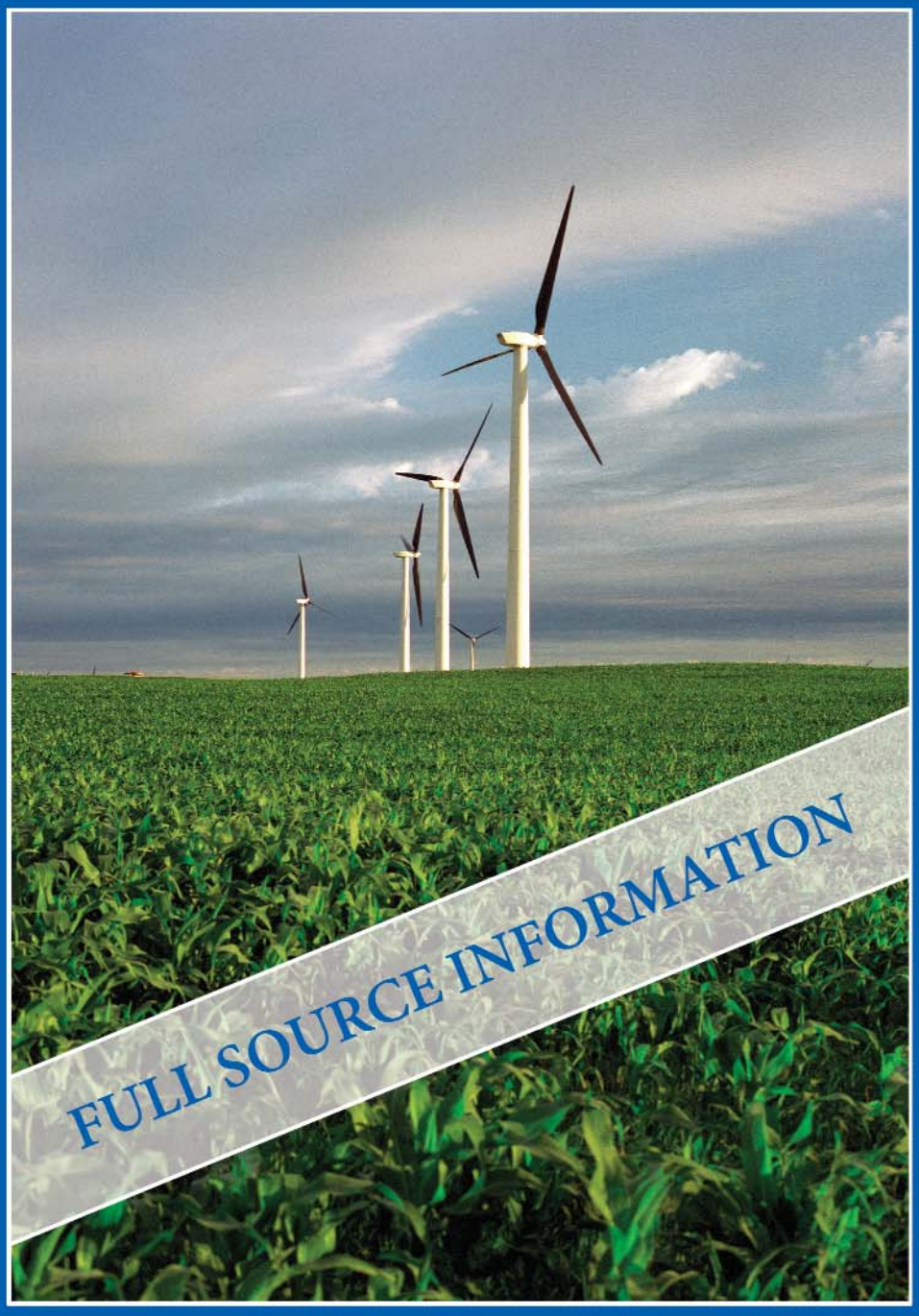
American Energy

The Renewable Path to Energy Security



Worldwatch Institute
Center for American Progress

21st Century Energy

Note: References are numbered by page number and paragraph order.

[6–2] Estimate of 6 percent calculated by Worldwatch with 2004 data from U.S. Department of Energy (DOE), Energy Information Administration (EIA), *Renewable Energy Annual* (Washington, DC: June 2006), at www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea_sum.html; fossil fuels meet 85 percent of U.S. energy needs from DOE, "Energy Sources: Fossil Fuels," www.energy.gov/energysources/fossilfuels.htm, viewed 13 September 2006.

[6–5] Tripling of global wind energy and U.S. wind leadership from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 36. Powering 30 million American homes calculated by Worldwatch based on 2005 year-end installed global wind power capacity of nearly 60,000 megawatts (from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 37, on assumed average capacity factor of 26 percent, average U.S. household size of 2.6 people (from U.S. Census Bureau, 2003 data), and on average U.S. household electricity use of 11,852 kilowatt-hours (from EIA, "Table 10a: U.S Electricity Supply and Demand Base Case," *Short-Term Energy Outlook* (Washington, DC: May 2006)).

[6–6] Solar as one of fastest growing industries from REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 4; 45 percent increase from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 38.

[6–7] Fuel ethanol and biodiesel production increases from Suzanne Hunt and Peter Stair, "Biofuels Hit a Gusher," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 41.

[6–8] Renewables investment of $38 billion from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 2; 20 percent and renewable energy investment increases are Worldwatch estimates based on data from idem, p. 2. Estimate assumes 2005 global investments in the conventional power system were approximately the same as in 2004 ($150 billion), as per REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 4; trends in venture capital investments from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 14.

[6–9] Two million jobs based on total jobs exceeding 1.7 million in 2004 from REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 4.

[6–10] Quote from U.S. President George W. Bush, "State of the Union Address" (Washington, DC: 31 January 2006), at www.whitehouse.gov/news/releases/2006/01/20060131-10.html; over 100 coal-fired plants and impacts from Mark Clayton, "New Plants Bury 'Kyoto,'" *Christian Science Monitor*, 23 December 2004, at www.csmonitor.com/2004/1223/p01s04-sten.html.

[7–1] Prominence of Germany and Spain in wind power and of Germany and Japan in solar power from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 3; and from Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: May 2004), pp. 27–33.

[7–3] States with renewable energy policies from Database of State Incentives for Renewable Energy (DSIRE), North Carolina State University, at www.dsireusa.org/summarytables/reg1.cfm?&CurrentPageID=7&EE=1&RE=1, viewed 10 July 2006. The states that enacted renewable energy laws are Delaware, District of Columbia, and Montana (2005); Colorado, Maryland, New York, Pennsylvania, and Rhode Island (2004); Minnesota (2003); California and New Mexico (2002); and Arizona, Hawaii, and Nevada (2001), per REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 23. The four states that updated their Renewable Portfolio Standards in 2005 were New Jersey, Nevada, Connecticut, and Wisconsin, per REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 9.

[7–4] California electricity estimate of 31 percent from all renewables and 12 percent from non-hydro renewables from EIA, "Renewable State Profile: California," at www.eia.doe.gov/cneaf/solar.renewables/page/state_profile/california.html; Texas as largest U.S. wind energy producer from State of Texas, Energy Conservation Office, "Texas Wind Energy," www.seco.cpa.state.tx.us/re_wind.htm, viewed 23 August 2006; Iowa ethanol production meeting half of gasoline requirements is a Worldwatch estimate based on the following: in 2004, total Iowa gasoline consumption was 4,480.6 gallons/day, or 1,635,419,000/year, per EIA, "Iowa Total Gasoline All Sales/Deliveries by Prime Supplier," updated 16 August 2006, at http://tonto.eia.doe.gov/dnav/pet/hist/c100020191A.htm; in 2005, Iowa produced 1,211,812,177 gallons of ethanol, per Iowa Corn Promotion Board, "Iowa Ethanol-Blended Gasoline Sales 2005" (Johnston, IA: 2005), at www.iowarfa.org/PDF/resources_statistics/Copy_of_2005_Ethanol_Sales.pdf; and 1 gallon of ethanol has the energy-equivalent of 2/3 gallon, per Environmental Entrepreneurs, "State of the Union," *Environmental Entrepreneurs Update*, February 2006, at www.e2.org/ext/jsp/controller?docId=9684&section=stateofunion.

[7–5] Information from 25 x '25, America's Energy Future, "About 25 x '25," www.25x25.org/index.php?option=com_content&task=view&id=12&Itemid=41, viewed 29 August 2006; Rand Corporation economic analysis is a draft report prepared for the Energy Future Coalition, scheduled for release in late 2006.

[7–9] Reduction in spending of $300 billion is an estimate by Christopher Flavin, Worldwatch Institute, based on figures of 13 million barrels a day (EIA, http://tonto.eia.doe.gov/dnav/pet/hist/mttntus2A.htm) at $70 per barrel (EIA, www.eia.doe.gov/emeu/steo/pub/contents.html). For a more detailed study on the costs of U.S. import dependence see David L. Greene and Sanjana Ahmad, "Costs of U.S. Oil Dependence: 2005 Update" (Oak Ridge, TN: Oak Ridge National Laboratory, February 2005), at www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM2005_45.pdf.

SOURCES FOR FIGURES:
U.S. energy consumption by source from EIA, "The Role of Renewable Energy Consumption in the Nation's Energy Supply, 2004," in *Renewable Energy Trends 2004* (Washington, DC: 2004), at www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html.

Average annual growth of various energy sources based on the following: PV data from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 38–39; wind data from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 36–37; biofuels from Suzanne Hunt and Peter Stair, "Biofuels Hit a Gusher," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 40–41; coal, natural gas, and oil from BP, *BP Statistical Review of World Energy 2006* (London: 2006), at www.bp.com/productlanding.do?categoryId=91&contentId=7017990; nuclear power from Nicholas Lenssen, "Nuclear Power Inches Up," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 34–35.

Vision for a More Secure and Prosperous America

ENHANCING ENERGY SECURITY (pp. 8–9)

[8–2] Imports of 13 million barrels a day from EIA, "U.S. Imports by Country of Origin," http://tonto.eia.doe.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_m.htm; 60 percent of daily consumption is a Worldwatch estimate based on total daily U.S. consumption of 20,656,000 barrels/day, per EIA, "Basic Petroleum Statistics," www.eia.doe.gov/neic/quickfacts/quickoil.html; annual cost of $300 billion is an estimate by Christopher Flavin, Worldwatch Institute, based on figures of 13 million barrels a day (EIA, http://tonto.eia.doe.gov/dnav/pet/hist/mttntus2A.htm) at $70 per barrel (EIA, http://www.eia.doe.gov/emeu/steo/pub/contents.html). For a more detailed study on the costs of U.S. import dependence see David L. Greene and Sanjana Ahmad, "Costs of U.S. Oil Dependence: 2005 Update" (Oak Ridge, TN: Oak Ridge National Laboratory, February 2005), at www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM2005_45.pdf; estimate of 70 percent (net imports of crude oil and refined products projected to be 68 percent of total U.S. demand) by 2025 from EIA, *Annual Energy Outlook 2005* (Washington, DC: February 2005), p. 7, at http://tonto.eia.doe.gov/FTPROOT/forecasting/0383(2005).pdf. Note that EIA has adjusted projections based on higher oil prices, reducing assumed net imports by 2025 to 60 percent of demand, per EIA, "Overview," in *Annual Energy Outlook 2006* (Washington, DC: 2006), at www.eia.doe.gov/oiaf/aeo/pdf/overview.pdf. Quote from U.S. President George W. Bush, "State of the Union Address" (Washington, DC: 31 January 2006), at www.whitehouse.gov/news/releases/2006/01/20060131-10.html.

[8–3] U.S. oil peak from EIA, "U.S. Crude Oil Production," http://tonto.eia.doe.gov/dnav/pet/hist/mcrfpus1A.htm; Indonesia from Association for the Study of Peak Oil and Gas (ASPO), "Country Re-Assessment—Indonesia," *ASPO Newsletter*, January 2006, at www.peakoil.ie/newsletters/705; Norway from ASPO, "Country Assessment—Norway," *ASPO Newsletter*, January 2003, at www.peakoil.ie/newsletters/133; United Kingdom from ASPO, "Country Re-Assessment—United Kingdom," *ASPO Newsletter*, March 2006, at www.peakoil.ie/newsletters/738.

[8–4] Ownership and control of 85 percent of world's oil reserves from National Center for Policy Analysis, "How Economic Freedom Can Increase Oil Supplies," at www.ncpa.org/pub/ba/ba562 ("only 16% of world reserves are explored, produced or delivered by private companies").

[8–5] Middle East contains 60 percent of reserves from EIA, "Persian Gulf Oil and Gas Exports Fact Sheet," www.eia.doe.gov/emeu/cabs/pgulf.html; nearly half (40 percent) through Straits of Hormuz from EIA, "Persian Gulf Oil and Gas Exports Fact Sheet" (Washington, DC: October 2004), at www.eia.doe.gov/emeu/cabs/pgulf.html; rising demand increases oil prices from Barbara Hagenbaugh, "Global Tension Pushes Oil to Record," *USA Today*, 13 July 2006; price spikes leading to recession from Steve Hargreaves, "$70 Oil: Get Used to It," CNNMoney.com, 11 July 2006, at money.cnn.com/2006/07/11/news/economy/oil_prices/index.htm; and from United States Congress, Joint Economic Committee, "Energy Prices and the Economy" (Washington, DC: January 2006), at www.house.gov/jec/publications/109/energy01-26-06.pdf, which notes that 9 of the last 10 post-war recessions were preceded by spikes in oil price.

[9–1] Estimate of 10 percent of refining capabilities still crippled from Jewish Institute for National Security Affairs, "Energy Security Now a National Buzzword" (Washington, DC: 18 October 2005), at www.jinsa.org/articles/articles.html/function/view/categoryid/171/documentid/3181/history/3,2360,656,171,3181.

[9–2] Blackout costs of $4–10 billion from Electricity Consumers Resource Council, "The Economic Impacts of the August 2003 Blackout" (Washington, DC: February 2004), at www.elcon.org/Documents/EconomicImpactsOfAugust2003Blackout.pdf.

[9–3] Figure of 104 nuclear plants from EIA, "U.S. Nuclear Generation of Electricity," at www.eia.doe.gov/cneaf/nuclear/page/nuc_generation/gensum.html.

[9–4] Analysis of 2003 blackout and PV generation reducing outages from Richard Perez et al., "Solution to the Summer Blackouts? How Dispersed Solar Power-generating Systems Can Help Prevent the Next Major Outage," *Solar Today*, July/August 2005, at www.solartoday.org/2005/july_aug05/summer_blackouts.htm.

