



Market Transformation Challenge – How to accelerate adoption of new technologies and ideas

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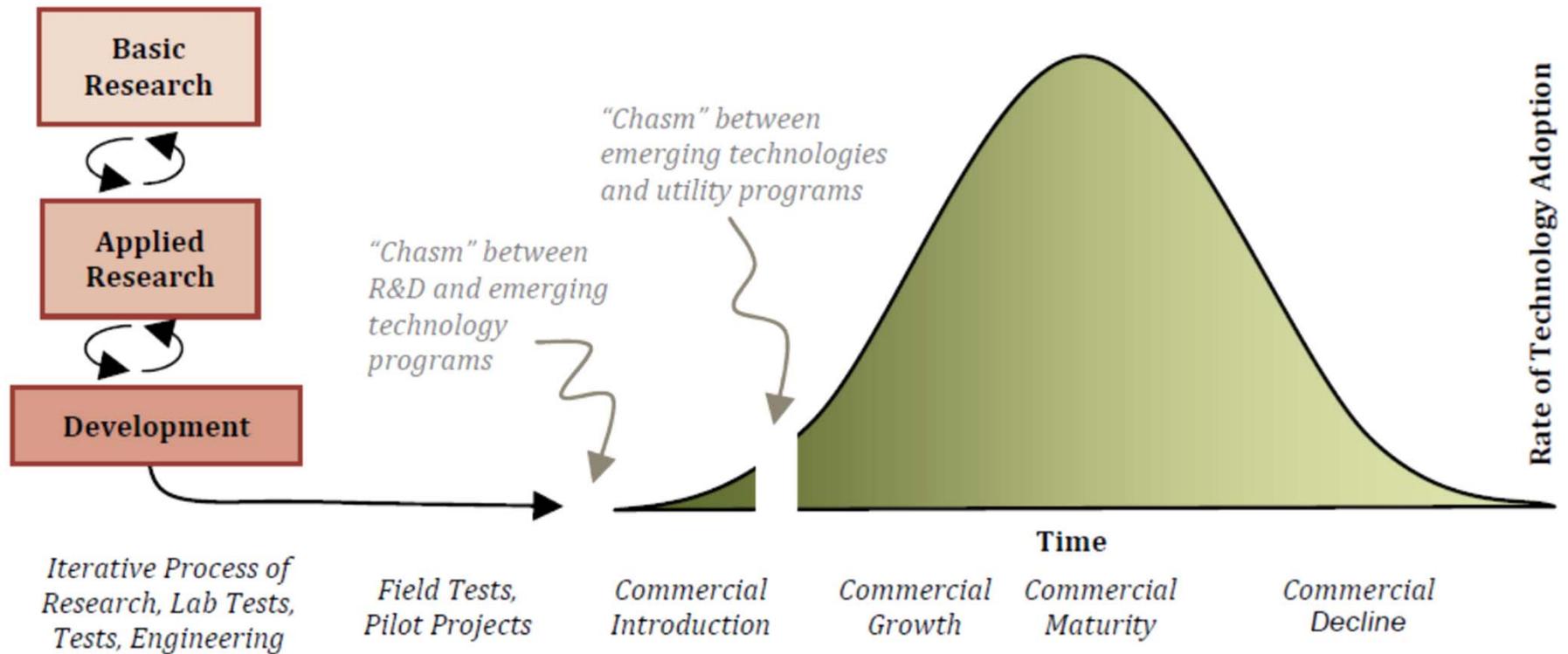
Presentation Agenda

- Presenter Background
- Market Transformation Challenge for CA
- Role of Research/Emerging Technologies
- Review of example projects
- Summary and Discussions

Market Transformation

- **Resource Acquisition (RA)** attempts to produce near-term savings as reliably and predictably as possible
 - Buying savings one kWh at a time
 - Financial incentives tend to play a central role
 - Focus tends to be on annual savings
- **Targeted Market Transformation Initiatives (MT)** attempt to produce sustained increases in the adoption of EE technologies and practices through structural changes in the market and in behaviors of market actors
 - Tend to involve a wider range of marketing approaches than RA
 - Success takes 5-10 years to achieve
 - Riskier than RA, but may produce outsized long-term gains

Market Transformation ‘Standard Practice’



About the Presenters

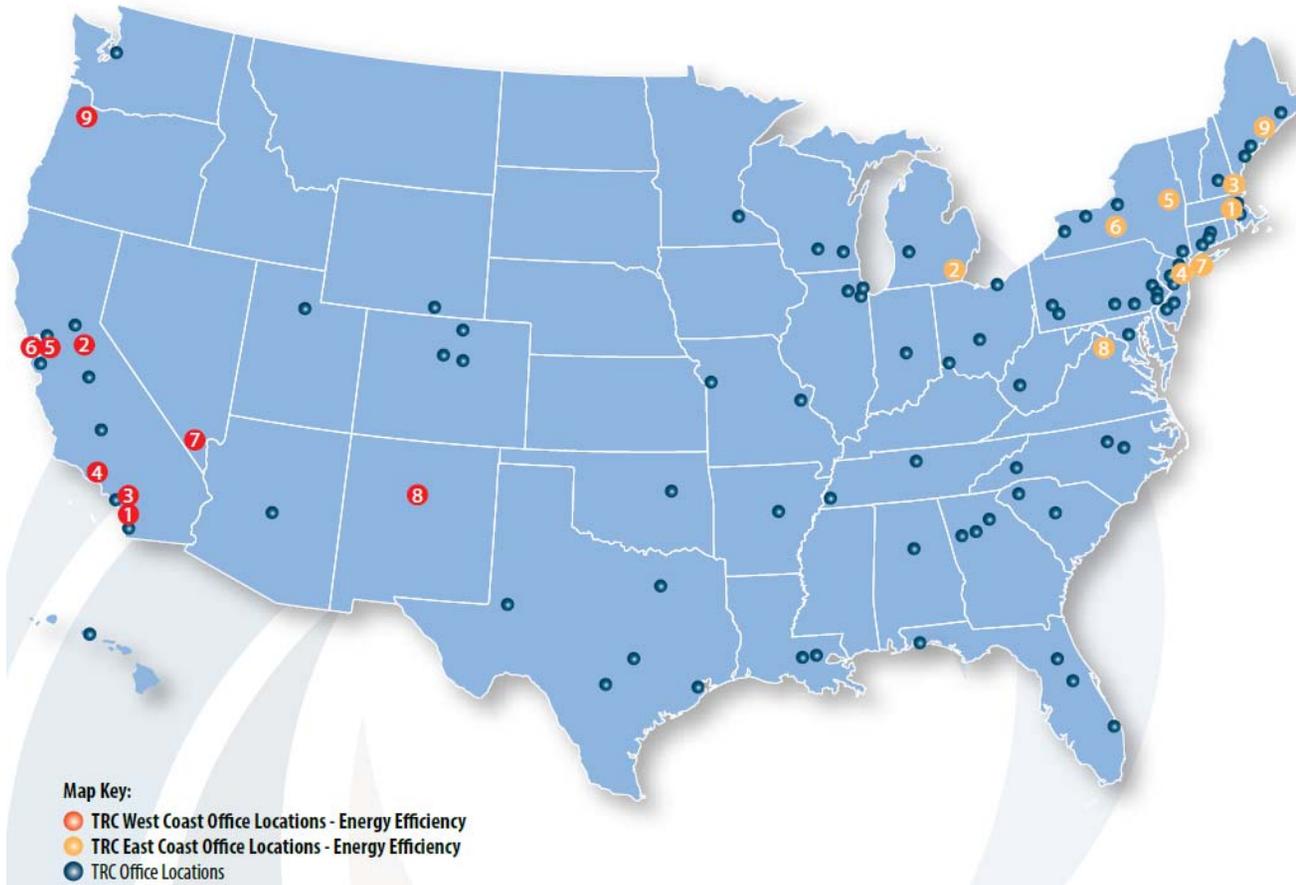


- And why we care about market transformation...

TRC Company Profile

A pioneer in groundbreaking scientific and engineering developments since 1969, TRC is a national engineering, consulting and construction management firm that provides integrated services to three primary markets:

Energy | **Environmental** | **Infrastructure** | **Pipeline**



130+
 Engineering, Building Science, Systems Design, Program & Project Mgmt., Other Experts

- Expert Problem Solvers
- Over 100 U.S. offices
- Over 3,000 Employees
- NYSE: TRR

Achieving critical client goals for 15+ Years

Energy & water efficiency programs | Grid resilience confidence

UTILITIES- Investor Owned & Municipal



Logos for various utility companies including PG&E, Southern California Edison (An EDISON INTERNATIONAL® Company), SDGE (A Sempra Energy utility®), Southern California Gas Company®, SMUD (SACRAMENTO MUNICIPAL UTILITY DISTRICT - The Power To Do More.®), ComEd (An Exelon Company), PSEG, DUKE ENERGY, CITY OF PALO ALTO UTILITIES (Inspired by a brighter tomorrow.), nationalgrid, Xcel Energy™, AMERICAN ELECTRIC POWER (AEP), PPL Electric Utilities (PPL), LIPA (Long Island Power Authority), and IDAHO POWER (An IDACORP Company).

