Energy storage a necessity for a low-carbon energy system

Stocarea energiei este o necesitate pentru un sistem energetic cu emisii scăzute de carbon

Dănuț Tokar[1], Adriana Tokar[1], Daniel Muntean[1], Marius Adam[1], Alexandru Dorca[1]

[1]Universitatea Politehnica Timișoara,
Piata Victoriei Nr.2, 300006 Timisoara, Romania
E-mail: danut.tokar@upt.ro, adriana.tokar@upt.ro, daniel-beniamin.muntean@student.upt.ro, adam.marius@upt.ro, alexandru.dorca@upt.ro

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Abstract. *As in 1973, the energy issue occupies the first page of the agenda of energy experts, social planners, politicians and, last but not least, consumers. The impact of renewable energy sources (wind and solar) on the energy infrastructure was analysed, while aiming to reduce carbon footprints. Demographic growth, urbanization, the targets imposed by Net Zero Emissions tend towards the massive forcing of energy towards renewable energy conversion and storage systems.*

Key words: storage, the oil crisis, greenhouse gases, renewable energy sources,

1. Introduction

The large amounts of greenhouse gases emitted into the atmosphere led to the need for the transition to a clean energy for which climate objectives were set worldwide. The Net Zero Emissions by 2050 scenario proposes the path towards the massive integration of renewable energy sources (RES) and considerable increase in total electricity demand [1].

The main sources considered are solar photovoltaic and wind, but the hourly and seasonal variability of their SRE energy production make it necessary to approach energy storage to ensure the maintenance of grid stability, flexibility, and reliability in the face of increasing demand. In a market economy where the low selling price of electricity can lead to the disconnection of certain production capacities, maintaining the stability of electric power systems puts pressure on energy specialists.

With all the advantages of modern computing technologies and/or artificial intelligence, the following of the load curve in economic conditions is achieved with a certain inertia.

In the "new oil crisis" the stability of the electrical energy systems is threatened on the one hand by the "big plantations", on the other hand by the domestic consumers who have "tasted" energy independence and installed photovoltaic systems with powers greater than their own needs (prosumers).

In order to maintain the stability of the NES, the national energy system coordinator (NESC) has the possibility of disconnection/connection, in case of necessity of the large production capacities, but has no lever of intervention on the prosumers.

Due to the underdevelopment of electricity distribution networks that make it difficult for the development of the built environment, during the day when electricity consumption is reduced, the line voltage increases. In these conditions, the protection systems of the inverters disconnect, the prosumers not being able to capitalize on their surplus of produced energy, generating dissatisfaction on their part and at the same time a challenge for specialists looking for solutions to integrate RES into the energy mix.

The large targets for RES integration, until 2050, in the EU energy system require the flexibility of national power systems [2]

The technical-economic benefits that RES energy conversion systems provide cannot be fully exploited without the existence of conventional systems capable of ensuring the stable operation of the NES. Maximizing the use of RES conversion systems implies the possibility of using the electricity produced when the weather conditions are favourable [3-6].

Therefore, energy storage is a crucial technology for the energy system of the future without greenhouse gas emissions (GHG) [2].

The article reviews energy storage systems and proposes, based on data provided in real time by Transelectrica, an analysis of electricity storage both in terms of energy balance and especially in terms of GHG reduction [7].

2. Electrical energy storage systems

Economic growth and the quality of life, demographic growth and urbanization force the electrical energy systems to adapt on the fly in order to be able to meet the growing demand for energy. We are practically witnessing the integration in NES of some hybrid conversion systems (conventional and renewable), whose stable operation is conditioned by the stochastic nature of renewable energy sources. Solar and wind systems play an important role in the energy mix, whose operation at accepted technical parameters is determined by weather conditions.

The need to store electricity, to ensure continuity of supply, has been known since the beginning of the 20th century. To ensure electricity during the night (when the power plants were closed) lead accumulators were used [5, 8].

Continuity in supply and safety in operation, adaptation to climate change is not possible without the integration of storage solutions. Storage must be looked at from several perspectives, but especially from the point of view of energy mixes.

Improperly used, the term electrical energy storage apart from storage in high-capacity capacitors and magnetic superconductors, storage involves the conversion of electrical energy into other forms of energy, Fig. 1 [5]. The return of stored electrical energy in such systems is influenced by the efficiency of the conversion system chosen.

