Potential and Goals Studies: Top-Down Stakeholder Presentation 1

Top-Down Study Part 1

February 4th, 2022

California Public Utilities Commission

Agenda

- Introduction & Goals
- What is a Top-Down Potential Analysis?
- Top-Down Methodology
    - Estimating potential
    - Cost modelling
- Results & Implications
    - Findings
    - Next Steps
- Questions to Stakeholders

Introduction & Goals

Context and Timeline

October 2019
Top-Down Approach Requested by Stakeholders

Fall 2020
Guidehouse to Develop Top-Down Prototype

January 2021
Initial Top-Down Approach Presented

July 2021
Draft of Quantitative Analysis Complete

January 2022
Part 1 Top-Down Report Published

Goals of today's presentation

What?

Review what we mean by prototype top-down potential analysis and how it differs from the conventional bottom-up.

How?

Provide a summary of the key steps in the analysis used to derive the projections of potential EE and total system benefit (TSB) presented in the report.

So What?

Share the key insights, and their implications, captured:

- In the development process
- As a result of the projected outputs for select segments

Next Steps

Answer questions and obtain feedback from stakeholders on:

- The materials presented in the report, and here today
- How ongoing development of a top-down potential analysis approach might benefit the CPUC, its stakeholders, and the people and businesses of California.

Prepare stakeholders to provide more specific feedback for next presentation, which will discuss implementation scenarios for a top-down potential analysis approach

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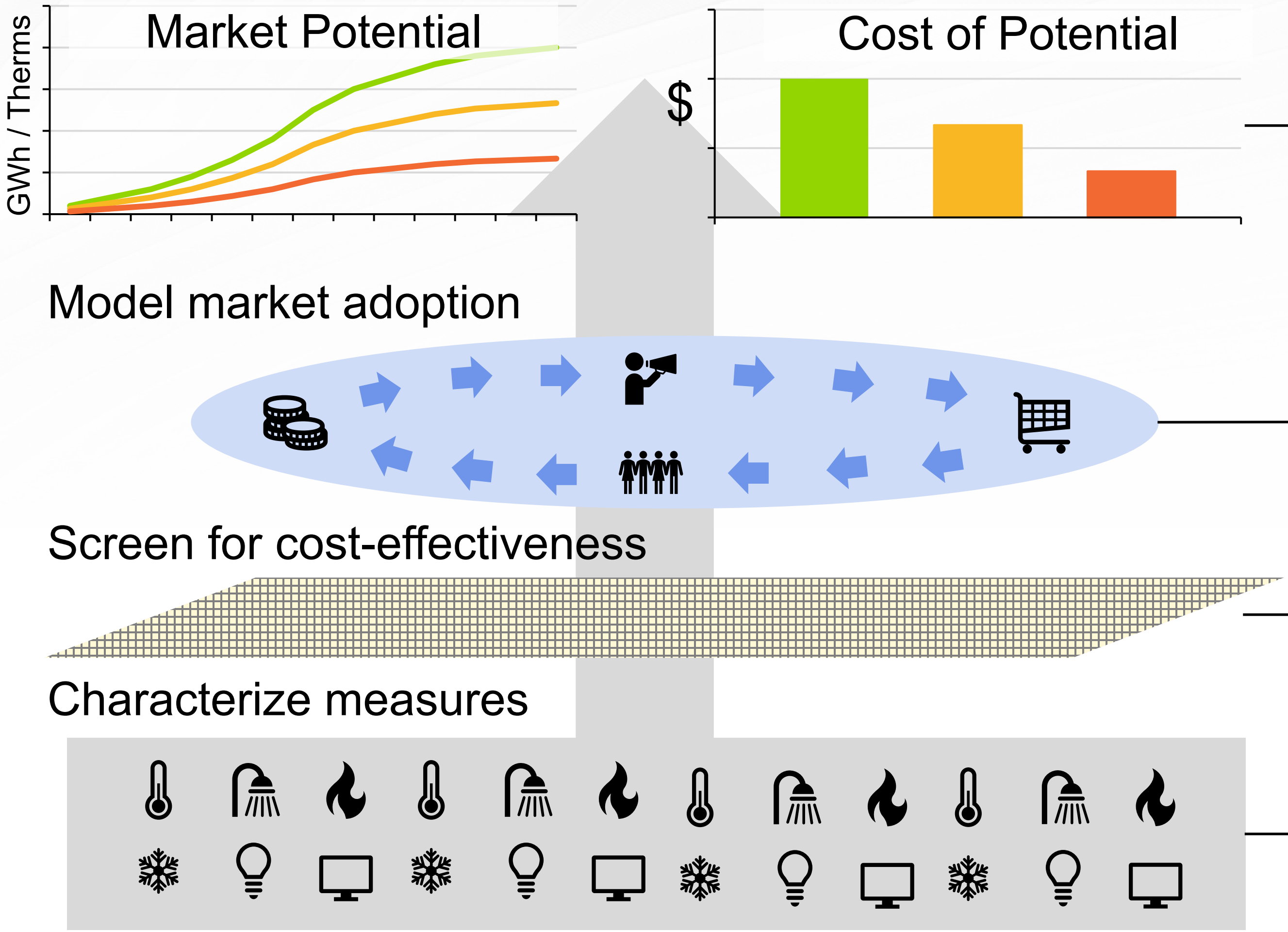
What is a Top-Down Potential Analysis?

What is a “bottom-up” potential estimation approach?

Bottom-up potential estimation is the standard approach in California and most other jurisdictions.



Key outputs of the analysis:

- **How much can we get?**
- **How much will that cost?**

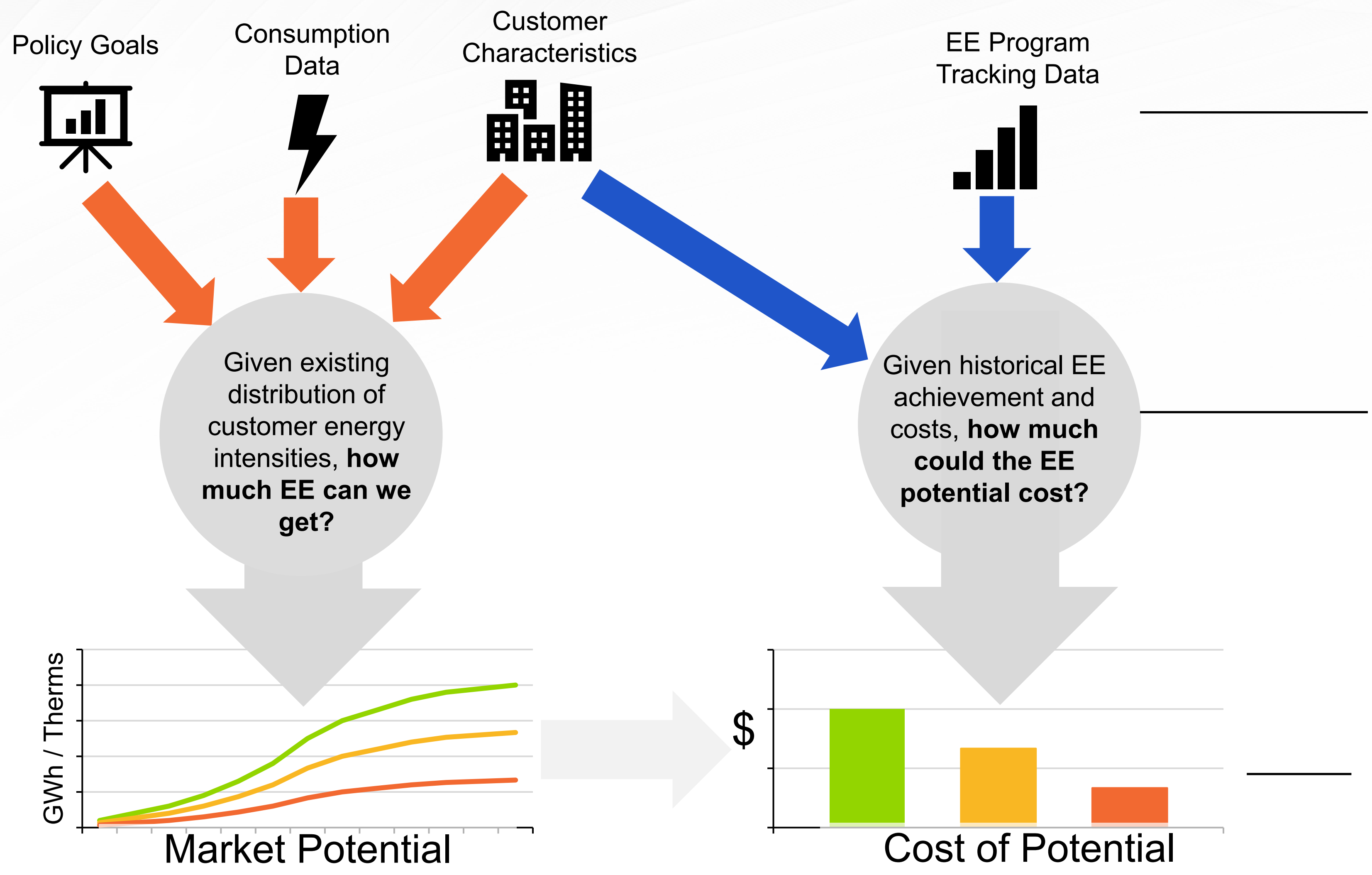
Adoption modeled as function of financial (measure payback) and non-financial (willingness-to-adopt) factors.

Remove all non-cost-effective measures.

- Identify EE measures
- Estimate measure characteristics (e.g., savings, EUL, cost)
- Estimate market characteristics (e.g., # of widgets per home, % that are already efficient, etc.)

What is a “top-down” potential estimation approach?

A top-down approach puts more weight on empirical analysis vs. bottom-up focus on engineering analysis.



Rely as much as possible on observed data (characteristics, consumption, EE acquisition).

Use observed data to estimate relationships between:

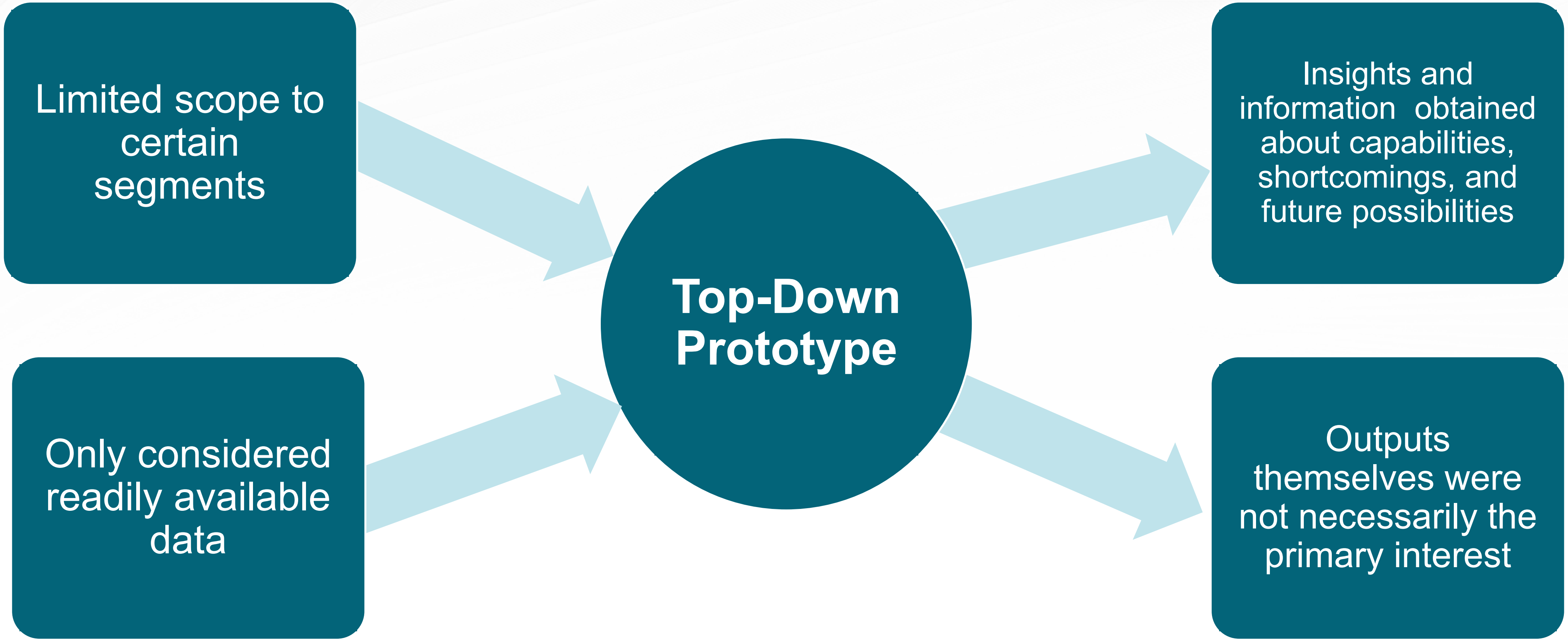
1. Program participation and individual customer energy efficiency (intensity);
2. Tracked savings (or observed consumption) and incremental expenditures.

