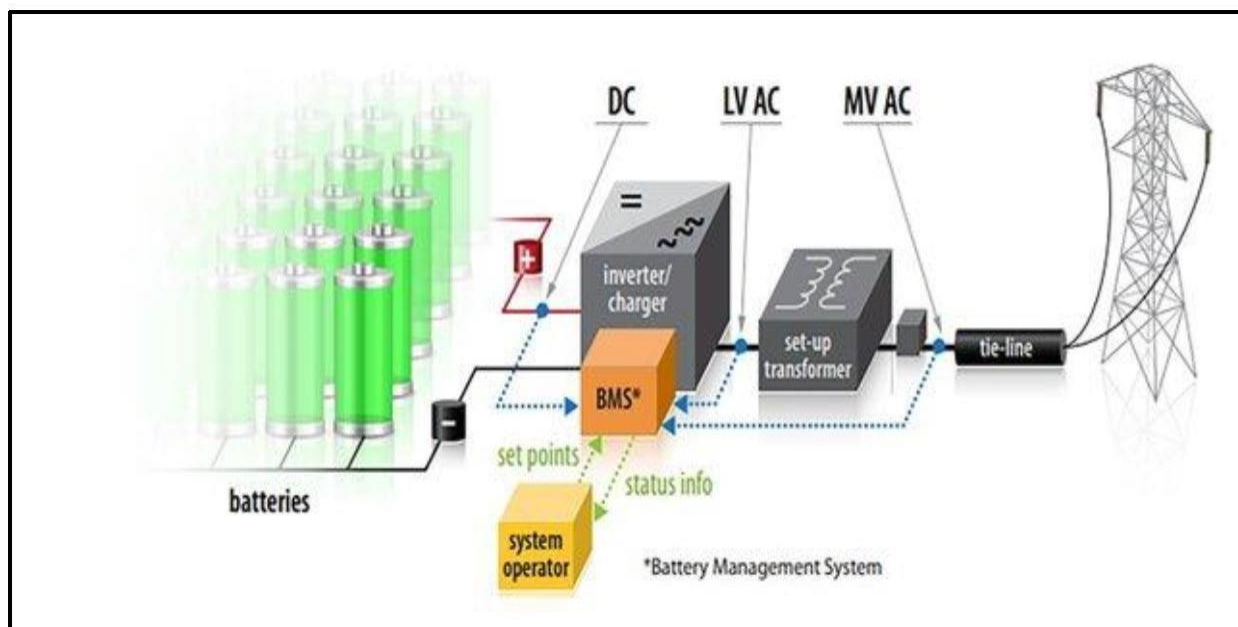


# Profitability Analysis of Long Duration Grid-scale Battery Storage Assets in the Nordic Spot Market and Ancillary Markets

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The looming threat of the climate change is triggering a green transformation of the energy systems worldwide. For the electricity sector this means more and more renewables coming into the grid. Among various renewable energy sources solar and wind energy are particularly popular. Although quite friendly for the environment, these energy resources are quite intermittent and unpredictable in nature. In an interconnected electric power system, the increasing proportion of such resources can pose a formidable threat to the grid stability. This is where large energy storages like pump storage plants and battery energy storage systems (BESS) come handy. A BESS system (Fig.1) coupled with a renewable generation has the capability to supply the grid with constant electric power.



**Figure 1.** Key components of a BESS system [1]

This thesis looks into the economic viability of energy storage projects in the Nordic electricity market. It uses some historical price data and a set of forecasted price data to judge the potential income of a BESS project over its lifetime. Batteries of various sizes e.g. 1-hour, 2-hour, 4-hour, 6-hour etc. and of various technologies, e.g. lithium-ion battery, redox-flow battery, sodium-ion battery etc. are studied. The potential income from various electricity market segments are assessed, e.g. day-ahead spot market, intraday market, ancillary services market etc. A business case is prepared by feeding in the costs and revenues of a BESS project as inputs. Some reasonable assumptions are made.

After the analysis the study finds out that a battery project is not looking profitable, given the price forecasts being used. Relative profitability increases if a battery participates in more than one markets instead of dedicating itself to a sole market segment. However, the price forecasts might be inaccurate and the battery costs are projected to reduce gradually over the next few years. Therefore a number of sensitivity analyses are performed that gives the price levels that will make the investment profitable. Among various battery technologies, sodium-ion batteries are found to be most attractive economically, followed by lithium-ion batteries. Moreover, the longer duration batteries are found to be relatively more attractive investment than 1-hour batteries.

[1] Image Reference: Gawusu S, Mensah RA, Das O. Exploring distributed energy generation for sustainable development: A data mining approach. J Energy Storage. 2022 Apr; 48:104018.