Sustainability | Energy Mgmt. | Engineering | Research | Policy | Codes & Standards

GOVERNMENT –Federal, State & Municipal

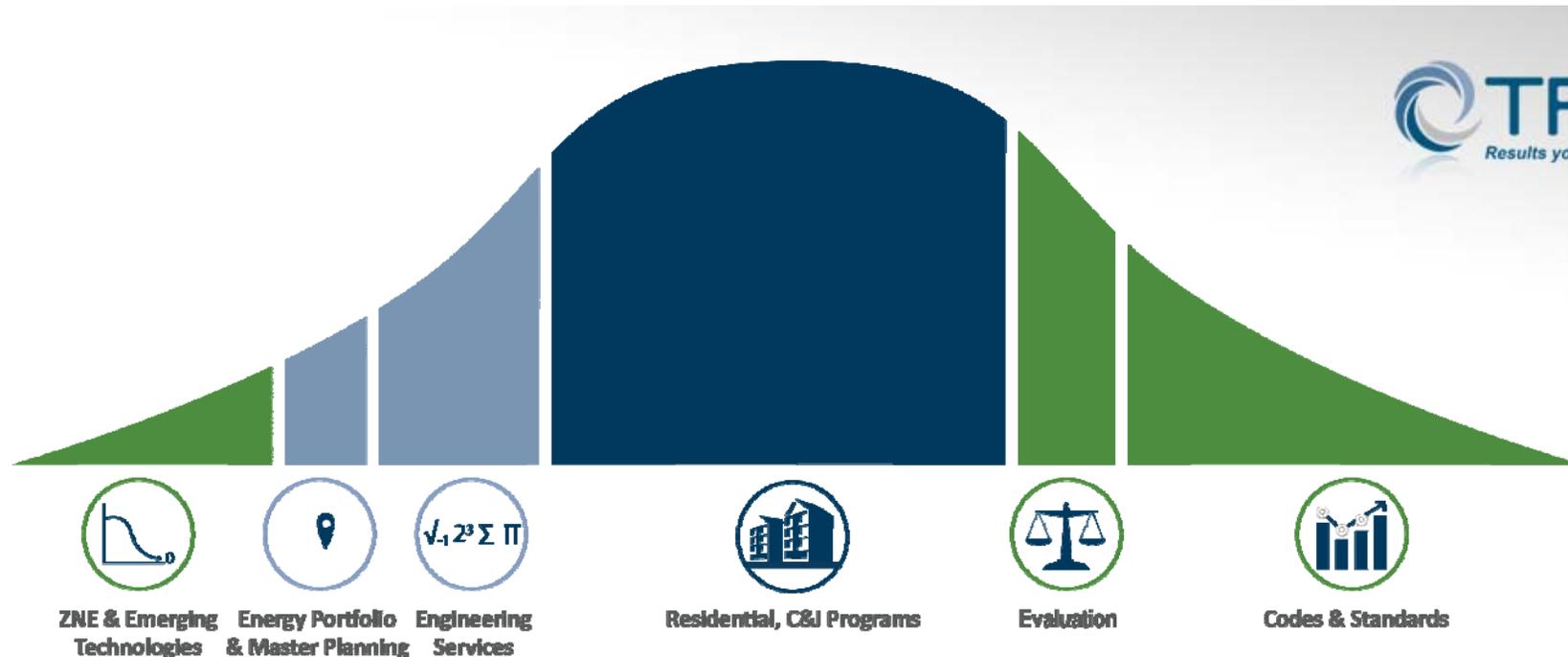


Logos for government entities including the STATE OF CALIFORNIA ENERGY COMMISSION, ENVIRONMENTAL PROTECTION AGENCY, NEW JERSEY BOARD OF PUBLIC UTILITIES (BPU), PUBLIC UTILITIES COMMISSION STATE OF CALIFORNIA, Metro (Los Angeles County Metropolitan Transportation Authority (Metro)), nyserderda (Energy. Innovation. Solutions.), The Port of LONG BEACH, OCTA, and San Francisco Water Power Sewer (Services of the San Francisco Public Utilities Commission).

BUSINESSES & PRIVATE CLIENTS



Logos for businesses and private clients including KAISER PERMANENTE®, verizon, ARCHDIOCESE NEW YORK, efficiency MAINE, neea, Marriott, EnergyTrust of Oregon, and starwood Hotels and Resorts.



Market Transformation & Regulatory Consulting	Energy & Resource Planning	Program Design, Implementation & Administration
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Services	Services	Services
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- ZNE Roadmaps
- Emerging Technology, Pilot, & Behavior Studies
- Codes & Standards
- Evaluation & Market Research
- Energy Modeling
- Microgrids & Distributed Generation
- Demand Response
- Water-Energy Nexus
- Energy Financing

- Master Plans, Sustainability Plans, & Resiliency Plans
- Commissioning & Retro-Commissioning
- ASHRAE & Custom Audits
- Site Inspections & Permitting
- Systems Integration
- Construction Management
- Workforce Development & Training

- Program Design, Implementation, Administration, & Support
- Energy Benchmarking
- Direct-Install, Whole-Building, & New Construction
- Energy Management Services
- Incentive Application Processing
- Trade Ally Management
- Targeted Marketing
- Database Management
- Quality Control

Market Transformation/Emerging Technology Services

- Market Needs Assessment
- Market Characterization
- Market Potential
- Savings assessments
- Saturation Studies

MARKET RESEARCH



- Energy savings estimates
- Energy Modeling
- Human Factors and Behavior
- Lab and Field Testing
- Cost effectiveness analysis
- Environmental impacts

TECHNOLOGY ASSESSMENTS



- Proof of Concept
- Demonstrations & Pilots
- Measurement & verification (M&V)
- Human Factors and Behavioral Impacts

TECHNOLOGY DEMONSTRATIONS & PILOTS



- Social Factors
- Cultural Factors
- Demographics
- Occupant Feedback
- Post Occupancy Evaluations

BEHAVIOR STUDIES



- Policy Advisory Services
- Identify Barriers, and opportunities
- Identify Growth Pathways & Strategies
- Action Items and Responsible Parties

TECHNOLOGY / ZNE ROADMAPS

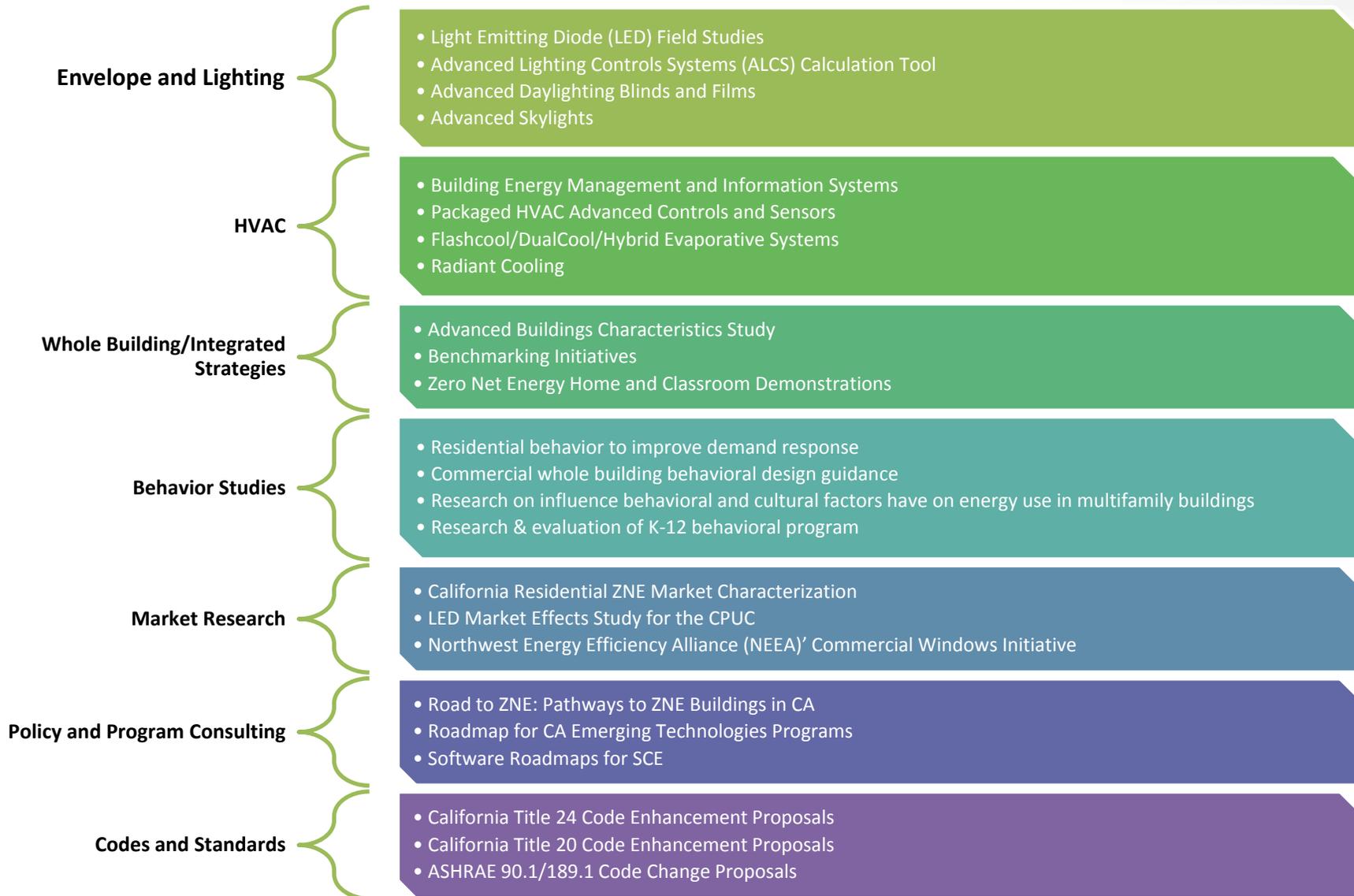


- Deployment Advisory Services
- Pilots
- Incentive Programs
- Codes & Standards
- Evaluation

