DOCKETED

Docket Number:	16-BSTD-06
Project Title:	Updates to the 2019 Time Dependent Valuation of Energy
TN #:	212357
Document Title:	E3 7-15-16 2019 TDV Workshop Presentation
Description:	PDF version of subcontractor E3's presentation at the 2019 TDV Lead Commissioner Workshop held on 7-15-16.
Filer:	Adrian Ownby
Organization:	E3
Submitter Role:	Public Agency
Submission Date:	7/19/2016 1:07:17 PM
Docketed Date:	7/19/2016

Energy+Environmental Economics

2019 TDV Updates

CEC Staff Workshop
July 15, 2016

Snuller Price, Senior Partner
Tory Clark, Consultant
Zachary Ming, Senior Consultant
Brian Conlon, Senior Associate
Hilary Staver, Associate

Agenda

- **2019 TDV Update**
  - TDV Methodology Background and History
    - SB350 Considerations + Sensitivities
  - Updates to TDVs
    - Updates since draft TDVs in May 2016
    - Updates to Methodology
    - Updates to Inputs
  - Results and Comparison to 2016
- **Building Electrification Analysis**

Energy+Environmental Economics

TDV METHODOLOGY BACKGROUND

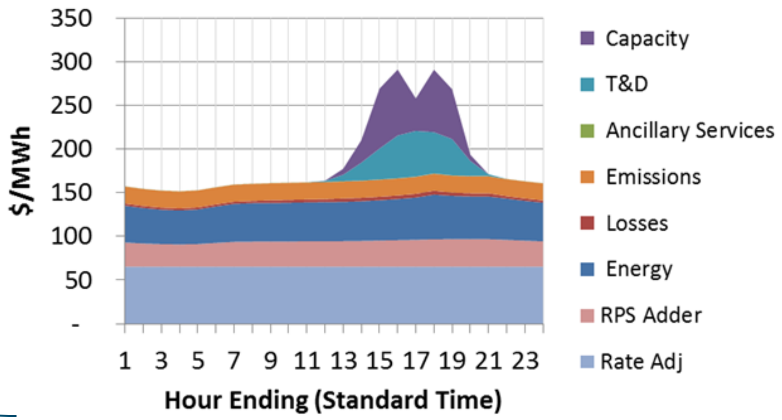
What are TDVs?

+ **The TDVs are a long term forecast of hourly electricity, natural gas and propane costs to building owners and are used for cost-effectiveness activities in Title 24 Building Code**

+ **The TDVs answer the question of what is cost-effective in the long term, as required by the Warren-Alquist Act**

- Time-differentiation reflects the underlying marginal cost of producing and delivering energy
- Area-correlation reflects underlying marginal cost shapes correlated with each climate zones weather file

Sample Annual Average Electric TDV, 2016



Similar for natural gas and propane

What are TDVs used for?

+ Two main uses for TDVs

1. Cost-effectiveness analysis in the CASE studies (Codes And Standards Enhancement studies) used to adopt new building measures in the prescriptive standard
2. Code compliance for buildings that wish to vary from the prescriptive standard using the ACM (alternative calculation methodology). TDVs are embedded in California Building Energy Code Compliance software (CBECC)

Frequently Asked Questions (1)

+ **Why do we use statewide average electricity and natural gas retail rate levels?**
    - With this approach, the code has similar overall stringency state wide and there can be similar construction practices across the state. Note that there are still variations for climate.

+ **Why don't we use the actual retail rate structures that are in place?**
    - We want the building code to be relatively stable over time and from cycle to cycle, the TDVs reflect a 'perfect' marginal cost of service which is a long term signal for retail rates
    - By using the underlying system marginal costs we are reflecting building measures that provide the greatest underlying value to the energy system, even if retail rates are flat or have a different time of use period

Frequently Asked Questions (2)

+ Why are the units of TDV in kBTU/kWh and kBTU/therm if they measure cost-effectiveness?

- The TDVs are calculated in lifecycle dollars per unit of energy ($/kWh, $/therm) in each hour and climate zone in California
- For the building code compliance, they are converted to different units of kBTU/kWh and kBTU/therm using fixed multipliers

Energy+Environmental Economics

SB 350 CONSIDERATIONS

SB350 Considerations

- **SB350 calls for 50% utility-procured renewable electricity and a doubling of energy efficiency by 2030**
- **Base Case; "SB-350-Friendly" scenario**
  - 2015 IEPR mid-case load forecast (including mid-case EV and mid CO2 price forecasts)
  - 50% renewables by 2030 from in-state resources
  - A doubling of the 2015 IEPR Additional Achievable Energy Efficiency (AAEE) mid-case by 2030
  - Diablo Canyon Nuclear Facility is retired

Sensitivities

+ **Several sensitivities have been evaluated to test the impact on the resulting TDVs, more and less stringent than the base case**

		Load Forecast	Energy Efficiency	CO2 price
1	Base Case	2015 IEPR Mid-demand	2x 2015 IEPR AAEE	2015 IEPR Mid Case
2	Low EE / High Electrification		1x 2015 IEPR AAEE	
3	High CO2 Price			2015 IEPR High Case

Energy+Environmental Economics

UPDATES TO TDVS

Updates to 2019 TDVs since draft workshop in May

Updates based on availability of data, stakeholder comments, model testing

Key changes

- Inclusion of T&D allocation factors with utility load data
- New temperature threshold for allocating capacity values to “peak” days. 90° F to 90.5°F, which smoothed out results
- Removal of a NOx adder to natural gas, which decreased natural gas TDVs
- Incorporated data from propane industry on seasonal shape

Minor changes and bug fixes

- Inclusion of CO_2 and variable O&M in the dispatch logic to calculate combustion turbine energy revenues which feeds into capacity value (net cost of new entry)
- Changed CO_2 units from short tons to long tons

Energy+Environmental Economics

UPDATES TO TDV T&D ALLOCATION METHODOLOGY

T&D Updated Methodology

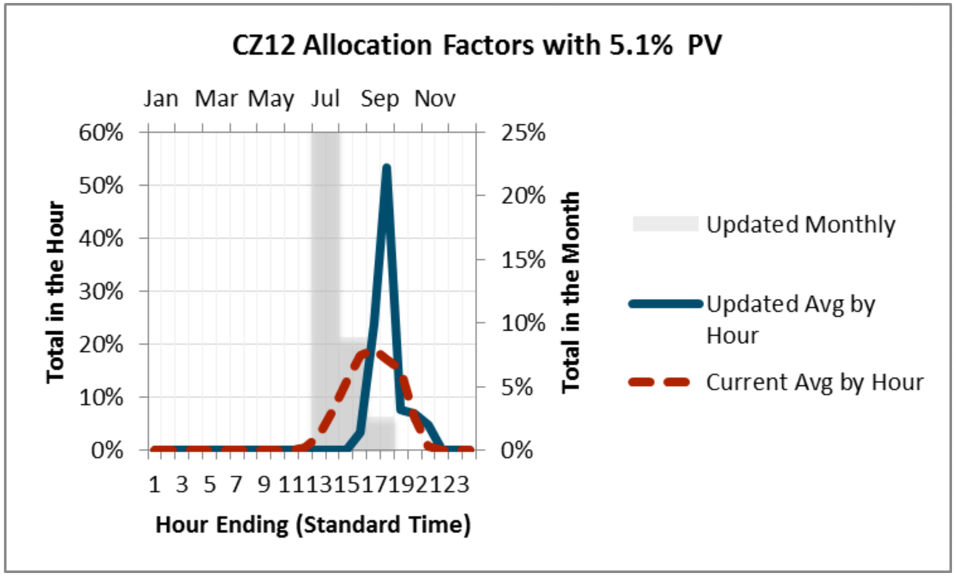
- **New methodology for T&D avoided cost allocation using actual distribution load data, not the temperature proxy that we have been using**
- **Benefits**
  - More accurately reflects usage patterns in a climate zone
  - Allows for local PV effects to be included
  - Is more consistent with industry view of peak demand
    - Provides more focused value in fewer hours to better value dispatchable options

T&D Allocation Method

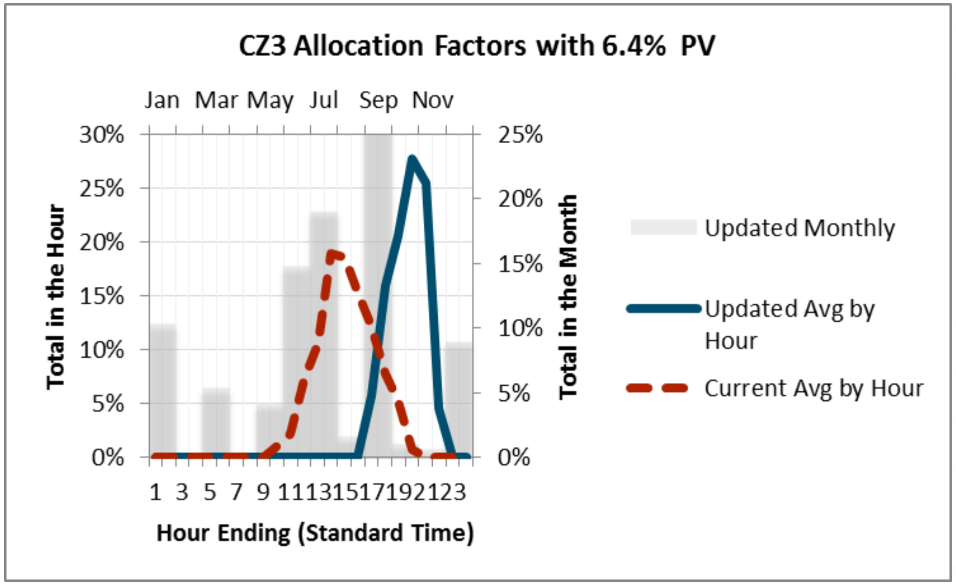
- **Use regression analyses to determine the relationship of area hourly loads to temperature**
  - Variables include dry-bulb temp, cooling degree hours, heating degree hours, lagged variables, moving averages of variables, as well as standard modeling dummy variables
  - Adjusted R-square results typically around 90%.
- **Apply the regression equations to the CTZ weather files to derive predicted CZ hourly loads**
- **Derive 2017 allocation factors based on the predicted hourly loads**
- **Adjust predicted loads for additional solar PV adoptions, and derive 2030 allocation factors**

