GEOTHERMAL TECHNOLOGIES PROGRAM

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE GTP Geothermal Vision Study Plan

February 1, 2011

Arlene Anderson, DOE
Kermit Witherbee, NREL

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

"Now, clean energy breakthroughs will only translate into clean energy jobs if businesses know there will be a market for what they're selling. So tonight, I challenge you to join me in setting a new goal: by 2035, 80% of America's electricity will come from clean energy sources. Some folks want wind and solar. Others want nuclear, clean coal, and natural gas. To meet this goal, we will need them all – and I urge Democrats and Republicans to work together to make it happen."

President Obama

State of the Union

January 25th, 2011

How could geothermal contribute to an 80% clean energy by 2030 future?

If there is a market for a high penetration geothermal scenario, what would it look like?

Purpose of Vision Study

Questions Study may Address

- What might a future high geothermal energy penetration scenario look like?
- What would be the impacts of this future scenario?
- What areas would such a high deployment future encourage us to look at?

Outcomes

- Informs road map and planning exercises
- Identifies key barriers to high geothermal deployment
- Assess opportunities and impacts of high geothermal deployment

Questions Study will not address

- Not a roadmap or planning exercise to reach a “goal”
- Not a prediction of what the future will look like

Planning Meeting Goals

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

This Evening's Goals

1. Present Geothermal Vision Study Plan
2. Obtain immediate feedback on the Vision Study Plan
3. Decide on study topics
4. Identify working group participants
5. Plan for kick-off meeting
6. Plan for scenario-analysis meeting

Proposed Vision Study Audience

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Primary Audience

- Geothermal Stakeholders
- Geothermal Policymakers

Secondary Audience

- DOE Leadership
- General/affected public

Previous Geothermal Studies

Study	Main Focus
MIT EGS Study	• "What will it take for EGS and other unconventional resources to provide 100GW of base-load generating capacity by 2050?" • Focused on technical feasibility, not impacts (e.g. job creation, water use, CO2 abated, transmission grid impacts)
Renewable Electricity Futures (ReEDS[1])	• Renewable energy to supply 80% US electricity by 2050 • Draft Under Review
EIA AEO 2008 (NEMS[2])	• EIA Annual Energy Outlook forecasting • Hydrothermal by 2030: 6.64 GW
GPRA FY11 (MARKAL[3])	• Annual Government Performance Reporting Act • Hydrothermal by 2030: 6 GW
GPRA FY 11 (SEDS[4])	• Designed to capture uncertainty of model input data • Hydrothermal by 2030: 2.8 GW • EGS by 2030: 1 GW
GPRA FY 11 (NEMS)	• Hydrothermal by 2030: 11.5 GW

1: Regional Energy Deployment System
2: National Energy Modeling System
3: Market Allocation
4: Stochastic Energy Deployment System

Summary Comparison
Solar and Wind Vision Studies

Parameter	Solar Vision Study[1]		Wind Vision Study[2]
Market Share	10%	20%	20%
Installed Capacity	179 GW	303 GW	300 GW
CO_2 Reduction by 2030 (Electricity Generation)	170 M Tons/13 % Reduction	600 M Tons/25% Reduction	825 M Tons/26% Reduction
Transmission	Achievable	Challenge	Challenge
Labor – Jobs Created	260,000	450,000	500,000
Foot Print	460,000 hectares[3]	790,000 hectares	100,000 to 250,000 hectares
Water Consumption	PV – uses very little CSP – dry or hybrid 40 - 97% reduction		17 % reduction

1-Solar Vision Study: Achieving 10%-20% of U.S. Electricity from Solar by 2030, Draft