DEPLOYMENT



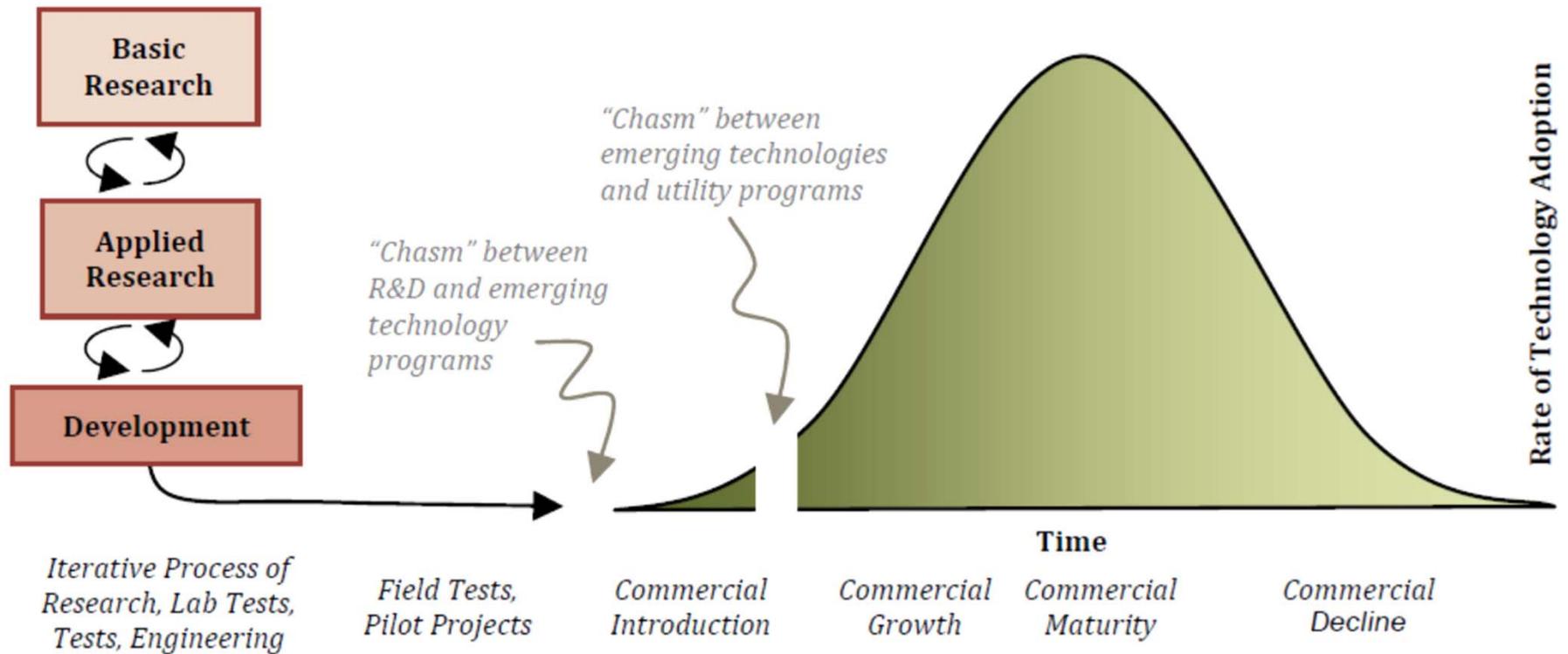
Representative Projects



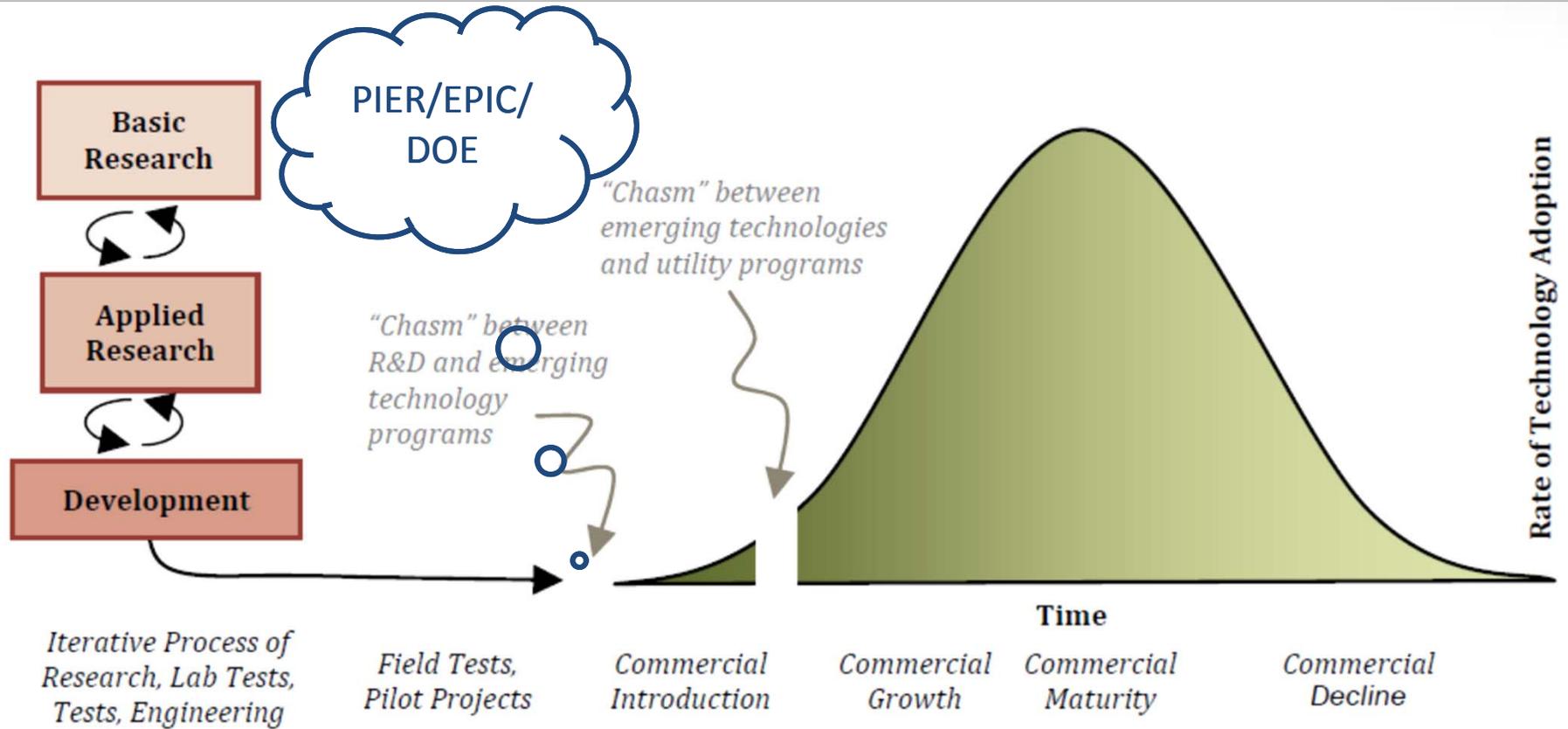
The Market Transformation Challenge

- Innovation at the Speed of Regulatory Processes...

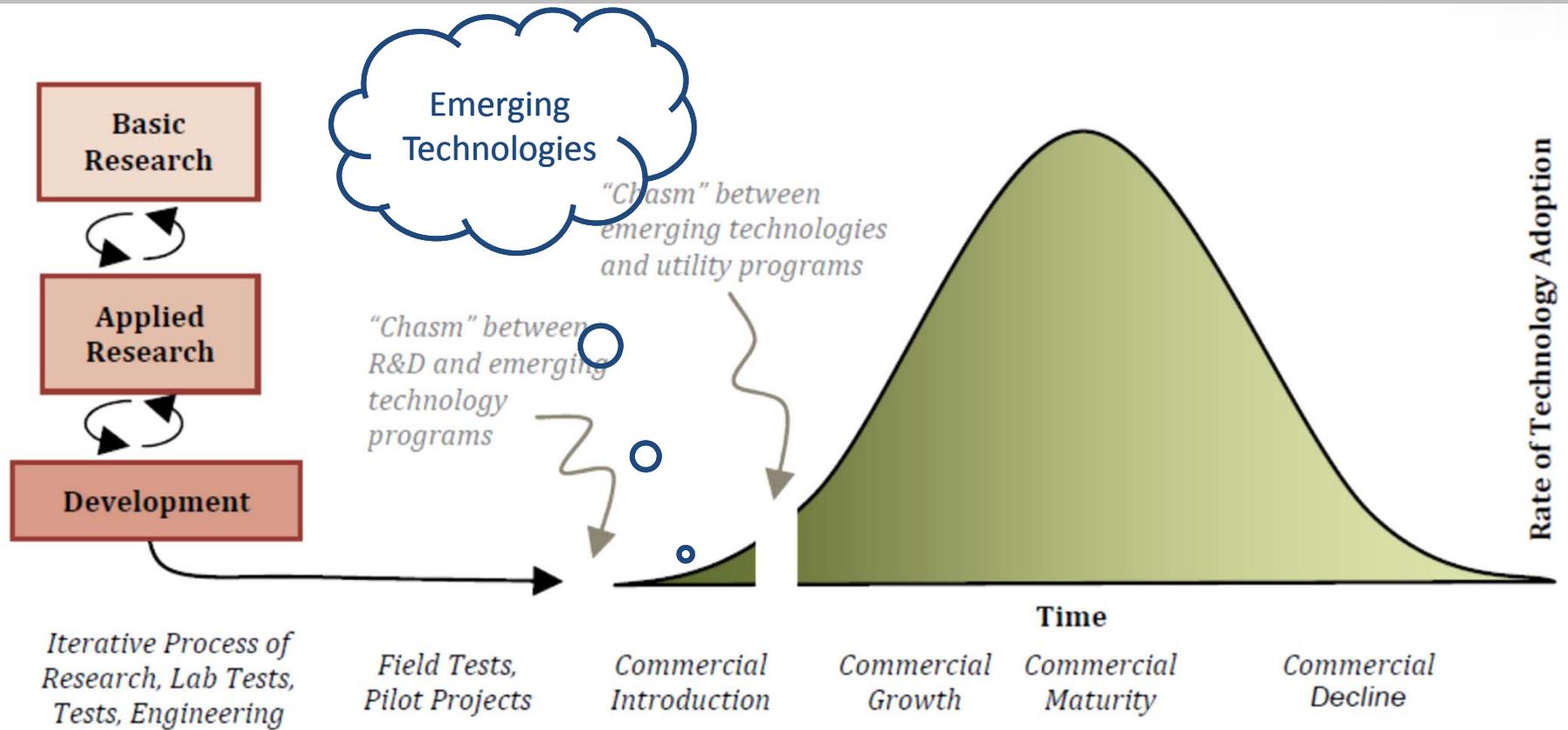
Market Transformation ‘Standard Practice’



