https://doi.org/10.32056/KOMAG2023.4.2

Legal and technical considerations for testing and certification of CHP units

Received: 15.12.2023

Accepted: 15.01.2024

Published online: 30.01.2024

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Abstract:

Cogeneration units, which generate heat and electricity using the same technological process, and which transmit their surplus electricity to the electricity grid, are subject to the provisions of Commission Regulation (EU) 2016/631 of April 14, 2016 establishing a network code on requirements for grid connection of generators (NC RfG). The article discusses the legal and technical conditions for cogeneration units, which were established in particular to ensure the safety of electricity supply. It also presents the procedure and rules for confirming the compliance of cogeneration units with the technical requirements of the Network Code mentioned above on the basis of tests and certification carried out at the KOMAG Institute.

Keywords: Combined Heat and Power, power generation units, network code, testing, certification

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1. Introduction

According to the European Climate Law, adopted by the European Parliament as part of the European Green Deal, greenhouse gas emissions should be reduced by at least 55% by 2030 and carbon neutrality, also known as climate neutrality, or net zero emissions, meaning a balance between CO_2 emissions and CO_2 uptake from the atmosphere, should be achieved in 2050 [1].

Achieving the above-mentioned goals requires taking action to develop clean energy sources, reduce emissions from the energy sector (fuel combustion is responsible for more than 3/4 of greenhouse gas emissions in the European Union) and reduce energy consumption.

Simultaneous generation of heat and electricity during the same technological process makes it possible to achieve efficiencies in excess of 90%, while the efficiency of generating only electricity does not exceed 40% [2].

Cogeneration units that generate heat and electricity during the same technological process, and that transfer their surplus electricity to the power grid, are subject to the provisions of the Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG) [3].

The establishment of the NC RfG Code was aimed at ensuring fair competition conditions in the European Union's internal electricity market, maintaining security of energy supply and integration of renewable sources of electricity. Power generating units, including cogeneration units, should meet the technical requirements of connection to the transmission and distribution system, so that they are characterized by an adequate response to deviation from the reference voltage and rated frequency, are immune to disturbance conditions in the system, and enable easy restoration of operation after a breakdown.

All new generating units, including CHP units, added into operation must meet the requirements of the NC RfG Code. In order to verify that generating units meet the technical requirements of the NC RfG Code, they should be certified by accredited certification bodies. Electricity system operators allow a certified generating unit to be connected to the grid without hindrance. Anticipating the need for the implementation of the NC RfG code in Poland, the KOMAG Institute has taken measures resulting in the construction of a research infrastructure, the implementation of research methods (Applied Research Laboratory) and a certification programme (Attestation Testing Department Certification Unit), allowing comprehensive testing and certification of generating units.

The KOMAG Institute, as the first organization in Poland, was accredited by the Polish Accreditation Centre for testing and certification of manufacturing units based on the criteria of the NC RfG network code.

2. Requirements for CHP units connected to the power grid

According to the NC RfG Code, CHP units, depending on their maximum generating capacity and voltage level at the point of connection, can be classified into one of four types of power-generation modules, designated as Type A, B, C and D (Table 1). Proposals for maximum power thresholds for type B, C and D generation modules are subject to approval by the relevant regulatory authority or, if applicable, by the member state. In Poland, the values proposed by national distribution system operators were approved by the President of the Energy Regulatory Office (ERO) - Decision of the President of the Energy Regulatory Office DRE.WOSE.7128.184.3.2018.ZJ dated July 16, 2018 [4].

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Table 1. Voltage level limits and maximum power thresholds for power-generating modules of types A, B, C, D

Type of generation unit (power generation module)	A	B	C	D
Voltage at the connection point	< 110 kV	< 110 kV	< 110 kV	≥ 110 kV
Maximum power threshold limit in Continental Europe	0.8 kW	1 MW	50 MW	75 MW
Maximum power threshold limit in Poland	0.8 kW	0.2 MW	10 MW	75 MW

The requirements of the NC RfG code for different types of power generation modules vary. In practice, cogeneration units that generate electricity and heat from the combustion of gaseous fuel (biogas, natural gas) or liquid fuel (bioliquids, diesel) can be classified as Type A modules (voltage lower than 110 kV, power not exceeding 200 kW) or Type B (voltage lower than 110 kV, power not exceeding 10 MW).

