ATTACHMENT A TO LETTER O-5: CONSOL BUILDING ANALYSIS

JACKSON PENDO DEVELOPMENT COMPANY

Building Analysis

An estimation of annual energy use and PV production for a sample residential building designed to meet the 2016 California Energy Code and the California Energy Commission's Zero Net Energy definition from the 2015 Integrated Energy Policy Report.

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EXECUTIVE SUMMARY

This report analyzes a sample single-family residential building design, representing a typical home, for the proposed master planned community located within Otay Ranch Village 14 and Planning Areas 16 and 19 in the Proctor Valley area of Otay Ranch. A sample residence is used as a prototype residence as building plans have yet to be developed for the site.

The objective of this report is to calculate the annual energy use when the prototype residence is configured with options that achieve: (i) the 2016 California Energy Code, and (ii) Zero Net Energy (ZNE) as defined in the California Energy Commission's (CEC) 2015 Integrated Energy Policy Report (2015 IEPR). This report also determines the amount of rooftop photovoltaic (PV) that is required for the prototype residence to achieve ZNE. In this analysis, total estimated annual energy use (in kWh and therms) was calculated for the prototype residence, and consists of "regulated loads"—end uses covered by the California Building Energy Efficiency Standards (California Energy Code Title 24, Part 6)—and "unregulated loads", such as plug-in uses, which are not regulated by Title 24.

The prototype residence used in the analysis is a 3,652 square foot, two-story, single-family residence, and the plans for this building were provided from ConSol's library of building plans[1].

Residential Assessment

Methods and Assumptions

ConSol modeled the prototype residence using the CEC's public-domain compliance software, known as CBECC-Res[2], to calculate code compliance and annual energy use. The residential building was modeled in Climate Zone 10 (Chula Vista).

ConSol modeled the residence with building features that are most likely to be used to achieve compliance with the 2016 California Energy Code. Code compliance is based on the CEC's 2016 Time Dependent Valuation (TDV) energy[3] metric. For a building to be code compliant, the proposed design TDV energy[4] must be less than the standard design TDV energy[5]. An additional model was created to achieve compliance with the ZNE definition in the 2015 IEPR. An 11%[6] increase in the TDV efficiency of the ZNE model over the 2016

[1] The master planned community proposes a variety of detached, single-family residential product types that may range from approximately 2,000 to 4,500 square feet. The prototype residence studied in this report was selected to represent the approximate weighted average square footage of the residential product types, thereby providing a reasonable representation of building energy consumption for purposes of the community's environmental analysis and specifically the estimation of the community's greenhouse gas emissions in the utilized modeling platform (the California Emissions Estimator Model). While the calculated weighted average square footage is 3,400, the utilization of a 3,652-square foot prototype residence reasonably represents the energy profile of the slightly smaller home and is conservative in the sense that it likely serves to over-estimate the energy demand profile of the project by some small increment.

[2] "CBECC-Res" is shorthand for California Building Energy Code Compliance – Residential.

[3] Time Dependent Valuation energy assigns greater value to electricity produced or consumed at peak periods.

[4] Proposed design TDV energy is the projected TDV energy used by the residence using the features modeled.

[5] Standard design TDV energy is the projected TDV energy used when the residence meets the prescriptive requirements listed in Table 150.1-A (Package-A) of the 2016 California Energy Code.

[6] The increased efficiency above the 2016 code is intended to represent efficiency improvements likely to be included in a Zero Net Energy home design.

code was assumed to represent the energy efficiency requirements from the next code cycle (2019 Title 24, Part 6). The site energy was calculated for the 2016 code compliant and the ZNE residences in kWh and therms.

A cardinal orientation analysis (N, E, S, W) was performed for the 2016 code compliant and ZNE residences, to determine the "worst case" (uses most energy) orientation. ConSol used the worst-case orientation to determine the energy features required to achieve code compliance for all orientations. The features used in the calculations were selected based on common industry practices, ConSol's experience with builder preferences, and cost-effectiveness.

