

Strengthening U.S. Leadership of International Clean Energy Cooperation

Proceedings of Stakeholder Consultations

December 2008

Report Number: NREL/TP-6A0-44261

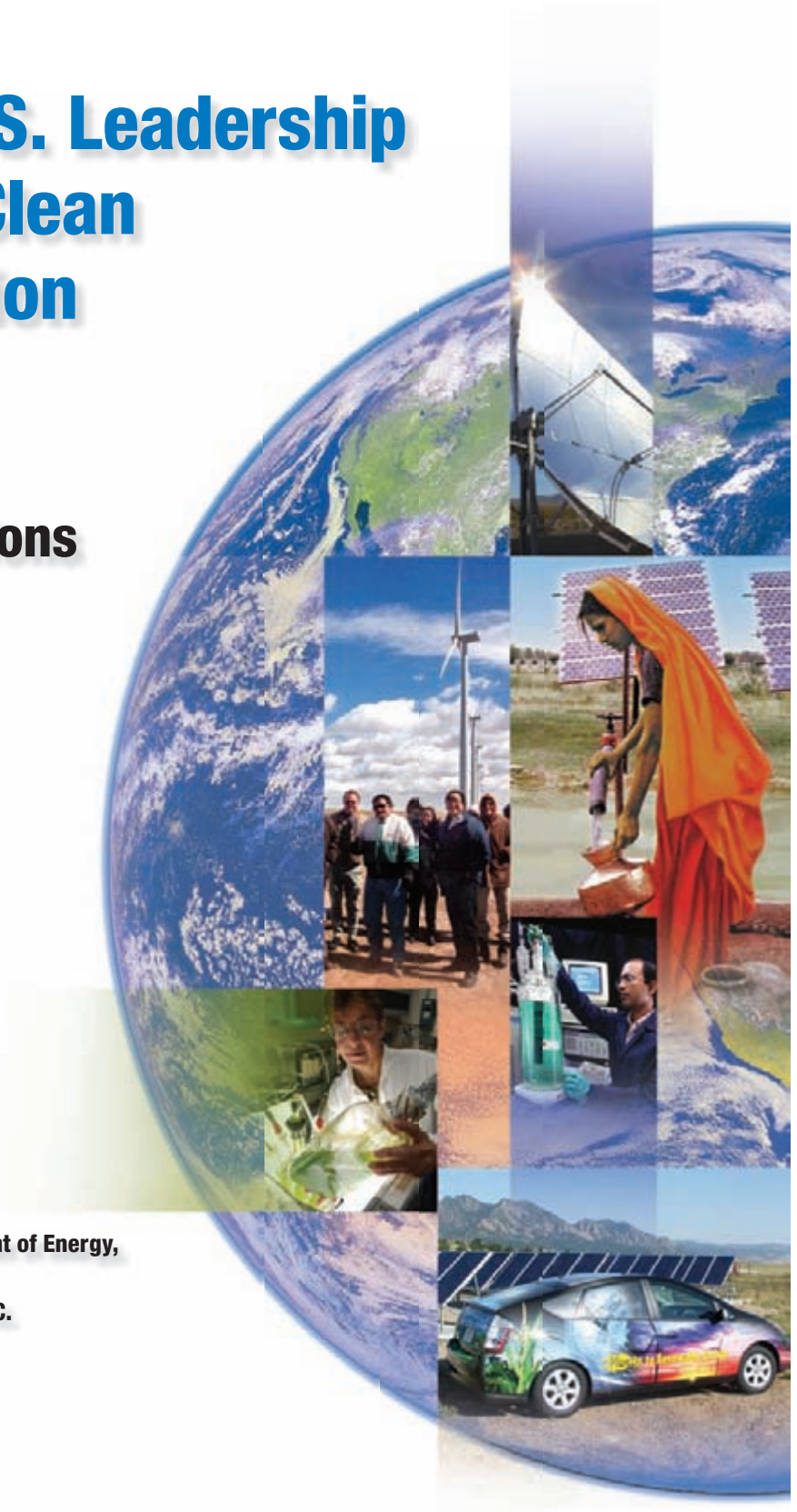
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Innovation for Our Energy Future



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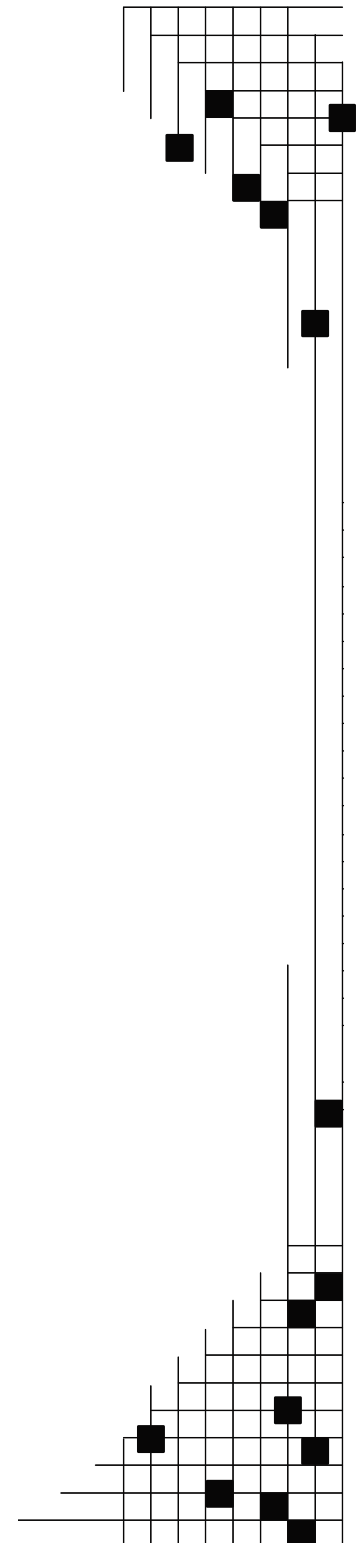
Prepared under Task No. 6A00.6003

Technical Report
NREL/TP-6A0-44261
December 2008

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Office of Energy Efficiency and Renewable Energy
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Acknowledgments

The National Renewable Energy Laboratory's (NREL's) International Advisory Council (IAC) greatly appreciates the input and strong cooperation received from the World Resources Institute (WRI) and the Center for Strategic International Studies (CSIS) in the preparation of this report. The council is grateful to Hank Habicht of the Global Environment and Technology Foundation (GETF) and SAIL Venture Partners for his adept and spirited leadership of this effort; and to Ron Benioff, David Kline, Dan Bilello, Bill Wallace, Michelle Kubik, and Rachel Gelman (all of NREL), and Britt Staley of WRI for preparing this report and supporting analyses. This report would not have been possible without the active engagement and insightful comments and recommendations offered by the many private-sector, nongovernmental, and academic organizations and representatives who participated in this activity.

List of Acronyms

ACORE	American Council on Renewable Energy
APP	Asia Pacific Partnership on Clean Development and Climate
ASTM	American Society for Testing and Materials
AWEA	American Wind Energy Association
BCSE	Business Council for Sustainable Energy
CSD	Commission on Sustainable Development
CET	Clean energy technology
CETE	Clean energy technology exports
CEQ	Council on Environmental Quality
CGIAR	Consultative Group on International Agricultural Research
COEECT	Committee on Energy Efficiency, Commerce, and Trade
CORECT	Committee on Renewable Energy, Commerce, and Trade
CSIS	Center for Strategic International Studies
CSD	Commission on Sustainable Development
CSP	Concentrated solar power
DOE	Department of Energy
EE	Energy efficiency
EERE	Office of Energy Efficiency and Renewable Energy
EPA	Environmental Protection Agency
EXIM	U.S. Export Import Bank
GBEP	Global Bioenergy Partnership
GEF	Global Environment Facility
GETF	Global Environment and Technology Foundation
GHG	Greenhouse gas
GVEP	Global Village Energy Partnership
IAC	International Advisory Council (NREL)
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFC	International Finance Corporation
IIASA	International Institute for Applied Systems Analysis
IP	Intellectual property
IPCC	Intergovernmental Panel on Climate Change
IPEEC	International Partnership for Energy Efficiency Cooperation
IPHE	International Partnership for Hydrogen Economy
IRENA	International Renewable Energy Agency
LBNL	Lawrence Berkeley National Laboratory
MEM	Major economy meetings
MRI	Midwest Research Institute
NGO	Nongovernmental organization
NREL	National Renewable Energy Laboratory
NVCA	National Venture Capital Association
OECD	Organization for Economic Co-operation and Development
OPIC	U.S. Overseas Private Investment Corporation

R&D	Research and development
RD ³	Research, development, demonstration, and deployment
RE	Renewable energy
REN21	Renewable Energy Policy Network for the 21st Century
RFF	Resources for the Future
RPS	Renewable portfolio standards
SARI/E	South Asia Regional Initiative for Energy
SEIA	Solar Energy Industries Association
TDA	U.S. Trade and Development Agency
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
WIREC	Washington International Renewable Energy Conference
WRI	World Resources Institute
WTO	World Trade Organization

Executive Summary

Pressing economic, energy security, and environmental concerns are driving rapid growth in global investments in renewable energy (RE), energy efficiency (EE), and other clean energy technologies. The U.S. government has an unparalleled opportunity to join forces with the private sector, international institutions, and other countries to accelerate this global clean energy market transformation and capture vital domestic benefits. The global financial crisis creates an even more urgent need for government programs to stimulate private investment in renewable energy and energy efficiency, which will foster U.S. and international job creation and economic vitality.

This report began with discussions among members of the International Advisory Council (IAC) for the National Renewable Energy Laboratory (NREL) regarding how NREL can better support U.S. global energy efforts. Members of NREL's International Advisory Council, the World Resources Institute (WRI), and the Center for Strategic International Studies (CSIS) launched a series of consultations with representatives from the clean energy business and financial community and nongovernment organizations to seek broad input on this topic. As part of developing recommendations for NREL roles, these stakeholder consultations also identified overarching strategies that the U.S. government could pursue to advance global clean energy cooperation. This report presents the results of these consultations.

U.S. international clean energy leadership can produce enormous benefits domestically and internationally (see "Benefits of U.S.-Led Global Clean Energy Cooperation"). The United States is

poised, with its wealth of human, institutional, political, and financial capital to take the world lead in a global transformation. During a global economic slowdown, it is especially important for the United States to help build new markets for clean energy technologies around the world that become a catalyst for economic development.

Benefits of U.S.-Led Global Clean Energy Cooperation

U.S. Benefits in 2020

- Up to \$40 billion/year increased clean energy exports, generating 0.25-0.75 million new jobs
- \$10-50 billion/year reductions in oil use costs
- A stronger dollar and improved trade balance, resulting in up to \$25 billion/year in benefits
- Enhanced U.S. diplomatic standing through assuming leadership on clean energy and issues

Global Benefits

- Reduced greenhouse gas (GHG) emissions (50-80% by 2050 relative to 2005 levels) avoiding dangerous climate change impacts
- Reduced global oil use (40% by 2050 relative to 2005 levels)
- Up to \$1 trillion a year in new investment opportunities
- Robust global economic development, with universal access to modern energy
- Reduced regional tensions and military conflicts from improved environmental and energy conditions.

NREL benefits estimates derived from IEA, IPCC, McKinsey, and other sources (see Appendix C).

Stakeholders have identified a portfolio of actions that the United States can pursue to lead this global clean energy transformation. These actions fall into four broad strategies:

1. **Lead with a Government-Wide Commitment to Action.** The President and Congress commit to specific international clean energy cooperation goals and priorities as well as a cohesive government-wide, stakeholder-inclusive implementation plan. They also expand U.S. leadership in key international forums, including the international climate change negotiations.
2. **Revitalize the Portfolio of U.S. Clean Energy Investment-Facilitation Programs.** Strengthen and consolidate U.S. government international clean energy investment programs to dramatically increase investments by U.S. firms in energy efficiency and renewable energy worldwide.
3. **Accelerate Global Renewable Energy and Energy Efficiency Technology Cooperation.** Scale-up global development and use of renewable energy and energy efficiency technologies through strategic research, development, demonstration, and deployment (RD³) partnerships.
4. **Transform Clean Energy Markets with Key Countries.** Partner with major developing countries and regions through initiatives to help create policy and market conditions that will foster sustained clean energy investment.

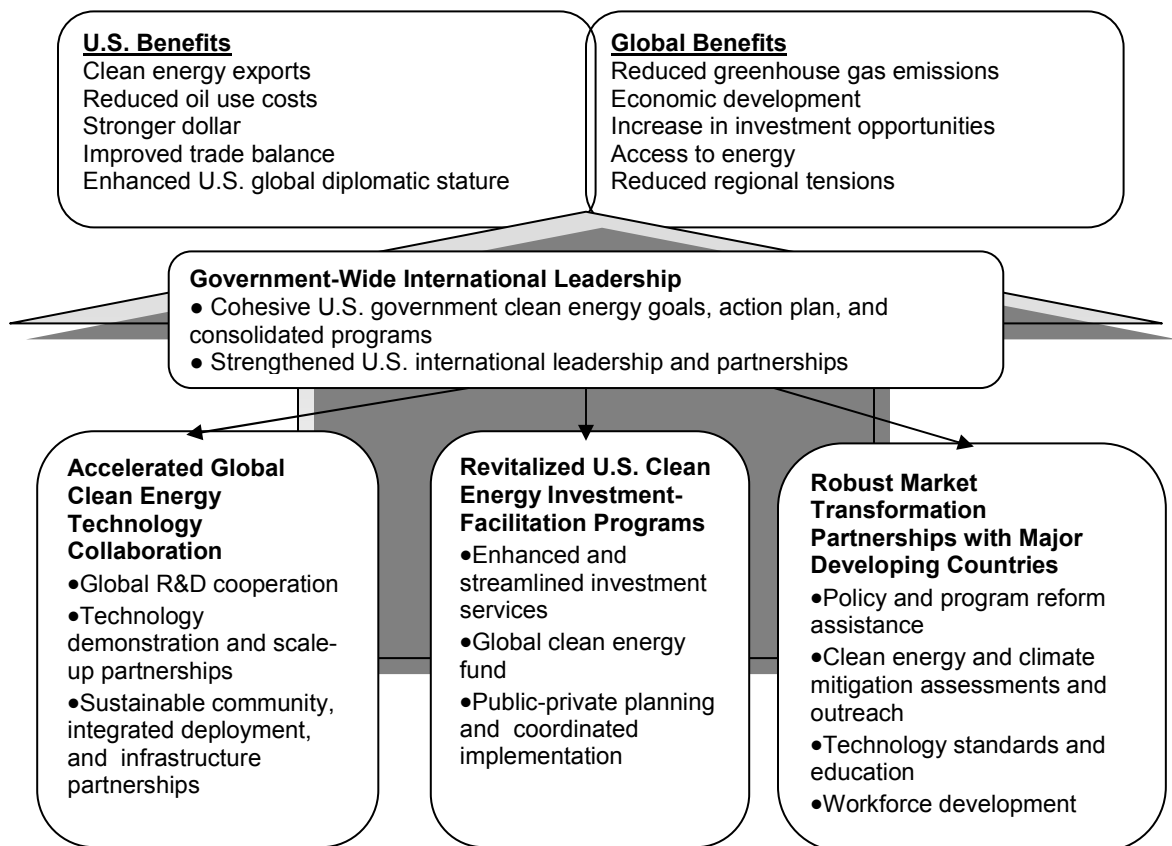


Figure ES-1. Strategies for enhanced U.S. international clean energy cooperation

Introduction

Global investments in renewable energy and energy efficiency are growing exponentially in response to increasing fossil fuel prices, reductions in costs of these clean energy technologies, and pressing energy security and environmental concerns. The United States has an unparalleled opportunity to advance this global energy market transformation. U.S. leadership of robust international clean energy cooperation programs can grow clean energy markets and reap vital domestic economic and energy security rewards while advancing U.S. foreign policy interests and reducing global greenhouse gas (GHG) emissions. The private sector, international institutions, and other countries have dramatically increased their engagement in international clean energy cooperation, and the time is ripe for the U.S. government to become a full partner in this transformation. The current financial crisis has elevated the need for government programs and incentives to maintain and grow global, private-sector clean energy investment, which can drive job creation and economic vitality for the United States and other countries.