Carry estimated relationships forward to project different EE potential scenarios and estimate cost of those scenarios.

What are the biggest differences?

Bottom-Up	Top-Down	The Trade-Off: Precision vs. Transparency
Measure-Level (“Widget”) Characterization	**Aggregate End-Use/Segment**	**Output Granularity** • Bottom-up: measure-level detail • Top-down: segment/end-use-level detail **Program Cost Analysis** • Bottom-up costs are forward-looking • Top-down costs reflect historic programs
Deterministic Market Dynamics	**Energy Intensity Comparison & Scenario Projection**	• Bottom-up identifies specific pathway to achievement. • Top-down identifies the consequences of achievement but is agnostic on pathway.

Why is it a “prototype” top-down potential analysis?



***Outputs from the prototype analysis will not be used to set policy or utility goals.**

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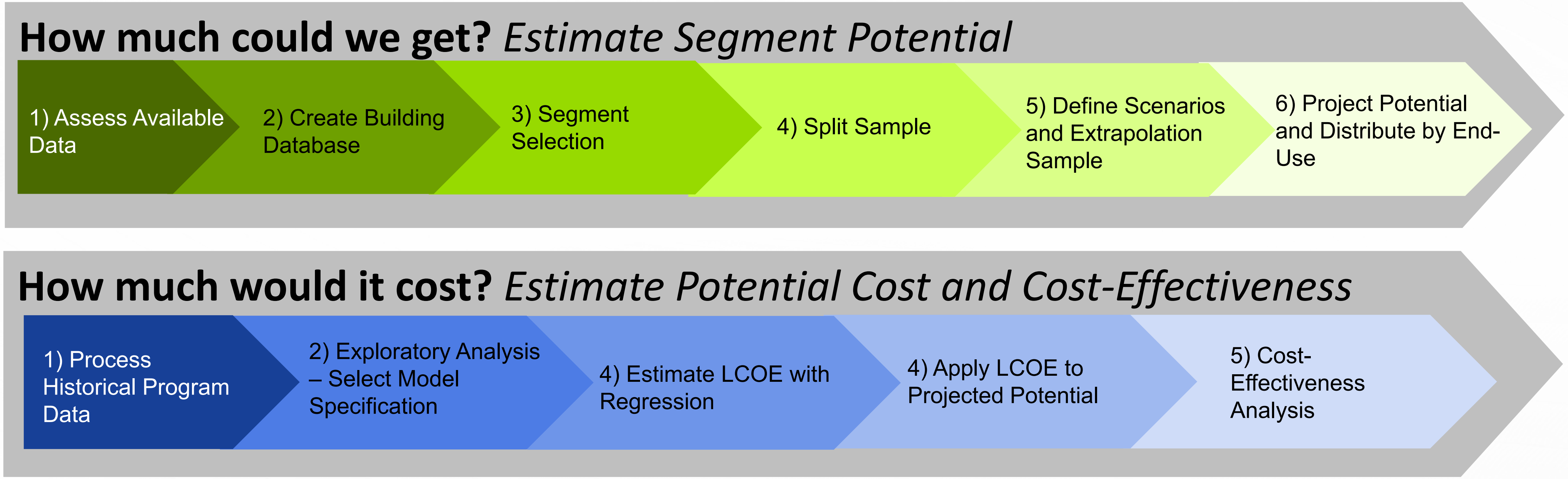
Top-Down Methodology

How was the analysis conducted?

The top-down analysis follows two workstreams



These two workstreams are independent.

- In the **bottom-up modeling**, a measure can only be included in market potential if it is cost-effective.
- In the **top-down analysis**, potential is identified. After that, its cost is estimated based on historic measure and program costs by end-use and segment.

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Approach to Estimating Potential

How much could we get?

Steps 1 through 3.

1. Assess Available Data

Four principal data sets used:

- CEC Building Benchmarking (Floorspace) (2019)
- Utility Account Billing Data (2017 thru 2019)
- IEPR Reference forecast (by segment, end-use)
- CEDARS Program Tracking Data (2017 thru 2019)

2. Create Building Database

Careful validation and data cleaning to match CEC DB to utility data

- CEC Benchmarking DB (Floorspace) (2019)
- Utility Account Billing Data (2017 thru 2019)
- CEDARS Program Tracking Data (2017 thru 2019)

↓

Building Database

3. Segment Selection

Four segments selected:

- Offices (Large)
- Lodging
- Grocery
- Warehouse

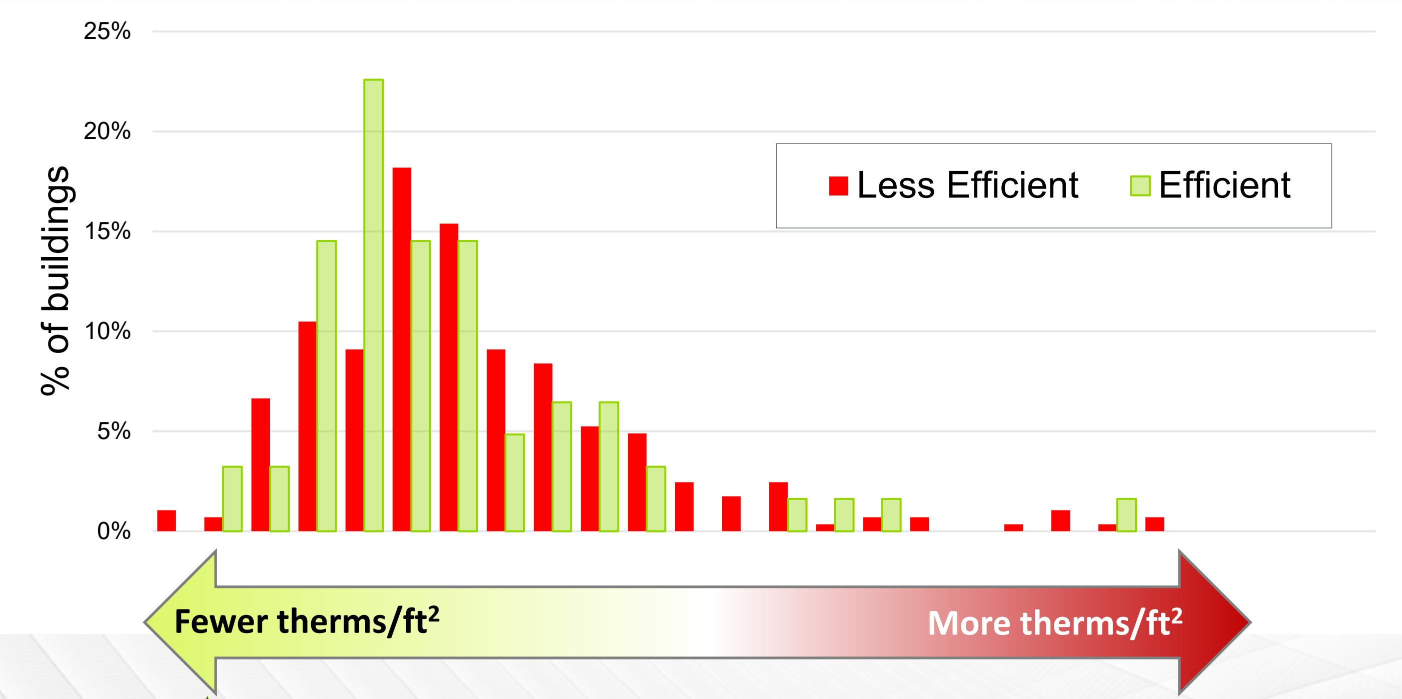
Key considerations for selection were:

- Size of sample
- Consistency within sample
- Sample as % of population

Step 4: Split Sample, Estimate Unit Potential.

- Top-down potential is derived through a comparison of two groups of buildings: *efficient* and *less efficient*.
- Acknowledging the reality of building diversity, this split is using a *proxy* and not energy intensity directly.
- The split is applied based on degree of past IOU program participation (2017 through 2019)

Example: Lodging, Gas



	Efficient	Less Efficient
# of Buildings	62	286
Mean Intensity (therm/ft²)	0.31	0.35

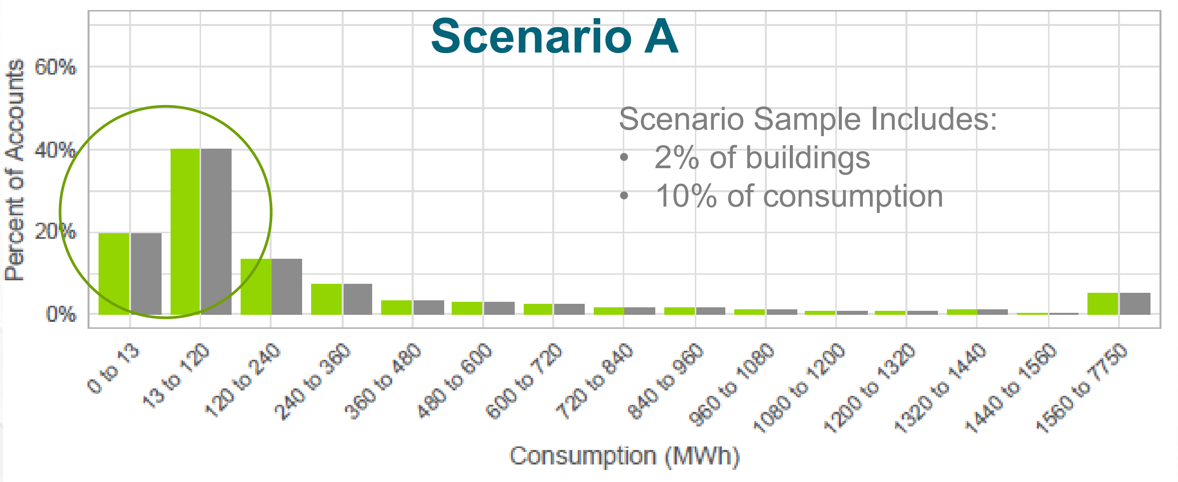
If ~80% of buildings can be improved to match the standards of the ~20% of buildings with recent IOU program participation, **10% savings can be achieved**

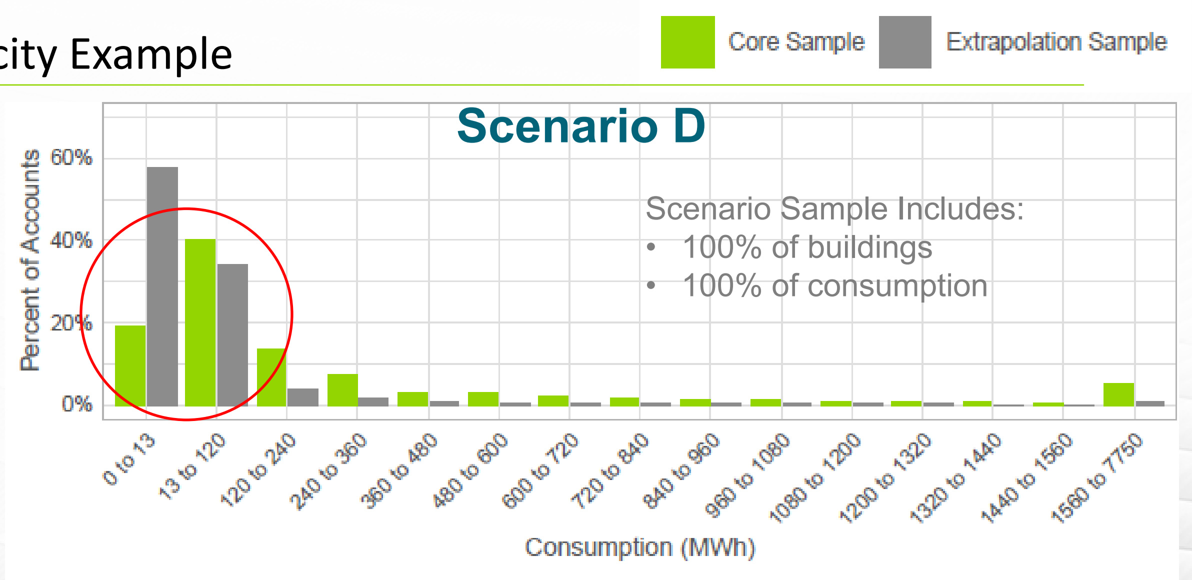
Step 5: Define Scenarios & Extrapolation Samples.

