CA | Energy Efficiency Strategic Plan

Research and Technology Action Plan 2012-2015

Developed with Stakeholder Input

California Public Utilities Commission
Energy Division

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Disclaimer

This report was prepared by staff of the Energy Division, California Public Utilities Commission (CPUC) and the Energy Research and Development Division, California Energy Commission. It does not necessarily represent the views of the CPUC, the Energy Commission, its employees, or the State of California. The CPUC, the Energy Commission, the State of California, its employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the CPUC or the Energy Commission, nor has the CPUC or the Energy Commission passed upon the accuracy or adequacy of the information in this report.

This Research and Technology (R&T) Action Plan was prepared in response to the goals and strategies of the California Energy Efficiency Strategic Plan and does not necessarily reflect the investment or strategic plans for the Electric Program Investment Charge (EPIC), AB 758, or any other programs at the California Energy Commission. As the Strategic Plan and EPIC have many comparable goals, some strategies and actions may be similar. The California Energy Commission staff will continue to work collaboratively with the CPUC staff and others to maximize synergies on the strategies and actions contained in this Action Plan.

Action Plan Funding

The key initiatives in this Action Plan represent what stakeholders have prioritized as those that will result in direct or indirect energy savings to help achieve the state's energy policy goals. However, these initiatives are not mandated and do not have any set aside funding earmarked for execution at this time. Possible funding sources for work on these initiatives may come from investor-owned utility (IOU) programs, publicly owned utility (POU) programs, state and federal government programs, public-private partnerships and other potential sources.

Abbreviations and Acronyms

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BBEES	Big Bold Energy Efficiency Strategies
BEM	Building Energy Model
BIM	Building Information Model
CBE	Center for the Built Environment
CBSM	Community Based Social Marketing
CEC	California Energy Commission (Energy Commission)
CEIC	California Energy Investment Center
CIEE	California Institute for Energy and the Environment
CLTC	California Lighting Technology Center
CEESP	California Energy Efficiency Strategic Plan (Strategic Plan)
CPUC/ED	California Public Utilities Commission/ Energy Division
CSI	California Solar Initiative
DG	Distributed Generation
DOE	Department of Energy
DR	Demand Response
DRRC	Demand Response Research Center
EE	Energy Efficiency
EM&V	Evaluation, Measurement, & Verification
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
ERDD	Energy Research and Development Division
ES	Energy Storage
ETP	Emerging Technologies Program
GE	General Electric
HP	Hewlett Packard
HVAC	Heating, Ventilation, and Air Conditioning
IBD&O	Integrated Building Design and Operation
IOU	Investor Owned Utility
LBNL	Lawrence Berkeley National Laboratory
NBI	New Buildings Institute
PG&E	Pacific Gas and Electric (IOU)
PGC	Public Goods Charge
PIER	Pubic Interest Energy Research
PMP	Performance Metric Protocol
POU	Publically Owned Utility
PV	Photovoltaic
R&T	Research and Technology
RD&D	Research, Development and Demonstration
RDD&D	Research, Development, Demonstration and Deployment
RESCO	Renewable Energy Secure Communities
SCE	Southern California Edison (IOU)
SDG&E	San Diego Gas and Electric (IOU)

SMUD	Sacramento Municipal Utility District (POU)
SoCal Gas	Southern California Gas (IOU)
TRIO	Technology Resource Incubator Outreach Program
TRIP	Technology Resource Incubator Program
WCEC	Western Cooling Efficiency Center
WHPA	Western HVAC Performance Alliance
ZNE	Zero Net Energy

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1. BACKGROUND

1.1. Overview

This Research and Technology (R&T) Action Plan was developed through a coordinated effort between staff from the California Public Utilities Commission's (CPUC), Energy Division, California Energy Commission (Energy Commission), Energy Research and Development Division, key research organizations, market actors and stakeholders. The R&T Action Plan was designed to help guide the research, development, demonstration, and/or deployment (RDD&D) initiatives to achieve the goals described in the California Energy Efficiency Strategic Plan (Strategic Plan).

"Technology advancement related to energy use and demand will match—or even eclipse—the consumer electronics industry in innovation, time to market, and consumer acceptance." (California Energy Efficiency Strategic Plan, page 79)

This plan does not discuss or cover all research and technology activities that would be required to achieve the zero net energy goals and strategies of the California Energy Efficiency Strategic Plan. This Action Plan highlights recommendations from the participating stakeholders who identified areas they considered in need of additional emphasis or activities that would support technology in reaching zero net energy goals.

1.2. The Strategic Plan

Published in 2008, the Strategic Plan outlines goals and strategies for key market sectors (commercial, residential, industrial and agricultural, etc.) and crosscutting initiatives (e.g., heating, ventilation, and air-conditioning (HVAC), lighting, codes and standards, and research and technology).[1] To reduce barriers to the adoption of efficiency measures (to the point where publicly-funded intervention is no longer appropriate or necessary), the Strategic Plan embraces four specific programmatic goals, known as the Big Bold Energy Efficiency Strategies or "BBEES," as set forth in CPUC Decision 07-10-032 and Decision 07-12-051.[2] This focus on market transformation and recognition that deep energy savings can only be achieved through a common vision and coordinated efforts of both utility and non-utility entities is the fundamental point of departure for the Strategic Plan.

[1] CPUC (Sep 2008), Table of Contents.

[2] Ibid, p. 4.

In theory, ratepayer funded efficiency programs over time have been designed to encourage suppliers, manufacturers, designers, researchers, and others, to provide efficiency products or services to "push" the market, or to encourage consumers and end-users to buy or use these products or services to "pull" the market. These rebates and other energy efficiency programs should aim to increase the market penetration of energy efficiency products and practices so that they become sustainable in the market without the need for further incentives or ratepayer subsidies. When appropriate, such measures and practices could then be incorporated into building codes and appliance standards.

Emerging technology programs are recognized as part of key market transformation activities that rely on RDD&D to move energy-efficient products and developments from the laboratory into the commercial marketplace. These programs help technologies to overcome the technical and economic "valleys of death" through demonstrations in actual facilities to monitor and verify energy savings and benefits.

Big Bold Energy Efficiency Strategies

- *All new residential construction in California will be zero net energy by 2020.*
- *All new commercial construction in California will be zero net energy by 2030.*
- *Heating, Ventilation, and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate.*
- *All eligible low-income customers will be given the opportunity to participate in the low-income energy efficiency program by 2020.*

RESEARCH & TECHNOLOGY CEESP GOAL ONE

Refocus utility and Energy Commission energy efficiency research and technology support to create demand pull and set the research agenda for both incremental and game-changing energy efficiency technology innovations.

GOAL ONE RESULTS:

Ratepayer-funded R&D programs will explicitly support widely applicable whole-building improvement, lighting, and plug load solutions envisioned in this Plan and will be used to leverage other private and public funds for the deployment of new technologies.

As part of the Plan's efforts to achieve the BBEES, innovations in a range of technologies, services and even philosophies in program design are required. Achieving the goals in the Strategic Plan requires active engagement and contribution from stakeholders in the RDD&D community and is beyond the scope and participation of the existing ratepayer-supported investor-owned utilities (IOUs) programs.

The Strategic Plan is a policy-oriented document that sets forth leadership and vision. The Research and Technology Chapter (Chapter 11) of the Strategic Plan provides strategies to meet the BBEES using emerging technologies and RD&D. This Research and Technology Action Plan identifies the actions needed to accomplish these strategies, is crosscutting, and addresses technology advancement in several market sectors and end-uses. This plan helps the broader California RDD&D community proceed

systematically toward achieving the Strategic Plan's vision, but it also provides meaningful engagement and collaboration for stakeholders and key regulatory and non-regulatory entities.

1.3. Research and Technology Action Plan

The content and scope of this plan represents the input obtained from three publicly noticed workshops. The first one-day workshop was held in July 2011, at the Energy Commission in Sacramento, and a two-day workshop was held November 2011, at the CPUC in San Francisco.

During these workshops, participants developed actions designed to meet the two goals of the R&T chapter of the Strategic Plan, which are described in the Research and Technology Chapter of the Strategic Plan.

Every effort has been made to accurately represent the intent and contributions of the stakeholders who participated in the workshops and during the development of this Action Plan. During the workshops, volunteers were solicited (initiative leads) to ensure that the actions and initiatives identified in the plan are implemented and future efforts are achieved with a unified vision across the key organizations and initiatives.

RESEARCH & TECHNOLOGY CEESP GOAL TWO

Conduct targeted emerging technologies R&D to support the Big, Bold Energy Efficiency Strategies and integrated energy solutions goals.

GOAL TWO RESULTS:

Profound improvement in equipment efficiency as well as new building materials and designs aimed at achieving more efficiency from new buildings than technically feasible today, and necessary to achieve Zero Net Energy and hot/dry climate HVAC outcomes.

As a result of these workshops, several collaborative groups were envisioned. Going forward, these groups will potentially provide a forum where stakeholders can guide the research agenda, assist policymakers and other stakeholders to leverage funding, prioritize and pursue current and future RDD&D initiatives to achieve the market transformation[3] goals envisioned in the Strategic Plan.

Prioritized Strategies

The R&T Action Plan is designed to identify key initiatives and timeline (2013-2015), to address these goals. These key initiatives are prioritized based on the current critical RDD&D needs to help achieve the BBEES goals.

[3] Market transformation is long-lasting, sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where continuation of the same publicly-funded intervention is no longer appropriate in that specific market. Market transformation includes promoting one set of efficient technologies, processes or building design approaches until they are adopted into codes and standards (or otherwise substantially adopted by the market), while also moving forward to bring the next generation of even more efficient technologies, processes or design solutions to the market. (Decision D0909047 p. 88-89)

R&T Action Plan Approach

The R&T Action Plan consists of four main chapters:

1. Integrated Building Design and Operation
2. Market Intelligence and Consumer Acceptance
3. Plug Loads
4. Advanced HVAC Technologies

These four areas were identified by stakeholders during the July and November workshops as high priority research areas. Though HVAC and Plug Loads are addressed in the HVAC Action Plan and the Commercial Zero Net Energy (ZNE) Action Plan, the Integrated Building Design and Market Intelligence aspects were missing focused attention and coordinated efforts. Therefore, the R&T Action Plan includes strategies and initiatives that target these areas.

