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Analysis and Cost Comparison of Renewable Power in California

Presented to the Little Hoover Commission

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28 February 2012

Overview

- **Objective:** Review the relative costs of renewable resource generation, including transmission, for delivery into California from the surrounding states

- **Contents:**
  - Executive Summary
  - Location of Renewable Resources
  - California's RPS Requirements
  - Cost of Limiting Renewable Imports

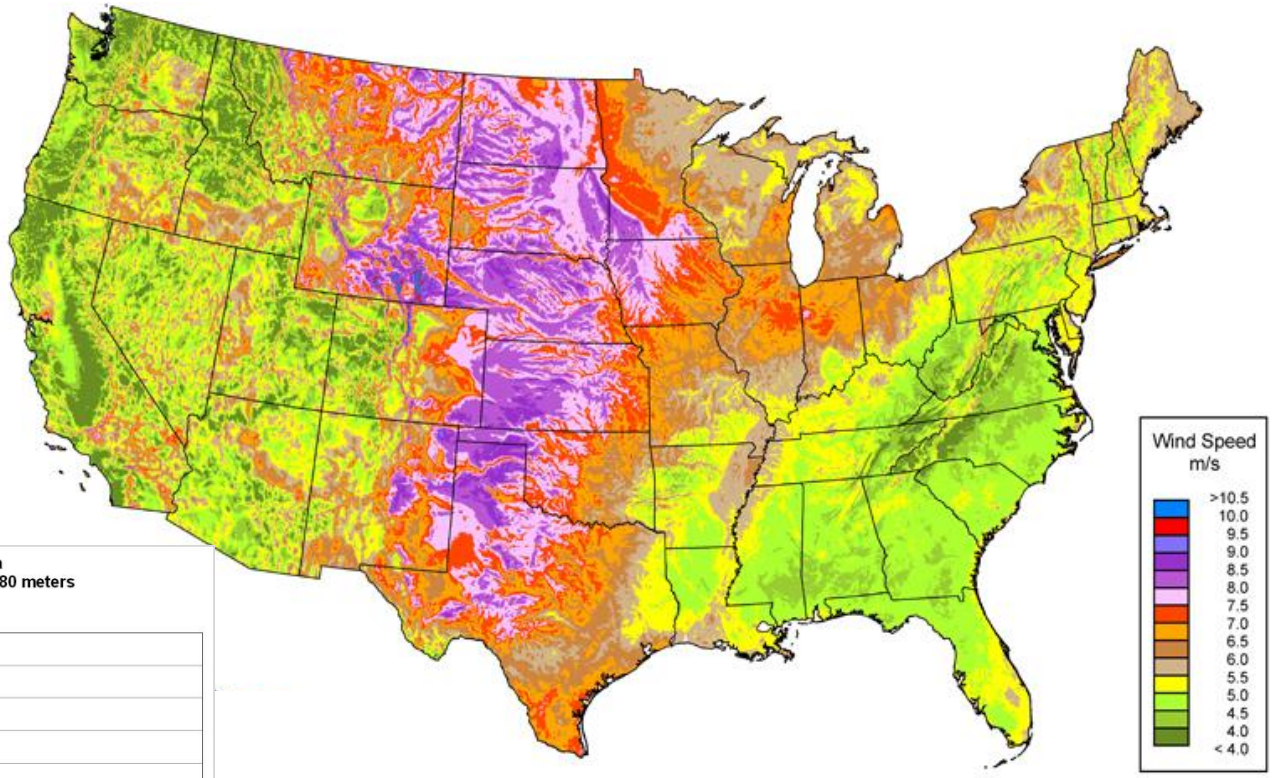
Executive Summary

- **Superior renewable resources exist outside of California**
  - Higher capacity factors
  - Lower construction costs
  - Greater geographical options
- **Long distance resources with more efficient production cost structures can off-set higher transmission costs required to deliver such power to market**
- **California's RPS legislation limits the share of renewable resources that can come from out-of-state**
  - Explicit limits for three separate "buckets"
  - Recent ruling does not provide sufficient clarity on what is required for out-of-state resources to be dynamically scheduled and delivered into California
  - As a result, California-based renewable resources could be 75 percent to 90 percent of the total portfolio
- **Limiting imports of renewable resources will cost California ratepayers**
  - Inability to access the most cost-effective resources
  - Lack of flexibility to integrate a diverse portfolio of renewable resources
- **The incremental costs of limiting renewable imports could exceed hundreds of million of dollars per year, costing ratepayers billions of dollars over the life of the RPS program**

Location of Renewable Resources

Renewable Resources | Wind Potential by State

Utility-Scale Wind Maps
For each of the 50 states and the total U.S., these estimates show windy land area with a gross capacity factor (without losses) of 30% and greater at 80-m height above ground development of the "available" windy land area after exclusions. Excluded lands include protected lands (national parks, wilderness, etc.), incompatible land use (urban, airports, wetland, and water features), and other areas unlikely to be developed for wind. The map illustrates wind energy potential by state.



Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: http://www.windnavigator.com | http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.

