



INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND
HOMELAND SECURITY
TRANSPORTATION AND
INFRASTRUCTURE
WORKFORCE AND WORKPLACE

This PDF document was made available from www.rand.org as a public service of the RAND Corporation.

[Jump down to document](#) ▼

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world.

Support RAND

[Purchase this document](#)

[Browse Books & Publications](#)

[Make a charitable contribution](#)

For More Information

Visit RAND at www.rand.org

Explore [RAND Infrastructure, Safety, and Environment](#)

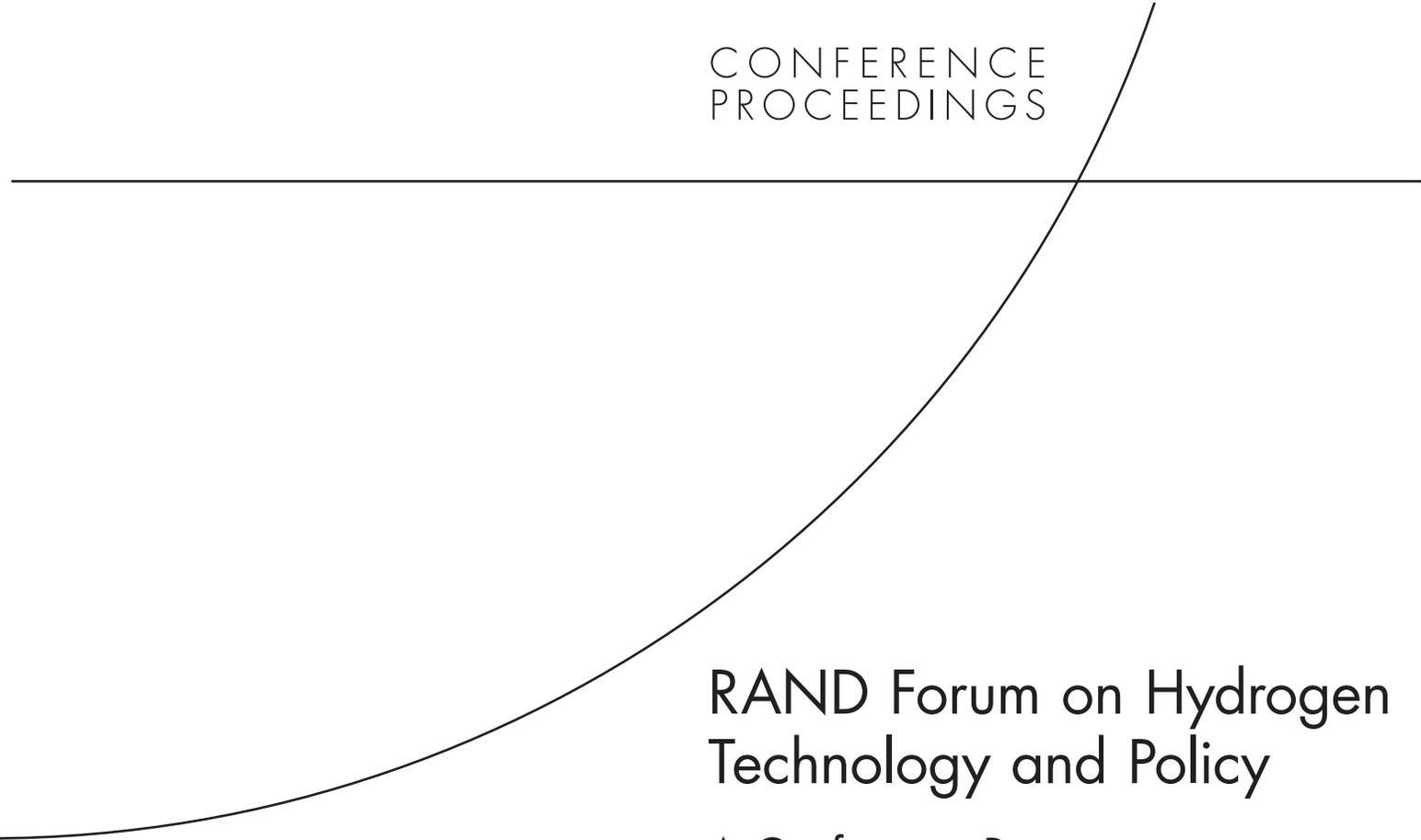
View [document details](#)

Limited Electronic Distribution Rights

This document and trademark(s) contained herein are protected by law as indicated in a notice appearing later in this work. This electronic representation of RAND intellectual property is provided for non-commercial use only. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use.

