Hydro Power Industry

Report
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Clean Energy Council

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Contents

1. Executive Summary

This report provides a description of the global and Australian hydro power industry, covering both the current status and future prospects for the industry.

Globally, hydro power will remain a vital zero emission generation source because of its critical role as a flexible and readily available stored energy to meet short term demand peaks; supporting more intermittent sources of renewable energy generation. There will be significant investment into hydro power assets both new and refurbished older assets. Hydro power growth opportunities are primarily in non-OECD countries but also in selected OECD countries. It is forecast that if Governments make a concerted effort to cap global greenhouse gas emissions then hydro power will contribute the largest share of global electricity capacity of all technologies.

In Australia, hydro power is the principal renewable electricity generation supply and in 2007/2008 contributed two thirds of Australia's renewable electricity generation representing 4.6% of Australia's total electricity generation. It is predicted that while hydropower capacity will continue to grow, the total contribution of hydro power as a proportion of Australia's overall electricity mix will reduce because of underlying growth in other generation sources such as gas and anticipated wind.

Hydro power has significant benefits to the national electricity market including its proven and relatively low cost energy production (compared to other renewable energy), low greenhouse gas emissions, reliability and support for network and intermittent sources of generation.

Large scale hydro power development in Australia is mature and no major hydro power generation projects (>50 MW in capacity) are planned in the near future. There is considerable development occurring in the upgrade and refurbishment of existing plant and in development of mini hydro opportunities by water management authorities. It will be important to retain the existing generation assets to avoid increasing the difficulty for Australia to increase its renewable energy generation.

For this report the major hydro developers in Australia were contacted to obtain details on their hydro power developments since 2009 and under active consideration. While the information obtained was incomplete, over 620 MW of new capacity and more than $1Bn of investment was identified. It can be expected that the new capacity and investment figures would increase significantly if all information had been provided from hydro power developers.

There are a number of concerns facing the hydro power industry in Australia. Principal amongst these is the ongoing decreased rainfall in parts of Australia and the impacts of climate change. These factors significantly affect the production capability of existing plant and influence investment decisions by companies into new assets. The fluctuating REC price and elusive carbon price together with the current low availability of project finance work against further investments.

1. Background

The Clean Energy Council (CEC) produces Industry Reports on all renewable energy technologies and industries. To date, papers have been produced for the solar and wind energy industries. This document provides an overview of the hydro power industry globally and within Australia.

Unlike some of the emerging renewable energy industries, hydro power generation technology is a mature technology. As a mature technology, technical improvements leading to large efficiency improvements or decreases in capital costs for hydro electric generation equipment are unlikely.

The first hydro power station in Australia was built in Launceston in 1895. There are two significant hydro systems in Australia, the Snowy Mountains hydro electric scheme and Tasmania's hydro electric system, both of which were constructed principally through the 1950's to the early 1990's. There are no large scale hydro power generation projects over 50 MW in capacity planned for Australia in the near future.

The largest privately owned hydro power systems operate in Victoria and the Ord River in Western Australia.

This document is an assimilation of existing published information and information sources used have been identified throughout the report. The report does not cover assets less than 100 KW installed capacity.

2. Overview of global hydro power trends

2.1 Current global status of hydro power

Hydro power generation is a mature technology that currently provides 16% of the world's electricity supply (REN21, 2010). Generation in 2008 from both OECD and non-OECD countries was approximately 3,287 TWh and global installed capacity was estimated to be 980 GW (refer Table 1).

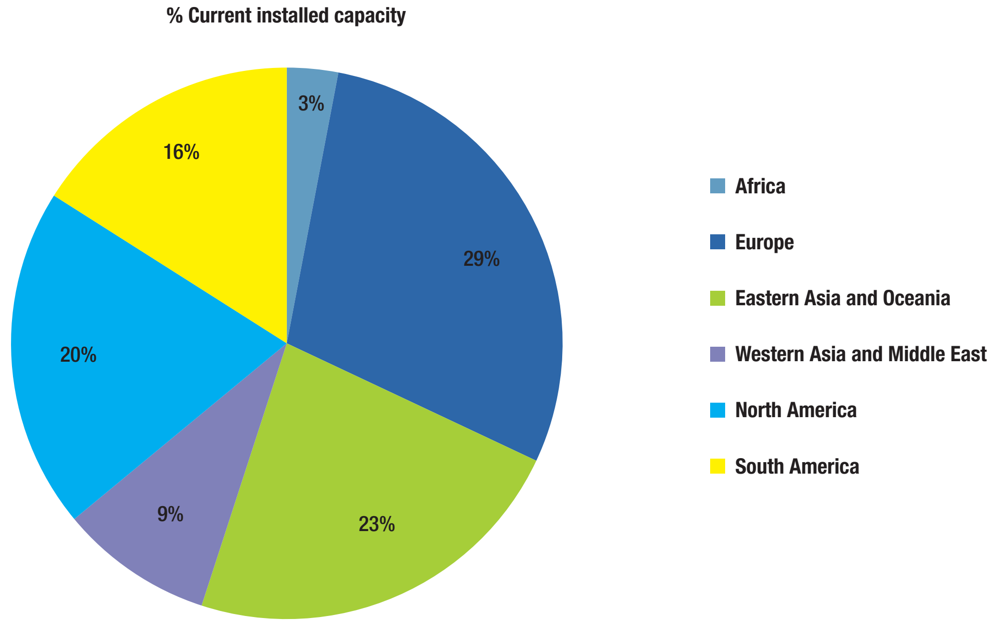
Table 1 Summary of current global hydro power data

Parameter	Measure	Reference
Gross global hydro power production (2008)	3287 TWh	IEA Statistics, Electricity information©OECD/ IEA, 2010, Part II, II.5 & II.9
Hydro power as a percentage of global electricity	16% in 2008	REN21. 2010 Renewables 2010 Global Status
Installed capacity – all hydro power	980 GW in 2008	As above
Technically feasible[1] hydro power	16,500 TWh	Geosciences Australia and ABARE, 2010

Recently, the major growth of installed capacity has been occurring in non-OECD countries such as China, Brazil, Vietnam, South America, India, Malaysia, Russia, Turkey, and Africa (refer Figure 1). China now has the largest installed capacity of any country, with 147 GW (17% of world capacity). The rate of growth of installed capacity in China is also the highest of any country. OECD countries that also have high growth rates in their installed capacity of hydro generation include the United States, Canada, Norway, Japan and South Africa.

