California Energy Commission

CONSULTANT REPORT

Early Adopter ZNE Program Measure List

For the City of Richmond Advanced Energy Community
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ABSTRACT

The Early Adopter Zero Net Energy (ZNE) Multi-Family Program is designed to complement the pending Richmond Multi-Family Ordinance (RMFO) and will utilize a dynamic list of eligible program measures that will evolve as the multi-family new construction industry advances towards ZNE. The list of eligible program measures will be tailored to each project through the ZNE Decision Tool software. Since the multi-family new construction industry is still in the nascent stages of ZNE design, this tool will overcome the hurdle of developers and designers assuming ZNE construction is not feasible by identifying multiple pathways and costs to achieving ZNE. The Tool will identify pathways to compliance with the pending RMFO, which requires an energy efficiency baseline of 15% better than Title 24, Part 6 for mixed-fuel low-rise buildings. Based on these pathways, the project can then compare the relative design strategies and costs of compliance with the RMFO and ZNE. This will allow projects to assess if ZNE is a viable option without having to put in excessive time and resources into a detailed design. Since the costs of program measures will continue to change over time, instead of using a static measure cost, the ZNE Decision Tool will include inputs from RSmeans, CALGreen CASE Reports and vendor published cost data. While the program measures and costs will continuously be updated, the initial program measure list can be found in Appendix A. This document provides further information on the concept behind and details of how the ZNE Decision Tool will operate.

Keywords: California Energy Commission, Richmond, ZNE, Advanced Energy Community, Multi-Family, Program Measure List, Energy Simulation Tool, Building Energy Modeling.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The proposed Richmond, California Multi-Family Ordinance (RMFO) for new construction sets aggressive goals for multi-family building energy performance. To support compliance with this ordinance, as well as to aid early adopters of multi-family zero net energy (ZNE) construction in Richmond, Energy Solutions has developed a proposed ZNE Decision Tool. The ZNE Decision Tool is software that enables multi-family building developers and designers to explore a variety of pathways toward RMFO and ZNE building performance during the early design phase. Based on five building prototypes designed to cover a range of typical multi-family designs, the tool draws from a list of available energy efficiency measures and their associated costs, as well as photovoltaic (PV) information, to iterate through numerous annual energy simulations using the California Building Energy Code Compliance (CBECC-Res) simulation engine. Based on simulation results, the tool optimizes efficiency measures and PV system size to find least cost pathways toward RMFO and/or ZNE building performance. The aim of the tool is to leverage the impacts of building energy simulation in the early design phase to help overcome barriers to ZNE performance in multi-family new construction.

CHAPTER 1:
ZNE Decision Tool

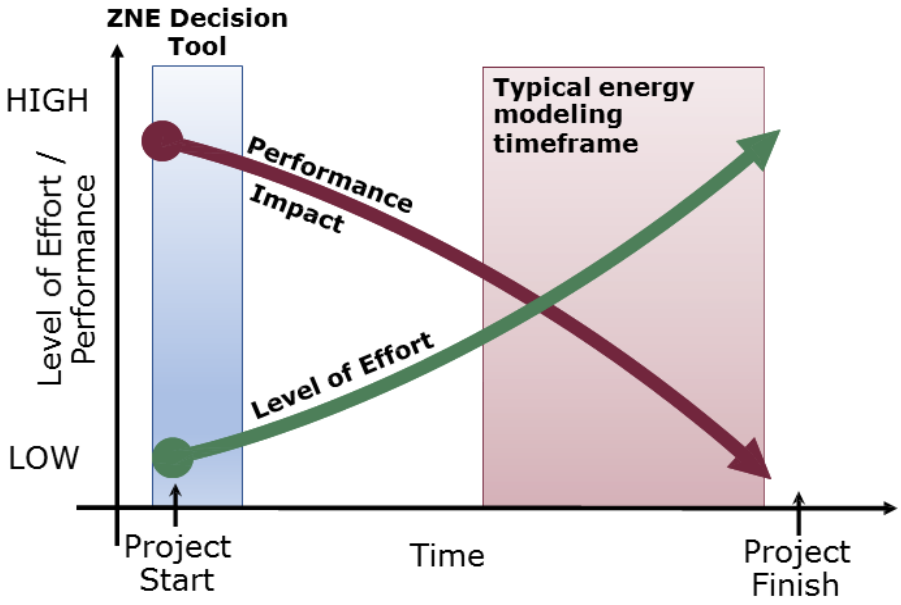
In place of a static program measure list, the Zero Net Energy (ZNE) Decision Tool is a software program intended to be used during early-phase design of low-rise multi-family new construction. The purpose of the tool is to help developers and designers identify feasible and least-cost pathways to both compliance with the pending Richmond Multi-Family Ordinance (RMFO) and ZNE building performance. The Early Adopter ZNE Program is designed to complement the existing PG&E California Multifamily New Homes (CMFNH) rebate program. Therefore, the ZNE Decision Tool will provide design options that also meet the minimum energy efficiency level required to participate in CMFNH. Another use-case of the Tool is to leverage the early design phase, shown in Figure 1, to support multi-family new construction and major alteration projects to consider ways to meet and exceed the proposed RMFO.[1] The ultimate aim of the Tool is to help support early adopters of ZNE multi-family construction in Richmond.