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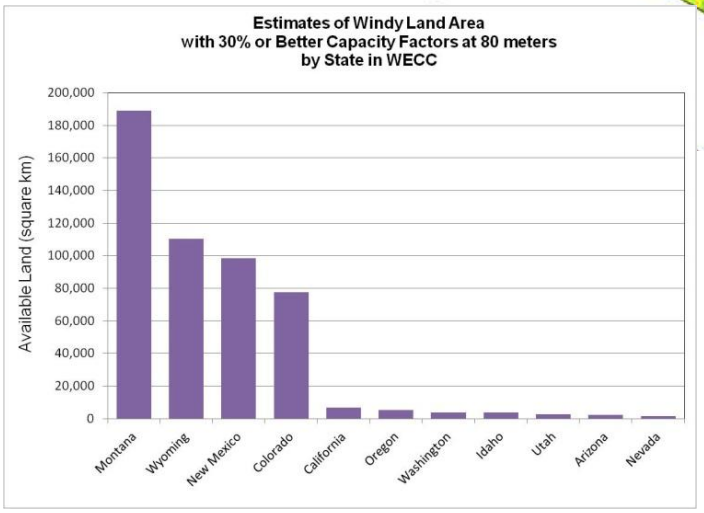
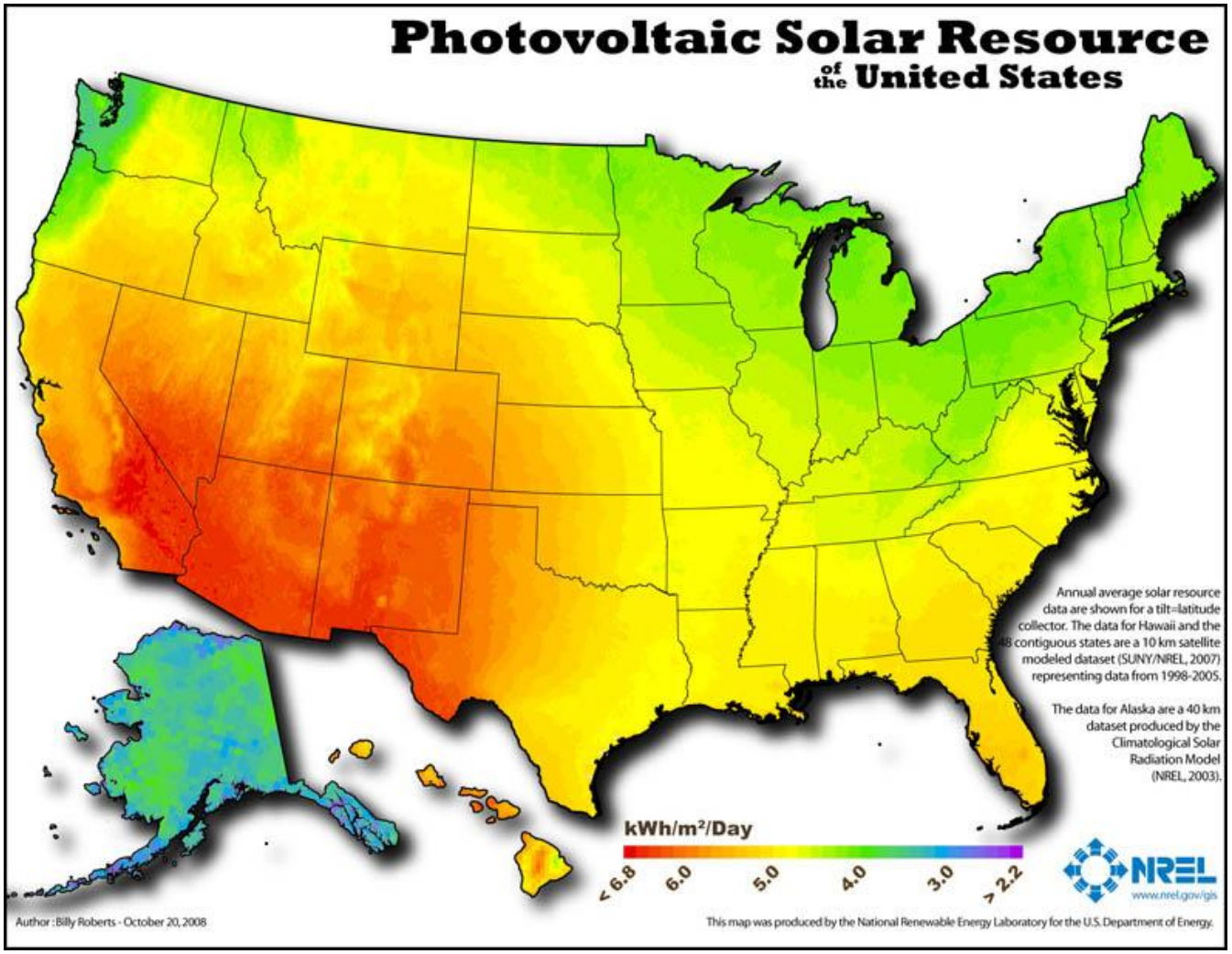


Substantially larger regions of superior wind sources exist outside of California

Source: FTI Analysis, DOE National Renewable Energy Laboratory (NREL) http://www.windpoweringamerica.gov/wind_maps.asp,

