アメリカの温暖化・環境政策最前線
ー石炭火力とクリーン電力の展望ー

CASA Seminar

July 10, 2014

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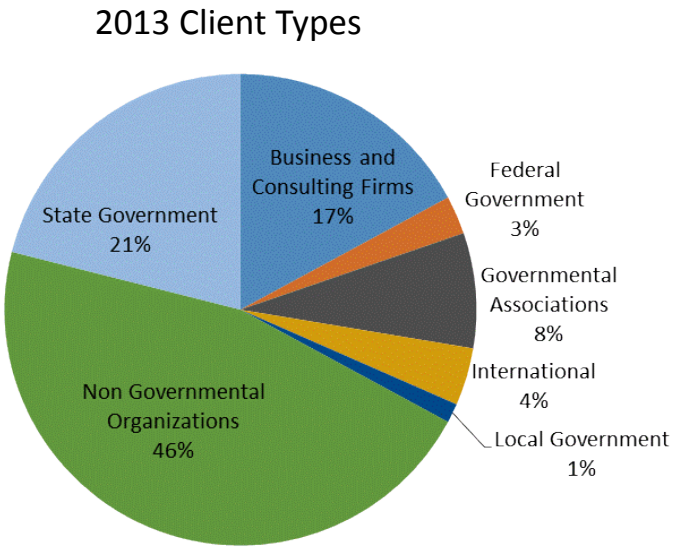
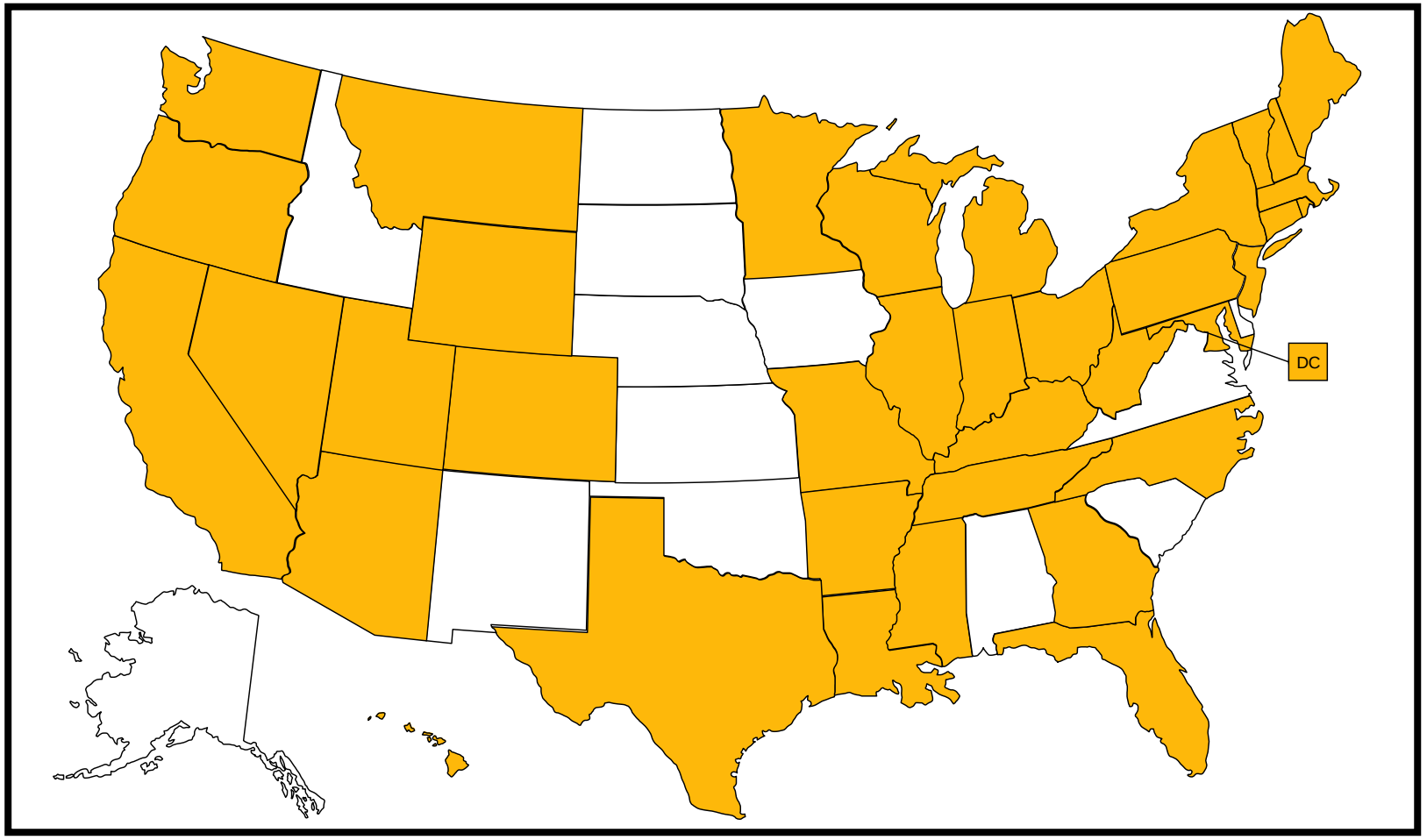
Synapse Energy Economics

- Founded in 1996 by CEO Bruce Biewald
- Leader for public interest and government clients in providing rigorous analysis of the electric power sector
- Staff of 30 includes experts in energy and environmental economics and environmental compliance



In 2013, we did work in 37 states and D.C.



In support of this work, Synapse staff took 190+ trips in 2013, traveling to 30 states, D.C., Nova Scotia, Ontario, Portugal, China, Slovenia, Germany, and Belgium.

Synapse Recent Accomplishments

- **Assessment of PacifiCorp Oregon General Rate Case (2013)**
  - *Impact:* The Commission imposed a 10 percent disallowance on imprudently incurred retrofit costs ($17 million) and required a refund to ratepayers in early 2013.
- **Energy Efficiency in Nova Scotia (2012)**
  - *Impact:* The settlement agreement between the parties accepts in its entirety Synapse recommendations regarding how to consider rate and bill impacts associated with energy efficiency programs. The Commission Order refers to Mr. Woolf's testimony, specifically.
- **Kentucky Power Application for Environmental Control Retrofit of Big Sandy 2 (2012)**
  - *Impact:* Kentucky Power withdraws its request to retrofit 800 MW coal unit.
- **Need for Proposed Potomac-Appalachian Transmission Highline (PATH) (2010)**
  - *Impact:* Proponents of the PATH transmission line withdraw application

アメリカの民主的、参加型電力事業規制制度

アメリカ電力規制の基礎

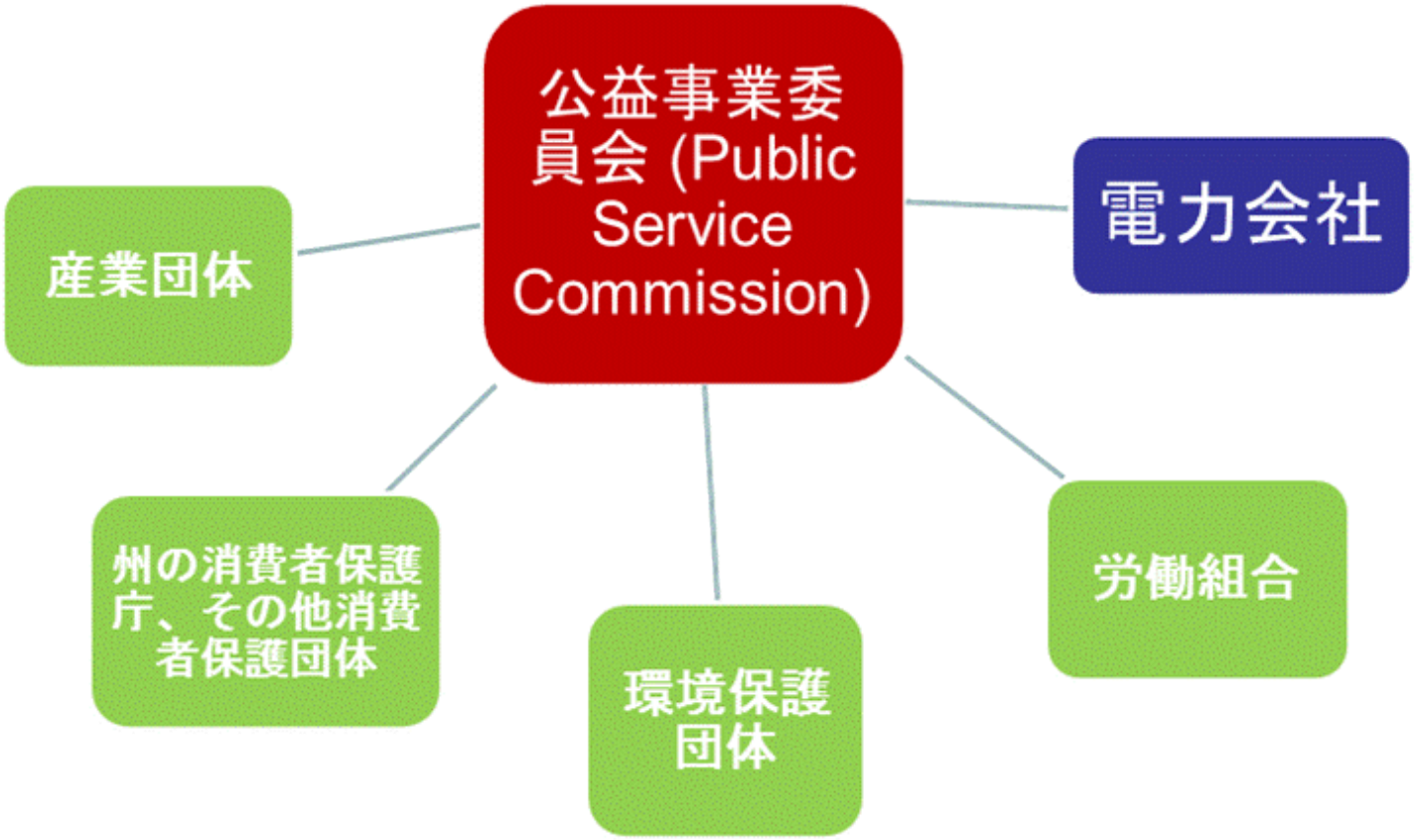
- Regulatory Compact（規制契約）
  - 地域独占の見返りに公共サービス提供の義務を負っている
- 規制の目的：
  1. 公共の利益を守ること
  2. 十分な電力サービスの安定供給をアフォーダブルで、公平かつ妥当な(just and reasonable)料金で提供させることを目指す
  3. ユニバーサルサービスの提供

「民主的」電力規制：参加型規制制度

- アメリカの民主的電力規制の重要な二つの方程式：
  - Complete open public access to information (誰でも情報を入手できるような環境がととのっている)
  - Full public participation in setting prices and standards of service （料金設定やサービス基準の設定において、完全な市民参加が認められている）

Source: Palast G., J. Oppenheim, and T. Macgregor. *Democracy and Regulation: How the Public can Govern Essential Services*. (Feb 1, 2003)

「民主的」電力規制：参加型規制制度



「民主的」電力規制：公益事業委員会の役割

- Rate Case（電力料金設定、改定）
- 電力資源調達ケース
  - Integrated Resource Planning（資源統合計画）
  - Prudence review (プルーデンス・レビュー）
  - CPCN (Certificate of public convenience and necessity)（公共サービス事業許可書）
  - RPS、グリーン電力プログラム
  - Energy efficiency (エネルギー効率化・省エネ対策）プログラム
- 電力会社合併
- サービス・クオリティ基準設定など

民主的電力規制の事例

- ヒューストン・パワー＆ライト会社
  - 解雇にともなう給与費用削減分着服の疑い
  - 二人の電力会社の社員が規制手続きを申請・要求
  - 会計情報をすべて入手、調査。結果、電力料金を値下げに成功（150億ドルを消費者に還元）
- シーブルック原子力発電所
  - 建設費用超過
  - 不可解なメンテナンスのスケジュール
  - “Operational planning and long-term capability planning are flawed, and that continued reliance on the process as currently designed could lead to unreliable service”(“Democracy and Regulation” page 60)
  - 料金値上げ申請却下される
- 2011年、LG&EとKUの排出量抑制技術設置のコスト回収要請ケース（ケンタッキー州）

民事訴訟に似た電力規制手続きの流れ

1. 公益事業委員会、電力会社その他のステークホルダーによる電力規制手続き（Regulatory Proceeding) 公開要請
2. 公益事業委員会が手続きを開始、公表、ステークホルダーに介入の要請
3. 電力会社が膨大な書類（証言書など）・データなどを提出
4. ステークホルダーによる書類・データのレビュー
5. Discovery Question/Information Request(情報要求プロセス）とそれへ電力会社による返答
6. ステークホルダーによる証言書（Testimony)提出, Rebuttal testimony
7. 公益事業委員会での公聴会で証言・質疑応答
8. 交渉・和解契約、和解決裂
9. 公益事業委員会の委員による意思決定

