorization of new installations in primary regime of electrical production cancelled (Royal Decree 1/2012). Moreover, the limited existing incentives for plants in operation were reduced by more than 25%. Subsequently, and coinciding with the 2008 economic crisis, legislation on on-site energy generation became very restrictive, with levies and obstacles imposed that made it difficult to generate electricity from biogas. For example, a ban on generating electricity for both on-site use and injection to the electricity grid, created a climate of fear around investing in on-site generation. That stopped the development and the implementation of this technology. In addition to the economic problem, the lack of a standardized procedures for the design of systems and prediction of the amount of biogas produced also brings uncertainty and mistrust in this technology, along with the difficulties of obtaining authorizations for the construction of new plants (Vitale 2019).

However, the political climate is changing. It is now possible to both generate energy on-site and be connected to the grid. Although specific support measures are still lacking, the current government is taking a more favourable approach to renewable energy, including biogas. Ministers recognize that biogas is critical for Spain to meet the requirements of the Paris

Agreement. Not only providing clean and renewable energy, but also circular economy benefits like effective waste management and the production of natural fertilizer from digestate.

As a result of this change in policy support, the gas sector is now willing to buy biogas and even finance the facilities for its production. Furthermore, the automotive sector has seen a 112% increase in the demand for vehicles powered by compressed natural gas (CNG), which can be derived from biogas. Even though there are only 50 gas refuelling stations in operation around the country, this number is set to double (Butler 2018).

By now there is still no stable regulatory framework, with incentives for renewable gas development projects. In 2020 there are supposed to be new announcements: an approval of regulatory measures for biogas and renewable gas and the development of specific incentive measures from the Institute for Diversification and Saving of Energy (IDEA) and other national and regional agencies (Fernández 2019). It is too early to judge the measures but by now the biogas sector is still just getting started.

The biogas sector in **Portugal** is also not very advanced, it produced only 90 MW for electricity production in 2018. So far, biogas has been used exclusively for electricity and the thermal energy has not been used (AHK Portugal 2018).

There are some countries that started promoting renewable energies like **Poland**. However, the pressure of the big energy providers is big. Since 2015, the government emphasizes national energy security as their priority and tries to keep to their fossil-based energy system. German difficulties with the integration of renewables into the grid and missing capacities of grid connections serve as a warning in Poland (Heinrich-Böll-Stiftung 2018). It fears cost explosions.

The Eastern European Countries like Romania, Bulgaria, Slovenia and others have quite a potential for biogas. Nevertheless, due to the existing bottlenecks in permitting procedures the establishment of agricultural biogas plants requires considerable time, which results in a slow market development. In countries with very small biogas markets (e.g. Romania, Bulgaria, Croatia, etc.), there is an urgent need to provide additional support to improve the framework conditions.

In **Romania** the pace of growth was slow until 2010, when the green certificates incentive system started. For over 10 years, Romania has applied a green certificates support scheme that covers projects commissioned until the end of 2016. Biogas received up to four green certificates per MWh, depending on the type of feedstock (energy crops were incentivized) and utilisation (CHP is incentivized). Romania did not support heat production from biogas other than the by-product of electricity generation in CHP plants. There is no incentive or legal framework for upgrading to biomethane and for the injection of biomethane in the national gas grid. In Romania, the level of support was enough to make most investments profitable. However, the scheme has undergone numerous changes that substantially reduced the original support, leading to a steep decline in investor confidence. On 18 March 2019, the Romanian Ministry of Energy put forward for public debate a document outlining a new mechanism for supporting low-carbon electricity generation, in the form of a Contract for Difference (CfD) scheme. Access to the scheme will generally be based on auctions (Cojocaru 2019). However, the permitting procedures for biogas projects are quite complicated. There is also considerable potential for biogas production from landfill waste and wastewater treatment plants. Many Romanian municipalities lack modern wastewater treatment facilities. With proper regulation and stable incentives in place, it should be possible to trigger investments in biogas production from both landfill and wastewater treatment plants in most of Romania´s municipalities. Biogas production in Romania will probably not overtake liquid biofuels, solar or wind power generation in the energy mix, remaining a marginal domestic source of energy supply (Tâlvescu 2017).

