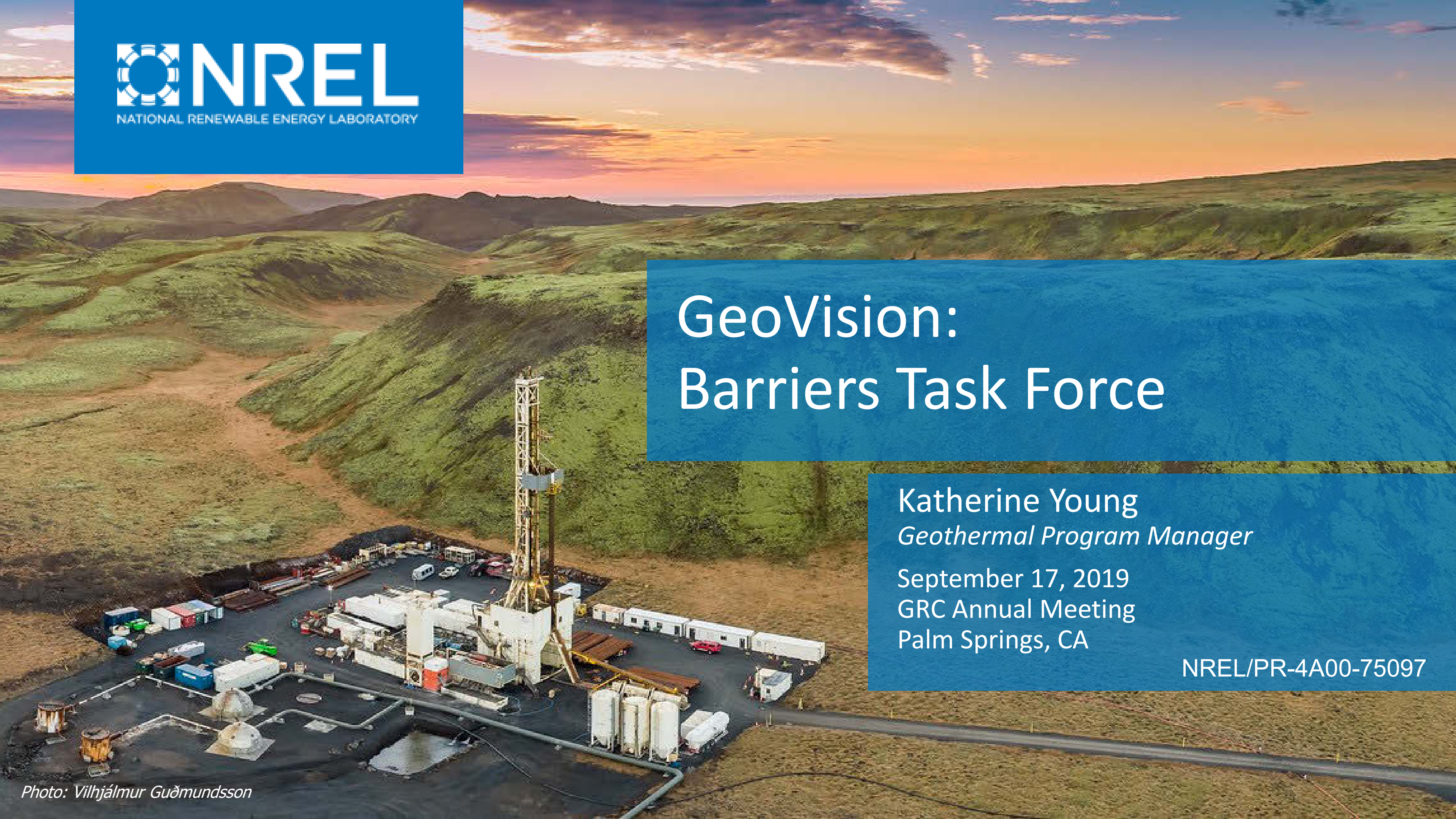

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

GeoVision: Barriers Task Force

Katherine Young
Geothermal Program Manager

September 17, 2019
GRC Annual Meeting
Palm Springs, CA

NREL/PR-4A00-75097

Photo: Vilhjálmur Guðmundsson

NREL Barriers Task Force Team

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GeoVision P2P Task Force Lead

Barriers Taskforce Goal

Quantitatively analyze barriers

- How do you quantify barriers?
- How do you analyze geospatially?
- How do you quantify impact?
- How do you analyze potential improvements?

Barriers Expert Team

ORMAT

EMPS inc.

U.S.Geothermal

PANORAMA ENVIRONMENTAL, INC.

EMA Environmental Management Associates

THE WORLD BANK

enel Green Power

Geothermal Energy Association

Blaydes and Associates

USGS

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

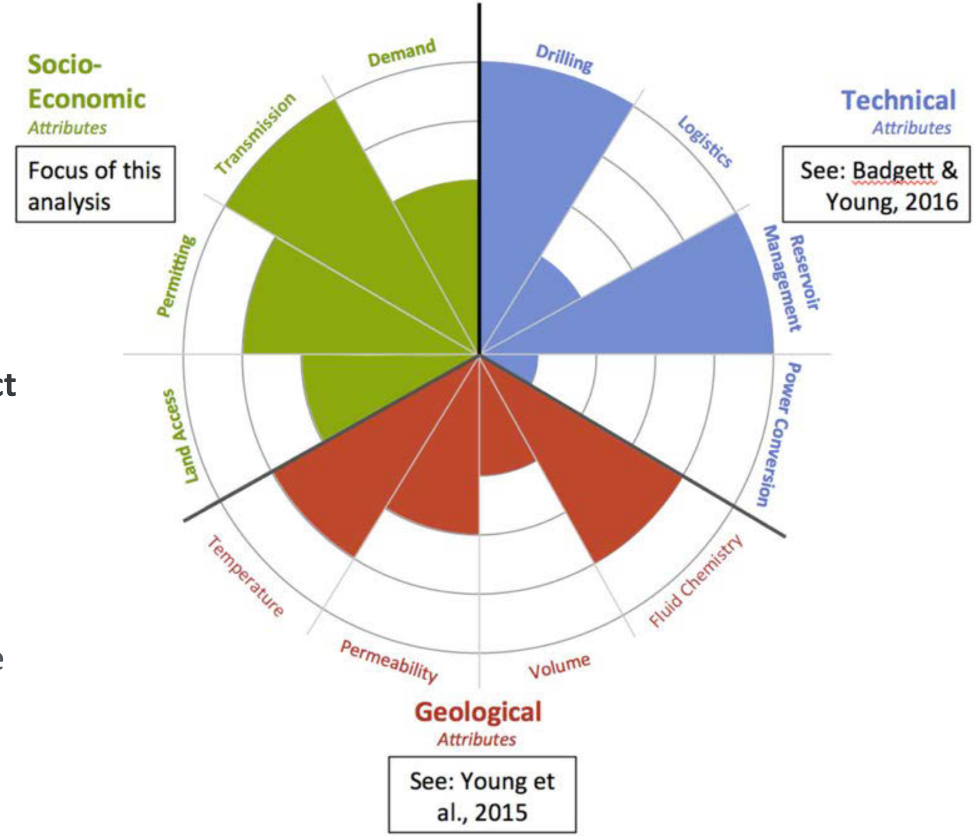
UNITED STATES NAVY

U.S. DEPARTMENT OF ENERGY

GeoRePORT

The GeoRePORT System:

- Was developed to address the need of the GTO to track and measure the impact of research, development, and deployment funding for GTO-funded geothermal projects.
- Is particularly useful for describing early-stage exploration projects.
- Is unique in providing a detailed system for reporting both the **resource grade** and the **project readiness level.** *The analysis conducted for GeoVision discusses only **resource grade** and not project readiness levels.*
- Is comprised of three assessment tools: **Geological**, **Technical**, and **Socio-Economic**.
- Each of the assessment tool's resource grades are divided into attributes and sub-attributes that describe the characteristics that contribute to feasibility of project development (see figure).



