Energy Policy 115 (2018) 302–316

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Assessment of renewable energy expansion potential and its implications on reforming Japan's electricity system

Takako Wakiyama[a,b,*], Akihisa Kuriyama[a]

[a] Institute for Global Environmental Strategies (IGES), Japan
[b] Integrated Sustainability Analysis (ISA), The University of Sydney, Australia

ARTICLE INFO

Keywords:
Electricity market reform
CO_2 emissions
Energy mix in 2030
Japan's NDC
2 °C scenario

ABSTRACT

This study assesses the regional energy mix potentials of Japan for maximised renewable electricity generation and reduced CO_2 emission intensity in the electricity sector, in view of the nationally determined contribution (NDC) mitigation target, and the 2 °C rise limit target. Beginning with the deregulation of the retail electricity market, discussions have been initiated about Japanese electricity system reforms towards 2020. This paper examines the potential energy mix up to 2030 at the regional level, and identifies the need to accelerate electricity system reforms to expand the transregional access to renewable electricity generation. By analysing available data, we assess how regional renewable energy potentials can be put to effective use, and identify how electricity reform should proceed, to both capitalise on renewables and reduce carbon intensity. Finally, we report the large renewable potentials in Japan. However, in order to maximise the use of these potentials, a combination of technologies and policies are required to promote flexible grid operation, and strengthen transmission capacity and renewable priority dispatch order, as well as to introduce technology for stabilizing electricity systems supplied by renewable electricity, such as pumped storage hydropower, storage cells, and demand-response, which can store surplus energy until it is needed.

1. Introduction

The Fukushima nuclear accident in 2011 starkly brought the inability to transmit electricity between regions within Japan into light. Much discussion has since transpired on reforming the electricity market and various energy related policies, including the feed-in tariff (FIT) (Huenteler et al., 2012; METI, 2013a, 2013b). The goal of the reform is to legally decouple electrical power production from distribution and transmission by 2020. On the other hand, in the 2016 Japan-ratified Paris Agreement to keep the global temperature rise to below 2 °C,[1] to put forward their best efforts through nationally determined contributions (NDCs), and to strengthen these efforts. Under such circumstances, electricity market reform towards 2020 and beyond needs to factor in effective reduction in CO_2 emissions, as well as meeting the following three government objectives: secure a stable supply of electricity, suppress electricity rates, and provide greater choice for consumers through competition amongst business entities.[2] Furthermore, increasing a share of clean electricity in the energy mix of the overall electricity supply will bring about a large reduction in the national CO_2 emissions (Keay et al., 2012; NIES, 2010; DDPP, 2015).

This study assesses regional energy mix potentials of Japan, to maximise the power generation of renewable electricity potentials and reduce the CO_2 intensity of the electricity sector. We focus on renewables over nuclear energy in terms of reducing CO_2 emissions and increasing domestic energy security to reduce dependence on primary energy imports and uncertainties of economic, social and environmental impacts by nuclear power plants such as nuclear accidents, and to achieve the Japanese climate target. Although there are various discussions on nuclear power generation (Karakosta et al., 2013; Pfenninger and Keirstead, 2015; Roth and Jaramillo, 2017), uncertainties regarding cost and safety surround it. In fact, since the Fukushima nuclear accident, the government budget spending on nuclear power has dramatically increased due to the newly introduced budget for Nuclear Damage Compensation – which started from JPY 5027 billion in 2011 and rose to JPY 8852 billion in 2014 – in addition to the existing nuclear power generation related subsidies,[3] and there are still

* Corresponding author.
E-mail address: takako.wakiyama@mx.iges.or.jp (T. Wakiyama).

[1] Citied as "Paris Agreement requires all Parties to put forward their best efforts through 'nationally determined contributions' (NDCs) and to strengthen these efforts in the years ahead." http://unfccc.int/paris_agreement/items/9485.php.

[2] METI Energy Market Reform in Japan: http://www.enecho.meti.go.jp/en/category/electricity_and_gas/energy_system_reform/.

[3] The governmental budget data is available from Ministry of Finance (MoF) database: http://www.bb.mof.go.jp/hdocs/bxsselect.html.

https://doi.org/10.1016/j.enpol.2018.01.024
Received 24 July 2017; Received in revised form 9 January 2018; Accepted 11 January 2018

