EPA's Clean Power Plan: Goal Calculation Methodology and Its Application to Arizona

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Overview – The 6 Steps

- Step 1: Calculate Baseline Rate
- Step 2: Adjust to Reflect Heat Rate Improvement for Coal (Building Block 1)
- Step 3: Adjust to Reflect Redispatch to Natural Gas Combined Cycle Generation [NGCC] (Building Block 2)
- Step 4: Adjust to Reflect Preservation of At-Risk Nuclear (4a) and Increase in Renewable Energy [RE] (4b) (Building Block 3)
- Step 5: Adjust to Reflect Improvement in Energy Efficiency [EE] (Building Block 4)
- Step 6: Calculate Interim and Final Rate-Based Goals

Overview – The Alternatives

- Focus on Alternative 1
  - BB1 and BB2 by 2020
  - Final goal set for 2030 based on increases in RE and EE from 2020 through 2029
- Alternative 2 –
  - BB1 and BB2 by 2020
  - Final goal set for 2025 based on increases in RE and EE from 2020 through 2024
  - Lower growth rate assumed for EE (“Option 2”)

Sources

- GHG Abatement Measures TSD (http://www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghg-abatement-measures.pdf) [GHGAM]
- Proposed Renewable Energy Approach Data File (XLS) (http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-proposed-re-approach.xlsx)
- Data File: GHG Abatement – Scenario 1 (EE Calculation, XLS) (http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-ghg-abatement-measures-scenario1.xlsx)
- Goal Computation TSD (http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-goal-computation) [GC]
- Goal Computation TSD Appendix 1 and 2 Data File (XLS) (http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-state-goal-data-computation_1.xlsx)

Step 1: Baseline

- Formulas
  - Baseline (Rate for Covered EGUs)

$$\frac{(\text{Coal Gen} \times \text{Coal ER}) + (\text{OG Gen} \times \text{OG ER}) + (\text{NGCC Gen} \times \text{NGCC ER}) + \text{Other Emissions}}{\text{Coal Gen} + \text{OG Gen} + \text{NGCC Gen} + \text{Other Gen}}$$

- "Gen" = Generation in MWh
- "ER" = Emission rate in lbs CO_2/MWh
- "OG" = Oil and Gas Steam
- "Other" generation consists of IGCC and high utilization (> 33% capacity factor [CF]) simple-cycle combustion turbines and useful thermal output from covered EGUs. Other generation is excluded from the redispatch calculations in Step 3.

Step 1: Baseline

- Formulas (cont'd)
  - Adjusted Baseline (taking at-risk nuclear and existing RE into account)

$$\frac{(\text{Coal Gen} \times \text{Coal ER}) + (\text{OG Gen} \times \text{OG ER}) + (\text{NGCC Gen} \times \text{NGCC ER}) + \text{Other Emissions}}{\text{Coal Gen} + \text{OG Gen} + \text{NGCC Gen} + \text{Other Gen} + Nuclear\ Gen_{uc+ar} + RE\ Gen_{2012}}$$

- Arizona
  - Baseline: 1551 lbsCO2/MWh
  - Adjusted Baseline: 1453 lbs CO2/MWh

Step 2: Coal Heat Rate Improvement (BB1)

- Adjust Coal ER downward by 6 % to reflect 6 % heat rate improvement (Coal ER_{hri})
- Arizona:

$$\text{Coal ER}_{\text{hri}} = 2{,}268 \times (1 - 6\%) = 2{,}132$$

  - Note: In applying BB2 to Arizona, the coal rate is multiplied by 0 MWh, so this step has no effect on Arizona's rate.

Step 3: Redispatch to NGCC (BB2)

- Step 3a: Adjust the generation for coal, OG and NGCC to reflect
  - An increase in the capacity factor for existing NGCC to 70 %
  - The "redispatch" of coal and OG generation to NGCC to the full extent allowed by that increase
- Note: EPA's Step 3b makes adjustments for redispatch to under-construction NGCC and is inapplicable to Arizona

Step 3: Redispatch to NGCC (BB2)

