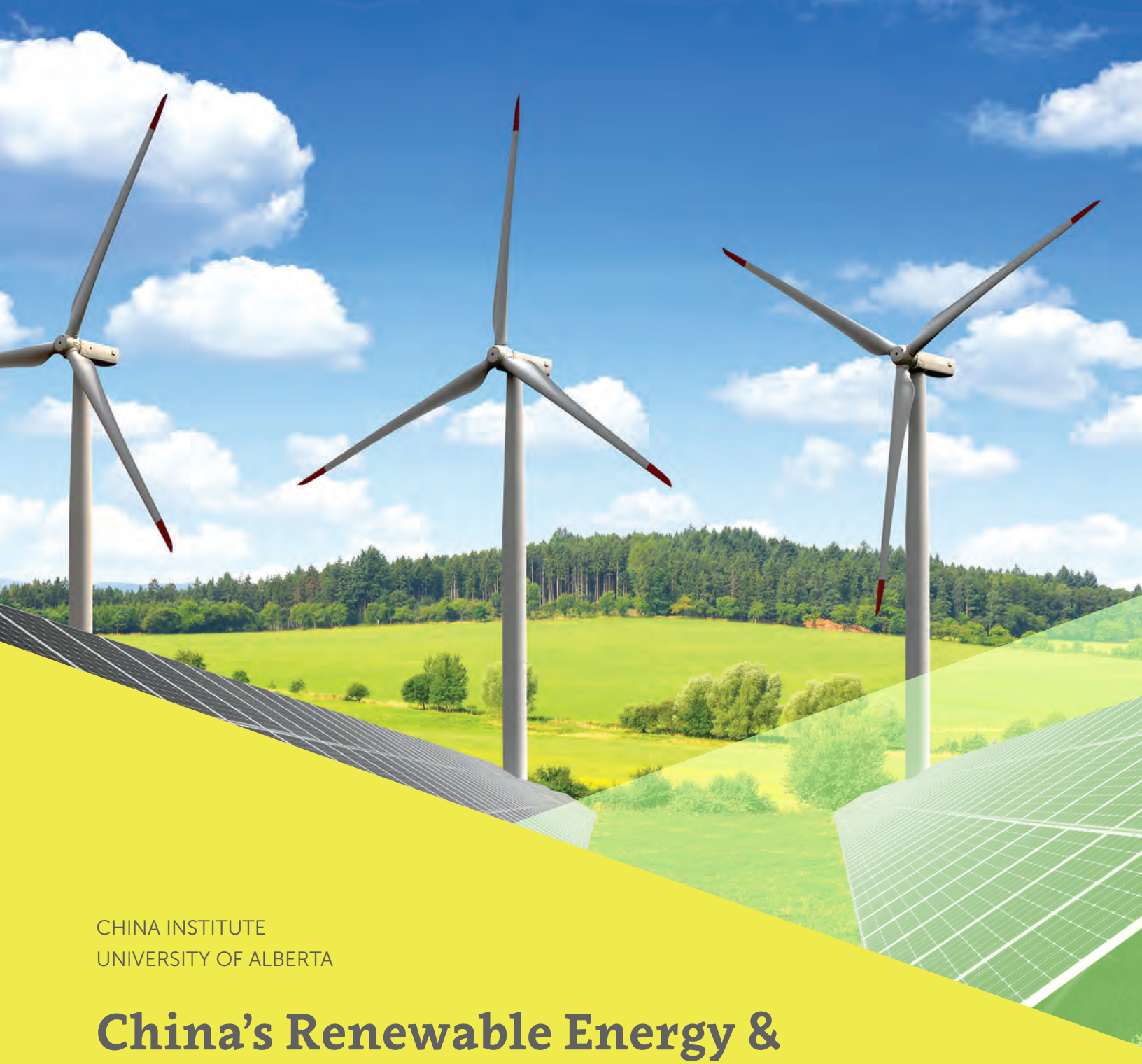

CHINA INSTITUTE
UNIVERSITY OF ALBERTA

China's Renewable Energy & Clean-Tech Market

Summary Report

March 2016

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TABLE OF CONTENTS

INTRODUCTION

Over the past several years, China has emerged as both the world's largest producer and consumer of renewable energy technologies, while the country's investment in renewable energy and clean technology has exceeded the combined total invested by Europe and the U.S.[1] According to the International Renewable Energy Association (IRENA), China will continue to account for nearly 40 percent of the world's renewable energy capacity growth until 2020. As the world's largest energy consumer, China's renewable energy investment could reach USD 145 billion per year by 2030, or USD 2.2 trillion in total.[2]

Due to its massive investment and strong commitment, China's renewable energy sector offers vast opportunities for Albertan firms specializing in renewable energy and clean technology. With Alberta's continuing technological innovation, support for low carbon policies and world-class research, all working to reduce renewable energy supply costs, Alberta can not only have a more prominent role in its own future energy supply mix, but can also play a more significant role in global renewable energy markets such as China's.

This summary report aims to capture key market information regarding China's renewable energy and clean-tech market. The policy objective is to produce a brief market report to help Alberta's renewable energy industry when seeking market development opportunities in China. It further intends to provide an overview of China's renewable energy and clean-tech market and identify major players, opportunities and challenges for Alberta.

The report will cover four major aspects of China's renewable energy and clean-tech market. In the first part, the report will give a general introduction of said market: more specifically, it will begin by examining the main reasons behind China's ongoing, extensive efforts in developing renewable energy and clean technology, reasons which include China's energy supply structure, energy demand stress, and increasing public concerns about pollution. It will then discuss the definition and types of renewable energy and clean technology within China. Finally, it will address China's legislation, policies and programs concerning renewable energy.

In the second part, the report will examine the development of China's renewable energy and clean technology in recent years. More specifically, the report will focus on the development of China's major conventional renewable energy sectors such as hydropower, wind, solar and biomass. It will assess their technological statuses from a global perspective and address their main market challenges. Moreover, it will discuss several renewable energy and clean-tech sectors such as nuclear, clean coal, green vehicles that are believed to have good market potential in China.

In the third part, the report will discuss China's market opportunities and challenges in the renewable energy and clean-tech industry for Alberta. First, it will examine several clean-tech sectors in China that might present business opportunities for Alberta; for instance, waste-to-energy, waste management, recycling, "green building", smart grids, energy storage, etc. Accordingly, it will discuss some specific market challenges in the above-mentioned industrial sectors. Finally, it will address a number of broad opportunities and challenges in China's current renewable energy and clean-tech market, including intellectual property rights, social and cultural barriers, and state-owned enterprises.

In the fourth part, the report will focus on the major players in China's renewable energy and clean-tech market, as well as opportunities for international collaboration. First, it will introduce some leading companies and notable cases in China's renewable energy and clean-tech market. Second, it will provide some useful resources for international companies when entering the Chinese market. In conclusion, with some analysis of the development trend of China's clean-tech market, the report will provide some recommendations for Alberta's renewable energy and clean-tech industry when seeking business opportunities in China.

[1] Liu Yuanyuan, "China's Investment in Renewable Energy Surpasses Europe, US Combined," *Renewable World Energy World.com*, November 25, 2015, http://www.renewableenergyworld.com/articles/2015/11/china-s-investment-in-renewable-energy-surpasses-europe-u-s-combined.html; Alex Morales, "China Beats U.S. on Renewable Energy Investment Ranking," *Bloomberg Business*, .September 8, 2010, http://www.bloomberg.com/news/articles/2010-09-07/china-supplants-u-s-at-top-of-ernst-young-ranking-for-renewable-energy.

[2] "China's Renewable Energy Sector Presents USD 2.2 Trillion Investment Opportunity to 2030", *World Energy Future Summit*, January 03, 2016, http://www.worldfutureenergysummit.com/Portal/news/3/1/2016/chinas-renewable-energy-sector-presents-usd-22-trillion-investment-opportunity-to-2030.aspx?ref=173

GENERAL OVERVIEW

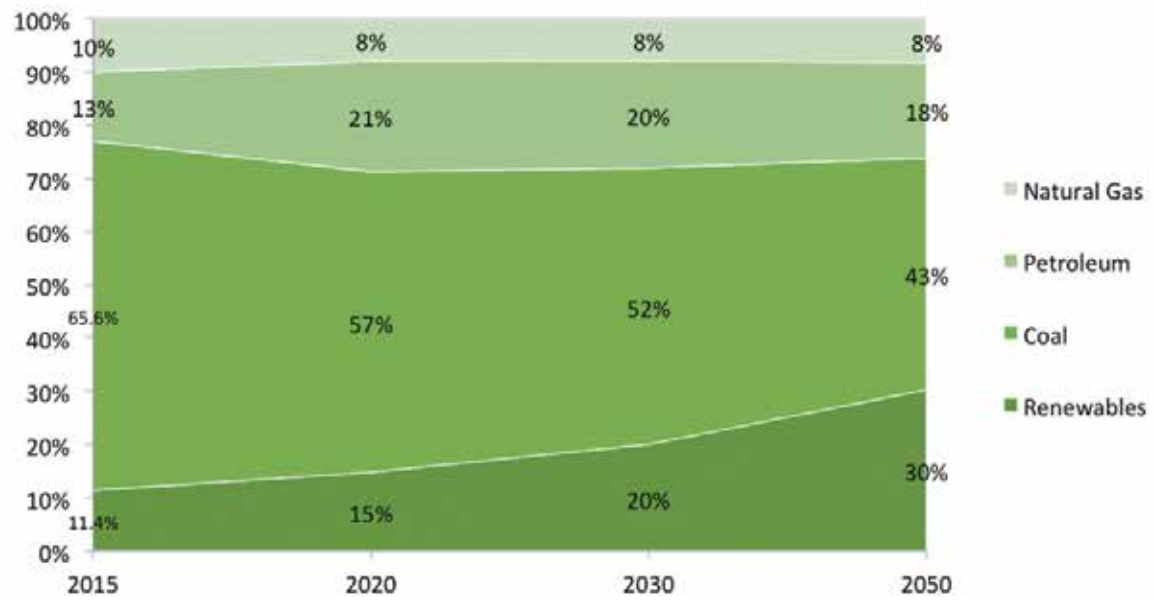
CHINA'S RENEWABLE ENERGY AND CLEAN-TECH MARKET

China's Motives for Pursuing Renewable Energy and Clean Technology

Since the late 1990s, the Chinese government has made great progress in developing a renewable energy and clean-tech market. Generally speaking, China's large-scale investment in the renewable energy and clean-tech market has primarily been driven by its coal-based energy consumption structure, increasing energy demand stress and growing public concerns about worsening pollution.

