MARCO - VENTILATION AIR METHANE UTILIZATION TECHNOLOGY – EXPERIENCE FROM THE PILOT PLANT AT THE GIG EXPERIMENTAL MINE *BARBARA*

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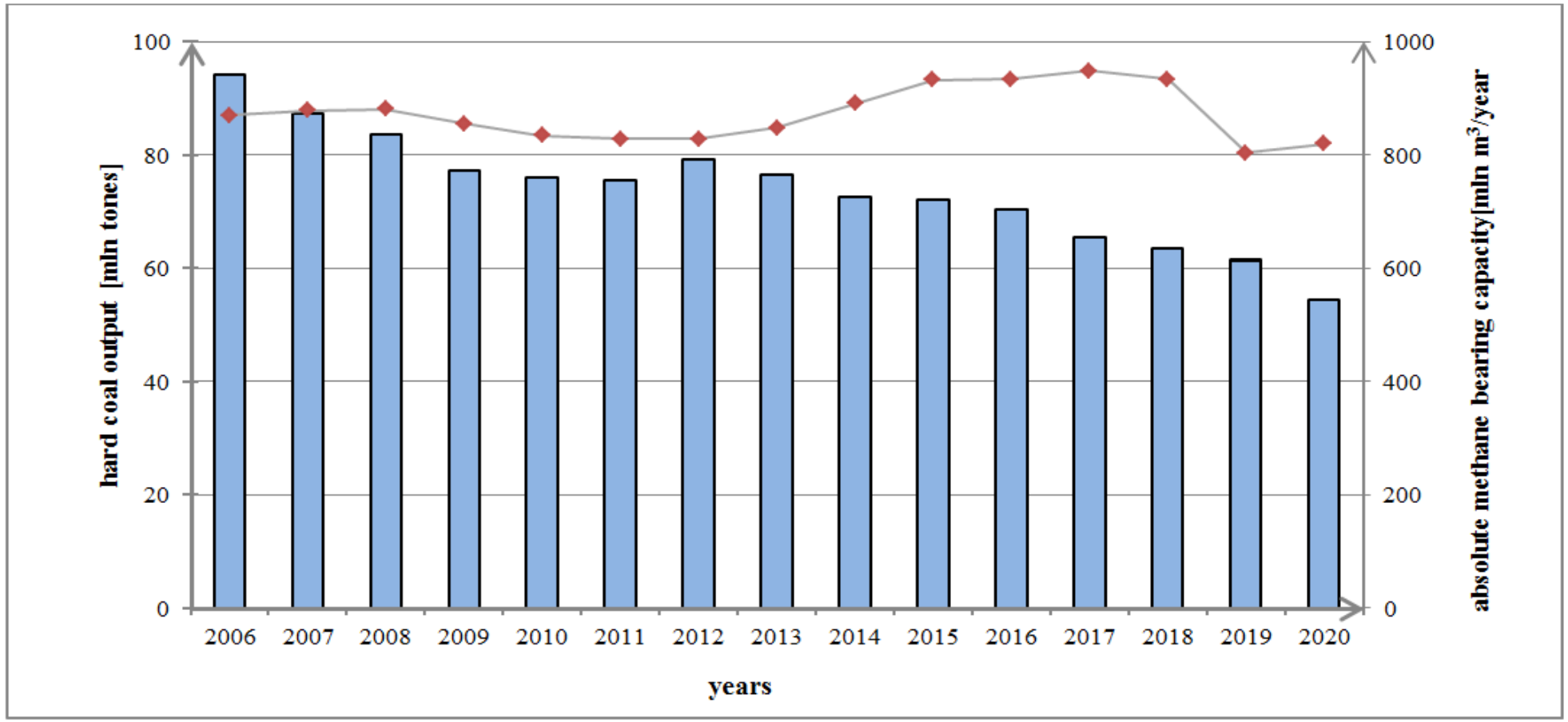
HR EXCELLENCE IN RESEARCH

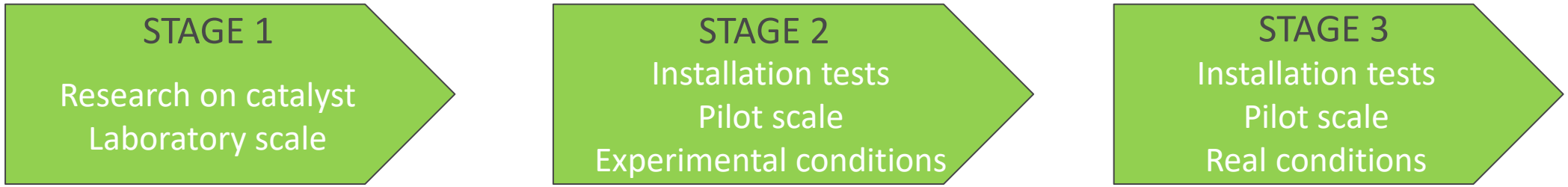
XXX School of Underground Mining, Cracow, September 27th, 2021

Absolute methane bearing capacity and hard coal output in Polish coal mines, 2006 – 2020



MARCO – R&D project

- The Marco R&D project ***„Development of an innovative catalytic and adsorption technology for neutralizing methane emitted to the atmosphere in ventilation gas from a hard coal mine based on a platinum catalyst with added value in the form of waste energy recovery”*** is authored and coordinated by PROFILE Sp. z o.o.
- It is carried out under the Intelligent Development Operational Program co-financed by the European Regional Development Fund, Measure 1.1. R&D projects of enterprises, Sub-measure 1.1.1. Industrial research and development work carried out by enterprises.
- The project is currently in progress.



GIG EM *Barbara*

Coal mine

- Underground Research Department of GIG Experimental Mine Barbara carries out industrial research involving the set-up of the installation as well as its functionality and efficiency tests for the utilization of ventilation air methane.

Aim of the research

The main purpose of the R&D work is to test the innovative catalytic-adsorption technology MARCO (Methane Adsorber Regenerative Catalytic Oxydation), enabling the utilization of methane emitted to the atmosphere in the ventilation air from hard coal mines, based on a catalytic bed with the recovery of waste energy. The research consisted in operational tests of the prototype installation in quasi-real conditions of the experimental mine. The results collected during the tests were the basis for determining the functionality of the installation and verification of the assumed parameters of its operation, in particular:

- methane elimination effectiveness,
- energy efficiency of the installation,
- the minimum threshold of methane concentration allowing for its autothermal operation.

Concept and assumptions of R&D work

The concept consisted in mapping the actual operating conditions of a methane mine and testing the installation in target conditions, i.e. locating it in the vicinity of the ventilation shaft and providing an appropriate connection with it. The following assumptions were made:

- the possibility of creating methane conditions and adjusting the parameters of the mine's ventilation air in the range of CH_4 concentration within 0-1 % and the air flow in the ventilation shaft 5 000 – 20 000 m^3/h,
- constant monitoring of ventilation air parameters along the path of its flow in underground workings and in the ventilation shaft, including the measurement of methane concentration, air velocity as well as its temperature and humidity,
- the possibility of operation of the tested installation when included in the mine ventilation system, without adversely affecting the parameters of ventilation of underground workings and the safety of the staff,
- continuous operation of the pilot plant (24/7) during whole testing period (> 14 days).

<u>The work plan was divided into three stages:</u>

- adaptation of the mine ventilation system and equipment of underground workings,
- development and connection of the tested installation with the ventilation shaft at EM *Barbara,*
- start-up and operation of the installation with continuous measurements.

