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# TOTAL ENERGY RECOVERY SYSTEM FOR AGRIBUSINESS

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## Abstract

Improvements in agribusiness biologic cycle efficiencies are attainable in controlled environments which utilize energy recovered from geothermal resources that are not suitable for power production. By combining greenhouse crops, mushroom culture, fish farming and biogas generation into an integrated biologic system, the waste or by-products of each subsystem cycle can be recovered to service input needs of companion cycles. The initial study concerned an evaluation of the cost and viability at an unspecified site of such combined thermodynamic and biologic cycles in a system known as the Total Energy Recovery System for Agribusiness (TERSA); TERSA is currently being modified for a best fit to a site in Lake County, California, with particular attention paid to relevant environmental and institutional factors.

## Summary

An initial ERDA funded engineering and economic study has been made to determine a practical balance of selected agribusiness subsystems resulting in realistic estimated produce yields for a geothermally heated system known as the Total Energy Recovery System for Agribusiness. The subsystem cycles for an average application at an unspecified hydrothermal resources site in the western United States utilize waste and by-products from their companion cycles insofar as practicable.

Subsystem activity sizes were predicated upon smallest commercially successful individual enterprises. The TERSA module was designed for a family style business involving four to six working members; this is the same labor basis as actual subsystem commercial units of approximate minimum successful size. For a starting point, small commercial units were selected at one-third normal size for each of the three major commercial activities. As other subsystem integrations progressed, these sizes were adjusted to obtain a balance of thermal, energy, nutrient, and space considerations, which in turn modified the commercial subsystem sizes - in other words, there was utilization of feedback between the engineering and economic studies.

In the Total Energy Recovery System for Agribusiness hydrothermal fluid passes through self-descaling heat exchangers under pressure and is reinjected with most of its original chemical content intact. A pumped hot water heating system of the type commonly utilized in institutional applications is piped to the clean water side of TERSA's heat exchanger loop.

The highest temperature clean water ($200^{o}F$) is used in an absorption refrigeration system used for product storage. Higher temperature hot water is used for space heating of the greenhouses, mushroom houses, and the laboratory/office. Following these applications, the water is used for prawn pond heating followed by biomass digester heating and, finally, the clean water is recirculated through the heat exchanger.

A TERSA family sized module occupies a little over six acres as sized for average conditions. Features of the module include:

- a required hydrothermal source providing 500 gpm at $250^{o}F$
- two heat exchangers of six million British thermal units per hour (Btuh) capacity each
- three greenhouses of 3000 square feet each
- three mushroom houses, each with 4000 square feet of bed space
- six prawn ponds of one-half acre each
- six biomass digestion units, each of 2500 cubic feet daily biogas production capacity, yielding biogas and organic compost that is utilized as planting mulch and fertilizer for the agricultural activities and as a fertilizer to promote best growing conditions for the prawn ponds
- two ten horsepower engine-generator sets to be powered by biogas
- absorption refrigerated temporary product storage area
- a combination laboratory and office occupying 900 square feet
- circulating pumps and various appurtenant facilities.

As configured, the Total Energy Recovery System for Agribusiness saves the equivalent of half a million gallons of oil yearly based upon a 0.5 use factor. TERSA is flexible in its adaptability

to local conditions as its subsystem agribusiness cycles can be modified in size and type of crops produced. The system size can be increased modularly or designed for less quantified additions. Finally, control system modifications can accommodate labor intensive or automated objectives as well as to further protect the environment and conserve water.

The initial TERSA study economics were based on conservative estimates of current controlled environment agribusiness yields, generalized produce wholesale market prices, production costs, and capital investment requirements. Actual determination of the margin of investment recovery can accurately be made only upon establishment of a specific project site with its affiliated land, well system, market and production costs.

