
# *Generating Renewable Energy from Co-Produced Water at Oil & Gas Wells – A Case Study*

**John Fox, CEO, ElectraTherm**

# ElectraTherm's Heat to Power Generator

**Based on the Organic Rankine Cycle**

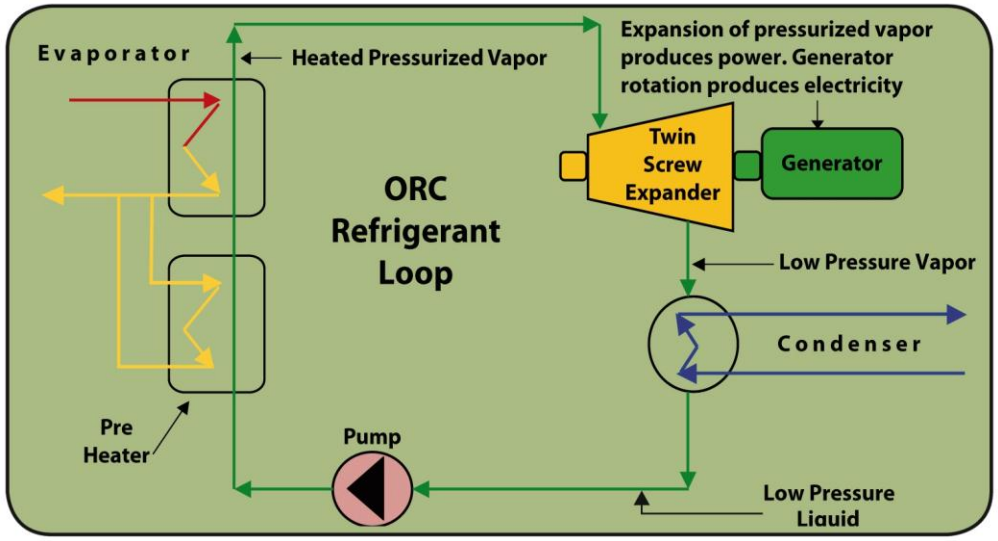

Exploits low grade waste heat:

- Produces 480V, 3phase, 50 or 60Hz power
- Modular and Commercially Mobile:
  - Weight: ~7,000 lbs.
  - Dimensions: 78 x 96 x 89 inches

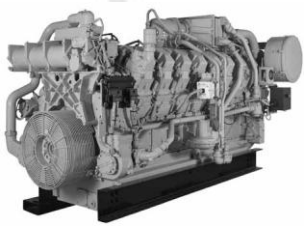
Patented technologies enable:

- Low maintenance
- No oil pump, no oil changes, no gearbox
- Off the shelf components & simple but robust design

# How It Works




*Captures Btu content from hot water to drive the hot side. Employs condensing water or direct-dry-cooler to create the delta-T that results in* ***fuel-free, emission free electricity****.*



*Hot Water In*

*Cooler Water Out*

kW Output

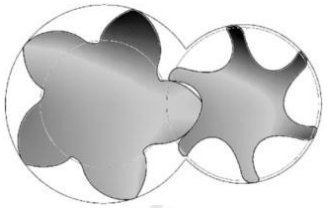
# Commercialized Product Ready to Ship

**Building on five years of comprehensive product development**

- 13 installed units
- Achieved 10,000+ hrs runtime in the field; 14,000 hrs including test cell
- Monitoring fleet performance + R&D testing
- Optimized design turn complete
- Building a backlog through dealer network


*ElectraTherm's 4-bay test cell.*

# IP, Advantages and Working Parameters



***Patented ORC Technology***
2 core patents issued and licensed

***Robust, Proven Hardware***
Patented Expander Rotor Profile:
- Allows “wet” operation
- Rotates at 4,200rpm
- Variable output range

