ENERGY SECURITY

How European Union countries cope with the energy crisis

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Introduction

Energy security is one of the key challenges of the modern world, with a significant impact on the economic, political and social stability of countries and regions. In the context of the European Union, ensuring energy security is a priority issue, requiring a comprehensive approach and cooperation on many levels. The purpose of this report is to examine the overall energy situation of EU countries, with a particular focus on energy security.

What exactly is energy security? In the simplest terms, it can be defined as the ability of a country or region to ensure a stable, **reliable and accessible energy supply** that meets socio-economic needs, while **minimizing the risk of supply disruptions**, and **reducing dependence on external energy sources**. It is a state in which a country or region is able to respond effectively to potential threats to energy security, such as energy supply disruptions, geopolitical crises or climate change.

Introduction

Energy security consists of many components that complement each other and form a comprehensive risk management system in the energy sector. The key components of energy security include:

- **Diversification of production capacities** – sustainable and well-balanced energy production systems encompassing diverse generation technologies and ensuring continuity of energy supply to consumers.
- **Prices** – the delivery of cheaper energy to the consumer is a result of the costs of its generation, transmission, and distribution. Disruption in supply networks can have a negative impact on price levels and create economic difficulties for countries.
- **Required level of investment** – The implementation of investments necessary to meet the projected growth in energy demand will be a significant factor influencing energy security in the coming years.
- **Transport** – energy must be available on demand.
- **Supplier concentration** – reliance on a limited number of suppliers of imported fuel can increase vulnerability and raise the risk of adversarial market influence in the fuel market.
- **Availability of infrastructure and expertise**
- **Interconnection network of energy systems** - a limited number of connections between energy systems can lead to an increased risk of energy supply disruptions.
- **Fuel interchangeability** – diversity in fuel consumption can be a significant factor in enhancing energy security.
- **Political threats** - disruptions in energy supply can be caused by political conflicts or terrorist attacks.

Dataset

Data selection

This report presents an analysis of energy security, which was conducted for 27 European Union countries based on 2022 data from the EUROSTAT database. The aim of the analysis was to identify key factors influencing energy security and assess the situation in individual EU countries.

Analyzed Indicator Groups:

1. **Production and use of energy:** This group includes indicators related to the production and consumption of energy in individual countries. These indicators include, among others, the share of various energy sources in total production, renewable energy production, and energy productivity.
2. **Energy and Economy**: This group is focused on the analysis of economic indicators related to the energy sector. They included, among others, energy prices for households, or the share of the environmental sector in GDP.
3. **Energy System Flexibility**: This group of indicators focused on assessing the flexibility and diversity of the energy system in a given country. These indicators included, among others, the diversity of energy sources and the state of energy reserves.
4. **Sustainable Transport**: The last group of indicators related to sustainable transport, considering its impact on energy security. These indicators included, among others, the share of public transport and electric vehicles in total road traffic.

The selection of indicators was made subjectively, based on both literature on energy security and the availability of data from the EUROSTAT database. Each indicator was carefully evaluated in terms of its significance for energy security analysis and representativeness for the situation in individual EU countries.

Selected indicators

X	Kategory	Indicator	Unit
X1	Production and use of energy	Final energy consumption	100000 TOE/capita
X2		Energy efficiency	euro/KOE
X3		Share of renewable energy in final consumption	%
X4		Nuclear power generation	GWh/1000 residents
X5		Share of fossil fuels in gross available energy	%
X6	Energy and Economy	Gross value added in the environmental goods and services sector	‰
X7		Average energy price per household	cent/kWh
X8		Population unable to heat their homes due to poverty status	%
X9	Energy System Flexibility	Energy storage capacity	MWh/mln. residents
X10		Natural gas and liquefied natural gas reserves	mln. m3/1000 residents
X11		Dependency on energy imports	%
X12		Indicator of energy source diversification in final consumption	HHI (0-100)
X13	Sustainable Transport	Liquid biofuel production capacity	t/1000 residents
X14		Share of public transport	%
X15		Share of electric and hydrogen vehicles	‰

Explanation of the abbreviations in the table:

- TOE - the equivalent of one metric ton of crude oil with a calorific value of 1,000 kcal/kg
- KOE - the equivalent of one metric kilogram of crude oil
- KWh - kilowatt hour, the amount of energy consumed per hour with a kilowatt-powered device
- GWh - gigawatt hour, 1 000 000 kWh
- mln. - milion
- HHI - Herfindahl-Hirschman index, a concentration index, in this case multiplied by 100

Dataset

Initial matrix

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Austria	29.10	10.63	33.76	0.00	65.96	43.80	22.49	2.70	1.56	84.37	74.45	17.90	70.90	18.80	15.21
Belgium	28.60	7.22	13.76	37.33	73.89	16.70	34.37	5.10	20.63	6.74	73.95	20.72	38.28	14.40	4.97
Bulgaria	15.30	2.53	19.10	25.53	69.15	25.00	10.93	22.50	0.00	6.89	37.13	16.23	41.57	10.10	0.37
Croatia	17.90	6.72	29.35	0.00	69.16	15.00	13.54	7.00	0.00	12.44	60.30	19.39	10.65	11.20	2.94
Cyprus	19.90	8.78	19.43	0.00	89.29	18.90	26.07	19.20	0.00	0.00	92.02	18.76	0.00	12.70	0.43
Czech Republic	23.40	4.71	18.20	28.65	71.28	26.80	24.45	2.90	0.00	26.99	41.79	14.86	38.79	15.00	1.93
Denmark	22.60	17.75	41.60	0.00	58.79	32.40	45.59	5.10	0.00	38.39	42.87	16.66	0.00	13.30	12.19
Estonia	20.70	4.19	38.47	0.00	72.75	49.70	20.56	3.40	0.00	0.00	6.16	18.64	0.00	10.70	1.30
Finland	42.00	6.38	47.89	45.54	38.33	62.40	19.34	1.40	7.37	1.37	40.88	18.05	107.84	12.30	3.23
France	20.30	10.28	20.26	43.30	51.06	20.00	20.92	10.70	28.64	15.51	51.92	19.83	33.86	14.00	12.01
Greece	15.50	8.32	22.68	0.00	83.37	22.90	21.01	18.70	0.00	1.77	79.60	18.54	0.00	12.90	0.13
Spain	17.00	9.26	22.12	12.19	74.08	26.90	30.71	17.10	0.14	7.82	74.35	21.88	88.16	12.60	3.97
Netherlands	24.50	9.85	14.97	2.33	87.58	26.00	4.51	5.30	8.42	65.81	80.23	21.09	121.55	10.60	13.74
Ireland	23.30	26.77	13.11	0.00	87.36	9.80	23.24	7.20	0.00	0.00	79.16	21.18	31.34	14.30	6.10
Lithuania	19.00	5.87	29.60	0.00	63.96	29.20	14.97	17.50	0.00	3.48	72.43	17.86	68.25	5.30	2.89
Latvia	21.10	5.55	43.32	0.00	53.32	27.30	17.59	7.10	0.00	0.52	38.75	19.40	91.87	11.50	1.67
Luxembourg	56.20	14.70	14.36	0.00	77.06	29.60	20.17	2.10	0.00	0.00	91.32	26.37	0.00	13.70	11.98
Malta	13.20	4.30	13.40	0.00	96.12	12.80	12.98	7.60	6.55	11.13	99.01	29.33	0.00	14.10	4.06
Germany	24.20	10.64	20.80	4.11	80.33	23.90	32.79	6.60	5.50	25.80	68.56	18.66	49.21	11.20	18.46
Poland	19.70	5.27	16.88	0.00	87.11	25.30	14.64	4.90	0.00	10.12	46.03	14.45	50.64	13.70	1.12
Portugal	16.10	8.54	34.68	0.00	68.59	24.00	21.99	17.50	0.00	5.71	71.27	18.41	68.91	8.70	2.09
Romania	12.60	6.03	24.14	5.82	71.80	25.80	23.62	15.20	0.00	12.92	32.41	17.20	15.75	17.00	0.55
Slovakia	19.80	5.40	17.50	29.33	61.68	16.20	17.96	7.10	0.00	65.72	69.63	15.38	22.10	16.30	0.61
Slovenia	22.30	7.24	25.00	26.48	60.67	17.30	13.90	2.60	30.49	0.00	53.97	21.31	0.00	10.00	2.53
Sweden	29.50	10.14	66.00	49.37	30.32	40.50	22.78	3.30	0.00	0.00	26.82	18.63	42.77	15.90	21.77
Hungary	19.00	5.39	15.19	16.48	67.57	5.90	9.48	4.70	2.88	46.05	64.18	18.90	22.92	20.70	3.64
Italy	19.00	11.09	19.01	0.00	79.07	24.60	31.15	8.80	53.17	26.92	79.42	19.66	37.59	17.20	3.35

elaboration based on EUROSTAT data

Preliminary analysis

Extreme values

Maximum values:

- The highest final energy consumption per capita is observed in Luxembourg (56.20) and Finland (42.00).
- The highest energy productivity is in Ireland (26.77).
- The largest share of renewable energy is observed in Sweden (66%).
- The production of energy from nuclear power plants per capita is highest in Sweden (49.37).
- Malta has the largest share of fossil fuels in gross available energy (96.12%).
- Finland has the highest share of the environmental goods and services sector in GDP (62.40‰).
- The average energy price for households is highest in Denmark (45.59).
- The highest percentage of population unable to heat their homes due to poverty is in Bulgaria (22.50%).
- Italy has the largest energy storage capacity (53.17).
- The highest state of natural gas and liquefied natural gas reserves is recorded in Austria (84.37).
- The energy import dependency is highest in Malta (99.01%).
- The highest energy source diversification in final consumption occurs in Poland (14.45).
- The production capacity of liquid biofuels is highest in the Netherlands (121.55).
- The highest share of buses and trains in transport is noted in Hungary (20.70%).
- The highest share of electric and hydrogen vehicles is recorded in Sweden (21.77%).

Minimum values:

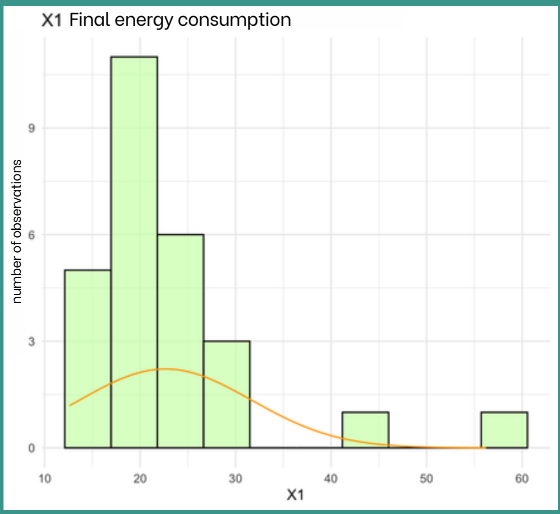
- The lowest final energy consumption per capita is observed in Romania (12.60).
- The lowest energy productivity is in Bulgaria (2.53).
- The lowest share of renewable energy is observed in Ireland (13.11).
- No production of energy from nuclear power plants in 14 countries.
- The smallest share of fossil fuels in gross available energy is in Sweden (30.32%).
- The lowest share of the environmental goods and services sector in GDP is in Hungary (5.9%).
- The lowest average energy price for households is in the Netherlands (4.51).
- The smallest number of people unable to heat their homes due to poverty is in Finland (1.40%).
- No energy storage facilities in 16 countries.
- No natural gas and liquefied natural gas reserves in 6 countries.
- The lowest energy import dependency is in Estonia (6.16%).
- The lowest energy source diversification is in Malta.
- No production capacity of liquid biofuels in 7 countries.
- The lowest share of buses and trains in transport is noted in Lithuania (5.30%).
- The lowest share of electric and hydrogen vehicles is recorded in Greece (0.13%).

