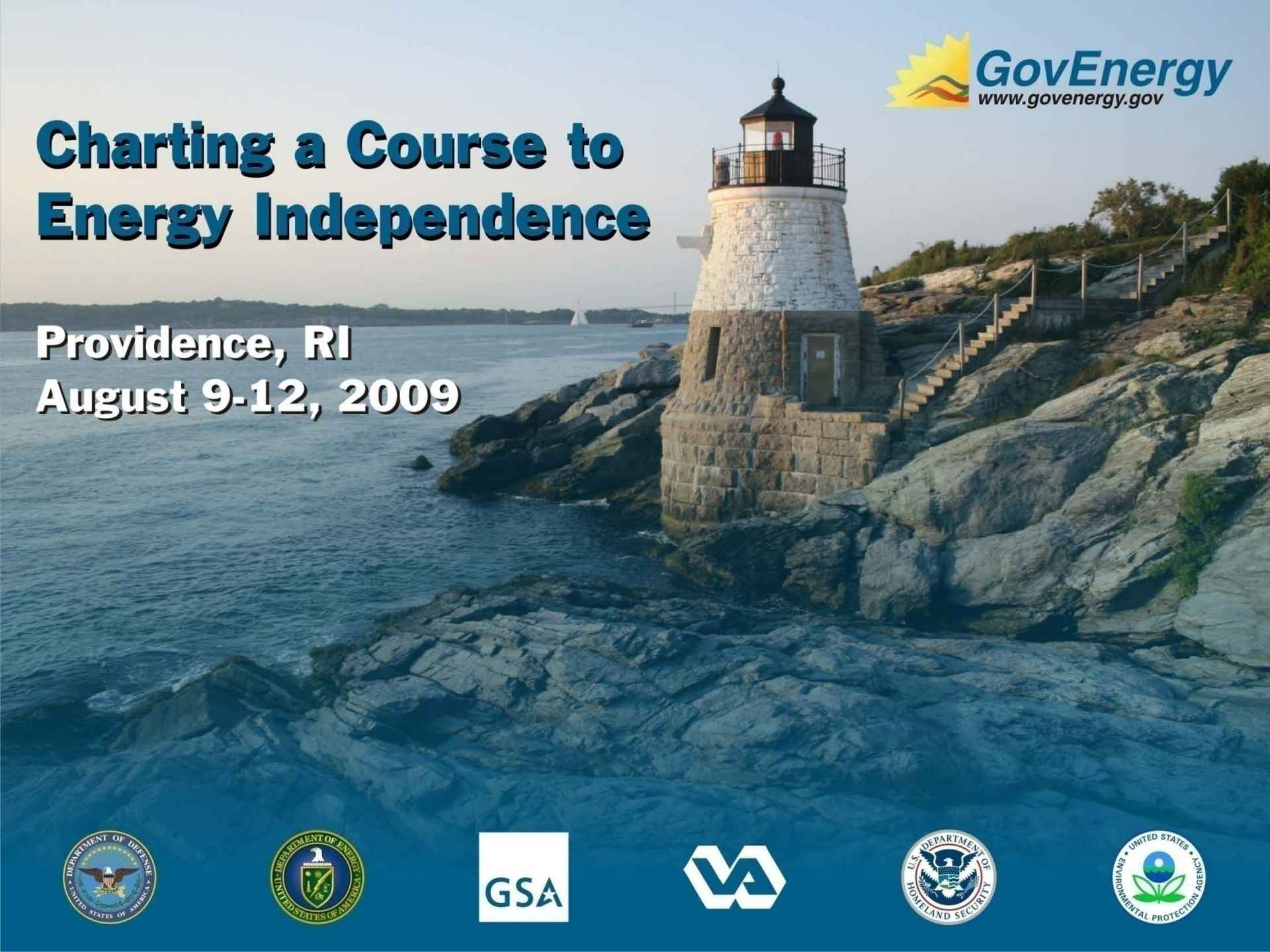
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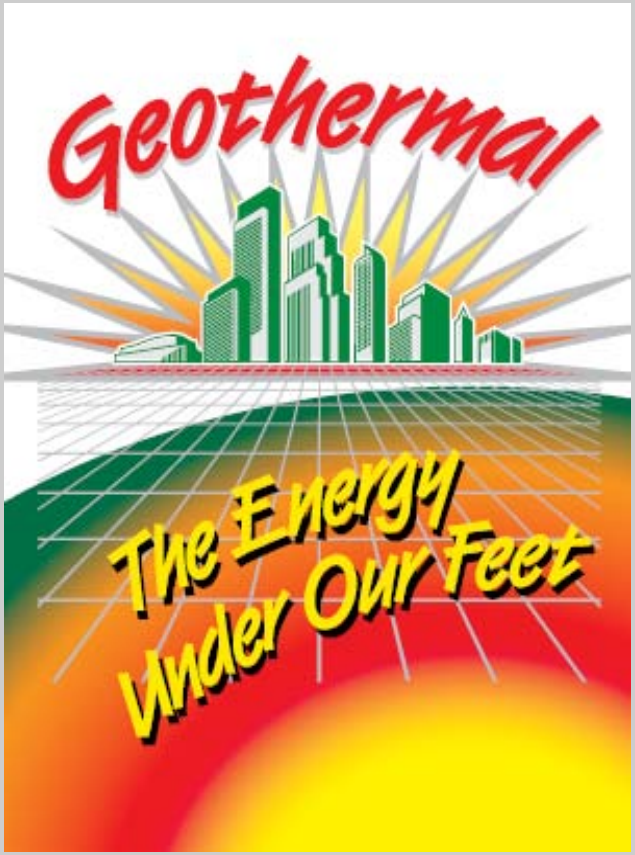
www.govenergy.gov
Charting a Course to Energy Independence
Providence, RI
August 9-12, 2009
GSA

