ComEd EE Potential Study

Draft forecast

Opinion Dynamics

February 23, 2016

Contents

- Study goals
- Key study elements
  - What's new
- Approach
- Draft forecast
- Next steps
- CHP

Study goals

- Meet statutory requirements
  - File with 3 year plan
  - Economic, economically efficient, program and max achievable potential
- Provide useful information to ComEd
  - Short-term planning
  - Strategic planning

Study elements

Study Element	Last Study	This Study
Levels of DSM potential	• Economic • Program achievable • Max achievable	• Technical • CHP only • Economic • Economically efficient • Program achievable • Max achievable

Time horizon	• 2013-2018
	  • 5 years
		• 2017-2030
		  • 14 years

Sectors	• Residential • Commercial • Industrial	• Residential • Commercial • Industrial

Study elements

Study Element	Last Study	This Study
Combined Heat and Power	No	Yes
Approach	• Bottom-up	• Bottom-up • Propensity analysis • Sensitivity analysis
Clean Power Plan (CPP) Analysis	No	Yes
Tools	• Energy Efficiency Potential Model (EEPM) • DSMore	• EEPM DSMore • CHPower • Integrated Planning Model (IPM – for CPP) • DSM Optimizer (Sensitivity analysis)

EE Potential definitions

- **Technical.** Total possible technically feasible savings
- **Economic.** Cost-effective subset of technical potential
  - Most technically-efficient cost-effective measures
- **Economically efficient.** Cost-effective subset of technical potential
  - Most cost-effective measures
- **Maximum achievable.** Program savings without budget cap
  - 100% incentives
- **Program achievable**. Program savings with budget cap

Study elements

Study Element	Source
Baseline data	• ComEd customer counts and load, rates, AMI meter forecast • ComEd baseline study (Opinion Dynamics 2013) • Market conditions update (2016) • U.S. EIA Industrial data
Measure data	• IL TRM 4.0 • Draft TRM 5.0 for HER • ICF Industrial databases • Custom engineering calculations • Secondary research
Achievable potential assumptions	• ComEd evaluation reports • ComEd program manager interviews • ICF program experience • Propensity analysis • Secondary research on market acceptance

Study bottom-up approach

1. Define measures
2. Calculate measure market size (eligible stock)
3. Calculate measure cost-effectiveness
4. Estimate economic potential
5. Build programs from measures and estimate achievable potential
6. Clean Power Plan Analysis
7. Sensitivity analysis

Eligible Stock

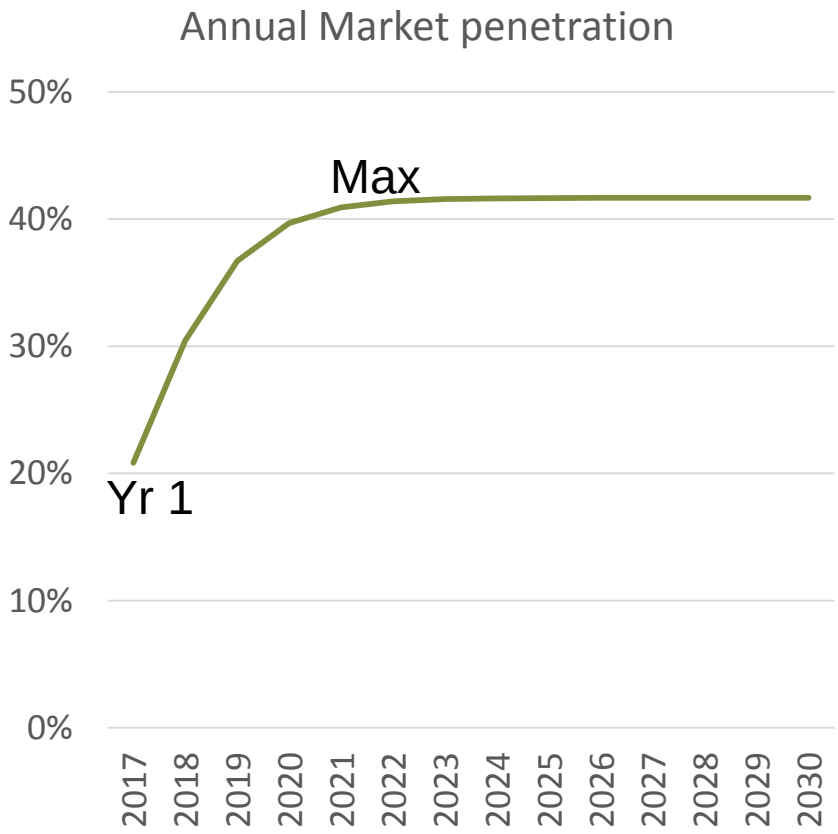
Applicable buildings in sub-sector	Number of measure units per building	% of buildings to which measure is technically applicable	Not-yet-adopted rate	Measure Eligible stock (units)
(a)	(b)	(c)	(d)	(a*b*c*e)
1000	10	100%	90%	9000

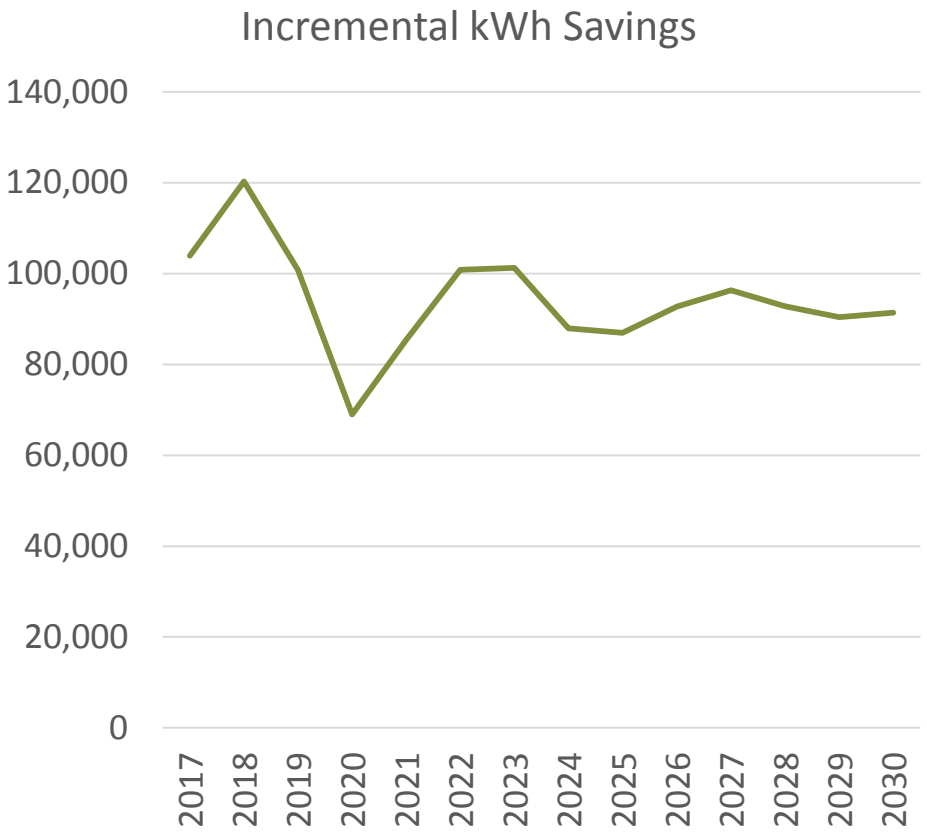
- ComEd customer data
- ComEd baseline study (Opinion Dynamics, 2013)
  - Market conditions update (2016)
- ICF industrial databases

Market conditions update

- Secondary research by Opinion Dynamics to update penetration estimates for potentially important measures
- Residential
  - Programmable and smart tstats
  - LEDs
  - Ductless heat pumps
- C&I
  - Occupancy sensors
  - Business energy management systems
  - Advanced Lighting Controls
  - LED lamps
  - Linear Florescent Lighting

Participation approach—illustrative adoption





Propensity scoring

- Measure adoption curves are a critical input to estimating market potential
- To help calibrate adoption curves, Opinion Dynamics is developing a customer propensity scoring model
  - Program participation is highly correlated with installation of EE measures
  - Model will forecast each customer's likelihood to participate in ComEd's DSM programs

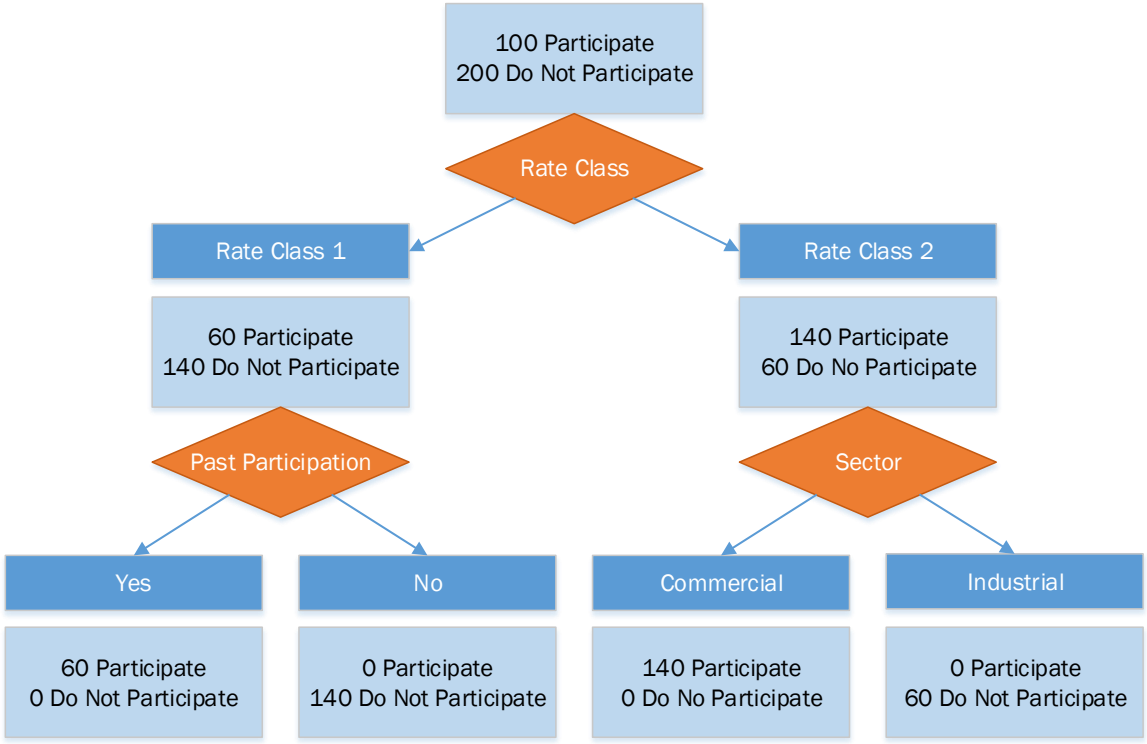
Propensity scoring model

- Opinion Dynamics compiled data from multiple sources:
  - ComEd customer information (e.g., name, account number, contact info, rate code, NAICS)
  - Monthly usage billing data (2007-2015)
  - Program tracking data (PY1-PY7)
- Models developed for different customer classes
  - Small, medium, and large C&I
  - Residential

Propensity scoring model

- Model uses a tree classifier based on classification and regression trees (CART)
- A CART model repeatedly partitions data in decision trees to estimate conditional distribution of a response variable given a set of predictors
- The model identifies the key predictor variables