Report Purpose and Audience

This report is designed with two goals in mind:

- Identify opportunities for the U.S. government to accelerate the global clean energy transformation and more fully capture economic, energy security, environmental, and international development benefits for the United States.
- Provide credible and objective information to inform the design of U.S. international clean energy programs during the next three to five years.

The report emphasizes how the capabilities of federal institutions, including NREL, can be more effectively aligned to support international energy objectives set by the President and Congress.

This report is written primarily for high-level U.S. government officials, including advisers to the President, congressional staff, and key officials at U.S. government agencies. The recommendations also may be of value to U.S. companies, financial institutions, research organizations, and NGOs active in international clean energy markets and policy issues. Because the report focuses on recommendations for the U.S. government, it is not designed for distribution to other countries and international partners.

Stakeholder Consultations

This report began with discussions among members of the International Advisory Council (IAC) for the National Renewable Energy Laboratory (NREL) regarding how NREL can better support U.S. global energy efforts. Members of NREL's International Advisory Council, the World Resources Institute (WRI), and the Center for Strategic International Studies (CSIS) launched a series of consultations with representatives from the clean energy business and financial community and nongovernment organizations to seek broad input on this topic (Table 1). This report presents the results of these consultations, while drawing on concepts and policy proposals presented in other studies.

The investment community stressed the importance of coordinated investment facilitation, especially in light of current global credit and economic conditions.

The strategies and actions presented here reflect recommendations provided by the participating stakeholders, who have endorsed the four high-level strategies presented in the report, but not necessarily all of the specific actions underneath each strategy or the opportunity and benefits analysis conducted by NREL.

Table 1. Participating Organizations

American Council on Renewable Energy (ACORE)	Brookings Institute	Green Strategies	Presidential Climate Action Project
Advanced Capital Markets	Citibank	Green Order	Resources for the Future (RFF)
Alliance to Save Energy	Conover & Associates	ICF International	SAIL Venture Partners
American Wind Energy Association (AWEA)	Credit Suisse	Jefferies & Company	Solar Energy Industries Association (SEIA)
Battelle	Center for Strategic International Studies (CSIS)	Lawrence Berkeley National Laboratory (LBNL)	UC Berkeley
Business Council for Sustainable Energy (BCSE)	Deutsch Bank	Morgan Stanley	UN Foundation
	Dow Chemical Company	Midwest Research Institute (MRI)	World Resources Institute (WRI)
	East Link Consulting	National Commission on Energy Policy	
	Energy Foundation	Novozymes	
	Energy Future Coalition	National Renewable Energy Laboratory (NREL)	
	Energy & Security Co.	National Venture Capital Association (NVCA)	
	EPS Capital Corp.		
	General Electric		
	Global Environment and Technology Foundation (GETF)		
	Goldman Sachs		

NREL's Role

The International Advisory Council for the National Renewable Energy Laboratory launched this effort in partnership with the World Resources Institute and the Center for Strategic International Studies. The group recognized the opportunity to more effectively tap the world's leading technology and analytic expertise at NREL and other national laboratories to advance global clean energy market transformation. NREL has world-class expertise in renewable energy and energy efficiency science; applied technology research and development (R&D); market, technology, and policy analysis; and commercialization and deployment programs. Through partnerships with the business and NGO community and other labs, NREL can play a leading role for the U.S. government in advancing international collaboration and networking, and can be an invaluable resource given its global credibility and expertise (see "Examples of NREL International Activities").

DOE's Office of Energy Efficiency and Renewable Energy (EERE) guides and supports most of NREL's international activities. The United States Agency for International Development (USAID), the Environmental Protection Agency (EPA), the State Department, and other U.S. federal agencies also support NREL international programs, along with United Nations agencies and other partners that provide limited funding. Expanded international engagement by NREL in cooperation with other partners can speed the rate of technology innovation and commercialization; enhance the competitiveness of U.S. industry; and help achieve global environmental, energy security, economic, and foreign policy goals.

The recommended strategies and actions in this report include initiatives that NREL could pursue in partnership with others and policy measures that go beyond NREL's role, which the U.S. government could undertake. All of the recommendations are based on comments and ideas provided by the organizations engaged in this process and based on review of reports and studies conducted by others on this topic. The NREL International Advisory Council, WRI, and CSIS have distilled these recommendations into the actions presented here.

Examples of NREL International Activities

These activities are conducted in support of DOE, other federal agencies, and international institutions.

- **China** – NREL is teaming with Chinese counterparts on analysis and decision tools; policies and standards; and R&D on advanced biofuels, wind, solar, and building technologies and eco-cities
- **India** – NREL is conducting joint resource and economic assessments; dissemination of decision tools; policy design; and R&D on solar, biofuels, and building technologies with Indian partners
- **Spain** – NREL and CENER, a counterpart Spanish lab, are collaborating on wind turbine testing and modeling
- **International Energy Agency (IEA)** – NREL is sharing R&D roadmaps and methods; working on technology standards and test methods; and conducting joint analyses with institutes from other countries in support of IEA implementing agreements on buildings, biomass, hydrogen, solar, and wind technologies
- **Climate Change** – NREL is evaluating options to enhance technology R&D, demonstration, and deployment cooperation among countries for the United Nations Framework Convention on Climate Change (UNFCCC) Expert Group on Technology Transfer.

Situation and Opportunity Assessment

This section outlines the scale of the global clean energy market-transformation opportunity and how the United States can more actively participate in global opportunity through robust international leadership. In addition, the report provides a brief review of current U.S. government international programs in the clean energy sector and of opportunities for enhanced leadership identified by stakeholders.

Rationale for Enhanced U.S. International Clean Energy Leadership

Climate change, the growing demand for fossil fuel resources, energy security, and sustainable development issues are recognized worldwide as critical challenges that require immediate attention. These concerns have helped create a growing consensus that global energy systems need to undergo a fundamental transformation toward clean energy technologies in the coming decades. At the same time, U.S. leadership in global clean energy markets has declined and economic opportunities are being lost to other countries. Through revitalized international clean energy programs, the United States can reap substantial economic, energy security, environmental, and global sustainable development benefits. These benefits include:

- Providing direct economic benefits to the United States—jobs, price reductions, economic stability, and enhanced trade balance
- Speeding the rate of development and market introduction of advanced clean energy technologies
- Enhancing the competitiveness of U.S. industry
- Tackling climate change and energy security through international cooperation

These benefits are summarized in Table 2 and presented in quantitative terms in the opportunity and benefits assessment section that follows.

Table 2. Value of U.S. International Clean Energy Cooperation

Provide Direct Economic Benefits to U.S.	Speed Rate of Innovation and Commercialization	Enhance U.S. Industry Competitiveness	Address Global Challenges
<ul style="list-style-type: none"> ○ Create new clean energy jobs through increased exports and manufacturing in U.S. ○ Reduce energy costs for U.S. consumers ○ Decrease volatility of energy markets ○ Improve U.S. trade balance 	<ul style="list-style-type: none"> ○ Increase researchers and resources tackling RD&D ○ Improve access to innovations and unique research capabilities in other countries ○ Accelerate technology learning and cost reductions 	<ul style="list-style-type: none"> ○ Industry access to international markets with U.S. help in removing policy or other barriers ○ International subsidies and policies help commercialize U.S. technologies ○ Industry access to IP, global innovations 	<ul style="list-style-type: none"> ○ Climate change mitigation requires rapid RE and EE scale-up by all major countries ○ Reduces global oil demand, prices, and volatility ○ Clean energy provides jobs and power for sustainable development worldwide

Existing U.S. International Clean Energy Programs

The U.S. government has a broad portfolio of international clean energy programs that can be grouped into three categories:

- Technology cooperation and market development, including bilateral and multilateral renewable energy and energy efficiency programs led by DOE, USAID, EPA, the U.S. Department of Agriculture (USDA), and others.
- Interagency climate change initiatives, such as the Asia-Pacific Partnership, the Major Economies Meetings, and other efforts in support of the climate change negotiations coordinated by the State Department.
- Trade and investment programs, including efforts by Commerce, Treasury, Export Import Bank (EXIM), Trade and Development Agency (TDA), Overseas Private Investment Corporation (OPIC), DOE, and others to provide financing and business matchmaking support for U.S. clean energy exports. This includes the recent proposal for a \$2 billion clean energy fund to be managed by the Treasury Department (totaling \$6.1 billion with matching pledges from other countries).

Current U.S. government programs are characterized by common themes of shared commitments under voluntary frameworks, enabling private investment, and fostering innovation and technology transfer (see Appendix D for more information).

Current Limitations and Future Opportunities Identified by Stakeholders

More than 40 stakeholders from the domestic and international clean energy industry and finance community, research organizations, and NGOs have participated in this effort and have provided a wealth of feedback on current limitations and future opportunities for U.S. international clean energy programs. This stakeholder feedback is summarized below and presented in more detail in Appendix B.

- **Resources** – U.S. government investments in international clean energy cooperation are at much lower levels and not coordinated across agencies in the manner needed to accelerate market transformation worldwide. For example, recent annual international appropriations (minus earmarks) for DOE's Office of Energy Efficiency and Renewable Energy have ranged from \$0-5 million/yr. with no international appropriations provided in FY08; this is compared with more than \$150 billion in global private investment in clean energy in 2007. The U.S. government reports (OECD 2007) spending more than \$1 billion a year in energy-related foreign assistance (largely dominated by the Department of Defense and Agency for International Development programs), with these resources spread across a large number of countries and not guided by a government-wide clean energy strategy.
- **Coordinated Goals and Plans** – The United States does not have well-defined, government-wide international clean energy goals and priorities or a cohesive implementation plan across agencies, with the private sector, and with international partners. Stakeholders emphasized the need to consolidate and better coordinate U.S. international clean energy programs across agencies to ensure that they all support a few well-defined goals and are implemented in an integrated manner; and so that business and other partners can have one primary focal point for collaboration.

- **Leadership** – U.S. leadership in key forums, such as the international climate change negotiations, must be more effective.
- **Technology Cooperation** – The U.S. government could significantly strengthen its technology research, development, demonstration, and deployment (RD³) cooperation with other countries and international institutions to leverage resources and accelerate progress toward common research and deployment goals
- **Investment Facilitation** – U.S. clean energy investment-facilitation programs are not fully addressing the private-sector need for risk mitigation and are not well-coordinated or streamlined (with exceptions such as EXIM programs)
- **Developing Country Market Reform** – The U.S. government is well-positioned to play a bigger role in teaming with major developing countries on assessments, policy-design support, technology standards, and workforce development needed for clean energy market transformation and private investment.
- **Domestic Action** – The United States must pursue domestic policies and measures in tandem with these international efforts to maintain a thriving clean energy industry and technology leadership that provides the foundation for international cooperation.

The stakeholders have identified four overarching strategies for enhanced U.S. international clean energy cooperation – 1) establish government-wide goals, an action plan, and strengthened international leadership; 2) revitalize U.S. investment-facilitation programs; 3) accelerate clean energy technology cooperation; and 4) pursue market-reform partnerships with key developing countries. These strategies and actions in support of each are presented in more detail in this report.

Scale of Opportunity and Benefits

The United States has an unprecedented opportunity to partner with other countries in rapidly accelerating global clean energy use and capturing large national and global benefits. According to analyses conducted by the International Energy Agency (IEA), Intergovernmental Panel on Climate Change (IPCC), the McKinsey

Benefits of U.S.-Led Global Clean Energy Cooperation

U.S. Benefits in 2020

- Up to \$40 billion/year increased clean energy exports, generating 0.25-0.75 million new jobs
- \$10-50 billion/year reductions in oil use costs
- A stronger dollar and improved trade balance, resulting in up to \$25 billion/year in benefits
- Enhanced U.S. diplomatic standing through assuming leadership on clean energy and issues

Global Benefits

- Reduced greenhouse gas (GHG) emissions (50-80% by 2050 relative to 2005 levels) avoiding dangerous climate change impacts
- Reduced global oil use (40% by 2050 relative to 2005 levels)
- Up to \$1 trillion a year in new investment opportunities
- Robust global economic development, with universal access to modern energy
- Reduced regional tensions and military conflicts from improved environmental and energy conditions.

NREL benefits estimates derived from IEA, IPCC, McKinsey, and other sources (see Appendix C).

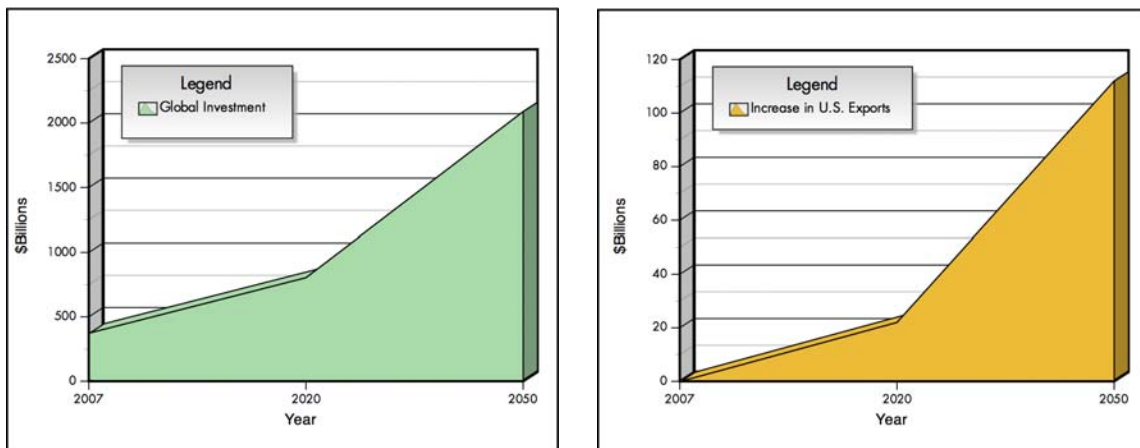
Global Institute, and others, robust international clean energy cooperation led by the United States can help reduce global GHG emissions by 50-80%¹ and reduce global oil use by up to 40% by 2050, while creating up to \$1 trillion per year of new renewable energy and energy efficiency investment opportunities worldwide. A global clean energy market transformation of this magnitude will yield significant benefits to the U.S. and global economies.