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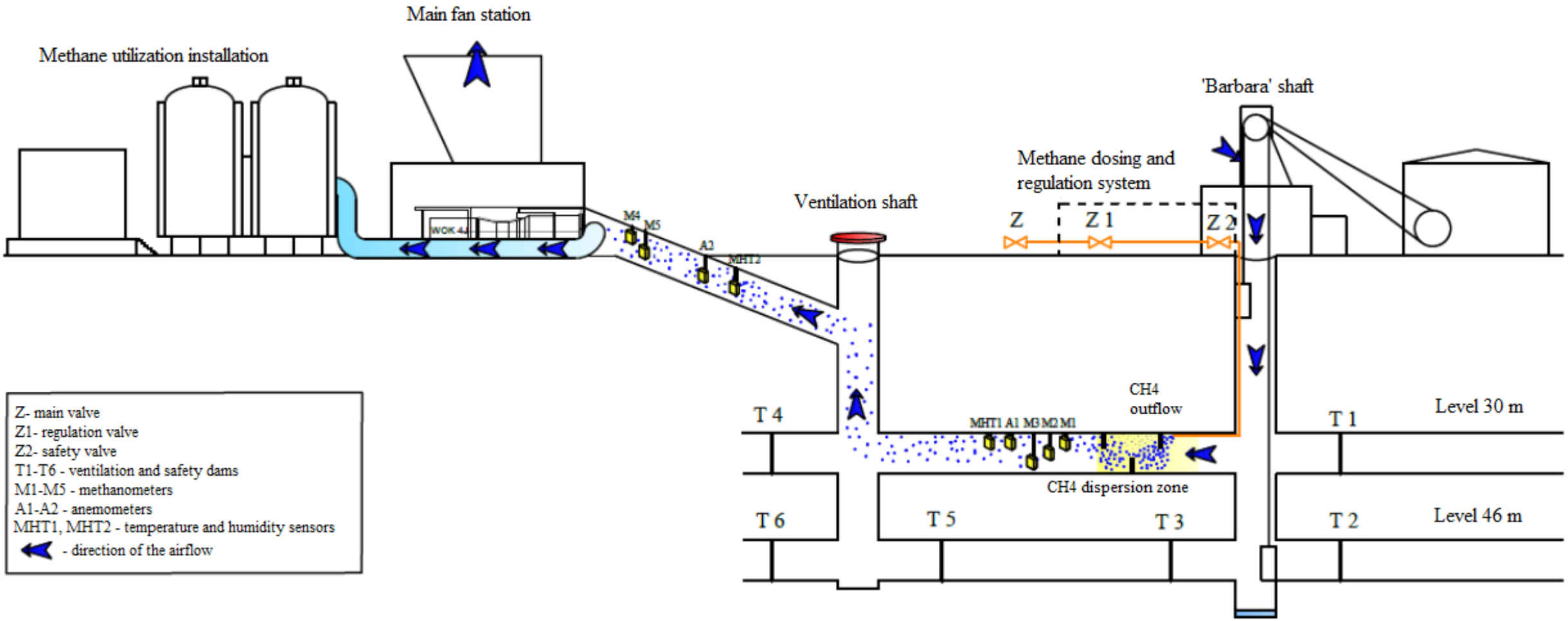
Research stand



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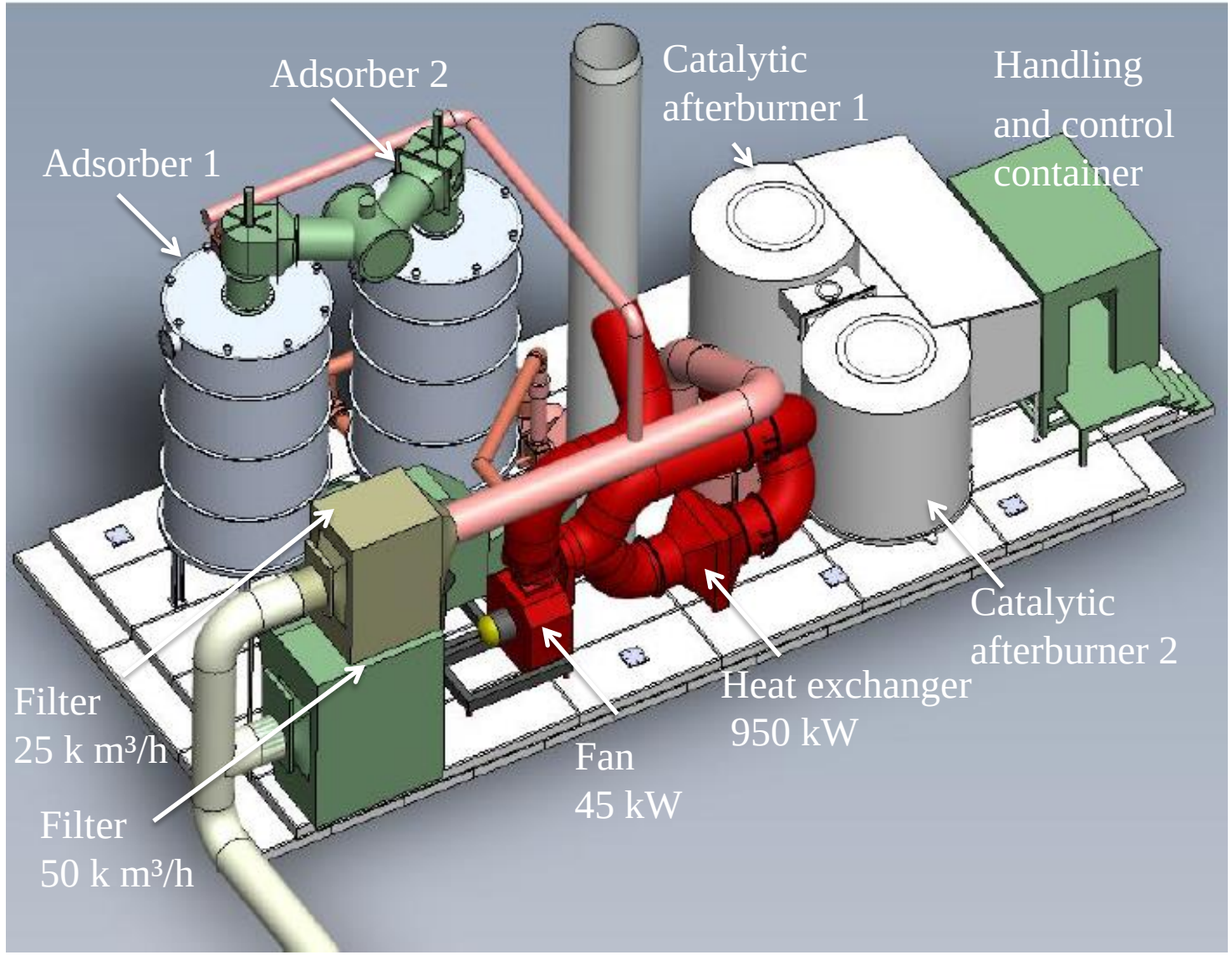
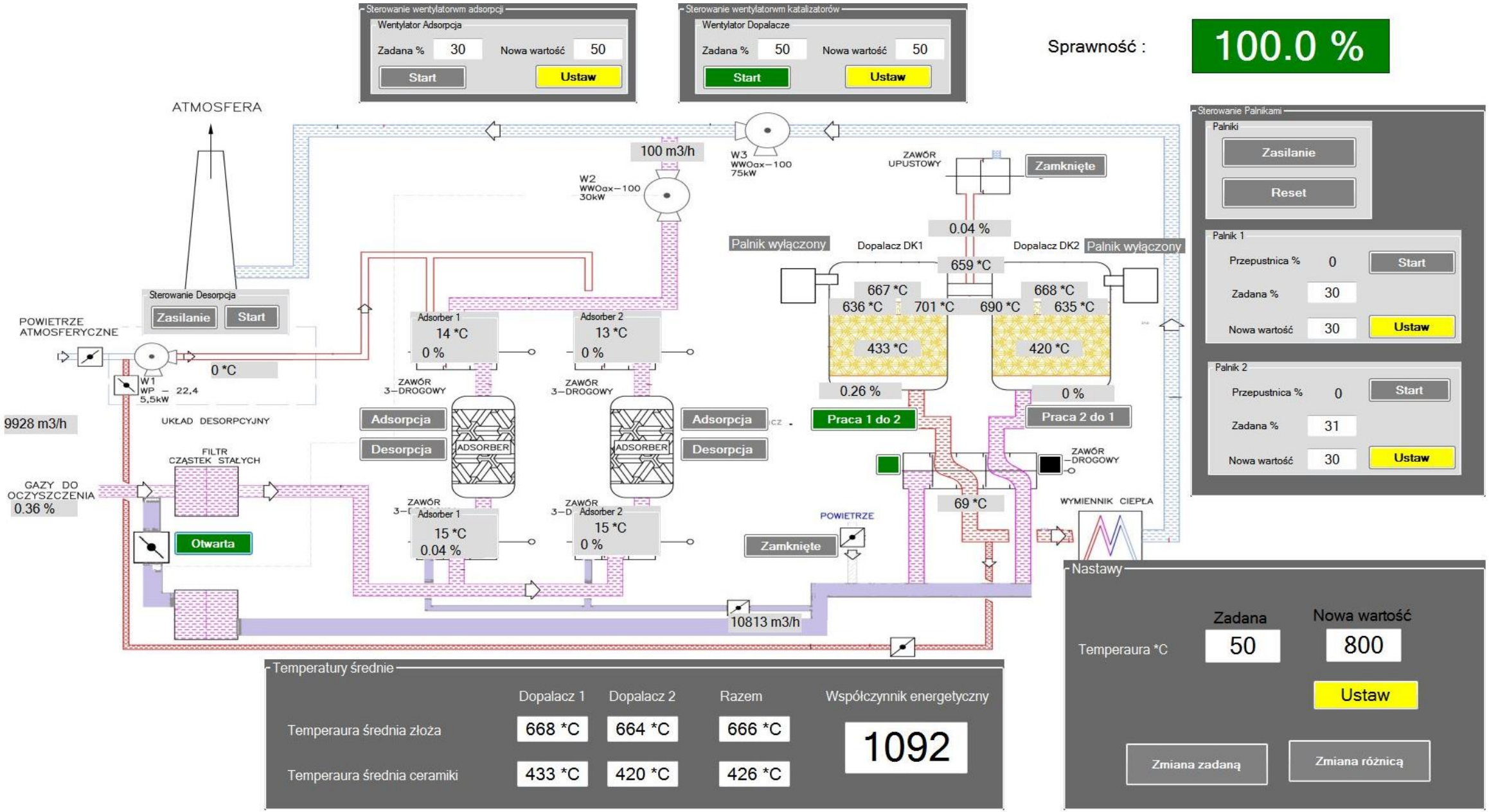
Operating parameters of the installation:

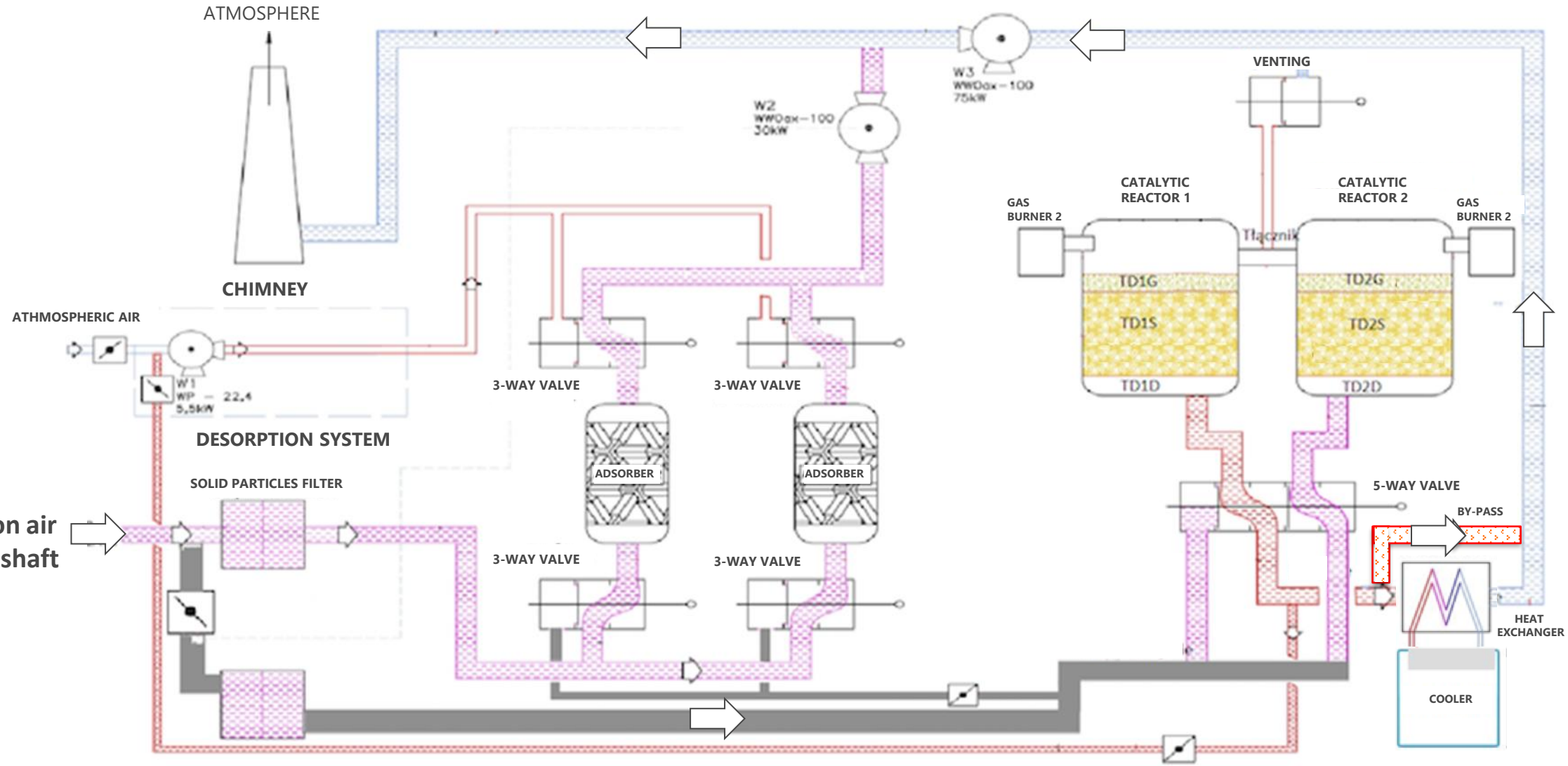
- rated capacity – 2 000 – 15 000 Nm³/h,
- maximum capacity – 25 000 Nm³/h,
- installed electric power 3 x 400 V – 96 kW,
- installed gas power – 2 x 75 kW,
- average operating power – 40 kW,
- heat recovery up to 950 kW,
- dimensions – 21,5 m x 9,0 m x 7,5 m,
- weight – 26,5 t.



