



Long-term electric energy consumption forecasting via artificial cooperative search algorithm



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ABSTRACT

This study mathematically formulates the effects of socio-economic indicators (gross domestic production, population, stock index, export, and import) on Iran's electric energy consumption. The path-coefficient analysis is implemented on linear, quadratic, exponential, and logarithmic models to determine the optimized weighting factors. On this basis, artificial cooperative search algorithm is developed to provide better-fit solution and improve the accuracy of estimation. Artificial cooperative search algorithm is a recently developed evolutionary algorithm with high probability of finding optimal solution in complex optimization problems. This merit is provided by balancing exploitation of better results and exploration of the problem's search space through use of a single control parameter and two advanced crossover and mutation operators. To assess the applicability and accuracy of the proposed method, it is compared with genetic algorithm, particle swarm optimization, imperialist competitive algorithm, cuckoo search, simulated annealing, and differential evolution. The simulation results are validated by actual data sets obtained from 1992 until 2013. The results confirm the higher accuracy and reliability of the proposed method in electric power consumption forecasting as compared with other optimization methods. Future estimation of Iran's electric energy consumption is then projected up to 2030 according to three different scenarios.

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1. Introduction

Energy consumption forecasting has been always playing a vital role in planning and power system management. Accurate electric power consumption forecasting can provide reliable guidance for power grid operation and power construction planning, which is also important for the sustainable development of a country. The accuracy of electricity consumption forecasting directly impacts the effectiveness of energy trading, system reliability, O&M (operation and maintenance) costs, T&D (transmission and distribution) expanding and generators scheduling.

The accurate forecasting of electric energy consumption gives more realistic spectrum for future country's energy sources consumption to move towards sustainable development in a globalizing world. Electric energy consumption reflects the degree of economic development in a country and much evidence supports a causal relationship between economic growth and electric power consumption. Due to rapid development in developing countries,

their macroeconomic variables have rapid fluctuation and there are no stable trends for those variables. Subsequently rapid fluctuation on macroeconomic variables will result strong fluctuation in electric energy consumption. Hence, provide an accurate estimation of electric energy consumption to facilitate energy planning, formulating strategies and recommending energy policies with consideration of economic growth in the future is one of the most critical and challenging issue for electric utilities [1].

The statistical report on electric power industry conducted by ministry of energy [2] reveals that the electric energy consumption of Iran has been growing from 5.5 MTOE (94.35 KGOE per-capital) in 1992 to 22.64 MTOE (293.69 KGOE per-capital) in 2013 with the average growth rate of 7%. Fig. 1 indicates the compositions of gross power generation from 1992 until 2013. According to this report in 1992, 66.21%, 16.98%, 14.89% 1.91% of gross power generation composition had generated by steam, gas, hydro, and diesel turbines respectively. On that year, 30.5%, 24.94%, 20.73%, 18.25%, and 5.58% of total generation were for residential sector, public services, industries, grid loss (transmission loss plus power plants consumption), and agricultural sector respectively. The electricity sales to various consuming sectors from 1992 until 2013 are shown

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