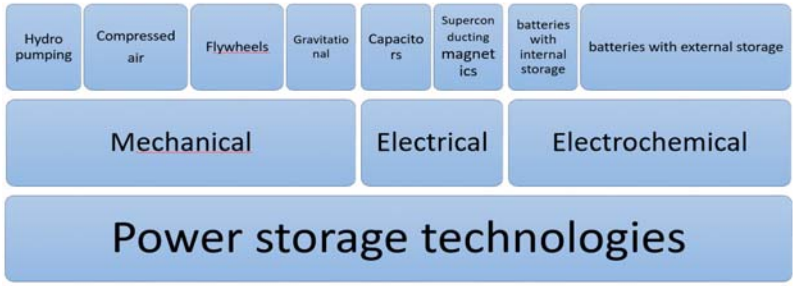

Fig. 1. Power storage technologies [5]

Part of the hybrid energy systems (HRES) that integrate renewable energy resources, the capacity of the storage systems is dimensioned according to the type of fluctuations in the energy system as a result of the RES integration, the storage time and last but not least the lifetime and the size of the storage system storage.

Fig. 2 shows the electrical energy storage systems ordered by power density (kW/kg), energy density (kWh/kg) that it can store, but also according to the time in which the storage system can return in SEN electrical energy stored [5].

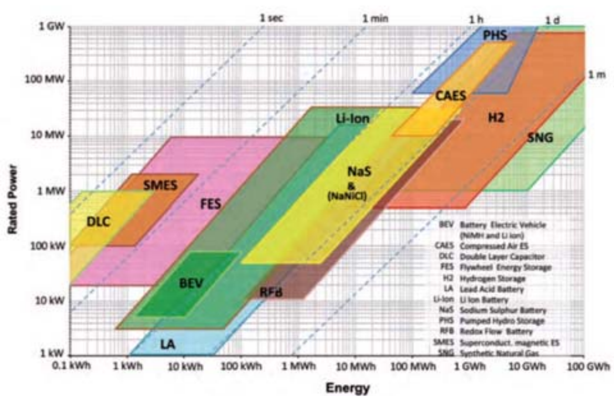

Fig. 2. Graph of the return of energy stored in storage systems

The choice of storage technologies must be analyzed both from an economic, constructive point of view, of the function of returning electricity, of occupied land surfaces, but especially after an analysis of the impact on the environment.

Currently, with all the obstruction from environmental activists, the most widely used storage technology is pumped storage (SEHP). Presenting the advantage of seasonal storage, these systems can compensate for day-night consumption, compensate for production gaps in the RES, and ensure a maximum of one hour, frequency regulation in the power system (SE) [9, 10].

Although our country has an important hydrographic network, with important hydroelectric energy production capacities, no SEHP has been realized until now [9].

Energy storage in compressed air (SEAC), in containers but especially in underground caverns [11], due to the fact that it can transfer large amounts of energy at high flow rates is proposed by Stal Laval and is recommended for the integration of RES energy production systems (especially wind and solar energy) [9].

In order to maintain voltage and frequency (ensuring the quality of electricity), without backup generators, energy can be stored in inertial (inertial) systems - SEV. These systems can provide a fast response of charge-discharge cycles [9].

Gravitational storage systems (SESGs) can store large amounts of potential energy, for long periods of time, and return this energy as needed by the SE.

Electrochemical storage Fig. 3, refers to storage in batteries, capacitors/supercapacitors and fuel cells, [9,12], represents one of the most common solutions with applicability, from simple to complex. They can be used from powering a trivial light source to balancing intermittent energy production from RES [9].

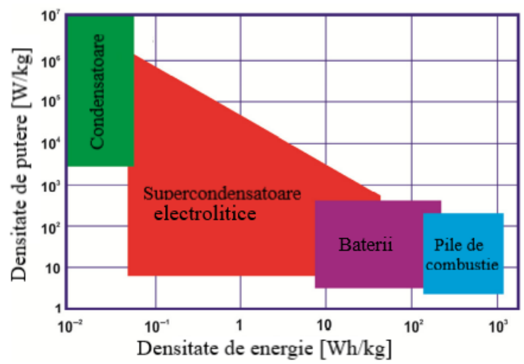

Fig. 3. Electrochemical storage systems [11]

A possibility of realizing a storage system is presented in Fig. 4 [12].