***Accepts a range of input parameters…***
160gpm @ 190-240°F on the hot side
200gpm @ 40-100°F for condensing

***…to produce a range of output***
30-65kW

# Commissioned Units & Target Markets

Co-Produced Water – Oil & Gas

Biomass

Solar Thermal

Biomass in United Kingdom

IC Engine in Texas

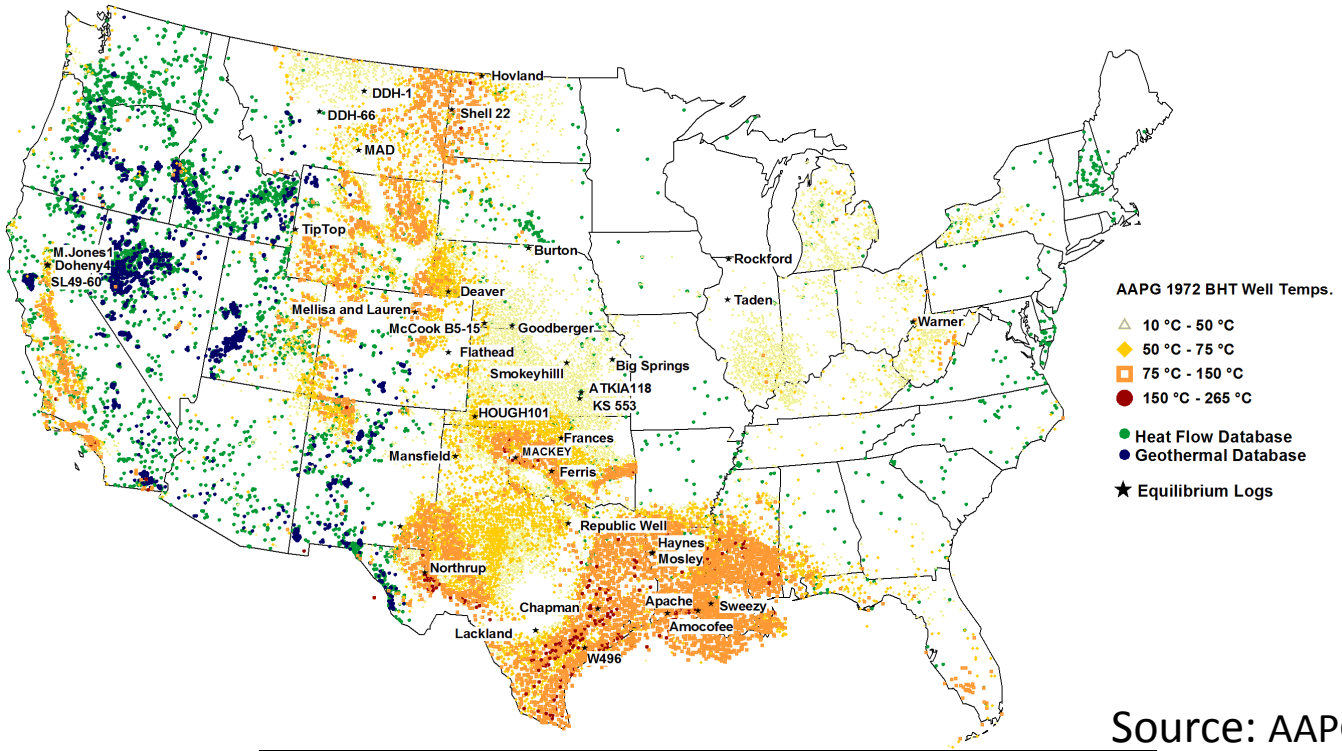

Industrial Boiler in Michigan

***ElectraTherm awarded $982,000 from the U.S. Department of Energy (DOE).***

*Small-scale power generation from co-produced geothermal fluids*

# The Opportunity

## *Co-Produced Water from Existing Wells*




Source: AAPG database

**823,000 oil & gas wells in the U.S.**
**3 million GPM of hot water in top 8 states**
**3GW power at 212°F**

*Sources: The Future of Geothermal Energy – 2006 MIT Report*
*U.S. Energy Information Administration - 2008*

**2,000 – 4,000 BPD = 30 - 65 kW Green Machine**
**ET's Green Machine is the right size**

# The Challenges

- Small producing wells – low  hot water flows
- “Hot” wells – not so hot
- Not Applicable to large scale power production
  - Need for aggregation of wells for larger plants
- Difficulties/expense of onsite construction in remote locations
- Operating Personnel
- Service support
- Not primary task of O&G producers
- Economics

# Co-Produced Water – A Case Study

"Electrical Power Generation from Produced Water: Field Demonstration of Ways to Reduce Operating Costs of Small Producers"

Denbury site (Summerland #22 Soso, Mississippi) was identified in 2008 as a suitable candidate for a Green Machine. Funding was secured from the Research Partnership to Secure Energy for America (RPSEA) under the Small Producer Program.

