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NOVIA

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***Please cite the original version*:**

Cynthia Söderbacka (2019). *Energy storage demo environment in Technobothnia*. Vaasa Insider, 11.12.2019.

Energy Storage Demo Environment in Technobothnia

When discourses about the benefits that come with renewable energy sources come up, one cannot avoid the discussion going into the irregular tendencies of these sources especially with reference to solar and wind energy and the challenges that come with that. Unfortunately, the future does not have much room for fossil fuels, the era of renewable energy sources is here and will continue to grow. According to the **International Renewable Energy Agency (IRENA)** renewable energy currently accounts for one third of the global power capacity and the share will grow to about 50% by 2050.

As the saying claims, desperate moments call for desperate measures and we are heading towards that. We cannot change the intermittent nature of these major energy sources, but we can learn to understand them and plan our new energy systems in such a way that they function as reliably as the conventional energy systems we are accustomed to. The key factor here is security of supply which comes with energy storage, store the energy during excess production and discharge when there is low or no production. Three universities, namely; **Novia University of Applied Sciences** (Novia UAS), **Åbo Akademi University** (ÅA), and **Vaasa University of Applied Sciences** (VAMK) have partnered up under the "**Energy Storage in Our Future Low Carbon Society (Energilagring!)**" project (1.5.2018-30.4.2020) to build an energy storage demonstration environment in **Technobothnia Education & Research Laboratory**.

The demo environment being built will be used for education, research and demonstration purposes and planning is in an advanced stage with at least four energy storage technologies to be implemented. With energy storage, it is not a One-Size-Fits-All, different needs require different solutions and that is why it is important to build a demo environment such as this one. Some of the technologies to be implemented are discussed below.

The first demo under the project is a **Flywheel Energy Storage (FES)** demo developed using existing components from the laboratory and can be rearranged and ready to use within 15 minutes. This demo is a first-generation FES, which stores energy in mechanical form by rotating the wheel in a certain direction and releases the stored energy by reversing the direction of rotation. The demo gets power from the grid and feeds back into a grid to demonstrate this technology and has storage capacity of 8.Wh. The cycle lasts less than a minute but long enough for students to observe what is going on and has an efficiency of ~50%. The demo [see Figure 1] has already been implemented in education in VAMK this fall term.

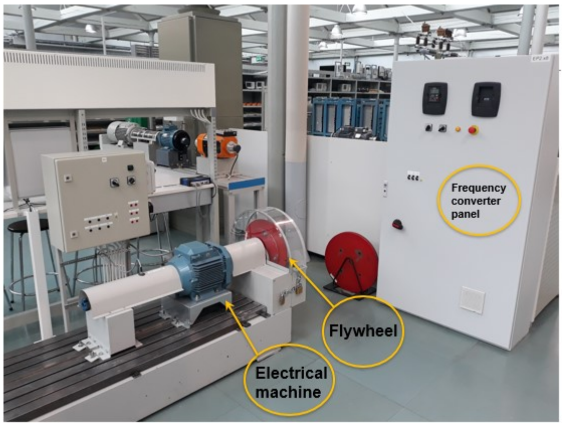

Figure 1: Flywheel Energy Storage demo [Picture by Jukka Hautala]

The European Project Semester (EPS) program, which Novia UAS is a part of, brings together students from different European universities to spend one semester in another university and work on a project. A team of these students are building a **Compressed Air Energy Storage (CAES)** demo as their project semester under our project. CAES stores energy by compressing air and storing the pressurized air in a reservoir or storage tank during excess production. The stored air is reused to produce electricity using a gas turbine when there is low or no production. The biggest challenge is sizing the demo to lab scale and still maintain good roundtrip efficiency and cost efficiency. A roundtrip efficiency of about 6% has been calculated for the system without **Thermal Energy Storage (TES)** and about 30% with TES (store and reuse waste heat from the compression process). The heat storage part is a Do-It-Yourself heat exchanger. A turbine has also been 3-D printed [see Figure 2] and will be compared with the air motor in the system, to see which of the two gives better system efficiency. Turbines offer better efficiency than air motors in such applications but it was way over budget and that is how the idea to 3-D print a turbine came about. It remains to be seen if this turbine will handle the process especially without TES (can the material handle the cold air?). If all goes according to schedule, the demo should be ready before Christmas this year.

