National Renewable Energy Laboratory
Innovation for Our Energy Future

NREL's New Directions in Geothermal R&D

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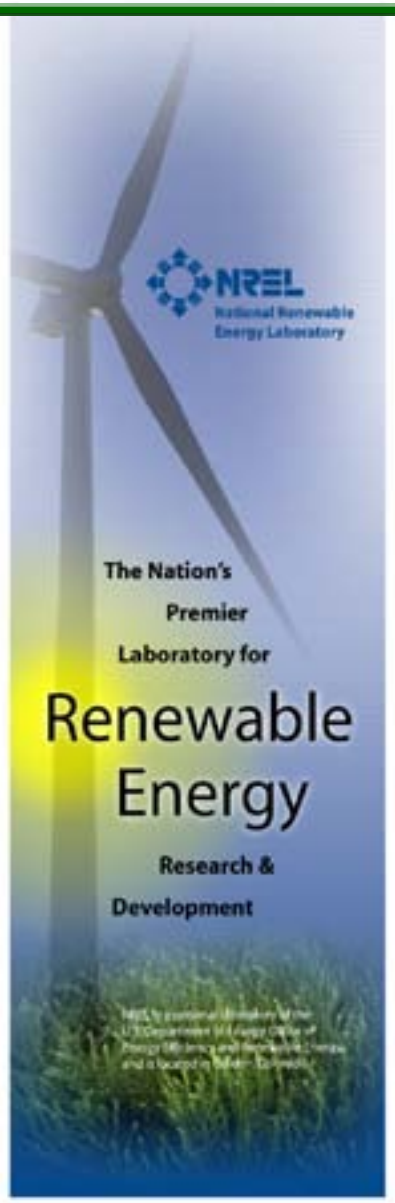
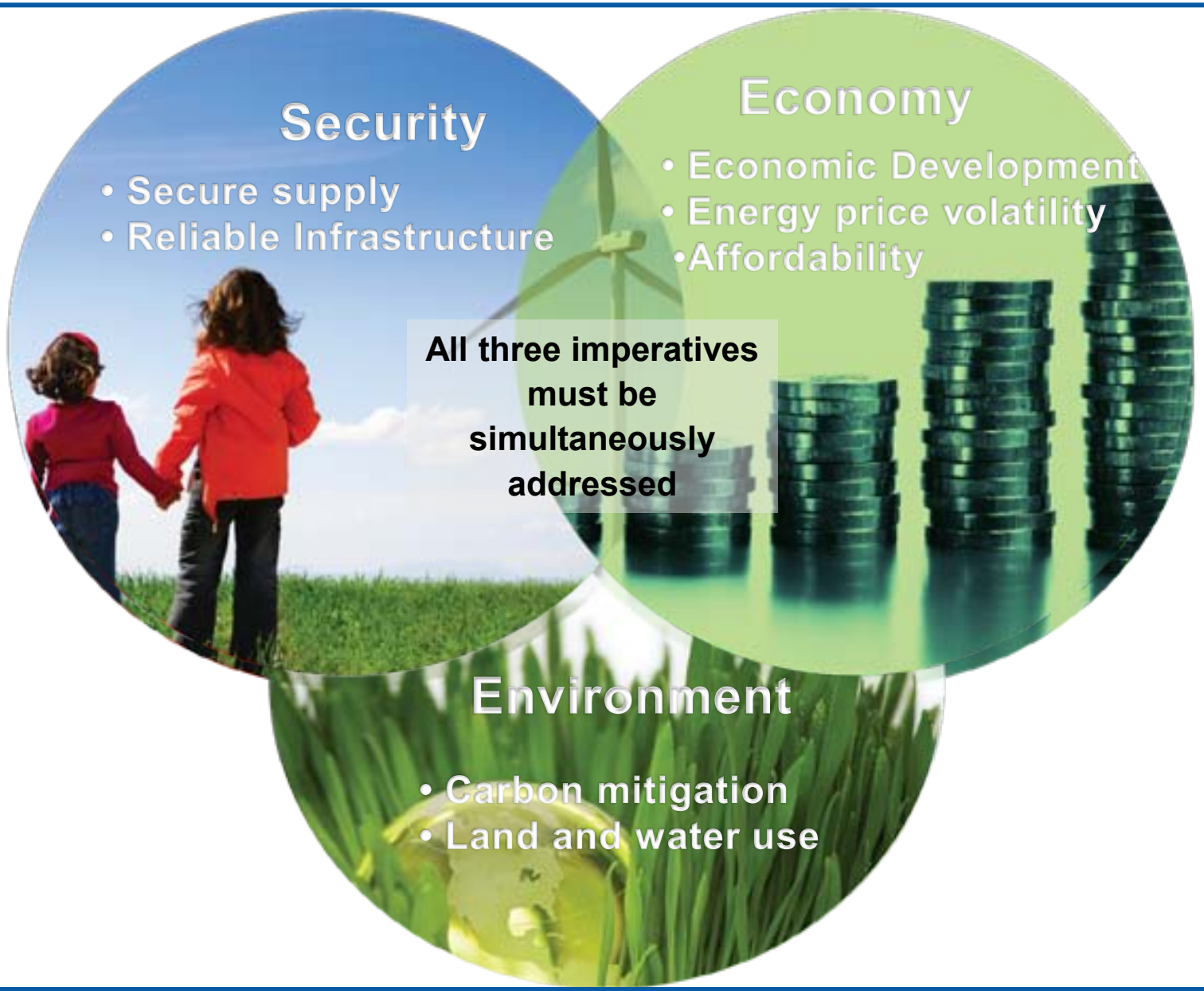
Geothermal Technologies