- The CEC building database is confined to buildings >50k ft^2 and not representative of the full commercial sector.
- We consider 4 scenarios to explore trade-off between risk-averse and inclusive extrapolation.

Scenario A: Most risk-averse. No extrapolation beyond database (core sample).	**Scenario C:** Extrapolate to more buildings than Scenario B.
Scenario B: Some extrapolation beyond core sample.	**Scenario D:** Most inclusive. Extrapolate effects estimated in core sample to entire population.

Warehouse, Electricity Example



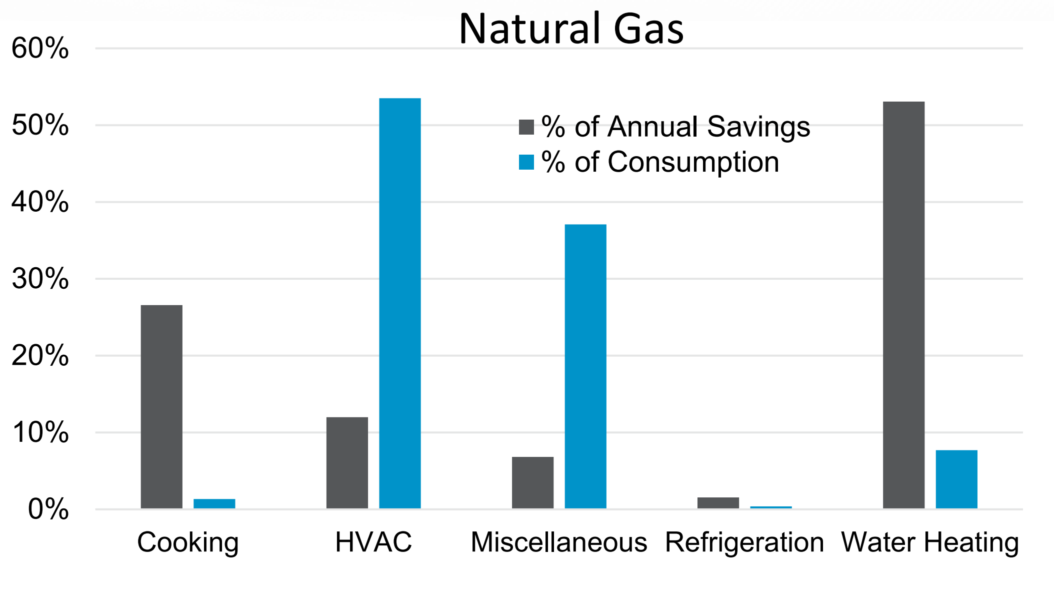


Step 6: Project Potential

- In Step 4, the ultimate/end-state EE potential was estimated for each segment/fuel (e.g., 10% savings for Lodging/Gas) on a *unit* basis.
- In Step 5, the ultimate/end-state EE potential was estimated under different scenarios of applicable population.
- In Step 6, the *pace* (over time) and *distribution* (by end-use) of achievement is estimated.
- Pace is defined by a standard S-shaped adoption curve, assumed to extend over 25 years.
- For the distribution of savings, Guidehouse considered two types of distribution:
  - Reflective of **historical program savings**
  - Reflective of **forecast consumption by end-use**

EE potential must be projected according to the distribution of forecast consumption.

For some end-uses – particularly for gas – there is a major discrepancy between the distribution of historical savings and forecast consumption.
For some scenarios, potential cannot be distributed to match historical savings as it will exceed consumption in that end-use.

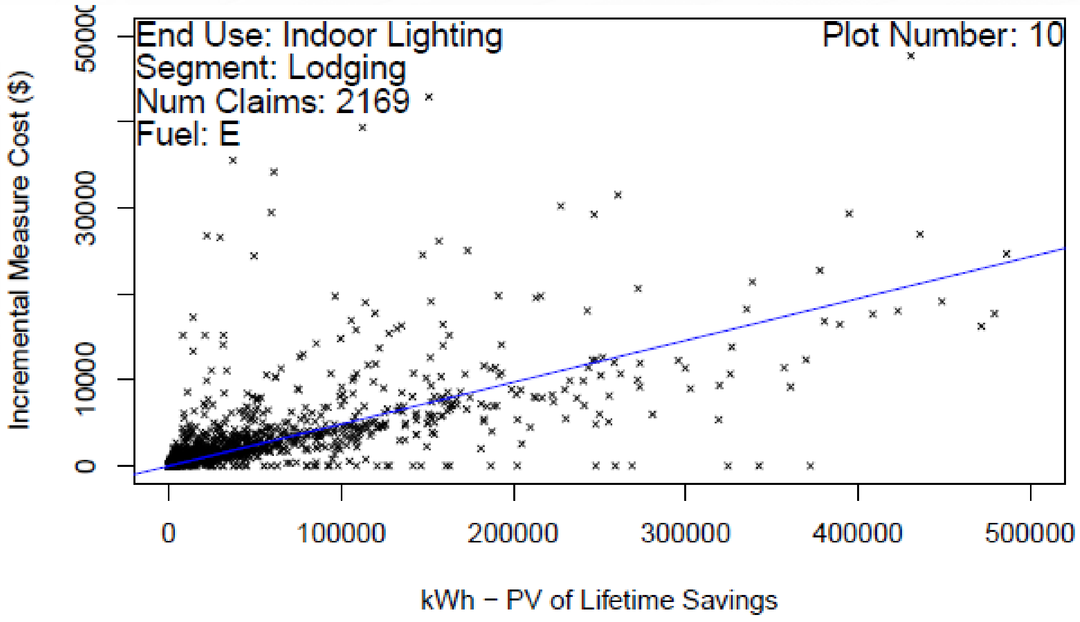


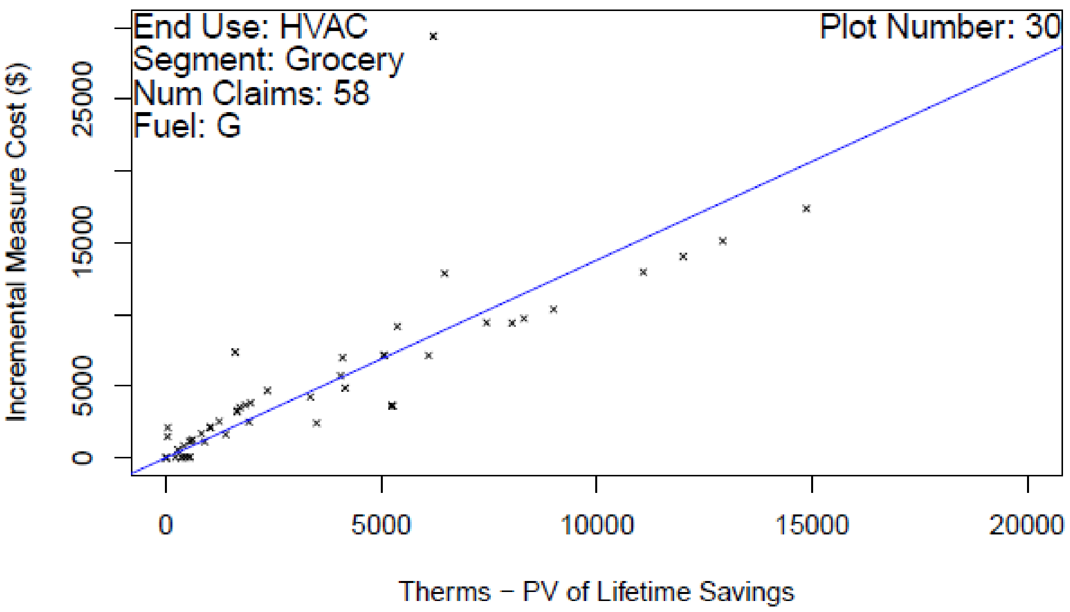
Approach to Estimating Cost and Cost-Effectiveness

How much would it cost?

Without tracking individual measures, a levelized cost of energy (LCOE) approach is required

Example LCOE Estimation by segment, fuel, and end-use





Points: incremental measure cost (Y-axis) & present value of lifetime energy savings (X-axis) pairs for each CEDARS measure

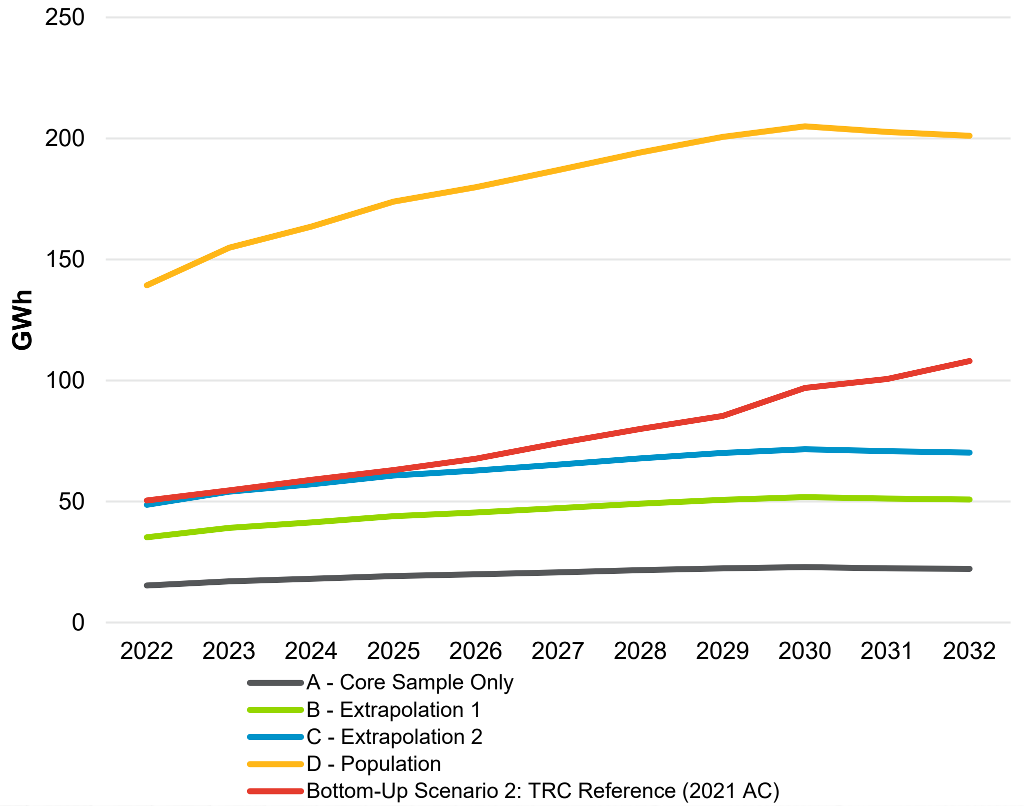
Line: Estimated LCOE. Converting measure cost into an LCOE using its expected useful life (EUL) is essential to track the cost of EE if individual measure installation timing is not known.

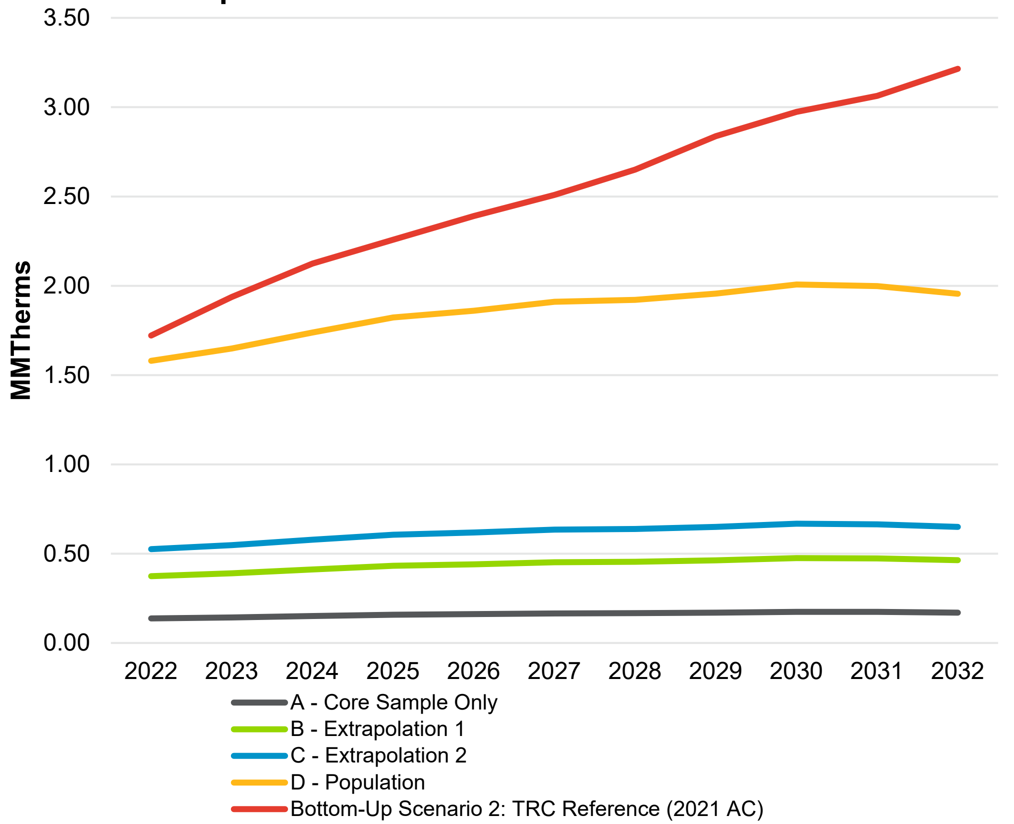
Results and Implications

What did we learn?

