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Optimisation of a seasonal thermal energy storage system for space heating in cold climate zones

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Introduction and Method

Background

➢In this investigation, a double U-tube borehole thermal energy storage (BTES) integrated with ground coupled heat pump (GCHP) and evacuated tube solar collectors (ETSC) system is considered for four selected cities in cold climate zones (See in Table 1) namely; Harbin (China), Ulaanbaatar (Mongolia), Sivas (Turkey) and Verkhoyansk (Russia).

Table 1: Locations and temperatures of the cities selected

	Harbin China	Ulaanbaatar Mongolia	Sivas Turkey	Verkhoyansk Russia
Latitude (°N)	45.75	47.93	39.73	67.55
Longitude (°E)	126.65	106.90	37.01	133.33
Altitude (m)	198	1330	1336	270
Maximum temperature (°C)	34.3	35.3	37.2	29.9
Minimum temperature (°C)	–28.0	–37.4	–19.0	–56.4
Mean annual temperature (°C)	5.48	–0.68	9.72	–14.1

Method

➢TRNSYS - a transient systems simulation program (Klein et al. 2014) is used for simulating the heating load of the building in each city.

➢In order to minimise the net present value (NPV) of the LCC (for 20 years project life), a Multi-Objective Building Optimisation tool (MOBO) (Palonen et al. 2013) is applied to determine the optimum system configuration of total solar collector area (SCA) and total borehole length (BHL).

