

Update on Future-Year Projections for the 2016beta Emissions Modeling Platform

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Overall approach summary (non-point)

- For non-point sources:
 - Production-related sources (SCCs)
 - used state historical production data (EIA) to grow from 2016 to 2017
 - used AEO 2018 reference case to grow from 2017 to 2023/2028
 - Exploration-related sources (SCCs)
 - Used exploration activity data from 2014 and 2016 and compute county averages
 - Used county averages in Oil and Gas Tool to generate new 2014-2016 averaged emissions

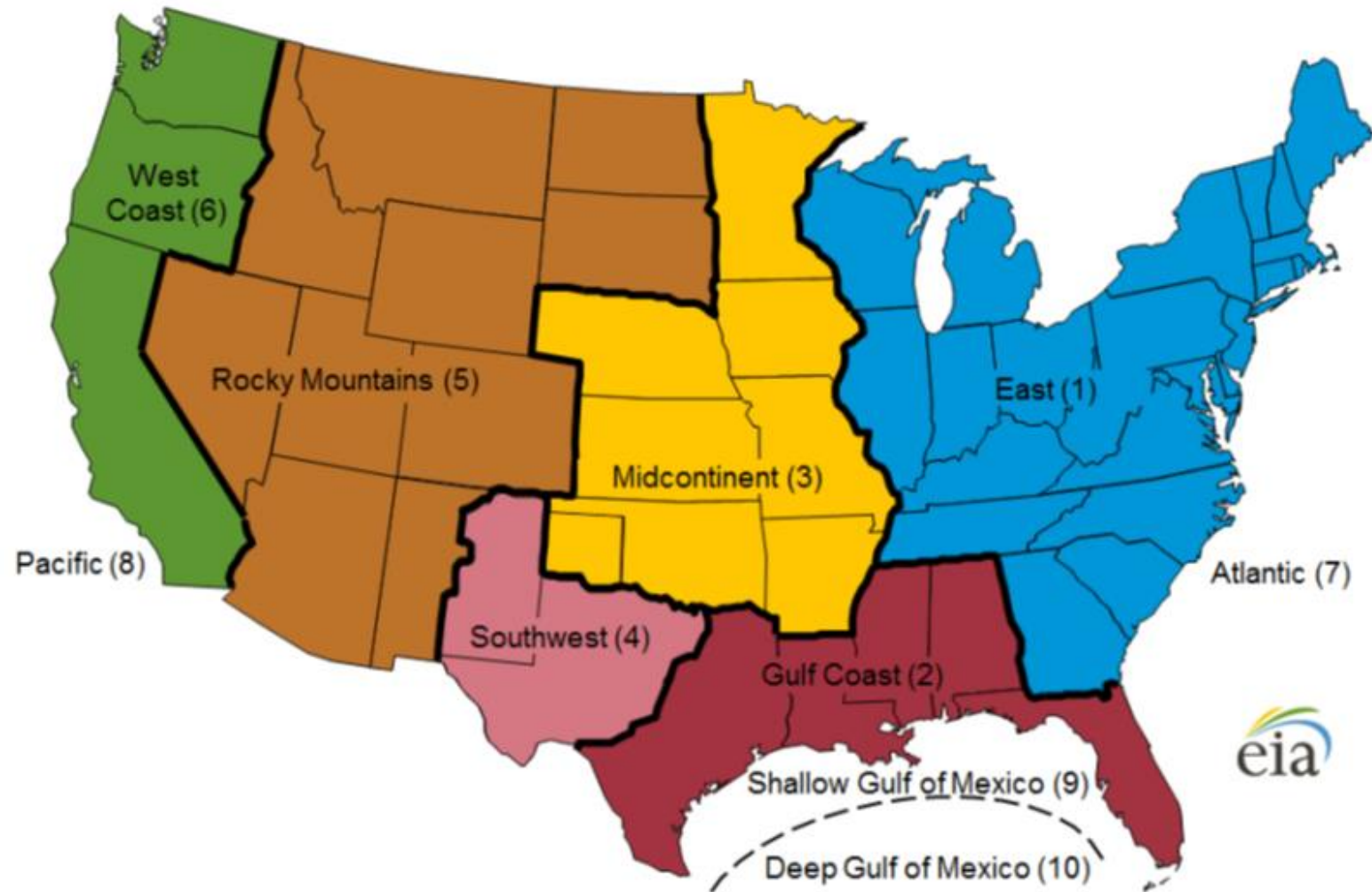
Overall approach summary (point)

