

RAND

Science and Technology Policy Institute

BUILDING BETTER HOMES

*Government Strategies for Promoting
Innovation in Housing*

SCOTT HASSELL

ANNY WONG

ARI HOUSER

DEBRA KNOPMAN

MARK BERNSTEIN

Prepared for the
U.S. Department of Housing and Urban Development (HUD)
Office of Policy Development and Research and
the Partnership for Advancing Technology in Housing (PATH)

The research described in this report was conducted by RAND's Science and Technology Policy Institute for the U.S. Department of Housing and Urban Development (HUD) Office of Policy Development and Research and the Partnership for Advancing Technology in Housing (PATH), under contract number ENG-9812731.

Library of Congress Cataloging-in-Publication Data

Building better homes : government strategies for promoting innovation in housing /
Scott Hassell ... [et al.].
p. cm.
"MR-1658."
Includes bibliographical references and index.
ISBN 0-8330-3332-8 (pbk.)
1. Housing policy—United States. I. Hassell, Scott, 1974–.

HD7293.B825 2003
333.33'8'0973—dc21

2002155749

RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis. RAND® is a registered trademark. RAND's publications do not necessarily reflect the opinions or policies of its research sponsors.

© Copyright 2003 RAND

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from RAND.

Published 2003 by RAND

1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

1200 South Hayes Street, Arlington, VA 22202-5050

201 North Craig Street, Suite 202, Pittsburgh, PA 15213-1516

RAND URL: <http://www.rand.org/>

To order RAND documents or to obtain additional information,
contact Distribution Services: Telephone: (310) 451-7002;

Fax: (310) 451-6915; Email: order@rand.org

PREFACE

This study was prepared in response to a request from the U.S. Department of Housing and Urban Development (HUD) Office of Policy Development and Research and the Partnership for Advancing Technology in Housing (PATH).

This report describes the importance of innovation in the U.S. housing industry, discusses the factors affecting such innovation, summarizes past efforts by the federal government to promote innovation, and suggests strategies that the federal government should consider to increase the rate of innovation in housing. The report was prepared for a broad audience including federal, state, and local government officials, participants in the homebuilding process, and those interested in better promotion and acceleration of innovation in housing.

Originally created by Congress in 1991 as the Critical Technologies Institute and renamed in 1998, the Science and Technology Policy Institute is a federally funded research and development center sponsored by the National Science Foundation and managed by RAND. The institute's mission is to help improve public policy by conducting objective, independent research and analysis on policy issues that involve science and technology. To this end, the institute

- supports the Office of Science and Technology Policy and other Executive Branch agencies, offices, and councils
- helps science and technology decisionmakers understand the likely consequences of their decisions and choose among alternative policies

- helps improve understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives. In carrying out its mission, the institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

Inquiries regarding the Science and Technology Policy Institute may be directed to the addresses below.

Helga Rippen
Director
Science and Technology Policy Institute

Science and Technology Policy Institute

RAND

1200 South Hayes Street

Arlington, VA 22202-5050

Tel: (703) 413-1100, ext. 5574

Web: <http://www.rand.org/scitech/stpi>

Email: stpi@rand.org

CONTENTS

Preface	iii
Figures	ix
Tables	xi
Summary	xiii
Acknowledgments	xix
Acronyms	xxi
Chapter One	
INNOVATION IN HOUSING	1
The Benefits of Innovation in Housing	2
Challenges to Innovation in the Housing Industry	4
Federal Government Support of Housing Innovation	4
Objective of the Study	5
Methodology	6
Report Organization	7
Chapter Two	
THE CONCEPT OF INNOVATION IN THE U.S. HOUSING INDUSTRY	9
The State of Innovation in Housing	9
Definitions	10
The Standard Model: Innovation as a Linear Process	11
A Better Model	12
Industry-Independent Limitations	13
Housing-Specific Limitations to the Linear Model	15

