

Development of renewable energy in Australia and China: A comparison of policies and status



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ABSTRACT

Both developed and developing countries have committed to reduce their emissions through the increased use of renewable energy. This paper aims to compare renewable energy deployment in developed and developing countries represented by Australia and China. The paper firstly argues the validity of comparison of renewable energy deployment in Australia and China. Then, the governance structures in both countries are compared; the paper also compares management mechanisms in terms of funding and incentive support, renewable energy grid-connection and coordination between different levels of governments in both countries. Moreover, the current status of renewable energy development in two countries is summarized. From the study, it can be concluded both countries have set a Renewable Energy Target and promulgated legislation and regulations to enlarge the scale of renewable energy; China shows a stronger commitment to renewable energy than Australia. However, Renewable Energy Certificate mechanism is implemented more effectively in Australia than in China. The paper suggests: augmenting and rebuilding the electricity network and strengthening coordination between different levels of governments for both countries; enhancing manufacturing facilities and incentives for the solar and wind industry for Australia, while developing more-detailed implementation legislation and renewable power quota system for China.

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1. Introduction

Increasing energy demand, security of energy supply and reduction of emissions are the essential challenges for the world [1]. Energy consumption which accounts for 60% global greenhouse gas emissions has mainly contributed to climate change [2]. How best to combat climate change and global warming while satisfying the world's energy consumption, without impairing the global economy is an urgent problem for every country.

Reduction of carbon intensity of energy is important for dealing with climate change in the future [2]. Renewable energy is an appropriate way to satisfy energy consumption without environmental degradation. Many countries' governments have committed to decreasing their emissions and respond actively through promoting renewable energy.

Therefore, in recent years, there are different levels of legislation

and policies promulgated to encourage renewable energy development not only in developed countries, but also in developing countries. By the year of 2013, there were at least 144 countries which had made different renewable energy targets and policies to support renewable energy development at the national level compared with only 55 countries in 2005. There are also a large number of state/provincial level and local level policies in different countries [3].

In 2012, there was \$244 billion of total investment in renewable energy which increased by 8% compared to the 2010 level globally. Renewable energy supplied approximately 19% of the world's energy consumption in 2012 [3]. In recent years, renewable energy has increased strongly in both developed countries and developing countries.

2. Validity of comparison of renewable energy deployment in Australia and China

Firstly, comparison can be used as a legitimate and significant method to scientifically explain and explore how political processes

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work [4]. Hill [5] argues it is essential to compare policies for development of policy theory since comparative analysis could look at more than one situation which are separated by policy issues, time and space rather than a particular case occurring at the same time even in the same place. In a comparative study, it is important to observe the extent of policy learning between different countries and over time. Therefore, comparison of renewable energy policies between different countries would contribute to the worldwide renewable energy policy study.

Furthermore, considering the Human Development Index (HDI) that is a composite index reflecting average national human development achievement from three basic dimensions—knowledge, a decent standard of living and a healthy and long life. Australia belongs to the group of Very High Human Development countries with an HDI of 0.933 and China belongs to the High Human Development group of countries with an HDI of 0.719. Australia and China rank at 2 and 91 across the world respectively [6]. HDI sometimes is used to distinguish whether a country is a developed or a developing country [7]. Thus, Australia is a developed country which is in the Very High Human Development ranking and China is a developing country. Comparative analysis of renewable energy policy in Australia and China could be the typical example of renewable energy policy between developed and developing countries.

Australia is endowed with abundant fossil fuel resources, which gives Australia a comparative advantage in relatively cheap electricity. However, high reliance on coal-fired electricity generation has caused Australia to become the highest per capital emitter globally [8]. The GHG emissions from fossil fuel production and combustion sectors account for 78% of total Australia's GHG emissions [9]. The electricity generated from fossil fuel, such as coal, oil and gas accounts for 90% of the total Australian electricity of which coal provides 68% of total Australian electricity [10]. The Australia Government pledged it will reduce its emissions by 5% with unconditional commitment and by 15% or 25% with conditional commitment based on 2000 level by 2020 [11].

On the other hand, Australia is also abundant in renewable energy resources and it is the sunniest country in the world [12]. Therefore, Australia has potential to develop its renewable energy to meet increasing energy demand meanwhile reducing the GHG emissions to respond to climate change proactively.

