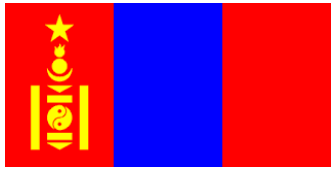

5th International Conference on Smart Energy Systems
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#SESAAU2019

Applicability of Solar-Assisted Heat Pump System for Space Heating in Mongolia

NYAMTSETSEG Ivanov
Mongolia
11th Sep, 2019

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OUTLINE

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II METHODOLOGY

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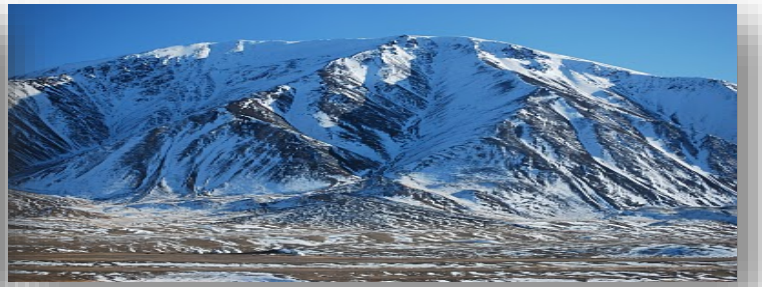
CONCLUSIONS

1.1 Background

- Territory: **1.564** million km²
- Population: **3.5** million
- Capital city: **Ulaanbaatar** (approx 1.5 million)
- Highest point: Huiten peak **(4374 a.s.l.m)**
- Lowest point: Khukh nuur depressions **(518 a.s.l.m)**
- Lowest annual average temperature: **-21°C - (-50°C)**
- Highest annual average temperature: **+23°C - (+40°C)**
- Official language: Mongolian
- Religion: Buddhism

1.1 Background (cont. 1)

Climate: Sharp continental, marked by four seasons.
Average **summer** temperature +17'C - (+40°C)
Average **winter** temperature -26'C - (-50°C)




1.1 Background (cont. 2)

Temperature of Ulaanbaatar, 2013

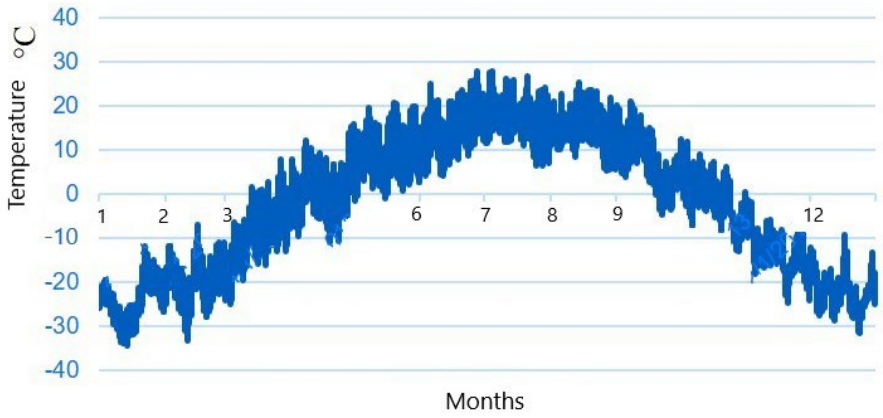


Figure 1 Annual Ambient temperature of Ulaanbaatar in 2013

less than **-40°C in the northern**

40°C in the Gobi Desert

An annual mean temperature of **-2.3°C**

Solar potential in Mongolia

Daily average insolation: **4.3-4.7 kWh/m2**

Sunny days per year: **270-300**

"Land of Blue Sky"

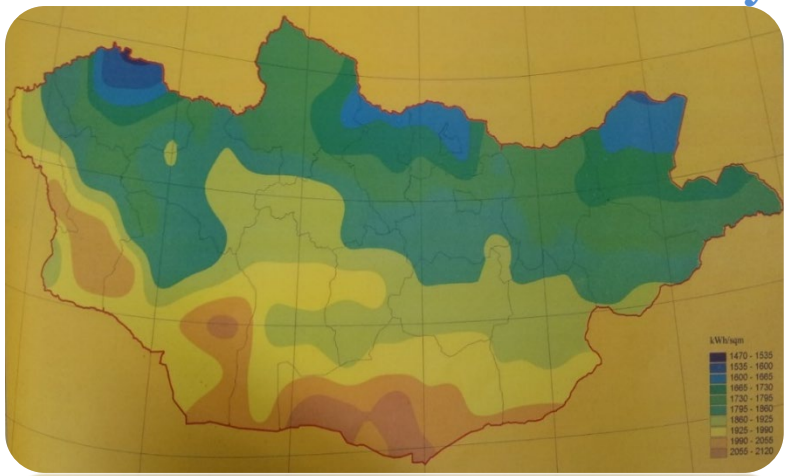


Figure 2 Annual global solar radiation of Mongolia
Source: Mongolian Academy of Sciences

