Technical University of Cluj-Napoca

Sustainable Energy and Climate Action Plan

2023

Signature Sheet:

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Beneficiary: Technical University of Cluj-Napoca

Times Higher Education
Impact Rankings
SDG7 AFFORDABLE AND CLEAN ENERGY
2023 **TOP 400**

Times Higher Education
Impact Rankings
SDG4 QUALITY EDUCATION
2023 **TOP 300**

Executive Summary

Up to date energy use:

Energy use		
2018	31.821	MWh/yr.
2023	31.285	MWh/yr.
	1.7%	reduction
	536	MWh

Up to date CO_2 emissions:

CO_2 emissions		
2018	6.936	tCO_2eq/yr.
2023	6.443	tCO_2eq/yr.
	7.6%	reduction
	528	tCO_2eq

In the las 5 years, the CO2 achieved emissions reduction is of 7.6%, i.e. 528 tons.

The Technical University of Cluj-Napoca is actively involved in the following project:

NetZeRoCities – National Competence Center for Intelligent and Carbon Neutral Cities:

Finanțat de Uniunea Europeană NextGenerationEU

PNRR: Fonduri pentru România modernă și reformată! Investiția I5. Înființarea și operaționalizarea Centrelor de Competență Număr contract: 760007 / 30.12.2022

Planul Național de Redresare și Reziliență

UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

ENTREC Energy Transition Research Center

entrec.utcluj.ro

NetZeRoCities

National Competence Centre and solutions for the development of ***Climate Neutral and Smart Cities***

Specific RDI project 2

Sustainable energy & environments

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SUMMARY

Energy efficiency and decarbonization are of considerable importance, confirmed by the management of the Technical University of Cluj-Napoca, through the measures, actions and solutions considered, including by assuming a programme of access (non)refundable funding and implementation of the priority projects outlined in the plan of this documentation.

Through energy efficiency at the level of the higher education institution, the Cluj-Napoca urban community and even extended to the metropolitan area and county level, we understand a determining factor for intelligent, healthy and sustainable economic growth, with a major impact in local urban development.

By energy efficiency at the level of buildings, we mean reducing the need and rational use of energy, while at the same time ensuring a suitable thermal comfort, indoor air quality and indoor lighting in compliance with the lighting standards in force and by adding local renewable sources for self-consumption.

This action plan provides analyses and solutions on:

- ✓ The systematic promotion of an energy management, according to procedures, roles, tools, responsibilities and the assumption of performance indicators;
- ✓ Reducing demand and waste of energy;
- ✓ More efficient use of energy in all types of activity;
- ✓ Promoting the production of energy from renewable sources;
- ✓ Conservation and sustainable use of existing natural resources;
- ✓ The rational use of fossil fuels and their gradual elimination in the energy transition;
- ✓ Promoting public-private partnerships for increasing energy efficiency, introducing local renewable sources and decarbonization;
- ✓ Informing and motivating employees about how to use energy efficiently;

The Action Plan for Climate and Sustainable Energy (PACED) was prepared by the Technical University of Cluj-Napoca as a key document defining energy policies for the next 10 years

with the aim of reducing CO_2 emissions by at least 80% throughout the UTCN contour. PACED 2030 also includes the Climate Change Adaptation Action Plan – PAASC, which summarizes response actions to mitigate the effects of climate change already felt or imminent at the local, national and global levels.

The reference year of the emissions inventory (GES) fixed for the values of 2018, contains the inventory of energy consumption in the building sector of the Technical University of Cluj-Napoca.

The analysis of energy consumption in the buildings included in PACED, allows the priority of measures and actions to be undertaken and thus, the following can be observed:

- ✓ The highest energy consumption is recorded among the buildings in Cluj-Napoca (81% of the total consumed), buildings of Baia Mare are in the second place with 14.8% of the consume, and the third place are the UTCN buildings from Zalău, with a much lower percentage, of only 1.8%.

  In decreasing order of energy consumption the hierarchy is completed with the buildings in Bistrița (1% of consumptions), the buildments in Satu Mare (0.9% of consums), the Buildings in Alba Iulia (0.5%) and the building in Marișel with 0.1% of the total energy consums of all buildings of the university.

Regarding energy carriers, it is noted that:

- natural gas is the main source of energy, accounting for 81% of the total energy consumption, being used mainly for heating of premises and for the preparation of hot water for households;
- electricity accounts for about 19% of total energy consumption and this share is expected to increase, especially for air conditioning and heating production;

A priority of action would be to find alternatives to natural gas, through the use of heat pumps and thermal solar panels.

For electricity, the promotion of energy production projects, necessary for consumption, through the use of local renewable energy sources will be identified.
CO_2 emissions corresponding to electricity consumption indicate a 20% share of the emissions produced.

Natural gas used for heating and preparing hot water for households is responsible for over 80% of total emissions.

It is required as a firm direction of action in PACED: local production of distributed electricity for self-consumption from renewable sources. One main argument is that in the field of building heating, we are witnessing in the current energy transition to electrification, with a positive impact in decarbonisation, at the same time that electricity becomes the predominant energy carrier, putting increased pressure on the production and food infrastructure.

1. INTRODUCTION

1.1. What is PACED?

The Action Plan for Climate and Sustainable Energy (PACED) is a medium and long-term strategic document that presents the vision for 2030 of local and institutional policies in the field of energy and the environment in order to the European Union's goal of reducing greenhouse gas emissions, by increasing energy efficiency, using renewable energy sources and adapting the locality to climate change.

It uses the results of the basic emission inventory to identify the best areas of action and opportunities to the greenhouse gas reduction target undertaken. The plan defines concrete measures to reduce energy consumption and CO2 emissions, otherwise deadlines, and allocated responsibilities, capable of translating the long-term strategy into action. PACED should not be seen as a fixed and rigid document, since circumstances are changing and as ongoing actions are yielding results and enabling experience, it is recommended that the plan be reviewed periodically.

1.2. PACED objectives

PACED must focus on measures aimed at reducing CO2 emissions and energy consumption by end users.

The main objectives of PACED are: - Limiting climate change, its costs and negative effects on society and the environment;

- Promotion of sustainable production and consumption patterns in buildings and other objectives;
- Improving management and avoiding over-exploitation of natural resources, recognizing the value of ecosystem services;
- Promoting good public health in a fair manner and improving protection against health threats;

- Creating a society of social inclusion by taking into account solidarity between and within generations, ensuring security and increasing the quality of life of citizens as a prerequisite forining individual well-being.

The Technical University of Cluj-Napoca intends to a reduction in CO_2 emissions at the institutional level by at least 60% by 2030, compared to the level of 2018.

1.3. Time horizon

The time horizon set is the year 2030, so the Action Plan for Climate and Sustainable Energy contains clear and detailed descriptions of the actions and measures that the Technical University of Cluj-Napoca intends to implement, to these goals by 2030. PACED can be developed for a longer period than 2030, but it is necessary to set intermediate targets.

1.4. Level of detail of PACED

The Action Plan for Climate and Sustainable Energy places great emphasis on solutions and measures aimed at reducing CO_2 emissions at the level of the buildings of the Technical University of Cluj-Napoca.

Thus, for each action, the following will be specified in a table:

- a brief description of the action;
- the cost estimate for each implementation period and overall;
- the main sources of financing (provisional);
- stakeholders.

The Action Plan for Climate and Sustainable Energy is simultaneously:

- a useful working tool, which must be used during its implementation;
- a communication tool in relation to the main stakeholders;

The level of detail must be sufficiently well outlined to highlight the concrete actions, the benefits obtained from them and the expected results.

1.5. Applicable legislation

Increasing energy performance in buildings and energy use targets is a strategic objective of national energy efficiency policies, as it contributes significantly to ensuring energy security, sustainable development, competitiveness and saving of primary energy resources and reducing CO2 emissions.

By energy efficiency at the level of urban communities and institutions, it is understood to be a determining factor for smart, healthy and sustainable economic growth. The development of the energy efficiency sector in Romania is closely linked to the dynamics of interventions by public, central and local authorities (particularly by attracting non-refundable funding from European funds), in the formulation of public policies, in line with national, European and international targets of reduction of energy consumption. **Law 121/ 2014** on energy efficiency, with its subsequent completions **(Law 160/2016 and OUG 184/2020,** as well as **OUG 1/2020, O.M. MEEMA 1726/2020, OM ME 64/2021)**, in accordance with article 2 (3) provides:

The National Energy Efficiency Policy defines the objectives for improving energy efficiency, indicative energy saving targets, related measures to improve energy efficiencies, in all sectors of the national economy, with special references on:

a) the introduction of high-energy efficiency technologies, modern measurement and control systems, as well as energy management systems, for monitoring, ongoing assessment of energy effectiveness and forecasting of energy consumption;
b) Promotion of the use of energy-efficient equipment and appliances, as well as renewable energy sources, by end consumers;
c) reducing the environmental impact of industrial activities and the production, transport, distribution and consumption of all forms of energy;
d) application of modern principles of energy management;
e) granting financial and fiscal incentives, in accordance with the law;
f) the development of the market for energy services.

Directive (EU) 2018/2002 of the European Parliament and of the Council amending European Directive 2012/27/EU on energy efficiency establishing a common framework of measures to promote energy efficiencies throughout the Union with a view to ensuring the achievement of the Union's main objectives in terms of energy effectiveness, of 20% by 2020, and of its main targets in the area of energy efficacy, of at least 32.5% by 2030, and to pave the way for future increases in energy efficience after these dates.

Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, which establishes that the share of renewables in the European Union's gross final energy consumption in 2030 is at least 32%. In line with the prospects of the European Union to build an energy policy, Romania has drawn up the Integrated National Plan in the field of Energy and Climate Change 2021-2030. Presentation of the main PNIESC objectives 2021 – 2030, at the level of 2030:

Prezentare generală a principalelor obiective a PNIESC 2021 – 2030, la nivelul anului 2030	
Emisii ETS (% față de 2005)	**-43,9%***
Emisii non-ETS (% față de 2005)	**-2%**
Ponderea globală a energiei din surse regenerabile în consumul final brut de energie	**30,7%**
↓	
Ponderea SRE-E	49,4%
Ponderea SRE-T	14,2%
Ponderea SRE-Î&R	33,0%
Eficiență Energetică (% față de proiecția PRIMES 2007 la nivelul anului 2030)	
Consum primar de energie	-45,1%
Consum final de energie	-40,4%

PNIESC objectives 2021-2030

Prezentare generală a principalelor obiective a PNIESC 2021 – 2030, la nivelul anului 2030	
Consum primar de energie (Mtep)	32,3
Consum final de energie (Mtep)	25,7

Overview of the main PNIESC objectives 2021-2030, at the level of 2030

Source: Analiză Deloitte pe baza documentelor oficiale elaborate de autoritățile implicate în elaborarea PNIESC.

1.6. Presentation of the Technical University

Today, more than 20,000 students study at the Technical University of Cluj-Napoca, led by approximately 1,000 teachers and scientific researchers, along with 888 members of the auxiliary and non-teaching teaching staff, which position it as the sixth largest university in Romania in terms of the number of students and the fourth in respect of the level of institutional funding. The university's educational offer includes 95 undergraduate programs, 103 master's programs, 14 doctoral fields, as well as continuing training, psychopedagogical training and post graduate academic studies.

Fundamental or applied scientific research, technological development and innovation position the University as one of the national universities of advanced education and research with broad visibility and national and international recognition. The research topics cover the fields of engineering, exact sciences and humanities and are addressed through 89 internally accredited research structures (Centres, Groups and Research Laboratories).

The material base of the University has expanded and diversified considerably, the buildings of the two university centers – Cluj-Napoca and Baia Mare – and of the 4 university extensions – Zalău, Satu Mare, Alba Iulia and Bistrița – totalling a total area of approximately 200,000 sq.m. The quality of the premises, as well as the energy performance of the buildings in the Campus (10 student hostels, 3 restaurants, 4 libraries, a bookstore and a printing house), has been continuously improved. In addition to these, the sports base comprising the swimming complex in Cluj-Napoca, two gyms and three sports fields for various activities, where at the level of energy efficiency, a number of intervention packages have been applied in recent years.

All these synthesized data undoubtedly highlight the fact that the Technical University of Cluj-Napoca today constitutes a modern, diverse and complex organization, both in terms of the human resources involved, those patrimonial, as well as the financial resources to be managed.

The Technical University of Cluj-Napoca recognizes and applies the value of the principles of sustainable development. Sustainable development implies a set of social, economic and environmental principles that enable the university to carry out all its specific activities within the society, meeting the requirements of the present and without compromising the ability of the new generations to meet their own requirements.

Also, thanks to the commitment and progress achieved, the Technical University of Cluj-Napoca is included in the world ranking of UI GreenMetric universities for energy and climate change, rising from position 641 in 2022 to position 527 in 2023.

This PACED document, is correlated with the Institutional Strategic Plan on Sustainable Development for the period 2024-2030, as an integral part of the professional activities of education, research, infrastructure development and university management, by creating a context based on awareness and involvement of the entire community in the University in its achievement.

The directions of action that support the implementation of the Strategic Plan for Sustainable Development are:

- Cultivating a culture of sustainable development oriented to the student, informed, current and with practical focus;
- The conscious involvement of the entire community (academic staff, students and administrative staff) in initiatives and actions on sustainable development, with the aim of becoming active citizens for a sustainable community;
- Efficiency and reduction of energy consumption in all buildings belonging to the university's heritage, through the adoption of an Action Plan for Climate and Sustainable Energy aimed at decarbonization by reducing the University's consumer footprint and increasing the degree of equipping the buildings with intelligent solutions and local renewable sources;
- Collaboration with various local groups and communities, especially with the municipalities in which the University has a presence, national and international to actively contribute to the creation of sustainable communities and participation in joint projects.

UTCN generic presentation

2. PRINCIPAL SECTIONS OF CONSUMING AND ENERGY USED

2.1. Building sector

Within UTCN, the building sector has the most impact in terms of energy consumption.

Energy consumption in UTCN buildings are determined by:

- Indoor and outdoor lighting installations;
- Heating systems;
- Household hot water preparation facilities;
- Ventilation and air conditioning;
- Office and electronic equipment.

In terms of final energy consumption, the following consumptions are recorded in buildings:

- Electricity consumption – for lighting, office, elevators, ventilation and air-conditioning, household appliances, other drives etc.
- Consumption of methane gas for own thermal plants – for heating and hot water for household use, especially in student homes.

2.2. Local production of energy from renewable sources

Renewable energy is widely available worldwide and can help reduce dependence on energy imports. One of the most important aspects of renewable energy is that it does not involve risks of rising costs to an unbearable level and also improves the security of energy supply.
SOLAR POTENTIAL

Currently, at the building level of the Technical University of Cluj-Napoca, solar energy is used at the level of public buildings, in a reduced proportion, so it is proposed to take into account the solar potential at building level, to ensure a basic consumption requirement. The conversion of solar energy into useful energy is achieved by the following ways:
Solar potential - photovoltaic cells

Photovoltaic cells				
Solar energy	→	Photovoltaic cells	→	Electricity
Photovoltaic cells are systems that convert solar energy into electricity. It is the most widespread technology worldwide.				
Return	10 - 25%			
Advantages	Technologies are constantly evolving			
	Pricable for both small and large capacities			
	Easy to install			
Disadvantages	Return still low			
	Requires large areas			
	Sensitive to external influences such as dust			
	High investment costs			
Solar Concentrators				
Solar energy	→	Concentrators	→	Electricity
Solar concentrators are solar radiation concentration systems with the purpose of heating a liquid and the resulting energy is converted into electricity through a generator.				
Return	15 - 25%			
Advantages	Using technologies available on the market			

	Due to the storage capacity of thermal energy, there is the possibility of conversion into electricity for a short period of time, when solar radiation is not available
Disadvantages	Use only direct radiation
	A system to track the position of the sun is required
	Priced for dry areas
	Priceable only for large capacities
	High investment costs

Solar potential - Solar thermal collectors

Solar thermal collectors				
Solar energy	→	Collectors	→	Thermal energy
Solar collectors are systems that convert solar radiation into thermal energy. There are different technologies widely used.				
Return	70%			
Advantages	Pricable for small and medium-sized systems			
	Low investment costs			
	Easy to install			
Disadvantages	Not pricable for high-capacity systems			
	High investment costs for the storage of thermal energy			

From the point of view of the theoretical potential in the area of Cluj-Napoca, according to statistical data related to "Photovoltaic Geographical Information System", part of the science and knowledge service of the European Commission, the average annual solar radiation is 1.303 kWh/m2/year.

Taking the optimal angle into account, a maximum potential of approximately 1.517 kWh/m2/year is obtained, above the theoretical potential of solar radiation on the horizontal plane. For the evaluation of the technical potential, the average efficiency of photovoltaic installations of about 23% will be taken into account, thus resulting in a technical potential of about 325 kWh/m2/year.

3. OBJECTIVES OF CLUJ-NAPOCA TECHNICAL UNIVERSITY

In the current context of climate change and the need to an energy transition towards decarbonization and an environment with low greenhouse gas emissions, in full agreement with the objectives, financial allocations and actions of decision makers in Romania and at European level, the following measures will be taken through the managerial programme undertaken:

- Coordination through the Technical Prorectorate, respectively through the General Administrative Directorate, of achieving an ambitious Action Plan for Climate and Sustainable Energy (PACED) for major renovation of UTCN buildings and of significant reduction in energy consumption and costs and greenhouse gas emissions;
- Coordination through the Financial Resources Management and Relationship with the socio-economic environment Prorectorates, of access and allocation of financial resources, priority non-refundable, as well as human resources for the significant increase of the comfort and energy efficiency of the building fund belonging to the University;
- Increase the level of awareness and involvement of the university and local community on the subject of energy efficiency and the transition to clean energy, through information campaigns, sensitization and training in the field.

Ambition:

- ✓ Technical University of Cluj-Napoca (UTCN) is the main promoter and provider of accredited courses and seminars to promote energy efficiency, renewable sources and the circular economy, at the national level;
- ✓ Through supported and developed research-innovation projects, UTCN will be a national leader in the field of sustainability and sustainable energy engineering and climate change;

Specific actions proposed:

- Tracking and attracting non-refundable funding from European, Norwegian, Swiss funds for major renovation projects of public buildings, to increase the interior comfort and energy performance of buildings in the financing period 2024 – 2027;

- Ensuring the participation of technical staff from the Technical Directorate and Building Administrators, in training sessions, awareness and competence development in the field of energy efficiency, through courses held in-house by members of the academic community, on a regular basis;
- Appointment of an Energy Manager, in accordance with the obligations of the Energy Efficiency Act No. 121/2014, to manage local production and use of energy in the university buildings, which will become prosumators;
- Launch of materials to promote energy efficiency in buildings: guides, posters, stickers, with suggestions and useful messages for the University and local community;
- Support and promotion of demonstration pilot projects, in particular those resulting from the Horizon 2020 and Horizon Europe projects, on innovative applications and solutions in the University's own buildings;
- Promotion for replication and access to new projects, living labs infrastructure with applications in energy efficiency, renewable sources, smart buildings, ecology and urban biodiversity etc.
- Development of electric vehicle power infrastructure adjacent to buildings by 2025;
- Openness within the applicable legal framework, for ESCO-type projects, through energy performance contracts, with payment of investments from the savings obtained;
- Maintaining the green building certification of the headquarters of the BT building, part of the Technical University; obtaining a Green Building certification for the new UTCN Conference Centre (formerly the Fashion House);
- The inclusion in the annual report of the Rector of the level of energy consumption and emissions, as well as the measures to reduce CO2 emissions in the buildings and infrastructure of the University;
- Dissemination and transfer of knowledge and results within ARUT.

Impact: increasing the University's score in international sustainability assessments (like GreenMetric http://greenmetric.ui.ac.id/ or chapters from other systems); increasing interior comfort in buildings; reducing environmental impact; sustainable operating costs.

4. ENERGY

Addressing a major challenge such as climate change requires a truly collaborative perspective, at the level of society as a whole. Technical University is an essential partner and is actively involved in the education, creation and support of policies and their implementation in the Campus and various communities, including in direct relationship with the Municipality of Cluj-Napoca, a community that has committed itself to decarbonizing its current level by more than 80% by 2030. In the current context of the need to an energy transition to renewable sources, decarbonization and an environment with low greenhouse gas emissions, our University, through all its actions and policies is fully in agreement with the objectives, financial allocations and actions of decision makers in Romania and at European level, the most important being the improvement of energy efficiency by at least 45% by 2030, respectively the introduction of local renewables for self-consumption.

The Technical University of Cluj-Napoca is committed to acting as an example of best practices at the local and regional level and to play the role of leader in the transition process towards the realization of a Green Campus.

Strategic Objective - Based on the progress made at the University level in recent years, we will continue to promote and use new technologies to increase the energy efficiency of heritage buildings in accordance with the Action Plan for Climate and Sustainable Energy (PACED), supporting an ambitious investment plan for the transition to carbon neutrality.

Objectives:

- Continue to demonstrate strategic vision by setting realistic targets in the field of sustainable energy and greenhouse gas emissions.
- Actively pursue the reduction of energy consumption, as well as achieving sustainable procurement.
- Diversify energy supply by investing in renewable energy sources and reinvesting energy cost savings into new sustainability projects.

- Awareness of the community about the importance of the energy transition and the role that each has.

The associated Sustainable Development Goals (SDGs) are:

5. Sources of funding provided in the Peace Investments

The implementation of energy efficiency projects requires significant financial efforts, projects that must be supported through a well-established and appropriate budget. In order to compile this budget, in addition to the own contributions of the Technical University of Cluj-Napoca, from its own budget, other sources and funding mechanisms must be taken into account, among which we mention the following:

- National Recovery and Resilience Plan (PNRR);
- Modernization Fund 10d; • Sustainable Development Operational Programme (SODD);
- National Investment Fund for Energy Efficiency and Climate Change;
- Regional Operational Programme 2021-2027;
- ESCO provider financing;
- Romanian Energy Efficiency Fund (FREE);
- Administration of the Environmental Fund (AFM);
- Operational Programme Administrative Capacity (POCA);
- Large Infrastructure Operational Programme (POIM);

Some sources of funding are described in detail below:

5.1. National Recovery and Resilience Plan (PNRR)

The European Union has decided to establish a temporary financial instrument with effect until 2026, with the aim of providing support to Member States to meet the challenges posed by the COVID-19 crisis and its economic consequences.

The National Recovery and Resilience Plan (PNRR) encompasses a coherent package of public investments and reforms proposed on the basis of the Country Specific Recommendations 2019-2020. This plan sets out the priority areas of investment for the exit from the crisis, economic recovery and increased resilience.

PNRR is based on 6 main pillars:

- Transition to a green economy;
- Digital transformation;
- Smart, sustainable and inclusive economic growth;
- Social and territorial cohesion;
- Health and institutional resilience;
- Children, young people, education and skills.

The mechanism is thought of on several pillars, one of which is the Green Transition:

- The green transition should be supported through reforms and investments in green technologies and capabilities, including in biodiversity, energy efficiency, building renovation and the circular economy, while contributing to the European Union's climate objectives, promoting sustainable growth, creating jobs andining energy security.