アメリカの環境規制と石炭火力発電

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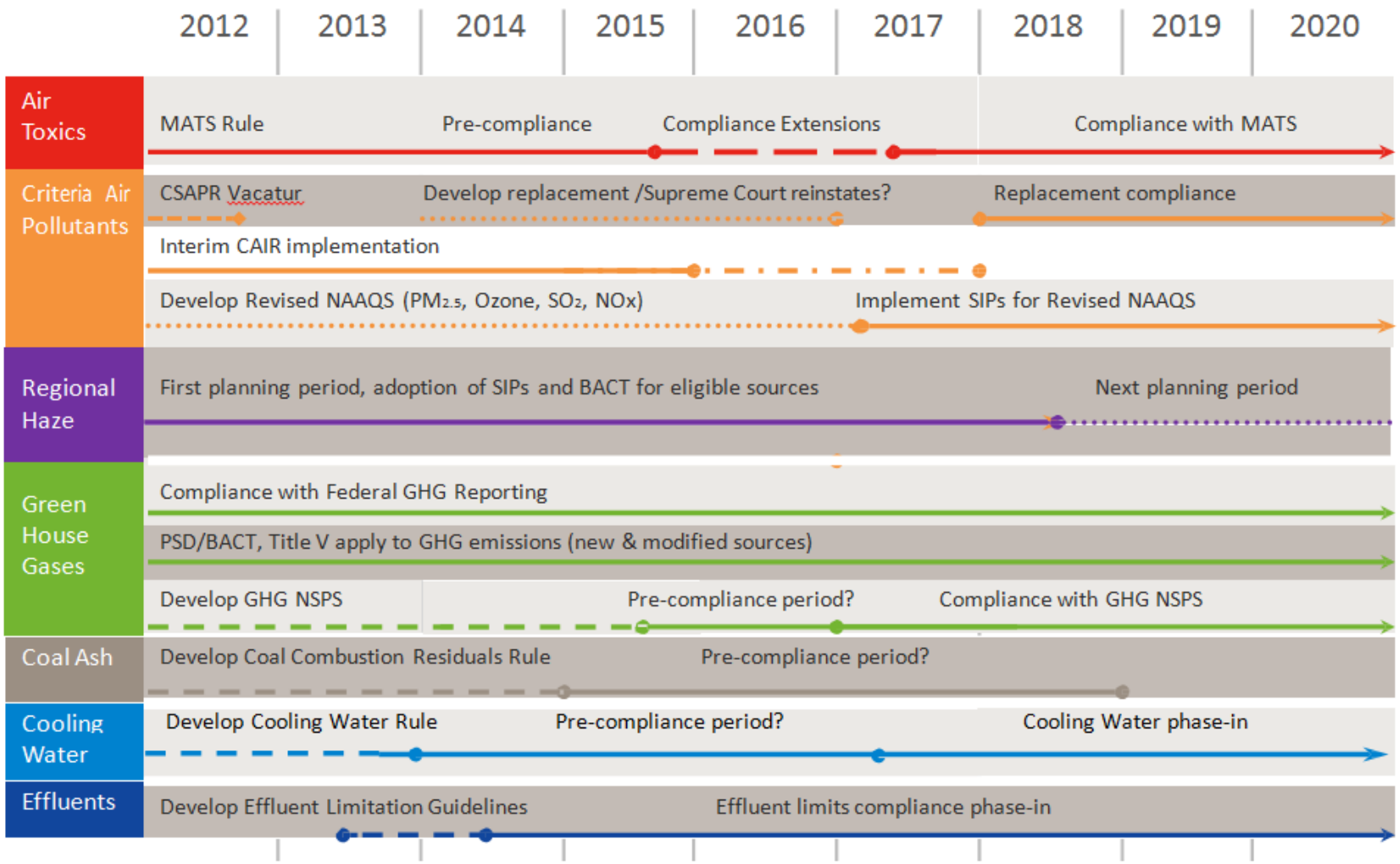
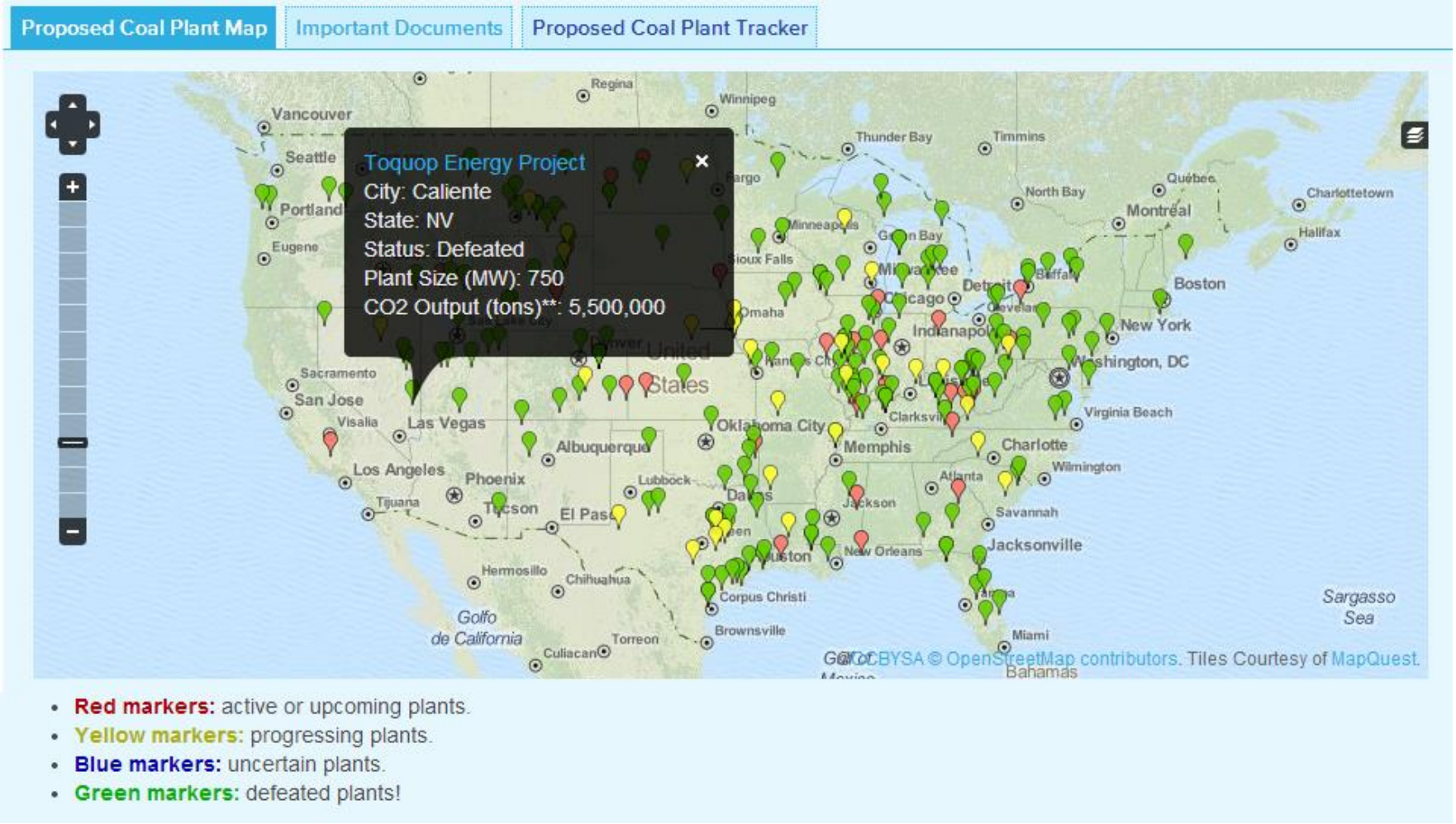
- Beyond Coalキャンペーン - シエラクラブの石炭火力廃炉戦略
- 石炭火力発電の経済性
- Synapse CAVT (Coal Asset Valuation Tool) - 石炭火力発電の経済性予測モデル
- TVA（テネシー川流域開発公社）ケーススタディー

アメリカ環境規制の概要



Source: Adapted by Synapse from ISO-NE presentation to Environmental Advisory Group, July 19, 2013.

石炭火力新規発電所計画の状況

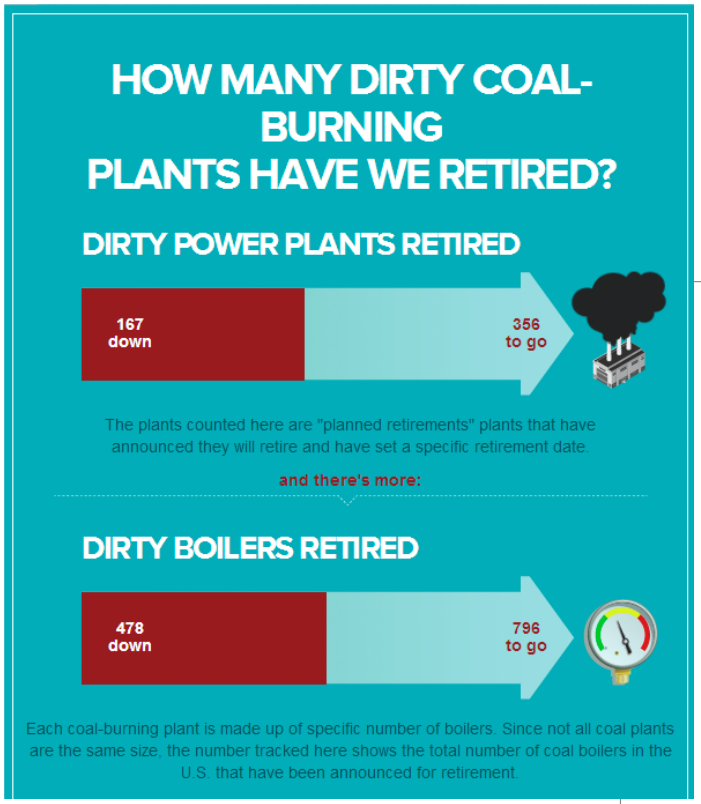


Source: Sierra Club, “Proposed Coal Plant Map”, available at http://content.sierraclub.org/coal/environmentallaw/plant-map

Beyond Coalキャンペーン

Source: Sierra Club, “Toxic Mercury Pollution Map”, available at http://vault.sierraclub.org/coal/map/

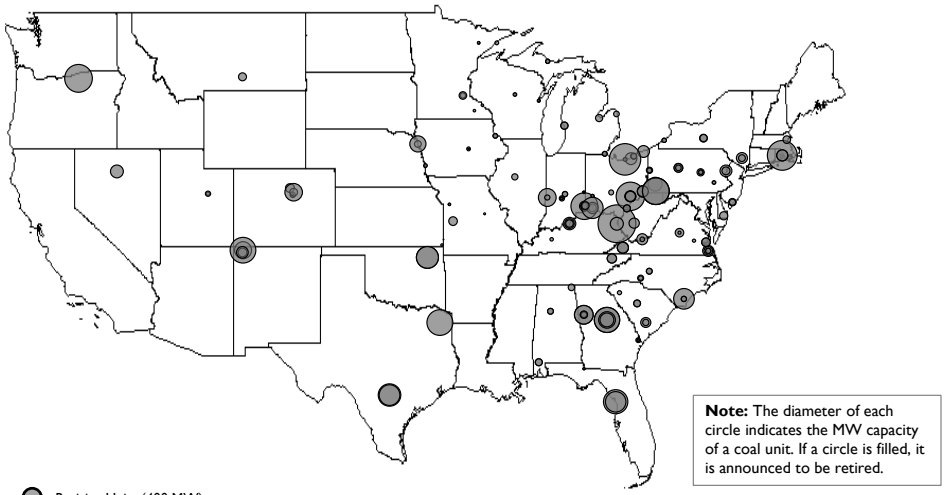
廃炉予定の火力発電所とその要因



Source: Sierra Club, “Success Stories”, available at http://content.sierraclub.org/coal/successes

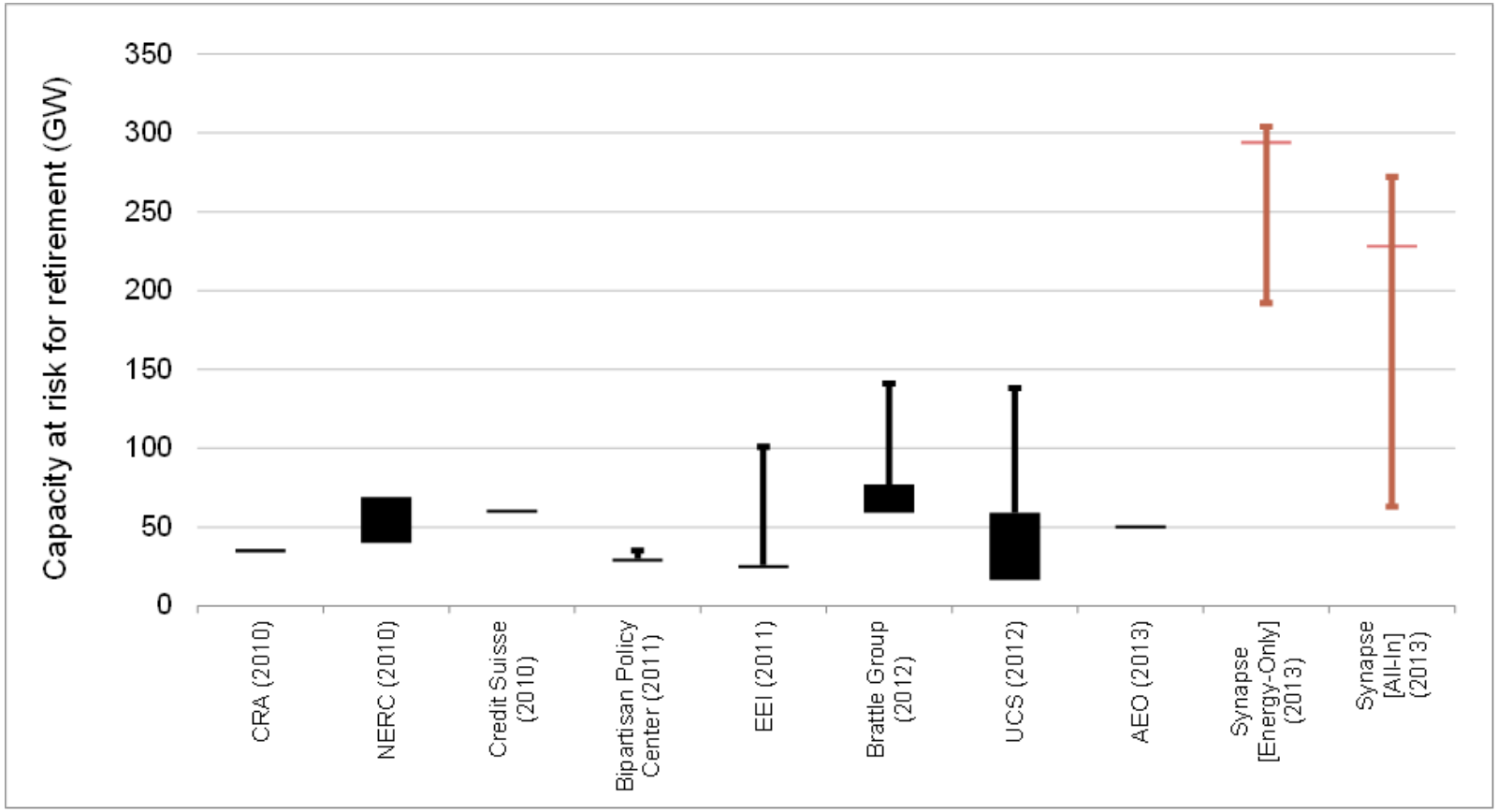
火力発電廃炉の3つの要因

- 天然ガス価格、市場電力価格下落
- 環境規制の強化
- 電力規制への市民参加活動



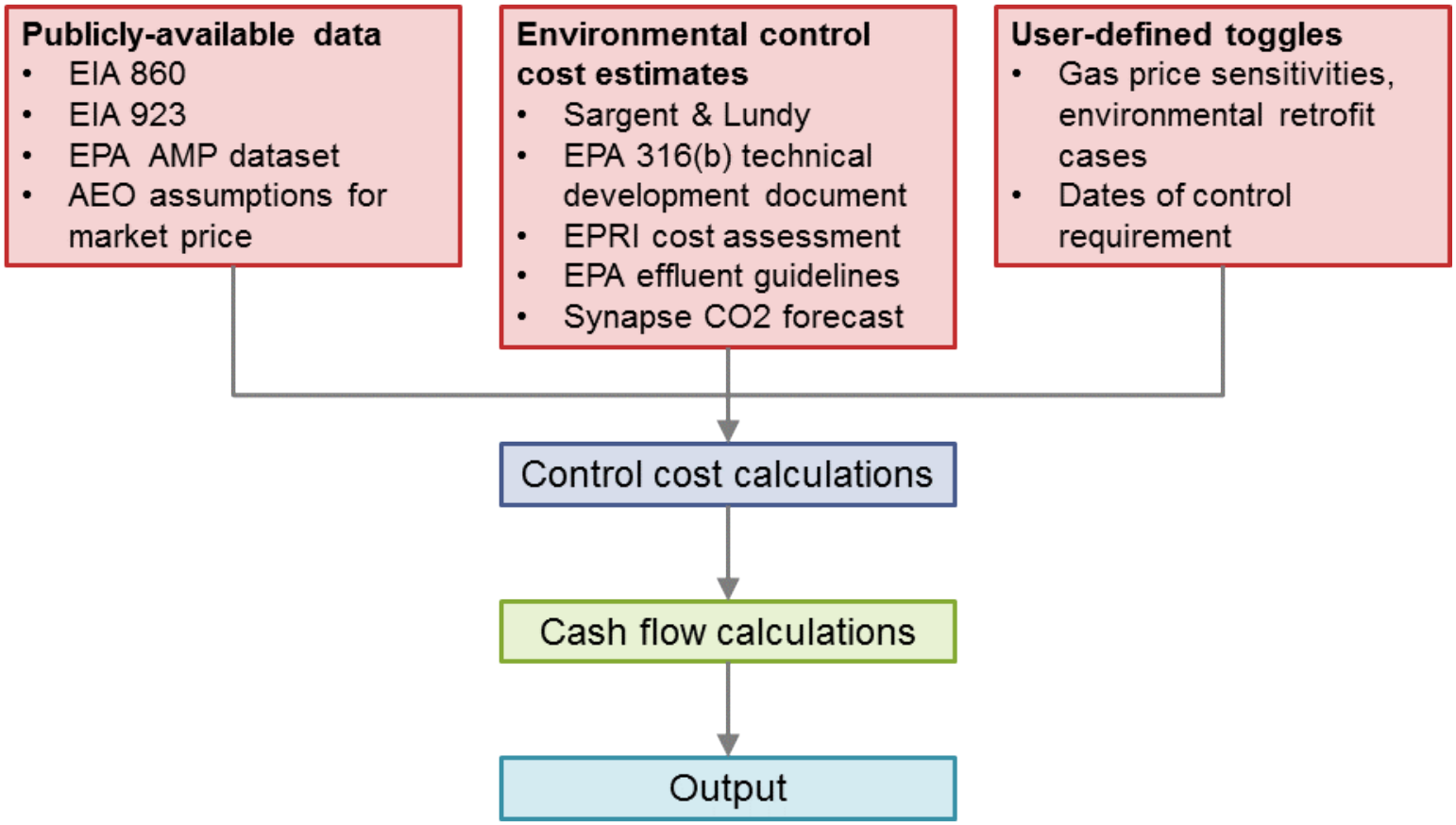
Source: Synapse Energy Economics (October 2013). “Coal Asset Valuation Tool (CAVT)”

