Efficiency of capturing methane from abandoned mines in Polish conditions

AKADEMIA GÓRNICZO-HUTNICZA IM. STANISŁAWA STASZICA W KRAKOWIE
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Marek Borowski, Prof. AGH UST

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2. Methane as a greenhouse gas
3. Methane as a source of heat and electricity
4. Abandoned mine methane capture on the example of the Krupiński coal mine
5. Examples of methane capture and use after the shut-down of hard coal mines in Poland
6. Summary

Methane in the rock mass

In general, reservoir properties governing coal mine methane emissions can be divided into two groups (Kissell, 2006):

» properties that determine the capacity of the seam for total gas production; e.g., adsorbed gas and porosity,

» properties that determine the rate of gas flow; e.g., permeability, reservoir pressure, and diffusivity of coal.

Methane in the rock mass

A contemporary mine can be considered as a flow system of air and gases consisting of tanks that are connected by excavations with each other and with the surface atmosphere. The synchronization of pressure changes in the mine and on the surface is determined by the pressure equalization rate, which in turn depends on the volume of all tanks and the flow rate through ventilation shafts and underground workings (Trutwin, 2012).

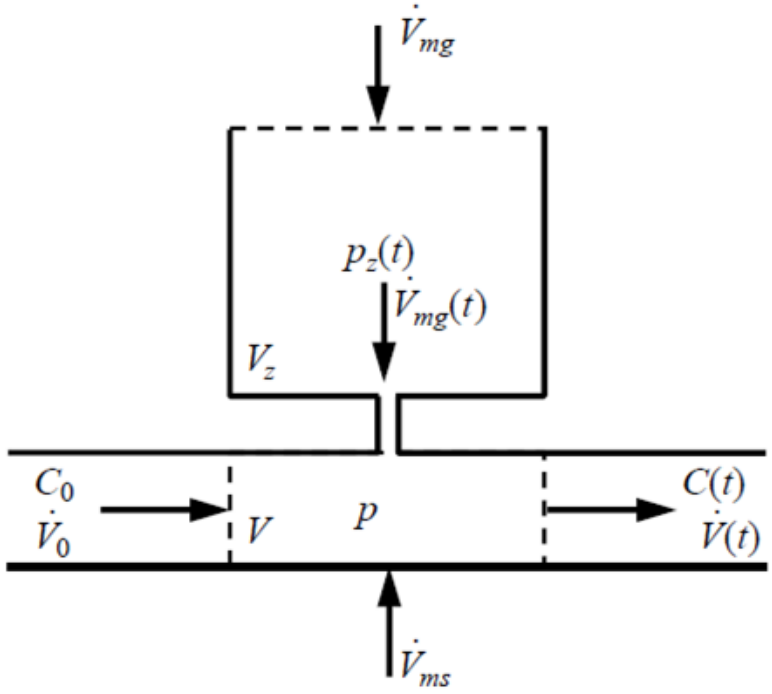

Figure 1. Model of the air flow and mixing process near the wall (Trutwin, 2012)

Methane as a greenhouse gas

Of all the greenhouse gases, methane is one of the most potent because of its ability to efficiently absorb heat in Earth's atmosphere. Methane is particularly problematic as its impact is 34 times greater than CO_2 over a 100-year period, according to the latest Intergovernmental Panel on Climate Change Assessment Report. Anthropogenic methane emissions are responsible for about 20% of the global radiative forcing of GHGs since preindustrial times, making it the second largest contributor after Carbon Dioxide (EPA, 2012).

Methane as a source of heat and electricity

Methane included in the methane drainage process of hard coal mines can be used economically as a gas fuel:

» directly as a result of controlled injection into the natural gas network,

» directly in gas burners, gas boilers, gas engines, gas turbines, indirectly after prior enrichment, sold to gas networks selling to entrepreneurs.

In most cases, methane from methane drainage is used as fuel for heating and energy installations located in the mines or in their close vicinity.

Methane as a source of heat and electricity

Ways of using gas from methane drainage of coal seams in the energy sector can be divided into:

- generating heat for heating and technological needs by burning gas in boilers or technological installations,
- combined generation of electricity and process steam,
- combined electricity and hot water production,
- combined electricity and refrigerant production for the needs of drying processes,
- combined heat, cold and electricity generation.