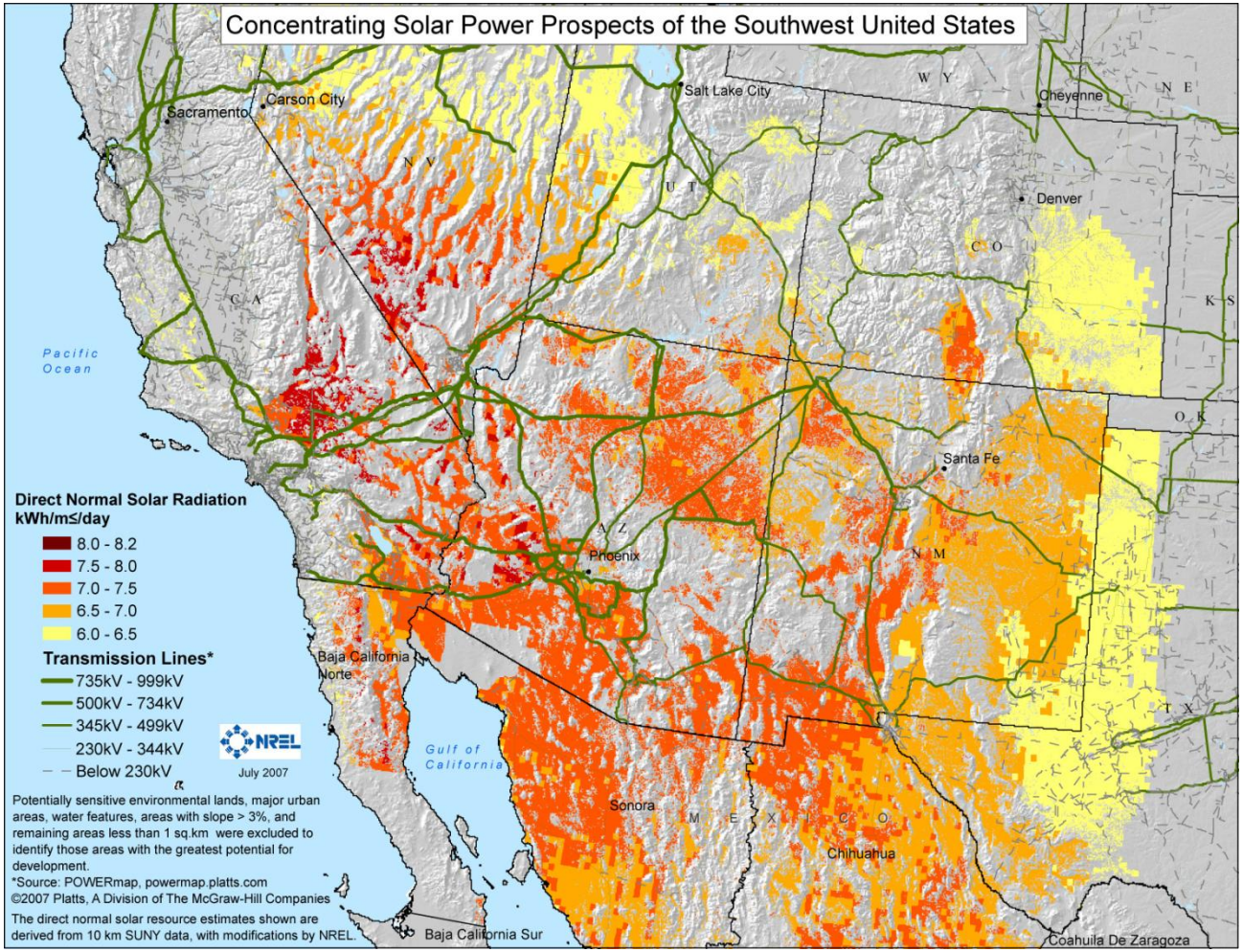
Renewable Resources | Photovoltaic Potential by State



Photovoltaic opportunities are plentiful in Southern California and surrounding states

Source: DOE National Renewable Energy Laboratory (NREL) http://www.nrel.gov/csp/maps.html

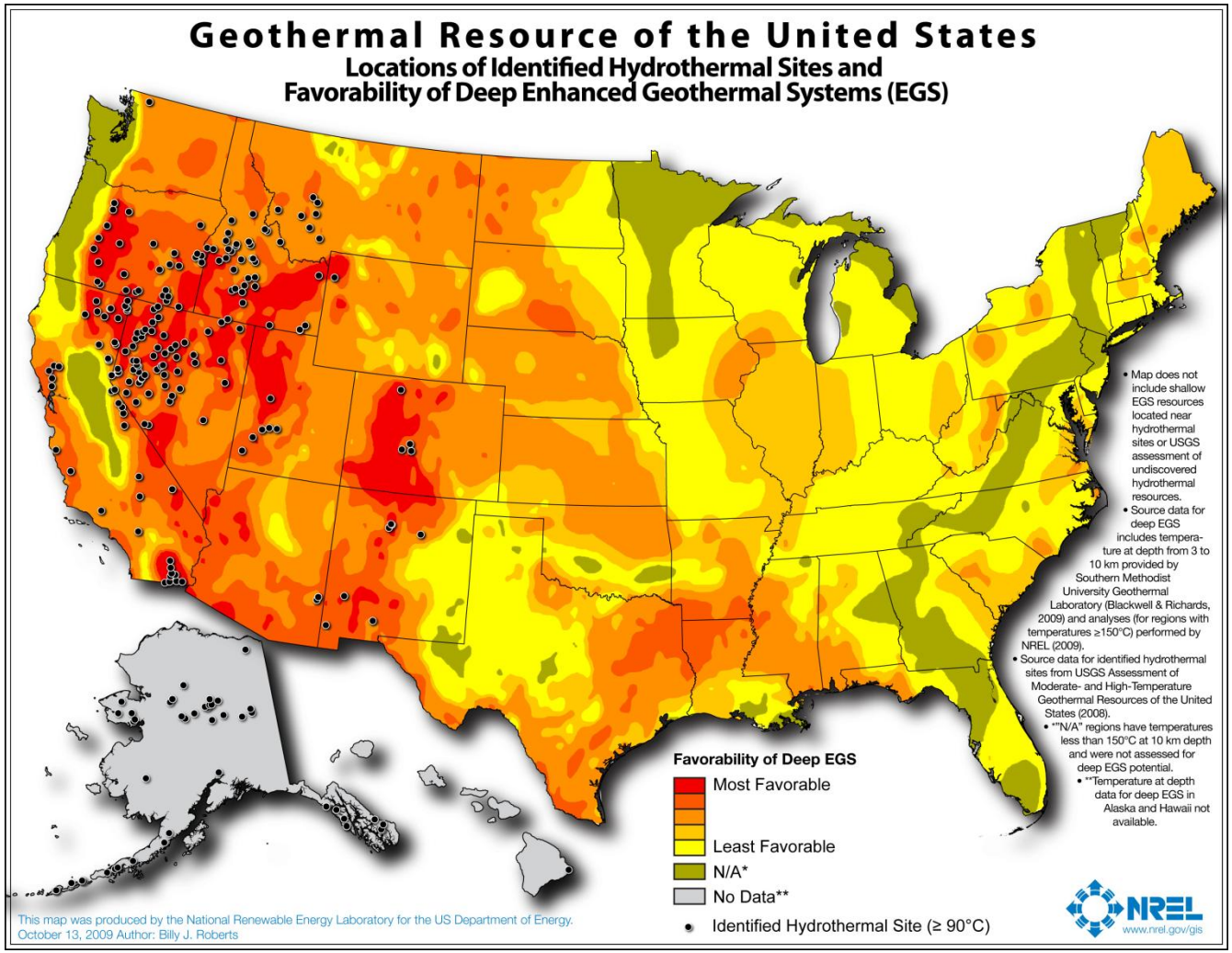
Renewable Resources | Solar Thermal Potential by State