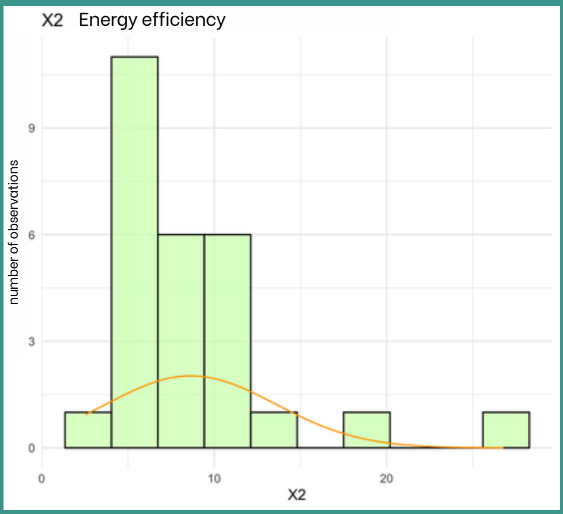
Basic statistics

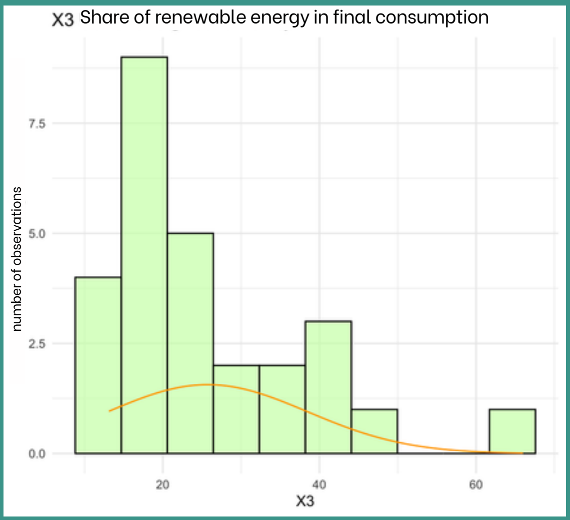
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Average	22,66	8,65	25,72	12,09	69,99	25,88	21,18	8,64	6,12	17,65	61,06	19,23	39,00	13,27	5,68
Median	20,30	7,24	20,80	0,00	71,28	25,00	20,92	7,00	0,00	7,82	68,56	18,66	37,59	13,30	3,23
Minimum	12,60	2,53	13,11	0,00	30,32	5,90	4,51	1,40	0,00	0,00	6,16	14,45	0,00	5,30	0,13
Maximum	56,20	26,77	66,00	49,37	96,12	62,40	45,59	22,50	53,17	84,37	99,01	29,33	121,55	20,70	21,77
Lower quartile	18,45	5,48	17,19	0,00	62,82	18,10	14,81	4,05	0,00	0,94	42,33	17,88	5,32	11,20	1,49
Upper quartile	23,80	10,21	31,68	26,01	79,70	28,25	24,04	12,95	6,02	26,36	76,80	20,28	59,44	14,70	9,04
Standard deviation	8,82	4,83	12,52	16,49	14,88	11,88	8,50	6,14	12,47	22,83	22,05	3,09	34,65	3,17	5,99
Coefficient of variation	38,92	55,84	48,66	136,39	21,26	45,90	40,16	71,03	203,65	129,34	36,12	16,09	88,85	23,86	105,54
Kurtosis	5,17	4,51	1,48	-0,64	0,26	1,40	0,57	-0,83	4,92	1,09	-0,59	2,38	-0,56	0,21	0,12
Skewness	2,16	1,96	1,37	0,97	-0,67	1,11	0,64	0,80	2,33	1,47	-0,43	1,33	0,66	0,02	1,18

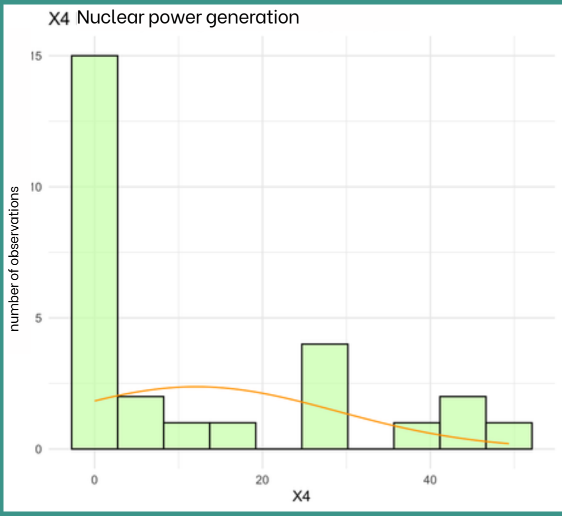
1. **Average and median**: For most variables, the mean values are close to the median values, suggesting a symmetric distribution of data. Exceptions include variables with many zero values (X4 and X9), as well as X10, where the median is significantly lower than the mean, which may indicate the presence of outliers or data asymmetry.
2. **Minimum and maximum**: The minimum and maximum values vary significantly between variables, indicating a diverse range of data. For example, for variable X4, the maximum value (49.37) is much higher than the minimum value (0.00), indicating its high variability.
3. **Quartiles**: The distribution of data for most variables appears to be concentrated within a specific range, as confirmed by the lower and upper quartiles. The values of the lower and upper quartiles allow us to see which parts of the data distribution are concentrated within specific intervals.
4. **Standard deviation**: The standard deviation provides information about the spread of data around the mean. Large standard deviation values, such as for variables X10, X11, X13, may indicate high variability in the data.
5. **Coefficient of variation**: The coefficient of variation allows for comparing the variability of data between different variables. Higher coefficient of variation values indicate greater variability of the data relative to their mean. The variable X9 exhibits the highest variability, where there are many zero values.
6. **Kurtosis and skewness** are measures of the shape of the data distribution. Kurtosis and skewness values close to zero indicate a more symmetric distribution of data, while values different from zero may indicate the presence of asymmetry or extreme values. Variables X1 and X9 exhibit high skewness exceeding the range [-2:2].