China is the world's largest developing country, with more than 1.3 billion people. For the past thirty-eight years, China has achieved impressive economic growth, with an average annual GDP growth rate of 9.7%. However, China's long-term economic development has been constrained by its energy consumption structure. For decades, China has been extremely dependent on coal for energy consumption; according to the U.S. Energy Information Administration (EIA), about 66% of China's electricity power came from coal in 2012. Today, China is the largest coal producer and consumer in the world and is also ranked first in the world with regards to electricity consumption and coal-derived electricity. Since 2007, China has become the largest emitter of carbon dioxide in the world; as the Chinese public has become more and more worried about environmental problems associated with coal-burning, China's traditional reliance on coal makes the transformation of its energy structure more urgent. As a result, the government has initiated many favorable policies in recent years to encourage the significant development of renewable energy and clean technology. Figure 1 illustrates China's official targets for renewable energy from 2015 to 2050.

Figure 1: China's Energy Consumption Structure
Renewables will increase to 15% in 2020, 20% in 2030, and 30% in 2050 respectively, from 11.4% in 2015.[3]



[3] Data are based on China's Energy and Climate Goals of the 12th Five-Year Plan (2010-2015), http://www.c2es.org/international/key-country-policies/china/energy-climate-goals-twelfth-five-year-plan; China's Energy Policy White Paper (2012), http://news.xinhuanet.com/english/china/2012-10/24/c_131927649.htm

Definition and Types of Renewable Energy

In the journal *Reviewable and Sustainable Energy Reviews*, renewable energy is defined as "energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical, and photo-electric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources"[4] However, with the advance of modern technology, many renewable energy projects now involve technologies designed to improve energy efficiency, develop clean energy and achieve sustainable development. Thus today there is not a standard definition about renewable energy or "clean technology". It can refer to conventional renewable energy, hybrid and co-generation of energy and energy efficient technologies for power generation, green chemistry, information technologies, alternative fuels and advanced technologies for transportation.

In the Renewable Energy Law of China, adopted on February 28, 2005 and amended on December 26, 2009, renewable energy is narrowly defined as "non-fossil energies, such as wind energy, solar energy, hydro-energy, bio-energy, geothermal energy and ocean energy, etc."[5] In this paper, we will first introduce the development of China's major conventional renewable energy sectors, such as hydropower, wind, solar and biomass. Then, we will discuss several renewable energy and clean-tech sectors, such as nuclear, clean coal and green vehicles, which are believed to have good market potentials in China. Finally, we will also address several clean-tech sectors such as waste-to-energy, waste management, recycling, green building, smart grid, energy storage, etc.

Regulatory Framework and Policies on Renewable Energy

Since the mid-1990s, China has begun to establish a legal framework for regulating renewable energy and relevant clean technologies. China's Electricity Law of 1995 went into effect on April 1, 1996, with several articles of the law encouraging the use of cleaner fuels. They require environmental facilities to be built in tandem with new generation facilities and identify renewable energy as a means to develop electrification, especially in rural areas. In 1997, the Standing Committee of the National People's Congress passed the Energy Conservation Law in order to promote energy conservation and energy-saving technologies. Article 38 requires government at all levels to use renewable resources sustainably, especially in rural areas. Article 39 focuses on improving energy efficiency in a variety of applications. Article 40 directs all trades and professions to seek and disseminate energy-efficiency technologies.[6] In 2000, the law for Prevention and Control of Air Pollution was enacted, which encourages the support and development of clean technology for solar energy, wind energy and water energy.

China made significant progress in legislation and policies to promote renewable energy and clean technology in the mid-2000s. As one of the first among developing countries, China's 2005 Renewable Energy Law explicitly states in its first chapter that the development and the usage of renewable energy is a prioritized area in energy development. Article 7 allows for middle- and long-term national targets to be set for the total volume of renewable energy development. Article 14 mandates the connection to the grid by and the purchase of electricity from licensed renewable energy generators. Article 25 and Article 26 describe preferential loans with subsidized interest rates and tax benefits for renewable energy projects.[7] In 2009, the Renewable Energy Law was amended in order to boost China's renewable energy. Under this new law, electric grid companies are required to buy all the electricity produced by renewable energy generators. Grid companies refusing to buy power

[4] Omar Ellabban, Haitham Abu-Rub, Frede Blaabjerg, "Renewable energy resources: Current status, future prospects and their enabling technology", *Renewable and Sustainable Energy Reviews*, 39 (2014), 748–764, page 749.

[5] "Renewable Energy Law of China", *Ministry of Commerce*, December 23, 2013, http://english.mofcom.gov.cn/article/policyrelease/Businessregulations/201312/20131200432160.shtml

[6] Richard J. Campbell, "China and the United States: A Comparison of Green Energy Programs and Policies", *Congressional Research Service*, April 30, 2014, pages 5-6.

[7] Richard J. Campbell, "China and the United States: A Comparison of Green Energy Programs and Policies", *Congressional Research Service*, April 30, 2014, page 7.

produced by renewable energy generators could be fined up to double the economic loss suffered by the renewable energy generator.[8]

In the 11th Five-Year Plan (2006-2010), a 20% overall reduction in the energy intensity of the economy and 10% of total energy consumption coming from non-fossil energy were set as targets. In the 12th Five-Year Plan (2011-2015), China set targets to reduce energy intensity by 16% and decrease carbon intensity by 17% by 2015. In the meantime, China aimed to source 11.4% of its primary energy from renewable sources by 2015, and 15% by 2020. A number of priority renewable energy programs were laid out, with the emphasis on planned large-scale wind power bases in the North, Northeast and Northwest regions, off-shore wind development and large-scale, grid-connected solar photovoltaic bases in desert areas. The Five-Year Plan also made renewable-based distributed generation a priority, particularly in 100 planned "new energy cities" and 200 planned "green counties". Furthermore, the State Council released a comprehensive work plan including 50 specific measures regarding energy efficiency and emission reduction to support the energy intensity target. On October 24, 2012, the State Council released China's Energy Policy White Paper, pledging to develop more vigorously new renewable energy as a key strategic measure.[9]

THE DEVELOPMENT

China's Investment and Installed Capacity in Renewable Energies

In a relatively short period, China has gone from a minor player to the world's largest producer and consumer in renewable energy and clean technology. According to the Renewables 2015 Global Energy Status Report released by the Renewable Energy Policy Network for the 21st Century (REN21), China ranked highly in a number of categories to do with annual investment, net capacity additions, production, total capacity and generation as of the end of 2014. In the same year, China also led the world in new wind and solar installations, with 19.81 GW and 10.60 GW respectively. It has widely been recognized that China's massive investment in renewable energy will make China the largest market for hydropower, wind, solar technology, nuclear energy, and other clean-technology in both the short- and medium-term.

According to the data released by Bloomberg New Energy Finance, China increased its investment in renewable energy and clean technology, with a total of USD 89.5 billion in 2014, up 32% from the previous year. This was nearly 73% more than the United States, the next largest investor. China also increased its installed solar photovoltaic (PV) capacity by 29% in 2014.[12] Figure 4 shows the top countries in clean energy investment in 2014.

[8] Lucy Hornby, "China Introduces Laws to Boost Renewable Energy", *Green Business*, December 28, 2009, http://www.reuters.com/article/us-china-energy-renewables-idUSTRE5BQ08Q20091228

[9] "China Strives to Develop New Renewable Energy", Xinhuanet: *White Paper*, October 2012, http://news.xinhuanet.com/english/china/2012-10/24/c_131927576.htm

[10] "Renewables 2015 Global Status Report", *Renewable Energy Policy Network for 21st Century*, http://www.ren21.net/status-of-renewables/global-status-report/

[11] "Renewables 2015 Global Status Report", *Renewable Energy Policy Network for 21st Century*, http://www.ren21.net/status-of-renewables/global-status-report/

[12] "China on the Fast Track to A Renewable Future", *RE 100 China Analysis: April 2015*, http://www.theclimategroup.org/_assets/files/RE100-China-analysis.pdf

Figure 2: Top Countries in Total Renewable Energy Capacity as of End-2014[10]

TOTAL CAPACITY OR GENERATION AS OF END-2014

	1	2	3	4	5
POWER					
Renewable power (incl. hydro)	**China**	United States	Brazil	Germany	Canada
Renewable power (not incl. hydro)	**China**	United States	Germany	Spain / Italy	Japan / India
Renewable power capacity *per capita* (among top 20, not including hydro[3])	**Denmark**	Germany	Sweden	Spain	Portugal
Biopower generation	**United States**	Germany	China	Brazil	Japan
Geothermal power capacity	**United States**	Philippines	Indonesia	Mexico	New Zealand
Hydropower capacity[4]	**China**	Brazil	United States	Canada	Russia
Hydropower generation[4]	**China**	Brazil	Canada	United States	Russia
Concentrating solar thermal power (CSP)	**Spain**	United States	India	United Arab Emirates	Algeria
Solar PV capacity	**Germany**	China	Japan	Italy	United States
Solar PV capacity *per capita*	**Germany**	Italy	Belgium	Greece	Czech Republic
Wind power capacity	**China**	United States	Germany	Spain	India
Wind power capacity *per capita*	**Denmark**	Sweden	Germany	Spain	Ireland

Source: Renewable Energy Policy Network for the 21st Century

Figure 3: Top Five Countries in Annual Investment/Net Capacity Addition/Production in Renewable Energy in 2014[11]

TOP FIVE COUNTRIES

ANNUAL INVESTMENT / NET CAPACITY ADDITIONS / PRODUCTION IN 2014

	1	2	3	4	5
Investment in renewable power and fuels (not including hydro > 50 MW)	**China**	United States	Japan	United Kingdom	Germany
Investment in renewable power and fuels per unit GDP	**Burundi**	Kenya	Honduras	Jordan	Uruguay
Geothermal power capacity	**Kenya**	Turkey	Indonesia	Philippines	Italy
Hydropower capacity	**China**	Brazil	Canada	Turkey	India
Solar PV capacity	**China**	Japan	United States	United Kingdom	Germany
CSP capacity	**United States**	India	–	–	–
Wind power capacity	**China**	Germany	United States	Brazil	India
Solar water heating capacity	**China**	Turkey	Brazil	India	Germany
Biodiesel production	**United States**	Brazil	Germany	Indonesia	Argentina
Fuel ethanol production	**United States**	Brazil	China	Canada	Thailand

