Energy Management of Buildings With a Focus on Municipalities

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Due to the climate situation, the EU policy, the impact of the coronavirus pandemic and the war in Ukraine, it is necessary for municipalities to take a conceptual approach to their energy sector. A big topic of this issue and also the subject of this paper is the energy optimization of municipal buildings. The reality in the Czech Republic is that municipalities, with a few exceptions, do not combine data on energy and water consumption with the actual technical condition of the buildings concerned, so they have no basis for decision-making and individual projects are often dealt with in an unconceptual and ad-hoc manner. The methodology is based on an analysis of the situation in the South Moravian Region and a questionnaire survey of the Union of Towns and Municipalities of the Czech Republic. This article identifies the key areas that affect the energy efficiency of buildings and therefore specific data should be collected from these areas to form the basis for setting up the energy management of the city.

Keywords:
energy management,
municipality,
renewable energy,
measurement,
regulation,
green deal

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1 Introduction

This article deals with energy optimization of municipalities, specifically in the field of buildings. The European Union policy [1, 3] gave a sign of gradual pressure to reduce the energy intensity of the operations. However, the coronavirus pandemic and the war in Ukraine have accelerated the issue - these incidents have brought to light how the current European concept of energy is tied to fossil resources. The need to secure transitional fossil gas from countries other than the current majority Russia [2], to rebuild the energy mix in favour of renewables, and to decentralise previously robustly centralised sources of electricity has inevitably caused energy supply prices to jump. In addition, from 2025 onwards, the tariff structure in the Czech Republic is expected to be rebuilt to better reflect the impact of renewables on the resulting balance of the electricity system. These influences are forcing municipalities to rebuild from the base the current approach to their energy system. By making energy carrier payments a minority share of municipal budgets until recently, municipalities have not been motivated to optimise their buildings conceptually. By this is meant the implementation of energy management in accordance with ČSN EN 500001 and the renovation of buildings based on techno-economic grounds. For buildings, the heat loss through the building envelope and the performance and type of heat and cooling source are very closely related. For this reason, insulation with a constant thickness of polystyrene cannot be applied uniformly to all buildings, which is the idea of many municipal representatives of a sufficient energy solution.

Therefore, this article discusses the data sets that cities should track. This is a first step in the energy optimization of cities, because any further strategies need to be based on data that cities do not normally collect. These are data describing the building envelope and the technologies used that have an impact on energetics. Such datasets should provide a robust basis for municipalities to make energy optimisation decisions.

An important note is that the term "energy production and consumption" will be used here. While it is clear that energy is only converted, this terminology is used here because of its familiarity and not its factual correctness.

2 Methodology

The information on the current state of municipal energetics is obtained from the experience in the regional and district level municipalities of the South Moravian Region and from the questionnaire survey of the Union of Towns and Municipalities of the Czech Republic [4]. The South Moravian Region is a good reference region because on the one hand it contains very prosperous localities close to Brno, which is the second largest city in the Czech Republic. On the other hand, this region also includes relatively undeveloped areas in the south of the Czech Republic.

The analysis covered the current situation in the field of building energy management in municipalities of 5,000 - 30,000 inhabitants. The lower limit of 5,000 inhabitants was set because the smaller municipalities have a minimum of buildings under management - usually a municipal office, a fire station, a school and a kindergarten in the maximum version. This minimum of buildings can usually be secured by a more responsible mayor without extensive record keeping. Municipalities over 30,000 inhabitants have a contributory organisation that conceptually manages their energy. For municipalities in the range of 5,000- 30,000 inhabitants, existing practices were examined, both in terms of collecting and handling data on energy and water consumption and the technical condition of buildings. Based on these analyses, key datasets and practices were proposed to begin effective energy management.

The result of the research was that the majority of municipalities of the surveyed size do not systematically keep energy-related data. In most cases, knowledge of municipal assets is dispersed among a relatively large number of people in different departments (investment, finance, property, planning). Also, municipalities do not have professional management. If municipalities have their own energy manager, in most cases he/she is of very low professional level. Thus, the data is not approached conceptually and no linkage between them is observed (e.g. correlation between energy consumption and heat leakage). This article therefore provides a list of areas that municipalities should track in order to lay the basis for energy management.

3 Data collection areas

3.1 Energy consumption

Municipalities should register the consumption of energy in their utilities and subsidiary organisations. This includes consumption of electricity, gas and heat from central heating supply. These data should be recorded at least five years back and for average years - i.e. years not affected by the coronavirus pandemic or the war in Ukraine, as these events had a significant impact on energy consumption. Furthermore, it is advisable to register consumption at the finest granularity appropriate to the type of measurement used. Unfortunately, in the Czech Republic, quarter-hourly measurement is not yet commonplace.

This evidence plays a key role for a number of reasons:

3.1.1 Invoice control

Although it may not be obvious at first look, the value of the meter and the invoice do not always match. It is therefore necessary to compare the two values.

3.1.2 Monitoring the impact of the actions implemented

If any changes are made to the buildings (e.g. reduction of heat transfer through the structure or removal of thermal bridges), the impact of the changes can be accurately quantified through the energy consumption records. These savings can then provide an motivation to continue such actions.

3.1.3 Influencing the consumption profile

If the installation of renewable energy sources is intended, then in the case of the majority of photovoltaics in the Czech Republic it is possible to predict the production trend of this source quite accurately. In order to maximise the economic and environmental impact, it is necessary to ensure as far as possible that the production of the source and the consumption of the energy are coeval. Therefore, in these situations, it is necessary to take the consumption profile of the planned consumption points (community energy), identify the possibilities of influencing it in favour of the photovoltaic production curve and design the sizes and locations of photovoltaic plants accordingly. In the Czech Republic it is uneconomical to oversize photovoltaic power plants. Firstly, it increases the purchase price and secondly, the market is not interested in unused energy. In many cases, the distribution system is overloaded and does not even have the technical capacity to transfer the energy. These phenomena occur because the Czech electricity grid is already relatively saturated with photovoltaics and there is an excess of such energy in the grid during sunny periods, which has a number of other effects.

3.2 Envelope of the building

3.2.1 Energy efficiency of the building (Energy class)

To identify the energy efficiency of a building, a specialized technician performs a physical inspection of the building - factors such as insulation, windows, heating, ventilation, and more are measured and evaluated. In addition, the building's annual heating and cooling energy consumption is determined. Based on the calculations and measurements, the building is assigned to an energy class from A (low energy consumption, high energy efficiency) to G (high energy consumption, low energy efficiency). The result is presented on the energy label in the form of a graphic symbol with a letter indicating the class. This visual presentation facilitates a quick look at the energy efficiency of the building.The energy performance certificate also usually contains recommendations for improving the energy efficiency of the building. These can be specific suggestions for insulation, window replacement, heating upgrades, etc.

3.2.2 Thermal bridges

A thermal bridge is an area in a building structure where the thermal resistance of the material is lower than in surrounding areas. This means that heat can more easily leak or enter the building through this area. The most common places where thermal bridges occur are the connections of walls to the floor, ceiling or other walls, the connections of windows and doors, where pipes or electrical lines pass through insulation, and the corners of the building. Consequences of thermal bridges include increased energy consumption, condensation that promotes mould growth and lack of comfort due to uneven interior temperatures.

3.2.3 Heat transfer through the envelope

Assessing heat loss through the building envelope involves monitoring several key parameters for each part of the structure (walls, floors, roofs).

– **Walls, floors, ceilings**

The thermal conductivity of the material affects how quickly heat passes through the wall. The thickness and type of insulation is also analysed, as well as its potential compatibility with the building - taking into account the risk of moisture gain.
*Green roofs and walls - Vegetated surfaces on roofs and walls that can help with insulation and reducing heat loss.

– **Building envelope penetrations**

For the energy optimization of window and door frames, glass and sealing quality, various values and parameters are monitored that can affect the energy efficiency of a building. Here are the key values and parameters that should be monitored:

Heat transfer coefficient

This parameter indicates the thermal transmittance of a window or door system. A lower value means better insulation properties.

Seals

The quality of the sealing of window and door frames is a key element in preventing air leakage and minimising leakage.

Dimensions and positioning

Dimensions and placement can affect the amount of sunlight and natural lighting, which impacts overall energy efficiency.

3.3 Technologies

The technologies influencing municipal building energy can be diverse and depend on the specific conditions and strategies of each city. These technologies are mostly related to heating, ventilation, domestic hot water and energy production and management. It is important for the city to record their type, performance, scheduled revision dates and date of acquisition.

3.3.1 Air exchange

Air exchange in buildings can take place in a variety of ways, some of which include:

– **Native ventilation**

Takes advantage of temperature differences between the outside and inside environment to move air.

– **Mechanical ventilation**

Involves the use of fans and fan systems to actively exhaust air and bring in fresh air. It can be implemented using heat recovery systems to reuse the thermal energy from the exhaust air.

– **Hybrid or combined systems**

The combination of natural and mechanical ventilation allows optimised air exchange depending on the outdoor conditions and the requirements inside the building.

– **Underpressure or overpressure conditions**

Creating negative pressure or positive pressure conditions in designated areas of the building can control the direction of air exchange.

3.3.2 Use of renewable energy sources

The use of renewable energy sources is also a big topic in the energy optimisation of municipal buildings. This strategy relies in particular on the installation of solar photovoltaic panels, solar thermal systems and heat pumps. In this way, urban buildings contribute to environmental protection, reduce greenhouse gas emissions and increase their energy self-sufficiency. The implementation of these renewable technologies and innovative solutions brings economic savings, promotes innovation and contributes to the sustainable development of the urban environment. Municipalities should therefore register:

- Type of system and their consumption.
- The amount of energy produced by these technologies.
- Elements of smart technologies and automation - systems that control energy consumption according to predicted production, temperature settings, heating settings, etc.
- Storage elements - batteries, water storage.

