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DEHYDRATION OF FIBROUS WASTE FROM PAPER PRODUCTION

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As a result of the treatment of wastewater at enterprises of the paper industry, a large amount of fibrous-inorganic waste of treatment facilities, the so-called sludge, is formed [1]. Depending on the type of products produced, sludge can consist of 50-80% of the mineral component. On average, about 50 kg of sludge is produced per ton of paper. Utilization of fibrous waste (sludge) from paper production, which is generated in water treatment processes, is an important task, for the solution of which enterprises spend significant funds. One of the main disposal problems is the high-water content (93-98%), which requires dehydration before burial or incineration. The most popular way of dealing with sludge is to bury it. However, in the scientific literature, you can find a lot of information about ways to dispose of skunk, including its use as fertilizer, use of skunk in the production of building materials, biofuel [2-4]. In any case, an important stage of its processing is dehydration. The speed and efficiency of the process of dehydration of sludge depends on its properties and composition and is significantly improved with the use of additional chemicals.

The paper presented the result of the investigation of the influence of flocculants and coagulants consumption on the efficiency of sludge dehydration. As a starting material, sludge with a dry matter content of 16.2 g/dm^3 was used. The results of the research of the investigation of coagulants and flocculants application on the turbidity of filtrate and sediment moisture during sludge dewatering are presented on Fig.1-4.

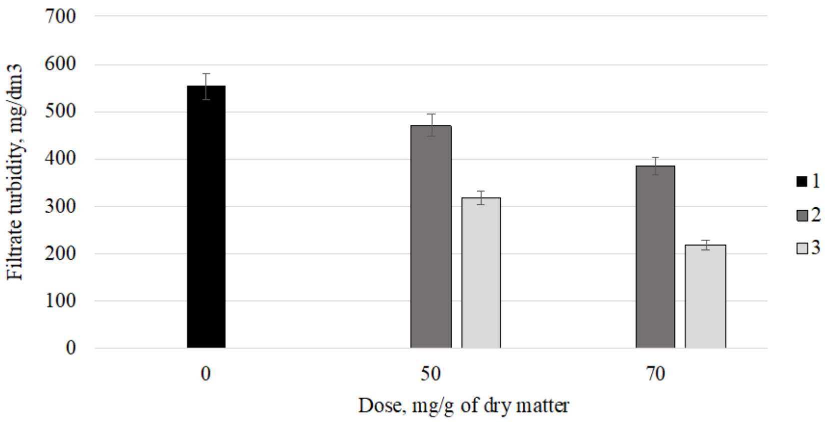

Fig. 1. The effect of the dose of coagulants on the filtrate turbidity during dewatering of slugde: 1 – without coagulant; 2 – with $Al_2(SO_4)_3$; 3 – with $Al_2(OH)_5Cl$.

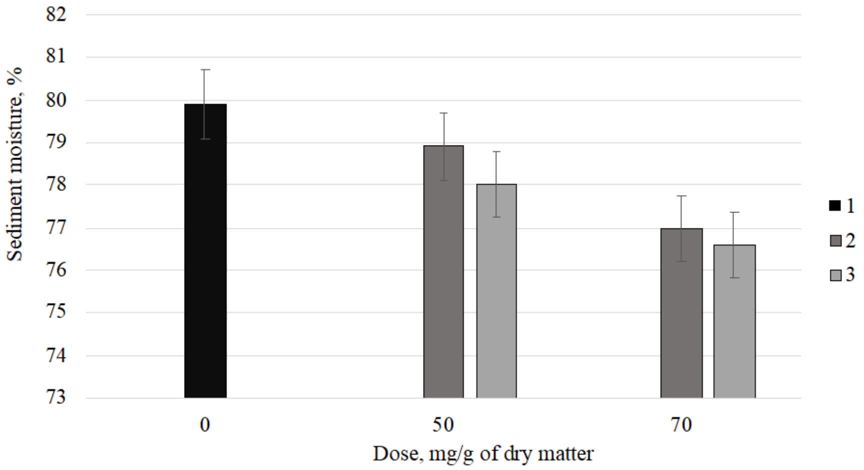

Fig. 2. The effect of the dose of coagulants on the sediment moisture during dewatering of slugde: 1 – without coagulant; 2 – with $A1_2(SO_4)_3$; 3 – with $A1_2(OH)_5C1$.