[9–5] Defense Department study from U.S. Department of Defense (DOD), Office of the Secretary of Defense, "Report to Congress—DOD Renewable Energy Assessment: Final Report" (Washington, DC: 14 March 2005), at www.acq.osd.mil/ie/irm/irm_library/Final%20Renewable%20Assessment%20Report.pdf; more than 8 percent of electricity from DOD, Office of the Deputy Undersecretary, "Report to Congress on DOD Renewable Energy Assessment: Status Report Update" (Washington, DC: March 2006), p. 6, at www.acq.osd.mil/ie/irm/irm_library/Renewable%20Report%20Update.pdf; military and CIA turning to solar from "Army Lightens Load with Solar Power," MSNBC.com, 5 May 2005, at www.msnbc.msn.com/id/7745709; and from John Dillin, "The Latest Investor in Green Energy—the CIA," *Christian Science Monitor*, 18 October 2005.

[9–6] Louisiana State Police use of solar from "Solar Powered Lighting for Katrina Relief Efforts," RenewableEnergyAccess.com, September 2005, at www.renewableenergyaccess.com/rea/news/story;jsessionid=aFFYPJw9E35_?id=36940; lack of power hindering Louisiana workers from Kevin Heslin, "The Winds of Change," *Energy & Power Management*, October 2005, p. 4; NJ Atlantic County Utilities Authority plan from Clean Energy Group, "Energy Security and Energy Preparedness" (Montpelier, VT: October 2005), at www.cleanegroup.org/Reports/CEG_Clean_Energy_Security_Oct05.pdf.

[9–7] Coupling renewables with traditional generators from DOD, Office of the Secretary of Defense, "Report to Congress—DOD Renewable Energy Assessment: Final Report" (Washington, DC: 14 March 2005); states view renewables as essential from Clean Energy Group, "Energy Security & Emergency Preparedness: How Clean Energy Can Deliver More Reliable Power for Critical Infrastructure and Emergency Response Missions" (Montpelier, VT: October 2005), at www.cleanenergystates.org/library/Reports/CEG_Clean_Energy_Security_Oct05.pdf.

SOURCES FOR FIGURES:
Domestic oil production from EIA, "U.S. Total Crude Oil and Petroleum Products Supplied" (Washington, DC: updated 28 July 2006), at http://tonto.eia.doe.gov/dnav/pet/hist/mttupus1A.htm; domestic oil consumption by source from EIA, "U.S. Crude Oil Field Production" (Washington, DC: updated 28 July 2006), at http://tonto.eia.doe.gov/dnav/pet/hist/mcrfpus1A.htm.

Crude spot prices from EIA, "Cushing, OK WTI Spot Price" (Washington, DC: updated 30 August 2006), at http://tonto.eia.doe.gov/dnav/pet/hist/rwtcA.htm.

CREATING JOBS (p. 10)

[10–1] For more information on the range of studies and reports, see Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" (Berkeley, CA: Energy and Resources Group and Goldman School of Public Policy, University of California at Berkeley, April 2004); renewable energy creates more jobs from Virinder Singh, "The Work That Goes into Renewable Energy" (Washington, DC: Renewable Energy Policy Project (REPP), November 2001); see also REPP, "Labor and Renewable Energy," www.repp.org/labor/index.html. Suzanne Tengen, "Statewide Economic Impacts of Wind Energy Compared with Coal and Natural Gas" (Golden, CO: NREL, March 2004); S. Clemmer, "Strong Winds: Opportunities for Rural Economic Development Blow Across Nebraska" (Cambridge, MA: Union of Concerned Scientists (UCS), 2001); and Kammen et al., op. cit. this note.

[10–2] Transition effects of shifting jobs from Kammen et al. (see above); 355,000 new jobs from UCS, "Renewing America's Economy" (Cambridge, MA: 2004), at www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=1505, and from UCS, "A 20 Percent National Renewable Electricity Scenario Creates Jobs and Boosts the Economy" (Cambridge, MA: October 2004).

[10–3] High paying jobs for skilled workers from Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: Worldwatch Institute, 2004), p. 16.

[10–4] Renewable Energy Policy Project study from George Sterzinger and Matt Svrcek, "Wind Turbine Development: Location of Manufacturing Activity," REPP Technical Report (Washington, DC: September 2004); five times today's level based on U.S. wind capacity of 9,149 megawatts (MW) at end of 2005, from American Wind Energy

Association (AWEA), "U.S. Wind Industry Ends Most Productive Year," *Wind Energy Weekly*, 27 January 2006; employment in ethanol industry and household income from John M. Urbanchuk, "Contribution of the Ethanol Industry to the Economy of the United States," prepared for the Renewable Fuels Association (RFA) (Washington, DC: February 2006), p. 3, at www.ethanolrfa.org/objects/documents/576/economic_contribution_2006.pdf.

[10–5] Environment California Research and Policy Center cited in Brad Heavner and Bernadette Del Chiaro, "Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California" (Los Angeles, CA: Environment California Research and Policy Center, July 2003).

[10–6] Decline in U.S. coal jobs from 1980–99 from National Mining Association, "Mining Industry Employment in the United States by Sector," at www.nma.org/pdf/e_sector.pdf; additional 30,000 jobs by 2020 from Daniel M. Kammen, Kamal Kapadia, and Matthias Fripp, "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" (Berkeley, CA: Energy and Resources Group and Goldman School of Public Policy, University of California at Berkeley, April 2004); impact on economy and transfer of jobs overseas from Russell Gold, "Natural-Gas Costs Hurt U.S. Firms," *Wall Street Journal*, 17 February 2004.

SOURCES FOR FIGURE:
Jobs in renewables and fossil fuels based on the following: REPP, European Wind Energy Association, Greenpeace, California Public Interest Research Group, and Bureau of Labor Statistics, all cited in Kammen et al. (see above).

THE GLOBAL MARKETPLACE (p. 11)

[11–1] Global investment in renewables from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), pp. 2, 7; $70 billion from Eric Martinot, Worldwatch Institute, e-mail to Janet Sawin, Worldwatch Institute, 18 March 2006.

[11–2] Wind and solar power world's fastest growing from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006); more wind than nuclear capacity from "Nuclear Construction Starts," Worldwatch Institute database, and from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 36–37; solar thermal increase is a Worldwatch calculation based on data from Werner Weiss, Irene Bergmann, and Gerhard Faninger, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2004* (Paris: International Energy Agency (IEA), Solar Heating and Cooling Programme, March 2006); ethanol and biodiesel growth from Christoph Berg, Senior Analyst, F.O. Licht, Agra Informa Ltd., Kent, UK, e-mail to Peter Stair, Worldwatch Institute, 25 January 2006.

[11–3] BP and Royal Dutch/Shell investment in renewables from Pew Center on Global Climate Change, "Energy Solutions," www.pewclimate.org/policy_center/policy_maker_s_guide/business/business_solutions.cfm, viewed 12 September 2006; GE investment from Michael Kanellos, "Newsmaker: Behind GE's Clean Energy Push," CNet News, 27 January 2006, at http://news.com.com/Behind+GEs+clean-energy+push/2008-1082_3-6031901.html; Dupont from "Chemical Giant Plans New Solar Strides," RenewableEnergyAccess.com, 14 April 2006; Honda from Jena McGregor, "The World's Most Innovative Companies," *Business Week*, 24 April 2006, p. 65.

[11–4] Germany and Spain's dominance in wind from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 36; Japan and Germany's dominance in PV from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 38. Japan produced 833 MW solar cells in 2005, or about 48 percent of the global total, from Prometheus Institute, *PV News*, March 2006, pp. 4–5; and from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006-2007* (New York: W.W. Norton & Company, 2006), pp. 38–39. Germany dominated the marketplace, installing about 600 MW of new capacity in 2005, from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006); Brazil biofuels production from Christopher Berg, Senior Analyst, F.O. Light, Agra Informa Ltd, Kent, UK, e-mail to Peter Stair, Worldwatch Institute, 25 January 2006;

China's share of small hydro and solar water heating from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 5.

[11–5] U.S. shares of global solar production are Worldwatch estimates based on data from Paul Maycock, PV Energy Systems, e-mails to Janet Sawin, Worldwatch Institute, 27 January 2005 and 27 February 2006; from Maycock, *PV News*, various editions; and from Prometheus Institute, *PV News*, March 2006, pp. 4–5.

SOURCES FOR SIDEBAR:
Green power demand from NREL, "Green Power Marketing in the United States: A Status Report" (Golden, CO: October 2005); leaders in green power purchasing from "U.S. Air Force, Whole Foods Top EPA List of Renewable Energy Users," GreenBiz.com, 26 January 2006; Statue of Liberty from "Nation's Landmarks Adopt 100% Renewable Energy," RenewableEnergyAccess.com, 27 February 2006; Colorado and Texas customers from DOE, Office of Energy Efficiency and Renewable Energy (EERE), "Green Pricing," at www.eere.energy.gov/greenpower/markets/pricing.shtml?page=2&companyid=50.

SOURCES FOR FIGURE:
Global construction starts from "Nuclear Construction Starts," Worldwatch database, and from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 36–37.

INVESTMENT OPPORTUNITIES (p. 12)

[12–1] Global investments increasing six-fold and $180 billion calculated by Worldwatch with data from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 7; $38 billion from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 2; $150 billion invested worldwide assumes that 2005 global investments in conventional power were approximately the same as in 2004 ($150 billion), per REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 4.

[12–3] CalPERS from "Catching the Wave," *Environmental Finance*, May 2006, at www.environmental-finance.com/2006/0605may/wave.htm.

[12–4] Investing in renewables also about making money from David Prend, managing partner of energy venture firm Rockport Capital, quoted in Jonathan Keehner, "Options Grow for Green Investors – Alternative Energy Indexes May Fuel More Sector ETFs: 'It is About Making Money,'" *Wall Street Journal*, 20 June 2006.

[12–5] Goldman Sachs from Claudia H. Deutsch, "Investors Are Tilting Toward Windmills," *New York Times*, 15 February 2006; NASDAQ, "Nasdaq Clean Edge U.S. Index," at www.nasdaq.com/services/indexes/ViewIndexes/Nasdaq_clean.aspx?symbol=CLEN; renewable energy as hottest arena from "Renewable Energy is Off and Running," in "Investing in America's Energy Future," *Business Week*, Special Advertising Section, 8 May 2006, at www.businessweek.com/adsections/2006/pdf/050806_Energy_new.pdf; just passed semiconductors from Cleantech Capital Group, LLC, "Cleantech Becomes Third Largest Venture Investment Category with $843 Million Invested in Q2 2006," press release (Ann Arbor, MI: 10 August 2006), at www.renewableenergyaccess.com/rea/market/business/viewstory?id=45688; Doerr quote from Red Herring, "Kleiner Perkins Debuts 3 Funds," 16 February 2006, at www.redherring.com/article.aspx?a=15754.

[12–6] Loans to ethanol plants, wind farms, and other renewable projects from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 14; U.S. banks lag from Michael Eckhart, President, American Council on Renewable Energy, e-mail to Janet Sawin, Worldwatch Institute, September 2004; production tax credit extended to other renewables from Salvatore Lazzari, "Congressional Research Service Brief for Congress, 'Energy Tax Policy,'" April 2005, at www.ncseonline.org/NLE/CRSreports/05apr/IB10054.pdf. Further information can be found at Robert H. Edwards, Jr., "U.S. Energy Policy Act: Renewables and the Act," *PFI Magazine* 21 September 2005, at www.hunton.com/files/tbl_s47Details%5CFileUpload265%5C1307%5CRenewables_Edwards_PFI_9.21.05.pdf.

[12–7] Archer Daniel Midlands from Bob Kelley, "Ethanol Fueling Growth for ADM," CNNMoney.com, 16 June 2006, at http://money.cnn.com/2006/06/16/markets/spotlight/spotlight_adm; Bill Gates from Bloomberg.com, "Goldman, Gates Bet Ethanol Boom Won't Repeat '80s-Style Bust," 25 May 2006, at www.bloomberg.com/apps/news?pid=10000086&sid=aW9UfHj_vugQ&refer=latin_america.

[12–8] Clean Energy Funds worth $3.5 billion in 13 states from Clean Energy States Alliance, "About CESA," at www.cleanenergystates.org/about.html, viewed 24 August 2006; cities getting involved from DOE, EERE, "Financing for Public Sector Renewable Projects" (Washington, DC: February 2006), at www.millionsolarroofs.org/articles/static/1/1138196910_1137083754.html.

SOURCE FOR FIGURE:
Global investment in renewables from Eric Martinot, Worldwatch Institute, e-mail to Janet Sawin, Worldwatch Institute, July 2006.

Building A New Energy Economy

BUILDING FOR THE FUTURE (p. 13)

[13–1] Commercial and residential buildings' shares of energy use and share of national emissions from Brigitte Preston and Deborah Fuller, "The Cost of LEED for Commercial Interiors," Environmental Design + Construction, 2 June 2006, at www.edcmag.com/CDA/Articles/Column/597b620eb9feb010VgnVCM100000f932a8c0.

[13–2] Green building movement from U.S. Green Building Council (USGBC), "An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System," PowerPoint presentation, October 2005, at www.usgbc.org/DisplayPage.aspx?CategoryID=20.

[13–3] Figure of 6,000 LEED members and government action from USGBC, "Membership"; at www.usgbc.org/DisplayPage.aspx?CategoryID=2; Atlanta, Boston, and San Francisco from "America's Cities LEED the Way," Buildings.com, May 2005, at www.buildings.com/Articles/detail.asp?ArticleID=2475. According to USGBC, 41 cities and counties had adopted some form of LEED certification by mid-2005. 500 U.S. buildings certified from Dara Zycherman, LEED Program Coordinator, USGBC, e-mail to Amanda MacEvitt, Worldwatch Institute, 24 July 2006. A total of 536 buildings were certified worldwide by 24 July 2006, 494 of which were in the United States.

[13–4] Walgreens from "Walgreens to Equip 112 Stores with Solar Power," *Environment News Service*, 18 January 2006; Solaire apartments from "First 'Green' High-Rise Residential Building in the World," *Real Estate Weekly*, 2 October 2002; from "Governor Pataki Unveils the Solaire, First 'Green' Residential Tower in the U.S." *Silicon Valley Biz Ink*, 5 September 2003; and from Joshua Radoff, "Green Buildings," *Gotham Gazette*, 1 January 2004; Battery Park City's 92 acres from Robin Pogrebin, "Putting Environmentalism on the Urban Map," *New York Times*, 17 May 2006.

