

# PROPOSED APPROACH FOR THE ZNE RESEARCH GAP ANALYSIS

## Project Background and Objectives

This contract will fund research to develop an analysis of the most critical RDD&D gaps that need to be addressed to achieve California's goals of zero net energy buildings for all new construction of residential buildings by 2020 and for commercial buildings by 2030. Results of the analysis will be used by Energy Commission staff to develop a research roadmap that strategically targets future EPIC investments in a manner that provides optimal benefits to Investor-Owned Utility (IOU) electric ratepayers, and maximizes the use of public research and development investments.

The goal of this Contract is to develop, in consultation with stakeholders and subject matter experts, a technical assessment of the current baseline and best-in-class ZNE building technologies and strategies; and a gaps analysis of key RDD&D needs for achieving the state's goals for ZNE buildings in a safe, equitable, and cost-beneficial manner. Specifically, the gaps analysis must synthesize the input of stakeholders and experts to:

1. Analyze stakeholder recommendations on research most needed to achieve cost-effective ZNE buildings.
2. Provide a detailed description of barriers that hinder the adoption of ZNE building technology in the marketplace.
3. Analyze performance and cost targets for promising ZNE technologies.
4. Develop critical indicators of success for ZNE building adoption.

## Scope

In terms of building sectors, the scope of the work will be new construction, residential (single family and multifamily) and for commercial we will target the building types based on criteria with highest impact in terms of energy and market penetration and growth.

Potential topics to be covered in the technical assessment and gaps analysis include, but are not limited to, the following:

- » Building energy efficiency technologies:
  - Lighting.
  - Heating, ventilation, and air conditioning (HVAC).
  - Water efficiency and reuse technologies that also provide electricity savings.
  - Building envelope.
  - Plug-loads.
  - Whole-building strategies such as DC-DC and appliance electrification.
- » Behavioral research of current and potential ZNE building residents.
- » Demand response.



- » Distributed- and community-scale renewables, as enabler for ZNE.
- » Smart grid connectivity related to ZNE, such as:
  - Interaction between building to electrical grid (B2G), including system capacity.
  - Smart building controls, home area networks, and information/action displays that give real-time data and control to the resident and/or building owner.
  - Electric vehicle charging and vehicle-to-grid (V2G).
  - Controllable loads.
- » Energy storage, as enabler to ZNE.
- » Public health and safety including indoor air quality (incorporating findings from the upcoming Energy Commission Environmental Public Health Research Roadmap).
- » Planning and permitting of ZNE buildings.

## Project Team:

### Prime + overall project coordination

#### DG + grid integration and other cross cutting

##### » Itron

- Smita Gupta - PM
- Jeremy Smith – assisting PM
- George Simons
- Mike Ting

#### Behavior, plug loads and other cross cutting

##### » UC Davis

- Siva Gunda
- Katherine Bannor

#### Administrative and coordination support

##### » Amerit consulting

### Commercial Buildings

#### » New Buildings Institute

- Cathy Higgins
- Ann Edminster
- Kevin Carbonnier & Weby Bowles

#### » Integral Group

- Neil Bulger
- Andrea Traber

### Residential Buildings (SF + MF)

#### » Electric Power Research Institute

- Ram Narayanamurthy

#### » Davis Energy Group (Frontier Energy)

- Dave Springer
- Bill Dakin



## Proposed approach

Given the relationship between GHG emissions, peak load and ZNE, we believe it is very important to view approaches to achieving ZNE in context of these combined objectives. In turn, we plan to approach the ZNE Roadmap with a holistic approach that includes the knowledge of the policy landscape, carbon reduction pressures, and building construction and operation aspects such as design, ZNE enabling technologies and their operation. But we will also go ‘beyond the building’ to include areas of the grid, storage, the environment, permitting, commercial real estate trends, decision maker and occupant behavior, community and aggregated energy services, and training to achieve sustainable ZNE in the built environment. Our research approach will be cross cutting through these components to layout a research roadmap that facilitates the state’s ZNE goals.

Our project approach for advancing this foundation of work to develop the Roadmap is grounded in two key tenets:

- 1. Build on what is in place.** This includes the extensive research and studies such as the ones demonstrated in our narrative below, but we will also highly leverage the market and empirical evidence from the actual leaders in ZNE. This is the most innovative and unique aspect of our proposed project approach and the Itron team – we have the pulse of the real market activity, issues, barriers and motivations that can inform the Roadmap and lead to recommendations that truly reflect the next steps of wise investments by the CEC.
- 2. Draw a wide circle.** This refers to both the research topic areas to get residential and commercial new construction aligned with the State’s ZNE timeframe and goals; and to the parties involved in the outreach. Our project will expand the circle of topics and go beyond the typical lists of advisors and stakeholders to include a greater representation of owners, manufacturer reps and design firms to develop a Roadmap that reflects a greater breadth and constituency toward the research needs.

The Roadmap approach will begin with bringing to the surface a clear summary of the market status and research that is done or underway by technology, practices and trends. This existing research and data forms the ‘landmarks’ on the roadmap – places that already exist that we want to visit and include in our representation of the overall California research needs to get to ZNE. Our Roadmap approach will then identify where these landmarks need some ‘paving’ to better form a part of the landscape and where infrastructure and new sites are needed.

This concept and analogy of the ZNE Roadmap first identifying existing lanes and roads overlaid on the landscape of California ZNE Building Technologies, Practices and Trends will help more clearly identify the recommended enhancements, versus new research roads needed to meet the goals. It will also ensure that the public funds are targeted to needed, not redundant, research areas meeting the objective of budget and cost-effective use of the EPIC funding.