- Methodology
  - Calculate NGCC generation at 70% capacity (NGCC at 70%):

$$\text{NGCC Cap (MW)} \times 8784 \times 70\%$$

    - Arizona:

$$11{,}202 \times 8784 \times 70\% = 68{,}878{,}858$$

  - Calculate sum of baseline Coal, OG and NGCC generation from covered EGUs subject to redispatch (Covered FF Gen):
    - Arizona:

$$24{,}335{,}930 + 1{,}033{,}871 + 26{,}782{,}235 = 52{,}152{,}127$$

  - Take the lower of NGCC at 70% or Covered FF Gen as the generation to be redispatched from coal and OG to NGCC ($NGCC_{rd}$ Gen):
    - Arizona: $52{,}152{,}127$

Step 3: Redispatch to NGCC (BB2)

- Methodology (Cont'd)
  - Calculate coal and OG generation after redispatch to NGCC. E.g. for coal generation after redispatch:

$$Coal\ Gen_{rd} = Coal\ Gen - ((NGCC\ Gen_{rd} - NGCC\ Gen) \times (Coal\ Gen \div (Coal\ Gen + OG\ Gen)))$$

    - In other words, multiply the increase in NGCC generation by the ratio of coal generation to total coal and OG generation and subtract the product from baseline coal generation.
    - Arizona coal:

$$24{,}335{,}930 - ((52{,}152{,}127 - 26{,}782{,}325) \times (24{,}335{,}930 \div (24{,}335{,}930 + 1{,}033{,}871))) = \mathbf{0}$$

    - The result is 0 for OG as well, because in Arizona, an increase in the NGCC capacity factor to less than 70% is sufficient to completely displace all coal and OG generation.

Step 3: Redispatch to NGCC (BB2)

- Methodology (cont'd)
  - Recalculate the rate after Building Block 2:

$$\frac{(\text{Coal Gen}_{rd} \times \text{Coal ER}_{hri}) + (\text{OG Gen}_{rd} \times \text{OG ER}) + (\text{NGCC } Gen_{rd} \times \text{NGCC ER}) + \text{Other Emissions}}{\text{Coal Gen}_{rd} + \text{OG Gen}_{rd} + \text{NGCC Gen}_{rd} + \text{Other Gen}}$$

  - Arizona:

$$\frac{(0 \times 2{,}132) + (0 \times 1{,}563) + (52{,}152{,}126 \times 900) + 17{,}227{,}768}{0 + 0 + 52{,}152{,}126 + 19{,}361}$$

$$= 900 \text{ lbs/MWh}$$

    - Share of reduction in Arizona's rate-based goal:

$$\frac{1{,}551 - 900}{1{,}551 - 702} = 77\%$$

Step 4a: At-Risk Nuclear (BB3)

- Step 4a: Increase the generation in the denominator to reflect under construction and preservation of "at-risk" nuclear generation.
  - Based on an EIA projection of 5.7 GW in "capacity reductions to the nuclear fleet" nationwide, EPA assumes 5.8 % of the nuclear capacity in each state is "at risk of retirement."
  - EPA assumes a 90 % CF for new and preserved at-risk nuclear generation.

$$\text{Nuclear gen}_{\text{uc+ar}} = (\text{Nuclear cap}_{\text{new}} + (\text{Nuclear cap}_{2012} \times 6\%)) \times 8784 \times 90\%$$

  - Arizona value: 1,818,486 (all at-risk)

Step 4b: Renewable Energy (BB3)

- EPA summary of methodology [GHGAM at 4-2]:
  - First, the country is divided into regions.
  - Second, an RE generation target is calculated for each region, based upon averaging all 2020 RPS [renewable portfolio standards] requirements in that region.
  - Third , an annual growth factor is calculated that would allow the *region as a whole* to reach the regional RE target in 2029 assuming that RE generation would increase from 2012 levels beginning in 2017.
  - Fourth, the annual growth factor for a given region is applied to individual states' 2012 RE generation to calculate future RE generation in that state from 2017 through 2029, *not to exceed a maximum RE generation level equivalent to the regional RE target*.
  - Finally, these annual RE generation levels for each state are used to calculate interim and final RE targets for that state.

Step 4b: Renewable Energy (BB3)

- Divide into regions
  - Arizona is in the West Region
  - Also includes California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming
  - "States within each region exhibit similar profiles of RE potential or have similar levels of renewable resources." [GHGAM at 4-12]

Step 4b: Renewable Energy (BB3)

- Calculate RE generation target
  - Determine effective RE level (EREL) for each state.
    - Primary RPS requirements for each state (that has them) adjusted, as necessary, for 2020. REST in Arizona.
    - ERELs for Arizona and West region (Idaho, Utah and Wyoming have no RPS):

State	Primary Target	Target Year	2020 EREL
Arizona	15%	2025	10%
California	33%	2020	33%
Colorado*	30%	2020	30%
Montana	15%	2015	15%
Nevada	25%	2025	22%
New Mexico	20%	2020	20%
Oregon	25%	2025	20%
Washington	15%	2020	15%
Average			**21%**

*Correction from 9/3/2014 version.

