Renewable and Sustainable Energy Reviews 15 (2011) 554–563

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Selecting sustainable renewable energy source for energy assistance to North Korea

Sul-Ki Yi [a,*], Hwa-Young Sin [b], Eunnyeong Heo [b]

[a] Korea Electrical Engineering & Science Research Institute, Bldg 130, Seoul National University, 599 Gwanangno, Gwanak-gu, Seoul 151-742, Republic of Korea
[b] Department of Energy Systems Engineering, Seoul National University, 599, Gwanang-no, Gwanak-Gu, Seoul 157-742, Republic of Korea

ARTICLE INFO

Article history:
Received 16 June 2010
Accepted 20 August 2010

Keywords:
Analytic hierarchy process
Benefit opportunity cost and risk
Negative priorities
North Korea
Renewable energy aid

ABSTRACT

Renewable energy (RE) is the best sustainable energy solution South Korea can provide to assist North Korea in overcoming its chronic energy shortage. Designed as a follow-on research to Sin et al. [1], a survey was conducted with a panel of experts consisting of various disciplines and affiliations using the analytic hierarchy process (AHP) with benefit, opportunity, cost, and risk (BOCR).

The results showed the panel viewed security as the most important factor among the strategic criteria. For the level 1 attributes, the panel showed no significant differences of opinion among the different alternatives; however, cost showed to be the most important factor for the panel. The panel chose wind power as the best alternative source of energy for North Korea; however, there were some differences in opinion among the sub-groups of the panel depending on the composition and the expertise of the sub-group.

Compared to other studies on the similar topic, this research stands out in that the research results were derived using AHP and BOCR and that the panel was composed of both Korean and foreign experts on North Korea affiliated with state-run research organizations, armed forces, non-governmental organizations, academic research organizations, private consulting firms, and journalism. The research arrived at the conclusion that the following factors must be considered as South Korea designs its future North Korean energy assistance policy: (1) RE assistance for North Korea can take on various forms; hence, experts consulted during the design, writing, and implementation phases of the policy in question must possess knowledge and expertise in the appropriate technology and methodology being considered; (2) possibility of a sudden destabilization of the Northeast Asian security paradigm due to the collapse of North Korea; and (3) continued nuclearization of North Korea.

Contents

* Corresponding author. Tel.: +82 2 880 7587; fax: +82 2 883 0827.
E-mail addresses: skyi@snu.ac.kr (S.-K. Yi), lovesin7@snu.ac.kr (H.-Y. Sin), heoe@snu.ac.kr (E. Heo).

1364-0321/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2010.08.021

1. Introduction

North Korea has been facing an energy crisis that it has not been able to solve through internal means [2,3]. While there is a desperate humanitarian need to provide North Korea with energy assistance, there are also numerous prerequisite issues that need to be addressed. Past and current energy assistance policies for North Korea, such as KEDO, heavy fuel oil aid, and direct power transfer, that the international community (to include South Korea) have implemented do not provide a fundamental or a permanent solution to resolving North Korea's energy problems. Energy assistance policies utilized thus far has faced several problems [4,5]. The outdated facilities and aging infrastructure of the North Korean energy sector make direct energy transfer (heavy oil and power) ineffective. South Korea and the international community discovered the truly decrepit nature of North Korea's energy infrastructure during the KEDO light-water reactor project [6]. North Korea has made a concerted effort to improve the situation; however, it has had little to no effect. Heavy fuel oil transfer has been delayed due to social and political controversies the heavy fuel oil transfers spark internal to the donor nation-states as well as the shortage of fuel storage facilities in North Korea [7]. There is a need for the North Korean government's political and physical will to truly resolve its energy shortage problem. As such, any policy planner who is working to implement an energy assistance policy for North Korea must first determine the North Korean Government's policy direction and then seek to find a cooperative framework that is compatible with it. Furthermore, the future energy assistance policies for North Korea, instead of being pedestrian short-range policies, must encourage internal changes and development of North Korea and fundamentally resolve the North Korean energy crisis by providing new energy technology transfers, facility and equipment support, infrastructure acquisition and expansion, and by encouraging international cooperation.