Economic and Market Benefits

U.S. leadership in clean energy markets will result in three types of direct economic benefits. First, U.S. clean energy businesses could increase their exports by up to \$40 billion per year in 2020 and by \$40-200 billion in 2050. Decreased oil global consumption will reduce oil prices relative to the baseline, saving U.S. consumers \$10-50 billion in 2020 and \$75-\$200 billion in 2050. By improving the U.S. balance of trade and strengthening the dollar, the increased exports and decreased costs of oil imports will create up to \$25 billion per year of additional savings in 2020 and up to \$60 billion per year in 2050.

Increased Clean Energy Exports

U.S. leadership in promoting clean energy internationally would enable U.S. manufacturers to dramatically increase their exports, with gains of up to \$40 billion in 2020 and \$40-\$200 billion per year in 2050. A robust U.S. clean energy industry will create significant new employment in the United States, between 250,000 and 750,000 jobs in 2020 and between 3 million and 8 million in 2050. Figure 1 illustrates the total growth in global renewable energy and energy efficiency markets and the corresponding increases in U.S. exports² resulting from a global clean energy market transformation.



Source: Global investment based on IEA Blue Map Scenario (2008a). Increased U.S. exports projected forward from current values.

Figure 1. Global renewable energy and energy efficiency investment and new U.S. exports from international collaboration

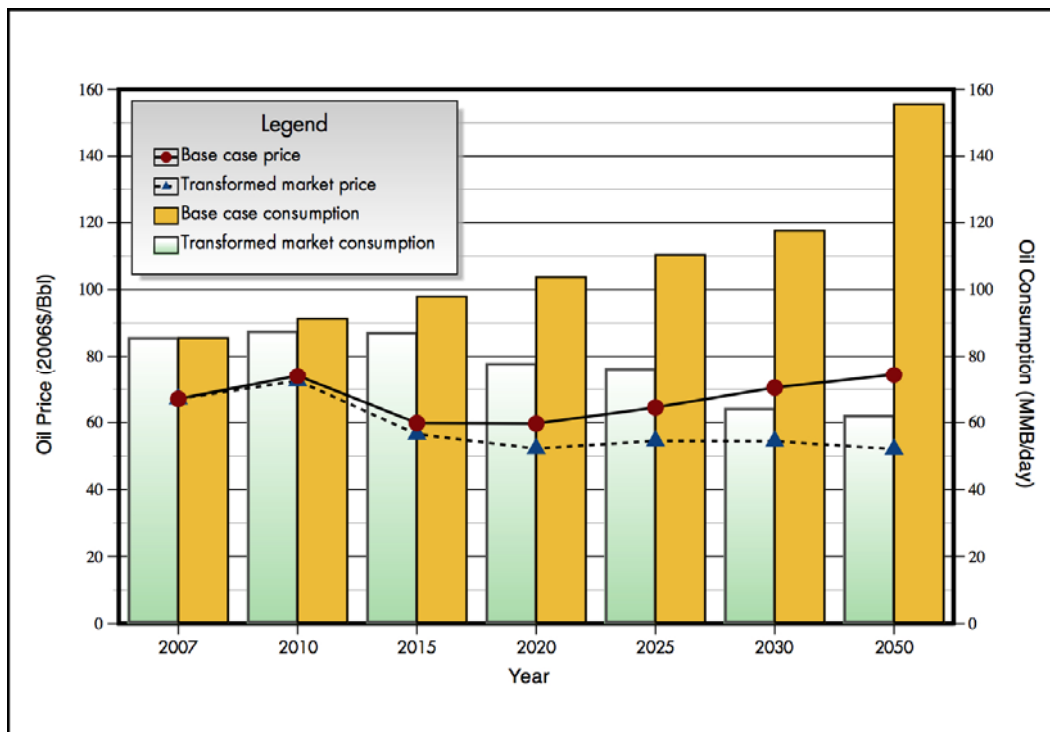
¹ Climate change scientists have determined that 50-80% reductions in global GHG emissions by 2050 are required to stabilize GHG concentrations at level that will prevent dangerous impacts.

² For simplicity, some of the figures in this section show point values for the impacts of the international clean energy effort. Appendix C presents the full range of the estimates and provides more information on the scenarios and analysis methodology.

Oil Market Benefits

U.S.-led international clean energy cooperation is estimated to reduce oil prices 5-10% from baseline levels in 2020, and 10-30% in 2050. Those lower oil prices will benefit the U.S. economy by \$10-\$50 billion in 2020 and \$80-\$200 billion in 2050. Biofuels and transportation efficiency technologies will reduce oil consumption by up to 40% in 2050 relative to the base case, creating a strong trend toward lower prices.³

Figure 2 shows the paths of world oil quantities and prices resulting from increased global use of transportation efficiency and biofuels technologies through international cooperation.



Source: EIA International Energy Outlook and Annual Energy Outlook extrapolated to 2050.

Figure 2. Impacts of international cooperation on oil consumption and prices

Balance of Payments Benefits

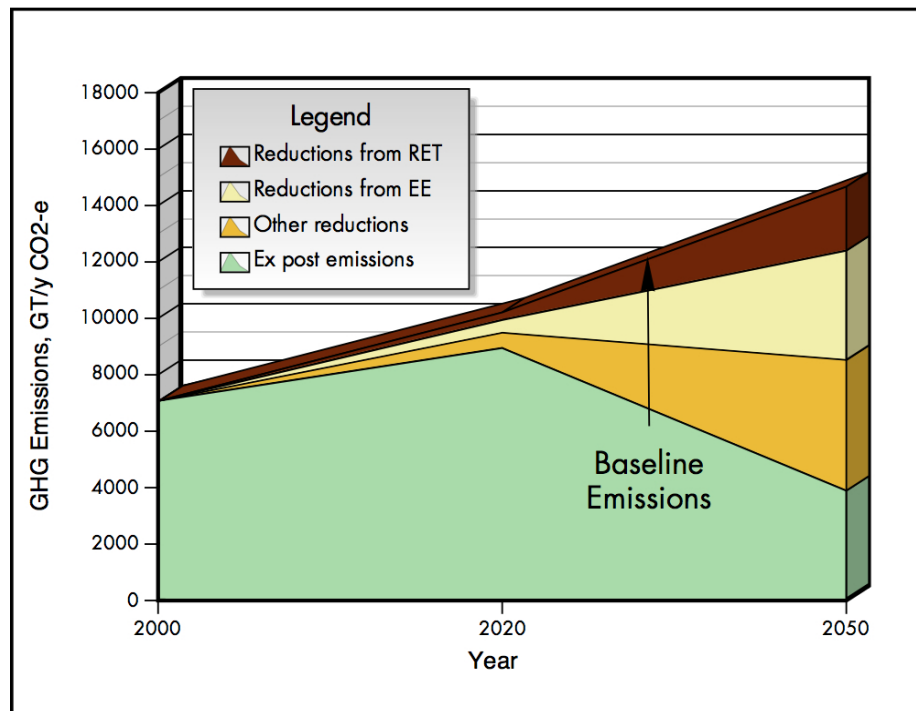
Both increased clean energy exports and reduced expenditures on oil imports will improve the U.S. balance of trade and strengthen the dollar, providing additional economic benefits. By improving these factors, the increased exports and decreased oil import costs will create up to \$25 billion per year of additional benefits in 2020 and up to \$60 billion in 2050.

³ Because so many factors affect world oil prices, it is difficult to attribute changes in oil prices to small, temporary shifts in demand. However, the initiative will permanently shift global consumption patterns downward by a significant percentage. Such a sustained shift may have a strong impact on prices, depending on the actions taken by oil-producing nations and other parties.

Environmental Benefits

Greenhouse Gas Impacts

The primary environmental benefit of the U.S.-led global clean energy market transformation will be reduced greenhouse gas emissions of 50-80% by 2050, which scientists think will prevent catastrophic climate change impacts—a large benefit to the U.S. and the global community. Clean energy technologies will provide more than half of the reductions needed to achieve that goal (Figure 3).⁴



Source: IEA (2008a)

Figure 3. Relative contributions of clean energy to 50% global greenhouse gas reductions

Other Environmental Benefits

Significant local air quality and other environmental benefits will accompany the reductions in greenhouse gas emissions. Reduced air emissions translate to improved health, lower health care costs, improved visibility, and reduced impacts on natural ecosystems. Increased use of clean energy also will reduce impacts from fossil fuel extraction and processing. Increased access to clean energy in the poorest regions of the world will reduce the use of firewood, enabling cleaner indoor air quality and contributing to local sustainable development.

Energy Security Benefits

In addition to the decreased oil prices mentioned above, international clean energy market transformation will reduce global vulnerability to supply and price shocks, and

⁴ In addition to clean energy technology, the IEA Blue Map Reduction Scenario (used for Figure 1) is based on the use of carbon capture and storage, nuclear power, and fuel switching.

could also decrease tensions over petroleum resources in key supply regions and U.S. costs of military intervention to help address conflicts that arise. Reductions in U.S. demand for oil, which will be enabled by accelerated cost reductions for biofuels and transportation efficiency technologies through international cooperation, also will decrease U.S. vulnerability.

Impacts on Development

The clean energy market transformation will accelerate global economic growth and stability by enhancing access to clean energy in rural and urban areas worldwide. More than 1 billion people around the world do not have modern energy services. Providing access to clean energy will provide the power necessary for micro-enterprises, health clinics, schools, water supply, enhanced agricultural production, and similar services. U.S. leadership in this area will enhance diplomatic influence and help achieve U.S. and global sustainable development objectives, including universal access to modern energy services around the world by 2020, which is consistent with the Millennium Development Goals.

Strategies and Actions Recommended by Stakeholders

This section of the report presents high-impact strategies and actions proposed by stakeholders to accelerate U.S. international clean energy cooperation. It also briefly highlights the needs for U.S. domestic action and other similar boundary conditions to provide a strong foundation for effective international engagement. The Executive Branch can do a lot on its own, but coordinated authorizing legislation and appropriations would create the most effective path forward.

Strategies for Enhanced U.S. International Clean Energy Cooperation

Industry and NGO stakeholders have identified one foundational strategy and three implementing strategies (along with supporting actions for each strategy) that the United States can pursue, which would accelerate global clean energy-market transformation in partnership with others. These strategies and actions are summarized below.



Figure 4. Strategies for enhanced U.S. international clean energy cooperation

Foundational Strategy – Government-Wide International Clean Energy Leadership

Many stakeholders stated that the most important action the U.S. government can pursue is to define clear international clean energy goals and priorities, and provide a well-coordinated, fully resourced, long-term implementation plan across all relevant agencies and departments to achieve these objectives. The President and Congress could jointly commit to specific international clean energy cooperation goals and priorities, and a cohesive government-wide, stakeholder-inclusive action plan. In addition, the United

States also will need to strengthen its leadership role in key international forums such as the international climate change negotiations, and strengthen partnerships with other countries and multilateral institutions.

Implementation Strategies

1. **Revitalize the Portfolio of U.S. Clean Energy Investment-Facilitation Programs.** Strengthen and consolidate U.S. government international clean energy investment programs to dramatically increase investment by U.S. firms in energy efficiency and renewable energy worldwide.
2. **Accelerate Global Renewable Energy and Energy Efficiency Technology Cooperation.** Scale-up global development and use of renewable energy and energy efficiency technologies through strategic research and development, demonstration, and deployment (RD³) partnerships.
3. **Partner with Major Developing Countries to Accelerate Clean Energy Market Transformation.** Partner with Brazil, China, India, and other priority countries, and through regional efforts in Africa, Latin America, Asia, and Newly Independent States to strengthen policy and market conditions that will grow and sustain clean energy investment.

The Energy Independence and Security Act (EISA) of 2007 (EISA 2007) calls for a similar portfolio of measures to strengthen U.S. government international clean energy investment, market development, and technology cooperation programs. Specific actions that can be pursued in support of each of these strategies are presented in the remainder of this report.

Boundary Conditions

The U.S. government will have greatest success with these international clean energy strategies if they are coupled with more comprehensive efforts that create the needed boundary conditions to allow these markets to flourish. Proposed boundary conditions include:

- Domestic policies that foster U.S. clean energy business growth
- An international agreement and effective global cooperation on climate changes that results in a strong and clear global price signal on carbon. This could include strategic bilateral and multilateral partnerships on climate change as proposed by the Council on Foreign Relations (CFR 2008) and others; and
- Robust U.S. clean energy R&D programs.

Proposed Actions

Table 3 presents the actions that stakeholders have identified as high-impact measures for supporting each of the strategies. Appendix A offers detailed descriptions for each of these measures.

Table 3. Actions Proposed by Stakeholders for High-Impact, U.S.-Led International Clean Energy Cooperation

Strategy	Actions	Key Steps and Program Elements
Foundational		
Develop Cohesive U.S. Action Plan and Leadership	1. Establish government-wide goals, action plan, and consolidated programs (see example goals in Appendix A)	<ul style="list-style-type: none"> • Articulate high-level shared administration and congressional international clean energy goals and priorities • Engage public-private task force in developing an interagency action plan • Consolidate and streamline U.S. international clean energy programs
	2. Strengthen U.S. partnerships and leadership in key international forums	<ul style="list-style-type: none"> • Bolster participation in leading global energy and environmental forums, including climate change negotiations • Coordinate efforts across the government to strengthen partnerships with international institutions and countries
Implementation		
Revitalize U.S. Clean Energy Investment-Facilitation Programs	1. Enhance and streamline high-impact investment services for U.S. companies	<ul style="list-style-type: none"> • Convene a clean energy global finance summit with U.S. firms to identify highest-value government services and efficiency delivery • Strengthen investment risk-mitigation vehicles for emerging markets • Consolidate and streamline services creating a “one-stop shop” for business-investment support (see EISA 2007 mandate for an interagency working group on clean energy exports) • Assist businesses in addressing policy, intellectual property (IP), and procurement barriers in key emerging markets • Convene enterprise growth forums in developing countries
	2. Continue effort to launch a global clean energy fund plus complementary services	<ul style="list-style-type: none"> • Establish global clean energy fund in partnership with other donors (while reviewing effective fund management structure), building on current \$6 billion in commitments by the U.S. and others • Create a complementary portfolio of investment products and advisory services to be used in tandem with fund grants
	3. Institute joint public-private program planning and implementation	<ul style="list-style-type: none"> • Develop mechanisms for joint U.S. government and private-sector planning and outreach, including possibly reinstituting the Committee for Renewable Energy Commerce and Trade (CORECT) and Committee on Energy Efficiency Commerce and Trade (COEECT) forums • Conduct annual program reviews with private-sector input • Establish resource center to share information and provide points of contact for the private sector

Accelerate High-Impact Technology Cooperation	1. Enhance global R&D cooperation	<ul style="list-style-type: none"> • Strengthen international clean energy R&D bilateral and multilateral partnerships and global and regional technical networks • Expand global clean energy R&D funds and prizes to promote distributed innovation in noncompetitive areas • Launch robust researcher-exchange and training programs
	2. Launch robust technology scale-up partnerships	<ul style="list-style-type: none"> • Support large-scale demonstration of near-commercial technologies in emerging markets with co-funding from host countries and international partners • Develop common global and regional roadmaps and systems to share results of technology pilots and demonstrations
	3. Support sustainable community, integrated deployment, and infrastructure partnerships	<ul style="list-style-type: none"> • Assist developing countries with sustainable community and infrastructure planning • Provide integrated deployment support to countries – including optimizing the use of a portfolio of clean energy solutions • Expand regional infrastructure and clean energy development forums and planning bodies
Partner with Major Developing Countries to Transform Clean Energy Markets	1. Strengthen clean energy policies and programs	<ul style="list-style-type: none"> • Assist countries with policy and program reforms and adopting best practices at all levels of government and considering sectoral approaches • Provide incentives for countries to adopt effective governance, free trade, and IP protection practices • Offer technical support – transferring U.S. expertise – with facilities and public lands energy management programs
	2. Develop robust clean energy and carbon assessment collaboration	<ul style="list-style-type: none"> • Launch a global clean energy assessment partnership with other countries and international institutions (strategic studies, data and tools repository, outreach and training) • Team with key developing countries on clean energy GHG mitigation supply analyses at national and regional levels to inform climate action plans and strategies
	3. Expand use of technology standards and promote education awareness	<ul style="list-style-type: none"> • Promote use of common technology performance standards and test methods around the world • Conduct education and outreach on standards and technology performance and benefits
	4. Support workforce development in key countries	<ul style="list-style-type: none"> • Establish joint workforce development plans with developing countries for key markets • Team with developing countries and international institutions to provide technical assistance with workforce development programs (train the trainers, model curriculums, community college peer exchange, etc.)