Step 4b: Renewable Energy (BB3)

- Calculate RE generation target (cont'd)
  - Calculate the regional RE generation target percentage from the ERELs for the region
    - EPA *initially* assumes each state in the region can achieve the average of the 2020 ERELs *in 2030.*
    - This assumption is limited by the growth factor discussed below.
    - Average for West region, and therefore region's RE generation target, is **21%**.

Step 4b: Renewable Energy (BB3)

- Calculate the annual growth factor for the region
  - Calculate the region's total RE generation target in MWh (RE Gen Target)
    - Sum of *total generation* in 2012 for each state in region multiplied by regional RE generation target percentage
    - In West: 146,877,467
    - Note: REST applies to retail electricity sales, not total generation
  - Calculate the region's total RE generation in 2012 in MWh (RE Gen 2012)
    - In West: 68,065,726

Step 4b: Renewable Energy (BB3)

- Calculate the annual growth factor for the region (cont'd)
  - Calculate the region's growth factor
    - Annual percentage growth in RE in the region needed during the period 2017 to 2029 to reach RE Gen Target

$$\mathrm{GF} = \left(\frac{\text{RE Gen Target}}{\text{RE Gen 2012}}\right)^{1/13} - 1$$

    - In West:

$$\left(\frac{146{,}877{,}467}{68{,}065{,}726}\right)^{1/13} - 1 = 6\%$$

      - ❖ Lowest rate among regions

Step 4b: Renewable Energy (BB3)

- Calculate the state's RE Gen goal (in MWh) for each year from 2017 to 2029
  - Calculate the RE generation in MWh that the state would reach in 2029 if it achieved the RE generation target % for the region (2029 RE Gen Target)
    - *Total generation* in 2012 multiplied by RE generation target % (21 % in West region)
    - Arizona: $95{,}016{,}925 \times 21\% = \mathbf{19,597,241}$

Step 4b: Renewable Energy (BB3)

- Calculate the state's RE Gen goal (in MWh) for each year from 2017 to 2029 (cont'd)
  - Calculate the state's 2017 RE Gen goal
    - Lesser of
      - 2029 RE Gen Target or
      - *Actual RE generation in 2012 increased by growth factor*
    - Methodology explicitly assumes no growth between 2012 and 2017
    - Arizona:
      - $1{,}697{,}752 \times (1 + 6\%) = 1{,}801{,}122$
      - $1{,}801{,}122 < 19{,}597{,}241$
      - RE Gen goal for $2017 = \mathbf{1{,}801{,}122}$

Step 4b: Renewable Energy (BB3)

- Calculate the state's RE Gen goal (in MWh) for each year from 2017 to 2029 (cont'd)
  - Calculate the state's RE Gen goal for 2018 to 2029
    - For each year, RE Gen goal is lesser of
      - RE Gen Target
      - Previous year RE Gen goal increased by growth factor
    - Arizona never reaches 2029 RE Gen Target. Its 2029 goal (3,663,325 MWh RE) is therefore based entirely on the growth factor.

Step 4b: Renewable Energy (BB3)

- Calculate the state's regional RE Gen goal (in MWh) for each year from 2017 to 2029 (cont'd)
  - Calculate the state's RE Gen goal for 2018 to 2029 (cont'd)
    - Four states (Iowa, Maine, Minnesota, South Dakota) had actual 2012 RE Gen > 2029 RE Gen Target.
    - The emission rate goals for these 4 states therefore assume *no* growth in RE Gen.
    - Sixteen states (including California, Colorado, Idaho, New Mexico and Oregon) are projected to hit their RE Gen Target before 2029.
    - The emission rate goals for these states assume no further growth in RE Gen after they hit the target.