石炭火力発電の経済性研究結果



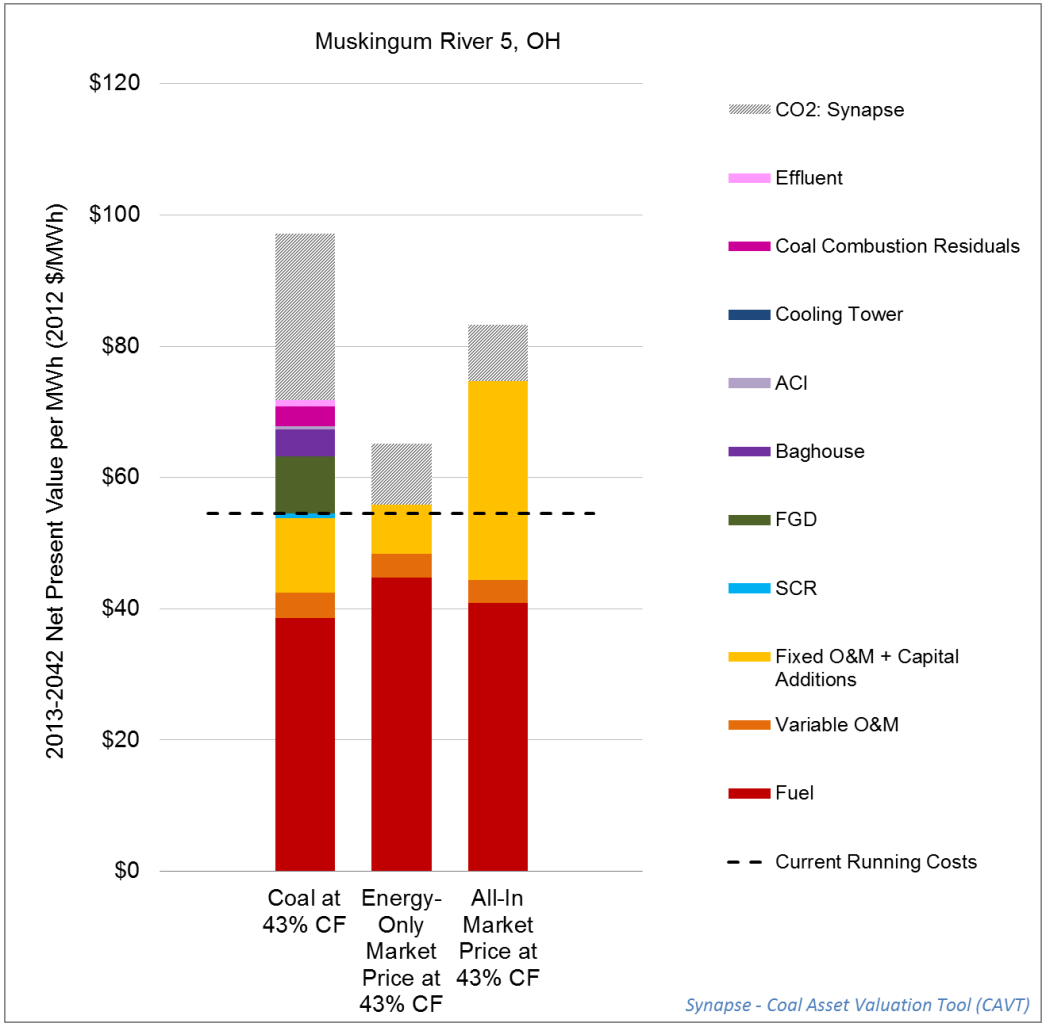
Source: Synapse Energy Economics. (October 2013). *Forecasting Coal Unit Competitiveness Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Available at http://www.synapse-energy.com/Downloads/SynapseReport.2013-10.EF.CAVT-Report.13-020A.pdf

Coal Asset Valuation Tool (CAVT) – 石炭火力発電の経済性予測モデル

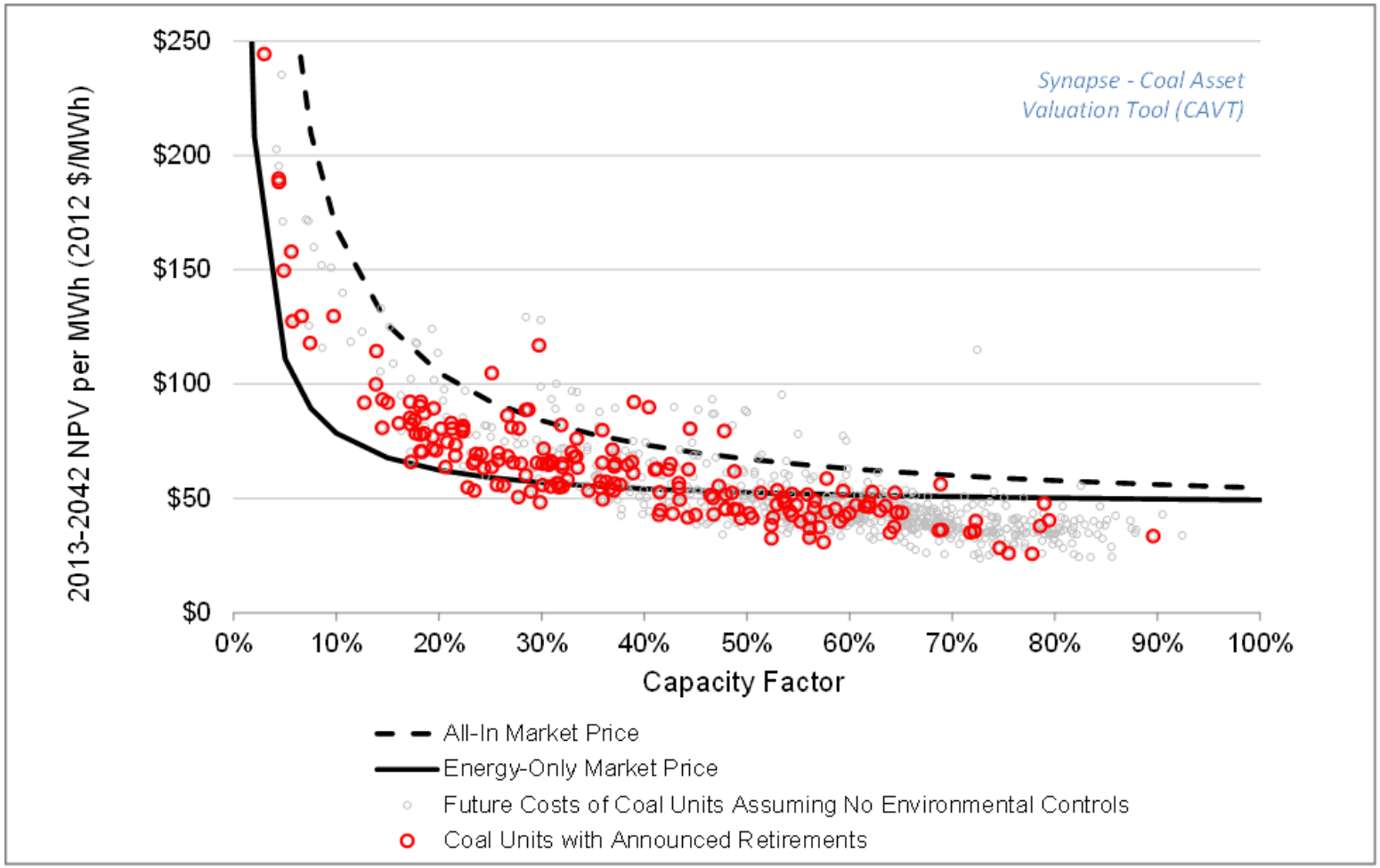


Note: 詳しくは以下のレポートを参照：Synapse Energy Economics. (October 2013). *Forecasting Coal Unit Competitiveness Coal Retirement Assessment Using Synapse's Coal Asset Valuation Tool (CAVT).* Available at http://www.synapse-energy.com/Downloads/SynapseReport.2013-10.EF.CAVT-Report.13-020A.pdf

Muskingum River 5:
A Case Study in Uneconomic Coal

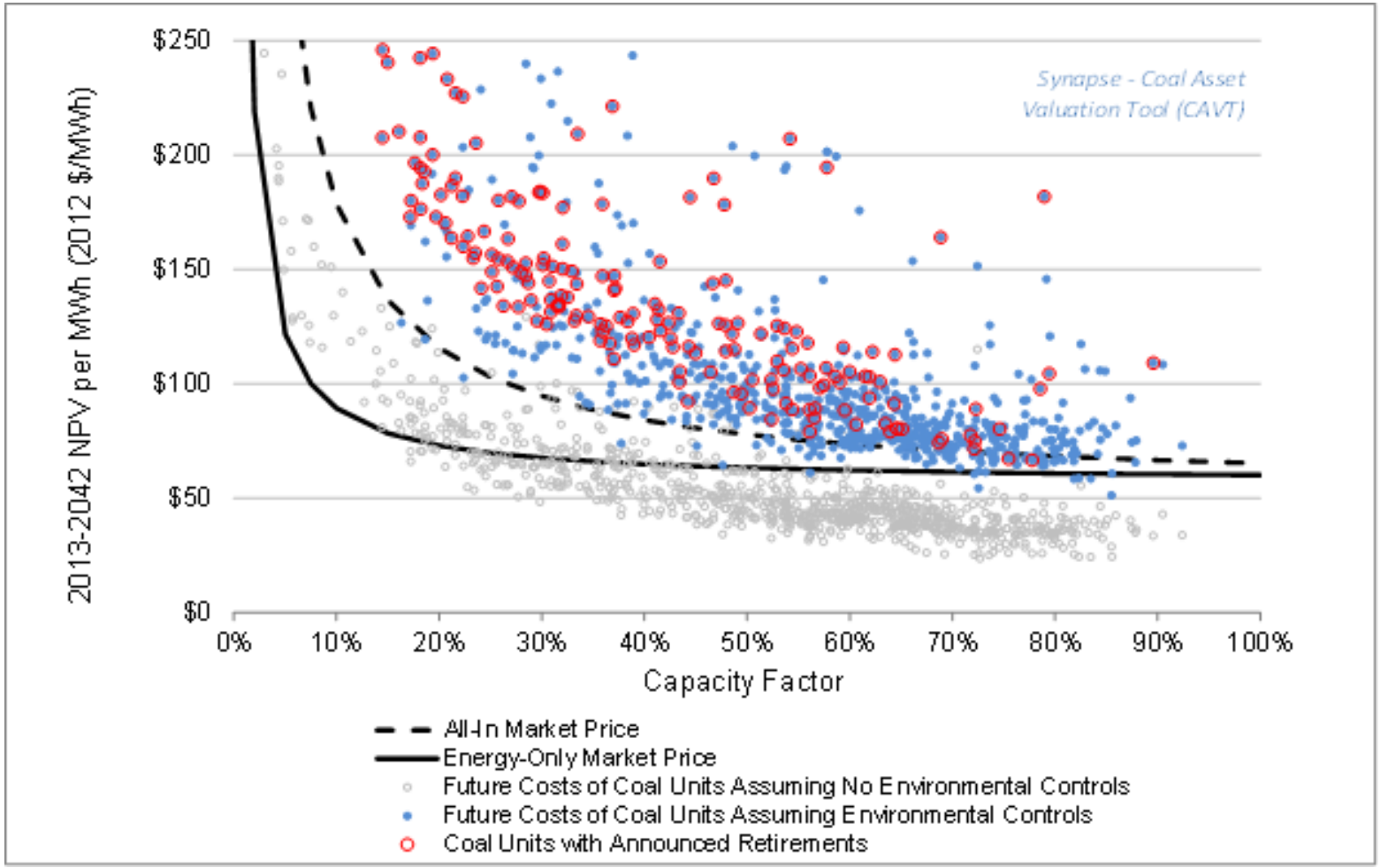


火力発電の経済性 – 環境対策改修工事なし



Many units currently announced for retirement are more economic than market price, if we assume no change in environmental controls.

火力発電の経済性 – 環境対策改修工事あり



Many units currently announced for retirement are more economic than market price, if we assume no change in environmental controls.

