



# Western Wind & Solar Integration Study

## Data, Work Plan, Base Scenarios

Dick Piwko, Kara Clark

Stakeholder Meeting  
August 14, 2008



imagination at work

# GE Project Team

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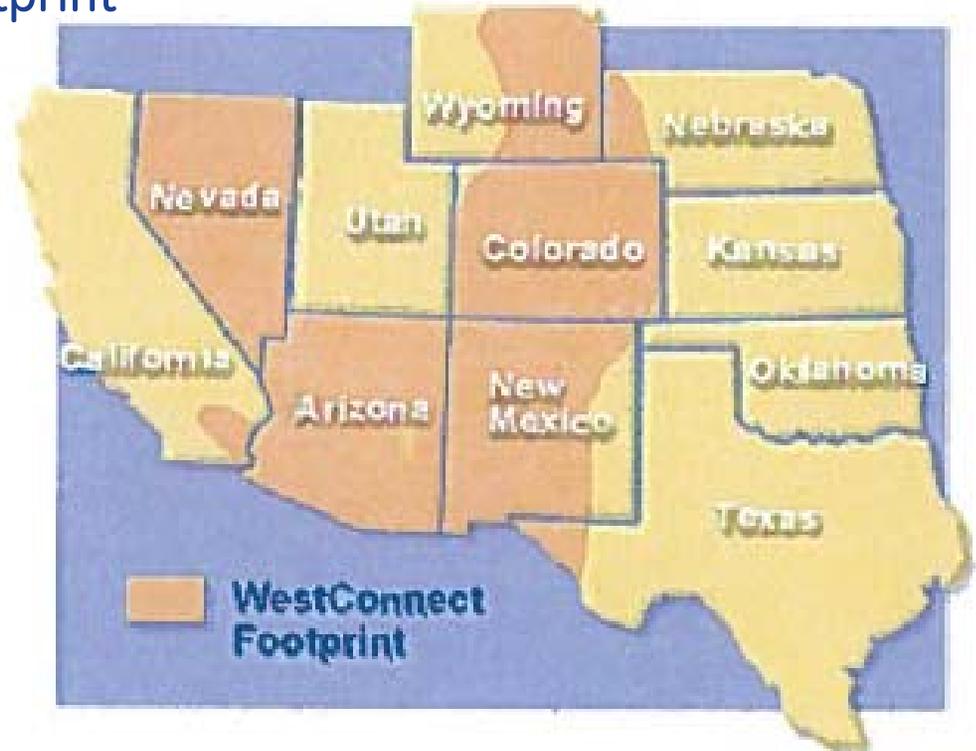
*and several other engineers  
in Schenectady, New York*

# Project Objective

“To help multiple utilities in the western U.S. understand the costs and operating impacts of the variability and uncertainty of wind and solar power on their grids and potential mitigation options for these impacts.”

## WestConnect Region - Study Footprint

- Arizona Public Service
- El Paso Electric
- Nevada Power
- Public Service of New Mexico
- Salt River Project
- Sierra Pacific Power
- Tri-State G&T
- Tucson Electric Power
- Xcel Energy
- Parts of WAPA



# Project Tasks

## 4.1: Preliminary Analysis and Scenario Development

- This is where we are today

## 4.2: Baseline Scenario for Year 2017

- Existing wind and solar as of 2008

## 4.3: Year 2017 with High Renewables Scenario

- Target 30% energy from wind in study footprint

## 4.4: Year 2017 with Variations on the High Renewables Scenario

## 4.5: ELCC and LOLE Analysis

- For three selected scenarios

## 4.6: Draft and Final Reports

# Types of Analysis for Each Scenario

## Statistical analysis

- Variability, uncertainty, seasonality, extreme events, etc
- Hourly, sub-hourly

## Production simulation analysis, MAPS

- Unit commitment, economic dispatch, spot price, energy displacement, storage, transmission constraints, emissions, etc
- “Transport” MAPS and “Full” MAPS

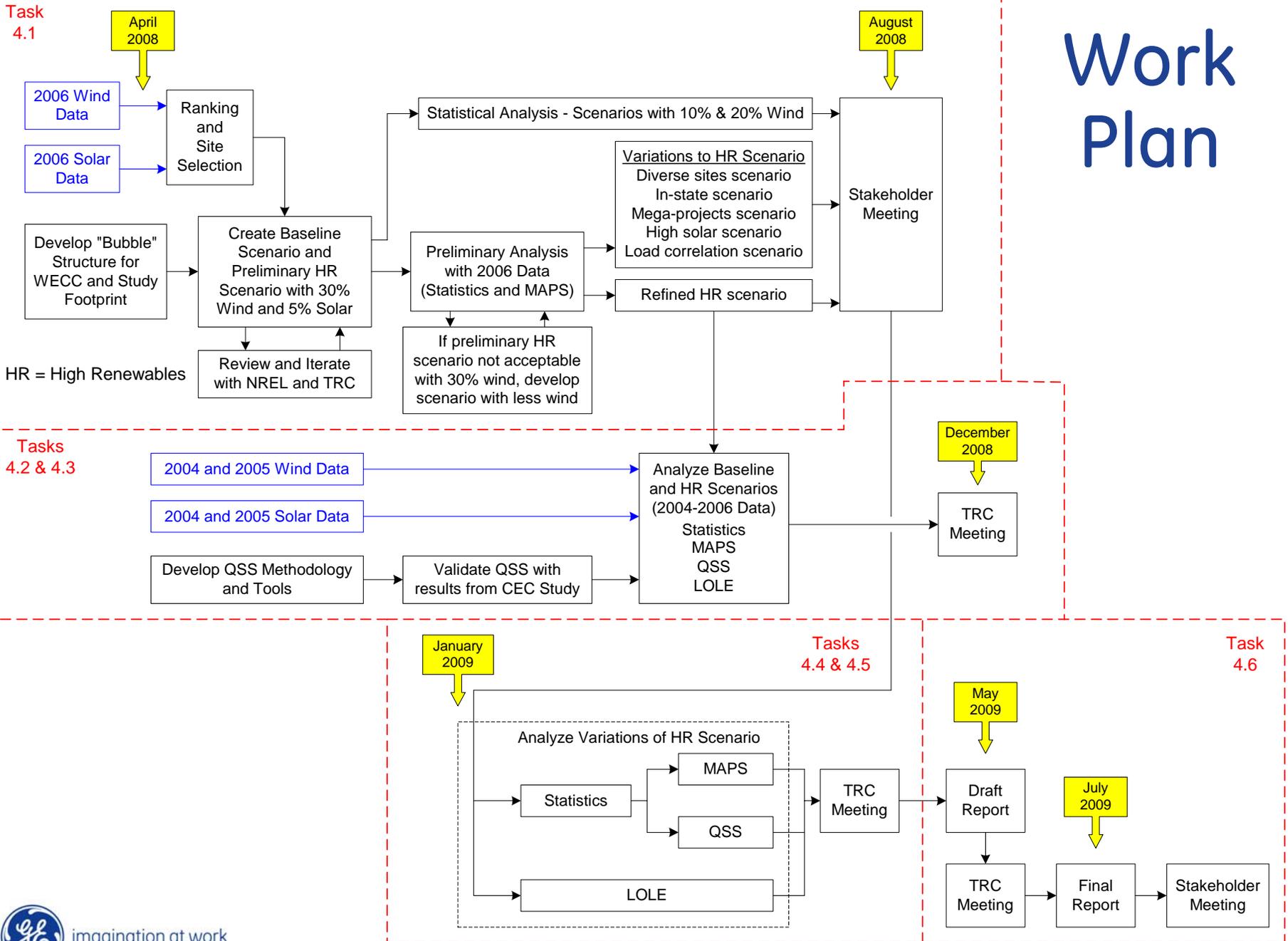
## Quasi-steady-state analysis, QSS

- Minute-by-minute simulations of selected time periods to evaluate system performance and potential mitigation measures

## Sensitivity analysis

- WTG technology, controls, operating strategies, flexibility of dispatchable generation resources, changes in balancing area size/practices, operation of hydro resources, etc

# Work Plan



# Available Data

## Wind

- 10-min and hourly profiles, 26,900 sites in WECC, 30 MW each, years 2004-2006
- Day-ahead hourly forecasts, years 2004-2006

## Solar

- Hourly profiles, 314 CSP sites in WECC, 100 MW each, years 2004-2006
- Hourly profiles, 245 PV sites in WECC, 100 MW each, years 2004-2006
- Day-ahead hourly forecasts, years 2004-2006

## Load

- Hourly profiles for all areas in WECC, years 2004-2006
- Load forecasts
  - NP, SPPC, PNM, SRP data for years 2004-2006
  - APS, TEP, Xcel data for selected time periods
- Sub-hourly profiles
  - NP, SPPC, PNM, SRP data for years 2004-2006
  - APS, TEP, Xcel data for selected time periods