Denbury

RPSEA
Research Partnership to Secure Energy for America

GulfCoast GREEN ENERGY

# Co-Produced Water – A Case Study

- Well produces at 9,500 ft. under geo-pressure.
- The well produces 100 BOPD and 4000 BWPD (98% water).
- Surface flowing temperature at 200°F.
- Displacing $.098 power vs. selling at $.044
- The well is not part of a CO2 flood.
- Six month field trial demonstration


# Step by Step through the Process


ElectraTherm mounted a Green Machine to a trailer in our manufacturing facility, with the dry cooler, hot water bypass and electrical controls installed. The goal was to have a plug and play installation upon site arrival.

# Step by Step through the Process

Truck arrives on site in Mississippi at 9 a.m. on Tuesday May 24th.

Mechanical installation begins.

ElectraTherm's Dealer, Gulf Coast Green Energy led the installation efforts onsite. Denbury very supportive.

# Tuesday, May 24

Knockout tank plumbing (supply) being installed

# Tuesday, May 24

Mechanical installation completed at 3 p.m. Tuesday.

# Wednesday, May 25

9 a.m. – Electrician arrives onsite to wire up the Green Machine.

2 p.m. – The machine is wired up and running with fans in manual mode.

# Thursday, May 26

9 a.m. – Fan controls are finalized and set up to run in automatic mode.

11 a.m. – **Installation complete.** The machine is running in complete auto mode.

# Results

**Gross Power Output: up to 18kW**
**Total Installation Time: 50 hrs**
**Total Run Hours: ~100**
**Thermal Heat Input: 500kWt**
**Hot Water Input Range: 200°F**
**Hot Water Flow: 120 GPM**
**Ambient Temp Range: 60-105°F**

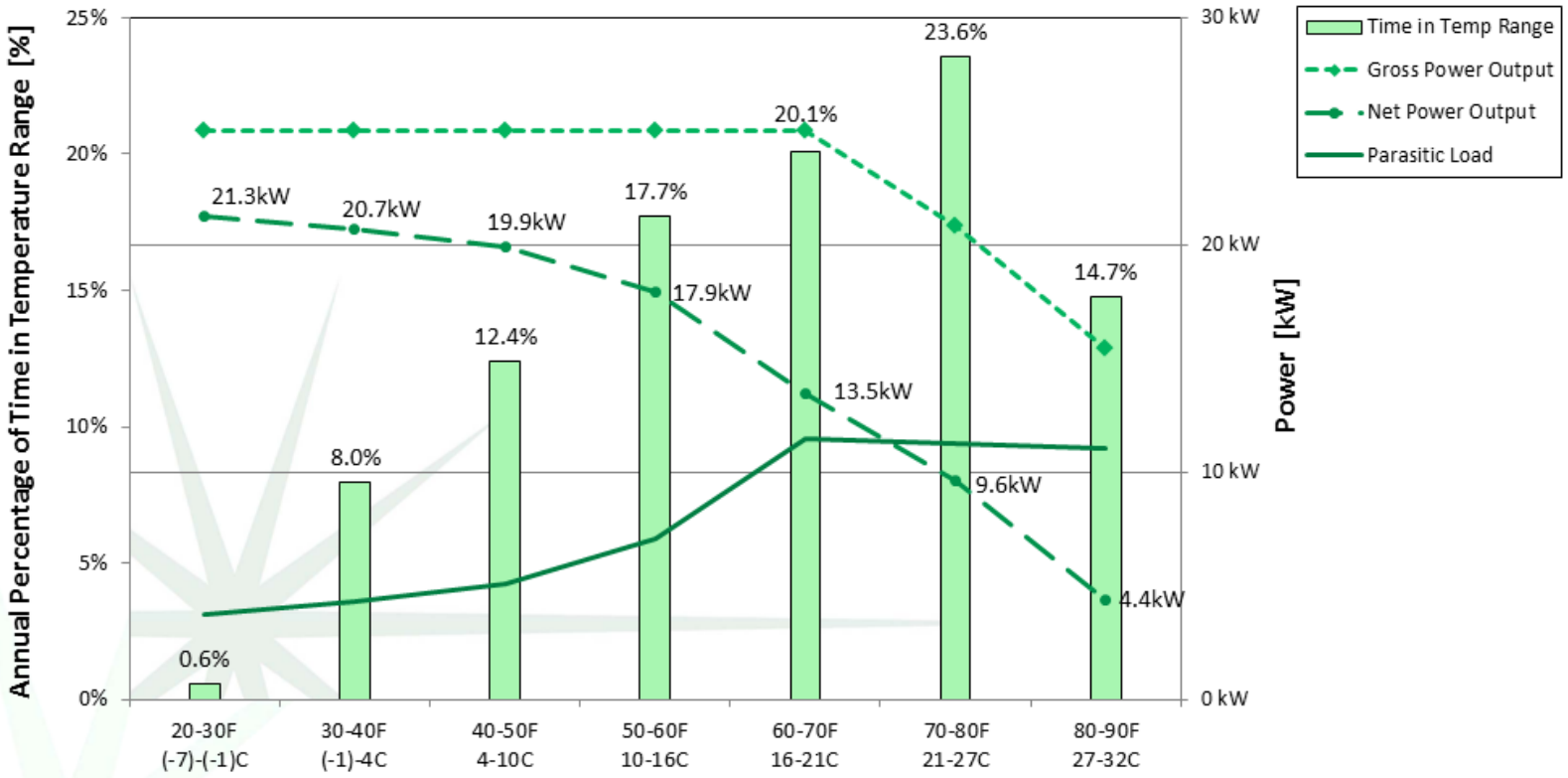
*"This Green Machine was designed on a truck bed for a simple plug-and-play upon arrival at the site. The truck arrived at 9 a.m. on Tuesday and the machine was running in auto mode by Thursday at 11 a.m."*