モデル試算結果: Mid-cases and sensitivities

Uneconomic Coal Capacity Compared to Energy-Only Purchases (GW)

Natural Gas Price	Environmental Retrofit: Lenient	Mid	Strict
High	192 (62%)		292 (94%)
Mid		295 (95%)	
Low	254 (82%)		306 (98%)

Uneconomic Coal Capacity Compared to All-In Purchases (GW)

Natural Gas Price	Environmental Retrofit: Lenient	Mid	Strict
High	63 (20%)		230 (74%)
Mid		228 (73%)	
Low	101 (33%)		274 (88%)

TVA・環境規制コスト試算

Plant / Unit	State	FGD (Million $)	SCR (Million $)	Baghouse (Million $)	ACI (Million $)	Wet Cooling Tower (Million $)	Coal Combustion Residuals (Million $)	Effluent Treatment (Million $)	Total Capital (Million $)
Gallatin 1	TN	$177	$67	$44	$3	$30	$58	$55	$434
Gallatin 2	TN	$177	$67	$44	$3	$30	$58	$55	$434
Gallatin 3	TN	$181	$71	$45	$3	$35	$59	$60	$465
Gallatin 4	TN	$180	$70	$45	$3	$34	$59	$60	$464
Allen Steam 1	TN	$190	$73	$48	$3	$32	$63	$76	$413
Allen Steam 2	TN	$190	$73	$48	$3	$30	$63	$76	$411
Allen Steam 3	TN	$189	$73	$48	$3	$28	$63	$76	$410
Colbert 1	AL	$132	$47	$35	$3	$18	$53	$36	$324
Colbert 2	AL	$132	$47	$35	$3	$16	$53	$36	$321
Colbert 3	AL	$132	$47	$35	$3	$14	$53	$36	$320
Colbert 4	AL	$132	$47	$35	$3	$17	$53	$36	$323
Colbert 5	AL	$273		$79	$4	$36	$68	$100	$560
Shawnee 1	KY	$122	$44		$4	$15	$50	$28	$263
Shawnee 2	KY	$122	$44		$4	$16	$50	$28	$264
Shawnee 3	KY	$122	$44		$4	$17	$50	$28	$264
Shawnee 4	KY	$122	$44		$4	$15	$50	$28	$263
Shawnee 5	KY	$122	$44		$4	$17	$50	$28	$265
Shawnee 6	KY	$122	$44		$4	$16	$50	$28	$264
Shawnee 7	KY	$122	$44		$4	$16	$50	$28	$264
Shawnee 8	KY	$122	$44		$4	$15	$50	$28	$263
Shawnee 9	KY	$122	$44		$4	$16	$50	$28	$264
Widows Creek 7	AL			$86	$4	$44	$62	$92	$288
Widows Creek 8	AL			$94	$4	$44	$61	$87	$291
Paradise 1	KY			$97	$4		$62	$88	$251
Paradise 2	KY			$97	$4		$62	$88	$251
Paradise 3	KY			$135	$4		$72	$103	$314
Bull Run 1	TN			$112	$4	$69	$101	$246	$532
Cumberland 1	TN			$161	$4	$145	$75	$176	$563
Cumberland 2	TN			$162	$4	$135	$75	$176	$553
John Sevier 3	TN	$131	$47	$35	$3	$19	$58	$62	$355
Kingston 1	TN			$31	$3	$9	$50	$29	$123
Kingston 2	TN			$31	$3	$7	$50	$29	$121
Kingston 3	TN			$31	$3	$9	$50	$29	$123
Kingston 4	TN			$31	$3	$8	$50	$29	$122
Kingston 5	TN			$35	$3	$11	$51	$33	$133
Kingston 6	TN			$35	$3	$13	$51	$33	$135
Kingston 7	TN			$35	$3	$11	$51	$33	$134
Kingston 8	TN			$35	$3	$12	$51	$33	$134
Kingston 9	TN			$35	$3	$13	$51	$33	$136
								Total	$11,810

$1.2 billion
(TVA announces $1.1 b)

$725 million
(TVA announces $650 m)

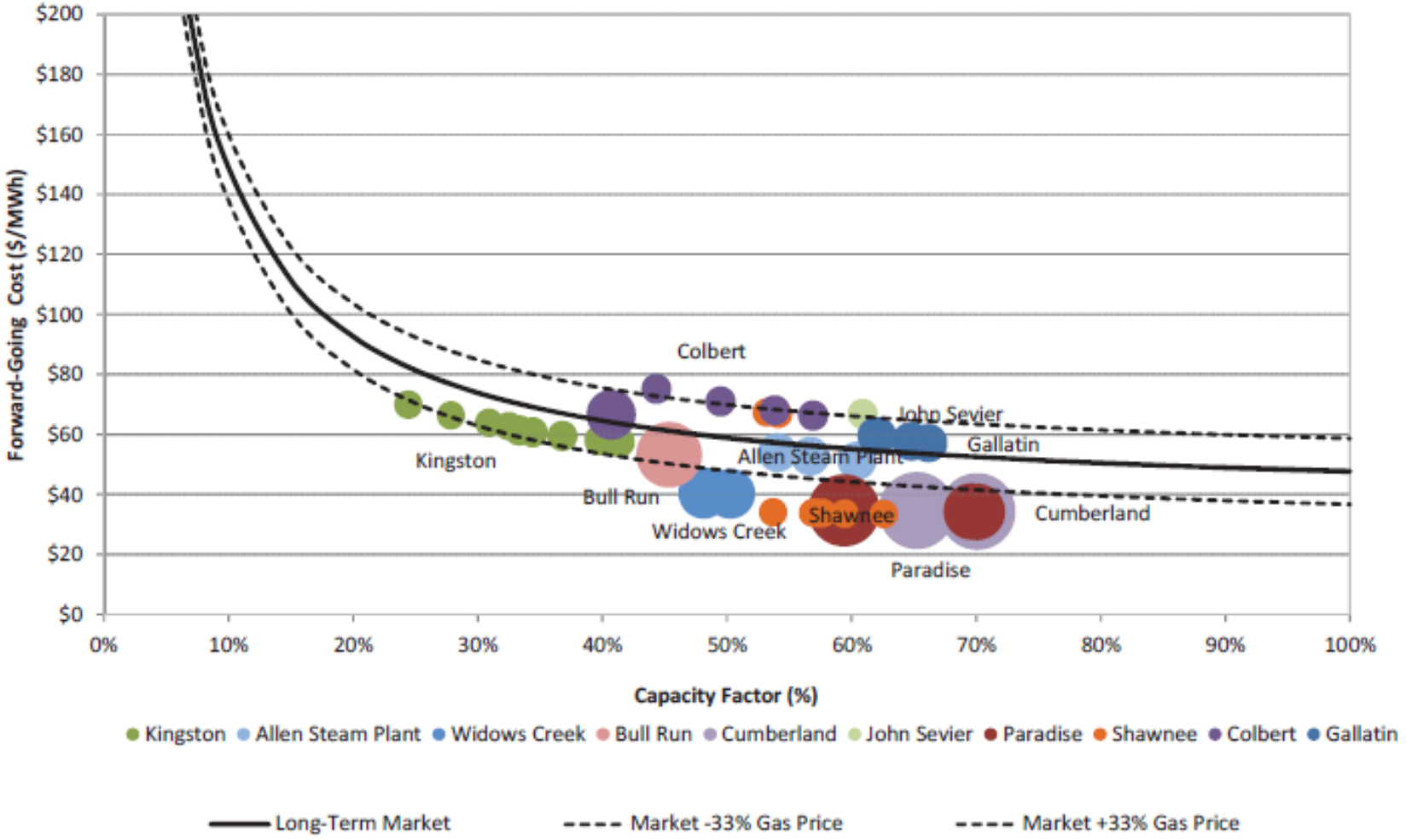
Consent Decree

- $3.9 Billion

CO2以外で予想されるすべてのEPA規制

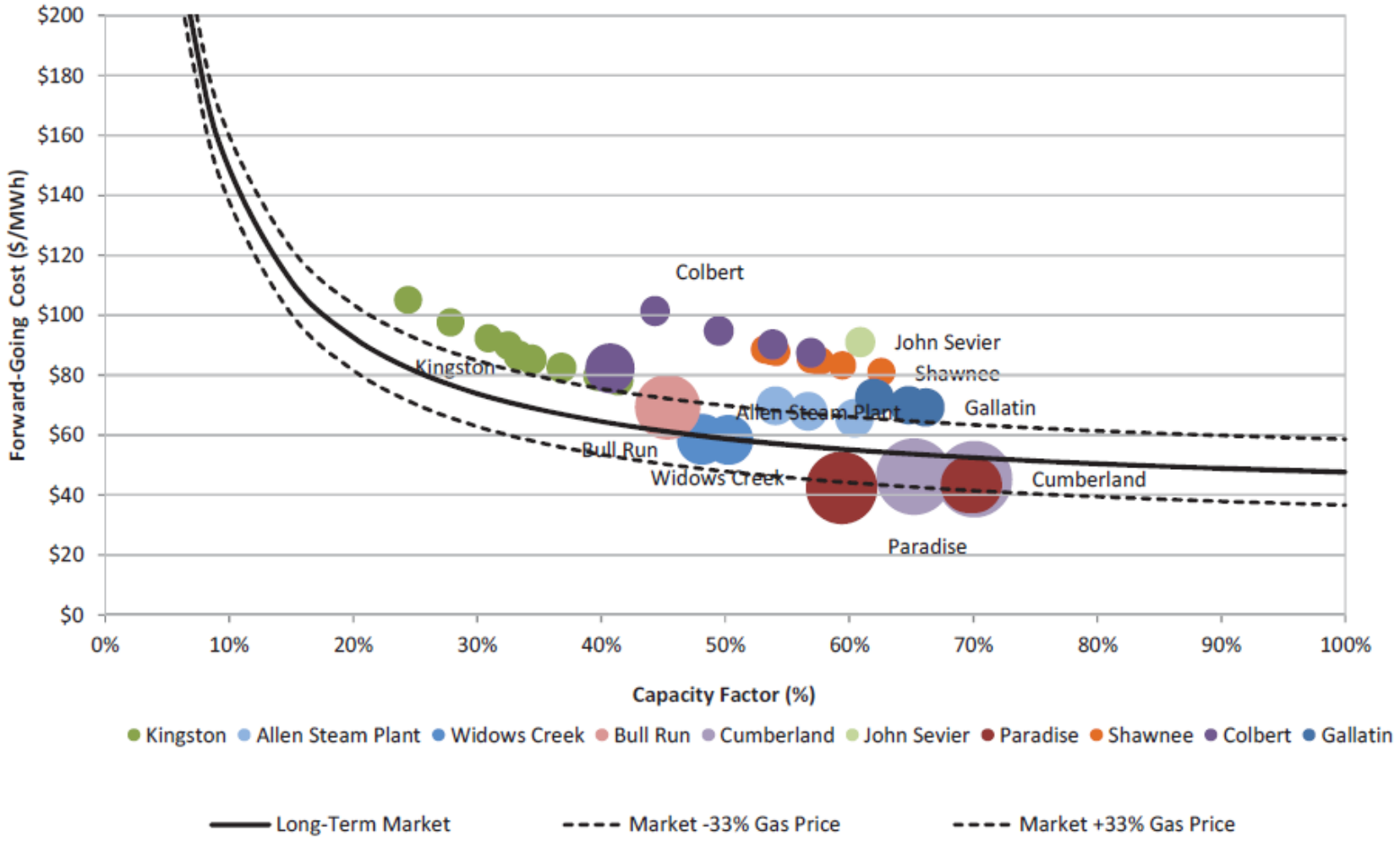
- $11.8 billion (Capital)
- $24.6 billion (Capital & O&M)

Consent Decree Only: Forward-Going Costs of Existing TVA Coal Units relative to Long-Term Market Costs



Source: Synapse Energy Economics. (2012). *TVA Coal in Crisis - Using Energy Efficiency to Replace TVA's Highly Non-Economic Coal Units,* available at http://www.synapse-energy.com/Downloads/SynapseReport.2012-08.SC.TVA-Coal-in-Crisis.12-041.pdf

All Environmental Regs + $0 CO2 price – 47% of the fleet is uneconomic



米国初、電力業界CO_2規制 Clean Power Plan ― 概要

Clean Power Plan クリーンパワー計画とは？

- 全国の既存発電所からCO_2排出量を削減する連邦初CO_2排出量規制制度。Clean Power Plan もしくは the Clean Air Act (CAA)の111(d)条項。
- 2014年6月2日にアメリカ環境保省がドラフト規制案を公表、10月までコメント受付、2015年6月に最終規制制度設定。
- 州実施計画提出期限は2016年から2017年まで。他州との合同計画は2018年まで
- 各州に2030年までのCO2排出率(lbs./MWh)を設定。どのようにそれを達成するかは州次第。州の事情と政策目標などに応じた柔軟な計画を認めている。
- EPAによる政策効果試算
  - 全国で（2005年比で）CO_2を30%トカット（約7.3億トンのCO2）
  - スモッグ、ばい煙などを25%カット
  - エネルギー効率化を促進し、電力料金約を平均8%カット
  - 2030年までには約500億から850億ドルに値する温暖化抑制や健康に関する社会的利益創出（2700から6600人の未熟児死亡者を回避、14万から15万人の喘息患者を削減を含む）

111(d) Timeline

1970	**Clean Air Act (CAA) enacted** by President Nixon in the face of growing national concern over air pollution, which culminated in the 1970 Earth Day protests
1990	**CAA amendments** put in place by President Bush, Sr.
2007	**Massachusetts v. EPA ruling by U.S. Supreme Court** determines that greenhouse gases are air pollutants
Dec 2009	**EPA endangerment finding** declares that current and projected concentrations of six key GHGs—including CO_2—threaten the public health and welfare of current and future generations
Jan 2011	**EPA's first regulation of GHGs** requires air permitting only for high-emitting new or modified facilities that would otherwise have to go through air permitting for non-GHG pollutants
Apr 2012	**Proposed New Source Performance Standard (NSPS) for CO_2** under Section 111(b) of the CAA requires CO_2 performance standards for new fossil fuel-fired power plants
June 2013	**Obama directs US EPA to use its authority under the CAA and issue standards, regulations or guidelines to reduce harmful carbon pollution**.
Jan 2014	**Initial 111(b) proposal withdrawn and new CO_2 NSPS for fossil fuel-fired power plants issued**
Jun 2014	**Proposed 111(d) Rule issued for CO_2 from existing fossil fuel-fired power plants**

EPAによるClean Power Planの社会・経済的利益見積もり

	Benefits	less	Costs	equals	Net Benefits
Electric Sector [for EE program participants and non-participants]	**$34** [benefits net of costs in IPM modeling]		**$21** [EE program administrator costs]		**$13** *0.3 cents/kWh reduction*
Energy Efficiency Program Participants	not monetized		**$21**		**($21)**
Societal	**$10-$94** [climate] **$24-$66** [health]		**$0**		**$10-$94** [climate] *$1-$10 per capita* **$24-$66** [health] *$69-$189 per capita*
Total	**$68-$194**		**$42**		**$26-$152**

111(d) Requirements

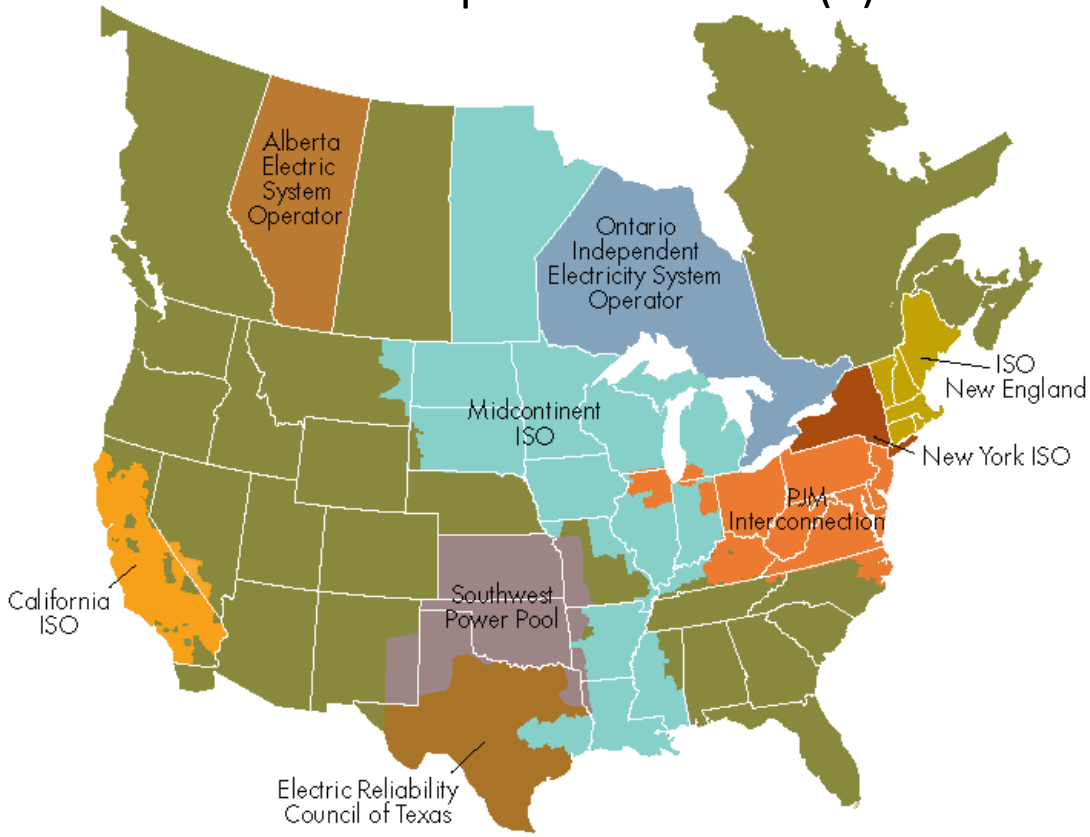
- Section 111(d) of the CAA requires EPA to develop a procedure for states to establish "standards of performance" for affected existing sources.
- 排出量削減のベストシステム：Performance standards must reflect the degree of emission limitation achievable through the application of the “best system of emission reduction” (BSER) that has been adequately demonstrated.
- ベストシステムの決定に次の要因を考慮にいれなければいけない
  - コスト：Cost of achieving the reductions and technical feasibility
  - 健康と環境影響：Non-air-quality health and environmental impacts
  - エネルギー消費：Energy requirements
- 排出量削減義務を負う発電所以外のシステム・対策も認めている：The “system” defined by US EPA includes measures “outside the fenceline” of individual generating units.