The programme will take place in the period 2021 – 2026

5.2. Modernization Fund 10d

The 10D Modernization Fund is a funding mechanism introduced by Directive (EU) 2018/410 of the European Parliament in order to profit from reducing carbon dioxide emissions and increasing investment in energy efficiency.

The objectives of the Modernisation Fund are:

- Transition to a low-carbon energy system, by stimulating investment in renewable energy sources, transmission networks that include the distribution of thermal energy in residential and commercial areas, interconnection of networks for the transport of electricity and natural gas, as well as energy storage, improving energy efficiency in energy production, including in the transport, building, construction, agriculture and waste sectors, and for a fair transition in coal-dependent regions.

The funding programme aims at increasing interconnections between Member States, as well as supporting a fair transition in carbon-intensive regions, so as to support relocation, re-qualification and skills improvement of workers, education, job-seeking initiatives and start-ups.

The programme will take place in the period 2021-2027

5.3. Sustainable Development Operational Programme (PODD)

The main areas to be funded through the PODD are energy efficiency, water and wastewater, waste management, biodiversity, air quality, risk management. The programme is dedicated to both SMEs and large companies.

The objectives of this programme are to ensure social, economic and territorial cohesion by supporting a low-emission greenhouse gas economy and ensuring the efficient use of natural resources.

Under the PODD, support is directed towards a limited number of sectors to serve the coherent use of Union funding and maximize the added value of financial support. Thus, the PODD will finance development needs in the following sectors: adaptation to climate change by increasing energy efficiency and the development of intelligent energy systems, storage solutions and adequacy of the energy system; water and sewage infrastructure; circular economy; conservation of biodiversity; air quality and decontamination of polluted sites; risk management.

Also, since the implementation of the circular economy is inherently linked to the emergence of innovation, local authorities must incorporate in their development plan and investment related to research and innovation, in close connection with universities and research-development-disclosure institutes.

Investment property: Promoting energy efficiency, intelligent energy systems and networks and storage solutions.

Action/Project types:

1. Demonstration and energy efficiency projects in SMEs and related support measures.

Energy efficiency projects in large enterprises and adjacent support measures.

The programme will take place in the period 2021-2027

5.4. National Investment Fund for Energy Efficiency and Climate Change

This fund is expected to be established by the Ministry of Energy – Energy Efficiency Directorate, with the aim of supporting projects to increase energy efficiency.

The programme will take place in 2022 – indefinitely

5.5. ESCO financing in the form of supplier credit

An ESCO company offers financing in the form of supplier credit for the implementation of the following energy efficiency projects:

- Cogeneration plants;
- Heat pumps;
- Photovoltaic power plants;
- Energy consumption monitoring systems;
- Modernization of thermal networks;
- Modernization of thermal plants and thermal points;
- Modernization of pumping systems;

- Modernization of indoor and outdoor lighting installations;
- Reactive energy compensation solutions;
- Solutions for crossing the boundary from low to medium voltage.

Main benefits of ESCO funding

Main Benefits
✓ Collaboration with a single supplier for the implementation of an integrated solution. ✓ Minimizing the technical and financial risks of the project.
✓ Implementation of the project does not require CAPEX available from the Beneficiary (payments related to the reimbursement of the investment are registered in OPEX). ✓ The funding granted and the savings achieved reduce the pressure on the recipient's cash flow. ✓ The investment does not appear as a long-term liability in the balance sheet of the Beneficiary.
✓ The reimbursement of the investment does not start immediately after the system is put into operation.
✓ Increased profit due to significant reduction in electricity costs. ✓ Image benefits: sustainable company, “green”, concerned with the environment.

5.6. Romanian Energy Efficiency Fund

Energy-saving loans, with negotiable interest depending on the attractiveness of the project, the amount of the loan and the scope of the investment.

The fund is dedicated to private or public-private corporations and public institutions of local or national interest.

The funding is granted for the implementation of the following energy saving measures:

1. Modernization of technological processes or manufacturing processes;
2. Boilers and heat exchangers, pumps;
3. Industrial heating, cogeneration;
4. "Smart grid", intelligent measurement, reactive energy compensation, energy consumption management;
5. Indoor and outdoor lighting, modernization of thermal power supply systems, “greening” of public buildings and transport;
6. Utilization of renewable energy sources for self-consumption

Financing up to USD 2.000.000/project

6. INVENTION OF ENERGY CONSUMING AND CO2 EMISSIONS

6.1. Data used for the preparation of the IRE

The starting point of the process of drafting the Action Plan for Climate and Sustainable Energy was the emissions reference inventory (IRE).

Following the drafting of the IRE, the next step has been taken, namely the establishment of relevant sets of actions and measures to reduce energy consumption and greenhouse gas emissions.

The action plan also seeks to monitor the actions implemented, but also in progress, to determine their impact, the aim being to create a clear picture of the situation of the university (where we are) in 2018.

The CO2 emission inventory requires adequate resources, to allow the collection and review of data, for a PACED that corresponds to the energy, emissions and other specific needs of the current situation of the Technical University of Cluj-Napoca.

In the reference range of greenhouse gas emissions, the energy consumption of all the buildings held by the university has been highlighted and evaluated.

As a result of the data collection and their centralization, the emission factors at the national level for final energy consumption have been used for the quantification of CO2 emissions.

The emission factors used for the reference inventory are presented in the following table:

CO2 emission factors used for IRE

Form of energy used	CO2 emission factor in 2018 [tonnes CO2/MWh]
Electricity	0,290
Natural gases	0,202

The emission factors used for the monitoring inventory are presented in the following table:

CO2 emission factors at the national level

Form of energy used	Form of energy used
Electricity	0,217
Natural gases	0,202

6.2. Reference inventory of CO2 consumption and emissions – 2018

The emissions reference inventory accounts for energy consumption and CO2 emissions in UTCN buildings at the 2018 level, which serves as a reference for the established emission reduction targets by 2030.

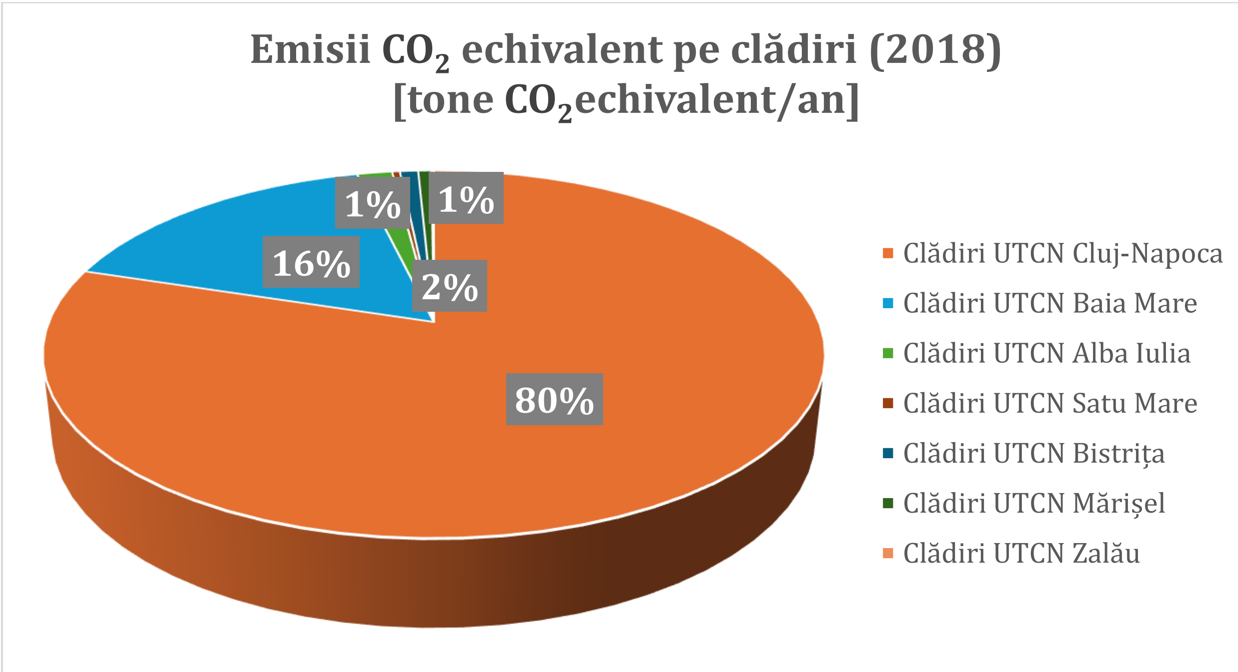
Energy consumption for 2018:

Place of consumption	Energy consumption in 2018 [MWh/year]	Energy consumption in 2018 [%]
Buildings UTCN Cluj-Napoca	25.219	79,3%
Buildings UTCN Baia Mare	5.347	16,8%
Buildings UTCN Zalău	590	1,9%
Buildings UTCN Alba Iulia	125	0,4%
Buildings UTCN Satu Mare	299	0,9%
Buildings UTCN Bistrița	212	0,7%
Buildings UTCN Mărișel	28	0,1%
Total energy consumption	**31.820**	**100%**

Disaggregation on the power carriers used:

Energy consumption for 2018 by type of energy

Place of consumption	Electricity [MWh/year]	Methane gas [MWh/year]
Buildings UTCN Cluj-Napoca	5037,00	20.183,0
Buildings UTCN Baia Mare	657,00	4.690,0
Buildings UTCN Zalău	-	590,0
Buildings UTCN Alba Iulia	11,00	114,0
Buildings UTCN Satu Mare	21,00	278,0
Buildings UTCN Bistrița	28,00	183,0
Buildings UTCN Mărișel	28,00	-
TOTAL	5.782	26.038



Energy consumption by UTCN buildings in 2018

Based on the analysis of energy consumption in 2018, at the level of UTCN buildings, the following can be concluded:

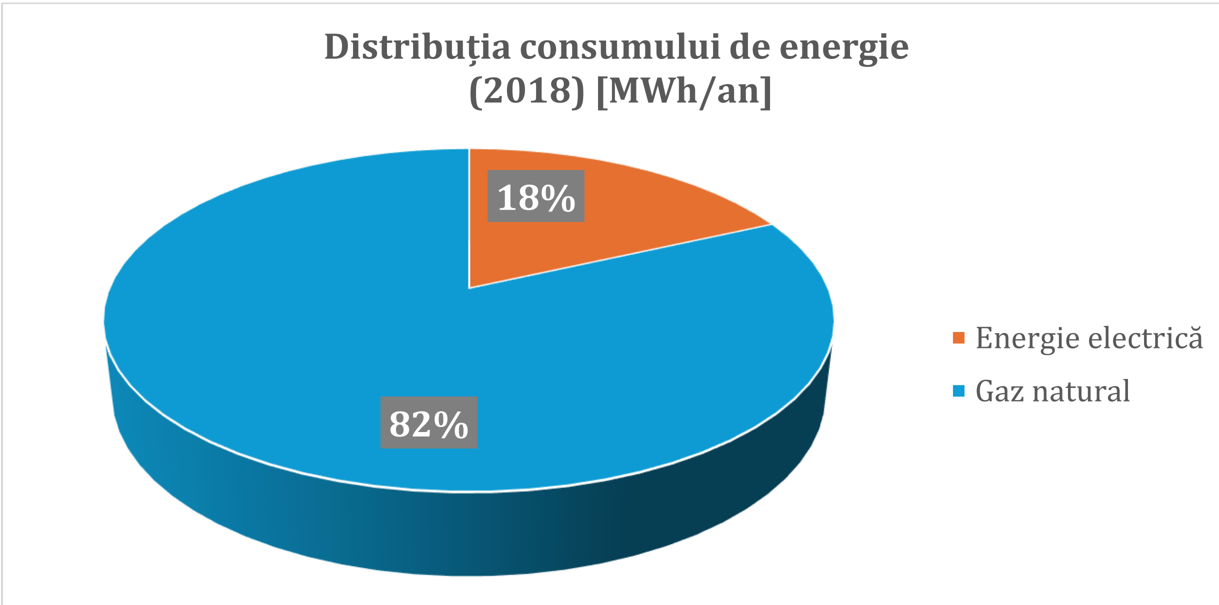
- The highest energy consumption is recorded among the buildings in Cluj-Napoca (79.3% of the total consumptions), buildings of Baia Mare are in the second place with 16.8% of the consumes, and the third place are the UTCN buildings from Zalău, with a much lower percentage, of only 1.9%.
  In decreasing order of energy consumption the hierarchy is completed with the buildings in Satu Mare (0.9% of the consumer), the buildments in Bistrița (0.7% of the consumptor), the building in Alba Iulia (0.4% of the Consumer) and the building at Marișel with 0.1% of the total energy consume of all buildings of the university.

Energy consumption in 2018 by types of energy carriers

Power Carrier	Quantity [MWh/year]	Percentage [%]
Electricity	5.782	18%
Natural gas	26.038	82%
TOTAL	**31.820**	100%

If we refer to the energy carrier consumed, in 2018, it is observed that the main source of energy used in the UTCN building is natural gas, in proportion of 82%. The gases are mainly used for heating premises and preparation of hot water for household use.

Electricity accounts for about 18% of total energy consumption, and is mostly used to provide indoor lighting, perimeter lighting and climate control in buildings.

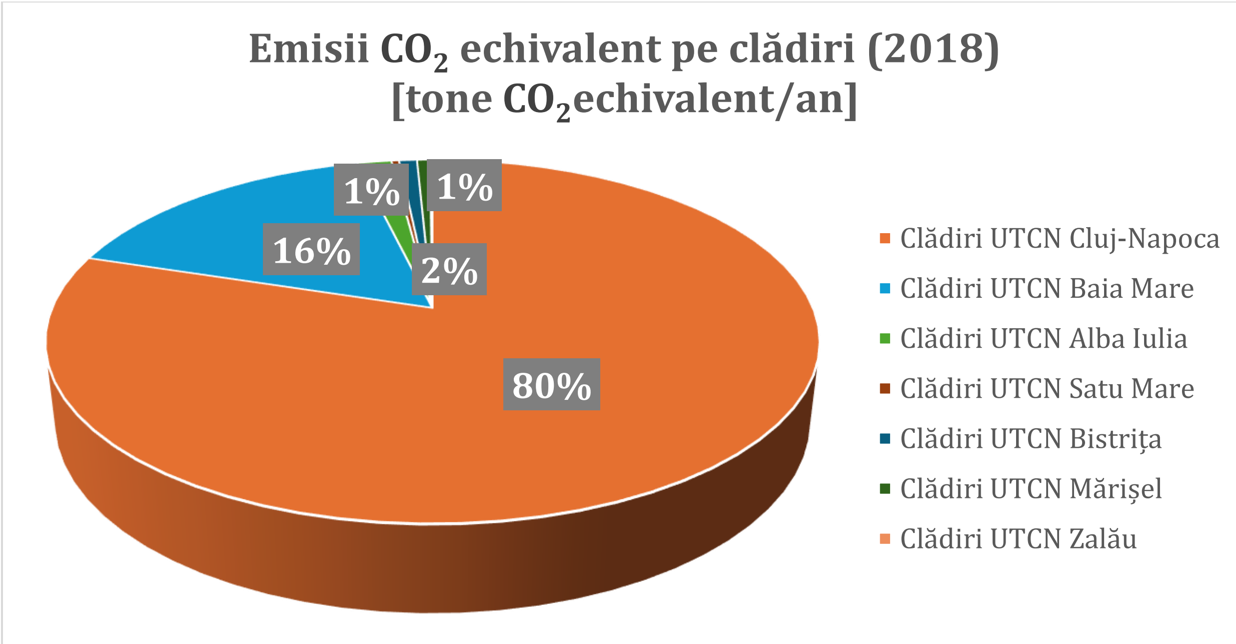


Distribution of energy consumption in 2018

CO2 emissions calculated at the level of 2018 are presented in the following table:

2018 emissions at the UTCN building level

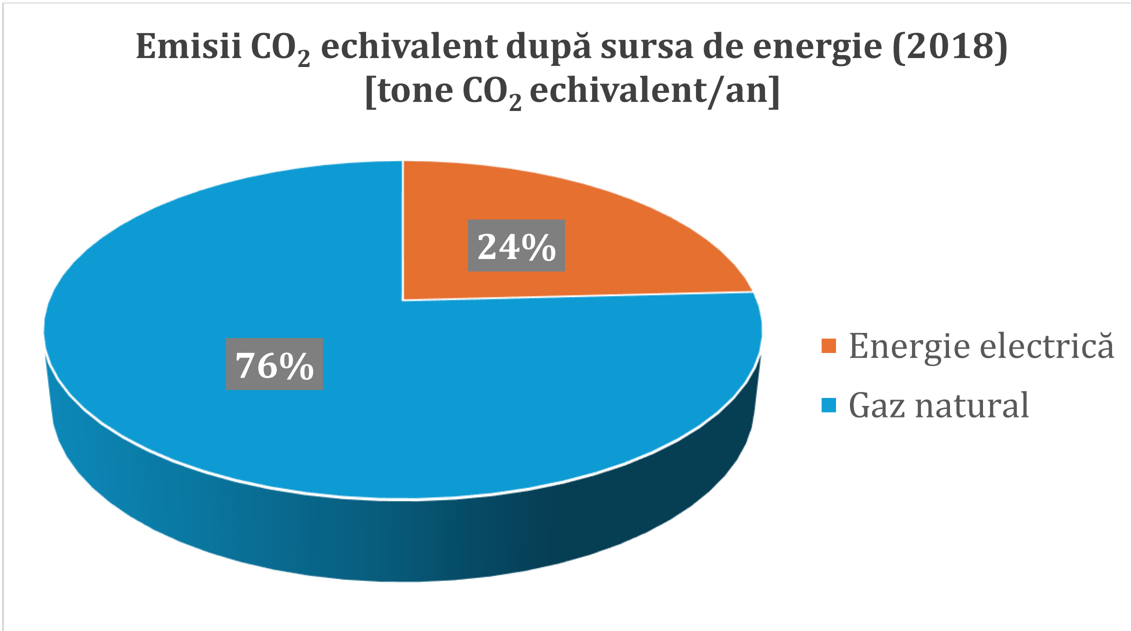
Place of consumption	Emissions for 2018 [tonnes CO2/year]	Emissions for 2018 [%]
Buildings UTCN Cluj-Napoca	5.538	79,8%
Buildings UTCN Baia Mare	1.138	16,4%
Buildings UTCN Zalău	119	1,7%
Buildings UTCN Alba Iulia	26	0,4%
Buildings UTCN Satu Mare	62	0,9%
Buildings UTCN Bistrița	45	0,6%
Buildings UTCN Mărișel	8	0,1%
Total energy consumption	**6.936**	**100%**



Equivalent emissions by sector in 2018

The following conclusions can be drawn from the analysis of the 2018 CO2 emissions for the university buildings:

- And greenhouse gas emissions follow the same order as energy consumption, so the highest levels of emissions were recorded among the UTCN buildings in Cluj-Napoca (79.8 % of total emissions), followed by the buildings of Baia Mare (16.4 % of the total emission), the Zalău buildings (1.7 % of all emissions); the Satu Mare buildings (0.9 % of overall emission); the Bistrița buildings (0.7 %), the Alba Iulia building (0.4 %) and the Marișel building (0.1 % of Total Emission).



Equivalent emissions by energy sources in 2018

In 2018, at the UTCN building level, emissions from electricity consumption account for a share of 24%, and natural gas used for building heating is responsible for 76% of emissions.

6.3. Monitoring inventory of CO2 consumption and emissions – 2023

The monitoring inventory accounts for energy consumption and CO2 emissions in the UTCN buildings at the 2023 level and establishes the current level at which the university is located.

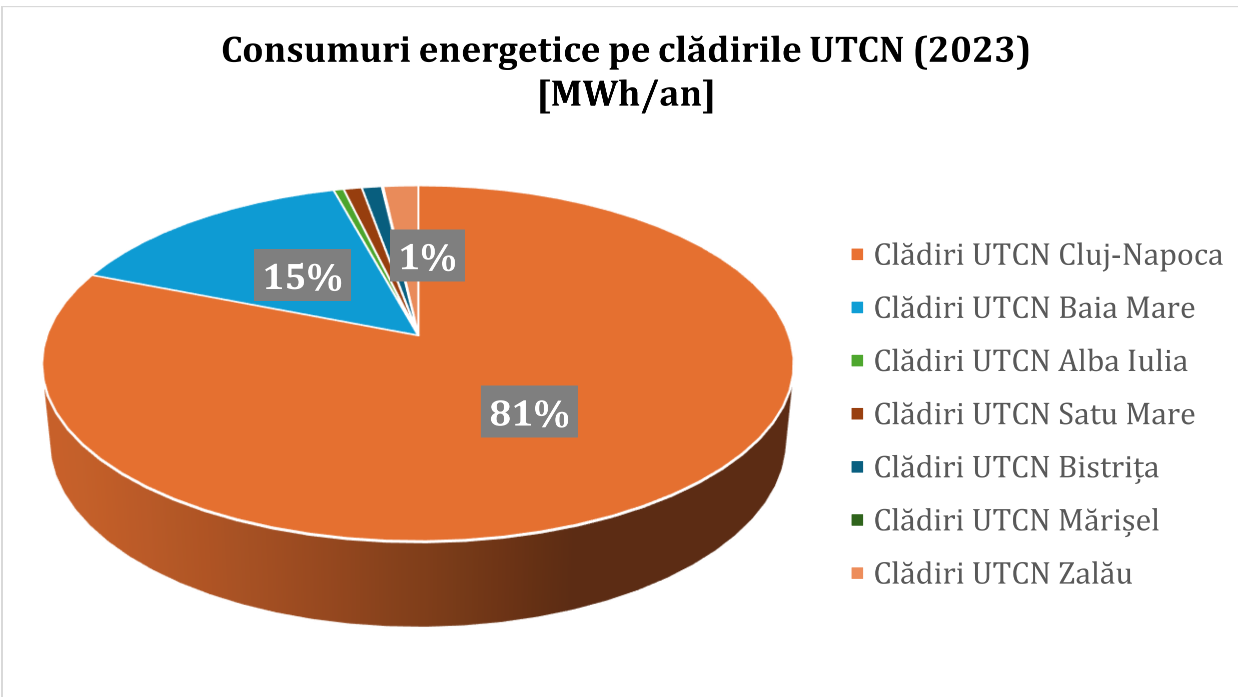
The following are the energy consumption for the year 2023:

Energy consumption for the year 2023

Place of consumption	Energy consumption in 2023 [MWh/year]	Energy consumption in 2023 [%]
Buildings UTCN Cluj-Napoca	25.340,83	81,0%
Buildings UTCN Baia Mare	4.618,81	14,8%
Buildings UTCN Zalău	158,03	0,5%
Buildings UTCN Alba Iulia	284,00	0,9%
Buildings UTCN Satu Mare	312,67	1,0%
Buildings UTCN Bistrița	20,56	0,1%
Buildings UTCN Mărișel	549,77	1,8%
Total energy consumption	**31.285**	**100%**

Energy consumption for the year 2023 by type of energy

Place of consumption	Electricity [MWh/year]	Methane gas [MWh/year]
Buildings UTCN Cluj-Napoca	5154,48	20.186,4
Buildings UTCN Baia Mare	607,05	4.011,8
Buildings UTCN Zalău	26,74	131,3
Buildings UTCN Alba Iulia	19,44	264,6
Buildings UTCN Satu Mare	44,04	268,6
Buildings UTCN Bistrița	20,56	-
Buildings UTCN Mărișel	-	549,8
TOTAL	**5.872**	**25.412**



Energy consumption by buildings in 2023

From the analysis of energy consumption in 2023, at the level of UTCN buildings, the following can be concluded:

- The highest energy consumption is recorded among the buildings in Cluj-Napoca (81% of the total consume), buildings of Baia Mare are in the second place with 14.8% of the consume, and the third place are the UTCN buildings from Zalău, with a much lower percentage, of only 1.8%.

