APPENDIX A
ACKNOWLEDGMENTS

COMMISSIONED PAPERS*

Alston, Julian M. and Philip G. Pardey, *International Approaches to Agricultural R&D: The CGIAR*
Julian Alston, University of California at Davis and visiting fellow at University of Melbourne
Philip G. Pardey, Environment and Production Technology Division, International Food Policy Research Institute, and University of Minnesota

Dean, Steven O. *Lessons Drawn from ITER and Other Fusion International Collaborations*
Fusion Power Associates.

Dooley, James J., and Paul J. Runci, *Adopting a Long View to Energy R&D and Global Climate Change*
Pacific Northwest National Laboratory, Battelle Memorial Institute

Adcock, Rick, *Financing Renewable Energy and Energy Efficiency Projects in International Markets*
Econergy International Corporation

Edmonds, Jae, S.H. Kim, and H. Pitcher, *The Long-Term Shape of Global Energy Systems*
Pacific Northwest National Laboratory, Battelle Memorial Institute

Fulkerson, William., Mark D. Levine, Robert N.Schock, and Thomas J. Wilbanks, *Developing Country Partnerships for Environmental Energy Technology Research, Development, Demonstration and Deployment (RD^3)*
William Fulkerson, Joint Institute for Energy and Environment, University of Tennessee, Tennessee Valley Authority and Oak Ridge National Laboratory
Mark D. Levine, Environmental Energy Technology Division, Lawrence Berkeley National Laboratory
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Goldemberg, José, *A Perspective from the South on ERD^3*
Universidade de São Paulo, Brasil

Kammen, Daniel M, *Building Institutional Capacity for Small-Scale and Decentralized Energy Research, Development, Demonstration, and Deployment (ERD3)in the South*
Energy and Resources Group, University of California at Berkeley

Levine, Mark D., *Opportunities for Partnerships between the United States and China in Energy Efficiency Research, Development, Demonstration and Deployment*
Environmental Energy Technology Division, Lawrence Berkeley National Laboratory

Siegel, Jack S., *International Collaborations in Fossil Energy Research, Development, Demonstration and Deployment*
Energy Resources International, Inc.

Siegel, Judith M. and Kevin Rackstraw,*U.S. Renewable Energy Experience In The International Marketplace*
Judith M. Siegel, Consultant
Kevin Rackstraw, Consultant

Taylor, John, *International Cooperation on Energy Research, Development, Demonstration, And Deployment (RD^3) For Nuclear Power*
Electric Power Research Institute (retired)

Witcher, Daniel (Júnior), *The Experience of the U.S. ESCO Industry in The International Market*
Consultant

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APPENDIX B
UNITS AND CONVERSION FACTORS

Length

1 centimeter (cm)
= 0.3937 inches

1 meter (m)
= 3.281 feet

1 kilometer (km)
= 0.6214 miles

1 inch (in)
= 2.540 centimeters

1 foot (ft) = 12 inches
= 0.3048 meters

1 mile = 5280 feet
= 1.609 kilometers

Area

1 square centimeter (cm^2)
= 0.1550 square inches

1 square meter (m^2)
= 10.76 square feet

1 hectare (ha) = 10,000 square meters
= 2.471 acres

1 square kilometer (km^2)= 100 hectares
= 0.3861 square miles

1 square inch (in^2)
= 6.452 square centimeters

1 square foot (ft^2)
= 0.09290 square meters

1 acre = 43,560 square feet
= 0.4047 hectares

1 square mile = 640 acres
= 2.590 square kilometers

Volume

1 cubic centimeter (cm^3) = 1 milliliter (ml)
= 0.06102 cubic inches

1 liter (l) = 1,000 cubic centimeters
= 0.2642 gallons (liquid, U.S.)

1 cubic meter (m^3)= 1,000 liters
= 35.31 cubic feet

1 cubic inch (in^3)
= 16.39 cubic centimeters

1 gallon (liquid, U.S.) =231.0 cubic inches
= 3.785 liters

1 cubic foot (ft^3) = 7.481 gallons (liquid, U.S.)
= 0.02832 cubic meters

1 barrel (bbl) (oil, US) = 42 gallons (liquid, US)
= 159.0 liters

Weight

1 gram (g)
= 0.03527 ounces

1 kilogram (kg)
= 2.205 pounds

1 metric tonne (t) = 1,000 kilograms
= 1.1023 short tons (U.S.)