- For point sources:
 - Production-related NAICS codes
 - used state historical production data (EIA) to grow from 2016 to 2017
 - used AEO 2018 reference case to grow from 2017 to 2023/2028
 - For other NAICS
 - Assume no growth for beta platform

Overall approach summary (point #2)

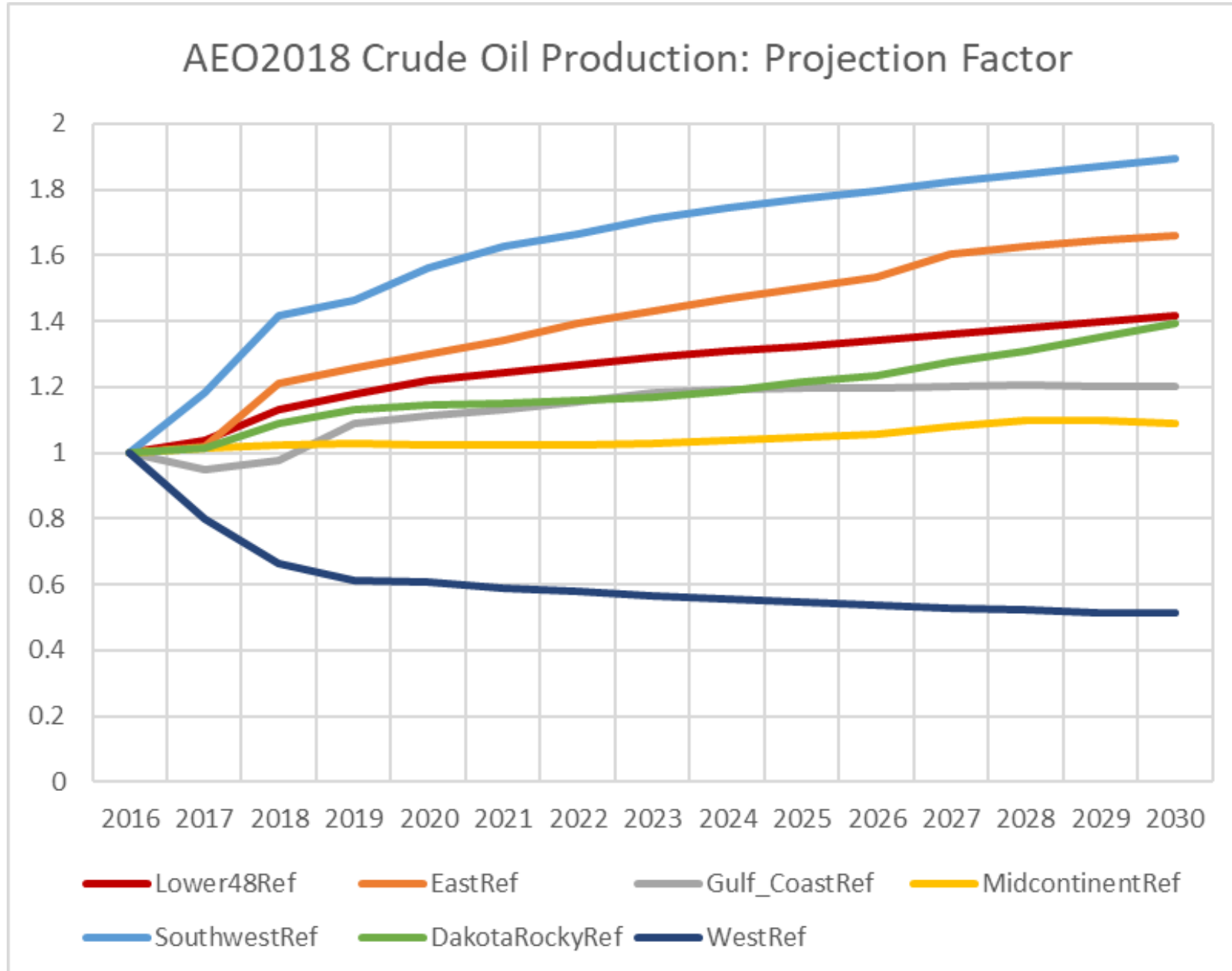
Industry Segment	SCC Clusters	NAICS for Point Sources	Area SCCs	2016beta approach
Exploration	1-5	213111,211111, 211112	National Emissions Tool SCCs or State E&P Approach	AEO Reference Case
Production				AEO Reference Case
Gathering				AEO Reference Case
Processing				AEO Reference Case
Storage	6,7	486110, 486210, 424710	Not applicable	No growth
Transmission				No growth
Distribution	8	221210	Not applicable	No growth
Support Activities for Oil and Gas Operations	9	213112	Not applicable	No growth