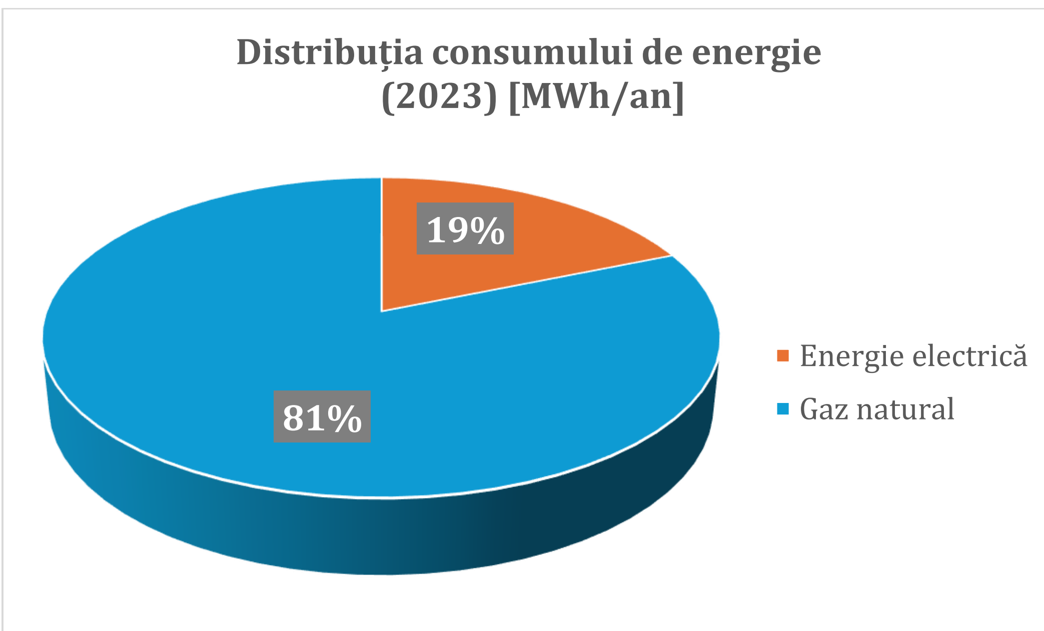
In decreasing order of energy consumption the hierarchy is completed with the buildings in Bistrița (1% of consumptions), the buildments in Satu Mare (0.9% of consums), the Buildings in Alba Iulia (0.5%) and the building in Marișel with 0.1% of the total energy consums of all buildings of the university.

Energy consumption in 2023 by types of energy carriers

Power Carrier	Quantity [MWh/year]	Percentage [%]
Electricity	5.872	19%
Natural gas	25.412	81%
TOTAL	**31.285**	100%

If we refer to the energy carrier consumed, in 2023, it is observed that the main source of energy used in the UTCN building is natural gas, in proportion of 81%. The gases are mainly used for heating premises and preparation of hot water for household use.

Electricity accounts for about 19% of total energy consumption, and is mostly used for indoor lighting, perimeter lighting and climate control in buildings.

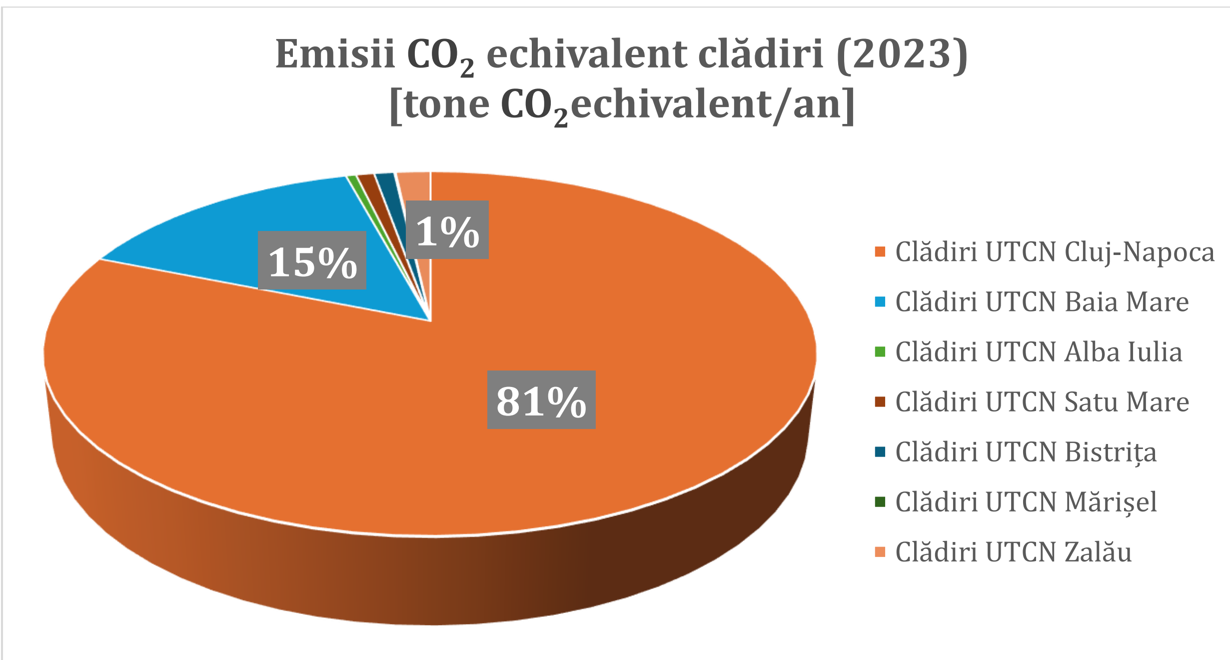


Energy consumption by fuel type in 2023

CO2 emissions calculated at the level of 2023 are presented in the following table:

2023 emissions at the UTCN building level

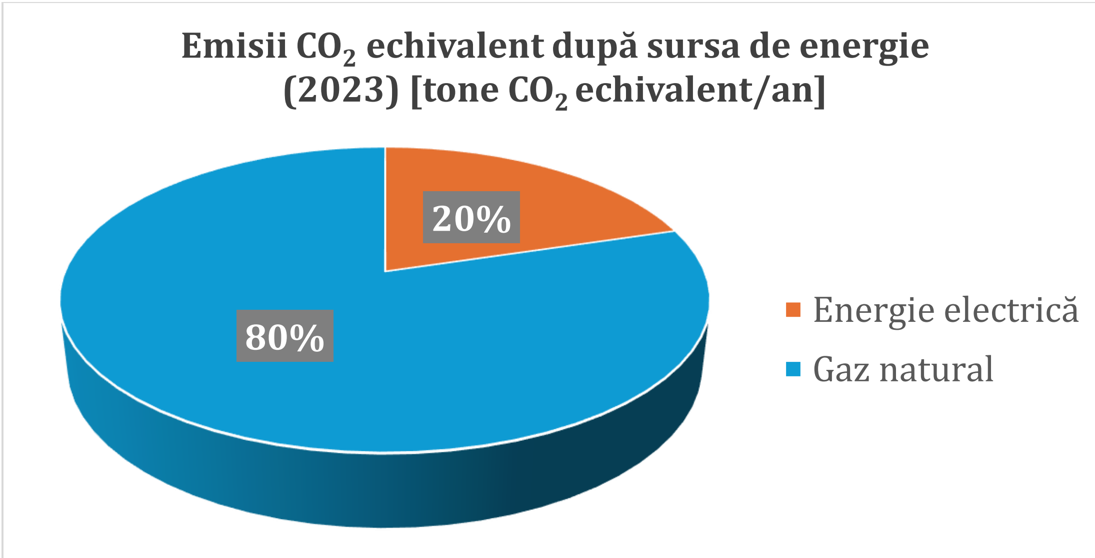
Place of consumption	2023 emissions [tonnes of CO2/year]	2023 emissions [%]
Buildings UTCN Cluj-Napoca	5.196	81,1%
Buildings UTCN Baia Mare	942	14,7%
Buildings UTCN Alba Iulia	32	0,5%
Buildings UTCN Satu Mare	58	0,9%
Buildings UTCN Bistrița	64	1,0%
Buildings UTCN Mărișel	4	0,1%
Buildings UTCN Zalău	111	1,7%
Total energy consumption	**6.408**	**100%**



Equivalent emissions per building in 2023

The following conclusions can be drawn from the analysis of the 2023 CO2 emissions for the university buildings:

- Greenhouse gas emissions follow the same order as energy consumption, thus the highest levels of emissions were recorded among the UTCN buildings in Cluj-Napoca (81.1% of total emissions), followed by the buildings of Baia Mare (14.7% of total Emissions), the Zalău buildings (1,7% of all emission), the Bistrița buildings (1% of all emisions), the Satu Mare buildings (0.9% of the total emission) and the Alba Iulia buildings (0.5% of the overall emission).



Equivalent emissions by energy source in 2023

In 2023, at the UTCN building level, emissions from electricity consumption indicate a share of 20%, and natural gas used for building heating is responsible for 80% of emissions.

Based on the analysis of energy consumption and CO2 emissions in UTCN buildings, the following can be concluded in the year 2023:

- A great potential for reducing energy consumption and greenhouse gas emissions has been identified at the level of UTCN buildings, by improving energy efficiency, but also by producing energy from renewable sources.
- A series of awareness-raising and behavioral change campaigns can be developed at the building level and through the promotion of modern technologies for automation and control of indoor lighting, automation of thermal and electrical energy systems.

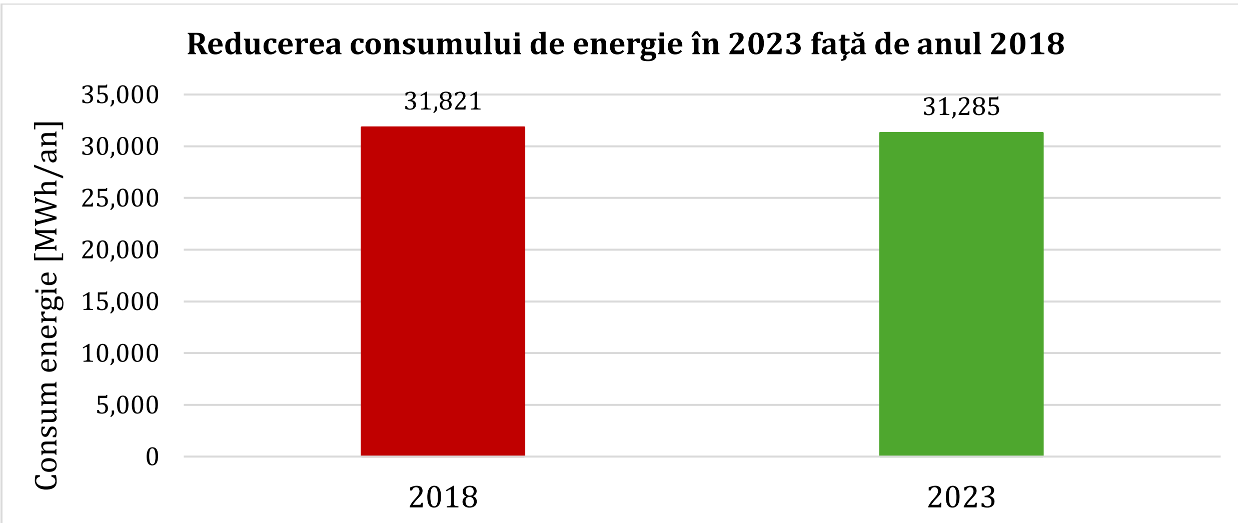
Following the analysis of the emissions level in 2018, respectively 2023, the following can be found:

Energy consumption

Energy consumption		
2018	31.821	MWh/year
2023	31.285	MWh/year
	1.7%	reduction in relation to the EIB
	536	MWh/year reduction

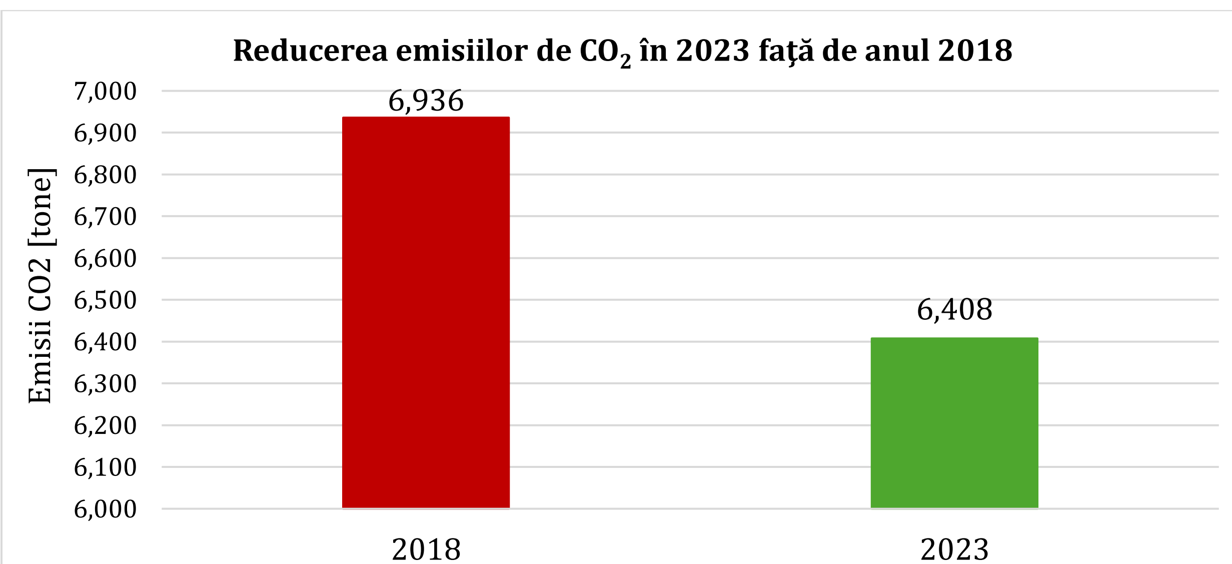
CO2 emissions

CO2 emissions		
2018	6.936	tCO2eq/year
2023	6.443	tCO2eq/year
	7.6%	reduction in relation to the EIB
	528	tCO2eq/year reduction



Reduction in energy consumption in 2023 compared to 2018

- Energy consumption decreased in 2023 by 536 MWh, which represents a decrease from 2018 by about 2%.



Reduction in CO2 emissions in 2023 compared to 2018

If we look at greenhouse gas emissions over the two years, it turns out that emissions decreased by 528 tonnes of CO2 in 2023, which is a decrease from about 8% in 2018.

7. VISION AND MISSION OF UTCN

7.1. Vision

The Technical University of Cluj-Napoca, wants to create a sustainable working and study environment that has a positive impact in all areas in which the University is involved.
The vision is to reach the top 3 most sustainable universities in the country, ensuring that everything it does is sustainable: the education it provides to students, research and innovation, and all the processes that take place in the Campus.
Based on a way of working in partnerships both at the local, regional and international levels, the sustainable development goals proposed by the UN will be addressed, leveraging the strengths in research and education, with the aim of promoting the solutions and cultural change needed for the transition to a sustainable future.

7.2. Mission

The mission of the University is to implement sustainability initiatives in an integrated approach by involving the entire academic community in the development of excellence practices that have the capacity to become a positive force in building a sustainable society for all.
The University has the responsibility to be a promoter in creating a world in which environmental, economic and social aspects exist in balance, to meet both the needs of current resources, but also of future generations. As a higher education institution, UTCN promotes and educates through current policies and example actions, inspiring new generations to share practices and knowledge with passion and ingenuity.

8. ACTIONS AND MEASURES PLANED FOR THE PERIOD 2024 – 2030

In this chapter are briefly presented the actions and measures proposed by the Plan of Action for Climate and Sustainable Energy 2024 -2030 of the Technical University of Cluj-Napoca. The measures include short, medium and long-term actions.

For a good coordination and management of energy efficiency and CO2 reduction projects, it is recommended to train the staff of the Technical University.

8.1. Buildings, equipment and facilities

The sector with the greatest potential for reducing energy consumption is the building sector. Energy savings in this sector can be achieved by applying local legislative regulations, such as Law 372/2005 on the Energy Performance of Buildings with all subsequent additions.
Through these legislative documents it is stipulated that all newly built buildings must be nZEB (nearly Zero Energy Building), i.e. must have superior energy performance.
According to the conclusions drawn from the base emissions inventory, the highest energy consumption and most significant CO2 emissions are among buildings.
According to various analyses carried out at European level, the building sector consumes approximately 40% of total energy consumption, thus placing it at the top of the list as the sector with the greatest potential for energy saving.
In accordance with the European Directive 31/2010 on the energy performance of buildings and the Energy Efficiency Action Plan, increased levels of energy performance and clear measures to reduce specific energy consumption are established among buildings, with the aim of achieving the goal of reducing final consumptions by 40% by the year 2030.
At the level of local communities in Romania, the situation is a little more special, if we take into account the high level of specific energy consumption in buildings, the duration of use, the age of the building, the difficulty of attracting funds necessary for carrying out the works to increase the energy performance, the budget available and necessary to support the works of increasing the energy efficiency, the standard of living.
Thermal energy accounts for approximately 70 to 80 % of the total consumption of a

building.

For UTCN buildings, aggregate measures to reduce energy consumption are proposed, taking into account the state and age in which they are.

A series of measures aimed at the UTCN buildings have been established, thus, the development of sources of energy production from renewable sources will be considered permanently, facilitating the transition to a new type of building, those with a near-zero energy consumption – nZEB.

Various demonstration projects can be promoted for the production of electricity by photovoltaic panels, or for the preparation of hot water by solar captors.

It is necessary to correctly establish the current state of energy consumption and to conduct or promote energy audits to determine the current energy performance of the building, in terms of specific energy consumes, expressed in kWh/mp/year.

These specific consumptions can be compared with other buildings in similar categories.

The energy audit of buildings will also provide a plan of specific measures and actions to reduce energy consumption and to assess the cost of these measures.

The action plan will form the basis for future projects to renovate and modernise buildings.

Measures and proposed actions for UTCN buildings:

- Built-in tires – to reduce heat losses;
- Systems for the production, distribution and use of heat and hot water;
- Ventilation and air conditioning systems;
- Use of renewable energy sources.
- Modernization of some systems/installations in buildings;
- Correct monitoring of energy consumption;
- Automation of adjustment systems;
- Other behavior change measures for building occupants.

9. SYNTHESIS PACED 2024 – 2030

The following table presents centrally the action plan for PACED. Through this set of measures, the university aims to its targets for 2030.

Actions for sustainable energy 2024 - 2030 at the Technical University level

ACTIONS FOR SUSTAINABLE ENERGY 2024 - 2030 WITH TECHNICAL UNIVERSITY OF CLUJ-NAPOCA									
Update April 2024									
Presentation of actions	**Responsible body**	**Push interval**		**Total implementation cost [euro]**	**Quantitative indicator**	**Energy savings [MWh/year]**	**Production of energy from renewable sources [MWh/year]**	**CO_2 emission reduction [tonnes/year]**	**Action Status**
Modernization, expansion and energy efficiency works at UTCN buildings	UTCN	2024	2030						proposed
Implementation of an energy management system for UTCN's own buildings - BMS type	UTCN	2024	2030	12.000.000	minimum 30 buildings	2.300		460	proposed
Energy standards towards nZEB (efficiency and renewable sources) for buildings and renovation works	UTCN	2024	2030	0	-	174	-	35	proposed
Development of Energy Performance Certificates for all UTCN buildings	UTCN	2024	2030	50.000		233		47	proposed
Electric vehicle charging stations in UTCN parking lots	UTCN	2024	2030	2.250.000				0	proposed
Energy awareness campaigns (Sustainable Energy Day, once a year)	UTCN	2024	2026	1.000	-	35	-	7,0	proposed
Energy training courses for UTCN employees	UTCN	2024	2026	1.000	-	12	-	2,3	proposed
Distribution of brochures on good environmental practices and energy saving in buildings	UTCN	2024	2026	1.000	-	12	-	2,3	proposed
Implementation of pilot ventilation system with heat recovery in at least one classroom and monitoring of indoor air quality	UTCN	2024	2028	10.000	Consumption reduction: kWh/mp/year Indoor air quality ppm CO_2	3	-	0,7	proposed
Pilot implementation of adaptive lighting system in at least 3 classrooms, from 3 different buildings, with bringing into standards of lighting parameters	UTCN	2024	2028	15.000	kWh/mp/year	2	-	0,5	proposed
Implementation of integrated energy	UTCN	2024	2028	15.000	kWh/mp/ year	15	-	3,0	proposed