Source: Renewable Energy Policy Network for the 21st Century

Figure 4: Top Countries in Clean Energy Investment in 2014[13]

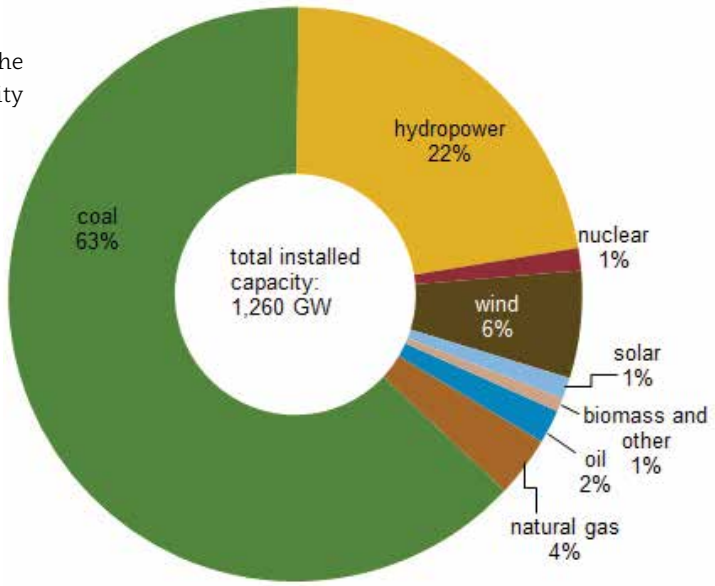
Clean energy investment by country				
Country	2014 ($bn)	Country	2004-2014 ($bn)	Total Installed capacity (MW)
China	89.491	US	447.642	121,660
US	51.770	China	427.617	224,788
Japan	41.342	Germany	244.949	86,946
Germany	15.299	Japan	189.188	32,679
UK	15.229	Italy	103.436	8,774
Canada	8.971	UK	101.030	23,346
India	7.937	Spain	100.038	23,014
Brazil	7.864	Brazil	78.943	22,852
France	7.017	India	72.828	36,753
Netherlands	6.727	France	56.931	9,194

Source: Bloomberg New Energy Finance, Global Data

Conventional Renewable Energy in China

This section introduces the development of China's conventional renewable energy, such as hydropower, wind energy, solar energy, and biomass. The following three figures illustrate China's installed electricity capacity share by fuel, including renewable energy, at the end of 2013 and China's comparative renewable electricity capacity by 2014.

Figure 5: China's Installed Electricity Capacity Share by Fuel, End 2013[14]

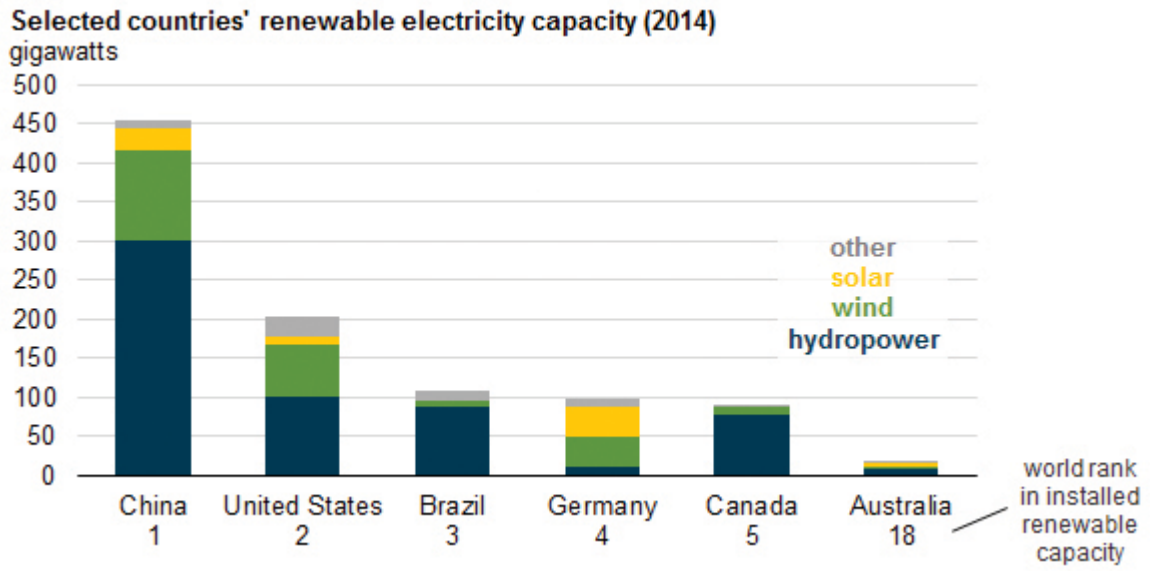


Source: U.S. Energy Administration Agency (EIA)

[13] "Clean Energy Investment", *Bloomberg New Energy Finance*, http://www.bloomberg.com/company/clean-energy-investment/

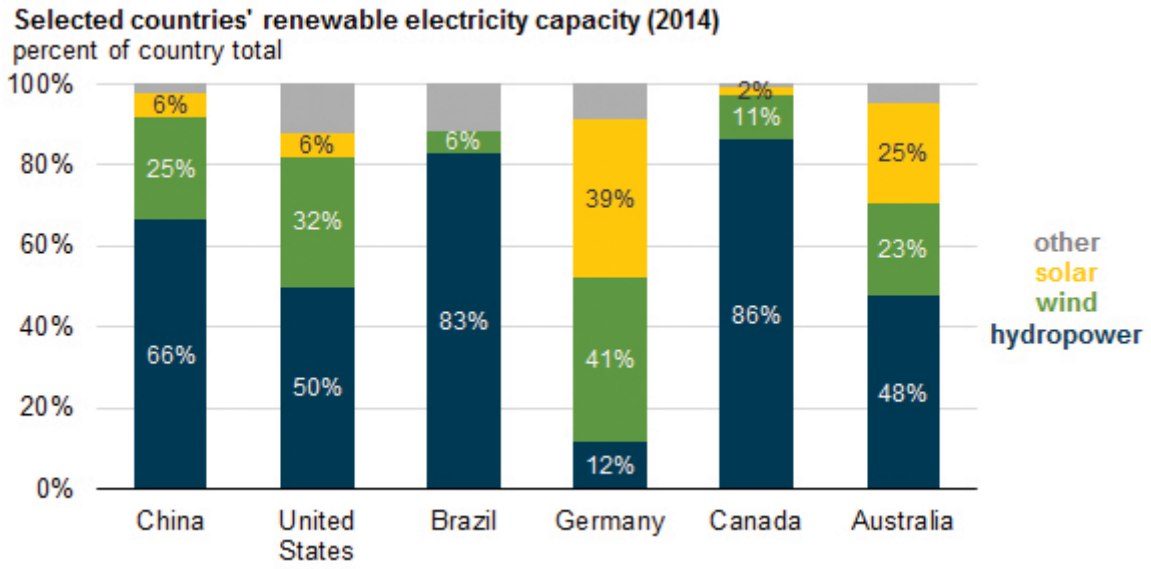
[14] "Electricity of China", *U.S. Energy Administration Agency (EIA)*, May 14, 2015, https://www.eia.gov/beta/international/analysis.cfm?iso=CHN

Figure 6: Selected Countries' Renewable Electricity Capacity (2014)[15]



Source: International Renewable Energy Agency (IREA)

Figure 7: Selected Countries' Renewable Electricity Capacity (2014)[16]



Source: International Renewable Energy Agency (IREA)

[15] "Renewable Energy Capacity Statistics 2015, *International Renewable Energy Agency* (*IREA*), http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Capacity_Statistics_2015.pdf; "Australia Shifts Investment from Wind Projects to Other Renewable Sources", *U.S. Energy Administration Agency* (*IEA*), August 20, 2015, https://www.eia.gov/todayinenergy/detail.cfm?id=22592

[16] "Renewable Energy Capacity Statistics 2015, *International Renewable Energy Agency* (*IREA*), http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Capacity_Statistics_2015.pdf; "Australia Shifts Investment from Wind Projects to Other Renewable Sources", *U.S. Energy Administration Agency* (*IEA*), August 20, 2015, https://www.eia.gov/todayinenergy/detail.cfm?id=22592

Figure 8 describes China's official deployment, targets and shares for conventional renewable energy, including hydropower, wind, solar and biomass by 2020.

Figure 8: China's Official Deployment, Targets and Shares for Renewable Energy[17]

	Cumulative					Annual Addition			
	2012	2013	2014	2015	2020	2013	2014	2015	5-yr aver ('15-'20)
	Gigawatts								
Hydro	212	233	261	289	430	21	28	28	28
Wind	48	66	83	100	200	18	17	17	20
Solar	3	13	24	35	50	10	11	11	3
Biomass	7	7	10	13	30	0	3	3	3
Total	270	319	378	437	710	49	59	59	55
	Share (%)								
Hydro	78%	73%	69%	66.1%	60.6%	42.9%	47.5%	47.5%	51.6%
Wind	17.8%	20.7%	22.0%	22.9%	28.2%	36.7%	28.8%	28.8%	36.6%
Solar	1.1%	4.1%	6.3%	8.0%	7.0%	20.4%	18.6%	18.6%	5.5%
Biomass	12.6%	2.2%	2.6%	3.0%	4.2%	0.0%	5.1%	5.1%	6.2%

Source: World Resource Institute

HYDROPOWER

China is the world's largest hydropower producer, with 856 terawatt-hours of electricity production by 2012. According to the "Renewables 2012 Global Status Report", China's hydropower capacity exceeds that of Brazil, the United States and Canada combined. By 2015, China's hydro power installations are targeted to reach around 325 GW, and with a newly revised target of 430 GW (up from 380 GW) by 2020.[18] Among the world's ten largest hydropower stations that are currently on operation, four of them are located in China. The Three Gorges Dam, completed in 2012, is the world's largest hydroelectric facility in terms of installed capacity (22,500 MW). Hydropower is China's second largest energy source only after coal and is the most widely used form of renewable energy. In 2013, hydropower accounted for about 16.9 percent of China's electricity source and China will continue to increase its hydropower capacity, aiming to achieve its ambitious targets of 350 GW from hydropower and 70 GW from pumped storage by 2020 and 510 GW from hydropower and 150 GW from pumped storage by 2050.[19]

It is generally believed that hydropower energy will continue to be China's dominant source of renewable energy for electricity generation in the foreseeable future. However, some scholars think that China's hydropower development has passed its peak for two reasons. First, hydropower was previously believed to possess evident advantages, for instance, flood control, enhanced irrigation and navigation, as well as China's endowment in many rivers and mountains. Thus hydropower had been utilized much more fully than other forms of renewable energy. However, most of China's current hydropower projects are located in Central and

[17] "Why Is China Taking Action on Clean Energy and Climate Change?" *World Resources Institute ChinaFAQs Issue Brief*, May 2013, page 4; Iacob Koch-Weser and Ethan Meick, "China Wind and Solar Sector: Tends in Deployment, Manufacturing and Energy Policy", *US-China Economic and Security Review Commission Staff Research Paper*, March 9, 2015, page 16.

