POTENTIALS

RFCS AM PROJECT

Synergistic potentials of end-of-life coal mines and coal-fired power plants, along with closely related neighbouring industries: update and re-adoption of territorial just transition plans

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Deliverable 2.3

List of key variables of the system

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POTENTIALS
RFCS AM PROJECT

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Executive summary

The general objective of the POTENTIALS Accompanying Measure is to identify and assess the challenges, opportunities and impacts related to the synergistic potentials of end-of-life mine sites and coal-fired power plants in transition (and related infrastructure), along with closely related neighbouring industries.

It will take advantage of their joint potential to stimulate new economic activities, develop jobs and economic value, especially to Coal Regions in Transition, and support the update and re-adoption of territorial just transition plans.

In Task 2.1 Defining relevant variables, the most important key variables were determined to address the synergistic potentials of end-of life coal mine sites and coal-fired power plants. These were defined against closely related neighbouring industries, implementing business models relying on renewable energy, circular economy and scaling energy storage. The outcome of this work was an unsorted list of 69 relevant variables that are important to understand the potential opportunities that end of life coal related infrastructure presents. During this work, a 69 × 69 Matrix that states these influences, based on the experts' knowledge and expertise, was provided.

In Task 2.2, with the information collected and after a two-round Delphi-based study to correct inconsistencies within the first Delphi round -that was conducted with 40 experts-, a Matrix of Direct Influence describing the relation of direct influences between the variables defining the system was then developed.

During the work developed in this Deliverable, structural analyses of mutual influences and relationships between variables were carried out. The MICMAC software was used to analyse direct, indirect and potential influences. The result of the analysis was a structured database of grouped variables.

Two methods were applied: the direct method, which estimates the overall direct influence and direct dependence of a variable in the system directly from the Matrix, and the indirect method, which estimates the overall influence and dependence of a variable through other system variables.

The comparison of the results (direct and indirect classification) enables the confirmation of the importance of certain variables and reveals certain variables that, because of their indirect actions, play a dominant role (and which the direct classification did not allow revealing).

Therefore, the comparison of the hierarchy of the variables in the various classifications is rich in information, providing the key variables of the system.

Main MICMAC method definition

The MICMAC method - is a form of structural factor analysis using impact matrix manipulation to ascertain indirect relationships and feedback between factors and infer the dynamic behaviour and evolution of a analysed system.

The MICMAC direct method – the direct method estimates the overall direct influence and dependence of a variable in the system directly from the matrix created by experts and workshop participants.

The MICMAC indirect method – the indirect method estimates the overall influence and dependence of a variable through other variables of the system by successive iterations (based indirect on the matrix created by experts and workshop participants).

The MICMAC potential method – the potential direct/indirect method represents the variables' present and potential influences and dependences. It complements the matrix created by experts and workshop participants by considering the possible future relations.

Influences between variables - the numerical value of the mutual influence of variables required, in mathematical terms, by the MICMAC software, based on the consensus of the majority of experts and workshop participants. The MICMAC's requirements necessitated the use of a four-point scale (from "0" as no influence to "3" very strong influence) for assessing the mutual influence of variables with the option of assigning a forward-looking potential score "P".

1 Introduction

The main objectives of this deliverable are:

- To properly identify the overall influence and dependence of the different variables involved.
- To confirm the importance of certain variables and reveal other variables that play a dominating role because of their indirect actions.

Identifying the key variables is the main step of the structural analysis, as some important measures that give a clue of the degree of importance of the variables can be computed from the Matrix of Direct Influence. One of the benefits of structural analysis is that it verifies hypotheses concerning how the system functions. In this way, a structural analysis may corroborate (or contradict) the group's initial hypotheses concerning which variables are important, influential, or dependent.

Two methods were used: the direct method, which estimates the overall direct influence and direct dependence of a variable in the system directly from the Matrix, and the indirect method, which estimates the overall influence and dependence of a variable through other variables of the system.

In the direct method, the total of connections in a row indicates the importance of the influence of a variable on the whole system. The total of links in a column indicates the degree of dependence of a variable (level of direct dependence).

With the indirect method, it is be possible to detect the hidden variables due to Matrix multiplication. This allows studying the diffusion of the impacts by the paths and the loops of feedback, and consequently to sort the variables: by order of influence (considering the number of paths and loops of length -1, 2... n- resulting from each variable), or by order of dependence (considering the number of paths and loops of length -1, 2... n- arriving on each variable). Generally, the classification becomes stable after multiplying the Matrix by itself 3, 4 or 5 times.

The comparison of the results (direct and indirect classification) obviously gives the possibility to confirm the importance of certain variables and reveal certain variables that, due to their indirect actions, play a dominating role (and that the direct classification did not allow to reveal). Therefore, the comparison of the hierarchy of the variables in the various classifications is rich in information, giving the key variables of the system.

This task is be led by GIG. The rest of the partners involved in this task were corroborate or contradict the initial hypothesis in their respective areas of knowledge: VGB (coal-fired power plants), CERTH (open pit coal mining), and UNIOVI and DMT (underground coal mining).

2 The MICMAC method

The MICMAC method was applied to develop structural analysis [Duperrin & Godet, 1975; Villacorta et al., 2012], based on expert studies on the interaction among the criteria [Agrawal, 2019; Dhir, 2020].

The research was based on the results of surveys carried out using the Delphi method, described in detail by [Frejowski & Kabiesz, 2020, Krause & Krzemień, 2014]. Forty experts took part in the survey. Główny Instytut Górnictwa was represented by 40% of the experts, Universidad de Oviedo and Hulleras del Norte, S.A. was represented by 15% of the experts, CERTH was represented by 10% of the experts, VGB was represented by 10% of the experts, THGA-DMT was represented by 7.5% of the experts, and the external experts were 17.5%. The range of years of experience in coal mining-related activities was from 3 to 40 years. Experts' competence calculated as K_k [Frejowski & Kabiesz, 2020, Krause & Krzemień, 2014] was in the range 0.5–1.0.

With the unsorted list of variables, a group of experts will state each variable's influence over the rest of the system's variables. Based on the experts ' knowledge, the group will provide an n × n integer Matrix that states these influences. A Matrix of direct influence describing the relation of direct influences between the variables defining the system will be developed with this information.

A variable does not exist in a systemic vision unless it is a part of the relational web with the other variables. In addition, the structural analysis allows connecting the variables in a two-entry Table (direct relations). This entry of the Matrix is generally quantitative, adjusting the intensities of the relations among the variables.

This phase of entry helps to put forward for n variables n × n questions, of which some would have escaped without such a systematic and comprehensive reflection. This procedure of questioning allows not only avoiding errors but also ordering and classifying the ideas by creating a common language. It also allows redefining the variables and thus modifying the system's analysis. Further, a brainstorming meeting was organized to use the experts' knowledge to achieve this goal.

Identifying the key variables is the main step of the structural analysis. Some important measures that provide the initial insight into the significance of the variables can be computed from the Matrix of direct influence.

Two methods can be applied: the direct method, which estimates the overall direct influence and direct dependence of a variable in the system directly from the Matrix, and the indirect method, which estimates the overall influence and dependence of a variable through other variables of the system.

In the direct method, the total of connections in a row indicates the importance of the influence of a variable on the whole system (level of direct motricity). The total in a column indicates the degree of dependence of a variable (level of direct dependence).

With the indirect method, it will be possible to detect the hidden variables due to Matrix multiplication. This allows studying the diffusion of the impacts by the paths and the loops of feedback, and consequently to sort the variables: by order of influence (considering the number of paths and loops of length 1, 2 … n resulting from each variable), or by order of dependence (considering the number of paths and loops of length 1, 2 … n arriving on each variable). Generally, the classification becomes stable after multiplying the Matrix by itself 3, 4, or 5 times.

The comparison of the results (direct and indirect classification) enables the confirmation of the importance of certain variables and reveals certain variables that, because of their indirect actions, play a dominant role (and which the direct classification did not allow revealing).

Therefore, the comparison of the hierarchy of the variables in the various classifications is rich in information, providing the key variables of the system.

The division into groups of variables is presented in Figure 1 [Frejowski & Koteras, 2016; Frejowski & Kabiesz, 2020, Frejowski at al., 2020].

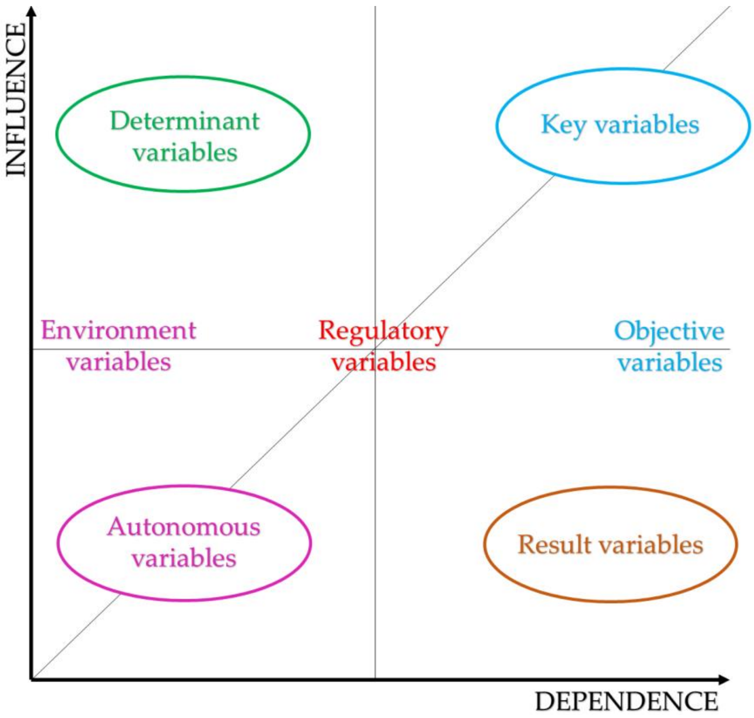


Figure 2-1. Map of direct influences and dependences between variables (factors)

There are 4 areas (quadrants) in Figure 2-1 that define the potential and significance of the variables (factors) on them:

- **Key variables**: They are situated in the first quadrant (upper right) and are characterized by both the highest degree of dependence and the highest influence on others. They are by nature, unstable and correspond to the challenges of the system.

- **Objective variables**: They are highly dependent and with a moderate degree of influence, hence their character of being treated as targets, since they can be influenced so that their evolution is the one that is desired.

- **Determinant or impact variables**: Situated in the second quadrant (upper left) and characterized by high impact and a limited dependence or relationship. Depending on their evolution, they can become brakes or drivers of the system.

- **Environment variables**: These are the variables with little influence on the system. They can be considered a decoration of the system.

- **Autonomous variables**: They are situated in the third quadrant (bottom left), not affect the system. They correspond to past trends or inertias of the system or are disconnected from it.

- **Result variables**: They are situated in the fourth quadrant (bottom right). They have a low influence on the others but high dependence. They are often, together with the target variables, descriptive indicators of the system's evolution.

- **Regulatory variables**: They are situated in the central area and characterized by both medium influence and medium dependence. They become the key to achieving compliance with the key variables. They determine the good functioning of the system under normal conditions.

Using the MICMAC software, the interrelationships between variables are analysed and interpreted using the following methods (Frejowski & Koteras, 2016; Villacorta et al., 2012):

- MDI (Matrix of Direct Influence) – the direct method estimates the overall direct influence and dependence of a variable in the system directly from the MDI Matrix.

- MPDI (Matrix of Potential Direct Influence) – the potential direct method represents the variables' present and potential influences and dependences. It complements the MDI by considering the possible future relations.

- MII (Matrix of Indirect Influence) – the indirect method estimates the overall influence and dependence of a variable through other variables of the system by successive iterations. The classification of the variables from this Matrix emphasizes the most important variables of the system.

- MPII (Matrix of Potential Indirect Influence) – the potential indirect Matrix corresponds to potential direct Matrix enhanced in power by successive iterations. From this Matrix, a new classification of the variables emphasizes the potentially most important variables of the system.

The following Figure 2-2 shows the procedure in Task 2.3:

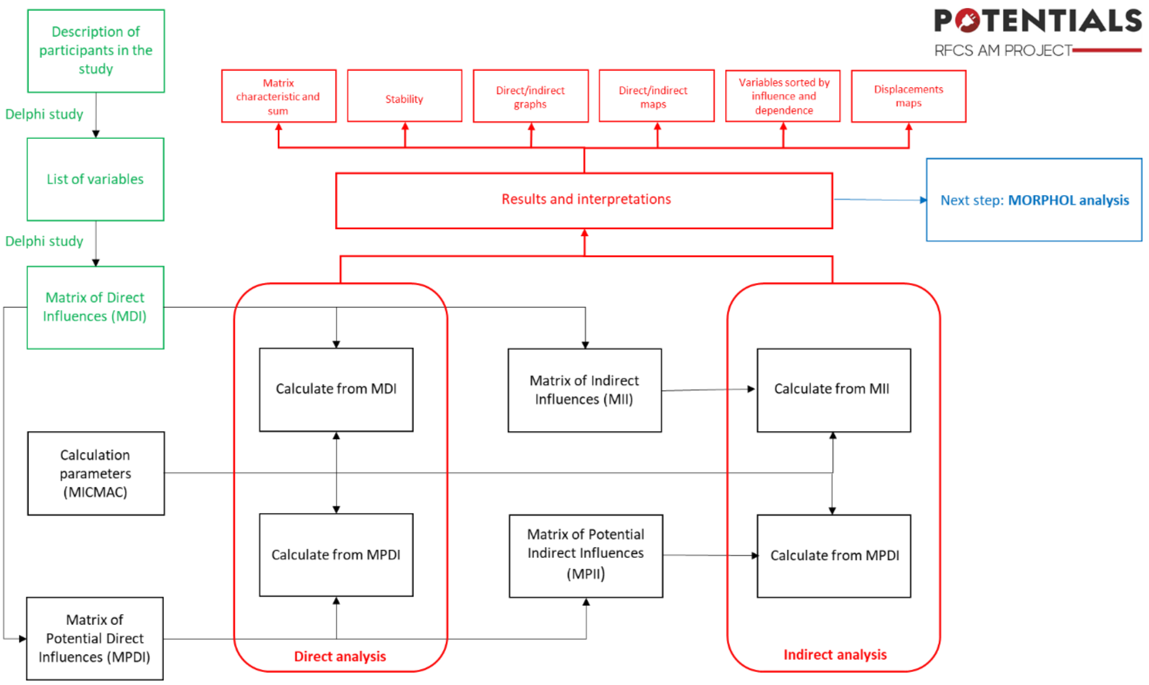


Figure 2-2. Procedures for using MICMAC software in Task 2.3

The first step of MICMAC software analysis is to enter the data into MICMAC:

- data of the experts participating in the Delphi study (list of participants),
- entering data from the MDI Matrix (Matrix of Direct Influences),
- establishing the calculation parameters (number of iterations to reach the stability of the system - from 2 to 9).

The group of experts provide an integer matrix. Every cell a_{ij} of matrix represents how variable *i* influences variable *j*. For each pair of variables *i* and *j*, the following question should be answered: Does factor *i* have a direct influence on factor *j*? If yes, is the influence small, medium, high, or potential? The answer is [Godet, 1994; Jasiulewicz-Kaczmarczyk, 2021]:

- 0 if there is no influence between *i* and *j*.
- 1 if there is a weak influence between *i* and *j*.
- 2 if there is a strong influence between *i* and *j*.
- 3 if there is a very strong influence between *i* and *j*.
- P if there is a potential influence between *i* and *j*.

All diagonal cells a_{ij} are equal to 0.

The direct analysis evaluates the overall direct influence DI_i and direct dependence DP_i of a variable in the system directly from the direct matrix. The direct influence DI_i, and direct dependence DP_i, are determined by the following formula:

$$DI_i = \sum_{j=1}^{n} a_{ij} (i = 1,2,3 \dots, n)$$

$$DP_i = \sum_{j=1}^{n} a_{ji} (i = 1,2,3 \dots, n)$$

Analyze the indirect influence. Indirect analysis evaluates the overall influence and dependence of a variable through other variables. Indirect classification is obtained after increasing the matrix power M (matrix multiplication $M^2 = M \times M$, $M^3 = M \times M \times M$, etc.) [Godet, 1994]. Algorithms used in MICMAC analyze the spread of interactions in the system through the connections and feedback loops linking individual factors. This allows prioritizing them based on the number of lap settings and a loop length of 1, 2, . . . , n, coming in and out of each factor. As a result, the hidden influences, which are difficult for experts to define directly, are revealed.

The next step is to create the MPDI Matrix by assigning a "P" (potential value) from the MDI Matrix. Experts typed a potential value P in the Matrix in situations where they anticipated the possibility of influence/dependence between criteria in the future. The MPDI matrix is created by changing the potential value of P to one of the following values: "0" - no impact, "1" - low impact, "2" - medium impact" or "3" - strong impact.

The Matrix of Potential Direct Influences MPDI represents the variables' current and potential influences and dependences. It supplements MDI matrix by also considering the foreseeable future relations; it appears more prospective than the matrix of current relations only. Its capture is carried out starting from the values of MDI. The two matrices are dependent and a modification of matrix MDI will also cause the corresponding modification on matrix MPDI.

Usually, two structural analyses are carried out. The first action is done starting from the matrix MDI that includes only the current relations. The second action is done starting from the matrix MPDI that includes the current and potential relations. The comparison of the outputs helps to understand how would the system change under the effect of the potential relations between the variables.

At the origin, matrix MPDI gives the possibility to assign a value to the intensity P expressed in MDI, which is not considered in the last calculations.

Nevertheless, the software also allows assigning possible values to "0, 1, 2, and 3" of matrix MDI. This function aims to bring new light to the reading of the matrix, particularly in the case of differences between the group members at the time of the input.

Here are some "standard" transformations to pass from MDI to MPDI:

- Assigning the value 0 to all the 1 of MDI to take into account only the strong relations
- Assigning to 1 all the sets of the non-zero values of matrix MDI to make a binary study of the relations of the influence between the variables
- Assigning to 0 all the values except the potential values P then valued to 1, to put forward the key potential variables

The user will be able to carry out other simulations to enrich the analysis of the structural matrix

To fill out the matrix MPDI, it is enough to assign a corresponding value to the values defined in MDI. By default, matrices MDI and MPDI are identical.

In the third step - using MICMAC software, the results of the MDI Matrix were presented in the form of a direct influence/dependence map and a direct influence graph.

For the variables in the MDI Matrix, we also identified:

- MDI Matrix characteristic (Matrix size, number of iterations, number of values: “0”, “1”, “2”, “3”, and “P”, number of total values, and filtrate). This allows the user to check the type of information entered and can help detect possible errors.
- Matrix row and column sum (total number of row and sum). These sums represent respectively in rows the influences of the variables between them and in columns the dependences.
- Stability (in percentage) of the system. If it is proven that any matrix must converge towards stability at the end of a certain number of iterations (generally 4 to 5 for a matrix of size 50), it would be interesting to be able to follow the evolution of this stability during successive multiplications. Without mathematically established criteria, it was chosen to rely on the number of permutations necessary to each iteration (balls sorting) to classify all the variables in influences and dependences.

The procedure was the following:

1. After opening the data file, MICMAC sorts the variables to obtain the direct classification. The number of permutations corresponding to this sorting is memorized;
2. With each iteration, MICMAC figures out a new hierarchy of the variables. The comparison between the number of permutations of *iteration I* and that of *iteration I-1* gives an indicator of stability expressed as a percentage. A result of 100% means that the number of permutations necessary to the classification of iteration *I* is identical to that necessary to *iteration I-1* and thus, the application is stable. The results can therefore vary around 100%.

In the fourth step using MICMAC software, the Matrix of Indirect Influences (MII) results were presented in the form of MII row and column sum (total number of row and column sum), and an indirect influence/dependence map and an indirect influence graph.

Analogous analyses were then performed for the Matrix of Potential Direct Influences (MPDI) and Matrix of Potential Indirect Influences (MPII).

Based on four influence/dependence maps (MDI, MII, MPDI, and MPII), factors (or variables) for each map/Matrix was selected:

- Key and objective factors located in the first quadrant (upper right).
- Determinant and environmental factors are located in the second quadrant (upper left).
- Secondary and autonomous factors are located in the third quadrant (bottom left).
- Result factor in the fourth quadrant (bottom right).
- Regulatory factors in the central area of the map.

The next step was to develop a list of variables in terms of influence/dependence - selecting key variables for the system. Key variables are characterised by strong influence on other variables and high dependence on other variables. Therefore, they are the variables that determine the system's stability and have the highest impact on it.

The final stage was the development of displacements maps that allowed us to determine how the position of the variables changed depending on the methodology used (direct, indirect).

Analyses were conducted for 4 alternative groups of variables:

1. MICMAC analysis for **"Power plant"** variables (section 3.1).
2. MICMAC analysis for **"Mining surface"** variables related to the surface part of the mine (section 3.2).
3. MICMAC analysis for **"Mining underground"** variables associated with the underground part of the mine (section 3.3).
4. MICMAC analysis for all variables - both "Mining" variables and "Power plant" variables, called **“Potentials”** (section 3.4).

3 Results and Discussion

3.1 "Power plant" variables

In this analysis, variables related to the "Power plant" were included, that is, variables No. 32 to No. 69 (Annex 1).

3.1.1 Matrix of Direct Influences (MDI)

Matrix of Direct Influences (MDI), based on the Delphi expert analysis performed under Task 2.2 is presented in Annex no 2 in Deliverable 2.2.

The results were calculated for 4 iterations. THE Matrix MDI characteristic is shown in Table 3-1 and the Matrix MDI sum in Table 3-2.

Table 3-1. Matrix characteristic – MDI characteristic for "Power Plant" variables

Indicator	Value
Matrix size	38
Number of iterations	3
Number of zeros	949
Number of ones	183
Number of twos	142
Number of threes	74
Number of P	96
Total	495
Filtrate	34,27978%

Table 3-2. Matrix sum – MDI row and column sum for "Power plant" variables

N°	Variable	Total number of rows	Total number of columns
32	Power plant connection capacity to the grid	11	9
33	Electricity production efficiency of power plant	0	15
34	Power plant concession expiry date	12	10
35	Expected technical lifetime	0	8
36	Number of units decommissioned	31	6
37	Water reservoir capacity	29	13
38	Repowering: possibility of adapting the boiler for biomass	9	16
39	Feasibility of reusing air cleaning installation for repowering	12	1
40	CO2 capture installation	6	3
41	District heating connection	23	5
42	Cooling water installation type	20	7
43	Wastewater treatment plant	23	13
44	Fly ash characterisation	14	10
45	Power plant landfill area. Hazardous/non-hazardous.	16	18
46	Coal ash waste landfill area availability	12	17
47	Available space for new technologies/projects	16	32
48	Obligations of thermal energy supply after the decommissioning	13	16
49	Availability of concession for power generation	20	18
50	Cost of decommissioning and remediation	10	37
51	Land use restrictions (power plant)	29	25
52	Character of the local area	55	24
53	Neighbourhood and proximity to the nearest urban/industry	54	33

N°	Variable	Total number of rows	Total number of columns
54	Access / proximity to road infrastructure	36	24
55	Access / proximity to railway infrastructure	33	24
56	Access / proximity to water reservoir	37	16
57	Access / proximity to the river (for transport)	11	16
58	Access / proximity to gas pipeline network connections	16	14
59	Proximity to industries	26	32
60	Water treatment plant	10	16
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	6	27
62	Power Plant employment (number of employees)	6	18
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	6	11
64	Temporary storage areas	21	11
65	Relevant resource for land lease & rental	13	19
66	Electro-intensive industries	17	31
67	Industries likely to use H2	6	28
68	Constant energy consumption industries	16	26
69	Companies manufacturers of goods and/or suppliers of services	14	40
	Totals	689	689

Figure 3-1 shows the calculation results for MDI for "Power plant" variables in the form of a map of direct influences and dependences between variables from No. 32 to No. 69.

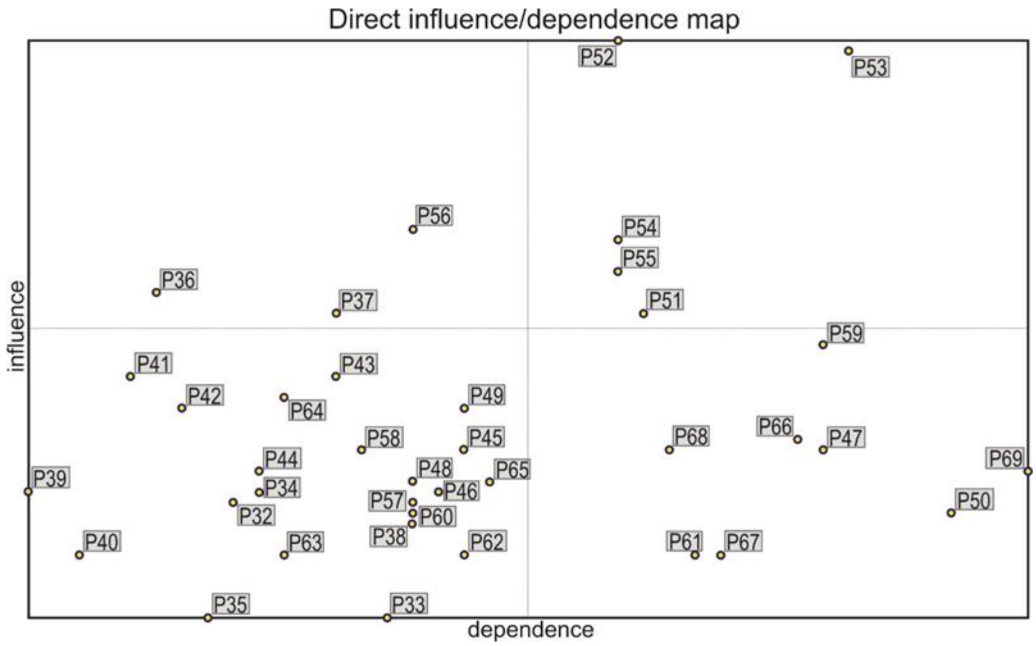


Figure 3-1. Map of direct influences and dependences (MDI) between "Power plant" variables

Table 3-3 provides a summary mapping of the analysed variables to the related factors, shown in Figure 3-1.

Table 3-3. Results of MDI analyses for "Power Plant" variables with allocation to relevant factor group/quadrant

MDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
51	Land use restrictions (power plants)
52	The character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access/proximity to road infrastructure
55	Access/proximity to railway infrastructure
MDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
36	Number of units decommissioned
37	Water reservoir capacity
56	Access/proximity to the water reservoir
MDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
47	Available space for new technologies/projects
50	Cost of decommissioning and remediation
59	Proximity to industries
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
66	Electro-intensive industries
67	Industries likely to use H_2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-2 shows the direct influence graph for “Power plant” variables.

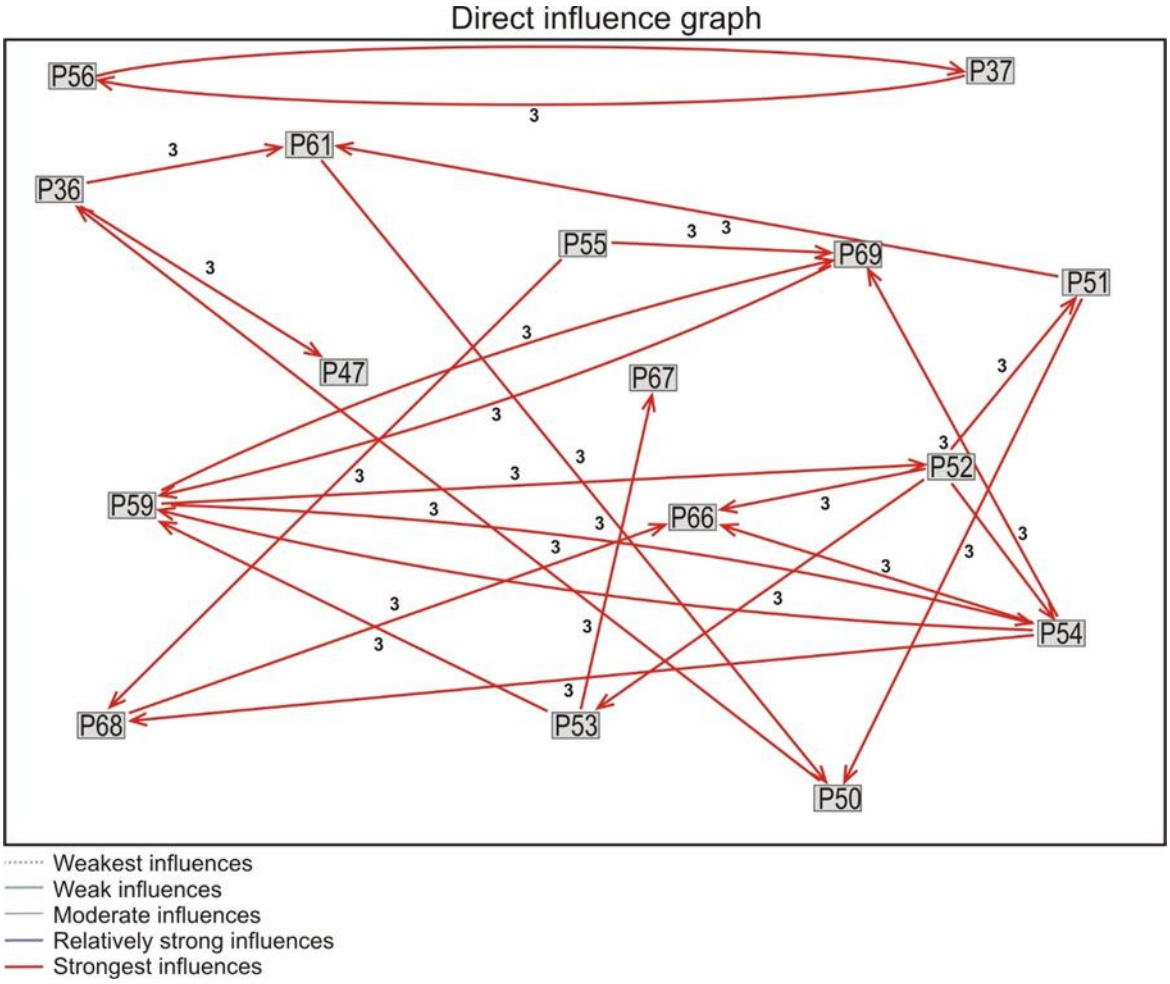


Figure 3-2. Graph of direct influences (MDI) for "Power plant" variables

3.1.2 Matrix of Indirect Influences (MII)

The results of the analysis of indirect influences calculated by MICMAC software – Matrix of Indirect Influences (MII) for "Power plant" variables are presented in Annex 2.

The results were calculated for 4 iterations. Matrix MII sum is shown in Table 3-4.

