Overview of Geothermal Energy Development

DOE Office of Indian Energy

Webcast: Overview of Geothermal Energy Development

Tuesday, January 10, 2012

Kermit Witherbee
Geothermal Geologist/Analyst

PRESENTATION OUTLINE

Geothermal Geology and Resources

Environmental Impacts

Geothermal Technology – Energy Conversion

Geothermal Leasing and Development

GEOTHERMAL GEOLOGY AND RESOURCES

Geology – Plate Tectonics

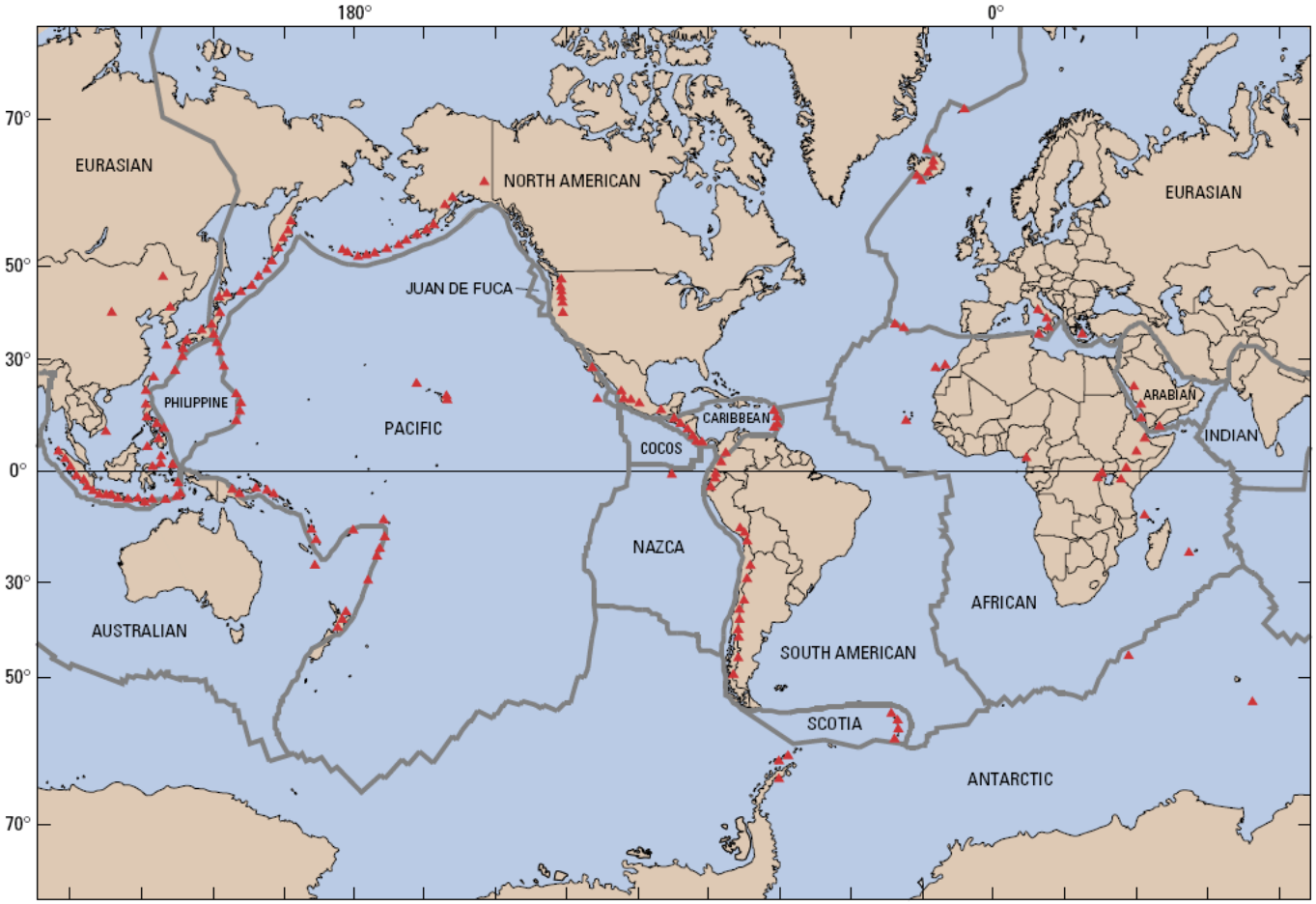
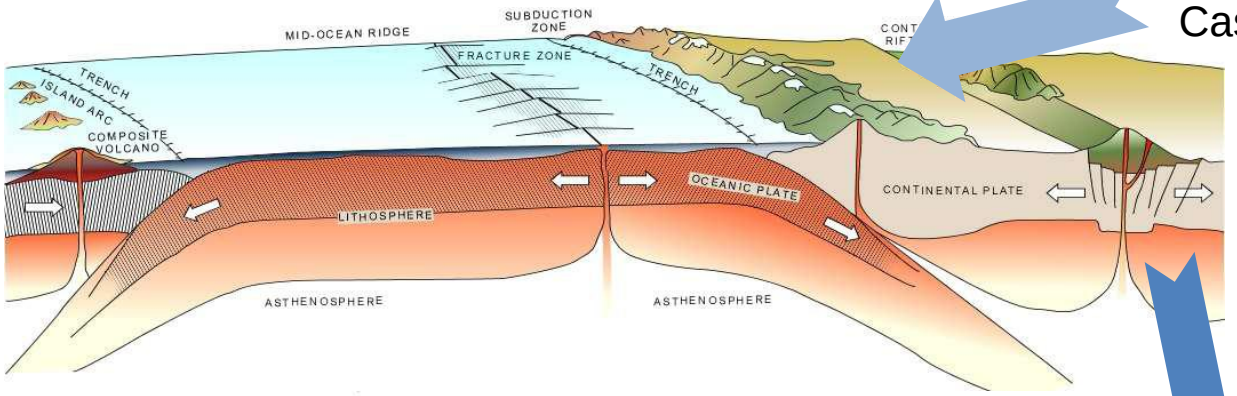
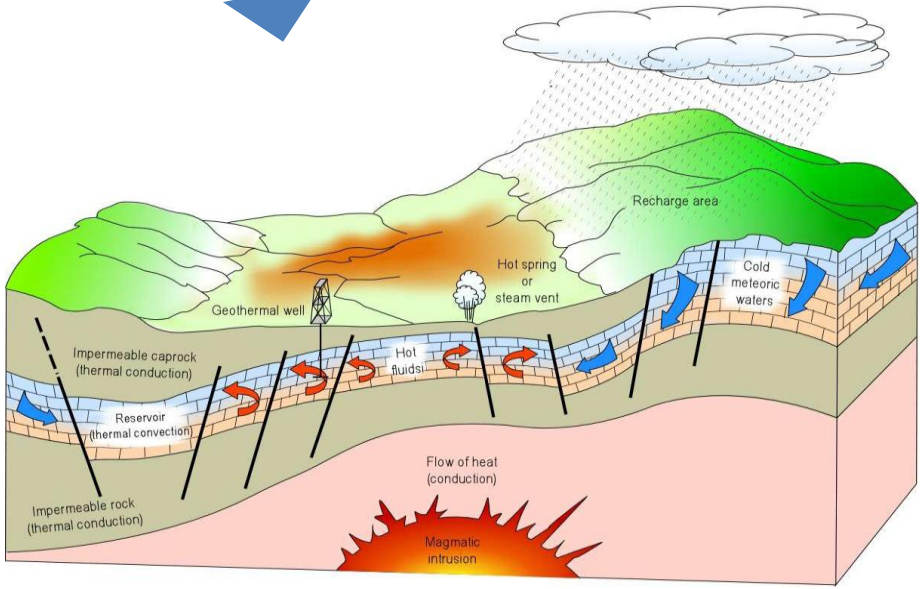


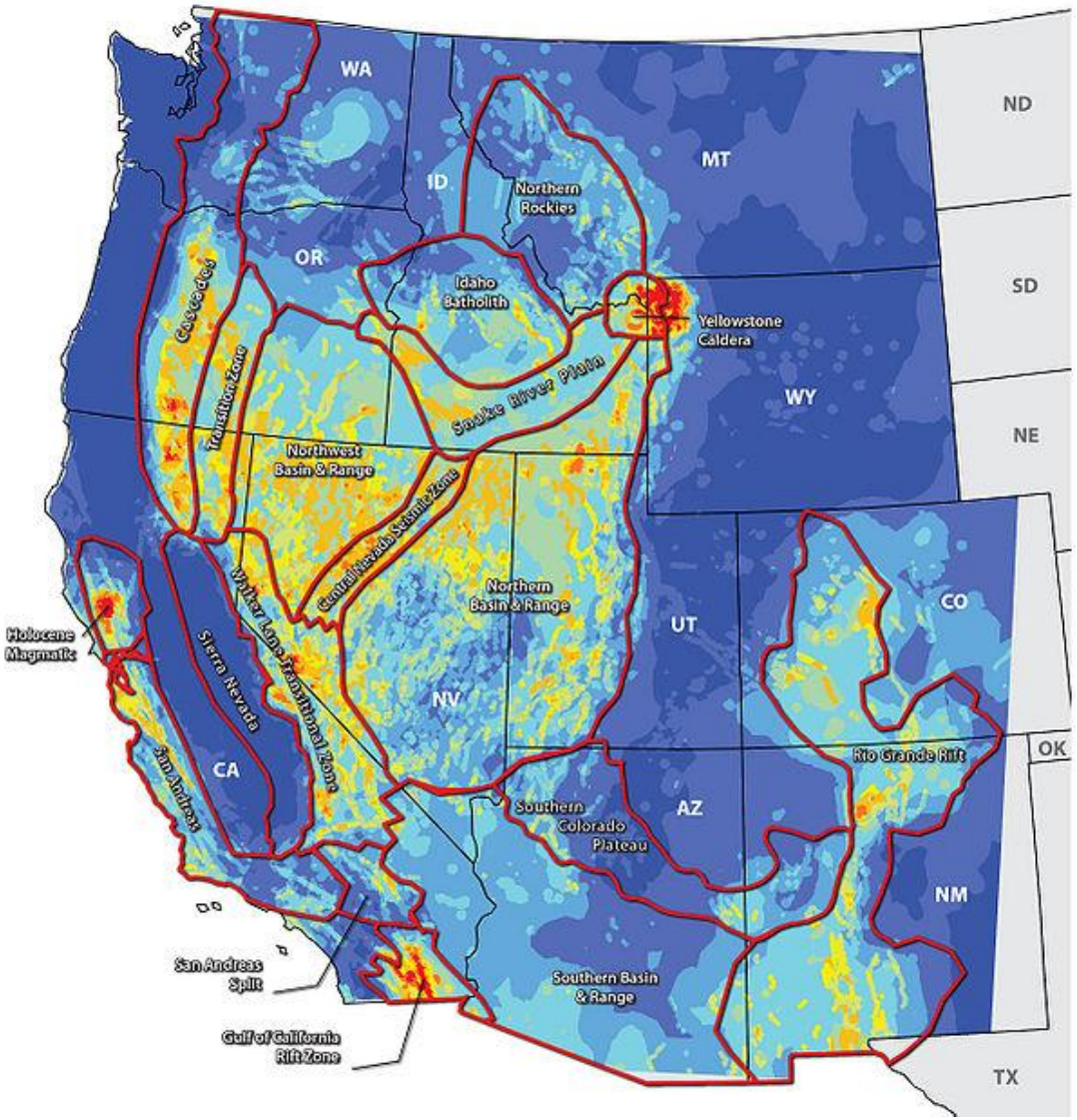
Plate Tectonic Processes Schematic Cross-Section

