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RETScreen® 지중열 히트펌프 모듈 한국 적용에 관한 연구

아메드 나비드[1], 박 상현[2], 이 의준[3], 김 병선[4]

RETScreen® Ground Source Heat Pump(GSHP) Application for Korea

Ahmed T Naveed, Sanghyun Park, Euijoon Lee, Byungseon Kim

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Abstract : Korea is utilizing geothermal resources mainly in the bathing and swimming facilities with very few applications for industrial processes or space heating. It is estimated that geothermal capacity and annual utilization are 36.2MWt and 761TJ/year as compared to global capacity and annual utilization of 15,145MWt and 190,699 TJ/year. RETScreen software is a user's friendly tool for analyzing the technical and financial pre-feasibility of potential Renewable Energy (RE) projects that promotes the use of RE applications through the capacity building of planners, decision-makers and industries for successful implementation of RE projects. Strong ties between Canada and Korean organizations such as Korean Solar Energy Society (KSES) and the Korea Institute of Energy Research (KIER) exist for knowledge transfer about RETScreen. In this paper, an overview of RETScreen and its ground source heat pump (GSHP) model with a practical example of an existing project of a community hall in Canada are described to illustrate effectiveness of RETScreenin the implementation of RE technologies. The same community hall project is then evaluated hypothetically considering its location at Kangnyng, Korea. The main objective is to demonstrate how RETScreen GSHP model can also be utilized effectively for GSHP applications in Korea.

1. Introduction

Geothermal energy utilization for bathing and swimming applications contributes about 42% of the total global geothermal direct energy use. Ground source heat pumps have had the second largest energy use growth since 1995, over 59% or 9.8% annually. The installed capacity is 5275 MWt and the annual energy use is 23,275 TJ/year in 26 countries[(1)]. Korea is utilizing geothermal resources mainly in the bathing and swimmingfacilities with very few applications for industrial processes or space heating. The ground water temperatures are in the range of 25 to 70℃. It is estimated that geothermal capacity and annual energy utilizations are 36.2MWt and 761TJ/year[(2)].

RETScreen is developed by the RETScreen International Clean Energy Decision Support Centre in Varennes, Quebec under the Department of Natural Resources of the Government of Canada[(3)]. The core objective is to promote the deployment of renewable energy systemsby building the capacity of planners, decision-makers and industry to implement more projects successfully. RETScreen makes it easier for people to consider renewable energy projects at the critically important initial planning stage, which is generally the best opportunity for introducing new technologies. It also significantly reduces the duration and cost of the analysis itself, so that more renewable energy projects can be considered and, ultimately, more will be built

1) RETCan
E-mail : naveed@kier.re.kr
Tel : (042) 860-3275 Fax : (042)860-3739
2) Yonsei university, Korea
E-mail : gadget@yonsei.ac.kr
Tel : (02) 2123-2791 Fax : (02)365-4668
3) KIER(Korea Institute of Energy Research)
E-mail : ejlee@kier.re.kr
Tel : (042) 860-3275 Fax : (042)860-3739
4) Yonsei university, Korea
E-mail : sean@yonsei.ac.kr
Tel : (02) 2123-2791 Fax : (02)365-4668

1.1 Software and Data Tools

RETScreen is an effective tool to evaluate the potential RE projects and is implemented in the form of MicrosoftExcel Workbooks. Thus, presence of Microsoft Excel on the user's computer is prerequisite for RETScreen to function. The software is comprised of 9 independent renewable energy technology models, with a 10th model (Refrigeration) currently under development. Technology-specific databases such as international weather and products' technical and cost data are integratedinto each model to put as much relevant information as possible at the user's fingertips, to speed up and simplify the analysis process. A comprehensive context-sensitive help system that guides users in using the software and provides valuable background and reference information is also provided.

All the enabling tools are provided free-of-charge in English and French to users around the globe and can be downloaded from the RETScreen website (www.retscreen.net).

2. The REScreen® Process

2.1 Analysis Principles

Most engineering and architectural projects follow a similar sequenceof steps: inception, feasibility, design, engineering and finally construction. It is usually at the initial stages when it is decided which technologies will be used. Resources are typically not available to analyze technology options that may be unfamiliar to the proponents and renewable energy technologies are thus often ignored.