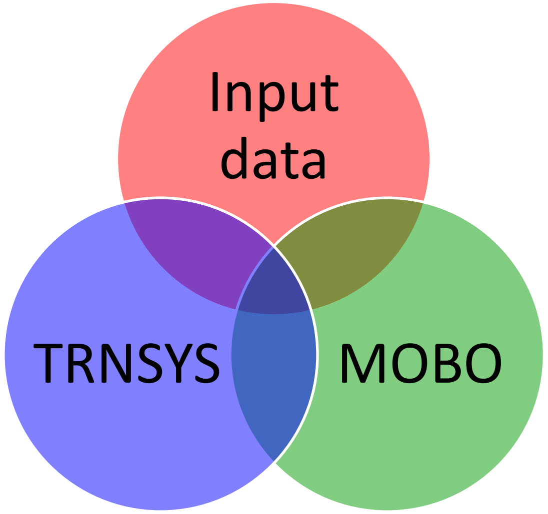

Figure 1: Concept of method

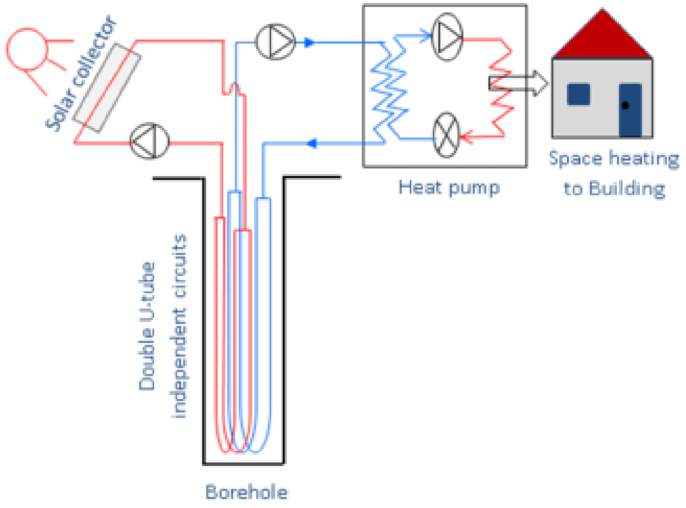

Figure 2: Concept of a seasonal thermal energy storage system

Results and discussion

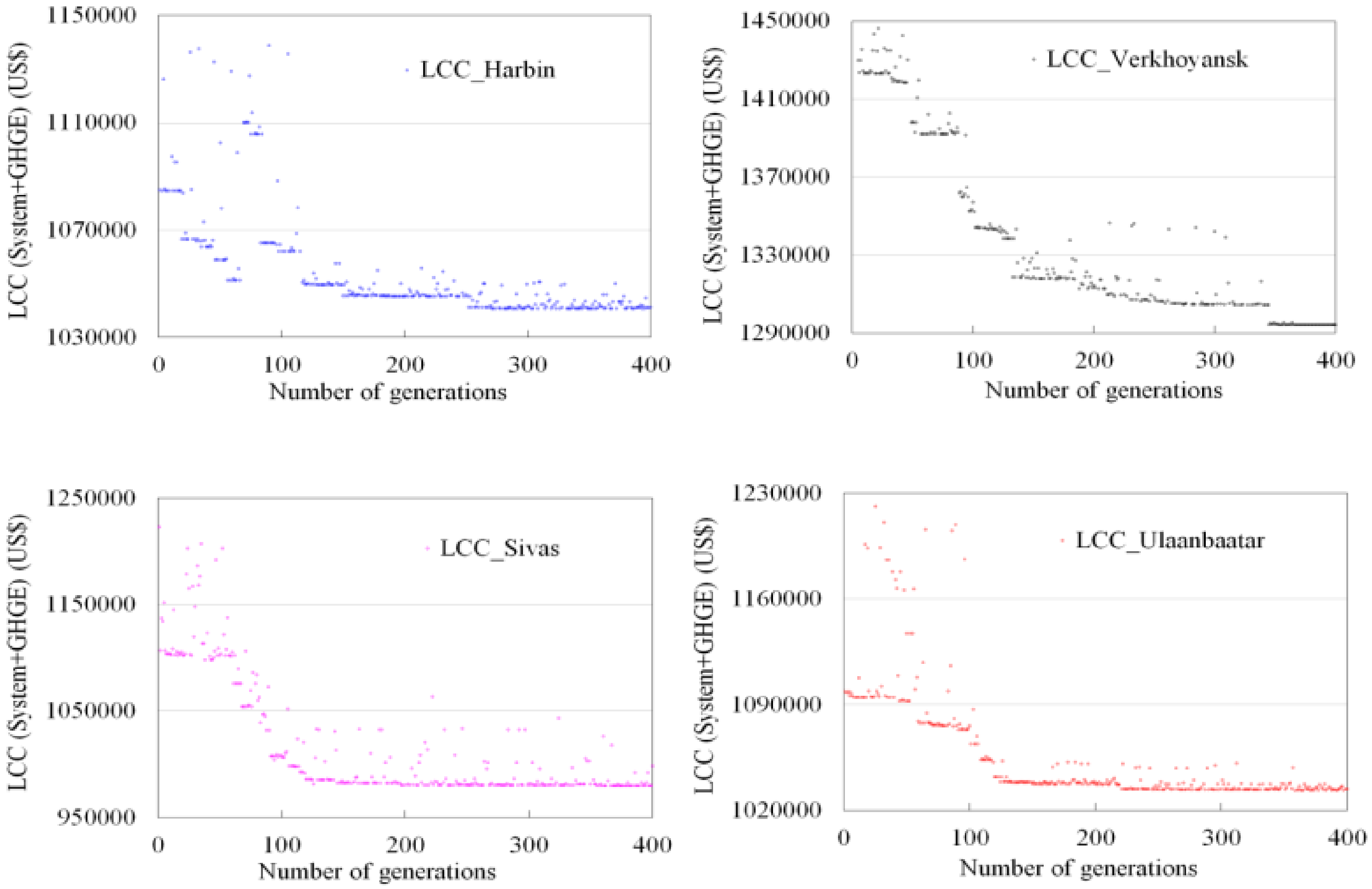

Figure 3: Status of LCC of selected climate zones

- The larger size of SCA and BHL was found at Verkhoyansk because of demand of heating load is high due to extreme cold climate than other zones.
- The maximum LCC were found at Verkhoyansk and minimum at Sivas.
- The maximum unit heating cost (UHC) was found at Sivas where the size of the heating application is smaller than others selected zone.
- The minimum UHC was found at Verkhoyansk where the size of the heating system is larger than the others zone.
- It shows good agreement that the UHC is low in larger system compare the smaller system.

Table 2: Unit cost of heating and others

Parameter (Unit)	Harbin	Ulaanbaatar	Sivas	Verkhoyansk
Solar collector area (m^2)	680	694	291	1627
Borehole depth (m)	3940	3754	2145	6000
LCC (US$)	1040826	1033286	979695	1294292
ALCC (US$)	122255	121369	115075	152027
UHC (US$ kWh_e^{-1})	0.177	0.166	0.275	0.130

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References

- Klein et al. (2014), TRNSYS 17: a TRaNsient SYstem Simulation program.
- Palonen et al. (2013), MOBO a new software for multi-objective building performance optimization. in Proceedings of the 13th International Conference of the IBPSA.

Team members

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Thank you