



Analysis of renewable energy development to power generation in the United States



Alireza Aslani ^{a, b, *}, Kau-Fui V. Wong ^b

^a Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa 65101, Finland

^b Department of Mechanical and Aerospace Engineering, College of Engineering, University of Miami, Miami, FL 33146, USA

ARTICLE INFO

Article history:

Received 2 May 2013

Accepted 28 August 2013

Available online 28 September 2013

Keywords:

Renewable energy portfolio

Cost analysis

Electricity generation

US

System dynamics

ABSTRACT

Renewable energy resources have historically played a small role for electricity generation in the US. However, concerns such as security of energy supply, limitations and price fluctuations of fossil fuels, and threats of climate changes have encouraged US policy makers to think and debate about diversification strategy in the energy supply and promotion of renewables. The current paper discusses the role of renewable portfolio in the US energy action plan during 2010–2030. A system dynamics model is constructed to evaluate different costs of renewable energy utilization by 2030. Results show that while renewables will create a market with near 10 billion \$ worth (in the costs level) in 2030, the total value of renewable energy promotion and utilization in the US will be more than 170 billion \$(in the costs level) during 2010–2030.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

One of the important factors of US energy production system is security of energy supply at this time. Energy security concerns along with consumption growth are rapidly rising in importance in the US. In response, renewable energy resources (RER) are options to reduce dependency on imported energy and provide social and environmental benefits. However, a key question is how RERs can be used to meet US energy needs and U.S. electricity needs?

RERs are typically used in three main frames: electricity generation, bio-products, and in heating/cooling systems. To succeed diffusion programs of renewable energy (RE) development, different strategies such as technological improvements, increased economies of scale, and strong policy support have been contributed in the US. Nevertheless, compared to traditional energy sources, promotion of electricity generation from RERs is limited because of its relative investment high costs, and strong penetration of nuclear and fossil fuel power plants in the US.

This study provides an evaluation to analyze the costs of RE promotion and operation according to the U.S. Department of Energy action plan for RE development by 2030. Owing to the complexity of such studies, as well as different factors and policies

effects on costs analysis, the system dynamics approach is implemented to analyze the effectiveness of RE policies.

The work is organized based on the following sections. Energy structure, supply, and consumption in the US are reviewed in Section 2. In Section 3, the role of RE utilization is discussed in the US. The important RERs and their potentials are also reviewed in that section. Related policies and government's schemes to promotion of RE utilization in the US are described in Section 4. Different parts of the development costs of RE in the US are reviewed in Section 5. Finally, a system dynamics model for cost analysis of RE utilization in the US during 2011–2030 is proposed in Section 6.

2. Energy structure in the US

The US with 315,746,720 populations (4.5% of world) consumes around 19.2% of the world's energy (83% of North America) [1,2]. The country is also the second largest energy consumer after China and ranks seventh in energy consumption per-capita after Canada and some small countries [2]. According to IEA energy statistics, fossil fuels are the majority of total primary energy supply (84.3% share in 2009) [3]. Oil with 37.1%, natural gas with 24.7%, and coal/peat with 22.5% are the main sources of fossil fuels for energy consumption in the US in 2009 [3]. RERs had a share of 5.8% in total primary energy supply in 2009 [3]. Fig. 1 and Table 1 show the share and amount of each renewables in both electricity and heat generation in the US in 2009 [4]. As Fig. 1 illustrates, the main RER in the US is hydropower utilized from hydroelectric dams.

* Corresponding author. Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa 65101, Finland. Tel.: +358 44 255 0010.

E-mail address: Alireza.aslani@uva.fi (A. Aslani).

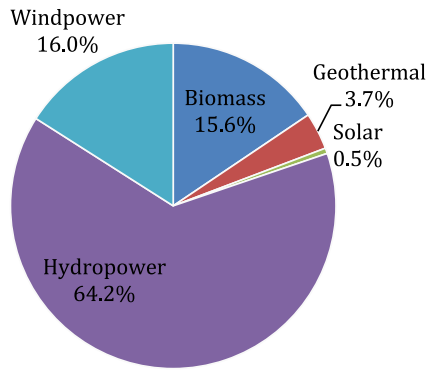


Fig. 1. Share of each renewables in electricity generation in US in 2009 [4].

While 41% of energy demand in the US was used for electricity generation, around 28% of energy demand was used for transportation in 2009 (20% industry and 11% residential and commercial). Fig. 2 shows the share of each source in each sector [5].

As energy consumption has always increased at a faster rate than energy production over the last decades in the US, the country is dependent to imports particularly for transportation sector. According to statistics, while total energy production in the US was 1686.4 Mtoe, the net imports was 559.01 Mtoe in 2009 (33%) [6]. During 2010–2011, while use of coal and oil fell in the US, use of natural gas increased [7].

