RENEWABLE ENERGY POTENTIAL FROM MICRO HYDRO FOR TECHNO-ECONOMIC UPLIFT – A BRIEF REVIEW

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ABSTRACT

Modern world requires energy more than ever. As the global population and modernization exhibit seemingly ever upward trends, it is certain that the crave for energy will continue to rise. However, conventional energy is depleting at an alarming pace, though renewable energy seems to prospect a promising alternative. Being one of the more established and successful renewable energy technologies, the authors attempt to review the micro hydro as well as its potential in providing sustainable energy to the mankind.

Keywords: renewable energy, micro hydro, sustainable energy

1. INTRODUCTION

The industrial revolution that occurred about a couple of centuries ago has drastically transformed each and every aspect of human activities [1]. Since then, various products, tools and devices are created and perfected to facilitate human activities and improve livelihoods. Nowadays in these modern societies, cars, phones, air-conditioners, lifts and lightings are some of the good examples that have become inevitable necessities to human. More so, numerous types of sophisticated machines and robots have been invented to perform tasks otherwise impossible or too dangerous to be carried out by human alone. Though these inventions provide great conveniences and possibilities to mankind, they all need energy to function – be it in the form of fuel, electricity or battery.

It is not exaggerating to claim that modern world as we are in now will not move without energy. Literally every aspect of human activities such as industries, agricultures, constructions, trasportations and communications require energy to perform or operate. All will come to a complete halt with the absence of energy [2]. Therefore, it is of prime importance for every modern society and nation to secure a sufficient, accessible and reliable energy provision [3].

As the human population and activities are progressively developing, it is most certain that the demand for energy worldwide is increasing as well – and this trend is most likely to continue in the future [3, 1]. As of now, conventional energy such as fossil fuels, firewood and nuclear power are still the primary energy sources consumed by the human [4, 5, 6]. According to America's Department of Energy (DOE), fossil fuels provide more than 85% of all the energy used in the United States, while more than 99% of the automobiles use oil as fuels [5, 7]. As for Malaysia, the total electricity generated in 2003 is around 79 billion kWh, for which 87% is thermal and remaining 13% is hydroelectric [8].

2. CONVENTIONAL AND RENEWABLE ENERGY

Conventional energy sources include fossil fuels, firewood and nuclear power. Fossil fuels refer to coal, oil and natural gas, which is the type of conventional energy sources that all modern societies consume the most. Conventional energy sources are comparatively inexpensive and require developed and established technologies that can produce sufficient and reliable energy to major cities around the clock [5, 6]. However, all types of conventional energy sources – fossil fuels, firewood and nuclear power included – have some grim drawbacks. The pollutants release by burning fossil fuels and firewoods and the radioactive residue of nuclear power generation are hazardous to all lifeforms. Moreover, conventional energy sources are diminishing rapidly – since the total capacity of fossil fuels, firewood and nuclear power on earth are finite. The exhaustion of conventional energy sources and the rising demand have compelled the planners and policy makers to look for alternative resouces [2].

Through various efforts, it seems that renewable energy is the best answer for the energy crisis. Unlike conventional energy sources, renewable energy sources are abundant in nature and easily accessible to mankind around the world. They are and will always present on earth whether being harnessed or not [2]. In addition, renewable energy is available in wide range, which includes but not limited to solar, hydro, wind, wave and ocean thermal energy [5, 9]. All these sources of energy are renewable; they replenish themselves and are virtually inexhaustible [2]. However, most renewable energy technologies are relatively new and still undergoing development. Moreover, unlike

conventional energy, renewable energy is expensive and functional under certain circumstances only; for example, solar plants require sunny days while wind mills require windy days [5]. More efforts are required to develop renewable energy into viable and competitive alternatives to conventional approaches [9]. As a matter of fact, in 2005, only 2% out of 17,450 TWh worldwide electricity generation came from renewable energy sources such as small hydro, wind and geothermal [3]. Nevertheless, the good news is that the magnitude of renewable energy sources are enormous – it is 140 times the worldwide annual energy consumption, and currently only 0.1% of these are being harnessed [2].

3. MICRO HYDRO

Among all types of renewable energy sources, micro hydro is the most established one. It is often regarded as the descendants of water wheels [10]. In fact, since the dawn of human civilization, ancient human are capable to harness energy from moving water by means of water wheels. Until today, water wheels can still be seen in service, though they are not as efficient as the modern hydroelectric systems. For this reason, micro hydro is not considered a new renewable energy technology; rather, it is an evolution and improvement of an ancient technology.

