

SUSTAINABLE DEVELOPMENT

# Innovation, Energy and the Environment: Opportunities for Leadership at the World Summit on Sustainable Development

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## Overview

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Innovation provides the life-blood of economic activity. By one measure, over 90% of new economic growth stems directly from technological innovation and the application of those inventions to meet emerging business opportunities, social needs, and environmental challenges. Despite these benefits, national systems for innovation, particularly in the energy sector, have proven difficult to maintain. Research and development (R&D) requires long-term commitment because the timescale to develop both new technologies and—more critically—generations of innovators takes years. The results can often be diffuse, with both specific innovations and individuals moving freely about, on occasion leaving the nurturing national with little quantifiable evidence to show for the investment. These features—particularly in poorer nations—make R&D capacity be seen largely as a luxury, rarely supported against the other more apparently pressing needs of development.

The neglect of energy R&D capacity to meet global and national energy needs results from the combination of two forces: the often-neglected domestic capacity for innovation in developing nations, and the lack of sustained support for energy R&D capacity by industrialized nations. The World Summit on Sustainable Development provides a critical opportunity to bring attention to this under-investment, and to build a full understanding of the importance of energy R&D.

Over two billion people worldwide depend on traditional biomass energy for the bulk of their energy needs, largely because of the unavailability or expense of grid-based energy services. Many more rely on kerosene lanterns or, when available, expensive gas—and diesel-burning electric generators. The economic, human health, and environmental costs of these technologies are high. The capacity for small-scale, often renewable, energy systems to provide an alternative to carbon-intensive fossil-fuel energy sources and to contribute to local and global sustainable development is profound. The positive human health impacts of locally developed, managed, and market-disseminated tools for clean development can also be tremendous (see Ezzati and Kammen in Further Readings).

The types of institutions, market policies, and training opportunities needed to develop both large-scale and small-scale and decentralized energy services are only beginning to be explored and implemented. Constructive donor nation and multinational policies can play a significant role in supporting existing institutions and promoting new groups and market policies to face the challenges of energy and development in developing countries

In this paper, I highlight the institutional capacity—training, research, outreach, commercialization, and implementation—of the diverse organizations that facilitate the development, dissemination, and deployment of a variety of renewable and fossil-fuel “appropriate” and decentralized energy systems that can meet the needs and challenges of sustainable development. The overall message is clearly “high-tech”—energy innovation capacity focused on the environment in developing nations is needed, and there is equal need for innovative research on small-scale and decentralized energy systems. Both of these areas are neglected.

In spite of these gaps, a number of impressive organizations do exist that focus on these “mundane” technologies (see Kammen and Dove, and Kammen (1999) in Further Readings), but they are frequently under-supported financially. They also often lack both training opportunities and

political opportunities to implement policies that would encourage innovative approaches to energy management. Research and implementation efforts focused on these technologies and management methods suffer from the perception that they do not require the sophisticated, sustained investment that has been accorded many fossil-fuel and “high-technology” systems. This perception is false and counter-productive.

The most promising way to reduce greenhouse gas (GHG) emissions to the atmosphere is the deployment of new and cleaner technologies to deliver energy. Specifically, a transition is needed from fuels and technologies with high carbon content to “decarbonized” fuels. Although there are wide national and regional variations, at the global level decarbonization has progressed at only about the rate of 1.3% per year. This has been accomplished through transitions from coal and oil to gas; to a far lesser extent, renewable energy sources; and increased energy efficiency. One of the best ways to gauge the prospects for deployment of these technologies is to measure the level of public and private investment in energy research. Figure 1 summarizes the levels of overall R&D investment in a number of industrialized nations