The Expanded Nonlinear Model of Housing Innovation	16
Motivations for Supporting and Adopting Innovation	17
Decisionmaking in the Innovation Process	19
Social and Historical Dimensions to Innovation	21
Participants in the Deployment Phase	22
Participants in the Invention, Development, and Demonstration Phases	23
Applying Innovation Concepts to Housing	23
Chapter Three	
THE U.S. HOUSING INDUSTRY AS THE CONTEXT FOR INNOVATION	25
What Is the U.S. Housing Industry?	25
Housing Stock, New Construction, and Remodeling	26
Overview of the Homebuilding Process	28
Land Development	28
Design	31
Pre-Construction	33
Construction	36
Post-Construction	37
The Homebuilding Process and Its Implications for Innovation	40
Chapter Four	
INDUSTRY CHARACTERISTICS AND MOTIVES AND THEIR EFFECT ON INNOVATION	41
Industry Characteristics and Their Effect on Innovation	41
Low Barriers to Entry Make the Housing Industry Highly Competitive	41
Cyclical Business Cycles Lead to Low Investment in Employees and Training	42
The Majority of Single-Family Homes Are Built by Small and Medium-Size Homebuilders	43
Fragmentation Slows Information Sharing and Innovation Acceptance	46
Benefits of Innovations Are Often Hard to Protect	48
Participants Motives Toward Innovation	49
Land Development	50
Design	53

Pre-Construction	54
Construction	56
Post-Construction	58
Implications for Innovation	62
Chapter Five	
FEDERAL EFFORTS TO PROMOTE INNOVATION IN HOUSING	63
Evolution of the Federal Approach to Innovation	63
Broad-Based Federal Efforts to Promote Innovation	64
Federal Support of Research and Development	65
Expanding Support for Innovation Beyond R&D	66
Systematic Efforts to Promote the Innovation Process	66
Targeted Federal Efforts to Promote Innovation in Housing	68
Federal Support of Housing R&D	68
Additional Support for Housing Innovation	71
Systematic Efforts to Support and Accelerate Innovation in Housing	73
Summary	80
Chapter Six	
FEDERAL STRATEGIES FOR PROMOTING INNOVATION IN HOUSING	83
Structuring Strategies to Improve Innovation	83
Enhance Research Activities	85
Sustained Research Support	85
Strengthen the Knowledge Base	85
Support Networking Across Horizontal and Vertical Boundaries	85
Coordinate Government Efforts	86
Search and Disseminate Information on Relevant Federal R&D	87
Support Education and Training	87
Support the ID3 Pipeline	88
Support Exploratory and Applied Research for Technology Transfer	88
Modify the Research and Experiment Tax Credit for Small Firms	89
Support Development and Demonstration	89
Explain the Regulatory Process to Innovators	90

Provide Technical and Standard Development Support	90
Public Procurement	90
Improve Market Linkages	91
Help Identify Market Trends and Opportunities	91
Support Product Performance Monitoring and Evaluation	91
Reward Important Innovations with Valuable Recognition	92
Create Linkages Among Markets	92
Create Financial Incentives for End Users	93
Conclusions	94
Bibliography	97

FIGURES

S.1. Innovation as the Invention, Development, Demonstration, and Deployment Process	xvi
2.1. A Linear Model of the Innovation Process	11
2.2. Our Model of the Innovation Process	16
2.3. Forces for Adoption and Diffusion over Time	19
2.4. Participants and the Innovation Process	20
3.1. Housing Stock and Housing Completions, 1999	27
3.2. The Homebuilding Process	28
3.3. The Land Development Stage	29
3.4. The Design Stage	31
3.5. The Pre-Construction Stage	34
3.6. The Construction Stage	36
3.7. The Post-Construction Stage	38
4.1. Single-Family Homebuilding Firms by Number of Employees and by Annual Value of Residential Construction Put in Place, 1997	44
5.1. Federal FY 1999 Investments in Housing-Related R&D	69
6.1. Key Components of the Housing Innovation Process	84

TABLES

S.1. Strategies for Promoting Innovation in Housing	xvii
5.1. Overview of Federal FY 1999 Investments in Housing- Related R&D	70

This report examines the structure, characteristics, and motivations of major participants in the housing industry to explore how innovation might be improved or accelerated within the industry as it currently exists. This approach recognizes that the housing industry is large and complex and changing any part would be difficult and changing the whole practically impossible. In this context, the report identifies options and strategies for the federal government to consider as it continues to further advance innovation in housing to make homes more affordable, durable, and safe for their occupants and builders, and to provide other benefits to society.

INNOVATION IS IMPORTANT TO THE U.S. HOUSING INDUSTRY

There have been many significant housing innovations in the last 100 years. Notable examples include the introduction of electricity and air conditioning, standardized building products such as 2x4 plywood boards, and factory-made components including roof trusses and kitchen cabinets.

