Solar-Wind Pump for a Mongolia Village

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Korea Tech

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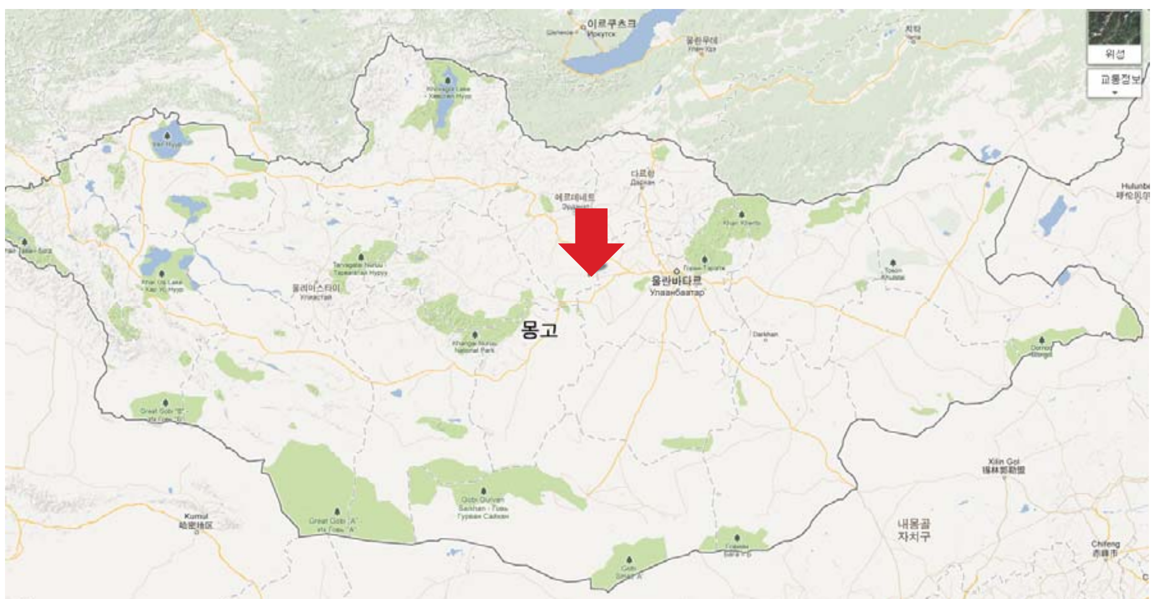
Location : Bayannuur, Bulgan, Mongolia (Lat : 47.83. Long : 104.44)

Population: 1000

Elevation : 850[m]

Wind Speed : 10~12[m/s]

Temperature : -42~30[℃]

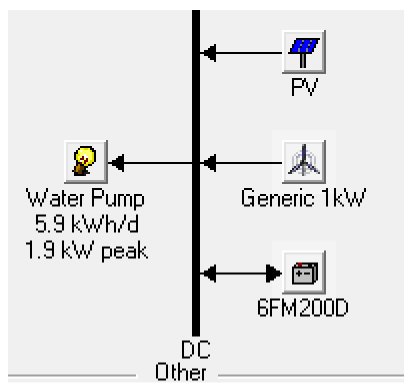


Project Goal

- Post-analysis of the solar pump installed in 2010
- Bringing up improvement and simulation of the new design

Approach

- Supplying power to a submerged pump from Solar and Wind energy sources and providing drinking water to the village folks.



Water Flow Calculation:

