Wind Power for the Poorest 2 Billion

Jon Leary*, Robert Howell[1] and Aidan While[2]

* Corresponding Author: dtp09jkl@sheffield.ac.uk
E-Futures PhD Student (http://www.sheffield.ac.uk/energy-dtc)
University of Sheffield, Department of Mechanical Engineering

[1] Department of Mechanical Engineering, University of Sheffield
[2] Department of Town and Regional Planning, University of Sheffield

Keywords

Wind, appropriate technology, small-scale, turbine

Background

It is a widely stated fact that two billion people are without access to affordable and clean energy services and another two billion are without reliable access (World Bank 2000; UNESCO 2010). Energy provides access to jobs, food, health services, education, comfortable housing and running water, all of which are basic requirements for human development. Electricity has made energy available to us at the flick of a switch and has played a vital role in the development of modern society (see Figure 1).

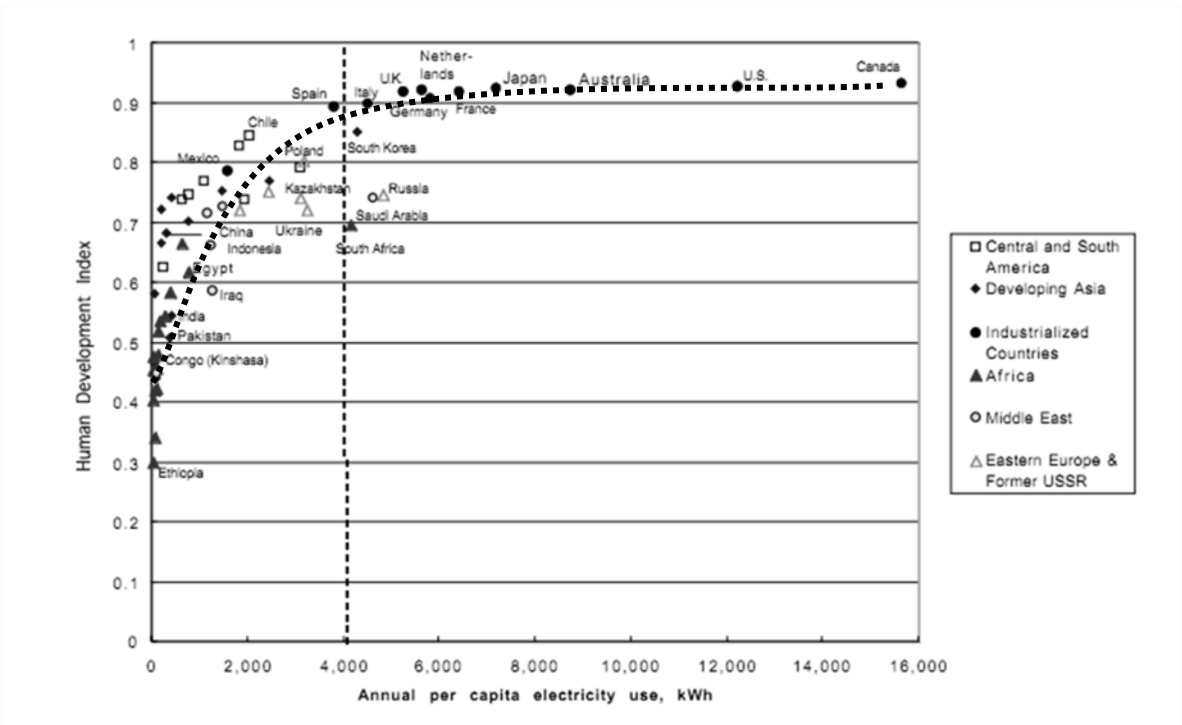

Figure 1 – Human Development Index (HDI) vs. electricity use for 60 countries, 1997 data (Pasternak 2000)

It is the rural poor who suffer most from the lack of electricity, where electrification rates can be ten times lower than those in urban areas (World Bank 2000). The remoteness of their location often presents the biggest challenge to rural electrification. It is unreasonable to expect governments or power companies to build long, expensive and inefficient power lines to connect all of these scattered communities to a central electrical grid. Diesel generators are often used in stand-alone power systems, but the problems with ongoing need for fuel distribution, rising fossil fuel prices and environmental contamination are obvious. However, where a suitable resource is available, renewable energy can provide a clean and affordable solution. In much of the developing world, the sun is shining, the wind is blowing or rivers are running, providing an abundant solar, wind and hydroelectric resource.

Where a suitable watercourse is available, micro-hydro installations are often the cheapest and most reliable source of electricity. Solar photovoltaic systems have no moving parts and therefore can offer a low-maintenance, if expensive, energy supply. However, in a suitably windy location, wind power systems can be the most appropriate option for rural electrification. Wind turbines have the advantage of being suitable for community-based manufacture, unlike solar panels, which must be manufactured in clean-rooms.

