

Analysis on the performance of GSHPs for New & Renewable Energy Certification program in Korea

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Abstract: All GSHPs, which were manufactured in Korea, should be tested for getting New & Renewable Energy Certification by KRAAC(Korea Refrigeration & Air-conditioning Assessment Center). The GSHPs could be tested at least one of three types test methods[NR-GT101(Water to water GSHP), NR-GT102(Water to air GSHP), NR-GT103(Water to multi-air GSHP)] In this paper, the heat balance and performance of tested water to water heat pumps were analyzed technically according to different test conditions of the GSHPs.

Key Words: GSHP(Ground Source Heat Pump), performance, heat balance

1 INTRODUCTION

With limited indigenous energy sources, Korea has to import almost entire energy demand. The cost for imported energy amounted to US\$ 172.5 billion in 2011. Korea is the 10th largest energy consuming nation in the world.

Due to the frequent fluctuation of oil prices and the changing of climate, consideration of renewable energy is becoming heightened. There are many government policies for supporting renewable energy in Korea. In order to accelerate the use of new and renewable energies, policies that support technology development and commercialization have been reinforced by setting policy target as 5%. Current government policy for supporting renewable energy can enhance the installing number of buildings in which has a renewable system for the cooling and heating load.

As one of the new and renewable energy source, geothermal energy has been used widely with heat pump system. GSHPs take heat from the ground and convert it into energy, which can be used to heat buildings. The earth stores the heat from the sun and maintains under the surface temperature of around 14~15°C even though the winter. The technology used is the same as that used in refrigerators. Just as a refrigerator extracts heat from the food and pumps it into the kitchen, so a GSHP extracts heat from the ground and pumps it into a building. Because a GSHP extracts heat from the ground, which has relatively constant temperature comparing with outdoor temperature, the GSHP is 300~400% efficient in terms of its use of electricity. At this efficiency level there will be less carbon dioxide emissions than

for gas boiler heating system. In many cases, it may also be possible to provide the required electricity by means of renewable energy, thus virtually doing away with any use of fossil fuels and reducing carbon emissions to zero.

To increase the system efficiency of GSHP (Ground source heat pump), various attempts have been applying in Korea. A hybrid cooling system that was installed in Korea with combining a chiller with a GSHP was evaluated on the system performance. (Jeon et al. 2010). Various studies of GSHP have been conducted for the performance of GSHP.

The Republic of Korea has the Promotional Law of New and Renewable Energy. The Law includes not only the definition of Geothermal Energy, but the accreditation process of the certification body and test laboratory for GSHP as New and Renewable Energy System. The performance of all GSHP should satisfy the Minimum Energy Performance Standard (MEPS) in Korea. Korea government accredited KRAAC (Korea Refrigeration & Air-conditioning Assessment Center) as the only test laboratory for testing performance of GSHP. It means that every GSHP should be tested by KRAAC to be sold in Korea as New and Renewable Energy system.

In this paper, I want to introduce KRAAC firstly, then performance of the water to water GSHPs which was tested within 2012 in Korea. Test standard and regulation for GSHP also briefly explained.

2 KRAAC (Korea Refrigeration & Air-conditioning Assessment Center)

KRAAC was established to promote the Korea HVAC-R industry in 2006 and to help local players achieve international certification. As an internationally accredited testing laboratory certified by Korea Laboratory Accreditation Scheme (KOLAS), KRAAC has done the assessment of HVAC products in Korea.

KRAAC can test almost all kinds of HVAC products with international test standards.

The republic of Korea accredited KEMCO (Korea Energy Management Corporation) as the certification body for almost all kinds of governmental mandatory energy relative program. KRAAC has been accredited by KEMCO as test laboratory for the governmental energy management program especially on the HVAC field. As easily know from the name of KRAAC, KRAAC also does for assessment of HVAC products in Korea with their own certification program.

KEMCO designated KRAAC as test laboratory for GSHP of New & Renewable Energy System, test laboratory for Energy Efficiency Label and Standard Program (EELSP). KRAAC can test almost all kinds of HVAC products which are classified with EELSP, and GSHP.