[1] Technically feasible – hydro power energy potential that can be exploited with current technologies. (Geosciences Australia and ABARE, 2010)

Figure 1: Current Installed hydro power capacity by region (International Hydropower Association, 2010)



In OECD countries, suitable and environmentally acceptable sites are increasingly difficult to locate and the resource likely to yield lower load factors than projects already developed. As a result, the OECD's hydro power capacity has slowed since 1990. (International Energy Agency, 2010). Notwithstanding, there are large installed hydro power capacities in USA at 81 GW in late 2009 and 74 GW in Canada at the end of 2008 (Ren21, 2009)). Other OECD countries with high levels of installed capacity include Norway, Japan, Sweden, France, Italy and Austria.

Australia is ranked 31st in the world in terms of hydro power electric production and 27th in the world in terms of gross theoretical potential[2] with 265 TWh per year (Geosciences Australia and ABARE, 2010).

[2] Gross theoretical potential – hydro power energy potential that is defined by hypothesis or theory, with no practical basis. This may be based on rainfall or geography rather than actual measurement of water flows (Geosciences Australia and ABARE, 2010).

2.2 Prospects for global hydro power industry

There is significant scope for further hydro power development around the world with estimates of the technically feasible hydro power being 16,500 TWh (refer Table 2). Not all of this development is economically feasible[3] under current policies and financial incentives. Much of the future growth is expected to occur in Brazil, China, India, Africa, Malaysia, and North America.

The International Energy Agency (IEA) has developed a range of scenarios that model the future global mix of energy generation sources in 2030. In both the IEA reference case (where no further government support for low carbon initiatives) and the IEA 450 scenario (where governments initiate comprehensive action to cap carbon emissions), hydro power is forecast to be a significant component of the world's electricity supply by 2030. For example in the IEA 450 scenario, hydro power is forecast to have the largest installed capacity (18.9%) in 2030 of all electricity generation sources. A summary of the key aspects of these scenarios is provided in Table 2.

Table 2: Projected 2007-2030 global hydro power generation in IEA reference and IEA 450 Scenarios

	Reference Scenario (International Energy Agency, 2009)	450 Scenario (International Energy Agency, 2009)
Forecast generation growth	From 3078 TWh in 2007 to 4680 TWh in 2030[4]	From 3078 TWh in 2007 to 5659 TWh[5]
% Global electricity production	13.6% in 2030	18.9% in 2030
Total hydro power capacity	n/a	Approx 1650 GW[6]
Additional capacity	n/a	832 GW[7]
Annual investment in 2030	n/a	$115 Bn ($2008)[8]

[3] Technically feasible – hydro power energy potential that can be exploited with current technologies. (Geosciences Australia and ABARE, 2010)

[4] IEA World Energy Outlook 2009, ©OECD/IEA, 2009, Part A, p101

[5] IEA World Energy Outlook 2009, ©OECD/IEA, 2009, Part B, p229

[6] IEA World Energy Outlook 2009, ©OECD/IEA, 2009, Part B, p329

[7] IEA World Energy Outlook 2009, ©OECD/IEA, 2009, Part B, p234

[8] IEA World Energy Outlook 2009, ©OECD/IEA, 2009, Part B, p270

Hydro power growth opportunities are expected to occur primarily in non-OEDC countries where growth is underpinned by resource availability and the cost competitiveness of hydro power compared with other means of electricity generation. Much of the growth is expected to be in small scale hydro power, although there are plans in many African countries to build large scale hydro power generation capacity (Geosciences Australia and ABARE, 2010). Current policy tends to favour projects with the minimum land use to energy production ratio. Typically, run of the river projects have lower land use to energy production ratios, hence, many new hydro projects are designed to have only run-of-river capabilities (International Hydropower Association, 2010).

Interest and support for hydro power projects in non-OECD countries is growing among international lenders and the private sector (International Energy Agency, 2009), particularly in South America and Asia. There are significant environmental and social issues to be addressed for many of these projects before construction can commence.

Funding is an impediment for further hydro power developments in Africa (International Hydropower Association, 2010) although the Clean Development Mechanism (CDM) established under the Kyoto Protocol now provides a key financial driver of hydro projects in non-OECD countries. As of 4 September 2010 1525 hydro projects with an installed capacity of 63,176 MW were registered or seeking registration with the CDM (Docker, 2010).

There are also some significant hydro power growth opportunities for both new developments and the modernisation of older plant in some OECD countries in North America, the European Union and Japan. For example, approximately 10 GW of new capacity is proposed in northern America as a result of favourable government policies, with up to 60 GW projected in coming years predominantly through repowering improvements and new technologies (Ren21, 2009). Some 11GW of hydro power potential has been identified in Canada (International Hydropower Association, 2010).

Further hydro power development opportunities could arise from adding a hydro power component to some of the worlds 45,000 large dams that do not already have these facilities (World Energy Council, 2007).

2.2.1 Pumped storage

Pumped storage hydroelectricity involves water being pumped to a high storage reservoir during off-peak hours using low price base-load energy, and then used to generate electricity during high price peak hours.

Currently, there are some 127 to 150 GW of pumped-storage capacity throughout the world (International Hydropower Association, 2010). It is anticipated that the market for pumped storage will increase by 60% over the next five years or so depending on the magnitude of the price differential between off-peak and peak demand times (International Hydropower Association, 2010). This growth could mean a total installed pumped-storage capacity of more than 203 GW by 2014 (Ingram, 2010).

