Keynote Speaker: **Patrick Walsh**

Vice President, Geothermal Resource, ORMAT

Patrick Walsh is Ormat Nevada Inc.'s Vice President – Geothermal Resource. He served as Ormat's Chief Geologist from 2011 to 2016, and Staff Geologist from 2008 to 2011. In this time, Patrick has had the opportunity to support Ormat's interests in over 17 geothermal projects in 5 countries. While focused on prospect assessment, exploration, resource development, reservoir maintenance, and drilling management, Patrick also provides insight into key geothermal business parameters such as acquisitions, development budgeting, project management, and operations forecasting. He is serving his second term on the Geothermal Resource Council's Board of Directors. Mr. Walsh obtained a Bachelor of Science in Geosciences from The Pennsylvania State University in 1998 and a Master of Science in Geological Sciences from The University of Texas at Austin in 2000. In his 19 years of experience, Mr. Walsh has specialized in geothermal, water and petroleum resource assessment, exploration, and development.

"Technical and economic development of high enthalpy upflow and low enthalpy outflow in volcanic and fracture-controlled geothermal systems"

Operating 917 MW globally, Ormat has developed projects and expertise in geothermal systems in volcanic, fracture-controlled, and sedimentary basins. Three systems in the portfolio have significant developed and/or potential upflow and outflow systems. These systems include Steamboat Hills, Nevada; Mammoth, California; and Amatitlan, Guatemala. This presentation will describe these systems, highlight

technical and economic aspects of these developments, highlighting the benefits of exploiting geothermal resource. We will also provide an update on a portion of Ormat's Operating portfolio with some lessons learned in various play types if time permits.

The Steamboat Hills Complex, Nevada produces 65 MW with 3 high enthalpy artesian wells, 19 pumped moderate to low enthalpy wells, and 8 injection wells. The system exploits a fracture-dominated system with an apparent magmatic component based on He isotopoic ratios. Mammoth Lakes produces 29 MW with another 30 MW under development exclusively from moderate-enthalpy outflow below a larger magmatic upflow system. Ten production wells are all pumped, and lower injectivity also requires injection pumps to permit injection flow with higher pressure that is maintained below fracture gradients. Amatitlan, Guatemala produces 20 MW from magmatic upflow. The project concession includes an as-yet undeveloped outflow featuring extensive surface manifestations, proven commercial temperature and anticipated fracture-controlled permeability.

Steamboat and Mammoth, 2 systems with developed outflow, have lower temperatures, permitting high flow rates from a single well with pumps (500 to 1400 tph) with temperatures up to 175 C. The pumps avoid flashing, use little or no inhibitor and therefore maintain lower Operations and Maintenance costs and offer nearly 99% plant availability. Conversley, Amatitlan has had significant scaling issues that require larger amounts of inhibitor and more frequent cleanouts, increasing O&M and resulting in more frequent well replacements. Binary power plants in all three locations allow increased flexibility for temperature decline over the long- life of the projects.