Country and International Institutional Partners

Stakeholder feedback, especially that from U.S. industry, has clearly indicated that the U.S. government will be most effective at implementing the above international clean energy initiatives if it is focused on a few well-defined priority countries and fully engages other key international players. The United States should pursue both bilateral and multilateral partnerships in conducting its priority actions for technology cooperation, investment facilitation, and market transformation. This includes regional initiatives for engaging multiple countries. Table 4 provides examples of potential priority partner countries and international institutions. In most cases, U.S. federal agencies, NREL, and other laboratories already have close relationships with these countries and organizations, which provide a solid foundation for enhanced collaboration.

Table 4. Examples of Partner Countries and International Institutions – Illustrative Only

	Market Reform and Investment Facilitation	Technology Partnerships
Country Selection Factors	<ul style="list-style-type: none"> • Large and growing clean energy markets and GHG emissions • Commitments to clean energy market growth • Strong high-level relationships with the U.S. • Global and regional leaders 	<ul style="list-style-type: none"> • Centers of technology innovation with significant R&D budgets • Effective IP protection • Strong relationships with the U.S. • Global and regional leaders
Candidate Countries and Regions	<ul style="list-style-type: none"> • Brazil • China • India • Mexico • S. Africa <u>Regional initiatives in:</u> <ul style="list-style-type: none"> • Africa • S.E. and southern Asia • Latin America • Newly Independent States 	<ul style="list-style-type: none"> • Australia • Brazil • Canada • China • Denmark • European Commission • Germany • Iceland • India • Israel • Japan • Netherlands • New Zealand • Singapore • South Korea • Spain • Sweden • United Arab Emirates (UAE) • United Kingdom (U.K.)
International Institutions	<ul style="list-style-type: none"> • World Bank, Global Environment Facility, IFC, and regional development banks • UNEP, UNDP, UNF, UNIDO, and UNFCCC processes and groups • IEA, IEC, and similar international R&D and standards organizations • IPCC, IIASA, OECD, WRI (and other U.S.-based international organizations) • IPEEC, GVEP, REN21, GBEP, IPHE, and similar global partnerships 	

Conclusions

The United States has an unparalleled opportunity to lead a global clean energy market transformation that will yield vital economic, energy security, environmental, and development benefits for the United States and the world as a whole. Concerted U.S. action, together with other partners, could generate up to \$40 billion/yr. in new clean energy exports and 750,000 new jobs by 2020, along with \$10 to 50 billion/yr. in additional savings from reduced oil prices and other critical economic and energy security benefits. Such a global clean energy market transformation is a necessary critical step in reducing worldwide greenhouse gas emissions by 50-80% by 2050, which is necessary to prevent dangerous climate change impacts. It also will foster revitalized economic growth and sustainable development in all regions of the world and ensure that all citizens worldwide have access to modern energy services.

Industry and NGO stakeholders have identified a portfolio of high-level strategies and actions that will enable the United States to spearhead international clean energy cooperation and capture these benefits. This effort includes foundational measures to establish a cohesive government-wide action plan and reassert U.S. leadership in key international forums and three key implementing strategies: 1) revitalized U.S. clean energy investment-facilitation programs; 2) accelerated renewable energy and energy efficiency technology cooperation; and 3) partnerships with major developing countries and others to transform clean energy markets. The United States will not succeed in implementing these actions alone and must actively engage developed and developing country partners and international institutions. Furthermore, the United States cannot afford to wait—it must seize the opportunity now to spark a worldwide transition to a brighter clean energy future.

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Appendix A. Detailed Description of Strategies and Actions

Foundational Strategy: Focused and Robust U.S. Leadership

Strategic goal: The President and Congress commit to specific international clean energy cooperation priorities and align all agencies behind a comprehensive implementation plan.

Most stakeholders identified the establishment of common government-wide international clean energy goals and priorities, along with a well-coordinated and fully resourced implementation plan across all relevant agencies as the most important action that the U.S. government can pursue. Several organizations, including key industry leaders, further noted that such common priorities, coordinated agency programs, and sustained commitments over multiple years are pre-requisites for them to develop a close partnership with the U.S. government. This section focuses on the actions that government, along with other agencies and key international partners, can take to establish shared high-level priorities and identifies the coherent and effective implementation programs needed to achieve them.

Foundational Action 1. Establish Government-Wide International Clean Energy Objectives, Action Plan, and Consolidated Programs

Goals

- Articulate common international clean energy goals and priorities for all U.S. government agencies and for Congress.
- Develop an integrated action plan and streamlined implementation structure to achieve these goals.

Primary Activities

- **Articulate High-Level Government-Wide International Clean Energy Goals and Priorities.** The next administration and Congress could work together to establish a common set of international clean energy market-transformation goals and priorities to guide U.S. programs for the next five years. These goals and priorities could incorporate the opportunities and strategies

Example of U.S. Government 2013 International Clean Energy Goals – Illustrative Only

1. U.S.-led international clean energy cooperation helps achieve global targets such as 10% of electricity from RE, 5% decline in oil use, and a \$200-300 billion/yr. RE and EE market.
2. Revitalized government investment-facilitation programs support \$2-4 billion/yr. of U.S.-industry RE/EE exports and trade projects (EXIM supported \$120 million of RE projects in 2007)
3. Expand high-value international clean energy technology RD&D cooperation to a \$100 million/yr. effort for the U.S. (~ 5-10x increase from current) and U.S. clean energy foreign assistance to \$2.5 billion/yr. (~ a 2x increase from current).
4. Robust clean energy market transformation partnerships implemented with China, India, Brazil; and regionally in Africa, Asia, and Latin America.

proposed in this report, along with recommendations made by others, into a focused set of international clean energy goals and strategic priorities (see “Example of U.S. Government 2013 International Clean Energy Goals”).

- **Engage Public-Private Task Force in Developing a Comprehensive Action Plan.** A public-private task force could establish a coordinated government-wide, multi-year action plan to achieve the U.S. international clean energy goals. This action plan should present a roadmap of actions over the next five years for achieving each goal and should identify annual targets and deliverables. The plan would leverage U.S. government resources with the U.S. private sector, foundations, and international partners, and could acknowledge the emergence of other countries as international clean energy market and policy leaders. This public-private task force could be engaged in annual reviews to assess progress in implementation and inform government-wide annual plans for the next year, similar to the planning process currently used by DOE technology programs. Note that Section 916 of the Energy Independence and Security Act of 2007 (EISA 2007) mandates the establishment of a task force across U.S. federal agencies to coordinate implementation of a U.S. clean energy strategy.
- **Consolidate and Streamline U.S. International Clean Energy Programs.** More than 10 U.S. government departments and agencies, and numerous programs within each organization, are engaged in international clean energy initiatives. This complex array makes it difficult for the U.S. government to act in a coordinated fashion and for industry and others to effectively partner with them. Several options for consolidation and streamlining could be considered, including:
 - Assigning responsibility for government-wide international clean energy coordination to the Council on Environmental Quality (CEQ), or possibly a new CEQ energy equivalent, as proposed by the Presidential Climate Action Project and others.
 - Consolidating international clean energy programs in a smaller number of departments or agencies or into a couple of interagency initiatives and portfolios—climate change, technology and market development, and investment and trade promotion;
 - Establishing government-wide leads for each program area with authority to coordinate activities across agencies; and
 - Creating an international clean energy resource center to serve as a focal point for streamlined assistance and partnership development with private-sector firms and others. This could build from the project assistance center concept under the Clean Energy Technology Exports (CETE) initiative proposed several years ago.

Potential Impacts

A tightly focused, effectively coordinated and resourced international clean energy program is essential for the United States to capture the economic, environmental, energy security, and development benefits presented earlier. A coherent and integrated program will help the U.S. government partner with the private sector, the international community, and others to achieve the scale of investment in key markets needed to create lasting clean energy market transformation.

Key Partners

The U.S. government would partner with the private sector, laboratories, universities, foundations, and NGOs to develop and achieve the international clean energy goals. A consortium of DOE labs could be established to help the government develop and implement the clean energy action plan in cooperation with other stakeholders. The U.S. government would design programs that could be implemented in close cooperation with other countries; international organizations such as the United Nations (UN), World Bank, and regional banks; and other international institutions.

Foundational Action 2. Enhance U.S. Engagement and Leadership in International Forums

Goal

- Actively and constructively engage in international forums to enhance the United States' role as a thought leader and solutions provider to common international energy challenges.

Primary Activities

- **Bolster U.S. Participation in Leading Global Energy and Environmental Initiatives and Forums.** The United States currently plays an active leadership role in several forums, including multilateral implementing agreements under the IEA, the work of the IPCC, and initiatives spearheaded by the United States (e.g., APP, MEMs, IPHE, Energy Development in Island Nations, etc.). At the same time, the United States is playing a diminished role in several other important international programs, such as the international climate change negotiations, the establishment of an International Renewable Energy Agency (IRENA), the Global Village Energy Partnership (which the United States helped establish), and other similar activities. Enhanced U.S. participation and leadership in these programs and forums is essential to make progress toward U.S. clean energy goals.
- **Coordinate Efforts Across the U.S. Government to Strengthen Partnerships with International Institutions and Other Countries.** Stronger partnerships with key countries (as defined further in this report) and international institutions including the IEA, World Bank and regional development banks, United Nations Environment Program (UNEP), United Nations Development Program (UNDP), UNFCCC Secretariat, IIASA, IPCC, and others) will yield effectively coordinated and leveraged programs that will accelerate progress toward common international clean energy goals. The U.S. government could define relationship managers for each key partner organization and establish government-wide strategic goals for each partnership. The United States is the single largest contributor to most of these international institutions and has an opportunity for significant influence on their programs that is not currently fully realized.

Potential Impacts

Through partnerships and the power of collective global action, the United States can have a much greater impact than through unilateral actions. U.S. international leadership can foster the concerted global effort across public and private sectors needed to transform markets, and the United States can leverage scarce resources through these partnerships.

Key Partners

The U.S. government would engage the private sector, laboratories, foundations, and NGOs in crafting and implementing this international partnership strategy. NREL, with other DOE labs, could lead strategy development for the U.S. government and assist with relationship management. The DOE labs have strong operational partnerships with most of these key international institutions and with leading technical counterparts in other developed countries.

Implementation Strategy 1: Revitalize U.S. Government Clean Energy Investment-Facilitation Programs

Strategic goal: Strengthen and consolidate U.S. government international clean energy investment programs to dramatically increase and accelerate investment by U.S. firms in energy efficiency and renewable energy worldwide.

The International Energy Agency (IEA) projects that \$45 trillion of new clean energy investment will be needed by 2050 to match growing energy demand in developing and developed countries and address climate concerns (IEA 2008a). Stakeholders have articulated the need for a more effective and consolidated portfolio of U.S. government programs that facilitate and support clean energy investments in these markets by U.S. firms.

Action 1.1. Enhanced and Streamlined Portfolio of High-Impact Investment-Facilitation Services for U.S. Companies

Goals

- Provide targeted portfolio of high-value international clean energy investment support services for U.S. firms.
- Deliver services in a highly efficient and streamlined manner so that support can be provided with limited transaction costs and on the time scale needed by the business community.

Primary Activities

- **Convene Clean Energy Finance Summit.** Conduct a summit with U.S. private-sector technology providers and investors, U.S. agencies, and other key players to identify the highest-value U.S. government investment-facilitation services and strategies for efficient delivery of these services. This summit could further explore several specific options identified through consultation with the private sector in this effort, including:
 - Taking key actions to increase demand for clean energy technologies and associated project development in key markets;
 - Enhancing timely access to risk insurance and guaranteed debt financing;
 - Establishing a new class of securities referred to as global development bonds; and
 - Creating new clean energy investment funds targeting emerging markets and high-risk technologies.
- **Strengthen Global and Regional Investment Risk-Mitigation Vehicles for Emerging Markets.** Enhance risk-mitigation vehicles for emerging markets (private firms identified this as a need). The United States could team with global institutions (e.g., the International Finance Corporation, GEF, UNFCCC, multilateral development banks, and others), and developed and developing countries to establish a more effective portfolio of global or regional loan guarantees, reduced rate loans, risk insurance, development bonds, and related

vehicles. This effort would support private investment from all sources in clean energy projects in developing countries.

- **Consolidate and Streamline Existing and New Services.** Consolidate investment services that are now offered across multiple U.S. agencies (EXIM, TDA, OPIC, Commerce, DOE, and others) and streamline the delivery of these services so businesses can have a “one-stop shop” for investment support. For example, this could be done through the creation of a government-wide clean energy project and investment center as proposed under the Clean Energy Technology Exports initiative that was planned several years ago. Section 916 of the Energy Security and Independence Act of 2007 also calls for the establishment of an interagency working group to coordinate clean energy export programs.
- **Provide Country Policy, Procurement, and IP Protection Support.** For priority markets, the United States government could work with host-country governments (building on the enabling activities described earlier) to enact policies, trade efforts, and programs to make their markets receptive to international private investment. This could include the development of government-procurement programs to stimulate market development, and programs to work with host countries to strengthen IP protection and enforcements while advising U.S. firms of IP risks (see “IP Risks and Opportunities”).
- **Convene Enterprise Growth Forums in Developing Countries.** Apply successful U.S. models for technology incubators and enterprise growth forums that help attract venture-capital funding to new technology businesses and expand these approaches to developing countries. The United States could use these forums to expose the investment and policy community to emerging technologies and to address technology performance or quality questions. Forums could be organized by sector within countries and regionally.

IP Risks and Opportunities

Stakeholders have identified the following key IP issues:

- Concerns about weak IP protection and enforcement in other countries can stop U.S. firms from pursuing clean energy investments in other countries or raise the costs and time required to negotiate deals.
- At the same time, a growing level of clean energy IP is generated in other countries and U.S. firms can benefit greatly by gaining enhanced access to this IP.
- There is an opportunity for the U.S. government to develop more effective mechanisms to more actively engage countries in strengthening IP protection and raising the visibility of cases where IP enforcement does not occur.
- The U.S. government and labs also have a role to play in monitoring clean energy IP development and protection in other countries and sharing this information with U.S. firms.
- The U.S. government and labs can also pursue cooperative R&D relationships that give enhance access to IP and unique innovations developed in other countries.

