Greenhouse and Aquaculture Applications of Geothermal Energy

Presented by
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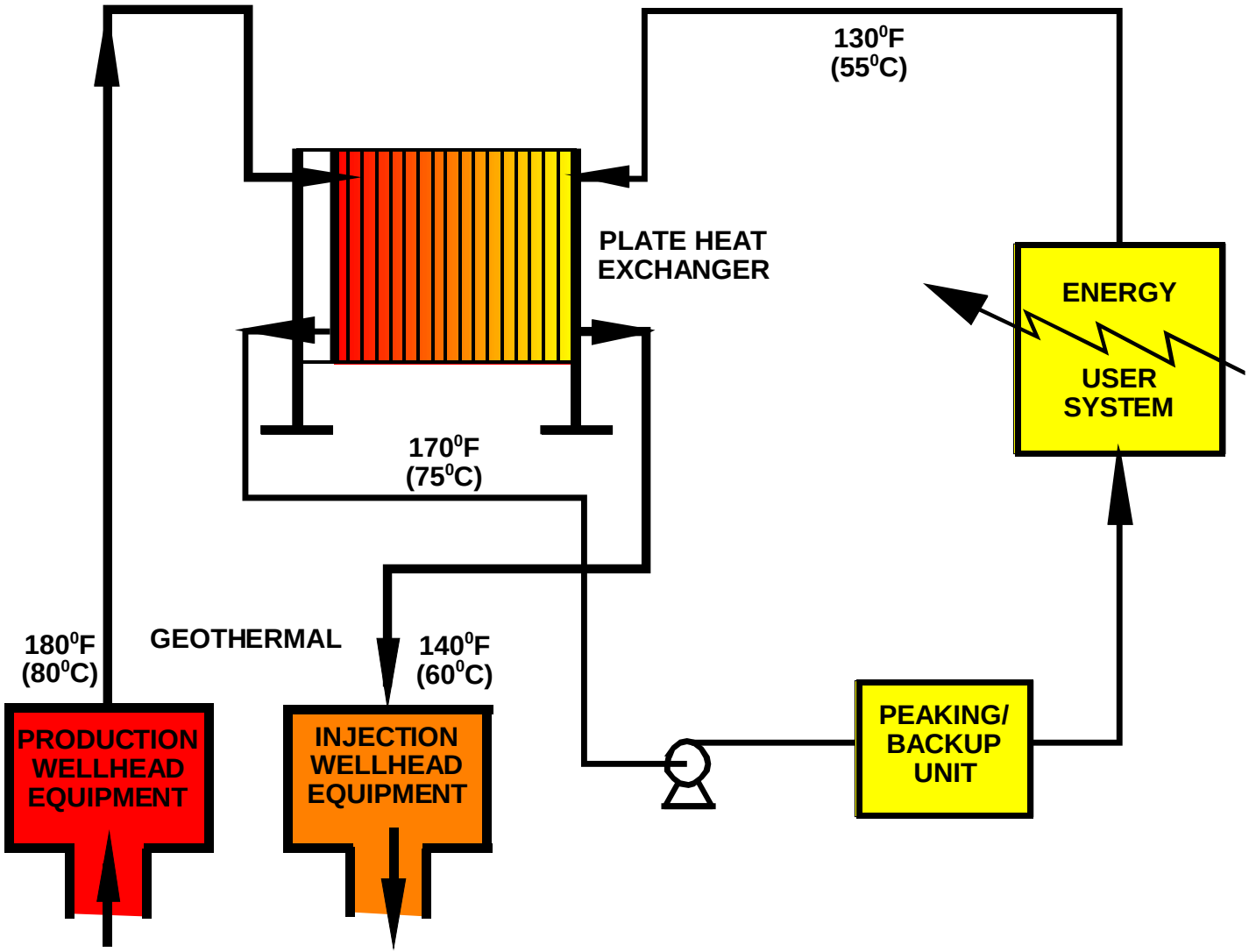