1 ounce (oz)
= 28.35 grams

1 pound (lb) = 16 ounces
= 0.4536 kilograms

1 short ton (U.S.) = 2,000 pounds
= 0.9072 metric tonnes

Energy

1 joule (J)
= 0.2388 calories (International Table)

1000 joules (J)
= 0.9479 Btu

1 kilowatthour (kWh) = 3.600 x 10^{6} joules
= 3,412 British thermal units

1 calorie (International Table)
= 4.187 joules

1 British thermal unit (Btu) = 252.0 calories
= 1055 joules

1 quad = 1 x 10^{15} British thermal units
= 2.931 x 10^{11} kilowatthours

Power

1 watt (W) = 1 joule per second
= 3.412 British thermal units per hour

1 kilowatt (kW)
= 0.9478 British thermal units per second
= 1.341 horsepower (imperial)

1 British thermal unit per hour (Btu/h)
= 0.2931 watts

1 British thermal unit per second (Btu/s)
= 1.055 kilowatts

1 horsepower (hp) (imperial) = 0.7068 British thermal units per second
= 0.7457 kilowatts

Temperature

From Centigrade(^{o}C) to Fahrenheit(^{o}F):
(^{o}C x 9/5) + 32 = ^{o}F

From Fahrenheit(^{o}F) to Centigrade(^{o}C):
(^{o}F - 32) x 5/9 = ^{o}C

Prefixes in the International System of Units

Multiplier	Symbol	Prefix
10^{18}	E	exa
10^{15}	P	peta
10^{12}	T	tera
10^{9}	G	giga
10^{6}	M	mega
10^{3}	k	kilo
10^{2}	h	hecto
10^{1}	da	deca
10^{-1}	d	deci
10^{-2}	c	centi
10^{-3}	m	milli
10^{-6}	µ	micro
10^{-9}	n	nano

Approximate Carbon and Thermal Conversion Factors

Fuel	Density (kg/liter)	Carbon [a] (kg C/GJ)	Energy
Coal (bituminous)		24.4	20.5 MMBtu/ton 23.8MJ/kg
Oil (crude)	0.744	18.9	5.8 MMBtu/Bbl
Natural Gas	1000 cubic feet = 19.18 kg	13.6	1025 Btu/cf
Ethanol	0.792	17.8	26.8 MJ/kg
Wood	0.7-0.8	NA	18-20 MJ/kg

[a] 1 kilogram of carbon is equivalent to 3.667 kgs. of carbon dioxide measured at full molecular weight

APPENDIX C: PCAST 1997 Recommended DOE Applied Energy-Technology R&D Initiatives and Budget Authority (in millions of as-spent dollars)