Compared with Australia, China is a manufacturing and developing country and therefore the energy demand has risen rapidly in recent years due to its speedy economic growth and modernization. On the other hand, China has become not only the largest energy consumer but also the largest CO₂ emitter in the world [13]. Likewise, the Chinese Government pledged to reduce the amount of carbon dioxide emissions (CO₂) by 40%–45% by 2020 based on 2005 level.

Fortunately, China is also rich in renewable resources, such as solar, wind, hydro, which supplies an opportunity for China to integrate renewable energy into Chinese energy mix to meet the energy demand and emission reduction goals.

As discussed above, renewable energy has become a viable option for both developed and developing countries. Investigating the governance and management of renewable energy development in Australia and China is a meaningful task so that they may learn from each other and seek co-operation to contribute to global emission reduction together. There are some similarities and also differences in the process of development of renewable energy in both countries. This article will firstly compare the governance and management mechanisms in both countries and then illustrate the status of renewable energy development in Australia and China.

3. Governance structures and their influences on renewable energy development

There are several similarities of renewable energy governance between Australia and China. Firstly, in order to meet the increasing energy demand and respond to climate change actively, both Australia and China have set renewable energy targets at national level and promulgated national legislation and regulations to promote renewable energy. Secondly, the state/provincial governments in both countries set their own renewable energy targets and released the state/provincial renewable energy legislation and regulations considering their regional renewable resources. However, they must comply with pertinent national legislation and regulations to ensure their own targets can be reached within the required time. In the light of different political systems in Australia and China, the following sections discuss the detailed governance structure in both countries respectively.

3.1. Governance structure of renewable energy development in Australia

In 2000, the Australian Government issued the Mandatory Renewable Energy Target (MRET) which set 9500 GWh by 2010 to encourage renewable energy investment through tradable renewable energy certificates (RECs, 1 REC = 1 MWh of electricity). This legislative target was met ahead in 2007. In 2009, the Australian Government implemented the Renewable Energy Target (RET) which was expanded from MRET. This target was designed to guarantee renewable resources will supply 20% of total Australian electricity by 2020 including meeting the 45,000 GWh renewable energy target. In January 2011, the RET was divided into two parts: the Large-scale Renewable Energy Target (LRET) and Small-scale Renewable Energy Target (SRET). This change aims to create separate incentives for large-scale renewable energy projects and small-scale technology which can decrease the competition with each other in the RET scheme [14].

In order to facilitate the implementation of RET scheme, the Australian Government promulgated national acts to ensure the target can be met in future. There are some legislations, such as Renewable Energy (electricity) Act 2000, Renewable Energy (Electricity) (Small-scale Technology shortfall Charge) Act 2010, Renewable Energy (Electricity) (Large-scale Generation Shortfall charge) Act 2000 and Renewable Energy (Electricity) Regulation 2001. This legislation establishes the liability framework, identifies the means of creating certificates and administration of arrangement and imposes the large-scale generation and small-scale technology shortfall charge at \$65 per MWh. These Acts place a legal obligation onto the liable entities. This means the electricity retailers and other large buyers are required to purchase renewable energy certificates (RECs) from accredited renewable energy providers [14]. If these entities cannot meet the required quotas, they would get fined at \$65 per MWh for shortfalls. The RECs can be used to demonstrate the liable entities' compliance with requirement of RET as a 'currency' form [15].

The Carbon Price commenced from 1 July 2012. To some extent, it has enhanced the competition of renewable energy with fossil fuel through increasing the cost of fossil fuel generation and make renewable energy more viable. This is because cost is the major barrier for renewable energy development which requires much higher up-front capital cost compared with fossil fuel generators. Another reason is that cost and risk of fossil fuel electricity are historically externalized, which leads to the lower private costs but higher social cost compared with renewable energy, and further decreases the competitiveness of renewable energy [16]. Carbon Price in Australia aimed to internalize environmental costs of fossil

fuel due to its emission. However, following a change in Government in 2013 the current government, as one of its first legislative changes, repealed the Carbon Price from 1 July, 2014. In addition a review of the renewable energy target, RET, was undertaken and recommended in August 2014 that the target be significantly reduced. As yet no agreed decision has been made on what the RET reduction should be. This has caused a great degree of uncertainty in the renewable energy market and investment has significantly declined, with some investors leaving the country and employment in renewables dropping. This will weaken the competitiveness of renewable energy again in future if the Government does not introduce other support policies. Therefore, in Australia, instability of current support policies that may change with whichever political party is in power, causes renewable energy deployment to suffer with stop-and-go situations influencing Australian renewable energy development [17–19].