Clean Power Plan の柔軟性

- 柔軟性１：EPAは各州に応じた量の4つの対策“Building Block”を勘案し、州のターゲットを設定した。しかし、各州はその4つの対策に従うことなく、柔軟に州の事情に応じて計画を策定できる。
  - 対策例：DSM、RPS、発電所熱効率向上、燃料転換、新規天然ガス発電、Co-firing、原子力発電、化石燃料発電所の廃炉、トレーディングプログラム
- 柔軟性２：他の州と共同で実施計画を策定してもよい
- 柔軟性３：排出率義務値を総排出量に換算して州の目標を設定してよい
- 各州はこれらを駆使してLeast Cost Plan（最小費用計画）を策定するべき

Multi-State Implementation Plans

- A logical grouping currently exists based on ISOs/RTOs
- In wholesale market areas, plants would be dispatched on a least-cost basis, taking into account the costs of compliance with 111(d)



米国初、電力業界CO_2規制 Clean Power Plan
―　州の目標設定

Clean Power Plan State Emission Rate

- Adjusted output-weighted-average emission rate in lbs of CO_2 per MWh
- The "currency" for both targets and compliance
- The same formula for initial year (2012), targets (2020-2030), and compliance measurement (2020-2030)

111(d) Emission Rate =

Fossil Fuel Emissions (lbs of CO_2)
Coal, natural gas CC and CT, oil, and IGCC, and useful thermal from co-generation from generators that existed in 2012 and use of NGCC's under construction in 2012+ above a 55% CF

Fossil Fuel Generation (MWh)
Coal, natural gas CC and CT, oil, and IGCC, and useful thermal from co-generation from generators that existed in 2012 and use of NGCC's under construction in 2012 above a 55% CF

+

Nuclear Generation (MWh)
From 2020, 5.8% of use of 2012 existing nuclear; Use of under construction in 2012+ nuclear

Renewable Generation (MWh)
Excludes hydro existing in 2012

Energy Efficiency (MWh)
Cumulative from 2017 with sunsetting; In 2012, this value is 0 MWh

The Clean Power Plan "Building Blocks" for "Setting State Emission Rates"

BB 1: Reduce Average Coal Emission Rate by 6%

BB 2a: Redispatch to Existing NG (up to an average of 70%, coal and oil capacity permitting)

BB 2b: Redispatch to Under-Construction NG (from 55% to 70%: only 15% difference counts)

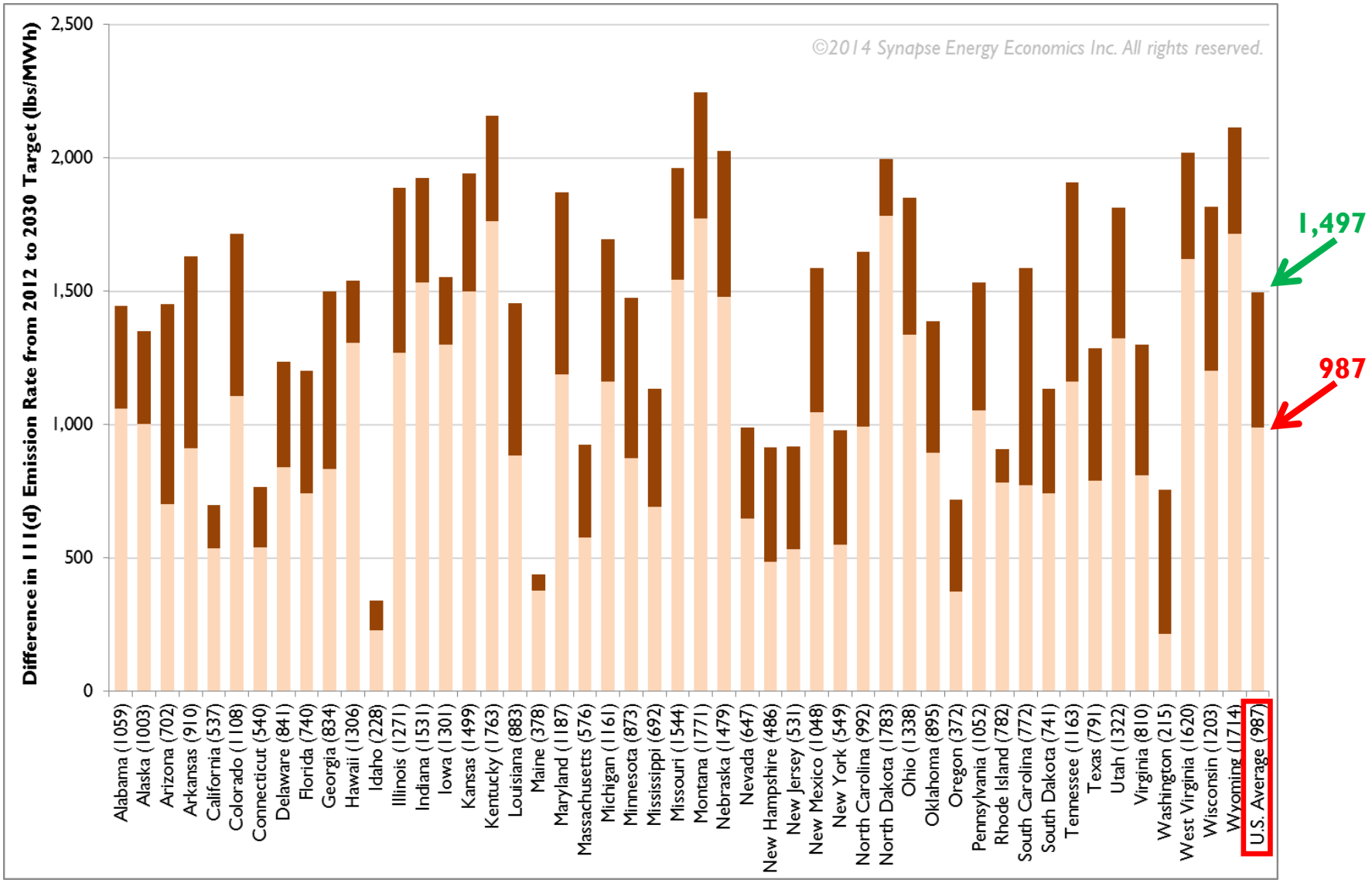
BB 3a-i: Credit for Existing "At-Risk" Nuclear (5.8% of 2012 nuclear fleet)

BB 3a-ii: Credit for Nuclear Under Construction in 2012

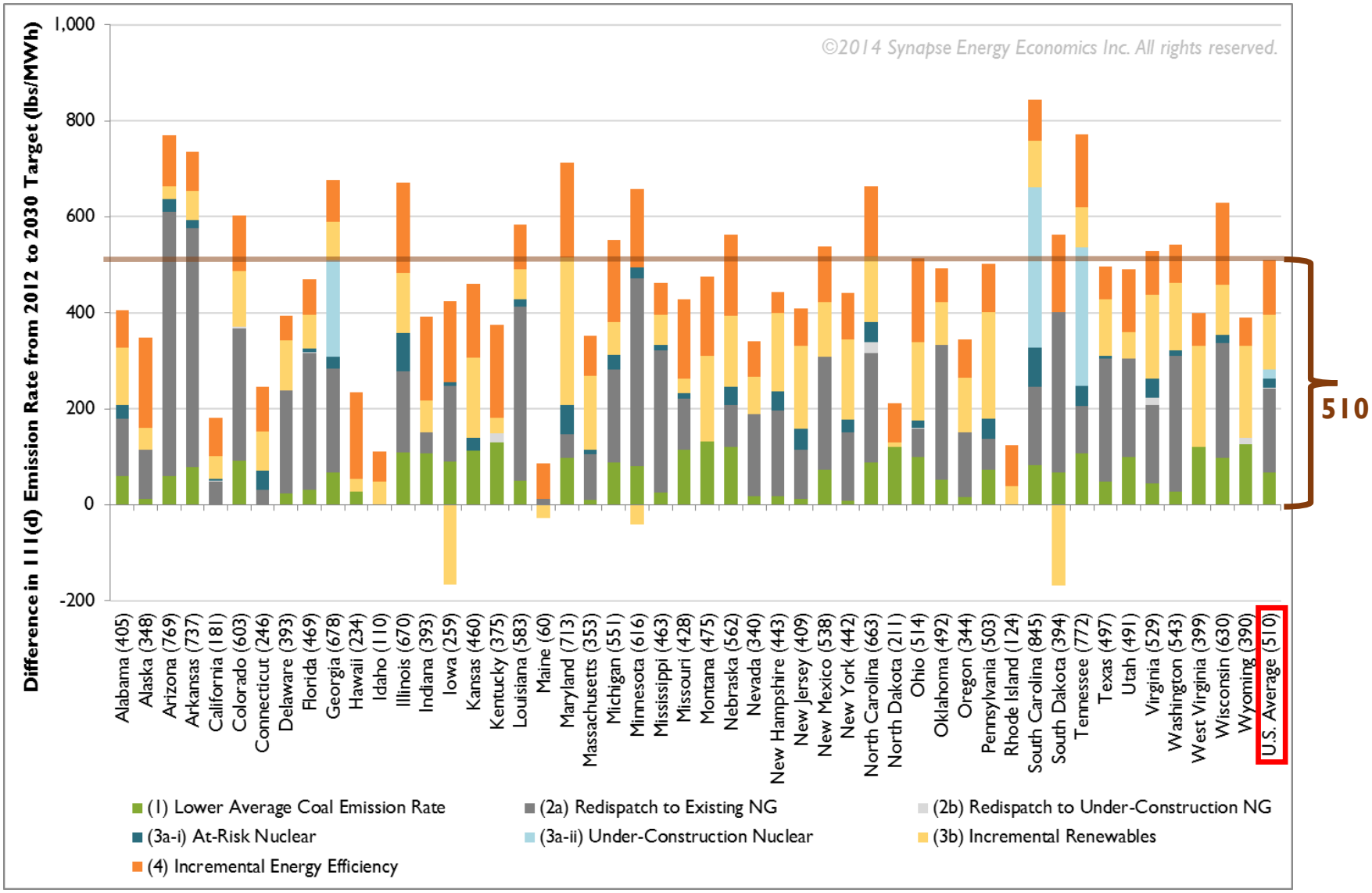
BB 3b: Credit for Renewable Generation (excludes existing hydro)

BB 4: Credit for Energy Efficiency Improvements (cumulative from 2017; in 2012, this value is 0 MWh)

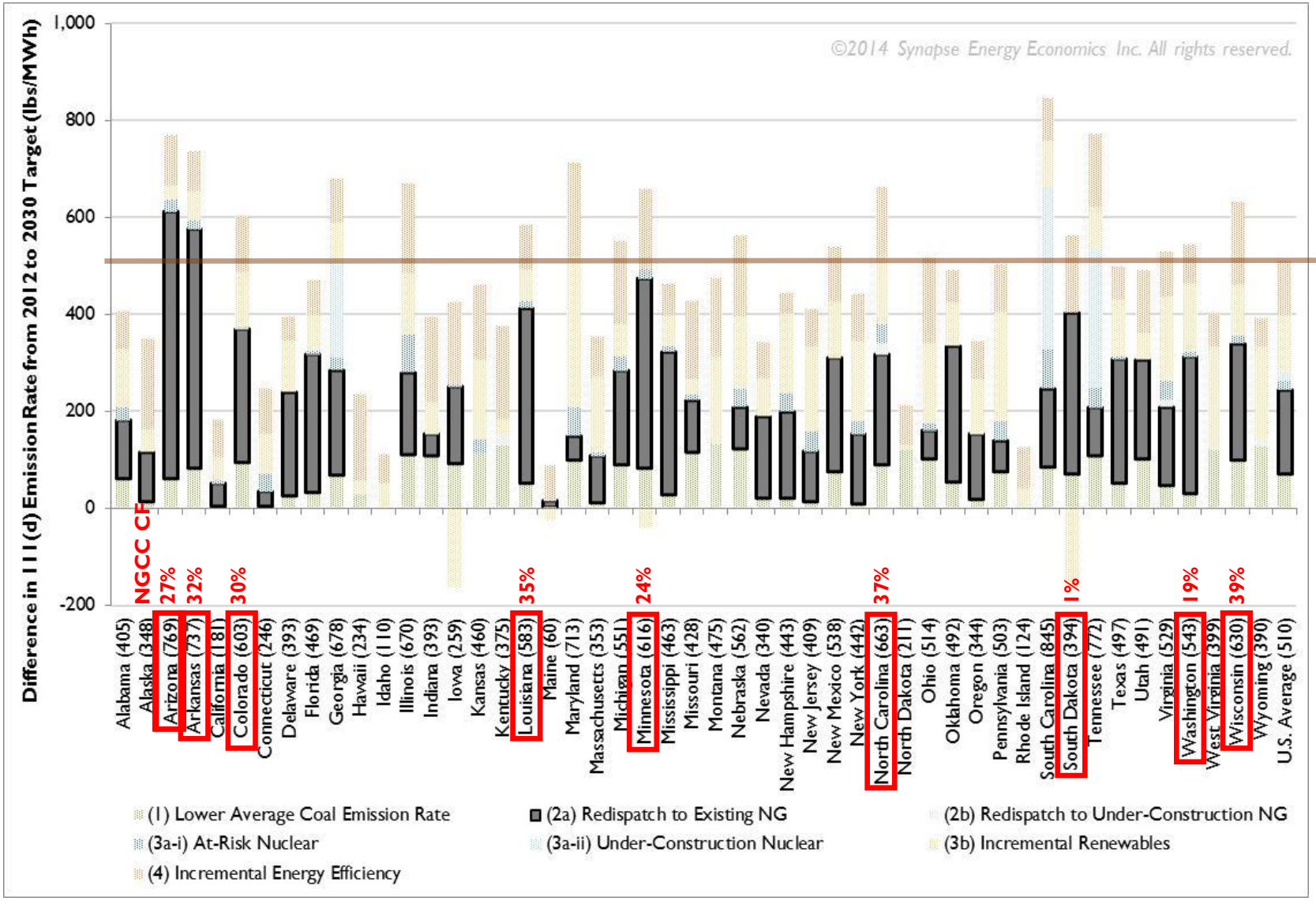
U.S. Average Initial and Target
Initial 2012 and Target 2030 111(d) Emission Rates