[13–5] Chicago Center from Terry Costlow, "Green Buildings Bloom Around the US," *Christian Science Monitor*, 18 July 2002; Dallas/Fort Worth Airport from "Smart Buildings Gain Momentum," CNN.com, 25 October 2004; Centex and Premier Homes from David Morrill, "Solar Energy Could Be a Hot Buy," *San Mateo County Times*, 14 October 2004.

[13–6] Economic reasons for constructing green buildings from USGBC, "Green Building by the Numbers," www.usgbc.org/DisplayPage.aspx?CMSPageID=1442, viewed 25 August 2006; California Sustainable Building Task Force report from Russ Banham, "Greener Buildings, 'Greener' Bottom Line," *The Economist*, 11 August 2004; and from Barnaby J. Feder, "Environmentally Conscious Developers Try to Turn Green into Platinum," *New York Times*, 25 August 2004; falling costs from Gregory H. Kats, "Green Building Costs and Financial Benefits" (Westborough, MA: Massachusetts Technology Collaborative, 2003), p. 3; better returns on investment from "Turner Green Building Survey Reveals 93% of Executives Working with Green Buildings Expect Green Workload to Rise in the Next Three Years," *Financial News*, 15 September 2004. For additional information about costs (2 percent premium) and benefits (higher rents, health, and productivity, etc.) of green buildings, see Gregory H. Kats, "Green Building Costs and Financial Benefits" (Westborough, MA: Massachusetts Technology Collaborative, 2003); and Judith Heerwagen, "Sustainable Design Can Be an Asset to the Bottom Line," *Environmental Design & Construction*, 15 July 2005, at www.edcmag.com/CDA/Archives/936335f1c9697010VgnVCM100000f932a8c0.

SOURCES FOR SIDEBAR:
Ford Motor Company from "Ford Overhauls Historic Factory to be Green," *Associated Press*, 27 April 2004, at www.msnbc.msn.com/id/4843708; potential savings from green roofs from Alexis Karolides, "An Introduction to Green Building, Part 3: Other Green Building Considerations," *RMI Solutions*, Summer 2003, p. 13; Hawaii's National Energy Laboratory from Greg Franta, "High-Performance Buildings Through Integrated Design," *RMI Solutions*, Summer 2006, p. 8; 4 Times Square from John Holusha, "Technology in the Front Seat at 4 Times Square," *New York Times*, 30 March 1997; Pittsburgh from "Greening Pittsburgh's Convention Center: Lessons in Market Transformation," proceedings from Green Building Alliance Symposium, Pittsburgh, PA, 14 November 2003, p. 9, at www.gbapgh.org/Education%20Resources/DLLCC_SymposiumProceedings%20_Full.pdf; energy savings from Tom Avril, "Pittsburgh Convention Center a 'Green' Feat," *Philadelphia Inquirer*, 30 November 2003; Genzyme headquarters from USGBC, "LEED Certified Project Case Study: Genzyme Center,"

http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=274, viewed 25 August 2006.

MEETING THE TRANSPORTATION CHALLENGE (p. 14)

[14–1] Transportation accounts for two-thirds (67 percent) of U.S. oil consumption (2004 data) from EIA, "Energy InfoCard—United States" (Washington, DC: updated September 2005), at www.eia.doe.gov/kids/infocardnew.html#PETROLEUM; cars as predominant source of domestic urban air pollution from U.S. Environmental Protection Agency (EPA), "Automobile Emissions: An Overview" (Chicago, IL: updated 26 April 2006), at www.epa.gov/reg5oair/mobile/auto_emis.htm; 95 percent from Worldwatch Institute, *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, report prepared for BMELV in coordination with GTZ and FNR (Washington, DC: 2006); 2 percent is a Worldwatch estimate based on the following: by volume, ethanol represented 2.71 percent of the U.S. gasoline market in 2005; accounting for ethanol's lower energy density, it was 1.85 percent of the fuel, per EIA, "U.S. Finished Motor Gasoline Product Supplied (Thousand Barrels)" (Washington, DC: updated 12 June 2006), at http://tonto.eia.doe/gov/dnav/pet/hist/mgfupus1A.htm; Christopher Berg, Senior Analyst, F.O. Licht, Agra Informa Ltd., Kent, UK, e-mail to Peter Stair, Worldwatch Institute, 25 January 2006; Lew Fulton et al., *Biofuels for Transport: An International Perspective* (Paris: IEA, 2004).

[14–3] Cars running on 10 percent ethanol blends and on E85 from Norma Mendoza, "E-85 touted for Madison County," *Edwardsville Intelligencer*, 1 September 2005, at www.zwire.com/site/news.cfm?newsid=15137798&BRD=2291&PAG=461&dept_id=473648&rfi=8; Ford, DaimlerChrysler, and GM from Micheline Maynard, "Ford Motor Gives up on Hybrid Sales," *International Herald Tribune*, 30 June 2006, at www.iht.com/articles/2006/06/30/business/ford.php; and from Chuck Glametta, "Distilling America's Home Grown Fuel," Consumer Guide Automotive, at http://auto.consumerguide.com/Articles/index.cfm/act/featuredarticles/article/FA_E85_DISTILLED.htm; 6 million E85 compatible vehicles from National Ethanol Vehicle Coalition, "Frequently Asked Questions," at www.e85fuel.com/e85101/faqs/number_ffvs.php.

[14–4] "Energy Policy Act of 2005, Bill H.R.6., One Hundred Ninth Congress of the United States of America, First Session," at http://thomas.loc.gov/cgi-bin/query/D?c109:6:./temp/~c109Ye5rFs.

[14–5] Hybrid-gas electric technology can be 30 percent more efficient in certain models, e.g. the Toyota Prius gets an estimated 40–60 miles per gallon (mpg), while the Honda Accord hybrid gets an estimated 34 mpg; hybrid trucks generally are 10–12 percent more efficient than conventional ones. Fuel economy is best in city driving where the electric motor is most active. Per DOE, EERE, "Hybrid Cars" (Washington, DC: updated 11 September 2006), at www.fueleconomy.gov/feg/hybrid_sbs_cars.shtml, and Jamie Lincoln Kitman, "Life in the Green Lane," *New York Times*, 16 April 2006.

[14–6] Tax credits for hybrid owners from U.S. Internal Revenue Service, "Hybrid Cars and Alternative Motor Vehicles," at www.irs.gov/newsroom/article/0,,id=157632,00.html. For a list of states with alternative vehicle purchase incentives, see DOE, EERE, "Alternative Fuels Data Center," www.eere.energy.gov/afdc/progs/in_matrx.cgi, viewed 4 July 2006.

[14–7] Electric cars on market from Electric Auto Association, "Electric Vehicles for Sale," www.eaaev.org/eaaevsforsale.html; new generation of plug-in hybrids from Mark Clayton, "Toyota Moves to Corner the 'Plug-In' Market," *Christian Science Monitor*, 20 July 2006, at www.csmonitor.com/2006/0720/p02s01-ussc.html. Plug-in hybrids are projected to be available on the market within the next 2–3 years, per Deron Lovaas, Vehicles Campaign Director, Natural Resources Defense Council (NRDC), e-mail to Suzanne Hunt, Worldwatch Institute, 3 July 2006.

[14–8] Hydrogen production and long-term potential from DOE, EERE, "Hydrogen Basics" (Washington, DC: updated 10 August 2006), at www.eere.energy.gov/RE/hydrogen_basics.html; hydrogen transportation and storage from DOE, EERE, "Hydrogen Transport and Storage" (Washington, DC: updated 10 August 2006), at www.eere.energy.gov/RE/hydrogen_transport.html; fuel cell vehicles from DOE, EERE, "Fuel Cell Vehicles," www.fueleconomy.gov/feg/fuelcell.shtml, viewed 25 August 2006.

SOURCES FOR FIGURE:
Number of alternative-fueled vehicles in use from EIA, "Estimated Number of Alternative-Fueled Vehicles in Use in the United States, by Fuel Type and Vehicle, 2000," at www.eia.doe.gov/cneaf/alternate/archive/datatables/table14.html; 2004 data from www.eia.doe.gov/cneaf/alternate/page/datatables/t2004.xls.

A NEW FUTURE FOR AGRICULTURE (p. 15)

[15–1] Jobs, household income, and tax revenues from RFA, "From Niche to Nation: Ethanol Industry Outlook 2006" (Washington, DC: February 2006), at www.ethanolrfa.org/objects/pdf/outlook/outlook_2006.pdf (note that federal tax revenues associated with the ethanol industry exceeded $1.9 billion in 2005, and state and local revenues were almost $1.9 billion); John M. Urbanchuk, "Contribution of the Ethanol Industry to the Economy of the United States," prepared for RFA (Washington, DC: 21 February 2006), at www.ethanolrfa.org/objects/documents/576/economic_contribution_2006.pdf; RFA, "Ethanol Facts: Economy," www.ethanolrfa.org/resource/facts/economy, viewed 4 July 2006.

[15–2] Benefits of cellulosic ethanol from Diane Greer, "Creating Cellulosic Ethanol: Spinning Straw Into Fuel," *BioCycle*, April 2005, at www.harvestcleanenergy.org/enews/enews_0505/enews_0505_Cellulosic_Ethanol.htm; and from Worldwatch Institute, *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, report prepared for BMELV in coordination with GTZ and FNR (Washington, DC: 2006).

[15–3] For more information on and examples of local benefits, see John M. Urbanchuk and Jeff Kapell, "Ethanol and the Local Community" (Mount Laurel, NJ: AUS Consultants and Boston, MA: SJH & Company, 20 June 2002), at www.ethanol.org/pdfs/ethanol_effects.pdf; more than half of U.S. soybean farmers using biodiesel from "Biodiesel Popularity on the Rise," *Environment News Service*, 4 August 2004, at www.ens-newswire.com/ens/aug2004/2004-08-03-09.asp#anchor4; "bio-refineries" from Diane Greer, "Creating Cellulosic Ethanol: Spinning Straw Into Fuel," *BioCycle*, April 2005, at www.harvestcleanenergy.org/enews/enews_0505/enews_0505_Cellulosic_Ethanol.htm.

[15–4] Royalties for wind turbines from the following sources: minimum of $1,000 from Catamount Energy Corporation, "Frequently Asked Questions," at www.catenergy.com/faq.html; $1,500–2,000 from Christine Stebbins, "Feature—US Midwest Farmer's Latest Harvest: Wind Energy," *Reuters*, 7 November 2005; $2,000–4,000 from Sally Barber, "Wind: The New Power Player," *Cadillac News*, 13 March 2006, at www.cadillacnews.com/articles/2006/03/13/news/news01.txt; increasing economic yield of land with wind energy from Lester R. Brown, "U.S. Farmers Double Cropping Corn and Wind Energy" (Washington, DC: Earth Policy Institute, 7 June 2000), at www.earth-policy.org/Alerts/Alert3.htm. For example, a wind turbine sited on a quarter acre of land can generate annual royalties of $2,000, while the same plot might produce $100 worth of corn.

[15–5] Solar-powered irrigation of 600 acres from California State Senate Republican Caucus, "Sunny Days at Teixeira Farms," press release (Sacramento, CA: 15 July 2005), at http://republican.sen.ca.gov/news/15/pressrelease3540.asp.

[15–6] Summary of "25 x '25" from 25 x '25, America's Energy Future, "About 25 x '25," www.25x25.org/index.php?option=com_content&task=view&id=12&Itemid=41, viewed 29 August 2006; endorsements available at 25 x '25, America's Energy Future, "Endorsements," www.25x25.org/index.php?option=com_content&task=view&id=24&Itemid=53, viewed 29 August 2006.

POWERING THE ELECTRICITY GRID (p. 16)

[16–2] Conventional energy's 95 percent share of U.S. generation in 2005 from EIA, "Electric Power Monthly, Table 1.1," at www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html; 12 percent from Pacific Gas & Electric, "Pacific Gas and Electric Company Adds More Renewable Energy to Customer Electric Mix," press release (San Francisco, CA: 16 May 2006), at www.pge.com/news/news_releases/q2_2006/060516.html; and from David Landes, Electricity Procurement, Pacific Gas & Electric Company, e-mail to Amanda MacEvitt, Worldwatch Institute, 26 June 2006.

[16–3] For information on wind prediction and forecasting tools and modeling, see Institut für Solare Energieversorgungstechnik (Institute for Solar Energy Technologies) Web site, www.iset.uni-kassel.de.

[16–4] Denmark meeting 20 percent of electricity needs from Cheryl Pellerin, "Wind Power World's Fastest-Growing New Electricity Source" (Washington, DC: U.S. Department of State, International Information Programs, 22 April 2005), at http://usinfo.state.gov/gi/Archive/2005/Apr/22-869267.html. Germany, the country with the most installed wind-generating capacity, now gets more than 6 percent of its electricity from about 18,400 MW of wind power (as of end of 2005), and more than 20 percent in some regions, per Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 36. Backup capacity and less than 1:1 ratio from Xcel Energy, PacifiCorp, BPA, We Energies, and consultant Eric Hirst, cited in Utility Wind Interest Group, "Wind Power Impacts on Electric-Power-System Operating Costs, Summary and Perspective on Work Done to Date" (Reston, VA: November 2003), at www.uwig.org/UWIGOpImpFinal11-03.pdf.

[16–5] Conventional power plant planning from Duke Energy, "New Generation: Protection the Environment While Meeting Growing Power Demand," www.duke-energy.com/about/plants/new_generation; and from Frederic Seitz, "Must We Have Nuclear Power?" *Reader's Digest*, August 1990, at www.me.utexas.edu/~ans/info/reactor4.htm. Note that nuclear power plant planning estimates vary because no plants have been built in the United States in more than 30 years; however, the American Nuclear Society, University of Texas Chapter has estimated 6–12 years based on experience in other countries, per Seitz, idem. Construction times for renewables projects vary depending on project type. For construction lead times for various renewable technologies, see EIA, "Chapter 5: Issues for Renewable Fuels in Competitive Electricity Markets," in *Challenges of Electric Power Industries Restructuring for Fuel Suppliers* (Washington, DC: 2005), at www.eia.doe.gov/cneaf/electricity/chg_str_fuel/html/chapter5.html; estimate of 3–6 months for new wind farms from FPL Energy, "A Leader in Clean Energy," at www.fplenergy.com/renewable/pdf/wind/pdf.

