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Designing Portable Micro - Hydro for Small Scale Hydro Power Plant Construction

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ABSTRACT

Most of the time diesel generators are the sources of electricity for electrical devices during a small-scale hydro power plant construction. The use of such diesel-fueled generator is becoming problematic due to costly and environmental pollution. In this study, a new concept of Designing Portable micro-hydro generator for small-scale hydropower system construction is proposed to overcome the stated problems. To make the research more feasible and acceptable two case studies (Naso and Wanja) were taken for detail analysis. During designing of portable micro-hydro power generator components, 0.25-1m^3/s propeller turbine, 19KVA three phase induction generators and 12.5KW Induction generator load controller has been selected. The total electric consumption of the electrical devices during small-scale hydro power plant constructions, total investment cost of the new project and total energy harvested per year by portable generator was calculated as 8kw, $5,297.4 and 29,200kwh respectively. The unit energy cost of portable micro-hydro power plant is found $0.18/kwh whereas the unit energy cost of diesel generators is $0.23/kwh. From this, it is clearly indicated that the unit energy cost of portable micro-hydro power plant is cheaper than diesel generators, on the other side 52.04 tones of CO_2 can be avoided if the new system would be implemented.

Key Words: *Electricity, Portable Micro-Hydro Generator, Diesel Generator, Unit Energy Cost and Green House Gas Emission*

1. INTRODUCTION

The world is entering to a new chapter in green energy generation, reducing CO_2 emissions, increasing energy security and enhancing sustainability. Nowadays, the utilization of renewable energy sources (RES) are increasing too matches because of the environmental concerns, fossil fuels depletion, economical and social aspects. In Ethiopia, there are many small-scale hydropower potential sites, which can be used to produce electricity for small villages of the rural areas which are so far from national grid [1], [2] and [3]. During construction of this small-scale hydro power plant, the diesel generators have to be replaced with some other alternative green energy sources to avoid high unit energy cost and environmental pollution. To overcome the specified problems the researchers was proposed a portable micro-hydro power plant (**PMHP**) as a source of electricity for electrical devices during a small-scale hydro power plant construction. In this portable micro hydro power plant, Induction Motors with capacitors are used instead of synchronous generators. This is mainly because it is much cheaper, simple, widely available, and robust and requires little maintenance. Induction generator controller (IGC) was proposed to maintain the voltage within the standard limits [2], [4], [5] and [7].

2. DESIGNING COMPONENTS OF PMHP

Before going to design the components of proposed portable micro-hydro power plant for small-scale hydropower plant construction, it is must to have clear and exact information about the possible ratings and types of electrical loads during small scale hydro-power power plant construction.

Accordingly, the total electric consumption of electrical loads during small-scale hydropower plant construction was 8kw.

2.1. Designing Civil works of the PMHP

Flow rates at Wanja and Naso is 0.25 m^3/s and 1m^3/s respectively. Designing values of Intake weir, Headrace canal and penstock tank at Wanja and Naso are A= 0.2m^2 and 0.8m^2, H=0.28m and 0.57m, L=30m and 40m with Dp=100mm and 400mm respectively.

2.2. Designing Electro-Mechanical of PMHP

0.25-1m^3/s propeller turbine, 19KVA three phase induction generator, 12.5Kw three phase induction generator controller **v** pulley belt are used.

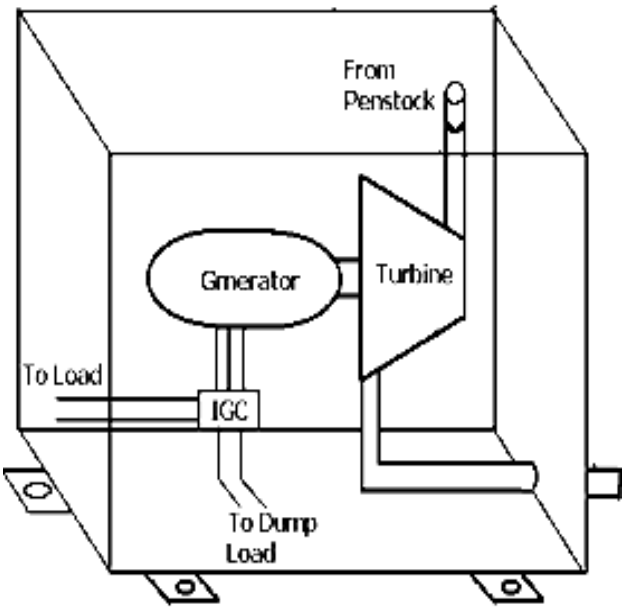

Figure 1: Model of PMHP

3. COST AND IMPACT ANALYSIS

As any other investment projects the economic feasibility of the portable micro-hydro for small scale, hydropower construction must be sound full and attractive for the customers. Even though the cost of the new proposed electricity generation system depends on geographical topology of the specific site, generating equipment, transmission lines, distribution feeders, protection mechanism and control system. Due to environmental issues, traditional life style and desistance of main grid from construction site, the new idea proposed in this study is more interesting, sound full and easily accessible for customers.