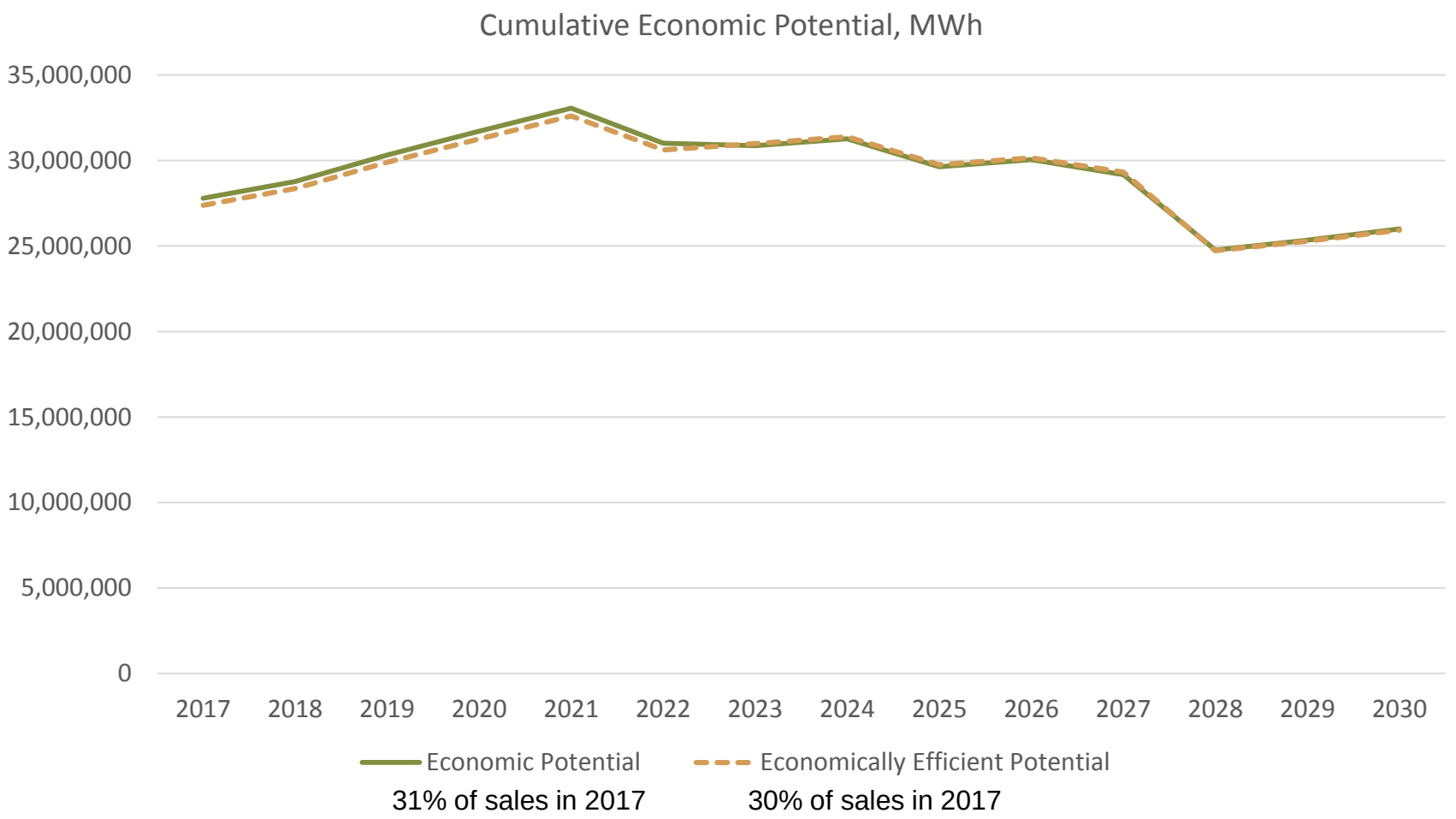
Example of CART Model



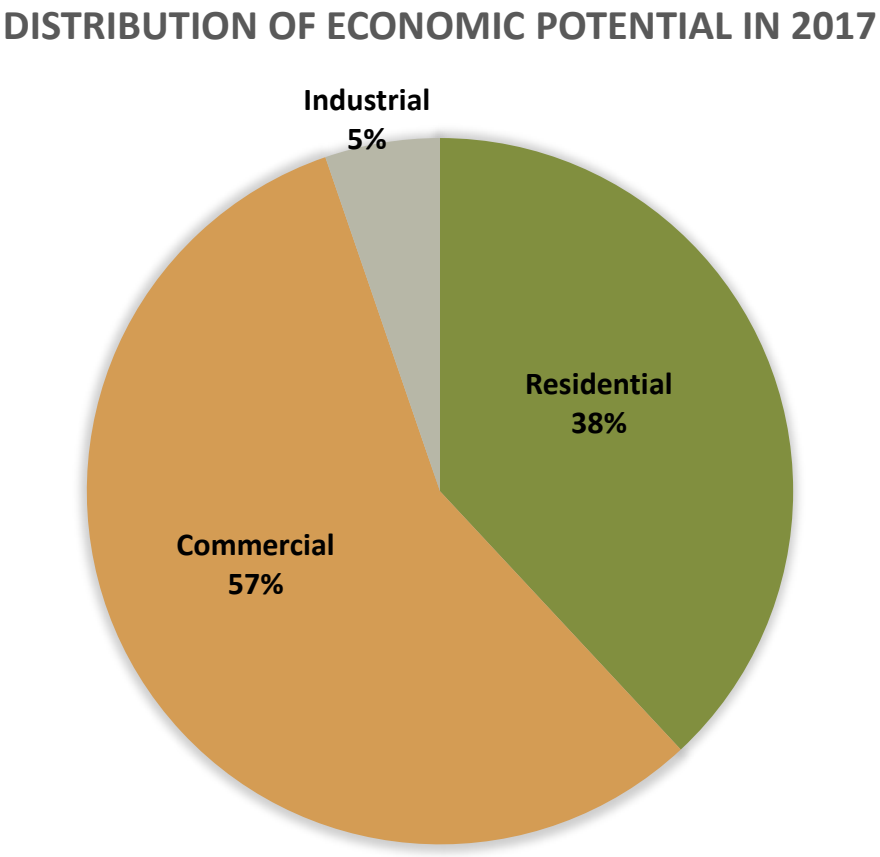
Key standard changes and savings approach method changes

- Adoption of IECC 2015
  - Minor residential impact: <1% lower EUI than 2012
  - Commercial EUI 11.1% lower than 2012
- Standard light bulbs
  - EISA 2007 backstop provisions
  - Current NOPR that may eliminate CFLs
  - LED bulb costs
- Home Energy Report savings decay and persistence
  - Per draft TRM update
- T12s and Magnetic Ballasts
  - EPAct 2005
  - 2009 DOE Lamp rule making
- C&I Unitary HVAC
  - Change to IEER and higher baselines in 2018 and 2023