[16–6] Renewable energy valuable part of utility portfolio from FPL Energy, "Renewable Energy," www.fplenergy.com/renewable/contents/renewable_energy.shtml; wind farms competitive with gas and coal from NRDC, "Wind, Solar and Biomass Energy Today," www.nrdc.org/air/energy/renewables/wind.asp, viewed 29 August 2006; GE Wind predictions from Michael Kujawa, "Large Wind Rising," *Renewable Energy World*, March–April 2003.

SOURCE FOR FIGURE:
U.S. net electricity generation from EIA, "Net Generation by Energy Source: Total," at www.eia.doe.gov/cneaf/electricity/epm/table1_1.html.

MICRO POWER (p. 17)

[17–2] Edison from IEEE Virtual Museum, "Pearl Street Station: The Dawn of Commercial Electric Power," at www.ieee-virtual-museum.org/collection/event.php?id=3456876&lid=1.

[17–3] Micro plants reduce transmission costs and losses from Andrew Goett et al., "The Benefits and Risks of Distributed Generation," in U.S. Congressional Budget Office, *Prospects for Distributed Generation* (Washington, DC: September 2003), at www.cbo.gov/ftpdocs/45xx/doc4552/Chapter3.pdf; improved reliability from Institute of Electrical and Electronics Engineers, "Electric Power Reliability Organization," at www.ieeeusa.org/policy/positions/reliability.html.

[17–4] Japanese companies from Kyocera Corporation, "Building Integrated Solar PV Module System Designed to Blend in with Flat Tiled Roofs," press release (Kyoto, Japan: 23 February 2005), at global.kyocera.com/news/2005/0201.html; and from Sharp Electronics Corporation, "Sharp's Integrated Solar Roof Modules Offer Efficient Installation and Enhanced Aesthetics," press release (San Francisco, CA: 1 June 2005), at solar.sharpusa.com/files/sol_dow_SolarRoof_PR060105.pdf; GE "plug-and-play" systems from GE Energy, "Residential Systems for New and Existing Homes," www.gepower.com/prod_serv/products/solar/en/prepkg_sys/resid_sys.htm, viewed 25 August 2006; solar experts from Scott Sklar, The Stella Group, Ltd., e-mail to Janet Sawin, Worldwatch Institute, September 2004.

[17–5] FedEx from PowerLight Corporation, "FedEx Corporation Project Background," www.powerlight.com/success/fedex.php, viewed 4 July 2006.

[17–6] Laws and regulations disadvantaging technologies from UCS, "Powerful Solutions: 7 Ways to Switch America to Renewable Electricity," at www.ucsusa.org/clean_energy/clean_energy_policies/powerful-solutions-7-ways-to-switch-america-to-renewable-electricity.html; net metering laws from DSIRE, "Net Metering Rules," at www.dsireusa.org/documents/SummaryMaps/NetMetering_Map.ppt; popularity of California rooftop systems from Craig D. Rose, "Harnessing Solar Energy," *San Diego Union Tribune*, 6 February 2003, at www.turn.org/newswire/020703.shtml.

SOURCE FOR FIGURE:
U.S. states with net metering map based on DSIRE, "Net Metering Rules," at www.dsireusa.org/documents/SummaryMaps/NetMetering_Map.ppt.

A Cleaner, Healthier America

CLEANER AIR AND WATER (p. 18)

[18–2] C.A. Pope III et al., "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution," *Journal of the American Medical Association*, Vol. 287 (2002), pp. 1132–41; see also Pam McDonnell, "Air Pollution's Impact on the Heart is as Bad as Having Been a Smoker" (New York: New York University Medical Center and School of Medicine, 16 December 2003), at www.medicalnewstoday.com/medicalnews.pgh?newsid=4888. Abt Associates study, asthma and workdays lost, and $160 billion from Abt Associates, *Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios* (Bethesda, MD: June 2004), at www.catf.us/publications/index.php. Note that the $160 billion in medical expenses is modeled by Abt Associates for 2010; actual figure in Abt report is $167.3 billion. It assumes implementation of several power plant-related clean air measures and thus could underestimate current costs

[18–3] Sulfur emissions and acid rain effects from EPA, "Acid Rain" (Washington, DC: updated 11 September 2006), at www.epa.gov/acidrain/index.html; nitrogen oxides, ground-level ozone, and smog from EPA, "Nitrogen Oxides" (Washington, DC: updated 7 March 2006), at www.epa.gov/otaq/invntory/overview/pollutants/nox.htm; sources and effects of exposure to volatile organic compounds from Minnesota Department of Health, "Volatile Organic Compounds (VOCs) in Your Home" (St. Paul, MN: updated 5 April 2006), at www.health.state.mn.us/divs/eh/indoorair/voc.

[18–4] Coal-fired plants emitting 48 tons per year of mercury and 42 percent of national emissions from National Wildlife Federation, "Mercury Deposition: Clean the Rain," at www.nwf.org/nwfwebadmin/binaryVault/CTR%20latest%20developments.PDF.

[18–5] EPA warning from Michael Janofsky, "EPA Says Mercury Taints Fish Across U.S.," *New York Times*, 25 August 2004; Ernie Florence, "1 in 6 American Women Have Unsafe Levels of Mercury in Their Blood," *Chicago Sun-Times*, 25 August 2005, at www.findarticles.com/p/articles/mi_qn4155/is_20050825/ai_n15360772; mercury's impacts from EPA, Office of Water, "Mercury Update: Impact on Fish Advisories," fact sheet (Washington, DC: June 2001), at www.epa.gov/waterscience/fishadvice/mercupd.pdf#search=%22mercury%20impacts%20fetus%20cardiovascular%20%22.

[18–6] Impacts of water requirements for conventional power plants from Pace University, *Environmental Costs of Electricity* (White Plains, NY: Oceana Publications, 1990), p. 287.

[18–7] Black lung kills 1,500 from National Black Lung Association, cited in Jason K. Howard, "Black Lung," Equal Justice Magazine, Fall 2004, at www.ejm.lsc.gov/EJMIssue7/feature001.htm; impacts on Appalachia from UCS, "Leveling a Mountain of Research on Mountaintop Removal Strip Mining" (Cambridge, MA: 2004), at www.ucsusa.org/global_environment/rsi/page.cfm?pageID=1442; and from Ken Ward, "Mountaintop Removal Battle Continues," *Charleston Gazette*, 19 February 2006, at www.appalachian-center.org/media/2006/02_19.html. Mountaintop mining, which began in the 1970s and has increased significantly over the past decade, now accounts for about 95 percent of surface mining in southern West Virginia and one-quarter to one-third of all coal mining in Appalachia, per Amanda Paulson, "In Coal Country, Heat Rises Over Latest Method of Mining," *Christian Science Monitor*, 3 January 2006; federal study projecting impact of continuing current trends from Joby Warrick, "Appalachia is Paying Price for White House Rule Change," *Washington Post*, 17 August 2004.

[18–8] External costs of energy in European Union from European Commission, "New Research Reveals the Real Costs of Electricity in Europe," press release (Brussels: 20 July 2001).

SOURCES FOR SIDEBAR:
More than 150 million Americans from Francine Laden et al., "Reduction in Fine Particulate Air Pollution: Extended Follow-up of the Harvard Six Cities Study," *American Journal of Respiratory and Critical Care Medicine*, 15 March 2006, pp. 667–72; see also American Lung Association, "State of the Air: 2006" (New York: 27 April 2006), at http://lungaction.org/reports/sota06exec_summ.html; study by Mount Sinai Center from Leonardo Trasande, Philip Landrigan, and Clyde Schechter, "Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain," *Environmental Health Perspectives*, May 2005,

pp. 590–96, at http://ehp.niehs.nih.gov/members/2005/7743/7743.pdf; Harvard University/Brigham and Women's Hospital study from Francine Laden et al., op. cit. this note, and from Harvard School of Public Health, "Harvard Six Cities Study Follow Up: Reducing Soot Particles is Associated with Longer Lives," press release (Boston: 15 March 2006), at www.hsph.harvard.edu/press/releases/press03152006.html; Atlanta from American Lung Association, "Health Effects of Ozone and Particle Pollution," in *State of the Air 2005* (Washington, DC: Spring 2005), at http://lungaction.org/reports/sota04_heffects3.html.

CLIMATE CHANGE AND ENERGY (p. 19)

[19–2] Atmospheric carbon dioxide increases of 20 percent and 36 percent is a Worldwatch calculation based on the following: concentrations have increased from 280 parts per million (ppm) in 1750, to 316.9 ppm in 1960, to an estimated 379.6 ppm in 2005. Data for 1750 include all the G8 countries plus Brazil, China, and India, per "Joint Science Academies' Statement: Global Response to Climate Change," statement issued 7 June 2005 by the national academies of Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, the United Kingdom and the United States, at www.nationalacademies.org/onpi/06072005.pdf; data for 1960 and 2005 from Lauren Sorkin, "Climate Change Impacts Rise," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 42; temperature increase of 1.8 degrees from National Aeronautics and Space Administration (NASA), Goddard Institute for Space Studies, "Global Temperature Trends: 2005 Summation," January 2006, at data.giss.nasa.gov/gistemp/2005; more than half of warming in last 30 years from NASA, "2005 Warmest Year in Over a Century," news feature (Washington, DC: 24 January 2006), at www.nasa.gov/vision/earth/environment/2005_warmest.html; 70 percent share of warming from European Renewable Energy Council, "Renewable Energy: The Solution to Climate Change" (Brussels: 2004), p. 4, at www.ren21.net/pdf/EREC_The%20solution_to_climate%20change_final.pdf; one-quarter of global emissions from G. Marland, T.A. Boden, and R.J. Andres, "Global, Regional, and National CO2 Emissions," in *Trends: A Compendium of Data on Global Change* (Oak Ridge, TN: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, DOE: 2006), at http://cdiac.ornl.gov/trends/emis/tre_usa.htm.

[19–3] Intergovernmental Panel on Climate Change (IPCC), *Climate Change: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), p. 10; expected impacts of warming from EPA, "Global Warming, Impacts," http://yosemite.epa.gov/OAR/globalwarming.nsf/content/Impacts.html, updated 7 January 2000.

[19–4] Rising economic losses from United Nations Environment Programme, "Weather Related Natural Disasters in 2003 Cost the World Billions," press release (Nairobi: 10 December 2003); 150,000 deaths from World Health Organization, *Climate Change and Human Health – Risks and Responses* (Geneva: 2003), at www.who.int/globalchange/publications/cchhsummary/en.

[19–5] CO2 higher than in past 650,000 years from Urs Siegenthaler et al., "Stable Carbon Cycle—Climate Relationship During the Late Pleistocene," *Science*, 25 November 2005, p. 1316; rate of increase accelerating from Tim Whorf, Scripps Institute of Oceanography, La Jolla, CA, communication with Janet Sawin, Worldwatch Institute, 25 February 2004. The new modeling system is the Community Climate System Model, version 3, at the National Center for Atmospheric Research in Colorado, per "Supercomputer Finds Climate Likely to Heat Up Fast," *Environment News Service*, 24 June 2004.

[19–6] King cited in Steve Connor and Andrew Grice, "Scientist 'Gagged' by No. 10 After Warning of Global Warming Threat," *The Independent*, 8 March 2004; Group of Eight (G8), "Climate Change, Clean Energy and Sustainable Development," political statement released at G8 Summit, Gleneagles, Scotland, July 2005; Clinton quote from World Economic Forum, "Clinton Weighs in on Climate Change," 28 January 2006, at www.weforum.org/site/homepublic.nsf/Content/Annual+Meeting+2006#31.

[19–7] Kyoto Protocol and 39 industrial countries from United Nations Framework Convention on Climate Change, "Status of Ratification," at http://unfccc.int/essential_background/kyoto_protocol/status_of_ratification/items/2613.php; U.S. companies under pressure from Juliet Eilperin, "U.S. Firms Look Ahead to Emissions Cuts

Overseas," *Washington Post*, 3 October 2004, at www.washingtonpost.com/wp-dyn/articles/A2936-2004Oct2.html.

SOURCE FOR FIGURE:
U.S. carbon emissions from EIA, "Emissions of Greenhouse Gases in the United States 2004" (Washington, DC: December 2005), at www.eia.doe.gov/oiaf/1605/ggrpt/excel/historical_co2.xls.

CONSERVING LAND AND WATER (p. 20)

[20–2] Wind resources in three states meeting U.S. needs is a Worldwatch estimate based on U.S. end-use demand of 3.5 trillion kWh in 2004, per EIA, "Annual Electric Power Industry Report," Table 7.2 in *Electric Power Annual 2005* (Washington, DC: 2005), and on estimated potential for three states of 3.47 trillion kWh, per Battelle/Pacific Northwest National Laboratory, *An Assessment of Available Windy Land Area and Wind Energy Potential in the Contiguous United States* (Richland, WA: August 1991). This Battelle/PNL assessment excludes 100 percent of environmental, 100 percent of urban, 50 percent of forest, 30 percent of agriculture, and 10 percent of rangelands. Note that wind energy technologies have advanced considerably since the assessment was carried out, and today's turbines have far higher hub heights; thus, actual potential today could be far greater. Wind farms occupy 60 acres per MW, but only about 3 acres is used for the actual turbine; the rest of the land can be used for compatible purposes such as ranching, per AWEA, "Wind Web Tutorial," www.awea.org/faq/wwt_environment.html, viewed 28 August 2006. Particularly on windy ridgelines, wind turbines could require as little as 2 acres per MW. Estimate of 1,400 acres to produce 1 billion kWh is calculated by Worldwatch and assumes 3 acres per MW (per AWEA, above), and conservative capacity factor of 25 percent (typically ranges from 25–30 percent), per Chris Tuttle, Rural Utilities Service, "Renewable Energy: Wind Power," presentation at Rural Utilities Service Electrical Engineering Seminar, Dallas, TX, 5–6 March 2002, at www.usda.gov/rus/electric/engineering/sem2002/tuttle.htm.

[20–3] Geothermal (74 acres) and coal (900 acres and hundreds of additional acres) land needs from David Pimentel et al., "Renewable Energy: Economic and Environmental Issues," *BioScience*, Vol. 44, No. 8 (1994); 94,000 homes estimate based on average household consumption of 10,656 kWh per year; 2001 figure (most recent available) from EIA, "Table US-1. Electricity Consumption by End Use in U.S. Households, 2001," at www.eia.doe.gov/emeu/reps/enduse/er01_us_tab1.html.

[20–4] Land area required for concentrating solar per billion kWh, 4,000 square miles, and 3.4 percent needed for 30 percent of electricity from Mark Mehos, Program Manager, Concentrating Solar Power, NREL, e-mail to Amanda MacEvitt, Worldwatch Institute, 7 July 2006.