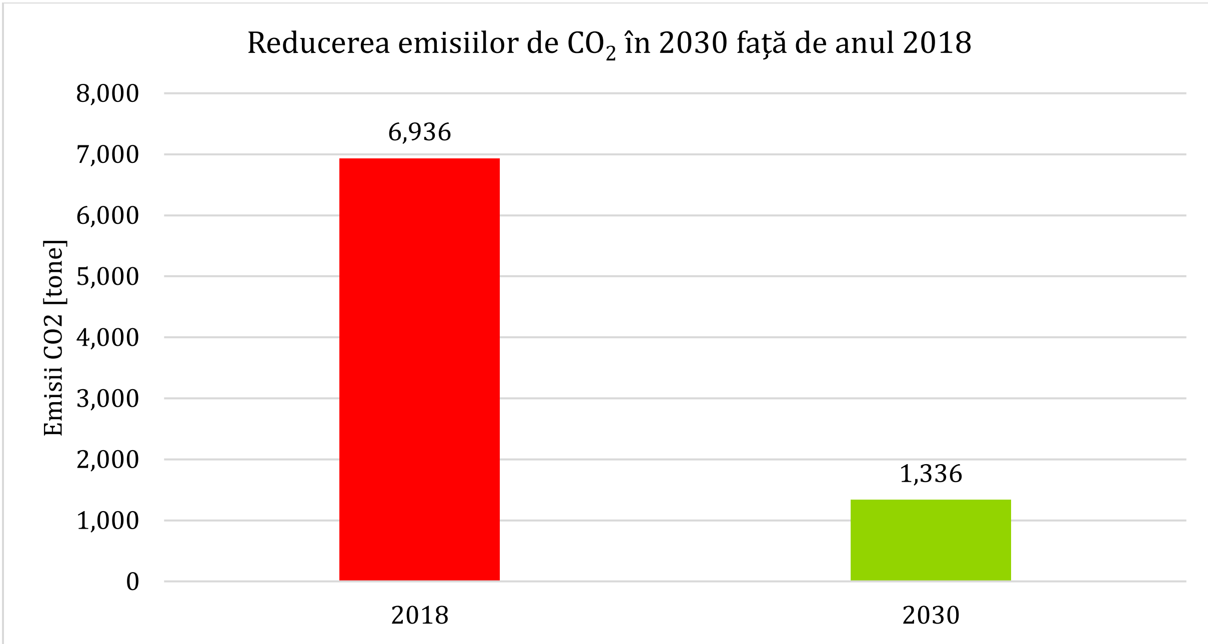
monitoring pilot system (electricity, methane gas, water) for a building									
Implementation of a pilot system for conditioning the power supply voltage level in a building	UTCN	20 24	2027	10.000	kWh/ year	5	-	0,9	proposed
Pilot implementation of renewable sources of electricity at the level of a building for self-consumption	UTCN	20 24	2026	15.000	kWh/mp/ year	1	-	0,2	proposed
Certification of a building to be modernised as a green building	UTCN	20 24	2025	5.000			-	0,0	proposed
Implementation of the standard energy management system ISO 50001 at the UTCN level	UTCN	20 24	2026	6.000			-	0,0	proposed
Implementation of a pilot project of thermal grid balancing and temperature control through thermostatic sensors in a building	UTCN			10.000		1	-	0,2	proposed
Encouragement and support for non-formal education initiatives for sustainability at the University	Educational professor, departmental directors		Permanent		Number of courses, workshops, summer schools (min. 2/year) Number of students (internal/external) participants				
Participation of technical staff from the General Administrative Directorate in training sessions, and competence development in the field of sustainable development and energy efficiency, through in-house courses	DGA Research Project Directors	20 24	2026		Number of courses (min. 2/year) Number of participants (aprox. 20)				
Proposal and implementation of research and institutional development projects in areas related to sustainable development (according to the 17 SDGs - Sustainable Development Goals)	CII Prorector, MURMSE Prorektor Project Directors Department Directors		Permanent		Number of research projects (min. 2/year) Number of publications (min. 200)				
Support and promotion of pilot demonstration projects of living labs, on innovative solutions with application in the University's own buildings aimed at energy	DGA, Project Managers	20 24	2027		Number of associated events (min.2)				

efficiency, renewable sources, smart buildings, etc.									
Increase the level of awareness and involvement of the university and local community on the subject of energy efficiency and the transition to clean energy, through information and training campaigns in the field. Launch of materials to promote energy efficiency in buildings: guides, posters, stickers	PRorector MRPF Office Image and Public Relations Project Directors Student Organizations		Permanent		Number of pilot projects (min. 2)				
Developing a Community-wide network for monitoring campus energy consumption. Installation of smart thermostats (temperature, humidity, CO2) Designation of an Energy Manager	Board of Directors				Structure of monitoring Energy Manager				
Monitoring the level of energy consumption and emissions, as well as measures to reduce CO2 emissions in the buildings and infrastructure of the University	DGA Commission for Sustainable Development Energy Manager		Permanent		Annual report				
Coordination of access and allocation of non-refundable financial resources for the significant increase in the comfort and energy efficiency of the building fund	CII Prorector MURMSE		Permanent		Number of projects (min. 2/year)				
Implementation of energy-efficient lighting systems. Motion sensors in corridors and in toilets. Classrooms equipped with presence sensors. Separate photovoltaic lighting from the outdoor lighting of the chimneys Development adjacent to buildings of some electric vehicle power infrastructure	DGA Prorector MRPF	2024	2026		Min 30% led type lighting Number of stations (min. 2)				
mplementation of infrastructures to support transformations in the heritage of buildings, where possible, so that they become prosumers	DGA Prorector MRPF	2024	2026		15% of energy from renewable sources Number of prosumatori				

					buildings (min. 1)				
Certification Green Buildings for new spaces under renovation	Energy Manager	2024	2026		Certificates for new campus buildings (BT and CM)				
Development and implementation of a sustainable procurement policy	Board of Directors	2024	2026		Procurement policy 25% Sustainable type procurement				
Reduction of water consumption (use of rainwater for irrigation and toilets)	Administrative Technical Directorate		Permanent		10% annually				
Active transport (bicycles, electric vehicles) achieved with the support of the local public administration that is already implementing its own public policies	DGA, Technical and Administrative Directorate Student Organizations	2024	2026		Specific bicycle parking spaces (min 1/sit from Campus) Electric vehicles (min. 2)				
Development of the Green University Charter in accordance with international and national policies	Board of Directors Commission on Sustainable Development	2024	2026		Green University Charter Accession “UI Green Metric World University” Evaluation and certification of UI GreenMetric				
TOTAL				**14.389.000**	**-**	**2.793**	**0**	**559**	**-**

The potential reduction of CO2 emissions in the year 2030, compared to the year 2018, by applying the measures listed will be of 5.600 to CO2/year, thus the Technical University of Cluj-Napoca, manages to exceed the ambitious targets proposed.

The calculated value of CO2 emission reduction as compared to the reference year 2018 is 81%, as shown in the following graph.



Reduction of CO2 emissions in 2030 compared to 2018

10. ADAPTATION TO CLIMATIC CHANGES

10.1. Local vision in the field of climate change adaptation

The Technical University's Action Plan for Climate and Sustainable Energy (PACED) is the planning document that combines sustainable energy planning with action in the area of adaptation to climate changes – a process carried out with both resources and involvement of the local government level, but which is also based on cooperation between the institutional, local, county/regional and national levels.

In this area, UTCN aims to align itself with the initiatives made by the municipality of Cluj-Napoca and other European communities – a unified effort to adapt to climate change, limit greenhouse gas emissions and improve the quality of life of citizens through a cleaner and safer environment, where the efforts of all decision-makers at the local, county/regional and national levels contribute to the objectives of environmental protection, conservation of natural resources and increasing the safety and quality of lives of the citizens.

The Climate Change Adaptation Action Plan (CAPAC) component complements past and current efforts to reduce the impact of human activities on the generation of greenhouse gases.

10.2. Evolution of climate risk factors at local level

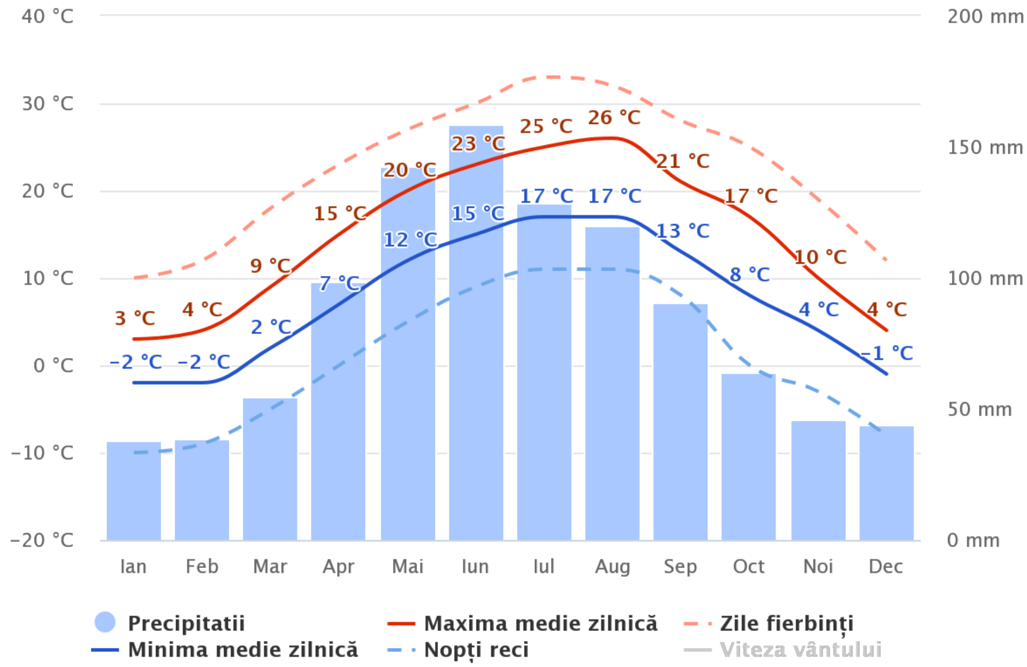
The analysis of meteorological environmental factors is based on a set of data at hourly resolution from the last 36 years.

The data arrangement for the analyzed point on the territory of the Municipality of Cluj-Napoca is based on some mathematical models, taking into account the nearest measurement points of conditions in the Territory and including information taken from satellite platforms and climate and meteorological observers. By aggregating these data, the climate situation at the local level was obtained. The data underlying the climate analysis are:

- Air temperature (2 m above ground) °C
- Relative humidity

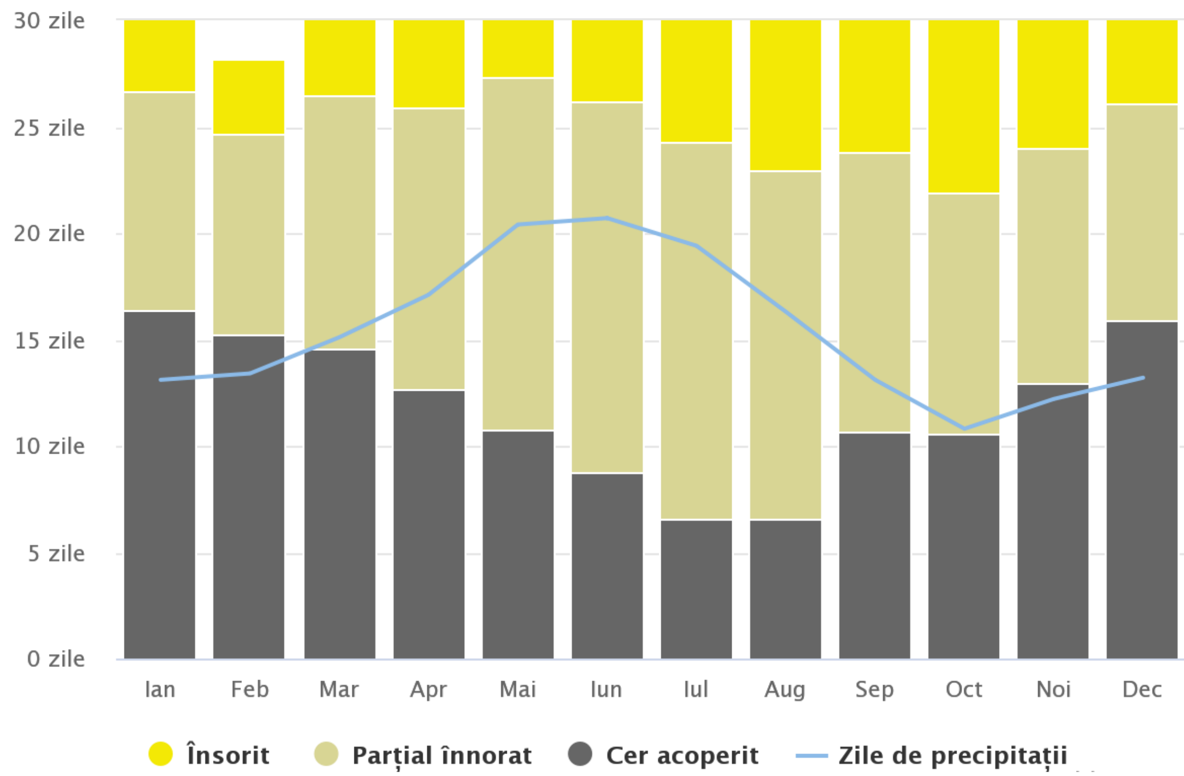
- Total precipitation per square meter (mm)
- Wind speed and direction

The main climatological variables relevant to the process of identifying climate trends are analyzed in the following sub-chapters.



Average monthly trends of climate parameters
Source: meteoblue.com

In the above diagram you can see the average monthly trends of several climatological parameters at the level of the Municipality of Cluj-Napoca. It is observed that the 24-hour air temperature variation is more pronounced in summer, with average differences of up to 10°C, and in the cold season thermal stability is better.

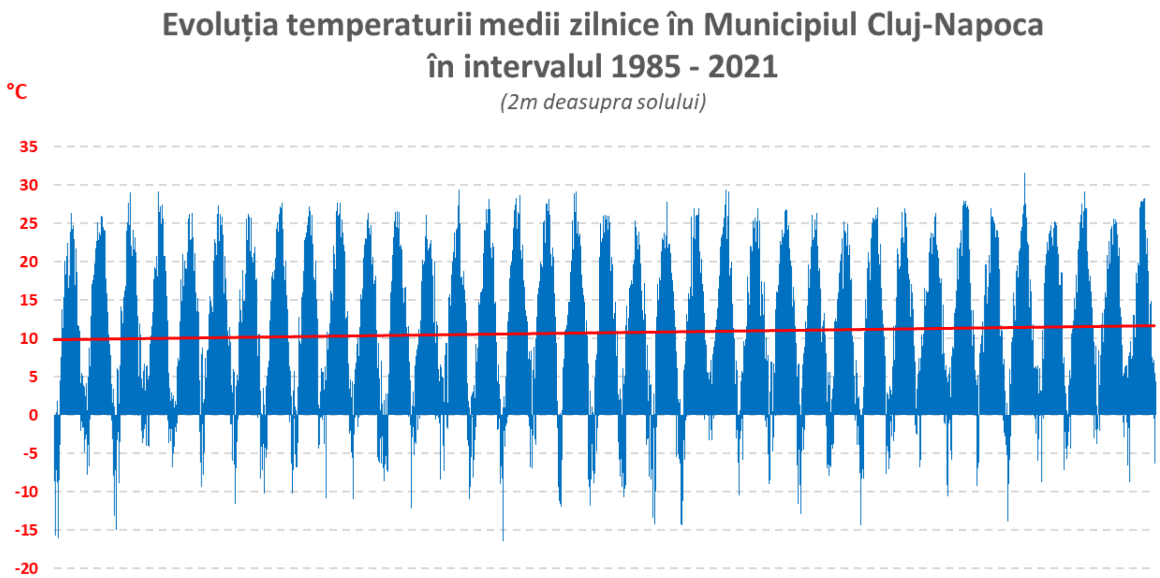


The predominance of clouds and other elements of atmospheric nebulosity throughout the year

Source: meteoblue.com

The previous chart reveals the predominance of clouds and other elements of atmospheric nebulosity throughout the year, and the most significant atmosphere variations near the ground occur in the spring, during which time the number of precipitation days is increasing. The months of the year with the best atmospheric stability are the autumn months – with the highest number of sunny days, and in the fall and winter months, according to statistics, the quantities of precipitation are lower.

10.2.1. Analysis of air temperature changes



Evolution of the average daily temperature in Cluj-Napoca Municipality in the period 1985-2021

Source: ANERGO Energy Observatory

The chart above shows the change in average daily temperature over the last 37 years. Average daily positive temperatures are observed during the summer period, with days when the 24-hour average temperature reaches 30 degrees Celsius, and the peak was in 2007, the day of August 4 when a daily average of 30.7 °C was recorded. These averages are based on temperature values from 2 m from the surface of the soil, each point on the diagram peaks representing the arithmetic 24-hour average of the hourly average temperatures of that day. The general analysis of the fluctuation of the daily average air temperature (red line) reveals a trend of increasing the recorded average temperature. Thus, if in 1985 we start from an average air temperature of approximately 8.8 °C, in 2021 the same parameter is at the value of 11.1°C, meaning an estimated increase of 2.3 °C.

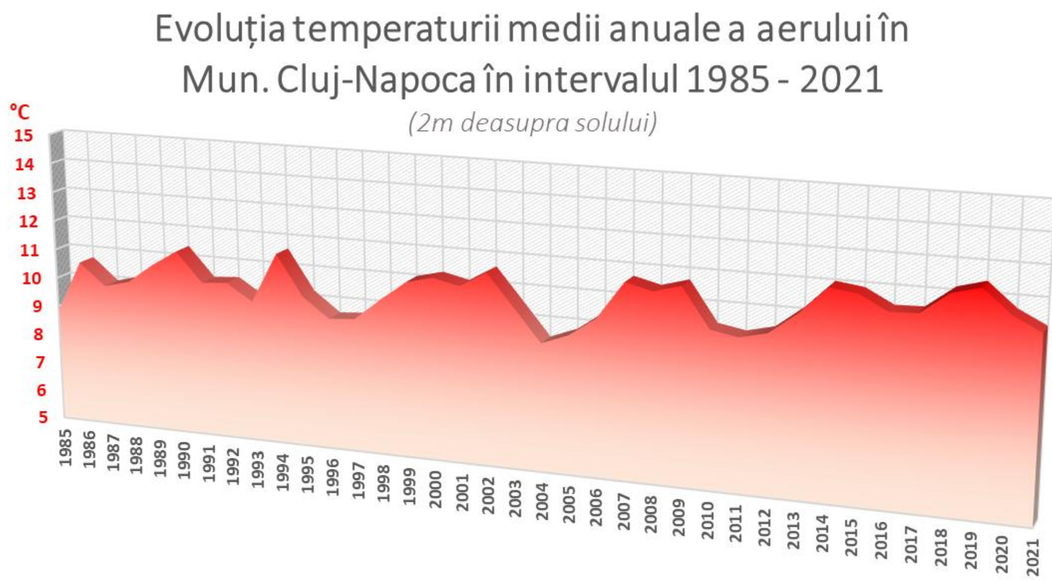
Evolution of the average annual air temperature

Evolution of the Average Annual Air Temperature (2 M of Soil) IN CLUJ-NAPOCA MUNICIPAL IN CINCINAL INTERVALS FOR THE PERIOD 1985 – 2020							
Analysed interval	**1985 - 1990**	**1990 - 1995**	**1995 - 2000**	**2000 - 2005**	**2005 - 2010**	**2010 - 2015**	**2015 - 2020**
Average first year [°C]	8,84	10,31	9,47	10,97	10,32	10,12	11,36
Average last year [°C]	11,3	10,14	11,17	9,67	10,29	11,84	11,57
Modification [°C]	**+2,47**	**-0,16**	**+1,70**	**-1,3**	**-0,03**	**+1,71**	**+0,22**

Source: ANERGO Energy Observatory

The above table shows the first significant variation in the average air temperature of almost 2.5 °C. This increase is mostly associated with the phenomenon of global warming, with the first strong effects of carbon emissions in the terrestrial atmosphere as a result of industrial development being observed in the '80s.

In the analyzed range there are 3 periods of 5 years recording at the ends drops of the average annual temperature (marked with a light blue background) but that fail to compensate for the increase in the average values of the air temperature in the other periods analyzed.

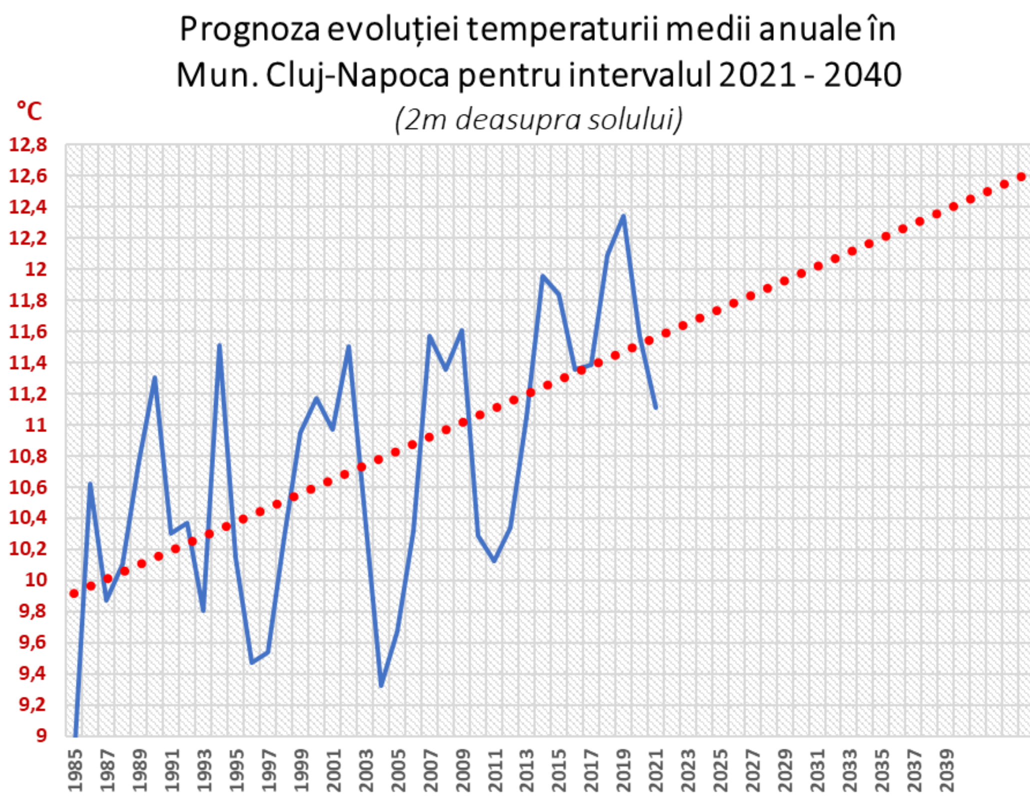


Evolution of the average annual air temperature in Cluj-Napoca Municipality in the period 1985 - 2021

Source: ANERGO Energy Observatory

The previous chart shows the year 2019 with the highest value in the last 37 years of the average annual air temperature, recording a record value of 12.34°C. If the average air temperatures in the subsequent years do not decline, an amplification of dangerous weather phenomena at the local and regional levels is traced.

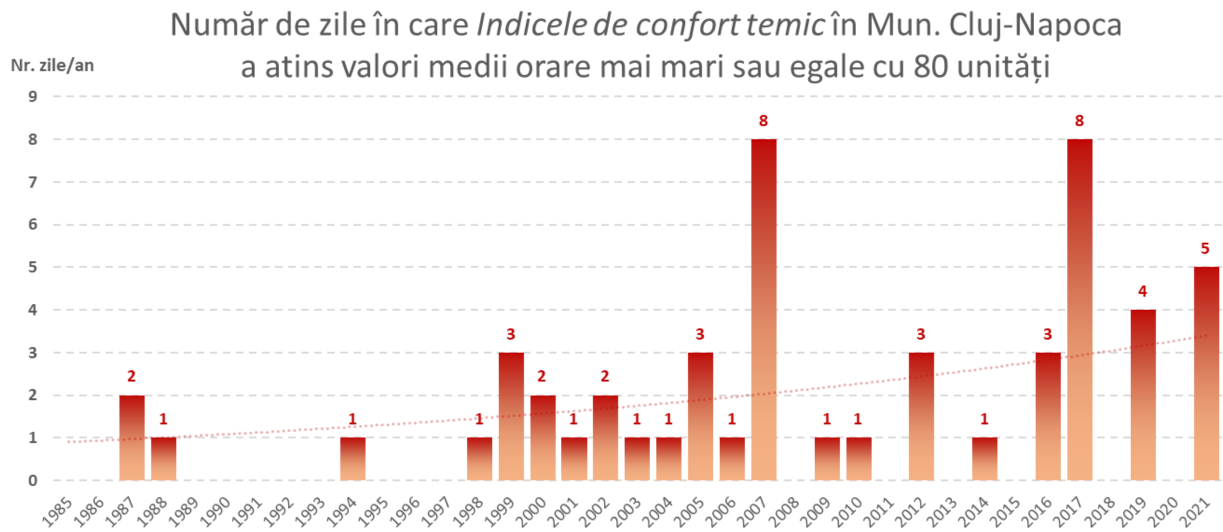
The following chart shows the forecast of the evolution of the average annual air temperature in the Municipality of Cluj-Napoca until 2040, following an optimistic linear growth scenario, based on the trend given by the development of the annual average values over the last 37 years. According to this estimate, the average annual temperature will be around 12.6°C in 2040. However, it is estimated that average air temperatures could rise even more, due to the complex effects of the global warming process that cause secondary processes capable of accelerating the basic process of atmospheric warming.