3. Renewable energy utilization in the US

RERs in the United States accounted for 11.1% of the electricity generation in 2009 [8]. This was increased to 13.2% in 2012 (19% growth). Fig. 3 shows the trend of electricity generation by RE in recent years.

Although the major RER for electricity generation in the US is hydropower (Table 1), some states such as California, Iowa, and North Dakota have generated more than 10% of their electricity just from wind power, solar power, and geothermal.

As diffusion of RERs along with improving energy efficiency are two important subjects of White house energy policies in order to response to challenges of energy security and climate change, development of RER utilization have been emphasized by the US policy makers in different levels and states [10]. According to the “New Energy for America plan”, the share of RERs in electricity generation should be increased to 25% by 2025 [11].

On the other hand, Feasibility studies show that all US states have strong potential for RER utilization at least in one source. For instance, a quarter of the U.S. land area has high potential for electricity generation from wind power with the same price of natural gas or coal. Further, solar energy in seven southwest states can provide 10 times of the current electric generation in the US [12]. Fig. 4 shows the portfolio map of RERs in the US extracted from the National Renewable Energy Laboratory (NREL) database [13].

As Fig. 4 illustrates, US has a strong potential for solar energy utilization. With annual growth averaging 11.7%, solar power along with wind power is the fastest growing of RERs in the country [23].

Table 1
Details of utilization of renewables for electricity and heat generation in the US in 2009 [4].

Resource	Biomass					Geothermal	Hydropower	Solar		Wind
	Municipal waste	Industrial waste	Primary solid biofuels	Biogases	Liquid biofuels			Photovoltaic	Thermal	
Gross elec. generation (GWh)	16,909	5532	40,478	9281	91	17,046	298,410	1698	816	74,226
Gross heat production (TJ)	11,736	3818	30,839	999	–	–	–	–	–	–

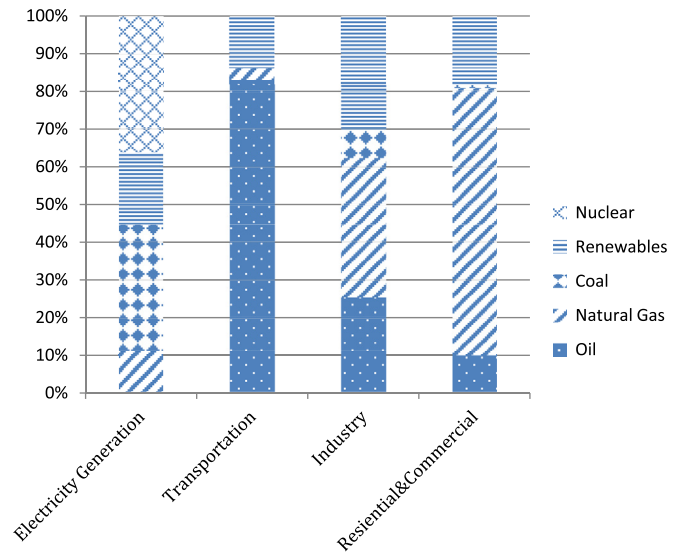


Fig. 2. U.S. primary energy consumption by source and sector [5].

While new and more efficient solar technologies are being developed, utilization of this source will be more popular [34]. Today Both Sandia National Laboratories and the National Renewable Energy Laboratory (NREL), as the main government organizations for supporting RE utilization, have heavy funded solar research programs. The Ivanpah solar project with 392 MW capacity is a solar thermal power facility that is under construction in south-eastern California [16]. However, because it currently accounts for only 0.5% of total renewable generation, solar would remain a minor part of the renewable mix.

Wind power utilization has swiftly grown over the past decade, from 18 GW to 179 GW during 2000–2010. It had a big jump, 26% growth, during 2010–2011 [7]. Western US, Alaska, and Appalachians are regions with strongest wind in the US. Texas, with 9728 MW and Iowa with 3670 MW are two examples of wind power utilization in the US.

On the other hand, the western US is the best region for geothermal utilization. Geothermal technologies can be used in three frames: heat pumps, direct systems, and deep reservoirs to generate electricity [14]. It is estimated the total production of geothermal will be 15,000 MW by 2025 [17]. Indeed, major hydro-electric dams are located in the Northwest, on the Colorado River, and Tennessee Valley. They provide about 67% of total electricity generation by RERs. Finally, biomass can potentially be produced almost anywhere in the US, in particular eastern US. In general, the share of total electricity generation by non-hydropower renewable generation should be increased from about 4 percent in 2010 to 9 percent in 2035 [23].

4. Policies related to renewable energy development in the US

The share of RERs in electricity generation in the US should grow to 25% by 2025 [30]. Most of the growth in RE electricity generation is the result of state renewable portfolio standards requirements,

Download English Version:

<https://daneshyari.com/en/article/6768644>

Download Persian Version:

<https://daneshyari.com/article/6768644>

[Daneshyari.com](https://daneshyari.com)