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ENERGY PRODUCTION FROM BIOGAS: COMPETITIVENESS AND SUPPORT INSTRUMENTS IN LATVIA

G. Klāvs, A. Kundziņa, I. Kudrenickis,

Institute of Physical Energetics, 21 Aizkraukles Str., Riga, LATVIA
e-mail: energy@edi.lv

Use of renewable energy sources (RES) might be one of the key factors for the triple win-win: improving energy supply security, promoting local economic development, and reducing greenhouse gas emissions. The authors ex-post evaluate the impact of two main support instruments applied in 2010-2014 – the investment support (IS) and the feed-in tariff (FIT) – on the economic viability of small scale (up to $2MW_{el}$) biogas unit. The results indicate that the electricity production cost in biogas utility roughly corresponds to the historical FIT regarding electricity production using RES. However, if in addition to the FIT the IS is provided, the analysis shows that the practice of combining both the above-mentioned instruments is not optimal because too high total support (overcompensation) is provided for a biogas utility developer. In a long-term perspective, the latter gives wrong signals for investments in new technologies and also creates unequal competition in the RES electricity market. To provide optimal biogas utilisation, it is necessary to consider several options. Both on-site production of electricity and upgrading to biomethane for use in a low pressure gas distribution network are simulated by the cost estimation model. The authors' estimates show that upgrading for use in a gas distribution network should be particularly considered taking into account the already existing infrastructure and technologies. This option requires lower support compared to support for electricity production in small-scale biogas utilities.

Keywords: *biogas, electricity production, energy production price, investment subsidies, feed-in tariff.*

1. INTRODUCTION

Taking into account the contribution of renewable energy sources (RES) not only to the reduction of greenhouse gas (GHG) emissions but also to enhancing energy security and promoting national economy, the extensive use of RES is one of the energy policy priorities in the EU on the whole and in Latvia, in particular. It is essential to meet the GHG emissions reduction target within both the EU 2020 Climate and Energy Package and the new EU 2030 Framework for Climate and Energy [1].

Today Latvia is definitely on the way of reaching the RES 2020 target (at least 40 % of the total gross final energy consumption (GFEC) from renewables);

namely, in 2014 the renewable energy accounted for 38.65 % of the total GFEC [2], according to the latest data, it amounted to ~172 PJ [3]. Regarding the contribution of different RES to total renewable energy, solid biomass accounted for 77.85 %, hydroenergy (normalised for annual variation) – 16.40 %, biogas ranked third with 3.60 %. As far as the RES target components are concerned, in 2014 the share of renewable energy was 52.19 % in heating and cooling (planned in 2020 – 59.8 %), 51.09 % in electricity consumption (planned in 2020 – 53.4 %) and only 3.23 % in transport (planned in 2020 – 10 %) [2].

Thus, we see that the RES ratio is high in the electricity sector. In the period of 2010–2015, RES capacity in Latvia grew by ~10 % (from 1622 MW_{el} to 1784 MW_{el}) and 30 % of this increase was related to biogas technologies. The total electrical capacity of biogas technologies has increased from 11 MW_{el} (2010) to 60 MW_{el} (2015), and it is mainly due to actively introducing biogas technologies in the agriculture sector [4].

Although electricity produced from biogas for the time being still makes up a small fraction (~5 %) of the electricity consumed, a variety of benefits might be reached owing to biogas utilisation. The issue under consideration should be the sustainability of national biogas policy allowing for the implementation of biogas capacities without the negative side effects such as exaggerated support to biogas and the risk of market distortion.

The policy implemented in Latvia in the 2007–2013 planning period provided that the electricity producer who used biogas could receive both the feed-in tariff (FIT) and the support investment within the framework of the national Rural Development Programme (RDP) [5] co-financed by the European Agricultural Fund for Rural Development. The simultaneous availability of both support instruments vitally promoted the implementation of biogas technologies in the agriculture sector. In 2014, biogas production reached 3.136 PJ, including biogas produced in the agriculture sector – 2.688 PJ, landfill gas – 0.355 PJ and sewage sludge gas – 0.093 PJ (for comparison, in 2008 the production of all types of biogas was only 0.369 PJ). In 2015, 49 biogas plants with the total capacity of ~50 MW_{el} operated in the agriculture sector, which, within the procedure of FIT, sold to the national grid ~316.5 GWh renewable electricity [6]. Thus, the average electrical capacity of single biogas plant operating in the agriculture sector in Latvia is relatively high ~1MW_{el}, being in the interval of 0.21–2.4 MW_{el}. To compare, in Germany the average electrical capacity of biogas plant in the agriculture sector is ~330 kW_{el} [7]. In the Latvian situation, biogas plants, largely developed as a separate activity of the agriculture sector, are mainly based on the use of dedicated energy crops for biogas fermentation. It has caused significant increase of areas sown under maize: in 2011–2015 the areas sown under maize have more than doubled (in 2005 – 2.9 thsd ha, in 2011 – 11.3 thsd ha, in 2015 – 25.6 thsd ha) [8].