3.3.3 Heating and hot water production

This subchapter achieves a slight overlap with the chapter about renewables. This is largely due to the fact that this chapter deals with the largest energy consumers in buildings and there is an attempt to replace them with renewable options. Municipalities should again register the input power, type, age and revision requirements for heat sources, for example:

- heat pumps
- gas-fired boilers
- solid fuel boilers
- central heating supply
- technologies using electricity (boilers, electric boilers, foils)
- cogeneration units
- waste heat recycling - waste heat exchangers

3.4 Lighting

Municipal lighting can be divided into indoor lighting and public lighting, which is evaluated according to energy consumption per 1 light point. Municipalities should register the technical condition of lighting and target the use of LED technology. The interesting thing is that cities can provide their public lighting for power balance services - in case of surplus energy in the network, this lighting would be lit even in the daytime and it would be one of the financial revenues for the city.

4 Conclusion

In the context of increasing pressure on municipal energy efficiency in the European Union, triggered not only by the coronavirus pandemic and the conflict in Ukraine, but also by the drive to gradually shift to renewable energy sources, it is becoming a key step for cities to rethink their approach to energy. This paper highlights that the current lack of procedures and the absence of systematic data management related to energy in municipal buildings hinders effective energy management. In the first part of the paper, the necessity of collecting and reporting data related to energy consumption and energy performance of buildings was presented. The information obtained will not only allow for an informed and conceptual planning of urban energy renewal, but also for controlling the effectiveness of implemented actions and the adequacy of energy expenditure. The next part of the paper focuses on specific areas of data collection on the building envelope, focusing on energy performance, thermal bridges and heat transfer through the envelope. Identifying and monitoring these factors are key to developing an effective building energy optimization strategy that leads to savings and improved energy efficiency. Finally, the technologies responsible for hot water, lighting, heat, electricity, heat recovery and air exchange were discussed. Proper inventory of system types, their performance and smart technologies allows municipalities to plan strategically and use available resources efficiently. Overall, effective data collection and use are key tools for municipal energy management. Municipalities that systematically register and analyse their energy indicators are better equipped to make informed decisions and successfully transition to a more sustainable energy model in line with current European guidelines and requirements.

Acknowledgments

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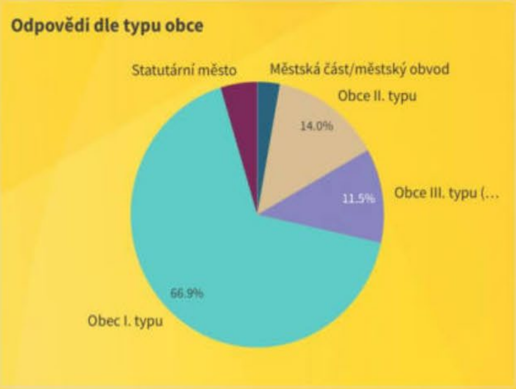