1.1 Background (cont. 4)

Overview of energy generation structure & heat consumption

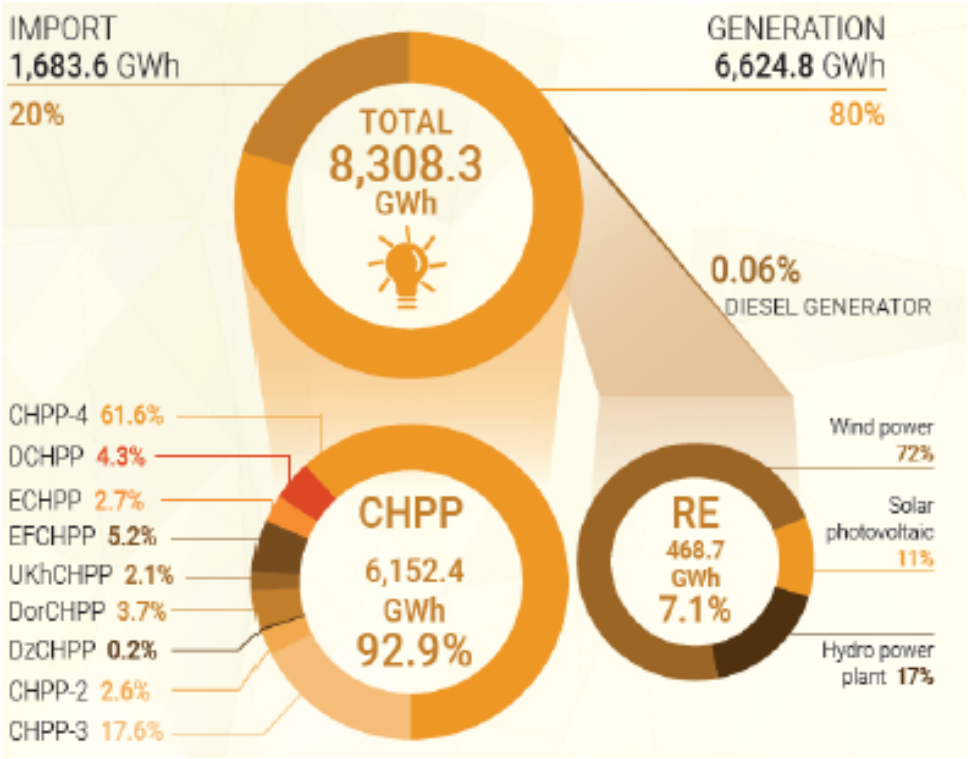


Figure 3 Energy generation structure and imports
Source: MOE, Mongolia, 2018

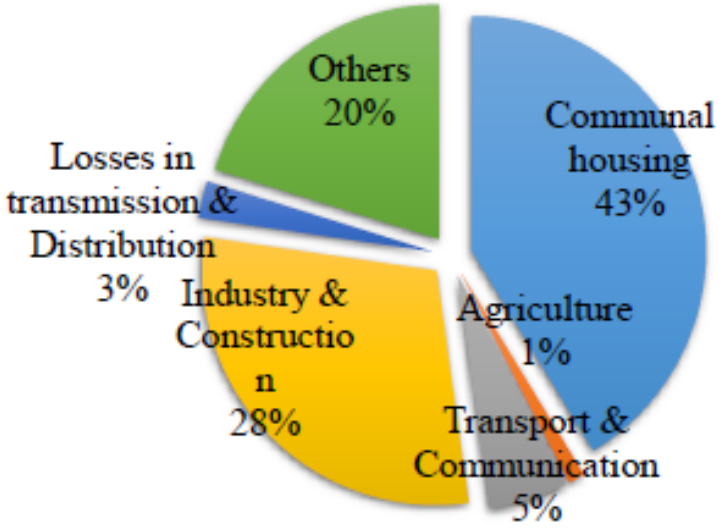


Figure 4 Heat consumption by sector
Source: NDCPS, Mongolia, 2018*

- 42.1 % - 148,651 householders /apartments/
- 57.9 % - 204,161 householders /Sub-Urban area/

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*NDCPS – National Dispatching Center of Power System.
*MOE – Ministry of Energy

1.2 Research statement

- WHO listed **Ulaanbaatar** as one of **most polluted five cities** in the world.
- The fine particulates level reaches as high as **750 $\mu g/m^3$** in winter season while the annual average ranges from **136 – 141 $\mu g/m^3$**
- WHO guideline level of **10 $\mu g/m^3$**

Figure 5 Sub-Urban area; clear and smoky day
Source: National Renewable Energy Center

1. A large emitter of CO2 !!!

-380,000-420,000 ton coal;
-7.39 million ton CO2 in 2018;

2. Huge air pollution !!!

District heating is urgently needed.

