ZERO-NET-ENERGY BUILDING CODES IN CALIFORNIA AND IMPACTS FOR ADVANCED TECHNOLOGIES

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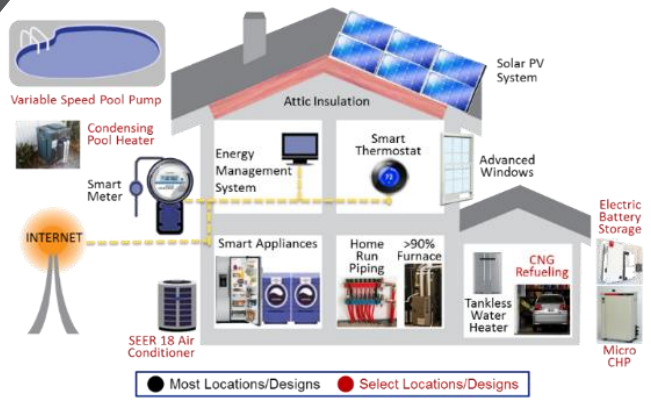

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OBJECTIVES

- Discuss residential building code trends and different ZNE home definitions
- Understand how differences in ZNE definition affect home design, technology selection, and other characteristics
- Compare the attractiveness of ZNE homes in California using natural gas appliances to electric-only designs
- Evaluate potential sensitivities for ZNE homes in the future