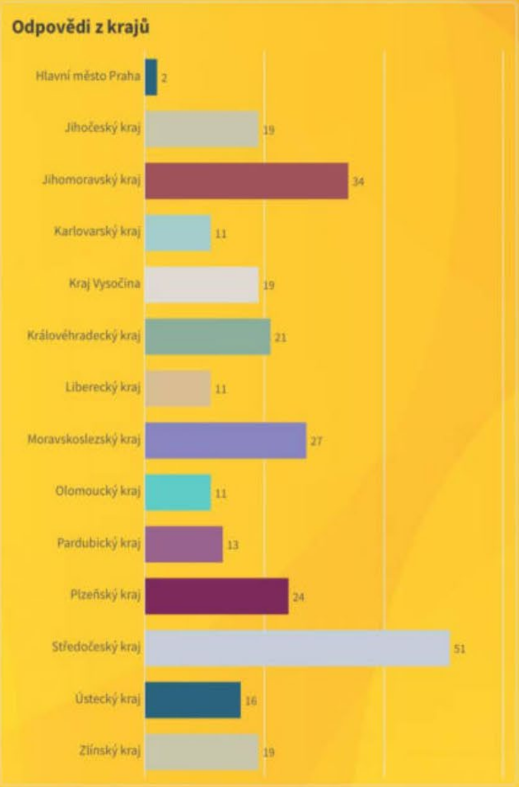

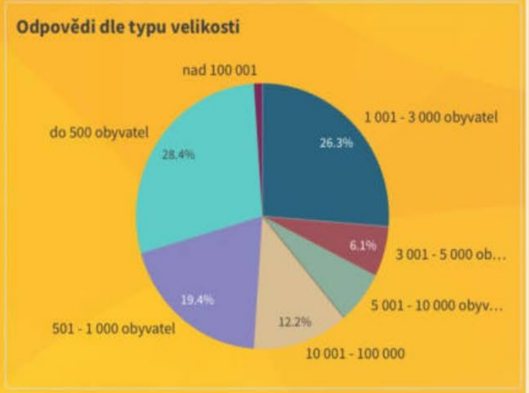

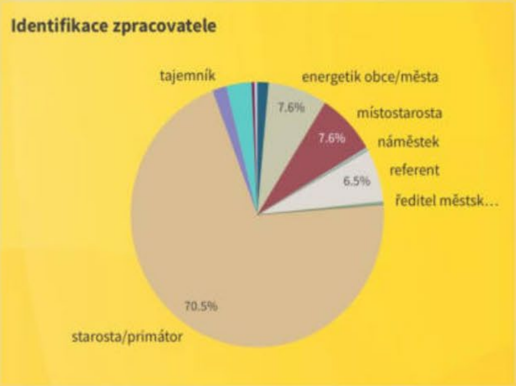

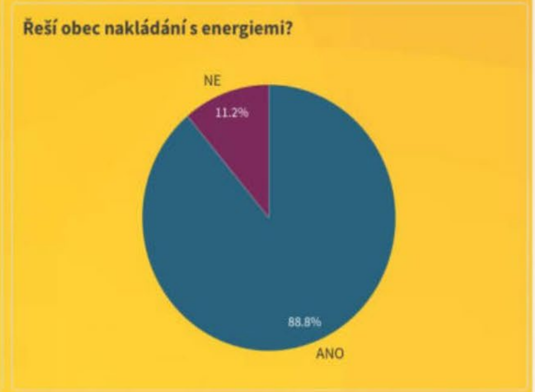

Kdo **řeší** energetiku

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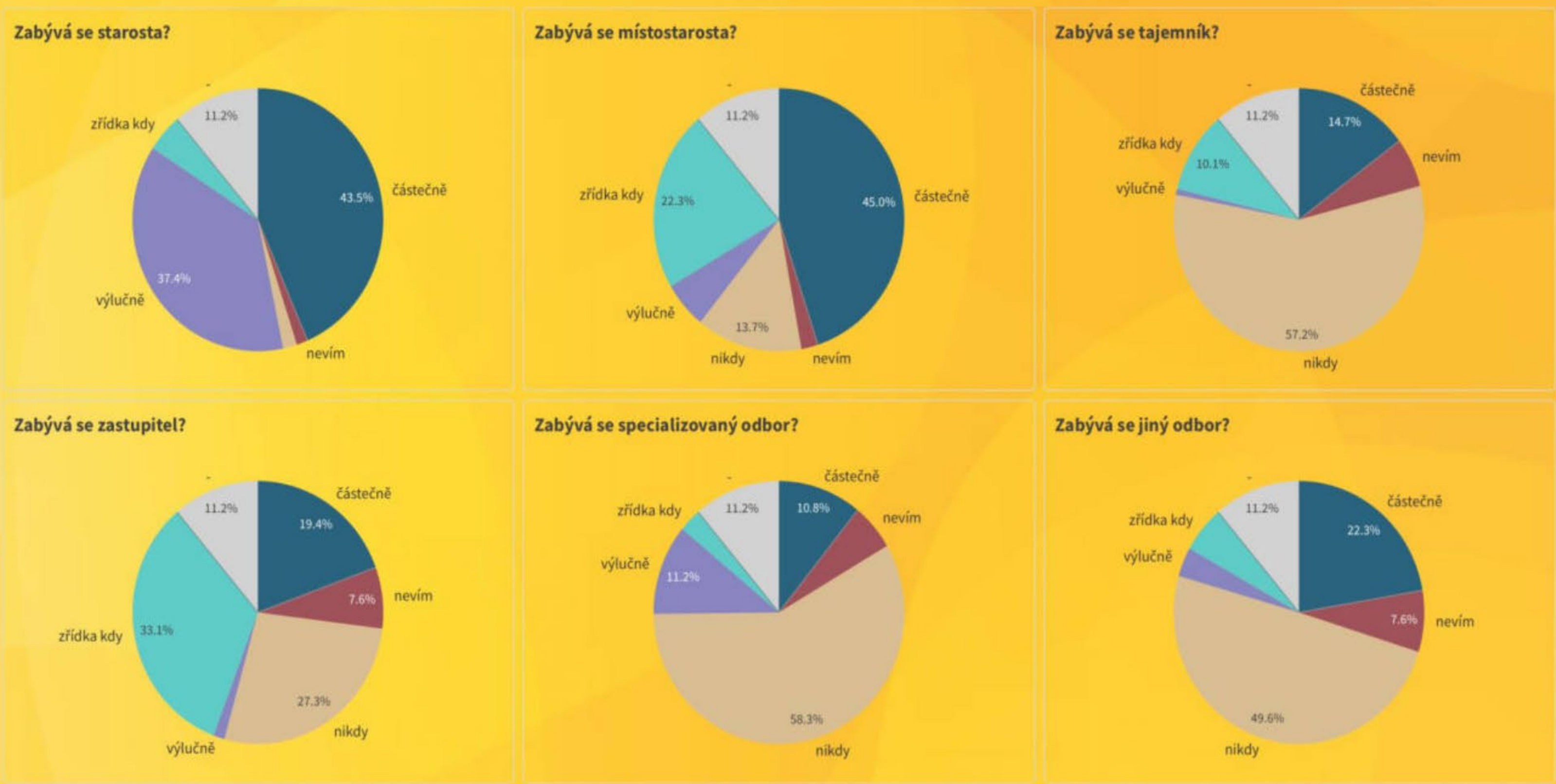
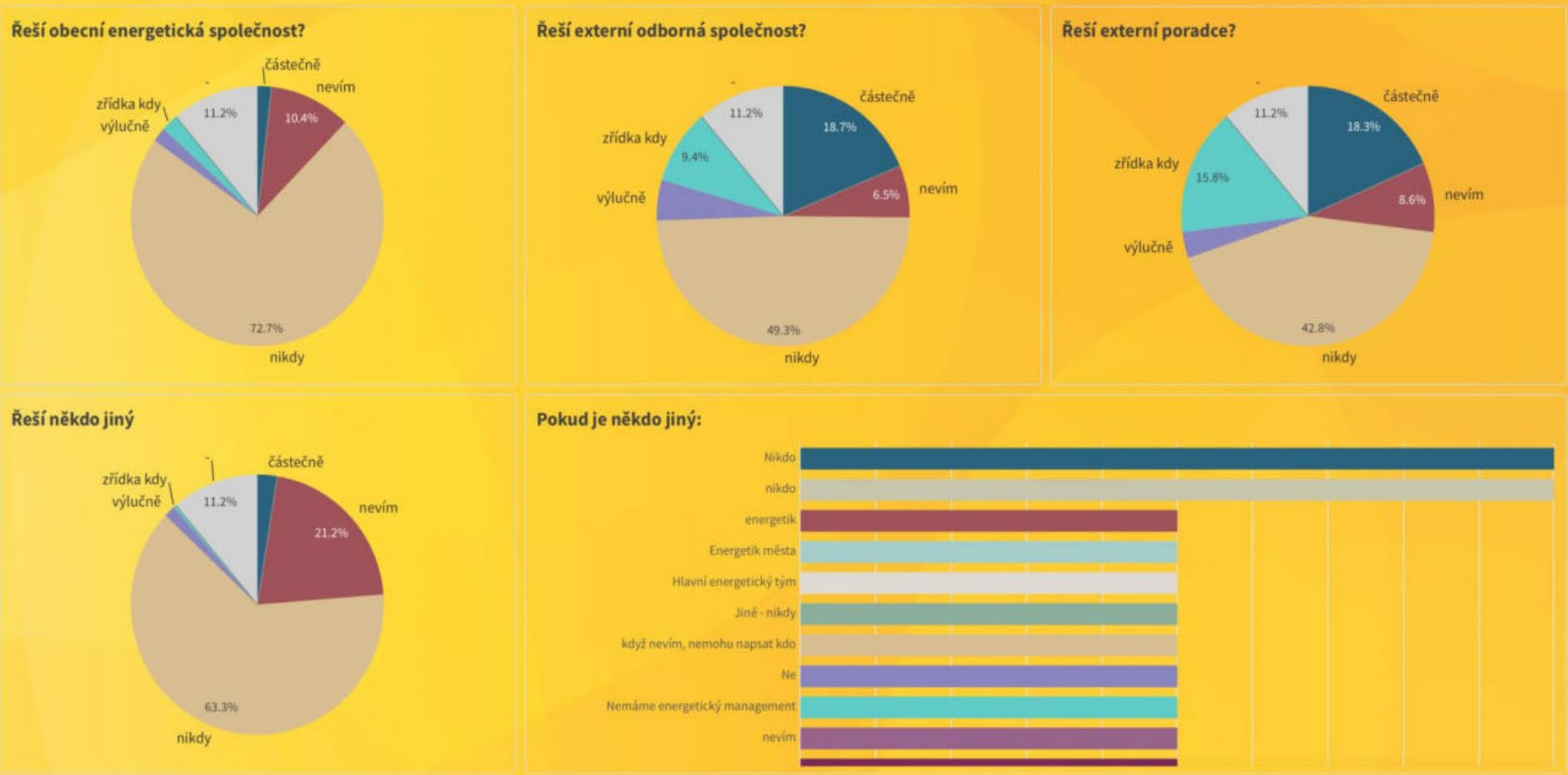


Energetické řešení



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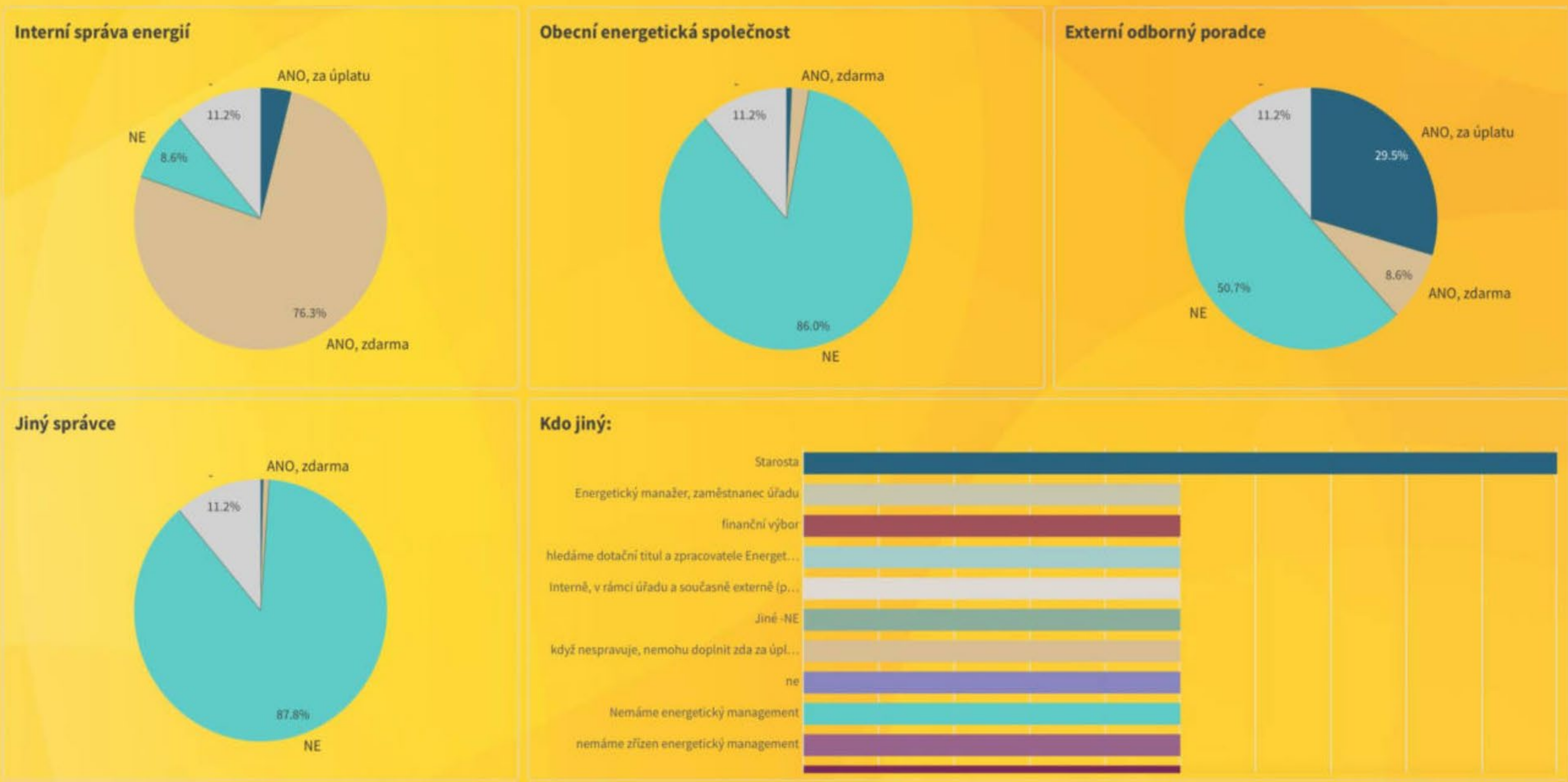
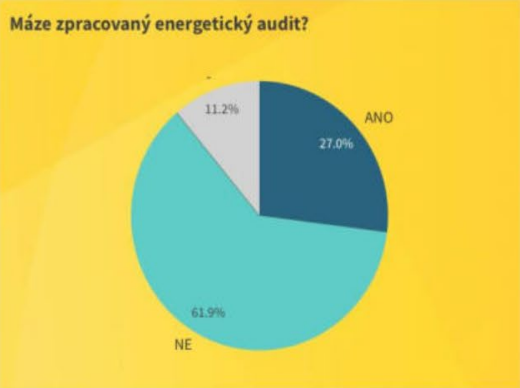
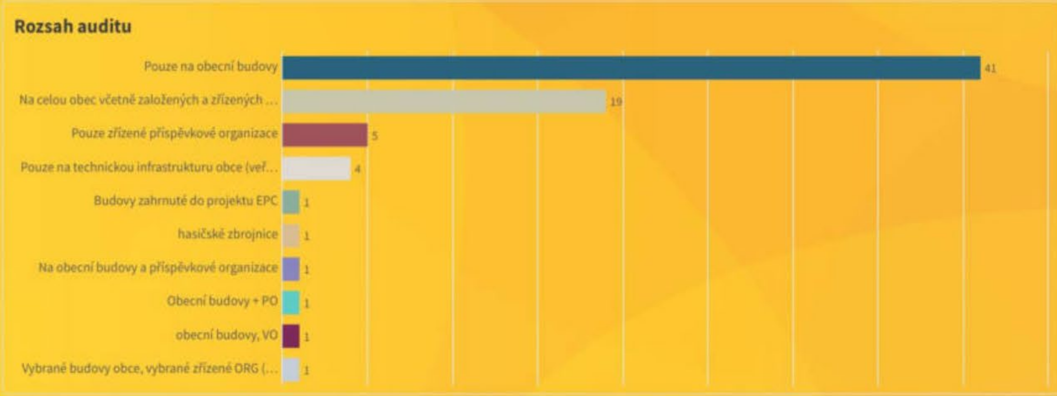
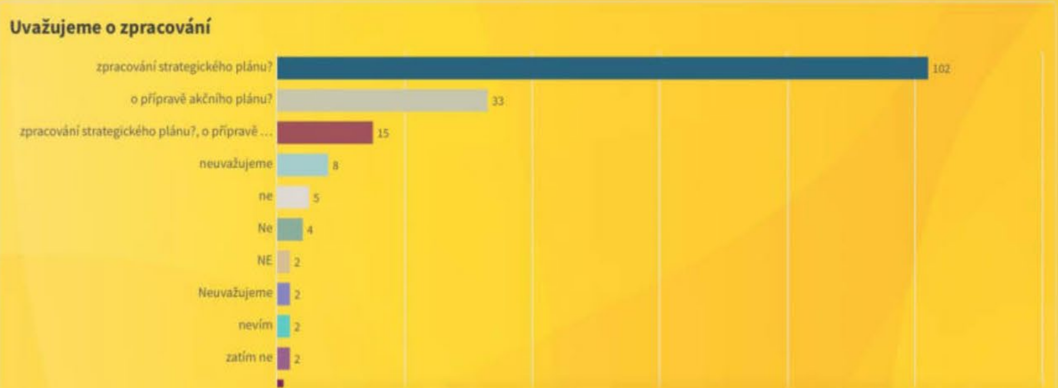
Správce energií

