# Office Building GSHP System Retrofit Analysis with RETScreen Plus

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## ABSTRACT

The Republic of Korea has implemented a Renewable Energy Obligation(REO) whereby public sector buildings larger than 1,000 $m^2$ must reduce their energy consumption by 18% in 2016 and at least 30% between by 2030. Well intended solutions have been proposed; however, not all options are evaluated on the same basis, potentially resulting in incomplete or sub-optimal solutions. What's more once projects are implemented, there are inconsistencies in the methods used to measure and evaluate operating performance of the post-retrofit case. In this study, a ground source heat pump has been developed to simulate the performance of the ground source heat pump. The three distinct energy zones involve heating, no-energy, and cooling. RETScreen Plus methodology is used to develop curve fits for each distinct zone as it builds a correlation with NASA satellite data. The model then factors the impact of information and control technologies(ICT) as a means to improve and lower the building's energy consumption. Two values of coefficient of performance(COP) are used – the first is a standard ICT COP, while the second is an improved ICT COP with a smart controller. This methodology can then be expanded to incorporate current and future smart meter technologies, time of use rates, energy price signals, demand response and electricity storage options. In summary, this methodology enables a building owner or energy conservation official to quickly and accurately determine the baseline energy for a building and the potential impacts of smart ICT technologies, especially for buildings equipped with GSHP technologies.

## KEYWORDS

RETScreen Plus, Energy Modeling, GSHP, ICT, Hybrid, Optimization Methodology

## NOMENCLATURE

COP – Coefficient of Performance
CUSUM – cumulative sum of variances

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GSHP – Ground Source Heat Pump
PLR – Part Load Ratio
ICT – Information and Communications Technology
MT&R – Monitoring, Targeting and Reporting

## INTRODUCTION

The RETScreen and RETScreen Plus is a freely available software tool developed by the Canadian Government which can be used to develop energy baselines of clean energy technologies. Using curve-fitting and statistical methods like CUSUM the software can combine actual energy performance with near real time weather information from NASA. The underlying methodology conforms to continuous improvement best practices of the ISO 50001 Energy Efficiency Standard as illustrated in Figure 1.

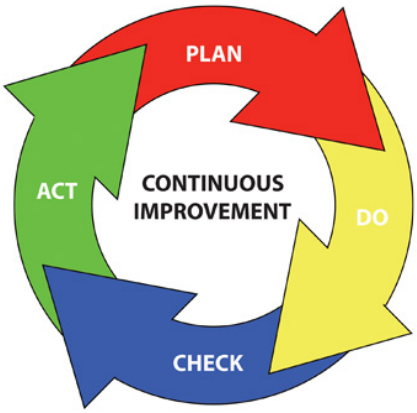


***Figure. 1*** *ISO 50001 continuous improvement cycle*

While RETScreen can be used to Plan and Do a project, RETScreen Plus can be used to check the results and Act on making improvements. RETScreen is freely available , operates in 35 languages and is widely used for clean project analysis. RETScreen has been widely used for consistent evaluation of both renewable energy and energy efficiency project options. RETScreen includes robust energy model templates for almost all clean energy technologies, likely to be used for Korea's REO including:

## RETSCREEN PLUS ANAYSIS

The Republic of Korea has implemented a Renewable Energy Obligation(REO) whereby public sector buildings larger than 1,000 $m^2$ must reduce their energy consumption by 18% in 2016 and at least 30% between by 2030. Heating technologies like GSHP can play an important role to achieve the intended REO option. The buildings sector in OECD countries consumes an average of 40% of all primary energy. An average of 60-70% of all energy consumed by buildings is for heating and cooling. According to the law of diminishing returns, as improvements are made in individual components it takes progressively more. Information and

Communications Technology (ICT) can be used to make step changes instead of incremental changes, especially for integrating the GSHP operation with smart electrical grids, weather information and statistical forecasting.