Control panel of the installation

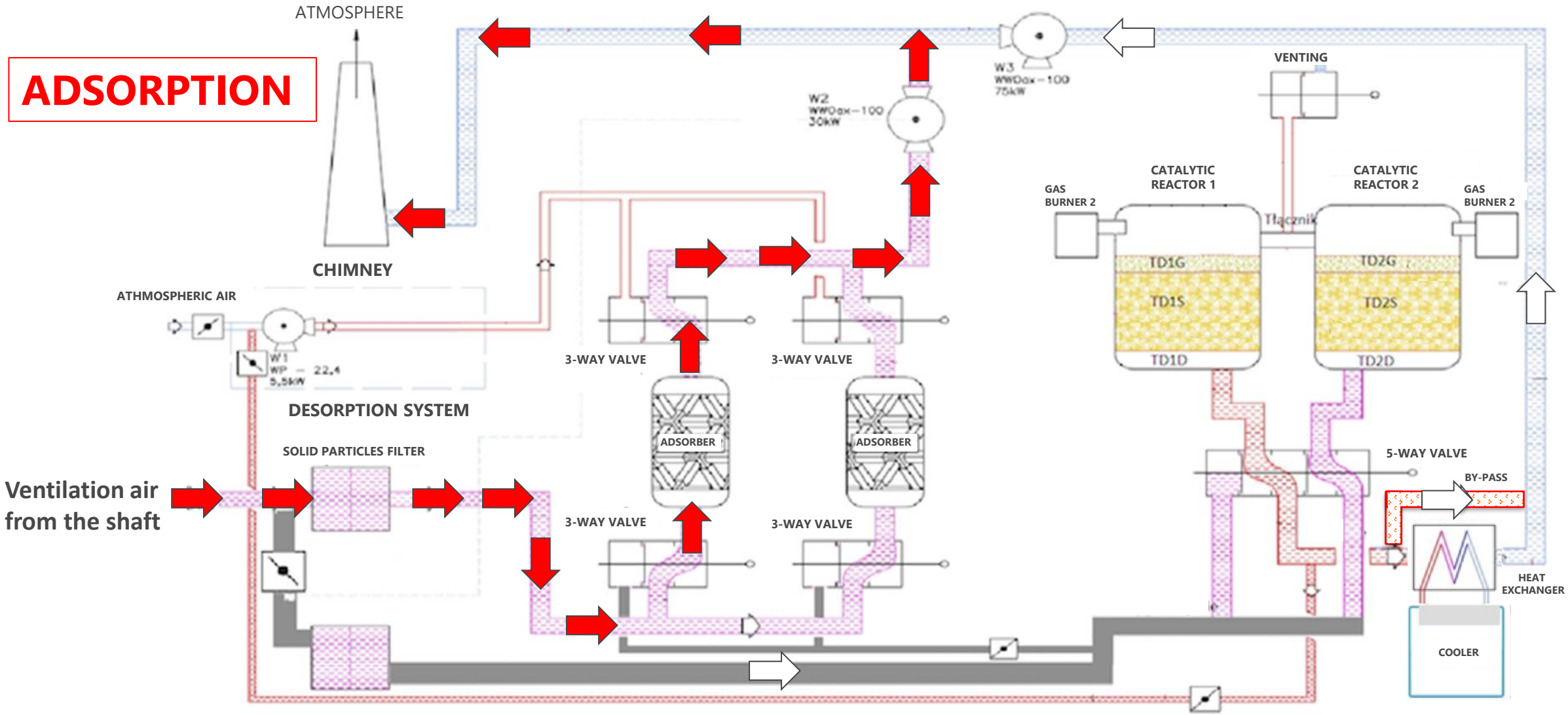


Flow chart of the installation – Methane Adsorber Regenerative Catalytic Oxydation



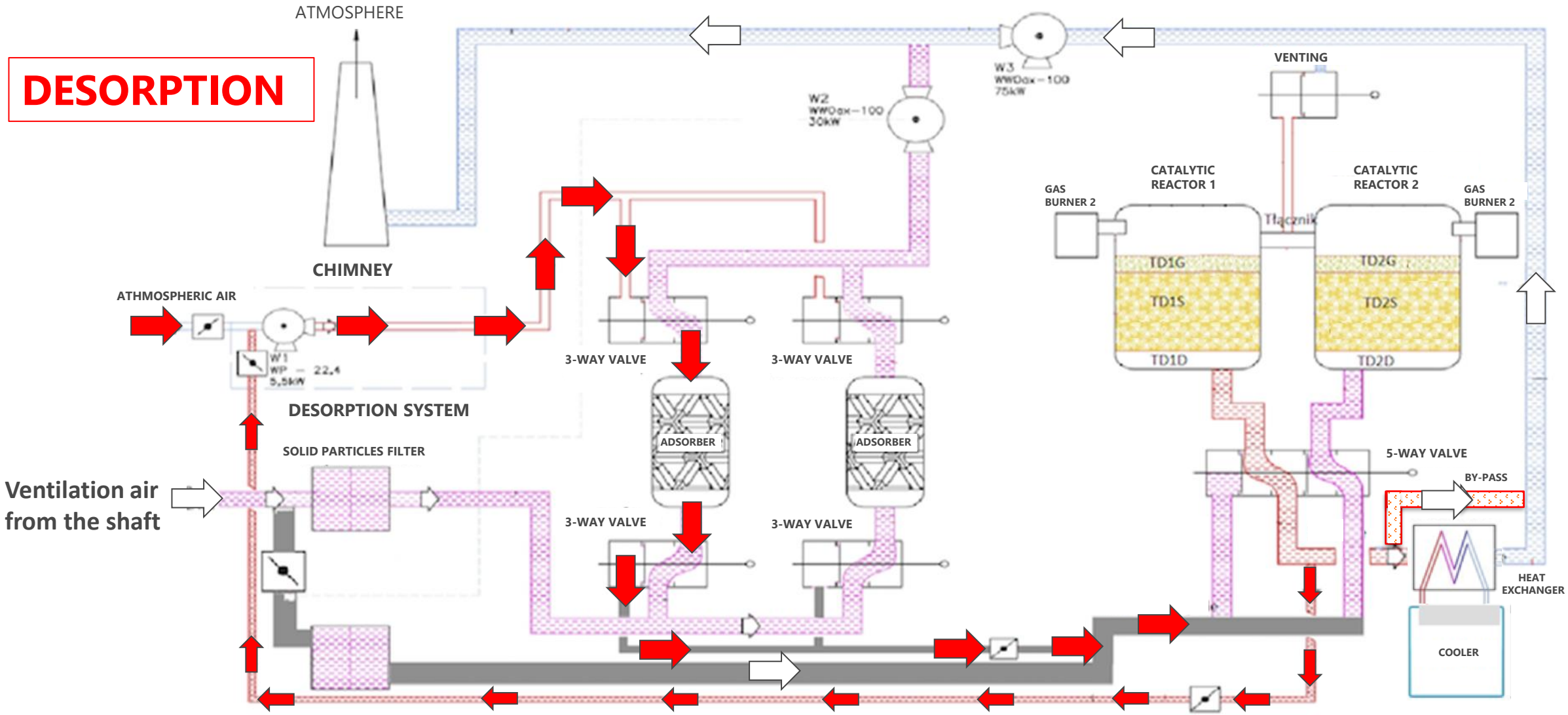
Flow chart of the installation – Methane Adsorber Regenerative Catalytic Oxydation

ADSORPTION



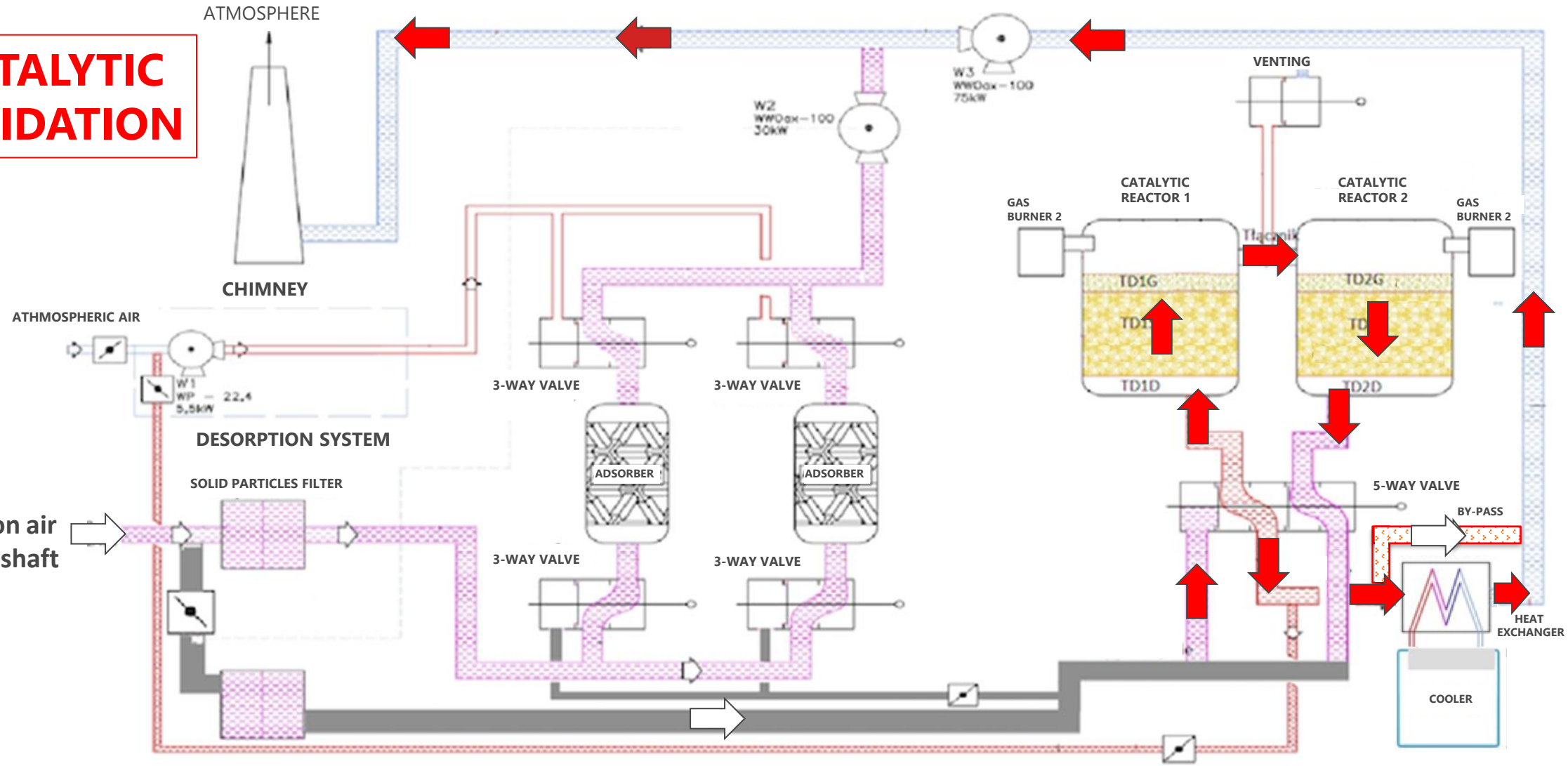
Flow chart of the installation – Methane Adsorber Regenerative Catalytic Oxydation