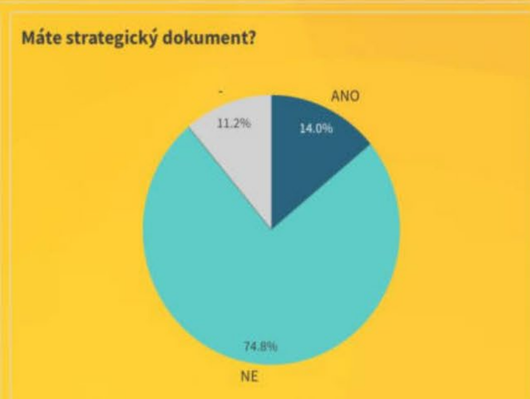


Energetický audit



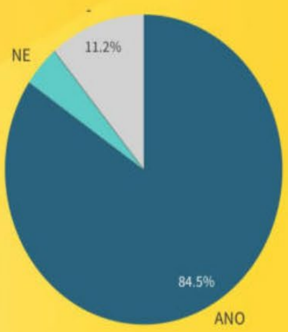






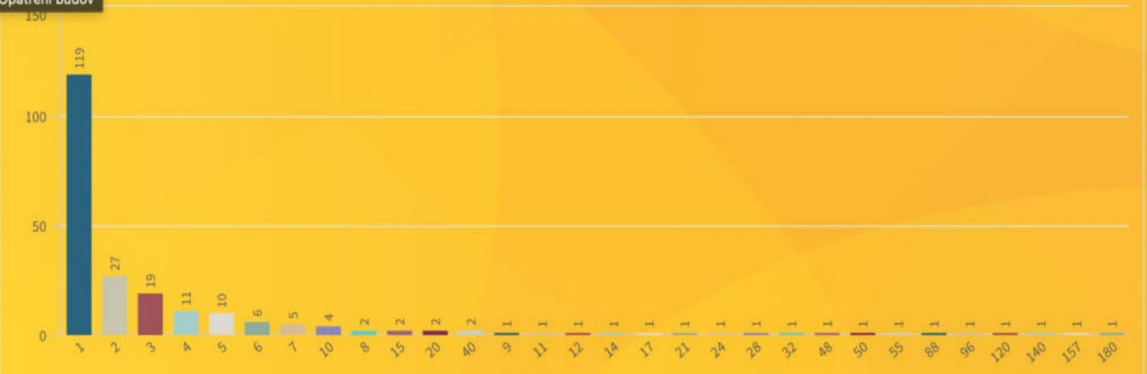
Opatření a strategie

Opatření pro spotřebu

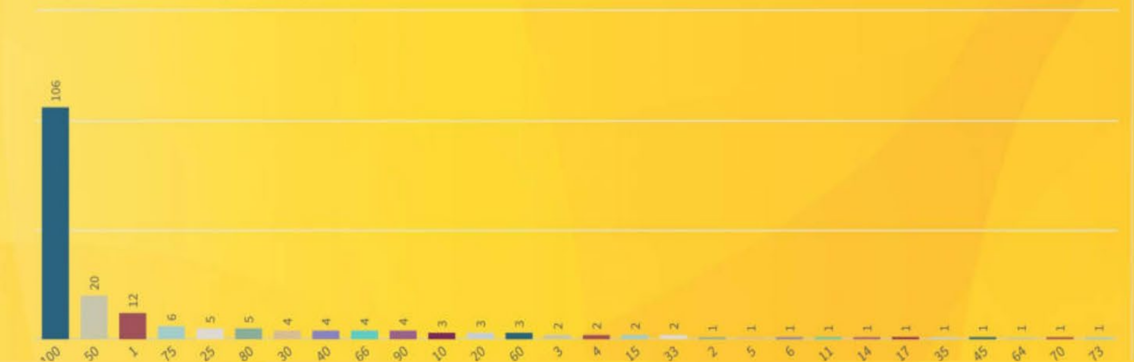


Next sheet: 7 - Opatření budov

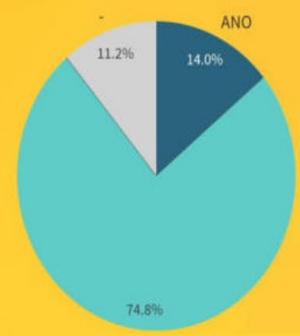
Obecní úřad - celkem budov



Kolika proces budov se opatření týká?

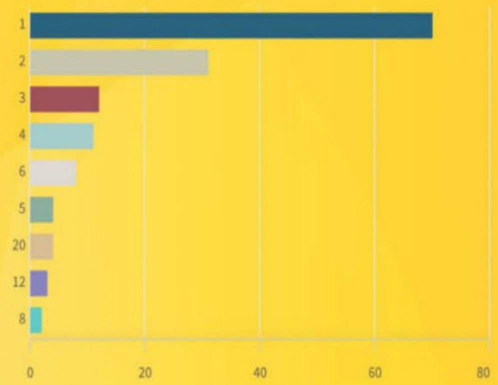


Máte strategický dokument?