These innovations have changed what homes are made of, how they are built, how they perform, who can afford them, and how well they serve their occupants. As a result of these improvements—referred to as *innovations* in this report—housing has improved significantly for most people and for the nation’s quality of life in general.

Innovation in housing has important economic ramifications. The U.S. housing industry represents nearly 20 percent of the nation’s

gross domestic product. It includes millions of people who design, build, finance, furnish, and maintain the nation's housing stock. It also represents the value of more than 115 million homes currently in stock and the nearly two million new units built each year.¹ In short, housing is the largest component of the nation's physical wealth. Perhaps even more important, homes are the largest expenditure in most household budgets and a home is usually the most valuable asset a family owns.

The assertion that the rate of innovation in housing has slowed or is slow compared to that in other industries is not uncommon among industry and other entities. However, there is no consensus on this claim, and a lack of data makes it difficult and perhaps impossible to verify.

Regardless of whether the rate of innovation in housing has slowed or is slower than that in other industries, innovation contributes positively to increase productivity and provide other benefits to all who are involved in housing. This would include a broad range of housing industry participants from homebuilders to manufacturers, insurers, regulators, homeowners, and others.

ACCELERATING INNOVATION IN THE CURRENT INDUSTRY CONTEXT

Concern for innovation in housing has prompted industry, government, and researchers to find ways to accelerate it in the housing industry. Driven by an implicit (and sometimes explicit) assumption that innovation is a natural occurrence, held back only by certain obstacles, many workshops, roundtables, surveys, research, and other efforts have tried to identify barriers to innovation and ways to overcome them. These efforts often end up pointing to certain structures and characteristics of the industry as barriers and recommending a range of actions, including government intervention and industry reform, to eliminate them and make way for innovation.

¹"Homes" in this study include both single- and multifamily housing units. Hence, homes or housing units include houses, apartment buildings, condominiums, townhouses, and manufactured homes among others.

That such prescriptions have not led to a higher rate of innovation or more innovations in the housing industry is not entirely surprising. Indeed, many industry features can affect innovation, including the following:

- Its highly competitive nature may deter industry participants from adopting innovations because they want to minimize risks.
- The boom-bust cycles lead to low investment in employees and training to prepare them for innovation.
- Dominance of the housing industry by small and medium-size homebuilders means that few have the resources to innovate.
- The fragmented nature of the industry slows information sharing and innovation acceptance.
- Construction is done in the open and the process involves a variety of independent actors so it is difficult for innovators to protect innovations (as intellectual properties) and exploit their competitive advantages long before others copy and use them.

However, designating these and other industry characteristics as barriers for removal may not be the best way to promote innovation, because the housing industry is large and complex, involving many public and private entities. The interests, roles, and capacities of each participant and the relationships they share have shaped the housing industry into what it is today and changing certain industry structures and characteristics means asking participants to change as well. For such a large and complex industry, any change in parts would be difficult and any change in its entirety would be practically impossible.

For this reason, this study takes a different approach to exploring how innovation might be accelerated in the housing industry. Instead of trying to identify barriers and asking the industry to change itself (or asking the government to change it), this study seeks to identify options to accelerate innovation within the housing industry as it currently exists. It begins by critically examining the concept of innovation and how it might be better understood within the context of the housing industry. What results is a departure from the linear model of innovation that assumes logical and unidirectional movement from research to development, demonstration, and deploy-

ment to one that recognizes much greater interactive dynamics in the innovation process. Research, in this model, is a base for knowledge, which contributes to invention, development, demonstration, and deployment. Moreover, all these activities or stages in the innovation process are affected by market forces. Therefore, whether an innovation emerges and goes through the innovation process and results in widespread adoption is not an automatic or natural progression (see Figure S.1).

To better explore how this model to understanding innovation might find application in the housing industry, this study then examines the structure and characteristics of the housing industry and the motivations that might drive industry participants to accept or reject innovation.

