

Carbon driven energy equilibrium at the municipal scale – Energy Equilibrium

Summary Report on the Energy Infrastructure (Poland)

Prepared by J.Ł., IMP PAN

1 Organization of electrical grid – transmission network

The electricity transmission network in Poland is managed by **Polskie Sieci Elektroenergetyczne SA (PSE)**, which is the sole transmission system operator (TSO) in the country. The entire power system in Poland and throughout Europe (excluding the frequency of railway electric traction in Germany and four other countries) operates at a frequency of 50 Hz.

1.1 Key Components of the Transmission Network

1.1.1 High-voltage transmission and distribution lines:

Transmission lines transport electricity over long distances from power plants to substations. They operate at high voltages to reduce energy loss during transmission (750 kV, 400 kV, 220 kV). High-voltage distribution network (110 kV) is part of the distribution network, however, due to the way it works, it is largely identical to the transmission network. Its work is mostly coordinated by the TSO.

Substations: These facilities step down the high voltage electricity to lower voltages suitable for distribution to homes and businesses (especially the main power supply points, Głównie Punkty Zasilania (GPZ) in Polish). RES installations are also connected to GPZ, such as the Jasna wind farm of Stadtwerke München in the municipality of Mikołajki is connected to GPZ Gdańsk-Błonia by an underground 110 kV high-voltage cable network. These substations also play a crucial role in managing the flow of electricity and maintaining grid stability.

National Power Dispatch Centre: This center is responsible for the real-time management of the power system, including balancing supply and demand, and ensuring the stability and reliability of the grid.

1.2 Responsibilities of PSE

Quality and security of supply: PSE ensures the continuous and reliable supply of electricity across the country. This involves maintaining and upgrading the transmission infrastructure to meet demand and prevent outages.

Network sufficiency: PSE is tasked with ensuring that the transmission network has sufficient capacity to handle current and future electricity demands.

Commercial balancing: PSE operates the national central commercial balancing mechanism, which involves managing the financial transactions related to electricity supply and demand.

European cooperation: As part of the European Network of Transmission System Operators (ENTSO-E), PSE collaborates with other TSOs to maintain the stability of the interconnected European electricity system (German 50Hertz Transmission GmbH, Swedish Svenska kraftnät, Czech ČEPS, a.s., and Lithuanian Litgrid).

1.3 Legal and Regulatory Framework

PSE operates under the guidelines set by the Energy Law of April 10, 1997, which outlines the responsibilities and standards for transmission system operators in Poland. The company is appointed by the President of the Energy Regulatory Office (Urząd Regulacji Energetyki (URE)) to perform its functions until December 31, 2030.

1.3.1 Distribution system operators in electrical grids

In Poland, the electricity distribution network is managed by several key distribution system operators (DSOs):

- **PGE Dystrybucja:** This is the largest DSO in Poland, serving a significant portion of the country (central and eastern part of Poland).
- **Tauron Dystrybucja:** Another major player, Tauron Dystrybucja, covers a large area in southern Poland.
- **Enea Operator:** Serving the western part of Poland, Enea Operator is known for its efforts in grid modernization and the implementation of smart metering systems.
- **Innogy Stoen Operator:** This DSO operates mainly in Warsaw and its surroundings, focusing on urban electricity distribution and the deployment of advanced metering infrastructure.
- **Energa Operator:** Operating primarily in the northern regions (especially in Pomerania), Energa Operator focuses on integrating renewable energy sources into the grid and enhancing grid reliability (the largest share of renewable energy sources (RES) in electricity production among Polish DSOs) and, similarly to Enea Operator, on implementing smart metering systems. This is the most interesting DSO from the point of view of the Energy Equilibrium project.

These DSOs are responsible for maintaining and upgrading the distribution networks, ensuring reliable electricity supply to homes and businesses, and integrating new technologies to improve efficiency and sustainability. Their networks operate hierarchically: high voltage (110 kV), medium voltages (mainly 15 kV), to distribute electricity from substations to local distribution points, and finally low voltage (phase voltage 230 V; recipients requiring higher power are supplied from a three-phase network with a phase-to-phase voltage of 400 V).

1.3.2 Stakeholders active in electricity storage

The owners and operators of electricity storage facilities are both TSO and DSOs. This applies to both pumped-storage power plants (the largest of them in Żarnowiec, with an installed capacity of 716 MW, owned by PGE) and electricity storage facilities based on lithium-ion batteries (including the one that PGE is building in Żarnowiec, with a target power of no less than 200 MW and a capacity of 820 MWh, thus creating a Commercial Hybrid Energy Storage facility).