DESORPTION



Flow chart of the installation – Methane Adsorber Regenerative Catalytic Oxydation

CATALYTIC OXIDATION



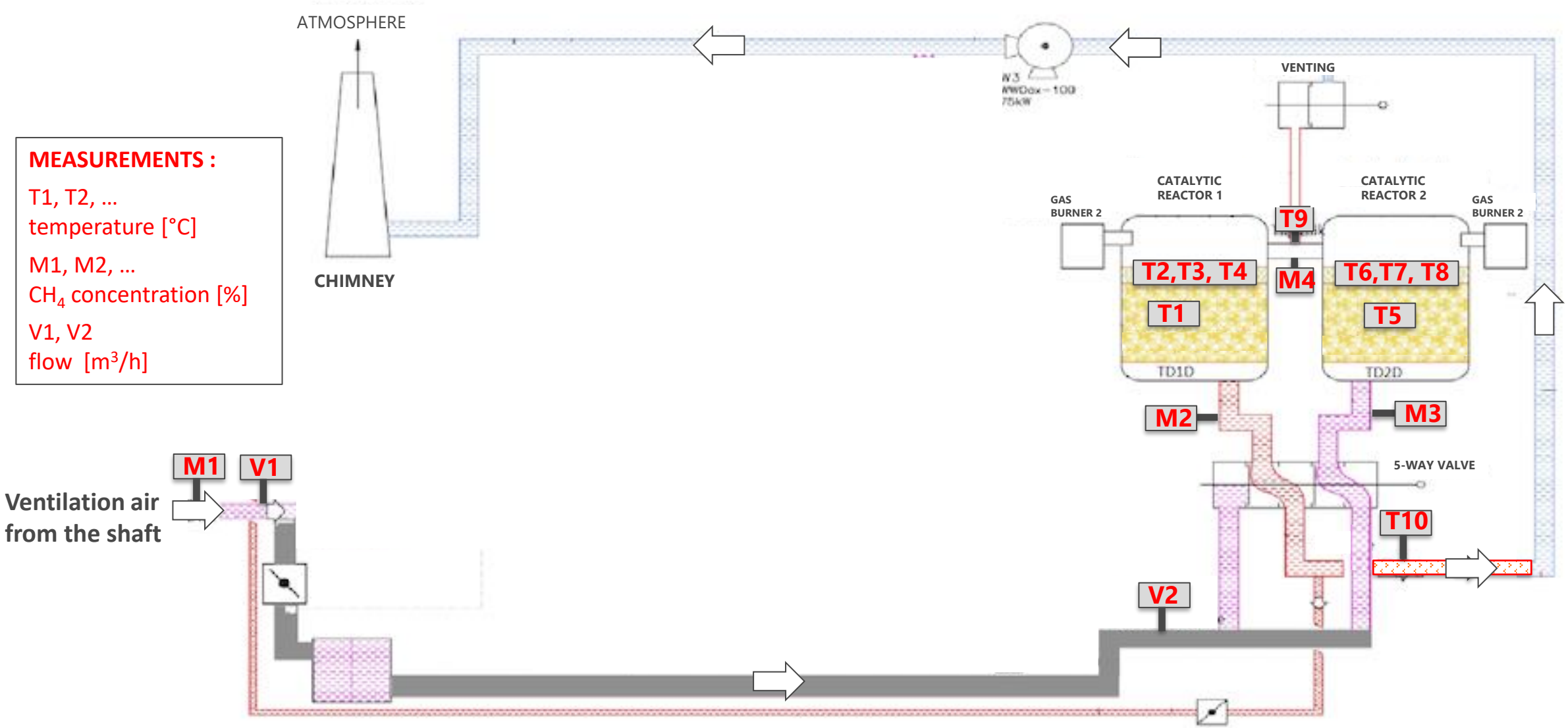
Flow chart of the installation – catalytic reactors tested within the R&D project

MEASUREMENTS :

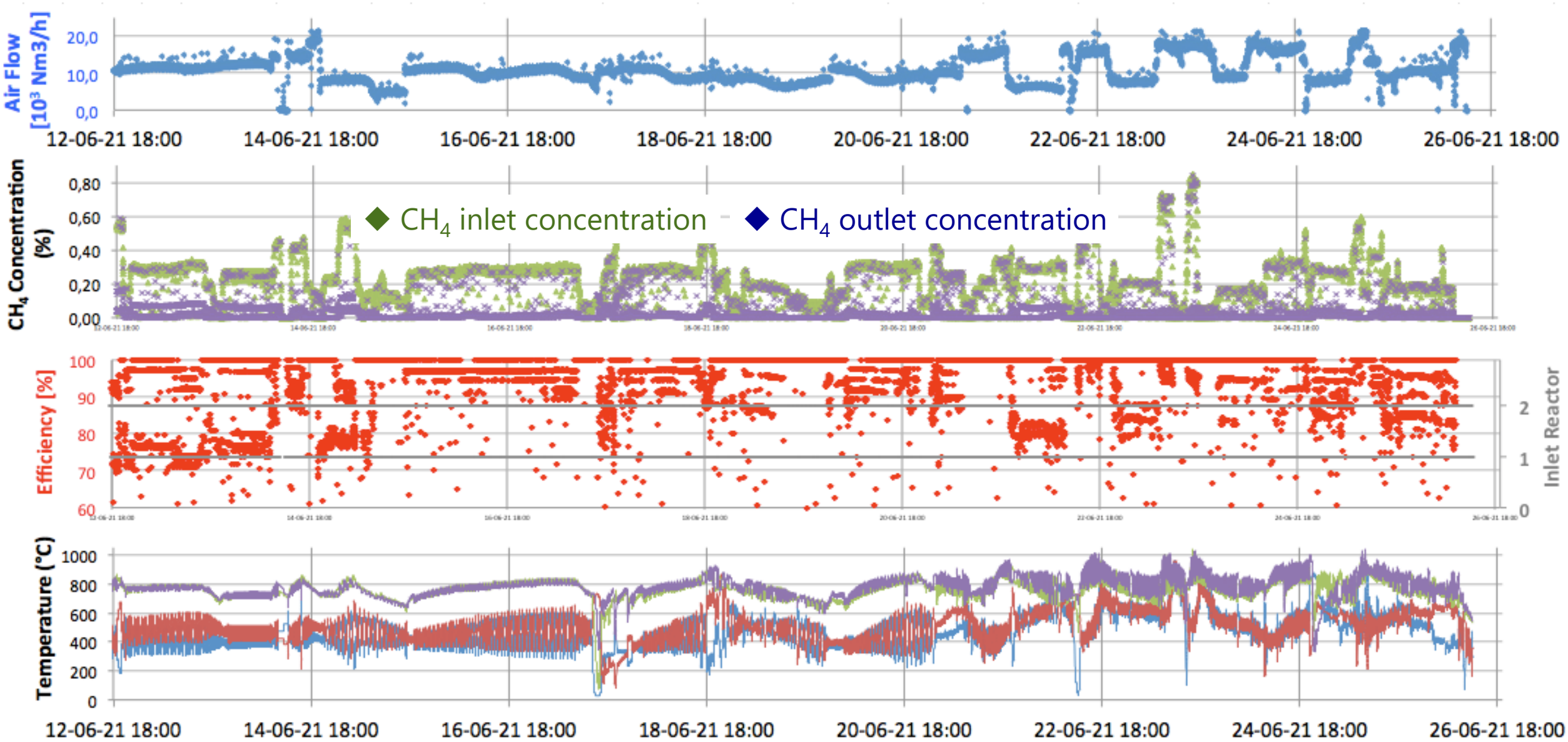
T1, T2, …
temperature [°C]

