Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 103 (2016) 419 – 424

Energy Procedia

Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid, 19-21 April 2016, Maldives

Multiple source sustainable hybrid micro-grid for urban communities: A case study in UAE

Mohammed Noorul Hussain[a], Isam Janajreh*[a] and Chaouki Ghenai[b]

[a]*Masdar Institute, Masdar City, Abu Dhabi 54224;* [b]*University of Sharjah, Sharjah 27272, UAE*

Abstract

Increasing pollution and depleting resources continue to be a growing problem to the environment and sustainability. Renewable sources of energy such as solar, wind and biofuel provide the advantage of scalability from small to very large applications. Integration of renewable energy to urban communities poses technical, economic, and logistic challenges. In this work we consider implementing a micro-grid powered by renewable energy sources to substitute a fraction of energy usage of an urban residential community in Abu Dhabi, UAE. The community is considered to have integrated photo-voltaic rooftop solar, horizontal axis wind turbine and waste cooking oil converted biodiesel power plant systems. This micro-grid system was evaluated for its technical and economic feasibility. Result showed that higher power share from the micro-grid is neither practically nor economically feasible due to low cost of electricity. Integrating wind energy also resulted in poor feasibility because the area is characterized with poor wind energy potential. The best hybrid system for such a community would be one powered by solar and biodiesel.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid.

Keywords : Sustaniable communities, Solar energy, Wind energy, Waste cooking oil, Biodiesel

1. Introduction

Increasing pollution and depleting resources continue to be a growing problem to the environment and sustainability. It is high time for a paradigm shift in the way we generate and use energy. There are already huge initiatives being taken in the world to use cleaner sources of energy. Several countries have defined targets to replace their conventional sources with cleaner and renewable energy sources. We feel that it is not enough to have only big central power plants, there is also a need to have distributed power generation plants within or close to cities and inhabitations.

* Corresponding author. Tel.: +971-2-810-9130; fax: +0-000-000-0000 .
E-mail address: ijanajreh@masdar.ac.ae.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, REM2016: Renewable Energy Integration with Mini/Microgrid.
doi:10.1016/j.egypro.2016.11.309

Such plants reduce the burden on governments by bringing in communities into the mainstream. To reduce further damage of environment, communities must be the drivers of change. In the least they can contribute by adopting strict sustainable measure and policies. To create a big impact the role of communities should take a transition from consumers of energy to producers and generators. Solar, wind and biofuels have the advantage of scalability. One way to benefit from this aspect is having small power generation systems employing either one or combination of the three resources in urban communities or rural inhabitations. This reduces many issues related to logistics and also reduces heavy losses that occur in transmission systems. Such systems with hybrid micro-grids can be integrated to central grids or be maintained as standalone grids depending on the amount of power generated.

The idea of having renewable energy sourced hybrid micro grids has been evaluated by few earlier researchers. Abdilahi et al. [1] conducted a feasibility study of PV solar, wind and diesel generator hybrid system in an urban center in Somaliland. They determined that such a system has the prospect of achieving 58% of renewable energy source penetration, 30 % reduction cost of energy and 25 % reduction in net present cost. The feasibility studies of Sivarasu et al. [2] of solar and wind hybrid system in India found that the cost of such a plant of capacity 1 kW would be close $2,500 and would have a payback period of 6-7 years. Patterson et al. [3] studied the hybrid micro grid with solar photovoltaic and fuel cell systems which can be used to charge electric vehicles. They found that having a PV with battery storage and fuel cell combination for the micro-grid is better in terms of micro-grid autonomy. However economically, the Net Present Cost was a little lower, when compared to micro-grids with just the fuel cell.

The UAE despite its position as fifth nation in Oil and Gas production and reserve, they have committed to achieving a renewable energy target of 7% by 2020. The renewable sources of wind and solar have shown good prospects in the UAE [4] [5]. In this work we study the feasibility of a hybrid solar, wind and biodiesel based micro grid for the Al Raha residential community in Abu Dhabi which is fully inhabited 10 year old development and consists of 1,400 villas and nearly 7,000 people [6]. The solar energy is considered to be harvested by rooftop PVs, the wind energy is from horizontal axis wind turbines and the biodiesel is considered to be a conversion product of the waste cooking oil (WCO) generated within the community from a conversion unit. This system will be studied for its technical and economic feasibility.

2. **Methodology**

The aim was to evaluate the optimum technical combination of the energy resources so as to have the best economic and energy sustainable model. *Firstly*, the electric consumption of the community was determined based on the statistical data of the UAE. *Secondly*, the waste cooking oil production of the community was determined from a short survey consisting of questions on amount and type of cooking oil used. This survey was distributed to about 100 people and 10 restaurants. Using this survey broad generation figures were obtained which were used to calculate the chemical requirements, such as methanol and sodium hydroxide, for the conversion process. It was also used to calculate the biodiesel production based on optimum parameters and conditions as per undergoing collection/conversion/utilization drive that is undertaken and managed by the authors and recent literature. *Thirdly,* the wind and solar energy of the region is assessed. The wind potential was evaluated based on several years of wind data records collected at the Masdar Institute field station which is located 1km distance from Al-Raha community. The mean wind speed and the Weibull shape parameters were used to calculate the capacity factor of commercially available wind turbines. The wind turbine selection was subject to the best capacity factor for the required power. The solar energy assessment was carried out using standard parameters of commercial solar panels and local historical irradiation of the region. *Fourthly*, and after the individual energy source is assessed the substitution percentage of renewable energy was determined. The number of solar panels per home and the number of required wind turbines for the community were major feasibility factors in determining the best hybrid model for this community. *Finally*, an economic analysis was carried out to find the investment requirement per villa, the energy savings, the cost savings and the payback period.