Construction of numerical models of ventilation network for future exploitation in underground coal mine under methane hazard conditions

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- The paper discusses the construction of numerical models of the ventilation network for future mining in an underground coal mine under methane hazard conditions. The work included several numerical models, which took into account various regulations, in order to ensure that the level of aerological hazards is minimized and that the amount of fresh air in the area of excavated headings and exploited longwalls is as high as possible.
- Factors such as serial ventilation, the length of air supply and exhaust routes, the methane-bearing capacity of coal seams, and deficiencies in the required amount of air for planned mining operations were analyzed for their impact on the level of aerological hazards. In the final phase of the article, the effectiveness of the regulations used was evaluated and optimal regulations were proposed for the mine's future ventilation network to ensure safe and efficient operation under methane hazard conditions.

Agenda

- **Introduction**
- **Stages of construction of the numerical model of the ventilation network LW Bogdanka in Ventsim software**
- **Stages of numerical modeling of the future ventilation network LW Bogdanka taking into account the methane hazard**
- **Summary**

Introduction

- **LW Bogdanka - is the mine with the largest production of thermal coal in Poland. The total mining area is about 200 km2 and is divided into three mining fields - Bogdanka field, Stefanów field and Nadrybie field. Each field has a pair of shafts: a ventilation shaft and an exit-material shaft.**

Introduction

The characteristics of the natural hazards occurring in the Lubelski Węgiel ,,Bogdanka'' S.A. mine are as follows [1]:

methane - category I

coal dust explosion- grade A, B

water - I, II degree

fire - IV self-flammability group

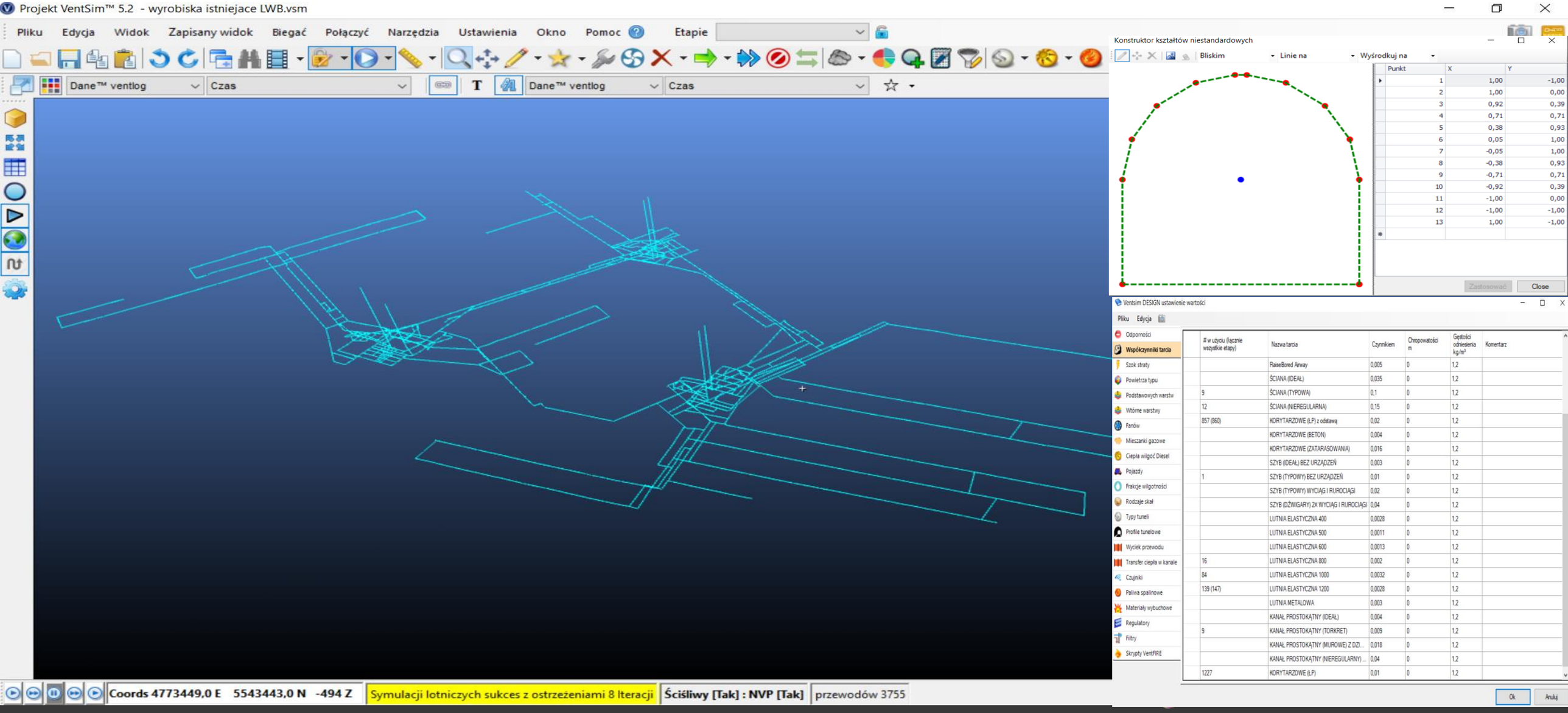
rock bumps - none

gas and rock outbursts - not present

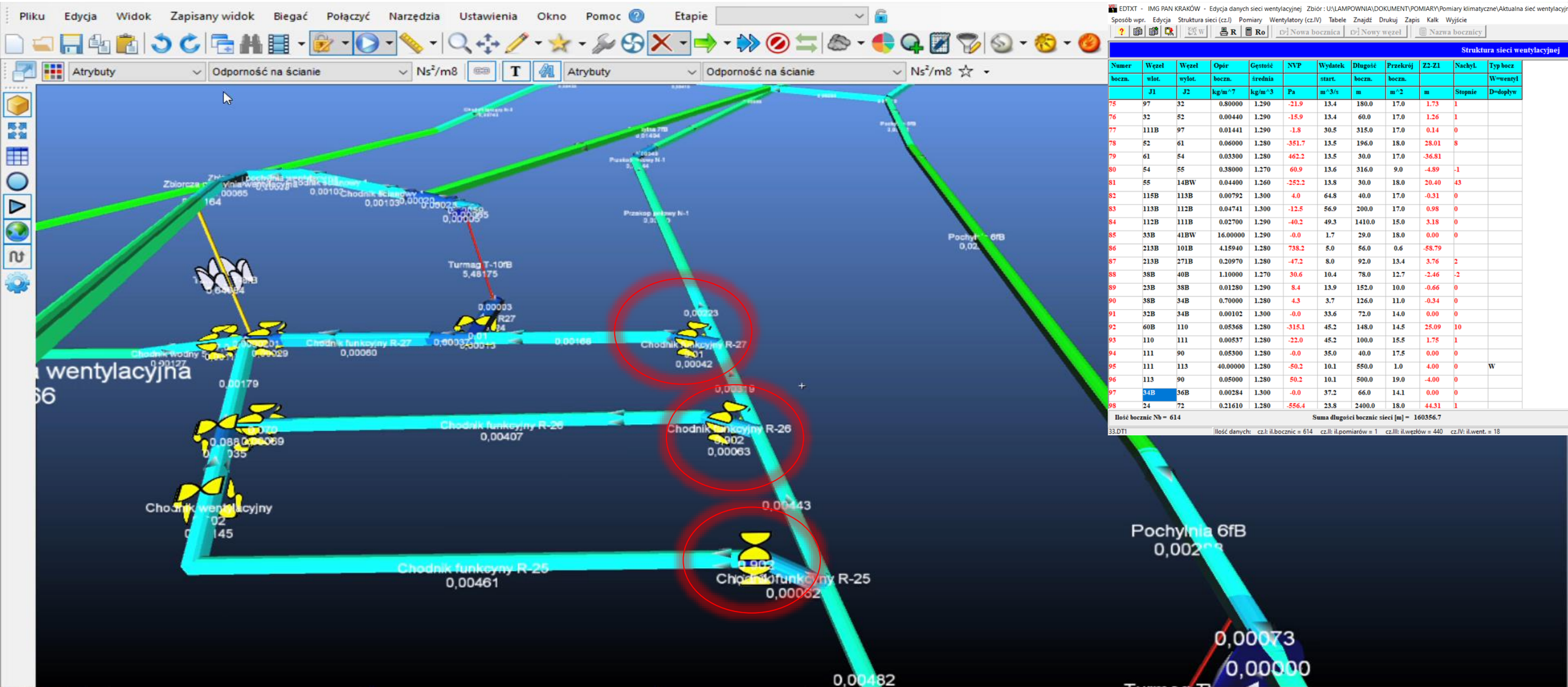
radiation - not endangered

climatic - not threatened, I and II degree.