Technologies of using gas from methane drainage

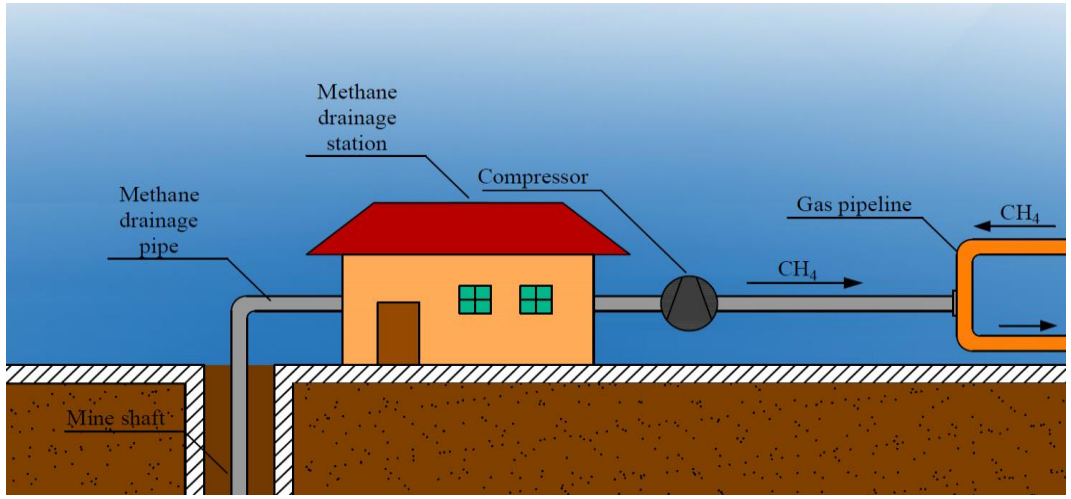

Figure 2. Scheme of injecting gas from methane drainage into the gas network

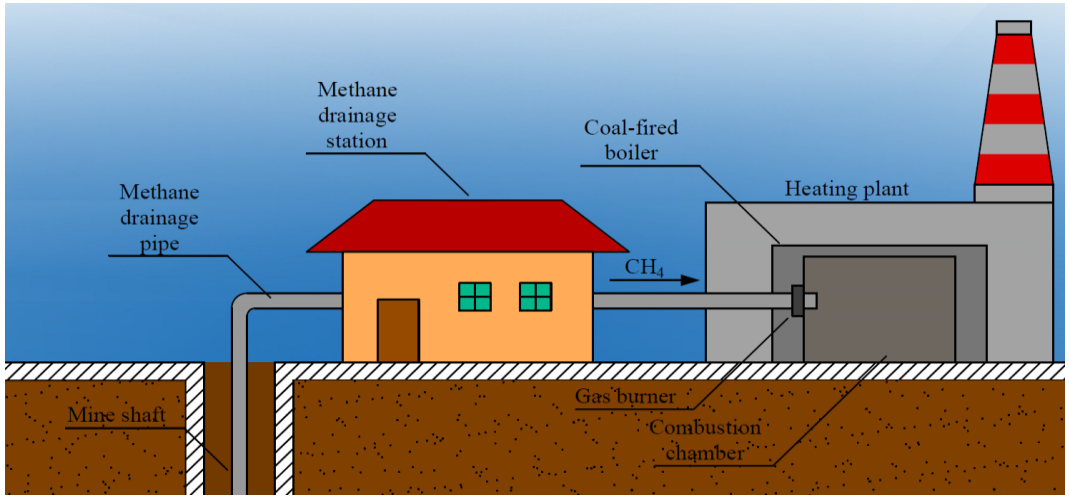

Figure 3. Schematic diagram of the installation of coal-fired boilers with gas burners for the combustion of gas from methane drainage

Technologies of using gas from methane drainage

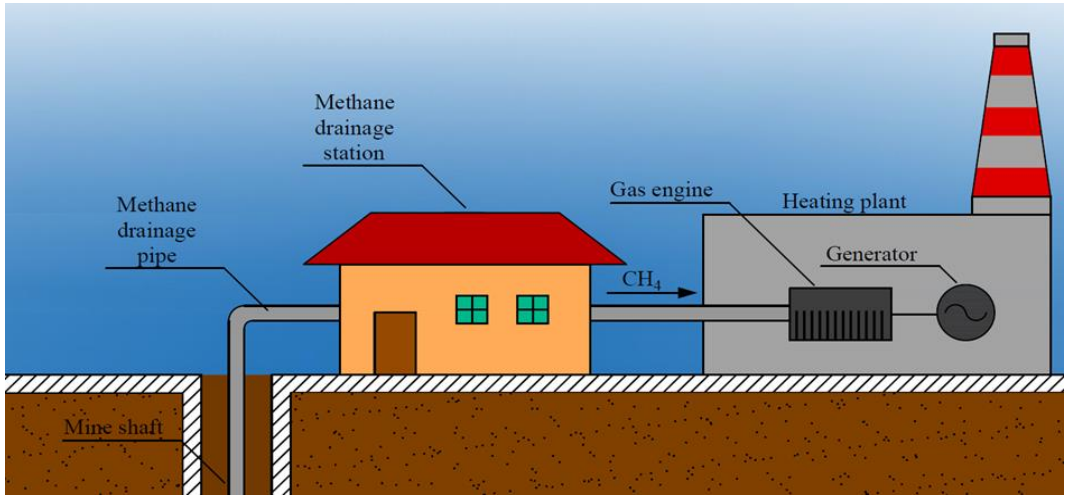

Figure 4. Schematic diagram of the installation with a gas engine for the combustion of gas from methane drainage