NREL Mission



From inspiration to installation: NREL's sole focus is to conduct research and development in renewable energy and energy efficiency technologies and to accelerate the adoption of these technologies into the market.

Energy Challenges



A Profound Transformation is Required

Today's Energy System

- Dependent on foreign sources
- Subject to price volatility
- Increasingly unreliable
- 2/3 of source energy is lost
- Produces 25% of the world's carbon emissions

Imperatives for Transformation

DEFINE THE END STATES

REDUCE NEW TECHNOLOGY RISK

ACCELERATE ADOPTION

Sustainable Energy System

- Carbon neutral
- Efficient
- Diverse supply options
- Minimal impact on resources
- Creates sustainable jobs
- Accessible, affordable and secure

NREL Signature Competencies Accelerate Transformation

Building on Today to Transform the Future

Inform

Strategic Analysis & Deployment

RE & EE Technology and System Data & Models

Geospatial Data and Analysis

Showcase Buildings

Integrated Analysis/ Joint Institute for Strategic Energy Analysis

Integrated Deployment

Model Sustainable Campus

Integrate

Systems Based Solutions

Thin-film PV Process Development

Wind Turbine Modeling and Testing

Cellulosic Biomass Process Dev & Testing

Renewable Systems Integration

- Biorefineries
- RE grid integration w/ smart grid
- Vehicles systems
- Net-zero energy buildings
- Sustainable communities

Innovate

Renewable Energy Conversion Science and Technology

Leading edge:

- Photoconversion processes
- Biomass Conversion processes

NREL-led Strategic Innovation Partnerships

Translational Energy Research

Achieving a Sustainable Energy Economy

*Requires a National Energy Grand Challenge**

Lead Coordinated RD3E Strategy in Sustainable Energy

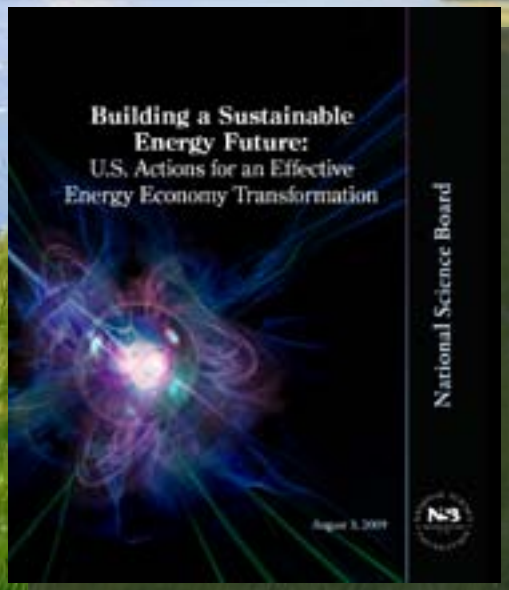
Boost R&D Investment

Construct Essential Policies & Market Conditions

Support Education & Workforce Development

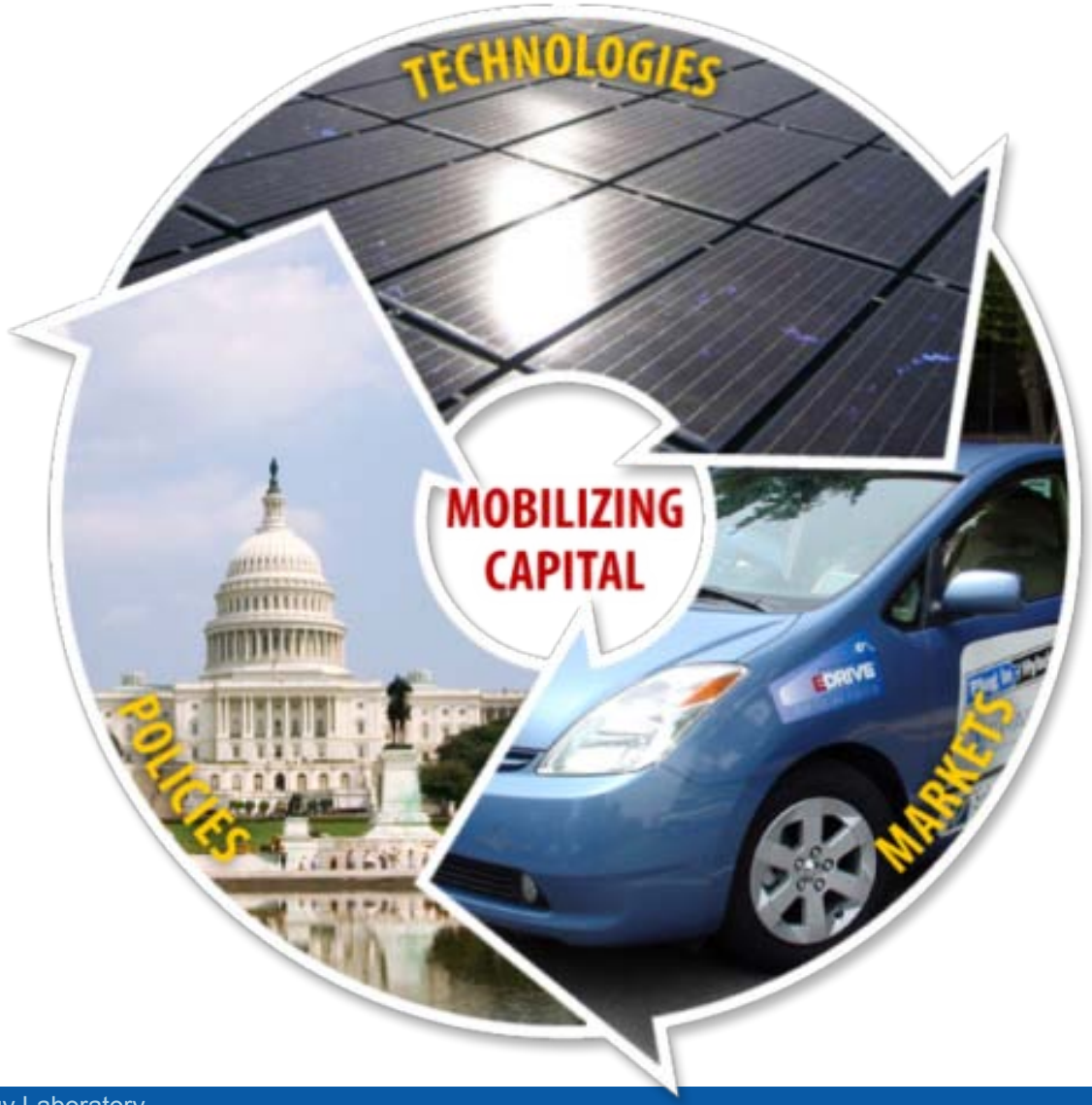
Lead Globally

Promote Public Awareness & Action



* Recommendations of the National Science Board Task Force on Sustainable Energy

An Integrated Approach is Required



Need a Sustainable "System of Systems"