Effects of the Update

- Concentration into fewer hours is common

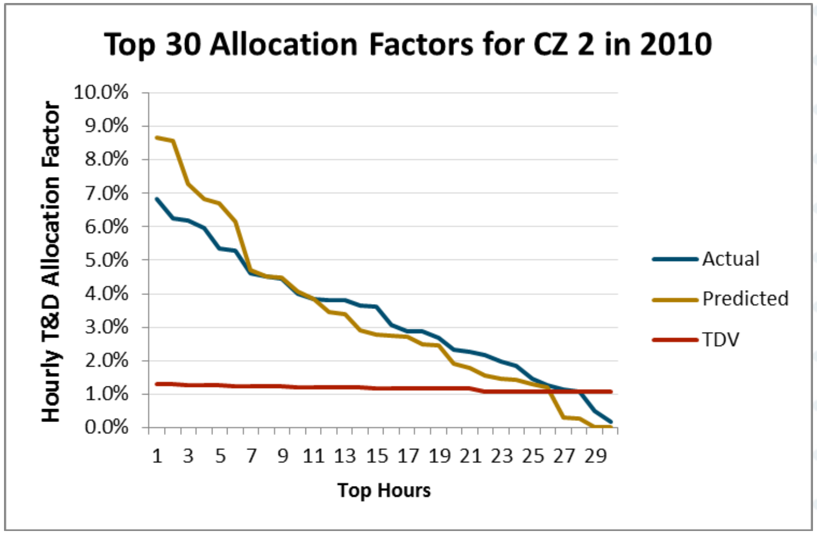


- Shifting to later hours also occurs in most CZ's



Update Places higher Emphasis on Top Hours

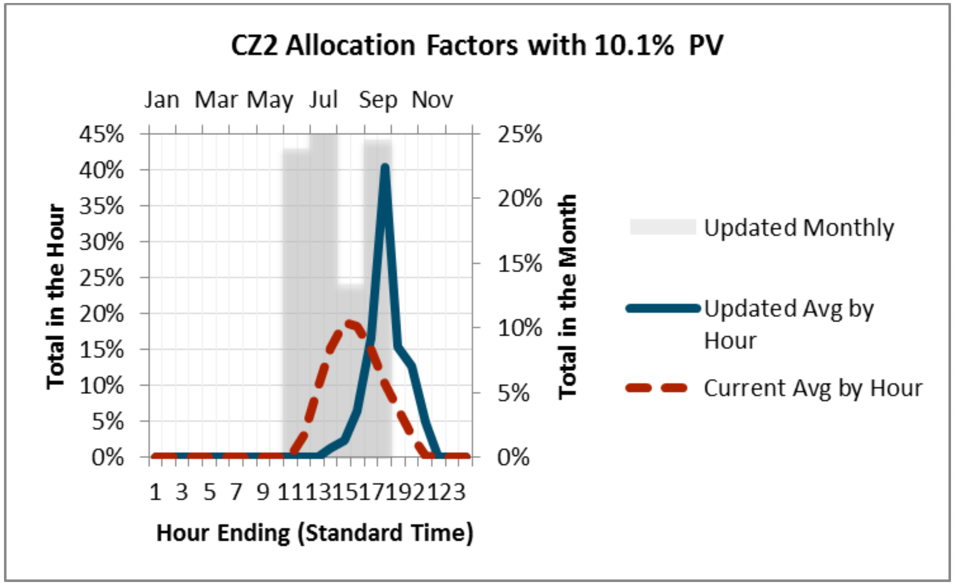
- Allocation factors shown based on actual and regression-predicted 2010 loads
- Allocation based on the PCAF method that is commonly used for T&D cost allocation. Factors kept from 2-250 hours.
- New factors are more appropriate for evaluating dispatchable technologies.



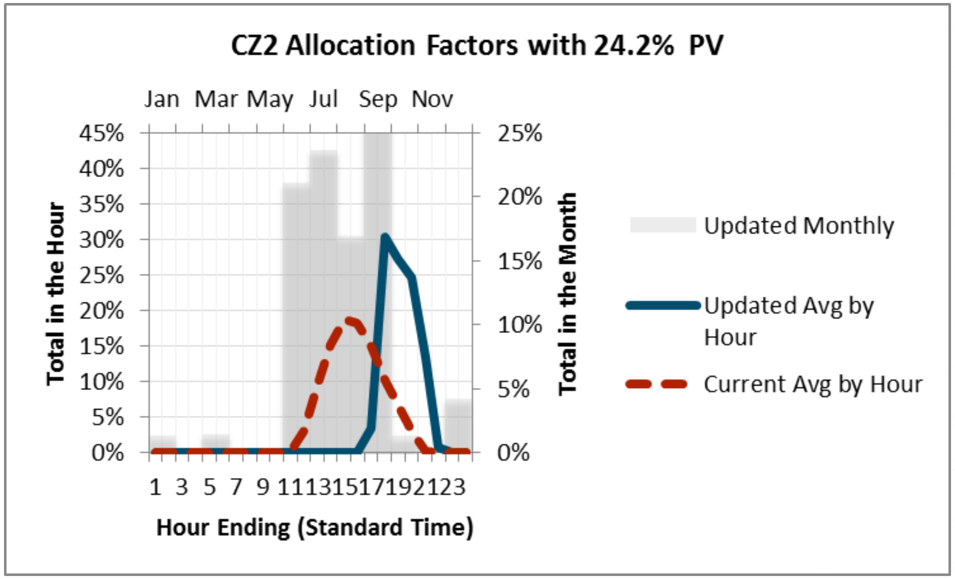
Increased Forecast Local PV also Affects the Allocators for 2030

- Peak shifts to later hours
- Peak can include other months
- But effect through 2030 is moderate

2020 Allocators



2030 Allocators

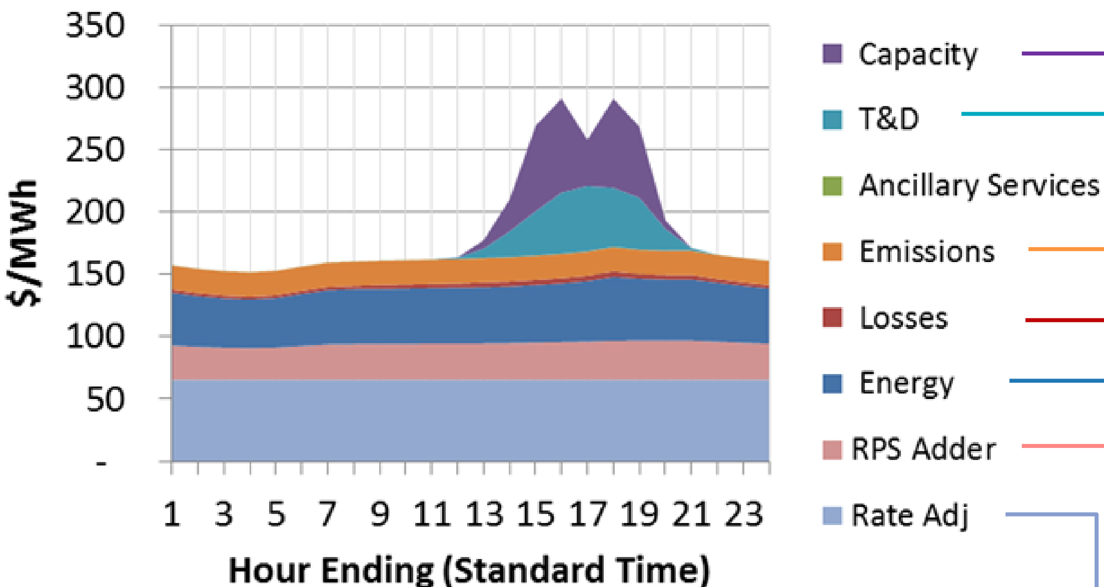


UPDATES TO TDV INPUTS

- ELECTRICITY
- NATURAL GAS AND PROPANE

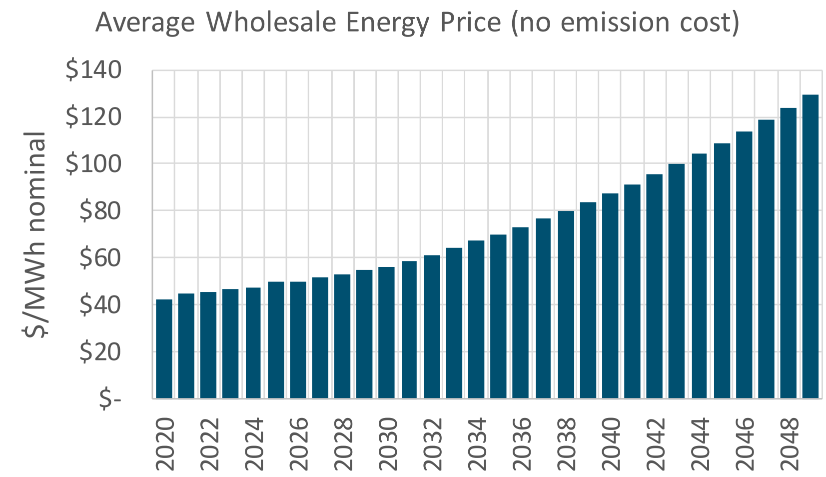
Updated Inputs to Electricity TDV

Sample Electric 2016 TDV – Residential CZ12

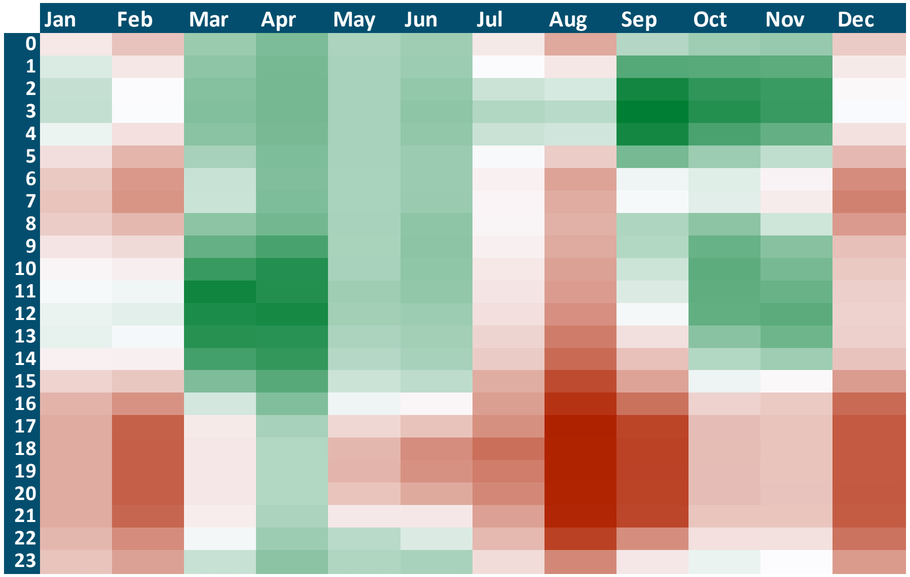


- Updated avoided capacity costs for SB350
- Updated avoided T&D costs
- Updated avoided ancillary services costs
- Updated avoided emissions cos
- Updated avoided cost of losses
- Updated PLEXOS production simulation to match new load forecasts and SB350
- Updated marginal costs of renewables
- Updated electric retail rate forecast

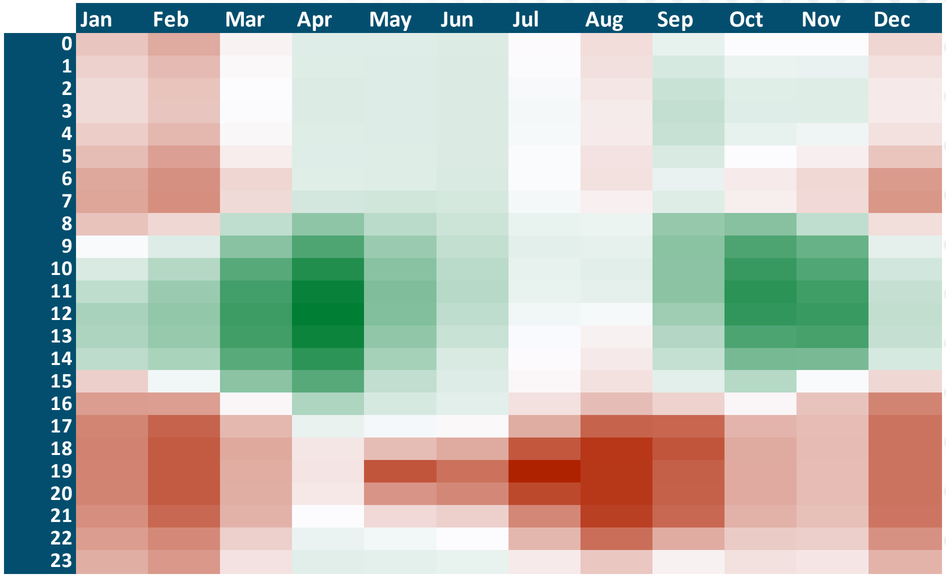
- Marginal energy price shape generated from PLEXOS production simulation modeling at CEC
- 50% RPS portfolio calculated with CPUC RPS Calculator
- 2026-2049 is assumed to have same price shape as 2026