Table 3-4. Matrix sum – MII row and column sum for "Power plant" variables

N°	Variable	Total number of rows	Total number of columns
32	Power plant connection capacity to the grid	2130512	1464267
33	Electricity production efficiency of power plant	0	1890871
34	Power plant concession expiry date	988267	1789026
35	Expected technical lifetime	0	781911
36	Number of units decommissioned	4593867	1352111
37	Water reservoir capacity	6358285	1977741
38	Repowering: possibility of adapting the boiler for biomass	874077	2500933
39	Feasibility of reusing air cleaning installation for repowering	940396	220295
40	CO2 capture installation	120641	439617
41	District heating connection	4404899	1329446
42	Cooling water installation type	1977731	793822

N°	Variable	Total number of rows	Total number of columns
43	Wastewater treatment plant	3936981	2112612
44	Fly ash characterisation	2076899	792075
45	Power plant landfill area. Hazardous/non-hazardous.	2850190	2350898
46	Coal ash waste landfill area availability	2269007	2267635
47	Available space for new technologies/projects	1792852	4286834
48	Obligations of thermal energy supply after the decommissioning	1435910	3072612
49	Availability of concession for power generation	3253552	2965267
50	Cost of decommissioning and remediation	859803	5793559
51	Land use restrictions (power plant)	4778062	3685259
52	Character of the local area	1,034418E+07	4536117
53	Neighbourhood and proximity to the nearest urban/industry	8759511	5880749
54	Access / proximity to road infrastructure	6119278	5137795
55	Access / proximity to railway infrastructure	5784488	4919658
56	Access / proximity to water reservoir	5724124	2994945
57	Access / proximity to the river (for transport)	2611664	3071224
58	Access / proximity to gas pipeline network connections	3303931	2489774
59	Proximity to industries	6352235	6849896
60	Water treatment plant	638400	2722788
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	317970	4275062
62	Power Plant employment (number of employees)	700723	2565461
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	786664	1713088
64	Temporary storage areas	3349216	1982529
65	Relevant resource for land lease & rental	2576887	3028715
66	Electro-intensive industries	4685396	5362112
67	Industries likely to use H2	1285219	5061233
68	Constant energy consumption industries	4589989	5061715
69	Companies manufacturers of goods and/or suppliers of services	3428229	7480378
	Totals	689	689

Figure 3-3 shows the results of the calculation for MII for “Power plant” variables in the form of a map of indirect influences and dependences between variables from No. 32 to No. 69.

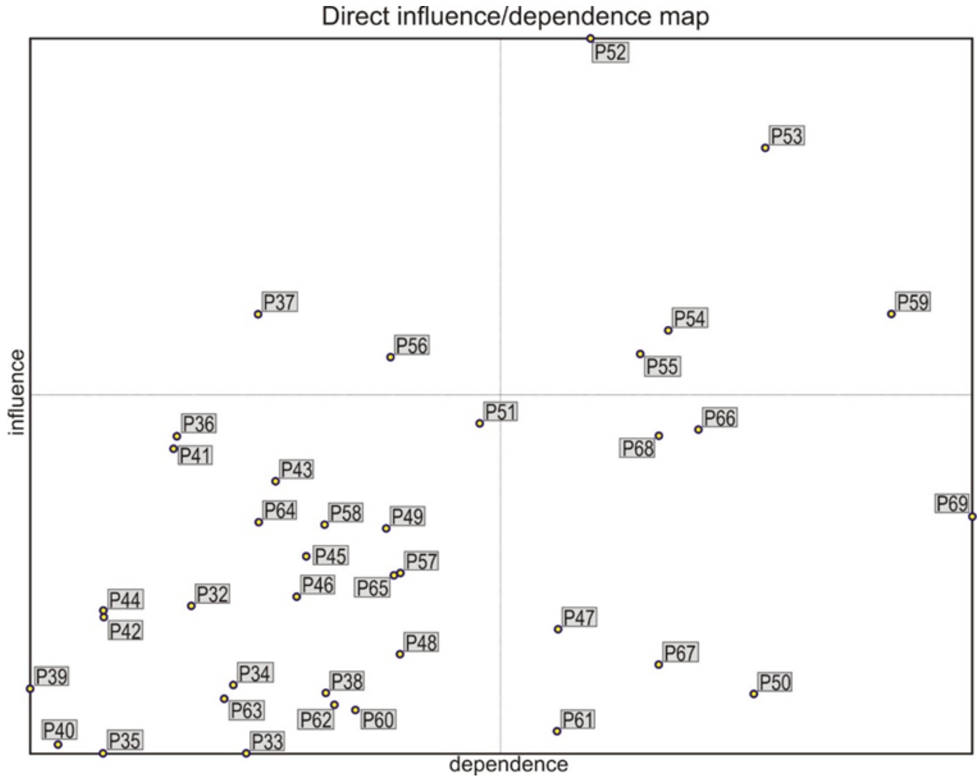


Figure 3-3. Map of indirect influences and dependences (MII) between “Power plant” variables

Table 3-5 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-3.

Table 3-5. Results of MII analyses for "Power Plant" variables with allocation to relevant factor group / quadrant

MII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
52	Character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure
59	Proximity to industries
MII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
37	Water reservoir capacity

56	Access / proximity to water reservoir
MII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS):	
No.	**Variable**
47	Available space for new technologies/projects
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
66	Electro-intensive industries
67	Industries likely to use H_2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-4 shows the indirect influence graph for “Power plant” variables.

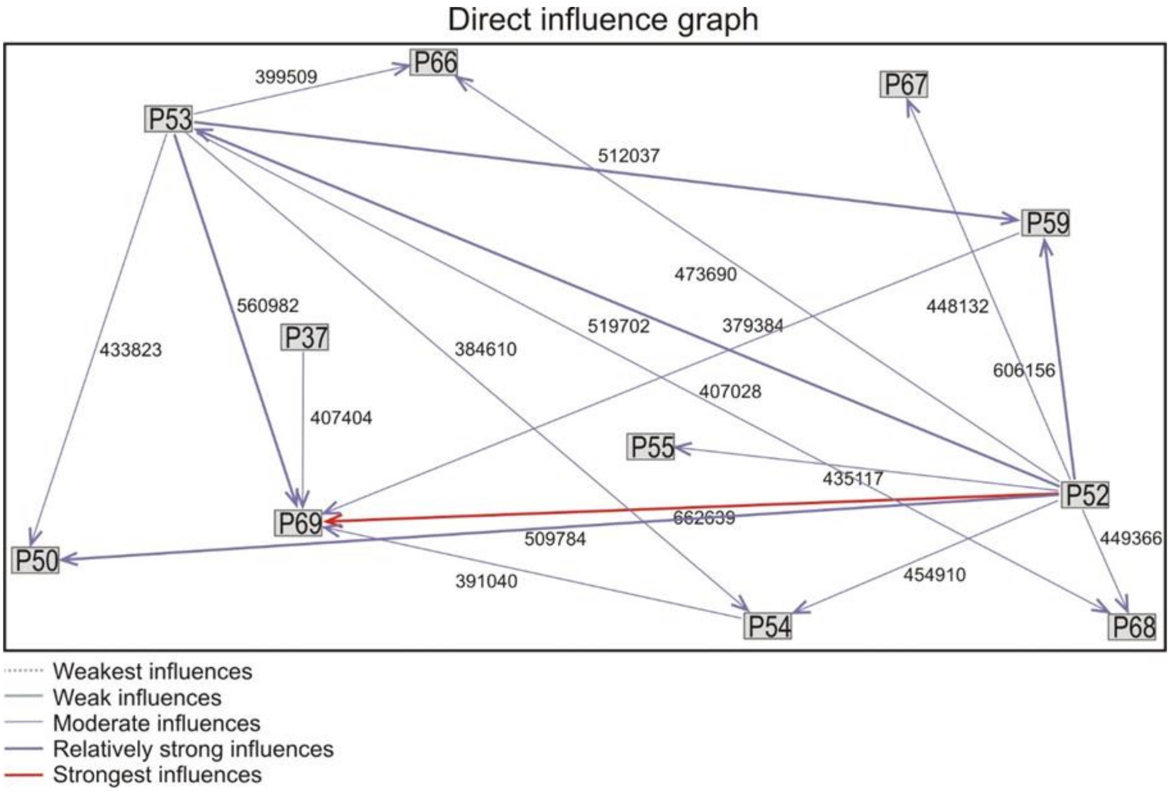


Figure 3-4. Graph of indirect influences (MII) for “Power plant” variables

The strongest indirect influence is between variable No. **52 Character of the local area** and variable **No. 69 Companies manufacturers of goods and/or services suppliers**.

3.1.3 Matrix of Potential Direct Influences (MPDI)

The the Matrix of Potential Direct Influences (MPDI) results were calculated for 3 iterations. It was assumed that the value assigned by the experts in the Delphi study as "P" (potential impact) for calculation purposes would have a value of "1" (low impact). THE Matrix MPDI characteristic is shown in Table 3-6 and the Matrix MDI sum in Table 3-7.

Table 3-6. Matrix characteristic – MPDI characteristic for "Power Plant" variables

Indicator	Value
Matrix size	38
Number of iterations	3
Number of zeros	949
Number of ones	279
Number of twos	142
Number of threes	74
Number of P	0
Total	495
Filtrate	34,27978%

Table 3-7. Matrix sum – MPDI row and column sum for "Power plant" variables

N°	Variable	Total number of rows	Total number of columns
32	Power plant connection capacity to the grid	12	12
33	Electricity production efficiency of power plant	7	18
34	Power plant concession expiry date	17	19
35	Expected technical lifetime	5	11
36	Number of units decommissioned	32	11
37	Water reservoir capacity	29	14
38	Repowering: possibility of adapting the boiler for biomass	10	21
39	Feasibility of reusing air cleaning installation for repowering	12	4
40	CO2 capture installation	6	8
41	District heating connection	23	9
42	Cooling water installation type	20	9
43	Wastewater treatment plant	26	14
44	Fly ash characterisation	15	11
45	Power plant landfill area. Hazardous/non-hazardous.	18	19
46	Coal ash waste landfill area availability	13	17
47	Available space for new technologies/projects	32	34
48	Obligations of thermal energy supply after the decommissioning	16	17
49	Availability of concession for power generation	20	22
50	Cost of decommissioning and remediation	14	43
51	Land use restrictions (power plant)	32	26
52	Character of the local area	55	27
53	Neighbourhood and proximity to the nearest urban/industry	54	35
54	Access / proximity to road infrastructure	36	25
55	Access / proximity to railway infrastructure	33	25
56	Access / proximity to water reservoir	37	16
57	Access / proximity to the river (for transport)	14	17
58	Access / proximity to gas pipeline network connections	16	14
59	Proximity to industries	31	35
60	Water treatment plant	10	19
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	8	32
62	Power Plant employment (number of employees)	6	19

N°	Variable	Total number of rows	Total number of columns
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	11	12
64	Temporary storage areas	23	12
65	Relevant resource for land lease & rental	14	25
66	Electro-intensive industries	27	34
67	Industries likely to use H2	21	31
68	Constant energy consumption industries	16	28
69	Companies manufacturers of goods and/or suppliers of services	14	40
	Totals	689	689

Figure 3-5 shows the calculation results for MPDI for "Power plant" variables in the form of a map of potential direct influences and dependences between variables from No. 32 to No. 69.

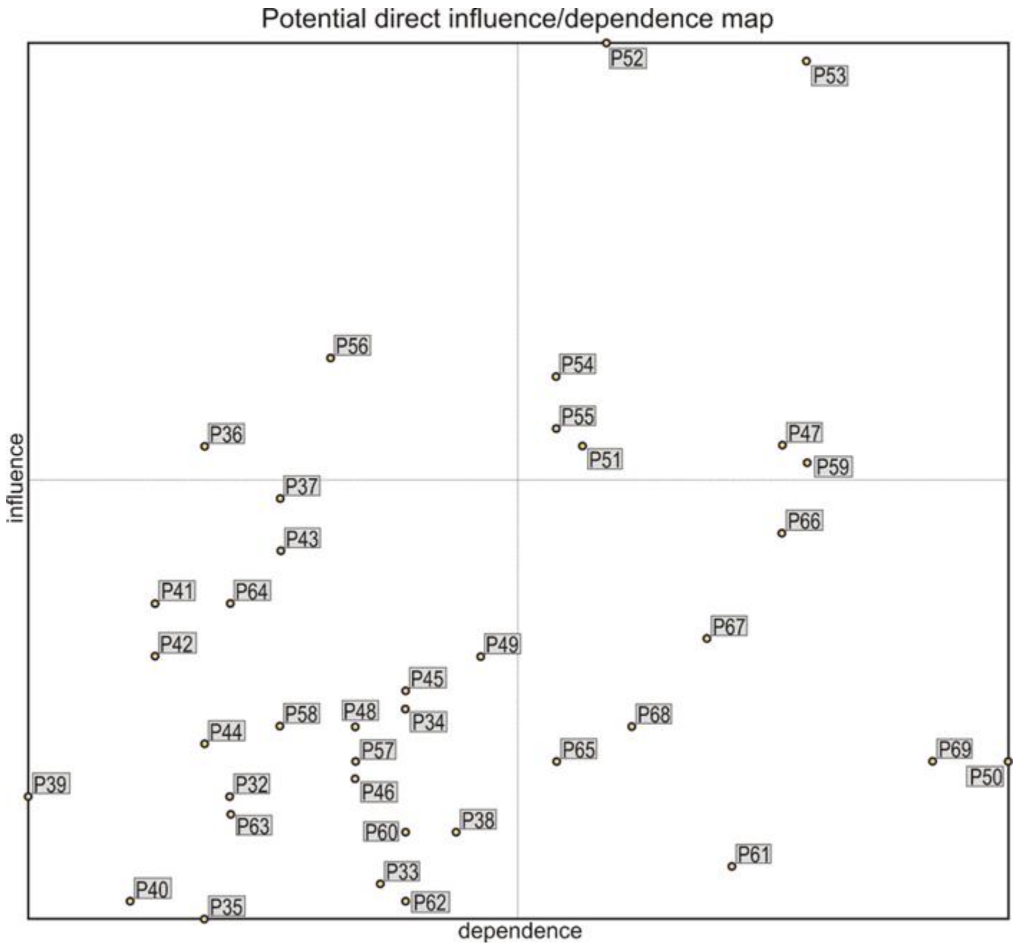


Figure 3-5. Map of potential direct influences and dependences (MPDI) between "Power plant" variables

Table 3-8 provides a summary mapping of the analysed variables to the related factors, shown in Figure 3-5.

Table 3-8. Results of MPDI analyses for "Power Plant" variables with allocation to relevant factor group / quadrant

MPDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
47	Available space for new technologies/projects
51	Land use restrictions (power plants)
52	The character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure
59	Proximity to industries
MPDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
36	Number of units decommissioned
56	Access / proximity to the water reservoir
MPDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
65	Relevant resources for land lease & rental
66	Electro-intensive industries
67	Industries likely to use H_2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-6 shows the potential direct influence graph for “Power plant” variables.

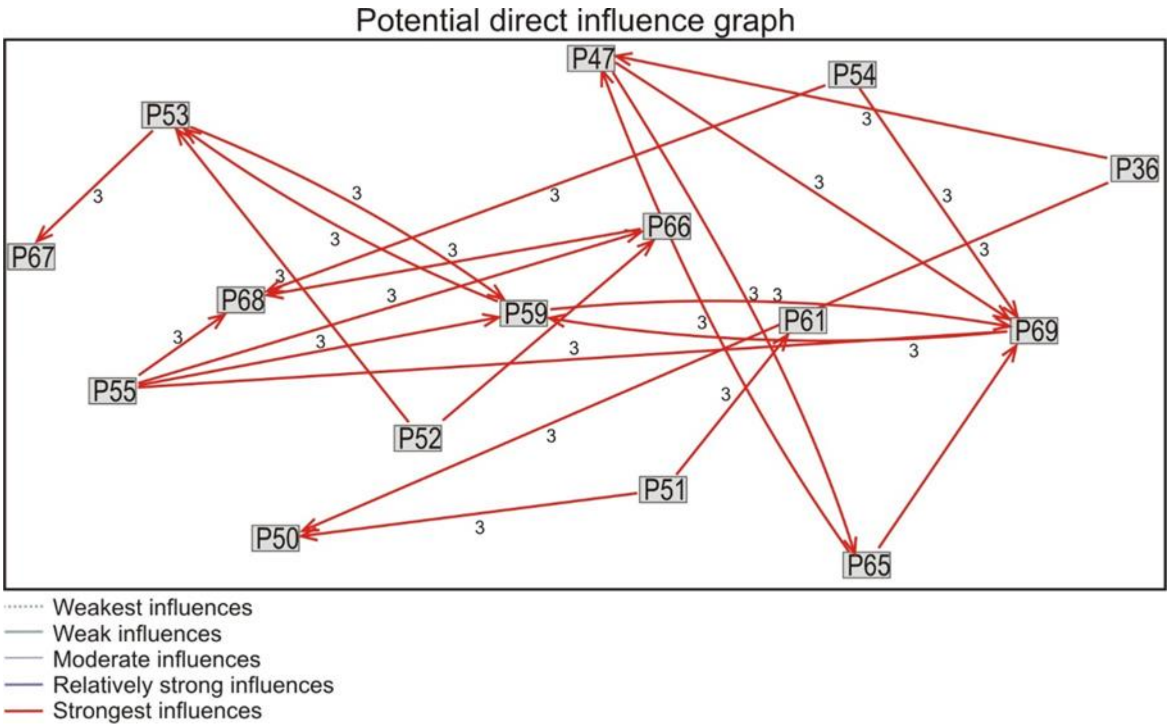


Figure 3-6. Graph of potential direct influences (MPDI) for "Power plant" variables

3.1.4 Matrix of Potential Indirect Influences (MPII)

The results of the analysis of potential indirect influences calculated by MICMAC software– Matrix of Potential Indirect Influences (MPII) for "Power plant" variables are presented in Annex 2.

The results were calculated for 3 iterations. Matrix MPII sum is shown in Table 3-9.

Table 3-9. Matrix sum – MPII row and column sum for "Power plant" variables

N°	Variable	Total number of rows	Total number of columns
32	Power plant connection capacity to the grid	139085	139531
33	Electricity production efficiency of power plant	58514	179382
34	Power plant concession expiry date	113211	222863
35	Expected technical lifetime	37762	102749
36	Number of units decommissioned	341513	152831
37	Water reservoir capacity	424281	148173
38	Repowering: possibility of adapting the boiler for biomass	92346	222840
39	Feasibility of reusing air cleaning installation for repowering	79506	69201
40	CO2 capture installation	19489	99700
41	District heating connection	314553	139997
42	Cooling water installation type	157802	73096
43	Wastewater treatment plant	336006	151437
44	Fly ash characterisation	158656	78722
45	Power plant landfill area. Hazardous/non-hazardous.	207764	172605
46	Coal ash waste landfill area availability	169707	162059
47	Available space for new technologies/projects	316361	322728
48	Obligations of thermal energy supply after the decommissioning	137874	228118
49	Availability of concession for power generation	246071	251350

N°	Variable	Total number of rows	Total number of columns
50	Cost of decommissioning and remediation	105300	470469
51	Land use restrictions (power plant)	359921	264892
52	Character of the local area	697666	336525
53	Neighbourhood and proximity to the nearest urban/industry	614075	420965
54	Access / proximity to road infrastructure	433634	350023
55	Access / proximity to railway infrastructure	407003	336154
56	Access / proximity to water reservoir	408496	193714
57	Access / proximity to the river (for transport)	193223	217212
58	Access / proximity to gas pipeline network connections	230322	167079
59	Proximity to industries	447504	472544
60	Water treatment plant	59542	212902
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	56481	353366
62	Power Plant employment (number of employees)	52762	208701
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	93151	141488
64	Temporary storage areas	263717	136681
65	Relevant resource for land lease & rental	197944	266593
66	Electro-intensive industries	363613	399075
67	Industries likely to use H2	227181	378758
68	Constant energy consumption industries	297558	356725
69	Companies manufacturers of goods and/or suppliers of services	231680	490026
	Totals	689	689

Figure 3-7 shows the results of the calculation for MPII for “Power plant” variables in the form of a map of potential indirect influences and dependences between variables from No. 32 to No. 69.

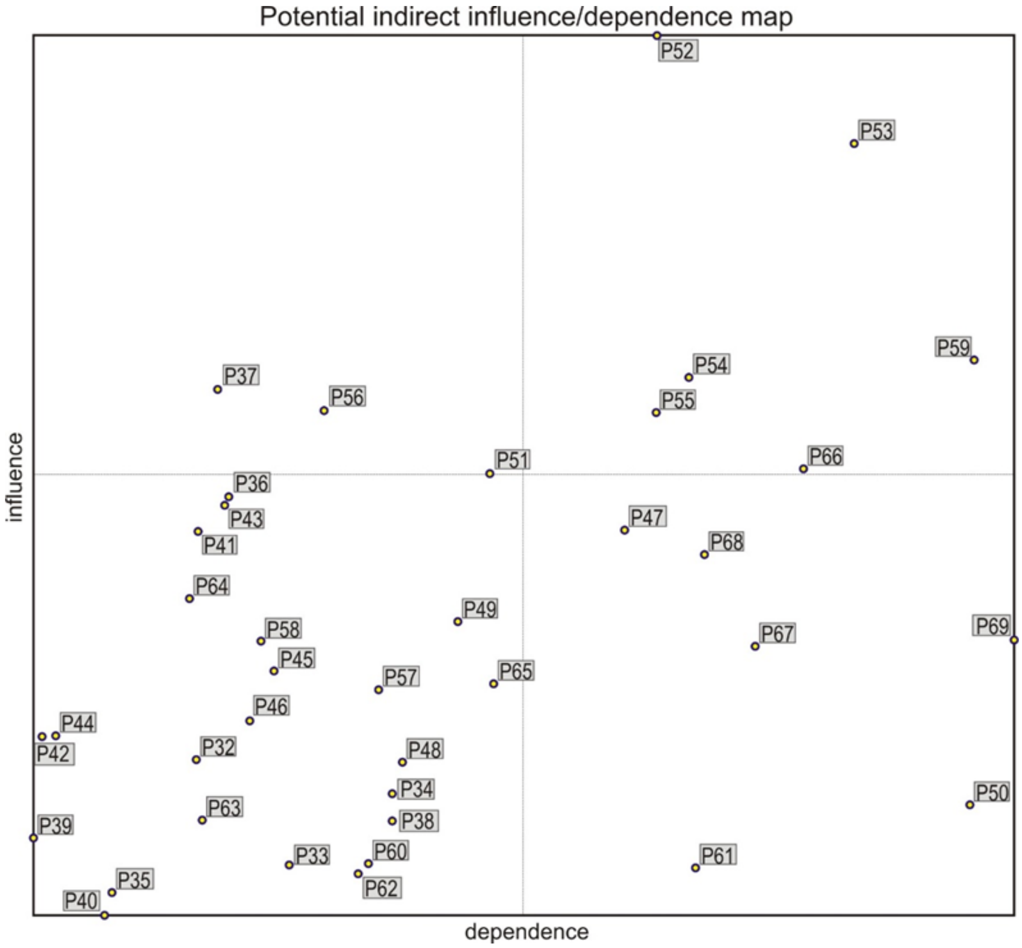


Figure 3-7. Map of potential indirect influences and dependences (MPII) between "Power plant" variables

Table 3-10 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-7.

Table 3-10. Results of MPII analyses for "Power Plant" variables with allocation to relevant factor group / quadrant

MPII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
52	Character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure
59	Proximity to industries
66	Electro-intensive industries

MPII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
37	Water reservoir capacity
56	Access / proximity to water reservoir
MPII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS):	
No.	**Variable**
47	Available space for new technologies/projects
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
67	Industries likely to use H_2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-8 shows the potential indirect influence graph for “Power plant” variables.

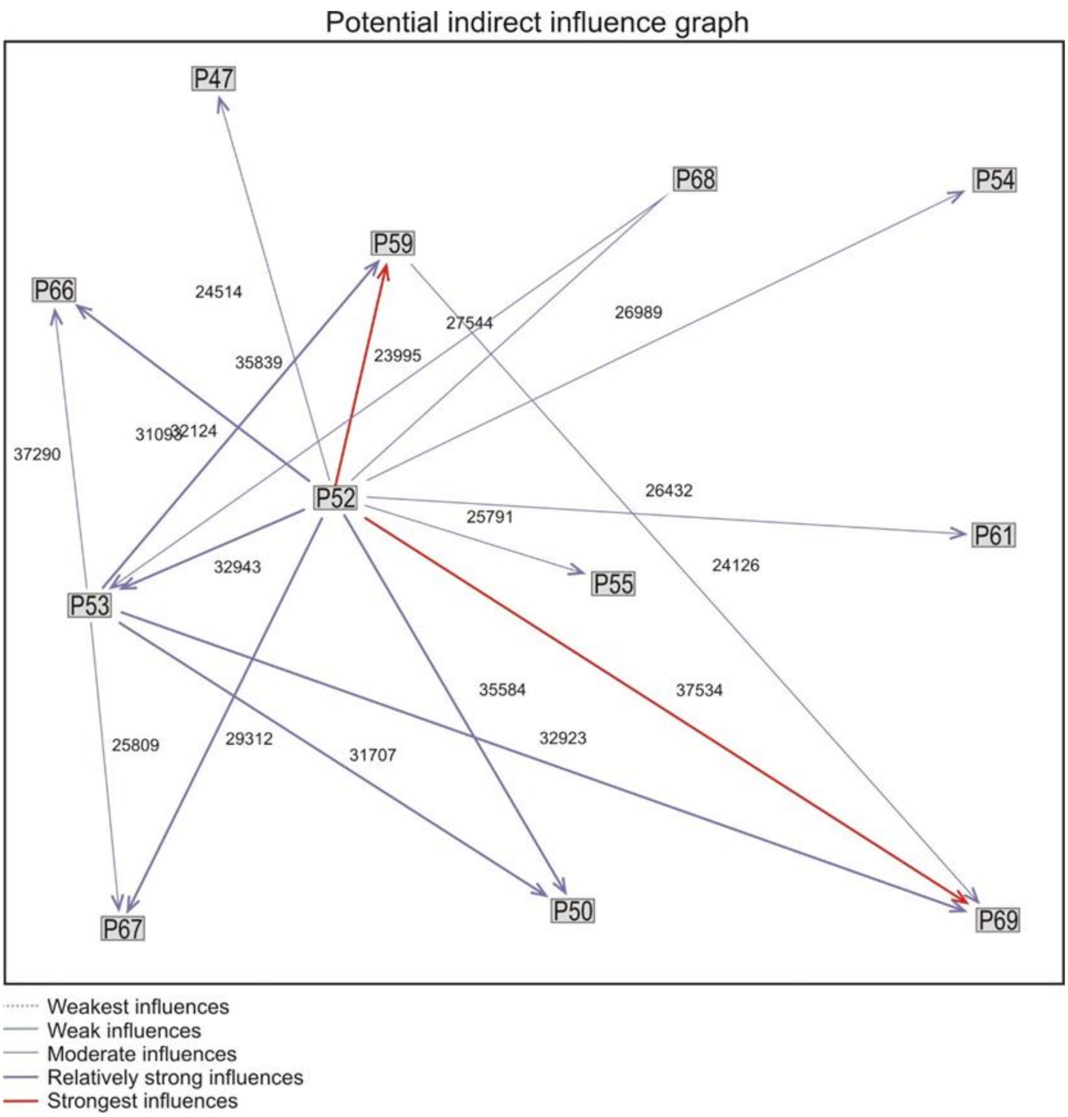


Figure 3-8. Graph of potential indirect influences (MII) for "Power plant" variables

The strongest potential indirect influence is between variable No. **52 Character of the local area** and variable **No. 69 Companies manufacturers of goods and/or suppliers of services** and between variable No. **52 Character of the local area** and variable **No. 59 Proximity to industries**.

To enrich the structural matrix analysis for the potential indirect analysis, it is assumed the value "0" to all the value "1" of MDI Matrix to take into account only the strong relations. Figure 3-9 shows a map of potential influences / dependencies for the values of the variables: the value "1" is equal to "0" and the value "P" is equal to "1".

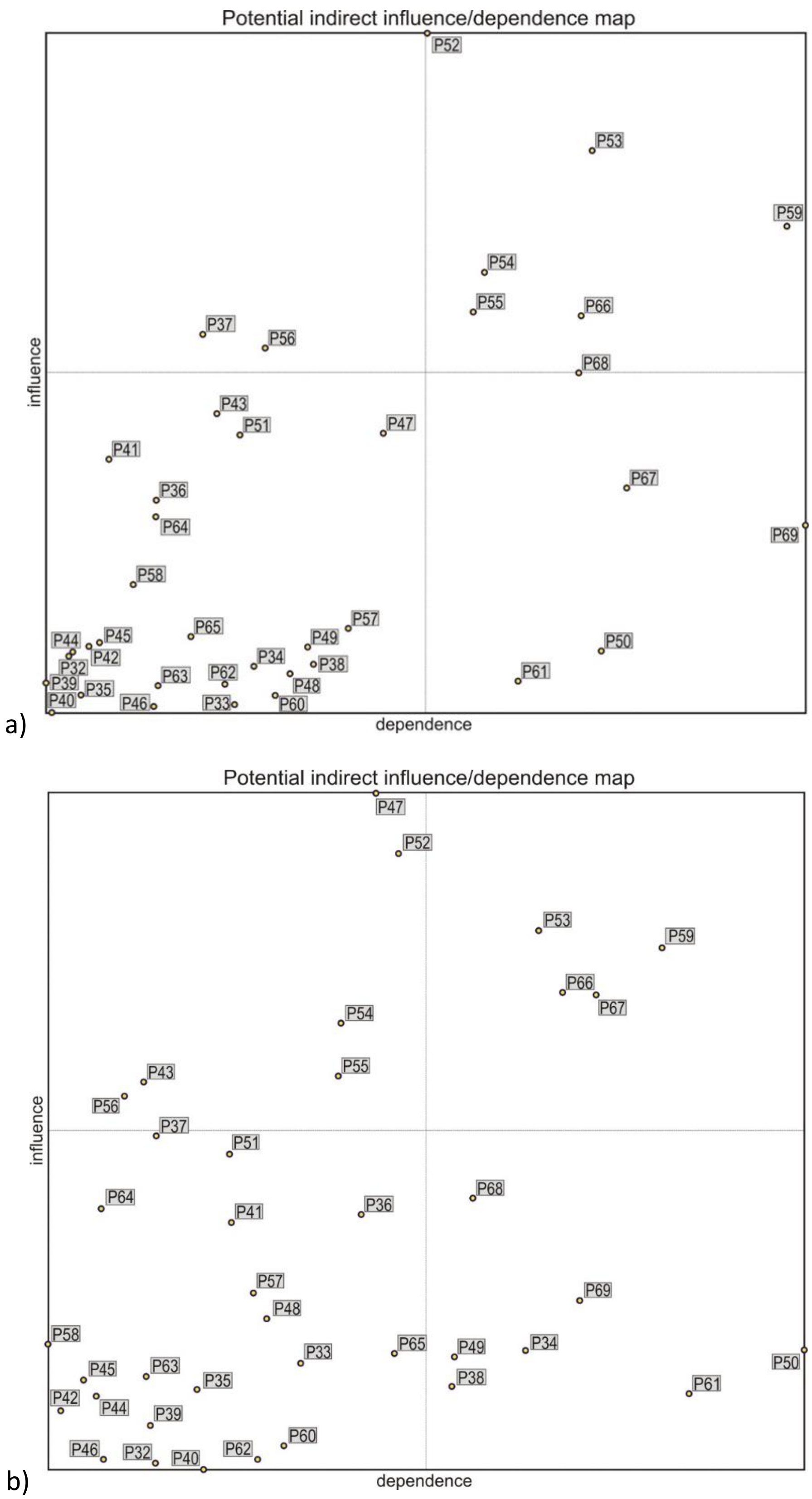


Figure 3-9. Map of potential indirect influences and dependences (MPII) between "Power plant" variables for a) value "1" = "0" and "P" = "1" b) value "1" = "0" and "P" = "3"

Compared to the previous MPII analysis, variable **No. 52 Character of the local area** moved from key factors towards impact factors, while variable **No. 68 Constant energy consumption industries** moved from the dependent factors towards the key factors (Figure 3-9a).

In Figure 3-9b variable **No. 49 Availability to concession for power generation** has been moved to quadrant IV (result factor), and variable **No. 56 Access/proximity to water reservoir** to quadrant II (impact factor).

3.1.5 Proportions and list of variables sorted by influence and dependence, and displacement map

Proportions, shown in Annex 3, allow to have a classification of the variables according to their influence and their decreasing dependence (direct and indirect); these influences and these dependences are normalized (and expressed in "for 10 000-th").