For CHP units categorized as Type A power generation modules, the requirements apply at the basic level, the achievement of which is necessary to ensure generation capacity with limited automatic response and minimal regulation by the system operator. The requirements for Type B power generation modules apply to a broader range of automatic, dynamic response to mitigate the effects of system events and provide a higher level of regulation by the system operator.

CHP units of type A and type B shall meet the technical requirements listed in Table 2.

Table 2. Requirements for cogeneration units type A and type B

No.	Requirement	NC RfG Code	Module type	
			A	B
1	Capability of remaining connected to the network and operate within the frequency ranges and frequency ranges and time periods specified in Article 13(1)(a)(i) of the NC RfG Code for the synchronous area - Continental Europe	Article 13(1) (a)(i)	X	X
2	Capability of staying connected to the network and operate at rates of frequency change (RoCoF – ang. Rate of Change of Frequency), df/dt.	Article 13(1) (b)	X	X
3	Capability of power-generating module of activating the provision of active power frequency response at a frequency threshold and droop settings specified by the relevant TSO[1]	Article 13(2) (a)(c)(d)(e)(f) (g)	X	X
4	Admissible active power generation reduction with a decrease in frequency.	Article 13(4)	X	X
5	Cease active power output within five seconds following an instruction being received at the input port (logical interface).	Article 13(6)	X	X
6	Capability of connecting automatically to the network - frequency ranges within which an automatic connection is admissible, the corresponding delay time and maximum admissible gradient of increase in active power output.	Article 13(7)	X	X
7	Regulation of active power output by the relevant system operator using instructions via the input port (logical interface).	Article 14(2)	-	X
8	Capability to staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults on the transmission system.	Article 14(3)	-	X

[1]TSO – transmission system operator

The following part of the article discusses how testing and certification of CHP units - processes conducled by an accredited testing laboratory and accredited certification body of the KOMAG

Institute, whose purpose is to verify compliance with the above-mentioned requirements of the NC RfG Code, are carried out.

3. KOMAG Institute's activities with regard to testing and certification of CHP units

The KOMAG Institute has actively engaged in activities aimed at reducing greenhouse gas emissions, promoting "green" technologies and environmental protection. One of these activities was the establishment in 2021 of a testing infrastructure at the Applied Research Laboratory, which allows the implementation of comprehensive testing of power generating units connected to the electricity grid, resulting from the Commission Regulation (EU) 2016/631 of April 14, 2016. (NC RfG Code).

The testing infrastructure was created mainly with the aim of conducting tests on photovoltaic inverters, inverters working with hydroelectric and wind turbines. It quickly became apparent that the laboratory's testing and organizational potential could be successfully used to test CHP units.

The Applied Testing Laboratory was the first laboratory in Poland to be accredited by the Polish Centre for Accreditation (accreditation certificate AB 665) to perform tests on power generating units with a rated power of up to 250 kW, in accordance with the requirements of the Commission Regulation (EU) 2016/631 of April 14, 2016 and the conditions [5] set by the Polish Power Transmission and Distribution Association (PTPiREE) – an association of the Distribution Network Operators and the Transmission Network Operator and energy industry employees.

As a natural consequence of the laboratory's extension of the scope of accreditation, the Division of Attestation Tests, Certifying Body (accreditation certificate AC 023) - a separate certification unit within the Institute - implemented a certification programme and was accredited by the Polish Centre for Accreditation.

Certification of power generating units (power generating modules) is carried out according to the following reference documents:

- Commision Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators - acronym of the document NC RfG [3],
- General Application Requirements resulting from the Commission Regulation (EU) 2016/631 of April 14, 2016 establishing a network code on requirements for grid connection of generators - approved by the decision of the President of the Energy Regulatory Authority DRE.WOSE.7128.550.2.2018.ZJ dated 2 January 2019 [6],
- Standard PN-EN 50549-1:2019-02 [7].

Certificates of conformity are issued by the Division of Attestation Tests, Certifying Body primarily on the basis of current measurements of physical characteristic related to the verified property of the tested power generating unit. The test results that are the basis for the issuance of a certificate of conformity are documented in the test report, which is made available to the appropriate network operator upon request.

