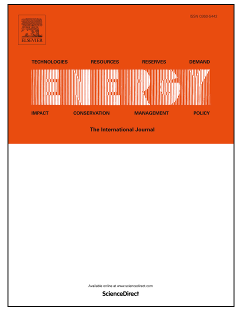
Accepted Manuscript



Smart rules and thermal, electric and hydro storages for the optimum operation of a renewable energy system

S. Rech, A. Lazzaretto

PII: S0360-5442(18)30097-5

DOI: 10.1016/j.energy.2018.01.079

Reference: EGY 12191

To appear in: *Energy*

Received Date: 29 October 2017

Revised Date: 10 January 2018

Accepted Date: 14 January 2018

Please cite this article as: Rech S, Lazzaretto A, Smart rules and thermal, electric and hydro storages for the optimum operation of a renewable energy system, *Energy* (2018), doi: 10.1016/j.energy.2018.01.079.

Smart rules and thermal, electric and hydro storages for the optimum operation of a renewable energy system

***Rech S.*[a], *Lazzaretto A.*[b]**

[a] *University of Padova - Dept. of Industrial Engineering, Padova, Italy,*
Interdepartmental Center "Giorgio Levi Cases" for Energy Economics and Technology
sergio.rech@unipd.it
[b] *University of Padova - Dept. of Industrial Engineering, Padova, Italy,*
andrea.lazzaretto@unipd.it

Abstract:

Smart energy systems are meant as groups of energy conversion units that fulfill the requirements of several users according to "smart rules". This paper considers an existing energy system including various units fed by renewable sources which serve thermal and electric users in a mountain resort. The goal is to find smart rules to operate the system by identifying the best operating alternative among a complete set deriving from connection to or isolation from the electric grid, inclusion or exclusion of storage systems and/or by-pass in the heat recovery system of the CHP units. To this end, detailed design and off-design models of each alternative are first built using field data or data supplied by manufacturers. The operation of each alternative and the capacities of the thermal and electric storages are then optimized to obtain the maximum profit. Results show that both electric and thermal storage systems must be included when the system works in isolation from the grid, but the profit is negative. Conversely, when the system is connected to the grid, the best operation strategy is achieved by including a thermal storage, while the inclusion of the electric storage is disadvantageous.

Keywords:

Smart energy systems, Renewable energy sources, Energy system modelling, Design and operation optimization, Energy storages, dynamic MILP problems.

1. Introduction

The strong variability of electricity and heat demands with time in domestic and industrial applications require "flexible" energy conversion systems, which are able to modify the production according to users' needs. Fossil fuelled energy conversion systems can vary the load more or less promptly depending on the design characteristics and size. In general, big size steam power plants are less suitable to load variations than the more compact natural gas combined cycle plants because of the higher thermal inertias of their components. Small size internal combustion engines or micro-turbines, fuelled by both fossil or renewable sources (such as bio-diesel, bio-oil, bio-gas) can also respond promptly to variable energy requirements. On the other hand, power and heat generated by renewable systems fed by solar or wind strongly depend on meteorological conditions, and in turn on the site features (latitude, proximity to the sea, altitude, etc.). Thus, these systems may require electric and/or thermal storages to fulfil users' demand in case of high shares or isolated systems. In general, when a country, region or municipality are served by groups of energy conversion systems fuelled by both fossil and renewable energy sources the users' demands must be matched with the generation of power and heat in the less costly, more efficient and more environmental friendly way. This is not an easy task, which involves both the design and operation phases. In fact, the proper choice of type and size of each production unit and a correct operation is crucial to guarantee the fulfilment of the energy requirements in agreement with the system goals. The experience of the designer/operator is fundamental in both phases, but not always sufficient to define the optimum size, type and loads when the number of generating units and storages operating under variable costs and prices is very high. To this end, adequate models and optimization tools may certainly