Recent efforts targeting a variety of small-scale traditional, fossil fuel, and renewable energy technologies have resulted in dramatic improvements in performance, marketing power, sales and leasing opportunities, and end-user satisfaction in developed and developing nations. Examples include the growth of local mini-grids using diesel or renewable energy sources, improved efficiency cookstoves, photovoltaic solar home systems, wind-turbines for household and micro-enterprise applications, micro-hydro generators, and biomass energy systems. Some of these technologies have already had a significant impact on local patterns of energy use, economic activity, and the environment. There are numerous examples that illustrate this potential, such as the dissemination of roughly 130,000 small wind energy systems in the Inner Mongolian Autonomous Region (see Byrne et al. and Williams in Further Readings) and 800,000 improved cookstoves in Kenya (see Kammen, 1995a,b, Karekezi and Ranja, and Ezzati and Kammen in Further Readings). A number of excellent collections documenting individual success stories now exist (see IPCC and CTI in Further Readings).

***Current Institutional Capacity and Future Needs***

Among the problems that plague institutions that support research and implementation of small-scale and decentralized energy technologies and management methods is lack of steady funding. Equally critical, however, are the paucity of training venues, technology and information ex-

**TABLE 1**  
**TURNOVER TIMES FOR SELECTED ENERGY SUPPLY AND END-USE TECHNOLOGIES (PCAST, 1997)**

Energy Technology	Turnover Time (years)
Industrial Process Equipment	3–20
Photovoltaic Panel Systems	3–20
Home Appliances	5–15
Electric Power Plants	30–50
Residential and Commercial Building Systems	50–100

change, and technology standards for these often-overlooked energy systems (see Kozloff and TERI in Further Readings). Micro-credit to foster locally designed and implemented commercialization efforts is scarcely available.

■ *Institutional Obstacles: Communication Problems*

Efforts to disseminate small-scale and decentralized energy systems have not benefited as much as they could have from the lessons learned by similar efforts or from the lessons in other sectors, such as agricultural research and extension. Communications across national borders and economic sectors remain needlessly limited. A growing number of governmental and nongovernmental organizations (NGOs) in the United States and elsewhere are, however, engaged in important projects to evaluate energy efficient, decentralized energy options. These programs are critical to building a base for international collaboration. At the same time, some members of the international renewable energy community are not fully aware of extensive technology development, field applications, and innovative institutional arrangements and policies promoting renewable energy elsewhere in the world. The small and sporadic funding levels with which many researchers and practitioners must contend leads to overly specific project and funding-driven investigations and does not encourage wide discussion and comparative analysis.

Exacerbating this problem has been the nature of a great deal of international attention to clean energy capacity in developing nations. In far too many instances, donors either micro-manage project funds and directions, or—as has become excessively popular—demand projects to be based entirely on “market mechanisms.” The meaning of the term “market” to many donors seems to be little more than a plea for projects that have immediate commercial appeal or where donor funding can be seen to leverage other resources. While this sentiment is in many ways an improvement over the donor-driven project dynamic, in many cases what is in fact needed is a fairly simple process. In many settings, the first step is an assessment of local technological and research capacity, followed by a clear commitment of sustained resources to build locally autonomous institutions that are funded and free to set their own agenda of what projects deserve attention. To many donors this approach—picking strong, or potentially strong local partners and then providing the resources to permit them to operate—clashes with the ever-present desire for micro-management. The key to addressing local issues is to foster not only local markets but also the local ability to set priorities and innovate.

■ *Institutional Obstacles: Absence of Scholarly Attention and Scholar-Practitioner Collaboration*

Scholarly attention to problems of small-scale and decentralized energy technology and technical expertise is notable primarily in its absence. There are very few research and teaching units in higher education devoted primarily to these topics. Much of the academic work that has been done in universities is in technology research and development and not the social science aspects of technology adoption, adaptation, and management. The renewable energy units of national laboratories and academies of science in many countries have typically focused on basic research and have ignored product commercialization. The consequence has been that issues—such as applications for rural development and methods to finance individual decisions to adopt and master new technologies—have been left to institutions and individuals lacking the resources, training, and in some cases the inclination to carry out systematic studies. The lack of an institutional base for renewable energy studies is reflected in the literature—there are, for example, few reputable

academic journals devoted to renewable energy per se, and very limited venues in other academic publications. Furthermore, some of what is published in the field lacks rigor and quantitative analysis.

