Due to the existing huge biogas resource in the rural area of China, biogas is widely used for production and living.Cogeneration system provides an opportunity to realize the balanced utilization of the renewable energy such as biogas and solar energy. This paper presented a numerical investigation of a hybrid energy-driven organic Rankine cycle (ORC) cogeneration system, involving a solar organic Rankine cycle and a biogas boiler. The biogas boiler with a module of solar Parabolic-Trough Collectors (PTC) is employed to provide heat source to the ORC via two distinct intermediate pressurized circuits. The cogeneration supplied the power to the air-condition in summer condition and hot water, which is heated in the condenser, in winter condition. The system performance under the subcritical pressures has been assessed according to the energy-exergy and economic analysis with the organic working fluid R123. The effects of various parameters such as the evaporation and condensation temperatures on system performance were investigated. The net power generation efficiency of the cogeneration system is 11.17%, which is 25.8% higher than that of the base system at an evaporation temperature 110°C. The exergy efficiency of organic Rankine cycle (ORC) system increases from 35.2% to 38.2%. Moreover, an economic analysis of the system is carried out. The results demonstrate that the profits generated from the reduction of biogas fuel and electricity consumption can lead to a significant saving, resulting in an approximate annual saving from $1,700 to $3,000. Finally, a case study based on the consideration of typical rural residence was performed, which needs a payback period of 7.8 years under the best case.