Using GeoRePORT for GeoVision

STEP 1: Identify market barriers (sub-attributes) and weight them according to impact

Barriers (Sub-Attributes)
1. Market demand
2. Price of electricity
3. Policies
4. Incentives

STEP 2: Develop grading system for the market attribute and each sub-attribute

EXAMPLE: Policy Sub-Attribute Grades

Grades	Description
A	Feed-in tariff for geothermal (standard offer contracts)
B	Interconnection set-aside or RPS or state purchase requirement **specific for geothermal**
C	State renewable purchasing requirements or RPS - **not preferential to a particular renewable**
D	State purchasing requirements or RPS - **with preferential consideration or set-asides for non-geothermal renewables**
E	No policies beneficial to renewables (No RPS)

STEP 3: Collect and/or develop data to create maps of each sub-attribute

EXAMPLES: Figures 4-7

STEP 4: Combine all attributes into a single attribute summary map

EXAMPLE: Figure 8

STEP 5: Identify thresholds (unallowed, significant barrier) for each sub-attribute

EXAMPLE: Table 4

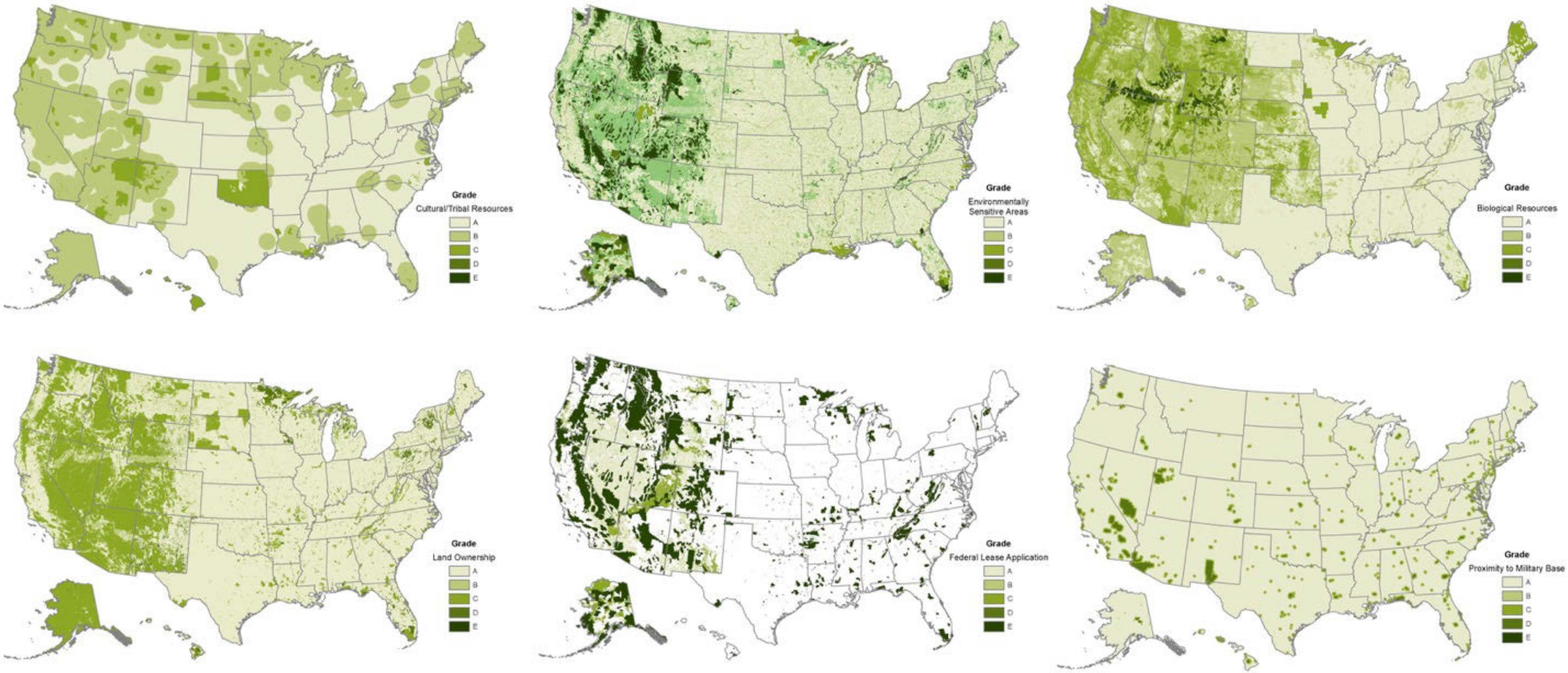
Sub-Attribute	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
Market Demand	--	--	**D, E**
Price of Electricity	--	--	--
Policies	--	--	--
Incentives	--	--	--

STEP 6: Estimate potential geothermal deployment for various market scenarios

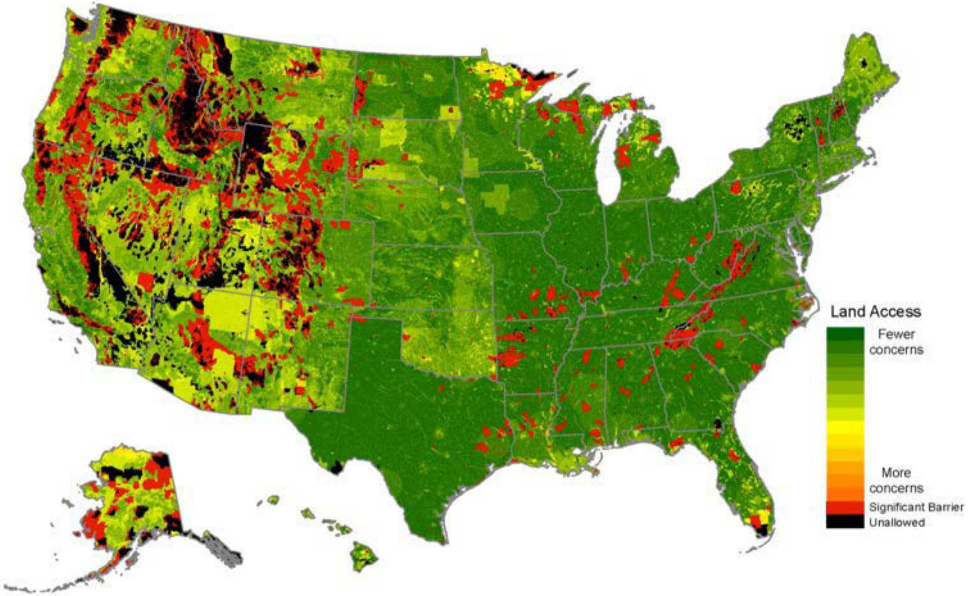
EXAMPLE: Table 5RPS

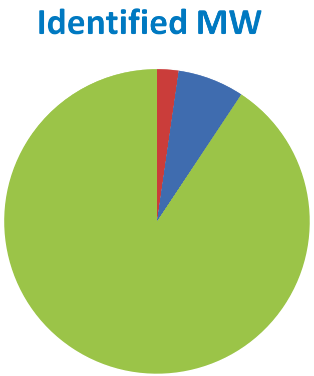
Scenarios	Potential improvement scenario
BAU	• Deployment based on current market conditions (current policies/incentives).
SCENARIO 1: Renewables	• Increased State renewable standards
SCENARIO 2: Baseload	• Baseload set-aside, or • Baseload tax incentive, or • Integration charge for VREs
SCENARIO 3: Geothermal	• Geothermal set-aside, or • Geothermal tax incentive