The RET implementation is overseen by the Clean Energy Regulator (CER) which also administrates the compliance with associated requirement by legislation. National policy and the legal framework are managed by the Department of Industry (DOI). The other responsible governmental agency is Australian Renewable Energy Agency (ARENA) which commenced operation in 1 July 2012 to supply funding support for renewable energy project, research and development activities together with knowledge capturing and sharing activities. ARENA had a \$2.5 billion budget [20]. However, after the 2014 Budget funding for ARENA was reduced to \$331 million in 2014–15, and \$15 million in 2015–16 and 2016–17. This is a massive reduction in funds.

Renewable energy policy in Australia is subject to regulations and influenced fiscally by all three spheres of governments which are the federal, state and local governments. These three Governments are coordinated by the Council of Australian Government (COAG) [21]. In Australia, the State government plays a significant role in renewable energy utilization.

Additionally, the Commonwealth Scientific and Industrial Research Organization (CSIRO) is a federal government funded national science agency researching and developing solar, wind, geothermal and other renewable technologies. The National Solar Energy Centre that is located in the CSIRO Energy Centre specializes in R&D of the advanced solar technologies including concentrated solar thermal, photovoltaics and solar cooling [22]. CSIRO also influences the decision-making of the renewable energy policies and the commercialization of renewable energy technologies in Australia as well.

3.2. Governance structure of renewable energy development in China

In China, the Chinese central government plays an important role in renewable energy development and deployment. To enlarge the scale of renewable energy application while meeting the 40%–45% of emissions reduction by 2020, the Renewable Energy Law (REL) of People's Republic of China, was put into effect on 1 January 2006. The purpose of the Renewable Energy Law is promoting the development and utilization of renewable energy, diversifying energy supplies, safeguarding energy security, improving energy structures, protecting the environment and considering the economic and socially sustainable development. The priority of energy development was given to the renewable energy promotion and utilization. Moreover, solar, wind, hydro, biomass, geothermal, ocean and other non-fossil energy were all defined as renewable energy in the law [23]. The renewable energy law was created as a framework for renewable energy development in China. Renewable Energy Law was amended in 2009 in which there were some important changes to improve the implementation of the REL

including enhancement of mandatory connection and purchase policy; streamlining renewable energy fund and strengthening the central governments' oversight of provincial and local governments' renewable energy planning and implementation [24]. The amended law was effective from 1 April 2010.

In order to implement and complement the REL effectively, in August 2007, the Mid- and Long-term Development Plan for Renewable Energy (MLDP) was released, in which the Chinese Government set the target for future renewable energy application. The target is – renewable energy will supply 15% by 2020 of total energy consumption in China. In addition, the China 12th Five Year Plan for Renewable Energy Plan (2011–2015) set specific targets for different renewable sources. Comparing with China, Australia has no primary energy reduction target but an electricity reduction target of 20% by 2020 and a greenhouse gas reduction target of 5%.

In China, there is no special government authority that is in full charge of renewable energy deployment [25]. Instead, more than ten regulations are in place and several national agencies are involved in renewable energy policies-making. The National Development and Reform Commission (NDRC) released The Regulation on Administration of Power Generation from Renewable Energy (NDRC Energy [2006] No.13); the State Electricity Regulatory Commission (SERC) which is responsible for regulating and overseeing China's electricity industry published the Measures on Supervision and Administration of Grid Enterprises in the Purchase of Renewable Energy Power (SERC [2007] No. 25). These regulations and measures were designed to remove the barriers to China's renewable energy development and ensure the reasonable return of renewable energy producers and provide an incentive to the market-based renewable energy industry. There is another government agency, the National Energy Administration (NEA) sitting within the NDRC which is responsible for energy planning. The large-scale application demonstration area scheme for distributed photovoltaic power generation has been proposed by NEA. Furthermore, taking into consideration of restrictions in suitable conditions, such as geographical location, power grid and resources and so on, the combination of the large scale mass exploitation and distributed development will be applied in renewable energy development. Therefore, the distributed electricity will become the main route for future Chinese renewable energy application [26]. Additionally, NDRC Pricing Bureau is in charge of setting the price for energy, including setting renewable energy feed-in tariff; Meanwhile, Ministry of Finance is in charge of providing funds for renewable energy programs. Besides, Ministry of Science and Technology (MOST), the Ministry of Environmental Protection (MOEP), the Ministry of Housing and Urban–Rural Development (MOHURD), the Ministry of Agriculture (MOA), the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) are also involved in renewable energy policy making. However, it is very difficult to coordinate different governmental authorities due to undertaking various functions [25]. As a result, regulatory system of renewable energy is inconsistent and regulations from different government authorities are heavily overlapped in China [27]. A separated political and regulatory authority that is fully in charge of renewable energy is recommended for China in future.