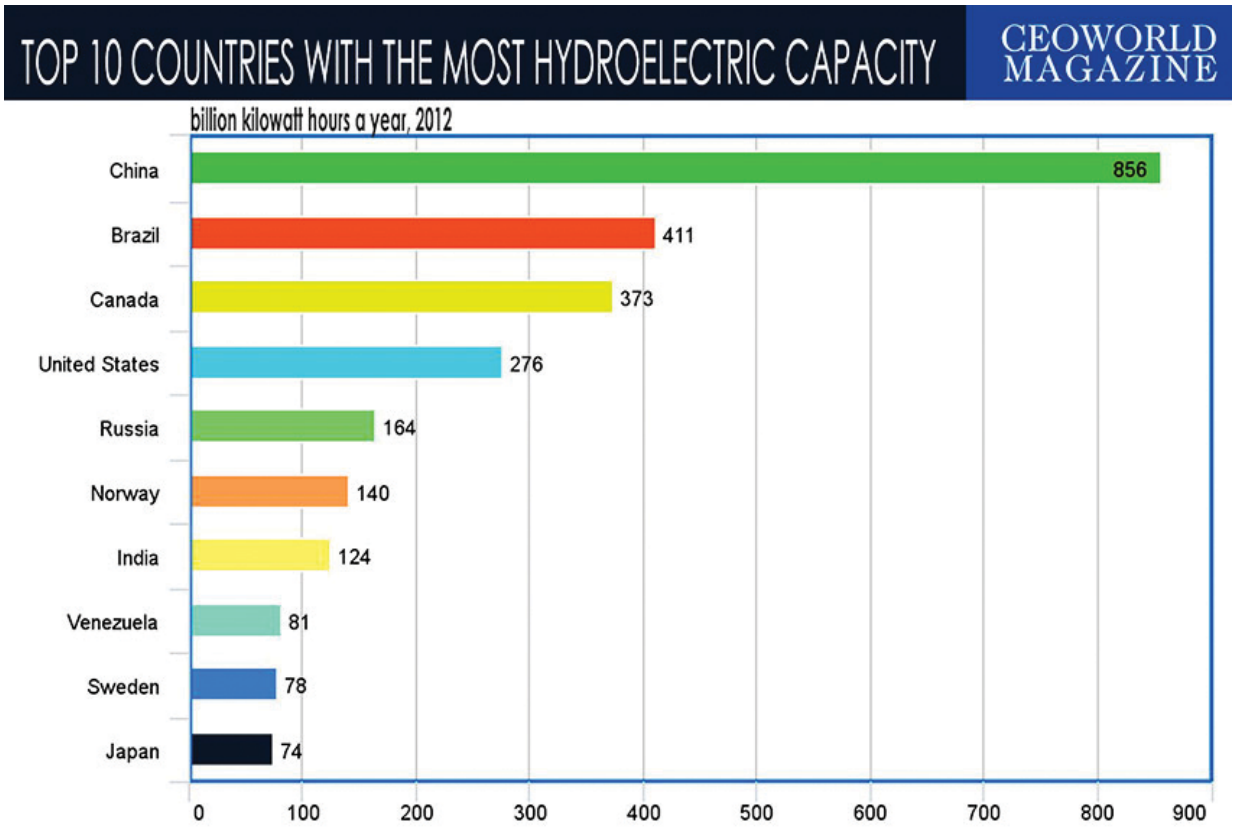
[18] "Hydropower in China", *Ecology*, March 28, 2013, http://www.ecology.com/2013/03/28/hydro-power-in-china/

[19] "China Statistics", *International Hydropower Association*, https://www.hydropower.org/country-profiles/china

Southwestern China. With the completion of major hydropower projects, China now has to seek remote areas for new hydropower projects, which entail more geographical and technical challenges. In 2014, about 80% of the additional capacity was installed in remote regions of Sichuan and Yunnan in the southwest.

Second, there is more public discontent regarding the environmental, ecological and social consequences of building dams. The Three Gorges Dam has been a controversial topic domestically and internationally since the 1990s. Some studies indicate that China's investment in hydropower will decline after 2020.[20] When developing new hydropower projects in the future, more attention will be paid to assessing their overall environmental impact involving green eco-systems, irrigation and drainage works and on-farming systems, agricultural support and services, forestry and wildlife. The Central government has begun to direct the development of hydropower in order for China to become more environmentally and socially sustainable.

Figure 9: Top Countries with the Most Hydroelectric Capacity[21]



Source: U.S. Energy Administration Agency (EIA)

[20] "China's Shift to Clean Energy", *European Parliament*, Brief May 2015, page 7; "Hydro Power in China", *Ecology Global Network*, March 28, 2013, http://www.ecology.com/2013/03/28/hydro-power-in-china

[21] "Top 10 Countries that Produce Most Electricity", *Geoworld Magazine*, October 14, 2015, http://ceoworld.biz/2015/10/14/top-10-countries-that-produce-the-most-hydroelectricity

WIND POWER

Wind is China's second largest source of renewable energy power and China has the world's fastest growing market in wind energy. The rapid development of China's wind energy industry was primarily encouraged by governments' fiscal and tax incentive policies. In 2006, the National Development and Reform Commission (NDRC) approved the construction of the five largest wind farms, all of which require a minimum capacity of 100 MW. In the same year, the first Renewable Energy Law went into effect, meaning power grid companies were required to sign a grid connection agreement with the wind power generating company and purchase the full amount of wind power generated by it. The Global Wind Energy Council (GWC) reported that the wind market in China grew by 45% in 2014, with an impressive 23 GW of new wind power installed. In 2014, China's wind power generation capacity reached 114.6 GW and generated 153.4 TWh of electricity, 2.78% of total national electricity consumption; in 2016, it reached 145 GW. China will install an estimated 23 to 25 GW output of wind energy, accounting for nearly half of all global wind installations. Wind power has overtaken nuclear power in China.[22] According to a report by Global Data 2015 forecast, China's installed wind capacity will grow to 347.2 GW by 2025, with annual installations peaking at 56.8 GW in 2022.[23]

Figure 10: Top Countries in Wind Energy Capacity by 2014[24]

Wind Energy Worldwide

Top 12 Countries by Total Wind Installations

Position 2013	Country/Region	Total Capacity End 2014 ** [MW]	Added Capacity 2014 *** [MW]	Growth Rate 2014 [%]
1	China	114,763	23,350.0	25.7
2	USA	65,879	4,854.0	7.8
3	Germany	40,468	5,808.0	16.8
4	Spain	22,987	27.5	0.1
5	India	22,465	2,315.1	11.5
6	United Kingdom	11,998	1,467.0	13.9
7	Canada	9,694	1,871.0	25.9
8	France	9,296	1,042.0	12.6
9	Italy	8,663	107.5	1.3
10	Brazil	6,182	2,783.0	81.9
11	Sweden	5,425	1,050.0	21.4
12	Denmark *	4,850	78.0	1.6
	Rest of the World	47,300	7,000 (estimated)	16.0
	Total	**370,000**	**51,753**	**16.2**

* by November 2014
** Includes all installed wind capacity, connected and not-connected to the grid.
*** Includes the net capacity added during the year 2014.

Source: Global Wind Energy Council

[22] "Wind power has taken China by storm", *Sun and Wind Energy*, http://www.sunwindenergy.com/wind-energy/wind-power-taken-china-storm

[23] Joshua S. Hill, "China's Wind Energy Capacity to Triple by 2020, Says GlobalData", *Clean Technica*, September 22, 2015, http://cleantechnica.com/2015/09/22/chinas-wind-energy-capacity-triple-2020-globaldata/

China's wind energy has a number of challenges. First, China's wind power resource is concentrated in three northern areas (Northeast China, North China and Northwest China), but the development of China's electricity grid has lagged behind the rapid expansion of wind projects. Many wind farms were built in remote areas without grid connections and there are substantial challenges in electricity grid infrastructure connecting these regions, which are rich in wind energy, with eastern regions, which are the main consumers of electricity. China has planned to increase dramatically investment in its transmission technology to keep pace with the development of wind energy.

