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# Turning Green into Gold The Economics of Renewable Projects

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# Overview

- Other sessions in Renewable Track focus on specific technologies or case studies
- This session compares & contrasts the economics of four primary renewable energy technologies and touches on several others.
- Goal is to provide federal customers with a better understanding of interplay between project cost components and incentives to help with the selection of renewables at their sites.

# Primary Technologies

Solar PV



Wind



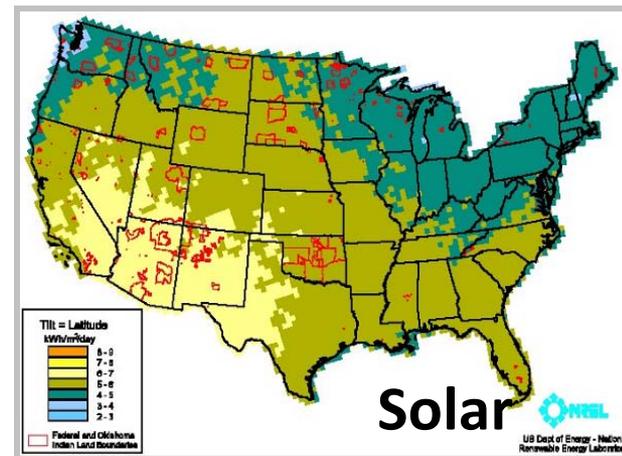
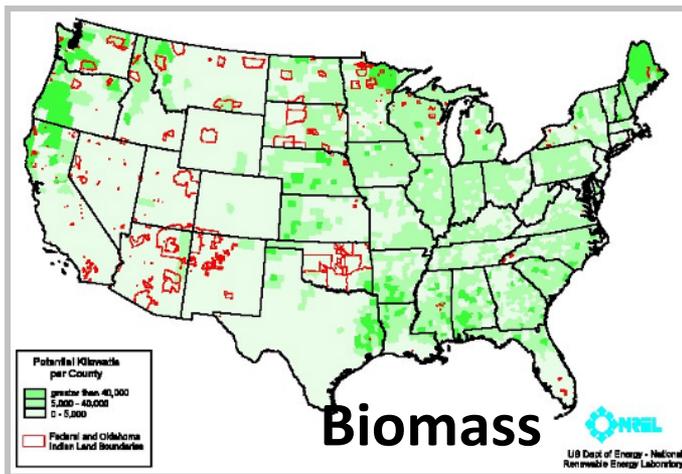
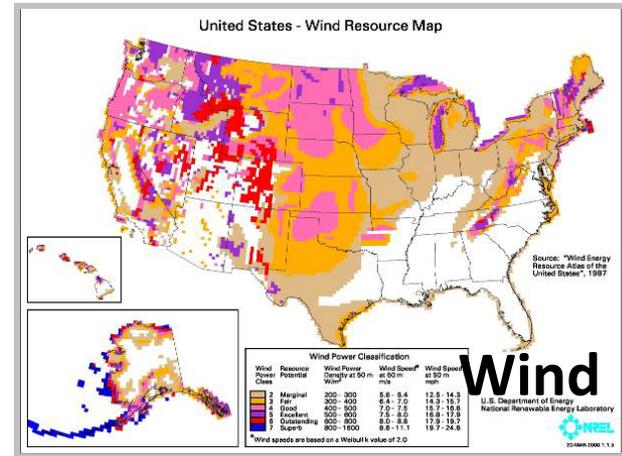
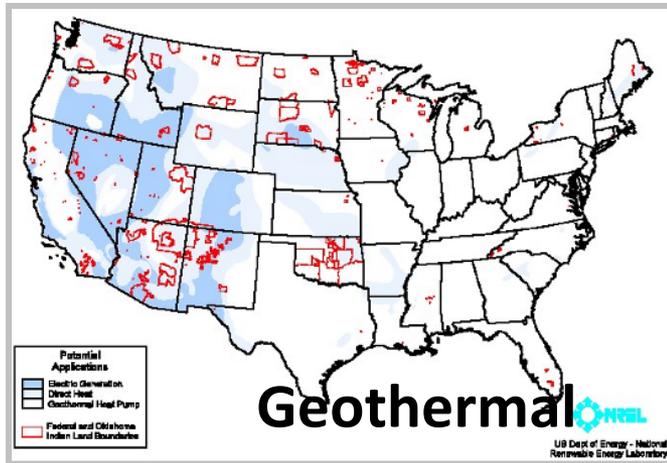
Biomass (power & co-gen)



Geothermal to power



# Resource Maps



# Costs & Incentive Ledger

## Cost Components (+)

- Equipment & Installation
- Cost of Capital
- Resource / fuel
- Operations & Maintenance