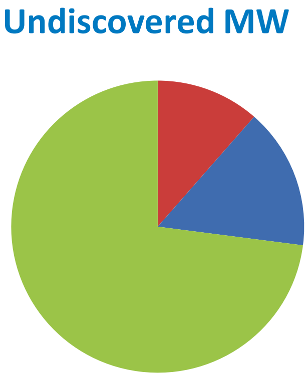
Land Access Sub-Attributes

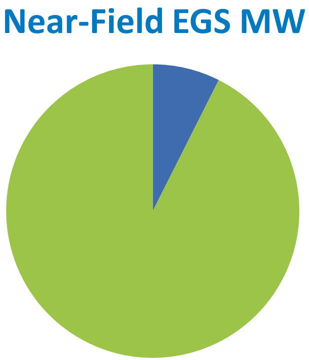


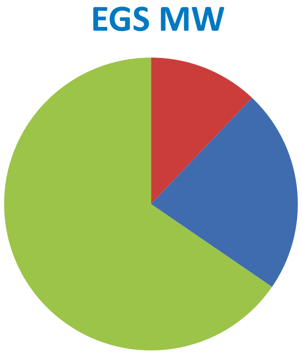
Land Access Summary











Unallowed | Significant Barriers | Developable

Permitting

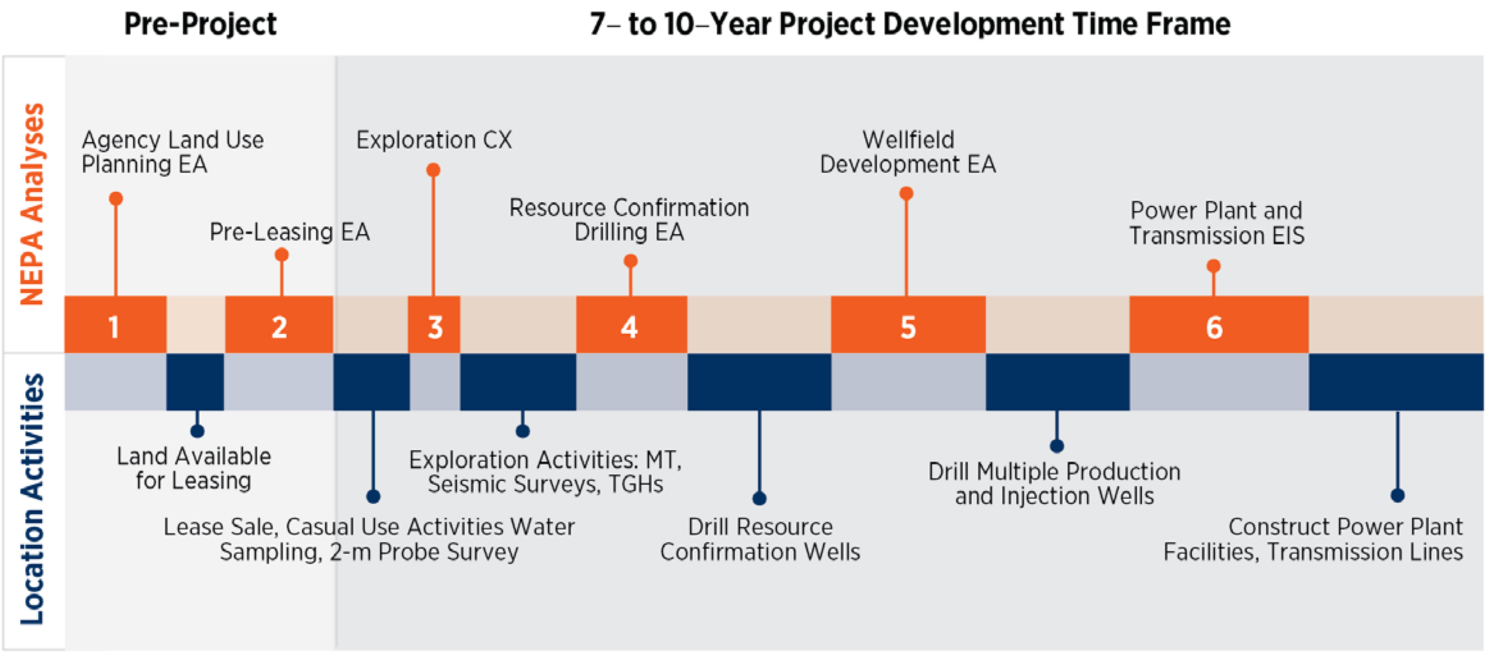


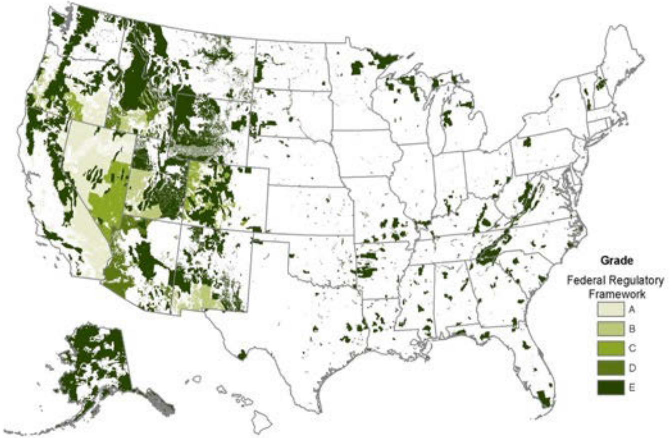
Figure 2-19. Example timeline of a geothermal project on federal lands, illustrating that a single location could trigger National Environmental Policy Act analysis six separate times

Source: Young et al. 2014

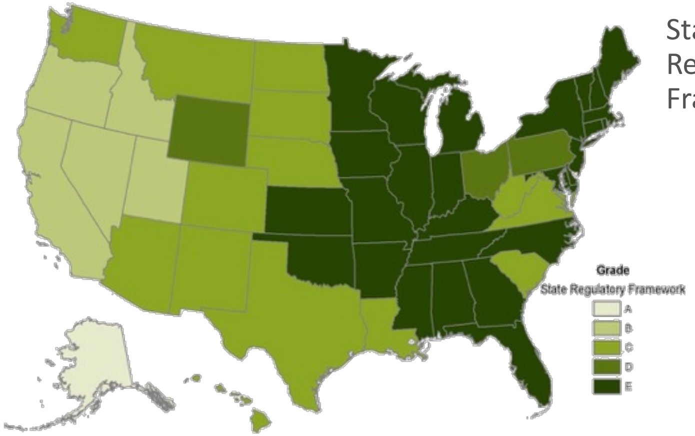
Figure Note: EA = Environmental Assessment, EIA = Environmental Impact Statement, CX = categorical exclusion, MT = magnetotelluric, and TGH = temperature-gradient hole.