Second, coal is cheap and abundant in China, while the wind power industry in China still heavily relies on governments' subsidies and supportive policies. However, it is true that wind energy has moved from a marginal option for electricity sourcing to a more affordable renewable energy. The average cost of onshore wind has fallen from $135 per MWh in 2009 to $59 in 2014, a 56% drop in five years.[25] It is believed that the costs of wind energy will continue to decrease steadily in the near future.[26]

Third, it is believed that China's offshore wind energy has great potential, but it faces challenges such as high costs, technical problems, a lack of skillful installers, and issues concerning jurisdiction over maritime areas. The EIA estimates new offshore wind farms coming online in 2019 will cost $204.10 per MWh – over three times the price of conventional gas-fired power.[27] In 2014, China added a total of 61 offshore wind power units, with a total capacity of 229.3 MW, marking an increase of 487.9% compared to the 39 MW of new offshore wind power capacity added in 2013.[28] It is estimated that China's offshore wind power potential is more than 750 million kW/h, more than twice the estimate of exploited onshore wind energy in China.[29]

SOLAR POWER (PHOTOVOLTAIC AND SOLAR THERMAL POWER)

Although it had a slow start, China has made significant progress in solar energy (photovoltaic – PV) within a few years. Since 2007, China has become the world's largest manufacturer and exporter of solar panels. The early development of the PV industry was primarily driven by overseas demand – about 95% of China's manufactured solar panels in 2008 were exported. With declining international demand after the global financial crisis, the Chinese PV industry has moved from a focus on exports to meeting domestic demand. In 2013, the Chinese government introduced new feed-in tariffs at both state and provincial levels, along with a series of solar subsidized policies. As a result, China's domestic installations of solar panels have been rising steadily, from 2.5 GW in 2011 to 5 GW in 2012, then to 11.3 GW in 2013 and to 10.6 GW in 2014. Qinghai province, which contains the city of Golmud, leads China in installation.[30]

Since 2015, China has overtaken Germany to become the world's leading country in terms of solar photovoltaic (PV) capacity. China Photovoltaic Industry Association (CPIA) data showed that China had added 15 GW of solar PV capacity in 2015, a 40-percent increase from 2014 data, which brought the country's total solar PV capacity to 43 GW, surpassing Germany's total PV capacity of about 40 GW. China has raised targets with the goal to install 20 GW annual of solar capacity from 2016 through 2020. Dong Xiufen, Director of New Energy for the National Energy Administration, revealed that China's solar capacity would reach 150 GW by 2020.[31] The following three figures show the top ten countries in solar installation in 2014, top ten countries in solar capacity by 2014 and top solar markets in 2015.

[24] "New Record in Worldwide Wind Installation", *World Wind Association,* February 5, 2015, http://www.wwindea.org/new-record-in-worldwide-wind-installations/

[25] "Comparing the Costs of Renewable and Conventional Energy Sources", *Energy Innovation*, February 7,2015, http://energyinnovation.org/2015/02/07/levelized-cost-of-energy/

[26] "Wind Energy Economics", *Wind Energy Foundation,* http://windenergyfoundation.org/about-wind-energy/economics/

[27] "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014", *the U.S. Energy Information Administration,* April 17, 2014, https://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf

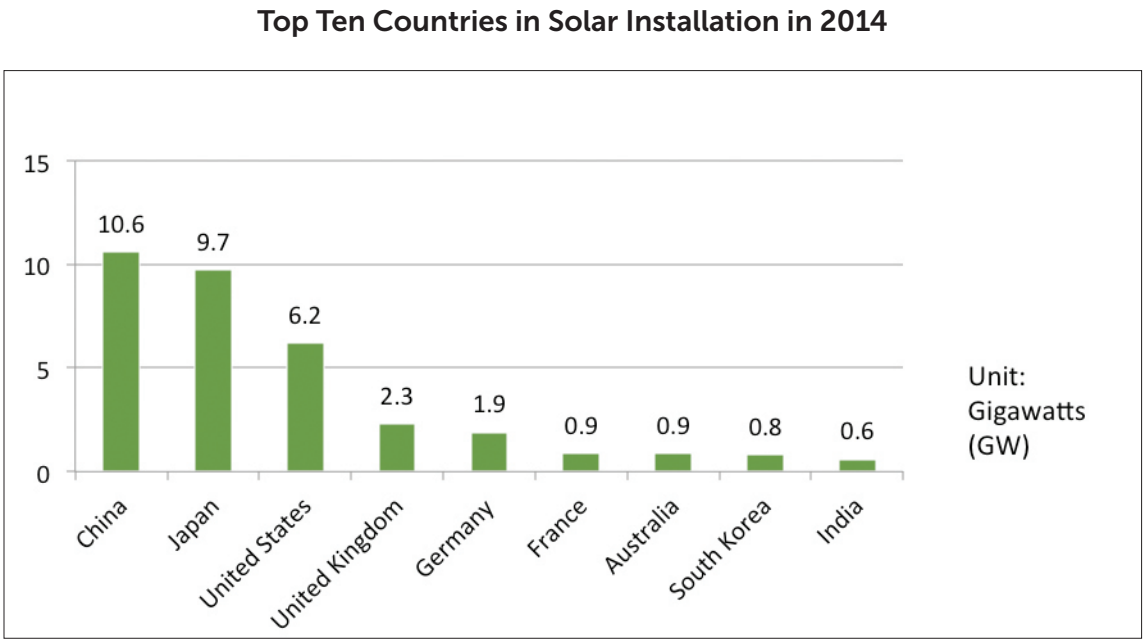
[28] Marc Howe, "China's Offshore Wind Growth Surges 487.9%", *Clean Energy,* April 1, 2015, http://cleantechnica.com/2015/04/01/chinas-offshore-wind-growth-surges-487-9/

[29] Richard J. Campbell, "China and the United States: A Comparison of Green Energy Programs and Policies", *Congressional Research Service,* April 30, 2014, page 13.

[30] "Qinghai leads in photovoltaic power", *China Daily,* March 3, 2012, http://europe.chinadaily.com.cn/business/2012-03/02/content_14744513.htm

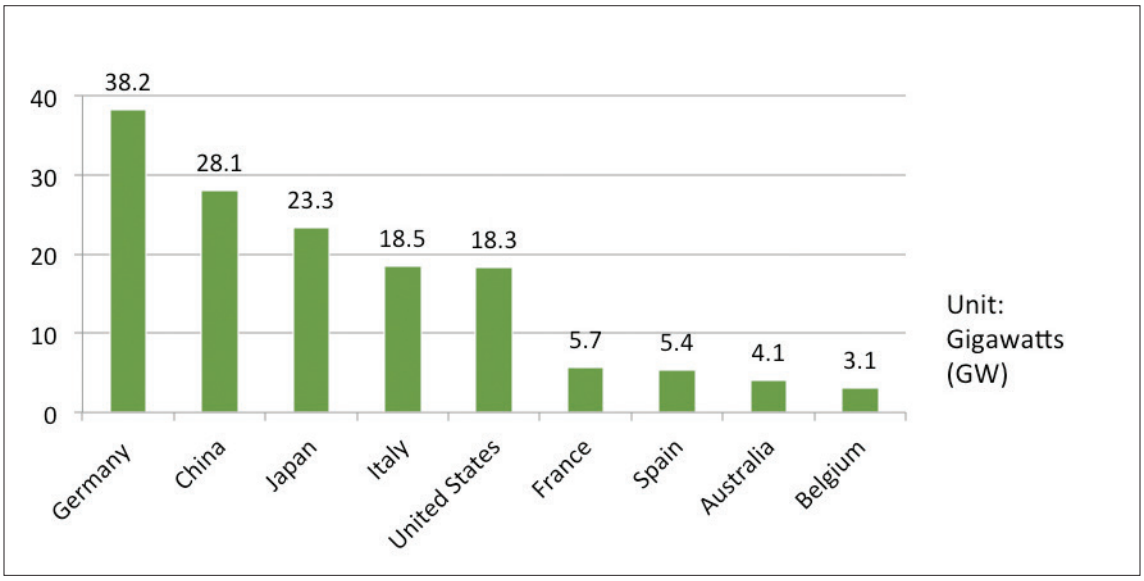
[31] Alex Nussbaum, "Chinese Solar to Jump Fourfold by 2020, Official Told Xinhua", *Renewable Energy.com,* October 14, 2015, http://www.renewableenergyworld.com/articles/2015/10/chinese-solar-to-jump-fourfold-by-2020-official-tells-xinhua.html

Figure 11: Top Ten Countries in Solar Installation in 2014 [32]



Source: Solar Power Europe

Figure 12: Top Ten Countries in Solar Capacity by 2014[33]

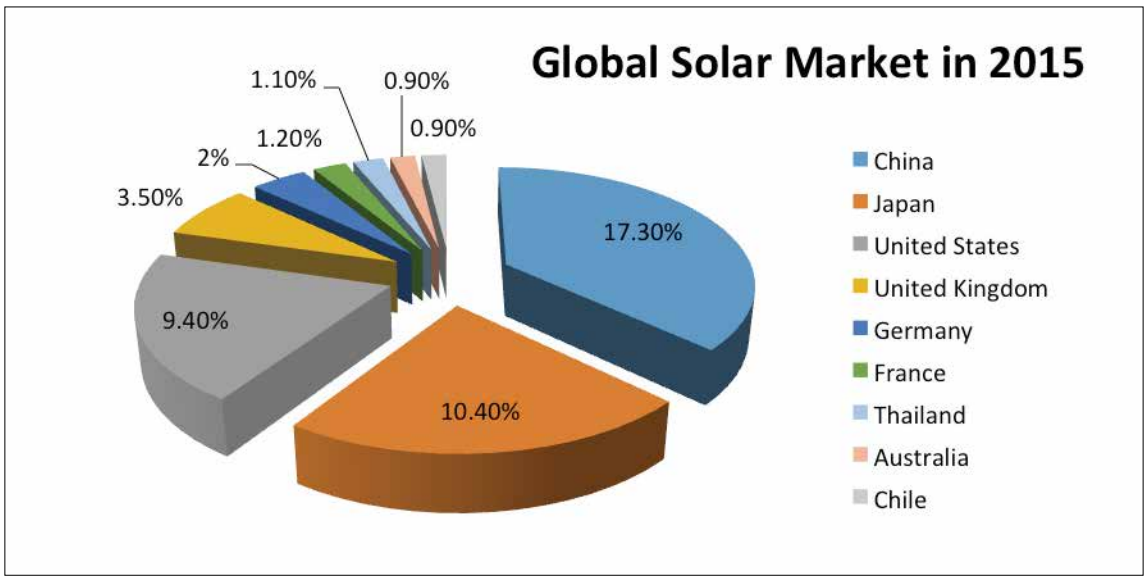


Source: Solar Power Europe

[32] "Global Market Outlook for Solar Power 2015-2019", *Solar Power Europe*,; "Renewable Energy", Powerweb, http://www.fi-powerweb.com/Renewable-Energy.html

[33] "Global Market Outlook for Solar Power 2015-2019", *Solar Power Europe*,; "Renewable Energy", Powerweb, http://www.fi-powerweb.com/Renewable-Energy.html

Figure 13: Top Solar Markets in 2015 [34]



Data Source: Solar Power World, IHS Inc.

