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# Editorial: Intelligent operation and control in next generation urban power grid

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Editorial on the Research Topic
Intelligent operation and control in next generation urban power grid

With the rapid development of the economy and the rapid growth of population over the decades, urbanization has today become a prevailing trend all around the world. With world urbanization, there is a great increase in electrical energy demand for urban activities. Urban power grids are facing many expansion and operational challenges. On the other hand, with the ever-increasing double pressure from the energy crisis and environmental protection, the need to accommodate the rising urban demand in a sustainable way is therefore of high priority. In order to confront the challenges above, some key technologies related to urban power systems have been developed rapidly, such as voltage source converter-based high voltage direct current transmission technology, flexible DC transmission/distribution grid technology, and large-scale new energy such as renewables and energy storage integration in urban areas, that would be of great importance as efficient and sustainable development options in both meeting the increasing urban power demand and reducing greenhouse gas emissions. It can be predicted that the next-generation urban power grid is characterized by high penetrations of renewable energies and high penetrations of power electronic converter devices. Moreover, the rapid integration of flexible loads with the characteristics of source and load, such as electric vehicles, further brings more uncertainties into the urban power system. These factors subsequently enable the rapid development of urban power grids into novel and complex forms. There is a significant change in “generation-grid-load” for next-generation urban power systems, particularly the high penetrations of renewable energies and high penetrations of power electronic devices into the generation, transmission, and distribution areas have great impacts on urban power systems control, operation, and stability. While facing more challenges and risks in system control, stability, and operation, the next generation urban power grids have better controllability with the increasing penetration of power converter interfaced devices. Therefore, the innovation of the technology and control strategy for the next urban power grids becomes essential.

This Frontiers in Energy Research special issue aims to promote theoretical and practical studies in the control and operation of the Next Generation Urban Power Grid so as to improve operating stability and flexibility and increase the affable integration of renewable energies and flexible loads. All original contributions covering a variety of topics related to the theme of the special issue are encouraged. There are in total 13 papers accepted for this research topic after the rigorous review process, and they cover the following four categories:1) Intelligent control for reliable operation in urban power grids; 2) Modelling theory and simulation methodologies for next-generation urban power systems; 3) Data-driven approaches to improve the operation quality of urban power grids; 4) Medium and low voltage level DC technology application in urban power grids. The papers accepted in this special issue are summarized below.

1) Intelligent control for reliable operation in urban power grids

With the increasing penetrations of renewable energies and power converter devices, the dynamic characteristics of the urban power system undergo a significant change; for instance, inertia in the urban power system becomes low, which can directly and negatively impact the urban power system operation in terms of stability and reliability. Hence, it is essential to develop intelligent control strategies to support the stable and reliable operation of the urban power grid. Li Q et al. propose a virtual inertia control strategy based on the fuzzy logic method for wind turbines to enhance the frequency stability of the power system. Xiao H et al. present a synchronous generator imitation control and dynamic power sharing method for the distributed power generation system based on voltage source converter (VSC) stations. High power density high-efficiency converter-interfaced devices such as modular multilevel converters (MMC) have played and will continue to play a significant role in urban power grids by providing efficient, clean electrical power conversion, transmission, and distribution. Qian J et al. describe an MMC-based wind energy conversion system and propose a constant capacitor voltage ripple (CCVR) control method in order to reduce the capacitance of the submodule capacitor of the MMC-based wind power converter, which improves MMC system economy and reliable operation.

2) Modeling theory and simulation methodologies for next-generation urban power systems

Modeling and simulation methodologies to analyze the static and dynamic characteristics of the urban power system with high penetrations of renewables and converters are the basis of operation, planning, control, and decision optimization in next-generation urban power grids. Zhu L et al. propose a dynamic equivalence method applicable to multiple wind farms with different wind turbine models in an urban power grid for analyses of the system operation. Xie X et al. propose a unified MMC modeling scheme in a synchronous reference frame for simulating the MMC-based flexible hybrid AC/DC power grids and analyzing the small-signal stability of the grid. Zhu L et al. propose a generic user-defined modeling (UDM) method applicable to various model objects in PSS/E and implement the detailed UDM of a modular multilevel converter high-voltage direct current (MMC-HVDC) transmission system following the proposed method.

3) Data-driven approaches to improve the operation quality of urban power grids

As the complexity of urban power grid operation progressively increases, advanced measurement and data-driven based artificial intelligence approaches are needed to improve the operation quality of urban power grids. She B et al. propose a data-driven approach to compensate for the time delay in voltage source converter-based high voltage direct current (VSC-HVDC) damping control based on synchronous phasor measurement unit (PMU) measurements, which leverages the modern recurrent neural network LSTM. Bai X et al. propose an event-triggered dual set-membership state estimation for power distribution networks (PDNs) to realize the online state monitoring and improve the perception ability of the PDNs, thereinto, the synchronous PMU provides an important measured data source for the PDNs estimation. The core of urban power grid operation is to keep electric power and energy balanced between supply and demand, where accurate load forecasting is a crucial aspect of properly balancing electricity supply and demand on the urban power grid, Xin J et al. propose a long short-term memory recurrent neural network and fully connected neural network (LSTM-RNN-FNN) model based on the assemblage perspective for electrical load forecasting. To facilitate urban power system operation, planning, and control in the context of high renewable energy sources penetration, Kim J et al. propose a probabilistic spectral clustering method applicable to large-scale power systems, including variable renewable energy sources. Meng X et al. present a method for generating grid operation databases based on a weighted elimination algorithm to improve the solving efficiency of data-driven power flow calculation problems in large-scale urban power grids.

4) Medium and low voltage level DC technology application in urban power grids

Medium and low voltage level direct current (DC) power distribution systems operating as a parallel path or an alternative option to the existing urban alternating current (AC) distribution networks is becoming a trend and the way of the future. Li L et al. present a novel isolated modular multilevel converter (I-M$^2$C) topology with symmetrical wiring and its bipolar balance control method for achieving reliable and efficient interconnecting architectures and power flow control among the low-voltage DC (LVDC), medium-voltage DC (MVDC), and medium-voltage AC (MVAC) distribution systems. Wang F et al. propose a comprehensive decision-making method for DC transformation priority of multiple AC distribution networks in urban distribution power grid upgrading, aiming to guide the planning department of the urban power grid to arrange the priority scheme of DC transformation objects reasonably.

In summary, the papers in this Frontiers Special Issue covered a variety of topics related to the operation and control of urban power grids. Renewables and new grid networking technologies pave the way for urban power grid transformation and upgrading. Still, there are many challenges and opportunities with the acceleration of the urban power grid transition process, and the application of advancing technologies and their related theory in the urban power grid need to be further investigated. It is hoped that this special issue will provide beneficial ideas and references for further theoretical and practical research related to next-generation urban power grids.

Finally, we would like to sincerely acknowledge the journal editors and editorial office of Frontiers in Energy Research for their valuable support during the elaboration of this special issue. We especially thank all the contributing authors and all the reviewers for their diligence and hard work in making this special issue possible.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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