

Alternative RE Approach Technical Support Document

1.1. Introduction

Renewable energy (RE) is a cost-effective approach for reducing carbon dioxide (CO₂) emissions from fossil fuel-fired electric generating units (EGUs) through the substitution of electricity generated from renewable resources. The portfolio of available RE sources encompasses a wide variety of technologies from utility-scale RE plants to smaller-scale distributed generation sited at residential, commercial, or industrial facilities. RE technologies are fueled by the sun, wind, water, organic matter, and other resources regularly replenished by physical and biological cycles. The EPA has developed an Alternative RE Approach that relies on the technical and market potential of new RE to determine how the rapidly increasing and evolving portfolio of RE can be integrated into the Best System of Emission Reduction (BSER).

Note that an accompanying excel file that contains the aggregate state level data, calculations, and proposed state RE targets is also available in the Docket for this rulemaking. The title of this document is “Alternative RE Approach Data File”.

1.2. Alternative RE Approach Methodology

As part of its effort to evaluate the potential for incremental RE as part of BSER, EPA developed an Alternative RE Approach that is based on the technical and market potential of RE by state.

To establish a technical potential benchmark for individual states, the Alternative RE Approach compares each state’s RE technical potential against its existing RE generation. For this purpose, EPA has utilized technical potential as measured by the National Renewable Energy Laboratory¹ (NREL) and existing RE generation as reported by EIA for 2012.² The comparison of RE technical potential to existing RE net generation yields - for each state and for each selected RE technology - a proportion of achieved renewable generation from technical potential, which can be represented as an RE development rate. For example, if a given state had 5,000 MWh of solar generation in 2012 and a solar generation technical potential of 50,000 MWh, then that state’s solar RE development rate is 10%. In the Alternative

¹ Lopez et al., NREL, “U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis,” (July 2012). Available at http://www.nrel.gov/gis/re_potential.html.

² Net Generation by State by Type of Producer by Energy Source (forms EIA-906, EIA-920, and EIA-923). Available at <http://www.eia.gov/electricity/data/state/>.

RE Approach, the average development rate of the top third (16) of states is designated a benchmark RE development rate for each technology type. The benchmark rate is then applied to each state's technical potential to calculate the benchmark generation for each technology type.

While the benchmark RE development rate offers a useful metric to quantify the proportion of RE generation consistent with what has been demonstrably achieved in practice by the top third of states, EPA recognizes that a metric based solely on technical potential has limitations. For example, technical potential data is typically unconstrained by grid limitations, costs associated with development, quality of resource, and may overstate electricity production potential because a given site cannot produce RE simultaneously from multiple technology types. In order to address these limitations, the Alternative RE Approach pairs the benchmark RE development rates described above with Integrated Planning Model (IPM) runs of RE deployment that reduces the cost of new renewable builds.³ The cost reduction in new RE is intended to represent the avoided cost of other actions that could be taken instead to reduce power sector CO₂, and to reflect continued reductions in RE technology costs. The state-level modeling results for this approach show RE deployment levels associated with a cost reduction of up to \$30 per MWh, which is consistent with the estimated cost of the proposed approach (up to \$40 per metric ton of CO₂).⁴

The RE generation projections considered from this IPM scenario are supported by analysis from a recent NREL study using the Regional Energy Deployment System (ReEDS) model, a capacity expansion and dispatch model with detailed assumptions regarding renewable technologies and associated power infrastructure. NREL modeled RE generation potential under lower cost assumptions for renewable technologies, based on DOE's RE cost and performance targets. Under the respective assumptions for each model, the IPM model run projects more RE generation in 2020 (582 TWh in IPM versus 484 TWh in ReEDS), while the ReEDS modeling projects more RE generation than IPM in 2030 (821 TWh in IPM versus 923 TWh in ReEDS). The regional distribution of generation across the two model scenarios are comparable (regional RE generation projections are within 7% of each other). Overall, both sets of modeling projections indicate a broad range of market potential for RE generation that can be developed in each state.⁵

Under the Alternative RE Approach, EPA would quantify target generation for most RE technologies as the lesser of that technology's benchmark rate multiplied by in-state technical potential,

³ IPM is EPA's multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. Refer to RIA Chapter 3 for additional detail on the IPM platform. Full documentation of IPM, including cost and performance assumptions for new generating resources can be accessed at <http://www.epa.gov/powersectormodeling/>.

⁴ For further discussion on the cost of RE, refer to Chapter 4 of the GHG Abatement Measures TSD. Full IPM run results for this scenario – the 'RE Market Potential Scenario' – can be found on the docket.

⁵ NREL, ReEDS Modeling of the President's 2020 RE Generation Goal, NREL/PR-6A20-62077, <http://www.nrel.gov/docs/fy14osti/62077.pdf>, May 2014.

or the IPM-projected market potential for that specific technology at a reduced cost of up to \$30/MWh. For example, if the benchmark RE development rate for solar generation is determined to be 10%, and this state possesses solar generation technical potential of 5,000 MWh, then the benchmark RE development level of generation for that state would be 500 MWh. If the IPM-projected market potential for solar generation at a cost reduction of up to \$30/MWh in that state were 750 MWh, then this approach would quantify target generation for solar as the benchmark RE development level (500 MWh) because it is the lesser amount of those two measures.

The methodology for quantifying target generation levels by technology type under the Alternative RE Approach is presented in Section 1.3 below.