RE is the most appropriate energy to resolve the North Korean energy shortage while overcoming the various issues involved with providing North Korea with energy. First reason is that the inter-Korean RE cooperation would be consistent with the policy direction of the North Korean government. Secondly, technology transfer effects can be expected beyond the one-dimensional or simple energy transfer. Thirdly, considering the state of the energy infrastructure and T&D network of the North Korea, RE, which utilizes localized energy system, is a reasonable alternative [8–10]. Fourthly, North Korea has already shown its desire to actively develop RE and North Korea has high potential for future RE development [11,12]. Fifthly, the inter-Korean RE cooperation can influence publicity both domestically here in South Korea and internationally; avoid the pitfalls of the issues related to nuclear problem, international relations, or technology diversion to the North Korean military; and North Korean government is more likely to be amenable to the construction of RE facilities within its borders.

RE assistance to North Korea is expected to bring about the international community's political cooperation out of the spirit of humanitarian assistance. Economically, South Korea's RE market can potentially benefit and expand from increased demand. Over the long-term, South Korea can prepare for the unification of the peninsula as it constructs and upgrades North Korea's energy infrastructure [13]. Other researches in this subject have shown that the inter-Korean RE cooperation is appropriate because RE utilizes localized energy system; is consistent with North Korea's policy direction; and is appropriate for the environmental conditions of North Korea. The core of the North Korean RE technology development policy, in fact, is built around balancing energy, environment, and ecological aspects, and the aim of the North Korean energy policy is to satisfy environmental requirements while satisfying demand and security requirements by increasing production of sustainable domestically produced energy – a very sound policy goal. The international community has already provided North Korea with wind power, solar power, solar heat, and biogas facilities, which were in line with the existing North Korean RE policy goals.

While other researches on this subject conducted surveys and collected experts' opinions [14] or selected alternatives using qualitative methods [15], this research, in contrast, surveyed technical and political experts' opinions using AHP with BOCR method focused on selecting those RE sources that can be utilized for sustainable inter-Korean energy cooperation for the mid- and long-term, with the ultimate goal of energy independence for North Korea through technical cooperation that is firmly grounded in a theoretical methodology.

The concept of "sustainable" was important for this research because the North Korean energy problem cannot be solved by one or two simple aid plans. To solve North Korea's energy problem, one must be able to supply enough energy to solve the daily energy shortage in the short-term and an internal system must be established that can meet the future energy demands without external assistance in the long-term. It is in this perspective, this research defined the characteristics of new and renewable energy that can satisfy the needs for short-term energy transfer, mid-term energy relief, and long-term energy independence as the concept of "sustainable."

2. Methodology

2.1. Analytic hierarchy process (AHP)

Analytic hierarchy process (AHP) is one of the decision making tool which is designed to make decision between several alternatives with multiple factors using multi-dimensional evaluation criteria. AHP is proposed by Tomas. L. Saaty in late 1960s. AHP provides a comprehensive framework by considering quantitative and qualitative factors based on the intuitive and rational/irrational judgments of the respondents. The best feature of the AHP is that it divides complex issues into key factors and sub-factors by layering, and then calculates the weight of the factors with the pairwise comparison [16]. Other researchers have utilized AHP for research examining subjects such as multi-criteria decision making in energy planning [17], evaluation of energy sources for heating [18], and making sustainable energy development strategies [19].

A study with AHP starts with identifying issues and set problems into hierarchical factors. Then, pairwise comparison is conducted between adjacent low level factors based on the high level factors. Priorities are calculated by pairwise comparison and as a result of synthesizing the results, full priorities are calculated. In the final step, hierarchical consistency is measured and dependency between factors is considered. AHP method, basically, is a systemic method to conduct pairwise comparison between factors.

2.2. AHP with BOCR

One of the difficulties of the AHP analysis is the selection of factors. Especially in a not previously studied field or a field where no similar case studies have been conducted. In these cases, a separate survey is carried out just to select the factors to examine. The problem is that there are cases where no consensus can be built among the panels participating in the survey. The AHP with BOCR is a useful method to solve this problem.

In early days, *risk* is added to B/C ratio from the Benefit and Cost so the $B/(C \times R)$ ratio was used for the preferences from each hierarchy. Afterwards, fourth factor, *opportunity* is added [20] to enable the BOCR analysis to use $(B \times O)/(C \times R)$ ratio.