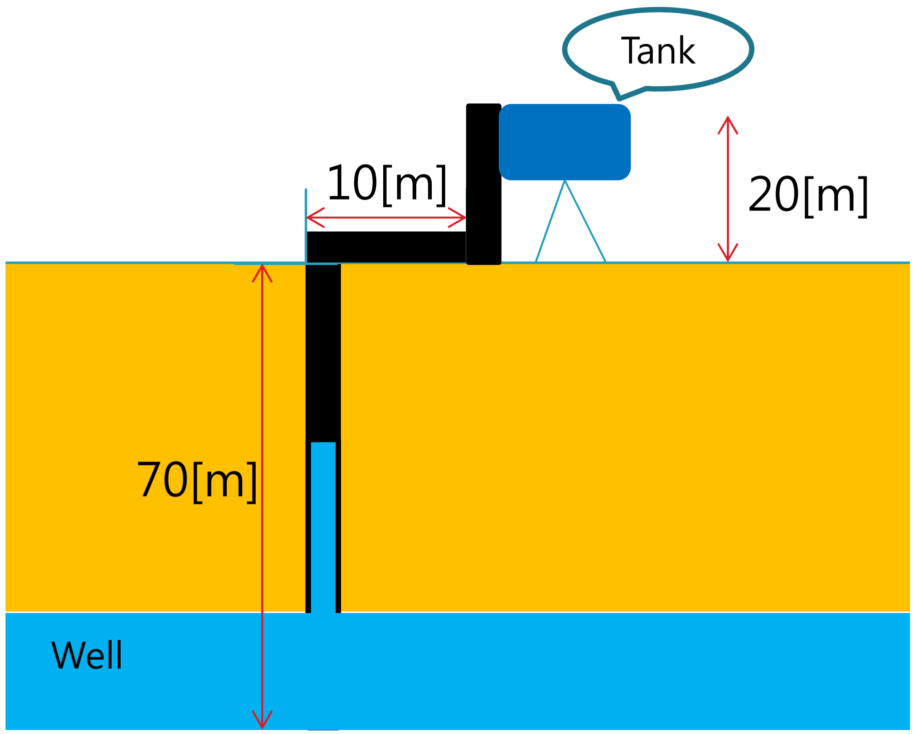
Water amount per capita = 1 gal/day
Water need for the village = 1000 gal/day

$$Q(\text{gpm}) = \frac{\text{Daily demand}}{\text{Insolation} \times 60} = \frac{1000}{4.04 \times 60} = 4.12 \approx 4.2(\text{gpm})$$

$$P_{in} = \frac{0.1885 \times 340(ft) \times 4.2}{0.3} = 897.6 \approx 900[W]$$

Static and Dynamic Head:
Elbow = 3[ea] ⇒ 6[ft]
Check Valve ⇒ 5[ft]
Gat Valve ⇒ 1[ft]

Total Head= 340[ft]



System Modeling

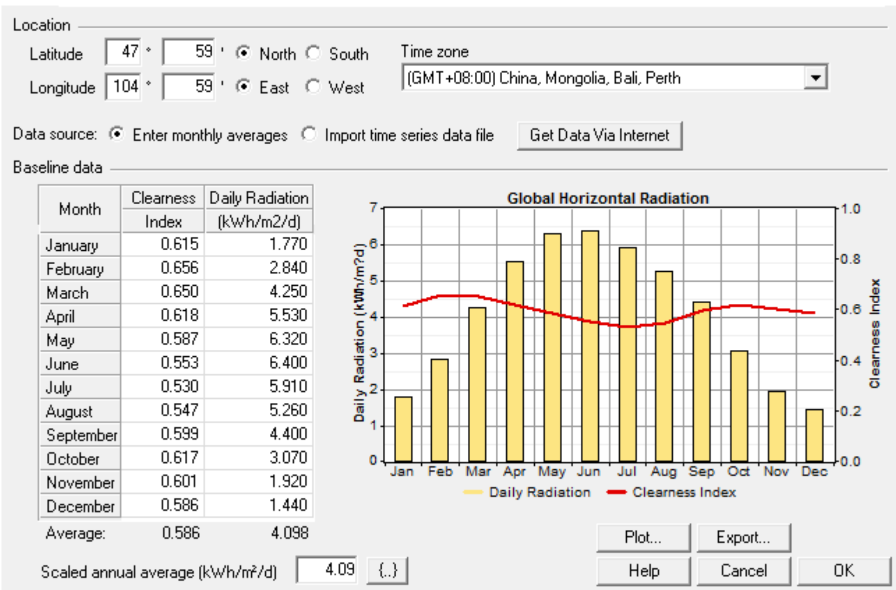
PV 2.4[kW]