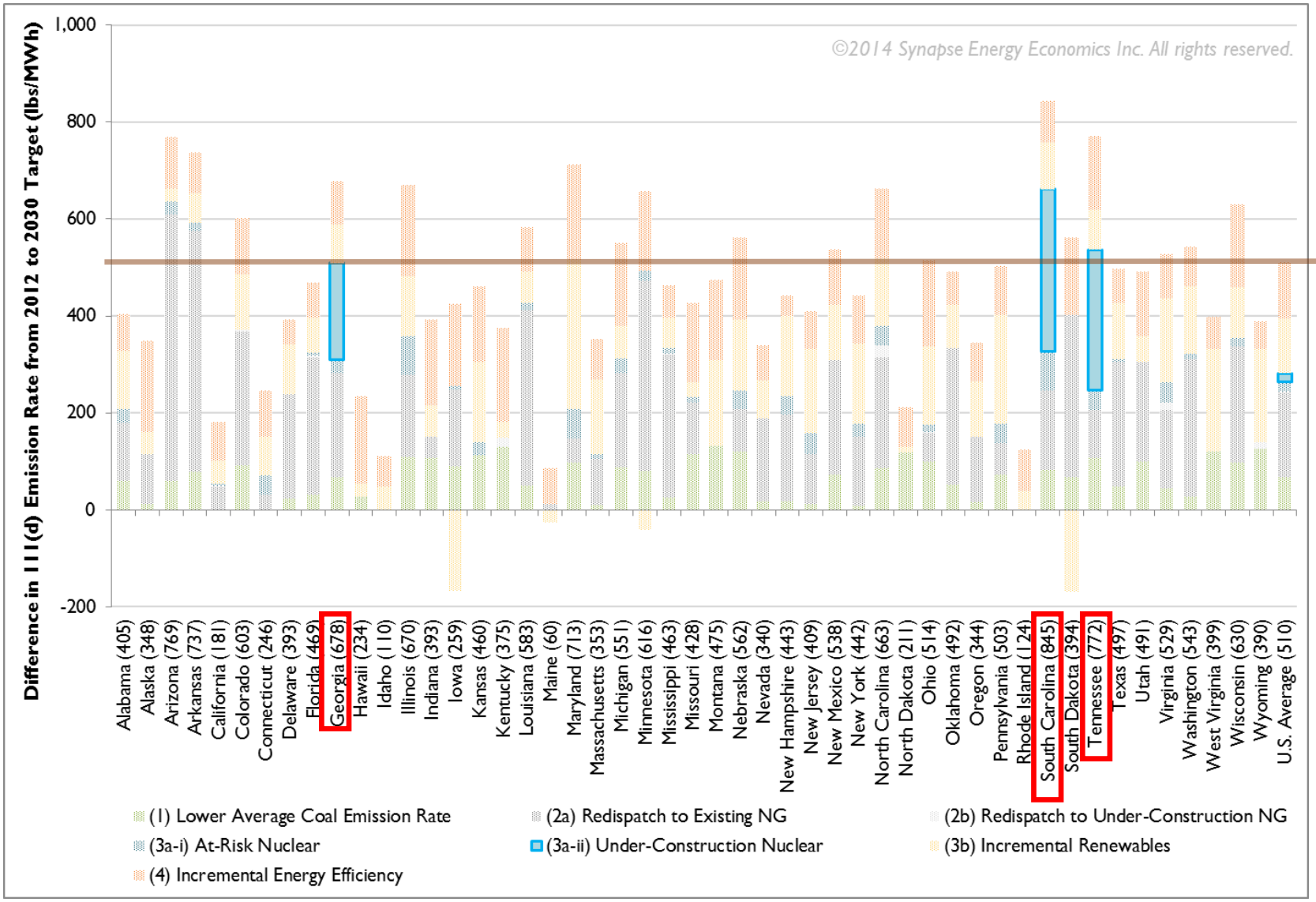
Difference between Initial 2012 and Target 2030 111(d) Emission Rates



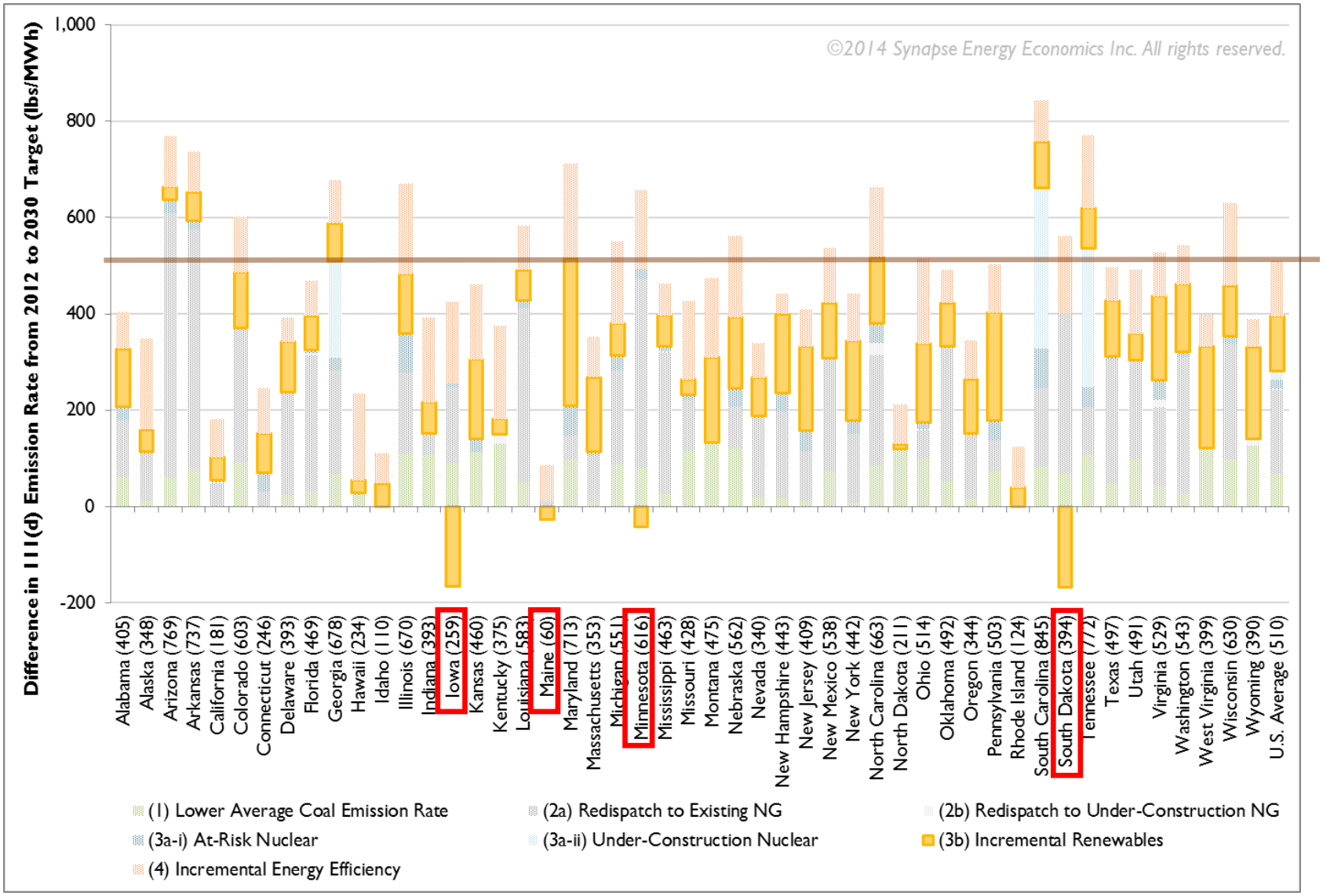
(2a) Redispatch to Existing NG
Difference between Initial 2012 and Target 2030 111(d) Emission Rates



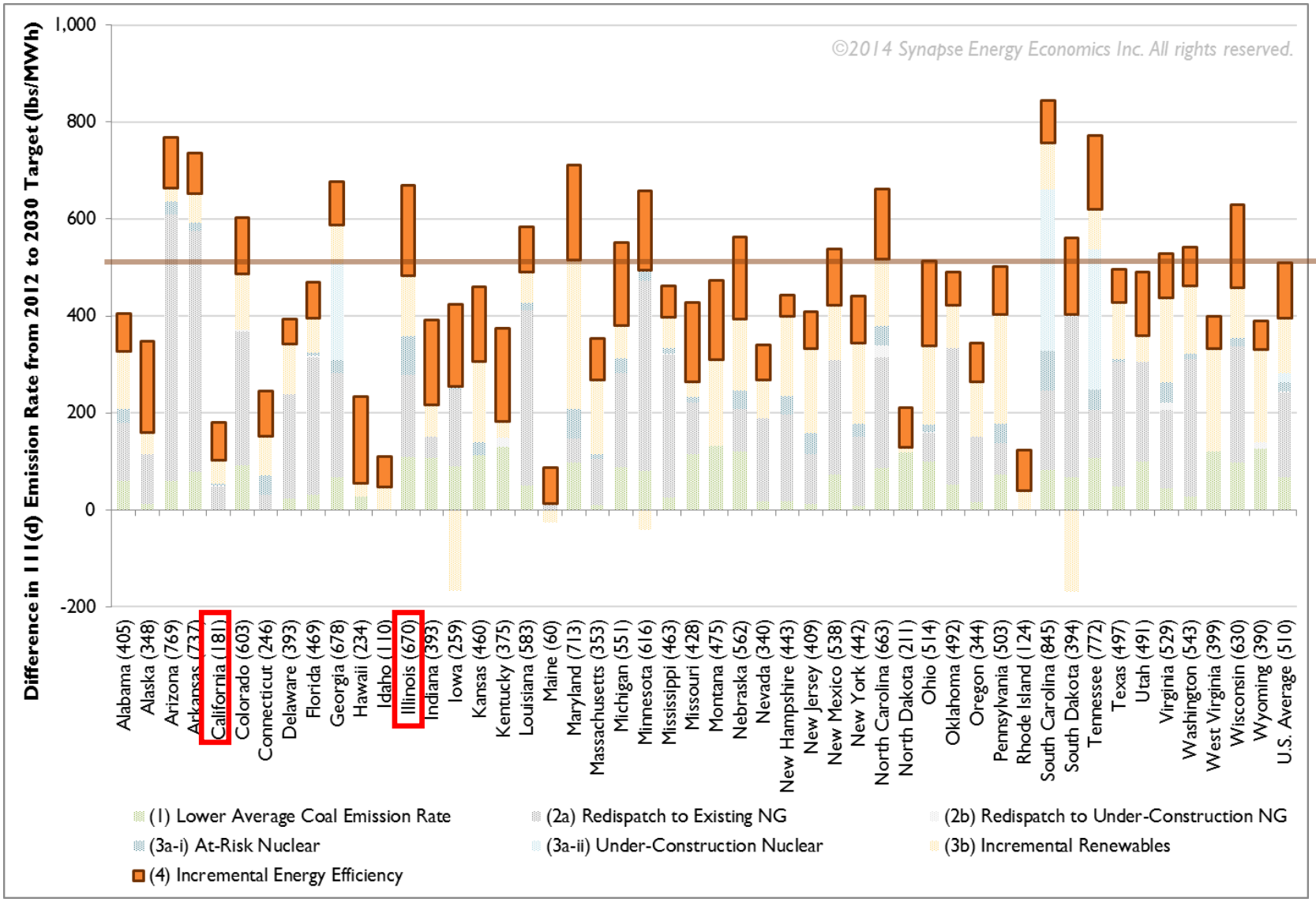
(3a-ii) Under Construction Nuclear
Difference between Initial 2012 and Target 2030 111(d) Emission Rates



(3b) Incremental Renewables
Difference between Initial 2012 and Target 2030 111(d) Emission Rates



(4) Incremental Energy Efficiency
Difference between Initial 2012 and Target 2030 111(d) Emission Rates



米国初、電力業界CO_2規制 Clean Power Plan ―エネルギー効率化対策

EEベストプラクティス・シナリオ

Input	Option 1	Option 2
Current Level of Performance (incremental savings as % of retail sales)	Data from 2012 EIA 861 (2012)	Data from 2012 EIA 861 (2012)
Best Practices Level of Performance (incremental savings as % of retails sales)	1.5%	1.0%
Start Year	2017	2017
Start Year Level of Performance	Data from 2012 EIA 861 (2012)	Data from 2012 EIA 861 (2012)
Pace of Improvement (increase in incremental savings rate per year)	0.20% per year	0.15% per year
Average Measure Life and Distribution of Measure Lives	10 years; evenly distributed across 20 years	10 years; evenly distributed across 20 years
Continued Performance	Once achieved, best practices level sustained through 2030	Once achieved, best practices level sustained through 2025

Source: US EPA (June 2014). Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants - GHG Abatement Measures, pp. 5-39

年間電力量削減レベル　現状と見通し

2012 Reported State Levels of Incremental Annual Savings

Incremental Savings as % of Retail Sales	# of States	States
>= 1.5%	3	AZ, ME, VT
1.0% to 1.49%	8	CA, CT, IA, MI, MN, OR, PA, WI
0.5% to 0.99%	14	
< 0.5%	25	

Levels of Incremental Savings Required by State Policy on or before 2020

Incremental Savings as % of Retail Sales	# of States	States
>= 1.5%	11	AZ, CO, IL, IN, MA, MN, NY, OH, RI, VT, WA
1.0% to 1.49%	5	HI, IA, ME, MI, OR
0.5% to 0.99%	3	AR, CA, WI
< 0.5%	1	TX

Source: US EPA (June 2014). Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants - GHG Abatement Measures, pp. 5-33

ポテンシャルスタディー・レビュー

Summary of Meta-Analyses of EE Potential at Utility, State, and Regional Levels

Study	Dates of Studies	Number of Studies	Average Annual Achievable Potential
Sreedharan (2013)	2001-2009	10	1.2%/year
Eldridge (2008)	2001-2007	20	1.5%/year
EPA (2014)	2010-2014	12	1.5%/year