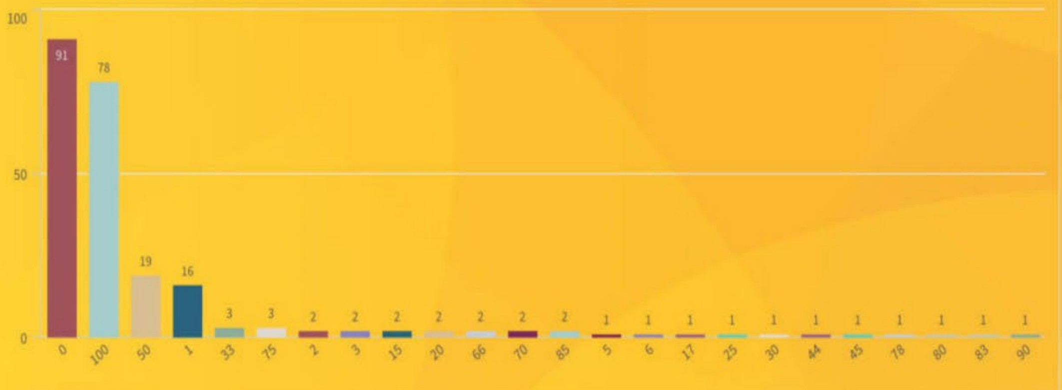


Školy

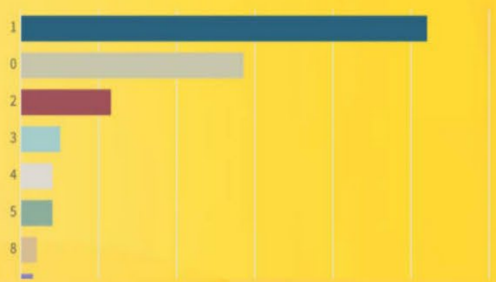
Základní školy - počet budov



Procentuální opatření základních škol



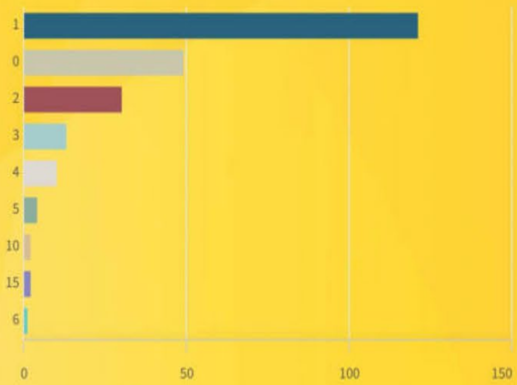
Mateřské školy - počet budov



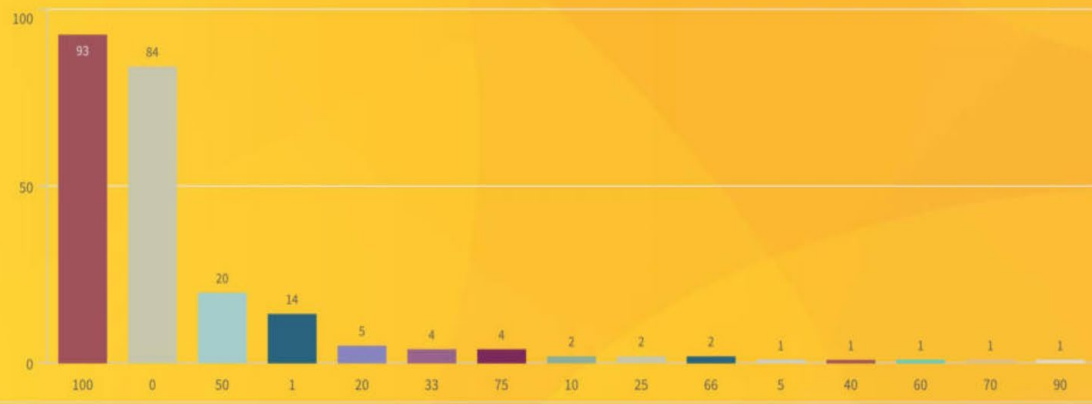
Procentuální opatření mateřských škol

Kultura s sport

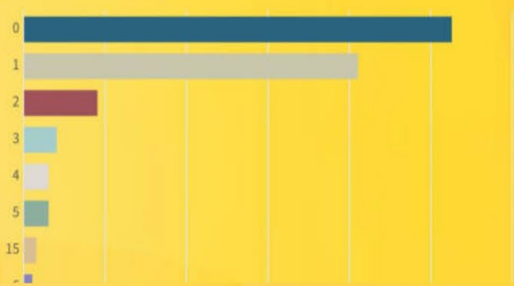
Kulturní zařízení - počet budov



Procentuální opatření kulturních zařízení



Sportovní zařízení - počet budov



Procentuální opatření sportovních zařízení

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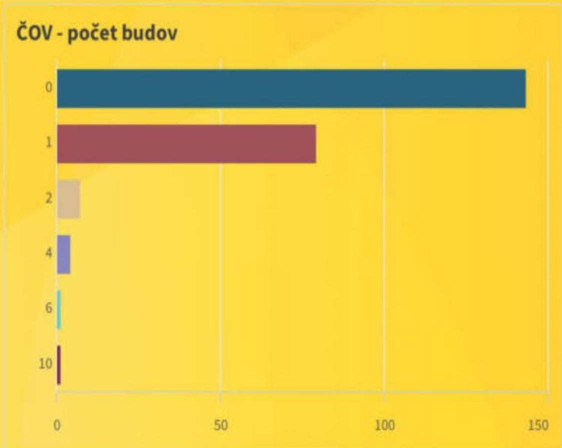
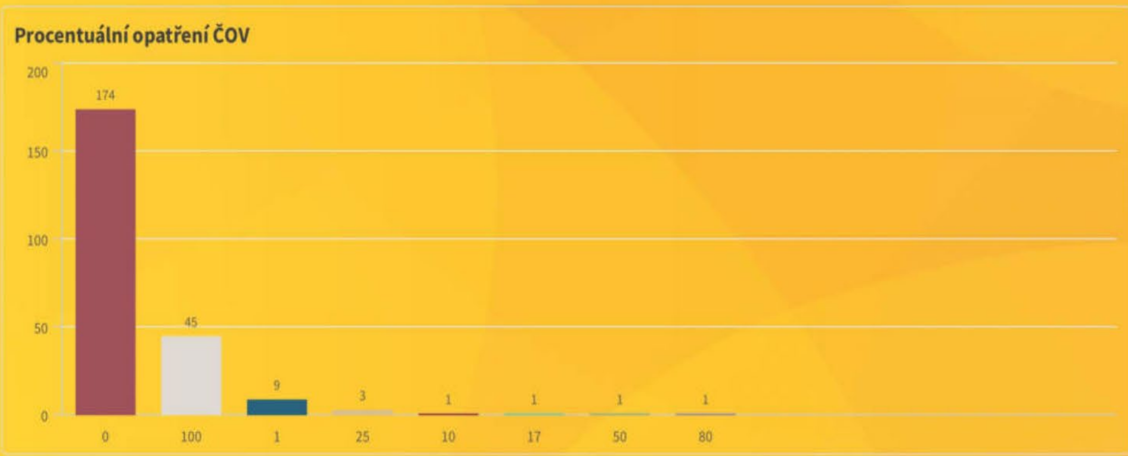
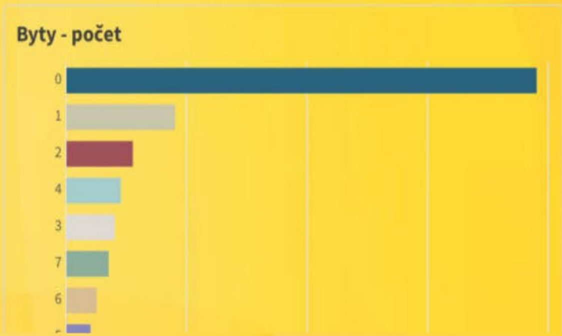
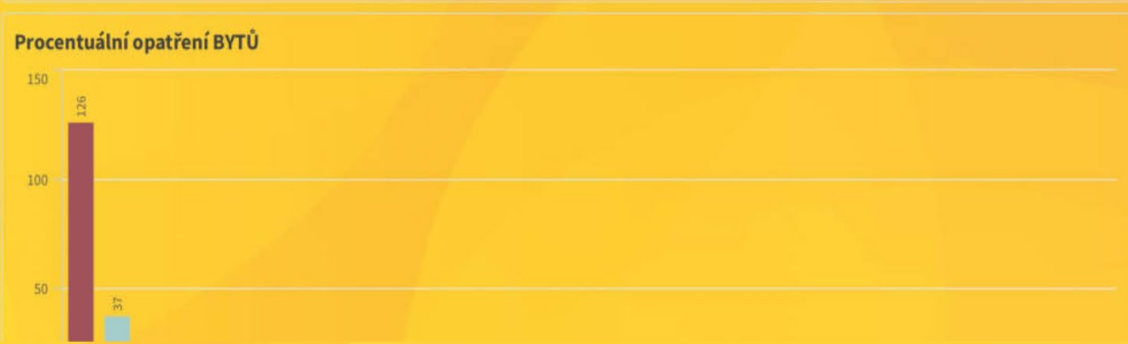
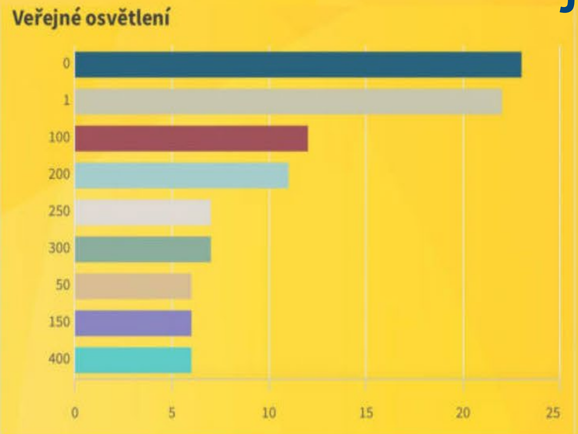