Inverter, Solar Controller

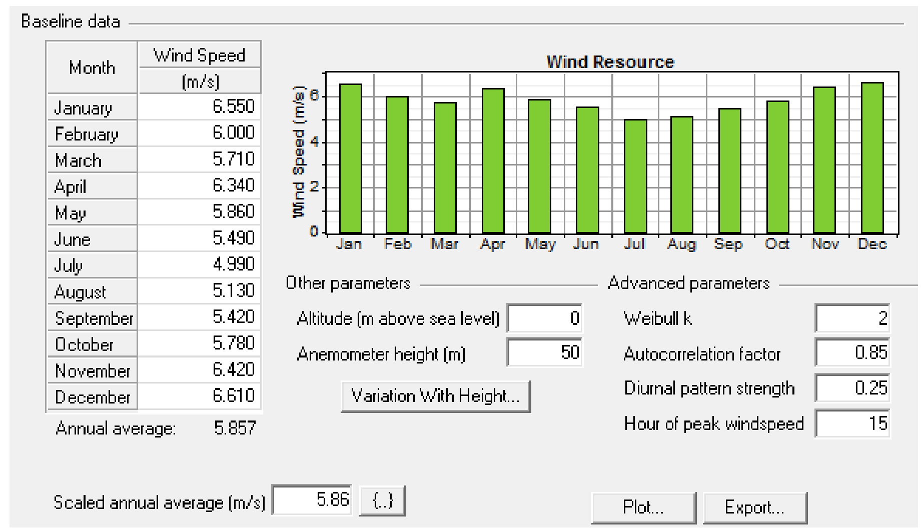
1[kW] Water Pump

Battery 12[V] 1000[AH]

