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Document Title:	May 21 Presentations - Scoping, and Scenario Impacts
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Building Decarbonization Scenario Impacts

AB 3232 - California Building Decarbonization Assessment

Commissioner Workshop

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May 21, 2021

Assembly Bill 3232

Friedman, Chapter 373, Statutes of 2018
requires the Energy Commission to:

> “[A]ssess the potential for the state to reduce the emissions of greenhouse gases in the state’s residential and commercial building stock **by at least 40 percent** below 1990 levels by January 1, 2030”

Source: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB3232

Defining the Scope of Assessing Building Decarbonization

Defining the Scope of Assessing Building Decarbonization

Scope of the analysis

2020-30 Baseline (BAU) Case

Staff relied on the 2019 Integrated Energy Policy Report's (IEPR) California Energy Demand forecast to establish the reference baseline (business-as-usual assumption) annual 2030 GHG emissions for the AB 3232 analysis.

Building Decarbonization Strategy
1. Building end-use electrification
2. Decarbonizing the electricity system
3. Energy efficiency
4. Refrigerant conversion and reduction
5. Distributed generation and storage
6. Decarbonizing the gas system
7. Demand flexibility

Summary of the Two 1990 GHG Baselines Considered in the Assessment ($MMTCO_2e$)

	GHG Emission Sources
Baseline 1: Systemwide Emissions	• Gas combustion • Behind-the meter gas leakage • Non-gas fuel combustion • Hydrofluorocarbon leakage from refrigeration and air conditioners* • **Electric generation system emissions attributed to the residential and commercial sectors**
Baseline 2: Direct Emissions	• Gas combustion • Behind-the meter gas leakage • Non-gas fuel combustion • Hydrofluorocarbon leakage from refrigeration and air conditioners* • **Incremental electric generation system emissions from building electrification**

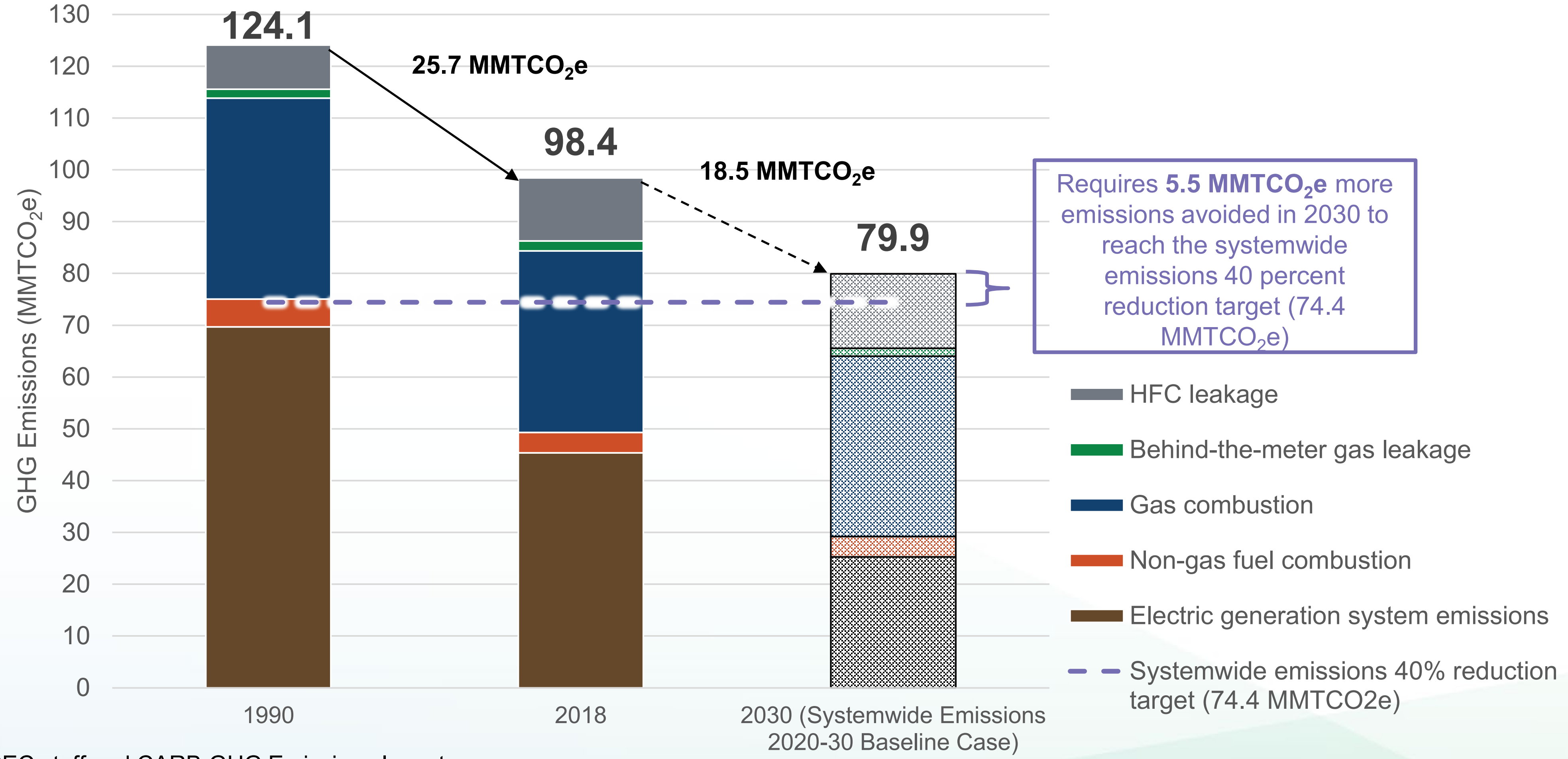
Source: CEC staff

*Please refer to the main report for how CEC staff handled HFC emissions in the 1990 base year.

Why Bring In the Electric Generating System to AB 3232?

- SB100 requires major changes in the electric generating system that greatly reduce its carbon emissions through time.
- Under business-as-usual demand assumptions the residential and commercial building sectors are about 70 percent of total electric system load.
- Emissions from the generating system are directly influenced by changes in electric consumption by the buildings sector.
- Reductions in electric consumption (energy efficiency, rooftop PV) included in the 2020-30 baseline or in new building decarb strategies will reduce electric generating system emissions.
- Increases in electric consumption through building electrification will increase electric generating system emissions in all years to 2045.

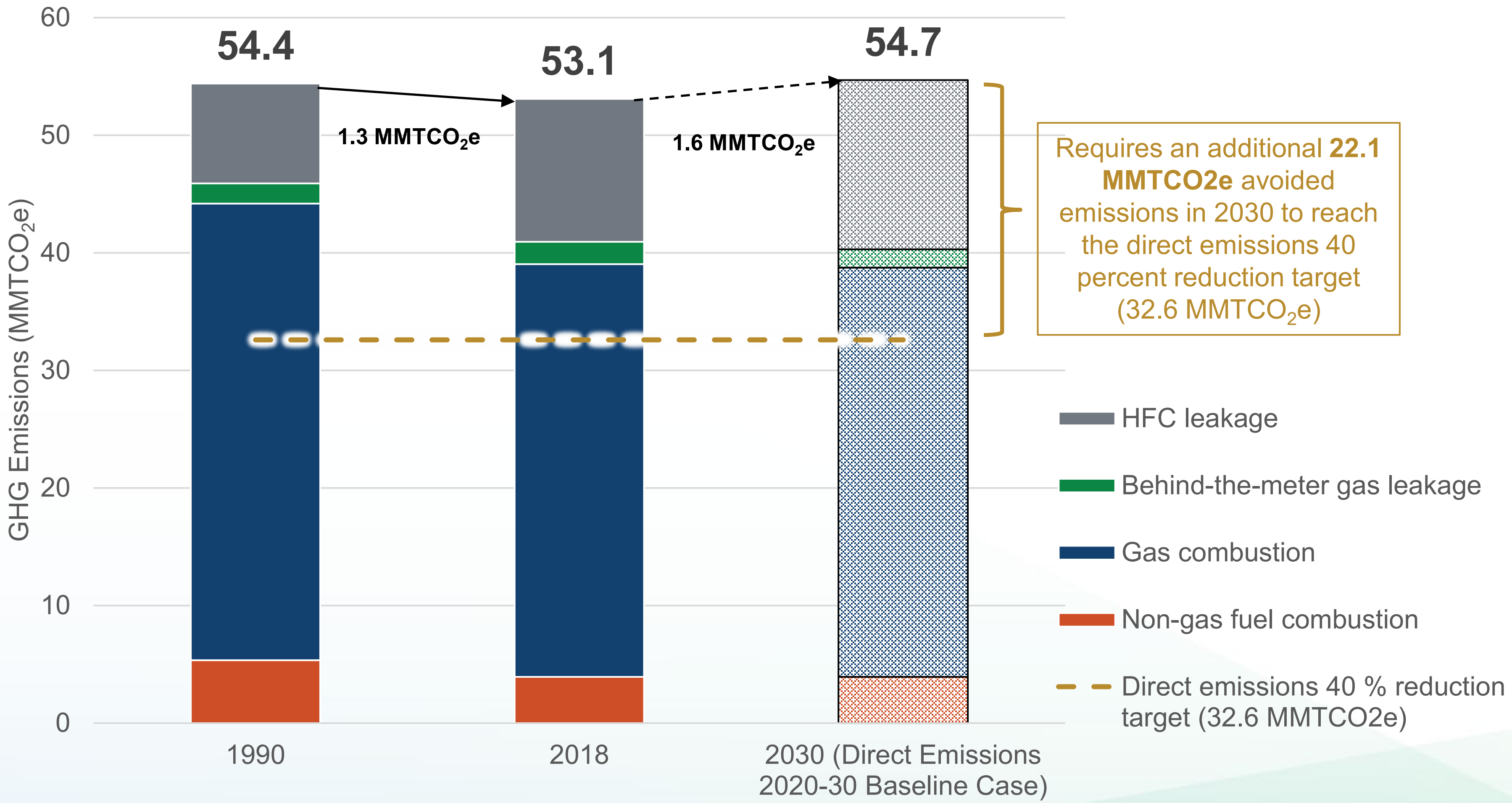
AB 3232 2030 Systemwide GHG Emissions Target



Source: CEC staff and CARB GHG Emissions Inventory

Note: As previously stated, the 2020-30 Baseline Case already contains building decarbonization strategies as a part of the 2019 IEPR Forecast. As reported in Appendix B, CEC staff's estimates of emissions may not align completely with the emissions or categories reported in the most recent CARB GHG Emissions Inventory.

A Direct GHG Emissions Baseline Requires More Emissions Reduction



Source: CEC staff and CARB GHG Emissions Inventory

Note: As previously stated, the 2020-30 Baseline Case already contains building decarbonization strategies as a part of the 2019 IEPR Forecast. As reported in Appendix B, CEC staff's estimates of emissions may not align completely with the emissions or categories reported in the most recent CARB GHG Emissions Inventory.

Defining the Scope of Assessing Building Decarbonization

Summary of scenarios examined & modeling assumptions

Scope of AB 3232 analysis

Building Decarbonization Strategy	Decarbonization Scenario(s) Analyzed	Used in Decarbonization Scenarios
1. Building end-use electrification		
2. Decarbonizing the electricity system		
3. Energy efficiency		
4. Refrigerant conversion and reduction		
5. Distributed generation and storage		
6. Decarbonizing the gas system		
7. Demand flexibility		

Mapping the strategies to analyzed scenarios & comparing to baseline

Building Decarbonization Strategy	Decarbonization Scenario(s) Analyzed	Used in the 2020-2030 Baseline (BAU) Case	Used in AB 3232 Decarbonization Scenarios
1. Building end-use electrification	• Minimal • Moderate • Aggressive • Efficient Aggressive		
2. Decarbonizing the electricity system	Accelerated renewable electric generation resources		
3. Energy efficiency	Incremental electric energy efficiency		
	Incremental gas energy efficiency		
4. Refrigerant conversion and reduction	Not assessed		
5. Distributed generation and storage	Incremental rooftop solar PV systems		
6. Decarbonizing the gas system	Decarbonizing gas system with renewable gas		
7. Demand flexibility	Demand flexibility		

Modeling electrification: Fuel Substitution Scenario Analysis Tool (FSSAT) main processes flow chart

Integrated Energy Policy Report (IEPR)

- **Gas Demand Forecast**

↓

Additional Achievable Energy Efficiency (AAEE)

- Reduces consumption of gas

↓

Technology Substitution

- Gas for various electric

→ **Annual Outputs**

- Technology Stock
- Costs of substitution
- Incremental electricity added
- **NET GHG emissions**

↓

Hourly Calculation

- End use consumption load curves

→ **Hourly Outputs**

- Hourly Electric consumption increase
- Hourly GHG emissions

Building end-use electrification scenarios:
Minimal, Moderate, Aggressive, Efficient Aggressive

<table>
<tr><th>Electrification Scenario Using FSSAT</th><th>New Construction (NC)</th><th>Replace on Burnout (ROB)</th><th>Early Replacement (RET)</th><th>Technology Efficiency</th><th>SB 1383 Goals Toggle</th></tr>
<tr><td>Minimal</td><td rowspan="4">100%
by 2030</td><td>15%</td><td rowspan="2">5%</td><td rowspan="3">High-Efficiency Weighted Mix</td><td rowspan="4">Potential of reducing 7.5 $MMTCO_2e$ of HFC Leakage in 2030</td></tr>
<tr><td>Moderate</td><td>50%</td></tr>
<tr><td>Aggressive</td><td rowspan="2">90%</td><td rowspan="2">70%</td></tr>
<tr><td>Efficient Aggressive</td><td>Single-Best Efficiency</td></tr>
</table>

Where:

- NC, ROB, and RET are percentages of eligible technologies by sector/end-use that will be electric in 2030
- The Minimal electrification scenario just meets the 40-percent AB 3232 target
- The impacts of the SB 1383 toggle are external to the FSSAT framework

Electric Generation Analyses

- For each scenario, develop annual electric consumption impacts, and then use hourly load shapes to develop 8760 load impacts
- Add these hourly loads to 2020-2030 baseline hourly loads

- Develop resource additions (renewables) to satisfy RPS requirements and battery storage to satisfy planning reserve margin requirements.
- Translate revised resource mix into Plexos production simulation inputs and run for benchmark years 2022, 2025, and 2030.
- Post process fuel consumption results into annual GHG emissions and interpolate to create 2020 through 2045 GHG emission intensity.

