Energy 61 (2013) 598–605

Contents lists available at ScienceDirect

Energy

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

Security aspects of future renewable energy systems—A short overview[☆]

Bengt Johansson [a,b,*]

[a] FOI, Swedish Defence Research Agency, SE-164 90 Stockholm, Sweden
[b] Environmental and Energy Systems Studies, Lund University, P.O. Box 118, SE 221 00 Lund, Sweden

ARTICLE INFO

Article history:
Received 13 May 2013
Received in revised form
20 August 2013
Accepted 10 September 2013
Available online 6 October 2013

Keywords:
Renewable energy
Energy security
Bioenergy
Wind energy
Solar energy

ABSTRACT

Energy security is sometimes used to advocate renewable energy systems. Renewable energy systems can improve some aspects of security, but they will not automatically lead to the removal of all types of security problems and new problems will most certainly arise. This paper analyses energy security aspects of renewable energy systems on the basis of a broad typology on energy and security. Renewable energy sources do not suffer from the same long-term resource availability problems as finite fossil resources and their geographical location is less concentrated, but other issues such as dependence on variable flowing resources and competition for scarce land resources will grow in importance. Many security issues related to energy are also dependent on the energy carrier rather than the energy resource and on the existence of effectively functioning institutions and regulations. New interdependencies will appear and will have to be handled within future international and bilateral institutional frameworks.

1. Introduction

The global energy system is dominated by fossil fuels. RE (Renewable energy)[1] currently contributes around 13% of total global primary energy supply [2] but the fraction is growing. In the EU, RE contributes around 11% of total energy [2], but its importance varies significantly between member countries. For example in Sweden and Finland, RE contributed 47% and 30% of total gross final energy, respectively, in 2009, while in other countries such as the UK and the Netherlands only a few per cent of total energy was supplied by RE in that year [3]. These differences are the result of variations in geographical conditions, energy system designs and political priorities.

EU energy policy is built on three pillars: competitiveness, security of supply and sustainability [4]. Although the expansion of RE is often motivated by its potential to reduce climate change, energy security has also been a strong driver for RE policy [5] As part of its energy and climate policy, the EU has issued a directive which requires member states to contribute to doubling RE from the 2005 level up to 20% of gross final energy consumption by 2020 [6]. In the longer term, this share could increase even more. In the scenarios developed for the EU energy roadmap [7], which envisage an emissions reduction of 80% by 2050 compared with 1990, the RE fraction varies between 55 and 75% of gross final energy consumption.[2]

The main body of literature on energy security focuses on the geopolitics and dependencies of fossil fuels (especially oil and gas), and the functionality of electricity systems. The security aspects of RE are seldom analysed and there is a significant research gap in this field [8], although there are a few reports and papers dealing with some aspects of the relationship between RE and energy security (e.g. Refs. [9–11]). There are several characteristics that make RE quite different from many fossil fuels: the dependence on flows rather than exhaustible stock, the widespread location of the resources, the variable character of some RE electricity production technologies and the close interaction between RE and biological

* Tel.: +46 8 5550 3379.
E-mail addresses: Bengt.H.Johansson@foi.se, bengt.johansson@miljo.lth.se.

[1] Following the definition of IPCC (Intergovernmental Panel on Climate Change) [1], "renewable energy (RE) is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. Renewable energy is obtained from the continuing or repetitive flows of energy occurring in the natural environment and includes low-carbon technologies such as solar energy, hydro power, wind, tide and waves and ocean thermal energy, as well as renewable fuels such as biomass".

[2] The share of primary energy consumption is lower.

0360-5442/$ – see front matter © 2013 The Author. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.energy.2013.09.023