Renewable energy dissemination suffers in several ways from this lack of research. There is surprisingly little information on issues such as long-term technology performance, economic costs and benefits, effectiveness of subsidy policies, and the social consequences of renewable energy. It is interesting that a similar situation developed in international agricultural research where the long-term performance of new “super” rice and wheat crops in the Green Revolution was not systematically investigated. There was considerable surprise when, after decades of Green Revolution projects, one of the few long-term cropping experiments reported that the average yields had actually declined (see Dove and Kammen in Further Readings).

This sort of applied yet basic question often goes unresolved for far too long in the field of energy and development. This kind of research is a public good that is often not pursued by businesses that must focus on corporate profits, NGOs that are tied to short-term and intermittent funding cycles, and even governments in which policy proponents may have disincentives to critically review their own programs. Academic research provides this type of public benefit. For example, forestry departments provide crucial information on a variety of technical and social issues on which national timber policies are based. Small-scale and decentralized energy planning requires this ongoing research and verification presence.

An area that particularly suffers from the lack of research is analysis of the relationship between renewable energy projects and the social and economic contexts in which they are embedded. All too often projects are planned, implemented, or evaluated based on unexamined assumptions about local conditions, and the social and economic consequences of the project. Broader discussions of the role of traditional renewable or stand-alone fossil-fuel energy in rural development strategies under conditions of economic globalization are rare, despite their obvious importance to questions such as rural electrification and the impacts of linking remote areas to the formal and cash economies.

The inadequacy of academic research on renewable energy for rural development stems from two things: a lack of funding and a lack of academic respectability. On the issue of funding, because analysis of small-scale and decentralized energy systems typically does not fall within the purview of existing academic departments, it lacks the usual pipelines of funding that support departmental research. At the same time, renewable energy for rural development does not fit well within the existing categories of government and donor funding. This stems in part from the fact that rural energy infrastructure in rich countries is developed and is no longer a priority, while poor countries lack the resources to support research in general. Nonetheless it is surprising, given the current climate of concern about global carbon emissions and the hopes placed on renewable energy, that more funding for academic research in this area has not been forthcoming.

Renewable energy (particularly for rural development) as a field of study suffers from the classic academic biases against interdisciplinary research. It is too specific, too applied, and too far outside the usual concerns of traditional disciplines. Conventional sociology departments find energy studies too technical, engineers find them too “soft,” and economists find them too marginal (see Kammen and Dove in Further Readings). Energy studies in general are considered to be too applied, relative to the emphasis on theory of mainstream departments in many institutions, and therefore are most commonly the subject of applied and interdisciplinary programs such as envi-

ronmental studies. Yet within these interdisciplinary departments, there is still a strong tendency towards theory (for fear of being seen as insufficiently theoretical) that works against the publication of research results, such as data from long-term case studies, which are seen as atheoretical. Ironically this bias against “mundane science” (see Kammen and Dove in Further Readings) is a major impediment to the theoretical growth of renewable energy studies in the long run, as it is inherently a data-driven field.

### ***Institutional Examples and Lessons from Developing Countries***

A critical mission for the WSSD to address is how to support the institutions that are achieving significant results and to foster new initiatives that define and address pressing social and environmental sustainability issues on their own terms. R&D funding from industrialized nations can be fickle—even if well intentioned—and often is designed more to meet practical or academic interests and agendas of the funding governments or agencies. These sorts of funds rarely provide groups in developing countries the long-term, unfettered support to plan and undertake research and policy projects that they see as most pressing. All too often, funds derived from developed countries carry the strings of micro-management that do not permit genuine innovation to flourish in the very groups that are best trained and best able to apply that knowledge to the issues facing poor countries and communities in the South.

