Chapter 8
Smart Grid and Demand Side Management:
Application of Metaheuristic and Artificial Intelligence Algorithms

Alper Ozpinar
Istanbul Commerce University, Turkey

Eralp Ozil
Zeta Information Technologies, Turkey

ABSTRACT

Energy becoming more and more crucial and critical in the civilized populations and locates itself as one of the major requirements of living standards. Obtaining the energy from fossil fuels still is one of the common sources of energy production; however, there is a common understanding of increasing the potential use of renewables, carbon capture and storage, energy efficiency and intelligence and smart applications for collecting, distributing and transmission of the energy between the supply and demand locations. Those applications and generating the new policies, roadmaps in order to make an energy revolution and increase the usage of low-carbon energy technologies targeting the decrease of energy related emissions. In this chapter, the authors explains the common issues about smart grid and demand side management and possible use artificial intelligence and metaheuristic algorithms for smart grid and demand side management optimization and scheduling.

INTRODUCTION

From the beginning of life in our universe, the mankind has needed and depended on energy in one form or another, from food to the operation of the most sophisticated machine we know today, for its existence, survival and progress. As the key commodity in the world, most physical laws, axioms and rules that are valid today either directly or indirectly related to energy. Especially with the start of industrial revolution it has become clear that the man needs to control the energy and the energy controls

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the man. This dual relationship finds its true meanings from the laws of thermodynamics. The first law of thermodynamics is actually nothing but the accounting process of the energy, which eventually leads to the somewhat philosophic statement of the concept of conservation of energy which means that the energy can be transformed from one form to another, but cannot be created or destroyed. In other words, as we engineers say, the total energy of an isolated system is constant. The second law identifies which processes naturally occur in the environment and which do not. Because these two laws and many others related ones tell us that it is impossible to create new energy in our universe, we have over all these years taken the only plausible route and have chosen to transform otherwise non useful forms of energy, however abundant they may be, such as fossil fuels and brought it in one useful form or another to our homes, to industry and put them into use wherever and whenever we need it. Transforming processes include exploration, extraction, enrichment, cleaning, transporting, conducting, transmitting, distributing of energy among others.

Among the forms of energy known to all of us, electricity has become the leading form of energy starting from the second half of the twentieth century. With the recent improvements on the global education, increased awareness on the environment, and the goal of all the countries on increasing the welfare and prosperity of their people, the demand for electricity is increasing at a faster rate than any other form of energy. It is a known fact that new technological advancements and related end products most likely require electricity. In addition, environmental concerns has inevitably increased the demand for electricity consuming equipment at end use levels. Especially ever increasing demand for use electricity both for short and long range transportation in the sector which is in dire need for pollution control, will skyrocket the demand for electrical power. Finally, the diurnal variation for electricity demand in the industry, buildings and the commercial sector necessitates larger production facilities with high peak loads. This unstoppable increase in demand for electricity puts the existing power grids in a tremendous stress in all the countries.

Power grid is defined as interconnected network of power stations, substations, transmission/distribution lines, transformers that produce electricity from the power plants and deliver to the consumers. Power stations are operated by fossil fuels such as natural gas, coal, oil, nuclear fuel or by renewable resources. For the majority of last century electricity was mostly generated in large centralized power plants (Chan et al., 2012). And no care was paid whether or not they were placed and operated near heavily populated area. Some of the major characters of this type of a power grid is that the power is produced centrally. Secondly, in these classical power grids, electricity flows only in one direction, from the production point to the consumption site. Finally, the longer the transmission and distribution network, lower is the efficiency, reliability, and security. we may also add to these drawbacks, the issue of sustainability.

However when the first signs of climate change and increasing pollution appeared during the second half of the last century, it became apparent that there was a need for implementing new policies on the choice and quality of the fuel types, production processes, and setting new stringent pollution targets. In other words, the whole system of electricity production, transmission, distribution and consumption on the supply side and the energy consuming systems on the demand side needed new thinking, research, design, production and operation methods to be redefined and realized.

The reduction of greenhouse gases and emissions by using carbon free and clean production technologies like renewables is fast becoming one of the major alternatives to energy harnessing. But the renewables have issues of their own. First of all, if not most of renewables such as solar, wind, and hydraulic energy to certain extend all are intermittently available and their intensities are low. Just like fossil fuels