Impacts

A streamlined portfolio of high-value clean energy investment services could help U.S. firms capture a greater percentage of the global renewable energy and energy efficiency market (estimated at nearly \$150 billion in 2007 by New Energy Finance), which is expected to grow to nearly \$1 trillion per year by 2050, according to the IEA.

Key Partners

The U.S. government could team with U.S. firms to develop a more effective and consolidated portfolio of investment vehicles to support U.S. clean energy exports while working with international partners (including the IFC) to develop global investment risk-mitigation vehicles for emerging markets. National labs could be teamed with private finance consultants to design and implement such programs.

Action 1.2. Global Clean Energy Fund

Goals

- Ensure adequate access to capital for higher-risk clean energy projects in developing countries that have significant GHG mitigation, energy security, and development value.
- Complement existing funds and financing mechanisms to accelerate clean energy investment.

Program Activities

- **Establish Clean Energy Fund.** Team with other developed countries and international institutions to establish a clean energy fund that would provide co-financing for projects that advance use of high-risk and emerging technologies and projects. Funds would be allocated only to projects where the host country has committed to necessary co-financing as well as policy and trade support to ensure thriving and sustained investment markets for the technology.
- **Create a Complementary Portfolio of Investment Products.** The fund would provide not only grants for project implementation, but could provide a broader portfolio of investment products to accelerate clean energy investment. This could include preferential loans, as well as access to equity financing, infrastructure financing, and other innovative global sources of capital (e.g., global development bonds).
- **Offer Project Development Advisory Services.** This fund would couple advisory services with grants, loans, and other financial packages to ensure that adequate business models are being designed and implemented, and that an appropriately trained management team is in place to execute the project. This holistic approach to fund management would ensure that the capability-development element cited by many country submissions is adequately addressed at the project level.

Potential Impacts

A well-developed, adequately resourced, and sustained global clean energy fund could dramatically accelerate clean energy investment. The U.S. government recently proposed

\$2 billion over the next three years for such a fund, and total funding commitments from 10 developed countries, including the United States, now total \$6.1 billion. This funding could leverage private investment at 10:1 or more, and could result in \$60 billion in the near term. The Better World Campaign recommends a global doubling of energy-related foreign assistance to \$15 billion per year with a U.S. share of \$2.5 billion per year (Purvis 2008).

Key Partners

The United States would continue to partner with other developed countries, the World Bank, and other international organizations (e.g., there is consideration of climate technology funds under the UNFCCC) in developing the fund; and would partner with the private sector for design and implementation. National laboratories could provide technical support to design fund programs and review proposals.

Action 1.3. Public-Private Program Planning and Implementation

Goals

- Develop an ongoing process for engaging U.S. firms in planning of U.S.-led international clean energy programs.
- Inform firms of U.S. programs and coordinate implementation with private-sector activities and interests.

Program Activities

- **Develop a U.S. Government/Private-Sector Planning and Outreach Forum.** The U.S. government could reinstitute the CORECT and COEECT models for holding ongoing (e.g., quarterly) meetings with industry to discuss government programs, highlight industry activities and priorities, seek input on new plans, and coordinate implementation.
- **Conduct Annual Program Review.** The U.S. government could conduct an annual international clean energy program with all key stakeholders to evaluate past performance and seek input on plans for the next year. This could follow the format for DOE technology program annual reviews.
- **Establish Clearinghouse and Resource Center for Private-Sector Partners.** The U.S. government could establish a Web site with up-to-date information on U.S. international clean energy programs across agencies and points of contact who could provide business representatives with information on programs and opportunities for participation. This also could match businesses with market and technical experts who can provide quick-response assistance as they evaluate new investment opportunities and share information on markets, existing analysis tools, and financing resources.

Potential Impacts

Engaging the business community in program planning and delivery will help U.S. government programs overcome the most critical barriers to accelerated and sustained private investment. This action also will ensure that government leverages its activities

effectively with the private sector and that these programs expand U.S. clean energy exports.

Key Partners

The U.S. government could team with industry associations to plan and coordinate technical-support activities with national labs and others, including providing expert assistance to firms.

Implementation Strategy 2: Technology RD³ and Infrastructure Partnerships

Strategic goal: Accelerate global renewable energy and energy efficiency development and deployment through technology cooperation.

Rapidly expanding investment in renewable energy and energy efficiency technology development and deployment represents the leading edge of a transition in the global economy, from one fueled by conventional fossil fuel resources to one powered predominantly by renewable resources. Various stakeholders have highlighted the need for a new paradigm of international global cooperation on technology research, development, demonstration, and deployment (RD³) to achieve this clean energy transformation. Several stakeholders also noted the need for the United States to scale-up its domestic RD³ programs to rebuild U.S. global leadership.

International RD³ cooperation can engage researchers and resources worldwide in speeding the rate of technology innovation and commercialization. Effective two-way cooperation enhances access to unique innovations and capabilities and market conditions in other countries for U.S. firms and research institutions, and ultimately leads to increased U.S. clean energy jobs and lower energy prices for consumers. Such global RD³ cooperation can proceed most easily when it focuses on foundational research, analysis and testing issues, technology demonstration and infrastructure, and related topics that do not involve sensitive IP or areas where U.S. firms are actively competing with foreign firms.

Stakeholders have proposed the following technology cooperation actions.

Action 2.1. Accelerated Global R&D Cooperation

Goals

- Speed clean energy technology innovation and leveraging of U.S. R&D investments through enhanced bilateral and multilateral R&D partnerships
- Prime clean energy markets in developing countries by enhancing the talent pool of clean energy researchers and professionals.

Primary Activities

- **Strengthen International Clean Energy Research Partnerships and Networks.** Expand current clean energy R&D partnerships through bilateral partnerships, the IEA, collaboration with the European Commission, and establishment of global research alliances. Bilateral partnerships can be highly effective means of leveraging resources and expertise in tackling common research challenges. Several countries worldwide have growing clean energy R&D programs, and there are large opportunities for more robust bilateral collaboration with these countries that build from existing relationships that DOE, NREL, and others have established (see “Potential Key Country and Regional Partners”). In addition, the United States and other partners can enhance the

extent of R&D collaboration through the IEA, including more full engagement of developing-country partners. The United States also should explore working with international partners to establish one or more networks of leading renewable energy and energy efficiency research organizations around the world to conduct cooperative research and analysis projects, identify and communicate needs for increased R&D investment, share research methods and results, conduct outreach, and facilitate professional exchanges and education programs. These alliances also could be structured to engage private-sector firms that are making large investments in R&D. This could include the establishment of a consultative group on clean energy research, modeled after the Consultative Group on International Agricultural Research (CGIAR), which would focus on the development and diffusion of low-cost clean energy technologies for use by low-income populations around the world.

- **Create Global Clean Energy R&D Funds and/or Prizes.** Team with other countries, international institutions, and the private sector to create global funds to support open and distributed innovation for priority clean energy technologies.⁵ Such funds could focus especially on common noncompetitive research topics, technologies, and applications with large global market potential that are currently underfunded by national programs. It also could focus on areas where distributed innovation will accelerate progress at paces much faster than could occur through separate national programs. The partners also could establish technology prizes (such as the X PRIZE for the first 100 mph car) to complement this fund and incentivize distributed private-sector R&D investment
- **Launch Robust Researcher Exchange and Training Programs.** Initiate active programs to sponsor exchange of U.S. researchers with other countries to enrich professional R&D collaboration and help the United States learn from and gain access to research knowledge in other countries, accelerating the pace of technology innovation. This also could include efforts to build a network of developing-country researchers through training and education programs so that businesses have a deeper talent pool to draw from in these countries, allowing these markets to grow more quickly.

Potential Impacts

Global R&D cooperation can have a tremendous impact in accelerating technology innovation and development. For example, the Humane Genome project pooled resources across countries and the private sector to decode the human genetic code at a rapid pace. Global cooperation can be a force multiplier, leveraging U.S. R&D funding with funding from other countries and the private sector.

Key Partners

The United States could partner with other developed and developing countries, the private sector, and international institutions. The national laboratories could provide technical leadership for the design and implementation of global R&D funds and prizes, research networks, and researcher-exchange and training programs.

⁵ As proposed by Milford et al., and similar to the proposal by the Better World Campaign (Purvis 2008) for an international fund for research and development on revolutionary climate technologies.

Action 2.2. Technology Demonstration and Scale-up Partnerships

Goals

- Accelerate the global adoption of targeted technologies through large-scale programs to fund the demonstration and deployment of near-commercial technologies.
- Accelerate learning, cost reductions, and market acceptance needed for broad deployment of near-commercial technologies.

Primary Activities

- **Support International Technology Scale-Up Programs.** The United States could team with other countries and international institutions to provide financial and technical support for large-scale demonstration of selected technologies in targeted developing-country markets. Technologies and markets could be selected based on industry and other stakeholder consultations, and criteria such as private-sector investment interest, GHG mitigation value, self-sustaining replication potential, environmental impacts, and other factors. Support for technology scale-up programs would be contingent on host-country co-funding and adoption of market-enabling policies and programs.
- **Develop Global and Regional Technology Roadmaps and Systems to Share Demonstration Results.** The United States could work with participating countries, companies, and international institutions to develop common global and regional technology deployment roadmaps for the target technologies. This would provide a foundation for implementing technology demonstrations and addressing the full suite of technical and market barriers to sustained investment. In addition, global sharing of data from demonstration projects and early market experiences can help advance technology learning and cost reductions.

Potential Impacts

Well-structured and targeted technology demonstration and scale-up partnerships could significantly increase deployment and self-sustaining market growth for selected technologies. For example, the IPCC has estimated the global concentrated solar power (CSP) potential will be between 630 to 4,700 GW by 2030 or 2040, compared to current installed CSP capacity (around 500 MW) and 11 GW of plants under development. The IEA also notes that once 10 carbon-capture storage demonstration plants are built and operating, the technology will be sufficiently proven for the investment community to undertake projects without government support (IEA 2006). Such technology scale-up programs can advance technology learning; reduce costs; and overcome market-specific policy, capacity, and investment barriers.

Key Partners

The U.S. government would team with the private sector, international institutions, and other developed and developing countries to implement such technology scale-up programs. NREL and other DOE laboratories can play a technical leadership role with such initiatives.

Action 2.3. Launch Sustainable Community, Integrated Deployment, and Infrastructure Partnerships

Goals

- Foster the development of sustainable communities worldwide that apply a holistic, systems-level approach across sectors to promote use of clean energy technologies.
- Assist countries and regions in identifying and applying the optimal portfolio of renewable energy and energy efficiency technologies to meet their energy, economic, and environmental goals
- Accelerate the development of new and modified infrastructures and increase investment in existing infrastructure to support the global transition to clean energy, based on renewable energy resources and energy efficiency.

Primary Activities

- **Support Sustainable Community and Regional Infrastructure Planning and Implementation.** In partnership with other countries and donors, provide financial and technical support to assist communities and regional organizations worldwide in designing and planning sustainable communities and infrastructure development needed for clean energy transformation. This could include the following components:
 - *Sustainable Community Design and Regional Infrastructure Planning Grants* to provide seed funds for the community design and planning, and coordinated investments in transmission and transportation infrastructure needed to support clean energy use;
 - *Sustainable Communities Clearinghouse* to provide information on best practices and analytical tools to support outreach programs, including the development of simulation and screening tools;
 - *Financing and Advisory Services* to provide communities with expert assistance in exploring innovative financing options and matchmaking between communities and potential sources of capital; and
 - *Sustainable Community and Infrastructure Planning Training* to build capacity in local governments and regional organizations to design and finance projects.
- **Assist Developing Countries in Optimizing Use of a Portfolio of Clean Energy Solutions.** Partner with host developing countries and donors to provide technical support for evaluating the most effective mix of renewable energy and energy efficiency technologies and programs to meet their needs, and implementing programs to accelerate investment in these technologies. This could build off the DOE and NREL integrated deployment partnership with Hawaii and related Clean Energy Islands Initiative.
- **Expand Regional Infrastructure and Clean Energy Development Forums.** These forums would support technology-specific infrastructure development and regional energy cooperation, such as Western Hemisphere biofuels planning and

development.⁶ North American energy cooperation would foster transmission and clean energy electricity planning among the United States, Canada, and Mexico. This also could include similar forums in other regions of the world to help grow these markets in coordinated fashions.

Potential Impacts

A complete transformation of energy systems requires optimizing the use of a mix of clean energy solutions and fundamental changes in infrastructure and community design. This would allow for new integrated systems that link electricity supply and distribution, fuel production, transportation, and energy end use in sustainable manners. By supporting integrated deployment programs and sustainable community and infrastructure design worldwide, the U.S. government and private sector can be at the forefront of this transformation and accelerate clean energy adoption and market growth.

Key Partners

The United States could build from existing DOE, NREL, and other integrated deployment, renewable energy and carbon neutral community, and infrastructure planning initiatives. It also could partner with existing international programs, such as the Global Village Energy Partnership and the work of the International Council for Local Environmental Initiatives. NREL and other DOE labs also could provide technical support for these initiatives.

⁶ See Western Hemisphere Energy Cooperation Forum as proposed in Senate Bill 1007 at the Library of Congress (2007).

Implementation Strategy 3: Partner with Major Developing Countries to Transform Clean Energy Markets

Strategic goal: U.S. partners with other countries and international institutions in strengthening policy and market conditions in key countries and regions worldwide that will foster sustained clean energy investment and transformation.

The U.S. government has a vital role to play in assisting key developing countries in strengthening policy environments, the analytic foundation, and the human capacity required for clean energy market transformation. Stakeholders have highlighted the critical need for improving in-country policy and market environments to attract and sustain high levels of private investment, and have identified several actions that the U.S. government can pursue. Such efforts can build on the strong government and lab relationships with counterparts in other countries, and must be driven by strong interest and support by the host countries. For example, DOE, NREL, and other labs have collaborated with China for the past decade on analytic and technical work to inform design and implementation of clean energy policies and programs. To achieve maximum impact, the United States should focus its market-transformation activities on key countries and regions (see “Potential Key Country and Regional Partners”). This also could build on proposals by the Council on Foreign Relations, Presidential Climate Action Project, and others for strategic climate cooperation partnerships with key countries, and on the approach of the Asia-Pacific Partnership to engage countries on collaborative programs to reduce GHG emissions from target sectors.

Potential Key Country and Regional Partners – Illustrative Only

- Countries – **Brazil, China, India, Mexico, and S. Africa.** These five countries have large and growing clean energy markets and GHG emissions, and play global and regional leadership roles on these issues. They also are centers of technology innovation (less so for Mexico and S. Africa) and countries with which the U.S. has close relationships.
- Regions – **Africa, Asia, Latin America, and NIS (newly independent states).** Regional programs, including policy support, energy assessments and decision tools, capacity building, and investment facilitation can be highly effective in advancing market transformation in these parts of the world.

Action 3.1. Partner with Key Countries to Strengthen Clean Energy Policies and Programs

Goals

- Assist key countries in strengthening policies and programs that will mobilize large-scale international clean energy investment.
- Leverage U.S. government investment with commitments from the host country and support for international donors and private firms for maximum impact.