Forecast of the evolution of the average annual temperature in the Municipality of Cluj-Napoca for the period 2021 - 2040

Source: ANERGO Energy Observatory

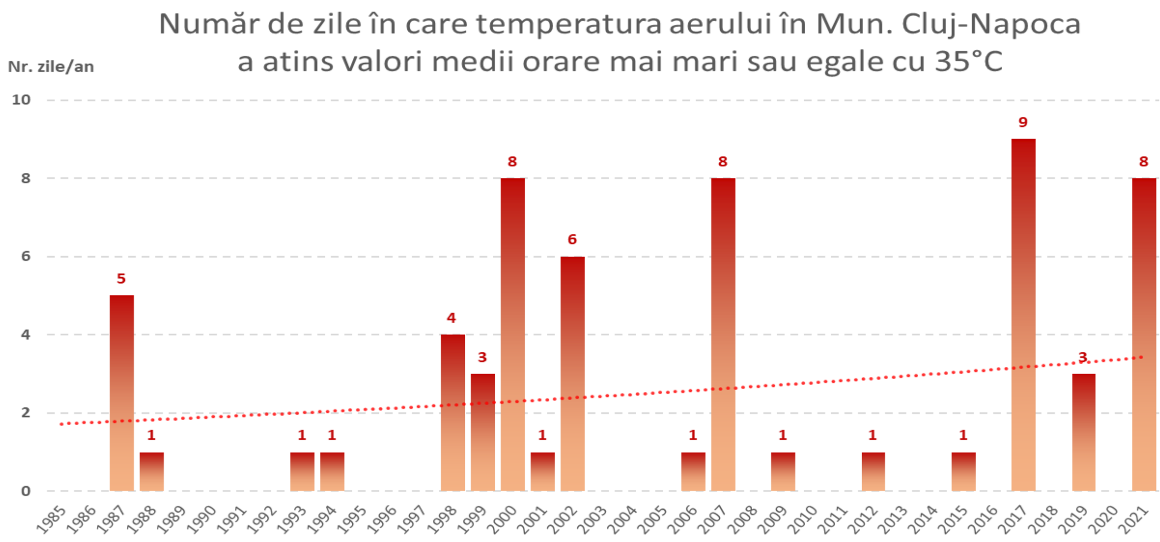
The Thermal Comfort Index (TIC) is a climatological parameter by which the thermal discomfort caused by the very hot air in summer days, but in particular air loaded with moisture, can be tracked. The phenomenon at its extremes is generating medical problems in the regional climate of Romania and usually leads to the suspension of some activities, at the same time triggering the application of strategies to combat adverse effects and to protect the population.



The number of days in which the thermal comfort index in Cluj-Napoca reached hourly mean values greater or equal to 80 units

Source: ANERGO Energy Observatory

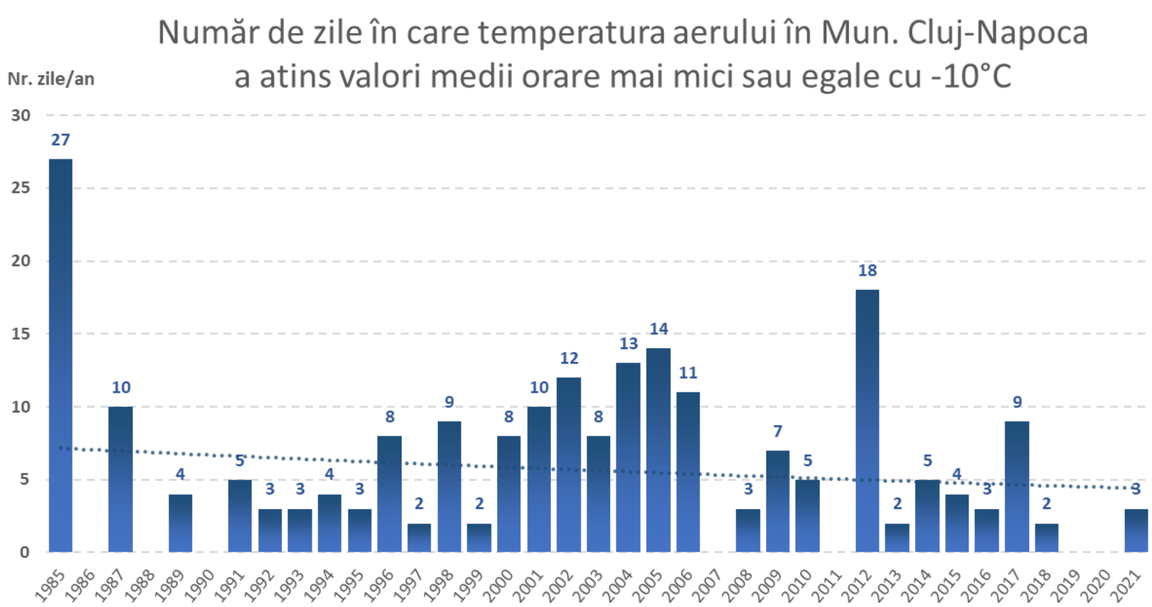
In the above diagram it is noted that during the period (1985-2021) at the level of the Municipality of Cluj-Napoca, the trend is rising with regard to the number of days in which ICT was greater or equal to 80 units. The phenomenon manifests more acutely once every 2-3 years. 2007 was the first year in the analyzed series in which ICT exceeded 80 units in 8 days of the year, breaking previous records.



The number of days in which the air temperature in Cluj-Napoca reached an average hourly value greater than or equal to 35 gr C

Source: ANERGO Energy Observatory

The number of days in which the air temperature reached average hourly values above 35°C in Cluj-Napoca Municipality also follows an increasing trend throughout the analyzed period. The year 2017 brought the highest number of days in which the phenomenon analyzed occurred: 9 days.

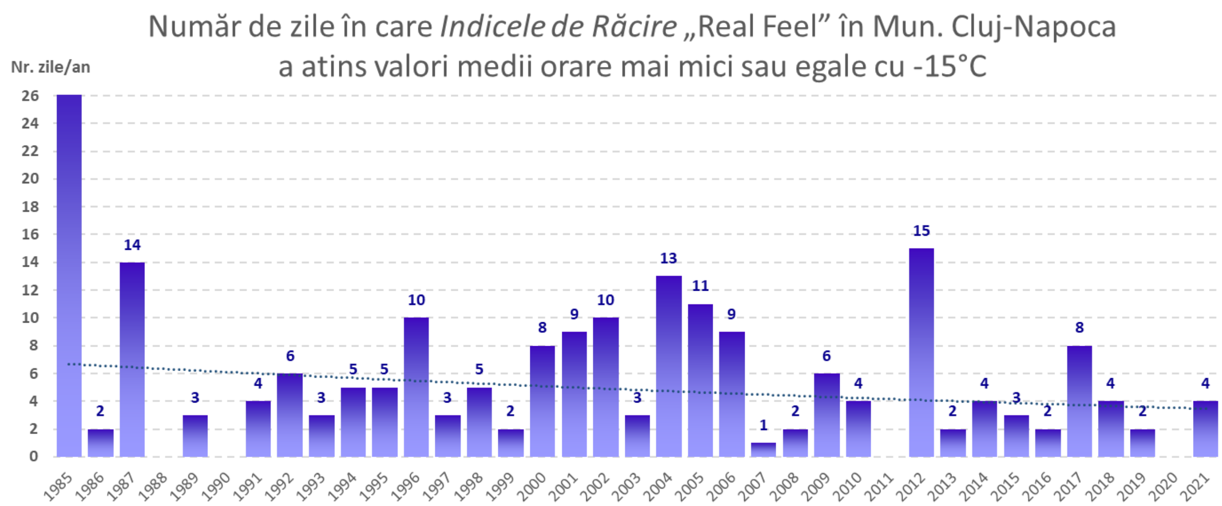


The number of days in which the air temperature in Cluj-Napoca reached an average hourly value less than or equal to - 10 gr C

Source: ANERGO Energy Observatory

The number of days in which the air temperature in Cluj-Napoca reached average hourly values below -10°C follows a downward trend during the period considered. In the last decade you can see only one year in which there have been more than 10 days in which the average minimum temperature in 1 hour was below -10°C (2012).

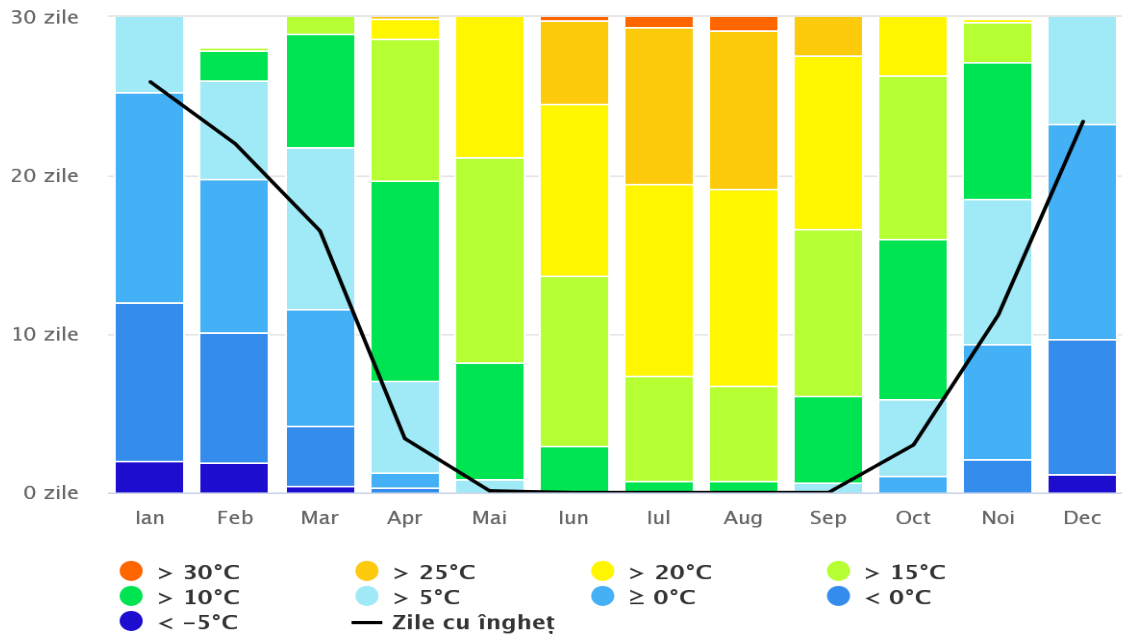
The Cooling Index (IR), also known as "Real Feel", is a standardized adimensional measurement that is mathematically determined on the basis of two factors: air temperature and wind speed.



The number of days in which the Cooling Index in Cluj-Napoca reached an average hourly value less than or equal to - 15 gr C

Source: ANERGO Energy Observatory

In the above diagram, the multi-year analysis carried out at the level of the Municipality of Cluj-Napoca in order to determine the number of days in which the Cooling Index has reached hourly mean values less than or equal to -15°C, reveals the fact that, on average, the annual number of the days follows a downward trend, making an exception to this trend year 2012, when there was a number of 15 days in the phenomenon analyzed.



Average air temperatures on thermal slopes
Source: meteoblue.com

In the above graph are represented the average air temperatures on thermal levels by monthly number of days (multi-annual average). It is noted that, at the level of the Municipality of Cluj-Napoca the situation of the arrangement of the thermal gradients is moderately positive in the months of June, July and August. A superior thermal comfort is achieved most often in May and September, respectively, with the highest portion (number of days) associated with the green and yellow colors, representing average air temperatures favourable for outdoor activities.

Average monthly air temperature in Cluj-Napoca (1985 - 2021)

Temperatura medie lunară a aerului în Municipiul Cluj-Napoca (1985-2021)													
°C	Ian	Feb	Mar	Apr	Mai	Iun	Iul	Aug	Sept	Oct	Nov	Dec	media
1985	*-5,7*	*-7,2*	*1,3*	*10,6*	*16,4*	*16,3*	*19,8*	*20,9*	*15,8*	*10,2*	*4,1*	*2,3*	8,7
1986	*0,3*	*-1,5*	*4,6*	*12,6*	*17,1*	*19,1*	*19,9*	*22,2*	*17,7*	*10,6*	*5,2*	*-1,0*	10,6
1987	*-4,0*	*0,2*	*1,5*	*9,2*	*13,9*	*19,2*	*23,4*	*18,4*	*19,1*	*9,9*	*6,1*	*1,0*	9,8
1988	*2,0*	*2,2*	*4,0*	*8,8*	*14,8*	*17,5*	*22,8*	*21,6*	*16,9*	*10,4*	*0,0*	*-0,3*	10,1
1989	*-1,4*	*2,2*	*7,6*	*14,0*	*14,7*	*17,2*	*20,8*	*21,0*	*16,6*	*11,5*	*4,1*	*0,3*	10,7
1990	*-0,6*	*4,1*	*9,1*	*11,6*	*16,1*	*19,1*	*21,4*	*21,3*	*14,8*	*11,2*	*6,9*	*0,0*	11,3
1991	*-0,2*	*-1,3*	*7,5*	*10,2*	*12,9*	*19,6*	*22,6*	*20,3*	*17,1*	*10,5*	*5,8*	*-2,2*	10,2
1992	*-2,1*	*-0,8*	*4,5*	*11,2*	*14,6*	*19,2*	*21,5*	*25,0*	*15,7*	*11,0*	*4,8*	*-0,7*	10,3
1993	*-0,9*	*-2,7*	*2,9*	*9,1*	*16,6*	*18,9*	*20,0*	*21,0*	*15,2*	*13,1*	*1,8*	*1,5*	9,7
1994	*1,3*	*1,6*	*6,4*	*11,7*	*15,8*	*19,0*	*23,1*	*21,9*	*21,0*	*10,2*	*5,0*	*0,5*	11,5
1995	*-2,0*	*3,6*	*5,2*	*9,0*	*14,5*	*19,5*	*23,5*	*20,6*	*15,4*	*12,3*	*0,9*	*-1,1*	10,1
1996	*-1,6*	*-3,1*	*-0,4*	*9,5*	*17,2*	*20,1*	*19,8*	*20,5*	*13,2*	*11,0*	*6,9*	*0,1*	9,4
1997	*-0,5*	*0,7*	*3,9*	*6,1*	*15,7*	*19,0*	*19,3*	*19,5*	*14,8*	*8,4*	*5,3*	*1,7*	9,5
1998	*1,0*	*2,8*	*2,4*	*12,2*	*15,3*	*19,7*	*21,5*	*21,6*	*15,3*	*11,8*	*2,6*	*-3,6*	10,2
1999	*0,0*	*-0,7*	*5,6*	*11,3*	*14,3*	*20,7*	*23,8*	*22,2*	*18,7*	*11,1*	*3,6*	*0,0*	10,9
2000	*-4,8*	*-0,1*	*3,9*	*12,8*	*17,3*	*20,2*	*21,1*	*22,9*	*16,2*	*12,5*	*8,9*	*2,9*	11,1
2001	*0,7*	*2,3*	*7,9*	*11,7*	*16,5*	*18,4*	*22,3*	*23,5*	*16,5*	*13,6*	*3,3*	*-5,6*	10,9
2002	*-2,8*	*4,8*	*7,5*	*10,8*	*18,3*	*21,0*	*24,4*	*21,3*	*16,8*	*11,1*	*6,8*	*-2,3*	11,5
2003	*-2,1*	*-4,6*	*3,6*	*8,4*	*20,2*	*21,9*	*22,2*	*23,1*	*15,8*	*9,1*	*6,7*	*-0,2*	10,3
2004	*-3,1*	*-0,7*	*4,0*	*10,4*	*13,6*	*17,7*	*20,1*	*18,8*	*14,2*	*11,1*	*5,0*	*0,5*	9,3
2005	*-0,8*	*-3,8*	*0,8*	*10,4*	*15,5*	*18,0*	*21,2*	*20,2*	*17,7*	*11,1*	*4,5*	*0,3*	9,6
2006	*-4,4*	*-2,3*	*3,2*	*11,6*	*15,3*	*18,9*	*22,5*	*20,1*	*17,2*	*12,5*	*6,6*	*2,0*	10,3
2007	*3,0*	*3,1*	*7,9*	*11,6*	*17,7*	*21,5*	*22,9*	*22,0*	*15,1*	*11,1*	*3,6*	*-1,3*	11,5
2008	*-1,3*	*2,9*	*6,7*	*11,8*	*16,0*	*20,9*	*21,0*	*22,1*	*15,5*	*12,3*	*6,0*	*2,1*	11,3
2009	*-0,8*	*0,7*	*4,7*	*13,4*	*16,9*	*19,9*	*22,6*	*22,0*	*18,4*	*12,0*	*7,5*	*1,4*	11,6
2010	*-1,9*	*1,0*	*4,5*	*10,6*	*15,7*	*19,1*	*21,3*	*21,5*	*15,1*	*7,9*	*8,4*	*-0,2*	10,2
2011	*-1,3*	*-1,3*	*5,2*	*11,1*	*15,6*	*18,6*	*20,0*	*20,2*	*18,2*	*9,4*	*3,1*	*1,9*	10,1
2012	*-1,9*	*-5,4*	*3,3*	*11,4*	*15,9*	*20,0*	*23,1*	*21,1*	*18,0*	*12,4*	*6,8*	*-1,2*	10,3
2013	*-1,5*	*1,6*	*4,4*	*12,5*	*17,1*	*20,1*	*21,3*	*22,2*	*14,8*	*12,1*	*8,0*	*-0,3*	11,0
2014	*1,7*	*4,0*	*9,5*	*12,5*	*15,8*	*18,9*	*20,9*	*21,3*	*17,4*	*12,2*	*6,6*	*2,1*	11,9
2015	*0,4*	*0,9*	*6,5*	*10,0*	*16,6*	*19,5*	*23,2*	*23,6*	*19,3*	*11,0*	*7,8*	*2,5*	11,8
2016	*-1,4*	*5,4*	*7,5*	*14,2*	*14,9*	*20,6*	*22,1*	*21,6*	*19,1*	*9,6*	*4,1*	*-1,4*	11,4
2017	*-6,0*	*2,7*	*8,6*	*10,0*	*15,9*	*20,4*	*22,3*	*24,7*	*17,4*	*11,7*	*6,3*	*2,0*	11,3
2018	*1,4*	*0,7*	*4,3*	*16,0*	*18,5*	*20,7*	*20,6*	*23,9*	*17,8*	*13,7*	*6,8*	*0,1*	12,0
2019	*-1,5*	*2,5*	*7,9*	*11,7*	*14,8*	*21,9*	*21,6*	*24,1*	*18,0*	*14,2*	*9,6*	*2,7*	12,3
2020	*-0,1*	*3,6*	*7,2*	*10,5*	*13,7*	*19,2*	*21,0*	*22,7*	*19,4*	*13,3*	*5,3*	*3,0*	11,6
2021	*0,4*	*3,3*	*4,5*	*8,4*	*14,3*	*20,2*	*23,9*	*22,8*	*16,7*	*9,9*	*6,5*	*2,0*	11,1
media	*-1,1*	*0,6*	*5,1*	*11,1*	*15,8*	*19,5*	*21,8*	*21,7*	*16,8*	*11,3*	*5,4*	*0,3*	°C

Source: ANERGO Energy Observatory

The table of average monthly air temperature values for the period 1985-2019 in Cluj-Napoca highlights primarily the areas with higher temperatures in the summer months. We note that the minimum was recorded in January and the maximum in August.

Minimum and maximum air temperatures (hour average) in Cluj-Napoca (1985 - 2021).

Temperaturi minime și maxime ale aerului (medii orare) în Municipiul Cluj-Napoca (1985-2021)																								
	Ian		Feb		Mar		Apr		Mai		Iun		Iul		Aug		Sept		Oct		Nov		Dec	
°C	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
1985	-20	2	-25	4	-9	15	0	21	3	25	7	28	6	34	10	32	4	29	-3	26	-4	18	-4	11
1986	-6	9	-10	10	-9	20	-1	25	1	28	5	31	9	31	6	33	1	32	-1	24	-3	16	-10	9
1987	-19	7	-13	12	-12	19	-3	19	2	23	5	32	8	36	5	30	6	31	-6	22	-4	19	-5	10
1988	-4	11	-8	13	-7	15	-3	24	2	25	6	26	9	39	6	34	4	29	-7	25	-8	10	-8	8
1989	-7	6	-4	15	-2	20	3	28	1	26	4	26	7	33	10	32	7	27	0	21	-9	19	-11	15
1990	-10	13	-3	17	-3	22	0	23	-2	32	3	33	7	34	9	33	3	31	-4	26	-2	17	-8	8
1991	-13	11	-14	12	-3	24	0	20	4	26	7	33	12	33	9	33	3	30	-5	32	-3	16	-10	6
1992	-14	7	-11	11	-3	21	-4	25	0	25	8	33	8	32	13	35	3	32	-3	28	-4	21	-8	11
1993	-13	11	-10	6	-8	18	-2	21	4	30	6	32	5	35	8	35	3	28	-3	29	-8	19	-7	12
1994	-5	11	-15	14	-3	18	0	24	-4	30	6	34	11	32	7	37	8	34	-4	28	-5	19	-7	9
1995	-15	9	-4	13	-6	16	-4	22	1	28	9	29	12	34	9	31	5	28	-4	25	-8	15	-11	12
1996	-10	4	-11	6	-11	11	-5	23	6	32	4	32	5	35	9	32	4	26	1	23	-2	19	-16	12
1997	-5	8	-10	14	-5	15	-6	18	2	27	3	32	10	34	10	30	1	28	-5	26	-3	18	-11	11
1998	-7	10	-12	15	-5	17	1	24	1	26	9	30	8	35	7	36	5	28	0	23	-6	19	-14	6
1999	-9	7	-8	11	-3	16	-2	22	-2	26	8	31	11	33	8	37	8	31	-3	28	-4	17	-13	12
2000	-23	3	-7	7	-5	18	-3	25	1	29	1	34	8	37	5	37	3	31	-2	26	-4	21	-11	13
2001	-11	12	-7	14	-4	27	-4	25	0	26	5	34	13	35	5	36	6	30	-3	28	-4	18	-15	3
2002	-16	13	-3	16	-3	20	-3	21	6	32	6	36	12	36	9	31	4	29	1	25	-2	19	-14	12
2003	-11	7	-12	6	-6	16	-5	27	4	32	7	34	10	34	7	35	0	29	-4	25	-2	20	-7	10
2004	-14	6	-14	12	-14	19	-2	21	1	24	8	26	6	33	10	29	1	26	-2	19	-7	21	-10	15
2005	-11	9	-17	6	-20	19	-3	22	0	28	6	30	10	34	9	34	8	27	-4	23	-8	16	-8	8
2006	-18	6	-14	10	-10	19	1	22	3	33	5	32	8	32	6	35	6	27	-3	29	-4	15	-6	12
2007	-7	12	-5	14	-2	19	-1	23	-1	30	9	34	7	38	10	36	5	27	-2	23	-6	14	-9	10
2008	-14	10	-8	19	-3	16	1	24	3	29	8	32	8	35	5	35	5	34	0	24	-4	22	-7	15
2009	-10	11	-7	14	-4	20	1	22	3	29	4	32	10	35	11	33	6	31	-2	26	-6	20	-15	14
2010	-16	11	-7	12	-8	19	2	21	6	26	7	33	12	31	9	32	4	25	-2	16	-3	19	-11	14
2011	-10	10	-10	8	-6	18	-1	22	-3	25	6	30	9	32	8	32	8	29	-2	24	-4	15	-5	14
2012	-17	5	-20	3	-12	18	-2	26	6	28	8	31	10	33	8	35	6	30	-1	27	0	19	-11	9
2013	-10	9	-6	13	-6	19	1	28	3	28	10	32	9	34	9	34	3	25	-2	23	-2	19	-5	8
2014	-10	12	-11	15	-1	22	2	21	3	26	9	30	9	30	8	34	3	28	-1	26	-4	20	-12	11
2015	-13	11	-7	17	-3	20	-4	24	7	29	9	31	8	34	13	34	5	35	0	23	-1	19	-9	11
2016	-12	10	-3	17	-2	20	-1	28	4	27	8	35	8	34	8	33	3	31	0	26	-5	18	-7	6
2017	-17	1	-7	16	-2	22	-3	27	1	26	8	34	8	35	9	40	1	32	-4	25	-2	17	-5	12
2018	-9	11	-13	11	-9	22	-1	27	7	29	9	32	7	29	13	31	-1	32	2	26	-11	25	-9	9
2019	-8	4	-6	12	-3	20	-1	25	2	28	8	31	8	35	11	37	0	33	3	27	-4	20	-5	14
2020	-6	7	-6	15	-3	19	-5	21	0	29	4	29	10	32	11	35	5	33	1	30	-2	15	-6	12
2021	-9	10	-12	17	-5	16	-4	21	1	28	8	35	11	36	10	36	2	30	-4	22	-4	23	-10	12
abs.	-23	13	-25	19	-20	27	-6	28	-4	33	1	36	5	39	5	40	-1	35	-7	32	-11	25	-16	15

Source: ANERGO Energy Observatory

At the level of the Municipality of Cluj-Napoca, the table of the minimum and maximum air temperature values in the period analysed, shows that the lowest value of the air temperature was in February 1985, and the highest value was recorded in August of 2017, when at 14:00 there were 39.6°C (approximately 40°C in the previous analysis).