System Modeling – Renewable Resources

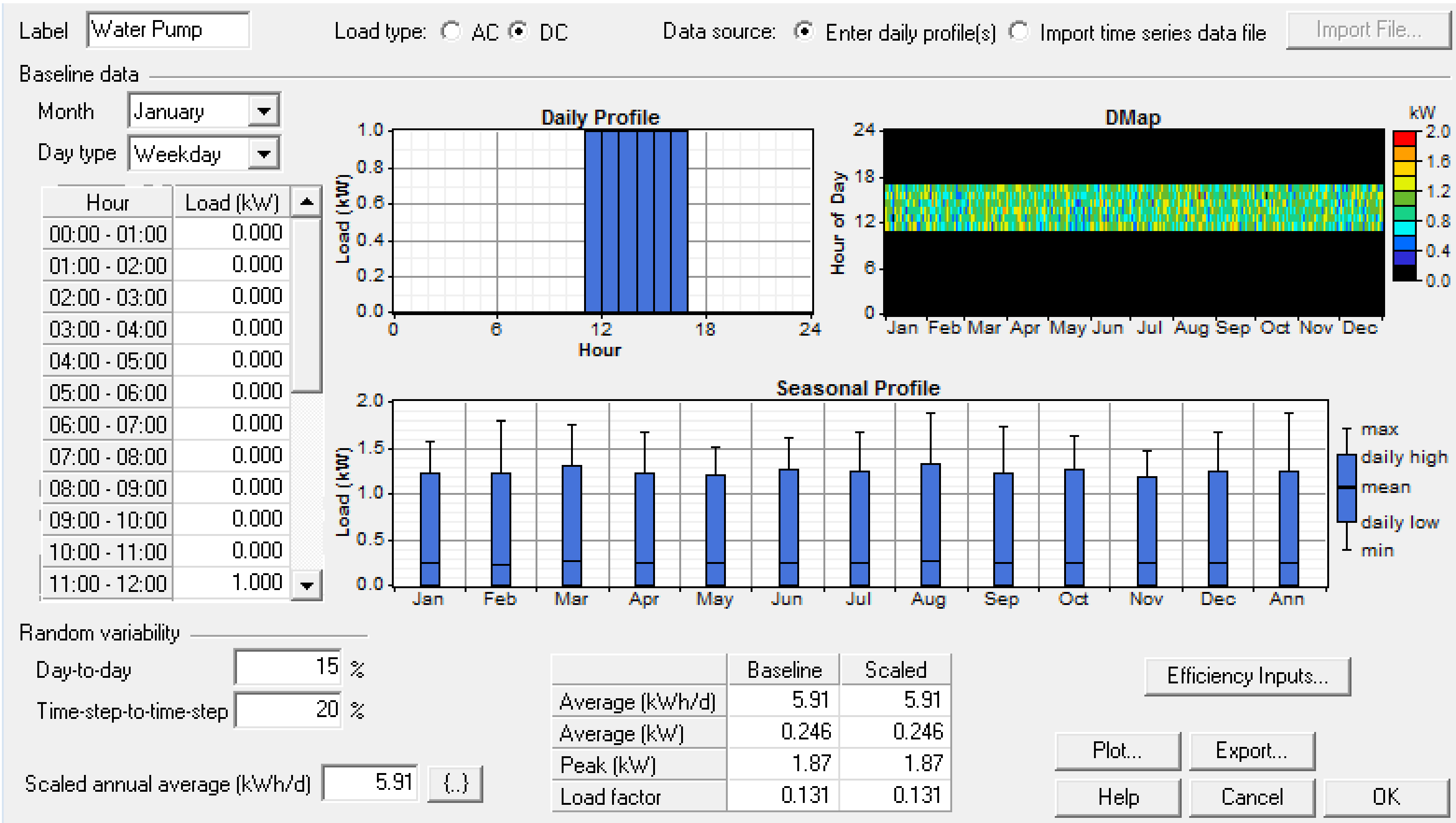


Solar resource



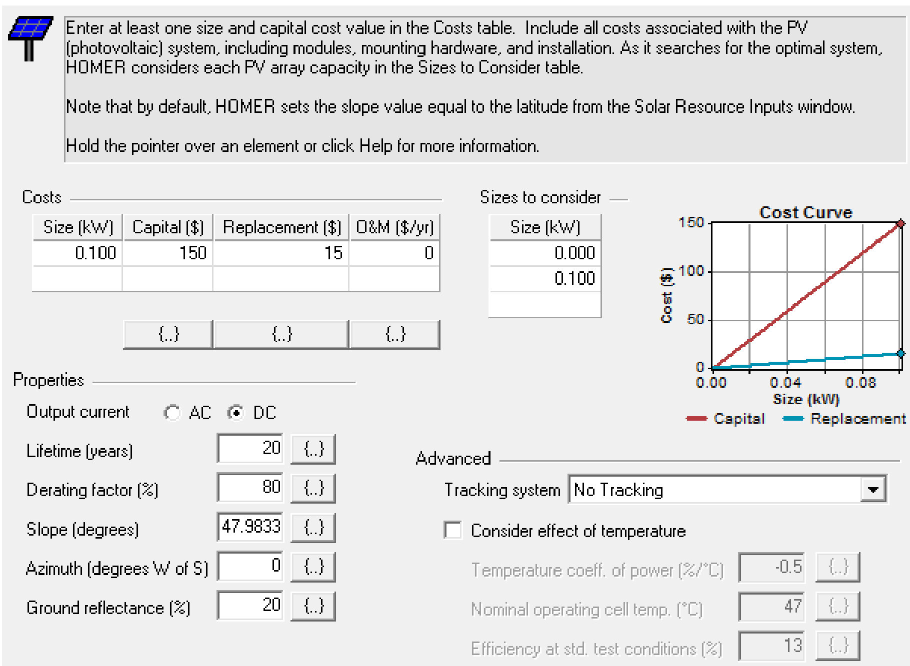
Wind resource

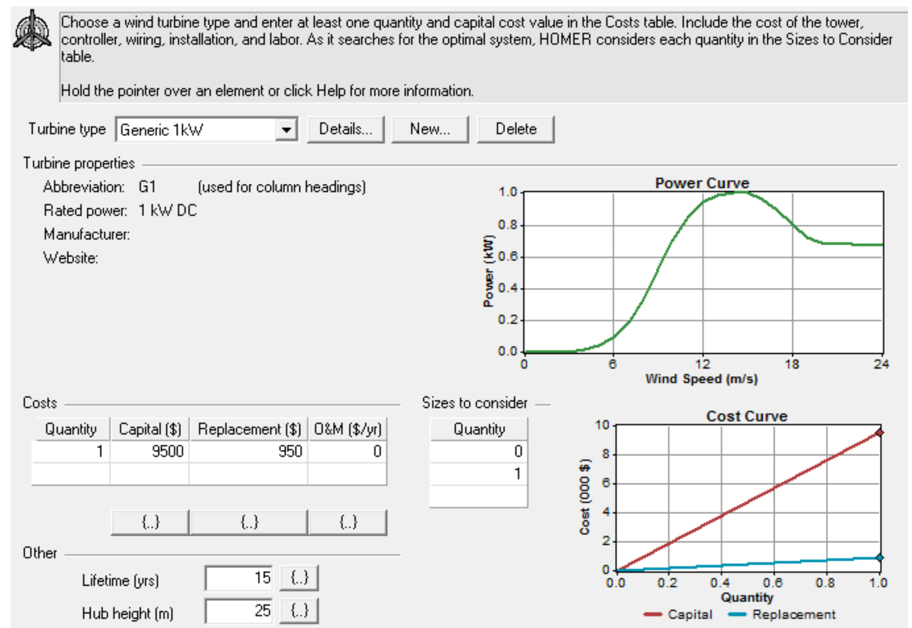