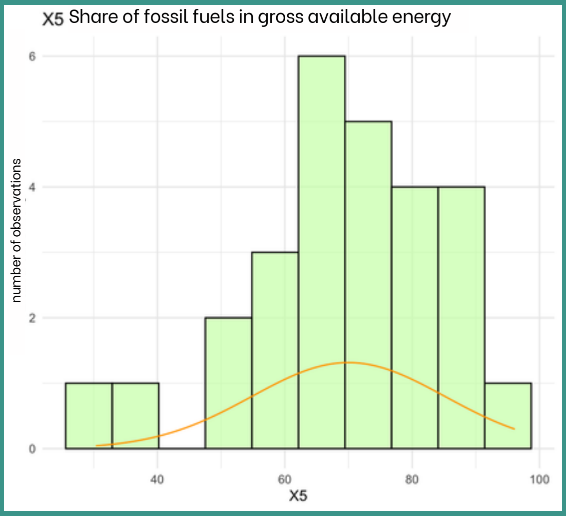
Preliminary analysis - histograms

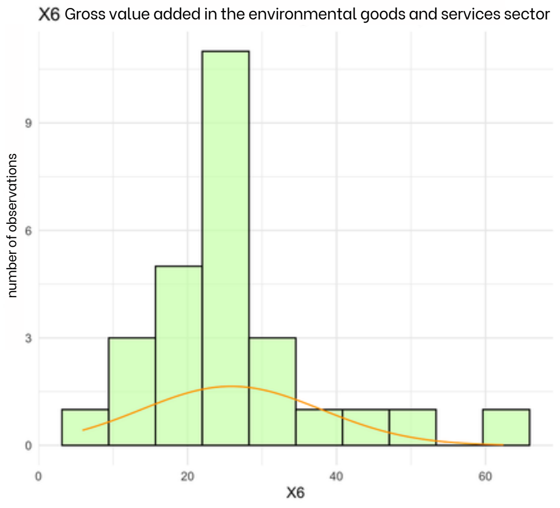




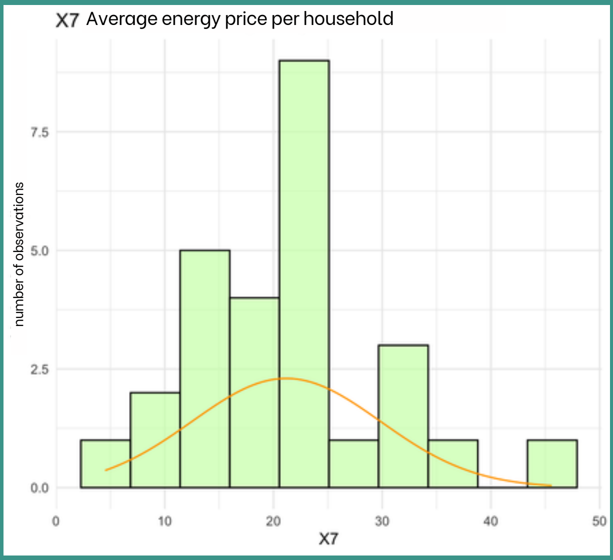


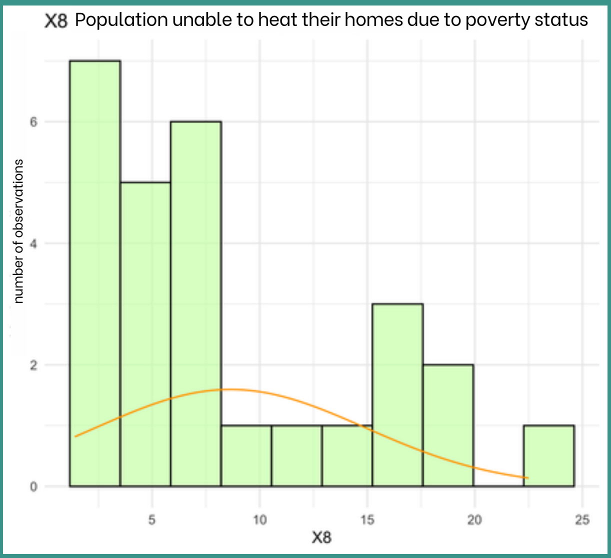


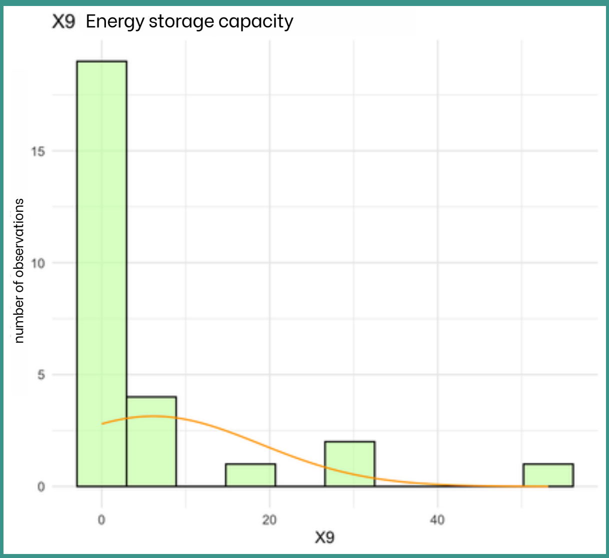


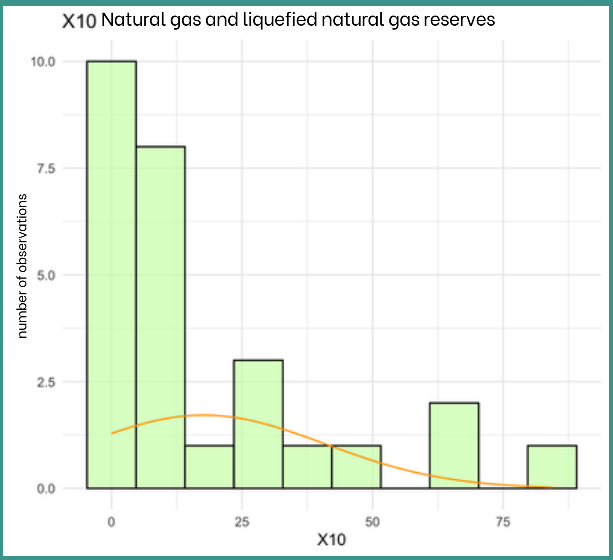


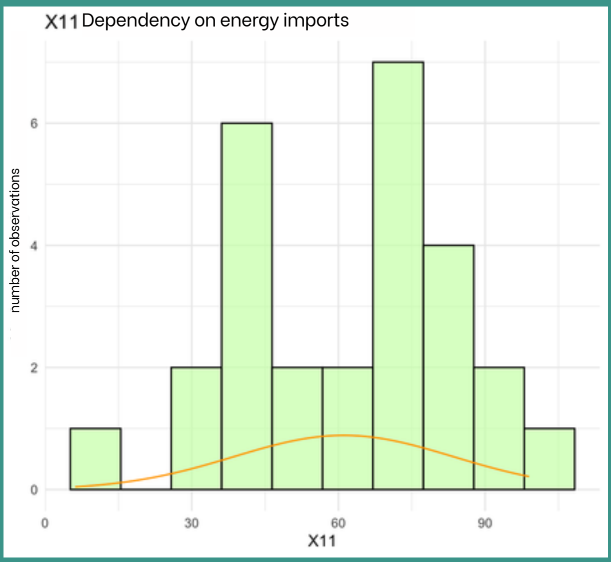
Analiza wstępna - histogramy

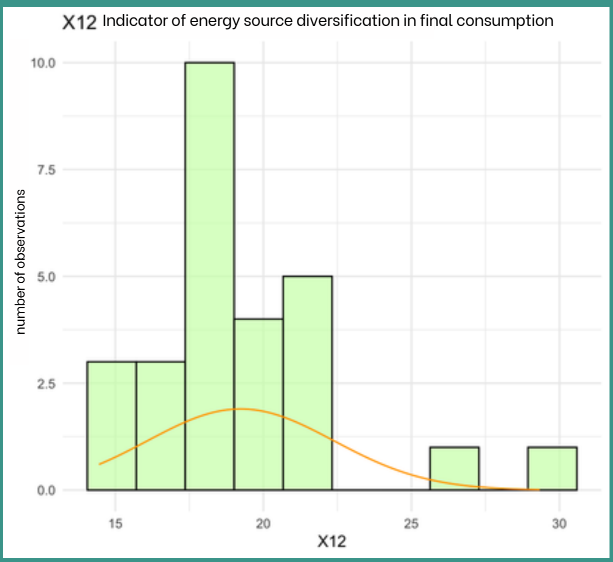












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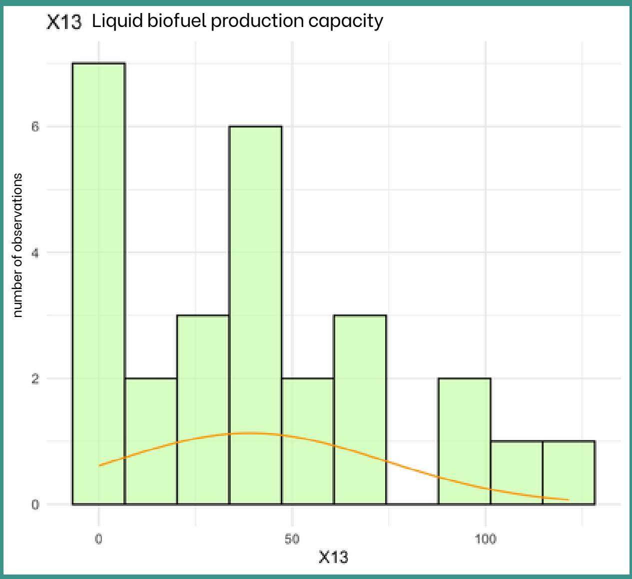
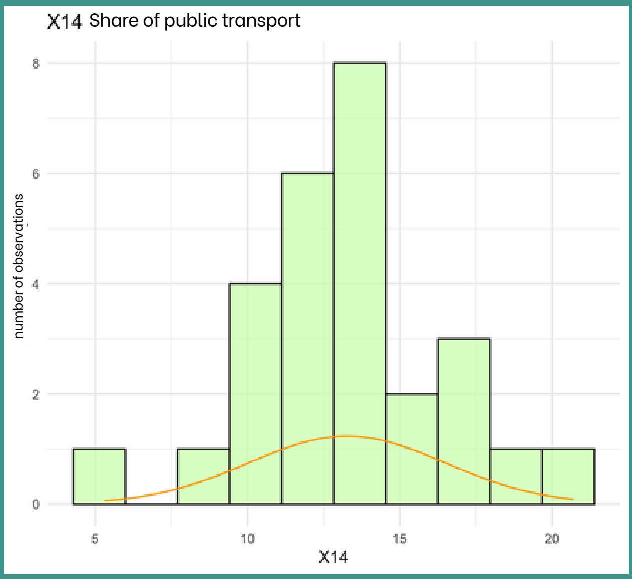
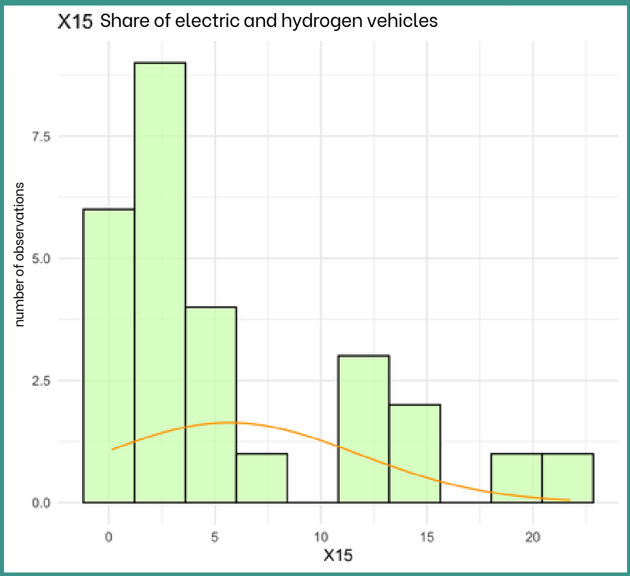






Linear ordering

Data preparation

Linear ordering involves arranging objects in a specific sequence based on the values of a certain characteristic or set of characteristics. Its goal is to organize data in a way that facilitates easier understanding of patterns, detection of trends, and making better decisions based on the data.

Methods used:

- Template Method
- Weighted Template Method
- TOPSIS

First, the coefficients of variation of all variables were analyzed once again. All variables were selected for analysis because for none of them the coefficient is less than 10%.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
Average	22.66	8.65	25.72	12.09	69.99	25.88	21.18	8.64	6.12	17.65	61.06	19.23	39.00	13.27	5.68
SD	8.82	4.83	12.52	16.49	14.88	11.88	8.50	6.14	12.47	22.83	22.05	3.09	34.65	3.17	5.99
Gini	18.10	27.05	25.17	68.72	11.66	23.88	21.87	38.26	81.22	63.76	20.25	8.17	49.24	13.16	53.89
CV	38.92	55.84	48.66	136.39	21.26	45.90	40.16	71.03	203.65	129.34	36.12	16.09	88.85	23.86	105.54

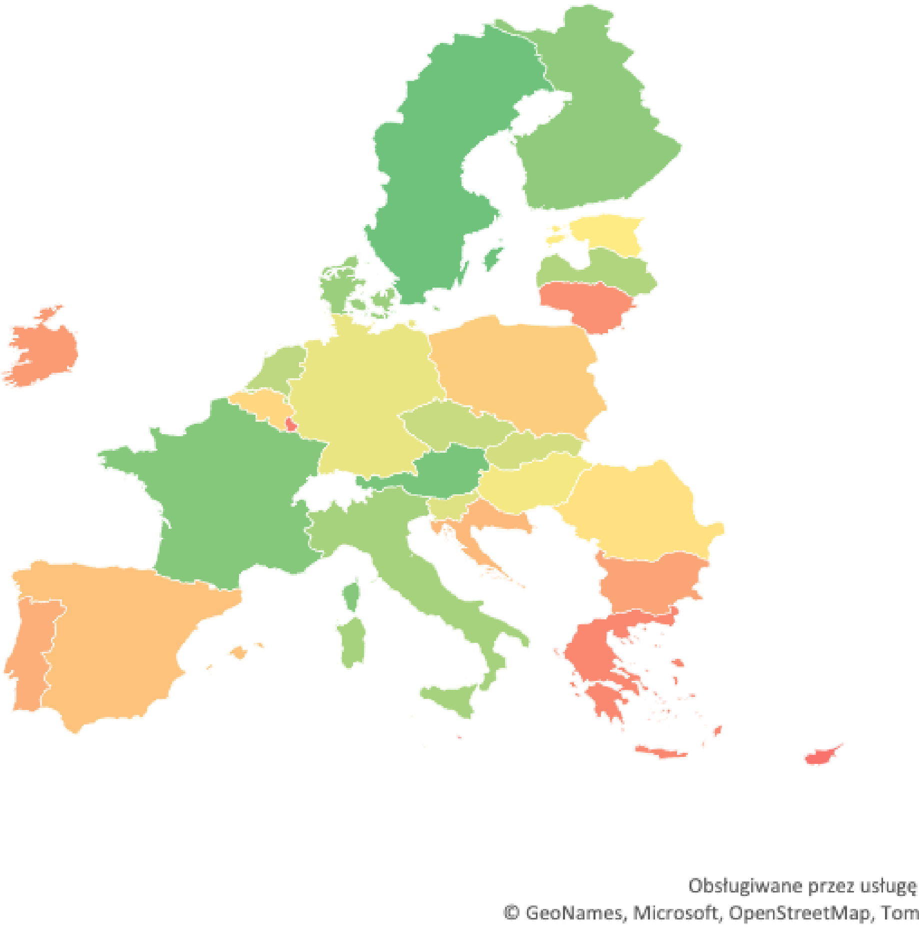
In the next step, the nature of the variables was determined - whether the variable is a stimulant (S) or a destimulant (D).

X	Indicator	S/D
X1	Final energy consumption	D
X2	Energy efficiency	S
X3	Share of renewable energy in final consumption	S
X4	Nuclear power generation	S
X5	Share of fossil fuels in gross available energy	D
X6	Gross value added in the environmental goods and services sector	S
X7	Average energy price per household	D
X8	Population unable to heat their homes due to poverty status	D
X9	Energy storage capacity	S
X10	Natural gas and liquefied natural gas reserves	S
X11	Dependency on energy imports	D
X12	Indicator of energy source diversification in final consumption	D
X13	Liquid biofuel production capacity	S
X14	Share of public transport	S
X15	Share of electric and hydrogen vehicles	S

Template Method

The template method in linear ordering is a technique that allows establishing a hierarchy of units (EU countries) based on their similarity to certain templates (variables X). In this method, each country is compared to the template and then classified in a predetermined order based on the degree of its similarity to the template. The template can serve as a reference point, representing an ideal characteristic or set of characteristics. The closer a country is to the template, the higher its position in the established linear order.

d_{io}	m_i	Country	Rank
8.1026	0.5118	Sweden	1
8.6386	0.4795	Austria	2
8.9695	0.4596	France	3
9.0409	0.4553	Finland	4
9.8550	0.4063	Denmark	5
10.1494	0.3885	Italy	6
10.1825	0.3865	Latvia	7
10.2397	0.3831	Netherlands	8
10.3772	0.3748	Czech Republic	9
10.4659	0.3695	Slovakia	10
10.5206	0.3662	Slovenia	11
10.5717	0.3631	Germany	12
10.7444	0.3527	Hungary	13
10.8203	0.3481	Estonia	14
10.8348	0.3472	Romania	15
11.1009	0.3312	Belgium	16
11.1303	0.3294	Poland	17
11.1957	0.3255	Spain	18
11.2092	0.3247	Croatia	19
11.2108	0.3246	Portugal	20
11.4819	0.3083	Bulgaria	21
11.5577	0.3037	Ireland	22
11.6163	0.3002	Lithuania	23
12.1104	0.2704	Greece	24
12.6108	0.2402	Luxembourg	25
12.7140	0.2340	Cyprus	26
13.3340	0.1967	Malta	27