"Magmatic" Systems
Cascade Range



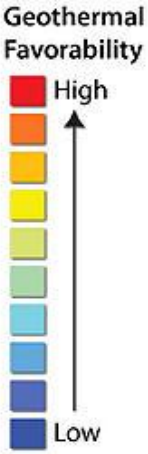
"Extensional" Systems– "Rifting"
Basin and Range
Rio Grand Rift
Imperial Valley
East Africa Rift Valley





Geothermal Exploration Districts and Favorability

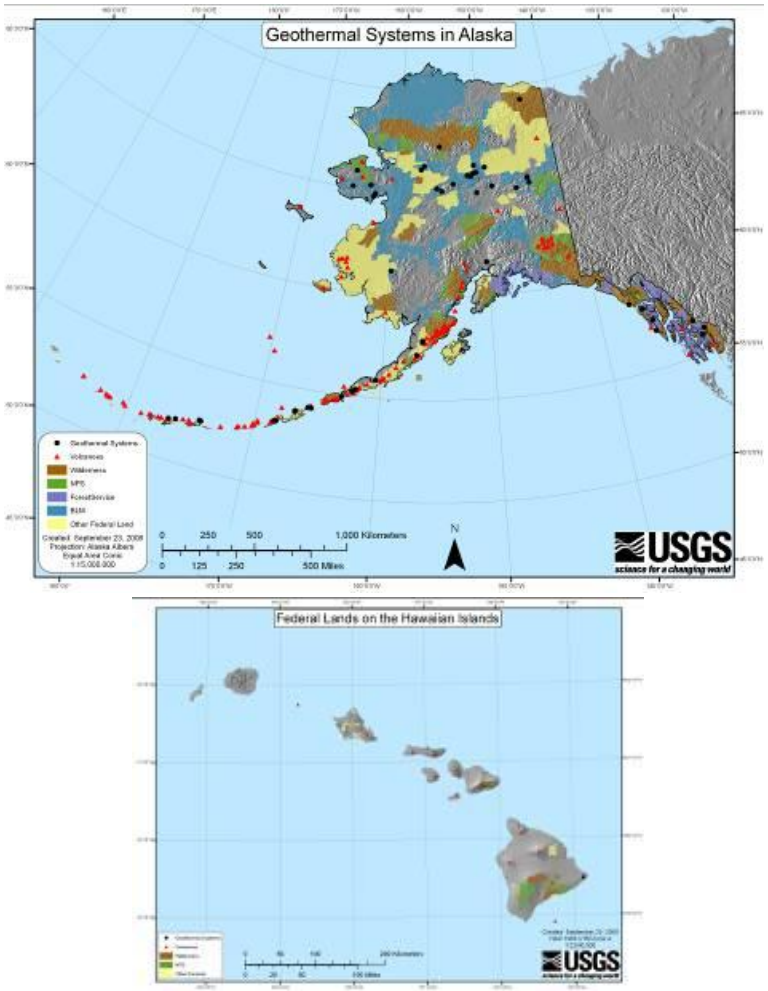
Geothermal favorability is a surface showing relative favorability for the presence of geothermal systems in the western United States. It is an average of 12 models that correlates different geological and geophysical factors to the known presence of moderate (90 - 150° C) to high (> 150° C) temperature geothermal systems. Exploration regions were derived from physiographic regions of the conterminous United States. Data sources: United States Geological Survey.

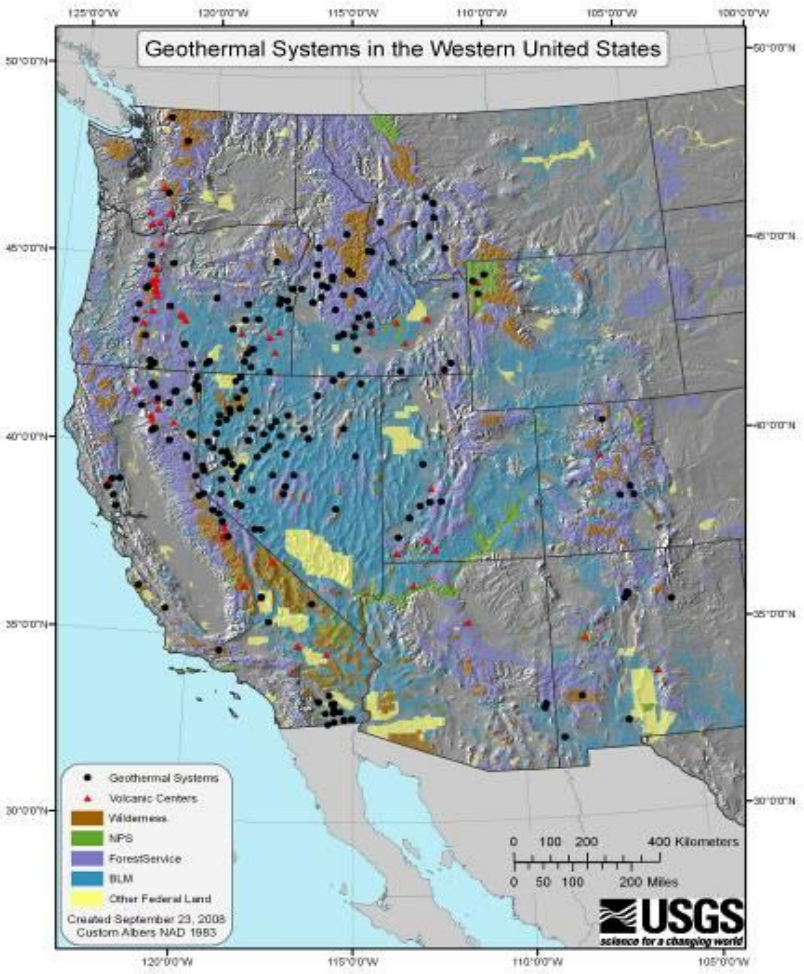


Geothermal Resources(USGS Fact Sheet 2008-3062)

State	Systems	Identified Mean (MWe)	Undiscovered Mean (MWe)	EGS Mean(MWe)
Alaska	53	677	1,788	NA
Arizona	2	26	1,043	54,700
California	45	5,404	11,340	48,100
Colorado	4	30	1,105	52,600
Hawaii	1	181	2,435	NA
Idaho	36	333	1,872	67,900
Montana	7	59	771	16,900
Nevada	56	1,391	4,364	102,800
New Mexico	7	170	1,498	55,700
Oregon	29	540	1,893	62,400
Utah	6	184	1,464	47,200
Washington	1	23	300	6,500
Wyoming	1	39	174	3,000
Total	248	9,057	30,033	517,800

