Computational Research Progress in Applied Science & Engineering
©PEARL publication, 2016

ISSN 2423-4591

CRPASE Vol. 02(03), 101-105, July 2016

Analysis of Diffusion of Biomass Energy Utilization

Aida Shahteymuri[a], Alireza Aslani[a,b*], Marja Naaranoja[b]

[a] *Faculty of New Science and Technologies, University of Tehran, Tehran, Iran*
[b] *Faculty of Technology, University of Vaasa, Finland*

Keywords

Biomass energy,
Biofuel,
Renewable energy,
System dynamics.

Abstract

Utilization of renewable energy resources is one of the important policies for governments in order to decrease dependency on fossil fuels and to achieve their sustainable targets. Among all kinds of renewables, biofuel has a significant share in providing clean energy. Despite the importance of renewables, successful diffusion and commercialization of renewables have faced with barriers and challenges. This work reviews the diffusion of biomass energy as one of the new source of energy in Iran. The work shows that three factors of marketing and customer trust, competitive price, and technology indigenous affect the diffusion of this technology in Iran. Due to the complexity of diffusion of biomass technology in Iran, the system dynamic approach has been used to show the effects of important adoption variables on the system.

1. Introduction

The energy demand has increased dramatically in the recent decades. Fossil fuels and nuclear power have dominate role in the world energy system. This bring challenges of energy supply, environmental effects, security issues, etc. for the both developing and developed societies. To response the challenges governments have provided different strategies. Diffusion of renewable energy resources (RER) is an important strategy, in particular after the first energy crisis in the world. Free, renewable, eco-friendly, and clean are the important advantages of RERs compared with other fuels. However, the diffusion and adoption of RE utilization has faced with challenges, in particular for fossil fuels exporters. While the oil, gas, and coal exporters have limit fossil sources, the economy of some of them like Iran has high dependency on the exports of these fuels. However, the energy domestic consumption growth in Iran has caused that the government starts to think about the utilization of renewables. Due to the high potential of the biomass energy Iran, in particular in the rural areas, this source can be a good replacement source. However, the low share of RERs shows that diffusion of RERs is not easy in Iran.

2. Literature Review

An economy is developing when more products and services are produced for consumption. Therefore, the governments not only have tried to keep a high level of the economic growth, but also they try to speed it for long term. As the energy is an input of products and services, increasing in products and services production means more demand for energy. Therefore, energy is one of the main factor of social and economic development in the societies.

Studies show that fossil energies cover around 80% of the world primary energy supply [1]. Increase in energy prices, volatility and uncertainty in supplying energy, and political factors are challenges of energy security. Therefore, utilization of alternative renewable energy sources is one of the solutions to maintaining competitive advantage and economic growth. The potential of renewable energy sources is enormous and can meet the world energy demand. Due to the limitations, supply risks, and environmental effects of fossil fuels, the utilization of renewable energy technologies, in particular, sources such as solar and wind power have been the subject of much interest within governments and policy makers. Given the developments of renewable energy technologies, the market opportunities of renewable energy products and services have been rapidly increasing and the advantages have been established for emerging renewable energy markets.

2.1. Overview on Renewable Energy Sources

2.1.1. Biomass

Biomass is obtained energy from plants or plant-derived materials. Wood is the largest biomass energy source from forestry, arboricultural activities or from wood processing

* Corresponding Author:
E-mail address: alireza.aslani@ut.ac.ir

Received: 12 March 2015; Accepted: 22 June 2015

[2]. However, there are other categories of biomass including crops, agricultural residues, co-products from manufacturing and industrial processes, and food and industrial wastes.

As a renewable energy source, biomass is used for combustion to electricity generation or heat production or various forms of biofuel. Approximately 62% of renewable energy utilization is for biomass that mainly use for heating. Biomass combustion is used for heat and power generation from wood, organic waste products, etc. Biomass is changed to biofuel by different methods such as chemical, thermal, and biochemical methods. According to the IEA energy statistics, total amount of biomass and waste utilization in primary energy supply was 1240 Mtoe in the world with the share of 10.2% in 2009 [3].