For this paper KRAAC analyzed the test data from water to water GSHP, which were tested during the year of 2012.

3 Test standard and MEPS for GSHP in Korea

Every water to water GSHP should be tested by NR GT 101 test method to get a New and Renewable Energy system certification in Korea.

Water to Air GSHP should be followed by the test method of NR GT 102. For the water to multi system, which has multi indoor unit like VRF system, NR GT 103 existed in Korea.

Table 1 shows the test conditions in NR GT 101 for thermal performance of water to water GSHP unit. It includes inlet water temperature in load-side, environment temperature of

tested heat pump, and inlet water temperature in source-side. NR GT provides two inlet temperature conditions to consider the different source types of ground-water and ground-loop.

NR GT 101 test method was developed on the basis of ISO 13256-2.

There are three main differences between ISO and NR GT test method.

First, inlet water temperature of source-side in heating mode is 5 °C in the NR GT which is greater than the inlet water temperature of source-side of ISO 13256-2.

Second, NR GT 101 limited the maximum water flow rate per capacity as 11.4 lpm/3.5kW to achieve economic system efficiency for customers.

Third, it has the Minimum Energy Performance Standard (MEPS) to verify the performance of water to water GSHP. Since the time of April 2013, water to water GSHP had to satisfy the new MEPS (Table 2)

Table 1 Standard test condition of NR GT 101

Type		Inlet water temperature in Load-side(°C)	Inlet water temperature in Source-side(°C)
Heating	Ground water	40	10
	Ground loop	40	5
Cooling	Ground water	12	15
	Ground loop	12	25

Table 2. MEPS of NR GT 101 for water to water GSHP

Type		Previous		Present (13.04 ~)	
		EER	COP	COP _c	COP _h
Water to Water	Close Loop	4.10	3.45	4.31	3.62
	Open Loop	4.80	3.6	5.04	3.78

4 Performance & Heat balance analysis for GSHP

KRAAC tested 43 water to water GSHP models in 2012. Each model had tested 4 different conditions including mode change(heating mode, cooling mode). The performance was analyzed by range of heating capacity.

Figure 1 shows the COP according heating capacity with inlet temperature for ground loop GSHP type. Some models in the range of 20 RT ~ 40 RT and 40 RT ~ 60 RT were failed to pass the test with showing lower performance than MEPS in 2012.

The new MEPS required more effort to increase efficiency of GSHPs. Average COP tells that present technical condition can not overcome the new MEPS. Comparison with the test results under the test condition of ground water type(Figure 2) tells that new technology to increase heating performance with low heat source should be required.

Figure 3 and Figure 4 presents the performance according to cooling capacity for water to water GSHP. Cooling efficiency status is relatively easy to satisfy the new MEPS with comparing to the heating efficiency. However, some GSHP which shows the minimum cooling performance have to be developed to achieve the new performance goal.

Sometimes certification test for GSHP was failed due to the unstable heat balance of GSHP system. Unstable heat balance can be occurred with several reasons for complicated system. If the heat pump does not have complicated compositions, reverse valve can make the unstable heat balance occasionally. Figure 5 and Figure 6 show the averaged heat balance according to heating capacity and cooling capacity of tested GSHP.

The test data can be interpreted physically with two analyzed conditions. First, the averaged heat balance was decreased from plus to minus by increasing both GSHP capacity of heating and cooling. Secondly, similar trend was found by increasing the temperature difference between the inlet water temperature of load-side and that temperature of source-

side. This trend tells us two possible causes. One is the physical leaking the refrigerant of GSHP system in the reverse valve because of high pressure difference. Another is the heat lose from the surface of tested heat pump.