For climates where there is a heating and cooling season, the GSHP and other HVAC equipment uses more energy for heating as the ambient temperature decreases and more energy for cooling as the ambient temperature increases. There is also shoulder season days where the building neither requires heating or cooling. The actual slope, shape and inflection points for the heating, cooling and neutral zones depend on the characteristics of each building and occupancy patterns. The cross-over temperature range between heating and cooling for many building can be can be from 12°C to 16°C.

RETScren Plus can be used by facility operators, managers and senior decision-makers to monitor, analyze, and report on key energy performance indicators in GSHP systems. It can be used for Monitoring, Targeting & Reporting (MT&R), Measurement & Verification (M&V) and Energy tracking. The software has the ability integrate near-real-time NASA satellite-derived weather data for all land points on the earth. This feature can be used to develop the energy performance baseline and also for adjustments to the baseline based on future weather factors.

Using RETScreen Plus, the near-real time historic weather information (air temperature, ground temperature, solar radiation, wind speed) can be automatically integrated from a NASA website link and incorporated into the baseline operating model which characterizes the behaviour of the GSHP and external influences like outdoor temperature, building occupancy.

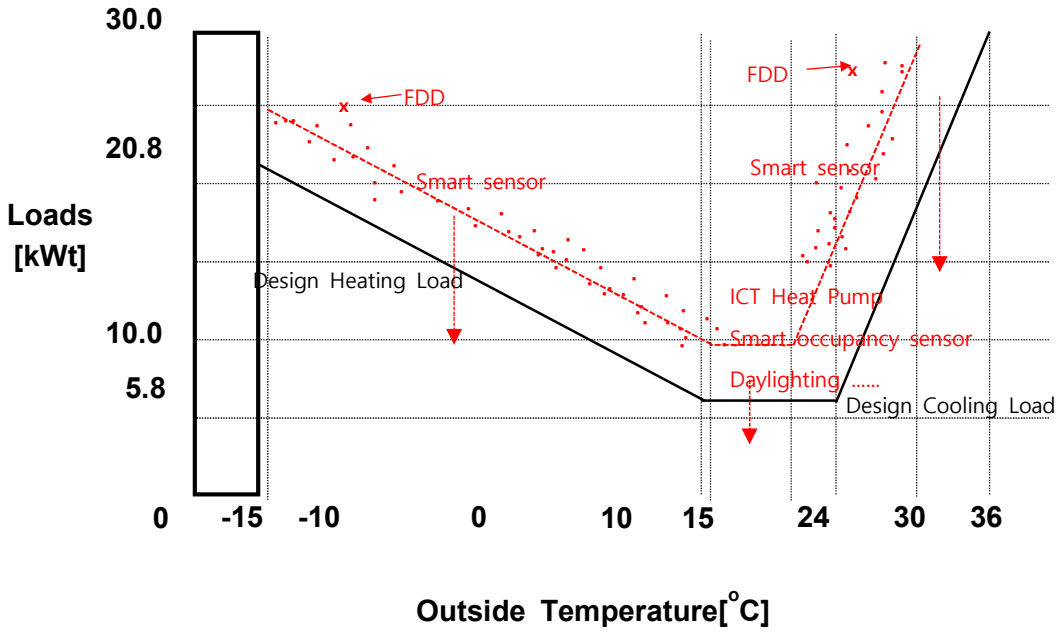


***Figure 2.*** *Optimization of GSHP with ICT and Sensors*

Once the optimal GSHP is selected to provide sufficient heating and cooling, the optimization of the PRL needs to be done. Figure 2 shows two conceptual scenarios

for the GSHP performance over a wide range of ambient temperatures in heating, cooling and neutral modes.

- The first scenario (dotted upper lines) reflects the energy performance using the conventional set points and typical operating parameters.
- The second scenario (solid lower lines) reflects the energy performance using the enhanced operation points. In this scenario the GSHP is adjusted based on sensors and telemetry information from ICT. In addition, the performance curves for heating and cooling modes are tuned using the analytical capabilities of RETScreen Plus.

The simulated energy results using RETScreen indicate that savings in the 10% for heating and cooling are plausible; however, this hypothesis needs to be tested through field analysis and pilot sites.