130⁰F
(55⁰C)
PLATE HEAT
EXCHANGER
ENERGY
USER
SYSTEM
170⁰F
(75⁰C)
180⁰F
(80⁰C)
GEOTHERMAL
140⁰F
(60⁰C)
PRODUCTION
WELLHEAD
EQUIPMENT
INJECTION
WELLHEAD
EQUIPMENT
PEAKING/
BACKUP
UNIT

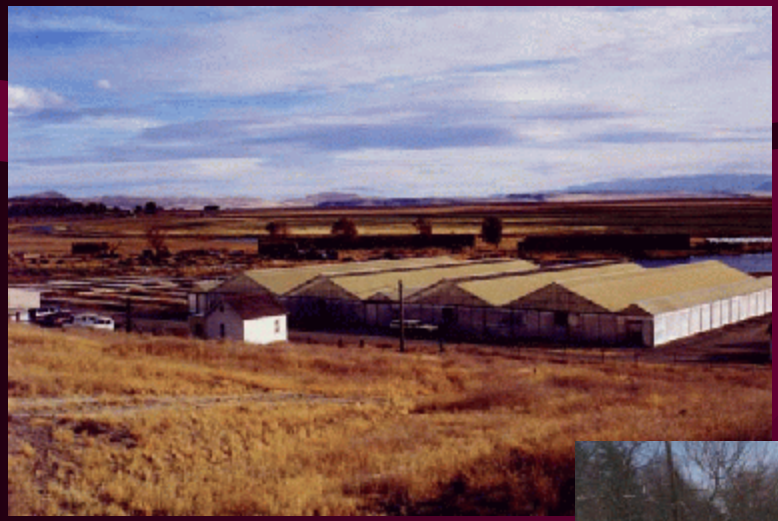
Geothermal Greenhouse Heating

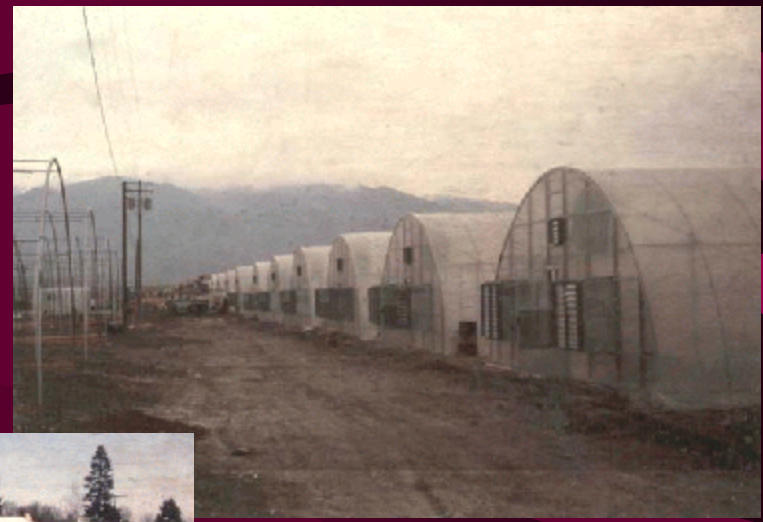
Geothermal Greenhouse Heating

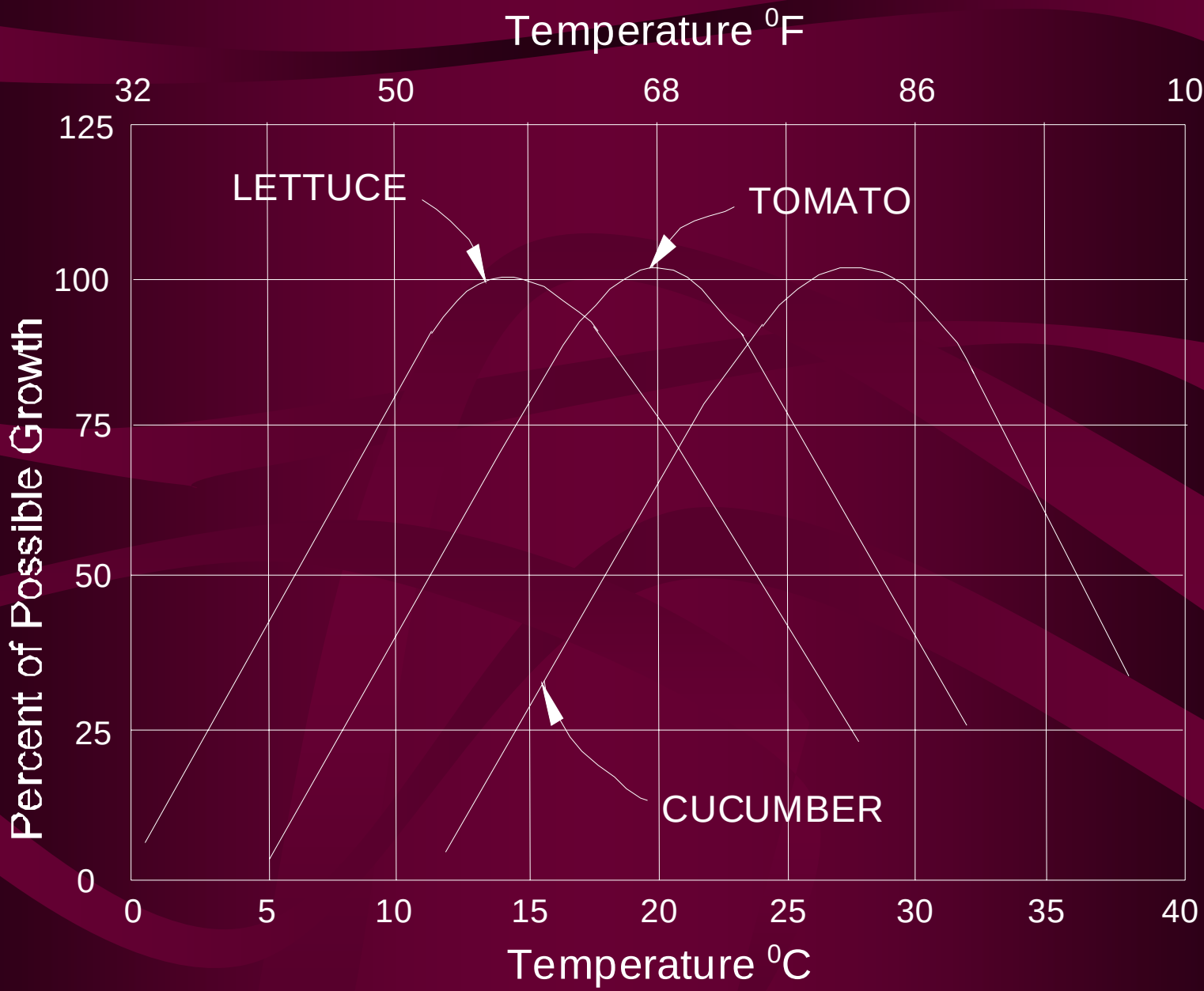
- Geothermally heated greenhouses
  - Have been in place since 1970
  - 44 applications in the 9 western states in the US
  - Utilization factor of 0.30
  - Approx. 93 MWt installed capacity
  - Approx. 201 GWh/yr utilization
  - Many installation in over 30 countries

Geothermal Greenhouse Heating

- One of the most common uses of geothermal resources
- Using geothermal energy is fairly simple
  - Use off the shelf equipment
- Most greenhouse heating systems are adaptable to geothermal
- Growth can be optimized in a controlled environment