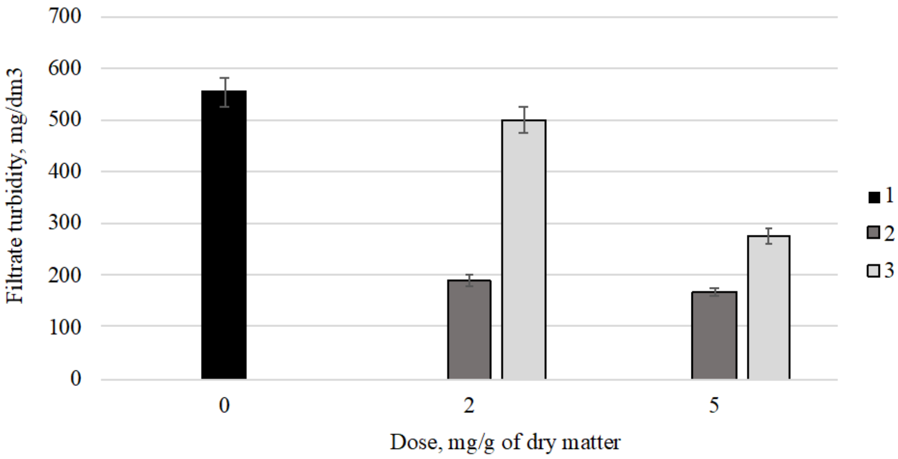

Fig. 3. The effect of the dose of flocculants on the filtrate turbidity during dewatering of slugde: 1 – without flocculant; 2 – with Polimin CK; 3 – witt Praestol 650BC.

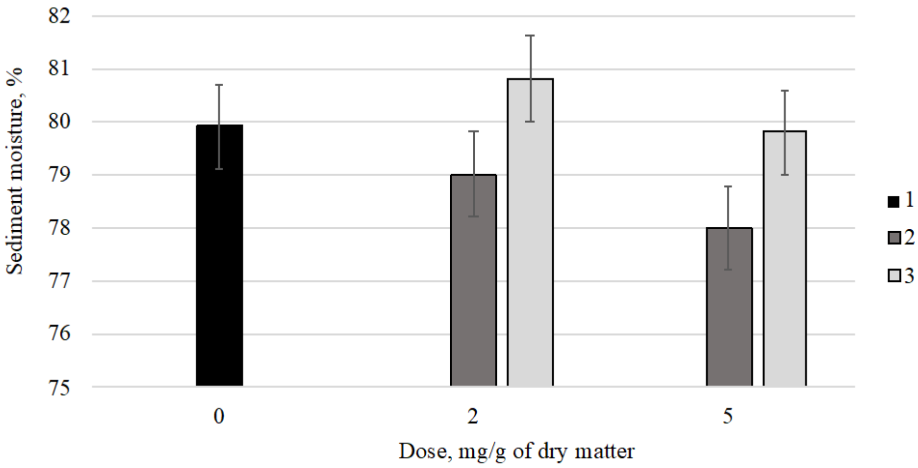

Fig. 4. The effect of the dose of flocculants on the on the sediment moisture during dewatering of slugde: 1 – without flocculant; 2 – with Polimin CK; 3 – witt Praestol 650BC.

As can be seen from the data shown in Fig. 1, coagulants contribute to the improvement of the process of dehydration of the sludge. The efficiency of dehydration increases with an increase in the dose of coagulant per gram of dry matter and with the transition from sulfate to aluminum hydroxochloride. In general, in the case of using flocculants, their higher efficiency should be noted compared to coagulants. The most effective were cationic flocculants, which provide a significant reduction in the filtrate turbidity.

Depending on the composition of paper and cardboard, the quality of wastewater entering local treatment facilities also changes. Under these conditions, the volume of sludge formation as well as its composition can vary widely from 8 to 30% of wastewater. During the dehydration of the sludge, a filtrate with a significant content of suspended substances is formed. It is apparent that the leachate contains residual concentrations of additional chemicals used for water clarification and during sludge treatment. Taking into account the high turbidity value of the filtrate, it is obvious that it cannot be reused in the technological process.

To study the process of clarifying the filtrate from the dehydration of the sludge by settling with the use of coagulants and flocculants, filtrates with a concentration of suspended solids of 4140 mg/dm^3 and 1900 mg/dm^3 were used in the work. During settling of filtrate with an initial content of suspended solids of 4140 mg/dm^3 and 1900 mg/dm^3 without the use of reagents, the process is quite efficient and the residual content of suspended solids is 360 mg/dm^3 and 255 mg/dm^3, the volume of the sediment formed is 540 cm^3/dm^3 and 50 cm^3/dm^3. Thus, in the first case, the degree of illumination is 91.3%, and in the second - 86.6%.