Construction of a 3D model of the mine's ventilation network.



Mapping the location of ventilation dams and their flow resistance



EDTXT - IMG PAN KRAKÓW - Edycja danych sieci wentylacyjnej Zbiór : U:\LAMPOWNIA\DOKUMENT\POMIARY\Pomiary klimatyczne\Aktualna sieć wentylacyjn

Sposób wpr. Edycja Struktura sieci (cz.I) Pomiary Wentylatory (cz.IV) Tabele Znajdź Drukuj Zapis Kalk Wyjście

Nowa bocznica Nowy węzeł Nazwa bocznicy

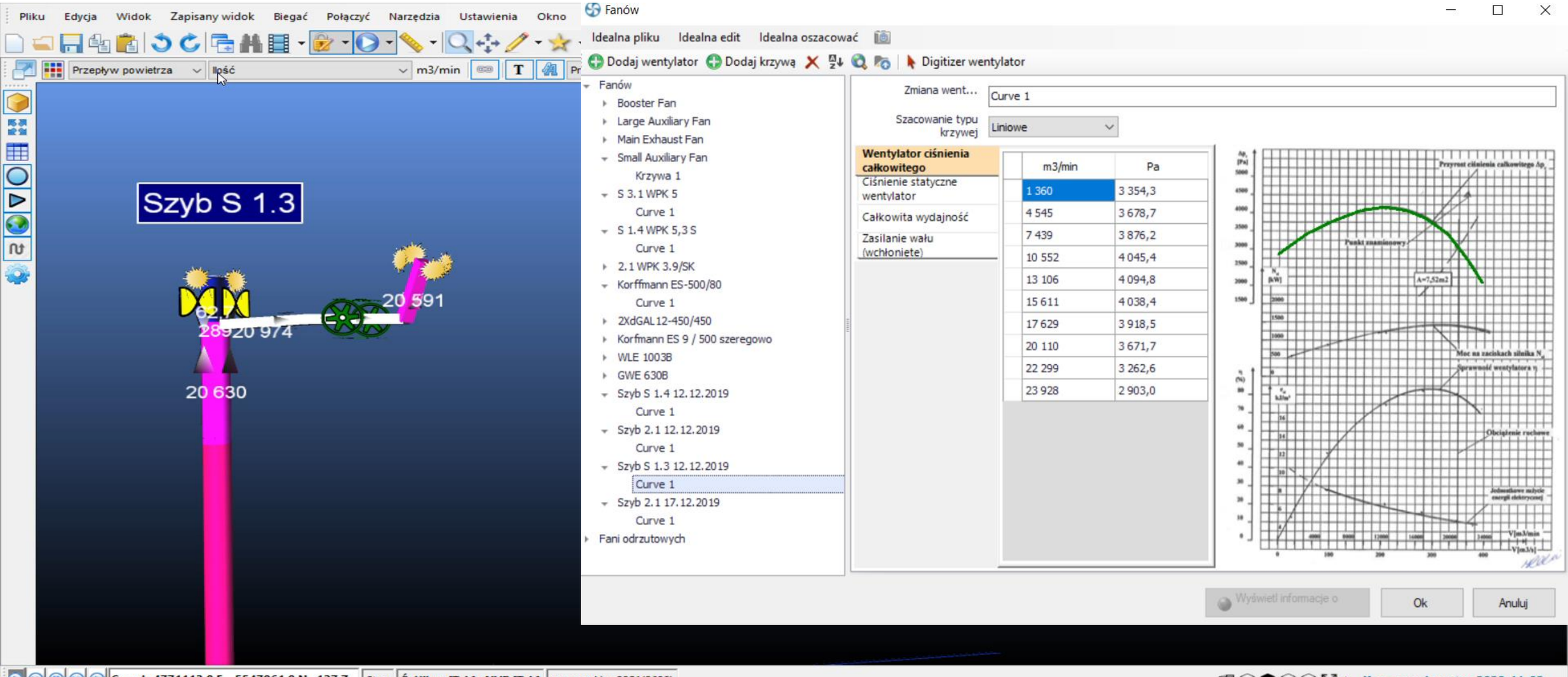
Struktura sieci wentylacyjnej

Numer	Węzeł	Węzeł	Opór	Gęstość	NVP	Wydatek	Długość	Przekrój	Z2-Z1	Nachyl.	Typ bocz
boczn.	wlot.	wylot.	boczn.	średnia		start.	boczn.	boczn.			W=wentyl
	J1	J2	kg/m^7	kg/m^3	Pa	m^3/s	m	m^2	m	Stopnie	D=dopływ
75	97	32	0.80000	1.290	-21.9	13.4	180.0	17.0	1.73	1	
76	32	52	0.00440	1.290	-15.9	13.4	60.0	17.0	1.26	1	
77	111B	97	0.01441	1.290	-1.8	30.5	315.0	17.0	0.14	0	
78	52	61	0.06000	1.280	-351.7	13.5	196.0	18.0	28.01	8	
79	61	54	0.03300	1.280	462.2	13.5	30.0	17.0	-36.81		
80	54	55	0.38000	1.270	60.9	13.6	316.0	9.0	-4.89	-1	
81	55	14BW	0.04400	1.260	-252.2	13.8	30.0	18.0	20.40	43	
82	115B	113B	0.00792	1.300	4.0	64.8	40.0	17.0	-0.31	0	
83	113B	112B	0.04741	1.300	-12.5	56.9	200.0	17.0	0.98	0	
84	112B	111B	0.02700	1.290	-40.2	49.3	1410.0	15.0	3.18	0	
85	33B	41BW	16.00000	1.290	-0.0	1.7	29.0	18.0	0.00	0	
86	213B	101B	4.15940	1.280	738.2	5.0	56.0	0.6	-58.79		
87	213B	271B	0.20970	1.280	-47.2	8.0	92.0	13.4	3.76	2	
88	38B	40B	1.10000	1.270	30.6	10.4	78.0	12.7	-2.46	-2	
89	23B	38B	0.01280	1.290	8.4	13.9	152.0	10.0	-0.66	0	
90	38B	34B	0.70000	1.280	4.3	3.7	126.0	11.0	-0.34	0	
91	32B	34B	0.00102	1.300	-0.0	33.6	72.0	14.0	0.00	0	
92	60B	110	0.05368	1.280	-315.1	45.2	148.0	14.5	25.09	10	
93	110	111	0.00537	1.280	-22.0	45.2	100.0	15.5	1.75	1	
94	111	90	0.05300	1.280	-0.0	35.0	40.0	17.5	0.00	0	
95	111	113	40.00000	1.280	-50.2	10.1	550.0	1.0	4.00	0	W
96	113	90	0.05000	1.280	50.2	10.1	500.0	19.0	-4.00	0	
97	34B	36B	0.00284	1.300	-0.0	37.2	66.0	14.1	0.00	0	
98	24	72	0.21610	1.280	-556.4	23.8	2400.0	18.0	44.31	1	