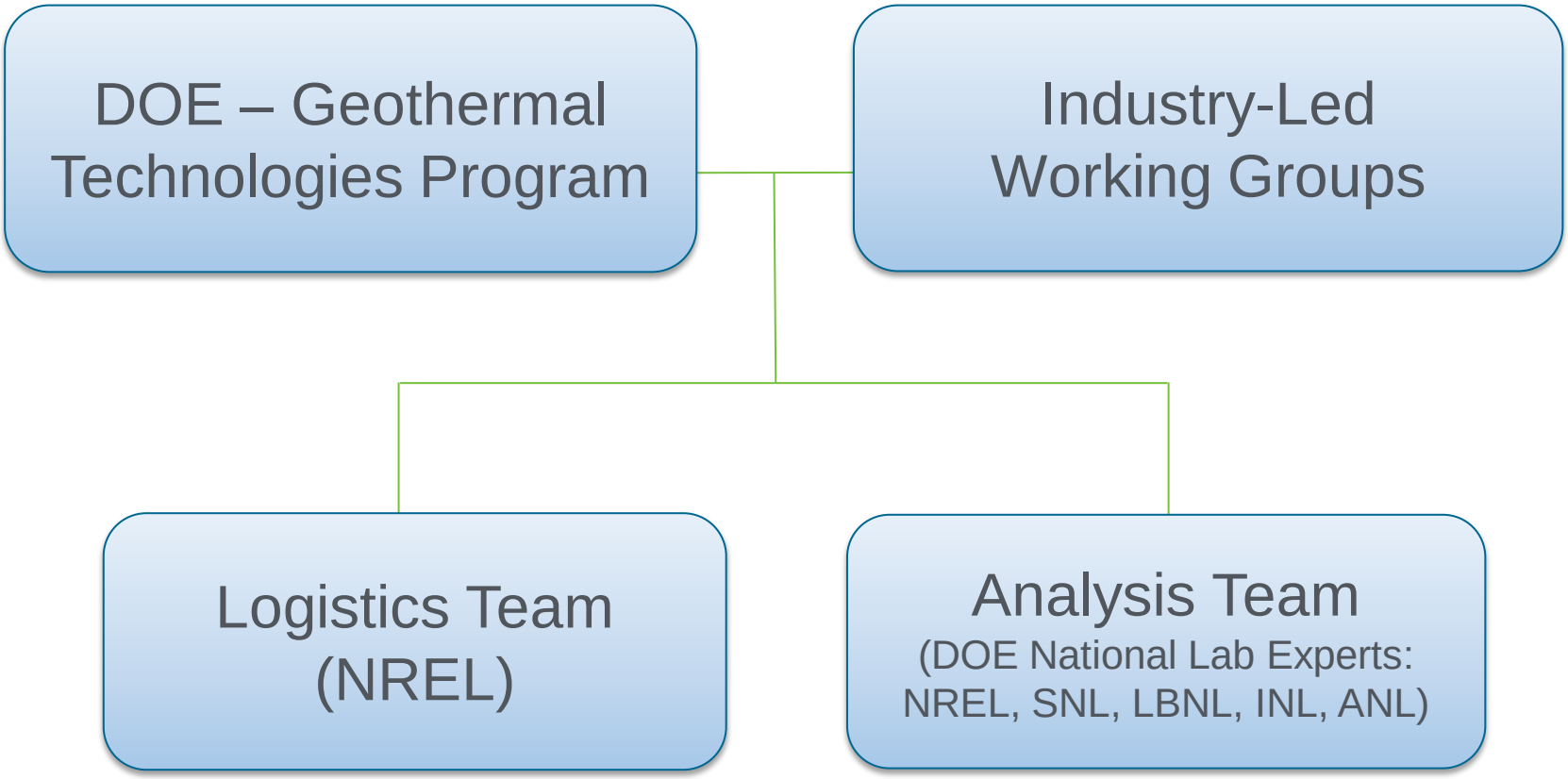
2- 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply, 2008, DOE/GO-102008-2567

3– One hectare = 2.47 acres

Key Issues Driving the Study

Wind & Solar	Geothermal
• Major concerns about high - deployment future were COST (required investment compared to a base case) and IMPACTS TO GRID RELIABILITY Major advantages are avoided CO2, with some economic (jobs) benefits	Major concerns and advantages to high deployment: • Water Use • Transmission (regionality of geothermal, seasonal effects on plant performance) • Safety/Induced Seismicity/Siting • Financing / Permitting • Hydrothermal – exploration risk • EGS – Cost/Technical Feasibility • Major Benefits – avoided CO2, grid reliability (base load), small footprint, jobs

Vision Study Organization



Vision Tools

- **Resource Assessments**
  - USGS, SMU, NREL
- **Technology Cost Models**
  - GETEM (INL)
  - SAM (NREL)
  - Adi Analytics
  - GeoFrac (EGI)
  - GEECO results
- **Market Analysis**
  - ReEDS, GridView (NREL)
- **Transmission Analysis**
  - GridView (NREL)
  - David Hurlbut (NREL)
- **Jobs and Economic Impacts**
  - JEDI (NREL)
  - EGI models
- **Environmental Impacts**
  - LCA (ANL)
- **Finance Models**
  - CREST (NREL)
  - SAM, GETEM
- **Reservoir Modeling**
  - FRACTSIM (INL)
  - Dynamic Simulations (SNL)

