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Abstract: This paper presents a procedure for multiobjective management of complex energy hubs. In distributed energy production, many energy sources can be present at the same time in an energy node: combined production of electrical and thermal power, renewable energy sources, exchanges with external grids etc.. Several strategies can be devised to manage this system in order to fulfil user demands and other technical constraints. Beyond maximal economic revenue, which is the most used single objective criterion for energy management, environmental impact of the system must be also taken into account, thus a multiobjective method must be used. A procedure, based on the Pareto optimality concept, which can face at the same time economic and environmental objectives has been developed and applied to the study of a Combined Heat and Power node. Results obtained are shown and discussed.

Keywords: Multiobjective optimization, Pareto optimality, Energy management system

I INTRODUCTION

Distribution of energy production, diversification of power sources and stringent technical and economical constraints require an attentive control strategy of energy units. During a given time interval, energy management must schedule power production fulfilling satisfaction of user constraints together with a skilled exploitation of economical opportunities coming from the cost/price dynamics [1, 2]. The Energy Management System (EMS) is the set of procedures which can pursue this aim and it is usually based on a theoretical model translating in mathematical language user requirements, technical constraints of the machines and economical revenue of the energy node. Using this model several optimization techniques can be used to drive the scheduling of power production toward a minimum cost/maximum revenue configuration [3, 4].
While EMS is usually focused on the attainment of an economic goal, if suitable emission models of the machines are available the introduction of multi-objective optimization algorithms allow to generate some helpful indications on the possible compromise between economic revenues and environmental emissions [5].
In this paper a multiobjective EMS is developed for a single co-generation unit: besides economical goal also emissions are evaluated and a multi-objective optimization procedure is applied to define the Pareto front representing the best trade-off set between cost and emission minimization.

II PROBLEM DEFINITION

The outline of the system under study is represented in fig. 1. The procedure takes into account a given scheduling period of time (one day, one week etc.) and defines a switch on and off of all machines present in the system according to fulfilment of user needs and technical constraints. The problem can be defined as a mixed integer linear optimization one where on/off status is represented by integer 0/1 variables and production level by real variables. For each configuration, three objectives can be defined: economic revenue of the system, global emission of the node using, as objective, the emission of carbon dioxide both of the energy nodes and of the external electrical network and local emissions of the node, using a weighted sum of carbon monoxide and nitrogen oxides. Due to the convexity property of the problem [6], the exploration of the Pareto front can be performed by a weighted sum of the three objectives changing their relative weights.

$$O = \alpha_1 O_{eco} + \alpha_2 O_{glo} + (1 - \alpha_1 - \alpha_2) O_{loc} \qquad (1)$$

where O_{eco} is the economic revenue objective expressed in €, O_{glo} is the global emission objective expressed in CO_2 grams, O_{loc} the local emission one expressed as a weighted sum of CO and NO_x grams and α_1 and α_2 are weighting coefficients ranging from 0 to 1. The Pareto front obtained in one particular case relevant to the European funded Project HEGEL [7], is shown in Fig. 2. Normalization is performed with respect to the non-cogenerative case.
Discussion on different management strategies associated to different points on Pareto front and on the use of these results to obtain the fulfilment of local emission limits will be performed in the full paper.

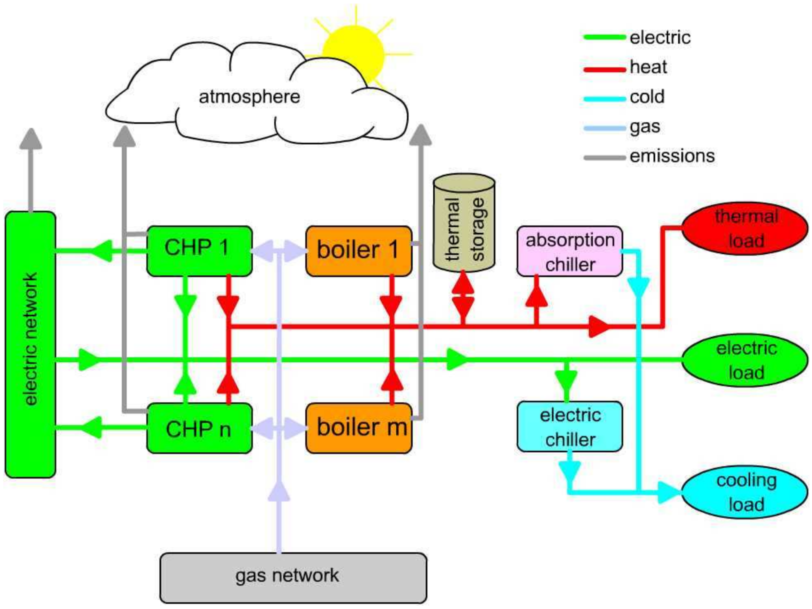

Figure 1: Energy node and its relations with external environment

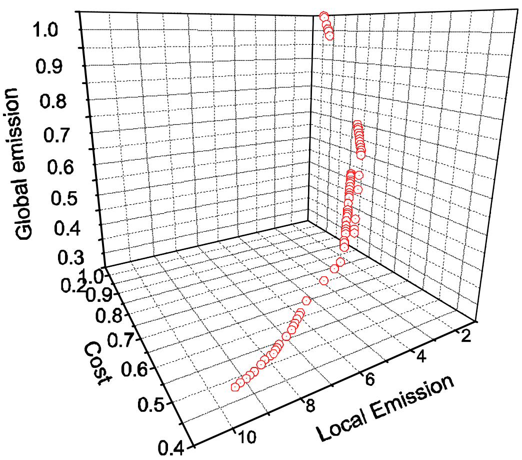

Figure 2: Normalized Pareto front

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