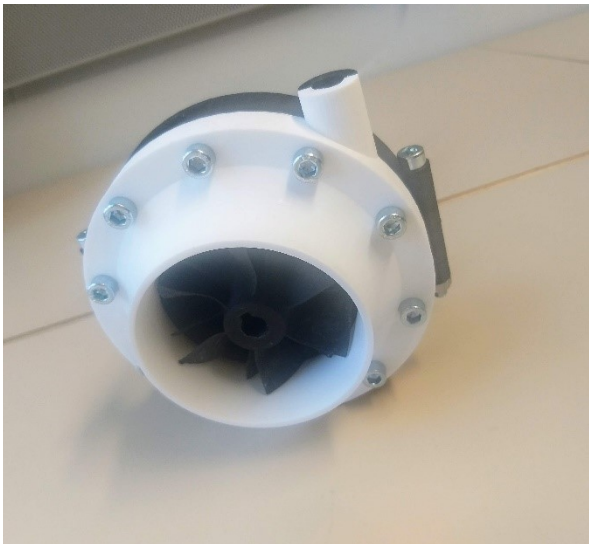
Figure 2: 3D- printed turbine made by Renier Looijen & Leon Verbene (EPS students 2019)

A thesis worker from ÅA is focusing on delivering a **Phase Changing Materials (PCM) Energy Storage** demo. PCMs store energy in the form of heat (latent heat) when undergoing a phase change from solid to liquid. This demo will focus on analysing thermophysical properties of PCMs using the T-history method. The focus will be on PCM with low melting points of about ~50 ˚C such as hydrate salts and paraffins. With this method, the materials are heated to temperatures above their melting points and then cooled down during which the temperature is continously measured. With these temperature measurements, latent heat and specific heat capacity can be calculated from which the amount of energy stored by that particular material can be calculated.

Power-to-Gas (PtG) is an important part of the renewable energy matrix, as it helps optimize the use of energy from intermittent sources by converting the excess electrical energy to gas form for easier and longer storage. The first stage is the conversion of electrical energy to hydrogen through the electrolysis of water, simply put use excess electricity to split water into hydrogen and oxygen. The renewable hydrogen can be used in the usual hydrogen applications or is further reacted with carbon dioxide over a catalyst to produce methane and water. Novia UAS and ÅAU started working on the Power-to-Gas demo[see figure 3] under the AIKO Gas CoE Project (1.1.2017-30.4.2019) to show the methanation of hydrogen and carbon dioxide. **VTT Finland** has been instrumental in the process as they provided free consultancy and a methantion reactor. Apart from the methanation process, this demo can also produce methane & hydrogen by Supercritical Water Gasification of biomass (SCWG). No tests have been run yet.

Figure 3: PtG demo- Built by ÅA Lab Engineers

Outside the project, the **Energy Lab in Technobothnia** is set to use electricity from renewable energy and, tapping from the grid if needed. This change comes with an investment from Technobothnia of a **Fronius Symo Hybrid Sytem** (inverter (5kW) & solar charge(8kW)), solar panels (5500W) and batteries (11.5kWh). The batteries will ,however, be installed at the **meteor impact site in Söderfjärden**. Even though the batteries will not be in

Technobothnia, historical data from both Technobothnia and the meteor impact site can be collected and analysed by students. Technobothnia has access to the live data from the site but historical data has more to offer for the students. The advantage of having batteries in such an environment is that a more realistic analysis can be achieved as they will be in a normal working system instead of in laboratory where charging & discharging are forced. The Lab Engineer at Novia UAS is in charge of this.

The project's aim is to build an energy storage demo environment that lives beyond the lives of the projects under which they are made. It is up to to the local industries to take advantage of such an environment and contribute to its growth by making use of it. The biggest challenge with these demos is the budget limitations which pose a challenge to deliver state-of-the-art solutions.

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Published in Vaasa Insider 12.12.2019 https://www.vaasainsider.fi/fi/nakokantoja/cynthia-soderbacka-energy-storage-demo-environment-in-technobothnia/