Temperature ^{0}F
32
50
68
86
104
125
100
75
50
25
0
Percent of Possible Growth
LETTUCE
TOMATO
CUCUMBER
0
5
10
15
20
25
30
35
40
Temperature ^{0}C

Geothermal Greenhouse Information Package

- Introduction
- Section 1 – Crop Market Prices
- Section 2 – Greenhouse Operating Costs
- Section 3 – Crop Culture Information
- Section 4 – Greenhouse Heating Systems
- Section 5 – Greenhouse Heating Equipment Selection Spreadsheet
- Section 6 – Greenhouse Heating with Geothermal Heat Pumps
- Section 7 – Case Studies of Geothermal Greenhouse Operations
- Section 8 – Farm Bill Information
- Section 9 – Vendor Information
- Section 10 – Other Information Services

Introduction

- Intended to provide a foundation of background information for developers of geothermal greenhouses

Section 1 – Crop Market Prices

- US wholesales price information for typical vegetable and flower crops grown in greenhouses
- US national and regional prices are included along with indication of seasonal variations
- Sources for current price information provided at the end of the section

Section 2 – Greenhouse Operation Costs

- Outlines ranges of costs for a typical operation
  - Such as labor, utilities, plant stock, and mortgage components
- Market concerns and cost ranges for structure construction are also provided

Section 2 – Greenhouse Operation Costs

- Greenhouse structure capital costs in the US varied with location
  - Total greenhouse costs (includes greenhouse and operating equipment) $11.34 – 14.24/ft^2 (avg. 12.65/ft^2) – 1997 costs
  - Construction costs alone $7.30 – 8.05/ft^2 (avg. $7.44/ft^2) – 1997 costs
  - Land costs is a significant portion of the total capital investment

Section 2 – Greenhouse Operation Costs

Depending on the region in the US, the operating budget distribution could look like this:

Labor	40-45%
Plants, supplies and materials	16-25%
Utilities (heating, lights, and water use)	6-16%
Loan Payment	17-19%
Other (miscellaneous)	8-10%

Section 2 – Greenhouse Operation Costs

- Questions to ask yourself before you grow anything are:
  - What is my product?
  - How much can be produced in the greenhouse?
  - Who will be buying my product?
  - How much will they pay for my product?
  - How much will it cost to produce this type of crop?
  - Finally, is this enough to make a profit or break even?

Section 3 - Crop Culture Information

- Some parameters that can affect growth in a greenhouse are:
  - Temperature requirements, relative humidity, CO_2, lighting, dissolved oxygen, pH, electrical conductivity and disease issues.
- Abbreviated culture information is provided for:
  - Tomatoes, cucumbers, hydroponic lettuce, carnation, roses

Section 4 – Greenhouse Heating Systems

- *Chapter 15 – Greenhouses*
  - from the Geothermal Direct Use Engineering and Design Guidebook
- Covers greenhouse construction, heating requirements, and greenhouse heating systems.
- Heating systems covered are finned pipe, standard unit heaters, low temperature unit heaters, fan coil units, soil heating and bare tube.

Section 5 – Greenhouse Heating Equipment Selection Spreadsheet

- A tool for evaluating the economics of various types of heating systems
- Seven systems are considered
  - Unit heaters (UH), finned pipe (FP), bare tube (BP), fan coil units (FC), combination fan coil/bare tube (FC/BP), low temperature unit heaters (GLW) and propane unit heaters (PP)

Section 6 – Geothermal Heaitng with Geothermal Heat Pumps

- Examines the feasibility of greenhouse heating with a geothermal heat pump system
- Closed- and open-loop systems are examined at four locations
- Net present value analysis is conducted for a 20-year life-cycle cost for various base-load fractions

Section 7 – Case Studies of Geothermal Greenhouse Operations

- Recent Case Studies of successful operations in the U.S.
  - Milgro-Newcastle Greenhouse, Newcastle, UT
  - Canyon Bloomers Greenhouse, Hagerman, ID