## Incentives (-)

- Grants & Rebates
- Tax Credits
- REC's
- CO<sub>2</sub> Credits

# Solar Electric Characteristics

- Capital Costs
  - PV: \$5000 - \$7000/kW (higher for ground mount, carport)
- Capacity Factor
  - PV: 11% to 19% (higher with Tracking)
- LCOE
  - PV: 22¢-32¢/kWh
- Other Considerations
  - Distributed PV competes against retail electricity, modular size
  - NEPA and permitting easier than most renewable technologies
  - Trough and tower usually large scale, >80MW



# Solar PV

Solar Energy Project Parameters					
<i>System Specifics</i>	<i>Inputs</i>	<i>One-time</i>	<i>Recurring</i>	<i>Elec Price/kWh</i>	
					<i>Cummulative</i>
PV System Design Capacity (kW)		1,000			
Capacity factor	16%	1,402			
Annual Potential Output (kwh/yr)			1,401,600		
<i>Project Parameters</i>					
Project Period (years)	20				
Project Interest Rate	6.5%				
<i>Project Costs</i>					
Capital Invest. \$/s/watt installed	6	\$ 6,000,000			
Annual Capital Payment			\$544,538	\$0.39	\$0.39
<i>Ongoing Costs</i>					
Fuel Costs			Free ☼		
Annual O&M	20		\$ 20,000	\$0.01	\$0.40
Annual Repair & Replacement	5	100000	\$9,076	\$0.01	\$0.41
<b>Total Annual Cost</b>			<b>\$ 573,614</b>		<b>\$0.41</b>
<i>Project Economic Incentives</i>					
Grants or Utility Rebate \$ per kW	500	\$ 500,000		\$0.03	\$0.38
Tax Benefits (less prop. tax & ins.)	28%	\$ 1,680,000		\$0.11	\$0.27
RECs Cents / kWh	18		\$ 252,288	\$0.18	\$0.09

# Wind Energy Characteristics

- Capital Costs: \$2600 to \$4000/kW < 20MW
- Capacity Factor: 15% to 35% (distributed wind)
- LCOE: 5¢-8¢/kWh
- O&M: 1.5- 2.5 cents/kWh
- Other Considerations
  - Intermittent, not dispatchable
  - Small-scale or on-site competes against retail electricity
  - Size can range from <1kW to 1.5 MW/turbine, multiple turbine wind farms common
  - No water demand
  - Visual impacts, compatibility with radar, avian habitat require careful planning
  - Direct water pumping systems also available



# Wind to Energy

Wind Energy Project Parameters						
System Specifics		Inputs	One-time	Recurring	Elec Price/kWh	
System Design Capacity (kW)			1,000			Cummulative
Capacity factor		25%	2,190			
Annual Potential Output (kwh/yr)				2,190,000		
<i>Project Parameters</i>						
Project Period (years)		20				
Project Interest Rate		6.5%				
<i>Project Costs</i>						
Capital Investment \$'s per watt		3	\$ 3,000,000			
Annual Capital Payment				\$272,269	\$0.12	\$ 0.12
<i>Ongoing Costs</i>						
Fuel Costs				Free ☀		
Annual O&M		0.015		\$ 32,850	\$0.02	\$ 0.14
Annual Repair & Replacement		0.005		\$ 10,950	\$0.01	\$ 0.14
<b>Total Annual Cost (Base Case)</b>				<b>\$ 316,069</b>		<b>\$ 0.14</b>
<i>Project Economic Incentives</i>						
Grants or Utility Rebate \$ per kW		0	\$ -		\$0.00	\$0.14
Tax Benefits (less prop tax & ins.)		28%	\$ 840,000		\$0.03	\$0.11
RECs Cents / kWh		2		\$ 43,800	\$0.02	\$0.09

# Biomass, WTE, LFG

- Capital Costs: Biomass \$2,500 - \$4,000 / kW
- Capacity Factors Biomass 75% to 90%, and high availability
- Usually >10MW for biomass
- LCOE Biomass 8¢-12¢/kWh
- CHP and co-firing potential
- Wood-fired, mass-burn WTE, landfill gas well-established
- Energy crops (woody and herbaceous) emerging
- Other Considerations
  - Fuel supply risk needs consideration
  - Plant & fuel storage requires available open land
  - Air emissions can require permitting