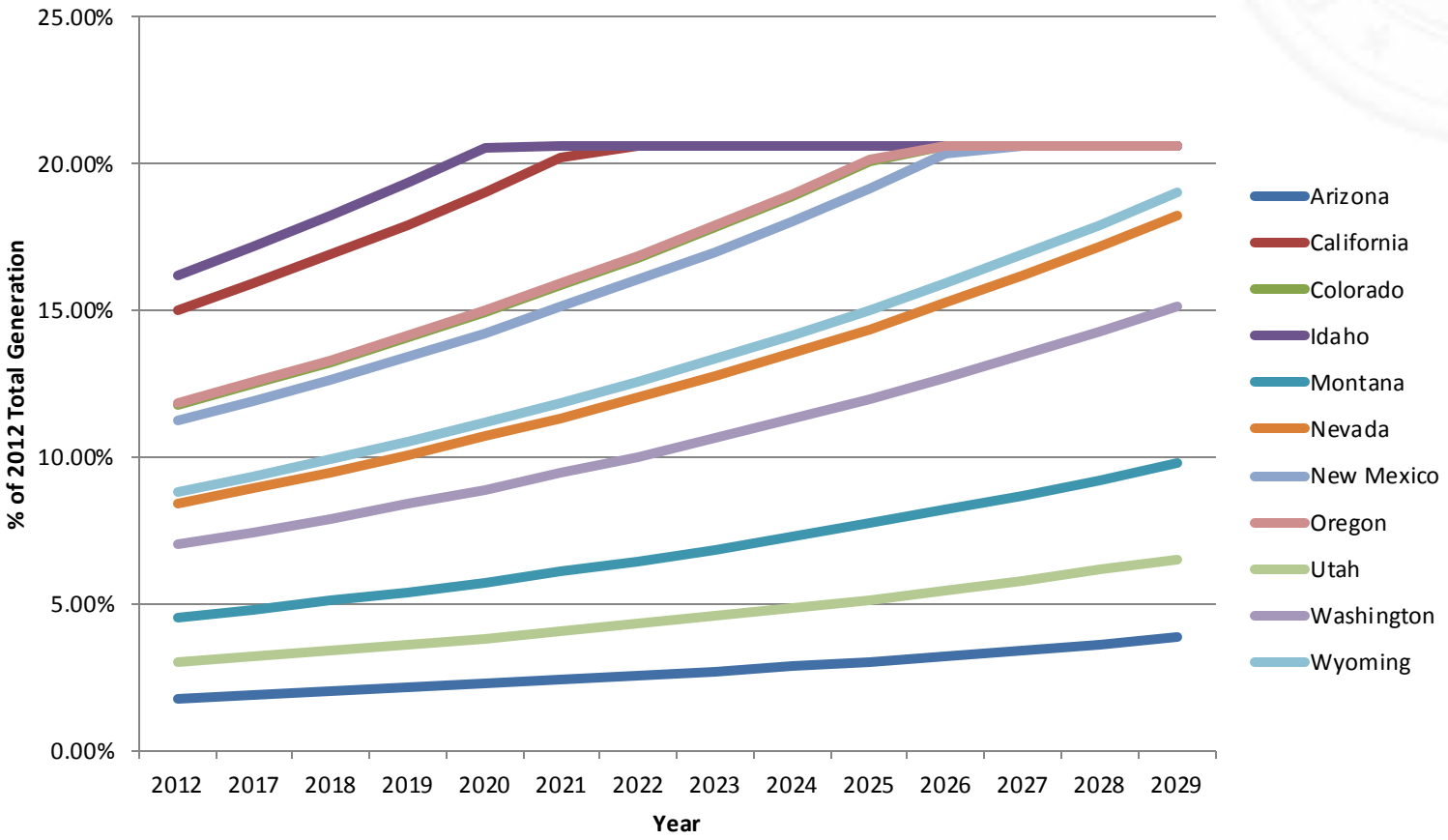
Step 4b: Renewable Energy (BB3)

- RE Gen Goals for Certain West Region States

	Arizona	California	Colorado	Idaho	New Mexico	Oregon
2012	1,697,652	29,966,846	6,192,082	2,514,502	2,573,851	7,207,229
2017	1,801,122	31,793,284	6,569,481	2,667,758	2,730,724	7,646,500
2018	1,910,898	33,731,042	6,969,882	2,830,354	2,897,158	8,112,544
2019	2,027,365	35,786,903	7,394,687	3,002,860	3,073,736	8,606,993
2020	2,150,930	37,968,066	7,845,383	3,185,880	3,261,076	9,131,577
2021	2,282,026	40,282,168	8,323,548	3,196,687	3,459,834	9,688,134
2022	2,421,112	41,150,704	8,830,857	3,196,687	3,670,706	10,278,613
2023	2,568,676	41,150,704	9,369,086	3,196,687	3,894,431	10,905,080
2024	2,725,233	41,150,704	9,940,119	3,196,687	4,131,791	11,569,730
2025	2,891,333	41,150,704	10,545,955	3,196,687	4,383,618	12,274,890
2026	3,067,555	41,150,704	10,839,820	3,196,687	4,650,794	12,567,372
2027	3,254,519	41,150,704	10,839,820	3,196,687	4,721,996	12,567,372
2028	3,452,877	41,150,704	10,839,820	3,196,687	4,721,996	12,567,372
2029	3,663,325	41,150,704	10,839,820	3,196,687	4,721,996	12,567,372