Projected Incremental Potential Compared

IMPORTANT: While the bottom-up estimated potential is explicitly a function of benefits (avoided costs) and measure costs, top-down potential is estimated independent of these factors.

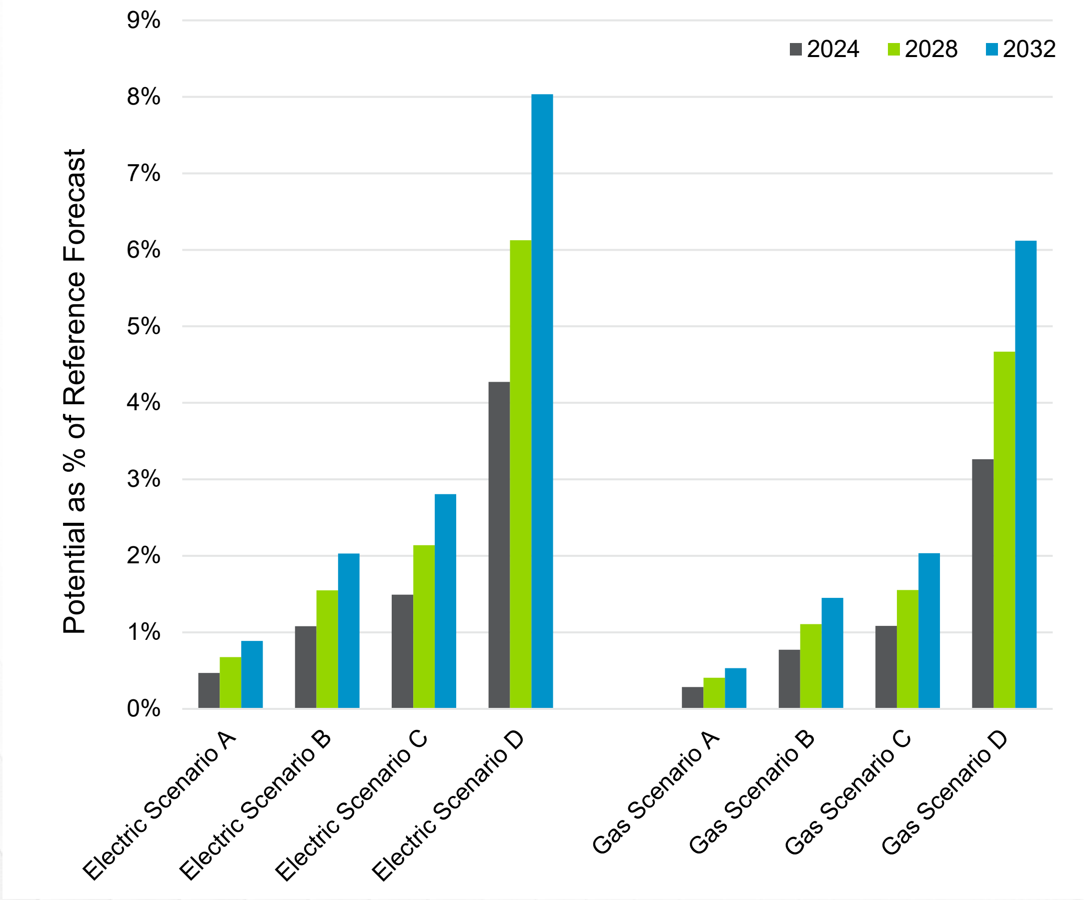




Note: In common units, electricity potential is considerably higher than natural gas potential.

Evaluating potential savings against forecast consumption is an important diagnostic.

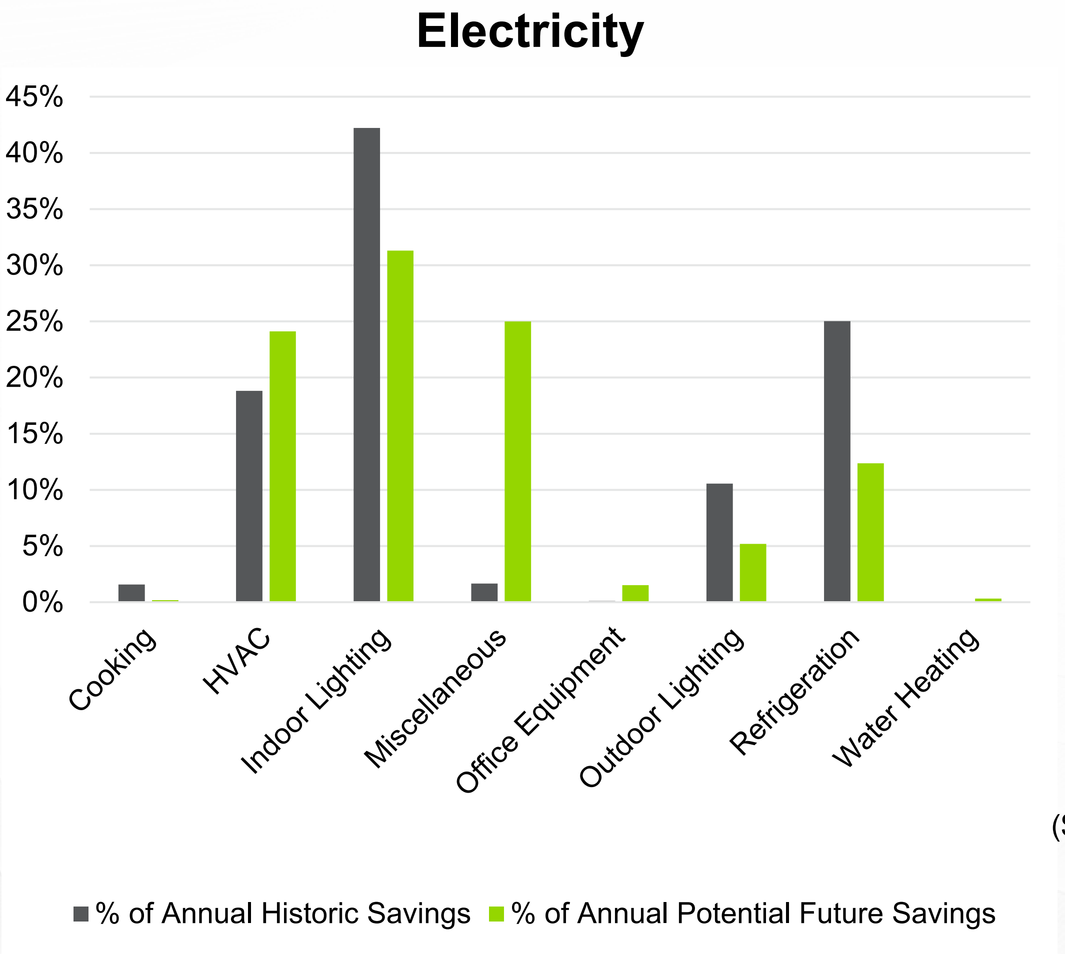
Overall "Cumulative*" Potential as a Percentage of Reference Forecast

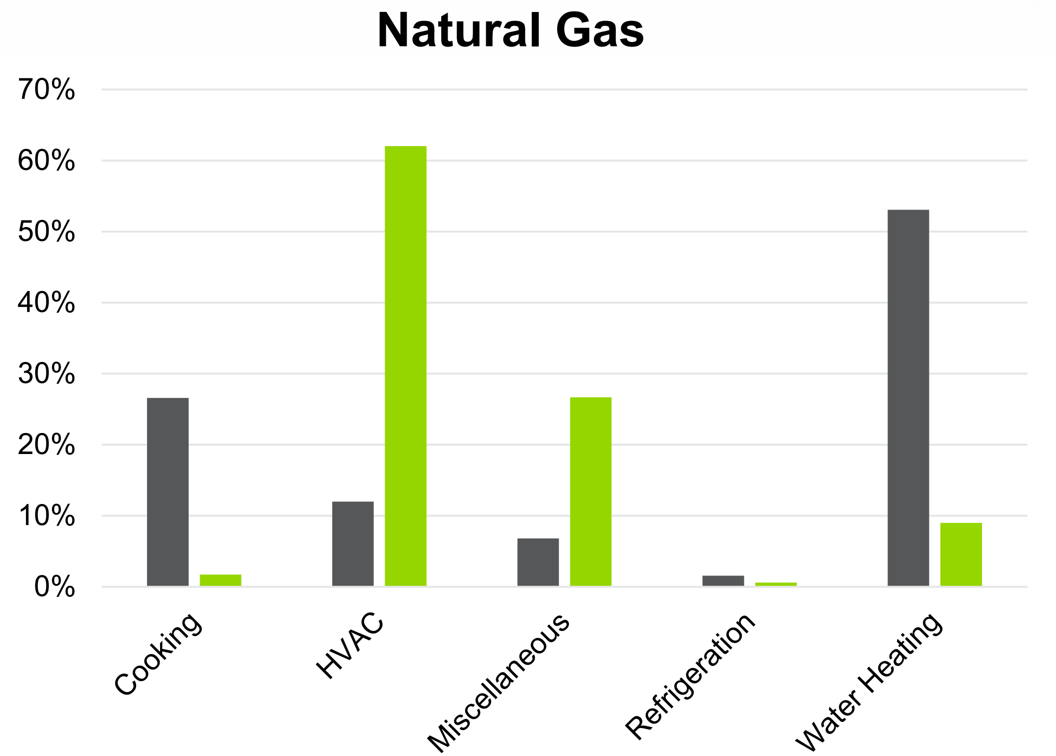


- The top-down analysis projects a potential reduction of as much as
  - 8% of electricity consumption and
  - 6% of natural gas consumption per year by 2032.
- This is derived through a comparison of:
  - The energy efficiency of buildings that have made material efforts in the last 3 years to reduce energy use via participation in EE DSM programs
  - The energy efficiency of those buildings that have not.