In addition, there are also non-government organizations involved in renewable energy development in China which can be categorized as academic research associations, industrial associations and the organizations conducting special activities in relevant area of renewable energy. The Chinese Renewable Energy Society (CRES) has been involved in drafting and research on renewable energy laws, regulations and technical standards and is one of many organizations taking part but it might be the most important non-government organization of renewable energy in China [28].

Table 1 shows renewable energy governance structure in Australia and China.

4. Compare management mechanisms between two countries

Both Australia and China have made great efforts to promote renewable energy deployment through different policy supports under their governance structure. There are several similarities and differences regarding to various aspects between two countries.

4.1. Funding and incentive support

Both countries have supplied funds to promote renewable energy. In Australia, Clean Energy Finance Corporation (CEFC) has been established with a budget of \$10 billion which provides the financial support for renewable energy, low emissions technologies and energy efficiency projects over 5 years from 1 July 2013; However, the new Government wishes to abolish the CEFC and will do so if it has the opportunity. ARENA has \$2.5 billion to be administered for renewable energy deployment, research and development, commercialization and demonstration although the fund has been reduced from \$3.2 billion due to \$435 million funding cut by the Abbott Government and an announced \$370 million deferral by Labor in 2013 [20]. Launched by the Gillard Government in the early 2012 to accelerate transition to a cleaner future, the Clean Technology Program included \$200 million Clean Technology Innovation Program for clean technology research and development, \$200 million Clean Technology Food and Foundries Investment Program and \$800 million for the Clean Technology Investment Program for incentivizing manufacturers to reduce pollution and improve energy efficiency. However, currently, the Abbott Government has announced they intend to discontinue funding for the Clean Technology Program with abolishment of the Carbon Price. Therefore, these three programs have been closed to new applications [29]. Unfortunately in Australia, as in many other countries, when there a change in Government occurs, some existing programs are terminated.

There were also renewable energy rebate schemes deployed by the Australian Government, such as the Solar Homes and Communities Plan, Residential and Medium-scale sub-program,

Renewable Remote Power Generation Program and Solar City Program [21]. Most of them are no longer in existence.

These past funding initiatives and programs have effectively promoted renewable energy development in Australia. However, the most effective scheme to increase residential roof top solar in Australia was the state-based feed-in tariff. A scheme introduced and administered, with slightly differing financial programs, by the States. It was a highly effective initiative as shown in Fig. 1, although it was so effective that the scheme was stopped at the end of 2013. However, as a result of it 2% of Australia's electricity is now from residential roof top solar and in States like South Australia almost 25% of households have PV on their roofs in 2014.

As there was never a national feed-in-tariff scheme in Australia and the State based schemes were only applied to small-scale systems and mostly for solar PV [21], the large-scale renewable energy application is impeded in Australia. Furthermore, Courvisanos & Effendi [31] argued that renewable energy gains less financial support from the Australian Government compared with fossil fuel sector. Riedy [32] estimates that most of the \$10 billion annual subsidy to energy sector flowed into the fossil fuel sector; and only 4% went to renewable energy sector in 2005–2006 financial year. There are also substantial funds from the Australian Government supporting clean coal research design and development (RD & D) [33]. Byrnes et al. argue the government funding prefers mature technologies and this may cause significant investment to flow to gas which is considered as a scalable and reasonably mature technology. According to Byrnes et al. [16], there was only 50% of \$10 billion Clean Energy Finance Corporation are committed to support renewable energy application (including hybrids). However, once the CEFC closes down it is not known how much funding will exist for large-scale renewable. This is mainly because fossil fuel plays an important role in Australia's economy. It is difficult to change the current situation in which fossil fuel cannot be challenged by renewable energy.

