

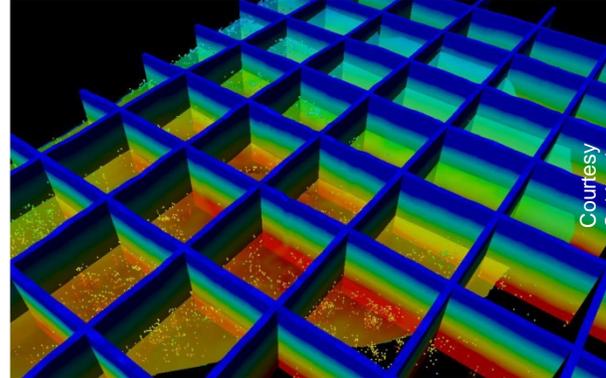
Systems Analysis and Low Temperature Program Overview



Courtesy Enel Green Power



Courtesy Bill Goloski



Courtesy



Courtesy Ben Phillips



Courtesy Geothermal Resources Council



Introduce you to

- **Geothermal Technologies Office – GTO**
 - **Goals and Objectives**
- **Technology Road Map**
- **Systems Analysis and Low Temperature Program - SALT**
 - **Barriers to low temperature uptake**
 - **Research into additional value streams**
- **Direct use Workshop – Pittsburgh – August 2015**
 - **Key Messages**
- **National Geothermal Data System - NGDS**

The mission of the Geothermal Technologies Program is to accelerate the deployment of domestic energy generation from geothermal resources by investing in transformative research, development, analysis and demonstration-scale projects that will catalyze commercial adoption. Successful efforts will promote a stronger, more productive economy; provide valuable, stable, and secure renewable energy to power the U.S.; and support a cleaner environment.

Supported Administration Goals

- By 2035, generate 80% of electricity from a diverse set of clean energy resources
- Reduce GHG emissions by 17% by 2020 and 83% by 2050 from 2005 baseline

GTO Program Goals and Objectives

GTO Goals	GTO Objectives
<ul style="list-style-type: none">• Develop advanced remote resource characterization tools to identify geothermal opportunities without surface expression• Purposeful control of subsurface fracturing and flow• Improve and lower \$/MW subsurface access technologies• Develop mineral recovery and hybrid systems to provide second stream of value	<ul style="list-style-type: none">• Demonstrate the capability to create and sustain a greenfield 5 MW Enhanced Geothermal Systems reservoir by 2020.• Reduce the LCOE of undiscovered hydrothermal to \$.10/kWh by 2020• Lower the levelized cost of electricity from newly developed geothermal systems to \$0.06/kWh by 2030.• Achieve \$1.70-\$2.60/m³ for desalinated water from geothermal by 2018.