** "Cumulative" refers to the savings each year delivered by the cumulative adoption of measures starting in 2022 up to and including the forecast year. This term is used here to aid comparison to the outputs of the bottom-up model.*

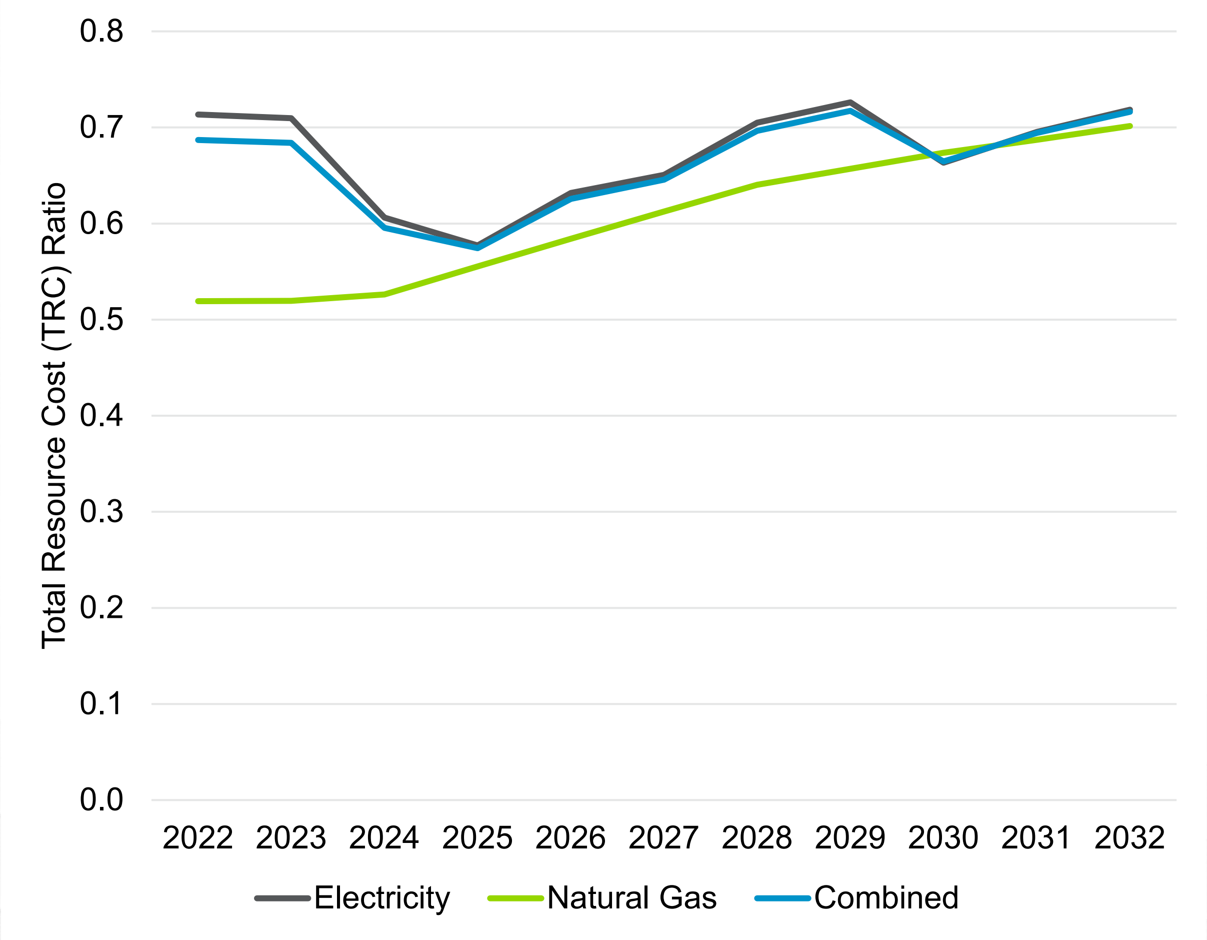
Potential savings patterns are proportionate to forecast consumption and look different from historic savings





	Cooking	HVAC	Miscellaneous	Refrigeration	Water Heating
LCOE ($/therm):	$0.53	$1.21	$1.22	$2.05	$0.41

Projected potential is not cost-effective <u>at historical cost of acquisition</u>



- Potential is estimated independently of cost – unlike bottom-up where potential is a *function* of cost-effectiveness.
- Bottom-up and top-down potential both use the same benefits (avoided costs)
- Key difference is that top-down carries historical costs forward – result: in aggregate potential isn't cost-effective.
- To expand energy efficiency going forward IOUs must significantly reduce savings acquisition costs.

Analysis Findings

What does the top-down analysis suggest for potential energy efficiency?

- **The "low-hanging fruit" are disappearing**.
  - Historically, more than 75% of natural gas savings have been obtained predominantly from water heating and cooking end-uses, which account only for ~10% of consumption.
  - Disproportionate historic achievement in these end-uses likely due to low cost of acquisition.
  - For electricity, historic savings are better aligned with consumption, but still gravitate to smaller consumption (but low-cost) end-uses like refrigeration compared to HVAC.
- **For programs in future to be cost-effective, acquisition costs must fall dramatically.**
  - When EE is acquired by end-use proportional to consumption, using historical costs, it is not cost-effective.
  - Costs of EE acquisition (measure and program costs) must fall dramatically going forward to ensure program cost-effectiveness.

Prototype Development Findings

What does the analysis tell us about the top-down approach?

- **More data are needed.** Given the currently available data, the top-down approach is at present an unsuitable as a complete replacement for the bottom-up approach for estimating commercial sector energy efficiency potential.
- **More segmentation is needed.** The precision of top-down commercial sector potential estimation could be significantly improved with additional segmentation to better control for building heterogeneity, for example by distinguishing conventional, limited assortment, and supercenter grocery stores.
- **Systematic examination of historical EE costs provides valuable insight.** Understanding historical costs is important context when contemplating future costs, cost-effectiveness, and planned achievement by end-use.
- **Top-down analysis offers increased transparency.** Moving away from widget-level detail, stock-and-flow and consumer choice modeling simplifies review and sensitivity testing, though it also decreases precision (i.e., measure-level) of outputs..

Questions to Stakeholders

Methodology and Values

- What are your thoughts on the benefits of a Top-Down approach compared to the Bottom-Up approach historically used?
- How important is the widget level detail in the Bottom-Up?
  - Do PAs use the widget level detail in building their portfolios?
  - What use case does the widget level detail satisfy?
  - Are these cases where a widget-based approach is not appropriate?
- The presented Top-Down approach is agnostic to market dynamics (e.g. stock turnover, customer decisions, etc.) whereas the Bottom-Up runs primarily on market dynamics. How important is the modelling of market dynamics for you?
  - If it is important, in what ways should it be integrated into the Top-Down approach?

Datasets

- What datasets could be useful to integrate into this Top-Down approach to improve its reliability and aid its expansion to other sectors and segments?
- The presented Top-Down approach uses a normalization baseline of commercial building floorspace. What other potential baselines could be explored including applications to other segments (e.g. industrial, agricultural)?

Going Forward

- Given your previous exposure to previous PG studies and the Bottom-Up approach, what do you think is the long-term potential for this Top-Down approach in this study?
- How can CPUC best take advantage of the granularity and extensive development of the Bottom-Up approach with the comparative transparency and simplicity of the Top-Down?
- Consider the following options:
    - Context & Credibility: Elements of the top-down analysis can be used to contextualize, add nuance to analysis of bottom-up modeling outputs, and provide more direct comparison between historical outcomes and projected potential.
    - Sector or Segment Replacement: Are there some sectors or segments where there could be a significant net benefit of completely replacing bottom-up modeling with top-down analysis?
    - Hybrid Allocation Approach: Might there be a benefit from maintaining the portfolio-optimizing capabilities of a bottom-up model, but using a top-down analysis (rather than market dynamic modeling) to estimate top-line potential?

Top-Down Study Next Steps

- Submit informal written comments to Part 1 of the Study by February 11th.
  - Submit via e-mail to Travis Holtby Travis.Holtby@cpuc.ca.gov
- Part 2 of Study to be sent out mid-late February.
- Part 2 of Study webinar planned for early-mid March.

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Appendix A

Additional Details

Context and Timeline

October 2019
Top-Down Approach Requested by Stakeholders

Stakeholders requested CPUC consider an approach to projecting EE potential using a "top-down" approach more closely tied to observed customer data.

Fall 2020
Guidehouse to Develop Top-Down Prototype

Guidehouse was engaged by CPUC to develop a prototype top-down potential projection.

January 2021
Initial Top-Down Approach Presented

Guidehouse presented:

- The motivation for developing a top-down approach
- A high-level description of the approach being developed
- A summary of the data identified as immediately available to support the analysis

July 2021
Draft Quantitative Analysis Complete

Guidehouse completed its first draft quantitative analysis of the Top-Down prototype.

January 2022
Part 1 Top-Down Report Published

Part 1 final report published explaining the Top-Down methodology used.

What are the biggest differences?

Bottom-Up	Top-Down	The Trade-Off: Precision vs. Transparency
Measure-Level (“Widget”) Characterization Measure characterized individually for segment and fuel (saturation, savings, etc.) using best available information	**Aggregate End-Use/Segment** Historical end-use savings data and historical and forecast end-use consumption used to allocate segment potential to end-uses.	**Cost Modelling: Future vs. Reality** • Bottom-up measure costs can account for future structural changes • Top-down projected costs reflect the reality of historic programs as-delivered. **Output: Precision vs. Transparency** • Bottom-up provides measure-level outputs • Top-down projected potential is more transparently grounded in historic savings and forecast consumption trends.
Deterministic Market Dynamics Measure uptake is determined by a market adoption model intended to reflect incentivized consumer/enterprise decision-making.	**Energy Intensity Comparison & Scenario Projection** Unit level potential identified through comparison of *efficient* and *less efficient* buildings. Projected potential identified through progressively more aggressive scenarios of uptake.	**Achievement: Pathway vs. Consequence** • Bottom-up identifies specific pathway to achievement (e.g., magnitude of incentives) but can be a “black box”. • Top-down’s focus is on the consequences of achievement, given existing information. • Top-down is agnostic as to mechanics of achievement but provides transparency for estimation of that achievement.

The six steps for top-down potential estimation.

1. Assessment of Available Data

Only data available at short notice from CPUC or publicly available were considered.

- CEC Benchmarking DB (Floorspace) (2019)
- CEDARS Program Tracking Data (2017 thru 2019)
- Utility Account Billing Data (2017 thru 2019)
- IEPR Reference forecast (by segment, end-use)

Consider limitations and possibilities of available data in the context of existing corpus of empirical energy efficiency planning work.
Identify building intensity as key assessment metric.

2. Create Building Database

Combine floorspace (CEC data), consumption (IOU data) and savings (CEDARS)

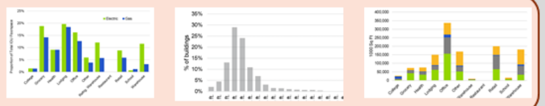
- CEDARS Program Tracking Data (2017 thru 2019)
- CEC Benchmarking DB (Floorspace) (2019)
- Utility Account Billing Data (2017 thru 2019)

→ Building Database

3. Segment Selection

Review Building Database: compare to segment population values, and review homogeneity of energy use.

Building Database



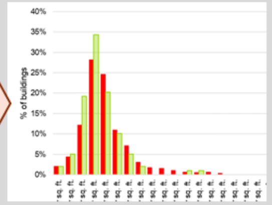
→ Grocery, Lodging, Offices, Warehouse

These first 3 steps *enable* the prototype analysis

4. Split Sample with Proxy

Use DSM program participation to divide buildings into “efficient” and “less efficient” groups.

Building Database: CEDARS Data ↔ Utility Account Billing Data

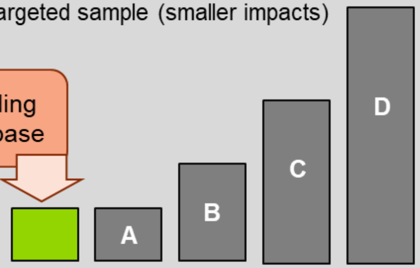


Compare intensity of “efficient” and “less efficient” buildings to define potential improvement (top-down EE potential)

5. Define Scenarios & Extrapolation Samples

The building database is not a representative sample. Different potential scenarios explore tradeoff of larger, less precise sample (larger impacts) and smaller, more targeted sample (smaller impacts)

Building Database

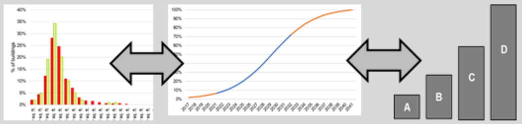


Core Sample

Scenario (Extrapolation) Samples

6. Project Potential

Apply estimated opportunity for intensity improvement (4) to diffusion curve, then to the scenario extrapolation sample, and then to the reference forecast to project potential

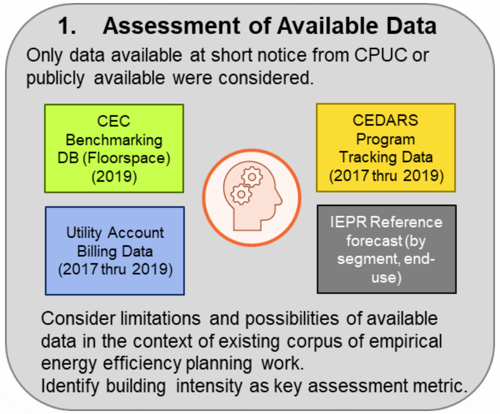


IEPR Reference forecast

Projected Potential (GWh/MMTherm per Year)

The last 3 steps are the core of the potential estimation analysis.

Step 1: Assess available data.