Geothermal Technologies

- Direct Use
- Power Production
- Heat Recovery
- Geothermal Heat Pumps



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Major Message

Cost-Effective Energy Efficiency is the 1st Choice

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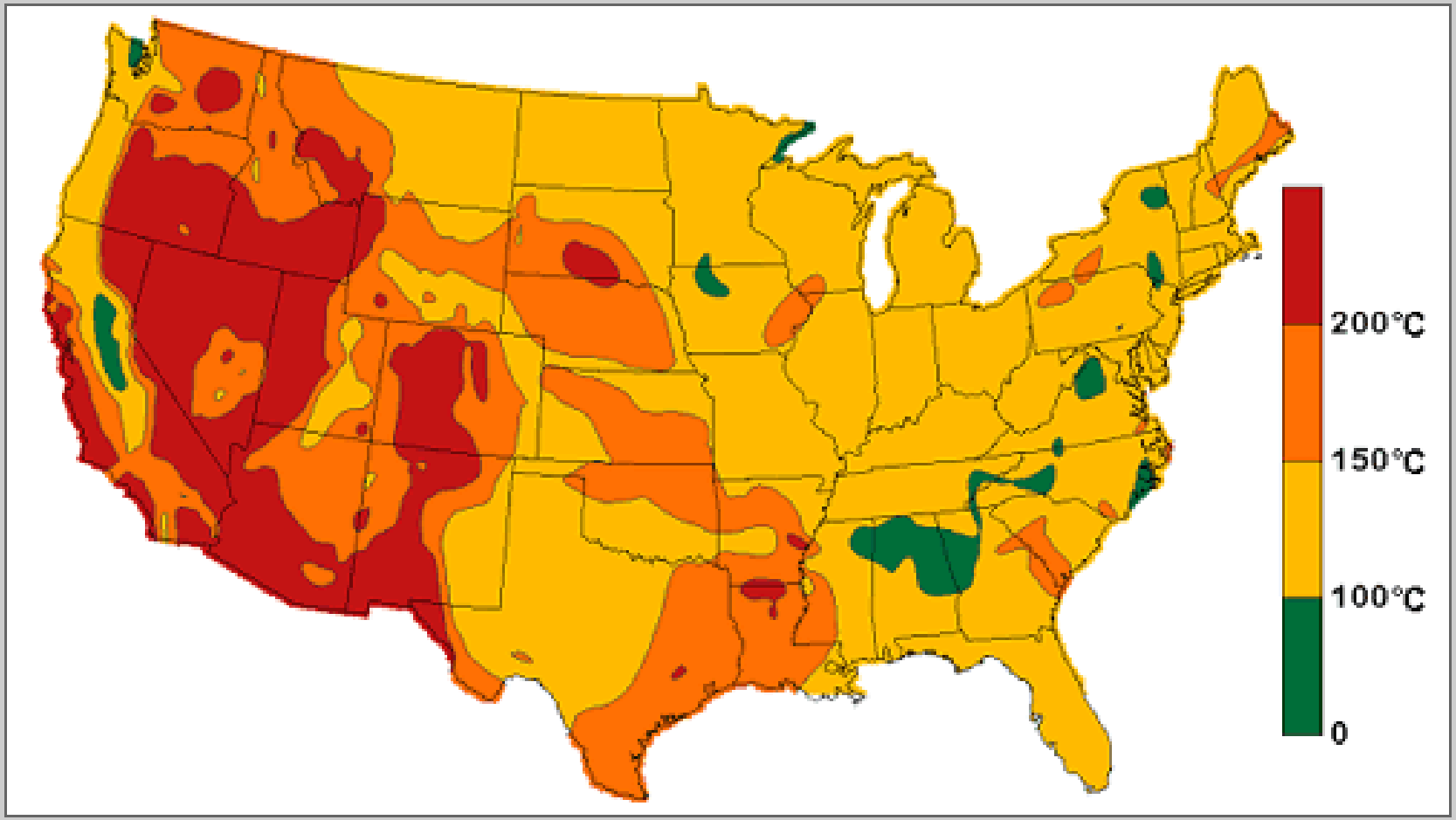
Duct Testing

Geothermal Resource Map



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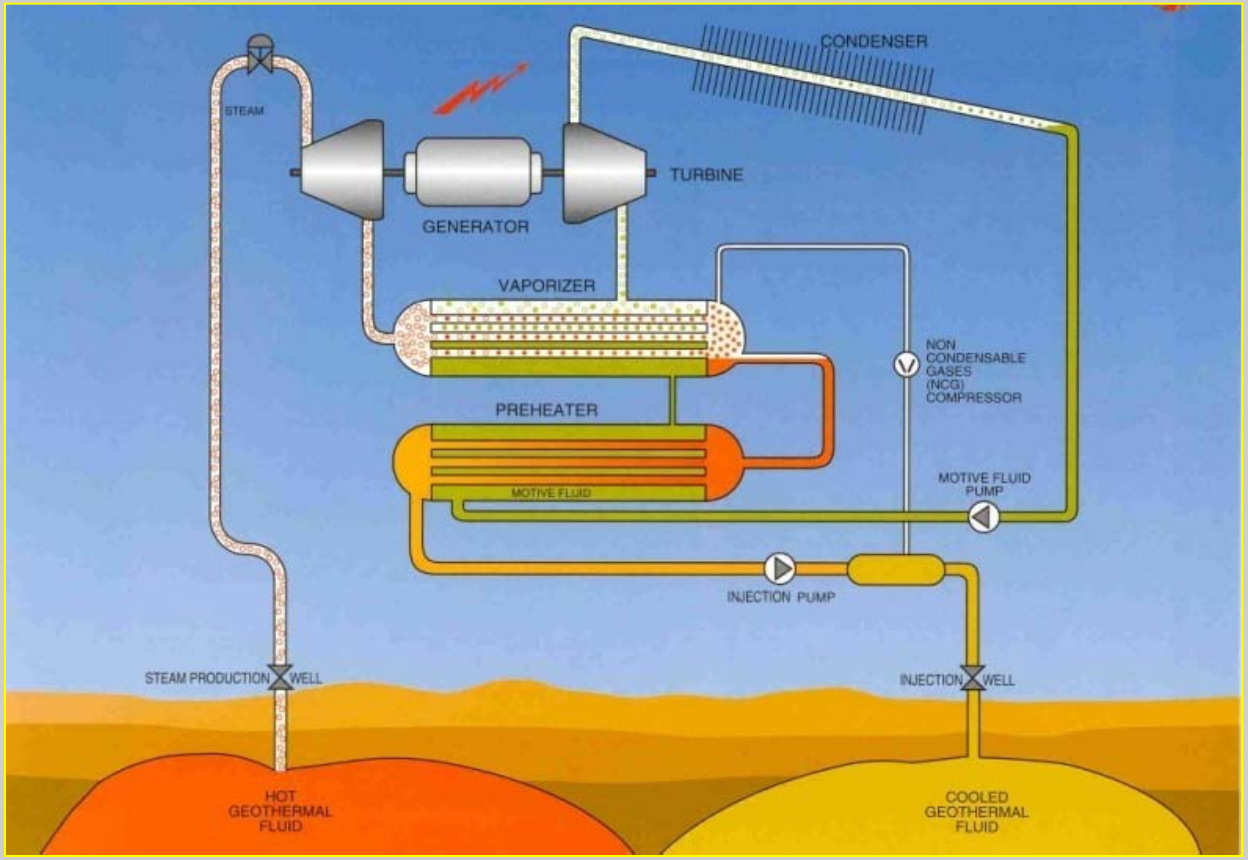
Geothermal Power Production

Combine Cycle Organic Rankine Technolgy



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Geothermal Power Plant Costs
($/kW)

1. Exploration & Resource Assessment	**$ 400**
12 Months time frame	
2. Well Field Drilling and Development	**1000**
12 Months time frame after completion of item 1	
3. Power Plant, Surface Facilities, & Transmission	**2000**
18 Months time frame with overlap of item 2	
4. Other costs:	**600**
o **Commitment fees**	
o **Legal & Accounting fees**	
o **Consultants,**	
o **Interest during construction, and**	
o **Debt service and operating reserve**	
o **Construction contingencies and Developers fee**	
12 Month process which should begin after completion of item 1	
5. TOTAL *FINANCED* COST	**~ $ 4000/kW**