**Figure 1: Summary of Proposed Approach for Research Roadmap Development**

### ***Task 2: Landscape Assessment of ZNE Technologies and Strategies***

The goal of this task is to develop a technical assessment of the current baseline and best in class zero net energy building technologies and strategies, including cost and performance attributes that can be used to inform and develop the ZNE Research Roadmap and identify gaps that need to be addressed with RDD&D projects to achieve ZNE in residential new construction by 2020 and commercial by 2030. A key performance target for success will be to make ZNE cost-effective so that a Title 24 approach can be used by these dates, or that it will be cost-effective for the market, or both.

#### **Landscape Assessment Approach**

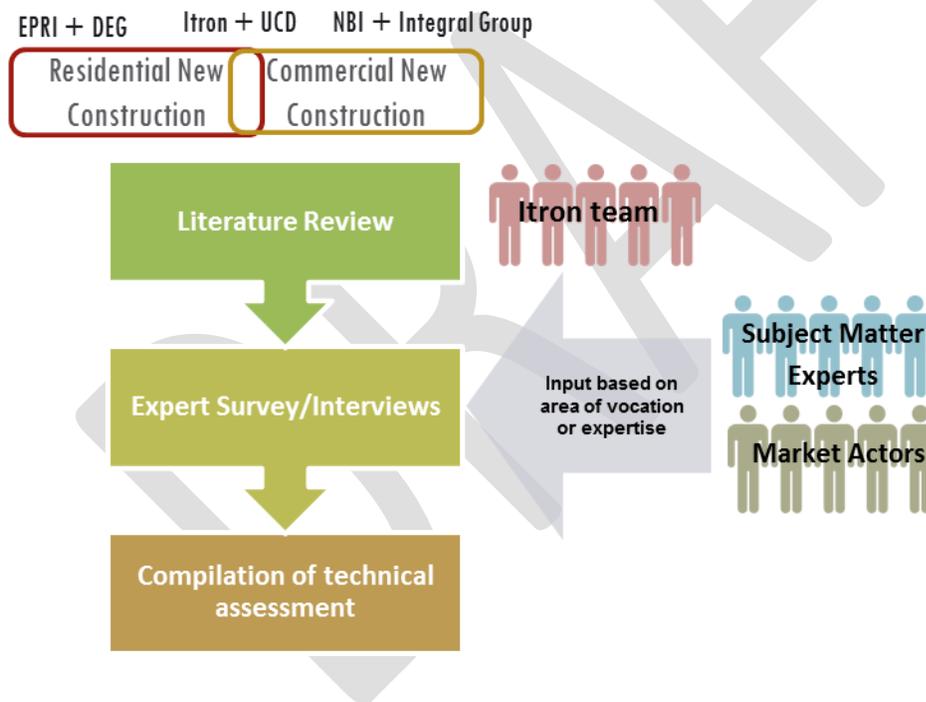
In this task we will develop a technical assessment of technologies and strategies for ZNE in both the residential and commercial market sectors. We will examine both baseline and best-in-class characteristics, ZNE associated costs, and performance metrics. Our approach for this will be to leverage the existing body of work, but with a focus on specific building types likely to yield the most information from the RDD&D effort. We will also focus more on strategies as represented by the Key Research Areas identified in Section 2.1 of this proposal. This effort will be guided by our team experience and expertise along with input from pertinent SMEs and market actors. Overall our approach will be to use the following four inputs:

1. Review of recent and relevant literature, which includes the recent studies and Action Plan by CPUC and IOUs.

2. Firsthand experience of the team on actual ZNE projects and other related activities such as Title 24 ZNE code development.
3. Input from SMEs on specific technologies and strategies.
4. In-depth survey interviews with relevant market actors that represent the perspective of a group as identified in the section above (Stakeholder and Expert Input). This group is important to collect input from but will need a carefully crafted softer approach that can derive the information based on the experience in their everyday business.

We expect the final resulting deliverable to be a standalone product which can be a resource not only to the next steps in the process of developing this roadmap, but also the ZNE community at large to reference. The technical assessment is going to provide the key input into the trends and drivers step of the overall process, while informing the planning scenarios and gap analysis steps. Our vision for this product is an online database of literature that we review and assign keywords which are searchable. We expect the product to be an interactive online searchable database of literature with review notes and tags on the research areas and building sector it addresses.

**Figure 2: Proposed Steps for Task 2 Technical Assessment**



### Literature Review

For the literature review effort, we will mine all the expected places, but our literature review effort is already well seeded by our team’s experience with, and contributions in developing, the key documents discussed earlier in this section.

The Itron team will leverage our experience and contributions on the above studies along with other relevant and related documents to round out the literature review for research areas and issues around



ZNE. We will also use the TAC and ZNE expert recruitment efforts to obtain information on cutting-edge and/or soon-to-be-released work. The deliverable for this sub-task will be an excellent resource for the ZNE community, and become a part of the technical assessment report.

### Leveraging Existing Research

There have been several studies in CA related to ZNE and relevant technologies in the last three to five years. The primary studies sponsored by State agencies or through utilities are listed below. Our team is intimately familiar with all of these works. In fact, through primary or contributing authorship, members of **our team have helped develop six of the seven studies** listed.