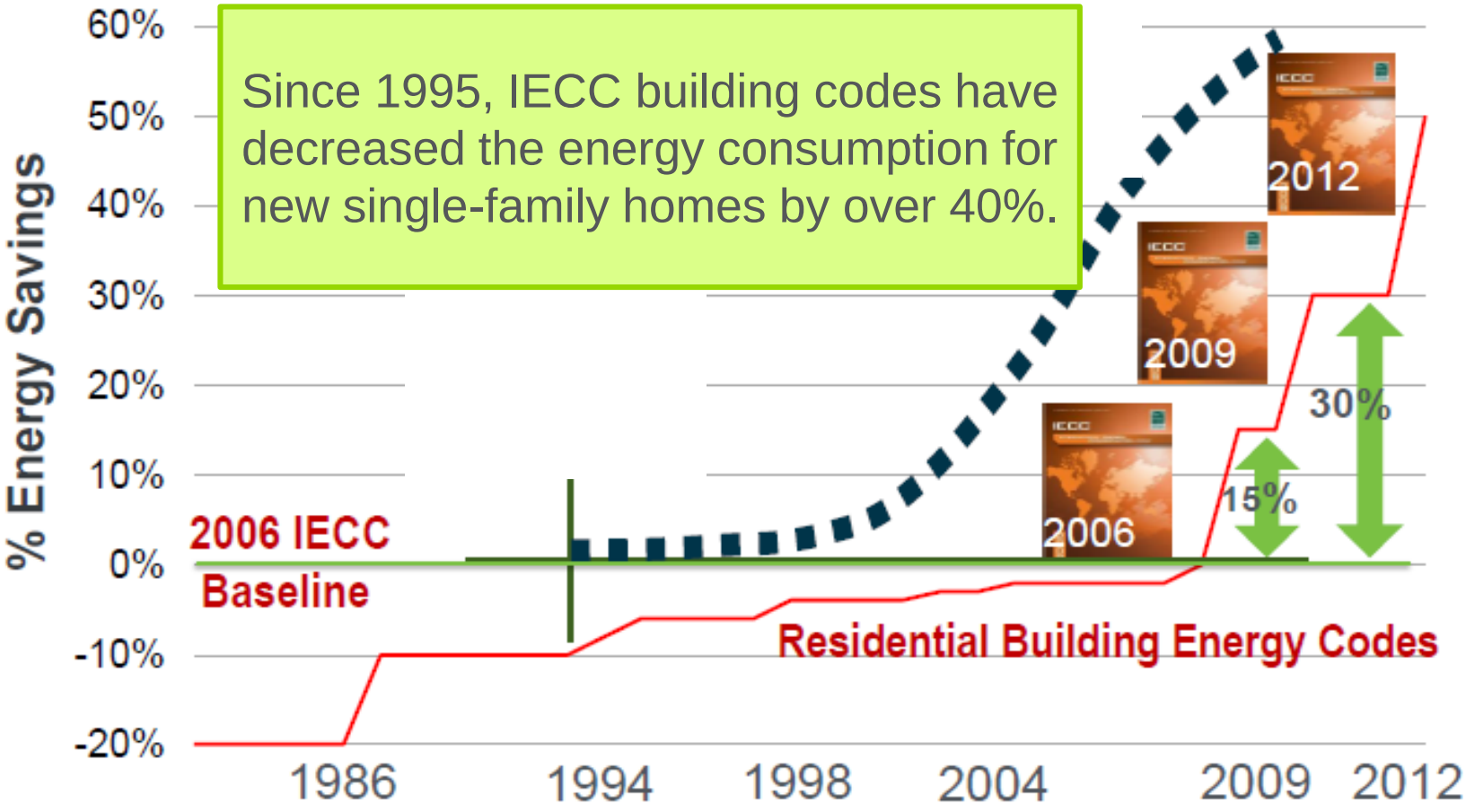
RESIDENTIAL BUILDING CODES

- State and local governments adopt residential building codes to establish minimum construction standards and protect public health and safety.

- Many requirements directly or indirectly affect energy consumption.

Residential Building Code Areas Affecting Energy Consumption	
• Building envelope • Windows • Insulation • Home framing • Duct layout and insulation • Ventilation and exhaust systems	• Plumbing layout and insulation • Interior and exterior lighting • Appliance efficiency (some) • Renewable energy system or dedicated space (some) • Others

RESIDENTIAL EFFICIENCY TRENDS



IECC – International Energy Conservation Code
Note - state by state adoption is somewhat delayed, and compliance is always an issue.

Source: Building America Program

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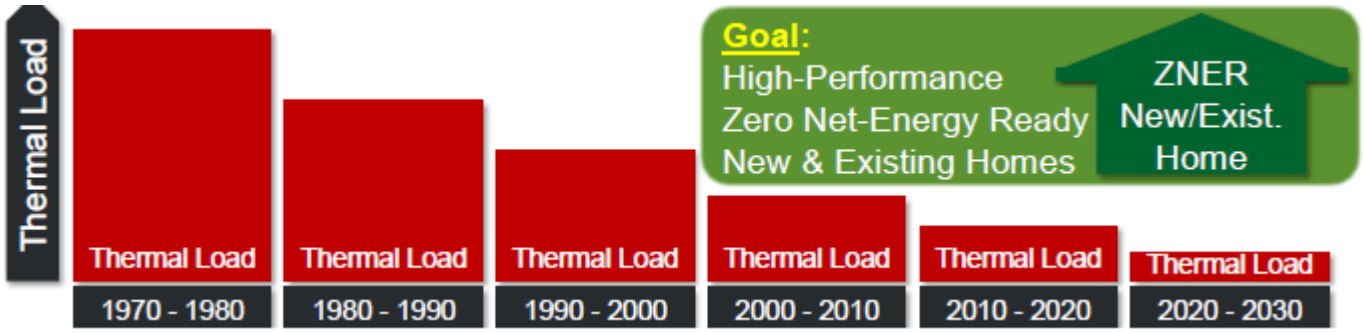
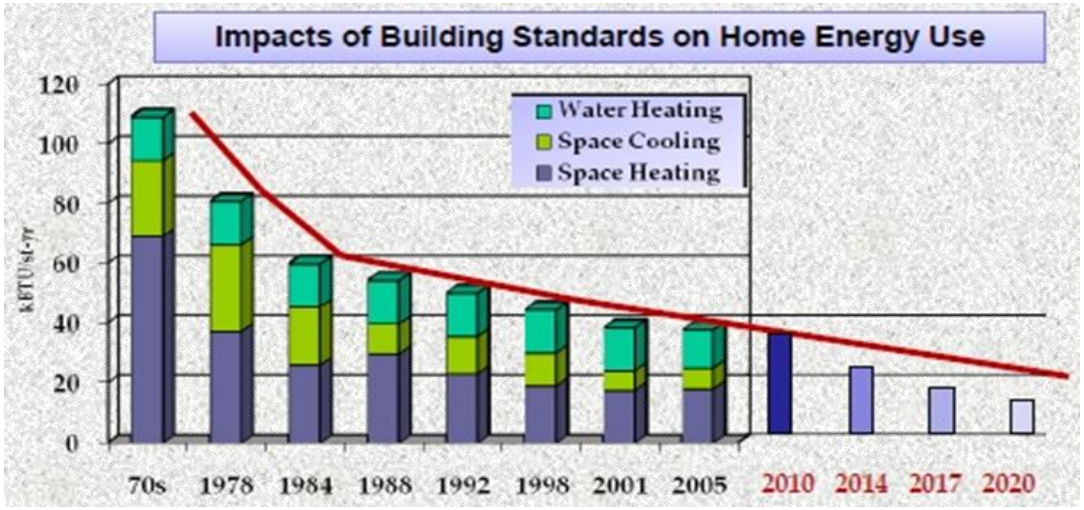
WHAT'S NEXT?