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Annualized Capital Cost

Geothermal Power Plant

Capital Costs $4000/kW

@ 0.2 Annual Factor, CC = 101 $/mWh

@ 0.15 Annual Factor, CC = 76 $/mWh

@ 0.10 Annual Factor, CC = 51 $/mWh

O&M costs ~ 15 $/mWh Fuel Cost = 0

Power Plant Time Line and Commodity Costs

Timeline

3-5 years

Cost

Capital = 5 to 10 cents/kWh

O&M = 1.5 cents/kWh

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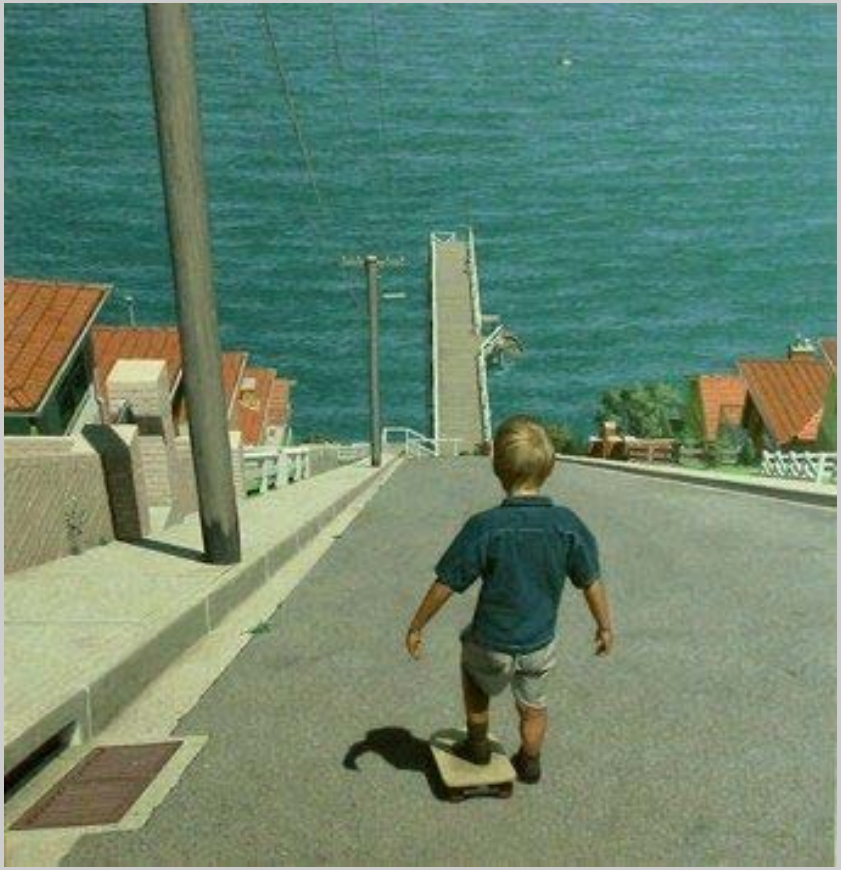
Utility Risk Considerations

- A delineated geothermal resource,
- A defined permitting path without pitfalls,
- A credible developer,
- The control of entire geothermal resource, and
- The use of proven technologies.