- Scale EG emission intensity by residential plus commercial building electricity consumption to get electric generation GHG emissions for the building sector.

Questions?

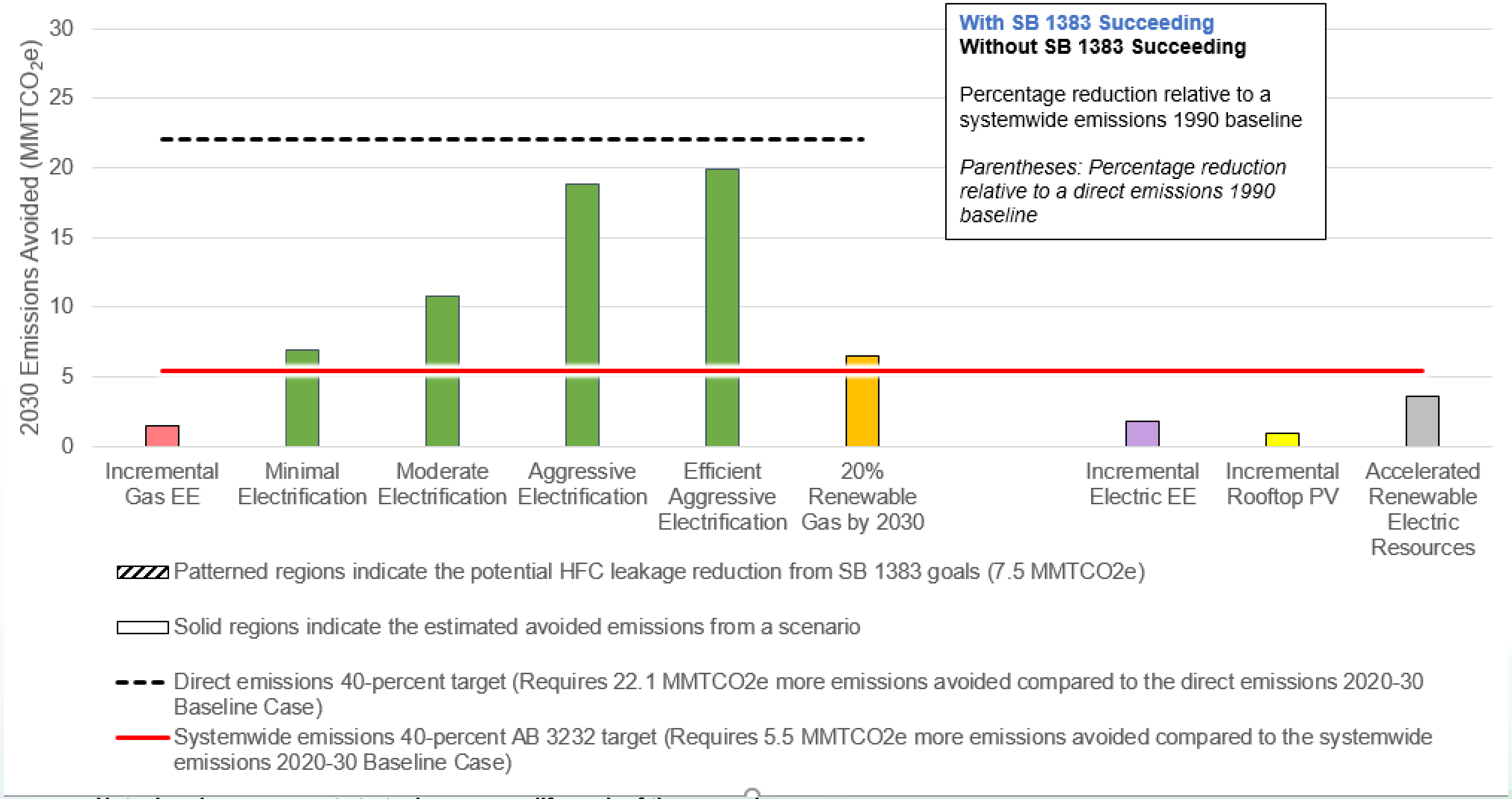
LUNCH

Building Decarbonization Scenario Impacts

Building Decarbonization Scenario Impacts

2030 GHG emission impacts by scenario

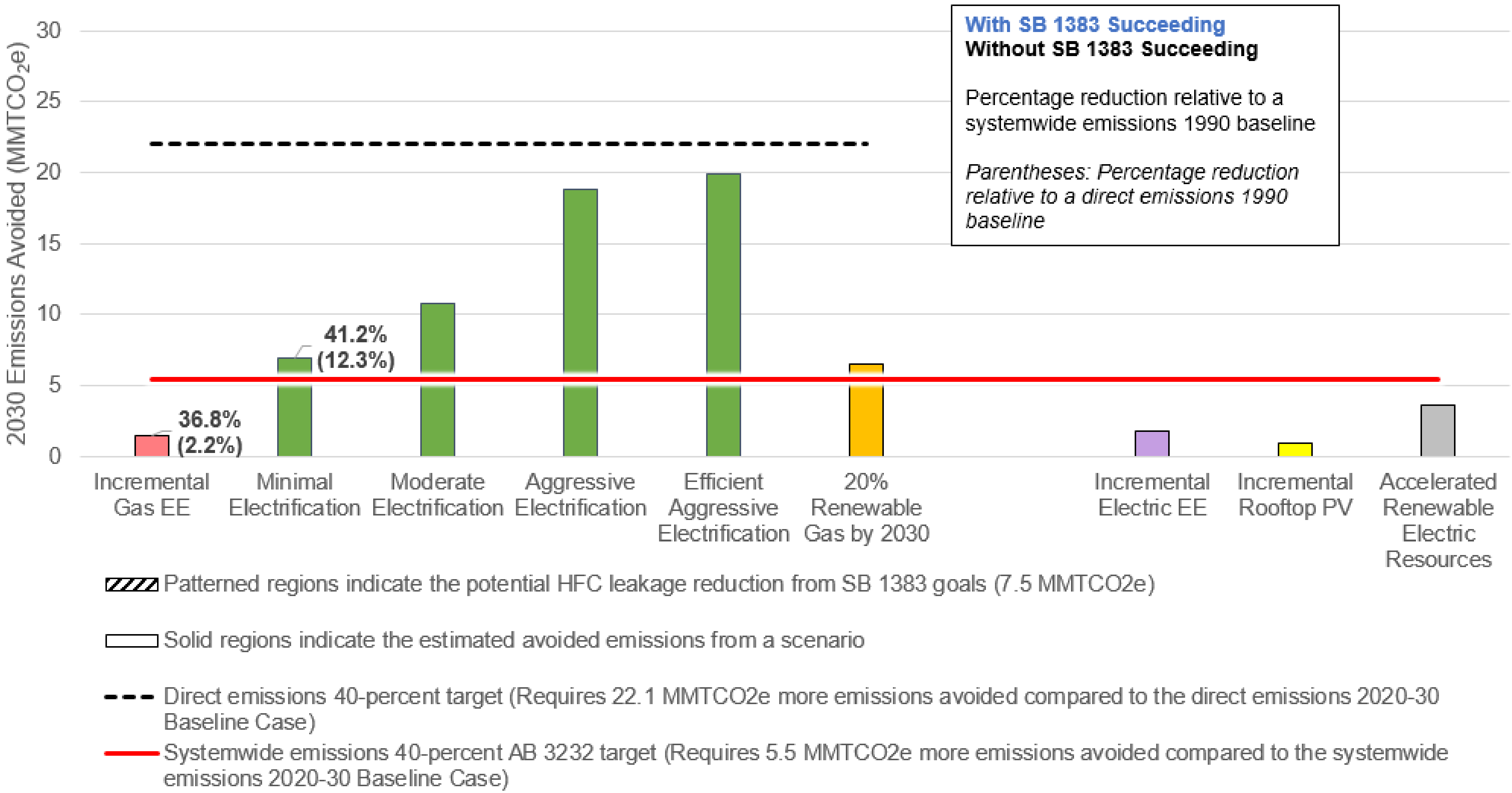
Abatement Potential: Annual GHG Reduction for 2030 by Scenario



Note: Load management strategies can amplify each of the scenarios

Source: CEC staff

Abatement Potential: Annual GHG Reduction for 2030 by Scenario



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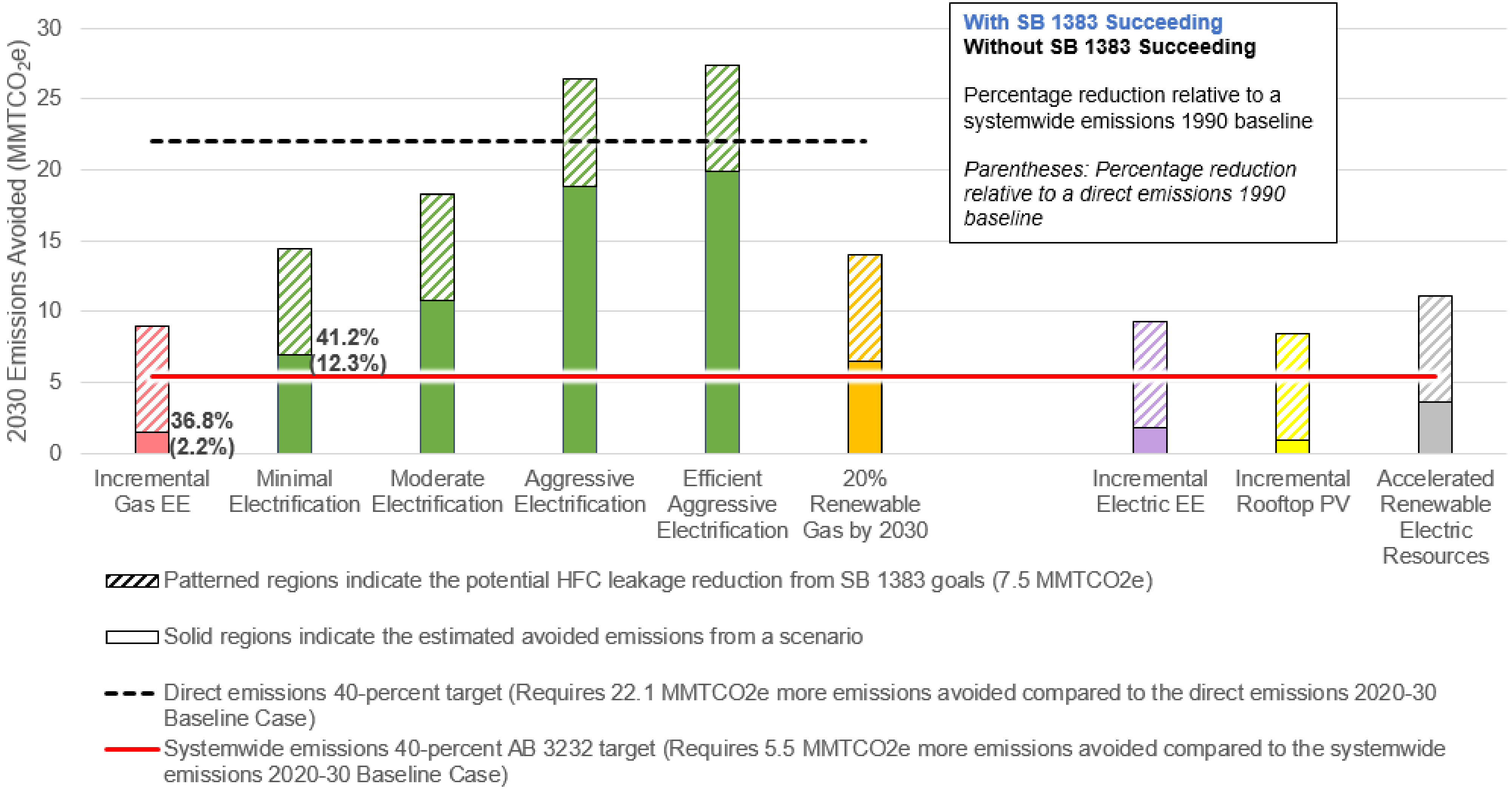
Source: CEC staff