# Scenario Overview

2017 Study Year

2006 Load Shape Escalated to 2017 (+1.8%/year, +21.7% total)

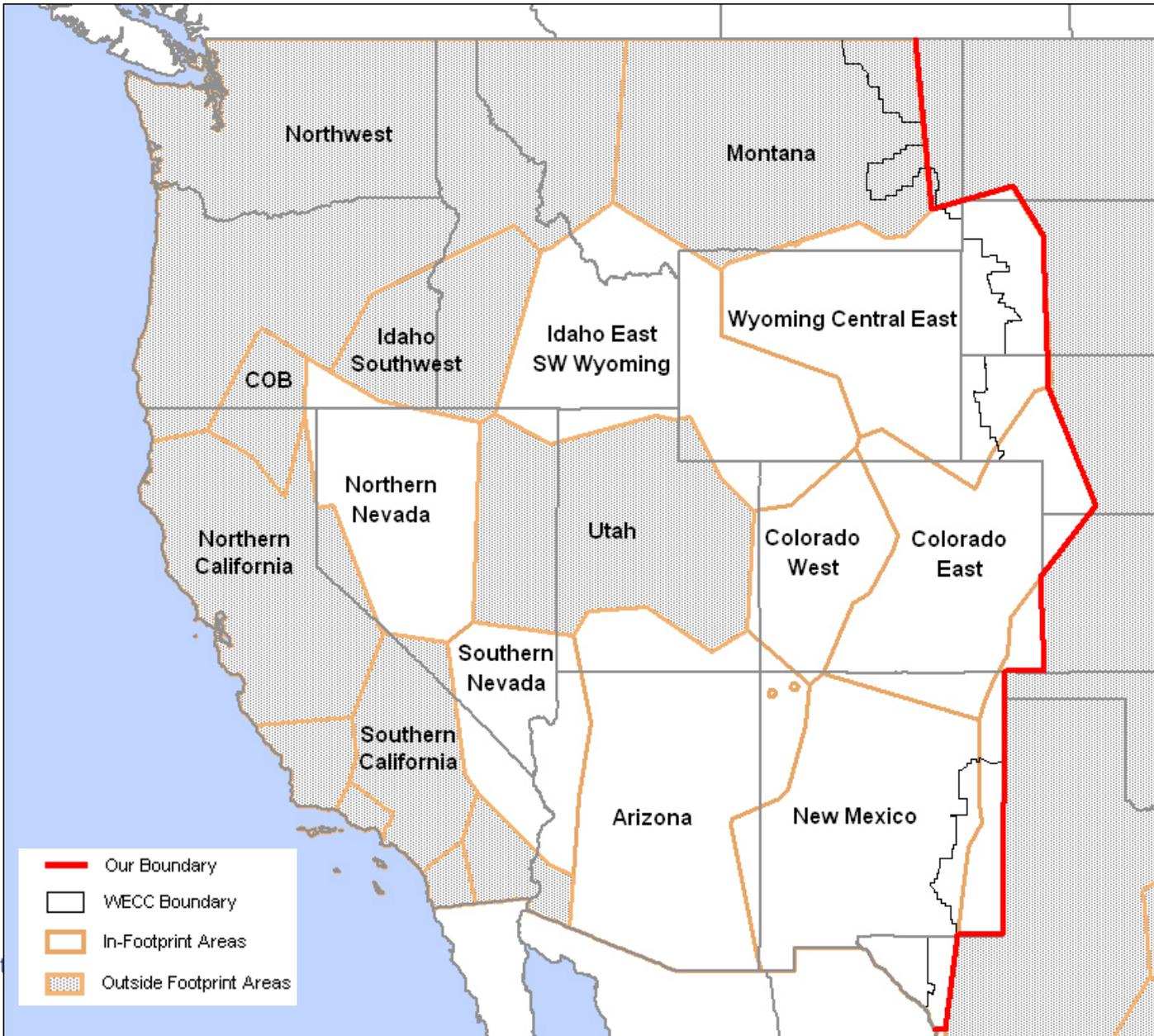
Wind and Solar Combinations (% Energy)

- 2017 Baseline: Preselected Wind, Embedded Solar
- 30% In-Area: 30% Wind, 5% Solar In Footprint  
20% Wind, 3% Solar Out of Footprint
- 20% In-Area: 20% Wind, 3% Solar In Footprint  
10% Wind, 1% Solar Out of Footprint
- 10% In-Area: 10% Wind, 1% Solar In Footprint  
10% Wind, 1% Solar Out of Footprint

Solar Mix

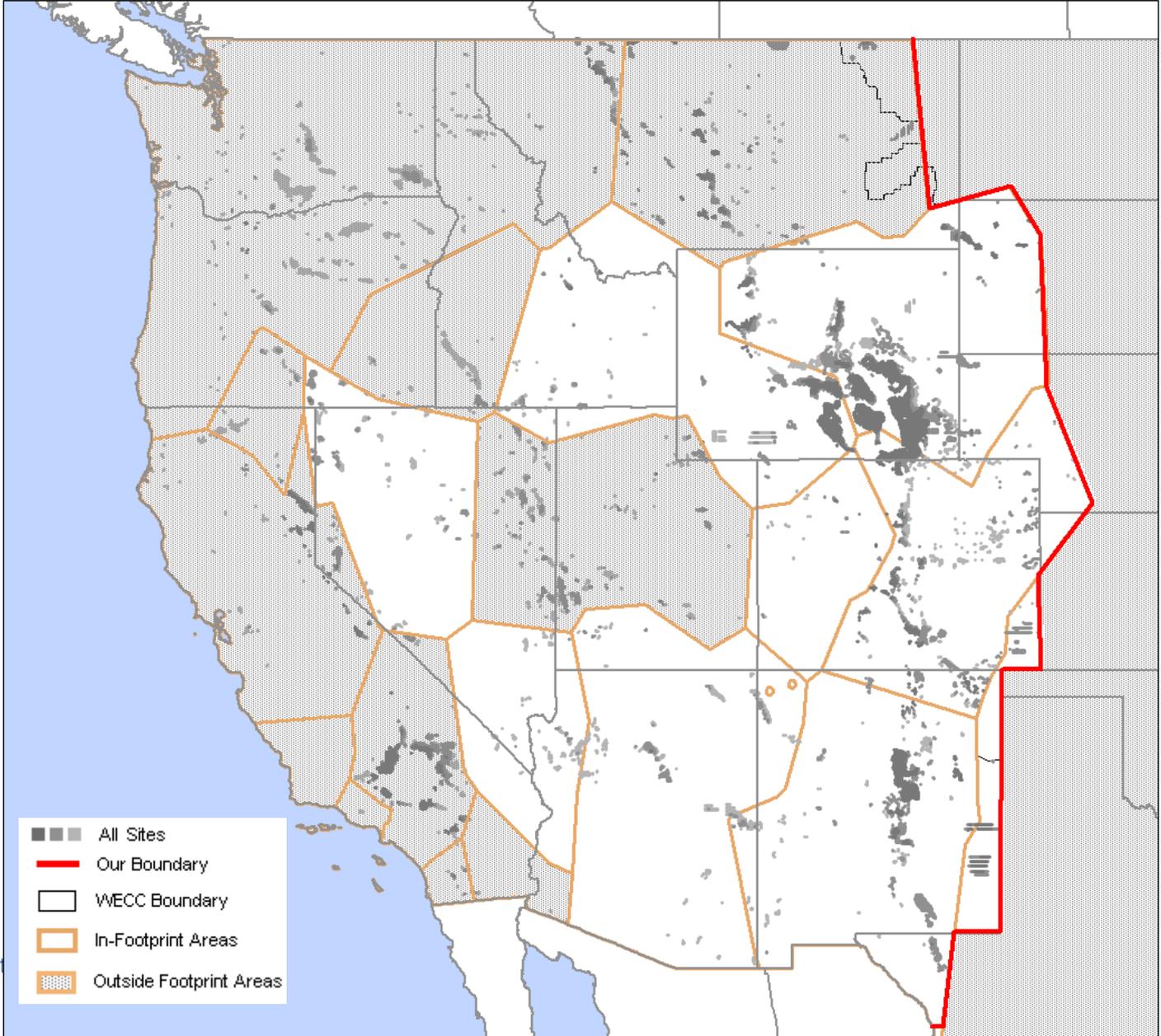
- 70% Concentrating Solar Plant with Storage (CSP w/S)
- 30% Photo-voltaic (PV)