- Building code organizations have shifted focus towards on-site generation to tackle the remaining load.





Source: Building America, Title 24-2016

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WHAT IS A ZERO NET ENERGY (ZNE) BUILDING?

What is California's ZNE Definition?

"A ZNE Building is one where the **net amount of energy produced** by onsite renewable energy resources is **equal to the value of the energy consumed annually** by the building at the level of a single 'project' …"

From CEC's Integrated Energy Policy Report (2013 IEPR)

What are California's ZNE Goals?

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DIFFERENT ZNE DEFINITIONS

The term “Zero-Net-Energy” has several interpretations.

Various ZNE Definitions	
• Energy Cost • Site Energy • Source Energy • CO_2 Emissions	• Time Dependent Valuation (TDV) of Energy* • Other – water, transportation, building materials, etc.

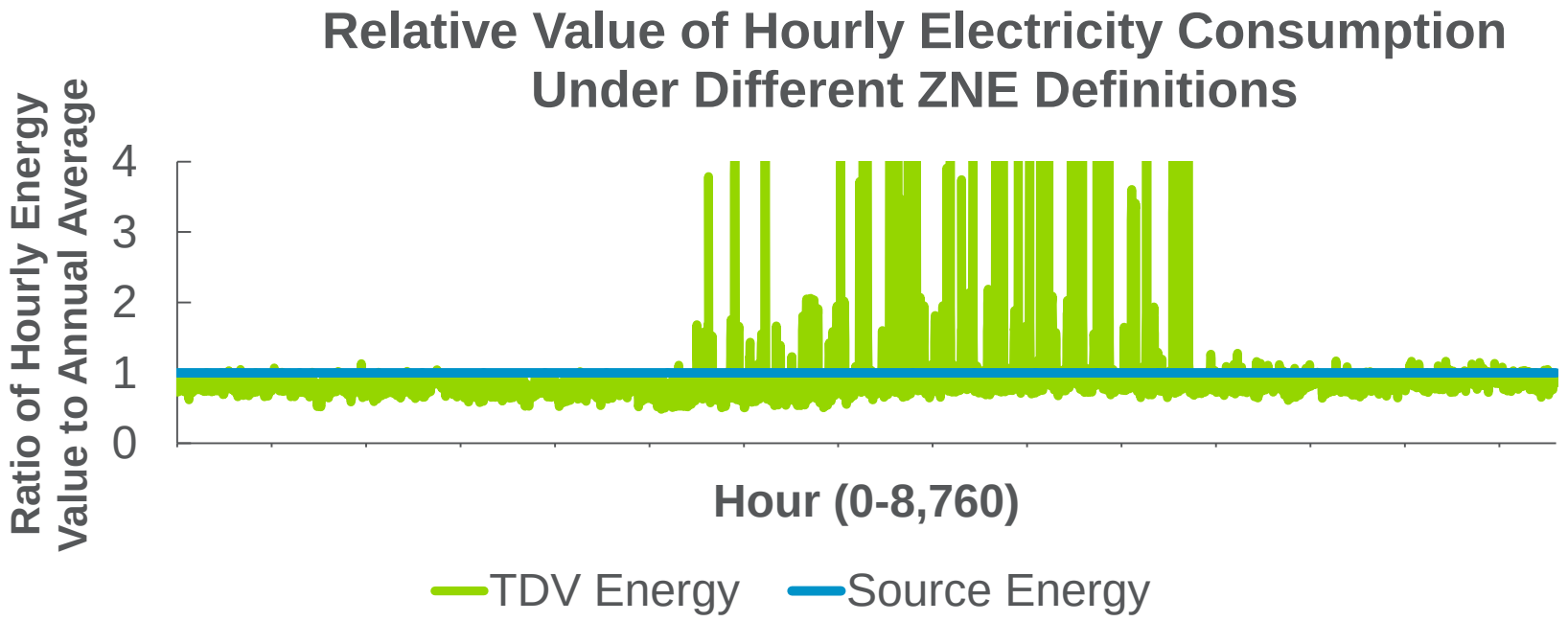
Why is this an issue?