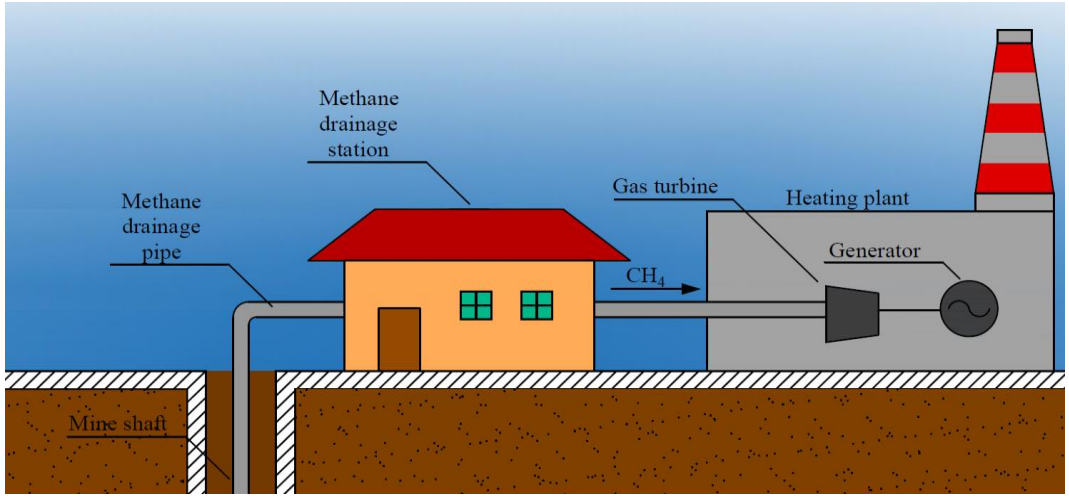

Figure 5. Schematic diagram of the installation using methane as fuel for gas turbine