2016 Vision Study Activities:

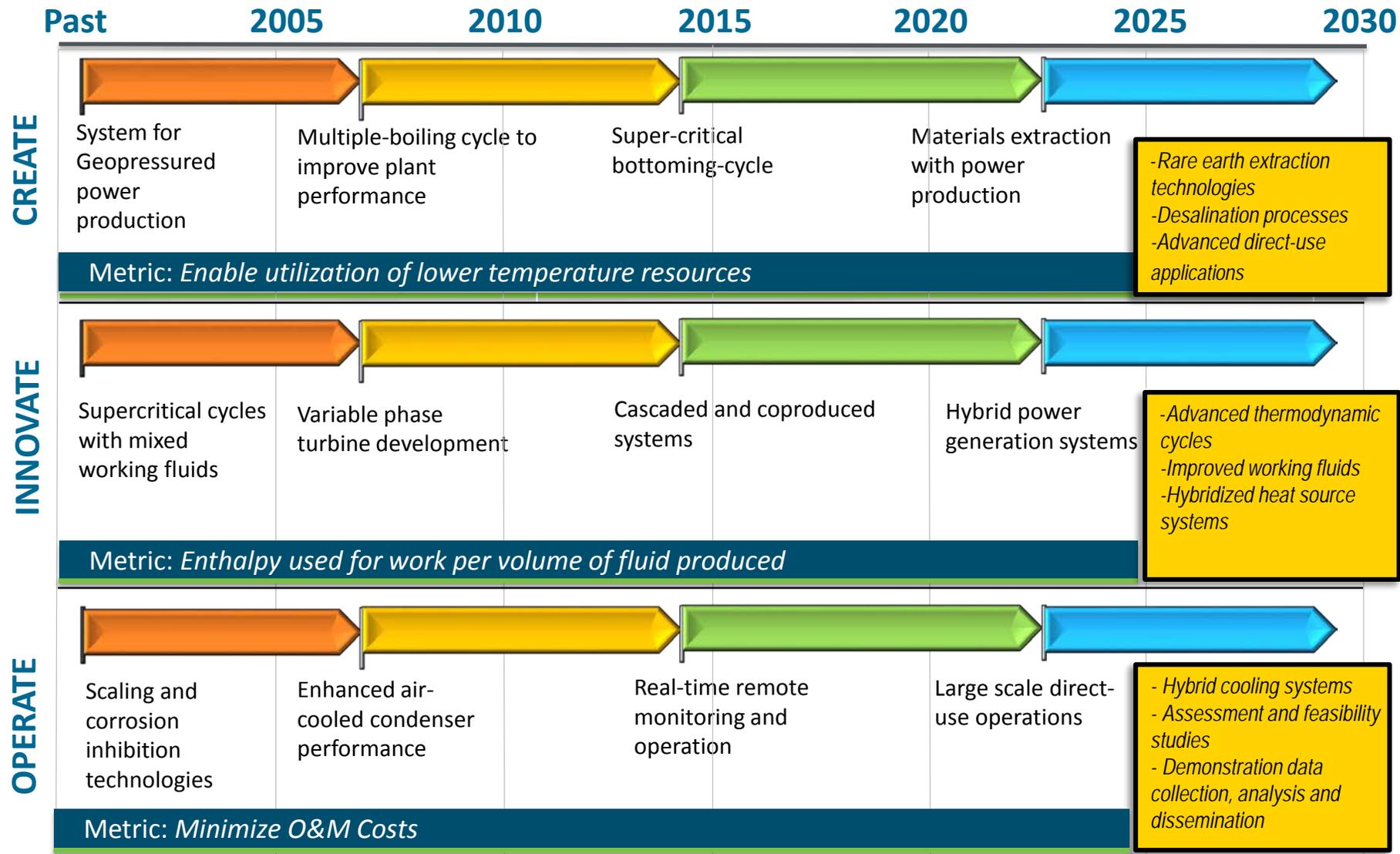
- DOE will develop credible analysis jointly with the geothermal community that:
 - Articulates clear strategies across different sectors and has a cohesive plan to attain the goals
 - Discusses geothermal growth scenarios for 2020, 2030 and 2050 backed by robust data, modeling and analysis
 - Addresses all market segments: existing and potential hydrothermal, electrical **and non-electrical usages**, new EGS sector, and other value streams
 - Supported by objective and peer-reviewed industry data and available to decision-makers
 - Is aspirational and inspirational

2017 Vision Study Activities:

- Complete strategic planning based upon growth scenario modeling.
- Use completed analysis to feed into **technology roadmaps** that will cover all identified market segments.
- Utilize peer-reviewed data and analysis as the basis for developing various technology R&D pathways.