[20–5] U.S. square miles of roof and façade area and nearly 30 percent (28 percent) electricity from Marcel Gutschner et al., "Potential for Building Integrated Photovoltaics" prepared by NET Nowak Energy & Technology Ltd. for the IEA (Paris: 2002), at www.iea-pvps.org/products/download/rep7_04.pdf. Data confirmed by Richard Perez, Research Professor, State University of New York, e-mail to Janet Sawin, Worldwatch Institute, 11 July 2006, who notes that "with PV efficiency now approaching 20 percent and grabbing a larger part of the roofs in new constructions, we could approach 50 percent.... add the parking lots and we're almost there."

[20–6] Coal plant water use of 2.2 billion gallons from UCS, "Environmental Impacts of Coal Power: Water Use," www.ucsusa.org/clean_energy/coalvswind/c02b.html, updated 18 August 2005.

[20–7] Estimates of 12 percent of the nation's corn crop and 11 million acres are Worldwatch calculations based on data from U.S. Department of Agriculture (USDA), World Agricultural Outlook Board, "USDA Agricultural Baseline Projections to 2015" (Washington, DC: February 2006), at www.ers.usda.gov/publications/oce061/oce20061.pdf; 4 billion gallons of ethanol production in 2005 from American Coalition for Ethanol, "ACE Ethanol 101: Frequently Asked Questions," www.ethanol.org/documents/EthanolFAQs_000.pdf#search=%22%22American%20Coalition%20for%20Ethanol%22%20%224%20billion%20gallons%22%22, viewed 31 August 2006; 2 percent is a Worldwatch estimate based on the following: by volume, ethanol represented 2.71 percent of the U.S. gasoline market in 2005; accounting for

ethanol's lower energy density, it was 1.85 percent of the fuel, per EIA, "U.S. Finished Motor Gasoline Product Supplied (Thousand Barrels)" (Washington, DC: updated 12 June 2006), at http://tonto.eia.doe/gov/dnav/pet/hist/mgfupus1A.htm; Christopher Berg, Senior Analyst, F.O. Licht, Agra Informa Ltd., Kent, UK, e-mail to Peter Stair, Worldwatch Institute, 25 January 2006; Lew Fulton et al., *Biofuels for Transport: An International Perspective* (Paris: IEA, 2004).

SOURCES FOR FIGURE:
Solar from Mark Mehos, Program Manager, Concentrating Solar Power, NREL, e-mail to Janet Sawin, Worldwatch Institute, 11 November 2005; wind from Christine Real de Azua, AWEA, e-mail to Janet Sawin, Worldwatch Institute, 28 September 2004; geothermal from David Pimentel et al. "Renewable Energy: Economic and Environmental Issues," *BioScience*, Vol. 44, No. 8 (1994).

Resources and Technologies

ENERGY EFFICIENCY (p. 21)

[21–2] Total energy per dollar reduced by 49 percent from U.S. House of Representatives, "Energy in the United States: 1635-2000" (Washington, DC: 2001), p. 7, at http://resourcescommittee.house.gov/Press/reports/energy/engyushis.pdf. Compared to 1973 baseline, "We now save more energy annually than we use from any single source," per Lowell Ungar, Senior Policy Analyst, Alliance to Save Energy, testimony before the U.S. House of Representatives Small Business Committee, Subcommittee on Tax, Finance, and Exports, 28 June 2006, at www.ase.org/content/article/detail/3182.

[21–3] U.S. energy use per dollar of GNP (energy intensity) as nearly double that of other industrial countries from EIA, "Energy Intensity [Total Primary Energy Consumption per Dollar of Gross Domestic Product]: Selected Countries and Years, 1980–2004 (Btu per (2000) US Dollars Using Purchasing Power Parities)" (Washington, DC: 23 August 2006), at www.eia.doe.gov/emeu/international/energyconsumption.html. In 2004, the United States used 9,336 Btu per dollar of GDP, while Hong Kong used 4,847, Ireland used 4,992, and Japan used 5,377. Conventional coal and natural gas fired power plants are 35–40 percent efficient from Arnie Heller, "Turning Carbon Directly Into Electricity," *Science & Technology Review* (Lawrence Berkeley National Laboratory), June 2001, at www.llnl.gov/str/June01/Cooper.html.

[21–4] Average fuel economy of light duty vehicles from EPA, Office of Transportation and Air Quality, "Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006" (Washington, DC: July 2006), p. 10, at www.epa.gov/otaq/cert/mpg/fetrends/420r06011.pdf.

[21–6] Americans spending $200 billion on electricity and potential for halving costs by increasing efficiency from Rocky Mountain Institute (RMI), "General Energy Policy: Electric Efficiency," www.rmi.org/sitepages/pid321.php, viewed 28 August 2006.

[21–7] Appliance efficiency standards enacted in 1987 from EIA, "U.S. Household Electricity Report" (Washington, DC: 14 July 2005), at www.eia.doe.gov/emeu/reps/enduse/er01_us.html; refrigerator efficiency tripled from Brian Halweil, "Appliances: Boosting Efficiency, Saving Energy," *Good Stuff* (Washington, DC: Worldwatch Institute, 2004), at www.worldwatch.org/node/1477; dishwasher efficiency more than doubled from RMI, "Home Energy Briefs: #6 Cleaning Appliances" (Snowmass, CO: 2004), at www.rmi.org/images/other/Energy/E04-16_HEB6CleaningApps.pdf. Eight years ago, a dishwasher typically used the equivalent of 700–850 kWh of electricity annually; today, several models on the market consume less than 400 kWh per year, with the most efficient units using less than 200 kWh per year.

[21–8] "Flex Your Power" from Craig Canine, "California Illuminates the World," *OnEarth*, Spring 2006, pp. 22–27, at www.nrdc.org/onearth/06spr/ca1.asp; lowest per capita energy consumption from California Energy Commission, "US Per Capita Electricity Use By State in 2003." at www.energy.ca.gov/electricity/us_percapita_electricity_2003.html.

[21–9] Increasing appliance efficiency by 33 percent and avoiding half of projected growth from Brian Halweil, "Appliances: Boosting Efficiency, Saving Energy," *Good Stuff* (Washington, DC: Worldwatch Institute, 2004), at www.worldwatch.org/node/1477.

[21–10] Savings from integration of building efficiency and renewable energy from RMI, "Passive Solar Design," at www.rmi.org/sitepages/pid706.php.

SOURCE FOR FIGURE:
Fuel efficiency of U.S. light vehicles from U.S. Department of Transportation, National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance" (Washington, DC: March 2005), at http://cta.ornl.gov/data/chapter4.shtml.

BIOFUELS (pp. 22–23)

[22–2] Typical 40 million gallon per year plant contribution from RFA, *Homegrown for the Homeland: Industry Outlook 2005* (Washington, DC: 2005); and from John Urbanchuk and Jeff Kapell, "Ethanol and the Local Community" (Mount Laurel, NJ: AUS Consultants and Boston, MA: SJH & Company, 20 June 2002), at www.ncga.com/ethanol/pdfs/EthanolLocalCommunity.pdf.

[22–3] Brazil and U.S. together produce 90 percent from "World Ethanol Production to Approach 50 Bln Liters," *F.O. Licht World Ethanol and Biofuels Report*, 9 May 2006; 40 percent of Brazil's fuel from REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005); U.S. passes Brazil from "World Ethanol Production to Approach 50 Bln Liters," *F.O. Licht World Ethanol and Biofuels Report*, 9 May 2006.

[22–4] Ethanol provides just over 2 percent of U.S. motor fuel from F.O. Licht, cited in RFA, "Table 1–1," *Homegrown for the Homeland: Industry Outlook 2005* (Washington, DC: 2005); production and use expanding from National Corn Growers Association, "Ethanol Production in the U.S." (Washington, DC: 10 June 2005), at www.ncga.com/ethanol/main/production.htm; and from RFA, "2005 Energy Bill Sparked Growth in Renewable Fuels," press release (Washington, DC: 6 August 2006), at www.ethanolrfa.org/media/press/rfa/2006/view.php?id=790.

[22–5] U.S. ethanol production doubled from RFA, "Historical U.S. Fuel Ethanol Production," at www.ethanolrfa.org/industry/statistics/#A. Production in 2000 was 1.6 billion gallons per year, rising to 3.9 billion gallons in 2005; different feedstock for producing ethanol from Allen Baker and Steve Zahniser, "Ethanol Reshapes the Corn Market," Amber Waves (USDA), April 2006, at www.ers.usda.gov/AmberWaves/April06/Features/Ethanol.htm; and from EIA, "Ethanol—A Renewable Fuel," www.eia.doe.gov/kids/energyfacts/sources/renewable/ethanol.html, updated May 2005.

[22–6] MTBE contamination and ethanol blended into 30 percent of U.S. gasoline from RFA, "From Niche to Nation: Ethanol Industry Outlook 2006" (Washington, DC: February 2006); most common blend is 10 percent from Larry Schafer, RFA, communication with Suzanne Hunt, Worldwatch Institute, 21 July 2006; E85 use from Downstream Alternatives Inc., "Infrastructure Requirements for an Expanded Fuel Ethanol Industry" (Oak Ridge, TN: Oak Ridge National Laboratory Ethanol Project, January 2002).

[22–7] Biodiesel production in 2005 and 1999 from National Biodiesel Board, "Fuel Fact Sheet," at www.biodiesel.org/pdf_files/fuelfactsheets/Production_Graph_Slide.pdf.

[22–8] Biodiesel feedstock from Rudy Pruszuko, "Rendered Fats and Oils as a Biodiesel Feedstock," *Render Magazine*, February 2006, pp. 10–12, at www.rendermagazine.com/February2006/RenderedFatsandOils.pdf#search=%22biodiesel%20feedstocks%20soybeans%22.

[22–9] Up to 20 percent blends and warrantees for 100 percent from Worldwatch Institute, *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, report prepared for BMELV in coordination with GTZ and FNR (Washington, DC: 2006), p. 208; more than 600 fleets from National Biodiesel Board, Information Services, e-mail to Peter Stair, Worldwatch Institute, 12 July 2006; U.S. Navy from National Biodiesel Board, "U.S. Navy to Produce its Own Biodiesel," press release (Port Hueneme, CA: 30 October 2003), at www.biodiesel.org/resources/pressreleases/gen/20031030_Navy_to_produce_Biodiesel.pdf.

[22–10] For more information regarding federal and state tax credits, see Organisation for Economic Co-operation and Development (OECD), Directorate for Food, Agriculture, and Fisheries, "Agricultural Market Impacts of Future Growth in the Production of Biofuels" (Paris: February 2006), p. 13, at www.oecd.org/dataoecd/58/62/36074135.pdf; and Worldwatch Institute, *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, report prepared for BMELV in coordination with GTZ and FNR (Washington, DC: 2006); subsidy of 51 cents per gallon from Alex Kaplun, "Ethanol: Bodman Rejects Efforts To Lift Tariff, Urges Study of Domestic Subsidy," *E&E News PM*, 23 June 2006.

[23–1] Ethanol as cost-competitive from $45 a barrel is based on 2004 data, ethanol from corn is cost-competitive with gasoline when oil is $44/barrel, from OECD, Directorate for Food, Agriculture, and Fisheries, "Agricultural Market Impacts of Future Growth in the Production of Biofuels" (Paris: February 2006), p. 13, at www.oecd.org/dataoecd/58/62/36074135.pdf.

[23–2] Biodiesel competitive at $65 per barrel, based on 2004 data and cost-competitive at $66/barrel in Canada, from OECD, Directorate for Food, Agriculture, and Fisheries, "Agricultural Market Impacts of

Future Growth in the Production of Biofuels" (Paris: February 2006), p. 13, at www.oecd.org/dataoecd/58/62/36074135.pdf.

[23–3] Impacts of tripling ethanol plant size and 40 percent reduction in costs from Lew Fulton, *Biofuels for Transport—An International Perspective* (Paris: IEA, 2004), at www.iea.org/textbase/nppdf/free/2004/biofuels2004.pdf; 40 million gallons from RFA, "From Niche to Nation: Ethanol Industry Outlook 2006" (Washington, DC: February 2006); 100 million gallons from American Coalition for Ethanol, "U.S. Ethanol Production: Complete list of plants operating and under construction" (Sioux Falls, SD: 21 July 2006), at www.ethanol.org/productionlist.htm.

[23–4] Biofuels energy balance and environmental impacts from Worldwatch Institute, *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century*, report prepared for BMELV in coordination with GTZ and FNR (Washington, DC: 2006).

[23–6] Estimate of 80 percent of cropland from Lew Fulton, "Driving Ahead—Biofuels for Transport Around the World." *Renewable Energy World*, July–August 2004; cellulose-derived ethanol and U.S. Department of Agriculture and DOE study from Robert Perlack et al., "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion Ton Annual Supply" (Oak Ridge, TN: Oak Ridge National Laboratory, April 2005).

[23–7] Iogen Corporation from Jeff Passmore, Vice President, Iogen Corporation, communication with Suzanne Hunt, Worldwatch Institute, 12 July 2006.

SOURCES FOR FIGURES:
World fuel ethanol production derived from Suzanne Hunt and Peter Stair, "Biofuels Hit a Gusher," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 41; U.S. figures from RFA, "Industry Statistics," at www.ethanolrfa.org/industry/statistics/#A.

World biodiesel production from Suzanne Hunt and Peter Stair, "Biofuels Hit a Gusher," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 41; U.S. biodiesel production from National Biodiesel Board, "Estimated U.S. Biodiesel Production," at www.biodiesel.org/pdf_files/fuelfactsheets/production_graph_slide.pdf.

BIOPOWER (p. 24)

[24–1] Biopower provides 2 percent of electricity from UCS, "Growing Energy on the Farm: Biomass Energy and Agriculture," at www.ucsusa.org/clean_energy/renewable_energy_basics/growing-energy-on-the-farm-biomass-and-agriculture.html.

[24–2] Most biopower used by forest products industries from Zia Haq, "Biomass for Electricity Generation" (Washington, DC: EIA, July 2002), at eia.doe.gov/oiaf/analysispaper/biomass/index.html.

[24–3] As of 2004, 106 plants co-fired biomass and coal, per EIA, "*Renewable Energy Trends 2004* Edition" (Washington, DC: August 2005), at www.eia.doe.gov/cneaf/solar.renewables/page/trends/rentrends04.html; costs of biomass substitution for coal from DOE and Electric Power Research Institute, *Renewable Energy Technology Characterizations* (Palo Alto, CA: December 1997), pp. 2–38.