Action Plans in support of CPUC's Strategic Plan where one or more members of the proposed team either led or played a seminal role (links provided as Reference Material A at the end of this section):

- » Research and Technology Action Plan 2012 – 2015
- » New Residential ZNE Action Plan 2015- 2020
- » Zero Net Energy Action Plan: Commercial Building Sector 2010 - 2012

IOU sponsored studies where one or more of the proposed team members contributed to content:

- » California Zero Net Energy Buildings Cost Study 2012
- » The Road to ZNE: Mapping Pathways to ZNE Buildings in California (2012)
- » The Technical Feasibility of Zero Net Energy Buildings in California (2012)

Other relevant studies:

- » Residential ZNE Market Characterization 2015

The Itron team will leverage our experience and contributions on the above studies along with other relevant and related documents to round out the literature review. There is extensive research relative to moving buildings and the market to ultra-low energy performance and ZNE that will also be considered as the foundation for the Roadmap. The team will review and create a baseline of recent and current research as a starting point mapping it across the sectors and topic areas.

The research review will be derived from the work underway or completed by EPIC relevant to the Roadmap as well as that of other entities such as the UC Davis Energy Efficiency Center, California Lighting Technology Center and Western Cooling Energy Center and the UC Irvine California Plug Load Research Center. Multiple related research projects underway. A sample list of specific related EPIC projects and other research sources is located in Reference Material A as a supplement to this section.

### Stakeholder and Experts Input

Input from key ZNE stakeholders and SMEs will be a key aspect of the process in developing the Research Roadmap.

The team plans to use its extensive network of contacts and associates along with its in-house expertise to fill this need. In our view there are four types of input groups:

- » ZNE Stakeholders
- » Subject Matter Experts (SME)
- » ZNE Market Actors
- » Technical Advisory Committee (TAC)

**ZNE stakeholders** is considered the super set of all player that impact or are impacted by ZNE in one way or another. This category covers the full range of end use home owner or building occupant to the builder/developer and right up to policy makers and the grid with utilities and CAISO level, all of whom have a stake in the ZNE built environment.

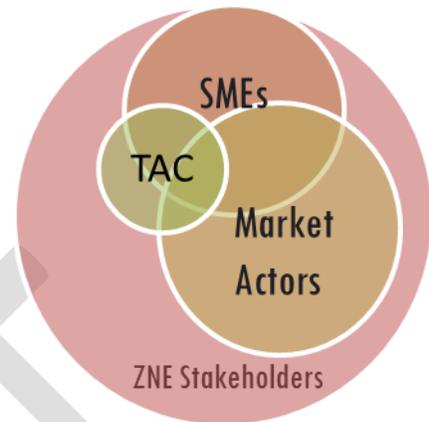
The **subject matter experts (SME)** is the subset of ZNE stakeholders that are experts in their field of vocation, be it HVAC, lighting, solar, storage, controls, monitoring, or any other aspect such as behavior and plug loads for example. The input from this set of stakeholders will be very focused to their area of expertise as it pertains to the ZNE puzzle.

The **ZNE market actors** are the sub set of stakeholders that impact the market knowingly or unknowingly. This group is fairly large and encompasses, appraisers, realtors, financiers, builders, developers, code officials and building facility managers to name a few. This group is important to collect input from but will need a carefully crafted softer approach that can derive the issues based on the experience in their everyday business. Their perspectives cover a broad spectrum of issues and concerns. We will be reaching out to each of the market actor groups to get their perspective and assess awareness, needs, barriers, attitudes, drivers and motivation towards ZNE. This group will be tapped early on in the project during technical assessment and identifying key trends and drivers. An initial list of market actor's groups is provided in the Reference Material A at the end of this section.

The **technical advisory committee (TAC)** for the project will be convened as a mix of SMEs and market actors that are deemed crucial and have the motivation, time and availability to provide input into the ZNE research roadmap process.

A targeted list of ZNE experts will be compiled from the literature review effort, from the Itron team's extensive existing contacts, and from the TAC. We will specifically recruit SMEs in the area of currently feasible energy demand targets and energy use intensity targets, cost and performance attributes for specific ZNE technologies and strategies, and other to-be-determined areas. Once again, the Itron team has extensive experience in many of these areas. Depending on the coverage needed and decided in discussion with the CAM, we will recruit experts in each category, but since most experts have cross-cutting knowledge we will leverage covering more than one area with a view to ensure *diversity* in view point, so as to avoid skewing the results in anyway.

The deliverable for this sub-task will be the List of Experts and their specific expertise, which will be used as the call list for the interviews in the next task. The Itron team will work closely with the CAM in developing this list of experts to ensure that critical areas are covered





Our team collectively has extensive experience in conducting interviews, both structured and in-depth as well as working to get input from small and large groups. We will especially leverage the experience of Itron and NBI in this arena and develop surveys and interview guides as appropriate to the group being contacted.

After getting the CAM’s approval on the surveys and interview guides, we will field the input collection using staff with technical expertise or staff who are less technical interview experts, as deemed appropriate to optimize cost ad resource allocation. These efforts will be conducted in parallel to cover residential and commercial market sectors led by the respective internal team leads with overall coordination from Itron.

