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Renewable energy sustainability with micro Hydro systems in Fujairah (UAE)

Amir J Majid

Ajman University, UAE

Abstract

Due to water scarce in Fujairah, several small dams and sand barriers were built to store water, prevent occasional flooding damage as well powering underground water beds. These water reservoirs are oversized 90% of the time. In this paper, a smart grid of multi micro hydro system is proposed to satisfy water and electricity demand for scattered mountainous villages in an optimal manner, by channeling water into needed reservoirs. Sustainability is to be achieved with micro hydro and wind/ solar hybrid systems which have been analyzed on aspects, such as environment, solar and wind regimes, existing mountainous reservoirs and dams, seawater desalination, as well as economic feasibility. This would in effect, reduce the dependency on federal electricity supply for Fujairah and surroundings, where notably a large number of residential and industrial installations are still in shortage of electricity. This work can be implemented as a future project. Firstly, in order to analyse the wind regime in Fujarirah area, a pilot hybrid solar-wind turbine, is used to calculate the daily, monthly and annually average generated electrical power. This set-up maybe reused in the field again in same region or other regions. Similarly, it is used to analyse the solar insolation in Fujairah area around mountainous areas. Thus, a feasibility study is to be conducted for the possibility of installing the proposed micro-hydro systems with accessory installations, such as solar-wind, magnetic generator, charging batteries, etc. as well as setting up a grid connection with this hybrid system.

Introduction

Water Resources and Dams of Fujairah

The mean annual rainfall in the UAE is about 100 mm, ranging from less than 40 mm around southern desert to about 160 mm in the north eastern mountains in Fujairah. Almost 90% of rainfall occurs during the winter (October-March) and the wettest month is February. Spring and summer witness only occasional fixed heavy rainfall. The rainfall delivery is highly variable over space and time. Rainfall tends to be more reliable in the north-eastern mountain region, as depicted As such, the total annual surface runoff composed from rain is about 150 million m3 , but there are no perennial streams. The average annual groundwater recharge is about 120 million m3 , most of which comes from infiltration from river beds. The total groundwater abstraction is around 1500 million m3 . This means that groundwater reduction probably amounts to almost 1500 million m3 /year. However, this figure does not consider the possible annual recharge of groundwater entering from neighbouring places. In any case, the over-extraction of groundwater resources has led to a lowering of the water table by more than one meter on average during the last two decades, while seawater intrusion is expanding in the coastal areas.

To increase the groundwater recharge, a number of dams have been built at various locations across the country. There are more than 50 dams and embankments of various aspect having a total storage capacity of over 100 million m3 . While most of these dams are basically built for recharge purposes, they also provide stability against damage caused by flash floods. There are also about 50 desalination plants with a total installed capacity of around 800-1000 million m3 /year, while total actual production is 50-70 % of it. Further, it is predicted that about 1000 million m3 a year of wastewater were produced in the urban areas, of which 25% of them were treated and reused.

Total water withdrawal was predicted at 10 billion m3 a year. Over 75% of the total water withdrawal was groundwater. Agricultural water withdrawal for crops was 5 billion m3 a year (all from groundwater), while landscape irrigation used 10% of it (all treated wastewater). Total water withdrawal for domestic and industrial purposes was predicted at 1 billion m3 (25% and 10% of total water withdrawal, respectively), of which 500 million m3 or 60% consisted of desalinated water and the remaining part of groundwater.

Renewable Projects Model for Water Sources

Whereas solar energy in Fujairah is highly applicable with up to 100% rate, the wind regime is unpredictable. In general steady wind energy is unavailable, yet occasional galls and gusty high speed winds blow for days. Fujairah gets both north western winds in winter and tropical winds in summer. There has been no detailed study on the wind energy in Fujairah, which has long open sea sides, as well as many mountainous areas with winds channeled through valleys. There is an space to measure and test wind energy with pilot wind turbine systems, whilst utilizing

Renewable projects for water resources

Around 50 small dams were built to establish water reservoirs for irrigation and drinking purposes. In order to accrue larger water reservoirs in the mountainous areas, it is suggested to connect them with channels of water pipelines, with reversible compressors electrified by both solar and wind renewable energy systems. These compressors can achieve as micro hydro systems for producing electricity when water heads were available.

Renewables systems in Enhancing Electric Grid

Above planed model can further be promote to generate electricity to enhance the national grid. The normal wind regime is highest at nights, whereas solar during day hours, which both may contribute towards charging all water reservoirs to be discharged during the day. As a result, extra electric power can be added to the grid, both to overcome short peak s as well long time steady-state demands. The added electric power is a twofold supply option; either local power demand can be supplied by the individual smaller-size micro hydro system due to header variations, or through one larger hydro system discharging to sea by gravity. In the latter case, it is estimated that for N micro hydro systems of Pi power generation capacity, a maximum of ΣP_i, $i=1$□N is added. The following model is formulated for the above system: For N reservoir systems sorted according to their vertical levels, sorted from $i=1$ the lowest to $i=N$ the highest, with Q_i and D_i being the particular power capacity and special power demand respectively

Renewables in Remote Places

With the above model in use, remote mountainous villages can be supplied by part or whole electric power produced by wind and solar hybrid systems already installed for the specific micro hydro systems, depending on load demand. As such, it acts as a smart grid arrangement, by either supplying the main hydro system of bulk reservoir storage and header, or channeling water compressors, or supplying local load demand. The specific micro hydro systems can also supply local demands, depending on availability

with this isolated arrangement, demands of either electricity or water can be met with both hybrid systems as well as the micro hydro system. Supplying water and electricity demands locally has the advantage to avoid losses, both electrically and mechanically, as well as avoiding extra electrifying installations in harsh environments.

Several scenarios arise with this dynamic agreement that requires optimization control system. For example, locating a micro hydro system at a particular site involves both fixed and variable costs. The following model yields the optimum, location and size of plant.