Hard coal mines in the Upper Silesian Coal Basin

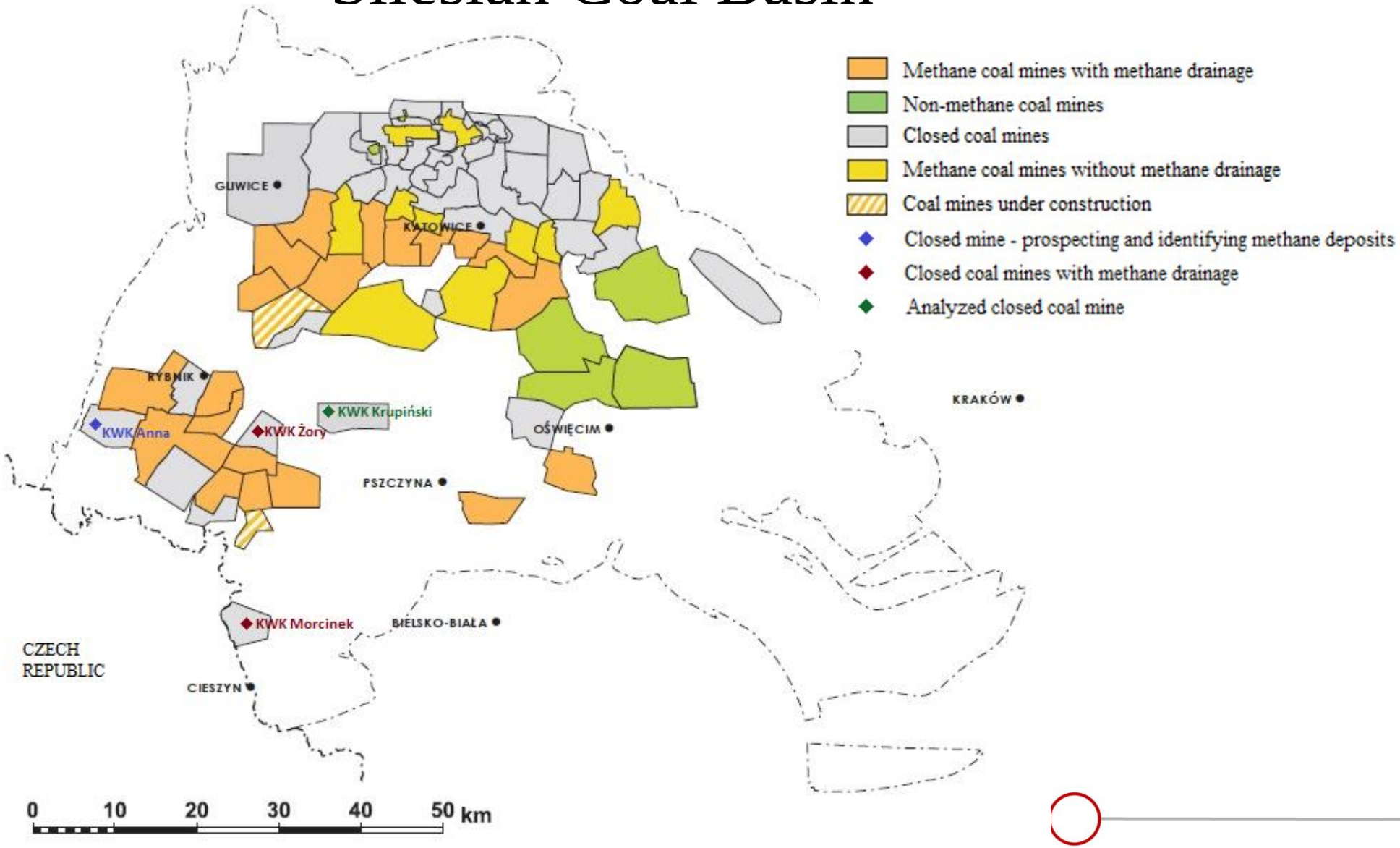

Figure 6. Location of mines in the Upper Silesian Coal Basin

Methane capture - Abandoned Coal Mine „Krupiński”

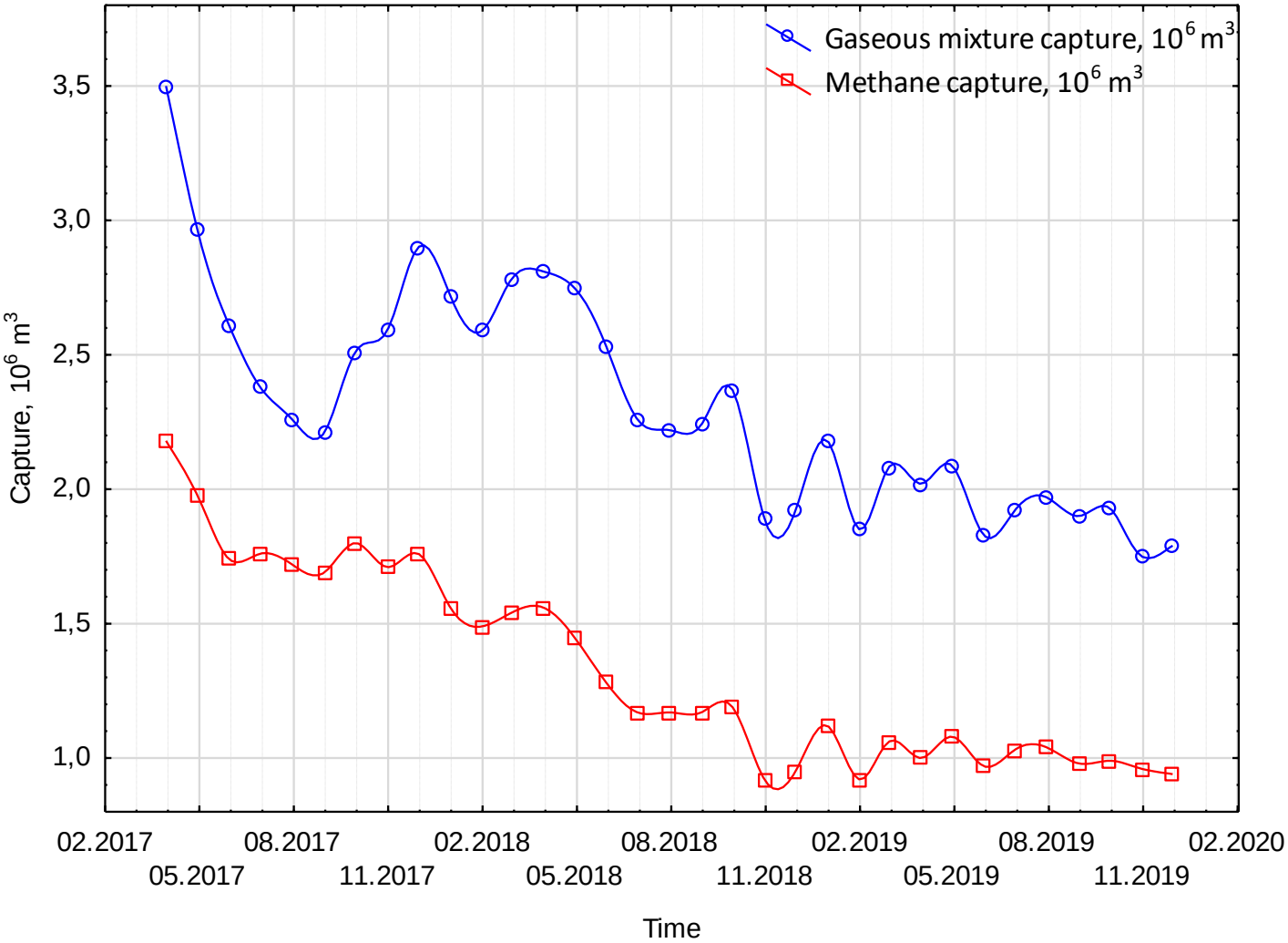

Figure 7. Gaseous mixture and methane capture from abandoned coal mine „Krupiński” 04.2017-12.2019

