Unlocking the Potential of Solar-Hydro Hybrid Solutions: Feasibility and Economic Analysis

Author: **Måns Rosberg**
Year: **2023**

Supervisor at IEA LTH: **Jörgen Svensson**
Supervisor at Eolus Vind AB: **Fredrik Liljehov**

This master thesis was conducted with the purpose of increasing the insights in hybrid power production systems containing solar and hydro power, from a profitability and feasibility perspective, by constructing and connecting a solar power plant to an existing hydro power plant at its grid connection point. Several methods of constructing and operating such a hybrid system were studied to get a better understanding of its potential.

A hybrid system containing solar and hydro power production is an interesting and important subject for future power systems as it can increase the utilisation of hydro power reservoirs as energy storage. The intermittent nature of solar power production combined with a more controllable energy source, such as a hydro power plant, introduce new aspects to power production where refinement methods for the hydro power production can be implemented to increase profits and smooth out power production throughout the day. In addition to this, the solar power investment costs can be minimised as the otherwise high costs for building a new grid connection point with all its components can be omitted. The study is mainly focused on analysing conventional solar power and hydro power as all simulations and calculations are based on such a system. However, it also introduces other interesting solutions to a possible solar-hydro hybrid system, such as pumped hydro power and floating solar panels. Pumped hydro power is a hydro power plant where water from the lower reservoir can be pumped back up to the upper reservoir.

The simulations and calculations are made for four different scenarios to make room for comparison between different systems. They include one scenario each for the hydro power and solar power plant running independently of each other and two scenarios where they act as a hybrid system, one which utilise a refinement method and the other that does not. The simulations were made for two sizes of the solar power plant with one producing above the grid connection capacity at peak hours and the other producing precisely the amount of power that the grid connection can handle. The results indicate that installing a hybrid system is feasible as the hydro power plant on a yearly average only utilise about half the available capacity in the grid connection point, leaving room for connecting a solar power plant. From a profitability perspective the hybrid systems can be considered more profitable than an independent solar power plant, mainly due to the minimised installation costs. The refinement method implemented in this study shows that by refining a hybrid systems power production, in form of utilising stored energy in a hydro power reservoir, the profitability is increased even further and less energy is wasted. When comparing the results for the two different sized solar power plants it is indicated that there is more curtailed energy in the case for the larger solar power plant. However, overall power production as well as the total yearly income is also increased. In the case of the larger solar power plant installation, pumped hydro power becomes an interesting solution as it can utilise the otherwise curtailed energy at peak solar power production by pumping water from the lower to the upper reservoir. Floating solar panels are also an interesting solution to a hybrid system, as it can be installed in the hydro power reservoir, minimising ground coverage and distance to the grid connection point at the hydro power plant.

What the future holds for solar-hydro hybrid power system is uncertain, but as this thesis indicate optimistic results, the research and implementation of such systems will hopefully expand in the future. Future research in the area is still needed to find the most viable and profitable solution. Pumped hydro power and floating solar panels introduce other dimensions to the hybrid system but requires further research, especially floating solar panels as it is a fairly new technology.