Geothermal Systems and Public Lands

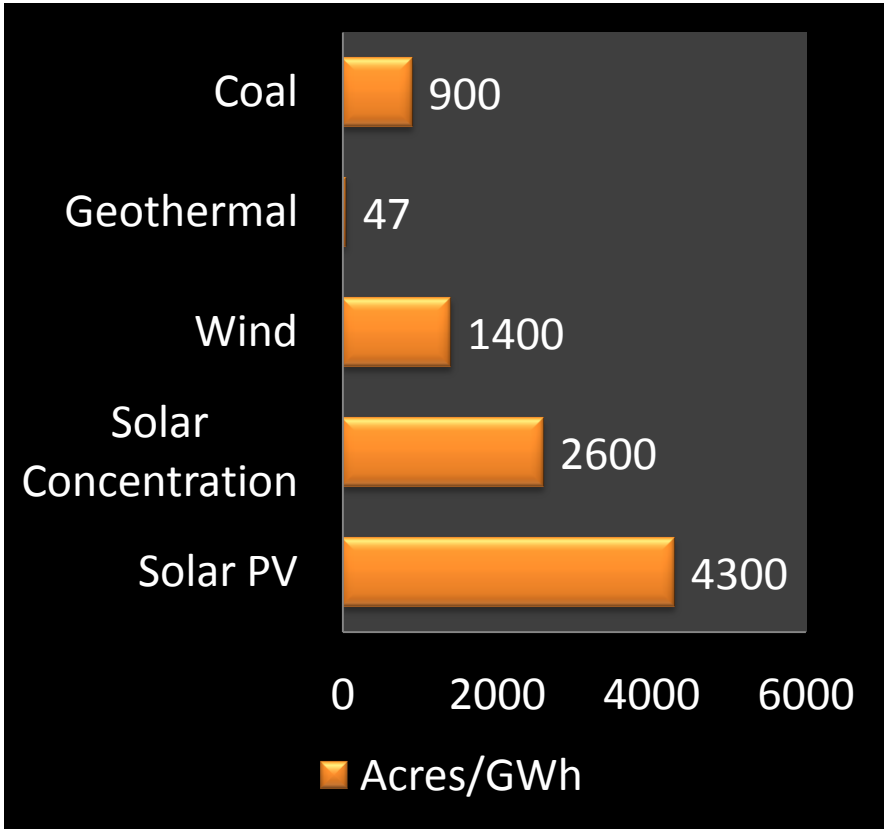




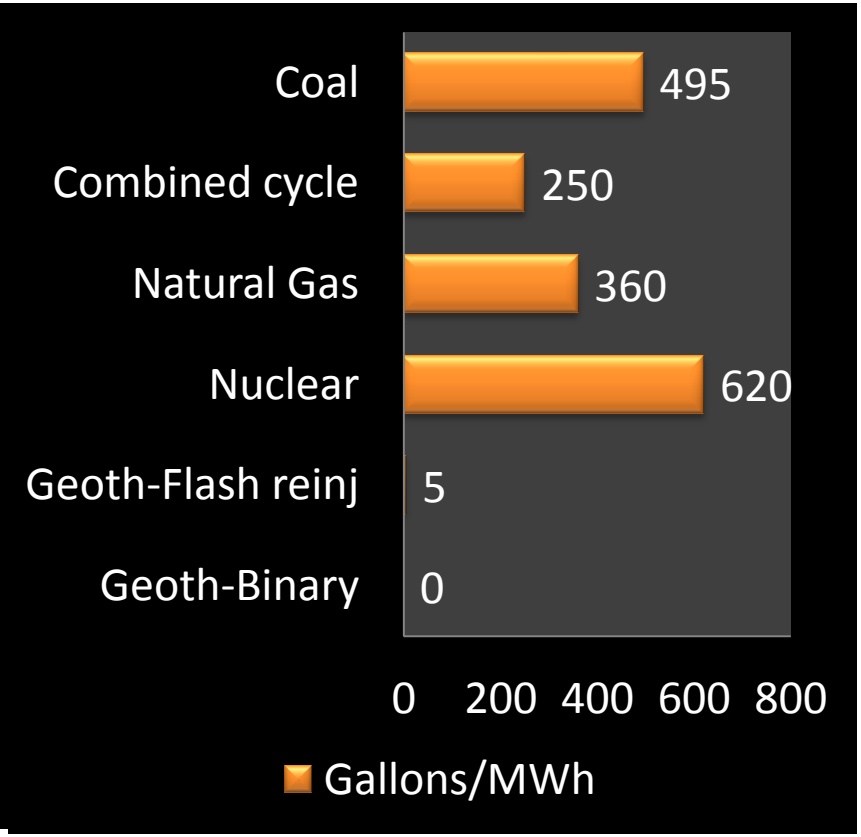
ENVIRONMENTAL IMPACTS

Foot Print and Water Consumption

Land Use by Energy Technology



Water Use by Energy Technology



Power Plant Comparison - Air Emissions

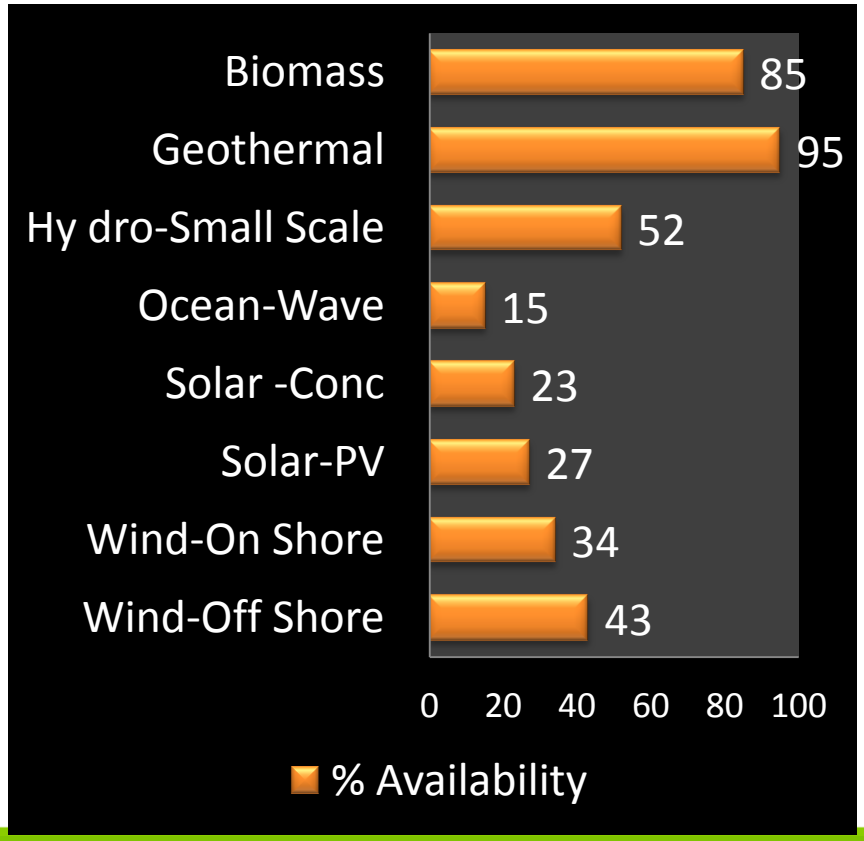
Plant Name	Year	Total MWh produced during specified year	Primary Fuel	NOx Emissions Rate (lbs/MWh)	SO_2 Emissions Rate (lbs/MWh)	CO_2 Emissions Rate (lbs/MWh)
Cherokee Station*	1997	4,362,809	Coal	6.64	7.23	2,077
Cherokee Station	2003	5,041,966	Coal	4.02	2.33	2,154
Sonoma County at The Geysers**	2003	5,076,925	Steam Geo.	.00104	.000215	88.8
Mammoth Pacific***	2004	210,000+	Binary Geo.	0	0	0

*Cherokee is a coal-fired, steam-electric generating station; data on Cherokee plant (Colorado) provided by Xcel Energy.
**Values represent averages for 11 Sonoma County power plants at The Geysers. Data provided by Calpine Corporation as submitted to the Northern Sonoma County Air Pollution Control District for 2003 emissions inventory.
***Data provided by Bob Sullivan, plant manager at Mammoth Pacific, LP
+ Represents average yearly output rather than specific output for 2004.

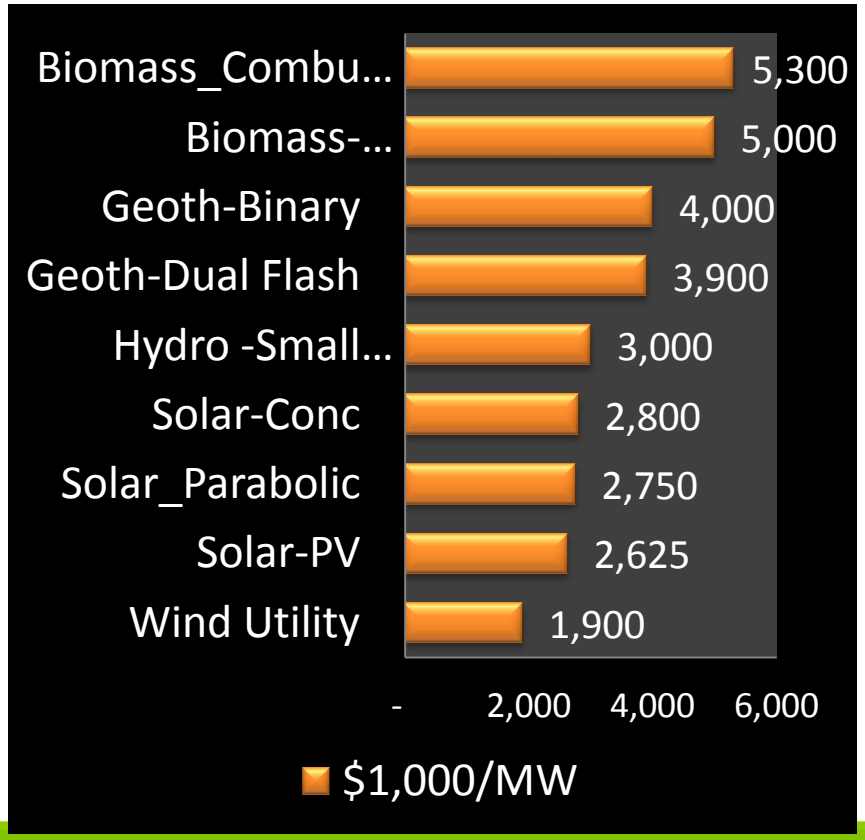
Geothermal Energy Association

Selected Renewable Energy Technologies

Capacity Factors



Investment Cost



GEOTHERMAL TECHNOLOGY – ENERGY CONVERSION

World's 1st Geothermal Power Plant

First Geothermal Power Plant, 1904, Larderello, Italy

Then: 1904

The engine used at Larderello in the first experiment in generating electric energy from geothermal steam, along with its inventor, Prince Piero Ginori Conti.

And Today: 473 MWe

Geothermal Environments

- Hydrothermal Systems
  - High Temperature (>150°C, > 302 °F)
    - Liquid- and Vapor -Dominated
  - Moderate Temperature (90 to 150°C, 194 °F to 302 °F)
    - Liquid-Dominated
  - Low Temperature (<90°C, < 194 °F)
    - Liquid-Dominated
- Hot Dry Rock
  - Enhanced (Engineered) Geothermal System
- Cogeneration
  - Oil and Gas
  - Geopressure

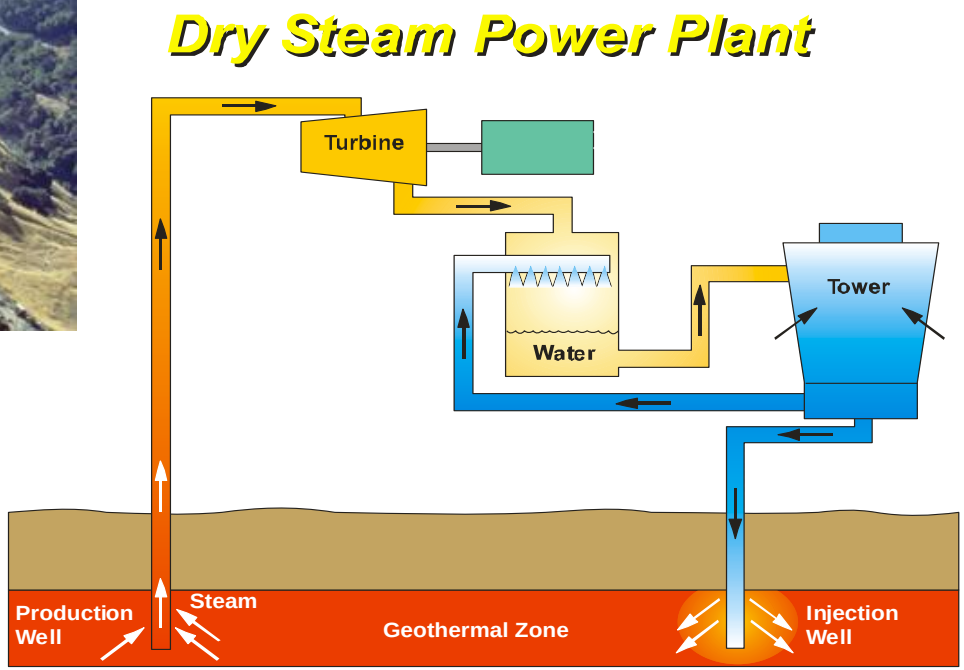
Dry Steam Power Plant (>455º F)

The Geysers Geothermal Area

World's largest dry-steam geothermal field, 22 power plants, total capacity of 750 MWe

Well Depth: 650-3350 M (2130 – 8200 Ft)
Temperature: 240 º- 250º C (460 -480 º F)

Steam is produced directly from the geothermal reservoir to run the turbines that power the generator, and no separation is necessary because wells only produce steam.

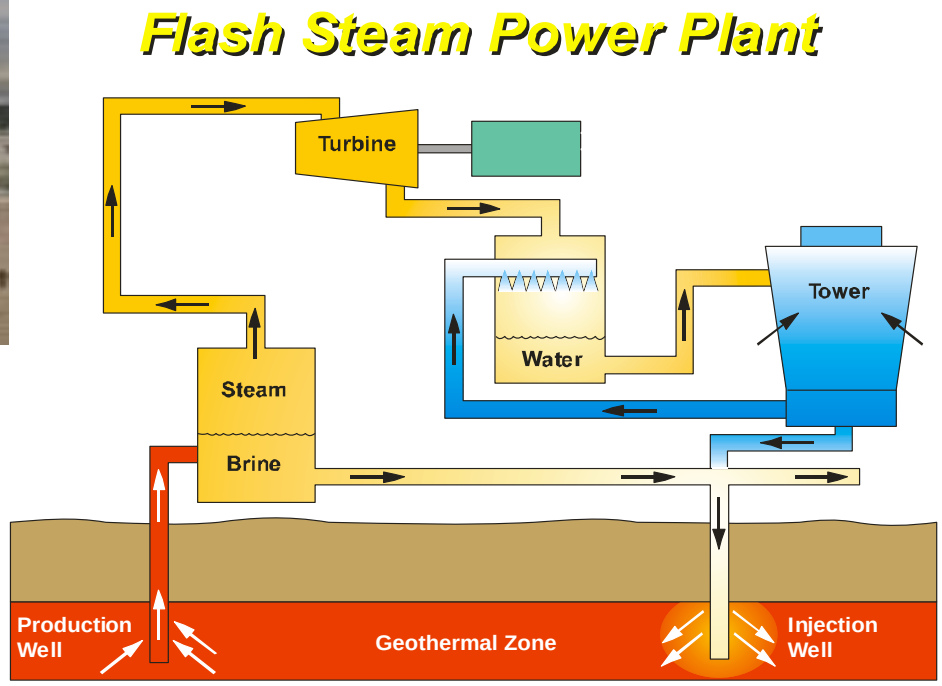


Flash Power Plant (300°F- 700°F)

Blundell Power Plant Flash plant with binary bottom cycling unit

Well Depth: 260 – 2230 M (850 – 7300Ft)
Temperature: : 138 °- 267° C (280-512° F)

Geothermally heated water under pressure is separated in a surface vessel (called a steam separator) into steam and hot water. The steam is delivered to the turbine, and the turbine powers a generator. The liquid is injected back into the reservoir. A dual flash cycle separates the steam at two different pressures and produces 20-30% more power than a single flash cycle at the same fluid flow.