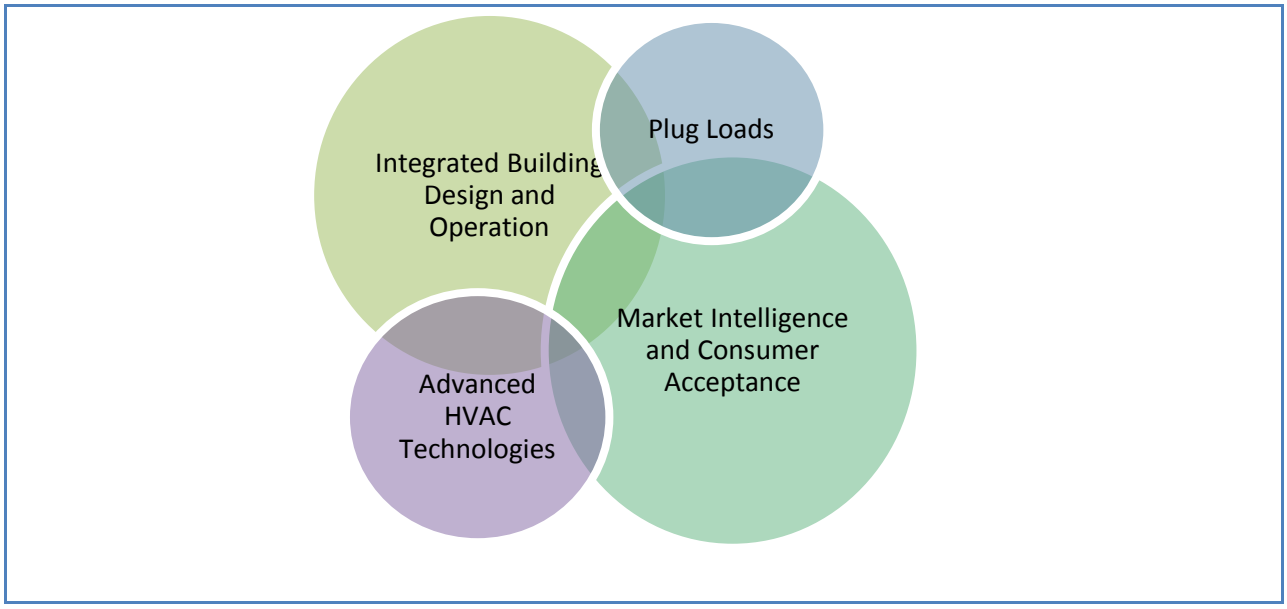

Figure 1: Conceptual overlap of the topic areas

Each of chapters on Integrated Building Design and Operations and Market Intelligence and Consumer Behavior, includes a visionary statement reflecting the comments from stakeholders to guide the current and future activities in plug loads and advanced HVAC technologies. In addition, each of these chapters outlines **Key Strategies**[4] that were developed to address the two goals of the R&T chapter of the Strategic Plan. Under each key strategy is a number of **Key Initiatives** that were developed to

[4] Note that the strategies included in this document are distinct from those outlined in the Strategic Plan Chapter. The strategies in this action plan are specific to each chapter and were developed by the Action Plan authors.

implement the actions required to advance the goals of the plan. For each initiative, potential **initiative leaders**[5] were identified to either implement and/or oversee the implementation of these activities.

R&T Implementation Plan: Near term (2013-2015)

California's energy efficiency goals require substantial changes in the technology advancement cycle including technology research and development, demonstration, deployment as well as marketing, education and outreach. The success of the implementation of this plan relies on harnessing the collective efforts and contributions of private market forces as well as regulatory-directed efforts (rate-payer funded R&D and energy efficiency and demand response programs).

Multiple collaborative, consortiums, and working groups have been envisioned as the result of stakeholder participation in the development of this plan. The formation of these working groups will potentially secure leadership from private industries and companies, governmental agencies, utilities and others needed to ensure a successful and sustained effort toward the implementation of the initiatives contained in this Action Plan. The newly envisioned working groups include:

- Consortium for Integrated Building Design and Operation
- Collaborative for Market Intelligence on Energy Efficiency
- Collaborative for Plug Loads
- Working Group for Advanced HVAC Technologies (under WHPA)

These working groups will meet as appropriate (quarterly or annually), with the CPUC/ED to provide update and progress on the initiatives taken on by the charter of these groups.

Critical Success Factors

- **Statewide Integration and Coordination**: Working groups must convene on a regular basis to ensure coordination among the stakeholders, report on the implementation and progress of the initiatives and share knowledge and lessons learned.
- **Financial Viability**: Cross-stakeholder consensus on the importance of RD&D initiatives needed to advance the ZNE goals and the need to secure stable long-term funding and leveraging of resources.
- **Robust RD&D Agenda**: There is a need for targeted collective efforts to establish and pursue a robust research agenda to steer the activities toward achieving the ZNE goals.
- **Track and Report on Progress**: The successful advancement of the visions contained in this plan will require timely execution of the initiatives, commitment and leadership of the stakeholders and continuous monitoring and reporting of progress toward achievement of the goals.

[5] Note that initiative leads are entities responsible for either directly implementing and/or overseeing the implementation of an initiative. These leads have either volunteered and/or are already working on some aspects of the action plan as part of their professional work.

- **Short-term Outcomes**: The success of the plan depends on meeting the various key initiatives within the established timeline.
- **Long-term Outcomes:** The visions in the Action Plan are aggressive goals and ultimately must be achieved to meet the market transformation goals of the Strategic Plan.

Priorities for the Future

Continuous and stable funding of research, development, demonstration and deployment of advanced energy efficient technologies, strategies, tools and models are critical to achieving advancement toward the ZNE goals of the Strategic Plan. Some suggested initiatives for future consideration include:

- Develop a roadmap to identify technological gaps where future financing should be targeted to support Strategic Plan goals.
- Develop a financing program for new/emerging technologies with proven energy savings that involves grants, rebates, or low or no interest loans depending on the maturity of the technology.
- Expand federal and private support for new/emerging technology integration with California initiative through leveraging of funds, advocacy or other actions.
- Explore the California Energy Investment Center (CEIC)[6] as a possible model to replicate.
- Examine the development of layered utility tariff structures and incentives for technologies that provide both energy efficiency (EE) and demand response (DR) benefits and that can financially reward both builder and consumer.
- Create a venue/forum that brings key RD&D participants together with the financial sector to share opportunities, best practices, funding options, and lessons learned (e.g., CalTech Open).
- Develop best practice guides to maximize energy efficiency for those who manage large buildings and highly energy efficient buildings.
- Explain issues around obtaining loans for commercial and residential buildings that are tied to energy use as a precursor to use with underwriters, specifically pertaining to general energy efficiency improvements.
- Develop new approaches for existing building upgrade market transformation targeted by AB 758.
- Conduct technology assessments to determine potential energy savings, projected costs, market size, technical and economic potential, and consumer acceptance.
- Develop integrated metrics and specifications to verify energy savings and benefits for end-use system performance and not just individual components for both residential and commercial buildings.
- Collaborate with manufacturers in new ambitious pilot programs including full-scale demonstrations of innovative systems and technologies.

[6] http://www.calenergyinvestment.com

- Work with industry & manufacturing trade associations to develop demonstration programs on innovative systems and technologies for its members.
- Work with public and private research organizations to collaborate on large scale multi-state demonstration projects in the Western United States.
- Develop state recognition programs to acknowledge buildings that are ZNE or close to ZNE.

1.4. Highlights from the Current RD&D Initiatives in California

California Energy Commission

Electric Research

On January 1, 2012, the funding provisions of the system benefits charge (Pub. Util. Code § 399.8), commonly known as the public goods charge or PGC, was sunset by law. The PGC funded the California Energy Commission's investments in research development and demonstration (RD&D) through the Public Interest Energy Research (PIER) Program. Its expiration elicited proposals for new legislation, which did not pass. As directed by Governor Brown, the California Public Utilities Commission (CPUC) established a new funding program called the Electric Program Investment Charge (EPIC), through Decision12-05-037, which was adopted on May 24, 2012.

The decision stipulates that EPIC funds will be collected at the level of $162 million per year beginning January 1, 2012 and ending December 31, 2020 and will be administered 80% by the Energy Commission and 20% by the three electric IOUs[7], with the IOU role limited to the area of technology demonstration and deployment. Funding collections during this period will coincide with the timeframe for completion of Renewable Portfolio Standard and AB 32 requirements.

The CPUC will conduct a public proceeding every three years to consider investment plans presented by the Energy Commission and the IOUs, and the CPUC will require the Energy Commission and IOUs to consult with stakeholders at least twice a year to seek input on the direction and progress of EPIC.

Investments will be made toward three different categories in the EPIC energy innovation pipeline. The categories are: Applied Research and Development, Technology Demonstration and Deployment, and Market Facilitation.

The decision establishes as a mandatory guiding principle electricity ratepayer benefits, defined as promoting greater reliability, lower costs, and increased safety. The decision also adopts the following related and complementary principles designed to guide investment decisions.

The IOUs and the Energy Commission submitted their respective EPIC Triennial Investment Plans to the CPUC on November 1, 2012. The CPUC will make its final decision regarding funding of initiatives in May of 2013. If approved, EPIC funding will be available through the Energy Commission and the IOUs

[7] Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric.

beginning July 1, 2013, at which time Energy Commission staff, with stakeholder input, will develop competitive solicitations for research initiatives as approved by the CPUC in the investment plan.

Natural Gas Research

In the CPUC Decision 04-08-010, the CPUC designated the Energy Commission as the administrator for the natural gas research program. In the last several years, the CPUC has allocated funding at $24 million per year and defined public interest natural gas RD&D as those that "are directed towards developing science or technology, and 1) the benefits of which accrue to California citizens and 2) are not adequately addressed by competitive or regulated entities." The decision also directs that natural gas RD&D projects meet the following criteria:

- Focus on energy efficiency, renewable technologies, conservation, and environmental issues.
- Support state energy policy.
- Offer a reasonable probability of providing benefits to the general public.
- Consider opportunities for collaboration and co-funding opportunities with other entities.

The Energy Commission develops annual budget plans with input from stakeholders at public workshops. Past budget plans can be viewed at:
http://www.energy.ca.gov/research/annual_reports.html

California Public Utilities Commission: Energy Division

The CPUC regulates California's four investor owned utilities: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E) and Southern California Gas (SoCal Gas). The IOUs design and implement energy efficiency programs and the CPUC's Energy Division (ED) oversees and evaluates these activities and provides recommendations to the Commission on future policy direction, program design improvements, and refinement of saving estimates.

The CPUC ED[8] is responsible for conducting primary research and evaluation for energy efficiency programs supported by the CPUC and implemented by California's investor-owned utilities (IOUs). Specific activities include evaluation, measurement and verification (EM&V), program evaluation, market assessment, policy planning and support, and financial and management auditing. See "2010 – 2012 EM&V Work Plan," available at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/

Information on the IOUs' portfolio of programs including program implementation plans as well as annual energy savings reports can be accessed at: http://eega.cpuc.ca.gov/. This encompasses numerous programs that are included in the Residential, Commercial, Industrial and Agricultural sectors implementation plans.

[8] Decision 09-09-047 authorizing the 2010 – 2012 energy efficiency portfolios authorized funding for evaluation research overseen by Energy Division and executed by both Energy Division and the Investor Owned Utilities, as further outlined in Decision 10-04-029.

There are over 100 EM&V studies from 2010-2012 including research plans and completed studies available at: http://www.energydataweb.com/cpuc/home.aspx

Once the studies are finalized they are archived on the CALMAC website at www.calmac.org. On either site, one can search for the document by relevant topic or sector, and sign up for automated messages when new studies are completed.

Pending studies and research funded through the Energy Efficiency portfolio including their current status, timeline, expected deliverables and contacts can be tracked on the Project Status Report website http://www.emvpsr.com/Projects/.

- The CPUC funded and directed two gap analyses that were conducted by CIEE on (1) current status on research and technology in California; and (2) current status on market intelligence research. Summary of the key findings from these two studies are provided in accompanying documents available alongside the Action Plan.
- The CPUC funded nine white papers on behavior and energy that were managed by the CIEE. Findings from these studies were used to inform the gap analysis studies (above). For details, refer to accompanying document Research and Technology Gap Analysis.