This product is part of the RAND Corporation conference proceedings series. RAND conference proceedings present a collection of papers delivered at a conference. The papers herein have been commented on by the conference attendees and both the introduction and collection itself have been reviewed and approved by RAND Science and Technology.

CONFERENCE
PROCEEDINGS



RAND Forum on Hydrogen Technology and Policy

A Conference Report

Mark A. Bernstein



INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

The research described in this report was funded by a consortium of companies and institutions interested in hydrogen technology and uses.

0-8330-3817-6

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

RAND[®] is a registered trademark.

© Copyright 2005 RAND Corporation

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 2005 by the RAND Corporation
1776 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

Summary

In recent years, hydrogen has drawn much attention due to its potential large-scale use in producing electrical energy through stationary fuel-cell technologies and in replacing gasoline for use in transportation. Among the advantages of hydrogen are its abundance and its ability to produce electricity in some applications with virtually no harmful emissions. Among its disadvantages are that it cannot be used without being transformed through a series of processes that require a significant energy input.

Decisionmakers in the public and private sectors do not have all the information they need for determining whether to invest in hydrogen research or to make investments in the infrastructure that would be needed to use hydrogen as a source of energy. Decisionmakers also lack information to help them decide whether to formulate policies that will hasten the development of hydrogen as a viable energy source.

This report provides an overview of the discussions that took place during a daylong forum on December 9, 2004, that was hosted and organized by the RAND Corporation. The forum was intended to facilitate open discussion of issues related to making hydrogen a viable alternative energy source and to describe a set of analyses and actions that are needed in the public and private sectors to improve decisionmaking on investments in hydrogen. The forum was in the format of a facilitated discussion. Each session of the forum started with a stated goal for the session or a question or anecdote to prompt discussion, and the floor was then opened for dialogue.

Potential Benefits of Hydrogen for Further Evaluation

A major conclusion drawn by forum participants was that while studies have been done on hydrogen technology, and policy papers have discussed numerous possible benefits that might accrue from the introduction of hydrogen as an energy carrier, some benefits of hydrogen have not been adequately addressed either in quantitative analyses or in policy discussions. (Hydrogen is referred to as an *energy carrier* because, like electricity, it needs to be made from a primary energy source, such as natural gas.)

The forum discussion was framed in the context of whether private-sector companies or the government should make investments in hydrogen research, development, and deployment. While forum participants did not address the costs of hydrogen, they identified the following potential benefits of hydrogen, which warrant further examination and assessment:

- Introducing hydrogen as an alternative energy source could add diversity to the supply of transportation fuels, thereby making the United States less dependent on petroleum and making fuel costs more stable and predictable.
- If hydrogen-based fuel cells were put to use generating electricity on a small scale close to areas where electricity is needed, the burden on the current electric grid—the system that generates and distributes electricity—could be eased.
- If renewable energy is used to make hydrogen, fuel cells could provide a means of storing renewable electricity—something that cannot be done today.
- If communities and companies had the ability to generate their own electricity via small fuel cells using renewable energy to make hydrogen, they could fulfill their energy needs locally and would not have to depend as much on imported energy.
- Private companies that develop innovative technologies for using hydrogen as an alternative energy source have the potential to become highly profitable, world-class technology leaders.
- Developing nations that put hydrogen to work right away could leapfrog over the environmentally destructive practices that have occurred in other countries.
- Reducing the use of petroleum could also reduce the environmental impacts of exploring for, producing, transporting, and refining petroleum, including the potential contamination of groundwater and surface water.