EIA Oil and Gas Supply Regions

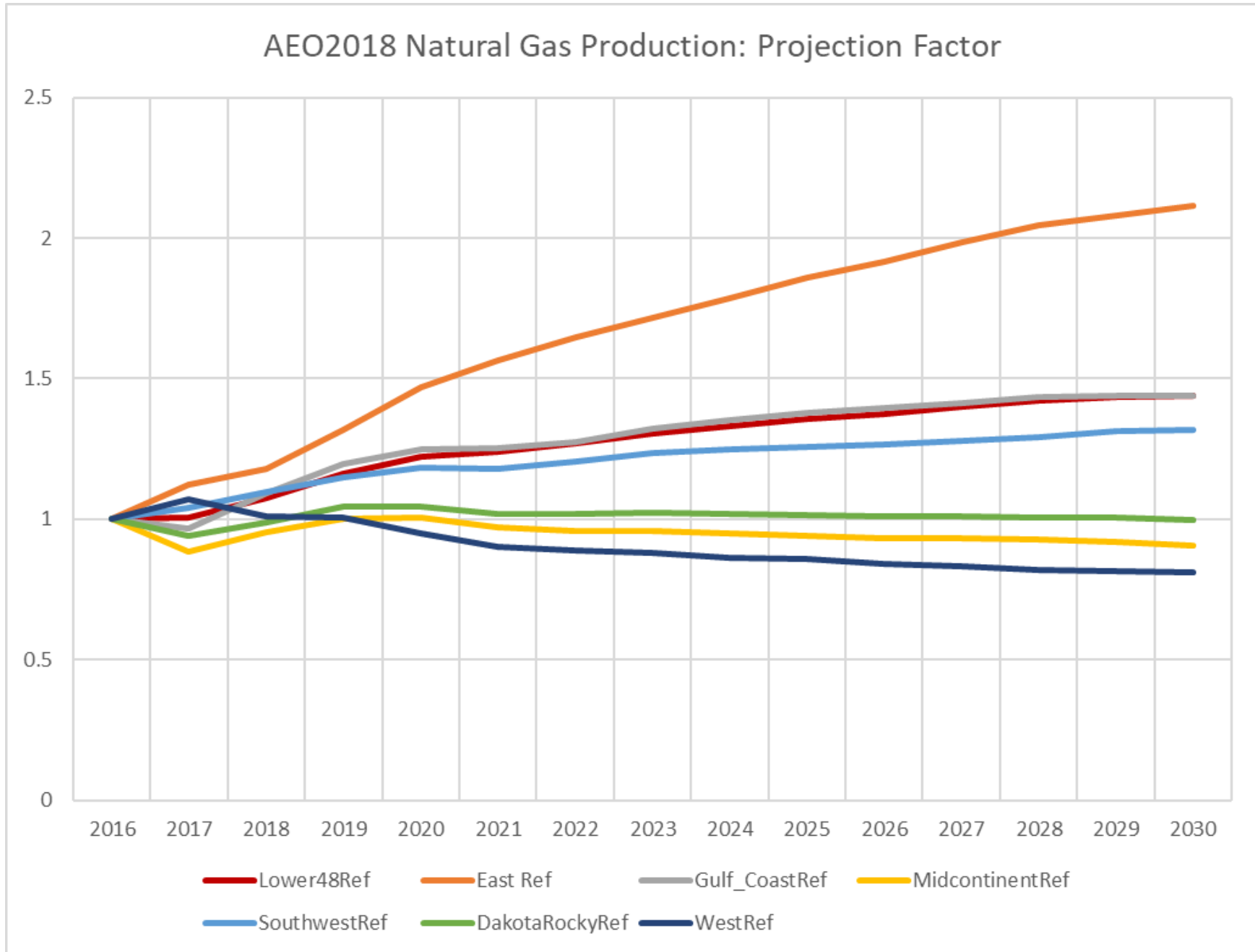


Source: U.S. Energy Information Administration.