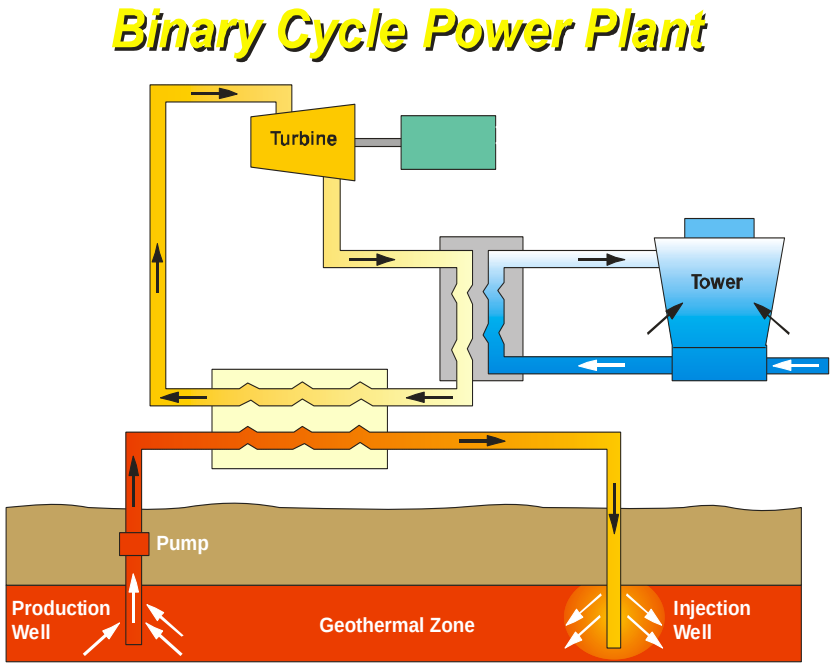


Binary Power Plant (250°F- 360°F)

Mammoth-Pacific Power Plants - Two hydrothermal binary power plants generate enough power for approximately 40 MWe.

Well depth: 150-750 M (490 – 2460 Ft)
Temperature: 150 °- 175° C (300 -350 ° F)

The geothermal water heats another liquid, such as isobutane, which boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid expands into gaseous vapor. The force of the expanding vapor, like steam, turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.



Low Temperature

- *Commissioned July, 2006*
- *1 system, 2nd unit in Dec 06*
- *Lowest geothermal temp in world <165'F*
- *Drivers: Off-Grid, sustainable geothermal power and heat, for multiple applications*

UTC Power
A United Technologies Company

Chena Hot Springs Resort, Alaska: lowest temperature, 165° F, in the world for commercial power production

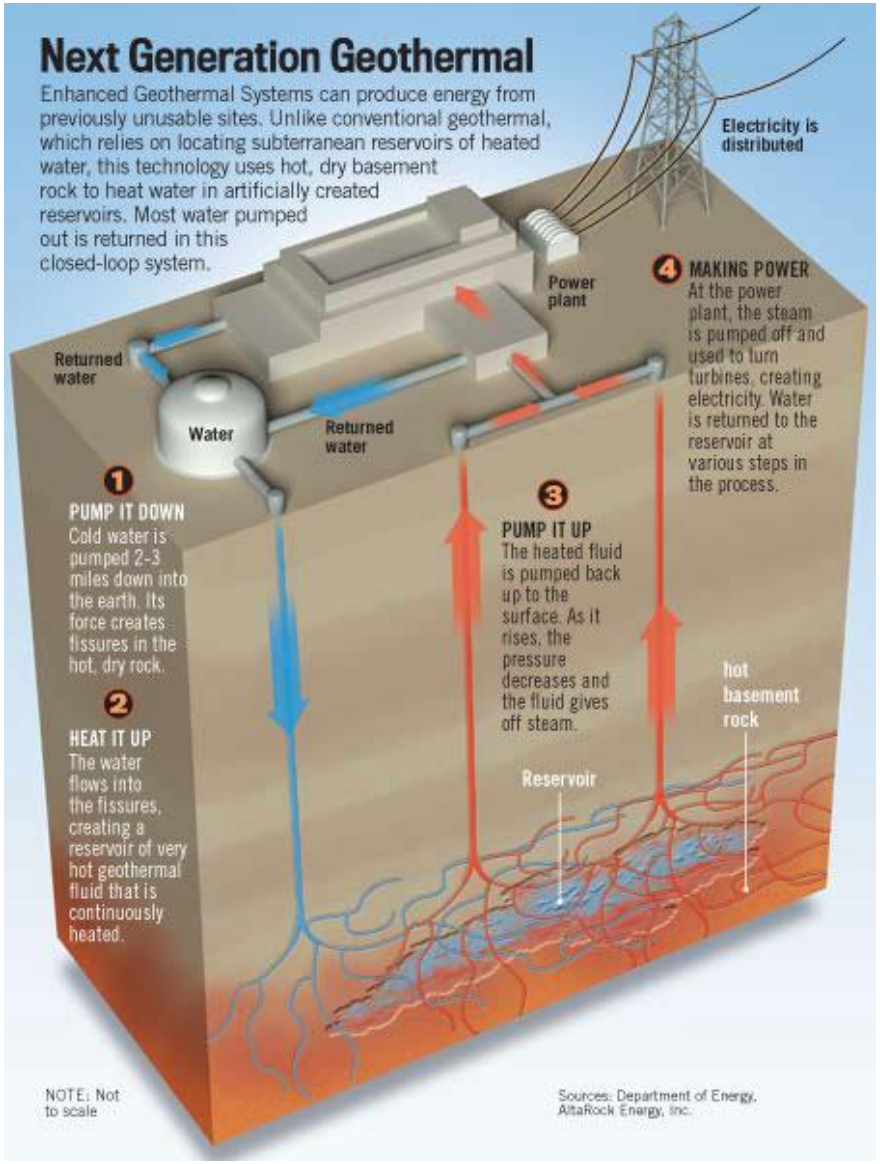
Oil and Gas Well Co-Production and Geopressure

Chena Power LLC: mobile geothermal power plant, partly funded by DOE to showcase low-temperature & coproduced resources.

Rocky Mountain Oil Field Testing Center oil and gas coproduction project with Ormat Technologies: 1st successful generation of electricity from binary geothermal technologies from an existing oil field.

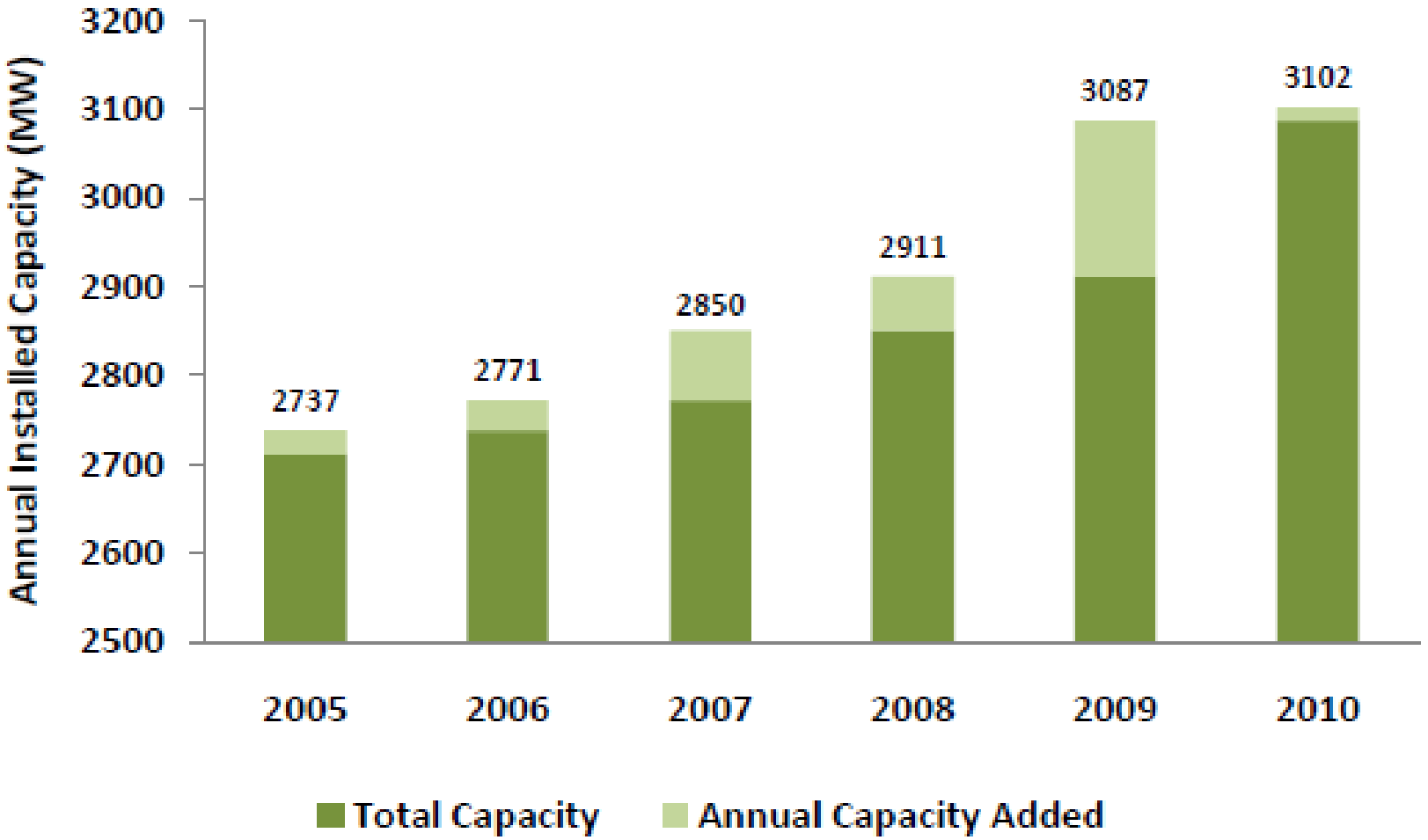
Engineered Geothermal Systems (EGS) The Energy Under Our Feet

EGS projects produce electricity using heat extracted with engineered fluid-flow paths in hot rocks. These pathways are developed by stimulating them with cold water injected into a well at high pressure (AltraRock Energy)