Risks of Inaction Perceived as Being Substantial

In addition to the benefits that might accrue from making investments in hydrogen, the participants concluded that there are significant risks in *not* making investments in hydrogen. While the participants pointed out that there are risks in making too large an investment too quickly, they believed that the risks from no action are greater than those from some action for various scenarios of the future. The group cited risks to the environment (both locally, in terms of pollution, and globally, in terms of climate change) as the most significant risks, followed by economic risks, of not taking actions to invest in hydrogen. These risks derive from the increasing costs associated with mitigating growing environmental problems, but also from the possibility that other countries will take the technological lead in hydrogen and renewable technologies, causing U.S. companies to lose economically. Additional risks include dependence on a single source of energy for transportation and risks from potentially reduced reliability of the electricity supply.

Hurdles to Implementing Hydrogen as an Energy Carrier

The discussions among forum participants frequently returned to the subject of the need to understand basic hydrogen infrastructure issues. That is, what will it take to make hydrogen work as an energy carrier or source of electricity? While the group acknowledged that there were technology hurdles to cross before hydrogen could be implemented as a transportation or electricity energy source, the general feeling among the group was that those hurdles could be overcome and that it would not take very long to do so. On the other hand, some other significant issues were identified that may not be so easily addressed:

- The question of who is going to pay for the hydrogen development activity that needs to occur between the research phase (which might be funded primarily by the government) and commercial deployment (which would consist of investments by the private sector)
- Lack of a coherent energy policy, which will hinder investments in hydrogen
- Regulatory roadblocks to introducing hydrogen
- Perception problems with hydrogen—primarily regarding the safety of hydrogen (on the part of the public) and regarding market opportunities (on the part of the private sector)
- Lack of a consistent set of economic metrics to value hydrogen that are needed to produce robust cost-benefit estimates.

Going Forward

When decisions concerning major technological transitions are on the horizon, they can often be informed by lessons learned during similar transitions in the past. Participants cited lessons to be learned from past efforts to ramp up biomass fuel programs (the use of organic matter to produce heat energy) and natural gas fuel programs, but also noted that the transition to hydrogen may substantially differ from those earlier experiences. Participants discussed the possibility that lessons may be learned from technological transitions in other markets—e.g., computers, compact disks, and MP3 players. Technology-diffusion paradigms may be shifting, participants observed, and technical specialists and decisionmakers need to incorporate these new paradigms in their assessments of how a transition to hydrogen might occur.

A consistent message from forum participants expressing a public-policy point of view was that hydrogen as an energy source could provide substantial benefits for California and for the United States as a whole. Participants said that more information is needed to help policymakers determine what role the government should, or should not, play in furthering the development of hydrogen. The U.S. Department of Energy's Hydrogen Posture Plan and the California Hydrogen Highway Blueprint Plan are both good jumping-off points for the development of hydrogen, but participants pointed out that the transition to hydrogen will not happen unless more robust, more objective, and more transparent information is made available to public- and private-sector decisionmakers. There is clearly a role that the public sector can play in assisting in the development of this information.

The private sector needs to better understand the prospects for hydrogen energy and the value of investments in hydrogen, and its investment decisions need to reflect an understanding of the risks associated with current patterns of energy use. Participants said that it is critically important for companies that are already engaged in the development of hydrogen-use technologies to demonstrate that the technologies are reliable and that they have the ability to warranty their "product," thereby reassuring the financial community of the viability of hydrogen.

There seemed to be general agreement that sooner is better than later for the public and private sectors to invest in hydrogen as an energy carrier. While there were differing opinions on how large the hydrogen energy market would be today, the general opinion was that sufficient technological improvements have been made in the past few years to make the

hydrogen energy marketplace viable for commercial development. However, the development of hydrogen energy needs a boost from government, and policymakers still need convincing to move aggressively forward on hydrogen policy, participants observed. Policymakers need more information on the unique potential benefits of hydrogen, the new opportunities for investments and jobs, and how a portfolio of policies and investment options can meet short-term and long-term goals for policy actions. While hydrogen as an energy carrier is not the only new technological and market opportunity available to investors, participants said that hydrogen, nevertheless, should be a significant part of the U.S. public and private investment portfolio.