

# **INDEX**

absorption spectra, 22, 24 methane, 288 photosynthesis, 273 oxygen, 22 production by EU, 288 ozone, 22 water vapor, 24 pyrolysis, 288 US law, 275, 284 acid rain, 317 biomass See biofuels aerodynamic drag, 161 agriculture sector, 105, 298 black-body radiation, 22 and land use, emissions from, building energy efficiency standards, 187 298 albedo, 38, 63 California codes, 181 alternative fuels program European codes, 182 See ethanol; hydrogen; buildings, 185-6 biofuels, methane, solar barriers to emission reduction, appliance standards, 153, 180, 186 electricity saving, 177 Arctic ice, melting, 71 energy audit, 187 Arrhenius, Svante, 30 necessity for regulation, 181, Atmosphere-Ocean General Circulation Models primary energy use, 174 See climate models residential savings potential 2030, 177 bagasse, 281 typical lifetime, 173 band gap, 269 Bush, George W., 334 business as usual See BAU batteries, 165 lithium-ion, 167 nickel-metal-hydride, 167 CAFE standards, 152, 158, 184 2007 changes, 316 BAU, business as usual scenario, 74, 75 California trajectory, 93, 340 cars, 326-7 environmental regulation, 325 biofuels, 304 biological systems, 288 Calvin, Melvin, 272 biomass, 238 Cap and Trade, 317 effectiveness relative to advantages, 321 gasoline, 275 complexity of administration, ethanol See ethanol



### Index

Cap and Trade (cont.) DICE model See Nordhaus, economic effects, 320 William EU experience, 320 diesel engine, 163 hybrid plan, 320 discount rate, 96–100 punishing the innocent, 318 DSM, demand side management, reduction in SO<sub>2</sub> emissions, California experience, 330 transportation, 318 electricity demand reduction, carbon capture and storage 187 See CCS carbon cycle E-ARPA, Energy Advanced Research Projects Agency, global, 36-41 carbon tax See emissions fee 330 Earth history, 45-55 carbon-free energy sources, 112, Earth Summit, Rio 1992, 333 CCS 140-6, 301 EGS, enhanced geothermal cost of electricity, 143 systems See geothermal El Baradei, Mohamed, 218 enhanced oil production, 142 FutureGen project, 145, 148 electric power grid, 168-9, 245, Norway, 141 268-71 separation of CO<sub>2</sub> 142 grid parity, 239 storage systems, 143 history, 270 ocean, 143 electrical power underground, 144 base-load power, 223 climate forcing, 35 US peak use, 21 climate models, 60 electricity generation, 131 AOGCM, 62-5 coal-based, 131-2 comparative costs, 306 Arrhenius, 30 feedback loops, 60-3 comparative health risks, 135 Hogbom, Arvid, 31 cost with carbon tax, 306 perturbation analysis, 64 efficiency, 136, 299 evolution, 133 climategate scandal, 54 CO<sub>2</sub> equivalent (CO<sub>2</sub>e) 80, 91 inefficiency, 132 CO<sub>2</sub>, atmospheric measurement, life-cycle emissions, 134 sources and emissions, 325 32, 41 Mauna Loa observations, 32 emission mitigation cost, 305-11 coal plants, 136-41 R&D expenditures since 1992, conversion, 149 coal, growing demand, 148 emissions fee, 318-19 combustibles, 107 EPA, 146 simplicity, 321 development phase emissions intensity, 111 Valley of Death, 328-31 end-use efficiency