California Solar Initiative (CSI) RD&D Program

Integrated demand side management (IDSM), is increasingly being referred to as the means to achieving zero net energy (ZNE) in buildings. It involves the integration of energy efficiency (EE) with demand response (DR) efforts along with energy storage (ES) and distributed renewable energy generation (DG).

Installing a photovoltaic (PV) system is one of a number of options available to customers seeking to achieve ZNE while reducing energy reliance on the grid and lowering utility bills. Energy efficiency measures, though more cost effective, often lack the visual appeal of solar panels. However, implementing energy efficiency measures along with demand response not only reduces electricity demand but also helps reduce the size and required capital for a PV system. Adding energy storage further enhances the availability of cost-effective options.

Currently, efforts funded under the California Solar Initiative's (CSI) RD&D Program address this integration and can provide insights into the challenges and opportunities available. The projects include a mix of tools and approaches to RD&D in new and retrofit residential markets.

CSI RD&D funded projects can be found at: http://www.calsolarresearch.ca.gov/

2. INTEGRATED BUILDING DESIGN AND OPERATION

2.1. Overview

Integrated Building Design and Operation (IBD&O) is a key strategy for achieving the Zero Net Energy goals in high-rise residential[9] and commercial buildings. The *Whole Building Design Guide*[10] identifies two components for a high performance building: an integrated design approach and an integrated team process.

VISION FOR INTEGRATED BUILDING DESIGN AND OPERATION

New Commercial and high-rise residential buildings in California will be transformed to high performance buildings by 2020 leading to ZNE buildings by 2030.

Integrated Building Design

"The Integrated Design Process (IDP) is a method for realizing high performance buildings that contribute to sustainable communities. It is a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle. The IDP is designed to allow the client and other stakeholders to develop and realize clearly defined and challenging functional, environmental and economic goals and objectives. The IDP requires a multidisciplinary design team that includes or acquires the skills required to address all design issues flowing from the objectives. The IDP proceeds from whole building system strategies, working through increasing levels of specificity, to realize more optimally integrated solutions[11]."

Integrated Building Operation

Buildings that are intended to be high performance through integrated design need to follow through with integrated operations approach to make them high performance in operation as well. Extending the integration to operations is key to realizing the actual potential of energy savings that a well-designed building can reap. A good control strategy and performance monitoring are some key aspects of high performance building operations. The energy saving potential of commercial buildings with operational strategies will be higher than those without. ASHRAE[12] is developing Performance Metrics Protocols to enable measuring the operational performance of commercial buildings. Residential

[9] High rise residential is four stories or more of multifamily residential dwelling units (apartment s and condominiums).

[10] Whole Building Design Guide, accessed May 1, 2012: http://www.wbdg.org/wbdg_approach.php

[11] Larsson, Nils. 2002. The Integrated Design Process; Report on a National Workshop held in Toronto in October 2001. Toronto: Buildings Group, CETC, Natural Resources Canada, Canada. http://www.greenspacencr.org/events/IDProadmap.pdf

[12] ASHRAE has Performance Metric Protocol 2010 and related Guidelines are under development.

buildings can benefit from smart control strategies and operational schedules, using such technologies as occupancy sensor light switches, programmable control thermostats and Home Area Networks (HANs) that can control all the energy-using systems in a home.

2.2. Progress to Date

In July 2007, the Whole Systems Integrated Process Guide (WSIP) 2007 for Sustainable Buildings & Communities, ANSI/MTS Standard WSIP 2007 was approved. This document is intended as a standard guideline to support the building industry in the practice of integrated design. The purpose of Integrative Design is to effectively manage the optimization of complex systems while pursuing sustainable practices in design and construction. To achieve cost effective and increasingly more effective environmental performance, it is necessary to shift from conventional linear design and delivery processes to the practice of interrelated systems integration. The purpose is to provide a common reference for all practitioners (architects, builders, designers, engineers, landscape architects, ecologists, clients, manufacturers, and so on) in support of process changes to effectively realize cost savings with a deeper understanding of human and environmental interrelationships.[13]

Under the auspices of the Institute for Market Transformation to Sustainability, a Guideline Standard entitled **The Whole System—Integrated Design Process**[14] . While focused on the green design process, the document also explores the question of how "integrated" is the design process.

The Roadmap for the Integrated Design Process[15] was published by Busby Perkins and

IDEAS' HEADQUARTERS BUILDING

IDeAs' new headquarters building was designed to meet 100% of its net energy requirements using renewable energy from PV. It is believed to be the first commercial building in the United States to be designed to a "Z2" energy efficiency goal; that is, net zero energy and zero carbon emissions. The building includes a fully integrated, grid-tied, net-metering, PV system sized to provide 100% of the net energy requirements, allowing it to make a zero contribution to global warming.

CHARTWELL SCHOOL, SEASIDE, CA

The key ideas for the Chartwell School project were: 1) to create the best possible learning environment by providing exceptional day-lighting, views, indoor air quality, and thermal comfort; 2) to make the sustainable design strategies a visible part of the students' education by developing the site as a teaching tool with natural drainage and native and food-producing plants; 3) to inspire and excite the community about the possibilities of sustainable design and in turn generate support and private funding; 4) to reach net-zero electricity use through exceptional efficiency and adding photovoltaic (PV) capacity to meet the remaining electrical demand; and 5) to reach these goals with only a modest cost premium.

[13] http://www.delvingdeeper.org/pdfs/wsip.pdf

[14] http://www.integrativedesign.net/images/WholeSystemIntegration.pdf

[15] http://cascadiapublic.s3.amazonaws.com/Large%20Cascadia%20Files/RoadmaptotheIDP.pdf

Will Stantec in 2007.The Integrated Design Process provides a means to explore and implement sustainable design principles effectively on a project while staying within budgetary and scheduling constraints. It relies upon a multi-disciplinary and collaborative team whose members make decisions together based on a shared vision and a holistic understanding of the project. It follows the design through the entire project life, from pre-design through occupancy and into operation.

2.3. Vision for IBD&O

To implement the vision of the IBD&O, the Research and Technology community needs to:

- Change the building industry from a design focus on building components to integrated design processes that optimize building systems and performance.
- Include "design" through "operations" to ensure that buildings perform as expected and real energy savings are achieved across the lifecycle of the building.
- Include an RD&D portfolio that enables the two solutions above to be rapidly and cost effectively scaled up to impact 99 percent of the new construction and retrofit market.

2.4. Key Strategies

The following key strategies are recommended to advance IBD&O in California:

Strategy 1: Form partnerships with industry and architectural/engineering schools and colleges to promote the education and practice of Integrated Building Design and Operations.

Strategy 2: Develop an RD&D roadmap and identify/develop tools and protocols for building commissioning, retro-commissioning, and measurement and verification (M&V) to enable the deployment of Integrated Design and Operations.

Strategy 3: Promote Integrated Design development by advancing California Building Standards (Title 24) and market activities.

A potential Consortium on IBD&O is envisioned to facilitate the partnership between key market actors and researchers in the industry and oversee the implementation of the initiatives in this Chapter.

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2.5. Key initiatives for Education & Outreach

Strategy 1: Form Partnerships with industry and architectural/engineering schools and colleges to promote the education and practice of Integrated Building Design and Operations

To promote the application and practice of IBD&O, a Consortium is envisioned to facilitate partnerships between key market actors and researchers including designers and architects, energy professionals, building owners and operators, facility managers, and others involved in both design and operation of high performance buildings. The potential Consortium will be charged with conceiving, organizing, coordinating, and guiding targeted RD&D in integrated building design and operation to advance ZNE goals. The potential Consortium will develop an RD&D roadmap, as explained in Strategy 2 and will align RD&D activities among the various entities and stakeholders.

A critical current need is to promote the practice of integrated IBD&O among design professionals as well as introduce the concept and skills in the education of design students.

Key Initiatives
1. Create a consortium on IBD&O to facilitate the partnership between key market actors and researchers in the industry.
2. Develop Continuing Education Credits for architects, engineering, others in Integrated IBD&O.
3. Develop Integrated IBD&O curriculum for architecture, engineering, etc.
4. Convince accreditation boards for schools of architecture, engineering, construction management, and other market actors to include IBD&O.
5. Support peer-to-peer education for building owners to recognize the value of IBD&O and integrated design and pay for it.
6. Encourage building owners to annually disclose the energy and performance metrics for their building.
7. Support IBD&O in existing certification programs.
8. Launch a training and certification program on targeted advanced IBD&O building design and operation approaches (building energy managers *et al*) to prepare the workforce in California.

2.6. Key Initiatives for Research and Development

Strategy 2: Develop an RD&D roadmap and identify/develop tools and protocols for building commissioning, retro-commissioning, and measurement and verification (M&V) to enable the deployment of Integrated Design and Operations.

Building Commissioning

ASHRAE Guideline 0-2005[16], *The Commissioning Process*, defines commissioning as "a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria." Commissioning is an all-inclusive process for all the planning, delivery, verification, and risk management of critical functions performed in, or by, facilities. Commissioning ensures building quality using peer review and in-field or on-site verification. Commissioning also accomplishes higher energy efficiency, environmental health, and occupant safety and improves indoor air quality by making sure the building components are working correctly and that the plans are implemented with the greatest efficiency. Commissioning is a quality assurance-based process that delivers preventive and predictive maintenance plans, tailored operating manuals and training procedures for all users to follow. Essentially, the commissioning process formalizes review and integration of all project expectations during planning, design, construction, and occupancy phases by inspection and functional performance testing, and oversight of operator training and record documentation.

Retro-commissioning

Retro-commissioning is the application of the commissioning process to existing buildings. Retro-commissioning is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, retro-commissioning can often resolve problems that occur during design or construction, or address problems that have developed throughout the building's life. In all, retro-commissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

All forms of building commissioning share the same goals: to produce a building that meets the unique needs of its owner and occupants, operates as efficiently as possible, provides a safe, comfortable work environment, and is operated and maintained by a well-trained staff or service contractor.

Measurement and Verification

Measurement and Verification (M&V) is a measurement approach that allows building owners and property managers to verify savings from any energy project they have undertaken by measuring and comparing the performance of an old system against the new system's results.

[16] http://unmsrmc.org/rfp/wp-content/uploads/2011/02/ASHRAE-Guideline-0-The-Commissioning-Process.pdf

The **RD&D roadmap** for Integrated Building Design and Operations (IBD&O) will:

- Outline critical research that is needed to achieve reliable and persistent improvement in building efficiency (beyond what is technically and pragmatically feasible today) by applying integrated building design approaches, including dynamic diagnostic and energy management systems. Such R&D will take a holistic view of building design, delivery and operations enabling consistent and widespread achievement of performance goals in the State's new and existing commercial and residential building stock.
- Identify small- scale deployment strategies (such as pilots and demonstration projects) and large-scale market transformation strategies that are replicable. This will stimulate major breakthroughs and adoption of IBD&O techniques and transform current building practices to high performance buildings in California.