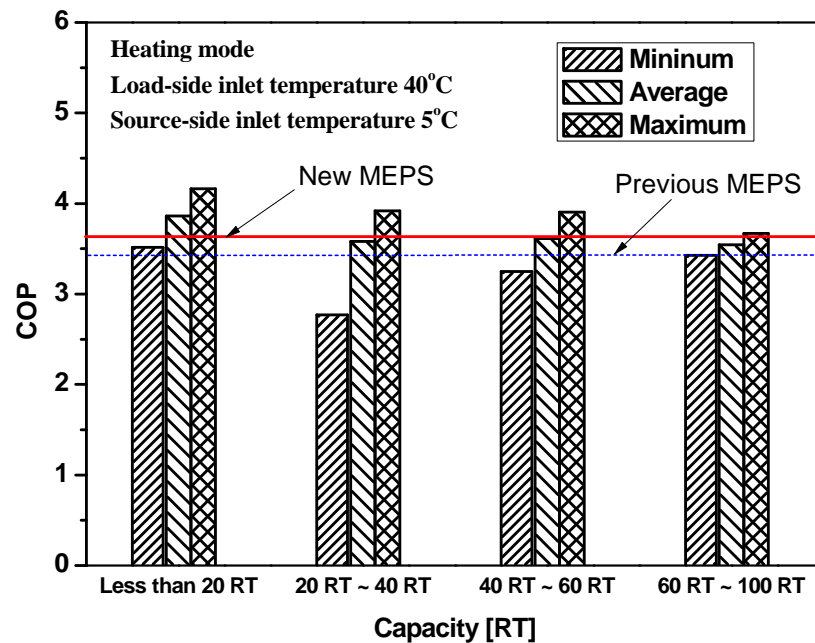


Figure 1: COP according to heating capacity for water to water GSHP unit. (Source Temp. 5 °C)

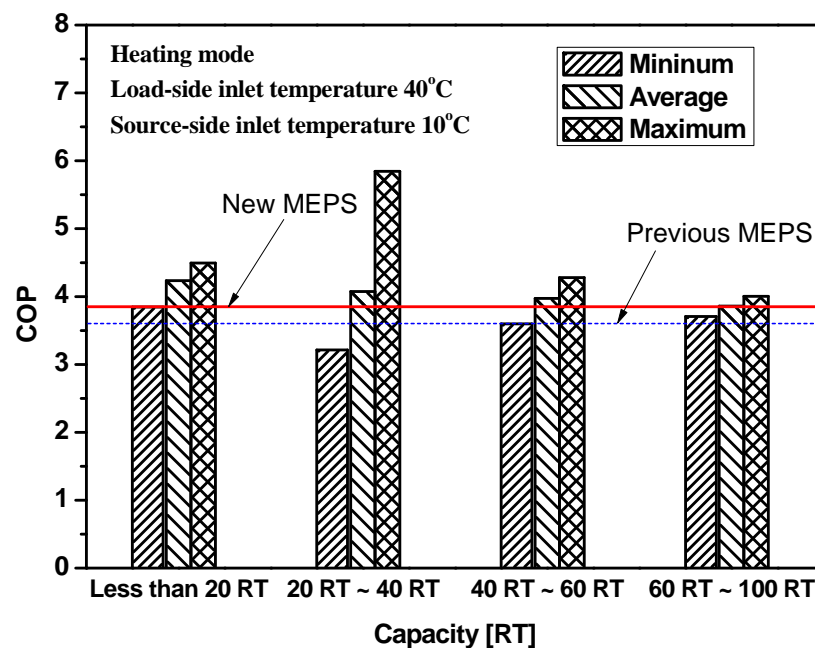


Figure 2: COP according to heating capacity for water to water GSHP unit. (Source Temp. 10 °C)