3.1. Unit Energy Cost ($/kwh) Calculation

The unit energy cost calculation is done by considering the total expenses for the portable micro-hydro generator and total energy harvested from this portable micro-hydro generator. The total annual cost for the proposed portable micro-hydro power plant is $5,297.4 and the total energy produced from this power plant is 29,200kwh. Therefore the unit energy cost (UEC) of the portable micro-hydro power plant can be calculated using the following empirical formula as follow.

$$UEC = \frac{\text{Total annual cost}}{\text{Energy produced per year}} \qquad (1)$$

$$UEC = \frac{\$5,297.4}{29,200\text{kwh}} = \$0.18/\text{kwh}$$

3.2. Green house gas emission (Em)

This indicator tells how much green house gas has been avoided by using the PMHP schemes as a power source in comparison to diesel power generators in construction. Reduction of green house gas emission is one of the criteria for the renewable and sustainable energy projects to be used as a key for sustainable economic development. Purely quantitative measure which is developed by International Department of Climate Change and Energy Efficiency organization guideline, the guideline, DCCEE, 2011.

$$E_m = \frac{Q*EC*EF}{1000} \qquad (2)$$

Where:

E_m: Total CO_2 emissions released in tones
Q: The quantity of fuel combusted in kL
EC: The energy content factor of the fuel in GJ/kL (38.6GJ/kL, DCCEE, 2011)
EF: The emission factor for the fuel in Kg CO_2/GJ (69.5 CO_2/GJ, DCCEE, 2011)
For diesel fuel consumption (FC) of the generator, the following log correlation has been used.

FC (L/kwh) = -0.03ln (η%) +0.2514 (3)

Quantity of fuel combusted will be calculated from time of use and capacity of the generator once the fuel consumption is obtained from the above relation. Hence, based on the amount of emitted CO_2 it will be clear that how much GHG emission has been saved from being released to the climate, which in turn tells as about the renewability and the sustainability of the project under investigation.
Generator working capacity = 0.85*10kw

= 8.5kw

Fuel Consumption = -0.03(ln(0.85))+ 0.2514

= 0.26L/kWh

Quantity of fuel consumed (Q) by generator

Q = 8760hr*8.5kw*0.26L/kwh = 19.4kL

For the given values of EC = 38.6GJ/kL and EF = 69.5 CO2 /GJ for stationery energy production purpose from the department of Climate Change and Energy Efficiency, the amount of CO_2 being avoided if PMHP is used instead of diesel generator can be calculated using equation 2.

$$\mathbf{E_m = \frac{19.4kL*38.6GJ/kL*69.5\ CO2\ /GJ}{1000} = 52.04}$$

Therefore the new PMHP can avoid 52.04 tones of CO_2 per year per generator from the environment.

4. RESULTS AND DISCUSSION

PMHP is highly competitive, economical, environmentally friendly technology. It should be underlined that, when compared to a diesel generator set, portable micro hydro generator can experience less running, maintenance cost and green energy. The investment cost for installing a diesel generator set is so low but maintenance and operation costs are comparatively high.

In PMHP the average unit energy cost is $0.18/kwh where as the average unit energy cost of the existing diesel generators excluding transportation, operation and maintenance is $0.23/kwh. The other issue of this research is how to make the world free of pollution during electricity production. If the new proposed PMHP would be implemented instead of diesel generators, 52.04 tones of CO_2 per year per generator will be avoided. Imagine how many generators are there for small scale hydro power plant construction in the country as well in the world and how much CO_2 can be funded to the environment from this bulk of diesel generators all over the world?

5. CONCLUSION

Finally to come to the main objective, the following specific tasks have been done. The first task was, is it possible and feasible to implement the proposed idea? Yes! it was tried to see the case for two specific studied micro hydro sites and finally the study results indicating that the idea is acceptable and can be implemented for the stated study sites. Following the total electrical power demand of electrical devices during hydro construction has been assessed and finally found 8kw. During designing of portable micro-hydro generator components, 0.25-1m^3/s propeller turbine, 19KVA three phase induction generators and 12.5KW Induction generator load controller has been selected. The total electric consumption of electrical devices during small scale hydro power constructions, total investment cost of the project and total energy produced per year by the portable generator was calculated as 8kw, $5,297.4 and 29,200kwh respectively. The unit energy cost of the portable micro-hydro power plant is $0.18/kwh where as the unit energy cost of the diesel generators is $0.23/kwh. From this it is clearly indicates that the unit energy cost per kwh of the PMHP is cheaper than the unit energy cost of diesel generators, on the other side 52.04 tones of CO_2 emissions will be avoided.

Bibliography

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