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An overview of Australia's hydropower energy: Status and future prospects

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ABSTRACT

Hydropower is the most advanced and mature renewable energy technology and provides some level of electricity generation in many countries worldwide. As hydropower does not consume or pollute the water it uses to generate power, it leaves this vital resource available for other uses. The objective of this article is to identify and analyse issues that are imperative for hydropower energy development in Australia. This study shows opportunities for further hydroelectricity generation in Australia are offered by refurbishment and efficiency improvements at existing hydroelectricity plants, and continued growth of small-scale hydroelectricity plants connected to the grid.

Contents

1. Introduction

Hydropower is the most advanced and mature renewable energy technology and provides some level of electricity generation in more than 160 countries worldwide. Hydropower plants convert potential energy of water into electricity. The water, after generating electrical power, is available for irrigation and other purposes [1].

From 2007 to 2035,world renewable energy use for electricity generation grows by an average of 3.0% per year and the renewable share of world electricity generation increases from 18% in 2007 to 23% in 2035 [2].

Yuksel [3] has discussed the advantages and disadvantages of the hydropower option in details. Hydro is a renewable energy source and has the advantages of low greenhouse gas emissions, low operating costs, and a high ramp rate (quick response to electricity demand) [3–6].

In several countries hydropower is the largest contributor to grid electricity. It is not uncommon in developing countries for a

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large dam to be the main generating source. Nevertheless Brazil, Canada, China, Russia and the United States currently produce more than half of the world's hydropower [7–9]. The world's total technically exploitable hydroenergy potential is estimated to be around 16500 TWh per year [10].

Hydroelectricity generation accounted for 2.2% of total primary energy consumption in 2007 (Table 1). World hydroelectricity consumption has grown at an average annual rate of 2% between 2000 and 2007. However, in the Organisation for Economic Cooperation and Development (OECD) countries, hydroelectricity consumption has been declining at an average annual rate of 0.3% [11].

In South America, the highest hydroenergy potential is in Brazil, where it exceeds 2200 TWh per year. In Africa, the Democratic Republic of the Congo has the highest hydroenergy potential, while Norway's potential resources are the highest in Western Europe. Other countries with substantial potential include Canada, Chile, Colombia, Ethiopia, India, Mexico, Paraguay, Tajikistan and the United States [10].

China's hydroenergy resources are the largest of any country. China is estimated to have a theoretical potential of more than 6000 TWh per year, approximately double current world hydroelectricity generation, and economically feasible potential of more than 1750 TWh per year [11].

According to outlook for the world hydroelectricity market In the International Energy Agency (IEA) reference case projections; world hydroelectricity generation is projected to increase to 4680 TWh in 2030, at an average annual rate of 1.8% (Table 2). Hydroelectricity generation is projected to grow in the Organisation for Economic Cooperation and Development (OECD) countries at an average annual rate of 0.7% and in non-OECD countries by an average annual rate of 2.5% [12].

Nevertheless, almost all countries have some hydroenergy potential, Australia's theoretical hydroenergy potential (265 TWh per year) is considered to be relatively small, ranking 27th in the world. High rainfall variability, low average annual rainfall over most of the continent, and high temperatures and evaporation rates limit the availability of surface water resources [10,12].

Table 1
Key hydro statistics (2009) [11,22,25].

	Unit	Australia	OECD countries	World
Primary energy consumption	PJ	43.4	4654	11,084
Share of total	%	0.8	2	2.2
Average annual growth, from 2000	%	−4.2	−0.3	2
Electricity generation				
Electricity output	TWh	12	1293	3078
Share of total	%	4.5	12.2	15.6
Electricity capacity	GW	7.8	366.9	848.5

Table 2
IEA reference case projections for world hydroelectricity generation [26].

	Unit	2009	2030
OECD, countries	TWh	1258	1478
Share of total	%	12.2	11.2
Average annual growth, present—2030	%	–	0.7
Non-OECD countries	TWh	1820	3202
Share of total	%	19.9	15.2
Average annual growth, present—2030	%	–	2.5
World	TWh	3078	4068
Share of total	%	15.6	13.6
Average annual growth, present—2030	%	–	1.8

2. Australia's hydroenergy resources

There is high variability in rainfall, evaporation rates and temperatures between years, resulting in Australia having very limited and variable surface water resources. Of Australia's gross theoretical hydro-energy resource of 265 TWh per year, only around 60 TWh is considered to be technically feasible [11,12,29].

Australia's economically feasible capacity is estimated at 30 TWh per year of which more than 60% has already been harnessed [11,12].

Australia currently has 108 operating hydroelectric power stations with total installed capacity of 7806 MW. These coincide with the areas of highest rainfall and elevation and are mostly in New South Wales (55%) and Tasmania (29%)[13,14]. There are also hydroelectricity schemes in north-east Victoria, Queensland, Western Australia, and a mini-hydroelectricity project in South Australia. Pumped storage accounts for about 1490 MW [12,15].

The hydroelectricity generation system in Tasmania comprises an integrated scheme of 28 power stations, numerous lakes and over 50 large dams. Hydro Tasmania, the owner of the majority of these hydroelectricity plants, supplies both base load and peak power to the National Electricity Market (NEM), firstly to Tasmania and then the Australian network through Basslink, the undersea interconnector which runs under Bass Strait [12,15,16]. Fig. 6 shows the majority of Australian hydropower (water) energy suppliers are located in New South Wales and Tasmania [28].

2.1. Key factors influencing Australia's hydroenergy resources

Most of Australia's best large scale hydroenergy sites have already been developed or, in some cases, are not available for future development because of environmental considerations. There is some potential for additional hydroenergy generation using the major rivers of northern Australia.

Hydroelectricity generation is a low-emissions technology, but future growth will be constrained by water availability and competition for scarce water resources [12].

Many of Australia's hydroelectric power stations are now more than 50 years old and will require refurbishment in the near future. This will involve significant expenditure on infrastructure, including the replacement and repair of equipment. The refurbishment of plants will increase the efficiency and decrease the environmental impacts of hydroelectricity [12].

Refurbishment of the power station at Lake Margaret, Tasmania—one of Australia's oldest hydroelectricity facilities (commissioned in 1914)—commenced in 2008. The main objective of the project was to repair the original wooden pipeline, which had deteriorated [11]. The project involved additional maintenance on the dam, minor upgrade of the machines, as well as replacement of a transformer. This upgrade, completed in late 2009, cost about $14.7 million to gain 8.4 MW of capacity at a capital spend rate of $1.75 million per MW, considerably less than the costs of new plant. Work has commenced on the redevelopment of the Lower Margaret Power Station [11].

2.2. Small scale hydro-developments in Australia

Most hydroelectricity plants installed in Australia in recent years have been mini hydro-schemes. These plants have the advantage of lower water requirements and a smaller environmental impact than larger schemes, especially those with large storage dams.