Permitting

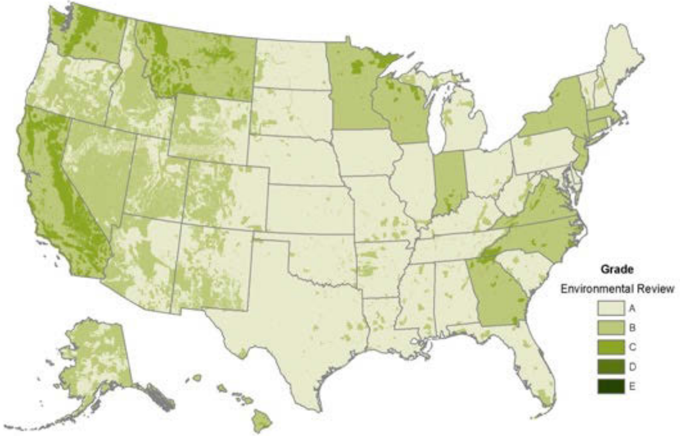
Federal Regulatory Framework



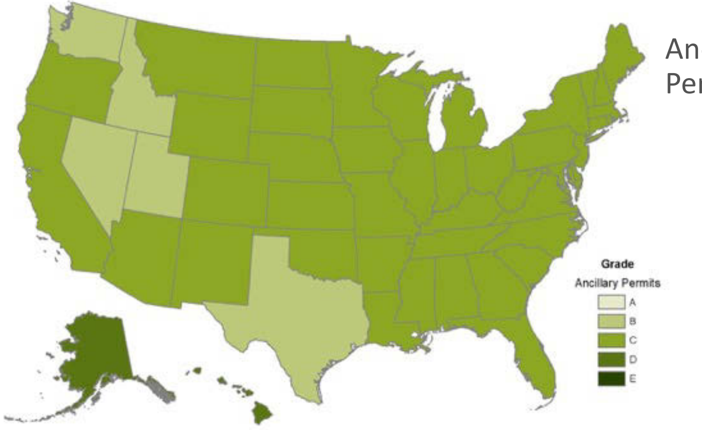
State Regulatory Framework



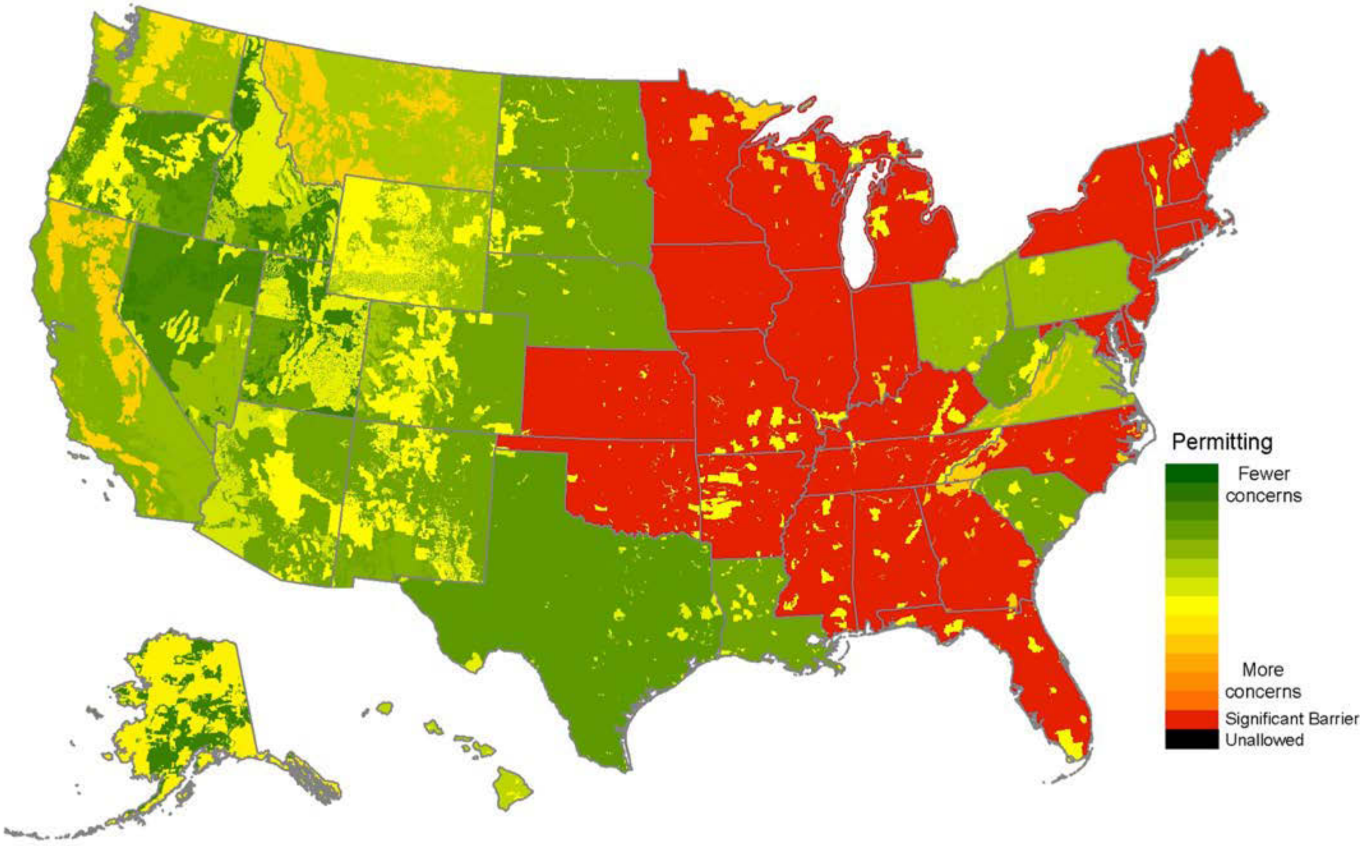
Environmental Review



Ancillary Permits

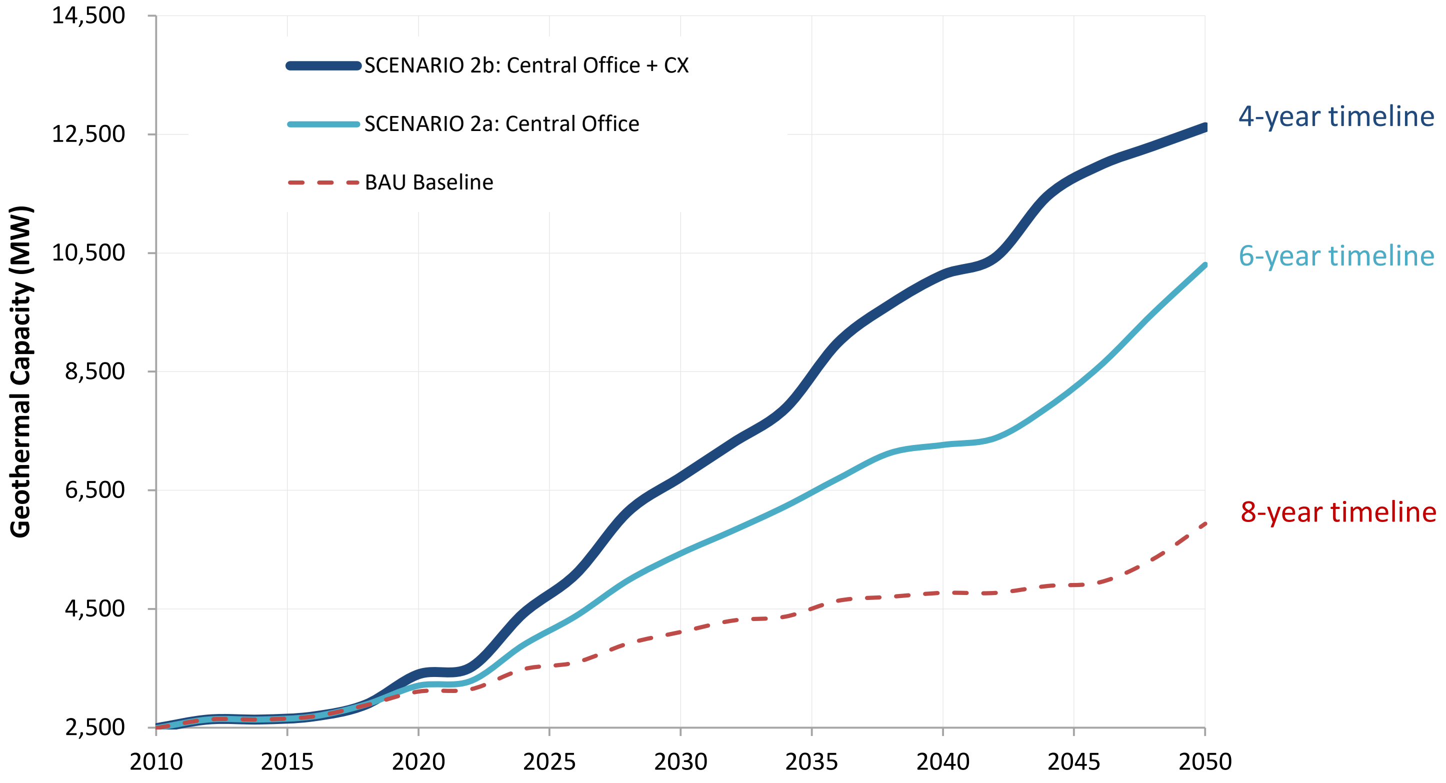


Permitting



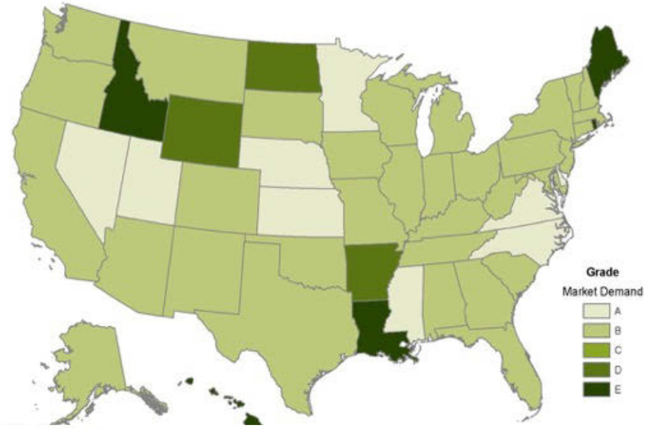
Permitting
Fewer concerns
More concerns
Significant Barrier
Unallowed