Wider expanses of solar thermal sites with accessible transmission occur outside of California

Source: DOE National Renewable Energy Laboratory (NREL) http://www.nrel.gov/csp/maps.html

Renewable Resources | Geothermal Potential by State



A significant number of identified geothermal sites are outside of California

Source: DOE National Renewable Energy Laboratory (NREL) http://www.nrel.gov/gis/images/geothermal_resource2009-final.jpg

California's RPS Requirements

RPS Requirements | Requirements and Restrictions

California Renewable Portfolio Requirements -- SB 2 (1X)

- California electric utilities must increase their retail sales from approved renewable resources according to the following timeline:
  - 20% of retail sales by 2013
  - 25% of retail sales by 2016
  - 33% of retail sales by 2020

Resource Restrictions:

- Utilities can fulfill their obligations from the following three types of renewable resources:

Bucket	Eligible Resources	Restrictions from 2017
#1	a) first point of interconnection with CA balancing authority or distribution system to serve CA end users b) energy scheduled into a CA balancing authority *without* substituting from another source c) energy deliverd to CA balancing authority under a dynamic transfer	>= 75% of total requirement
#2	a) firmed and shaped resources providing incremental electricity into a California balancing authority	Sum of #2 and #3 can never exceed 25%
#3	a) products not fitting buckets 1 or 2, including unbundled RECs that do not deliver energy into California	Can never exceed 10%

- Utilities and other market participants have expressed concern with these restrictions

When signing the bill, California Governor Brown expressed a desire for a 40 percent RPS target

Source: FTI Analysis, California Energy Commission

RPS Requirements | External Resources Face More Challenges than In-state

Bucket 1: Definition of Dynamic transfer is left to the balancing authority

- **Dynamic Transfer.** The term "dynamic transfer" refers to a range of methods by which a balancing authority receiving electricity generated in another balancing authority area may provide some or all of the functions and services typically provided by the balancing authority in which the generation facility is interconnected.
  - A dynamic transfer arrangement is made between balancing authorities, not the generator and the buyer.
  - Renewable generation claiming RPS-compliance under Bucket #1 must be covered by an agreement executed by a California balancing authority, before the electricity is generated, to dynamically transfer electricity from the external RPS-eligible generator into the California balancing area during the time period in which the RPS-eligible electricity is generated.

Bucket 2: Ongoing challenges remain for an external renewable resource to be eligible:

- **Firming Resources.** Ability to find cost-effective firming resources.
- **Shaping Resources.** Ability to find cost-effective shaping resources.
- **Incremental Resources.** Limitations on the entity from whom a renewable generator can purchase firm and shaping resources.
- **Cross-border Transmission Capacity.** Ability to schedule cross-border transfer capability for purposes of "scheduling into a California balancing authority".

RPS eligibility requirements are significantly greater for out-of-state resources versus in-state

Source: Ibid., http://docs.cpuc.ca.gov/WORD_PDF/FINAL_DECISION/156060.pdf, December 15, 2011

RPS Requirements | Methodology to Calculate Unmet Need

❖ **FTI Methodology:** Estimate the size of each market for renewable power using the following formula:

$$\text{Market Size} = (L \times R \times A) - ES - (AP \times S)$$

Where: L = Projected load R = State RPS goal A = Eligibility Adjustor ES = Existing supply
AP = Approved projects S = Approved project success rate

Bucket 1 Calculation

Target Market	L	R	A	ES	AP	S
Northern California	2020 load projection	33% of load	75% (Minimum Bucket 1 requirement)	Current RPS-compliant projects filed by IOUs, POUs and ESPs	Projects currently under development approved by IOUs and POUs	Low Case: 50% High Case: 90%
Southern California	2020 load projection	33% of load	75% (Minimum Bucket 1 requirement)	Current RPS-compliant projects filed by IOUs, POUs and ESPs	Projects currently under development approved by IOUs and POUs	Low Case: 50% High Case: 90%

Bucket 1 and 2 Calculation

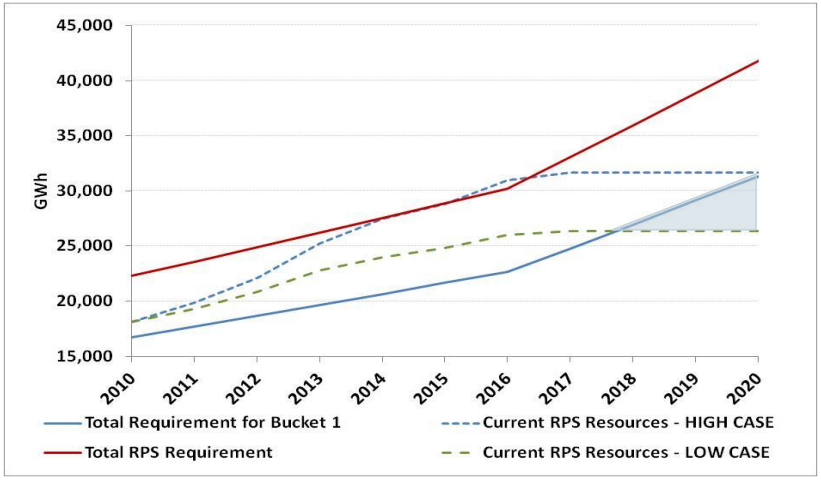
Target Market	L	R	A	ES	AP	S
Northern California	2020 load projection	33% of load	90% (Minimum Bucket 1 & 2 requirement)	Current RPS-compliant projects filed by IOUs, POUs and ESPs	Projects currently under development approved by IOUs and POUs	Low Case: 50% High Case: 90%
Southern California	2020 load projection	33% of load	90% (Minimum Bucket 1 & 2 requirement)	Current RPS-compliant projects filed by IOUs, POUs and ESPs	Projects currently under development approved by IOUs and POUs	Low Case: 50% High Case: 90%

