How Sensitive are Optimal Fully Renewable Power Systems to Technology Cost Uncertainty?

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Many studies have shown the feasibility of fully renewable power systems, in various countries. Yet little is known about the robustness of the results to uncertainty over the weather-year(s) chosen for the optimisation and over the future cost of key technologies. Most studies focus on one or a few weather-years, and sensitivity analyses on technologies costs vary each component separately, keeping the remaining parameters fixed. To overcome these limitations we have developed EOLES, a model optimising investment and dispatch of renewable energy and storage technologies, meeting hourly demand in France for 18 weather-years.

We show that optimising the energy mix on a randomly chosen weather-year may yield a very different mix than the one resulting from an optimisation over the 18 weather-years simultaneously. Then we perform a sensitivity analysis with 315 cost scenarios, by varying simultaneously the cost of PV (from –50% to +50%), wind (–25% to +25%), batteries (–50% to +50%) and power-to-gas (–50% to +50%).

We find that the system levelized cost of electricity, including generation and storage, ranges from €36.5 to €65.5/MWh_e, depending on the cost scenario, with an average value of €50/MWh_e. This average value is based on the assumption that the energy mix is optimized after the arrival of information on technology costs. If instead we assume that all investment must take place before knowing the true cost scenario, the average system-wide cost is only 4% (€2/MWh_e) higher and it is less than 9% higher in 95% of the scenarios. Hence the 'regret' is limited when the optimization is based on cost assumptions which do not materialize.

The main takeout message is thus that even though the technologies involved in a fully renewable power system are very different, they are by and large substitutable. For instance, if batteries are more expensive than expected, the optimal mix includes fewer batteries and less PV, but this is compensated for by additional windpower, with a very limited impact on the system-wide cost.

In addition, we show that the optimal power mix is highly sensitive to the chosen weather-year and to the cost assumptions. Finally, the cost of storage should not be overestimated: in our reference cost scenario, storage (batteries, pumped-hydro and methanation) accounts for only 14.5% of the system cost, vs. 85.5% for electricity generation.

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