Step 4b: Renewable Energy (BB3)

- RE Growth Assumed for Each State in West Region as % of Total Generation



Step 5: Energy Efficiency (BB4)

- Methodology Overview- For each year determine:
  - Annual business as usual (BAU) sales
  - Annual incremental EE savings (AIEES) as % of sales
  - Annual incremental EE savings in GWh
    - $\text{AIEES} \times \text{BAU}$
  - Annual expiring EE savings (EEES) in GWh
  - Net cumulative EE savings (NCEES) in GWh
    - $AIEES - EEES + SANEE_{previous\ year}$
  - Sales after net EE in (SANEE) in GWh (used in following year)
  - Net cumulative EE savings as % of BAU sales
    - $NCEES \div BAU$

Step 5: Energy Efficiency (BB4)

- Annual Business as Usual (BAU) Sales
  - Start with 2012 sales from EIA Form 861 data
  - Increase each year by average annual growth rate for region from AEO 2013 Reference Case
  - Arizona:
    - 2012 Sales = 76,275 GWh
    - Average regional growth rate = 1.3 %
    - 2017 BAU = 81,372 GWh

Step 5: Energy Efficiency (BB4)

- Annual Incremental EE Savings (AIEES) as % of Sales
  - Reduction in electricity use in a given year associated with new EE measures in that year
  - AIEES determination includes key assumptions for setting performance goal:
    - Best practices AIEES level
    - Pace of improvement
  - Best practices level
    - Based on past performance in 2012 and state requirements for 2020
    - Past performance: 3 states, including AZ, achieved AIEES of 1.5% or better (GHGAM Table 5-8); 8 states achieved 1-1.49%
    - State requirements: 11 states, including AZ, require 1.5% or better by 2020; 5 states require 1-1.49%
    - EPA chose **1.5%** for Option 1, which is used in calculating Alternative 1
    - EPA chose 1.0% for Option 2, used in Alternative 2

Step 5: Energy Efficiency (BB4)

- Annual Incremental EE Savings (AIEES) as % of Sales (cont'd)
  - Pace of Improvement
    - Also based on past performance and state requirements
    - Past performance
      - Looked at performance of "individual program administrators" from EIA 861
      - "Moderate" group achieved rate of improvement of 0.30 % growth per year; "high" group achieved 0.38 %
    - Requirements: 10 states with "clear schedules" for EE growth had average rate of improvement of 0.21 %
    - EPA selected:
      - **0.20 % per year** for Option 1
      - 0.15 % per year for Option 2

Step 5: Energy Efficiency (BB4)

- Annual Incremental EE Savings (AIEES) as % of Sales (cont'd)
  - 2017 baseline = Lesser of 2012 actual AIEES from EIA 861 or 1.5 %
  - Increase each year by 0.20 % until reach 1.50 % and then hold at that level
  - Arizona
    - AZ 2012 actual AIESS = 1.61 % (5.39 % cumulative)
    - Goal calculation for AZ assumes 1.50 % AIEES from 2017 to 2029

Step 5: Energy Efficiency (BB4)

- Annual Incremental EE Savings in GWh
  - 2017:

$$AIEES\ as\ \%\ of\ Sales\ in\ 2017\ \times BAU\ Sales\ in\ 2016$$

  - 2018-2029:

$$AIEES\ in\ GWh_{year\ i} = AIEES\ as\ \%\ of\ Sales_{year\ i} \times Sales\ After\ Net\ EE_{year\ i-1}$$