India expects to bring 400 MW of pumped storage capacity on line by 2012. Eskom in South Africa is constructing a 1,350 MW pumped storage facility to be operational by 2013 (Ren21, 2009).

2.2.2 Equipment Suppliers

Apart from 2009, the period 2007-2010 has been a period of significant business growth for hydro power electric equipment suppliers and pre-orders placed for turbines and related equipment in 2011 and beyond are high (Ren21, 2009).

3. Overview of Australian hydro power developments

3.1 Australian electricity generation context

Australia's current electricity supply is principally derived from coal fired plant with a small share 6.9% from renewable energy sources, principally hydro power (ABARE1, 2010) (refer Figure 2). According to ABARE (2010), Australia's gross electricity generation is projected to grow by nearly 50 per cent (or 1.8 per cent a year) from 247 TWh in 2007-08 to 366 TWh in 2029-30. This growth is expected to be dominated by gas-fired electricity generation (refer Figure 3) as well as an increase in renewable energy in part as a result of the Commonwealth Government's commitment to increasing renewable energy to 20% by 2020.

In 2007/2008 hydro power contributed two thirds of Australia's renewable electricity generation which was also 4.6% of Australia's total electricity generation (ABARE1, 2010). The other one third of renewable energy generation is primarily from wind energy and biomass.

A significant expansion in the use of non-hydro power renewable energy resources is forecast to occur by 2030. Wind energy is projected to account for the majority of the increase in electricity generation from renewable sources over the projection period, representing 12% of electricity generation in 2029-30. The contribution of hydro power generation is forecast to decrease from 5% in 2007-08 to 3% in 2029-30 (ABARE2, 2010). The existing hydro power is, however, predicted to increase in value arising from its zero emission status, its ability to balance intermittent renewable energy resources such as solar and wind, and its fast start capability helping to meet Australia's growing peak demand (Garnaut, 2008).

Figure 2: Electricity Generation by fuel (%) 2007-08 (ABARE2, 2010)

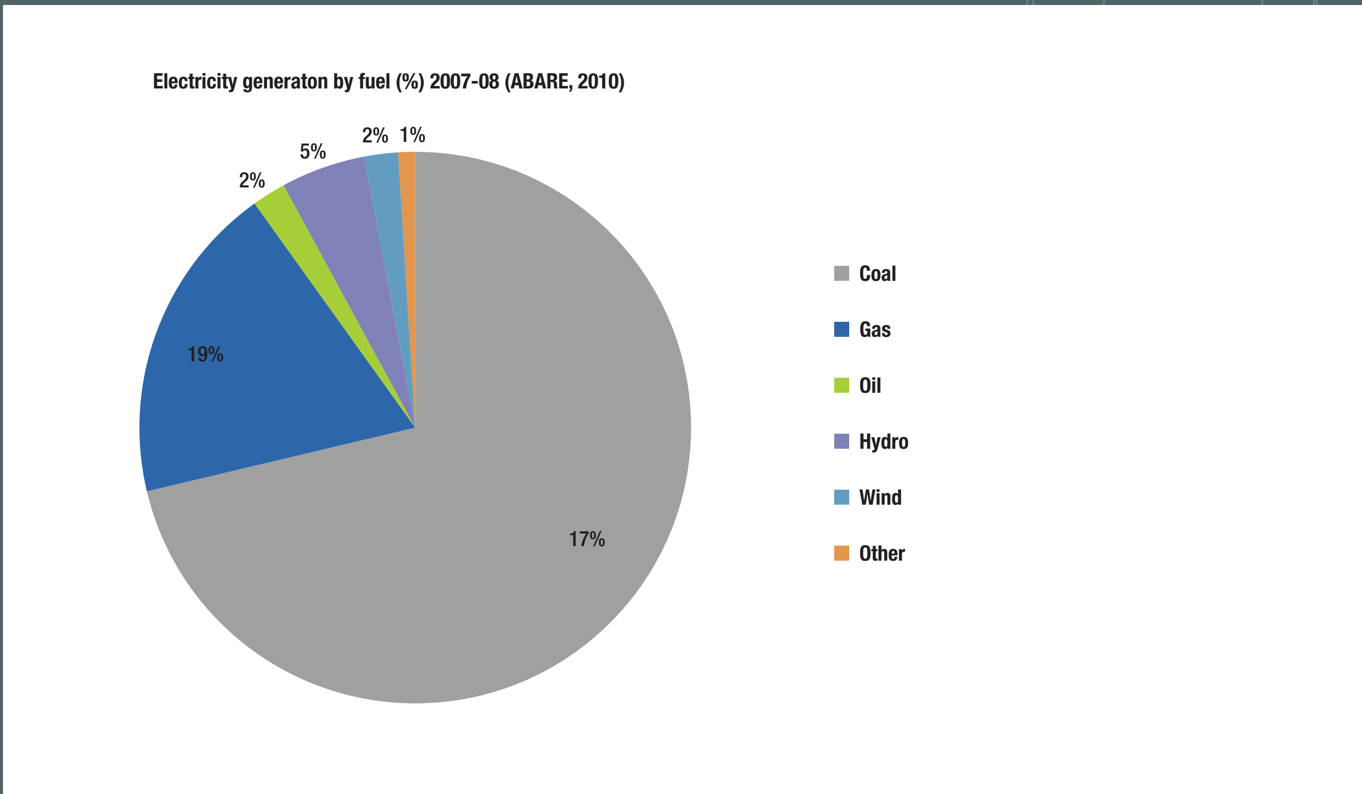
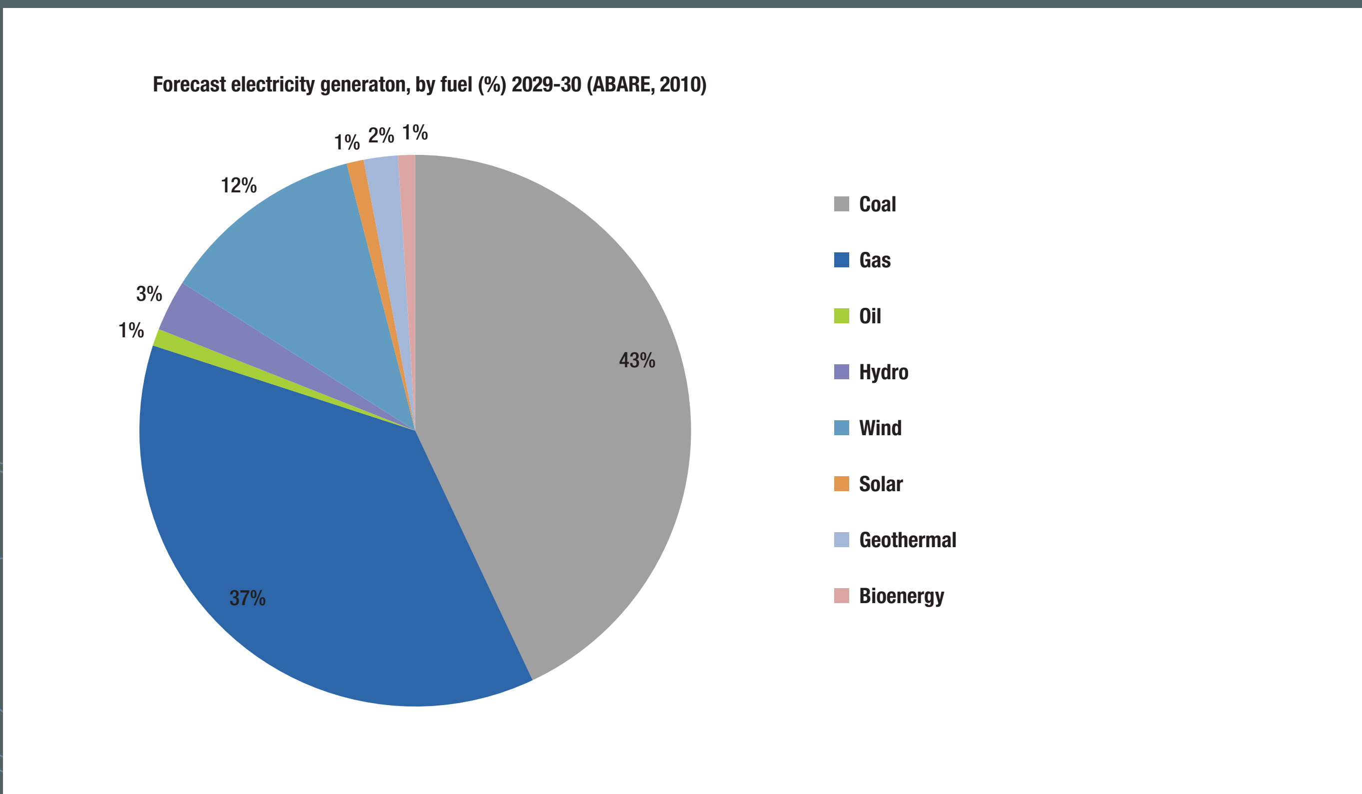