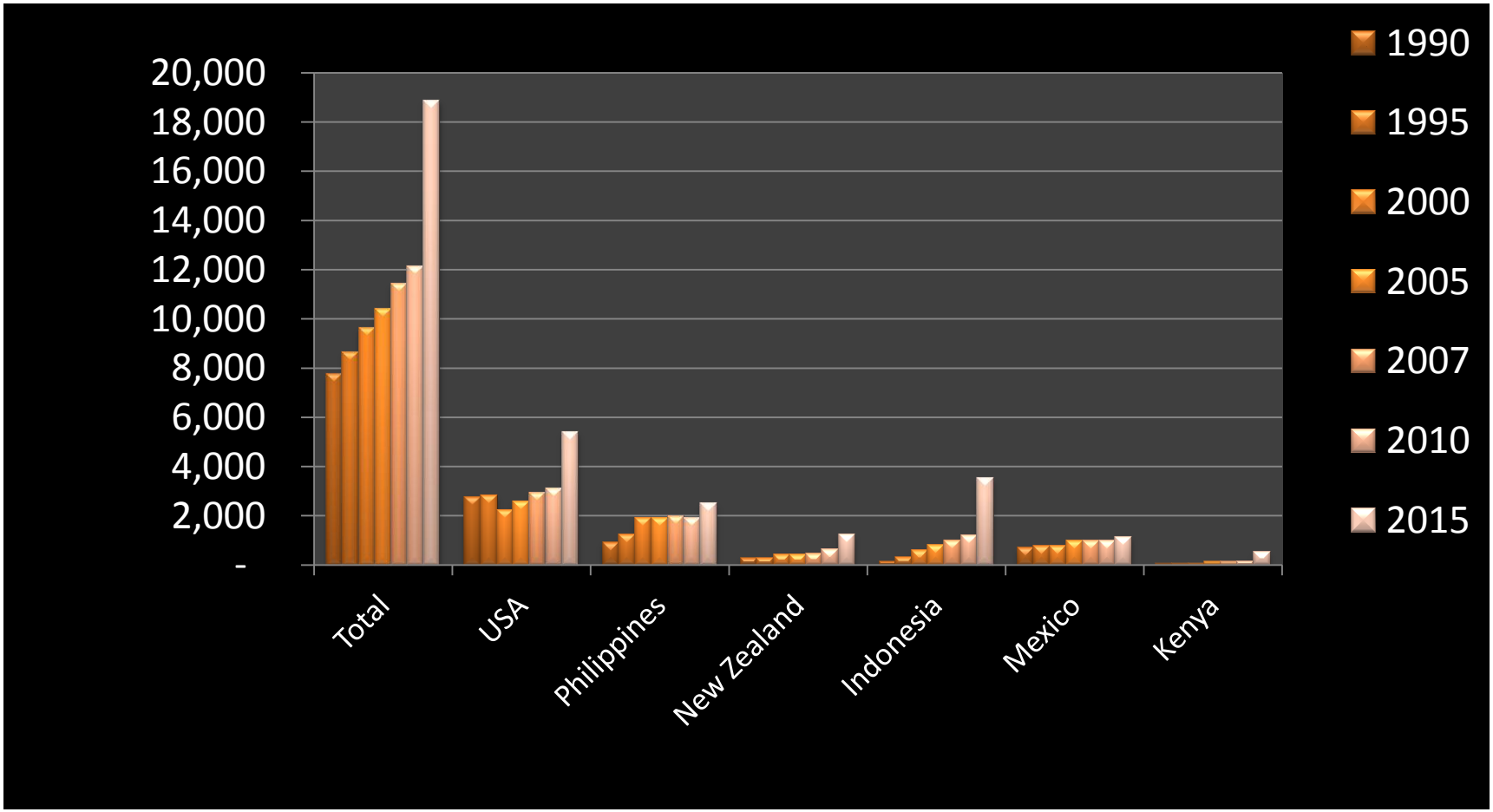
Current Development Projects

Total Installed Capacity 2005 - 2010



Source: GEA

Geothermal Powder: Top Countries. Installed Capacity (MW)



Source: Íslandsbanki Published: 24. 2. 2011

State	# Power Plants	Installed Capacity (MW)	Generation (GWh) 2009*	
Alaska	1	0.73		Chena Hot Springs
California	48	2565.5	13,022	
Hawaii	1	35	168	20 % of Big Island's demand
Idaho	1	15.8	107	
Nevada	21	441.8	1,616	
New Mexico	1	.24		
Oregon	1	0.28		Oregon Institute of Technology – Klamath Falls Campus
Utah	3	42	279	
Wyoming	1	0.25		DOE-Rocky Mtn Oil Test Center
TOTALs	78	3,102	15,192	

* EIA, Energy Statistics

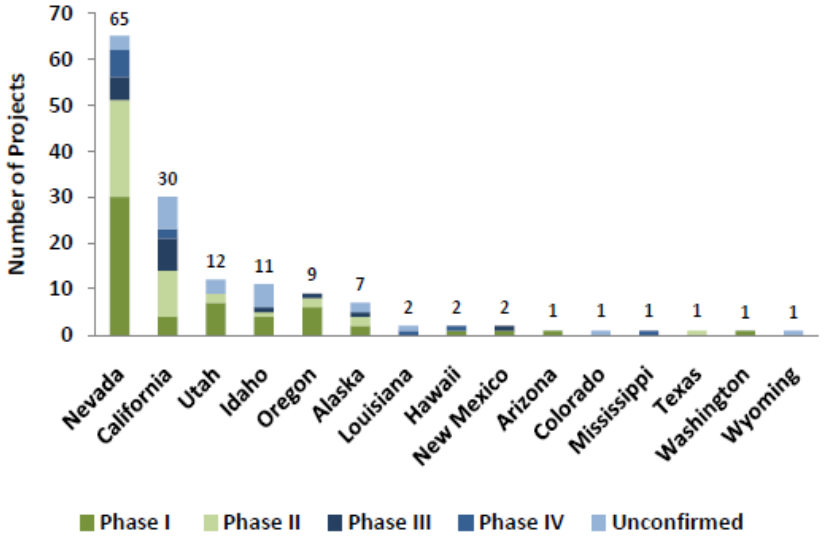
Total Projects in Development Totals by State

State	Phase 1 - 4 Development			
	Total Projects	PCA (MW)	Resource (MW)	Overall Total (MW)
Alaska	7	50	95	120
Arizona	1	2	0	2
California	30	712-738	1212-1358	1596-1768
Colorado	1	10	0	10
Hawaii	2	8	0	8
Idaho	11	26	589-664	589-664
Louisiana	2	0.05	5	5
Mississippi	1	0.03	0	0.03
Nevada	65	638-648	2132-2408	2250-2536
New Mexico	2	15	0	15
Oregon	9	111	225-250	276-301
Texas	1	1	0	1
Utah	12	40-55	90-160	130-215
Washington	1	0	100	100
Wyoming	1	0.28	0	0.28
Totals:	**146**	**1613-1664**	**4448-5040**	**5102-5745***

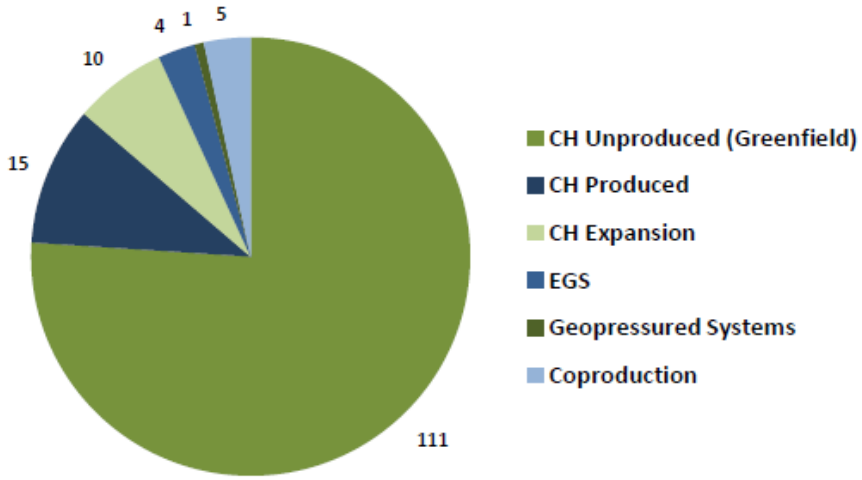
Source: GEA

*PCA and Resource Totals do not add up to Overall Totals because they have been adjusted to avoid double counting. In cases where respondents gave both a PCA value and resource value, it was assumed that the PCA was already included in the stated resource total. In

Growth of Geothermal Projects and Prospects



Source: GEA



Source: GEA

Geothermal Leasing and Development

Geothermal
Policy Drivers, Incentives & Programs

DOE Geothermal Technologies Program

- Instrumental in implementation of many of the incentives and subsidies that offset the risk and high upfront capital cost

Production Tax Credit

- Eligible power plants placed in service by 12/31/2013

Energy Policy Act of 2005

- Geothermal Leasing (PGEIS, Lease Sales)
- Geothermal Revenue Sharing with Counties
- Section 1705 – loan guarantees in lieu of PTC ($175.6M)

American Recovery and Reinvestment Act (AARA)

- DOE Cost-Share Geothermal Investment (total $666.4 M)

Renewable Energy Portfolio Standards

Geothermal Development Process

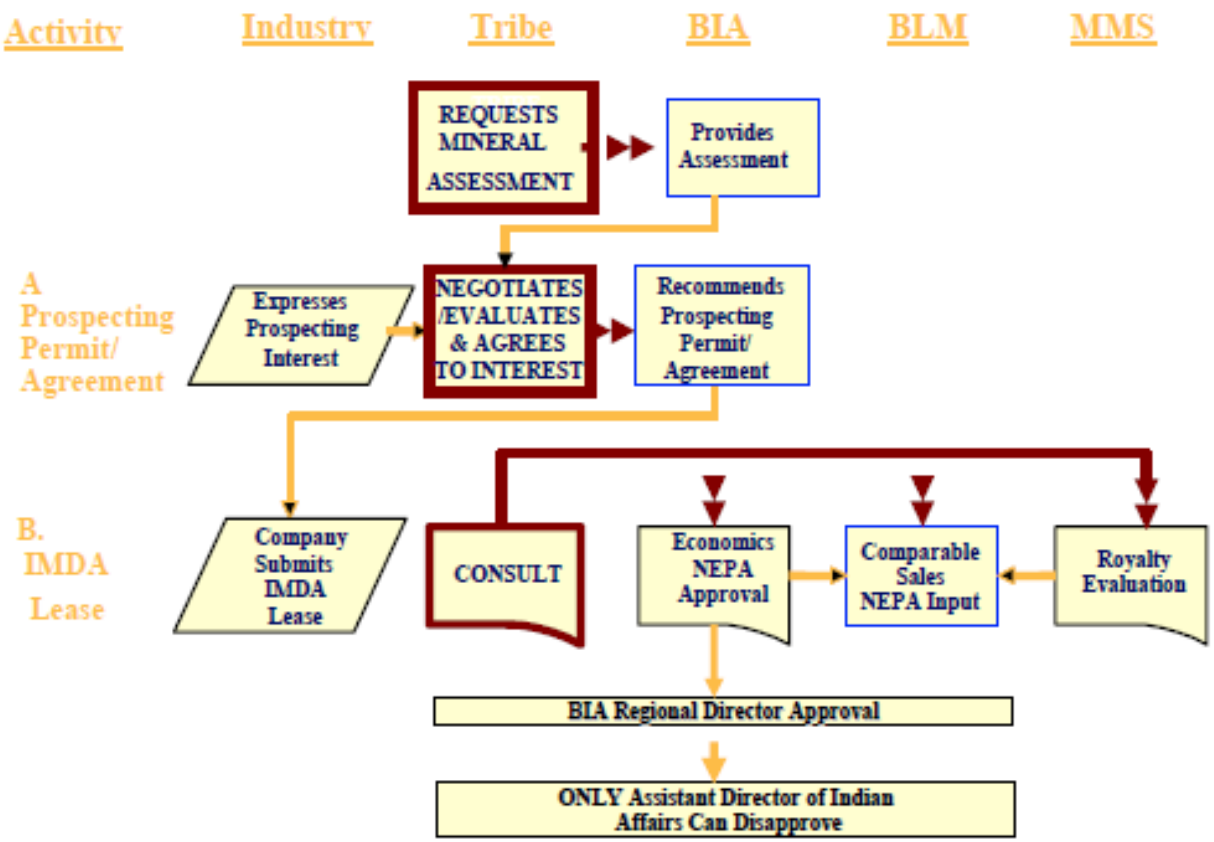
- Lease acquisition
  - Leasing: 25 CFR 211 - LEASING OF TRIBAL LANDS FOR MINERAL DEVELOPMENT
  - IMDA: 25 CFR 225 — OIL AND GAS, GEOTHERMAL, AND SOLID MINERALS AGREEMENTS
- Exploration activities
- Drilling production & injection wells
- Utilization
  - Power plants
  - Direct use facilities
- Abandonment of wells & facilities
- Reclamation of surface

Agency Responsibilities

	BIA	BLM	ONRR*
Geothermal Leasing (25 CFR 211 - LEASING OF TRIBAL LANDS FOR MINERAL DEVELOPMENT)	Advisory approval	Resource evaluation, minerals appraisal	
Indian Minerals Development Act (25 CFR 225 — OIL AND GAS, GEOTHERMAL, AND SOLID MINERALS AGREEMENTS)	Advisory, Approval	Resource evaluation, minerals appraisal	
Exploration Operations		Geophysical exploration, including TGWs	
Geothermal Drilling Operations		Geothermal drilling permit approvals	
Utilization of Geothermal Resources		Plant construction, transmission	
Geothermal Resources Unit Agreements		Approval	
Accounting and Auditing		Verification of production	Auditing, collection of revenues, disbursement to tribe/allotment owner