1.3. RE Target Generation Methodology by Technology Type

This section describes the methodology employed to produce target generation levels for each state by technology type. The RE technology types that contribute to each state's target generation level are utility-scale solar, onshore wind, conventional geothermal (hydrothermal), hydropower, and select existing biopower capacity types.⁶ EPA notes that RE target generation levels are used solely to inform each state's goal calculation and are not prescriptive of any RE compliance outcome – either in sum or by technology type.⁷ Consequently, whether or not any particular RE technology is considered in this Alternative RE Approach does not have any bearing on what types of RE generation a state may consider in developing its state plan for complying with its state goal. In selecting the technology types that contribute to the RE target generation level, EPA considered the availability of 2012 net generation data, technical potential estimates, and the ability to project economic deployment within the IPM modeling framework. For example, distributed generation RE technologies were omitted from the RE Alternative Approach because their market potential cannot be tested in the current IPM framework. Similarly, offshore wind was not considered under this methodology because there are currently no operational offshore wind facilities in the United States from which to calculate a benchmark development rate.

⁶ Existing dedicated biomass and landfill gas facilities contribute to RE target generation levels. The analysis in this TSD does not consider biomass renewables in its evaluation of renewable development potential for BSER, but the preamble discusses the possibility of a path for states to consider it in their plans.

⁷ Refer to the Goal Computation TSD for additional detail.

Solar

The solar development rate for each state was calculated utilizing EIA 2012 total electric power industry net generation for the solar thermal and photovoltaic energy source and NREL's technical potential estimates for urban utility-scale PV, rural utility-scale PV, and concentrated solar power (CSP). The average 2012 development rate for the top 16 states was 0.009%. The benchmark generation is defined as the greater of each state's reported 2012 solar generation or the benchmark rate of 0.009% multiplied by in-state technical potential. Total benchmark generation for the states affected by the Alternative RE Approach is 33,981 GWh, compared to 2012 net generation of 4,317 GWh.⁸

As part of the modeling that reduced the cost of new RE technologies by up to \$30/MWh, IPM projected total solar generation (utility-scale PV and CSP) of 20,153 GWh in 2020, increasing to 23,635 and 27,531 by 2025 and 2030, respectively.

The solar target generation for each state is the lesser of the benchmark solar generation or IPM-projected solar generation. This methodology produced a total solar generation target across all affected states of 8,477 GWh in 2020, 8,493 GWh in 2025, and 8,722 GWh in 2030.

Wind

The wind development rate for each state was calculated utilizing EIA 2012 total electric power industry net generation for the wind energy source and NREL's technical potential estimates for onshore wind. The average 2012 development rate for the top 16 states was 9%. The benchmark generation is defined as the greater of each state's reported 2012 wind generation or the benchmark rate of 9% multiplied by in-state technical potential. Total benchmark generation for the states affected by the Alternative RE Approach is 2,841,650 GWh, compared to 2012 net generation of 140,229 GWh.

As part of the modeling that reduced the cost of new RE technologies by up to \$30/MWh, IPM projected total onshore wind generation of 220,593 GWh in 2020, increasing to 296,720 and 442,417 by 2025 and 2030, respectively.

The wind target generation for each state is the lesser of the benchmark wind generation or IPM-projected onshore wind generation. This methodology produced a total wind generation target across all affected states of 189,687 GWh in 2020, 259,534 GWh in 2025, and 384,826 GWh in 2030.

⁸ Vermont is not subject to any RE requirement under BSER.

Geothermal

The geothermal development rate for each state was calculated utilizing EIA 2012 total electric power industry net generation for the geothermal energy source and NREL's technical potential estimates for geothermal (hydrothermal). The average 2012 development rate for all 5 states with reported geothermal generation for 2012 was 3.6%. The benchmark generation is defined as the greater of each state's reported 2012 geothermal generation or the benchmark rate of 3.6% multiplied by in-state technical potential. Total benchmark generation for the states affected by the Alternative RE Approach is 18,054 GWh, compared to 2012 net generation of 15,301 GWh.

As part of the modeling that reduced the cost of new RE technologies by up to \$30/MWh, IPM projected total geothermal generation of 32,609 GWh in 2020, increasing to 40,429 and 42,640 by 2025 and 2030, respectively.

The geothermal target generation for each state is the lesser of the benchmark geothermal generation or IPM-projected geothermal generation. This methodology produced a total geothermal generation target across all affected states of 16,516 GWh in all years.

Hydropower

Due to the unique nature of the hydropower technical potential data, EPA has used a different procedure for quantifying hydropower target generation under this alternative RE approach. In contrast with other RE technology types, the study that formed the basis of NREL's hydropower technical potential estimate applied a full set of feasibility criteria to the development opportunities for new low power and small hydroelectric plants.⁹ The feasibility criteria include site accessibility, load or transmission proximity, and environmental concerns that may hinder development efforts. EPA believes that the application of feasibility criteria represent a refinement to the technical potential data and thus obviates the need for EPA to identify a benchmark development rate for hydropower generation. Therefore, the benchmark hydropower generation for each state is defined as the greater of each state's reported 2012 conventional hydroelectric generation, or the feasible hydropower development potential

⁹ Paper available at <http://www1.eere.energy.gov/water/pdfs/doewater-11263.pdf>. NREL's technical potential estimate for hydropower also includes non-powered dams from the National Hydropower Asset Assessment Program.

identified by NREL. Total benchmark generation for the states affected by the Alternative RE Approach is 354,119 GWh, compared to 2012 conventional hydroelectric net generation of 273,441 GWh.

IPM is not currently configured to project the economic deployment of new hydropower resources in the United States. Therefore, the hydropower target generation for each state is the greater of the benchmark hydropower generation or the IPM-projected generation from existing hydropower resources in that state. This methodology produced a total hydropower generation target across all affected states of 358,665 GWh in all years.

Total Target Generation

The total RE target generation level for each state is simply the sum of all of the technology-specific target levels, which are inclusive of existing generation. The total RE target generation level informs the calculation of each state's goal.¹⁰ State-level results for RE target generation levels are provided in Section 1.4.