LT Technology Roadmap

Pathways: Create, Innovate and Operate



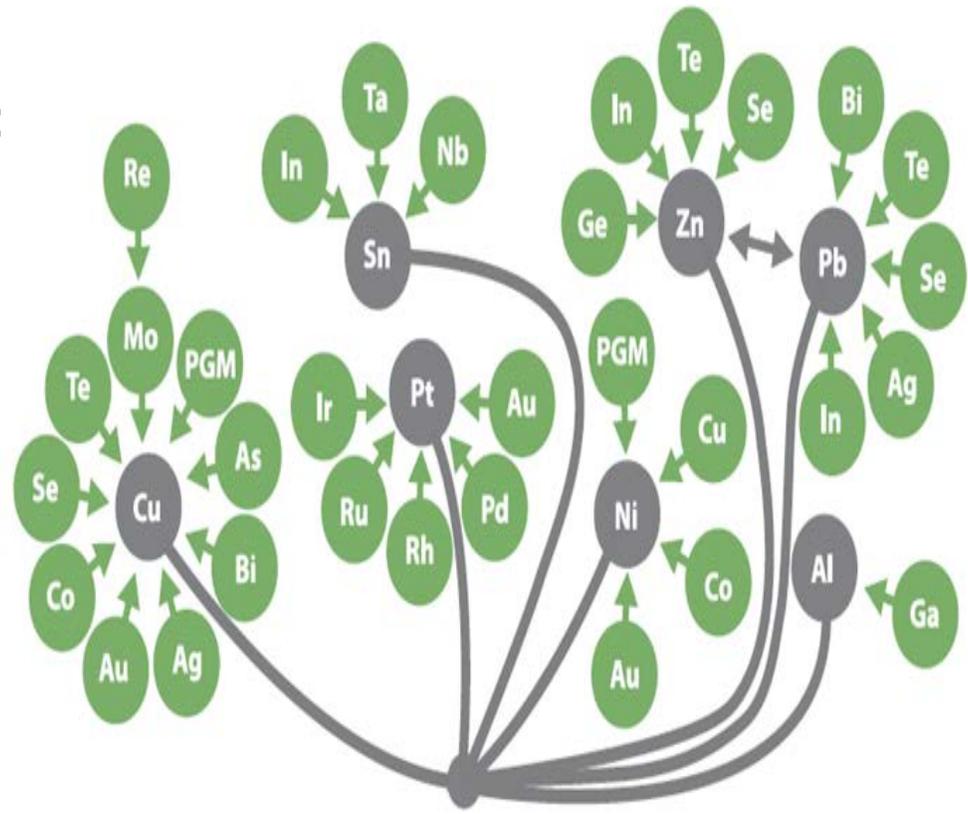


- **Low-Temperature Mineral Extraction** - Resource assessment and feasibility (ongoing)
- Large-scale **Direct Use**: where does it make technical and commercial sense?
- Use geothermal hot fluids for heating and cooling
- Potential displacement of traditional baseload generation on site-by-site basis
- Targeted RD&D on innovative energy conversion, additional **revenue-stream creation (e.g., hybrid systems & thermal desalination)**, and further development of power generation cycles



Benefits of Coupling mineral/material extraction methods with geothermal power:

- Rare Earth (REE) and Near Rare Earth Elements may be relatively prevalent in the brines
- Chemical elements are critical for domestic industries
- Geothermal fluid can contain minerals that are a major source of corrosion and scaling