**Table 1: Initial Groups of Market Actors**

Market Actors	Residential	Commercial
ZNE and near ZNE Builders	X	X
Non ZNE Builders/developers	X	X
Developers + Land use Planners	X	X
Appraisers	X	X
Financers/Lenders	X	X
HERS raters	X	
Facility Managers		X
Energy Consultants	X	X
Designers	X	X
Solar Installers	X	X
Building Officials	X	X
ZNE and near ZNE building occupants	X	X
Prospective ZNE buyers/renters	X	X
Realtors + Sales Associates	X	X
Utility Program Staff	X	X
Local Governments	X	X

### **Stakeholder Engagement**

#### Identification and Solicitation of Stakeholders

1. Draw from the initial list in the proposal and expand on the matrix structure that partitions the various areas of desired input according to technical subject area (lighting, HVAC, enclosure, etc.), sphere of influence (finance, real estate, construction, permitting, etc.), and other relevant dimensions or aspects of ZNE.
2. Outreach to identified candidates asking them to respond to a short survey about:
  - a. Their level of interest in participating.
  - b. The amount of time they are able and willing to devote.
  - c. The areas in the tree/matrix which correspond to their interest(s) and area(s) of expertise. Respondents may indicate high-medium-low interest and may specify whether they prefer to offer input at a broad/general level and/or at a more specific/granular level (we may be able to use a specific survey instrument



designed for participation polling). (This approach to engagement is likely to result in better buy-in than a simple yes/no request, or a request in which we determine in advance the area(s) where we want their input.)

3. Create a stakeholder portal on the team website (see below).
4. Obtain commitments for the various stakeholder and TAC roles

### Project and stakeholder coordination portal

<http://zneroadmap.researchenergy.net/>

The project team will establish a password-protected portal for use by the team, TAC, and CEC, and for stakeholders to obtain, exchange and communicate regarding the project.

Features include but not limited to:

- » Participation survey – allow stakeholders to indicate their area(s) of interest, by level (low-med-high), in a tree or matrix framework. Each interest area should have a title and a description field (could be rollover or pop-up). The framework should be visible to all persons surveyed and should allow them to suggest additional participants (stakeholders) via private message to the project team.
- » Group and sub-group chat – ability for stakeholders, once assigned (by project team) to one or more topic areas, to see one another’s contributions and engage in dialogue; each stakeholder should be able to participate in as many or as few groups as s/he chooses, and subscribe/unsubscribe to each as desired.
- » Literature database – dynamic feature that initially will be populated by the project team, to which stakeholders may add additional listings. It should be searchable/sortable by date, author, organization, title, and keyword (mandatory fields). The group member listing the item should also be identified. Each listing should also allow for inclusion of a brief description (optional field).
- » Meeting/call scheduling (similar to Doodle) – administered by the project team but visible to group members.
- » Bulletin board – ability for project team and/or group members to post notices of interest to the whole stakeholder community; moderated by the project team.

### *Compilation of Technical Assessment of ZNE Technologies and Strategies*

Using information from the literature review and expert interviews, the team will prepare and submit a draft *Outline of the Technical Assessment* to the CAM for review and approval. We will then revise the outline based on the comments and prepare a draft *Technical Assessment of Zero Net Energy Technologies and Strategies* for review and comment. We will then plan to finalize the report based on the feedback. Additionally, we propose a meeting with the TAC before finalizing the report to include their comments and perspective as well, but this will be discussed and based on the decision from CAM.



### Residential New Construction

The team will subdivide the residential market sector as single family (track and custom homes) and multifamily (low rise and high rise). We will structure the assessment around these two basic types and all relevant climate zones in the state where there is significant building activity.

### Commercial New Construction

For the diverse commercial market sector, we will conduct our initial review of existing studies, data and resources across building types. From this we will work with the CEC to identify screening criteria and priority building types. We will select building types bounded within the range of cost and performance expected and priorities set with the CEC CAM seeking building types that both represent the best potential for ZNE and that have the largest gaps to achieve this potential. Finally, but most importantly, we will choose building types for which the results gathered from the assessment can be used to support the previously defined Key Research Areas that are building type dependent. An example of the matrix for assessing existing research and factors to be considered for the sector prioritization by building types is provided in

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**Table 2.** There are also valuable cost and analysis on getting to ZNE that cross sectors including the data used for the PG&E ZNE Technical Assessment, analysis underway for T24 paths to ZNE that includes technical and cost data, the NREL report on delivering ZNE buildings, MacClay/VEIC study on a comprehensive ZNE community costs and Skanska/NBI study on costs for ZNE for the District of Columbia that the team. Cost effectiveness and market side cost impacts are examples of other factors that will be added to the matrix during the research.

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**Table 2: Example of Criteria Used to Select Targeted Building Types**

CEUS Building Types	Key Research Areas				Potential for on-site DG	CEUS Energy Intensity (kWh/ft <sup>2</sup> )	% Share of CA Comm. Energy Use	Existing ZNE Case Studies
	Integrated Building Design and Operations	Market Intelligence and Behavior Science	Grid Impacts	Plug Loads				
Colleges	X		X	X	X	12.3	3.8%	X
Grocery	X		X	X	X	41.0	8.8%	
Health	X		X	X	X	19.6	6.8%	
Small Office				X	X	13.1	7.1%	
Large Office	X	X	X	X	X	17.7	17.4%	X
Lodging	X				X	12.1	4.9%	
Miscellaneous				X		9.8	16.1%	
Refrigerated Warehouse	X		X	X	X	20.0	2.9%	
Restaurant				X		40.2	8.9%	
Retail	X				X	14.1	14.7%	
School	X				X	7.5	5.0%	X
Warehouse					X	4.5	3.7%	

### Cross Cutting Technologies and Strategies

Some of the cross-cutting strategies and related technologies that will be covered under each market sector as relevant include:

- » Integrated building design and operations
- » Communications and Controls devices and strategies
- » Occupant behavior
- » Grid interconnection
- » Off- site renewables and community/campus ZNE

### Deliverables

- » Literature Review
- » Stakeholder input
- » Landscape Assessment of Zero Net Energy Technologies and Strategies

### Task 4: Gap Analysis

While it is widely acknowledged that the current state of technology is already able to address meeting the goal, a more holistic view to combining and optimizing the technologies in the built environment is needed.