### ***Sustaining Markets for Small-Scale and Decentralized Energy Technologies***

Policy efforts to develop and sustain the market for new decentralized and small-scale energy technologies are also difficult because of the capital turnover issue in developing nations. Table 1 illustrates the typical turnover, or replacement times, for energy technologies in developed nations. Small-scale technologies in poor nations face an even slower process, however. Lack of available capital, and the tendency of officials to be risk averse when faced with a new, untested, and potentially imported, technology contribute to retard the market for new innovations. These effects slow the technology turnover process even further, particularly for small-scale technologies that may in some cases replace tasks such as wood collecting and making charcoal, tasks that are undervalued because they are often done by women, children, or the elderly. In these cases, the impetus to invest in new innovations is reduced still further. In this context, efforts to not only develop but test market, popularize, and adapt the technology are particularly important.

The policies discussed above have, in many cases, pointed to the need to support not only the institutions that design, develop, or adapt small-scale and renewable energy technologies, but also the market for the new technology. The linkage between basic R&D and dissemination is obvious, but is particularly important for small-scale technologies where the market may not identify even an ideal new invention. In this setting, efforts to stimulate, or transform the market should be coupled to the basic R&D process. This simple lesson, of supporting both technology development (the so-called technology push) and market growth (demand-pull) has consistently eluded well-meaning institutions and governments, largely because it appears to require attention to all phases of the clean energy innovation chain. Precisely!

## ***Conclusions and Recommendations***

The conclusions emerging from the study of successful institutions for innovation in developing countries and their partners and supporters in developed countries include the following recommendations, each of which I recommend for discussion and adoption at the World Summit on Sustainable Development:

### **■ Energy Innovation Requires Sustained Support.**

International funding agencies have focused excessively on implementation and have in many cases neglected capacity building and research (see Kozloff, Mcilwain, and Kammen (1999) in Further Readings). This area, however, is arguably the most critical part of the dissemination process for the success of small-scale and decentralized technologies. In fact, the adoption of small-scale and decentralized technologies requires significant level of attention—certainly more than the introduction of most large-scale, industrial energy systems.

### **■ Build Portfolios Partnering Innovation with Dissemination**

The lessons from the history of R&D capacity from industrialized nations is largely one of success when innovation was supported over an extended period of time, and when that technology push (R&D) was balanced with market pull (market and demand stimulation, or at least opening) policies. This is perhaps the most basic and critical observation of all, leading directly to specific policy recommendations. Market reform to permit clean energy and other environmentally friendly technologies access to markets can be difficult but must be the paramount mission of all nations claiming to favor sustainable development and health environment.

### **■ Don't Micro-Manage Projects; Support Sustainable Institutions**

International funding and support should focus more on the institution and not specific projects. Project-based funding emphasizes technology selection as dictated by the donor and does not support institutional capacity and local sustainability. Project-based support also promotes boom-bust cycles for already small and under-funded organizations, further weakening their capacity to develop or implement innovative solutions to local energy needs.

A number of nations have neglected or been unable to pursue locally appropriate solutions such as widespread introduction of grid-connected or stand-alone wind-energy, biomass, or fuel-cell infrastructures because international support was only available for technology and not human and institutional resources and capacity.

### **■ Interdisciplinary Work Requires More than Lip Service**

Institutional capacity building must be interdisciplinary, including economic, social, and policy research as well as the more traditional engineering and environmental methods. The small (and declining) number of research groups and institutes that focus on small-scale and decentralized energy issues is a fundamental obstacle to building the necessary capacity. Because these groups are often small in size, a modest level of sustained support could yield significant returns in capacity building.

### ■ Innovation Takes Place in Global Networks, Support Them

Regional networks that build capacity and cooperation among developing countries and between developing and developed countries have proven to be an effective means to support sustainable energy solutions. These groups remain under supported by the international community.

### ■ Clean Energy Technologies Face Major Market Barriers that Must be Addressed

Subsidies for R&D and market support coupled with market mechanisms to set prices have been shown to be highly effective in building sustainable industries for small-scale and decentralized energy systems.

