



# RAND-QATAR POLICY INSTITUTE

- CHILDREN AND FAMILIES
- EDUCATION AND THE ARTS
- ENERGY AND ENVIRONMENT
- HEALTH AND HEALTH CARE
- INFRASTRUCTURE AND TRANSPORTATION
- INTERNATIONAL AFFAIRS
- LAW AND BUSINESS
- NATIONAL SECURITY
- POPULATION AND AGING
- PUBLIC SAFETY
- SCIENCE AND TECHNOLOGY
- TERRORISM AND HOMELAND SECURITY

The RAND Corporation is a nonprofit institution that helps improve policy and decisionmaking through research and analysis.

This electronic document was made available from [www.rand.org](http://www.rand.org) as a public service of the RAND Corporation.

Skip all front matter: [Jump to Page 1](#) ▼

## Support RAND

[Purchase this document](#)

[Browse Reports & Bookstore](#)

[Make a charitable contribution](#)

## For More Information

Visit RAND at [www.rand.org](http://www.rand.org)

Explore the [RAND-Qatar Policy Institute](#)

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. Unauthorized posting of RAND electronic documents to a non-RAND website is prohibited. RAND electronic documents are protected under copyright law. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please see [RAND Permissions](#).

This product is part of the RAND Corporation monograph series. RAND monographs present major research findings that address the challenges facing the public and private sectors. All RAND monographs undergo rigorous peer review to ensure high standards for research quality and objectivity.

# Recommended Research Priorities for the Qatar Foundation's Environment and Energy Research Institute

---

Nidhi Kalra, Obaid Younossi, Kristy N. Kamarck, Sarah Al-Dorani, Gary Cecchine, Aimee E. Curtright, Chaoling Feng, Aviva Litovitz, David R. Johnson, Mohammed Makki, Shanthi Nataraj, David S. Ortiz, Parisa Roshan, Constantine Samaras

Sponsored by the Qatar Foundation for Education, Science,  
and Community Development



RAND-QATAR POLICY INSTITUTE

This research was sponsored by the Qatar Foundation for Education, Science, and Community Development and was conducted in the RAND-Qatar Policy Institute and the Environment, Energy, and Economic Development Program within RAND Infrastructure, Safety, and Environment.

**Library of Congress Cataloging-in-Publication Data** is available for this publication

ISBN: 978-0-8330-5820-1

The RAND Corporation is a nonprofit institution that helps improve policy and decisionmaking through research and analysis. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

**RAND®** is a registered trademark.

*Cover image courtesy of iStockphoto/fleag. Used with permission.*

© Copyright 2011 RAND Corporation

Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Copies may not be duplicated for commercial purposes. Unauthorized posting of RAND documents to a non-RAND website is prohibited. RAND documents are protected under copyright law. For information on reprint and linking permissions, please visit the RAND permissions page (<http://www.rand.org/publications/permissions.html>).

Published 2011 by the RAND Corporation

1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

1200 South Hayes Street, Arlington, VA 22202-5050

4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665

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](mailto:order@rand.org)

# Summary

---

## Purpose

Qatar is developing and growing rapidly. Its rich fossil fuel resources have enabled high economic growth in the past several decades. Today, it has one of the highest gross domestic products (GDPs) based on purchasing power parity per capita in the world.<sup>1</sup> Qatar also has a rapidly growing population.<sup>2</sup> Qatar has invested heavily in developing its national infrastructure, human capital, and social and cultural institutions.

Simultaneously, population growth and industrial development have increased Qatar's energy, water, and other resource needs substantially and threaten its environmental sustainability. In response, Qatar's leadership has created a vision of sustainable development for the country.<sup>3</sup> QF is moving this vision of sustainable development forward in part by establishing a national research institute that conducts and collaborates on applied research in energy, environment, and water issues.<sup>4</sup>

---

<sup>1</sup> International Monetary Fund, 2010.

<sup>2</sup> In 1960, Qatar's population was estimated to be only 45,000 people. By 2009, its population had grown more than 3,000 percent, to 1.4 million. This growth partly reflects a large influx of expatriates into the country (World Bank, undated).

<sup>3</sup> General Secretariat for Development Planning, undated (b).

<sup>4</sup> The Qatar Foundation is a private, chartered, nonprofit organization that addresses education, scientific research, and community development in the country (QF, undated).

To arrive at a better design for the Qatar Environment and Energy Institute, QF asked RQPI to recommend research priorities based on Qatar's needs and goals in these areas. These research priorities will help QF develop a research portfolio for the institute and frame an approach for shaping that portfolio over time.