  - Sales after net EE for *current year* are calculated in later step
- Annual Expiring EE Savings in GWh
  - To determine net cumulative EE savings, have to account for "measure life"
  - EPA assumes an average measure life of 10 years, which it says is conservative, and "an even distribution from one year in length to two times the average measure life (twenty years) in length"
  - Works out to 5% decline per year in EE savings for EE measures implemented in a particular year (GHGAM Table 5-15, Fig. 1)
  - Total expiring EE Savings for a given year = sum of expiring savings for all previous implementation years

Step 5: Energy Efficiency (BB4)

- Annual Expiring EE Savings in GWh (cont'd)
  - Arizona:

EE Measures Implementation Year	Annual Incremental Savings (GWh) by Year								
	2017	2018	2019	2020	2021	2022	2023	2024	2025
	1205	1203	1201	1201	1202	1205	1208	1213	1218
	Annual Expiring EE Savings (GWh) by Year								
2017		63	63	63	63	63	63	63	63
2018			63	63	63	63	63	63	63
2019				63	63	63	63	63	63
2020					63	63	63	63	63
2021						63	63	63	63
2022							63	63	63
2023								64	64
2024									64
2025									
Total		63	127	190	253	316	380	443	507

Step 5: Energy Efficiency (BB4)

- Net Cumulative EE Savings (GWh)

$$\text{Net Cumulative EE Savings}_{\text{year i}} = \text{AIEES in GWh}_{\text{year i}} - \text{Expired EE Savings}_{\text{year i}} + \text{Net Cumulative EE Savings}_{\text{year i}-1}$$

- Sales After Net EE (GWh)

$$\text{BAU Sales} - \text{Net Cumulative EE Savings}$$

- Net Cumulative EE Savings as % of BAU Sales

$$\text{Net Cumulative EE Savings} \div \text{BAU Sales}$$

Step 5: Energy Efficiency (BB4)

- Arizona

Calculation Step	Year									
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
BAU Sales (GWh)	84,593	85,695	86,811	87,942	89,087	90,247	91,423	92,613	93,820	95,041
Annual Incremental EE Savings (%)	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Annual Incremental EE Savings (GWh)	1,201	1,202	1,205	1,208	1,213	1,218	1,225	1,233	1,242	1,252
Expiring EE Savings (GWh)	190	253	316	380	443	507	571	636	701	766
Net Cumulative Savings (GWh)	4,430	5,379	6,268	7,096	7,865	8,576	9,230	9,827	10,368	10,854
Sales After Net EE	80,163	80,316	80,544	80,846	81,222	81,671	82,193	82,786	83,452	84,188
Net Cumulative Savings (%)	5.24%	6.28%	7.22%	8.07%	8.83%	9.50%	10.10%	10.61%	11.05%	11.42%

Step 5: Energy Efficiency (BB4)

- Calculating EE Savings for 2020-2029:
  - Multiply net cumulative EE savings as % of sales by 2012 retail sales
  - Increase by 7.51 % to account for transmission and distribution losses
  - If the state is a net importer of electricity, multiply by state's generation share of it's sales. "This last step helps assure that building block four reductions for net importer states are linked to their own in-state generation." [GC at 17 & n.22]
    - N/A to AZ

Step 5: Energy Efficiency (BB4)

- Calculating EE Savings for 2020-2029:
  - Arizona:

Year	Goal
2020	4,228,711
2021	5,067,998
2022	5,826,583
2023	6,512,538
2024	7,125,863
2025	7,666,557
2026	8,150,761
2027	8,562,334
2028	8,917,416
2029	9,216,009

Step 6: Calculate Rate-Based Goals

- Equation for Rate-Based Goals:

$$\frac{(\text{Coal Gen}_{rd} \times \text{Coal ER}_{hri}) + (\text{OG Gen}_{rd} \times \text{OG ER}) + (\text{NGCC } Gen_{rd} \times \text{NGCC ER}) + \text{Other Emissions}}{\text{Coal Gen}_{rd} + \text{OG Gen}_{rd} + \text{NGCC Gen}_{rd} + \text{Other Gen} + \text{Nuclear Gen}_{\text{uc+ar}} + \text{RE Gen} + \text{EE Savings}}$$

- Interim Goal
  - Apply to each year from 2020 to 2029
  - Take average of results
- Final Goal = 2029 Result