Permitting – Impact on Deployment

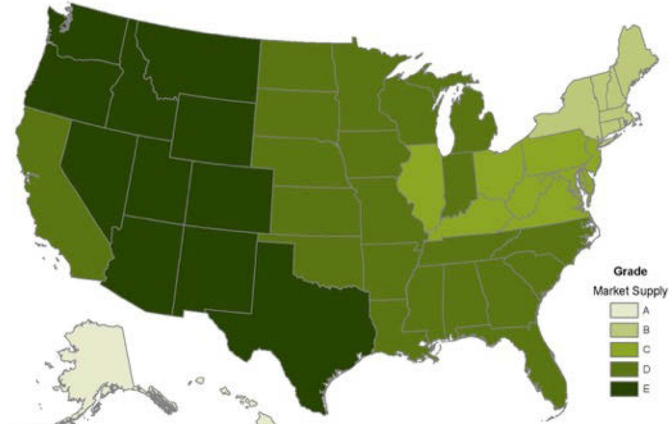


Market

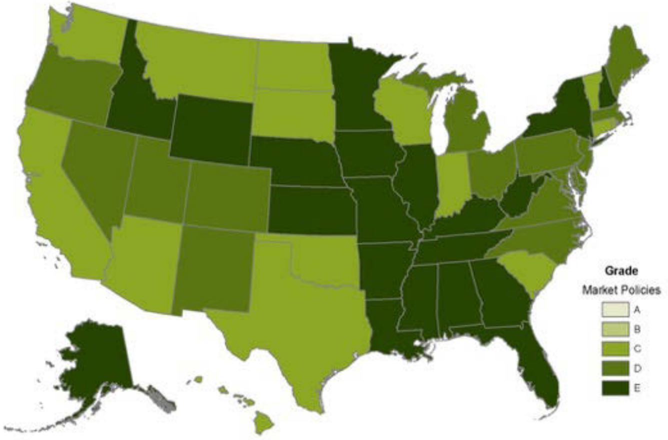
Demand



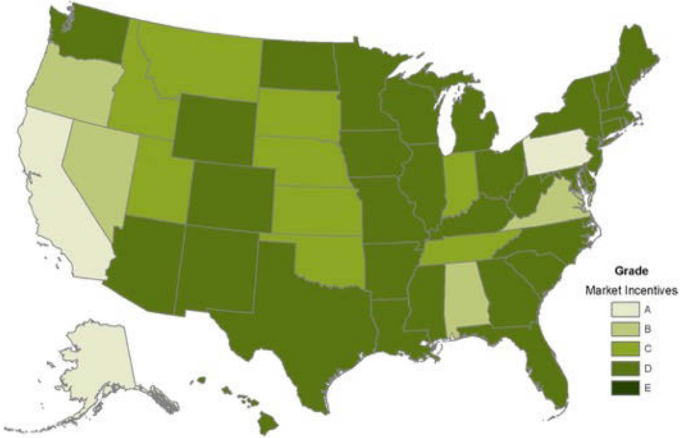
Supply



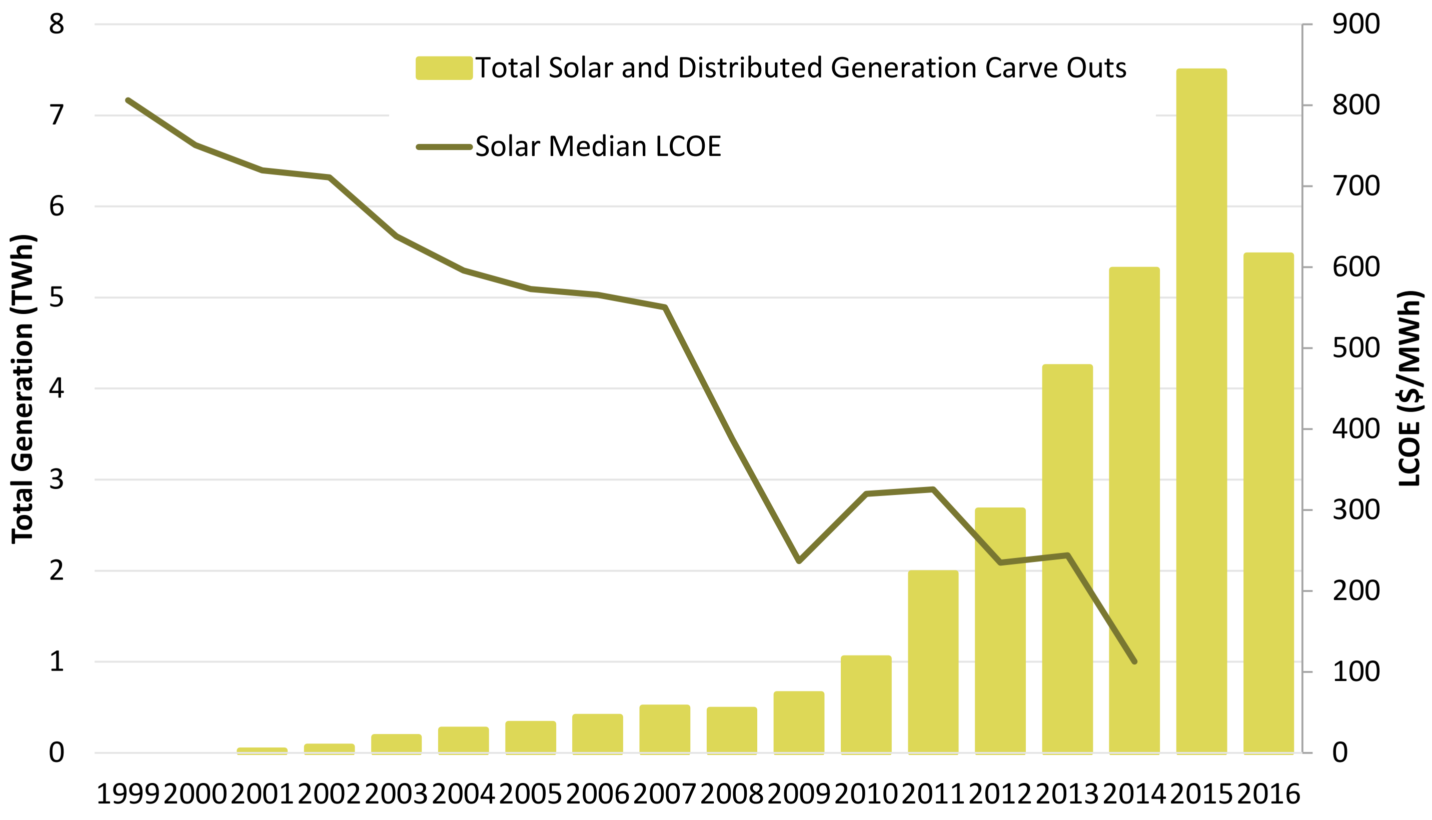
Policies



Incentives

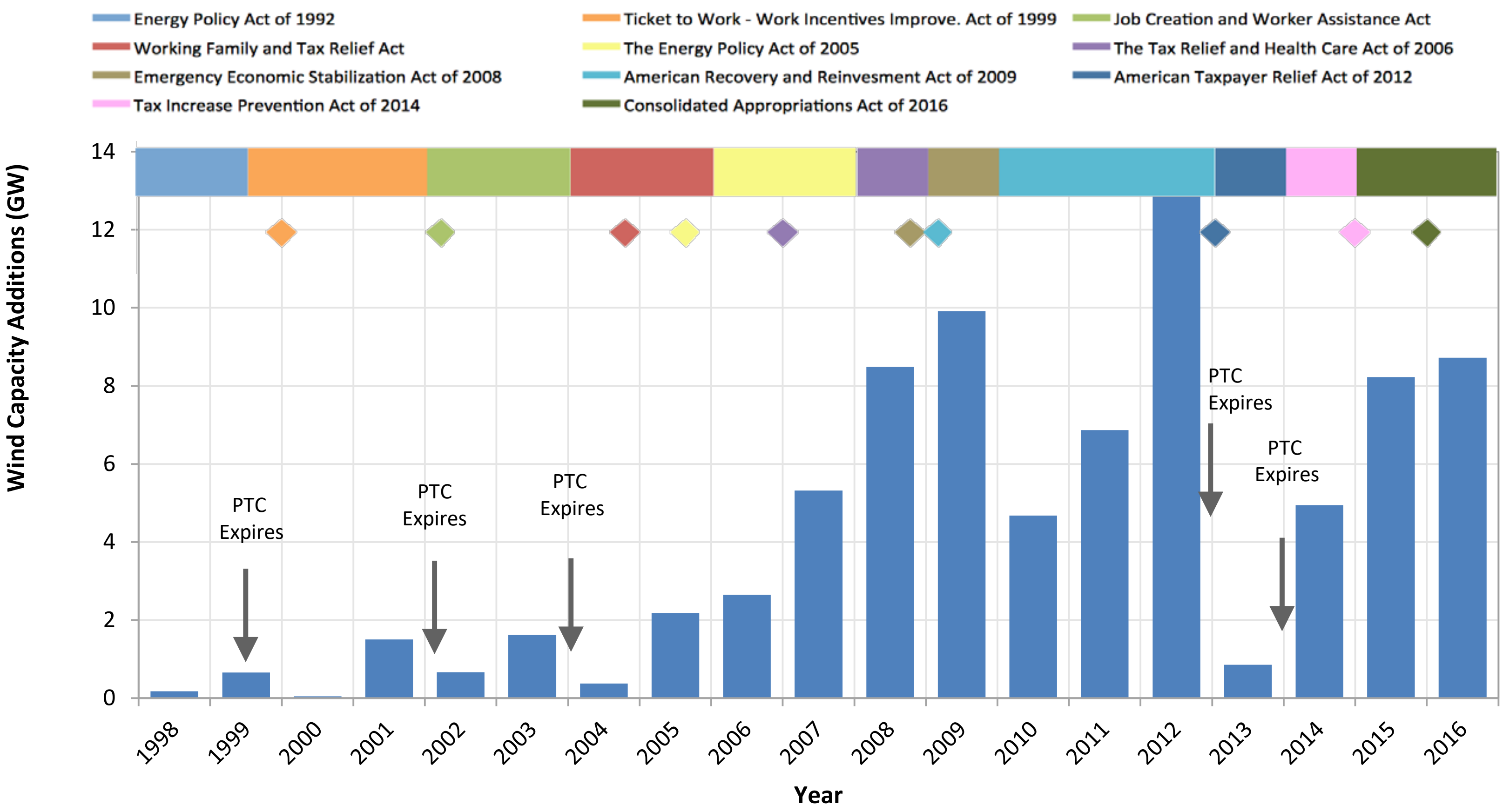