# Transmission Areas





# Available Wind Sites



# Selecting Wind and Solar Plants within Areas

More available sites than needed to meet the study's energy objectives

Need analytical method to select a subset of the available sites

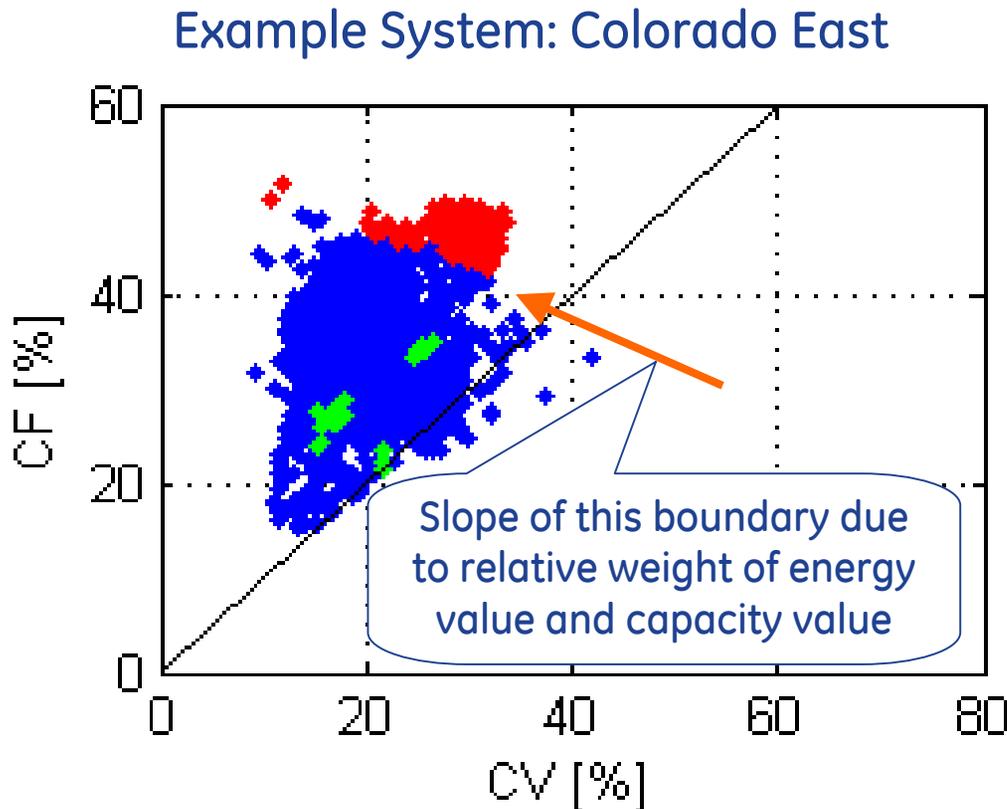
The method should:

- Satisfy energy objectives
- Consider expected market value of energy produced
- Include capacity value of sites
- Recognize that geographic diversity within areas has value
- Include pre-selected wind plants
- Independently select Wind, PV, and CSP w/storage

**A 'Global Siting Algorithm' was created.....**

# Step 1: Intra-Area Ordering

The intent of intra-area ordering is to sort candidate sites within each area from best to worst, according to a mix of energy value, geographic diversity and capacity value.



Algorithm Parameters:

Energy value:

**Hourly historical hub spot prices**

Capacity value:

**\$100/kW-yr**

Geographic diversity value:

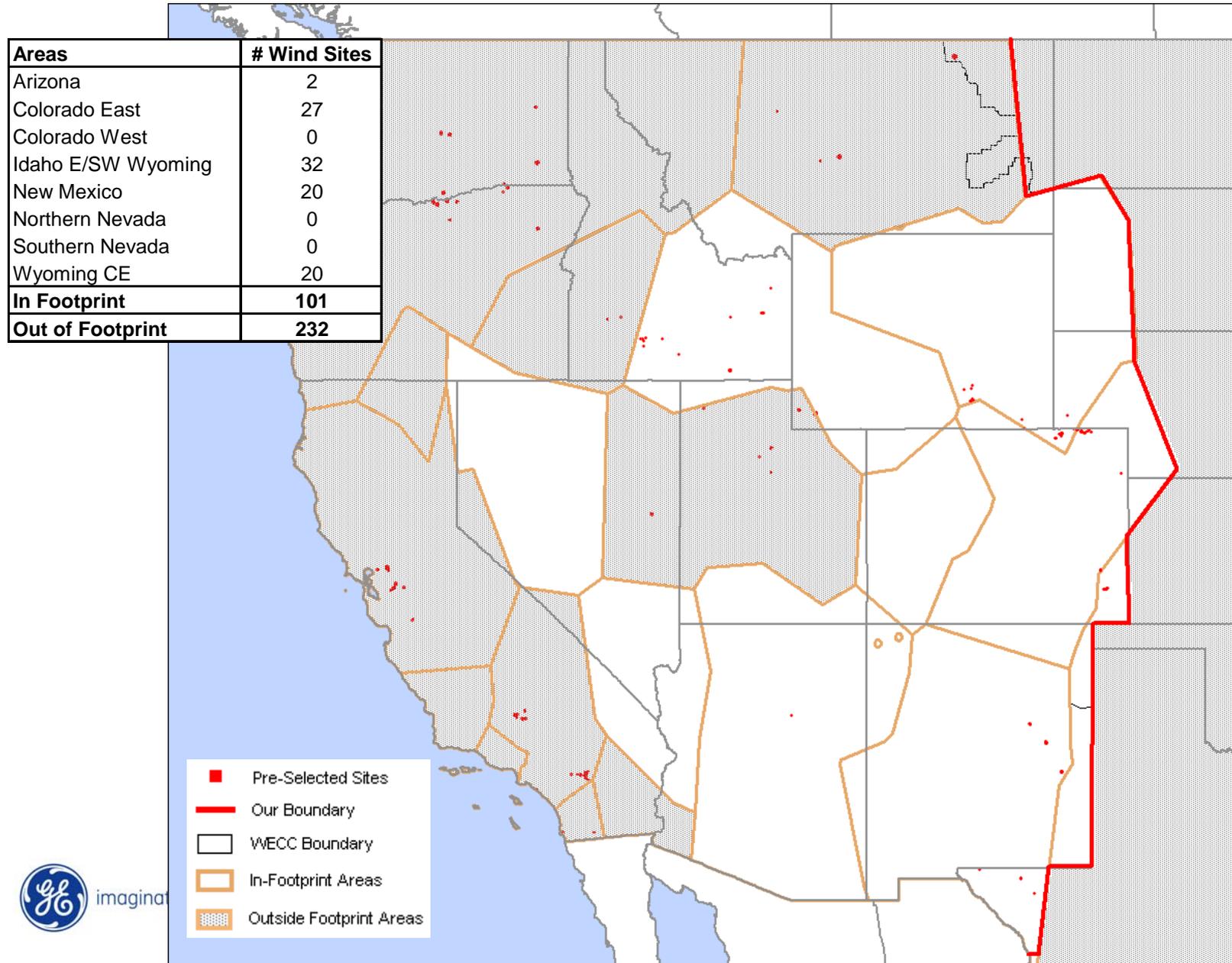
**1%/100 mile dispersal**

Legend:

- **Pre-selected Sites (27)**
- **New Selected Sites (136)**
- **Remaining sites (2671)**

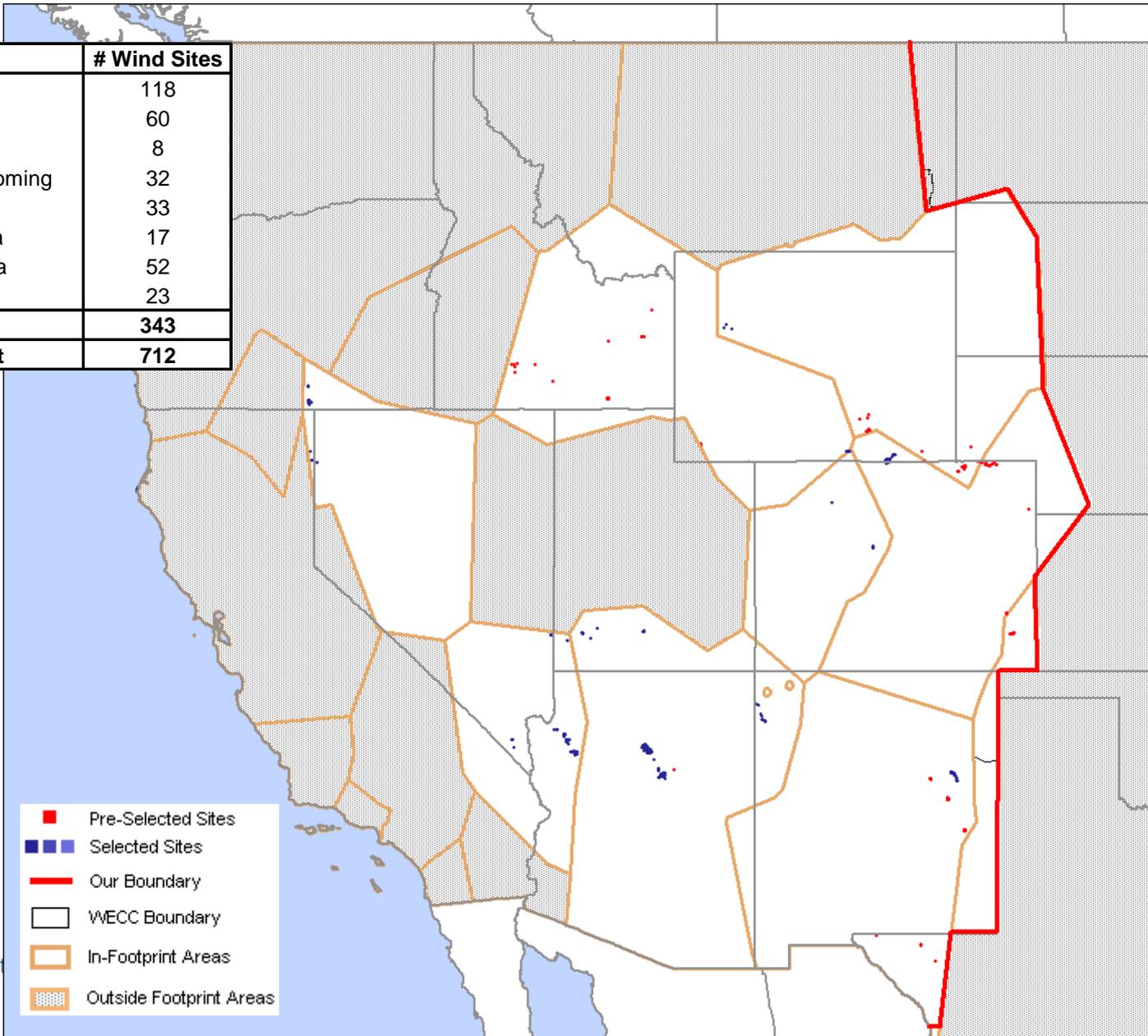
# Pre-Selected Wind Sites (2017 Baseline)

