Application of innovations

China case study: New energy in the water supply system of Gangcha County [1]

Under the program of China IWHR
and Qinghai Institute of Water Resources (QIWR)

Location: Gangcha County of Huaibei Tibetan Autonomous Prefecture, China.

Main challenges: Adjacent to Qinghai Lake, Gangcha County is a pastural area with a relatively dispersed population where drinking water is mostly supplied via decentralized systems.

The target territory faced major issues with accessing water from wells. Gangcha County had no power supply, so it was necessary to find a designated power source for water pumps. Internal combustion engines could perform the task, but this approach appeared too costly and cause environmental damage. The total water demands of three demonstration projects was estimated at 24.56 cubic metres per day, 21.98 cubic metres per day, and 20.22 cubic metres per day, respectively. The fuel demand for water intakes was approximately 0.2litres per cubic metre. Assuming the price of a litre of fuel of USD1.13, the daily water intake cost would be approximately USD0.22 per cubic meter.

Main goal: Provide access to drinking water for the villagers of three remote settlements by using advanced alternative water sources.

Main approach: The scheme utilizes three different water supply technologies using new renewable energy: (a) a solar powered, motor pumped well, (b) shafts using solar powered water pumps, and (c) motor pumped wells using solar and wind power.

(a) Solar powered, motor pumped well, well water source → main solar powered water intake → reservoir → secondary solar powered water intake → user.

The main water pumps are operating continuously with sunlight input. Most of the time, the system functions in 'high lift, low flow rate' mode, that is, the water drawn from the water source is stored in reservoirs. If necessary, the solar power system switches from the main pump to the secondary water pumps. The secondary water pumps draw water from the reservoirs and pumps it to water tankers or troughs. In this instance, the whole system shifts to 'low lift, high flow rate' mode, and when it is complete, the mode resets. The total capacity of the reservoirs in the system normally equals the daily water usage of the users.

For the scheme to operate efficiently, the water sources need to be wells more than 30 meters deep and the reservoirs need to be able to resist low temperatures. The project covers 10 households (23 residents), as well as supplying water for over 800 sheep and over 300 yaks. The water source is a motor pumped well of 49m depth and 0.11m diameter (see Figures 6 and 7).

(b) Solar powered water pump shaft—water source (shaft) → solar powered water intake → users

The solar power system provides electricity for the water pump to draw water from the source, working continuously with sufficient sunlight. The whole system is set in 'low lift, high flow rate' mode. The water pumped from the shaft is pumped directly to the users.

For this scheme, the water sources need to be shafts less than 30 meters deep and for water sources with insufficient water it is necessary to add reservoirs to the system. The project covers three households of 11 residents. In addition, the scheme supplies water for over 900 sheep and over 210 yaks. In this case, the water source is a shaft of 6m depth and 0.8m diameter (see Figures 8 and 9).

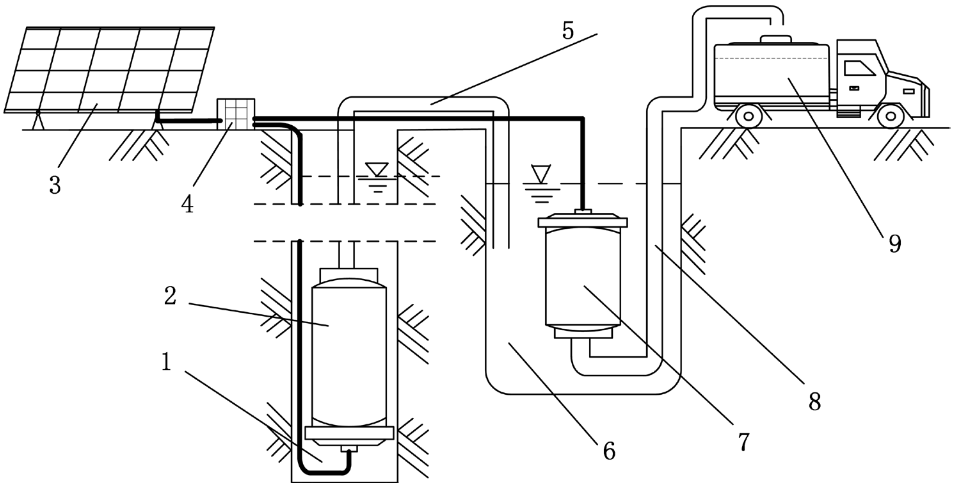

Figure 6. Configuration of the solar powered, motor pumped well system:

1 (water source), 2 (main water pump), 3 (solar power system), 4 (control system), 5 (upstream piping), 6 (reservoir), 7 (secondary water pump), 8 (downstream piping), and 9 (water tankers)

Figure 7. Demonstration project in Huanlunxiuma Village

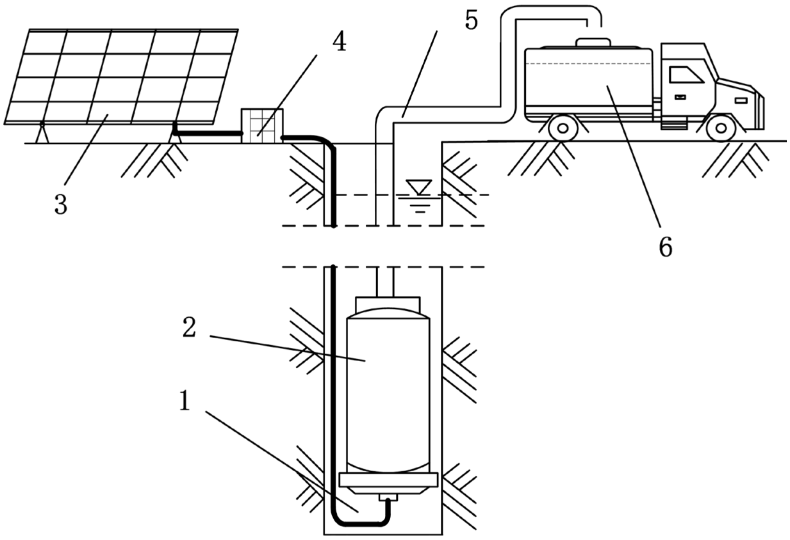

Figure 8. Configuration of shafts using solar powered water pumps:

1 (water source), 2 (water pump), 3 (solar power system), 4 (control system), 5 (piping), and 6 (water tankers).

Figure 9. Demonstration project in Jiaoshikexiuma Village

(c) Motor pumped wells using solar and wind power—water source (deep well) → main water intake → reservoirs → secondary water intake → users

This approach is applicable to deep, 80m to 150m, motor pumped wells in locations with a relatively high water supply demand. Whereas the main water intake system operates in 'high lift, low flow rate' mode to pump water to the reservoirs, the secondary water intake system works in 'low lift, high flow rate' mode to pump water from the reservoirs to the water tankers and troughs. The system is mainly solar powered. From 5pm to 9am when few people are using water, the system switches to wind power. The wind power system provides electricity to the main water intake system to pump water to the reservoirs. In case the users need water, the secondary water intake system operates as it does during the daytime. The project covers two households of 8 residents and supplies water for over 300 sheep and over 370 yaks (see Figures 10 and 11).

All the water sources referred to in this section comply with the 'Standards for Drinking Water Quality (GB5749).'

Financial aspects: The Research and Application Special Fund (RASP) of Qinghai Province and central finance supported the projects. Based on Table 15, the cheapest practice is the Solar powered, Water Pump Shaft. However, it cannot operate without sufficient sunlight. The most expensive model is the Motor pumped Wells Using Solar and Wind Power; this option allows water to be pumped at a stable rate thanks to the ability to switch between solar and wind power.