The Nordic countries, however, were quite successful in promoting biogas or biomethane.

In **Denmark**, the biogas sector developed through the 80's and 90's in a small way. For the Danish biogas industry, the real game changer was the adoption of the "Energy Agreement" in 2012. The new legislation introduced a feed-in-subsidy for injection into the gas grid. With access to the gas grid a series of larger biogas plants was constructed. These grid-connected biogas plants are typically developed by large energy corporations. By the end of 2018, there were more than 90 manure-based biogas plants in operation in Denmark, and 24 of these are upgrading biogas and injecting biomethane into the gas grid. The current subsidy scheme for biogas injected to the natural gas grid consists of three feed-in premiums (FIPs). All premiums are adjusted annually in January.

In 2018, a new subsidy scheme was introduced which will come into force in 2020 for new biogas plants. This new scheme will use auctions - there will be an annual subsidy pool to be allocated to the best bids. This scheme will put a quantitative limit to the deployment of new biogas plants. With this tender-based subsidy scheme, biogas production is expected to develop more slowly.

The main new requirement is that the biogas plant does not use more than 12% energy crops, measured in weight. A problem with the current subsidy scheme is that it is very difficult to control and predict the financial costs of the subsidy scheme as the sector develops. Consequently, the cost of the subsidy has increased past DKK 1.6 billion (EUR 215.4 million) in 2017. The Danish Parliament became increasingly concerned that the costs of the biogas subsidy scheme would go out of control. The new subsidy scheme, relying on a fixed annual pool of DKK 240 million (EUR 32 million), is a direct response to this growing concern (ISIC 2019).

How to best use biomethane is much debated – many prefer the use in the transport sector. However, the policies which should enable this utilization do not exist yet. On the contrary, taxes on bio-CNG vehicles were increased recently. In addition to this, the national Government has presented in 2019 a policy plan which will forbid new bio-CNG shuttle busses from 2025, by only allowing new zero-emissions buses. Another issue is that the tax system does not allow a distinction between biomethane and natural gas as soon as it has first entered the natural gas system. Bio-CNG as a vehicle fuel is thus taxed as natural gas, at a higher rate than fossil diesel. As a result of this, biogas and biomethane is used primarily to produce heat and power (ISIC 2019).

Sweden uses its biomethane primarily in the transport sector. There are tax exemptions from energy and carbon dioxide taxes for biogas. In 2015 these were prolonged to 2020, but what will happen after that is not clear. There was a 40% reduction of income tax for use of company Natural Gas Vehicles (NGVs) until end of 2019. There were investment grants for marketing of new technologies and new solutions for biogas during 2010-2016. Until the end of 2018 there was a so-called climate investment grant for municipalities. In addition, there is a joint electricity certificate market between Norway and Sweden. The producer gets one certificate for every MWh electricity produced from renewable resources and electricity consumers must buy certificates in relation to their total use. There is a bonus of 0.43 cent/kWh for manure-based biogas production to reduce methane emissions from manure till 2023 (IEA Bioenergy 2016).

These examples all show how diverse the biogas promotion in Europe is. It depends not only on the financial systems but also on other regulatory frameworks.

(2) Success factors and barriers

All in all, it can be said that barriers in all these countries differ but can be summarized as follows:

- Financial support not enough or missing
- Regulatory framework missing
- Complicated procedures
- Unclear competences
- Non-functioning administration
- Missing political will
- Missing public support
- Sudden change in support systems
- Inflexible approaches lead to high financial costs

Without suitable framework conditions, including legislation with feed-in tariffs and willingness of politicians, only very small (if any) developments can be achieved. Even in countries with established biogas markets, non-technical support is needed. Bioenergy, including biogas and biomethane, are facing continuous criticism. Therefore, there is a need to improve the biogas value chains in order to positively influence the public perception. This includes for example the reduction of environmental hazards and improvement of plant safety, increase of efficiency (heat use), as well as public consultation for new projects.