Compared with Australia, China has more specific funding support programs to different stakeholders and shows more firm confidence in renewable energy development. This might be due to the huge annual energy consumption and a lack of fossil fuel resources in China.

There are economic incentive policies carried out by the Chinese Government, such as tax preferential policy for enterprises which

Table 1
Comparison of governance structure related to renewable energy in Australia and China.

	Australia	China
Renewable energy target	Renewable Energy Target (Large-scale Renewable Energy Target (LRET) Small-scale Renewable Energy Target (SRET))	Renewable Energy Law (REL) Mid-and Long-term Development Plan for Renewable Energy (MLDP) China 12th Five Year Plan for Renewable Energy Plan (2011–2015)
Relevant government authority	Federal government, State government, local government; Clean Energy Regulator (CER); Department of Industry (DOI); Australian Renewable Energy Agency (ARENA)	Central government, provincial government, local government; National Development and Reform Commission (NDRC); State Electricity Regulatory Commission (SERC); National Energy Administration (NEA); NDRC Pricing Bureau
Non-government organization	Clean Energy Council (CEC), Australian PV Institute (APVI), Australian Solar Council (ASC)	Chinese Renewable Energy Society (CRES)
Legislation and regulation	Renewable Energy (electricity) Act 2000, Renewable Energy (Electricity) (Small-scale Technology Shortfall Charge) Act 2010, Renewable Energy (Electricity) (Large-scale Generation Shortfall Charge) Act 2000, Renewable Energy (Electricity) Regulation 2001, Renewable Energy Certificates (RECs), Carbon Price (repealed)	Renewable Energy Law, Regulation on Administration of Power Generation from Renewable Energy, Measures on Supervision and Administration of Grid Enterprises in the Purchase of Renewable Energy Power, The trial Management Measures for Renewable Power Pricing and Cost Share, The Trial Management Measure for Allocation of Renewable Energy Tariff Surplus Revenue, Notice of Strengthening the Construction and Management of Biofuel Ethanol and Promoting Sound Industrial Development, The Trial Management Measures for the Special Development Fund Implementation, Guidelines on Promoting Wind Power Industry, The Catalogue of Guide to Renewable Energy Development

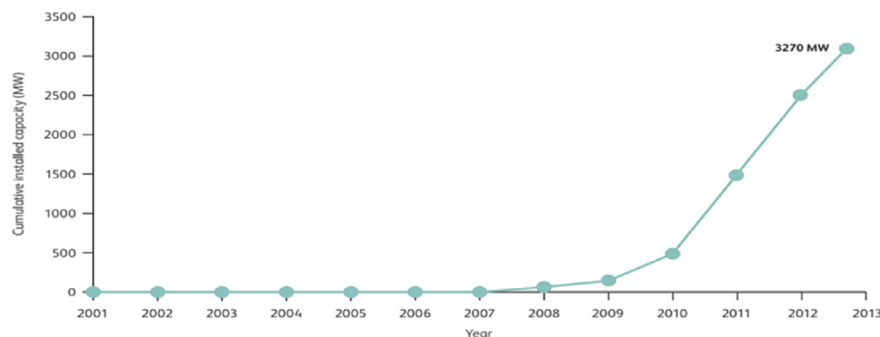


Fig. 1. Installed capacity of small-scale solar power system-cumulative in Australia. Source [30].

engage in renewable energy projects, price preferential policy that ensure the renewable producer can cover costs and gain reasonable profit through setting national feed-in-tariffs with differing values depending on the type of renewable source and for different sized generator, and investment subsidy policy which has been implemented through different programs [34].

In 2009, in order to assist Chinese photovoltaic industry development under the circumstance of its high dependence on export and aggravated by trade frictions with the United States and the European Union, the Chinese Government rolled out two programs. One is Solar Roofs Program which aimed to supply subsidy to build integrated photovoltaic system with 20 RMB/W and rooftop system with 15 RMB/W in 2009 [35]. With the decrease of the price of solar PV modules, the subsidy has been decreased to 7.5 RMB/W for rooftop system and 9 RMB/W for BIPV system later [36], (on 31 July of 2014, 1 AUD = 5.74 RMB). In July of 2009, in order to further develop the solar energy application, the Chinese Government implemented the “Golden Sun Pilot Project” which aims to subsidize 50% of the total cost including transmission and distribution networks to the projects that meet relevant criteria. If the project is in rural areas without grid coverage, the supplied subsidy can be as high as 70% of total investment [37]. Moreover, the first 108 Green Energy Demonstration Counties have been approved by the Chinese Government in the mid of 2011 [38]. 200 Green Energy Counties construction will be finished in the end of 2015 in China. In addition, 100 New Energy Demonstration Cities will be built in future [26].