Section 8 – Farm Bill Information

- Information on the Farm Bill Initiative
  - Current link to the website
  - Information contained on the website
  - Links to the templates for geothermal direct-use and geothermal applications

Section 9 – Vendor Information

- Provides a list of US vendors for
  - Components of geothermal systems
  - Greenhouse structures and equipment
  - Space heating equipment
  - Well pumps
  - Plate heat exchangers
  - Plant materials (seed and plants)
  - Hydroponic systems

Section 10 – Other Information Services

- Extensive list of sources including
  - State extension agencies
  - USDA state offices

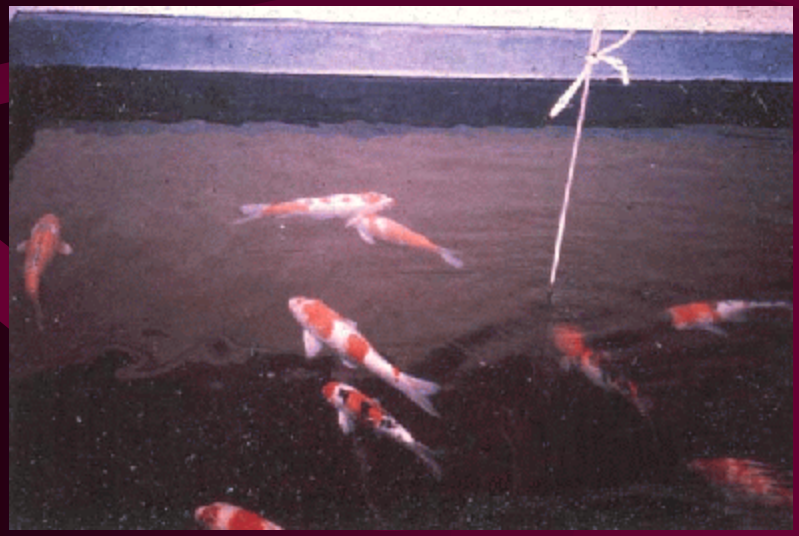
Geothermal Aquaculture Pond and Raceway Heating

