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Recovering energy from train braking for traction and grid use

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Abstract

Aiming to help cities make a smart and efficient use of their energy resources, Saft, world-leading designer, developer and manufacturer of advanced technology battery systems for industrial applications, has implemented several Energy Storage Systems (ESS) around the world.
One of these solutions relies on an advanced battery storage system installed at a trackside substation to capture and reuse the regenerative energy from braking trains. This storage serves a triple valorization purpose:
- Reducing the grid energy consumed by assisting the acceleration of trains
- Supporting the grid with primary frequency regulation and voltage support
- Providing "power backup" in case of an emergency outage
Major actor of this smart integration dynamic, Saft has deployed an Intensium Max 20 containerized Li-ion battery system for one of the Southeastern Pennsylvania Transportation Authority's (SEPTA) railway substations in Philadelphia, USA. This battery is controlled by a Power Controller System (PCS) that commands when to store or to restitute energy. This balance is optimized by a software that computes in real-time the most profitable way to use the system. Based on financial and technical criteria and perfectly synchronized with the other devices of the system, the software will choose to deliver energy or store it, assist to the traction or participate to the energy market, deliver frequency regulation services, demand response or storage capacity.
One year after its implementation, the system had already delivered 1,380 MWh of energy savings, capacity services and grid regulation yielding a gross benefit of almost a half-million dollars.

Energy Storage | *System Regenerative braking* | *Trackside* | *Frequency regulation* | *Energy savings*

Introduction To SEPTA's Challenge

With the need to move to cleaner and more efficient energy resources to meet the demands of an increasing urban population, cities are rethinking the way energy is generated, distributed and consumed, notably by using decentralized renewable energy production. To reach this goal Lithium-ion energy storage systems (ESS) have already proven their

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technological maturity. Indeed, they are the keystones of the closed loop systems that can help big energy consumer to be less energy intensive.
The next step is the full integration of ESS into smart grids with bi-directional flows of information using specific IT infrastructure and software. Thank to this integration operation cost savings can be increased and new business models of ancillary services become even more attractive. Therefore, the use of ESS to serve both internal demand and external regulation, appears like the new trend to help companies reach the best trade between efficiency, cost-savings and environmental print.
The Southeastern Pennsylvania Transportation Authority (SEPTA), running the public transport system for the US city of Philadelphia, is the second-largest consumer of electricity in its local energy company's service territory. Due to increase in energy cost, SEPTA needed to find innovative ways to become both environmentally and economically more efficient. The main goal of the sustainability program it has fixed itself was to reduce by 10% their energy intensity, defined as energy use per passenger mile. Given that more than 80% of the nearly 500 GWh of electricity yearly used by SEPTA is for propulsion power, recovering energy lost during braking seemed to be one of the best initiatives to reduce its energy consumption. This prompted the decision to take an innovative approach that would use a system to capture the kinetic energy of braking train and store it in a large-scale battery system.
Moreover, SEPTA is in the operating area of PJM, a Regional Transmission Operator (RTO) that has opened its frequency regulation market to non-traditional resources. Therefore, SEPTA chose to carry out the project with a smart grid specialist: Viridity Energy. Their role was to optimize the use of the energy between assistance to the traction and participation to the energy market. Saft was chosen to provide its Intensium Max 20P lithium-ion energy storage system and Envitech Energy was responsible for the power control, conversion and system integration.
This paper aims to describe the operation profile, the optimization of ESS's sizing as well as the benefits and revenues of such an application.

Stakeholders	Description
SEPTA	Railway operator (client)
Envitech Energy	System integrator and PCS supplier
Viridity Energy	Optimization software supplier
Saft	Containerized Li-ion battery supplier
PJM	Regional Transmission Operator

Table 1: Overview of the various stakeholders engaged in the project – Overview: Saft

1. Energy Optimization Served By BESS, The Solution Chosen By Septa

1.1 Recovering braking energy, an emerging industry trend

The concept of recovering the braking energy in transportation has been around for some time. By using regenerative braking process to convert the kinetic energy of the vehicle into electricity, the transportation industries have progressively found ways to recycle this energy. For instance, hybrid cars and buses can be up to 30% more fuel-efficient than their combustion-only counterparts in urban environments.
Electrically powered trains also use regenerative braking, but since trains are not designed with on-board energy storage capacity like hybrid vehicles, the regenerated energy from a braking train can only be used if there is another train accelerating in the immediate area. The solution chosen by SEPTA is a wayside energy storage system which supplies the catenary of an electric train system and captures through a third rail this otherwise wasted braking energy into resistors. The ESS feeds the energy back to the trains, typically to assist their acceleration when demand is at its peak. Depending on the time of the day and frequency of trains, between 5% and 25% of the traction energy gets recovered as shown later in this paper.
The cost savings enabled by this energy recovery are increased thanks to the PJM demand response program. This utility offers compensation to end-use customers for reducing their electricity use, during periods of high power prices or when the grid is stressed.