Reference case



Reference case



Growth factor calculation summary: OGS Region 1 (East)

State historical data used

AEO2018 data used

Final beta growth factors

		OIL	OIL	OIL	OIL	OIL	NGAS	NGAS	NGAS	NGAS	NGAS
state	OGS Region	2016 to 2017 fac	2017 to 2023 fac	2017 to 2028 fac	2016 to 2023 fac	2016 to 2028 fac	2016 to 2017 fac	2017 to 2023 fac	2017 to 2028 fac	2016 to 2023 fac	2016 to 2028 fac
Illinois	1	0.96	1.00	1.00	0.96	0.96	0.98	1.00	1.00	0.98	0.98
Indiana	1	0.98	1.00	1.00	0.98	0.98	0.95	1.00	1.00	0.95	0.95
Kentucky	1	0.95	1.00	1.00	0.95	0.95	0.97	1.00	1.00	0.97	0.97
Maryland	1	#DIV/0!	1.00	1.00	#DIV/0!	#DIV/0!	0.94	1.00	1.00	0.94	0.94
Michigan	1	0.94	1.00	1.00	0.94	0.94	0.95	1.00	1.00	0.95	0.95
New York	1	0.82	1.00	1.00	0.82	0.82	0.84	1.00	1.00	0.84	0.84
Ohio	1	0.88	1.40	1.60	1.23	1.40	1.23	1.53	2.04	1.88	2.52
Pennsylvania	1	1.04	1.40	1.60	1.46	1.66	1.05	1.53	2.04	1.60	2.14
Tennessee	1	1.05	1.00	1.00	1.05	1.05	0.83	1.00	1.00	0.83	0.83
Virginia	1	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00	0.96	0.96
West Virginia	1	1.24	1.40	1.60	1.74	1.98	1.16	1.53	2.04	1.77	2.36

Growth factor calculation summary: OGS Region 2, 3 and 4(Gulf Coast, Midcontinent and Southwest)

State historical data used

AEO2018 data used

Final beta growth factors

		OIL	OIL	OIL	OIL	OIL	NGAS	NGAS	NGAS	NGAS	NGAS
state	OGS Region	2016 to 2017 fac	2017 to 2023 fac	2017 to2028 fac	2016 to 2023 fac	2016 to 2028 fac	2016 to 2017 fac	2017 to 2023 fac	2017 to 2028 fac	2016 to 2023 fac	2016 to 2028 fac
Alabama	2	0.84	1.24	1.27	1.05	1.07	0.91	1.37	1.49	1.25	1.35
Florida	2	0.99	1.24	1.27	1.24	1.26	1.18	1.37	1.49	1.62	1.76
Louisiana	2	0.92	1.24	1.27	1.14	1.16	1.20	1.37	1.49	1.64	1.78
Mississippi	2	0.87	1.24	1.27	1.08	1.11	0.79	1.37	1.49	1.08	1.18
Texas	2	1.09	1.24	1.27	1.36	1.39	0.98	1.37	1.49	1.34	1.46
Arkansas	3	0.96	1.01	1.08	0.97	1.03	0.86	1.08	1.05	0.93	0.90
Kansas	3	0.94	1.01	1.08	0.96	1.02	0.88	1.08	1.05	0.95	0.92
Missouri	3	0.92	1.01	1.08	0.93	0.99	1.00	1.08	1.05	1.08	1.05
Nebraska	3	0.93	1.01	1.08	0.94	1.00	0.87	1.08	1.05	0.94	0.91
Oklahoma	3	1.07	1.01	1.08	1.08	1.15	1.02	1.08	1.05	1.10	1.07
Texas	3	1.09	1.01	1.08	1.11	1.18	0.98	1.08	1.05	1.06	1.03
New Mexico	4	1.17	1.45	1.56	1.69	1.83	1.03	1.18	1.24	1.22	1.28
Texas	4	1.09	1.45	1.56	1.58	1.71	0.98	1.18	1.24	1.16	1.22

