CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

# 2019 Residential New Construction

## Cost-effectiveness Study
## DRAFT Results

March 7, 2019

**Bill Dakin – Frontier Energy**



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Pacific Gas and Electric Company
SDGE A Sempra Energy utility
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## Residential Assumptions and Methodology

- Single family, low-rise multifamily new construction
  - Low-rise Multifamily (LRMF) = 3 habitable stories or less
  - Mixed-fuel and all-electric cases
  - All-electric vs. mixed fuel comparison
- CBECC-Res 2019.0.11 Alpha (1242)
- Energy Design Rating (EDR)
  - Metric for 2019 Residential code compliance
  - Delta EDR used instead of absolute values
- Cost effectiveness metrics (30 years)
  - TDV per CEC methodology
  - Customer based: TOU utility rates. Reflect rate schedules for 2020
- GHG impacts per CBECC-Res

# Residential Building Prototypes

- Single Family: Blended 2,430 ft$^2$, 45% 1-story, 55% 2-story
- Multifamily: 6,960, 2-story, 8-unit, exterior loaded

| Characteristics of the Mixed Fuel vs All-Electric Prototype | | |
|---|---|---|
| | **Mixed Fuel** | **All-Electric** |
| **Space Heating/Cooling[1]** | Gas furnace 80 AFUE<br>Split A/C 14 SEER, 11.7 EER | Split heat pump 8.2 HPSF,<br>14 SEER, 11.7 EER |
| **Water Heater[1,2,3]** | Gas tankless UEF = 0.81 | 50gal HPWH UEF = 2.0<br>SF = located in garage<br>MF = located in living space<br>exterior closet (CZ 1, 3, 5) |
| **Hot Water Distribution** | Code minimum. All hot water lines insulated | Basic compact distribution credit (CZ 6-8,15)<br>Expanded credit (other CZs) |
| **Drain Water Heat Recovery Efficiency** | None | CZ 1 & 16 only |
| **Cooking** | Gas | Electric |
| **Clothes Drying** | Gas | Electric |

[1]Equipment efficiencies comply with minimum federal appliance efficiency standards.
[2]The multifamily prototype is evaluated with individual water heaters
[3]UEF = uniform energy factor. HPWH = heat pump water heater. SF = single family. MF = multifamily.

# Four Measure Packages

- **Efficiency – Non-Preempted**: Efficiency measures that don't trigger federal preemption including envelope, and water heating and duct distribution efficiency.
- **Efficiency – Equipment, Preempted**: HVAC and water heating equipment that are more efficient than federal standards.
- **Efficiency & PV**: Using the Efficiency – Non-Preempted package as a starting point, add PV to offset most of the estimated electricity use. All-Electric case only. In mixed-fuel cases, 100% of projected electricity use is already offset in efficiency only packages.
- **Efficiency & PV/Battery** : Using the Efficiency – Non-Preempted package as a starting point, add PV and a battery system. TOU battery strategy

# PV System Sizing Options in CBECC-Res

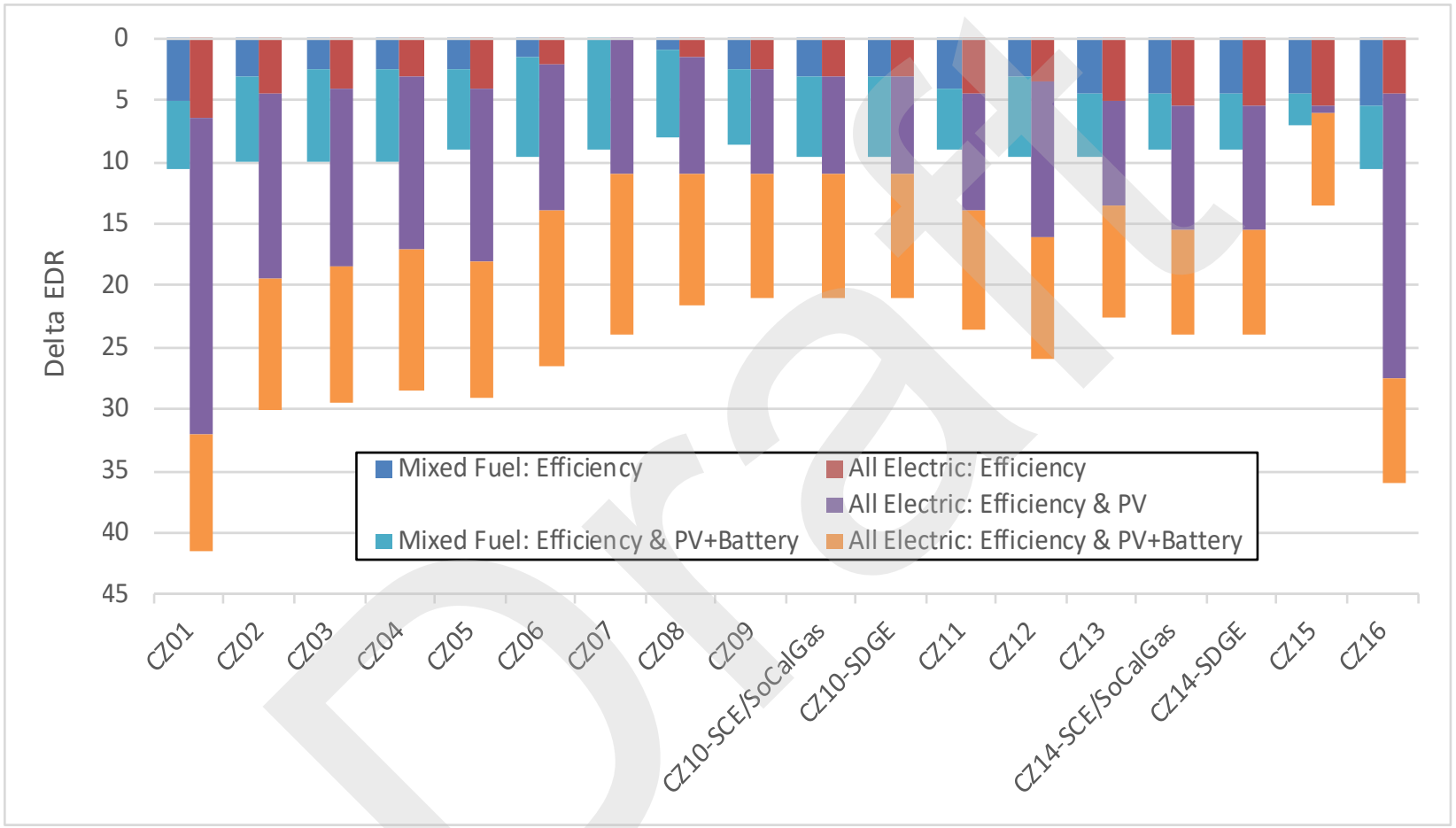
- **Standard Design PV**: Same PV capacity as is required for the Standard Design case. Offset electricity use of loads typically electric in a mixed fuel home, excluding space heating, water heating, clothes drying, and cooking.
- **Maximum PV for Compliance Credit**: PV system sized to offset 100% of the estimated electricity use of the Proposed Case.
- **Specify PV System Scaling**: PV system sized to offset a specified percentage of the estimated electricity use of the Proposed Case