Figure 3-10 is presented in decreasing order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

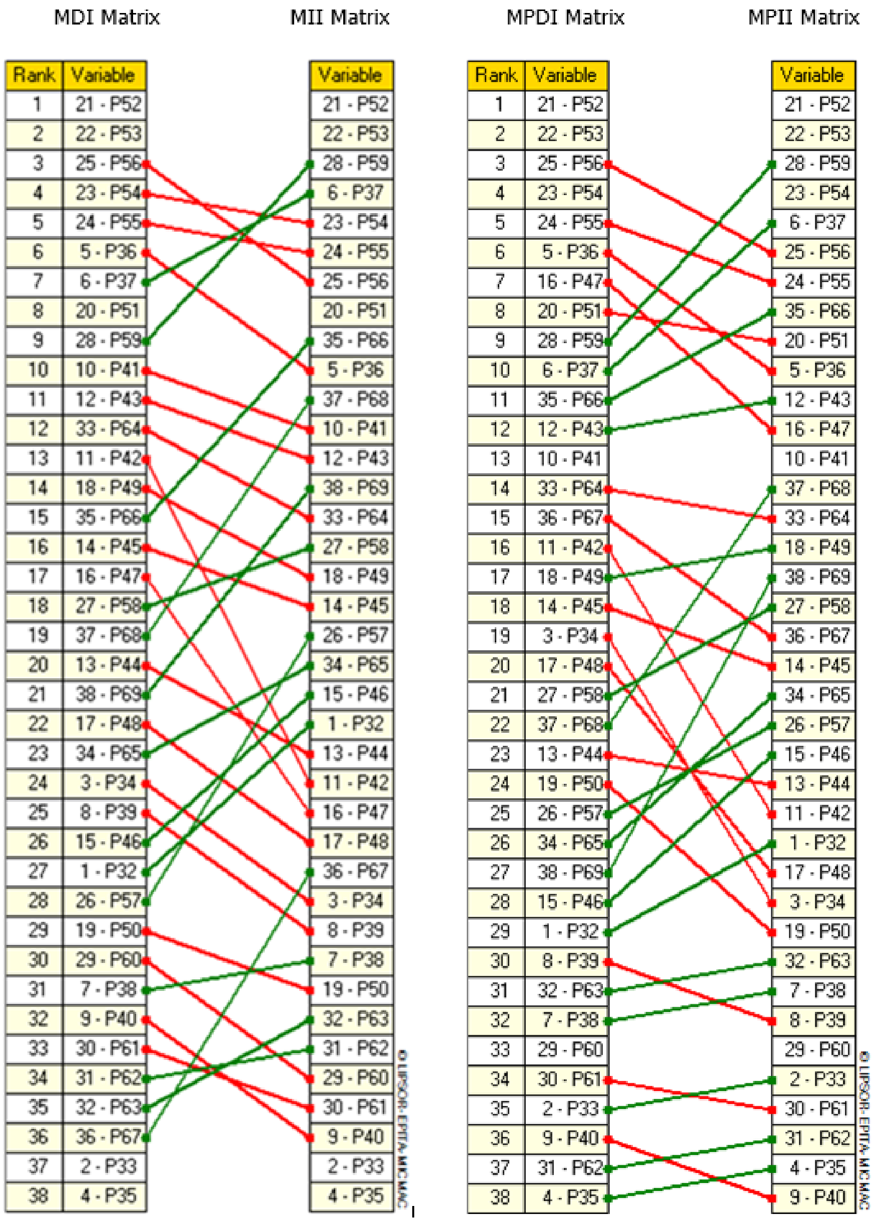


Figure 3-10. Classifying "Power plant" variables according to their influences

In the Figure 3-11 are presented in descending order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

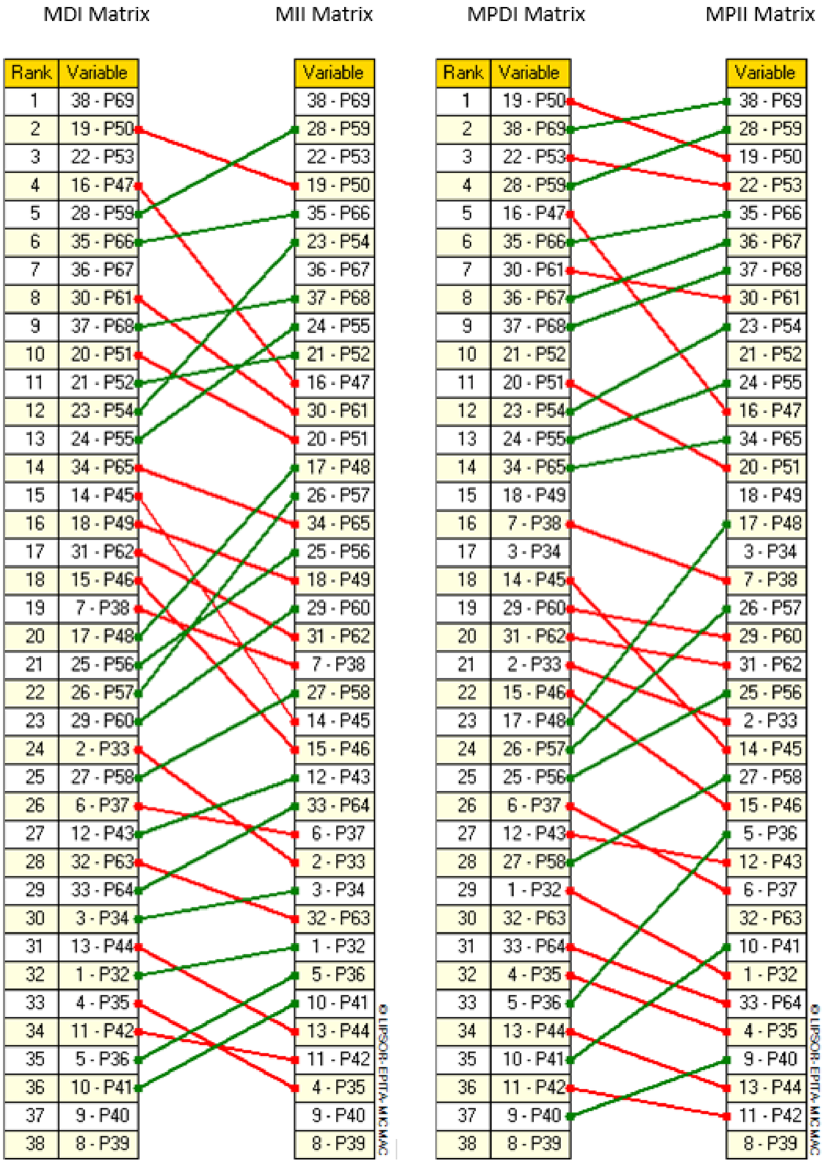


Figure 3-11. Classify "Power plant" variables according to their dependences

In Figure 3-12 and Figure 3-13 the displacement map is presented. It shows the variation of the position in the system of variables "Power plant" depending on the methodology adopted: direct and indirect, and potential direct and potential indirect.

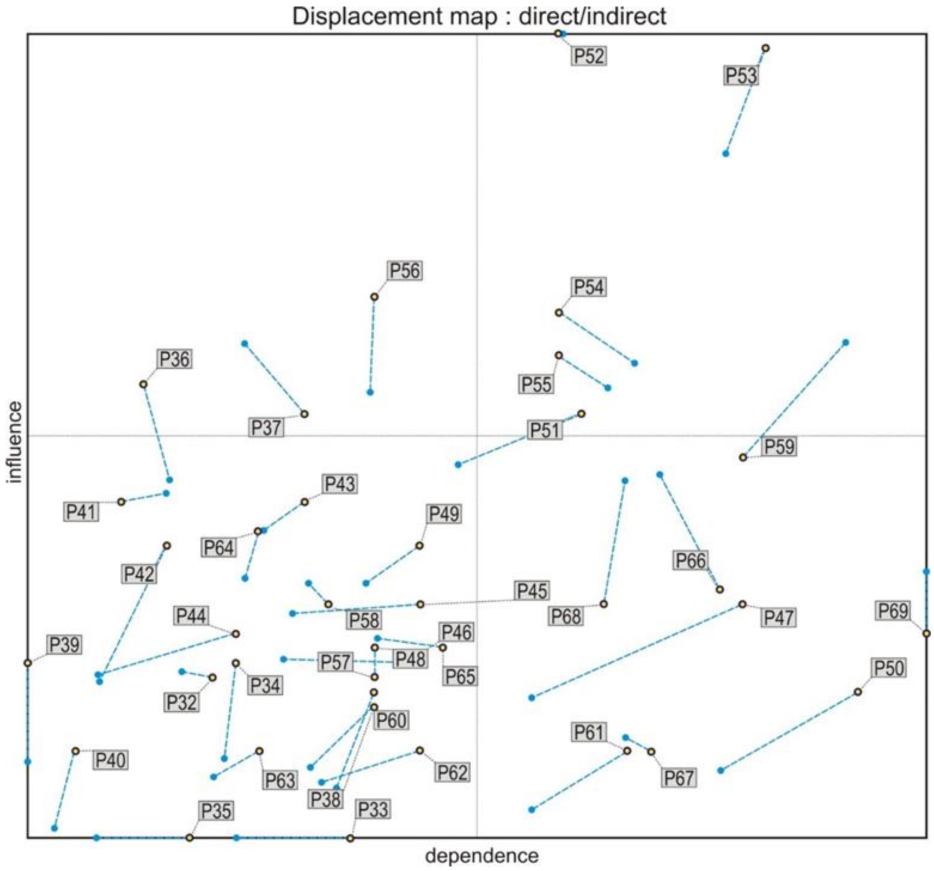


Figure 3-12. Displacement map for "Power plant" variables in MDI Matrix and MII Matrix

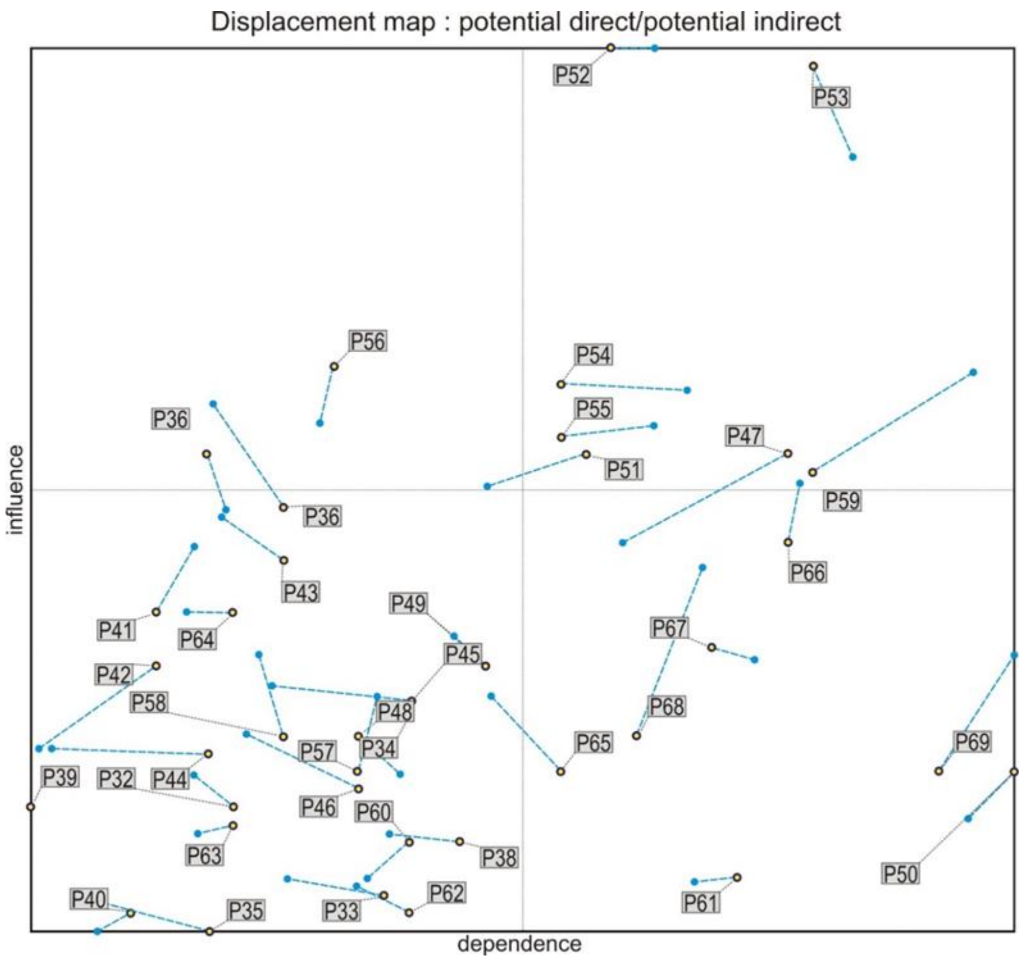


Figure 3-13. Displacement map for "Power plant" variables in MPDI Matrix and MPII Matrix

3.1.6 Summary

A total of 38 criteria from the "Power plant" group were subjected to structural analysis using MICMAC software. The "Power plant" matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. The 34.3% fill rate reflects the direct influences between system variables, and it is considered a good rate of filling. The rest 65.7% represents the indirect influences between the variables of this system, of which the rest of the MICMAC method is based. As a result of direct and indirect analyses, 9 variables were defined as key factors.

Table 3-11 summarises the results (detected key factors) of the MICMAC analyses for the "Power Plant" variables.

Table 3-11. Summarize of the MICMAC analysis – key factors

<table>
<tr><th></th><th>Matrix of Direct Influence

MDI</th><th>Matrix of Indirect Influences

MII</th><th>Matrix of Potential Direct Influence

MPDI</th><th>Matrix of Potential Indirect Influence

MPII

P=1</th><th>Matrix of Potential Indirect Influence

MPII

1=0, P=1</th></tr>
<tr><td rowspan="8">Key factors</td><td></td><td></td><td>47: Available space for new technologies/projects</td><td></td><td></td></tr>
<tr><td>51: Land use restrictions (power plants)</td><td></td><td>51: Land use restrictions (power plants)</td><td></td><td></td></tr>
<tr><td colspan="4">52: Character of the local area</td><td></td></tr>
<tr><td colspan="5">53: Neighbourhood and proximity to the nearest urban/industry</td></tr>
<tr><td colspan="5">54: Access / proximity to road infrastructure</td></tr>
<tr><td colspan="5">55: Access / proximity to railway infrastructure</td></tr>
<tr><td></td><td colspan="4">59: Proximity to industries</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">66: Electro-intensive industries</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>68: Constant energy consumption industries</td></tr>
</table>

Structural analyses carried out using the MICMAC software allowed for the selection of the following key criteria, i.e. criteria with the highest impact on others and the highest dependence on other variables.

- **47: Available space for new technologies/projects**
- **51: Land use restrictions (power plants)**
- **52: Character of the local area**
- **53: Neighbourhood and proximity to the nearest urban/industry**
- **54: Access / proximity to road infrastructure**
- **55: Access / proximity to railway infrastructure**
- **59: Proximity to industries**

- **66: Electro-intensive industries**
- **68: Constant energy consumption industries**

Due to their high dependence and influence, the key factors are extremely important for assessing the stability of the system and evaluating future scenarios built on their basis.

3.2 "Mining surface" variables

Variables related to the surface part of a coal mine were included in the analysis. These are shown in Table 3-12.

Table 3-12. List of "Mining surface" variables with short description

N°	Long label	Short label	Description
1	Methane surface emissions (AMM)	M4	The variable determines the concentration, flow and an estimation of future emissions of Abandoned Mine Methane (AMM).
2	Methane resources (CBM)	M5	The variable refers to the reserve of natural gas stored in coal seams, called Coal Bed Methane (CBM).
3	Area of the waste heap	M18	This variable refers to the area [m2] of heaps of extractive waste from excavation or coal processing wastes that are generated at extraction/processing sites.
4	Height of the waste heap	M19	The variable determines the waste heap height [m] as a distance between the heap base and the top.
5	Angle of slopes of the waste heap	M20	The variable describes angle of the slopes [o] of the waste heap.
6	Geometry of the waste heap	M21	The variable describes the geometrical shape of the heap (cone, truncated cone, trapezoid, irregular, etc.)
7	Material type deposited on the waste heap	M22	This variable refers to the specific characteristics of the materials that are deposited in the waste heaps, as well as if they are separated in extractive waste and coal processing waste or mixed together.
8	Geotechnical stability of waste heaps	M23	This variable refers to the geotechnical stability of the waste heaps, with special focus on landslides and stability protection against wind and water erosion.
9	Fire hazard at the waste heap	M24	This variable refers to a potential fire hazard in waste heaps, usually related with the presence of coal in the waste heaps.
10	Gas hazard at the waste heap	M25	This variable refers to a potential gas hazard in the waste heaps, usually related with the presence of coal in the waste heaps.
11	Acidity potential of the waste heap material	M26	Mining activities produce wastes which can be categorized in waste rock, tailings and mine water. Waste heaps are dynamic systems, usually composed of sulphide minerals and when exposed to atmospheric conditions, they may generate acid drainage and cause pH variations.
12	Status of reclamation of the waste heap	M27	The variable describes the status of reclamation (active waste disposal heap, non reclamated, partially reclamated, fully revitalised) as well as the ownership of the waste heap
13	Neighbourhood density	M28	This variable refers to the number of people that live in the proximity of the mine.
14	Existence of historic or singular buildings	M29	This variable refers to the existence of heritage buildings, singular buildings, or industrial infrastructure, that must be conserved or that it is interesting to conserve by the coal mine.
15	Land use restrictions (mine)	M30	This variable refers to any kind of land use restrictions, mainly related with territorial development plans approved by the authorities, that may condition specific industrial, commercial, business centres or residential deployments.
16	Connection capacity of mine to the grid	M31	This variable refers to the connection capacity [MW] and voltage [kV] to the grid that are usually connected to medium voltage lines between 1 and 60 kV through substations.

3.2.1 Matrix of Direct Influences (MDI)

Matrix of Direct Influences (MDI), based on the Delphi expert analysis performed under Task 2.2 is presented in Annex no 2 in Deliverable 2.2.

The results were calculated for 3 iterations. Matrix MDI characteristic is shown in Table 3-13 and Matrix MDI sum is shown in Table 3-13.

Table 3-13. Matrix characteristic – MDI characteristic for „Mining surface" variables

INDICATOR	VALUE
Matrix size	16
Number of iterations	3
Number of zeros	160
Number of ones	16
Number of twos	35
Number of threes	34
Number of P	11
Total	96
Filtrate	37,5%

Table 3-14. Matrix sum – MDI row and column sum for „Mining surface" variables

N°	VARIABLE	TOTAL NUMBER OF ROWS	TOTAL NUMBER OF COLUMNS
1	Methane surface emissions (AMM)	4	4
2	Methane resources (CBM)	3	0
3	Area of the waste heap	17	15
4	Height of the waste heap	15	14
5	Angle of slopes of the waste heap	11	17
6	Geometry of the waste heap	15	19
7	Material type deposited on the waste heap	24	9
8	Geotechnical stability of waste heaps	24	22
9	Fire hazard at the waste heap	14	15
10	Gas hazard at the waste heap	9	13
11	Acidity potential of the waste heap material	9	5
12	Status of reclamation of the waste heap	22	22
13	Neighbourhood density	4	4
14	Existence of historic or singular buildings	3	7
15	Land use restrictions (mine)	14	20
16	Connection capacity of mine to the grid	0	2
	Totals	188	188

Figure 3-14 shows the calculation results for MDI for "Mining surface" variables in the form of a map of direct influences and dependences between variables shown in Table 3-12.

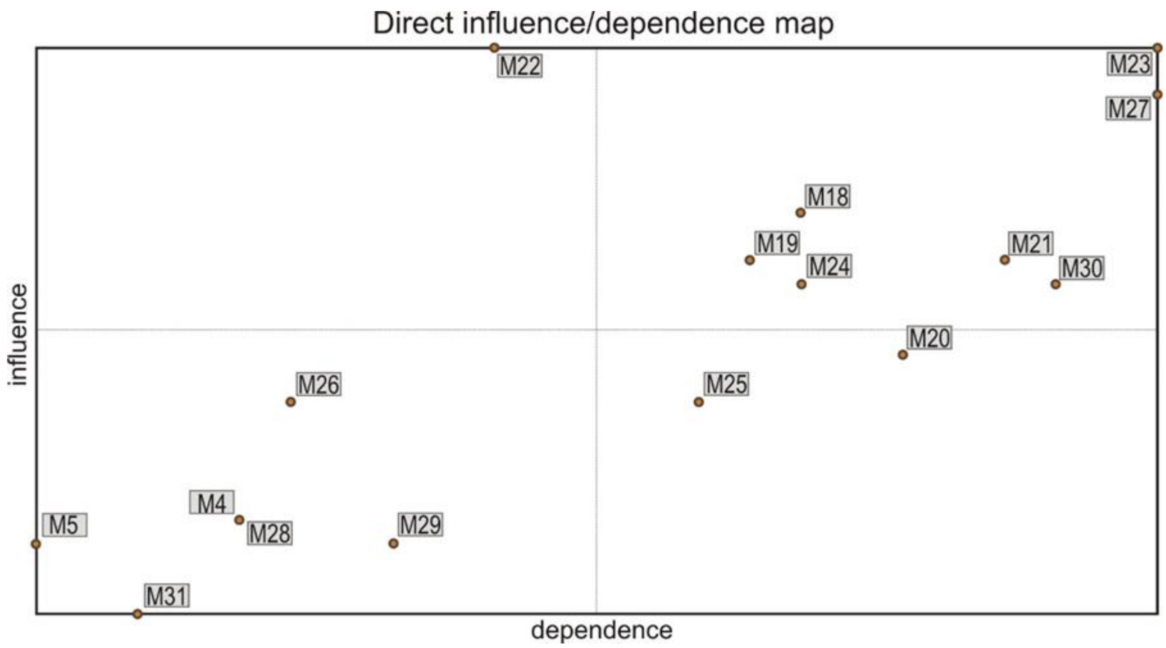


Figure 3-14. Map of direct influences and dependences (MDI) between "Mining surface" variables

Table 3-15 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-14.

Table 3-15. Results of MDI analyses for "Mining surface" variables with allocation to relevant factor group / quadrant

MDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
18	Area of the waste heap
19	Height of the waste heap
21	Geometry of the waste heap
23	Geotechnical stability of waste heaps
24	Fire hazard at the waste heap
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
MDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
22	Material type deposited on the waste heap
MDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	

No.	Variable
20	Angle of slopes of the waste heap
25	Gas hazard at the waste heap

Figure 3-16 shows the direct influence graph for “Mining surface” variables.

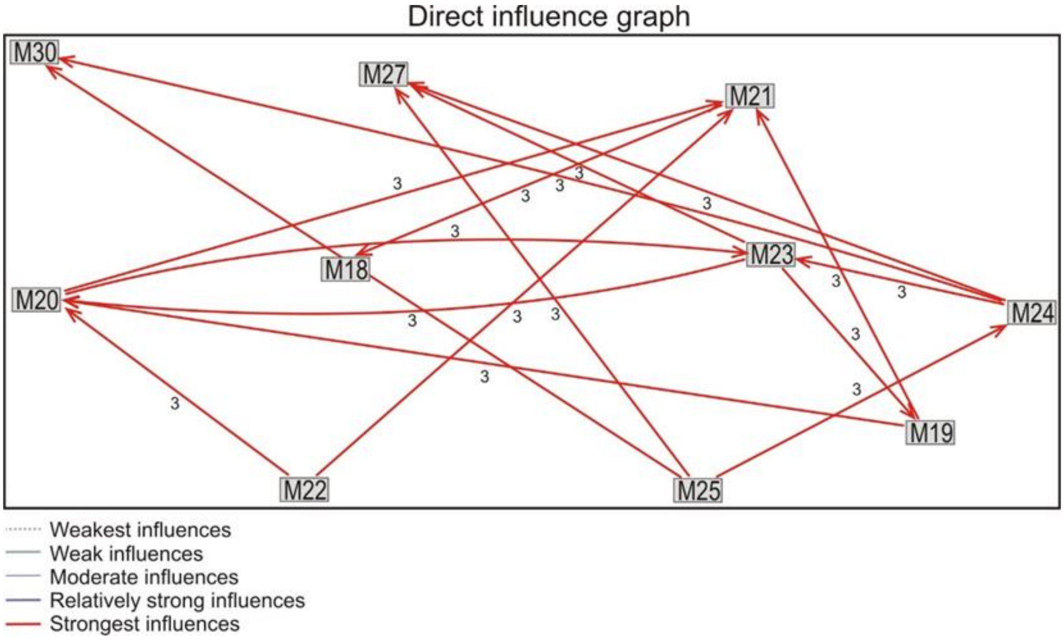


Figure 3-15. Graph of direct influences (MDI) for “Mining surface” variables

3.2.2 Matrix of Indirect Influences (MII)

The results of the analysis of indirect influences calculated by MICMAC software – Matrix of Indirect Influences (MII) for “Mining surface” variables are presented in Figure 3-16.

	1 : M4	2 : M5	3 : M18	4 : M19	5 : M20	6 : M21	7 : M22	8 : M23	9 : M24	10 : M25	11 : M26	12 : M27	13 : M28	14 : M29	15 : M30	16 : M31
1 : M4	102	0	1386	1348	1519	1609	659	1864	1138	999	357	1648	186	255	1313	184
2 : M5	18	0	306	273	255	279	153	315	210	186	63	306	9	99	276	36
3 : M18	414	0	6918	6651	7125	7606	3269	8683	5466	4779	1611	7929	656	1380	6220	784
4 : M19	351	0	6324	6094	6409	6886	2966	7852	4967	4306	1441	7218	575	1243	5563	720
5 : M20	300	0	5262	5009	5396	5705	2494	6461	4125	3601	1201	5920	455	1057	4653	586
6 : M21	423	0	6357	6244	6676	7184	3034	8296	5118	4485	1474	7614	630	1266	5881	696
7 : M22	513	0	7839	7722	8172	8823	3795	10092	6237	5400	1767	9282	795	1587	7155	972
8 : M23	636	0	9297	9023	9995	10607	4288	12359	7571	6639	2379	10895	1110	1734	8515	1142
9 : M24	342	0	6102	5883	6171	6597	2934	7419	4779	4146	1356	6927	504	1278	5397	654
10 : M25	189	0	3600	3426	3750	3993	1596	4641	2856	2526	924	4059	408	690	3057	432
11 : M26	177	0	3219	2998	3322	3473	1450	3970	2502	2210	830	3440	366	628	2772	410
12 : M27	516	0	7329	7284	7866	8460	3528	9799	6030	5240	1720	9004	797	1439	6938	816
13 : M28	30	0	423	463	499	535	209	601	370	321	99	547	54	69	386	34
14 : M29	27	0	714	684	723	773	319	872	564	488	165	797	57	147	585	68
15 : M30	342	0	5175	5030	5432	5808	2430	6747	4180	3650	1226	6150	525	1013	4806	568
16 : M31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-16. Matrix of Indirect Influences for "Mining surface" variables

The results were calculated for 3 iterations. Matrix MII sum is shown in Table 3-16.

Table 3-16. Matrix sum – MII row and column sum for "Mining surface" variables

N°	VARIABLE	TOTAL NUMBER OF ROWS	TOTAL NUMBER OF COLUMNS
1	Methane surface emissions (AMM)	14567	4380
2	Methane resources (CBM)	2784	0
3	Area of the waste heap	69491	70251
4	Height of the waste heap	62915	68132
5	Angle of slopes of the waste heap	52225	73310
6	Geometry of the waste heap	65378	78338
7	Material type deposited on the waste heap	80151	33124
8	Geotechnical stability of waste heaps	96190	89971
9	Fire hazard at the waste heap	60489	56113
10	Gas hazard at the waste heap	36147	48976
11	Acidity potential of the waste heap material	31767	16613
12	Status of reclamation of the waste heap	76766	81736
13	Neighbourhood density	4640	7127
14	Existence of historic or singular buildings	6983	13885
15	Land use restrictions (mine)	53082	63517
16	Connection capacity of mine to the grid	0	8102
	Totals	188	188

Figure 3-17 shows the results of the calculation for MII for „Mining surface" variables in the form of a map of indirect influences and dependences between variables from the Table 3-12.

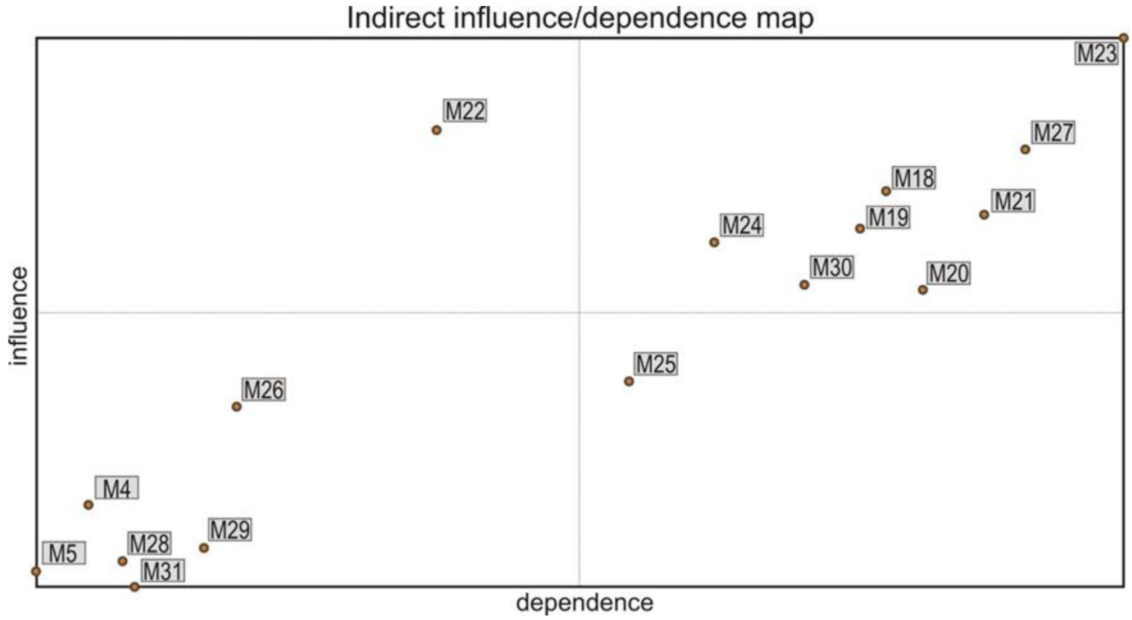


Figure 3-17. Map of indirect influences and dependences (MII) between "Mining surface" variables

Table 3-17 provides a summary mapping of the analysed variables to the related factors, shown in Figure 3-17.

Table 3-17. Results of MII analyses for "Mining surface" variables with allocation to relevant factor group / quadrant

MII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
18	Area of the waste heap
19	Height of the waste heap
20	The angle of slopes of the waste heap
21	The geometry of the waste heap
23	Geotechnical stability of waste heaps
24	Fire hazard at the waste heap
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
MII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
22	Material type deposited on the waste heap

MII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS):	
No.	**Variable**
25	Gas hazard at the waste heap

Figure 3-18 shows the indirect influence graph for “Mining surface” variables.