Alaska and Hawaii

In order to quantify technical and market potential for RE generation in Alaska and Hawaii (which are often not included in power sector capacity expansion models like IPM), the Alternative RE Approach adopts annual growth factors for each state based on the difference between each state's 2002 and 2012 RE generation. These annual growth factors are calculated as 11.4% for Alaska and 7.9% for Hawaii.¹¹ Based on the application of these annual growth factors, EPA has derived a 2020 RE target level for Alaska of 1,637 GWh in 2020, increasing to 1,681 GWh and 1,738 GWh in 2025 and 2030, respectively. 2012 RE net generation in Alaska was 1,615 GWh. EPA has derived a 2020 RE target level for Hawaii of 1,368 GWh, increasing to 1,948 GWh and 2,600 GWh in 2025 and 2030, respectively. 2012 RE net generation in Hawaii was 1,039 GWh.

¹⁰ Refer to Goal Computation TSD.

¹¹ Refer to Chapter 4 of the GHG Abatement Measures TSD for further detail on the calculation of RE growth factors for Alaska and Hawaii.

1.4. Potential Alternative Method Using Technical and Economic Potential

This section specifies a potential alternative approach to quantification of renewable generation that also relies on a state-by-state assessment of RE technical and economic potential. This approach would compare the estimated cost of new renewable energy to the avoided cost of energy from implementing clean energy generation, by comparing the total cost of generation for each renewable energy technology by region to the estimated fuel, operating, and capital costs avoided by adding that generation. This calculation can be carried out at a high level of granularity when data is available, and then aggregated to the state or regional level. This general economic potential approach can be summarized in three steps:

Step 1: Use best available regional information (with areas excluded due to physical features and other possible criteria) and data on current technology costs and regional construction cost differences to estimate a total cost of clean energy for each location. Note this can include an adder for potential new transmission or pipeline needs. The result of this is a clean energy supply curve at many locations, with the cost and available generation for that region.

Step 2: Estimate the avoided energy cost. This is calculated based on the particular generation mix by region, providing information about the generation that would be displaced by the clean energy technology. This is composed of avoided fuel and operating costs, avoided capital costs, and a range of costs for avoided environmental externalities.

Step 3: For each resource area, compare the cost of new clean generation (found in step 1) to the avoided costs (found in step 2). If the costs are lower than avoided cost, include the generation and capacity available in this region in the “cost-effective potential”. Sum the supply curve for each state and region to estimate cost-effective potential at those scales.

1.5. State-Level Results

This section contains state-level RE target generation levels for 2020, 2025, and 2030. Interim generation targets for Option 1 are the average target generation levels from 2020-2029; interim generation targets for Option 2 are the average from 2020-2024. Final targets for Option 1 are represented

by the 2030 target generation levels; final targets for Option 2 are equivalent to the 2025 levels.¹² Results are presented both with existing hydropower included as part of RE (Tables 1.1 and 1.2) and without (Tables 1.3 and 1.4). RE target generation levels for Alaska and Hawaii are presented both with and without existing hydropower in Tables 1.5 and 1.6, respectively. IPM projections, technical resource estimates, and 2012 net generation levels are available in the Appendix to this TSD.

Under this alternative RE approach, states would not be required to achieve the absolute levels of target generation quantified below; instead, the target generation presented below would be incorporated into the denominator of the state goals as demonstrated in the Goal Computation TSD. States will have the flexibility to consider the extent to which RE is used in their state plans as a compliance measure.

Table 1.1. State-Level Target Generation Levels Under the Alternative RE Approach (Gigawatt-hours)

State	2012 RE*	RE Alternate Methodology Target Generation (GWh)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
AL	10,212	8,117	8,117	8,117	8,117	8,117	8,117	8,117
AZ	8,415	10,034	10,034	10,035	10,034	10,035	10,034	10,034
AR	3,859	6,246	6,247	6,255	6,248	6,255	6,246	6,247
CA	56,804	57,776	59,027	57,821	58,410	57,821	58,276	59,027
CO	7,689	16,499	17,116	19,136	17,335	19,136	16,746	17,116
CT	979	950	950	950	950	950	950	950
DE	131	111	111	111	111	111	111	111
FL	4,674	2,700	2,701	2,690	2,698	2,690	2,700	2,701
GA	5,515	3,759	3,780	3,783	3,774	3,783	3,767	3,780
ID	13,455	21,492	21,513	21,551	21,514	21,551	21,500	21,513
IL	8,484	18,447	23,485	23,817	22,040	23,817	20,462	23,485
IN	3,980	13,285	22,384	22,384	19,654	22,384	16,924	22,384
IA	14,950	16,644	21,378	30,806	21,844	30,806	18,538	21,378
KS	5,263	11,271	22,486	50,905	24,805	50,905	15,757	22,486
KY	2,695	4,392	4,395	4,395	4,394	4,395	4,393	4,395
LA	3,110	2,503	2,503	2,503	2,503	2,503	2,503	2,503
ME	7,831	8,356	8,356	8,210	8,327	8,210	8,356	8,356
MD	2,555	2,446	2,446	2,446	2,446	2,446	2,446	2,446
MA	2,756	1,767	1,767	1,723	1,758	1,723	1,767	1,767
MI	5,000	11,340	11,864	12,077	11,749	12,077	11,550	11,864
MN	10,015	12,498	15,585	19,208	15,384	19,208	13,733	15,585

¹² It is typical for power sector models to group calendar years into a single run year to reduce model size. In the IPM runs that support the Alternative RE Approach, the relevant model run years are 2020 (2019 – 2022), 2025 (2023-2027), and 2030 (2029 – 2033). The 2024 and 2029 results presented above are taken from IPM projections for the 2025 and 2030 run years, respectively. For further detail on the use of model run years in IPM, please refer to <http://www.epa.gov/powersectormodeling/>.

