Best practice site visit Békéscsaba

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Smart Grid in Electric Power Systems (lithium-ion battery storage system)

- **Location:** Solar PV Park in Békéscsaba (HU)
- **Date:** 2024.03.06
- **Installed Technology**: Smart Grid system (lithium-ion battery storage system), Solar Park
- **Operator:** Békéscsaba Energia Esco Ltd.
- **Participants:**

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Introduction

Solar PV Park, Békéscsaba (HU): This event, hosted by Békéscsaba Energia Esco Ltd. (established in 2020 and indirectly owned by the local government of Békéscsaba), aims to support the implementation of complex energy projects within the Modern Cities Programme. Their focus includes operational tasks related to energy and smart infrastructures in Békéscsaba, as well as promoting, developing, and managing innovative projects such as energy-related developments, smart transformation, and greenport initiatives.

During the visit to the Békéscsaba Solar Park, Mr. Gyula Kovács, the Managing Director of Békéscsaba Energia Esco Ltd., presented the operation of the Smart Grid system and the Solar Park at the Visitor Center. The Smart Grid system in Békéscsaba is the first of its kind in Hungary, offering real-time monitoring of energy conditions.

Visitor Center, Békéscsaba (HU)

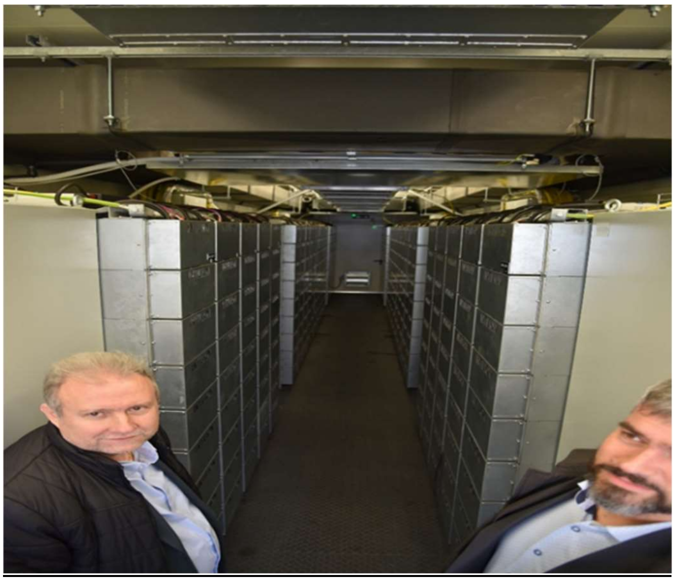
Smart Grid Components:

PV Solar Parks:

We visited three interconnected PV solar parks, with a combined output of 1.3 MWp, supported by over 3000 panels. The system is managed by two inverters, each with a capacity of 650 kW, allowing for future expansion.


Energy Storage Unit:

The energy storage unit has a total output of 1.2 MW and a capacity of 2.4 MWh, utilizing Samsung lithium-ion batteries with over 7000 cells. It features a unique fire protection system for enhanced safety and optimizes usage by maintaining the State of Charge (SoC) between 15% and 85%.



Lithium-ion Battery Energy Storage System (BESS)

Visitor Center and Smart System Control:

The Visitor Center educates the public about the Smart Grid System through interactive touch screens, 3D animations, and real-time reports. The Smart System Control operates remotely, ensuring security through a redundant system that includes both landline and mobile connections. On-site requirements are minimal, limited to technical maintenance.

Visitor Center, Smart Grid System

System Overview:

The Békéscsaba Smart Grid system includes a solar power plant with a peak capacity of 1.3 MW, consisting of three solar parks, a 1.2 MW capacity battery storage system with

2.435 MWh, a smart center to control these elements, and connecting electrical/data transmission and data collection network components and equipment. It connects to the distributor's medium voltage network (11 kV) and holds licenses for small-scale power generation (50 kW – 50 MW output) and storage. Key electrical consumers currently include the Sports Hall, the Fencing Hall, and auxiliary operations necessary for the Grid system itself (including control systems, computers, fire and security systems, lighting, heating, and cooling) and a 150 kW bus charger. Surplus energy is stored and fed back to the electricity provider according to existing agreements. The storage system can meet consumption needs during night-time and low-light periods, minimizing the increasingly costly grid electricity purchases in the future.

Lithium-ion Battery Energy Storage System (BESS)

Operational Aspects Examined

During the on-site visit, we thoroughly examined the system's operational aspects, including transformers (11 kV / 0.36 kV / 0.36 kV, 2 x 800 kVA), converters (600 kW each), an ICU controller, and a Battery Management System (BMS). The energy storage units contain DC distribution cabinets and multiple battery banks, each with a BMS for precise management. Equipped with certified safety mechanisms, fire protection compartments, and advanced climate and ventilation systems managed by the ICU controller, the system uses INFOWARE and INTILION technologies, and AI-based forecasting and optimization algorithms to ensure efficient operation. With a capacity of 1.2 MW / 2.4 MWh, the system optimizes energy production and consumption, reduces dependency on the public grid, provides backup power during grid failures, and supports off-grid mode and synchronous reconnection under load. Operating costs are low due to the efficiency and long lifespan of the lithium-ion batteries, and maintenance mainly involves regular inspections of the battery units and control systems.

