

SUSTAINABILITY AND RENEWABILITY OF GEOTHERMAL POWER CAPACITY

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ABSTRACT

For the purposes of this paper, sustainability is defined as the ability to economically maintain the installed capacity, over the amortized life of a power plant, by taking practical steps (such as, make-up well drilling) to compensate for resource degradation (pressure drawdown and/or cooling). Renewability is defined here as the ability to maintain the installed power capacity indefinitely without encountering any resource degradation; renewable capacity is, however, often too small for commercial development. This paper also considers an additional level of commercial capacity (above the sustainable level) that is not planned to be maintained fully over the entire plant life as mitigation of resource degradation would become uneconomic or otherwise impractical at some point. This declining capacity above the sustainable level is considered commercial only if the levelized power cost is lower than that from alternative renewable, or environmentally benign, energy sources. Even if power cost at this un-sustained commercial generation level proves higher than that from fossil fuels, this additional capacity can reduce fossil fuel usage if power from renewable or environmentally benign energy resources is given adequate tax breaks or price support. Displacement of fossil fuel usage is a social imperative that would reduce environmental pollution today and preserve these fuels as raw material for organic chemicals, and for potentially cleaner power generation in the future. Renewable capacity of a field corresponds to the power capacity equivalent of the natural heat recharge, both conductive and convective, into the system, which may increase with exploitation. Sustainable capacity is supported by mining of the stored heat in addition to natural heat recharge. With an un-sustained commercial capacity, heat mining rate is initially kept higher than can be maintained for the plant life, but is eventually allowed to decline. This paper reviews both published and unpublished results of numerical simulation and surface heat flow studies of more than half of the 65 or so liquid-dominated geothermal fields in the world that have supplied commercial power; the rate of natural heat recharge into such a reservoir has been assumed equal to the total rate of heat discharge at the surface over the thermal anomaly. The review shows that the sustainable capacity of a field is about 5 to 45 times the renewable capacity, with ten times being most likely. Commercial capacity is much more project-specific and higher than the sustainable capacity. Simple quantitative expressions are given for approximate assessment of renewable, sustainable and commercial capacities of liquid-dominated geothermal systems. A case history of approximate assessment of renewable and sustainable capacities based on actual production history is given from the Wairakei field in New Zealand. This assessment is based on a simple "lumped-parameter" model, while more accurate assessment of these capacities would call for detailed numerical simulation

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