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How to power an off-grid telescope? Comparative life cycle analysis of renewable-based energy systems

Isabelle Viole[1], Guillermo Valenzuela Venegas[1], Li Shen[2], Luis Ramirez Camargo[2], and Sabrina Sartori[1]
[1]University of Oslo, Department of Technology Systems, Norway (isabelle.viole@its.uio.no)
[2]University Utrecht, Copernicus Institute of Sustainable Development, Energy & Resources

A new radio telescope in the Atacama desert, Chile, is currently under design and envisaged to be powered by an off-grid energy system of photovoltaic arrays during the day-time and a hybrid energy storage system for non-sunny hours. Similar isolated solar energy systems employ Lithium-ion or Lead-acid batteries as storage, which either increase the pressure on critical materials like lithium and cobalt or contain lead which mining brings a set of harmful environmental impacts. Hydrides based on intermetallic compounds are emerging as a viable solution for energy storage in stationary applications and are particularly appealing due to their abundance and non-toxicity. Here, by developing a multi-objective techno-environmental optimization, we size a power system that can fuel the telescope's demand economically while also maintaining a low life cycle carbon footprint. The optimization includes life cycle inventory data of potential components next to costs, including monocrystalline photovoltaic arrays, lithium-ion batteries, hydrogen storage in metal hydrides and as compressed gas, alkaline electrolyzers, PEM fuel cells and diesel generators.

Pure techno-economical optimization without life-cycle inventory optimizes towards power systems with up to 32% of curtailed photovoltaic power. Levelized costs of electricity resulted in $120/MWh with photovoltaics, hybrid storage systems and diesel generators as a backup, and $140/MWh for systems relying on solely batteries and photovoltaics. With our optimization, we propose a system resulting in a low life cycle carbon footprint and acceptable electricity prices, analyzing indirect carbon emissions of the stationary system as well as costs.

The life-cycle carbon footprint optimization performed allows both the remote telescope in question and other off-grid energy systems to make informed decisions on sustainable solutions to fuel their power needs.