In the case of using reagents for clarification of filtrates, the degree of clarification can be increased only up to 96%. Under these conditions, coagulants are the most effective. Flocculants, unlike coagulants, provide an increase in the degree of purification only up to 94%. Obviously, such a small influence of reagents is due to the fact that during the treatment of scum with flocculants, the main mass of negatively charged suspended and colloidal substances contained in water and sediment has already been removed. And the surface charges of the remaining particles are mostly neutral. Therefore, in this case, cationic and anionic flocculants, as well as coagulants, are close in their effectiveness.

In the real industrial conditions of operation of local sewage treatment plants, the construction of separate devices for cleaning filtrates is impractical. From the point of view of resource efficiency, the best way to dispose of filtrate is to pass it to local treatment plants. There will be some recirculation of water at the treatment facilities, but this will reduce the load on the biological treatment of the plant-wide treatment facilities.

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DATA ANALYSIS OF THE INNOVATIVE DEMONSTRATIVE PAVILION WITH WATER FLOW GLAZING WINDOWS

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1. Introduction

Energy efficiency in buildings is a key role in achieving the ambitious goal of carbon-neutrality by 2050, set out in the European Green Deal [1]. These intentions require large-scale action in all economic sectors: investment in new environmentally friendly technologies; innovations in industry; cleaner and cheaper transport; decarbonisation of the energy sector; renovation of the building stock. Improving existing buildings and striving for smart solutions and energy efficient materials can reduce energy losses. In 2020, roughly 75% of the EU building stock is energy inefficient. All buildings in the EU are responsible for 40% of our energy consumption and 36% of greenhouse gas emissions, which mainly stem from construction, usage, renovation and demolition [2].

In modern buildings, especially offices, the glazing surface makes up most of the façade, which increases the impact of windows on the overall energy efficiency. The optimization of the glazing facades by transforming them into renewable energy sources can significantly improve the building energy profile and its cost. There have been developments in the use of solar energy in buildings and later ideas for integrating glazed facades with water flow (WFG). The first step of using sunlight and an absorbent building facade is a development called the Thrombus Wall. It has functions for cooling, heating or as an architectural element. Another type of thrombus wall is the water wall, which performs the same functions [3]. Building envelopes are crucial to reduce energy used for heating and cooling. The Heating, Ventilation and Air-conditioning (HVAC) system that provides heating, cooling and ventilation is the largest single end-user in both commercial buildings and residential buildings and is responsible for 33% and 48% of electricity consumption, respectively [4].

The building envelope has energy saving potential in case of good construction design. The subject of consideration is the application of innovative facade technology in the construction of a demonstrational pavilion and the use of a renewable energy source through a PV system. Application of WFG (Water Flow Glazing) façade is an innovative solution, which combines heating and cooling systems and renewable technology in one technical solution to achieve nZEB. WFG can fully substitute regular facades with their mechanical and thermal characteristics. WFG façade elements are working as transparent low temperature solar collectors. Façade characteristics (g-factor, U-value) may be actively manipulated to achieve the best energy performance of the façade. WFG elements can be used as vertical walls, partition walls / ceiling elements or exterior elements. WFG is important part in building and HVAC system with a radiant heating/cooling element. Because of the high absorption of IR spectra of the façade elements, the peak loads of the conventional cooling system may be significantly reduced. The amount of energy absorbed (renewable solar summer excess) may be used directly for Domestic Hot Water (DHW) and for improved performance of the heat pump.

In this paper we present the energy performance for August, 2023 of an innovative demonstrational pavilion that implements Water Flow Glazing technology. The WFG elements in the pavilion are connected to a heat pump, which regulates the temperature inside and ensures that the inner space is properly conditioned. Electricity covering the needs of the equipment inside the pavilion is supplied by a PV system mounted on the rooftop.

The Water flow glazing elements of the pavilion bear monitoring equipment, recording their performance and energy utilization. Weather station is mounted on the rooftop and constantly monitors the outdoor climate conditions. The data from the weather station provides information about the outdoor environment in which the WFG elements and the PV system operate.