**TABLE 2**

**ESTIMATES OF THE NUMBER OF IMPROVED STOVES DISSEMINATED IN EASTERN AND SOUTHERN AFRICA IN 1995 (KAREKEZI AND RANJA, 1997)**

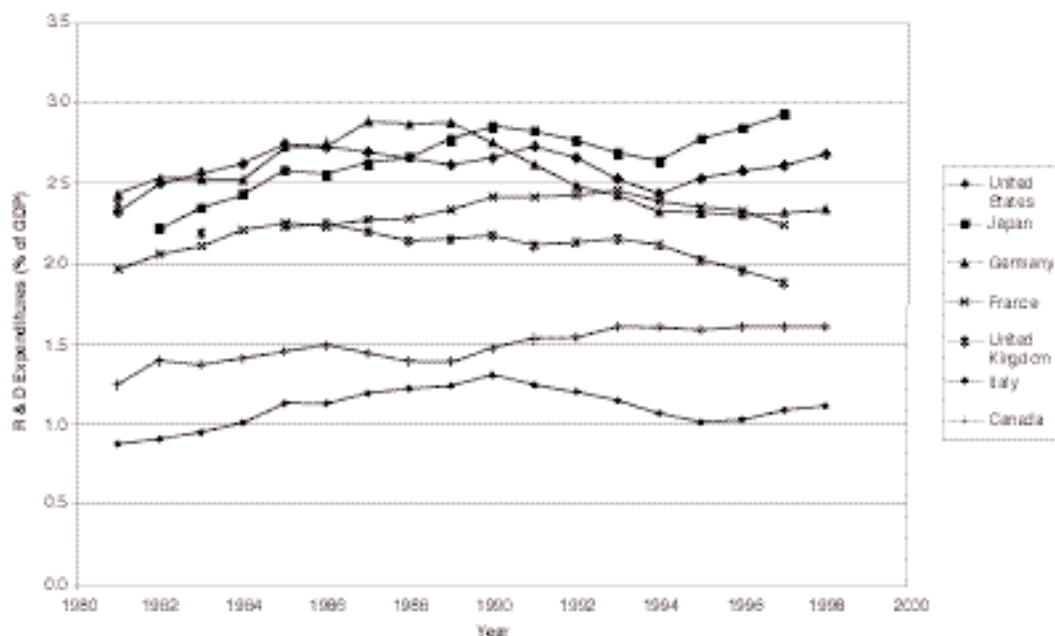
Country	Urban	Rural	Total
Kenya	600,000	180,000	780,000
Tanzania	54,000		54,000
Uganda	52,000		52,000
Ethiopia	23,000	22,000	45,000
Rwanda*	30,000		30,000
Sudan	27,000	1,400	28,400
Zimbabwe	11,000	10,000	21,000
Burundi*	20,500		20,500
Somalia*	15,400		15,400

\* Civil strife has significantly impacted stove programs and/or reduced the number of improved stoves in use.

(—) indicates data not available.