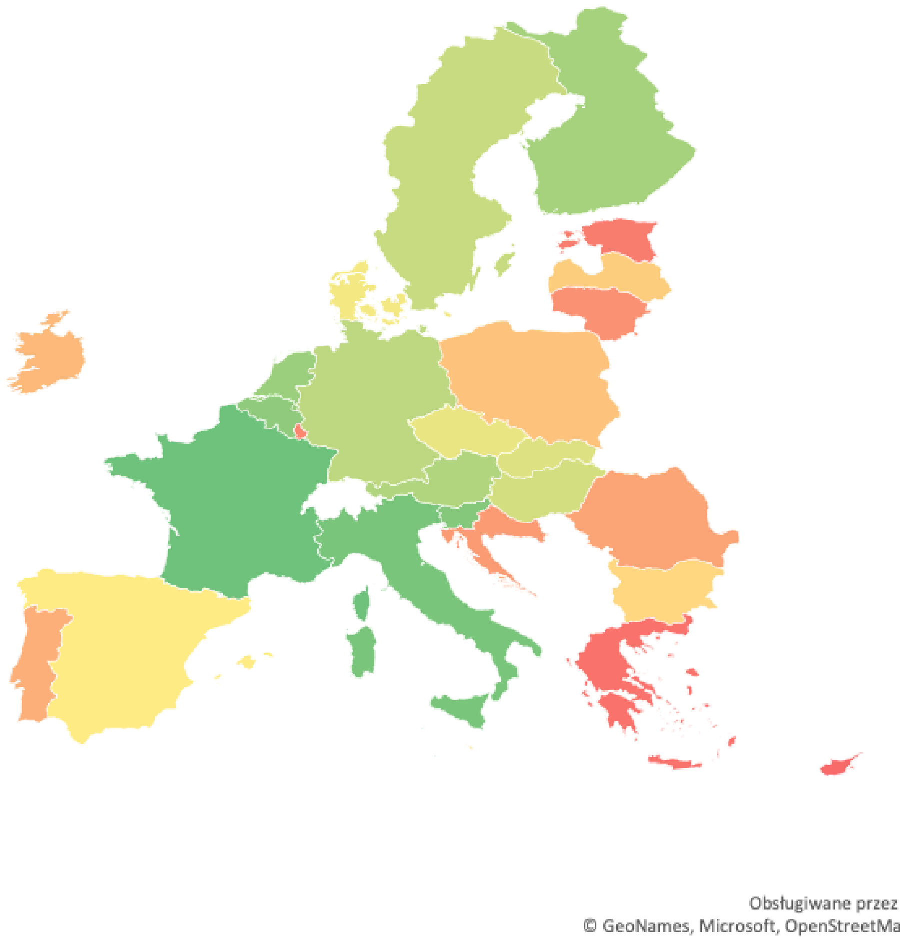


Weighted Template Method

The weighted template method in linear ordering is a technique that allows establishing a hierarchy of units (EU countries) by considering the diversity of variables (X) and their importance. In this method, each country is compared to a selected pattern, with each variable X assigned a weight reflecting its significance in the analysis. Based on the weights and the degree of similarity to the pattern, each country is classified in a predetermined order.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
WEIGHTS	0,0367	0,0526	0,0458	0,1285	0,0200	0,0432	0,0378	0,0669	0,1918	0,1218	0,0340	0,0152	0,0837	0,0225	0,0994

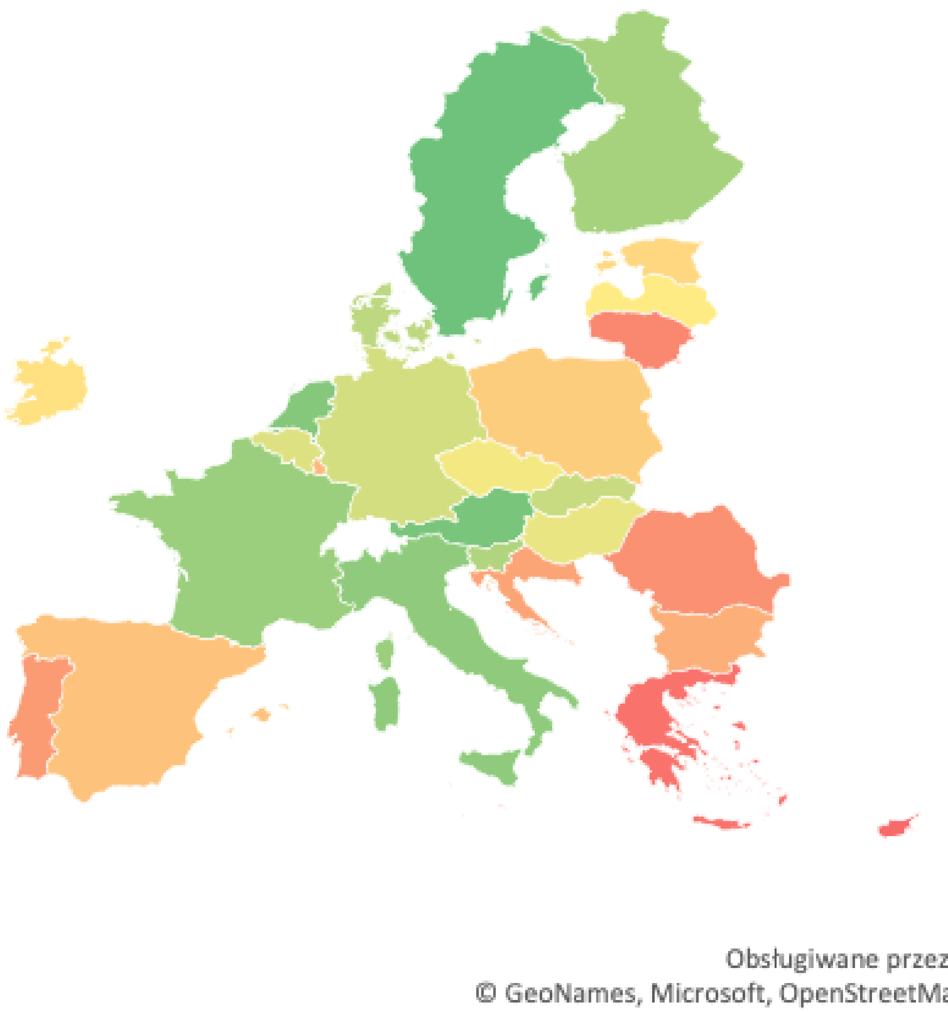
d_{i0}	m_i	Country	Rank
0.6784	0.4549	France	1
0.7028	0.4354	Italy	2
0.8105	0.3489	Slovenia	3
0.8366	0.3279	Belgium	4
0.8669	0.3035	Netherlands	5
0.9323	0.2509	Finland	6
0.9379	0.2465	Austria	7
0.9547	0.2330	Germany	8
0.9807	0.2121	Sweden	9
0.9990	0.1974	Hungary	10
1.0094	0.1890	Slovakia	11
1.0297	0.1727	Czech Republic	12
1.0307	0.1719	Denmark	13
1.0730	0.1379	Spain	14
1.0767	0.1350	Malta	15
1.1047	0.1125	Bulgaria	16
1.1077	0.1100	Latvia	17
1.1147	0.1044	Poland	18
1.1152	0.1040	Ireland	19
1.1161	0.1033	Portugal	20
1.1165	0.1030	Romania	21
1.1180	0.1018	Croatia	22
1.1228	0.0979	Lithuania	23
1.1245	0.0966	Luxembourg	24
1.1443	0.0806	Estonia	25
1.1727	0.0578	Greece	26
1.1829	0.0496	Cyprus	27



TOPSIS method

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method in linear ordering is an evaluation technique that allows establishing a hierarchy of units (EU countries) based on a set of variables (X). This method relies on the concept of ideal and anti-ideal solutions for each variable X, which are then used to calculate the distance of each country from these solutions. Based on this, for each country, proximity to the ideal solution and distance from the anti-ideal solution are determined. Then, for each country, the TOPSIS index is calculated, which takes into account both maximum proximity to the ideal solution and minimum distance from the anti-ideal solution. Countries are then ordered according to the TOPSIS index values, allowing for the determination of their relative positions in the hierarchy. The TOPSIS method is useful in linear ordering because it allows for considering both approximation to desired characteristics (ideal solution) and avoidance of undesired characteristics (anti-ideal solution), leading to a more comprehensive analysis of the data.

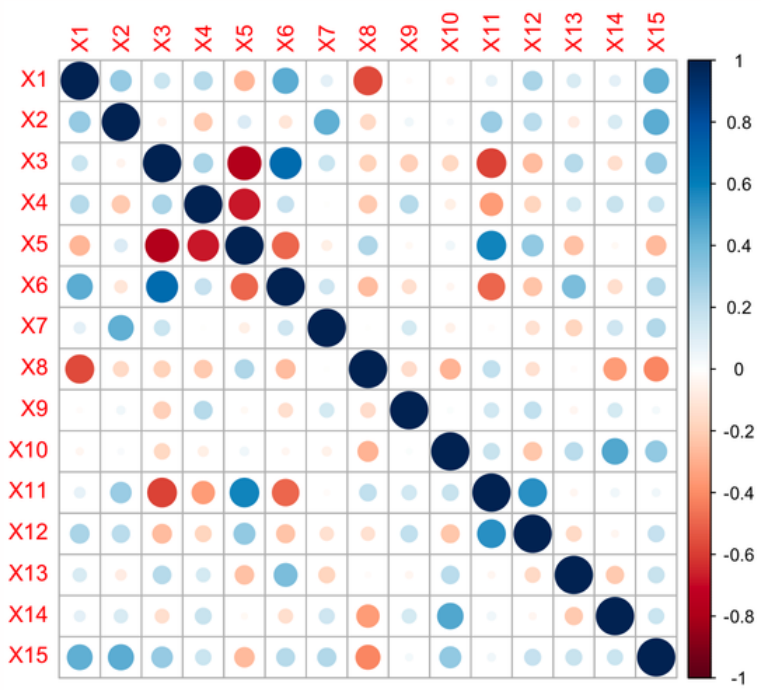
q_i	Country	Rank
0.487	Sweden	1
0.481	Austria	2
0.475	Netherlands	3
0.475	Italy	4
0.474	France	5
0.460	Finland	6
0.405	Slovenia	7
0.386	Denmark	8
0.385	Slovakia	9
0.383	Germany	10
0.374	Belgium	11
0.370	Hungary	12
0.358	Czech Republic	13
0.347	Latvia	14
0.343	Ireland	15
0.336	Estonia	16
0.319	Poland	17
0.310	Spain	18
0.309	Luxembourg	19
0.308	Bulgaria	20
0.298	Croatia	21
0.293	Portugal	22
0.292	Romania	23
0.292	Lithuania	24
0.290	Malta	25
0.244	Greece	26
0.217	Cyprus	27



Principal component analysis

Variables selection

Principal Component Analysis (PCA) is a statistical technique used to reduce the dimensionality of data by transforming a set of original variables into a new set of variables called principal components. The principal components are linear combinations of the original variables, arranged in decreasing order of variability in the dataset. PCA enables understanding the structure of data by identifying dominant patterns, reducing noise, and detecting significant relationships between variables. During PCA analysis, combinations of variables that maximize the variance in the data are sought, leading to the extraction of the main sources of variability in the dataset.



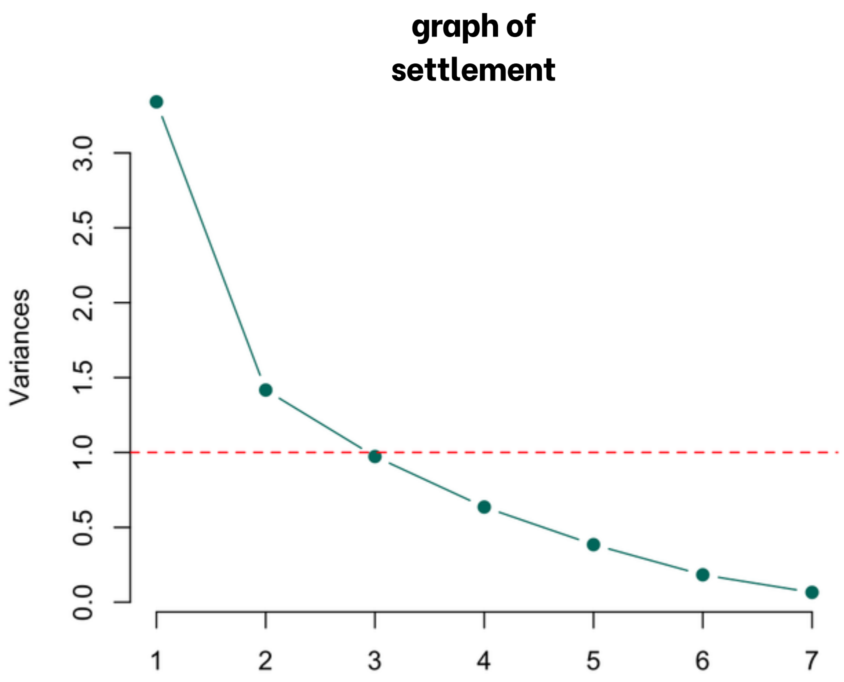
Based on the provided matrices, variables X2, X7, X9, X10, X12, X13, X14, and X15 were excluded.

Number of components

To determine the number of components for analysis, eigenvalues were computed for the previously selected 7 variables. Using **Kaiser's criterion** and **Cattell's rule**, it was decided to choose two components, which together explain approximately 68% of the variability.

