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APPENDIX N - Presentation 15

Topic: Environmental Control Technology

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DISCLAIMER

ENVIRONMENTAL CONTROL TECHNOLOGY (ECT) FOR GEOTHERMAL PROCESSES

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The objectives of the ECT program are to develop research priorities, research new and alternative technologies and to improve economics and performance of ECT systems. The Interagency Geothermal Coordinating Council, Environmental Control Panel developed priorities and obtained industry input during 1980. H_2S controls, injection monitoring, solid waste characterization and control and subsidence were reviewed as high priority while noise controls were considered low priority. Since geothermal technology is still developing there is a need to continue researching new and alternative ECT. Often ECT systems must be designed for site specific applications and need modification for use of other sites. Most of the US geothermal experience is found at the Geysers, California where H_2S abatement is required. Various systems have been tested with mixed results. The bottom line is that the economics and performance of H_2S abatement systems are less than desirable.

There are numerous technical issues the ECT program must deal with. These issues fall into the categories of liquid discharges and withdrawl, air emissions, solid wastes, subsidence, seismicity and noise. Geothermal liquid discharges can impact either surface or subsurface waters. EPA and most state/local water regulatory agencies have water standards and require permits for such discharges. Withdrawl of geothermal fluids can cause hydrogic alteration such as drawdown of surface features (e.g. geysers). Geothermal processes release a variety of gases. CO_2 H_2S, Hg, Rd, Bo, SO_2 and other gases are often associated with geothermal resources. Solid wastes are generated by geothermal drilling, energy conversion processes and the H_2S abatement systems. Some of the solids generated can be toxic and require costly disposal techniques. Disposal sites are often limited and a distance from the geothermal operations. Highly saline geothermal brines such as those found in the Salton Sea, California area will generate significant quantities of solid waste requiring costly disposal. Both subsidence and seismicity may occur as a result of geothermal operations. In both cases it may be difficult to differentiate geothermal induced events from natural occurrences. Noise is not a signficant problem from geothermal operations except when wells are open vented to the atmosphere.

The ECT program is presently in a close-out mode due to funding limitations. Three projects are being completed this fiscal year. LLNL is in the process of doing field experiments to develop techniques to track fluid migration from geothermal injection wells to protect underground sources of drinking water. Two geophysical techniques appear to offer promise. Geotomography is a technique which enhances images of borehole to borehole electric measurements. Tidal response is a technique which determines flow paths by measuring pressure fluctuations in a non-producing well from earth tides. Two H_2S abatement

experiments will also be completed. These are the Sheinbaum direct chlorination process being tested at HGP-A in Hawaii and the Research Cottrell/Ion Physics E-beam laboratory experiment. Both process produce elemental sulfur as a by-product. Other work completed in past years include the EIC copper sulfate upstream scrubber, UOP catalytic oxidation process, LBL partitioning model, ETEC H_2S and solid waste state-of-the-art studies, Accurex solid waste characterization and the LBL subsidence program. Some work on seismicity has been coordinated with the USGS activities.

There have been four significant accomplishments of the ECT program. These are the UOP catalyst research, ENEL project coordination, LLNL injection and monitoring project and LBL H_2S partitioning model. UOP was selected through an RFP which contained selection criteria designed to obtained a source who would commercialize a process without further DOE funding. UOP did just that. After successful completion of DOE funded research MCR Geothermal sponsored a field test at the Geysers which appears to have been quite successful. Coordination with ENEL, Italy has added much perspective to the ECT program. Project 5, Environmental Research, has been approved providing a mechanism for information exchange. LLNL is developing two new geophysical techniques to aid reservoir engineers understand injected geothermal fluid migration. LBL H_2S partitioning computer model has been transferred to PG&E and is being used for abatement system design.

Industry perceived ECT for geothermal as a problem. H_2S abatement costs are very high, often results in other problem such as solid waste and in some causes damage to power plant materials. Injection monitoring is felt to be important but more from a reservoir engineering/performance standpoint. OSHA concerns are becoming significant. Arsenic and safety issues are presently concerns at the Geysers. Solid waste costs are projected to impact some Imperial Valley, California developments and industry by-product recovery research is on-going. Subsidence concerns have caused local resistance to some geothermal projects in the Imperial Valley.