Market

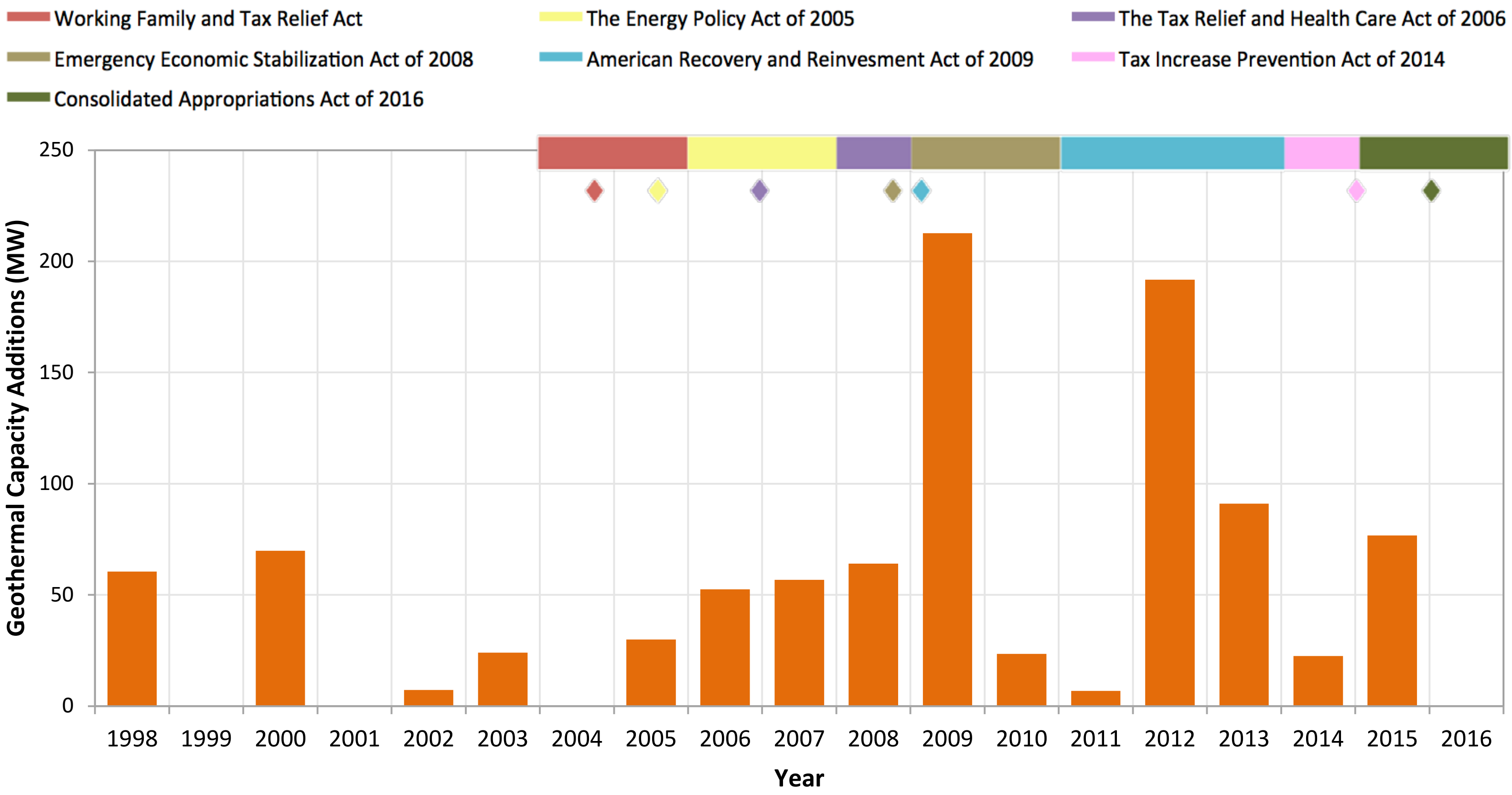


Total Solar and Distributed Generation Carve Outs
Solar Median LCOE
Total Generation (TWh)
LCOE ($/MWh)
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
800
900
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