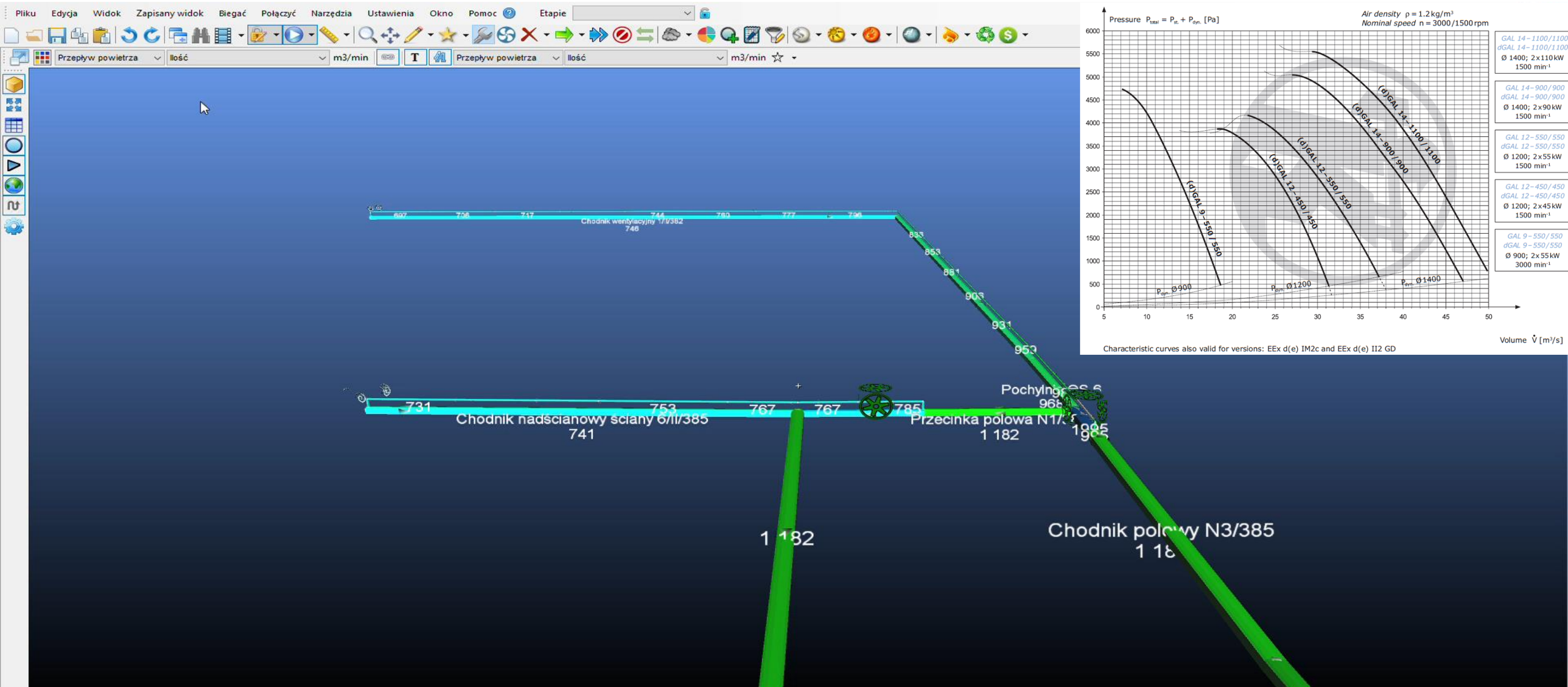
Ilość bocznic Nb = 614 Suma długości bocznic sieci [m] = 160356.7

33.DT1 Ilość danych: cz.I: il.bocznic = 614 cz.II: il.pomiarów = 1 cz.III: il.węzłów = 440 cz.IV: il.went. = 18

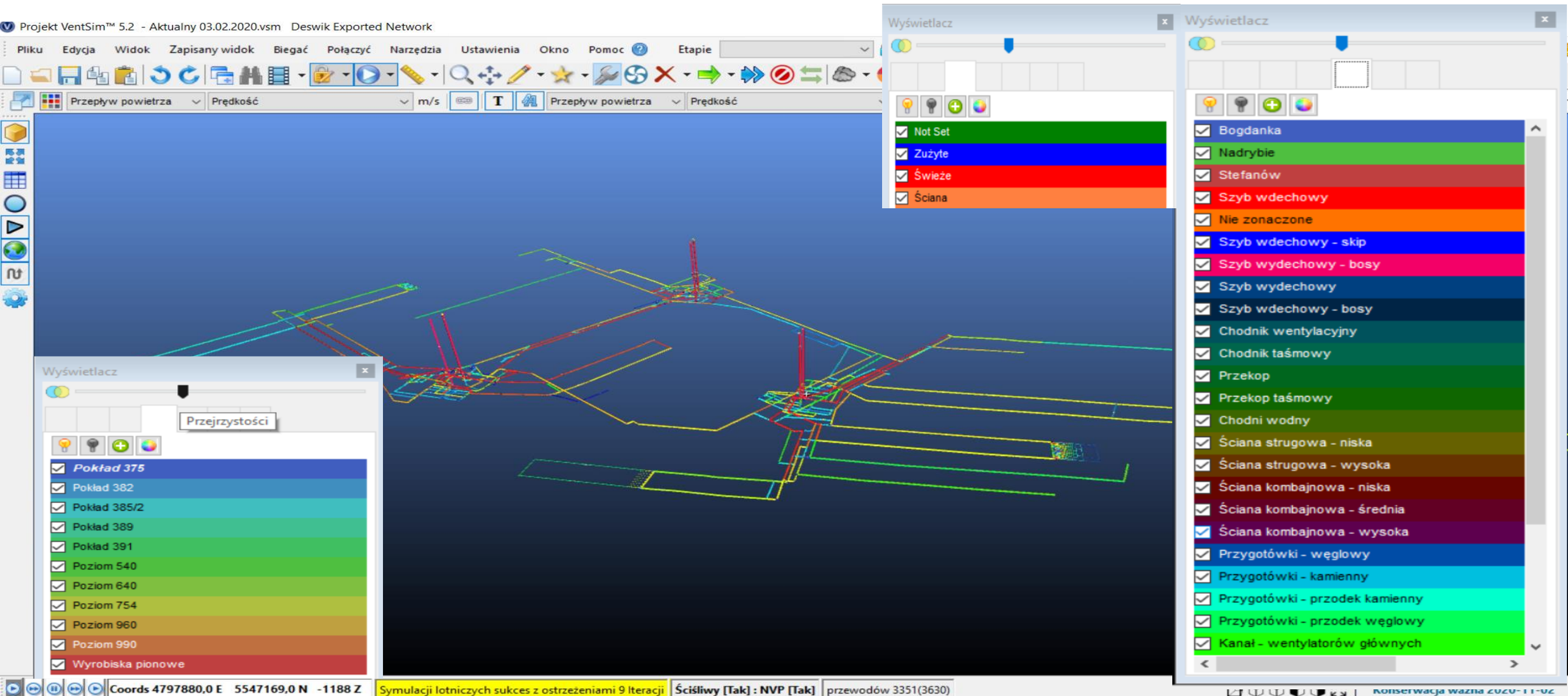
Mapping the shafts and introducing the characteristics of the main fans