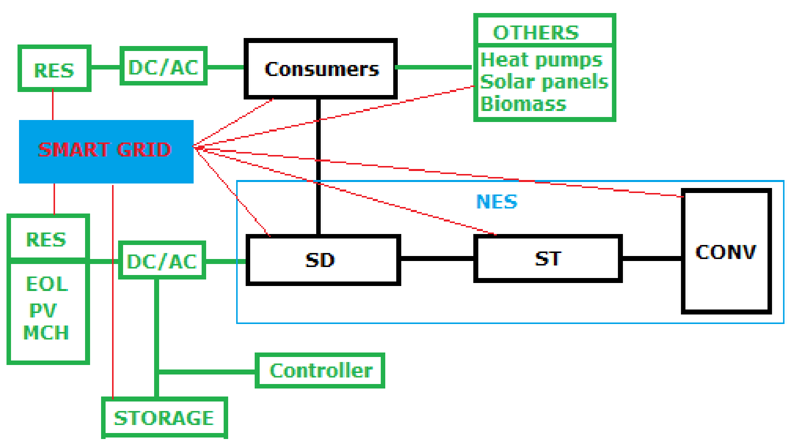

Fig. 4. Storage energy system proposed [13].

RES - Renewable energy sources; EOL - Wind energy; PV - Photovoltaic energy, MCH – Microhydro plants; AC - Alternative current; DC - Continuous current; SD - Distribution system; ST - Transportation system; CONV - Conventional energy source; NES - National energy system

3. Analysis of the national energy system during the period 01.06.2023 - 30.08.2023

Based on the data provided by Transelectrica S.A., available online, the load curve and electricity production (wind, solar, hydroelectric) during the period 01.06.2023- 30.08.2023 was represented, Fig. 5, 6, 7.

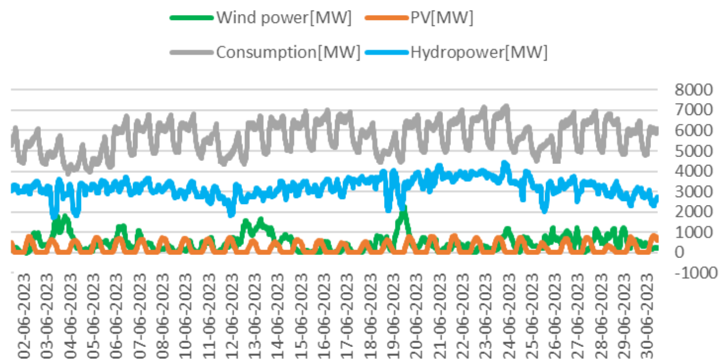

Fig. 5. The variation of consumption and production of electricity from.RES June 2023

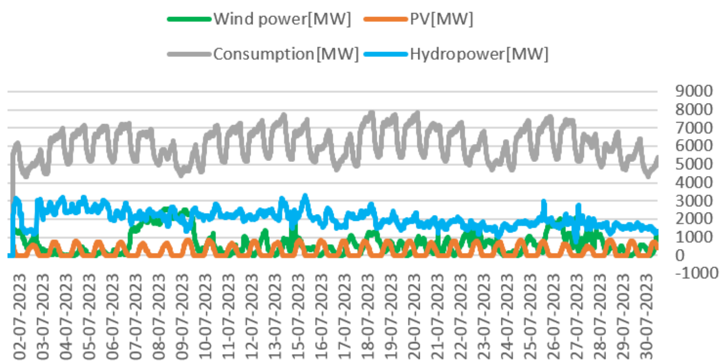

Fig. 6. The variation of consumption and production of electricity from.RES July 2023