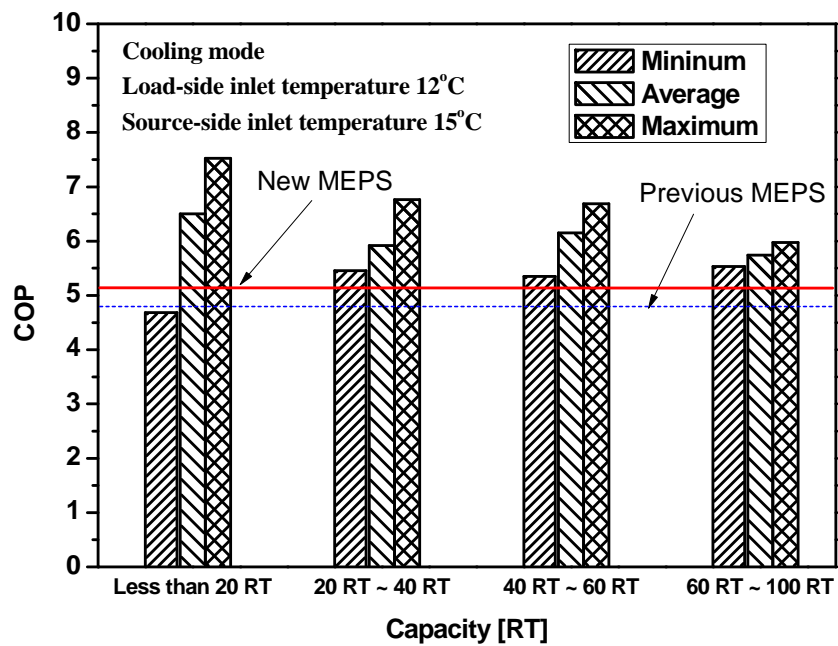


Figure 3: COP according to cooling capacity for water to water GSHP unit.(Source Temp. 15 °C)

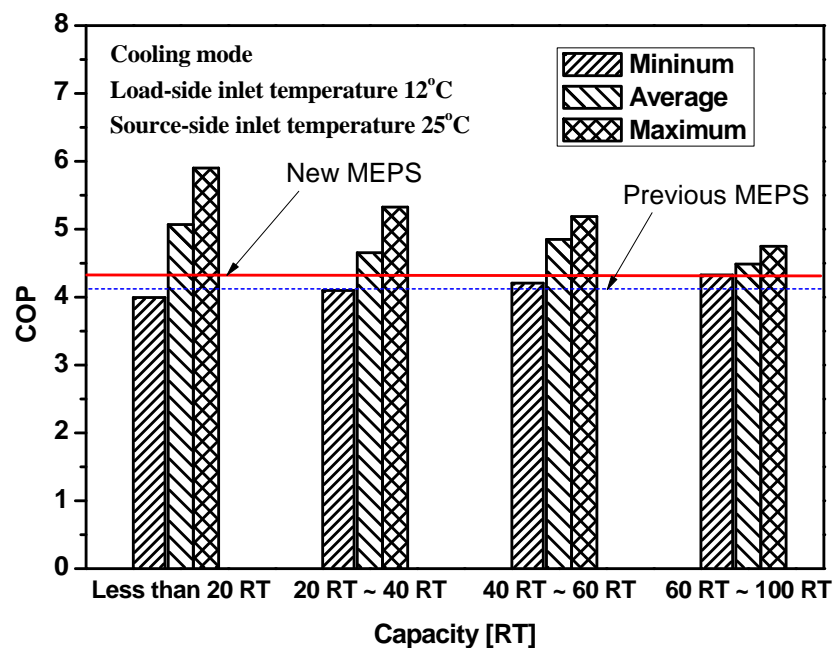


Figure 4: COP according to cooling capacity for water to water GSHP unit.(Source Temp. 25 °C)