The Early Adopter ZNE Program defines a ZNE building as a building in which the time dependent valuation (TDV) of energy consumed over a year is equal to the TDV of on-site generation[2]. This corresponds to an energy design rating (EDR) score of 0. If 2019 EDR standards are amended in the California Title 24 building energy code, the tool would be updated to reflect such changes. This could include incorporation of the TDV value of energy storage or other demand flexibility strategies.

1 Glazer, Jason, Erik Kolderup. (2016) ASHRAE Standard 209P: Energy Simulation-Aided Design for Buildings. International Building Performance Simulation Association. June 2016.

2 Shirakh, M., Meyer, C., Pennington, B., (2017) 2019 Building Energy Efficiency Standards ZNE Strategy: Staff Workshop Presentation. California Energy Commission Building Standards Office. April 2017.

Figure 1: Benefits of Energy Modeling in the Early Design Phase



(Source: International Building Performance Simulation Association.)

Description

The proposed ZNE Decision Tool is based on the California Building Energy Code Compliance (CBECC-Res) software. Using the CBECC-Res hourly simulation engine, the Tool runs numerous energy simulations with varying combinations of energy efficiency measures and photovoltaic (PV) system size. Drawing on outside cost data, the tool optimizes the efficiency and PV parameters to find least-cost solutions to ZNE design. The Tool does not provide detailed energy simulations of specific building designs. Rather, given the Richmond, CA climate zone and a multi-family building prototype, the Tool provides a menu of optimal design packages, each with an associated cost, that could achieve compliance with the pending Richmond multi-family reach code and ZNE building performance.

User Inputs

The user of the ZNE Decision Tool will include designers, developers, energy consultants, and potentially building owners. The user will be prompted to choose from a list of five pre-specified multi-family building prototypes. The five prototypes will be designed to cover a range of typical multi-family home designs and sizes. Each prototype will have a description of the building including number of stories, number of units and their size, total floor area, rooftop area, window-floor-ratio, and a high-level description of the heating, ventilation and air conditioning (HVAC) and water heating systems. The user will also be able to define options for shared laundry facilities, mixed-fuel or all-electric, and whether the building will be designated as low-income housing. These options will help inform the energy use profiles of the building and, in the case of a low-income development, would incorporate any available rebates into the cost inputs. Each prototype will also contain embedded information about construction assemblies, fenestration geometry, plug loads, and lighting.

The five prototypes will be located in California building climate zone 3 and all will be minimally compliant with Title 24, Part 6.

Tool Maintenance

The ZNE Decision Tool will have a list of available energy efficiency measures for each building prototype and the associated cost of each measure. These parameters will be updated as necessary to stay in line with industry changes. The idea is that the total building cost per design can be compared to the prototype building that meets Title 24, Part 6 to create a total project incremental cost. PV systems will also be included as an available measure with an associated cost, as the tool will weigh the relative trade-off between additional energy efficiency and added PV. Given that CBECC-Res does not have the ability to take cost inputs, the Tool will process cost data from a separate input file. Cost data will be drawn from CalGreen CASE reports, large construction cost databases such as RSMeans, and internet research that pulls in actual vendor cost information. This data collection will be automated to update frequently ensuring up-to-date measure and cost information. For each measure where a range of values are worth considering, the measure name will map to a range of CBECC-Res parameters, each with an associated cost. An illustrative example of the cost input file is below in Table 1.