* - Office of Natural Resources Revenue (formally MMS)

IMDA Process



Source: California Geothermal Energy Collaborative, 2006
California Tribal Workshop

Geothermal Permitting - Exploration

Overview of Exploration Permitting

Definition

(43 CFR 3200.1)

Any activity that:

- requires physical presence on the land
- may cause damage to those land

Exploration Permitting Requirements

All Activities

- Evidence of Bond Coverage
- Notice of Intent (Form 3200-9
  - Estimate of surface disturbance
  - Measure to protect the environment
  - Reclamation methods
  - Other information that may be required

For Temperature Gradient Well (TGW)

- 12 items required (43 CFR 2151.11c)

Other than TWG

- accurate description
- starting and ending dates

Exploration Includes:

- Construction of Roads & Trails
- Cross-Country Transit
- Geophysical Operations
  - Gravity
  - Magnetics
  - Seismic exploration
- Geochemical Sampling
- Drilling
  - Temperature Gradient Holes
  - Drilling of Shot-holes
  - Core-Drilling

Exploration does not include:

- Direct testing of geothermal resource
- Drilling of production or injection wells

Exploration Operations

Exploration Bonding

- Necessary prior to surface disturbance
- Amounts (minimum):
  - $5,000 single operation
  - $25,000 for all operations in a single state
  - $50,000 for all operations nationwide
- Released:
  - After request (not automatic)
  - All wells P&A'd
  - Surface reclaimed

Geothermal Permitting - Drilling

- **Geothermal Drilling Permit**

The Geothermal Drilling Permit describes the operational aspects of well drilling, including:

- Description of equipment, materials & procedures
- Proposed depth
- Directional specifics, including plan & vertical section
- Casing & Cementing program
- Circulation media (drilling fluids)
- Log description
- Blow Out Prevention Equipment (BOP)
- Fresh Water Zones
- Anticipated Reservoir Temperature & Pressure
- Anticipated Temperature Gradient
- Survey Plat by Licensed Surveyor
- Procedures and durations of well testing
- Well stimulation –hydro-fracturing
- Any other information the BLM requires

General Rules

- Do not start work until approved
- Operator must notify local BLM prior to initiating work
- File NOI on Sundry Notice
  - If not previously submitted, include all well completion data
  - Address all 6 items required (43 CFR 3263.11)
- BLM may grant oral approval - but operator must submit required info within 48 hrs.
- Restore the surface

BLM may require abandonment

- If well is no longer needed
- If well is not mechanically sound

GDPs – Bonding

Drilling Operations Bonding

- Necessary prior to surface disturbance
  - No Cash Bonds
  - Only LOC or Surety
- Amounts (minimums)
  - $10,000 for individual lease
  - $50,000 for statewide
  - $150,000 for nationwide
- Released:
  - After request (not automatic)
  - All wells P&A'd
  - Surface reclaimed

GDPs – Miscellaneous

Miscellaneous -

- The drilling permit, drilling program and operations program can be submitted together
- If Operations Plan submitted separately
  - Submit prior to drilling permit & program
  - Sundry notice for well pad construction
- Operations plan and drilling program can cover several wells, but each drilling permit is well specific
- Subsequent changes to drilling plan via sundry notice
  - Oral approval option

Well Testing

Exploration Operations

Abandonment

- When no longer necessary
- When BLM requires it
- File NOI on Sundry Notice
- Do not start work until approved

Reports

- Your lease, submit all data
- Unleased acreage or other parties lease, not required to submit unless for Diligent Exploration Expenditure (DEE)
- Signed NOC 30 days after operations conducted

Confidential Information

- Held confidential per FOIA provisions (all Indian mineral data is confidential)
- Details at 43 CFR Part 2

GDPs – Abandonment

Plugging and Abandonment

- Do not start work until approved
- Operator must notify local BLM prior to initiating work
- File NOI on Sundry Notice
  - If not previously submitted, include all well completion data
  - Address all 6 items required (43 CFR 3263.11)
- BLM may grant oral approval -
  But operator must submit required info within 48 hrs.
- Restore the surface
- BLM may require abandonment
  - No longer needed
  - Not mechanically sound

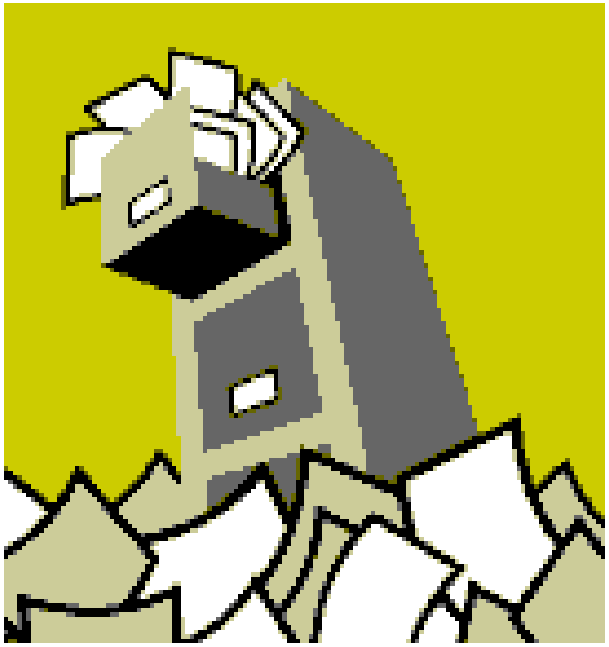
GDPs – Reports

Reports (43 CFR 3264)

- Newly completed wells
  - Completion Report (Form 3260-4)
  - 30 days after completion
  - 4 specific data items
- Subsequent Workovers
  - Subsequent Report
  - 30 Days following activity
  - 5 specific data items
  - BLM may waive this for routine operations

Confidential Information (43 CFR 3266)

- Held confidential per FOIA provisions
- Details at 43 CFR Part 2
- Items not held confidential:
  - Surface location
  - Surface elevation
  - Well status



Geothermal Permitting - Utilization

Types of Geothermal Utilization

Direct

- Applicant filed
- Can be issued non-competitively if no interest after 90 days
- State, Tribal, or Local Governments use resource without sale and for public purposes other than commercial generation of electricity

Indirect

- Heat energy is used indirectly, most common is Electrical Generation
- EPAct requires nominated tracts to first go through competitive process
- After sale goes over the counter (retains configuration for 30 days)

Provision for Mining Claims

- Provision in EPAct
- Allows mining claimants to obtain a non-competitive geothermal lease to avoid “top-filing” and utilize the resource
- Approved mining plan of operations

DEVELOPERS' Permitting Checklist

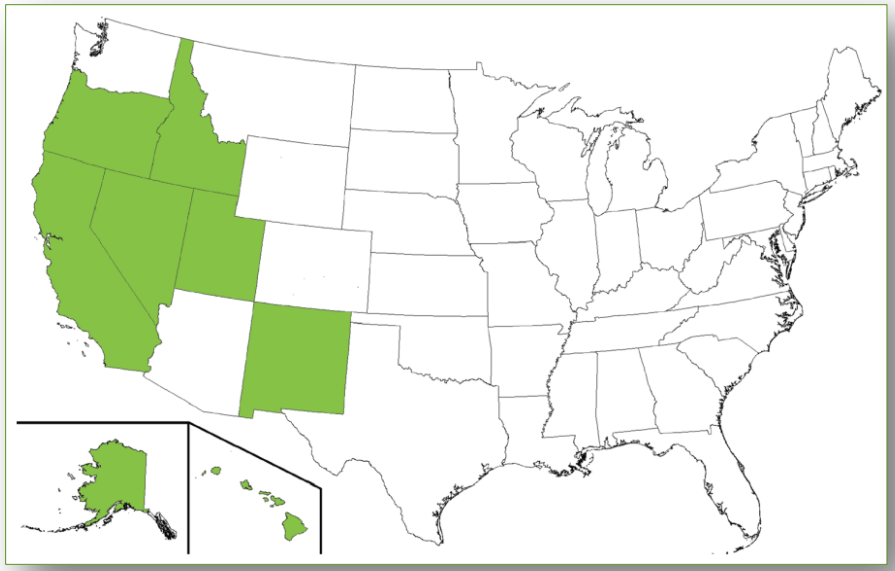
DATA COLLECTED FOR:

http://www.nrel.gov/geothermal/developer_checklist

- 12 steps (see next slide)
- 8 states (AK, CA, HI, ID, NV, NM, UT, WY)

LEVELS OF DATA:

- 2 main levels: federal, state
- Sublevels: Land Ownership
  - federal (BLM, NFS)
  - private (if applicable and available)



AUDIENCE:

- Project developers scoping out potential projects
- Project developers developing at a selected location (known state, land owner)
- Investors looking at permitting process of potential investment
- State/local agencies looking to develop and/or improve permitting process – can compare permitting process/regulations in other states

NOTE:

- The checklist is a starting point—developers should work with local stakeholders, supporting organizations, local agencies, and professional experts to maximize their project's success.

Geothermal Financing Overview

Office of Indian Energy Webcast: Overview of Geothermal Energy Development
January 10, 2012

Paul Schwabe

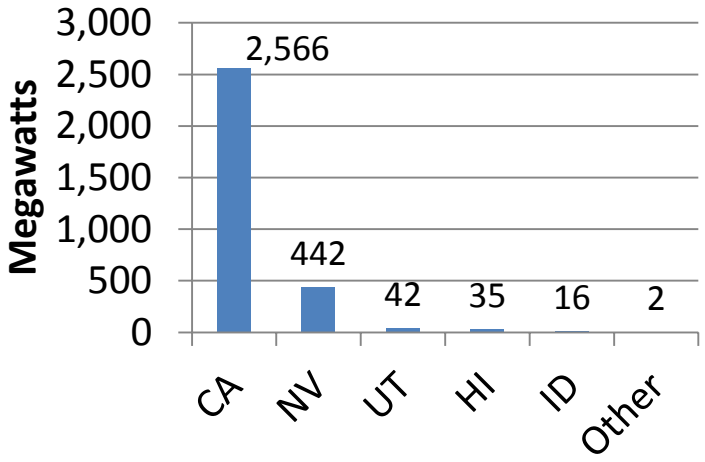
National Renewable Energy Laboratory

Agenda

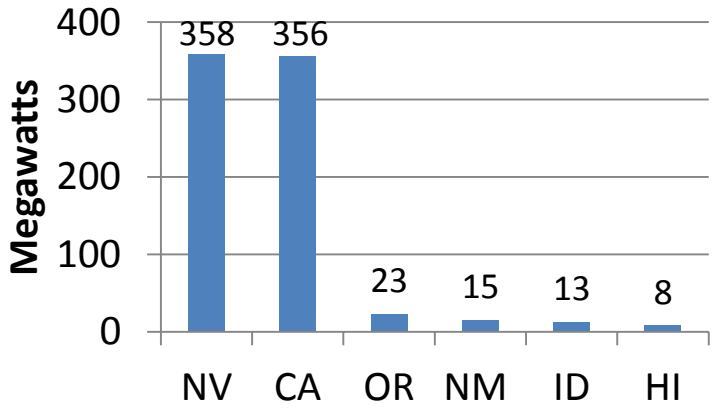
1. U.S. Geothermal Market Snapshot
2. Federal Incentives for Geothermal Energy
3. Geothermal Project Development and Finance
4. Challenges to Financing Geothermal
5. Key Takeaways and Resources

Geothermal Energy in U.S.