Primary Activities

- **Assist Key Countries with Policy and Program Reforms.** The United States could expand its current partnerships with key countries (e.g. China, India, Brazil, and regional efforts) to assist them in refining and strengthening clean energy policies and programs that will accelerate private investment and technology use. Such efforts would focus on those policies and programs where the host countries are interested in U.S. analytic and expert assistance and could be informed by barriers identified by U.S. firms. U.S. assistance could include:
 - Resource, infrastructure, and economic analysis to guide policy and investment decisions and action plans;
 - Expert technical support and training on clean energy policy and program design and implementation at national and provincial levels;
 - Development and support of policy-decision tools for use by government decision-makers and key business and technical partners in the countries;
 - Investment risk mitigation and other investment-facilitation activities to promote investment by U.S. firms in each country; and
 - Development of national renewable energy and energy efficiency strategies and action plans.
- **Link Assistance to Incentives for Countries to Adopt Governance, IP Protection, and Free Trade Policies and Best Practices.** The U.S. government could link increased support of key countries to progress in improving governance, IP protection, trade policies, and enabling environments in the host countries, similar to the Millennium Challenge Corporation approach and work by USAID and the World Bank in this area.
- **Provide Technical Support in Design of Government Procurement and Facilities Energy Management Programs.** The United States can assist countries in applying effective approaches and tools developed through the Federal Energy Management Program (FEMP) and similar state and local efforts to strengthen government procurement programs. Such procurement provides not only cost, energy use, and emissions reductions for governments, but also provides the leadership, stimulus, and certainty needed to develop new markets and offer a prominent model that can motivate private-sector adoption of renewable energy and energy efficiency.

Potential Impacts

Comprehensive market-enabling programs in China, for example, could help achieve China's goal of 15% of primary energy from renewable energy by 2020, representing a total investment opportunity of \$265 billion (Cai 2007) and reducing China's GHG emissions by 1.2 billion tons of CO₂ per year by 2020 (CCAP 2008).

Key Partners

The U.S. government would partner with the host country to implement market-enabling programs and could establish a technical team (e.g., NREL and other labs, consultants, etc.) to deliver technical services to the countries. U.S. companies could help identify priorities for policy reform in key countries and could partner with other international donors to implement this program.

Action 3.2. Develop Clean Energy and Climate Assessment Partnerships - Providing Objective and Credible Data and Decision Tools

Goals

- Launch a global clean energy assessment initiative to develop and maintain comprehensive data on technology costs, environmental and economic impacts, market potential, policy impacts, and analytic tools.
- Establish a knowledge transfer and outreach capability to broadly share the data and tools to inform private-sector investment and government policy decisions.

Primary Activities

- **Launch a Global Clean Energy Assessment Partnership.** Team with other countries (e.g., European countries, Japan, China, India, Brazil, etc.) and international institutions (e.g., REN21, IEA, IIASA, World Bank, UN agencies, etc.) to develop a cooperative global clean energy assessment initiative. This partnership would not duplicate existing efforts but build on initial efforts of REN21 and others working on this challenge. Through this partnership or separate U.S. efforts, the following activities could be conducted:
 - **Create a Centralized Repository of Renewable Energy and Energy Efficiency Assessment Data and Tools.** This repository could develop and maintain accurate information on life-cycle costs and environmental and economic impacts, market potential and penetration scenarios for different world regions and major countries, status of policies and data on policy impacts and best practices, and data on clean energy investment trends and drivers.
 - **Conduct Studies to Fill Key Data Gaps.** The United States and other partners could supplement available data with new studies in key areas and maintain accurate information to inform policy and investment decisions.
 - **Adapt and Enhance Existing Analytic Tools for International Applications.** This could include providing technical resources to support use of these tools.
 - **Conduct Outreach and Training on Assessment Data and Analytic Tools.** Such training and outreach would target government decision-makers in key countries as well as private-sector investors.
- **Team with Key Developing Countries on Clean Energy GHG Mitigation Analyses.** Partner with major developing countries (starting with China and India) and others to conduct rigorous assessments of the potential contributions of clean energy to reducing GHG emissions, which would inform climate-mitigation action plans for these countries. This would include developing and maintaining renewable energy and energy efficiency supply curves at national and regional levels that reflect policy and technology and infrastructure development scenarios. This effort also would evaluate the health, air quality, and economic co-benefits of greater clean energy use to inform national and regional plans and programs. The partners also would provide enhanced tools for ongoing climate clean energy supply and co-

benefits analysis to decision-makers at national and regional levels. This could build from work by DOE, EPA, McKinsey, NREL and others on this topic.

Potential Impacts

Comprehensive and objective information on technology costs, impacts, market potential, and policies is essential to educate policy makers, investors, and consumers, as well as inform policy and project design. The debate about the sustainability impacts of biofuels is a good example of where strong opinions based on very limited information are driving policy and investor decisions and influencing consumer acceptance, which potentially impedes the global transition to advanced biofuels.

Key Partners

As noted above, the U.S. government could develop a partnership with other countries and international institutions to achieve the ambitious goals of this initiative. A technical team (NREL and other labs, consultants, etc.) could lead the assessment activities.

Action 3.3. Expand Use of Common Technology Standards, and Global Education and Awareness of Clean Energy Technology Benefits

Goals

- Support the development and use of common global performance standards, testing, and certification methods for clean energy technologies worldwide.
- Team with others on global education and training programs for consumers, private-sector firms, and government officials on technology performance and applications.

Primary Activities

- **Promote Use of Common Technology Performance Standards and Test and Certification Methods Worldwide.** Join various international bodies (e.g., IEC, IEEE ISO, ASTM, IEA, etc.) already establishing performance standards, and test and certification methods for clean energy technologies. In many developing countries, these standards are not well understood or applied consistently across all products. In addition, global standards do not exist for all emerging technologies, especially applications geared to developing country markets. The United States could team with the key standard and certification bodies and other countries to fill gaps in standards, testing, and certification methods and promote their consistent use.
- **Conduct Education and Outreach Programs on Technology Standards and Test Methods, Product Labeling, and Clean Energy Opportunities.** Support global-, regional-, and national-level education and outreach on performance standards and test methods. This also could include sharing information on available certification and testing institutes worldwide. Additionally, the partnership could support common global product-labeling programs and promote broad awareness of the opportunities and benefits of clean energy technologies.
- **Provide Training and Technical Assistance on Standards, Testing and Certification, and on Technology Applications.** Provide training on the

standards, test and certification methods, and accreditation procedures to country institutes. For example, the UNDP provided China with technical assistance to establish national solar water heating test centers and a product certification and labeling program (Wallace et al. 2006). Training also could be expanded to cover the full range of technology application issues to support workforce development in key target markets. This training would be most effective if it builds on, without duplicating, other existing similar initiatives and programs for each sector and complements private-sector activities.

Potential Impacts

Rigorous performance standards, testing, and certification are essential for establishing investor and user confidence in a product. Without such standards, it will be difficult to attract investment and consumers, and investors may have negative experiences with inferior products that will diminish their future interest in the technology and impede broad acceptance. In addition, consistent global standards, testing, and certification programs ensure that consumers in developing countries are aware of differences in performance (where they exist) between imported (e.g., from the United States) and locally manufactured products.

Key Partners

The U.S. government could partner with existing international energy standards and certification organizations, as well as other countries and international institutions on this effort. A technical team (NREL and other labs, consultants, etc.) could lead implementation of the activities.

Action 3.4. Support Workforce Development in Key Countries

Goals

- Provide assistance to important developing-country partners to build the capacity of their clean energy workforce and provide the technical skills needed for sustained market growth
- Emphasize workforce development in areas where U.S. firms active in these markets need enhanced in-country capacity to support their business plans

Primary Activities

- **Establish Joint Workforce Development Plans with Key Country and International Partners.** Work with the countries and U.S. businesses active there to identify priority workforce-development needs. Based on these needs, the partners would design joint professional education and capacity-building programs.
- **Team with International Institutions and Other Countries to Provide Technical Support for Workforce Development.** Provide train-the-trainer workshops, common curriculum and educational resources, networks that link U.S. community colleges with counterparts in other countries, dissemination of best practices and lessons with clean energy professional education programs, and expert assistance.

Potential Impacts

This effort will ensure that adequate technical capacity in developing countries supports rapidly growing clean energy markets. It also will provide the workforce skills needed for U.S. firms to increase their investments in these markets.

Key Partners

The U.S. government could partner with other developed countries, developing countries, and international institutions in implementing these workforce development activities. A technical team that taps both expertise at the laboratories and at U.S. colleges and educational facilities could lead the implementation of the activities.

Appendix B. Summary of Stakeholder Comments

The table below presents a synthesis of input received from more than 40 stakeholders participating in this effort.

Table B-1. Stakeholder Comments on U.S. International Clean Energy Opportunities and Actions

Theme	Comments
U.S. Leadership and Organization	<ul style="list-style-type: none"> • U.S. government should establish a few strategic international clean energy cooperation goals and priorities and a coordinated and well-resourced long-term program across agencies to achieve these goals. • The broader domestic and international community (both public and private) must be directly engaged in the formulation, as well as the implementation of these strategies. • Revitalized U.S. programs must be based on sound science and economics and align with U.S. national objectives – particularly in the areas of economic growth, energy security, and fostering global sustainable development. • A concerted effort to re-engage in key international forums and to achieve an effective global climate agreement is needed. • U.S. government should acknowledge that it is no longer the leader in most global clean energy markets and that it would benefit greatly from bilateral and multilateral partnerships.
Investment Facilitation	<ul style="list-style-type: none"> • Industry can partner best with the U.S. government when the U.S. maintains well-resourced programs in a few strategic areas over multiple years and speaks with one common voice • Current U.S. clean energy financing and investment programs need to be streamlined and reformed to better respond to the needs of the private sector players they seek to support • Many of the U.S. finance and trade institutions and mechanisms are bureaucratic, difficult to access, and unresponsive on the timescales that the private sector requires, creating obstacles for businesses to take advantage of the tools the U.S. government provides; • Past efforts to coordinate programs and conduct joint planning with industry (e.g., CORECT and COEECT) have had significant value. • There is great value in high-level U.S. government engagement with in-country policy makers to establish policy frameworks that are attractive for private investment.
Technology Cooperation	<ul style="list-style-type: none"> • Significant benefits can be derived from international technology partnerships and research alliances designed to leverage resources and capabilities with partners around the world and to work toward common goals. • U.S. has much to learn from world class clean energy technology expertise in other countries (including major developing countries that are centers of innovation) and should pursue balanced and two-way technology cooperation partnerships. • U.S. government should identify and create opportunities to make international partners aware of U.S. technologies and expertise • U.S. should more actively seek to engage international private

	<p>enterprises in technology commercialization</p> <ul style="list-style-type: none"> • International partnerships can facilitate cooperation on foundational research, codes and standards, analysis issues, and other non-competitive topics. At the same time, there are also opportunities for technology partnerships to advance technology development with shared IP and incentives for protecting IP across national borders
Enabling Clean Energy Markets	<ul style="list-style-type: none"> • United States has rich technology and analytic expertise to apply in leading global clean energy technology and market assessments and in building worldwide knowledge on renewable energy and energy efficiency. • U.S. government has a critical role to play in partnership with others on effective in-country policies, common global standards, and sound trade policies. • U.S. programs should be tailored to the stages of energy market development and governance in countries and incentivize progress • Holistic long-term programs (ranging from policy reform to capacity building and financing assistance) tailored to countries and market conditions and that engage the private sector and international institutions have the greatest potential for long-term success.

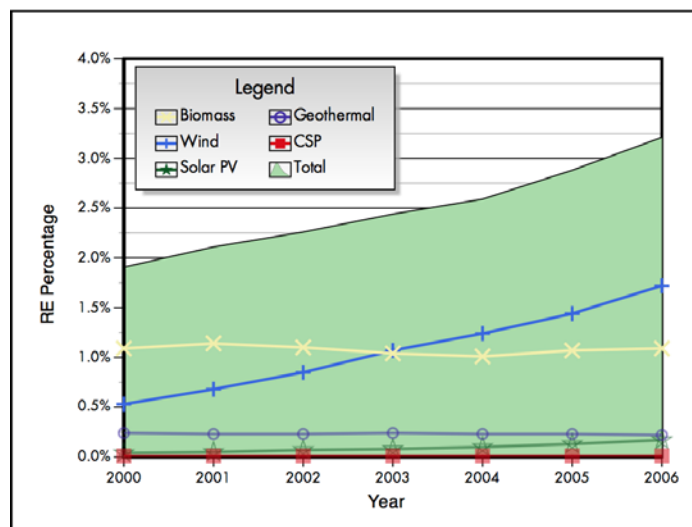
Appendix C. Description of Clean Energy Scenarios and Benefits Assessment

This appendix presents the scenarios from various sources that were used to estimate levels of global RE and EE market penetration and investment, reductions in oil use, and reductions in GHG emissions that could be achieved through concerted international cooperation. It also summarizes the methodology used in applying these scenarios to estimate benefits to the United States.

NREL reviewed several prominent scenarios—including the IEA Blue Map Scenario, the IPCC scenarios, and the McKinsey scenarios for achieving climate stabilization—and used these and other studies to develop ranges for global RE and EE market growth and oil-use reduction as inputs for the benefits analysis. The benefits analysis focuses on benefits to the United States from global clean energy market transformation in 2020 and 2050. In several cases, extrapolations of existing scenarios were conducted to develop estimates for 2020 for the benefits analysis. This appendix presents both baseline and action (e.g., robust international cooperation) projections for these variables and the methodology for the benefits analysis.

Renewable Energy Status and Baseline Projections

Renewable electricity generation capacity reached approximately 240 GW worldwide in 2007, implying growth of 50% more than 2004 capacity levels. Excluding large hydropower, renewables account for 5% of global power capacity and 3.4% of global power generation (DOE 2008) (Figure C-1). In the IEA Blue Scenario, the electricity mix in 2050 is approximately 50% renewables, 25% nuclear, and the remaining 25% fossil fuels with CO₂ capture and storage capability. The IEA projects that the annual growth of the supply of energy from renewables through 2030 is 6.7%, faster than any other fuel type (IEA 2007).



Source: "DOE EERE Renewable Energy Databook" (2008)

Figure C-1. Renewables as a percent of total capacity worldwide

Renewable Energy Global Potential Under Action Scenarios

Table C-1 summarizes the scenarios for global renewable energy use in the electricity sector through concerted international action reviewed by NREL.

Table C-1. Renewable Energy Scenarios

Renewable Energy Scenarios	
Scenario	Global RE Market Penetration
IEA Blue	46% by 2050
IPCC (\$50/ton CO ₂)	34% by 2030
Shell	50% by 2050
G8	25% by 2025
European Renewable Energy Council and Greenpeace	70% by 2050

Based on the above scenarios, NREL developed estimates of ranges for global renewable energy use in the electricity sector for 2020 and 2050. These ranges are presented in Table C-2.

Table C-2. Renewable Energy Projections

Renewable Energy Projections	
2020	15-20% of electricity produced by renewables
2050	45-70% of electricity produced by renewables

Energy Efficiency Status and Baseline Projections

Developing countries, whose economies and populations are growing fastest, will contribute 74% of the increase in global energy use in the coming years. About 45% of the increase can be attributed to growth in China and India alone. Global demand for energy will grow at a rate of 1.8% per year through 2030 (a 55% increase in 2030 over 2005 levels) (IEA 2007). Given the rapid build-out in China and India, there is an opportunity to incorporate efficient, low-emissions technology in the infrastructure.

Energy Efficiency Global Potential Under Action Scenarios

Table C-3 summarizes the scenarios for global energy efficiency use in the electricity sector through concerted international action reviewed by NREL. These scenarios show reduced growth rates in global primary energy demand resulting from use of energy efficiency technologies and practices.