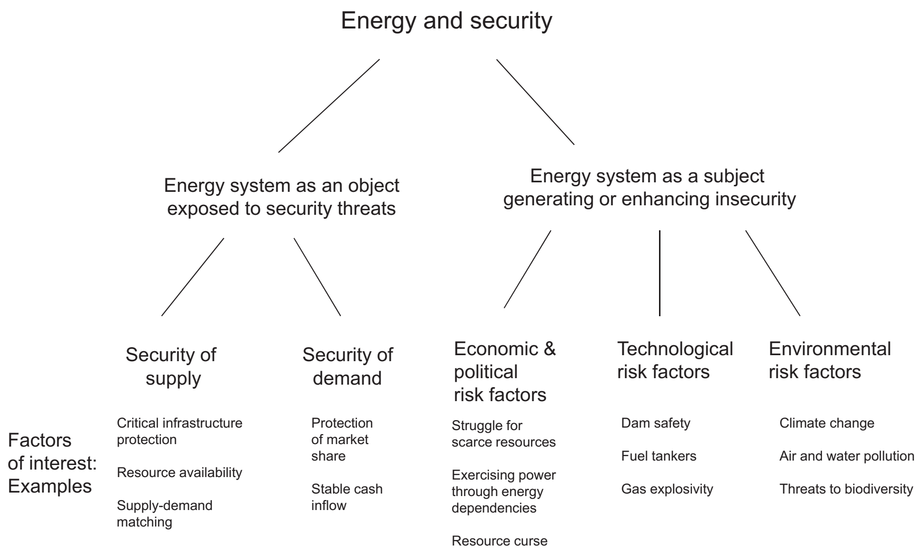

Fig. 1. The analytical structure used to study the relationships between energy and security. Based on [14].

systems (especially biomass). All this leads to security aspects that partly differ from those arising from fossil fuel-based energy systems. It is worth noting that in many studies; it is explicitly or implicitly assumed that RE is typically a domestic resource (see e.g. Refs. [7,9]), thereby reducing import dependence. Although this is largely true for the current situation, it may be quite different in the longer term if RE increases in line with the EU energy roadmap. In that case many countries will not be able to manage with local supply and will have to depend on energy imports (compare for example the discussions on the Netherlands and Germany in Refs. [12,13]).

In the following sections, the security aspects of RE are discussed following an analytical framework developed by Johansson [14]. The discussion concentrates on bioenergy, hydro power, wind power and solar energy (thermal and PV (photovoltaic)), which in most scenarios appear to be the important RE alternatives for the future. The security consequences of RE are described and compared with those of the currently dominating fossil fuels and nuclear power.

2. Relationship between energy and security

Previous studies provide a variety of definitions and approaches to energy security depending on their scope and scientific background (see e.g. Refs. [15–20]). An effort to describe the variety of perspectives was made by Ref. [14], who highlighted two approaches to energy and security that differ in principle, namely whether the energy system is an object exposed to security threats, or a subject generating or enhancing insecurity (Fig. 1). The analytical framework in Ref. [14] was developed to be applicable to any type of energy system and was chosen as basis for the analysis in this article. The structure is more inclusive than many other frameworks on energy security and encompasses a variety of security and safety issues and potential risk factors.

Within the *energy system as an object* approach, the focus lies on securing the functionality of the energy system, enabling it to provide the energy services demanded in society without major interruptions or severe price effects (see e.g. Refs. [21,22]). These aspects are usually included in the term *security of supply*. One could also choose to take the perspective of the energy supplier for which *security of demand* is essential for preserving stable income, etc. Integrating the perspectives of the consumer and supplier could be justified by their mutual, but differing, interests in an efficiently functioning energy system.

In the *security of* supply side of the approach, the focus is on the energy consumer, be it an individual, a nation or the global community. In this approach, considerations regarding long-term resource issues and short and medium-term balance between supply and demand are both of relevance, as is the adequacy and functioning of transportation, transmission and distribution infrastructure. Factors often used to qualify security of supply include resource availability, import dependency, supplier reliability, diversity in energy resources, secure transit routes, infrastructure reliability, etc. (cf. [23]).

The approach to the energy system as a *subject generating or enhancing insecurity* can in turn be divided into three different types of risk areas: *Economic-political*, *technological* and *environmental* (Fig. 1).

Economic-political risk factors arise from the competition around scarce and valuable resources, tensions, conflicts and violence resulting from overly abundant resources (the so-called resource curse), and the risk of the owner of a strategic resource using it as tool for achieving political and economic advantage. A consequence of the latter is that import dependency may appear as a negative factor in the discourse. However, liberal international relations theory presents a contrasting perspective and views interdependency as an important security-building factor (see e.g. Refs. [24,25]). According to this theory, the more dependent countries are on each other, the more secure the world will be, which will also bring security to individual countries.

Technological risk factors are associated with the physical characteristics of energy technologies, potentially leading to severe negative consequences and threats to security in cases where the system is not functioning as intended. This could be due to accidents (see e.g. Ref. [26]), hostile attacks (e.g. on hydro dams or gas or nuclear facilities)[3] or the use of radioactive material for weapon production or extortion.

[3] Attacks, for which the physical consequences are less profound, and for which it is mainly economic or political losses at stake, would more suitably be classified as belonging to economic and political risk factors.