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Dynamic Optimization and Control Strategy for the Planning of a Waste Management System involving Multiple Cities

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Abstract

Consumption habits and population growth have drastically increased the waste production around the world. In consequence, several alternatives to use and dispose the municipal solid waste have been proposed. Nevertheless, in most developing countries there is not an adequate management of the residues. Therefore, in this work a mathematical formulation for the optimal planning of a waste management system is proposed, which considers the waste production in a set of distributed sites as well as the separation and distribution of waste into a production system in order to obtain useful products. The mathematical model takes into account the dependence over the time for the variables and parameters in a robust way through a set of differential equations; which are solved via the orthogonal collocation method using finite elements for proper capture of the dynamic behaviour. Furthermore, the proposed approach contemplates the order balances to implement a control strategy with the intention of maximizing the amount of consumed waste. The proposed approach was applied to case study for a small region of Mexico, where there is lack of infrastructure for the adequate waste management. The model is formulated as a mixed integer differential optimization problem, which was reformulated as a mixed integer nonlinear programming problem and was implemented in the software GAMS. Results show that given the data of potential locations for sites, landfills, processing plants and consumers, as well as the prices of useful products, availability of waste, upper and lower limits for unitary costs of the different activities carried out in the waste management system and initial values for inventory and order levels, it is possible to obtain the optimal selection and location of the entities of the waste management system as well as the values of capacity of the plants, material flows to be transported, processed, stored and sold. Finally, the model is useful to make decisions about the design of a waste processing system in order to promote the creating of public polices and cooperation among multiple cities for waste management issues.

Keywords: Waste Management System, Differential Equations, Multiobjective Optimization

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Optimal Coupling of Demand Patterns for Improving the Performance of CHP Systems

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Abstract

This work addresses the impact of the readjustment of energy demand patterns for the end user on the economic and environmental performance of combined heat and power systems (CHP). In this work is presented a multi-objective analysis, which shows that readjustments in demand patterns provide significant flexibility to synchronize the demands with the operation of the CHP system and this way minimizing the water consumption, emissions and cost. As consequence of the readjustment, the levels of dissatisfaction of the end users take a significant importance. To address this issue we use a multi-stakeholder framework that considers the priorities of the end users. The proposed method can be used to inform the utility users about the impact of their priorities and the demand behaviour on the CHP performance.

Keywords: CHP systems, multi-stakeholder, demand patterns.

1. Introduction.

Combined Heat and Power systems (CHP) are the core of the decentralized energy systems due to their efficiency and operative flexibility (Mehleri et al., 2012). The energy demand patterns of the end users have a definitive impact in factors as the configuration, size, operational policy and the interaction with external energy carriers of the system (Fuentes-Cortes et al., 2015). Usually, there are considered flexible energy demands (Fubara et al., 2013), the changes in the energy demands for mitigating costs and environmental impact have been previously addressed (Silvente et al., 2015). However, the interdependence effects of consumer demands and CHP performance have not been addressed considering the participation of multiple decision makers. This coupling requires linking the preferences of the consumer to the operative objectives, which depend on the geographical location, as well as environmental, economic and social issues. In this work, we propose a multi-stakeholder decision-making framework to explore the impact of adjusting consumer energy demands to enhance the economic and environmental performance of CHP systems. Under this framework, stakeholders express their willingness to adjust their patterns to identify an optimal trade-off with CHP performance in terms of cost, emissions, and water usage.

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Optimal Design of Cogeneration Systems Based on Flaring and Venting Streams and Accounting for the Involved Uncertainty

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Abstract

This work presents an optimization approach to design cogeneration systems able to use flare streams as supplementary fuel during normal and abnormal operation in oil complexes, while the problems associated with flaring are mitigated. A MINLP model is proposed to sizing and designing the cogeneration system that maximizes the net profit and minimizes the greenhouse gas emissions of the system accounting for the uncertain variables associated with abnormal situations and flare streams like flow, frequency, flaring gas quality, and volatility price. This paper proposes a solution approach that enables to determine cumulative probability curves to give to decision makers a useful tool to know the financial risk related to the implementation of the proposed system, and the results show that the proposed system is a suitable option to reduce carbon dioxide emissions and to decrease the operating costs.

Keywords: Flaring management, Cogeneration, Uncertainty, Carbon emissions

1. Introduction

Flaring is an oxidation process used to burn gas mixtures, mainly hydrocarbons, when their recuperation is not economically feasible. In the fossil fuel industry, flaring is one of the most challenging energy and environmental concerns (Farina, 2011). Recently, the integration of cogeneration systems with flare streams has been presented in different works. For example, Kamrava et al. (2015) presented the benefits of using cogeneration and flare streams as supplementary fuel in an ethylene plant. The results showed that carbon dioxide emissions and operating costs can be diminished using flare streams. Kazi et al. (2015) took the case study mentioned before to develop a multi-objective optimization approach for sizing a cogeneration unit using genetic algorithms, and the results were presented in Pareto fronts that show the relationship between decision variables and their economic, technical and environmental impacts. Kazi et al. (2016) extended the mentioned optimization framework to study the benefits of integrating cogeneration with a wastewater treatment facility to increase the process efficiency. Previous works have demonstrated the advantages of using flare streams to feed cogeneration systems. Nevertheless, the above mentioned works have not studied scenarios where flare streams cannot be handle by the cogeneration system because of

Optimal Design of Macroscopic Water and Energy Networks

Ramón González-Bravo, Fabricio Nápoles-Rivera and José María Ponce-Ortega

Abstract Water scarcity has led to an increase in the extraction of fresh water from aquifers, dams and lakes in certain regions where water availability is low. It has created serious problems in overexploitation of ground and surface water resources. This issue has been intensified due to population growth and increases in energy and water demands in the industry, agriculture, and households. In this chapter, a mathematical model for energy and water distribution networks in a macroscopic system is proposed. This model considers that the water and electricity demands can be satisfied by the existing power plants in the region and the installation of new power-desalination plants. Also, the model considers that the water demand can be satisfied by supplying water from dams, rivers, and aquifers. The model considers a macroscopic system that involves several cities in a water-stressed region. It accounts for variations in water demands throughout the year, for domestic, agricultural, and industrial users. The model considers both installation costs and operating costs of the new power-desalination plants, the installation of new storage tanks, pumping, and piping costs. The results show attractive solutions, where interesting economic profits can be obtained as well as the potential recharge of aquifers can be achieved.

List of Symbols

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- g Location of agricultural users
- i Existing aquifer
- j Deep wells

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