Green Energy Prospects: Trends and Challenges

S. Filippov, Energy Research Institute of the Russian Academy of Sciences, Moscow, Russia
N. Mikova, Higher School of Economics, Moscow, Russia
A. Sokolova, Higher School of Economics, Moscow, Russia

ABSTRACT

The transition of energy systems moving from non-renewable fossil-nuclear to renewable sources is a key challenge of climate mitigation and sustainable development. Green energy technologies can contribute to solutions of global problems such as climate change, growth of energy consumption, depletion of natural resources, negative environmental impacts, and energy security. In this article the prospective directions of technology development in green energy are studied and analyzed using a combination of qualitative and quantitative methods. Qualitative research involves participation of key experts in the field of green energy, while quantitative analysis includes collecting and processing data from different information sources (scientific publications, patents, news, foresight projects, conferences, projects of international organizations, dissertations, and presentations) with a help of Vantage Point software. In addition, key challenges for green energy as well as its relationships with other technological and non-technological areas are identified and briefly described on the basis of expert and analytical results.

Keywords: Data Clustering, Foresight, Global Challenges, Green Energy, Qualitative and Quantitative Methods, Sustainable Development, Technology Trends

INTRODUCTION

Energy is an important component of global social and economic infrastructure. The effective use of natural resources and the potential of the energy sector contribute to providing sustainable economic growth, a higher quality of life, and strengthening foreign economic positions. Currently, the development of the energy sector is associated with such global challenges as climate change, growth of energy consumption, depletion of natural resources, negative environmental impacts, and energy security. These challenges are widely discussed in various reports at the global level (Glenn et al., 2011; European Commission, 2007; European Commission, 2011; Intergovernmental Panel on Climate Change, 2007; International Energy Agency/OECD, 2011; National Intelligence Council, 2012; OECD, 2012). To reduce negative effects connected with these challenges and to move towards sustainable energy infrastructure, national governments need to be aware of the key technologies which can help address the
problems identified. World experience shows that one of the most significant ways to increase an economy’s energy efficiency is by developing green energy technologies. These technologies can make an appreciable contribution to the sustainable development of the energy sector and economy as a whole through the production of clean and inexhaustible energy.

This paper investigates the main trends in green energy development by using two principal approaches to technology forecasting: expert (qualitative methods) and analytical (quantitative methods). The expert approach compiles a list of technology directions, based on the opinions of leading specialists in the subject area. The analytical procedures involve automatic processing of quantitative data from different sources using a specialized computer software (for example, Vantage Point). In theoretical works devoted to identifying technology trends the most frequently used sources of data are scientific publications (Chen, 2006; Cobo et al., 2011; Daim et al., 2006; Guo et al., 2011; Kajikawa et al., 2008; Kostoff et al., 2008; Morris et al., 2002; Porter & Cunningham, 2005; Shibata et al., 2008; Smalheiser, 2001; Upham & Small, 2010) and patents (Campbell, 1983; Corrocher, 2003; Daim et al., 2006; Dereli & Durmusoglu, 2005; Fattori et al., 2003; Kim et al., 2008; Kim et al., 2009; Lee et al., 2009; Lee et al., 2011; Li et al., 2009; Porter & Cunningham, 2005; Trappey et al., 2006; Tseng et al., 2007; Wang et al., 2010; Yoon & Park, 2004). However, in addition to publications and patents, technology forecasting can draw on information from news bulletins (Daim et al., 2006); business resources, such as the Lexis-Nexis database (Porter & Cunningham, 2005), venture capital funds and start-ups data (Cozzens et al., 2010)); information from thematic conferences (Porter & Cunningham, 2005), and others. The aim of this paper is to study the prospects for green energy technology development using a combination of expert and analytical methods, identify socio-economic and other challenges in energy use, as well as to analyze adjacent technological and non-technological areas, which are capable of significantly contributing to sustainable energy development.

**METHODOLOGY**

The current study carried out expert analysis (qualitative) to identify the prospects of technology development in green energy. It also analyzed a range of sources (scientific publications, patents, news, foresight projects, conferences, projects of international organizations, dissertations, presentations) to find information about the key technologies in green energy area.

The expert analysis highlighted six key technology fields in green energy: solar energy, wind energy, bioenergy, electricity storage, fuel cells, and green energy infrastructure. Next, a number of sources listed below was analyzed for containing information on emerging green energy technologies developed from 2003 to 2012 (see Table 1).

The analytical (quantitative) approach to identifying key technology directions in green energy involved the following steps: 1) creating data collections (scientific publications, patents, news, foresight projects, conferences, projects of international organizations, dissertations, and presentations); 2) importing data into Vantage Point software; 3) pre-preparing data; 4) clustering keywords (factor analysis).

Table 2 shows aggregate data of eight collections created for green energy area: data sources, the number of documents, the names of bibliometric fields that are being processed, and also the format of collections before and after pre-preparation of data.

As a result, a total of 69 699 documents in different formats (*.txt, *.html, *.doc, *.pdf, *.ppt) were collected, most of which were converted into *.xml format for further processing in Vantage Point software.

Vantage Point uses customized import filters for uploading data collections, which makes it possible to import data from most of the popular electronic databases (Web of Science, Scopus, Derwent Innovations Index, Factiva, etc.). Next, at the stage of pre-preparing data,
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