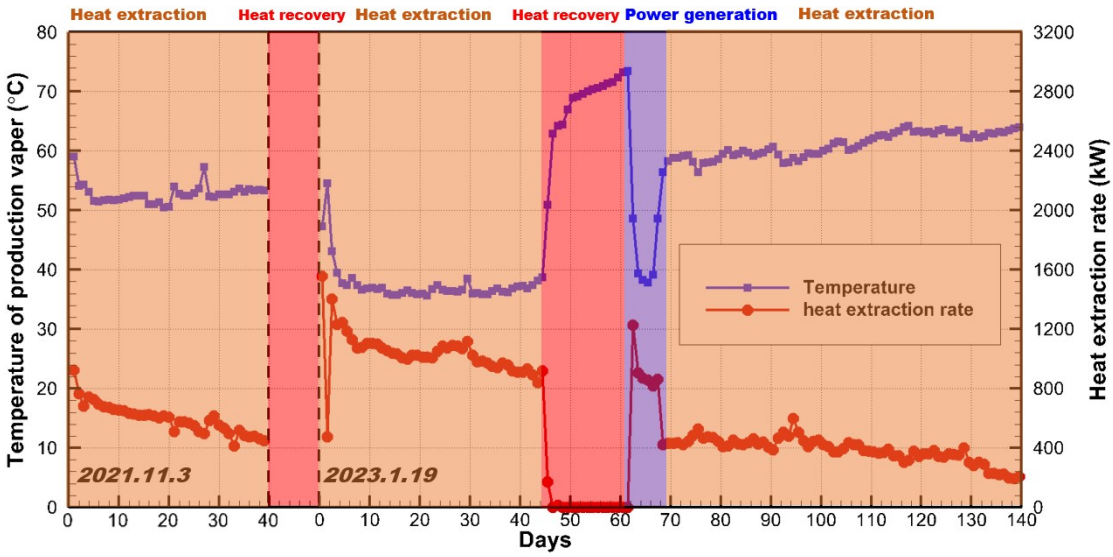
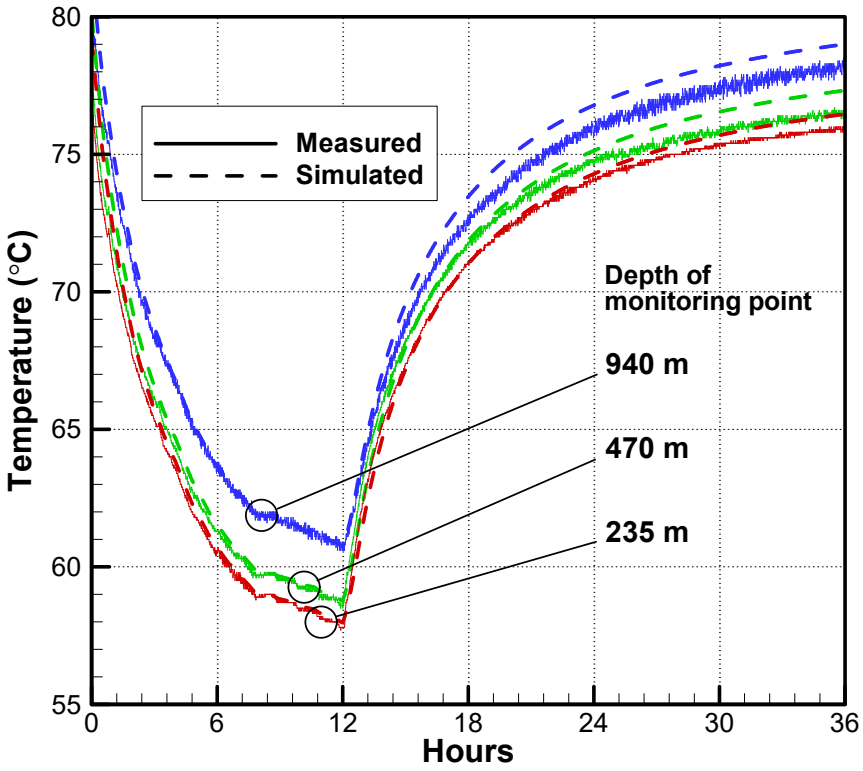
Extended Data Fig. 1 Photo image of the SLGHP geothermal system built in Xiong'an New Area, China. This pilot SLGHP geothermal system underwent two sets of tests for heat extraction and power generation, respectively.