# Biomass Energy

<b>Biomass to Electric Project Parameters</b>						
<i>System Specifics</i>		<i>Inputs</i>	<i>One-time</i>	<i>Recurring</i>	<i>Elec Price/kWh</i>	
Design Capacity (kW)			10,000			Cummulative
Capacity factor		90%	7,884			
Annual Potential Output (kwh/yr)				78,840,000		
<i>Project Parameters</i>						
Project Period (years)		20				
Project Interest Rate		6.5%				
<i>Project Costs</i>						
Capital Invest. \$'s per watt		4	\$ 40,000,000			
Annual Capital Payment				\$3,630,256	\$ 0.05	\$ 0.05
<i>Ongoing Costs</i>						
Fuel Costs	\$ per ton	30		\$ 2,365,200	\$ 0.03	\$ 0.08
Annual O&M	\$ 85k per staff	20		\$ 1,500,000	\$ 0.02	\$ 0.10
Repair & Replace	% of Plant Cost	5		\$ 2,000,000	\$ 0.03	\$ 0.12
<b>Total Annual Cost (Base Case)</b>				<b>\$ 9,495,456</b>	<b>\$ 0.12</b>	<b>\$ 0.12</b>
<i>Project Economic Incentives</i>						
Grants or Utility Rebate	\$ per kW	0	\$ -		\$0.00	\$0.12
Tax Benefits (less prop. tax & ins.)		28%	\$ 11,200,000		\$0.01	\$0.11
REC	Cents / kWh		3	\$ 2,365,200	\$0.030	\$0.08

# Biomass Energy

<b>Biomass Cogeneration Project Parameters</b>						
<i>System Specifics</i>		<i>Inputs</i>	<i>One-time</i>	<i>Recurring</i>	<i>Elec Price/kWh</i>	
Biomass System Design Capacity (kW)			10,000			Cummulative
Capacity factor		90%	7,884			
Annual Electric Potential Output (kwh/yr)				78,840,000		
Annual Output for electric (MMBtu/yr)				269,160		
<i>Project Parameters</i>						
Project Period (years)		20				
Project Interest Rate		6.5%				
<i>Project Costs</i>						
Capital Investment	\$'s per watt	4.5	\$ 45,000,000			
Annual Capital Payment				\$4,084,038	\$ 0.05	\$ 0.05
<i>Ongoing Costs</i>						
Fuel Costs	\$ per ton	30		\$ 2,601,720	\$ 0.03	\$ 0.08
Annual O&M	\$ 85k per staff	25		\$ 1,875,000	\$ 0.02	\$ 0.11
Repair & Replace - % of Plant Cost		5		\$ 2,250,000	\$ 0.03	\$ 0.14
<b>Total Annual Cost (Base Case)</b>				<b>\$ 10,810,758</b>		<b>\$ 0.14</b>
<i>Project Economic Incentives</i>						
Grants or Utility Rebate	\$ per kW	0	\$ -		\$0.00	\$0.14
Tax Benefits (less prop. tax & ins.)		28%	\$ 12,600,000		\$0.01	\$0.12
RECs	Cents / kWh	2		\$ 1,576,800	\$0.020	\$0.10
Excess Thermal Output	MMBtu/yr			807,479		
Excess Thermal Value	\$ per MMBtu	7		\$ 5,652,355		\$ 0.07