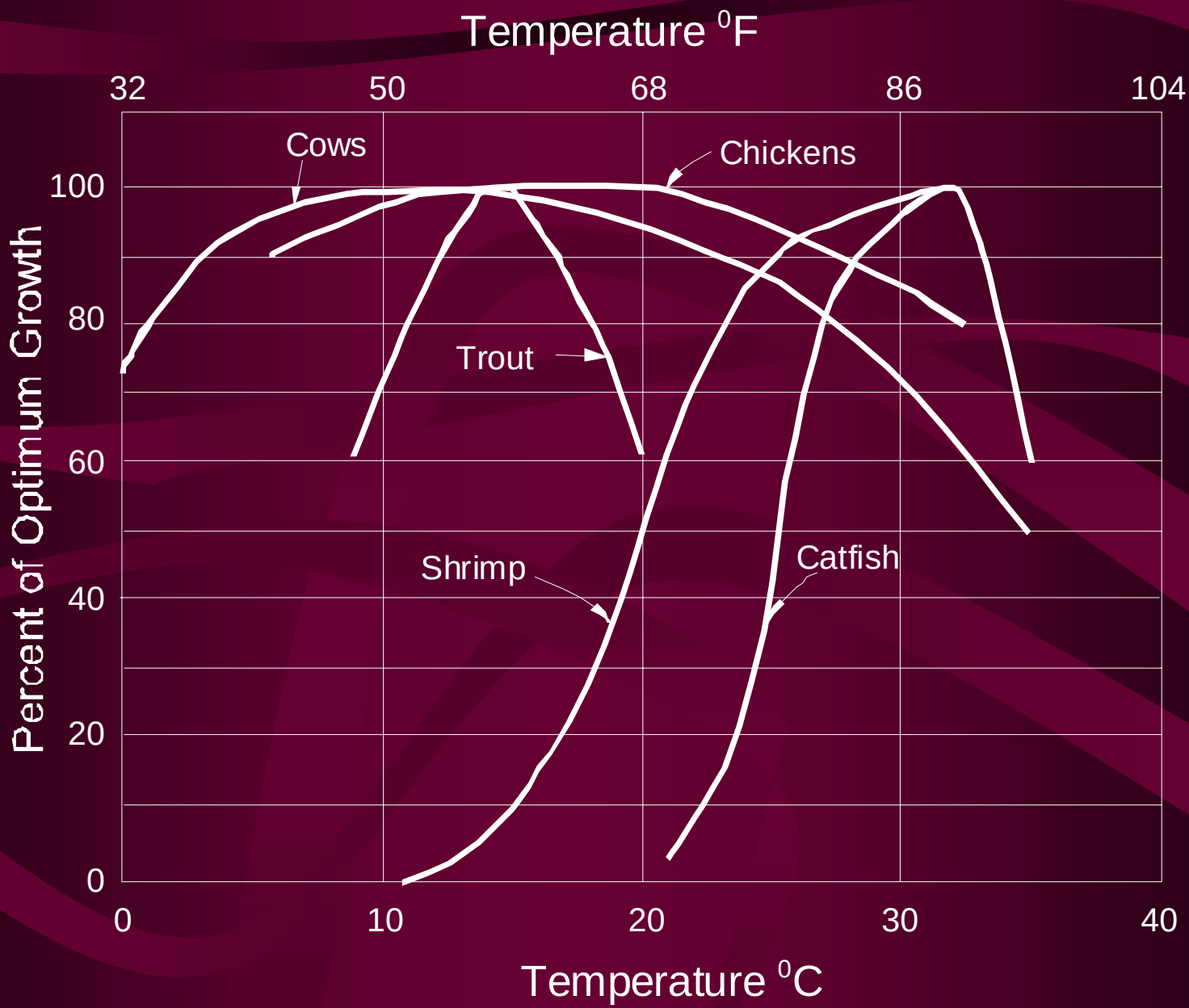
Geothermal Aquaculture Pond and Raceway Heating

- Geothermal aquaculture projects
  - Been in place since 1970
  - 48 applications in the 11 western states in the US
  - Utilization factor of 0.69
  - Approx. 133 MWt installed capacity
  - Approximately 800 GWh/yr utilization
    - (660,000 bbl of oil equivalent)
  - Many installation in 17 countries

Geothermal Aquaculture Pond and Raceway Heating

- One of the most common uses of geothermal resources
- Using geothermal energy is fairly simple
  - Use off the shelf equipment
- A number of freshwater or marine organisms can be raised
  - Including Tilapia, catfish, Malaysian prawns, tropicals, alligators and eels
- Enhanced production rates can be optimized in a controlled environment




Temperature ^{0}F
32
50
68
86
104
Cows
Chickens
Trout
Shrimp
Catfish
Percent of Optimum Growth
100
80
60
40
20
0
0
10
20
30
40
Temperature ^{0}C

Aquaculture Information Package

- Introduction
- Section 1 – Market and Price Information
- Section 2 – Water Quality Issues in Aquaculture
- Section 3 – Culture Information
- Section 4 – Pond and Raceway Heat Loss Calculations
- Section 5 – Aquaculture and Geothermal Heat Pumps

Aquaculture Information Package

- Section 6 – Case Studies of Geothermal Aquaculture Operations
- Section 7 – Farm Bill Information
- Section 8 - Aquaculture Bibliography
- Section 9 – Aquaculture Glossary
- Section 10 – State/Regional/University/ Extension Aquaculture Offices
- Section 11 – State Aquaculture Permit Requirements

Introduction

- Intended to provide background information to developers of geothermal aquaculture projects