Eigenvalues

Value number	eigenvalue	% of total variance	Cumulative eigenvalue	cumulative %
1	3,3412	47,7318	3,3412	47,7318
2	1,4168	20,2405	4,7581	67,9723
3	0,9731	13,9007	5,7311	81,8731
4	0,6355	9,0786	6,3666	90,9517
5	0,3845	5,4930	6,7511	96,4447
6	0,1830	2,6148	6,9342	99,0595
7	0,0658	0,9405	7,0000	100,0000

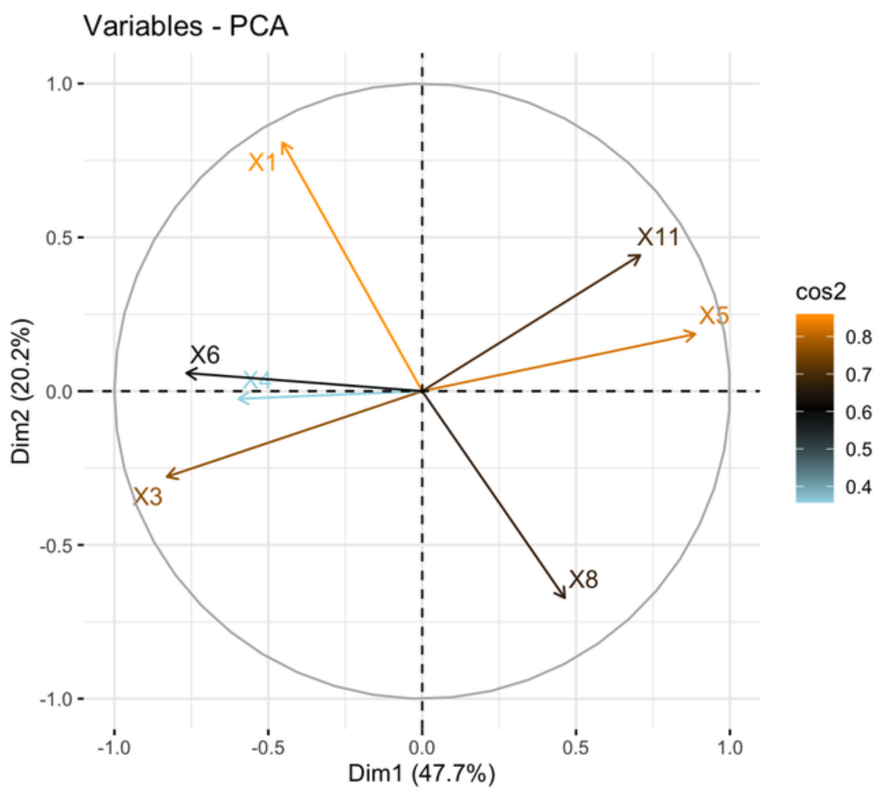


Character of components

To examine the nature of the selected components and how they interact with the units, eigenvectors of the correlation matrix and factor scores were calculated. In the next step, variables were projected onto the plane of components 1 x 2.

	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7
X1	**-0,248**	**0,679**	0,061	-0,337	-0,147	0,539	-0,219
X3	**-0,454**	**-0,234**	0,305	-0,122	0,536	-0,113	-0,576
X4	**-0,327**	**-0,021**	-0,763	-0,175	-0,278	-0,342	-0,293
X5	**0,485**	**0,156**	0,248	0,192	-0,379	-0,252	-0,659
X6	**-0,419**	**0,050**	0,505	-0,222	-0,471	-0,469	0,277
X8	**0,253**	**-0,565**	0,057	-0,675	-0,252	0,294	-0,090
X11	**0,387**	**0,371**	-0,049	-0,547	0,430	-0,459	0,124

	Component 1	Component 2	Component 3	Component 4	Component 5	Component 6	Component 7
X1	**0,454**	**0,808**	0,061	0,269	0,091	0,23	0,056
X3	**0,830**	**-0,278**	0,3	0,097	-0,333	-0,048	0,148
X4	**0,597**	**-0,025**	-0,752	0,14	0,173	-0,146	0,075
X5	**-0,887**	**0,186**	0,244	-0,153	0,235	-0,108	0,169
X6	**0,766**	**0,059**	0,498	0,177	0,292	-0,2	-0,071
X8	**-0,463**	**-0,672**	0,056	0,538	0,156	0,126	0,023
X11	**-0,708**	**0,442**	-0,048	0,436	-0,266	-0,196	-0,032



Principal components

Based on the eigenvectors and factor coordinates, principal component equations were determined. The most significant variables in these components were also identified. The first equation is primarily related to the source of energy production, particularly the share of renewable energy sources and fossil fuels in the energy mix. The second equation is mainly associated with energy consumption, including final energy consumption and the percentage of the population unable to heat their homes due to poverty.

energy mix

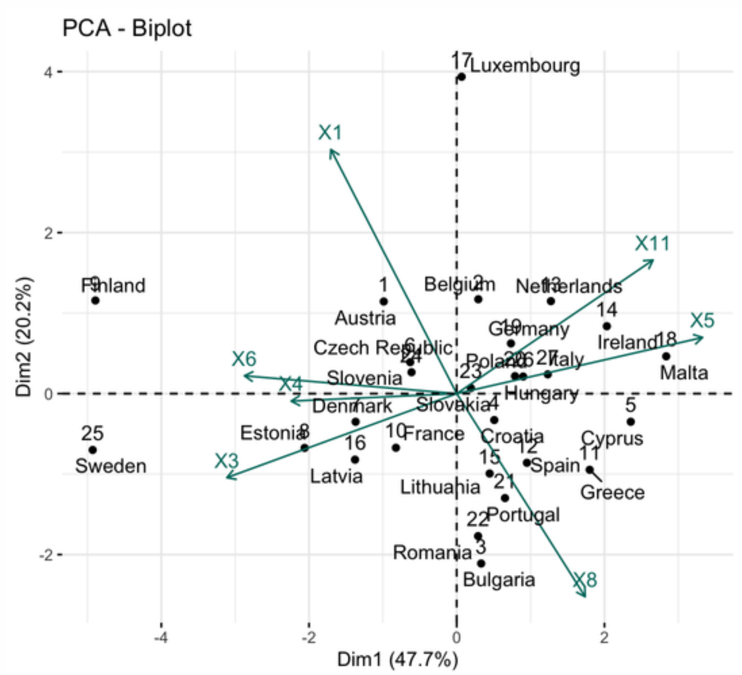
$$Y1 = -0{,}248\,X1 \mathbf{\;-\;0{,}454\,X3} - 0{,}327\,X4 \mathbf{\;+\;0{,}485\,X5} - 0{,}419\,X6 + 0{,}253\,X8 + 0{,}387\,X11$$

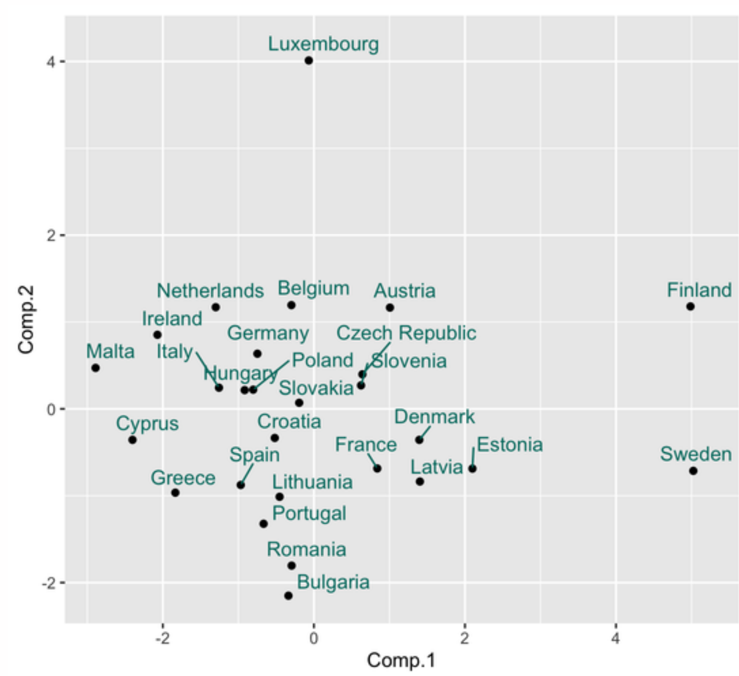
(0,454) **(0,830)** (0,597) **(-0,887)** (0,766) (-0,463) (-0,708)

energy consumption

$$Y2 = \mathbf{0{,}679\,X1} - 0{,}234\,X3 - 0{,}021\,X4 + 0{,}156\,X5 + 0{,}050\,X6 \mathbf{\;-\;0{,}565\,X8} + 0{,}371\,X11$$

(0,808) (-0,278) (-0,025) (0,186) (0,059) **(-0,672)** (0,442)





In the case of principal component analysis, it's challenging to unequivocally determine the best units. It all depends on the perspective we choose in interpreting the results. One country that deserves attention is **Sweden**, which stands out from other units due to its high share of renewable energy sources (X3), low share of fossil fuels (X5), and a small percentage of energy-poor households (X8).

Cluster analysis

Introduction

Cluster analysis is a data analysis technique aimed at dividing a dataset into groups (clusters) of similar objects. The main goal of cluster analysis is to find natural divisions in the data that allow for the identification of patterns and structures within the dataset. During cluster analysis, objects are grouped based on their similarity, where similarity is determined by a measure of distance or similarity between the features of the objects.

To conduct this analysis in the project, three **hierarchical clustering methods** were utilized:

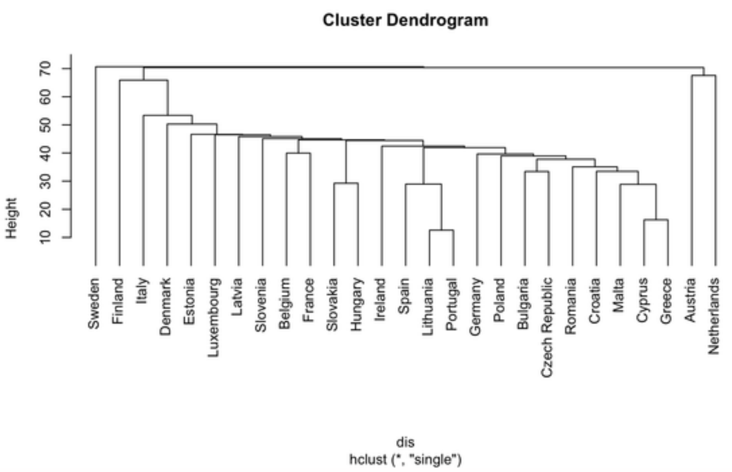
- **Euclidean distance** method
- method of **squared Euclidean distances**
- **Manhattan Distance** method

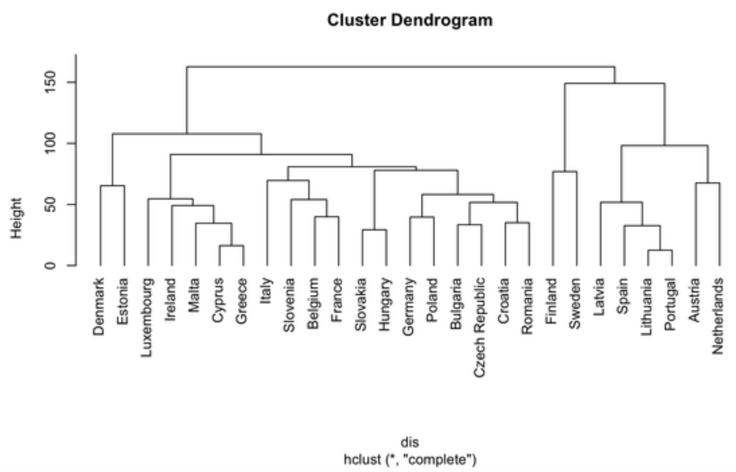
In order to improve the readability of the matrix, the following abbreviations for countries have been used:

- Belgium (BE) Greece (EL) Lithuania (LT) Portugal (PT)
- Bulgaria (BG) Spain (ES) Luxembourg (LU) Romania (RO)
- Czechia (CZ) France (FR) Hungary (HU) Slovenia (SI)
- Denmark (DK) Croatia (HR) Malta (MT) Slovakia (SK)
- Germany (DE) Italy (IT) Netherlands (NL) Finland (FI)
- Estonia (EE) Cyprus (CY) Austria (AT) Sweden (SE)
- Ireland (IE) Latvia (LV) Poland (PL)