These profiles will help QF identify areas in which there might be gaps or duplication in research areas, and the profiles would form the basis for exploring collaboration opportunities. This monograph presents the methodology and findings of our work.

## Approach

This research was undertaken in two phases. In phase 1 of the project, RQPI surveyed the Gulf countries and existing literature to identify major research institutions in the GCC member states, areas of research on energy and the environment being conducted or planned by these institutions, and research programs funded by the GCC states undertaken outside of the GCC.

Phase 2 identified priority research areas for Qatar, focusing on the most important and promising in light of Qatar's unique challenges and resources. It drew on phase 1 work to identify opportunities for collaboration in the GCC and beyond in each of these areas.

Recognizing that there is a large and growing body of research in this area, as part of this endeavor, QF asked RQPI to survey the Gulf region to profile institutions engaged in energy and environment research. We undertook phase 2 in six steps and drew heavily on different expert panels, operating independently of each other, from RAND and Carnegie Mellon University (CMU). Steps 1–3 laid the groundwork for identifying priority research topics. In step 1, we generated a collection of research topics that could be considered for Qatar's institute. In step 2, we identified Qatar's energy, environment, and water situation, including goals and challenges. In step 3, we established the criteria by which topics should be assessed and selected. In steps 4 and 5, we brought these three elements together to select 14 priority research topics for the institute and synthesize our

findings. In step 6, we reported on each priority research topic in a detailed white paper.

## **Findings on Environment and Energy Research in the Gulf Cooperation Council**

We identified 15 major institutions in Qatar and the rest of the GCC member states directly engaged in research in energy and the environment. We determined the energy and environment research these institutions are undertaking or planning to undertake. Additionally, growing populations have sharply increased energy demands, making renewable energy sources and energy-efficiency key concerns. Where possible, we assessed missions, the extent to which they collaborated with each other, and other institutional features. We have used these observations to provide guidance for the institute.

### **Gulf Cooperation Council Countries Share Common Resources and Common Concerns**

Countries in the GCC have common resources and concerns that are a result of shared geography, culture, and development. Common natural resources among GCC countries include sunlight, water and fish from the Gulf, crude oil, and natural gas. Sustainability is a shared concern among all GCC countries. The desert climate and regional geology limit the natural supply of freshwater and domestic capacity for food production, making the countries dependent on desalination. They also share a concern for protecting coastal resources from pollution to sustain fish stocks as a food supply. Additionally, growing populations have sharply increased energy demands, making renewable energy sources and efficient energy key concerns. Desert climates, climate change, and expanding populations also raise environmental concerns, such as desertification, which further reduces agricultural output. Environmental health, particularly air quality, is a concern due to rapid industrial expansion and high levels of particulate matter in the air.

### **Gulf Cooperation Council Institutions Are Engaged in a Range of Research Activities to Address These Concerns**

The institutions we reviewed engage in a range of energy, water, and environment research to address these challenging issues. There are many common areas of research across countries and institutions. Common energy research includes developing solar energy, improving oil and natural gas recovery and reservoir management, developing carbon capture and storage (CCS), and using energy more efficiently with green buildings and smart grids. Water research largely focuses on desalination, increasing water efficiency, and wastewater management. Environmental research addresses air quality, marine and coastal environments, and conservation and rehabilitation. The research in the region addresses these issues through technology development, policy analysis, and resource management. Activities also range from basic science to applied research to commercialization of technologies. Also, many of the institutions we surveyed have a broader mandate than managing a research portfolio. Some are also involved in funding and policymaking.

### **Like Others, Qatar's Institute Should Take a Multidisciplinary Approach**

Real-world energy and environment challenges are multidisciplinary. Accordingly, many of the institutions that we contacted take a multidisciplinary approach to research and study through multidisciplinary degree programs or integrated centers of excellence. We recommend that the institute similarly take an intentionally multidisciplinary approach to its research and focus its work around problem statements or topical centers of excellence. Additionally, there might be opportunities for the institute to collaborate with QF's two other research centers: the Qatar Biomedical Research Institute and the Qatar Computing Research Institute. In Chapter Seven, we suggest topics for which such cross-institutional collaboration might be appropriate.

### **Common Research Interests and a Shortage of Human Capital Suggest That the Institute Should Collaborate**

The common research interests among GCC institutions leads to some duplication of research. Duplication in critical areas of research could be desirable and lead to faster, better, or more-diverse solutions to energy and environment problems. Although there is a desire for collaboration in the region, actual collaborative efforts between institutions in the GCC and even within countries have been limited. It could also help to build local human capital, which many regard as the biggest hurdle to achieving regional research objectives.