2.1.2. Hydropower

Hydropower refers to using water for electricity generation. Water behind the dam flows and turns a generator to produce electricity through a turbine. Hydropower is a flexible source from the power grid operation aspect. In fact, generated electricity and reservoirs by hydropower can meet sudden fluctuations in demand or help compensate for the loss of other supply options. According to the IEA energy statistics, total amount of hydropower utilization in primary energy supply was 280 Mtoe in the world with the share of 2.3% in 2009 [3]. Large-scale hydropower provides 21% of electricity generation by RERs. The main sources of electricity generated by hydrpower are large dams. However, some hydropower power plants in the rivers use canals to channel water through a turbine [4]. Indeed, the small or micro hydroelectric power system can generate electricity for private usages at homes or farms.

2.1.3. Wind Power

Wind power is the fastest growing and most attractive technology compared with other RERs. From engineering viewpoint, wind power is dependent on the cube of the wind speed within the operating range [5]. This means wind turbines commonly operate with the speed of 2.5 to 25 m/s and are not available at times of low or very high wind speeds. To capture the most energy, turbines are mounted on tall towers with two or three blades. The output of a wind turbine depends on the location and capacity factor and is variable in time-scales from minutes to hours or seasonal. According to the IEA energy statistics, total amount of wind power utilization in primary energy supply was 273153 GWh in the world in 2009 [3].

2.1.4. Solar Power

Technologies of the solar power provide heat, light, hot water, electricity, and even cooling for different sectors. Solar energy can be utilized in two main frames: solar photovoltaics (PV) and solar thermal. Photovoltaic (PV) is a technology to electricity generation by converting solar radiation into direct current electricity using semiconductors and solar panels. According to the IEA energy statistics, total amount of world's solar power utilization in primary energy supply was 20155 GWh in 2009 [3].

2.1.5. Geothermal

Geothermal is thermal energy produced and stored in the Earth. It range from shallow ground to hot water and hot rock found a few miles under Earth's surface and deeper to the extremely high temperatures of molten rocks [2]. Most geothermal power is generated using steam or hot water with three main technologies including direct-use system, use of deep reservoirs to generate electricity, and geothermal heat pumps. Geothermal heat pumps is the main technology of this source. The system of geothermal heat pump include a heat pump, a heat exchanger, and an air delivery system. The heat is removed from the heat exchanger and pumped it into the indoor air delivery system in winter. The process is reversed and the heat is removed from the indoor air into the heat exchanger in summer. The heat removed from the indoor air is used as a source of hot water for summer [2]. Indeed, according to International Geothermal Association (IGA) , the total world's electricity generated by geothermal power was 67,246 GWh in 2010 [6].

2.2. Biomass Dispersion

According to the statistics, around 13% of world primary energy is supplied from renewable energy sources in 2005 that the share of biomass was 79.9% (most share is wood). Biofuels such as bioethanol, bioethanol and biodiesel have been considered in many countries. Brazil has replaced a large part of its gasoline consumption with renewable fuels. Also these types of fuels have been used as a replacement for gasoline and MTBE (an additive to gasoline to improve its combustion) in United States, part of Europe, America, Africa, and recently in Asia. It is predicted that the share of renewable energy in transport sector is increasing. bioethanol annual production is exceeding 33 billion liters in the world in 2005 that the share of each America and Brazil was 15 billion liters. Also the share of the Germany was 1.9 liters in this year [7]. Iran has the 99th rank in GDP per unit of energy use (a measure of efficiency in the use of energy) among all countries. This means that energy consumption in Iran is not efficient and the main part of the energy is not consumed in the industry.

Besides new and efficient biomass Flogies and providing competitive price, having good marketing and costumer trust are key factors that could be obtained from external information sources and contribution of word of mouth encounters.

2.3. Biomass Power Generation Technologies

In order to analyze the use of biomass for power generation, it is important to consider three critical components of the process:

- Biomass feedstocks: They come in a variety of forms and have different properties that impact their use for power generation (Table 1).
- Biomass conversion: This is the process by which biomass feedstocks are transformed into the energy form that will be used to generate heat and/or electricity.

- Power generation technologies: There is a wide range of commercially proven power generation technologies available that can use biomass as a fuel input.