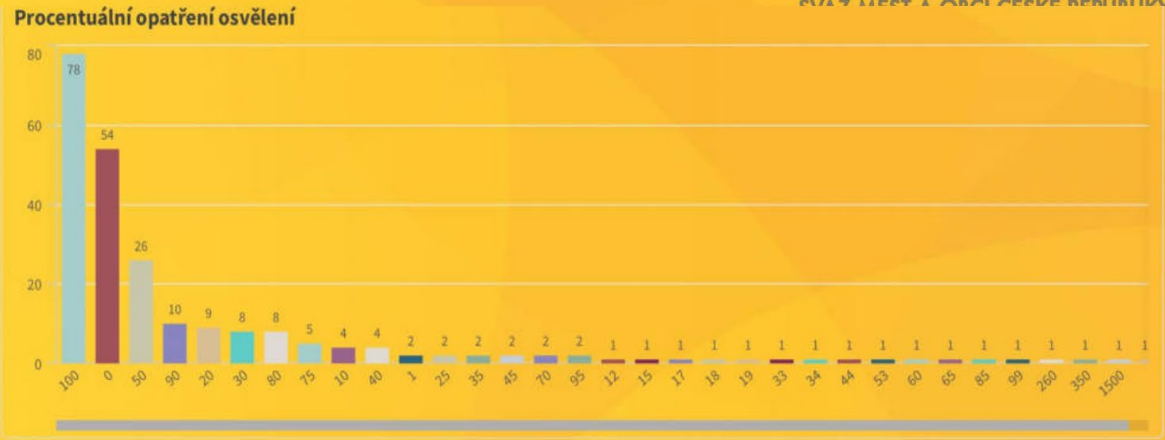


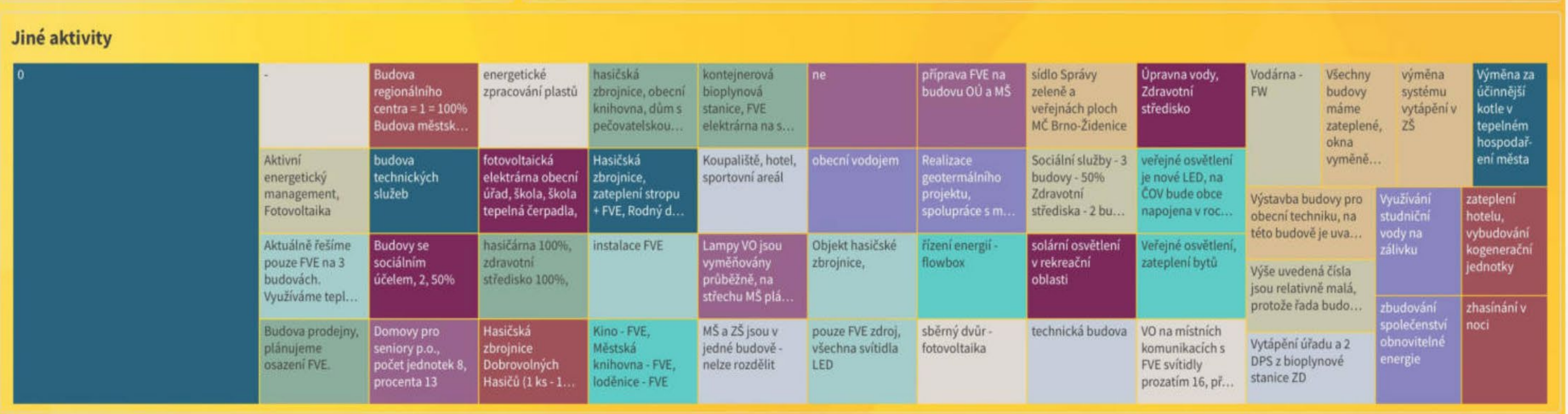




Ostatní zdroj







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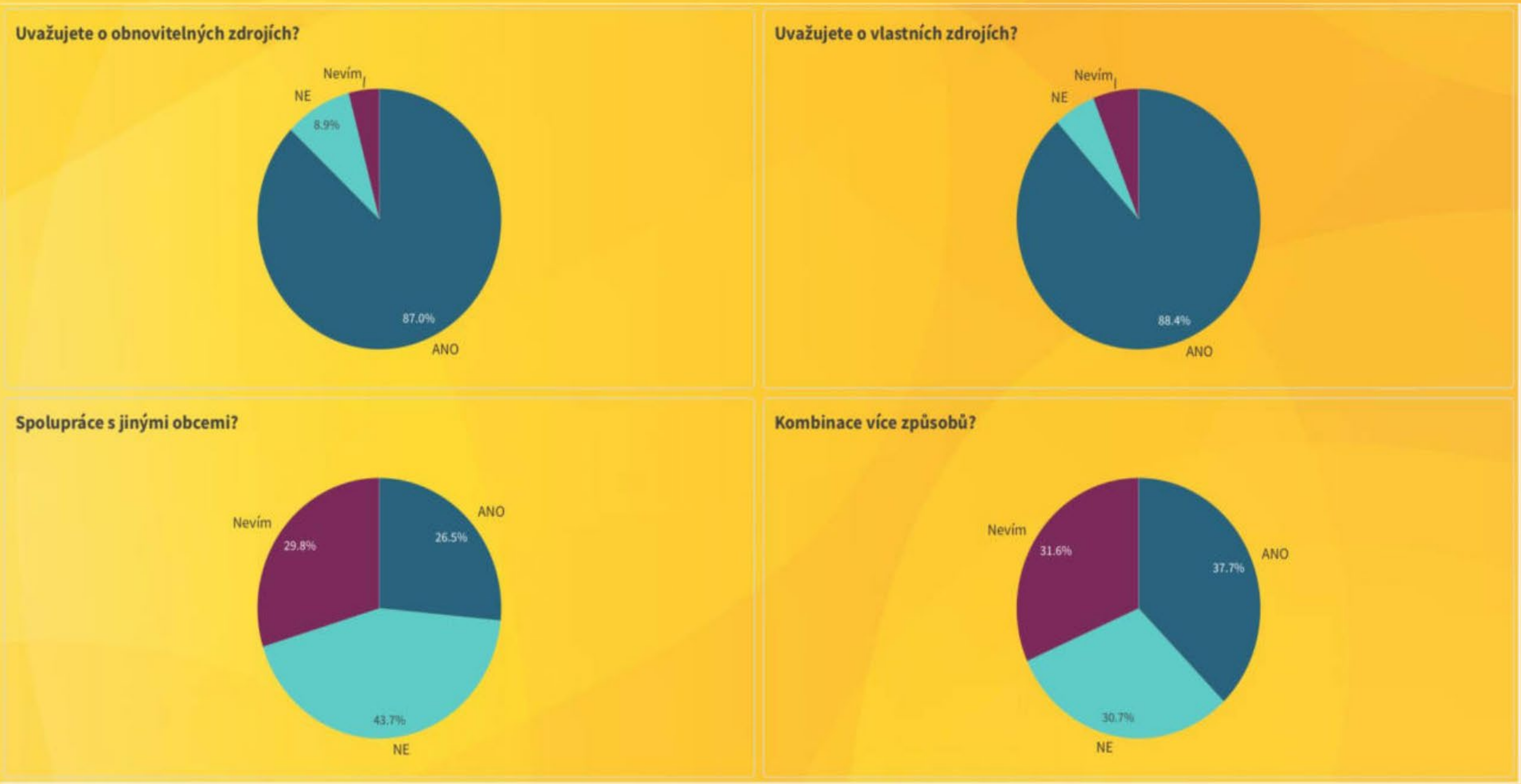

Fotovoltaiky

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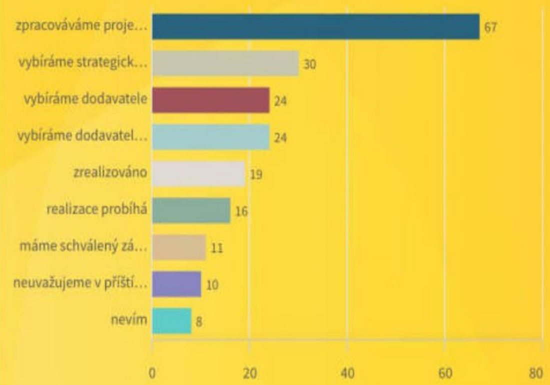
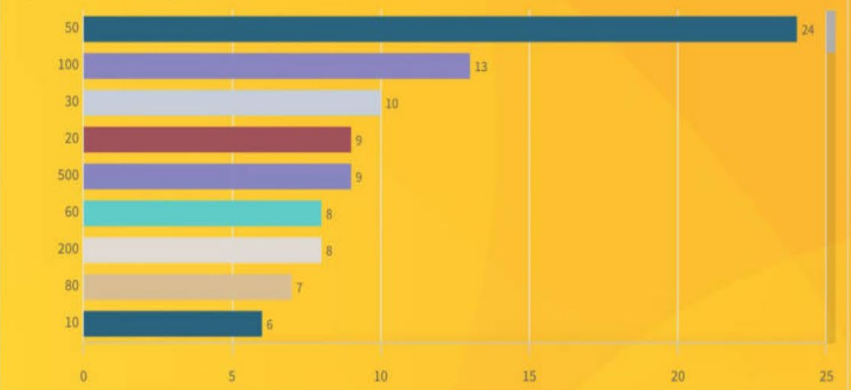
Fotovoltaika na budovách



Výkon fotovoltaiky na budovách



Celkem výkon

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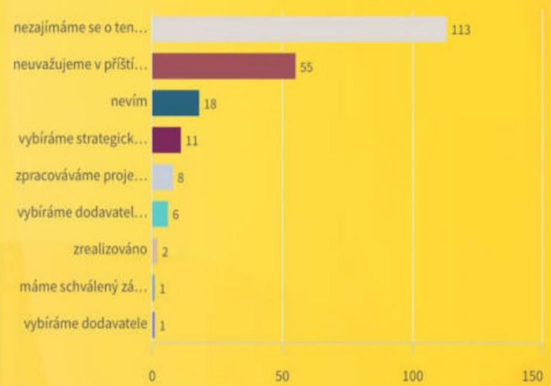
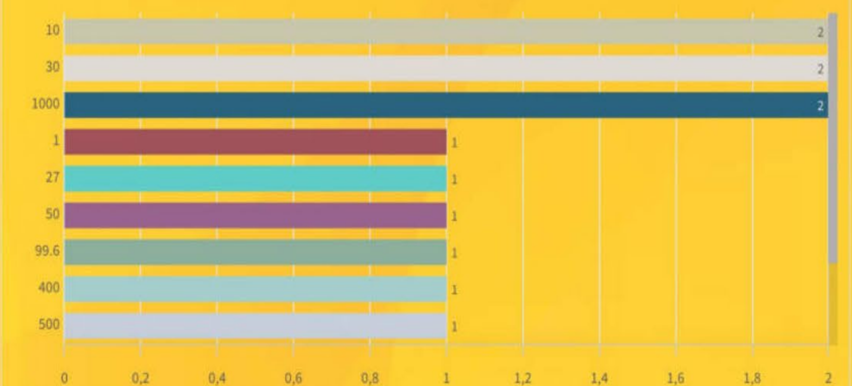
Fotovoltaika volně