Section 1 – Market and Price Information

- Information on the current status of the catfish and Tilapia markets in the US
- The Catfish market
  - US production, pond acreage, type of production and end market served
- The Tilapia market
  - US production figures, current price data and brief summary of the international import volume

Section 2 – Water Quality Issues in Aquaculture

- A listing of some of the major water quality issues for aquaculture and explains the importance of these factors important for fish survival

- Temperature
- Dissolved oxygen
- Nitrogenous wastes
- pH
- Alkalinity
- Hardness
- Carbon Dioxide
- Salinity
- Chlorine
- Hydrogen sulfide

Section 3 – Culture Information

- Cultural information provided for the following species
  - Tilapia
  - Channel catfish
  - Prawns

Temperature requirement and growth periods for selected aquaculture species

Species	Tolerable Extremes (°F)	Optimum Growth (°F)	Growth Period to Market Size (mos)
Oysters	32 to 97	76 to 78	24
Lobsters	32 to 88	72 to 75	24
Penaeid Shrimp			
Kuruma	40 to ?	77 to 87	6 to 8 typ
Pink	52 to 104	75 to 85	6 to 8
Freshwater Prawns	75 to 90	83 to 87	6 to 12
Catfish	35 to 95	82 to 87	6
Eels	32 to 97	73 to 86	12 to 24
Tilapia	47 to 106	72 to 86	--
Carp	40 to 100	68 to 90	--
Trout	32 to 89	63	6 to 8
Yellow Perch	32 to 86	72 to 82	10
Striped Bass	? to 86	61 to 66	6 to 8

Section 4 – Pond and Raceway Heat Loss Calculations

- *Chapter 16 Aquaculture*
  - From the Geothermal Direct Use Engineering and Design Guidebook
- The maximum pond area that can be developed is restricted by the maximum heat available from the resource
- Heat losses to take into consideration are evaporation, convection, radiation and conduction
- Some ways to reduce heat losses are discussed such as surface covers, pond enclosures and thermal mass

Section 5 – Aquaculture with Geothermal Heat Pumps

- Examines the feasibility of aquaculture tank heating with a geothermal heat pump system
- Closed- and open-loop systems are examined for heating uncovered and greenhouse covered tanks at three locations
- Net present value analysis is conducted for a 20-year life-cycle cost for various base-load fractions with natural gas-fired boiler peaking

Section 6 – Case Studies of Geothermal Aquaculture Operations

- Recent Case Studies of successful operations in the U.S.
  - "Gone Fishing" Aquaculture Project, Klamath Falls, OR
  - Fish Breeders of Idaho Inc., Hagerman, ID

Section 7 – Farm Bill Information

- Information on the Farm Bill Initiative
  - Current link to the website
  - Information contained on the website
  - Links to the templates for geothermal direct-use and geothermal applications

Section 8 – Aquaculture Bibliography

- Provides a list of useful aquaculture references in the areas of
  - General aquaculture
  - Economics
  - Culture systems
  - Broodstock
  - American eel
  - American lobster
  - Channel catfish
  - Freshwater prawns
  - Lake trout
  - Striped bass
  - Tilapia
- Information is also provided on where to obtain these publications and how to order them

Section 9 – Aquaculture Glossary

- Defines typical terms used in the aquaculture industry such as
  - Broodstock
  - Fingerlings
  - Seine

Section 10 – State/Region/University /Extension Aquaculture Offices

- Contact information provided for a variety of technical experts in the US who may be of use to the aquaculture developer

Section 11 – State Aquaculture Permit Requirements

- Summarizes the permits and regulations impacting the aquaculture industry for the following states
  - Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah and Washington
- The four main issues covered are
  - Water use, effluent discharge, production and marketing

How to Obtain These Publications

Available for downloading from the

Geo-Heat Center Website

http://geoheat.oit.edu

Downloadable Papers page

http://geoheat.oit.edu/pdf/pdfindex.htm