System Modeling – Load Profile



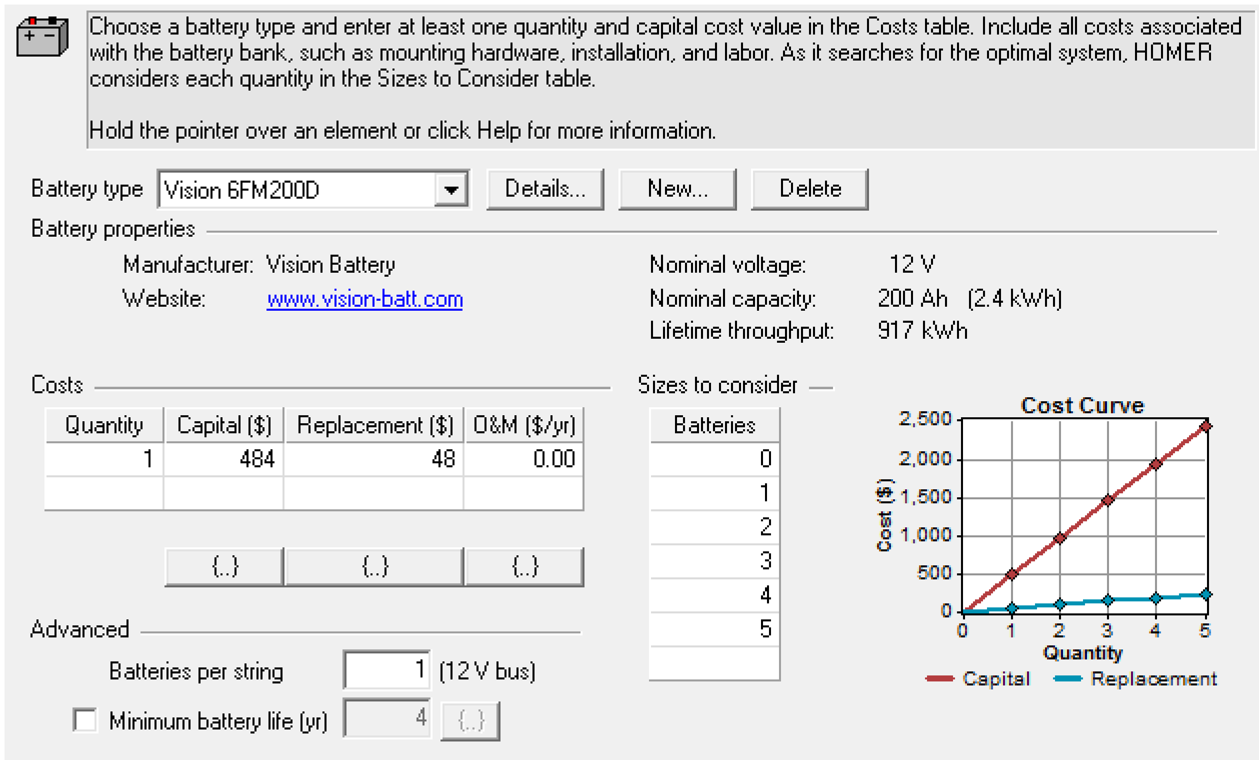
Under the assumption of running the water pump for 6 hours a day following the peak-sun hour of the location in the design (worst) month.