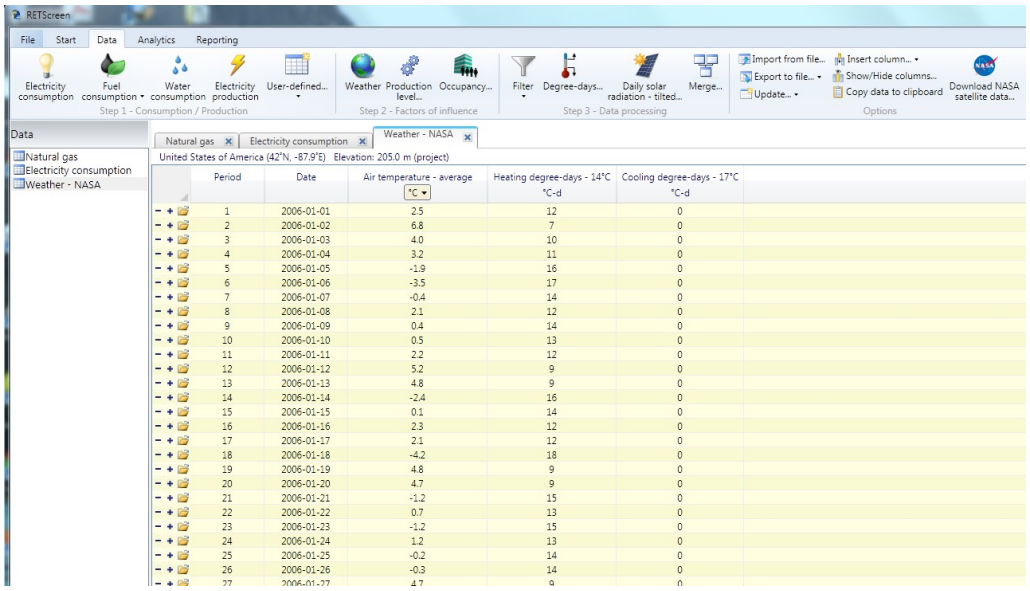


***Figure 3.*** *Data Entry Screen for RETScreen Plus*

Once the project is built and operating, daily data for GSHP energy performance should be recorded. The next series of steps involve using the RETScreen Plus software to compute the set point and run time for optimal the PLR. As shown in Figure 3, the daily data for electricity consumption, supplementary natural gas consumption and thermal performance of the GSHP is input into RETScreen Plus. The corresponding daily data can be downloaded to the model from the built in link to the NASA website.