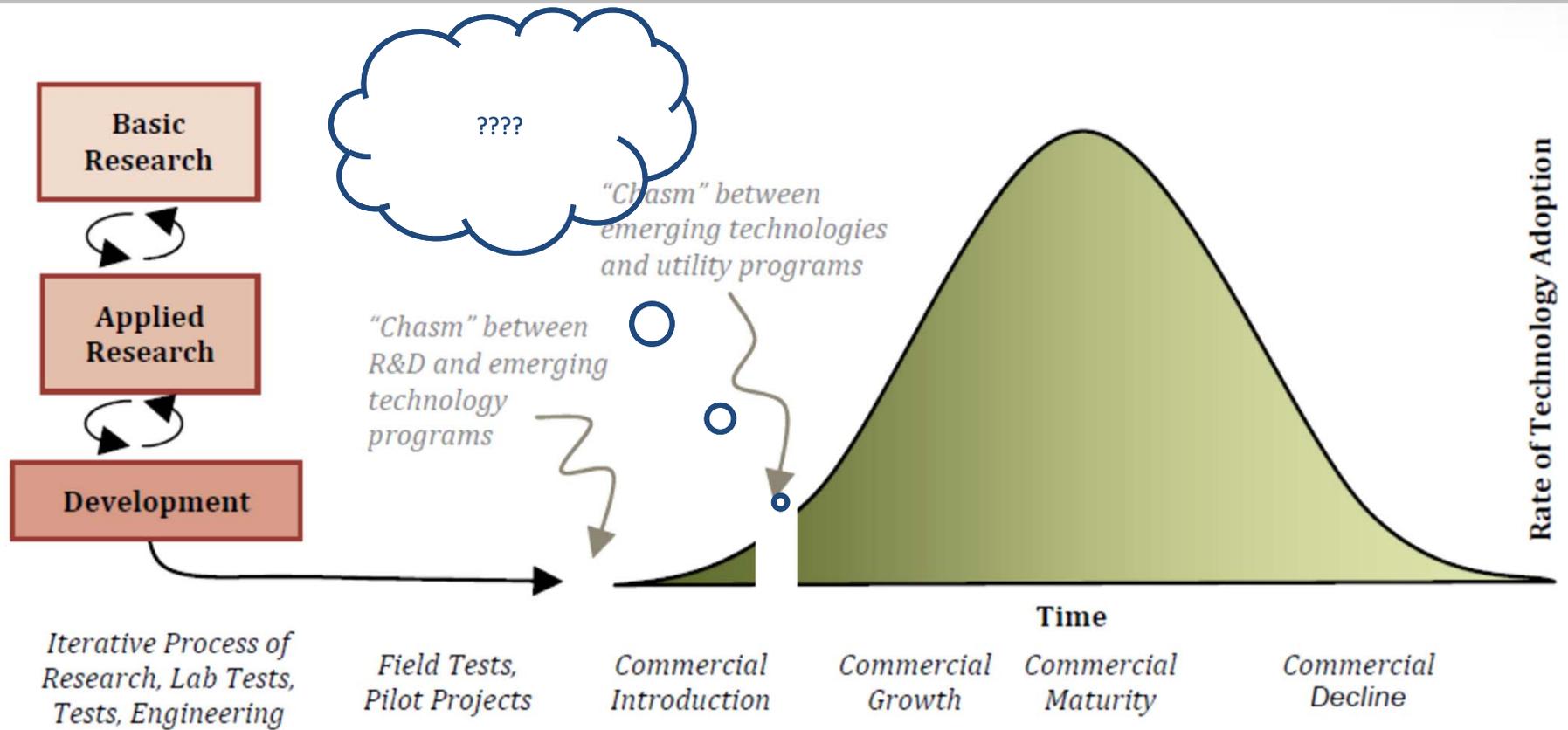
Market Transformation ‘Standard Practice’



Market Transformation 'Standard Practice'



Market Transformation ‘Standard Practice’



Source: National Energy Efficiency Technology Roadmap Portfolio, March 2013

California Aims to Change 'Standard Practice'

California Energy Efficiency Strategic Plan - 2008



Big Bold Energy Efficiency Strategies

Commercial New Construction

- All new commercial construction in California will be zero net energy by 2030.

Residential / Small Commercial HVAC

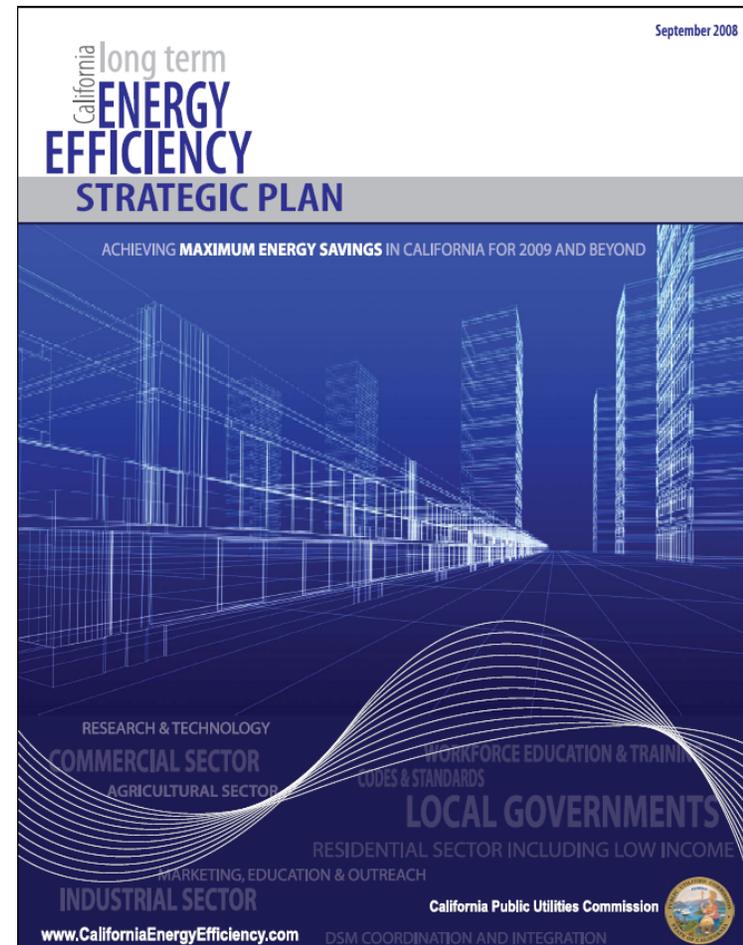
- Heating, Ventilation, and Air Conditioning (HVAC) industry will be reshaped

Residential New Construction

- All new residential construction in California will be zero net energy by 2020.

Low-Income Energy Efficiency

- All eligible homes energy-efficient by 2020



September 2008

California **long term ENERGY EFFICIENCY STRATEGIC PLAN**

ACHIEVING **MAXIMUM ENERGY SAVINGS** IN CALIFORNIA FOR 2009 AND BEYOND

RESEARCH & TECHNOLOGY
COMMERCIAL SECTOR
 AGRICULTURAL SECTOR

WORKFORCE EDUCATION & TRAINING
 CODES & STANDARDS
LOCAL GOVERNMENTS
 RESIDENTIAL SECTOR INCLUDING LOW INCOME
 MARKETING, EDUCATION & OUTREACH

INDUSTRIAL SECTOR

California Public Utilities Commission

www.CaliforniaEnergyEfficiency.com DSM COORDINATION AND INTEGRATION

Key State Policies Driving Energy Efficiency

Focus Area	Goal	Now	2020	2025	2030	2050
Residential Buildings	New Construction ZNE ¹		100%			
	Existing Homes (reduction relative existing stock) ¹		40%			
Commercial Buildings	New Construction ZNE ¹				100%	
	Existing ZNE ¹				50%	
State Buildings	New Construction & Major Retrofit ZNE ²		50%	100%		
	Existing ZNE (by square footage) ²			50%		
SB 350	Increase energy efficiency in existing buildings				50%	
Existing Buildings	New and enhanced codes & standards, code simplification, increased compliance, asset ratings, purchase agreements, etc. ³	X	X	X	X	
GHG Emissions	Statewide GHG Emissions (all sources) ⁴		1990 Levels		40% Below 1990	80% Below 1990
Water Efficiency	25 percent reduction in urban water use ⁵	X				

1. California's Long Term Energy Efficiency Strategic Plan.
2. Executive Order B-18-12
3. Assembly Bill 758; Existing Buildings Action Plan
4. Assembly Bill 32 for 2020; Executive Order B-30-15 for 2030 and 2050
5. Executive Order B-29-15

Supporting Agencies



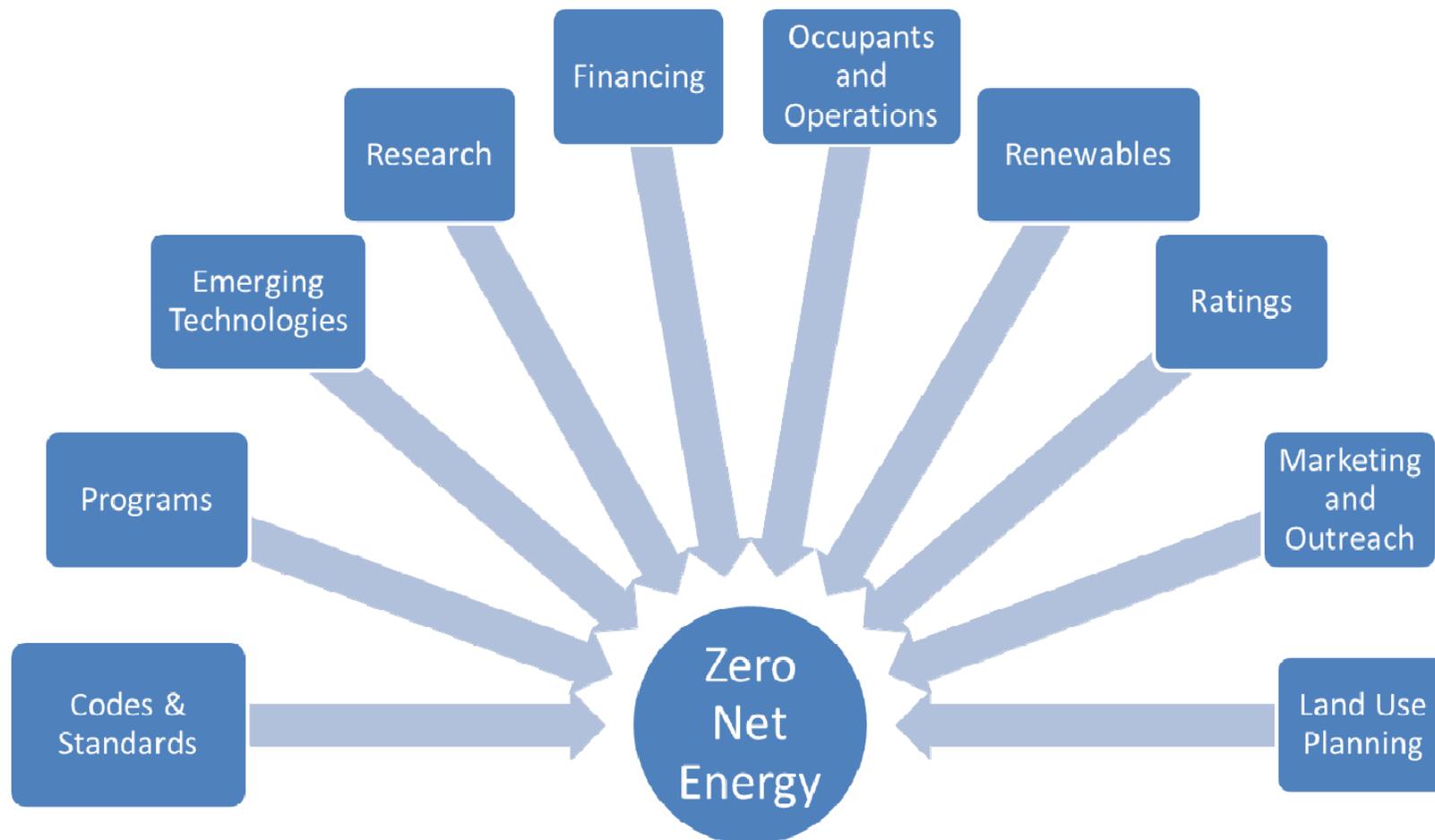
Policy Choices Leading to Higher Goals

- ZNE requires ~50% reduction in energy use compared to 2013 Title 24
 - Residential New Construction by 2020
 - Nonresidential New Construction by 2030
- SB 350 Requires a doubling of energy efficiency from existing buildings by 2030
- Both require Significant Ramp-up in energy efficiency activity
 - Puts more emphasis on programmatic efforts