| Package | Mixed Fuel | All-Electric |
|---|---|---|
| Efficiency (Envelope & Equipment) | Max PV | Std Design PV |
| Efficiency & PV | n/a | PV Scaled @ 90% |
| Efficiency & PV/Battery | PV Scaled @ 100%<br>5 kWh battery / SF<br>2.75kWh battery / MF apt<br>TOU battery control | PV Scaled @ 100%<br>5 kWh battery / SF<br>2.75kWh battery / MF apt<br>TOU battery control |

Self-Utilization Credit taken with batteries

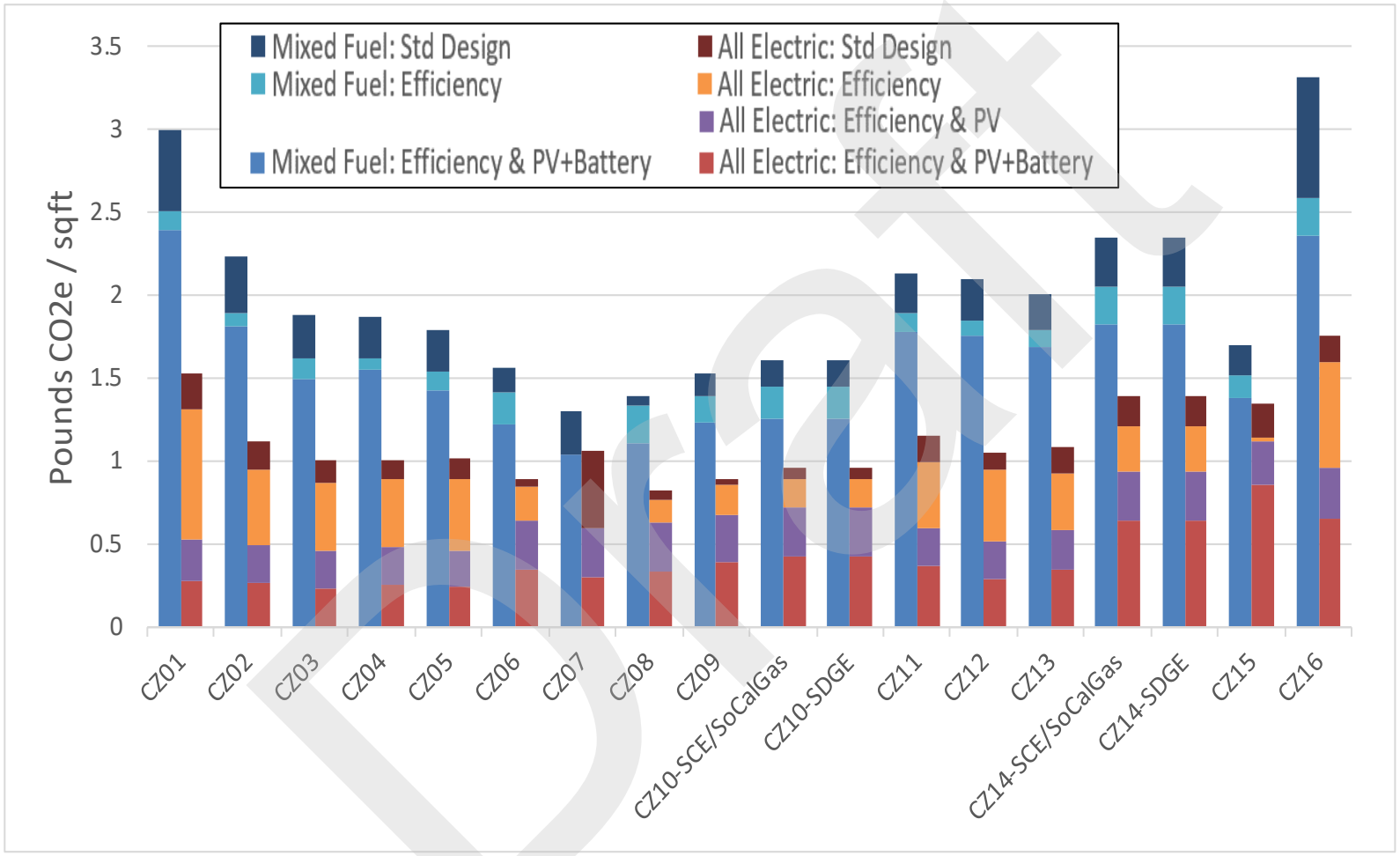
# Single Family Results

# Single Family "Delta EDR" Comparison




- Target Delta EDRs based on cost effectiveness in at least one metric
  - TDV cost effectiveness tends to be better than On-Bill