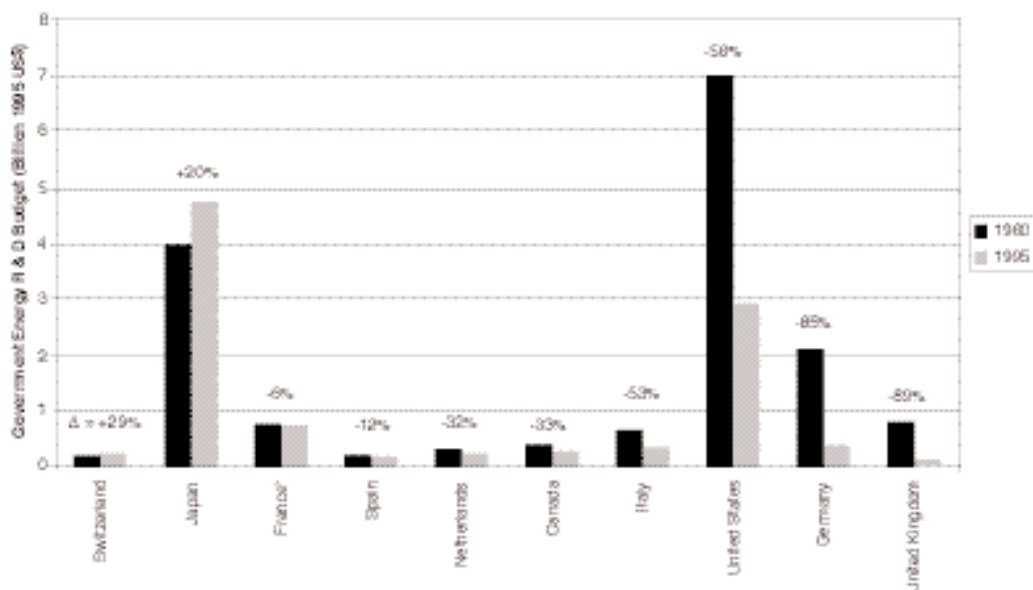


**FIGURE 1. R & D EXPENDITURES AS PERCENTAGE OF GDP FOR SELECTED OECD COUNTRIES**



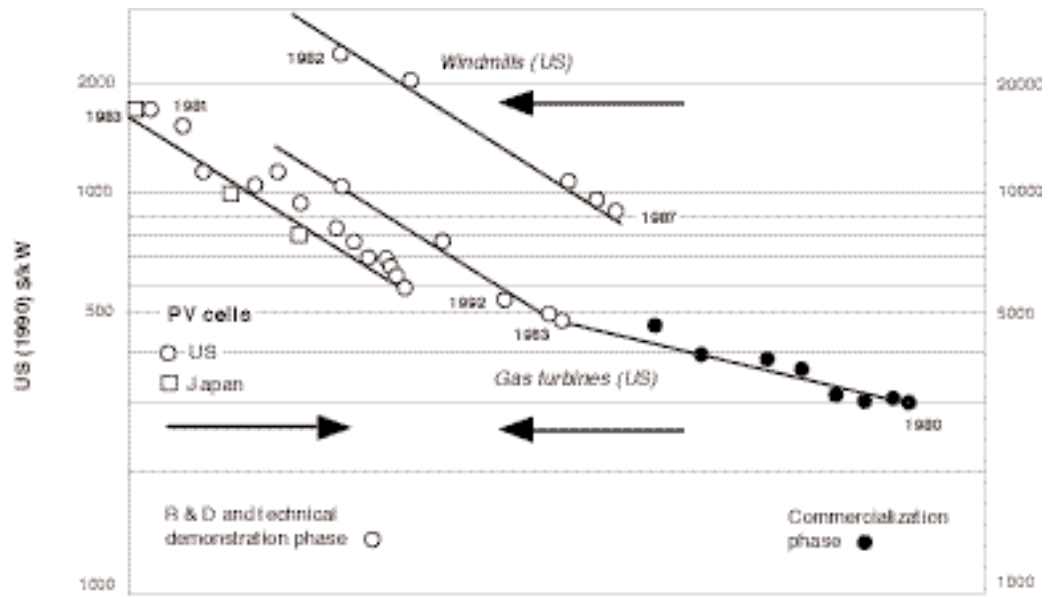
**Figure 1.** R&D as a percentage of gross domestic product for selected Organisation for Economic Co-operation and Development countries.

**FIGURE 2. GOVERNMENT ENERGY R & D BUDGETS FOR SELECTED IEA COUNTRIES, 1980 AND 1995**



**Figure 2.** Government energy technology R&D budgets for selected International Energy Agency countries.

FIGURE 3



Sources: Margolis and Kammen

**Figure 3.** Experience curve relationships for photovoltaics, wind generators, and gas turbines. All three have initial progress ratios of approximately 0.8; however, after 1963, the gas turbine PR increased substantially, indicating attenuated experience effects. Source: IIASA/WEC (1995) and Duke and Kammen, (1999).