[24–4] Washington state producing 15.5 billion kWh of electricity from Washington State Department of Ecology, "Abundance of Organic Waste Could Help Power Washington," press release (Spokane, WA: 23 February 2006), at www.ecy.wa.gov/news/2006news/2006-027.html.

[24–5] Pollution control technologies removing particles from Northeast Sustainable Energy Association, "Biopower," at www.nesea.org/energy/info/biopower.html; biomass reduces sulfur dioxide and CO2 emissions from Zia Haq, "Biomass for Electricity Generation" (Washington, DC: EIA, July 2002), at eia.doe.gov/oiaf/analysispaper/biomass/index.html. Biomass co-firing could reduce nitrogen oxide emissions as well, but research is inconclusive, per EPA, *Documentation of EPA Modeling Applications (V.2.1) Using the Integrated Planning Model* (Washington, DC: March 2002), pp. 5–18; methane is more than 21 times more potent from EPA, "Global Warming—Emissions," at http://yosemite.epa.gov/OAR/globalwarming.nsf/content/Emissions.html.

[24–6] Current farm digesters keep more than 5,000 metric tons of methane out of the atmosphere each year; figure of 426,000 tons assumes digesters would be cost-effective at 3,000 U.S. farms, per Harvesting Clean Energy, "Anaerobic Digestion," www.harvestcleanenergy.org/biopower/sub_biopower_anaerobicdigestion.htm; Central Vermont Public Service from Conservation Law Foundation, "Vermont Advances Electricity from Farm Waste," Conservation Matters, Summer 2006, p. 6.

[24–7] Power generation with biomass requires 20 times more personnel than natural gas-fired plants per MW of generating capacity when personnel in the fuel supply infrastructure are included, per Western Governor's Association, "Clean and Diversified Energy Initiative," Biofuels Task Force Report (Denver, CO: January 2006), at www.westgov.org/wga/initiatives/cdeac/Biomass-full.pdf.

[24–8] Inconsistent availability of subsidies from Environmental and Energy Study Institute, "2005 Year in Review, U.S. Biomass Energy Policy," *Renewable Energy Access*, 4 January 2006, at www.renewableenergyaccess.com/rea/news/story?id=41189.

SOURCES FOR FIGURE:
U.S. net electricity generation from biopower from EIA, "Power Plant Report," Form EIA-906; from Combined Heat and Power Plant Report," Form EIA-920; and from earlier forms, at www.eia.doe.gov/cneaf/electricity/epm/table1_1_a.html.

GEOTHERMAL ENERGY (p. 25)

[25–2] More than 600,000 heat pumps and growth of 15 percent from Alyssa Kagel, "Geothermal Energy 2005 in Review, 2006 Outlook," RenewableEnergyAccess.com, 5 January 2006; Boise, Idaho, from DOE, EERE, "Geothermal Technologies Program," at www.eere.energy.gov/geothermal/gpw_idaho.html.

[25–3] Hydrothermal systems are primary technology from "Geothermal Has 25,000 MW of Untapped Resources," *Refocus Weekly*, 14 September 2005.

[25–4] Global capacity in 24 countries, and annual generation from "Earth Energy Adds 13,000 MW of Green Heat Capacity in Five Years," *Refocus Weekly*, 2 November 2005; 2,828 MW of U.S. capacity at end of 2005 from "U.S. Geothermal Power Poised to Double, Survey Shows," RenewableEnergyAccess.com, 28 March 2006; four states from Geothermal Energy Association, "Powerplants," at www.geo-energy.org/information/plants.asp; more than 60 million barrels from New Mexico State University, "New Mexico Geothermal Use," at www.nmsu.edu/~tdi/Geothermal-Energy/NMgeo-use/NM-Geo-Use.html; 22 million tons from DOE, "Geopowering the West" (Washington, DC: September 2002), at www.nrel.gov/docs/fy02osti/32835.pdf; $1.5 billion of electricity from DOE, EERE, "Geothermal Energy," at https://cfwebprod.sandia.gov/cfdocs/GPI; 4 million people from L.R. Lawrence, "The Role of Technology in the Development of Geothermal Energy," testimony before the U. S. House of Representatives Committee on Resources, 15 July 2004, p. 2 at http://resourcescommittee.house.gov/archives/108/testimony/2004/boblawrence.pdf.

[25–5] One in five wells from National Geothermal Collaborative, "Benefits of Geothermal Energy" (Denver, CO: July 2004), at www.geocollaborative.org/publications/Benefits_of_Geothermal_Energy.pdf#search=%22geothermal%20%22exploratory%20wells%22%20success%22. For locating new wells in already developed areas, the success rate is approximately 80 percent. Projects planned or under development and double current capacity from Geothermal Energy Association, "2006 Update on U.S. Geothermal Power Production and Development" (Washington, DC: 14 March 2006), at www.geo-energy.org/publications/reports.asp.

[25–6] Figures of 30,000 MW of power, 6 percent of demand, 130,000 new jobs, and $70 billion in investment from "Geothermal Could Meet 6% of U.S. Electrical Needs by 2025," RenewableEnergyAccess.com, 3 May 2006, at www.renewableenergyaccess.com/rea/news/story?id=44795.

[25–7] Carbon dioxide emissions from geothermal plants average about 5 percent of the emissions from existing natural gas fired plants and 2.7 percent of emissions from existing coal fired plants, calculated from National Geothermal Collaborative, "Benefits of Geothermal Energy," Figure 2 (Denver, CO:

July 2004), at www.geocollaborative.org/publications/Benefits_of_Geothermal_Energy.pdf#search=%22geothermal%20%22exploratory%20wells%22%20success%22; new technologies, such as closed-loop systems, scrubbers, and re-injection of steam, can reduce from emissions from UCS, "Environmental Impacts of Renewable Energy Technologies" (Cambridge, MA: 10 August 2005), at www.ucsusa.org/clean_energy/renewable_energy_basics/environmental-impacts-of-renewable-energy-technologies.html; land requirements lowest from EPA, "Electricity From Non-Hydroelectric Renewable Energy Sources," www.epa.gov/cleanrgy/renew.htm, updated 19 July 2006.

SOURCE FOR FIGURE:
U.S. geothermal resource map from Idaho National Laboratory, "Geothermal Energy, Maps," http://geothermal.inl.gov/maps/index.shtml, updated 8 August 2005.

POWER FROM THE WIND (pp. 26–27)

[26–1] One-fourth of U.S. land area from "Wind Gives U.S. Strong Power Play," *InTech*, August 2003, at www.findarticles.com/p/articles/mi_qa3739/is_200308/ai_n9277949; Kansas, North Dakota, and Texas are a Worldwatch estimate based on U.S. end-use demand of 3.5 trillion kWh in 2004, per EIA, "Annual Electric Power Industry Report," Table 7.2, in *Electric Power Annual 2005* (Washington, DC: 2005), and on estimated potential for three states of 3.47 trillion kWh, per Battelle/Pacific Northwest National Laboratory, "*An Assessment of Available Windy Land Area and Wind Energy Potential in the Contiguous United States*" (Richland, WA: August 1991). This Battelle/PNL assessment excludes 100 percent of environmental, 100 percent of urban, 50 percent of forest, 30 percent of agriculture, and 10 percent of rangelands. Note that wind energy technologies have advanced considerably since the assessment was carried out, and today's turbines have far higher hub heights; thus, actual potential today could be far greater.

[26–2] Wind power provides less than 1 percent from EIA, Table H-1, in *Renewable Energy Trends 2004*, at www.eia.doe.gov/cneaf/solar.renewables/page/trends/trends.pdf; source data at www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html. 100 kW in 1980s to 1,200 kW today from Birger Madsen, BTM Consult ApS, Ringkøbing, Denmark, e-mail to Janet Sawin, Worldwatch Institute, 20 February 2004; 5,000 kW machines under development from LM Glasfiber, "Wind Turbine Blades," at www.lmglasfiber.com/dalmg/wind_turbine_blades.htm; blade spans over 300 feet from J. Cotrell, W. Musial, and S. Hughes, "Necessity and Requirements of a Collaborative Effort to Develop a Large Wind Turbine Blade Test Facility in North America" (Golden, CO: NREL, May 2006), at www.nrel.gov/docs/fy06osti/38044.pdf. The wingspan of a 747-400 is 212 feet, per Boeing, "747 Commercial Transport," www.boeing.com/history/boeing/747.html, viewed 5 September 2006.

[26–3] Figure of 3–5 cents per kWh from, e.g., AWEA, "Wind Energy Costs," at www.awea.org/faq/tutorial/wwt_costs.html; see also AWEA, "The Economics of Wind Energy," at www.awea.org/pubs/factsheets/EconomicsOfWind-Feb2005.pdf, and FPL Energy, "A Leader in Clean Energy," at www.fplenergy.com/renewable/pdf/wind.pdf; least expensive resource in some areas from L. Bird et al., "Policies and Market Factors Driving Wind Power Development in the United States" (Golden, CO: NREL, July 2003); from Wilbur Wood, "When California Stops Sneezing, We Get Healthy," *The Billings Outpost*, 19 January 2006, at www.billingsnews.com/story?storyid=18967&issue=305; and from State of Texas, Energy Conservation Office, "Texas Wind Energy," www.seco.cpa.state.tx.us/re_wind.htm, viewed 13 September 2006. Note that the price of Austin (Texas's) Energy's GreenChoice green power option was below that for its standard portfolio of coal, natural gas, and nuclear power in early 2006, due to low wind costs, saving residential customers up to $230 a year (based on average usage of 1,000 kWh per month) compared to non-subscribers, per "Austin Energy to Hold Raffle for Participation in Green Power Program," *Wind Energy Weekly*, 13 January 2006.

[26–4] Installations in 1995 and 2005, and largest markets in Germany and Spain from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), pp. 36–37. Note that Denmark's market has slowed considerably in recent years, but Denmark remains one of the world leaders in wind capacity and one of the top wind turbine manufacturers thanks to

past market growth. See, for example, Janet L. Sawin, "Global Wind Growth Continues," in Worldwatch Institute, *Vital Signs 2005* (New York: WW. Norton & Company, 2005), p. 34, and Janet L. Sawin, "Wind Power's Rapid Growth Continues," in Worldwatch Institute, *Vital Signs 2003* (New York: WW. Norton & Company, 2003), p. 38.

[26–5] General Electric from "Blowing a Big Opportunity?" *The Economist*, 7 April 2005, at www.economist.com/displayStory.cfm?story_id=3850262; Florida Power and Light from FPL Energy, "A Leader in Clean Energy," at www.fplenergy.com/renewable/pdf/wind/pdf; and from "600 MW of Wind Power Expands Renewable Energy Projects," RenewableEnergyAccess.com, 15 September 2005.

[26–6] United States in 1980s from Lester R. Brown, "Europe Leading World Into Age of Wind Energy," *Eco-Economy Update* (Washington, DC: Earth Policy Institute, 8 April 2004), at www.earth-policy.org/Updates/Update37.htm; installations for 2001–04 are Worldwatch estimates based on AWEA, "Wind Power: U.S. Installed Capacity (Megawatts), 1980–2005," at www.awea.org/faq/instcap.html.

[26–7] Record installation of 2,431 MW in 2005 from AWEA, "U.S. Wind Industry Ends Most Productive Year," *Wind Energy Weekly*, 27 January 2006; wind farms as second largest source of new generating capacity from AWEA, "First Quarter Market Report: Wind Energy on Track for Another Record Year," press release (Washington, DC: 3 May 2006). U.S. capacity to meet needs of 2.3 million households assumes average capacity factor of 31 percent for the total cumulative installed capacity, and DOE's latest (2001) household electricity consumption data (10,656 kWh/year), per AWEA, "U.S. Wind Industry Ends Most Productive Year," op. cit. this note; Germany and Spain from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 36; record-setting years in 2006 and 2007 from AWEA, "First Quarter Market Report: Wind Energy on Track for Another Record Year," op. cit. this note, which projects installations of 3,000 MW for 2006.

[26–8] Denmark meeting 20 percent of electricity needs from Cheryl Pellerin, "Wind Power World's Fastest-Growing New Electricity Source" (Washington, DC: U.S. Department of State, International Information Programs, 22 April 2005), at http://usinfo.state.gov/gi/Archive/2005/Apr/22-869267.html. Germany, the country with the most installed wind-generating capacity, now gets 6 percent of its electricity from 18,400 MW of wind power; Spain, in second place with over 10,000 MW of capacity, gets 8 percent of its electricity from wind, per Earth Policy Institute, "Global Wind Power Expands in 2006" (Washington, DC: 28 June 2006), at www.earth-policy.org/Indicators/Wind/2006.htm.

[27–2] "Persian Gulf" of wind from Matt Bivens, "Fighting for America's Energy Independence," *The Nation*, 8 April 2002, at www.thenation.com/doc/20020415/bivens; 900,000 MW of generating capacity from U.S. Department of the Interior, Minerals Management Service, "Technology White Paper on Wind Energy Potential on the U.S. Outer Continental Shelf" (Washington, DC: May 2006), p. 2, at http://ocsenergy.anl.gov/documents/docs/OCS_EIS_WhitePaper_Wind.pdf; offshore potential is enormous from DOE, Massachusetts Technology Collaborative, and GE, *A Framework for Offshore Wind Energy Development in the United States* (Westborough, MA: September 2005), p. 10, at www.masstech.org/offshore/final_09_20.pdf.

[27–3] Sizable wind projects planned from AWEA, "Wind Energy Projects Throughout the United States of America," www.awea.org/projects/index.html, updated 26 April 2006; largest offshore project near Texas from "Acciona and GE Open New Facilities in China," *Renewable Energy World*, 16 May 2006, at www.earthscan.co.uk/defaultREW_news.asp?sp=&v=3.

[27–4] Killing of bats and birds from Ed Douglas, "The Hidden Cost of Wind Turbines," *New Scientist*, 8 July 2006; other hazards to birds from Paul Gipe, *Wind Power Comes of Age* (New York: John Wiley & Sons, May 1995); from National Wind Coordinating Committee, "Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States," August 2001; and from Danish Energy Agency, *Wind Power in Denmark: Technology, Policies and Results 1999* (Copenhagen: Ministry of Environment and Energy, September 1999), p. 21; reducing bird strikes from AWEA,

"Proposed Repowering May Cut Avian Deaths in Altamont," *Wind Energy Weekly*, 28 September 1998; and from Christine Real de Azua, AWEA, e-mail to Janet Sawin, Worldwatch Institute, 9 March 2004.

