EGW-2015, Strasbourg, 19-20 October, 2015 – Poster

Adaptable long-term sustainable development strategies by using reservoir simulators

Chris Bromley and Gudni Axelsson

**GNS Science, Wairakei Research Centre, Bag 2000, Taupo 3352, New Zealand*
Chairman : IEA-Geothermal Implementing Agreement

Extended Abstract

A review of the long-term historical performance of geothermal reservoirs, world-wide, has been undertaken. When considered together with simulations of their likely future performance using reservoir models, some important messages are revealed regarding the use of simulators to help select scenarios and optimize strategies for sustainable development.

Key factors are, firstly, choosing the appropriate installation capacity for an initial stage of production and, secondly, maintaining an adaptable on-going development strategy. At the earliest exploration stages, in the absence of robust reservoir permeability and fluid recharge information, a simple volumetric stored heat and recovery factor calculation (within uncertainty bands) is often applied to justify an initial installed capacity. The limitations of such an approach are well known. With time, knowledge from monitoring reservoir responses informs a more sophisticated resource assessment and modelling process. The timing and sizing of subsequent expansion stages, is important. The objective is to avoid excessive pressure or temperature draw-down, and to allow for sufficient reservoir response over time to provide an opportunity for good history matching using the simulator. A third key factor is the ability to adapt reinjection strategy (location, depth, fluid chemistry and temperature) throughout the productive lifetime of the resource, as new information from monitoring of production/injection effects becomes available. The information required includes pressure and temperature changes, phase state (liquid/steam/gas) and chemical changes. A fourth key factor is the early recognition of the dynamic response of a resource to its utilisation, with better constraints being placed on the source location, chemistry and temperature of induced recharge fluids, and on permeability changes through induced seismicity or mineral deposition and dissolution.

Tracer technology also provides a better understanding of the heterogeneity of permeability and fluid characteristics along the reservoir flow-paths between injection and production sectors in geothermal reservoirs, and how they change over time. Better calibration of reservoir models enables improved characterisation of the permeability structure and boundary recharge parameters that dictate long-term reservoir behaviour. Over timescales of about 100 years, instead of resources being uniformly depleted, in accordance with the simplistic volumetric stored heat model, reservoirs are more likely to reach a near steady-state condition, wherein induced mass and heat recharge almost balances the net mass and heat extracted. If, however, this strategy is not economically sustainable, because of reduced output, there will still be other options for sustainable development. These might involve cyclic or intermittent energy extraction. A term to describe this process is ‘heat grazing’. Neighbouring parts of a large heat resource may be developed in rotation, or the deeper roots of an existing development may later be targeted.

The rotation strategy provides for recovery periods, wherein the drawn-down state of the drilled part of a geothermal resource is allowed to recover naturally, before extraction is re-initiated. The ‘deep-roots’ strategy uses the acquired knowledge and simulated behaviour from early production stages to plan deeper drilling, and targeting of the primary hot-fluid upflows. Over time, the shallow parts of a resource are ‘retired’ and bore-holes tap directly into higher enthalpy and more productive sectors of the resource. Challenges associated with this strategy include the need to reduce the cost of deep drilling, and to develop technologies to deal with super-critical reservoir fluids and potentially corrosive fluids. The impact of downward migration of rock cooling, through long-term reinjection, deep into the brittle-ductile transition zone, also needs further investigation.

A collaborative research effort has been carried out into these issues, under the auspices of the IEA Geothermal Implementing Agreement, through the Sustainability Task of its Environmental Annex (www.iea-gia.org) and a new Annex XII investigating 'deep roots'. Cooperation amongst member countries has facilitated knowledge sharing and exchanges of geothermal operational and modelling experience. These are important if we are to learn from mistakes made in the past. We must grow confidence in the renewability and long term sustainability of geothermal resources as a viable and economic alternative to fossil fuel energy, in our global efforts to mitigate the adverse effects of climate change.

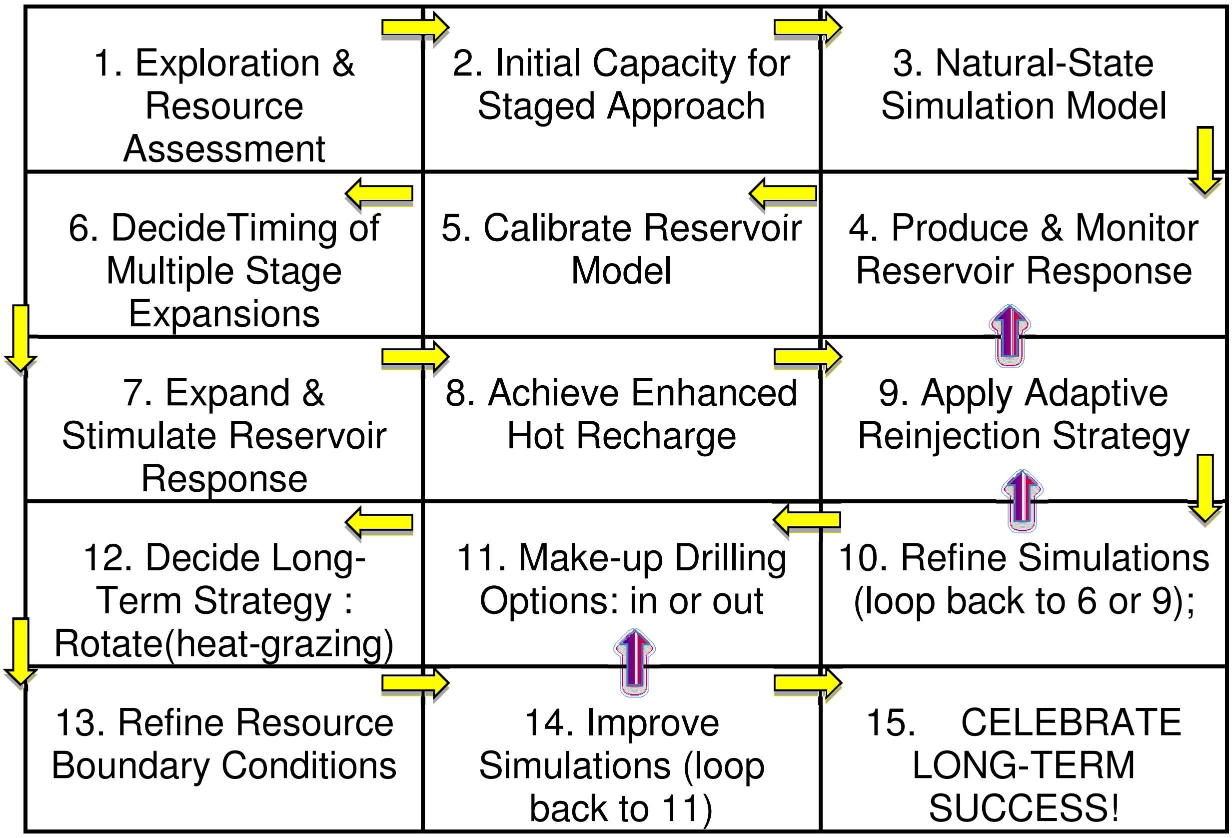

Figure 1. Flow chart of a designed sequence of geothermal reservoir development strategies, aimed at minimizing risk, and optimizing productivity through an adaptive and sustainable approach.