Výkon fotovoltaiky volně



Celkem výkon

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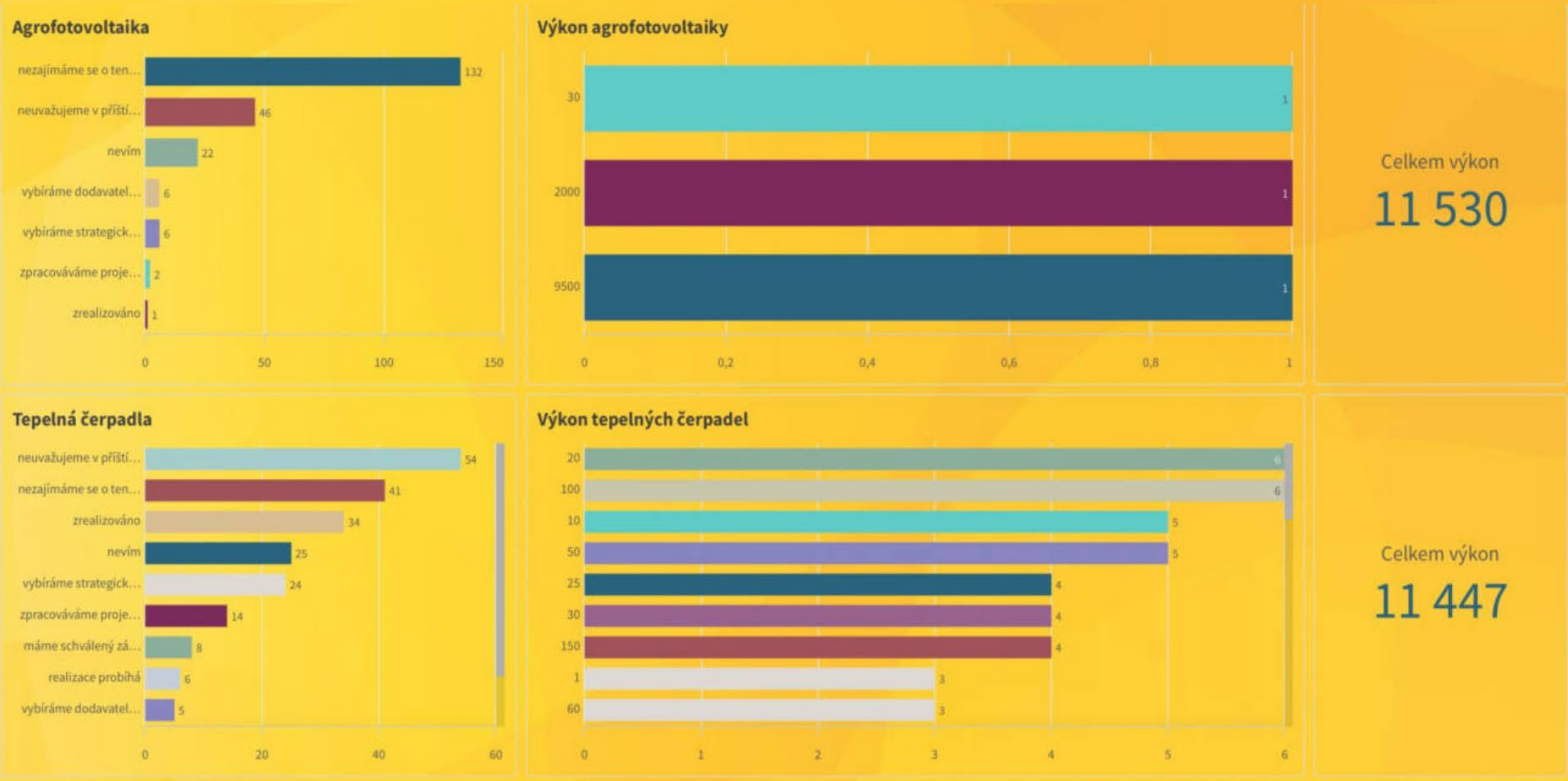
Agro + **čerpadla**



Bioplyn + **větrné**

Vodní a **celkové** zdroje

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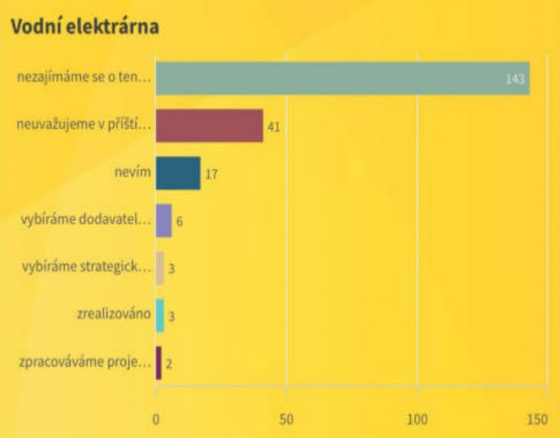

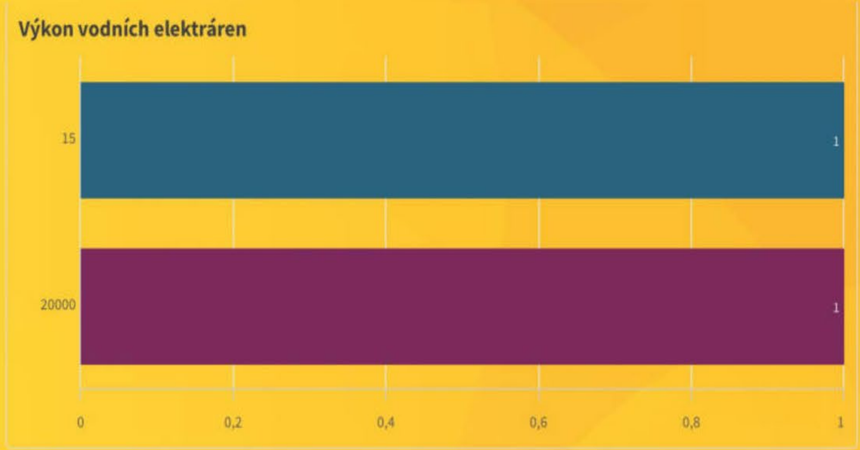

Celkem výkon

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Počet všech nových zdrojů

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Výkon nových zdrojů celkem

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Investice a zdroje

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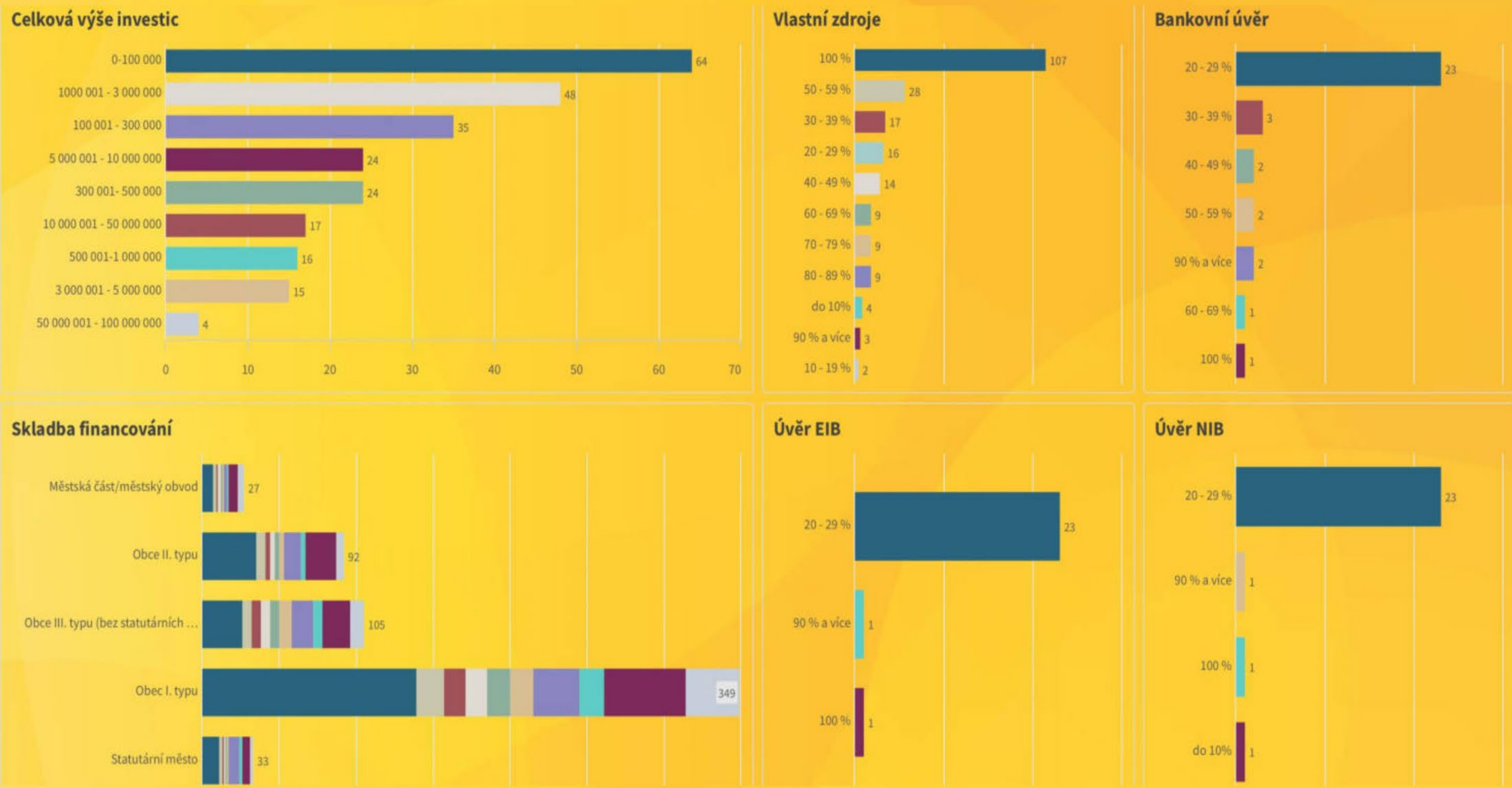

Podpora

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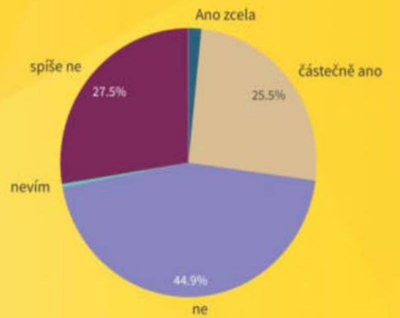
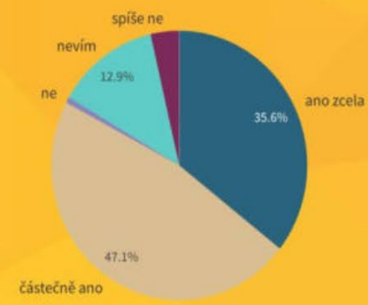
Bude obec soběstačná

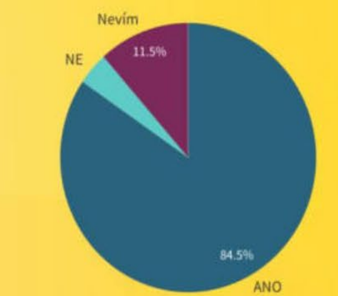


Je trh předvídatelný?

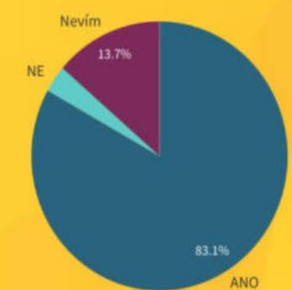
Jsou nároky na výpočet dopadů vysoké?