How to solve this faced problem? → **Low carbon heating system**

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*WHO – The World Health Organization

* UBDHC – Ulaanbaatar District Heating Company

1.3 Purpose

The main objective is to investigate the applicability of solar-assisted heat pump (SAHP) system instead of conventional coal-fired furnaces applied for

Why this new technology: An energy saving, customer satisfying, and environmental friendly independent heating system.

2.1 Study area

Ulaanbaatar divided into nine districts and municipal sub-districts. Each municipal sub-districts have an administrative building which includes:

- ✓ Administration office
- ✓ Bank,
- ✓ Police station,
- ✓ Clinic.

Figure 6 19th khoroo, Chingeltei district

Table 2 Building description

Building establishment	2010
Total floor area:	450 m2
Roof area:	178.5 m2
Max. heating load:	45 kW
Design outside temperature:	- 39°C
Coal consumption:	40 t

Therefore, a conventional coal-fired heating system supplies the desired heating demand. Efficiency is 45%

2.2 System design & Configuration

Three kinds of systems which are:

- ✓ **Conventional coal-fired heating system /Efficiency is 45%/,**
- ✓ **A solar collector heating system,**
- ✓ **SAHP system.**

① *Conventional coal-fired heating system:*

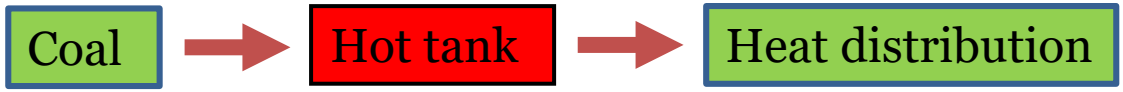

Figure 7 Energy flow chart of conventional coal-fired heating system

② *Solar collector heating system:*

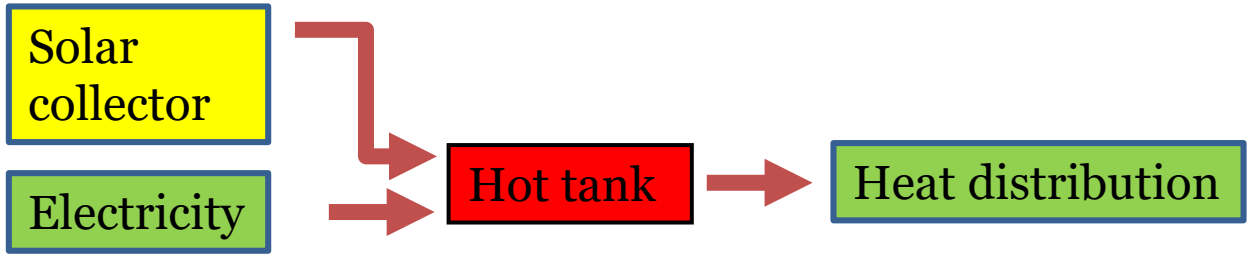

Figure 8 Energy flow chart of a solar collector heating system

2.2 System design & Configuration (cont. 1)

③ SAHP system:

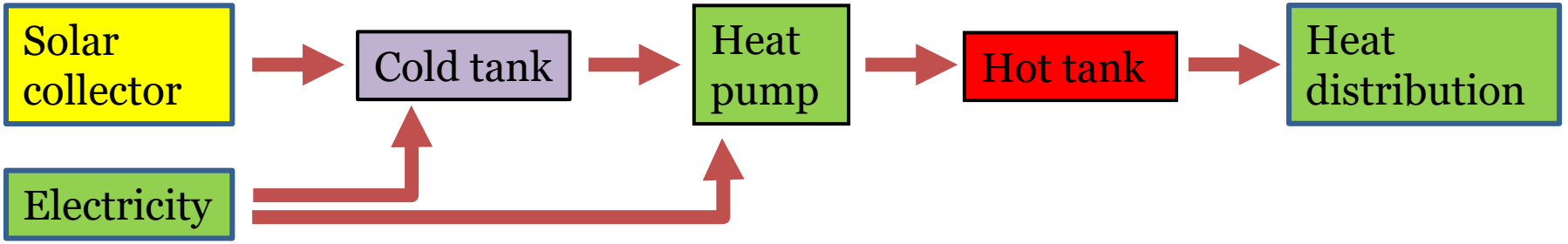

Figure 9 Energy flow chart of SAHP system

The research has carried out as a total heating load is 45 kW based on the water source heat pump system, through a flat-plate collector integrated system.