Abatement Potential: Annual GHG Reduction for 2030 by Scenario



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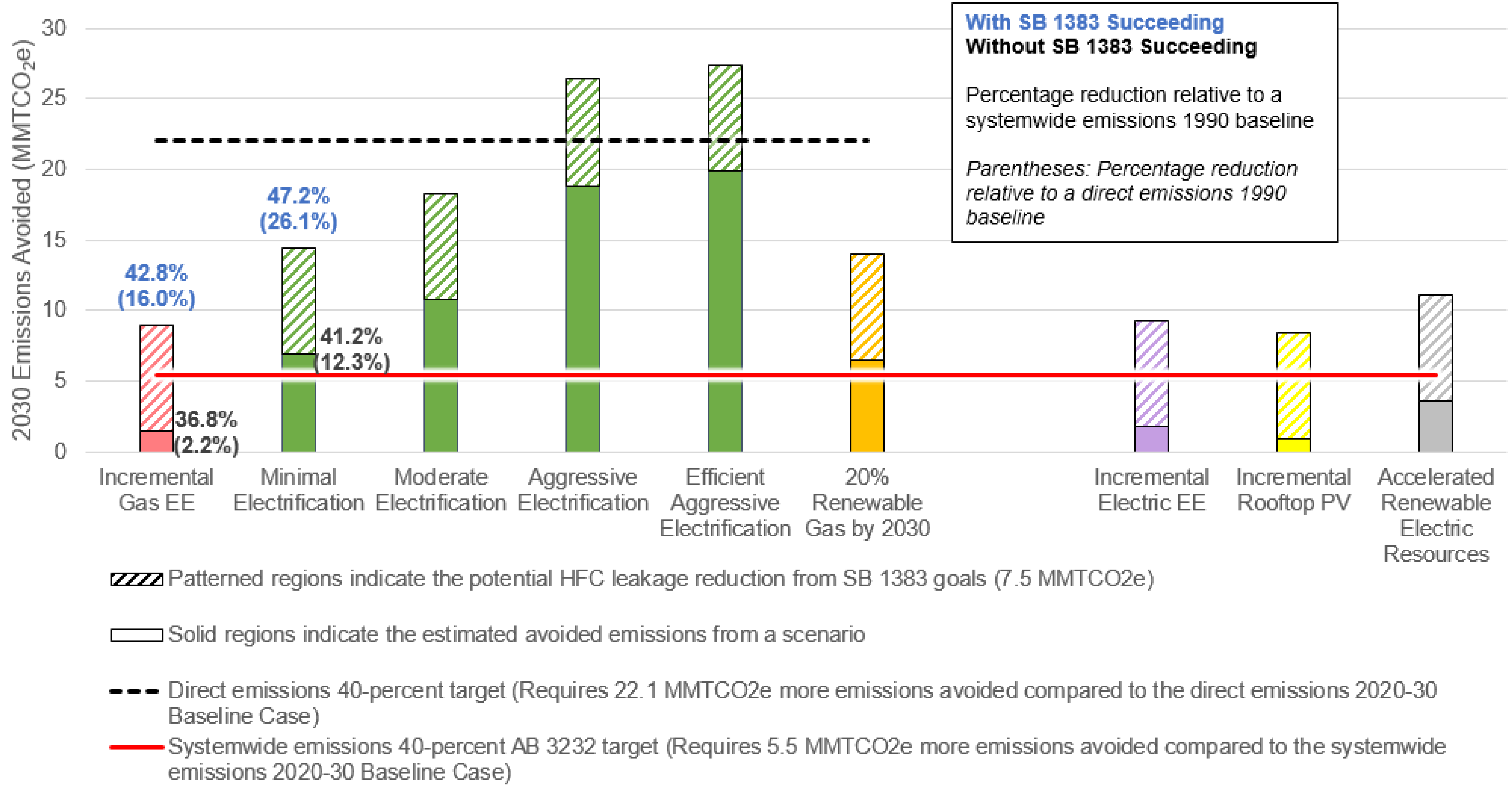
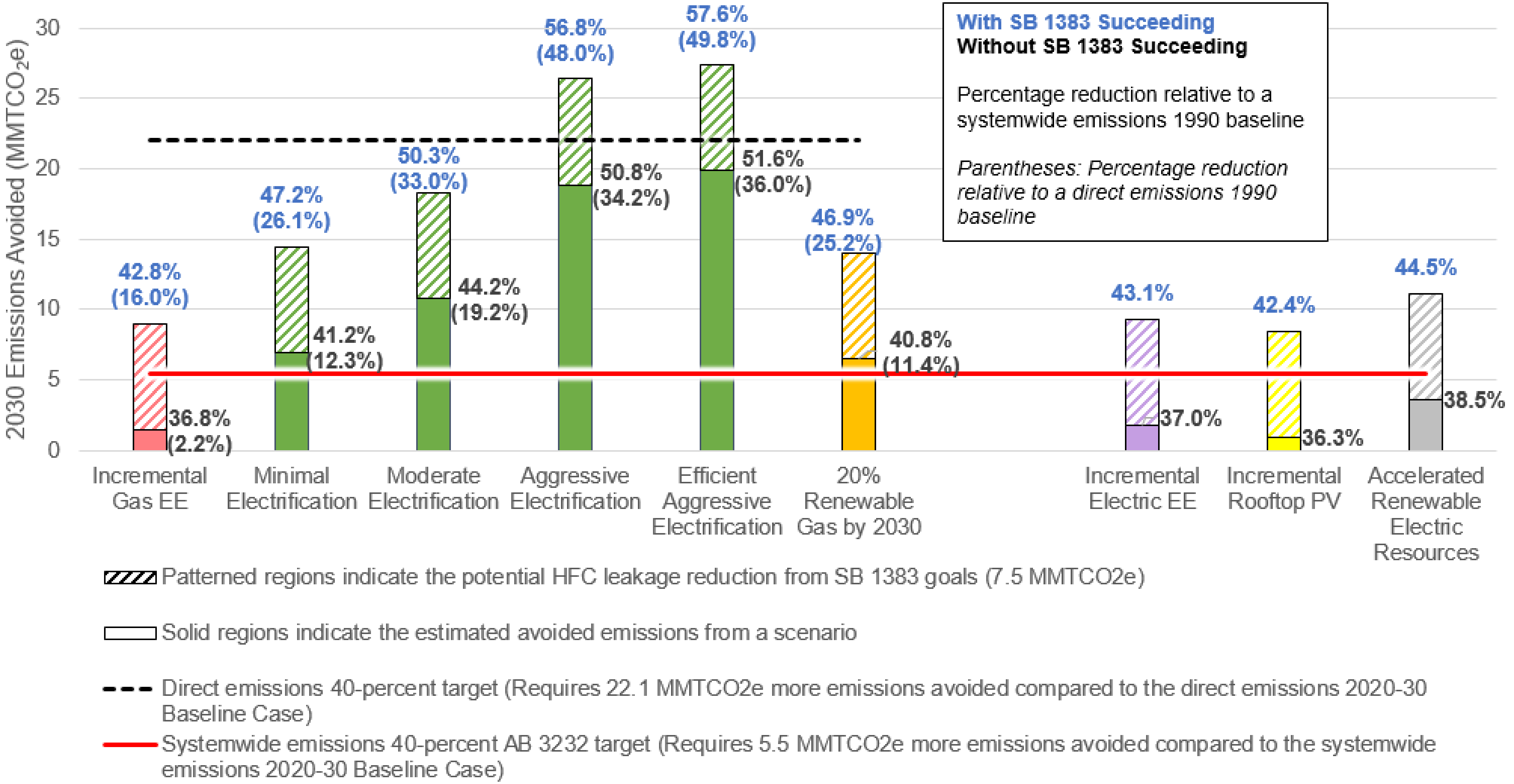
Abatement Potential: Annual GHG Reduction for 2030 by Scenario



Note: Load management strategies can amplify each of the scenarios

Source: CEC staff

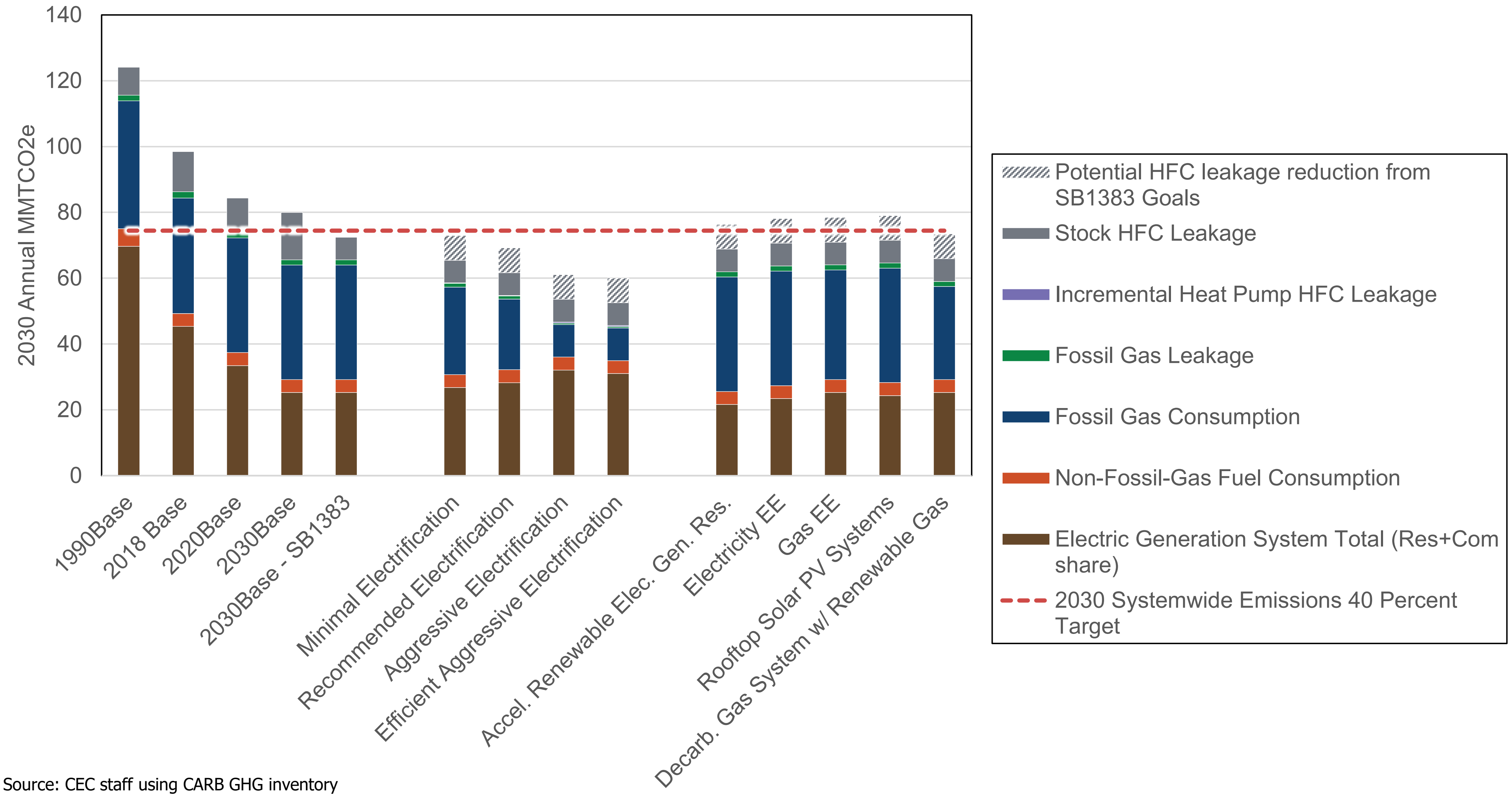
Abatement Potential: Annual GHG Reduction for 2030 by Scenario