Power Plant Cost Caveats

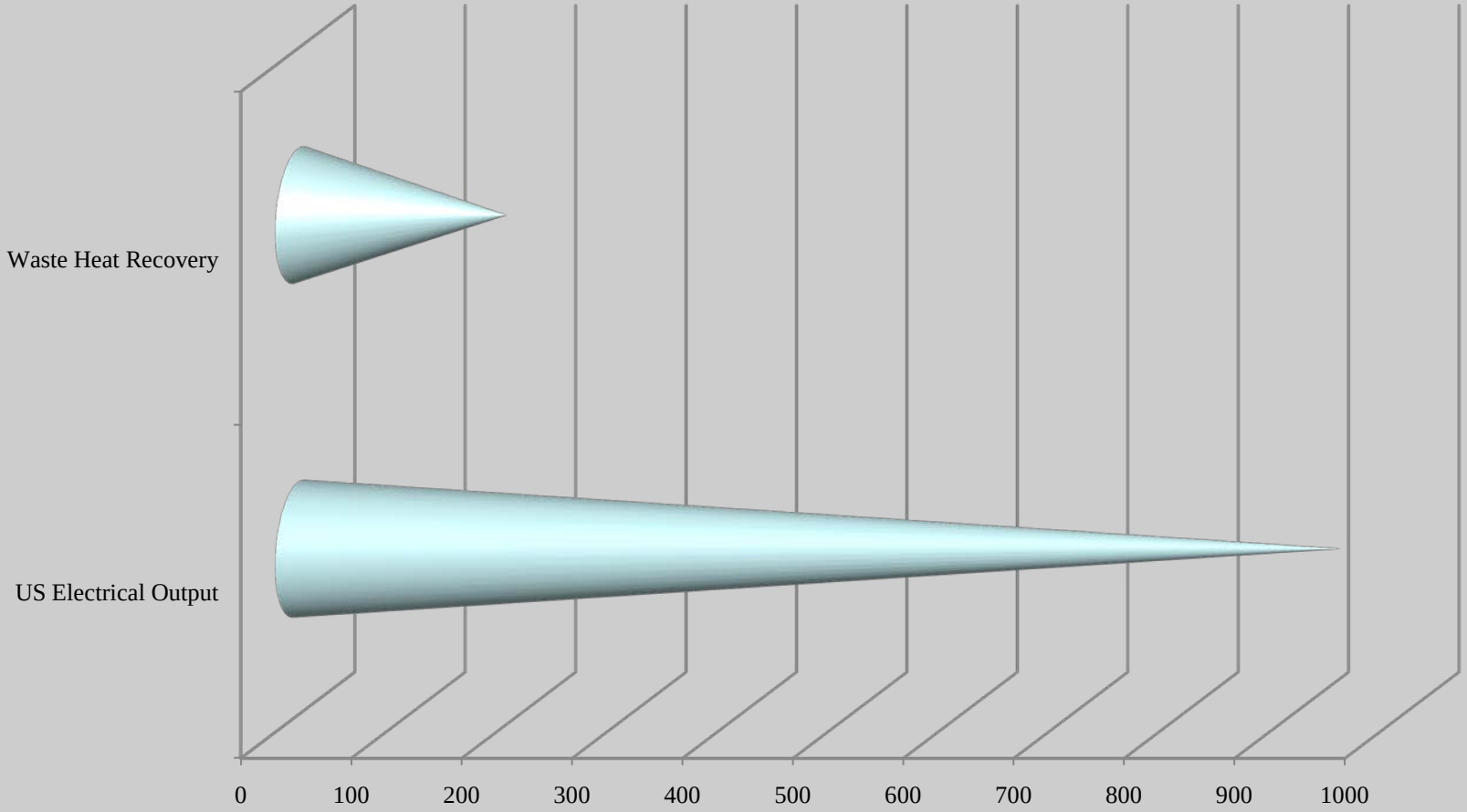
Competition for Commodities

Size and Modularity

New Technologies

Skill Demography

US Potential for Geothermal Technologies in Heat Recovery gW



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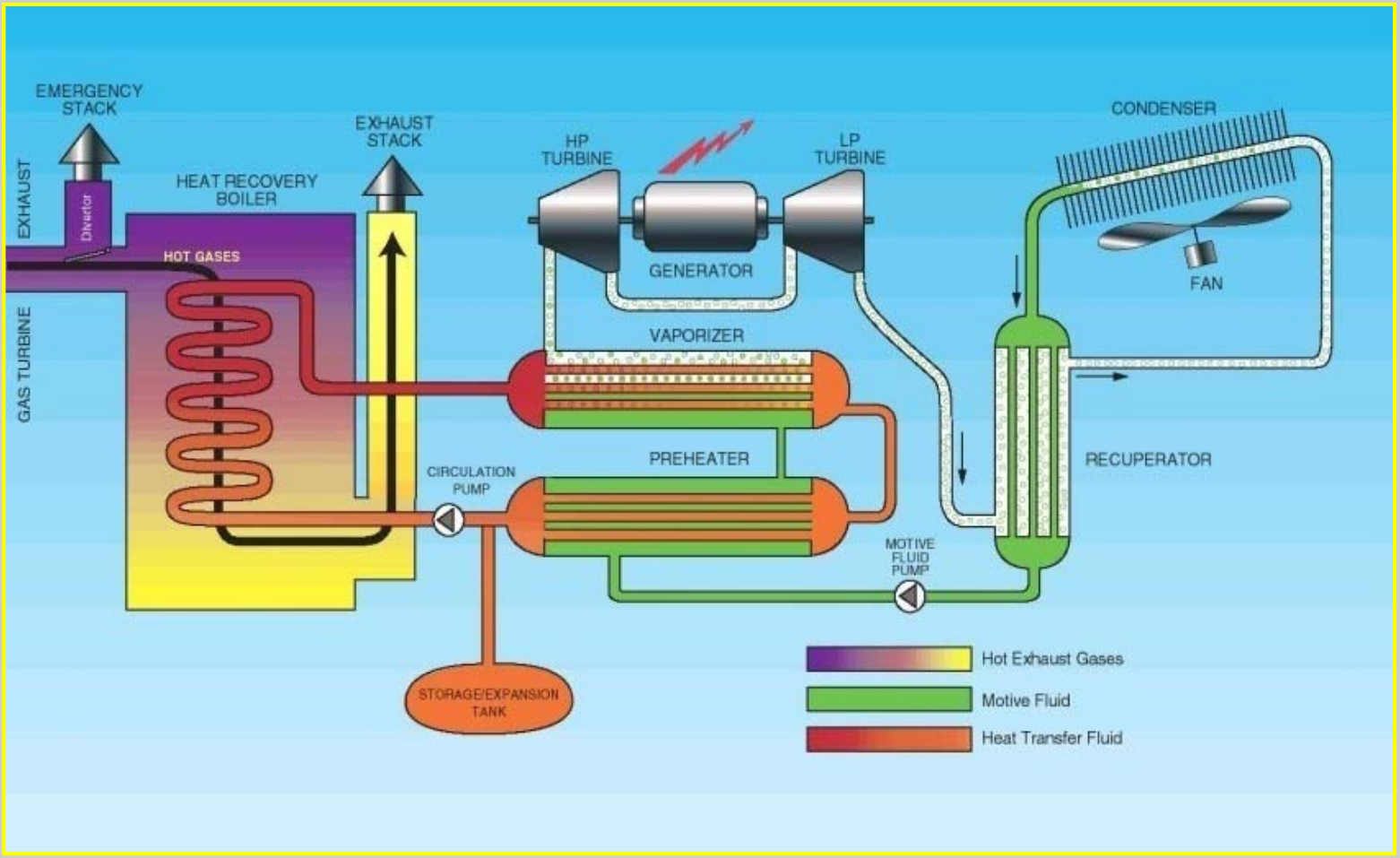
Organic Rankine Cycle

Heat Recovery Flow Diagram



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Cost Comparison ($/kW)

Geothermal Power vs Heat Recovery

Rec	Conv Geo	ORC Heat
Resource assessment (1)	$ 400	$ 200
Well field development	1000	-0-
Power plant & transmission	2000	2000
Other costs(2)	600	600
	4000	2800
TOTAL COST FOR 10 MW PROJECT	$ 40 MM	$ 28 MM

(1) Includes exploration costs

(2) commitment, consulting, development, contingency, legal & accounting fees, interest during construction, and operating reserve

Annualized Capital Costs

Capital Costs $2800/kW

@ 0.2 Annual Factor, CC = 71 $/mWh

@ 0.15 Annual Factor, CC = 53 $/mWh

@ 0.10 Annual Factor, CC = 36 $/mWh

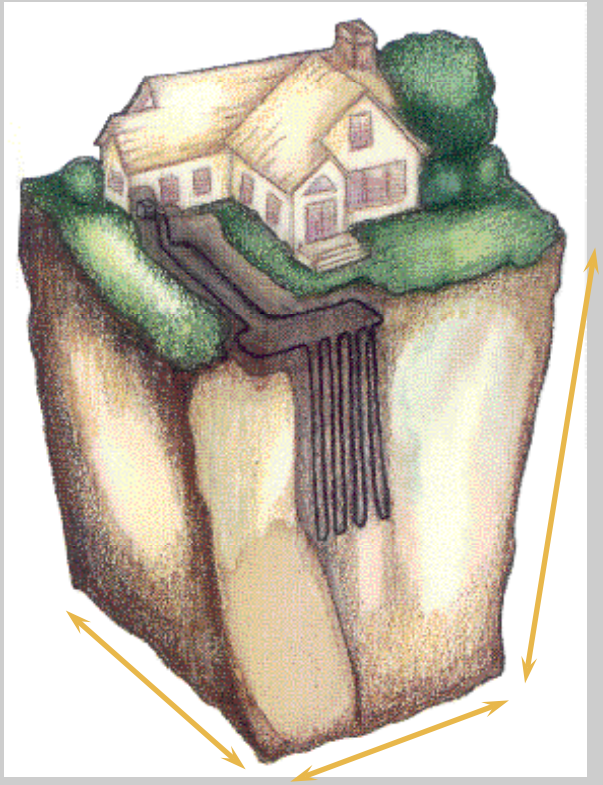
O&M costs ~ 15 $/mWh Fuel Cost = 0

Geothermal Heat Pumps (GHP)

