Present challenges and future of Geothermal Energy in Australia

Queensland Geothermal Energy Centre of Excellence
Professor Hal Gurgenci, Director, h.gurgenci@uq.edu.au
www.uq.edu.au/geothermal
Australian Geothermal Energy Targets

- At the present, there is no firm Commonwealth target for future share of geothermal energy
- Commonwealth Energy White paper is expected to be released next year
- Geothermal energy features a significant portion of the 2030 energy mix in all of these scenarios
- The share of geothermal energy is sensitive to the carbon price


June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
Scenario 1 (Fast rate of change):

successful deployment of both centralised and decentralised supply-side technologies, combined with high demand side participation, facilitates a rapid transformation of the sector to meet strong emission targets.

Australia remains competitive on the global stage and reaps the benefit of strong international growth.

Prepared for AEMO by Intelligent Energy Systems Pty Ltd (IES) - 6 December 2010
Scenario 1 (Fast rate of change):
successful deployment of both centralised and decentralised supply-side technologies, combined with high demand side participation, facilitates a rapid transformation of the sector to meet strong emission targets.

Australia remains competitive on the global stage and reaps the benefit of strong international growth.

Other scenarios are
- An uncertain world
- A decentralised world
- Oil shock and adaptation
- Slow rate of change
Cost of Renewable Electricity

(First column in each group is 2015, second column is 2030)

from "Australian Electricity Generation Technology Costs – Reference Case 2010"

- Weighted cost of capital (real, before tax) = 8.4%
- Excludes financial support mechanisms
- Excludes grid connection, transmission, and firming (standing reserve requirements)
- Includes a notional allowance of 7.5% for site-specific costs
- Baseload technologies assumed to have a capacity factor of 85%
- NOTE: Simplified pro-forma technology costs, individual projects may lie outside this range
As technology moves along the continuum of development, the accuracy of performance and cost estimates tends to improve. At the R&D level, technologies face a high degree of both technical and estimation uncertainty. The bandwidth of the uncertainty depends on the number of new and novel parts in a technology and the degree of scale-up required for commercial deployment.

from "Australian Electricity Generation Technology Costs – Reference Case 2010"
Grubb Curve for Fossil Fuels

from "Australian Electricity Generation Technology Costs – Reference Case 2010"

H Gurgenci (h.gurgenci@uq.edu.au)
Grubb Curve for Renewable Energies

- More appropriate for Geothermal
Electricity Generation from a Hydrothermal Reservoir

The Geysers reservoir electricity generation in 2007 = 750 MWe

June 2011

H Gurgenci (h.gurgenciuq.edu.au)
Engineered Geothermal Systems (EGS)

- The underground fracture system connects the two wells together.
- Cold fluid is injected down the injection well.
- The fluid is heated while passing through the fracture system.
- It is pumped up the production well.
- The preliminary fracturing work on the reservoir is called “reservoir stimulation”.
- Such systems are called “Enhanced” or “Engineered” Geothermal Systems or EGS.
Geothermal Energy in Australia

- **HSA**
  - radiogenic granites (or magma)
  - reservoir stimulation is not needed
  - temperatures are lower
  - wells are shallower

- **HDR**
  - radiogenic granites
  - needs hydraulic stimulation of the reservoir to create permeability
  - temperatures are higher
  - wells are deeper
Australian Geothermal Resource

OzTemp - Interpreted Temperature at 5km Depth

Distribution of temperature data used in the interpretation.

Colour in the above image provides an indication of the confidence of the interpretation. The brighter the colour the higher the degree of confidence.
Australian geothermal projects - 2009

- HRL, Koroit, 10MW, GDP $7m
- GDY, Bulga, GDP $7m + NSW $10m
- GDY, Innamincka, 25MW, REDP $90m
- GDY, Innamincka, 25MW, REDP $60m + GDP $7m
- GRK, Perth, Air con, GDP $7m
- TEY, Parachilna, 7MW, GDP $7m
- PTR, Paralana, 30MW, REDP $60m + GDP $7m
- PAX, Penola, 10MW, GDP $7m
- HRL, Koroit, 10MW, GDP $7m
- GER, Geelong, 12MW, GDP $7m + VIC $25m

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
GDY, Innamincka, 25MW REDP $90m

PTR, Paralana, 30MW, REDP $60m + GDP $7m

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
Geothermal Energy in Australia

1. Cold water is pumped under pressure down an injection well and is heated in the geothermal reservoir.
2. The hot water returns to the surface under pressure.
3. The hot water heats up a secondary working fluid via a heat exchanger.
4. The vapour from that fluid spins a turbine to generate electricity.