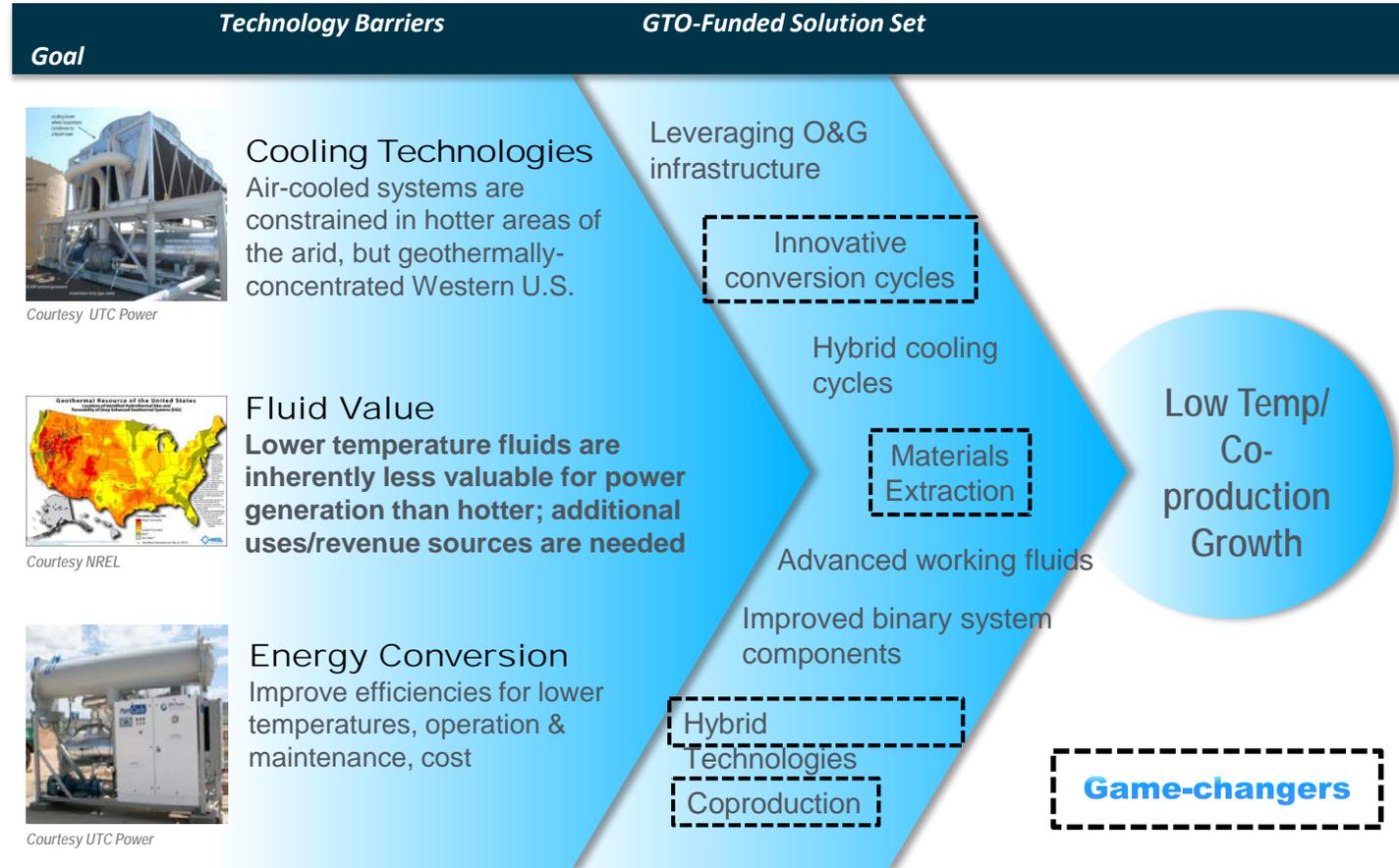


Technology metals produced as byproducts of base metals.

This matrix was used in the "Critical Materials for Sustainable Energy Applications" report by the Resnick Institute in 2011. (Original source: Hagelucken, C., and Meskers, C.E.M.: Complex Life Cycles of Precious and Special Metals)

Key Barriers to LT Expansion

Technology and Engineering Needs





- More than 65 participants, roughly 1/3 in each of private industry/consultant, academics, and government/contractors
- Leverages DOE (NETL) 21st Century Infrastructure MOU with City of Pittsburgh by exposing energy and green buildings stakeholders to the potential for Geothermal Direct Use in key MOU localities within the Appalachian Basin
- City of Pittsburgh, Chief Resilience Officer presented emerging opportunities to develop **district energy** in cities like Pittsburgh that are experiencing growth and re-development.
- Icelandic consultant discussed geothermal district heating with an established geothermal resource, and provided insights into different heating and cooling needs and approaches that would be relevant to Pittsburgh.