State	2012 RE*	RE Alternate Methodology Target Generation (GWh)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
MS	1,509	2,506	2,506	2,506	2,506	2,506	2,506	2,506
MO	2,013	12,789	12,789	12,789	12,789	12,789	12,789	12,789
MT	12,545	16,516	17,285	21,489	17,895	21,489	16,824	17,285
NE	2,604	4,791	9,632	22,431	10,740	22,431	6,727	9,632
NV	5,409	6,087	6,092	6,297	6,132	6,297	6,089	6,092
NH	2,671	2,931	2,951	2,904	2,935	2,904	2,939	2,951
NJ	1,291	1,372	1,372	1,372	1,372	1,372	1,372	1,372
NM	2,797	4,735	7,058	16,664	8,282	16,664	5,664	7,058
NY	29,845	31,433	31,970	31,970	31,809	31,970	31,648	31,970
NC	6,432	6,211	6,211	6,211	6,211	6,211	6,211	6,211
ND	7,757	8,729	11,257	17,339	11,715	17,339	9,740	11,257
OH	2,153	10,372	15,200	15,200	13,752	15,200	12,303	15,200
OK	9,666	13,432	16,705	25,404	17,463	25,404	14,741	16,705
OR	46,617	47,512	47,606	47,606	47,578	47,606	47,550	47,606
PA	6,701	11,892	11,892	11,892	11,892	11,892	11,892	11,892
RI	106	441	441	441	441	441	441	441
SC	3,564	2,825	2,825	2,825	2,825	2,825	2,825	2,825
SD	8,896	9,394	13,154	25,137	14,423	25,137	10,898	13,154
TN	9,132	8,420	8,423	8,423	8,422	8,423	8,421	8,423
TX	34,601	39,527	51,965	79,022	53,645	79,022	44,502	51,965
UT	1,848	4,728	4,729	4,731	4,729	4,731	4,728	4,729
VA	3,402	6,731	6,731	6,541	6,693	6,541	6,731	6,731
WA	97,679	97,500	97,512	97,512	97,508	97,512	97,505	97,512
WV	2,728	5,705	5,705	5,705	5,705	5,705	5,705	5,705
WI	4,745	6,899	6,974	7,476	7,052	7,476	6,929	6,974
WY	5,263	8,570	8,570	8,695	8,595	8,695	8,570	8,570
Total	490,344	602,680	673,799	797,506	677,205	797,506	631,128	673,799

*Total electric power industry net generation for energy sources geothermal, hydroelectric conventional, other biomass, wood and wood derived fuels, solar thermal and photovoltaic, and wind.

Table 1.2. State-Level Target Generation Levels Under the Alternative RE Approach (Percent of 2012 Generation)

State	2012 RE*	RE Alternate Methodology Target Generation (% of 2012 Generation) ^{13,14}						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
AL	7%	5%	5%	5%	5%	5%	5%	5%
AZ	9%	11%	11%	11%	11%	11%	11%	11%
AR	6%	10%	10%	10%	10%	10%	10%	10%
CA	28%	29%	30%	29%	29%	29%	29%	30%
CO	15%	31%	33%	36%	33%	36%	32%	33%
CT	3%	3%	3%	3%	3%	3%	3%	3%
DE	2%	1%	1%	1%	1%	1%	1%	1%
FL	2%	1%	1%	1%	1%	1%	1%	1%
GA	5%	3%	3%	3%	3%	3%	3%	3%
ID	87%	139%	139%	139%	139%	139%	139%	139%
IL	4%	9%	12%	12%	11%	12%	10%	12%
IN	3%	12%	20%	20%	17%	20%	15%	20%
IA	26%	29%	38%	54%	39%	54%	33%	38%
KS	12%	25%	51%	115%	56%	115%	35%	51%
KY	3%	5%	5%	5%	5%	5%	5%	5%
LA	3%	2%	2%	2%	2%	2%	2%	2%
ME	54%	58%	58%	57%	58%	57%	58%	58%
MD	7%	6%	6%	6%	6%	6%	6%	6%
MA	8%	5%	5%	5%	5%	5%	5%	5%
MI	5%	10%	11%	11%	11%	11%	11%	11%
MN	19%	24%	30%	37%	29%	37%	26%	30%
MS	3%	5%	5%	5%	5%	5%	5%	5%
MO	2%	14%	14%	14%	14%	14%	14%	14%
MT	45%	59%	62%	77%	64%	77%	61%	62%
NE	8%	14%	28%	66%	31%	66%	20%	28%
NV	15%	17%	17%	18%	17%	18%	17%	17%
NH	14%	15%	15%	15%	15%	15%	15%	15%
NJ	2%	2%	2%	2%	2%	2%	2%	2%
NM	12%	21%	31%	73%	36%	73%	25%	31%
NY	22%	23%	24%	24%	23%	24%	23%	24%
NC	6%	5%	5%	5%	5%	5%	5%	5%
ND	21%	24%	31%	48%	32%	48%	27%	31%
OH	2%	8%	12%	12%	11%	12%	9%	12%
OK	12%	17%	21%	33%	22%	33%	19%	21%

¹³ This alternative approach may yield, at the individual state level, increases in RE generation that exceed the amount of generation reported in that state in 2012. EPA has invited comment on this topic in the preamble, focusing on whether this approach should be modified such that the difference between the RE target and the state's 2012 level of corresponding RE generation does not exceed the amount of fossil fuel-fired generation reported for that state in 2012.

¹⁴ Values greater than 100% are possible, as these percentages represent increased deployment of future RE generation (which may exceed a state's historic generation) divided by 2012 total in-state generation.