The source and sustainability of the biomass feedstock is critical to a biomass power generation project's economics and success.

Bioenergy can be converted into power through thermal-chemical processes (i.e. combustion, gasification and pyrolysis) or bio-chemical processes like anaerobic digestion [8].

Table 1. Biomass Feedstock [8]

Rural	Urban
Forest residues and wood waste	Urban wood waste (packing crates, pallets, etc.)
Agricultural residues (corn stovers, wheat stalks, etc.)	Wastewater and sewage biogas
Energy crops (grasses or trees)	Landfill gas
Biogas from livestock effluent	Municipal solid waste food processing residues

Power generation from biomass can be achieved with a wide range of feedstocks and power generation technologies. Different feedstocks and technologies are limited or more suited to different scales of application (Figure 1).

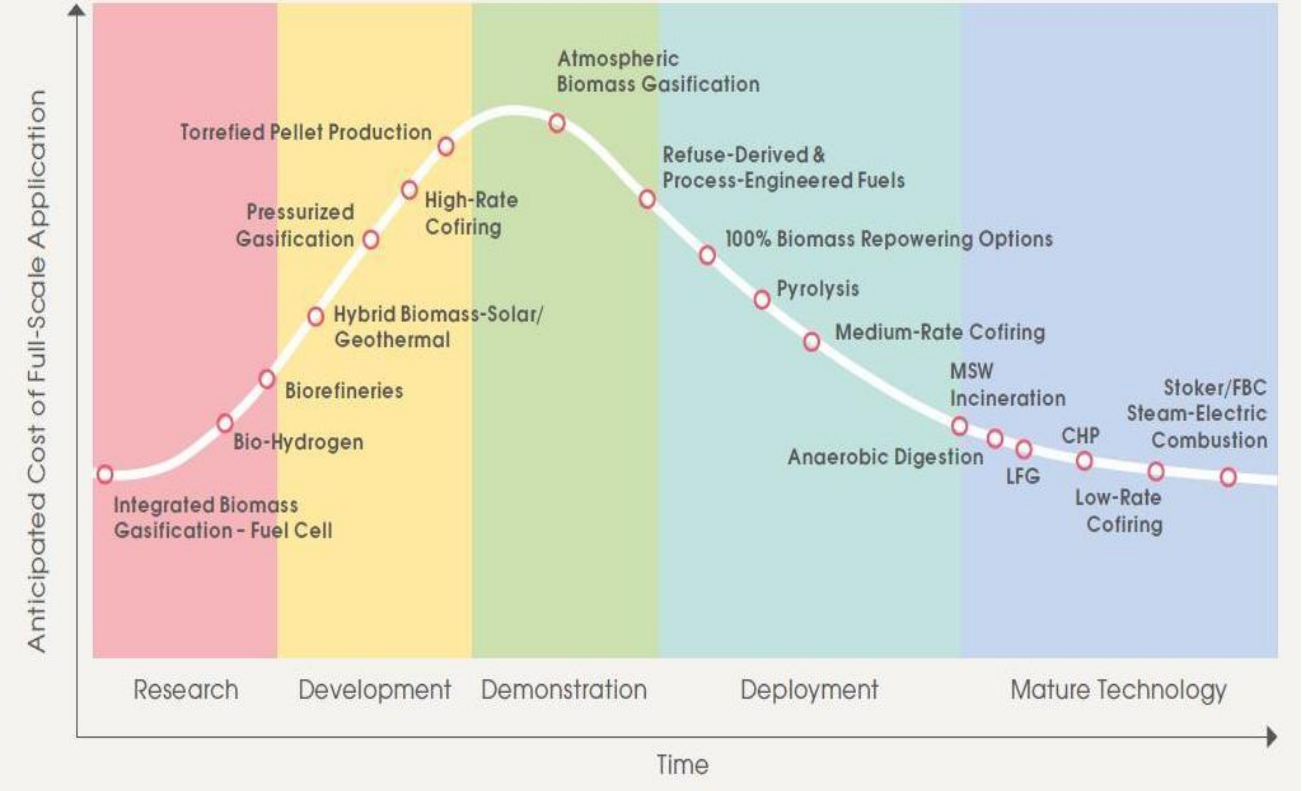

Figure 1. Biomass power generation technology maturity status [9]

2.4. Using System Dynamics for the Diffusion of Biomass

System Dynamics (SD) is a quantitative modeling tool that uses systems thinking to analyze the impact of feedback loops in complex dynamic systems. This paper uses SD to model and then simulate the dynamics of biomass diffusion for using in private cars. This work suggests extension of the Bass diffusion model for handling the adoption of biomass-based fuel by drivers. Therefore, this approach differs from those that focus on short period therefore considers factors that can affect on the adopters' ideas in a long term.