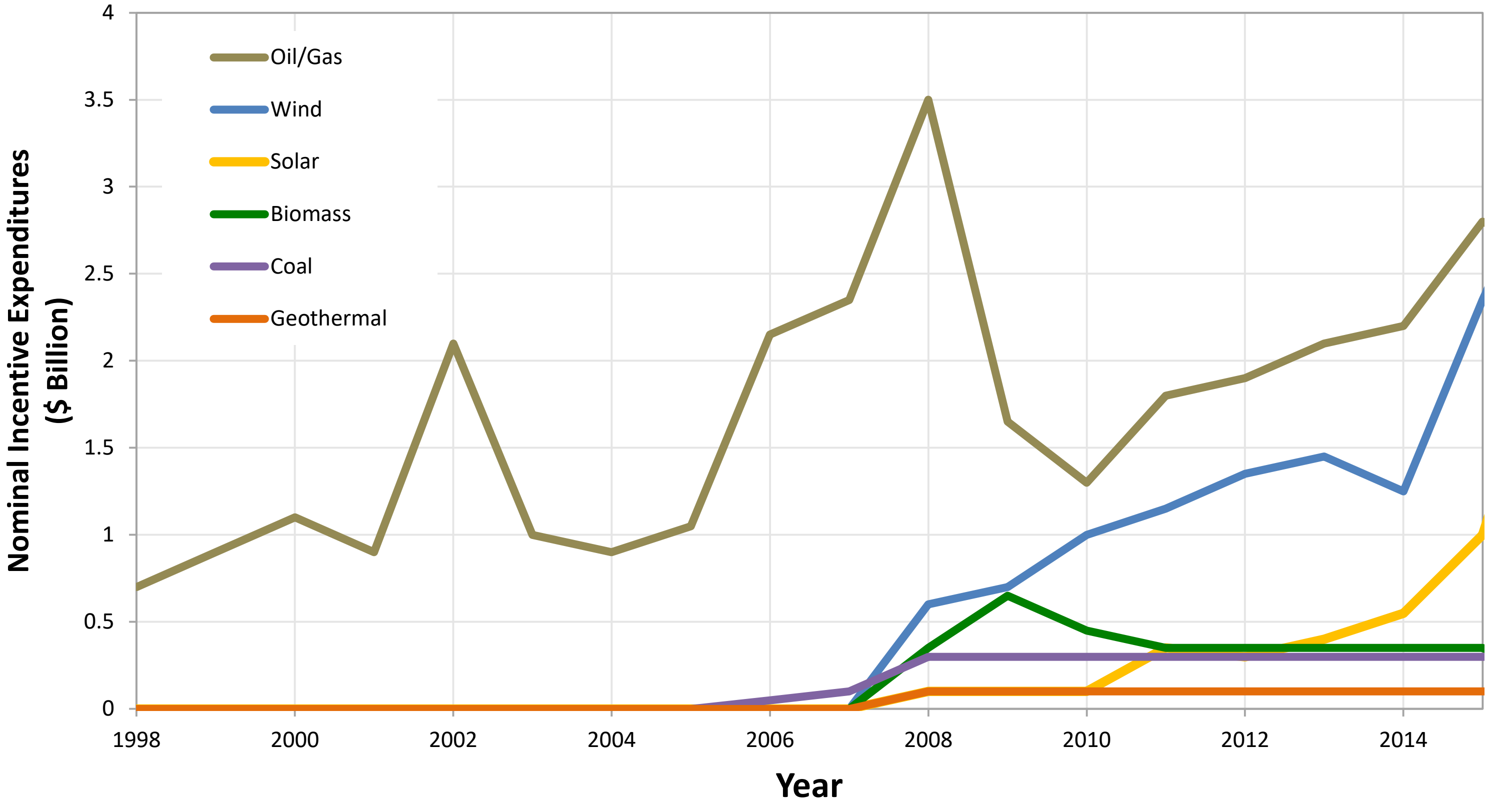
Market


Energy Policy Act of 1992
Ticket to Work - Work Incentives Improve. Act of 1999
Job Creation and Worker Assistance Act
Working Family and Tax Relief Act
The Energy Policy Act of 2005
The Tax Relief and Health Care Act of 2006
Emergency Economic Stabilization Act of 2008
American Recovery and Reinvesment Act of 2009
American Taxpayer Relief Act of 2012
Tax Increase Prevention Act of 2014
Consolidated Appropriations Act of 2016
Wind Capacity Additions (GW)
0
2
4
6
8
10
12
14
PTC Expires
PTC Expires
PTC Expires
PTC Expires
PTC Expires
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

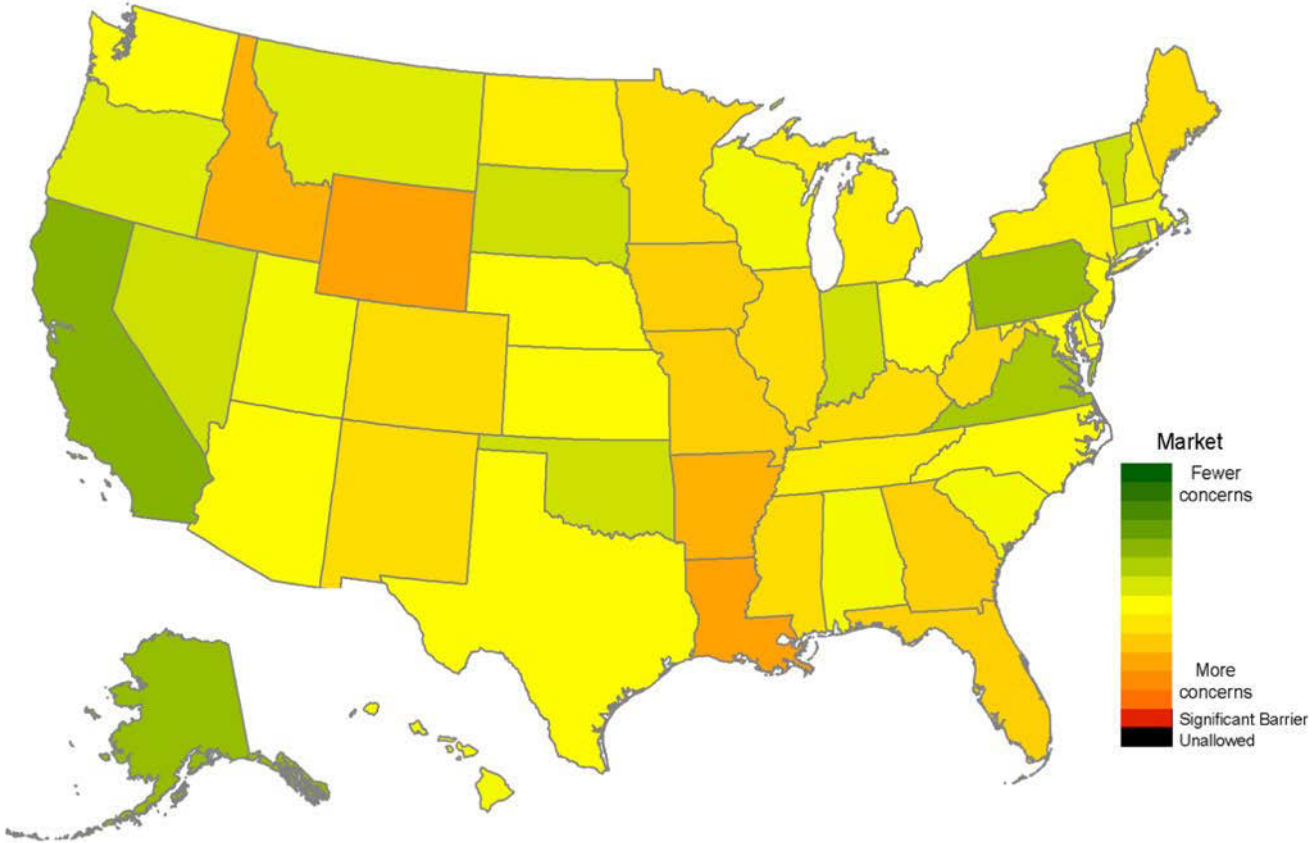
Market


Working Family and Tax Relief Act
The Energy Policy Act of 2005
The Tax Relief and Health Care Act of 2006
Emergency Economic Stabilization Act of 2008
American Recovery and Reinvesment Act of 2009
Tax Increase Prevention Act of 2014
Consolidated Appropriations Act of 2016
Geothermal Capacity Additions (MW)
250
200
150
100
50
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

Market

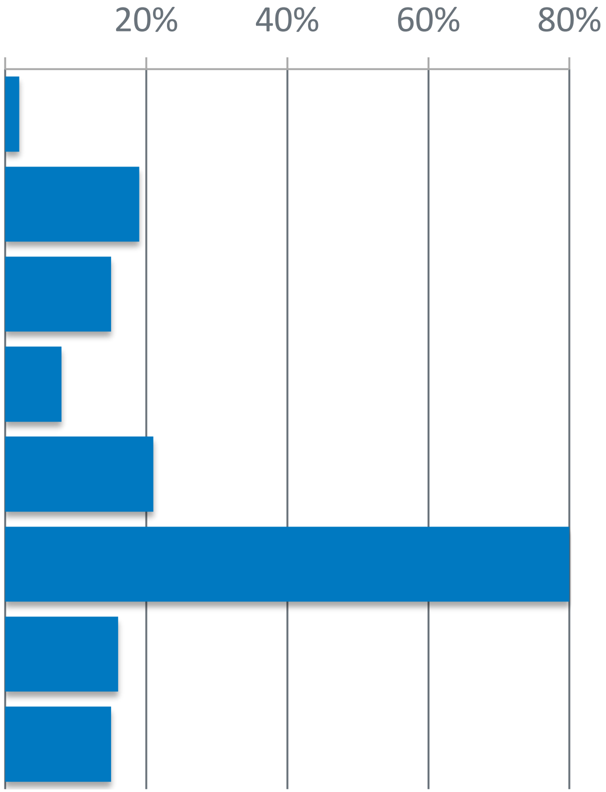

Oil/Gas
Wind
Solar
Biomass
Coal
Geothermal
Nominal Incentive Expenditures ($ Billion)
0
0.5
1
1.5
2
2.5
3
3.5
4
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

Market


Market
Fewer concerns
More concerns
Significant Barrier
Unallowed

Market

Scenario		2050 Deployment	Improvement over BAU
BAU	BAU Baseline	5,940 MW	N/A
SCENARIO 1: Renewable Benefits	**1a:** Increased Renewables (49% State RPS)	6,080 MW	140 MW (2%)
SCENARIO 2: Baseload-specific benefits	**2a:** Federal Baseload 30% Tax Credit	7,090 MW	1,150 MW (19%)
	2b: RPS with 20% Baseload Set-aside	6,850 MW	900 MW (15%)
	2c: 30% Transmission charge for VREs	6,440 MW	500 MW (8%)
SCENARIO 3: Geothermal-specific benefits	**3a:** Federal Geothermal 30% Tax Credit	7,200 MW	1,260 MW (21%)
	3b: State Geothermal Set-Aside	10,710 MW	4,770 (80%)
SCENARIO 4: Changes in Market Conditions	**4a:** High Natural Gas Prices	6,870 MW	930 MW (16%)
	4b: High Electrification	6,810 MW	870 (15%)