IV. Summary and Recommendations

Renewables policy performance depends on several key factors including financial sustainability, adequate infrastructure, good and competent administration, clear proceedings, standardization and clear interconnection rules. If one is missing, the market might not develop. On the other hand, if support mechanisms, like FIT, are too high it has the consequence of very fast development. The downside could be high social costs, due too much money spent for FIT and some needed adaptions of legal requirements might be lagging behind the development. So careful settings are necessary.

(1) Climate goals

Uncertainty and inconsistency about targets and policies, including retroactive changes, significantly hamper renewable energy expansion, as support schemes or procedures that are unclear lower confidence amongst investors. Clear national or regional goals are decisive. The government must have a vision or clear objective where renewables are supposed to stand at a certain date and which sector to develop in what way. As seen in the countries' examples, the setting determines whether biomethane as transport fuel or biogas for electricity will be established. Clear and long-term goals also offer investment security and make stable conditions possible that are favourable for long-term development of a market. Retroactive changes must be avoided at all circumstances as they undermine trust in the long run.

(2) Feed-in tariffs or feed-in premiums vs. tendering

Through a FIT the legislator determines a remuneration for a certain period (often up to 20 years) depending on the type of plant. This provides a high level of investment security and is seen as an ideal mechanism for bringing technologies to market maturity. However, due to limited up-front knowledge regarding the cost structures of the projects, an appropriate determination of the subsidy rate is a great challenge for the legislator. The development "on ground" must be monitored, compared with the governmental targets and several other regulations should be adapted to ensure a sane development according to the targets.

Important for the design of a FIT is that it must be fitted to the region where it is used. A tailor-made approach is necessary that reflects the local market and institutional settings. It is also a dynamic process; most FIT policies have required successive adjustments in various countries in order to correct unintended consequences as, for example, the increase of use of food and feed crops in Germany that led to a lesser acceptance of biogas plants. One of the most important lessons learned from the FIT experience is that enough flexibility must be built into the rules to ensure that prices adapt to changes in the market, while still offering the security that investors need. A tariff-based incentive must ensure favourable tariff rates that guarantee investors income that covers costs and additional return on capital enough to motivate investment. The price should be guaranteed for a specific period reflecting the cost of investment, usually around 20 years. A FIT may also be necessary to overcome barriers in the banking sector. Regulatory oversight of FIT programs is essential. Feed-in premiums (FIP) however, are a good method to bring renewables closer to a competitive status if the market is already under development.

However, tendering, by which investors compete for a project through a competitive bidding system initiated by a government department or agency, is rarely suitable for the development of a market. It is very difficult to design the auctions in a way that guarantees enough covering of investments costs (BKIR 2020). Additionally, many stakeholders in the biogas market and

biogas plant operators are farmers. A FIT system is relatively easy to understand and implement. Offers within a tender system are more complex and many farmers fear the administrative burden for such procedures. If tenders are used the projects tend to be big centralized ones because bigger players can more easily cover the costs for the applications. However, energy transition in Germany, for example, is supposed to be decentral thus giving rural areas possibilities to develop and help farmers to stabilize their income. Thus, auctions tend to run against this principle of decentralization.

(3) Greenhouse gas emission reductions

Now there is a huge opportunity as lots of developing countries must define their Low Emission Development Strategies and Nationally Appropriate Mitigation Actions (NAMAs) to fulfil their National Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC). In the European Union the National Energy and Climate Plans (NECPs) are the new framework within which EU Member States must plan, in an integrated manner, their climate and energy objectives, targets, policies and measures. The NECPs are mandatory under the new Governance Regulation (EU 2018) from the European Union. If countries have clear goals of reducing greenhouse gas (GHG) emissions, there are also good possibilities to provide support for renewables over a CO_2-reducing system. This can be a CO_2 price or a quota obligation for reducing GHG emissions.