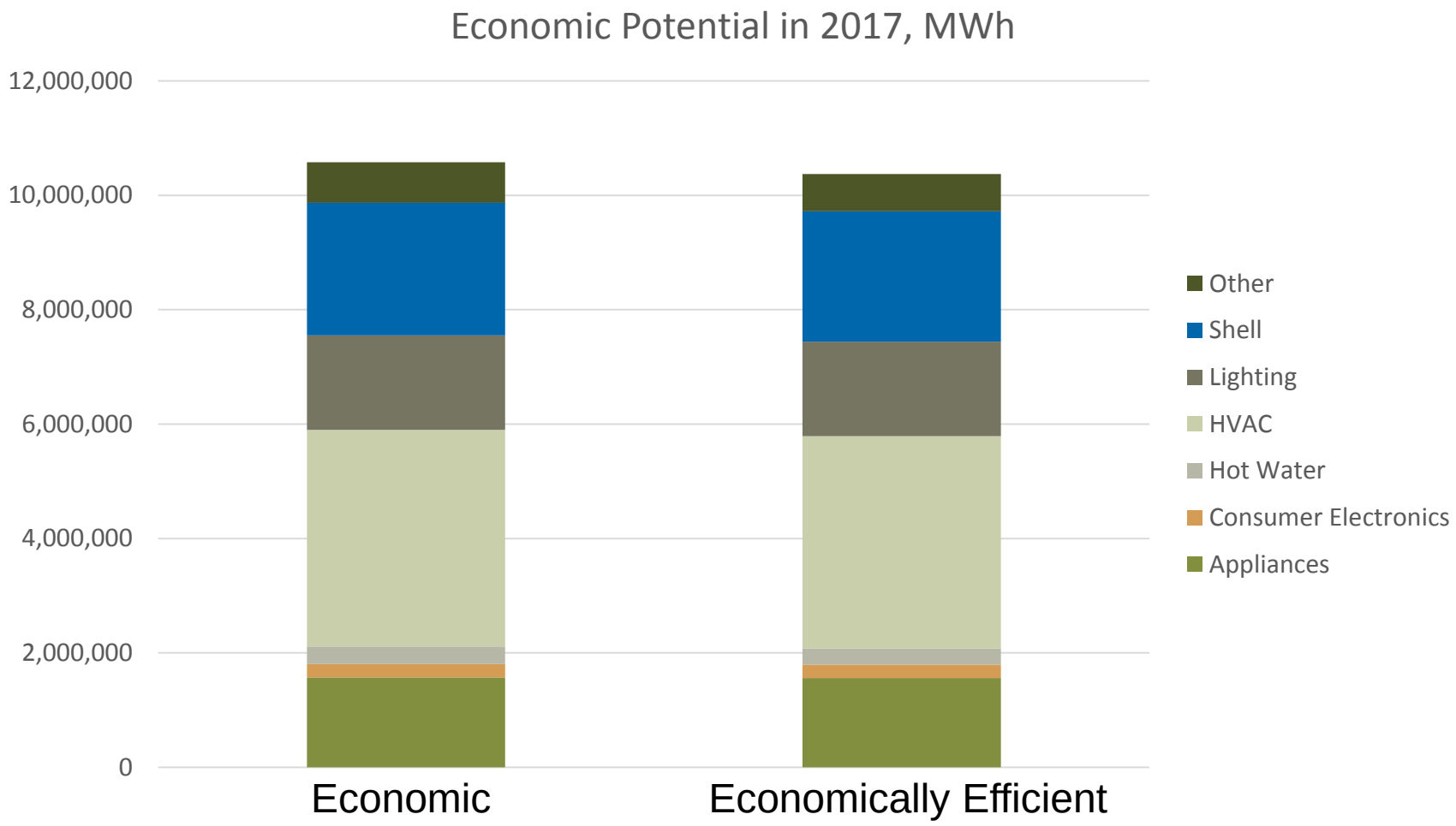
Economic potential – total



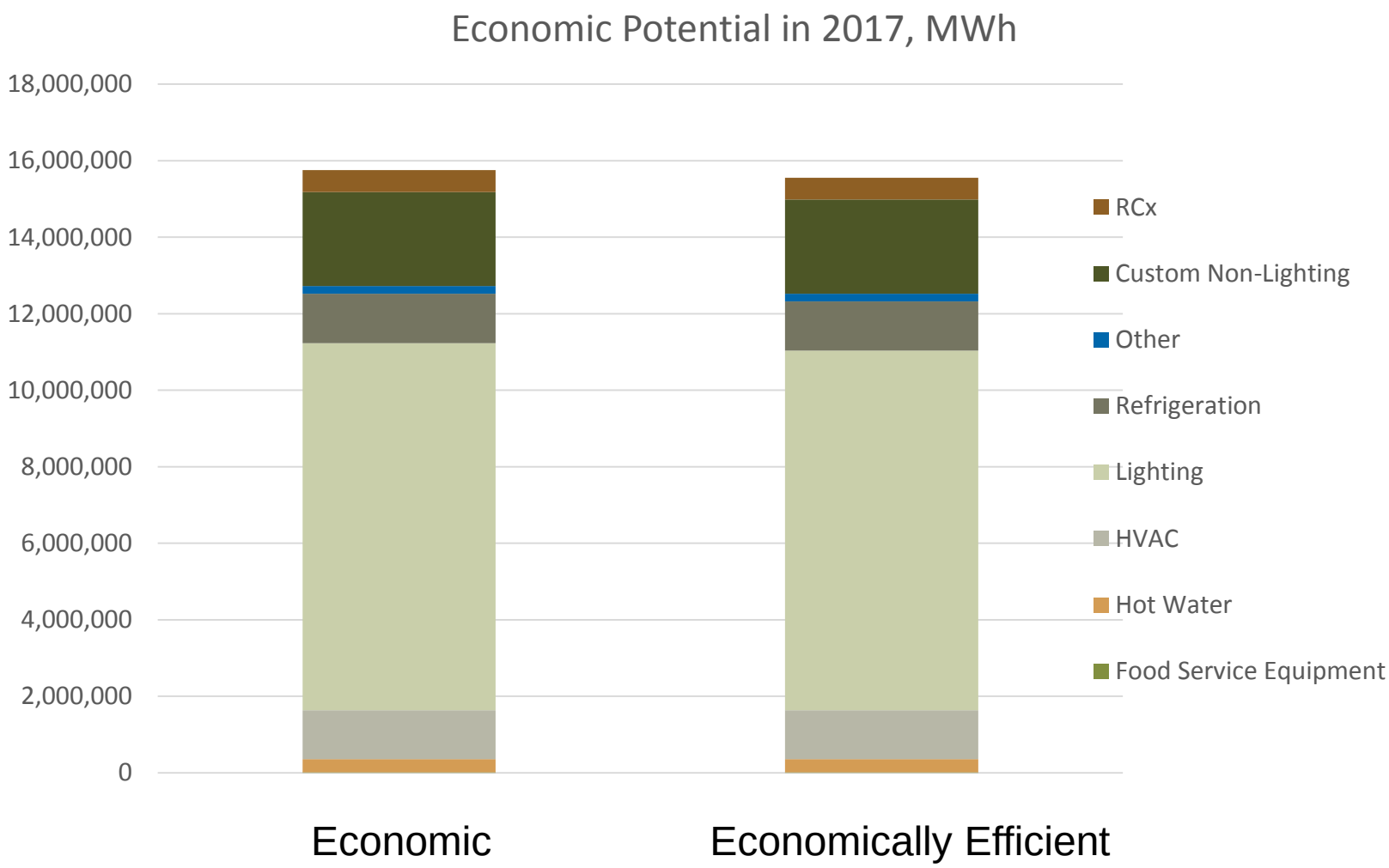
Economic Potential



Residential Economic potential

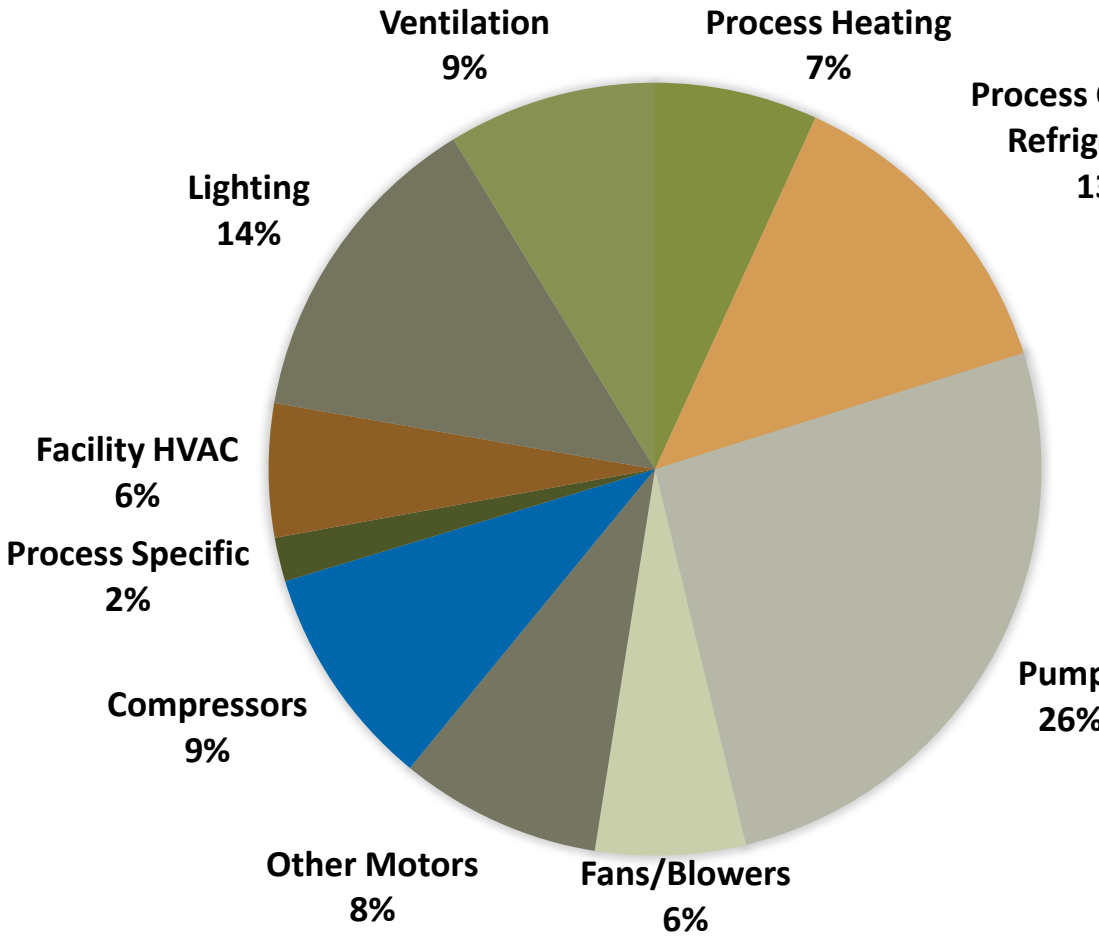


Commercial Economic Potential



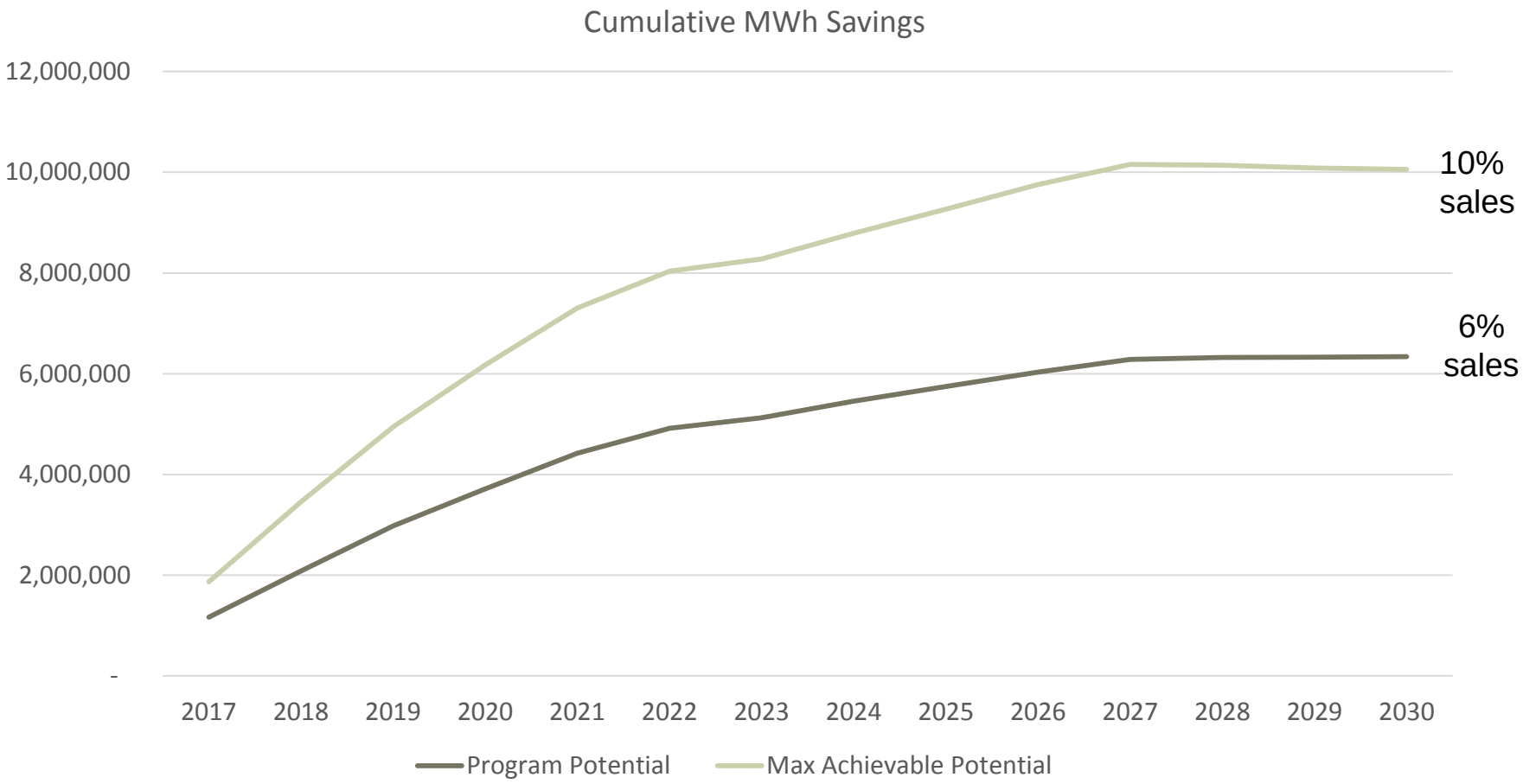
Industrial Economic Potential

Distribution of Industrial Economic Potential, 2017 (1,463 GWh total)

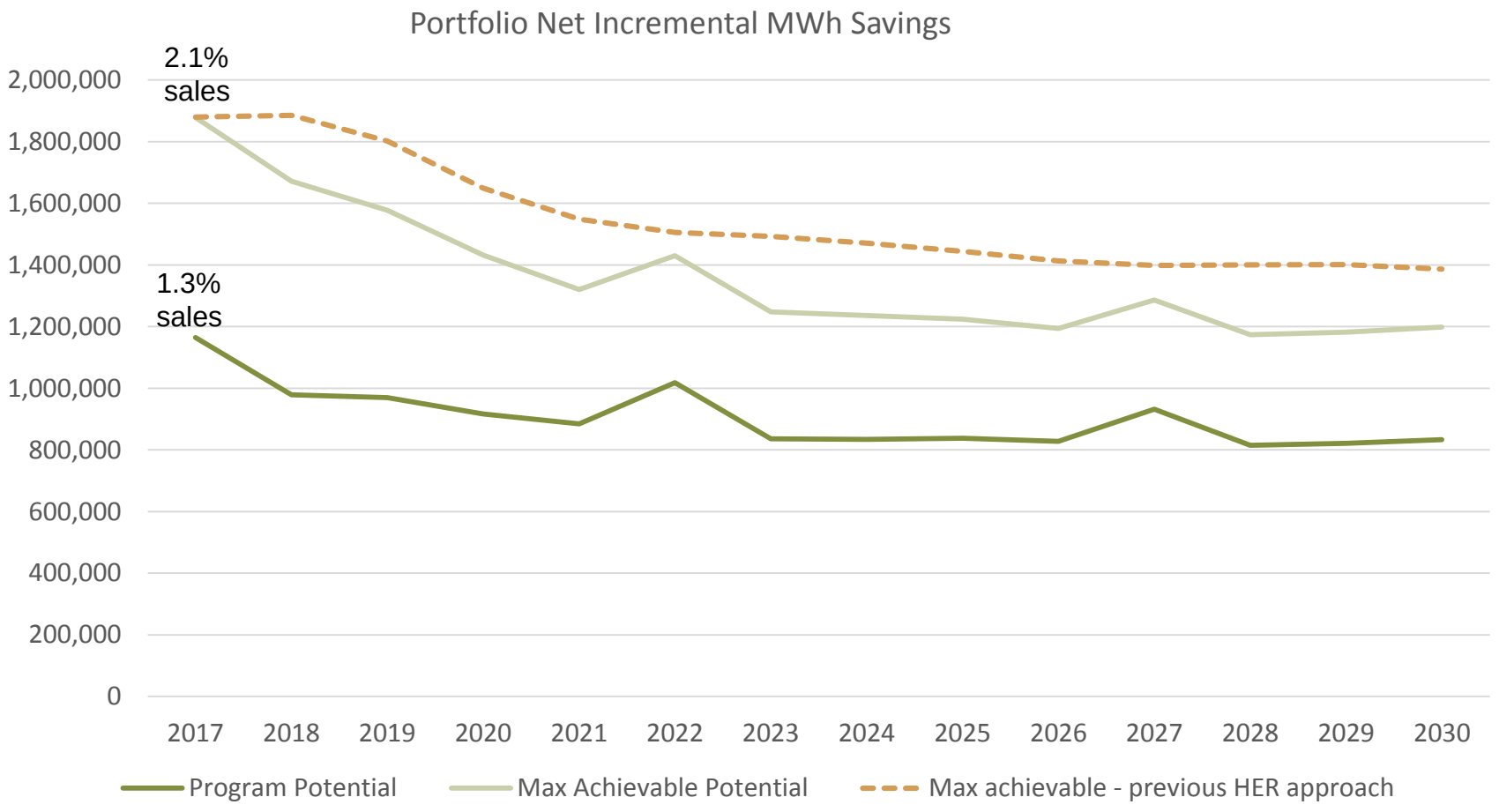


*No difference between economic and economically efficient potential for industrial