- Each definition has major impacts on building design, energy consumption/production, and project costs.
- This definition issue has created significant confusion among homebuyers, builders, utility staff, policy-makers, and others.

*Time Dependent Valuation (TDV) is based on the forecasted seasonal and hourly costs for production, transmission, and distribution of electricity and natural gas, including peak and off-peak considerations.

SOURCE VS. TDV ENERGY

- For example, the TDV values for electricity change both daily and seasonally to reflect peak demand periods.



- Under TDV definition, technologies that significantly alter a home's grid-supplied demand or shift consumption during peak hours have the greatest TDV impact and cost-effectiveness.

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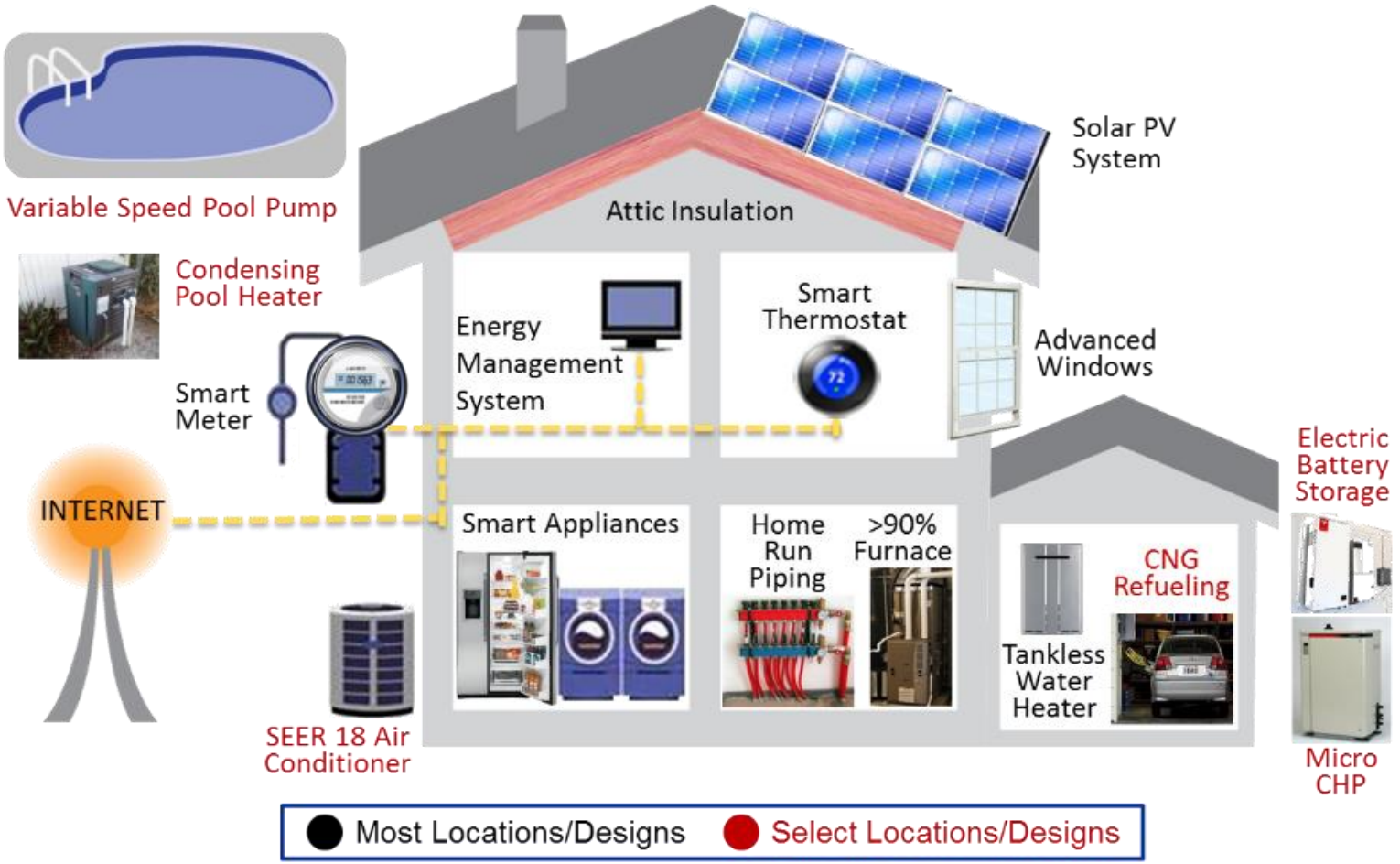
ZNE FEATURES AND TECHNOLOGIES