Fluctuation of the air temperature in 24 hours (hour average) in Cluj-Napoca (1985 - 2021).

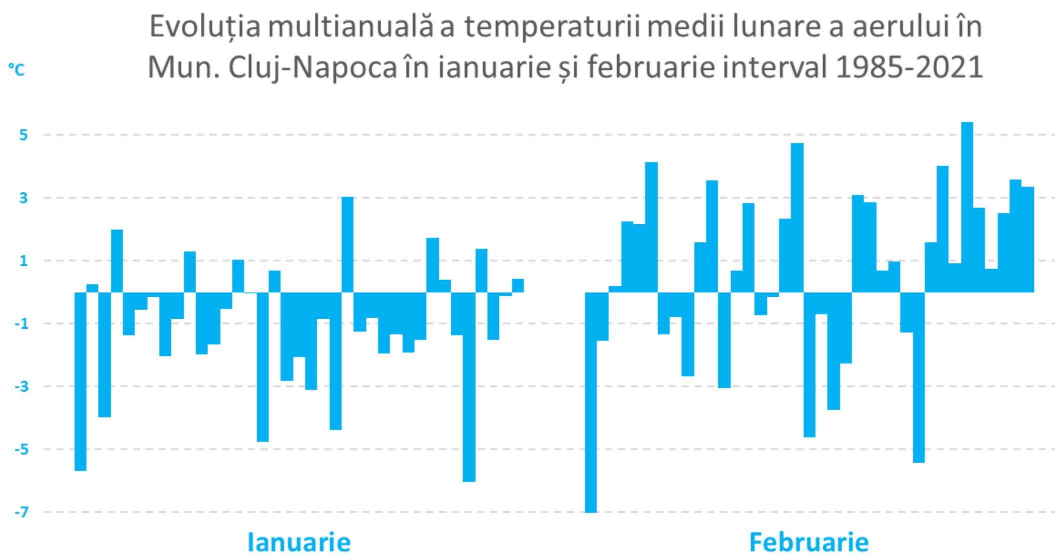
Oscilația temperaturii aerului în 24 de ore (medii orare) în Municipiul Cluj-Napoca (1985-2021)

	Ian		Feb		Mar		Apr		Mai		Iun		Iul		Aug		Sept		Oct		Nov		Dec	
°C	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
1985	1	9	3	16	2	14	3	16	3	16	4	14	4	18	5	18	7	16	5	16	3	15	2	9
1986	2	8	2	11	2	16	5	18	6	18	5	17	4	16	8	19	8	18	4	17	4	13	2	10
1987	2	12	3	11	2	13	5	18	4	18	6	16	4	18	4	19	6	21	4	19	4	13	2	7
1988	3	9	4	10	3	14	3	18	4	19	4	14	8	20	5	19	3	17	6	16	4	14	2	8
1989	2	8	4	13	4	16	3	20	4	17	4	16	6	17	3	16	4	14	4	15	3	13	4	11
1990	2	14	5	16	4	17	4	18	5	20	6	18	6	21	5	19	4	20	5	18	5	15	1	6
1991	1	9	2	13	4	17	4	17	2	17	5	18	6	18	4	16	5	19	3	19	2	13	2	7
1992	2	8	2	10	6	15	4	18	7	20	6	15	6	18	5	19	5	20	4	16	3	14	3	12
1993	3	13	3	9	2	15	5	18	3	18	6	22	6	19	4	21	3	19	6	20	3	13	2	10
1994	2	9	4	14	5	17	6	17	4	19	5	20	5	17	4	20	5	21	3	19	4	12	2	8
1995	1	8	3	12	4	15	6	16	4	16	4	16	6	18	2	18	6	18	6	15	1	10	2	9
1996	2	7	1	9	4	11	7	15	4	19	5	18	6	18	4	20	3	14	3	18	4	14	2	12
1997	2	8	3	13	5	12	2	15	5	18	4	19	5	17	4	15	4	19	5	17	3	15	3	10
1998	2	9	5	12	2	15	4	17	5	16	4	15	7	20	3	19	4	20	4	15	3	13	2	8
1999	2	7	2	11	6	15	6	19	6	17	5	17	5	17	5	19	5	18	4	19	2	14	2	12
2000	2	13	1	9	3	15	5	17	6	18	7	21	4	23	10	20	5	17	9	19	6	17	2	12
2001	4	9	1	13	6	19	4	18	8	19	4	20	4	20	5	19	1	18	4	16	1	12	2	13
2002	1	12	5	11	5	19	5	16	7	18	6	19	6	21	4	17	5	19	6	19	2	15	2	11
2003	1	9	3	10	4	14	4	18	7	19	9	20	6	17	12	21	4	18	4	16	3	16	2	10
2004	1	9	0,5	14	3	13	3	13	5	15	6	14	5	16	5	16	3	16	3	13	2	10	3	11
2005	3	9	1	9	2	16	3	16	4	15	6	17	4	16	4	16	4	15	6	16	3	13	1	8
2006	1	10	2	8	3	14	3	16	5	17	4	16	6	18	5	17	7	18	5	19	4	14	2	12
2007	3	10	5	11	6	18	7	19	6	20	4	19	5	22	5	16	2	16	4	16	4	10	2	8
2008	2	8	3	16	4	16	4	17	3	18	6	17	6	20	4	19	3	18	3	17	5	11	2	10
2009	3	10	1	12	3	14	8	19	6	19	6	20	6	18	6	17	9	18	3	16	4	12	1	13
2010	2	8	2	10	3	16	3	14	3	15	4	15	3	13	4	18	3	15	5	13	3	15	2	14
2011	1	8	1	10	3	16	6	19	4	17	4	15	4	14	6	16	4	16	4	15	5	12	2	12
2012	2	8	1	11	2	16	5	17	3	14	5	15	7	18	7	17	7	16	4	14	4	13	1	9
2013	2	8	2	12	4	15	3	18	4	17	4	14	6	17	4	17	4	16	4	16	4	12	3	9
2014	2	10	4	16	5	18	4	16	5	16	6	18	4	18	7	17	5	16	4	16	2	14	2	10
2015	3	11	2	16	3	18	3	20	4	19	3	16	9	17	5	18	2	20	2	15	1	14	4	10
2016	2	10	6	14	4	16	5	21	4	15	4	19	7	17	4	17	6	20	1	15	3	13	2	8
2017	2	10	3	12	6	16	3	20	4	19	4	18	4	19	8	21	4	21	3	18	3	13	1	10
2018	3	10	2	12	3	17	5	20	5	18	4	16	2	13	8	15	7	19	6	19	2	15	1	9
2019	2	7	3	13	4	18	5	18	4	15	5	18	6	18	6	18	5	20	4	19	3	16	3	12
2020	2	8	5	16	3	15	7	18	5	21	4	15	4	16	5	21	3	19	4	21	2	11	2	11
2021	2	12	5	13	3	15	2	16	4	19	7	18	5	18	4	21	5	18	4	19	4	15	2	13
abs.	1	14	0,5	16	2	19	2	21	2	21	3	22	2	23	2	21	1	21	1	21	1	17	1	14

Source: ANERGO Energy Observatory

The table of 24-hour oscillation values of the air temperature (hour average) in Cluj-Napoca, shows that there were months in which there were days in which the oscillations were minimal (February 2004) below 1°C but also sharp, with differences of 23°C in July of 2013, against the background of the accelerated drive of some air masses with different thermodynamic properties, which generated a wide thermal gradient.

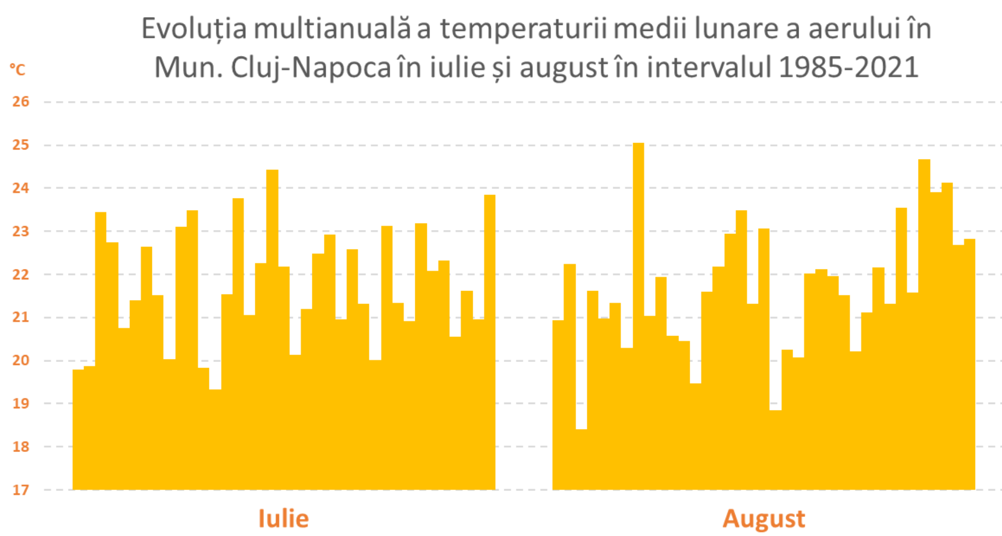
Increased thermal oscillation values are an important climate risk factor, because the higher the temperature fluctuations, the more the built environment and living organisms, including humans, are affected.



Multi-year evolution of the average monthly air temperature in Cluj-Napoca Municipality in January and February 1985 - 2021

Source: ANERGO Energy Observatory

The detailed day analysis of the 2 months of the cold season reveals that during the period (1985 – 2021) there were approximately 5 days/month with average air temperature values in 24 hours significantly below the freezing point. These days when the air temperature remains low, especially at night, constitute an environmental risk whose variability can be influenced by climate change.



Multi-year evolution of the average monthly temperature of the era in Cluj-Napoca Municipality in July and August in the period 1985 - 2021

Source: ANERGO Energy Observatory

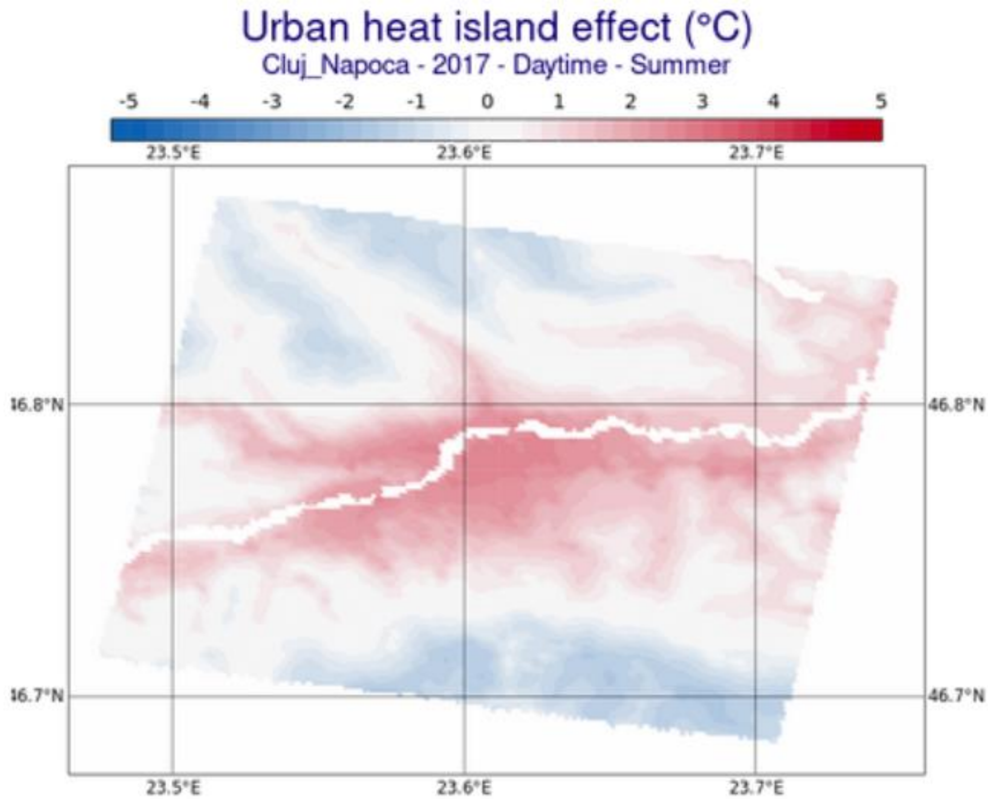
Similar to the analysis of air temperatures in the cold season, in the previous diagram, in which a vertical column represents a day, it is observed that in the months of July and August in the warm season, there are approximately 5 days with average temperatures over 24 hours higher than 23°C, these being days with minimum temperatures above 10°C during the night and above 30°C in the noon period, day.

This phenomenon must also be linked to local needs and the provision of assistance aimed at protecting the environment, animals and people from the effects of the heat.

10.2.2. Urban heat island

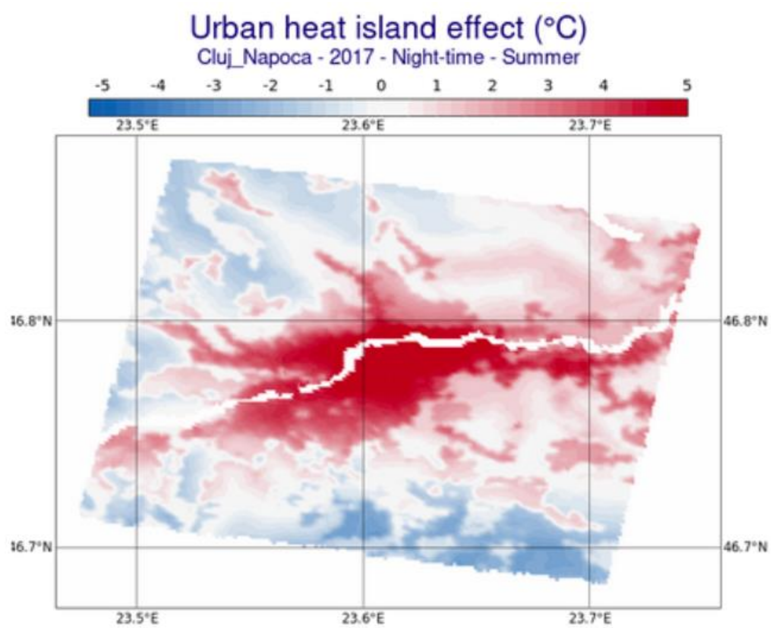
In the simulations below, made available on the infoclima.ro portal, the local manifestation of the urban heat island ICU phenomenon is observed, whose effect is highlighted during the night time, when the thermal energy conservation effect of construction materials in the urban area together with the effect of limiting air currents to replace the captive air between buildings with a cooler one, lead to the intensification of the ICU effect. The elements that shape this phenomenon are:

- Percentage of green spaces in the urban area
- Relative humidity of the air, respectively the occurrence of precipitation
- Wind speed and direction
- Density and height regime of buildings in the urban area
- Street arrangement of urban and peri-urban buildings
- The color of the buildings and the building materials used
- Configuration and geometry of streets and roads
- Local topographic characteristics



Urban heat island effect – Day – Summer

Source: infoclima.ro



Urban heat island effect – Night - Summer

Source: infoclima.ro

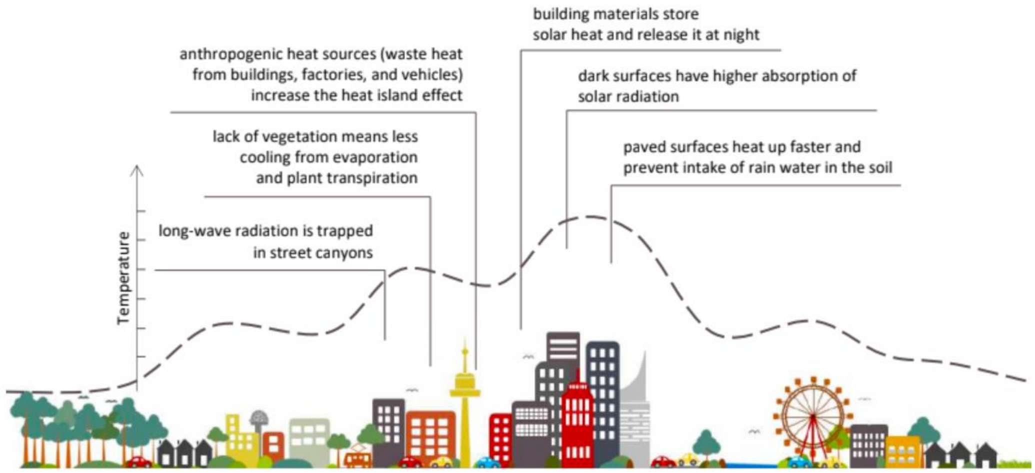


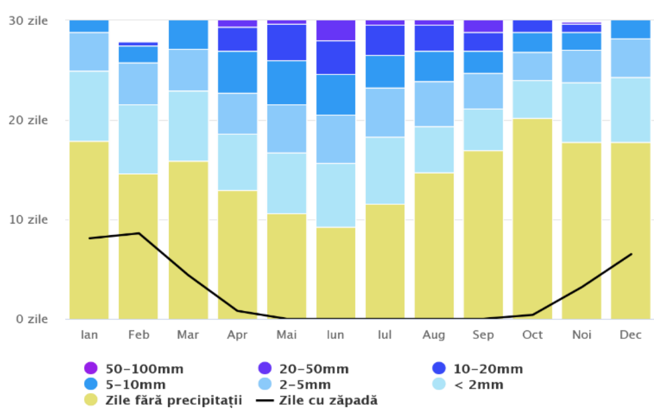
Illustration of the urban heat island effect, respectively the main factors contributing to the increase in air temperatures in the urban area

(sursa: infoclima.ro)

In the above diagram, it is noted that, at the level of the Municipality of Cluj-Napoca, there are significant differences between the average 24-hour air temperatures between the 2 autumn months. Thus, on average, the month of November is characterized by average daily temperatures about 10°C lower compared to the days of October.

10.2.3. Analysis of the evolution of precipitation quantities

The amount of local accumulated rainfall is an important factor in understanding the local climatological specifics. In the Municipality of Cluj-Napoca there are specific oscillations of the Transylvanian Depression during the calendar year, according to the following diagram:

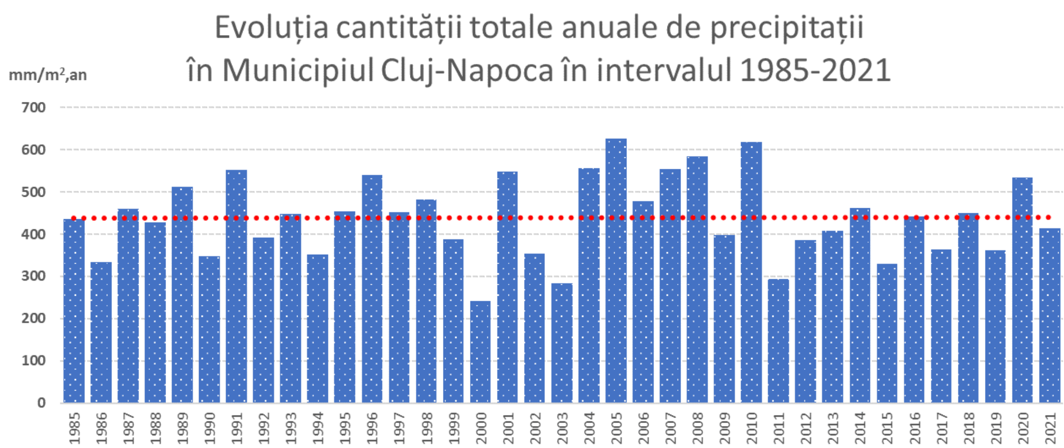


Local accumulated rainfall

sources: meteoblue.com

According to the previous chart, statistically there is an increase in the number of days with precipitation in the summer months. Snow days have a higher incidence in January and February.