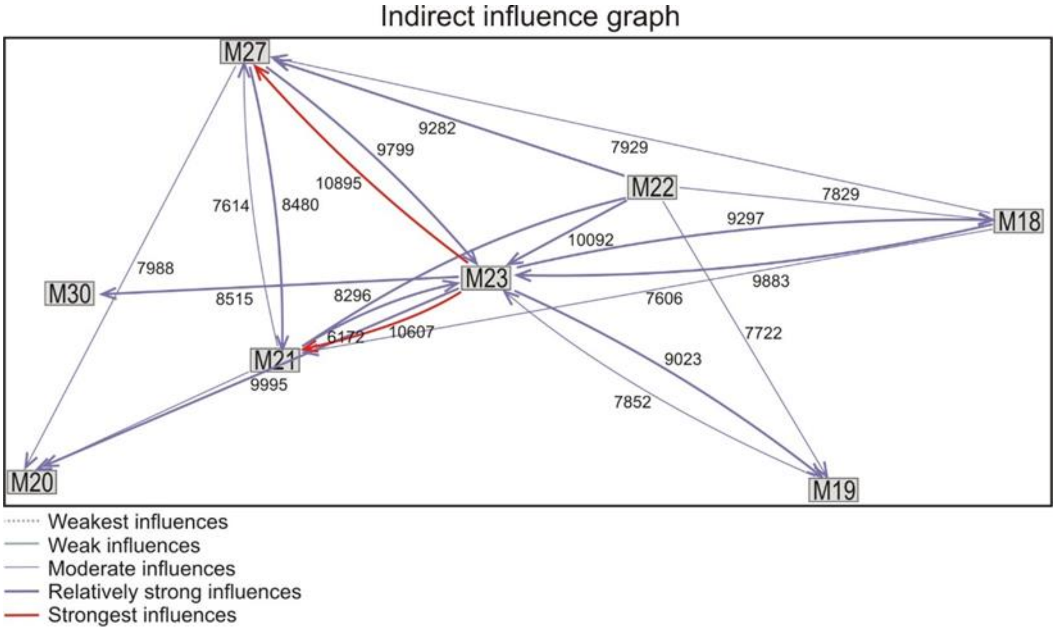


Figure 3-18. Graph of indirect influences (MII) for “Mining surface” variables

The strongest indirect influence is between variable **No. 23 Geotechnical stability of waste heaps** and variable **No. 27 Status of reclamation of the waste heap,** and between variable **No. 23 Geotechnical stability of waste heaps** and variable **No. 21 Geometry of the waste heap**.

3.2.3 Matrix of Potential Direct Influences (MPDI)

The results from Matrix of Potential Direct Influences (MPDI) were calculated for 3 iterations. It was assumed that the value assigned by the experts in the Delphi study as "P" (potential impact) for calculation purposes would have a value of "1" (low impact). THE Matrix MPDI characteristic is shown in Table 3-18 and the Matrix MDI sum in Table 3-19.

Table 3-18. Matrix characteristic – MPDI characteristic for “Mining surface” variables

Indicator	Value
Matrix size	16
Number of iterations	3
Number of zeros	160
Number of ones	27
Number of twos	35
Number of threes	34
Number of P	0
Total	96

Indicator	Value
Filtrate	37,5%

Table 3-19. Matrix sum – MPDI row and column sum for "Mining surface" variables

N°	Variable	Total number of rows	Total number of columns
1	Methane surface emissions (AMM)	4	4
2	Methane resources (CBM)	4	0
3	Area of the waste heap	18	16
4	Height of the waste heap	15	14
5	Angle of slopes of the waste heap	11	17
6	Geometry of the waste heap	15	19
7	Material type deposited on the waste heap	25	11
8	Geotechnical stability of waste heaps	24	23
9	Fire hazard at the waste heap	15	15
10	Gas hazard at the waste heap	12	13
11	Acidity potential of the waste heap material	10	6
12	Status of reclamation of the waste heap	22	23
13	Neighbourhood density	5	5
14	Existence of historic or singular buildings	3	8
15	Land use restrictions (mine)	14	23
16	Connection capacity of mine to the grid	2	2
	Totals	188	188

Figure 3-19 shows the results of the calculation for MPDI Matrix for "Mining surface" variables in the form of a map of potential direct influences and dependences between analysed variables.

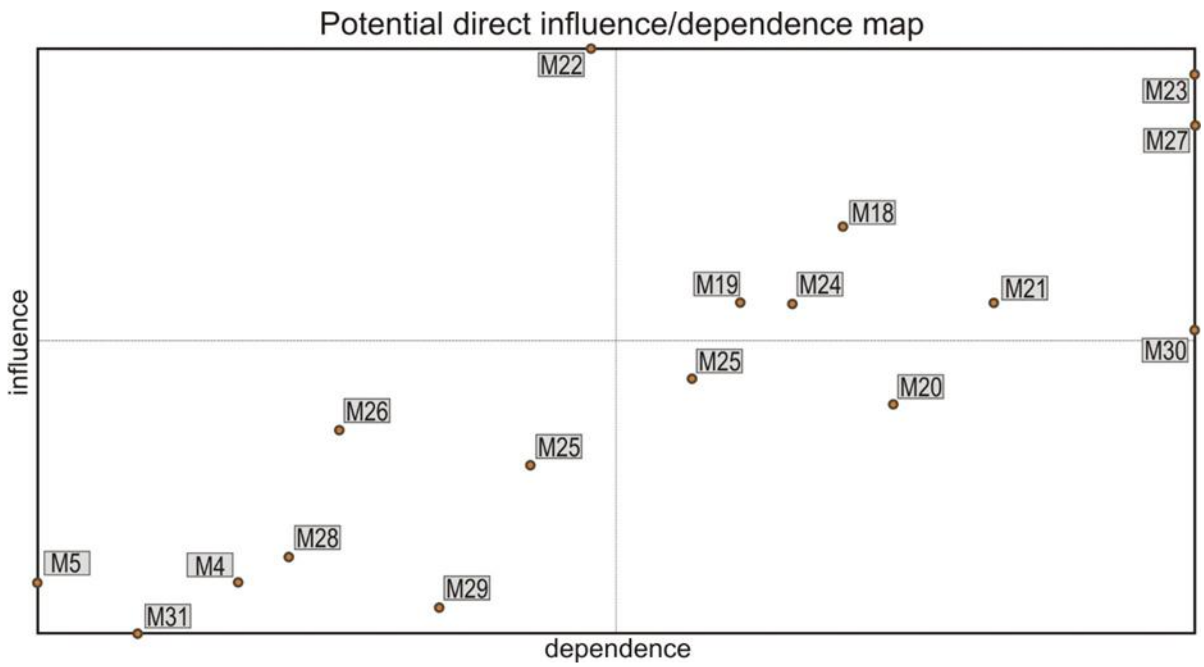


Figure 3-19. Map of potential direct influences and dependences (MPDI) between "Mining surface" variables

Table 3-20 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-19.

Table 3-20. Results of MPDI analyses for "Mining surface" variables with allocation to relevant factor group / quadrant

MPDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
18	Area of the waste heap
19	Height of the waste heap
21	Geometry of the waste heap
23	Geotechnical stability of waste heaps
24	Fire hazard at the waste heap
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
MPDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
22	Material type deposited on the waste heap
MPDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
20	Angle of slopes of the waste heap
25	Gas hazard at the waste heap.

Figure 3-20 shows the potential direct influence graph for "Mining surface" variables.

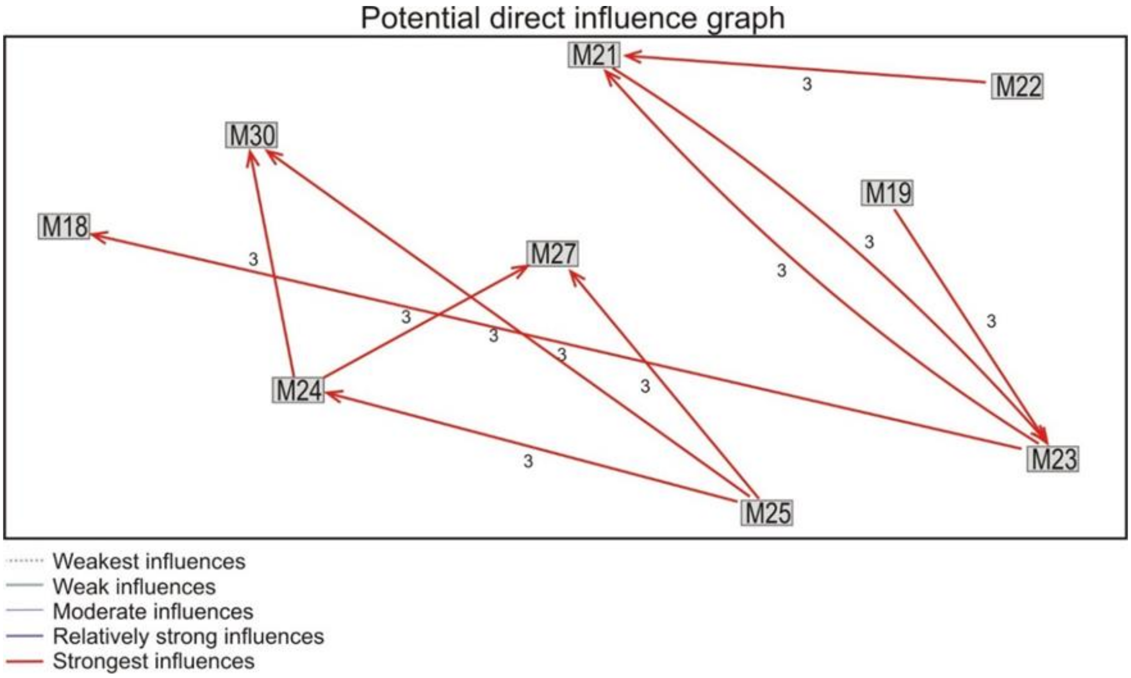


Figure 3-20. Graph of potential direct influences (MPDI) for "Mining surface" variables

3.2.4 Matrix of Potential Indirect Influences (MPII)

The results of the analysis of potential indirect influences calculated by MICMAC software– Matrix of Potential Indirect Influences (MPII) for "Mining surface" variables are presented in Annex 4.

The results were calculated for 3 iterations. Matrix MPII sum is shown in Table 3-21.

Table 3-21. Matrix sum – MPII row and column sum for "Mining surface" variables

N°	Variable	Total number of rows	Total number of columns
1	Methane surface emissions (AMM)	17153	4781
2	Methane resources (CBM)	6681	0
3	Area of the waste heap	76054	79073
4	Height of the waste heap	67910	75129
5	Angle of slopes of the waste heap	55521	81939
6	Geometry of the waste heap	71151	87658
7	Material type deposited on the waste heap	94308	44497
8	Geotechnical stability of waste heaps	105703	103022
9	Fire hazard at the waste heap	72172	62869
10	Gas hazard at the waste heap	54256	55060
11	Acidity potential of the waste heap material	39235	22930
12	Status of reclamation of the waste heap	84877	92216
13	Neighbourhood density	10161	14021
14	Existence of historic or singular buildings	7607	17517
15	Land use restrictions (mine)	57097	73962
16	Connection capacity of mine to the grid	3960	9172
	Totals	188	188

Figure 3-21 shows the calculation results for MPII for "Mining surface" variables in the form of a map of potential indirect influences and dependences between analysed variables.

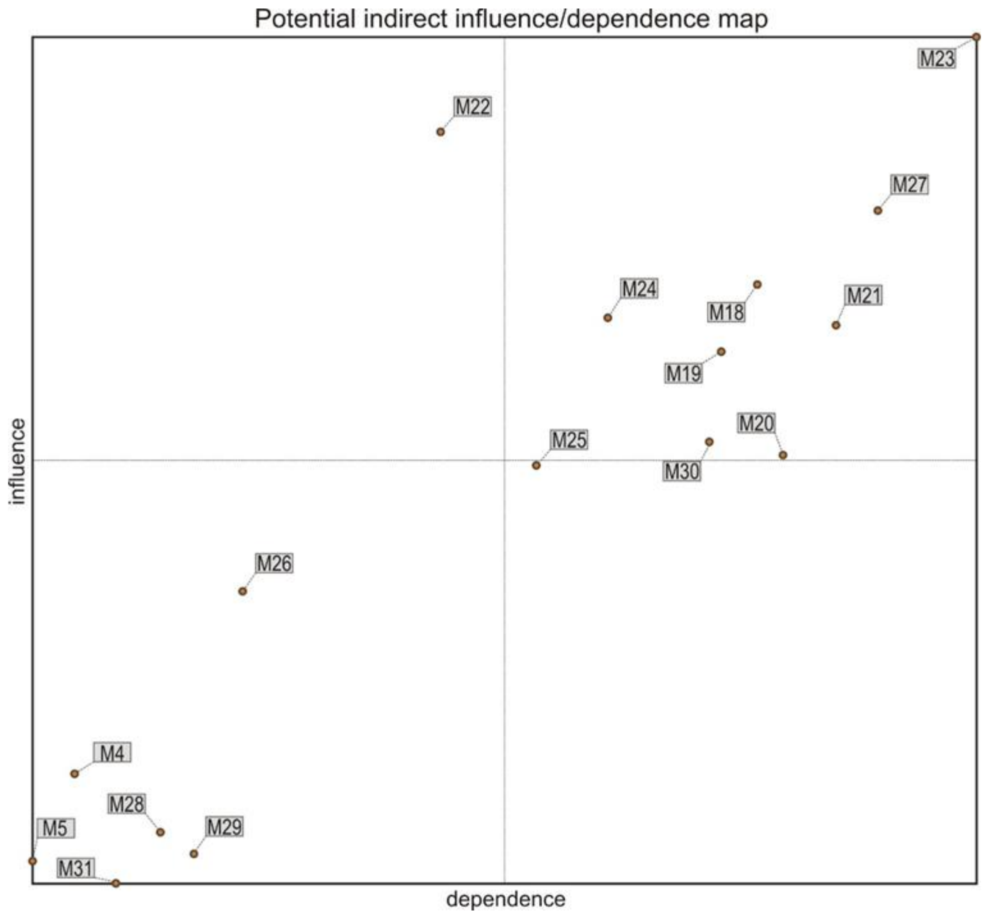


Figure 3-21. Map of potential indirect influences and dependences (MPII) between "Mining surface" variables

Table 3-22 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-21.

Table 3-22. Results of MPII analyses for "Mining surface" variables with allocation to relevant factor group / quadrant

MPII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
18	Area of the waste heap
19	Height of the waste heap
20	Angle of slopes of the waste heap

21	Geometry of the waste heap
23	Geotechnical stability of waste heaps
24	Fire hazard at the waste heap
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
MPII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
22	Material type deposited on the waste heap

Figure 3-22 shows the potential indirect influence graph for "Mining surface" variables.

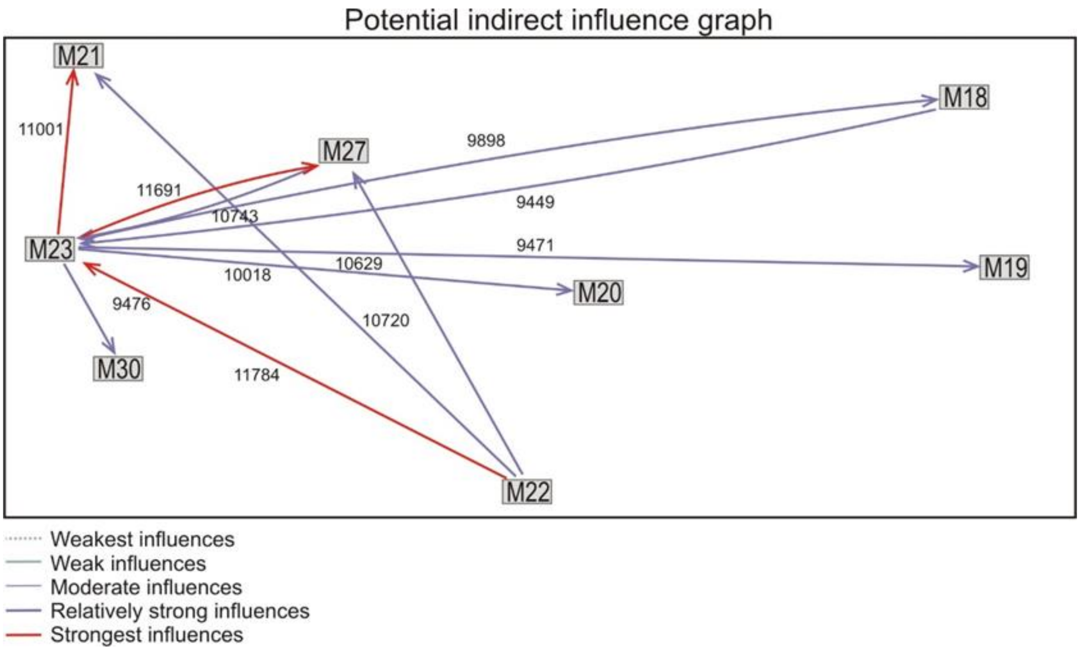


Figure 3-22. Graph of potential indirect influences (MPII) for "Mining surface" variables

The strongest indirect influence is between variable No. **23, Geotechnical stability of waste heaps** and variable **No. 21 Geometry of the waste heap** and between variable No. **23 Geotechnical stability of waste heaps** and variable **No. 27 Status of reclamation of the waste heap,** and **between variable No. 22 Material type deposited on the waste heap,** and variable **No. 23 Geotechnical stability of waste heaps**.

To enrich the structural matrix analysis for the indirect potential analysis, it assumed the value “0” to all the value “1” of MDI Matrix to take into account only the strong relations. Figure 3-23 shows a map of potential influences / dependencies for the values of the variables: the value "1" is equal to "0" and the value "P" is equal to "1".

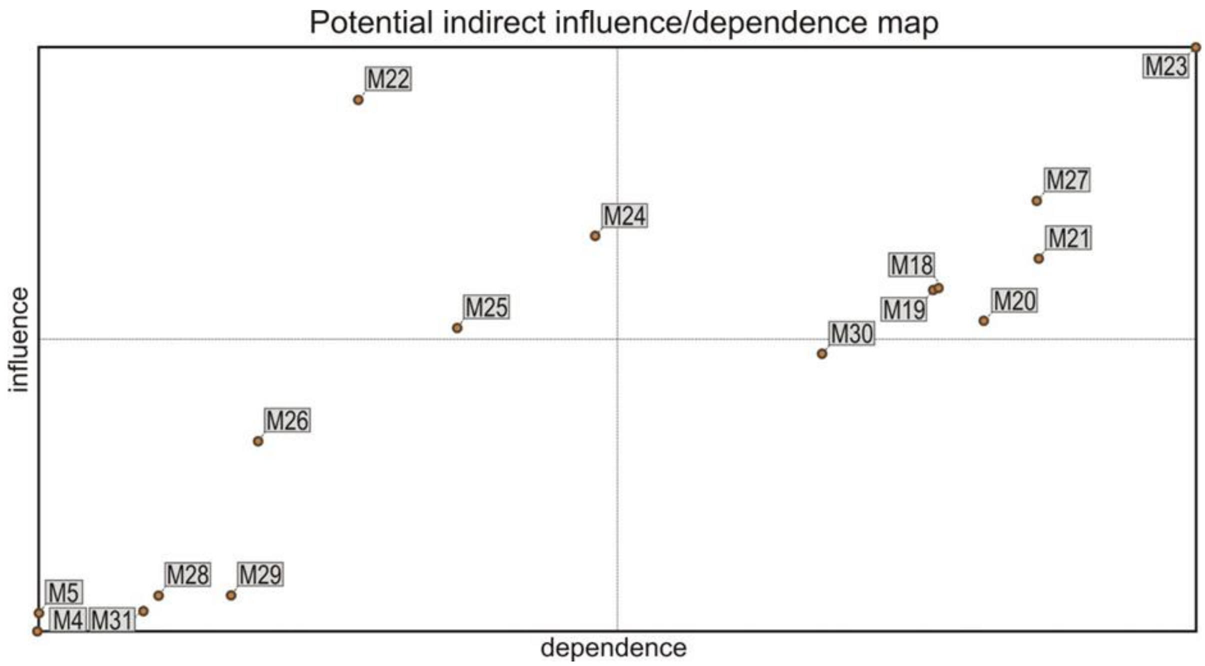


Figure 3-23. Map of potential indirect influences and dependences (MPII) between “Mining surface” variables for value “1” = “0”

Compared to the previous MPII analysis, variable **No. 24 Fire hazard at the waste heap** moved from key factors towards impact factors, while variable **No. 30 Land use restrictions (mine)** moved from key factors towards dependent factors.

3.2.5 Proportions and list of variables sorted by influence and dependence

Proportions, shown in the Annex 5, allows to have a classification of the variables according to their influence and their decreasing dependence (direct and indirect); these influences and these dependences are normalized (and expressed in "for 10 000-th").

In the Figure 3-24 variables are presented in decreasing order: one for the direct classification, the other for the indirect classification according to their influences. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

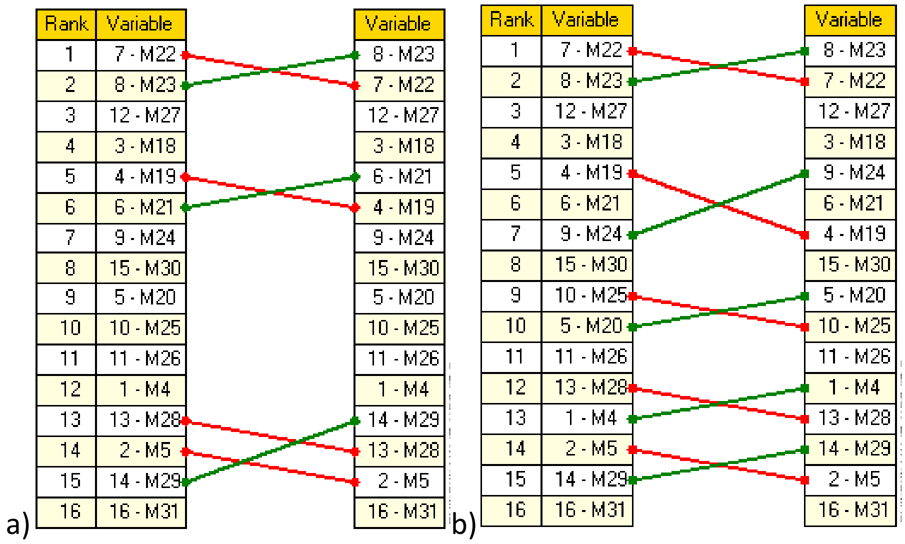


Figure 3-24. Classifying "Mining surface" variables according to their influences a)MDI-MII b)MPDI-MPII

In the Figure 3-25 variables are presented in decreasing order: one for the direct classification, the other for the indirect classification according to their dependences. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

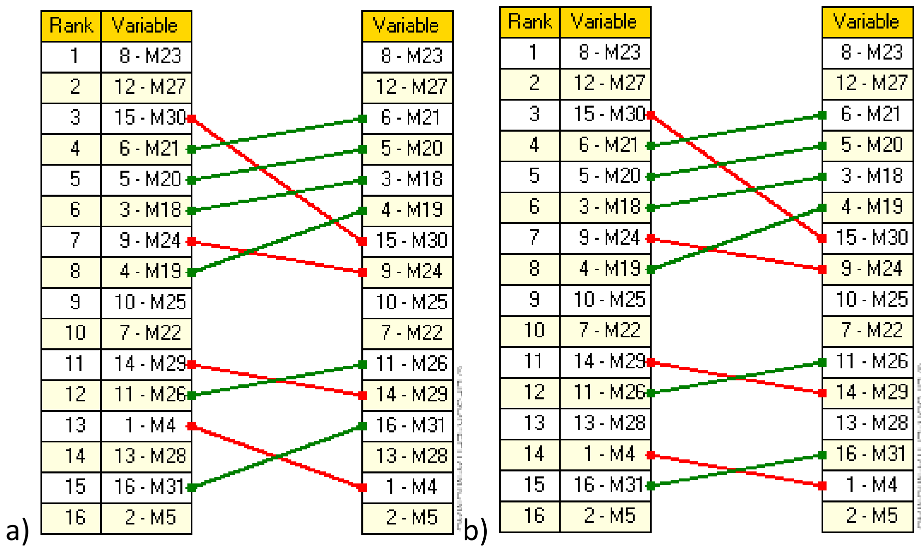


Figure 3-25. Classifying "Mining surface" variables according to their dependences a)MDI-MII b)MPDI-MPII

In Figures 3-26 and 3-27 the displacement map is presented. It shows the variation of the position in the system of variables „Mining surface" depending on the methodology adopted: direct and indirect, and potential direct and potential indirect.

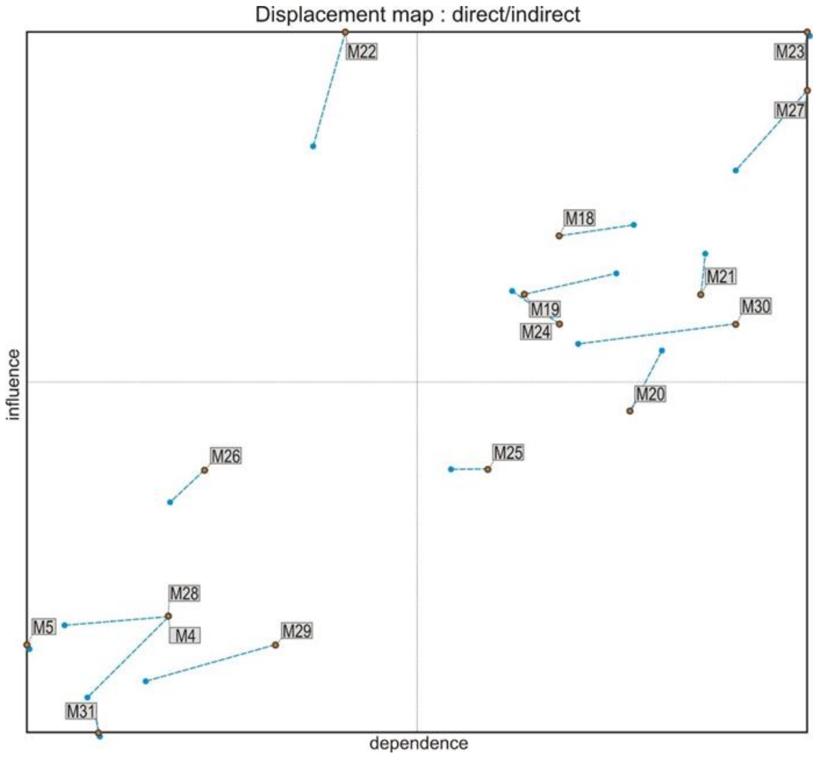


Figure 3-26. Displacement map for “Mining surface” variables in MDI Matrix and MII Matrix

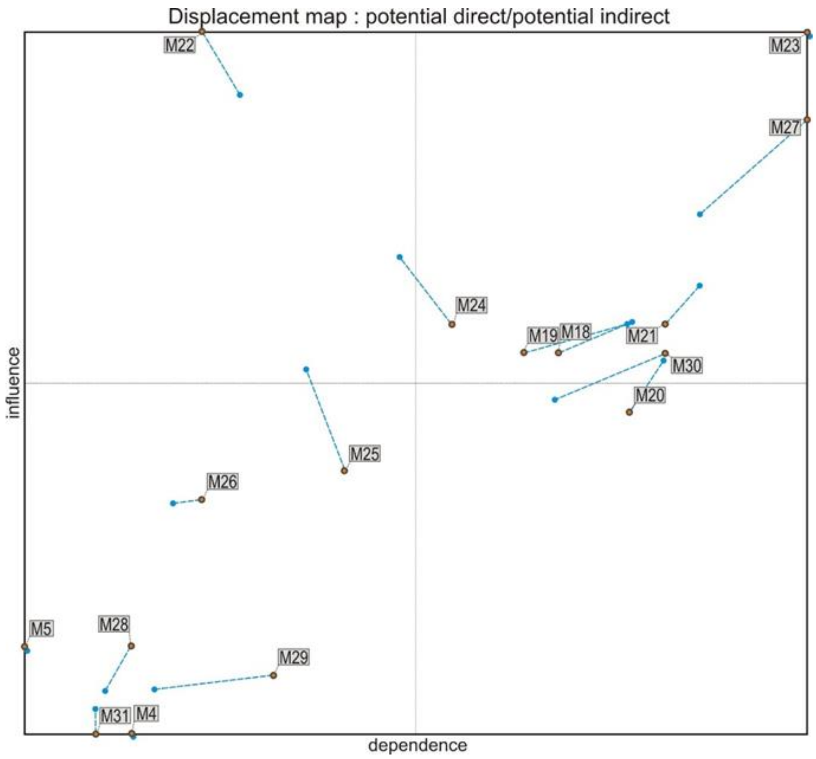


Figure 3-27. Displacement map for “Mining surface” variables in MPDI Matrix and MPII Matrix

3.2.6 Summary

A total of 16 criteria from the "Mining surface" group were subjected to structural analysis using MICMAC software. The “Mining surface” matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. The 37.5% fill rate reflects the direct influences between system variables, and it is considered a good rate of filling. The rest 62.5% represents the indirect influences between the variables of this system, of which the rest of the MICMAC method is based. As a result of direct and indirect analyses, 8 variables were defined as key factors. Table 3-23 summarises the results of the MICMAC analyses for the “Mining surface” variables.

Table 3-23. Summaries of the MICMAC analysis – key factors

<table>
<tr><th></th><th>Matrix of Direct Influence
MDI</th><th>Matrix of Indirect Influences
MII</th><th>Matrix of Potential Direct Influence
MPDI</th><th>Matrix of Potential Indirect Influence
MPII
P=1</th><th>Matrix of Potential Indirect Influence
MPII
1=0, P=1</th></tr>
<tr><td rowspan="8">Key factors</td><td colspan="5">18: Area of the waste heap</td></tr>
<tr><td colspan="5">19: Height of the waste heap</td></tr>
<tr><td>-</td><td>20: Angle of slopes of the waste heap</td><td>-</td><td colspan="2">20: Angle of slopes of the waste heap</td></tr>
<tr><td colspan="5">21: Geometry of the waste heap</td></tr>
<tr><td colspan="5">23: Geotechnical stability of waste heaps</td></tr>
<tr><td colspan="4">24: Fire hazard at the waste heap</td><td>-</td></tr>
<tr><td colspan="5">27:Status of reclamation of the waste heap</td></tr>
<tr><td colspan="4">30: Land use restrictions (mine)</td><td>-</td></tr>
</table>

Structural analyses carried out using the MICMAC software allowed for the selection of the following key criteria, i.e. criteria with the highest impact on others and the highest dependence on other variables.

- **18: Area of the waste heap**
- **19: Height of the waste heap**
- **20: Angle of slopes of the waste heaps**
- **21: Geometry of the waste heap**
- **23: Geotechnical stability of waste heaps**
- **24: Fire hazard at the waste heap**
- **27: Status of reclamation of the waste heap**
- **30: Land use restrictions (mine)**

Due to their high dependence and influence, the key factors are extremely important for assessing the stability of the system and evaluating future scenarios built on their basis.

3.3 "Mining underground" variables

Variables related to the surface part of a coal mine were included in the analysis. These are shown in Table 3-24.

Table 3-24. List of "Mining underground" variables with short description

N°	Long label	Short label	Description
1	Depth of mine	M1	The variable determines the maximum depth of the mine - the depth at which the deepest exploitation level is located or where the deepest workings/goafs are located and that can be adapted to produce green energy.
2	Ground movement	M2	The variable determines the possible tectonic movement of rock mass influencing underground workings/reservoirs/shafts and infrastructure on the surface (after the end-of-life of the coal mine with or without flooding of the mine).
3	Geological singularities of the mine	M3	The variable refers to the existence of singular geological structures in the mine: impermeable strata, absence of faults, etc. (with no geological disturbance)
4	Methane surface emissions (AMM)	M4	The variable determines the concentration, flow and an estimation of future emissions of Abandoned Mine Methane (AMM).
5	Methane resources (CBM)	M5	The variable refers to the reserve of natural gas stored in coal seams, called Coal Bed Methane (CBM).
6	Coal spontaneous ignition	M6	The variable determines the ability of coal in coal seams to develop endogenous fires that may affect both underground and surface by means of pollution of the atmosphere and change of mine water chemistry.
7	Volume of pumped water	M8	The variable determines the amount of water [m3/h] that can be pumped from the mine to its surface using existing shafts per unit time for production of geothermal energy or UPSH.
8	Pumped water chemistry/quality	M9	The variable determines the quality and chemistry (content of mineral substances [mg/dm3] & pH) of pumped mining water.
9	Hazardous substances in the pumped mine water	M10	Pumped mine water may contain hazardous substances that are toxic for the environment, such as heavy metals, radioactive elements (226Ra and 228Ra) or PCBs (polychlorinated biphenyls) used in electrical equipment (as dielectric fluids).
10	Depth of the shafts	M11	The variable determines the depth of the shaft [m] understood as distance between surface level and shaft bottom.
11	Shaft diameter	M12	The variable determines the shaft diameter [m]
12	Shaft technical condition	M13	The variable describes the shaft technical condition that can be: good (with no repairs required), average (minor repair required - small cracks of the lining, loss in lining structure), bad (mayor repair required - the technical condition is hazardous for shaft stability and general safety)
13	Function/status of shaft (liquidated, pumping station, ventilation working)	M14	The variable describes the shaft status and function. Some shafts are used as pumping stations and cannot be liquidated or repurposed, also reopening of liquidated shafts is questionable.
14	Water inflow	M15	The variable determines the amount of natural water inflow [m3/h] to the mine during the exploitation and possible inflow after the end of exploitation.
15	Pumped water temperature	M16	The variable determines the temperature [°C] mining water pumped from the underground workings to the surface.
16	Flooding status of the mine	M17	The variable describes the flooding status of a liquidated mine, related to the depth to which it was flooded and the flooded area.