Common research interests and a shortage of human capital suggest a great need for collaboration and coordination among GCC institutions, which could also increase the capacity for quality research. Although there is a desire for collaboration in the region, actual collaborative efforts between institutions within the GCC and even within the same country have been limited.

We recommend that the Qatar Environment and Energy Institute develop relationships with institutions and other scientists in the region. We suggest that QF draw from the GCC Energy and Environment Research Database we have developed to identify potential institutional partners. We also urge QF to develop the institute's research portfolio and programs in close coordination with other institutions in the country and collaborate where possible. This will help avoid duplicate research where it is not needed. Sharing human capital can help avoid competition between institutions, which could be counterproductive to addressing research problems. Along with shared facilities, this can also help the institute undertake research quickly.

### **The Institute Should Seek Input from and Involve the Qatari Government**

Government funding and policymaking are needed to promote research that can have long-term benefits and promote the public good. Additionally, government is a key stakeholder and a potential collaborator for research, particularly in public policy research. Thus, it is important that research institutions and governments align their research priorities and collaborate. In our survey, we found that, although GCC

governments are involved in funding research on energy and the environment, their funding priorities are not always clearly identified or integrated with existing research capabilities.

We recommend that QF seek input from and involve the Qatari government. The Qatari government recently articulated some of its energy and environment priorities in the launch of its *National Development Strategy* for 2011–2016.<sup>5</sup> The institute’s overall research portfolio should be consistent with these and other priorities. Additionally, the institute should engage with government agencies, such as the Ministry of Environment and the Ministry of Energy and Industry, and others to ensure that

- research priorities are aligned in specific areas
- resources allocated to energy and environment research reflect the institute’s capabilities and needs
- research findings reach their intended audience
- the institute and government agencies collaborate.

## Recommendations for Priority Research Topics

We identified 14 priority research topics that QF should consider for the Environment and Energy Institute (see Table S.1). These topics address Qatar’s most-pressing issues in energy production and use, water production and use, and environmental preservation.

### Recommended Topics for Energy Research

Oil and natural gas are Qatar’s critical energy resources, and they are the backbone of Qatar’s economy and its critical industries. Today, Qatar faces important opportunities and challenges in oil and natural gas. Qatar’s oil and gas are limited resources, and Qatar must find ways of using these resources efficiently and to the greatest benefit for its economy and population. Fossil fuels such as these are responsible for approximately 75 percent of global anthropogenic (human-

---

<sup>5</sup> General Secretariat for Development Planning, undated (a).

**Table S.1**  
**Priority Research Topics for Qatar’s Environment and Energy Institute**

Topic Area	Topic
Energy	1. Natural gas production and processing
	2. Petroleum production and processing
	3. CCS
	4. Solar energy development
	5. Fuel cells
	6. Green buildings
	7. Smart grids
	8. Strategic energy planning
Water	9. Desalination
	10. Groundwater sustainability
	11. Water demand management
	12. IWRM
Environment	13. Environmental characterization
	14. Crosscutting environmental research

NOTE: Numbers correspond to topic numbers within this book and are not intended to convey any sense of priority among the topics. IWRM = integrated water resource management .

caused) greenhouse gas (GHG) emissions from the past 20 years. Thus, although fossil fuels remain the primary source of energy globally, demands for clean energy—including clean fossil fuels—are growing. Qatar is seeking ways of responding to these demands. Additionally, as Qatar’s fossil fuel reserves are depleted, Qatar will need alternative, renewable forms of energy.

We recommend that the institute help Qatar address these challenges and capitalize on opportunities by conducting research in several key areas. The institute should improve the production and processing of natural gas and petroleum and help Qatar use CCS to respond to the demand for clean energy. It should develop solar energy to con-

serve these resources and provide an alternative, renewable source of energy, and develop fuel cells to improve electricity generation in the long term. The institute should also conduct research that increases domestic energy efficiency through the use of green buildings and smart grids. Finally, the institute should help Qatar develop a long-term strategic energy plan to help prioritize competing energy issues.

We recommend that the institute conduct research to improve Qatar's *natural gas production and processing* (topic 1). Natural gas has several advantages over other fossil fuels: It burns more cleanly and emits fewer GHGs than other fossil fuels, and natural gas-fired power plants are less expensive to construct and operate than coal-fired power. Because of this, natural gas is already a preferred fuel for electricity generation in the United States and elsewhere. Yet, there are resource, logistical, economic, and environmental challenges to the increased development of natural gas in Qatar. Thus, research should focus on two strategic issues: (1) minimizing emissions of GHGs from natural gas and its derivative products and (2) meeting the growing demand for specialized refined and synthetic products and on improving liquefied natural gas operations.