Mass market opportunities

GreenHeat

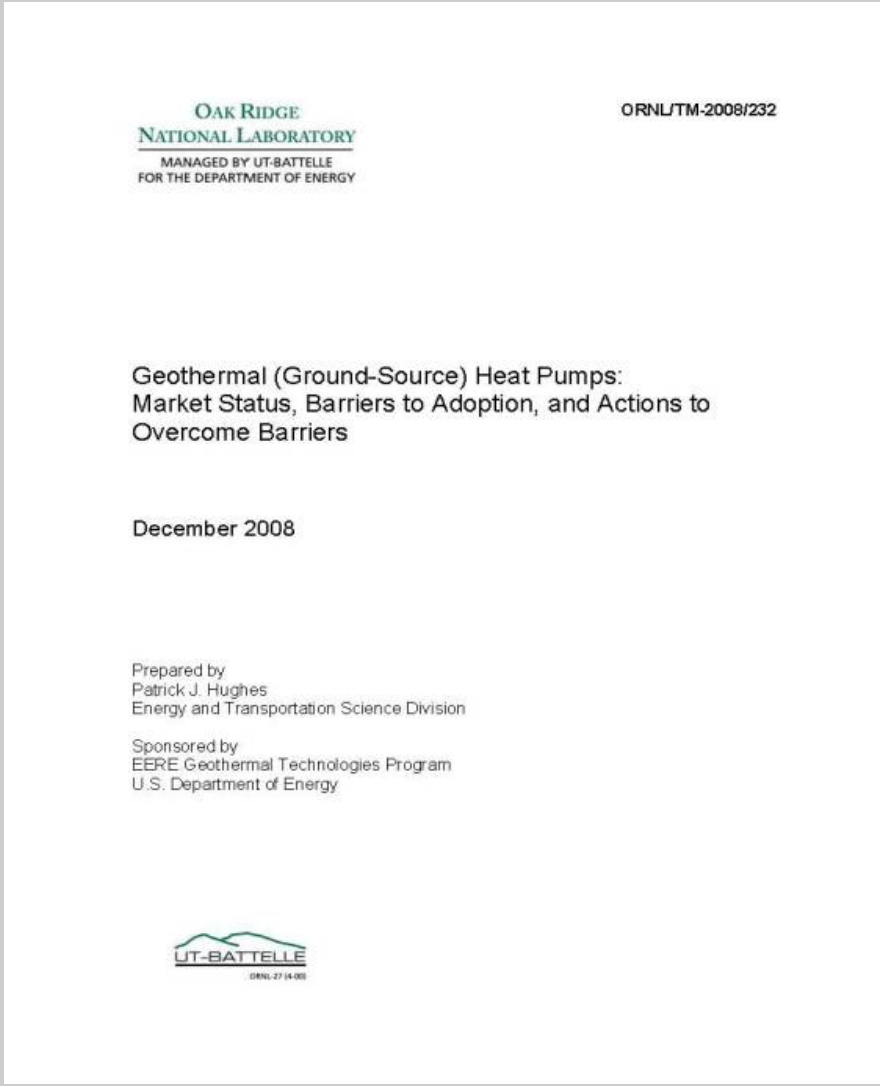
heating & cooling a different world
with renewable energies



Geothermal Heat Pumps

- DOE Report on GHP
- Sponsor DOE GTP
- www.zebralliance.com
- Implementation Barriers

and ways to over come them



OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE
FOR THE DEPARTMENT OF ENERGY

ORNL/TM-2008/232

Geothermal (Ground-Source) Heat Pumps:
Market Status, Barriers to Adoption, and Actions to Overcome Barriers

December 2008

Prepared by
Patrick J. Hughes
Energy and Transportation Science Division

Sponsored by
EERE Geothermal Technologies Program
U.S. Department of Energy

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DOE Report Key Barrier ID

1. High first-cost of GHP to consumers
2. Lack of consumer and policy maker knowledge and/or trust in benefits
3. GHP design and business Model infrastructure limitations
4. Lack of new technologies and techniques to improve GHP system cost/performance

Another Lack of Knowledge Barrier Jump

A Tale of Two Buildings

PROJECT RESULTS FROM:

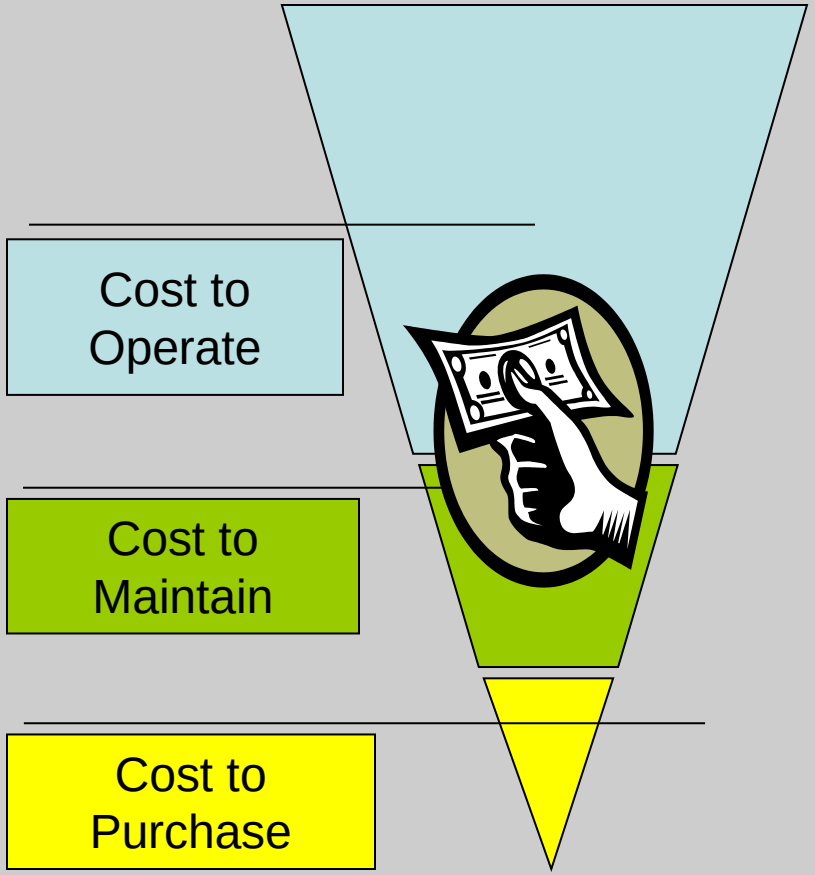
A "side by side" Comparison of a Ground Source Heat Pump System vs. Conventional HVAC System between two "identical" buildings.

Impacts of Investment Decisions

Utility M&V programs will help quantify the impacts

"We have always dealt with hassles short term. What is valued now is looking at the long term hassle of the decisions we make with a short term attitude."