The report prepared by the President of the Energy Regulatory Office discusses the current state of energy storage in Poland as of May 2024. It highlights that there are 12 energy storage facilities with a capacity of at least 50 kW, but not exceeding 10 MW integrated into the transmission and distribution networks (1,465 MW). The report also mentions that since the introduction of regulations in 2021, energy storage facilities with a capacity greater than 10 MW require a license from the URE. The total installed capacity of electricity storage facilities for the five largest distribution system operators and the transmission system operator is 4,200 MW (however, in the main capacity market auctions for 2021–2028, 7.6 GW was reported for existing and modernized storage facilities, as well as 1.9 GW for new units based on lithium-ion batteries).

The above report does mention several challenges and limitations related to energy storage in Poland:

Regulatory Barriers: The need for licenses for energy storage facilities with capacities greater than 10 MW can be a hurdle for some projects.

Integration Issues: Ensuring that energy storage systems are fully integrated with the transmission and distribution networks can be complex and time-consuming.

Ownership Restrictions: The 2023 amendment to the energy law restricts system operators from owning, building, or managing energy storage facilities unless specific conditions are met and approved by URE, which can limit the development and deployment of these systems.

Approval Processes: The process of getting energy storage facilities recognized as fully integrated with the network involves multiple decisions and can be lengthy, with some applications still under review.

These challenges highlight the need for continued regulatory adjustments and technological advancements to fully leverage the potential of energy storage in Poland.

1.4 The role of local authorities in electricity storage

In short – local authorities do not play any role in electricity storage systems. Their role of hydrogen and Power-to-X installations in today's energy system is practically negligible; a complex of electrolyzers is being built only in Konin, which are to be powered by a biomass power plant being built next to the decommissioned brown coal power plant (however, this is doubtful in an area of structural drought).

1.5 Business models for energy (electricity) storage

Generally, the following some common business models for electricity storage could be presented:

- **Demand Charge Management:** This model targets commercial and industrial customers who face high demand charges. Energy storage systems are used to reduce peak demand, thereby lowering electricity bills.
- **Grid-Scale Renewable Power Integration:** Large-scale energy storage systems are deployed to store excess energy generated from renewable sources like wind and solar. This stored energy can be released when generation is low, ensuring a stable supply.
- **Small-Scale Solar-Plus-Storage:** Residential and small commercial customers combine solar panels with battery storage. This setup allows them to store excess solar energy generated during the day for use at night or during power outages.
- **Frequency Regulation:** Energy storage systems help maintain the balance between supply and demand on the grid by quickly absorbing or releasing energy to stabilize frequency.
- **Energy Arbitrage:** This involves buying electricity when prices are low (usually during off-peak hours) and storing it for sale when prices are high (during peak hours).
- **Backup Power:** Energy storage systems provide backup power during outages, ensuring continuous operation for critical infrastructure and services.
- **Transmission and Distribution Deferral:** Energy storage can defer or eliminate the need for expensive upgrades to transmission and distribution infrastructure by managing load and reducing congestion.
- **Ancillary Services:** Energy storage systems provide various ancillary services to the grid, such as voltage support, spinning reserve, and black start capabilities.

These models highlight the versatility and economic potential of energy storage in different segments of the electricity market. There are four types of initiatives in this area, especially city-scale renewable energy systems. These systems, combined with storage, can significantly enhance urban energy resilience and sustainability:

- **Public-Private Partnerships (PPP):** Collaboration between government entities and private companies to fund, build, and operate RES-plus-storage systems.
- **Utility-Owned Systems:** Utilities invest in and manage large-scale renewable energy and storage projects, integrating them into their existing infrastructure.
- **Community Energy Projects:** Local communities invest in shared renewable energy and storage systems, benefiting from collective ownership and shared savings.

- **Energy-as-a-Service (EaaS):** Companies provide renewable energy and storage solutions as a service, with cities paying for the energy consumed rather than the infrastructure.

1.6 The organization of other energy storage systems

Heat storages are not yet very common in Poland, but there are some examples, like facilities of PGE. PGE Energia Ciepła already has heat storage systems in its combined heat and power plants (CHP), e.g. in Toruń, whose task is to optimize the production profile of electric power in cogeneration and to use peak power in transitional periods. The company also completed two research projects related to cooling networks, e.g. in Zielona Góra.

A heat accumulator has been in operation at the Białystok CHP Plant (Enea) since December 2011, with basic parameters:

thermal power – 130 MW,

max. amount of stored heat – 780 MWh (water temperature of 40 - 98 °C),

working capacity of 12,000 m³, total 13,000 m³,

loading speed 3,000 m³/h and discharging 2,000 m³/h.

There is a big heat storage system with total capacity of 30,000 m³ at the Siekierki CHP Plant (PGNiG Termika) in Warsaw, since 2009.

The most interesting solution seems to be the implementation of the Power-to-Heat (P2H) technology, which uses the ability to store surplus electricity in the form of heat, using a cooperating electrode boiler and heat accumulator. This has already been partially implemented at the Gdańsk CHP Plant (PGE Energia Ciepła), i.e. two electrode boilers, with a capacity of 35 MW each, and a heat storage tank is planned.