Figure 3: Forecast electricity generation by fuel (%) 2029-30 (note: no carbon price included in technology cost) (ABARE2, 2010)



3.2 Current status of Australian hydro power industry

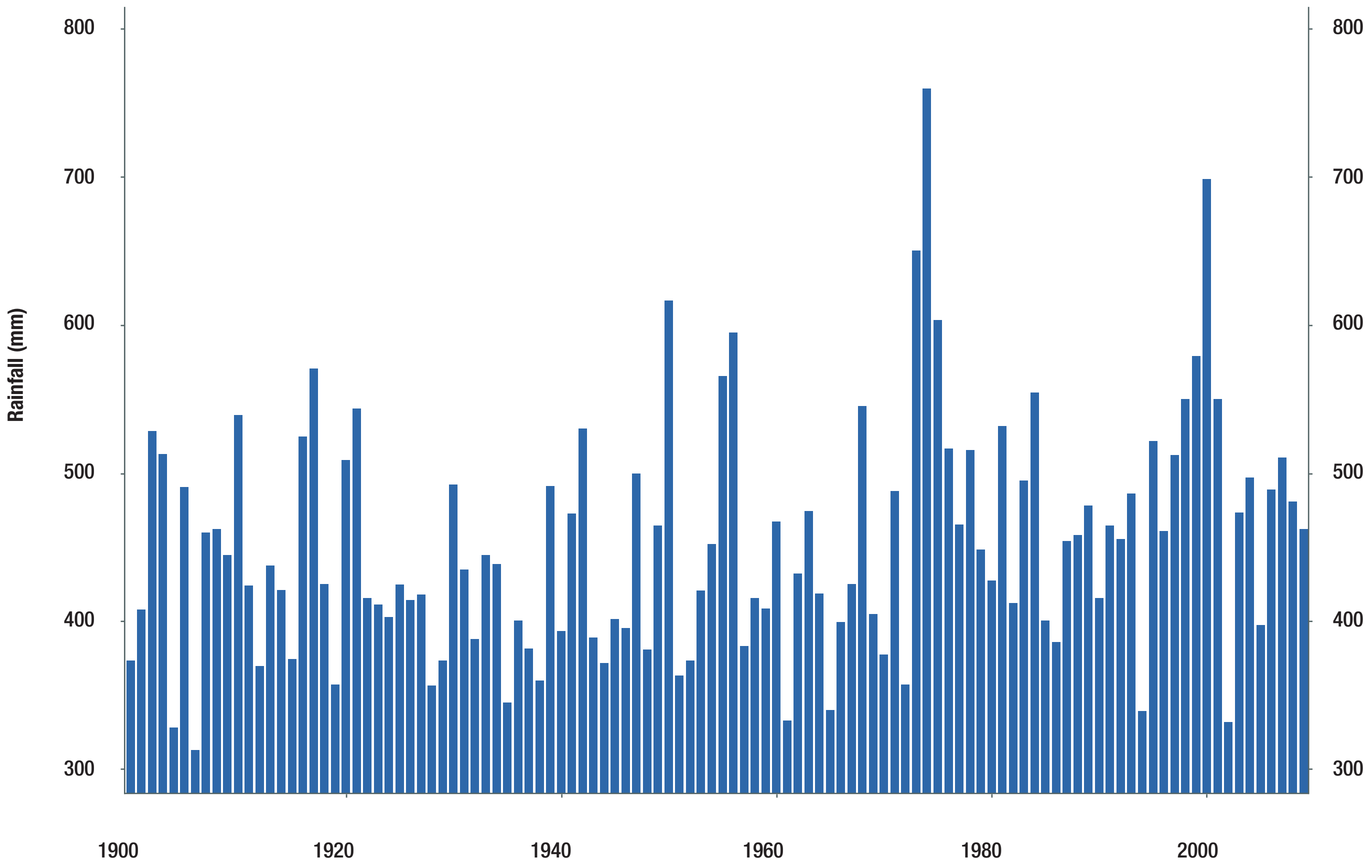
It is estimated that 60% of Australia's economically feasible hydro power potential has already been developed (Geosciences Australia and ABARE, 2010). Much of the remaining economically feasible hydro is not available for development because it is located in environmentally protected areas, there are competing uses for the water, or the resource is considered unreliable due to drought.