Brion McDonald, President, Universal Building Systems, Palo Alto, CA



Oklahoma City Buildings

Conventional 15,000 sq ft

GHP 20,000 sq ft

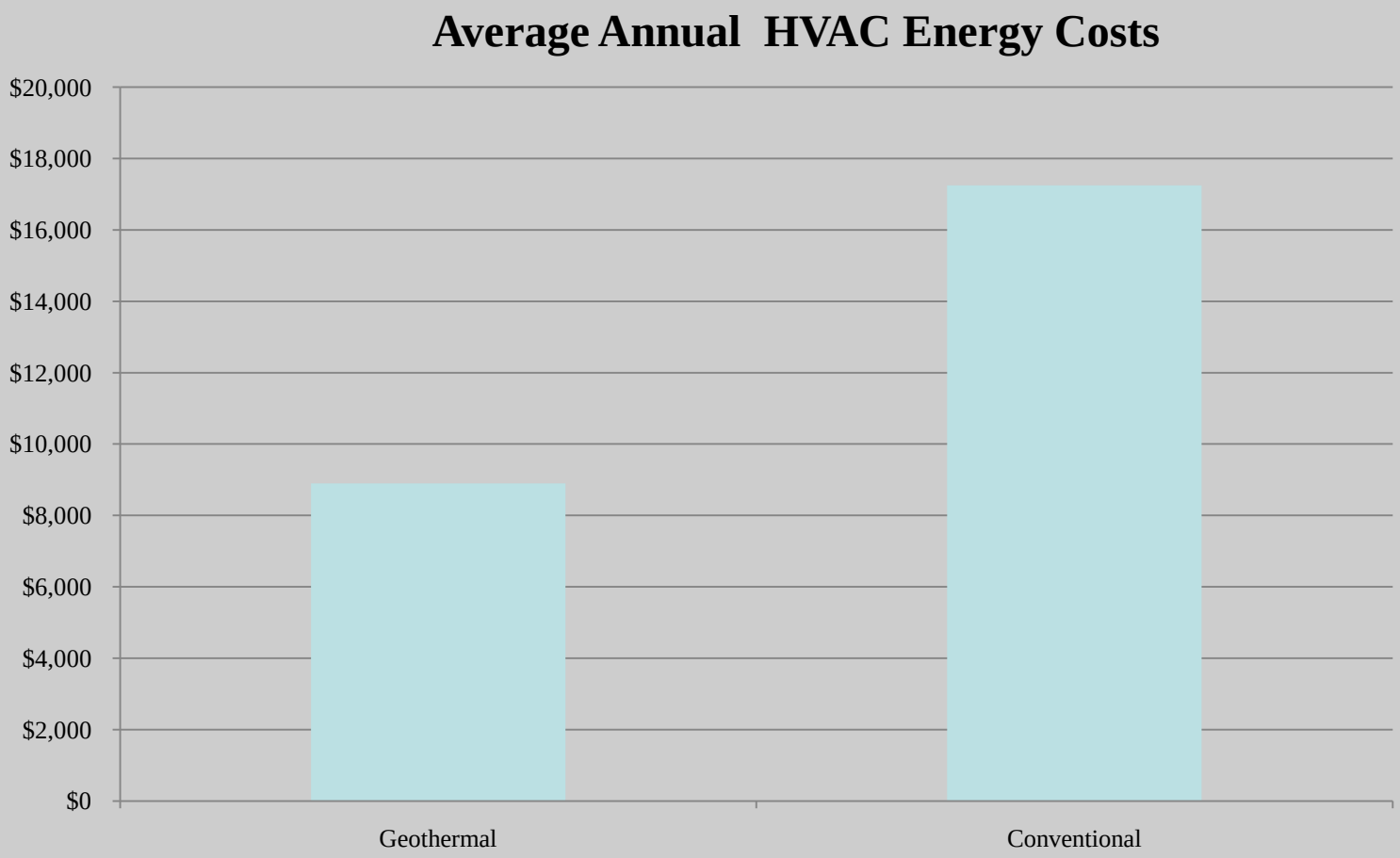
Conventional Roof Top VAV Building Built in 1987

GHP Building Built in 1997

40 boreholes drilled 250 feet deep on 20 foot centers and 3/4 inch PE pipe

16 Ceiling Mounted Units

OK City Buildings



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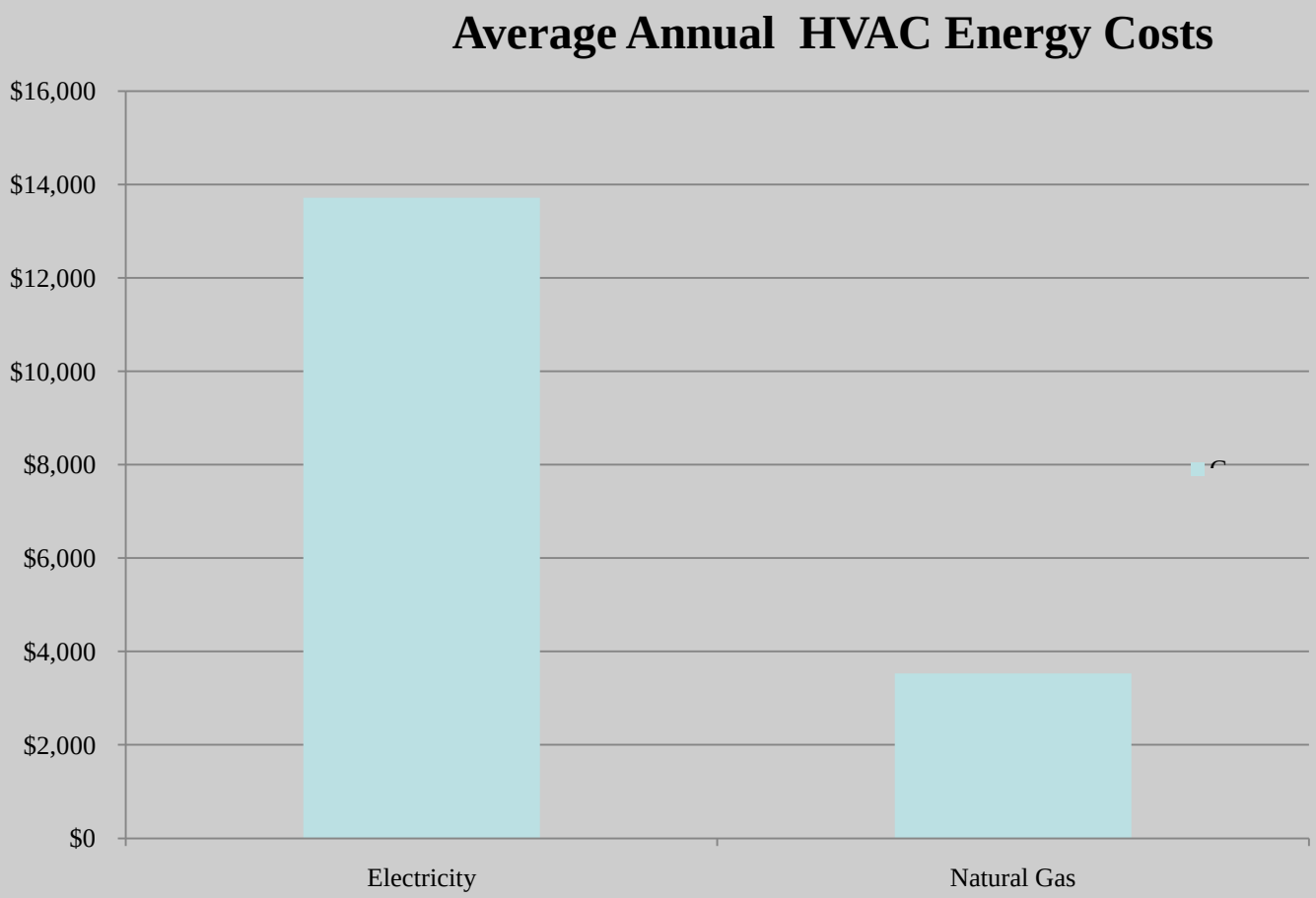
Conventional OK Building