The scope of the RD&D roadmap will encompass the following:

- Literature review (current and past) to identify research gaps and needs for technology, tools and protocols for IBD&O including new construction and retrofits, lessons learned and best practices in integrated building design.
- Identification of short-term and long-term IBD&O research needs, including: goals and milestones, key actions, priorities and timeline, and estimated cost-benefits for key actions.

Some of the **RD&D needs** for integrated solutions include:

- An IBD&O Design Protocol to implement Building Information Model (BIM)[17] to Building Energy Model (BEM)[18] vision including rapid cost estimation during design decisions. The protocol will address standardized interoperable BIM, commissioning methods, performance metrics tracking systems, energy analysis design and operating data for all key end-uses design monitoring systems.
- Integrating tools for building energy simulation and operation, including energy management systems and controls.
- Tools that are compatible with integrating Distributed generation, Energy Efficiency, Demand Response and Energy Storage (Smart Grid/Smart Meters)

[17] Building information modeling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of a facility. The resulting building information models become shared knowledge resources to support decision-making about a facility from earliest conceptual stages, through design and construction, through its operational life and eventual demolition.

[18] Building Energy Modeling is the virtual or computerized simulation of a building/complex that focuses on energy consumption, utility bills, and life cycle costs of various energy related items such as air conditioning, lights, and hot water. It is also used to evaluate the payback of green energy solutions like solar panels/photovoltaic, wind turbines, and high efficiency appliances.

Key Initiatives
1. Develop an RD&D Roadmap for Integrated Design and Operations.
2. Validate and improve models and tools to account for systems integration and real performance of buildings and incorporate funding models and metrics.
3. Develop a design-phase capability for models such as EnergyPlus[19] and others to support Integrated Design at conceptual and schematic levels.
4. Develop Integrated Building Design and operation Protocol to implement BIM to BEM vision including rapid cost estimation during design decisions.
5. Develop pilot projects to monitor the operation of buildings that have been developed through IBD&O to make the case of improved performance and operations to improve visibility and assessment of performance data.

[19] EnergyPlus is a whole building energy simulation program developed by DOE that engineers, architects, and researchers use to model energy and water use in buildings. Modeling the performance of a building with EnergyPlus enables building professionals to optimize the building design to use less energy and water

2.7. Key Initiatives for Early Deployment

Strategy 3: Promote high performance buildings by enabling regulatory and market strategies.

Several activities can advance the development of IBD&O design and range from regulatory tools such as codes and standards to market forces. A key opportunity to advancing IBD&O design is using outcome-based energy code policy drivers. This would include requirements to enable performance monitoring in updates to the California Building Energy Efficiency Standards (Title 24, Part 6) and requirements for benchmarking at the time of lease or sale of property.

Current energy code strategies primarily address the physical characteristics of buildings; they do not address how the buildings use energy once they are completed. However, the way the building is operated and occupied has a major impact on annual energy use, and this is an area that current codes are unable to address.

Energy policy could support high performance building operation. In fact, improvements in operational practices and tenant behavior can be highly cost effective, even in the absence of specific codes targeting building operation. To implement such an approach, there is a need for standard data sets to be able to evaluate, understand, and validate building performance.

To develop and implement energy policy to enable high performance building operation would require a number of data and administration steps, including:

1. **Better data on actual building performance:** Information about how the building stock is currently performing is sparse. More and better information about building performance must be made available to policymakers, code jurisdictions and the market so that realistic building performance targets can be set. Some jurisdictions have adopted disclosure ordinances which require building owners to provide current building energy performance information to interested parties in a leasing or sale transaction.
2. **Adjustable tracking/reporting tools:** Tools and methodologies are needed for consistent reporting of building performance information. Although better disclosure information may allow jurisdictions to set building performance targets, these targets must account for typical variation in schedule, use, occupant density, and other factors associated with individual building use patterns.
3. **Metering capabilities:** To manage operational energy use effectively, building operators and tenants must have access to good information about how the building is performing on an ongoing basis. This would require that various feedback and sub-metering capabilities be integrated into the building design to enable real-time performance monitoring and response.

Key Initiatives
1. Develop specifications for mandatory energy metering and sub-metering in buildings through building standards. Better energy metering will determine if building performance has benefited from integrated building design.
2. Develop protocols, metrics, and reporting requirements for energy performance, to be adopted by standard bodies and others, e.g., ASHRAE[20], ASTM, and USGBC.
3. Further enhance comprehensive whole building energy (and water nexus) performance models.

[20] ASHRAE has Performance Metric Protocol 2010 and related Guidelines are under development.

3. MARKET INTELLIGENCE AND CONSUMER ACCEPTANCE

3.1. Overview

California's Energy Efficiency Strategic Plan (Strategic Plan) identifies the need for a coordinated effort to expedite the adoption of advanced energy efficiency technologies leading to sustainable market transformation toward zero net energy (ZNE) buildings in the residential and non-residential sectors. In order to accelerate the adoption of technology which typically far lags research and development, there is a need to (1) understand the motivations, desires and priorities of consumers (adopters) of energy management technology, in order to anticipate their needs and expectations and bring the most relevant and valued technologies and practices to market, and (2) accelerate the adoption (e.g., market share) of emerging energy-efficient technologies. The type of research needed to help to accelerate the adoption of technologies is classified as Market Intelligence research. It is not clear whether all of the Market Intelligence research needed to address this need is actually being conducted in California or outside California.

VISION FOR MARKET INTELLIGENCE AND CONSUMER ACCEPTANCE

By 2020, consumer needs and barriers will be better understood and a strategic approach will be developed for a more coordinated effort to expedite the adoption of advanced energy efficiency technologies.

Consumers are the key determining factor in realizing the full potential of energy savings regardless of the market availability, economic benefits and technical viability of energy- efficient technologies. Studies have shown that in reality, consumers do not consider expenditure on energy efficiency as only an economic investment[21]. Rather, consumers are influenced by a variety of non-economic variables including structural and institutional factors, cultural values and norms, individual beliefs and attitudes and interpersonal dynamics. Recognizing and understanding this complex array of social, cultural and psychological factors that shape consumer behavior can result in more effective programmatic initiatives and policies.

[21] Loren Lutzenhiser et al. 2009. Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs. Berkeley, CA: CIEE. Report, Summary and Presentation available at: http://uc-ciee.org/behavior-decision-making/1/lbrsearch. Michael Sullivan. 2009. Behavioral Assumptions Underlying Energy Efficiency Programs for Businesses. Berkeley, CA: CIEE. Report, Summary and Presentation available at: http://uc-ciee.org/behavior-decision-making/1/lbrsearch

The potential impact of behavior-related energy savings is in the range of 20-30 percent.[22] Programmatic designs that take into account consumer needs and behavioral trends are critical to achieve sustainable change toward the adoption of advanced energy efficiency technologies and practices. Hence, strong social marketing schemes and better outreach and communication tools are needed to encourage the adoption of such technologies and practices.

Successful community-based social marketing (CBSM) recognizes the multiple internal and external barriers that may hinder widespread public participation in any form of sustainable behavior. The success of targeting programs is well documented in the healthcare field and is gaining increased attention among researchers and practitioners in the energy efficiency arena. [23]

Informing consumers about energy- efficient technologies and practices will enable consumers to make informed decisions. Labeling strategies for appliances and other electronic products is an example that will help inform consumers of purchase decisions. European Union (EU) labeling schemes have achieved significant outcomes in terms of consumer awareness, market impacts and energy savings. Currently, the main information that consumers receive about energy consumption is the energy bill. Energy bills typically report the total amount of electricity and gas consumed and the total cost incurred. Energy bills are insufficient to provide the level of details and timely feedback that consumers need if they are to manage their own energy consumption more effectively. Recent research indicates that providing energy consumers with targeted information about their specific energy

HIGHLIGHTS ON MARKET STUDIES AND BEHAVIORAL RESEARCH

- *A California Statewide Segmentation Study includes a framework for examining segmentation and technology adoption based on consumer awareness, knowledge, and attitudes.*
- *UC Davis' Energy Efficiency Center has a Market Assessment Assistance Program that relies on market segmentation.*
- *NYSERDA has conducted extensive (over 50) market analyses of different market segments since 2003.*
- *Multi-lab studies (Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory and Pacific Northwest National Laboratory) are examining the topic of market actor needs and behavioral drivers, and decision making in the non-residential sector related to ZNE buildings.*

[22] John (Skip) Laitner, Karen Ehrhardt-Martinez, and Vanessa McKinney. 2009. "Examining the scale of the behavior energy efficiency continuum, in the *Proceedings of the 2009 ECEEE Summer Study*, European Council for an Energy-Efficient Economy, Paris, France.

[23] Action Research, Inc. 2010. Community-based Social Marketing to Inform Homeowner Participation in California Energy-Efficiency Home Improvement Programs, Action Research, Inc., San Marcos, CA.

consumption practices can result in residential savings between 5 and 15 percent[24]. Improved information about public programs, incentives, tax deductions and resources can also benefit consumers to make informed decisions.

3.2. Progress to Date

Information was collected on the following research topics as part of the development of this Action Plan:

- Market Studies and Behavioral Research
- Analysis of energy efficiency service delivery mechanisms
- Pilots and demonstrations for advancing adoption of advanced energy efficient technologies and practices
- Market Alliances

Key findings on current research activities include:

In the residential and non-residential sectors, several research projects focus on emerging technologies/strategies: e.g., ZNE buildings, smart grid, Light emitting diode lighting (LEDs), integrated classroom lighting, in-home displays, home area networks, etc. In particular, many of the process evaluations of energy efficiency programs focus on the needs, drivers and decision-making processes of consumers for investing in energy efficiency.

HIGHLIGHTS ON STUDIES ON ENERGY EFFICIENCY SERVICE DELIVERY MECHANISMS

- *The focus of this research is on the Non-Residential sector.*
- *The US Department of Energy has created a green lease site.*
- *The California Sustainability Alliance has provided information on green leasing for offices managed by the California Department of General Services.*
- *UC Davis' Energy Efficiency Center is looking at green leases and other market mechanisms for the light commercial sector.*
- *The Business Council on Climate Change's Green Lease is oriented to San Francisco buildings but can be applied anywhere.*
- *The CPUCheld a workshop on financing options and the IOUs in California are developing new and innovative financing programs based on current research findings.*

Residential Sector

Numerous market segmentation studies have been conducted in the residential sector (some of these are confidential and proprietary, while others are publicly available). These segmentation studies have focused on consumer attitudes, needs and behavior of specific population segments: e.g., low income, middle income, low energy users, and specific industry groups. These studies have used one or more different metrics: e.g., demographic, psychographic, geography, ethnicity, lifestyle, energy consumption,

[24] Sarah Darby. 2006. *The Effectiveness of Feedback on Energy Consumption*. Environmental Change Institute, University of Oxford, England.

energy burden (energy use compared to income), energy insecurity (frequency of bill payment difficulties), and technology type (e.g., LED purchasers).

Non-Residential Sector

In the Non-Residential sector, market segmentation studies have been conducted, but to a lesser extent than in the residential sector. Segmentation studies have used one or more different metrics: e.g., industry/activity type, technology type, ownership, energy consumption, size, and tenant loads.