PROGRAM[a]	R&D Activities, Initiatives, and Budget Changes	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003
Efficiency: Buildings	Building System Design and Operation: advanced sensors; smart controls; automated diagnostics; and whole-building optimization and design tools.	24	33	38	48	60	72	84
	Building Equipment and Materials: advanced materials; advanced energy-efficient HVAC, lighting, windows, appliances, office equipment, etc.; and insulation initiative.	27	37	57	72	85	98	111
	Codes and Standards: for efficient appliances and buildings; technical assistance.	12	21	25	25	25	25	25
	Crosscutting Activities: technology roadmapping and partnership development with industry following the model of the DOE Industries of the Future program.	--	--	20	25	30	35	35
	Other: management and planning, and other activities.	19	20	20	20	20	20	20
	Subtotal	81	111	160	190	220	250	275
Efficiency: Industry	Industries of the Future: advanced technologies for energy intensive industries—aluminum, cement, chemicals, forest products, glass, metal casting, refining, steel, agriculture—and for emerging energy-intensive industries following technology roadmaps.	46	56	65	75	85	95	110
	Crosscutting Activities: advanced microturbines (40-200 kW), sensors, motor drive systems, and materials; work with DOE/OUT on biomass Integrated Gasification Combined Cycle.	38	38	70	80	90	95	100
	Technology Access: innovation grants; industrial assessments, "Climate Wise", and motors.	25	37	40	40	45	45	50
	Other: management and planning, and other activities	7	8	10	10	10	10	10
	Subtotal	116	139	185	205	230	245	270
Efficiency: Transport	PNGV: better emissions controls for light diesels; hybrid vehicles; and system integration.	105	129	100	100	100	100	75
	PNGV II: fuel cells, microturbines, advanced energy storage, system integration.	--	--	75	85	100	100	125
	Advanced Heavy Vehicles: efficient diesels, diesel pollution reduction, and hybrids.	20	18	30	40	50	55	60
	Advanced Materials: high-temperature/high-strength materials to reduce weight 25%.	33	31	35	40	40	40	45
	Technology Deployment: clean cities program, alternative fuel vehicles, and other activities.	11	17	20	20	20	20	20
	Other: management and planning, and other activities	7	9	10	10	10	10	10
	Subtotal	176	204	270	295	320	325	335
Fossil Energy	Coal Power: end Low Emission Boiler System, phase out near-term clean coal activities, accelerate R&D on advanced power systems.	86	84	79	90	87	88	82
	Coal Fuels: end direct liquefaction and solid fuels and feedstocks R&D; develop science-based hazardous air emissions program.	16	16	9	12	15	16	16
	Gas Power: strengthen solid-oxide fuel-cell R&D and other advanced research.	97	78	92	92	83	74	70
	Oil and Gas Production and Processing: maintain oil programs for marginal resources; strengthen gas production and processing R&D; and increase advanced research.	70	77	86	94	107	110	113
	Carbon Sequestration: strengthen science-based carbon sequestration program.	1	2	10	11	17	23	22
	Methane Hydrates: develop science-based program with industry, Federal agencies, and the Navy to understand the potential of methane hydrates worldwide	0	0	5	5	11	11	12
	Hydrogen Manufacture/Infrastructure: conduct R&D on hydrogen production from fossil fuels	0	0	1	2	6	6	7
	Technology/Oil Price Elasticities: analyze technologies to reduce cost of oil shocks.	0	0	1	1	1	1	0
	Developing-Country Technologies: conduct collaborative R&D with other countries.	0	0	1	2	6	6	6
	Other: management and planning; environmental restoration; cooperative R&D, etc.	95	89	95	97	100	102	105
	Subtotal	365	346	379	406	433	437	433