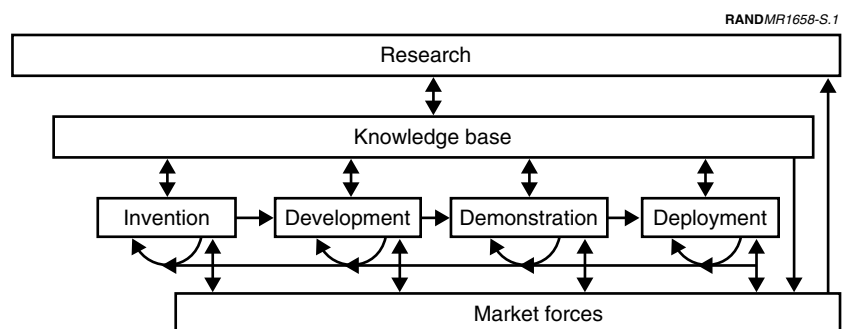


Figure S.1—Innovation as the Invention, Development, Demonstration, and Deployment Process

PROPOSALS FOR FEDERAL GOVERNMENT ACTION

Since the federal government has an interest in increasing innovation in housing, specific options for federal action are put forth. These proposals are made with full appreciation of the federal government’s involvement in innovation in housing over the past 30 years. Investment in research for this study indicates a commitment to increasing innovation in housing and willingness to experiment with new ideas and approaches as the federal government works with industry and other interested participants.

These proposals are divided into four categories:

- enhance research activities,
- strengthen the knowledge base,
- support product development, and
- improve market linkages.

Under each category are a number of strategies for federal consideration (see Table S.1). These strategies are not exhaustive or exclusive. They are meant to illustrate actions for consideration. It was beyond the scope of this study to take the next step—to examine cost-effectiveness or how one strategy might work with another.

These potential strategies could enable the federal government to advance innovation by better leveraging what it is already doing and

Table S.1

Strategies for Promoting Innovation in Housing

Enhance Research Activities

Sustain support for research

Strengthen the Knowledge Base

Support networking across horizontal and vertical boundaries

Coordinate government efforts

Search for and disseminate information on relevant federal R&D

Support education and training

Support Product Development

Support exploratory and applied research for technology transfer

Modify the research and experiment tax credit for small firms

Support development and demonstration

Explain the regulatory process to innovators

Provide technical and standard development support

Use public procurement

Improve Market Linkages

Help identify market trends and opportunities

Support product performance monitoring and evaluation

Reward important innovations with valuable recognition

Create linkages between markets

Create financial incentives for end users

what currently exists in the housing industry. In short, these strategies would focus resources on doing what is possible and practical to achieve measurable success.

ACKNOWLEDGMENTS

The authors would like to thank many individuals in the private sector, government, and academia who shared their time and insights during the past three years. Their assistance helped us to better understand the housing industry and its many participants, perspectives, and challenges. In particular, we would like to thank Carlos E. Martin and David Engel of the U.S. Department of Housing and Urban Development; John Talbott of the U.S. Department of Energy; Andy Fowell, previously of the National Institute of Standards and Technology; David Dacquist, Ross Heitzmann, and Larry Zarker; and David Conover of the National Evaluation Service.

We would also like to thank those who reviewed and critiqued this report, in particular, William Butz and David Adamson of RAND and Ronald Wakefield of Virginia Polytechnic Institute and State University. Finally, we thank Heather Roy for her help in preparing the manuscript.

ACRONYMS

AHTP	Advanced Housing Technology Program
ATP	Advanced Technology Program
CRADA	Cooperative Research and Development Agreement
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
EEM	Energy Efficiency Mortgage
EIFS	External Insulation Finishing Systems
EPA	Environmental Protection Agency
GDP	Gross domestic product
HUD	U.S. Department of Housing and Urban Development
HVAC	Heating, ventilating, and air-conditioning
IBHS	Institute for Business and Home Safety
ICC	International Code Council
ICF	Insulating concrete forms
ID3	Invention, development, demonstration, and deployment
IOF	Industries of the Future
IT	Information technology
MEP	Manufacturing Extension Program
NAHB	National Association of Home Builders
NIST	National Institute of Standards and Technology

NSF	National Science Foundation
NSTC	The National Science and Technology Council
PAIR	Partnership for the Advancement of Infrastructure and Its Renewal
PATH	Partnership for Advancing Technology in Housing
PCAST	President's Council of Advisors on Science and Technology
R&D	Research and Development
RDDD or RD3	Research, development, demonstration, and deployment
SBIR	Small Business Innovation Research