H Gurgenci (h.gurgenci@uq.edu.au)
Present and future EGS costs

Present - 26.9¢/kWh
30 kg/s; 250 °C; Well Cost=High; ACC; 10% interest; 3 cents/kWh O&M

Natural Draft Towers
- 24.7¢/kWh
  + Supercritical Cycle
    - 21.8¢/kWh
      + Nat Draft Towers
        - 12.1¢/kWh
          + Supercritical Cycle
            - 10.6¢/kWh
              + Cheaper wells
                - 8.5¢/kWh
Triple the flow
- 15.9¢/kWh
  + Cheaper wells
    - 11.4¢/kWh
  + Nat Draft Towers
    - 11.4¢/kWh
  + Supercritical Cycle
    - 10.6¢/kWh

Double the flow
- 10.8¢/kWh
  + Nat Draft Towers
    - 10.8¢/kWh
  + Supercritical Cycle
    - 10.3¢/kWh

Cheaper Wells
- 18.0¢/kWh
  + Nat Draft Towers
    - 17.2¢/kWh
  + Supercritical Cycle
    - 15.6¢/kWh
What Technology Improvements Will Reduce Cost?

• “Cost of drilling
  • 20% reduction in cost of drilling
  • Fewer casing strings
  • Better rate of penetration

• “Reservoir Stimulation
  • Double the flow per well from 40 l/s to 80 l/s without thermal breakthrough
  • Reduce the stimulation cost by better stimulation design (do it once, do it right)

• “Power Plant
  • 20% improvement in conversion efficiency”


The US DoE Programs adopted the above goals.
QGECE is investigating the most efficient transmission option for bringing remote geothermal electricity into the national power grid. System stability, reliability and cost are important considerations. We collaborate with PowerLink, the Queensland transmission company.

QGECE started a collaborative project with the US turbine and power plant manufacturer Verdicorp to develop supercritical turbines and plants using such turbines. The target technologies have the potential to increase the geothermal productivity by 50%.

At the first instance, two supercritical turbine and cycle testing facilities will be built next year on the Pinjarra Hills campus of the University of Queensland to test and demonstrate supercritical cycles for medium and high-temperature resources. The medium-temperature plane will be transportable for testing and demonstrating the benefits of the new power plant technologies at remote geothermal sites. The above shows a pictorial view of this plant which will be commissioned by the end of 2011.

The QGECE is investigating new heat exchanger technologies and cooling tower construction methods for natural draft dry cooling towers. The use of natural draft towers in place of fan-cooled condensers has the potential to increase the net power production by up to 15% for a typical geothermal binary power plant.
QGECE Post-Graduate Students

1. Aleks Atrens  Supercritical CO$_2$ Geothermal Siphon
2. Ampon Chumpia  Metal Foam Heat Exchangers
3. Jason Czapla  Supercritical impulse turbine
4. Carlos Ventura  Supercritical radial turbine
5. M H Nikooravesh (Niko)  Design/test small supercritical turbine for geothermal/solar thermal apps
6. Mehryar Sakhaei  Scaled cooling tower tests in the lab
7. Rajinesh Singh  Supercritical cycle control issues
8. Braden Twomey  Mobile geothermal plant design/testing
10. Yuanshen Lu  Design and optimisation of natural draft dry cooling towers
11. Mustafa Odabaei  Modelling metal foam heat exchangers
12. Huong Mai Nguyen  Power system stability
13. Kazi Nazmul Hasan  Power system reliability
15. Craig McClaren  Queensland heat flow/geochemistry
16. Alexander Middleton  Queensland fluid flow events
17. Jacobus van Zyl  Geochemistry of heat producing granites
18. Behnam Talebi  Geothermal Prospectivity of Eastern Queensland
19. Shaun Dunne  Binary Plant Design and Optimisation
20. Pourya Forooghi  Supercritical heat transfer
22. Hugh Russell  Use of shallow aquifers for power plant cooling
23. Abdullah AlKhodair  Natural Draft Wet/Dry Hybrid Cooling Towers
24. Jie Zhang  Optimum fluid selection and Turbine Design

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
QGECE Laboratories – High Pressure Turbine laboratory

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
QGECE Laboratories – High Pressure Turbine laboratory

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
QGECE Heat Exchanger laboratory
QGECE Heat Exchanger Laboratory

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
QGECE Geochemistry Laboratories

- Access to most of the necessary equipment and laboratory facilities

June 2011

H Gurgenci (h.gurgenci@uq.edu.au)
Present and future EGS costs

Present - 26.9¢/kWh
30 kg/s; 250 ºC; Well Cost=High; ACC; 10% interest; 3 cents/kWh O&M

Natural Draft Towers
24.7¢/kWh

+ Supercritical Cycle
21.8¢/kWh

Triple the flow
12.1¢/kWh

Double the flow
15.9¢/kWh

Cheaper Wells
18.0¢/kWh

+ Nat Draft Towers
11.4¢/kWh

+ Cheaper wells
11.4¢/kWh

+ Nat Draft Towers
17.2¢/kWh

+ Supercritical Cycle
10.6¢/kWh

+ Cheaper wells
8.5¢/kWh

+ Supercritical Cycle
10.3¢/kWh

+ Supercritical Cycle
15.6¢/kWh

May 2011
How to Double the Flow Rate -- 1

- The water moves at a rate of meters/day in the reservoir
- Near the production well, the velocity gets very high
- High turbulence causes high pressure drops
- Create a collection manifold near the production well
- Easy to do in soft rock (like coal) but much harder in hard rock
How to Double the Flow Rate -- 2

- The well is the main cost item
- The pressure drop inside the well is not the main chokepoint
- Increasing the number of reservoirs feeding the same well will increase the flow