State	2012 RE*	RE Alternate Methodology Target Generation (% of 2012 Generation) ^{13,14}						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
OR	77%	78%	78%	78%	78%	78%	78%	78%
PA	3%	5%	5%	5%	5%	5%	5%	5%
RI	1%	5%	5%	5%	5%	5%	5%	5%
SC	4%	3%	3%	3%	3%	3%	3%	3%
SD	74%	78%	109%	209%	120%	209%	91%	109%
TN	12%	11%	11%	11%	11%	11%	11%	11%
TX	8%	9%	12%	18%	12%	18%	10%	12%
UT	5%	13%	13%	13%	13%	13%	13%	13%
VA	5%	10%	10%	9%	9%	9%	10%	10%
WA	84%	83%	83%	83%	83%	83%	83%	83%
WV	4%	8%	8%	8%	8%	8%	8%	8%
WI	7%	11%	11%	12%	11%	12%	11%	11%
WY	11%	17%	17%	18%	17%	18%	17%	17%
Total	12%	15%	17%	20%	17%	20%	16%	17%

*Total electric power industry net generation for energy sources geothermal, hydroelectric conventional, other biomass, wood and wood derived fuels, solar thermal and photovoltaic, and wind.

Table 1.3. State-Level Target Generation Levels under the Alternative RE Approach, Excluding Existing Hydropower (Gigawatt-hours)

State	2012 RE*	RE Alternate Methodology Target Generation, Excluding Existing Hydropower (GWh)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
AL	2,777	682	682	682	682	682	682	682
AZ	1,698	3,317	3,317	3,318	3,317	3,318	3,317	3,317
AR	1,660	4,047	4,049	4,057	4,050	4,057	4,048	4,049
CA	29,967	30,938	32,189	30,983	31,573	30,983	31,439	32,189
CO	6,192	15,002	15,618	17,639	15,838	17,639	15,249	15,618
CT	667	637	637	637	637	637	637	637
DE	131	111	111	111	111	111	111	111
FL	4,524	2,549	2,550	2,540	2,548	2,540	2,549	2,550
GA	3,279	1,522	1,544	1,547	1,538	1,547	1,531	1,544
ID	2,515	10,552	10,572	10,611	10,574	10,611	10,560	10,572
IL	8,373	18,335	23,374	23,706	21,929	23,706	20,351	23,374
IN	3,546	12,851	21,951	21,951	19,221	21,951	16,491	21,951
IA	14,183	15,878	20,612	30,040	21,077	30,040	17,772	20,612
KS	5,253	11,261	22,475	50,895	24,795	50,895	15,747	22,475
KY	333	2,030	2,033	2,033	2,032	2,033	2,031	2,033
LA	2,430	1,823	1,823	1,823	1,823	1,823	1,823	1,823
ME	4,099	4,624	4,624	4,477	4,594	4,477	4,624	4,624

State	2012 RE*	RE Alternate Methodology Target Generation, Excluding Existing Hydropower (GWh)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
MD	898	790	790	790	790	790	790	790
MA	1,843	855	855	810	846	810	855	855
MI	3,785	10,126	10,649	10,862	10,535	10,862	10,335	10,649
MN	9,454	11,937	15,024	18,647	14,823	18,647	13,172	15,024
MS	1,509	2,506	2,506	2,506	2,506	2,506	2,506	2,506
MO	1,299	12,075	12,075	12,075	12,075	12,075	12,075	12,075
MT	1,262	5,233	6,001	10,206	6,612	10,206	5,540	6,001
NE	1,347	3,534	8,375	21,174	9,482	21,174	5,470	8,375
NV	2,969	3,646	3,652	3,856	3,691	3,856	3,649	3,652
NH	1,381	1,641	1,661	1,615	1,646	1,615	1,649	1,661
NJ	1,281	1,361	1,361	1,361	1,361	1,361	1,361	1,361
NM	2,574	4,512	6,835	16,441	8,059	16,441	5,441	6,835
NY	5,192	6,781	7,317	7,317	7,156	7,317	6,995	7,317
NC	2,704	2,483	2,483	2,483	2,483	2,483	2,483	2,483
ND	5,280	6,251	8,779	14,862	9,237	14,862	7,263	8,779
OH	1,739	9,958	14,786	14,786	13,338	14,786	11,889	14,786
OK	8,521	12,287	15,560	24,259	16,317	24,259	13,596	15,560
OR	7,207	8,102	8,196	8,196	8,168	8,196	8,139	8,196
PA	4,459	9,650	9,650	9,650	9,650	9,650	9,650	9,650
RI	102	437	437	437	437	437	437	437
SC	2,143	1,405	1,405	1,405	1,405	1,405	1,405	1,405
SD	2,915	3,413	7,173	19,156	8,442	19,156	4,917	7,173
TN	836	124	128	128	127	128	126	128
TX	34,017	38,942	51,380	78,438	53,060	78,438	43,917	51,380
UT	1,100	3,980	3,981	3,983	3,981	3,983	3,981	3,981
VA	2,358	5,687	5,687	5,497	5,649	5,497	5,687	5,687
WA	8,214	8,036	8,047	8,047	8,044	8,047	8,040	8,047
WV	1,297	4,274	4,274	4,274	4,274	4,274	4,274	4,274
WI	3,223	5,377	5,452	5,954	5,530	5,954	5,407	5,452
WY	4,369	7,677	7,677	7,801	7,702	7,801	7,677	7,677
Total	216,903	329,238	400,358	524,065	403,763	524,065	357,686	400,358

*Total electric power industry net generation for energy sources geothermal, other biomass, wood and wood derived fuels, solar thermal and photovoltaic, and wind.