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SOCAL GAS ZNE STUDY

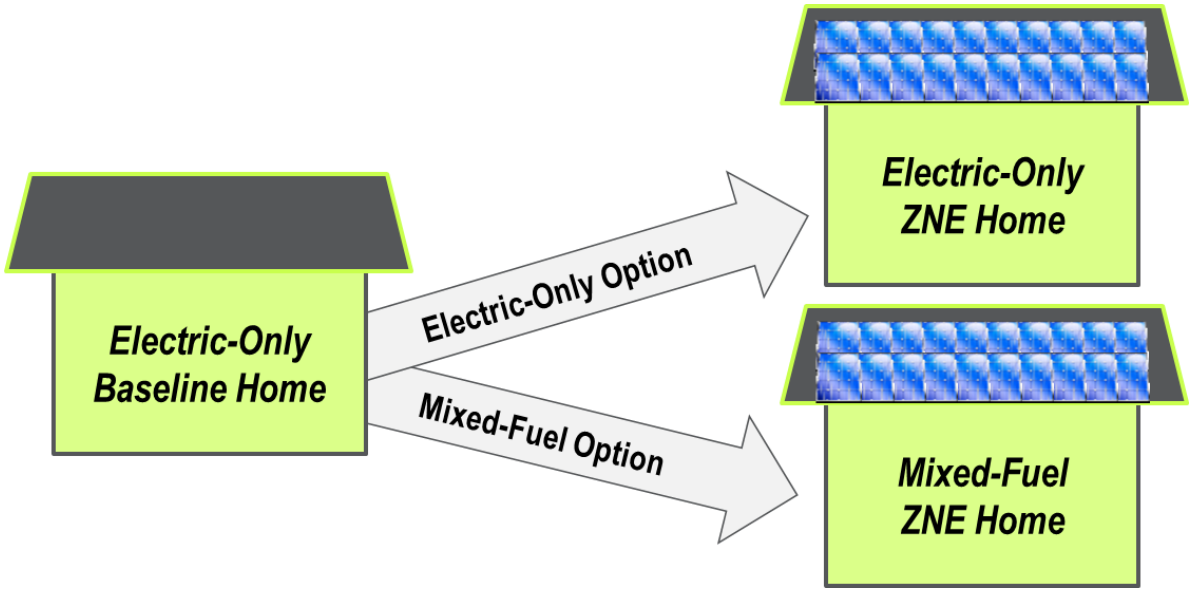
- Navigant conducted a building simulation study and supporting analysis to assist in technical discussion of ZNE building codes in California.