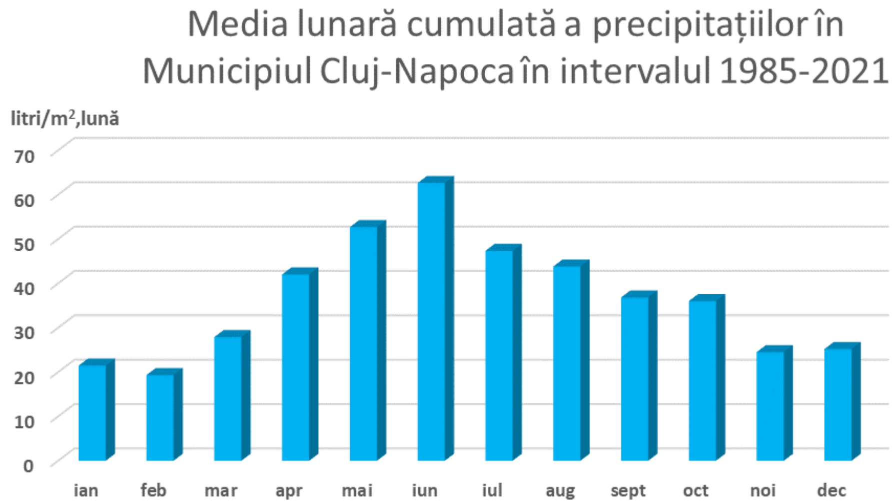
The analysis of the evolution of precipitation levels at the Cluj-Napoca Municipality level is represented by the following graphs, developed on the basis of the data set analyzed for the period 1985 – 2021, with relevance in understanding the development of phenomena related to the water circuit in the soil, the phenomenon of drought and other risk-generating phenoms associated with precipitation, accumulation over time or their absence.



Evolution of the total annual amount of precipitation in Cluj-Napoca Municipality in the period 1985 - 2021

Source: ANERGO Energy Observatory

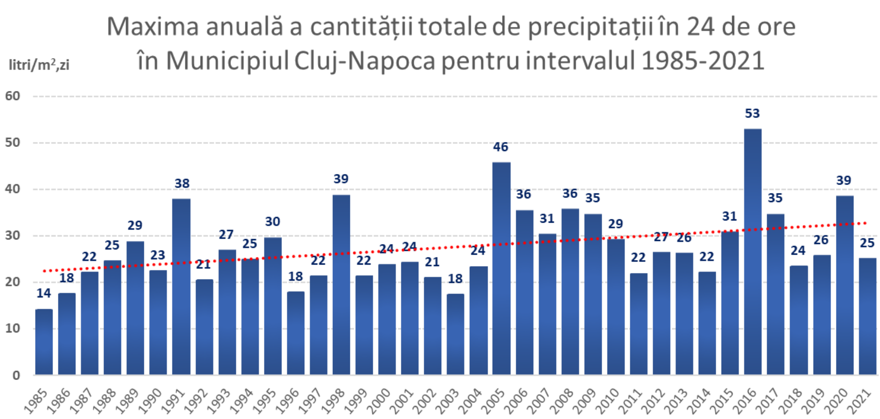
In the previous diagram it is noted that at the local level in Cluj-Napoca Municipality, the multi-year trend regarding the annual amount of precipitation remained stable over time, with average annual quantities between 242 l/m2, year (in 2000) and reaching 626 L/m2 years (in 2005).



Cumulative monthly average of precipitation in Cluj-Napoca Municipality in the period 1985 - 2021

Source: ANERGO Energy Observatory

The average monthly amount of rainfall at the local level shows significant variations throughout the calendar year, with the month of June being marked with higher accumulations of precipitation. On average, during the year, quantities ranging from 19 to 63 litres/m2 per month were recorded. The following chart shows that there may be days (meaning 24-hour intervals) in which precipitation accumulations exceed the monthly multiannual averages described above:



Maximum annual amount of total rainfall in 24 hours in Cluj-Napoca Municipality for the period 1985 - 2021

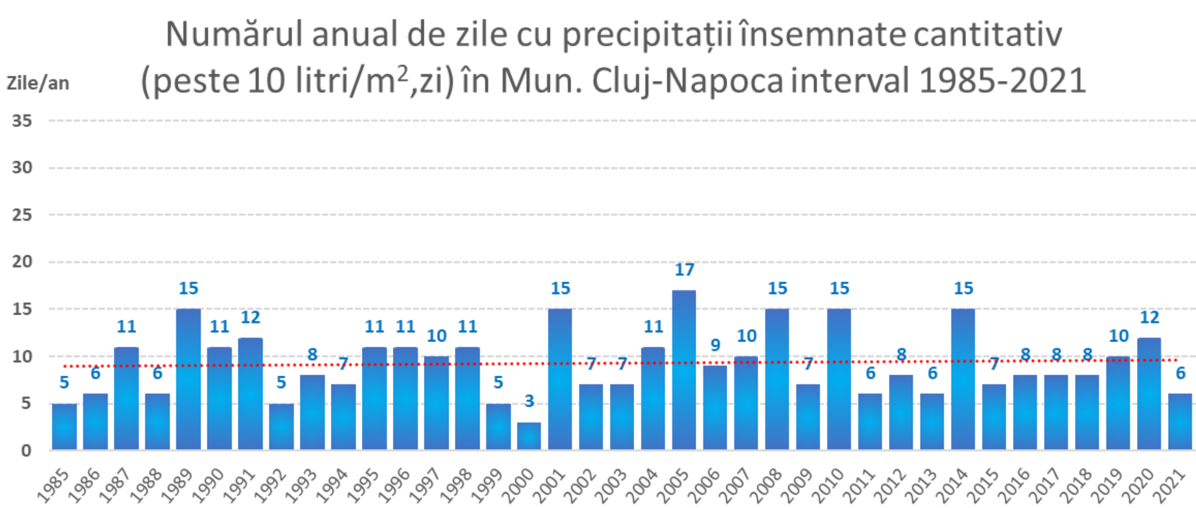
Source: ANERGO Energy Observatory

The chart above shows the largest amount of rainfall in 24 hours for each year in the analyzed range. On the territory of the Municipality of Cluj Napoca is observed maximum precipitation ranging from 14 litres/m2,day to 53 liters/m2day.

Top 10 days after the accumulation of rainfall in Cluj-Napoca (1985 - 2021)

TOP 10 DAYS AFTER THE ACCUMULATION OF PREFLUTIONS IN MUN. CLUJ-NAPOCA IN THE INTERVIEW 1985 – 2021	
Date	**Quantity [liters/m2,day]**
12.10.2016	53
18.08.2005	45,8
19.06.1998	38,9
23.06.2020	38,6
28.07.1991	38
05.10.2008	35,8
02.06.2006	35,6
13.10.2009	34,8
20.04.2017	
26.09.2020	34,6

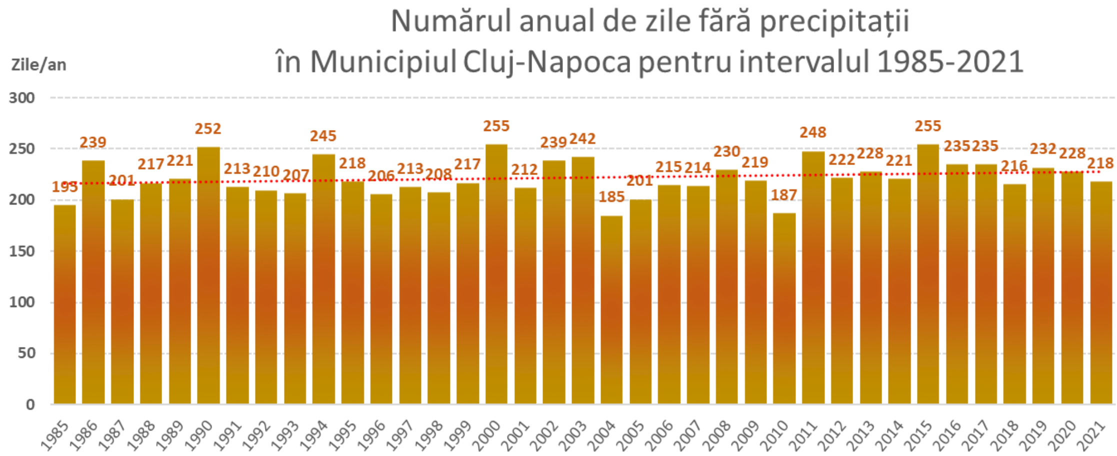
Source: ANERGO Energy Observatory



Annual number of days with significant quantitative precipitation (over 10 l/mc, day) in Cluj-Napoca Municipality between 1985 - 2021

Source: ANERGO Energy Observatory

In the above diagram it can be seen that the frequency of years with a number of days with significant quantitatively precipitation is increasing slightly.



Annual number of days without rainfall in Cluj-Napoca Municipality for the period 1985 - 2021

Source: ANERGO Energy Observatory

The previous chart highlights the driest years as well as the rainy ones. The annual number of days without rainfall in Cluj-Napoca Municipality follows a slightly rising trend in the analyzed range. On average there are approximately 221 days without rainfall per year - approx. 61% of the total number of days per year.

Total monthly precipitation accumulated in Cluj-Napoca Municipality (1985 - 2021)

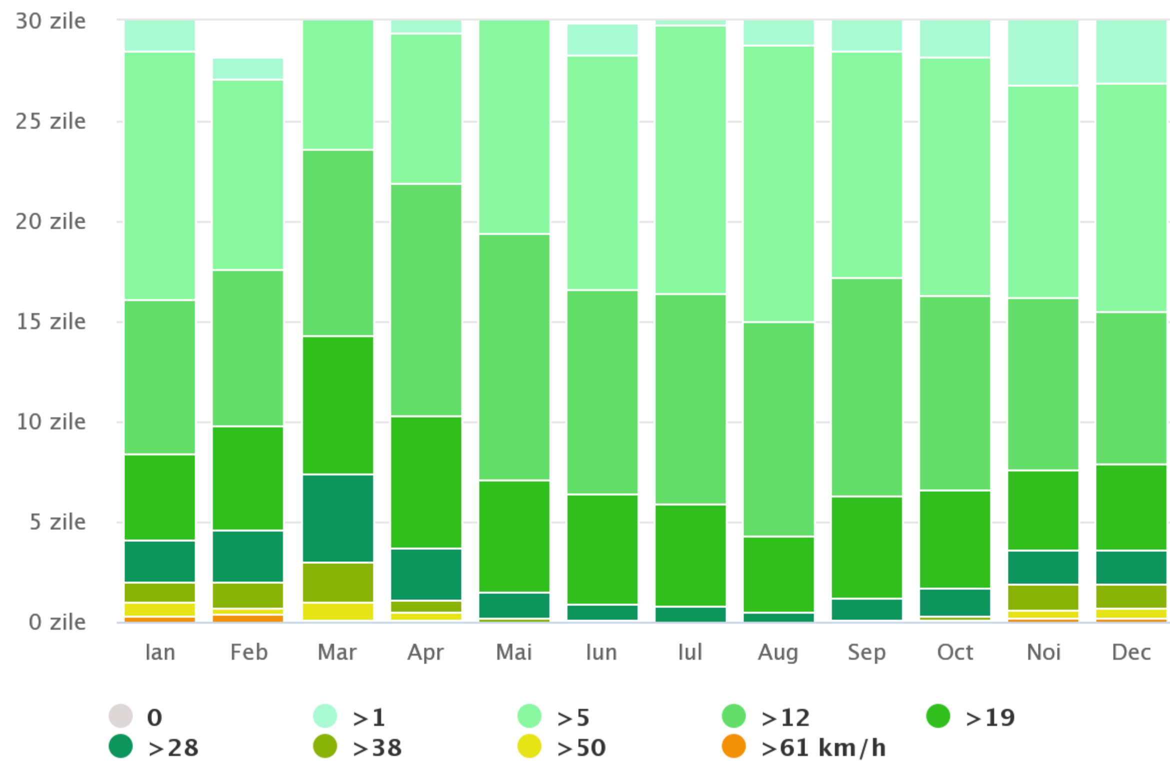
Precipitații totale lunare acumulate în Municipiul Cluj-Napoca (1985-2021)													
l/m²	Ian	Feb	Mar	Apr	Mai	Iun	Iul	Aug	Sept	Oct	Nov	Dec	total
1985	*31*	*23*	*13*	*60*	*45*	*91*	*52*	*47*	*12*	*19*	*25*	*18*	*436*
1986	*18*	*34*	*21*	*71*	*28*	*58*	*56*	*27*	*2*	*12*	*2*	*7*	*335*
1987	*17*	*16*	*31*	*40*	*106*	*37*	*46*	*43*	*8*	*28*	*49*	*39*	*460*
1988	*41*	*30*	*57*	*39*	*45*	*96*	*22*	*28*	*32*	*7*	*7*	*25*	*428*
1989	*5*	*17*	*28*	*50*	*74*	*94*	*24*	*147*	*31*	*32*	*10*	*2*	*513*
1990	*4*	*4*	*3,3*	*42*	*34*	*39*	*57*	*24*	*29*	*55*	*4*	*54*	*349*
1991	*22*	*16*	*21*	*11*	*134*	*62*	*122*	*32*	*35*	*49*	*23*	*25*	*552*
1992	*17*	*10*	*14*	*48*	*25*	*74*	*26*	*25*	*30*	*53*	*43*	*26*	*392*
1993	*6*	*17*	*46*	*60*	*27*	*60*	*35*	*60*	*44*	*23*	*53*	*17*	*447*
1994	*12*	*6*	*14*	*30*	*55*	*30*	*42*	*37*	*19*	*80*	*16*	*11*	*352*
1995	*24*	*17*	*17*	*29*	*53*	*63*	*14*	*71*	*54*	*5*	*60*	*50*	*455*
1996	*26*	*35*	*22*	*24*	*56*	*36*	*36*	*61*	*119*	*22*	*31*	*72*	*540*
1997	*23*	*19*	*8*	*71*	*49*	*59*	*60*	*58*	*35*	*35*	*18*	*16*	*452*
1998	*22*	*4*	*31*	*45*	*36*	*123*	*39*	*40*	*54*	*40*	*34*	*15*	*483*
1999	*26*	*41*	*8*	*33*	*46*	*38*	*38*	*24*	*43*	*23*	*36*	*32*	*388*
2000	*7*	*13*	*42*	*31*	*15*	*23*	*50*	*4,5*	*37*	*3*	*2*	*16*	*242*
2001	*15*	*23*	*28*	*51*	*25*	*92*	*69*	*29*	*132*	*14*	*63*	*9*	*549*
2002	*5*	*8*	*21*	*25*	*20*	*40*	*49*	*48*	*43*	*37*	*39*	*19*	*354*
2003	*48*	*12*	*23*	*25*	*21*	*12*	*37*	*5*	*25*	*41*	*18*	*17*	*284*
2004	*30*	*19*	*23*	*71*	*48*	*48*	*65*	*84*	*67*	*36*	*46*	*20*	*556*
2005	*31*	*19*	*32*	*98*	*46*	*88*	*77*	*165*	*23*	*3*	*19*	*26*	*626*
2006	*14*	*34*	*68*	*53*	*51*	*104*	*16*	*90*	*14*	*21*	*4*	*12*	*478*
2007	*15*	*33*	*44*	*11*	*49*	*31*	*44*	*102*	*94*	*70*	*54*	*8*	*554*
2008	*24*	*12*	*24*	*61*	*92*	*52*	*139*	*27*	*37*	*64*	*14*	*38*	*584*
2009	*10*	*25*	*39*	*4*	*32*	*61*	*25*	*60*	*2*	*72*	*32*	*37*	*397*
2010	*48*	*32*	*29*	*50*	*84*	*123*	*83*	*31*	*43*	*45*	*11*	*41*	*619*
2011	*27*	*22*	*13*	*16*	*23*	*57*	*83*	*10*	*17*	*12*	*0*	*14*	*293*
2012	*26*	*32*	*11*	*60*	*49*	*45*	*18*	*22*	*24*	*33*	*11*	*57*	*385*
2013	*18*	*13*	*40*	*45*	*58*	*73*	*14*	*58*	*39*	*43*	*5*	*0*	*407*
2014	*28*	*7*	*11*	*51*	*76*	*21*	*82*	*18*	*29*	*43*	*43*	*53*	*462*
2015	*9*	*11*	*28*	*17*	*48*	*56*	*26*	*43*	*24*	*40*	*27*	*1*	*330*
2016	*36*	*14*	*30*	*27*	*64*	*44*	*19*	*29*	*8*	*132*	*34*	*4*	*441*
2017	*3*	*11*	*25*	*74*	*61*	*48*	*25*	*16*	*30*	*37*	*13*	*20*	*363*
2018	*28*	*40*	*77*	*16*	*32*	*115*	*47*	*5*	*14*	*12*	*20*	*45*	*450*
2019	*37*	*10*	*9*	*28*	*113*	*41*	*30*	*10*	*14*	*37*	*20*	*14*	*362*
2020	*4*	*20*	*42*	*26*	*76*	*140*	*43*	*23*	*64*	*45*	*19*	*33*	*534*
2021	*36*	*16*	*40*	*62*	*58*	*45*	*44*	*18*	*38*	*10*	*5*	*43*	*414*
media	21	19	28	42	53	63	47	44	37	36	24	25	l/m²

Source: ANERGO Energy Observatory

The table of monthly accumulations of precipitation in the Municipality of Cluj-Napoca, reveals the characteristic of the phenomenon in the analyzed range. In the table it is noted December 2013 as the driest month in the period analysed, and August 2005 as the richest in precipitation, when in 30 days there were accumulated approximately 165 millimeters of precipitation per square meter. During the period, the rainy year was 2010 and the dryest year was 2000.

10.2.4. Analysis of the evolution of the movement of air masses

The most important phenomenon in the dynamics of the Earth's atmosphere is the movement of air masses. The magnitude of this phenomenon is directly proportional to the manifestation of other atmospheric phenomena, including those that pose environmental risks such as storms, frost, snowshooting, the transportation of some air fronts with a high load of precipitation and can lead to the amplification of electrical phenoms in the atmosphere.



Movement of air masses

Source: meteoblue.com

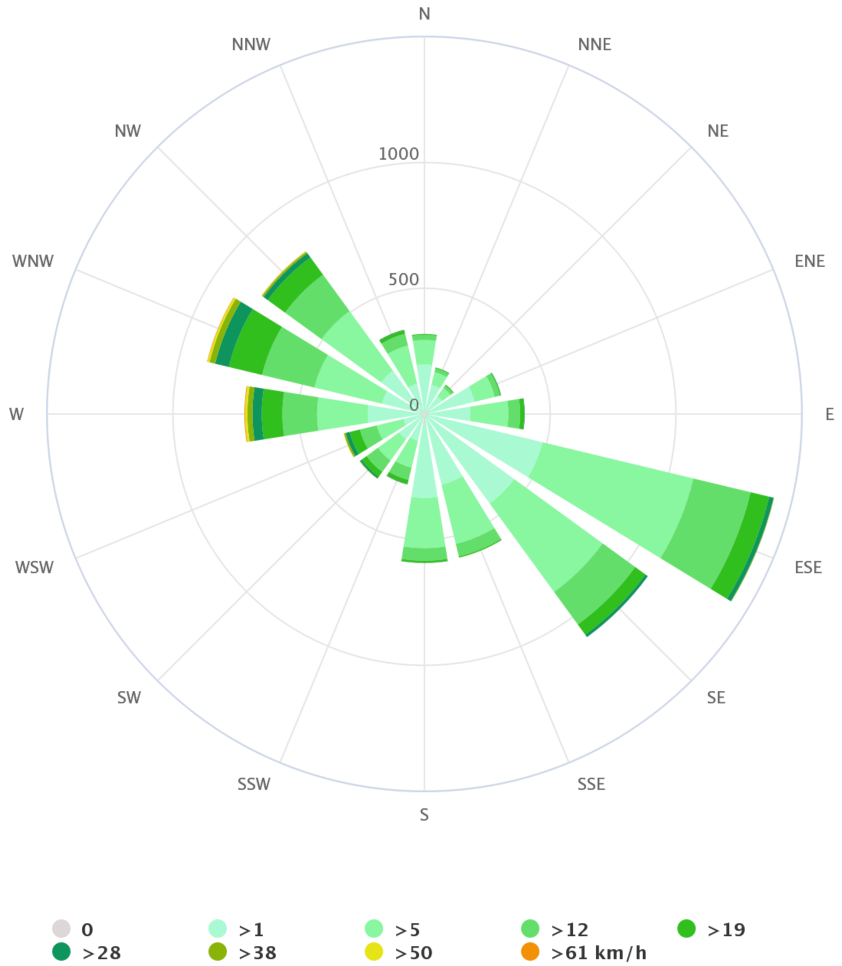
In the above diagram it is noted that, at the level of the Municipality of Cluj-Napoca, the greatest time scale of the phenomenon analyzed is recorded in the winter months, respectively in the first part of spring (March and April months).