With respect to renewable energy manufacturing, China is committed to developing a strong renewable energy industry contrary to the Australian Government's attitude. According to Liu et al. [13], currently, China has become the largest producer and consumer of solar water heaters in the world which accounts for 50% of global production and 65% of global total installation; China also supplies 30% of world's PV panels and ranks second in wind power production. Compared with China, Australia has world-class renewable technologies, but it is difficult to find suitable local manufacturers which have capability and interest to transformed commercialized technology into the real product under government funded programs [39]. There is a lack of manufacturing facilities for solar and wind industry in Australia [21], since with a population just 1/60 that of China Australia does not have the local market that China has.

4.2. Renewable energy grid-connection

Renewable energy grid-connection is a major issue in both countries. There are some similarities between Australia and China. As renewable electricity increases, insufficient electricity network capability is reported in both countries. It is urgent and necessary to extend and upgrade the present electricity network, to meet the

renewable energy target in Australia [40]. In China, there is a bottleneck between the increasing renewable energy production and inadequate electricity grid-connection facilities [37]. Therefore, augmenting and rebuilding a network that has sufficient capacity and flexibility to facilitate renewable energy grid-connection is suggested for both countries.

There is also a difference related to this issue between the two countries. The Australian Government implements RET through Renewable Energy Certificates (RECs) which place a legal obligation onto electricity retailers and other large wholesale buyers to source a proportional share of the target from eligible renewable energy sources (1 REC = 1 MWh). RECs are a tradable commodity and, depending on the price received aid the competitiveness of renewable electricity. Currently, with the aid of RECs, both wind and roof top solar are most competitive with fossil fuels. Compared with Australia, China's renewable energy grid-connection is operating at a lower efficiency level, although Renewable Portfolio Standard (RPS) which was introduced by NDRC in 2007 in MLDP requires electricity retailers to purchase a certain quantity of renewable energy [41]. Grid companies were assigned to have 1% and 3% non-hydro of renewable energy by 2010 and 2020 respectively and generators were assigned 3% and 8% non-hydro by 2010 and 2020 respectively in their generation mix [42]. However, there are some grid firms that are reluctant to connect renewable energy into network [43]. It was reported that none of six largest generators met the 3% of renewable energy requirement and there is no report about imposing penalties for non-compliance grid companies in China [24]. On one hand, due to a lack of monitoring and compliance requirement and the grid companies' consideration of the possible destabilization to networks by accidents occurring, the grid companies are reluctant to accept the renewable electricity in some places [24]. Qiu & Li [27] argue current renewable energy laws are too ambiguous to enforce and more-detailed implementation legislation is recommended for better enforcement. Contrary to the situation in China, in Australia, the substantial barrier is the connection cost rather than technical issues [44]. On the other hand, focus of installed capacity rather than generation is another reason of poor integration of renewable energy into grid. Thus, the renewable power quota system and developing technical standards for renewable energy grid-connection should be suggested for China. Fortunately, the Draft Renewable Power Regulation has been issued for public discussion now in China. It is reported that Renewable Power Regulation will be promulgated in 2015, which will hopefully increase renewable energy integration into grid.

4.3. Coordination between different levels of governments

Jones [39] argues that there is a lack of coordination between the federal government and state government in Australia.

Table 2
2011–12 Australian energy consumption/electricity generation, by fuel type.

	Energy consumption		Electricity generation	
	GWh	Share%	GWh	Share%
Total	1,721,932	100	253,851	100
Fossil fuel	1,647,984	95.7	229,824	90.5
Coal	588,804	34.2	175,362	69.1
Oil	670,258	38.9	3070	1.2
Gas	388,922	22.6	48,892	19.3
Other	0	0	2500	0.98
Renewable	73,670	4.3	24,028	9.5
Biomass	45,807	2.7	2343	0.92
Biogas/Biofuels	3058	0.18		
Hydro	14,178	0.82	14,083	5.5
Wind	6116	0.36	6113	2.4
Solar	4726	0.27	1489 (Solar PV)	0.59

Source [45].