3.3.1 Matrix of Direct Influences (MDI)

Matrix of Direct Influences (MDI), based on the Delphi expert analysis performed under Task 2.2 is presented in Annex no 2 in Deliverable 2.2.

The results were calculated for 3 iterations. Matrix MDI characteristic is shown in Table 3-25 and Matrix MDI sum is shown in Table 3-26.

Table 3-25. Matrix characteristic – MDI characteristic for "Mining underground" variables

Indicator	Value
Matrix size	16
Number of iterations	3
Number of zeros	152
Number of ones	41
Number of twos	31
Number of threes	29
Number of P	3
Total	104
Filtrate	40,625%

Table 3-26. Matrix sum – MDI row and column sum for "Mining underground" variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	34	9
2	Ground movement	5	10
3	Geological singularities of the mine	22	3
4	Methane surface emissions (AMM)	1	23
5	Methane resources (CBM)	5	11
6	Coal spontaneous ignition	5	9
8	Volume of pumped water	25	17
9	Pumped water chemistry/quality	15	14
10	Hazardous substances in the pumped mine water	14	14
11	Depth of the shafts	15	8
12	Shaft diameter	3	1
13	Shaft technical condition	0	15
14	Function/status of shaft (liquidated, pumping station, ventilation working)	2	10
15	Water inflow	16	15
16	Pumped water temperature	0	13
17	Flooding status of the mine	28	18
	Totals	190	190

Figure 3-28 shows the calculation results for MDI for "Mining underground" variables in the form of a map of direct influences and dependences between the variables shown in Table 3-24.

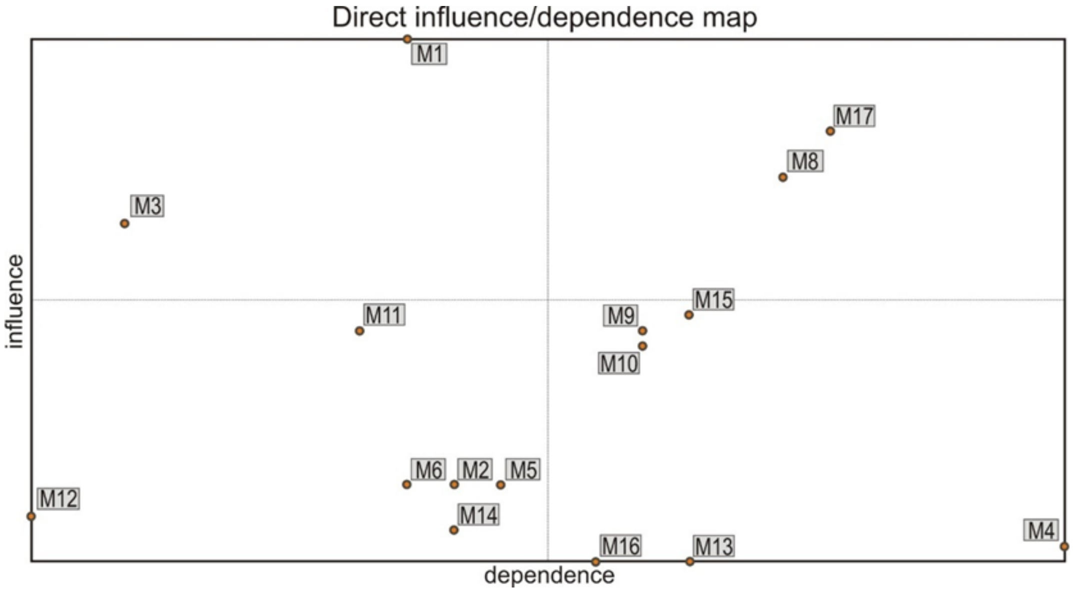


Figure 3-28. Map of direct influences and dependences (MDI) between "Mining underground" variables

Table 3-27 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-28.

Table 3-27. Results of MDI analyses for "Mining underground" variables with allocation to relevant factor group / quadrant

MDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
8	Volume of pumped water
17	Flooding status of the mine
MDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
1	Depth of mine
3	Geological singularities of the mine
MDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
4	Methane surface emissions (AMM)
9	Pumped water chemistry/quality1
10	Hazardous substances in the pumped mine water
13	Shaft technical condition

15	Water inflow
16	Pumped water temperature

Figure 3-29 shows the direct influence graph for "Mining underground" variables.

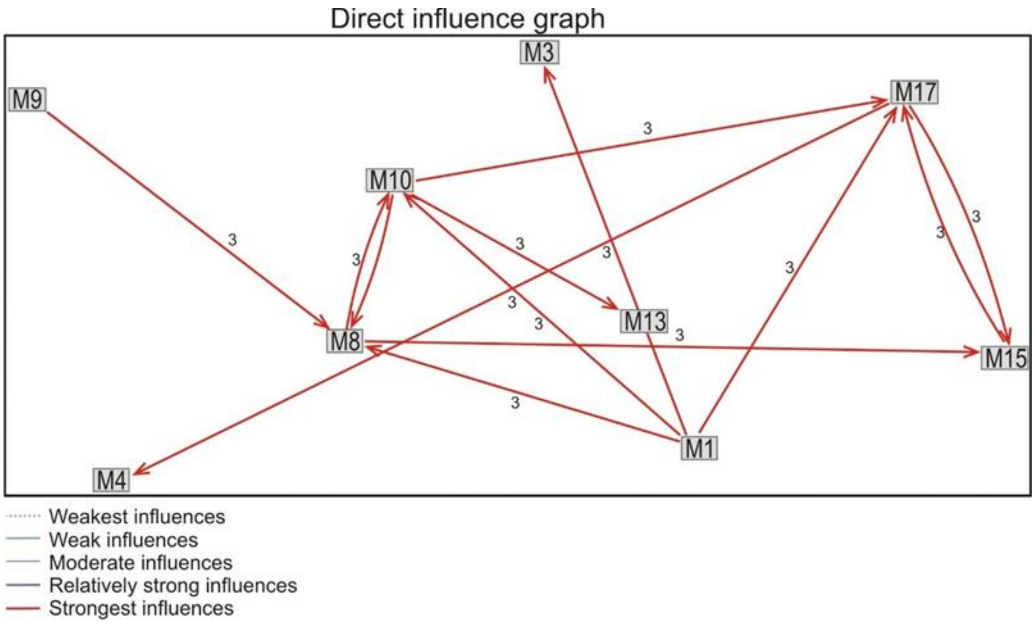


Figure 3-29. Graph of direct influences (MDI) for "Mining underground" variables

3.3.2 Matrix of Indirect Influences (MII)

The results of the analysis of indirect influences calculated by MICMAC software– Matrix of Indirect Influences (MII) for "Mining underground" variables are presented in Annex 6.

The results were calculated for 3 iterations. Matrix MII sum is shown in Table 3-28.

Table 3-28. Matrix sum – MII row and column sum for "Mining underground" variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	55162	9244
2	Ground movement	5947	12564
3	Geological singularities of the mine	35385	2547
4	Methane surface emissions (AMM)	4880	35443
5	Methane resources (CBM)	7068	15328
6	Coal spontaneous ignition	4753	13808
8	Volume of pumped water	29470	24238
9	Pumped water chemistry/quality	21814	23055
10	Hazardous substances in the pumped mine water	24795	22675
11	Depth of the shafts	33493	10520
12	Shaft diameter	10624	849
13	Shaft technical condition	0	27029
14	Function/status of shaft (liquidated, pumping station, ventilation working)	2189	18735

N°	Variable	Total number of rows	Total number of columns
15	Water inflow	20119	24523
16	Pumped water temperature	0	21178
17	Flooding status of the mine	34596	28559
	Totals	190	190

Figure 3-30 shows the results of the calculation for MII for "Mining underground" variables in the form of a map of indirect influences and dependences between variables from the Table 3-12.

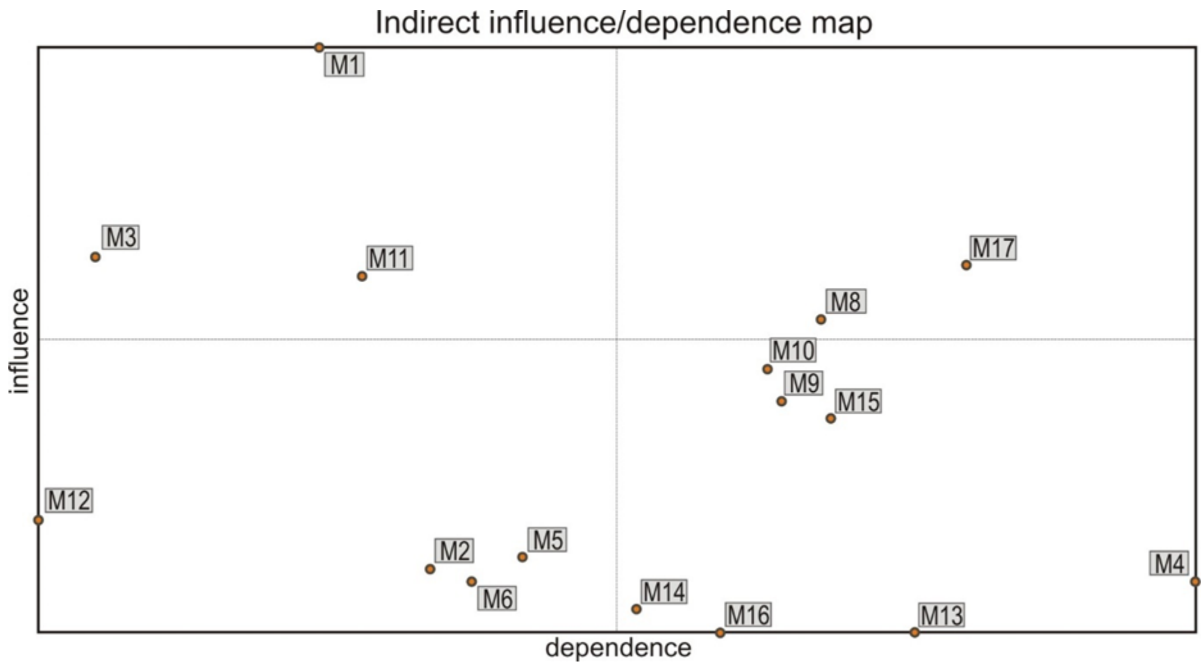


Figure 3-30. Map of indirect influences and dependences (MII) between "Mining underground" variables

Table 3-29 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-30.

Table 3-29. Results of MII analyses for "Mining underground" variables with allocation to relevant factor group / quadrant

MII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
8	Volume of pumped water
17	Flooding status of the mine
MII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
1	Depth of mine

3	Geological singularities of the mine
11	Depth of the shafts
MII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
4	Methane surface emissions (AMM)
9	Pumped water chemistry/quality1
10	Hazardous substances in the pumped mine water
13	Shaft technical condition
14	Function/status of shaft (liquidated, pumping station, ventilation working)
15	Water inflow
16	Pumped water temperature

Figure 3-31 shows the indirect influence graph for “Mining underground” variables.

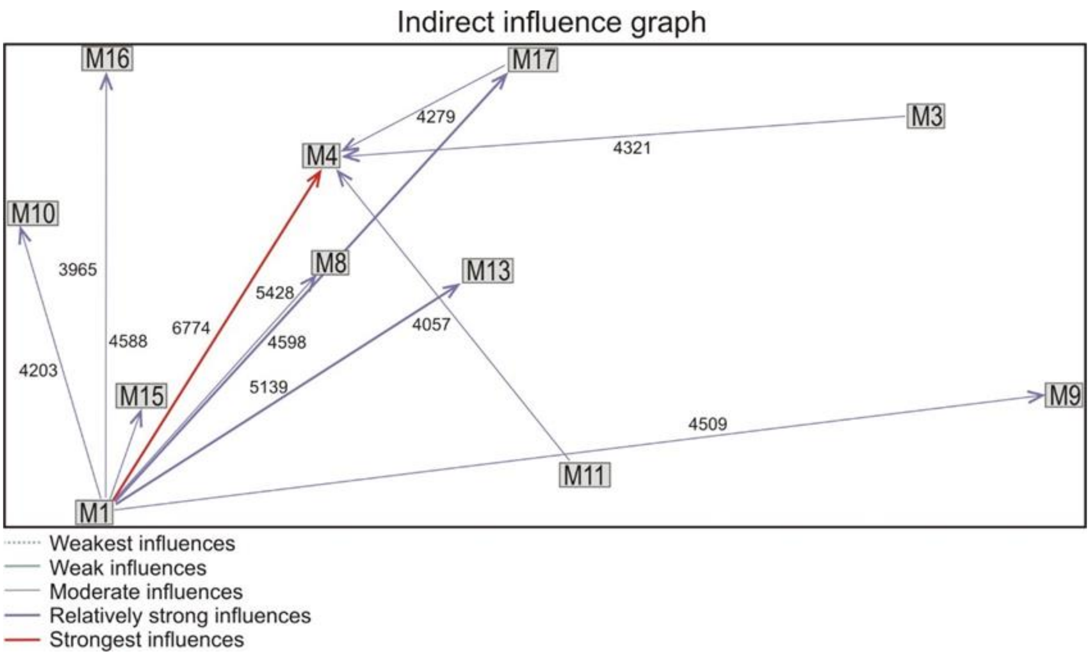


Figure 3-31. Graph of indirect influences (MII) for “Mining underground” variables

The strongest indirect influence is between variable **No. 1 Depth of the mine** and variable **No. 4 Methane surface emissions (AMM).** Relative strong influences are between variable **No. 1 Depth of the mine** and variable **No. 13 Shaft technical condition** and **No. 17 Flooding status of the mine.**

Due to the small number of values "P" (3 out of 256, or about 1%) in the MDI Matrix, MDPI and MPI analyses were not performed.

3.3.3 Proportions and list of variables sorted by influence and dependence

Proportions, shown in the Annex 7, allows to have a classification of the variables according to their influence and their decreasing dependence (direct and indirect); these influences and these dependences are normalized (and expressed in "for 10 000-th").

In the Figure 3-32 variables are presented in decreasing order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the two types of classification (MDI Matrix and MII Matrix).

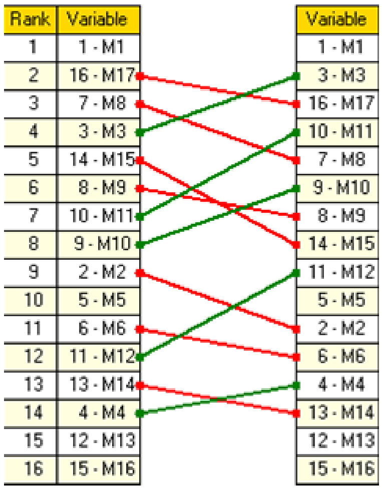
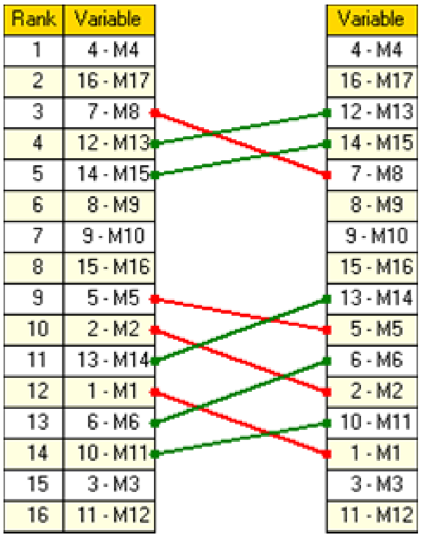


Figure 3-32. Classifyin "Mining underground" variables according to their influences

In the Figure 3-33 variables are presented in decreasing order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the two types of classification (MDI Matrix and MII Matrix).



Rank	Variable	Variable
1	4 - M4	4 - M4
2	16 - M17	16 - M17
3	7 - M8	12 - M13
4	12 - M13	14 - M15
5	14 - M15	7 - M8
6	8 - M9	8 - M9
7	9 - M10	9 - M10
8	15 - M16	15 - M16
9	5 - M5	13 - M14
10	2 - M2	5 - M5
11	13 - M14	6 - M6
12	1 - M1	2 - M2
13	6 - M6	10 - M11
14	10 - M11	1 - M1
15	3 - M3	3 - M3
16	11 - M12	11 - M12

Figure 3-33. Classifying "Mining underground" variables according to their dependences

In the Figure 3-34 the displacement map is presented. It shows the variation of the position in the system of variables "Mining underground" depending on the methodology adopted: direct and indirect, and potential direct and potential indirect.

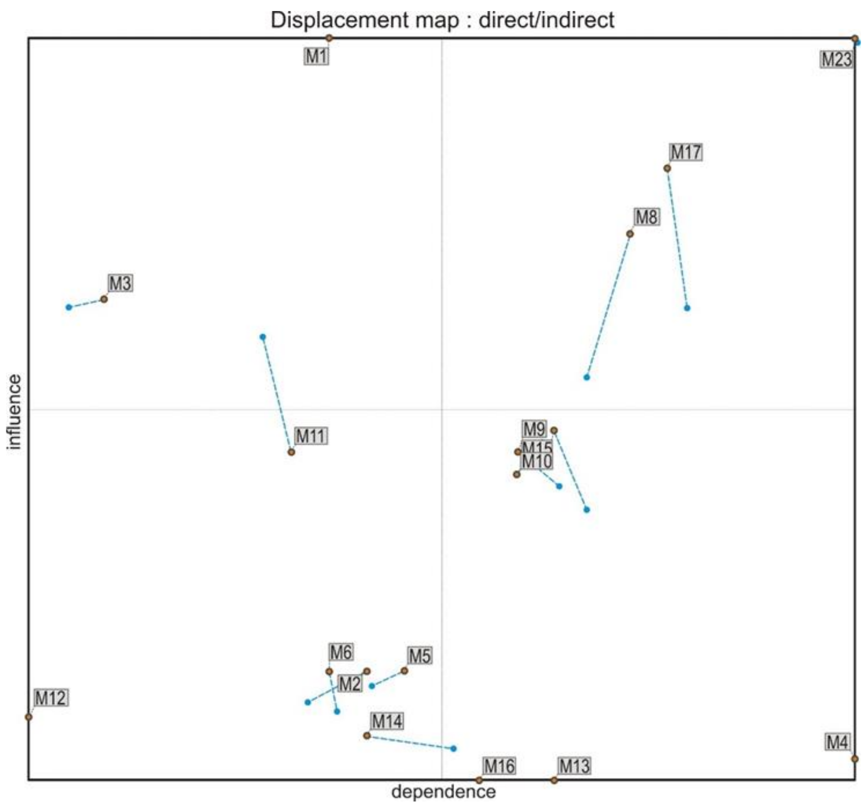


Figure 3-34. Displacement map for "Mining underground" variables in MDI Matrix and MII Matrix

3.3.4 Summary

A total of 16 criteria from the "Mining underground" group were subjected to structural analysis using MICMAC software. The “Mining underground” matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. The 40.6% fill rate reflects the direct influences between system variables, and it is considered an average rate of filling. The rest 59.4% represents the indirect influences between the variables of this system, of which the rest of the MICMAC method is based. As a result of direct and indirect analyses, 2 variables were defined as key factors.

Structural analyses carried out using the MICMAC software allowed for the selection of the following key criteria, i.e. criteria with the highest impact on others and the highest dependence on other variables:

- **8: Volume of pumped water**
- **17: Flooding status of the mine**

Due to their high dependence and influence, the key factors are extremely important for assessing the stability of the system and evaluating future scenarios built on their basis.

3.4 “Potentials” variables

All variables related to the coal mine and power plants (from variable No. 1 to variable No. 69) were included in the analysis.

3.4.1 Matrix of Direct Influences (MDI)

Matrix of Direct Influences (MDI), based on the Delphi expert analysis performed under Task 2.2 is presented in Annex no 2 in Deliverable 2.2.

The results were calculated for 9 iterations. Matrix MDI characteristic is shown in Table 3-30 and Matrix MDI sum is shown in Annex 8.

Table 3-30. Matrix characteristic – MDI characteristic for “Potentials” variables

INDICATOR	VALUE
Matrix size	69
Number of iterations	9
Number of zeros	4027
Number of ones	262
Number of twos	214
Number of threes	141
Number of P	117
Total	734
Filtrate	15,41693%

Figure 3-35 shows the results of the calculation for MDI for "Potentials" variables in the form of a map of direct influences and dependences between all the variables.

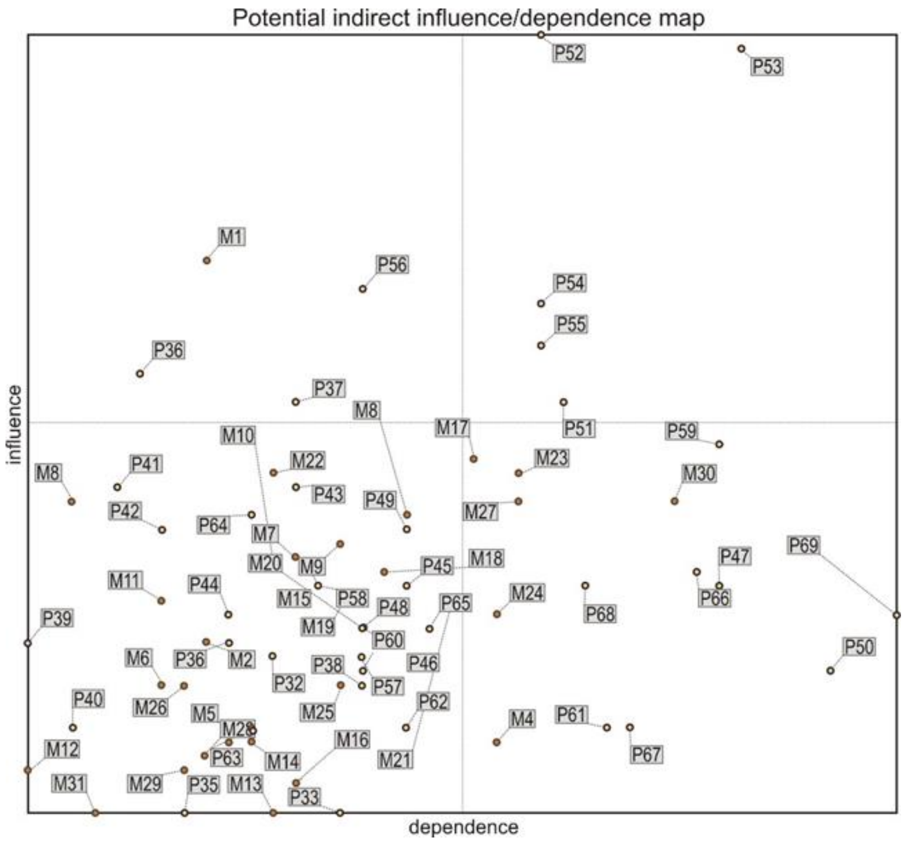


Figure 3-35. Map of direct influences and dependences (MDI) between "Potentials" variables

Table 3-31 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-35.

Table 3-31. Results of MDI analyses for "Potentials" variables with allocation to relevant factor group / quadrant

MDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
51	Land use restrictions (power plant)
52	The character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure

55	Access / proximity to railway infrastructure
MDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
1	Depth of mine
36	Number of units decommissioned
37	Water reservoir capacity
56	Access / proximity to water reservoir
MDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
4	Methane surface emissions (AMM)
21	Geometry of the waste heap
23	Geotechnical stability of waste heaps
24	Fire hazard at the waste heap
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
47	Available space for new technologies/projects
50	Cost of decommissioning and remediation
59	Proximity to industries
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
66	Electro-intensive industries
67	Industries likely to use H2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-36 shows the direct influence graph for “Potentials” variables.

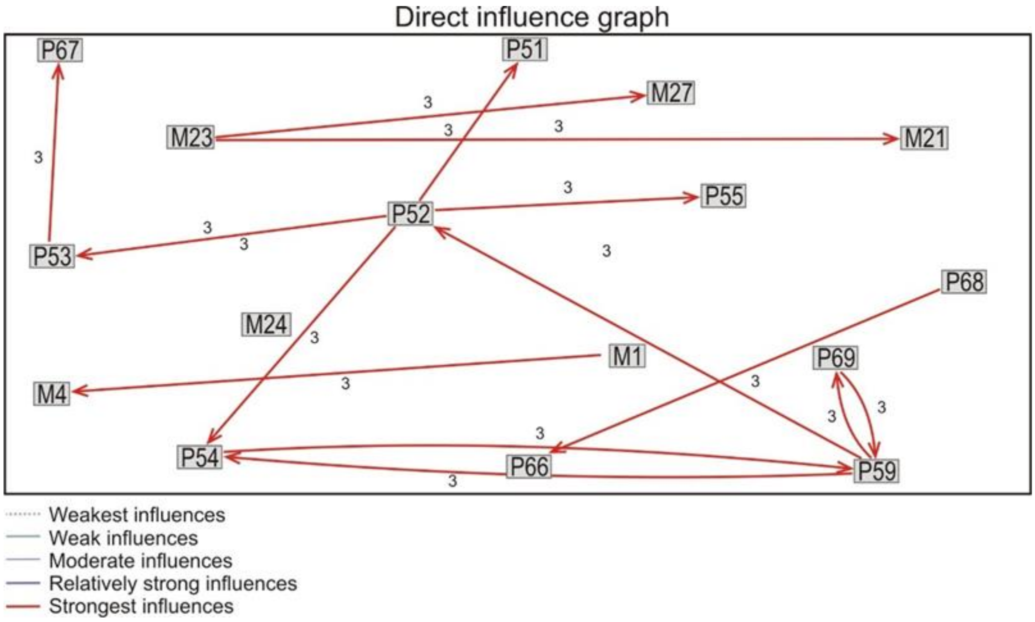


Figure 3-36. Graph of direct influences (MDI) for "Potentials" variables

3.4.2 Matrix Indirect Influences (MII)

The results of the analysis of indirect influences calculated by MICMAC software – Matrix of Indirect Influences (MII) for „Potentials" variables. The results were calculated for 9 iterations. Matrix MII sum is shown in Annex 9.

Figure 3-37 shows the results of the calculation for MII for „Potentials" variables in the form of a map of indirect influences and dependences "Potentials" between variables.

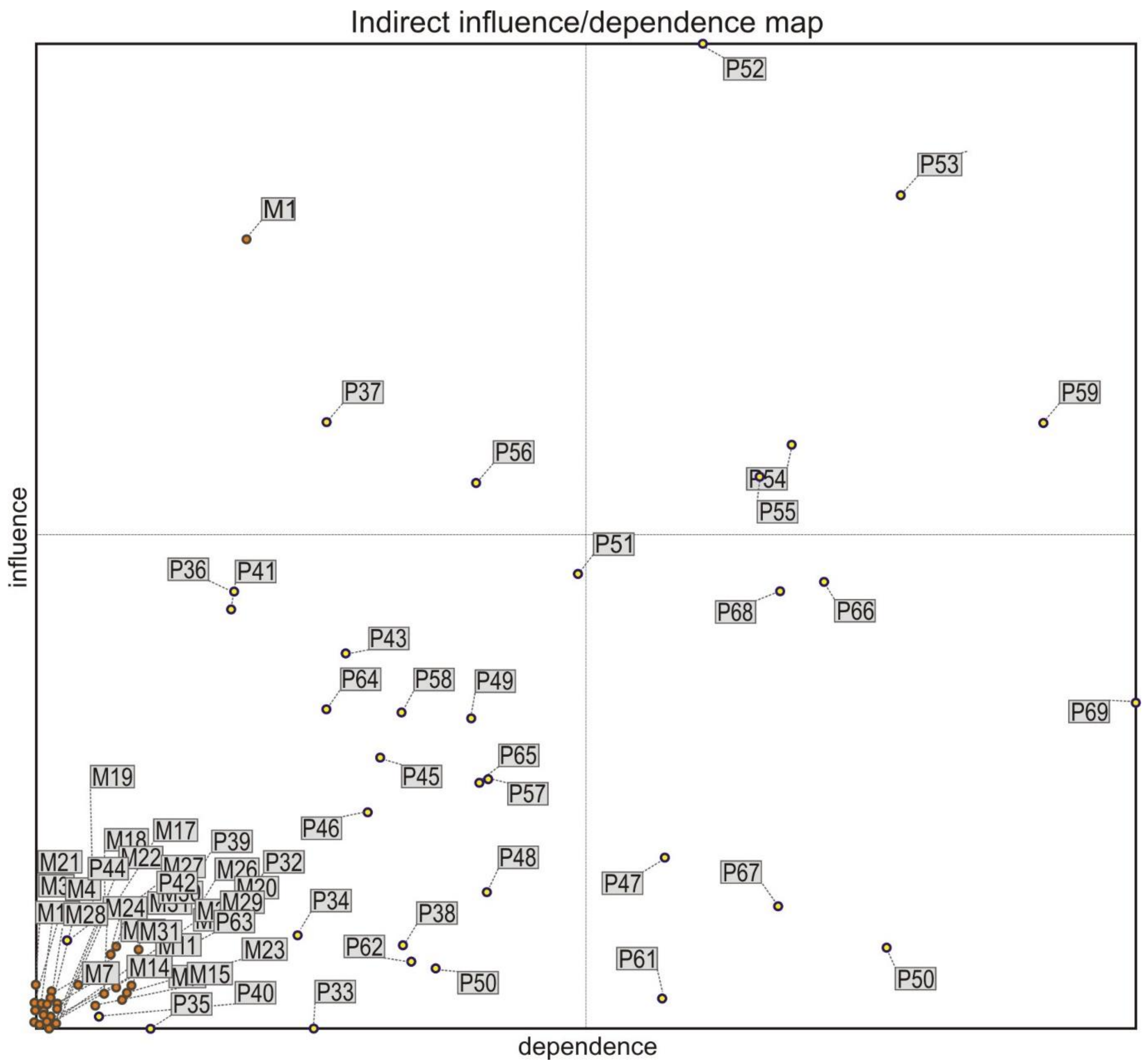


Figure 3-37. Map of indirect influences and dependences (MII) between "Potentials" variables

Table 3-32 provides a summary mapping of the analysed variables to the related factors, shown in Figure 3-37.

Table 3-32. Results of MII analyses for "Potentials" variables with allocation to relevant factor group / quadrant

MII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
52	The character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure

59	Proximity to industries
MII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
37	Water reservoir capacity
56	Access / proximity to water reservoir
MII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
47	Available space for new technologies/projects
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
66	Electro-intensive industries
67	Industries likely to use H2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-38 shows the indirect influence graph for “Potentials” variables.