RETScreen has addressed this problem by specifically targeting the pre-feasibility and feasibility levels of analysis so that viability of one or more RET options can be evaluated quickly and inexpensively. A survey of project costs for small hydroelectric projectsconducted by World Bank suggests that it is often not practical or necessary to define a project with great accuracy at the early stages of its development cycle(figure 1). Rather, it is often in the interest of the project to evaluate multiple technology options at a preliminary level of analysis. Once the most promising technology is identified, more effort and resources may be justified to improve the accuracy of the analysis.

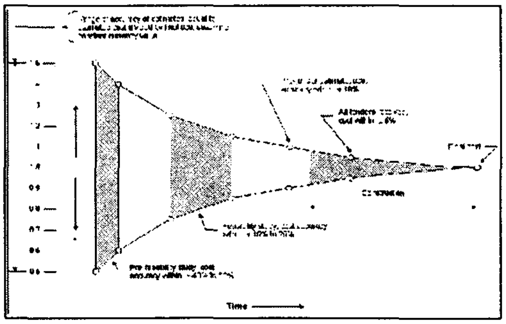

Fig. 1 Accuracy vs investment cost

2.2 Caculation Algorithms and Validation

The calculation approach for each technology model is unique, but in all cases the algorithms are simplified to minimize calculation times and input requirements. The individual technology models are based on simplified monthly analyses of energy flows or on annual calculations. Nevertheless, the calculation algorithms are generally powerful enough to account for numerous design variations and yield analysis results that correlate well with measured data and / or more powerful hourly simulation tools.Ground source heat pump model flow chart is shown in figure 2. The inputs required are GSHP system, building and weather data

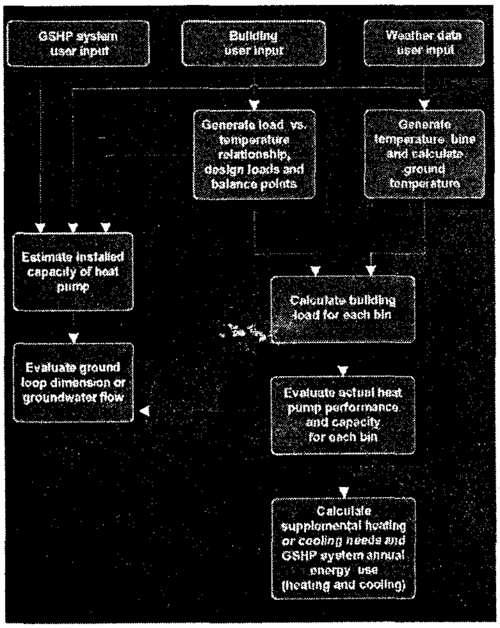

Fig. 2 RETScreen GSHP model flowchart

All technology models have been validated against available references, usuallyhourly simulation tools that are accepted as industry benchmarks. For each technology model, the detailed calculations algorithms as well as validation results are presented in the RETScreen e-Textbook. Monitored and RETScreen calculated results for ground source heat pump model are shown in Table 1. There is good agreement between the calculated and monitored results.

Table 1 RETScreen calculated and monitored heating energy use data

		Heating Energy use kWh	Diffenece %
Toronto	RETScreen	37,202	1.4
	Monitored	36,686	
Montreal	RETScreen	36,138	1.8
	Monitored	35,490	
Charlottetown	RETScreen	37,158	0.6
	Monitored	36,922	
Winnipeg	RETScreen	33,243	1.0
	Monitored	32,926	
Vancouver	RETScreen	37,888	-3.0
	Monitored	39,016	

3. Project Application

The ultimate goal of the RETScreen International Clean Energy Decision Support Centre is to help bring about the realization of more and better Clean Energy projects. The following example of a real-life GSHP project illustrates how RETScreen can be used at the feasibility study stage to model and predict both the technical and financial performance of such projects. This allows for a relatively comprehensive yet quick assessment of projects early on in the decision making process, enabling the decision maker to focus time and resources on those scenarios that are most likely to succeed. The easy to understand and standardized format of the analysis also provides an effective document that can be used to promote the project and to communicate its details to others. The example is not intended to explain the operating principles of the ground source heat pumps but to illustrate how real projects may be modeled using the RETScreen software.