Source: FTI Analysis, Energy Information Administration, California Energy Commission, California Public Utility Comission, North America Electric Reliability Corporation

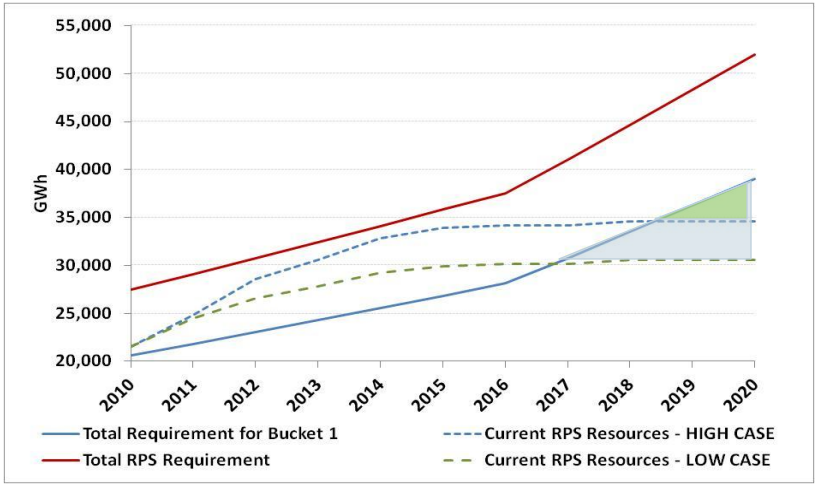
RPS Requirements | Unmet Need for Bucket 1 (33% RPS)

RPS Projections – Bucket 1

Northern California



Southern California



Bucket 1 Projections (GWh)

Low Demand*

	2016	2020
Load	120,916	126,605
Total RPS	30,229	41,780
Total Bucket 1	22,672	31,335
Current Bucket 1	30,992	31,636
Unmet Need	**(8,320)**	**(302)**

High Demand**

	2016	2020
Load	120,916	126,605
Total RPS	30,229	41,780
Total Bucket 1	22,672	31,335
Current Bucket 1	26,028	26,386
Unmet Need	**(3,356)**	**4,949**

Low Demand*

	2016	2020
Load	150,027	157,571
Total RPS	37,507	51,999
Total Bucket 1	28,130	38,999
Current Bucket 1	34,182	34,576
Unmet Need	**(6,052)**	**4,423**

High Demand**

	2016	2020
Load	150,027	157,571
Total RPS	37,507	51,999
Total Bucket 1	28,130	38,999
Current Bucket 1	30,140	30,534
Unmet Need	**(2,010)**	**8,465**

Demand for renewable resources is met through existing and planned projects through 2017

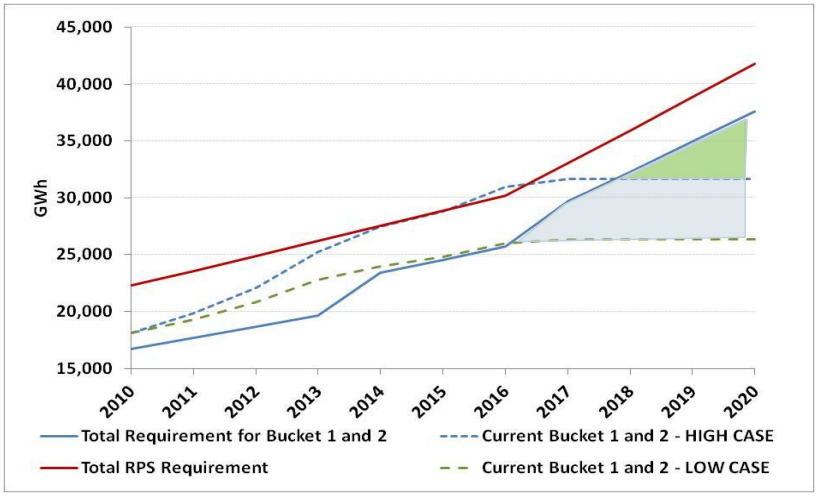
* Low Demand represents RPS requirements assuming an approved project high success rate of 90%

** High Demand represents RPS requirements assuming an approved project low success rate of 50%

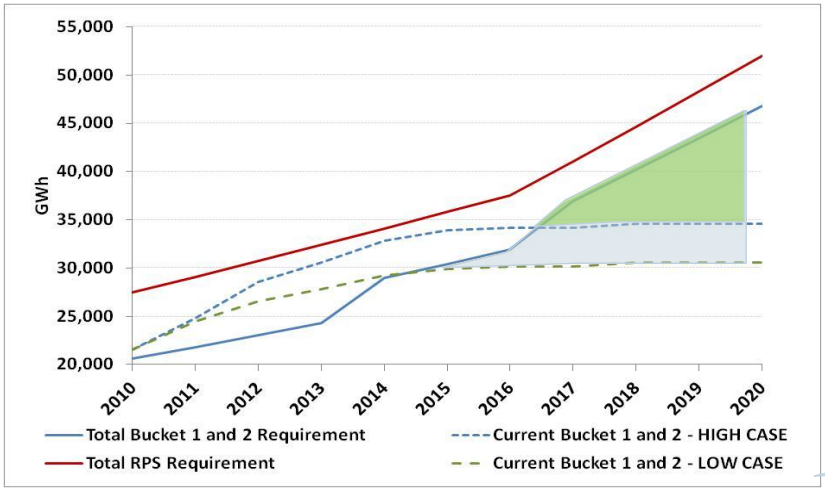
RPS Requirements | Unmet Need for Bucket 1 and 2 (33% RPS)