# Single Family GHG Comparison



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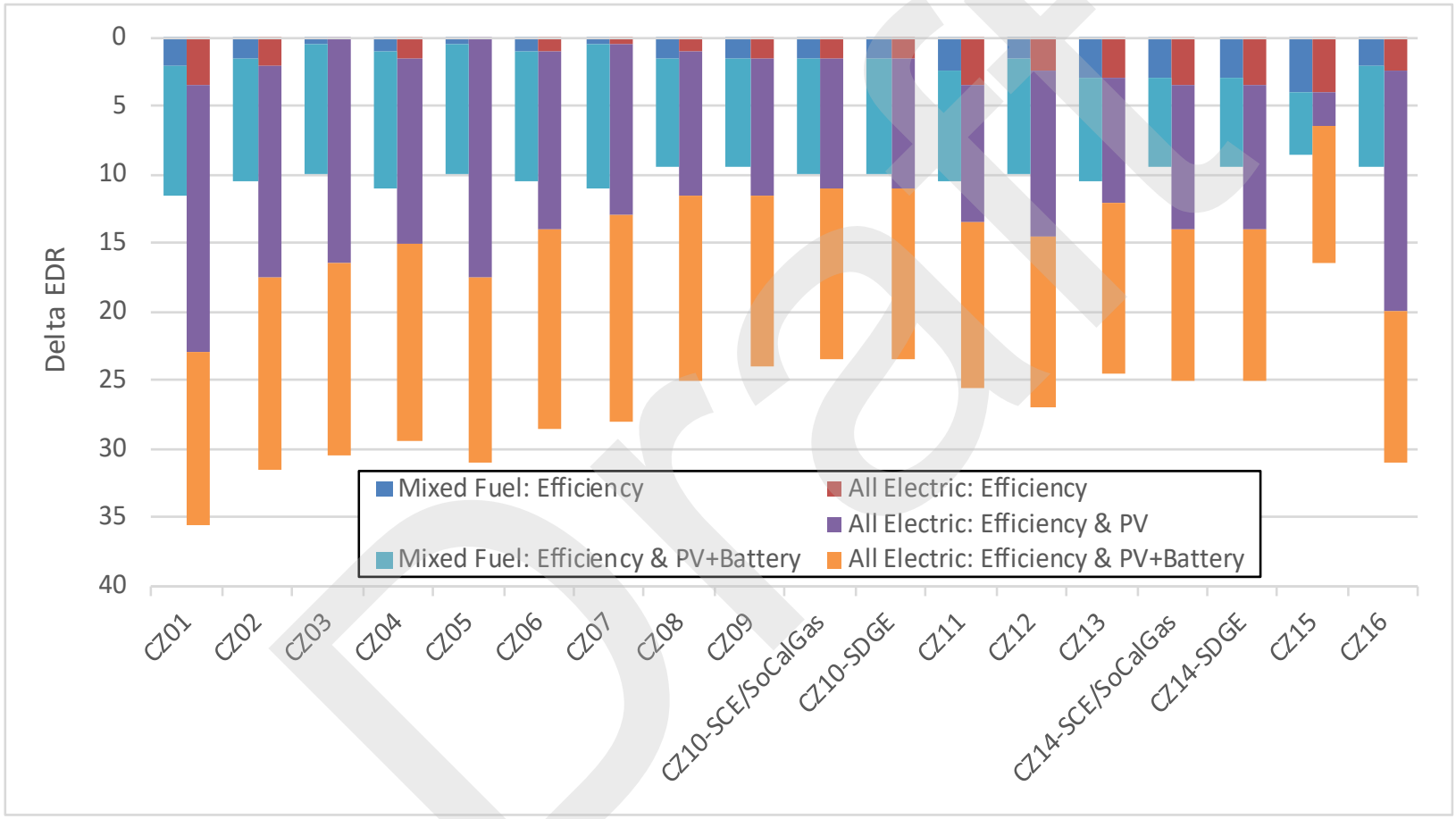
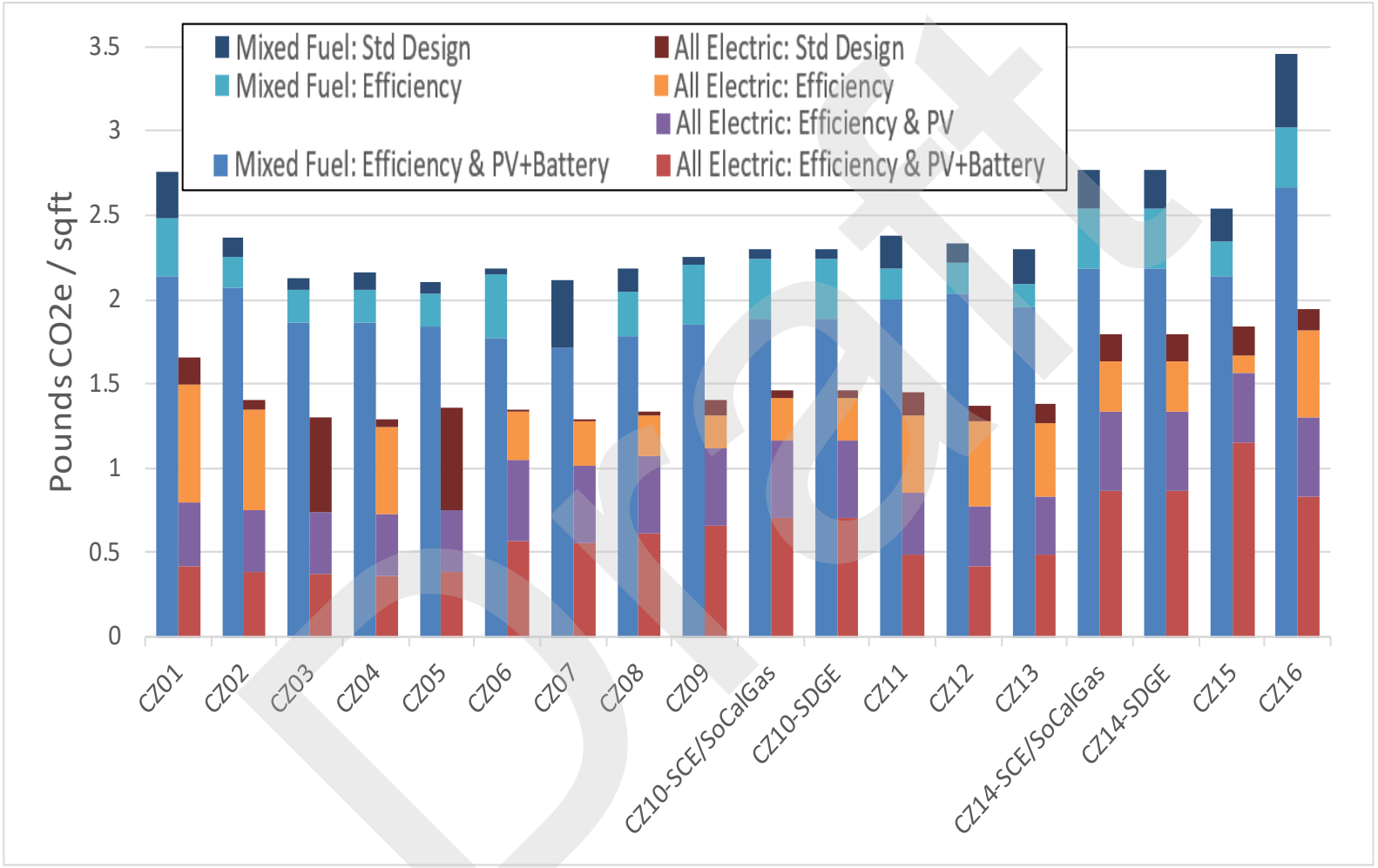
# Low-Rise Multifamily Results