ZNE and Deep Energy Retrofits Require Coordinated Efforts

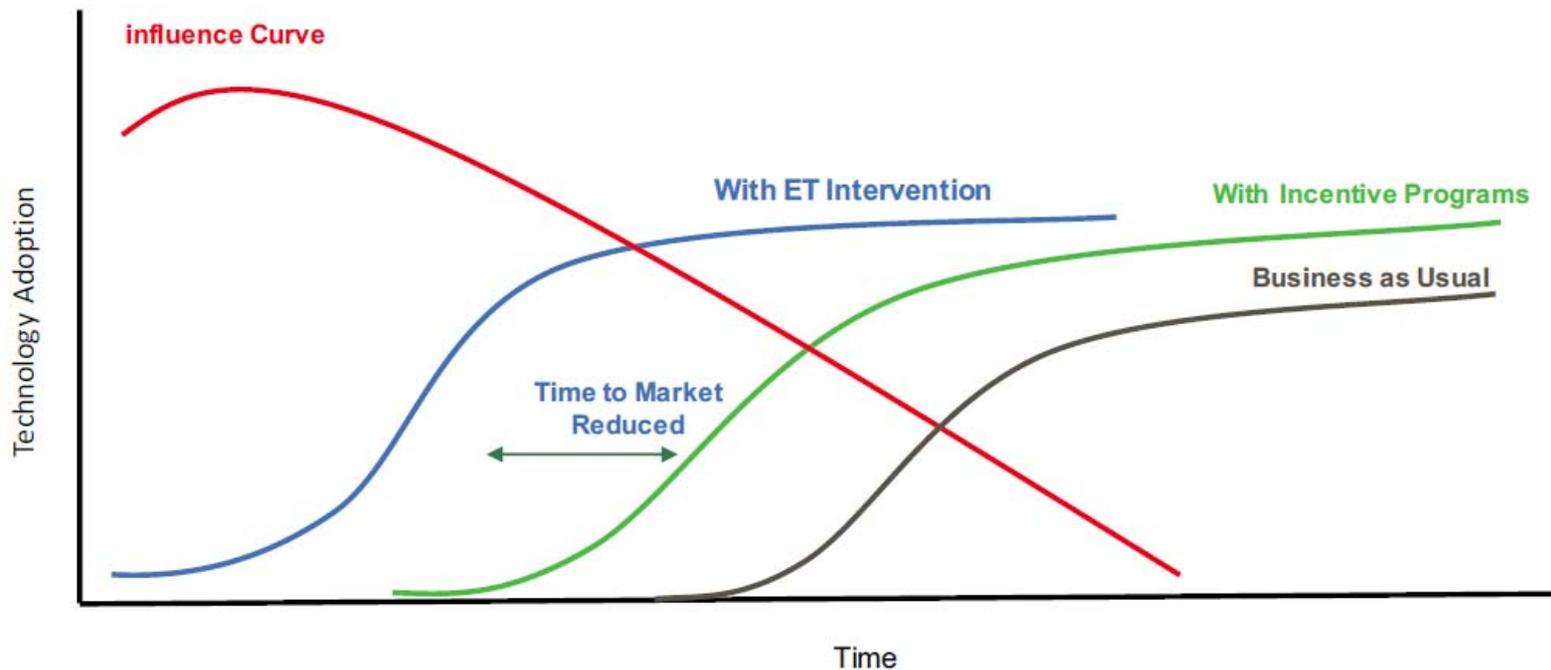
- “Road to ZNE”, ZNE Residential Characterization studies conducted on behalf of Investor Owned Utilities call for a Market Transformation approach to ZNE/Deep Retrofits
 - ZNE goals require rapid changes in industry practices
 - for design, construction and operation that cannot be achieved through incentives or training alone
 - Stakeholders responses to interviews demonstrate
 - the majority of construction industry will only adopt ZNE as standard practice once two things are clear:
 - There is a sustained market demand for ZNE
 - The resulting buildings are deemed cost-effective and ‘feasible’ by market actors and building owners/operators

The Breadth of ZNE Planning is Expansive and Will Require a High Level of Coordinated Effort



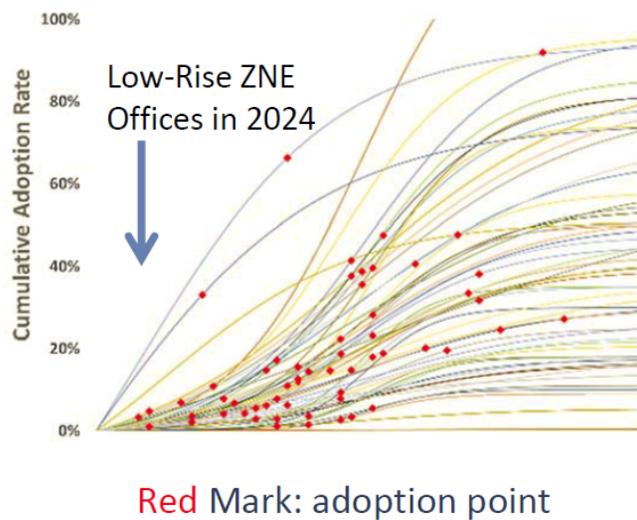
Goal of Research and ET Changes

Emerging Technologies Program Overview Technology Influence and Adoption Life Cycle – Conceptual

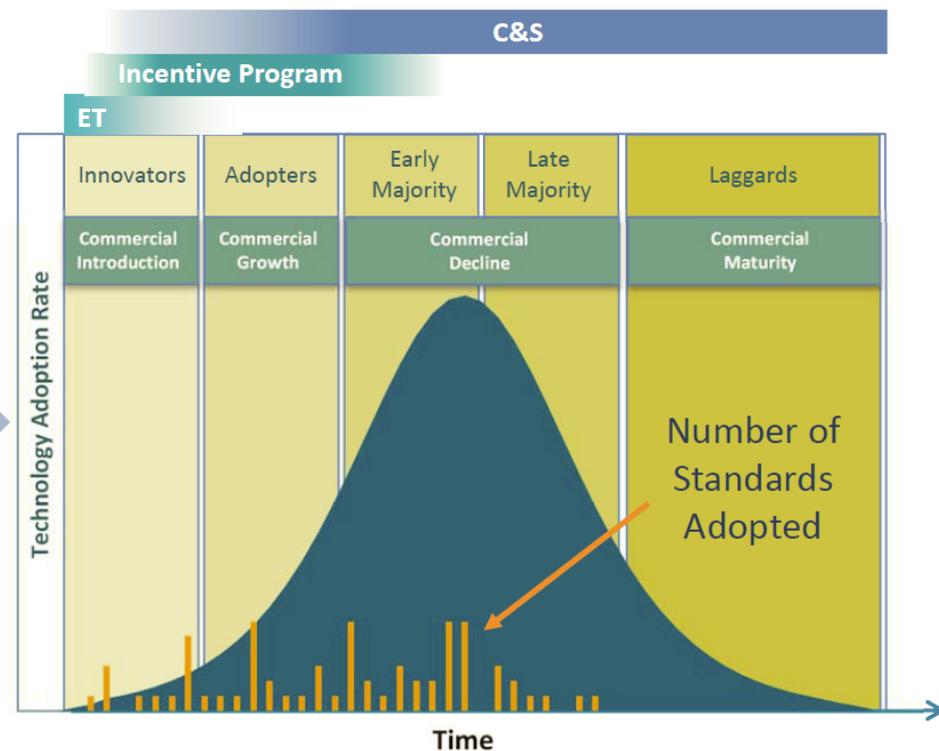


Myth: Codes and Standards deals with Laggards

Naturally Occurring Market Adoption (NOMAD) Curves



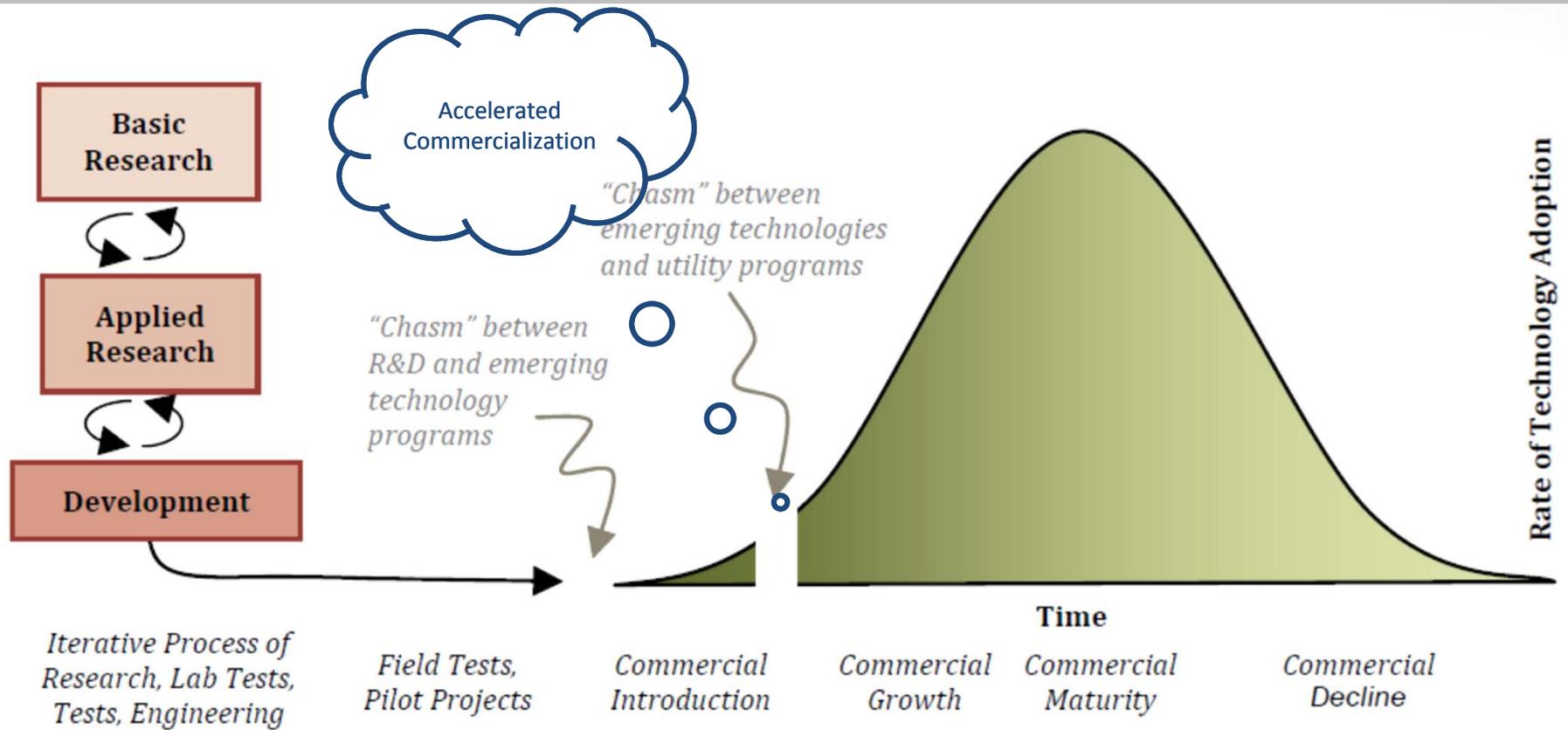
Source: CPUC C&S Impact Evaluations



Shrinking the Technology Adoption Curve

- Codes are getting aggressive
 - Targeting earlier in the curve
- Emerging technologies looking further up the curve
- Excellent opportunity to coordinate efforts and drive market transformation
 - If programs are incorporated into the mix optimally
- Programs have a dual challenge
 - Reduce operational costs
 - Increase energy savings
 - Ripe opportunity for disruptive technologies and solutions