At present, new rights to sell electricity through the FIT programme are not being granted and a topical issue is the development of new legislation for promoting renewable electricity that ensures compliance with the principles set in the Communication from the European Commission 2014/C200/01 [9]. The research below presents an ex-post evaluation of the Latvian support scheme in relation to biogas production development and effective utilisation of it both from private investors' point of view and optimal use of state resources. To determine the optimal support for promoting biogas production, a cost estimation model has been simulated both for on-site production of electricity and upgrading to biomethane for use in a low-pressure gas distribution network.

2. FEED-IN TARIFFS FOR BIOGAS ELECTRICITY

Two Regulations of the Latvian Cabinet of Ministers (CMR) provide for the application of FIT for the existing plants. Out of all biogas plants operating in the agriculture sector, 30 (total electrical capacity ~30.5 MW_{el}) operate under the CMR regarding electricity production utilising RES [10] and 19 (total electrical capacity ~19 MW_{el}) operate under the CMR regarding electricity production in combined heat-power (CHP) mode [11].

The Regulations [10] determined FIT depending on unit capacity: $FIT = 188 \cdot k$ for the first 10 years after starting the operation of the unit (k - differentiating coefficient, varies within the range from 1.24 for units with electrical capacity of 0.08 MW_{el} and to 1.008 for units with electrical capacity of 2 MW_{el}); for the next 10 years FIT is decreased by 20 % ($FIT = 188 \cdot k \cdot 0.8$).

In the case of [11], the FIT depends both on unit capacity and the end-user natural gas tariff T_g approved by the Public Utilities Commission, $FIT=(T_g \cdot k / 9.3)\cdot 4.5$. T_g depends directly upon the purchase price of natural gas (PPNG) at the border [12] and it is different for different groups of end-users depending upon the consumption volume of natural gas. The Amendments of [11], adopted in August 2013, introduced the 10-year limit for FIT application. This provision will be in force from 1 January 2017. It can be concluded that the instability of FIT due to the dependence on natural gas price turned out to be one of the main disadvantages, e.g., in the period of October 2008 – April 2014 the highest and lowest PPNG differed more than twice [13]. The Amendments of [11], adopted in April 2014, introduced the maximum value of PPNG applied for FIT calculation – 277.46 EUR/1000 m^3.

The biogas plants operating in the agriculture sector were launched after 2010 and in compliance with the above CMR they would maintain their rights still for a long time. To find a legally correct solution for optimising the present FIT scheme and avoid overcompensation, in 2014 the Subsidised Electricity Tax Law was adopted [14]. In the summer 2016, the Cabinet of Ministers adopted new Amendments to both CMRs introducing a special coefficient to avoid overcompensation as well as revoked the link with the end-users' natural gas tariff. The evaluation presented in this article is based on the FIT support scheme prior to the adoption of these Regulations.

3. METHODOLOGY OF ASSESSMENT

The calculated costs of biogas produced in the agriculture sector set the basis for the objective of the research, which is to find the most competitive and for the state support most efficient solution for biogas use. The research presents a comparative analysis of two solutions: 1) on-site production of electricity and (2) upgrading to biomethane for use in a low-pressure gas distribution network. The methodology is based on the mathematical modelling and analysis of key parameters determining the price of biogas and the produced end product.

Investment cost, raw material cost and operation cost are taken into account in the calculation of biogas production costs. Investment cost and operation cost (Table 1) are based on average values, which are obtained from analysing the information about biogas technologies used in Latvia and other European countries [15]–[22]. The calculation is performed for a 10-year period; the IRR for the period is 10 %. The algorithm is provided to calculate both the costs of biogas volume and electricity production for the capacities of 250 kW_{el}, 500 kW_{el}, 1000 kW_{el} and 2000 kW_{el} of an electricity generation utility (internal combustion engine).The utility annual operation is presumed to be 7000 hours.