Sometimes state schemes are not coordinated with the federal schemes. This causes barriers for renewable energy development in Australia. Schuman & Lin [24] report that in China provincial renewable energy planning and development lacks coordination with the central government as well. Hence, strengthening coordination between federal/central government and state/provincial government is suggested for both countries.

5. The status of renewable energy development in Australia and China

As shown in the following table and figures, Table 2, Figs. 2 and 3 show the energy consumption and electricity generation by fuel type in Australia and China respectively.

In terms of energy consumption, as shown in Table 2, during 2011–2012, the total energy consumption in Australia was about 1.72×10^6 GWh, in which there are 7.36×10^4 GWh from renewables. The energy from renewables accounts for 4.3% of total energy consumption in Australia, including 0.82% from hydro. Compared with Australia, Fig. 2 shows in China, in 2012, the total energy consumption is about 9.05×10^6 GWh (3620 million tce, 1 GWh = 400 tce), in which there are 8.25×10^5 GWh from renewables. This constitutes about 9.0% including 7.8% from hydro of total energy consumption in China. Therefore, if hydro power is removed, renewable energy shares more of total energy consumption in Australia than China, though much of Australia's renewable energy is from biomass. In China, as a percentage of total energy, non-hydro renewables play a very small part, only 1.2% in

the mix of energy consumption.

When it comes to the electricity generation by fuel type in both countries, as shown in Table 2, in 2011–2012, the total electricity generation in Australia is about 2.54×10^5 GWh in which there are 2.4×10^4 GWh from renewables. This accounts for 9.4% including 5.5% from hydro of total electricity generation in Australia. Meanwhile, in China, in 2012 as shown in Fig. 3, the Chinese electricity generation is about 4.98×10^6 GWh, in which there are 1.007×10^6 GWh from renewables. This shares about 20.2% including 17.4% from hydro of total electricity generation in China. Therefore, the percentages of non-hydro renewable electricity in both Australia and China are similar (3–4%), which is considered very small.

On the other hand, there is another similarity of status of renewable energy in both countries. This is the percentages of electricity from all renewables (9.4% in Australia; 20.2% in China) are higher than the percentages of energy consumption from renewables (4.3% in Australia; 9.0% in China). This means the electricity generation is the dominated form of renewable application.

6. Conclusion and recommendation

Development of renewable energy has been considered as a viable option to meet the increasing energy consumption and reduce carbon emissions effectively in both developed and developing countries. Both Australia and China have set renewable energy targets to enlarge the scale of renewable energy application, introduced legislation and regulations at national and state/provincial level, implemented different governmental programs and provided incentives and funding to ensure their targets can be met in required time. A unified and top-down approach is applied to implement renewable energy programs and policies in China whereas there are more strong decision-making and diversity of renewable energy policies among the state governments in Australia.

The Chinese Government is now confronted more severely with conflict about energy supply and environmental protection so that it shows more confidence in renewable energy development compared with the Australian Government.

The Chinese Government shows a stronger commitment to renewable energy than Australia, though both countries still have a very low penetration of non-hydro renewable energy in their primary energy mix. China also supplies significant incentives for renewable energy manufacturers to boost relevant industries while Australia supplies little support for renewable energy

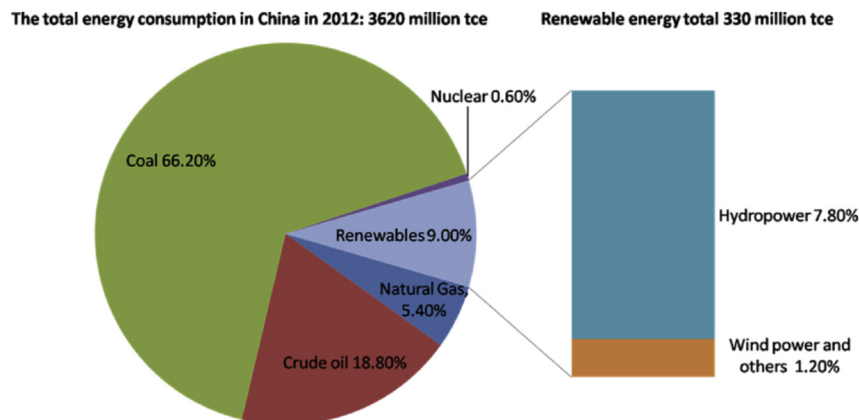


Fig. 2. 2012 China's total primary energy consumption.
Source [46].