# Multifamily "Delta EDR" Comparison



# Multifamily GHG Comparison

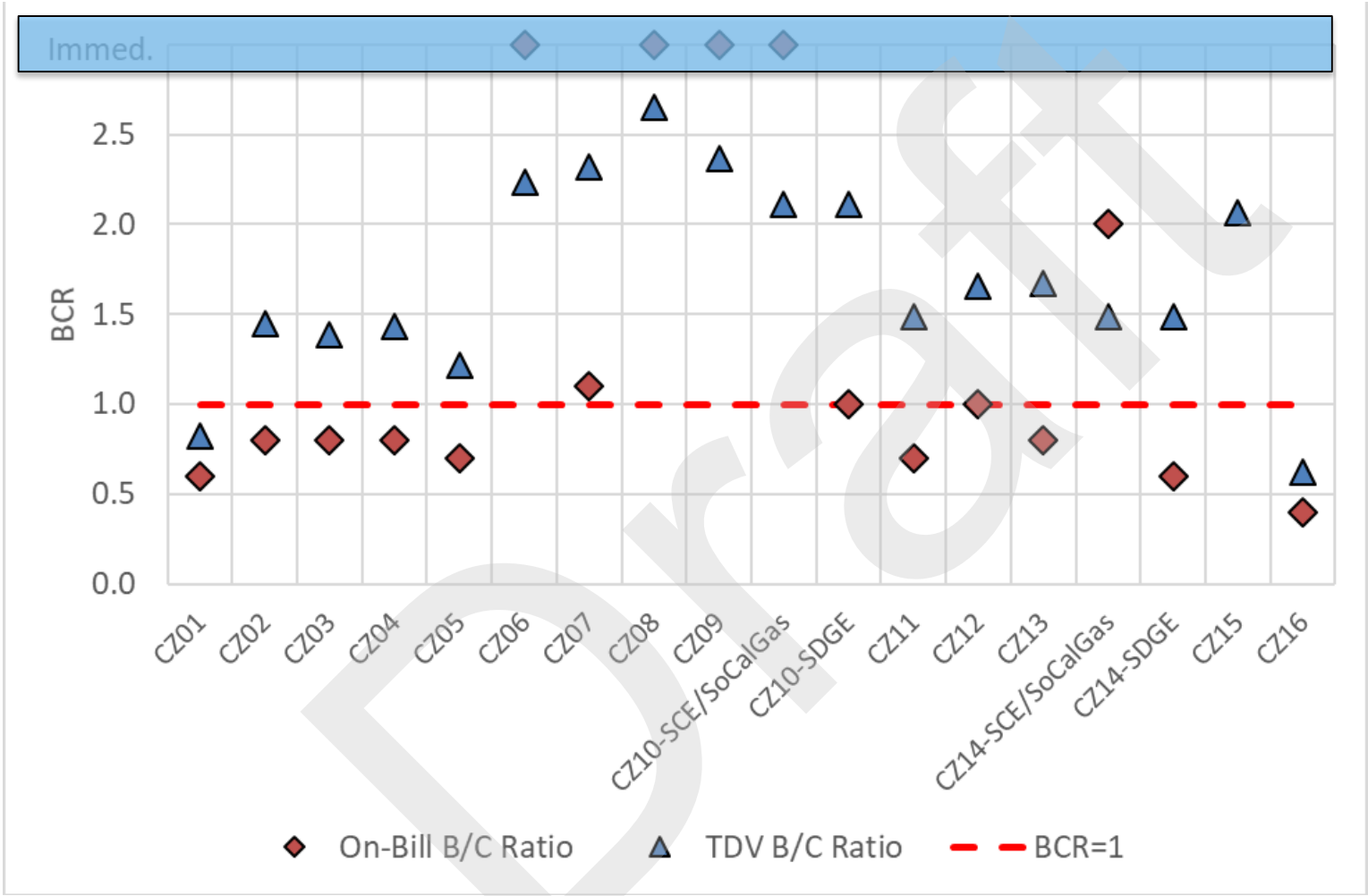


# Electrification Results

# All-Electric Compared to Mixed Fuel Home

- **Incremental Costs:**
  - SF: ~$4,000 lower cost for all-electric
  - MF: ~$2,000 lower cost / apt for all-electric
  - Lifetime costs (includes fuel escalation, and equipment replacement)
- **Cases:**
  - **2019 Code Compliant**: Code compliant mixed fuel vs code compliant all-electric
  - **Efficiency & PV**: Code compliant mixed fuel vs. all-electric package w/ efficiency and PV to offset 90% estimated electricity use.

# B/C Ratio: Single Family – 2019 Code Compliant



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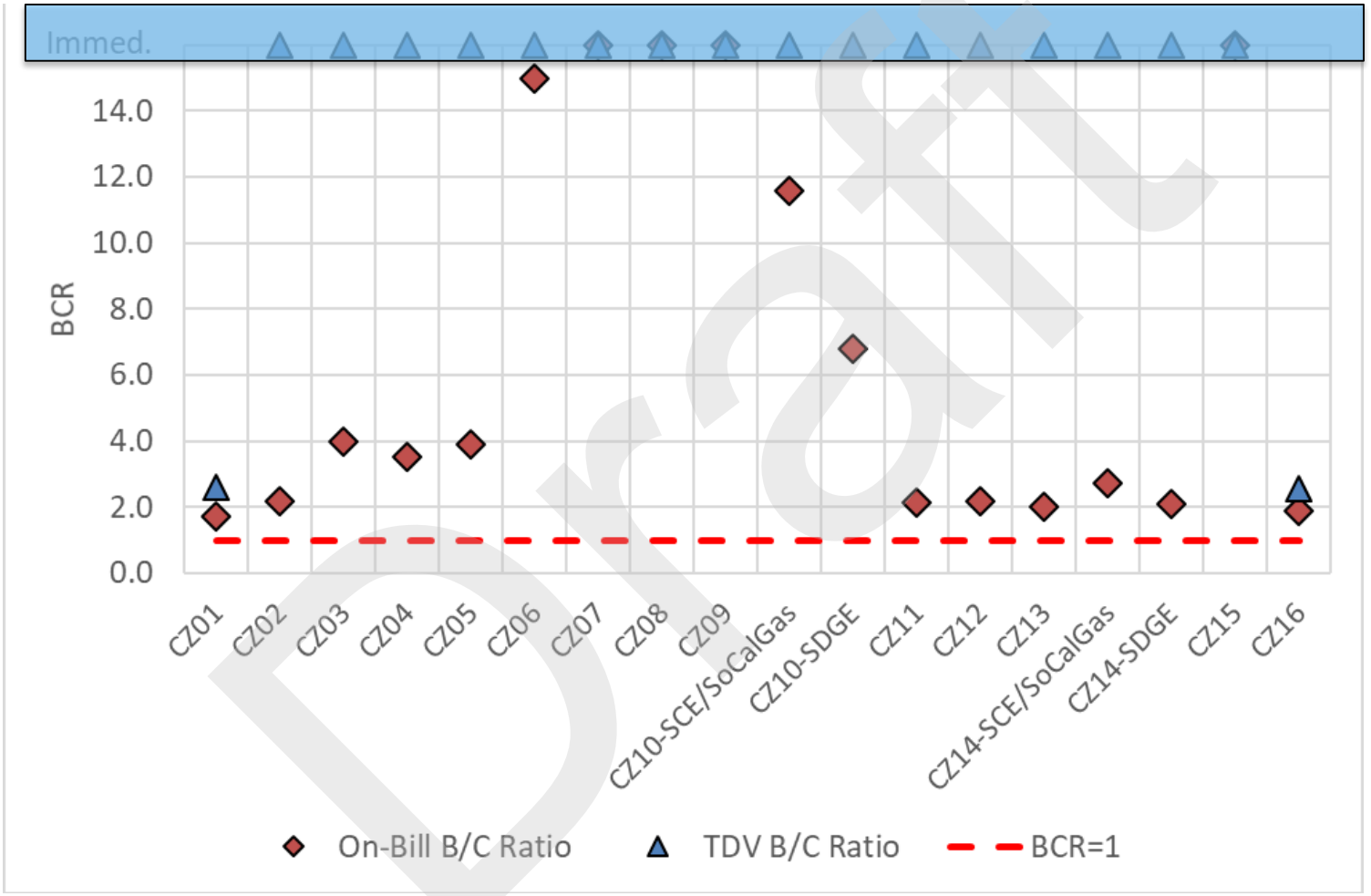
# B/C Ratio: Single Family – Efficiency & PV Package



