Distributed Low-temperature Geothermal Power from Oil and Gas Wells

Ruben Havsed, Rakshith Sachitanand

Abstract

Introduction

The potential for electricity production from the heat generated from oil and gas wells is well-known but no larger commercial deployments have been done so far. Climeon Heat Power is a 150kW modular ORC system that focus on low-temperature (70-120°C) power production. It is based on a patented low-pressure cycle that enable a conversion efficiency that is comparable to what 10MW Binary Power Plants achieves at 130°C. The combination of a modular and scalable solution with high conversion efficiency have the potential to make electricity production from oil and gas wells commercially viable.

In August 2017 Climeon receive an order for 100 modules for distributed geothermal power production on Iceland where each power plant will have an installed capacity of 300 kW to 1,5MW. The power plants will utilize heat from wells that today only are utilized for heating purposes. The project proves that it is possible to deploy small scale geothermal power plant in a market with electricity prices of 40 $/MWh, which is similar to the electricity prices in Texas where most of the oil and gas wells suitable for low-temperature power production are located.

C3 Technology

Climeon Heat Power solution is based on the propriety C3 Technology developed by Climeon AB. The system is designed to give the highest possible efficiency from low-temperature heat between 50-120°C. The C3 technology operates with a partial vacuum within the system. The low-pressure system enables materials and pumps to have slimmer dimensions. Additional key aspects of the C3 technology are the choice of working fluid and the unique and patented direct contact condensation solution. Over 3,000 different chemicals were studied to find the most suitable for the low temperature and pressure.

The modular system, built on the basis of 150 kWel base modules that bundled together can produce multiple MW of power per plant. The technology differs from traditional ORC units in some key areas. The system is based on the Rankine cycle but the condensation side is under vacuum, and no heat recuperation downstream of the turbine is required. A controlled amount of a benign working fluid is evaporated significantly below 4 bar(a) in a heat exchanger, avoiding droplet formation which could be damaging for the turbine by overheating. A highly efficient and specially designed radial turbine which extracts energy from the expanding medium is coupled to an electrical generator capable of producing 400 or 690 V three-phase electricity at 50 or 60 Hz. The expanded working fluid is easily condensed clearly below 0.6 bar(a) using a modified direct contact technology. Condensed working fluid is cooled via a second heat exchanger and partly recycled to the condenser, partly fed to the evaporation section. The whole design enables a large pressure ratio of >6 with minimal wear of components and a cost-efficient solution. The system has been approved by Lloyds Register LLC for use in environments which are extremely demanding regarding safety, such as the maritime industry and cruise vessels in particular.

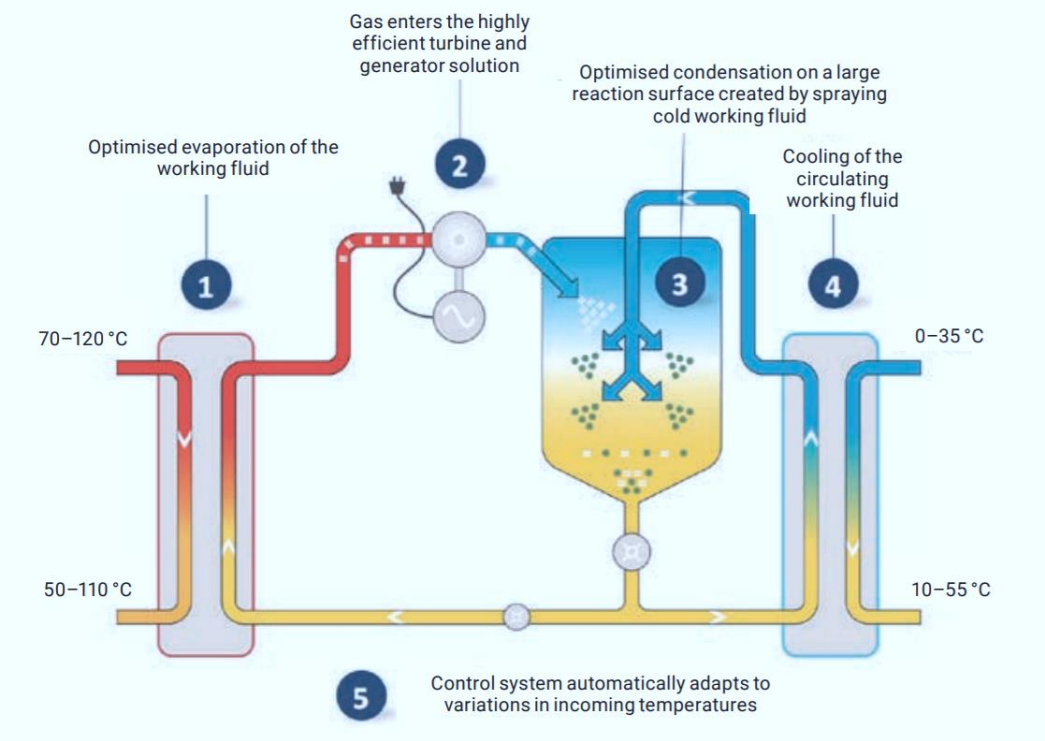

Figure 1: Showing a Climeon Heat Power System with 3 modules with a total output of 450 kW

The technology achieves >50% Carnot efficiency, or >10% net efficiency for 90°C / 20°C heating / cooling due to the high turbine efficiency, minimum losses in heat exchanging operations, and minimum internal power requirements. The parasitic load of the module is only 4 kW_{el} and the net electrical output is 150 kW_{el}. The high efficiency entails benefits such as low space requirement – the 150 kW_{el} module has a 2x2m footprint. The high energy density and possibility to stack modules together makes it possible to deploy 2,1 MW with a footprint of 28 m^2.

The modular approach is highly advantageous for cost reasons, both relating to mass production, transport, installation, commissioning and spare part ware-housing, and because modules can be operated independently at optimum conditions, e.g. under partial load or during routine service.
One of the most prominent benefits of a modular well-head power plant is the possibility to shorten the lead time of the project development and mitigate the financial risk. An incremental model for the deployment of geothermal projects makes it possible to finance the expansion with the cash flow from the previous power plant.

Achieving a high utilization factor of a geothermal power plant can be challenging since it is difficult to fully estimate the performance of a well before it has been flow tested. This can delay the project and result in the need to drill additional wells or installing an oversized power plant that cannot be fully utilized. Climeon Heat Power System consists of 150kW building blocks and the power plant can therefore be designed to fit the exact characteristics of each individual well. This saves cost and gives a higher utilization factor of the power plant since only the capacity needed is installed. It is also possible to move individual modules between sites if the well performance changes over time.

Each Climeon Heat Power module operates independently and if one module is taken out of production for maintenance the other modules will keep producing electricity, and if there is capacity available, the modules can even take over the load from that idle module. This create a redundant system that can follow an optimized maintenance schedule that minimize loss of production and guarantees stable baseload electricity to the grid.

The system can be configured both in parallel and series. This flexibility makes it possible to optimize the utilization of the available flow and temperature. The module has a nominal water flow of 30 kg/s and normally utilizes a dT of ~10°C. Modules connected in series can utilize a broader dT.

Figure 2: Showing a Climeon Heat Power System with 3 modules with a total output of 450 kW