Certificates of compliance are the basis for including the certified device in the list [8] managed by the Polish Electricity Transmission and Distribution Association and thus obtaining a permit to connect the device to the power grid.

4. Testing of CHP units

Testing of CHP units is carried out in accordance with the programme established by the certification body. The programme refers to the technical requirements of the NC RfG Code listed in Table 2. Part of the testing can be performed by the laboratory's specialists at the manufacturer's site, using the manufacturer's infrastructure, usually due to the need to provide an adequate amount of fuel. The test object is a certified product or a sample representative of a series of products. An example of a CHP unit subjected to testing at the KOMAG Institute is shown in Fig. 1.

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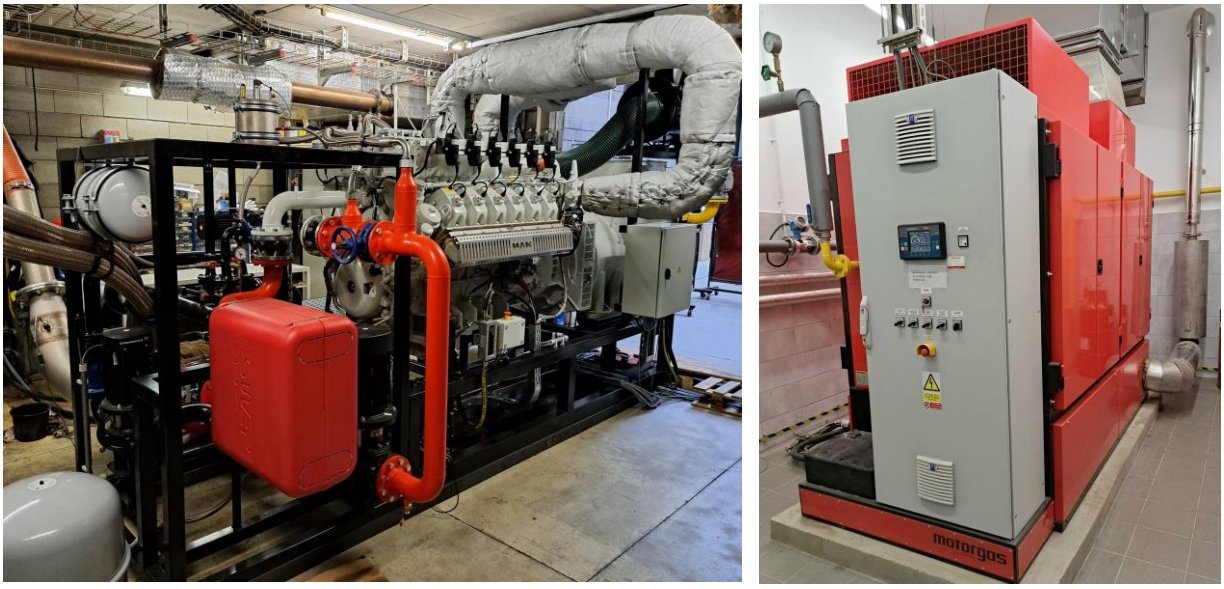

Fig. 1. CHP unit (example)

Testing of CHP units is carried out in the Applied Research Laboratory in the configuration shown in Fig. 2. Electrical parameters at the point of connection of the unit to the grid (under laboratory conditions to the grid simulator) are measured and recorded.