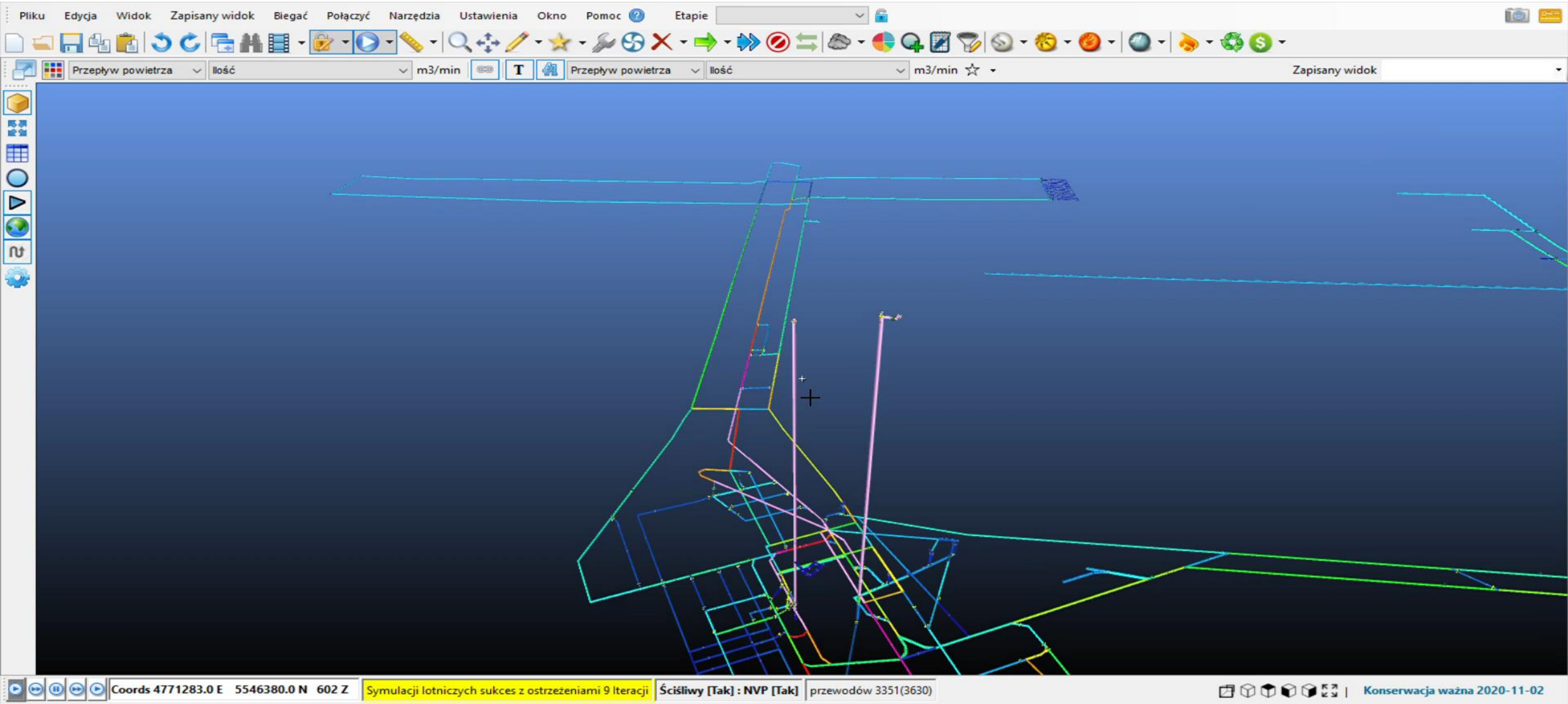
Introduction of auxiliary fan characteristics



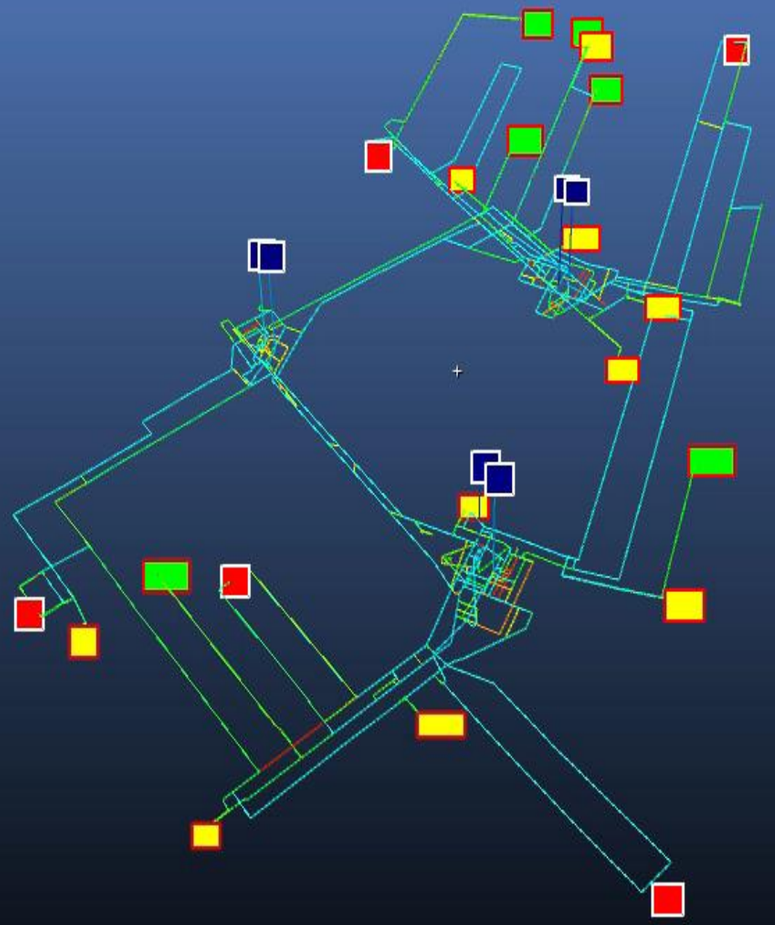
Assignment of attributes of individual sidings of the ventilation network



Finished 3D model of the ventilation network



Finished 3D model of the ventilation network



The amount of air supplied to the mine is:
shaft S-1.2.- approximately 14,300m³/s,
shaft S-1.5.- approximately 15,200m³/sec.
shaft S-2.2.- approximately 19,000m³/s,
approximately 48,500m³/s.
The amount of discharged used air is:
shaft S-1.3. - about 20,300m³/s,
S-2.1. shaft - about 18,000m³/s,
S-1.4. shaft - about 12,000m³/s,
approximately 50,300m³/s.

Stages of numerical modeling

- **Taking into account the methane hazard, numerical models of the ventilation network of LW Bogdanka were made for future exploitation in longwall regions 3/VII/385, 2/II/382, 8/II/385, 1/IV/391.**
- **The models took into account methane evolution in the longwall region in the Ventsim software on the basis of the forecasted absolute methane intensity made on the basis of the prepared algorithm for the forecast of absolute methane intensity for the longwall region.**

Stages of numerical modeling

Analyzing the schedule of mining operations keeping in mind the projected total methane rate, the following characteristic mining time periods were selected, which were divided into three stages:

Stage I - Model 1 - the state of the mine's ventilation network at the end of December 2022 with longwall 2/II382.

Stage II - Model 2 - the state of the mine's ventilation network at the end of March 2023 with longwall 3/VII/385 and longwall 8/II/385.

Phase III - Model 3 - the state of the mine's ventilation network at the end of September 2023 with longwall 1/VI/391.

