Obstacles and opportunities for key technologies of smart energy systems

The use of low-carbon energy has increased globally, and smart energy systems are being developed to advance smart cities and achieve carbon neutrality. Dr. Dongdong Zhang from Guangxi University, China, together with his collaborators, have identified obstacles and opportunities of six hotspot technologies for smart energy systems. This research aims to advance the sustainable development of society with the creation of smart energy systems. It addresses the shortfalls with a comparative analysis and introduces performance factors in terms of efficiency together with applications of the technologies supporting smart energy systems.

Global concern surrounding energy use is exacerbated by climate change and environmental pollution. These have recently been aggravated by both the outbreak of COVID-19 and the energy crisis. Across the world, renewable energy is being pursued together with the development of multiple energy sources. Information technology progresses at speed as the energy industry embarks on a dramatic transformation towards the panacea of zero-carbon emission. Intensifying energy conservation and reducing emissions globally calls for the assimilation of innovative energy and information technologies, together with the construction of an intelligent, information-transparent, connected smart multi-energy system. Globally, there is an increase in low-carbon energy use as smart energy systems are being developed to advance smart cities and realise carbon neutrality.

Dr. Dongdong Zhang from the Department of Electrical Engineering at Guangxi University, China, and his collaborators have identified obstacles and opportunities of six hotspot technologies for smart energy systems (SESs). Their extensive literature review has shown that the power industry has fast-tracked their development of flexible distributed energy to contend with the issues surrounding environmental pollution, vast transmission distances, and the substantial energy loss accompanying conventional plans for large-scale centralised power.

INTEGRATED ENERGY SYSTEM

Industry and academia alike welcome the integrated energy system combining energy production, storage, conversion, transportation, and consumption. The integrated energy system is significant in improving the power grid's economy and flexibility with the efficient use of multiple energy sources. In addition to improving energy production and consumption methods, the integrated energy system provides a solution to the issues of randomness, high volatility, and the low energy flow density of renewable energy. The energy flow density denotes the energy flow that can be harnessed from a particular unit of volume, area, or mass. The energy flow density of renewable energy is considerably lower than that of fossil fuel; for example, solar energy has a density of 1.5 microwatts per cubic meter which is more than twenty quadrillion times less than oil's 35-45 gigajoules per m².

Innovative energy systems are being examined across the world. Many countries are carrying out research accelerating changes in both energy consumption and its structure, while promoting the creation of a contemporary low-carbon, clean, efficient, and safe energy system.

SMART ENERGY SYSTEMS

Integrating large-scale distributed new energy into the grid brings fresh challenges — including variable power quality, waste, low energy efficiency, and uncoordinated system operation. These issues are now being resolved at a technical level with advances in artificial intelligence (AI) technology facilitating the production and consumption of SESs. Employing technologies, for instance intelligent control, enables SESs to conduct real-time analysis and data integration from many sources. SESs establish more stringent resource allocation rules over multiple energy sources. These ensure the system operates efficiently and economically, and that it possesses the flexibility required by the diverse commercial applications relying on the network.

ADVANTAGES AND DISADVANTAGES

The researchers performed a detailed review of the literature, analysing and comparing the pros and cons discussed in recent articles reviewing SES technologies. SESs offer adaptable management for multi-energy control within a diverse range of settings. These can be unpredictable and harsh and deliver a greater diversity of energy sources and applications. Consequently, they are particularly suited to sustainable development of smart cities. This comparative study found several researchers already investigating the technology, concept, and use of SESs. Technology developments provide new challenges and opportunities for SESs, although there is evidence of weaknesses in the concepts and discussions observed in the research. This research addresses these shortfalls in a comparative analysis and introduces performance characteristics in terms of efficiency together with the applications of six main hotspot technologies supporting SESs: new energy-generation prediction technology; demand-response technology; collaborative energy management of multiple energy flows; advanced energy-storage technology; information-exchange technology; and digital energy integration market and service mechanism.

CHALLENGES

Zhang and colleagues discovered that these new power system technologies face a number of challenges. New power generation production technology can predict performance to the minute or even the second. When faced with unanticipated extreme situations, however, the instability of new power generation in real-time poses problems that can result in power outages. Furthermore, there are challenges surrounding the deployment of increasingly precise prediction technology in remote areas where intelligent technology remains underdeveloped.

There are currently two key issues with demand-response technology. Firstly, from the user's perspective, sustainable energy is not consistent, so the load analysis requires precision. Moreover, the effect of price sensitivity on the demand's uncertainty and the impacts of multiple user interactions requires further consideration. Secondly, changes in pricing affect the use of various energy systems, requiring a robust demand response multi-energy price mechanism is required.

Intensifying energy conservation and reducing emissions globally calls for the assimilation of innovative energy and information technologies.

The collaborative management of multi-energy flow and energy conversion technology is crucial to the balanced running of SESs. Multi-energy flow collaborative management research tends to focus on establishing various models of energy flow, but there is relatively little work into controlling the direction of mutually coupled multi-energy flows. Furthermore, the coupling element's dynamic characteristics and the energy lag receive little attention. The team advocates the integration of...
Behind the Research

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Dr Zhang identifies obstacles and opportunities of six hotspot technologies in smart energy systems.

Detail

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Personal Response

What would you consider to be the most important factors in developing and implementing an SES?

The most important factors in the development and implementation of SES include the following two aspects: i) smart energy system research should begin with a combination of technological innovation and practical application; ii) key technologies in smart energy systems should consider the needs of people’s livelihoods to evolve in a more intelligent and diverse path, thus effectively promoting the sustainable development of society.

References


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The potential for new energy goes beyond what is currently under development. New energy development and technology for its use are required if energy is to be gathered from diverse sources and still protect the environment. Further research into efficient advanced intelligent technologies that can handle the challenges posed by large-scale epidemics, such as COVID-19, is needed to construct SESs that can sustain a stable operation during a major disaster.

In summary, this research aims to expand the development of sustainable society with the development of SESs. The researchers recommend that smart energy system research commences with a blend of practical application and technological innovation. Furthermore, the central technologies in SESs must recognize people’s livelihoods and their fundamental requirements if they are to evolve in a more diverse and intelligent direction.

Obstacles

Taking a global viewpoint on realising carbon neutrality, the team examines the fundamental impediments to the advancement of an SES. They analyse these with reference to the social environment, technology constraints, extreme climate conditions, and human survival. Currently, prediction technology is concentrated on forecasting individual entities. Intelligent production technology is required to manage multiple uncertainties.

The increasingly diverse nature of the market means that more research is required into the breadth and depth of the application of communication technology within the digital energy market. This should focus on implementing transactions, improving security, preventing leaks of user information, and improving the digital energy market trading platform’s quality of service.

Obstacles

Intelligent technology in order to achieve real-time energy conversion management and monitoring within the system, that can measure the effect of mirror changes in real time and rapidly apply emergency response measures.

Advanced energy-system technology requires efficient storage of an assessment of energy to help manage the inherent uncertainty of energy use, distribution and production. Large-scale parallel storage is needed for multiple energy sources to improve the energy supply’s flexibility and reliability.

The most important factors in the development of society.

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References