

Foreword

Carbon neutrality is currently an important policy for most governments all over the world, to combat the severe problem of climate change. Many countries have committed to a target date to achieve carbon neutrality. From the view of electrical engineering, there are many frontier technologies that may be used to address the issues within the carbon neutrality area of the power and energy discipline. The theme of the International Council on Electrical Engineering (ICEE) Conference 2023 was exactly this. Authors of 12 carefully selected papers from the Conference were invited to revise and refine their papers to form this specially themed issue of *HKIE Transactions*.

The paper by Cha and Ko develops a settlement rule that incorporates the penalty within a proposed capacity factor-based capacity payment coefficient. The rule is capable of minimising the prediction errors associated with aggregated energy resources. Their analysis encompasses variations in profit for aggregators and strategies for their profit maximisation for deploying distributed energy resources.

The paper by Zhang et al. develops an adaptive zero-sequence mutual compensation method for distance protection. This can enable the compensation adaptively based on the zero-sequence current direction and the phase current direction. Hence the performance of the pilot distance protection of a power system can be calculated using the new method, and the pilot distance protection was found to operate correctly which verifies that the method is valid. This improvement of the protection of power systems can enhance their reliability and effectiveness as efficient energy carrying networks.

The paper by Zulu et al. proposes models for quantifying the impacts of electric vehicles and battery energy storage systems on the PV hosting capacity of distributed networks (DNs) using the stochastic particle swarm and gradient descent algorithm (PSO-GD). The simulation results of case studies have shown that the proposed method is accurate, fast, and efficient. Hence, it could predict the maximum amount of PV which could be integrated into a DN without violating these network operational limits.

The paper by Xie et al. proposes a novel robust economic dispatch model of renewable energy in which the operator can buy predictions from distributed forecasters to build a better uncertainty set and enhance dispatch efficiency. This will then reduce the energy losses during the distribution of electrical renewable energy. The proposed model renders a two-stage robust optimisation problem with decision-dependent uncertainty. Case studies show that the proposed method is effective.

The paper by Tomita et al. presents a study which measured the electrochemical impedances of several lithium-ion batteries with varying electrode materials and levels of cycle degradation. The measurements were analysed using the distribution of relaxation times (DRT) method to investigate the effects of different electrode materials and cycle degradation on the batteries' electrochemical impedance. This type of study is important to understand the characteristics of different lithium-ion batteries, which are important energy storage devices for power systems.

The paper by Yamazaki et al. proposes a calculation method of the parameters required to manage distributed energy resources. The proposed method takes into account the balance between power supply and demand. It formulates a power transaction between retail electricity suppliers, especially those with the function of energy resource aggregation, and their customers under a framework of social welfare maximisation (SWM). Hence, it will benefit both retailers and their customers, and thus promote distributed energy resources.

The paper by Takashima et al. describes a wireless inchworm with a small battery and a control circuit which eliminate the effect of wiring tension. The inchworm consists of piezoelectric actuators and electromagnets. A converter with a high boost ratio is required to boost the voltage from the battery to the maximum applied voltage of the piezoelectric actuators. The boost converter with a tapped inductor achieves a high boost ratio of approximately 16.7. The wireless inchworm eliminates the effects of wiring tension caused by power supply cables, hence improving the reliability of the system.

The paper by Xie et al. introduces typical Grid-Forming (GFM) technologies in power grids, including steady-state and fault current limiting strategies, studies the equivalent structures of steady-state and fault traversal under GFM technology, analyses electrical characteristics under different fault types from the voltage plane, and illustrates the differences from traditional synchronous systems. The analysis shows that the GFM technology creates a relatively good operating environment for relay protection by simulating the basic characteristics of synchronous generators, which is conducive to improving the operational performance of relay protection in power grids.

In the paper by Fujishima et al., in order to protect the photovoltaic modules installed on large ships from lightning strikes, the height of lightning rods or overhead ground wires was specially designed. Simulated lightning strike experiments were conducted to evaluate whether the designed lightning rods or the overhead ground wires can protect the photovoltaic modules from lightning strikes. The results of the experiments showed that overhead ground wires installed on both sides of a ship have a higher protection probability of the modules than using lightning rods. Such design will promote the adoption of photovoltaic systems on large ships and hence reduce the emission of greenhouse gases from ships' generators.

The paper by Wang et al. develops a novel load frequency control (LFC) approach for microgrid (MG) systems with distributed energy resources which is based on adaptive model predictive control (AMPC). A simplified internal prediction model (a first-order lag system consists of a gain and a time constant) is applied to the online state estimation of the AMPC. This will enable the easier integration of distributed renewable energy resources into the power grid, and hence will reduce the emission of greenhouse gases.

The paper by Nguyen et al. introduces a method for calculating the critical inertial energy of a power system operator, as well as to analyse the impact of incorporating grid-forming inverter-based renewable energy sources (RESs) on the frequency stability of the power grid. The technique introduced in this study can serve as an approximation method to calculate the inertial energy requirements for other nations' power systems. The outcomes of this paper could assist in establishing a Net-Zero power grid with a high proportion of grid-forming renewable energy sources.

The paper by Hashiguchi presents a method for estimating the power system characteristics related to inertia and the damping constant using phase measurement unit (PMU) data, which may enable the rapid determination of transient and steady-state conditions in power systems. The implementation of this system will enable adaptive control based on the results of online data analysis, facilitate investment decisions for new installations, and improve the utilisation of the power system.

I would like to express my sincere gratitude to the HKIE Secretariat, members of the HKIE Transactions Committee, the authors, and the reviewers for their time and efforts in enabling this meaningful and interesting themed issue on frontier technology in carbon neutrality power and energy which I hope will inspire more new ideas from engineering professionals in Hong Kong and other parts of the world.

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