[27–5] Offsetting 3.5 million tons of CO2 and reducing natural gas demands from "U.S. Wind Industry Predicts Record Installations in 2005," *Refocus Weekly*, 9 November 2005. Estimate of 5 percent assumes that about 10 cubic feet of natural gas are needed to generate 1 kWh of electricity and that, on average, 80 percent of wind generation ultimately replaces natural gas-fired electricity, per AWEA, "U.S. Wind Industry Ends Most Productive Year, Sustained Growth Expected for at Least Next Two Years," press release (Washington, DC: 24 January 2006). Wind farms can be built faster from AWEA, "U.S. Wind Industry to Break Installation Records, Expand by More than 35% in 2005," press release (Washington, DC: 3 November 2005). From groundbreaking to commercial operation takes 3–6 months, from FPL Energy, "A Leader in Clean Energy," at www.fplenergy.com/renewable/pdf/wind/pdf; and from "600 MW of Wind Power Expands Renewable Energy Projects," RenewableEnergyAccess.com, 15 September 2005; 100 MW wind capacity creating 200 construction jobs, 2–5 permanent jobs, and $1 million in tax revenue from Patrick Mazza, "Farm Groups Pushing for Renewable Energy Standards," Harvesting Clean Energy Issue Brief (Olympia, WA: August 2004), p. 5, at www.harvestcleanenergy.org/documents/RES/RES_Report.pdf.

[27–6] Utilities and 20 percent wind share from R. Watson, M. C. Zinyowera, and R. H. Moss, eds., *Climate Change 1995—Impacts, Adaptations and Mitigation of Climate Change: Scientific Technical Analyses*, Contribution of Working Group II to the Second Assessment Report of the IPCC (New York: Cambridge University Press, 1996).

[27–8] Department of Energy Commitment from AWEA, "Energy Department, Wind Industry Join to Create Action Plan to Realize National Vision of 20% Electricity from Wind," press release (Pittsburgh, PA: 5 June 2006).

SOURCES FOR FIGURES:
Cumulative global wind capacity from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 37.

Annual wind power capacity additions derived from the following sources: U.S. from Paul Gipe, communications with Janet Sawin, Worldwatch Institute, 1 October 1998 and 23 March 2001; and from AWEA, various press releases; Europe from BTM Consult ApS, *World Market Update* (Ringkøbing, DK: various years); from Janet L. Sawin, "Global Wind Growth Continues," in Worldwatch Institute, *Vital Signs 2005* (New York: W.W. Norton & Company, 2005), p. 34; and from Janet L. Sawin, "Wind Power Blowing Strong," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 36.

ROOFTOP SOLAR POWER (pp. 28–29)

[28–1] Solar resource in Maine versus Los Angeles from Rhone Resch, Executive Director, Solar Energy Industries Association (SEIA), e-mail to Janet Sawin, Worldwatch Institute, September 2004.

[28–2] Six-fold increase in annual global production from Paul Maycock, *PV News*, various editions; and from Prometheus Institute, *PV News*, March 2006, pp. 4–5; plans for continued expansion, capacity increase of 55 percent to 3.1 GW, and fastest growing source of power from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), pp. 2, 7.

[28–3] Cost reductions from Bernie Fischlowitz-Roberts, "Sales of Solar Cells Take Off," *Eco-Economy Update* (Washington, DC: Earth Policy Institute, 11 June 2002); new technologies from SEIA, "Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond" (Washington, DC: September 2004), p. 13, at www.seia.org/roadmap.pdf.

[28–4] Solar most economical for off-grid applications from Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: Worldwatch Institute, May 2004), p. 24.

[28–5] Thousands of solar-powered homes from SEIA, "The Solar Photovoltaic Industry in 2006," at www2.dupont.com/Photovoltaics/

en_US/assets/downloads/pdf/SEIA_StateofSolarIndustry2006.pdf. By the end of 2005, the California state rebate program had led to installation of at least 15,000 systems on homes and businesses in that state alone. Builders and developers in Southern California are promoting solar power as an inviting new feature on new buildings: in San Diego, for example, Altair Energy, in partnership with KD Development, installed solar panels on several hundred new buildings, allowing customers to generate up to 80 percent of their electricity from the sun; many of the buildings with solar panels were pre-sold, per Altair Energy, "San Diego Homebuilder Brings Solar Electricity Into Mainstream," press release (San Diego, CA: 29 October 2003), at www.solarschoolhouse.org/solareclips/2003.11/20031111-4.html. PVs on high-rise apartment buildings from "News-in Brief," *Refocus Weekly*, 11 October 2005; urban metro stations from Aaron Dalton, "Solar Power Brightens NYC Commute, *Wired News*, 28 October 2005, at www.wired.com/news/technology/0,1282,69354,00.html; Domaine Carneros' Winery from Powerlight, "Powerlight Completes Installation of Largest Solar Photovoltaic System at a U.S. Winery," press release (Napa, CA: 20 June 2003).

[28–6] Competitive with peak electricity prices from IEA, *Renewables for Power Generation: Status and Prospects* (Paris: 2003), p. 24. For example, PV power is cost-competitive with peak power in California. PV is cheaper than façade materials from Steven Strong, "Solar Electric Buildings: PV as a Distributed Resource," *Renewable Energy World*, July–August 2002, p. 171.

[28–7] Reducing environmental and safety risks from Larry Kazmerski, "Photovoltaics—Exploding the Myths," *Renewable Energy World*, July–August 2002, p. 176; and from U.K. Department of Trade and Industry, "Photovoltaics," www.dti.gov.uk/renewable/photovoltaics.html, viewed 3 September 2002, cited in Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: Worldwatch Institute, May 2004), p. 26.

[29–1] Industry moving towards recycling old solar cells from Germany's SolarWorld AG (only company that had actually begun recycling by late 2005); it takes old solar modules and converts them to a high quality input material for new solar silicon cells and modules, per "A Rebirth for Germany's Oldest Solar Power Plant," RenewableEnergyAccess.com, 26 September 2005.

[29–2] Japanese leadership and government incentives from Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: Worldwatch Institute, May 2004), p. 31; half the solar resource of California from Paul Maycock, PV Energy Systems, communication with Janet Sawin, Worldwatch Institute, 23 February 2004; 80 percent drop in costs for 3 kW systems is an estimate based on graphs in Doug Allday, "KYOCERA Solar, Inc.," presentation for UPEx Conference, 9 October 2003, at www.solarelectricpower.ewebeditpro/items/O63F3392.pdf.

[29–3] Japan as leading PV manufacturer and 48 percent of production calculated by Worldwatch based on data from Paul Maycock, *PV News*, various editions; and from Prometheus Institute, *PV News*, March 2006, pp. 4–5; benefit of high purchase prices from Janet L. Sawin, "Mainstreaming Renewable Energy in the 21st Century," *Worldwatch Paper 169* (Washington, DC: May 2004), pp. 28–31; Germany dominates marketplace and 600 MW added in 2005 from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 2. U.S. capacity was an estimated 475 MW in early 2006, per Solar Energy Industries Association, "The Solar Photovoltaic Industry in 2006," at www2.dupont.com/Photovoltaics/en_US/assets/downloads/pdf/SEIA_StateofSolarIndustry2006.pdf; Germany and Japan benefits from Sawin, op. cit. this note, pp. 30–33; Spain as first to require PV from REN21, op. cit. this note, p. 2.

[29–4] Sharp, Kyocera, BP, and Royal Dutch/Shell from David Lipschultz, "Solar Power is Reaching Where Wires Can't," *New York Times*, 9 September 2001, at www.greenstar.org/pressroom/Solar-NYTimes-901.htm; General Electric from J.R. Pegg, "General Electric Energized by Green Markets," *Environment News Service* (Washington, DC: 9 May 2005), at www.ens-newswire.com/ens/may2005/2005-05-09-10.asp; Dupont from "Chemical Giant Plans New Solar Strides," RenewableEnergyAccess.com, 14 April 2006.

[29–5] U.S. producers represented 44 percent of global market in 1996 and below 9 percent in 2005 calculated by Worldwatch based on

data from Paul Maycock, PV Energy Systems, e-mails to Janet Sawin, Worldwatch Institute, 27 January 2005 and 27 February 2006; from Maycock, *PV News*, various editions; and from Prometheus Institute, *PV News*, March 2006, pp. 4–5. U.S. producers' share of the domestic market fell from 100 percent in 1997 to 73 percent in 2003, per SEIA, "Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond" (Washington, DC: September 2004), p. 4, at www.seia.org/roadmap.pdf.

[29–6] California's $3.2 billion in customer rebates, 2017 goal, and current capacity from "California Energy Regulators OK Solar Program," *Associated Press*, 12 January 2006; New Jersey rebates and second largest market from SEIA, "The Solar Photovoltaic Industry in 2006," at www2.dupont.com/Photovoltaics/en_US/assets/downloads/pdf/SEIA_StateofSolarIndustry2006.pdf.

[29–7] Estimate of 55 percent based on 2003 U.S. electricity demand, per IEA, Photovoltaic Power Systems Programme, "Potential for Building Integrated Photovoltaics" (Paris: 2002), p. 8; original IEA estimate for U.S. was 57.8 percent for 1998 electricity demand; recalculated for 2003 demand. Also from Robert Margolis, Senior Energy Analyst, NREL, e-mail to Janet Sawin, Worldwatch Institute, 17 November 2004. PV industry providing half of new US electricity generation by 2025 and 130,000 new jobs from SEIA, "Our Solar Power Future: The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond" (Washington, DC: September 2004), pp. 2, 7, at www.seia.org/roadmap.pdf.

[29–8] IEA and very-large-scale PV from study by IEA Task VIII, led by Kosuke Kurokawa and Kazuhiko Kato, cited in "Power from the Desert: Very Large-scale Photovoltaics," *Renewable Energy World*, May–June 2003.

SOURCES FOR FIGURES:
Cumulative global PV production from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 39.

PV module prices from Strategies Unlimited and BP Solar internal estimates, provided by Jean Posbic, Director, Global Product Lines, BP Solar.

Annual PV capacity additions from IEA, Photovoltaic Power Systems Programme; from Paul Maycock, discussion with Janet Sawin, 8 March 2004; from Maycock, cited in Eric Martinot, Worldwatch Institute, e-mail to Janet Sawin, Worldwatch Institute, 24 May 2006; from Prometheus Institute, *PV News*, May 2006; from *Marketbuzz 2006*, cited in "Solarbuzz Reports World Solar Photovoltaic Market Grew 34% in 2005," Solarbuzz.com, 15 March 2005, at www.greenjobs.com/public/industrynews/i_news_00412.htm; and from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 2.

DESERT SOLAR POWER (p. 30)

[30–1] Solar potential of U.S. Southwest and 7 million MW from Mark S. Mehos and Brandon Owens, "An Analysis of Siting Opportunities for Concentrating Solar Power Plants in the Southwestern United States" (Golden, CO: NREL and Boulder, CO: Platts Research and Consulting 2004); and from Mark Mehos and Richard Perez, "Mining for Solar Resources: U.S. Southwest Provides Vast Potential," *Imaging Notes*, Summer 2005. The seven states are Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah; 10 times generating capacity from Mark S. Mehos and David Kearney, "Tackling Climate Change in the U.S.: The Potential Contribution from Concentrating Solar Power," report e-mailed to Janet Sawin, Worldwatch Institute, July 2006, p. 2.

[30–2] Nine plants totaling 354 MW in Mohave Desert from California Energy Commission, "Solar Thermal Parabolic Trough Electric Power Plants for Electricity Utilities in California" (Sacramento, CA: November 2005), at www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-175.html.

[30–3] Cost reductions from 45 cents to 9–12 cents and 4–7 cents from Environmental and Energy Study Institute, "Renewable Energy Fact Sheet" (Washington, DC: May 2006), at www.eesi.org/publications/Fact%20Sheets/EC_Fact_Sheets/Concentrating_Solar.pdf.
[30–4] Solargenix 64 MW plant from Fred Morse, President, Morsa Associates, Washington, DC, e-mail to Janet Sawin, Worldwatch Institute, 6 July 2006; 2 percent backup from Jesse Broehl, "A New Chapter

Begins for Concentrated Solar Power," RenewableEnergyAccess.com, 11 February 2006; Stirling Energy Systems and 1,750 MW from California Energy Commission, "2006 Renewable Energy Investment Plan," at www.energy.ca.gov/2006publications/CEC-300-2006-003/CEC-300-2006-003-CMF.PDF.

[30–5] Generator in Spain from Mike Stirzaker, "Mirrored Sunshine," *Renewable Energy World*, 3 February 2006, at www.earthscan.co.uk/news/article/mps/UAN/642/v/3/sp/332472698408344516404; 4,000 MW of central solar power plants from Western Governors' Association Solar Task Force, "Draft Report of the WGA Solar Task Force" (Denver, CO: September 2005 draft), at www.westgov.org/wga/initiatives/cdeac/Solardraft9-15.pdf; thousands of new jobs from "Western Governors Hone in on Solar Goals," RenewableEnergyAccess.com, 20 September 2005; and from Western Governors' Association Solar Task Force, "Draft Report of the WGA Solar Task Force" (Denver, CO: September 2005 draft), at www.westgov.org/wga/initiatives/cdeac/Solardraft9-15.pdf.

[30–6] Most valuable solar resources from NREL, "Assessing Climate to Improve Solar Design" (Golden, CO: June 2001), at www.nrel.gov/docs/fy01osti/28419.pdf#search=%22southwest%20%20best%20%22solar%20resources%22%20desert%20world%22. Land requirements based on NREL estimate that "A solar plant 10 square miles would be equivalent to roughly 1 GW of capacity. 1 GW CSP capacity operating at a 45% capacity factor (a trough system with storage) would produce approximately 4 billion kWh/year, which exactly matches the output of the Hoover Dam," per Mark Mehos, NREL, e-mail to Amanda MacEvitt, Worldwatch Institute, 10 July 2006. See also U.S. Department of the Interior, Bureau of Reclamation, "Frequently Asked Questions: Power," at www.usbr.gov/lc/hooverdam/faqs/powerfaq.html.

SOURCES FOR SIDEBAR:
Parabolic trough, central receiver, and dish systems from Solar Paces, "CSP—How It Works" (Paris: IEA, updated 28 March 2004), at www.solarpaces.org/csp_technology.htm.

Concentrating photovoltaic systems from NREL, "Concentrating Photovoltaic Technology," www.nrel.gov/csp/concentrating_pv.html, viewed 29 August 2006.