We also recommend that the institute conduct research to improve *petroleum production and processing* (topic 2). Qatar Petroleum spearheads petroleum research in Qatar. Its research needs and agenda are not public, but it is known that Qatar Petroleum is undertaking research in a wide range of areas, including improving oil and gas operations, environment and climate change, and reservoir engineering and management. We believe that reservoir engineering and management, which includes estimating reserve sizes and developing extraction strategies for high recovery rates, are particularly important for Qatar. The institute should directly and closely collaborate with Qatar Petroleum to identify a complementary research agenda and to execute its research. The institute can play an important role in contributing to long-term, environmentally conscious development and use of Qatar's petroleum resources.

The institute should also research *CCS* (topic 3), the process of capturing carbon dioxide ( $\text{CO}_2$ ) and depositing it in a reservoir for permanent storage. This prevents  $\text{CO}_2$  from contributing to the GHG

effect and makes fossil fuel use more environmentally sustainable. The institute's research should focus on two aspects of CCS most relevant to Qatar. First, research should address the technical and logistical challenges of storing CO<sub>2</sub> in the region, including identifying storage sites and assessing both their long- and short-term stability for containing CO<sub>2</sub>. Second, the institute should initiate research on developing natural gas combustion-specific CCS technologies.

*Solar energy* (topic 4) is a largely untapped resource for Qatar and is its only major source of renewable energy. We recommend that the institute conduct research in four areas: designing hybrid power plants with solar energy and natural gas, advancing solar energy-driven space and water heating and cooling, advancing solar photovoltaics (PV), and improving solar desalination.

*Fuel cells* (topic 5) are electrochemical devices that combine a fuel (such as natural gas) and oxygen to produce electricity. Fuel cells are more efficient than combustion-based methods, using less fuel and emitting fewer GHGs per kilowatt-hour. They use much less water, and, if used to generate electricity at or near the use site, they can reduce or eliminate transmission losses. We recommend that the institute conduct research to reduce the cost of fuel cells and increase their power output without sacrificing their reliability or longevity.

Improving energy sources is an important component of the institute's research agenda, but greater efficiency is also an important research area. We recommend that the institute undertake green building and smart grid research to improve energy efficiency.

*Green buildings* (topic 6)—buildings that use energy, water, and natural resources efficiently—can help Qatar's economic development become more sustainable. We recommend that the institute conduct research on improving green building designs and technologies with particular emphasis on water and energy conservation. This research should also consider effectiveness, feasibility, and appropriateness of different policy options to encourage the use of green building designs and technologies.

*Smart grids* (topic 7) consist of flow-control and monitoring technologies that can improve efficiency, reliability, security, and flexibility of the electrical grid. They offer several potential advantages for Qatar:

more-efficient use of the gas supply, integration of distributed renewable energy sources, and pricing mechanisms that can reduce demand. The institute should pursue smart grid research if such benefits become key energy goals for Qatar.

Many activities in the energy sector are interlinked. For example, an emphasis on solar PV makes smart grids an important area to pursue. *Strategic energy planning* (topic 8) is needed to ensure that all elements operate in concert and not at cross-purposes. This strategy should establish national priorities and take into account the linkages between the energy sector and other parts of the economy.

### **Recommended Topics for Water Research**

Water is a critical resource, and water security is a critical issue in Qatar. Water consumption is high, for both municipal and industrial use. We recommend three areas of water research: improving water supplies through desalination and groundwater sustainability, managing water demand, and developing a holistic process for achieving water security through IWRM.

Qatar uses *desalination* (topic 9) to produce about 180 billion liters of water annually. Its desalination plants are energy-intensive and burn fossil fuels. The country should explore technologies that improve the efficiency of the process and drive down the cost. We recommend that the institute conduct research on technologies to increase the energy efficiency of thermal desalination, including hybridizing the thermal desalination process with reverse osmosis desalination, a process that requires much less energy than other methods do. We also recommend that the institute conduct research on alternative methods of desalination, improved materials and processes for desalination, and colocation of desalination and power plants.

Qatar's *groundwater* (topic 10) is overexploited. One potential result of this exploitation is that groundwater could be depleted in the coming years. Qatar needs a comprehensive groundwater sustainability research program to help manage this critical resource. A first step would be a comprehensive monitoring program. Complementary research could focus on reducing demand for groundwater, reducing demand for water services, developing alternative options for agricul-

ture water services, and developing ways to increase the amount of groundwater. The institute should also research how climate change could affect Qatar's groundwater.