2020 Shape

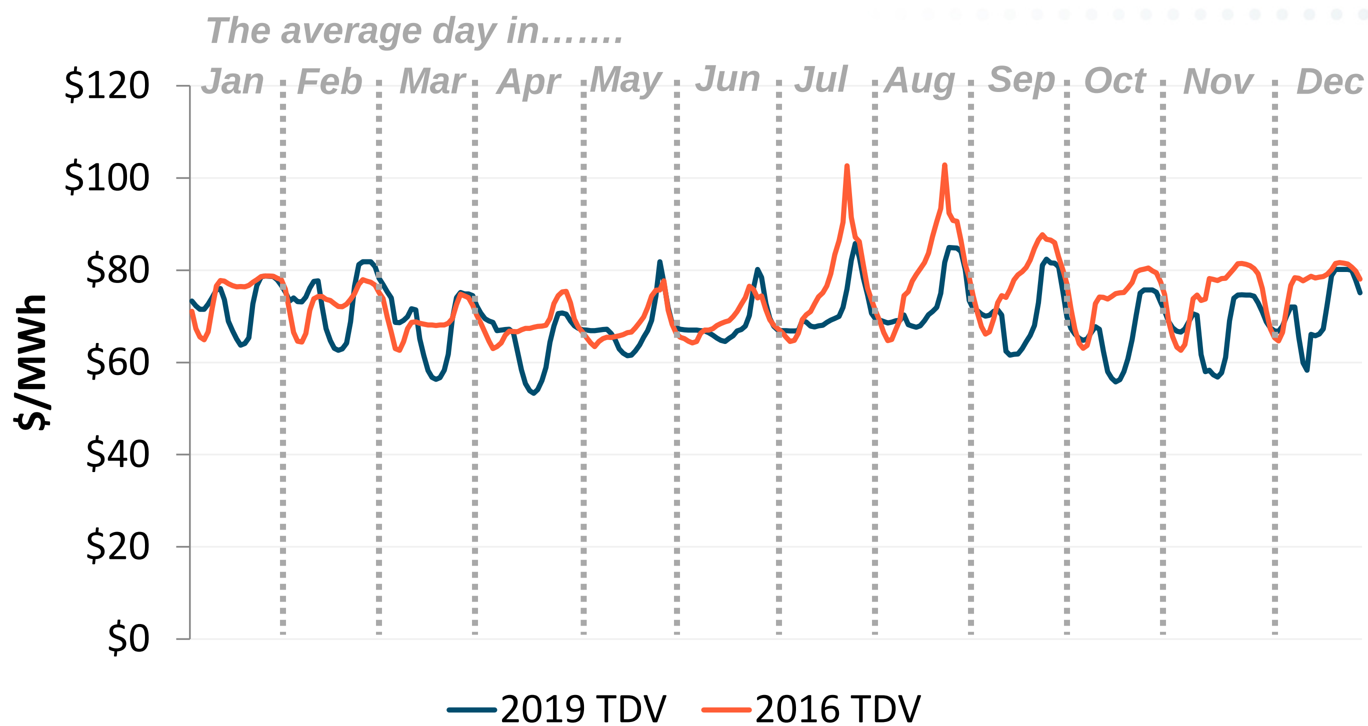


2026 Shape



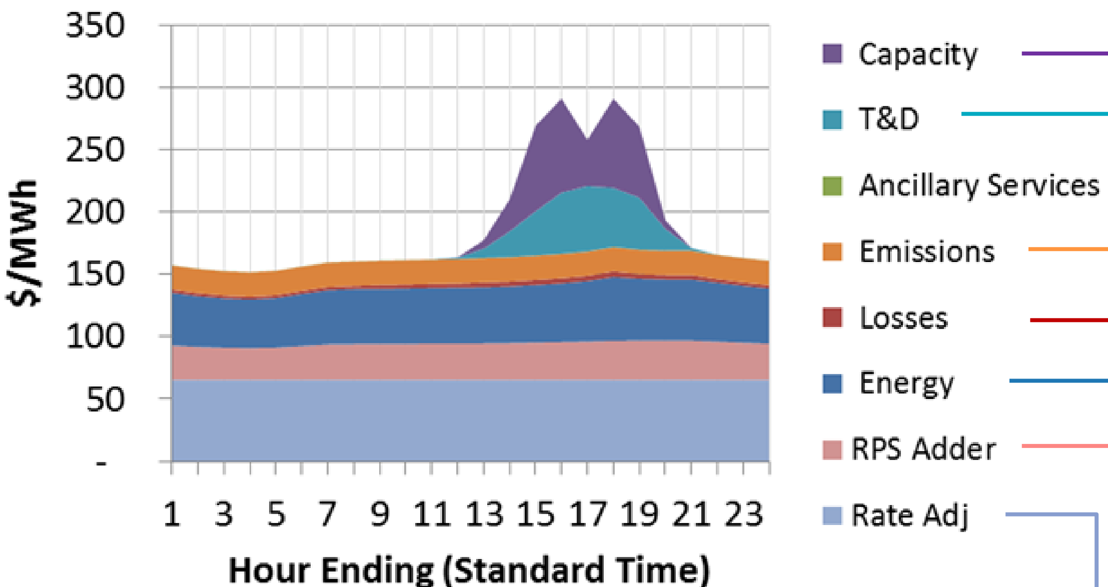
Energy Price Shape Comparison

+ **Updated PLEXOS results begin to show lower mid-day energy prices due to higher RPS and solar penetration**



Updated Inputs to Electricity TDV

Sample Electric 2016 TDV – Residential CZ12

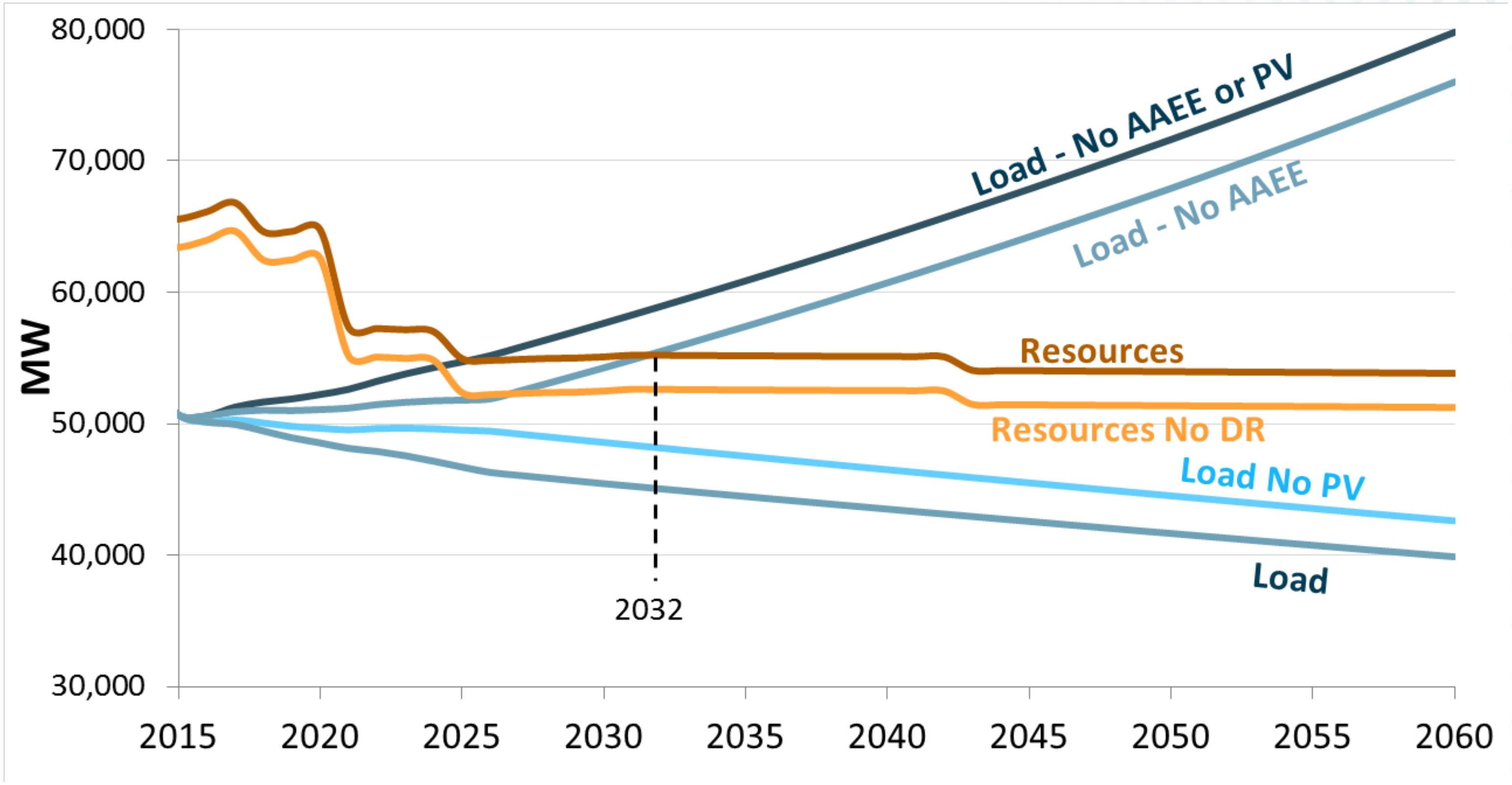


- Capacity → Updated avoided capacity costs for SB350
- T&D → Updated T&D costs
- Ancillary Services → Updated ancillary services costs
- Emissions → Updated emissions cost
- Losses → Same loss %'s → new value
- Energy → Updated PLEXOS production simulation to match new load forecasts and SB350
- RPS Adder → Updated marginal costs of renewables
- Rate Adj → Updated electric retail rate forecast

Generation Capacity (1)

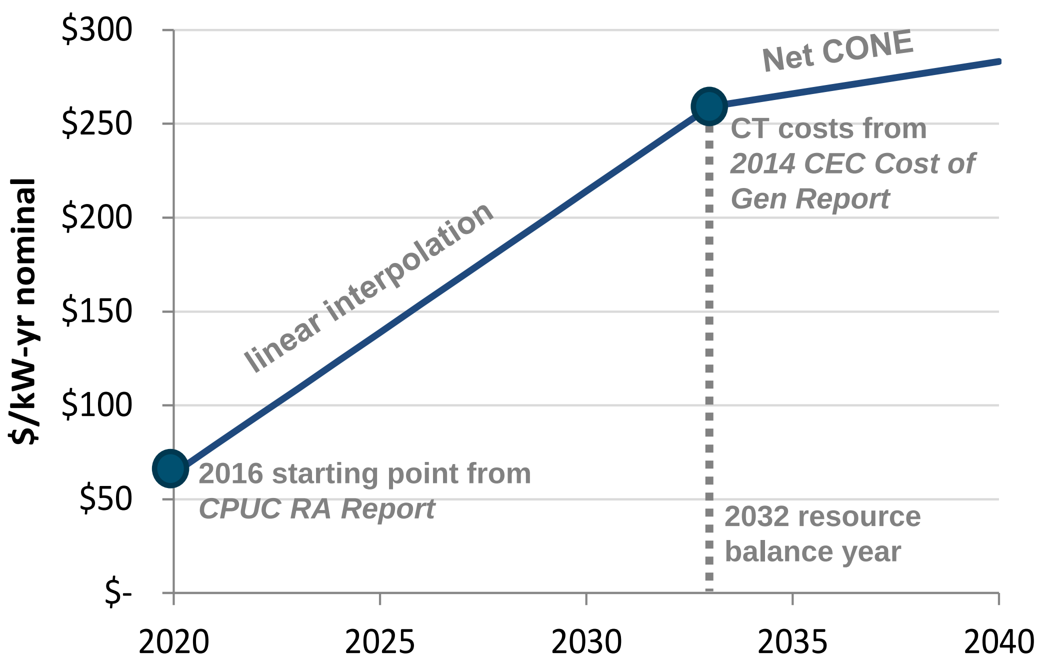
+ Updated resource balance year

- Expected renewable build extends resource balance year and reduces the value of capacity in the near-term
- Calculated using RPS Calculator (no uncommitted AAEE included in load forecast)