The greenhouse gas quota used in Germany commit the oil industry to reduce their GHG emissions by 6 % every year; if they do not fulfil this quota, there is a fine to pay. With this system, it is important that the fine is so high that the utilities do everything to fulfil the GHG quota. Furthermore, it is important that the quota is high enough to induce further development within the renewables. The GHG quota has the advantage that it is technology neutral. With this as with FIT it is necessary to carefully think about the setting of the quota in detail. More important, science-based greenhouse gas calculation methods must be developed that cover GHG balances from Well-to-Wheel. It is also necessary to have accurate fossil fuel comparators in order to set the reference right.

Another method of support would be a high CO_2 price. The advantage is that it is technology neutral. However, it is necessary to set a floor price in order to avoid a price too low to induce any investments in renewables. The European Emission Trading System (EU ETS) was non-functioning for years because no floor price was set. With this, it is also important to set good data that encompass all GHG emissions within the renewable pathways as well as the fossil fuel ones that are set as comparator.

(4) Regulatory framework

It is vital to establish a regulatory framework before implementing the polices. Clear rules for interconnection and cost distribution must be in place. Also, competences must be clearly distributed, and a uniform application of rules must be ensured. In addition, policy interaction and compatibility need to be considered because complex interactions among programs and unintended effects can reduce the net benefits of the programs (BKIR 2020). It is especially important to give renewables projects access to the grid - the electricity network or the natural gas grid in case of biomethane. Network operators must be obliged to grant access to the grid for every facility with no undue costs. In addition, it is necessary to have feed-in priority for renewables over fossil fuels in order to guarantee their selling.

In addition, technical specifications must be standardized and clear rules for emission and handling of digestate must be made. All in all, the goal of renewables promotion is to reduce GHG emissions and enhance environmentally friendly technologies in order to solve energy problems with fossil fuels and combat climate change. Thus, it is vital to control the plants and their emissions and to ensure a safe and environmentally friendly operation.

Loan guarantees and tax incentives may also be helpful of pushing a market. Loan guarantees can especially address difficulties with the banks. Often, if technologies are new, banks are not keen on financing them without additional securities. However, without access to enough funding, projects will not be realized.

V. Outlook

In the long-term, policy makers should make sure that renewable energy technologies can operate in the energy system on a level playing field with other technologies. Thus, innovation will be facilitated, and supply and consumption of renewable energy can take place in all end-uses. It is necessary to plan well ahead, and to integrate exit strategies from fossil fuels already in advance. If investment periods of 30-40 years for fossil fuel-based projects are considered, it is vital to stop supporting such projects in time in order to avoid stranded investments. In order to keep investor's confidence and to reach sustained growth long-term targets must be anchored. However, policies need also to be flexible, to continuously adapt to changing market conditions, to achieve cost-competitiveness and to integrate renewables into the system. Often there is still a lack of adequate funding opportunities and financing products for renewables (IRENA 2018). This has different reasons: either financing is not available, suitable financial instruments are difficult to access or institutions or administration have a lack of knowledge. With increasing shares of renewables, grid integration can be challenging. This also must be planned well ahead; the grid infrastructure must be adapted in time or even be upgraded in order to avoid curtailment of renewable energy. In addition, a lack of district heating or adequate cooling infrastructure hinders progress in the heating and cooling sector, and the absence of appropriate engines in vehicle fleets hampers the deployment of biofuels in the transport sector, for example biomethane use if there are no natural gas vehicles running. Institutional and administrative barriers must be removed; institutions and authorities must be trained in renewables in order to achieve success. Responsibilities must be clearly defined, and licensing procedures must be simplified. Clear rules for land acquisition must exist, well-balanced planning guidelines are needed and permitting processes must be transparent and fast. Public acceptance is vital, otherwise projects may not be realized due to strong protests on site. A lack of public acceptance can lead to higher costs, delays and even to the cancellation of projects. In addition, fossil fuel prices must be high enough in order to push renewable fuels, especially in the heating and transport sector (IRENA 2018).

All in all, it is wise to exchange views with countries that successfully promoted renewable energies to avoid their mistakes and to learn from the experiences. It must be examined in what way the own country differs, what specific conditions there are, how the country is structured and what transfers can be done and cannot be done.

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