Stages of numerical modeling

In the design of numerical and 3D graphical models for the analyzed periods of the future structure of the ventilation network of the mine L.W. "Bogdanka" S.A., the following were used [1]:

the numerical model for the fourth quarter of 2022 after introducing the results from the conducted study of isentropic potentials in the mine network,

current spatial diagram of the ventilation network of the Bogdanka mine,

maps of access and exploitation of seams 382, 385/2, 389 and 391,

schedule of mining works,

data from the Desvik program,

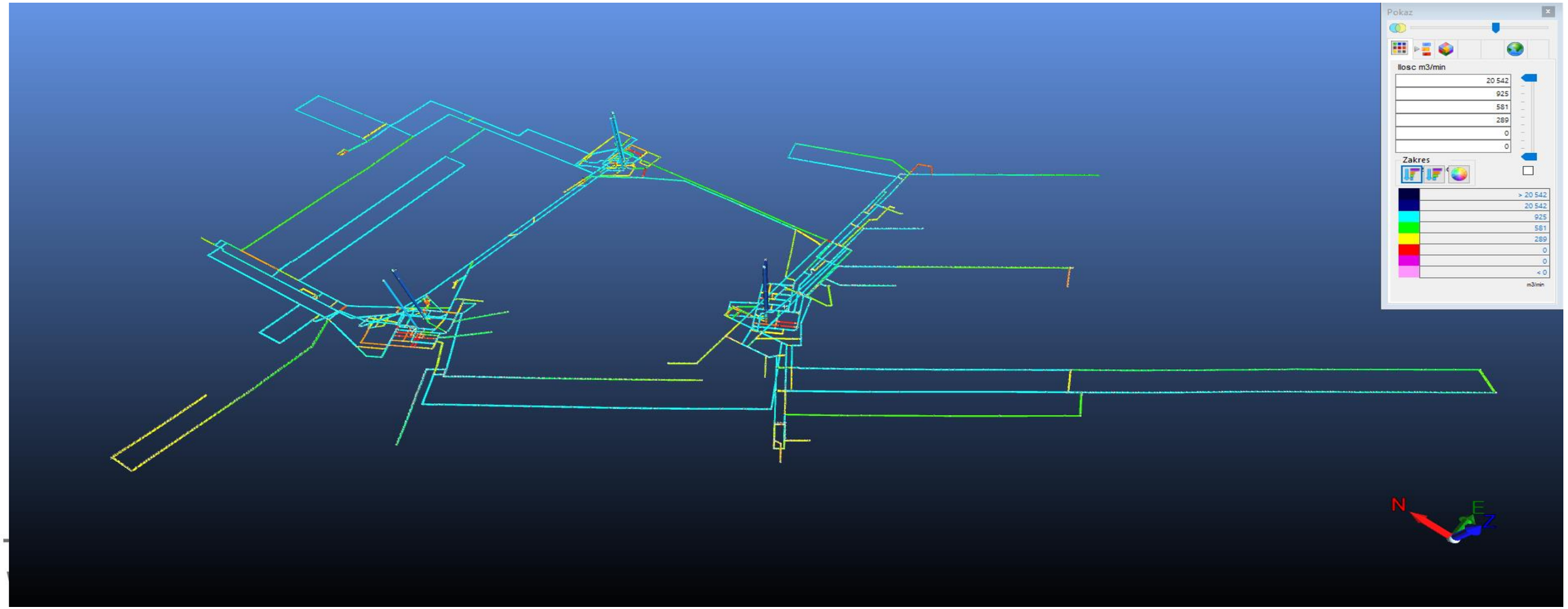
results of air volume measurements in underground workings,

information on the level of aerological hazards,

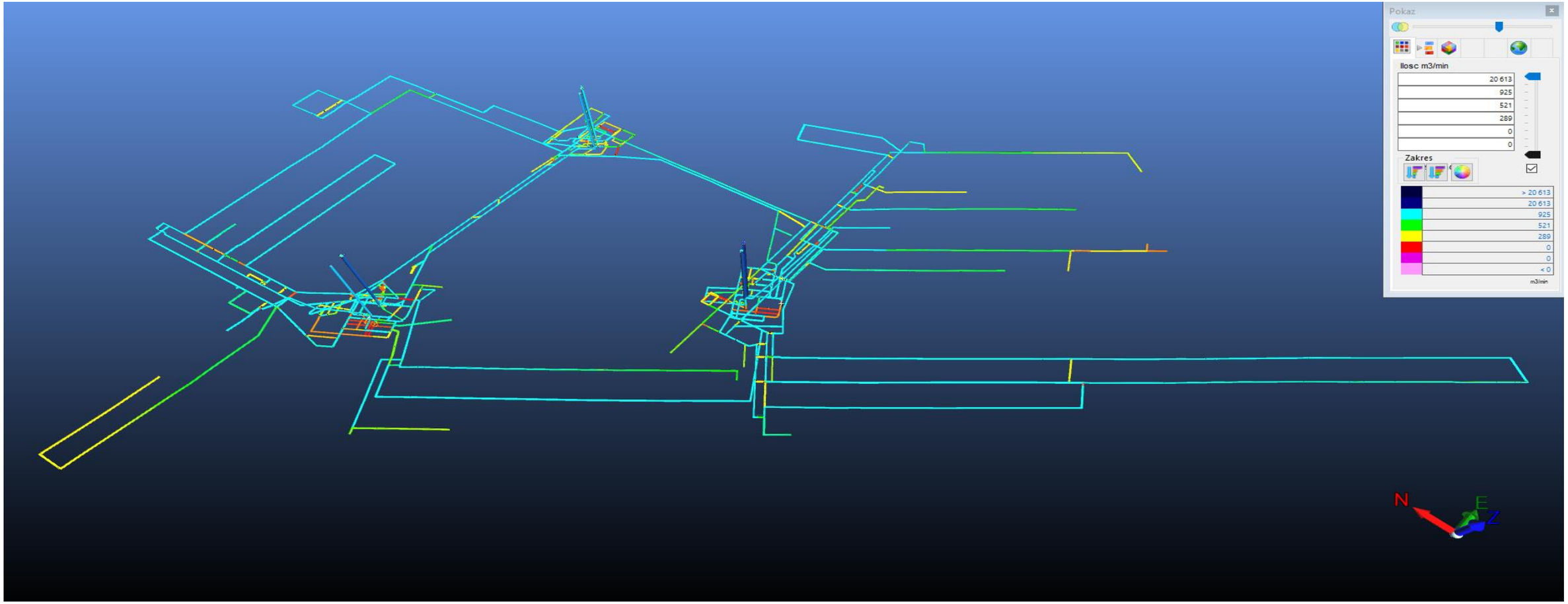
results of recorded values by the mine's gasometric system,