Inputs to the model:

- Outdoor temperature,
- Source fluid inlet temperature,
- Supply fluid outlet temperature,

Outputs:

- Return water temperature,
- Heating load,
- Energy consumption,
- Water storage temperature.

2.2 System design & Configuration (cont. 2)

Solar collector heating system main components:

- ✓ Solar collector
- ✓ Storage tank,
- ✓ Controller,
- ✓ Circulating pumps,

Auxiliary components:

- ✓ Weather data reader,
- ✓ Space heating load model,
- ✓ Online plotter,
- ✓ Printer.

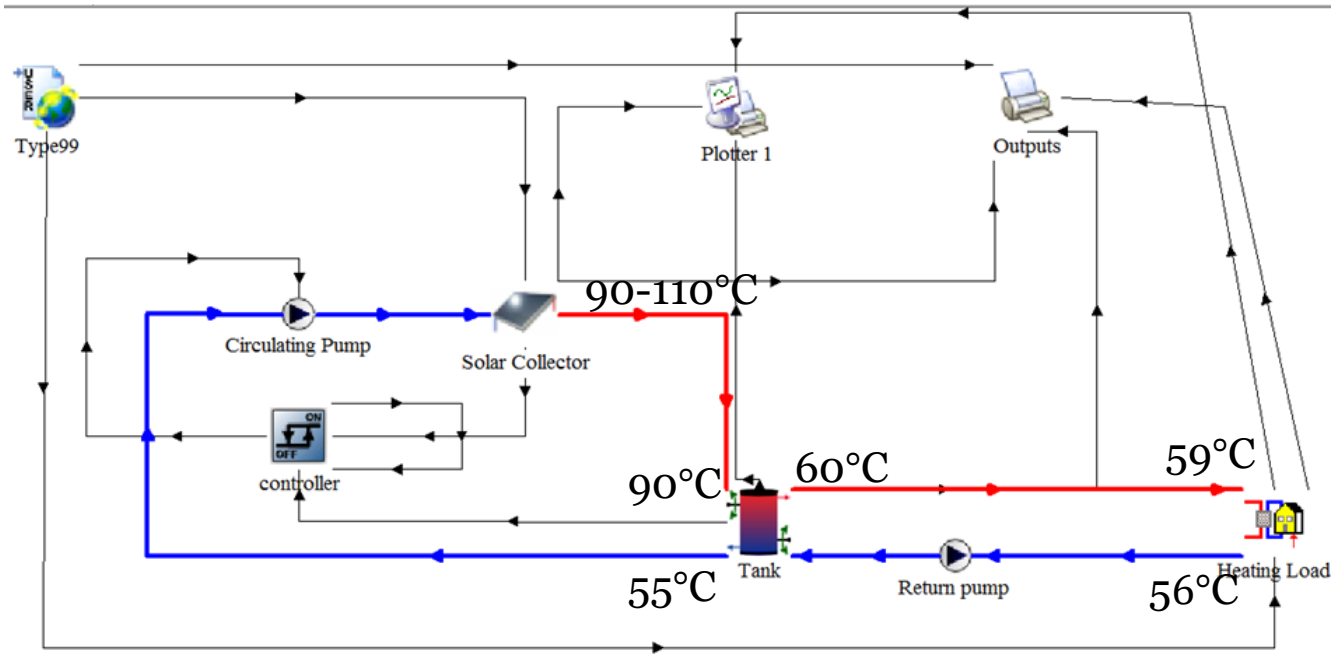

Figure 10 Solar collector system model

2.4 System design & Configuration (cont. 3)

SAHP system main components:

- ✓ Heat pump,
- ✓ Solar collector,
- ✓ Storage tanks,
- ✓ Controller,
- ✓ Circulating pumps,

Auxiliary components:

- ✓ Weather data reader,
- ✓ Space heating load model,
- ✓ Online plotter,
- ✓ Printer.