Gaining access to the technology required to harvest these resources is unfortunately very difficult for many people who could benefit from them, due to lack of skills, knowledge, tools and/or materials. Diesel generators can generally be bought off-the-shelf and fuel obtained from regular petrol stations, but obtaining electricity from a solar panel or a wind turbine is a specialist task that generally involves importing expensive components, or even whole machines, from abroad. Resource assessment and choosing a proper site for the machine requires a certain amount of knowledge and, even if it can be installed properly in a good location, problems often arise post-installation when unfamiliarity with the foreign technology results in inability to operate, maintain or repair the system correctly. In remote areas, finding a suitably trained technician and importing spare parts can be difficult and expensive, if possible at all.

Community-based manufacture can help overcome some of these problems. The construction of renewable energy technology in local workshops by local people using locally available materials will provide local employment; in addition, the end product will be cheaper, familiarity with the technology and availability of spare parts will make operation and maintenance of the technology easier and the knowledge gained will help facilitate local capacity-building.

Of course, the risk with community-based manufacture is that lack of skills, knowledge and quality standards will result in the production of low quality equipment that will fail to meet the expectations of the end user and will undermine the reputation of the technology. Even if the equipment can be produced adequately, it is of little use if it is not appropriate for the local conditions and not capable of meeting the needs of the end user.

Despite these difficulties, wind turbines have been successfully used in rural electrification projects in many developing countries from Sri Lanka (Dunnett, Khennas et al. 2001) to Peru (Chiroque, Escobar et al. 2009) (see Figure 2). For example, following a three year demonstration project starting in 1981, the government of the Chinese autonomous region of Inner Mongolia succeeded in disseminating the use of household wind generators (HWGs) for distributed energy production in remote areas. Conditions were right - the region contains 40% of China's exploitable wind resource, government subsidies of 15-20% of the initial cost were made available and all counties set up energy stations for the sale and service of HWGs. Local universities and research institutions were supported to develop 20 models of HWG from 50W-5kW and by 1997 137,000 HWGs installed in the area were supplying 18.5MW of electricity. One of the key ingredients in the success of the scheme was the reliance on local resources. All of the HWGs were built within Inner Mongolia, bringing an affordable energy system to the masses and creating a supporting network for distribution, installation and maintenance of the machines (Xiliang, Gan et al. 1999; Dunnett, Khennas et al. 2001).

Figure 2 – Scenes from the installation of a 100W household and a 500W community wind turbine in El Alumbre, Peru

Plan of Work

This research aims to use the University of Sheffield's technical resources to comprehensively evaluate the performance of wind turbine technology currently being produced in the developing world. The following avenues will be pursued during the course of the PhD level research:

- Geometric performance testing of Savonius, Darreius and conventional horizontal axis wind turbines using a newly commissioned 20m/s wind tunnel with a 1.2x1.2m working section and low turbulence intensity (0.25%) and CFD (Computational Fluid Dynamics) modelling
- Evaluation of generator electrical performance
- Compatibility analysis of the mechanical and electrical systems
- Manufacturability analysis with respect to locally available skills, tools and materials
- Field testing of the full turbines in identical real world conditions
- Economic analysis of the complete wind power system
- Materials selection and structural analysis
- Investigation into the socio-technical factors involved in creating an appropriate wind energy system for rural electrification, such as local skill level, access to materials or resource availability
- Use of GIS (Geographical Information System) mapping to determine the appropriateness of wind turbines within a defined geographical area

Conclusion

It is clear that the potential is there for wind power to bring light, communication, heath and all those other essential ingredients for human development to the world's 2 billion most needy. What is needed is a comprehensive evaluation of the available technology, so that it can be optimised and so that the information is available for people around the world to select and adapt the most appropriate technology for both their needs and the local conditions.

References

Chiroque, J., R. Escobar, et al. (2009). El Alumbre: Design, Implementation and Management of a Community Small-Scale Wind Generation Project. International Workshop on Small Wind Energy for Developing Countries. Nairobi, Kenya.

Dunnett, S., S. Khennas, et al. (2001). Small Wind Systems for Battery Charging: A guide for development workers, DfID (UK Department for International Development) and ITDG (Intermediate Technology Development Group - now Practical Action).

Pasternak, A. D. (2000). Global Energy Futures and Human Development: A Framework for Analysis, University of California, Lawrence Livermore National Laboratory for the U. S. Department of Energy.

UNESCO (2010). Engineering: Issues Challenges and Opportunities for Development. Paris.

World Bank (2000). Energy and Development Report 2000: Energy Services for the World's Poor. Washington DC, The World Bank ESMAP (Energy Sector Management Assistance Programme).

Xiliang, Z., L. Gan, et al. (1999). Wind energy technology development and diffusion: A case study of Inner Mongolia, China. Oslo, Center for International Climate and Environmental Research - Oslo, Norway

Institute for Techno-economics and Energy Systems Analysis - Tsinghua University, Beijing, China.