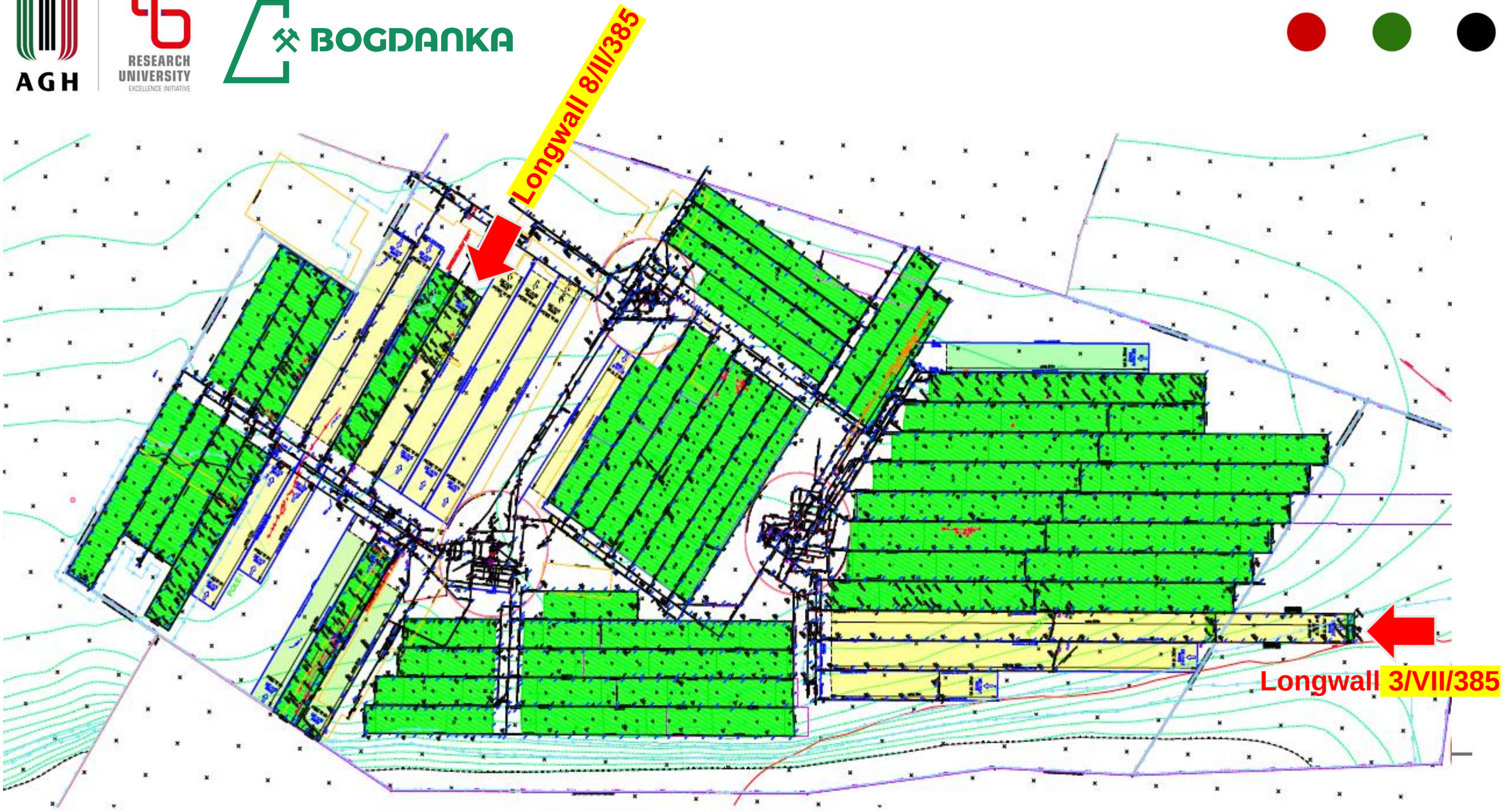
operating characteristics of the main ventilation fans located at exhaust shafts 1.3 (WPK-5.0), 1.4 (WPK-5.3 spec) and 2.1 (WPK 3.9/SK).

Numerical model 1 - state of the mine ventilation network at the end of December 2022 with longwall 2/II/382 after adjustment