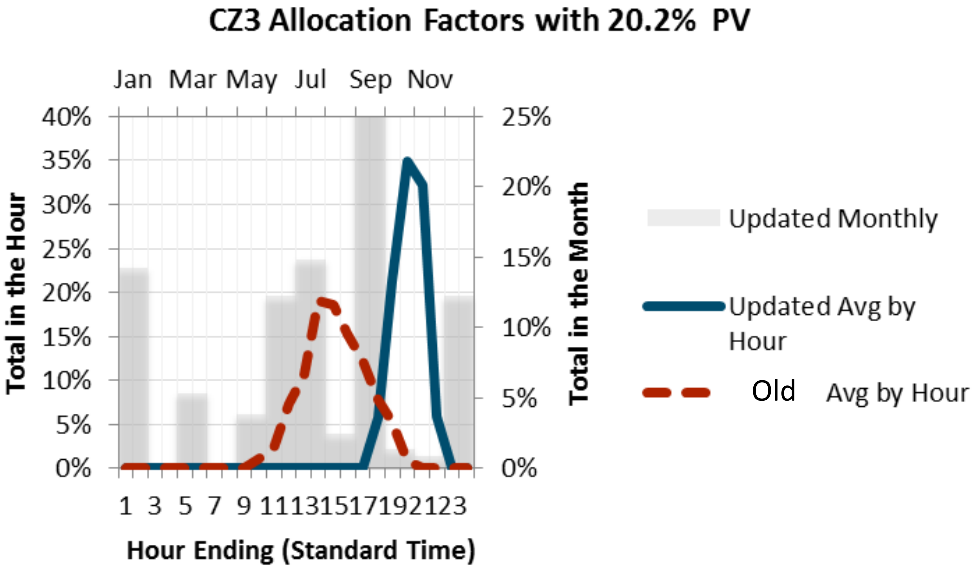
Generation Capacity (2)

+ **Updated capacity value allocation**
  - 50% RPS shifts value to later in the evening and later in the summer
  - Calculated using E3 RECAP model and allocated to hours in TDV weather year



T&D Capacity

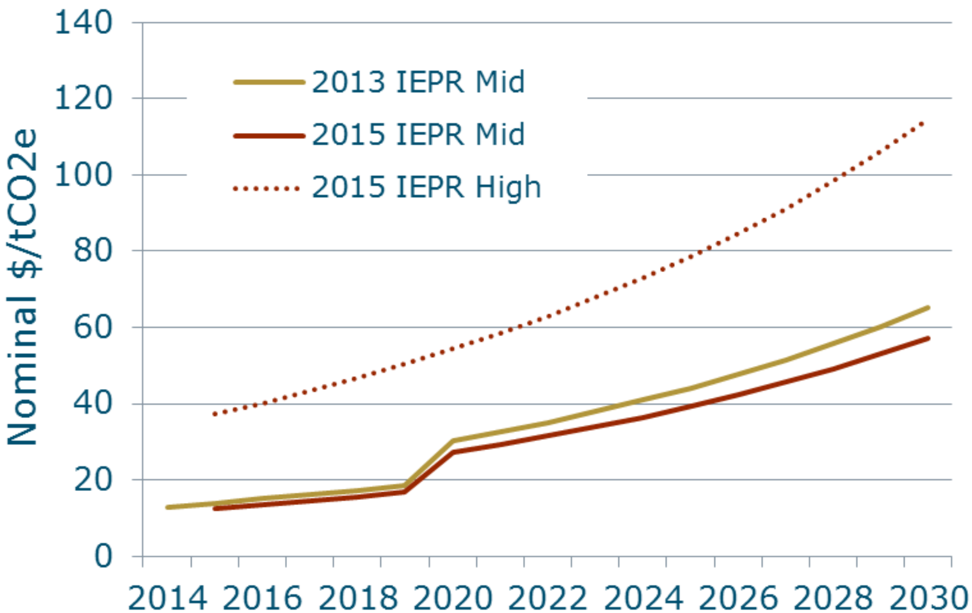
+ **T&D avoided costs are calculated using weighted average from the latest utility GRCs**
  - Transmission: $33.63/kW-yr
  - Distribution: $83.99/kW-yr
  - GRC Sources: PG&E 2014, SCE 2015, SDG&E 2015
+ **Costs are allocated to climate zones using new methodology of actual utility loads and forecast behind-the-meter PV forecasts**
  - Replaces temperature-only allocation
  - Shifts allocation to later in the evening



Source: E3 regression of PG&E and SCE load data

Ancillary Services, Emissions, and Losses

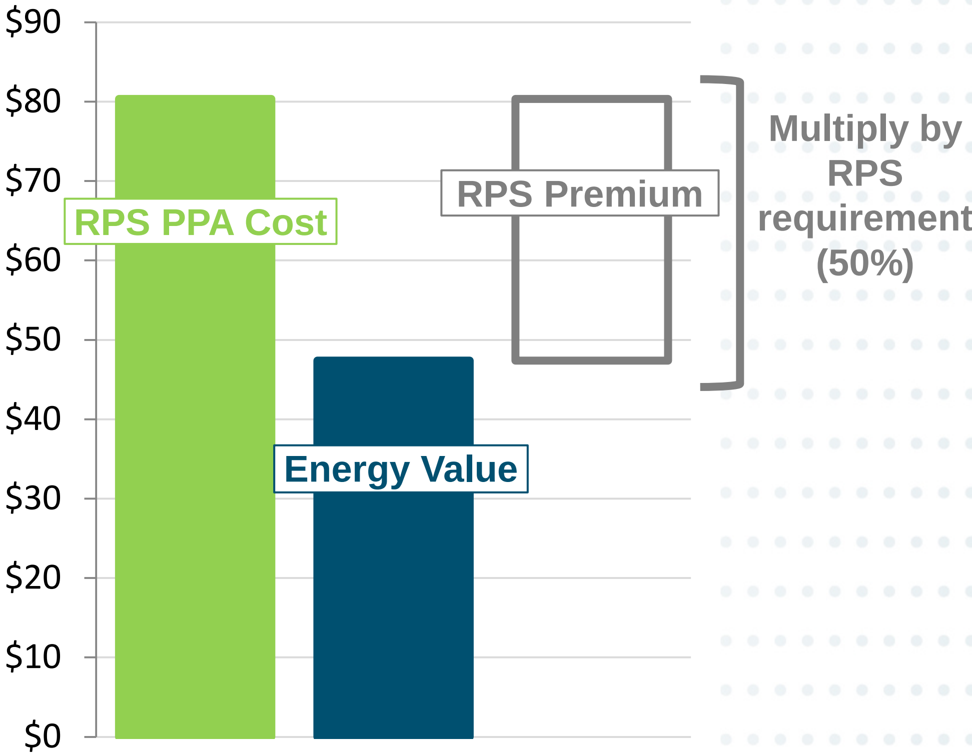
- **Ancillary Services**
  - Continue to use 0.5% of energy
- **Emissions**
  - Updated GHG price forecast to 2015 IEPR
  - Continue to calculate marginal emission rate on hourly implied heat rate using energy and gas prices
- **Losses**
  - Continue to use utility-specific loss factors retained from 2013 TDV analysis



Description	PG&E	SCE	SDG&E
Summer Peak	1.109	1.084	1.081
Summer Shoulder	1.073	1.080	1.077
Summer Off-Peak	1.057	1.073	1.068
Winter Peak	0.000	0.000	1.083
Winter Shoulder	1.090	1.077	1.076
Winter Off-Peak	1.061	1.070	1.068
Generation Peak	1.109	1.084	1.081
Transmission Peak	1.083	1.054	1.071
Distribution Peak	1.048	1.022	1.043

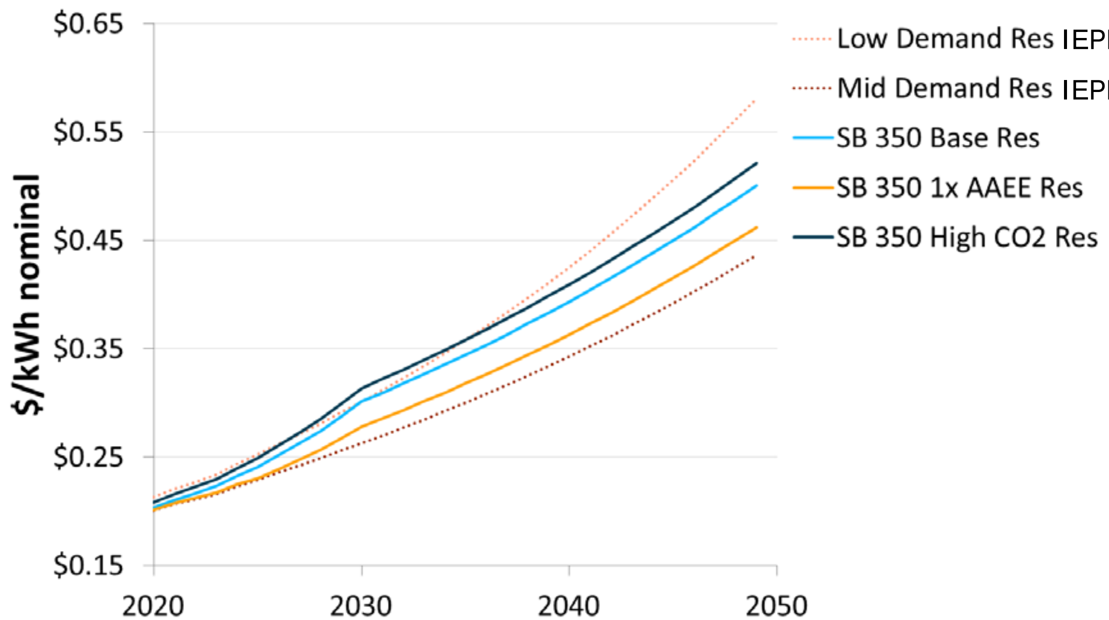
RPS Premium

- Avoided cost of procuring additional RPS energy
- Marginal RPS cost data from CPUC RPS Calculator Version 6.2
  - Assumed to be energy-only resource with **no** incremental transmission costs and **no** capacity value
- Decline in RPS costs has decreased this component
- NOTE: this component has no effect on the shape of TDV outputs since it is flat – its inclusion simply reduces the retail rate adder



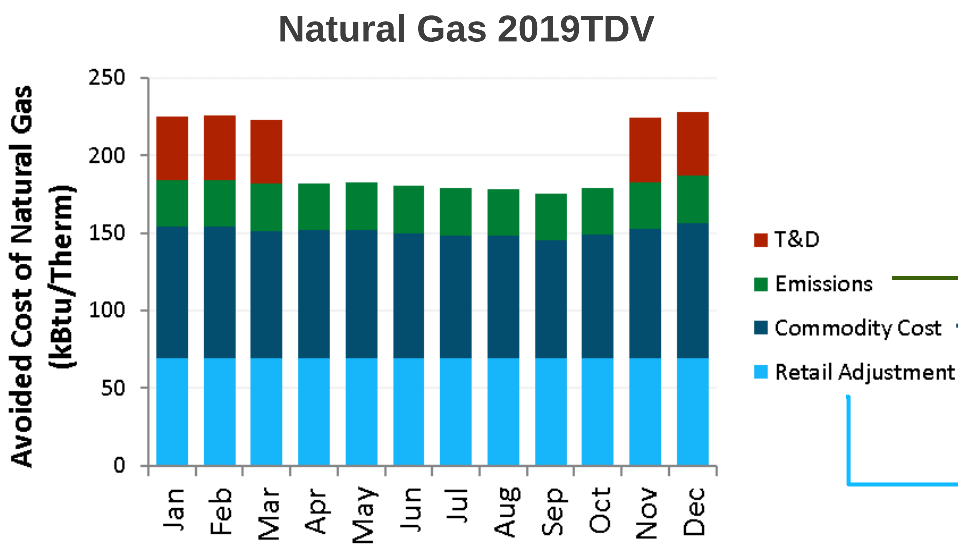
Retail Rate Adjustment

- **Retail rate adder is used to ensure that the load weighted average TDVs are equal to customer retail rate**
- **Mid-Demand and Low-Demand rate forecasts provided by 2015 IEPR**
- **SB-350 retail rate adjustment was estimated by E3**
- **Approach**
  - CPUC RPS Calculator to calculate average rates under IEPR mid demand and SB 350 friendly assumptions
  - Apply this % impact to the IEPR mid electric rate forecast



