Energy Policy 36 (2008) 4048–4056

Contents lists available at ScienceDirect

Energy Policy

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

Potentials and prospects for renewable energies at global scale

Gustav Resch [a,*], Anne Held [b], Thomas Faber [a], Christian Panzer [a], Felipe Toro [c], Reinhard Haas [a]

[a] Energy Economics Group, Institut für Elektrische Anlagen und Energiewirtschaft, Technische Universität Wien, Gußhausstraße 25-29/373-2, 1040 Vienna, Austria
[b] Fraunhofer Institute Systems and Innovation Research, Breslauer Str. 48, D-76139 Karlsruhe, Germany
[c] BSR Sustainability GmbH, Königsbergerstr. 2 h, D-76139 Karlsruhe, Germany

ARTICLE INFO

Available online 15 August 2008

Keywords:
Renewable energies
Potentials
Prospects

ABSTRACT

Renewable energies (RE) represent a cornerstone to steer our energy system in the direction of sustainability and supply security. Generating electricity, heat or biofuels from renewable energy sources has become a high priority in the energy policy strategies at national level as well as at a global scale. Challenging goals for these "new" supply options to meet our energy demands have been set, e.g. at European level by the commitment of meeting 20% of the overall energy demand from renewable energy sources by 2020.

A broad set of different RE technologies and resources exist today. Obviously, for a comprehensive investigation of the future RE development it is of crucial importance to provide a detailed investigation of the country-or region-specific situation—e.g. with respect to the potential of the certain RE's in general as well as the part that can be realised in the near future.

It is the core objective of this paper to fulfil above-mentioned constraints, aiming to present an overview on the RE potentials and prospects globally—but based on region- and/or country-specific assessments of the resource conditions, the overall energy system boundaries and the related energy policy framework. Thus, a topical focus is put on both the near to mid future up to 2020 and the long-term perspective, indicating besides theoretical and technical potentials also the realisable mid- and long-term potentials referring to the time-horizon between 2030 and 2050 and prospects for the various renewable energy options. Future prospects are discussed by means of analysing energy policy scenarios as conducted for the International Energy Agency (IEA)'s "World Energy Outlook"-series. In this context, emphasis is given on the illustration of the possible contribution of renewable energies to power supply.

1. Introduction

Renewable energies (REs) represent a cornerstone to steer our energy system in the direction of sustainability and supply security. Generating electricity, heat or biofuels from RE sources has become a high priority in the energy policy strategies at national level as well as at a global scale. Challenging goals for these "new" supply options to meet our energy demands have been set, e.g. at European level by the commitment of meeting 20% of the overall energy demand from RE sources by 2020.

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The core objective of this paper is to present an overview on the RE potentials and prospects globally—based on region-and/or country-specific assessments of the resource conditions, the overall energy system boundaries and the related energy policy framework. Thus, a topical focus is put on both the near to mid future and the long-term perspective, indicating besides theoretical and technical potentials also the realisable mid-and long-term potentials and prospects for the various RE options. In this context, emphasis is given on the illustration of the possible contribution of REs to power supply. Geographically, global figures will be accompanied by data on country/regional level, comprising major industrialised countries and emerging economies—i.e. US, Japan, EU27, Russia, China, India and Brazil.

As starting point, the applied method of approach is discussed in a subsequent section. This comprises a concise discussion of the overall approach and an explanation of the applied terminology. Next, Section 3 illustrates the derived data on the various potentials for the individual RE options. Then, corresponding future prospects are discussed in Section 4 by analysing energy policy scenarios on their resulting future RE deployment. These

* Corresponding author. Tel.: +43 1 58801 37354; fax: +43 1 58801 37397.
E-mail address: Gustav.Resch@tuwien.ac.at (G. Resch).

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doi:10.1016/j.enpol.2008.06.029

scenarios represent the outcomes of modelling work conducted for the International Energy Agency (IEA)'s "World Energy Outlook"-series. Finally, conclusions end this concise review.

2. Method of approach

2.1. Assessment of RE potentials

Mid-term and long-term potentials and prospects of REs as presented in this paper build to a large extent on a series of studies as conducted by the authors themselves. In contrast, the global theoretical and technical potentials are based on an in-depth literature survey.

From a historical perspective the starting point for the assessment of realisable mid-term potentials was geographically the European Union, where corresponding data was derived for all Member States initially in 2001 based on a detailed literature survey and a development of an overall methodology with respect to the assessment of specific resource conditions of several RE options. In the following, within the framework of the study "Analysis of the Renewable Energy's" evolution up to 2020 (FORRES 2020)" (see Ragwitz et al., 2005) comprehensive revisions and updates have been undertaken, taking into account reviews of national experts, etc. Consequently, this paper builds directly on these consolidated outcomes as presented in the European Commission's Communication "The share of renewable energy" (European Commission, 2004). This finally derived data on mid-term potentials for RE fits to the requirements of the model *Green*-X[1]—a modelling and analysis tool for the assessment of energy policy instruments in the field of RE, geographically currently constraint to European countries.