Methane capture - Abandoned Coal Mine „Krupiński”

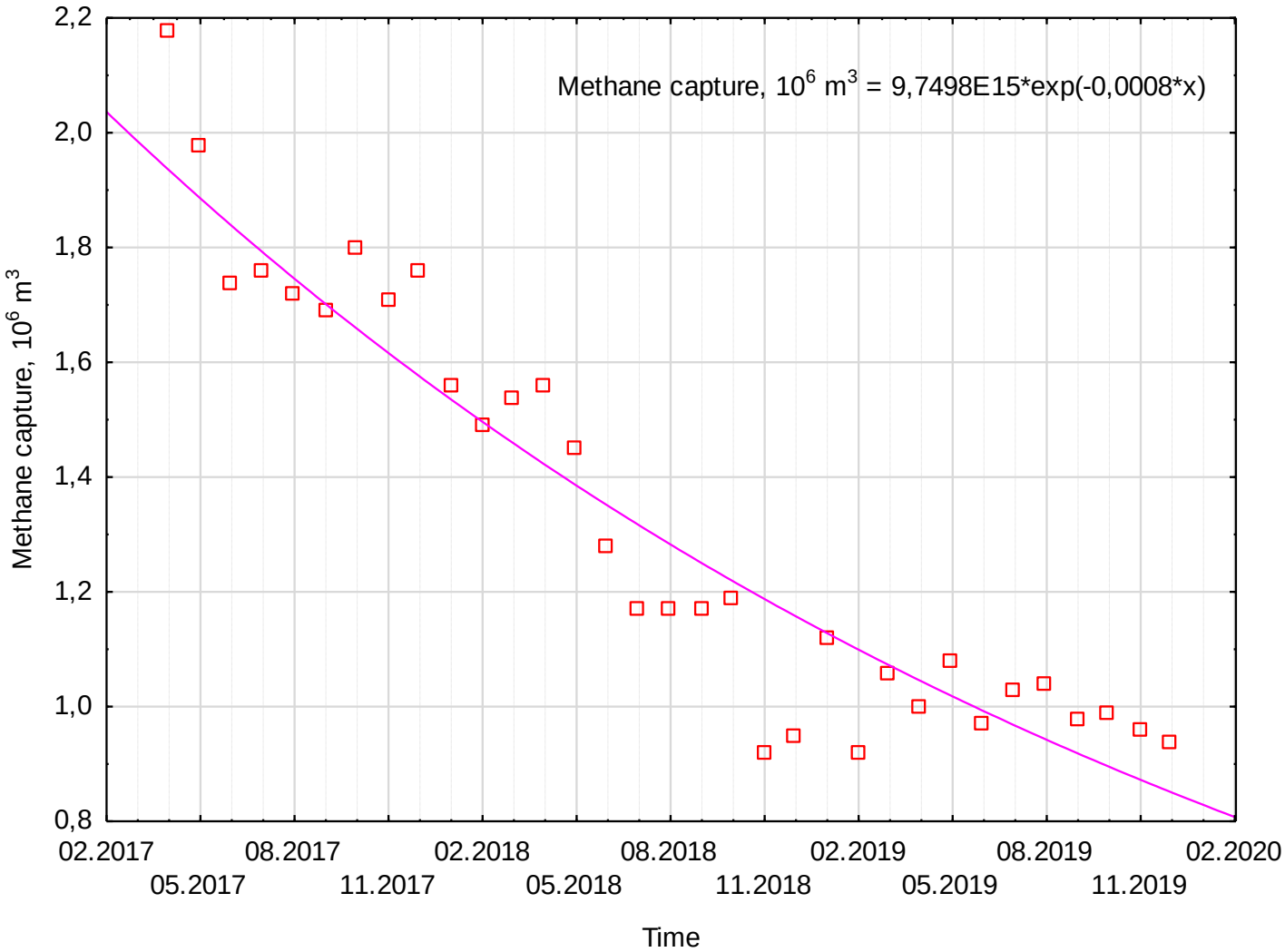

Figure 8. Methane capture from mine „Krupiński” 04.2017-12.2019

Methane capture - Abandoned Coal Mine „Krupiński”