Table 1.4. State-Level Target Generation Levels under the Alternative RE Approach, Excluding Existing Hydropower (Percent of 2012 Generation)

State	2012 RE*	Target Generation, Excluding Existing Hydropower (% of 2012 Generation)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
AL	2%	0%	0%	0%	0%	0%	0%	0%
AZ	2%	3%	3%	3%	3%	3%	3%	3%
AR	3%	6%	6%	6%	6%	6%	6%	6%
CA	15%	16%	16%	16%	16%	16%	16%	16%
CO	12%	29%	30%	34%	30%	34%	29%	30%
CT	2%	2%	2%	2%	2%	2%	2%	2%
DE	2%	1%	1%	1%	1%	1%	1%	1%
FL	2%	1%	1%	1%	1%	1%	1%	1%
GA	3%	1%	1%	1%	1%	1%	1%	1%
ID	16%	68%	68%	68%	68%	68%	68%	68%
IL	4%	9%	12%	12%	11%	12%	10%	12%
IN	3%	11%	19%	19%	17%	19%	14%	19%
IA	25%	28%	36%	53%	37%	53%	31%	36%
KS	12%	25%	51%	115%	56%	115%	35%	51%
KY	0%	2%	2%	2%	2%	2%	2%	2%
LA	2%	2%	2%	2%	2%	2%	2%	2%
ME	28%	32%	32%	31%	32%	31%	32%	32%
MD	2%	2%	2%	2%	2%	2%	2%	2%
MA	5%	2%	2%	2%	2%	2%	2%	2%
MI	3%	9%	10%	10%	10%	10%	10%	10%
MN	18%	23%	29%	36%	28%	36%	25%	29%
MS	3%	5%	5%	5%	5%	5%	5%	5%
MO	1%	13%	13%	13%	13%	13%	13%	13%
MT	5%	19%	22%	37%	24%	37%	20%	22%
NE	4%	10%	24%	62%	28%	62%	16%	24%
NV	8%	10%	10%	11%	10%	11%	10%	10%
NH	7%	9%	9%	8%	9%	8%	9%	9%
NJ	2%	2%	2%	2%	2%	2%	2%	2%
NM	11%	20%	30%	72%	35%	72%	24%	30%
NY	4%	5%	5%	5%	5%	5%	5%	5%
NC	2%	2%	2%	2%	2%	2%	2%	2%
ND	15%	17%	24%	41%	26%	41%	20%	24%
OH	1%	8%	11%	11%	10%	11%	9%	11%
OK	11%	16%	20%	31%	21%	31%	17%	20%
OR	12%	13%	13%	13%	13%	13%	13%	13%
PA	2%	4%	4%	4%	4%	4%	4%	4%
RI	1%	5%	5%	5%	5%	5%	5%	5%
SC	2%	1%	1%	1%	1%	1%	1%	1%
SD	24%	28%	60%	159%	70%	159%	41%	60%
TN	1%	0%	0%	0%	0%	0%	0%	0%
TX	8%	9%	12%	18%	12%	18%	10%	12%

State	2012 RE*	Target Generation, Excluding Existing Hydropower (% of 2012 Generation)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
UT	3%	11%	11%	11%	11%	11%	11%	11%
VA	3%	8%	8%	8%	8%	8%	8%	8%
WA	7%	7%	7%	7%	7%	7%	7%	7%
WV	2%	6%	6%	6%	6%	6%	6%	6%
WI	5%	8%	9%	9%	9%	9%	8%	9%
WY	9%	15%	15%	16%	16%	16%	15%	15%
Total	5%	8%	10%	13%	10%	13%	9%	10%

*Total electric power industry net generation for energy sources geothermal, hydroelectric conventional, other biomass, wood and wood derived fuels, solar thermal and photovoltaic, and wind.

Table 1.5. Alaska and Hawaii Target Generation Levels under the Alternative RE Approach

State	2012 RE	RE Target Generation (GWh)						
		2020	2025	2030	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
Alaska	1,615	1,637	1,681	1,738	1,680	1,738	1,652	1,670
Hawaii	1,039	1,368	1,948	2,600	1,922	2,600	1,582	1,814
RE Target Generation (% of 2012 Generation)								
Alaska	23%	24%	24%	25%	24%	25%	24%	24%
Hawaii	10%	13%	19%	25%	18%	25%	15%	17%

Table 1.6. Alaska and Hawaii Target Generation Levels under the Alternative RE Approach, Excluding Existing Hydropower

State	2012 RE	RE Target Generation (GWh)						
		2020	2024	2029	Option 1 Interim	Option 1 Final	Option 2 Interim	Option 2 Final
Alaska	40	62	106	163	105	163	77	95
Hawaii	925	1,254	1,833	2,303	1,807	2,485	1,468	1,699
RE Target Generation (% of 2012 Generation)								
Alaska	1%	1%	2%	2%	2%	2%	1%	1%
Hawaii	9%	12%	18%	22%	17%	24%	14%	16%

Appendix

Table 1.7. IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2020
(Gigawatt-hours)

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2020 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
AL	-	-	304	-	7,814	8,117
AR	-	0	152	-	3,815	3,967
AZ	2,217	456	240	-	7,221	10,135
CA	8,124	15,147	2,883	25,178	31,102	82,433
CO	283	8,361	67	-	1,891	10,601
CT	-	17	22	-	475	514
DE	48	24	52	-	-	125
FL	276	-	1,741	-	186	2,203
GA	7	-	1,016	-	2,736	3,759
IA	-	13,716	110	-	925	14,751
ID	19	2,438	207	70	10,318	13,053
IL	50	12,271	1,243	-	141	13,705
IN	36	10,510	344	-	422	11,313
KS	-	8,719	44	-	35	8,799
KY	4	-	133	-	3,269	3,405
LA	-	-	79	-	1,056	1,135
MA	58	1,673	285	-	1,068	3,084
MD	1,205	2,779	120	-	1,946	6,049
ME	-	5,921	1,844	-	3,846	11,611
MI	2	8,211	1,820	-	1,308	11,340
MN	1,132	9,573	737	-	699	12,141
MO	500	4,939	188	-	1,558	7,186
MS	-	-	295	-	-	295
MT	-	1,911	58	-	10,192	12,161
NC	2,845	1,343	1,430	-	4,226	9,843
ND	0	6,251	-	145	1,731	8,128
NE	-	1,598	50	-	570	2,218
NH	47	2,349	669	-	1,526	4,592
NJ	611	418	489	-	27	1,546
NM	439	2,470	-	835	264	4,008
NV	809	408	82	3,369	2,116	6,785
NY	143	3,835	1,607	-	25,858	31,443
OH	54	6,838	434	-	427	7,754
OK	-	10,416	-	-	2,949	13,365
OR	4	10,943	1,103	2,000	34,676	48,726
PA	102	7,717	1,342	-	2,822	11,983