Key to the issue of water supply is *managing demand* (topic 11). The institute should undertake a comprehensive research agenda to reduce the consumption of water. Research on water demand-side management should include pricing and nonprice policies for residential water and agricultural demand for water, reducing transmission and distribution losses, and developing education campaigns to encourage conservation.

Because the approaches to deal with water management are inter-related, Qatar should *integrate water resource management* (topic 12). IWRM is a holistic approach to water management that takes into account links between different types of water sources, as well as the links between water management and other aspects of the economy. We recommend that the institute help Qatar assess and potentially adopt an IWRM process that is attuned to Qatar's needs. If the institute determines that IWRM would be valuable and the Qatari government agrees to embark on an IWRM process, then the institute should help identify an appropriate framework for implementing IWRM in Qatar.

### **Recommended Topics for Research on the Environment**

The combined forces of population growth, industrialization, and coastal development have adversely affected Qatar's environment. Sustainable development indicators from Qatar's Statistics Authority suggest that air pollution levels in Doha are rising, that many land areas are undergoing desertification, and that Qatar's marine environment is damaged. Qatar has taken several steps to address its environmental challenges. However, a great deal of uncertainty remains about the current health of Qatar's environment.

We recommend that the institute first *characterize the current state of Qatar's environment* (topic 13). This includes coastal and desert ecosystem and biodiversity characterization. It also includes assessing human-made pollution and waste in the air, water, and land. The study

of ecosystems and pollutants are linked: For example, coastal water pollution will affect the health of fisheries and coastal ecosystems.

We also recommend that the institute undertake *crosscutting environmental research* (topic 14) that will help Qatar address these environmental challenges and that will inform water and energy issues. This includes evaluating risks from climate change; using environmental economics to identify solutions to energy, water, and environment challenges; and undertaking a mass–energy balance.

## Next Steps

These priorities are only the beginning of a journey to realize such a bold vision. We recommend that QF develop an initial research portfolio for the institute from the list of priority topics identified in this research.

### Select Initial Research Topics

The institute’s portfolio should consist of only two or three topic areas in the initial two to three years. This controlled growth allows some diversity in research capabilities from the beginning, while also enabling the institute to mature and develop a governance approach, funding mechanisms, an institutional culture, partnerships, and other facets. The two to three initial research topics will serve as a test bed for this institutional framework.

Initial topics should be of utmost importance to Qatar’s energy and environment and ones in which research results can be applied in the near term. The choice of topic will also depend on the ability to recruit research staff and develop facilities, whether the work is complementary to other work in Qatar or the region, and whether Qatar has a strategic advantage in undertaking it.

This monograph principally offers guidance on the importance of a topic to Qatar’s energy and environment goals, and it offers insights about human capital and about research being conducted in the region. Based on this, several topics stand out as strong candidates for these initial topics. These are natural gas (topic 1), desalination

(topic 9), groundwater (topic 10), water demand–management research (topic 11), and environmental characterization (topic 13).

### **Create Conditions for Continued Growth**

QF should also create conditions for this research portfolio to grow and address many of the 14 priority research areas. This can be done in the near term by developing a five- to ten-year roadmap for expanding the institute’s research capabilities into other areas. This top-down mapping can be complemented by a bottom-up approach to growth, in which investigators suggest research topics, submit proposals, and compete for supplementary funding from the institute. Such an approach draws on the talents and knowledge of existing researchers, creates opportunities for more junior staff to lead research, can serve as a form of peer review and quality assurance, and grows the program organically. Because it requires a modest base of researchers, this mechanism might be feasible only after the first few years.

### **Track Progress**

This endeavor is ambitious. It will require a long-term commitment by QF. As we recommend for the research it will be sponsoring with the institute, we recommend that QF approach this overall endeavor as an experiment in itself, in which decisions to invest in a research area are treated as hypotheses that can be tested and altered as new evidence is available. The hypothesis is that the recommended research topic will yield benefits to Qatar at an investment cost that is reasonable. This hypothesis can be testable by estimating potential outcomes and comparing them with evidence that emerges as research is funded and undertaken. We recommend that the institute focus on at least two kinds of outcomes that reflect the institute’s mission: (1) the extent to which the institute is furthering Qatar’s energy and environment goals and (2) the extent to which it helps realize Qatar’s goals of becoming an international leader in research. Initial topics, metrics, and thresholds should be developed as part of the mapping and strategic-planning process, but the slate of research topics presented here provides seeds for this endeavor to grow.