Segmentation studies, particularly for PG&E and SCE, have focused on consumer attitudes and behavior of specific industry segments: e.g., glass, water and wastewater, paper, cement and concrete, chemicals, metalworking, mineral, food sector/grocery, and plastics. There are ongoing inspections of retrofits to assess the performance of contractors, and process evaluations of energy efficiency programs.

In general, research is lacking in the Non-Residential sector to assess the social structure factors affecting the development of clean energy market.

In the Residential and Non-Residential sectors, there has been limited research conducted in developing market alliances. The residential energy efficiency programs have relied on market alliances to promote specific energy efficiency technologies (e.g., lighting, appliance and consumer electronics – monitors and plug loads, Energy Star products) and to promote energy efficiency in specific residential and non-residential market segments (e.g., low income, communities, local government, and corporations).

HIGHLIGHTS ON PILOTS AND DEMONSTRATIONS

Energy Trust of Oregon's Path to Net Zero pilot include:

- *Pilots and demonstrations that assess adoption of new technologies (e.g., ZNE buildings) in schools, churches, community organizations*
- *Pilots and demonstrations that assess consumer adoption of new technologies (e.g., in-home displays).*

3.3. Vision for Market Intelligence and Consumer Acceptance

The Research and Technology community needs to pursue the following elements:

- An improved understanding of consumer needs and acceptance.
- A common vision among regulators, researchers, funders and implementers on the research needed on market intelligence and consumer acceptance of energy efficiency technologies.
- Coordinated effort by multiple stakeholders to create market demand for advanced energy-efficient technologies and practices.

3.4. Key Strategies

The following key strategies are identified for Market Intelligence:

Strategy 1: Enhance Market Intelligence and behavioral research activities related to advanced energy-efficient technologies.

Strategy2: Expand activities to create market pull (demand) for advanced energy-efficient technologies and practices.

A potential Collaborative for Advanced Energy Efficiency Market Intelligence is being explored to advance the goals of the Strategic Plan and, in particular, to apply social and behavioral science theory and methodology to encourage the adoption and best use of energy efficiency technologies and practices in California.

Experts representing various market actors in California were convened to initiate the framework that is needed for implementing the strategies in this chapter. This team is envisioned to collaborate with key market actors as well as contributors who volunteered to support the work on this Action Plan to ensure the successful implementation of the initiatives. Additional involvement of a wider group will be sought over time that can take on the form of a self-sustaining collaborative that can serve the industry to deliver energy efficiency toward the ZNE goals.

The Collaborative for Advanced Energy Efficiency Market Intelligence[25] **will be charged with conceiving, coordinating, and overseeing the implementation[26] of the key initiatives under each of the two key strategies identified in this chapter.** This Collaborative will develop an RD&D roadmap, as explained in **Strategy 1** and will align RD&D activities among the various entities and market actors. The Collaborative will identify specific timeline and activities needed to complete the initiatives.

An exploratory committee for the potential Collaborative on Market Intelligence was formed to facilitate the partnership between key market actors and researchers in the industry.

POTENTIAL INITIATIVE LEADS

Exploratory Committee for potential Collaborative on Market Intelligence

- *Ben Finkelor, UC Davis*
- *Nicole Biggart, UC Davis*
- *Claudia Barriga, UC Davis*
- *Kristin Heinemeier, UC Davis – WCEC*
- *Alan Meier, UC Davis/LBNL*
- *Andrew Isaacs, UC Berkeley*
- *Jerry Mix, Finelite*
- *Ed Vine, LBNL/CIEE*
- *Bruce Ceniceros, SMUD*
- *Edwin Hornquist, SCE ETP*
- *Chris Hammer, Sustainable Design + Behavior*

[25] Note that key to the success of the implementation of these initiatives is to secure a funding source for formation of this Collaborative as well as finding the funding resources to support the activities under each initiative.

[26] Note that members of the Collaborative can implement part or all of these initiatives.

3.5. Key Initiatives to Enhance Market Intelligence

Strategy 1: Enhance Market Intelligence and behavioral research activities related to advanced energy-efficient technologies.

Multiple barriers influence the consumer adoption of advanced energy-efficient technologies. Consumers have certain needs (energy and non-energy) and have varied decision-making processes (in residential and non-residential sectors). Due to the limited amount of research that has been conducted in this area, there is a need for sponsoring fundamental research on consumer needs, behavior drivers, and decision-making processes, as well as developing guidance in key market segments for the adoption of advanced energy-efficient technologies.

Key Initiatives
1. Develop RD&D Roadmap to identify and prioritize consumer needs, behavioral drivers and decision processes.
2. Develop RD&D roadmap related to HVAC behavioral activities.
3. Develop best practices guidance that is applicable to California consumers' needs in key market segments (e.g. single-family and multi-family residences, offices, department stores, grocery stores etc.) to encourage the adoption of advanced energy efficiency technologies and practices.
4. Explore and assess current tools available in the market toward adoption of advanced technologies and practices.
5. Develop a knowledge management system (databases) to enhance the visibility and exchange of findings from RD&D activities related to this strategy.

3.6. Key Initiative to Create Market Pull

Strategy 2: Expand activities to create market pull (demand) for advanced energy-efficient technologies and practices.

In order to accelerate the adoption of technology that typically lags research and development, there is a need to:

- Identify and understand the motivations, desires and priorities of consumers (adopters) of energy management technology and anticipate their needs and expectations and bring the most relevant and valued technologies and practices to market;
- Accelerate the adoption (e.g., market share) of advanced energy-efficient technologies and practices.

Key Initiatives
1. R&T community to form alliances with the information technology community and entrepreneurs to develop Social Networking Tools and to provide access to experts to engage in the design through examples such as: Create ZNE platform to invite private developers to develop smart phone apps (solutions)
2. Develop techniques to integrate customer influences in emerging technologies project screening.
3. Develop outreach campaign to increase awareness about the process for new technologies to get approved in incentive programs for rapid deployment (through ETCC website).
4. Generate list of strategically targeted pilots and demonstrations projects by key market segment.
5. Engage customers via market alliances to adopt energy efficiency. Examples include: Retail, corporate campuses, master planners, multi-family, low-income Housing, hospitality, etc.
6. Develop a communication/outreach protocol to inform IOU “customers” of their ongoing energy performance as a result of program intervention
7. Create an Investor-Emerging Technologies network to share market information and expedited access to incentive programs.

4. PLUG LOADS

4.1. Overview

Energy use in the residential and commercial sectors in California for plug loads is growing rapidly. Some studies show residential and commercial plug loads are responsible for in excess of 30 percent, and 10 to 15 percent of electric energy use, respectively[27]. Some estimates show plug loads will exceed 50 percent of residential electric consumption by 2030. Plug loads, if not addressed quickly, could hinder California's goals for reaching ZNE by 2020. Current research is needed to focus on creating more energy efficient devices that will provide the foundation for future plug load standards and understanding consumer behavior that drives demand for plug load use.

VISION FOR PLUG LOADS

Research and energy efficient devices will be developed to reduce Plug Load consumption in Residential and Commercial Buildings to reach 2020 and 2030 ZNE goals and technology advances will form the basis of future Plug Load Standards.

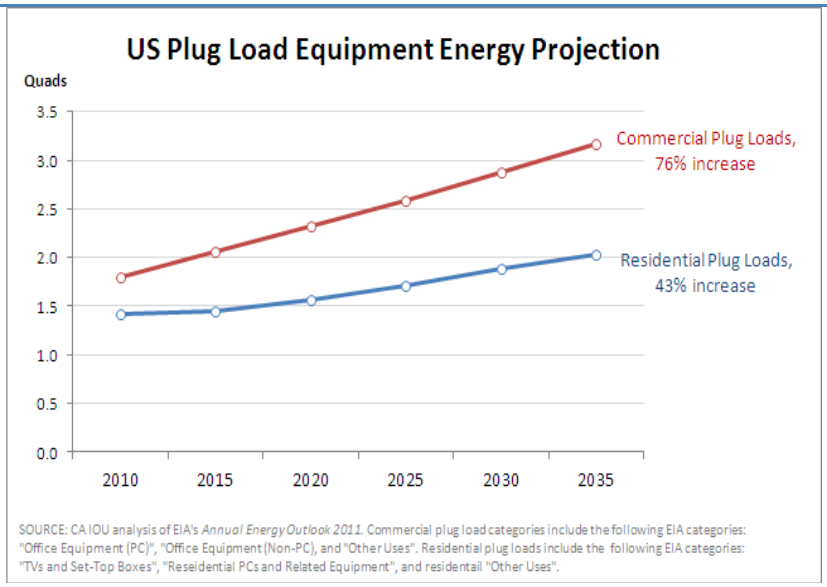

Figure 2: US Plug Load Equipment Energy Projection
Source: CA IOU Analysis of EIA's Annual Energy Outlook 2011

Residents and businesses bring a wide variety of energy-consuming devices into their homes and buildings. These include consumer and office electronics, such as televisions, cell phones, copiers,

[27] Based on RASS (http://www.energy.ca.gov/appliances/rass/) and CEUS data (http://capabilities.itron.com/ceusweb/)

printers, computers and battery chargers. To exacerbate the situation, a majority of these devices consume power even when not in use and account for over 15 GW of power consumption, worldwide.

