

Abstract

Stabilizing the carbon dioxide-induced component of climate change is an energy problem. Establishment of a course toward such stabilization will require the development within the coming decades of primary energy sources that do not emit carbon dioxide to the atmosphere, in addition to efforts to reduce end-use energy demand. Mid-century primary power requirements that are free of carbon dioxide emissions could be several times what we now derive from fossil fuels ($\approx 10^{13}$ watts), even with improvements in energy efficiency. Here we survey possible future energy sources, evaluated for their capability to supply massive amounts of carbon emission-free energy and for their potential for large-scale commercialization. Possible candidates for primary energy sources include terrestrial solar and wind energy, solar power satellites, biomass, nuclear fission, nuclear fusion, fission-fusion hybrids, and fossil fuels from which carbon has been sequestered. Non primary power technologies that could contribute to climate stabilization include efficiency improvements, hydrogen production, storage and transport, superconducting global electric grids, and geoengineering. All of these approaches currently have severe deficiencies that limit their ability to stabilize global climate. We conclude that a broad range of intensive research and development is urgently needed to produce technological options that can allow both climate stabilization and economic development.