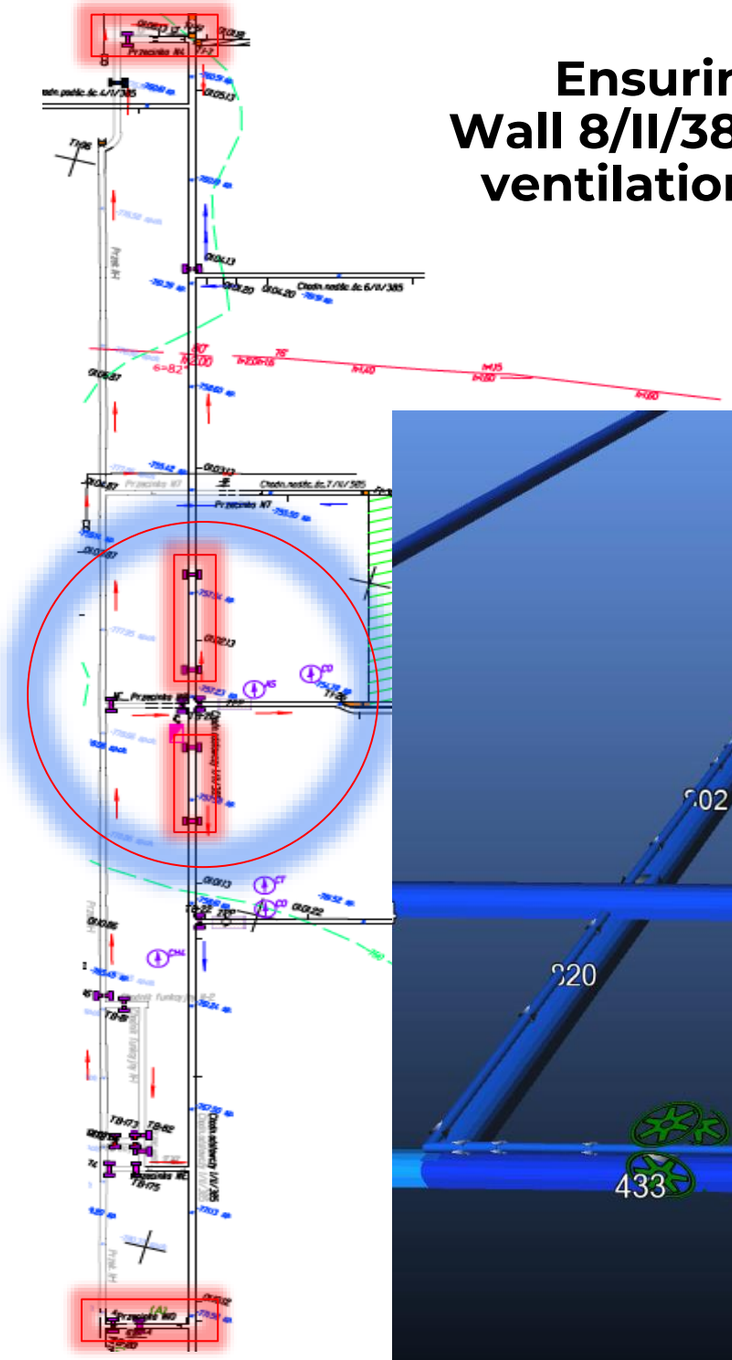


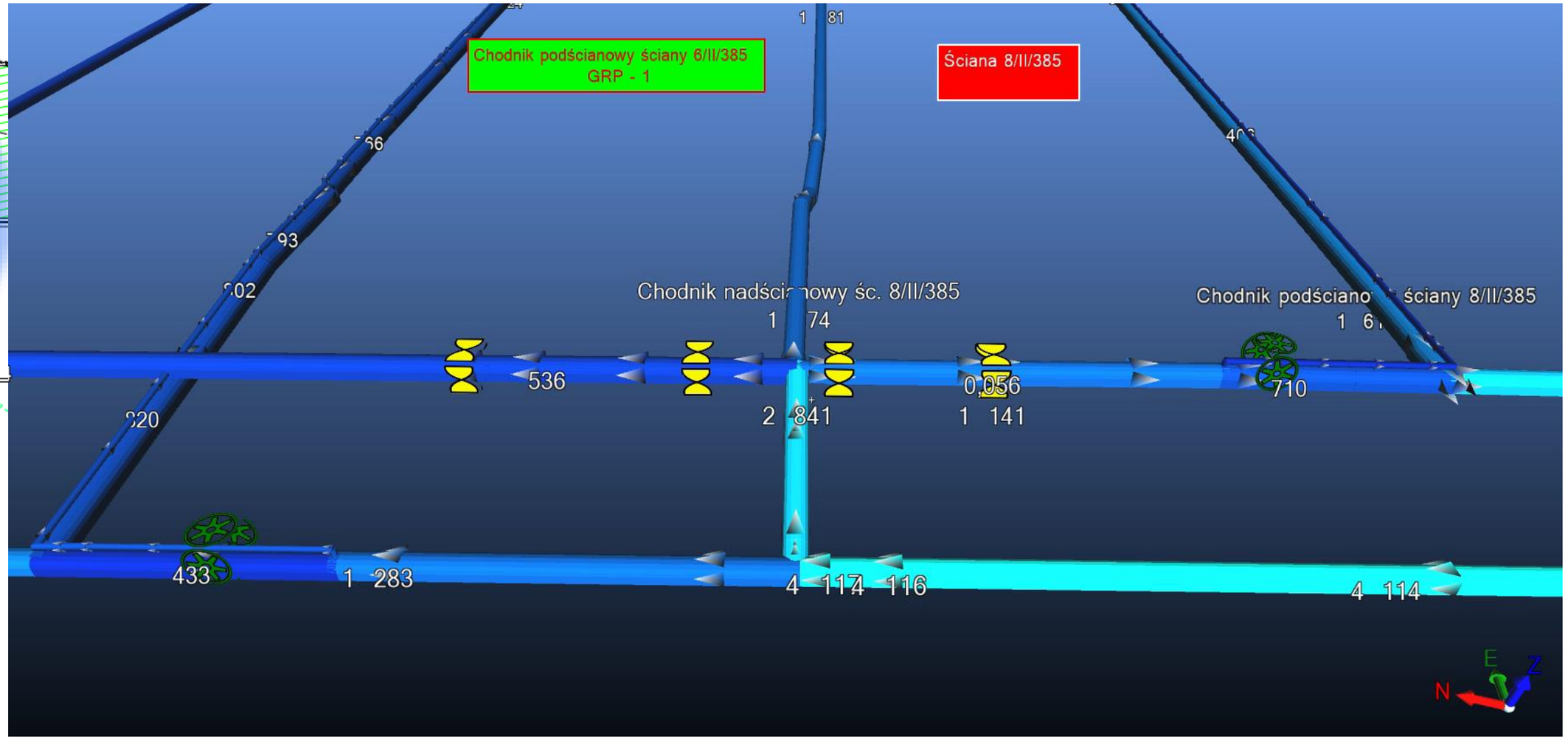
Numerical model 2 - state of the mine ventilation network at the end of March 2023 with longwall 3/VII/385 and longwall 8/II/385 after adjustment



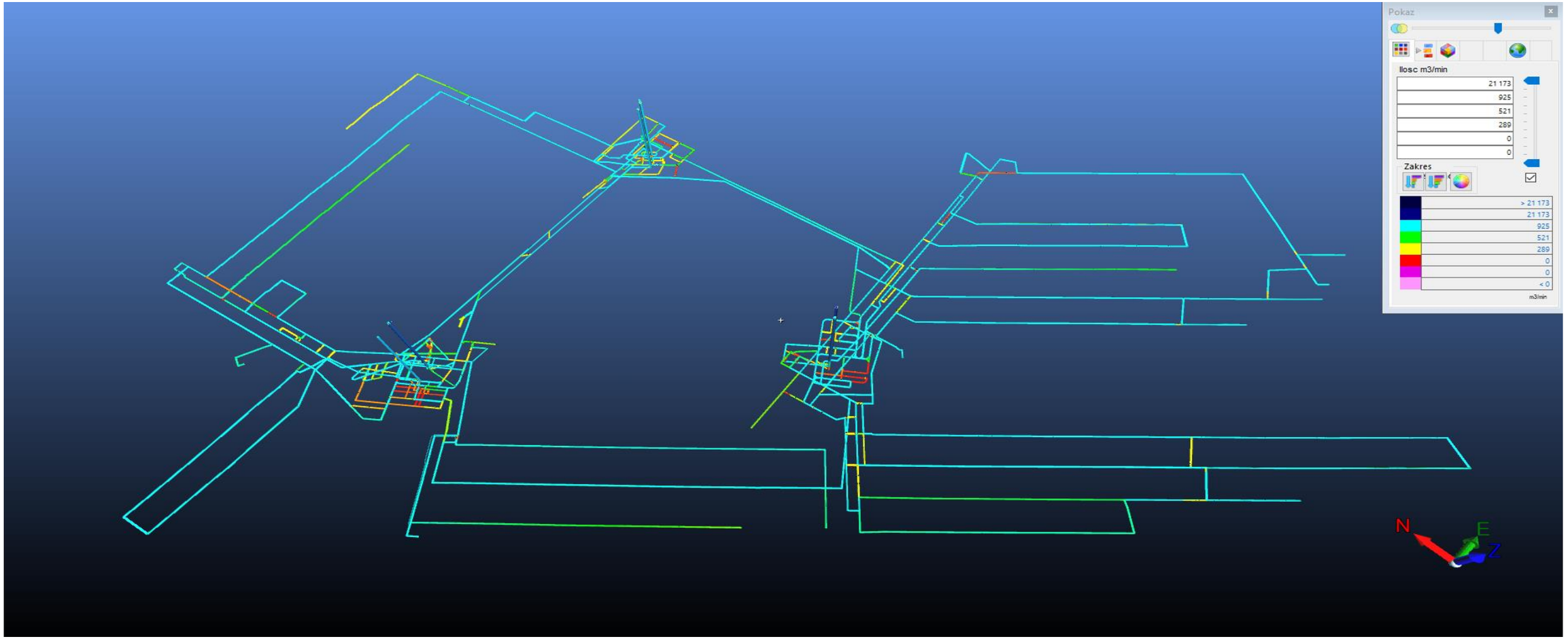

Longwall 8/III/385
Longwall 3/VII/385

Ensuring stability and required air volumes in the area of Wall 8/II/385 is dependent on the proper functioning of the dams ventilation dams in 4 sidings constituting the so-called. , "short ventilation coupling”