Table 1 lists the features that were used in each configuration. The first column in the table represents the building energy efficiency requirements needed to meet the 2016 code. The second column represents the building energy efficiency requirements needed to achieve ZNE, prior to the addition of the PV system. Features that are highlighted in yellow represent a change from the features listed in the 2016 code compliance configuration. The features used in each configuration show one option to meet the desired code compliance. In accordance with Title 24's performance-based approach, feature tradeoffs can be used in each configuration as long as the desired compliance margins are met.

Table 2 shows the annual site energy use and identifies the necessary PV system sizing requirements for the prototype residence's achievement of ZNE.

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TABLE 1: 2016 CALIFORNIA ENERGY CODE AND ZNE COMPLANCE OPTIONS

Jackson Pendo Development Company Chula Vista Climate Zone 10 3652 Sqft / 2-Story / 17.2% Glazing	2016 Building Features	ZNE Building Features
Run	Base	Base w/ HPA (R-38 BN), 14 SEER/12.2 EER HVAC, 0.96 AFUE, 0.95 EF Water Heater & Windows (U-factor 0.34, SHGC 0.23)
File Number	0	1
Software	CBECC-Res 2016.2.0 (857)	CBECC-Res 2016.2.0 (857)
Compliance Margins		
Worst Case % Above Code (2016 Code)	0.7%	11.5%
Worst Case Magin Above Code (2016 Code) - kTDV	0.18	3.12
Proposed Design Budget	26.99	24.05
Envelope: Opaque Surfaces		
Wall Insulation - 2x4 Exterior Walls	N/A	N/A
Wall Insulation - 2x6 Exterior Walls	R-21+R4, R-21	R-21+R4, R-21
Wall Insulation - 2x4 Interior Garage Walls	N/A	N/A
Wall Insulation - 2x6 Interior Garage Walls	R-21	R-21
Wall Insulation - Kneewalls	N/A	N/A
Insulated Entry Door(s)	N/A	N/A
Wall Insulation - 2x4 Exterior Garage Walls	N/A	N/A
Wall Insulation - 2x6 Exterior Garage Walls	R-0+R4	R-0+R4
Attic Insulation - Flat Portions	R-38	R-0
Attic Insulation - At Furnace Platform	R-21	R-0
Floor Insulation - Above Garage	R-30	R-30
Floor Insulation - Cantilever	R-30+R-4	R-30+R-4
Insulation Installation [Verification] - QII	Required	Required
Air Infiltration [Testing] - Blower Door	5.0 ACH	5.0 ACH
Roofing Material	Tile	Tile
Roofing Properties (Reflectance / Emittance)	0.10 / 0.85	0.10 / 0.85
Below Roof Deck Insulation	R-13	R-38
Ventilated Attic (Yes / No)	Yes	No
Envelope: Glazing (U-Factor / SHGC)		
Horizontal Slider	0.32 / 0.25	0.34 / 0.23
Single Hung	0.32 / 0.25	0.34 / 0.23
Fixed	0.32 / 0.25	0.34 / 0.23
Patio Door	0.32 / 0.25	0.34 / 0.23
French Door	0.32 / 0.25	0.34 / 0.23
HVAC: Space Heating, Cooling Systems		
Space Heating Type	Furnace	Furnace
Space Heating Efficiency (AFUE)	0.80	0.96
Space Cooling Type	ACSplit	ACSplit
Space Cooling Efficiency (SEER / EER)	15 / 13	14 / 12.2
SEER [Verification]	Required	N/A
EER [Verification]	Required	Required
Refrigerant Charge [Verification/Testing]	Required	Required
Fan Watt Draw [Testing]	0.58 W/cfm	0.58 W/cfm
Adequate Airflow [Testing]	350 cfm/ton	350 cfm/ton
HVAC: Duct System		
Duct Insulation R-Value	R-8	R-8
Duct Location	Attic	Attic
Low Leakage (Tight) Ducts [Testing]	Required @ 5%	Required @ 5%
HVAC: Mechanical Ventilation		
Minimum Whole-House Ventilation, Continuous	74 cfm	74 cfm
Ventilation System Type	Exhaust	Exhaust
Ventilation System Efficiency (cfm / W/cfm)	74 / 0.25	74 / 0.25
Water Heating		
Water Heater Type	Tankless	Tankless
Water Heater Efficiency (EF)	0.82	0.95
Fuel Source	Natural Gas	Natural Gas
Distribution Type	Standard	Standard