Areas	# Wind Sites
Arizona	2
Colorado East	27
Colorado West	0
Idaho E/SW Wyoming	32
New Mexico	20
Northern Nevada	0
Southern Nevada	0
Wyoming CE	20
<b>In Footprint</b>	<b>101</b>
<b>Out of Footprint</b>	<b>232</b>



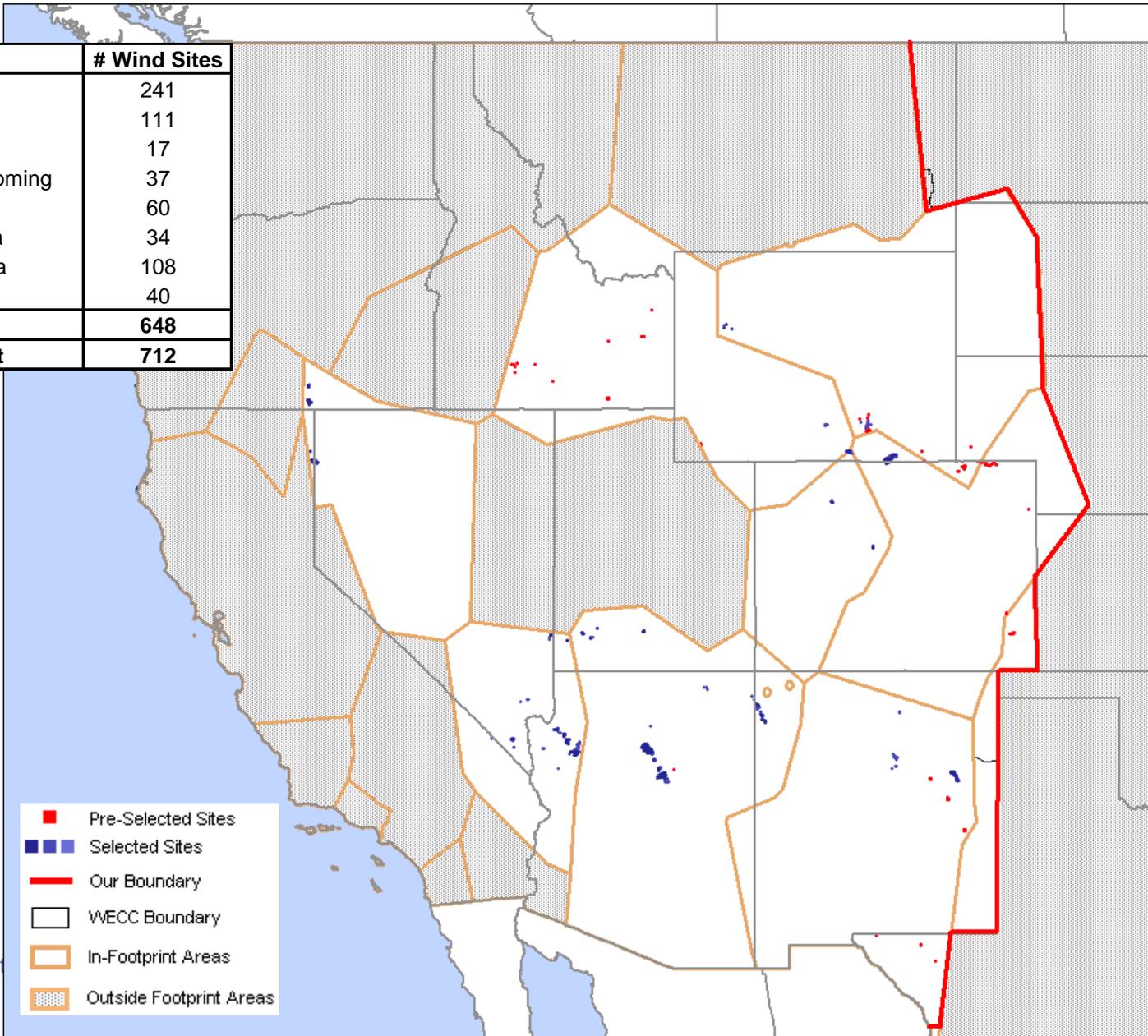
# Wind Sites for 10% Energy by Area

Areas	# Wind Sites
Arizona	118
Colorado East	60
Colorado West	8
Idaho E/SW Wyoming	32
New Mexico	33
Northern Nevada	17
Southern Nevada	52
Wyoming CE	23
<b>In Footprint</b>	<b>343</b>
<b>Out of Footprint</b>	<b>712</b>



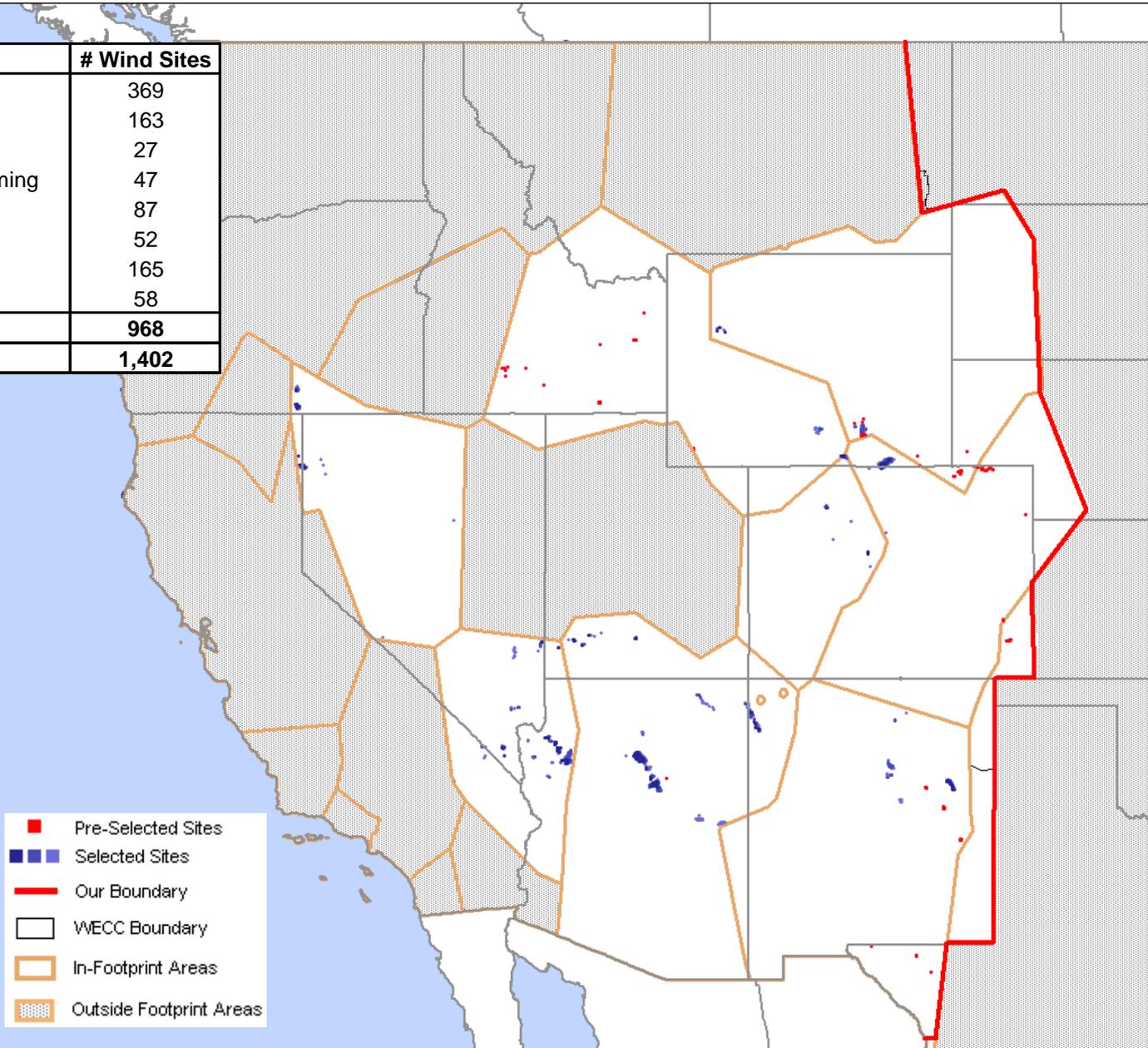
# Wind Sites for 20% Energy by Area

Areas	# Wind Sites
Arizona	241
Colorado East	111
Colorado West	17
Idaho E/SW Wyoming	37
New Mexico	60
Northern Nevada	34
Southern Nevada	108
Wyoming CE	40
<b>In Footprint</b>	<b>648</b>
<b>Out of Footprint</b>	<b>712</b>