The gaps will be considered for one or both market sectors residential and commercial as relevant.



The gaps are identified based on the difference between the goal for the market and the current status of the market and technologies. We will use the input from the technical assessment to inform the baseline for this exercise coupled with trends and drivers in the industry that are shaping the future. After identifying gaps, the appropriate research will be identified to fulfill the gaps and move the industry and the market towards the state's ZNE goals.

Our team will base the gap analysis on:

- » Conducting independent analyses to identify and articulate customer needs and requirements for key California industries and economic sectors in IOU service territories.
- » Develop path-to-market strategies for zero net energy building technologies and strategies.
- » Evaluating innovative financing mechanisms, business models and other strategies that can help overcome market adoption barriers for zero net energy building technologies and strategies.
- » Identifying critical indicators of success for zero net energy building technologies and strategies, as well as a methodology utilizing these indicators to estimate benefits, including benefits to IOU electric ratepayers.

### *Planning Scenarios*

Planning scenarios help identify the external conditions which cannot be controlled but are critical in shaping the landscape for which the roadmap is being created. While planning scenarios do not claim to forecast the future, they help with laying out a future that may be otherwise overlooked with a bias towards a desirable or optimal future. However, not recognizing the value of planning for more than one future scenario can be a significant pitfall.

Some useful scenarios for planning research in the ZNE realm can be:

- » All electric end uses based in GHG reduction
- » Mixed fuel with both electric and gas end uses
- » Community ZNE as opposed to individual site ZNE

The team would like to get feedback from the CAM and TAC on which are the realistic scenarios for framing this work, so that the gaps and priorities can be appropriately identified in each.

### *Research Prioritization*

The prioritization of research needs will need to be based on identification of the issues, its impact on enabling ZNE and time urgency to complete research and get into the market. The level of funding needed will be another parameter to associate.

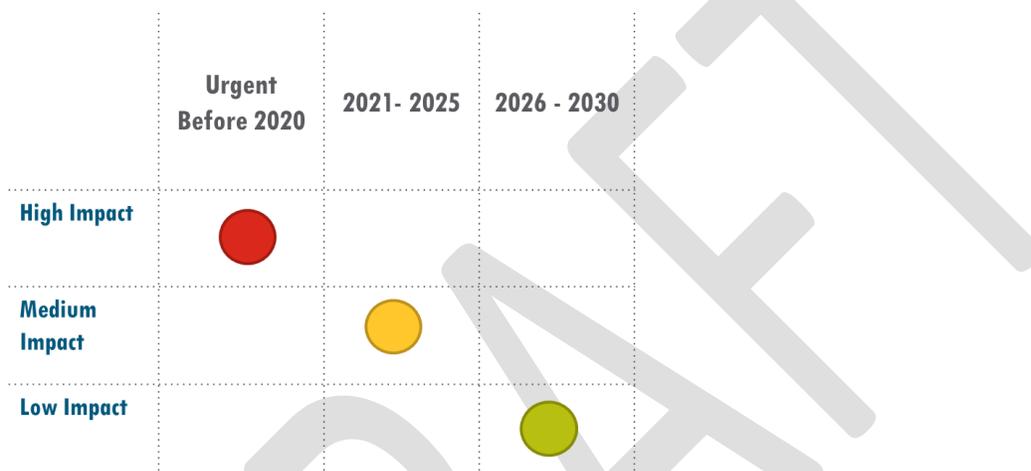
Our team has extensive experience conducting and facilitating prioritization exercises, and we will do so with the team of people that is determined relevant in consultation with the CAM. The Itron team will create a preliminary list of research needs and group them into themes around high level topic areas. We anticipate there to be about 3-5 higher level topical groups. The prioritization exercise will be conducted with each of these groups along with stakeholders and relevant Energy Commission staff.

The prioritization exercise is typically conducted through a facilitated in-person meeting. We can also employ electronic portals to conduct this exercise, thus making it viable to include remote participation to reduce carbon footprint and preserve state budget when feasible.

The Itron team has experience with all formats and will employ the ones most feasible for the specific group in question and that is cost effective to the project.

Example of a prioritization exercise is seen in the figure below. The matrix on the left places research along the impact vs. time urgency axis. Thus making the high impact and urgent research needs a higher priority (in red) over the ones in the low impact and longer term need (in green).

**Figure 3: Example of Prioritization Exercise**



The goal of this task is to develop the content that will lend itself to the Research Roadmap in accordance with methodology finalized. The ZNE Research Roadmap will identify the critical gaps that need to be addressed with RDD&D projects to achieve ZNE in residential new construction by 2020 and commercial by 2030. A key performance target for success will be to make ZNE cost-effective so that a Title 24 approach can be used by these dates, or that it will be cost-effective for the market, or both.

Based on our proposed methodology, the key steps in executing the methodology will be:

- » Identify gaps in research and efforts to address them based on the input of the technical assessment available from Task 2. The Itron team will use the input collected during the technical assessment to come up with a preliminary gap analysis and associated research needs.
- » Conduct prioritization exercise to rank the research needs. We propose using the weight of impact of addressing the research plus the time urgency of the results needed in the market as a means to prioritize and allocating funding, which will also be based on assessment of level of research needed. We expect this preliminary work to be completed by the Itron team in conjunction with the Energy Commission staff.
- » Conduct sessions to collect input from expert stakeholder on 3-5 high level areas that serve to group the research gaps. We expect to group the gaps and resulting research needs into

3-5 high level themes or topical areas. The targeted set of expert stakeholders relevant to each group will be invited to provide input the preliminary gap analysis and priority

- » Prepare draft of the research gap priorities based on the input from the various topical group prioritization exercises.

