

Chapter 1: Introduction

The California Energy Commission funded the multi-project RESAVE research and development (R&D) program to focus on residential energy savings, air-tightness, and ventilation excellence for California homes. This report focuses on the program's results and its associated conclusions and recommendations.

The program's overall goal was to facilitate the substantial reduction of energy and peak power that is used in California homes to condition air that enters from outdoors. Ventilation, either by infiltration (the uncontrolled exchange of air through building envelope leaks and penetrations) or deliberately through mechanical or passive systems, typically accounts for over one-third of the energy used for total space conditioning.

While in older, leakier homes infiltration may have provided sufficient air exchange to control indoor-generated contaminants, designed ventilation is required in all new homes in California to provide acceptable indoor air quality (IAQ) because newer homes have much tighter envelopes. As both new and existing homes are made more airtight to reduce infiltration energy losses, the needs for having efficient ventilation are increased.

Currently new homes in California are required to meet the California Title 24 2008 Building Energy Efficiency Standards. This standard specifies minimum continuous mechanical ventilation rates. While it does not specifically address the issues of source control or ventilation load shifting, it does allow alternative approaches to be used if they can be shown to provide equivalent performance. A key objective of the RESAVE program was to develop alternatives that would allow equal or better indoor air quality performance at a substantially reduced energy cost and substantially lower peak power consumption.

The existing building stock is considerably leakier than typical new construction. Given the small percentage of homes built each year, substantially more energy can be saved through retrofitting the existing stock. Therefore, another RESAVE objective was to demonstrate the energy saving-potential of improving the envelope air-tightness of the existing stock.

A key barrier to improved envelope air-tightness is the real concern that indoor air quality will be compromised. Unlike new construction, existing homes have no mandate to meet any ventilation or indoor air quality standard. Therefore, a further RESAVE objective was to generate appropriate guidance for making existing homes more airtight while maintaining acceptable indoor air quality.

1.1 RESAVE Program

The RESAVE program was intended to facilitate the "Built Tight, Ventilate Right" strategy, which implies that first one builds a high-quality building, (e.g., low air leakage, low source emission) and then finds the most efficient ventilation system to provide acceptable indoor air quality (which includes health and comfort related to odor and irritation).

Infiltration and ventilation are responsible for one-third to one-half of the space conditioning load, but are often unappreciated by the occupants because of the difficulty of sensing air losses. These factors cannot, however, be arbitrarily reduced below a level that supplies acceptable indoor air quality without providing mechanical ventilation or some other mechanism for doing so.

Therefore, RESAVE was designed to address two issues: first, to both reduce the direct losses from infiltration and to control key sources, and second, to find the most energy-efficient methods available to supply the necessary whole-house ventilation. This “Built Tight, Ventilate Right” approach is generally accepted as the best for building high-quality homes, but it is not easy to implement without strong technical backup and appropriate standards to follow.

The ventilation technologies found in California homes typically consist of operable windows or envelope leakage with a small mixture of ventilation fans, usually without heat recovery. The technology developed by the RESAVE program can provide equivalent ventilation at much lower energy costs by using efficient fans and control devices, as well as through heat recovery. The cost savings can be achieved through identification of the appropriate systems to use in specific circumstances and identification of where public-sector resources can be used to leverage private-sector activities.

The key RESAVE products are: (1) technical articles that substantiate the characteristics and performance of the approaches developed, (2) the demonstration of new products or techniques for saving energy and improving IAQ, (3) updates to professional and consensus documents (such as ASHRAE Standards and Handbook), (4) information that can be used in future Title 24 for new and existing homes, and (5) retrofit guidance documents.

1.2 Research Background

As California looks to reduce its carbon footprint, the buildings sector has an important role to play. Increasing energy efficiency for both new and existing homes is a key part of any strategy for reducing fossil fuel consumption. California regulations and incentive programs continue to make strides at changing the industry.

Air sealing and air-tight construction have been proven to be able to provide substantial energy reductions. A key barrier to implementation of these approaches is the impact that they would have on indoor air quality. Mechanical ventilation, as is currently required in Title 24, can provide acceptable IAQ but at an energy cost. Research is needed to optimize the solution to these twin problems. This issue is recognized broadly at the national and international level. RESAVE leverages much of that work and helps focus it on the needs of California.

Pieces of this RD&D are going on around the world, but the specifics in this program are not. The current standards, codes, and guidelines being used in California are themselves relatively new for the State, but they also only represent a first (albeit major) step toward very low-energy, high-quality indoor climates for California residences.

There are existing technologies can meet the current minimum requirements. Advance controls, air-tightness and system integration of the type developed in this program can allow those requirements to be met more efficiently. Understanding the impact of the current requirements can allow performance-based alternatives that can further reduce energy requirements.

Air-tightness and ventilation need ultimately to be included in a whole-building approach to reducing energy requirements. The results of this work should be used for taking that next step to full building specific ventilation system integration

1.3 Link to the PIER Program

RESAVE was funded by a Public Interest Energy Research (PIER) solicitation (resulting in contract #CEC-500-08-061) and was designed to address focus areas of the PIER energy efficiency program. Because this program focused on the cross-cutting issue of reducing the energy impact of air leakage and providing acceptable IAQ, the program addresses several target areas of research of interest to the PIER efficiency program.