## ***Further Readings***

- Agrawal, A. 1995 "Dismantling the divide between indigenous and scientific knowledge," *Development and Change*, **26**, 413–439.
- Anderson, D. 1997. "Renewable energy technology and policy for development." *Ann. Rev. Energy Environ.* **22**, 187-215.
- Barnes, D. F., Openshaw, K., Smith, K. R., and van der Plas, R. 1994. *What makes people cook with improved biomass stoves?* Technical Paper No. 242: Energy Series (: Washington, DC: The World Bank)
- Barnes, D., Jechoutek, K., and Young, A. 1998. *Financing Decentralized Renewable Energy: New Approaches*, Energy Issues Paper No.15 (Washington, DC: The World Bank).
- Byrne, J. Shen, B. and Wallace, W. 1998. "The economics of sustainable energy for rural-development—A study of renewable energy in rural China," *Energy Policy*, **26**, 45–54.
- Cabraal, A., Cosgrove-Davies, M. and Schaeffer, L. 1996. *Best Practices for Photovoltaic Household Electrification Programs: Lessons from Experiences in Selected Countries*. (Washington DC: The World Bank).
- Cohen, L. R., and Noll, R. G. 1991. *The Technology Pork Barrel* (Washington, DC: The Brookings Institution).
- Climate Technology Initiative, Contributing Author.2002. *Technology Without Borders: Case Studies of Successful Technology Transfer* (Paris, France: International Energy Agency).
- DeCanio, Stephen J. 1998. *The Economics of Climate Change* (San Francisco, CA: Redefining Progress).
- Dong, F., Lew, D., Li, P., Kammen, D. M., and Wilson, R. 1998 "Strategic options for reducing CO2 in China: Improving Energy Efficiency and Using Alternatives to Fossil Fuels" in *Energizing China: Reconciling Environmental Protection and Economic Growth*, M. B. McElroy, C. P. Nielsen, & P. Leiden (eds.), (Cambridge, MA: Harvard University Press), 119–166.
- Dove, M. R. and Kammen, D. M. 1997. "The epistemology of sustainable resource use: Managing forest products, swiddens, and high-yielding variety crops," *Human Organization*, **56 (1)**, 91–101.
- Duke, R. D., and Kammen, D. M. 1999. "The economics of energy market transformation initiatives," *The Energy Journal*, **20 (4)**, 15–64.
- Duke, Richard. D, Jacobson, Arne, and Daniel M. Kammen. 2001. "Product quality in the Kenyan solar home industry," *Energy Policy*, **30 (6)**, 477–499.
- Ezzati, M. and Kammen, D. 2000. "Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: An exposure-response study," *The Lancet*, **358**, 619–624.
- Hankins, M., Omondi, F., and Scherpenzeel, J. 1997. *PV Electrification in Rural Kenya: A Survey of 410 Solar Home Systems in 12 Districts*. (Nairobi, Kenya: ESMAP World Bank).
- Inversin, A. R. 1996. *New Designs for Rural Electrification: Private Sector Experiences in Nepal*. (Washington, DC: NRECA, International Programs Division).
- Intergovernmental Panel on Climate Change Working Groups II and III.2000. *Methodological and Technological Issues in Technology Transfer* (New York, NY: Cambridge University Press).ISTI (1995) *New and Renewable Energy—Technologies and Products in China* (Chongqing Institute of Scientific and Technical Information of China).