Growth factor calculation summary: OGS Region 5 and 6 (Rocky Mtn/Dakotas and West Coast)

State historical data used

AEO2018 data used

Final beta growth factors

		OIL	OIL	OIL	OIL	OIL	NGAS	NGAS	NGAS	NGAS	NGAS
state	OGS Region	2016 to 2017 fac	2017 to 2023 fac	2017 to 2028 fac	2016 to 2023 fac	2016 to 2028 fac	2016 to 2017 fac	2017 to 2023 fac	2017 to 2028 fac	2016 to 2023 fac	2016 to 2028 fac
Arizona	5	1.63	1.15	1.29	1.87	2.10	1.19	1.09	1.07	1.30	1.27
Colorado	5	1.12	1.15	1.29	1.29	1.45	1.00	1.09	1.07	1.09	1.07
Idaho	5	0.42	1.15	1.29	0.49	0.55	0.82	1.09	1.07	0.89	0.87
Montana	5	0.89	1.15	1.29	1.03	1.15	0.94	1.09	1.07	1.03	1.01
Nevada	5	1.03	1.15	1.29	1.19	1.33	1.00	1.09	1.07	1.09	1.07
North Dakota	5	1.04	1.15	1.29	1.19	1.34	1.13	1.09	1.07	1.23	1.21
South Dakota	5	0.93	1.15	1.29	1.07	1.20	1.05	1.09	1.07	1.14	1.12
Utah	5	1.12	1.15	1.29	1.29	1.45	0.86	1.09	1.07	0.94	0.92
Wyoming	5	1.04	1.15	1.29	1.20	1.35	0.98	1.09	1.07	1.06	1.04
New Mexico	5	1.17	1.15	1.29	1.35	1.51	1.03	1.09	1.07	1.13	1.10
California	6	0.94	0.71	0.65	0.66	0.61	1.02	0.82	0.76	0.84	0.78
Oregon	6	#DIV/0!	0.71	0.65	#DIV/0!	#DIV/0!	0.82	0.82	0.76	0.68	0.63

2016 to 2017 Historical trends

- Based on EIA state historical data
- Crude Oil Production up about 6% from 2016 to 2017 in Lower 48 states
 - AEO forecast table had a 3.5% increase for this time period
- Natural Gas Production up about 3% from 2016 to 2017 in Lower 48 states
 - AEO forecast table had 0.5% increase for this time period

Coal Bed Methane and NG Liquids forecasts

- Coal Bed Methane production forecast to drop about 20% by 2023 and 25% by 2028 in national forecast outlook by AEO (in both reference and High O&G RT cases)
- Natural Gas Liquids production forecast to rise about 50-67% by 2023 and by 60-85% by 2028 in national forecast outlook by AEO (Ref case to HighO&G RT case ranges)

Estimating controls/ control efficiencies in beta platform

- Non-point
 - RICE NSPS (NO_x, CO) and Oil and Gas NSPS (VOC)
- Point
 - RICE NSPS, Oil and Gas NSPS
 - Natural Gas Boiler NSPS (NO_x) and Process Heaters NSPS (NO_x)
 - *MJO-State supplied information*
 - *Boiler MACT impacted a couple sources in NC*
 - *MANEVU Sulfur rules*

Estimating NSPS control efficiencies in beta platform

$$\text{Control_Efficiency}_{2023}(\%) = 100 * (1 - [(\text{Pf}_{2023}-1)*\text{Fn} + (1-\text{Ri})^{12} + (1-(1-\text{Ri})^{12})*\text{Fn}] / \text{Pf}_{2023})$$

$$Q_n = Q_o \{ [(1 + \text{Pf})^t - 1] \text{Fn} + (1 - \text{Ri})^t \text{Fe} + [1 - (1 - \text{Ri})^t] \text{Fn} \} \quad \textit{Equation 1}$$

where:

Q_n = emissions in projection year

Q_o = emissions in base year

Pf = growth rate expressed as ratio (e.g., 1.5=50% cumulative growth)

t = number of years between base and future years

Fn = emission factor ratio for new sources

Ri = retirement rate, expressed as whole number (e.g., 3.3%=0.033)

Fe = emission factor ratio for existing sources

The first term in Equation 1 represents new source growth and controls, the second term accounts for retirement and controls for existing sources, and the third term accounts for replacement source controls.