3. Analysis

3.1. The System Dynamics Model Description

Figure 2 is a causal loop diagram that represents the proposed diffusion model focusing the social and economic aspects affecting on biomass diffusion. This model is an extension of the Bass diffusion model. As shown in the figure, potential adaptors are car drivers who do not use of biomass fuel and their number increases with the arrival of new cars on the road with the rate of net added cars. Then they turn into buyers with the buyers' adoption rate. The buyers' adoption rate of the system represents the sum of the adoption by innovator and the adoption by imitator, affected by the net cost per buyer.

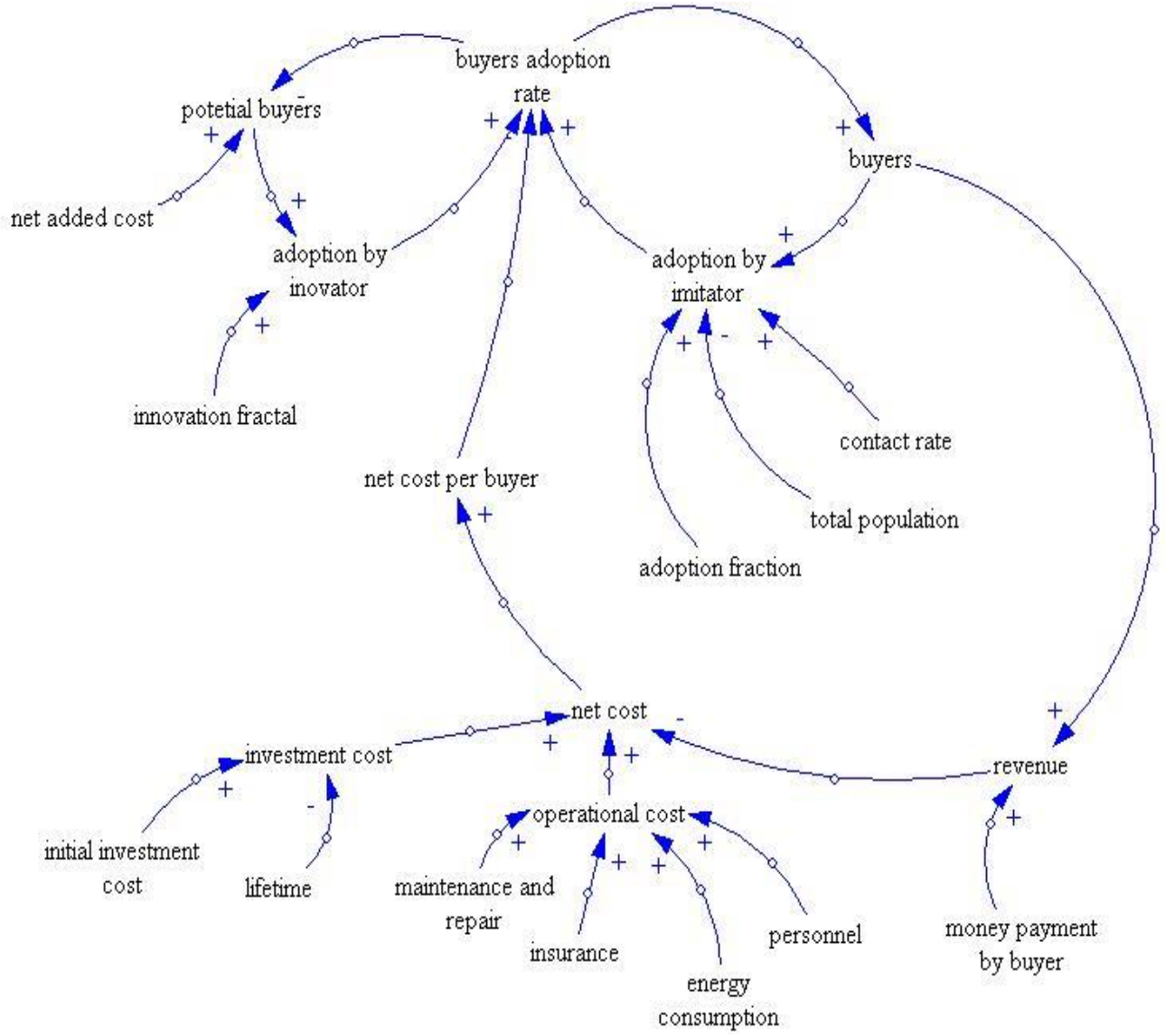

Figure 2. System dynamics causal loop diagram

Besides net cost per buyer that affect drivers' decisions, two factors of adoption by innovator and adoption by imitator influence on attracting costumer and providing costumer trust. We assume that potential adopters become aware of the innovation through external information sources whose amount and strength are almost constant over time. So the probability that a potential adopter will adopt as the result of exposure to a given amount of advertising and the volume of advertising and other external influences each period are constant. The advertising effect will be largest at the start of the diffusion process and steadily decrease as the pool of potential adopters is reduced.

Adoption by imitators state that new ideas spread as those who believe them come into contact with those who do not and persuade them to adopt the new belief and some are persuaded to try it or buy it themselves.

The adoption rate from advertising does not depend on the adopter population. When the innovation or new product is introduced, the adoption rate consists entirely of people who learned about the innovation from external sources of information such as advertising. As the pool of potential adopters declines while the adopter population grows, the contribution of advertising to the total adoption rate falls while the contribution of word of mouth rises.

Adopters and potential adopters encounter one another with a frequency determined by the contact rate. Word of mouth encounters that might result in adoption could occur by telephone, mail, email, or other remote means and do not require physical proximity. Not every encounter lead to adoption. The proportion of contacts that are sufficiently persuasive to induce the potential adopter to adopt the innovation is named the adoption fraction.

Figure 3 shows a stock- flow diagram that states Net cost per buyer has a negative influence on the adoption rate. Net cost is assumed the sum of the investment cost, operational cost including maintenance and repair,

insurance, energy consumption and personnel will be deducted from revenue acquired from the buyers.