- Kammen, D. M. 1995a. "Cookstoves for the developing world," *Scientific American*, **273**, 72–75.
- Kammen, D. M. 1995b. "From energy efficiency to social utility: Improved cookstoves and the *Small is Beautiful* Model of development," in *Energy as an instrument for socio-economic development*, Goldemberg, J. and Johansson, T. B. (eds.) (New York: United Nations Development Programme), 50–62.
- Kammen, D. M. 1999. "The commercial dissemination of photovoltaic systems in Kenya—technology transfer a few watts at a time," Intergovernmental Panel on Climate Change (Working Group II *Special Report on Methodological and Technological Issues in Technology Transfer*).
- Kammen, D. M. 1999. "Bringing power to the people: Promoting appropriate energy technologies in the developing world," *Environment*, **41** (5), 10–15, 34–41.
- Kammen, D. M. 2000. "Case Study #1: Research, development, and commercialization of the Kenya Ceramic Jiko (KCJ)," in *Methodological and Technological Issues in Technology Transfer* (New York, NY: Cambridge University Press), 383–384.
- Kammen, D. M. 2001. "Exposure to indoor air pollution from biofuel stoves in rural Kenya," in *Field Guide to Appropriate Technology*, B. Hazeltine and C. Bull (eds.) (San Diego, CA: Academic Press).
- Kammen, D. M. and Dove, M. R. 1997. "The virtues of Mundane Science," *Environment*, **39** (6), 10–15, 38–41.
- Karekezi, S. and Ranja, T. 1997. *Renewable Energy Technologies in Africa* (London: African Energy Policy Research Network & SEI and Zed Books).
- Kozloff, K. L. 1995. "Rethinking development assistance for renewable electricity sources," *Environment*, **37** (9), 6–15, 32–38.
- Lu, Y. 1993. *Fueling One Billion: An Insider's Story of Chinese Energy Policy Development* (Washington, DC: Brookings Institute).
- Macilwain, C. 1998. "World Bank backs Third World centres of excellence plan," *Nature*, **396**, 711.
- Margolis, R. and Kammen, D. M. 1999. "Underinvestment: The energy technology and R&D policy challenge," *Science*, **285**, 690–692.
- Margolis, R. M. and Kammen, D. M. 2002. "Energy R&D and Innovation: Challenges and Opportunities" in Schneider, S, A Rosencranz, and J. Niles, (eds.), *A Reader in Climate Change Policy* (Washington, DC: Island Press).
- McElroy, M. B., Nielsen, C. P., and Leiden, P. 1998. *Energizing China: Reconciling Environmental Protection and Economic Growth* (Cambridge, MA: Harvard University Press)
- President's Committee of Advisors on Science and Technology (PCAST). 1997. *Federal Energy Research and Development for the Challenges of the Twenty-First Century*. (Washington, DC: Energy Research and Development Panel, President's Committee of Advisors on Science and Technology).
- Ramani, K. V. 1992. *Rural Electrification and Rural Development: Rural Electrification Guidebook for Asia and the Pacific*. (Bangkok, Thailand: Asian Institute of Technology and the Commission of the European Communities).
- Ryder, S. 1999. "The Poland Efficient Lighting Project," Intergovernmental Panel on Climate Change (Working Group II: *Special Report on Methodological and Technological Issues in Technology Transfer*).

- Smith, K. R., Shuhua, G., Kun, K. and Daxiong, Q. 1993. "100 million biomass stoves in China: How was it done?" *World Development*, **18**, 941–961.
- TERI (Tata Energy Research Institute) 1998. *Climate Change: Post-Kyoto Perspectives from the South* (New Delhi, India: Tata Energy Research Institute).
- Walubengo, D. 1995. "Commercialization of improved stoves: The case of the Kenya Ceramic Jiko (KCJ)", in *Stove Images: A Documentation of Improved and Traditional Stoves in Africa, Asia, and Latin America*, Westhoff, B. and Germann, D. (eds.), (Brussels, Belgium: Commission of the European Communities).
- Williams, J. 1999. "Wind electric systems in Inner Mongolia," Intergovernmental Panel on Climate Change—Working Group II *Special Report on Methodological and Technological Issues in Technology Transfer*, in press.

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