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2020 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
RI	-	102	370	-	9	481
SC	889	384	657	-	1,788	3,718
SD	-	3,413	-	-	4,506	7,919
TN	23	66	35	-	7,702	7,827
TX	217	34,552	1,752	-	1,148	37,669
UT	8	671	56	1,012	794	2,541
VA	0	3,795	2,660	-	1,366	7,821
WA	0	7,107	1,436	-	78,087	86,630
WI	-	3,444	1,168	-	1,683	6,295
WV	-	1,680	11	-	1,520	3,211
WY	-	4,125	-	-	965	5,090

*Dedicated biomass and landfill gas facilities.

Table 1.8. IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2025 (Gigawatt-hours)

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2025 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
AL	-	-	304	-	7,814	8,117
AR	-	2	152	-	3,815	3,968
AZ	2,217	456	240	-	7,221	10,135
CA	9,033	19,049	4,134	30,566	31,102	93,884
CO	283	8,977	67	-	1,891	11,217
CT	-	17	22	-	475	514
DE	48	24	52	-	-	125
FL	276	-	1,742	-	186	2,204
GA	7	3	1,034	-	2,736	3,780
IA	-	18,450	110	-	925	19,485
ID	19	2,443	222	70	10,318	13,073
IL	50	17,309	1,243	-	141	18,743
IN	36	19,610	344	-	422	20,412
KS	-	19,934	44	-	35	20,013
KY	4	3	133	-	3,269	3,409
LA	-	-	79	-	1,056	1,135
MA	58	1,673	285	-	1,068	3,084
MD	1,205	2,779	120	-	1,946	6,049
ME	-	7,080	1,844	-	3,846	12,770
MI	2	8,720	1,834	-	1,308	11,864
MN	1,169	12,705	691	-	699	15,265

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2025 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
MO	755	4,939	188	-	1,558	7,441
MS	-	-	295	-	-	295
MT	-	2,680	58	-	10,192	12,930
NC	5,109	1,373	1,430	-	4,226	12,137
ND	0	8,779	-	145	1,731	10,656
NE	-	6,439	50	-	570	7,059
NH	47	2,349	689	-	1,526	4,612
NJ	611	418	489	-	27	1,546
NM	451	4,782	-	1,482	264	6,979
NV	814	409	82	4,581	2,116	8,002
NY	143	4,371	1,607	-	25,858	31,979
OH	54	12,817	437	-	427	13,736
OK	-	13,689	-	-	2,949	16,638
OR	4	10,962	1,197	2,000	34,676	48,839
PA	102	7,717	1,342	-	2,822	11,983
RI	-	102	370	-	9	481
SC	889	384	657	-	1,788	3,718
SD	-	7,173	-	-	4,506	11,679
TN	23	73	35	-	7,702	7,833
TX	217	47,053	1,688	-	1,148	50,107
UT	8	672	56	1,583	794	3,113
VA	0	3,795	2,660	-	1,366	7,821
WA	0	7,119	1,447	-	78,087	86,654
WI	-	3,583	1,104	-	1,683	6,370
WV	-	1,680	11	-	1,520	3,211
WY	-	4,125	-	-	965	5,090

*Dedicated biomass and landfill gas facilities.

Table 1.9. IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2030 (Gigawatt-hours)

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2030 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
AL	-	-	304	-	7,814	8,117
AR	-	10	152	-	3,815	3,976
AZ	2,217	457	240	-	7,221	10,136
CA	10,608	37,296	2,928	31,619	31,102	113,553

State	IPM-Projected RE Power Sector Generation from \$30/MWh Reduced Cost Run, 2030 (GWh)					
	Solar	Wind	Biomass (Existing)*	Geothermal	Hydropower	Total
CO	283	10,997	67	-	1,891	13,237
CT	-	17	22	-	475	514
DE	48	24	52	-	-	125
FL	276	-	1,732	-	186	2,194
GA	7	6	1,034	-	2,736	3,783
IA	-	27,878	110	-	925	28,913
ID	19	2,482	222	70	10,318	13,112
IL	50	17,641	1,243	-	141	19,075
IN	36	19,610	344	-	422	20,412
KS	-	48,353	44	-	35	48,432
KY	4	3	133	-	3,269	3,409
LA	-	-	79	-	1,056	1,135
MA	58	1,673	241	-	1,068	3,040
MD	1,205	2,779	120	-	1,946	6,049
ME	-	7,437	1,697	-	3,846	12,980
MI	2	9,137	1,630	-	1,308	12,077
MN	1,203	16,480	540	-	699	18,922
MO	814	4,939	188	-	1,558	7,500
MS	-	-	295	-	-	295
MT	-	6,884	58	-	10,192	17,134
NC	7,107	1,398	1,430	-	4,226	14,161
ND	0	14,862	-	145	1,731	16,738
NE	-	19,239	50	-	570	19,859
NH	48	2,349	643	-	1,526	4,566
NJ	611	418	489	-	27	1,546
NM	478	14,360	-	1,482	264	16,584
NV	1,015	412	82	5,740	2,116	9,365
NY	143	4,371	1,607	-	25,858	31,979
OH	54	14,327	437	-	427	15,246
OK	-	22,388	-	-	2,949	25,337
OR	4	11,071	1,197	2,000	34,676	48,948
PA	102	7,717	1,342	-	2,822	11,983
RI	-	102	370	-	9	481
SC	889	384	657	-	1,788	3,718
SD	-	19,156	-	-	4,506	23,662
TN	23	75	35	-	7,702	7,836
TX	217	74,034	1,765	-	1,148	77,164
UT	8	674	56	1,583	794	3,115
VA	0	3,795	2,470	-	1,366	7,631
WA	0	7,273	1,447	-	78,087	86,808
WI	-	3,977	1,212	-	1,683	6,872
WV	-	1,680	11	-	1,520	3,211
WY	-	4,250	-	-	965	5,214

*Dedicated biomass and landfill gas facilities.