U.S. Cumulative Installed Capacity in 2011



U.S. Capacity in Drilling or Construction Phase

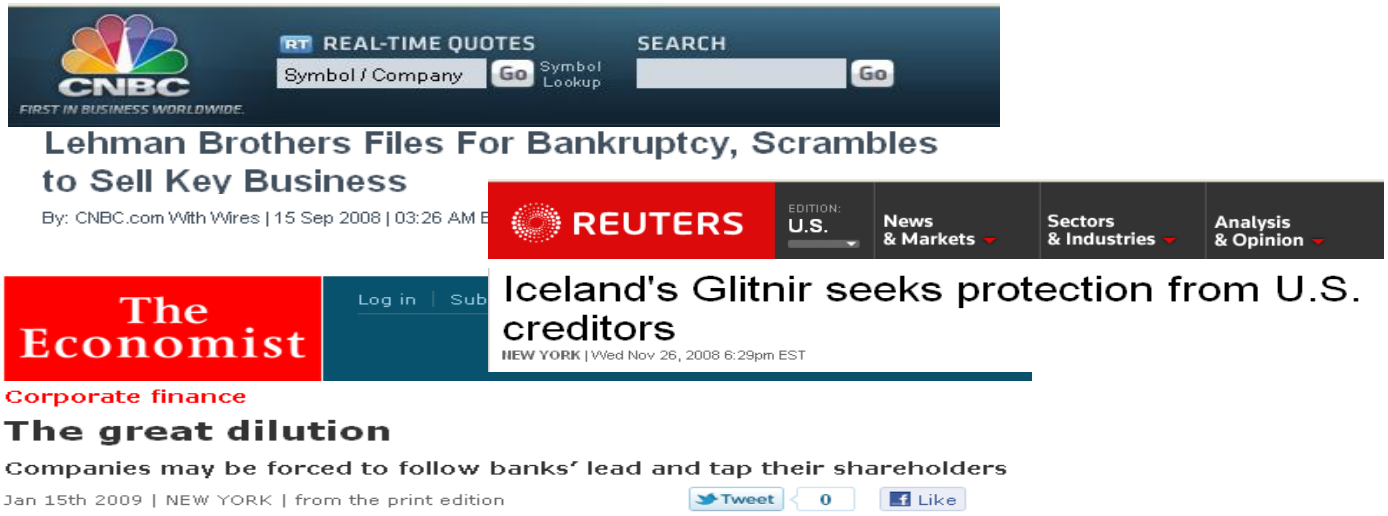


Source: "Annual U.S. Geothermal Power Production and Development Report," Geothermal Energy Association.

Industry Development in 2010-2011:

- One 15MW project came online in U.S. in 2010
- One 8.6 MW project reached "Mechanical Completion" in U.S. in 2011

Lingering Difficulties of the 2008-2009 Financial Crisis on Geothermal Development



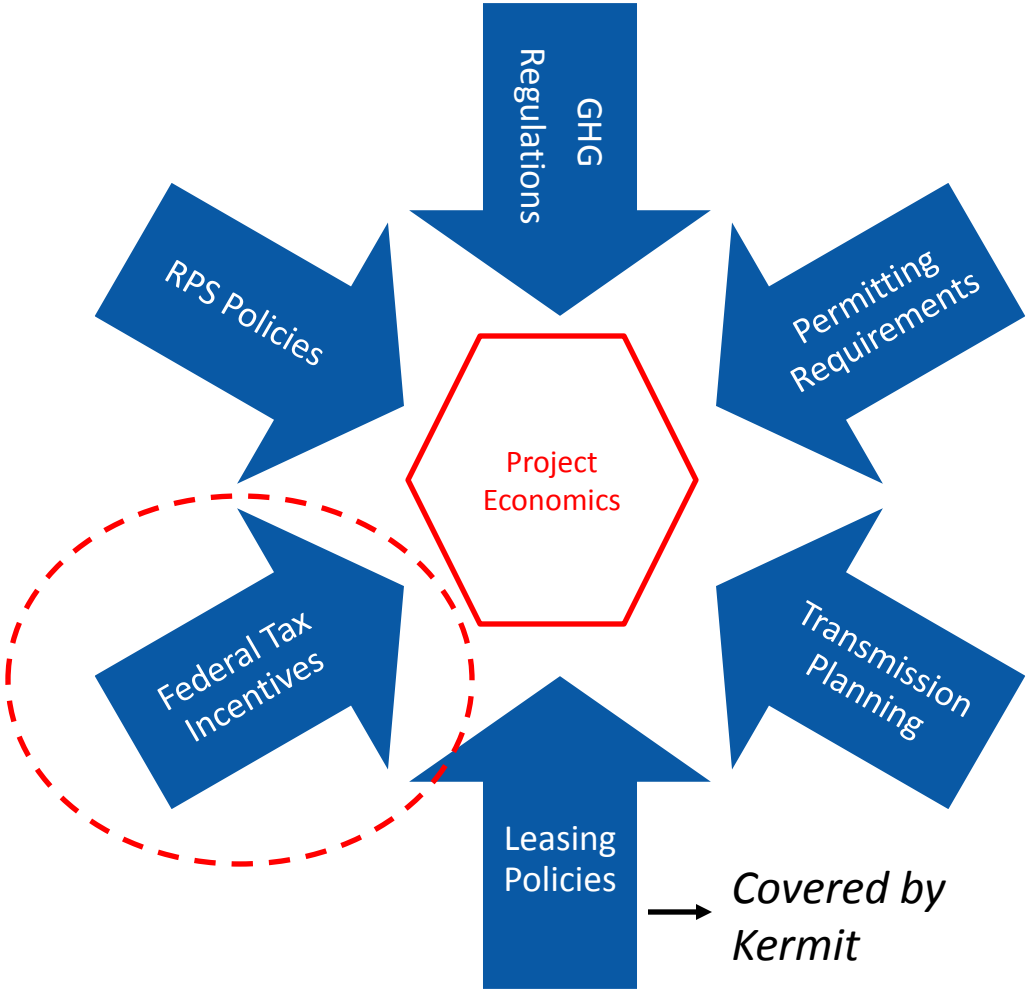
Lower Risk Tolerances and Shortages of Investment Capital

- During the economic downturn, some investors left the market, and those that remained adjusted their tolerance for risk
- Bloomberg New Energy Finance expects that 2011 was "bottom of the trough" for geothermal market development *(Geothermal Market Outlook Q2 2011)*

Agenda

1. U.S. Geothermal Market Snapshot
2. Federal Incentives for Geothermal Energy
3. Geothermal Project Development and Finance
4. Challenges to Financing Geothermal
5. Key Takeaways and Resources

Policies Impacting Geothermal Profitability



Focus of this presentation

Federal Financial Incentives for Geothermal

Financial Incentive		Description	Timing	Tax Liability Required	Relevant Dates
Choose only one	Production Tax Credit (PTC)	2.2 cents / kWh years	First 10 years	Yes	In service by 12/31/13
	Investment Tax Credit (ITC)	30% of eligible tax basis	At end of 1st tax year	Yes	In service by 12/31/13
Modified Accelerated Cost Recovery System		Accelerated depreciation 5-6 years	At end of first 6 tax years	Yes	None

Note: Non-exhaustive. For example a diminished 10% ITC is available for projects in service by 12/31/16. Timing and value of federal incentives may change with future federal legislation.

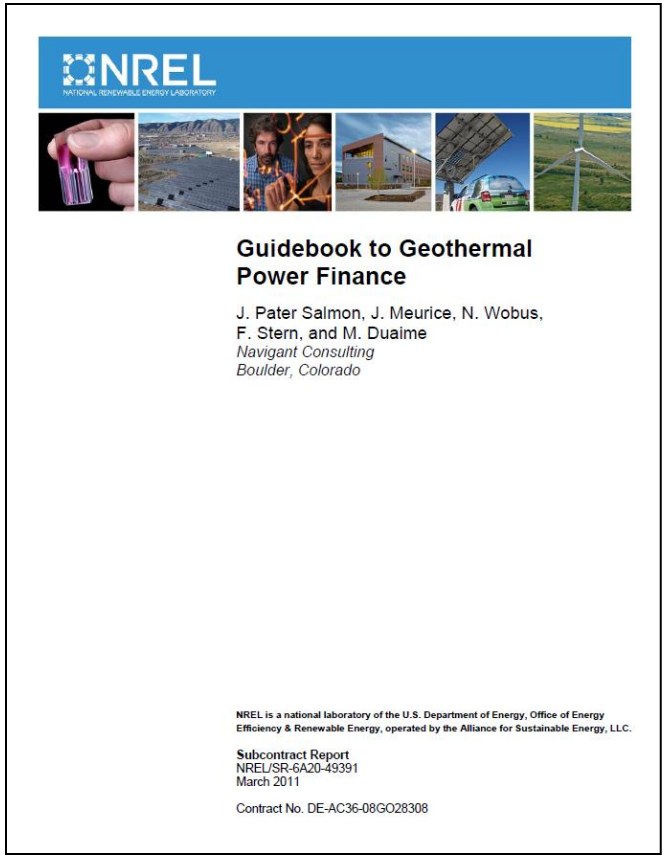
If utilized, these incentives can recover around half of geothermal project's total installed cost *

•*See: https://financere.nrel.gov/finance/content/chicken-every-pot-there-enough-tax-equity-sustain-re-market*

Agenda

1. U.S. Geothermal Market Snapshot
2. Federal Incentives for Geothermal Energy
3. Geothermal Project Development and Finance
4. Challenges to Financing Geothermal
5. Key Takeaways and Resources

Geothermal Financing Information


NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Guidebook to Geothermal Power Finance

J. Pater Salmon, J. Meurice, N. Wobus, F. Stern, and M. Duaime
Navigant Consulting
Boulder, Colorado

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Subcontract Report
NREL/SR-6A20-49391
March 2011