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TABLE 2: SITE ENERGY USES AND PV SIZING

Jackson Pendo Development Company Chula Vista Climate Zone 10 3652 Sqft / 2-Story / 17.2% Glazing	2016 Building Features	ZNE Building Features
Run	Base	Base w/ HPA (R-38 BN), 14 SEER/12.2 EER HVAC, 0.96 AFUE, 0.95 EF Water Heater & Windows (U-factor 0.34, SHGC 0.23)
File Number	0	1
Software	CBECC-Res 2016.2.0 (857)	CBECC-Res 2016.2.0 (857)
Regulated Loads from CBEEC Log File (Space Heating, Cooling & Water Heating)		
kWh	1048	971
Therms	253	220
Unregulated Loads from CBECC Log File (Inside & Exterior Lighting, Appliance & Cook, Plug Loads)		
Interior Lighting kWh	791	791
Appliance & Cooking kWh	1072	1071
Plug Load kWh	2371	2371
Exterior Lighting kWh	202	202
Appliance & Cooking Therms	45	45
Total kWh	5484	5406
Total Therms	298	265
Final EDR of Proposed Design w/ PV		-0.8
PV Sizing (kW)		5.0
PV Production kWH		8093
PV Production TDV		53.2
PV Production EDR		38.3
Proposed Design TDV		52.0
Proposed Design EDR		37.5

Predicted Energy Consumption

CBECC-Res estimates the annual site energy consumption for the 3,652 square foot house in Chula Vista (Climate Zone 10) that meets the 2016 code is 1,048 kWh and 253 therms for the regulated loads and 4,436 kWh and 45 therms for the unregulated loads. This equates to a total annual site energy consumption of 5,484 kWh and 298 therms for the 2016 code compliant residence. The energy consumption of the residence designed to achieve ZNE is predicted to be 971 kWh and 220 therms for regulated loads and 4,435 kWh and 45 therms for the unregulated loads. This equates to a total annual site energy consumption of 5,406 kWh and 265 therms for the ZNE residence. This reflects the increased efficiency of the ZNE residence features. (The software uses default values and building configurations, such as the number of bedrooms, to calculate the unregulated loads for each configuration. The calculations of the unregulated loads are independent of the regulated loads, causing them to be the same between the two configurations regardless of the increase of energy efficacy. While conservatively not reflected in the model, it is reasonable to anticipate future decreases in the energy demand of unregulated loads as the CEC (and others) adopt regulations and programs to minimize the energy consumption of appliances and other plug-in loads.)

The CBECC-Res software calculates the TDV energy use of the residence to verify that the proposed design meets current code. As previously mentioned, for a residence to be code compliant, the proposed design

TDV energy[7] must be equal to or less than the standard design TDV energy[8]. In this analysis, the residence designed to meet the 2016 code has a TDV energy of 26.99 kTDV/ft2-yr. This is a 0.7% (.18 kTDV/ft2-yr) improvement over the standard design. The TDV energy use for the residence designed to achieve ZNE is calculated to be 24.05 kTDV/ft2-yr, an 11.5% (3.12 kTDV/ft2-yr) improvement over the 2016 code standard design. The increase in compliance of the ZNE residence represents the increase in energy efficiency that is anticipated in the next code cycle (2019 Title 24, Part 6).