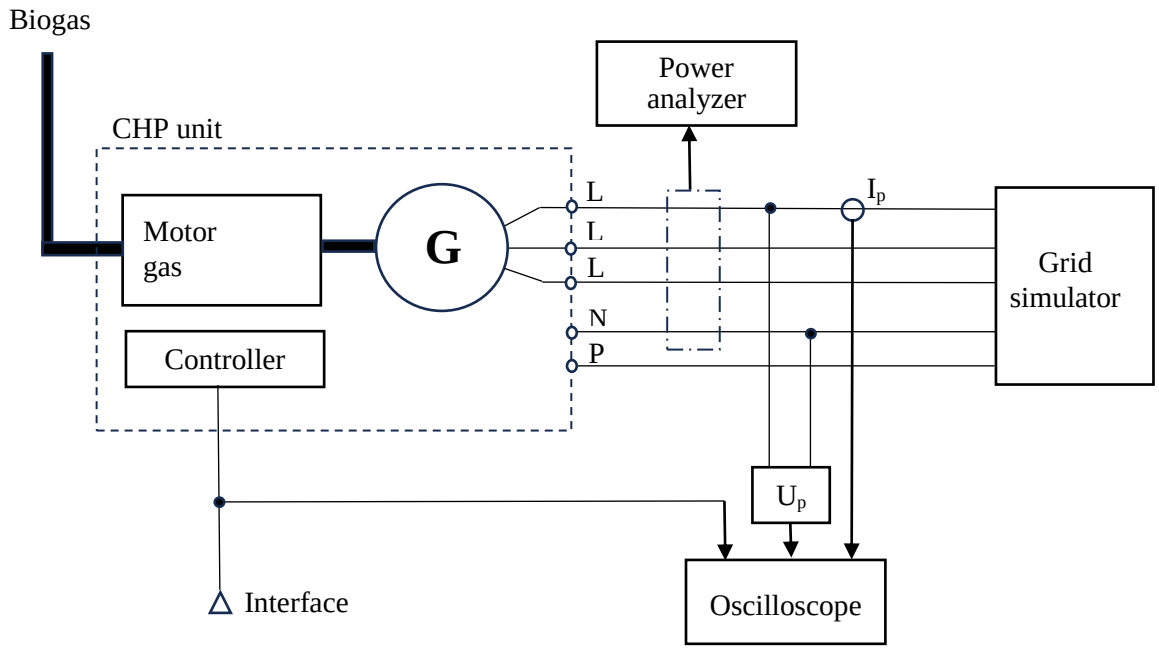

Fig. 2. Schematic of the system for testing CHP units

The values obtained during the tests are recorded and analyzed in terms of meeting the requirements of the NC RfG Code, General Application Requirements (PSE) as well as PN-EN 50549-1:2019-02.

The charts below show selected sample test results, the object of which was a CHP unit.

a) Tests of power response to increased frequency (LFSM-O).
Requirement: Article 13, paragraph 2 - NC RfG and item 4.6.1 of EN 50549-1:2019-02.

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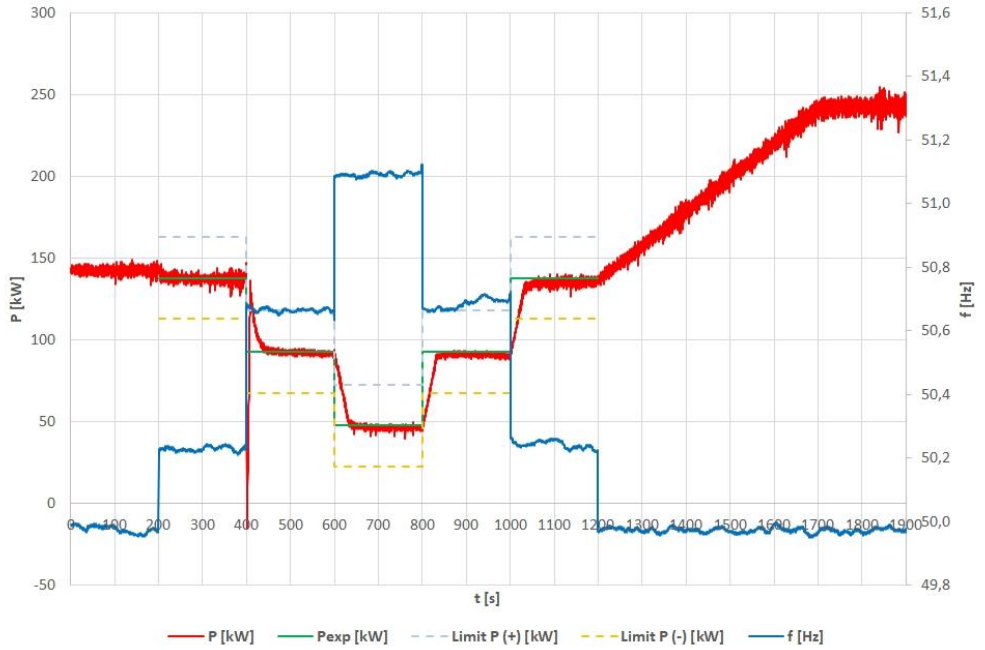