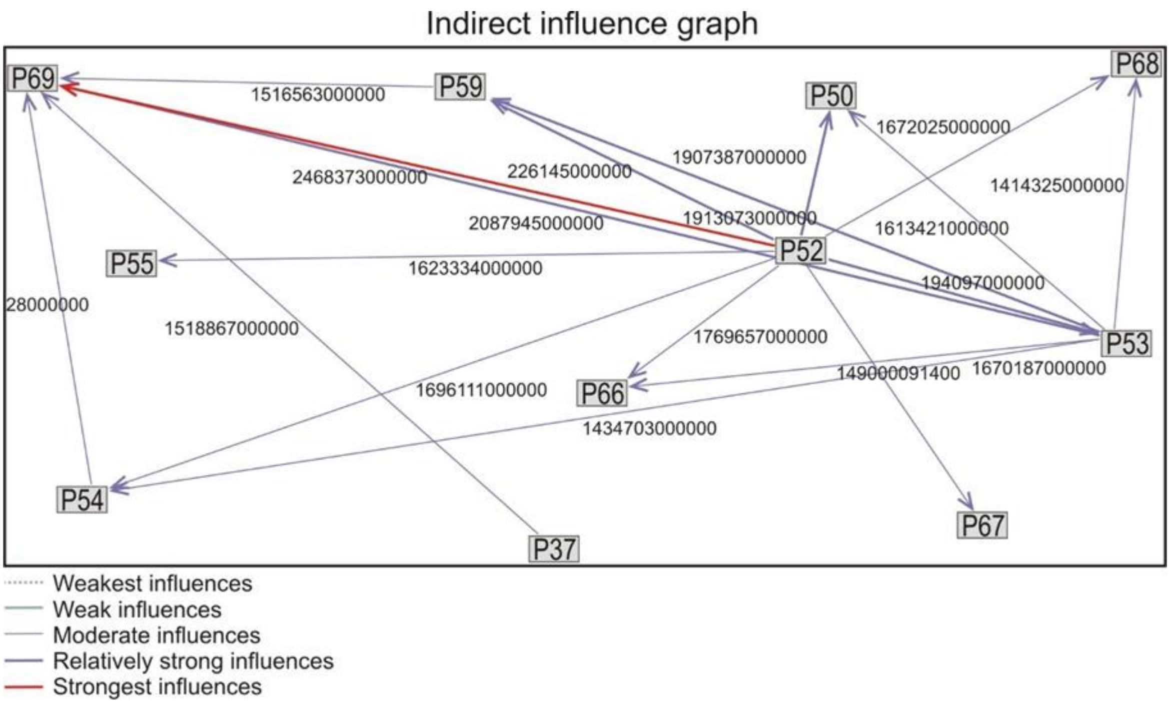


Figure 3-38. Graph of indirect influences (MII) for “Potentials” variables

The strongest indirect influence is between variable **No. 52 Character of the local area** and variable **No. 69 Companies manufacturers of goods and/or suppliers of services.**

3.4.3 Matrix of Potential Direct Influences (MPDI)

The Matrix of Potential Direct Influences (MPDI) results were calculated for 8 iterations. It was assumed that the value assigned by the experts in the Delphi study as "P" (potential impact) for calculation purposes would have a value of "1" (low impact). Matrix MPDI characteristic is shown in Table 3-33 and Matrix MPDI sum is shown in Annex 10.

Table 3-33. Matrix characteristic – MPDI characteristic for “Potentials” variables

INDICATOR	VALUE
Matrix size	69
Number of iterations	8
Number of zeros	4027
Number of ones	379
Number of twos	214
Number of threes	141
Number of P	0
Total	734
Filtrate	15,41693%

Figure 3-39 shows the results of the calculation for MPDI Matrix for “Potentials” variables in the form of a map of potential direct influences and dependencies between analysed variables.

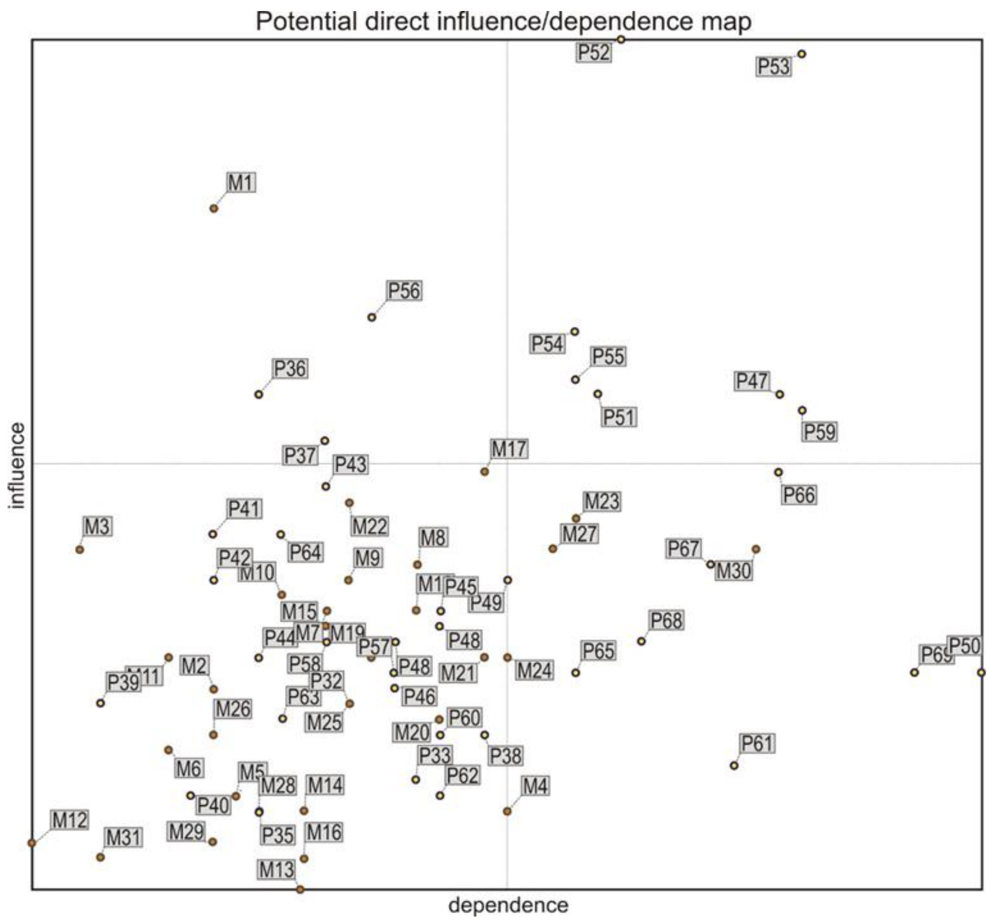


Figure 3-39. Map of potential direct influences and dependences (MPDI) between "Potentials" variables

Table 3-34 provides a summary mapping of the analysed variables to the related factors, shown in the Figure 3-39.

Table 3-34. Results of MPDI analyses for "Potentials" variables with allocation to relevant factor group / quadrant

MPDI: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
47	Available space for new technologies/projects
51	Land use restrictions (power plant)
52	Character of the local area
53	Neighbourhood and proximity to the nearest urban/industry
54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure
59	Proximity to industries

MPDI: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
1	Depth of mine
36	Number of units decommissioned
37	Water reservoir capacity
56	Access / proximity to water reservoir
MPDI: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
23	Geotechnical stability of waste heaps
27	Status of reclamation of the waste heap
30	Land use restrictions (mine)
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
65	Relevant resource for land lease & rental
66	Electro-intensive industries
67	Industries likely to use H2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-40 shows the potential direct influence graph for “Potentials” variables.

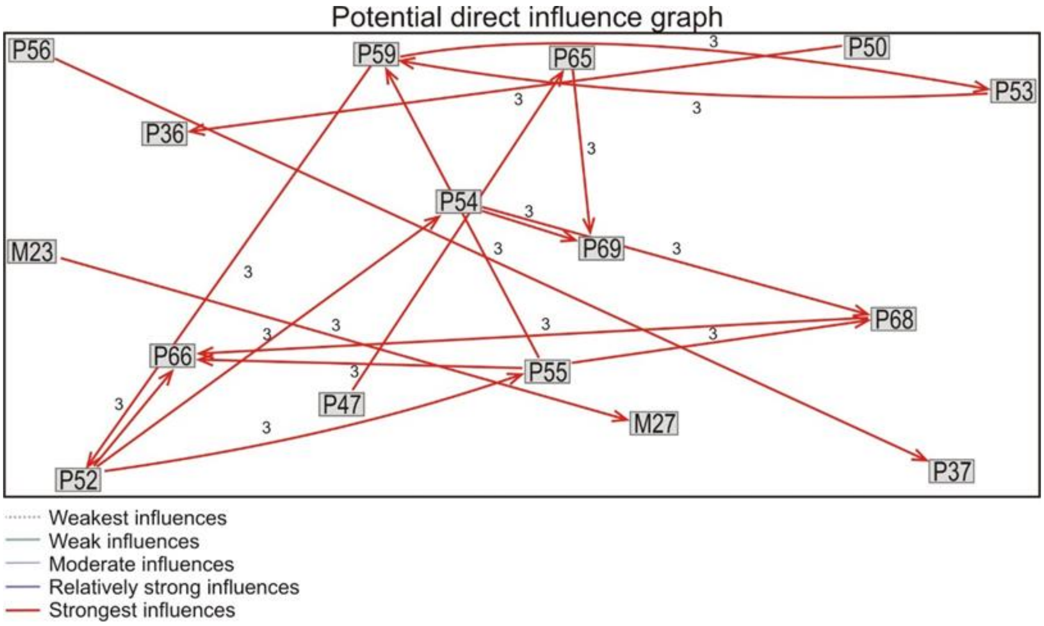


Figure 3-40. Graph of potential direct influences (MPDI) for "Potentials" variables

3.4.4 Matrix of Potential Indirect Influences (MPII)

The results of the analysis of potential indirect influences calculated by MICMAC software– Matrix of Potential Indirect Influences (MPII) for "Potentials" variables. The results were calculated for 8 iterations. Matrix MPII sum is shown in Annex 11.

Figure 3-41 shows the results of the calculation for MPII for "Potentials" variables in the form of a map of potential indirect influences and dependencies between analysed variables.

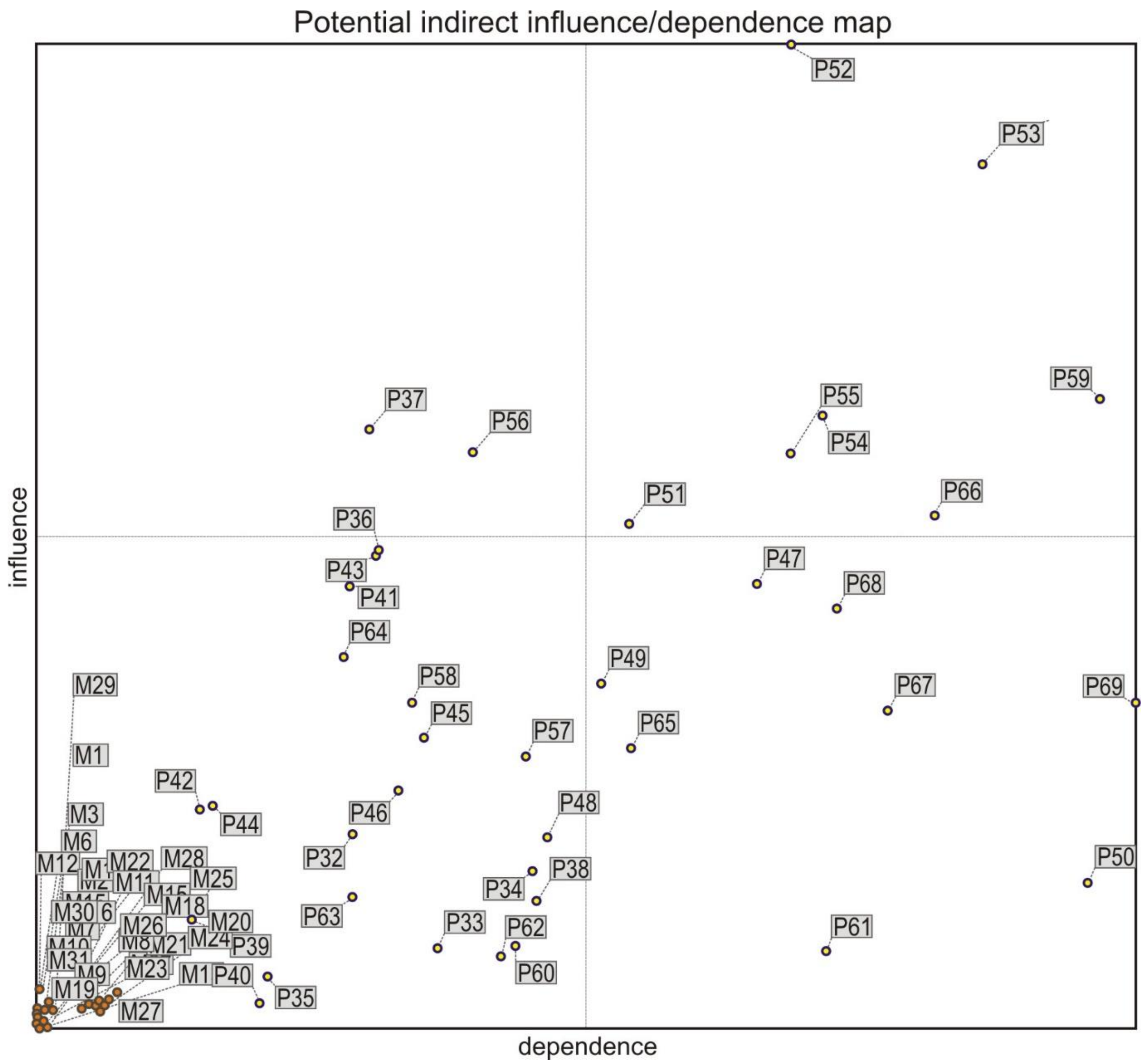


Figure 3-41. Map of potential indirect influences and dependences (MPII) between "Potentials" variables

Table 3-40 provides a summary mapping of the analysed variables to the related factors, shown in Figure 3-41.

Table 3-35. Results of MPII analyses for "Potentials" variables with allocation to relevant factor group / quadrant

MPII: The first quadrant (upper right)—variable factors (KEY FACTORS)	
No.	**Variable**
52	The character of the local area
53	Neighbourhood and proximity to the nearest urban/industry

54	Access / proximity to road infrastructure
55	Access / proximity to railway infrastructure
59	Proximity to industries
66	Electro-intensive industries
MPII: The second quadrant (upper left) – impact factors (DETERMINANT FACTORS)	
No.	**Variable**
37	Water reservoir capacity
56	Access / proximity to water reservoir
MPII: The fourth quadrant (bottom right)— dependent factors (RESULT FACTORS)	
No.	**Variable**
47	Available space for new technologies/projects
49	Availability of concession for power generation
50	Cost of decommissioning and remediation
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
65	Relevant resource for land lease & rental
67	Industries likely to use H2
68	Constant energy consumption industries
69	Companies manufacturers of goods and/or suppliers of services

Figure 3-42 shows the potential indirect influence graph for “Potentials” variables.

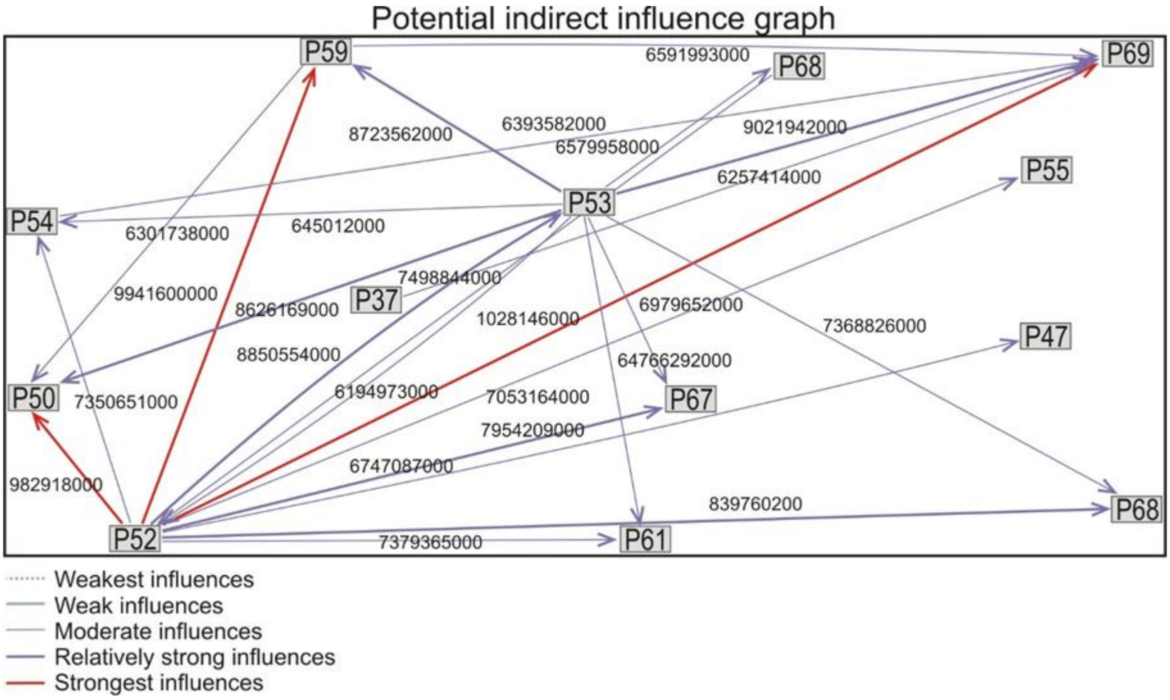


Figure 3-42. Graph of potential indirect influences (MPII) for "Potentials" variables

The strongest indirect influence is between variable **No. 52 Character of the local area** and variable **No. 69 Companies manufacturers of goods and/or suppliers of services,** and between variable **No. 52 Character of the local area** and variable **No. 59 Proximity to industries,** and **between variable No. 52 Character of the local area** and variable **No. 50 Cost of decommissioning and remediation**.

Compared to the previous MPII analysis, variable **No. 24 Fire hazard at the waste heap** moved from key factors towards impact factors, while variable **No. 30 Land use restrictions (mine)** moved from key factors towards dependent factors.

3.4.5 Proportions and list of variables sorted by influence and dependence

Proportions, shown in the Annex 12, allows to have a classification of the variables according to their influence and their decreasing dependence (direct and indirect); these influences and these dependences are normalized (and expressed in "for 10 000-th").

In the Figure 3-43 variables are presented in decreasing order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

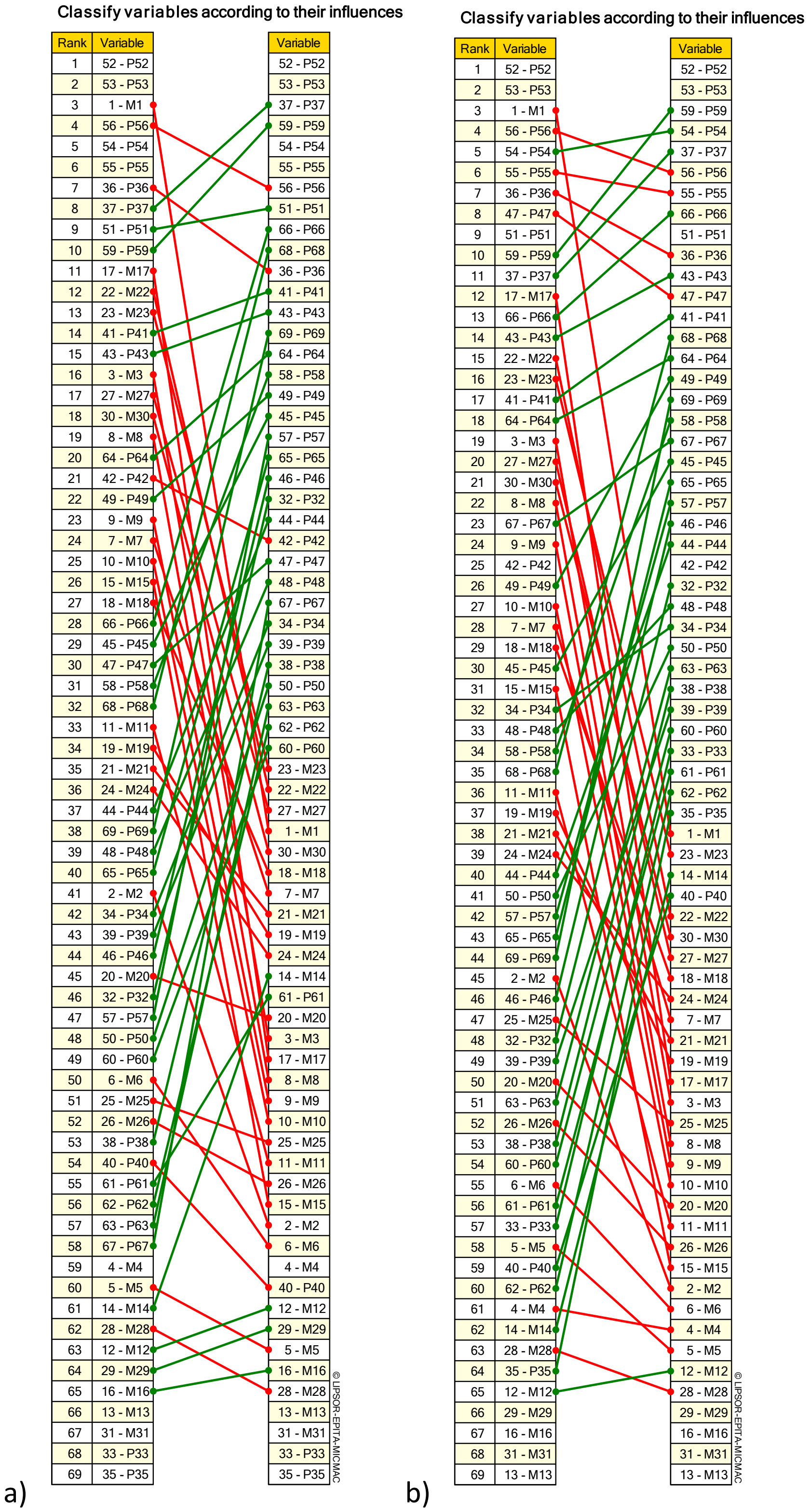


Figure 3-43. Classifying “Potentials” variables according to their influences a)MDI-MII b)MPDI-MPII

In the Figure 3-44, variables are presented in decreasing order: one for the direct classification, the other for the indirect classification. The variables are also localizable by their number. This presentation highlights in a simple way the differences between the four types of classification (MDI Matrix, MII Matrix, MPDI Matrix, and MPII Matrix).

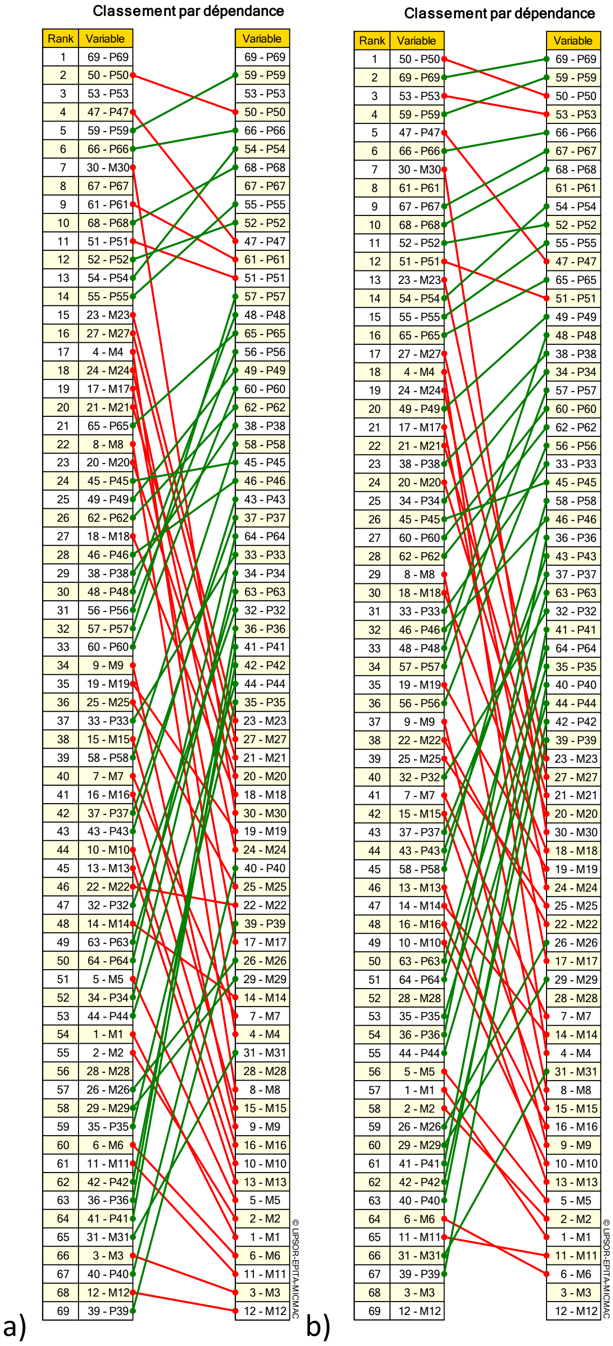


Figure 3-44. Classify "Potentials" variables according to their dependences influences a)MDI-MII b)MPDI-MPII

3.4.6 Summary

A total of 69 criteria from the "Potentials" group were subjected to structural analysis using MICMAC software. The "Potentials" matrix becomes stable starting from iteration 9; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. The 15.4% fill rate reflects the direct influences between system variables, and it is considered a very good rate of filling. The rest 84.6% represents the indirect influences between the variables of this system, of which the rest of the MICMAC method is based. As a result of direct and indirect analyses, 8 variables were defined as key factors.

Structural analyses carried out using the MICMAC software for all variables ("Potentials" variables) allowed for the selection of the following key criteria, i.e. criteria with the highest impact on others and the highest dependence on other variables:

- **47: Available space for new technologies/projects**
- **51: Land use restrictions (power plant)**
- **52: Character of the local area**
- **53: Neighbourhood and proximity to the nearest urban/industry**
- **54: Access / proximity to road infrastructure**
- **55: Access / proximity to railway infrastructure**
- **59: Proximity to industries**
- **66: Electro-intensive industries**

Due to their high dependence and influence, the key factors are extremely important for assessing the stability of the system and evaluating future scenarios built on their basis.

4 CONCLUSIONS AND LESSONS LEARNT

The aim of Task 2.3 was to find the key variables for the system under analysis. The variables considered were analysed into four groups:

- “Power plant” group – section 3.1;
- “Mining surface” group – section 3.2;
- “Mining underground” group – section 3.3;
- “Potentials” group – section 3.4.

A summary of the results of the analyses conducted, using the different MICMAC method – the selected key variables - is presented in Table 4.1.

Thirty eight criteria from the "Power plant" group were subjected to structural analysis using MICMAC software. The “Power plant” matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. As a result of direct and indirect analyses, 9 variables were defined as key factors.

Sixteen criteria from the "Mining surface" group were subjected to structural analysis using MICMAC software. The “Mining surface” matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. As a result of direct and indirect analyses, 8 variables were defined as key factors.

Sixteen criteria from the "Mining underground" group were subjected to structural analysis using MICMAC software. The “Mining underground” matrix becomes stable starting from iteration 3; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. As a result of direct and indirect analyses, 2 variables were defined as key factors.

Sixty nine criteria from the "Potentials" group were subjected to structural analysis using MICMAC software. The “Potentials” matrix becomes stable starting from iteration 9; this means that from this iteration the classification of the variables by influence and by dependence no longer changes because all indirect influence relationships have been detected. As a result of direct and indirect analyses, 8 variables were defined as key factors.

Table 4-1. Summary of key variables analysis

Method of MICMAC analysis	LIST OF KEY VARIABLES			
	"POWER PLANT"	"MINING SURFACE"	"MINING UNDERGROUND"	"POTENTIALS"
	Section 3.1	Section 3.2	Section 3.3	Section 3.4
Matrix of Direct Influences (MDI)	51: Land use restrictions (power plants)	18: Area of the waste heap	8: Volume of pumped water	51: Land use restrictions (power plants)
	52:Character of the local area	19: Height of the waste heap	17: Flooding status of the mine	52:Character of the local area
	53. Neighbourhood and proximity to the nearest urban/industry	21: Geometry of the waste heap		53. Neighbourhood and proximity to the nearest urban/industry
	54:Access / proximity to road infrastructure	23:Geotechnical stability of waste heaps		54:Access / proximity to road infrastructure
	55: Access / proximity to railway infrastructure	24: Fire hazard at the waste heap		55: Access / proximity to railway infrastructure
		27: Status of reclamation of the waste heap		
		30: Land use restrictions (mine)		
Matrix of Indirect Influences (MII)	51: Land use restrictions (power plants)	18: Area of the waste heap	8: Volume of pumped water	52:Character of the local area
	53. Neighbourhood and proximity to the nearest urban/industry	19: Height of the waste heap	17: Flooding status of the mine	53. Neighbourhood and proximity to the nearest urban/industry
	54:Access / proximity to road infrastructure	20: Angle of slopes of the waste heap		54:Access / proximity to road infrastructure
	55: Access / proximity to railway infrastructure	21: Geometry of the waste heap		55: Access / proximity to railway infrastructure
	59:Proximity to industries	23:Geotechnical stability of waste heaps		59: Proximity to industries
		24: Fire hazard at the waste heap		
		27: Status of reclamation of the waste heap		
		30: Land use restrictions (mine)		
Matrix of Potential Direct Influences (MPDI)	47: Available space for new technologies/projects	18: Area of the waste heap		47: Available space for new technologies/projects
	51: Land use restrictions (power plants)	19: Height of the waste heap		51: Land use restrictions (power plants)
	52:Character of the local area	21: Geometry of the waste heap		52:Character of the local area
	53. Neighbourhood and proximity to the nearest urban/industry	23:Geotechnical stability of waste heaps		53. Neighbourhood and proximity to the nearest urban/industry
	54:Access / proximity to road infrastructure	24: Fire hazard at the waste heap		54:Access / proximity to road infrastructure
	55: Access / proximity to railway infrastructure	27: Status of reclamation of the waste heap		55: Access / proximity to railway infrastructure
	59:Proximity to industries	30: Land use restrictions (mine)		59:Proximity to industries
Matrix of Potential Indirect Influences (MPII)	52:Character of the local area	18: Area of the waste heap		52:Character of the local area
	53. Neighbourhood and proximity to the nearest urban/industry	19: Height of the waste heap		53. Neighbourhood and proximity to the nearest urban/industry
	54:Access / proximity to road infrastructure	20: Angle of slopes of the waste heap		54:Access / proximity to road infrastructure
	55: Access / proximity to railway infrastructure	21: Geometry of the waste heap		55: Access / proximity to railway infrastructure
	59:Proximity to industries	23:Geotechnical stability of waste heaps		59:Proximity to industries
	66: Electro-intensive industries	24: Fire hazard at the waste heap		66: Electro-intensive industries
		27: Status of reclamation of the waste heap		
		30: Land use restrictions (mine)		

Table 4-2 summarises the results showing the strongest influences between the variables analysed in the four groups. The direction of influence plays a significant role in the analysis. Results on the strongest influences between variables were obtained from indirect and indirect potential structural analysis of the variables performed with MICMAC software and presented in the report as graphs.

According to the indirect influences (MII) for “Power plant” variables, the strongest indirect influence is between variable No. 52 Character of the local area and variable No. 69 Companies manufacturers of goods and/or services suppliers.

According to the indirect influences (MII) for “Mining surface” variables, the strongest indirect influence is between variable No. 23 Geotechnical stability of waste heaps and variable No. 27 Status of reclamation of the waste heap, and between variable No. 23 Geotechnical stability of waste heaps and variable No. 21 Geometry of the waste heap.

According to the indirect influences (MII) for “Mining underground” variables, the strongest indirect influence is between variable No. 1 Depth of the mine and variable No. 4 Methane surface emissions (AMM). Relative strong influences are between variable No. 1 Depth of the mine and variable No. 13 Shaft technical condition and No. 17 Flooding status of the mine.