PV Sizing to meet ZNE

ConSol also used the CBECC-Res software to determine the required PV system size needed to achieve ZNE, as defined in the 2015 IEPR. The PV system was sized using the worst-case building orientation, which represents the largest PV system required to achieve ZNE; however, the CBECC model assumes all PV panels will be facing south. It is important to note that if the prototype residence is built in orientations other than the one reviewed, the PV system size would likely be different. A typical neighborhood will have houses facing in a variety of directions; therefore, the roof planes available for solar panel installation could also be facing a variety of directions. It is still possible for any given home to reach ZNE, regardless of which direction the home faces; however, annual solar generation will vary depending on the directional attributes of the installed solar panels. In some cases, the size of the solar system for a given house may be larger than the 5.0 kW system identified for the prototype residence; e.g., if some panels need to be installed facing north, east or west. In some cases, the size of the solar system could be smaller than the 5.0 kW identified by the model; e.g., if the house is facing an orientation where energy use is lower and there is south or west facing roof available for PV panel installation.

Using the CBECC-Res software, an Energy Design Rating (EDR) was calculated for the prototype residence to demonstrate that the building is designed to reach ZNE. The EDR is an energy use estimate that represents the regulated energy consumption, unregulated energy consumption, and annual PV production. All energy measurements (consumption and production) are based on the CEC's TDV energy[9] metric. The EDR metric is the CEC's energy code metric to demonstrate energy use and thus, ZNE, in California. To achieve ZNE on a residence, the EDR of the home must be less than the EDR of the PV system (i.e., the sum of the consumption EDR and generation EDR must be equal to or less than zero).

The PV system that ConSol used in the calculation consisted of standard PV panels facing 180° (South). The best orientation for PV generation in Climate Zone 10 is 180°. As shown in Table 2, this system configuration for the prototype residence requires a 5.0 kW PV system to reach ZNE. The prototype

[7] Proposed design TDV energy is the projected TDV energy used by the residence using the features modeled.
[8] Standard design TDV energy is the projected TDV energy used when the residence meets the prescriptive requirements listed in Table 150.1-A (Package-A) of the 2016 California Energy Code.
[9] The Time Dependent Valuation (TDV) metric assigns greater value to electricity produced or consumed at peak periods. The prototype residence was modeled using the 2016 TDV values. While still under development, the 2019 code will most likely propose different TDV values that may cause an increase in the PV system size needed to reach ZNE. This report's analysis was developed with the best information available at the time of its completion; during build-out, the project will consider new information regarding the achievement of ZNE as it becomes available.

residence has an EDR of 37.5 while the PV system has an EDR of 38.3 (see Table 2). A minimum of 8,093.3 kWh of annual PV production is needed for the residence to be ZNE. Standard 285-watt panels and a standard central inverter were used to calculate the PV system size. (More efficient panels, however, may be used to achieve ZNE as long as the minimum annual PV production is achieved. Relatedly, the utilization of more efficient panels is an option that can be considered to reduce the square footage of roof area needed for solar panel installation, regardless of orientation.)

To meet the required production, nineteen standard 285-watt panels (approx. 5.5 ft x 3.5 ft) are needed. This equates to approximately 366 square feet of south facing roof area. The California Fire Code (Section 605.11) dictates that PV arrays must be a minimum of three feet from the ridge, have one-and-a-half-foot clearance on each side of the array, as well as one-and-a-half-foot clearance from hips and valleys. If the required roof area is unavailable on south facing roofs, additional PV panels can be located on remaining roof orientations to meet the minimum required yearly production. If additional roof orientations are used, the PV system size may need to be increased due to PV production being proportional to orientation, as described above. During the building design phase, it is recommended that builders be mindful of roof penetrations (vents, chimneys, skylights, etc.) in roof surfaces where the PV system will be located. A possible option for roof penetrations is to locate those penetrations in the clearance areas required by the Fire Code.

The analysis provided in this report demonstrates the energy efficiency features and PV system size that would need to be included in the construction of a single-family residence, similar in size to the sample building, in Climate Zone 10 (Chula Vista), to reach the current working definition of ZNE. The building plans used for the sample residence are representative of a mid-level, single family residence; residences of varying sizes, or multi-family buildings, likely would have different energy profiles and therefore, different PV requirements to meet the ZNE definition. The prototype residence analyzed in this report is able to accommodate the required 5.0 kW PV system, assuming that the roof is designed with adequate area for solar panels. In developing a plan for ZNE homes or a ZNE community, it is important to design buildings with adequate solar roof areas.