Currently, micro hydro and wind are considered the most sustainable renewable energy sources for electricity generation. However, wind energy has an intermittent nature [3]. Besides, among various renewable energy technologies, micro hydro is inherently cheaper to install and operate [11]. This advantage gives micro hydro an edge for the developing countries in providing electricity to remote and small demand areas that are distant from major economic activity [9]. According to M. R. Nouni et al, subject to availability of the resource, micro hydro appears to be the best option for hilly areas and it should be the first choice for providing electricity in the remote and inaccessible areas. By studying various methods of providing electricity to rural and inaccessible areas, M. R. Nouni et al found out that micro hydro requires the lowest cost to install, operate and maintain – approximately 8 times cheaper than photovoltaic systems and 4 times cheaper than diesel and natural gas engines [12]. For this reason, micro hydro has been widely accepted worldwide – especially in the developing countries.

4. MICRO HYDRO IN SARAWAK, MALAYSIA

Sarawak is the largest state of Malaysia, located on the northwest portion of Borneo island. It is one of the states blessed with abundant oil and natural gas. However, with its large land, rugged terrain and sparcely dispersed rural communities, about 20% of the people do not have access to the grid power [13, 14, 15]. These rural communities are mainly aboriginal people who do not have access to electricity, clean water and information such as television, radio and internet. They live in small clusters and are far away from the local grid; extension of local grid to power these isolated and scattered remote areas are extremely uneconomical. Nevertheless, there are several potential renewable energy sources available to them: solar, micro hydro, wind and biomass. Among these, micro hydro has the greatest potential – since Sarawak has vast networks of streams and rivers [14]. As such, implementing independent and standalone renewable energy generation plants appears to be a viable option to bridge the gap.

In order to provide electricity to the rural communites, the government has taken initiatives through its public works department, Jabatan Kerja Raya (JKR) Sarawak. Since 1991, JKR Sarawak has participated in the installlation of renewable energy supplies for government agencies such as rural airfields, schools, clinics and community halls in remote areas like Bario, Long Banga and Long Akah. Most of them are solar photovoltaic cells [13, 14]. In 1994, the government approved the implementation of alternative electrification scheme, involving usage of diesel-powered gensets, solar energy and micro hydro for the rural communities. Under this scheme, Telok Melano and Bario were chosen for implementation of micro hydro/genset hybrid project, costing RM 3.47 million and RM 10.59 million each. Before this, the villagers have to spend RM 200 – 300 per household every month on diesel fuel (diesel fuel costs RM 25 per gallon) to operate small gensets of 3 – 8 kW. All these gensets are privately owned or shared by a few household units.With a total costing of RM 14.06 million, these 2 micro hydro/genset hybrid projects were supposed to benefit at least 270 houses and 20 public premises. They were completed in October 1997. However, the 2 projects did not work well because of slow water retention and low water pressure, which were not powerful enough to turn the turbines for generating electricity. In fact, the turbines only run for 30 minutes each but it took 3 – 5 hours to replenish the water. As a result, these 2 micro hydro/genset hybrid systems were abandoned since then [16]. In 2005, JKR Sarawak, together with engineering staffs from local universities, were assigned the task to investigate these 2 projects. Upon investigation, it was found that the micro hydro/genset hybrid systems are unserviceable and beyond any rehabilitation effort: the mini dam has badly silted up over the years; the penstock had been swept away and scattered all over the place by torrential rains which washed away the footings of the supporting pillars; the switchboards, wirings and equipments in the power house had been badly vandalized. The investigation team also found that with the available water flow rate and head, the calculated power was about 25 kW, which is only about 25% of the rated output of 100 kW for the turbine driven generator. In other context, the existing quantity of water and flow rate is grossly insufficient to generate the desired power output [16].