Step 6: Calculate Rate-Based Goals

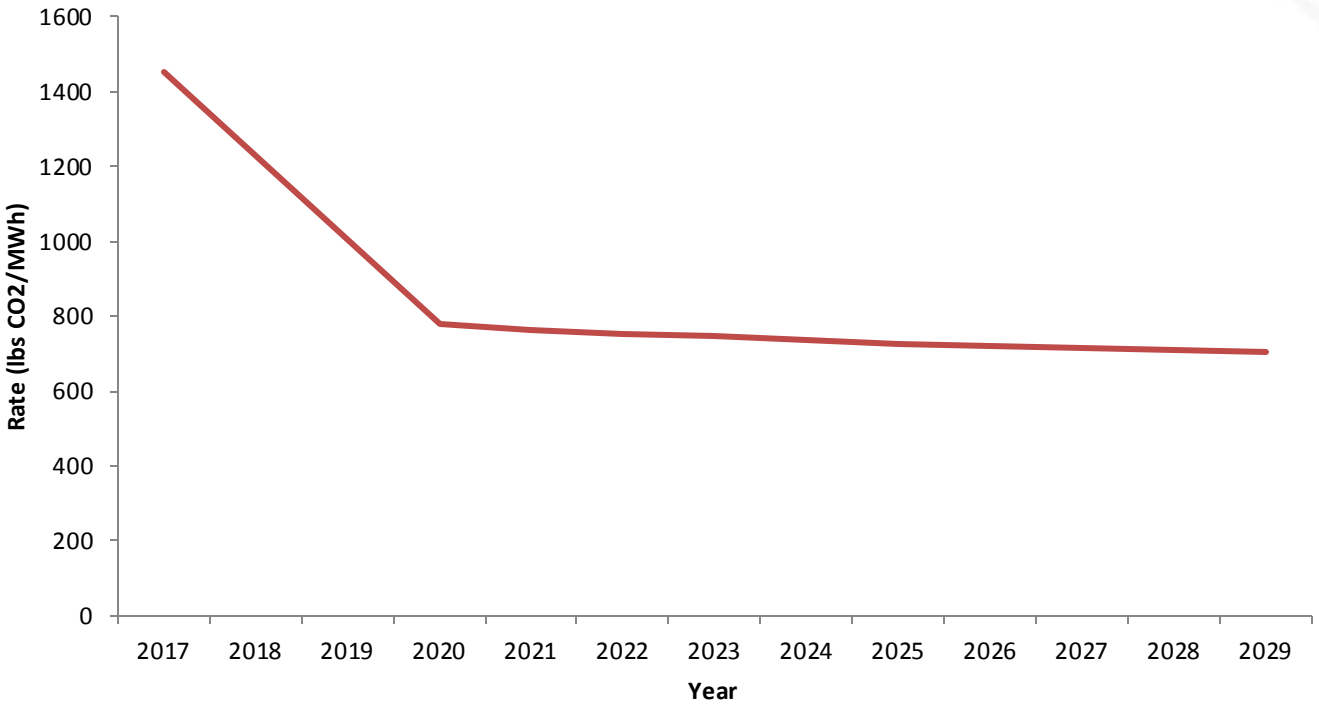
- Arizona
  - Application to 2020-2029:

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Rate	778	765	754	744	735	727	720	713	707	702

  - Baseline: 1453 lbs CO2/MWh
  - Interim Goal: 735 lbs CO2/MWh
  - Final Goal: 702 lbs CO2/MWh

Step 6: Calculate Rate-Based Goals

- Arizona
  - Rate Reduction Curve:



Step 6: Calculate Rate-Based Goals

- Arizona
  - Interim Goal Problem:

	Step 3a & 3b (Redispatch)			Step 6&7 (State Goal Phase I & II (lbs/MWh))	
Scenario	Redispatched Coal Gen. (MWh)	Redispatch O/G steam Gen. (MWh)	Redispatched NGCC Gen. (MWh)	Interim Goal or Rate (2020 - 2029 average)	Final Goal or Rate (2030 and thereafter)
1. EPA Goal Calculation	0	0	52,152,127	735	702
2. 15 % RE and 1.61 % Incremental EE Savings	6,532,309	277,514	45,342,304	774	702
3. 21 % RE and 1.61 % Incremental EE Savings	9,707,768	412,418	42,031,940	803	702
4. 33 % RE and 2.00 % Incremental EE Savings	17,289,395	734,511	34,128,220	858	702
5. 33 % RE and 2.00 % Incremental EE Savings	9,476,915	402,611	42,272,601	735	601

- Scenarios presented for illustration only. ADEQ has not evaluated the technical or economic feasibility of any of the RE or EE alternatives included.