Market Transformation 'Standard Practice'



Source: National Energy Efficiency Technology Roadmap Portfolio, March 2013

Accelerated Commercialization

NYSERDA Emerging Technologies Accelerated Commercialization Program

- Scaled demonstrations
- Field Placement
- EM&V
- Targeted to specific end uses and building types

NEEA Initiatives

- E.g. Heat Pump Water Heaters
- Coordinated Strategy involving ET, Research, Programs, Codes
- From “lab to market”

Non-Utility Efforts

- VC Funded product development and research
- ‘Fail Fast’ ideology

Role of Research and Emerging Technologies

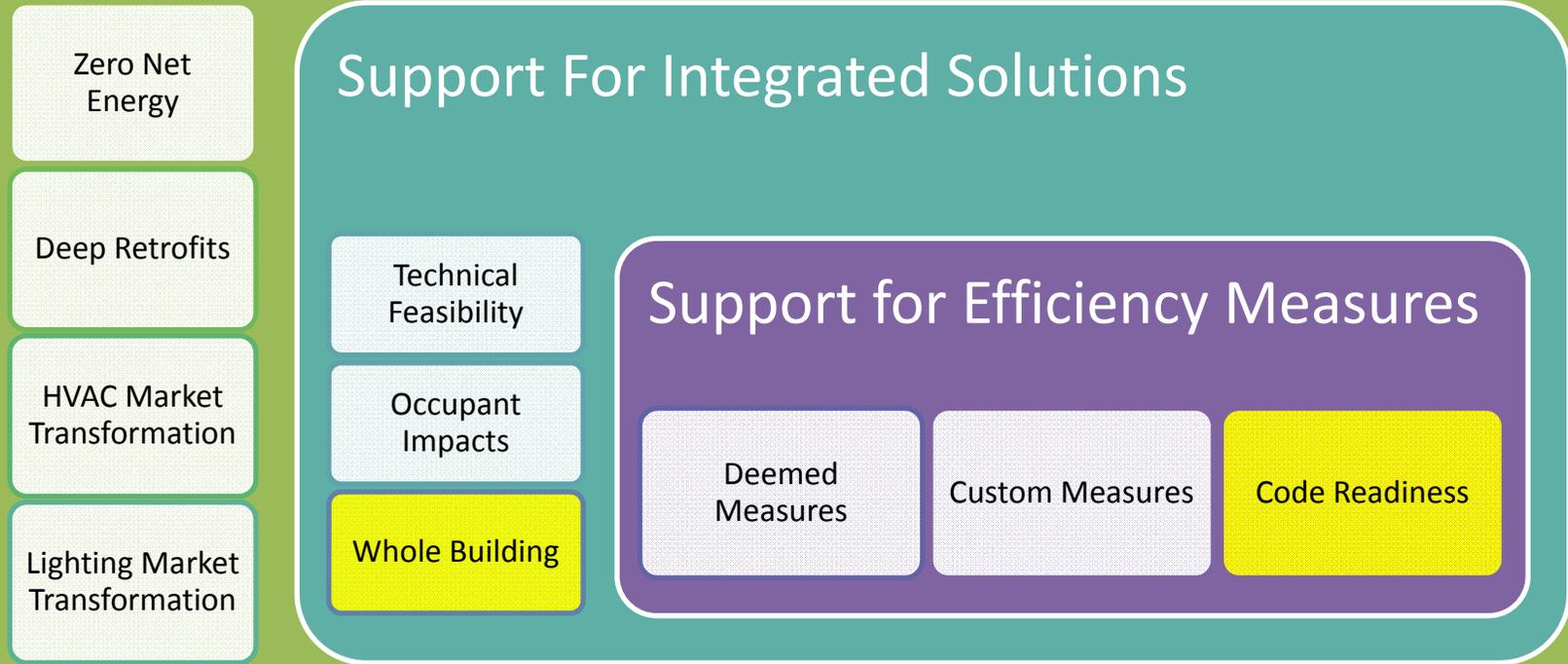


- From 'Great ideas' to market adoption....

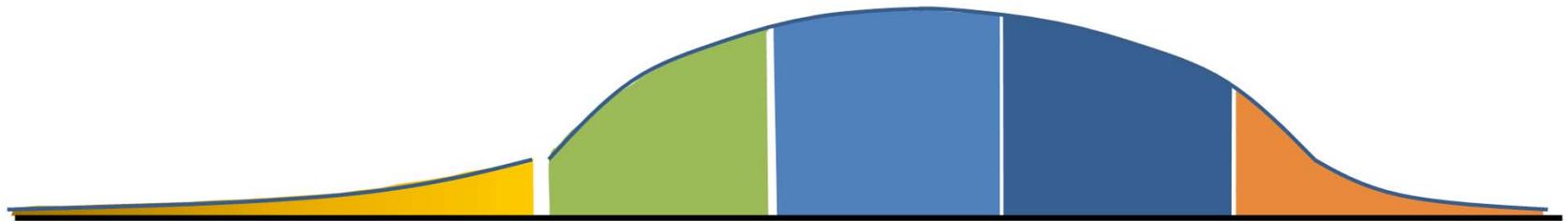
A Topdown View of Priorities for Research and Emerging Technologies



Long Term Energy Efficiency Strategic Plan Goals



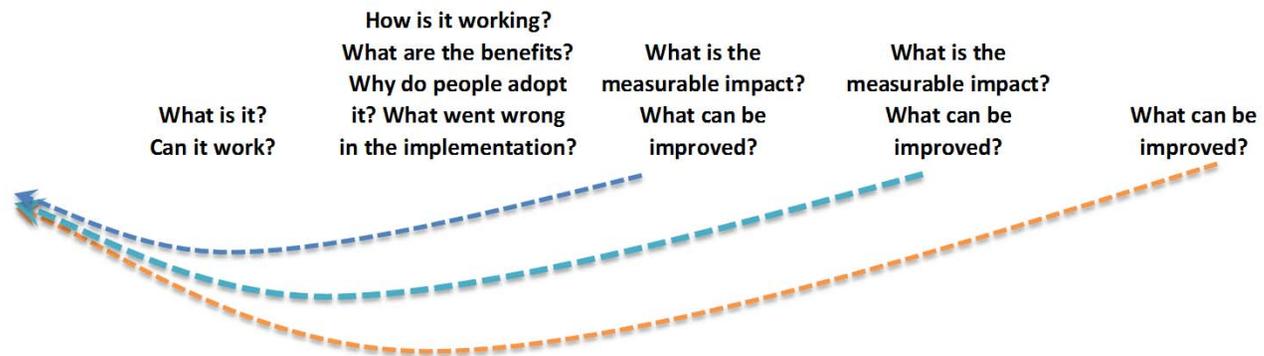
Research and Emerging Technologies Span The Adoption Curve



Sample Tactics

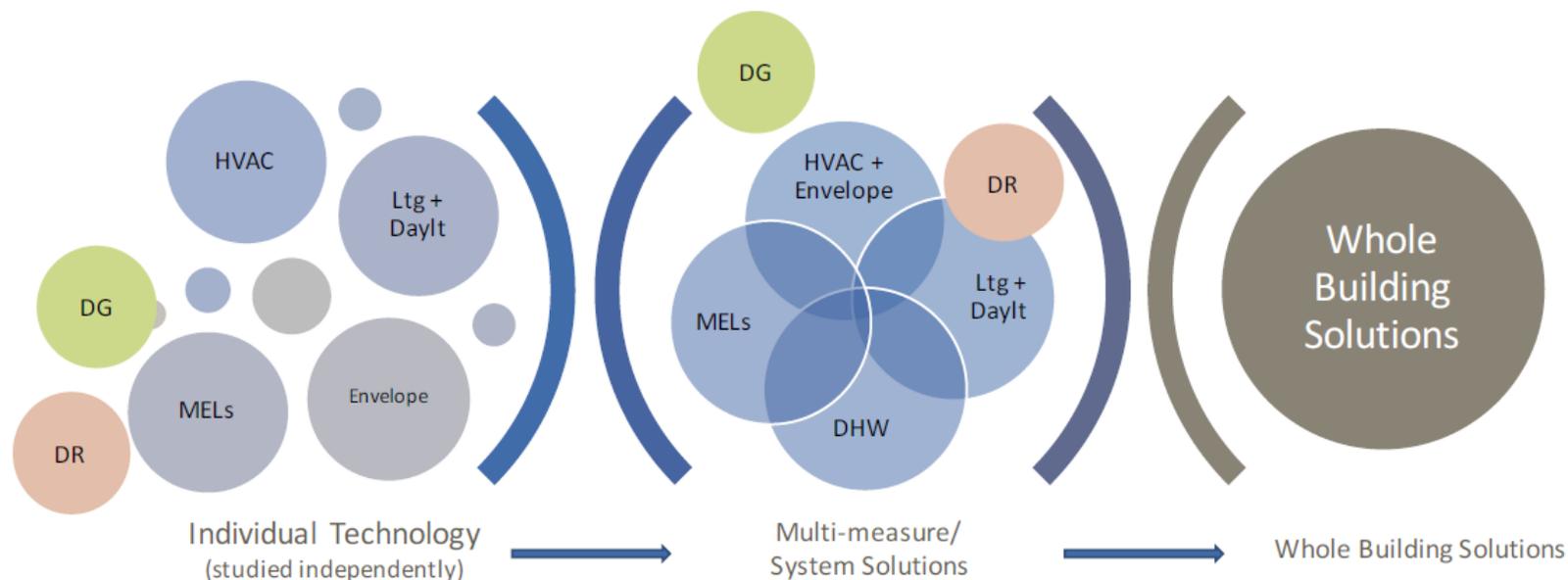
Technology Assessment	X	X	x		
Scaled Field Placement	x	X	X		
Scaled Field Assessments			x	x	X
Demonstration Showcases		X	x		
Market and Behavioral Studies	x	X	x	x	x
Technology Development Support	X	X	x		
Business Incubation Support (TRIO)		X	x		
Technology Test Centers	X	X			
Codes and Standards Support		x	X	X	