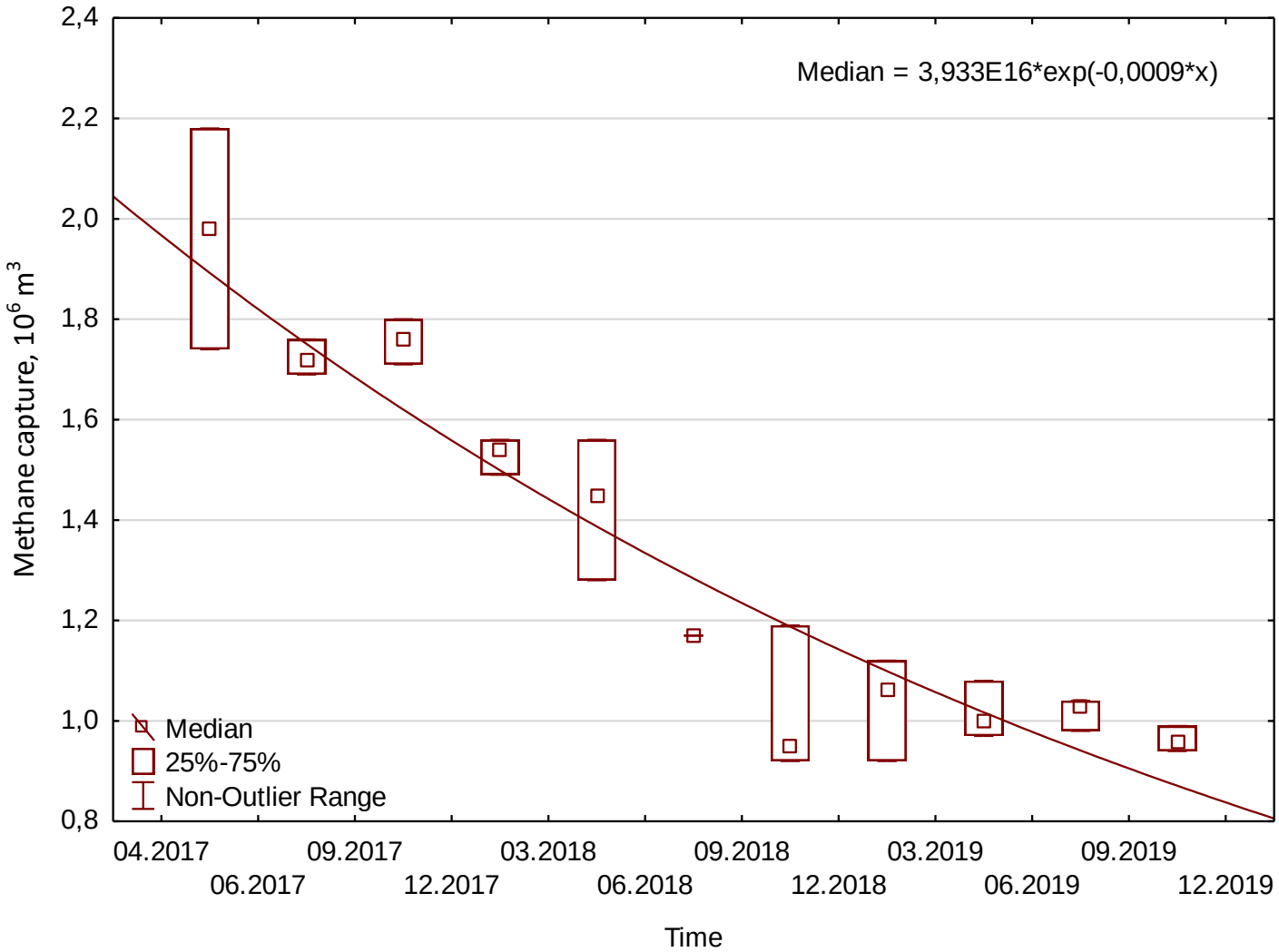

Figure 9. Methane capture from mine „Krupiński” 04.2017-12.2019

Methane capture - Abandoned Coal Mine „Krupiński”

