**Renewable Energy Sources and Climate Change Mitigation**

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**References to energy/power density**

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**Definitions**

Energy density is the amount of energy per unit volume or mass (for example, the heating value of a litre of oil). Power density is typically understood as the capacity deliverable of solar, wind, biomass, hydropower or ocean power per unit area (watts/m2). For batteries the capacity per unit weight (watts/kg) is used.

**Summary**

Some renewable resources such as wind and solar energy are variable and may not always be available for dispatch when needed. Furthermore, the energy density of many renewable sources is relatively low, so that their power levels may be insufficient on their own for some purposes such as very large-scale industrial facilities. P 44

**Executive Summary p 165**

**Some RE, including wind and solar power, are variable and may not always be available for dispatch when needed. The energy density of some RE is also relatively lower, so that reducing the delivered energy needed to supply end-use energy services is especially important for RE even though benefi ting all forms of energy.**

1.4.3 Issues

Issues are not readily amenable to policies and programs.

An issue is that the resource may be too small to be useful at a particular location or for a particular purpose. For example, the wind speed may be too low or too variable to produce reliable power, the topography may be either too flat or there may be insufficient fl ow to sustain lowhead hydro or run-of-river systems for hydropower, or the demands of industry may be too large to be supplied by a local renewable source

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3.3.5 Solar fuel production

Solar fuel technologies convert solar energy into chemical fuels, which can be a desirable method of storing and transporting solar energy. They can be used in a much wider variety of higher-effi ciency applications than just electricity generation cycles. Solar fuels can be processed into liquid transportation fuels or used directly to generate electricity in fuel cells …or for producing industrial or domestic heat.

The challenge is to produce large amounts of chemical fuels directly from sunlight in cost-effective ways and to minimize adverse effects on the environment (Steinfeld and Meier, 2004).

Solar fuels that can be produced include pure hydrogen (H2) gas… The high energy density of H2 (on a mass basis) and clean conversion give it attractive properties as a future fuel and it is also used as a feedstock for many industrial processes. H2 has a higher energy density than batteries, although batteries have a higher round-trip effi ciency. However, its very low energy density on a volumetric basis poses economic challenges associated with its storage and transport p 358

‘Free fl ow’ or ‘hydrokinetic’ generation captures energy from moving water without requiring a dam or diversion. While hydrokinetic technology includes generation from ocean tides, currents and waves, it is believed that its most practical application in the near term is likely to be in rivers and streams (see Section 6.3.4). Hydrokinetic turbines have low energy density. P 478

All ocean energy technologies, except tidal barrages, are conceptual, undergoing R&D, or are in the pre-commercial prototype and demonstration stage. The globally distributed resources and relatively high energy density associated with most ocean energy sources provide ocean energy with the potential to make an important contribution to energy supply and to the mitigation of climate change in the coming decades, if technical challenges can be overcome and costs thereby reduced p 503

Hydrogen transported via existing natural gas grids may fi rst require some upgrading of the pipelines and components (Mohitpour and Murray, 2000; Huttenrauch and Muller-Syring, 2006). Since pure hydrogen has a lower volumetric density compared to natural gas, hydrogen pipelines will require either operation at higher pressures or around three times larger diameter pipes in order to carry the same amount of energy per unit time as a natural gas pipeline p 650

Commercializing new vehicle drive technologies could require large amounts of scarce, hard to access mineral resources. For example, automotive fuel cells require platinum, electric motors require powerful lightweight magnets that may use neodymium and lanthanum , and the most likely next generation of advanced, lightweight, high-energy-density batteries will require lithium. P 664

Aircraft will continue to rely mainly on liquid fuels due to the need for high energy density fuels in order to minimize fuel weight and volume. In addition, due to safety, the fuels need to meet more stringent requirements than for other transport modes, including thermal stability (to assure fuel integrity at high engine temperatures and to avoid freezing or gelling at low temperatures), specifi c viscosity, surface tension, ignition properties and compatibility with aircraft materials. Compared to other transport sectors, aviation has less potential for switching to lower carbon footprint fuels due to these special fuel requirements p 671

RE tends to have a low energy density and often high capital investment costs, so reducing the energy demand by effi ciency measures can help reduce the initial investment needed to meet the total energy demand of the building p 675