Within the framework of a recent study conducted for the IEA (see Resch et al., 2008) it was envisaged to geographically extend this survey to other countries, namely the other OECD countries as well as the emerging economies classified as BRICS countries—incl. Brazil, Russia, India, China and South Africa. Thus, long-term potentials on various RE technologies and the corresponding global RE forecast model, World*RES*,[2] served as solid basis for the following steps: Applying a similar bottom-up in-depth assessment of the prospects for REs in the near future for these countries as done for European countries was not feasible due to time and budget constraints. Accordingly, it was aimed to make use of the available data, i.e. the historical record and assessed long-term potentials by RE technology, as well as the corresponding modelling tool World*RES*. This meant in particular elaborating on the mid-term realisable potentials for the various RE technologies by means of scenario projections, transferring the same level of ambition for RE's to other countries as observed for Europe.

With regard to the individual RE technologies, this potential assessment focuses on the following options for power generation: Biomass, onshore and offshore wind, hydropower, solar energy (where feasible subdivided into solar thermal electricity and photovoltaics (PV)), tidal and wave energy, and geothermal electricity.

2.2. Prospects for RE technologies

Prospects for RE technologies are presented in this paper at a global level, illustrating the feasible deployment of these technologies by means of scenarios depending on the applied energy policies. These future projections as published in the latest IEA "World Energy Outlook 2007" (IEA, 2007a) were conducted with the above-discussed model World*RES*. Two differing cases will be discussed, which aim to illustrate the feasible RE deployment exemplarily for the electricity sector: A *reference* scenario, illustrating a conservative view of the future RE deployment based on the currently applied energy policy support and the corresponding observed framework conditions that often comprise several deficits for an accelerated RE deployment. In contrast to this, an *alternative policy* scenario aims to indicate the feasible RE deployment if support measures as currently in the pipeline of political decision making will become effective. This also comprises an improvement with regard to pending non-economic obstacles.

3. The potential for REs at global scale

3.1. Classification of potential categories

The possible use of RE depends in particular on the available resources and the associated costs. In this context, the term "available resources" or RE potential has to be clarified. In literature potentials of various energy resources or technologies are heavily discussed. However, often no common terminology is applied. In order to contribute to the comprehension of the derived data, we start with an introduction on the applied terminology:

- *Theoretical potential*: For deriving the theoretical potential general physical parameters have to be taken into account (e.g. based on the determination of the energy flow resulting from a certain energy resource within the investigated region). It represents the upper limit of what can be produced from a certain energy resource from a theoretical point-of-view—of course, based on current scientific knowledge.
- *Technical potential*: If technical boundary conditions (i.e. efficiencies of conversion technologies, overall technical limitations as, e.g. the available land area to install wind turbines) are considered the technical potential can be derived. For most resources the technical potential must be seen in a dynamic context—e.g. with increased R&D conversion technologies might be improved and, hence, the technical potential would increase.
- *Realisable potential*: The realisable potential represents the maximal achievable potential assuming that all existing barriers can be overcome and all driving forces are active. Thus, general parameters as, e.g. market growth rates, planning constraints are taken into account. It is important to mention that this potential term must be seen in a dynamic context—i.e. the realisable potential has to refer to a certain year.
- *Mid-term potential*: The mid-term potential is equal to the realisable potential for the year 2020.

Fig. 1 shows the general concept of the realisable mid-term potential up to 2020, the technical and the theoretical potential in a graphical way.

[1] The *Green*-X model, an independent computer programme, is the core product developed in the project Green-X in the period 2002–2004. Later on, an extended version with regard to the geographical and sectoral coverage for RE was produced. It covers besides all Member States of the European other European countries such as Croatia, Norway or Switzerland. It enables a comparative and quantitative analysis of the future deployment of RE in all energy sectors (i.e. electricity (grid-connected and non-grid), heat and transport) based on applied energy policy strategies in a dynamic context. For details regarding the project or the model Green-X we refer to www.green-x.at.

[2] The projections of renewable energies of last year's "World Energy Outlook 2007" (IEA, 2007a) were derived in the separate model World*RES*, allowing assessments of the future deployment of renewable energies and the investment needs related to such deployment. This model has been developed for this purpose by the Energy Economics Group (EEG) at Vienna University of Technology in cooperation with Wiener Zentrum für Energie, Umwelt und Klima (WZE). This builds on previous work as done in a fruitful cooperation in the context of IEA's last years world energy outlook series.