Table C-3. Energy Efficiency Scenarios

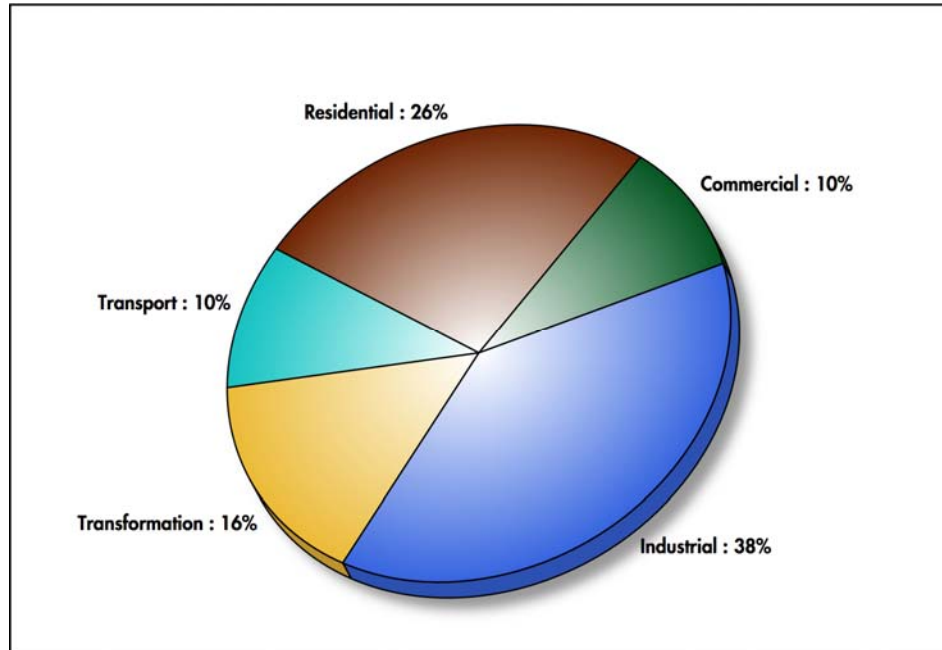
Energy Efficiency Scenarios	
Scenario	Percent Increase in Primary Energy Demand from 2005 (as compared to ~ 100% increase by 2050 or 2.2 % per year in the baseline)
IEA Blue	25% by 2050
McKinsey	0.7% per year
European Renewable Energy Council and Greenpeace	-3% by 2050

Based on the above scenarios, NREL developed estimates of ranges for global reductions in primary energy demand for 2020 and 2050. These ranges are presented in Table C-4.

Table C-4. Energy Efficiency Projections

Energy Efficiency Projections	
2020	Limit primary demand growth to (2%) to 20%
2050	Limit primary demand growth to (3%) to 35%

McKinsey (McKinsey 2008) has broken down opportunities for reducing global energy demand into five sectors: transportation, transformation, industrial, commercial, and residential (Figure C-2).



Source: McKinsey Carbon Productivity Report (2008)

Figure C-2. Opportunities for improving energy efficiency

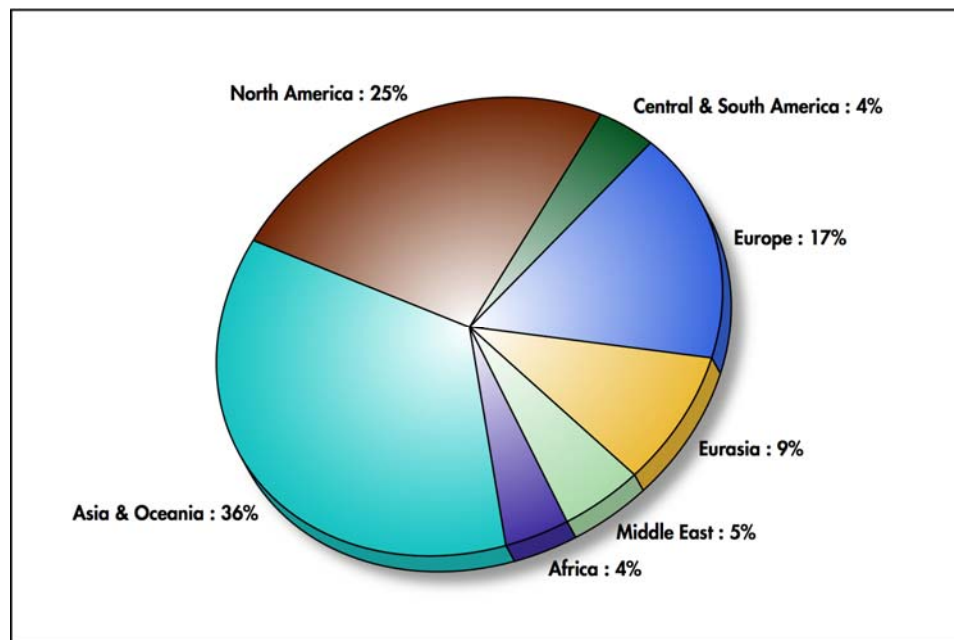
The majority of efficiency opportunities are in the United States and developing countries, such as China (McKinsey 2008).

International GHG Reduction Levels

GHG Emissions Status and Baseline Projections

CO₂ concentrations have increased from a pre-industrial level of 280 parts per million (ppm) to 379 ppm in 2005 (Figure C-3). Global CO₂ emissions are expected to grow annually at a rate of 1.8% from 2005 to 2030 (2.5% from 2005 to 2015) (IEA 2007).

Efforts to reduce emissions in the next few years will impact whether the increase in global temperatures can be limited to less than 3.0°C. According to the IPCC, CO₂ concentrations must be stabilized at 350 to 400 ppm to avoid a global temperature increase of 2.0°C to 2.4°C or more.



Source: Energy Information Administration

Figure C-3. World CO₂ emissions from the consumption of fossil fuel (2005)

GHG Emissions Under Action Scenarios

Table C-5 summarizes the scenarios for global GHG emission reductions through concerted international action that were reviewed by NREL.

Table C-5. GHG Emission Reduction Scenarios	
GHG Emission Reduction Scenarios	
Scenario	Global GHG Emission Reduction
IEA Blue	50% by 2050
G8	50% by 2050
McKinsey	68% by 2030 and 76% by 2050
WWF	60-80% by 2050

Under the IEA Blue Scenario and the G8 Summit goal, a 50% reduction in CO₂ below 2005 levels is being targeted by 2050 to limit a global temperature increase to 2.4°C,

translating to a stabilization in CO₂ concentrations at approximately 450 ppm. End-use efficiency accounts for 36% of CO₂ emissions savings, 21% for renewables, and 10% for CO₂ capture and storage. The remaining 24% is attributed to nuclear power, fossil fuel switching capability, and efficiency in power generation (IEA 2008b). McKinsey has a more aggressive approach, suggesting that to stabilize the climate, emissions must be reduced by 68% by 2030 and 76% by 2050 relative to current levels.

Based on the above scenarios, NREL developed estimates of ranges for global reductions in GHG emissions for 2020 and 2050. These ranges are presented in Table C-6.

Table C-6. GHG Emission Reduction Projections

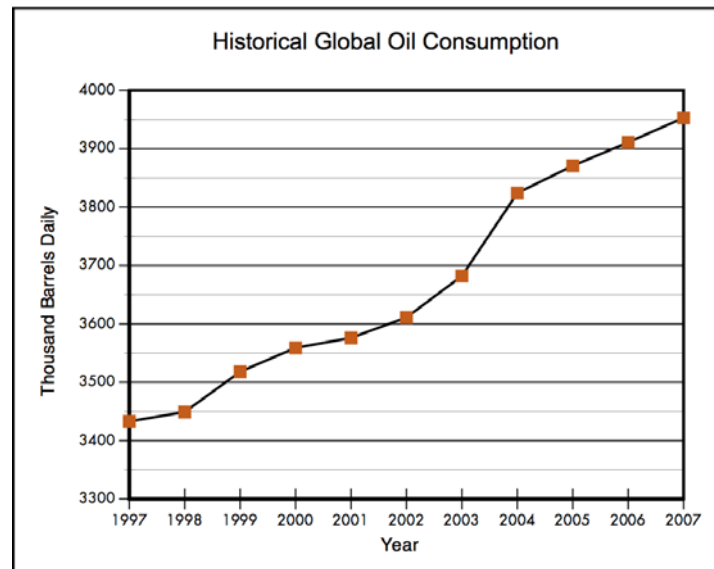
GHG Emission Reduction Projections	
2020	10-20% reduction from current levels
2050	50-80% reduction from current levels

Reductions in Global Oil Use

Global Oil Use Status and Baseline Projections

According to the World Energy Outlook, global oil demand will reach 116 million barrels per day in 2030, a 37% increase over 2006 levels, with the transportation sector being the main driver of demand. Oil will continue to be the single largest fuel source globally, though its share will fall from a current level of 35% to 32% in 2030. China and India account for 42% of this increase.

Global oil consumption has increased more than 15% since 1997 (Figure C-4).



Source: "BP Statistical Review of World Energy" (2008)

Figure C-4. Historical global oil consumption

Global Oil Use Under Action Scenarios

Table C-7 summarizes the scenarios for global reductions in oil use through concerted international action reviewed by NREL.

Table C-7. Oil Use Reduction Scenarios

Oil Use Reduction Scenarios	
Scenario	Percent Decrease in Global Oil Use Compared to 2005
IEA Blue	27% by 2050
McKinsey	Up to 25% by 2030

Under the IEA Blue Scenario, oil demand will be 27% below 2005 levels by 2050, easing the supply challenge but still requiring investment in new supply. McKinsey notes that oil demand could be decreased by up to 25% from 2005 levels by 2030. Most of the reduction can be attributed to higher fuel economy standards, improved mass transit, and second-generation biofuels (McKinsey 2008). According to the IPCC, biofuels used as gasoline additives and substitutes could account for 5-10% of the transport energy demand by 2030 (Metz et al. 2007).

Based on the above scenarios, NREL developed estimates of ranges for global reductions in primary energy demand for 2020 and 2050. These ranges are presented in Table C-8.

Table C-8. Oil Demand Reduction Projections

Oil Demand Reduction Projections	
2020	10-20% reduction in demand
2050	25-50% reduction in demand

Levels of Private Investment

Private Investment Status and Baseline Projections

In 2007, more than \$100 billion was invested in the renewable energy space for new capacity, manufacturing plants, and R&D (not including large hydropower). Although the majority of investment is occurring in Europe, China, and the United States, emerging markets are capturing escalating shares of investment in new capacity, infrastructure, manufacturing, and R&D, notably Brazil and India (REN21 2007). In comparison, only about \$10 billion annually in global R&D investments is aimed at energy efficiency and carbon capture technologies (McKinsey 2008). According to *New Energy Finance*, global venture capital investments in renewable energy and energy efficiency in the first eight months of 2008 totaled approximately \$24 billion.

Sources of finance and investment for renewable energy are diverse, and private investment (both mainstream and venture capital) for proven technologies and those in development is increasing rapidly. Venture capital financing increased dramatically during 2006/2007, with a focus on solar PV and biofuels, exceeding the \$3 billion mark worldwide in 2006. The United States is the market leader in venture capital investment, contributing more than 60% of the world's venture capital in renewables during 2006,

\$800 million of which was committed for biofuels alone, significantly aiding in the development and commercialization of the ethanol industry (REN21 2007).

Private Investment Under Action Scenarios

Table C-9 summarizes the scenarios reviewed by NREL for increased investment in renewable energy and energy efficiency resulting from concerted international action.

Table C-9. Renewable Energy and Energy Efficiency Investment Scenarios

Renewable Energy and Energy Efficiency Investment Scenarios	
Scenario	Projected Total Global RE and EE Investment
IEA Blue	\$45 trillion by 2050 (~ \$1.1 trillion/yr.) for all clean energy technologies with much of this investment to be directed towards energy efficiency and renewable energy
McKinsey	\$170 billion/yr. just in energy efficiency investment

In the IEA BLUE Map Scenario, it is projected that to reduce CO₂ emissions to 50% below 2005 levels by 2050, the energy sector will require an investment of \$45 trillion above baseline by 2050 (\$1.1 trillion per year, or approximately 1.1% of global gross domestic product), with much of the funding directed toward demand-side investments. This figure translates into additional investments in the energy sector beyond those for CO₂ reduction totaling \$100-200 billion per year in the near term, increasing to \$1-2 trillion by 2030 and \$2-5 trillion per year in 2050 (IEA 2008a). McKinsey estimates an annual investment of \$170 billion between now and 2020 to reduce energy demand in 2020 by 20-25%.

Based on the above scenarios, NREL developed estimates of ranges for global increases in energy efficiency and renewable energy investment levels. These ranges are presented in Table C-10. The analysis assumes that the levels of clean energy investment ramp up over time and one-third to two-thirds (consistent with the IEA Blue Scenario and other similar scenarios) of the total clean energy investment from the IEA scenario goes to energy efficiency and renewable energy, and the remainder to nuclear, clean coal, and other clean energy technologies.

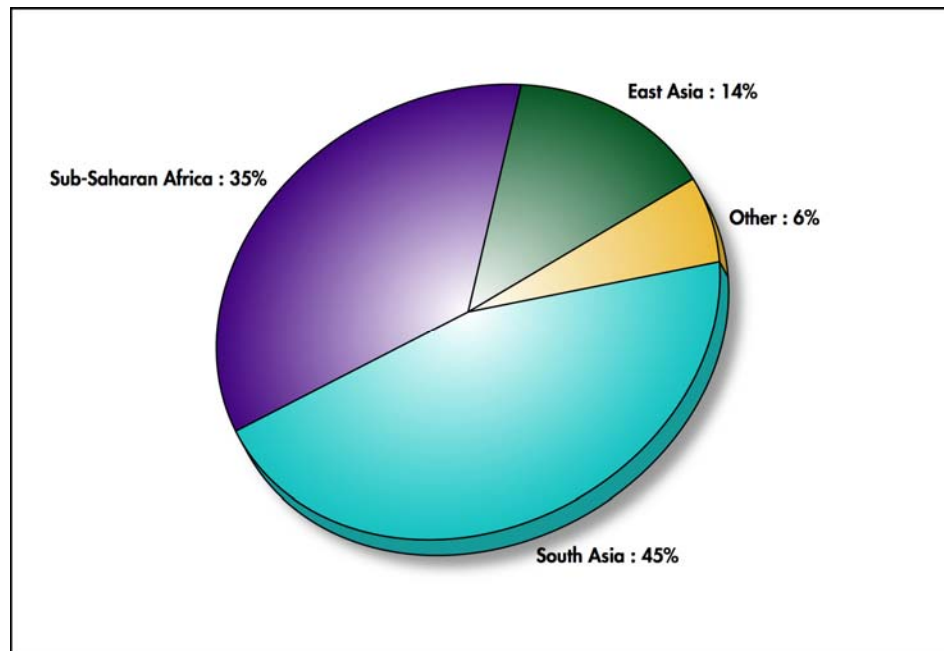
Table C-10. RE and EE Global Investment Projections

RE and EE Global Investment Projections	
2020	\$300-600 billion/year
2050	\$600-1,200 billion/year

Rural Electrification Impacts

Rural Electrification Status and Baseline Projections

Stable energy supplies are a prerequisite for economic development. More than one-quarter of the world's population (1.6 billion people) did not have access to electricity in their homes in 2002 (World Energy Outlook 2004) (Figure C-5).