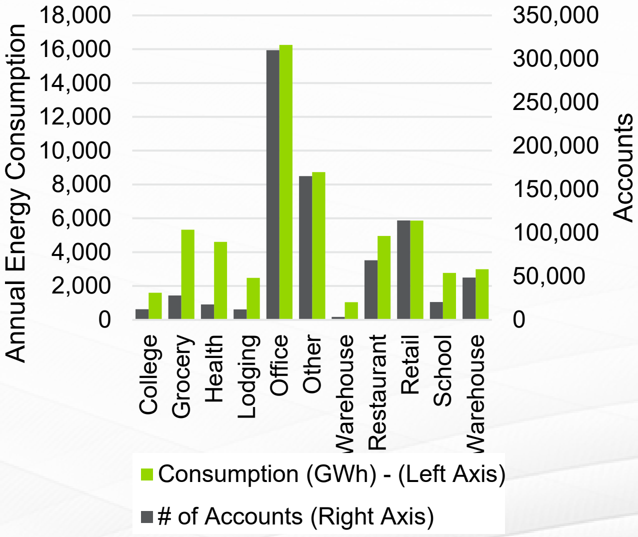


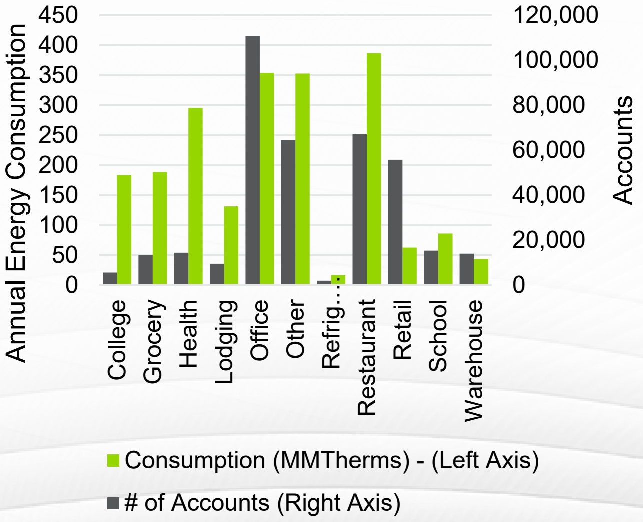
- Key consideration: **are the data easily and quickly available?**
- Purpose of analysis: to quickly develop a prototype analysis to better identify the possibilities of the approach.
- Goal of this step: keep time and cost associated with data gathering and processing to a minimum

CEC Building Database

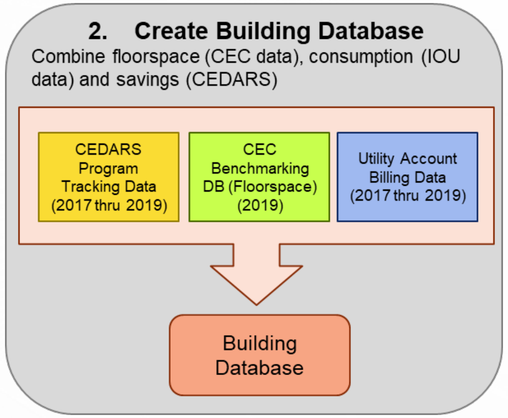
Segment	Floorspace (Million Sq Ft.)	GWh	MMTherm	# of Buildings
Multifamily	635	3,070	122	3,978
Office	382	5,289	52	2,218
Other	234	2,905	28	1,609
Retail	240	2,872	450	1,495
Warehouse	287	1,210	8	1,265
Grocery	80	2,223	460	772
Lodging	166	1,923	72	680
Health	82	1,915	53	540
College	28	396	16	162
School	18	101	2	140
Refrig. Warehouse	14	328	1	70
All Other Industrial	1	62	3	7
Restaurant	0.1	1	0.02	5

Utility Consumption Data & Customer Counts





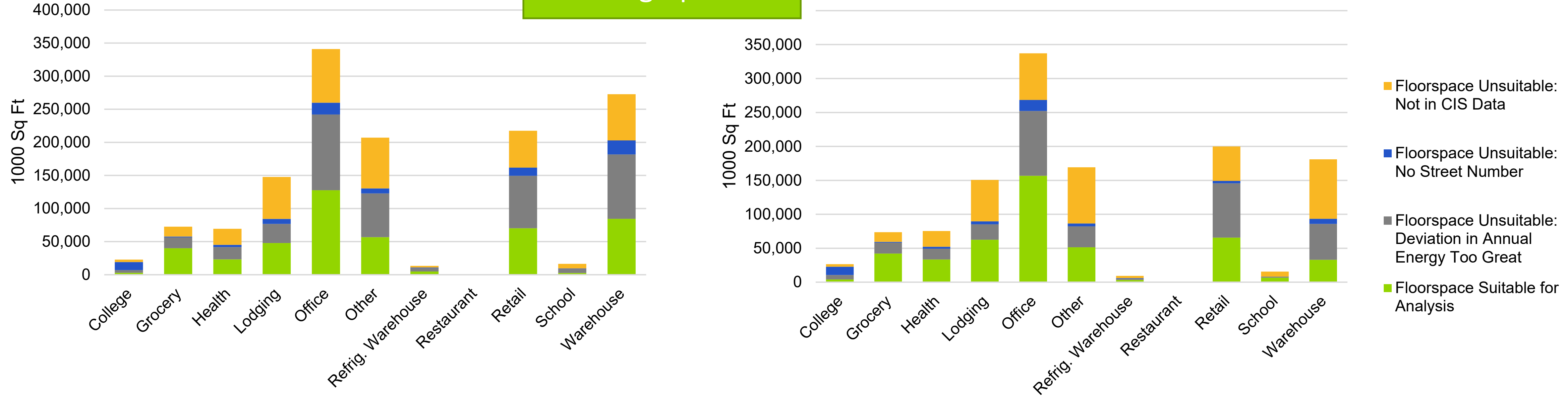
Step 2: Create Building Database.



- Merge data across sets (CEC, CEDARS, utility) and validate matches.
- Matching by address can be imprecise – quality cross-checks of utility load data with CEC DB consumption data essential.

Appendix – impact of cleaning keep one graphic.

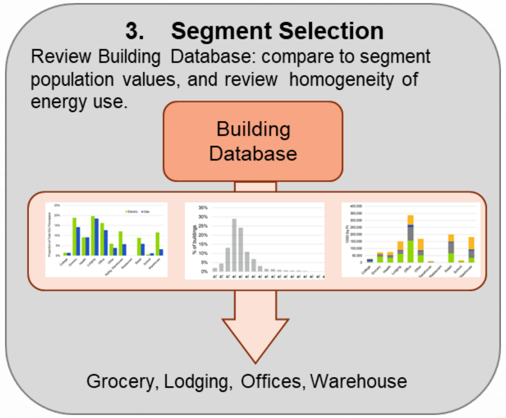
Summ ase Volumes



Top-Down Building Database Summary

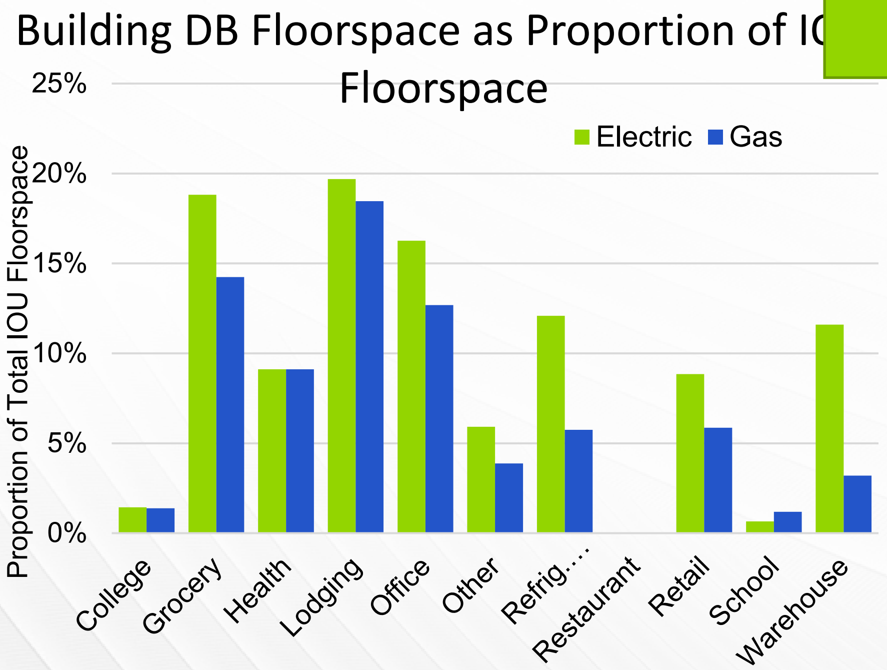
Fuel	Segment	Number of Buildings	Mean Accts/Building	# of Buildings with ANY CEDARS Claims	Avg # Claims (2017 - 2019) per Building with >0 Claims
Electricity	College	15	1.5	4	2.3
	Grocery	**352**	**1.8**	**204**	**1.5**
	Health	193	3.6	39	0.9
	Lodging	**293**	**2.0**	**158**	**1.4**
	Office	**824**	**4.3**	**231**	**1.4**
	Other	491	2.1	92	4.4
	Refrig. Warehouse	23	1.6	4	0.7
	Retail	403	6.5	211	1.6
	School	26	1.6	6	1.4
	Warehouse	**395**	**2.7**	**52**	**1.4**
Natural Gas	College	24	1.1	3	0.4
	Grocery	**387**	**1.2**	**198**	**1.1**
	Health	245	1.4	42	0.9
	Lodging	**348**	**1.3**	**132**	**1.2**
	Office	**930**	**1.3**	**164**	**1.4**
	Other	430	1.2	45	3.4
	Refrig. Warehouse	14	1.0	1	0.3
	Retail	403	1.9	94	1.9
	School	65	1.3	13	0.6
	Warehouse	164	1.2	11	1.1

Step 3: Segment Selection.

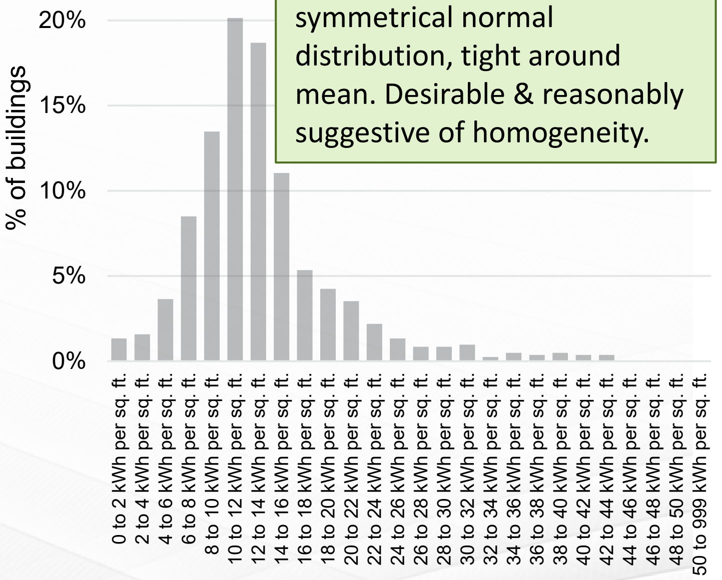


- Review summary statistics and identify most promising commercial segments for prototype analysis
- Key characteristics of interest: sample size, floorspace coverage, distribution of individual building intensities.

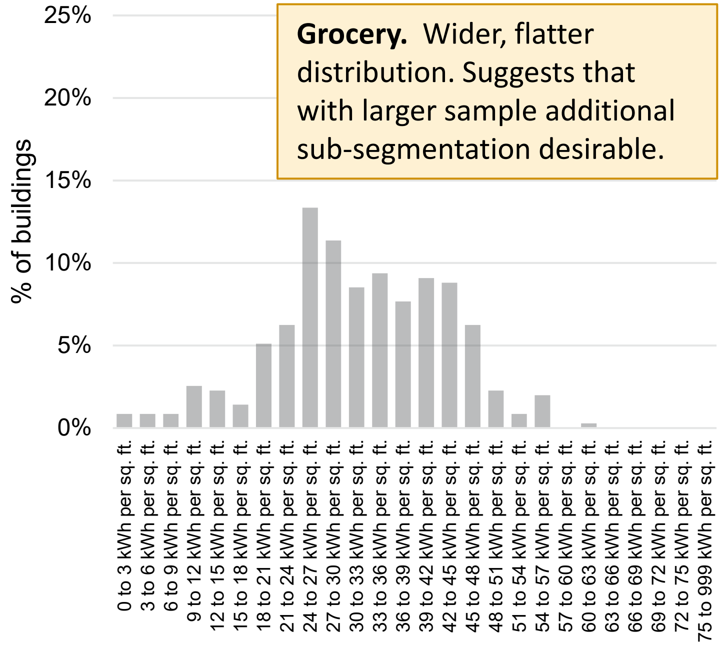
Appendix



Intensity Distributions



Office (Large). Approximately symmetrical normal distribution, tight around mean. Desirable & reasonably suggestive of homogeneity.