3.1 Ground-Source Heat Pump Project

The earth's surface acts as a massive solar collector, absorbing radiation from the sun. Several meters below the surface, the ground maintains a constant temperature of about 10oC. In the winter this temperature is warmer than the air above it. Ground source heat pumps GSHP can be used to extract this heat fromthe ground and pump it into a building to provide space heating and to pre-heat domestic hot water. In the summer months the ground temperature is cooler than the air on the surface. The function of a GSHP can be reversed and used as a cooling mechanism, drawing heat out of a building. Because GSHPs raise the temperature to approximately 40oC they are most suitable for under floor heating systems such as in Korea, which require temperatures of 30 to 35oC, as compared to conventional boiler systems, which require higher temperatures of 60 to 80oC. GSHP systems can be used in virtually any size of building. They are durable, reliable and often take up less interior space than conventional heating and cooling systems. GSHP systems are also often cost competitive with conventional systems, particularly in new construction applications.RETScreen can be used to calculate the system sizes for vertical closed-loop, horizontal closed-loop and ground water type of ground heat exchanger system for space cooling and heating applications.

3.2 Project Overview
: Community Hall, Manitoba, Canada

The community hall located in Manitoba, Canada is a single story building with a floor area of 929m². Constructed in 1974, it has relatively low insulation levels and an average number of windows. Electric space heaters provided heating and standard rooftop units provided air conditioning and make up air. The hall is mostly used in the daytime for community or private functions. The equipment and lighting use for the building is relatively low. The community hall had 2000m² of land available for the GSHP system installation. The soil at the site is primarily damp clay and the mean earth temperature is about 5.5℃ with annual amplitude of 20℃.

3.2.1 RETScreen Worksheets GSHP

The following figures show all input and output worksheets of RETScreen for the GSHP example project, in sequential.