Australia has 108 operating hydro power stations (Geosciences Australia and ABARE, 2010) with an installed capacity of 9.30 GW including 1.49 GW of pumped storage in 2008[9]. Taken as a whole, Australia's hydro power stations are modest in size compared with installed plant overseas. Australia has only 3 hydro power plants with a capacity of 500 MW or more and the largest hydro power plant in Australia (Tumut 3) has a capacity of 1500 MW, which is mid-sized by international standards (Geosciences Australia and ABARE, 2010).

Australia's annual hydro power production has been variable since 1974, with 2008 production (11.91 TWh) being less than 1974 production (13.16 TWh)[10] (IEA 2010). This can be largely attributed to the variable rainfall received by hydro power catchments during this period (refer to Figure 3).

[9] [10] IEA Statistics, Electricity information ©OECD/IEA, 2010, Part IV, IV.132, Table 4

Figure 4: Annual rainfall for Australia (Australian Bureau of Meteorology, 2010)



Source: Australian Bureau of Meteorology

Australia's two major hydro power systems are:

- The Snowy Mountains hydro electric scheme - with a capacity of 3,800 MW, this scheme accounts for around half of Australia's total hydro power generation capacity and only 22 percent of actual production (Geosciences Australia and ABARE, 2010). The scheme also has a significant proportion of Australia's installed pumped storage with Tumut 3 at 1500 MW the largest pumped storage in Australia.
- Tasmania's hydro electric system – with an installed capacity of 2,270 MW (Hydro Tasmania, 2009), this system produced 62.6% of Australia's total hydro power generation in 2008/2009.

At the other end of the scale, there are some 60 small and mini hydro power plants (less than 10 MW capacity) with a combined capacity of just over 150 MW. (Geosciences Australia and ABARE, 2010).

Many of Australia's hydro power stations are more than 40 years old and have either been refurbished or are in need of refurbishment. Loss of these generators will make the challenge to increase overall renewable energy generation in Australia even harder.

3.3 Prospects for Australia's hydro power industry

Projected hydro power growth in Australia to 2030 is modest with an increase of only 1TWh (from 12TWhs to 13TWhs) predicted between 2007-08 to 2029-30 (ABARE2, 2010). While there is some potential for additional hydro power generation using the major rivers of northern Australia this is limited by the region's remoteness from infrastructure and markets and the seasonal nature of the flow of the rivers. Other potential hydro generation is not available for future development because of environmental considerations (Geosciences Australia and ABARE, 2010).

Australia has 30TWh of potential increased generation from economically feasible hydro power mostly from upgrades, refurbishments and mini hydro power developments (Geosciences Australia and ABARE, 2010). Some of this economically feasible hydro power is being developed and information on the developments is included in Appendix 1.

While growth in Australia's hydro power industry is low compared to many other countries, there is still over one billion dollars of new developments that have just been completed or are being developed (Refer Section 5).

The Garnaut report identified the increasing value of hydro to help balance intermittent supply technologies such as wind and solar and to help meet the increasing peak demand growth in Australia. In particular the Snowy Mountains scheme and Tasmanian hydro electric system, with zero emissions status and low underlying operating costs could be substantially expanded through judicious investment (Garnaut, 2008).

4. New Developments

Appendix 1 provides a summary of new hydro power developments in Australia that:

- Have been completed since 2009
- Are currently under construction
- Where there are advanced plans to undertake new hydro power developments.

Information has been obtained from publically available information and verified as accurate with the relevant asset owners. In many cases information was either not available or could not be provided for commercial reasons. Where this has occurred the relevant tables are annotated with n/a (not available).

Details on capacity and efficiency gains from improving existing plant through upgrading (i.e. increasing the capability of the plant), refurbishing,(i.e. extending the life of existing asset) and modernisation (i.e. replacing old technologies with new technologies) are also provided.

The bulk of the new hydro power capacity is being developed by Snowy Hydro with their publically stated 300-400 MW upgrade (refer Appendix 1). Other significant developments have included the Bogong hydro power plant and some works undertaken by Hydro Tasmania.

Many companies were reluctant to provide information on the new capacity, estimated additional generation and costs. Therefore the information on hydro power developments is incomplete. Notwithstanding, the data that has been obtained shows that there is more than 620 MW of new capacity that has either been constructed since 2009 or is in the advanced planning stage. It is clear that over $1Bn of investment has been committed since 2009 to new hydro developments.