Finally, and according to the indirect influences (MII) for “Potentials” variables, the strongest indirect influence is between variable No. 52 Character of the local area and variable No. 69 Companies manufacturers of goods and/or suppliers of services.

Table 4-2. Summary of the strongest influences between variables

<table>
<tr><th rowspan="3">Method of MICMAC analysis</th><th colspan="4">The strongest influences between variables</th></tr>
<tr><th>"POWER PLANT"</th><th>"MINING SURFACE"</th><th>"MINING UNDERGROUND"</th><th>"POTENTIALS"</th></tr>
<tr><th>Section 3.1</th><th>Section 3.2</th><th>Section 3.3</th><th>Section 3.4</th></tr>
<tr><td rowspan="2">Matrix of Indirect Influences (MII)</td><td rowspan="2">Between variable No. 52 (Character of the local area) and variable No. 69 (Companies manufacturers of goods and/or suppliers of services)</td><td>Between variable No. 23 (Geotechnical stability of waste heaps) and variable No. 27 (Status of reclamation of the waste heap and variable)</td><td rowspan="2">Between variable No. 1 (Depth of the mine) and variable No. 4 (Methane surface emissions AMM)</td><td rowspan="2">Between variable No. 52 (Character of the local area) and variable No. 69 (Companies manufacturers of goods and/or suppliers of services)</td></tr>
<tr><td>Between variable No. 23 (Geotechnical stability of waste heaps) and variable No. 21 (Geometry of the waste heap)</td></tr>
<tr><td rowspan="4">Matrix of Potential Indirect Influences (MPII)</td><td rowspan="2">Between variable No. 52 (Character of the local area) and variable No. 69 (Companies manufacturers of goods and/or suppliers of services)</td><td>Between variable No. 23 (Geotechnical stability of waste heaps) and variable No. 27 (Status of reclamation of the waste heap and variable)</td><td rowspan="4">No analysis has been done</td><td>Between variable No. 52 (Character of the local area) and variable No. 69 (Companies manufacturers of goods and/or suppliers of services)</td></tr>
<tr><td rowspan="2">Between variable No. 23 (Geotechnical stability of waste heaps) and variable No. 21 (Geometry of the waste heap)</td><td rowspan="2">Between variable No. 52 (Character of the local area) and variable No. 59 (Proximity to industries)</td></tr>
<tr><td rowspan="2">Between variable No. 52 (Character of the local area) and variable No. 59 (Proximity to industries)</td></tr>
<tr><td>Between variable No. 23 (Geotechnical stability of waste heaps) and variable No. 22 (Material type deposited on the waste heap)</td><td>Between variable No. 52 (Character of the local area) and variable No. 50 (Cost of decommissioning and remediation)</td></tr>
</table>

Due to the similarity of some of the analysed variables related to mines (variables No. 19, 20 and 21) and power plants (variables No. 52, 53 and 54 as well as variables No. 54 and 55), it was proposed, for future purposes, to combine them - as shown in Table 4-3. The new variables are shown in blue.

Table 4-3. Grouping of variables with related meanings and characteristics

No.	Variable	New variable	Short definition
1	52: Character of the local area	**52bis: Character of local area/proximity to industry**	The variable refers to the characteristics of the surrounding areas (urban/industry) and the distance of the coal mine/power plant to it.
	53. Neighbourhood and proximity to the nearest urban/industry		
	59: Proximity to industries		
2	54: Access / proximity to road infrastructure	**54bis: Acces/proximity to transport infrastructure**	The road/railway infrastructure refers to all types of roads/rail linesand includes all structures such as tunnels, Bridges, buildings, and equipent to suport rail lines that reduce the travel time and provide a safer transportation system. The access to road infrastructure is highly important for the transport of employees, goods and services at all operation stages.
	55: Access / proximity to railway infrastructure		
3	19: Height of the waste heap	**21bis: Geometry of the waste heaps**	The variable describes the geometrical shape of the heap (cone, truncated cone, trapezoid, irregular, etc.) and its dimensions.
	20: Angle of slopes of the waste heap		
	21: Geometry of the waste heap		

Taking all the previous steps in consideration, Table 4-4 summarizes the variables assigned to three groups of factors: key variables, impact or determinant variables, and result variables. These variables (factors) should be given special attention when developing scenarios under WP 3.

In the Figure 2-1 (see below) the distribution of the variables is shown in terms of mutual influences and dependencies and the map of their distribution is divided, according to the Cartesian system, into four quadrants/squares. Key variables are situated in the first quadrant (shown on Figure 2-1 - upper right quadrant) and are characterized by both the highest degree of dependence and the highest influence on others. They are by nature, unstable and correspond to the challenges of the system. Determinant or impact variables are situated in the second quadrant (shown on Figure 2-1 - upper left quadrant) and characterized by high impact and a limited dependence or relationship. Depending on their evolution, they can become brakes or drivers of the system. Finally, result variables are situated in the fourth quadrant (shown on Figure 2-1 - bottom right quadrant). They have a low influence on the others but high dependence. They are often, together with the target variables, descriptive indicators of the system's evolution. As in the previous Table, the new variables are shown in blue.

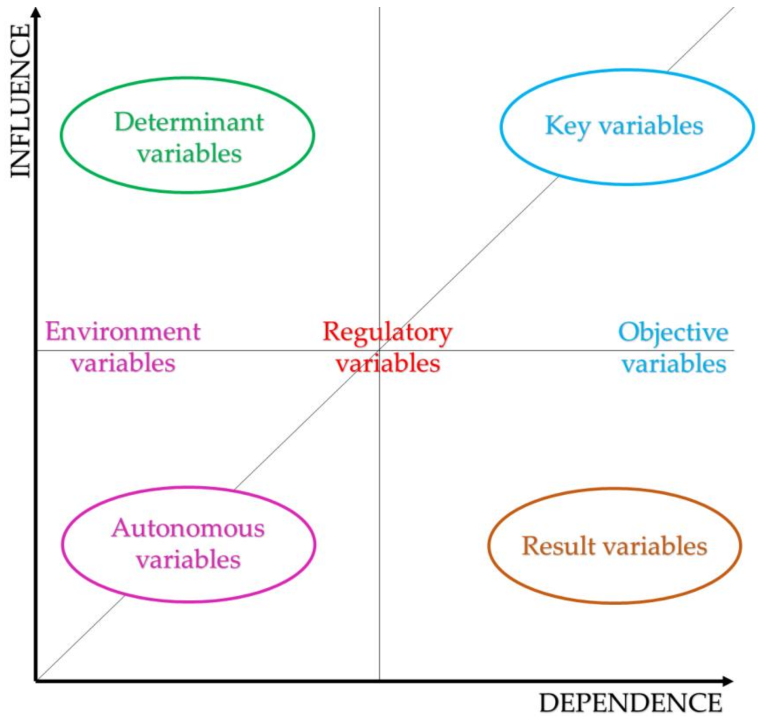


Figure 2-1. Map of direct influences and dependences between variables (factors) – the figure copied from page 14 of this report

Table 4-4. Relevant variables for scenarios development

MICMAC ANALYSIS VARIABLES	VARIABLES			
	"POWER PLANT"	"MINING SURFACE"	"MINING UNDERGROUND"	"POTENTIALS"
KEY VARIABLES (strong influence & strong dependence of variables)	47: Available space for new technologies/projects	18: Area of the waste heap	8: Volume of pumped water	47: Available space for new technologies/projects
	51: Land use restrictions (power plants)	19: Height of the waste heap	17: Flooding status of the mine	51: Land use restrictions (power plants)
	52bis: Character of local area/proximity to industry	**21bis: Geometry of waste heaps**		**52bis: Character of local area/proximity to industry**
	54bis: Access / proximity to transport infrastructure	24: Fire hazard at the waste heap		**54bis: Access / proximity to transport infrastructure**
	66: Electro-intensive industries	27: Status of reclamation of the waste heap		66: Electro-intensive industries
	68: Constant energy consumption industries	30: Land use restrictions (mine)		
DETERMINANT VARIABLES (strong influence & low dependence of variables)	36: Number of units decommissioned	22: Material type deposited on the waste heap	1: Depth of mine	1: Depth of mine
	37: Water reservoir capacity		3: Geological singularities of the mine	36: Number of units decommissioned
	56: Access / proximity to water reservoir		11: Depth of the shafts	37: Water reservoir capacity
				56: Access / proximity to water reservoir
RESULT VARIABLES (low influence & strong dependence of variables)	49: Availability to concession for power generation	25: Gas hazard at the waste heap	4: Methane surface emissions (AMM)	4: Methane surface emissions (AMM)
	50: Cost of decommissioning and remediation		9: Pumped water chemistry/quality	**21bis: Geometry of waste heaps**
	61: Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned		10: Hazardous substances in the pumped mine water	23:Geotechnical stability of waste heaps
	65: Relevant resources for land lease & rental		13: Shaft technical condition	24: Fire hazard at the waste heap
	67: Industries likely to use H_2		14: Function/status of shaft (liquidated, pumping station,	27: Status of reclamation of the waste heap
	69:Companies manufacturers of goods and/or suppliers of services		15: Water inflow	30: Land use restrictions (mine)
			16: Pumped water temperature	49: Availability of concession for power generation
				50: Cost of decommissioning and remediation
				61: Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned
				65: Relevant resource for land lease & rental
				67: Industries likely to use H_2
				68: Constant energy consumption industries
				69:Companies manufacturers of goods and/or suppliers of services

In total, 6 variables from "Power plant", 6 variables from "Mining surface" and 2 variables from "Mining underground" were classified as key factors. The structural analyses performed for all the variables ("Potentials" variables - synergy of mining and power plant) made it possible to identify 5 key variables.

Two were the main lessons learnt within this task. In the first place, the main problem when performing structural analyses was the wide variety and range of variables. The number and diversity of variables on the one hand accounted for the high content value of the matrix, and on the other hand posed a challenge for the appropriate selection of parameters for the analyses.

The structural analysis performed for all variables clearly indicated that the key variables for the whole system are only those from the "Power plant" group. This was mainly due to the fact that the variables in the "Mining" group referred to both the underground and surface parts of the mine, which meant that most of them did not show any influence/dependence on the others. In contrast, there was a greater number of influences/dependencies between the variables in the “Power plant” group, which consequently caused the variables in this group to 'dominate' the results of the analyses.

Therefore, it was decided, in addition to the system-wide analysis, to conduct analyses for three groups of variables: "Power plant", "Surface mining" and "Underground mining" separately. The results obtained from these analyses allowed the identification of key variables in the above areas, which would not have been possible with a holistic analysis.

In the second place, it was observed that in three cases variables with similar characteristics occupied places close to each other in the system, which allowed them to be combined into one variable without any negative impact on the system.

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Annex 1: "Power plant" variables

N°	Long label	Short label	Description
1	Power plant connection capacity to the grid	P32	This variable refers to the connection capacity of the power plant [MW] and voltage [kV] to the grid. A substation is a vital part of electricity generation, transmission, and distribution. It transforms voltage from high to low or vice versa, or execute other roles. It can be used for the new green power plant to reduce costs.
2	Electricity production efficiency of power plant	P33	The efficiency [%] of energy conversion from primary heat potential to actual power plant output.
3	Power plant concession expiry date	P34	This variable refers to the power plant concession expiry date (before 2030/after 2030).
4	Expected technical lifetime	P35	This variable refers to the technical lifetime of the power plant, giving a clear indication of the expected lifetime of all the auxiliary equipment that are part of it.
5	Number of units decommissioned	P36	This variable refers to the number of units, their type and the power generated by each unit, that are being decommissioned in order to be able to know the dimensions and capacity of the power plant.
6	Water reservoir capacity	P37	This variable refers to the proximity of the power plant to reservoirs or water courses, as well as the reservoir capacity and/or the flow rate in the water course [m3/h].
7	Repowering: possibility of adapting the boiler for biomass	P38	This variable refers to the existence of infrastructure, external and internal, that may facilitate the adaptation of the power plant to biomass.
8	Feasibility of reusing air cleaning installation for repowering	P39	This variable refers to the feasibility of reusing the air cleaning installation for repurposing the power plant. This includes: desulphurization, NOx reduction, dust reduction and ash removal.
9	CO2 capture installation	P40	As the price of CO2 allowances is increasing dramatically, the existence of CO2 capture installation might be beneficial for alternative developments of the future reuse of power plants.
10	District heating connection	P41	This variable refers to the existence of a system for distributing heat generated as steam by the power plant.
11	Cooling water installation type	P42	This variable refers to the specific type of the cooling water installation, as well as the cooling water requirements of the power plant [m3/h].
12	Wastewater treatment plant	P43	This variable refers to the control and treatment technologies of wastewater discharges in the power plant and their capacity in [m3/h].
13	Fly ash characterisation	P44	This variable refers to the specific characteristics of the fly ash composition, which is the residue from the combustion of coal. Its chemical characterization is very important, as it can be toxic when leaching due to the amount of trace elements it contains.
14	Power plant landfill area. Hazardous/non-hazardous.	P45	Landfills are areas where waste coal power plants is disposed; an easy and cost efficient waste management option, yet with high environmental risks.
15	Coal ash waste landfill area availability	P46	This variable refers to the area [m2] of coal ash waste landfill area that are generated at the power plant.
16	Available space for new technologies/projects	P47	This variable refers to the accessible space for new technologies installation (apart from waste disposal areas). The space consists of all the area [ha] provided from the surroundings of coal mines and power plants.
17	Obligations of thermal energy supply after the decommissioning	P48	Thermal energy supply (District Heating) is the pipe distribution of heating and domestic hot water (DHW), to heat the buildings of a city by a central heating system. If there are legal obligations to provide thermal energy [MW] after coal power plant decommission, a plan will be needed to ensure that the city's thermal needs are covered without extra cost for the residents or environmental negative impacts.
18	Availability of concession for power generation	P49	This variable refers to the amount of time [years] during which the power plant will still have the concession for power generation.
19	Cost of decommissioning and remediation	P50	Decommissioning and remediation costs include all the expenses that may arise from utility separation, asbestos and hazardous material abatement, structural demolition, salvage and scrap recovery and land restoration of the site to a safe, environmentally sound condition. Where the installation has caused significant contamination of soil or groundwater by relevant hazardous substances compared to the prior land state, the operator must take the necessary measures to address this contamination and return
20	Land use restrictions (power plant)	P51	This variable refers to the existing legal restrictions of using the land after mine closure and decommission of power plant. Legal framework determines the criteria of land utilisation and its future use.
21	Character of the local area	P52	The variable refers to the characteristics of the surrounding areas: urban, suburban, villages, agricultural, industrial, post-industrial, etc.

N°	Long label	Short label	Description
22	Neighbourhood and proximity to the nearest urban/industry	P53	The variable refers to the distance of the coal mine/power plant to the nearest urban/industrial area.
23	Access / proximity to road infrastructure	P54	The road infrastructure refers to all types of roads in a given area [4] and includes structures such as tunnels and bridges that reduce the travel time and provide a safer transportation system. The access to road infrastructure is highly important for the transport of employees, goods and services at all operation stages.
24	Access / proximity to railway infrastructure	P55	A railway infrastructure includes all the structures, buildings, land, and equipment to support rail lines. The access to rail infrastructure is highly important for the transport of employees, goods and services at all operation stages.
25	Access / proximity to water reservoir	P56	Water reservoirs are natural or artificial storage areas where water is collected and stored. Natural water reservoirs include rivers, lakes, aquifers and the sea. The availability of water reservoir is important for the power sector as it depends on it for cooling and other services during operation of the plant.
26	Access / proximity to the river (for transport)	P57	The proximity to a river provides a financially efficient means of transportation from and towards the mine and power plant. It may be used for transportation of fuel, equipment, for product export, at a lower cost than transportation via road.
27	Access / proximity to gas pipeline network connections	P58	Gas pipeline network is a complex system that transports gas from an industrial area to a market area for consumption. A gas transmission network can consist of thousands of kilometres of pipelines with several entry points in different countries. It is considered an essential asset for a power plant using natural gas or producing hydrogen.
28	Proximity to industries	P59	This variable refers to the existence of industries in the proximity of the power plant and the coal mine, their amount and the number or workers.
29	Water treatment plant	P60	This variable refers to the treatment technologies used to prepare the raw water from a river or lake which is used for cooling processes or to prepare demineralised water for power boilers, and its capacity in [m3/h].
30	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	P61	This variable indicates any obligations arising from concessions, contracts and others that may condition the future repurposing of the power plant.
31	Power Plant employment (number of employees)	P62	This variable refers to the number of employees still working at the power plant.
32	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	P63	Screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs) refer to the management options of companies to reduce their number of employees without firing someone.
33	Temporary storage areas	P64	This variable refers to the existence of temporary storage areas and their total surface available [m2].
34	Relevant resource for land lease & rental	P65	This variable refers to the existence of land use & rental resources, and the total surface available [m2].
35	Electro-intensive industries	P66	The variable refers to the existence of electro-intensive industries in the proximity of the coal mine/coal power plant, with a need for stable constant power supply such as the aluminium industry.
36	Industries likely to use H2	P67	The variable refers to the existence of industries in the proximity of the coal mine/power plant likely to use H2 as an energy input, to reduce greenhouse gas emissions.
37	Constant energy consumption industries	P68	The variable refers to the existence of industries with constant energy consumption such as green data centres or aluminium industry.
38	Companies manufacturers of goods and/or suppliers of services	P69	The variable refers to the existence of companies manufacturers of goods and/or suppliers of services, providing possible opportunities to develop alternative business models together with coal mines/coal power plants.

Annex 2: Matrix of Indirect Influences (MII) for “Power plant” variables

	1 : P32	2 : P33	3 : P34	4 : P35	5 : P36	6 : P37	7 : P38	8 : P39	9 : P40	10 : P41	11 : P42	12 : P43	13 : P44	14 : P45	15 : P46	16 : P47	17 : P48	18 : P49	19 : P50	20 : P51	21 : P52	22 : P53	23 : P54	24 : P55	25 : P56	26 : P57	27 : P58	28 : P59	29 : P60	30 : P61	31 : P62	32 : P63	33 : P64	34 : P65	35 : P66	36 : P67	37 : P68	38 : P69
1 : P32	27067	34910	32144	14699	24885	36316	44585	4090	8104	24086	14952	39127	14490	43207	41829	77946	55481	54508	105431	66845	82019	106678	93179	89445	54743	56198	45106	124891	50445	77127	46816	31413	36194	54656	97760	92237	91153	135750
2 : P33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3 : P34	12348	15950	15330	6405	11943	16225	20426	1908	3790	11255	6297	17558	7151	20418	20480	36525	26081	25629	50897	30932	37780	48665	42731	41258	24777	25452	20923	56753	22906	36433	23028	16261	17401	25912	44495	41952	41496	62496
4 : P35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 : P36	56992	73410	70584	30235	53737	77023	98176	8703	17259	52079	30278	81996	31399	92464	89358	169059	120996	116785	228302	144642	177670	230745	201410	193012	116922	120048	97891	268270	106117	168716	102399	68931	78596	119133	210740	198550	198373	292867
6 : P37	80283	103568	96316	43542	71977	108918	136462	11931	23929	72177	44367	116060	42159	127320	121707	231996	166701	160145	311980	200955	246989	321179	279559	267144	164023	167973	136002	373358	149205	230576	136774	90488	107109	163902	292162	275733	276212	407404
7 : P38	10745	13927	13683	5718	10742	14184	17742	1677	3411	9758	5451	15151	6645	18056	18392	32826	23072	22732	45719	27327	33194	43175	37724	36470	21647	22208	18563	50174	19876	32464	20893	14794	15553	22846	39374	36952	36245	54967
8 : P39	11346	15111	15250	6707	12178	15384	19285	1634	3618	10200	6082	16048	7320	19601	20012	36211	24455	24058	49369	29572	35612	46209	39961	38920	23294	23467	19654	53392	20994	36018	22788	15382	16312	24933	42104	40131	38785	58999
9 : P40	1429	1919	2146	906	1852	1879	2497	214	473	1271	731	1955	995	2565	2697	4828	2934	2991	6556	3820	4547	5735	5059	4947	2812	2875	2448	6538	2538	4940	3399	2196	1976	3349	5164	4978	4823	7659
10 : P41	55158	70892	66939	29428	51071	74343	93108	8510	16810	50010	29535	79256	29919	89325	86072	161331	116107	113013	218943	138049	169889	221215	192965	185212	112737	115593	93799	257983	103047	160355	96562	65499	75417	113521	202473	190443	189535	280835
11 : P42	24593	32096	30656	13428	23247	33445	42275	3662	7501	22357	13408	35482	13828	39784	38980	72959	51530	49776	99519	62498	76511	98836	86304	82880	50196	51376	41955	114641	45534	72569	44677	29811	33509	51814	89666	85365	84932	126131
12 : P43	49369	63633	59713	26736	45387	66922	84023	7439	14833	44580	27170	71333	26316	79202	75904	144214	103218	99869	193859	124002	152485	198484	172965	165514	101165	103665	83883	231046	92048	143379	85365	57018	66525	101394	181237	170819	170424	251843
13 : P44	25893	33727	32825	13919	25400	34606	44517	3849	7707	23716	13691	37148	14064	42237	41082	76621	54082	52500	104067	65454	80356	103066	90644	87058	52548	53857	43769	119969	47884	77524	47034	31249	34942	54604	93727	89273	89352	132938
14 : P45	35706	46285	44468	19156	33632	47834	60645	5267	10711	32190	19417	51186	19734	57380	56410	105360	74301	71508	143071	90486	110316	142799	125072	119623	71973	74104	60836	165375	65551	105413	64061	42727	48138	74189	129104	122186	122110	181866
15 : P46	28132	36440	35323	15551	27014	38182	48456	4241	8607	25467	15237	40390	15635	45763	44254	83955	59282	57100	113182	71820	87609	114099	99310	95077	57635	59100	48488	131919	52108	83762	51080	34094	38483	58831	103421	97764	97582	144614
16 : P47	22172	28775	27323	11627	20527	29840	38198	3357	6678	20480	11897	32024	12208	36027	34972	65703	47236	45645	89373	56092	69805	89973	78812	75472	45951	46951	38042	105227	41424	65670	39249	26667	30598	46561	82053	77325	77795	115123
17 : P48	17612	23017	22704	9759	17648	23660	30405	2682	5412	16135	9292	25140	10022	29414	28699	53523	37354	36361	72766	45172	55378	71483	62441	60026	36244	37006	30401	82776	32686	53723	33097	22491	24477	37611	64764	61391	61393	91745
18 : P49	40364	52173	50362	21970	38070	54958	70108	6055	12219	36596	21958	58227	22145	65047	62677	120064	85162	81610	160992	103085	126250	163924	142839	136609	82829	85029	69484	189812	74826	119953	72768	48046	54973	84355	149089	140786	140718	207420
19 : P50	10539	13977	13960	5569	11010	13731	18178	1553	3102	9919	5257	14938	5883	17867	17796	31993	22242	21597	44141	27043	33350	42048	37381	35955	21360	21858	18121	48898	19310	32867	20774	14289	14761	22948	37882	36261	36476	54969
20 : P51	59362	76678	72818	31691	55103	80434	101567	9062	18043	54148	31728	85678	32759	96236	92909	175372	126229	122071	237534	149929	184654	240079	209095	200688	122434	125227	101688	279940	111097	174180	105451	71204	82178	123582	219829	207036	206185	304164
21 : P52	130035	168060	158116	68921	119053	175494	222430	19314	38579	118155	70979	188238	69394	206882	199212	377512	271479	261310	509784	326205	402032	519702	454910	435117	265472	272447	219830	606156	241479	377520	225036	149156	174193	268146	473690	448132	449366	662639
22 : P53	110071	142971	134684	58482	101539	148264	187974	16228	32589	100058	60010	159303	59218	175418	169921	320127	229241	220918	433823	276153	340680	438574	384610	368294	224271	229895	185530	512037	204012	320710	192670	127236	147272	227981	399508	378873	379384	560982
23 : P54	76660	98462	91816	40126	69120	103576	130141	11684	23049	69798	41403	110870	41331	122848	118199	223150	162011	156775	301685	191662	237289	308179	269060	257815	157515	161399	130208	360579	143527	221557	131986	89224	104678	157426	282618	265499	265313	391040
24 : P55	72616	93402	87027	38457	65697	98209	123195	11036	21856	65914	39481	104979	38993	116182	111616	210975	152639	147881	285110	181287	224258	291205	254161	243550	148953	152557	122969	340432	135770	209513	124743	83785	98354	149034	266770	250990	250761	370131
25 : P56	72701	93688	86466	38338	65133	98112	122532	10826	21464	65454	40062	105464	38253	114463	110368	208200	149759	145229	281568	180115	222374	287149	251715	241223	147127	151177	121088	336233	135137	207192	123521	81515	96047	148111	262841	248861	248105	366513
26 : P57	32749	42245	39205	17860	29286	44553	55556	4959	9947	29523	18054	47345	17522	52585	50335	95437	68871	66387	128763	82208	101133	132071	114498	109582	67587	68979	55980	153513	61288	94271	56162	37840	44617	67103	120556	113243	113029	166822
27 : P58	41439	53268	50018	21352	37141	55843	71378	6240	12183	38039	22364	60012	21637	65800	62730	119816	87272	83607	161553	103951	129076	166935	146480	139763	85105	87447	70414	195190	77181	120086	70303	46609	55632	85194	152244	143387	144785	212457
28 : P59	79296	102315	97592	42818	73017	107643	137053	11893	23832	71937	43345	114345	42471	127112	121457	232963	166769	159517	312939	201199	246743	321175	279793	266982	162844	167150	136111	372017	147072	232455	138072	91768	106939	164073	291236	274761	276503	407028
29 : P60	7875	10168	9957	4248	7619	10575	13753	1204	2398	7203	4214	11247	4417	12877	12450	23689	16649	16119	31970	20086	24809	31989	28027	26829	16162	16568	13479	37109	14567	23717	14182	9544	10629	16746	29038	27356	27679	41252
30 : P61	3707	4852	5351	2206	4355	4964	6295	592	1322	3249	1899	5082	2871	6592	7198	12783	8100	8096	17663	10063	11931	15473	13478	13151	7351	7573	6656	17622	6638	12524	8867	6142	5600	8544	14049	13085	12441	19605
31 : P62	8671	11214	10658	4831	8014	11847	14541	1317	2718	7706	4794	12431	5095	14193	14060	26152	18333	17745	35591	22173	26965	35376	30642	29446	17722	18121	15008	40929	16079	25541	15813	10843	12100	17986	32115	30142	29587	44224
32 : P63	9860	12751	12090	5444	9360	13320	16814	1515	2973	8935	5295	14195	5256	16080	15279	28795	20517	20034	38910	24727	30304	39387	34268	32908	20266	20704	16673	45770	18459	28765	17311	11522	13325	20404	35898	34016	34058	50476
33 : P64	41731	53665	51500	21795	38460	56316	72797	6288	12381	38291	22449	60228	22067	66747	63790	122499	88095	84246	164511	105751	130765	168892	148105	141325	85614	88068	71375	196511	77421	123097	72732	48136	56131	86971	153820	144995	146430	215221
34 : P65	32269	41274	39097	16876	29197	43715	55838	4923	9644	29407	17405	46618	17083	51293	48705	93973	68106	65281	126002	81222	100248	130358	113924	108749	66184	68116	54998	151805	60086	93618	55202	36694	43377	66456	119063	111949	112783	165349
35 : P66	58741	75660	71366	31449	53524	79569	100464	8865	17634	53248	32006	84799	31352	93918	89761	171148	123296	118502	230549	147831	181729	236718	206370	197187	120474	123640	100213	275285	109288	170425	101220	67419	79265	120589	215319	202983	203691	299899
36 : P67	16110	20690	19349	8214	14632	21580	27370	2471	4788	14826	8539	23292	8602	25797	24750	46588	34054	32996	63147	40113	49917	64647	56828	54399	33072	33989	27268	76034	30145	46590	27632	18532	21939	33003	59247	55733	55971	82365
37 : P68	57599	74250	69989	30789	52497	78046	98346	8659	17255	52158	31417	83203	30798	91912	88108	167647	120662	116049	225999	144793	178112	231634	202182	193359	117867	120960	97967	269757	107078	167096	99571	65843	77528	118276	211105	199090	199079	293309
38 : P69	43027	55448	52201	22659	39044	58231	73803	6447	12798	39121	23358	62264	23043	68286	65466	124894	90296	86677	168291	107997	133338	172893	151293	144669	88069	90447	72954	201955	79965	124716	74223	48720	57761	88531	157951	148956	149161	219276

Annex 3: Proportions for "Power plant" variables

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	P52	798	P69	580	P52	881	P69	638
2	P53	783	P50	537	P53	748	P59	583
3	P56	537	P53	478	P59	542	P53	501
4	P54	522	P47	464	P37	541	P50	497
5	P55	478	P59	464	P54	520	P66	456
6	P36	449	P66	449	P55	492	P54	438
7	P37	420	P67	406	P56	487	P67	431
8	P51	420	P61	391	P51	408	P68	431
9	P59	377	P68	377	P66	399	P55	419
10	P41	333	P51	362	P36	393	P52	387
11	P43	333	P52	348	P68	391	P47	367
12	P64	304	P54	348	P41	376	P61	366
13	P42	290	P55	348	P43	336	P51	315
14	P49	290	P65	275	P69	291	P48	262
15	P66	246	P45	261	P64	285	P57	261
16	P45	232	P49	261	P58	279	P65	260
17	P47	232	P62	261	P49	279	P56	255
18	P58	232	P46	246	P45	245	P49	252
19	P68	232	P38	232	P57	222	P60	232
20	P44	203	P48	232	P65	218	P62	221
21	P69	203	P56	232	P46	195	P38	213
22	P48	188	P57	232	P32	182	P58	212
23	P65	188	P60	232	P44	178	P45	201
24	P34	174	P33	217	P42	170	P46	195
25	P39	174	P58	203	P47	153	P43	180
26	P46	174	P37	188	P48	124	P64	169
27	P32	159	P43	188	P67	108	P37	168
28	P57	159	P63	159	P34	85	P33	162
29	P50	145	P64	159	P39	83	P34	153
30	P60	145	P34	145	P38	76	P63	147
31	P38	130	P44	145	P50	74	P32	125
32	P40	87	P32	130	P63	67	P36	116
33	P61	87	P35	116	P62	60	P41	113
34	P62	87	P42	101	P60	55	P44	68
35	P63	87	P36	87	P61	29	P42	67
36	P67	87	P41	72	P40	11	P35	66
37	P33	0	P40	43	P33	0	P40	37
38	P35	0	P39	14	P35	0	P39	18
Rank	Label	Potential direct influences	Label	Potential direct dependence	Label	Potential indirect influence	Label	Potential direct dependence
1	P52	700	P50	547	P52	767	P69	539
2	P53	687	P69	509	P53	675	P59	519
3	P56	471	P53	445	P59	492	P50	517

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
4	P54	458	P59	445	P54	476	P53	463
5	P55	420	P47	433	P37	466	P66	438
6	P36	407	P66	433	P56	449	P67	416
7	P47	407	P61	407	P55	447	P68	392
8	P51	407	P67	394	P66	399	P61	388
9	P59	394	P68	356	P51	395	P54	385
10	P37	369	P52	343	P36	375	P52	370
11	P66	343	P51	331	P43	369	P55	369
12	P43	331	P54	318	P47	347	P47	354
13	P41	292	P55	318	P41	345	P65	293
14	P64	292	P65	318	P68	327	P51	291
15	P67	267	P49	280	P64	290	P49	276
16	P42	254	P38	267	P49	270	P48	250
17	P49	254	P34	242	P69	254	P34	245
18	P45	229	P45	242	P58	253	P38	245
19	P34	216	P60	242	P67	249	P57	238
20	P48	203	P62	242	P45	228	P60	234
21	P58	203	P33	229	P65	217	P62	229
22	P68	203	P46	216	P57	212	P56	213
23	P44	191	P48	216	P46	186	P33	197
24	P50	178	P57	216	P44	174	P45	189
25	P57	178	P56	203	P42	173	P58	183
26	P65	178	P37	178	P32	152	P46	178
27	P69	178	P43	178	P48	151	P36	168
28	P46	165	P58	178	P34	124	P43	166
29	P32	152	P32	152	P50	115	P37	162
30	P39	152	P63	152	P63	102	P63	155
31	P63	140	P64	152	P38	101	P41	153
32	P38	127	P35	140	P39	87	P32	153
33	P60	127	P36	140	P60	65	P64	150
34	P61	101	P44	140	P33	64	P35	113
35	P33	89	P41	114	P61	62	P40	109
36	P40	76	P42	114	P62	58	P44	86
37	P62	76	P40	101	P35	41	P42	80
38	P35	63	P39	50	P40	21	P39	76

