Chris Bromley
Comments on IPCC Geothermal Paper
(via e-mail; received: 27 June 2008)

Comments on paper by Friedleifsson, et al (11 Feb 2008):
"The Possible Role and contribution of geothermal energy to the mitigation of climate change"

Initial comments by Chris Bromley 12/6/08:

1. Firstly, I would like to commend the authors on an excellent summary of the current state of geothermal and its future role, particularly given the tight timetable to produce it.
2. Secondly, in general, I agree with the detailed comments and suggestions by Mike Mongillo, as posted on the IEA-GIA website, so will not repeat them here.
3. In addition, I would like to add some comments on the average **capacity factor** quoted in Table 1 (p5) for geothermal in 2005 (73%). It could perhaps be pointed out that this is a world-wide average capacity factor which bundles together all causes for lost generation opportunity. Most of these causes are not related to steam/water availability from the resource. From my study of Philippine developments, for example, I found that the average capacity factor in recent years- (delivered/installed) was about 72%, but the average **steam availability** factor was about 84%. The reasons for this difference are varied: transmission grid constraints, typhoon damage, daily load following constraints, economic constraints delaying turbine repairs, etc. Sometimes investment in maintaining steam supply is also postponed because of delays or financial constraints in repairing turbine or transmission line damage.
   In New Zealand, the average capacity factor is now about 90%, but this is increasing with time as economics favour more make-up drilling to sustain full output from installed plant (eg Ohaaki, Poihipi).
   Any comparison of resource availability between the renewable resources should really use a value for geothermal that more correctly portrays its true baseload capability (average 95%?). For other resources such as wind, solar, hydro and ocean tidal currents, I presume that the low resource availability factor dominates the capacity factor calculation.
   Another consideration is the issue of whether gross or net installed capacity should be used in a calculation of capacity factor. In many country reports, the authors simply add up the gross installed capacity (probably because it appears more impressive!) without consideration of the variations in net output.
   For modern conventional geothermal power plant the difference is about 6%. For older plant, or higher NCG resources, it can reach about 10 to 20%. Sometimes there is a trade-off between more efficient use of the available resource, and higher parasitic loads from air-cooling fans or water pumps.(eg Binary plants) For some pumped EGS systems, parasitic loads may reach 35%, but surplus low-grade heat may be distributed into district heating schemes, thereby improving the overall efficiency of resource use.
   All these issues are difficult to lump together in one comparative number.

4. **Geothermal potential** (fig 4, p6). I agree with Mike Mongillo, and others, that the future potential (with technology improvement, and changing economic drivers) should be revised upwards. We need an approach that matches the other renewable predictions…perhaps conservative estimates and optimistic estimates.
   Also, it would be useful to have a breakdown of the potential new sources of geothermal energy that might be realisable with the benefit of new technology, improved economics, and significant investment in new drilling rigs, over a period of about 50 to 100 years. (optimistic predictions)
   Eg. (the numbers are only guesses at present; we need to debate them thoroughly)
   1) Undiscovered/deeper conventional on-land resources- 1.5 TWe ?
   2) On-shore EGS resources (USA *10?) - 1 TWe ?
   3) Super-critical temperature resources (magma) - 0.5 TWe ?
   4) Off-shore (eg mid-ocean ridge) hydrothermal resources - 0.5 TWe ?
   5) Binary power from lower temperature (<150?) aquifers - 0.2 TWe ?
   6) Heat pumps (heating and cooling) 0.2 TW(th)
   7) Non-electrical direct use of lower temperature resources- 4 TW (th)

The combined future potential geothermal electrical generation (using these guesses) would be about 3.7 TWe (nearly twice the 2006 worldwide electricity generation of about 2.1 TWe). This compares favourably with the worldwide potential wind power estimates of 39000 to 58000 TWhrs/yr (= 4.4 to 6.6 TWe)
The non-electrical heating potential of about 4.2 TW (th) has the potential of displacing a similar amount of electrical or fossil fuel heating.

5. (Abstract, p1) **Costs** of geothermal power stations can be lower than 2 M euro/MWe in some countries. (eg, a 90 MW plant at Kawerau, New Zealand is about to be commissioned at a cost of about 1.5M euro/MWe). Although steamfield (drilling and pipeline) costs would add perhaps 0.5M euro/MWe.
6. Operating costs can be much lower than 40 euro /MWh for larger sized projects in some countries. (eg in NZ, plant and steamfield O&M , excluding make-up drilling, averages at about 4 euro/MWh.) Averaged over the lifetime of the power plant, at 4% per annum, replacement make-up drilling might add another 1.6 euro/MWh

In summary, it seems that key information that should be collected to help with improvements (over the next 2 years) in assessing the role geothermal could play in the future are:

Better resource assessments.
Probable technology advances
Costs and predicted cost trends
Strategies for long term sustainable use

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