It can be expected that the new capacity, additional generation and investment would increase significantly if all information had been provided from asset owners.

5. Industry key concerns

5.1 Introduction

In this section some of the key concerns and issues facing Australian hydro power developers are discussed. These issues have been identified through industry feedback in industry forums and publications.

5.2 Drought and climate change

Reduced rainfall and inflows has a direct impact on the level of hydro generation in Australia. This has been caused over recent years by drought and the potential impacts of climate change. For example, persistently lower inflows have resulted in Hydro Tasmania reducing its long term energy forecast energy production by 13% from the long term average. Some developers, such as Delta Energy have deferred building of mini hydro power plant.

Rainfall trends since 1950 show a substantial rainfall decline on the east coast of Australia, Victoria and southwest Australia. In contrast the north west of Australia has experienced an increase in rainfall over this period (CSIRO and BOM, 2007). Climate change models suggest the outlook for south eastern Australia is for drier conditions with reduced rainfall and higher evaporation, and a higher frequency of large storms. Reduced precipitation and increased evaporation are projected to intensify by 2030, leading to water security problems in southern and eastern Australia in particular (CSIRO and BOM, 2007).

It also predicts that decreases in annual average rainfall are likely in southern Australia - rainfall is likely to decrease in southern areas during winter, in southern and eastern areas during spring, and along the west coast during autumn. For 2030, there will be little annual rainfall change in the far north (CSIRO and BOM, 2007).

Recently, the Council of Australian Governments (COAG) has initiated through CSIRO a comprehensive scientific assessment of water yields in all major water systems across the country. The Tasmania Sustainable Yields Project has modelled four scenarios involving a range of climate conditions and catchment development levels. The modelled results reveal geographic, annual and seasonal changes to rainfall runoff. (Viney NR, 2009).

The results of these climate change studies will be important inputs to hydro power asset owners planning for inflows to their catchments.

5.3 Regulatory uncertainty

5.3.1 Climate change policy

Regulatory changes can result in both opportunities and constraints for hydro power developers. The Renewable Energy Target (RET) and the possible future carbon price will increase the wholesale price of energy, and therefore revenue to the hydro power industry.

It is predicted that until at least 2030 the RET will continue to provide the most important existing policy incentive for investing in new assets and modernisation/upgrades and refurbishment. However, this incentive will reduce over time as sufficient new developments are installed to meet annual RET targets, and the remaining time for the RET incentives decrease.

The uncertainty surrounding the introduction of a price on carbon is constraining further development both within the hydro power industry and other renewable technologies.

5.3.2 Water policy

Water policy will play a key role in the future development of hydro power in Australia. State and Federal Government water policy will seek to balance the requirements of water for different purposes including environmental protection, industrial and agricultural uses, and power generation and domestic use. Competition for water resources will ultimately affect the future availability of water for hydro power generation.

One recent example is the review of the Snowy Water licence by the NSW Government. The amended licence strikes a balance between these competing demands for water, including power generation, irrigation and environmental protection.

5.4 Transmission investment

With the forecast change in profile of Australia's electricity generation (i.e. increased gas-fuelled and renewable energy generation) there will need to be some significant changes to the energy infrastructure including an expansion in transmission infrastructure to facilitate a more flexible and decentralized grid.

The increased deployment of a range of distributed renewable energy sources may have some impact on the level of transmission congestion and therefore access to electricity markets by existing generators, including hydro power generators. There are a number of processes underway to review the current and future arrangements with respect to network augmentation and access arrangements for both new and existing generation. Clearly this may have some impact on hydro power and the costs and certainty relating to network access.

5.5 Barriers for embedded generators

Embedded generators[11] including some mini hydro asset owners have previously experienced barriers to entering the National Electricity Market (NEM).

These barriers have included:

- variable connection requirements depending on the relevant jurisdictional regulator;
- excessive planning approvals required
- complex registration and data collection processes
- disproportionately high costs for registration and ongoing fees
- limited reward for reducing the need for network investment
- fees for ancillary services
- the need for greater education about embedded generation.

These barriers have been recognised through the Framework Design prepared by Australian Energy Market Operator's (AEMO) Small Generator Reference Group(Australian Energy Market Operator, 2010)

[11] Generators that are less than 5MW or less than 30MW and exporting less than 20GWhs/annum to the grid and usually connected to the distribution grid

5.6 Finance issues

5.6.1 Incentives for retaining ageing assets

Many of the hydro power assets in Australia are aging and in need of further investment to ensure their ongoing reliability. Replacement of these aging assets by new renewables would require significantly larger capital investment. It is therefore important that the right incentives be in place to ensure investments are made to maintain, upgrade and refurbish the older assets.

The commercial decision to invest in these aging assets must be balanced with the level of certainty of an ongoing financial return. The RET will remain critical to providing incentives to maintain and refurbish aging hydro plant and ongoing changes with policies such as the RET can undermine investor confidence and the business cases for such investments.

5.6.2 Uncertainty of future revenue streams

There is a need for a strong and clear price signal to drive investment in the maintenance of existing plant and development of new hydro assets. If wholesale price of electricity increases due to a clear carbon price signal, it will be of great benefit to the hydro electric generation industry. Until business cases relating to new developments, machine modernisation for efficiency gains, or augmentation of water capture schemes can factor in the expected higher revenue streams, many projects will remain in the concept phase of development.

5.6.3 Access to finance

The global finance crisis has presented challenges in securing low cost finance particularly for early stage development of new projects. Smaller developers are also finding it hard to find a counterparty ready to enter into a PPA (Power Purchase Agreement) on reasonable terms (Curnow, 2010). Many of the upgrades/refurbishments/modernisation projects identified in this report are balance sheet funded.