## Conclusions

- Cost-effective packages across the state for both SF and MF buildings
  - Packages are c/e under either On-Bill or TDV, not always both
  - No c/e efficiency only package for SF CZ7 or MF all-electric in CZ3 & 5
- All-electric design reduces GHG emissions 40-50% in most cases relative to a comparable mixed fuel design
  - Code compliance all-electric home c/e in ~half of CZs based on On-Bill; c/e in all CZs except 1 & 16 based on TDV
  - Efficiency & PV all-electric home c/e across the state based on On-Bill & TDV

# Thank you.

Bill Dakin – Frontier Energy

# Background Slides

# Efficiency Measures

## Non-Pre-empted

- Improved windows
- High performance walls / attics
- Reduced infiltration
- Cool roofs
- Slab edge insulation
- Low pressure drop duct design
- Ducts in conditioned space
- Reduced duct leakage / LLAH
- Compact DHW distribution
- Drainwater Heat Recovery

## Federally Pre-empted

- High efficiency AC/furnace
- High efficiency heat pump
- High efficiency water heating equipment
  - Condensing tankless WH
  - NEEA Tier 3 HPWH

# Summary of Multifamily Target "Delta EDRs"

| Summary of Multifamily Target Delta EDRs | | | | | |
|---|---|---|---|---|---|
| Climate Zone | Mixed Fuel | | All-Electric | | |
| | Efficiency | Efficiency & PV/Battery | Efficiency | Efficiency & PV | Efficiency & PV/Battery |
| 01 | 2.0 | 11.5 | 3.5 | 23.0 | 35.5 |
| 02 | 1.5 | 10.5 | 2.0 | 17.5 | 31.5 |
| 03 | 0.5 | 10.0 | n/a | 16.5 | 30.5 |
| 04 | 1.0 | 11.0 | 1.5 | 15.0 | 29.5 |
| 05 | 0.5 | 10.0 | n/a | 17.5 | 31.0 |
| 06 | 1.0 | 10.5 | 1.0 | 14.0 | 28.5 |
| 07 | 0.5 | 11.0 | 0.5 | 13.0 | 28.0 |
| 08 | 1.5 | 9.5 | 1.0 | 11.5 | 25.0 |
| 09 | 1.5 | 9.5 | 1.5 | 11.5 | 24.0 |
| 10-SCE/SoCalGas | 1.5 | 10.0 | 1.5 | 11.0 | 23.5 |
| 10-SDGE | 1.5 | 10.0 | 1.5 | 11.0 | 23.5 |
| 11 | 2.5 | 10.5 | 3.5 | 13.5 | 25.5 |
| 12 | 1.5 | 10.0 | 2.5 | 14.5 | 27.0 |
| 13 | 3.0 | 10.5 | 3.0 | 12.0 | 24.5 |
| 14-SCE/SoCalGas | 3.0 | 9.5 | 3.5 | 14.0 | 25.0 |
| 14-SDGE | 3.0 | 9.5 | 3.5 | 14.0 | 25.0 |
| 15 | 4.0 | 8.5 | 4.0 | 6.5 | 16.5 |
| 16 | 2.0 | 9.5 | 2.5 | 20.0 | 31.0 |

*n/a = cases where no cost effective non-preempted package was identified*

# Summary of Single Family Target "Delta EDRs"

| Summary of Single Family Target "Delta EDRs" | | | | | |
|---|---|---|---|---|---|
| Climate Zone | Mixed Fuel | | All-Electric | | |
| | Efficiency | Efficiency & PV/Battery | Efficiency | Efficiency & PV | Efficiency & PV/Battery |
| 01 | 5.0 | 10.5 | 6.5 | 32.0 | 41.5 |
| 02 | 3.0 | 10.0 | 4.5 | 19.5 | 30.0 |
| 03 | 2.5 | 10.0 | 4.0 | 18.5 | 29.5 |
| 04 | 2.5 | 10.0 | 3.0 | 17.0 | 28.5 |
| 05 | 2.5 | 9.0 | 4.0 | 18.0 | 29.0 |
| 06 | 1.5 | 9.5 | 2.0 | 14.0 | 26.5 |
| 07 | n/a | 9.0 | n/a | 11.0 | 24.0 |
| 08 | 1.0 | 8.0 | 1.5 | 11.0 | 21.5 |
| 09 | 2.5 | 8.5 | 2.5 | 11.0 | 21.0 |
| 10-SCE/SoCalGas | 3.0 | 9.5 | 3.0 | 11.0 | 21.0 |
| 10-SDGE | 3.0 | 9.5 | 3.0 | 11.0 | 21.0 |
| 11 | 4.0 | 9.0 | 4.5 | 14.0 | 23.5 |
| 12 | 3.0 | 9.5 | 3.5 | 16.0 | 26.0 |
| 13 | 4.5 | 9.5 | 5.0 | 13.5 | 22.5 |
| 14-SCE/SoCalGas | 4.5 | 9.0 | 5.5 | 15.5 | 24.0 |
| 14-SDGE | 4.5 | 9.0 | 5.5 | 15.5 | 24.0 |
| 15 | 4.5 | 7.0 | 5.5 | 6.0 | 13.5 |
| 16 | 5.5 | 10.5 | 4.5 | 27.5 | 36.0 |