# Wind Sites for 30% Energy by Area

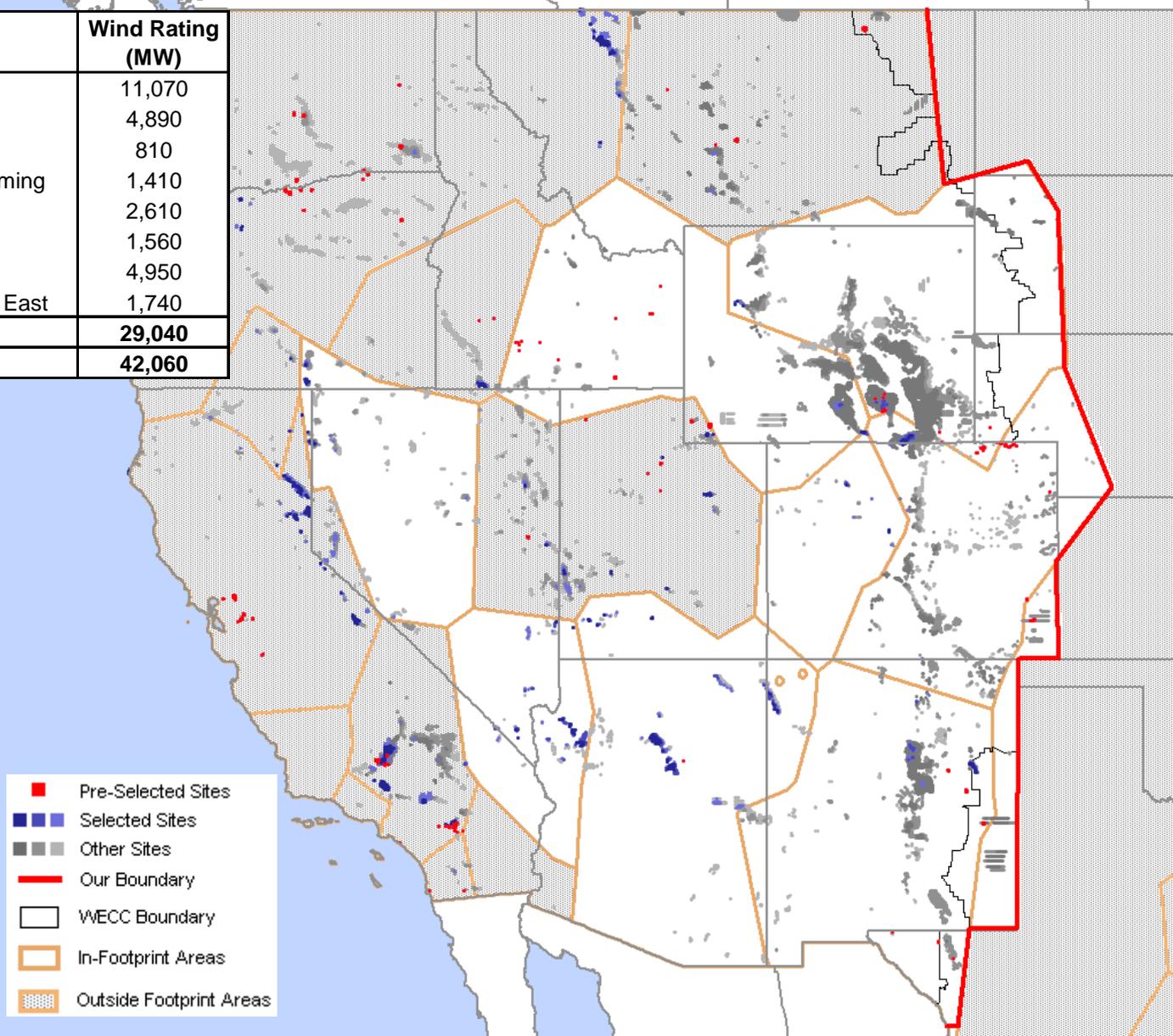
Areas	# Wind Sites
Arizona	369
Colorado East	163
Colorado West	27
Idaho E/SW Wyoming	47
New Mexico	87
Northern Nevada	52
Southern Nevada	165
Wyoming CE	58
<b>In Footprint</b>	<b>968</b>
<b>Out of Footprint</b>	<b>1,402</b>



# In and Out of Footprint Wind Sites (30% In-Area)

30% Energy In Footprint, 20% Energy Out of Footprint

Areas	Wind Rating (MW)
Arizona	11,070
Colorado East	4,890
Colorado West	810
Idaho E/SW Wyoming	1,410
New Mexico	2,610
Northern Nevada	1,560
Southern Nevada	4,950
Wyoming Central East	1,740
<b>In Footprint</b>	<b>29,040</b>
<b>Out of Footprint</b>	<b>42,060</b>



# 30% In-Area Scenario

## Observations:

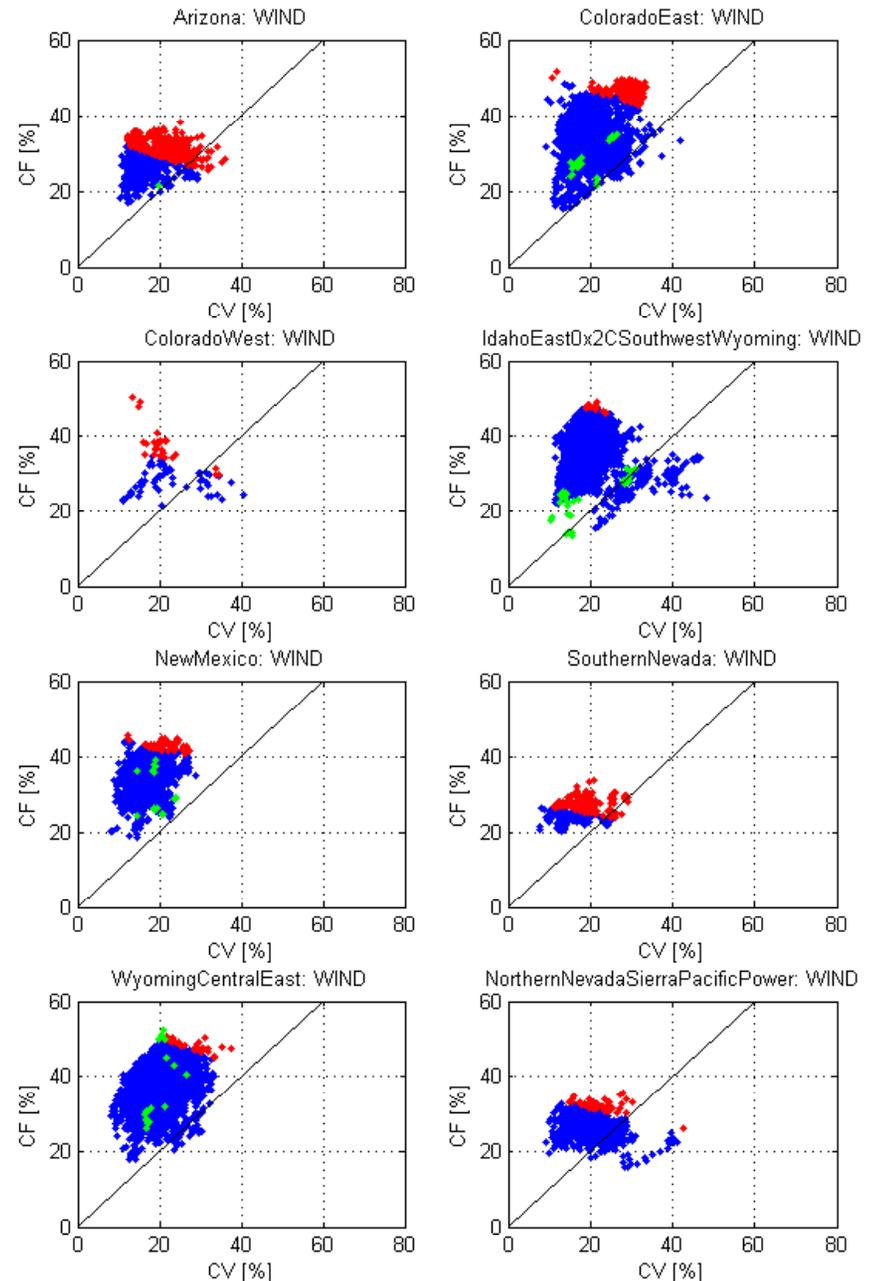
Wyoming has many available sites of relatively high capacity factor