RPS Projections – Bucket 1 and 2

Northern California



Southern California



Bucket 1 and 2 Projections (GWh)

Low Demand*

	2016	2020
Load	120,916	126,605
Total RPS	30,229	41,780
Total Buckets 1 and 2	25,695	37,602
Current Buckets 1 and 2	30,992	31,636
Unmet Need	**(5,297)**	**5,965**

High Demand**

	2016	2020
Load	120,916	126,605
Total RPS	30,229	41,780
Total Buckets 1 and 2	25,695	37,602
Current Buckets 1 and 2	26,028	26,386
Unmet Need	**(333)**	**11,216**

Low Demand*

	2016	2020
Load	150,027	157,571
Total RPS	37,507	51,999
Total Buckets 1 and 2	31,881	46,799
Current Buckets 1 and 2	34,182	34,576
Unmet Need	**(2,301)**	**12,223**

High Demand**

	2016	2020
Load	150,027	157,571
Total RPS	37,507	51,999
Total Buckets 1 and 2	31,881	46,799
Current Buckets 1 and 2	30,140	30,534
Unmet Need	**1,741**	**16,265**

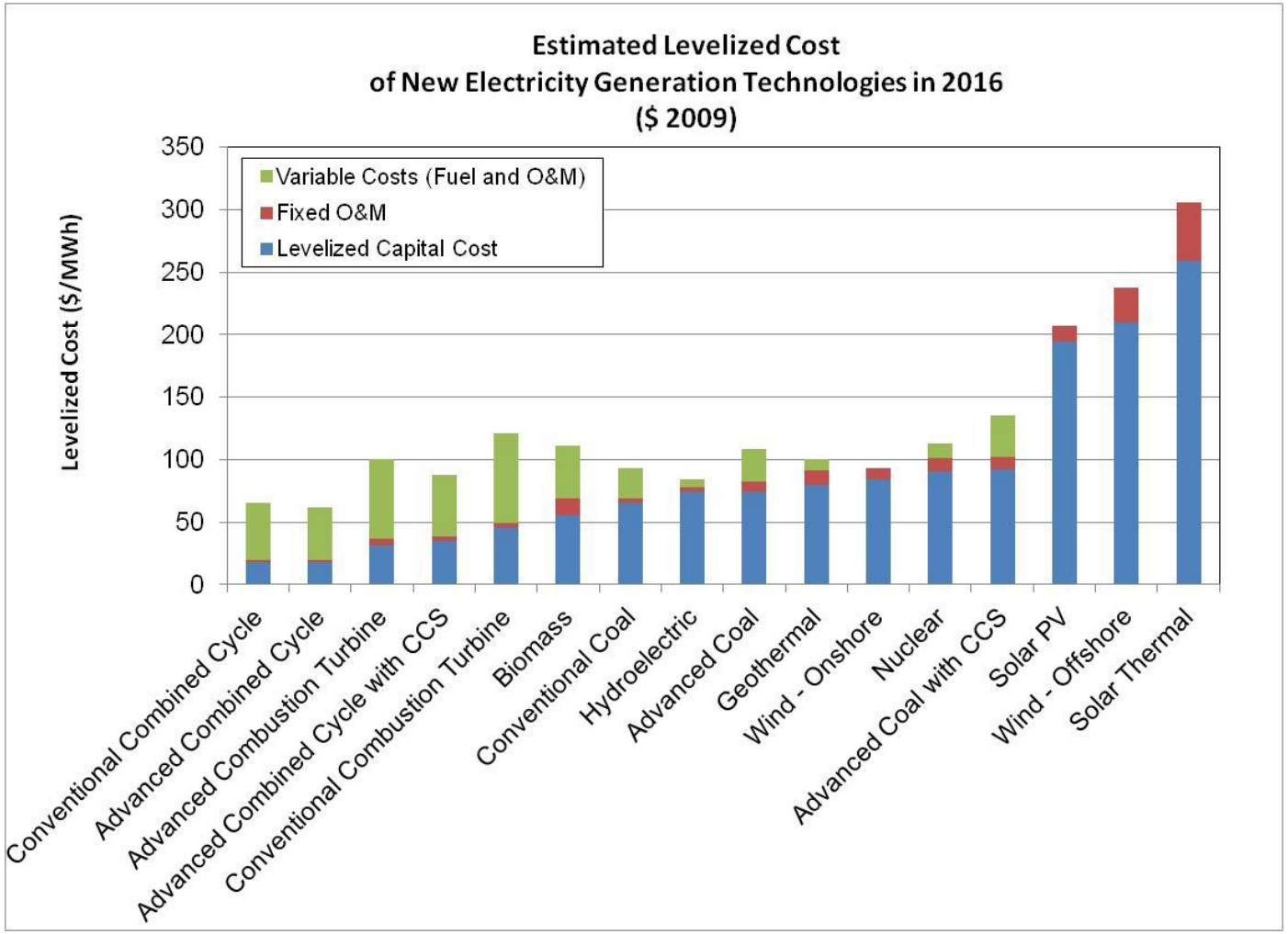
Demand for renewable resources is met through existing and planned projects through 2015

* Low Demand represents RPS requirements assuming an approved project high success rate of 90%