### Index

buildings, 300 price, 129 transportation, 300 reserves, 117 energy balance, 20 coal, 127 energy demand gas, 123-7 oil See oil future, 88 energy efficiency France end-use, 155 electricity generation, 132, energy flow, US, 109 energy intensity, 82-4, 110 long-term nuclear development vs time, 152 plan, 227-8, Parliamentary Office for energy sources, natural, 103-4 Scientific and energy subsidies, 308 energy use, US, 154 Technological Assessment energy, winners and losers, 310 (POSTA), 229 enhanced geothermal systems fuel cycle (EGS), 266 internationalizing, 234 Australia and Europe, 263 fuel economy, 158-63 seismic concerns, 262 fuel efficiency surface area need, 262 "tank-to-wheels," 161 EPA limits, 146 fusion, 219 ethanol, 272 cost, 276 GDP and emissions correlation, ethanol, cellulosic, 283 ethanol, corn-based, 170, 275-81 General Motors EV-1, 156 corn prices, 278 geoengineering, 42-4 energy inputs, 277 ocean seeding, 43 tax credit, 277 sulfate aerosols, 42 US program's political basis, sunshade, 43 unintended consequences, 43 278 water requirements, 278 glacier movement, 71 ethanol, sugarcane-based, 281-3 Gore, Al, x greenhouse effect, 19-20 bagasse, 281 Brazilian program, 281 Mars, 26 land use, 282 science of, 24-7 import duty, 277 Venus, 26 EVMT, emissions per vehicle greenhouse gases aerosols, 38 mile traveled, 326 externality, 101 agriculture, 80 annual emissions, 91 feedback loops, 30, 60 anthropogenic emission, 80 Fischer-Tropsch process, 288 black carbon, 38 flex-fuel cars, 282 carbon dioxide, 21, 35 fossil fuels emission goals, 89-93



### Index

greenhouse gases (cont.) internal combustion engine emission indicators, 342 (ICE) emissions from fossil fuels, 107 energy efficiency, 161 emissions reduction See Cap International Atomic and Trade; emissions fee; Energy Agency (IAEA), carbon tax constraints, 318 International Energy Agency greenhouse gas reduction (IEA), 107 standard (GRS), 325 **IPCC** fluorocarbons, 35 Assessment Reports, 57-60 global emissions 2004, 91 assessments methane, 35 scenarios, 65-71 history, 33 nitrous oxide, 35 projected global surface previous 1000 years, 50 removal times, 35 warming, 67 sources, 104 scenarios, 64 tropospheric ozone, 35 21st century temperature water vapor, 21 projections, 70 prediction ranges, 65 Hardin, Garrett, 8 temperature change HCCI, homogeneous charge estimates, 71 compression ignition engines, 163 JASON Climate Model, 56 hockey stick curve See Earth history Keeling, C.D., 29, 31 Koonin, Steven, 122 Hubbert, M.K., 119 Hubbert's peak, 119 Krewitt, W., 135 Kyoto Protocol (1997), 7, 90, hybrid cars plug-in See PHEV 193, 333-7 serial hybrid, 162 Annex B, 336 Toyota Prius, 161 clean development mechanism, hydropower See renewable CDM, 336 offsets, 323 energy Kyoto-2, 338-47 hydrothermal See renewable Copenhagen meeting (2009), energy, geothermal 338, 345 role of developing countries, ice cores, 47, 48 IIASA-WEC economic growth scenario, 84, 337 IMF vehicle projection, 183 Lake Nyos, 1986 catastrophe, 145 Intergovernmental Panel on LCFS, low-carbon-fuel standard, Climate Change (IPCC) See IPCC California version, 326-8