Overall there are ECT problems remaining. First is the "Puna Speaks vs DOE, et al " litigation which shows that in the environmental area you may never do enough. The HGP-A project employes state-of-the-art H_2S abatement systems yet DOE is being sued for H_2S emissions. The present cost of ECT systems is very high and the performance of many existing systems is marginal. Last without funding even the long term ECT research needs will not be accomplished.

If ECT funding is available the following program strategy is recommended. Continue research in brine injection environmental controls. Three somewhat related research areas are recommended. Brine injection treatment technology is needed to protect drinking water aquifers (not to mention keeping injectivity high in the injection wells). The GLEF clarifyer system is on example already

developed by DOE. Other technologies should now be explored. Assuming no treatment technology will ever be 100% efficient there may be a strong future need for injection monitoring. While injection monitoring can be accomplished through witness wells this can be quite expensive. Completing the LLNL

Injection Monitoring Project and developing a technology base for industry would be useful. Last in brine injection research I recommend a project to develop economic solid waste treatment technology. The largest geothermal solid waste load will be from brine injection treatment systems. Techniques will be required to either reduce the waste load or utilize it for eocnomic recovery. Both by-product recovery and detoxification research is needed. Continued H_2S research would be highly desirable but is not essential since industry is presently performing a modest research program. If H_2S research does continue two projects are recommended. First an economic H2S control program is proposed for geothermal flash power plants HGP-awould make an ideal test bed. Also as the litigation in Hawaii developed I discovered the need for an H2S in-stack and ambient monitoring state-of-the-art report. ETEC could perform this analysis.

ENVIRONMENTAL CONTROL TECHNOLOGY

(ECT)

OBJECTIVES

- o DEVELOP ECT RESEARCH PRIORITIES
- o RESEARCH NEW AND ALTERNATIVE TECHNOLOGIES
- o IMPROVE ECONOMICS AND PERFORMANCE

TECHNICAL ISSUES

- o LIQUID DISCHARGES AND WITHDRAWL
- o AIR EMISSIONS
- o SOLID WASTES
- o SUBSIDENCE
- o SEISMICITY
- o NOISE

PROGRAM STATUS

- o GEOTHERMAL INJECTION MONITORING PROJECT (LLNL)
- o H_2S ABATEMENT
  - COPPER SULFATE UPSTREAM SCRUBBER (EIC)
  - CATALYTIC OXIDATION (UOP)
  - E-BEAM (RC/IP)
  - DIRECT CHLORINATION (SHEINBAUM)
  - PARTITIONING MODEL (LBL)
  - STATE OF THE ART (ETEC)
- o SOLID WASTE
  - CHARACTERIZATION (ACCUREX)
  - STATE OF THE ART (ETEC)
- o SUBSIDENCE RESEARCH PROGRAM (LBL)
- o SEISMICITY PROGRAM

ACCOMPLISHMENTS

- o UOP CATALYST RESEARCH
- o ENEL PROJECT COORDINATION
- o LLNL INJECTION MONITORING
- o LBL H_2S PARTITIONING MODEL

INDUSTRY PERCEPTION

- o H_2S ABATEMENT COST AND PERFORMANCE
- o INJECTION MONITORING RESERVIOR ENGINEERING USE
- o OSHA CONCERNS (ARSENIC, SAFETY)
- o SOLID WASTE
- o SUBSIDENCE

PROBLEMS

- HGP-A LITIGATION
- OVERALL ECT COST AND PERFORMANCE
- FUNDING

FUTURE PROGRAM STRATEGY

- BRINE INJECTION TREATMENT
- GEOTHERMAL INJECTION MONITORING
- ECONOMIC SOLID WASTE TREATMENT
- ECONOMIC H_2S CONTROLS FOR GEOTHERMAL FLASH PLANTS
- H_2S IN-STACK AND AMBIENT MONITORING STATE OF THE ART