Source: CPUC RPS Calculator, 2015 IEPR

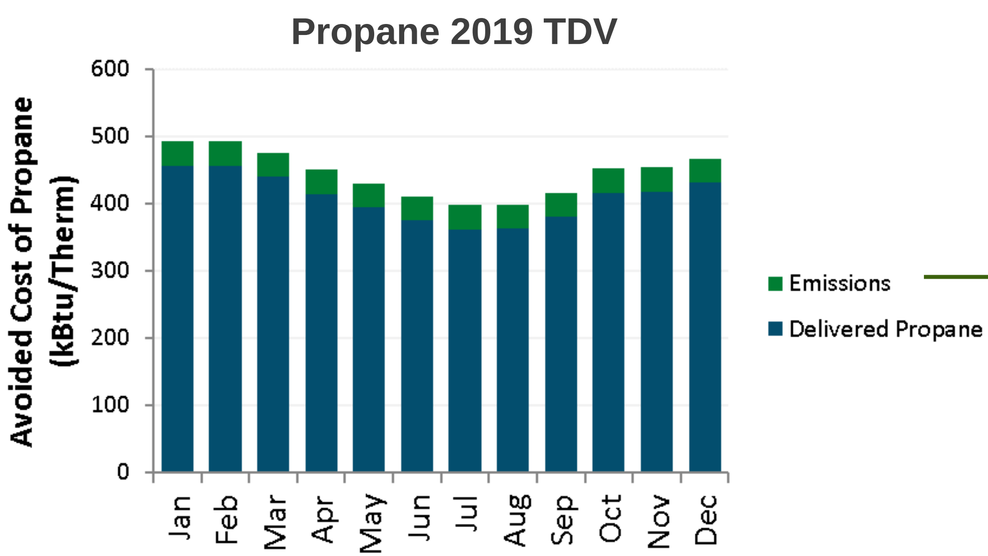
Updated inputs to Natural Gas and Propane TDV



Updated CO2 price forecast

Updated Henry Hub price forecast

Updated natural gas retail rate forecast



Updated CO2 price forecast

Updated propane retail rate forecast and seasonal shape

Natural gas and propane retail rate forecasts

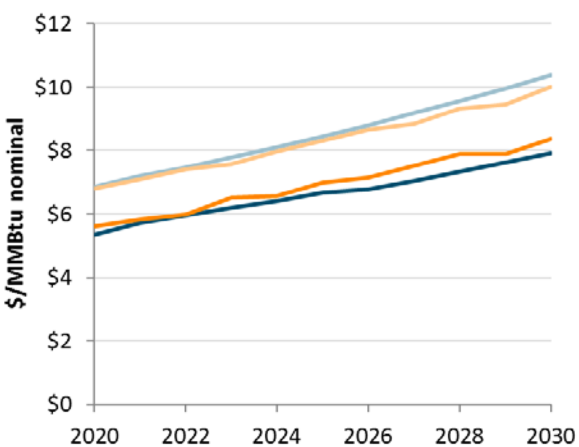
+ Natural gas commodity price update

- Natural gas burnertip price forecast from 2015 IEPR

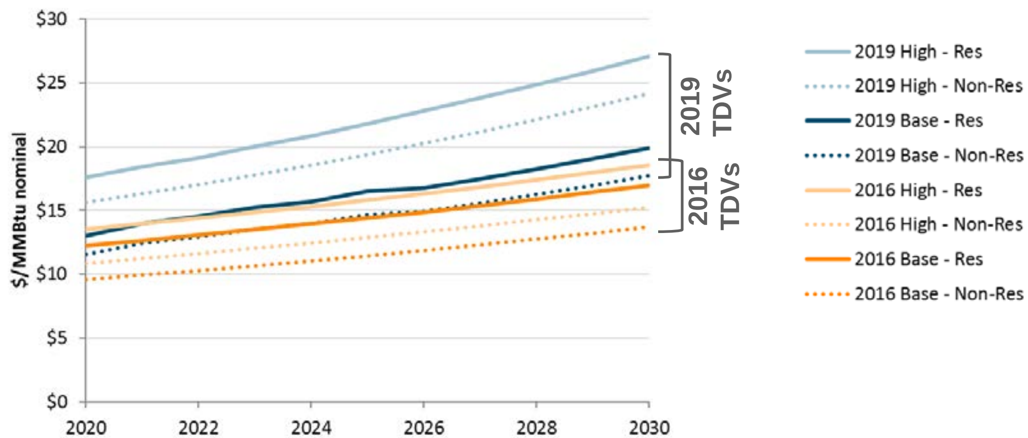
+ Natural gas retail rate price update

- Retail rate forecast from 2015 IEPR

Natural Gas Commodity



Natural Gas Retail Rates



+ Propane price forecast

- EIA AEO 2013 Pacific region forecast, normalized to IEPR through natural gas rates – Propane Price_{EIA} * (NG Price_{IEPR}/NG Price_{EIA})

Energy+Environmental Economics

DRAFT TDV RESULTS

Changes in TDVs from Last Cycle

+ **Increase in retail rate forecast drives average TDV level higher**

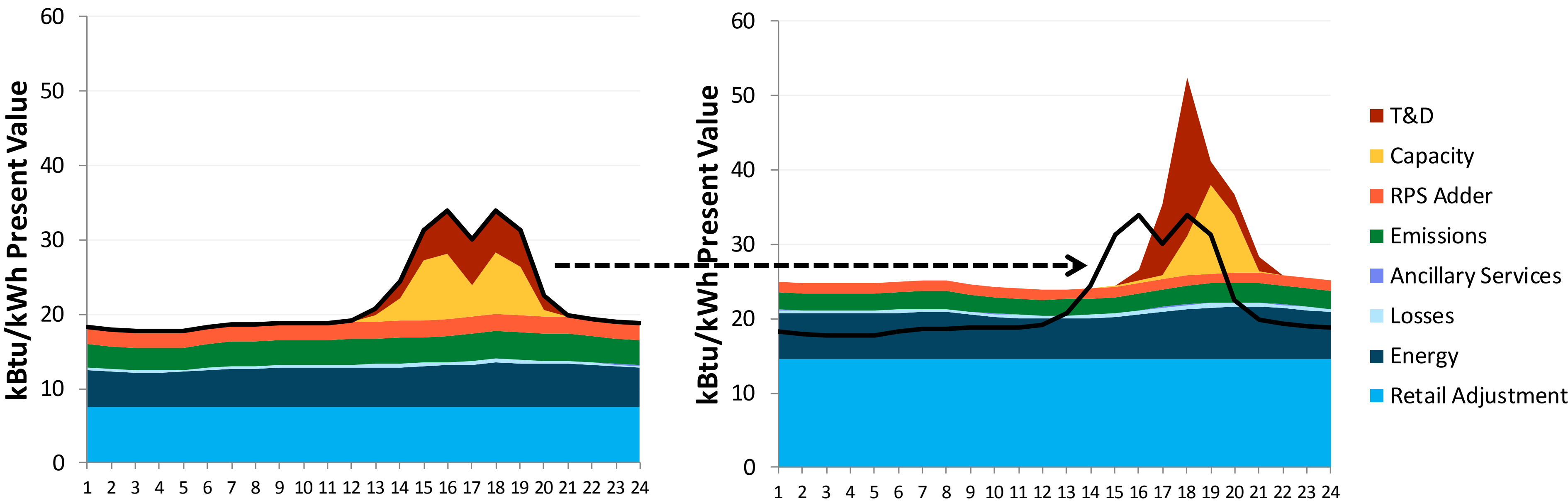
+ **Generation capacity and T&D capacity have shifted to later in evening**

Res (30-yr), CZ 12	Electric (kBtu/kWh)	Gas (kBtu/therm)	Propane (kBtu/therm)
2019 Avg TDV	27.7	197.4	446.9
2016 Avg TDV	21.9	165.1	323.4
% Change	+27%	+20%	+38%

Non-Res (15 yr), CZ 12	Electric (kBtu/kWh)	Gas (kBtu/therm)	Propane (kBtu/therm)
2019 Avg TDV	27.5	179.1	380.8
2016 Avg TDV	20.7	142.7	276.6
% Change	+33%	+26%	+38%