China's existing solar industry has three main challenges. First, after rapid expansion, China's solar PV industry now faces problems of overcapacity, low demand, price competition and foreign tariffs. Because of overcapacity and falling prices, many Chinese solar manufacturers have suffered great losses in recent years. Second, grid infrastructure poses substantial challenges, as solar power energy plants have trouble getting fully connected to the grid. Most of China's large-scale utility projects are concentrated in the Northwest, which has lower electricity demand. Project owners have also faced interconnection delays. Third, Chinese firms are behind their Western counterparts in some key solar technologies and R&D. In January 2016, Bloomberg reported that 23% of panels sampled around the country failed to meet China's technical standards. In recent years, Chinese solar companies have been encouraged to engage in outbound investment in order to seek innovative technologies.

[34] Data are from IHS Inc.'s Forecast at Solar Power Energy, April 27, 2015, http://www.solarpowerworldonline.com/2015/04/ihs-releases-industry-update-on-inverters-storage-solar-modules/

BIOENERGY (BIOMASS)

China has experienced a steady growth in the field of bioenergy, particularly in biomass power generation, biogas from methane capture, biomass pellets, and liquid biofuels. China is abundant in biomass resources such as agricultural waste, scraps from forestry, fallen leaves, poultry manure, and industrial and municipal waste, etc. Biomass projects are located throughout China, but with a concentration in eastern regions and about 80% of biomass energy is located in rural China. From 2005 to 2012, China invested a total of 61 billion yuan in its rural biogas programs.[35] According to the 12th Five-Year Plan of renewable energy, the development goal of biomass power generation capacity was determined to be 13 GW over 5 years (2010–2015). [36]

Bioenergy has played only a comparatively minor role in the current development of China's renewable energy. It is estimated that only less than 5% of China's biomass potential has been fully utilized, significantly lower than biomass utilization in the United States or European countries (over 85% in Denmark). From 2004 to 2012, China's biomass industry went through an acceleration of the industrial cycle from rapid growth to gradual progress. Some technological barriers, underinvestment in fuel supply and logistical infrastructure, food security and environmental concerns are among the major factors for this shift.[37]

Statistics show that China's installed capacity of biomass power projects remained at a mere 5.5 GW during the five years between 2006 and 2010. Combined installed biomass power capacity was on track to reach 13 GW by 2015, according to the country's biomass power development program for 2010-2015. In particular, installed capacity of agricultural and forest biomass, biogas and waste incineration power projects is scheduled to reach 8 GW, 2 GW and 3 GW, respectively.[38] Under the 12th Five-Year Plan, the annual utilization of bio-energy will exceed 50 million tons of standard coal equivalent and annual output value will reach RMB 130 billion. The targets for biogas production and liquid bio-fuel utilization are 22 billion cubic meters and 5 million tons respectively, including 4 million tons of ethanol and 1 million tons of biodiesel in 2015.[39]

[35] "The Green Tech Market in China", *EUSMU Centre*, 2014, http://www.eusmecentre.org.cn/report/green-tech-market-china

[36] Xingang Zhang, Zhongfu Tan, Pingkuo Liu, "Development goal of 30 GW for China's biomass power generation: Will it be achieved?", *Renewable and Sustainable Energy Review*, Volume 25, September 2013, Pages 310-317.

[37] Simon Park, "The Status of Biomass Industry in China", *DP Clean Tech*, Nov 4, 2015, http://www.dpcleantech.com/medias/notice-board/biomass-industry-china

[38] Liu Yuanyuan, "Biomass Energy Potential Far From being Fully Exploited by China", *Renewable energy World.com*, October 2, 2015, http://www.renewableenergyworld.com/articles/2015/10/biomass-energy-potential-far-from-being-fully-exploited-in-china.html

[39] Anders Hove, Guo Hong and Oriental Kenzo, "Opportunities for Dutch Clean Energy Company in China", *Azure International*, December 2013, page 33-34.

Other Select Renewable Energy and Clean-Tech Markets in China

NUCLEAR ENERGY

Since 2001, support for nuclear energy has grown substantially in China. In the tenth Five-Year Plan (2001-2005), China established a target for the country's annual nuclear power capacity to grow 30% each year from 2001-05. In early 2008, PRC officials raised their projections for China's installed nuclear capacity to 60 GW and for nuclear power to account for 5% of electricity production by 2020.[40] However, after Japan's Fukushima nuclear incident, China froze new nuclear plan approvals and the target adopted by the State Council in October 2012 became 60 GW by 2020, with 30 GW under construction. In 2015 the target for nuclear capacity in 2030 was set to 150 GW, providing almost 10% of electricity; and 240 GW in 2050, providing 15% of electricity. [41]

As of December 2015, China has 31 nuclear power reactors operating with a capacity of 26.7 GW and 21 reactors under construction with a capacity of 21.1 GW.[42] In 2014, nuclear energy accounted for about 2% of China's electricity, which is significantly lower than nuclear-generated electricity in the developed countries – for instance, 16.8% in Canada, 19.5% in the United States, and 76.9% in France. It is apparent that nuclear energy will be a rapidly growing portion of China's energy mix. China plans to build around 40 domestic nuclear plants from 2016 to 2020. By 2020, nuclear energy will contribute about 6% of China's electricity. [43] In recent years, China has been very active in working with foreign companies on nuclear projects. Now, China is using cutting edge AP1000 reactors designed by Westinghouse and other foreign suppliers. The World Nuclear Association believes that China has shown "unprecedented eagerness to achieve the world's best standards in nuclear energy".[44]

CLEAN COAL TECHNOLOGY

Clean coal technology refers to the collection of technologies designed to mitigate the environmental impact of coal energy generation. As coal will still play a major, though receding, role in China's energy mix in the foreseeable future, how to use coal more cleanly is essential for China to reduce carbon emissions. It is predicted that coal will still account for about 55% of China's energy consumption before 2030. Clean coal technologies currently being developed in China include high efficiency combustion and advanced power generation, coal transformation, integrated gasification combined cycle and carbon capture, utilization and storage technologies.[45]

Starting in the mid-2000s, China has made steady progress in clean coal technologies. In 2006, the first 100MW ultra-supercritical unit was established in Yuhuan, Jiangsu province. From 2009 to 2012, several demonstration pilot plants and commercial prototypes were built to improve key technologies, including tougher emission standards for coal-fired power plants. China is the first to achieve large scale industrialization in direct coal liquefaction and coal to olefins. China has reached advanced levels in key coal technologies, catalysts, equipment, systemic technologies, and engineering technologies for coal to liquids, and coal to chemicals.[46] The government has installed technologies such as electrostatic precipitators and baghouses to remove particulates and flue-gas desulfurization (scrubbers) to carry out sulfur dioxide capture. In China's 12th special clean coal plan (2010-2015), four focuses of clean coal technologies were emphasized: advanced coal-based power generation, technological development to generate clean fuels based on coal, post emissions reduction treatment and industrial energy efficiency, especially in the iron and steel sector.[47]

[40] Ryan Ong, "A Boost for Nuclear Power", *China Business Review*, May 1, 2010.

[41] "Nuclear Power in China", *World Nuclear Association*, March 7, 2016, http://world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[42] "Power Reactor Information System: China", *International Atomic Energy Agency*, https://www.iaea.org/pris/CountryStatistics/CountryDetails.aspx?current=CN

[43] Richard L. Ottinger, *Renewable Energy Law and Development*,

Jon Stone, "China to Build about 40 Nuclear Power Plants over the Next Five Years", *Independent*, January 4, 2016, http://www.independent.co.uk/news/uk/politics/china-to-build-40-nuclear-power-plants-over-the-next-five-years-a6795401.html

[44] "Nuclear Power in China", *World Nuclear Association*, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[45] "Clean Coal Technology", *International Trade Administration of the United States of America*, December 10, 2014, http://export.gov/china/doingbizinchina/leadingsectors/eg_cn_081021.asp

[46] Ren Xiangkun, "Status and Cooperation Prospect for Coal/NG Chemical and CCUS Technology between US and China", Presentation at *US Energy Association*, October 28, 2014, https://www.usea.org/event/clean-coal-technologies-development-china

[47] Xu Tang, Simon Snowden, Benjamin C. McLellan, Mikael Hook, "Clean Coal Use in China: Challenges and Policy Implications", *Energy Policy*, 87 (2015), pages 517-523.

In spite of many successes, China still has two major challenges facing clean coal technologies. First, a set of specific laws, detailed implementation and supervision policies in governing the clean coal industry are in great need of being formulated. In the US and Europe, environmental regulations concerning standards for environmental control and provisions for criminal sanctions against noncompliance are clearly stated. However, China's coal-related laws lack mandatory requirements and an effective government supervision mechanism in the coal industry. Because China has abundant cheap coal, with low legal liability, local enterprises are reluctant to implement strict clean coal policies due to their own interests. As coal mines are divided into three levels of ownership (state/local state/township and village) in China, conflicting interests among them result in no coherent arrangement for clean coal use.

Second, China's clean coal technologies still have significant room for technological improvement, which requires more cooperation with international companies. In recent years, China and the US have taken major steps to advance clean coal technologies. The agreement between the US Department of Energy and China's National Energy Administration has allowed the two nations to share their results in the study of advanced coal technologies.[48]

GREEN VEHICLES (NEW ENERGY VEHICLES)

China is the world's largest manufacturer and sales market for automobiles. China's rapid growth of automobile sales has profound implications for energy consumption, urban transportation, and the environment. Since 2009, the Chinese government has implemented a series of preferential policies with subsidies to encourage the development of new energy vehicles. In 2009, China launched a new energy pilot project, "10 cities and 1000 vehicles," in four ministries. New energy vehicles were listed by the State Council as being among seven strategic emerging industries addressed in the 12th Five-Year Plan. In 2014, President Xi Jinping stressed the importance of developing new energy vehicles and the government implemented many policies to promote the purchase of new energy vehicles through incentives. In recent years, China has begun to take a global lead in both manufacturing and sales of new energy vehicles. By the end of 2015, China has surpassed the United States to be the world's largest market for all-electric and hybrid vehicles. In 2015, Chinese manufacturers produced 340,471 all-electric and plug-in hybrid vehicles (cars, buses and trucks) and sold 331,092.[49] In 2015, new energy vehicles made up 1.5% of China's total output of vehicles (24.5033 million units), jumping by 400% from 2014.[50]

Lately, China has begun to address two main challenges facing its new energy vehicle industry. First, the recent boom of the industry has been heavily dependent on government subsidies and policies. The majority of China's electric cars are low-end models with government subsidy support covering around two-thirds of the car's price. In Shanghai, many people purchase plug-in hybrid cars only because it is extremely difficult and expensive to get a license plate for a conventionally-fuelled car. For the healthy development of China's new energy vehicles in a long term, it is necessary to take steps to boost technological innovation through market competition. The Chinese government will cut 2017-2018 subsidies by 20% from those granted in 2016, and 2019-2020 subsidies will be 40% less than this year's.

