

Subject Code: OMT (Other Major Topics – Geothermal Energy)

Title: Testing and Operating Experience of the 2 MW Kalina Cycle Geothermal Power Plant in Húsavík, Iceland

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Purposes of the Work: The Orkuveita Húsavíkur Geothermal Power Plant in Húsavík, Iceland, was developed and built in 1998-2000 to accomplish two purposes:

1. To establish a municipal electrical power plant and cascaded direct use system to derive energy for domestic and commercial use for the town Húsavík, using hot fluid piped from the Hveravellir geothermal field south of the town;
2. To establish a vivid example of the viable application of an advanced high-efficiency binary heat recovery cycle – the Kalina Cycle – to efficiently recover energy from a low-temperature geothermal source and cost-effectively use it to generate electricity.

Approach: The work was approached as a commercial/public works venture by a company, Orkuveita Húsavíkur, associated with the City of Húsavík and the existing geothermal heating system, which had been serving the town since 1970. The objective was an ambitious expansion of the system to include addition of a geothermal generation plant, installation of a new insulated pipeline from the Hveravellir field, and an expansion and improvement of the hot water distribution system downstream from the power plant. Downstream direct uses for exhausted resource and cooling water include heating for a hardwood drying facility, a shrimp processing plant, a trout and salmon farm, and a fish drying plant. The principals of Orkuveita Húsavíkur obtained the cooperation of a number of Icelandic companies in the venture, and then invited performance and financial bids from turnkey providers of low-temperature heat recovery technology, based on resource flow and temperature data provided by Orkuveita Húsavíkur. The bids were evaluated on straightforward commercial terms, and the contract for plant design and supply was awarded to the bid prepared by Exergy, Inc. for a binary cycle plant using the Kalina Cycle. (The Kalina Cycle is a proprietary technology owned by Exergy.) Equipment for the power plant was designed and supplied by Exergy to fit into the broader scope of system improvements managed by Orkuveita Húsavíkur, including design and construction of the power house and the electrical distribution and interconnection with the Icelandic utility grid.

Scientific Innovation and Relevance: The relevance of the work is in its direct contribution to what must be one of the most ingenious geothermal cascaded use systems anywhere on earth, and in its demonstration of the practical value of a Kalina Cycle plant in cost-effectively generating electrical power for domestic and industrial uses from a low-temperature geothermal resource. The Kalina Cycle – an advanced cycle using an ammonia water mixture as the working fluid – has been contemplated for many years as a distinct thermodynamic improvement over conventional binary cycle plants based on the organic Rankine cycle. So the successful and profitable pioneer application of the Kalina Cycle to geothermal energy recovery on a high-visibility site such as Húsavík, readily accessible to interested others in the European renewables community, is proposed as highly relevant to future commercial development of renewable energy from low-temperature resources, which are widely found throughout the world.

Results: The Orkuveita Húsavíkur Geothermal Power Plant in Húsavík, Iceland, which entered service in July 2000, is the first geothermal power application of the Kalina Cycle. Designed to produce 2,000 kW (net) utilizing a brine flow of 90 kg/s at 124 °C, the new plant is effectively integrated into the municipal district heating system. In its 18 months of operation, the plant encountered some challenges in achieving design output; the problems were traced to a badly fabricated component and a resource flow supplied to the plant below design temperature, at an average temperature of approximately 121 °C. These pesky conditions limited the electrical output of the plant to approximately 1,700 kW. After a shakedown outage and the identification and replacement of the offending component, an ASME performance test conducted in November, 2001 showed that the plant's net output, corrected for the new resource temperature, gives 95% of the predicted design of the plant, thereby confirming the efficiency claims of the Kalina Cycle in comparison with competing organic Rankine cycle technologies. The Húsavík plant is the fourth operational Kalina Cycle power plant. All plant data now confirm the efficiency and environmental advantages of this new power generation technology. Exhausted resource and cooling water are used downstream and effectively displace fossil fuel use for process heating in a variety of industrial applications.

Conclusions: After 18 months of operation, the Húsavík geothermal plant has been successfully integrated into the Húsavík municipal geothermal extraction and distribution system. The Kalina Cycle power plant at the hot end of the resource utilization system has realized Orkuveita Húsavíkur's technical and commercial objectives – 1,700 kW of cost-effective baseload power at an exceptional level of efficiency, reliability and availability – in an advanced geothermal energy system in a remote and formidable environment in the North Atlantic.