Arizona and Nevada sites have relatively lower capacity factors

Large load areas, Arizona and Southern Nevada, use a higher percentage of the available sites

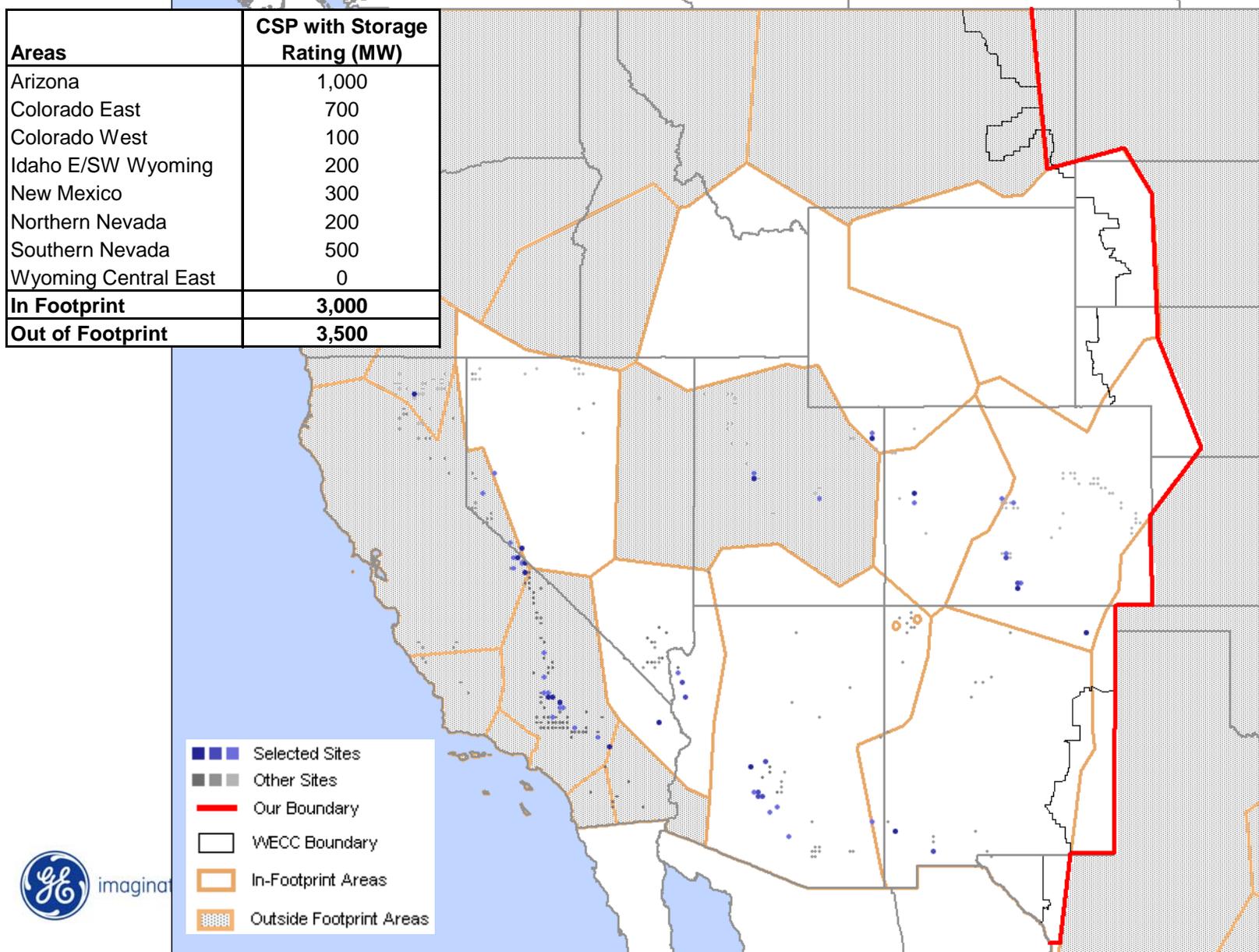
### Legend:

- Pre-selected Sites
- Selected Sites
- Remaining sites



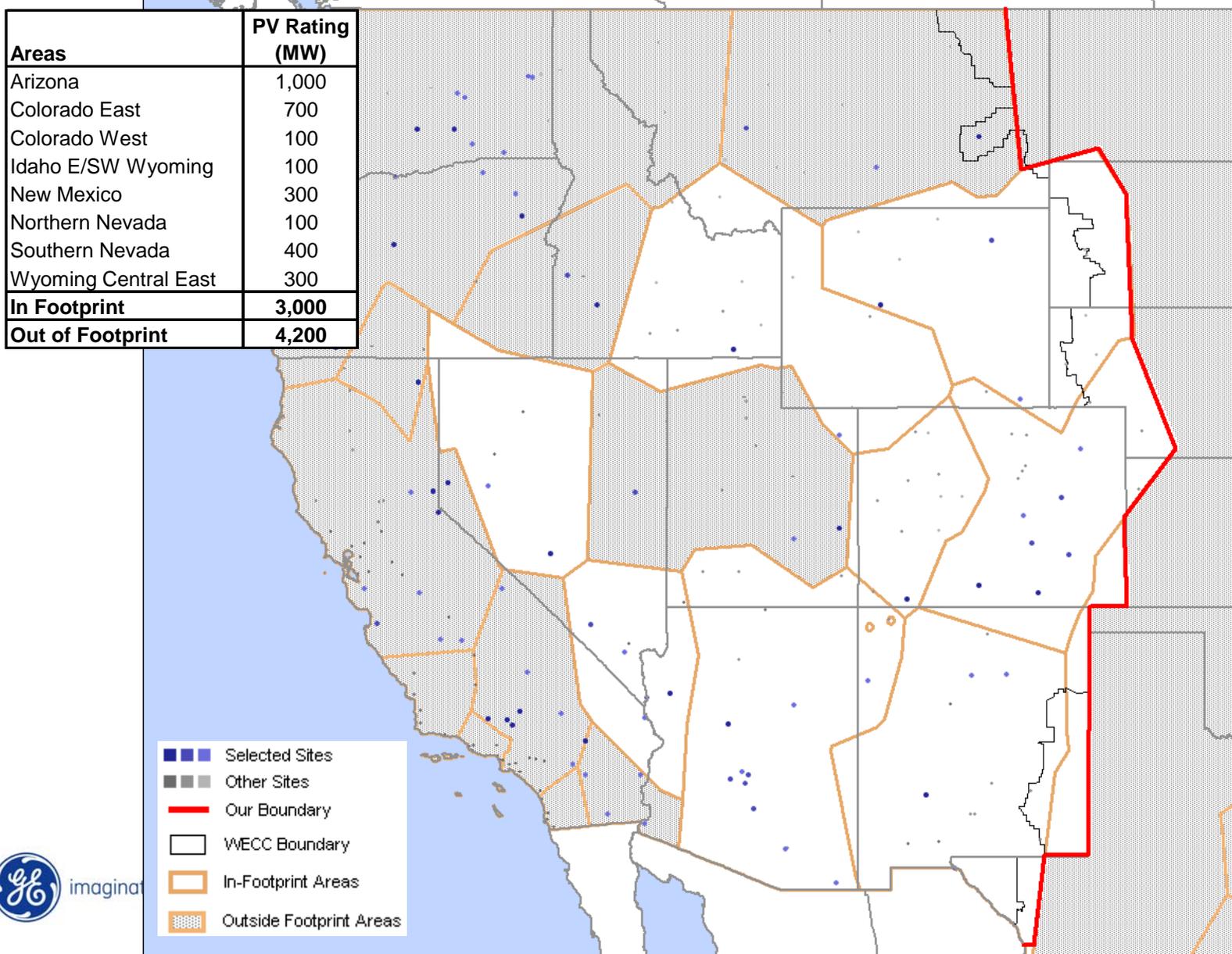
# CSP with Storage Site Selection (30% In-Area)