Source: United Nations Development Program Annual Report (2008)

Figure C-5. People without electricity (millions, 2004)

For example, more than 400 million people in India do not have access to electricity, and there is still limited access to clean burning fuels for cooking and space heating in rural China (although its rural electrification program has been very successful) (IEA 2007).

Rural Electrification Under Action Scenarios

The World Bank and others have determined that energy access is key to achieving the broad portfolio of Millennium Development Goals. They have set targets to reduce the global unelectrified population to fewer than 1 billion by 2015, and to have universal electricity access by 2030. Robust international clean energy cooperation can ensure that these goals are met and could accelerate achievement of nearly universal access to electricity by 2020.

Quantifiable Benefits to the U.S. Economy

Overview

The previous discussion describes a wide range of opportunities and benefits for the United States from coordinated international action to promote clean energy technologies (CETs); however, not all of those benefits are readily quantified. This section describes a very circumscribed effort to estimate direct economic benefits to the United States. The

analysis estimates net economic benefits to the United States from increased global CET use. It will quickly become apparent that this assessment can only be done very approximately. Accordingly, the results are expressed as ranges and although the range is wide, it still demonstrates that the direct economic benefits to the United States of expanded international CET cooperation would be significant.

The estimated range of net economic benefits to the United States in 2020 is \$30-80 billion per year, and the corresponding range for 2050 is \$100-\$300 billion per year. These estimates include all the benefits resulting from global cooperation to accelerate CET use. These domestic benefits cannot be achieved through U.S. efforts alone. Because climate change is a global challenge, these benefits will be realized only through coordinated efforts across countries, with the private sector, and with international institutions. U.S. participation is necessary, but not sufficient. U.S. leadership in such an initiative will also play a key role in helping U.S. CET firms capitalize on the significant opportunities presented by an expanded global CET market.

While this analysis considers only those benefits derived from international cooperation, strong U.S. international leadership will complement domestic public and private actions, which will be required for the United States to adapt to the fundamental shifts in the energy system.

Framing the Problem Scenarios

The estimates described below were scaled by using the scenarios from the literature discussed above. The analysis combined the range of underlying trends described in those scenarios with economic forecasts and parameters to develop a range of economic benefits.

Driving Forces

In the scenarios mentioned above, the two key parameters, or “driving forces,” are central to the estimation of benefits: the increase in the size of the global CET market and the decrease in global demand for petroleum products.⁷ If the United States successfully captures some of the markets created by those two underlying changes, several types of benefits accrue to the U.S. economy as described in the next section.

Estimating Benefits

Nominal values⁸ of the two key parameters are derived from the above scenarios as follows: Increased U.S. net CET exports are derived from the increased levels of global investment in CET. First, we estimate the fraction of that increased investment that will

⁷ In this discussion, all references to changes in variables refer to the difference between a “business as usual” scenario and an “*ex ante*” scenario that more aggressively pursues CET worldwide. For example, in many of the scenarios that we used to develop the ranges for the key parameters, the business as usual case represents current levels of climate mitigation and the *ex ante* case illustrates the CET and other actions necessary to achieve a specified carbon reduction goal.

⁸ The discussion of nominal values makes it clear that estimating them incorporates considerable judgment and that their values are necessarily quite uncertain. We use the term “nominal values” because the analysis incorporates a range for all these uncertain parameters, which results in a range for the benefits estimates.

occur outside the United States. That estimate represents the target market. Next, we estimate the fraction of that market that successfully positioned U.S. exporters could capture.

The nominal value of the decrease in oil prices is estimated directly from the decrease in global petroleum demand.

Sources of Benefits

Benefits from Clean Energy Markets

Both U.S. producers and consumers stand to benefit from significant global shifts toward clean energy technologies. The first impact comes through an increase in the export of CET products by U.S. producers.

However, U.S. CET producers will benefit from increased sales overseas *only if they are successful in positioning themselves in the global CET market*. The importance of early and decisive actions to position U.S. industry in global markets cannot be overstated. The work by Paul Krugman (1991), for which he was awarded the 2008 Nobel prize in economics, describes one of the important ways countries that first enter a newly opened global market sector can develop significant and permanent cost advantages over later entrants.

Consumers can benefit from enhanced efforts in CET markets through lower CET prices. The CET initiative is posited to include enhanced R&D efforts that will reduce technology costs and improve performance. In addition, increased production will reduce prices through the learning curve effect. Increased CET demand will create a countervailing trend toward higher prices. Although, on balance, we expect CET prices to decline in the *ex ante* case, the range of benefit estimates accounts for the possibility that prices might increase.

Benefits from Reduced Global Petroleum Consumption

Reduced petroleum consumption will ease pressure on oil markets and will tend to reduce prices. Reduced prices benefit U.S. consumers directly, both through their own petroleum consumption and by lowering the prices of transportation services and many other goods.⁹

Benefits from International Trade

Both increased CET net exports and reduced world oil prices will improve the United States' trade balance. That improvement will increase the value of the dollar, which will provide economic benefits by reducing the price of imports to the United States.¹⁰

⁹ While it is also true that U.S. oil producers will be adversely affected by lower world oil prices, on balance the net effect to the U.S. economy is strongly positive.

¹⁰ U.S. exporters of goods besides CET products may be adversely affected by a stronger dollar, which makes their exports more expensive overseas. The net economic benefit estimate takes this effect into account.

Limitations and Uncertainty

As mentioned above, the benefits estimated here are only those that can be readily quantified, and the resulting estimate omits a number of significant benefits mentioned in the paper. And although we can quantify the economic benefits, we can only develop a rough approximation. The estimates depend on a number of variables whose values are imperfectly known. Those parameters include market factors such as future oil prices and U.S. consumption, as well as future clean energy revenues and exports. The estimates also depend on economic parameters such as elasticities of supply and demand. Because the values of the parameters are uncertain, we have used ranges for them, rather than point estimates. The ranges for the inputs then determine the ranges for the output estimates.

Appendix D. Examples of U.S. Government International Clean Energy Programs

Table D-1. Examples of U.S. Government International Clean Energy Programs

Program Type	Program or Agency	Programmatic Focus
Interagency Climate Initiatives	Major Economies Meetings	Meeting of 17 major economies to advance climate solutions
	Asia-Pacific Partnership	Cooperation on renewable energy, and buildings and industrial efficiency with emphasis on China and India
	State Department	Lead for bilateral and multilateral energy agreements including UNFCCC negotiations, MEM process, APP, CSD, WIREC, and limited support to other initiatives, including REN21
Technology Cooperation and Market Development	DOE/EERE	RE and EE market and technology cooperation with China, India, Brazil; R&D and analysis cooperation with EU countries, Israel, and others and through IEA agreements; Global RE and EE assessments
	U.S. AID	Global Climate Change and Regional Energy Initiatives such as SARI/E, Empowering Development Program, and other energy/economic development activities led primarily by local USAID missions
	EPA	Voluntary programs such as Methane to Markets and ENERGY STAR have expanded their focus to working internationally; integrated environmental strategies and co-benefits analysis
	USDA	Biomass and rural energy cooperation with Brazil, China, India, and other countries
Trade and Investment	Commerce	Supports trade missions and has energy representatives in several countries around the world
	Treasury	Clean Technology Fund (not in place in FY08, proposed funding of \$400M in FY09) and manages U.S. funding to the Global Energy Facility (~\$80 million per year)
	Export/Import Bank	Provides export finance products to renewable energy, water, and hydroelectric power projects
	Overseas Private-Investment Corporation	Political risk insurance and other guarantees for U.S. firms in developing countries
	Trade Development Administration	Project pre-feasibility studies

Appendix E. Summary of Recommendations for International Clean Energy Initiatives from Other Studies and Forums

National Commission on Energy Policy

- Double federal expenditures for energy technology R&D.
- Triple funding for international cooperation efforts.

Energy Futures Coalition

- Mobilize private-sector capital.
- Establish global development bonds.
- Create rural energy fund.
- Provide extended term financing for export credit agencies.
- Establish energy efficiency financing protocols.

Presidential Climate Action Project

- Reaffirm U.S. commitment to addressing climate change and to the Bali Action Plan.
- Seek a bilateral agreement with China on technology cooperation and emissions reduction.
- Review the priorities of the Asia-Pacific Partnership.
- Decarbonize international development assistance programs.
- Create an International Renewable Energy Agency; provide financing/technical assistance.
- Assess impact of GHG emissions for developing world practices and technologies.
- Promote “clean energy sovereignty to ensure that national GHG emission reduction policies are exempt from WTO challenges.”
- Negotiate a phase-out of subsidies for fossil fuels around the world.
- Implement a carbon debit mechanism to ensure that lenders take account for carbon emissions of their projects.
- Develop global roadmaps for a carbon-free, nuclear-free global energy economy.

Better World Campaign. U.S. Global Leadership to Safeguard our Climate, Security, and Economy. Nigel Purvis (2008)

- Advance international cooperation on research, development, and demonstration of advanced clean energy technologies, including:
 - Increased domestic R&D spending
 - Formation of international research partnerships to jointly fund research on key emerging technologies
 - Establish a consultative group on clean energy research to coordinate development of low-cost clean energy technologies for poor populations
 - Accelerate global use of energy efficiency, through improved standards and technical assistance to developing countries, and domestic action

- Negotiate new international climate agreements and partnerships that result in timely and equitable action by all major emitting countries.
- Team with the international community to expand economic incentives for adoption of climate response technologies by developing countries.

Climate Choreography Paper (July 2008). Lewis Milford, Daniel Dutcher, and Todd Barker

- Establish a global program to support distributed and open innovation on climate change technologies and implementation mechanisms at global, regional, and national levels and private-sector initiatives.

International Climate Change Task Force. Stephen Byers and Olympia Snowe, (co-chairs); Bob Carr, John P. Holdren, Martin Khor Kok-Peng, Nathalie Kosciusko-Morizet, Claude Martin, Tony McMichael, Jonathon Porritt, Adair Turner, Ernst Ulrich von Weizsäcker. (January 2005). *Meeting the Climate Challenge: Recommendations of the International Climate Change Taskforce*. Institute for Public Policy Research, Center for American Progress, and Australia Institute.

Recommendations for International Framework, post-Kyoto:

- All G8 countries commit to a national RPS with a goal of at least 25% of electricity from RE renewable energy by 2025;
- G8 countries should double spending on RD³ for alternative technology, energy efficiency, and zero/low-carbon technology;
- Partnerships should be facilitated between developed and developing countries;
- The G8 countries should shift agricultural subsidies towards biofuel development;
- All developed countries should develop a mandatory carbon emissions cap-and-trade system for the national level, with the end goal of integrating the national programs into a single, international cap-and-trade system;
- Governments should begin phasing out subsidies to fossil fuels; and
- Developed countries should increase financial and technical assistance to developing countries.

Bierbaum, R.; J. Holdren; M. MacCracken; R. H. Moss; P. H. Raven. UN Foundation & Sigma Xi. (2007). *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. Scientific expert group report on climate change and sustainable development, prepared for the 15th session of the Commission on Sustainable Development.

- Pursue solutions that can mitigate climate change and provide a more sustainable energy future by focusing on energy efficiency, transportation efficiency, and building efficiency; expand transportation biofuels development; and prevent negative land-use changes.
- Aspire to triple or quadruple total investments in energy technology research, focusing on energy efficiency and clean energy technologies. Encourage private-public partnerships across multiple disciplines and national borders.

Pew Center on Global Climate Change. (2005). *International Climate Efforts Beyond 2012: Report of the Climate Dialogue at Pocantico*.

Recommends a global climate framework under the UNFCCC that engages all major economies by allowing different types of commitments and could include the following elements:

- An aspirational long term to drive and frame the international effort.
- Stronger international support for adaptation, including new funding commitments to help highly vulnerable countries cope with urgent needs as well as support the development of comprehensive national adaptation strategies.
- Emission targets and international emissions trading.
- Sectoral approaches to reduce emissions from key greenhouse gas-generating sectors such as transportation, power, land use, and energy-intensive industries.
- Policy-based approaches incorporating national policies that moderate emissions while advancing core economic, social, and development objectives.
- Technology cooperation to advance research and development and to support deployment of climate-friendly technologies in developing countries.

Testimony of Karan Bhatia, Vice President and Senior Counsel for General Electric, before the Committee on Energy and Natural Resources of the U.S. Senate (June 25, 2008).

The United States should:

- Be involved in providing assistance to developing countries in implementing policies that provide cleaner energy technology incentives.
- Participate in multilateral funds to provide financial support for cleaner energy technology.
- Promote the protection of intellectual property rights.
- Promote reduction of trade barriers, which impact the trade of cleaner energy technology.
- Promote cleaner energy technology exports.
- Along with other governments, promote the creation of an international framework that provides long-term support for GHG reductions.
- Advocate public-private partnerships in RD³ of cleaner energy technology.
- Renew national RE incentive programs.
- Support the creation of international funds dedicated to providing assistance to developing countries in adapting to climate change. Such a fund should be technology-neutral and effectively leverage funding.

A Call for Action – Consensus Principles and Recommendations from the U.S. Climate Action Partnership: A Business and NGO Partnership

- The United States should engage in international cooperation with the goal of achieving GHG reduction commitments from all major emitting countries.
- The post-2012 framework should include international GHG emissions markets, assistance strategies, and support for vulnerable populations; and increase support of climate-friendly technology, particularly in developing countries.

REPORT DOCUMENTATION PAGE

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1. REPORT DATE (DD-MM-YYYY) December 2008			2. REPORT TYPE Technical Report		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Strengthening U.S. Leadership of International Clean Energy Cooperation				5a. CONTRACT NUMBER DE-AC36-08-GO28308		
				5b. GRANT NUMBER		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Proceedings of Stakeholder Consultations				5d. PROJECT NUMBER NREL/TP-6A0-44261		
				5e. TASK NUMBER 6A00.6003		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401-3393				8. PERFORMING ORGANIZATION REPORT NUMBER NREL/TP-6A0-44261		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S) NREL		
				11. SPONSORING/MONITORING AGENCY REPORT NUMBER		
12. DISTRIBUTION AVAILABILITY STATEMENT National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT (Maximum 200 Words) Pressing economic, energy security, and environmental concerns are driving rapid growth in global investments in renewable energy (RE), energy efficiency (EE), and other clean energy technologies. The U.S. government has an unparalleled opportunity to join forces with the private sector, international institutions, and other countries to accelerate this global clean energy market transformation and capture vital domestic benefits. The global financial crisis creates an even more urgent need for government programs to stimulate private investment in renewable energy and energy efficiency, which will foster U.S. and international job creation and economic vitality. A group of stakeholders has identified four overarching strategies for enhanced U.S. international clean energy cooperation – 1) establishment of government-wide goals, an action plan, and strengthened international leadership; 2) revitalized U.S. investment-facilitation programs; 3) accelerated clean energy technology cooperation; and 4) market reform partnerships with key developing countries. These strategies and actions in support of each are presented in this report.						
15. SUBJECT TERMS renewable energy; energy efficiency; NREL International Advisory Council; clean energy technologies; U.S. government; international programs; investment; economic benefits; environmental benefits; energy security; global; developing countries;						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UL	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (Include area code)	

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18