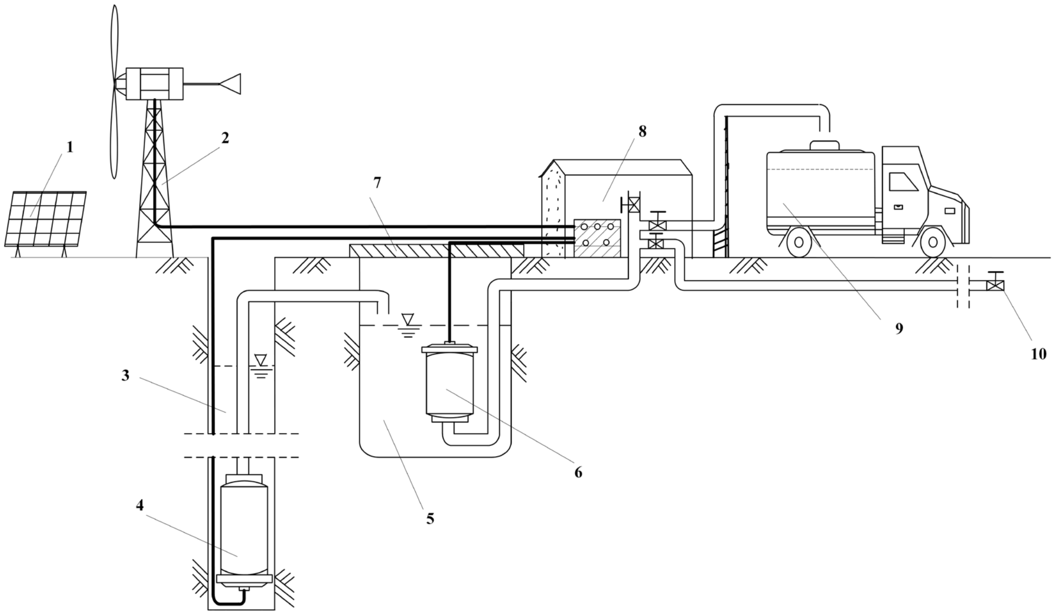

Figure 10. Configuration of motor pumped wells using solar and wind power:

1 (power system), 2 (control system), 3 (cabling of main water intake system), 4 (water source), 5 (main water intake system), 6 (cabling of secondary water intake system), 7 (reservoir), 8 (heat preservation facilities), and 9 (secondary water intake system).

Figure 11. The Demonstrationproject in Gangchagongma Village

Table 15. Total cost of water supply equipment and water source projects for the three new energy water supply schemes

Village	Model	Number of households benefiting	Cost of water supply system (financed by RASP of Qinghai Province)		Cost of water source project (well) (financed by central finance)	
			Total	Per family	Total	Per family
Huanlunxiuma	Solar powered motor pumped well	10	USD4,995	USD499	USD5,295	USD529
Jiaoshikexiuma	Solar powered water pump shaft	3	USD1,305	USD435	USD1,050	USD350
Gangchagongma	Solar and wind powered motor pumped well	2	USD12,045	USD6,022	USD7,995	USD3,997

Main results: The application of this technology has greatly improved the water supply guarantee rate in the target areas and the overall health of the residents. The project has also addressed the shortage of drinking water for cattle, sheep, and goats, which is a significant contribution to the development of local animal husbandry. The life quality of local residents has also improved considerably. Each project covers three to ten households and is managed by its users.

The described technologies are environmentally friendly. Saving up to 13.35litres of fuel per day, or 4,873.5 litres per year, equaling an annual reduction in carbon dioxide emissions of 10.7 tons. Operating the projects for 25 years could save 122 cubic meters of fuel and prevent the release of 267.5 tons of carbon dioxide into the atmosphere.

Sustainability: The life span of solar power systems is usually 25 years, against 8 years for internal combustion engines. Thanks to the control system, the water supply systems can operate automatically, requiring no manual control or management. Over its lifespan, the system requires only a one-time maintenance of the power equipment and the water pumps need to be replaced twice.

The main advantage of the Solar powered; Motor pumped Well model in Huanlunxiuma Village is that this technology can be used for deep wells that were rarely used before. However, the main drawbacks are that it is impossible to operate in insufficient sunlight such as in cloudy weather or at night and the high investment requirement.

The relatively low initial investment is the main advantage of the Shafts Using Solar powered Water Pumps model in Jiaoshikexiuma Village. However, the main disadvantage of such systems is the possibility of their failure in insufficient sunlight.

Likewise, the management and maintenance of these two schemes can be relatively challenging. For the Motor pumped Wells Using Solar and Wind Power model in Gangchagongma Village, the main advantage is that it can function well without sufficient sunlight or wind. It is also easy to use, and the water supply guarantee rate is high. However, the main weaknesses of this technology are a relatively high construction cost and high management and maintenance requirements.

Next steps: The three water supply systems using renewable energy sources introduced in Gangcha County all have their own pros and cons, yet at least one of them could be suitable for a specific application scenario. Systems using only one kind of renewable energy (RE) tend to lose stability in case of a power outage, easily caused by weather changes. This instability can lead to insufficient water supply and low water supply guarantee rates. Although the hybrid systems face instability issues, in practice the systems using both solar and wind power demonstrate a better performance than those using only solar or only wind, while systems using only wind power perform least well. Economic analysis shows that the RE-based systems require a large initial investment, although the payback period is long, and long-term investment is much less demanding. Such systems can unburden rural residents from hard labour and greatly improve water use convenience, as well as reducing water fees. The application of RE removes the need to use fuels like petroleum for water supply purposes, thereby benefiting the environment. On average, each of the described demonstration projects can save labour to equal to five people. The corresponding effect will grow exponentially with the broader application of the technologies and it is strongly recommended to deploy such. systems in other pastural areas.

References:

1. IWHR and QIWR, 2019. Integration and demonstration of key technologies for water supply in rural and pasturing areas. Beijing, China.