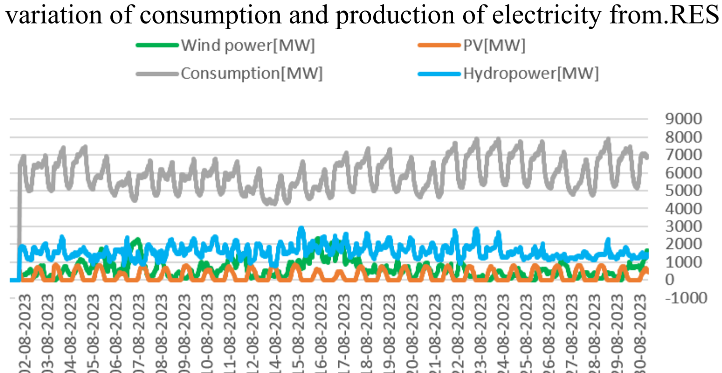

Fig. 7. The variation of consumption and production of electricity from.RES August 2023

The variation of the balance of energy during the period 01.06.2023- 30.08.2023 was drawn, Fig. 8, 9, 10.

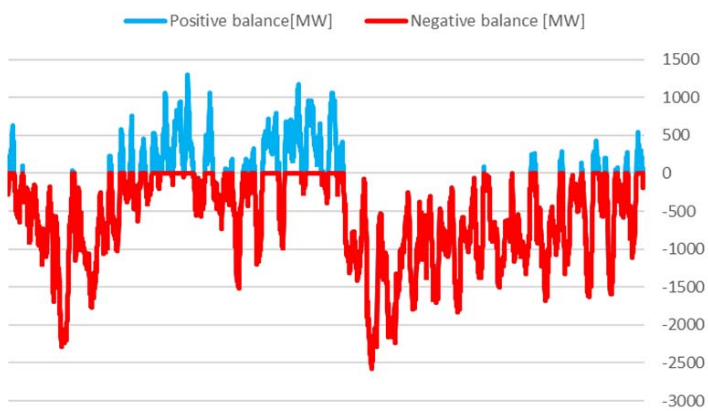

Fig. 8. Balance of energy. June 2023

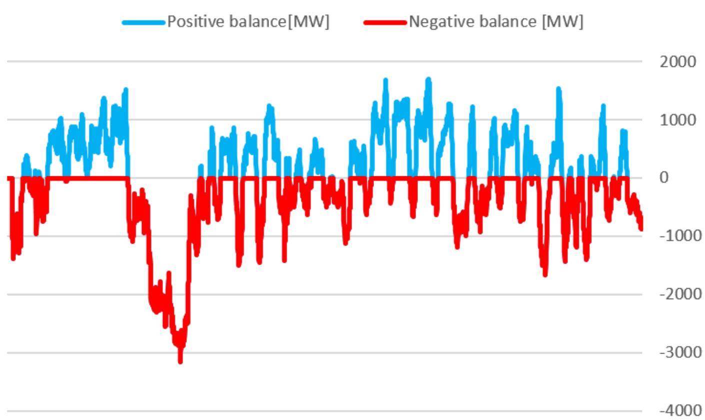

Fig. 9. Balance of energy. July 2023

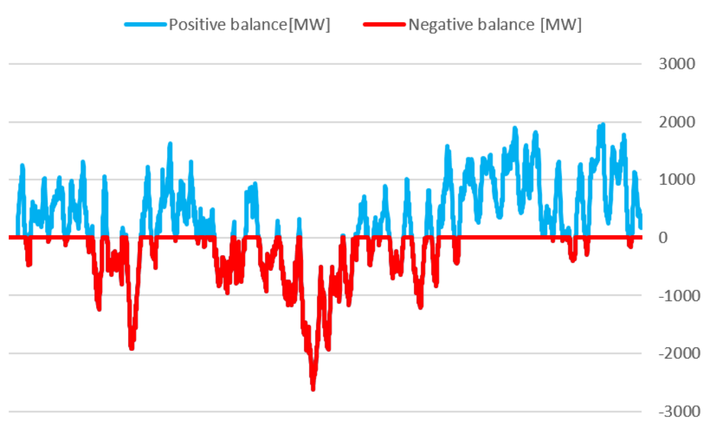

Fig. 10. Balance of energy. August 2023

The production of electricity using fossil fuels has been graphed, Fig. 11, 12, 13.