Nuclear Fission	Operating Reactors: R&D to address problems that may prevent continued operation of existing reactors.	4	25	10	10	10	10	10
	Nuclear Energy Research Initiative: competitively select among proposals by researchers from universities, national laboratories, and industry that address issues including proliferation-resistant reactors or fuel cycles, new reactor designs with higher efficiency, lower cost, and improved safety; low-power reactors; and new techniques for on-site and surface storage and for permanent disposal of nuclear waste	0	0	50	70	85	100	103
	Education: university research reactors and other support	4	6	6	6	6	6	6
	Other: advanced light water reactor and reactor concepts	34	15	0	0	0	0	0
	Subtotal	42	46	66	86	101	116	119
Nuclear Fusion	Plasma Science: conduct research on fundamental plasma science; develop fusion science and technology and plasma confinement innovations; and pursue fusion energy science and technology as a partner in international efforts.							
	Subtotal	232	225	250	270	290	320	328
Renewable Energy	Biomass Fuels: strengthen feedstock development; advance enzymatic hydrolysis and other conversion technologies in integrated power and fuel systems.	28	38	58	76	94	97	99
	Biomass Power: develop biomass materials handling equipment; integrated gasification combined cycles; biogasification-fuel cell systems; and small gasification-engine systems.	28	38	63	86	89	91	93
	Geothermal: strengthen hydrothermal research; reactivate R&D on advanced resources; expand advanced drilling R&D; and increase R&D on reservoir testing and modeling.	30	30	42	49	50	51	52
	Hydrogen: reorient near-term demonstrations and launch initiative with DOE Fossil Energy on innovative hydrogen production from fossil fuels with sequestration.	15	15	16	16	17	17	17
	Hydropower: develop "fish-friendly" turbines and low-head run-of-river turbines; analyze coupling of hydropower to intermittent renewables.	1	1	4	8	11	11	12
	Photovoltaics: accelerate basic PV science; develop laboratory scaleup to first-time manufacturing; and support engineering science for large-volume, low-cost production.	60	77	105	130	133	137	140
	Solar-Thermal: strengthen power tower and dish-stirling, esp. optical materials and solar manufacturing initiative; launch initiative on advanced high-temperature receivers.	22	20	32	43	44	46	47
	Wind: accelerate R&D on lightweight adaptive systems, direct-drive variable speed generators, hybrid systems, system integration—including with storage; wind technology manufacturing initiative; fundamental work on materials, and computational aerodynamics.	29	43	53	65	66	68	70
	Systems and Storage: energy storage, esp.. for system integration with intermittents.	32	46	51	54	55	57	58
	Solar Buildings: R&D in efficient and passive whole building design and design tools; building integrated PVs and thermal systems; and initiative on low cost solar water heaters and others.	3	4	6	9	9	9	9
	International: applications-specific systems integration and development, and field studies; collaborative R&D and training; technical assistance; technical/policy analysis.	1	7	11	13	13	14	14
	Resource Assessment: integrated assessments across all resources; further development of geographic information systems; and collaborative R&D with developing nations.	0	0	5	5	6	6	6
	Analysis: systematic analyses of technologies, system integration, markets, and policies.	0	0	4	5	6	6	6
	Other: management and planning; renewable energy production incentive, other.	21	26	25	26	27	26	29
	Subtotal	270	345	475	585	620	636	652
SUBTOTAL		1282	1416	1785	2037	2214	2329	2412

[a]Activities should be done through various partnerships between industry, national laboratories, universities, and Federal/state agencies, as appropriate.

President's Committee of Advisors on Science and Technology, "Federal Energy Research and Development for the Challenges of the Twenty-First Century", November 1997.

APPENDIX D
ACRONYMS

ADB:	Asian Development Bank
AFDB:	African Development Bank Group
APEC:	Asia-Pacific Economic Cooperation
BAU:	Business-As-Usual
CAES:	Compressed-Air Energy Storage
CDM:	Clean Development Mechanism
CENEf:	Russian Center for Energy Efficiency
CET:	Clean Energy Technology
CETO:	Clean Energy Technology Obligation
CHP:	Combined Heat and Power
CNG:	Compressed Natural Gas
CO_2:	Carbon Dioxide
CoC:	Council on Competitiveness
COEECT:	Committee on Energy Efficiency Commerce and Trade
COP:	Conference of the Parties
CTI:	Climate Technology Initiative
DCs:	Developing Countries
DOC:	Department of Commerce
DOE:	Department of Energy
DSF:	Demonstration Support Facilities
DSM:	Demand-Side Management
EBRD:	European Bank for Reconstruction and Development
ECCJ:	Energy Conservation Center, Japan
EE/FSU:	Eastern Europe/Former Soviet Union
EE:	Energy Efficiency
EFL:	Energy Feed Law
EIA:	Energy Information Administration
EJ:	Exajoules
EnEffect:	Bulgarian Center for Energy Efficiency
EOP:	Executive Office of the President
EOR:	Enhanced Oil Recovery
EPA:	Environmental Protection Agency
EPRI:	Electric Power Research Institute
ERD^3:	Energy Research, Development, Demonstration, and Deployment
ERI:	Energy Research Institute
ESCOs:	Energy Service Companies
EU:	European Union
Ex-Im Bank:	Export-Import Bank of the United States
FBR:	Fast Breeder Reactor
FEWE:	Polish Foundation for Energy Efficiency
FSU:	Former Soviet Union
FY:	Fiscal Year
GAO:	Government Accounting Office
GATT:	General Agreement on Tariffs and Trade
GDP:	Gross Domestic Product
GEF:	Global Environment Facility
GHG:	Greenhouse Gas
GNP:	Gross National Product
GPO:	Government Printing Office
GRI:	Gas Research Institute
GtC:	Giga-tonnes Carbon
HIPC:	Heavily Indebted Poor Countries
HVAC:	Heating, Ventilation and Air Conditioning
IAEA:	International Atomic Energy Agency
$ICERD^3$:	International Cooperation in Energy Research, Development, Demonstration, and Deployment
ICSU:	International Council for Science
IDB:	Inter-American Development Bank
IEA:	International Energy Agency
IERE:	International Electric Research Exchange
IFC:	International Finance Corporation
IGCC:	Integrated Gasification Combined Cycle
IIASA:	International Institute for Applied Systems Analysis
IPCC:	Intergovernmental Panel on Climate Change
IRP:	Integrated Resource Planning
ITER:	International Thermonuclear Experimental Reactor
kWh:	Kilowatt-hours
LDC:	Less Developed Countries
LPG:	Liquid Petroleum Gas
LWR:	Light Water Reactor
MDB:	Multilateral Development Banks
MTIs:	Market Transformation Initiatives
NERI:	Nuclear Energy Research Initiative
NFFO:	Non-Fossil Fuel Obligation
NGOs:	Non-Governmental Organizations
NPV:	Net Present Value
NREL:	National Renewable Energy Laboratory
NSB:	National Science Board
NSF:	National Science Foundation
NSTC:	National Science and Technology Council
OECD:	Organization for Economic Cooperation and Development
OPEC:	Organization of Petroleum Exporting Companies
OPIC:	Overseas Private Investment Corporation
OPs:	Operational Programs