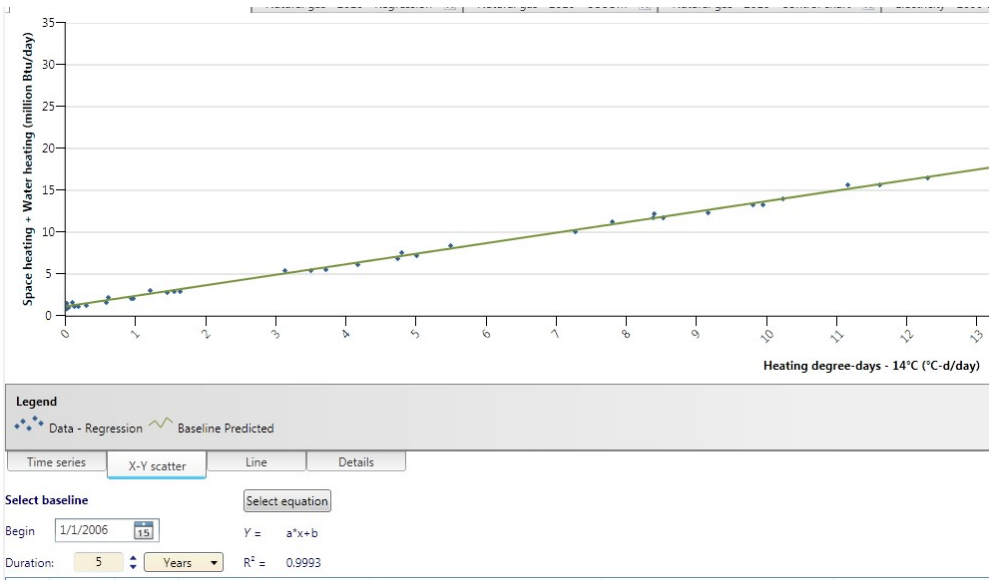


***Figure 4.*** *Polynomial Equation to Fit Data Points*

Using the built in Analysis tool the best fitting linear, polynomial or exponential relationship involving the dependent and independent variable is selected as shown in Figure 4.

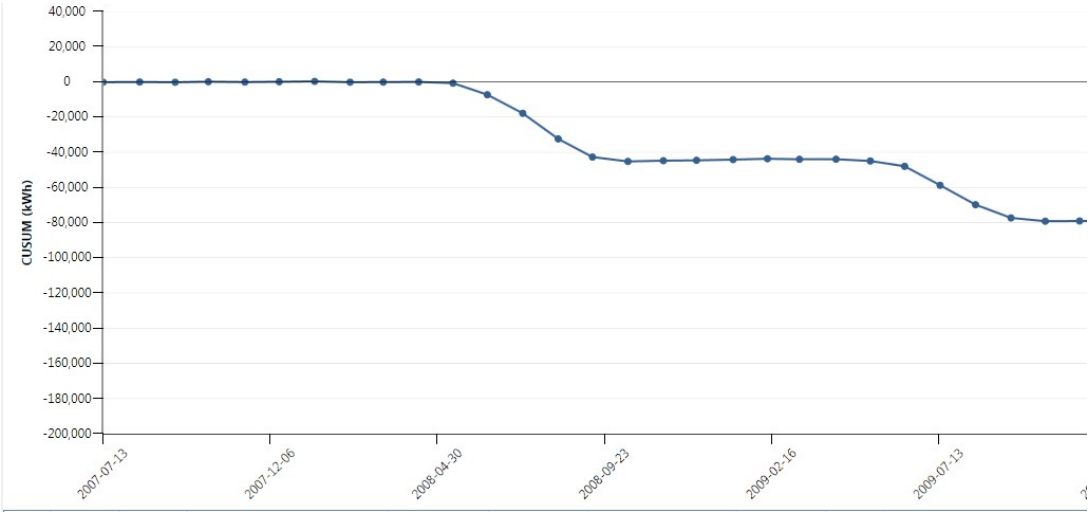


***Figure 5.*** *CUSUM Line*

The cumulative sum of the variance (CUSUM) is also generated by RETScreen. It shows the difference between the predicted or baseline energy consumption and the resultant energy consumption as a result of a change. The CUSUM line will slope downwards as energy efficiency improves, and slope upwards when energy efficiency decreases. A horizontal CUSUM line is one indicator that the system has been stabilized. Figure 5 is an example of the CUSUM line output from RETScreen.

Optimization of the GSHP system can therefore be made over a period of time by making slight changes to the PLR operating point and noting the energy consumption for the day ahead. After several periods of examining “cause and effect” the optimal

PLR operating point can be selected. The analysis process is computed daily and the new PLR level can be automatically adjusted by a smart controller. This procedure needs to be done separately for the heating and the cooling modes.

## CONCLUSION

Combining the GSHP with ICT sensors and telemetry is one example of using a smart grid technology. In the years ahead this method of analysis and finding the optimal set point can be used to reduce the overall capital and operating cost of a GSHP and carbon footprint. The RETScreen Plus tool provides the user with near real-time weather information which is a key component to the optimization process. It also provides powerful analytic tools to for analysis and statistical validation of results using established M&V and Monitoring and Targeting techniques. The use of this methodology can assist Korea's public sector to achieve the national goal of using a higher amount of energy from renewable sources and also reducing the carbon emission impact.

## ACKNOWLEDGEMENTS

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