TECHNO-ECONOMIC MODELLING OF HYBRID RENEWABLE POWER SYSTEMS FOR THE MINING INDUSTRY

Research problem

The mineral sector is responsible for more than 38% of total industrial energy use and 11% of total final energy consumption. At the same time, the sector is coming under significant pressure to decrease the amount of energy consumed and greenhouse gases emitted.

In the mining sector, the economic assessment of hybrid renewable systems is dependent upon complex relationships between non-linear costs, geographical attributes, uncertainty parameters, financing mechanisms, and energy demand. These systems also face problems over amortization. Mining time-frames are not always compatible with the lifetime required to recover the investment. Financing these systems brings additional challenges associated with risk and uncertainty over cash flows, especially for the newest technologies.

The cost effective design of hybrid renewable systems is very complex due to a number of major problems:

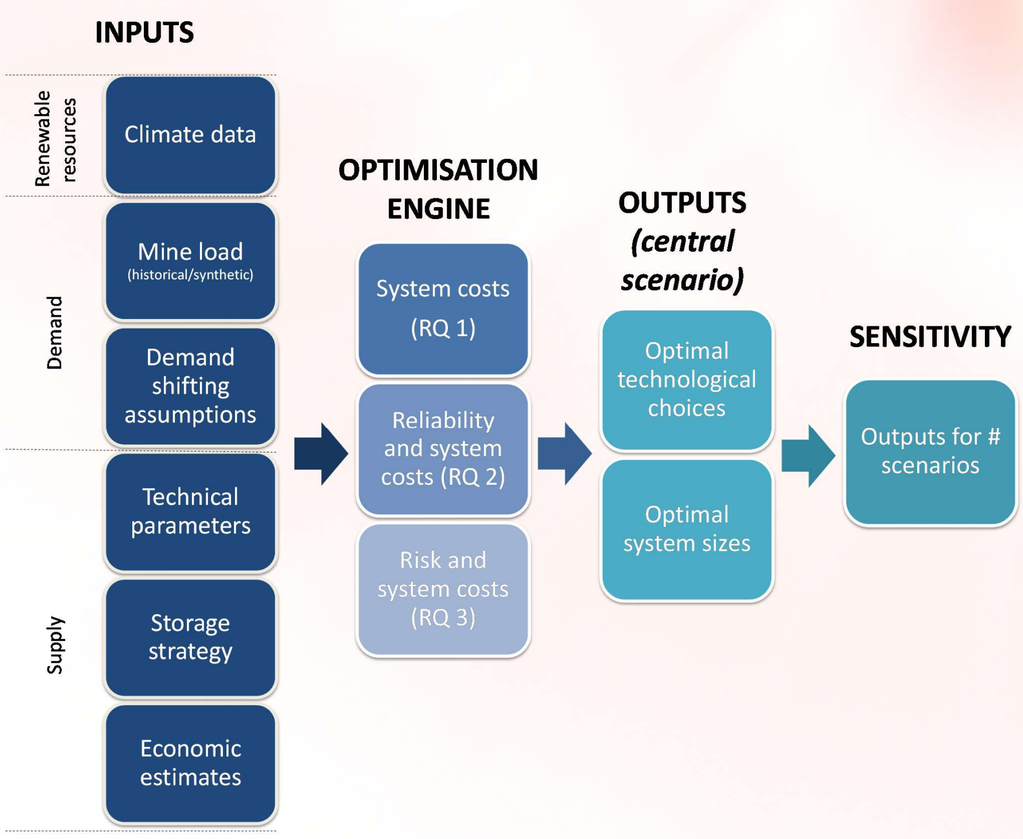
1. Hybrid energy system are capital intensive, especially for renewable generation and energy storage
2. The desirability to match the load with intermittent outputs, while minimizing the amount of energy storage
3. The conflict between the aim of minimizing storage and maintaining an adequate level of reliability
4. Different cost risks are associated with different system configurations

An optimisation model has been developed in order to search for the least-cost system with regards to optimal system size, technological choice, reliability cost, and cost risk.

Research questions

1. What is the optimal level of installed capacity and system configuration that provides the optimal economic return?
2. How do reliability requirements, in terms of adequacy and security, affect the electricity costs?
3. To what extent do such systems influence the cost risk of electricity?

Research model



Focus

Energy systems that include two or more energy sources with at least one renewable energy source are called hybrid renewable systems. These systems can sometimes present lower costs and higher reliability than traditional systems that include only one source of energy.