Euclidean distance

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	EL	ES	NL	IE	LT	LV	LU	MT	DE	PL	PT	RO	SK	SI	SE	HU	IT
AT	0.00	101.67	102.81	101.57	120.23	83.93	95.17	131.49	114.80	101.89	115.99	86.02	67.56	105.72	86.75	98.20	118.31	118.27	70.38	90.71	85.27	105.22	70.98	123.66	122.44	79.84	90.65
BE	101.67	0.00	56.23	60.32	65.61	47.48	82.74	99.62	105.62	39.96	64.16	63.38	114.53	52.05	62.89	88.00	70.13	70.70	47.11	59.57	61.61	66.32	69.41	54.01	92.12	59.54	56.12
BG	102.81	56.23	0.00	51.67	78.71	33.43	77.54	69.87	96.58	48.27	67.76	65.51	115.64	65.42	53.62	66.38	89.68	87.25	56.85	38.97	54.81	37.81	73.49	60.51	77.06	59.64	80.86
HR	101.57	60.32	51.67	0.00	46.00	51.40	54.07	67.67	127.53	62.66	33.48	83.71	128.64	45.92	62.65	88.50	58.87	52.72	52.20	49.37	62.18	35.08	64.72	45.60	94.18	44.46	69.25
CY	120.23	65.61	78.71	46.00	0.00	79.28	79.40	96.24	150.12	85.98	16.26	93.03	142.34	42.45	78.11	115.96	46.50	28.87	65.92	72.12	77.15	66.94	84.80	66.19	124.31	70.22	73.69
CZ	83.93	47.48	33.43	51.40	79.28	0.00	62.66	72.92	96.93	44.66	70.22	67.23	107.25	64.33	61.62	73.53	83.62	84.86	44.46	40.44	60.63	40.70	53.26	61.24	77.63	45.07	72.81
DK	95.17	82.74	77.54	54.07	79.40	62.66	0.00	65.36	133.35	76.34	69.43	105.14	142.69	80.97	91.27	104.94	82.42	89.87	67.25	78.02	88.33	50.29	68.82	70.58	90.56	66.32	84.10
EE	131.49	99.62	69.87	67.67	96.24	72.92	65.36	0.00	129.88	89.88	82.23	117.36	162.70	96.65	99.53	102.14	99.05	107.65	92.58	74.77	99.79	46.64	106.99	73.21	88.88	94.94	107.80
FI	114.80	105.62	96.58	127.53	150.12	96.93	133.35	129.88	0.00	98.15	143.17	83.30	115.18	129.08	87.44	65.90	142.90	158.78	106.19	103.79	90.04	120.18	129.60	127.25	76.92	128.22	126.25
FR	101.89	39.96	48.27	62.66	85.98	44.66	76.34	89.88	98.15	0.00	78.04	78.04	121.82	74.11	71.04	84.91	88.68	90.49	61.53	68.01	71.57	60.59	65.77	45.12	70.66	58.24	66.18
EL	115.99	64.16	67.76	33.48	16.26	70.22	69.43	82.23	143.17	78.04	0.00	90.63	140.61	42.99	72.79	107.94	49.70	34.65	62.35	63.96	72.26	53.19	79.20	56.76	113.90	63.41	71.82
ES	86.02	63.38	65.51	83.71	93.03	67.23	105.14	117.36	83.30	78.04	90.63	0.00	76.77	67.23	32.64	51.76	101.66	99.21	49.08	55.30	28.94	84.95	93.13	100.94	102.65	84.12	77.79
NL	67.56	114.53	115.64	128.64	142.34	107.25	142.69	162.70	115.18	121.82	140.61	76.77	0.00	116.30	90.04	96.30	144.06	137.06	88.91	98.69	89.25	132.46	109.72	148.32	149.09	108.14	107.56
IE	105.72	52.05	65.42	45.92	42.45	64.33	80.97	96.65	129.08	74.11	42.99	67.23	116.30	0.00	57.86	90.51	54.36	49.11	44.42	49.51	55.43	62.54	81.49	68.41	113.51	61.88	65.28
LT	86.75	62.89	53.62	62.65	78.11	61.62	91.27	99.53	87.44	71.04	72.79	32.64	90.04	57.86	0.00	46.57	85.92	85.90	45.40	44.82	12.58	69.63	86.27	84.17	92.86	73.56	72.37
LV	98.20	88.00	66.38	88.50	115.96	73.53	104.94	102.14	65.90	84.91	107.94	51.76	96.30	90.51	46.57	0.00	118.83	123.94	72.06	61.12	45.84	83.34	108.79	104.10	82.26	96.80	98.20
LU	118.31	70.13	89.68	58.87	46.50	83.62	82.42	99.05	142.90	88.68	49.70	101.66	144.06	54.36	85.92	118.83	0.00	54.62	71.17	81.01	88.16	80.26	90.90	70.23	119.58	77.97	82.77
MT	118.27	70.70	87.25	52.72	28.87	84.86	89.87	107.65	158.78	90.49	34.65	99.21	137.06	49.11	85.90	123.94	54.62	0.00	69.95	77.12	85.35	77.34	82.04	70.99	135.47	65.70	72.08
DE	70.38	47.11	56.85	52.20	65.92	44.46	67.25	92.58	106.19	61.53	62.35	49.08	88.91	44.42	45.40	72.06	71.17	69.95	0.00	39.65	41.91	58.16	63.53	74.31	97.57	52.05	53.38
PL	90.71	59.57	38.97	49.37	72.12	40.44	78.02	74.77	103.79	68.01	63.96	55.30	98.69	49.51	44.82	61.12	81.01	77.12	39.65	0.00	43.93	44.59	77.96	72.59	97.35	59.43	69.51
PT	85.27	61.61	54.81	62.18	77.15	60.63	88.33	99.79	90.04	71.57	72.26	28.94	89.25	55.43	12.58	45.84	88.16	85.35	41.91	43.93	0.00	68.16	85.30	85.15	93.12	72.56	70.21
RO	105.22	66.32	37.81	35.08	66.94	40.70	50.29	46.64	120.18	60.59	53.19	84.95	132.46	62.54	69.63	83.34	80.26	77.34	58.16	44.59	68.16	0.00	71.82	53.40	86.10	56.14	77.48
SK	70.98	69.41	73.49	64.72	84.80	53.26	68.82	106.99	129.60	65.77	79.20	93.13	109.72	81.49	86.27	108.79	90.90	82.04	63.53	77.96	85.30	71.82	0.00	78.58	107.33	29.26	78.36
SI	123.66	54.01	60.51	45.60	66.19	61.24	70.58	73.21	127.25	45.12	56.76	100.94	148.32	68.41	84.17	104.10	70.23	70.99	74.31	72.59	85.15	53.40	78.58	0.00	87.81	63.61	69.62
SE	122.44	92.12	77.06	94.18	124.31	77.63	90.56	88.88	76.92	70.66	113.90	102.65	149.09	113.51	92.86	82.26	119.58	135.47	97.57	97.35	93.12	86.10	107.33	87.81	0.00	104.07	119.06
HU	79.84	59.54	59.64	44.46	70.22	45.07	66.32	94.94	128.22	58.24	63.41	84.12	108.14	61.88	73.56	96.80	77.97	65.70	52.05	59.43	72.56	56.14	29.26	63.61	104.07	0.00	68.13
IT	90.65	56.12	80.86	69.25	73.69	72.81	84.10	107.80	126.25	66.18	71.82	77.79	107.56	65.28	72.37	98.20	82.77	72.08	53.38	69.51	70.21	77.48	78.36	69.62	119.06	68.13	0.00



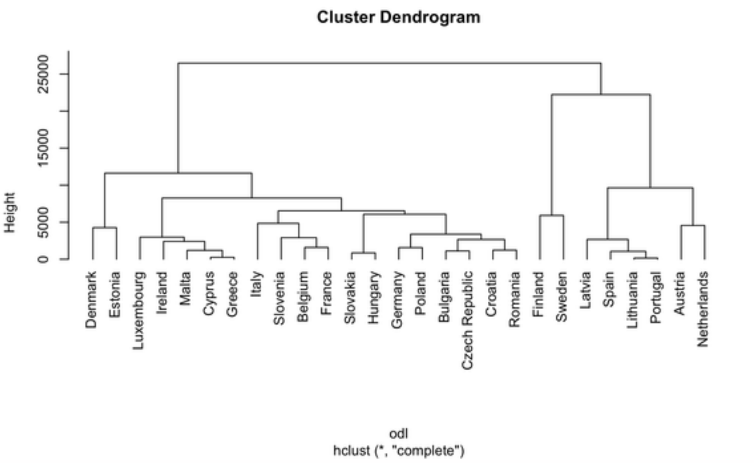


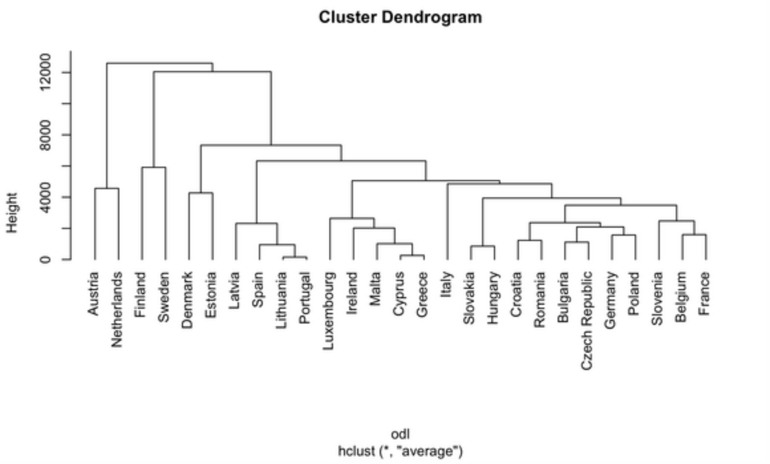
Based on Euclidean distances, three distinct clusters can be identified as follows:

- Sweden
- Austria and the Netherlands
- Other countries

Squared Euclidean distances

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	EL	ES	NL	IE	LT	LV	LU	MT	DE	PL	PT	RO	SK	SI	SE	HU	IT
AT	0	10336	10570	10316	14455	7045	9057	17291	13180	10382	13453	7399	4565	11177	7526	9644	13998	13987	4953	8229	7271	11071	5038	15291	14992	6374	8217
BE	10336	0	3162	3639	4304	2254	6845	9924	11155	1597	4116	4016	13118	2710	3955	7744	4919	4999	2219	3548	3795	4399	4818	2918	8487	3545	3150
BG	10570	3162	0	2670	6196	1117	6013	4881	9328	2330	4592	4292	13372	4280	2875	4407	8042	7613	3232	1518	3005	1429	5401	3661	5938	3556	6538
HR	10316	3639	2670	0	2116	2642	2923	4580	16263	3926	1121	7007	16547	2109	3925	7831	3466	2779	2725	2437	3866	1230	4188	2080	8869	1977	4796
CY	14455	4304	6196	2116	0	6285	6305	9263	22537	7392	265	8654	20262	1802	6101	13448	2163	834	4345	5202	5951	4481	7191	4381	15453	4931	5431
CZ	7045	2254	1117	2642	6285	0	3926	5318	9395	1994	4931	4520	11503	4139	3797	5406	6992	7202	1977	1635	3676	1656	2836	3750	6027	2031	5301
DK	9057	6845	6013	2923	6305	3926	0	4272	17781	5828	4821	11054	20361	6556	8329	11012	6793	8077	4523	6087	7802	2529	4736	4982	8201	4398	7073
EE	17291	9924	4881	4580	9263	5318	4272	0	16870	8078	6762	13772	26472	9340	9906	10432	9811	11589	8571	5590	9959	2175	11447	5359	7900	9014	11621
FI	13180	11155	9328	16263	22537	9395	17781	16870	0	9633	20498	6939	13267	16662	7645	4343	20422	25210	11276	10772	8106	14444	16797	16192	5917	16440	15939
FR	10382	1597	2330	3926	7392	1994	5828	8078	9633	0	6090	6091	14839	5492	5047	7209	7863	8188	3785	4626	5122	3671	4325	2036	4993	3391	4380
EL	13453	4116	4592	1121	265	4931	4821	6762	20498	6090	0	8214	19772	1848	5298	11650	2470	1200	3887	4091	5221	2829	6273	3222	12973	4021	5159
ES	7399	4016	4292	7007	8654	4520	11054	13772	6939	6091	8214	0	5894	4519	1065	2679	10334	9843	2409	3058	838	7216	8674	10188	10537	7075	6051
NL	4565	13118	13372	16547	20262	11503	20361	26472	13267	14839	19772	5894	0	13527	8107	9273	20753	18785	7904	9741	7966	17544	12039	21999	22228	11695	11568
IE	11177	2710	4280	2109	1802	4139	6556	9340	16662	5492	1848	4519	13527	0	3347	8193	2955	2412	1973	2452	3072	3912	6640	4680	12885	3829	4261
LT	7526	3955	2875	3925	6101	3797	8329	9906	7645	5047	5298	1065	8107	3347	0	2169	7382	7379	2061	2009	158	4848	7443	7085	8624	5411	5237
LV	9644	7744	4407	7831	13448	5406	11012	10432	4343	7209	11650	2679	9273	8193	2169	0	14119	15361	5193	3735	2101	6945	11835	10838	6766	9370	9644
LU	13998	4919	8042	3466	2163	6992	6793	9811	20422	7863	2470	10334	20753	2955	7382	14119	0	2983	5065	6563	7772	6442	8263	4932	14299	6080	6851
MT	13987	4999	7613	2779	834	7202	8077	11589	25210	8188	1200	9843	18785	2412	7379	15361	2983	0	4893	5948	7284	5981	6730	5039	18353	4316	5196
DE	4953	2219	3232	2725	4345	1977	4523	8571	11276	3785	3887	2409	7904	1973	2061	5193	5065	4893	0	1572	1757	3383	4036	5523	9519	2709	2849
PL	8229	3548	1518	2437	5202	1635	6087	5590	10772	4626	4091	3058	9741	2452	2009	3735	6563	5948	1572	0	1930	1989	6077	5269	9477	3532	4831
PT	7271	3795	3005	3866	5951	3676	7802	9959	8106	5122	5221	838	7966	3072	158	2101	7772	7284	1757	1930	0	4646	7276	7251	8671	5265	4930
RO	11071	4399	1429	1230	4481	1656	2529	2175	14444	3671	2829	7216	17544	3912	4848	6945	6442	5981	3383	1989	4646	0	5159	2851	7412	3152	6003
SK	5038	4818	5401	4188	7191	2836	4736	11447	16797	4325	6273	8674	12039	6640	7443	11835	8263	6730	4036	6077	7276	5159	0	6174	11520	856	6140
SI	15291	2918	3661	2080	4381	3750	4982	5359	16192	2036	3222	10188	21999	4680	7085	10838	4932	5039	5523	5269	7251	2851	6174	0	7711	4046	4846
SE	14992	8487	5938	8869	15453	6027	8201	7900	5917	4993	12973	10537	22228	12885	8624	6766	14299	18353	9519	9477	8671	7412	11520	7711	0	10830	14174
HU	6374	3545	3556	1977	4931	2031	4398	9014	16440	3391	4021	7075	11695	3829	5411	9370	6080	4316	2709	3532	5265	3152	856	4046	10830	0	4642
IT	8217	3150	6538	4796	5430	5301	7073	11621	15939	4380	5159	6051	11568	4261	5237	9644	6851	5196	2849	4831	4930	6003	6140	4846	14174	4642	0