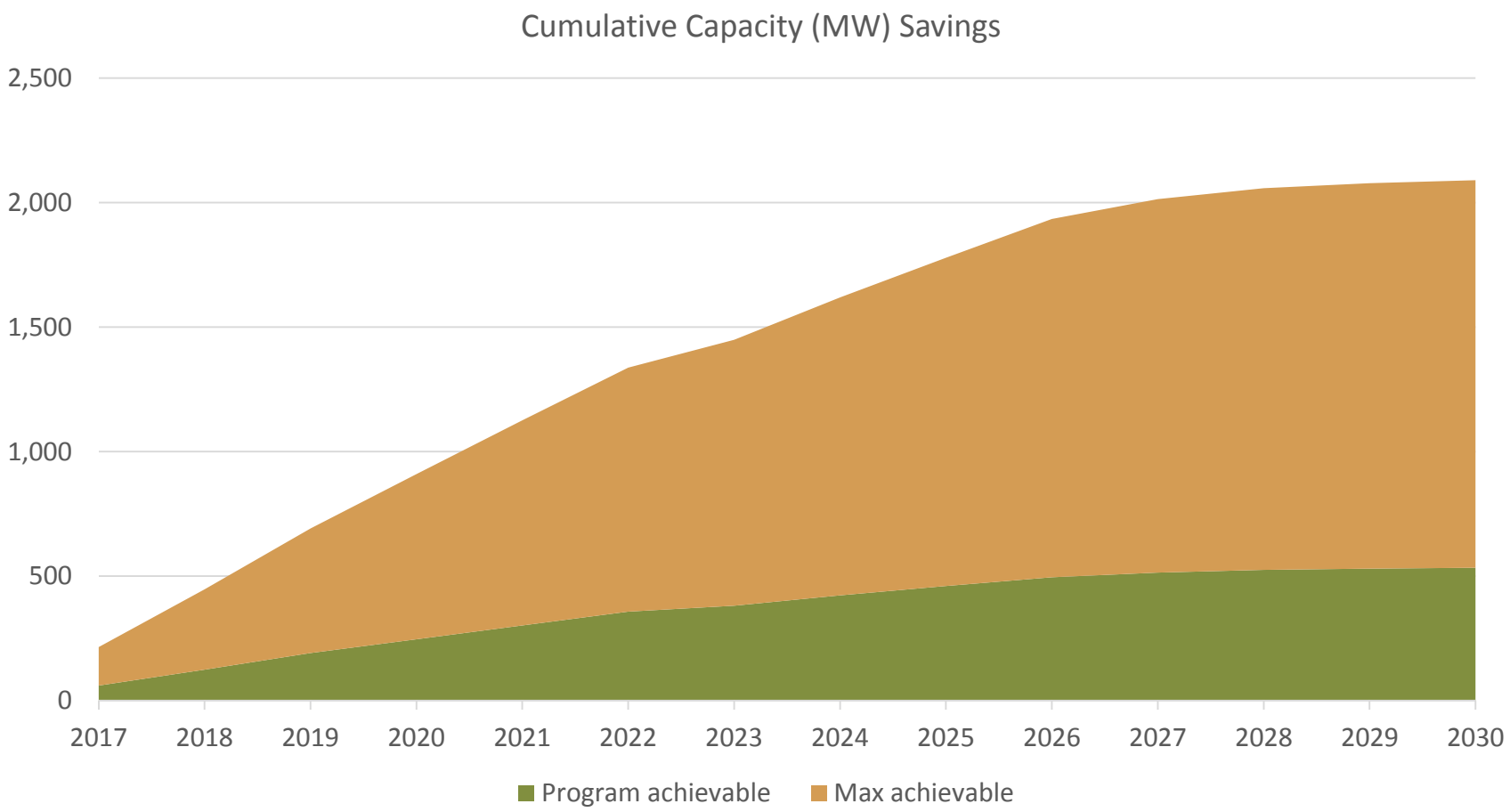
Cumulative achievable potential



Incremental achievable potential

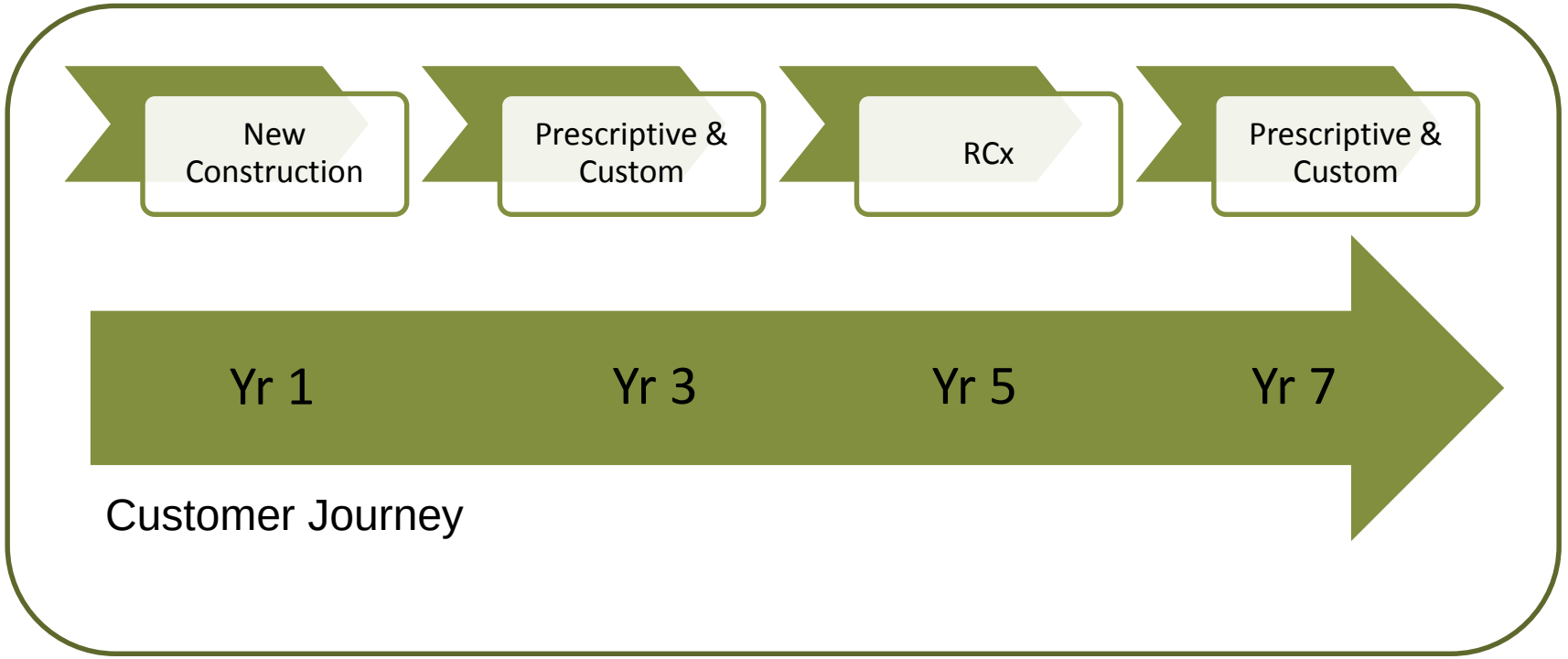


Demand savings potential



Some key ComEd portfolio trends

- High level of maturity
- Long-term customer engagement



Smart Ideas Business Savings

Residential

- Program achievable programs
  - Lighting
  - Fridge & Freezer Recycling
  - Multifamily
  - Home Energy Report
  - Home Energy Assessment
  - Appliance Rebates
  - HVAC and Weatherization
  - New Construction
  - Elementary Education
  - DCEO

Residential

- Maximum achievable programs
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  - New Construction
  - Elementary Education
  - DCEO
  - Retail Products Platform
  - Online Marketplace
  - Connected Home

Residential

- Retail Products Platform
  - The ENERGY STAR Retail Products Platform (RPP) applies a consistent national program design—including product categories, specifications, data requirements, and general approach (i.e., midstream incentives)—with the goal of creating critical scale that lowers per-unit incentive and administrative costs for both program administrators and retailers. Through the RPP, retailers agree to provide access to sales and market share data to program administrators in exchange for targeted product categories and consistent and streamlined data and reporting requirements from program administrators. Retailers and program administrators work together to tailor local go-to-market strategies built on the national framework allowing for some flexibility in local markets.

Residential

- Online Marketplace
  - Online Marketplace (OM) creates a new market for EE measures by providing instant discounts on efficient lighting, appliances, and consumer electronic purchased through a program Web site. Customers who shop via OM can access products and discounts across vendors and gain specific insights optimized to their circumstances. For example, customers can customize based on what is most important to them (size, brand, energy savings, life cycle cost). As with any online shopping portal, OM can also save customers time. The program works with retailers to develop instant discounts on qualifying products.

Residential

- Connected Home
  - Connected home is a platform designed to help customers better understand and manage their energy use. It requires an AMI meter, a web portal that explains household energy use to the customer, connectivity to household devices, along with the ability to control the devices. The most commonly controlled devices to date are thermostats but the number of controllable devices is expected to grow as Smart Grid technology matures. This could be a standalone program and/or promoted in conjunction with other EE programs. It can also be paired with demand response.

Commercial & Industrial

- Program achievable programs
  - Commercial Prescriptive & Custom
  - Street Lighting
  - Midstream Incentives
    - Lighting
  - C&I New Construction
  - Small Business
  - Retrocommissioning
  - Data Center
  - AirCare+
  - DCEO

Commercial & Industrial

- Maximum achievable programs
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  - Street Lighting
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  - Retrocommissioning
  - Data Center
  - AirCare+
  - Industrial Systems
  - Industrial Custom
  - Strategic Energy Management
  - DCEO

Savings by program - residential

Incremental MWh

Program	2017 - Program	2017 - Max	% Program Total	% Max Total	2018 - Program	2018 - Max	% Program Total	% Max Total	2020 - Program	2020 - Max	% Program Total	% Max Total	2030 - Program	2030 - Max	% Program Total	% Max Total
Lighting	158,985	191,851	33.1%	35.5%	148,482	182,975	56.9%	55.2%	90,257	127,361	40.7%	41.0%	55,410	76,586	25.7%	26.4%
Fridge & Freezer Recycling	27,508	27,508	5.7%	5.1%	27,473	27,473	10.5%	8.3%	24,036	25,331	10.8%	8.2%	16,619	15,982	7.7%	5.5%
Multifamily *	5,832	5,314	1.2%	1.0%	5,307	4,996	2.0%	1.5%	3,277	3,415	1.5%	1.1%	2,057	2,188	1.0%	0.8%
Home Energy Report	269,046	269,046	56.0%	49.8%	57,330	57,330	22.0%	17.3%	78,829	78,829	35.5%	25.4%	116,242	116,242	54.0%	40.1%
Home Energy Assessment *	6,371	9,644	1.3%	1.8%	7,229	10,947	2.8%	3.3%	7,365	11,387	3.3%	3.7%	6,594	10,735	3.1%	3.7%
Appliance Rebates *	4,229	5,610	0.9%	1.0%	6,169	8,180	2.4%	2.5%	7,980	10,565	3.6%	3.4%	8,480	11,323	3.9%	3.9%
HVAC and Weatherization *	7,559	21,711	1.6%	4.0%	8,567	24,320	3.3%	7.3%	9,634	26,601	4.3%	8.6%	9,558	24,806	4.4%	8.6%
New Construction	358	358	0.1%	0.1%	361	360	0.1%	0.1%	292	291	0.1%	0.1%	196	196	0.1%	0.1%
Elementary Education	137	512	0.0%	0.1%	137	511	0.1%	0.2%	136	383	0.1%	0.1%	134	380	0.1%	0.1%
Retail Products Platform	N/A	3,197		0.6%	N/A	4,674		1.4%	N/A	6,090		2.0%	N/A	6,643		2.3%
Online Marketplace	N/A	2,566		0.5%	N/A	2,722		0.8%	N/A	2,853		0.9%	N/A	2,869		1.0%
Connected Home *	N/A	3,284		0.6%	N/A	7,157		2.2%	N/A	17,522		5.6%	N/A	22,103		7.6%
ComEd Total	**480,026**	**540,602**			**261,055**	**331,646**			**221,806**	**310,629**			**215,290**	**290,051**		
DCEO	6,804	6,804			6,811	6,811			6,826	6,826			6,899	6,899		
Grand Total Residential	**486,831**	**547,406**			**267,867**	**338,457**			**228,632**	**317,455**			**222,190**	**296,951**		

