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Policies and demonstrations of micro-grids in China: A review ☆

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ABSTRACT

Micro-grids are effective concepts and systems to interface renewable and sustainable energy resources into utility, which has been paid significant attention. In this paper, the policies and demonstrations of micro-grids for researches and developments, as well as practical applications in China have been comprehensively reviewed. Many recent policies on renewable energy and micro-grids are summarized, which have been guiding and contributing the development of micro-grids in China. Additionally, the available micro-grids demonstrations in China are also introduced in detail. Finally, the emergency necessaries and trends of micro-grid applications in China have been concluded.

Contents

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1. Introduction

Recently, the traditional transmission and distribution network have met essential challenges on security, reliability, and low emission issues [1–3]. On one hand, the blackout of North American in 2003, due to the unreliable equipment and cascading failure of utility, has turned out that the distributed generation systems are good choices to enhance the security and reliability of utility instead of the centralized one [4,5]. Simultaneously, the extreme climate disasters and geology disasters can also be serious barriers for the security of utility, such as the Ice Disaster in 2007 and Wenchuan Earthquake in 2008 of China [6–8]. As a result, distributed, flexible, and autonomic distribution network are gradually paid much more expectation, which can greatly reduce the power delivery and lower the economic loss because of the disasters. On the other hand, aiming to the global environment pollution and energy crisis, green power and low emission are emergency issues of utility. Taking China for example, the shortage of fossil fuels and greenhouse gas emission-reduction hinder the further economic development; in particular, China has suffered the heavy Haze Weather in 2013. Furthermore, how to interface the randomness, intermittent and uncontrollable renewable energy sources (RESs) into utility is a key problem. Taking such conditions into consideration, distributed generation systems are gotten increasing focuses, which are not only an important supplements of traditional utility, but also can effectively interface the renewable and sustainable resources into utility [9,10].

Micro-grid is a special kind of distributed generation system, which consists of RESs, local loads, energy storage devices, supervisor, protection, and control units [11,12]. It is considered as a better solution of distributed generation system in low-capacity customer-ends. Because of its inverter-oriented configuration, two flexible operation modes (namely islanded mode and grid-tied mode) and its capability to suppress the power fluctuation of RESs due to the embedded energy storage devices can be realized. Additionally, micro-grids are expected to achieve many advanced abilities for utility, such as active/reactive power supporting, customized power quality and reliability, black start, and so on. Therefore, several countries and organizations have carried out many demonstrations to verify the micro-grid concept and its advanced abilities. The micro-grid researches and demonstrations by the Consortium for Electric Reliability Technology Solutions (CERTS) of U.S., the European fifth and sixth research frameworks, and the New Energy and Industrial Technology Development Organization (NEDO) of Japan, are well documented and reviewed in [13–16]. However, the works on micro-grid in China have been hardly introduced as far as now, although the exploitations and applications of RESs and micro-grids have been quickly increased in China recently to deal with the energy crisis, environment pollution, and greenhouse gas emission issues [17].

The main contribution of this paper is to give a comprehensive overview on the policies and demonstrations of micro-grids in China. The rest of the paper is organized as follows. In Section 2, the policies and standards of China on renewable energy applications and micro-grids are summarized. Furthermore, the available micro-grid demonstrations in China are explained and depicted in detail in Section 3. Some emergency necessaries and trends on the micro-grid research and development (R&D) and demonstration in the near future of China are conducted in Section 4. Some conclusions are drawn in Section 5.

2. Policies on renewable energy and micro-grids in China

2.1. Some national laws, regulations, and plans on renewable energy application

China aims to exploit and apply renewable energy due to the numerous coal-fired power plants result in serious pollution, severe emission, and the shortage of fossil fuels. Many policies have been carried out to enhance the development of renewable energy implementations and micro-grid demonstrations in China [18–25]. The status of some policies on renewable energy application is summarized as follows.

- The *Renewable Energy Law* was issued in 2006, in which the renewable energy application is ensured as a national policy. This law gives the basic confirmation for the renewable energy application including wind energy, solar energy, and so on.
- The *On-Grid Price of Renewable Energy Generation and the Cost-Sharing Management Pilot Scheme* was formulated in 2006 by National Development and Reform Commission (NDRC). According to this scheme, on-grid price of wind power should