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Status of geothermal energy amongst the world's energy sources

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Abstract

The world primary energy consumption is about 400 EJ/year, mostly provided by fossil fuels (80%). The renewables collectively provide 14% of the primary energy, in the form of traditional biomass (10%), large (>10 MW) hydropower stations (2%), and the “new renewables” (2%). Nuclear energy provides 6%. The World Energy Council expects the world primary energy consumption to have grown by 50–275% in 2050, depending on different scenarios. The renewable energy sources are expected to provide 20–40% of the primary energy in 2050 and 30–80% in 2100. The technical potential of the renewables is estimated at 7600 EJ/year, and thus certainly sufficiently large to meet future world energy requirements. Of the total electricity production from renewables of 2826 TWh in 1998, 92% came from hydropower, 5.5% from biomass, 1.6% from geothermal and 0.6% from wind. Solar electricity contributed 0.05% and tidal 0.02%. The electricity cost is 2–10 US\$/kWh for geothermal and hydro, 5–13 US\$/kWh for wind, 5–15 US\$/kWh for biomass, 25–125 US\$/kWh for solar photovoltaic and 12–18 US\$/kWh for solar thermal electricity. Biomass constitutes 93% of the total direct heat production from renewables, geothermal 5%, and solar heating 2%. Heat production from renewables is commercially competitive with conventional energy sources. Direct heat from biomass costs 1–5 US\$/kWh, geothermal 0.5–5 US\$/kWh, and solar heating 3–20 US\$/kWh.

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1. Introduction

With increasing awareness of the detrimental effects of the burning of fossil fuels on the environment, there has been an increasing interest worldwide in the use of clean and renewable energy sources. It is important for the proponents of renewable energy sources to be aware of the outlines of world energy use. The present paper starts with a description of recent energy forecasts for the world in the new century and the increasing role that renewable energy sources are expected to play in the world energy mix. The forecasts referred to here have been initiated by the World Energy Council. The present use of energy sources is summarised. A comparison is made of geothermal energy with other renewable energy sources based on data presented in the World Energy Assessment report (WEA, 2000) prepared by the United Nations Development Programme, the United Nations Department of Economic and Social Affairs, and the World Energy Council. The present paper is largely based on two review papers recently published by the author (Fridleifsson, 2001, 2002).

2. World energy forecasts

Amongst the top priorities for the majority of the world's population is access to sufficient affordable energy. There is a very limited equity in the energy use in the different parts of the world. Some 70% of the world's population lives at a per capita energy consumption level that is one-quarter that of Western Europe, and one-sixth that of the USA (WEC, 1993). Two billion people, a third of the world's population, have no access to modern energy services. A key issue to improve the standard of living of the poor is to make clean energy available to them at prices they can cope with. The world population is expected to double by the end of the 21st century. To provide sufficient commercial energy (not to mention clean energy) to the people of all continents is an enormous task.

The World Energy Council (WEC) has presented several scenarios for meeting the future energy requirements, with varying emphases on economic growth rates, technological progress, environmental protection and international equity. All the scenarios provide for substantial social and economic development, particularly in the developing countries. They provide for improved energy efficiencies and environmental compatibility. During 1990–2050, the primary energy consumption is expected to increase by some 50% according to the most environmentally conscious scenario, and by some 275% according to the highest growth rate scenario. In the environmental scenario, the carbon emissions are expected to decrease slightly from 1990 levels. The high growth rate scenario is expected to lead to a doubling of the carbon emissions (Nakicenovic et al., 1998).

The scarcity of energy resources forecasted in the 1970s did not occur. With technological and economic development, estimates of the ultimately available energy resource base continue to increase. Economic development over the next century will apparently not be constrained by geological resources. Environmental concerns,

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