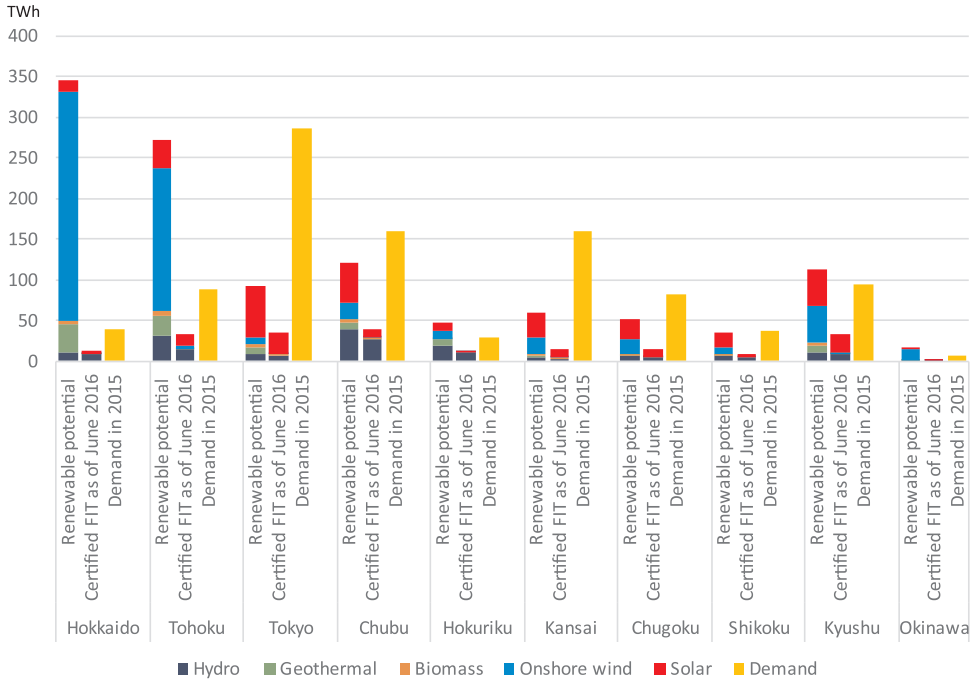

Fig. 1. Annual regional electricity potential, certified capacity, and demand by region.
Source: Made from the following sources: Renewable potentials, certified FIT (METI's FIT data) METI's FIT data: http://www.fit.go.jp/statistics/public_sp.html, Demand (METI's electricity demand and supply survey data) METI's electricity demand and supply survey data: http://www.enecho.meti.go.jp/statistics/electric_power/ep002/results_archive.html

issues to deal with regarding the disaster-related costs of nuclear power plants.[4] On the other hand, renewables could have the potential to increase local employment, facilitate local autonomy via decentralised power generation (Blazejczak et al., 2014; Vivoda, 2016), and could be more cost-effective than nuclear power (Sovacool, 2010), as it found that operation costs of nuclear power has been rising in countries such as Germany and the United States (Froggatt and Schneider, 2015).

This paper considers two scenarios based on the mitigation target of Japan as issued by government and determined by the NDC, called the "NDC scenario", and based on the target estimated by IEA 450 scenario for Japan to limit the global rise in temperature to below 2 °C, called the "2 °C scenario (2DS)". These two targets are rather top-down targets and not well examined regional details and from regional integration point of view. Regional differences exist in the regional electric power capacity, as well as the demand and supply structure in Japan. By looking closer at these variations, this paper highlights the gap between the estimated electricity supply and demand in these regions, to identify both the transmission capacity, and the challenges in expanding renewables. It also highlights the barriers in transmitting electricity from regions with large renewable potential to other regions. The findings from the analysis are intended to help shape the electricity system reform due to take place in 2020.

The paper is structured as follows: the next section covers the current structure of the electricity system in Japan, and the challenges involved with it; section three explains the methodology for the study; section four introduces spreadsheet data analysis to assess the regional energy mix; section five addresses recent discussions surrounding the electricity market reform towards 2020, and the feasibility of such reforms based on the regional electricity mix anticipated for 2030. Finally, it concludes with a summary of the main points and policy implications of reforming the electricity market of Japan.

2. Background and literature review

2.1. Renewable potentials in Japan

After the Fukushima nuclear accident, it became clear that there was a need to expand renewable energy as an alternative electricity source (EEC, 2012; Huenteler et al., 2012; Muhammad-Sukki et al., 2014). This resulted in the introduction of the FIT scheme in July 2012, after which Japan has had a marked increase of up to 30.7 GW in solar PV capacity, and the total renewable electricity installed capacity is 32.2 GW including other renewables, between July 2012 and September 2016. If certified FIT is included, the total generation from renewable sources approaches 120.8 GW excluding large hydropower. Here, certified FIT means all of the approved capacities of renewables as calculated by applicants (individual electricity producers or electricity businesses) who plan to install renewable electricity, and who have obtained FIT approval from the Ministry of Economy, Trade and Industry (METI), and electricity companies, although are yet to begin installed.[5]

In Japan, while disparities in power capacity exist among the regions, they are more pronounced in the renewable potential (Wakeyama and Ehara, 2011; Wakiyama and Kuriyama, 2015) – Hokkaido and Tohoku have huge renewable power surpluses and less power demands, however, the Tokyo, Chubu, and Kansai regions have high power demands (Fig. 1).

[4] Reuters, 9 December 2016, "Japan nearly doubles Fukushima disaster-related cost to $188 billion": https://www.reuters.com/article/us-tepco-fukushima-costs/japan-nearly-doubles-fukushima-disaster-related-cost-to-188-billion-idUSKBN13Y047.

[5] Although equipment such as solar panels are not necessarily purchased at this approval level, documents on manufacturers and model numbers of such equipment to be installed need to be registered. Prior to April 2015, when regulations changed, approval from a regional electricity company to connect generated renewables to its grid was not required. Furthermore, for solar PV, a certified copy of land registration and a legal installation procedure status report for the site were not required, and there was no regulation then from approval to installation. Since April 2015, all renewable electricity producers need approval, not only from the government, but also from electricity companies to connect their produced electricity to the grid. In addition, solar PV electricity producers of more than 50 kW installed capacity need to submit a certified copy of land registration, legal procedure status report of the installation site, and equipment procurement documents within 180 days (maximum extended days is 360 days), otherwise they face expiry of the registered 'approved capacity' and obtained procurement price. Since "certified FIT" is registered in the FIT system and requires government approval, the relevant data are collected by the government. See the following METI site for information on the FIT (METI FIT database:http://www.enecho.meti.go.jp/category/saving_and_new/saiene/kaitori/nintei_setsubi.html).