*n/a = cases where no cost effective non-preempted package was identified*

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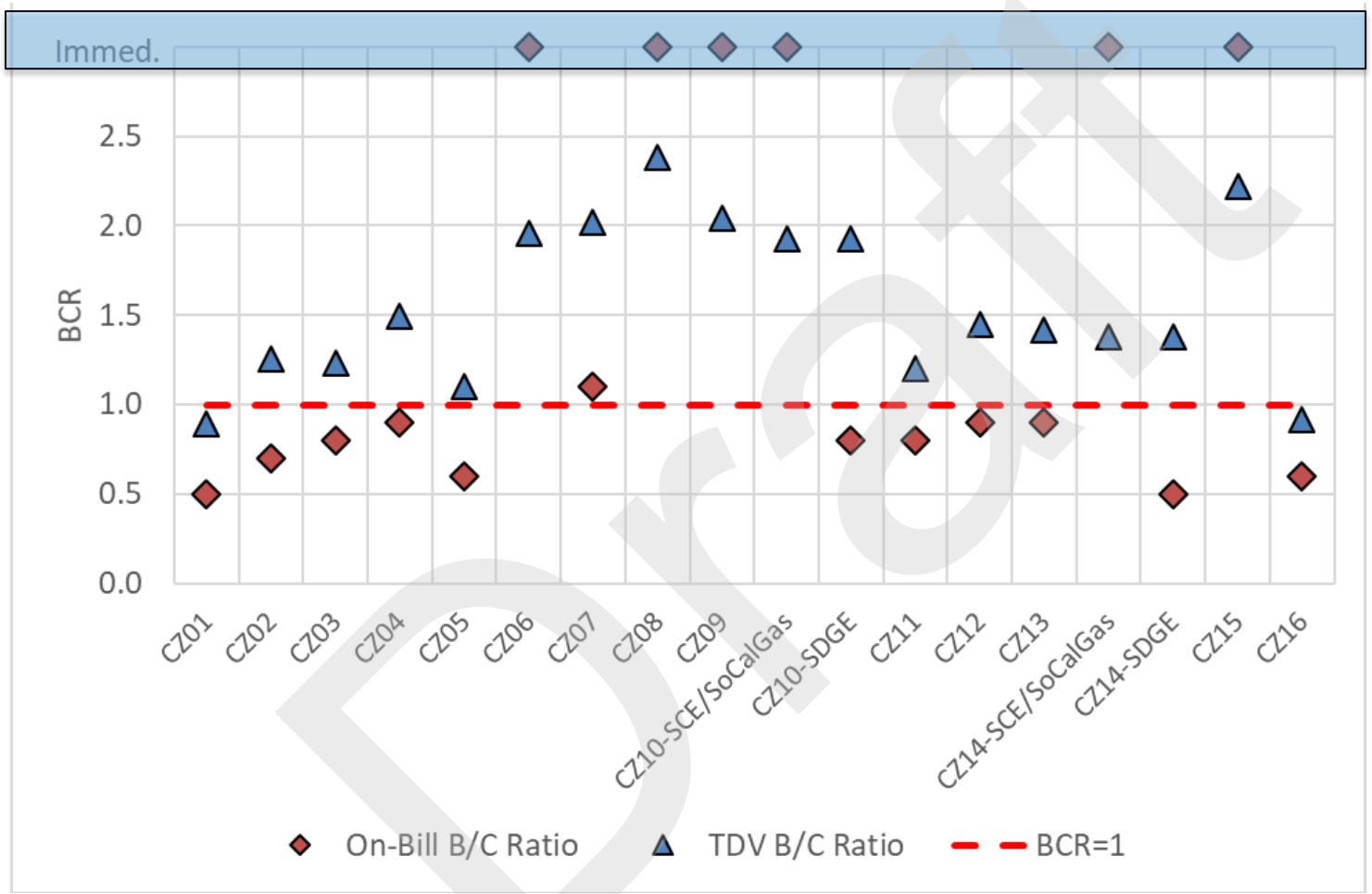
# Incremental Costs
## All-Electric Compared to Mixed Fuel Home