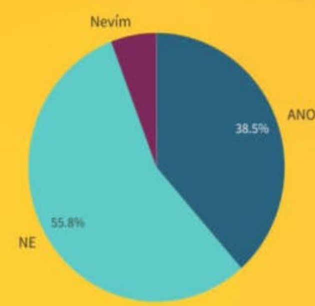
Uvítáte metodickou podporu státu?



Uvítáte poradenství SMO?



Řešíte požadavky občanů v energii?



Zdroje **informací**

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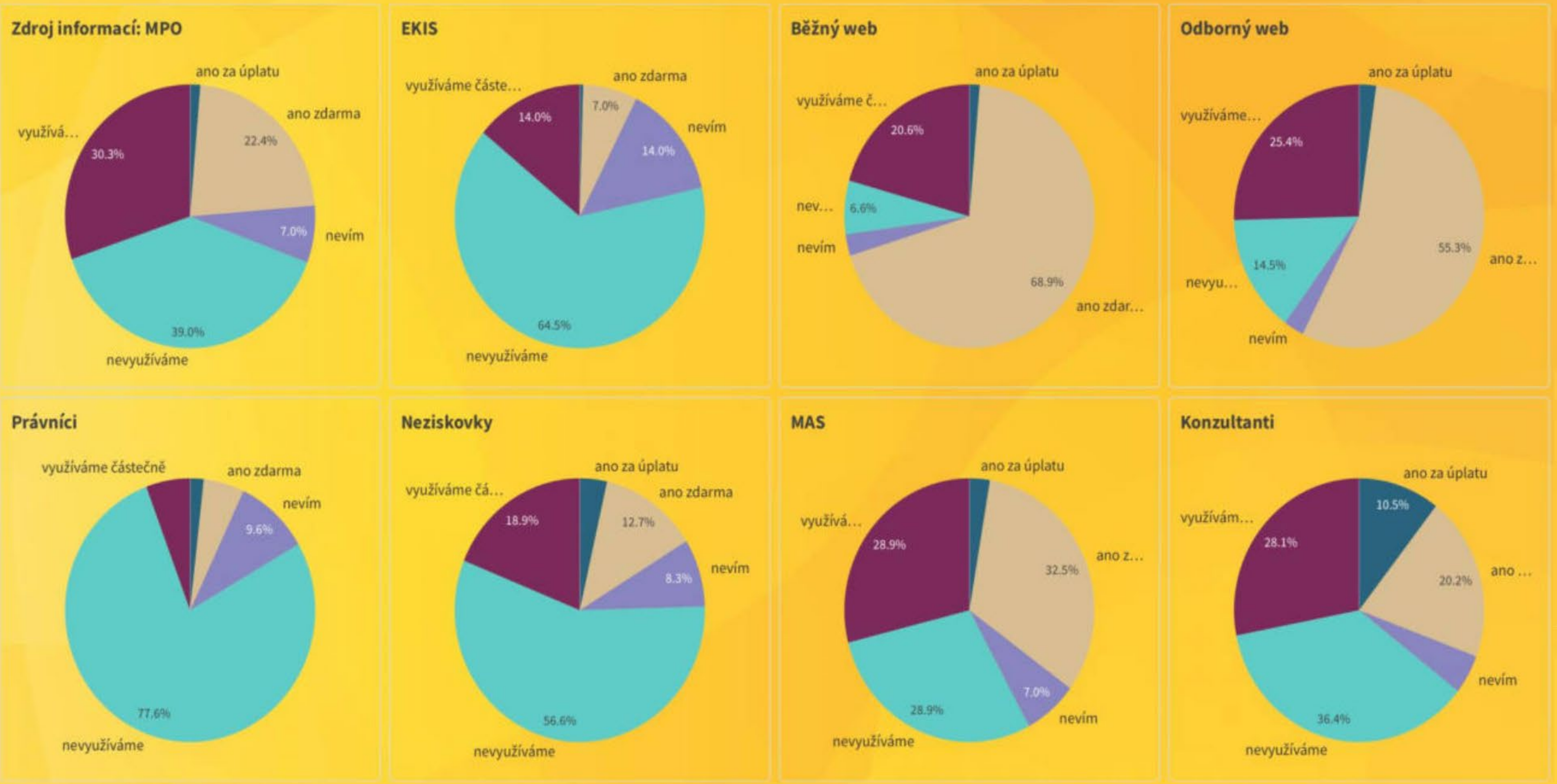

Komunitní energetika

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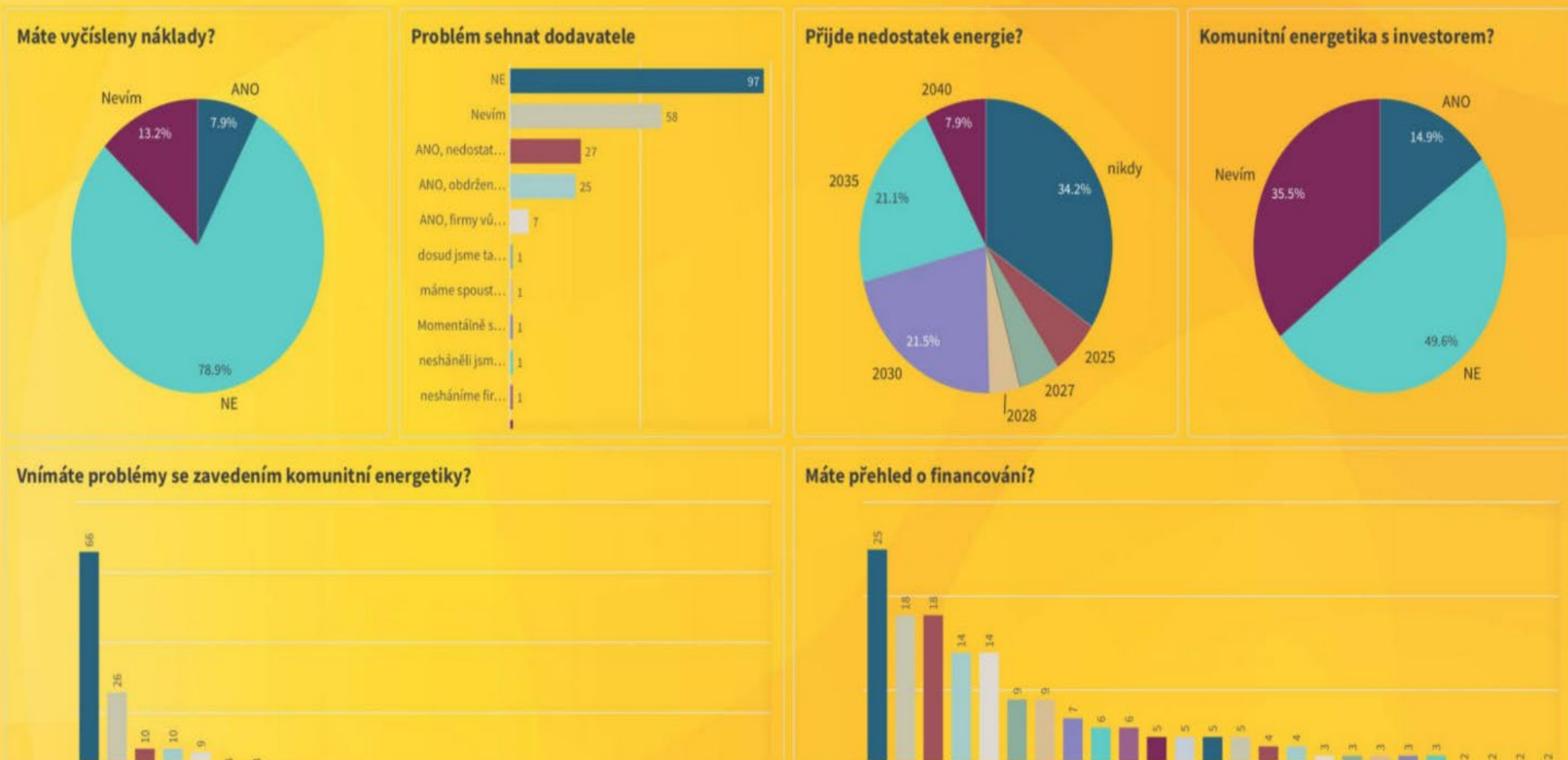
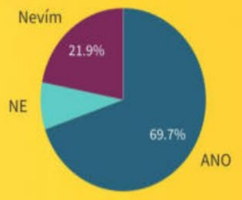
Budoucnost



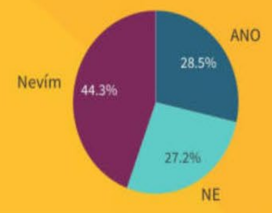
Máte vyčísleny náklady?
Nevím
ANO
13.2%
7.9%
78.9%
NE
Problém sehnat dodavatele
NE 97
Nevím 58
ANO, nedostat... 27
ANO, obdržen... 25
ANO, firmy vů... 7
dosud jsme ta... 1
máme spoust... 1
Momentálně s... 1
nesháněli jsm... 1
nesháníme fir... 1
Přijde nedostatek energie?
2040
7.9%
2035
21.1%
nikdy
34.2%
21.5%
2030
2025
2027
2028
Komunitní energetika s investorem?
ANO
14.9%
Nevím
35.5%
49.6%
NE
Vnímáte problémy se zavedením komunitní energetiky?
66
26
10
10
6
Máte přehled o financování?
25
18
18
14
14
9
9
7
6
6
5
5
5
5
4
4
3
3
3
3
3
2
2
2
2

Začátek komunitní energetiky

Uvítáte pomoc se založením komunity?



Uvítali byste spolupráci se zahraničními partnery?



Jak diskutujete komunitu s občany??