Note: Load management strategies can amplify each of the scenarios

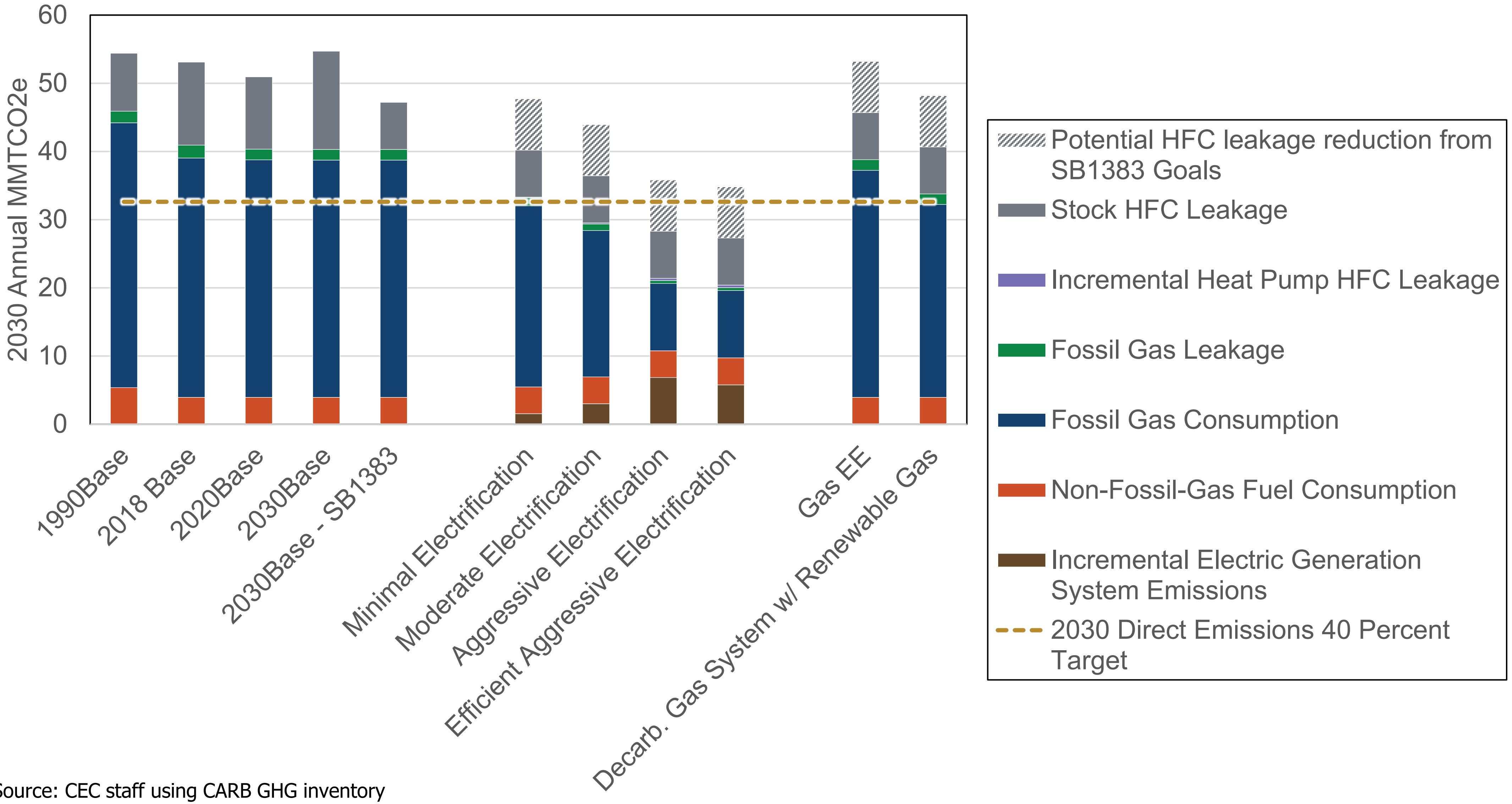
Source: CEC staff

2030 Statewide GHG Emissions: Using a Systemwide Emissions Baseline



Source: CEC staff using CARB GHG inventory

2030 Statewide GHG Emissions:
Using a Direct Emissions Baseline



Source: CEC staff using CARB GHG inventory

Building Decarbonization Scenario Impacts

Costs and cost-effectiveness

Costs and Cost effectiveness

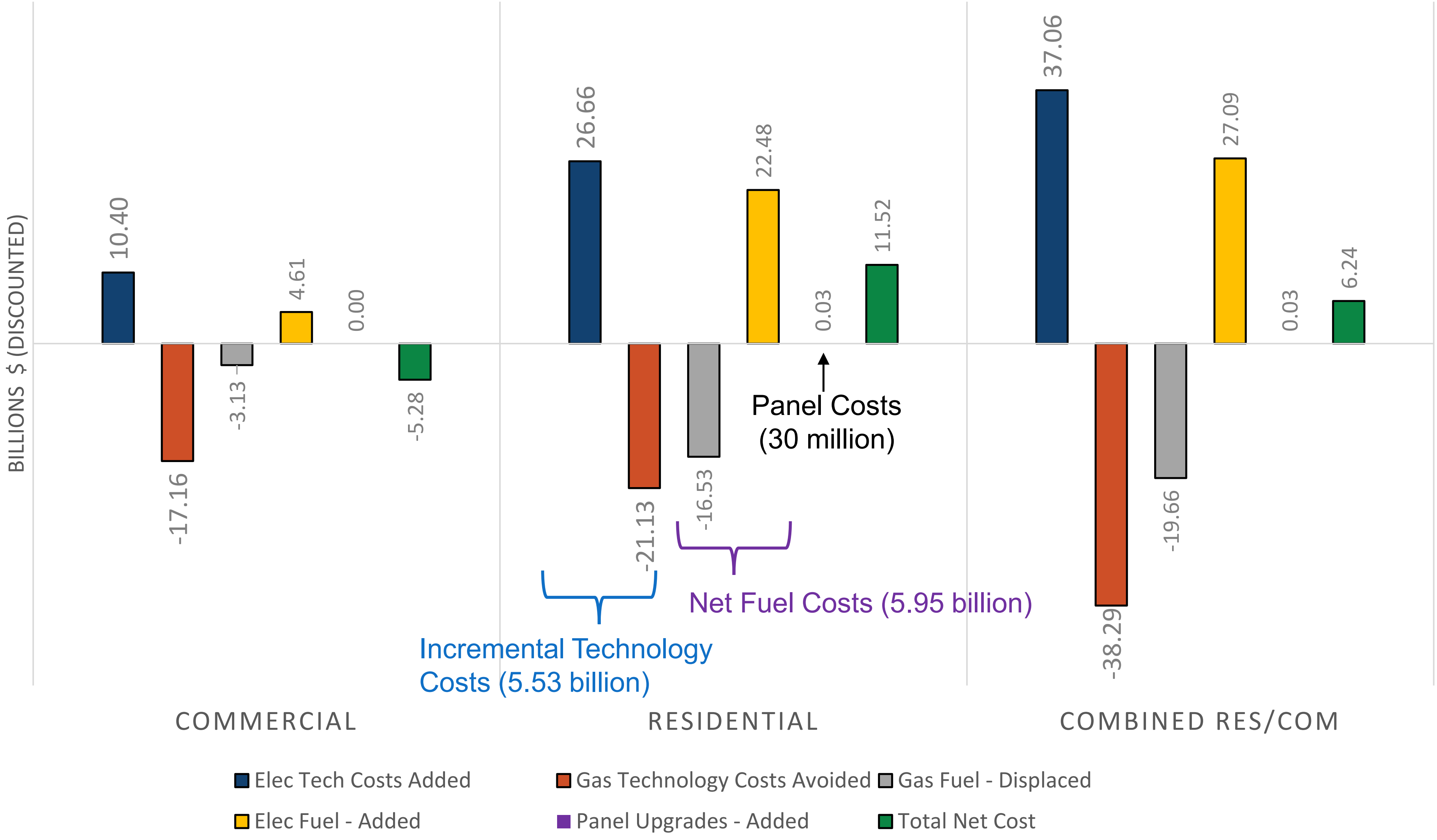
- Many definitions of cost effectiveness
- AB 3232 analysis applies the same definition of **cost effectiveness** as *CARB 2017 Scoping Plan:*
  - "Under AB 32 [(Nuñez, Chapter 488, Statutes of 2006)], cost-effectiveness means the relative ***cost per metric ton*** of various GHG reduction strategies, which is the traditional cost metric associated with emission control." (Page 44)
- The calculated dollar per ton estimates reflect the average costs of activities occurring between 2020-2030 over a time horizon out to 2045 since emissions reductions and costs occur beyond 2030

Source: CARB 2017 Scoping Plan https://ww3.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf

Cost calculation assumptions

- All scenarios:
  - Assume a 2 percent annual **inflation rate**
  - Apply a 10 percent **discount rate** to all costs, same as *2017 CARB Scoping Plan*
  - **Net fuel costs** calculated using the retail rates from 2019 the IEPR Demand Forecast
- Cost components of electrification scenarios:
  - **Incremental technology costs**
    - **Air conditioning costs**
  - **Net fuel costs**
  - **Electrical panel upgrade costs**

“Moderate Electrification Scenario” Cumulative Costs by Category and Customer Sector



Costs and Avoided Emissions by Scenario

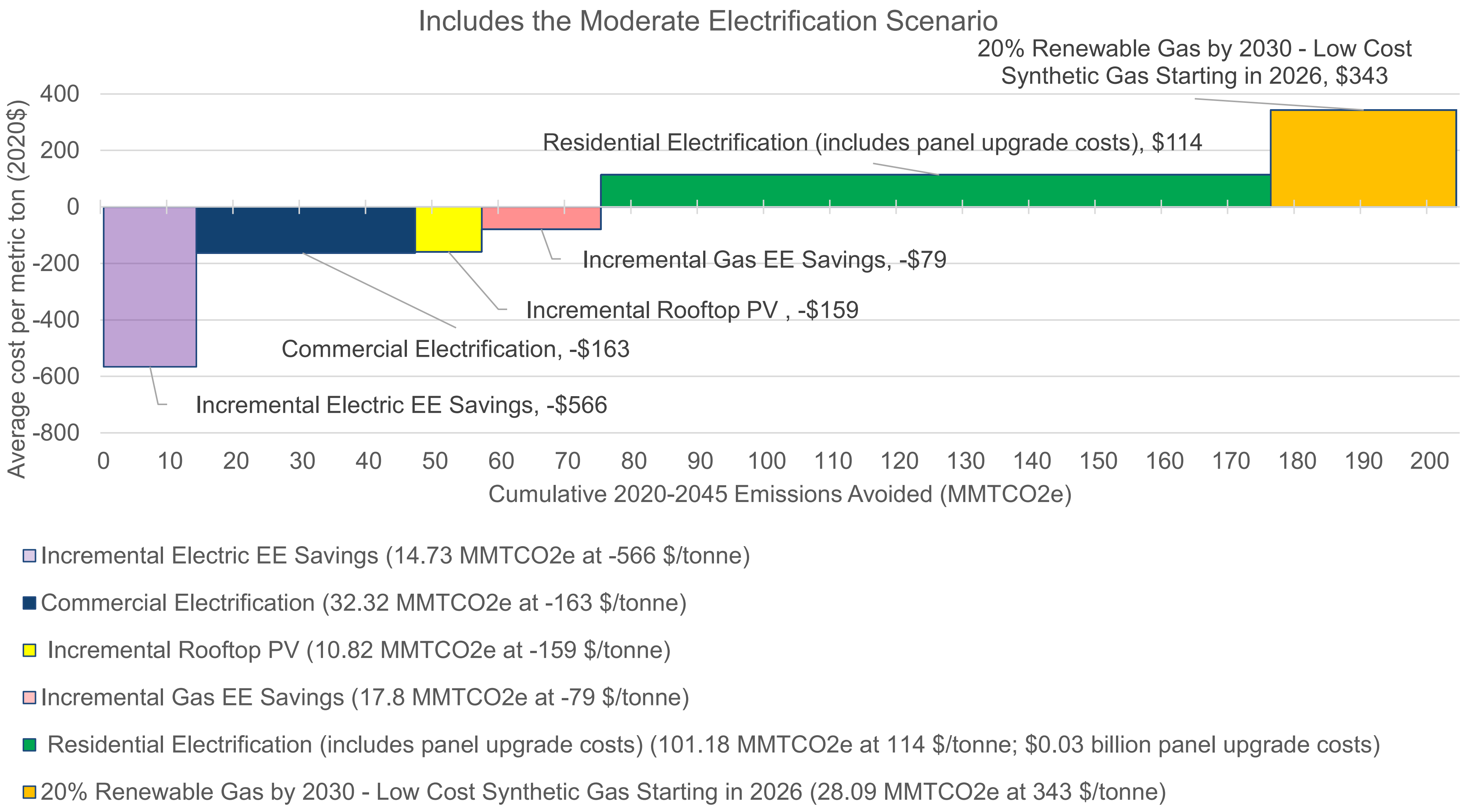
Scenario	Annual avoided GHG emissions in 2030 ($MMTCO_2e$)*	Cumulative avoided GHG emissions 2020-2045 ($MMTCO_2e$)	Total discounted net costs (Mil. 2020$)	Discounted costs per avoided GHG emissions (cost per metric ton in 2020$)
Building end-use electrification scenarios				
Minimal: 100% New Construction, 15% Replace on Burnout, 5% Early Retirement, no panel upgrades	7.0 (14.5)	74.2	2,880	$39
Moderate: 100% New Construction, 50% Replace on Burnout, 5% Early Retirement	10.8 (18.3)	133.5	6,236	$47
Aggressive: 100% New Construction, 90% Replace on Burnout, 70% Early Retirement	18.9 (26.4)	270.4	37,862	$140
Efficient Aggressive: 100% New Construction, 90% Replace on Burnout, 70% Early Retirement (single-best efficient technology)	19.9 (27.4)	281.2	39,947	$142
Impact scenarios				
Accelerated Renewable Electric Generation Resources	3.6 (11.1)	n.a.	n.a.	n.a.
Electricity Energy Efficiency	1.8 (9.3)	14.7	-8,338	-$566
Gas Energy Efficiency	1.5 (9.0)	17.8	-1,415	-$79
Rooftop Solar PV Systems	0.9 (8.4)	10.8	-1,715	-$159
Decarbonizing Gas System with Renewable Gas: 20% Renewable Gas by 2030 – Low-Cost Synthetic Gas starting in 2026	6.5 (14.0)	28.1	9,634	$343

*Parentheses values includes 7.5 $MMTCO_2e$ HFC emission abatement if SB 1383 achieves 2030 goals compared to 2020-30 Baseline.