- Dave Mendershausen, Field Engineer, ElectraTherm

# Reality of Denbury Site Conditions

## Estimated Air Cooled Annual Output for Denbury Project

**Total Annual Net Power Output: 102,775 kWh** **Average Net Power Output: 13.0 kW** **Average Gross Power Output: 21.9 kW**




*Please note: This chart is only an *estimate* based on customer supplied information and past average weather data

Ambient Weather Temperature: 64.3 F (18.0C)
Hot Water Temperature: 200 F (93C)
Available Heat: 500 kW
90% Annual Runtime

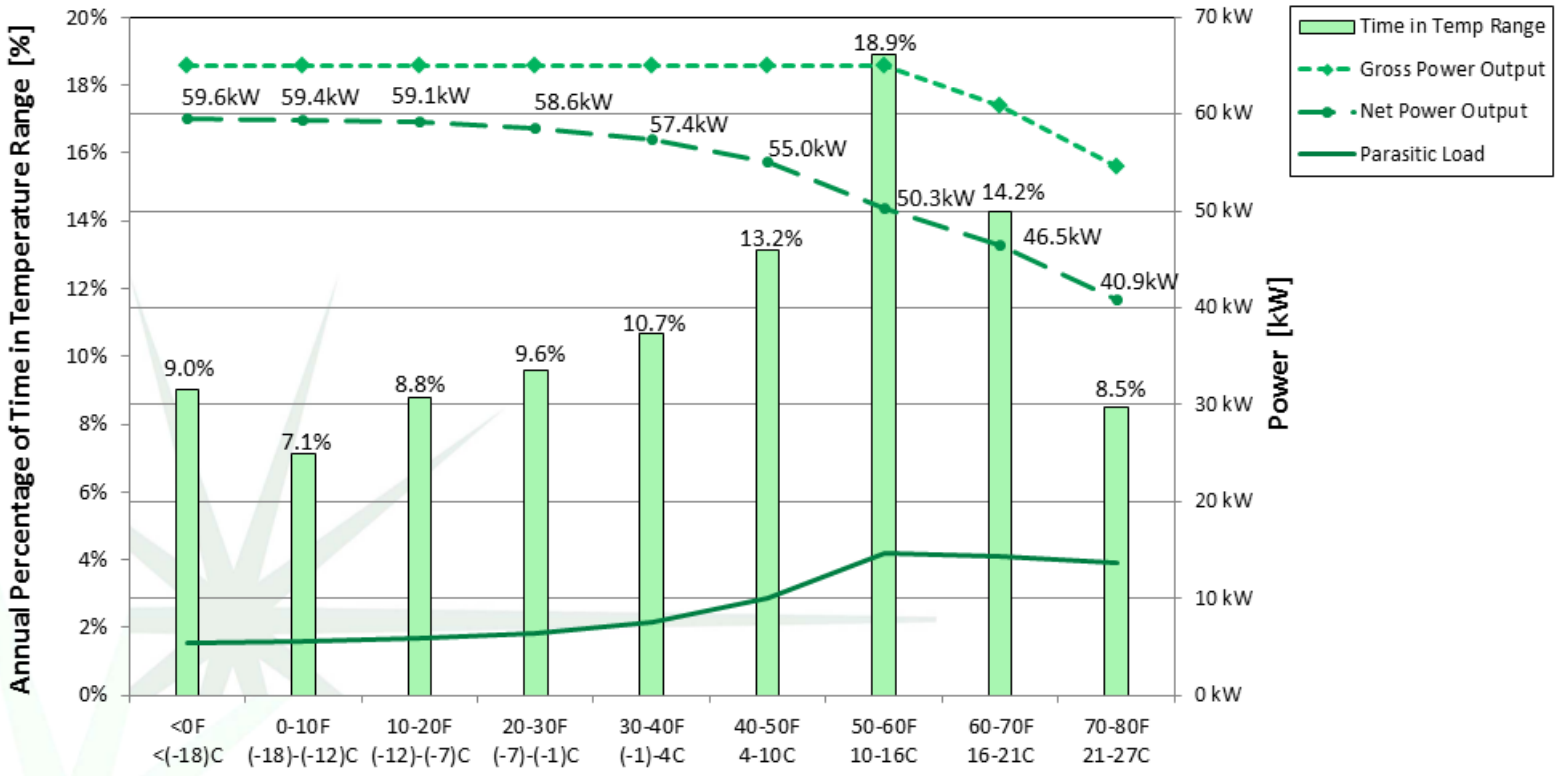
# Lessons Learned to Date

- 200F + high ambients = low delta T = derate
- Condenser is undersized (concurrent testing at ET shows ~40% derate)
- Flow is sub-optimal (25% below)
- Mobility and small scale adds value
- 50 hour install on #1 could be cut in half
- AT&T set-up vs. Verizon and easy corrective action
- New programming for ambient temp. limiting start ups above 85F – Auto shut down at 95F
  - New PLC and modem shipped and loaded by Denbury personnel

# Example Site #1

## Estimated Air Cooled Annual Output for Wolf Point, Montana

**Total Annual Net Power Output: 421,027 kWh** **Average Net Power Output: 53.4 kW** **Average Gross Power Output: 63.5 kW**



