

2. Techno-Economic Analysis and Market Studies

The economic and commercial viability of solar power systems depends not only on their technical performance, but also on the investment, operation and maintenance costs. In order to investigate the economics of different solar power plant concepts and proposed cost-optimised designs, the CSP group at KTH has developed sophisticated techno-economic and electricity market analysis tools.

2.1 Economic Power Plant Design and Operation

Economic analysis of individual power plant designs is performed using the in-house tool DYESOPT (for DYnamic Energy Systems OPTimiser). This integrated tool is capable of performing all the steps of a techno-economic analysis: moving from power plant design, to transient annual simulation (including off-design operation) through to equipment costing and maintenance prediction. The program condenses these results into a series of techno-economic performance indicators (such as CAPEX, OPEX, levelised electricity costs, specific carbon emissions and many more. Detailed breakdowns of the different cost and performance indicators can also be obtained, as shown in the examples in Figure 1 and Figure 2, respectively.

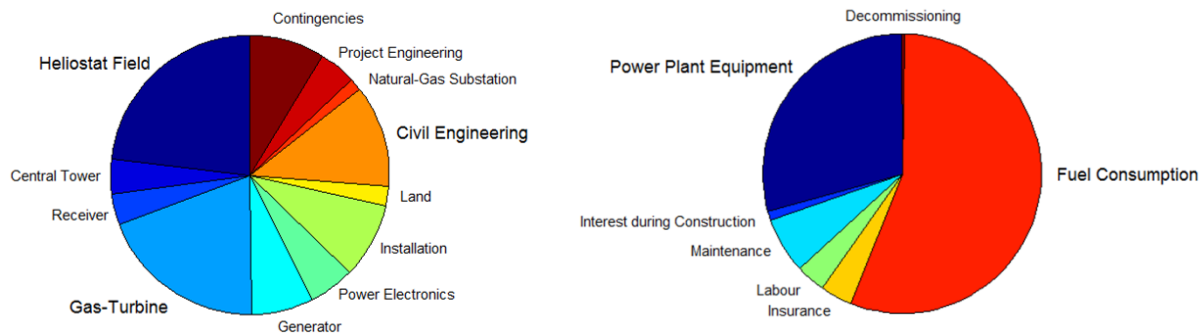


Figure 1: Breakdown of the Investment and Electricity Costs.

Different operating strategies can also be implemented, and the effects of these changes on the performance and economics of the power plant can be examined. Furthermore, the influence of the operating strategy on the maintenance requirements of major items of power plant equipment can be determined, and used to optimise the running of the power plant.

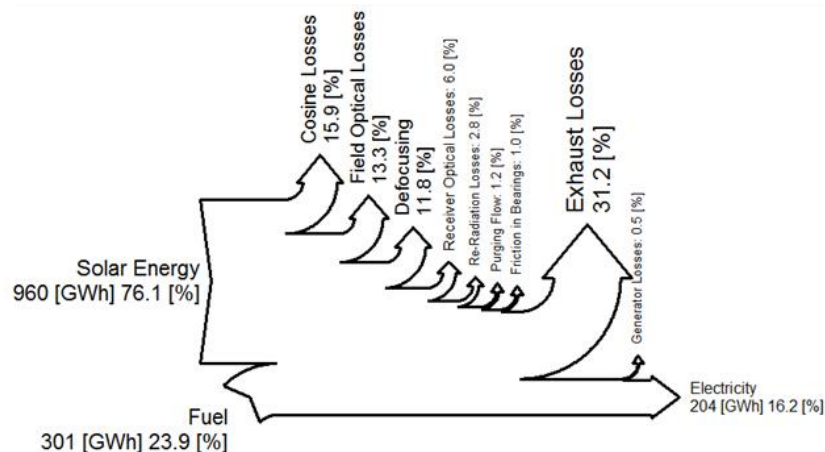


Figure 2: Breakdown of Energy Losses.

The majority of cases of energy system analysis require the consideration of multiple, conflicting, objectives. It is usually desirable that power plants produce electricity at the most economically competitive rates, but also produce minimum CO₂ emissions and consume as little water as possible. In order to examine the trade-offs that must be made between different performance targets, the DYESOPT tool integrates multi-objective optimisation using genetic algorithms. Pareto-optimal decisions can then be taken concerning the conflicts between economic and environmental indicators, based on the trade-off curves obtained by the optimiser (see Figure 3 for example).