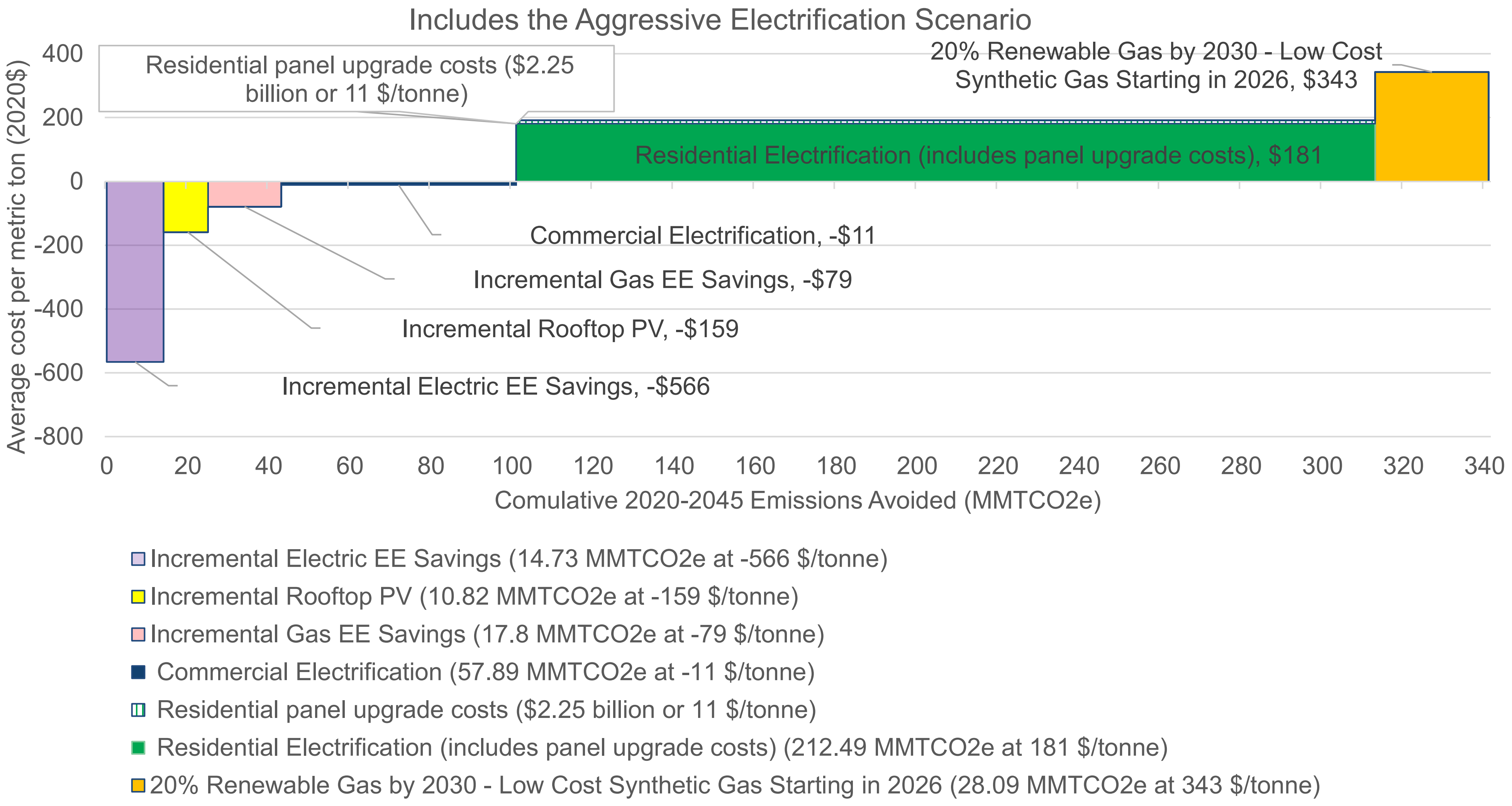
Marginal abatement cost curves (MAC curves)

- Definition
  - MAC curves plot the marginal costs of achieving a cumulative level of emissions abatement in order from the least- to most-expensive scenario, measure, or technology
- MAC curves are a commonly used policy tool indicating emission abatement potential and associated abatement costs and provide a simplified and useful tool illustrating the complex issue of cost-effective emissions reduction

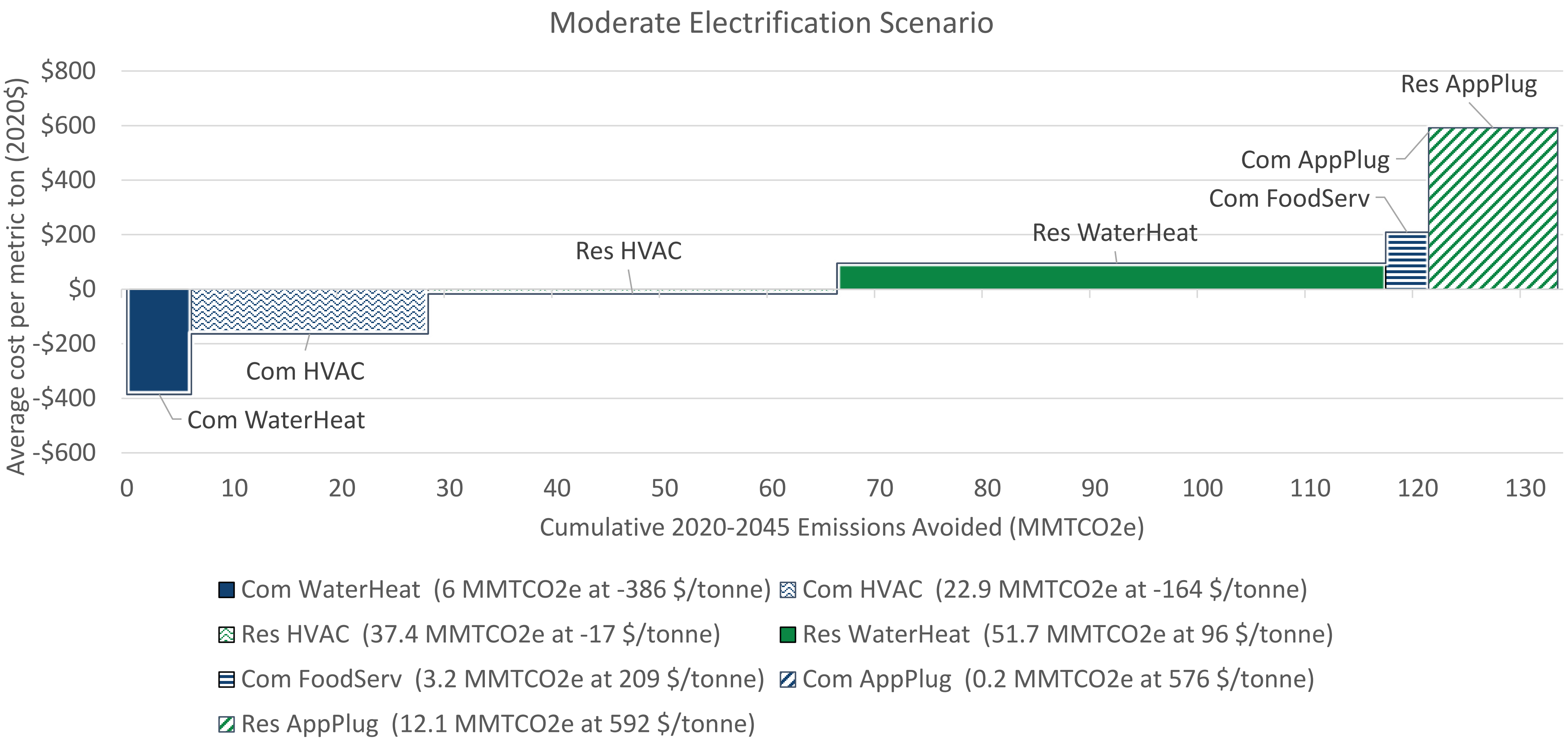
Aggregated Marginal Abatement Cost Curve Using the "Moderate Electrification Scenario" (100% NC, 50% ROB, 5% RET)



Aggregated Marginal Abatement Cost Curve Using the "Aggressive Electrification Scenario" (100% NC, 90% ROB, 70% RET)



Marginal Abatement Cost Curve by End Use for "Moderate Electrification Scenario" (100% NC, 50% ROB, 5% RET)



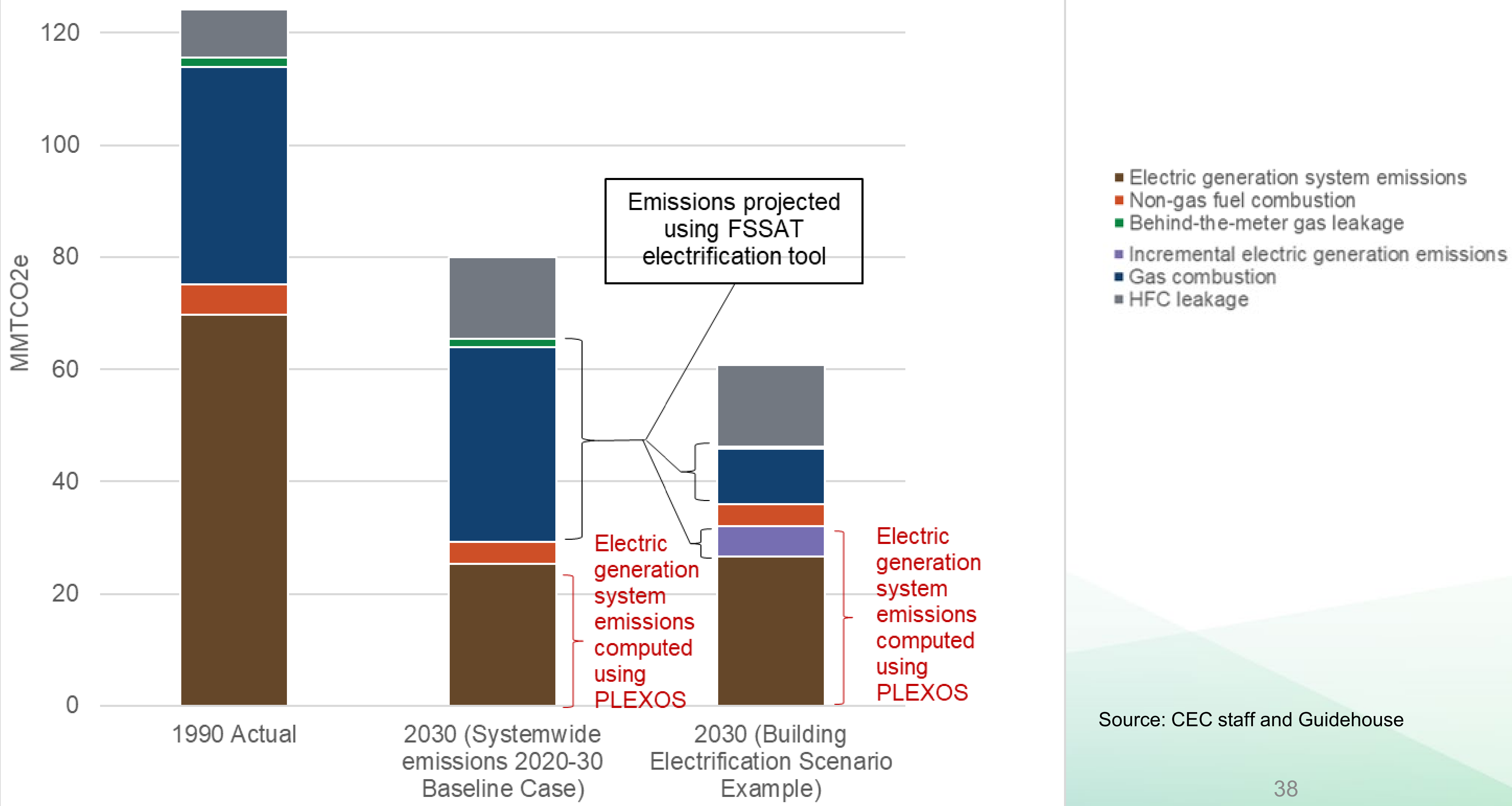
Building Decarbonization Scenario Impacts