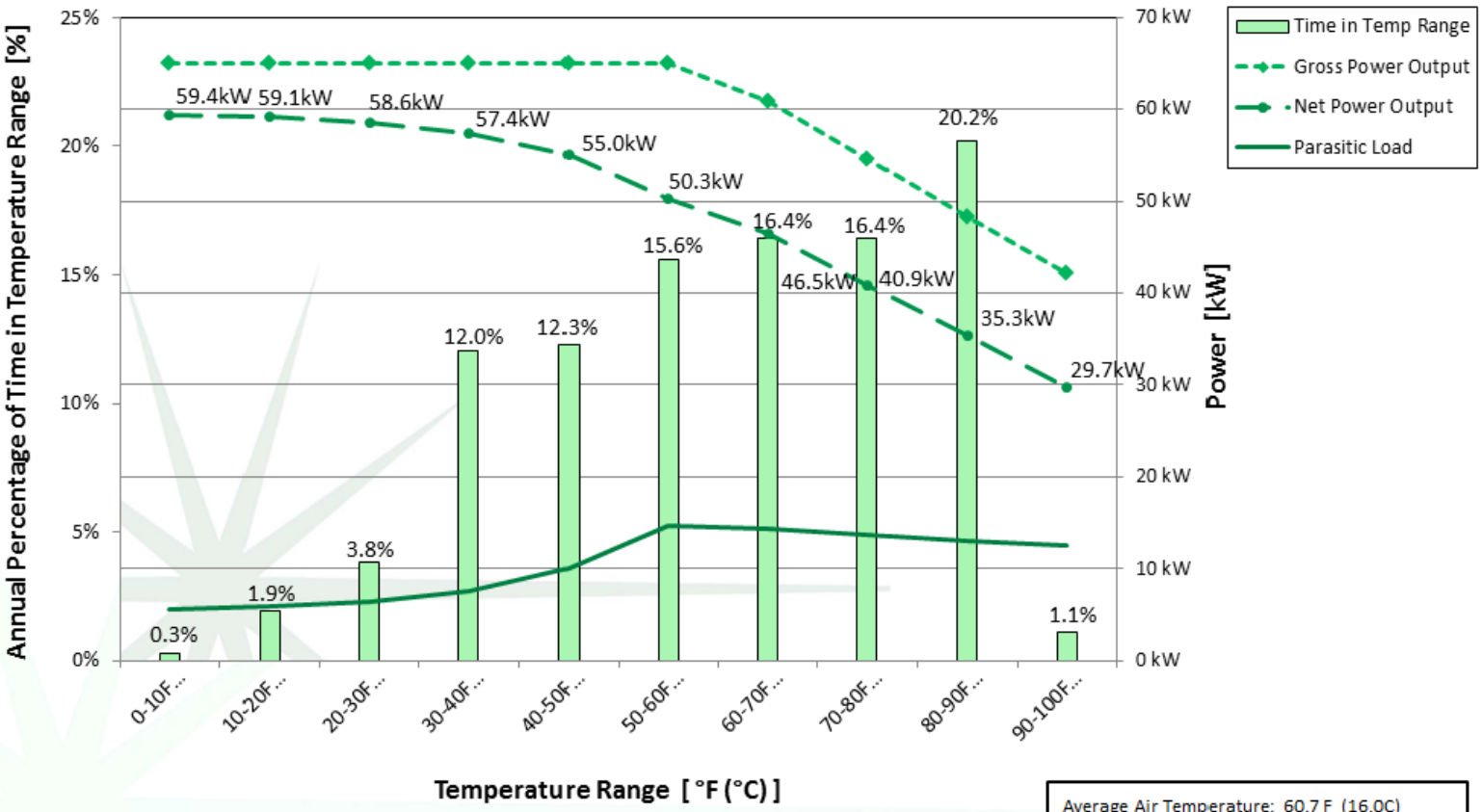

*Please note: This chart is only an ***estimate*** based on customer supplied information and past average weather data

Average Ambient Air Temperature: 39.0 F (3.9C)
Hot Water Temperature: 240 F (116C)
Available Heat: 800 kW
90% Annual Runtime

# Example Site #2

## Estimated Air Cooled Annual Output for Tulsa, Oklahoma

**Total Annual Net Power Output: 369,198 kWh** **Average Net Power Output: 46.8 kW** **Average Gross Power Output: 59.0 kW**



