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Feasibility study on simultaneous generation of electricity and heat using renewable energies in Zarrin Shahr, Iran

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ABSTRACT

The increasing urban population and incorrect patterns of urban activities along with inappropriate development of cities have incurred significant damage to the environment and have faced man with numerous problems such as fossil fuels deficiency. The environmental problems owing to fossil fuels and increasing demand for energy have made the approach to renewable energies and the development and utilization of these sources more and more necessary. The development and promotion of renewable energies aid the realization of countries' developmental goals in economic, social, and environmental aspect which is one of the basic factors in achieving sustainable development in any country. Biomass is one of the sources that no acceptable assessment of its technical-economic production feasibility has been done yet in various regions of Iran. Biomass is of considerable importance among renewable energy resources and its usage in energy generation prevents pollution caused by its discharge into the environment along with generating clean energy similar to that obtained from other renewable sources. Since biomass is not well known as a source of energy generation in Iran and because there are no clear regulations concerning its use for this purpose, this paper used the HOMER software to study four scenarios of utilizing wind, solar, and biomass energies for the simultaneous generation of electricity and heat in ZarrinShahr located in Isfahan Province. Results showed that receiving electricity from the national grid is superior to the use of biomass if the under study place is less than 2.58 km away from access points to this grid. Otherwise, based on economic optimization performed by HOMER software, it is recommended that a hybrid system of renewable energy including a solar panel, a biomass-fuelled generator, two batteries and a converter at a cost of 1.019 $/kWh be used, in which 1955 kWh is generated by the solar panel and 92 kWh by the biomass-fuelled generator. According to the study of previous researches, no reviews have been made thus far on the use of dump load for the provision of electricity and heat in hybrid renewable energy systems.

1. Introduction

Following manpower, having sufficient energy sources is the main economic factor in industrial societies and cities (Jahangiri & Alidadi Shamsabadi, 2017, Jahangiri, Ghaderi, Haghani, & Nematollahi, 2016), since energy is a basic need for continuous economic development, social welfare, improved quality of life, and security of society. If energy is produced and consumed in a way that can guarantee, in the long run, the human development in all the economic, social, and environmental aspects, the sustainable energy conception will be realized. For these reasons, an increasing attention has been made by various developing and advanced countries to renewable energies with the aim of diversifying the energy sources, reducing the dependency on a single energy carrier, and appreciating environmental considerations to achieve sustainable energy.

Contrary to other reserves of energy that are concentrated in a limited number of countries, renewable energy sources are present in widespread geographical areas. Rapid deployment of equipment for utilizing renewable energy and energy productivity have been achieved due to the considerable energy security, reduced climate change, achieving sustainable social development and economic benefits that accompany renewable energy utilization (International Energy Agency, 2012; He, Xu, Pang, Tian, & Wu, 2016). This deployment can also reduce environmental pollution such as air pollution caused by burning of fossil fuels and premature death resulting from this pollution (Jacobson et al., 2015). According to the report published by REN21 in 2014, renewable energies contributed about 19% to global energy consumption compared to 2012, 9% of which was obtained from conventional

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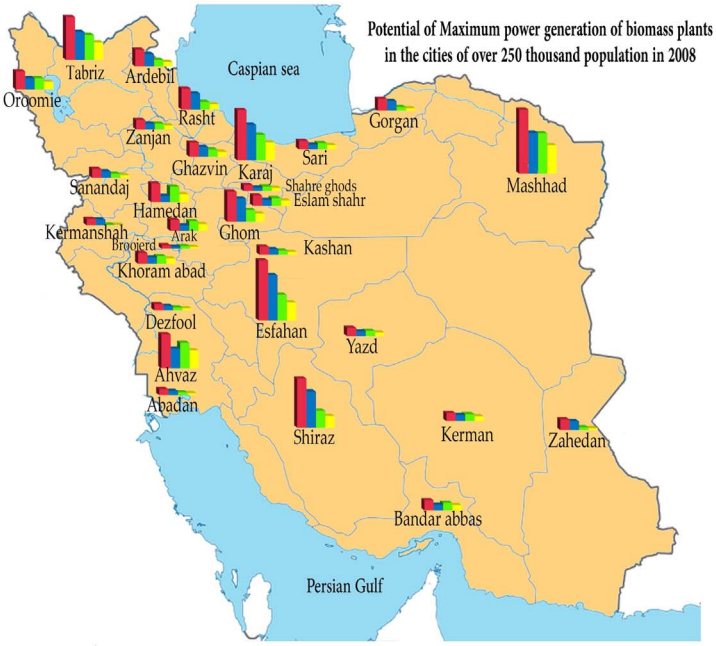