SOLAR HEATING (p. 31)

[31–2] Chicago v. Miami from Scott Sklar, The Stella Group, Ltd., e-mail to Janet Sawin, Worldwatch Institute, 13 September 2006; 80 percent of hot water from DOE, EERE, "Solar FAQs—Solar Heating—Applications" (Washington, DC: Solar Energy Technologies Program, updated 7 June 2006), at www.eere.energy.gov/solar/cfm/faqs/third_level.cfm/name=Solar%20Heating/cat=Applications#Q94.

[31–3] Initial costs of $1,500–$3,500 for solar hot water versus $150–$450 for electric or gas water heaters and solar system paybacks in 4–8 years, 15–40 year life from Environmental and Energy Study Institute, "Renewable Energy Fact Sheet: Solar Water Heating—Using the Sun's Energy to Heat Water" (Washington, DC: May 2006), at www.eesi.org/publications/Fact%20Sheets/EC_Fact_Sheets/Solar_Water_Heating.pdf.

[31–4] Offsetting a nuclear plant from Scott Sklar, "Selecting a Solar Heating System," *Solar Today*, Sept/Oct. 2004, pp. 42–45. Based on total installed capacity exceeding 1,000 MW, from Environmental and Energy Study Institute, "Renewable Energy Fact Sheet: Solar Water Heating—Using the Sun's Energy to Heat Water" (Washington, DC: May 2006), at www.eesi.org/publications/Fact%20Sheets/EC_Fact_Sheets/Solar_Water_Heating.pdf; 8 percent of U.S. systems for water and space heating as of 2003 from Werner Weiss and Irene Bergmann, "Solar Heating Worldwide" (Paris: IEA Solar Heating and Cooling Programme, May 2005); Hawaii from "Hawaii Reaches Solar Thermal Milestone," SolarAccess.com, 12 June 2003, at http://144.16.65.194/hpg/envis/doc99html/ensol230617.html.

[31–5] Solar radiation conversion of 80 percent from DOE, Office of Solar Energy Technologies, "Transpired Solar Collectors" (Washington, DC: Solar Buildings Program, September 1998 and revised August 2002), at www.nrel.gov/docs/fy00osti/23667.pdf#search=%22%22transpired%20solar%20collectors%22%20%22department%20of%20energy%22%20%22Solar%20buildings%20program%22%22.

[31–6] Doubling of solar heating market (excludes pool systems) and China and Europe are Worldwatch calculations based on data from Werner Weiss, Irene Bergmann, and

Gerhard Faninger, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2004* (Paris: IEA Solar Heating and Cooling Programme, March 2006); and from REN21, "Renewables 2005 Global Status Report" (Washington, DC: Worldwatch Institute, 2005), p. 4; IEA estimates of 196 million square yards from Werner Weiss, Irene Bergmann, and Gerhard Faninger, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2004* (Paris: IEA Solar Heating and Cooling Programme, March 2006). Calculation is as follows: 196 million square yards converted from 164 million square meters; 30,000 football fields assumes NFL football field area of 100 yards by 53 1/3 yards converted to meters at the rate of 1 yard equals .9144 meters. Total area of football field is 4,460 square meters, which is the equivalent of 36,771 football fields.

[31–7] DOE study from Lew Pratsch, DOE, EERE, Washington, DC, communication with Janet Sawin, Worldwatch Institute, 30 September 2004.

SOURCES FOR FIGURES:
Solar hot water capacity by country/region in 2005 from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), p. 5.

Total world solar water heating capacity from Janet L. Sawin, "Solar Industry Stays Hot," in Worldwatch Institute, *Vital Signs 2006–2007* (New York: W.W. Norton & Company, 2006), p. 39.

HYDROPOWER (p. 32)

[32–2] One-fifth of world's electricity from UCS, "How Hydroelectric Energy Works," www.ucsusa.org/clean_energy/renewable_energy_basics/how-hydroelectric-energy-works.html, updated 19 September 2005; nearly 7 percent of U.S. electricity, largest share of renewables, and 270 billion kWh from National Hydropower Association, "Hydropower's Current Contribution in the United States" (Washington, DC: February 2006), at www.hydro.org/Hydro_Facts/Fact_Sheets/113.cfm.

[32–3] Lifespan of hydropower plant and ability to quickly change electricity output from DOE, EERE, "Hydropower: Setting a Course for Our Renewable Energy Future" (Washington, DC: July 2004), at http://hydropower.inel.gov/techtransfer/pdfs/34916.pdf#search=%22hydropower%20lifespan%22.

[32–5] Doubling of current contribution from DOE, cited in Consumer Energy Council of America, "Fueling the Future: Better Ways to Use America's Fuel Options" (Washington, DC: May 2006), p. ES-11, at www.hydro.org/searchable_files/filemanager/CECAReport2006Final.pdf; more than 78,000 MW in 2004 from EIA, "Table 23: Renewable electricity capacity and generation in two cases, 2005, 2015, and 2025," in *Annual Energy Outlook 2005* (Washington, DC: February 2005), p. 61; 21,000 MW capacity added from a DOE study cited in National Hydropower Association, "Spotlight-Hydropower Research and Development," www.hydro.org/Hydro_Facts/Issue_Briefs/665.cfm, updated 1 March 2006, and in Consumer Energy Council of America, "Fueling the Future: Better Ways to Use America's Fuel Options" (Washington, DC: May 2006), pp. ES-11 and 100, at www.hydro.org/searchable_files/filemanager/CECAReport2006Final.pdf; 80,000 dams and 3 percent from Linda Church Ciocci, Executive Director, National Hydropower Association, e-mail to Michael Eckhart, American Council on Renewable Energy, January 2005.

[32–6] Licensing process and lack of tax incentives from Linda Church Ciocci, Executive Director, National Hydropower Association, e-mail to Michael Eckhart, American Council on Renewable Energy, January 2005.

[32–7] Irreversible impacts of hydropower from UCS, "How Hydroelectric Energy Works," www.ucsusa.org/clean_energy/renewable_energy_basics/how-hydroelectric-energy-works.html, updated 19 September 2005; from International Rivers Network, "About Rivers and Dams," www.irn.org/basics/ard; and from World Commission on Dams, *Dams and Development: A New Framework for Decisionmaking, The Report of the World Commission on Dams* (Sterling, VA: Earthscan, November 2000); industry measures to reduce impacts from National Hydropower Association, "Protecting Fish: Creative Solutions and New Technologies" (Washington, DC: August 2004), at www.hydro.org/searchable_files/filemanager/R%2DFish%20Protection.pdf.

[32–8] Majority from large-scale facilities from DOE, EERE, "Small Hydropower Systems" (Washington, DC: July 2001), at www.nrel.gov/docs/fy01osti/29065.pdf; significant share are micro-scale or small-scale from Linda Church Ciocci, Executive Director, National Hydropower Association, e-mail to Michael Eckhart, American Council on Renewable Energy, January 2005; small turbines rely on water pressure from DOE, EERE, "Small Hydropower Systems" (Washington, DC: July 2001), at www.nrel.gov/docs/fy01osti/29065.pdf.

[32–9] Environmental impacts curtailed from Pioneer Valley Planning Commission and the Franklin Regional Council of Governments, "Small-scale Hydropower," at www.pvsustain.com/hydro_factsheet.pdf; small hydro systems have minimal impact from DOE, EERE, "A Guide to Tribal Energy Development: Small-Scale Hydropower," www.eere.energy.gov/tribalenergy/guide/hydropower_small.html, updated 16 March 2005.

SOURCES FOR FIGURE:
Hydropower capacity in top 10 U.S. states from EIA, "Annual Electric Generator Report," at www.eia.doe.gov/cneaf/electricity/page/eia860.html.

MARINE ENERGY (p. 33)

[33–1] Oceans cover 70 percent of Earth's surface from NASA, Jet Propulsion Laboratory, "The Vast Oceans," www.jpl.nasa.gov/earth/ocean_motion/ocean_motion_index.cfm, viewed 12 September 2006; 800 times as dense from "Tides Turn for Ocean-based Renewable Energy," SolarAccess.com, 6 April 2004; 835 times from World Energy Council, "Survey of Energy Resources: Ocean Thermal Energy Conversion" (London: 2001), at www.worldenergy.org/wec-geis/publications/reports/ser/ocean/ocean.asp; marine energy magnitude from John D. Isaacs and Walter R. Schmitt, "Ocean Energy: Forms and Prospects," *Science*, Vol. 207 (1980), pp. 265–73.

[33–2] Avoid the environmental impacts from "Tidal Energy Project Approved for Construction," RenewableEnergyAccess.com, 21 December 2005; innovations in tidal research and estimate of 10–20 years behind from George Hagerman, Research Associate, Virginia Tech Alexandria Research Institute, e-mail to Janet Sawin, Worldwatch Institute, 14 July 2006; coming of age from Roger Bedard, Ocean Energy Leader, Electric Power Research Institute, cited in Adam Aston, "Here Comes Lunar Power," *Business Week*, 6 March 2006, p. 32.

[33–3] Europe, Australia, and Japan from John W. Griffiths, "Wave Energy," in World Energy Council, *Survey of Energy Resources 2001* (London: 2001), at www.worldenergy.org/wec-geis/publications/reports/ser/wave/wave.asp; Electricité de France from "Tides Turn for Ocean-based Renewable Energy," SolarAccess.com, 6 April 2004. Norsk Hydro Technology Ventures, and Sustainable Asset Management (SAM) Group are also now involved in some European prototype projects, per idem and per SAM Private Equity press releases, 26 January 2004 and 25 June 2004, at www.sam-group.com/htmle/priveq/press.cfm.

[33–4] Projects begun or proposed for U.S. states and cities from Jeff Johnson, "Power from Moving Water," *Chemical and Engineering News*, 4 October 2004; see also Roger Bedard, Ocean Energy Leader, Electric Power Research Institute, cited in Adam Aston, "Here Comes Lunar Power," *Business Week*, 6 March 2006, p. 32; East River tidal project from idem, p. 34.

[33–5] EPRI estimates for 2,300 terawatt-hours and eight times yearly output from Adam Aston, "Here Comes Lunar Power," *Business Week*, 6 March 2006, p. 34; one MW wave project hurdles from George Hagerman, Research Associate, Virginia Technical Center for Energy and the Global Environment, Alexandria Research Institute, presentation at World Future Society annual conference, Washington, DC, 2 August 2004.

[33–6] Economically attractive for remote use from John W. Griffiths, "Wave Energy," in World Energy Council, *Survey of Energy Resources 2001* (London: 2001), at www.worldenergy.org/wec-geis/publications/reports/ser/wave/wave.asp. For example, in the Maldives, where as of 2001 all electricity was produced from diesel generators, the government has announced plans to introduce wave energy. EPRI report on economic feasibility of wave power from Roger Bedard, "Project Definition Study: Offshore Wave Power Feasibility Demonstration Project," Final Summary Report (Palo Alto, CA: 15

January 2005), at www.epri.com/attachments/297213_009_Final_Report_RB_01-14-05.pdf. Ocean Power Technologies claims costs will be 3–4 cents/kWh; total costs include maintenance, operating, and amortized capital costs of equipment, as per "Wave Power System Receives More U.S. Funding," *Refocus Weekly*, 12 October 2005.

SOURCES FOR SIDEBAR:
Canada, China, Russia, and France from World Energy Council, "Survey of Energy Resources: Tidal Energy," at www.worldenergy.org/wec-geis/publications/reports/ser/tide/tide.asp; prototype turbines in UK and Norway from A. Jones and A. Westwood, "Power from the Oceans," *The Futurist*, 3 January 2005, at www.energybulletin.net/3881.html; OTEC in Hawaii and Japan from NREl, "Achievements in OTEC Technology," www.nrel.gov/otec/achievements.html, viewed 29 August 2006.

American Energy Policy Agenda

[34–1] Estimates for federal fossil fuel subsidies have a tremendous range: see, e.g., estimate of $5 billion a year, per Taxpayers for Common Sense, at www.taxpayer.net/TCS/fuelsubfact.htm. DOE and the Alliance to Save Energy also vary widely in their assessments of domestic energy subsidies: in 1989, DOE estimated them between $4.9 and $14.1 billion; in 1992, the Alliance to Save Energy estimated them between $21 and $36 billion, as cited in http://uspirg.org/uspirg.asp?id2=5231&id3=USPIRG&#f1. Other sources include military actions in the Middle East in their estimates, which adds another $40–$60 billion, per Jo Campbell, "Energy of Our Own," www.ecotopics.com/articles/energy.htm.

SOURCES FOR SIDEBAR:
Effectiveness of feed-in laws and price paid for wind in United Kingdom versus Germany from Janet L. Sawin, "National Policy Instruments: Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World," prepared for the International Conference for Renewable Energies, Bonn, Germany, January 2004, at www.renewables2004.de/pdf/tbp/TBP03-policies.pdf. 41 countries and four U.S. states from REN21, "Renewables Global Status Report: 2006 Update" (Paris: REN21, and Washington, DC: Worldwatch Institute, 2006), pp. 3, 27. Other states considering implementing similar laws include California and Oregon, per Paul Gipe, "Renewable Tariffs and Standard Offer Contracts in the USA," 24 April 2006, at www.wind-works.org/FeedLaws/USA/USAList.html. For more information on how feed-in laws can avoid subsidies, see Catherine Mitchell, Warwick Business School, University of Warwick, UK, "The England and Wales renewables obligation," presentation at "Renewable Energy in America" conference of the American Council on Renewable Energy, Washington, DC, 8–9 July 2003; Robert Kleiburg, Vice President Strategy and Planning, Shell International Renewables BV, comments provided to Janet Sawin, Worldwatch Institute, 28 November 2003; Volkmar Lauber, "REFIT and RPS: Options for a Harmonized Community Framework," *Energy Policy*, Vol. 32 (2004), pp. 1405–14; and Philippe Menanteau, Dominique Finon, and Marie-Laure Lamy, "Prices Versus Quantities: Choosing Policies for Promoting the Development of Renewable Energy," *Energy Policy*, Vol. 31 (2003), pp. 799–812.

SOURCES FOR FIGURES:
State leaders with renewable portfolio standards and/or funds from DSIRE, "Renewable Portfolio Standards," at www.dsireusa.org/documents/SummaryMaps/RPS_Map.ppt.

Cumulative federal energy R&D funding for 1974–2005 calculated with data from IEA, "RD&D Budgets," Beyond 20/20 Web Server, electronic database, 2006 edition, at www.iea.org/rdd/eng/TableViewer/Wdsview/dispviewp.asp?ReportId=1.