3.5% Energy In Footprint, 2.1% Energy Out of Footprint



# PV Site Selection (30% In-Area)

1.5% Energy In Footprint, 0.9% Energy Out of Footprint



# 2017 Baseline Scenario Summary - GWh

Preselected Wind Energy, Embedded Solar Energy In Footprint

Preselected Wind Energy, Embedded Solar Energy Out of Footprint

Areas	Load	Wind	
	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)
Arizona	100,516	112	2 / 958
Colorado East	61,372	2,003	27 / 2834
Colorado West	8,717	0	0 / 84
Idaho East / SW Wyoming	12,449	1,898	32 / 2447
New Mexico	30,208	1,584	20 / 2977
Northern Nevada	14,460	0	0 / 712
Southern Nevada	39,642	0	0 / 321
Wyoming Central East	22,155	1,916	20 / 7375
<b>In Footprint</b>	<b>289,519</b>	<b>7,513</b>	<b>101 / 17708</b>

~2.5% Energy

Areas	Load	Wind	
	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)
COB Transmission Hub	1,759	0	0 / 309
Idaho Southwest	17,962	101	2 / 482
Montana	14,161	1,991	26 / 1165
Northern California	128,944	1,988	40 / 701
Northwest	178,359	5,586	83 / 3120
Southern California	224,215	3,726	57 / 2006
Utah	41,433	1,341	24 / 1479
<b>Out of Footprint</b>	<b>606,833</b>	<b>14,733</b>	<b>232 / 9262</b>

~2.5% Energy

# 2017 Baseline Scenario Summary - MW

Preselected Wind Energy, Embedded Solar Energy In Footprint

Preselected Wind Energy, Embedded Solar Energy Out of Footprint

Areas	Load		Wind		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration	
				% Min	%Max
Arizona	7,113	23,168	60	1%	0%
Colorado East	4,493	11,589	810	18%	7%
Colorado West	713	1,527	0	0%	0%
Idaho East / SW Wyoming	975	2,063	960	98%	47%
New Mexico	2,473	5,195	600	24%	12%
Northern Nevada	1,308	2,362	0	0%	0%
Southern Nevada	2,277	9,645	0	0%	0%
Wyoming Central East	1,897	3,313	600	32%	18%
<b>In Footprint</b>	<b>21,249</b>	<b>58,862</b>	<b>3,030</b>	<b>14%</b>	<b>5%</b>

High penetration at minimum load

Areas	Load		Wind		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration	
				% Min	%Max
COB Transmission Hub	138	294	0	0%	0%
Idaho Southwest	1,188	3,592	60	5%	2%
Montana	1,151	2,339	780	68%	33%
Northern California	10,298	28,320	1,200	12%	4%
Northwest	14,278	30,953	2,490	17%	8%
Southern California	16,675	46,426	1,710	10%	4%
Utah	2,600	7,771	720	28%	9%
<b>Out of Footprint</b>	<b>46,328</b>	<b>119,696</b>	<b>6,960</b>	<b>15%</b>	<b>6%</b>

High penetration at minimum load

# 30% In-Area Scenario Summary - GWh

30% Wind Energy, 5% Solar Energy (70% CSP w/S, 30% PV) In Footprint

20% Wind Energy, 3% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

Areas	Load	Wind		CSP with Storage		PV		Total Renewable
	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
Arizona	100,516	30,181	369 / 958	3,699	10 / 41	1,547	10 / 18	35,427
Colorado East	61,372	18,501	163 / 2834	2,286	7 / 44	1,035	7 / 16	21,822
Colorado West	8,717	2,665	27 / 84	297	1 / 7	148	1 / 10	3,110
Idaho East / SW Wyoming	12,449	3,779	47 / 2447	568	2 / 4	142	1 / 12	4,489
New Mexico	30,208	9,146	87 / 2977	1,073	3 / 16	478	3 / 14	10,697
Northern Nevada	14,460	4,391	52 / 712	648	2 / 17	160	1 / 4	5,199
Southern Nevada	39,642	11,937	165 / 321	1,898	5 / 21	631	4 / 7	14,466
Wyoming Central East	22,155	6,751	58 / 7375	0	0 / 0	420	3 / 11	7,171
<b>In Footprint</b>	<b>289,519</b>	<b>87,351</b>	<b>968 / 17708</b>	<b>10,469</b>	<b>30 / 150</b>	<b>4,561</b>	<b>30 / 92</b>	<b>102,381</b>

Areas	Load	Wind		CSP with Storage		PV		Total Renewable
	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
COB Transmission Hub	1,759	420	5 / 309	294	1 / 22	142	1 / 4	856
Idaho Southwest	17,962	3,614	40 / 482	0	0 / 0	134	1 / 5	3,748
Montana	14,161	2,932	34 / 1165	0	0 / 0	126	1 / 11	3,058
Northern California	128,944	25,855	339 / 701	2,750	8 / 38	1,270	9 / 30	29,875
Northwest	178,359	35,716	403 / 3120	0	0 / 0	1,574	13 / 52	37,290
Southern California	224,215	44,926	482 / 2006	8,845	23 / 83	2,213	14 / 39	55,984
Utah	41,433	8,303	99 / 1479	886	3 / 21	437	3 / 12	9,626
<b>Out of Footprint</b>	<b>606,833</b>	<b>121,766</b>	<b>1402 / 9262</b>	<b>12,775</b>	<b>35 / 164</b>	<b>5,896</b>	<b>42 / 153</b>	<b>140,437</b>

# 30% In-Area Scenario Summary - MW

30% Wind Energy, 5% Solar Energy (70% CSP w/S, 30% PV) In Footprint

20% Wind Energy, 3% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
Arizona	7,113	23,168	11,070	156%	48%	1,000	14%	4%	1,000	14%	4%	2,000	28%	9%
Colorado East	4,493	11,589	4,890	109%	42%	700	16%	6%	700	16%	6%	1,400	31%	12%
Colorado West	713	1,527	810	114%	53%	100	14%	7%	100	14%	7%	200	28%	13%
Idaho East / SW Wyoming	975	2,063	1,410	145%	68%	200	21%	10%	100	10%	5%	300	31%	15%
New Mexico	2,473	5,195	2,610	106%	50%	300	12%	6%	300	12%	6%	600	24%	12%
Northern Nevada	1,308	2,362	1,560	119%	66%	200	15%	8%	100	8%	4%	300	23%	13%
Southern Nevada	2,277	9,645	4,950	217%	51%	500	22%	5%	400	18%	4%	900	40%	9%
Wyoming Central East	1,897	3,313	1,740	92%	53%	0	0%	0%	300	16%	9%	300	16%	9%
<b>In Footprint</b>	<b>21,249</b>	<b>58,862</b>	<b>29,040</b>	<b>137%</b>	<b>49%</b>	<b>3,000</b>	<b>14%</b>	<b>5%</b>	<b>3,000</b>	<b>14%</b>	<b>5%</b>	<b>6,000</b>	<b>28%</b>	<b>10%</b>

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
COB Transmission Hub	138	294	150	109%	51%	100	73%	34%	100	73%	34%	200	145%	68%
Idaho Southwest	1,188	3,592	1,200	101%	33%	0	0%	0%	100	8%	3%	100	8%	3%
Montana	1,151	2,339	1,020	89%	44%	0	0%	0%	100	9%	4%	100	9%	4%
Northern California	10,298	28,320	10,170	99%	36%	800	8%	3%	900	9%	3%	1,700	17%	6%
Northwest	14,278	30,953	12,090	85%	39%	0	0%	0%	1,300	9%	4%	1,300	9%	4%
Southern California	16,675	46,426	14,460	87%	31%	2,300	14%	5%	1,400	8%	3%	3,700	22%	8%
Utah	2,600	7,771	2,970	114%	38%	300	12%	4%	300	12%	4%	600	23%	8%
<b>Out of Footprint</b>	<b>46,328</b>	<b>119,696</b>	<b>42,060</b>	<b>91%</b>	<b>35%</b>	<b>3,500</b>	<b>8%</b>	<b>3%</b>	<b>4,200</b>	<b>9%</b>	<b>4%</b>	<b>7,700</b>	<b>17%</b>	<b>6%</b>

# 20% In-Area Scenario Summary - GWh

20% Wind Energy, 3% Solar Energy (70% CSP w/S, 30% PV) In Footprint

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

	Load	Wind		CSP with Storage		PV		Total Renewable
Areas	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
Arizona	100,516	20,146	241 / 958	2,224	6 / 41	924	6 / 18	23,294
Colorado East	61,372	12,372	111 / 2834	1,327	4 / 44	599	4 / 16	14,298
Colorado West	8,717	1,780	17 / 84	0	0 / 7	148	1 / 10	1,928
Idaho East / SW Wyoming	12,449	2,535	37 / 2447	287	1 / 4	142	1 / 12	2,964
New Mexico	30,208	6,138	60 / 2977	714	2 / 16	315	2 / 14	7,167
Northern Nevada	14,460	2,908	34 / 712	338	1 / 17	160	1 / 4	3,406
Southern Nevada	39,642	7,997	108 / 321	1,147	3 / 21	322	2 / 7	9,466
Wyoming Central East	22,155	4,484	40 / 7375	0	0 / 0	142	1 / 11	4,626
<b>In Footprint</b>	<b>289,519</b>	<b>58,360</b>	<b>648 / 17708</b>	<b>6,037</b>	<b>17 / 150</b>	<b>2,752</b>	<b>18 / 92</b>	<b>67,149</b>