2. Demonstrational pavilion with the innovative design built in the Scientific Campus II of the Bulgarian Academy of Science

2.1. Integration of Water Flow Glazing (WFG) façade

The demonstrational pavilion with an innovative facade system was built in Sofia, Bulgaria, according to the European project Horizon 2020 - 'Secure, clean and efficient energy' is split into three focus areas: Energy-efficiency; Low carbon technologies; and Smart Cities & Communities., project ref. 680441 InDeWaG: Industrialized Development of Water Flow Glazing Systems. (fig. 1.). The building is oriented in clear geographic directions east-west, north-south. The east, west and south facades are transparent and built with the WFG modules. In addition, there is an internal partition wall. North façade is opaque and there are the entrance door and technical equipment and installation block.

The interior of the pavilion is single volume space with a partition wall, built with WFG technology. This allows maximum utilization of daylight, high transparency and optimal indoor comfort. It consists of triple glazing with two chambers (fluid chamber and argon chamber) and a modular aluminium frame. The main advantage is that the fluid in the transparent glazing transforms the passive facades into active solar collectors. The heat from the fluid in the glazing is used for heating and cooling. WFG increases natural interior lighting. It is a vertical-shaped module with dimensions of 1.3m x 3m, suitable for the facade element of office buildings. Each module includes its own circulation pump and heat exchanger, which make the individual elements of the module independent. The circulation pump provides flow rates in the glazing up to 8.0 l/min. These modules are composed of standardized building elements, they are fully replaceable and easy to connect to each other.

The demonstrational pavilion uses WFG as heating and cooling devices. The water circulating in the glazing provides energy for the air conditioning of the building. The installed air-to-water heat pump ensures that the water temperature is maintained within pre-set limits to achieve comfort in the pavilion. In summer, excess heat is captured by the water and the heat pump provides cooling through the internal partition walls. The facade system during the summer months works as a radiant cooling device.

Fig. 1. Innovative demonstrative pavilion in the Bulgarian Academy of Science, Sofia, Bulgaria

One major objective of the pavilion is to show the integration of the WFG technology into heating, ventilation and air conditioning (HVAC) systems in winter and summer modes.

2.3. Monitoring of innovative demonstrational pavilion in Sofia

The monitoring of the pavilion is real time and records the measured value every 5 minutes and ensures the accurate operation of the installations. The control functions of the monitoring system enhance the management of the WFG installation, lightning and other consumers of electricity. The goals are to ensure high energy efficiency and maintain living comfort. On each facade - internal and external are mounted the pyranometers to measure the total incoming irradiance of the façade. A pyranometer installed on the southwest façade measures the global solar irradiance. The temperature sensors over a distance of 0.7 m in height (Pt 1000; class A) are installed on a single WFG module on every facade. All temperature and irradiance data are collected by data acquisition system Keysight Technologies 34980A. Meteo Station is mounted on the roof for monitoring Relative Pressure, Outdoor Humidity, Temperature, Wind, Dewpoint Gust, Rain[10].

3.Data analysis

Monitoring, and researching of the pavilion during its operation helps to improve the work of the systems and assess the indoor comfort of the building. WFG systems can control temperatures and provide comfortable indoor environment. The proposed solutions with the use of various technologies implemented in the pavilion are optimal for the design of an office building with nearly zero energy consumption. Ongoing monitoring will show different problems and solutions which will provide more information about the operation of the pavilion and its systems.