M1, M2, …
CH_4 concentration [%]

V1, V2
flow [m^3/h]



Test results of the catalytic reactor system



Test results of the catalytic reactor system

Continuous running test
24/7, 14 days

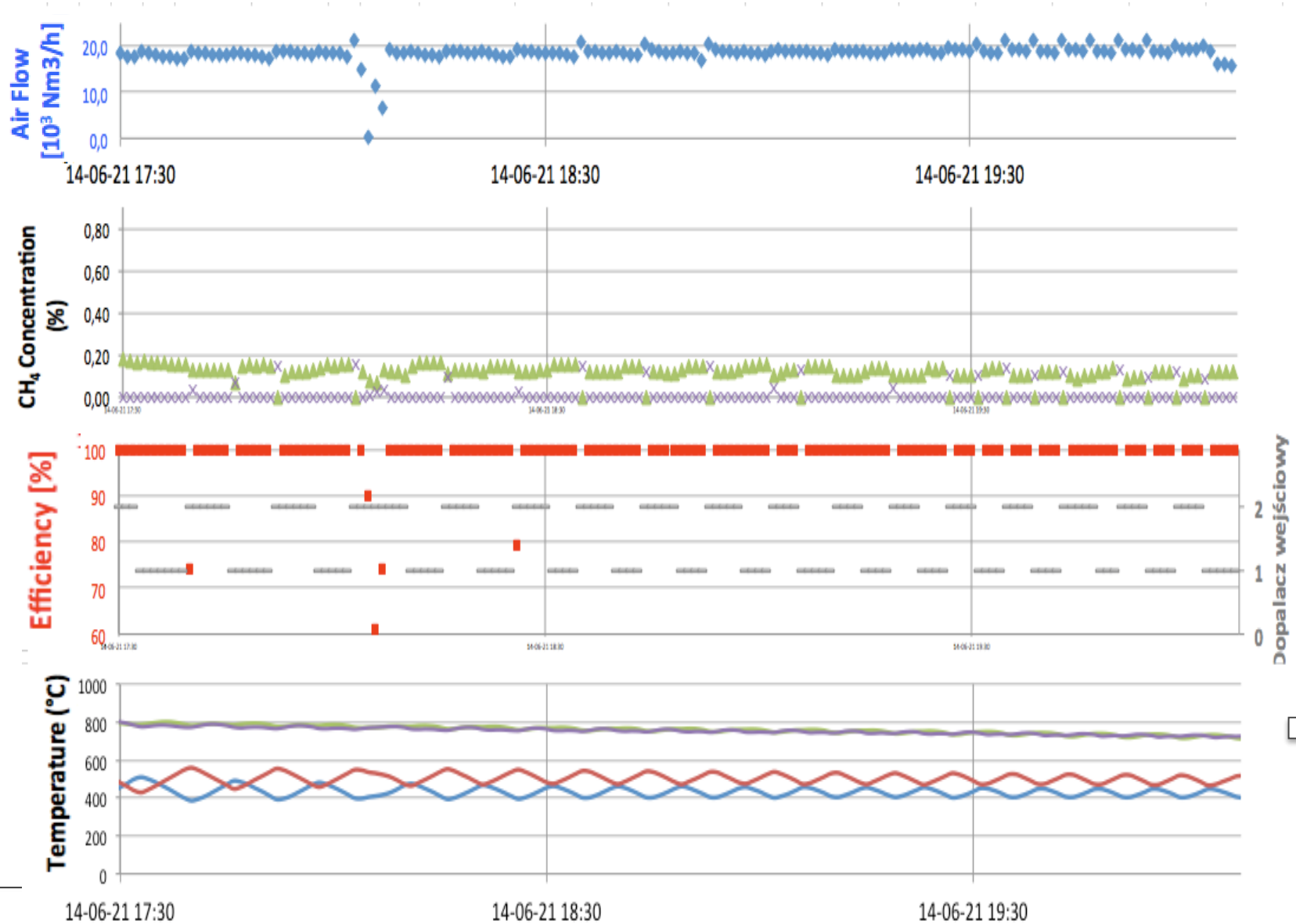
Flow: 5 000 – 20 000 Nm^3/h

CH_4 inlet concentration:
0,05 – 0,8 %

Average efficiency of CH_4 elimination > 90 %

Autothermal work (11 h) starting from the CH_4 concentration > 0,15 %

Test results of the catalytic reactor system – 0,1 % CH_4



⇨ Test running time 2,5 h

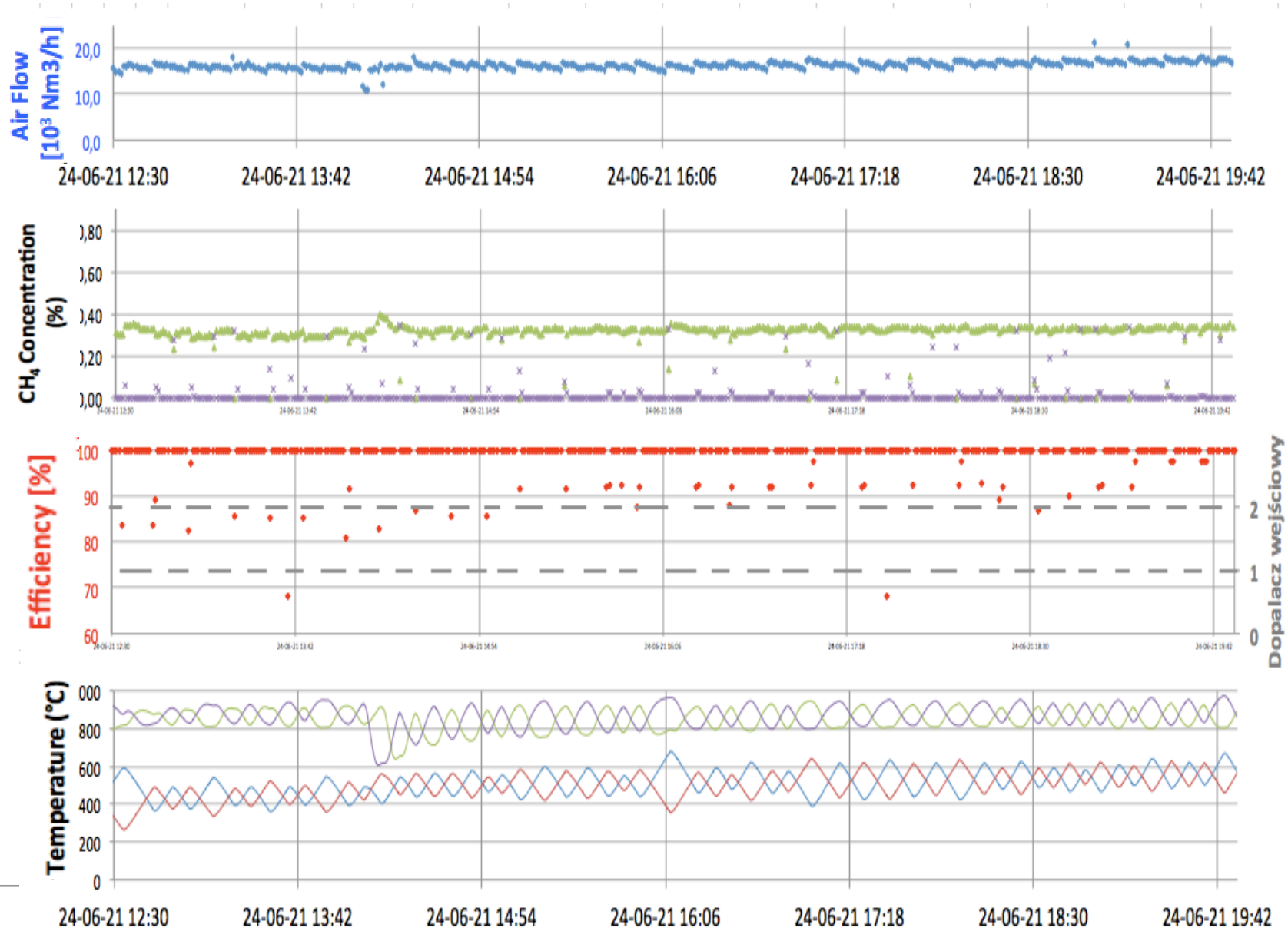
⇨ Average flow: 19 000 Nm^3/h

⇨ Average CH_4 inlet concentration: 0,1 %