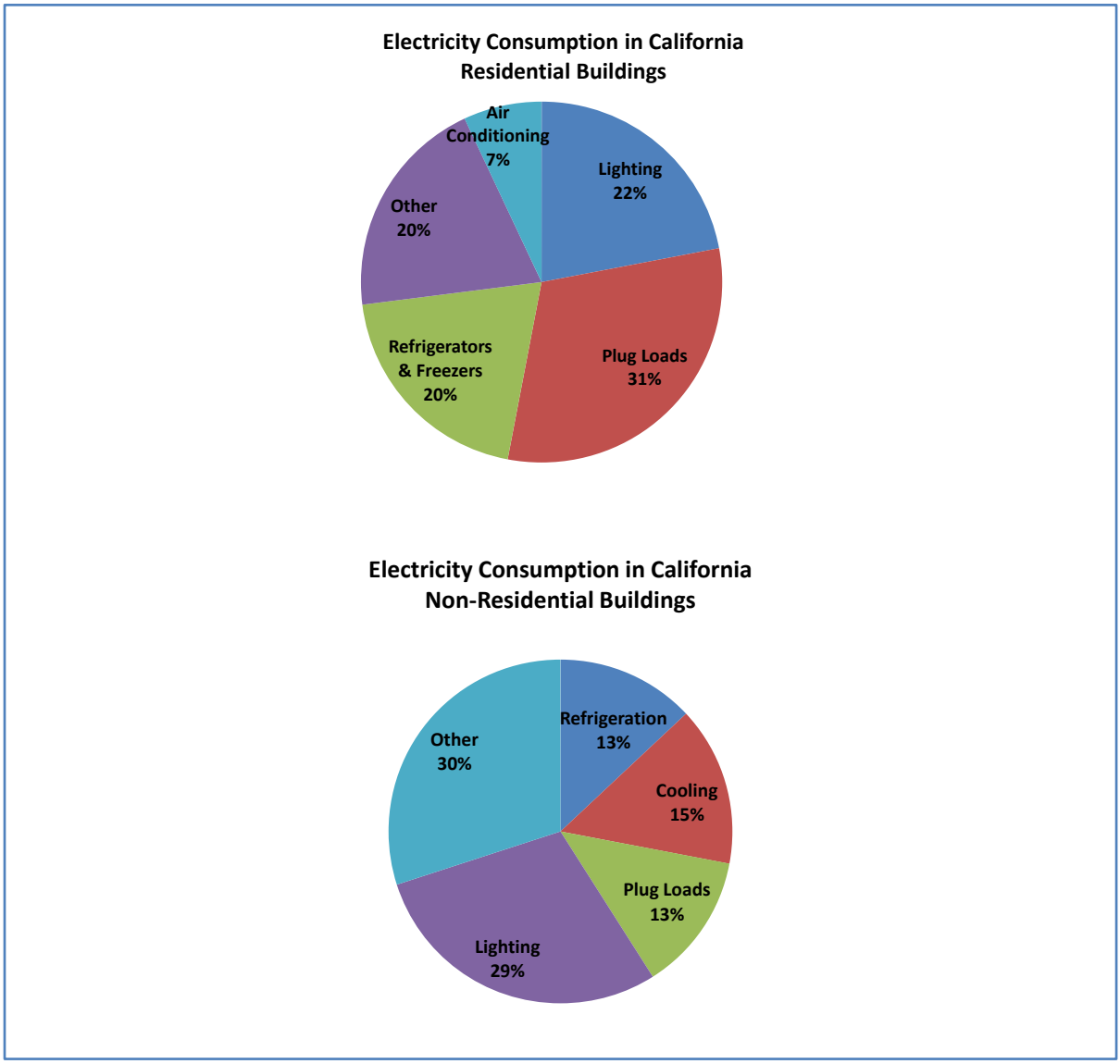

Figure 3: Residential and Nonresidential Consumption
(Source: Residential Appliance Saturation Survey 2009[28] and California Commercial End Use Survey[29] 2006)

[28] http://www.energy.ca.gov/appliances/rass/

[29] http://www.energy.ca.gov/ceus/

The biggest energy consumer in the residential sector is entertainment equipment, such as TVs, stereos, cable and satellite receiver boxes (also known as set top boxes) and gaming consoles. Collectively these represent about 10 percent of a typical home's annual electric bill. Information technology, such as computers, cell phones, tablets, printers, monitors and other electronic equipment are about five percent of a typical home's annual electric bill. Plug loads have been estimated to be as much as 31 percent of a household's annual electric bill.

On the business and commercial side, computer-related equipment, such as computers, monitors, printers, peripherals, A/V and telephony, make up about 86% of plug load energy use. The California Commercial End-Use Survey[30] indicated that plug loads are 13 percent of an office's annual electricity use. However, monitoring indicates that it could be as much as 25-30 percent if you include office servers. This survey also found that plug load energy use and peak demand is higher than an office's lighting energy use. Lighting is generally 29 percent of an office's annual electric bill. Computers and monitors alone accounted for 66% of the energy used by office plug loads. The survey also found that power management is still not being fully utilized for information technology (IT) equipment, and much of the equipment is left on around the clock.

New LEED silver, gold or platinum buildings can have higher energy savings potential than other buildings. However, even buildings that are otherwise very efficient can fail to meet energy use projections if the plug loads installed in them are inefficient, uncontrolled (left on 24/7), and occupant behaviors remain unchanged**.**

According to a recent study by the Center for the Built Environment (CBE)[31], consumer behavior regarding use of these electrical devices varies by region, consumer age and type of equipment. Generally, consumers have little knowledge about the energy consumption of each plug load device. However, the devices are growing and so is the load. Homes that once had five electronic devices now may have 50. Many of these products consume power even when turned off, and the old equipment

CALIFORNIA PLUG LOAD RESEARCH CENTER AT UC IRVINE

The California Plug Load Research Center (CalPlug), funded by the Energy Commission, was established to improve energy efficiency in the use and design of appliances and consumer electronic devices.

http://calplug.uci.edu/

FOCUS AREAS OF RESEARCH FOR CALPLUG:

- *Topical studies of plug load appliances and devices in use (set-top-box, digital entertainment, personal computing, medical devices, etc.).*
- *Micro grid power management systems.*
- *Electronic Engineering and Computer Science breakthroughs for device efficiency.*
- *Consumer behavior studies Energy conservation in server rooms and small-business data centers Benchmarking energy efficient prototypes and products.*
- *Plug load energy efficiency standards and policy.*

[30] http://capabilities.itron.com/ceusweb/

[31] http://www.cbe.berkeley.edu/research/plug-loads.htm

often remains plugged in, consuming power even though it's seldom used. As a result, plug loads are one of the fastest growing energy loads and are also the least defined and most difficult to regulate.

4.2. Progress to Date

The California Energy Commission currently supports the California Plug Load Research Center (CalPlug) at UC Irvine. CalPlug's purpose is to conduct research on the most promising, innovative, early-stage research and development projects in the plug load area by:

- Developing projects that target efficiency improvements in existing and future plug load devices.
- Working with industry, utilities, and standard setting groups to accelerate implementation of plug load improvements into the marketplace.

The development and commercialization of energy-efficient plug load devices will help put California on the path to zero net energy (ZNE) buildings.

ON-GOING AND POTENTIAL FUTURE ENERGY COMMISSION RESEARCH AREAS:

- *Set top boxes (STB)*
- *Energy use savings opportunities for servers and server closets*
- *Energy savings from behavioral changes*
- *Assessment of Incremental cost of measures*
- *Analysis of plug load demand impacts*
- *Develop consistent plug load definitions for benchmarking*
- *Investigation of better methods of wiring commercial buildings to enable metering key sub-stations that can provide adequate feedback to building occupants*
- *Low-end kiosks and point-of-sale terminals*
- *Improvements to multimedia and high-end gaming systems to address energy use associated with graphics*
- *Development of home audio test procedures*

Energy Commission Research

Since 2003, the California Energy Commission has spent about $4.5 million on consumer electronics and office equipment research. The following are some examples:

- Developed Test Procedure for External Single Volt Power Supply Test Procedure that resulted in a Title 20 Standard in 2005.
- Conducted TV energy use research that resulted in a Title 20 Standard in 2010
- Developed Battery Charger Test Procedure that resulted in a Title 20 Standard in 2012.
- 80 Plus Program,[32] which is an initiative to promote energy efficiency in computer power. The program now has over 3,300 qualified power supplies.
- Revised Energy Star specification for computers that include power factor correction.
- Energy Commission funded building low and ultra-low energy computers. These computers led manufacturers to build computers that use less energy.

[32] http://www.plugloadsolutions.com/80PlusPowerSupplies.aspx

- Influenced Energy Efficiency Ethernet IEEE 802.3AZ [33]and a Protocol to communicate with an external proxy.

Other related research activities

- New Buildings Institute – An Energy Commission funded contract to develop a Best Practice Guide is currently being scoped with actionable information on how to save money by reducing plug load energy use in offices. The primary audience of this guide is office managers; Secondary audiences will be owners, tenants, procurement managers, and energy/sustainability managers.[34]
- Technical Assessment Potential for Commercial ZNE.
- Center for the Built Environment (CBE)[35]: Study on Simulated and Actual Energy Use: The Role of Plug Loads: Understanding and tightening the gap.

4.3. Vision for Plug Loads

To implement the vision for high efficiency plug load devices and controls, the Research and Technology community needs to implement the following:

- Develop market intelligence to ensure an on-going RD&D portfolio to advance the manufacturing of smart devices and appliances.
- Develop a robust commercialization/marketing support for such products, including rebates and incentives programs.
- Stimulate consumer demand and behavior through informational initiatives that include unbiased and ubiquitous labeling.

4.4. Key Strategies

Strategy 1: Form partnerships with industry leaders, energy utilities' energy efficiency programs, consumer groups, plug load trade associations, and key institutions to encourage the adoption of energy efficient consumer electronics and smart appliances. Expand activities to increase the availability of high efficiency and smart appliances in the marketplace and pilot programs that empower energy consumers to adopt smart appliances.

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[33] Energy-Efficient Ethernet is a set of enhancements to the twisted-pair and backplane Ethernet family of computer networking standards that will allow for less power consumption during periods of low data activity. The intention was to reduce power consumption by 50% or more, while retaining full compatibility with existing equipment. The Institute of Electrical and Electronics Engineers (IEEE), through the IEEE 802.3az task force developed the standard. The IEEE ratified the final standard in September 2010.

[34] Energy Commission Agreement 500-08-049, New Buildings Institute

[35] http://www.cbe.berkeley.edu/research/plug-loads.htm

Strategy 2: Conduct targeted R&D to achieve higher improvements in appliance efficiencies than technically feasible today.

CalPlug is one of the organizations that can lead and coordinate RD&D initiatives in the area of plug loads and smart appliances. Other key organizations include the electronics and manufacturing and design industry (this isn't an organization), IOUs and POUs, consumer groups and trade associations, codes and standards groups, researchers (not an organization, California POUs, and the Energy Commission. Research results can form the basis to justify the need for future Title 20 appliance standards and for strategic incentives/rebates offerings to customers through IOUs energy efficiency programs.

Coordination and collaboration with the other Strategic Plan Action Plans involving Commercial ZNE and Codes and Standards will be important to ensure alignment of goals and actions and reduce the redundancy of similar efforts. Additional collaboration with the manufacturing and design industry is also needed to ensure successful implementation of the initiatives embodied in this chapter.

POTENTIAL INITIATIVE LEADS

- *CalPlug, UC Irvine*
- *Plug Load Champion Group, Commercial ZNE Action Plan*
- *Appliance Standards Initiative Leads, Codes and Standards Action Plan*

POTENTIAL COLLABORATORS:

- *IOU/C&S Program*
- *IOU/POU ETP*
- *UCB Center of the Built Environment*
- *Energy Commission*
- *CPUC*
- *NBI and other private researchers*
- *NRDC and consumer groups*
- *Electronic Industry*
- *Trade associations*

RD&D funding entities such as the Energy Commission, the CPUC (through programmatic IOU initiatives), and others need to continue support to enable advanced energy efficient technologies and strategies becoming normal market practice. Research institutions and technical consulting entities could provide the perspective for future RD&D and become an integral part of these initiatives.

This R&T Action Plan envisions the coordination of efforts between the ongoing initiatives of CalPlug and the Plug Loads Champions group along with other relevant players. Such a partnership can enable RD&D initiatives on highly efficient and advanced appliances and devices, strategies and tools that will contribute toward minimizing the energy use classified as plug loads. These groups could potentially form a self-sustaining collaborative that can serve California to advance RD&D in plug loads to meet the ZNE goals of the Strategic Plan.

4.5. Key Initiatives for Promoting Adoption

Strategy 1: Form partnerships with industry leads, utilities energy efficiency programs and key institutions to encourage the adoption of efficient and smart appliances[36]. Also, expand activities to increase the availability of high efficiency and smart appliances in the marketplace and launch pilot programs that empower energy consumers to adopt smart appliances.

Purchasing and usage behavior by consumers is a very critical aspect of making near term impacts on the plug-load energy use. This aspect needs understanding of the behavior and then finding intervention opportunities to inform motivate and empower consumers. This activity involves a multitude of market players, such as the Energy Commission, CPUC, IOUs and POUs who can assist in education and outreach campaigns. Retailers and manufacturers that directly interface with consumers also play an important role.