Annex 4: Matrix MPII for “Mining surface” variables

	1 : M4	2 : M5	3 : M18	4 : M19	5 : M20	6 : M21	7 : M22	8 : M23	9 : M24	10 : M25	11 : M26	12 : M27	13 : M28	14 : M29	15 : M30	16 : M31
1 : M4	112	0	1586	1510	1714	1824	901	2169	1306	1147	506	1899	353	355	1569	202
2 : M5	30	0	690	619	637	688	389	789	508	447	191	739	86	189	603	76
3 : M18	434	0	7360	6956	7565	8087	4155	9449	5802	5089	2103	8499	1251	1627	6829	848
4 : M19	359	0	6657	6288	6702	7207	3722	8439	5203	4524	1868	7630	1057	1456	6032	766
5 : M20	304	0	5434	5087	5579	5904	3065	6822	4266	3742	1528	6174	864	1193	4951	608
6 : M21	431	0	6770	6488	7019	7565	3865	8940	5404	4747	1929	8094	1198	1504	6453	744
7 : M22	552	0	9030	8644	9265	10018	5165	11784	7138	6189	2537	10720	1595	2082	8487	1102
8 : M23	668	0	9898	9471	10629	11301	5510	13458	8097	7123	3094	11691	2017	2074	9476	1196
9 : M24	398	0	7074	6649	7159	7634	3996	8840	5517	4822	1998	8018	1155	1621	6485	806
10 : M25	282	0	5289	4924	5383	5759	2914	6765	4120	3647	1539	6026	907	1239	4832	630
11 : M26	223	0	3797	3548	3986	4186	2064	4888	3008	2666	1176	4202	723	822	3474	472
12 : M27	530	0	7952	7694	8399	9043	4551	10743	6467	5633	2306	9684	1503	1751	7729	892
13 : M28	56	0	974	962	1046	1108	528	1266	778	686	280	1102	173	220	872	110
14 : M29	30	0	764	722	764	818	404	954	586	506	198	855	96	171	655	84
15 : M30	354	0	5414	5188	5689	6085	3063	7217	4361	3825	1574	6438	987	1129	5173	600
16 : M31	18	0	384	379	403	431	205	499	308	267	103	445	56	84	342	36

Annex 5: Proportions for "Mining surface" variables

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	M22	1276	M23	1170	M23	1348	M23	1260
2	M23	1276	M27	1170	M22	1123	M27	1145
3	M27	1170	M30	1063	M27	1075	M21	1097
4	M18	904	M21	1010	M18	973	M20	1027
5	M19	797	M20	904	M21	916	M18	984
6	M21	797	M18	797	M19	881	M19	954
7	M24	744	M24	797	M24	847	M30	890
8	M30	744	M19	744	M30	743	M24	786
9	M20	585	M25	691	M20	731	M25	686
10	M25	478	M22	478	M25	506	M22	464
11	M26	478	M29	372	M26	445	M26	232
12	M4	212	M26	265	M4	204	M29	194
13	M28	212	M4	212	M29	97	M31	113
14	M5	159	M28	212	M28	65	M28	99
15	M29	159	M31	106	M5	39	M4	61
16	M31	0	M5	0	M31	0	M5	0

Rank	Label	Potential direct influences	Label	Potential direct dependence	Label	Potential indirect influence	Label	Potential direct dependence
1	M22	1256	M23	1155	M23	1283	M23	1250
2	M23	1206	M27	1155	M22	1144	M27	1119
3	M27	1105	M30	1155	M27	1030	M21	1064
4	M18	904	M21	954	M18	923	M20	994
5	M19	753	M20	854	M24	876	M18	959
6	M21	753	M18	804	M21	863	M19	911
7	M24	753	M24	753	M19	824	M30	897
8	M30	703	M19	703	M30	693	M24	763
9	M25	603	M25	653	M20	673	M25	668
10	M20	552	M22	552	M25	658	M22	540
11	M26	502	M29	402	M26	476	M26	278
12	M28	251	M26	301	M4	208	M29	212
13	M4	201	M28	251	M28	123	M28	170
14	M5	201	M4	201	M29	92	M31	111
15	M29	150	M31	100	M5	81	M4	58
16	M31	100	M5	0	M31	48	M5	0

Annex 6: Matrix MPII for “Mining underground” variables

	1 : M1	2 : M2	3 : M3	4 : M4	5 : M5	6 : M6	7 : M8	8 : M9	9 : M10	10 : M11	11 : M12	12 : M13	13 : M14	14 : M15	15 : M16	16 : M17
1 : M1	1908	2400	411	6774	2873	2639	4598	4509	4203	1984	137	5139	3606	4588	3965	5428
2 : M2	185	273	51	712	322	286	487	477	467	217	17	556	391	504	431	571
3 : M3	1065	1538	399	4321	1903	1658	2958	2704	2818	1316	133	3225	2200	3014	2620	3513
4 : M4	137	221	75	591	273	226	406	351	397	197	25	425	290	422	368	476
5 : M5	327	313	24	895	360	354	594	603	497	251	8	644	468	557	478	695
6 : M6	149	176	21	601	224	230	414	402	352	164	7	472	321	394	338	488
7 : M8	881	1245	255	3609	1512	1394	2483	2396	2265	1077	85	2799	1912	2474	2137	2946
8 : M9	664	949	174	2648	1159	1030	1785	1748	1737	763	58	2049	1440	1866	1610	2134
9 : M10	780	1055	180	2987	1319	1197	2086	1950	1978	859	60	2367	1638	2125	1821	2393
10 : M11	1006	1484	378	4057	1821	1577	2784	2555	2677	1262	126	3046	2104	2869	2484	3263
11 : M12	324	483	120	1270	592	503	877	798	863	399	40	961	671	921	793	1009
12 : M13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 : M14	70	89	18	280	108	100	179	184	166	73	6	204	139	176	158	239
14 : M15	661	879	135	2419	1066	986	1696	1614	1563	725	45	1919	1344	1711	1450	1906
15 : M16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 : M17	1087	1459	306	4279	1796	1628	2891	2764	2692	1233	102	3223	2211	2902	2525	3498

Annex 7: Proportions for "Mining underground" variables

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	M1	1789	M4	1210	M1	1900	M4	1220
2	M17	1473	M17	947	M3	1218	M17	983
3	M8	1315	M8	894	M17	1191	M13	931
4	M3	1157	M13	789	M11	1153	M15	844
5	M15	842	M15	789	M8	1015	M8	834
6	M9	789	M9	736	M10	854	M9	794
7	M11	789	M10	736	M9	751	M10	781
8	M10	736	M16	684	M15	693	M16	729
9	M2	263	M5	578	M12	365	M14	645
10	M5	263	M2	526	M5	243	M5	528
11	M6	263	M14	526	M2	204	M6	475
12	M12	157	M1	473	M4	168	M2	432
13	M14	105	M6	473	M6	163	M11	362
14	M4	52	M11	421	M14	75	M1	318
15	M13	0	M3	157	M13	0	M3	87
16	M16	0	M12	52	M16	0	M12	29

Annex 8: MDI Matrix sum for "Potentials" variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	39	9
2	Ground movement	12	9
3	Geological singularities of the mine	22	3
4	Methane surface emissions (AMM)	5	22
5	Methane resources (CBM)	5	10
6	Coal spontaneous ignition	9	7
7	Coal processing plant capacity	18	13
8	Volume of pumped water	21	18
9	Pumped water chemistry/quality	19	15
10	Hazardous substances in the pumped mine water	18	12
11	Depth of the shafts	15	7
12	Shaft diameter	3	1
13	Shaft technical condition	0	12
14	Function/status of shaft (liquidated, pumping station, ventilation working)	5	11
15	Water inflow	17	14
16	Pumped water temperature	2	13
17	Flooding status of the mine	25	21
18	Area of the waste heap	17	17
19	Height of the waste heap	15	15
20	Angle of slopes of the waste heap	11	18
21	Geometry of the waste heap	15	20
22	Material type deposited on the waste heap	24	12
23	Geotechnical stability of waste heaps	24	23
24	Fire hazard at the waste heap	14	22
25	Gas hazard at the waste heap	9	15
26	Acidity potential of the waste heap material	9	8
27	Status of reclamation of the waste heap	22	23
28	Neighbourhood density	4	9
29	Existence of historic or singular buildings	3	8
30	Land use restrictions (mine)	22	30
31	Connection capacity of mine to the grid	0	4
32	Power plant connection capacity to the grid	11	12
33	Electricity production efficiency of power plant	0	15
34	Power plant concession expiry date	12	10
35	Expected technical lifetime	0	8
36	Number of units decommissioned	31	6
37	Water reservoir capacity	29	13
38	Repowering: possibility of adapting the boiler for biomass	9	16
39	Feasibility of reusing air cleaning installation for repowering	12	1
40	CO2 capture installation	6	3
41	District heating connection	23	5
42	Cooling water installation type	20	7
43	Wastewater treatment plant	23	13
44	Fly ash characterisation	14	10
45	Power plant landfill area - hazardous/non-hazardous	16	18
46	Coal ash waste landfill area availability	12	17
47	Available space for new technologies/projects	16	32
48	Obligations of thermal energy supply after the decommissioning	13	16
49	Availability of concession for power generation	20	18
50	Cost of decommissioning and remediation	10	37
51	Land use restrictions (power plant)	29	25
52	Character of the local area	55	24
53	Neighbourhood and proximity to the nearest urban/industry	54	33

N°	Variable	Total number of rows	Total number of columns
54	Access / proximity to road infrastructure	36	24
55	Access / proximity to railway infrastructure	33	24
56	Access / proximity to water reservoir	37	16
57	Access / proximity to the river (for transport)	11	16
58	Access / proximity to gas pipeline network connections	16	14
59	Proximity to industries	26	32
60	Water treatment plant	10	16
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	6	27
62	Power Plant employment (number of employees)	6	18
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	6	11
64	Temporary storage areas	21	11
65	Relevant resource for land lease & rental	13	19
66	Electro-intensive industries	17	31
67	Industries likely to use H2	6	28
68	Constant energy consumption industries	16	26
69	Companies manufacturers of goods and/or suppliers of services	14	40
	Totals	1113	1113

Annex 9: MII Matrix sum for “Potentials” variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	1,641589E+12	6,372254E+10
2	Ground movement	6,613307E+11	1,038501E+11
3	Geological singularities of the mine	9,882872E+11	1,254575E+10
4	Methane surface emissions (AMM)	4,376265E+11	3,922234E+11
5	Methane resources (CBM)	1,734768E+11	1,253929E+11
6	Coal spontaneous ignition	5,573967E+11	5,497378E+10
7	Coal processing plant capacity	1,395137E+12	3,928634E+11
8	Volume of pumped water	9,459811E+11	2,923453E+11
9	Pumped water chemistry/quality	9,355258E+11	1,641359E+11
10	Hazardous substances in the pumped mine water	9,120463E+11	1,4381E+11
11	Depth of the shafts	7,624403E+11	5,468E+10
12	Shaft diameter	2,123997E+11	4,181915E+09
13	Shaft technical condition	0	1,271535E+11
14	Function/status of shaft (liquidated, pumping station, ventilation working)	1,220909E+12	3,985306E+11
15	Water inflow	6,818415E+11	1,954568E+11
16	Pumped water temperature	1,708126E+11	1,639897E+11
17	Flooding status of the mine	9,464602E+11	5,526785E+11
18	Area of the waste heap	1,519784E+12	2,115368E+12
19	Height of the waste heap	1,372466E+12	2,031087E+12
20	Angle of slopes of the waste heap	1,092626E+12	2,198476E+12
21	Geometry of the waste heap	1,385562E+12	2,34844E+12
22	Material type deposited on the waste heap	1,707119E+12	1,072241E+12
23	Geotechnical stability of waste heaps	2,074152E+12	2,702505E+12
24	Fire hazard at the waste heap	1,365598E+12	1,748345E+12
25	Gas hazard at the waste heap	8,526198E+11	1,502209E+12
26	Acidity potential of the waste heap material	7,200336E+11	5,416212E+11
27	Status of reclamation of the waste heap	1,686641E+12	2,454955E+12
28	Neighbourhood density	1,347543E+11	3,009876E+11
29	Existence of historic or singular buildings	2,036638E+11	4,597555E+11
30	Land use restrictions (mine)	1,623352E+12	2,059668E+12
31	Connection capacity of mine to the grid	0	3,24185E+11
32	Power plant connection capacity to the grid	7,932721E+12	5,576733E+12
33	Electricity production efficiency of power plant	0	7,10297E+12
34	Power plant concession expiry date	3,650597E+12	6,708335E+12
35	Expected technical lifetime	0	2,93065E+12
36	Number of units decommissioned	1,710475E+13	5,06261E+12
37	Water reservoir capacity	2,374403E+13	7,446207E+12
38	Repowering: possibility of adapting the boiler for biomass	3,222021E+12	9,402387E+12
39	Feasibility of reusing air cleaning installation for repowering	3,452975E+12	8,265208E+11
40	CO2 capture installation	4,363921E+11	1,647853E+12
41	District heating connection	1,640704E+13	4,997104E+12
42	Cooling water installation type	7,347425E+12	2,993075E+12
43	Wastewater treatment plant	1,468871E+13	7,945504E+12
44	Fly ash characterisation	7,707109E+12	2,964185E+12
45	Power plant landfill area. Hazardous/non-hazardous.	1,059422E+13	8,812149E+12
46	Coal ash waste landfill area availability	8,438339E+12	8,488339E+12
47	Available space for new technologies/projects	6,684457E+12	1,607269E+13
48	Obligations of thermal energy supply after the decommissioning	5,320784E+12	1,154127E+13
49	Availability of concession for power generation	1,212031E+13	1,112567E+13
50	Cost of decommissioning and remediation	3,171981E+12	2,172201E+13
51	Land use restrictions (power plant)	1,779828E+13	1,383748E+13
52	Character of the local area	3,858759E+13	1,704673E+13
53	Neighbourhood and proximity to the nearest urban/industry	3,264051E+13	2,209841E+13

N°	Variable	Total number of rows	Total number of columns
54	Access / proximity to road infrastructure	2,284607E+13	1,930621E+13
55	Access / proximity to railway infrastructure	2,159163E+13	1,847792E+13
56	Access / proximity to water reservoir	2,136258E+13	1,125896E+13
57	Access / proximity to the river (for transport)	9,74922E+12	1,154725E+13
58	Access / proximity to gas pipeline network connections	1,236383E+13	9,350156E+12
59	Proximity to industries	2,370811E+13	2,57469E+13
60	Water treatment plant	2,375342E+12	1,023098E+13
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	1,15457E+12	1,60341E+13
62	Power Plant employment (number of employees)	2,604702E+12	9,608972E+12
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	2,927179E+12	6,4013E+12
64	Temporary storage areas	1,251007E+13	7,435477E+12
65	Relevant resource for land lease & rental	9,635097E+12	1,136411E+13
66	Electro-intensive industries	1,749399E+13	2,014397E+13
67	Industries likely to use H2	4,803094E+12	1,901213E+13
68	Constant energy consumption industries	1,713504E+13	1,903254E+13
69	Companies manufacturers of goods and/or suppliers of services	1,280708E+13	2,809727E+13
	Totals	1113	1113

Annex 10: MPDI matrix sum for "Potentials" variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	44	9
2	Ground movement	13	9
3	Geological singularities of the mine	22	3
4	Methane surface emissions (AMM)	5	22
5	Methane resources (CBM)	6	10
6	Coal spontaneous ignition	9	7
7	Coal processing plant capacity	18	14
8	Volume of pumped water	21	18
9	Pumped water chemistry/quality	20	15
10	Hazardous substances in the pumped mine water	19	12
11	Depth of the shafts	15	7
12	Shaft diameter	3	1
13	Shaft technical condition	0	13
14	Function/status of shaft (liquidated, pumping station, ventilation working)	5	13
15	Water inflow	17	14
16	Pumped water temperature	2	13
17	Flooding status of the mine	27	21
18	Area of the waste heap	18	18
19	Height of the waste heap	15	16
20	Angle of slopes of the waste heap	11	19
21	Geometry of the waste heap	15	21
22	Material type deposited on the waste heap	25	15
23	Geotechnical stability of waste heaps	24	25
24	Fire hazard at the waste heap	15	22
25	Gas hazard at the waste heap	12	15
26	Acidity potential of the waste heap material	10	9
27	Status of reclamation of the waste heap	22	24
28	Neighbourhood density	5	11
29	Existence of historic or singular buildings	3	9
30	Land use restrictions (mine)	22	33
31	Connection capacity of mine to the grid	2	4
32	Power plant connection capacity to the grid	12	15
33	Electricity production efficiency of power plant	7	18
34	Power plant concession expiry date	17	19
35	Expected technical lifetime	5	11
36	Number of units decommissioned	32	11
37	Water reservoir capacity	29	14
38	Repowering: possibility of adapting the boiler for biomass	10	21
39	Feasibility of reusing air cleaning installation for repowering	12	4
40	CO_2 capture installation	6	8
41	District heating connection	23	9
42	Cooling water installation type	20	9
43	Wastewater treatment plant	26	14
44	Fly ash characterisation	15	11
45	Power plant landfill area. Hazardous/non-hazardous.	18	19
46	Coal ash waste landfill area availability	13	17
47	Available space for new technologies/projects	32	34
48	Obligations of thermal energy supply after the decommissioning	16	17
49	Availability of concession for power generation	20	22
50	Cost of decommissioning and remediation	14	43
51	Land use restrictions (power plant)	32	26

N°	Variable	Total number of rows	Total number of columns
52	Character of the local area	55	27
53	Neighbourhood and proximity to the nearest urban/industry	54	35
54	Access / proximity to road infrastructure	36	25
55	Access / proximity to railway infrastructure	33	25
56	Access / proximity to water reservoir	37	16
57	Access / proximity to the river (for transport)	14	17
58	Access / proximity to gas pipeline network connections	16	14
59	Proximity to industries	31	35
60	Water treatment plant	10	19
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	8	32
62	Power Plant employment (number of employees)	6	19
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	11	12
64	Temporary storage areas	23	12
65	Relevant resource for land lease & rental	14	25
66	Electro-intensive industries	27	34
67	Industries likely to use H2	21	31
68	Constant energy consumption industries	16	28
69	Companies manufacturers of goods and/or suppliers of services	14	40
	Totals	1113	1113

Annex 11: MPII matrix sum for "Potentials" variables

N°	Variable	Total number of rows	Total number of columns
1	Depth of mine	1,024706E+10	3,449092E+08
2	Ground movement	3,145319E+09	5,379219E+08
3	Geological singularities of the mine	5,15493E+09	6,97165E+07
4	Methane surface emissions (AMM)	2,26766E+09	1,991591E+09
5	Methane resources (CBM)	1,341064E+09	6,511574E+08
6	Coal spontaneous ignition	2,610654E+09	2,932165E+08
7	Coal processing plant capacity	6,760563E+09	2,183927E+09
8	Volume of pumped water	4,526331E+09	1,508243E+09
9	Pumped water chemistry/quality	4,681513E+09	8,628392E+08
10	Hazardous substances in the pumped mine water	4,603941E+09	7,539647E+08
11	Depth of the shafts	4,1325E+09	3,000125E+08
12	Shaft diameter	1,167076E+09	2,323883E+07
13	Shaft technical condition	0	7,110428E+08
14	Function/status of shaft (liquidated, pumping station, ventilation working)	5,281837E+09	2,126883E+09
15	Water inflow	3,254551E+09	1,022946E+09
16	Pumped water temperature	8,070427E+08	8,59602E+08
17	Flooding status of the mine	4,953585E+09	2,818762E+09
18	Area of the waste heap	6,987238E+09	1,039608E+10
19	Height of the waste heap	6,208722E+09	9,781744E+09
20	Angle of slopes of the waste heap	4,865192E+09	1,073844E+10
21	Geometry of the waste heap	6,309347E+09	1,148132E+10
22	Material type deposited on the waste heap	8,511773E+09	6,282101E+09
23	Geotechnical stability of waste heaps	9,552767E+09	1,351558E+10
24	Fire hazard at the waste heap	6,772847E+09	8,570511E+09
25	Gas hazard at the waste heap	5,200617E+09	7,372554E+09
26	Acidity potential of the waste heap material	3,712775E+09	3,233158E+09
27	Status of reclamation of the waste heap	7,802222E+09	1,209564E+10
28	Neighbourhood density	1,065131E+09	2,485309E+09
29	Existence of historic or singular buildings	9,341026E+08	2,556459E+09
30	Land use restrictions (mine)	7,425082E+09	1,05692E+10
31	Connection capacity of mine to the grid	4,906951E+08	1,624567E+09
32	Power plant connection capacity to the grid	3,775604E+10	3,860138E+10
33	Electricity production efficiency of power plant	1,560588E+10	4,900274E+10
34	Power plant concession expiry date	3,036281E+10	6,059726E+10
35	Expected technical lifetime	1,005352E+10	2,81406E+10
36	Number of units decommissioned	9,272186E+10	4,169261E+10
37	Water reservoir capacity	1,160143E+11	4,07314E+10
38	Repowering: possibility of adapting the boiler for biomass	2,484789E+10	6,099764E+10
39	Feasibility of reusing air cleaning installation for repowering	2,110586E+10	1,903834E+10
40	CO2 capture installation	4,994442E+09	2,728731E+10
41	District heating connection	8,556176E+10	3,823795E+10
42	Cooling water installation type	4,247246E+10	2,002938E+10
43	Wastewater treatment plant	9,160096E+10	4,144561E+10
44	Fly ash characterisation	4,305201E+10	2,148843E+10
45	Power plant landfill area. Hazardous/non-hazardous.	5,625308E+10	4,723329E+10
46	Coal ash waste landfill area availability	4,599131E+10	4,40694E+10
47	Available space for new technologies/projects	8,612338E+10	8,800684E+10
48	Obligations of thermal energy supply after the decommissioning	3,711619E+10	6,248427E+10
49	Availability of concession for power generation	6,676673E+10	6,876485E+10
50	Cost of decommissioning and remediation	2,826398E+10	1,282662E+11
51	Land use restrictions (power plant)	9,77641E+10	7,238547E+10
52	Character of the local area	1,90627E+11	9,209113E+10
53	Neighbourhood and proximity to the nearest urban/industry	1,672801E+11	1,154537E+11

N°	Variable	Total number of rows	Total number of columns
54	Access / proximity to road infrastructure	1,185344E+11	9,586718E+10
55	Access / proximity to railway infrastructure	1,112522E+11	9,19882E+10
56	Access / proximity to water reservoir	1,115541E+11	5,317664E+10
57	Access / proximity to the river (for transport)	5,263575E+10	5,966006E+10
58	Access / proximity to gas pipeline network connections	6,330753E+10	4,577404E+10
59	Proximity to industries	1,222196E+11	1,29667E+11
60	Water treatment plant	1,602918E+10	5,83601E+10
61	Obligations arising from concessions, contracts and other regulations in case of a power plant decommissioned	1,494473E+10	9,626971E+10
62	Power Plant employment (number of employees)	1,413406E+10	5,677017E+10
63	Special screening mechanisms for employees (early retirement, paid long-term leaves, voluntary leave programs)	2,523932E+10	3,846756E+10
64	Temporary storage areas	7,200483E+10	3,742573E+10
65	Relevant resource for land lease & rental	5,421076E+10	7,248237E+10
66	Electro-intensive industries	9,917018E+10	1,095153E+11
67	Industries likely to use H2	6,174338E+10	1,037388E+11
68	Constant energy consumption industries	8,134253E+10	9,779928E+10
69	Companies manufacturers of goods and/or suppliers of services	6,343418E+10	1,340959E+11
	Totals	1113	1113

Annex 12: Proportions for "Potentials" variables

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	P52	494	P69	359	P52	830	P69	604
2	P53	485	P50	332	P53	702	P59	554
3	M1	350	P53	296	P37	511	P53	475
4	P56	332	P47	287	P59	510	P50	467
5	P54	323	P59	287	P54	491	P66	433
6	P55	296	P66	278	P55	464	P54	415
7	P36	278	M30	269	P56	459	P68	409
8	P37	260	P67	251	P51	383	P67	409
9	P51	260	P61	242	P66	376	P55	397
10	P59	233	P68	233	P68	368	P52	366
11	M17	224	P51	224	P36	368	P47	346
12	M22	215	P52	215	P41	353	P61	345
13	M23	215	P54	215	P43	316	P51	297
14	P41	206	P55	215	P69	275	P57	248
15	P43	206	M23	206	P64	269	P48	248
16	M3	197	M27	206	P58	266	P65	244
17	M27	197	M4	197	P49	260	P56	242
18	M30	197	M24	197	P45	228	P49	239
19	M8	188	M17	188	P57	209	P60	220
20	P64	188	M21	179	P65	207	P62	206
21	P42	179	P65	170	P46	181	P38	202
22	P49	179	M8	161	P32	170	P58	201
23	M9	170	M20	161	P44	165	P45	189
24	M7	161	P45	161	P42	158	P46	182
25	M10	161	P49	161	P47	143	P43	171
26	M15	152	P62	161	P48	114	P37	160
27	M18	152	M18	152	P67	103	P64	160
28	P66	152	P46	152	P34	78	P33	152
29	P45	143	P38	143	P39	74	P34	144
30	P47	143	P48	143	P38	69	P63	137
31	P58	143	P56	143	P50	68	P32	120
32	P68	143	P57	143	P63	63	P36	108
33	M11	134	P60	143	P62	56	P41	107
34	M19	134	M9	134	P60	51	P42	64
35	M21	134	M19	134	M23	44	P44	63
36	M24	125	M25	134	M22	36	P35	63
37	P44	125	P33	134	M27	36	M23	58
38	P69	125	M15	125	M1	35	M27	52
39	P48	116	P58	125	M30	34	M21	50
40	P65	116	M7	116	M18	32	M20	47
41	M2	107	M16	116	M7	30	M18	45
42	P34	107	P37	116	M21	29	M30	44
43	P39	107	P43	116	M19	29	M19	43
44	P46	107	M10	107	M24	29	M24	37
45	M20	98	M13	107	M14	26	P40	35
46	P32	98	M22	107	P61	24	M25	32
47	P57	98	P32	107	M20	23	M22	23
48	P50	89	M14	98	M3	21	P39	17
49	P60	89	P63	98	M17	20	M17	11
50	M6	80	P64	98	M8	20	M26	11
51	M25	80	M5	89	M9	20	M29	9
52	M26	80	P34	89	M10	19	M14	8
53	P38	80	P44	89	M25	18	M7	8
54	P40	53	M1	80	M11	16	M4	8

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
55	P61	53	M2	80	M26	15	M31	6
56	P62	53	M28	80	M15	14	M28	6
57	P63	53	M26	71	M2	14	M8	6
58	P67	53	M29	71	M6	11	M15	4
59	M4	44	P35	71	M4	9	M9	3
60	M5	44	M6	62	P40	9	M16	3
61	M14	44	M11	62	M12	4	M10	3
62	M28	35	P42	62	M29	4	M13	2
63	M12	26	P36	53	M5	3	M5	2
64	M29	26	P41	44	M16	3	M2	2
65	M16	17	M31	35	M28	2	M1	1
66	M13	0	M3	26	M13	0	M6	1
67	M31	0	P40	26	M31	0	M11	1
68	P33	0	M12	8	P33	0	M3	0
69	P35	0	P39	8	P35	0	M12	0

Rank	Label	Potential direct influences	Label	Potential direct dependence	Label	Potential indirect influence	Label	Potential direct dependence
1	P52	447	P50	349	P52	729	P69	512
2	P53	439	P69	325	P53	639	P59	495
3	M1	357	P53	284	P59	467	P50	490
4	P56	300	P59	284	P54	453	P53	441
5	P54	292	P47	276	P37	443	P66	418
6	P55	268	P66	276	P56	426	P67	396
7	P36	260	M30	268	P55	425	P68	374
8	P47	260	P61	260	P66	379	P61	368
9	P51	260	P67	252	P51	373	P54	366
10	P59	252	P68	227	P36	354	P52	352
11	P37	235	P52	219	P43	350	P55	351
12	M17	219	P51	211	P47	329	P47	336
13	P66	219	M23	203	P41	327	P65	277
14	P43	211	P54	203	P68	311	P51	276
15	M22	203	P55	203	P64	275	P49	262
16	M23	195	P65	203	P49	255	P48	238
17	P41	186	M27	195	P69	242	P38	233
18	P64	186	M4	178	P58	242	P34	231
19	M3	178	M24	178	P67	236	P57	228
20	M27	178	P49	178	P45	215	P60	223
21	M30	178	M17	170	P65	207	P62	217
22	M8	170	M21	170	P57	201	P56	203
23	P67	170	P38	170	P46	175	P33	187
24	M9	162	M20	154	P44	164	P45	180
25	P42	162	P34	154	P42	162	P58	175
26	P49	162	P45	154	P32	144	P46	168
27	M10	154	P60	154	P48	141	P36	159
28	M7	146	P62	154	P34	116	P43	158
29	M18	146	M8	146	P50	108	P37	155
30	P45	146	M18	146	P63	96	P32	147
31	M15	138	P33	146	P38	95	P63	147
32	P34	138	P46	138	P39	80	P41	146
33	P48	130	P48	138	P60	61	P64	143
34	P58	130	P57	138	P33	59	P35	107
35	P68	130	M19	130	P61	57	P40	104
36	M11	121	P56	130	P62	54	P44	82
37	M19	121	M9	121	M1	39	P42	76

Rank	Label	Potential direct influences	Label	Potential direct dependence	Label	Potential indirect influence	Label	Potential direct dependence
38	M21	121	M22	121	P35	38	P39	72
39	M24	121	M25	121	M23	36	M23	51
40	P44	121	P32	121	M22	32	M27	46
41	P50	113	M7	113	M27	29	M21	43
42	P57	113	M15	113	M30	28	M20	41
43	P65	113	P37	113	M18	26	M30	40
44	P69	113	P43	113	M24	25	M18	39
45	M2	105	P58	113	M7	25	M19	37
46	P46	105	M13	105	M21	24	M24	32
47	M25	97	M14	105	M19	23	M25	28
48	P32	97	M16	105	M14	20	M22	24
49	P39	97	M10	97	M25	19	M26	12
50	M20	89	P63	97	M3	19	M17	10
51	P63	89	P64	97	P40	19	M29	9
52	M26	81	M28	89	M17	18	M28	9
53	P38	81	P35	89	M20	18	M7	8
54	P60	81	P36	89	M9	17	M14	8
55	M6	73	P44	89	M10	17	M4	7
56	P61	65	M5	81	M8	17	M31	6
57	P33	56	M1	73	M11	15	M8	5
58	M5	48	M2	73	M26	14	M15	3
59	P40	48	M26	73	M15	12	M9	3
60	P62	48	M29	73	M2	12	M16	3
61	M4	40	P41	73	M6	9	M10	2
62	M14	40	P42	73	M4	8	M13	2
63	M28	40	P40	65	M5	5	M5	2
64	P35	40	M6	56	M12	4	M2	2
65	M12	24	M11	56	M28	4	M1	1
66	M29	24	M31	32	M29	3	M11	1
67	M16	16	P39	32	M16	3	M6	1
68	M31	16	M3	24	M31	1	M3	0
69	M13	0	M12	8	M13	0	M12	0