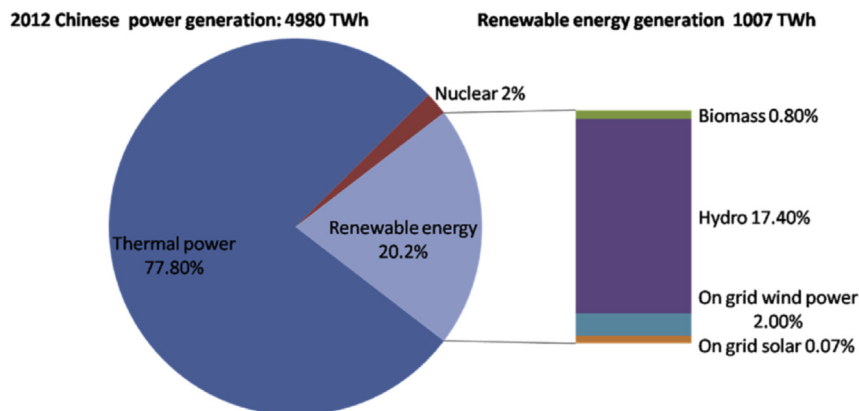


Fig. 3. 2012 Power generation in China.

Source [46].

manufacturing industry although it has world-class renewable energy technologies and resources. However, with respect to renewable energy integration, Australia's Renewable Energy Certificate mechanism is implemented more effectively than China's due to guaranteeing renewable energy can be purchased by electricity companies by legislation. Furthermore, both countries are suffering the dilemma in which their electricity network has lagged behind the renewable energy development. Additionally, both countries lack coordination between the central/federal government and provincial/state governments.

Therefore, augmenting and rebuilding the electricity network to meet the renewable energy integration requirement and strengthening coordination between federal/central government and state/provincial governments are recommended for both Australia and China. Enhancing manufacturing facilities and incentives for the solar and wind industries is recommended for Australia while promulgating more-detailed implementation legislation for better enforcement and developing a renewable power quota system and technical standards for renewable energy grid-connection is suggested for China. Moreover, for both countries, developing cost effective and environmentally benign storage technologies and systems and integration technologies to deal with future high penetration of intermittent power generation in the electricity network will be areas of future importance.

List of acronyms

AEMC	Australian Energy Market Commission
AGCCA	Australian Government Climate Change Authority
AGI	An Australian Government Initiative
AGO	Australian Greenhouse Office
APVI	Australian PV Institute
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine
ARENA	Australian Renewable Energy Agency
ASC	Australian Solar Council
BREE	Bureau of Resources and Energy Economics
CEC	Clean Energy Council
CEFC	Clean Energy Finance Corporation
CER	Clean Energy Regulator
CNREC	China National Renewable Energy Centre
COAG	Council of Australian Government
CRES	Chinese Renewable Energy Society
CSIRO	Commonwealth Scientific and Industrial Research Organization
DCCEE	Department of Climate Change and Energy Efficiency

DOI	Department of Industry
DRET	Department of Resources, Energy and Tourism
GHG	Greenhouse Gas
GWh	Gigawatt hour
HDI	Human Development Index
LRET	Large-scale Renewable Energy Target
MLDP	Mid-and Long-term Development Plan for Renewable Energy
MOA	Ministry of Agriculture of the People Republic of China
MOEP	Ministry of Environmental Protection
MOF	Ministry of Finance
MOHURD	Ministry of Housing and Urban–Rural Development
MOST	Ministry of Science and Technology
MRET	Mandatory Renewable Energy Target
MWh	megawatt
NEA	National Energy Agency
NDRC	National Development and Reform Commission
RD & D	Development, Demonstration, and Deployment
R&D	Research and development
RECs	Renewable energy certificates
REL	Renewable Energy Law
REN21	Renewable energy policy network for the 21st century
RET	Renewable Energy Target
RPS	Renewable Portfolio Standard
SRET	Small-scale Renewable Energy Target
SERC	State Electricity Regulatory Commission
tce	tonne of standard coal equivalent (1 GWh = 400 tce)
UN	United Nations
UNDP	United Nations Development Programme

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