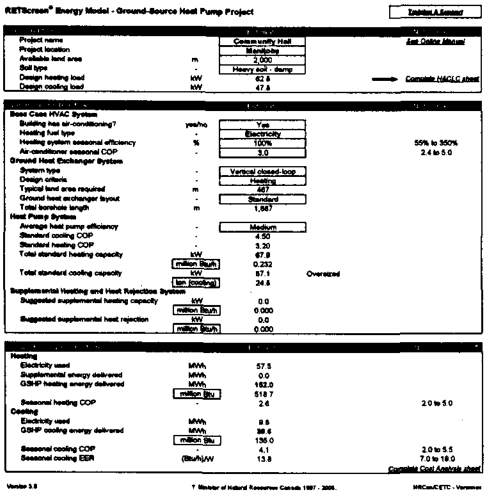

Fig. 3 Energy Model-community project, Manitoba, Canada

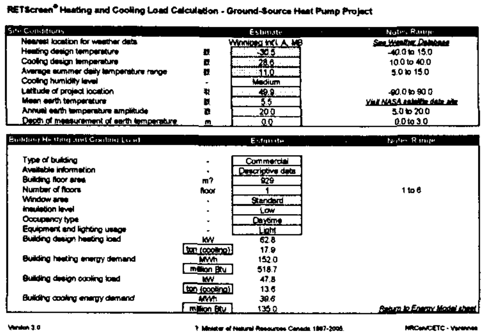

Fig. 4 Heating and Cooling Load Calculation

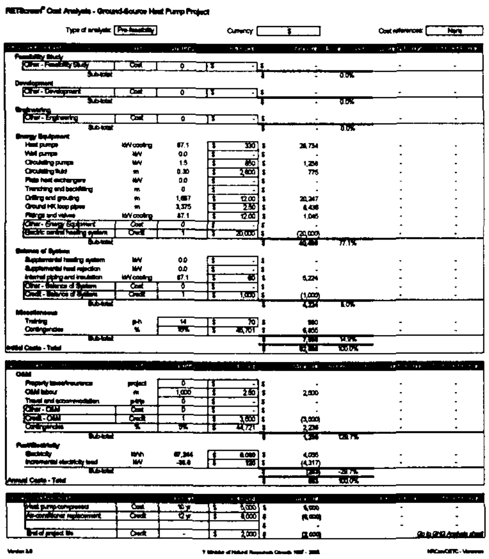

Fig. 5 Cost analysis

Vertical closed-loop type system is suggested as the calculated ground space required for horizontal closed-loop system was 2494m2 which is larger than the available land area 2000m2. The total suggested borehole length is 1687m. In the real project, the total borehole length is 1824m. The weather data for the specificproject location is not available, however, the weather data from the nearest weather station of Winnipeg international airport in Manitoba has been used for energy modeling. The type of building is commercial and only available information is in the form of descriptive data. RETScreenhas calculated building design heating and cooling loads of 62.8kW and 47.8kW respectively. Based on these calculated loads, a ground source heat pump system of 24ton is suggested.

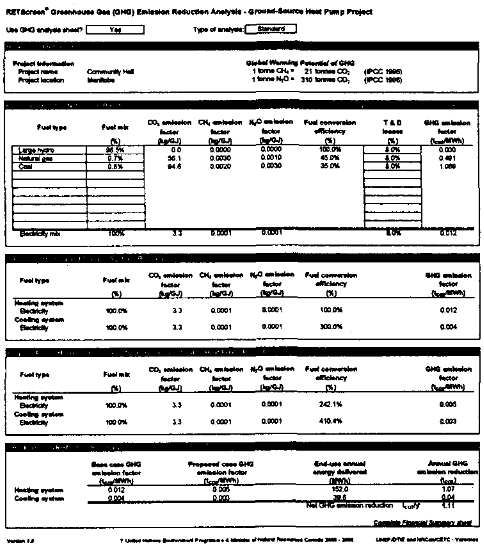

Fig. 6 GHG emission reductions

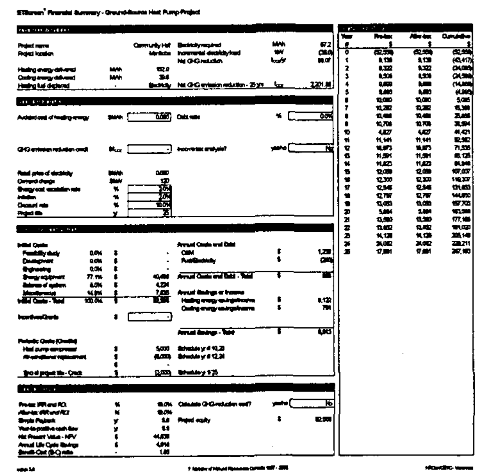

Fig. 6 GHG emission reductions

In the real project, two 10-ton GSHP have been installed. No initial credits are available in this case as the GSHP system is replacing an existing electric heating and cooling system that does not need to be replaced. However, for a new construction cost credits can be included which will reduce the payback period. The annual green house gas (GHG) emission reductions are 1.11 tco2which are low because it is assumed that the existing grid mix is the base case electricity system in Manitoba, wheremost of the electricity generation is from hydroelectric facilities. However, it will be significantly higher at locations where the major part of generated electricity comes from coal or gas. For example, by changing the electricity generation mix to 50% by large hydro, 30% by gas and 20% by coal will result in annual green house gas emission reductions of 33.49 tco2for similar GSHP system.

The financial analysis of the project shows that under the modeled conditions, the installation is cost effective with a simple payback period of 5.9 years. The pre-tax internal rate of return (IRR) and return on investment (ROI) are 19.0% which makes the project financially feasible. Tax analysis has not been included as municipal facilities are in general exempted from income tax or property taxes. The GSHP project is financially and technically feasible according to the RETScreen analysis under the given conditions. Technical design suggested is also very close to the one which was selected for the community hall project. However, RETScreenis not a designing tool but is only pre-feasibility evaluation software and it should not be used for the final designing of the project.