Project Objectives

- **Conduct a building simulation study** for various parameters for ZNE homes, including: home size, location, fuel type, technology mix, orientation, and building loads.
- **Evaluate the potential benefits and opportunities** of mixed-fuel ZNE homes compared to baseline electric-only homes under the time-dependent-valuation (TDV) definition.
- **Understand how advanced technologies** could impact future ZNE homes under current and projected cost/performance characteristics.
- **Identify potential regulatory, program, and research activities** to address technical, market, and policy gaps for mixed-fuel ZNE homes.

BASELINE ASSUMPTIONS

- We evaluated mixed-fuel and electric-only ZNE homes against a baseline electric-only home compliant with Title 24-2016.
- Starting in 2020, builders must design homes to ZNE standards, but they will still have a choice of fuels.
- We selected a baseline electric-only home as a reference point since this is perceived as the “default” design for ZNE homes.



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BASELINE ASSUMPTIONS

- Our analysis considered a variety of ZNE home designs, features, and appliances meeting current and proposed building codes and advanced technologies.
  - 3 floor plans
  - 5 California climate zones
  - Time-of-use rates and net metering rules for each location.

- We optimized each home design for the TDV metric using NREL's BEopt software.
  - The software uses a staged optimization process that selects a package of efficiency and renewable energy technologies with the lowest life-cycle costs .
  - For California, the study optimized on a TDV basis ($/TDV-offset).

SUMMARY OF FINDINGS

- The analysis revealed that ZNE homes using natural gas appliances offer several key technical, economic, and regulatory advantages under the TDV definitions.

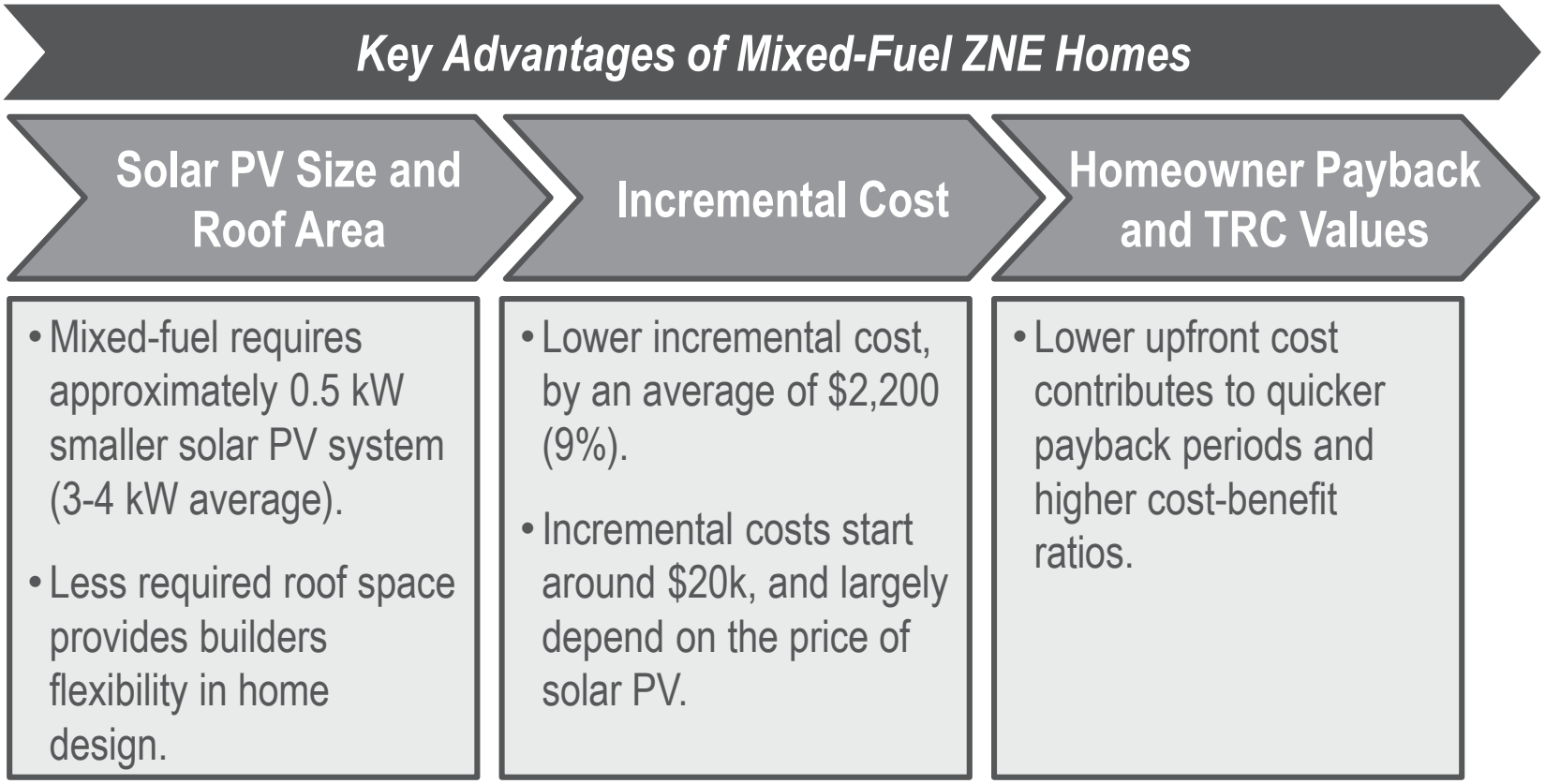
Compared to baseline electric-only home, mixed-fuel ZNE homes require **smaller PV systems**, carry **lower incremental cost**, and offer **higher cost-benefit ratios** than electric-only designs.