** High Demand represents RPS requirements assuming an approved project low success rate of 50%

Cost of Renewable Resources

Cost of Renewables | Levelized Cost by Generation Technology



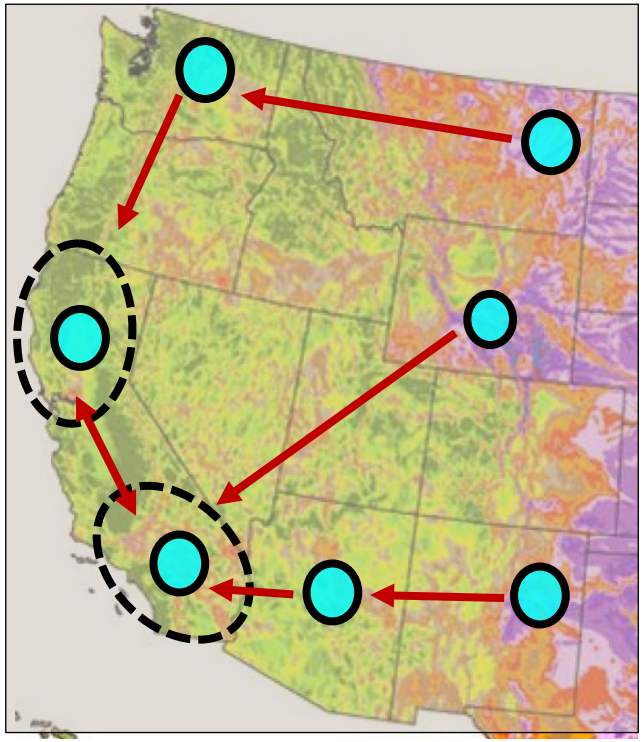
The cost to build and operate generation plants varies by technology

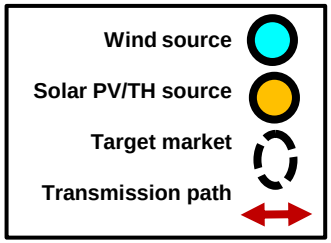
Source: FTI Analysis of Energy Information Administration, Annual Energy Outlook 2011, http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html
Does not include environmental cost of emissions

Cost of Renewables | Supply Sources and Transmission Paths

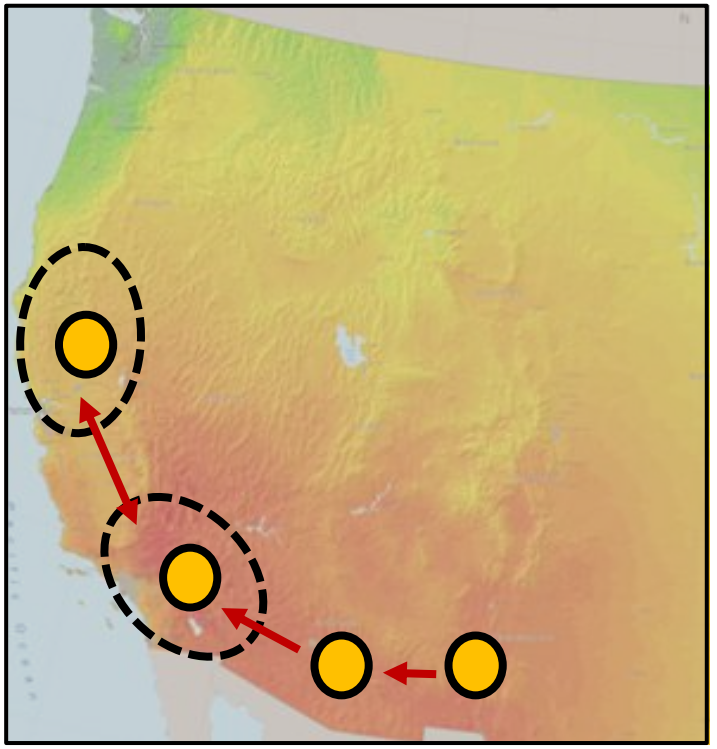
- Renewable resource supply may be sourced from different geographic regions
- Existing and planned transmission lines can be used to deliver renewable resources from optimal locations to California

Wind Supply Sources





Solar Supply Sources



Superior capacity factors allow longer distance renewable resources to be competitive

Source: FTI Analysis, Energy Information Administration, FERC, NREL

Cost of Renewables | Long-run Marginal Cost of Delivered Renewables

- **Approach:** FTI calculated and ranked the long-run marginal cost of different renewable resources for target markets incorporating renewable resource efficiency and distance from source to sink
- **Methodology:** Estimate the relative position of renewable resources using the following formula:

$$LRMC = \overbrace{G \times (1 - FG)}^{\text{Production Cost}} + \overbrace{Tr}^{\text{Delivery Cost}}$$

Where: LRMC = Long Run Marginal Cost of Production

G = Levelized capital cost of generation, adjusted for local resource capacity factors ($/MWh)

Tr = Transmission Cost ($/MWh)

Drivers of Long-run Marginal Cost

Variable	Long-run Marginal Cost Component	Source
G =	Local Cost of Technology Adjusted for Capacity Factor	EIA levelized capital cost estimates ($/MWh)
	Capacity Factor of Resource	NREL wind and solar resource data
FG =	30% Federal Grants / Tax Credits	Assumed to be zero
Tr =	Cost of Transmission	Existing tariffs

Total delivered costs include options for transporting renewable energy from other states

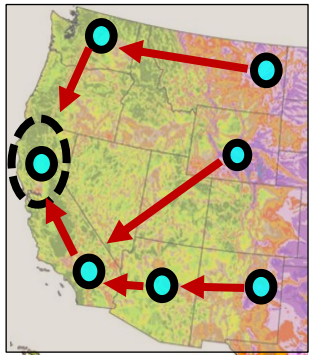
Cost of Renewables | Comparative Renewable Costs – Existing Tariffs