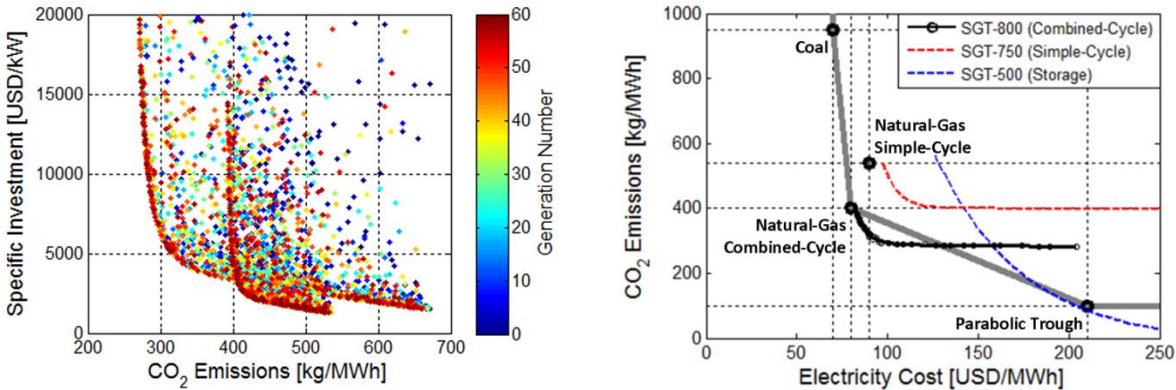


Figure 3: Algorithm Convergence and Pareto-Optimal Trade-Off Curves.

Having established the set of Pareto-optimal power plant designs for each gas-turbine, the designs lying on the trade-off curve can be analysed in more detail. Detailed cost breakdowns, such as those shown in Figure 1 are available for each design, as well as all the equipment sizing data. The configurations that lie on the Pareto-optimal fronts are the only truly ‘optimal’ designs, as for each design it is not possible to improve one objective without making the other worse.

2.2 Market Roles and Grid Integration

The high level of detail within the DYESOPT tool means that only a single power plant can be analysed and optimised at a time. Furthermore, the operating strategy for the power plant, although variable, has to be manually defined. Power plants are rarely operated in isolation, and their operation depends upon the behaviour of other power plants in the grid, especially with the growing deployment of non-controllable renewable technologies such as wind and solar photovoltaics.

In order to examine the behaviour of novel solar power plant concepts and identify their potential market roles, a grid simulation and power plant dispatching model known as EDGESIM (for Electricity Distribution and Generation SIMulator) has been developed. The tool can be set up to simulate any configuration of electricity grid, by defining the mix of technologies, the structure of the transmission network, pricing schemes, etc. In order to be able to take into account the interaction of solar power plants with other technologies in the market, the simulation tool includes not only solar technologies, but also the full range of conventional technologies in the grid. (see Figure 4 for example).

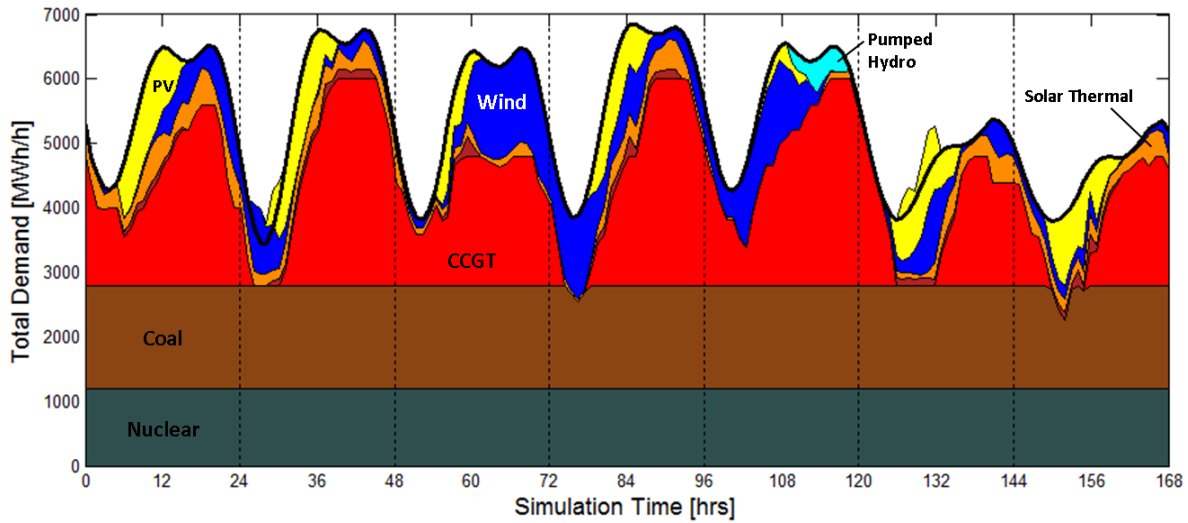


Figure 4: Power Plant Dispatching and Generation Simulation.

Using the EDGESIM tool, changes in power plant operation can be examined as the mix of available power generation technologies is altered. The hourly evolution of the electricity price as well as the cost of electricity production can be determined, alongside capacity factors, ramp rates, spinning reserve requirements and more.

Furthermore, the required market conditions for the successful deploy of the novel solar power concepts can be established. Multi-objective optimisation can be performed in order to examine the optimal mix of solar technologies for different markets as well as the market volume for each technology. This information allows companies to make choices with regards to solar technologies and power plant configurations, and thus better evaluate the potential for investment and development of the different technologies.