Learnt from previous failure, the government changes the focus from external contractors to local expertise. The micro hydro/genset hybrid projects at Telok Melano and Bario were carried out by contractors from Kuala Lumpur; therefore, for the new renewable energy project at Abok Mawang, JKR Sarawak and Martin Anyi, a local lecturer from the department of electronics at the engineering faculty of Universiti Malaysia Sarawak (UNIMAS) were involved instead. This project turned out to be a great success. Rumah Donald, a 15-door long house at Abok Mawang can finally enjoy a 24-hour supply of electricity [17, 18]. What makes this project special is that unlike the projects at Telok Melano and Bario, this project utilized a 'process based, learning-by-doing' approach to build and operate a micro hydro. Most parts of this project – such as the locally fabricated pelton turbine – were build using scrap materials [17]. Meanwhile, JKR Sarawak provides equipment, logistic support and construction materials left over from other projects. The community also agreed to assist in installing the micro hydro system, run and maintain the completed power system by themselves and pay for the electricity and maintenance cost. As a result, this project only costed RM 157,000. This proves that local people, with the help of the state government, can build the system without engaging foreign expertise. Though not as grand as the projects at Telok Melano and Bario, the 30 kW single phase synchronous generator functions perfectly and fits the needs of the local people [18]. Now, not only the long house folks can save the cost on purchasing fuels like diesel and kerosene, they also have the privilege of improved air quality and longer lighting for children studying at night. In short, their overall quality of life is improved.

The success at Abok Mawang encourages Sarawak Energy Berhad (SEB) to participate in micro hydro as well. SEB's wholly owned subsidiary, Syarikat SESCO Berhad, is the sole company that has the right to provide electricity for Sarawak. In 2008, SEB has collaborated with JKR Sarawak to identify potential sites for micro hydro throughout Sarawak [14].

5. MICRO HYDRO IN INDIA

In India, there are many remote and isolated villages that are beyond the reach of conventional grid power. Even in the near future, providing grid connectivity would be uneconomical. This is due to the fact that India still suffers from high transmission and distribution losses, frequent disruption in supply of grid power, practical difficulties and financial unavailability of extending grid to remote and inaccessible areas and dispersed population in small villages. All these problems are plaguing the rural electrification programme in India [12]. For these unelectrified villages, renewable energy based decentralized electricity generation with local distribution network seems to be an ideal solution, especially when it is cheaper than the total cost of generating electricity at the centralized plant, transmitting electricity through the transmission network and distributing the electricity through the distribution network [12].

There are many remote small villages in India that comprise around 20 households and require domestic lighting for 3 – 4 hours in the evening. Since extending local grid to these villages requires extremely high cost, renewable energy based decentralized electricity generation such as biomass gasifier based dual fuel engines, diesel generating systems, micro hydro systems, photovoltaic systems and small wind mills become appealing approaches. Depending on resource availability and other operating factors under Indian conditions, different renewable energy technologies may be suitable for some cases but definitely not all cases. However, as mentioned before, Nouni et al found out that among all types of viable renewable energy technologies, micro hydro is the cheapest to install, operate and maintain [12]. In fact, for a small village with low peak loads, low load factors and at a certain distance away from existing grid, renewable energy based decentralized electricity generation options may provide cheaper and higher quality electricity, as compare to grid extension option.

6. MICRO HYDRO IN RWANDA

Rwanda is a developing country that relies on local firewood and imported fossil fuels to generate electricity, where firewood constitutes 80.4% of the total energy consumption. As a result, Rwanda suffers from environmental degradation. However, the electricity generating capacity is very low and the access to electricity is very limited – in 2010, only 4.3% of the population has access to electricity [19].

With the growing population and increasing industrialization, coupled with the lack of investment in the energy sector, Rwanda has incessantly experienced energy crisis. The cost of energy per kWh rises from 17 RWF (1995), 42 RWF (1997), 82 RWF (2005) to 112 RWF (2006) [19]. Its grid infrastructure is small and old – causing the supply prone to be disturbed and inefficient; yet, the demand never stop rising. Moreover, the demand for firewood is exceeding the exhausted supply, and policy measures must be taken to substitute the firewood with other forms of energy – preferably renewable energy – before all the national forest resources are depleted. To cope with this, the government of Rwanda has commissioned the construction of micro hydros in places where access to national grid is still difficult. There are 8 sites of micro hydro which are expected to be online by the end of 2009, providing extra electricity totaling 6.4 MW. Beside that, there are 6 micro hydro projects of total 1.6 MW that are currently being

developed by private companies in collaboration with ELECTROGAZ, a 100% publicly owned company, the sole grid electricity supplier in the country [19].