Table 1: Example of Measures and Cost Inputs for ZNE Decision Tool

Available Measure	Baseline Building Prototype	CBECC Parameters	Measure Cost
Increase wall insulation	R-19	Wall cavity insulation R21, R25, R30	R-21: $xxx R-25: $xxx R-30: $xxx
High efficiency windows	U-0.3	U-value of windows 0.27, 0.25, 0.23	U-0.27: $xxx U-0.25: $xxx U-0.23: $xxx
High efficiency boiler	AFUE 90	AFUE boiler rating 94, 96; Constant capacity	AFUE 94: $xxx AFUE 96: $xxx
Photovoltaic System	10 kW	PV System size, 10-15kW	$x,xxx/kW

Note: As described above cost information will be pulled dynamically into the tool. Therefore, this table does not include cost information, but is an example of what inputs will be used.

Simulation Process

Once the input parameters have been specified by the user, the ZNE Decision Tool will begin simulation. The simulation process may take upwards of 20 minutes depending on the number of measures available to the building prototype selected. The tool will use a multi-objective optimization algorithm with the dual goals of minimizing up-front cost and EDR. It

will be constrained by a maximum PV system size based on available rooftop area of each building prototype, and a maximum EDR score to be compliant with the RMFO. It will further be constrained by designs with an efficiency EDR (excluding PV) of at least 3 points lower than the standard design. This constraint will ensure that each solution will also qualify for the PG&E CMFNH Program. Each simulation will be a unique combination of energy efficiency measures and PV system size. As the tool iterates through these different combinations, it will 'learn' from the previous combinations and results to optimize solutions that minimize both cost and EDR.

Results

The results of the simulation will be a menu of possible efficiency packages and PV system sizes that all produce an EDR score compliant with RMFO. Each solution will have a unique cost and EDR associated with it, but all will be 'optimal' in that any further decrease in cost would result in a higher EDR and any further decrease in EDR would result in higher cost. If users wish to evaluate only ZNE solutions, there will be an option in the results to display only those solutions with an EDR score of 0 or less. Given the EDR scores of each solution, the up-front costs in the results will be adjusted to reflect any available rebates through the performance-based CMFNH Program.

Each of the solutions will then be further analyzed by the Tool to determine the electricity and natural gas life-cycle cost compared to the baseline building prototype over a 30-year time horizon. This analysis will compare the TDV annual energy consumption and generation of the proposed ZNE design to the baseline building prototype. These net TDV energy units will then be converted to life-cycle costs according to the methodology laid out in the 2013 Title 24 standards[3]. The Tool's ultimate output will be a spreadsheet of RMFO-compliant solutions listing the specific energy efficiency measures, PV system size, project cost increase from a Title 24 minimally-compliant building, and the life-cycle cost as shown below in Table 2.

Table 2: Illustrative Example of ZNE Decision Tool Output

Sol.	Energy Efficiency Measures	PV System Size (kW)	EDR	Up-front Project Cost Increase	Life-Cycle Costs Compared to Baseline
1	• High efficiency doors (U-0.2) • Heat pump space heating • Quality insulation installation • Compact hot water distribution	16	3	$61,920	$3,096

3 Architectural Energy Corporation. (2011) Life-Cycle Cost Methodology: 2013 California Building Energy Efficiency Standards. Prepared for the California Energy Commission. January 2011.

2	• R-50 roof • Heat pump water heating • Combined hydronic space heating • High efficiency walls	14.2	(1.2)	$100,300	($550)

Note: While based on previous analysis, efficiency packages and cost information should not be considered accurate. They are included for illustrative purposes only.

Building designers and developers can then take this output and identify the most cost-efficient measures which will advance the RMFO and ZNE goals in the context of their unique multi-family new construction project.

CHAPTER 2: Conclusion

This document serves as a concept description of the ZNE Decision Tool and a roadmap for being able to build the Tool. The Tool is principally designed to help early adopters overcome barriers to ZNE multi-family new construction. This is accomplished by providing an easy-to-use early-design phase tool that quickly evaluates several potential RMFO and ZNE pathways and their associated costs. Projects may still decide not to pursue ZNE performance, but at least they would do so knowing the relative cost and performance trade-offs. The Tool's functional aim rests on previous analysis showing that in the Richmond, CA climate zone, ZNE multi-family construction is very close to being cost-effective, with benefit-cost ratios of 0.95[4]. Continued support and well-placed incentives will help to further pave the way for ZNE early adopters.