Community & Industrial Systems

Integrated Systems
Sustainable Design

Electricity Generation & Delivery Systems

Distributed & Utility-Scale Renewable Power

Fuel Production Systems

Renewable Fuels

Highly Efficient • Integrated Renewables

The Built Environment

Highly Efficient • Fuel Flexible

Transportation Systems

Opportunities for Low Temp Geothermal

Community & Industrial Systems

Integrated Systems
Sustainable Design

Electricity Generation & Delivery Systems

Distributed ~~& Utility-Scale~~
Renewable Power

~~Highly Efficient •~~ Integrated Renewables

The Built Environment

Low Temperature Geothermal – A Suite of Opportunities

Coproduction:

- An estimated 10 barrels of water are produced per barrel of oil in North America.
- Facilities have lower cost, shorter lead time, broader geographic distribution than conventional geothermal.

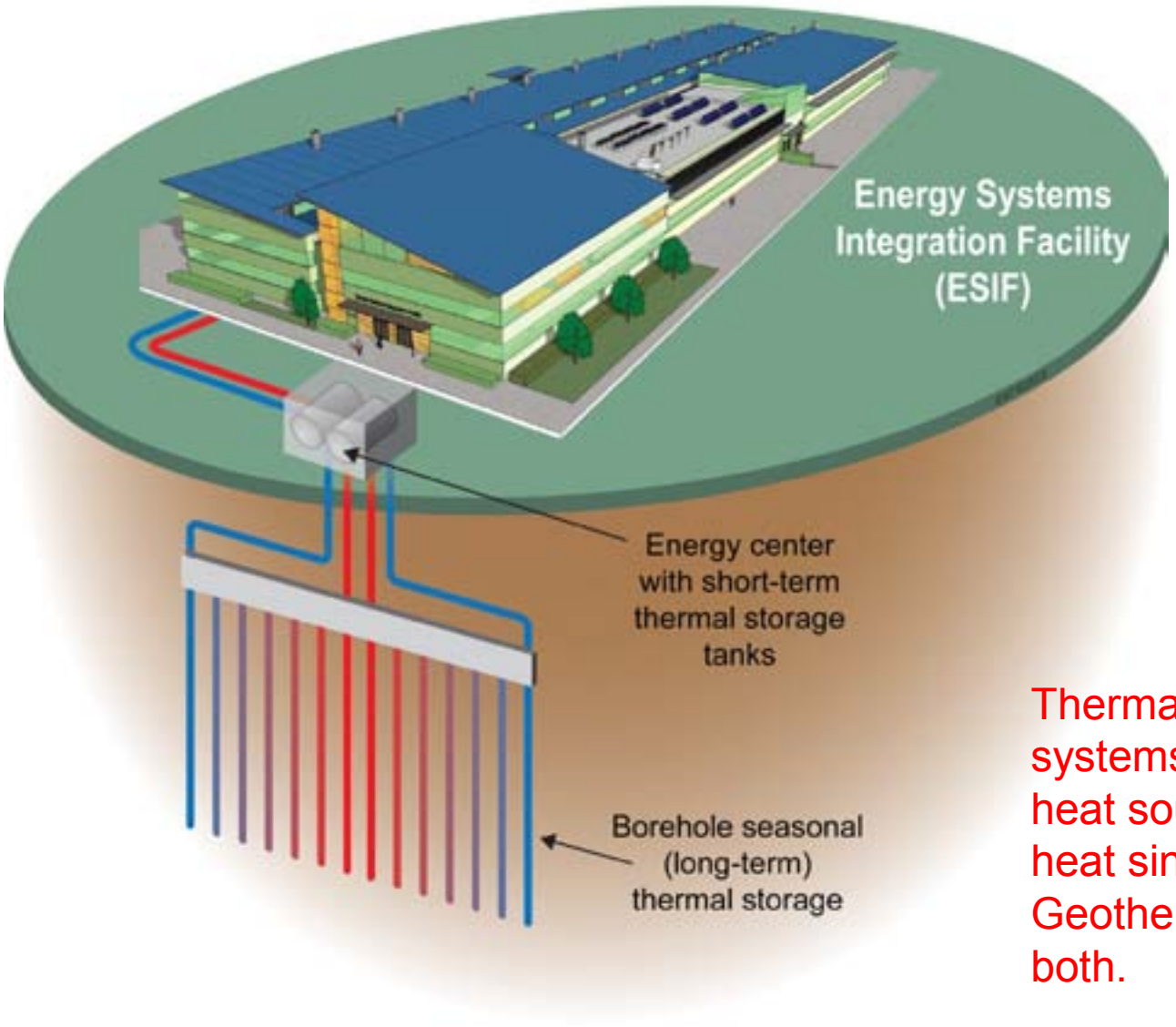
Thermal Resources for Electricity:

- Distributed power systems
- Secure energy facilities (DOD, communities)

Thermal Resources for Direct Use:

- District and building heating
- Greenhouses and aquaculture
- Tourism

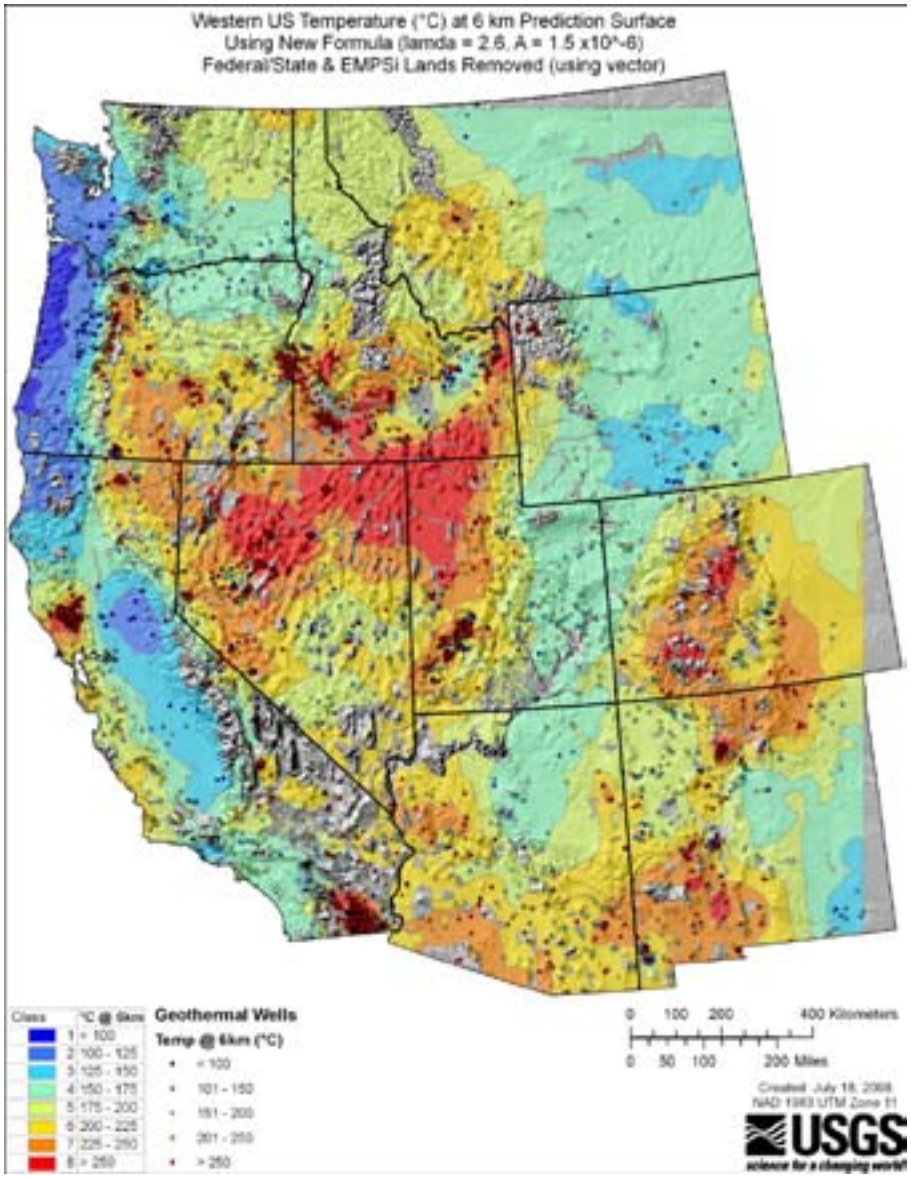
Opportunity: Geothermal Heat Sinks



Thermal energy systems need a heat source and a heat sink. Geothermal can do both.