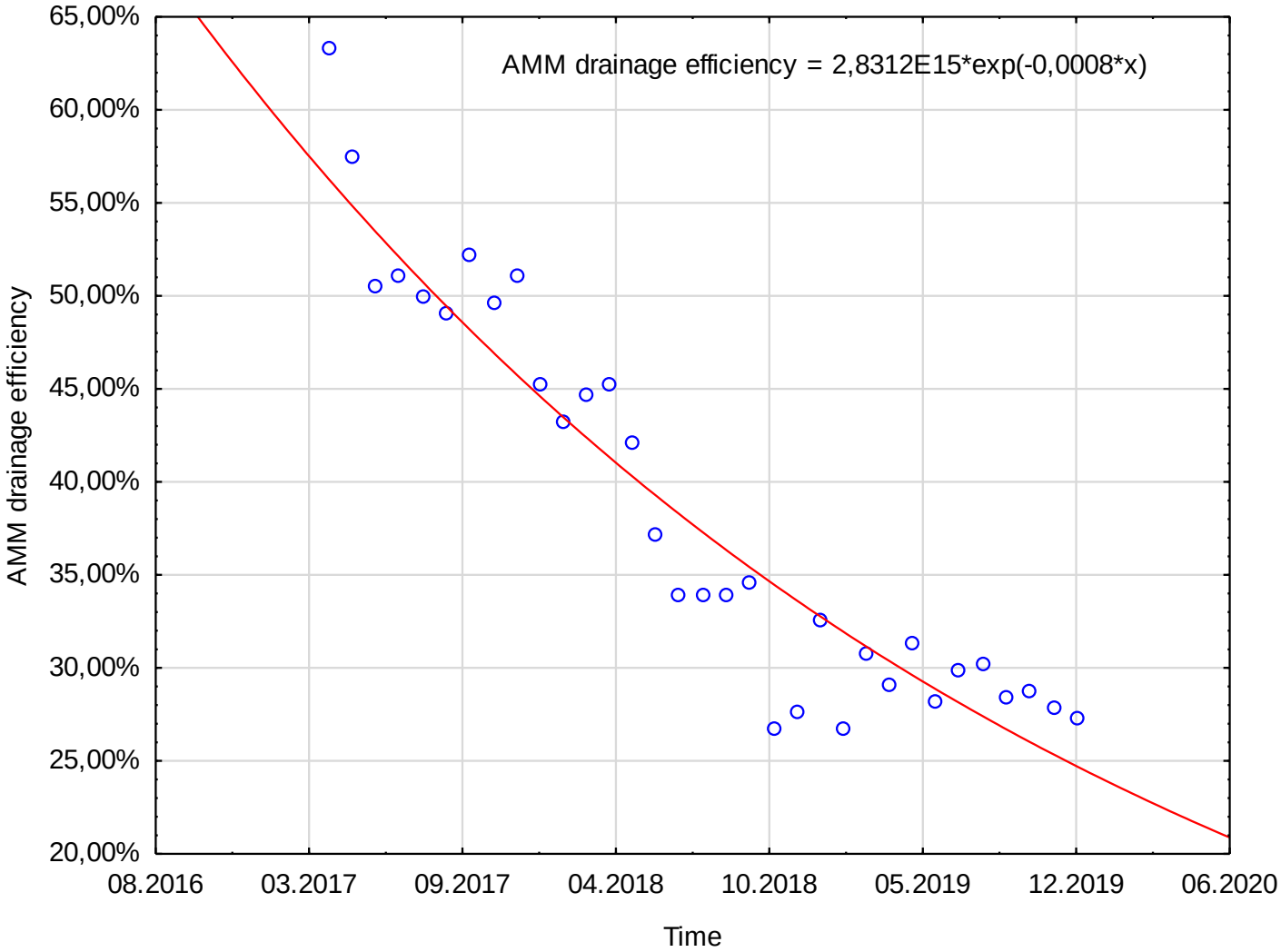

Figure 10. AMM drainage efficiency - mine „Krupiński” 04.2017-12.2019

$$E = \frac{V_{C_{AMM}}}{V_{C_{CMM}}} \cdot 100\%$$

$V_{C_{AMM}}$ - AMM capture, 10^6 m^3/y

$V_{C_{CMM}}$ - CMM capture , 10^6 m^3 /y

Methane capture - Abandoned Coal Mine „Krupiński”