Wind Vision Study Chapters and Leads

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

1. Executive Summary & Overview
   4 lead authors
2. Wind Turbine Technology
   Michael Robinson , NREL Chairperson + 1 Lead Author + 7 team
3. Manufacturing, Material & Resources
   Lawrence Willey, GE Energy, Chairperson + 2 Lead authors + 4 Team
4. Transmission & Integration into the U.S. Electric System
   J. Charles Smith, Utility Wind Integration Chair person+ 1 Lead author +17 team
5. Wind Power Siting & Environmental Effects
   Laurie Jodziewicz, American Wind Assoc. Chairperson + 2 lead authors + 6 team
6. Wind Power Markets Appendices
   Larry Flowers, NREL Chairperson, + 5 Lead authors + 3 team

Solar Vision Study Chapters and Leads

1. Introduction
   4 Working group leaders and lead authors
2. Solar Energy Market Evolution & Technical Potential
   6 Working group leaders and lead authors + 5 team members
3. Analysis of Solar Growth Scenarios
   5 Working group leaders and lead authors + 19 team members
4. Photovoltaics: Technologies, Cost, & Performance
   5 Working group leaders and lead authors + 11 team members
5. Concentrating Solar Power: Technologies, Cost, and Performance
   4 Working group leaders and lead authors + 17 team members
6. Solar Heating and Cooling: Technologies, Cost, and Performance
   5 Working group leaders and lead authors + 9 team members
7. Integration of Solar into the U.S. Electric Power System
   6 Working group leaders and lead authors + 13 team members
8. Solar Power Environmental Impacts and Siting Challenges
   7 Working group leaders and lead authors + 191team members
9. Solar Industry Financial Issues and Opportunities
   6 Working group leaders and lead authors + 3 team members
10. Solar Policy Options
    5 Working group leaders and lead authors + 17 team members

Proposed Vision Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Date	Task
Feb 2011	Present study plan • Posted on GTP website for public comment • Presented during Stanford Workshop (Tues., Feb. 1st) Complete study plan Select working group leaders
Mar 2011	Launch Study, select working group members
April 2011	Scenario Analysis meeting (webinar)
May 2011	First working group meeting(s)
Sept 2011	Chapter Rough Drafts from working groups
Dec 2011	Internal Reviews of chapters complete
Feb 2012	External reviews of chapters complete
June 2012	Final Draft Study sent to publications

Overview

POSSIBLE SCENARIO:

10% of Electricity Demand Delivered from Geothermal by 2030

Goals of the Vision Study

- Identify the impacts and benefits to determine what is possible
- Raise awareness & visibility of Geothermal
- Identify and characterize the primary technical, economic, and environmental constraints to achieving the vision
- Incorporate geothermal stakeholder perspective in crafting geothermal future
- Support DOE decisions in Geothermal RD&D

Scope

- All geothermal technology pathways that can contribute to geothermal electricity production (hydrothermal, EGS, co-production, geopressured, permeable sedimentary geothermal)
- All technologies, but level of detail will vary according to analysis and information available.

Participation

- Geothermal stake holders (developers, suppliers, power providers, researchers, laborers, environmental advocates, government and trade associations) to provide insight and perspective on what is achievable by 2030

Launch in Winter 2011

- Scheduled for release in late- 2012

Proposed Vision Study Working Group Topics

1. Geothermal Energy Market Current Status and Technical Potential
2. Technologies, Cost, and Performance
3. Analysis of Geothermal Growth Scenario
4. Integration of Geothermal into the U.S. Electric Power System
5. Challenges to Geothermal Resource Identification and Development
6. Geothermal Power Environmental Impacts
7. Geothermal Power Siting Challenges
8. Geothermal Industry Financial Issues and Opportunities
9. Effect of Policy Options on Geothermal Deployment

Planning Meeting Goals

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

This Evening's Goals

1. Obtain immediate feedback on the Vision Study Plan
2. Decide study topics
3. Identify working group participants
4. Plan for kick-off meeting
   discussion of project scope/topics
   (tentative: March 16, 2011 – Golden, CO)
5. Plan for scenario-analysis meeting
   discussion of geothermal vision scenarios
   (tentative: April 13, 2011 – Washington, D.C.)