System impacts and grid implications

Energy System Impacts and Grid Implications

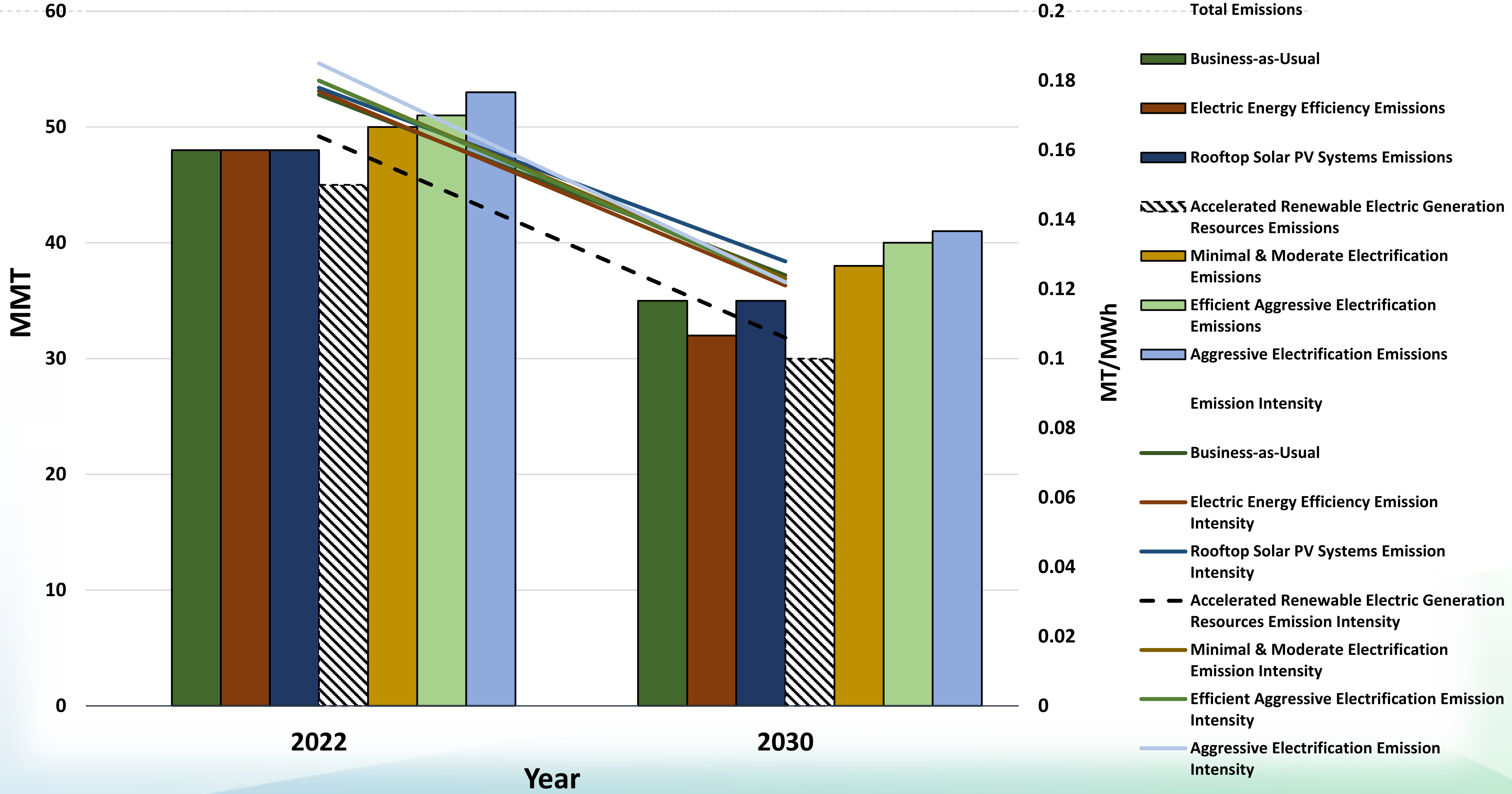
Summary of Results

Interaction Between Electrification and Electricity Generation System Emissions



Source: CEC staff and Guidehouse

Projected California Electric Sector GHG Annual & Average Emission Intensity

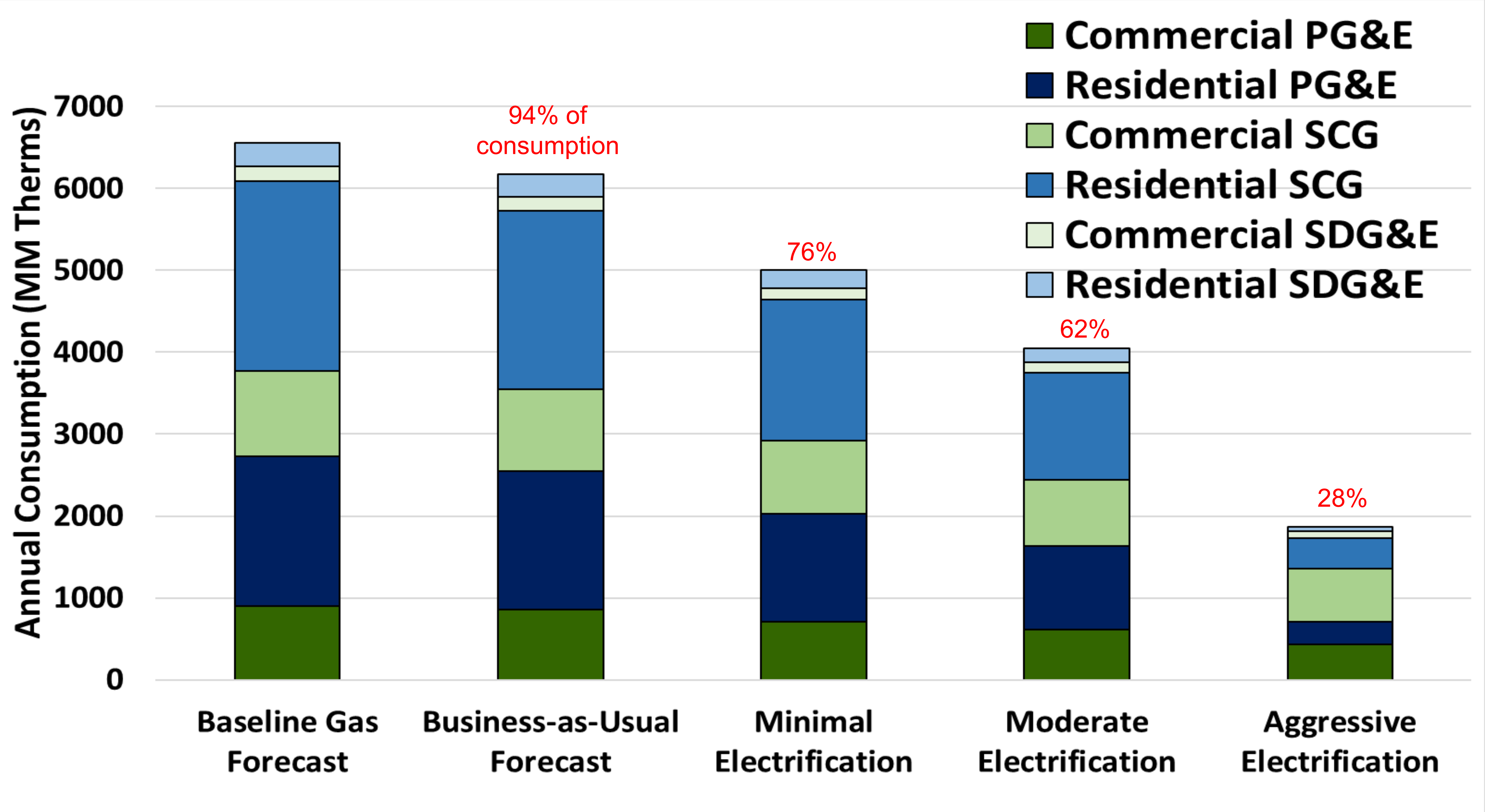


Background material for slide 39

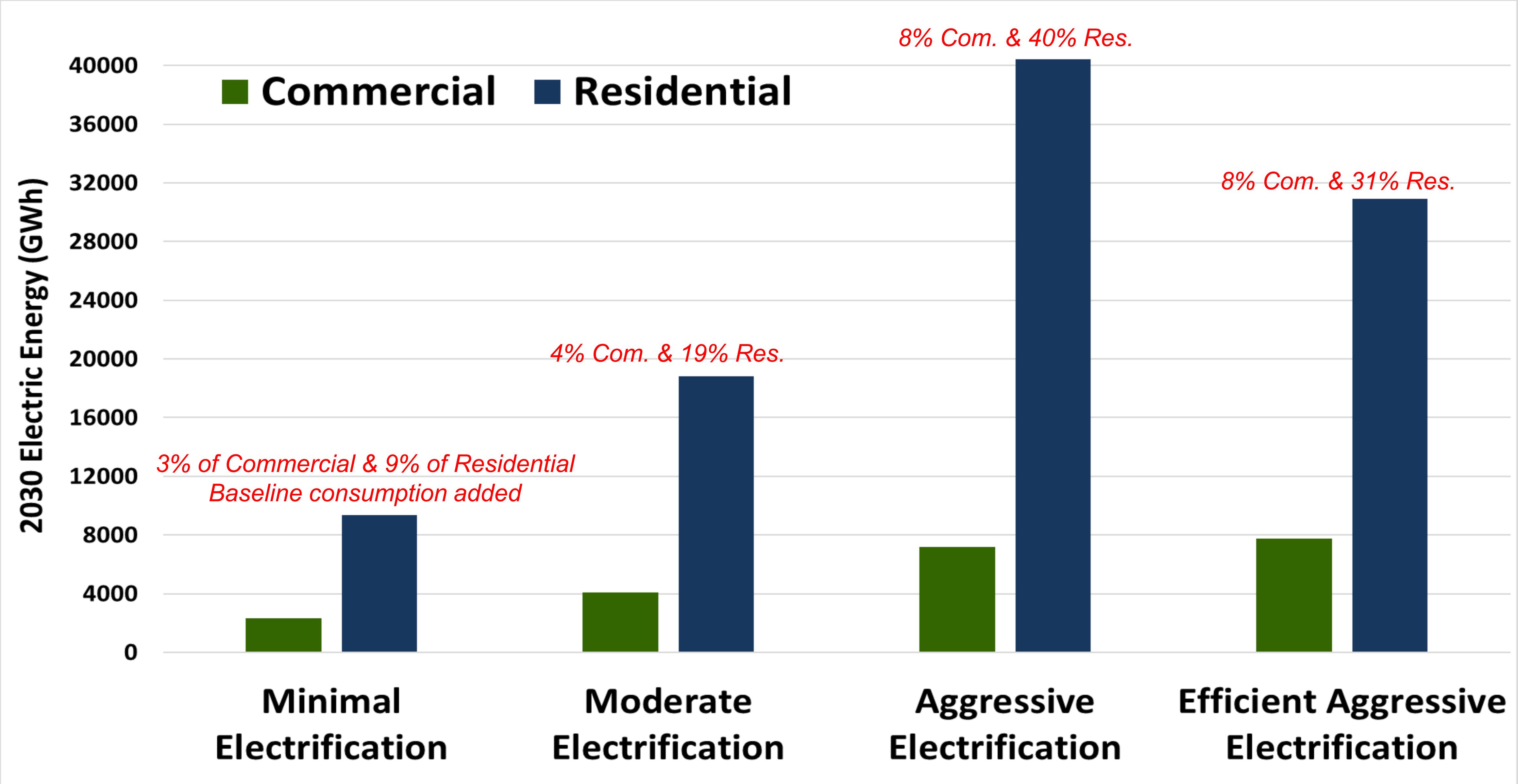
Background material for slide 37, “Projected Electric Generation Sector California GHG Emissions & Emission Intensity”

- June 7, 2018 IEPR Committee Workshop on Doubling Energy Efficiency Savings
  - Greenhouse Gas Emission Intensity Projections – Methods and Assumptions
  - https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2018-integrated-energy-policy-report-update-0