NETL George Richards Provided Outstanding Support to GTO



WVU Brain Anderson Geothermal Play Fairway Analysis for the **Appalachian Basin:**

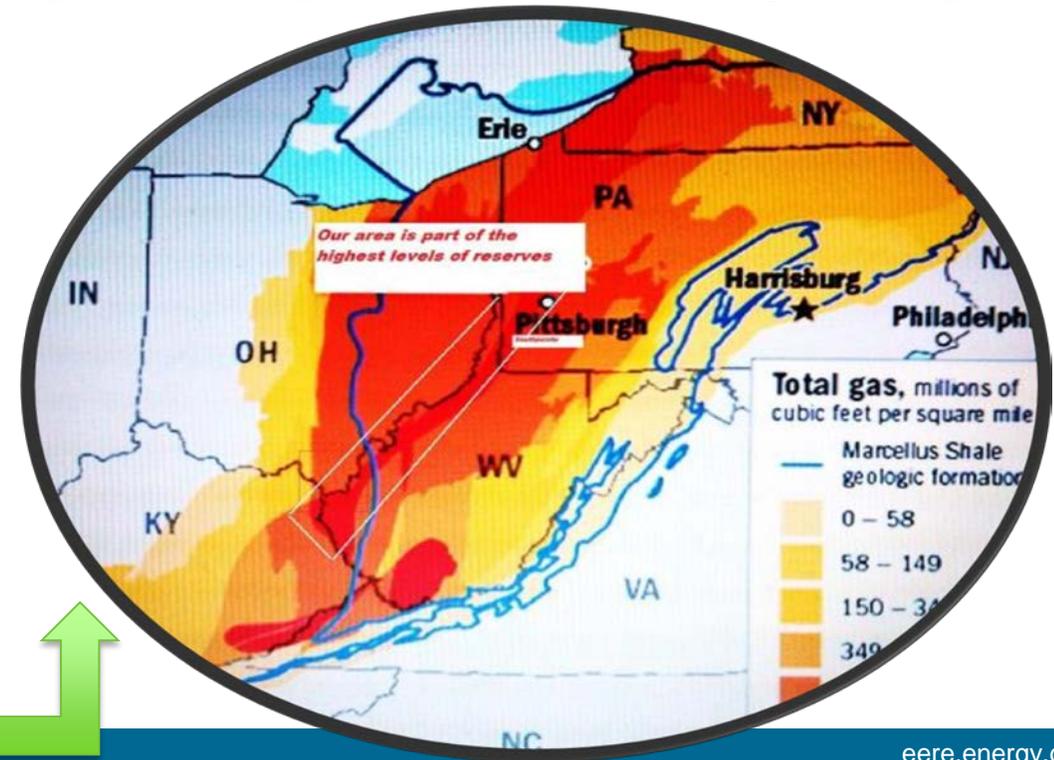
Industry Engagement

- **NRG Energy District Energy** CEO and Plant Manager toured workshop participants through their Northside District Energy Plant discussing potential methods to integrate geothermal energy. Interested in EGS and cascaded Direct Use applications.
- **GRC** Executive Director and Incoming President attended interested in incorporating Direct Use and GSHP into membership base and working with International Ground Source Heat Pump members.
- **GEA** 2015 Update to include Direct Use – a first!
- **Frick Park Environmental Center**, through use of geothermal heating and cooling, slated to meet “Living Building Challenge” requiring stringent use of water and net zero energy

Potential Partnerships

- **WV National Guard** (Camp Dawson)
- **City of Pittsburgh** – 21st Century Infrastructure MOU
- **UAE Sustainable Fish Production**
- **Bayer MaterialScience**
- **CMU Center for Building Performance**
- **Kasese Solar Power Ltd**
- **Thar Energy**
- **NETL, NREL, and ORNL resource assessment**
- **Pittsburgh Southpointe Chamber of Commerce** (Exhibitor)