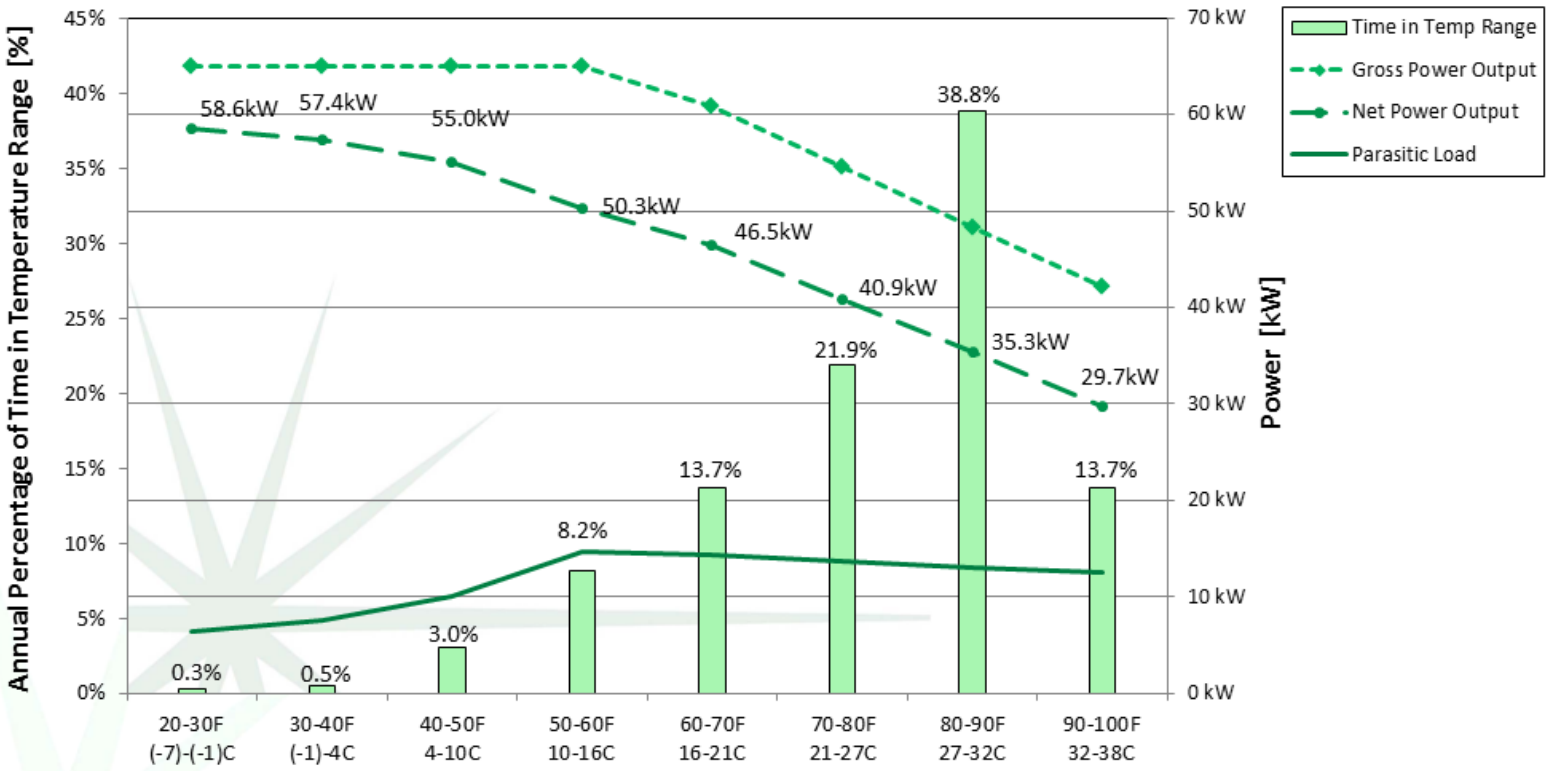

*Please note: This chart is only an ***estimate*** based on customer supplied information and past average weather data

Average Air Temperature: 60.7 F (16.0C)
Hot Water Temperature: 240 F (116C)
Available Heat: 800 kW
90% Annual Runtime

# Example Site #3

## Estimated Air Cooled Annual Output for Laredo, Texas

**Total Annual Net Power Output: 309,819 kWh** **Average Net Power Output: 39.3 kW** **Average Gross Power Output: 52.6 kW**




*Please note: This chart is only an ***estimate*** based on customer supplied information and past average weather data

Average Air Temperature: 77.3 F (25.2C)
Hot Water Temperature: 240 F (116C)
Available Heat: 800 kW
90% Annual Runtime

# The Challenges

- Low hot water flows (160gpm optimal)
- "Hot" wells – not so hot (200F good/220F better/240F best)
- Not Applicable to large scale power production
  - *NO* Need for aggregation of wells
- Difficulties/expense of onsite construction in remote locations
- Operating Personnel (not required - operation controlled from Reno)
- Service support
- Not primary task of O&G producers
- Economics (30% ITC + 10 cent+ power = 3-4 year payback)

# In Summary

• ElectraTherm targets existing sources of waste heat to convert to electricity via an Organic Rankine Cycle (ORC).

• Our applicability to the Oil & Gas industry is existing – small-scale power generation from co-produced water/rejected heat from gas compression/amine processing plants/etc.

• First successful plug and play install in Mississippi, with more projects and field trial learning planned.

• 823,000 Oil & Gas wells equals waste heat resources available today. No drilling, no risks. Wells are characterized. There are up to 3 GW of potential power currently waiting to be tapped.

• Come and visit the GCGE booth to learn more.

# ElectraTherm, Inc.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NCET | Nevada's Center for Entrepreneurship and Technology

**NCET**
**2009 Green Company of the Year**

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POPULAR SCIENCE THE FUTURE NOW BEST OF WHAT'S NEW '08
"Best Green Tech" Award 2008

**Popular Science Best of 2008**
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Best of Show 2007 Geothermal Energy Association
GRC Best Scientific Paper Award 2007 Geothermal Resources Council Annual Meeting

**Geothermal Energy Association** Best of Show; Best Scientific Paper 2007