Name of cities	Pinc (MW)	Pslf (Mw)	Pad (MW)	Pslf (MW)
Abadan	2.12	1.53	1.03	0.72
Arak	3.91	1.95	3.44	2.43
Ardebil	5.95	4.48	2.42	1.71
Oroomie	6.5	4.03	4.06	2.86
Eslam shahr	3.64	2.08	2.74	1.92
Esfahan	21.16	16.02	9.06	6.39
Ahvaz	12	6.9	8.99	6.34
Borojerd	1.23	0.68	0.94	0.66
Bandar abbas	3.62	2.02	2.68	1.89
Tabriz	15.11	9.85	8.82	6.22
Tehran	110.8	80.37	51.04	25.99
Khoram abad	3.89	2.31	2.72	1.92
Dezfool	2.2	1.59	1.07	0.75
Rasht	7.42	5.7	2.79	1.97
Zahedan	3.81	3.15	1	0.71
Zanjan	3.41	2.19	2.12	1.49
Sari	3.05	1.73	2.26	1.59
Sanandaj	3.2	2.33	1.49	1.05
Shahre ghods	2.09	1.19	1.57	1.11
Shiraz	17.29	12.72	5.98	4.22
Ghazvin	5.11	3.58	2.63	1.85
Ghom	10.64	8.22	4.21	2.97
Kashan	2.92	2.05	1.52	1.07
Karaj	17.78	12.58	9.07	6.4
Kerman	2.85	2.14	2.46	1.73
Kermanshah	2.25	2.09	0.3	0.21
Gorgan	4.22	3.45	1.26	0.89
Mashhad	22.6	14.43	14.26	10.05
Hamedan	6.56	2.21	5.47	2.86
Yazd	2.98	1.66	1.9	1.34
Total	311.28	217.15	159.31	112.34

Legend:
(Pinc) Maximum capacity of waste incinerators plant power generation from input waste to landfill in MW
(Ppg) Maximum capacity of pyrolysis-gas plant power generation from input waste to landfill in MW
(Pad) Maximum capacity of anaerobic digestion power generation from input waste to landfill in MW
(Pslf) Maximum capacity of engineering landfill plant power generation from input waste to landfill in MW

Fig. 1. Maximum potential of electricity generation in the various types of biomass-fuelled power plants in cities with populations of over 250000 (Renewable Energy and Energy Efficiency Organization of Iran).

Fig. 2. Map of Iran indicating the city of Zarrin Shahr (Isfahan province is shown in highlight).

biomass, 4.2% from heat energy (non-biomass), 3.8% from hydroelectricity, and 2% electricity from wind, solar, geothermal and biomass energy sources (REN21, 2014).

The 2014 World Energy Outlook report by the International Energy Agency (IEA) predicted that renewable energy supply would increase from 1700 GW in 2014–4550 GW in 2040. Fossil fuels received about 550 billion dollars government subsidies in 2013, whereas the total subsidies for all renewable energies were 120 billion dollars (Tweed, 2014). It has been estimated that wind has the potential to generate five times the current world energy generation or 40 times the present global electrical energy consumption. This of course requires overcoming of all the practical obstacles that exist in the way of wind energy utilization and installation of wind turbines in extensive areas that have greater wind power, including coastal regions because average wind speed in these areas is about 90% more than the world average. Thus, coastal regions can generate far more energy than turbines installed inland (Archer & Jacobson, 2005). In 2013, wind and solar energy contributed about 3 and 1% of the total global electricity generation, respectively (BP Statistical Review of World Energy, 2014). Presently, wind energy is extensively utilized in Europe, China, and the United States. The capacity to use wind energy by installed turbines expanded from 2004 to 2014 and increased more than 7-fold from 47 to 369 GW, and installation of equipment for wind energy utilization globally reached a new record in 2014 (GWEC, 2015). Furthermore, it is predicted that solar energy will become the world's greatest source of energy generation by 2050, with solar photovoltaic energy and concentrated solar energy contributing 16 and 11% of the total, respectively. This will require the capacity in installing PV to increase to 4600 GW, more than half of it in China and India (International Energy Agency, 2014).

As an energy source, biomass can be directly used to generate heat through combustion or indirectly utilized after being converted into various forms of biofuels. The total primary energy supply obtained from biomass reached about 57 EJ in 2013, of which about 60% comes from conventional biomass and the rest from modern biomass including solid, gaseous, and liquid fuels. Biomass is mainly used in heat generation so that heating capacity for modern biomass has increased by 1% and reached 296 thermal GW. Global capacity in generating electricity from biomass has risen from 5 to 88 GW and electricity generation from biomass (including combined heat and power systems or CHPs) reached 400 TW in that year, and demand for modern biomass in solid biofuels production including pellets has increased (REN21, 2014).

Recent studies conducted with the help of the HOMER software on