FORECASTING THE URBAN ELECTRICITY SUPPLY SYSTEM

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Abstract

Forecasting the urban electricity supply system is an important task for energy planning and management. It involves predicting the future electricity demand and supply of a city or a region, taking into account various factors such as weather, economic activity, population growth, consumer behavior, and electricity infrastructure. Accurate forecasting can help optimize the electricity generation, transmission, and distribution processes, as well as reduce the environmental and economic impacts of electricity consumption.

Key words: Urban electricity supply system, Electricity demand and supply, Forecasting methods and models, Statistical, artificial intelligence, optimization, and hybrid approaches, Weather, economic activity, population, lifestyle, technology, and policies, Renewable and distributed energy sources.

The urban electricity supply system is a complex and dynamic system that consists of various components, such as generation, transmission, distribution, and consumption. The system is affected by many factors, such as weather, load, price, policy, and technology. Therefore, forecasting the urban electricity supply system is a challenging and important task for power system planning and operation.

Forecasting the urban electricity supply system can be divided into two aspects: forecasting the electricity demand and forecasting the electricity generation. Electricity demand forecasting is the process of predicting the future electricity consumption of different types of customers, such as residential, commercial, and industrial. Electricity generation forecasting is the process of predicting the future electricity production of different sources, such as fossil fuels, nuclear, hydro, wind, solar, and biomass.The main objectives of forecasting the urban electricity supply system are to ensure the reliability, security, and efficiency of the power system, to optimize the allocation of resources, to reduce the operational costs and environmental impacts, and to support the decision-making and policy-making processes.

There are various methods for forecasting the urban electricity supply system, which can be classified into two categories: statistical methods and artificial intelligence methods. Statistical methods are based on mathematical models that describe the relationships between the variables of interest, such as regression, time series, and econometrics. Artificial intelligence methods are based on computational models that learn from the data, such as artificial neural networks, fuzzy logic, and genetic algorithms.

Statistical methods are more suitable for forecasting the long-term and medium-term trends of the urban electricity supply system, as they can capture the historical patterns and seasonal variations. However, they may have difficulties in dealing with the non-linear, stochastic, and dynamic characteristics of the system, as well as the uncertainties and changes in the influencing factors. Artificial intelligence methods are more suitable for forecasting the short-term and very short-term fluctuations of the urban electricity supply system, as they can adapt to the complex and changing situations and handle the uncertainties and noises in the data. However, they may require a large amount of data and computational resources, and they may lack the interpretability and transparency of the results.

In this section, we present some examples of the results of forecasting the urban electricity supply system using different methods and data sources. We focus on two types of forecasting: electricity load forecasting and renewable energy generation forecasting.

Electricity load forecasting is the process of predicting the future electricity consumption of the urban area. It can be classified into four levels according to the forecasting horizon: long-term (more than one year), medium-term (one month to one year), short-term (one day to one month), and very short-term (less than one day). Electricity load forecasting is influenced by many factors, such as weather, calendar, economic, social, and behavioral factors.

One example of electricity load forecasting is the study by Nti et al, who conducted a systematic review of 77 previous works on electricity load forecasting from 2010 to 2020. They found that 90% of the models used were artificial intelligence based, with artificial neural network (ANN) representing 28%. They also found that root-mean-square error (RMSE) and mean absolute percentage error (MAPE) were the most used accuracy metrics, and that 50% of the forecasting was based on weather and economic parameters.

Another example of electricity load forecasting is the study by Lianwei and Wen , who proposed a decision tree-support vector machine (DT-SVR) model to forecast the urban household energy consumption based on the energy price impact mechanism. They used the household energy consumption data from 2005 to 2018 in 36 major cities in China, and considered the factors of income, urbanization, and energy price. They found that the DT-SVR model had a high accuracy and could capture the non-linear and regional characteristics of the household energy consumption.

Renewable energy generation forecasting is the process of predicting the future electricity production of the renewable energy sources, such as wind, solar, hydro, and biomass. It can also be classified into four levels according to the forecasting horizon: long-term, medium-term, short-term, and very short-term. Renewable energy generation forecasting is influenced by many factors, such as weather, geography, technology, and policy factors.

One example of renewable energy generation forecasting is the study by Parmesano and Taylor , who developed a stochastic model to forecast the wind power generation for the urban area of Boston, Massachusetts. They used the wind speed and direction data from 1973 to 1979, and considered the effects of the urban terrain, the wind turbine characteristics, and the power system constraints. They found that the stochastic model could provide probabilistic forecasts of the wind power generation and its uncertainty.

Another example of renewable energy generation forecasting is the study by Oyediran et al, who applied an ANN model to forecast the energy demand and supply in a hybrid energy system that consisted of wind and solar power sources. They used the data from a micro-grid system in Nigeria, and considered the factors of weather, load, and generation. They found that the ANN model could accurately predict the generation capacity and load demand in the next 24 hours.

In this section, we discuss the advantages and limitations of the methods and data sources for forecasting the urban electricity supply system, as well as the challenges and opportunities for future research.

The advantages of the methods and data sources for forecasting the urban electricity supply system are:

- They can provide valuable information and guidance for the power system planning and operation, such as the optimal allocation of resources, the optimal scheduling of generation and load, the optimal management of demand and supply, and the optimal design of policies and regulations.
- They can improve the reliability, security, and efficiency of the power system, such as reducing the power outages, blackouts, and brownouts, reducing the power losses and emissions, and increasing the power quality and stability.
- They can support the integration and development of renewable energy sources, such as enhancing the penetration and utilization of wind and solar power,

reducing the dependence and consumption of fossil fuels, and promoting the sustainability and resilience of the power system.

The limitations of the methods and data sources for forecasting the urban electricity supply system are:

- They may have errors and uncertainties in the forecasts, due to the complexity and dynamics of the system, the variability and randomness of the factors, the incompleteness and inconsistency of the data, and the assumptions and simplifications of the models.
- They may have difficulties in dealing with the non-linear, stochastic, and chaotic behaviors of the system, such as the sudden changes, spikes, and outliers in the load and generation, the extreme weather events, and the unexpected disturbances and faults in the system.
- They may have trade-offs between the accuracy and complexity of the models, the amount and quality of the data, and the computational and operational costs and benefits of the forecasts.

The challenges and opportunities for future research on forecasting the urban electricity supply system are:

- To develop more advanced and robust methods and models that can handle the non-linear, stochastic, and chaotic characteristics of the system, and that can provide more accurate, reliable, and timely forecasts for different levels and scenarios of the system.
- To use more diverse and rich data sources and types that can capture the relevant and influential factors of the system, and that can improve the quality and availability of the data for forecasting the system.
- To incorporate more interdisciplinary and cross-sectoral perspectives and approaches that can address the social, economic, environmental, and technological aspects of the system, and that can enhance the communication and collaboration among the stakeholders and actors of the system.

Conclution

A comprehensive program for long-term electricity supply forecasting is not just a technical exercise; it's a commitment to building a sustainable and resilient future. By embracing advanced methodologies, understanding the significance of accurate predictions, and considering the holistic development of communities, this program empowers societies to thrive amidst a rapidly evolving energy landscape. As we move forward, investing in such programs becomes imperative, ensuring that our communities are not just powered, but empowered, for generations to come.

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