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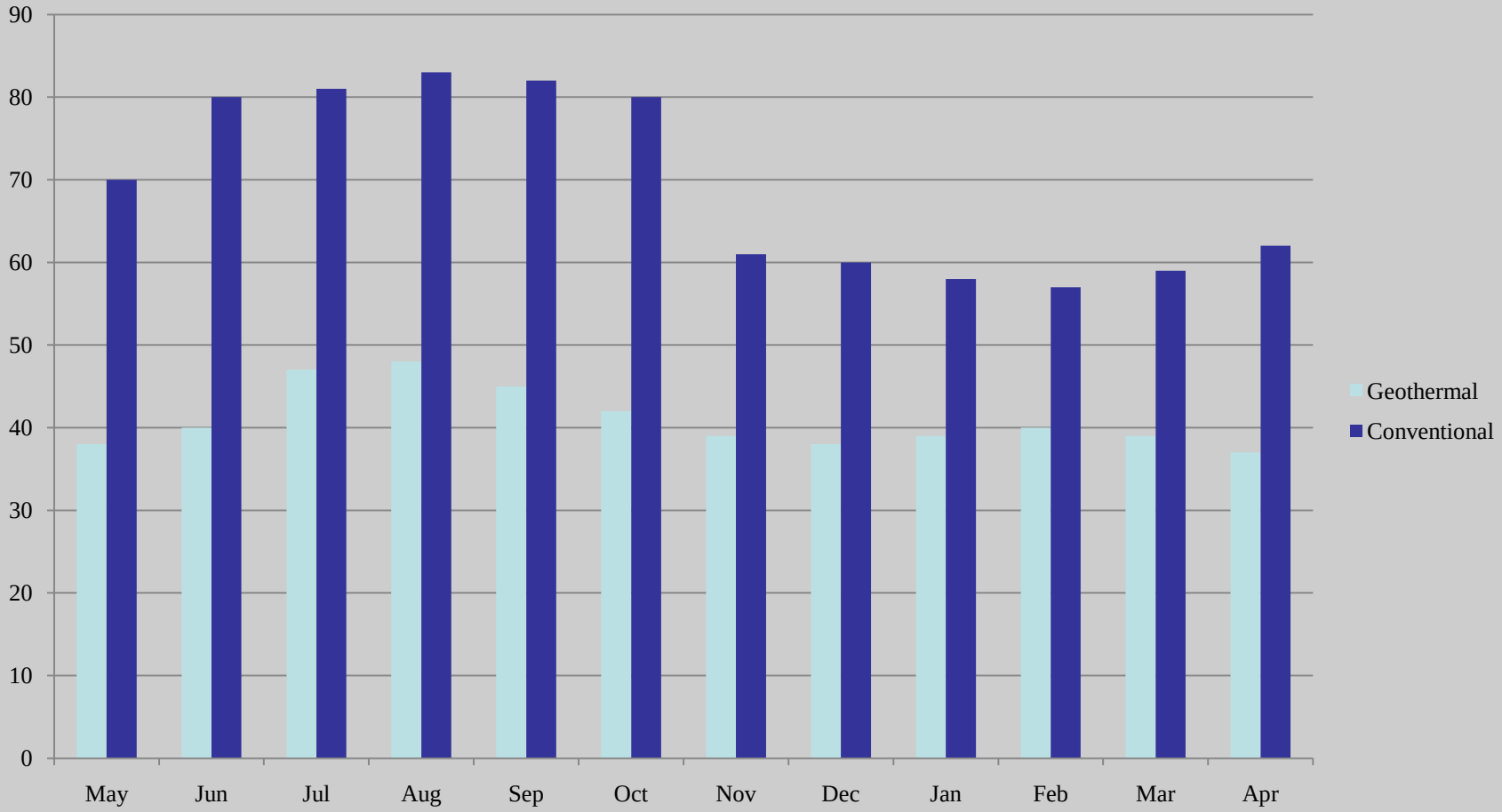
OK Buildings kW demand

Four Year Average



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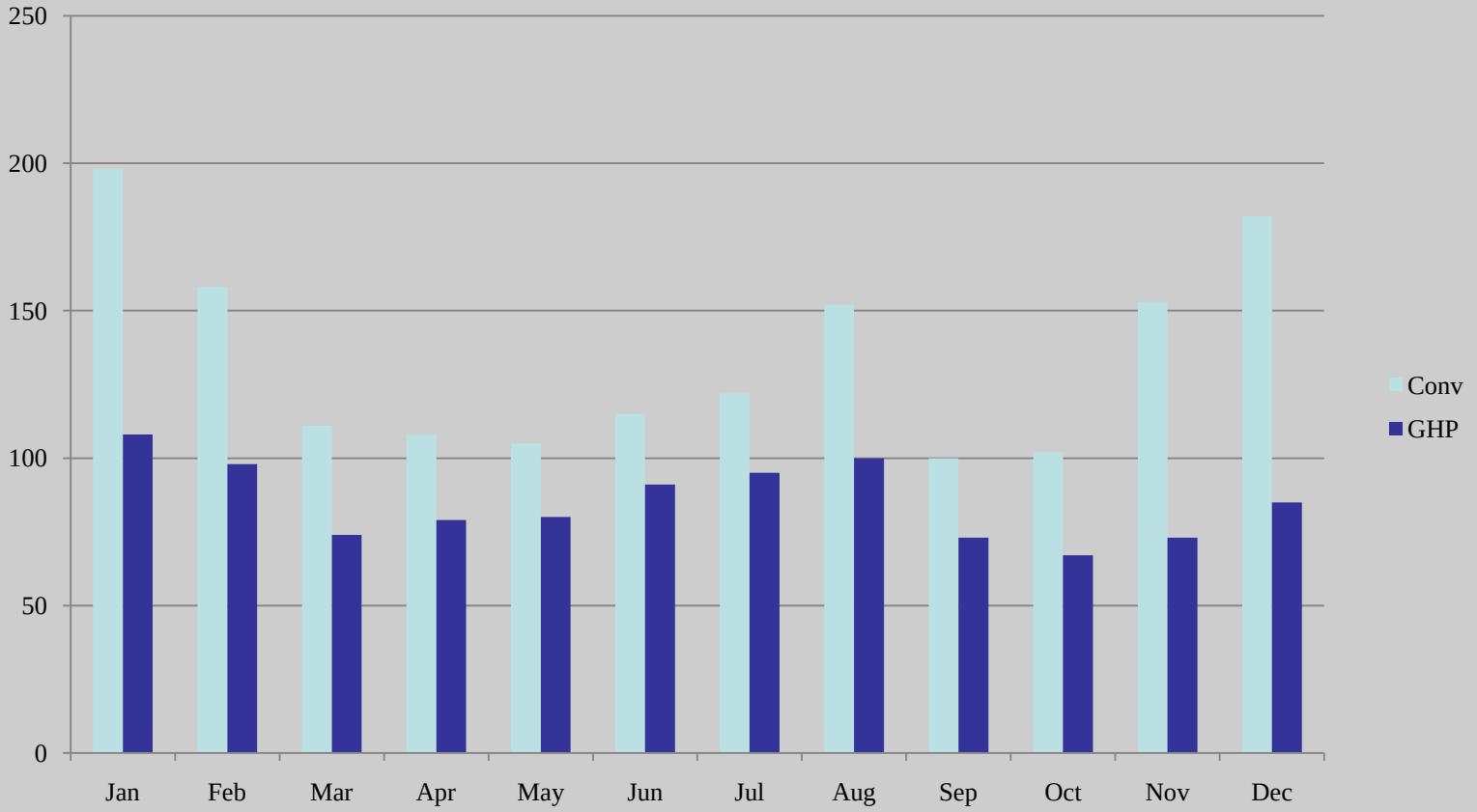
Average Meter Data Results