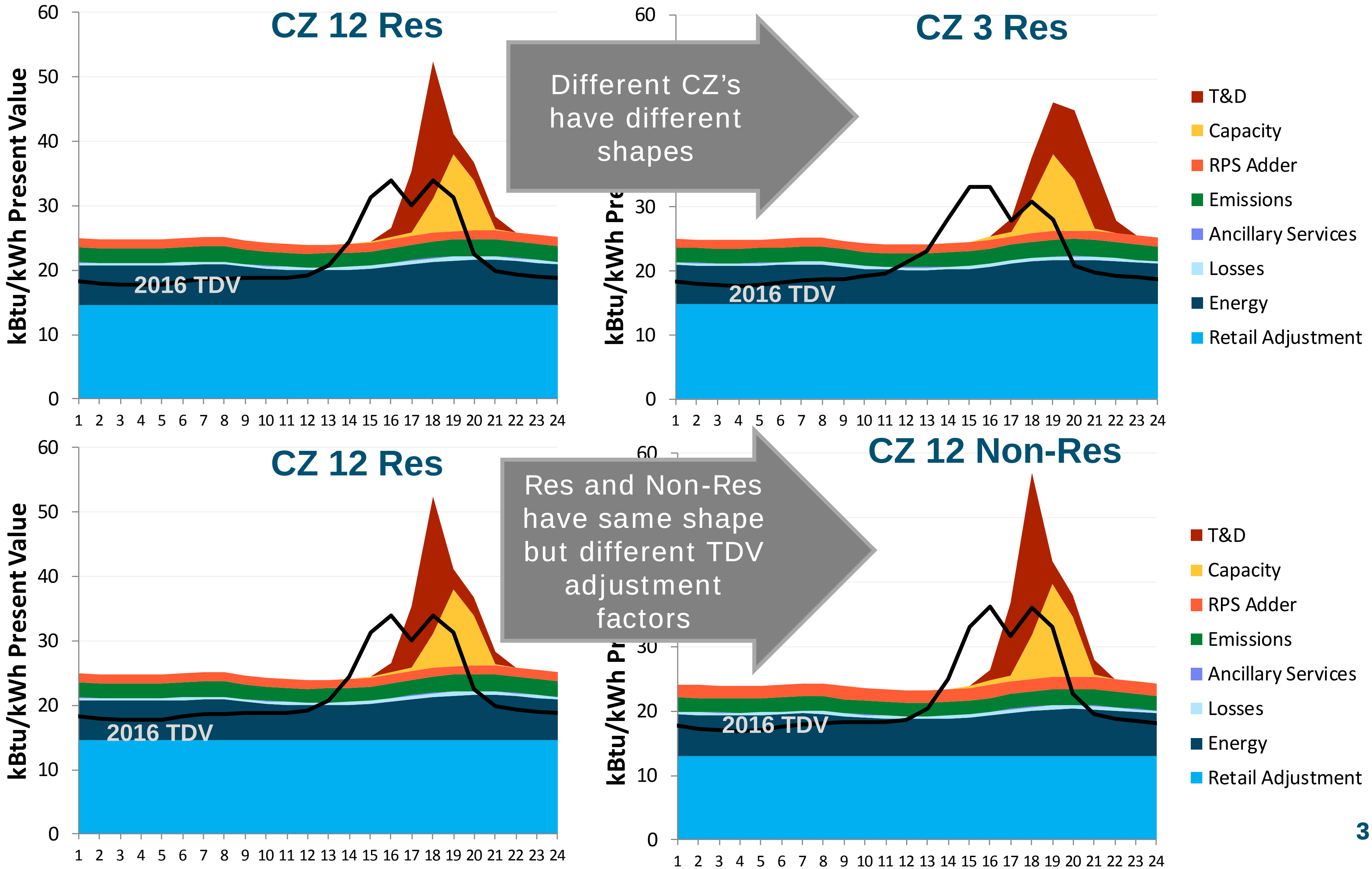
2016 Electric TDVs*

2019 Electric TDVs*



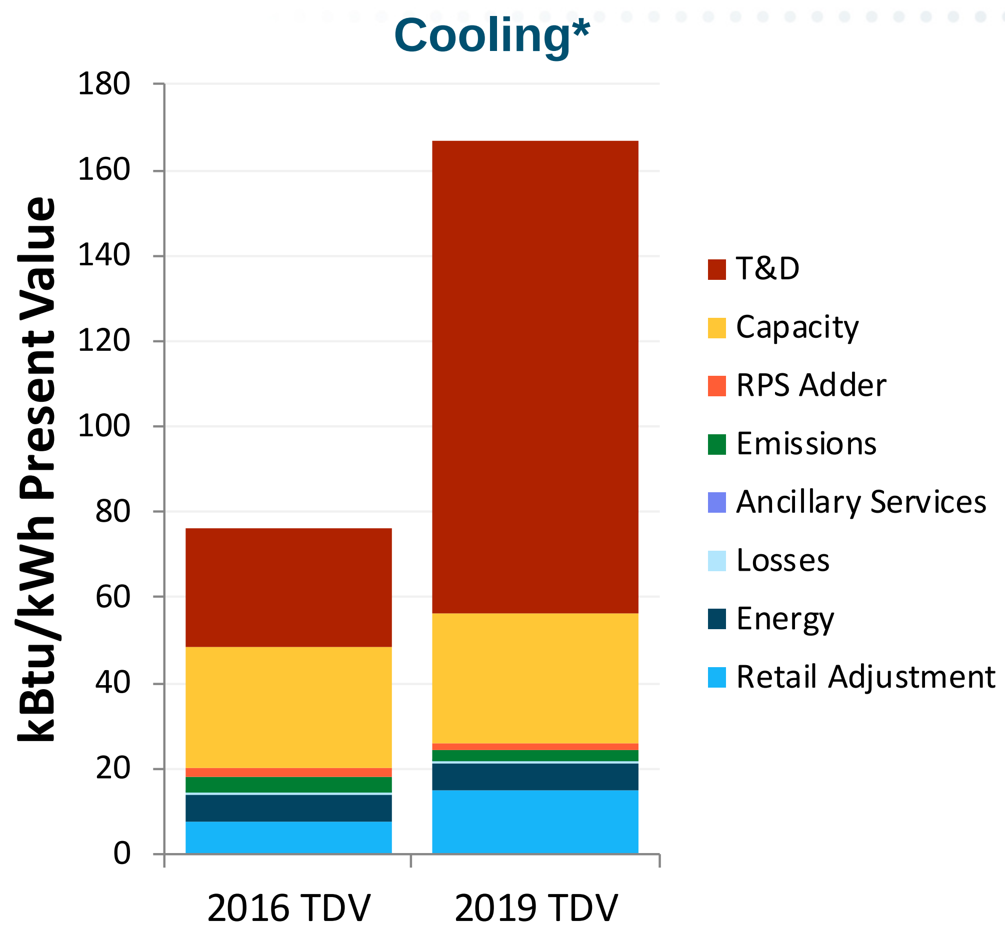
*CZ 12 Residential 30-Yr Present Value

Comparisons between TDVs



Impact on Electric End Uses
Cooling

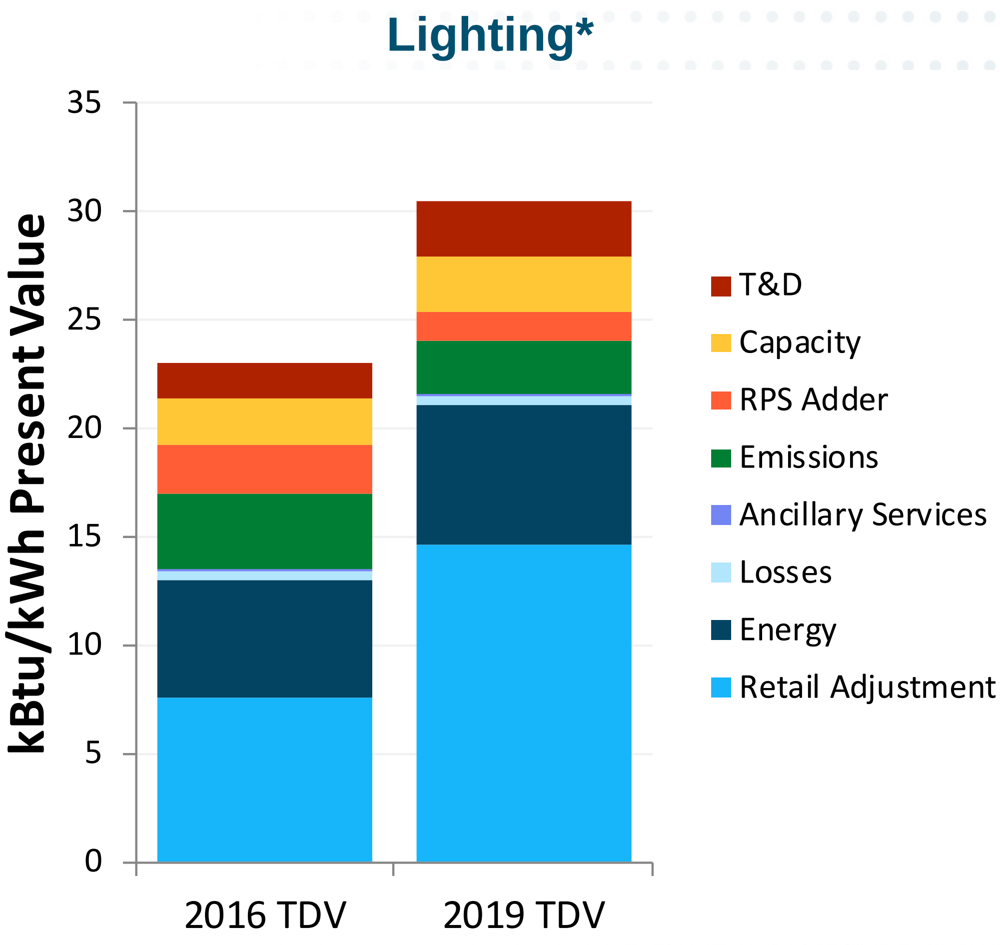
+ Larger T&D capacity deferral value coupled with better coincidence with cooling loads drive increase in TDV value
+ Shift of generation capacity value into evening reduces value
+ Retail rate increase drives some TDV value increase



*CZ 12 Residential 30-Yr Present Value

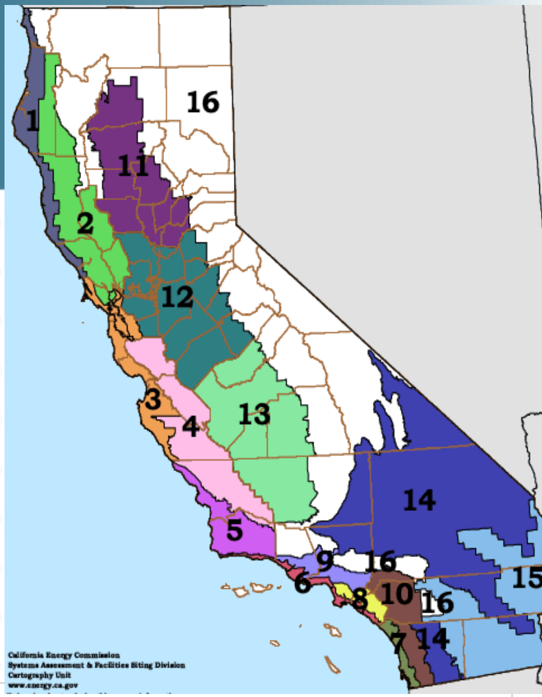
Impact on Electric End Uses
Lighting

- Increase in retail rates drives large portion of lighting TDV value increase
- Better coincidence of generation capacity and T&D capacity value and lighting load shape drive increase in total TDV value



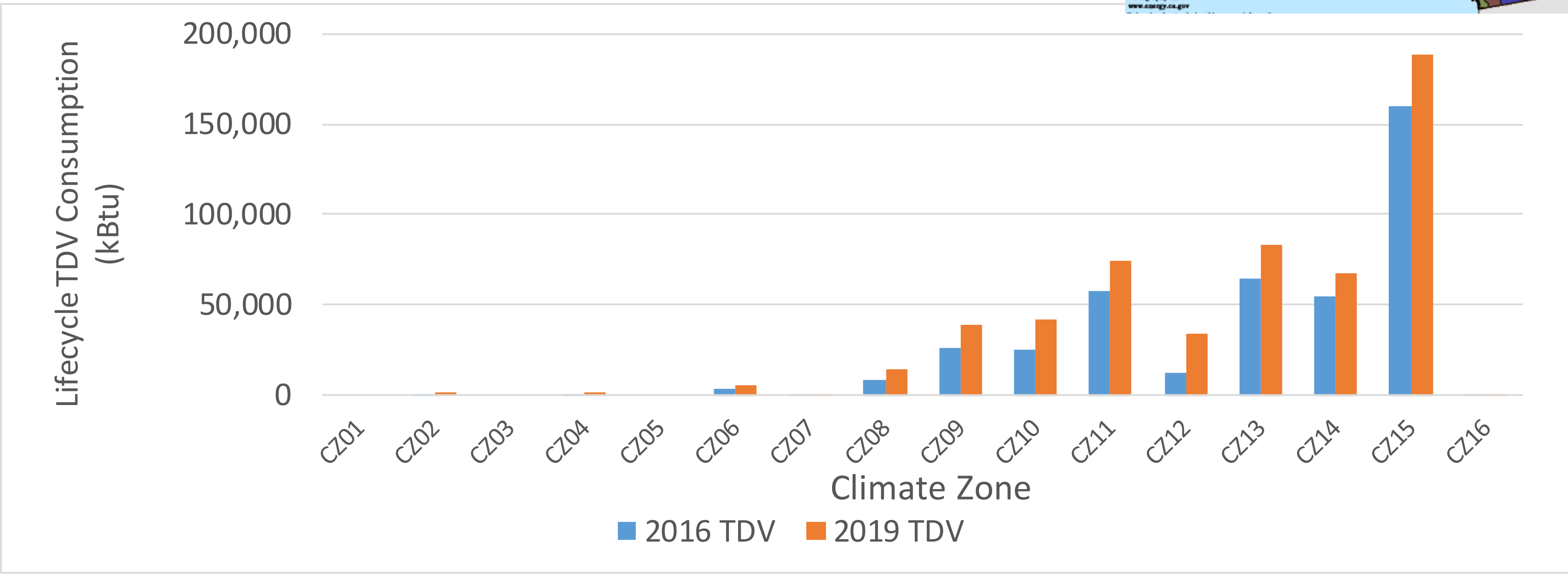
*CZ 12 Residential 30-Yr Levelized

Cooling TDV by Climate Zone



+ Cooling TDVs vary by

- TDV profile within each climate zone
- Cooling shape (coincidence with TDV profile)
- Cooling load (quantity of cooling kWh's)