A number of energy sources are considered in this research as part of hybrid renewable power systems located at the mine site, including:

- CSP Tower / Parabolic Trough (with gas-backup)
- PV fixed tilt / East-West tracking
- Wind turbine (with de-icing system when appropriate)
- Thermal Storage (i.e. Molten Salt, Oil)
- Li-Ion Battery Storage
- Diesel generators
- Gas turbines / CCGT
- Grid-connection

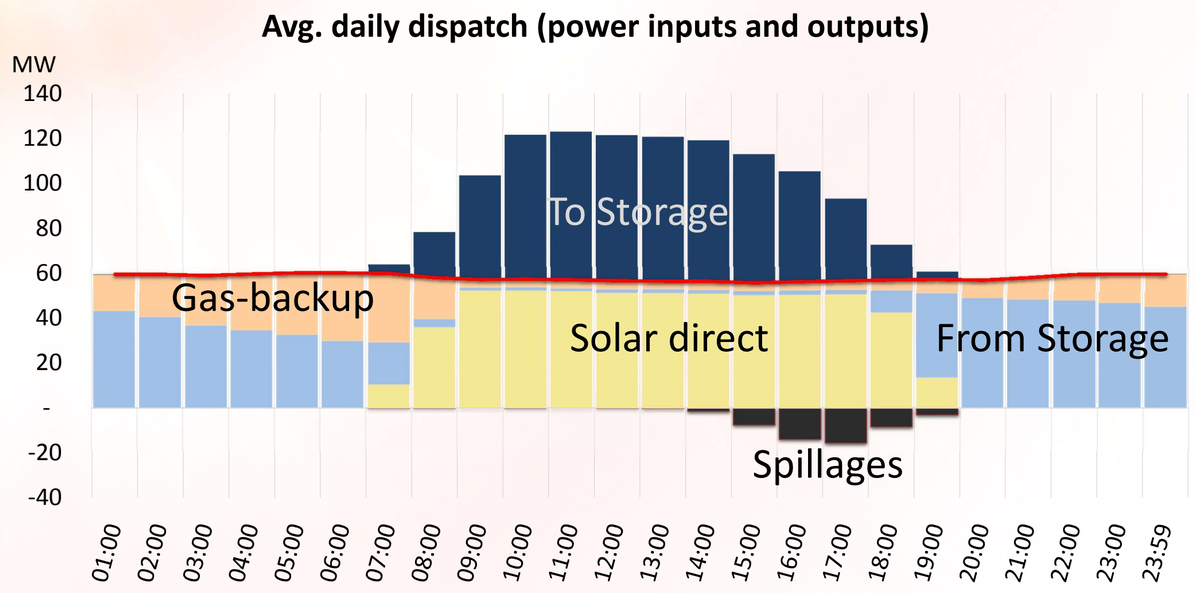
Three mines have been selected for this research based on their geographical attributes and their variety of renewable resources at mine sites:

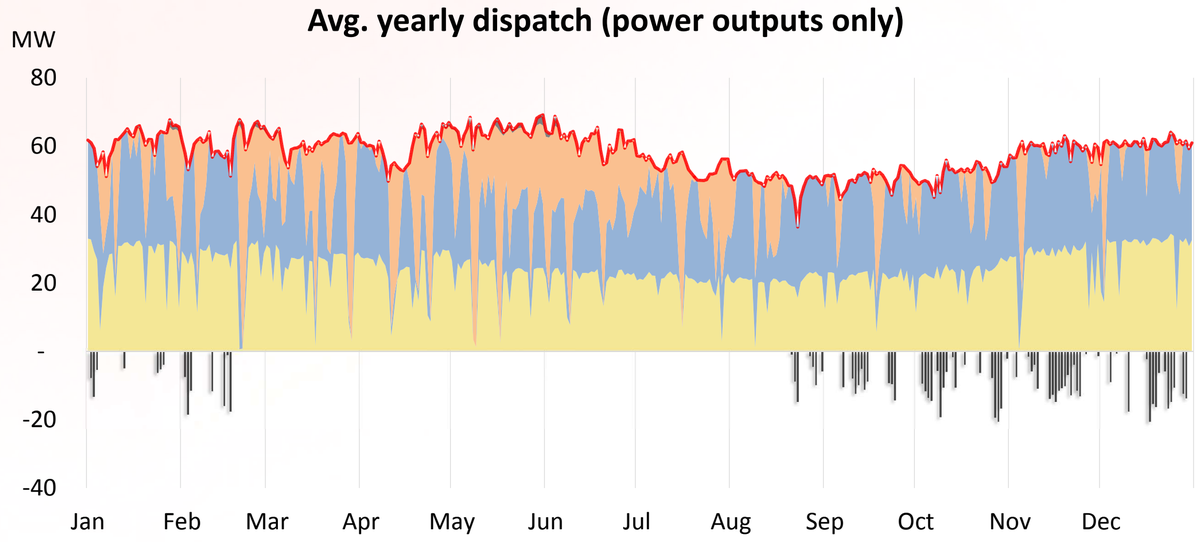
- An open-pit copper mine in Northern Chile (Grid-Connected)
- An open-pit copper/gold mine in Northern Canada (Off-grid)
- An underground gold mine in Northern Africa (Off-grid)

Results

Based on an initial optimisation of the research model, the CSP Tower Plant have been found to provide the optimal economic return over 25 years of mine-life for the Chilean mine (with grid-power for backup/peak demand). However, the cost of other hybrid systems such as Battery & PV is rapidly falling and might become cost competitive over the next 3/5 years.

The two following charts illustrate the hourly and daily dispatch of an hybrid CSP system in mining settings – optimised by the research model.





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