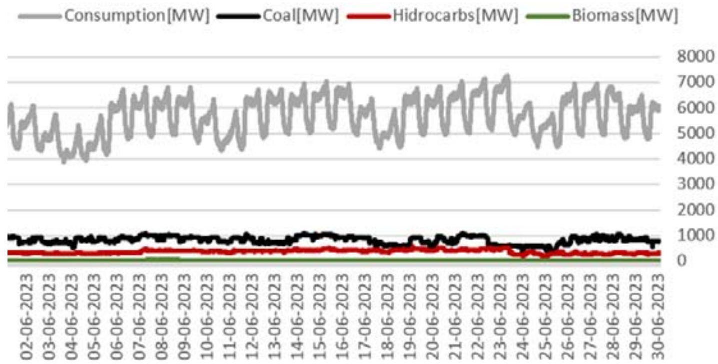

Fig. 11. Variation of electricity consumption and production from conventional energy sources. June 2023

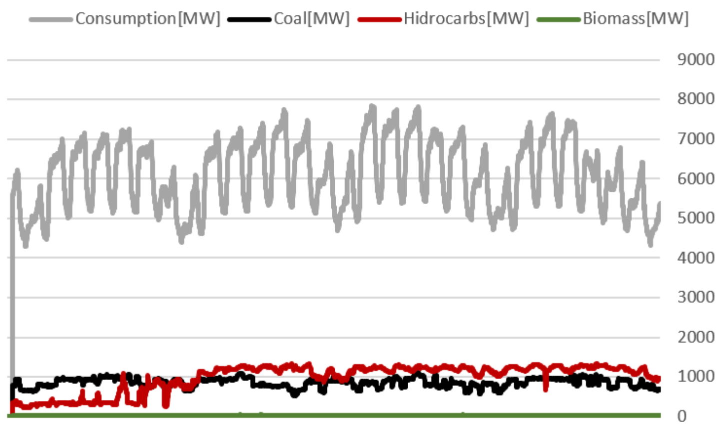

Fig. 12. Variation of electricity consumption and production from conventional energy sources. July 2023

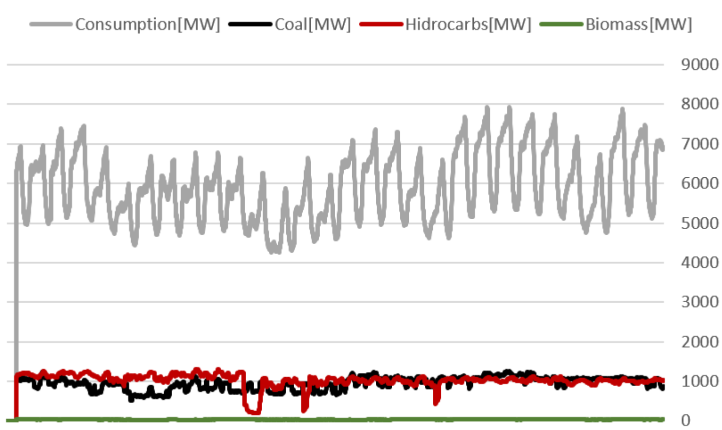

Fig. 13. Variation of electricity consumption and production from conventional energy sources. August 2023

The amount of greenhouse gases as a result of the production of electricity using fossil fuels has been graphed, Fig. 14, 15, 16.

