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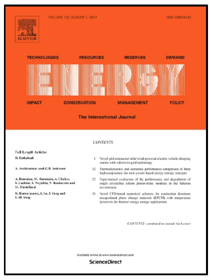

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Economic Dispatch of Multiple Energy Carriers

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***Abstract*—Energy hubs can provide high flexibility in the operation of the integrated systems. This paper presents Time Varying Acceleration Coefficients Particle Swarm Optimization (TVAC-PSO) algorithm to optimize the Multiple Energy Carriers Economic Dispatch (MECED) problem for hybrid electrical and natural gas networks. The simulation results on two case studies are reported. The first one verifies an introduced gas loss formula and another one is devoted to a modified version of IEEE 14-bus test system. The results are compared with PSO, Genetic Algorithm (GA), and Differential Evolution (DE) technique. They show that a hybrid system can operate at a lower cost than independently-operated systems; CHP units can supply more electrical demand than the electrical network while their contribution in supplying the heat demand may be smaller than that of gas furnaces. In a hybrid system, energy efficiency can be reached, producing electrical power and heat locally; CHP units have a great role in reduction of operational cost; In the coupled mode, electrical power losses are decreased, while the gas losses are increased; The simple proposed gas loss formula can provide acceptable results; Cost reductions due to employing CHPs and applying the proposed optimization technique are greater than the other methods.**

***Index Terms*—Energy hub, gas loss formula, hybrid system, multiple energy carriers, economic dispatch.**

I. INTRODUCTION

The advent of new equipment for energy conversion and storage, dispersed generation, Combined Heat and Power (CHP) generation produced a general interest in a more efficient use of energy through exchanges of multiple energy carriers in urban smart districts, industrial parks, and large tertiary facilities involving the integration of distribution systems. At the same time, the need to make national energy infrastructures more resilient to global energy price–volatility, supply and demand drastic changes due to new more affordable fuels such as the shale gas, new technologies coming up (renewables, poly-generation, etc.) or dramatic financial or geo-political crises renewed the interest toward the integration of multiple energy carriers at the transmission level [1].

Some examples of contact points between gas infrastructures and electricity ones are: large Combined Cycle Gas Turbine (CCGT) power plants, CHP generation for large industrial facilities, Liquefied Natural Gas (LNG) regasification terminal built close to gas infrastructures and power stations, Underground Natural Gas Storage (UNGS), Flex-Fuel Poly-generation (FFPG) conversion stations such as co-fired and dual-fueled plants [1,2], Integrated Gasification Combined Cycle (IGCC) technology and the so-called methane refineries capable to convert syngas into liquid hydrocarbons and electrical energy, etc. This new scenario opens the doors to a new coordinated way to plan national or regional energy infrastructures and introduce the concept of energy hubs, sometimes constituted by an entire region or nation, at the transmission level and long-distance transportation of energy [3]. Furthermore, more and more electrical energy is produced by renewables characterized by very different levelized production costs and a limited controlled capacity. Nowadays, renewable energy only relies on electrical transmission lines to be transferred from production to load centers, but new ways are available to convert Power to Gas (P2G) which creates a new connection between electrical and gas infrastructures [4,5].

Many evolved energy infrastructures have been developed during the second half of the 20th century, and it is questionable if they meet the today's (and also tomorrow's) power system requirements. In addition to the congested transmission networks, a lot of facilities and infrastructures are approaching the end of their lifetime. Moreover, other challenges like the continuously growing different demands of energies, the power industries restructuring, the dependency on the finite fossil energy sources, and utilizing more environmentally friendly and sustainable energy resources raise the question of whether piecewise changes applied to the existing systems are sufficient to solve all these problems. Residential, commercial, and industrial consumers need different carriers provided by various energy infrastructures. In the industrialized world, petroleum products, coal, biomass, and the other carriers like natural gas, electricity, heat, and cool energies are typically utilized [6]. So far, different energy transportation infrastructures are planned and operated separately to meet reliability, efficiency, cost-effectiveness, and environmental requirements (e.g. for gas systems in [7] and for district heating systems in [8]). This leads to low efficiency and reliability, high operational cost and energy losses, etc. Because, for example, one type of loads like electricity can only be supplied by the power system and the other energy infrastructures do not have any role in supplying this demand (through converters).

Recently, an integrated view of energy networks in which various energy carriers such as electricity, natural gas, etc. are simultaneously optimized, has been suggested in [9–11] and different projects have been defined which can realize this

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