Applied Thermal Engineering 43 (2012) 158–162

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Environmental and economic aspects of higher RES penetration into Macedonian power system

Boris Ćosić [a,*,1], Natasa Markovska [b], Goran Krajačić [a], Verica Taseska [b], Neven Duić [a,2]

[a] Department of Energy, Power Engineering and Environment, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Ivana Lučića 5, 10002 Zagreb, Croatia
[b] Research Center for Energy, Informatics and Materials, Macedonian Academy of Sciences and Arts, Krste Misirkov 2, 1000 Skopje, Macedonia

ARTICLE INFO

Article history:
Received 16 August 2011
Accepted 19 October 2011
Available online 29 October 2011

Keywords:
Renewable energy
CO_2 emissions
Energy system analyses
EnergyPLAN model
Macedonian energy system

ABSTRACT

The energy sector in Macedonia is the main emitter of greenhouses gases (GHG) with share of about 70% in the total annual emissions. Furthermore, within the energy sector, 70–75% of emissions are associated with the electricity generation due to the predominant role of the lignite fuelled power plants. This makes the electricity sector the most significant key source and, at the same time, the main target for CO_2 emissions reduction. Recently, the government has adopted a strategy for the use of RES which identifies a target of 21% of final energy consumption from RES by 2020. The main goal of this paper is to investigate environmental and economic aspects of higher penetration of renewables into energy system of Macedonia. For this purpose a reference energy scenario for the power system expansion is developed by making use of EnergyPLAN model. The reference energy system was developed for the year 2020, and then used in the scenario analyses. The analyses of four 'RES' scenarios reveal that renewables can reduce CO_2 emissions between 0.84% and 9.54% compared to reference scenario. Increase of CO_2 price for double, compared to today's price, will lead to increase of annual operating costs over 26% in all the scenarios considered. In the case of doubling the lignite price, annual operating costs in scenarios will be increased between 6.5% and 7.6%.

1. Introduction

At the moment the most critical issues in European energy sector are security of supply and greenhouse gas emissions. These emissions are closely related to energy generation and exploitation and because of this they're becoming one of the major technological and socio–political challenges in the world [1]. One of the most promising solutions for alleviation of energy import and diversification of the energy resources, which at the same time reduce the GHG emissions, are renewable energy sources. Besides that, the utilisation of RES provides for additional environmental benefits (mitigating local pollution), create employment and leads to potential development of rural economies Unfortunately, the intermittent nature of renewable energy sources (RES), except biomass, leads to substantial RES penetration limits, especially during the period of low electricity consumption such as the night time [2] and [3]. To solve such a problem, effective tools are needed to provide insights into the problem and to provide possible solutions [4].

In order to increase penetration limits of intermittent or variable RES and use them effectively it is necessary to increase flexibility of the power system. Flexibility can be increased by use of more dispatchable plants, by better interconnection with other power systems, by demand side measures and by energy storage [5]. This energy storage is used in order to transfer energy surplus from the period of excess electricity production to other more appropriate periods [6] and [7]. However, due to high investment cost in the storage systems the usage of RES is becoming even more expensive [8] and [9].

Many authors have evaluated and analyzed the benefits of integration RES and energy storage in terms of reduction CO_2 emissions and energy import dependency. The use of RES-pumped hydro storage systems is proposed in [10], RES-hydrogen systems in [11] and use of RES-heat pumps and thermal storage systems in [12].

In the case of Macedonia, electricity production is based mainly on the low-quality domestic lignite and hydro. Macedonia's electricity consumption is characterised by excessive demand peaks in winter, which are largely due to the use of electricity heating to supplement fuelwood heating in the residential sector during very cold periods [13]. To some years ago, due to stagnation in the

* Corresponding author. Tel.: +385 1 616 8242; fax: + 385 1 615 6940.
E-mail addresses: boris.cosic@fsb.hr (B. Ćosić), natasa@manu.edu.mk (N. Markovska), goran.krajacic@fsb.hr (G. Krajačić), verica@manu.edu.mk (V. Taseska), neven.duic@fsb.hr (N. Duić).
[1] http://www.powerlab.fsb.hr/bcosic.
[2] http://www.powerlab.fsb.hr/neven.

1359-4311/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.applthermaleng.2011.10.042