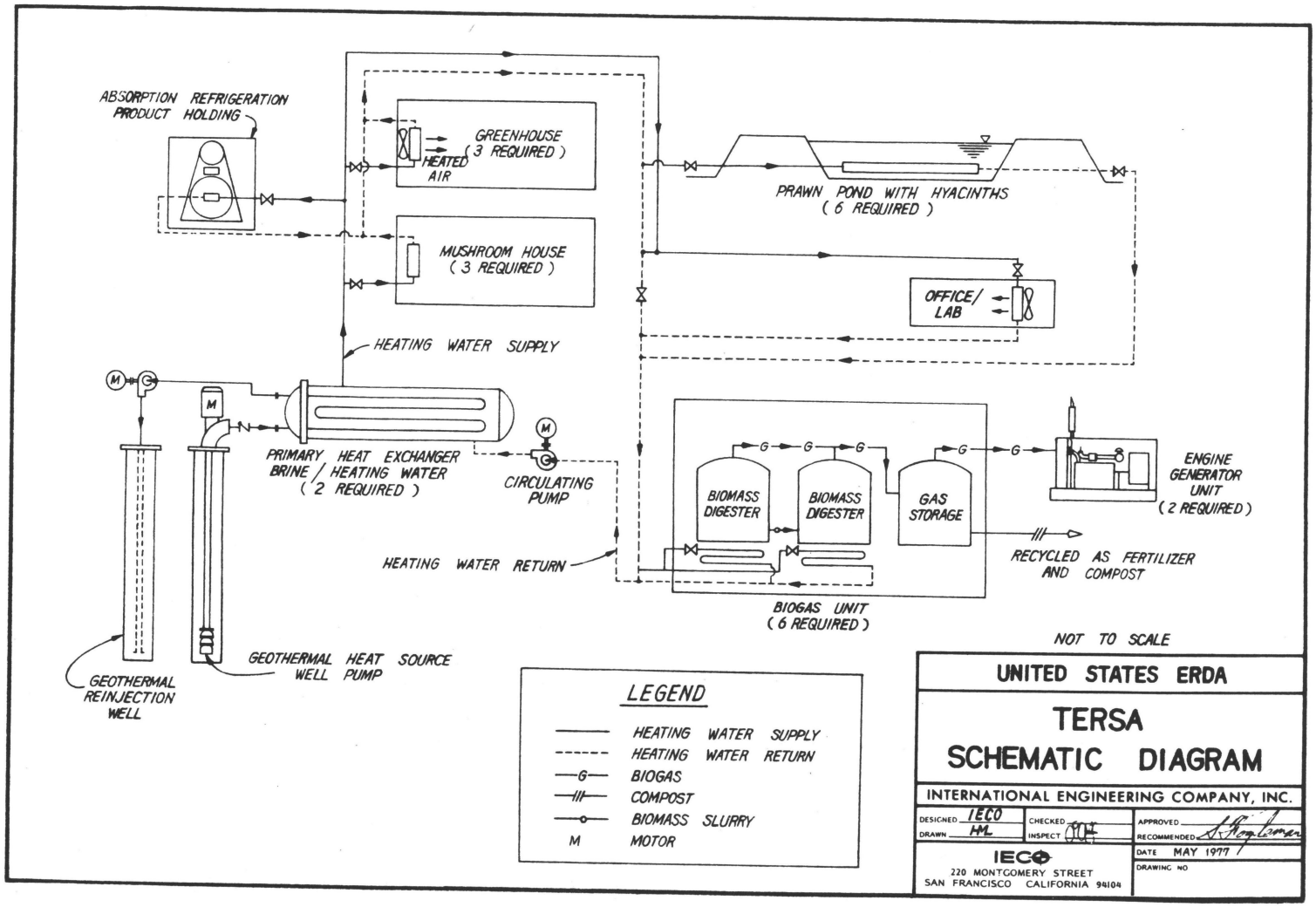
To this end, the Department of Energy has funded a follow-on study to begin moving the TERSA conceptual design towards a practical demonstration or pilot plant application. Known Geothermal Resource Areas in Lake County, California, are in the process of being evaluated for TERSA module suitability on the basis of: hydrothermal resource quality, temperature and flow; local climate and resources; local costs; product markets; and degree of potential local participation. The generalized TERSA cycles will be modified for best fit to the sites investigated and comparitive evaluations will be made to determine a single best Lake County site. Weighted criteria for comparison have been established and the relevant features of each site pertaining to these criteria are listed side by side in such a manner that a selection matrix of criteria and features is created. The results of this selection process will be used for conceptual design of a "new" TERSA module involving modified site specific cycles.

Although economic viability is the key factor in site selection and cycle modification in order that private industry and local government will be made aware of the potential of such a geothermally assisted enterprise, institutional and environmental factors play a particularly significant role in these activities.

Lake County environmental forces are quite active and specific factors to be considered include: endangered species; archaeological sites; flooding; and landslides. The standard concerns of air, water, and visual pollution and their mitigations are, of course, of tremendous importance as well.

Institutional factors to be considered include the standard items of: zoning; integrated land use compatibility; ownership; employment; liability; and training. Institutional concerns particular to the Total Energy Recovery System for Agribusiness include: the necessarily phased nature of development of integration of the cycles and portions of the subsystem activities themselves; State of California regulations and permitting processes regarding, in particular, the aquatic components of TERSA; transportation tariffs presently in existence for the Lake County; GRIPS (Geothermal Resources Impact Projection Study), a four county effort intended to provide tools for interim and long range planning and management of geothermal development; the Lake County Energy Council; the Geothermal Association for Lake County; bonding requirements for geothermal well drilling; recent court decisions regarding some Homestead Act lands; the way in which the land use portion of current geothermal leases is written; and the requirement for locally perceived physical benefits from geothermal developments.

As can be seen from this partial listing of relevant environmental and institutional factors, economic viability alone cannot guarantee a successful TERSA or other non-electric geothermal application project. However, as has been expressed repeatedly by local residents and officials at both state and local levels, suitably modified Department of Energy efforts such as TERSA can serve to provide the catalyst for widespread direct geothermal applications in Lake County and elsewhere.


ABSORPTION REFRIGERATION PRODUCT HOLDING
GREENHOUSE ( 3 REQUIRED )
HEATED AIR
MUSHROOM HOUSE ( 3 REQUIRED )
PRAWN POND WITH HYACINTHS ( 6 REQUIRED )
OFFICE/ LAB
HEATING WATER SUPPLY
M
PRIMARY HEAT EXCHANGER BRINE / HEATING WATER ( 2 REQUIRED )
CIRCULATING PUMP
HEATING WATER RETURN
BIOMASS DIGESTER
BIOMASS DIGESTER
GAS STORAGE
G
ENGINE GENERATOR UNIT ( 2 REQUIRED )
RECYCLED AS FERTILIZER AND COMPOST
BIOGAS UNIT ( 6 REQUIRED )
GEOTHERMAL REINJECTION WELL
GEOTHERMAL HEAT SOURCE WELL PUMP
LEGEND
HEATING WATER SUPPLY
HEATING WATER RETURN
BIOGAS
COMPOST
BIOMASS SLURRY
M MOTOR
NOT TO SCALE
UNITED STATES ERDA
TERSA
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