Information can empower customers to make informed purchasing choices and utility incentives can overcome the incremental costs that are usually a barrier to first adoption. Technologies such as energy display devices, load-sensor plug strips and timers can motivate customers to pursue efficient energy practices.

One approach to expedite the adoption of advanced technologies is through targeted marketing and outreach initiatives to create the market pull and engagement of up and mid-stream market actors-such as manufacturers and distributors. Keeping retailers engaged is an important aspect as they are an important source of market data and a good channel for marketing to customers. However, they will need to make the business case for incentives and financial motivation such as “Mid-stream marketing” [37].

Businesses could pursue different demonstration strategies, such as:

- Develop awareness campaigns to educate building occupants of the benefits and importance of powering down equipment at night.
- Institute networked power management systems that allow IT managers to power networked devices on and off as required for updates.
- Replace nonfunctioning or inefficient devices with high efficiency models. Consumer resources such as high-efficiency TopTen models could be used to guide decision making. [38]
- Establish procurement procedures and guidelines with a focus on plug load energy reduction.

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[36] Refer to Chapter 3 for outreach related initiatives that would apply to Plug Loads as well.

[37] Mid-stream marketing refers to outreach toward designers and retails that influence the downstream end user, with the manufacturers being upstream.

[38] TopTen USA is a widely used resource of independent information on the energy efficiency of common products. A nonprofit, TopTen identifies and publicizes the most energy-efficient products on the market. For more information: www.toptenusa.org

- Install smart plug strips that typically employ some combination of load sensors, remote controls, occupancy sensors, and timers to automatically shut off equipment when not used.

Similar to the successes in reducing lighting power density (LPD) through integrated lighting technology design, technology development and design can play an important role in reducing the plug loads.

Key Initiatives
1. Develop and implement EE and DR programs that offer incentives for a wider range of high efficiency appliances, as well as display and control devices.
2. Develop and implement a wide variety of the customer intervention options based on findings/best-practices from current research and studies.[39]
3. Develop programs and initiatives that use strategies that target, inform, motivate and empower energy consumers.

[39] Based on EMI presentation - AJ Howard, Robert Bordner - Preliminary Findings: BCE Process Evaluation and Strategy Recommendations! February 22, 2012 Prepared for PG&E and SCE.

4.6. Key Initiatives for Research and Development

Strategy 2: Conduct targeted R&D to achieve higher improvements in appliance efficiencies than technically feasible today.

R&D activities are needed to maximize the energy efficiency potential of plug load devices. This research could include optimizing energy use at the micro level in computer processing units that could be embedded in most plug load devices and appliances and positively affect market transformation and consumer behavior. For instance, the transition of an emerging technology to code causes a once high-margin product to become an industry standard, thereby reducing the overall cost to society for energy efficiency. This commoditization effect, in turn, spurs innovation for new high-margin products since most manufacturers and other industry practitioners seek to compete in part on high-margin differentiated products. A good example is the proliferation of energy efficient television models since adoption of the state's television standards. Regulations also improve equity in benefits from IOU customer investments in energy efficiency through rates. Through codes and standards, positive changes initiated through voluntary programs targeting early adopters have been extended to all customers.

Key Initiatives
1. Conduct R&D to enable Low Power Mode and improve enabling control and smart features of equipment such as power management software, improved power strips, set top boxes, gaming consoles, inter-device control, etc.
2. Conduct R&D to enable built in networks to improve efficiency of routers, switches, Ethernet, mobile operating systems for control of equipment, wireless controls, voice over internet, proxying technology, etc.
3. Conduct and evaluating impacts of plug load energy use in California residences. a. Develop an accurate and relevant forecast of residential plug load energy consumption. b. Set a target for reducing plug load consumption over time.
4. Explore the development of Residential Plug-load Controls that limit the stand-by losses when the appliances are not in use that could potentially be adopted in the 2016 T24 Standards.

5. ADVANCED HVAC TECHNOLOGIES

5.1. Overview

VISION FOR HVAC

(Strategic plan, page 53)

The residential and small commercial heating, ventilation, and air conditioning (HVAC) industry will be transformed to ensure that technology, equipment, installation, and maintenance are of the highest quality to promote energy efficiency and peak load reduction in California's climate.

Heating, ventilation, and air conditioning (HVAC) technologies have historically been the subject of R&T activity. Manufacturers continually refine and improve their offerings, responding to the needs of the customer, as well as to changes in appliance standards and building codes.

Equipment advances have come in the area of **Climate Responsive HVAC** Technologies—that is, *technologies that are optimized to reduce energy consumption and peak demand in the hot-dry and mild climates represented in California.* Evaporative pre-cooling, evaporative stand-alone, variable capacity heat pumps, hot/dry air conditioners, advanced desiccant cooling, and radiant cooling are all established technologies that are ready to be moved to the market. However, market acceptance of these technologies has been slow. Significant work still needs to be done to address issues such as added maintenance requirements and water quality issues.

Advances in integrated system operations are being made in the HVAC technology arena. Integrated compatibility has benefits for Integrated Demand Side Management (IDSM) which includes distributed energy (distributed generation (DG)/Renewable Energy (RE), energy efficiency (EE), demand response (DR) and energy storage (ES). Controls and advanced applications have very recently been the focus of new technology development. Advanced controls, such as technologies for retrofitting a standard roof top unit (RTU) and allowing it to vary its capacity in an efficient way, are now available in the marketplace. Embedded and after-market fault detection and diagnostics (FDD) has finally begun to achieve its promise and is starting to be seen in many high-end HVAC components. Stand-alone diagnostics for providing quality service to HVAC systems are currently available through multiple vendors. However, there is still room in the market for standardized or validated processes and algorithms. Sensor technology is advancing, although the drive to provide systems at a minimum cost continues to make it difficult to justify higher accuracy sensors.

With these advances in integrated operation, the need for commissioning and quality installation are more important than ever. Quality Installation (QI) and Quality Maintenance (QM) are becoming a major focus for the industry.

For both QI and QM, technician training is critical, as is the use of adequate and calibrated instrumentation. Customer acceptance of QI and QM is slowing the standardization of the processes, as it has been difficult to convince customers to pay a premium for "quality" when they already believe they are receiving quality service. Promises of energy savings must be well founded and verified.

5.2. Progress to date

Western HVAC Performance Alliance (WHPA)

The Western HVAC Performance Alliance was established in 2009. Its mission is to provide input from the HVAC community to California's IOUs in support of the goals of the California Energy Efficiency Strategic Plan.

Through this collaboration, the residential and small commercial HVAC industry will be transformed to ensure that technology and equipment installation and maintenance are of the highest quality to promote energy efficiency and peak load reduction.

In response to Chapter Six of the Plan, the HVAC Action Plan Team[40] developed the following three goals to meet the needs for further improvement in HVAC technology areas:

TERMINOLOGY

Advanced HVAC *technologies include discrete equipment and components, as well as integrated systems with advanced applications, and quality installation and maintenance practices.*

Climate Responsive HVAC Technologies *are optimized to reduce energy consumption and peak demand in the hot-dry and mild climates represented in California.*

Quality Installation (QI) *includes appropriate sizing and other design considerations, construction quality assurance, and functional performance tests upon system start up.*

Quality Maintenance (QM) *includes development of a Preventive Maintenance plan that specifies what will be maintained, by whom, and at what intervals, as well as providing other information needed for proper servicing of equipment and systems.*

1. Maximize the many benefits of cooling, heating, indoor air quality, and energy efficiency services to consumers.
2. Minimize the use of gas and electricity via sustainable practice and programs.
3. Benefit the individuals and organizations that ably deliver the above to consumers and society.

The Western Cooling Efficiency Center of UC Davis (WCEC)

WCEC has been very active in the development, testing, and demonstration of advanced climate-appropriate technologies for California. In particular, their Western Cooling Challenge has spurred manufacturers to develop hybrid rooftop units utilizing evaporative pre-cooling as well as vapor compression cooling. This Challenge is a prime example of how R&D can move the market.

[40] HVAC Action Plan developed for the HVAC Chapter 6 of the CLTEESP could be accessed: http://www.performancealliance.org/Library/CAEnergyEfficiencyStrategicPlan/tabid/257/Default.aspx

Energy Commission and utility Emerging Technology Programs (ETP)

Energy Commission and ETP have promoted advanced HVAC technologies, including climate-responsive technologies and fault detection and other advanced control applications, strategies, tools and models. They have also researched and addressed deployment gaps in these technologies. Additionally, some the Energy Commission's research has been used to inform updates of the Building Energy Efficiency Standards.

The Air Conditioner Contractors of America (ACCA)

ACCA has developed state-of-the-art Standard 5, to describe the QI process. ASHRAE has joined forces with ACCA to develop Standard 180 that describes the QM process. In addition, utilities IOU programs in California are beginning to recognize the value of QI in their upstream rebate programs.

5.3. Vision for Advance HVAC Technologies

According to the Strategic Plan, the vision for the research and technology in HVAC is the following

"The residential and small commercial heating, ventilation, and air conditioning (HVAC) industry will be transformed to ensure that technology; equipment, installation, and maintenance are of the highest quality to promote energy efficiency and peak load reduction in California's climate"[41]

5.4. Key Strategies

The following key strategies are needed to pursue RD&D activities that enable the adoption of Advanced HVAC Technologies in California:

Strategy 1: Form partnerships with industry, training centers, trade schools and universities to promote the value of quality HVAC technologies to consumers, contractors and technicians, and to expand education and training to prepare the workforce to install and maintain Advanced HVAC technologies.

Strategy 2: Expand R&D activities to enhance the performance characteristics and operational attributes of Advanced HVAC Technologies.

Strategy 3: Develop, demonstrate and deploy advanced HVAC

POTENTIAL INITIATIVE LEADS

- *WHPA Market Adoption Committee*
- *Kristin Heinemeier, WCEC*

POTENTIAL COLLABORATORS:

- *Equipment manufacturers (Danfoss, Daikin) who have expressed interest*
- *IOU/POU Emerging Technology Programs*
- *IOU C&S Program*
- *Energy Commission - EPIC*
- *EPRI*
- *GTI*
- *C&S Action Plan initiative Leads*

[41] California Energy Efficiency Strategic Plan, Jan 2011 update; page 53

technologies.

This R&T Action Plan envisions the formation of a working group to facilitate the partnership between key market actors and researchers. This working group will expand on existing RD&D activities under the WHPA to target and improve the performance of climate responsive HVAC technologies.

Western Cooling Efficiency Center's (WCEC) Kristin Heinemeier and Mark Modera and WHPA's Dale Gustavson, Mark Cherniack and other staff and members have provided input into shaping the initiatives under this strategy. WHPA is seen as the best entity suited to lead the efforts under this Chapter through coordination with other market actors which include utility programs, manufacturers, and other research organizations (such as EPRI and GTI). Daikin and Danfoss Corporations have participated in the workshops, provided valuable input to this chapter and expressed specific interest in pursuing and participating in the initiatives with the HVAC manufacturer perspective. The involvement of Demand Response Research Center (DRRC) will be useful in coordinating any DR related initiatives.