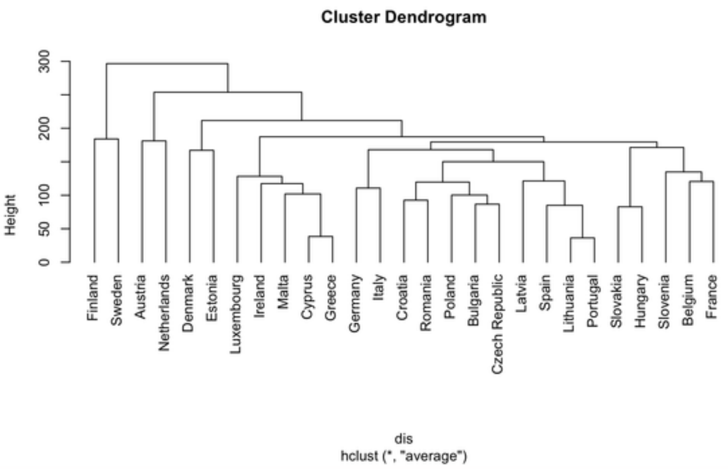


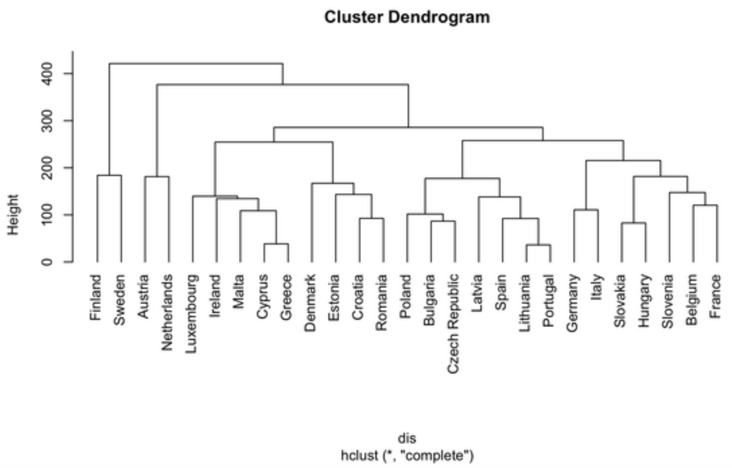
Based on squared Euclidean distances, three distinct clusters can be identified as follows:

- Finland and Sweden
- Austria and the Netherlands
- Other countries

Manhattan distance

	AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	EL	ES	NL	IE	LT	LV	LU	MT	DE	PL	PT	RO	SK	SI	SE	HU	IT
AT	0.0	257.8	286.4	234.0	289.8	224.1	225.3	282.7	305.4	279.7	264.6	201.7	181.2	250.3	170.9	225.5	269.3	319.1	172.2	228.5	162.9	261.4	194.4	315.5	294.2	217.3	234.9
BE	257.8	0.0	163.3	167.5	185.2	128.7	257.8	265.5	284.3	120.6	181.2	149.0	269.8	137.6	187.8	249.2	202.7	197.7	134.1	168.2	175.3	192.5	165.2	147.5	248.2	167.8	140.4
BG	286.4	163.3	0.0	137.2	189.9	86.7	234.6	192.4	266.9	155.5	159.8	153.4	296.1	198.8	135.8	162.9	253.5	226.2	175.3	101.8	133.5	99.0	169.5	160.7	225.9	163.7	215.1
HR	234.0	167.5	137.2	0.0	122.2	146.8	157.8	143.5	315.9	168.2	97.9	168.2	272.3	135.0	119.7	166.9	167.9	124.6	144.5	113.0	117.8	92.6	143.1	114.7	280.6	113.5	175.1
CY	289.8	185.2	189.9	122.2	0.0	205.0	213.5	181.9	389.1	231.1	38.5	168.8	282.0	107.5	164.5	242.0	114.1	95.1	168.5	153.3	152.2	145.7	202.6	170.9	339.3	201.8	173.6
CZ	224.1	128.7	86.7	146.8	205.0	0.0	172.4	191.0	252.1	135.0	189.3	167.4	266.1	177.5	176.7	177.3	227.1	235.0	125.9	98.8	169.7	107.8	122.9	164.1	207.2	133.3	163.3
DK	225.3	257.8	234.6	157.8	213.5	172.4	0.0	167.2	328.6	223.3	195.4	257.9	318.7	231.5	230.1	204.9	210.6	254.6	181.3	202.4	223.3	164.2	209.4	202.7	260.8	203.6	233.6
EE	282.7	265.5	192.4	143.5	181.9	191.0	167.2	0.0	284.2	266.0	157.0	257.4	376.6	226.8	207.0	182.0	202.8	232.1	241.1	177.8	200.9	133.2	264.1	179.4	234.7	246.5	276.0
FI	305.4	284.3	266.9	315.9	389.1	252.1	328.6	284.2	0.0	254.2	361.2	257.0	335.3	362.2	254.8	159.4	360.1	421.3	319.3	279.6	260.3	309.1	341.9	288.2	184.0	351.7	386.7
FR	279.7	120.6	155.5	168.2	231.1	135.0	223.3	266.0	254.2	0.0	214.0	207.8	308.1	203.7	208.6	216.5	258.8	251.5	169.0	179.0	202.5	173.0	169.6	122.2	202.7	181.6	170.6
EL	264.6	181.2	159.8	97.9	38.5	189.3	195.4	157.0	361.2	214.0	0.0	146.9	270.9	110.2	134.0	216.3	119.8	108.8	154.9	137.8	118.4	113.0	187.8	154.2	318.4	185.9	160.7
ES	201.7	149.0	153.4	168.2	168.8	167.4	257.9	257.4	257.0	207.8	146.9	0.0	195.6	166.9	92.3	138.1	222.5	224.6	127.0	146.7	77.7	160.5	216.6	230.1	298.8	206.0	170.4
NL	181.2	269.8	296.1	272.3	282.0	266.1	318.7	376.6	335.3	308.1	270.9	195.6	0.0	236.3	227.2	248.4	289.5	271.6	182.3	216.9	228.8	311.8	232.7	334.4	417.6	232.4	240.0
IE	250.3	137.6	198.8	135.0	107.5	177.5	231.5	226.8	362.2	203.7	110.2	166.9	236.3	0.0	165.7	221.4	139.7	134.6	137.9	130.4	155.1	175.7	193.8	202.1	300.8	167.6	152.3
LT	170.9	187.8	135.8	119.7	164.5	176.7	230.1	207.0	254.8	208.6	134.0	92.3	227.2	165.7	0.0	110.9	212.0	214.5	146.3	118.2	36.3	156.7	198.3	196.1	272.3	192.8	188.8
LV	225.5	249.2	162.9	166.9	242.0	177.3	204.9	182.0	159.4	216.5	216.3	138.1	248.4	221.4	110.9	0.0	271.3	285.7	202.0	134.9	114.9	171.8	252.2	215.6	217.1	247.5	257.8
LU	269.3	202.7	253.5	167.9	114.1	227.1	210.6	202.8	360.1	258.8	119.8	222.5	289.5	139.7	212.0	271.3	0.0	139.6	192.7	200.0	215.4	205.0	248.6	200.0	320.7	232.1	218.6
MT	319.1	197.7	226.2	124.6	95.1	235.0	254.6	232.1	421.3	251.5	108.8	224.6	271.6	134.6	214.5	285.7	139.6	0.0	199.9	166.2	213.0	183.7	216.7	189.8	394.6	180.8	199.5
DE	172.2	134.1	175.3	144.5	168.5	125.9	181.3	241.1	319.3	169.0	154.9	127.0	182.3	137.9	146.3	202.0	192.7	199.9	0.0	115.1	128.9	162.6	179.7	215.4	263.7	162.5	110.7
PL	228.5	168.2	101.8	113.0	153.3	98.8	202.4	177.8	279.6	179.0	137.8	146.7	216.9	130.4	118.2	134.9	200.0	166.2	115.1	0.0	122.3	114.0	182.0	187.8	259.1	161.9	165.2
PT	162.9	175.3	133.5	117.8	152.2	169.7	223.3	200.9	260.3	202.5	118.4	77.7	228.8	155.1	36.3	114.9	215.4	213.0	128.9	122.3	0.0	141.6	203.1	208.3	268.9	196.8	174.9
RO	261.4	192.5	99.0	92.6	145.7	107.8	164.2	133.2	309.1	173.0	113.0	160.5	311.8	175.7	156.7	171.8	205.0	183.7	162.6	114.0	141.6	0.0	170.4	168.2	244.6	158.9	186.3
SK	194.4	165.2	169.5	143.1	202.6	122.9	209.4	264.1	341.9	169.6	187.8	216.6	232.7	193.8	198.3	252.2	248.6	216.7	179.7	182.0	203.1	170.4	0.0	173.5	301.3	82.8	203.2
SI	315.5	147.5	160.7	114.7	170.9	164.1	202.7	179.4	288.2	122.2	154.2	230.1	334.4	202.1	196.1	215.6	200.0	189.8	215.4	187.8	208.3	168.2	173.5	0.0	265.3	170.8	211.1
SE	294.2	248.2	225.9	280.6	339.3	207.2	260.8	234.7	184.0	202.7	318.4	298.8	417.6	300.8	272.3	217.1	320.7	394.6	263.7	259.1	268.9	244.6	301.3	265.3	0.0	314.8	345.0
HU	217.3	167.8	163.7	113.5	201.8	133.3	203.6	246.5	351.7	181.6	185.9	206.0	232.4	167.6	192.8	247.5	232.1	180.8	162.5	161.9	196.8	158.9	82.8	170.8	314.8	0.0	185.8
IT	234.9	140.4	215.1	175.1	173.6	163.3	233.6	276.0	386.7	170.6	160.7	170.4	240.0	152.3	188.8	257.8	218.6	199.5	110.7	165.2	174.9	186.3	203.2	211.1	345.0	185.8	0.0