# Geothermal

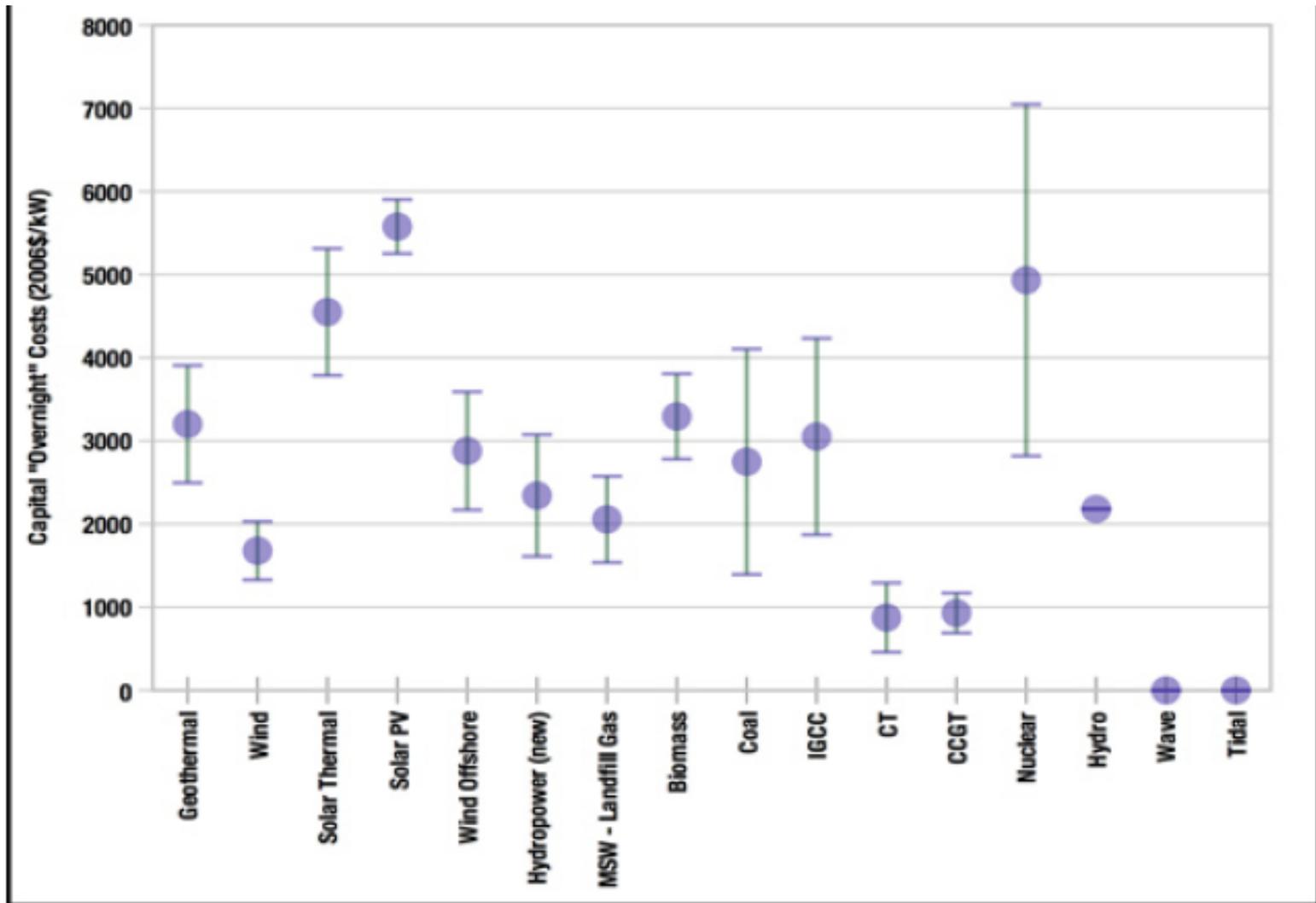
- Capital Costs - \$4,000 to \$6,000 / kW
- High capacity factors, 75% to 90% and high availability
- Usually >10MW
- Other Considerations
  - High cost & risk to verify resource
  - Resource has historically been very site oriented.
  - Enhanced geothermal is expanding opportunities to areas with lower temperatures
  - Environmental concerns from water discharge



