Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 75 (2015) 1072 – 1079

Energy Procedia

The 7th International Conference on Applied Energy – ICAE2015

On the possible wind energy contribution for feeding a high altitude Smart Mini Grid

Stefania Proietti[a], Paolo Sdringola[b], Francesco Castellani[b]*, Alberto Garinei[a], Davide Astolfi[b], Emanuele Piccioni[b] ,Umberto Desideri[c], Elisa Vuillermoz[d]

[a]*Department of Mechanical Systems and Infrastructures, Guglielmo Marconi University, via Plinio 44, Rome 00193, Italy*
[b]*Department of Engineering, University of Perugia, via G. Duranti 93, Perugia 06125, Italy*
[c]*Department of Energy, Systems, Territory and Constructions Engineering, University of Pisa, largo L. Lazzarino, Pisa 56122, Italy*
[d]*Association Ev-K2-CNR, Via San Bernardino 145, Bergamo 24126, Italy*

Abstract

The use of renewable energy sources to increase electricity access, especially in *remote areas* as high mountains, is a possible contribution to poverty reduction, climate change mitigation and improved resilience. In this paper an evaluation of the wind potential of a remote area in Nepal is performed, using CFD methods and the simulation of a micro wind turbine projected by Perugia University. With an accurate analysis of wind data and air density effects it is possible to test energy production potential in areas with high average wind speed. The overall estimated production for each turbine is an interesting result and an easily exportable contribution to the perspective of sustainable development at very high altitudes and remote areas.

Peer-review under responsibility of Applied Energy Innovation Institute

Keywords: high altitude; rural electrification; wind energy; wind meso and micro modeling.

1. Introduction

In the last 20 years, the exploitation of non-renewable resources and the effects of their applications on environment and human health were considered central topics in political and scientific debate at worldwide scale. Both on legislative and research level, attention is focused on the adoption of systems

* Corresponding author. Tel.: +39-075-5853709; fax: +39-075-5853703.
E-mail address: francesco.castellani@unipg.it

Peer-review under responsibility of Applied Energy Innovation Institute
doi:10.1016/j.egypro.2015.07.483

that aim at energy saving and use of renewable energies, in a "*rational use of energy*" scenario. Numerous technical solutions have been developed in order to save energy, avoid GHG emissions and then face the climate change. *Distributed Generation* (DG), i.e. any source of electric power of limited capacity, directly connected to the power system distribution network where it is consumed by the end users, has gained a lot of attractions in the power sector due to its ability in power loss reduction, increased reliability, low investment cost, and most significantly, to exploit renewable energy resources. The annual distributed renewable generation capacity around the world is estimated to increase from 6,000 in 2009 to 17,000 MW in 2015 [1-2]. Using renewable energy sources to increase electricity access, especially in *remote areas* as high mountains, would contribute to poverty reduction, climate change mitigation and improved resilience. An off-grid power generation system that is reliant on different renewable and conventional energy sources and distributes power through a local grid network is often known as a *smart mini grid* [3-4]. This technology occupies a middle ground of electrification options between traditional network extension and individual home systems, with a range of potential benefits and risks [5]. A *characterization process* should be undertaken to avoid assessment mistakes in terms of real sustainability. *Upstream processes* include raw material extraction, transformation and transports, often carried out in extreme conditions (e.g. along trekking routes). During the *electricity generation phase*, energy balance is affected by the specific atmospheric conditions, as air density or solar radiation. Finally, *downstream processes* may consider different waste treatments (reuse, recycling and/or landfilling). Therefore potential energy savings and avoided GHG emissions from renewables should be evaluated from a whole life cycle perspective [6].

This study is focused on the possible exploitation of wind energy potential in a high altitude large area. The wind potential is strongly affected by variability in time and space, but an accurate study of the anemology of the area can help to figure out possible uses. Wind energy may give an important contribution to the energy balance in off-grid areas, where even other energy sources are variable and not programmable [3, 7].

2. Study area

The study is geographically focused within the Khumbu Valley, located in the central part of the Himalayan Range; this area is strategic to study climate change and its effects on mountain ecosystems, containing the southern half of Mount Everest and its summit (8,848 m).

The Khumbu Valley partially includes the Sagarmatha National Park (SNP), a wide area on the Nepalese mountainside of Everest and declared as World Heritage Site since 1979. In recent years the park was the focus of several studies and initiatives, aimed at improving the management of its many-sided ecosystem, significantly influenced by climate change and by the increase of human activities (e.g. tourism). The scarcity of energy resources in some sub-realities of the park constrains local people to burn strongly impacting fuels that, together with bad daily habits and obsolete technologies, cause high levels of indoor air pollution. This reduces the quality of life and determines a number of respiratory diseases especially in elderly people, women and children.

Because of the lack of a regulation on forests conservation management, an over-consumption of firewood contributed to a progressive deforestation and consequent alteration of the hydro-geological system [8-9].

2.1. Available resources and energy balance

Renewable energy sources are freely available in the region, but energy produced from these sources is still rather scarce (overall little more than 10%). In particular, the park already hosts n. 6 *hydro*power