Fig. 3. Time diagram of P_{EUT}, f_{EUT} for active power response tests at increased frequency (f_1 = 50,2 Hz, f_{stop} = 50,2, s = 5%, Pset > 60% Pn)

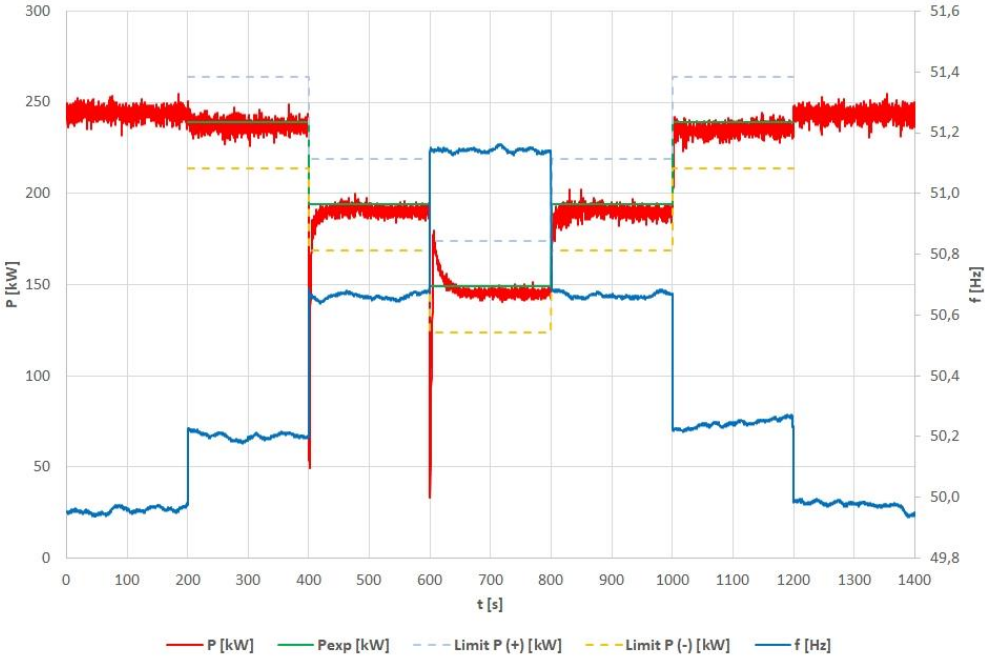

Fig. 4. Time diagram of P_{EUT}, f_{EUT} for active power response tests at increased frequency (f_1 = 50,2 Hz, f_{stop} = 50,2, s = 5%, Pset > 100% Pn)

b) Cease active power output within five seconds following an instruction being received at the input port (logical interface).

Requirement: Article 13, paragraph 2 - NC RfG and item 4.6.1 of EN 50549-1:2019-02.

The test is designed to verify the functionality of the CHP unit to stop active power generation after receiving the applied command on the available logical interface. Testing is performed for all available logical interfaces, such as binary input or MODBUS protocol, based on RS485

(MODBUS ASCII or RTU) and Ethernet (MODBUS TCP) interfaces. The condition that confirms proper operation is the cessation of active power generation (phase current decay) within five seconds of receiving a command.

Fig. 5. A diagram illustrating the time to stop active power generation after accepting a command at the input port (logical interface)

c) Regulation of active power output by the relevant system operator using instructions via the input port (logical interface).

Requirement: Article 14, paragraph 2 - NC RfG and item 4.11.2 of EN 50549-1:2019-02.