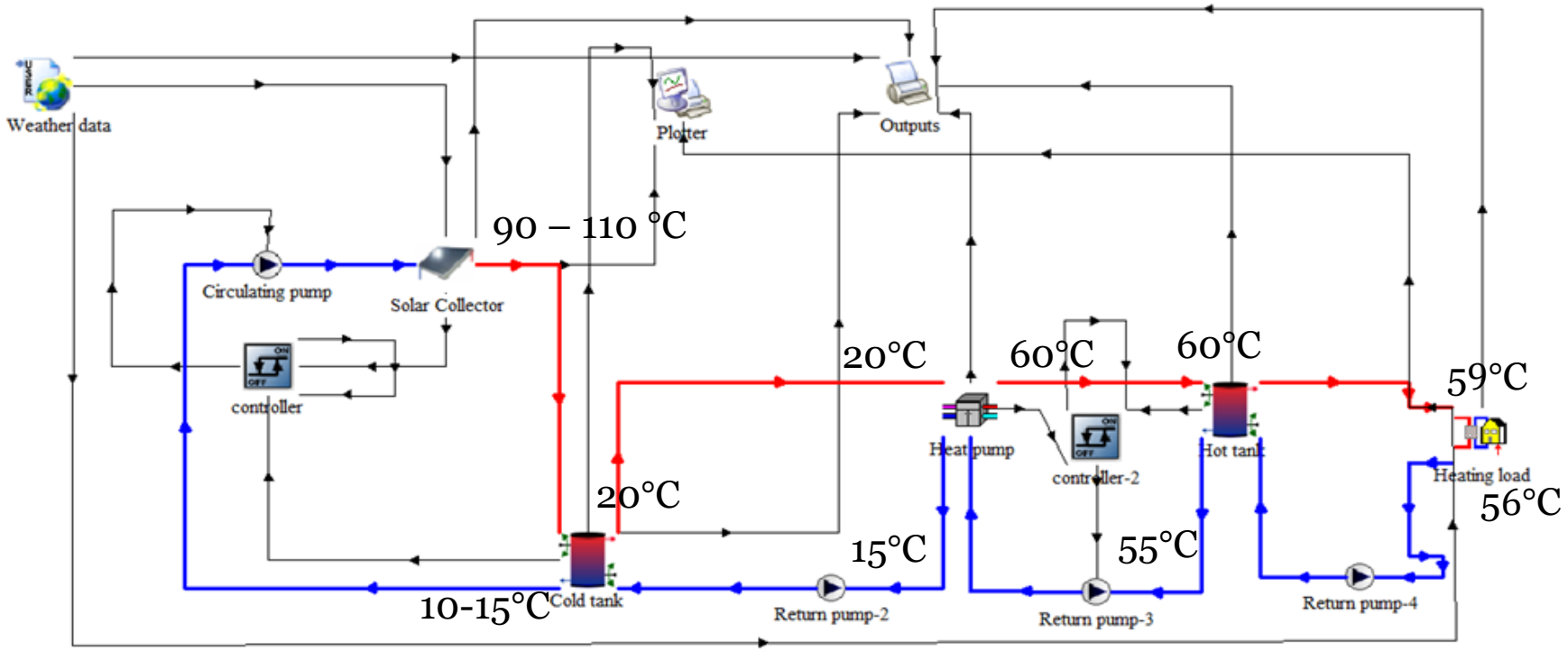

Figure 11 SAHP system base model

3.1 Solar collector heating system results

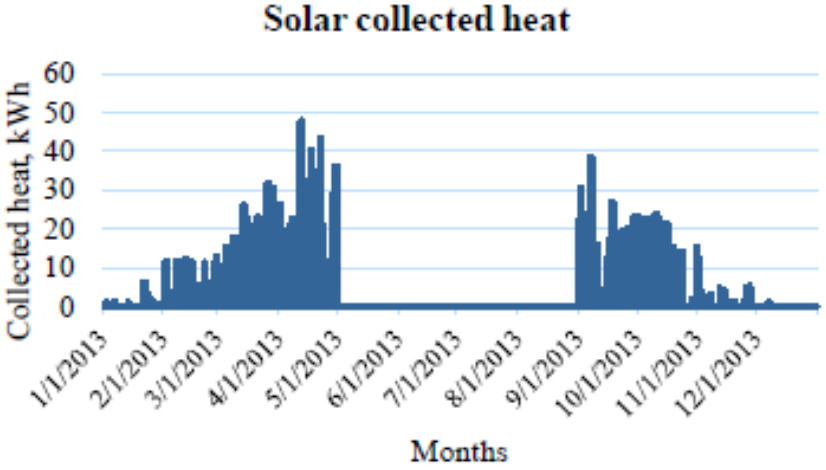

Figure 12 Collected solar heat from the solar collector loop

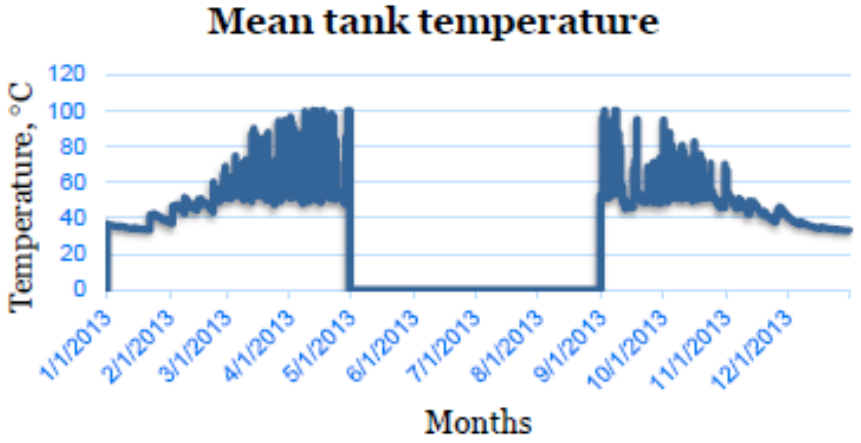

Figure 13 Mean temperature of hot water tank