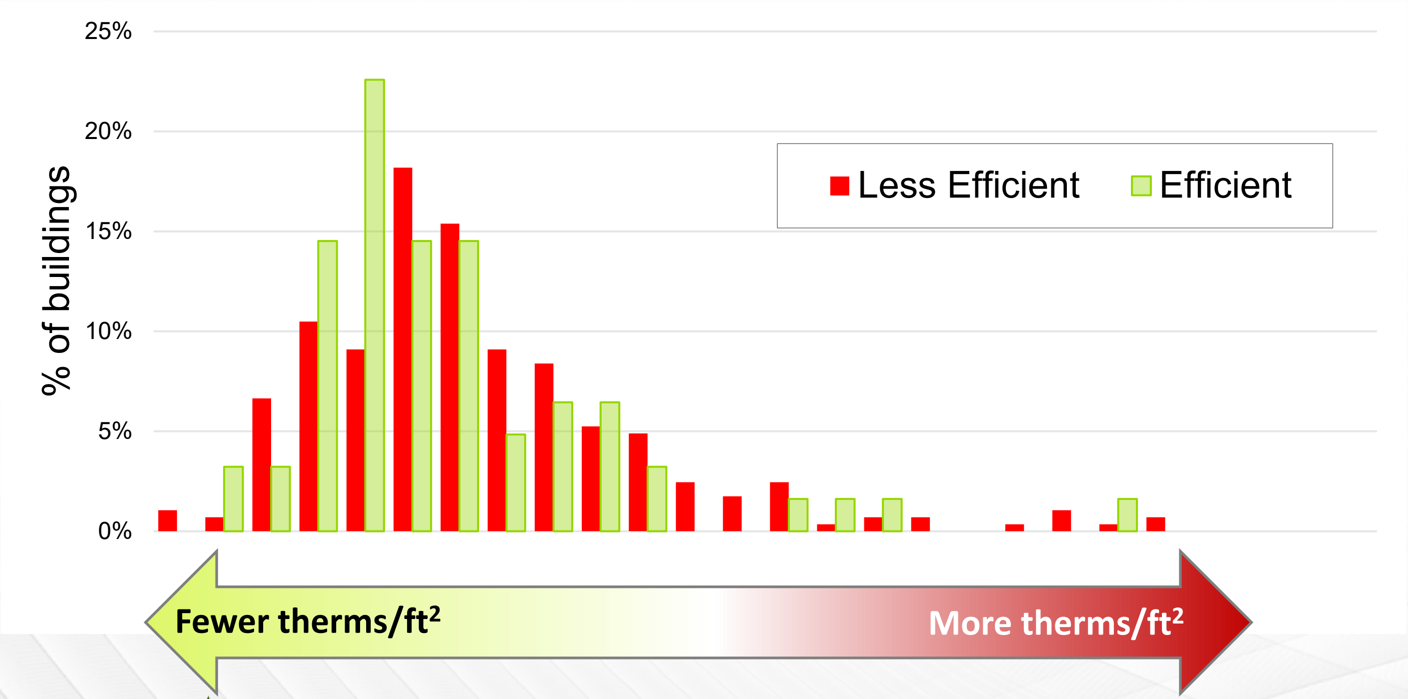


Grocery. Wider, flatter distribution. Suggests that with larger sample additional sub-segmentation desirable.

Step 4: Split Sample, Estimate Unit Potential.

- Top-down potential is derived through a comparison of two groups of buildings: *efficient* and *less efficient*.
- Acknowledging the reality of building diversity, this split is using a *proxy* and not energy intensity directly.
- The split is applied based on degree of past program participation

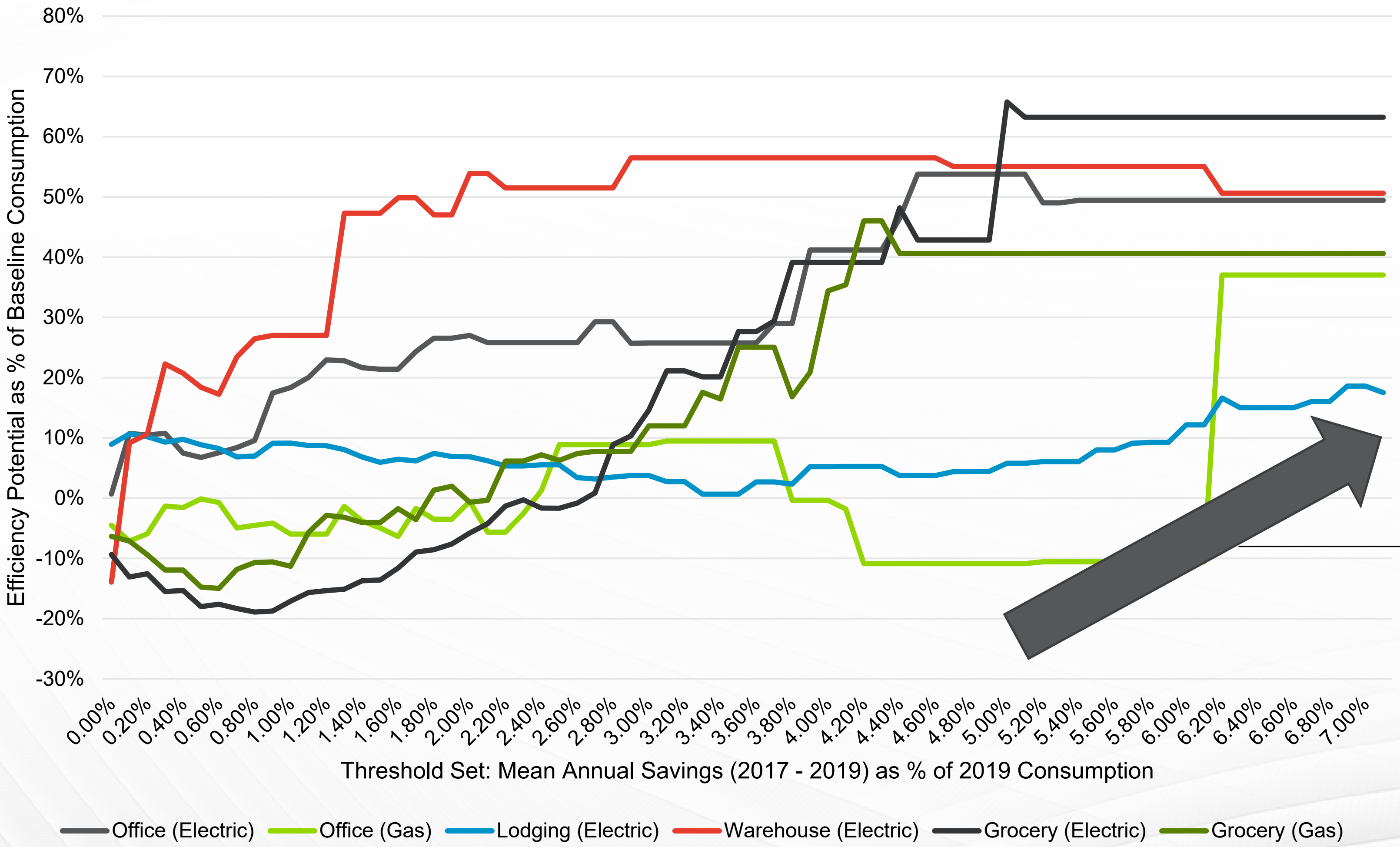
Example: Lodging, Gas



	Efficient	Less Efficient
# of Buildings	62	286
Mean Intensity (therm/ft^2)	0.31	0.35

If ~80% of buildings can be improved to match the standards of the ~20% of buildings with active program participation, **10% savings can be achieved**

Sidebar 1: Sensitivity of Potential to Comparison Threshold



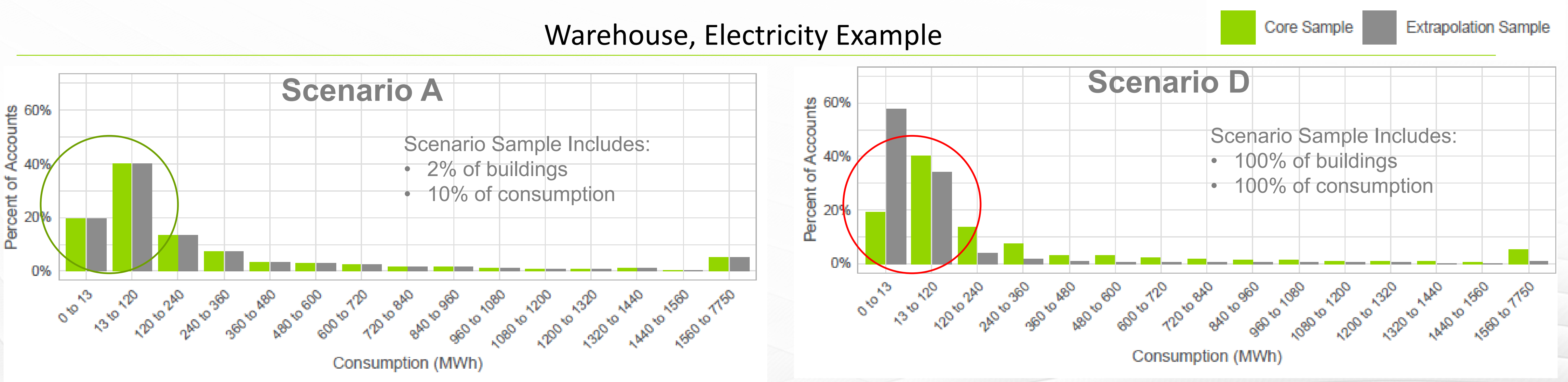
Consistent upward trend in % efficiency potential as a function of: CEDARS savings as % of building energy use.

Step 5: Define Scenarios & Extrapolation Samples.

- The CEC building database is mostly confined to buildings >50k ft^2 and not representative of the population of customers.
- We consider 4 scenarios to explore trade-off between risk-averse and inclusive extrapolation.

Scenario A: Most risk-averse. No extrapolation.	**Scenario C:** Extrapolate to more buildings than Scenario B.
Scenario B: Some extrapolation beyond core sample of buildings in database.	**Scenario D:** Most inclusive. Extrapolate effects estimated in core sample to entire population.

Warehouse, Electricity Example

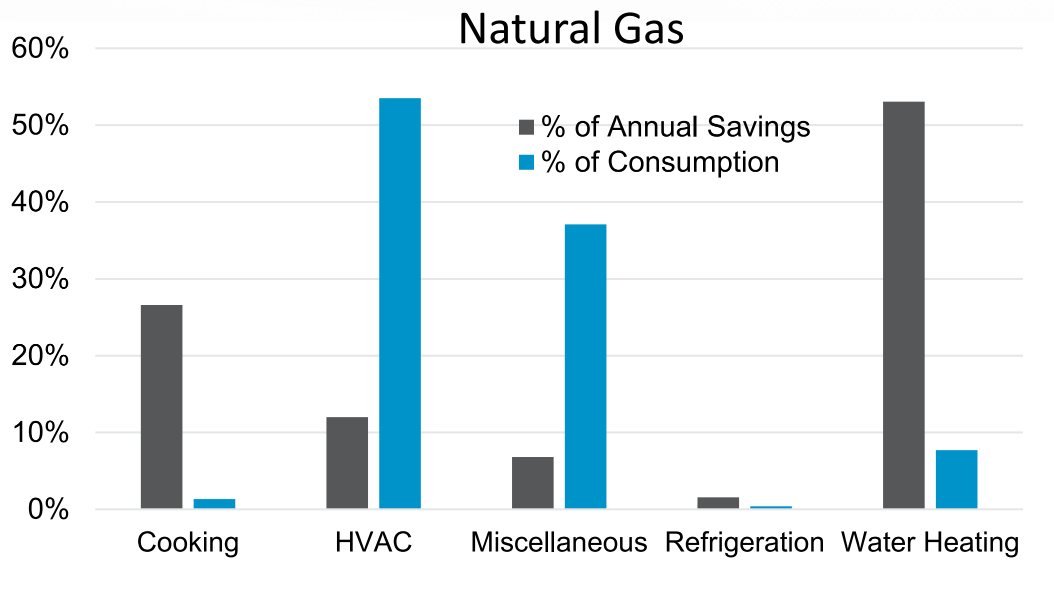


Step 6: Project Potential

- In Step 4, the ultimate/end-state EE potential was estimated for each segment/fuel (e.g., 10% savings for Lodging/Gas).
- In Step 6, the *pace* (over time) and *distribution* (by end-use) of achievement is estimated.
- Pace is defined by a standard S-shaped adoption curve, assumed to extend over 25 years.
- For the distribution of savings, Guidehouse considered two types of distribution:
  - Reflective of **historical program savings**
  - Reflective of **forecast consumption by end-use**

EE potential must be projected according to the distribution of forecast consumption.

