Optimal design of an interconnected and fully renewable energy system for South America considering green hydrogen production

In the developed world, the transition towards carbon-neutral sources has been planned intensively. However, the amount of research trying to understand South America as an interconnected energy system is limited, despite its great renewable energy potential and its population increasing to levels comparable to Europe or North America.

This master thesis aims to model South America's electricity transition until the year 2050. A comprehensive energy database for this region was developed considering the highest spatial resolution up to date, and high temporal resolution. Besides a mathematical minimization model to simulate optimal expansion pathways was assessed. The model considers hourly energy production from solar, wind, and hydro sources and uses diverse energy storage technologies to match the projected power demand. The spatial resolution of the system was systematically varied in scenarios to analyze the implications of planning with different numbers of nodes being 1, 16, 30 and 43 points.

The results show that South America has not only, as to be expected, enough potential for a fully renewable power supply, but that renewable technologies also allow a cheaper supply than the current fossil-based system. Solar energy is projected to become the main power source followed by wind and hydropower. Storage technologies such as Li-ion batteries and pumped energy storage buffer the variability of RE sources. In terms of studying the spatial variation, the high spatial resolution of 43 nodes discloses a 6% of higher total costs that would else remain hidden in a simplistic 1-node approach. This higher resolution is also important to more precisely understand the tradeoffs between storage and transmission facilities. Modeling with 30 nodes also seems to be a fair tradeoff between precision (2% cost difference) and computing costs.