	Load	Wind		CSP with Storage		PV		Total Renewable
Areas	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
COB Transmission Hub	1,759	251	3 / 309	294	1 / 22	0	0 / 4	545
Idaho Southwest	17,962	1,799	20 / 482	0	0 / 0	132	1 / 5	1,931
Montana	14,161	1,991	26 / 1165	0	0 / 0	0	0 / 11	1,991
Northern California	128,944	12,919	166 / 701	1,059	3 / 38	431	3 / 30	14,409
Northwest	178,359	17,898	206 / 3120	0	0 / 0	617	5 / 52	18,515
Southern California	224,215	22,472	237 / 2006	2,749	7 / 83	655	4 / 39	25,876
Utah	41,433	4,148	54 / 1479	303	1 / 21	144	1 / 12	4,595
<b>Out of Footprint</b>	<b>606,833</b>	<b>61,478</b>	<b>712 / 9262</b>	<b>4,405</b>	<b>12 / 164</b>	<b>1,979</b>	<b>14 / 153</b>	<b>67,862</b>

# 20% In-Area Scenario Summary - MW

20% Wind Energy, 3% Solar Energy (70% CSP w/S, 30% PV) In Footprint

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
Arizona	7,113	23,168	7,230	102%	31%	600	8%	3%	600	8%	3%	1,200	17%	5%
Colorado East	4,493	11,589	3,330	74%	29%	400	9%	3%	400	9%	3%	800	18%	7%
Colorado West	713	1,527	510	72%	33%	0	0%	0%	100	14%	7%	100	14%	7%
Idaho East / SW Wyoming	975	2,063	1,110	114%	54%	100	10%	5%	100	10%	5%	200	21%	10%
New Mexico	2,473	5,195	1,800	73%	35%	200	8%	4%	200	8%	4%	400	16%	8%
Northern Nevada	1,308	2,362	1,020	78%	43%	100	8%	4%	100	8%	4%	200	15%	8%
Southern Nevada	2,277	9,645	3,240	142%	34%	300	13%	3%	200	9%	2%	500	22%	5%
Wyoming Central East	1,897	3,313	1,200	63%	36%	0	0%	0%	100	5%	3%	100	5%	3%
<b>In Footprint</b>	<b>21,249</b>	<b>58,862</b>	<b>19,440</b>	<b>91%</b>	<b>33%</b>	<b>1,700</b>	<b>8%</b>	<b>3%</b>	<b>1,800</b>	<b>8%</b>	<b>3%</b>	<b>3,500</b>	<b>16%</b>	<b>6%</b>

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
COB Transmission Hub	138	294	90	65%	31%	100	73%	34%	0	0%	0%	100	73%	34%
Idaho Southwest	1,188	3,592	600	51%	17%	0	0%	0%	100	8%	3%	100	8%	3%
Montana	1,151	2,339	780	68%	33%	0	0%	0%	0	0%	0%	0	0%	0%
Northern California	10,298	28,320	4,980	48%	18%	300	3%	1%	300	3%	1%	600	6%	2%
Northwest	14,278	30,953	6,180	43%	20%	0	0%	0%	500	4%	2%	500	4%	2%
Southern California	16,675	46,426	7,110	43%	15%	700	4%	2%	400	2%	1%	1,100	7%	2%
Utah	2,600	7,771	1,620	62%	21%	100	4%	1%	100	4%	1%	200	8%	3%
<b>Out of Footprint</b>	<b>46,328</b>	<b>119,696</b>	<b>21,360</b>	<b>46%</b>	<b>18%</b>	<b>1,200</b>	<b>3%</b>	<b>1%</b>	<b>1,400</b>	<b>3%</b>	<b>1%</b>	<b>2,600</b>	<b>6%</b>	<b>2%</b>

# 10% In-Area Scenario Summary - GWh

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) In Footprint

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

	Load	Wind		CSP with Storage		PV		Total Renewable
Areas	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
Arizona	100,516	10,128	118 / 958	743	2 / 41	312	2 / 18	11,183
Colorado East	61,372	6,173	60 / 2834	331	1 / 44	160	1 / 16	6,664
Colorado West	8,717	902	8 / 84	0	0 / 7	0	0 / 10	902
Idaho East / SW Wyoming	12,449	1,898	32 / 2447	0	0 / 4	0	0 / 12	1,898
New Mexico	30,208	3,088	33 / 2977	359	1 / 16	161	1 / 14	3,608
Northern Nevada	14,460	1,486	17 / 712	338	1 / 17	0	0 / 4	1,824
Southern Nevada	39,642	4,013	52 / 321	387	1 / 21	162	1 / 7	4,562
Wyoming Central East	22,155	2,299	23 / 7375	0	0 / 0	142	1 / 11	2,441
<b>In Footprint</b>	<b>289,519</b>	<b>29,987</b>	<b>343 / 17708</b>	<b>2,158</b>	<b>6 / 150</b>	<b>937</b>	<b>6 / 92</b>	<b>33,082</b>

	Load	Wind		CSP with Storage		PV		Total Renewable
Areas	Energy (GWh)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)	# Sites (Used/Available)	Energy (GWh)
COB Transmission Hub	1,759	251	3 / 309	294	1 / 22	0	0 / 4	545
Idaho Southwest	17,962	1,799	20 / 482	0	0 / 0	134	1 / 5	1,933
Montana	14,161	1,991	26 / 1165	0	0 / 0	0	0 / 11	1,991
Northern California	128,944	12,919	166 / 701	1,059	3 / 38	437	3 / 30	14,415
Northwest	178,359	17,898	206 / 3120	0	0 / 0	625	5 / 52	18,523
Southern California	224,215	22,472	237 / 2006	2,749	7 / 83	655	4 / 39	25,876
Utah	41,433	4,148	54 / 1479	303	1 / 21	148	1 / 12	4,599
<b>Out of Footprint</b>	<b>606,833</b>	<b>61,478</b>	<b>712 / 9262</b>	<b>4,405</b>	<b>12 / 164</b>	<b>1,999</b>	<b>14 / 153</b>	<b>67,882</b>

# 10% In-Area Scenario Summary - MW

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) In Footprint

10% Wind Energy, 1% Solar Energy (70% CSP w/S, 30% PV) Out of Footprint

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
Arizona	7,113	23,168	3,540	50%	15%	200	3%	1%	200	3%	1%	400	6%	2%
Colorado East	4,493	11,589	1,800	40%	16%	100	2%	1%	100	2%	1%	200	4%	2%
Colorado West	713	1,527	240	34%	16%	0	0%	0%	0	0%	0%	0	0%	0%
Idaho East / SW Wyoming	975	2,063	960	98%	47%	0	0%	0%	0	0%	0%	0	0%	0%
New Mexico	2,473	5,195	990	40%	19%	100	4%	2%	100	4%	2%	200	8%	4%
Northern Nevada	1,308	2,362	510	39%	22%	100	8%	4%	0	0%	0%	100	8%	4%
Southern Nevada	2,277	9,645	1,560	69%	16%	100	4%	1%	100	4%	1%	200	9%	2%
Wyoming Central East	1,897	3,313	690	36%	21%	0	0%	0%	100	5%	3%	100	5%	3%
<b>In Footprint</b>	<b>21,249</b>	<b>58,862</b>	<b>10,290</b>	<b>48%</b>	<b>17%</b>	<b>600</b>	<b>3%</b>	<b>1%</b>	<b>600</b>	<b>3%</b>	<b>1%</b>	<b>1,200</b>	<b>6%</b>	<b>2%</b>

Areas	Load		Wind			CSP with Storage			PV			Total Solar		
	Minimum (MW)	Maximum (MW)	Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration		Rating (MW)	Penetration	
				% Min	%Max		% Min	% Max		% Min	% Max		% Min	% Max
COB Transmission Hub	138	294	90	65%	31%	100	73%	34%	0	0%	0%	100	73%	34%
Idaho Southwest	1,188	3,592	600	51%	17%	0	0%	0%	100	8%	3%	100	8%	3%
Montana	1,151	2,339	780	68%	33%	0	0%	0%	0	0%	0%	0	0%	0%
Northern California	10,298	28,320	4,980	48%	18%	300	3%	1%	300	3%	1%	600	6%	2%
Northwest	14,278	30,953	6,180	43%	20%	0	0%	0%	500	4%	2%	500	4%	2%
Southern California	16,675	46,426	7,110	43%	15%	700	4%	2%	400	2%	1%	1,100	7%	2%
Utah	2,600	7,771	1,620	62%	21%	100	4%	1%	100	4%	1%	200	8%	3%
<b>Out of Footprint</b>	<b>46,328</b>	<b>119,696</b>	<b>21,360</b>	<b>46%</b>	<b>18%</b>	<b>1,200</b>	<b>3%</b>	<b>1%</b>	<b>1,400</b>	<b>3%</b>	<b>1%</b>	<b>2,600</b>	<b>6%</b>	<b>2%</b>