Disadvantages:

- The operation of lithium-ion energy storage systems presents several challenges. Chief among these is the occurrence of energy losses during storage and retrieval, which typically range between 5% and 15%, depending on factors such as ambient temperature, system efficiency, and cycle depth. These losses can add up significantly over time, reducing the overall system efficiency and increasing operational costs. Another notable issue is the difficulty in accurately determining the energy charge level, or State of Charge (SoC), which limits precise energy management and forecasting capabilities.
- A recurring issue faced by the operator is the regularity of malfunctions within the system. These malfunctions typically require maintenance and occur approximately 6–8 times annually, leading to temporary suspensions of solar PV operations. Such interruptions can last several hours to days, depending on the nature of the fault, creating inefficiencies and lost production time. Although the system is equipped with advanced control and diagnostic tools, the frequency of these events underscores the need for robust maintenance schedules and contingency measures.
- Another significant challenge is the reliability of the indicated SoC provided by the Battery Management System (BMS). Operators have observed discrepancies between the actual SoC and the system's estimated values. This is primarily due to the BMS relying on computational algorithms to estimate the SoC rather than direct measurements. Such deviations can lead to unexpected drops in the battery's functional capacity, affecting the system's ability to meet energy demands or maintain grid stability during critical periods. Addressing these issues would require advancements in BMS technology to ensure more accurate and reliable SoC estimations.
- Additionally, the system's operational capacity is constrained by measures taken to preserve the battery's health and longevity. To mitigate degradation, the battery is charged and discharged only between 85% and 15% of its nominal capacity. While this approach significantly extends the battery's lifespan and reduces the risk of performance drops, it also means that only 70% of the battery's capacity is available for use. This limitation, while necessary, reduces the system's overall efficiency and may necessitate larger or additional storage units to meet energy demands effectively.

Operational Experiences:

- Park1 solar park produces a maximum output of 650 kW in ideal sunny conditions.
- Park2 and Park3 can produce a maximum output of 650 kW in similar conditions.
- The energy storage unit can produce a maximum output of 1.2 MW at full charge, and the combined output of the solar park and storage unit reaches 2.5 MW.

- As describe above, to maximize battery lifespan, the system regulates the state of charge, avoiding levels below 10% and above 90%. Additionally, the charge rate is reduced above 85%, and the discharge rate is limited below 15%. The storage unit consists of two sub-units to balance the state of charge and utilization, further extending battery life.

- Remote Access and Monitoring: Remote access for system diagnostics is established through a VPN connection. The Smart Grid monitoring interface is accessible via a web interface, displayed on a touchscreen TV at the local smart center. The interface consists of:

  - A graphical overview with a 3D site illustration and simplified circuit paths, showing real-time solar park production, storage status, and current consumption and output.
  - The SCADA interface, which details the technical operation of the facility's components, including events, fault indications, circuit paths, voltage/current/power values, and other numerical data. This interface does not allow intervention but serves as a central software control tool for the technical operator.
  - The "Historian" interface, which provides graphical visualization and retrieval of previously measured and recorded quantities.

Energy Storage Unit's Role in Schedule Adherence:

- If solar panel production exceeds expectations, excess energy is stored in the unit up to a 85% charge, preventing surplus power from being fed into the grid and maintaining the schedule.

- If solar panel production is lower than expected, the storage unit meets the shortfall, maintaining the schedule up to a minimum 15% charge. At dusk, when no further solar charging is expected, the converters switch to a low-power mode, minimizing standby power consumption and drastically slowing the self-discharge rate during evening or low-sunlight hours.

In case of overproduction, if the battery's capacity does not allow further storage, the solar park inverters can regulate down to prevent excess energy from being fed into the grid.

Consumer Experiences:

As the heating season ended, consumption decreased, then gradually increased again with the onset of summer cooling needs. Grid power consumption steadily decreased to a minimal level, due to faster daytime charging of the battery storage and increasingly accurate consumption/production forecasts from learning optimization algorithms in the plant's control technology. The amount of power that can be drawn from the grid is a critical parameter, as it determines the performance fee paid to the distribution licensee. The medium voltage network and connection point from the substation have a maximum capacity of 2.548 kW, designed to handle the maximum output of the solar panels and storage unit.

Conclusion

The best practice visit to the Solar PV Park in Békéscsaba underscored the potential of energy storage systems in enhancing the efficiency and reliability of renewable energy projects. Lithium-ion storage systems, with their high energy density, operational flexibility, and advanced optimisation capabilities, have proven to be effective in supporting clean energy goals. Their ability to reduce grid dependency, provide backup power during outages, and balance energy production and consumption offers significant advantages for modern energy infrastructures.

However, the challenges associated with lithium-ion technology, such as limited operational capacity due to conservation measures, environmental concerns related to mining and disposal, and frequent maintenance interruptions, highlight the need for alternative solutions. Additionally, the reliance on finite resources like lithium and cobalt makes the long-term sustainability of this technology questionable. While lithium-ion systems have laid the groundwork for large-scale energy storage, their limitations emphasise the urgency of developing more environmentally friendly and resource-efficient alternatives.

To ensure the sustainability and scalability of renewable energy systems, the exploration and adoption of alternative storage technologies—such as solid-state batteries, flow batteries, or hydrogen-based systems—are crucial. These emerging solutions offer the promise of greater environmental compatibility, reduced resource dependence, and improved system longevity, paving the way for a more sustainable energy future.