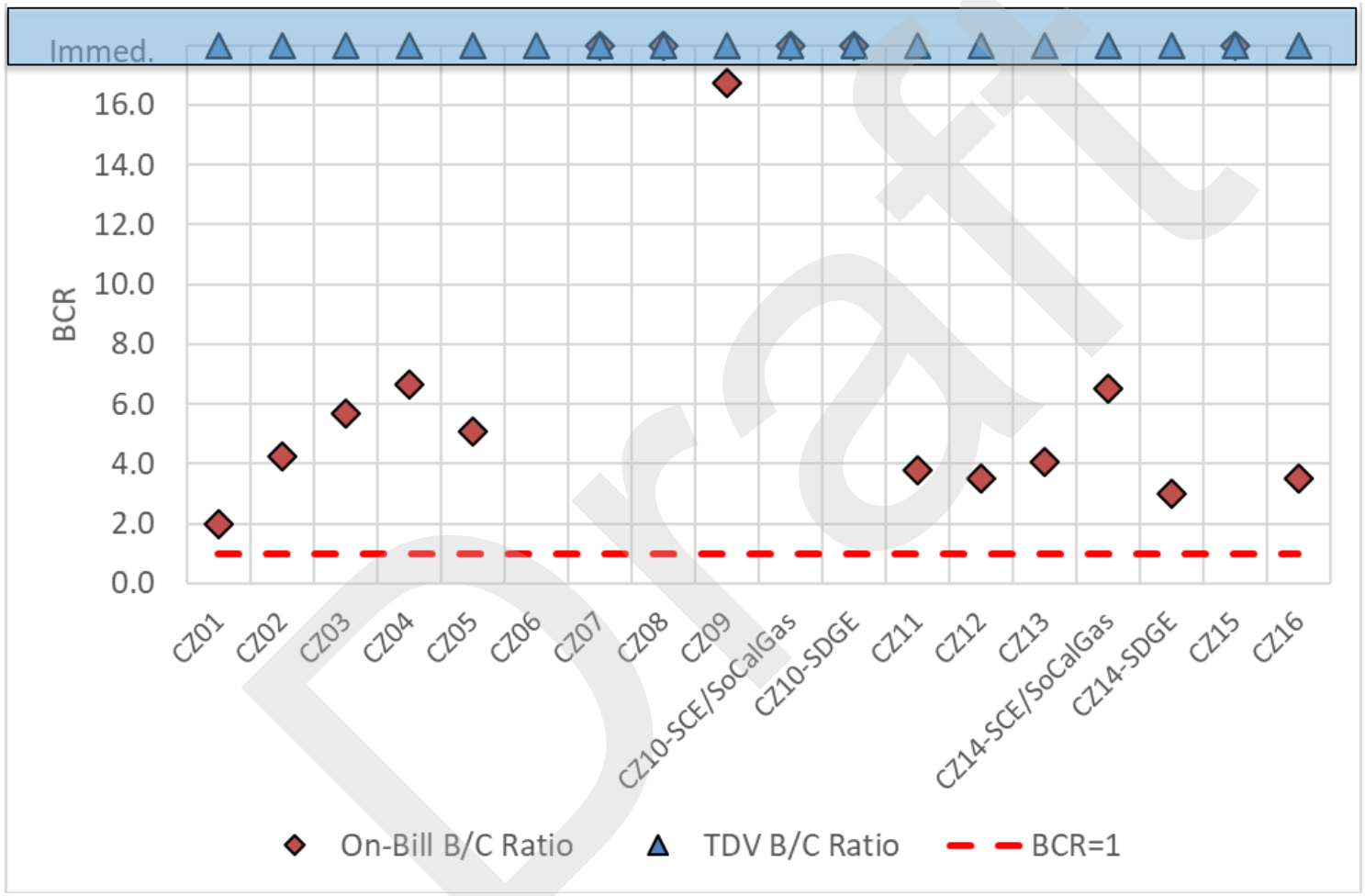
| Measure | Incremental Cost ($2020) | |
|---|---|---|
| | Single Family | Multifamily |
| | Typical | Typical |
| Heat pump vs gas furnace / AC [1] | $567 | $567 |
| Heat pump water heater vs gas tankless | $478 | $478 |
| Electric vs gas clothes dryer | $0 | $0 |
| Electric vs gas cooking | $0 | $0 |
| Electric service upgrade (in-house) [2] | $600 | $600 |
| In-house gas infrastructure [3] | ($800) | ($600) |
| Site gas Infrastructure [4,5] | ($5,750) | ($3,150) |
| **Total On-Bill** | **($4,905)** | **($2,095)** |
| **Total TDV** | **($10,991)** | **($5,419)** |

1. Appliances – Installed cost include NPV of replacement
2. Assumes 220V for 3 additional appliances (HVAC, HPWH, stove)
3. In-house gas runs to 4 appliances
4. SF – Costs from PG&E. Assume new subdivision in an undeveloped area, requiring a new main.
   MF – Costs from TRC's Palo Alto study (2018)
   Include 50% refund per Rule 15 for extension and service lateral, and deduction for allowances of gas appliances.
5. Costs for TDV analysis assume total cost of gas infrastructure (No Rule 15 deductions)

# B/C Ratio: Multifamily – 2019 Code Compliant



# B/C Ratio: Multifamily – Efficiency & PV Package



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# Cost Effectiveness Results for Single Family Electrification

| 2019 Code Compliant Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average Annual Utility Bill Impact[1] | | | Lifetime Utility Bill Savings | Lifetime Equipment Cost Savings | On-bill BCR[2] | TDV BCR |
| Climate Zone | Electricity | Natural Gas | Net Utility Cost | | | | |
| 01 | -($1,021) | +$730 | -($291) | -($8,725) | +$4,905 | 0.6 | 0.8 |
| 02 | -($703) | +$496 | -($207) | -($6,200) | +$4,905 | 0.8 | 1.4 |
| 03 | -($607) | +$398 | -($209) | -($6,281) | +$4,905 | 0.8 | 1.4 |
| 04 | -($604) | +$395 | -($209) | -($6,277) | +$4,905 | 0.8 | 1.4 |
| 05 | -($624) | +$374 | -($250) | -($7,491) | +$4,905 | 0.7 | 1.2 |
| 06 | -($257) | +$278 | +$21 | +$637 | +$4,905 | >1 | 2.2 |
| 07 | -($386) | +$241 | -($145) | -($4,343) | +$4,905 | 1.1 | 2.3 |
| 08 | -($196) | +$240 | +$43 | +$1,297 | +$4,905 | >1 | 2.6 |
| 09 | -($226) | +$261 | +$35 | +$1,053 | +$4,905 | >1 | 2.4 |
| 10-SCE/SoCalGas | -($252) | +$270 | +$18 | +$535 | +$4,905 | >1 | 2.1 |
| 10-SDGE | -($459) | +$296 | -($163) | -($4,904) | +$4,905 | 1.0 | 2.1 |
| 11 | -($689) | +$455 | -($234) | -($7,007) | +$4,905 | 0.7 | 1.5 |
| 12 | -($630) | +$465 | -($165) | -($4,961) | +$4,905 | 1.0 | 1.7 |
| 13 | -($632) | +$421 | -($211) | -($6,317) | +$4,905 | 0.8 | 1.7 |
| 14-SCE/SoCalGas | -($478) | +$396 | -($81) | -($2,438) | +$4,905 | 2.0 | 1.5 |
| 14-SDGE | -($720) | +$465 | -($255) | -($7,638) | +$4,905 | 0.6 | 1.5 |
| 15 | -($222) | +$187 | -($35) | -($1,053) | +$4,905 | 4.7 | 2.1 |
| 16 | -($1,103) | +$729 | -($374) | -($11,235) | +$4,905 | 0.4 | 0.6 |

[1] Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

[2] ">1" indicates cases where there are both first cost savings and annual utility bill savings.