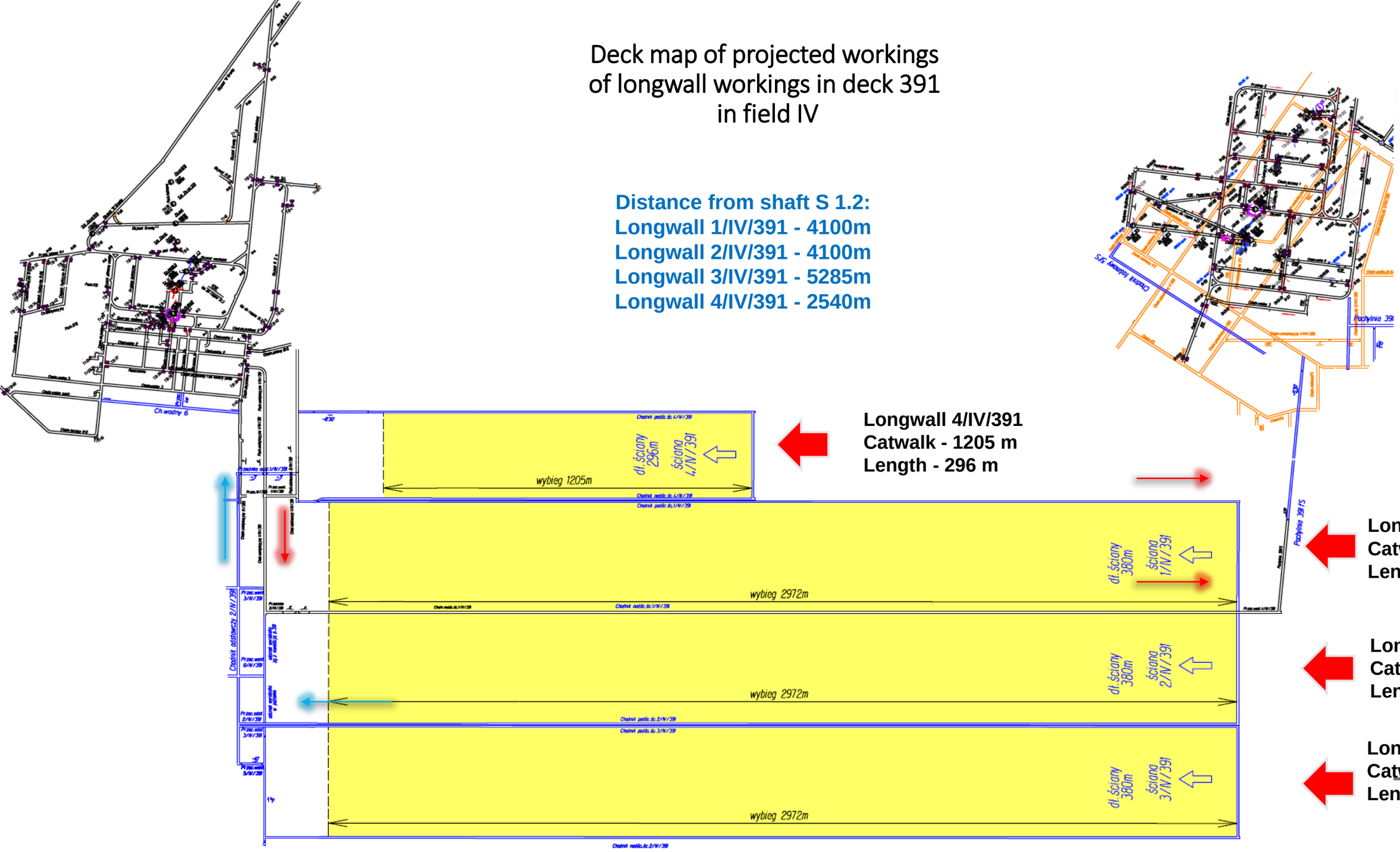


Numerical model 3 - the state of the mine's ventilation network at the end of September 2023 with longwall 1/IV/391 after adjustment.



Deck map of projected workings of longwall workings in deck 391 in field IV

Distance from shaft S 1.2:
Longwall 1/IV/391 - 4100m
Longwall 2/IV/391 - 4100m
Longwall 3/IV/391 - 5285m
Longwall 4/IV/391 - 2540m

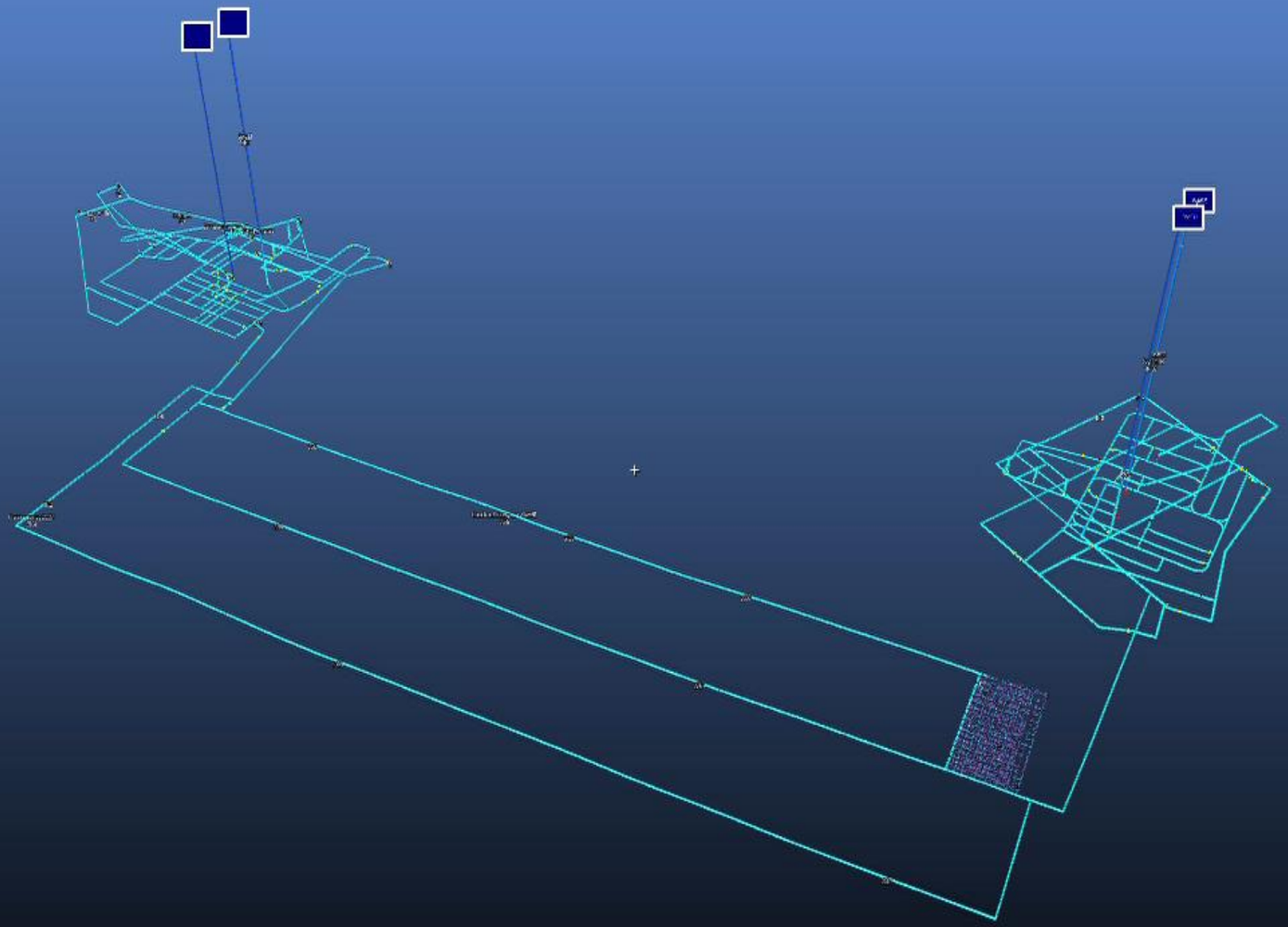


Longwall 4/IV/391
Catwalk - 1205 m
Length - 296 m

Longwall 1/IV/391
Catwalk - 2972 m
Length - 380 m

Longwall 2/IV/391
Catwalk - 2972 m
Length - 380 m

Longwall 3/IV/391
Catwalk - 2972 m
Length - 380 m



Summary

- In situ air volume measurements in the ventilation regions showed high agreement with the air volume calculated numerically using the VentSim software package for the analyzed stages of future operation at LW Bogdanka.
- The safety factors B of the operation of the main ventilation fans in the Bogdanka, Nadrybie and Stefanów fields showed safe cooperation.

Summary

- The progress of the wall depends on the projected total methane concentration of the wall. Under Polish regulations, the concentration of methane in the wall cannot exceed 2%.
- A properly designed numerical model of the ventilation network has a major impact on the safety of the crew, as future prophylactic measures against the methane hazard are adopted on its basis.
- The increase in methane hazard at LW Bogdanka occurs most often during barium declines. Therefore, the correct selection of auxiliary ventilation equipment at the intersection of a longwall and a roadway carrying away used air should be verified each time under underground conditions.

Summary

- **Verification of systems for combating methane hazards involves conducting tests to verify that the systems are operating in accordance with safety requirements. Verification includes checking the amount and speed of air in selected pits, checking the effectiveness of detection and activation of alarms related to methane hazards, assessing the safety of equipment operation, analyzing air quality in various pits and the effectiveness of fire systems.**


Thank you for your attention