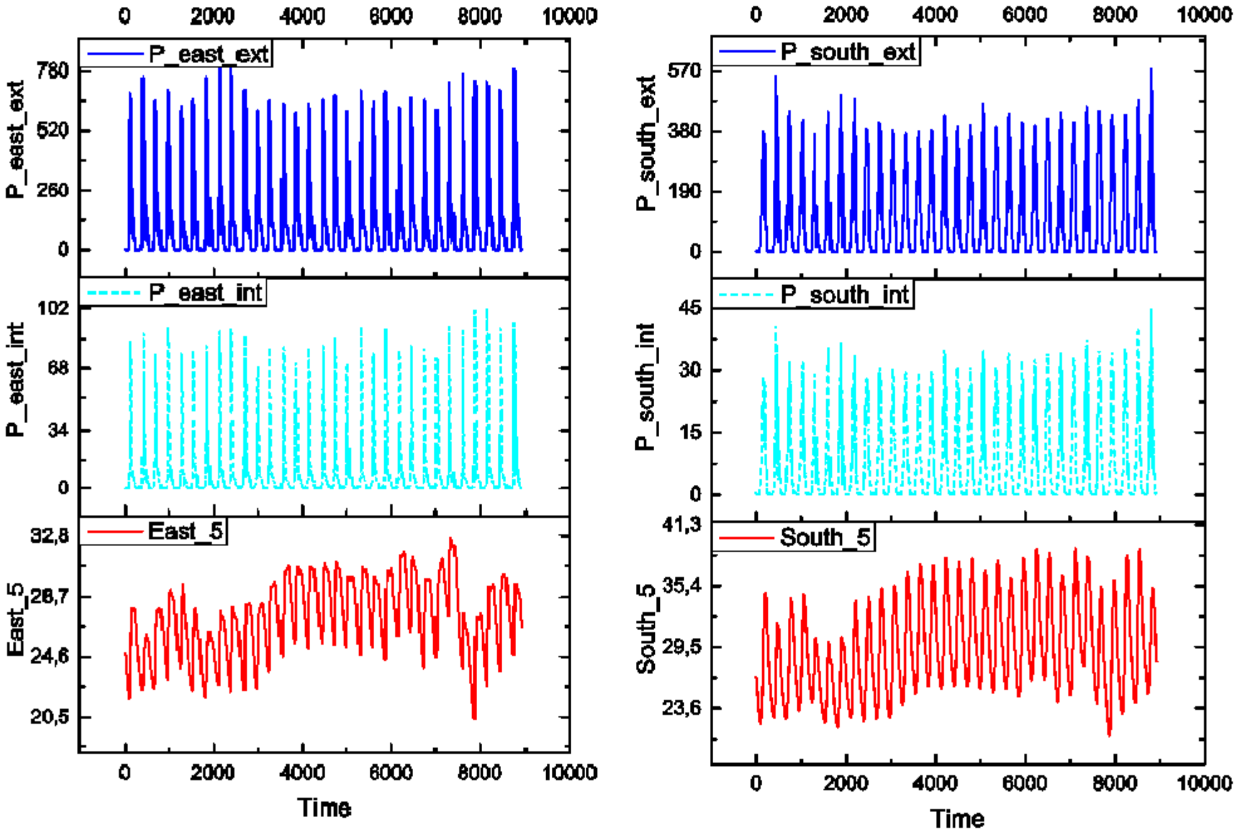

Fig. 1 – External and internal solar radiation on the East and South Water flow glazing and the temperature achieved in the WFG module for August,2023.

Fig. 1 is connected with the solar radiation on the South WFG. We can state here that during the monitored month we have solar radiation on the outside over 650 W/m^2 almost every day. This is connected with higher internal temperature in the demonstrational Pavilion. Concerning all of this we can state that the consumption for heating will be high. This can be seen from the fig. 3 where is shown the electricity consumption of the Pavilion. We have consumed total energy of almost 700 kWh for cooling the building. We have produced from the PV system over 750 kWh.