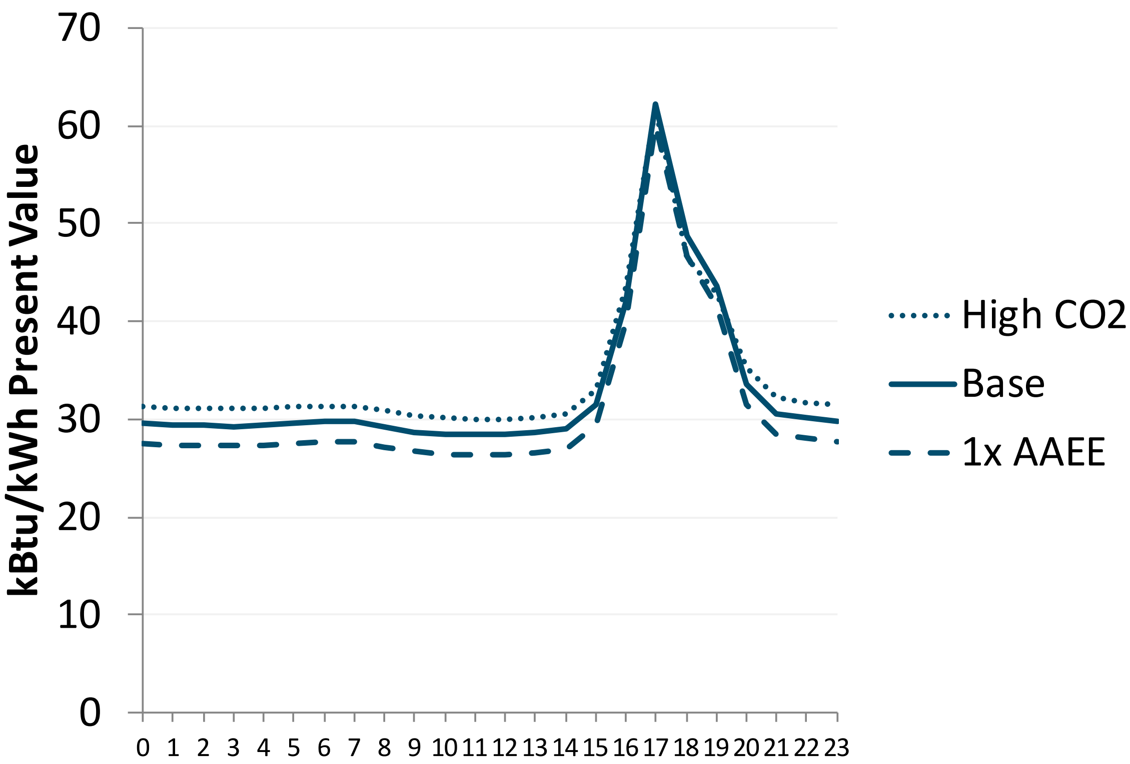
Scenario Analysis

- **Differences between scenarios are largely driven by resultant retail rate forecasts**

- **High CO2**
  - CO2 price drives up retail rate because California GHG household credit is not tied to electricity consumption

- **1x AAEE**
  - Less efficiency means fixed costs can be spread over more retail sales which results in lower rates

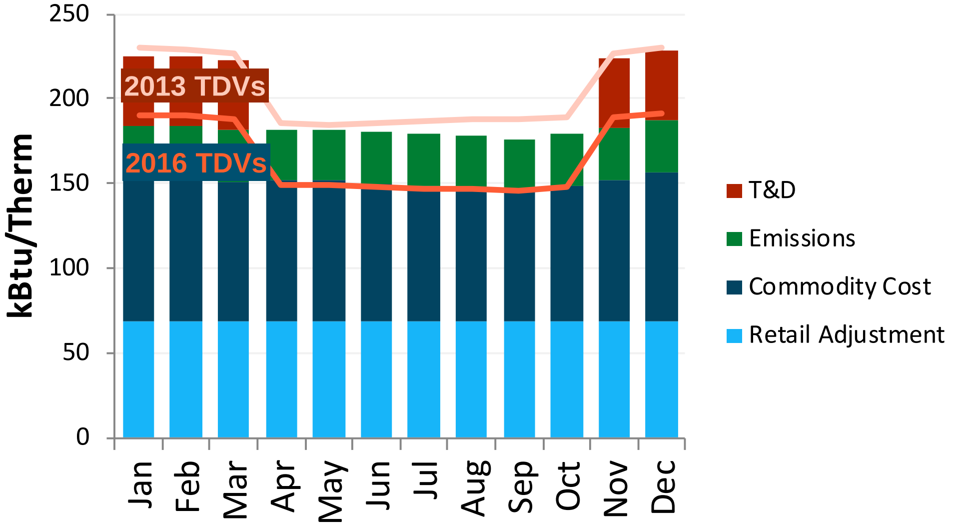
Electric Total TDV Daily Averages*

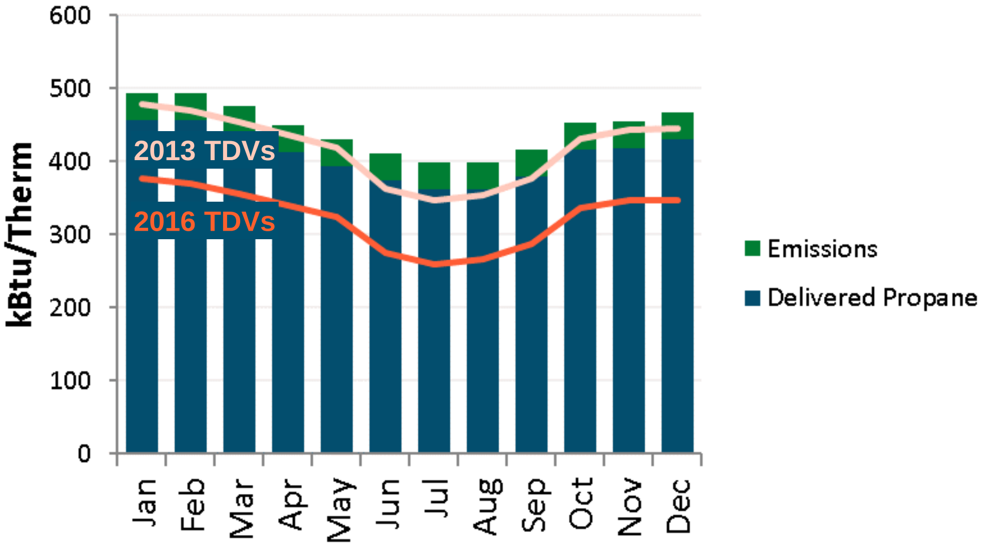


*CZ 12 Residential 30-Yr Present Value

Natural Gas and Propane TDVs

+ **Natural gas and propane both increase in TDV value due to increase in natural gas retail rate forecast**





*Residential 30-Yr Present Value

ELECTRIFICATION

Electrification Analysis

- **A number of stakeholders commented and raised questions about the implications of TDV and using electricity in buildings in place of natural gas**
- **E3, Bruce Wilcox and Ken Nittler at Enercomp did a <u>preliminary</u> investigation using the final TDVs on the implications of residential electrification**
  - CBECC-Res version 838r561
  - 2019 Title 24 TDVs
- **This is initial since we evaluated only three prototypes, and one combination of building measures and features**
  - Analysis does not tell us whether all-electric would be likely to pass using a performance approach

Methodology Overview

+ **Results for single example, then parametrics**
+ **Approach for analysis**
  - CO_2 and consumer bill trade-off
    - Step 1: Simulate building energy consumption
    - Step 2: Calculate consumer bills
    - Step 3: Calculate CO_2 emissions
  - Implied CO_2 Price
  - Required difference in construction costs

Completed for 16 Climate Zones, 3 building prototypes (2100 sqft, 2700 sqft, and multi-family). We will walk through an example of 2100 sqft home in CZ12.

Step 1: Simulate building energy consumption

- **CBECC-Res Building Simulation* Runs of identical 2,100sqft home in Climate Zone 12 (R19, QII, windows with 0.29 U-factor, doors with 0.2 U-factor)**
  - **Mixed-Fuel home**: 2016 prescriptive standard appliances including tankless gas water heater (EF=0.82), gas central furnace space heater, stove, and clothes dryer
  - **All-Electric Home**: Electric heat pump water heater (Model AO Smith HPTU 50, EF 3.6), electric central split heat pump space heater, stove, and clothes dryer
- **33,016 kBtu Gap for all-electric to be cost-effective**

Annual Energy Consumption	A. Mixed Fuel			B. All-Electric		
	kWh	Therms	TDV (kBtu)	kWh	Therms	TDV (kBtu)
CZ12	4,054	348	220,403	7,854	-	253,419

*Building simulation runs were conducted in CBECC-Res Compliance Software version 838r561 by Enercomp, Inc

Step 2: Calculate consumer bills

- Use hourly 2019 TDV ($/kWh; $/therm) and hourly energy consumption from building simulations (kWh; therm) to calculate annual and monthly bills for each home
- Climate Zone 12, 2,100sqft home would have an increased monthly bill of $23 by moving to all-electric from mixed-fuel.

Customer Bills	A. Mixed Fuel			B. All-Electric		
	Electricity	Natural Gas	Total	Electricity	Natural Gas	Total
$/Lifecycle	$25,466	$12,708	$38,174	$43,892	$0	$43,892
$/year	$1,261	$ 629	$ 1,891	$2,174	$0	$2,174
$/mo	$105	$ 52	$ 158	$181	$0	$181

Lifecycle difference of $5,718, Annual difference $283

Step 3: Calculate CO_2 Emissions

- Use building consumption by fuel to calculate lifecycle emissions over the building life
- Natural gas emissions use emissions rate of 0.0585 tons CO_2 / MMBtu
- Electricity emissions use marginal emissions rate corrected for increasing RPS, resulting in average emissions rate of 0.26 tons CO_2 / MWh
  - Forthcoming appendix to TDV report will provide this calculation

Lifecycle CO_2 Emissions	A. Mixed Fuel			B. All-Electric		
	Electricity	Natural Gas	Total	Electricity	Natural Gas	Total
tons CO_2	31	61	92	60	--	60

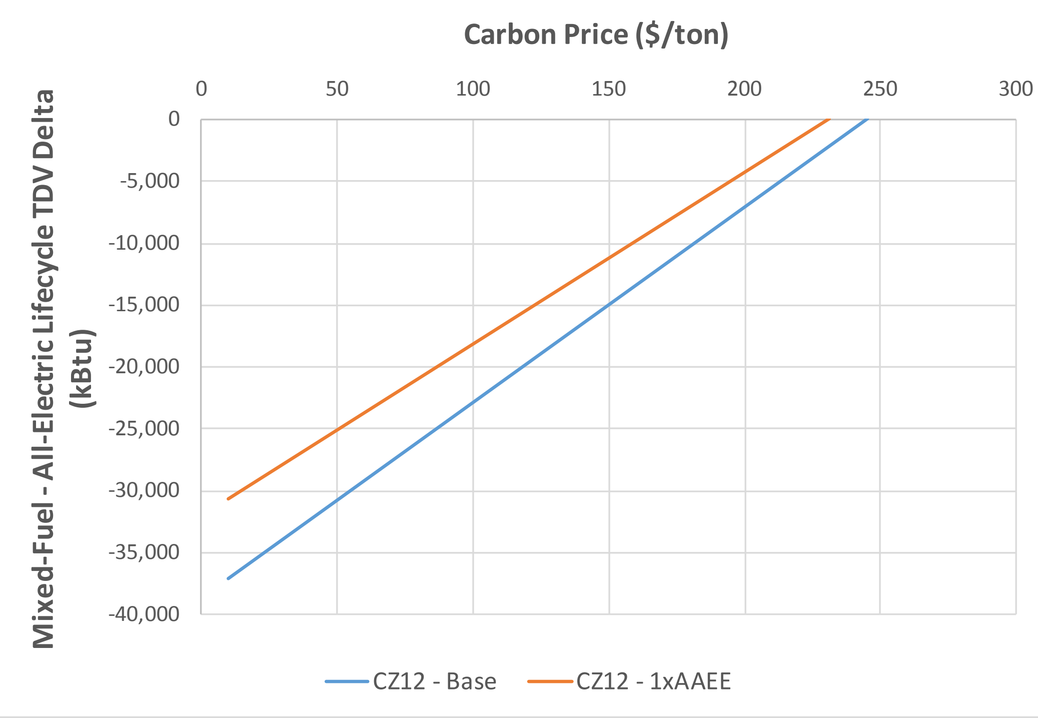
Implied CO2 Price & Sensitivity

+ Implied carbon price

- Increasing the carbon price will make all-electric homes look more cost-effective
- $245/ton breakeven for CZ12

+ Retail electric rates

- Lower rates will make all-electric homes more competitive
- $231/ton breakeven for CZ12