These benefits appear to **support past research showing homeowner preferences** for improved roof **aesthetics**, lower ownership **costs**, and **incorporating gas appliances for** cooking, space heating, and other end-uses.

Solar PV will be the primary technology for reaching ZNE goals both today and in the future, but several **advanced natural gas technologies could become attractive** with further development.

RD&D activities are necessary to ensure **mixed-fuel ZNE homes can maintain their competitiveness** against expected cost reductions in solar PV and other electric systems.

KEY ADVANTAGES OF MIXED-FUEL ZNE HOMES



- Combined with overwhelming customer preference for gas appliances (80-95%), mixed-fuel homes have an major role in California's ZNE future.

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ROADMAP FOR ADVANCED TECHNOLOGIES

ZNE Homes 2016-2020

ZNE Homes 2020-2030

Cost-Effective Efficiency Measures

- Efficiency measures targeting building envelope, HVAC and water heating, including:
  - Advanced thermostats
  - Improved insulation
  - Advanced windows
  - Condensing furnaces
  - Tankless water heaters
  - Condensing pool heaters.

Solar PV System

- Solar PV offers the most cost-effective TDV savings by:
  - Offsetting grid-supplied electricity
  - Operating during high TDV hours
  - Requiring zero fuel consumption
  - Decreasing costs in recent years.
- Solar PV offers the most cost-effective TDV savings by:

Potentially Attractive Advanced Technologies

- Several technologies can provide TDV energy savings, but require further cost/ performance breakthroughs:
  - Fuel cell mCHP systems
  - Gas heat pumps for heating
  - On-site electric batteries.

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POTENTIAL ISSUES AND SENSITIVITIES

- The future attractiveness of all ZNE homes depends on many market and regulatory factors and could change in the future.

Infrastructure Costs

Roof Availability

Technology Costs

Non-Traditional Building Loads

Utility Rates, TDV Values

Net Metering, Tariffs, Incentives

MIXED-FUEL ZNE HOME BENEFITS

Conclusions

- Compared to baseline electric-only home, mixed-fuel ZNE homes require **smaller PV systems**, carry **lower incremental cost**, and offer **higher cost-benefit ratios** than electric-only designs.
- These **benefits support homeowner preferences** for improved roof aesthetics, lower ownership costs, and incorporating gas cooking equipment, heating systems, and other end-uses (e.g., fireplaces).
- **Solar PV will be the primary technology** for reaching ZNE goals both today and in the future, but several advanced technologies (e.g., mCHP systems) could become attractive with further development.
- RD&D activities are necessary to **ensure mixed-fuel ZNE homes can maintain their competitiveness** against expected cost reductions in solar PV and other electric systems.

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QUESTIONS & DISCUSSION

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