The model proceeds on the assumption that biogas is produced from dedicated energy crops, primarily maize, and the cost of this raw material in Latvia is 25 EUR/ton [23]. The assumed cost of the raw material is slightly lower than that used in calculations in other EU countries, where it ranges between 31–35 EUR/ton (e.g., [8], [15]).

When assessing on-site production of electricity, in the modelling only the income from electricity sales, according to FIT, is taken into account, but not the income from the sale of thermal energy. Such an approach is due to the limitations in the use of thermal energy.

When assessing upgrading to biomethane for use in a low-pressure gas distribution network, the model presumes that the investment cost for building the gas pipeline and necessary connection [24] amounts to average 1000 EUR/m and in all cases the gas pipeline is built of equal length (500 m).

Table 1

Assumptions of Technical and Financial Data for Biogas Equipment

Installed electrical capacity, MW_{el}	0.25	0.50	1.00	2.00
	Biogas production equipment			
Specific investments, 1000 EUR/MW_{el}	3785	2990	2590	2290
Specific annual operational costs, 1000 EUR/MW/year	670	626	603	593
	Internal combustion engine			
Specific investments, 1000 EUR/MW_{el}	946	747	647	498
Specific fixed operational costs, 1000 EUR/ MWh	25	25	25	25
	Biogas upgrading to biomethane facility			
Specific investments, 1000 EUR/MW_{el}	1765	1395	1210	1070
Specific fixed operational costs, 1000 EUR/ MWh	12.7	10	8.7	7.7

FIT values are calculated according to the formulae above as defined in CMR [10] and [11]. It is essential to compare FIT values and electricity market price. According to the Nord Pool Spot information, in 2015 the average electricity market price in the Latvian price region was 41.8 EUR/MWh. Figure 1 clearly reveals that the FIT value was essentially, about 3–4 times, higher than the electricity market price.

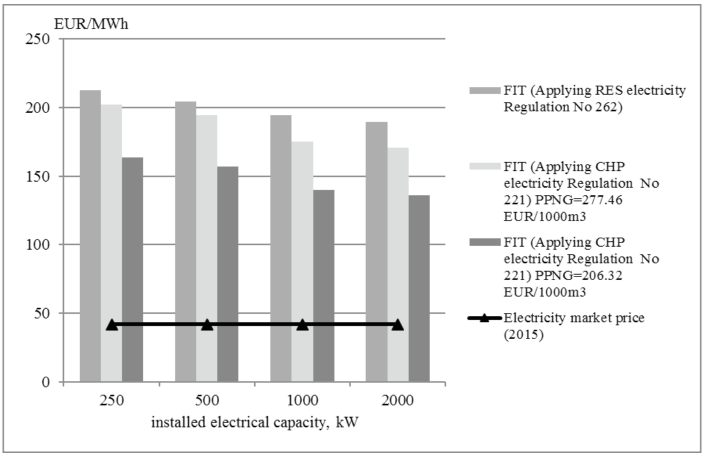

Fig. 1. Comparison of feed-in tariff and electricity market price: a case of Latvia.

4. RESULTS AND DISCUSSION

At first, the biogas production cost was compared with the price of natural gas for end-users with the annual consumption within the range of 1.26–12.6 Mm^3 that corresponded to the installed electricity generating utility with the capacity of 0.7–7 MW_{el}. Figure 2 reveals that the cost of biogas produced in the agriculture sector is high, and the difference is most outspoken with the biogas production equipment of smaller capacity.

In its turn, the biogas production equipment that ensures the required volume of biogas for 2 MW_{el} electricity generating utility is the approximate margin when the production cost of unpurified biogas and the price of natural gas for end-user become comparable upon the condition that PPNG is ~327 EUR/1000m^3. If PPNG is 277.46 EUR/1000 m^3 (corresponds to the maximum PPNG value in the FIT calculation, see above), the biogas production cost also in such 2 MW_{el} biogas production utility considerably exceeds (for more than 7 EUR/MWh) the price of natural gas for the end-user.