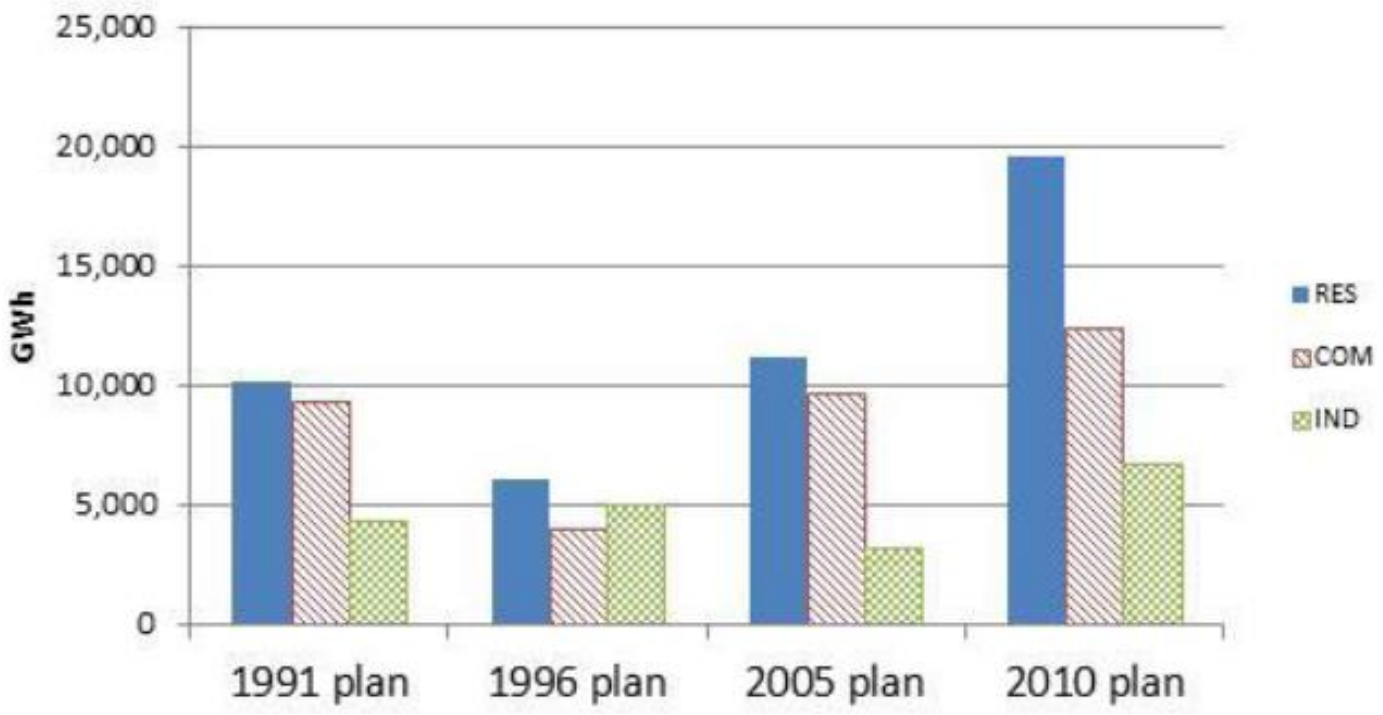
Summary of National EE Potential Studies

Study	Study Type	Average Annual Achievable Potential
EPRI (2009)	Bottom-up, engineering	0.2%-0.4%/year (realistic to maximum achievable)
EPRI (2014)	Bottom-up, engineering	0.5%-0.6%/year (achievable to high achievable)
ACEEE (2014)	Top-down, policy-based	1.5%/year

Source: US EPA (June 2014). Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants - GHG Abatement Measures, pp. 5-23 – 5-24

省エネ効果の持続可能性

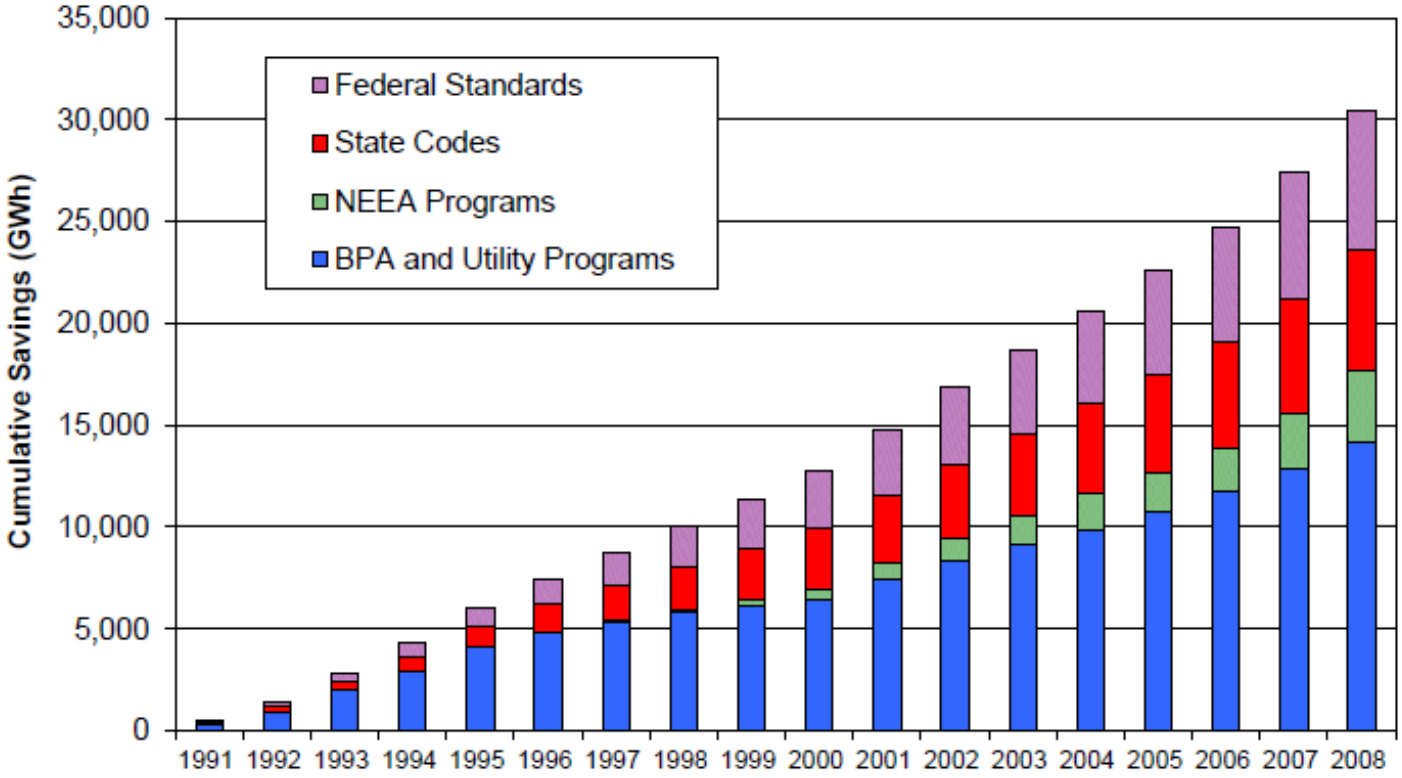
Comparison of Energy Efficiency Potential Estimates for Pacific Northwest by NWPCC's Historical Regional Power Plans (GWh)



Source: Gordon et al (2008). Gordon Fred, Lakin Garth, Tom Eckman, and Charles Grist. "Beyond Supply Curves," Proceedings of 2008 ACEEE Summer Study on Energy Efficiency in Buildings, August 17, 2008; Eckman (2010). Raw data titled "Regional Conservation Summary 1978 - 2008 Adjusted for BPA co-funding and including line losses" obtained from Tom Eckman on March 1, 2010

省エネ効果の持続可能性

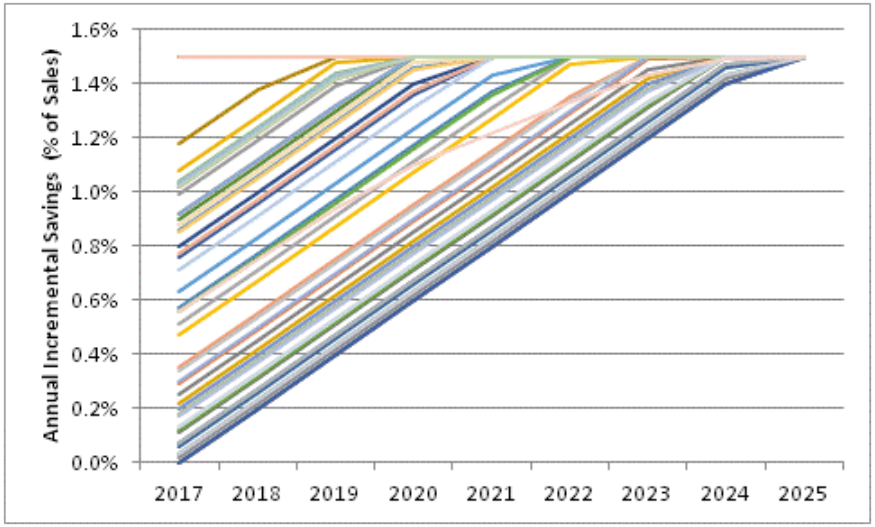
Cumulative Energy Efficiency Savings Estimates in the Pacific Northwest Region since 1991 (GWh) (Eckman 2010)



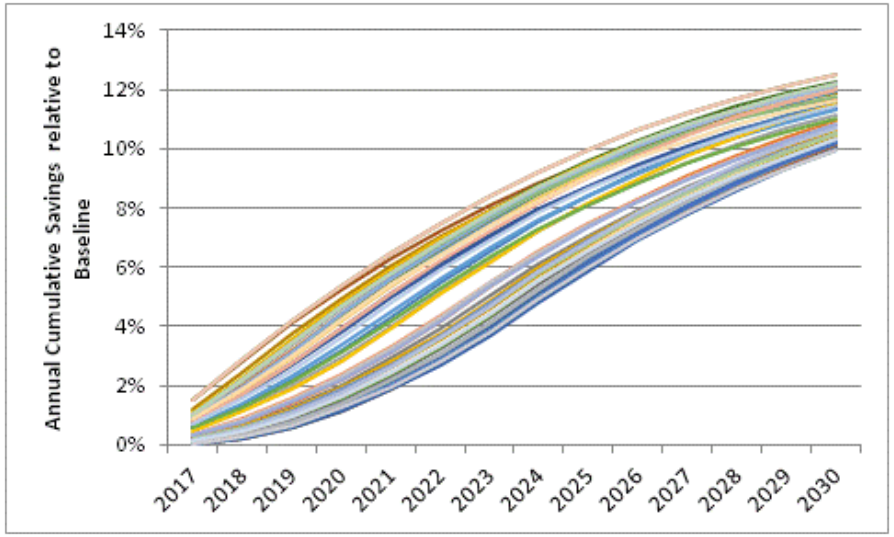
Source: Eckman (2010). Raw data titled "Regional Conservation Summary 1978 - 2008 Adjusted for BPA co-funding and including line losses" obtained from Tom Eckman on March 1, 2010