RESAVE supports the *Building Envelope* target area because it looks at the quality of construction of the building envelope with respect to both air tightness and contaminant emissions from the building. Insufficient air tightness wastes energy by allowing excess infiltration, and high contaminant emissions from materials may require excessive ventilation. These issues, along with occupant use of building systems, are addressed in Chapters 2 and 3.

The RESAVE program supports the *HVAC Controls and Diagnostics* target area because it looks at ventilation equipment, systems, and controls for providing acceptable indoor air quality. Smart ventilation systems that can make use of knowledge about the way the building and its systems are operating, and they can substantially reduce the energy use associated with the designed ventilation. This topic is primarily addressed in Chapter 4.

The program also supports the *Codes and Standards Support, Information Resources and Market Connections* target area because at every step of the program the RD&D is connected to market players. Chapter 5 focuses on making changes to existing codes and standards (including both Title 24 and ASHRAE Standard 62.2), as well as providing explicit guidance to market implementers. In addition, RESAVE has market players, including cost-sharing manufacturers, as integral participants. The integrated nature of the manufacturers' participation assures that the information generated in the program will be presented in a way that is more likely to be adopted by industry and to address industry concerns.

Although there is cost-sharing from private-sector parties, all benefits generated by RESAVE are public benefits. These benefits will appear through improved codes and standards, public domain implementation guidelines, and technical publications in the open literature, as well as through new technologies (e.g., RIVEC). This output of RESAVE will facilitate the generation of subsequent public and private research that will provide specific technologies to reduce the energy and peak power consumptions associated with infiltration and mechanical ventilation.

1.3.1 Relationship to PIER Goals

The RESAVE program meets the PIER goal of advancing market adoption of research products by encouraging projects which are technically feasible, potentially cost effective, and which have paths to the market through relationships with manufacturers, customers, builders, regulators, and other market participants. This research will advance California Title 24 and facilitate the objective of zero-energy buildings. RESAVE output supports AB 32,¹ and this agreement is consistent with the California Public Utilities Commission's "Big Bold" strategies.

1.3.1.1 Goals of the Research

The RESAVE program's goal was to facilitate the substantial reduction of energy spent in homes to condition air that enters from outdoors. The RD&D attempted to achieve this goal by (1) finding methods and approaches that improve air tightness, (2) determining methods of incorporating source control features in such a way that whole-house ventilation can be reduced, and (3) developing and evaluating procedures and technologies for providing the required whole-house ventilation more energy efficiently, while lowering peak demand.

To facilitate implementation of that RD&D, RESAVE worked to advance relevant codes and standards (including Title24 and ASHRAE Standard 62.2), worked directly with industry to develop practical solutions, and to help industry players readily adopt them, and created information products and direct assistance that allows implementation through voluntary programs.

1.3.1.2 Objectives of the Research

The programmatic objectives of RESAVE were to facilitate the following:

- Eliminate energy demand due to ventilation during four peak hours of each day
- Reduce energy attributable to infiltration by 25 percent in existing homes and 50 percent in new homes
- Reduce the need for whole-house ventilation by 20 percent using contaminant control measures
- Increase the number of quality ventilation and ventilation control technologies by 50 percent
- Improve the energy and/or IAQ performance of existing ventilation strategies by 20 percent using control and commissioning strategies

RESAVE focused on providing information that is helpful in setting standards and providing enabling technologies, approaches and methods. The outputs are primarily information products, including technical reports, potential upgrades to Title 24, and retrofit/commissioning guides.

¹ The Global Warming Solutions Act of 2006. Assembly Bill 32 (Nuñez), Chapter 488, Statutes of 2006.

1.4 Structure of this Report

This report summarizes and documents the findings of the RESAVE program. Chapter 1 provides the background for why the program was important to California and why PIER funded it.

Chapters 2 through 5 summarize the program's technical results. The details of the activities are contained in the various RESAVE technical products, which are referenced in those chapters. The product list is at the end of this report. The chapters are as follows:

- Chapter 2 focuses on the air tightness research. The biggest effort in that area was the creation of an air leakage database. The data were used to determine the stock characteristics of home air-tightness and associated impacts. The researchers also analyzed potential air-tightness measurement techniques for use in multizone (e.g., multifamily) buildings.
- Chapter 3 focuses on key contaminants inside homes. This effort sought to find a short list of key contaminants and to discuss source control methods. Cooking is a major source of indoor contaminants and is discussed.
- Chapter 4 focuses on ventilation systems. Detailed simulations of extant and proposed ventilation systems were conducted to determine optimal paths. The research also investigated a smart ventilation controller and passive ventilation systems. The role of commissioning ventilation systems is discussed.
- Chapter 5 focuses on getting the research results generated in the previous chapters into the hands of institutions that can make use of them. It describes the activities of the program's industry partners and the work with industry and professional groups to implement RESAVE results.

Chapter 6 summarizes the conclusions and recommendations.