3.2.2 Real Project:

The community hall GSHP system consists of two 10-ton heat pumps connected toa ground source heat exchanger that uses a water/methanol mix as the working fluid. The ground heat exchanger is installed in a field of 48 boreholes, each 10 cm in diameter and 38 meters deep. To limit pumping power, the borehole field is segmented to match the loads. For example, when ice making is not needed, only the heating and cooling segment of the heat exchanger is utilized to meet the space heating and cooling loads. During winter operation, the ice making system sis rejecting heat to the ground while the space heating heat pumps are drawing heat from the ground. This boosts the efficiency and performance of both heat pumps systems.

4. Application for Korea

4.1. Community Hall in Kangnyng, Korea

RETscreen has been used to evaluate the feasibility of same Manitoba community hall project by hypothetically assuming that it is located in Kangnyng, South Korea. One more assumption has been made that it is a new project and GSHP is not replacing any existing heating/cooling system that will allow an initial credit for the cost of new heating/cooling system. Following are all the worksheet for the GSHP project in the sequential order.

Greenhouse gas emission reduction calculations show that the project will result in GHG reduction of 2.61tco2 per year. For the purpose of financial analysis, electricity and heating costs of KRW60/kWh and KRW506/m3are used respectively. The price of thecomplete ground source heat pump system including installation is KRW5.0M/ton as provided in " The second basic plan of renewable energy technology, development, use and spread " [4]. LNG has been considered as the existing heating fuel which will be replaced by GSHP.

Under the modeled conditions, simple payback period of the system is about 19years with RRI of 8.0%. Though the simple payback period is higher due to higher cost of GSHP in Korea, however, with the existing government subsidy of 70% on the initial cost of the GSHP reduces the simple payback period to only 1.4 years making GSHP a very attractive space heating and cooling option in Korea. RETScreen GSHP module can be a very beneficial tool in creating awareness and allowing the end users to compare various renewable energy options. Also, the financial incentives for the use of GSHP can also boost their applications in the country, consequently, reducing the initial costs and making the GSHP applications more attractive heating and cooling option.

The important parameters of the two GSHP projects are presented in Table 2 for comparison. The comparison of the two RETScreen feasibility studies suggests that GSHP system can be economically viable in Kore

Table 2 Comparison of main features of RETScreen feasibility of same project in Canada and Korea.

	Community Hall project	
	Manitoba, Canada	Kanynyng, Korea
Floor area(m^2)	929	929
GSHP system type	Vertical closed-loop	Vertical closed-loop
Typical land area required(m^2)	467	175
Total bore length suggested(m)	1687	676
heating capacity (ton(cooling))	19.3	8.1
Cooing capacity (ton(cooling))	24.8	15.2
system costs(KRW)	66,370,000	58,230,955
Heating fuel type	Electricity	LPG
Heating cost	KRW 60/kWh	KRW 506/m^3
Annual savings(KRW)	9.913M	4.670M
Simple Payback Period(year)	11.3	19.3 1.4*
IRR(%)	12.7	8.1 78.6*
Lifetime GHG emission reduction (T_{co2})	26.4	184.0
Project life0	25	25

* With government subsidy of 70% of initial GSHP cost.

5. Conclusions

RETScreencan significantly facilitate the development and implementation of ground source heat pump projects in Korea. Furthermore, RETScreen and its associated materials can also serve as effective educational tools for raising awareness of Renewable Energy technologies among a wide variety of professionals and decision makers.

Ground source heat pump is a mature technology and can meet the heating and cooling loads of any size of building as required in Korean seasonal conditions. GSHP produces heat in the temperature range (35-40oC) that is the most suitable for the traditional under floor heating systems in Korea. Also, it can be used in hot summer weather for air conditioning. RETScreen GSHP model can very effectively evaluate the technical and financial feasibility of GSHP application in Korea with levels of accuracy acceptable in the initial stages of the projects. Weather data from four meteorological stations, Jeju, Kangnyng, Seoul and Taegu is already integrated into the RETScreenGSHP model. Other required information such as typical system costs, boring or trenching costs etc can also be incorporated into the existing model which will allow the users to assess the GSHP projects even more quickly.

RETScreen feasibility analysis of a hypothetical community hall project in Kanyang, Korea suggests that GSHP can be economical and technical feasible especially with the existing government incentive of 70% on the initial costs of GSHP.

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