### ***Task 5: Finalize Gap Analysis and Prioritization towards Roadmap***

Per the goal of this task the team will finalize the Research Gap Analysis in accordance with the proposed methodology and the input received from experts and stakeholders. A big part of this step will be one public workshop which will present the draft gap analysis to all ZNE stakeholders. The intent of this workshop will get feedback on the proposed research roadmap and fill out any remaining gaps and round out the roadmap. Another big part of exposing the roadmap to the stakeholder public at large will be to get them to recognize and embrace the plan to impact moving the market.

The input from the public workshop will be discussed with the CAM and discussed for inclusion towards finalization of the ZNE Research Roadmap.

Itron as the prime, will lead this effort with support from the entire team and deliver a high quality final document that meets all the criteria identified in the RFP, which have been slightly enhanced by the Itron team:

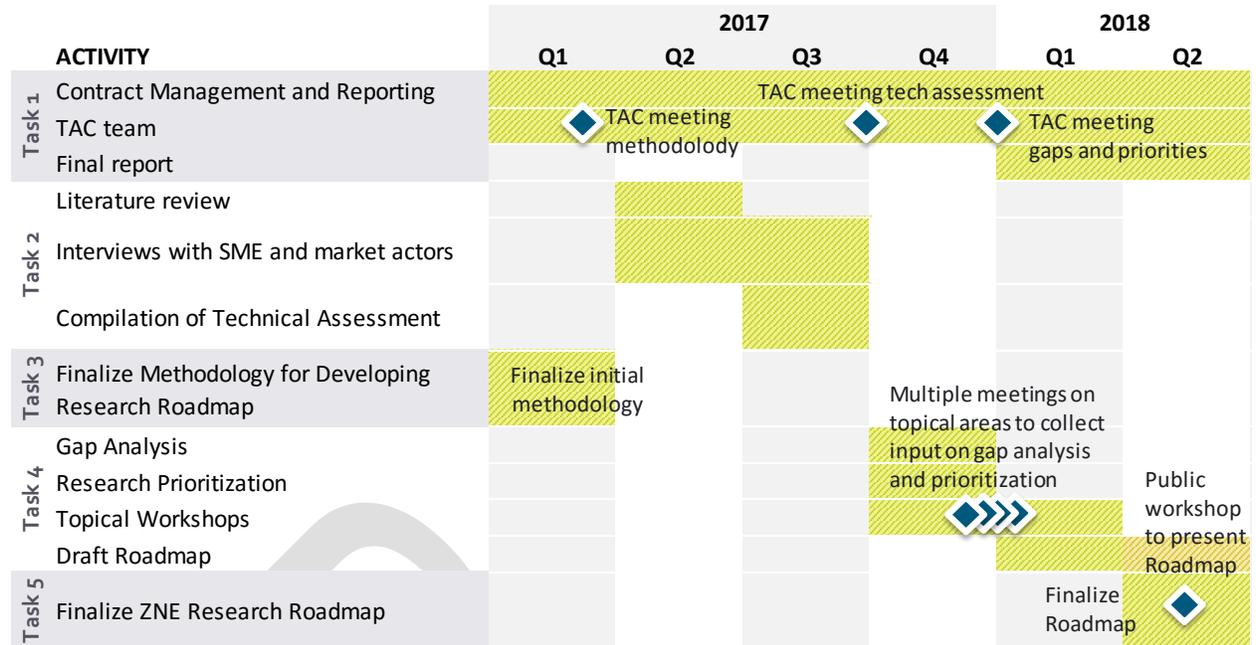
- » Prioritize the research most needed to achieve cost-effective ZNE *new construction* buildings *by the goal dates*.
- » Provide a detailed description of market barriers
- » Identify performance and cost targets for promising ZNE technologies *and strategies*
- » Develop critical indicator of success [KPIs Key Performance Indicators]

Our vision for the final product is a multi-dimensional relational database of the results, which include the rich depth of information that has been accumulated through the course of the project in an easy to use and digest format. While we will prepare a report, to will be more to document and summarize the findings, the richness of the details will be available through the web portal. Each cell will then lead to the depth and background of information available for that building type and feature/technology/strategy.

## Proposed Schedule

This schedule is very high level and deals with the project timeline in terms of quarters. A higher resolution timeline and schedule will be developed and maintained on the project collaboration web-portal for easy access, and will be updated continuously throughout the project to keep the activities on track, on time and on budget.

**Figure 4: Proposed Schedule**





## Technical Advisory Committee (TAC):

Name	Organization	Title	Perspective Representation
Andrew Lee	Architecture 2030	Project Manager	Commercial design/International
Robert Raymer	CBIA	Senior Engineer/Technical Director	CA residential builder industry
Brad Williams	CEC	Mechanical Engineer	CEC research
Heather Bird	CEC	Specialist III	CEC research
Joshua Croft	CEC	CAM – CEC PM	CEC research
Danny Tam	CEC	Codes and Standards	Codes and Standards
Sasha (Alex) Merigan	CPUC	ET Program and ZNE Lead	CPUC Emerging Tech and ZNE Policy
Steve Selkowitz	LBNL	Research Lab ZNE Expert	Commercial ZNE/National Lab Research
Sandy Mendler	Mithun	Principal	Design Industry
Pat Eilert	PG&E	Energy Codes & Standards Lead	IOU/Codes and Standards
Ramin Faramazi	NREL	Principal Engineer	Commercial Buildings & Thermal Systems Center Emerging Technologies

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## REFERENCE MATERIAL A

### Existing Research and Literature

#### *Supplement: Research Examples*

##### EPIC and Other Research to be Considered in the ZNE Roadmap

The research team will review a wide range of existing research and studies to establish the ‘landmarks’ for the Roadmap. This list reflects a sample of some of the current and recent research that the team will consider and incorporate into the investigation of the barriers and gaps.