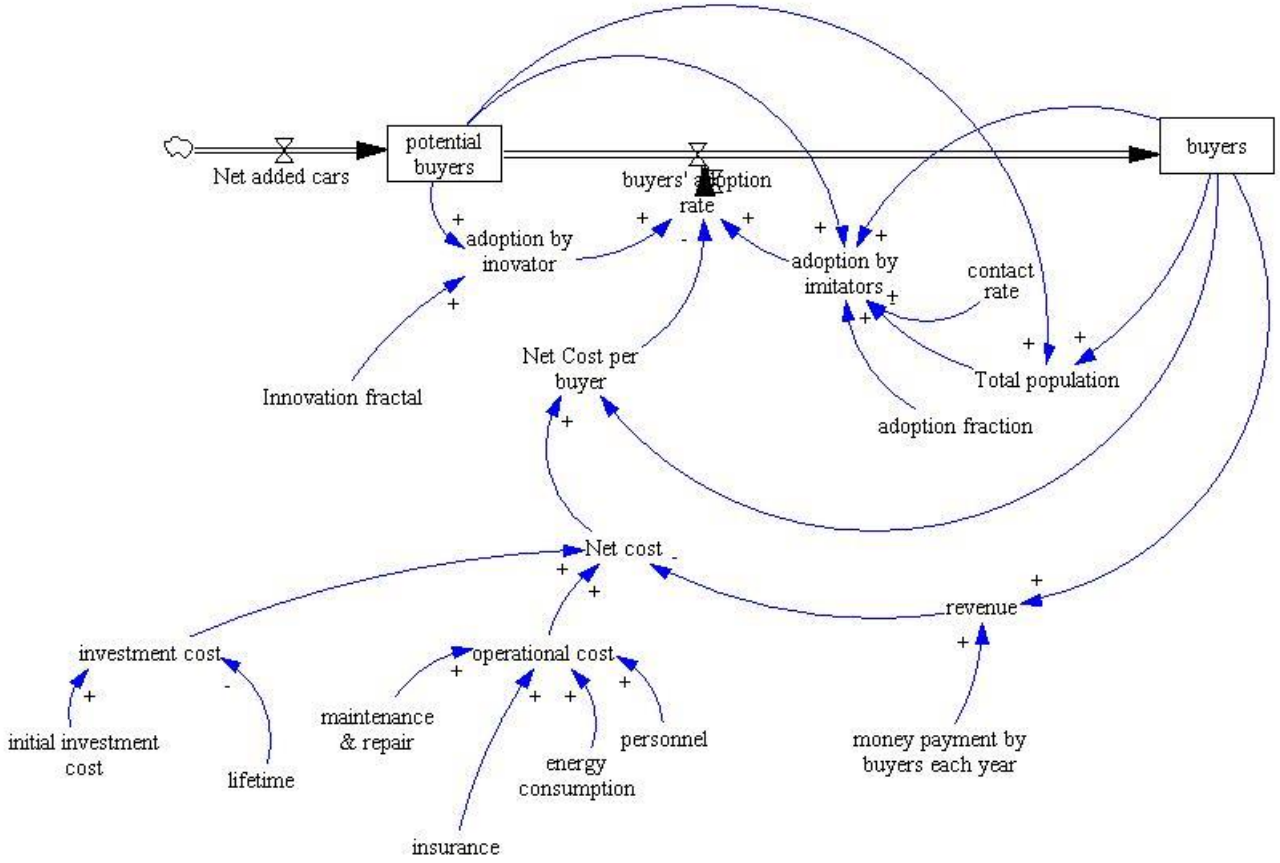

Figure 3. System Dynamics stock- flow diagram

Economic parameters analysis as net cost per buyer and also agents affecting costumer trust and social factors analysis specify buyer's adoption rate.

4. Conclusion

This article discussed about the strategic necessity for conversion from oil to renewable energy. Two system dynamics conceptual models were showed to present the effective factors on diffusion of biomass technologies in a region. Next researches can be done on mathematical modelling of the presented models. Indeed, dynamic analysis of other renewable energy technologies can be considered as future works.

References

[1] M. Yousef Jamali, A. Aslani, B. Farhang, M. Naaranoja, M. Dehghani Madvar Analysis of photovoltaic technology development based on technology life cycle approach, Journal of Renewable Sustainable Energy 8 (2016) 035905.

[2] World Energy Council. Renewable Energy Projects Handbook, World Energy Council, 2004.

[3] Energy Statistics, Share of total primary energy supply in 2009, International Energy Agency, 2009, http://www.iea.org/stats/pdf_graphs/29TPESPI.pdf

[4] Renewable Energy Sources in the United States, National atlas, 2013, http://nationalatlas.gov/articles/people/a_energy.html

[5] IRENA Handbook on Renewable Energy Nationally Appropriate Mitigation Actions (NAMAs) for Policy Makers and Project Developers, IRENA (International Renewable Energy Agency), 2012, http://www.irena.org/DocumentDownloads/Publications/Handbook_RE_NAMAs.pdf

[6] A. Holm, L. Blodgett, D. Jennejohn, K. Gawell, Geothermal Energy: International Market Update, Geothermal Energy Association, 2010, http://www.geo-energy.org/pdf/reports/GEA_International_Market_Report_Final_May_2010.pdf

[7] Renewable Energies Organization of Iran (SUNA), 2014, http://www.suna.org.ir/en/home.

[8] A. Michaelowa, B. Dransfeld, C. Blodgett, A. Galante, A. Basu, M. Eschmann, IRENA Handbook on Renewable Energy Nationally Appropriate Mitigation Actions (NAMAs) for Policy Makers and Project Developers, IRENA (International Renewable Energy Agency), Abu Dhabi, United Arab Emirates, 2012.

[9] EPRI. Electric Power Research Institute, 2011, http://www.epri.com/gg/newgen/disgen/index.html.