ETP Elements/ Key Research Outcomes
Feedback to next iteration of ETP efforts



From Widgets to Solutions

Vision for ETP



High potential individual technology solutions

- ◆ Advanced lighting LED fixture retrofit with built-in communications
- ◆ Climate optimized HVAC rooftop unit

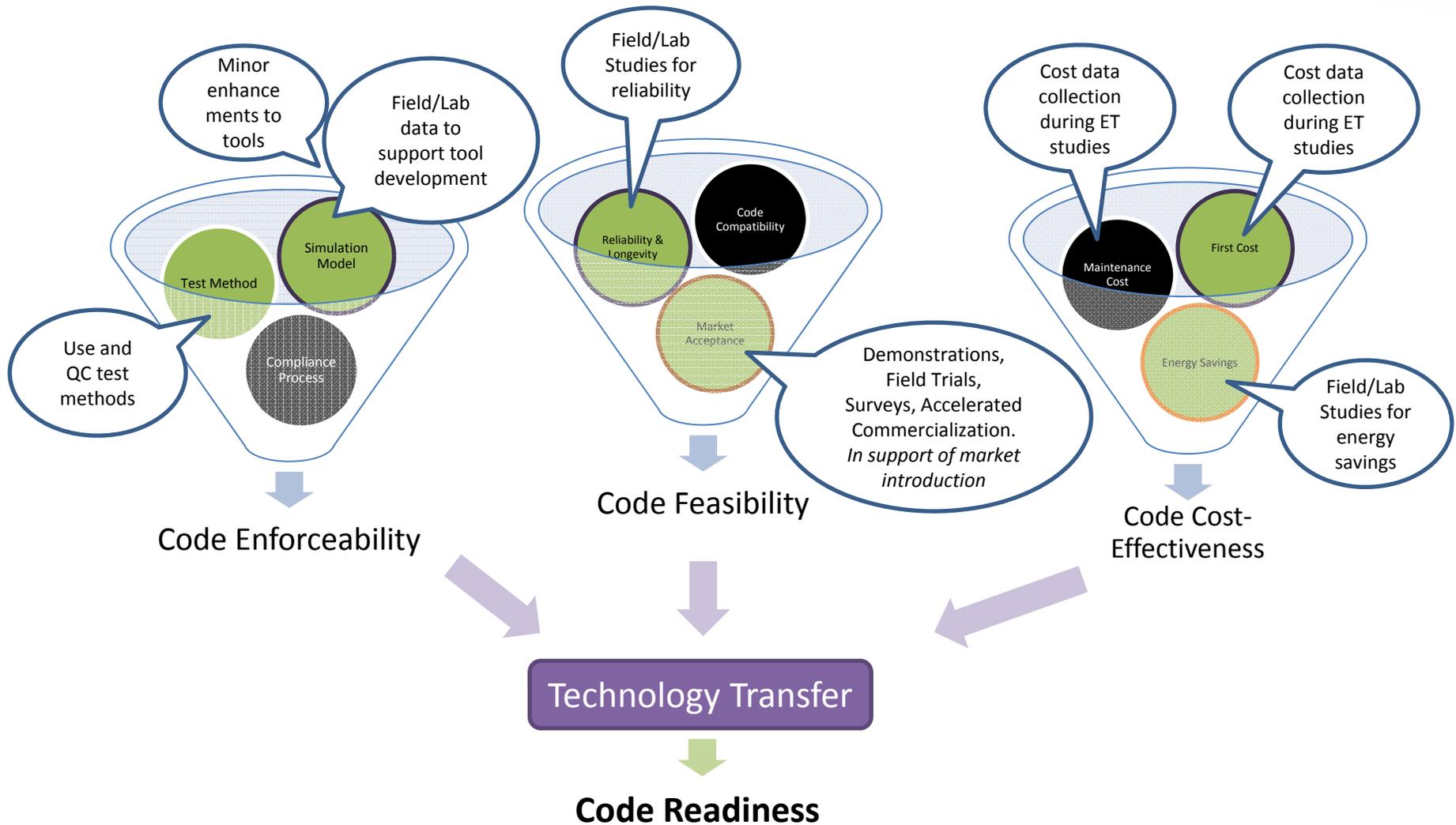
Optimized single or multiple system level savings

- ◆ Lighting system with integrated occupancy sensing, and daylighting controls
- ◆ Envelope measure integrated with properly sized HVAC equipment measure

Deep savings solutions (low volume/highest potential)

- ◆ Commercial whole retrofit involving building envelope measures with advance lighting systems and properly sized HVAC systems
- ◆ New construction demonstration targeting ZNE with integrated storage

Goal Driven Data Gathering



Challenges and Opportunities

- **Integrated Design Solutions**
 - Deeper Savings, but are Not Universally Applicable
 - High Cost Barrier
 - Increased Complexity
 - Success depends on understanding customer preferences, goals and timing of engagement with customers
- **Deep Energy Retrofits**
 - Deeper Savings but High Transaction Costs
 - Need breakthrough solutions that reduce transaction costs and increase adoption
- **Still need Individual Technologies**
 - Need to be strategically important
 - Cost-effective solutions that can scale (wider deployment)

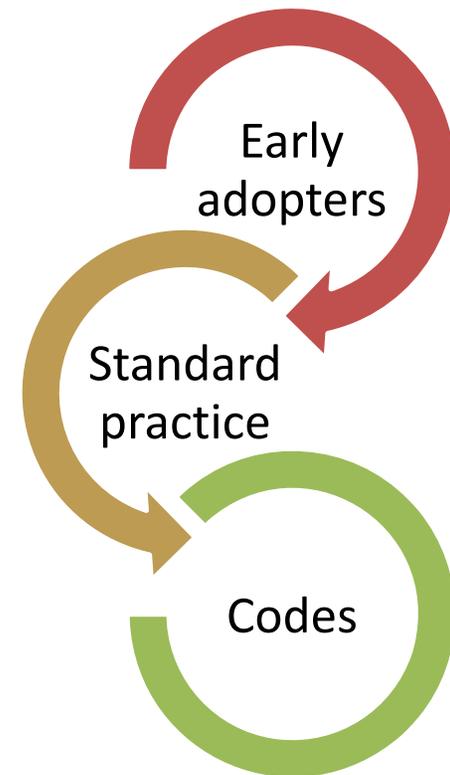
From Theory to Practice

- Nonresidential: Advanced Buildings Characteristics Study
- Residential: Ducts in Conditioned Spaces

Advanced Building Characteristics Study

More result in ACEEE 2016 Proceedings

- **Purpose**
 - Use market to guide policy & research
 - Identify advanced features/strategies in ZNE & near ZNE commercial buildings
 - Identify barriers and opportunities
- **Outcomes**
 - Catalog measures and integrated design packages (IDP)
 - Recommend opportunities for ET research, incentive programs, and code readiness