The investigation of the existing research will have areas that are discrete to each sector (residential and commercial) as well as topics that overlap and apply across sectors such as distributed generation technologies, inverter and grid intertie developments, micro-grids, and some technologies applicable to both sectors such as LED lights, simple HVAC control, package HVAC systems, and plug load strategies.

- » UC Davis California Lighting Technology Center (CLTC), From the Laboratory to the California Marketplace: **A New Generation of LED Lighting Solutions**. This project will design and develop innovative light-emitting diode lighting solutions for three key product categories: screw-base replacement lamps, linear tubular replacement lamps, and spectrally optimized dedicated LED luminaires.
- » EPRI, **Climate Appropriate HVAC Systems for Commercial Buildings** to Reduce Energy Use and Demand. This project will develop and demonstrate a climate-appropriate heating, ventilating and air conditioning system for commercial buildings that integrates variable refrigerant flow technology, indirect evaporative cooling and the building control system to reduce energy use and peak demand.
- » UC Berkeley, **Very Low Cost MEMS Based Ultrasonic Anemometer for use in HVAC Ducts**. This project will develop low-cost, low power, accurate, calibration-free, and compact airflow sensors (anemometers) for measuring: (1) room airflow in occupied commercial buildings; and (2) volumetric air flow in Heating, Ventilating, and Air Conditioning (HVAC) systems and laboratory fume hoods.
- » Robert Bosch, LLC, **A Renewable Based Direct Current Building-Scale Microgrid**. This renewable-based DC microgrid proposes to connect on-site generation with loads and provides a low cost, high energy efficiency solution.
- » Ronnen Levinson LBNL, **Solar-Reflective "Cool" Walls: Benefits, Technologies, and Implementation**. This project will evaluate the benefits of solar reflective "cool" walls, assess existing cool wall technologies, develop new cool wall solutions, and create the infrastructure needed to implement cool walls to save energy, reduce peak power demand, and improve air quality in California.
- » LBNL. **Direct Current as an Integrating and Enabling Platform**. This project will research direct current (DC) and alternating current (AC)-DC hybrid power applications in buildings



and develop resource information, end-use templates, and building guidelines that could improve the ability to achieve zero net energy buildings.

- » Sunspec Alliance, **Smart Inverter Interoperability Standards and Open Testing Framework** to Support High-Penetration Distributed Photovoltaics and Storage. This project will test the functionality of smart invertors at high level of PV penetration, assess the potential of integrated storage systems participating in ancillary service markets, and evaluate the market potential of a standardized communication interface.
- » LBNL Demonstration of **integrated photovoltaic systems and smart inverter functionality** utilizing advanced distribution sensors. The research will develop, demonstrate, and evaluate the ability of an integrated, advanced PV, storage system, and smart inverter control to enhance and optimize grid support and system performance.
- » Bay Area Climate Collaborative, College of San Mateo **Internet of Energy**. This project will demonstrate integrated solar photovoltaic, energy storage, and advanced power electronics within a single module to reduce community energy load variability.
- » Chabot-Las Positas Community College District, Las Positas **Community College Microgrid**. This project will demonstrate the ability of a commercial-scale microgrid to optimize distributed energy resources for customers, distribution utilities and the California ISO.
- » UC Riverside, Demonstration of **Community Scale Generation System** at the Chemehuevi Community Center. This project will deploy and demonstrate two pre-commercial solar technologies with flow-battery energy storage at the Chemehuevi Indian Tribe Community Center.
- » Center for Sustainable Energy. San Diego **Public Libraries Zero Net Energy and Integrated Demand Side Management Demonstration Project: Achieving Clean Energy Solutions through a Public-Private-Non Profit Partnership**
- » Prospect Silicon Valley. Market-Zero: Taking an existing grocery store to scalable near ZNE
- » LBNL. **Healthy Zero Energy Buildings (HZEB)** research program is to develop the information needed for scientifically-sound commercial building ventilation standards.
- » UC Berkeley. **Radiant Heating and Cooling Systems**. The project will identify the technology feasibility, modifications, application and cost, energy and occupant impacts to support advancing radiant heating and cooling in commercial buildings.
- » UC Davis Energy Efficiency Center, California Lighting Technology Center and Western Cooling Energy Center and the UC Irvine California Plug Load Research Center. Multiple related research projects underway.
- » EPRI, **Assessing the Ability of Smart Inverters and Smart Consumer Devices to Enable More Residential Solar Energy**. The project will identify, implement, and test optimal methods by which smart inverters can mitigate the grid issues that otherwise would limit local high penetrations of residential PV.
- » LBNL, Comparing **Attic Approaches for Zero Net Energy Homes**. This project will develop alternative attic construction practices that contribute to lower residential heating, ventilation, and air conditioning system energy consumption.
- » BIRA Energy, Inc. **Cost- and Energy-Efficient Attic Designs for CA Homes**. This project will develop new approaches to home attic design using novel construction and materials that



have lower incremental cost compared to current accepted methods for sealing and insulating attics.

