To Store or Not to Store

The article aims to demystify the economics behind use of Energy Storage in Stationary Energy Shifting Applications. In such applications the determining factor is cost of energy over a period of time. As the cost of renewables has reached a level where it is not only viable to use it directly when available but also to store it for later use. While there maybe several factors to consider use of Energy Storage such as Sustainability or Energy Security however in most cases it comes down to economic viability. One factor which can summarize the cost effectiveness of Storage is Levelized Cost of Energy from Storage (LCOE_S).

A lot of us are familiar with the capital cost of renewables and its LCOE_R in our respective regions. Using these two inputs along with basic information about storage (Capex, efficiency and life) one can arrive at LCOE_S for storage or a combined LCOE_Avg for both Renewables + Storage.

Capital Cost of Renewables vs Energy Storage

The capital cost of renewables (CAPEX_R) such as Solar/Wind is stated in terms of per unit of Power i.e. USD/MW whereas storage (CAPEX_S) is mentioned in terms of per unit of energy i.e. USD/kWh. To calculate the LCOE_R first thing that is done is to calculate the Energy generated by the Renewable plant over the course of the day/month/year over 25 years using the Plant Capacity Utilization Factor (CUF) also known as Plant Load Factor (PLF). It is the ratio of actual annual average electricity production to that of maximum possible under ideal condition. For most PV + Storage Energy shifting applications the storage is sized to cycle once during the day i.e. charged during the solar hrs and discharged during the non-solar hrs. The capital cost of renewable plant can be benchmarked against storage by converting the cost per kW to cost per KWh using the daily energy output using the following formula.

CAPEX_R (USD/kWh) = CAPEX_R (USD/kW) / (CUF * 24hrs)

For Ex. Solar @ 500 USD/kW with CUF of 20% (Typical Nos for MW scale PV in India)

CAPEX_R (USD/kWh) = 500 (USD/kW) / (20% * 24 hrs) = 104 USD/kWh

Levelized Cost Comparison

The simplistic LCOE (ignoring cost of capital) will be the CAPEX_R (USD/kWh) divided by the total energy produced in the project term of 25 years. However, the capital cost incurred on setting up a renewable plant is upfront whereas the returns are over a period of 25 yrs. Thus, the actual LCOE calculation takes into account the cost of capital, Taxes, incentives etc.. to arrive at an effective LCOE_R. However, these financial factors are applicable to storage as well assuming a 25 year term. In case of reoccurring expenses due to battery replacement one should use the prevalent discount rate to arrive at a Net Present Cost or Value (NPV). Now since both the capital cost of Storage and renewables are available in terms of per unit cost and LCOE_R is known one can compute the LCOE_S. Unlike

Renewables which is a source of energy, Energy Storage has to be charged and some of the energy is lost due to battery inefficiency. So, there is an additional charging cost associated with LCOE_S.

LCOE_S = (LCOE_R/Eff) + (CAPEX_S * LCOE_R)/CAPEX_R

For Ex. The LCOE_R of large scale Solar is 0.035 $/kWh with a CAPEX_R of 104 USD/kWh (As per above calculation) with ESS @ 300 USD/kWh with 75% Efficiency

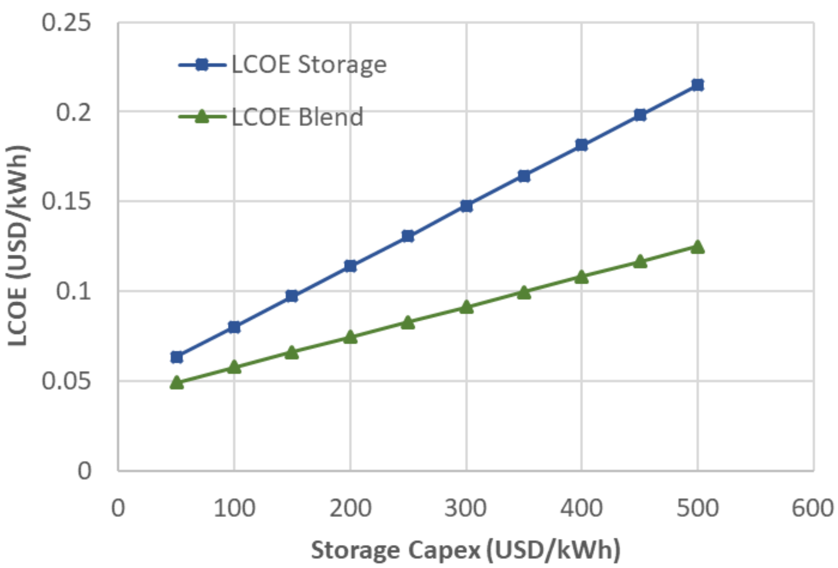
LCOE_S = (0.035/0.75) + (300 * 0.035)/104 = 0.0467 + 0.1008 = 0.148 USD/kWh

One should also look at an average LCOE_Avg of Renewable + Storage plant. Based on the relative sizing of the plant the LCOE_Avg will be a weighted average of the LCOE's based on their relative output (Note that the energy lost in battery has already been accounted for in LCOE_S).

LCOE_Avg = (1-X)*LCOE_R + X*LCOE_S   where X is percentage Energy delivered by Storage out of the total Energy throughput of Renewable + Storage

For Ex. For a 1:1 sizing where 50% of Energy is directly delivered by renewables and balance by storage

LCOE_Avg = ((1-0.5) * 0.035) + (0.5*0.1475) = 0.091 USD/kWh



LCOE as a function of Storage Capex. (CAPEX_R 500 USD/kW, 20% CUF, LCOE_R = 0.035 USD/kWh, 75% ESS Eff. 25 yr term)

The nos calculated above are typically within few percentage points of a full financial models which need a lot more inputs. It can be used as a quick gauge by customers who are looking to incorporate storage along with renewables or even product or solution providers to gauge the viability of their products across geographies based on the prevalent energy tariff and storage economics.

Acronyms

ESS – Energy Storage System

CUF – Capacity Utilization Factor

PLF – Plant Load Factor

LCOE_S – Levelized Cost of Energy from Storage

LCOE_R – Levelized Cost of Energy from Renewables

LCOE_Avg – Levelized Cost of Energy of Renewables + Storage plant

CAPEX_S – Capital Cost of Storage Plant (Net Present Cost for 25 Years. Calculated using applicable discount rate which are region specific)

CAPEX_R – Capital Cost of Renewables

Eff – ESS Efficiency

NPV – Net Present Value