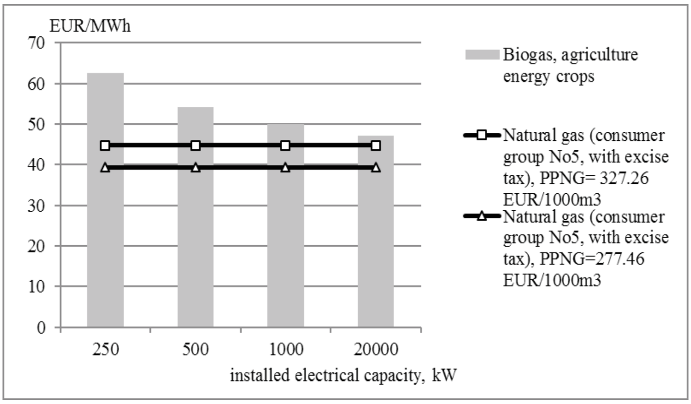

Fig. 2. Comparison of biogas costs, produced from agricultural energy crops, and natural gas end-use tariff.

Figure 3 provides the comparison of the upgraded to biomethane biogas production cost with the above-mentioned price of natural gas for end-users. It reveals that for low-scale plants the production cost of upgraded to biomethane biogas per 1 MWh is considerably higher, as well as the specific costs (per 1 MWh) are considerably higher for the connection to a natural gas network.

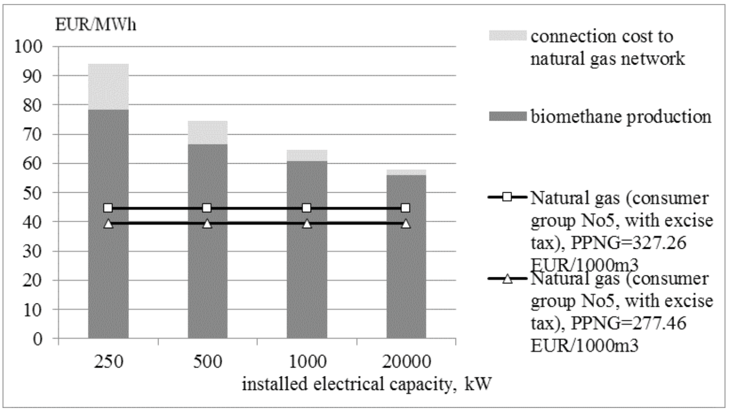

Fig. 3. Comparison of biogas cost, produced from agricultural energy crops and upgraded to biomethane for use in low-pressure gas distribution network, and natural gas end-use tariff.

In the final stage of the research, the electricity generation cost at a biogas plant and FIT values were compared. Figure 4 describes the situation if FIT is the only applied support instrument. The following conclusions may be drawn from the modelling results:

RES electricity [10] FIT value exceeds electricity generation cost at biogas plants with the electrical capacity above 1000 kW_{el}, at the capacity of 500 kW_{el} the electricity generation cost and FIT are practically the same; however, electricity generation cost at low-scale (~250 kW_{el}) biogas plants is higher than RES electricity FIT.

CHP electricity [11] FIT value, calculated at the highest historically PPNG=327 EUR/1000 m^3, considerably exceeds electricity generation cost at biogas plants with the electrical capacity above 500 kW_{el}, but does not exceed at low-scale (~250 kW_{el}) biogas plants. When setting limitations for CHP electricity FIT, the calculated FIT value at PPNG=277.46 EUR/1000m^3 is lower than electricity generation cost at all biogas plants of all the described range of capacities.

The modelled results clearly notify of a critically different situation if the owner of biogas equipment had a chance to use the RDP investment support [5] and sell electricity under FIT. Figure 5 compares FIT values with the modelled electricity generation cost at a biogas plant that has received the maximum 40 % of investment support. The following conclusions may be drawn from the modelling results:

Using RES electricity under FIT, support to biogas plants exceeds the generation cost by 25–40 EUR/1 MWh, depending upon the installed electrical capacity (the higher the capacity, the greater the difference between the generation cost and FIT).

Even at the set PPNG limitations for CHP electricity FIT, the calculated FIT value (at PPNG=277.46 EUR/1000m^3) exceeds the generation cost by 25–27 EUR/MWh.

Consequently, it implies that in the case of combined support (investment support and FIT) when FIT values considerably exceed electricity generation cost the intensity of the applied support mechanism is too high.