* Includes WiFi thermostats

Savings by program – C&I

Incremental MWh

Program	2017 - Program	2017 - Max	% Program Total	% Max Total	2020 - Program	2020 - Max	% Program Total	% Max Total	2030 - Program	2030 - Max	% Program Total	% Max Total
Commercial Prescriptive & Custom	165,623	423,477	28.9%	34.6%	174,512	337,404	29.6%	33.4%	149,759	248,347	28.9%	30.6%
Street Lighting	5,387	6,671	0.9%	0.5%	5,116	1,788	0.9%	0.2%	5,814	2,162	1.1%	0.3%
Midstream Incentives	120,706	243,134	21.1%	19.9%	126,382	203,834	21.4%	20.2%	118,461	193,034	22.9%	23.8%
C&I New Construction	31,888	38,455	5.6%	3.1%	30,294	36,532	5.1%	3.6%	23,441	28,268	4.5%	3.5%
Small Business	139,329	331,737	24.3%	27.1%	139,171	290,644	23.6%	28.8%	113,693	196,409	22.0%	24.2%
Retrocommissioning	32,598	86,928	5.7%	7.1%	32,677	59,394	5.5%	5.9%	31,342	60,877	6.1%	7.5%
Data Center	15,639	16,681	2.7%	1.4%	15,464	16,482	2.6%	1.6%	15,010	15,967	2.9%	2.0%
AirCare+	3,068	5,071	0.5%	0.4%	5,163	7,946	0.9%	0.8%	5,380	8,360	1.0%	1.0%
Multifamily Common Area	3,923	4,484	0.7%	0.4%	3,198	3,629	0.5%	0.4%	1,697	1,892	0.3%	0.2%
Industrial Systems	38,110	41,586	6.6%	3.4%	38,946	36,925	6.6%	3.7%	34,717	34,488	6.7%	4.3%
Industrial Custom	10,907	17,081	1.9%	1.4%	9,159	4,393	1.6%	0.4%	8,415	12,518	1.6%	1.5%
Strategic Energy Management	6,230	8,058	1.1%	0.7%	9,802	11,323	1.7%	1.1%	9,903	8,426	1.9%	1.0%
Total	**573,409**	**1,223,363**			**589,886**	**1,010,294**			**517,632**	**810,747**		
DCEO	107,801	107,801			104,019	104,019			91,045	91,045		
Grand Total C&I	**681,210**	**1,331,164**			**693,905**	**1,114,313**			**608,677**	**901,792**		

Program costs—program potential

Residential

C&I

Program	2017	2018	2019	2020	2025	2030
Lighting	$ 33.1	$ 30.3	$ 28.7	$ 16.9	$ 13.4	$ 11.9
Fridge & Freezer Recycling	$ 9.2	$ 9.2	$ 9.0	$ 9.0	$ 8.7	$ 8.5
Multifamily	$ 1.5	$ 1.4	$ 1.2	$ 0.6	$ 0.6	$ 0.5
Home Energy Report	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0
Home Energy Assessment	$ 5.7	$ 6.5	$ 7.3	$ 7.4	$ 8.2	$ 8.2
Appliance Rebates	$ 2.9	$ 4.0	$ 4.8	$ 5.2	$ 5.4	$ 5.6
HVAC and Weatherization	$ 8.0	$ 8.9	$ 9.5	$ 9.8	$ 9.5	$ 9.3
New Construction	$ 0.5	$ 0.5	$ 0.5	$ 0.4	$ 0.2	$ 0.2
Elementary Education	$ 0.4	$ 0.4	$ 0.3	$ 0.3	$ 0.2	$ 0.1
Residential Total	**$ 73.2**	**$ 73.2**	**$ 73.3**	**$ 61.5**	**$ 58.3**	**$ 56.5**
Commercial Prescriptive & Custom	$ 30.0	$ 31.8	$ 32.6	$ 32.1	$ 28.7	$ 28.2
Street Lighting	$ 0.8	$ 1.2	$ 1.1	$ 0.8	$ 0.3	$ 0.9
Midstream Incentives	$ 6.7	$ 7.4	$ 7.4	$ 7.0	$ 6.6	$ 6.6
C&I New Construction	$ 6.8	$ 6.8	$ 6.5	$ 6.5	$ 5.8	$ 5.0
Small Business	$ 21.4	$ 22.0	$ 21.9	$ 21.4	$ 18.3	$ 17.4
Retrocommissioning	$ 5.3	$ 5.7	$ 5.6	$ 5.3	$ 5.1	$ 5.1
Data Center	$ 1.8	$ 1.8	$ 1.8	$ 1.8	$ 1.8	$ 1.7
AirCare+	$ 0.8	$ 1.1	$ 1.2	$ 1.3	$ 1.4	$ 1.4
Multifamily Common Area	$ 1.5	$ 1.4	$ 1.3	$ 1.2	$ 0.9	$ 0.6
Industrial Systems	$ 9.0	$ 10.5	$ 9.6	$ 9.2	$ 8.1	$ 8.2
Industrial Custom	$ 3.0	$ 4.0	$ 3.8	$ 2.5	$ 1.0	$ 2.3
Strategic Energy Management	$ 0.6	$ 0.8	$ 1.0	$ 1.0	$ 1.0	$ 1.0
C&I Total	**$ 87.7**	**$ 94.6**	**$ 93.8**	**$ 90.0**	**$ 78.8**	**$ 78.5**
Total ComEd	**$ 160.9**	**$ 167.7**	**$ 167.1**	**$ 151.6**	**$ 137.1**	**$ 135.0**
Total Portfolio	$ 32.5	$ 32.5	$ 32.5	$ 31.7	$ 29.2	$ 28.9
Grand Total	**$ 193.4**	**$ 200.2**	**$ 199.6**	**$ 183.3**	**$ 166.3**	**$ 163.9**

Program costs—maximum achievable potential

Residential

C&I

Program	2017	2018	2019	2020	2025	2030
Lighting	$ 50.9	$ 47.6	$ 45.5	$ 29.0	$ 21.9	$ 19.0
Fridge & Freezer Recycling	$ 9.7	$ 9.7	$ 9.6	$ 9.5	$ 9.0	$ 8.8
Multifamily	$ 1.4	$ 1.3	$ 1.2	$ 0.6	$ 0.6	$ 0.6
Home Energy Report	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0	$ 12.0
Home Energy Assessment	$ 9.4	$ 10.7	$ 12.2	$ 12.0	$ 16.0	$ 15.8
Appliance Rebates	$ 4.5	$ 6.2	$ 7.4	$ 8.0	$ 8.2	$ 8.5
HVAC and Weatherization	$ 20.2	$ 22.6	$ 23.9	$ 24.5	$ 23.9	$ 22.9
New Construction	$ 0.7	$ 0.7	$ 0.7	$ 0.6	$ 0.4	$ 0.4
Elementary Education	$ 0.4	$ 0.4	$ 0.3	$ 0.3	$ 0.2	$ 0.1
Retail Products Platform	$ 1.4	$ 1.7	$ 1.9	$ 2.0	$ 2.1	$ 2.1
Online Marketplace	$ 0.5	$ 0.49	$ 0.5	$ 0.5	$ 0.5	$ 0.5
Connected Home	$ 3.9	$ 7.9	$ 13.7	$ 18.8	$ 23.6	$ 23.6
Residential Total	**$ 115.0**	**$ 121.2**	**$ 128.9**	**$ 117.8**	**$ 118.3**	**$ 114.2**
Commercial Prescriptive & Custom	$ 164.0	$ 161.8	$ 150.0	$ 135.8	$ 103.9	$ 90.3
Street Lighting	$ 3.2	$ 2.8	$ 1.4	$ 0.6	$ 0.3	$ 0.8
Midstream Incentives	$ 10.1	$ 10.7	$ 9.7	$ 8.4	$ 7.0	$ 7.2
C&I New Construction	$ 10.0	$ 10.0	$ 9.5	$ 9.5	$ 8.6	$ 7.4
Small Business	$ 60.2	$ 59.5	$ 56.5	$ 52.8	$ 36.0	$ 35.6
Retrocommissioning	$ 14.3	$ 13.8	$ 11.9	$ 9.8	$ 10.4	$ 10.0
Data Center	$ 2.3	$ 2.3	$ 2.3	$ 2.3	$ 2.2	$ 2.2
AirCare+	$ 0.8	$ 1.1	$ 1.2	$ 1.3	$ 1.3	$ 1.3
Multifamily Common Area	$ 2.3	$ 2.1	$ 2.0	$ 1.8	$ 1.3	$ 1.0
Industrial Systems	$ 14.5	$ 16.4	$ 14.4	$ 12.9	$ 12.1	$ 12.0
Industrial Custom	$ 7.0	$ 8.2	$ 5.5	$ 1.8	$ 2.2	$ 5.1
Strategic Energy Management	$ 1.6	$ 2.1	$ 2.3	$ 2.3	$ 1.9	$ 1.7
C&I Total	**$ 290.5**	**$ 290.9**	**$ 266.9**	**$ 239.3**	**$ 187.2**	**$ 174.8**
ComEd Total	**$ 405.5**	**$ 412.1**	**$ 395.8**	**$ 357.1**	**$ 305.5**	**$ 289.0**
DCEO	$ 32.5	$ 32.5	$ 32.5	$ 31.7	$ 29.2	$ 28.9
Grand Total	**$ 438.0**	**$ 444.6**	**$ 428.4**	**$ 388.8**	**$ 334.7**	**$ 317.9**
% of Program potential spend	227%	222%	215%	212%	201%	194%

Levelized costs

Program	Levelized $ per kWh	
	Program	Max
Residential		
Lighting	$ 0.030	$ 0.036
Fridge & Freezer Recycling	$ 0.062	$ 0.066
Multifamily	$ 0.043	$ 0.043
Home Energy Report	$ 0.084	$ 0.092
Home Energy Assessment	$ 0.163	$ 0.189
Appliance Rebates	$ 0.080	$ 0.094
HVAC and Weatherization	$ 0.097	$ 0.088
New Construction	$ 0.182	$ 0.279
Elementary Education	$ 0.089	$ 0.089
Retail Products Platform		$ 0.040
Online Marketplace		$ 0.020
Connected Home		$ 0.245
DCEO	$ 0.149	$ 0.149
C&I		
Commercial Prescriptive & Custo	$ 0.030	$ 0.060
Street Lighting	$ 0.020	$ 0.056
Midstream Incentives	$ 0.012	$ 0.027
C&I New Construction	$ 0.022	$ 0.022
Small Business	$ 0.019	$ 0.038
Retrocommissioning	$ 0.037	$ 0.016
Data Center	$ 0.014	$ 0.057
AirCare+	$ 0.089	$ 0.054
Multifamily Common Area	$ 0.039	$ 0.052
Industrial Systems	$ 0.106	$ 0.150
Industrial Custom	$ 0.033	$ 0.048
Strategic Energy Management	$ 0.022	$ 0.044
DCEO	$ 0.054	$ 0.054