### Index

light water reactor (LWR), 198, sources and prices, 121 supply, conventional, 120 supply, unconventional, 120, present generation, 225 low-carbon energy sources, 111 oil shock See OPEC oil embargo OPEC oil embargo, 151 MacDonald, Gordon, 56 market exchange rates, 86 Mars, 27 permafrost, 73 methane hydrate, 123 perturbation analysis See climate Montreal Treaty (1992) 342 models MOX reactor fuel, 228 PHEV, plug-in hybrid electric Muller, Richard, 55 vehicles, 164-7, 183 plutonium, reactor-grade, 214 Non-Proliferation Treaty plutonium, weapons-grade, 214 (NPT), 216 population, 85 extract, 232-3 prediction, 85 Nordhaus, William, 96, 102 world increase, 85 nuclear power population, world, 34 breakout scenario, 233 POSTA See France primary energy, 88, 106, 155 cost, 305-9 comparison, 306 emissions from, 107 opposition to, 193 sources, 105 radiation, 195-7 proliferation, 213-19 safety, 198-206 fuel cycle, 211–13 US role, 224 Iran, 216 waste disposal, 206-13 North Korea, 216 proxies, temperature, 49-54 weapons proliferation, 213-19 nuclear reactor, 225 purchasing power parity (PPP), LWR, light water reactor, 236 nuclear weapons PV, photovoltaic *See* solar-energy enriched uranium, 230-1 systems gas centrifuges, 230-1 plutonium, 231–2 radiation, 195-7 spent fuel reprocessed, 232 annual doses, 196 radioactive waste disposal, ocean systems See renewable 206-12 fission fragments, FF, 207 energy oil geological depository, 207 Enhanced Oil Recovery once-through system, 208 (EOR), 122 reprocessing, 211 horizontal drilling in shale, 124 spent fuel, 207 refining products, 157 transmutation, 208 transuranics, TRU, 208 reserves



### Index

radioactive waste disposal (cont.) output by time of day, 256 photovoltaic, 250-5 uranium, 207 Yucca Mountain, 212 thermoelectric, 254-7 history, 208–10 efficiency, 254 spent fuel See radioactive waste radioactivity, natural, 196 disposal body, 194-6 compared to coal-fired plant, stabilization global model for, 345 compared to nuclear plant, stabilization trajectories, 93 196 stabilization wedges, 114-15 radon gas, 195 Stern Report, 96 radon gas See radioactivity Stern, Nicholas, 96 reactor accidents Sun Chernobyl (1986), 192, 200-1 radiation spectrum, 23 RMBK-1000 reactors, 200 surface temperature, 22 Three Mile Island (1979), 198-200 tar sands, Canada, 327 consequences, 199 thermometer, invention, 50 exposures, 199 Total Primary Energy Supply renewable energy See TPES TPES, 104, 154, 294, 336-7 geothermal, 257-63 enhanced geothermal buildings See buildings, total system, 260-3 energy use CO2 emissions, 107 heat pumps, 263 hydrothermal, 258 projected under BAU, 295 hydropower, 264-5 renewables contribution, new construction, 264 238-9 ocean, 266 transportation energy consumption, 174 cost, 266 solar See solar-energy systems fuel economy, US, 158 wind See wind power US daily oil consumption, 157 Revelle, Roger, 29, 56 VMT, vehicle miles traveled, RMBK reactors See reactor 165-7 accidents Chernobyl (1986) Roentgen, W.C., 196 UN Framework Convention on rolling resistance, 161 Climate Change RPS, Renewable Portfolio (UNFCCC), 57 Standards, 315, 324-6 uranium, enriched, 214, 236 US policy options scorecard, social discount rate, 99 328-31 solar-energy systems Valley of Death See development hot water and heat, 249, 250 hours of sunlight, 252 phase



## Index

vehicle safety
aggressivity, 164
crash avoidance, 164
crashworthiness, 164
vehicle weight *See* vehicle safety
vehicles
weight *vs* acceleration, 158
vehicles, all-electric, 167
Venus, 24
volcanic eruptions, 64
Vostok ice cores, 47–50

Wagoner, Rick, 156 wind power, 240–8 backup power, 245 capacity and output, 243 correlation length, 246 E.ON (Germany), 242
history, 240
IEA Wind consortium, 242
turbines, 240–3
capacity and output, 240
sites, 241
US sites, 244
variability, 242, 244
world energy demand
future, 82
poorest countries, 81

Yucca Mountain, Nevada *See* radioactive waste disposal

zero net energy (ZNE), 182