Contract No. DE-AC36-08GO28308

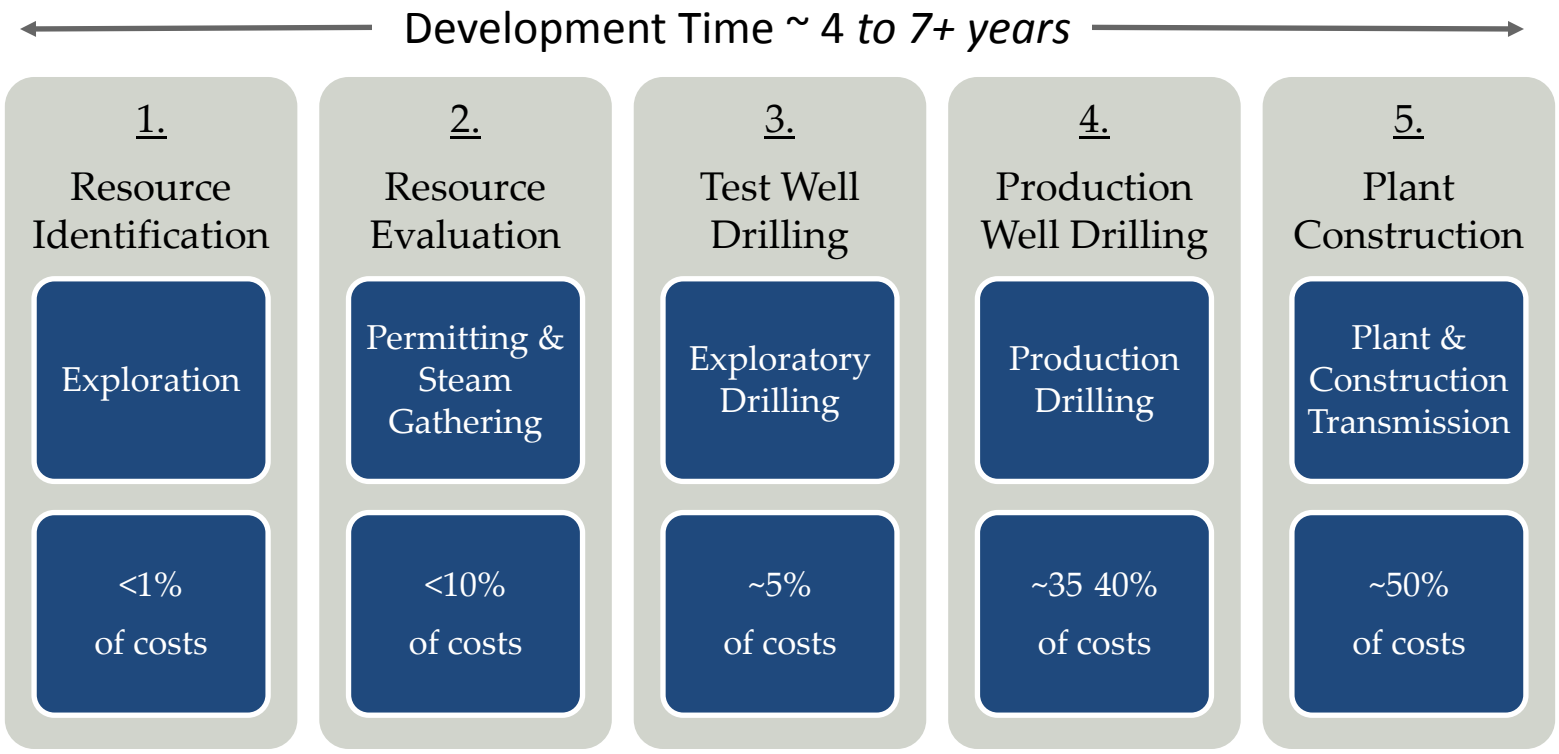
Guidebook to Geothermal Power Finance

- Geothermal Electric Power
- Conventional Technologies
- Utility Side of Meter (i.e. several MWs)

Distilled Information available at:

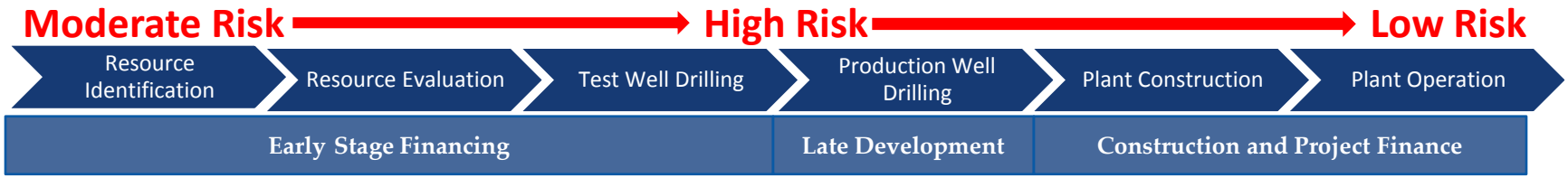
http://www.nrel.gov/geothermal/financing/

Stages of Geothermal Development



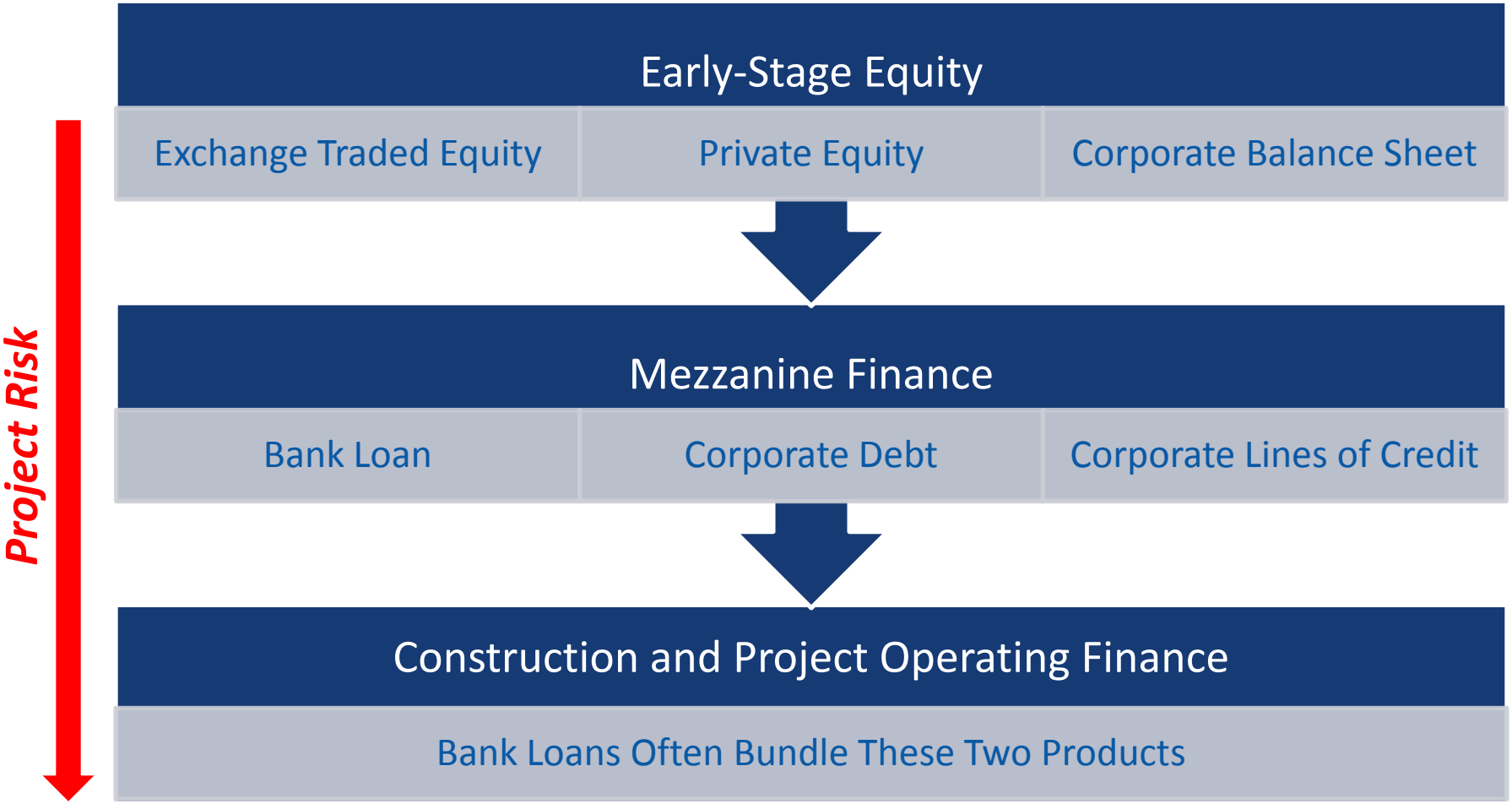
Source: Adapted from "2008 Geothermal Technologies Market Report," U.S. DOE, July 2009.
http://www1.eere.energy.gov/geothermal/pdfs/2008_market_report.pdf

Staging of Geothermal Financing & Development

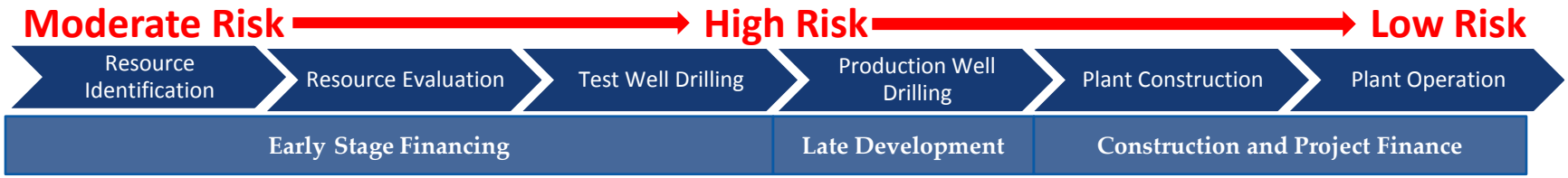


Multiple investors with diverse risk profiles are typically needed to raise the capital needed for geothermal power projects

Sources of Funds for Geothermal Financing



Staging of Geothermal Financing & Development



Non Financial Requirements / Milestones

- » Experienced and qualified management team
- » Risk mitigation strategies in place
- » PPA with creditworthy counterparty
- » Resource assessment from a well-respected firm
- » Drilling contract in place
- » Engineers' report affirming resource availability for 20 years
- » At least 50-80% of production wells drilled
- » Engineering, procurement, construction (EPC) contract

Examples of Recent Financing Strategies

Financing Type	Financing Cost	Example
Exchange Traded Equity / Public Issuance	High	•Ram Power •ENEL Power •Ormat •Calpine Corporation
Private Equity	High	•Gradient Resources / Vulcan Power •Terra-Gen Power
Mezzanine Finance	Moderate to High	•Glitnir Bank / Islandsbanki
Balance Sheet	Moderate	•Ormat •Chevron Corporation
Construction / Permanent Financing	Moderate to Low	•Common industry practice

Agenda

1. U.S. Geothermal Market Snapshot
2. Federal Incentives for Geothermal Energy
3. Geothermal Project Development and Finance
4. Challenges to Financing Geothermal
5. Key Takeaways and Resources

Challenges to Financing Geothermal: Failing to Plan for Risk

Risk Not Adequately Accounted For

- Failure to plan for the unexpected
- Inadequate contingency funds
- "The process takes longer and costs more than anticipated" – Daniel Fleischman, Ormat

Seeking Funding from Improper Source

Seeking Financing before Meeting Milestones

Challenges to Financing Geothermal: Seeking Funding from Improper Source

Risk Not Adequately Accounted For

Seeking Funding from Improper Source

- Must match investor risk appetite with appropriate project stage
- At best, results in extended project timeline
- At worst, inability to secure financing

Seeking Financing before Meeting Milestones

Challenges to Financing Geothermal: Seeking Funding before Meeting Milestones

Risk Not Adequately Accounted For

Seeking Funding from Improper Source

Seeking Financing before Meeting Milestones

- Must meet milestones/metrics set by investors at each stage
- Similar consequences as seeking funding from improper source

Agenda

1. U.S. Geothermal Market Snapshot
2. Federal Incentives for Geothermal Energy
3. Geothermal Project Development and Finance
4. Challenges to Financing Geothermal
5. Key Takeaways and Resources

Key Takeaways

- No magic bullet for financing geothermal power projects
- Innovative approaches to investment in geothermal power projects leverage state and federal policies and target specific investor profiles
- Staging investment enables project developers to match the project's risk profile at a given stage with investors' risk tolerance
- Developers can address key challenges to financing geothermal power projects by being aware of investors' requirements and needs

Additional Information:

- DOE's Tribal Energy Program:

http://apps1.eere.energy.gov/tribalenergy/

- DOE's Geothermal Technologies Program:

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

- NREL's Financing Geothermal Power Projects:

http://www.nrel.gov/geothermal/financing/

Thank You!

Paul Schwabe
Renewable Energy Financing Analyst
National Renewable Energy Laboratory
(303)-384-7468
paul.schwabe@nrel.gov

Guide to Geothermal Power Finance Online Resource

www.nrel.gov/geothermal/financing

Geothermal Investment by Utilities

- Utilities have not been fully active in geothermal project investment for reasons listed below, however
- One important role that utilities do play is to sign contracts for geothermal power and RECs that are fundamental to financing projects

Unfamiliarity
Utilities are unfamiliar with the technology.
Similarly, regulators are not familiar with technology.

Insufficient Returns
Utilities' approved rates of return are not sufficient to accommodate the early stage risk.

Regulator Concern
Regulators hesitate to commit ratepayer funds to risky development (20% to 50% dry holes).

Competition for Projects
By the time utilities' rates of return are sufficient to warrant investment (i.e., Construction), other entities offer financing at attractive rates.