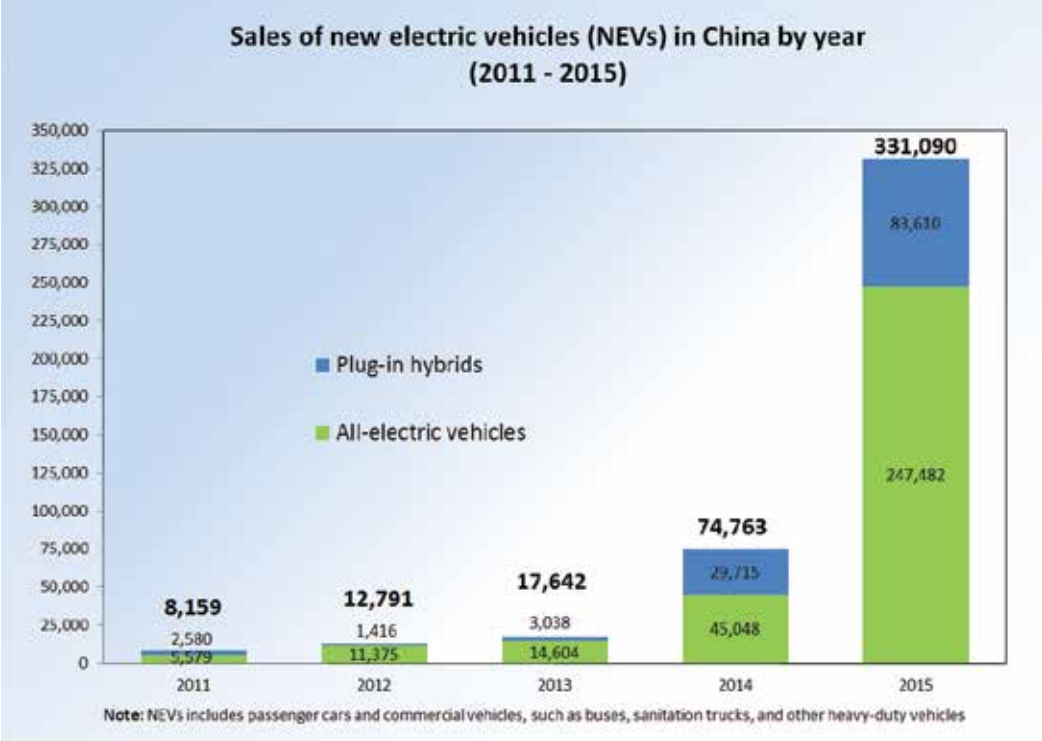
[48] "Advanced Coal Technology", *US-China Clean Energy Research Center*, http://www.us-china-cerc.org/Advanced_Coal_Technology.html

[49] "China Plans to End New Energy Vehicle Subsidies after 2020", *Bloomberg News*, January 23, 2016, http://www.bloomberg.com/news/articles/2016-01-23/china-plans-to-end-new-energy-vehicles-subsidies-after-2020

[50] "China EV Charging Station and Charging Pile Market Report, 2016-2020", *PR Newswire*, February 2016, http://www.prnewswire.com/news-releases/china-ev-charging-station-and-charging-pile-market-report-2016-2020-300216712.html

Second, China's supporting facilities have fallen short of the growing demand of new energy vehicles. Electric cars are still limited by speed and range and many customers complain of problems such as not enough electric charge stations, poor charging services, long charge times, battery replacement issues, etc. In order to promote new energy vehicles, China announced plans to build 12,000 centralized charging/battery swap stations and 4.8 million scattered charging piles across the country by 2020. In the latest Five-Year Plan (2016-2020), the Chinese government reaffirmed its priority to promote electric vehicles.

Figure 14: Sales of New Electric Vehicles in China (2011-2015)[51]



Source: Society of Motor Manufacturing and Traders

[51] Mario Roberto Durán Ortiz, " PEV Registrations China from 2011", January 21, 2016. Data from *China Association of Automobile Manufacturers, cars21.com, Spanish Reve* (*Wind and Electric Vehicle Magazine*).

OPPORTUNITIES AND CHALLENGES

Emerging Clean-Tech Sectors in China

China now is the world's largest and one of the most dynamic markets in many sectors of renewable energy and clean technologies. It offers significant opportunities for Albertan firms that are specialized in renewable energy and clean technologies. The following section introduces some emerging clean-tech industrial sectors, such as waste-to-energy (waste management), recycling, green building, small grid and energy storage that may present business opportunities for Albertan entrepreneurs in the future.

WASTE-TO-ENERGY AND WASTE MANAGEMENT

Municipal solid waste (MSW) is listed by the United States Environmental Protection Agency as a renewable energy source. MSW refers to the collection and disposal of urban waste, waste that consists mainly of paper, food, wood, garden, cotton and leather waste, as well some fossil fuel materials, such as plastics and fabrics.[52] Because of China's rapid industrialization, urbanization and the improvement of people's living standards, urban waste disposal problem has become a huge challenge for the Chinese authorities. According to the China Environmental Development Report, China's annual waste disposal capacity growth rate has surpassed 10%. China produces approximately 210 million tons of waste every year.[53] It is estimated that China's MSW will reach around 323 million tons by 2020 and 480 million tons by 2030.[54]

China has surpassed the United States as the largest MSW generator, but more than 400 Chinese large- and medium-sized cities now are confronting serious waste management problems. State investigations in China's 47 key cities indicate that national landfills are commonly subject to leakage and their operating conditions and secondary emissions do not meet national standards.[55] From 2011 to 2015, China's waste incineration sector has grown rapidly, with waste to energy plants that are either operational or under construction numbering over 300 by the end of 2015, when China's annual solid waste incineration capacity reached 100 million tons.[56] The world's largest waste to energy plant will be built in the outskirt of Shenzhen, which will have the incineration capacity to handle 5,000 tons of waste a day.[57]

There are still several barriers in China's waste-to-energy market. First, because many Chinese cities have high population densities with shortages of land, it is extremely difficult to find suitable locations for waste-to-energy facilities in big cities. At present, China's waste-to-energy rate is only around 30%. Second, after the process of high temperature incineration, the waste-to-energy process greatly reduces the harmful components of municipal solid waste, but the Chinese public generally doubts the safety of today's incineration facilities. In China, there have been a number of sensational protests against incineration plants by local residents in recent years. Foreign advanced equipment is very expensive, but it does not necessarily provide better performance in China because of issues of poor waste classification, high organic waste composition and moisture content. China's domestic waste-to-energy equipment is cheap, but they are largely built with lower environmental standards, leading to complaints from nearby residents.

[52] Dongliang Zhang, Guangqing Huang, Yimin Xu, and Qinghua Gong, "Waste-to-Energy in China: Key Challenges and Opportunities", *Energies*, 2015, 8, 14182-14196.

[53] J.Q. Liu, "China Environmental Development Report 2013", *Social Sciences Academic Press:Beijing, China*, 2013; F. Chen, "The influence of waste incineration with electricity generation on environment in China, Chemical Enterprise Management", 2014, 28, pages 90–93.

[54] N. Yang, H. Zhang, M. Chen, L. Shao, P. He, "Greenhouse Gas Emissions from MSW Incineration in China: Impacts of Waste Characteristics and Energy Recovery, *Waste Management*, 2012, 32, 2552-2560.

[55] Dongliang Zhang, Guangqing Huang, Yimin Xu, and Qinghua Gong, "Waste-to-Energy in China: Key Challenges and Opportunities", *Energies*, 2015, 8, 14182-14196.

[56] Liu Yuanyuan, "Chinese Waste to Energy Market Experiences Rapid Growth during Last Five Years", *Renewable Energy World.com*, April 28, 2015, http://www.renewableenergyworld.com/articles/2015/04/chinese-waste-to-energy-market-experiences-rapid-growth-during-last-five-years.html

[57] Karissa Rosenfield, "6 Compete to Design World's Largest Waste-to-Energy Plant in Shenzhen", *Arch Daily*, November 2, 2015, http://www.archdaily.com/776429/6-compete-to-design-worlds-largest-waste-to-energy-plant-in-shenzhen

RECYCLING

In addition to the booming industrial sectors of waste-to-energy, wastewater and sewage management, China also has risen to become a global operational hub for imported recycling materials. Today, China is the world's largest importing country in recyclable waste materials such as paper, plastic, steel and cooper. According to the United Nations Statistics Division in 2012, scrap and waste were China's biggest import from the United States. The United Kingdom (UK) exports approximately 70% of domestic plastic waste and nearly 90%of these exports end up in China. During the past decade, imports of recyclable waste materials from the UK by China have increased more than ten times.[58] In total, China receives about 56% (by weight) of the global imports of plastic, and Europe is significantly dependant on China when exporting European plastic waste.[59]

Before 2006, China's recycling industry simply responded to market demand and most recycling factories, especially in plastic, were medium- and small-sized. After 2006, the Chinese government began to take measures to regulate recycling processes such as water treatment and air emissions. In 2008, China adopted the Circular Economy Promotion Law to boost the recycling economy. At present, there are more than 20 large recycling parks in China, the largest being the Tianjin Ziya Circular Economy Industrial Area that was built in 2006. Said area is a national ranked electric product recycling and dismantling treatment demonstration base. The town of Guiyu in Guangdong province has the world's largest recycling center for e-waste, which has nearly 5000 workshops processing used hard drives, cell phones, computer screens and other electronic parts from around the world.

The development of China's recycling industry has two top challenges. First, there are growing concerns regarding China's lack of efficient law enforcement and environmental control capacity in the recycling industry. Technical and academic communities have expressed concerns over health and environmental implications of China's recycling industry, for instance, health and safety risks for recycling workers and potentially polluted materials being transported to China, among others. In February 2013, China imposed the Green Fence Policy to prevent the imports of contaminated shipments, which set a limit of 1.5% of allowable contaminant in recycle materials. In 2014, China made efforts to eliminate illegal reprocessing operations without licenses. Second, because of rising labour costs and living standards in China as well as falling commodity prices in the global market, China's recycling business has suffered. Today, China's recycling industry is still primarily labour-intensive, with heavy reliance on inefficient manual sorting. In the future, more automated sorting, a better working environment, and more health and environmental controls will boost the development of China's recycling industry.