Top emitting states: Base, Growth and after Controls (Final): **point** source oil and gas NOX

state	poll	2016ff	2023ff growth only	2023ff final	2028ff growth only	2028ff final
Texas	NOX	53,444	63,801	56,536	66,586	56,279
Oklahoma	NOX	46,054	48,811	42,718	49,228	40,346
Louisiana	NOX	29,676	34,715	30,001	35,800	29,133
Colorado	NOX	24,568	28,411	23,568	29,653	22,523
Kansas	NOX	23,398	23,082	22,134	23,098	21,515
Mississippi	NOX	12,259	12,279	11,181	12,291	10,519
Ohio	NOX	11,413	11,744	10,674	11,981	10,242
Michigan	NOX	10,700	10,336	9,786	10,080	9,217
West Virginia	NOX	10,059	10,597	9,889	10,950	9,793
New Mexico	NOX	9,748	11,005	9,534	11,321	9,185
Wyoming	NOX	8,850	9,227	8,518	9,260	8,165

Top emitting states: Base, Growth and after Controls (Final): **point** source oil and gas VOC

state	poll	2016ff	2023ff growth only	2023ff final	2028ff growth only	2028ff final
Oklahoma	VOC	29,946	32,036	31,735	32,578	32,335
Colorado	VOC	23,943	27,188	27,086	27,859	27,745
Texas	VOC	23,382	29,065	28,588	30,493	29,900
Louisiana	VOC	11,098	14,462	14,218	15,178	14,882
Wyoming	VOC	8,262	9,015	8,973	9,446	9,392
California	VOC	3,680	2,776	2,650	2,612	2,496
New Mexico	VOC	3,018	3,432	3,372	3,529	3,455
Kansas	VOC	2,979	2,903	2,903	2,891	2,891
West Virginia	VOC	2,454	3,066	2,939	3,536	3,318
Ohio	VOC	1,691	2,261	2,175	2,671	2,522
Mississippi	VOC	1,450	1,485	1,484	1,498	1,494
Pennsylvania	VOC	1,408	1,499	1,361	1,581	1,350

Top emitting states: Base, Growth and after Controls (Final): non-point source oil and gas NOX

state	poll	2016ff	2023ff growth only	2023ff final	2028ff growth only	2028ff final
Texas	NOX	179,392	248,381	198,538	261,075	191,394
Oklahoma	NOX	56,046	64,205	58,021	64,638	56,651
Kansas	NOX	49,832	46,986	44,893	46,976	43,560
Colorado	NOX	36,645	27,563	26,465	27,156	25,620
New Mexico	NOX	33,143	39,007	32,206	38,958	30,056
West Virginia	NOX	29,249	50,587	32,522	65,862	34,315
Louisiana	NOX	28,442	44,319	28,912	47,713	27,706
Illinois	NOX	23,478	22,758	22,657	22,745	22,571
Pennsylvania	NOX	22,441	17,219	11,787	22,402	12,676
Wyoming	NOX	16,882	19,425	18,386	20,699	19,276
Kentucky	NOX	15,903	15,354	14,381	15,353	13,637
North Dakota	NOX	14,572	23,647	21,091	24,982	21,503

Top emitting states: Base, Growth and after Controls (Final): non-point source oil and gas VOC

state	poll	2016ff	2023ff growth only	2023ff final	2028ff growth only	2028ff final
Texas	VOC	1,136,375	1,623,924	1,285,519	1,729,967	1,323,051
North Dakota	VOC	450,336	544,771	490,384	608,964	531,787
New Mexico	VOC	180,794	266,422	207,470	280,548	212,122
Oklahoma	VOC	179,035	199,977	188,672	203,752	190,413
Pennsylvania	VOC	145,977	212,405	180,190	277,733	231,913
Illinois	VOC	117,342	114,995	114,188	114,979	114,172
West Virginia	VOC	108,456	190,663	137,441	249,114	162,859
Kansas	VOC	89,595	89,417	86,671	92,032	89,286
Colorado	VOC	83,334	101,716	88,025	100,294	80,602
Utah	VOC	78,696	94,615	82,427	103,122	91,518
Wyoming	VOC	72,803	81,979	77,294	84,860	77,937
Louisiana	VOC	57,592	78,582	66,448	82,480	65,853