Boosts local economy

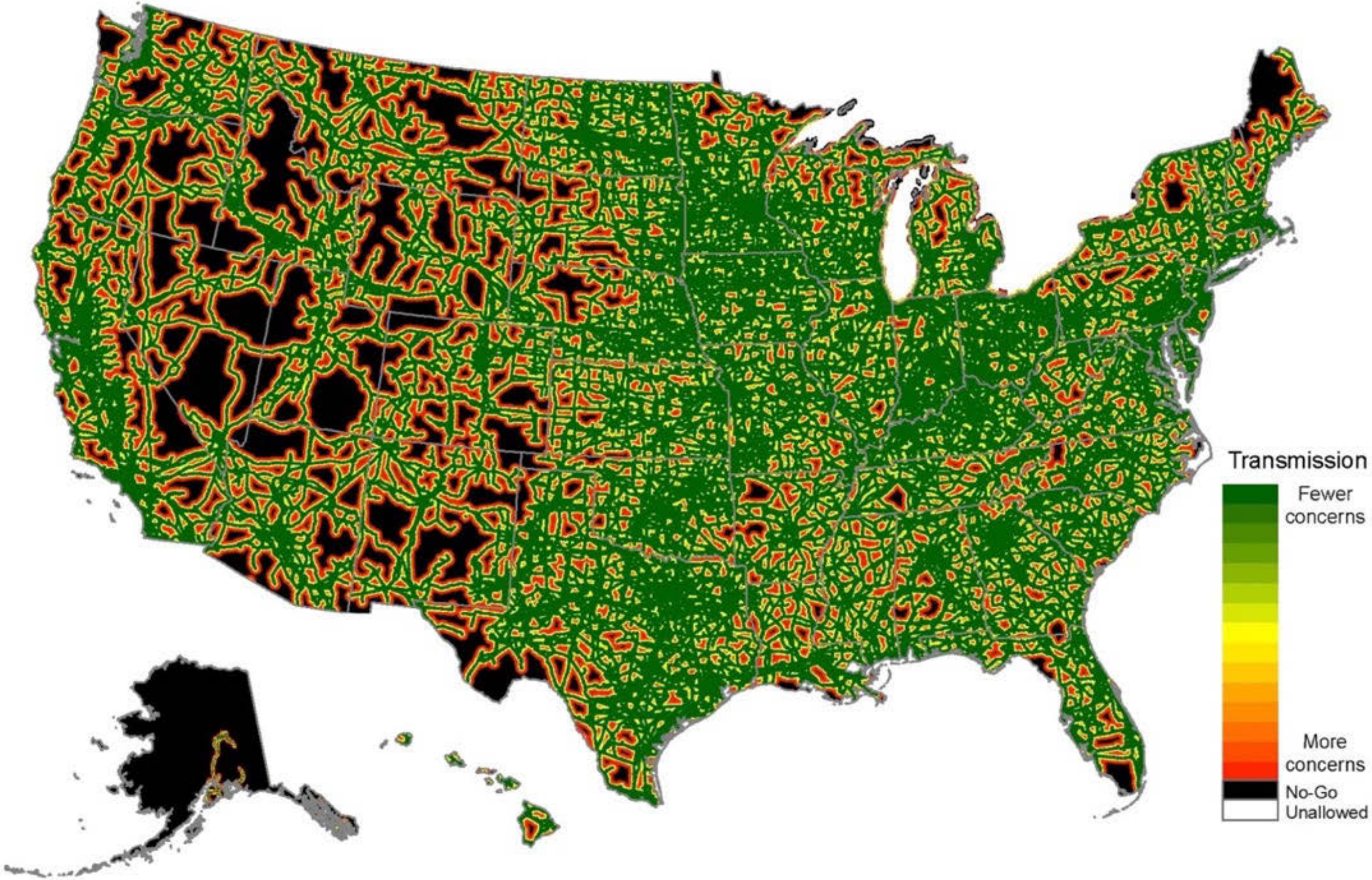

Creates long-term jobs
THINK SAFETY


Causes little impact


Is always available


Provides grid stability & reliability

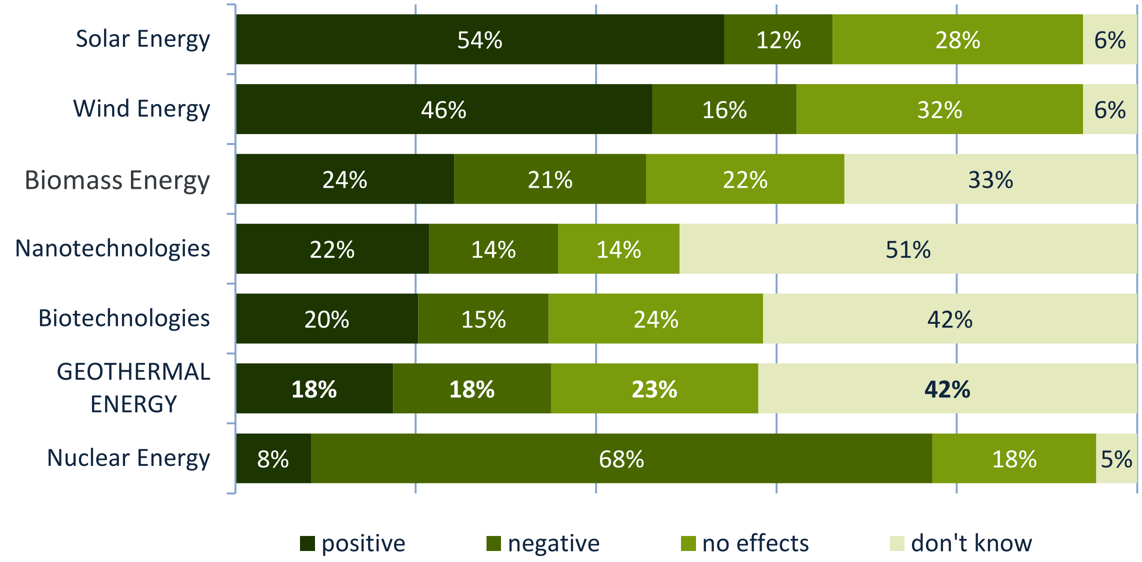
Transmission



Social Acceptance

Optimism About Technologies

"Which one of these technologies will have a positive, negative, or no effect on our way of life in the next 20 years?"



Pellizzone et al. (2015)

adapted from Wüstenhagen et al. 2007

Take Aways

- **Flat line** in geothermal **deployment** in recent years **may be due to institutional/soft-cost** (and not technical cost) barriers. Overcoming these barriers could lead to increased deployment slopes.
- The **geothermal resource supply curve is decreasing** due to growing environmental and land-use restrictions. Technology improvements and mitigation techniques may be able to reduce the impact these restrictions have on future geothermal development.
- **Permitting and land access challenges** can impact accessibility and development timeframes, **severely impacting deployment** potential. Modeling suggests these challenges reduce deployment by more than 50% in the BAU case and by 15% in the Barrier Technology Improvement (BTI) case.
- Well-designed policies and incentives can drive deployment:
  - **Set-asides** – Historical set-asides have allowed for deployment of non-economically competitive technologies (e.g., solar); the model demonstrates similar impact if geothermal set-asides were implemented.
  - **Tax credits** – Historical PTC has driven deployment of (cost-competitive) wind. Geothermal project timelines are too long to take advantage of this structure (as implemented). Historical oil and gas tax credits are exploration related and help to lower upfront risk.
  - **RD&D funding** – Historical (worldwide) government research funding in solar has helped drive reduction of solar LCOE, raise social acceptance of solar, and encourage policy/incentive development for increased solar deployment. Historical high geothermal budgets (e.g., 1980s) drove similar increases in geothermal deployment.

Take Aways

- Benefits of geothermal (e.g., economics, jobs, land use) relative to other technologies suggest states and **communities would benefit from increased geothermal deployment**.

- Local and federal **economic paybacks are high** compared to other renewables, so states that support development of geothermal will have greater economic benefit:
  - Local, full-time, living wage jobs Federal, state, and local annual royalties back into communities—if developed on state or federal land
  - High O&M spending into local communities Federal and state taxes, so geo generation produces more tax income for states and federal government.

- **Environmentally friendly** – low greenhouse gas emissions, small footprint, low water use, etc.
- The geothermal industry could benefit from **improved, targeted marketing and advocacy** to improve the community, market, and socio-political acceptance of geothermal development.

NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems.

Thank you

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