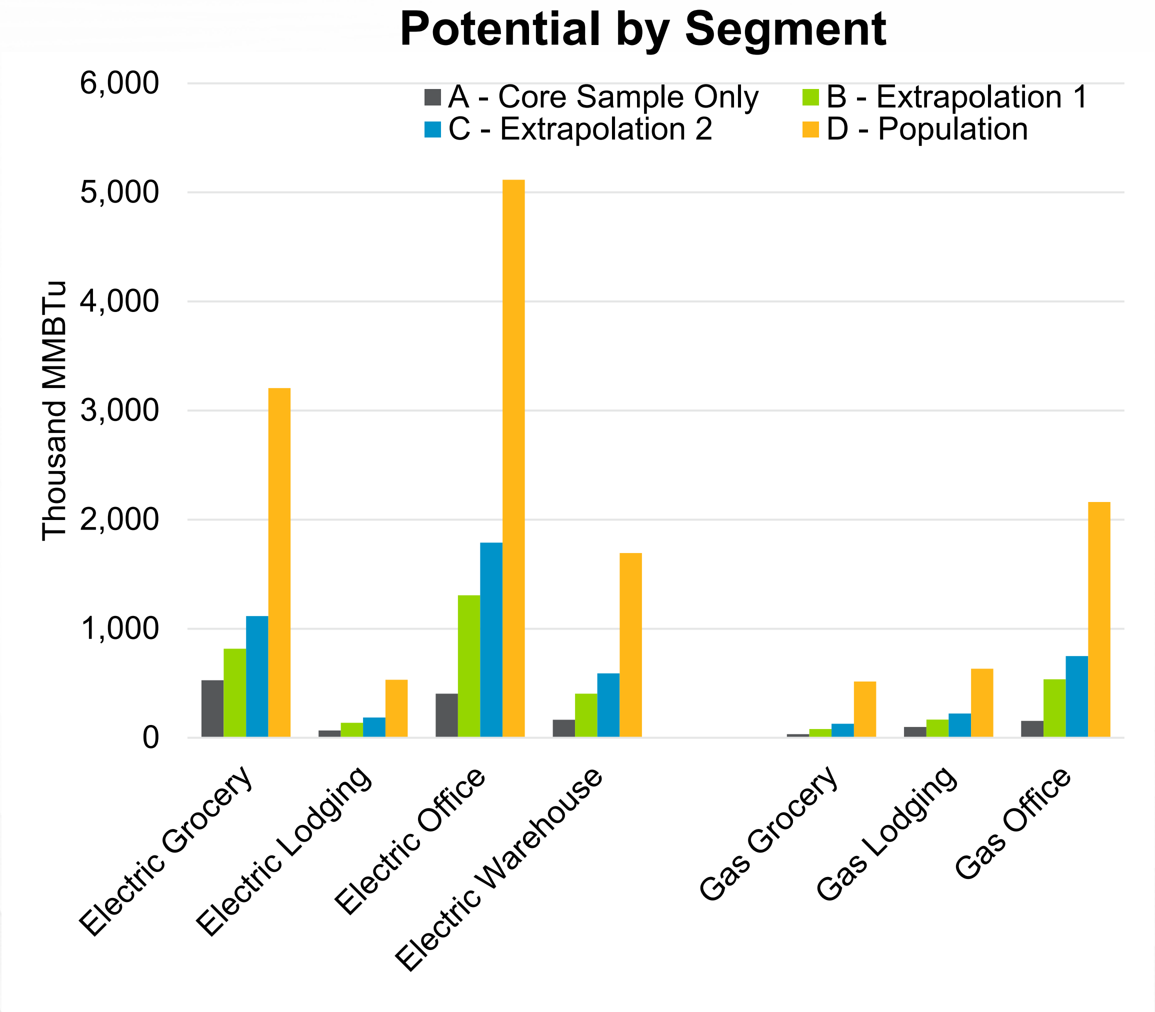
For some end-uses – particularly for gas – there is a major discrepancy between the distribution of historical savings and forecast consumption.
For some scenarios, potential cannot be distributed to match historical savings as it will exceed consumption in that end-use.

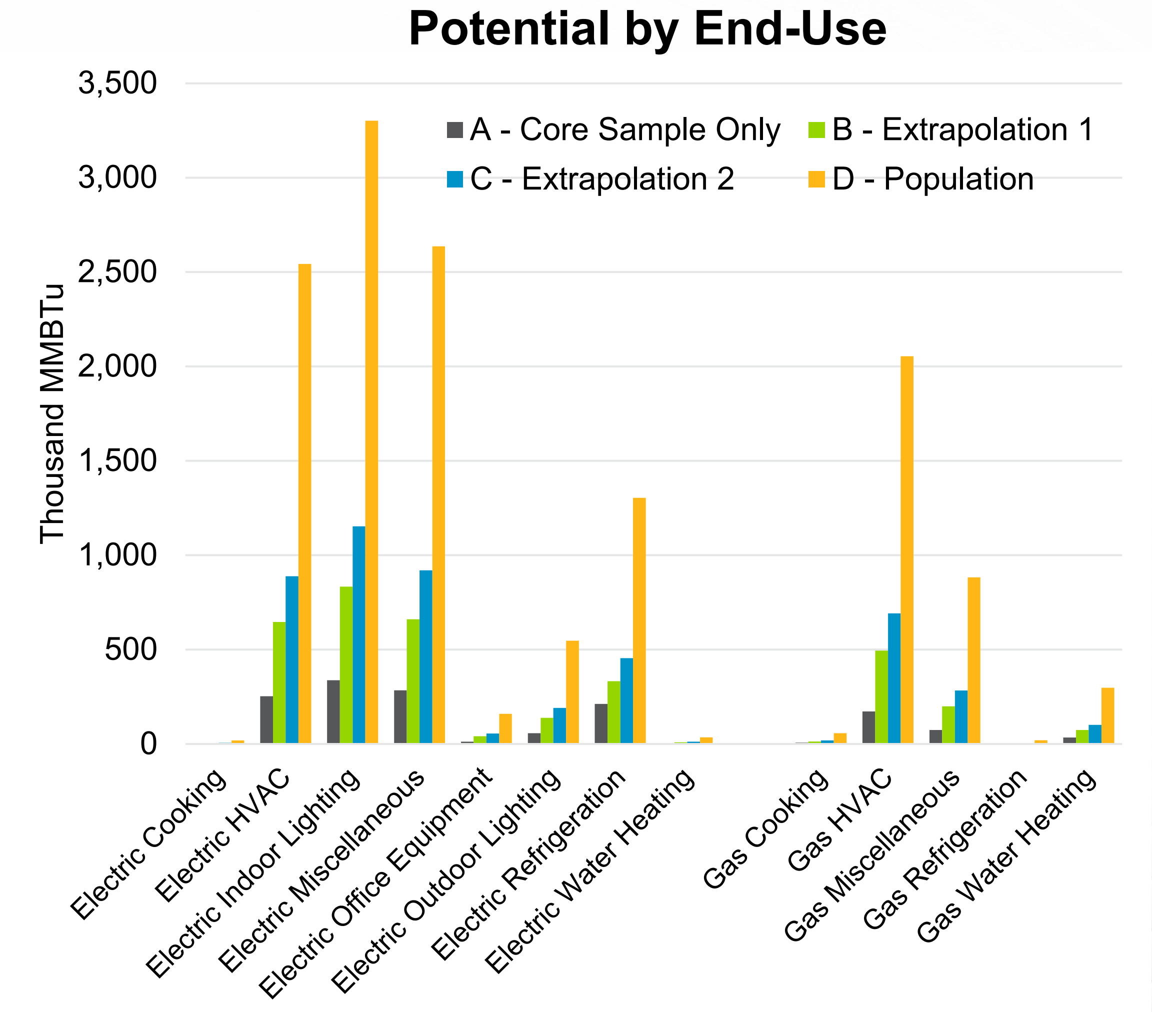


Estimated Levelized Costs of Energy.

Fuel	Unit	End-Use	Grocery	Lodging	Office	Warehouse
E	$/kWh	Cooking	$0.09	$0.06	$0.05	$0.02
E	$/kWh	HVAC	$0.07	$0.08	$0.08	$0.08
E	$/kWh	Indoor Lighting	$0.09	$0.05	$0.10	$0.06
E	$/kWh	Miscellaneous	$0.05	$0.06	$0.10	$0.06
E	$/kWh	Outdoor Lighting	$0.05	$0.12	$0.10	$0.06
E	$/kWh	Refrigeration	$0.04	$0.05	$0.05	$0.02
E	$/kWh	Water Heating	$0.02	$0.07	$0.01	NA
E	$/kWh	Office Equipment	NA	NA	$0.21	NA
G	$/therm	Cooking	$0.45	$0.66	$0.47	
G	$/therm	HVAC	$1.38	$0.66	$1.59	
G	$/therm	Miscellaneous	$2.00	$1.38	$0.28	
G	$/therm	Refrigeration	$1.82	NA	$2.27	
G	$/therm	Water Heating	$0.28	$0.44	$0.50	

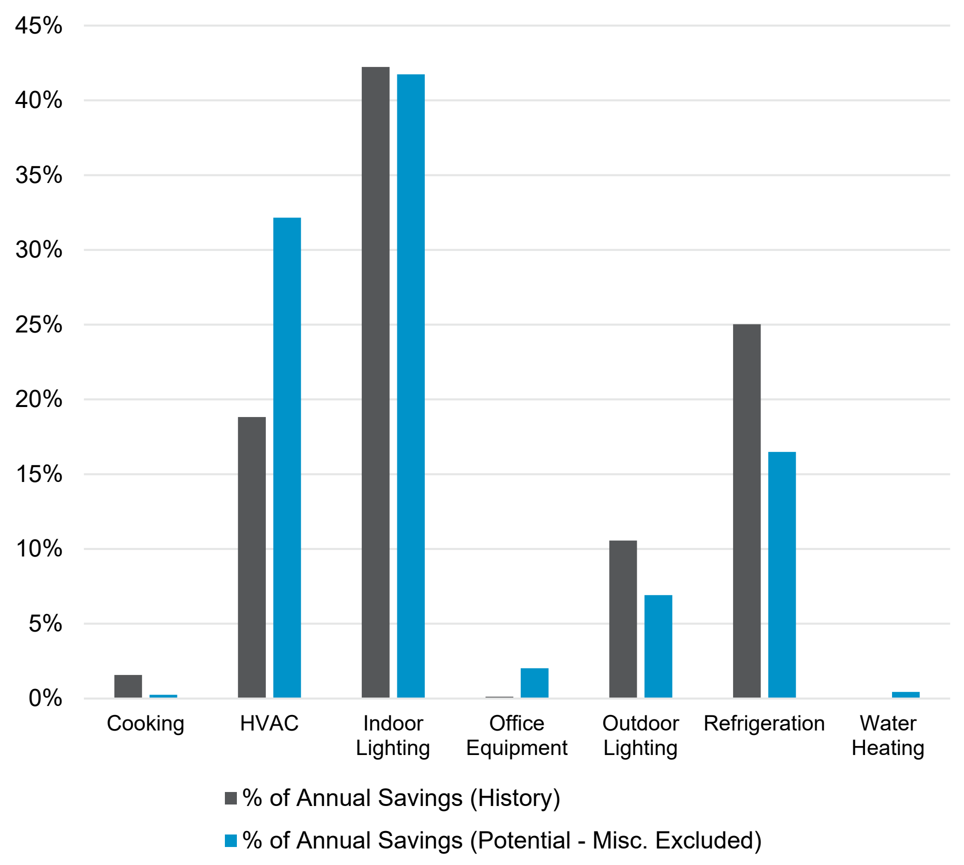
Potential Comparison – Common Units





Potential Vs. History

Excluding the Miscellaneous end-use highlights disproportionately low HVAC acquisition.



- Miscellaneous end-use likely very difficult potential to attain given heterogeneous equipment types – comparison of history and projected should perhaps exclude.
- When Miscellaneous excluded, however, evident that HVAC EE acquisition is disproportionately low.

Next Steps/ Recommendations

Short-term:

- Leverage existing CEDARS data
- Explore and identify data sources that could allow for intensity-normalization of energy consumption in agricultural and industrial sectors
- Expand commercial floorspace data to expand top-down approach across more commercial segments
- Examine data in the 2022 CEUS (yet to be published) to evaluate its alignment with the top-down study
- Evaluate degree of suitability of a top-down approach for fuel substitution potential and costs

Medium-term:

- Consider using top-down analysis to enhance or replace bottom-up model for commercial sector
- Prototype top-down approach for agricultural and industrial sectors.

Long-term:

- Consider using top-down analysis to enhance or replace bottom-up model for industrial, agricultural, and residential sectors