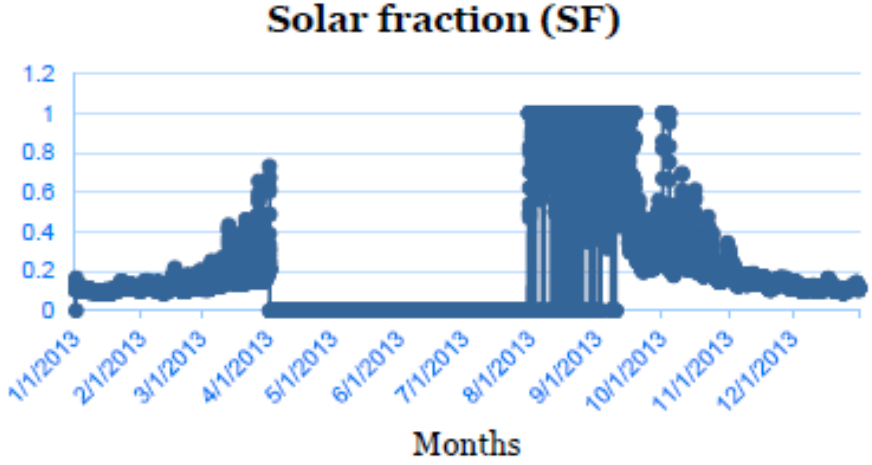

Figure 14 Solar fraction

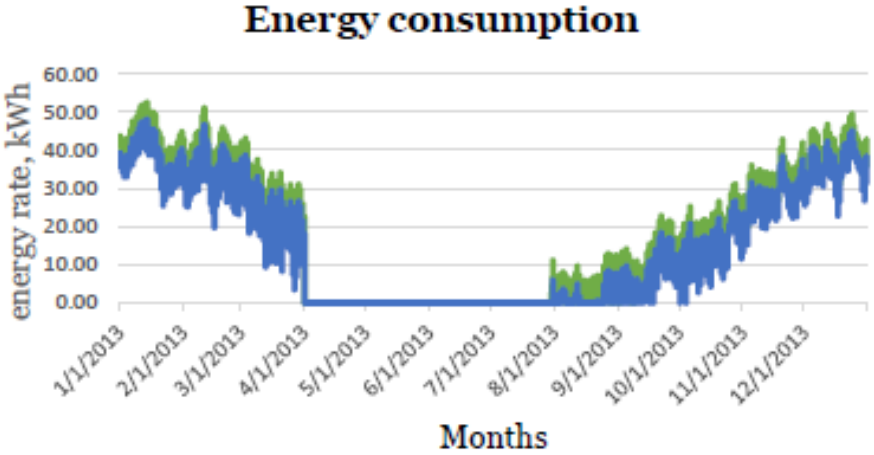

Figure 15 Energy consumption

3.2 SAHP base model results

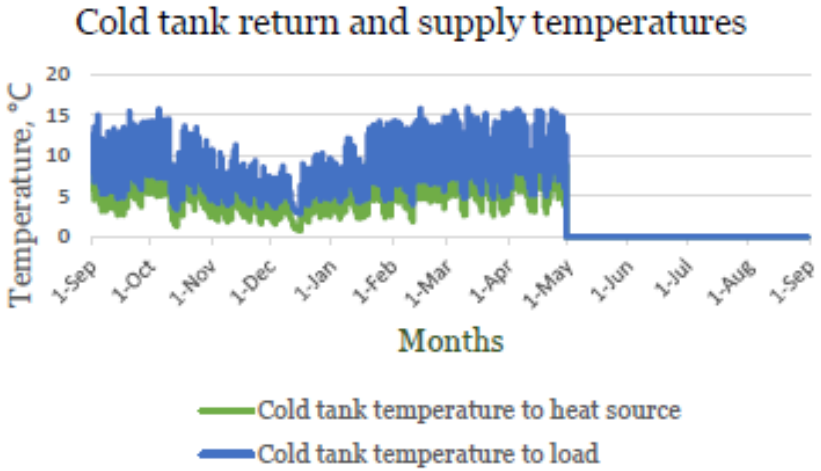

Figure 16 Cold tank temperatures to heat source and load.