Cost-effectiveness

Scenario	TRC Costs ($Mil)	TRC Benefits ($Mil)	Net TRC Benefits ($Mil)	TRC Test
Program Achievable	1,144	4,546	3,402	4.0
Maximum Achievable	1,935	8,126	6,191	4.2

Next steps

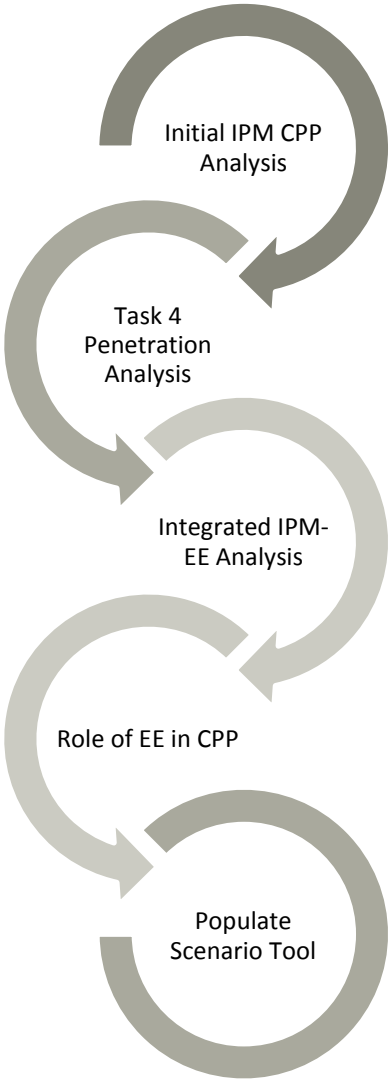
- Incorporate CHP
- Calibrate achievable forecasts using propensity analysis
- Run Clean Power Plan Analysis
- Sensitivity Analysis

Assessing Impacts of the Clean Power Plan

- Design choices by states across many state plan components will determine outcomes on power market behavior – prices, investments, closures – and the role of energy efficiency
- ICF's scenario-based state plan evaluation tool will evaluate alternative plan designs
- Tool relies on IPM analysis to project values for key metrics of interest
- Achievable energy efficiency potential estimates will be isolated to quantify its value in Clean Power Plan compliance
- Results will allow ComEd to quantify relative benefits of alternative design plans and value trade-offs among design components

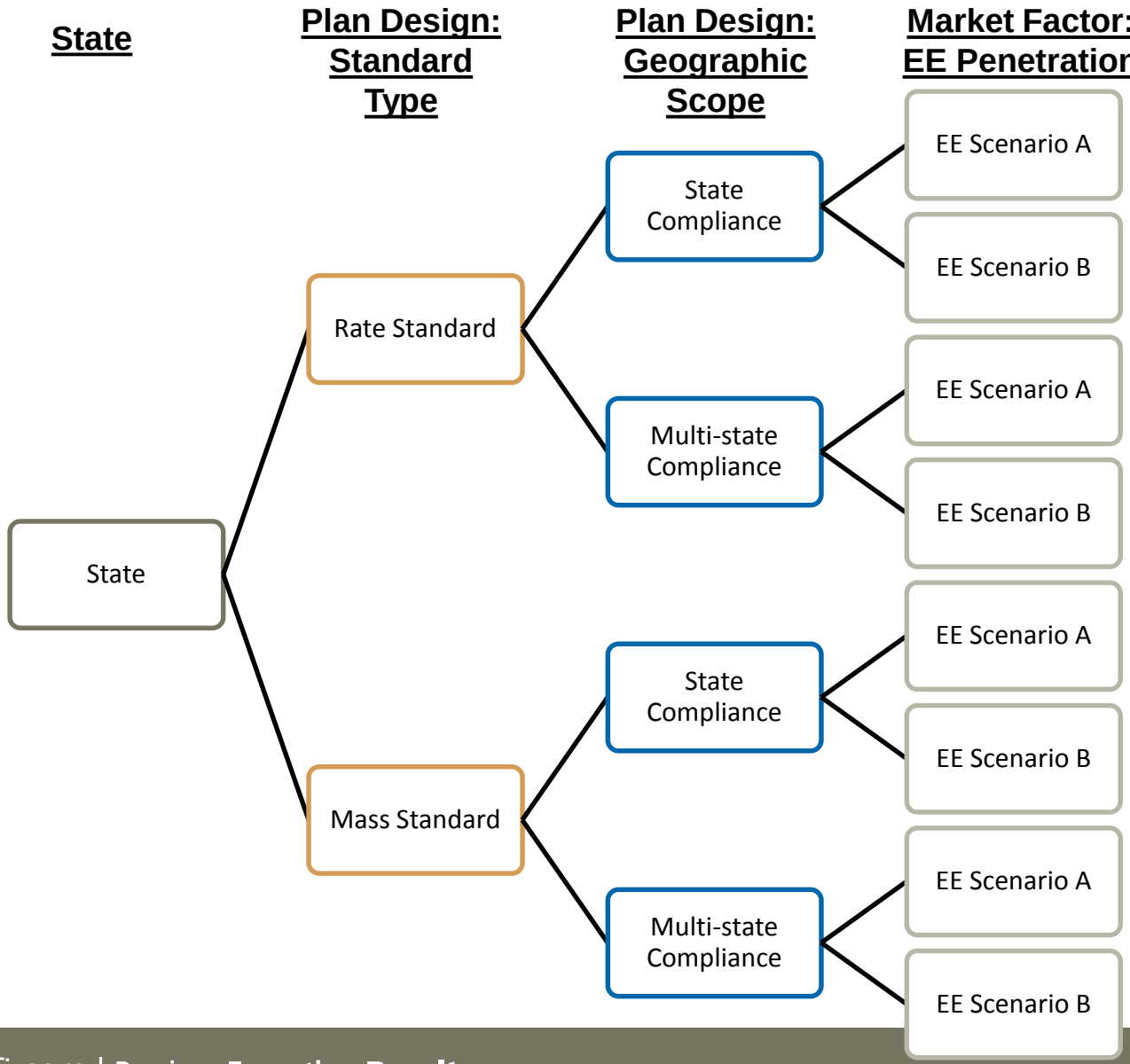
ICF uses its Integrated Planning Model (IPM), the same model used by EPA for its analysis, to support utilities, NGOs, and other stakeholders in evaluating the implications of the Clean Power Plan for their businesses and states

ICF's Approach to Evaluating the Interaction of the Clean Power Plan and EE



- Step 1: Perform initial power sector analysis of the Clean Power Plan (CPP) based on EPA assumptions for two potential CPP state plan design scenarios
- Step 2: Integrate the power and CO2 credit price projections from that analysis with the achievable potential analysis to determine potential EE penetration level scenarios
- Step 3: Based on those EE scenarios, analyze a full set of CPP state plan design scenarios for Illinois
  - The following page shows the potential CPP plan designs
- Step 4: Generate projections from IPM for a number of metrics to evaluate the benefit of EE to state CPP compliance and the impact of CPP on EE penetration
  - The metrics are shown on the following page on the right
- Step 5: Populate spreadsheet-based scenario tool with projections to provide ComEd with ready access to projections and key findings

Scenario Tool Quantifies Relative Benefits of Alternative State Plan Designs Across Several Metrics



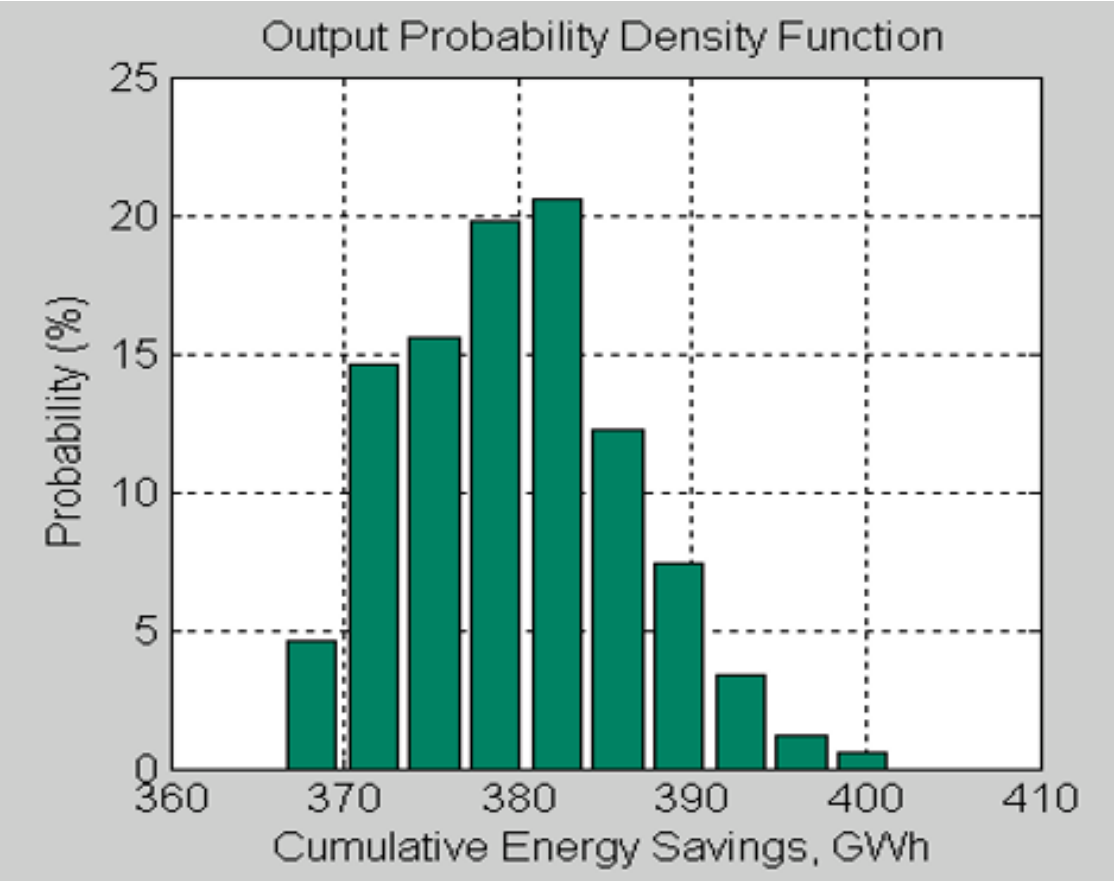
Metrics for Evaluation

- Production Costs
- Wholesale Prices
- Retail Rates
- Payments to EE (Rate Standard)
- CO2 Emissions
- CO2 Credit Prices (Trading)

Sensitivity Analysis & Scenario Analysis

- Investigate impacts of uncertainty around key measures and program assumptions
  - HIMs
  - Program assumptions
  - NTG
  - Some utility assumptions, e.g. rates
- Why do sensitivity analysis?
  - Recognize uncertainty
  - Identify and manage portfolio risks, and opportunities
  - As market penetration of distributed energy resources, or DERs (EE, DR, DG, Storage) increases, forecasting needs shift from:
    - **Deterministic**: Build y generation to meet x load, to
    - **Probabilistic**: Multiple DER penetration and other market scenarios
      - Meet system engineering needs optimally at specific locations, e.g., capacity constraints
      - Requires efficient pricing and policy framework