US Geothermal Resource

- Identified Hydrothermal Systems = 9,057 MWe
- Undiscovered Hydrothermal Resources = 30,033 MWe
- Much of this potential is for resources below 150 °C



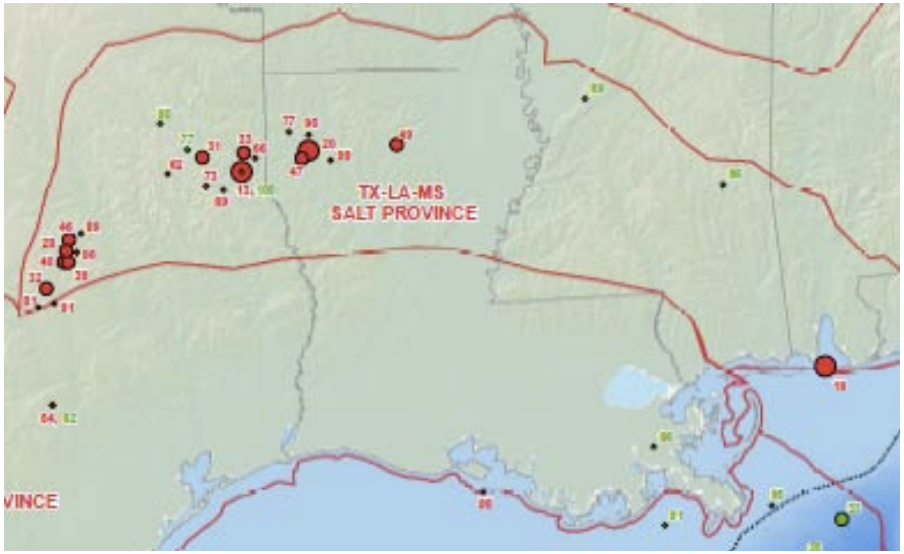
Coproduction Resource: Gulf Coast

Petroleum production data indicate most of the TX-LA-MS basins host elevated temperatures and potential for significant water flow

Thousands of wells produce 250-400°F (120-200°C) water

Example: Freestone County, East Texas >300°F (150°C), 11,000-13,000'

1-5 GW potential electricity production in the seven state Gulf Coast trend*



Major Unitized Fields and Operators

Carthage, TX (Anadarko)

Oak Hill, TX (Energen)

Elm Grove, LA (Petrohawk)

* McKenna, Blackwell and Moyes, 2005, Oil and Gas Journal

Low Temperature Geothermal Energy Perceptions

Modest technical issues – modest technical challenges

Significant resource size – large potential benefits

Low Emphasis in Past – opportunities may have been overlooked

Geographically dispersed – broader availability than high temperature

Low thermodynamic efficiency – there is no cheating Carnot

Significant Business Challenge – making money has been tough

Applying NREL Signature Competencies to Low Temperature Geothermal

Building on Today to Transform the Future

Inform

Strategic Analysis & Deployment

Market Impacts and Policy Modeling

Seminal Studies such as MIT Report

Deployment Support To DOD, FEMP, State and Local Governments

Geothermal Campus Showcases

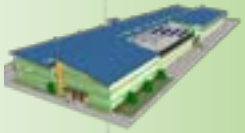
Integrate

Systems Based Solutions

Systems Integration and Economic Models

Pilot Project Data Collection and Evaluation

Improved Project Assessment Tools

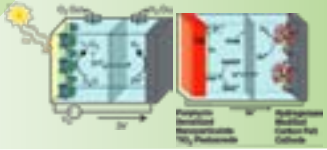


Institutional Knowledge Repository

Innovate

Renewable Energy Conversion Science and Technology

Capabilities in thermal sciences, computational sciences, geology and chemistry available but not effectively tapped



Strategic Partnerships for Geothermal Research

Identify and Pursue New Applications and Research Thrusts

Tools and Data Portal