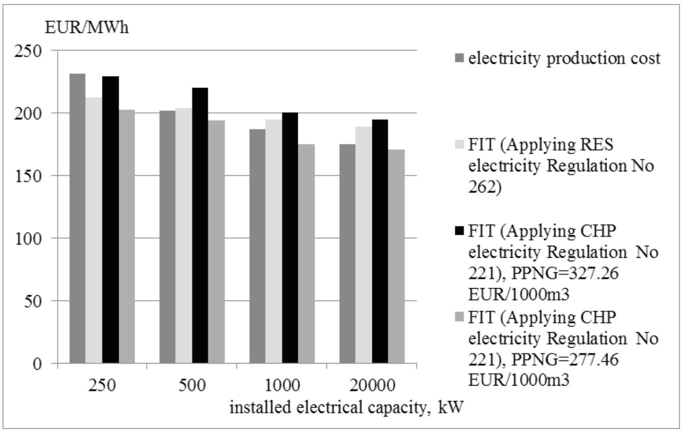

Fig. 4. Comparison of electricity production cost (without investment support) and feed-in tariffs.

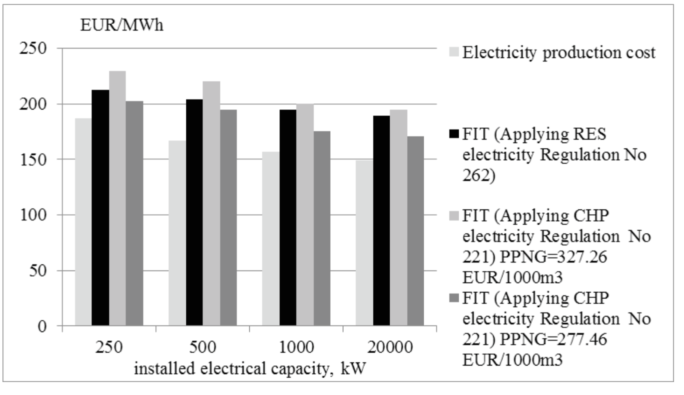

Fig. 5. Comparison of electricity production cost (with additional investment support 40 %) and feed-in tariffs.

When assessing the economic basis for different ways of biogas use, the calculation was performed for two options to find out the difference between: (1) electricity generation cost at biogas plants and electricity short-term marginal cost at natural gas CHP (condensing mode), (2) upgraded biogas cost and natural gas end-users' price (at PPNG=277.46 EUR/1000m^3) both expressed as fuel components for the generated electricity with effectiveness ratio of 55 %; investment support were not considered in the present research.

Figure 6 reveals the necessary support for each of the ways of biogas use. It shows that smaller subsidies are necessary for biogas upgrade to biomethane for use in a low-pressure gas distribution network than for electricity generation at small-scale biogas plants. When analysing the results, it should be taken into account that this upgrading may require bigger subsidies if the biogas plant is located farther away from the natural gas network and larger investments are needed for building a longer gas pipeline. If the natural gas price drops, the subsidy amount increases for injecting biogas in a natural gas network.

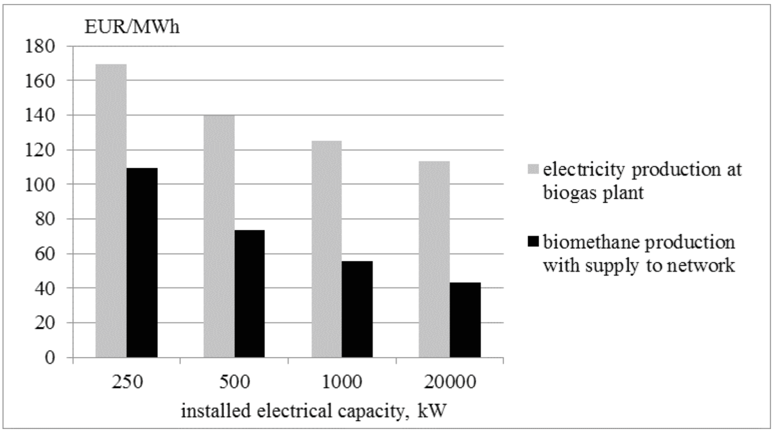

Fig. 6. Estimated necessary support per unit of produced electricity for different ways of use depending upon the capacity of the biogas utility.

5. CONCLUSIONS

The results show that the modelled price of electricity providing economic viability of electricity producing biogas utility in the agriculture sector is significantly higher than the average electricity market price. This causes the necessity to apply a support mechanism in order to facilitate the introduction of biogas electricity technologies.