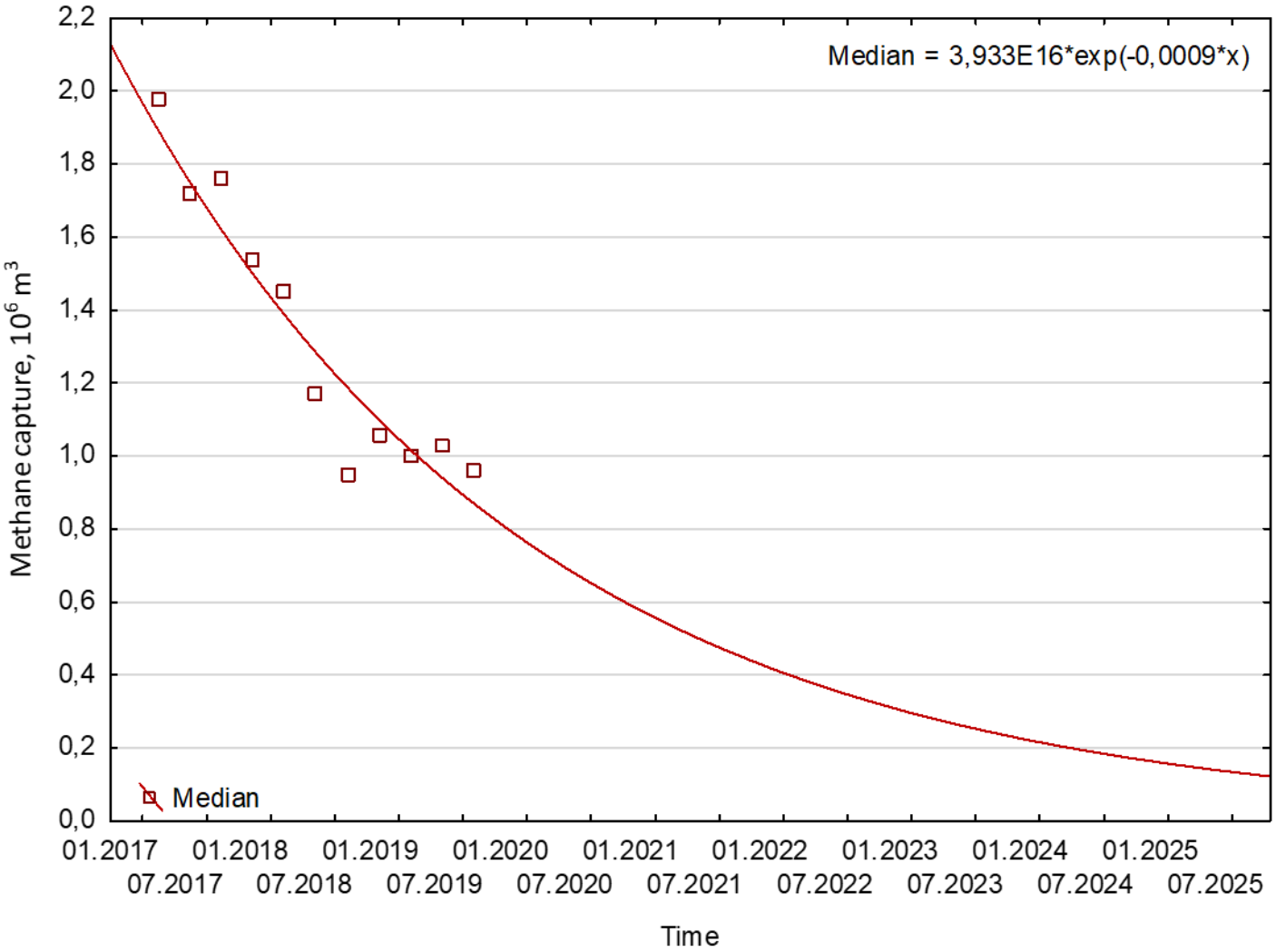

Figure 11. Forecasted methane capture from abandoned coal mine „Krupiński” 2020-2025

Examples of abandoned mine methane capture and use in Poland

1. Abandoned Mine Żory - Gas Cogeneration Project

The first well drilled within the Żory mine area, to the depth of 209 m, was put on production in 2012. A 2MW combined heat and power cogeneration unit was installed. Since March 2012, methane has been extracted and sold to a customer generating electricity and heat from cogeneration from it - this heat is used to heat a nearby housing estate. Its recent annual methane production as of the end of 2017 was 3.25 MMm^3. Another production well was drilled in 2013 and its recent annual methane production as of the end of 2017 was 1.93 MMm^3 (UNECE, 2019).

Examples of abandoned mine methane capture and use in Poland

2. Abandoned Mine Morcinek

The extraction of methane from the abandoned underground excavations of the closed Morcinek mine began in August 2001. Gas is discharged through the Kaczyce 1/01 well, drilled to a depth of 680 m. The annual methane production as of the end of 2017 was 2.29 MMm^3.The main consumer is Green Gas DPB, based in Pasków in the Czech Republic. Gas is sent through a pipeline to a mine where it is burned in gas engines (UNECE, 2019).

Examples of abandoned mine methane capture and use in Poland

3. Abandoned Mine Anna

On 11 November 2016 the Minister of Environment granted TERMOSPEC with a license to prospect and identify methane deposits form coal seams from around the “Anna” area located on the territory of the following cities: Pszów, Radlin and Wodzisław Śląski.

Summary

- The domestic potential of methane utilization technology from abandoned mines is associated with large AMM resources, which in the perspective of the further process of mine closure may be even larger.
- Cogeneration solutions, combined production of electricity and heat, allow reducing the operating costs of facilities.
- Additionally, important benefits of AMM extraction and use are significantly reducing the risk of uncontrolled emissions at the surface and mitigating GHG emissions.

Summary

» Analyzing the measurements of methane capture from the abandoned mine „Krupiński”, the amount of methane collected every month is constantly decreasing, and the dependence of methane capture on time can be described by exponential dependence. According to the forecast, at the end of 2024, maintaining the current trend, the methane capture will fluctuate around 0.2 MM m^3.