Average wind speed in Cluj-Napoca (1985 - 2021)

Viteza medie a vântului la 10 m de sol în Municipiul Cluj-Napoca (1985-2021)													
km/h	**Ian**	**Feb**	**Mar**	**Apr**	**Mai**	**Iun**	**Iul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**med.**
1985	*7,5*	*16,7*	*11,7*	*12,0*	*8,5*	*10,5*	*8,6*	*9,7*	*9,2*	*6,7*	*12,5*	*9,7*	***10,3***
1986	*14,0*	*12,7*	*10,5*	*9,2*	*7,0*	*9,5*	*7,9*	*7,9*	*8,4*	*7,3*	*6,9*	*10,0*	***9,3***
1987	*12,1*	*8,7*	*10,6*	*12,1*	*10,2*	*8,0*	*7,1*	*9,8*	*8,4*	*8,2*	*9,9*	*10,2*	***9,6***
1988	*9,0*	*13,0*	*15,3*	*13,1*	*9,0*	*9,7*	*7,7*	*7,4*	*8,9*	*7,5*	*10,9*	*12,8*	***10,4***
1989	*5,9*	*8,8*	*9,9*	*11,1*	*9,0*	*9,2*	*7,7*	*7,5*	*6,9*	*9,1*	*12,1*	*9,1*	***8,9***
1990	*7,2*	*13,4*	*15,2*	*10,0*	*8,4*	*7,7*	*8,5*	*7,1*	*9,6*	*8,0*	*7,6*	*8,4*	***9,3***
1991	*7,6*	*13,3*	*10,8*	*10,6*	*13,2*	*9,8*	*6,9*	*6,8*	*8,0*	*9,2*	*7,0*	*9,3*	***9,4***
1992	*11,5*	*11,5*	*15,6*	*11,2*	*9,3*	*8,1*	*7,8*	*6,7*	*9,8*	*12,1*	*13,2*	*7,9*	***10,4***
1993	*12,9*	*8,8*	*11,6*	*10,6*	*8,7*	*10,1*	*10,4*	*7,7*	*8,5*	*8,9*	*10,6*	*13,7*	***10,2***
1994	*10,2*	*11,1*	*15,7*	*11,0*	*9,3*	*9,5*	*7,0*	*8,4*	*8,0*	*8,8*	*11,0*	*10,3*	***10,0***
1995	*11,2*	*11,8*	*14,9*	*15,3*	*11,1*	*8,6*	*6,6*	*7,5*	*9,5*	*4,6*	*10,5*	*10,2*	***10,2***
1996	*9,3*	*9,8*	*11,2*	*9,8*	*8,3*	*7,8*	*8,9*	*8,6*	*10,9*	*8,6*	*7,3*	*7,3*	***9,0***
1997	*7,1*	*13,5*	*11,7*	*17,9*	*10,2*	*8,3*	*8,6*	*7,0*	*8,1*	*9,6*	*8,1*	*8,8*	***9,9***
1998	*10,7*	*9,4*	*17,5*	*12,0*	*8,1*	*8,4*	*10,0*	*6,7*	*10,9*	*10,5*	*11,2*	*8,6*	***10,3***
1999	*6,7*	*15,4*	*11,6*	*10,9*	*7,5*	*7,8*	*8,4*	*7,2*	*8,0*	*10,5*	*11,2*	*10,3*	***9,6***
2000	*13,5*	*10,8*	*15,5*	*12,4*	*7,8*	*9,7*	*12,4*	*7,4*	*7,6*	*7,6*	*6,7*	*7,3*	***9,9***
2001	*9,4*	*13,9*	*15,1*	*10,1*	*10,1*	*12,4*	*7,6*	*7,5*	*8,9*	*6,5*	*13,7*	*7,5*	***10,2***
2002	*8,7*	*10,6*	*12,5*	*10,9*	*9,8*	*9,1*	*9,0*	*8,2*	*6,9*	*10,1*	*8,8*	*9,2*	***9,5***
2003	*8,7*	*8,3*	*10,6*	*13,4*	*8,3*	*8,7*	*8,5*	*8,9*	*8,2*	*10,6*	*6,4*	*9,3*	***9,2***
2004	*10,9*	*14,3*	*10,2*	*9,1*	*9,6*	*8,3*	*6,5*	*6,1*	*6,9*	*7,0*	*12,8*	*6,4*	***9,0***
2005	*10,8*	*8,3*	*13,8*	*9,2*	*8,1*	*8,4*	*6,5*	*6,7*	*5,1*	*9,0*	*7,0*	*10,0*	***8,6***
2006	*6,2*	*9,1*	*12,4*	*8,5*	*8,9*	*6,7*	*7,1*	*7,3*	*9,4*	*6,6*	*10,1*	*4,8*	***8,1***
2007	*13,8*	*12,5*	*11,5*	*8,7*	*9,6*	*7,8*	*10,2*	*6,8*	*8,3*	*6,7*	*13,0*	*6,0*	***9,6***
2008	*9,1*	*9,9*	*13,3*	*9,0*	*7,8*	*6,4*	*9,1*	*7,8*	*8,0*	*6,9*	*9,9*	*11,0*	***9,0***
2009	*7,3*	*11,7*	*13,6*	*8,5*	*7,9*	*9,2*	*8,3*	*6,1*	*6,9*	*8,7*	*7,3*	*7,8*	***8,6***
2010	*8,1*	*11,3*	*12,5*	*8,1*	*8,6*	*7,4*	*6,1*	*6,7*	*7,2*	*7,0*	*9,0*	*11,0*	***8,6***
2011	*5,9*	*8,5*	*8,4*	*12,5*	*8,1*	*9,6*	*6,3*	*6,7*	*6,3*	*7,1*	*4,2*	*8,1*	***7,6***
2012	*12,9*	*10,6*	*11,2*	*9,1*	*6,8*	*7,1*	*6,9*	*6,5*	*7,3*	*6,7*	*6,2*	*8,8*	***8,3***
2013	*9,9*	*10,0*	*15,4*	*8,3*	*9,6*	*6,3*	*7,0*	*5,8*	*9,0*	*6,0*	*7,7*	*8,6*	***8,7***
2014	*8,4*	*6,9*	*10,8*	*10,4*	*8,5*	*8,4*	*7,3*	*6,9*	*8,9*	*7,5*	*7,1*	*10,4*	***8,5***
2015	*12,1*	*8,0*	*9,9*	*14,8*	*8,1*	*7,2*	*7,6*	*6,4*	*8,9*	*7,5*	*8,0*	*6,2*	***8,7***
2016	*10,4*	*11,5*	*8,8*	*11,0*	*8,5*	*7,2*	*8,9*	*7,1*	*6,1*	*9,4*	*9,9*	*9,7*	***9,0***
2017	*9,4*	*9,3*	*10,4*	*12,6*	*8,3*	*9,4*	*8,3*	*7,7*	*8,6*	*10,5*	*7,9*	*10,6*	***9,4***
2018	*10,0*	*11,5*	*11,1*	*10,1*	*7,9*	*7,0*	*6,8*	*5,5*	*7,9*	*8,6*	*7,2*	*9,3*	***8,6***
2019	*11,8*	*9,7*	*11,5*	*10,4*	*9,9*	*6,6*	*7,9*	*7,7*	*8,2*	*5,7*	*10,3*	*9,1*	***9,1***
2020	*7,4*	*14,5*	*11,6*	*8,2*	*11,7*	*7,4*	*6,5*	*7,6*	*8,1*	*7,7*	*4,1*	*7,7*	***8,5***
2021	*10,8*	*12,0*	*10,4*	*9,8*	*9,9*	*7,0*	*8,0*	*7,0*	*7,6*	*8,0*	*7,6*	*12,4*	***9,2***
media	*9,7*	*11,1*	*12,3*	*10,9*	*9,0*	*8,4*	*8,0*	*7,3*	*8,2*	*8,1*	*9,1*	*9,1*	**km/h**

Source: ANERGO Energy Observatory

The chart of the movement of air masses at the level of the Municipality of Cluj-Napoca for the analyzed range shows that the fastest winds blow in the winter and spring months, and in summer and autumn the average wind speed decreases.



Prevailing direction of air currents

Source: meteoblue.com

In the above diagram (wind rose) it is observed that at the local level, the predominant direction of low-intensity air currents, with average speeds of approx. 15 km/h, is from southeast and east-south-east, with more than 1,000 hours/year. From the west-north-west direction winds with moderate or high speeds (12-28 km/h), but for shorter periods of time (about 300 hours/year). The general directions of the winds of low, medium and high intensity are determined by the position and morphology of the Western Carpathians, the Transylvanian Depression and the Carpathian arc in general, in relation to the geographical position of the Municipality of Cluj-Napoca, which brings strong winds in the direction south-west – northeast.

Maximum wind speed (hour average) in Municipoiul Cluj-Napoca (1985 - 2021)

Viteze maxime (medii orare) ale vântului la rafală în Municipiul Cluj-Napoca (1985-2021)													
km/h	Ian	Feb	Mar	Apr	Mai	Iun	Iul	Aug	Sept	Oct	Nov	Dec	max.
1985	50,4	81,7	50,0	64,8	69,5	49,7	39,2	34,2	43,6	33,8	53,3	76,7	**81,7**
1986	71,3	52,6	46,1	35,6	35,3	45,0	33,5	37,1	37,4	44,3	59,4	76,3	**76,3**
1987	63,0	41,8	60,5	54,4	47,2	36,4	41,8	36,4	44,3	32,8	50,8	56,5	**63,0**
1988	37,1	90,7	56,5	67,0	40,3	50,8	36,4	38,9	38,5	36,4	70,2	76,7	**90,7**
1989	40,3	63,7	55,1	51,8	53,6	40,3	34,6	36,4	35,3	48,2	54,4	75,6	**75,6**
1990	38,2	81,7	67,7	40,7	45,4	38,2	37,4	41,8	40,7	43,6	47,5	49,7	**81,7**
1991	46,1	54,0	44,6	47,5	52,2	34,6	34,2	25,6	47,2	42,8	37,1	60,5	**60,5**
1992	89,6	78,1	66,6	55,1	33,8	32,4	32,4	32,8	50,8	53,3	52,9	40,3	**89,6**
1993	77,0	40,7	69,5	54,0	50,0	38,5	47,9	34,2	35,6	45,4	58,7	65,9	**77,0**
1994	56,5	44,6	79,9	58,7	46,1	59,4	31,3	49,7	40,7	40,7	62,3	49,7	**79,9**
1995	69,8	57,6	61,2	60,1	57,2	33,5	34,9	37,1	41,0	34,2	70,6	50,4	**70,6**
1996	40,7	43,6	39,2	48,6	43,2	32,8	36,4	37,4	54,4	32,8	39,6	42,8	**54,4**
1997	62,3	59,8	54,4	86,4	54,4	38,2	34,9	32,4	43,2	46,8	42,1	40,0	**86,4**
1998	65,5	49,7	77,0	53,3	42,8	55,8	60,8	33,1	47,5	54,0	47,2	40,0	**77,0**
1999	41,8	79,2	39,6	50,4	34,2	32,4	33,1	46,4	43,2	44,6	60,5	58,7	**79,2**
2000	85,0	61,2	71,3	64,4	31,3	49,0	54,7	33,8	37,1	37,4	34,6	54,7	**85,0**
2001	56,9	74,9	70,2	45,4	45,4	54,0	32,8	47,5	36,7	40,0	77,0	70,2	**77,0**
2002	58,7	48,2	61,9	55,8	36,7	42,1	35,3	44,6	28,1	71,6	52,9	41,8	**71,6**
2003	61,9	49,7	57,2	75,2	37,4	40,3	41,4	44,3	31,7	52,6	36,4	65,5	**75,2**
2004	48,6	73,4	45,0	44,6	36,4	38,9	32,8	24,8	39,6	52,2	72,4	35,3	**73,4**
2005	51,5	44,6	64,8	40,0	32,4	42,8	27,4	37,4	21,2	41,4	42,1	70,6	**70,6**
2006	44,6	34,9	62,6	38,2	40,7	42,5	37,8	35,3	55,1	40,7	50,0	43,2	**62,6**
2007	88,2	78,8	58,0	46,4	43,9	51,8	52,6	26,3	36,0	44,3	54,7	40,7	**88,2**
2008	68,8	51,8	69,8	43,6	39,6	30,6	42,5	33,8	34,6	38,2	56,2	59,0	**69,8**
2009	38,5	38,2	62,6	40,3	47,9	41,0	37,1	25,9	34,2	61,2	43,9	43,2	**62,6**
2010	45,4	71,6	66,6	36,7	50,0	44,3	39,6	34,6	49,3	41,0	63,7	67,0	**71,6**
2011	57,6	82,1	44,3	64,8	40,0	43,6	40,0	32,0	44,3	40,3	34,2	62,6	**82,1**
2012	64,4	55,8	78,8	53,6	43,9	40,7	46,4	42,5	38,9	54,4	53,3	57,2	**78,8**
2013	55,4	45,7	60,1	47,2	41,8	20,5	32,8	31,7	44,6	28,8	36,0	69,5	**69,5**
2014	55,1	40,0	59,4	42,5	42,1	42,1	31,7	32,4	39,6	37,4	32,8	50,8	**59,4**
2015	68,4	38,5	45,7	61,9	41,0	33,8	28,8	29,9	37,4	41,8	56,9	67,3	**68,4**
2016	54,4	63,4	43,6	43,9	36,0	43,6	41,8	30,2	30,2	36,4	64,8	79,9	**79,9**
2017	48,2	50,0	67,0	52,2	30,6	50,0	41,4	41,0	41,0	62,3	49,0	47,5	**67,0**
2018	65,5	48,6	42,8	54,4	37,8	37,8	27,7	29,2	38,5	50,8	38,2	70,2	**70,2**
2019	51,1	63,7	62,6	41,8	43,2	31,7	45,4	34,6	50,0	27,4	45,7	39,2	**63,7**
2020	62,3	72,0	49,7	42,8	48,2	35,3	37,4	34,9	43,9	41,4	20,5	43,6	**72,0**
2021	43,6	57,6	46,8	38,9	42,1	39,6	41,4	41,0	49,3	43,9	43,2	60,5	**60,5**
maxima	89,6	90,7	79,9	86,4	69,5	59,4	60,8	49,7	55,1	71,6	77,0	79,9	**km/h**

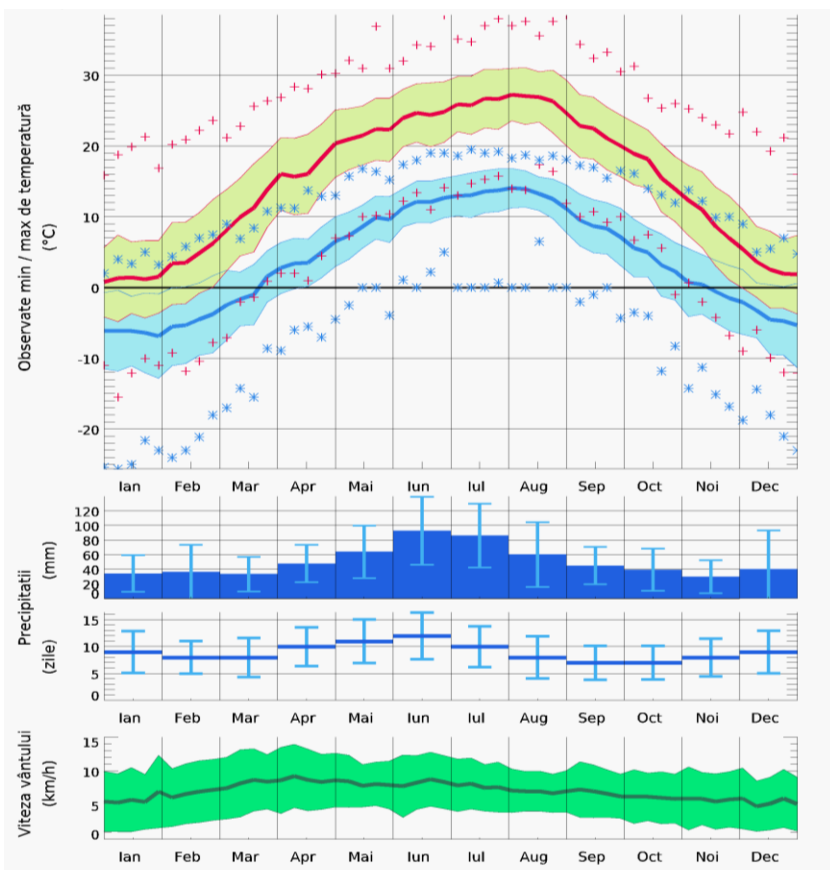
Source: ANERGO Energy Observatory

The chart of maximum speeds (hour average) at the local level, in Cluj-Napoca Municipality, shows that the winter and spring months represent the main period of the year when the phenomenon is increasing in frequency and intensity. These events are based on the location of the Municipality of Cluj-Napoca in a hill area, as well as the geographical position of the municipality in the Depression of Transylvania - the origin of higher-intensity air currents.

10.2.5. Conclusions

In the conclusion of the climatological analysis which included the main weather phenomena and their associated effects, at the level of the Municipality of Cluj-Napoca, we note specific atmospheric trends of the height regime of the hills, most of the local occurrences bearing the imprint of the intracarpathian positioning in the hilly Depression of Transylvania.

The main climate characteristics generating risks are associated with heat waves, processes of erosion and soil washing after drought or heavy rain, but also imbalances of the ecosystems in the region arising as a result of the increase in temperature averages. These phenomena put pressure on the balances of the ecosystems created by indigenous flora and fauna and facilitate the proliferation of insect and animal species not specific to the area, some of which can be poisonous or dangerous.



Local weather trends in Cluj-Napoca City

Source: meteoblue.com

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- This paper consists of content taken over and restructured, from:

- Action Plan for Sustainable Energy and Climate – PACED 2030 of Alba Iulia Municipality;
- Sustainable Energy and Climate Action Plan for Iași Municipality;

- https://www.meteoblue.com/en/weather/week/cluj-napoca_romania_681290
- For situations not covered by this documentation with an impact on this program, the laws and regulations in force in Romania (legislation on labour protection, legislation in the field of social insurance, legislative in the area of environmental protection and emergency situations PSI etc.) apply.

ANNEX

ANNEX 1. – List of abbreviations and symbols

Km^2 – square kilometers

M^2 – square meter

m/s – meters per second

m^3 – cubic meter

Nm^3 – normal cubic meter

Nmc – normal cubic meter

J – Joule

MJ – Megajoule

GJ – Gigajoule

TJ – Terajoule

PJ – Petajoule

EJ – Exajoule

W – Watt

kWh – kilowatt hour

MWh – megawatt hour

kcal – kilocalories

Gcal – Gigacalories

tep – tonne oil equivalent

Mtep – Millions of tons oil equivalent

η – Return

LPG – Liquefied Petroleum Gas

IPCC – Intergovernmental Panel on Climate Change

ANNEX 2. – Conversions to measurement units

1 kWh = 3.6 MJ

1 kWh = 0,0008604 Gcal

1 kWh = 0.000085984522 tep

Mass Densities:

1 litre Diesel = 0.832 kg

1 litre of GPL = 0.51 kg

1 m^3 Natural gases = 0.8 kg

1 m^3 Biogas = 1.1 kg

Energy densities:

1 liter Diesel = 12.5 kWh

1 litre Gasoline = 10 kWh

1 litre of GPL = 6.93 kWh

1 m^3 Natural gases = 10.83 kWh (average value for higher heat capacity)

1 m^3 Biogas = 5.4 kWh CO2 equivalent emissions - Electricity = 710 g/kWh

CO_2 equivalent emissions - Natural gases = 202 g/kWh

CO_2 equivalent emissions – Liquefied petroleum gas = 227 g/kWh

CO_2 equivalent emissions – Diesel = 267 g/kWh

CO_2 equivalent emissions – Gasoline = 249 g/kWh

CO_2 equivalent emissions – Biofuel (carbon neutral) = 1 g/kWh

CO_2 equivalent emissions – Wood biomass = 403 g/kWh

Note: Emission factors have been taken from the IPCC Guide 2006.

ANNEX 3. – Terms and definitions

Energy audit – the systematic procedure for obtaining data on the existing energy consumption profile of a building or group of buildings, of an activity and/or industrial facility or of private or public services, for identifying and quantifying cost-effective opportunities for achieving energy savings and reporting results;

Energy auditor – a natural or legal person certified/authorized, in accordance with the law, who has the right to perform the energy audit provided for in point (a). Energy auditors, individuals, carry out their activities as authorized natural persons or as employees of legal persons, in accordance with the legislation in force;

White certificates – certificates issued by independent certification bodies that confirm the statements of market participants that energy savings are a consequence of measures to improve energy efficiency;

Energy service company (SSE) – an authorized legal or natural person who provides energy services and/or other measures to improve energy efficiency within the consumer's facility or premises and who, as a result of the provision of these services or measures, accepts a degree of financial risk. Payment for services provided is based, in whole or in part, on the improvement of energy efficiency and on the fulfilment of other performance criteria agreed by the parties;

ESCO energy service company – an authorized legal or natural person who provides energy services and/or other measures to improve energy efficiency within the consumer's facility or premises and who, as a result of the provision of these services or measures, accepts a degree of financial risk; payment for the services provided is based, in whole or in part, on the improvement of energy efficiency and on the fulfilment of other performance criteria agreed by the parties;

energy conservation – the totality of activities oriented towards the efficient use of energy resources in the process of extraction, production, processing, storage, transport, distribution and consumption, as well as towards attracting to the economic circuit of renewable energy resources; energy conservation includes 3 essential components: efficient use of energy, increased energy efficiency and replacement of scarce fuels;

final consumer – a natural or legal person who buys energy exclusively for own consumption;

"**energy performance contract**" – means a contractual agreement between the beneficiary and the provider of a measure aimed at improving energy efficiency, normally SSE, in which the investment necessary for the implementation of the measure must be paid in accordance with the level of improvement of energy efficiencies provided for in the contract;

primary energy consumption – gross domestic consumptions, excluding non-energy uses;

final energy consumption – all energy supplied to industry, transport, households, service sectors and agriculture, excluding energy intended for the production of electricity and thermal energy and to cover own technological consumptions from the installations and equipment related to the energy sector;

"energy distributor" – means a natural or legal person, including a distribution operator, responsible for the transmission of energy for its delivery to end consumers or to distribution stations which sell energy to end users in efficient conditions;

Energy savings – the amount of energy saved determined by measuring and/or estimating consumption before and after the application of one or more energy efficiency improvement measures, irrespective of external factors affecting energy use;

energy efficiency – the ratio between the value of the performance result obtained, consisting of services, goods or energy resulting and the energy value used for this purpose;

“energy” – means all forms of energy available on the market, including electricity, thermal energy, natural gas, including liquefied natural gas and liquid petroleum gas, any fuel for heating and cooling, coal and lignite, peat, fuels, except aviation and maritime fuels and biomass, as defined in Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal market for electricity;

“energy service provider” – means a natural or legal person who provides energy services or other measures to improve energy efficiency in the final consumer’s facility or premises;

Third-party financing – a contractual agreement involving, in addition to the energy supplier and beneficiary, a third party providing capital for the measure in question. The financial value of the energy savings generated by the improvement of energy efficiency determines payment to the third party. This third party may or may not be a SSE;

energy -saving financial instruments’ means any financial instrument, such as funds, grants, tax cuts, loans, third-party financing, energy performance contracts, energy savings guarantees, outsourcing contracts and other similar contracts made available on the market by public institutions or private bodies, to cover part or all of the initial cost of energy efficiency improvement measures;

improving energy efficiency – increasing energy efficiencies in end consumers as a result of technological, behavioural and/or economic changes;

‘**efficient heating and cooling’**– means a heating or cooling option that, compared to a basic scenario reflecting the normal situation, measurably reduces the consumption of primary energy required to supply a unit of delivered energy, within a relevant system limit, in a cost-effective manner, as assessed in the cost-benefit analysis, taking into account the energy required for extraction, conversion, transport and distribution;

energy management – the whole of the activities of organizing, managing and managing the energy processes of a consumer;

Energy manager – a natural or legal person providing certified energy services, whose object of activity is the organization, management and management of energy processes of a consumer;

Energy efficiency improvement measures – any action that normally leads to a verifiable improvement in energy efficiency and which can be measured or estimated;

Energy efficiency mechanisms – general instruments used by the Government or governmental bodies to create an appropriate framework or incentives for market players to provide and purchase energy services and other measures to improve energy efficiency;

'**distribution operator'–** means any natural or legal person who owns, under any title, a distribution network and who is responsible for the operation, maintenance and, if necessary, development of the distribution system in a given area and, where appropriate, its interconnections with other systems, as well as for ensuring the long-term capacity of the network to meet a reasonable level of demand for energy distribution under efficient conditions;

Energy efficiency improvement programmes – activities that focus on groups of end consumers and which normally lead to a verifiable, measurable or estimable improvement in energy efficiency;

substantial renovation – renovation whose costs exceed 50% of the investment costs for a new comparable unit;

Complex renovation – works carried out on the tires of the building and/or its technical systems, the costs of which exceed 50% of the taxation/inventory value of the buildings, if applicable, excluding the value of land on which the building is located;

‘**energy service’ –** means an activity that results in a physical benefit, utility or good obtained from a combination of energy with an energy-efficient technology and/or action which may include the operations, maintenance and control necessary for the provision of the service, which is provided on a contractual basis and which, under normal conditions, results in an improved and verifiable and measurable energy efficiency and/ or primary energy savings;

renewable energy sources – as defined in Directive 2001/77/EC of the European Parliament and Council of Europe;

international standard – standard adopted by the International Organization for Standardization and made available to the public;

Total useful area – the useful area of a building or part of the building where energy is used to adjust the indoor climate by: heating/cooling, ventilation/air conditioning, preparation of hot water for household use, lighting, as appropriate;

Cogeneration unit – production group that can operate in cogeneration mode.