In case electricity is generated at low-scale (up to 2 MW_{el}) biogas utilities and feed-in tariff (FIT) is the only support instrument, then the electricity generation cost at biogas utilities is approximately that of the FIT provided for in Cabinet of Ministers Regulation No. 262. At a high natural gas price (PPNG = 327.26 EUR/1000m^3), the FIT in accordance with Cabinet of Ministers Regulation No. 221 was also approximately that of electricity generation cost at a biogas utility. If the natural gas price drops, the FIT is insufficient for covering electricity generation cost at a biogas utility.

The analysis of FIT and investment support policy in Latvia revealed that the application of both these instruments was unbalanced and provided unreasonably high support for biogas utility developers. Such an unbalanced policy of too high subsidies sends wrong signals to long-term investments in new technologies, causes unequal competition in the RES electricity market and eventually creates problems to justify the RES policy to the society.

Supporting electricity generation at small-scale (up to 250 MW_{el}) biogas utilities, a compromise should be found between the economy-dictated development of projects with a larger capacity and the development of small-scale projects, which better correspond to the local needs.

At present, maize constitutes most of raw material for biogas production in Latvia, but in the future more attention should be devoted to the use of manure and manufacturing waste.

The research shows that in terms of biogas utilisation development, biogas upgrading for further injection in a natural gas network is more profitable with regard to the state support as it requires smaller amount of support. Considering the requirements provided for by the Directive on the deployment of alternative fuels infrastructure (2014/94/EU), further assessment, additional to the above, is necessary to assess the economic viability of upgraded biogas use in the transport sector.

Undoubtedly, also in the future in Latvia the use of biogas will be an important component of RES, climate policy and regional development. Consequently, a sustainable support mechanism of this resource is to be developed, which takes into account the interaction between the tendencies in the energy, agriculture and waste management sectors.

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ENERĢIJAS RAŽOŠNA NO BIOGĀZES: KONKURĒTSPĒJA UN VEICINĀŠANAS INSTRUMENTI LATVIJĀ

G. Klāvs, A. Kundziņa, I. Kudreņickis

K o p s a v i l k u m s

Atjaunojamo enerģijas resursu (AER) izmantošana ir nozīmīgs faktors enerģijas apgādes drošuma paaugstināšanai, vietējās ekonomiskās attīstības veicināšanai un siltumnīcefekta gāzu emisiju samazināšanai, tā panākot trīskāršā ieguvuma efektu. Autori analizē un novērtē divus galvenos veicināšanas instrumentus – investīciju atbalsta (IA) un elektrības obligātā iepirkuma tarifa (OIT) ietekmi, kuri abi tika izmantoti 2010-2014. gadu periodā, lai nodrošinātu mazas jaudas (līdz 2MW_{el}) lauksaimniecības sektora biogāzes staciju ekonomisko dzīvotspēju. Pētījuma rezultāti, kas iegūti, izmantojot izmaksu novērtējuma modeli, parāda, ka elektrības ražošanas izmaksas biogāzes stacijās aptuveni atbilda minētajā laika periodā eksistējošiem OIT, kurus noteica atbilstošie Ministru Kabineta Noteikumi par elektrības ražošanu, izmantojot AER. Situācija ir radikāli atšķirīga, ja papildus OIT tiek piešķirts arī IA. Proti, analīze parādīja, ka abu šo iepriekš minēto veicinošo instrumentu kombinācijas piemērošanas prakse Latvijā nav bijusi optimāla, jo tā sniedza nesamērīgi augstu atbalstu biogāzes stacijas attīstītājam. Ilgtermiņa perspektīvā šāds pārkompensēts atbalsts sniedz nepareizus signālus attiecībā uz investīcijām jaunajās tehnoloģijās un rada nevienādas konkurences nosacījumus AER elektrības tirgū. Lai nodrošinātu optimālu atbalstu biogāzes ražošanai, ir nepieciešams analizēt tās izmantošanas dažādus veidus. Ar izmaksu novērtējuma modeli autori rakstā analizē divus šos veidus: biogāzes izmantošana elektrības ražošanai uz vietas mazas jaudas biogāzes stacijā un biogāzes bagātināšana līdz biometānam un tā iesūknēšana zema spiediena dabasgāzes tīklā. Veiktais novērtējums parāda, ka biogāzes bagātināšana prasa mazāku publiskā atbalsta apjomu, salīdzinot ar elektrības ražošanu uz vietas, un tādējādi šī alternatīva ir īpaši apspriežama, ņemot vērā pastāvošo infrastruktūru un tehnoloģijas.

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