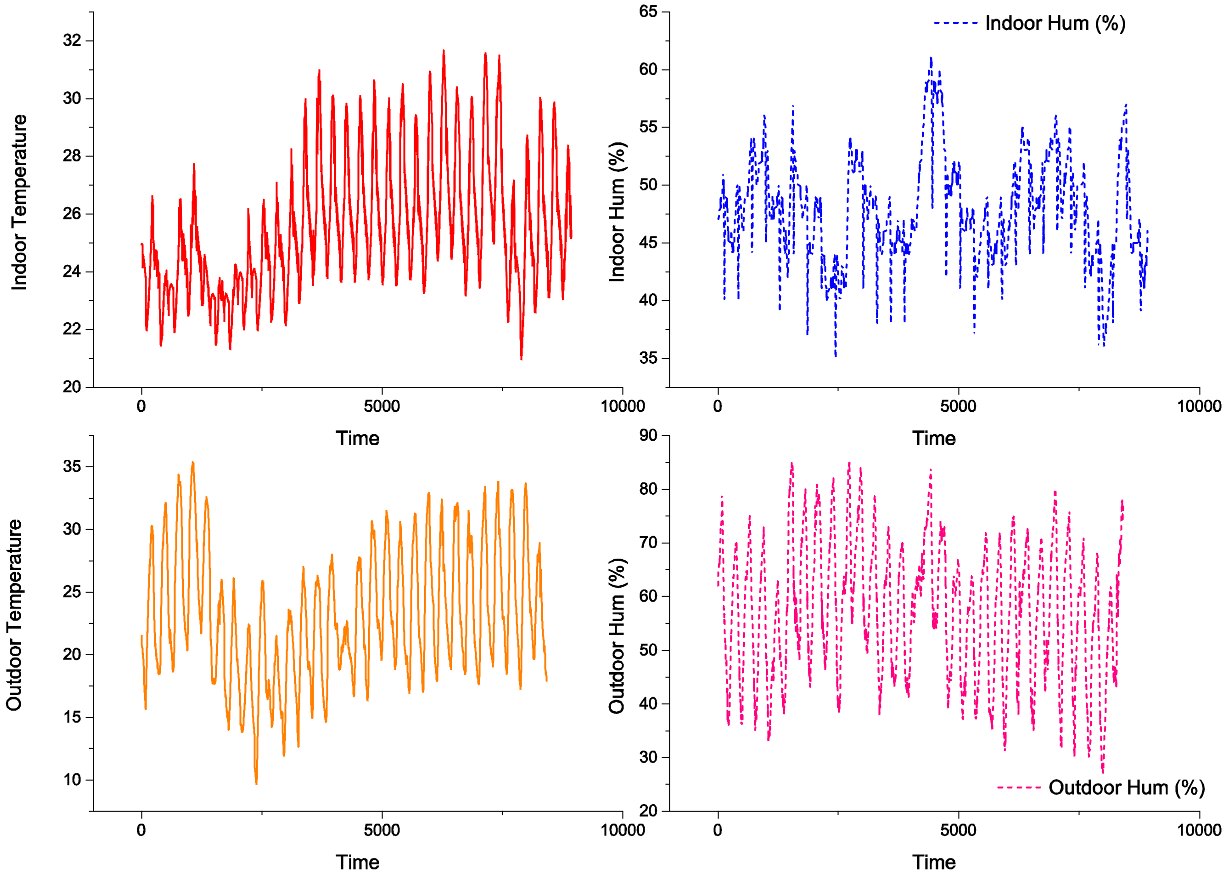

Fig. 2 – Internal and external temperature and humidity for August, 2023

This figure shows the behaviour of the WFG system. This is the most important characteristics of the Pavilion – the internal temperature connected with the outside temperature [2]. The temperature outside the Pavilion is over 30 degrees almost every day. The internal temperature is little lower than the maximum outside temperature. This shows that the system is capable of conserving the solar energy for further usage.

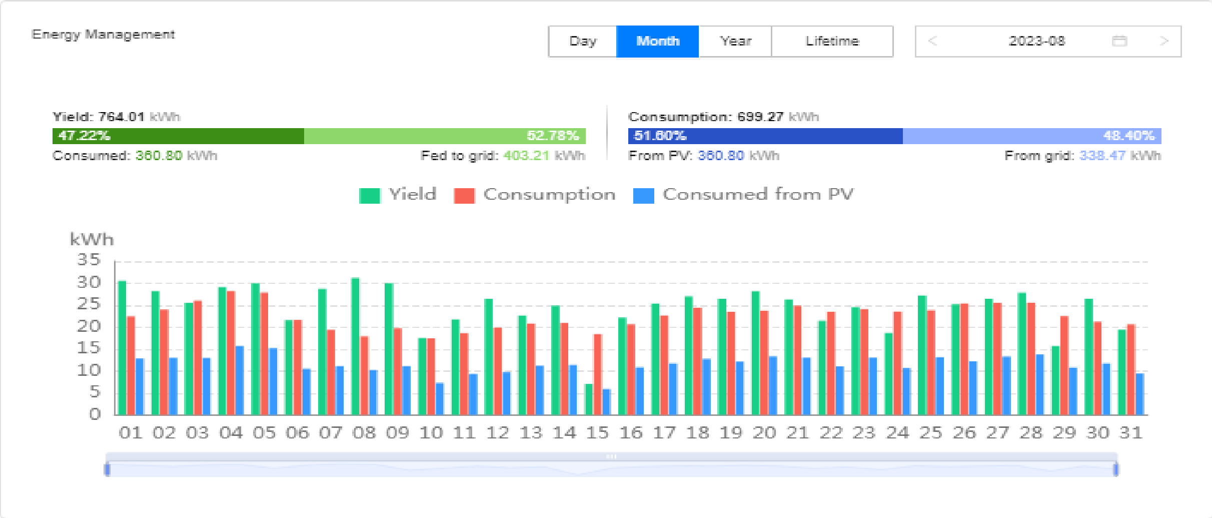

Fig. 3 – Produced, consumed and imported from the grid electricity.

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