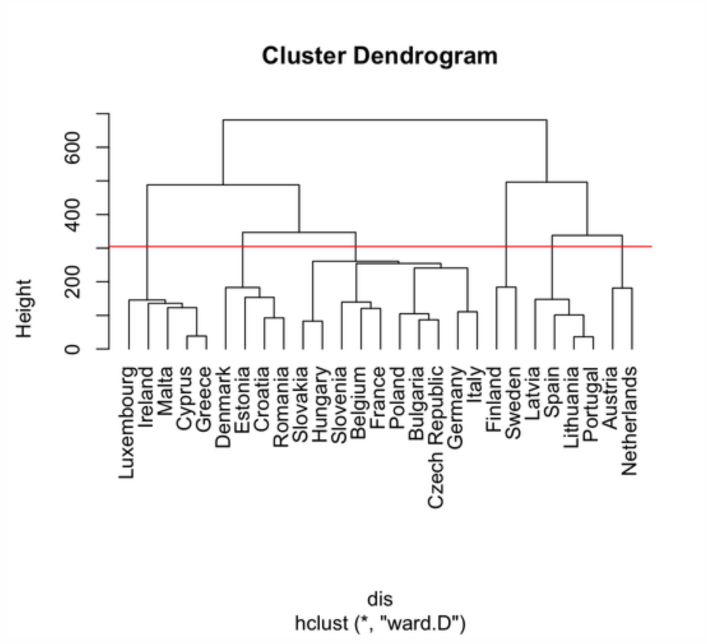
Based on Manhattan distances, three distinct clusters can be identified as follows:

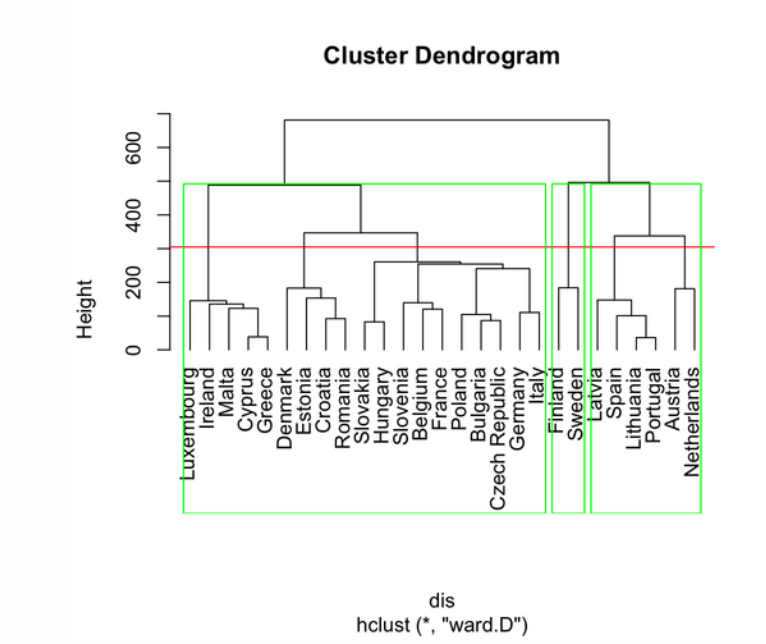
1. Finland and Sweden
2. Austria and the Netherlands
3. Other countries

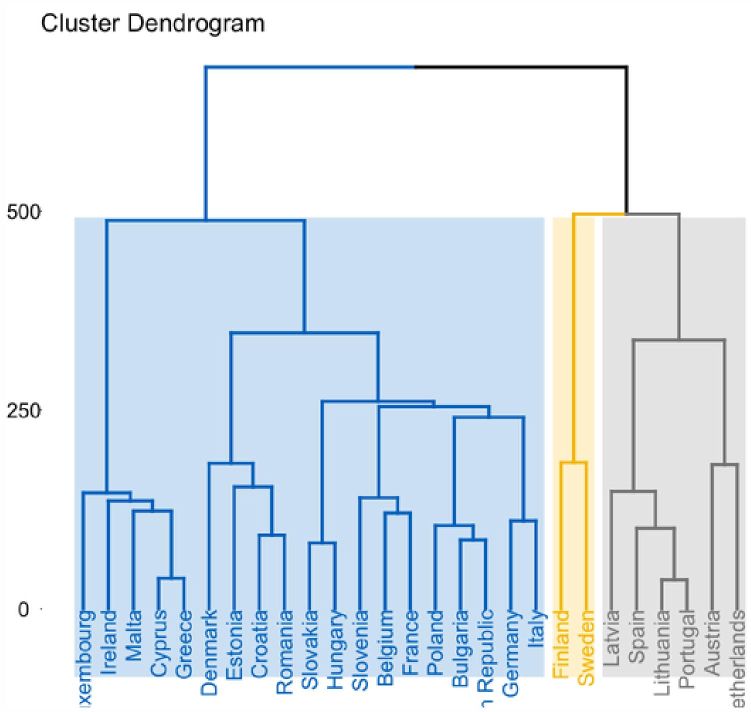
Division into clusters

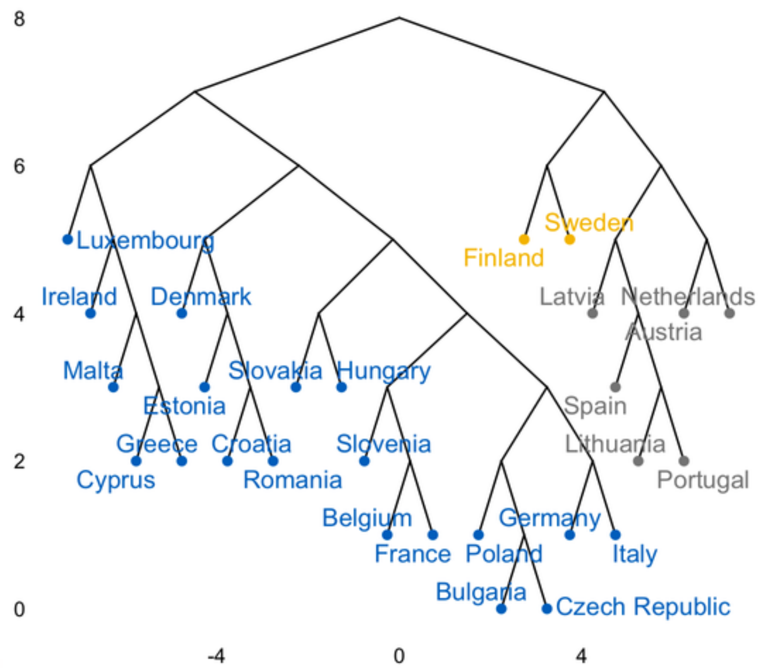
In the first step, the Mojen criterion was applied to unambiguously divide the units into 3 clusters. This resulted in the following clusters:

1. Latvia, Spain, Lithuania, Portugal, Austria, Netherlands
2. …
3. Finland and Sweden



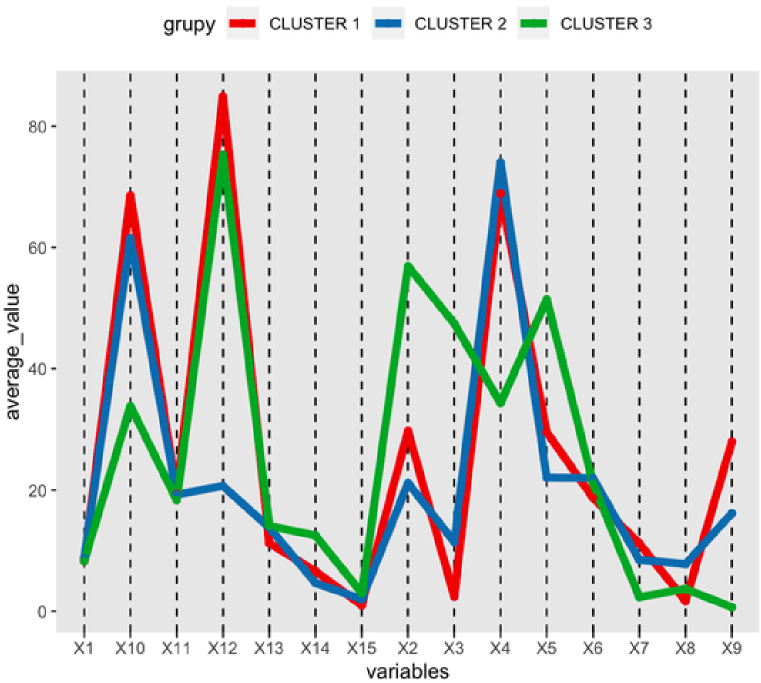


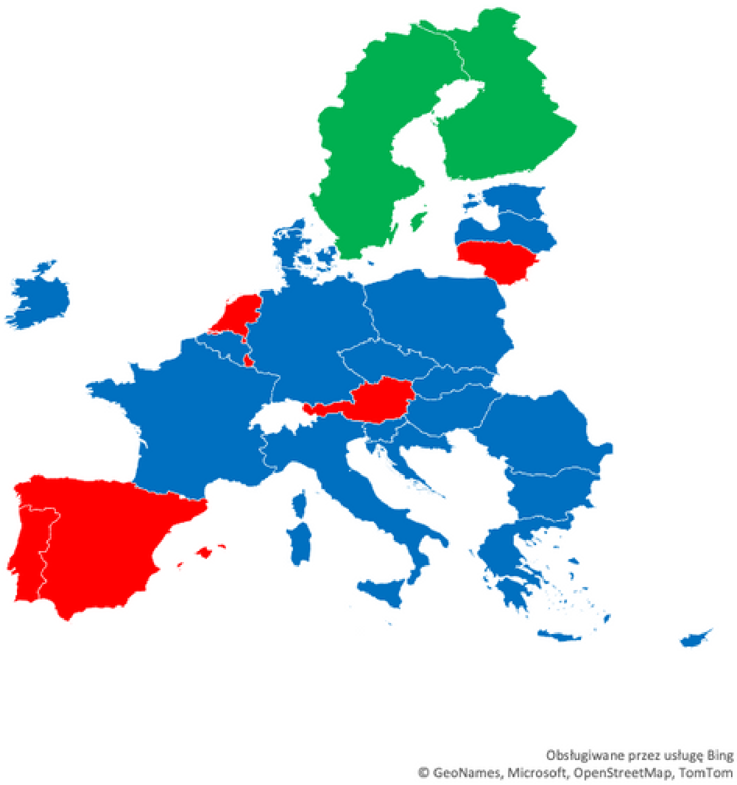




Division into clusters

In the next step, the **k-means method** was used, resulting in 3 identical clusters. Based on this, an average plot for each cluster was created.





Cluster 3, comprising **Sweden and Finland**, can be decisively considered as states characterized by the best indicators here because:

- They are less dependent on energy imports (X11).
- They have a high capacity for biofuel production (X13).
- They significantly differ from others in terms of the share of renewable energy sources (X3), energy production from nuclear power plants (X4), and a smaller share of fossil fuels (X5).
- They also have a larger share of the environmental goods and services sector in GDP (X6).
- There is a smaller proportion of the population unable to heat their homes due to poverty (X8).

Cluster's 1 advantage lies in:

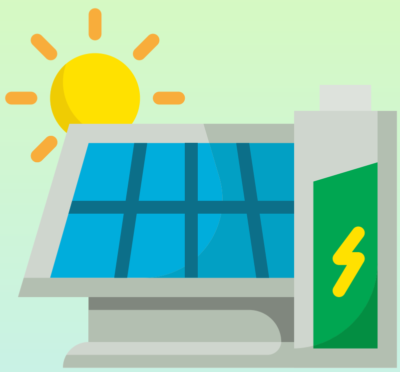
- Very high biofuel production capacity (X13).
- A larger gas reserve compared to other countries (X10).

Summary

Energy security

In conclusion, the analysis regarding energy security in the European Union countries, it is worth taking a closer look at the key aspects of this issue, especially in the context of the current energy crisis, which has escalated due to Russia's aggression against Ukraine.

Energy security now becomes even more significant due to the instability of supplies, increased dependency on imports, and growing risks of disruptions in energy distribution networks.



Analyses conducted

The analysis based on various methods such as linear ordering, principal component analysis, and cluster analysis has enabled a comprehensive assessment of the situation and identification of areas requiring urgent action.

Among the key variables analyzed during this process were the share of renewable energy, the share of fossil fuels, energy import dependency, energy consumption, and the number of people unable to heat their homes.

Results and conclusions

The European Union countries that stood out with the best energy security indicators are primarily **Sweden**, thanks to its developed energy infrastructure and high share of renewable energy. Next, attention should be paid to **Finland, Austria**, and the **Netherlands**, which also demonstrate stable energy security indicators.

However, in the face of the current energy crisis, decisive actions are necessary at both national and international levels to increase energy independence and diversify energy sources. This is crucial to minimize the risk of supply disruptions and ensure economic and social stability.

Sources

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