Incremental Cost of Renewables to Northern California

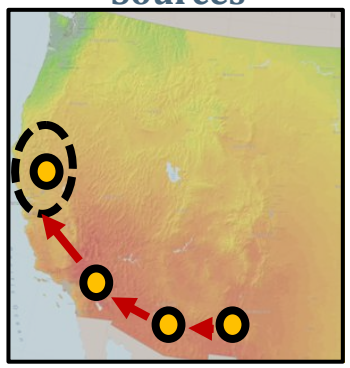
OATTS Existing Tariffs

Rank	Resource	Levelized Cost (2010 $/MWh)	Incremental Cost to NoCal (2010 $/MWh)
1	Montana Wind	$ 94.75	$ (9.58)
2	Wyoming Wind	$ 101.70	$ (2.62)
3	New Mexico Wind	$ 104.32	$ (0.01)
4	No Cal Wind	$ 104.33	$ -
5	So Cal Wind	$ 111.87	$ 7.54
6	Pac Northwest Wind	$ 113.11	$ 8.78
7	Arizona Wind	$ 113.58	$ 9.25
8	Arizona Solar - PV	$ 180.45	$ (30.68)
9	So Cal Solar - PV	$ 191.03	$ (20.10)
10	New Mexico Solar - PV	$ 202.80	$ (8.33)
11	No Cal Solar - PV	$ 211.13	$ -
12	Arizona Solar - TH	$ 280.81	$ (74.33)
13	New Mexico Solar - TH	$ 316.72	$ (38.41)
14	So Cal Solar - TH	$ 320.93	$ (34.21)
15	No Cal Solar - TH	$ 355.14	$ -

Wind Supply Sources

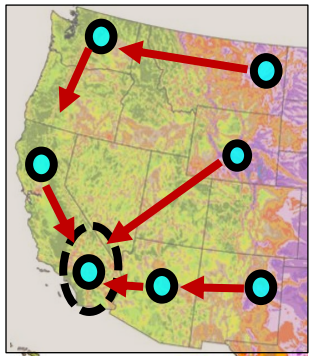


Solar Supply Sources

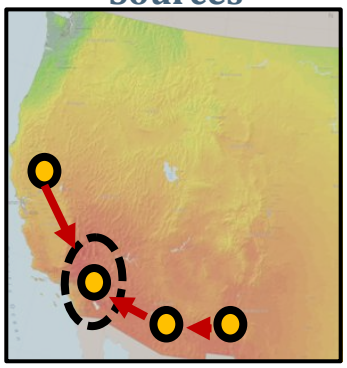


Incremental Cost of Renewables to Southern California

Wind Supply Sources



Solar Supply Sources



OATTS Existing Tariffs

Rank	Resource	Levelized Cost (2010 $/MWh)	Incremental Cost to SoCal (2010 $/MWh)
1	Wyoming Wind	$ 99.48	$ (3.85)
2	New Mexico Wind	$ 100.25	$ (3.09)
3	Montana Wind	$ 100.81	$ (2.52)
4	So Cal Wind	$ 103.33	$ -
5	Arizona Wind	$ 109.51	$ 6.17
6	No Cal Wind	$ 112.86	$ 9.53
7	Pac Northwest Wind	$ 115.11	$ 11.77
8	Arizona Solar - PV	$ 176.37	$ (6.12)
9	So Cal Solar - PV	$ 182.49	$ -
10	New Mexico Solar - PV	$ 198.73	$ 16.23
11	No Cal Solar - PV	$ 219.66	$ 37.17
12	Arizona Solar - TH	$ 276.74	$ (35.66)
13	So Cal Solar - TH	$ 312.39	$ -
14	New Mexico Solar - TH	$ 312.65	$ 0.26
15	No Cal Solar - TH	$ 363.67	$ 51.28

Source: FTI Analysis, does not include subsidies, grants or tax credits

Cost of Renewables | Incremental Cost of Restricting Imports

- **Approach:** Multiply the incremental cost of California-based renewable resources vs. out-of-state options and by the unmet need for renewable resources in California
- **Conclusion:** Estimated range of the incremental cost of limiting renewable resources to California resources is:
  - Under a 33% RPS Requirement: $100 million to $300 million per year
  - Under a 40% RPS Requirement: $450 million to $700 million per year
  - Incremental costs of limiting renewable resources to in-state could cost ratepayers billions of dollars over the life of the RPS regulations

		Incremental Cost of California Renewables ($/MWh)					
		5	10	15	20	25	30
Unmet Need (GWh)	5,000	$ 25,000,000	$ 50,000,000	$ 75,000,000	$ 100,000,000	$ 125,000,000	$ 150,000,000
33% RPS	10,000	$ 50,000,000	$ 100,000,000	$ 150,000,000	$ 200,000,000	$ 250,000,000	$ 300,000,000
	15,000	$ 75,000,000	$ 150,000,000	$ 225,000,000	$ 300,000,000	$ 375,000,000	$ 450,000,000
	20,000	$ 100,000,000	$ 200,000,000	$ 300,000,000	$ 400,000,000	$ 500,000,000	$ 600,000,000
	25,000	$ 125,000,000	$ 250,000,000	$ 375,000,000	$ 500,000,000	$ 625,000,000	$ 750,000,000
40% RPS	30,000	$ 150,000,000	$ 300,000,000	$ 450,000,000	$ 600,000,000	$ 750,000,000	$ 900,000,000
	35,000	$ 175,000,000	$ 350,000,000	$ 525,000,000	$ 700,000,000	$ 875,000,000	$ 1,050,000,000
	40,000	$ 200,000,000	$ 400,000,000	$ 600,000,000	$ 800,000,000	$ 1,000,000,000	$ 1,200,000,000
	45,000	$ 225,000,000	$ 450,000,000	$ 675,000,000	$ 900,000,000	$ 1,125,000,000	$ 1,350,000,000
	50,000	$ 250,000,000	$ 500,000,000	$ 750,000,000	$ 1,000,000,000	$ 1,250,000,000	$ 1,500,000,000

- Additional costs also include higher integration costs associated with a limited subset of resources

Actual costs depend on resource constraints, cost of those resources and foregone cost savings