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Editorial

Clean, affordable and reliable energy systems for low carbon city transition

Cities account for approximately two-thirds of the world's overall energy consumption and contribute an estimated 70% of the world's greenhouse gases, and therefore play a major role for securing their economic competitiveness and quality of life for urban populations continuously on the rise. This Special Issue to be published in Applied Energy, with theme of "power the city with clean, affordable & reliable energy", forcefully tackle the current global and local challenges, such as climate change, efficiency and scarcity of resources. It brings together a range of studies focused on urban energy systems, covering the topics of energy supply, distribution, and end use; smart eco-cities, urban transportation with efficient energy and low emissions; microgrid and smart home; building integrated photovoltaics (BIPV) and renewable applications; urban waste to energy; nexus of energy-water; and urban energy policy etc.

In recent years, especially after the 21st Conference of the Parties of the UNFCCC in Paris, energy security and climate change have become burning issues. The rising concern on energy security and climate change implies a possible, or almost inevitable, shift of current economic paradigm to a low-carbon one. Making the transition to a low carbon economy requires active participation of the global society. Except national strategies, cities, which are the economic development units, are key elements in low carbon economic transition. By concentrating people and energy consuming activities, cities as the major greenhouse gas emitters have contributed significantly to the effects of climate change [1]. The reliance on carbon-intensive fossil fuels for powering cities and lack of low-carbon and renewable energy propel the research on low-carbon energy system design. This Special Issue, through a focus on various aspect of energy system, provides insights to understand energy issues in the context of low carbon urban development.

An energy system is more than a technical system embracing technologies and infrastructures, which consists of multiple and inter-discipline issues such as markets, institutions, consumer behaviours, environmental concerns and other factors affecting the way infrastructures are constructed and operated. Energy systems have been in transition, extending their boundaries beyond the energy systems themselves, the 3-D interactive extensions, that relate to the dimensions of physical Space, Time scale and Human behaviors – STH extension. Under the new circumstance of the STH-demission, we need new approaches and solutions to solve the challenging issues associated with new transitions of future clean energy systems [2].

Thus, the aim of this special issue is to explore and tackle how to enable the development of a low carbon and sustainable energy system through a better understanding of both existing and emerging advanced technologies as well as of new approaches to the design and management of energy systems at city level.

A large number of submissions from 7 countries were received for this special issue and 49 papers were accepted after peer review. These submissions address a variety of technological issues and managerial implications related to urban energy system design, including (1) Advances in power grid integrated with renewable energy. (2) Energy efficiency of buildings and energy storage. (3) Battery energy storage technologies and their energy management systems. (4) Insights for energy economics and management. (5) Interactions of energy and environment.

1. Advances in power grid integrated with renewable energy

With the integration of renewable energy (PV, wind) and electric vehicles (EVs), power system is now facing more and more challenges in the stages of planning and operation. The mechanism of the system stability should be re-investigated. New technique and new methodology should also be derived to make the system more stable, reliable and sustainable.

New generator technique and system estimation and control method were investigated in Refs. [3–6]. In paper [3] by Bai et al., a new solar-biomass power generation system that integrated a two-stage gasifier was proposed, and the on-design and off-design thermodynamic performances were analyzed. Simulation results revealed that it was a promising approach for the efficient utilization of the abundant renewable solar and biomass energy resources in western China. A method for estimating the rooftop solar PV potential by analysing the available rooftop area through Hillshade analysis was proposed in Hong et al. [4]. The influence of the shadows from the surrounding buildings could be properly considered. A load profile estimation algorithm based on K-means cluster analysis method and smart meter information was developed in Al-Wakeel et al. [5]. The methods in [4,5] can improve the estimating precise of PV output and load profile, which is helpful for the system monitoring and control. Jin et al. [6] analyzed the reason of active power and reactive power oscillations in the DG devices, and an improved hierarchical control strategy was proposed to achieve a better performance in the oscillation suppression.

Based on the V2G (Vehicle to Grid) technique, EVs are regarded as a good candidate to the load demand response (DR). Teng et al. [7] developed a techno-economic evaluation framework to quantify the challenges on primary frequency control and assess the benefits of EVs in providing primary frequency response. In Li et al. [8], range-extended electric vehicle (REEV) was deeply

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investigated. Control strategy and energy management method for REEV's auxiliary power unit (APU) were proposed. The APU's dynamic response characteristics were greatly improved.

Virtual energy storage system (VESS) technique was analyzed in Cheng et al. [9] and Jin et al. [10] to consider DR's group effect, in which domestic refrigerators and low-carbon buildings were respectively regarded as DR resources. The methods to estimate the VESS's regulation capacity and benefit were proposed. The research results showed that usage and cost of the traditional energy storage could be reduced once the VESS was made good use of.

2. Energy efficiency of buildings and energy storage

The building sector is one of the key sectors for energy efficiency improvement in a city. Energy storage in particular thermal energy storage has been developed to integrate with buildings to improve the energy performance.