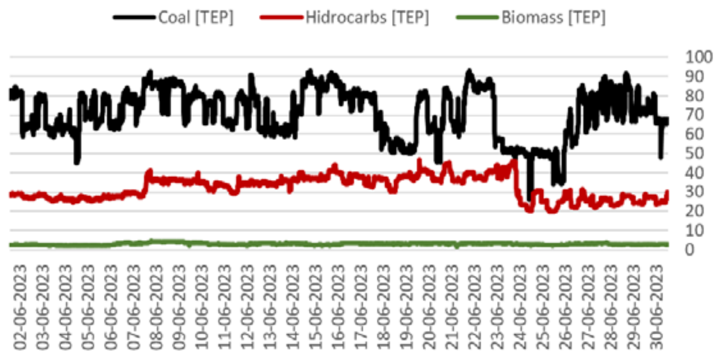

Fig. 14. Greenhouse gas emissions expressed in TEP. June 2023

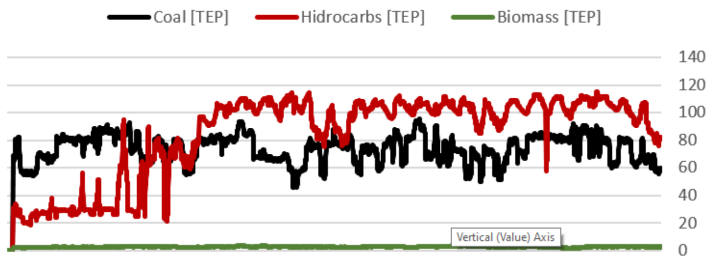

Fig. 15. Greenhouse gas emissions expressed in TEP. July 2023

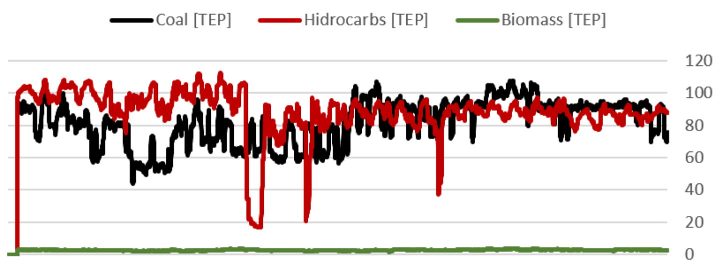

Fig. 16. Greenhouse gas emissions expressed in TEP. August 2023

The amount of greenhouse gases produced by electricity production systems using fossil fuels was calculated, after the adoption of energy storage solutions.

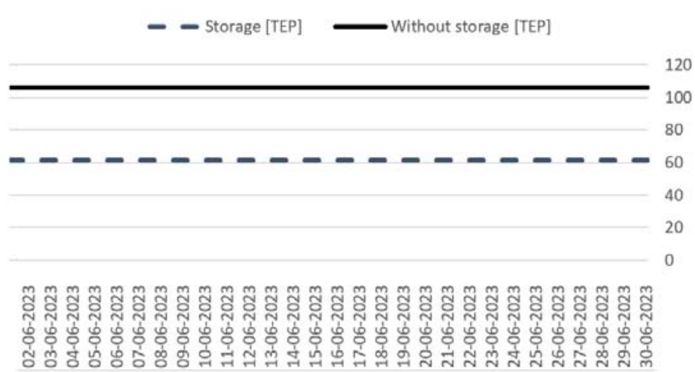

Fig. 17. Average greenhouse gas emissions expressed in TEP. June 2023

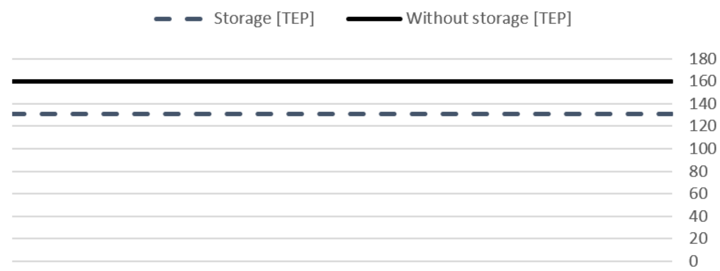

Fig. 18. Average greenhouse gas emissions expressed in TEP. July 2023

Fig. 19. Average greenhouse gas emissions expressed in TEP. July 2023

4. Conclusions

Starting from the national energy mix [7]., the paper analyzes the energy balance, emphasizing the need to reduce electricity consumption by modernizing and making the existing equipment more efficient.

Analysing the contribution of solar energy and wind energy in the energy mix, a low level of implementation of these renewable resources is found, the production share being owned by hydropower, Fig. 5-7. From the same graphs, it can be seen that during the studied period, the photovoltaic systems had a relatively similar operation.

In June, the degree of use of hydrocarbons was below the level of coal use, in July and August the use of hydrocarbons exceeded the level of June.

Even if the energy balance is negative, Fig. 8-10, (electricity production is higher than consumption), the management of NES is worrying because important amounts of energy are imported in periods of the year when energy from RES should cover a good part of consumption.

Analysing the energy balance in the period June 1-August 30, 2023, Fig. 17-19, it is noted the need to implement some storage systems in the national energy mix that would lead to a decrease of GHG by 41.6% in June, by 18.4% in July and by 12.1% in August.

Based on the above observations, it can be stated that grid-scale storage plays an important role in the net-zero scenario by 2050.

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