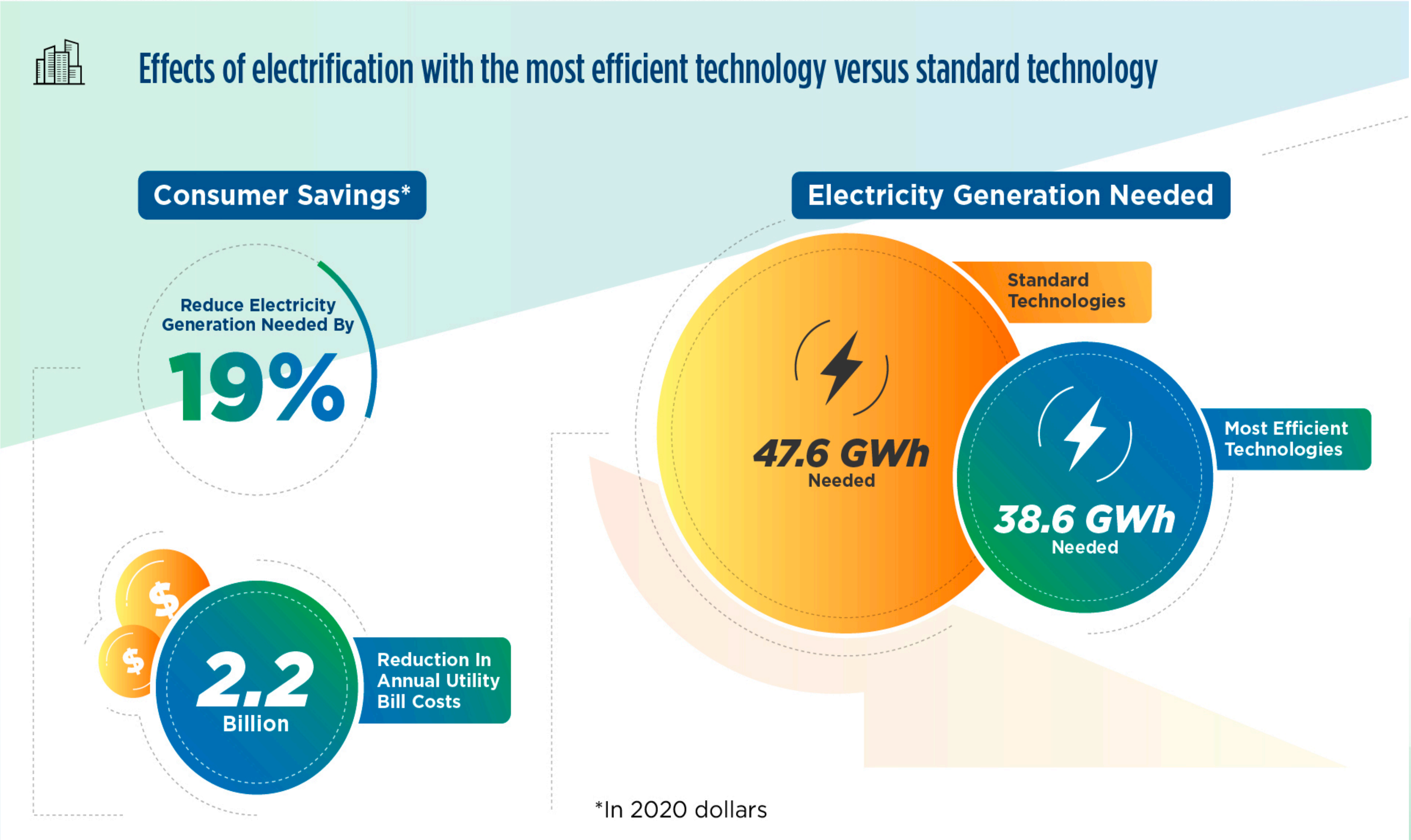
Statewide Annual Gas Demand by 2030



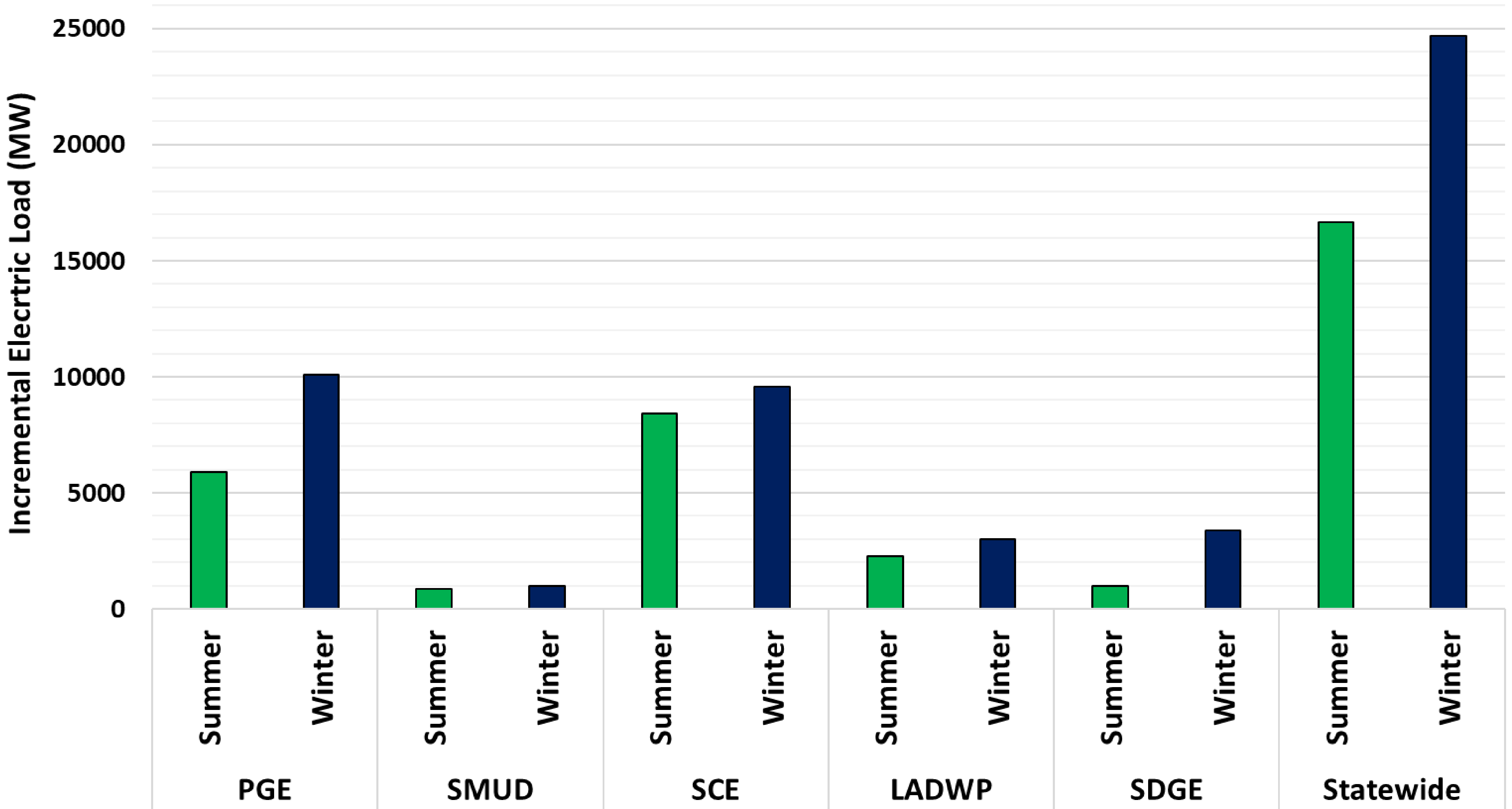
Statewide Annual Incremental Electricity Demand by Scenario-Specific Electrification in 2030



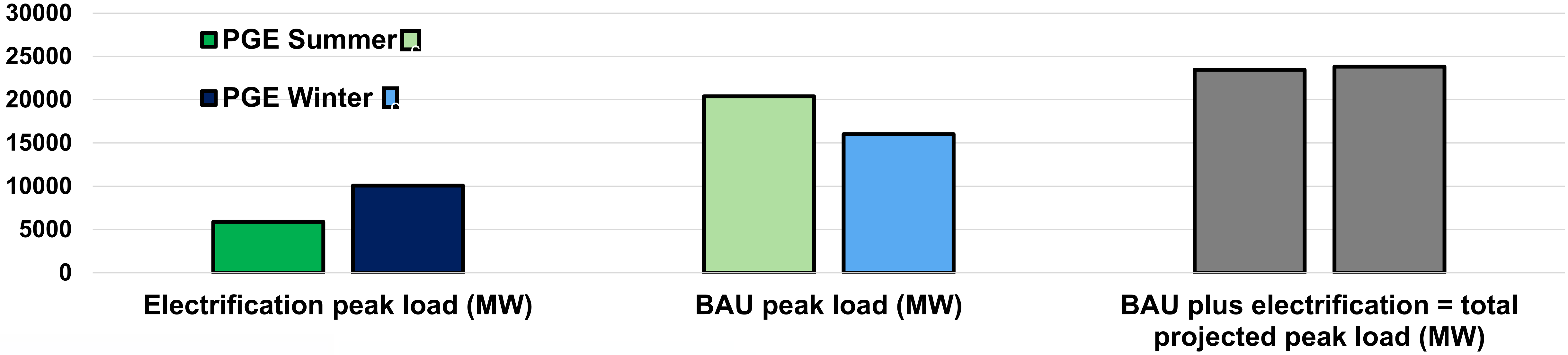
Electricity added by End Use after Aggressive vs. Efficient Aggressive Electrification



Seasonal Maximum Incremental Load Growth in 2030 after Aggressive Electrification



Summer and Winter Peak Load Impacts in 2030 after Aggressive Electrification



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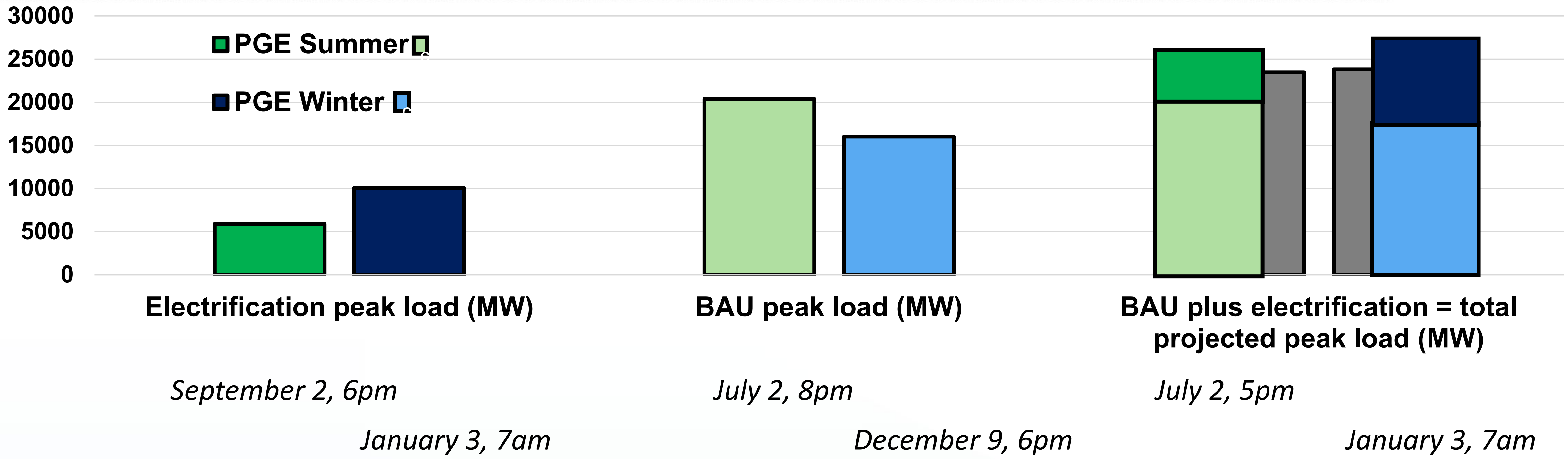

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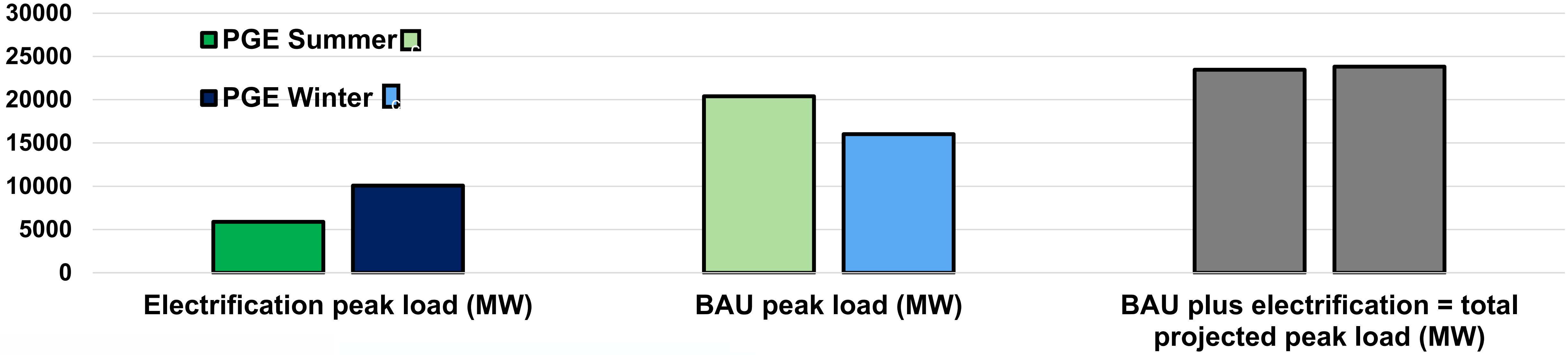
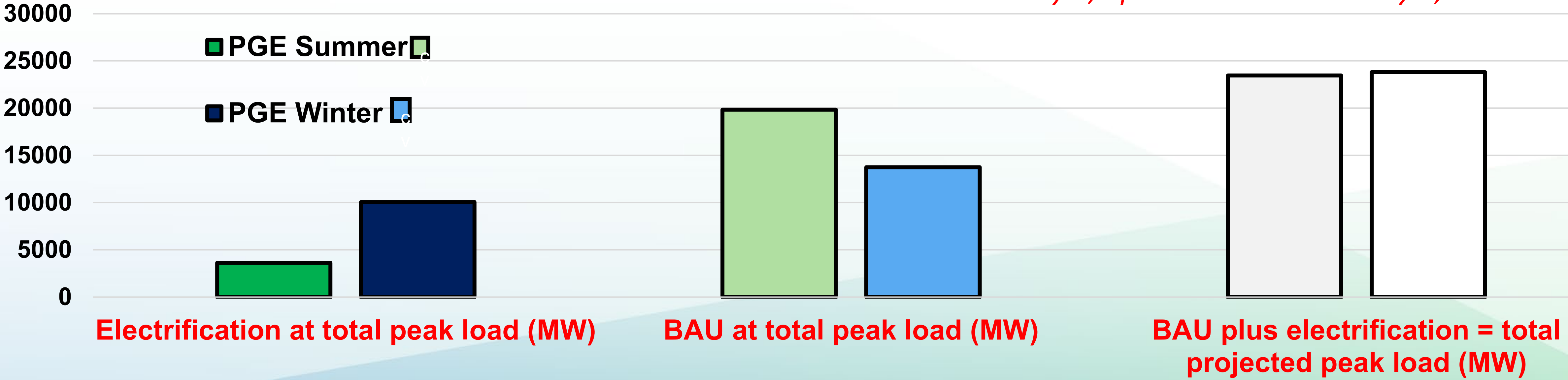