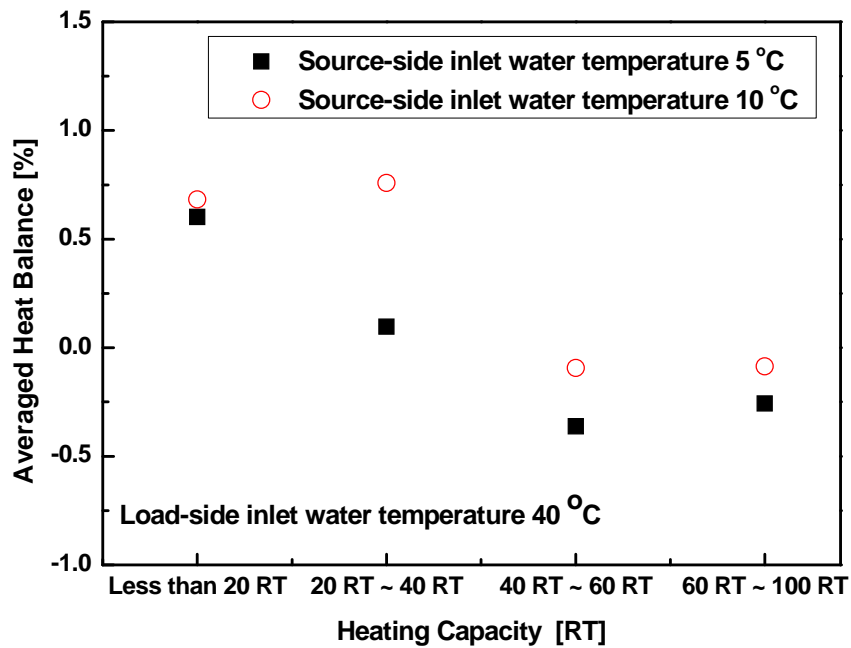


Figure 5: Averaged heat balance according to heating capacity

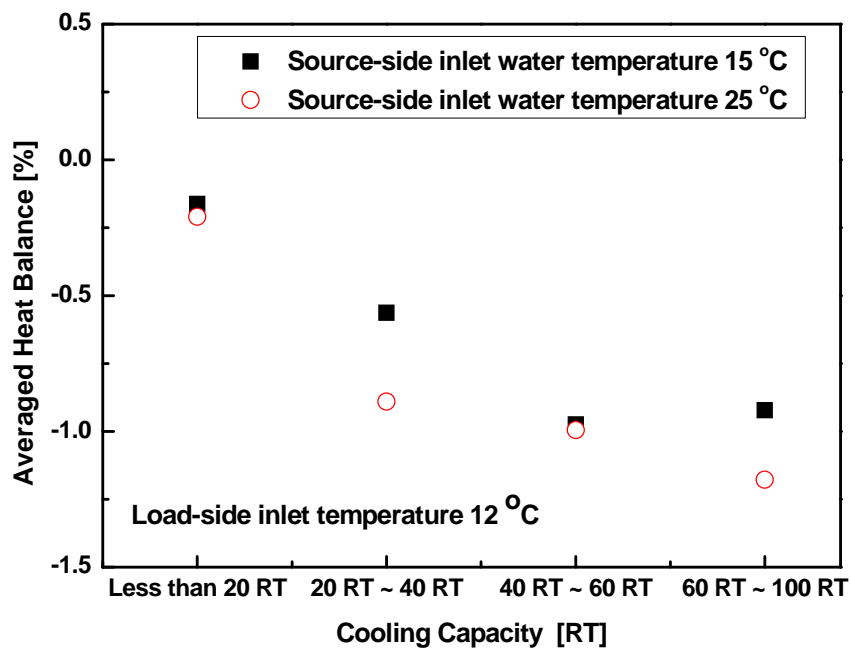


Figure 6: Averaged heat balance according to cooling capacity

6 CONCLUSION

In this paper, New and Renewable Energy System Certification for GSHP was discussed and the performance of tested GSHP was analyzed according to the capacity.

Every GSHP heat pump should be tested by KRAAC, which was accredited by Korea government to test the GSHP as New and Renewable Energy System. KEMCO, which was accredited by government as certification body for GSHP, managed the test method of NR GT for GSHP. NR GT 101 for water to water GSHP was originated from ISO 13256-2. However, NR GT is not same as ISO 13256-2. It limited the maximum water flow rate of GSHP system to get economic system efficiency for customer.

Revised NR GT 101 was applied from April 2013. The performance of water to water GSHP was analyzed according to the capacity and checked with new MEPS.

Current technical level should be increased to achieve the revised MEPS, especially in heating mode with the low temperature heat source.

One of the causes for test failure is unstable heat balance of tested GSHP system. The averaged heat balance was reviewed to interpret the occurring reason.

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