7. MICRO HYDRO IN PAKISTAN

Similar to Rwanda, Pakistan is an energy-deficient country that has to spend US$ 3 billion annually to import oil [2]. In Pakistan, majority of the rural folks have no access to the commercial energy sources and national grid. Therefore, renewable energy sources like wind, micro hydro, biomass and biogas can provide electricity to them to raise their standard of living to a respectable level. Among these, micro hydro is the most widely installed due to the resource availability throughout Pakistan terrain. Beside providing electricity for domestic purposes, these micro hydro are also used to run the small industries like flour mills and cotton ginning [2].

Most of the time, the recipients are willing to do the civil works of installing power channel, powerhouse, electric poles and distribution network. Meanwhile, Pakistan government will assist its people through the Pakistan Council for Appropriate Technology (PCRET), which is in charge of providing equipment and supervision with technical expertise [2].

8. LIMITATIONS OF MICRO HYDRO

Micro hydro is a good way of providing electricity to the off-grid remote and isolated areas and to regions that suffer energy deficit, especially for the developing countries where funding is of primary concern. Nevertheless, it is incorrect to treat micro hydro as a miraculous solution for providing electricity; it still has its own shortcomings. The main problem is its high initial cost – compares to conventional energy of course, as it is still cheaper than other renewable energy technologies like solar and wind. Micro hydro cannot be built anywhere. Clearly, it requires suitable site – a site without water flow, stream or river is impossible to construct micro hydro. Sometimes the site has difficult topography, i.e. highlands and poor geological conditions, i.e. unstable and porous soils [9]. In addition, if there is increase in the power demand in the future, energy expansion is not possible; unless of course, the water flow, stream or river also happen to expand [11].

In order to successfully construct a micro hydro, the basic resources, i.e. technical expertise, human resource, funding and equipment are necessary. For these resources to arrive at the designated site that is usually a remote and isolated location, transportation is needed. Once installed, the micro hydro should be managed properly – usually by the local community or the project stakeholders [15].

Sometimes the proposals have been characterized by over-optimistic assumptions about costs, performance, reliability and the skills required to manage the projects [9]. More so, the proposers may have limited understanding of the energy needs fo the recipients and did not communite and involve the recipients inadequately. The projects at Telok Melano and Bario, Sarawak should serve as good and expensive lessons for us to learn from.

M. Jafar also observed that some companies have the tendency to treat renewable energy technologies as equipment to be sold, rather than as services to be provided in the manner of public utilities. This will leave the recipients without follow-up support, who usually happen to be rural folks that are not highly educated [9]. Though micro hydro requires minimal maintenance when compared to other renewable technologies such as solar and wind, it will not operate sustainably without receiving regular maintenance by the recipients, and the recipients require basic technical assistance from the companies [15]. Though today's advanced technology has made possible for us to produce individual system components nearing perfection in terms of performance and reliability, attention on the system as a whole is still needed, since most problems arise when these individual components are put together to work as an integrated entity [9]. The hybrid energy schemes and their system behaviours have been reviewed in published journals, e.g. Abdullah et al. [20], and to which the reader is referred for more details.

9. CONCLUSION

Indeed, micro hydro is undeniably one of the most reliable and mature renewable energy technologies available to the mankind. Though micro hydro itself will not solve all the energy problems around the globe, through proper and careful planning and implementation involving the recipient communites it can serve as an excellent decentralized electricity generation grid or as a secondary power generating unit, making the grid more robust.

Micro hyrdo benefits the rural folks which have no accessibility to the grid electricity the most. In rural areas where extension of grid electricity is prohibitively high, micro hydro is usually the best option to relieve the rural folks' dependence on the conventional oil and natural gas gensets. Providing electricity to a remote and isolated unelectrified community will have positive impacts on the socio-economic aspects of the community. Domestic improvements such as lightings, information and communication are fundamental; some can even engage in small-scale agro-based activities like grain grinding, rice hulling and oil extraction.

It is good to promote micro hydro among the developing countries which suffer from energy problems. Local governments and international authorities such as United Nation (UN) Agencies can play the primary role in

encouraging research and development activities. Education, financial incentives, human resources and the corresponding infrastructures require initiatives from the authorities as well [2].
Just like any project, M. Jafar has concluded that micro hydro must not be handle imprudently. Hasty decisions and introductions of new renewable energy technologies have done more harm than good [9, 16].

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