PBF:	Public Benefits Fund
PCAST:	The President's Committee of Advisors on Science and Technology
PM-10:	Particular Matter of diameter greater than 10 microns.
PNGV:	Partnership for the Next Generation of Vehicles
PNNL:	Pacific Northwest National Laboratory
PPP:	Purchasing Power Parity
PROCEL:	Brazil's National Electricity Conservation Program
PV:	Photovoltaic
R&D:	Research and Development
RD&D:	Research, Development, and Demonstration
RD^3:	Research, Development, Demonstration, and Deployment
REEF:	Renewable Energy and Energy Efficiency Fund
REFs:	Reforming Economies (EE/FSU)
RET:	Renewable Energy Technologies
RPS:	Renewable Portfolio Standard
SDC:	Solar Development Corporation
SEVEn:	Czech Energy Efficiency Center
STE:	Solar Thermal Electric
T&D:	Transmission and Distribution
TC:	Transition Countries, e.g. Eastern Europe and Former Soviet Union
TDA:	Trade and Development Agency
TERI:	Tata Energy Research Institute
TSP:	Total Suspended Particulate
UNDP:	United Nations Development Program
UNEP:	United Nations Environment Program
UNFCCC:	United Nations Framework Convention on Climate Change
USAID:	United States Agency for International Development
USGS:	United States Geological Survey
USTDA:	United States Trade and Development Agency
WANO:	World Association of Nuclear Operators
WEC:	World Energy Council

APPENDIX E
GLOSSARY

As-spent dollars: expenditures or outlays made in a given fiscal year, before adjustment for inflation.

Business-as-usual (BAU): the projected future state of energy and economic variables in the event that current technological, economic, political, and social trends persist.

Capacity building: Developing skills and capabilities for energy-technology innovation in the relevant government, private-sector, academic, and NGO institutions.

Carbon sequestration: the capture and secure storage of carbon that would otherwise be emitted or remain in the atmosphere, either by (1) diverting carbon from reaching the atmosphere; or (2) removing carbon already in the atmosphere. Examples of the first type are the trapping of CO_2 in power plant flue gases, and capturing CO_2 during the production of decarbonized fuels. The common approach to the second type is to enhance the ability of soils to absorb CO_2 naturally.

Clean Energy Technologies (CET): energy supply and end-use technologies that simultaneously: (a) emit substantially lower levels of pollutants and greenhouse gases, and (b) generate substantially smaller and less toxic volumes of solid and liquid waste over their lifecycle.