Sensitivity Analysis



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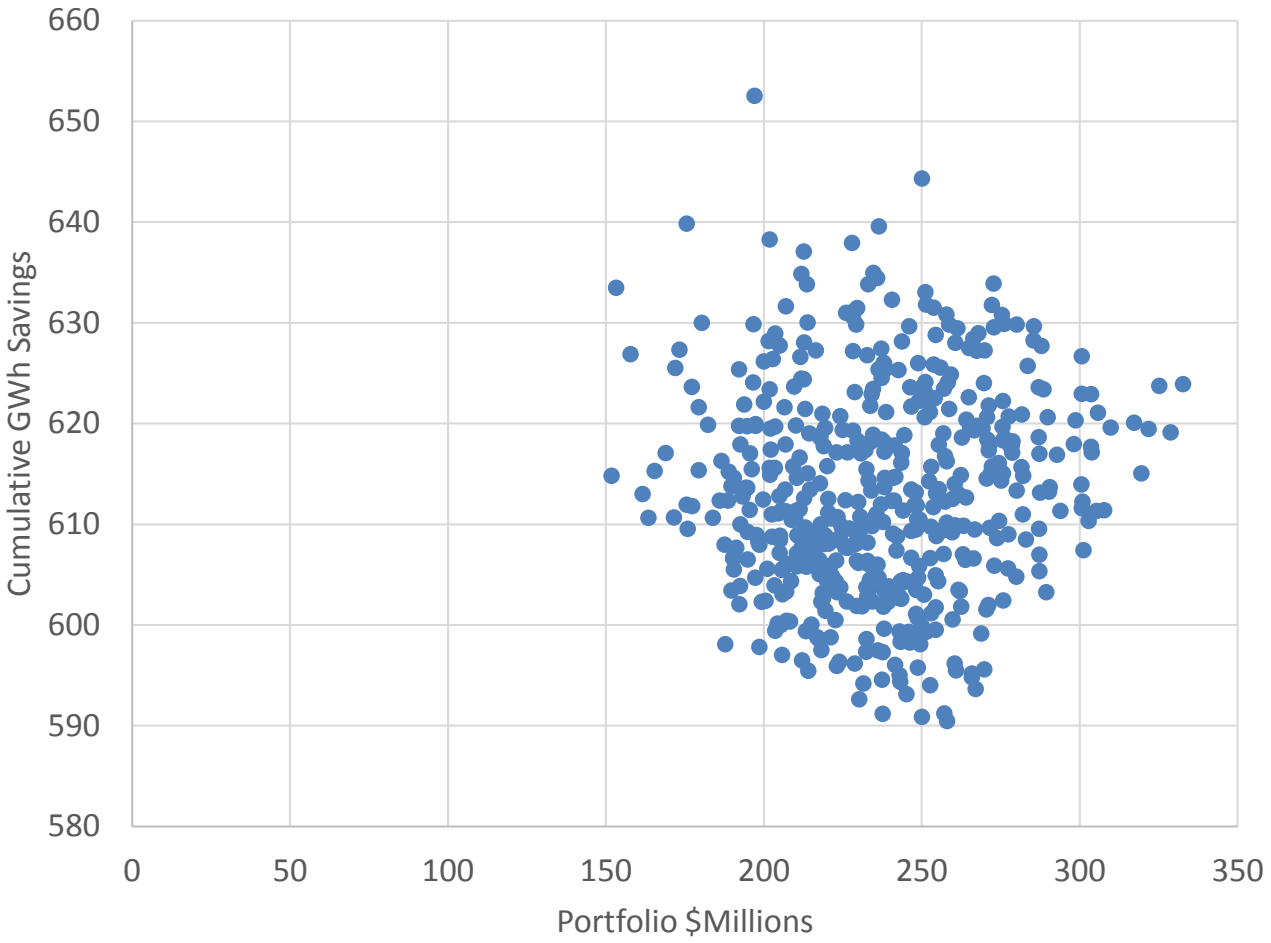
Sensitivity analysis



Graph illustrative only

Emerging tech

Measure Source	Measure Name	Principal Applicable Sector	End Use	Measure Type
DOD ESTCP	Energy Efficient Phase Change Materials (PCM) Insulation	Commercial	Building Envelope	Walls, Roof, & Floors
E3T	Daylight Redirecting Window Film	Commercial	Building Envelope	Windows
E3T	Engineered Window Louvers for Daylighting	Commercial	Building Envelope	Windows
E3T	Vacuum Insulation Panels	Commercial	Building Envelope	Walls, Roof, & Floors
DOD ESTCP	Air Source Cold Climate Heat Pump	Commercial	HVAC	Space Heating & Cooling
DOD ESTCP	Innovative Phase Change Approach for Significant Energy Savings	Commercial	HVAC	Space Cooling
E3T	HVAC Embedded Fault Detection and Diagnostics	Commercial	HVAC	Other
DOD ESTCP	NDW Cognitive Energy Management System	Commercial	Other	Energy Management
DOD ESTCP	Converged Energy Management Control System	Commercial	Other	Energy Management
DOD ESTCP	Collaborative Building Energy Management and Control	Commercial	Other	Energy Management
E3T	Condensing Residential Clothes Dryers	Residential	Appliances	Appliances
E3T	Networked Home Energy Automation Controls	Residential	Other	Energy Management

* DOD ESTCP = U.S Department of Defense Strategic Environmental Research and Development

* E3T = The Bonneville Power Administration's (BPA) Energy Efficiency Emerging Technology (E3T)

Combined Heat & Power

Evaluating the Potential for ComEd CHP

- ICF used the CHPower™ model to evaluate the technical and economic potential for CHP in Commonwealth Edison's territory, with market penetration estimates through 2030
- The analysis only considers the most economically efficient CHP technologies, as they are applied to ComEd's customer base
- Information required to evaluate economic potential and 2017-2030 penetration forecast
  - ComEd Technical Potential for CHP
  - Current electric and gas prices
  - Electric and gas rate escalation
  - CHP technology cost and performance
  - Applicable CHP incentives
    - 10% Federal ITC
    - ComEd CHP Program: 7 cents/kWh for first-year production (capped at $2 Million)

ComEd Technical Potential for CHP

- ICF has identified 4.7 GW of onsite CHP potential at 5,616 sites within ComEd's territory
- The capacity is split almost evenly between the industrial and commercial sectors
  - 2,113 MW industrial (primarily in chemical, refining, and food processing)
  - 2,546 MW commercial (primarily in colleges and commercial buildings)
- Majority of technical potential (3.2 GW) comes from high load factor applications – CHP operates at full load 24/7, nearly year-round (industrial, hospitals, universities, military, etc.)
  - These applications also tend to have the strongest economics for CHP
- Remaining potential comes from low load factor applications – CHP only operates at full load during operational hours, often shutting down for nights and weekends/holidays (office buildings, retail, etc.)

Electric Rates and Escalation

- Performed Bottom-up rate analysis on ComEd applicable tariffs.
  - Used the BES and RDS tariff schedules for medium, large, very large, extra large and high voltage load customers (depicted below)

Tariff Assumption		Medium Load Delivery	Large Load Delivery	Very Large Load Delivery	Extra Large Load Delivery	High Voltage Delivery
Voltage		Secondary	Secondary	Primary	Primary	Trans.
Capacity Assumption (kW)		275	750	3,000	12,500	40,000
	Load Factor	50-500kW	500-1,000kW	1-5MW	5-20MW	>20MW
Retail Rate ($/kWh)	High Load Factor	$0.0798	$0.0797	$0.0773	$0.0765	$0.0664
	Low Load Factor	$0.0877	$0.0890	$0.0854	$0.0843	$0.0694
	Cooling	$0.1086	$0.1126	$0.1067	$0.1048	$0.0777
Avoided Cost of Electricity ($/kWh)	High Load Factor	$0.0694	$0.0690	$0.0674	$0.0670	$0.0612
	Low Load Factor	$0.0721	$0.0731	$0.0706	$0.0700	$0.0616
	Cooling	$0.0773	$0.0807	$0.0770	$0.0762	$0.0622
% Avoided Cost	High Load Factor	87%	87%	87%	88%	92%
	Low Load Factor	82%	82%	83%	83%	89%
	Cooling	71%	72%	72%	73%	80%

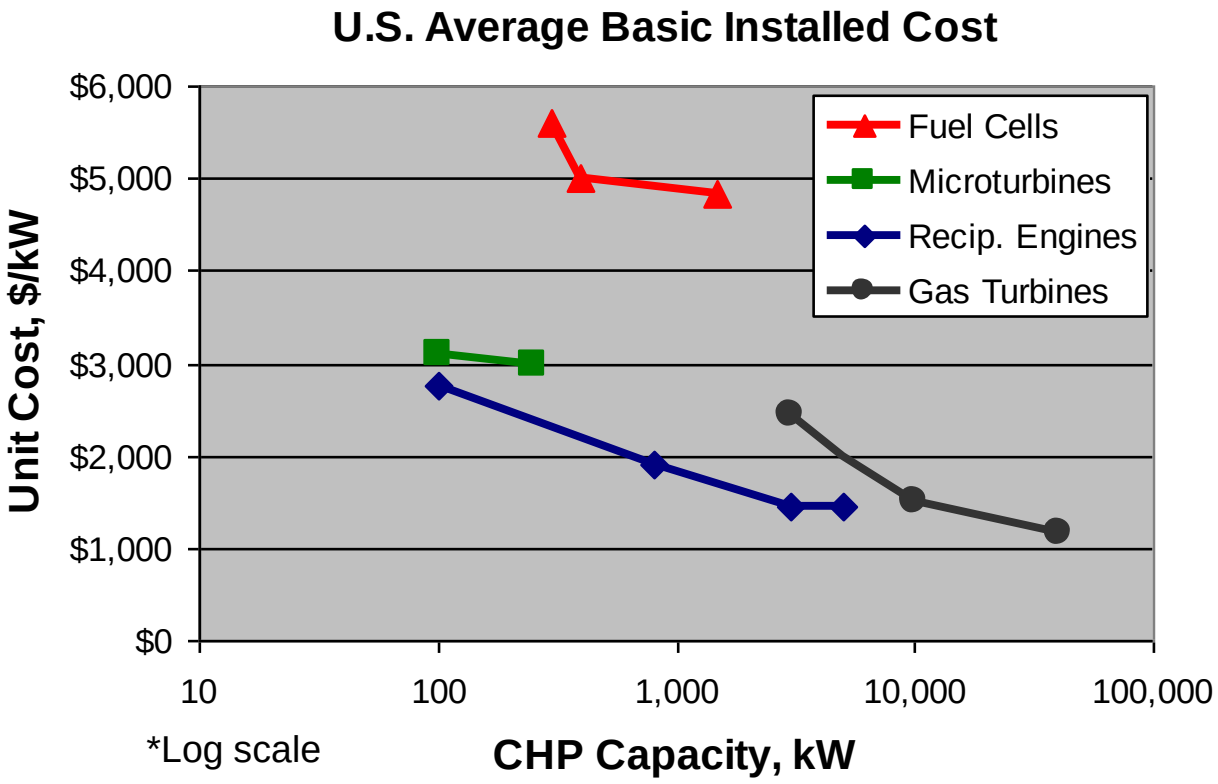
- Applied escalation rate of 0.93% to the 2015-2030 analysis
  - 2015 EIA Annual Energy Outlook's average electricity escalation from 2015-2030 for the East North Central Census Division

Natural Gas Rates and Escalation

- EIA state-specific average industrial, commercial, and citygate gas prices are taken on a 12 month rolling average basis.
  - Rates range from average commercial price (for smallest installations) to average citygate price + $1/MMBtu (for the largest installations)
  - Additional fuel purchases for CHP are assumed to lower gas rates by 10%
- Applied regional gas growth rates from EIA Annual Energy Outlook
  - 1.92% growth rate from 2015-2030 for East North Central Census Division – calculated prices for the midpoint of each 5-year range

	Retail NG Rate				
CHP Size Bin	50-500 kW	500-1,000 kW	1-5 MW	5-20 MW	> 20 MW
Customer Size	275	750	3000	12500	40000
2015-2020	$9.41	$8.47	$6.21	$5.68	$5.17
2020-2025	$10.35	$9.31	$6.83	$6.25	$5.69
2025-2030	$11.38	$10.24	$7.51	$6.87	$6.25

CHP Technology Costs and Assumptions



- Available Incentives
  - The base case includes the 10% Federal Investment Tax Credit and the ComEd incentive offering 7 cents per kWh for the first year of operation ($2 million cap)

- Focus on 50 kW – 40 MW (recips and gas turbines)
  - Capital cost
  - Heat rate
  - Thermal availability
  - Operating and maintenance
- Capital cost adjustments
  - State-specific construction cost adjustments are incorporated (Army Corps of Engineers Cost Index)
  - Emissions after-treatment
  - Federal investment tax credit
- Payback period based on total costs (w/incentives), gas rates and avoidable electric costs