5.7 Hydro power's role in providing ancillary services

With greater use of technologies that cannot provide the full range of network ancillary services (wind turbines for example), there may be increasing opportunity for hydro to supply these services. Australian hydro power generators may be able to benefit from increased revenue streams from the supply of these services if the generation mix in the market results in a lack of supply of these services.

These services can be grouped under three main categories

1. Frequency Control Ancillary Services (FCAS)
2. Network Control Ancillary Services (NCAS)
3. System Restart Ancillary Services (SRAS).

Australian hydro power generators play a critical role in providing these services. The capabilities of different hydro generators to provide FCAS services differ depending on the type of hydro turbine used and the hydraulic characteristics of the plant. Modifications to existing plant, however, should take into account the increase in future revenue streams that may be possible if the capabilities of the plant are improved in order to be able to provide ancillary services to the market. Energy market reform may be required to incentivise hydro generators to provide these ancillary services. For example, there is currently no market mechanism for rewarding generators for provision of inertia to the network.

5.8 Environmental and social issues

Construction of hydro electric dams can result in social, and environmental impacts often including significant resettlement of existing communities, changed waterways, disruption to waterway ecosystems and downstream impacts. In some instances this has resulted in significant public opposition to proposed hydro electric projects.

In recognition of the need to ensure that impacts of hydro dams are minimised the International Hydro Power Association (IHA) has developed and promulgated the IHA Sustainability Guidelines that promote greater consideration of environmental, social and economic aspects in the sustainability assessment of new hydro projects and the management and operation of existing power schemes. In recent times, the IHA has formed a hydropower sustainability assessment forum to develop a sustainability assessment tool (the Hydropower Sustainability Assessment Protocol) to measure and guide performance in the hydropower sector.

6. Conclusions

The global hydro power energy industry will continue to provide a significant contribution to the global electricity demand even if Governments take no further actions to address climate change. Globally, there are significant opportunities for growth in all aspects of hydro power generation, especially in the non OECD countries.

It is forecast that if Governments make a concerted effort to cap global greenhouse gas emissions (the IEA 450 scenario) then hydro power will contribute the largest share of global electricity capacity of all technologies.

Hydro power has been the mainstay of Australia's renewable electricity production. Other renewable electricity sources such as wind energy are predicted to grow their share of renewable electricity production at the expense of hydro power's overall share. Over the next few decades, hydro power will remain a vital zero emission generation source because of its critical role as a flexible and readily available stored energy to meet short term demand peaks; supporting more intermittent sources of renewable energy generation.

Opportunities in hydro power growth have been identified, principally in developing mini hydro plant or in refurbishing, upgrading and modernising Australia's aging fleet of hydro power stations. These developments will all contribute to an enhanced role for hydro power in the future including helping meet growing peak demand, supporting intermittent generation and providing ancillary services for the market.

According to the information collated during the production of this report, there has been over one billion dollars of investment committed to Australian hydro power developments. This figure is conservative, because of the incomplete information obtained.

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Appendix 1: New developments by company

The developers listed below have recently completed, or are now constructing, or have advanced plans to undertake new hydro power developments. Where information has not been available from the company it is noted with n/a for not available.

Snowy Hydro Ltd. (Please note: overall additional capacity and cost is provided in final row of this table).

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Jounama small hydro power at Talbingo[12] (Snowy Hydro Limited, 2010)	14.4	55	30	Opened in June 2010.
Guthega Power Station	0	2-3	n/a	Refurbishment, upgrade and control system replacement at Unit 1 completed in July 2010 along with extensive repairs to the main mechanical components.
Tumut 1 and 2 Power Stations	n/a	n/a	n/a	Contracts are now in place for replacement of the main transformers and 330kV cables for Tumut 1 underground Power Station, and supply of new turbine runners for Tumut 1 and 2 Power Stations. The first of the Tumut 2 runners is scheduled for delivery in early 2013.
Tumut 3 Power Station (Figure 5 below)	125-250	n/a	n/a	Units 1,2,3 and 4 completed. The fifth generator of Unit 6 is currently being overhauled.
Jindabyne Pumping Station	0	n/a	n/a	Replacement of control and protection planned for 2010. Work yet to commence.
Murray 1 Power Station	n/a	n/a	n/a	Preliminary investigations have commenced to assess the Murray 1 Power Station refurbishment scope of works. Likely to commence in 2015.

[12] (Snowy Hydro Limited, 2010)

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Murray 2 Power Station	~ 70	n/a	n/a	Unit 14 has had new control and protection systems installed, 3 units left to do.
Blowering Power Station	0	n/a	n/a	Replacement of station control and protection system – completed in 2009.
Scheme- wide enhancements	n/a	n/a	n/a	20 air-blast generator circuit breakers have been replaced with SF6 insulated breakers. All 11kV distribution circuit breakers have been replaced.
Overall modernisation programme (Snowy Hydro Limited, 2010)	300 - 400	n/a	400	

Figure 5 Stator lift (249 tonne) at Tumut 3

Hydro Tasmania

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Lower Lake Margaret mini hydro power	3.2	21	13.2	Commissioned in June 2010.
Lake River pipeline	8	n/a	2.05	Commissioning was expected in September 2010.
Poatina Power Station	9	~20	53	Modernisation of three machines completed in 2010.
Tungatinah Power Station	12	9	45	Modernisation of three of 5 machines. Planning, design and procurement work completed. Construction to commence in 4th Quarter of 2010 and commissioning will likely occur at the rate of 1 machine starting late in 2011 and running into 2014.
Upper Lake Margaret	8.4	50	14.7	Commissioned in October 2009.
Red Hills Diversion	n/a	10	4.4	Diversion of water into Tribute Power Station headrace tunnel. Completed in May 2010.
Catagunya Dam upgrade	n/a	n/a	38	This project is to replace corroded post-tensioned cables to ensure the future stability of the dam and improve flood handling capability. Construction started in the summer of 2008/09 and is expected to be complete in summer 2010/11.
Scheme-wide Kaplan impeller replacement programme	n/a	5.5	60	Construction likely to commence in 4th quarter of 2010 and it is planned to have 1 machine commissioned per year from 2013 to 2017.