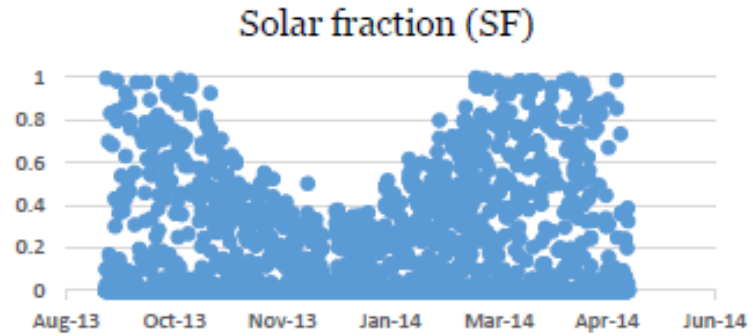

Figure 18 Solar fraction of SAHP system.

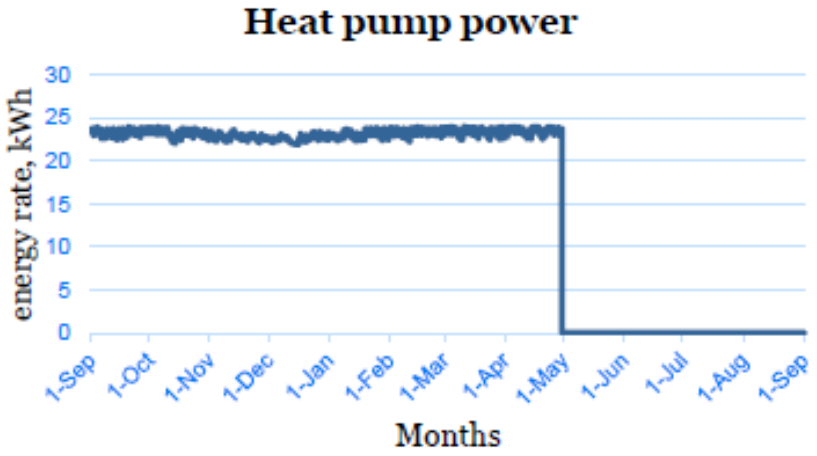

Figure 17 Heat pump power.

- ✓ Heat pump power ranges between 22 and 24 kWh during the heating season. As a result, heat pump COP is 1.82 due to too low ambient temperature.
- ✓ SF is from 40% to 100% due to cold tank water temperature.

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3.2 SAHP base model results (cont. 1)