In addition this working group will build upon existing relationships with key organizations such as, WCEC, DOE, AHRI, HARDI (distributor industry group for HVAC), SMACNA, ACCA, and ASHRAE Technical Committees (TCs) to build industry and key market-actor collaboration and consensus on initiatives to expedite the deployment of HVAC advanced technologies and climate responsive technologies. Distributors and contractors should be engaged to champion deployment of higher efficiency technologies into the market.

5.5. Key Initiatives for Marketing, Education & Outreach

Strategy 1: Form partnerships with industry, training centers, trade schools and universities to promote the value of quality HVAC technologies to consumers, contractors and technicians and expand education and training to prepare the workforce to install and maintain advanced HVAC technologies.

Additional work is needed in the areas of marketing, education and outreach. HVAC equipment and services are seen as commodities; lower cost providers do better in the marketplace because of the inability or refusal of end users to differentiate between a higher and a lower quality provider. This is most dramatically seen in the very low rate of compliance with Title 24 in HVAC replacements. It is difficult for a contractor who intends to take out a permit and fully comply with all the Title 24 requirements to compete with one who has no such intention and can offer the service at a correspondingly lower price. If there were a "brand" that came to symbolize quality in HVAC equipment and services, it would help the market.

A solid understanding of the behavior of end users would also help to promote the market for quality HVAC taking into consideration factors like low maintenance and replacement of inefficient systems.

Some of the existing industry quality brands and standards related to HVAC are: Residential Quality Installation is defined by ASNI/ACCA Standard 5; Residential Quality Maintenance is defined by ANSI/ACCA Standard 4; Commercial Quality Maintenance is defined by ANSI/ASHRAE/ACCA Standard 180; Energy Star Residential HVAC Quality Installation is built on ANSI/ACCA Standard 5 and ANSI/ACCA Standard 9 (Quality Installation Verification Protocols).

Well established, "prestigious and hard-to-earn" HVAC industry credentials such as Journeyman Pipefitter, Journeyman Sheet Metal Worker, NATE certified technician, STAR certified technician, HVAC Excellence certified technician, RSES certified technician (and BPI certified technician) increase the likelihood of a "QI" or a "QM." These credentials need to be supported and amplified and the importance made known to consumers.

The HVAC marketplace also needs development of curriculum that includes advanced HVAC technologies for architecture and engineering course work. Training and certification programs on targeted QI/QM in advanced HVAC technologies, advanced diagnostics and controls to prepare the workforce (contractors and technicians) in California also need to be expanded. Potentially the North American Technical Excellence (NATE) technician certification program to enhance QI/QM methods could be considered for adapting to California specific requirements. QI and QM are defined by ANSI-accredited standards; however, the standards are purposely written as "high level" documents that declare what is to be done, but not "how". The "how" has long been taught in community and private colleges and union training centers by association-sponsored training (ACCA, IHACI, MCAA/MSCA, RSES, SMACNA, and others). One of the most serious deficiencies in existing training/education is not about the "how" it is about the existence of the standards, where they came from, who developed them, and under what process ("ANSI Essentials") and how doing excellent work meets or exceeds those standards (and benefits clients).

Key Initiatives
1. Convene a working group on advanced HVAC technologies to facilitate the partnership between key market actors and researchers in the industry. Include a representative cross section of equipment manufacturers, component manufacturers, energy consultants, energy advocates and utility participants.
2. Develop programs that use strategies to inform, motivate, and empower energy consumers by integrating the value of quality HVAC equipment and services.
3. Develop an educational program targeting consumers, building owners and end users that provide clear information on energy use through in-home and in-building feedback devices, energy reports, internet tools and labels.
4. Develop marketing and outreach plan on available advanced HVAC, diagnostics and control technologies for contractors and technicians, including access to training, certification and rebate programs and initiatives.
5. Develop Continuing Education Credits for architects, engineering, in advanced HVAC technologies, advanced diagnostics and controls.
6. Develop integrated curriculum including advanced HVAC technologies for architecture, engineering, etc.
7. Expand training and certification programs on targeted QI/QM in advanced HVAC technologies, advanced diagnostics and controls to prepare the workforce (contractors and technicians) in California.
8. Research the viability and attributes of a statewide HVAC quality brand acknowledging current HVAC industry quality brands and standards already in the market, and assess the effectiveness of existing HVAC quality brands.

5.6. Key Initiatives for Research and Development

Strategy 2: Expand R&D activities to enhance the performance characteristics and operational attributes of Advanced HVAC Technologies.

The research community needs to develop an R&D agenda through coordinated effort to prioritize the next generation of advanced HVAC technologies that are appropriate for California's climate including compatible controls and advanced diagnostics. Initial technologies to consider include evaporative pre-cooling, evaporative stand-alone, variable capacity heat pumps, hot/dry advanced controls, technology diagnostics and fault detection, and advanced desiccant cooling that specifically address the California climate focus called out in the Strategic Plan.

There is also a gap in existing diagnostic protocols. These protocols, implemented in embedded, after-market, or in-field applications, are needed to ensure that diagnostic techniques are capable of providing the benefits that manufacturers expect. Because some of these diagnostic techniques were built into utility programs and Title 24, there is a need to assess and improve the effectiveness of the tools and the algorithms behind them. After benchmarking and assessing the protocols, appropriate products can be produced and disseminated more universally. The first step in addressing this need is to conduct a gap analysis of existing protocols and future needs. Currently, 2013 Title 24 mandatory measure for RTU economizer FDD have work underway through SCE on Methods of Test for residential & RTU FDD along with work underway nationally through ASHRAE SPC207 Laboratory Method of Test of Fault Detection and Diagnostics Applied Commercial Air-Cooled Packaged Systems.

Researchers need to identify technologies that could produce the savings needed to meet California's energy savings and peak reduction goals. There is a need to conduct comprehensive cost-benefit analysis of leading and prospective advanced technologies and applications. Because HVAC has such an impact on peak demand, the regulatory policy makers and industry need to coordinate to update the "Total Avoided Cost Model" and Title 24 "Time Dependent Valuation" calculations, including use of peak energy values to properly value HVAC's contributions. There is a need to evaluate existing computer applications for modeling and identify necessary revisions for relevant computer modeling applications. This involves the coordination between Energy Commission (Title 24) staff, IOU ratemaking/regulatory staff, CPUC along with modeling tool providers and potentially IOU/POU ETP staff.

In addition, there is a need to develop energy efficiency performance specifications (EER, SEER AC) to guide improvements in existing HVAC technologies including compressor technologies, evaporator technologies, controls, and variable-flow. Research is needed to develop robust performance mapping for variable refrigerant flow including the identification of specific temperature and humidity conditions that affect operations; and address variance in expected versus realized energy savings through climate-specific testing.

DOE has also instituted a national HVAC Roadmap development process with Oakridge National Laboratory in the lead. The Roadmap will be used by DOE to prioritize HVAC related funding resources. California also needs to be a part of this national effort to ensure inclusion of priorities related to the state's climate.

Key Initiatives
1. Develop R&D agenda for short-term and long-term research needs targeting hot/dry HVAC technologies, controls and advanced diagnostics, efficient distribution systems with related designs and controls.
2. Conduct R&D to verify performance characteristics and potential energy savings, demand response and price response capabilities of prospective and advanced HVAC technologies including systems and components that interact with Smart Grid/Smart Meter functionality.
3. Assess and update existing diagnostic protocols to ensure proper implementation in embedded, after-market, and in-field applications.
4. Assess and update existing computer modeling applications to include peak energy values related to HVAC's contributions. Improve understanding of performance and cost trade-offs between optimizing HVAC systems for energy efficiency at peak load and full year energy efficiency.
5. Conduct R&D to enhance the interactive compatibility of advanced HVAC technologies and components including variable compressors and radiant-based distribution systems, with other energy systems and building components to reduce whole-building energy consumption and peak demand.
6. Identify potential for integrating advanced HVAC technologies with building area networks/ home area networks, and with Smart Grid and Smart Meters.
7. Review ANSI/ASHRAE Standard 55-2010 Thermal Environmental Conditions for Human Occupancy and other appropriate human health research to optimize human comfort indices and energy efficiency in buildings.
8. Collaborate with US Department of Energy on its national HVAC Roadmap on 1) HVAC Technology Application Issues, 2) Utility and Regulatory Issues, 3) Education and Outreach, 4) Software Integration

5.7. Key Initiatives for Early Deployment

Strategy 3: Develop early deployment strategies for advanced HVAC technologies.

There are a number of specific gaps that must be addressed by the R&T community to help achieve the goals of the Strategic Plan. As new and innovative technologies appear on the horizon, there is a gap between the demonstration of valid technologies and uptake by large manufacturers and the market. Demonstrations commonly find that the technologies have operational attributes that make them difficult to sell to end-users, such as the increased requirement for maintenance of advanced equipment and commissioning of advanced controls. These additional requirements are perceived as threats to occupant comfort, and there seems to be a normal hesitancy to try a new and potentially "bleeding-edge" technology. The first step in disseminating and deploying advanced technologies is to identify prospective and advanced HVAC technologies, which is being done by research entities across the state and country.

Another need is for HVAC to be understood and be part of a whole building that consists of a number of interacting systems that work together to reduce energy consumption and peak demand. Some technologies that make sense for California's climates are challenging to implement if there is not a whole-building perspective. These technologies include radiant cooling, ductless systems, and ground source heat pumps. Pilots of these and other integrated technologies would help to promote these technologies and achieve the goals of the Strategic Plan.

Energy efficiency programs in California need to prioritize and assess incentive options to enable the deployment of advanced HVAC technologies and practices.

There is a need to develop assessment methods and protocols to move emerging HVAC technologies from R&D phases to pilot and consequently to market and to be able to disseminate information requirements and specifications to manufacturers. This includes the need for third party test facilities that can independently verify manufacturer claims and put products on the fast track to deployment. Some existing California HVAC lab testing facilities are: SCE Refrigeration and Thermal Test Center (RTTC); PG&E's San Ramon HVAC test facility; WCEC (a new facility will have a test chamber); and LBNL is building its Facility for Low Energy Experiments in Buildings (FLEX) including HVAC capabilities. However, there is need for collaboration and coordination in the use of these facilities to certify emerging HVAC technologies that can be catapulted to early deployment.

Key Initiatives
1. Identify costs and benefits of new HVAC technologies ready for pilots and demonstrations, such as variable speed AC, heat pumps, and home energy (electric) storage appliances (HESA) combined with renewables (rooftop solar).
2. Develop pilots to test the integration compatibility of advanced HVAC technologies to reduce energy consumption and peak demand including evaluation of demand response capabilities, and verify energy savings and other benefits and costs.
3. Develop and publish a framework and process to identify existing opportunities and programs in California to move the next generation HVAC technologies through the product development pipeline

Key Initiatives
4. Identify HVAC products that could benefit from a design and performance measurement competition like the Western Cooling Challenge (specification for advanced rooftop cooling unit sponsored by CEC and SCE) [42]
5. Identify technologies, funding opportunities and partners for monitoring HVAC performance in smaller commercial and residential buildings
6. Develop scaled pilots that identify generic specifications for advanced HVAC technologies such as, Indirect Evaporative Cooling.
7. Create third party lab testing to certify emerging HVAC technology

[42] http://wcec.ucdavis.edu/programs/western-cooling-challenge/

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