July 2, 5pm Summer & January 3, 7am Winter



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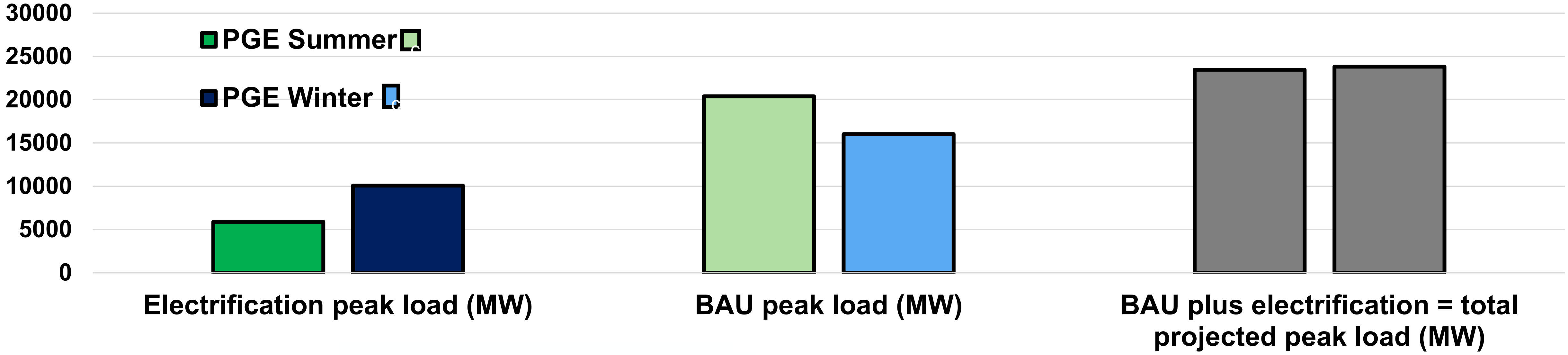

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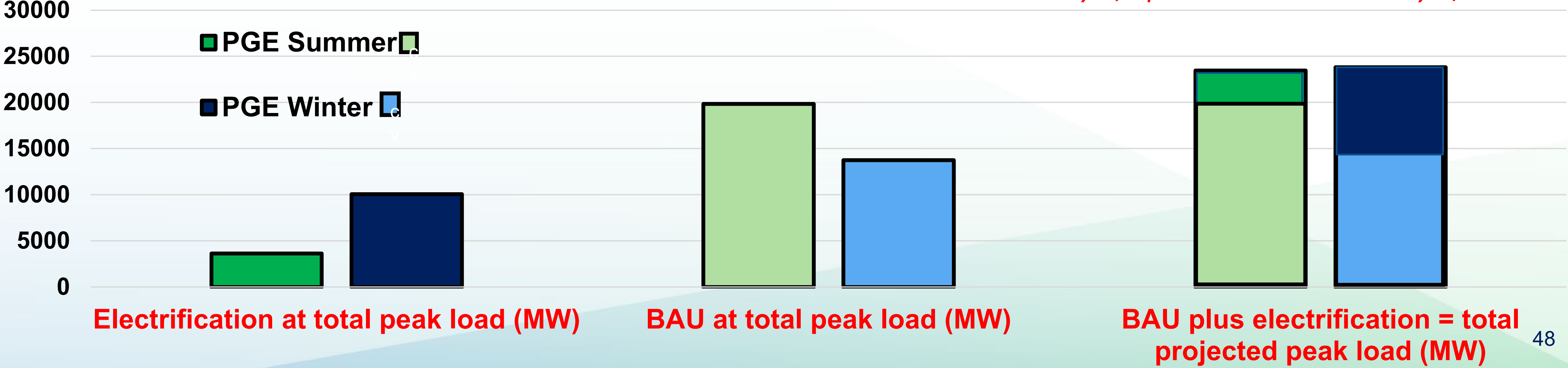
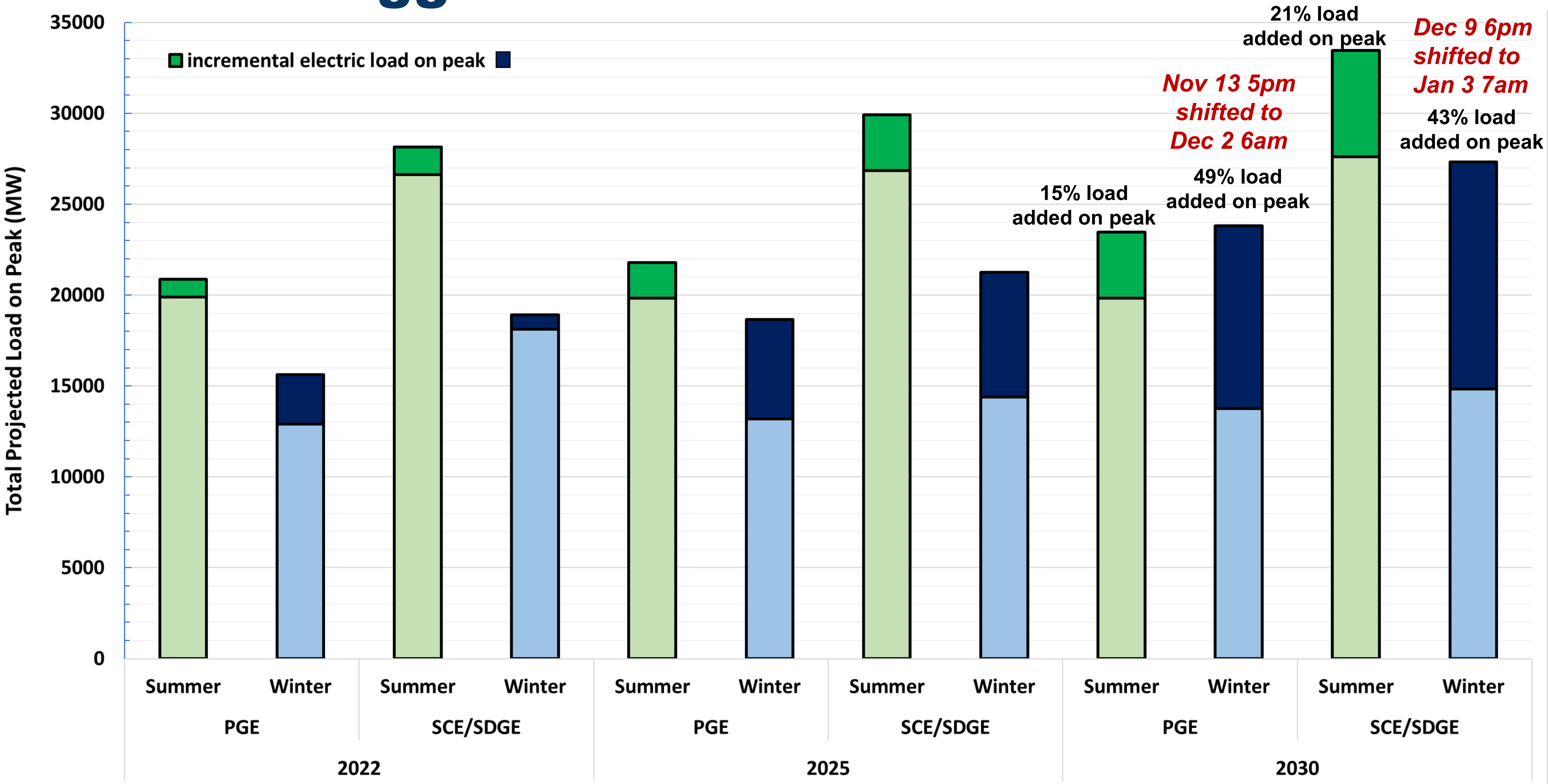


Summer and Winter Peak Load Impacts after Aggressive Electrification



Load Flexibility Analysis

Load Flexibility for AB 3232

1. “Load Flexibility” == “Load Shift” according to CPUC definition, for this analysis
2. Load shifting constrained to 20% of end use demand
3. Only studied additional load shift potential of newly electrified end uses
4. Only HVAC and water heating studied – appliances not included

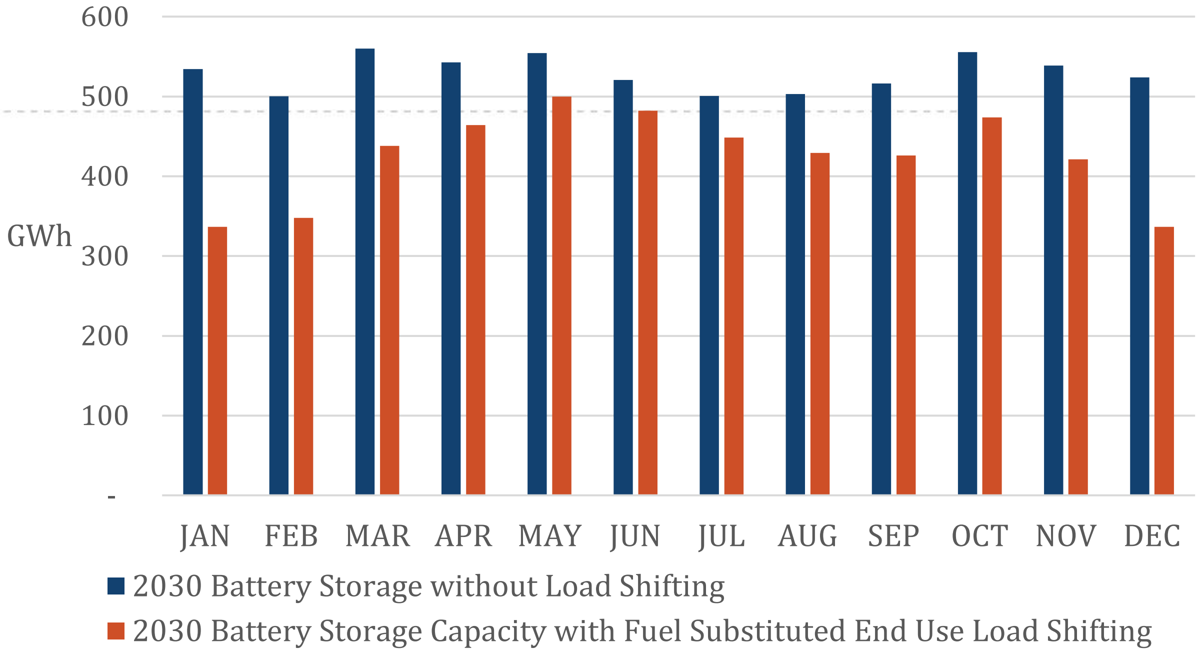
Load Shift End Use	2030 GWh per shift event
LBNL Commercial HVAC	2.5
FS Commercial Space Heating	0.9
FS Residential Space Heating	2.9
FS Residential Water Heating	4

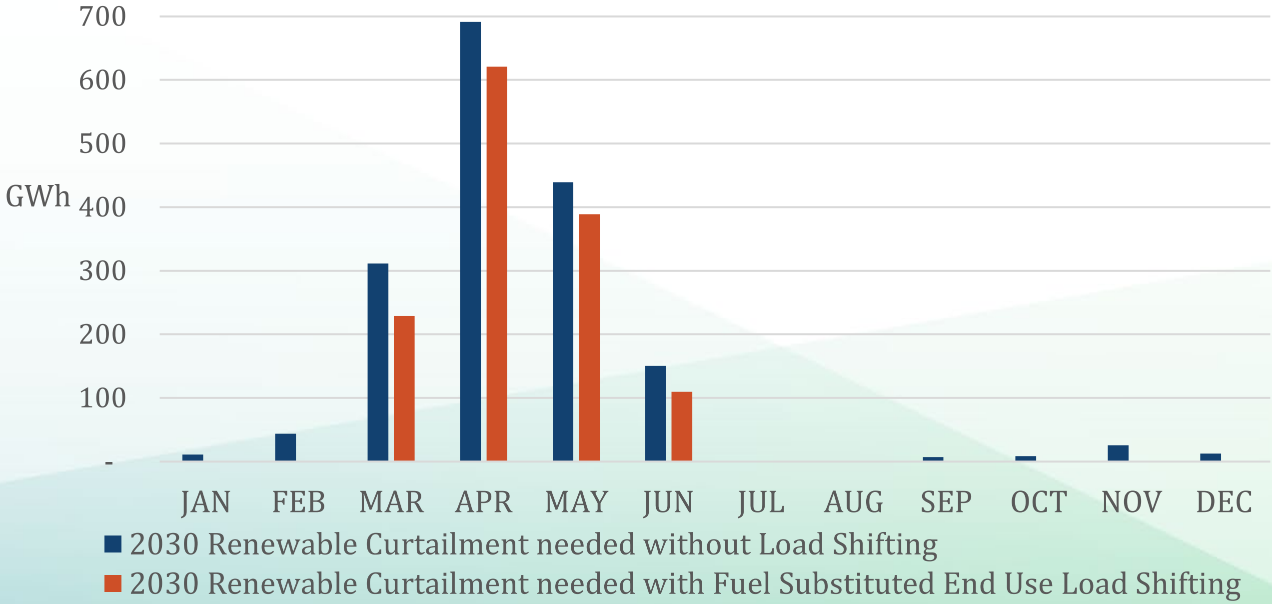
Potential Electricity System Impacts of Load Shifting

1. Reduced Battery Storage 1,250 GWh in 2030

2. Reduced Renewable Generation Curtailment 350 GWh in 2030

3. Assumes Load Shifting every day of the year





More background materials

- **SB 100:**
  - **2021 SB 100 Joint Agency Report: Achieving 100 Percent Clean Electricity in California: An Initial Assessment.** March 2021. CEC-200-2021-001. https://www.energy.ca.gov/sb100
- **EPIC-funded study of the impacts of high electrification levels on the gas system**
  - Aas, Dan, Amber Mahone, Zack Subin, Michael Mac Kinnon, Blake Lane, and Snuller Price. 2020. **The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs and Public Health Benefits of Reducing Natural Gas Use. California Energy Commission.** Publication Number: CEC-500-2019-055-F. https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/index.html.
- **Technical details of AB 3232 Analysis**
  - See Appendix C in report. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237733&DocumentContentId=70963

Thank you! Questions?

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