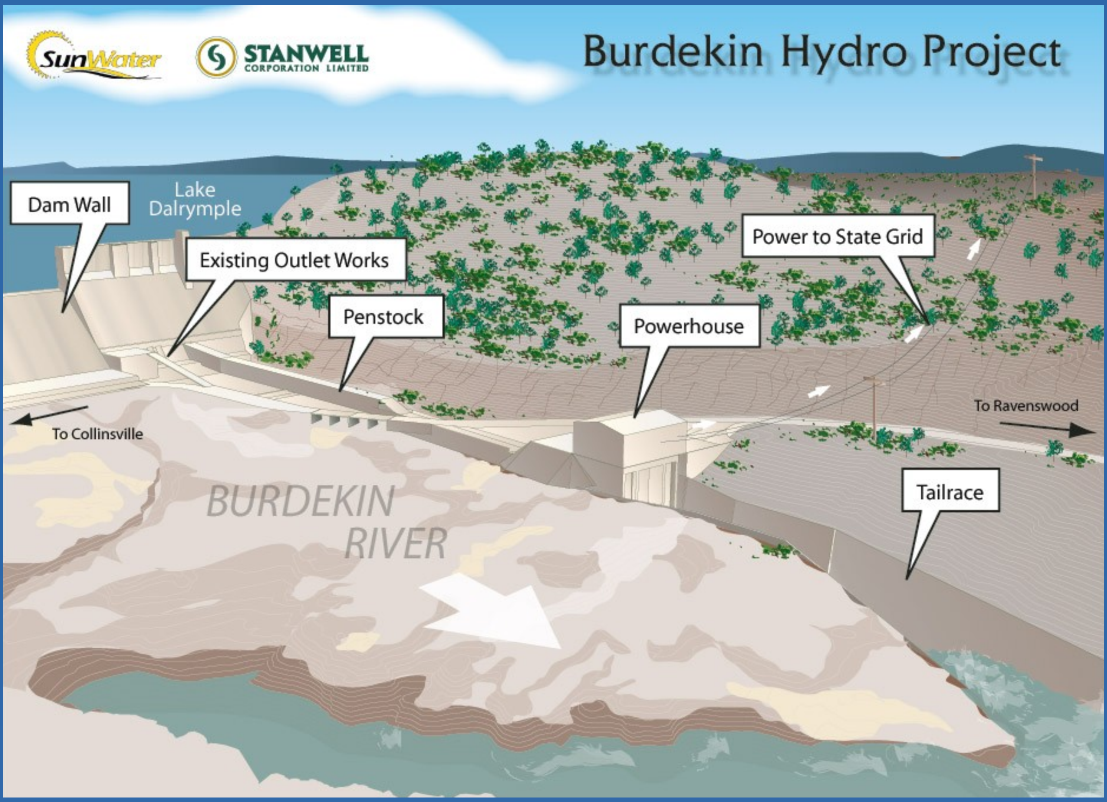
Figure 6 Lake Margaret mini hydro

Stanwell Corporation Limited

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Burdekin Falls Dam (See Figure 4 below) [13]	37	~125	~155	Feasibility study underway. Construction aimed to start in late 2011 and commissioning in late 2014.
Barron Gorge Hydro power (Stanwell Corporation Limited, 2010)	Expected 6MW increase (10%)	n/a	5	Unit 1 completed i.e. new core and stator windings and fully refurbished rotor. Unit 2 scheduled to commence in 2011-12.

[13] (Stanwell Corporation Limited, 2010)

Figure 7: Schematic of Burdekin hydro power project



Melbourne Water

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Mini hydro powers installed at Olinda, Mt View, Upper Yarra, Notting Hill, Silvan, Preston water catchments (Melbourne Water, 2010)	7	40	n/a	Completed.
Dandenong Reservoir, Boronia Reservoir, Wantirna Reservoir, Mt.Waverley Reservoir	<0.5	n/a	n/a	Construction estimated to begin in 2011 with commissioning expected in 2012.
Thomson Dam (upgrade)	7.5	n/a	n/a	Upgrade not yet commenced.
Sugar loaf mini hydro power (Melbourne Water, 2010) (See Figure 5 below)	4	n/a	n/a	Commissioned in February 2010.

Figure 8: Sugarloaf mini hydro (Melbourne Water, 2010)

AGL

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Bogong	140	94	240	Completed in November 2009.
West Kiewa upgrade	12	n/a	n/a	n/a

Figure 9: Bogong Power station construction - turbine inspection

Delta Energy

Development	Additional capacity (MWs)	Additional annual production (GWhs)	Cost ($M)	Status
Glennies Creek	0.63	~2.8	~ 1.1	Development Application approved but project on hold due to drought conditions. There is a low likelihood of this project proceeding.
Windamere Dam	0.63	~2.1	~1.1	As above.

ACTEW Corp

Murrumbidgee to Googong Transfer Project (mini hydro power)	n/a	One fifth of energy required to operate the pump station	n/a	Awaiting final Commonwealth approval and expected to begin by the end of 2010.

Delta Energy

North Head sewage treatment plant	n/a	n/a	n/a	n/a
Woronora water filtration plant	n/a	n/a	n/a	n/a

Eraring Energy

Burrinjuck Power Station mini hydro power	4	n/a	n/a	Feasibility studies commissioned. Projects will need input of 'green' funding to support initial capital outlay in order to be viable. Using environmental flows.
Warragamba power station mini hydro power	1	n/a	n/a	As above.
Hume Power station mini hydro power	1-2	n/a	n/a	As above.
Kangaroo Valley units 3 and 4 refur-bishment (Eraring Energy, 2009)	n/a	n/a	n/a	Detailed 5 year plan has been developed.

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