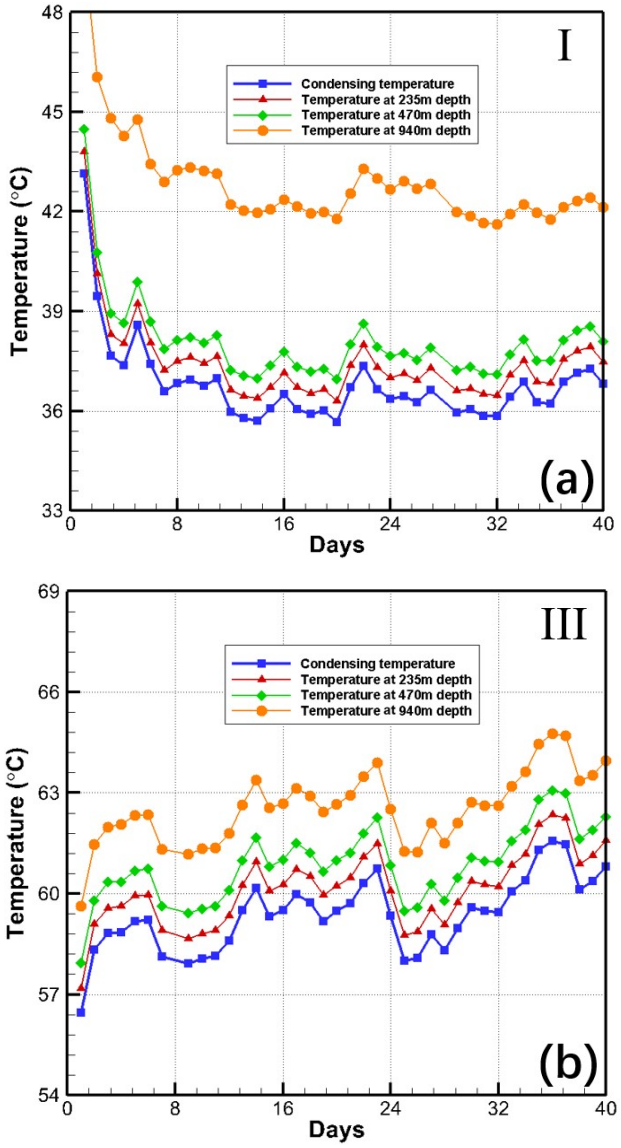


Extended Data Fig. 2 Tests conducted with the SLGHP geothermal system. The testing lasted a total of 170 days, including a 40-day continuous heat extraction test, a 45-day continuous heat extraction test, a 3-day power generation test, and an 80-day continuous heat extraction test. The site records of production vapor temperature and measured heat extraction rate are presented as a function of testing time.



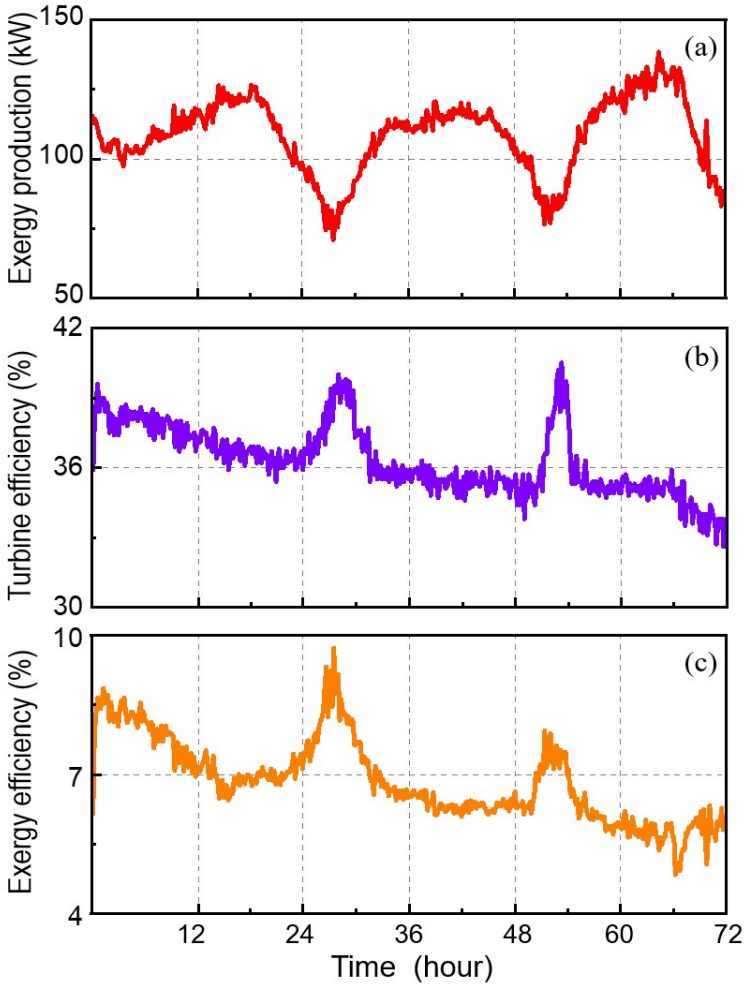
Extended Data Fig. 3 Comparison of the measured and predicted temperature at different depths, in particular, 235 m, 470 m, and 940 m, respectively, during a test consisting of a 12-hour heat extraction and a 60-hour heat recovery.

Overall, the predictions and measurements are in good agreement. In particular, it can be clearly noted that the predicted temperatures closely match the experimental data during the 12-hour heat extraction test; during the 60-hour heat recovery test, the simulation results tend to be slightly higher than the experimental results, which may be due to the eventual occurrence of ammonia vapor sub-cooling in the shallow low temperature regions. The numerical model does not have the in-built capability for the prediction of this phenomenological occurrence.



Extended Data Fig. 4 SLGHP temperatures measured at three monitoring points at depths of 235 m, 470 m, and 940 m, respectively, under the test conditions I (a) and III (b).

Extended Data Fig. 5 Photo image of the SLGHP direct-driven power generation system. The ammonia vapor produced by the heat pipe directly enters the first stage turbine, and then goes to the second stage. After driving the turbine, the ammonia exhausting the turbine enters the condenser through the orange pipeline on the right-hand side of the photo.



Extended Data Fig. 6 Calculated parameters of the power generation system. (a) exergy production from the SLGHP; (b) turbine efficiency; (c) exergy efficiency.

The exergy production rate is ~ 100 kW, fluctuating between 70.92 kW and 138.43 kW, and its temporal behavior is similar to that of the heat extraction rate. The turbine efficiency varies between 32.6% and 40.5%, with an average value of 36.3%, which is significantly lower than that of turbines used in traditional industries; the design of the ammonia-driven turbine used in the present study still requires considerable developmental work. The time-changing trend of the exergy efficiency is opposite to that of the exergy production, thus the power generation (Fig. 5b) is relatively stable.