Clean Energy Technology Obligation (CETO): competitive instrument used to bridge the gap between the demonstration phase and widespread deployment of an energy technology. CETO would use auctions (or other instrument) to buy-down the cost of the energy technology to a level that is competitive with market proven technologies.

Concessionary financing: a loan offered at below market rates.

Cost buy-down: the process of paying the difference in unit cost (price) between an innovative energy technology and a conventional energy technology in order to increase sales volume, thus stimulating cost reductions through manufacturing scaleup and economies of learning throughout the production, distribution, deployment, use, and maintenance cycle.

Demonstration Support Facility (DSF): financial mechanism which funds private sector projects designed to show the feasibility of clean energy and energy-efficient technologies in cases where these technologies are not yet commercially viable.

Debt swap: a situation in which the lender country or institution erases the debt owed by a borrower country provided that the latter creates social programs, environmental programs (such as "debt for nature" swaps), or other programs and policies.

Energy Research, Development, Demonstration and Deployment (ERD^3): the linked process by which an energy-supply or energy-end-use technology moves from its conception in theory and in the laboratory to its feasibility testing, its small-scale implementation, and finally its large-scale deployment with long-term market viability.

Energy-sector restructuring and reform: encouraging privatization (transfer of ownership from the public- to the private-sector) and market competition in energy supply, while removing subsidies and other distortions in energy pricing and preserving public benefits.

Financial mechanism: a mechanism intended to assist the supply of capital available for undertaking an energy technology project, frequently for projects having a specialized purpose (such as the climate change projects targeted by the GEF).

Global Environment Facility (GEF): A financial institution that provides grants and concessionary financing to developing countries and economies-in-transition for projects and activities that provide global benefits in four topical areas: climate change; biological diversity; international waters; and stratospheric ozone. The GEF was established for the purpose of implementing agreements stemming from the 1992 U.N. Conference on Environment and Development, including the Framework Convention on Climate Change. The World Bank Group is one of the three implementing agencies for the GEF, together with the United Nations Development Program and the United Nations Environment Program.

Greenhouse gases (GHGs): heat-trapping gases in the atmosphere that warm the earth's surface by absorbing outgoing infrared radiation and re-radiating part of it downward. Water vapor is the most important naturally occurring greenhouse gas, but the principal greenhouse gases whose atmospheric concentrations are being augmented by emissions from human activities are carbon dioxide, methane, nitrous oxide, and halocarbons.

Infrastructure: the physical structures and delivery systems necessary to supply energy to end-users. In the case of power plants, the infrastructure is the high-tension wires needed to carry the electricity to consumers; in the case of natural gas, it is the pipeline network; in the case of liquid fuels, it is the fueling stations.

InterGovernmental Panel on Climate Change (IPCC): a multilateral scientific organization established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization to assess the available scientific, technical, and socio-economic information in the field of climate change and to assess technical and policy options for reducing climate change and its impacts.

OECD (Organization for Economic Cooperation and Development): A multilateral organization of 29 industrialized nations, producing among them two-thirds of the world's goods and services. The objective of the OECD is the development of social and economic policies and the coordination of domestic and international activities.

Public Benefits Fund (PBF): a financial mechanism created to serve the greater public interest by funding programs for environment and public health, services to the poor and disenfranchised, energy technology innovation through the ERD^3 pipeline, or other public good that is not accounted for by a restructured energy sector.

Tied aid: a method of trade distortion in which one government offers attractive financing (grants, soft loans, etc.) to a second government provided that the aid is used to purchase goods from companies in the originating country. Tied aid can have a leveraging effect such that the recipient country will continue to purchase goods from manufacturers in the originating country even after the financial aid package is exhausted. Since 1992 within the OECD, the use of tied-aid for capital goods is subject to formal challenge when the project in question is commercially viable.

World Bank Group: A multilateral United-Nations-affiliated lending institution, which annually makes available roughly $20 billion in loans to developing countries, mainly but not exclusively for large scale infrastructure projects. The World Bank Group comprises five agencies: the International Bank for Reconstruction and Development, the International Development Association, the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the International Centre for Settlement of Investment Disputes (ICSID). The World Bank Group raises capital from both public sources and financial markets.