Table 1.10. NREL Renewable Energy Technical Potential by Selected Technology Type (Gigawatt-hours)¹⁵

State	NREL Renewable Energy Technical Potential by Selected Technology Type (GWh)			
	Utility-Scale Solar (PV and CSP)	Onshore Wind	Geothermal (Hydrothermal)	Hydropower
AL	3,742,689	283	-	4,103
AZ	24,533,333	26,036	8,330	1,303
AR	5,015,349	22,892	-	6,093
CA	17,592,841	89,862	130,921	30,024
CO	19,436,079	1,096,036	8,954	7,789
CT	27,344	62	-	922
DE	287,189	22	-	31
FL	5,210,493	1	-	682
GA	5,535,350	323	-	1,988
ID	7,462,920	44,320	17,205	18,758
IL	8,194,537	649,468	-	4,883
IN	4,975,001	377,604	-	2,394
IA	7,021,251	1,723,588	-	2,818
KS	22,506,111	3,101,576	-	2,508
KY	1,850,491	147	-	4,255
LA	4,170,275	935	-	2,423
ME	1,103,543	28,743	-	3,916
MD	614,500	3,632	-	814
MA	99,674	2,827	-	1,197
MI	5,266,485	143,908	-	1,181
MN	10,826,184	1,428,525	-	1,255
MS	5,007,619	-	-	2,211
MO	5,365,818	689,519	-	7,198
MT	9,739,000	2,746,272	6,548	14,547
NE	14,126,640	3,011,253	-	3,142
NV	16,935,101	17,709	45,321	846
NH	61,154	5,706	-	1,741
NJ	484,081	317	-	549
NM	33,202,248	1,399,157	12,933	1,363
NY	1,545,369	63,566	-	6,711
NC	4,301,136	2,037	-	3,037
ND	9,775,369	2,537,825	-	347
OH	3,712,677	129,143	-	3,046
OK	14,459,998	1,521,652	-	3,016

¹⁵ Please refer to data file at http://www.nrel.gov/gis/re_potential.html.

State	NREL Renewable Energy Technical Potential by Selected Technology Type (GWh)			
	Utility-Scale Solar (PV and CSP)	Onshore Wind	Geothermal (Hydrothermal)	Hydropower
OR	6,578,388	68,767	18,200	18,184
PA	609,518	8,231	-	8,368
RI	15,424	130	-	59
SC	2,788,808	428	-	1,889
SD	11,643,106	2,901,858	-	1,047
TN	2,276,233	766	-	5,745
TX	62,075,015	5,552,400	-	3,006
UT	10,282,917	31,552	12,982	3,528
VA	1,909,919	4,589	-	3,657
WA	1,933,554	47,250	2,547	27,249
WV	55,718	4,952	-	4,408
WI	5,097,198	255,266	-	2,287
WY	11,140,864	1,653,857	1,373	4,445
Total	390,594,517	31,394,989	265,313	230,965

Table 1.11. EIA 2012 Net Generation by RE Capacity Type (Gigawatt-hours)¹⁶

State	EIA 2012 Net Generation by RE Capacity Type (GWh)			
	Solar Thermal and Photovoltaic	Wind	Geothermal	Hydroelectric Conventional
AL	-	-	-	7,435
AZ	955	532	-	6,717
AR	-	-	-	2,198
CA	1,382	9,754	12,519	26,837
CO	165	5,969	-	1,497
CT	-	-	-	312
DE	23	4	-	-
FL	194	-	-	151
GA	3	-	-	2,236
ID	-	1,891	75	10,940
IL	31	7,727	-	111
IN	0	3,210	-	434
IA	-	14,032	-	766
KS	-	5,195	-	10
KY	-	-	-	2,362

¹⁶ Please refer to data file at <http://www.eia.gov/electricity/data/state/>.

State	EIA 2012 Net Generation by RE Capacity Type (GWh)			
	Solar Thermal and Photovoltaic	Wind	Geothermal	Hydroelectric Conventional
LA	-	-	-	680
ME	-	887	-	3,733
MD	22	322	-	1,657
MA	30	90	-	912
MI	-	1,132	-	1,215
MN	-	7,615	-	561
MS	-	-	-	-
MO	-	1,245	-	714
MT	-	1,262	-	11,283
NE	-	1,284	-	1,257
NV	473	129	2,347	2,440
NH	-	209	-	1,289
NJ	304	12	-	11
NM	334	2,226	-	223
NY	53	2,992	-	24,652
NC	139	-	-	3,728
ND	-	5,275	-	2,477
OH	37	985	-	414
OK	-	8,158	-	1,146
OR	6	6,343	26	39,410
PA	32	2,129	-	2,242
RI	-	1	-	4
SC	-	-	-	1,420
SD	-	2,915	-	5,981
TN	12	47	-	8,296
TX	118	32,214	-	584
UT	2	704	335	748
VA	-	-	-	1,044
WA	1	6,600	-	89,464
WV	-	1,286	-	1,431
WI	-	1,558	-	1,522
WY	-	4,369	-	893