System Modeling – PV and WT





System Modeling - Battery



Result – Optimization by NPC

Sensitivity variables

Global Solar (kWh/m?d) 4.09 Wind Speed (m/s) 5.86

Double click on a system below for simulation results

PV (kW)	G1	6FM200D	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
2.2	1	5	$ 15,220	43	$ 15,769	0.572	1.00
2.4	1	5	$ 15,520	43	$ 16,073	0.583	1.00
2.8	1	4	$ 15,636	41	$ 16,161	0.586	1.00

Best Combination:
2.2[kW] PV + 1[kW] Wind Turbine

Result – Sensitivity Analysis

Location

Latitude 47 ° 59 ' (•) North ( ) South

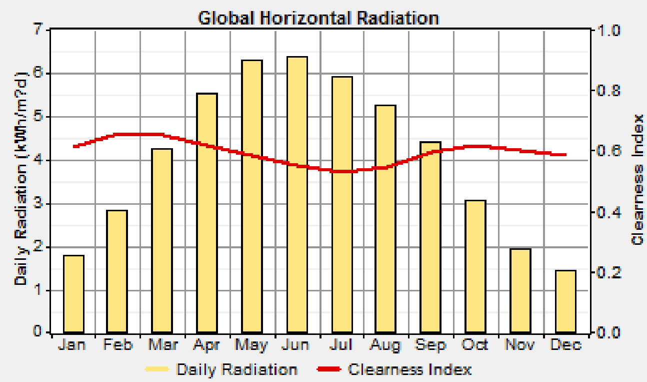
Longitude 104 ° 59 ' (•) East ( ) West

Time zone: (GMT+08:00) China, Mongolia, Bali, Perth

Data source: (•) Enter monthly averages ( ) Import time series data file [Get Data Via Internet]

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.615	1.770
February	0.656	2.840
March	0.650	4.250
April	0.618	5.530
May	0.587	6.320
June	0.553	6.400
July	0.530	5.910
August	0.547	5.260
September	0.599	4.400
October	0.617	3.070
November	0.601	1.920
December	0.586	1.440
Average:	0.586	4.098



Scaled annual average (kWh/m²/d) 4.09 [{..}]

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In consideration of the months

Between April and September,

⇒ 3[kW] PV is most economical

Sensitivity variables

Global Solar (kWh/m²d) 5 Wind Speed (m/s) 5.86

Double click on a system below for simulation results.

	PV (kW)	G1	6FM200D	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
PV, battery	3,0		5	$ 6,920	19	$ 7,163	0,260	1,00
PV, wind, battery	1,6	1	5	$ 14,320	42	$ 14,856	0,539	1,00
PV, wind, battery	1,8	1	5	$ 14,620	42	$ 15,161	0,550	1,00

Result – Sensitivity Analysis

Sensitivity variables

Global Solar (kWh/m?d) 3 Wind Speed (m/s) 6

Double click on a system below for

			PV (kW)	G1	6FM200D	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
			2,4	2	5	$ 25,020	68	$ 25,895	0,940	1,00

In winter months, the combination of

2.4[kW]PV and 2[kW]Wind Turbine is required,

due to the extreme dropping of PV

Generation during the harsh weather condition.

Conclusion

- Goal of the project: Solar-Wind Water Pump Feasibility Study
- Broad Impact: Small step toward stopping global warming and preventing the desertization of Mongol
- Findings:
  - Solar energy alone [the 2010 configuration] cannot be used during the winter months between October and March.
  - The PV+ WT configuration is more suitable for annual operation of the pump