⇨ Average efficiency of CH_4 elimination: 97 %

⇨ Cooling down of the system: approx. 20 °C/h

Test results of the catalytic reactor system – 0,3 % CH_4



⇨ Test running time 7 h

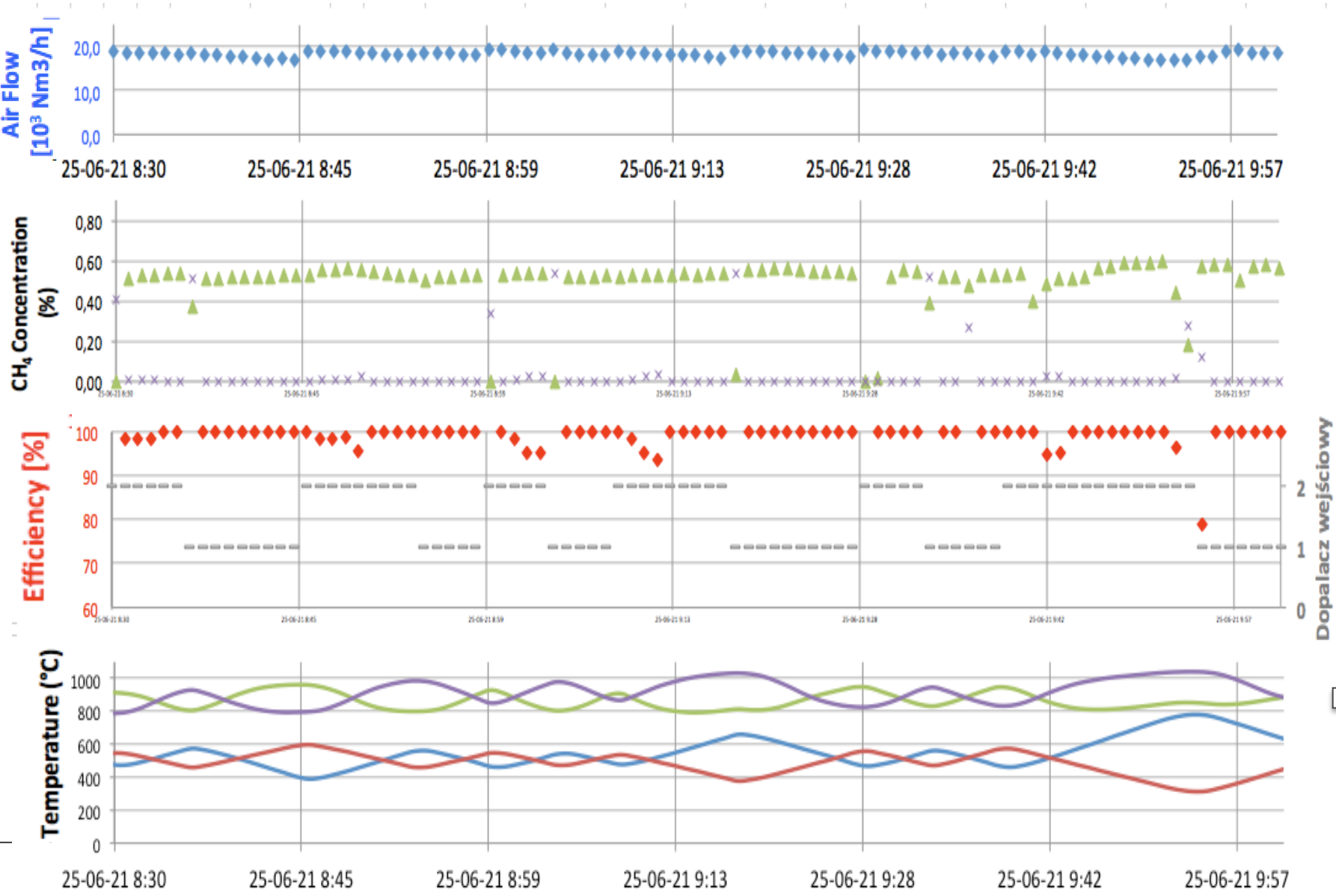
⇨ Average flow: 16 000 Nm^3/h

⇨ Average CH_4 inlet concentration: 0,3 %

⇨ Average efficiency of CH_4 elimination: 98 %

⇨ Stable work of catalysts: 800 – 950 °C

Test results of the catalytic reactor system – 0,5 % CH_4



⇨ Test running time 7 h

⇨ Average flow: 18 000 Nm^3/h

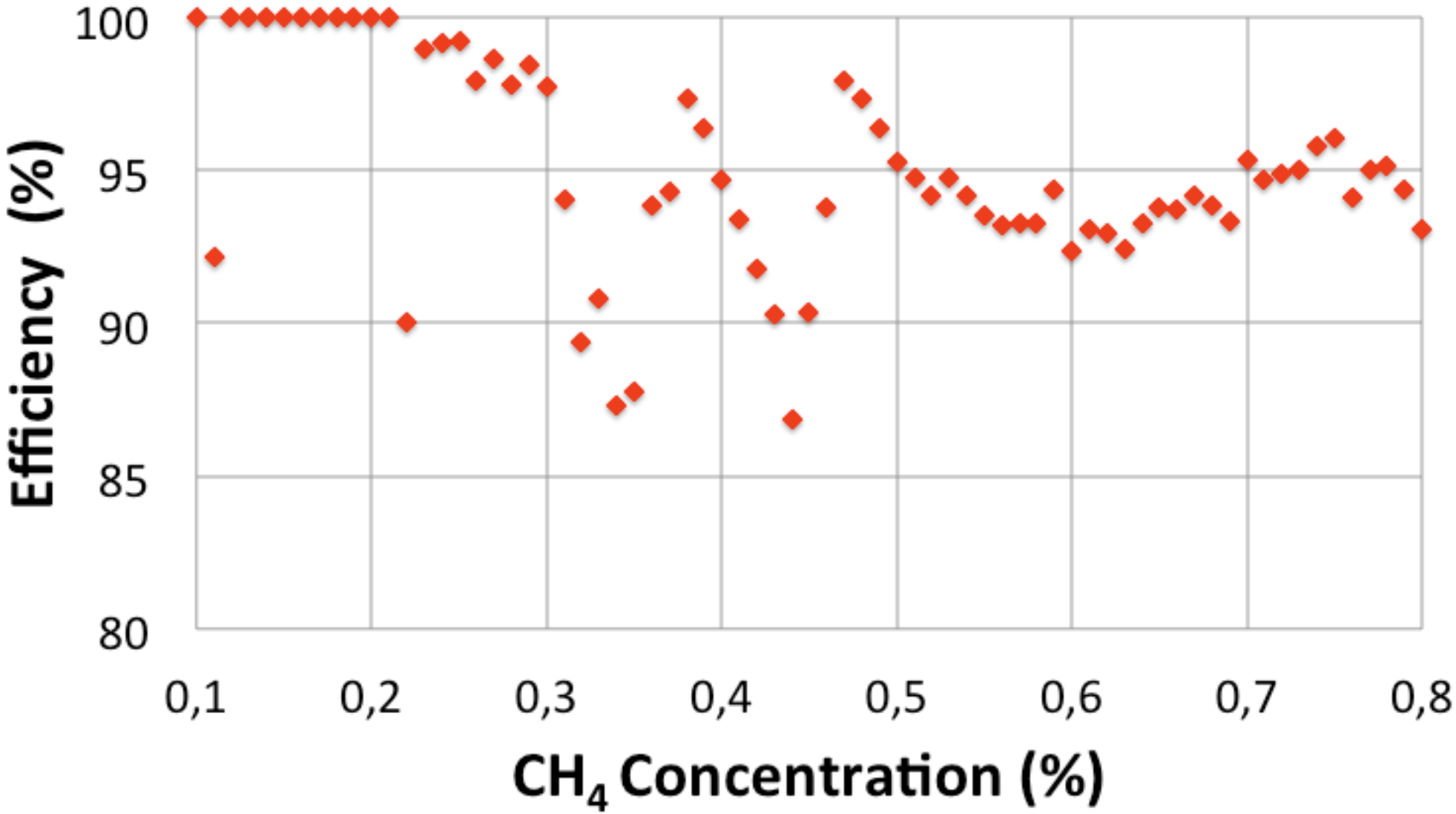
⇨ Average CH_4 inlet concentration: 0,5 %