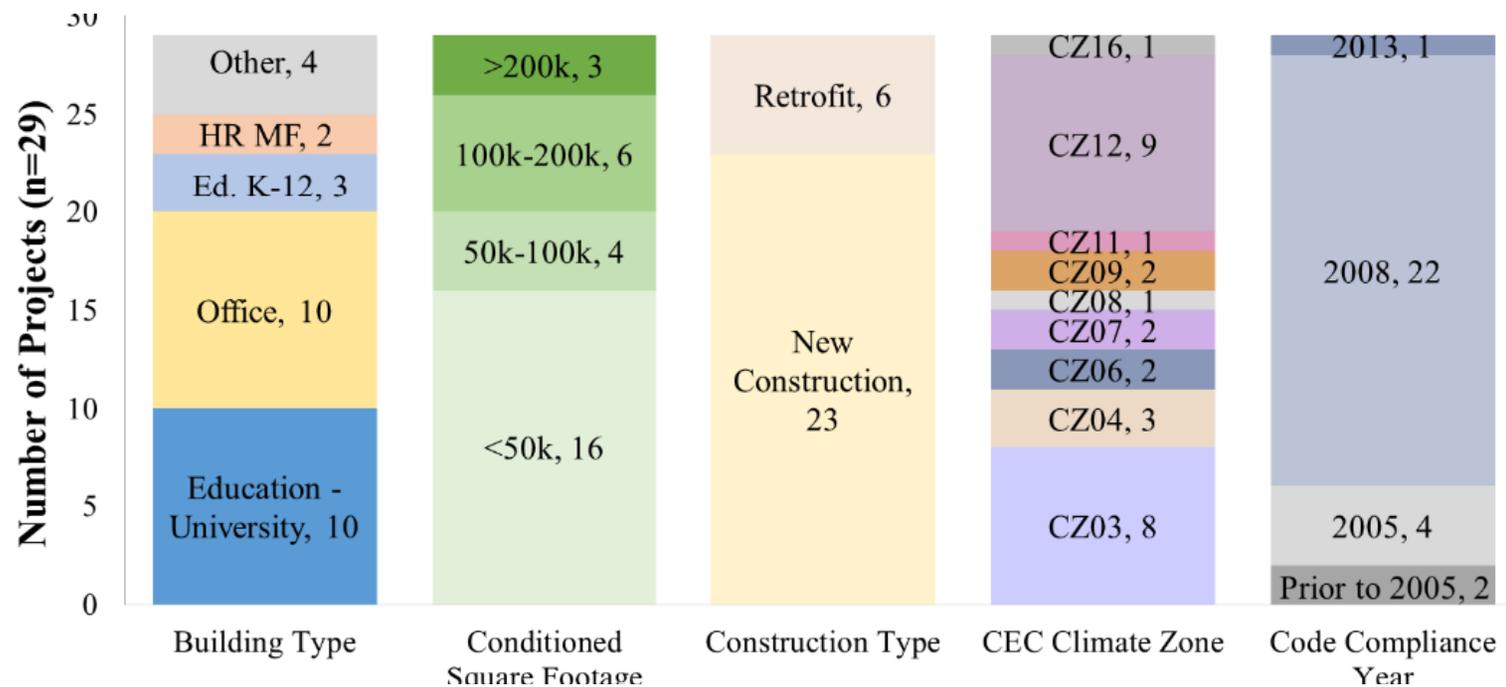


Advanced Building Surveyed

29 California buildings with ZNE or near-ZNE goal - average modeled EUI < 40 kBtu/ft²

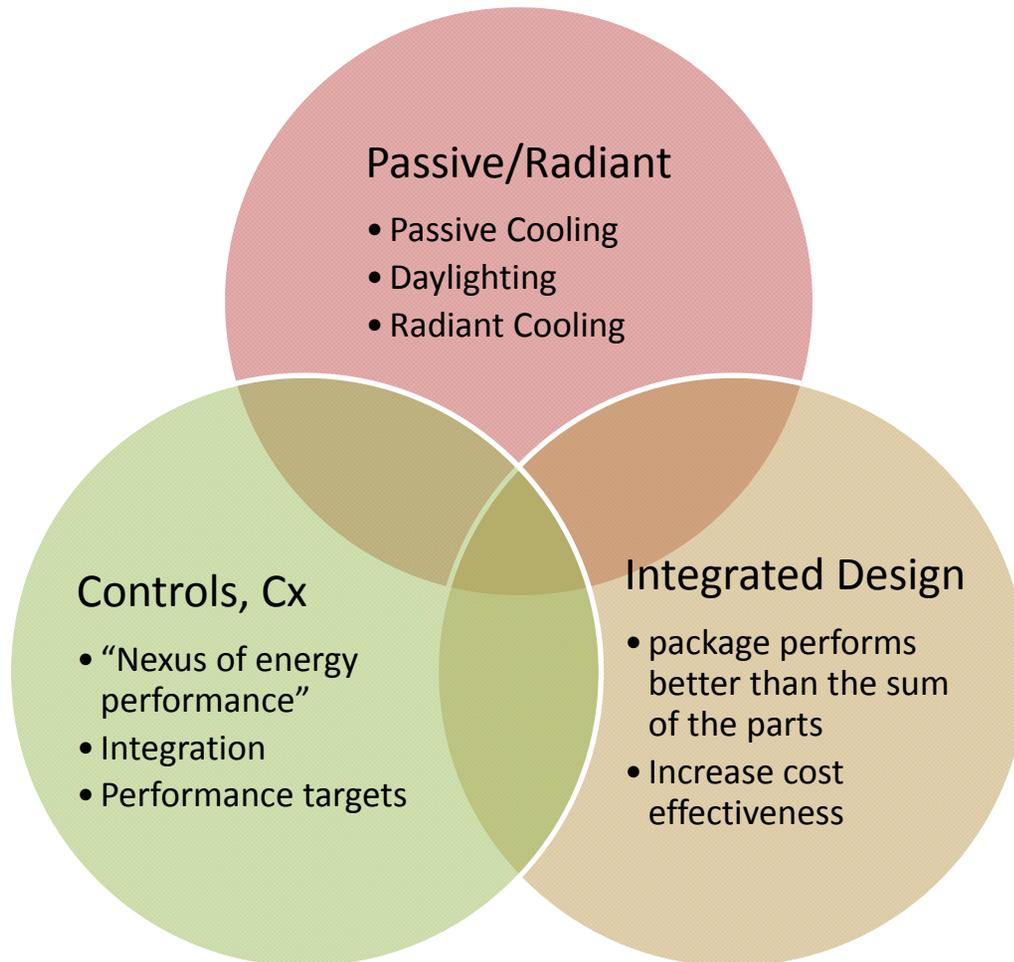
39 interviews: engineer, architect, contractor, owner

Review models and design drawings



Study limitation: Focused on leaders pushing the envelope. Small sample size.

Key Themes



Load Reduction

- Enables passive/radiant
- Solar & plug load reduction

Occupant Centric Solutions

- *“provide service for the occupant rather than the building”*
- Addresses variability of passive systems & enables mixed-mode
- Ceiling/desk fans, task-ambient lighting, operable windows, etc.

Integrated Design Packages (IDPs)

Passive (natural) and Mixed-Mode Cooling IDPs (n=18)

Common Essential Elements	Alternatives/Variations
<ul style="list-style-type: none"> • solar control • reduce plug load • mass • ceiling fans 	<ul style="list-style-type: none"> • night pre-cooling • automated window or louver • narrow floor plate

Radiant Cooling IDPs (n=11)

Common Essential Elements	Alternatives/Variations
<ul style="list-style-type: none"> • Solar control • Reduce plug loads • Evap cooled water (compressorless) 	<ul style="list-style-type: none"> • Mixed-mode: Passive cooling+Radiant • Ceiling fans • Thermal energy storage • Night pre-cooling • Heat pump (bay water, geothermal)

Daylighting and Lighting Controls IDPs (n=27)

Common Essential Elements	Alternatives/Variations
<ul style="list-style-type: none"> • Solar control • Light shelves or clerestories • High efficacy lighting • Controls 	<ul style="list-style-type: none"> • Occupant response controls • Skylights • Narrow floor plate

Barriers and Opportunities

- Knowledge gaps:
 - Engineering fundamentals
 - Design tools to decrease transaction cost and risk
 - Controls integration and ongoing commissioning
 - Contractor and/or operator experience
- Integrated Design (ID) challenges:
 - ID is a process, not a solution, with more complexity
 - Lack of knowledge and tools to support ID
 - Simulation critical, but bugs and multiple tools are time consuming (\$\$\$\$)
- Difficult to predict PV size for ZNE

Recommendations

- Candidates for ET and Incentive Programs to support market adoption ----->
 - Integration and scalability is critical to move these measures into standard practice
- Support and enable integrated design (ID)
 - ID process and packages of measures important for achieving deep efficiency cost effectively
 - Identify ID packages and best practices
 - Develop ID analysis tools – e.g. pre-defined parametric analysis including cost effectiveness
- Improve energy predictions to size PV for ZNE
 - Benchmarking
 - Plug load and behavior libraries closer to reality

Natural ventilation design
Mixed-mode systems
Comfort performance simulation
Radiant cooling design
Daylighting design and control
Task-ambient strategies
Occupant responsive controls
Controls integration/optimization
Ongoing Commissioning & EIS

Applied Research Pushing Technology To Market: Current Commercial Building Activity



Market adoption scope

Changing the Rules – Occupant Responsive HVAC Systems and Controls (PIER)

- Field demonstrations integrating new technology
- Novel new controls integration & optimization
- Occupant in the loop

Optimizing Radiant Systems for Energy Efficiency and Comfort (EPIC)

- Designer Interviews to document best practice
- Field demonstration of controls solutions
- Case studies including costs
- Design tool

Integrating Smart Ceiling Fans and Communicating Thermostats to Provide Energy-Efficient Comfort (EPIC)

- Large scale demonstration
- Develop performance test standard (ASHRAE 216)
- Design tool & best practices guide

Very Low-Cost MEMS-Based Ultrasonic Anemometer for Use Indoors and in HVAC Ducts (EPIC)

- Identify HVAC applications
- Demonstrate HVAC applications

Residential: Ducts in Conditioned Spaces

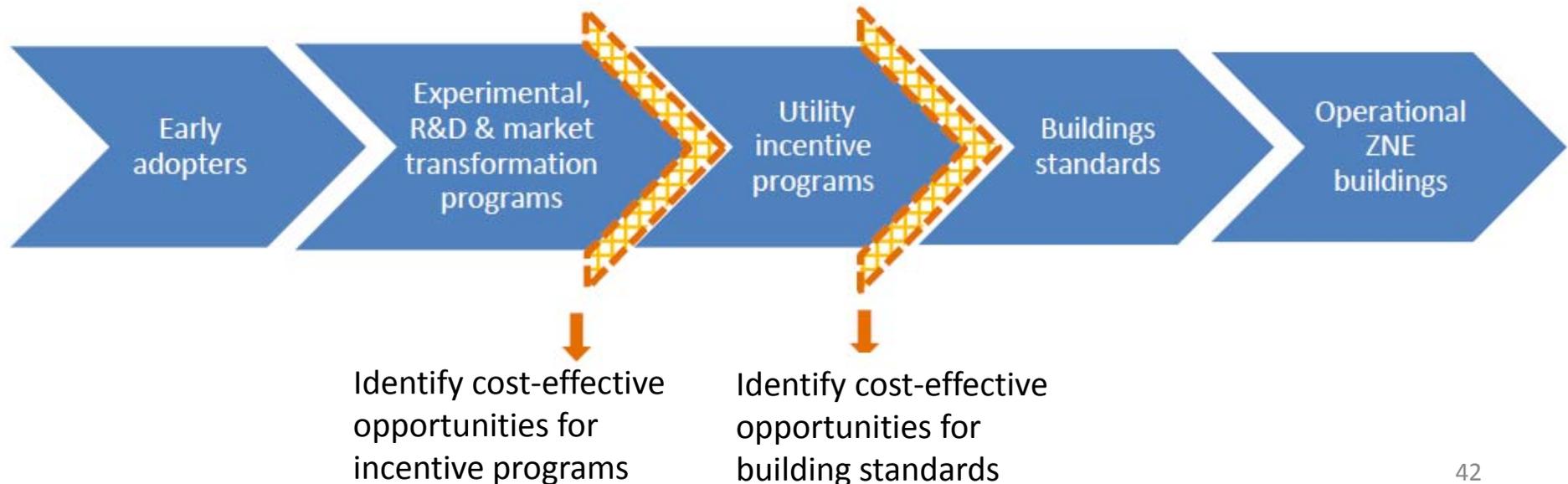
- **Standard Practice:**
 - Ducts in Attic
 - No Insulation at roof deck
 - Insulation on ceiling
- **Result:**
 - Coldest air (within air conditioning ducts) is directly next to the hottest part of the house
- **Solution:**
 - Move ducts into conditioned space
 - Or, add insulation at the roof deck

Residential: Ducts in Conditioned Spaces

- ET studies co-funded by C&S
 - Early adopter demonstrations and testing
- Manufacturer and builders trials
 - Field trials and data gathering
- Code analysis based on early adopters
 - Cost-effectiveness showing it is feasible
 - Stakeholder engagement to show industry support
- Code Readiness Efforts
 - Train builders new to the concept on how to incorporate ducts into conditioned spaces
- Training and Outreach
 - EPIC funded study to educate trades

Takeaways

- Use ET, pilot programs, and above-code programs to address knowledge gaps
 - Examples, lessons learned, and best practices, design guides
 - Tunneling through the cost barrier
 - Reduce transaction costs and risk
 - Not ‘Max Efficiency’ but ‘Optimal efficiency’



Thank you

Questions?

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