Project Sponsorship and Contractor Support

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

To provide comment on this Geothermal Vision Study Plan, visit the DOE Geothermal Technologies Program Website at:

http://www1.eere.energy.gov/geothermal/

Project Sponsor:

U.S. DOE, Office of Energy Efficiency and Renewable Energy
Geothermal Technologies Program
Arlene F. Anderson
Lead Analyst and Manager National Geothermal Data System
Arlene.Anderson@ee.doe.gov
202-586-3818

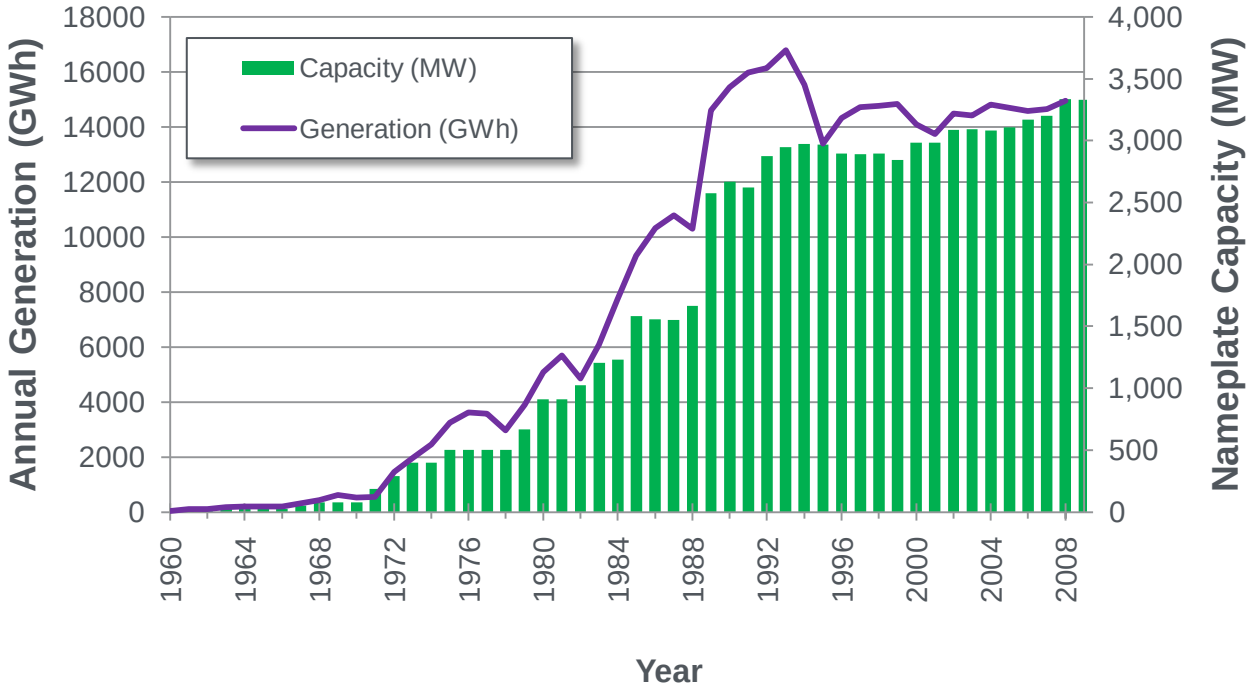
Project Logistics Support, National Renewable Energy Laboratory:

Kermit Witherbee
Geothermal Geologist/Analyst
Kermit.Witherbee@nrel.gov
303-275-3882

Chad Augustine
Geothermal Engineer/Analyst
Chad.Augustine@nrel.gov
303-384-7382

Katherine Young
Geothermal Engineer/Analyst
Katherine.Young@nrel.gov
303-384-7402

Installed Geothermal Capacity



Generation Data Source: EIA ; Nameplate Capacity Data Source: EIA (1960-1999), SNLi (2000-2009)

- The combination of a small, undercapitalized industry, leasing regulations dating back to 1970, and historically, an R&D program with insufficient resources to address important technological problems accounts for the lack of growth in installed capacity
- Resurgence of interest in the 2000s was propelled by government incentives, fresh capital from private equity investors and revamped leasing regulations