⇨ Average efficiency of CH_4 elimination: 97 %

⇨ Stable work of catalyst: 800 – 1050 °C

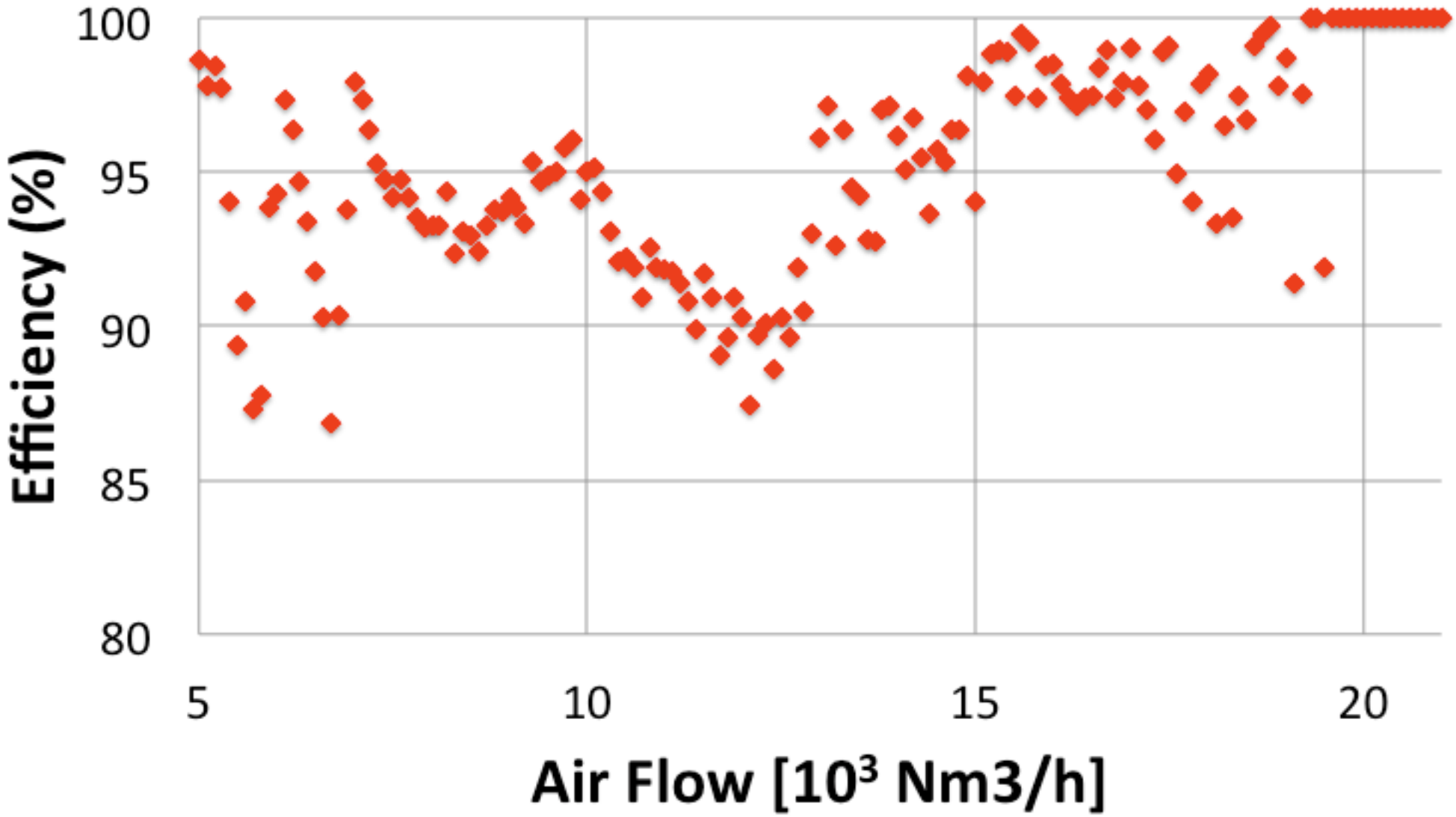
Average efficiency of the system of catalytic reactors

CH_4 elimination efficiency as a function of CH_4 concentration for flows in a range of 5 000 – 20 000 Nm^3/h



Average efficiency of the system of catalytic reactors

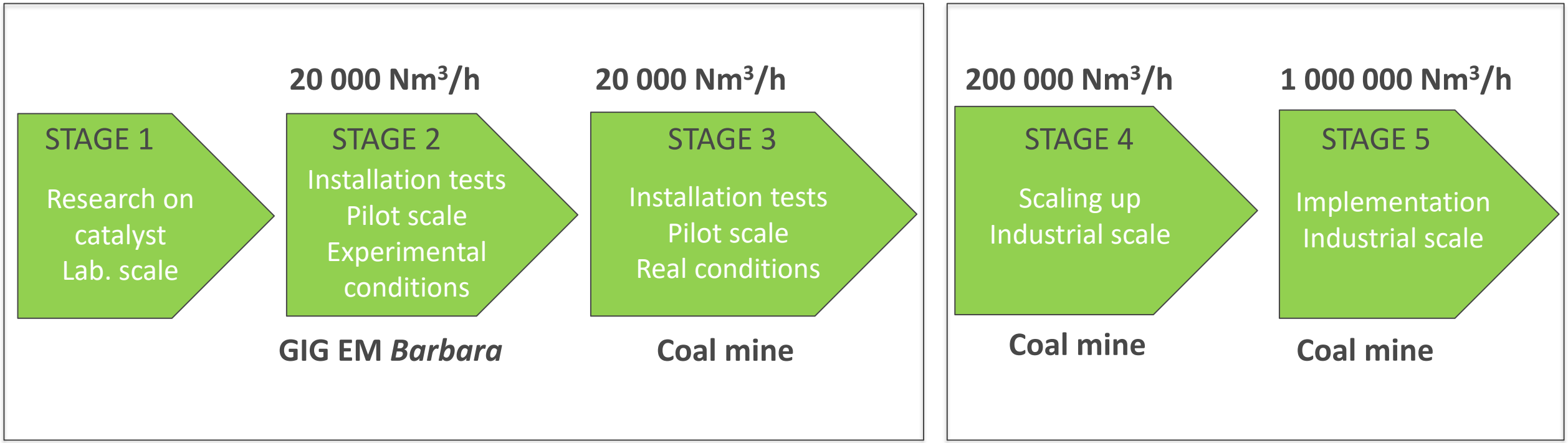
CH_4 elimination efficiency as a function of flow of CH_4 concentrations in a range of 0,1 – 0,8 %



Conclusions:

- operation of the installation verified in a continuous operation 24/7 during 14 days,
- concentration of CH_4 from 0,05 to 0,8 %,
- flow range: 5 000 – 20 000 Nm^3/h,
- catalyst operating temperature range: 750 – 1050 °C,
- methane elimination effectiveness > 90 %,
- possibility of autothermal work from 0,15 % CH_4.

Prospects



CURRENT PROJECT (POIR.01.01.01-00-0367/18)

IMPLEMENTATION OF THE PROJECT RESULTS

Thank you for your attention