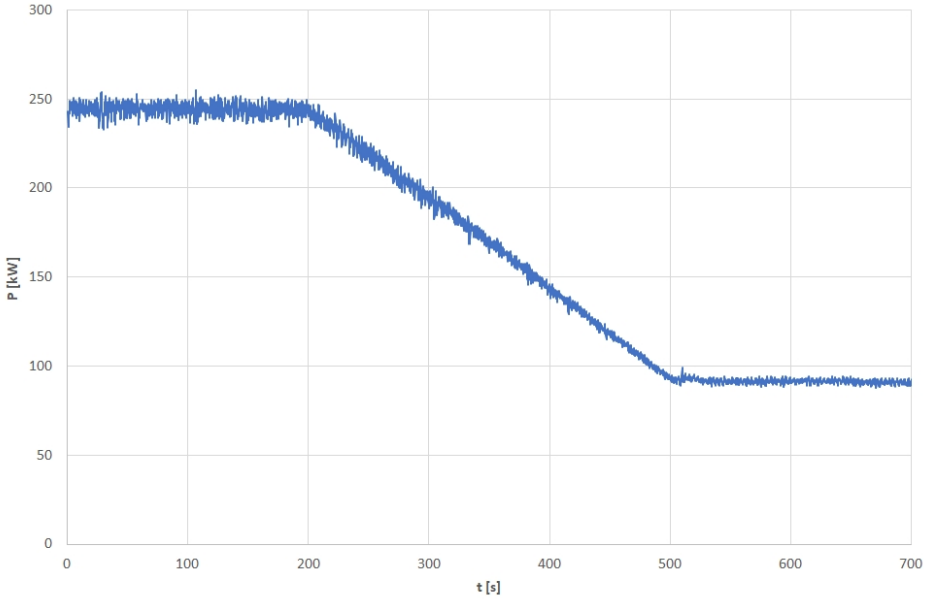

Fig. 6. A diagram illustrating the regulation of active power by the logic interface up to 40% of rated power

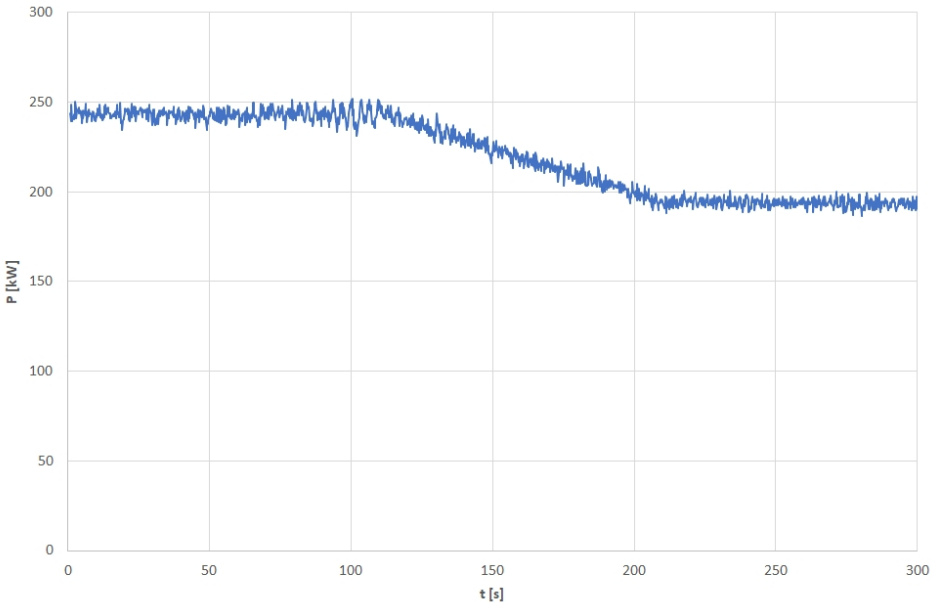

Fig. 7. A diagram illustrating the regulation of active power through the logic interface to 80% of rated power

5. Conclusions

The KOMAG institute's activities under the provisions of the Commission Regulation (EU) 2016/631 of April 14, 2016, establishing a network code on requirements for the connection of generating units to the grid (NC RfG) have led to the fact that producers of generating units can have them subjected to the necessary testing and certification at a national unit offering its services under the accreditation of the Polish Centre for Accreditation. This also applies to CHP units, the use of which is growing steadily, due to the significantly higher efficiency of heat and electricity generation during the same technological process, as well as the possibility of using biogas and biofuels.

The experience gained during the testing of CHP units, selected results of which are presented in this article, confirm the desirability of subjecting these products to testing and certification. These activities reassure manufacturers and power system operators about the characteristics of power generating units offered on the market, including CHP units.

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