The ZNE Decision Tool is also designed to complement and support the current PG&E CMFNH Program. By constraining the results to design solutions with an efficiency EDR of at least 3 points lower than the standard design, each solution is ensured to be eligible for the CMFNH performance-based rebates. Additionally, by including measures with CMFNH financial kickers (see Appendix A), the tool will support buildings to take advantage of the kickers and to effectively use those measures as part of a broader ZNE package that contributes to progressive whole-building energy performance.

While the above description explains how the ZNE Decision Tool can be used to support both the RMFO compliance and ZNE performance of multi-family new construction, the Tool could be amended to support other building types as well. For example, single-family ZNE design would be a relatively straightforward modification of the Tool. As California compliance software continues to improve and supports the ability to model more complex multi-family buildings (i.e. high rise or mixed retail/residential), the Tool could be amended to support these building types as well.

4 Davis Energy Group, Inc., Enercomp, Inc., Misti Bruceri & Associates, LLC. (2016) CA Statewide Codes and Standards Program Title 24, Part 11 Local Energy Efficiency Ordinances: CALGreen Cost Effectiveness Study. Prepared for Marshall Hunt, Codes and Standards Program, Pacific Gas and Electric Company. September 2016.

APPENDIX A:
INITIAL MEASURE LIST

The following table is a list of initial measures that the ZNE Decision Tool will use to explore pathways to the RMFO and ZNE performance. Only specific subsets of this measure list will be available to each building prototype. The list will be updated within the Tool on a quarterly basis with available measures for each building prototype and cost data. For measures that are included in PG&E's CMFNH program, and cannot be modelled by CBECC-Res, the Decision Tool will apply the CMFNH EDR adjustment value, noted in *italics* in the table below. The majority of the information below is sourced from the CA Statewide Codes and Standards Program Title 24, Part 11 Local Energy Efficiency Ordinances: CALGreen Cost Effectiveness Study cited above in footnote number 4.

Design Strategy	Measure	Cost Data	CBECC-Res Parameters	Range
Building Envelope	Advanced framing: 24-inch on center walls, floors, attic	RSMeans	Construction assemblies, 24" centers	NA
	Structural Insulated Panels (SIP)	RSMeans	Construction assemblies, SIPS wall	NA
	QII (Quality Insulation Installation)	City of Palo Alto Reach Codes	Project, improved insulation installation	NA
	Wall Cavity Insulation*	RSMeans	Construction assemblies, cavity path insulation	R-20, R-25, R-30
	High Performance Attic: R-13 under roof deck	2016 CALGreen Cost-effectiveness Study	Construction assemblies, roof deck cavity	NA
Fenestration	Window U-factor*	RSMeans, EnerComp	Window type, U-factor	0.2, 0.23, 0.27
	Door U-factor*	NREL cost database	Door data	0.2, 0.23, 0.27
HVAC	Heat Pump Space Heating/Cooling	RSMeans	Mechanical, heating /cooling systems, HSPF, SEER, COP values	Depends on application

	Heat Recovery Ventilation (HRV)*	RSMeans	IAQ balanced, recovery effectiveness	50%, 60%, 70%
	Duct Insulation	RSMeans	Mechanical systems, duct insulation	R-8
	Duct Sealing - low leakage	RSMeans	Mechanical, duct insulation	NA
	Efficient Central Air Conditioner	Internet vendor pricing, RSMeans (labor)	Mechanical, cooling systems, SEER value	14, 12, 10
	Efficient Gas Furnace	RSMeans	Mechanical, heating systems, furnace, AFUE value	90, 94, 96
	Hydronic Heating	RSMeans	Mechanical, heating systems	NA
Water Heating	Heat Pump Water Heater	Internet vendor pricing, RSmeans (labor)	Mechanical, water heater	COP 2.5, 3, 3.5
	Hot water compact distribution	HERS rater verification fee	Mechanical, water heater data	NA
	Efficient Gas or Electric Water Heater	Internet vendor pricing, RSMeans (labor)	Mechanical, water heater, EF value	90, 94, 96
Plug Loads	Interior and Exterior LED lighting* *1 EDR point adjustment*	Internet vendor pricing, RSMeans	NA	NA
	ENERGY STAR Laundry Facility*	Internet vendor pricing, RSMeans	Shared laundry facility	NA
	ENERGY STAR Tier II Appliances* *1 EDR point adjustment*	Internet vendor pricing	NA	NA

Solar	Photovoltaic system	Go Solar California	Project, PV System	Depends on rooftop area

*denotes measure with an existing PG&E CMFNH Program kicker