# Cost Effectiveness Results for Single Family Electrification

| Efficiency & PV Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average Annual Utility Bill Impact[1] | | | Lifetime Utility Bill Savings | Lifetime Equipment Cost Savings | On-bill BCR[2] | TDV BCR |
| Climate Zone | Electricity | Natural Gas | Net Utility Cost | | | | |
| 01 | -($85) | +$730 | +$645 | +$19,341 | -($11,214) | 1.7 | 2.6 |
| 02 | -($77) | +$496 | +$419 | +$12,584 | -($5,762) | 2.2 | >1 |
| 03 | -($74) | +$398 | +$324 | +$9,710 | -($2,442) | 4.0 | >1 |
| 04 | -($74) | +$395 | +$321 | +$9,641 | -($2,725) | 3.5 | >1 |
| 05 | -($84) | +$374 | +$290 | +$8,706 | -($2,242) | 3.9 | >1 |
| 06 | -($0) | +$278 | +$278 | +$8,336 | -($557) | 15.0 | >1 |
| 07 | -($137) | +$241 | +$105 | +$3,141 | +$1,098 | >1 | >1 |
| 08 | -($0) | +$240 | +$240 | +$7,189 | +$206 | >1 | >1 |
| 09 | -($0) | +$261 | +$261 | +$7,819 | +$116 | >1 | >1 |
| 10-SCE/SoCalGas | +$0 | +$270 | +$270 | +$8,092 | -($699) | 11.6 | >1 |
| 10-SDGE | -($138) | +$296 | +$158 | +$4,741 | -($699) | 6.8 | >1 |
| 11 | -($125) | +$455 | +$330 | +$9,896 | -($4,601) | 2.2 | >1 |
| 12 | -($80) | +$465 | +$385 | +$11,561 | -($5,254) | 2.2 | >1 |
| 13 | -($122) | +$421 | +$299 | +$8,963 | -($4,418) | 2.0 | >1 |
| 14-SCE/SoCalGas | -($0) | +$396 | +$396 | +$11,888 | -($4,370) | 2.7 | >1 |
| 14-SDGE | -($158) | +$465 | +$307 | +$9,210 | -($4,370) | 2.1 | >1 |
| 15 | -($51) | +$187 | +$136 | +$4,086 | +$184 | >1 | >1 |
| 16 | -($113) | +$729 | +$616 | +$18,485 | -($9,765) | 1.9 | 2.6 |

[1] Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

[2] ">1" indicates cases where there are both first cost savings and annual utility bill savings.

# Cost Effectiveness Results for Multifamily Electrification

| 2019 Code Compliant Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average Annual Utility Bill Impact[1] | | | Lifetime Utility Bill Savings | Lifetime Equipment Cost Savings | On-bill BCR[2] | TDV BCR |
| Climate Zone | Electricity | Natural Gas | Net Utility Cost | | | | |
| 01 | -($337) | +$197 | -($140) | -($4,206) | +$2,095 | 0.5 | 0.9 |
| 02 | -($262) | +$165 | -($98) | -($2,925) | +$2,095 | 0.7 | 1.3 |
| 03 | -($235) | +$145 | -($90) | -($2,690) | +$2,095 | 0.8 | 1.2 |
| 04 | -($224) | +$146 | -($77) | -($2,323) | +$2,095 | 0.9 | 1.5 |
| 05 | -($252) | +$143 | -($109) | -($3,283) | +$2,095 | 0.6 | 1.1 |
| 06 | -($78) | +$155 | +$77 | +$2,317 | +$2,095 | >1 | 2.0 |
| 07 | -($200) | +$135 | -($65) | -($1,938) | +$2,095 | 1.1 | 2.0 |
| 08 | -($61) | +$151 | +$90 | +$2,697 | +$2,095 | >1 | 2.4 |
| 09 | -($71) | +$153 | +$82 | +$2,457 | +$2,095 | >1 | 2.0 |
| 10-SCE/SoCalGas | -($79) | +$153 | +$75 | +$2,241 | +$2,095 | >1 | 1.9 |
| 10-SDGE | -($228) | +$138 | -($90) | -($2,703) | +$2,095 | 0.8 | 1.9 |
| 11 | -($247) | +$156 | -($91) | -($2,732) | +$2,095 | 0.8 | 1.2 |
| 12 | -($235) | +$158 | -($77) | -($2,317) | +$2,095 | 0.9 | 1.5 |
| 13 | -($229) | +$149 | -($80) | -($2,396) | +$2,095 | 0.9 | 1.4 |
| 14-SCE/SoCalGas | -($144) | +$179 | +$35 | +$1,051 | +$2,095 | >1 | 1.4 |
| 14-SDGE | -($305) | +$173 | -($132) | -($3,965) | +$2,095 | 0.5 | 1.4 |
| 15 | -($67) | +$136 | +$69 | +$2,069 | +$2,095 | >1 | 2.2 |
| 16 | -($344) | +$228 | -($116) | -($3,475) | +$2,095 | 0.6 | 0.9 |

[1] Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

[2] ">1" indicates cases where there are both first cost savings and annual utility bill savings.

# Cost Effectiveness Results for Multifamily Electrification

| Efficiency & PV Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average Annual Utility Bill Impact[1] | | | Lifetime Utility Bill Savings | Lifetime Equipment Cost Savings | On-bill BCR[2] | TDV BCR |
| Climate Zone | Electricity | Natural Gas | Net Utility Cost | | | | |
| 01 | -($20) | +$197 | +$178 | +$5,327 | -($2,719) | 2.0 | >1 |
| 02 | -($12) | +$165 | +$153 | +$4,594 | -($1,079) | 4.3 | >1 |
| 03 | -($13) | +$145 | +$132 | +$3,948 | -($694) | 5.7 | >1 |
| 04 | -($10) | +$146 | +$137 | +$4,106 | -($619) | 6.6 | >1 |
| 05 | -($20) | +$143 | +$123 | +$3,693 | -($724) | 5.1 | >1 |
| 06 | +$0 | +$155 | +$155 | +$4,653 | -($126) | 36.9 | >1 |
| 07 | -($59) | +$135 | +$76 | +$2,278 | +$210 | >1 | >1 |
| 08 | -($0) | +$151 | +$151 | +$4,524 | +$169 | >1 | >1 |
| 09 | +$0 | +$153 | +$153 | +$4,577 | -($273) | 16.7 | >1 |
| 10-SCE/SoCalGas | +$0 | +$153 | +$153 | +$4,598 | +$46 | >1 | >1 |
| 10-SDGE | -($79) | +$138 | +$59 | +$1,772 | +$46 | >1 | >1 |
| 11 | -($24) | +$156 | +$132 | +$3,947 | -($1,039) | 3.8 | >1 |
| 12 | -($13) | +$158 | +$145 | +$4,363 | -($1,242) | 3.5 | >1 |
| 13 | -($25) | +$149 | +$124 | +$3,735 | -($922) | 4.1 | >1 |
| 14-SCE/SoCalGas | -($0) | +$179 | +$179 | +$5,385 | -($829) | 6.5 | >1 |
| 14-SDGE | -($90) | +$173 | +$83 | +$2,488 | -($829) | 3.0 | >1 |
| 15 | -($0) | +$136 | +$136 | +$4,091 | +$474 | >1 | >1 |
| 16 | -($23) | +$228 | +$205 | +$6,158 | -($1,752) | 3.5 | >1 |

[1] Red values in parentheses indicate an increase in utility bill costs or an incremental first cost for the all-electric home.

[2] ">1" indicates cases where there are both first cost savings and annual utility bill savings.