# Geothermal Energy

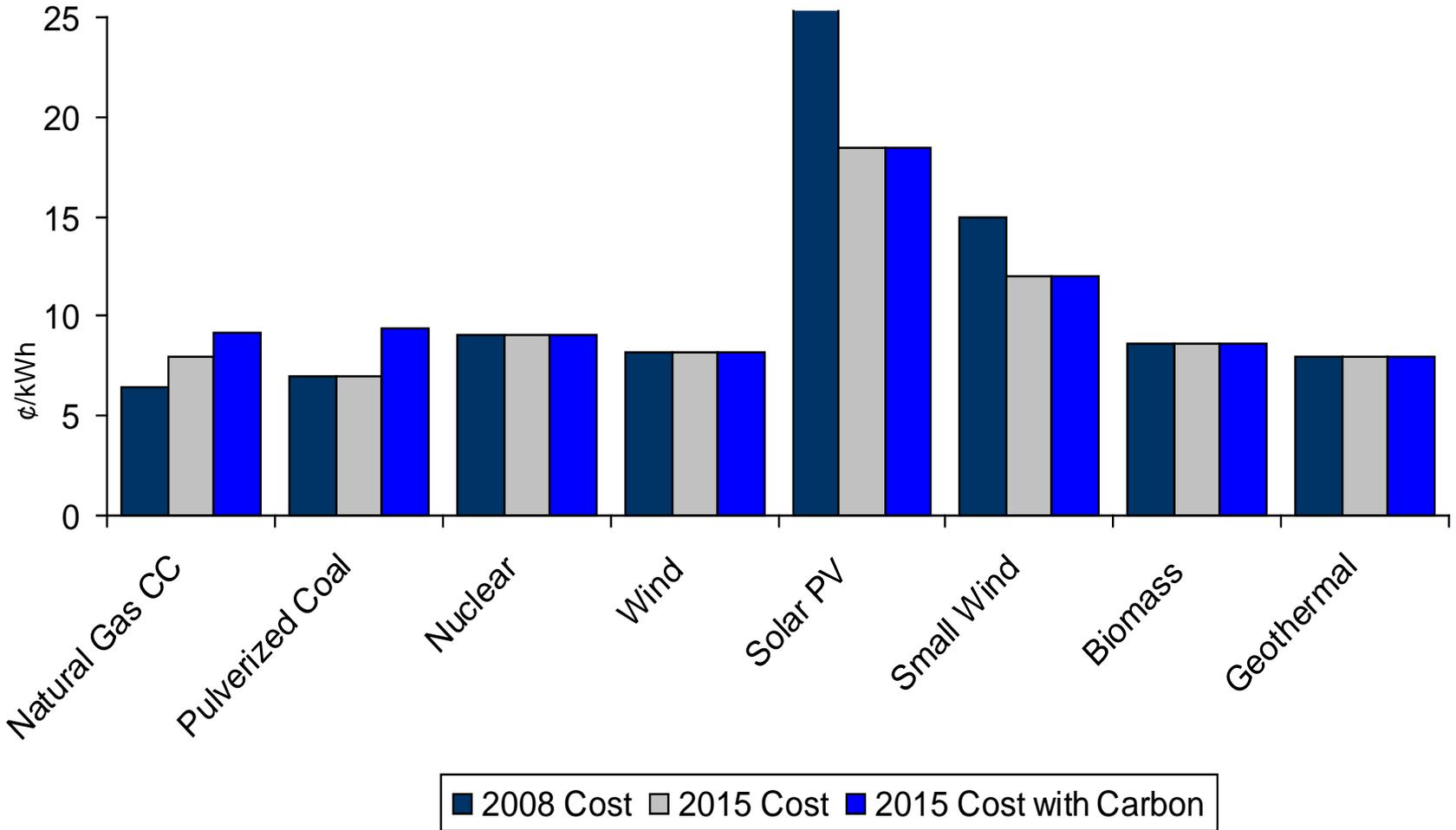
<b>Geothermal Energy - Project Parameters</b>						
<i>System Specifics</i>		<i>Inputs</i>	<i>One-time</i>	<i>Recurring</i>	<i>Elec Price/kWh</i>	
System Design Capacity (kW)			15,000			Cummulative
Capacity factor		90%	7,884			
Annual Output (kwh/yr)				118,260,000		
<i>Project Parameters</i>						
Project Period (years)		20				
Project Interest Rate		6.5%				
<i>Project Costs</i>						
Capital Investment	\$'s per kW	5	\$ 75,000,000			
Annual Capital Payment				\$6,806,730	\$ 0.06	\$ 0.06
<i>Ongoing Costs</i>						
Fuel Costs		0		\$ -	\$ -	
Chemical & Supplies	\$ per MWh	5		\$ 591,300	\$ 0.01	\$ 0.06
Annual O&M	\$ 85k per staff	20		\$ 1,500,000	\$ 0.01	\$ 0.08
Repair & Replacement - % Cost		5		\$ 3,750,000	\$ 0.03	\$ 0.11
<b>Total Annual Cost (Base Case)</b>				<b>\$ 12,648,030</b>		<b>\$ 0.11</b>
<i>Project Economic Incentives</i>						
Grants or Utility Rebate	\$ per kW	0	\$ -		\$0.00	\$0.11
Tax Benefits (less property tax & ins.)		28%	\$ 21,000,000		\$0.02	\$0.09
RECs	Cents / kWh		1	\$ 1,182,600	\$0.010	\$0.08

# CAPITAL COST REALITY CHECK



Source: NREL (May 2009)

# COST OF ENERGY - REALITY CHECK



Note: Carbon Price = \$30/tonne of CO<sub>2</sub>, Natural Gas Price = \$7/MMBTU in 2008 & \$10/MMBTU in 2015

# Disclaimer

- Model and values provided here were for demonstration purposes and may bear little relation to actual project economics
- Much more formal modeling would be needed to make economic decisions which would include:
  - Multi-year income statements
  - Better time value of money (non-uniform cash flows)
  - Construction period expenses
  - Depreciation & taxes
  - Different equity & debt mixes with varying returns

# Closing Thoughts

- Most places in the country are good candidates for at least one type of renewable project
- Making projects work involves the interplay of cost and incentive components presented here
- Variations in resource availability, ownership structures and REC markets dictate positive results
- Technologies and incentive programs are constantly evolving, so be ready to capitalize on opportunities

# Further Information

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