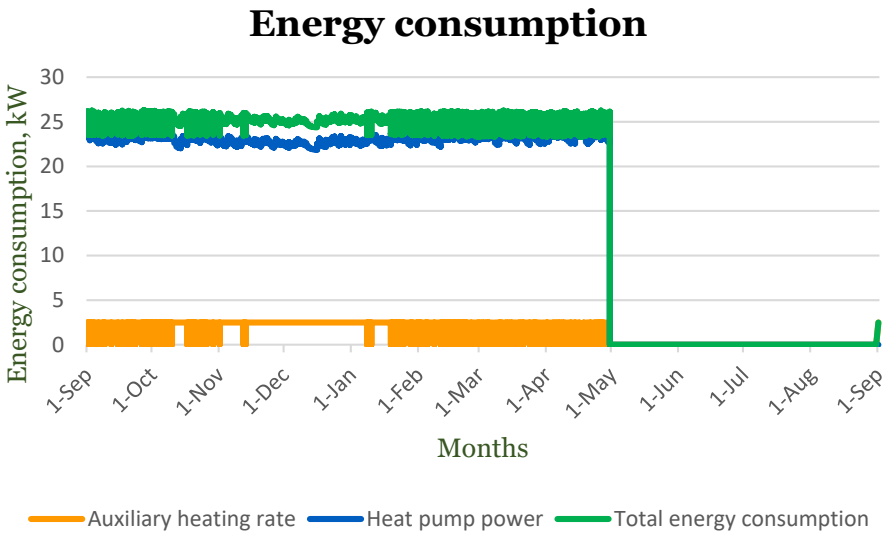

Figure 19 Energy consumption

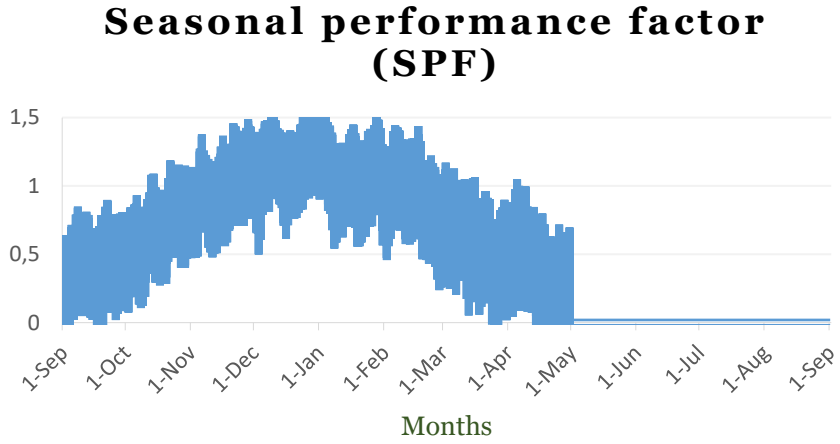

Figure 20 SAHP system performance.

- ✓ The energy consumption is higher in the severe cold months than a mild season. Conversely, system performance is lower in winter.

SPF of SAHP which is the ratio of the total loads met by the system to the total energy consumed

3.2 SAHP base model results (cont. 2)

Comparison with conventional heating system

The research work considered three different heating system concepts compared within TRNSYS simulations for the space heating.

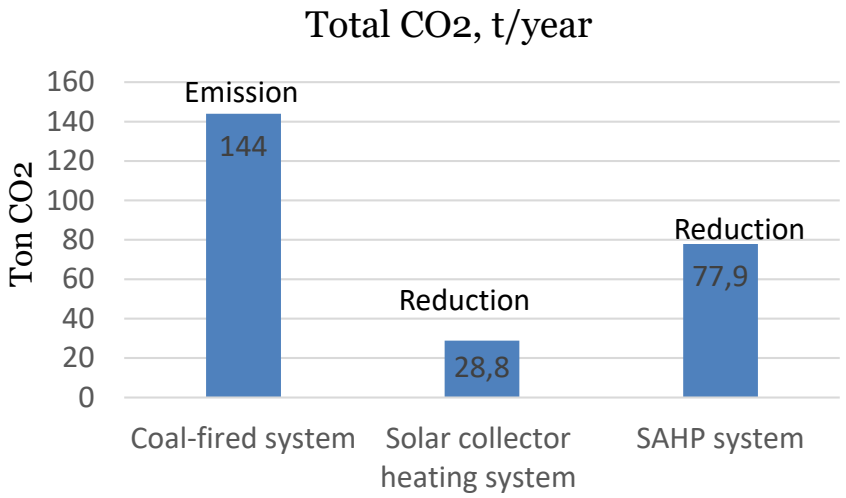

Figure 21 CO2 emission and reduction comparison of three different systems

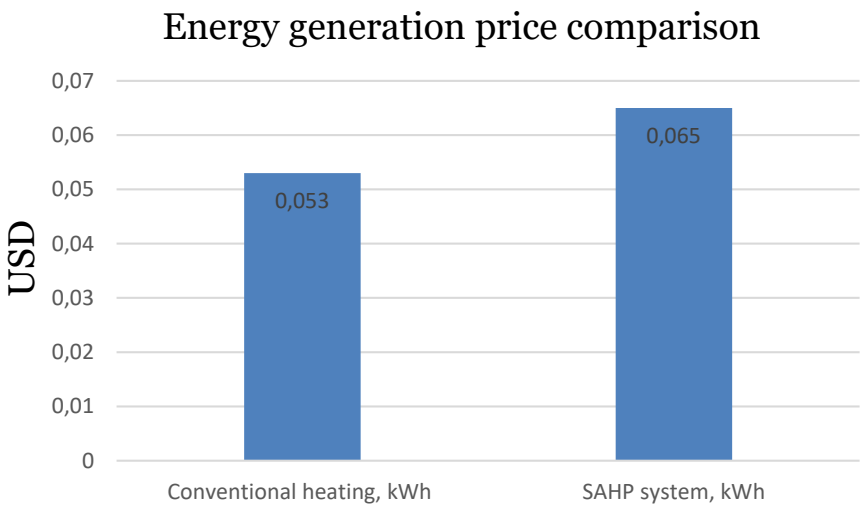

Figure 22 Energy generation price comparison

Conclusion

- **Conventional heating system:** CO2 emission - **144.4 ton/year.**
- **Solar collector heating system:** CO2 emission reduction is **28.8 ton/year**.
- **SAHP system:** Energy saving for the SAHP system - **54%**

CO2 emissions reduction - **77.9 ton/year.**

Technically Yes!!!

SAHP system is applicable for the space heating in Mongolia.

Financially and Economically feasible to use this technology.

Thank you for your kind attention

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