- » EPRI, **Development and Testing of the Next Generation Residential Space Conditioning System** for California. This project will develop and test the next generation residential space conditioning system by combining and integrating several advanced technologies into a single space conditioning system that cost-effectively fits California's climate conditions.
- » Prospect Silicon Valley. **Innovate Net Zero: First ZNE Demonstration in Existing Low-Income Mixed-Use Housing**
- » California Homebuilding Foundation. **Workforce Instruction for Standards and Efficiency (WISE)**
- » Center for Sustainable Energy. **Expanding Energy-Related Career Pathways in the Electrical Industry: Increasing Workforce Development Opportunities in Disadvantaged Communities**

### ***Links to Recent ZNE Research Studies***

- » Research and Technology Action Plan 2012 – 2015  
[http://www.cpuc.ca.gov/NR/rdonlyres/CC69F767-3665-472A-850F-52DD3BBF6ABA/0/RT\\_ActionPlan\\_20130715\\_rev1.pdf](http://www.cpuc.ca.gov/NR/rdonlyres/CC69F767-3665-472A-850F-52DD3BBF6ABA/0/RT_ActionPlan_20130715_rev1.pdf)
- » New Residential ZNE Action Plan 2015- 2020  
[http://www.cpuc.ca.gov/NR/rdonlyres/92F3497D-DC5C-4CCA-B4CB-05C58870E8B1/0/ZNERESACTIONPLAN\\_FINAL\\_060815.pdf](http://www.cpuc.ca.gov/NR/rdonlyres/92F3497D-DC5C-4CCA-B4CB-05C58870E8B1/0/ZNERESACTIONPLAN_FINAL_060815.pdf)
- » Zero Net Energy Action Plan: Commercial Building Sector 2010 – 2012  
<http://www.cpuc.ca.gov/NR/rdonlyres/6C2310FE-AFE0-48E4-AF03-530A99D28FCE/0/ZNEActionPlanFINAL83110.pdf>
- » California Zero Net Energy Buildings Cost Study 2012  
[http://newbuildings.org/sites/default/files/PGE\\_CA\\_ZNE\\_CostStudy\\_121912.pdf](http://newbuildings.org/sites/default/files/PGE_CA_ZNE_CostStudy_121912.pdf)
- » The Road to ZNE: Mapping Pathways to ZNE Buildings in California (2012)  
[http://www.energydataweb.com/cpucFiles/pdaDocs/899/Road%20to%20ZNE%20FINAL%20Report\\_withAppendices.pdf](http://www.energydataweb.com/cpucFiles/pdaDocs/899/Road%20to%20ZNE%20FINAL%20Report_withAppendices.pdf)
- » The Technical Feasibility of Zero Net Energy Buildings in California (2012)  
[http://www.energydataweb.com/cpucfiles/pdadocs/904/california\\_zne\\_technical\\_feasibility\\_report\\_final.pdf](http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf)
- » Residential ZNE Market Characterization 2015  
[http://www.calmac.org/publications/TRC\\_Res\\_ZNE\\_MC\\_Final\\_Report\\_CALMAC\\_PGE0351.01.pdf](http://www.calmac.org/publications/TRC_Res_ZNE_MC_Final_Report_CALMAC_PGE0351.01.pdf)



## REFERENCE MATERIAL B

### Potential Stakeholder list

Market Group /Subject Matter Expertise	Sector	Name	Affiliation
Asset Valuation	Comm	Mark Jewell	EESG
Building Industry	Res	Raymer	CBIA
Customer engagement and behavior	Comm + Res	Carrie Armel	Stanford
Customer engagement and behavior	Comm + Res	Chris Hammer	Consultant
Customer engagement and behavior	Comm	Lindsey Baker	Building Robotics
Designer/Architects	Comm	Clark Brockman	SERA Architects - Google project
Designer/Architects	Comm	Ed Dean	Bernheim & Dean
Designer/Architects	Comm	J.F. Finn	Gensler
Energy Consultant	Res	Rob Hammon	BIRAenergy
HVAC	Comm	Peter Rumsey	Point Energy Innovation
HVAC	Comm + Res	Kristin Heinemeier	WCEC - UCD
HVAC	Comm + Res	Dale Gustavson	WHPA
HAVC, Benchmarking, Solar, Battery Storage	Comm	Dave Houghton	Ecos Research
Industry, Manufacturers, Contractors	Comm	Margie Gardner	CA Energy Efficiency Council Exec Dir
IOU ZNE	Res	John Morton	SCE
IOU ZNE	Comm	Peter Turnbull	PGE
Lighting	Comm + Res	Michael Siminovitch	CLTC - UCD
Plug Loads	Comm + Res	GP Li	UCI
Plug Loads	Comm	Pierre Delforge	NRDC
Solar industry	Res	Matt Brost	SunPower
Solar industry group	Comm + Res	Bernadette Del Chiaro	CALSEIA
Storage industry group	Comm + Res	Janice Lin	CESA Storage -Janice Lin
T24 compliance/Design	Comm	Beth Brummitt	CEM/CEA
Urban Planning	Res+Comm	Joe DiStefano	Calthorpe Analytics
ZNE Appraisal	Res	Debra Little	Efficiency First
ZNE Builder	Res	CR Hero	Meritage
ZNE Builder	Comm	Ken Huesby	Hillhouse construction
ZNE Builder	Comm	Mike Humphreys	DPR Construction
ZNE Builder	Res	Sean Armstrong	Redwood Energy
ZNE Code	Comm + Res	Martha Brooks	CEC
ZNE Developer	Comm	Kevin Bates	Sharp Development
ZNE policy	Res	Ann Peterson	PIER CEC association
ZNE tool	Comm	Paul Tortellini	NREL
ZNE tool (BEopt)	Res	Craig Christensen	NREL