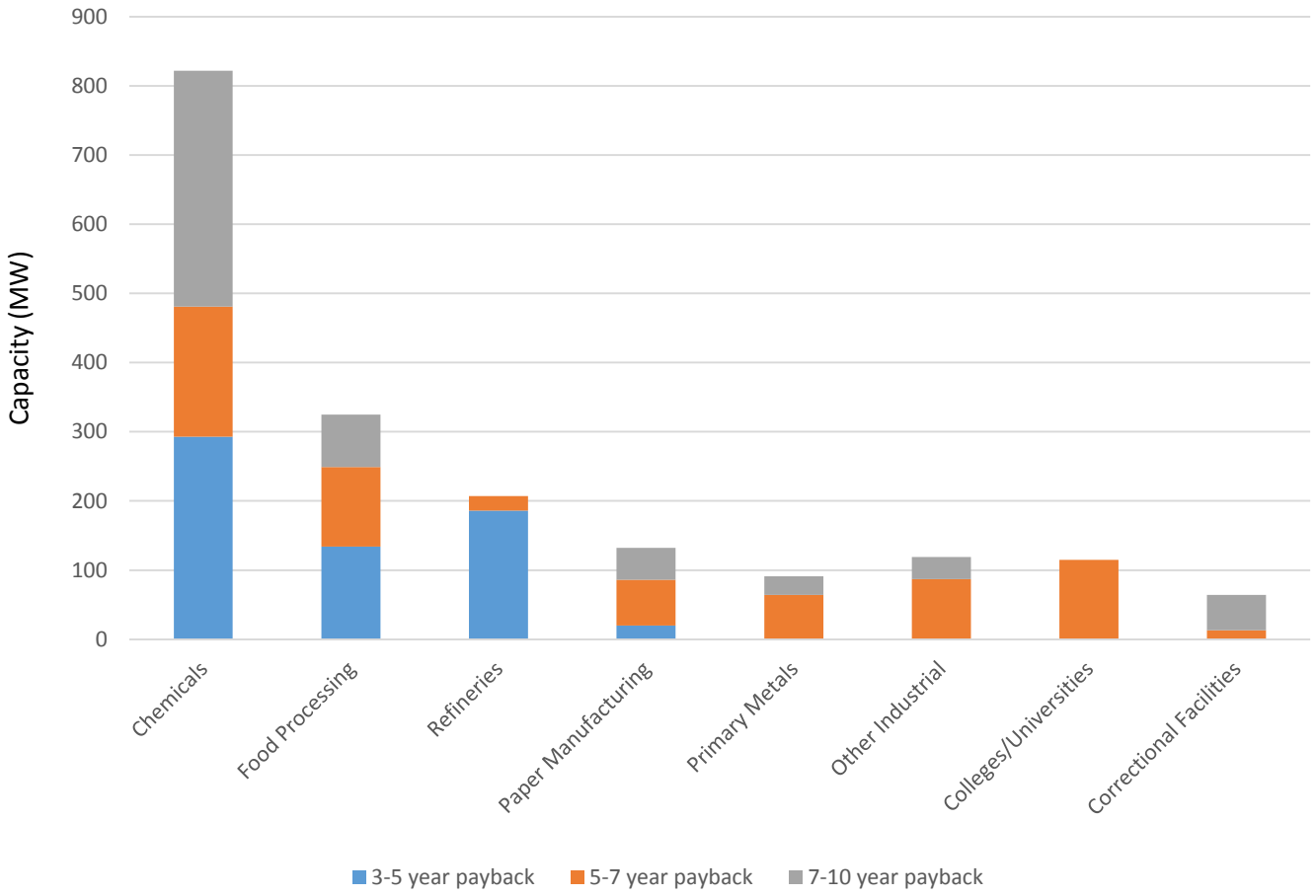
ComEd Economic Potential for CHP

Total Potential for CHP (MW) by Estimated Payback Period Range

	Payback Period					
Application	**<3 years**	**3-5 years**	**5-7 years**	**7-10 years**	**>10 years**	**Total**
High Load Factor - Traditional	0	633	541	585	421	**2,180**
High Load Factor - Cooling	0	0	115	0	925	**1,040**
Low Load Factor - Traditional	0	0	0	0	63	**63**
Low Load Factor - Cooling	0	0	0	0	1,376	**1,376**
All Applications	**0**	**633**	**656**	**585**	**2,785**	**4,659**

- 1.9 GW of economic potential (payback period <10 years)
  - 7 cents/kWh (first year) incentive was applied to all potential installations
  - All economic potential is from high load factor applications
  - 633 MW with payback under 5 years, all from industrial facilities capable of installing >20 MW gas turbines
  - 5-10 year paybacks for other engine and turbine applications >1 MW in size
  - More than 14,000 GWh of annual consumption if all customers with economic potential adopted CHP

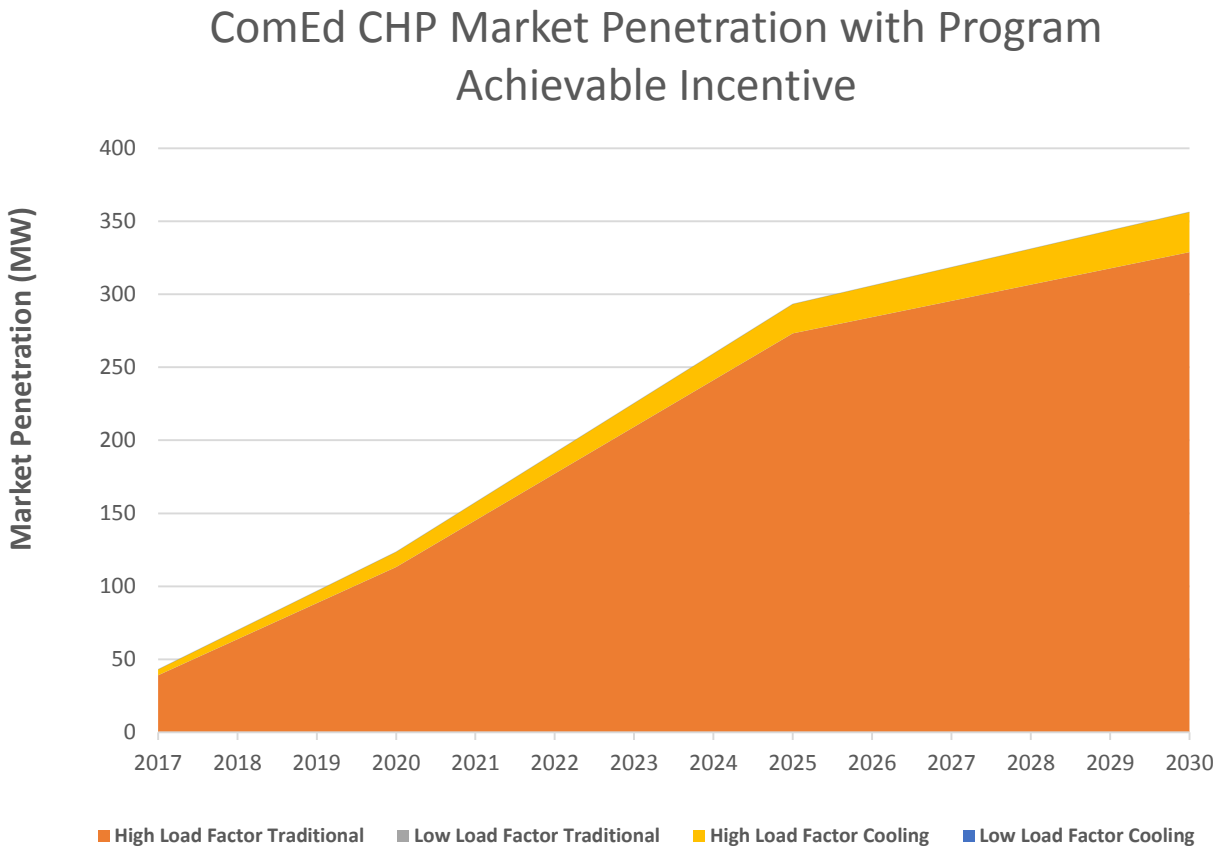
ComEd Economic Potential by Sector



- Economic Potential for CHP comes from industrial facilities, colleges/ universities, and correctional facilities

Program Potential

- Using a Bass diffusion model with payback period acceptance rates, the CHP market penetration through 2030 was estimated with a 7 cents/kWh incentive from 2017-2030

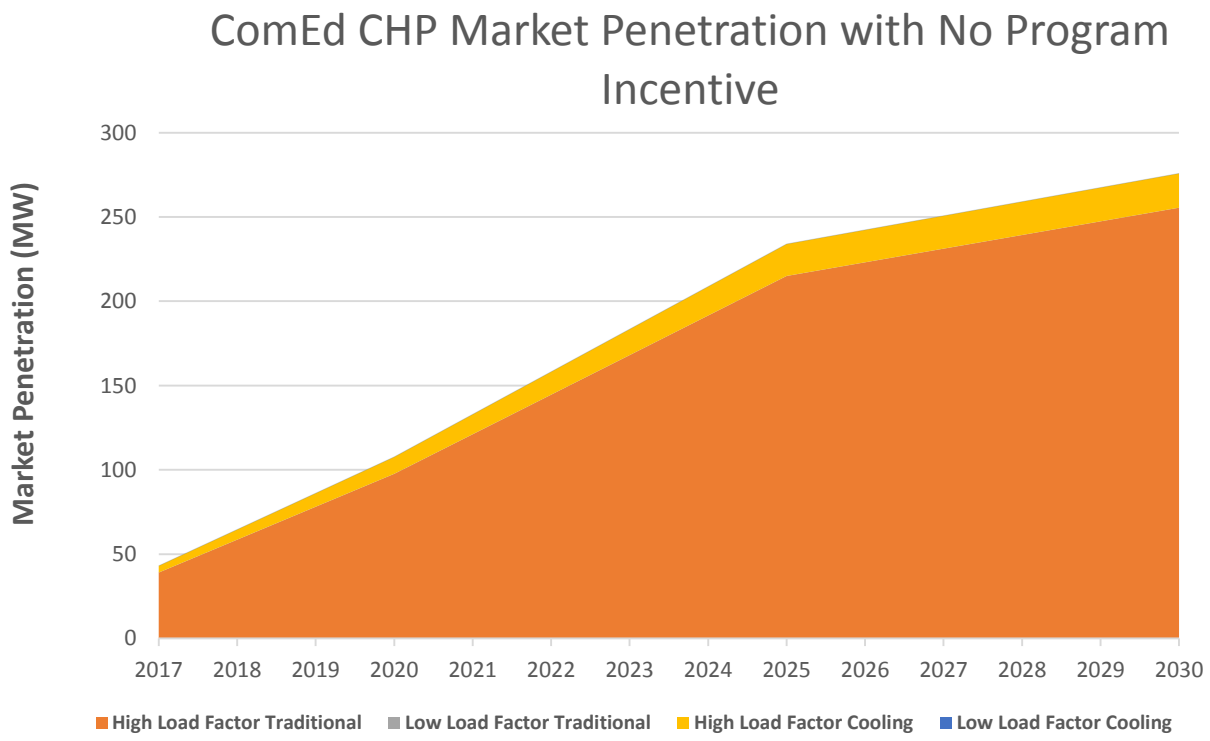


313 MW of new capacity from 2017-2030, consuming over **2,347 GWh** annually by 2030

Program Potential: 313 MW - Naturally Occuring Potential (from next slide) of 233 MW **= 80 MW,** and 600 GWh

Naturally Occurring Potential

- Without incentives payback periods are not as favorable, so market penetration estimates are reduced
  - 5-7 year paybacks for large industrial applications and college campus installations
  - 7-10 year paybacks for high load factor applications 1-20 MW in size



233 MW of new capacity from 2017-2030, consuming over **1,747 GWh** annually by 2030

Next Steps

- Estimate maximum achievable program potential
- Develop final estimates for economic potential, market penetration, and program potential
- Integrate findings into EE potential study