111(d)・州別省エネターゲット

Option 1: Incremental % Savings by State

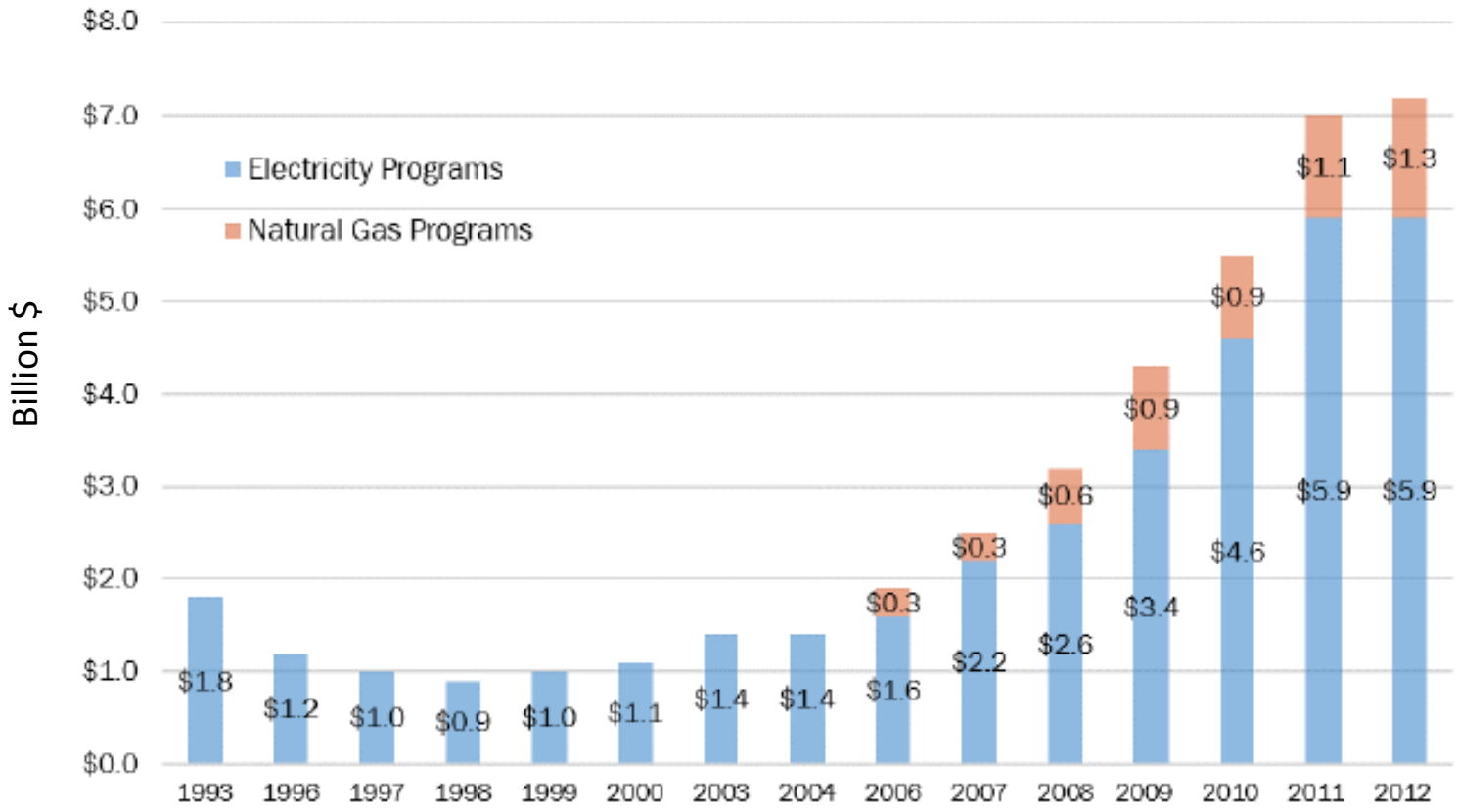


Option 1: Cumulative % Savings by State



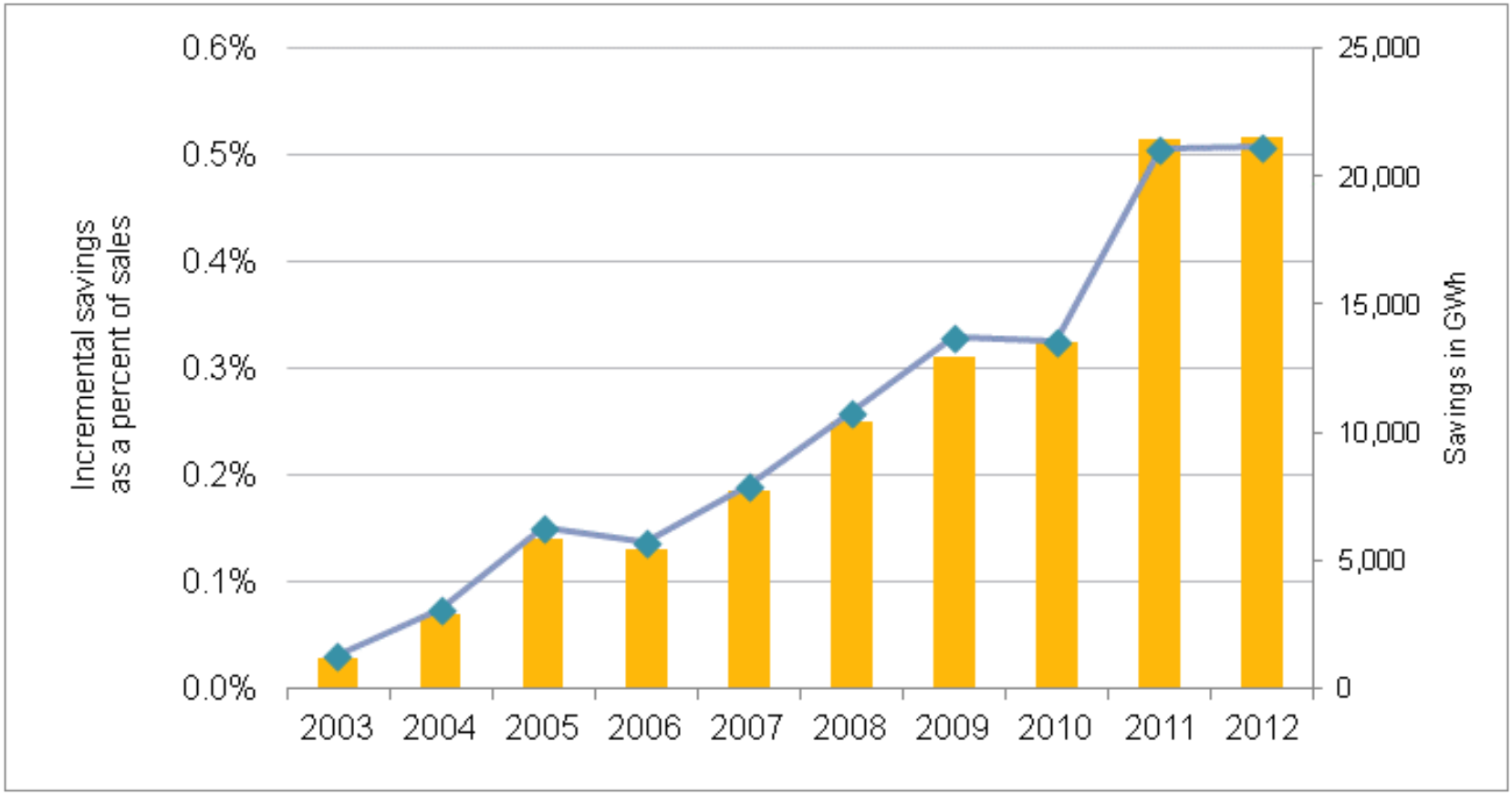
Source: Developed based on US EPA (June 2014). Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants - GHG Abatement Measures, Appendix 5-5

省エネプログラムトレンド



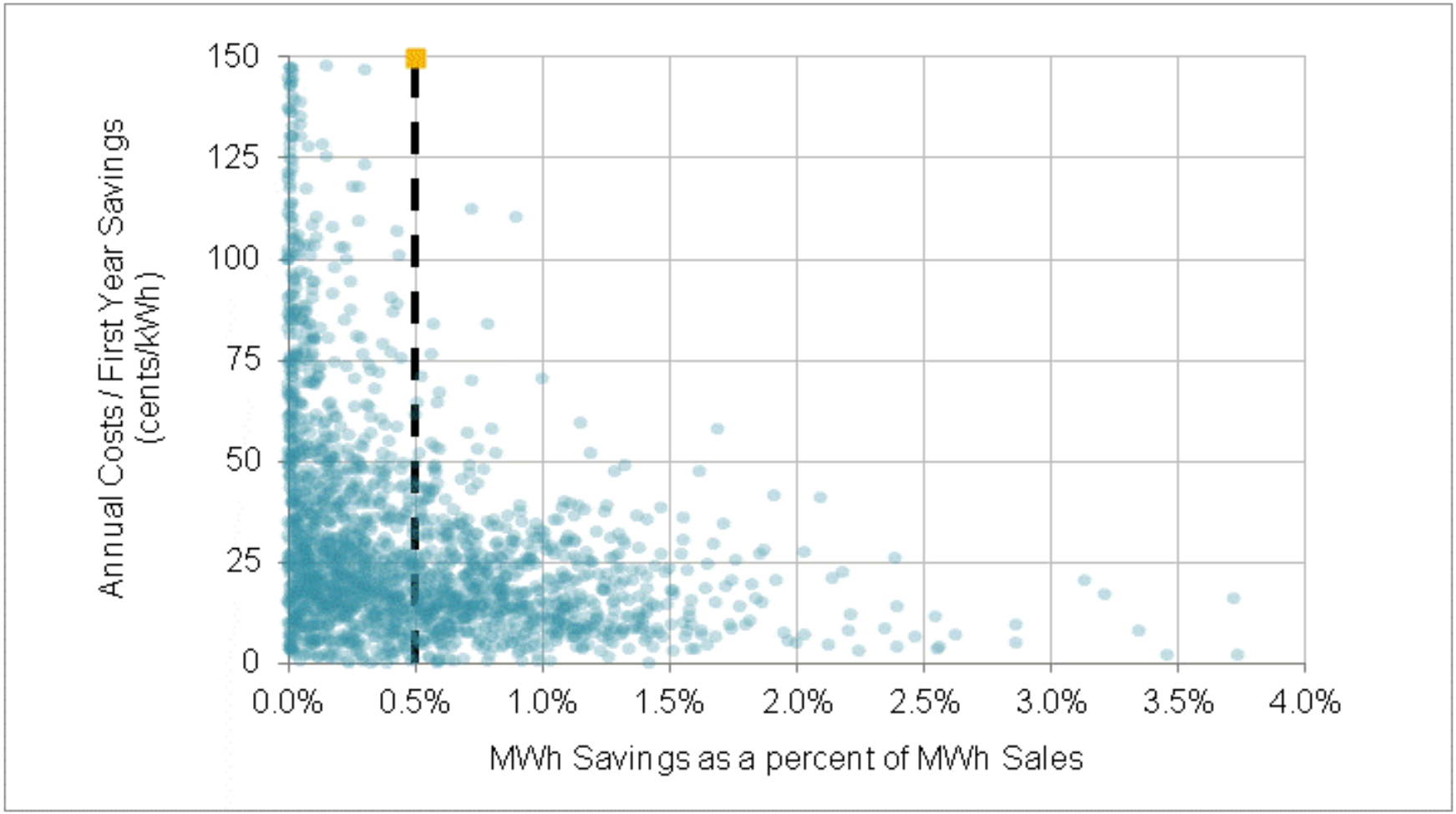
Source: ACEEE 2013 State Energy Efficiency Scorecard

省エネプログラムトレンド



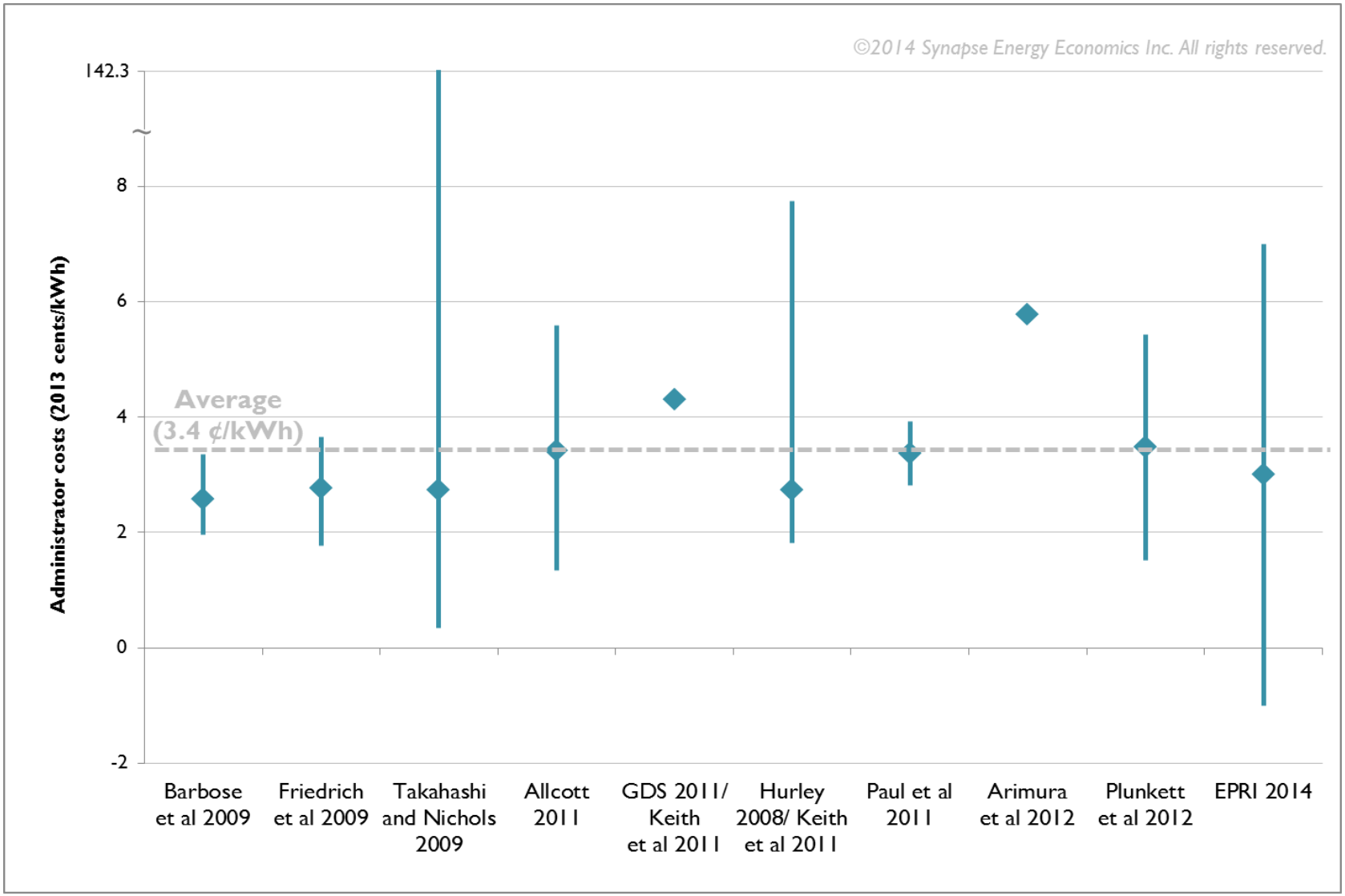
Source: EIA 861 Database

プログラム費用とエネルギー削減量

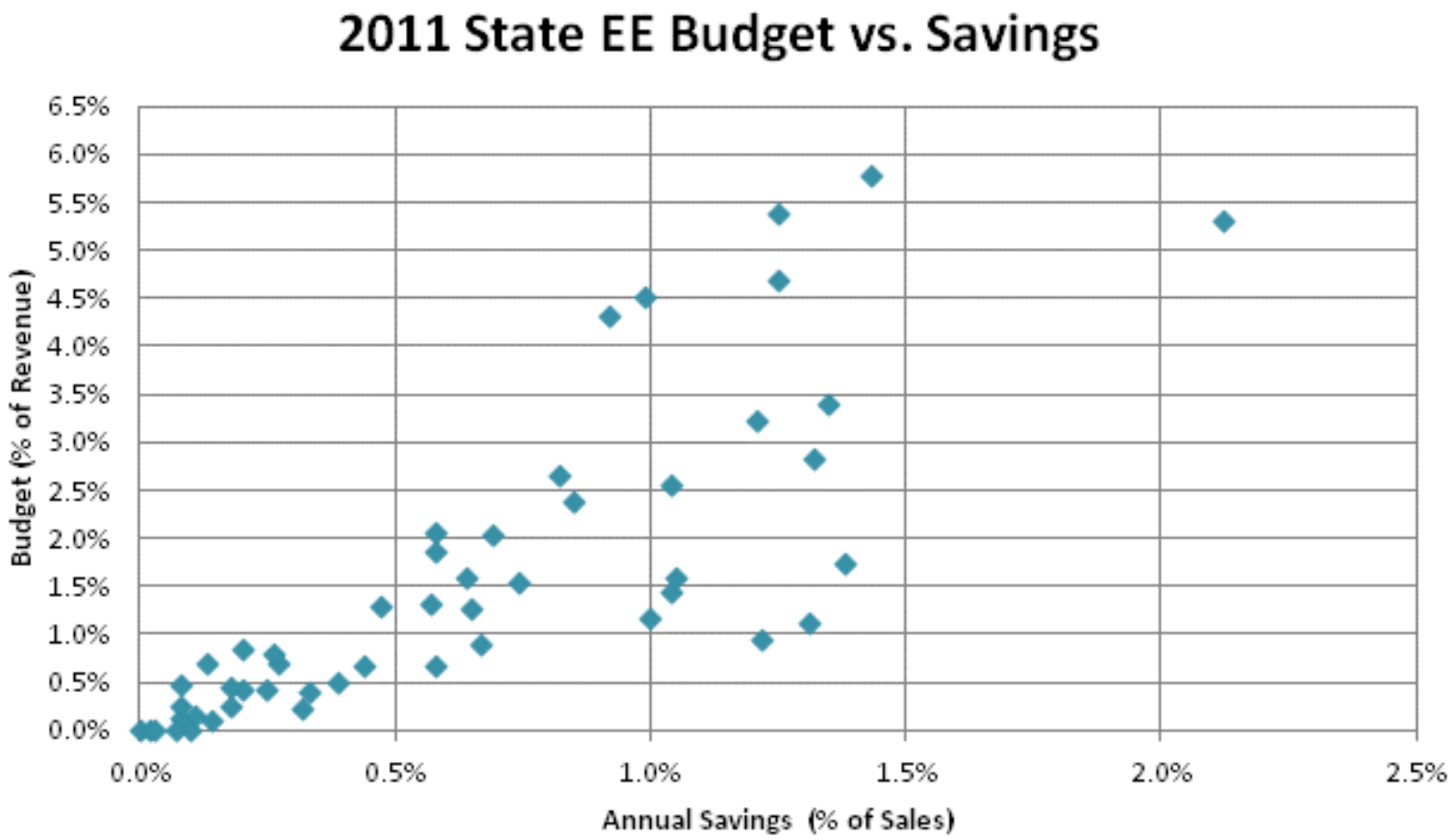


Source: EIA 861 Database

Synapse Research on the Cost of Saved Energy



プログラム費用とエネルギー削減量



Source: ACEEE 2013 State Energy Efficiency Scorecard; ACEEE 2012 State Energy Efficiency Scorecard

Any Questions?

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