# Optimal management of smart grid systems considering multiple criteria

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## 1 Introduction

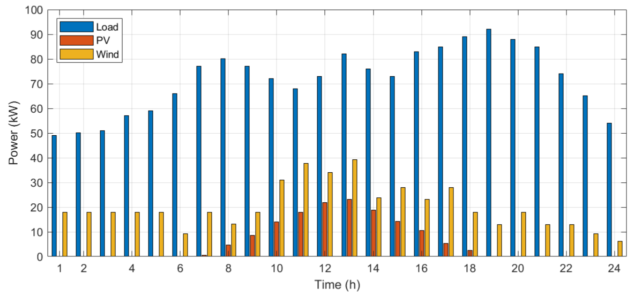
The concept of smart grid is closely related to the efficient management and design of a power grid. A smart grid attempts to predict and intelligently respond to the behaviour and actions of all electric power users connected to it—suppliers and consumers—in order to efficiently deliver reliable, economic and sustainable electricity services. A smart grid consists of 1) an advance metering infrastructure (e.g., digital meters), 2) smart distribution boards and circuit breakers, 3) renewable energy resources and 4) energy storage systems.

The intermittency and variability of renewable energy resources such as wind and sun impose a significant challenge to the grid operation when the penetration level increases, so it is necessary to perform appropriate planning to facilitate the suitable operation of these resources and their optimal management while considering different criteria. Various models and methods have been proposed for energy management systems using different optimisation algorithms. In [1] the optimal management of the system is performed only from an economic perspective employing a Lyapunov optimisation approach. In [2] the smart grid management, integrating economic and environmental aspects, is addressed through a metaheuristic (MOPSO algorithm), however, only small instances of the problem are investigated since equality constraints rapidly become difficult to handle with such an approach. In this work, the power management of a residential smart grid is investigated taken into account economic and environmental aspects. The adopted solution approach is an exact one and the model formulation is adapted from [2].

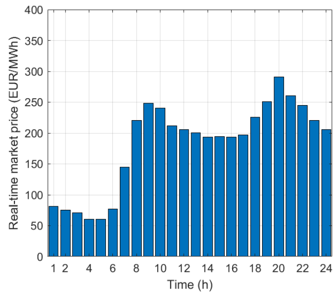
## 2 Methodology

The accurate modelling of a smart grid needs to consider the stochastic aspects related to renewable energies, load demand and, as a consequence, the variability in electricity price. Also, the model needs to account for storage systems, able to store energy when the generation exceeds the load or if it is economically or environmentally attractive. The model considered in this work is of deterministic nature, yet the input data allows for considering the random variations mentioned before. The optimisation problem can thus be enunciated as: given the load profile, the electricity market price, the predicted power for renewable energies and associated data corresponding start-up and shut-down costs, energy prices for each technology and greenhouse gas (GHG) emissions, the problem consists in finding the smart grid operation that minimises costs and emissions simultaneously.

The instance studied here comprises five distributed generators, namely, a microturbine, a wind turbine, solar photovoltaics, a lithium-ion battery and the electrical grid (which can supply or absorb electricity). The optimal management of the residential grid is simulated for one week with an hourly time slot (see Figure 1 for a one-day typical data). The problem




(a) Typical daily load profile.




(b) Typical spot market price.

FIG. 1: Partial data considered for case study 1.

is formulated as a bi-objective linear programming problem and solved using the $\varepsilon$-constraint method, for each single-objective optimisation CPLEX solver is used. The obtained approximation of the Pareto front is shown in Figure 2. It is observed that trade-off solutions are obtained that entail emissions in the range of $\approx$ 40-240 kgCO2-eq/MWh, with a corresponding cost of $\approx$ 90-145 EUR/MWh.

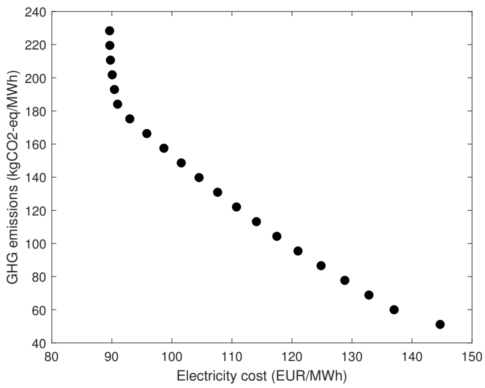



FIG. 2: Obtained approximation of the Pareto front.

## 3 Conclusions and perspectives

The optimal management of a given smart grid was carried out allowing to quantify its potential benefits and thus providing important information that can aid the decision makers. The perspectives of this work are related to 1) the model complexity, in order to take into account the smart grid design which eventually might necesitate the integration of binary variables and nonlinear terms, and 2) to explore a matheuristic as solution approach, which might be particularly adapted to tackle the resulting problem.

## References


[1] Yuanxiong Guo, Miao Pan and Yuguang Fang. Optimal power management of residential customers in the smart grid. *IEEE Transactions on Parallel and Distributed Systems*, 9(23): 1593–1606, 2012.

[2] Gholamreza Aghajani and Noradin Ghadimi. Multi-objective energy management in a micro-grid. *Energy Reports*, 4: 218–225, 2018.