Hope Crossing, OK (GHP saves $580/yr)



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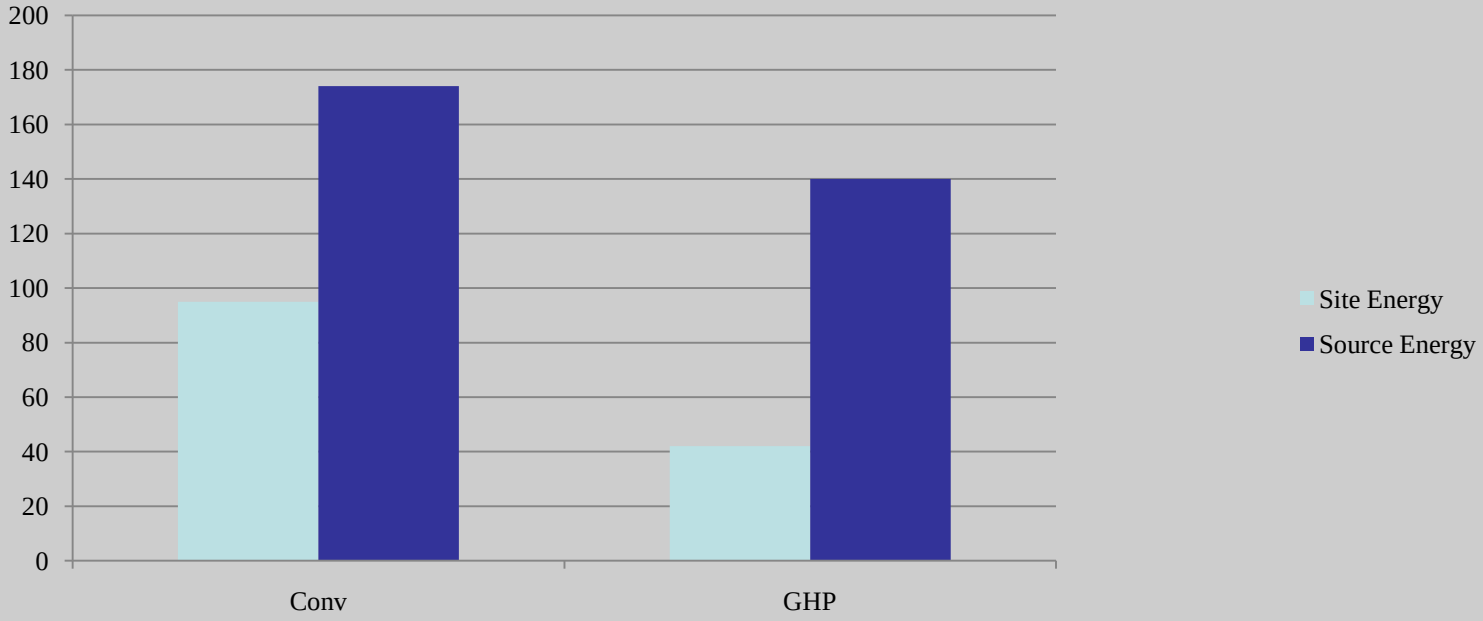
Site & Source Energy Consumption
Hope Crossing, OK

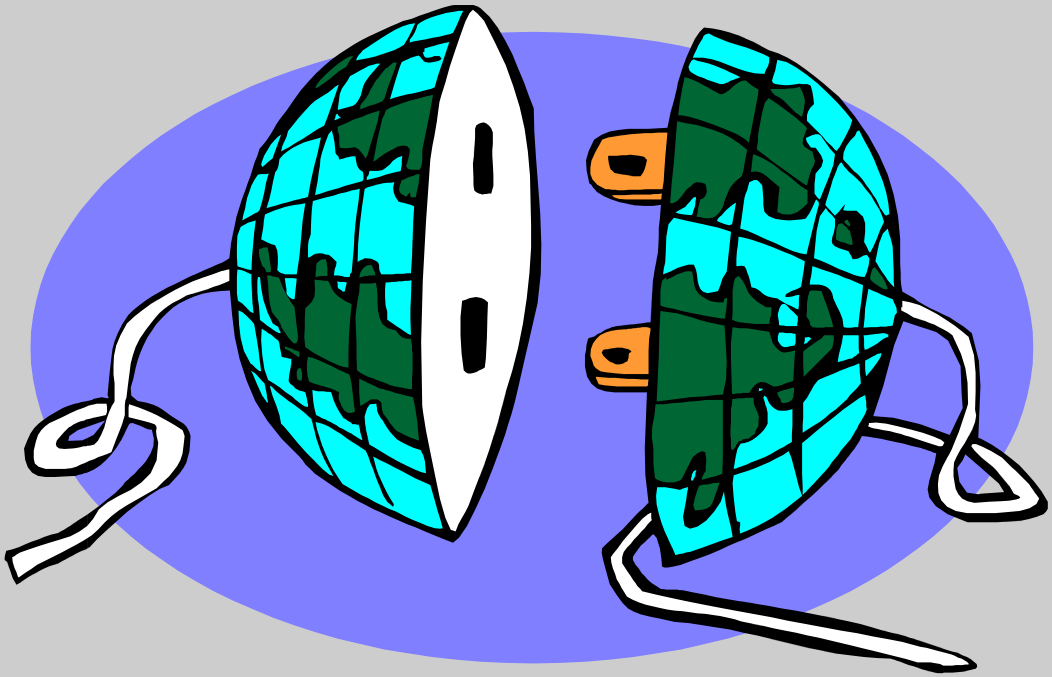
34 MM Btu /yr lower for GHP = 17 MM Btu per Ton

1 ton of CO2/yr reduction per ton of GHP



GHP Non-Energy Benefits

- **Space Requirements**
- **Noise**
- **Maintenance**
- **Ambient Conditions**
- **Vandalism**



Is This a Great Time to be in the GHP Business . . . Or What???

- State Energy Program Formula Grants
- Energy Efficiency Block Grants
- Greening of the Planet

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GRC 2009 Annual Meeting

Reno, NV Peppermill October 3-7, 2009

- Pre and Post Meeting Workshops
- Field Trips
- Exhibits
- Technical Papers

Updates and other info at
www.geothermal.org

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www.govenergy.gov

Let's get Going

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Geothermal Resources Council