Map Courtesy of Marcellus Shale Chamber



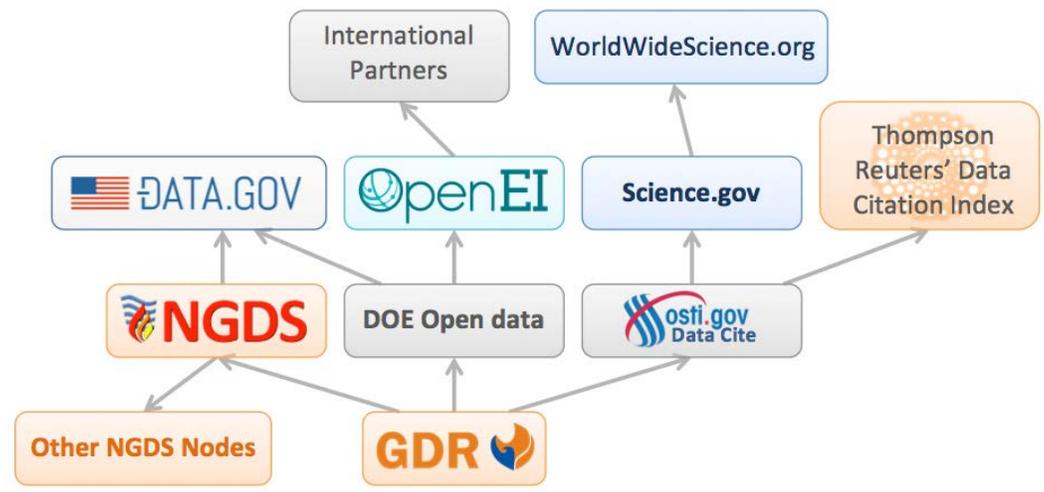


Key Messages:

- Hot spots in NY, PA and WV can result in Deep Direct Use Applications. Cornell Case Study including EGS and Deep Direct Use of interest to others interested in pursuing sustainable development.
- Deep Direct Use applications lend themselves to large scale, commercially viable systems that optimize the value stream of lower temperature resources through a cascade of uses, from electricity generation to direct heating and cooling, industrial and commercial applications, and agricultural uses.
- District Heating Infrastructure in need of upgrading, opportunity to transition from natural gas to geothermal
- Documented audience opinions on potential impact for direct-use, technical challenges that require further research, and potential barriers for development, key information to present to Geothermal Vision Study Thermal Task Force.



DOE's node on the National Geothermal Data System (NGDS) is the DOE Geothermal Data Repository (GDR)



Over **500** geothermal projects data submissions from over **60** DOE GTO funds

Over **1,000** direct downloads with more than **11,000** downloads from users discovering GDR data



“reduce the inherent risk in early stages of development and encourage an independent investment market” - Deloitte LLP, Geothermal Risk Mitigation Strategies (2008)

The screenshot displays the NGDS Geographic Search interface. At the top left, the title "NGDS Geographic Search" is visible. A search bar at the top right contains the text "ground source heat pump". The main area is a map of the United States with several orange circular markers indicating search results. On the right side, a results panel shows "Results 0 - 50 of 166". The first result is titled "Ground Source Heat Pump Computational Results Orlando_Plots.pdf" and includes a summary: "loop heat pump systems located in 6 different cities across the United States. The cities are Boston, MA, Dayton, OH, Omaha, NE, Orlando, FL...". Below this, there are two green buttons: "Hide Area on Map" and "Go To Dataset Details Page". The second result is titled "Ground Source Heat Pump Computational Results Dayton_Plots.pdf" and includes the same summary. Below it are two more green buttons: "Available Resources" and "Download PDF Resource". The third result is titled "Ground Source Heat Pump Computational Results Sacramento_Plots.pdf" and includes the same summary. The map on the left shows various cities and states, with orange markers placed over several locations, including Minneapolis, Omaha, Lincoln, Indianapolis, Dayton, and Sacramento.

- **To connect with Arlene Anderson**

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Thank you