The paper by Luo et al. [11] developed a model with CFD technology for internally-cooled liquid desiccant dehumidifier to simulate its interior heat and mass transfer processes and detailed performance as well. It was also demonstrated the necessity of considering the variable properties of desiccant solution during the two dimensional CFD simulation. Ramakrishnan et al. [12] investigated the potential applications of PCMs to be integrated into buildings to reduce heat stress risks during extreme heatwave periods through numerical simulations. The dynamic thermal simulations for a benchmark study have been undertaken to reveal the performance of, and factors that influence the adoption of PCM in non-air-conditioned buildings to reduce heat stress during heatwave periods. Chen et al. [13] set up a green building meta-model for a representative passively designed high-rise residential building in Hong Kong. Modelling on such typical building in hot and humid climates was conducted with EnergyPlus to explore the relationship between input parameters and output indices and provide reliable building performance predictions.

Chen et al. [14] conducted the sensitivity analysis among seven parameters by orthogonal test based on the experimental-validated indirect evaporative cooler (IEC) model considering condensation condition. The optimization was then operated to the most influential and engineering controllable parameters, with the results showing that the channel gap and cooler height are the key influential factors on IEC thermal performance. Kang et al. [15] proposed a new CCHP system consisting of a power generation unit (PGU), an absorption chiller, a storage tank and a ground source heat pump (GSHP) to substitute conventional electric chiller and auxiliary boiler to supply the deficient cooling or heating load. Three basic load following strategies, following electric load (FEL), following thermal load (FTL) and following hybrid load (FHL), were employed to analyze the annual total cost, operational cost, carbon dioxide emissions and primary energy consumption based on a case study of Sino-Singapore eco-city. Monthly results under different loads demonstrated that FTL was suitable for the cold winter and hot summer, while FEL and FHL were suitable in the transition season.

Hong et al. [16] conducted the nonlinearity analysis of the shading effect on the technical–economic performance of the building-integrated photovoltaic blind (BIPB), which was designed as a preliminary study to evaluate the feasibility of the BIPB before its implementation. The results may help design the BIPB before its implementation, which ensure to meet the client expectations on both technical performance and economic performance. Guo et al. [17] provided a techno-economic assessment of the mobilized thermal energy storage (M-TES) system based on a case study in China. The results demonstrated that M-TES system was not suitable for the existing heating systems with radiator ends, but it was recommended for existing heating systems with fan-coil unit or under-floor pipe ends.

An optimization model was proposed by Si et al. [18] for the integrated solar energy systems to figure out the optimal utilization and economic efficiency of solar energy resources for buildings in cold plateau areas. A case study in Lhasa city was carried out to evaluate the energy and economic performances with the developed model. The results indicated that such optimal matching between solar thermal and photovoltaic systems may vary in regions with different energy prices and solar resources. Zhang et al. [19] proposed a gravity heat pipe exchanger used for cooling the communication base station to replace the traditional air conditioning system during winter and transition seasons. The electricity saving of a typical communication base station subject to the five climatic zones of China were investigated. The economic efficiency of gravity heat pipe exchanger applied in communication base station was also analyzed. The results showed that the larger the air flow rate, the smaller the NTU and the larger the cooling capacity. It was proved that the gravity heat pipe exchanger could reduce running time and operating cost of air conditioning system.

Solidification features of PCM saturated in open-cell metallic foams were investigated analytically, numerically and experimentally by Yang et al. [20]. Based on pore-scale thermal equilibrium assumption, an analytical extension of the classical Neumann's solution was made to predict phase change heat transfer in PCM-foam composites. The present findings could provide new insights for cold energy storage design, utilization and economic analysis in HVAC systems.

Antonelli et al. [21] presented an interesting hybrid solution including a large-scale energy storage system coupled with power generation and fast responding energy storage systems, which was able to deliver the energy previously stored by using an air liquefaction process either with or without the contribution of additional energy from combustion. Different process schemes for such hybrid plants were modelled. It was concluded that hybrid power plants based on Liquid Air Energy Storage (LAES) may be a promising solution to store energy and use it at peak times with good performance.

3. Battery energy storage technologies and their energy management systems

Battery plays an important role in the energy storage. Many efforts have been made to improve battery performance from the material perspective. In order to identify the relation between the morphological features of the electrodes and the macroscopic battery performance, Jiang et al. [22] proposed a two-dimensional (2D) lattice Boltzmann model of ion and electron transport within LIB porous electrodes. Ke et al. [23] used a surface coating in order to reduce solid electrolyte interfacial reactions and consequently enhance its cycling performance. Lu et al. [24] conducted experimental analysis to study the mechanisms and intrinsic correlations of catalyst to Nafion ratio, microchannel thickness, electrolyte flow rate and CO_2 supply for an optimized outcome. Based on the present battery material technology level, an effective battery management system is needed to further improve battery performance. To improve the estimation accuracy and reliability of state-of-energy (SoE), Lin et al. [25] proposed a novel multi-model fusion estimation approach against uncertain dynamic load and different temperatures. The results demonstrated the advantages of using single model and its robustness to the temperatures with the guaranteed reliability. Zhang et al. [26] also developed a polarization based charging time and temperature rise optimization strategy for lithium-ion batteries.

The highly effective energy management system can ensure EVs work properly in a long life range with excellent power