

# Chapter 10

## Energy Network Operation in the Supercomputing Era

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### ABSTRACT

*Power delivery has become more dissimilar with that of the previous era. Conventional power and energy materials, such as relic fuels, nuclear power, and renewable energy (solar power, geothermal, hydroelectric, wind power, and biomass), are already present. The energy network operation becomes complicated because the integration of power generation, energy conversion, power transportation, and power utilization should be considered. There is an intricate assignment for us to perform swift power transmission for the extremely urgent situations. These situations are the results of regional lack of energy that needs to be brought back as soon as possible. Advanced supercomputing has already been one of the powerful solutions to work out these issues. This chapter initially presents an introduction of some of the supercomputing techniques and then the potential applications and demonstration examples follow to give the readers some hint on the handling of energy network operation.*

### INTRODUCTION

The trouble of energy network operation has become a very hot topic in the twenty first century. Challenged by the oil and the other energy source depletion, the comprehensive consideration of power system operation should be included. The regional energy network has the facilities of power generation, energy conversion, power transportation and power utilization. The development of technology in the field of energy does give us

more possibility and flexibility in our solution space. In the meantime, there comes the higher requirements for the engineers and scientists to take an inclusive thought of all the energy operations: it is really a multifaceted target.

For example, if there is some energy shortage in some region due to the mismatch between the energy supply and energy demand, swift power dispatching is a must to tackle with such kind of urgent events: the regional power deficiency needs to be recovered as soon as possible. In order to

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find the optimal scheduling and planning strategy, supercomputing can aid in the large scale modeling, simulation and optimization. The result will help us find out the best restoration solution of energy systems. Due to the inherent characterization of complication, the computations are always facing the problems of highly nonlinear multi-objective MINLP (Mixed Integer Nonlinear Programming). These are not easy to be solved with the current common solvers without the competence of MINLP.

Therefore, it will be good to use the computational algorithm multi-objective genetic algorithm (MGA). Pareto frontier of the targeted objectives in the final step can be obtained straightforwardly. It can be regarded as the combination of potential patterns and optimization scenarios with multi-objective genetic algorithm. Because the computation will go through the entire space of decision variables, there will be a tradeoff between the computational effort and the accurate characterization of the population. The binary or integer logic variables and the continuous process variables will be alternated to make the assessment on the targeted objective functions of energy system performance. The whole spatial and temporal space needs to be separated into a lot of small intervals. The energy condition of each interval will be calculated. There will be lots of repetitive simulations with a heavy computational duty. Furthermore, the situation of imprecision and uncertainty will be faced definitely.

However, the models are still expected to have the characterization of tractability, robustness and low computational effort. Thanks to the developments of high performance and cloud computing, there are a lot of applications which have been achieved especially in the field of renewable energy integration and energy efficiency improvement. As what has been introduced before, the high performance and cloud computing techniques are having the greatest competence of large scale computations. This chapter can help the readers to enhance the understanding of the significance

of supercomputing in the energy network operation. For this purpose, in the beginning some of supercomputing techniques will be introduced briefly. Next, some potential applications and demonstration examples which can be used as references to give the readers in the future practice will be shared accordingly.

## **TECHNIQUE INTRODUCTION**

Normally, the basic computer can take the responsibility of the basic computational tasks. On the contrary, the computation in the scientific research and engineering always require marvelous capacity of computational processing as well as the calculation speed. The supercomputer or high performance computer is a computer with the above characterizations. Another necessary element of the supercomputers is that they should have the sufficient memory because the computational processing will generate a lot of data which needs to be stored in the computers. Most research institutes have their own computational facilities. For example, there is one Blue Gene/P supercomputer in the Argonne National Laboratory. It can have more than 250,000 processors during the computational run. These processors can be grouped into 72 racks or cabinets. They are integrated with a high-speed optical network (IBM, 2007). Many artificial neurons can be simulated with the help of the IBM Blue Gene/P computer. The function is similar with 1% of a human cerebral cortex (IBM, 2007) or the entirety of a rat's brain (Kaku, 2011). The supercomputers are also used in the field of weather forecasting. They are used by NOAA to combine the huge datasets of information of weather monitoring observations in order to get more precise predictions and dynamic change trends (National Geographic, 2010).

Furthermore, the application of high performance computers has been expanded to the fields of aerodynamic research (Cray Research, 2011), probabilistic analysis (Joshi, 1998), radia-

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