Incremental construction cost

+ **In addition to utility bills (A), up-front fixed costs must also be considered**
  - **Appliance capital costs (B)**: Increased costs of heat pump water and space heaters compared to gas appliances
  - **Infrastructure capital costs (C)**: Avoided costs of plumbing natural gas lines within home and to the home (when service connection exceeds Rule 15's allowable costs), larger electric panel for all electric home
+ **Bookend Analysis calculates breakeven cost for all-electric to have equivalent total lifecycle costs to mixed-fuel**

A. Higher lifecycle utility bills (i.e. Mixed-fuel TDV – All-electric TDV) ~$5,700

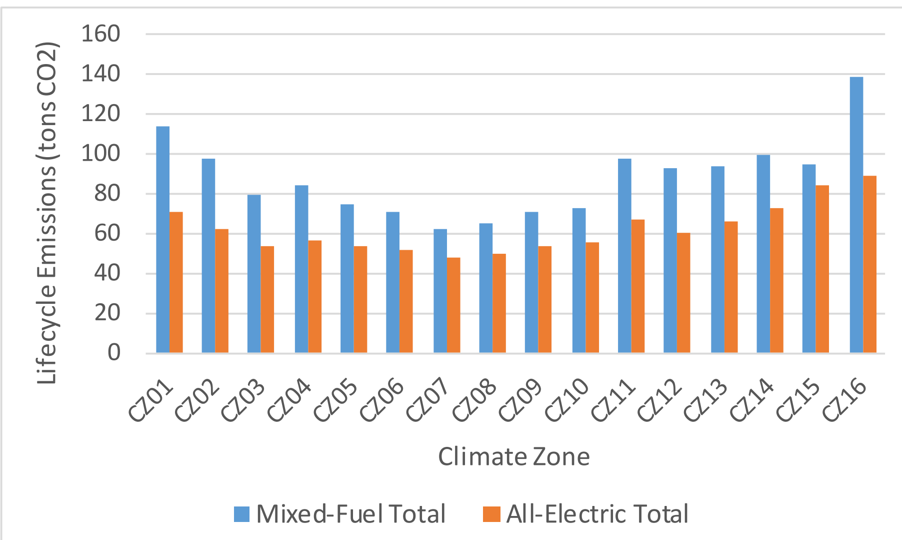
B. Higher appliance costs ~$1,000

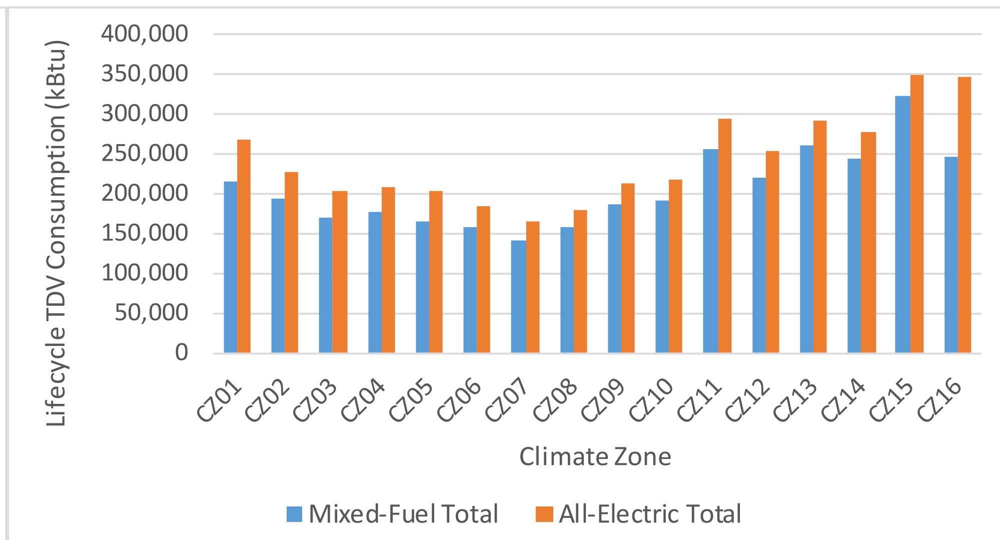
C. Higher electric panel costs

C. Natural Gas plumbing and infrastructure costs would need to be ~$7,000 less for all-electric to breakeven in CZ12 for 2,100 sqft single family

Lifecycle Emissions and TDV

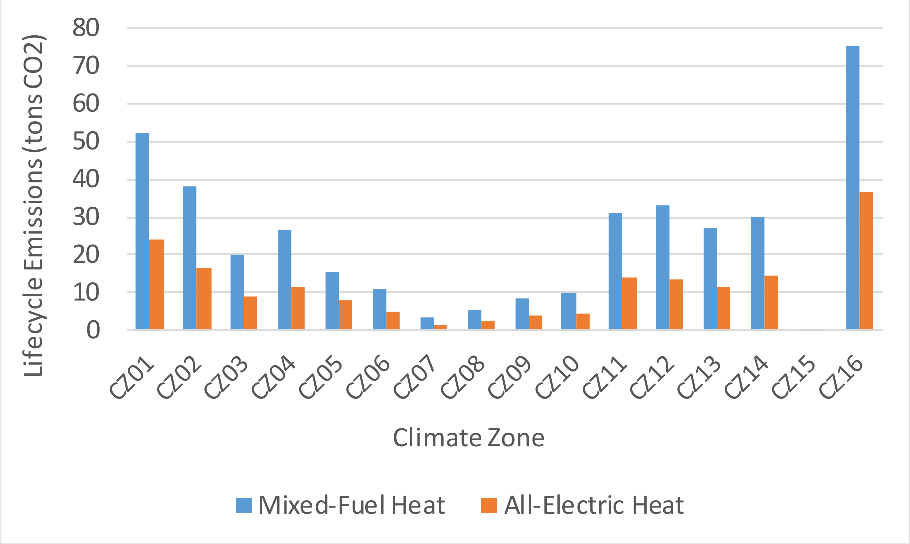
- Draft results for 2,100 sqft prototype for emissions and lifecycle TDVs compared between Mixed-fuel and all-electric prototype homes
- All-electric homes require more TDV energy, but result in lower GHGs in buildings

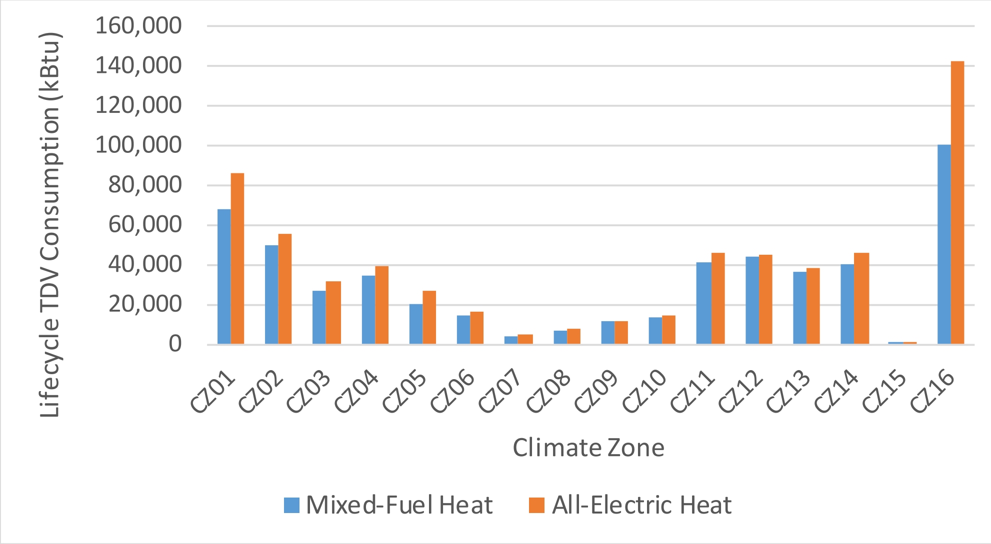




Lifecycle emissions and TDV – Space Heating

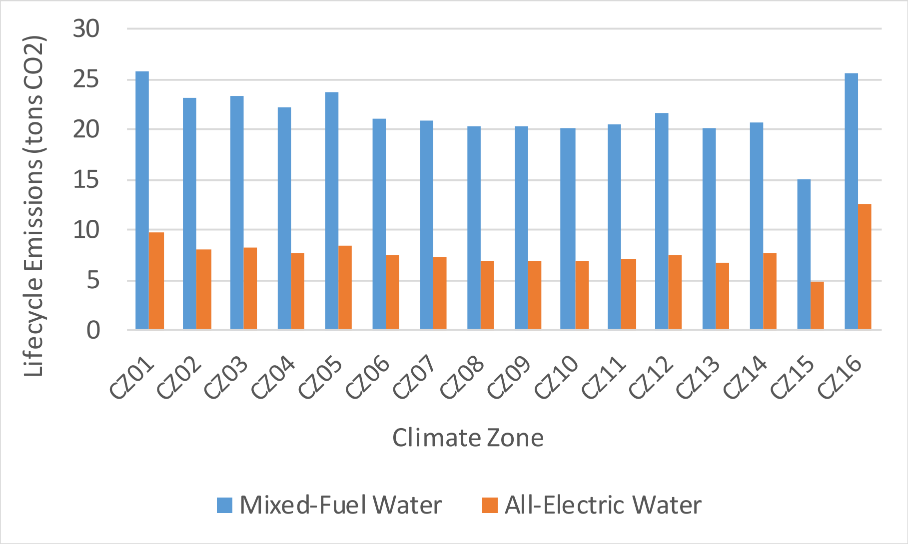
- Draft results for 2,100 sqft prototype for emissions and lifecycle TDVs compared between Mixed-fuel and all-electric
- All-electric homes require more energy, but produce less GHGs for space heating

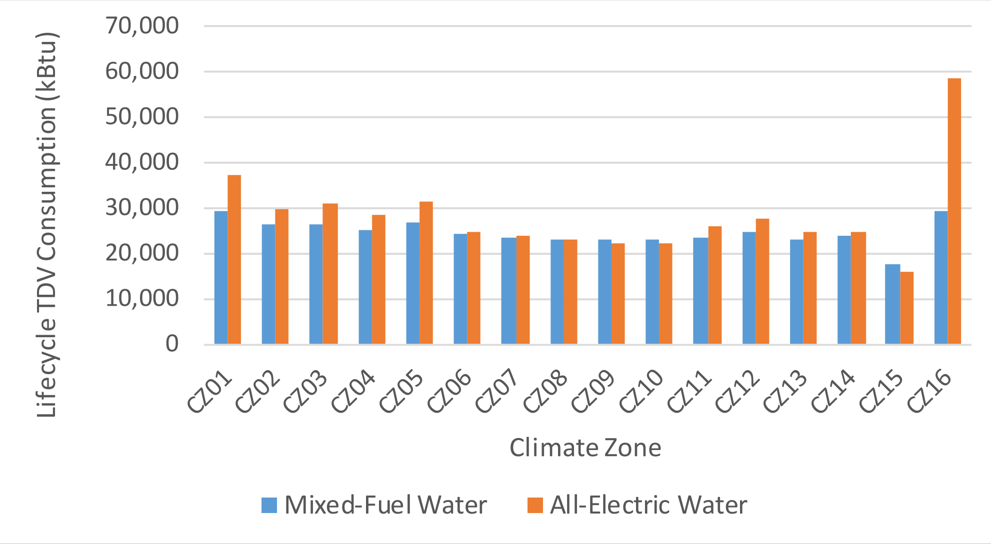




Lifecycle emissions and TDV – Water Heating

- Draft results for 2,100 sqft prototype for emissions and lifecycle TDVs compared between Mixed-fuel and all-electric
- All-electric homes typically require more energy, but produce less GHGs for water heating





Lifecycle emissions and TDV – Space Cooling

- Draft results for 2,100 sqft prototype for emissions and lifecycle TDVs compared between Mixed-fuel and all-electric
- All-electric homes require nearly equal energy and GHGs for cooling (same home and same equipment)