[58] Ashish Chaturvedi and Nicole McMurray, "China's Emergence as a Global Recycling Hub – What Does it Mean for Circular Economy Approaches Elsewhere", *IDS Institute of Development Studies*, Evidence Report No.146, September 2015, page 5.

[59] Costas Velis, "Global Recycling Market: Plastic Market", *International Solid Waste Association*, September 2014, https://www.iswa.org/

GREEN BUILDING

The objective of green building is to reduce the impact of buildings on the environment by improving buildings' energy consumption efficiency, conserving natural resources with renewable energy and using environmentally friendly building materials. Buildings are an important contributor to China's energy consumption: according to research by Tsinghua University and Germany's Ministry of Industry and Commerce, energy consumption in buildings comprises 30% of China's primary energy consumption.[60] However, green buildings only make up a very small portion of China's construction industry. At present, China's per capita building energy consumption is among the lowest in the world, only one fifth that of Japan and South Korea and one third that of the EU countries. This low energy consumption is a result of poor living standards, with rising incomes leading to heating and air conditioning becoming common and well-insulated buildings and the greening of China's buildings will become an urgent task.[61]

Since the mid-2000s, the Chinese government has made ambitious plans for green building initiatives. A mandatory energy conservation plan was laid out to require new buildings to be 50-65% more efficient than the basic standard of the 1980s. In 2006, the government issued the first voluntary green building rating system, while by the end of 2013, the number of China's green buildings grew to 2500, totalling over 143 million square meters of gross floor space. In 2013, the State Council issued the Green Building Action, which set the following goals: 20% of all new buildings would be green by 2015; all newly built public buildings and affordable housing financed by the state have to be green certified; and 2-star and 3-star rated buildings will be eligible for state subsidies and local planning priorities.[62] In addition to green building initiatives, China has been pushing to develop more sustainable communities such as green cities (or eco-cities) in recent years, which might greatly influence the future development of China's green buildings. Tianjin hosts the world's largest eco-city, which will house 350,000 people in a low-carbon, green environment around half the size of Manhattan by 2020. Today, more than 100 such eco-projects are planned throughout China's cities.

Figure 15: Top Ten Countries/Regions outside the United States with LEED Certified and LEED Registered Projects in 2015[63]

	Countries	GSM of LEED-certified space (million)	Total GSM of LEED-certified and registered space (millions)	Total number of LEED-certified and registered projects
1	Canada	26.63	63.31	4,814
2	China	21.97	118.34	2,022
3	India	13.24	73.51	1,883
4	Brazil	5.22	24.50	991
5	Republic of Korea	4.81	17.47	279
6	Germany	4.01	8.42	431
7	Taiwan	3.84	9.08	149
8	United Arab Emirates	3.13	53.44	910
9	Turkey	2.95	23.74	477
10	Sweden	2.54	4.20	197
*	United States	276.90	727.34	53,908

Source: United States Green Building Council

[60] Shi Jiang, "Energy Use from China's Buildings 'to Peak in 2020': Study", *China Dialogue*, May 6, 2015, https://www.chinadialogue.net/blog/7956-Energy-use-from-China-s-buildings-to-peak-in-2-2-study/en

[61] Yu Zhou, "State Power and Environmental Initiatives in China: Analyzing China's Green Building Program through an Ecological Modernization Perspective", Geoforum, 61(2015)1-12, page 4.

China's ambitions for green buildings and green cities face several hurdles. First, China still lacks consensus on what constitute green buildings and green cities. Green buildings and green cities require a comprehensive technology that incorporates design, construction and operational practices that use sustainable materials in construction, achieve energy efficiency and water savings and improve indoor air quality, among other measurable targets. There are different standards for green buildings even in the same region, city and level of government in China. The concept is so broad that many provinces have developed their own versions of green buildings. In the meantime, the international Leadership in Energy and Environmental Design (LEED) rating system has been criticized for its insensitivity to China's local conditions.

Second, the majority of China's current green buildings are highly concentrated in the coastal regions and green building materials currently represent only 5% of the total market. In big cities where real estate prices are high, governments find it much easier to force the additional cost of green building requirements. In inland cities, local governments are reluctant to impose strict rules, with a fear of upsetting local real estate markets. As a result, less developed regions have little incentive to push for green building development.

Finally, it is necessary for China to establish a more regulated legal environment for the healthy development of the green building industry. The future successful development of China's green building industry requires enforceable regulations, more transparent governance, credible evaluation processes, robust market-based environments and the collaborative efforts of many stakeholders.

SMART GRID AND ENERGY STORAGE

China is well-positioned to be the world's largest market for smart grid and energy storage. As China's electric power network has already become the world's largest, both in terms of installed generation capacity and produced total electricity capacity, China's grid infrastructure must be quickly upgraded to be compatible with the rapid expansion of China's electricity industry and renewable energy. The massive development of China's renewable energy requires that China's grid infrastructure significantly improve its reliability in terms of communications, information, control technologies and energy storage. For years, China's wind and solar producers have had troubles connecting energy to the grid. In 2015, 9% of the country's solar output was curtailed through the first half of the year due to grid constraints; in Gansu province, 28%of solar generation never made it onto the grid; in Xinjiang province, 19% of solar electricity was cut back; and one-fifth of China's total wind electricity was curtailed in the first three months of 2015.[64]

Smart grid and energy storage technology have huge potential in China. From 2009-2020, the total smart grid investment is expected to reach RMB 3.8 trillion. In the 12th Five-Year Plan, the State Grid Corporation of China will invest RMB 1.6 trillion into grid expansion and upgrades, with RMB 286 billion into smart grid projects.[65] The smart grid investment will be evenly divided between transmission and distribution level projects. 50% of distribution level investment will go towards rural electrification projects.[66] Smart grid project development in China has advanced from Phase One (planning and pilot project: 2009-2010) to Phase Two (comprehensive construction: 2011-2015) into the Phase Three period (leadership: 2016-2020). China aims to lead the world in the management, technology and equipment for a strong smart grid network by 2020.

[62] Yu Zhou, "State Power and Environmental Initiatives in China: Analyzing China's Green Building Program through an Ecological Modernization Perspective", *Geoforum*, 61(2015)1-12, page 4.

[63] "Top Ten Countries for LEED in 2015", *PWC Luxembourg Newsletter*, October 2015, http://newsletter.pwc.lu/newsletter/sustainability/newsletter-oct2015/news-6.html

[64] Stephen Lacey, "Another Reason We Can't Fully Trust China's Solar Installation Numbers", *Greentechmedia*, July 29, 2015, http://www.greentechmedia.com/articles/read/another-reason-we-cant-trust-chinas-solar-installation-numbers

[65] "Social Responsibility Report 2012", Feb 25, 2013, *China State Grid*, www.sgcc.com.cn.

[66] Anders Hove, Guo Hong and Oriental Kenzo, "Opportunities for Dutch Clean Energy Company in China", *Azure International*, December 2013, page 23.

Compared to developed countries, the development of China's energy storage industry began relatively late. Although China has the world's largest grid capacity, China currently only has 4% of worldwide energy storage capacity. As a result, China's energy storage industry has been one of the fastest growing markets in the last several years. In 2014, China's installed capacity of energy storage for their grid system (excluding pumped storage, compressed air storage and thermal storage) accounted for about 10% of the world, up over 50% from 2013; meanwhile , China's development pace was far higher than the global growth rate.[67] In 2014, China installed 31 MW of energy storage with a cumulative total of 84.4 MW of energy storage installation. Currently in China, 74% of the energy storage battery market is in lithium-ion, 17% is in lead acid, and 9% is in flow batteries.[68] In the meantime, China's grid system is mainly controlled by state-owned enterprises such as State Grid. Tight administrative control and current electricity trading practices in China also create hurdles for the rapid development of China's energy storage and smart grid industries.

Opportunities and Challenges for Albertan Firms in China

China is a global leading market in renewable energy and clean technology in the short- and medium-term. As a very large but unique market, China presents three opportunities for Albertan firms.

First, China's strong commitment to a greener future implies large-scale opportunities across a wide range of renewable energy and clean-tech sectors. China's investment, policy supports and subsidies will create potential markets for Albertan firms that intend to engage in foreign trade in or bilateral investment with China in the sectors of renewable energy, clean technology and their relevant services. Joint ventures between Chinese and Albertan firms could result in the rapid development of more affordable clean-tech products and services, benefiting the economies and environments of both China and Alberta.

Second, although China is the world's top investor and consumer in renewable energy and clean technology, China still should be defined as a developing country, or as a country with both developed and under-developed regions. China still lags behind most developed countries in key industrial sectors, especially in terms of innovation, cutting- edge technology, patents, high-tech manufacturing and services. To be sure, every renewable energy and clean technology venture has its own story and unique issue. But to a large extent, China's renewable energy and clean technology sectors are still dominated by labor-intensive manufacturing industries. In clean technology innovation indices, the United States, EU, Japan, South Korea and Germany often are ranked as the top five. Some of China's manufacturers may provide cheaper products for renewable energy; however, those products are often not actually competitive in international markets – they are either strongly dependent on government subsidies or largely based on lower environmental standards with poorer quality. There is still a gap between China and developed countries in terms of technological innovation, the standardization of markets and the sophistication of manufacturing capability. As Alberta has a good record in some of the renewable energy sectors, Albertan firms might find many opportunities in some of China's clean technology sectors highlighted in this report.

Third, in recent years, under the "Go Out" (or "Go Global) development policy, Chinese firms have been encouraged to seek markets, resources and technology overseas. As a part of this picture, China's outbound foreign direct investment has reached renewable energy and clean-tech sectors. Since 2010, China has appeared as one of the world's top investors in overseas renewable energy. For instance, in 2010, Wanxiang group invested USD 12.5 million to build a solar panel plant in Illinois, US; in 2012, Goldwind developed a 20 MW wind farm in Montana

[67] China Energy Storage for Grid System Industry Report, 2015-2018, Research and Markets, September 2015, http://www.researchandmarkets.com/research/k24vc3/china_energy

and Hanergy acquired a California based thin-film solar firm, Miasole, with injected capital; in 2015, the Chinese wind group Envision purchased a controlling stake in a 600 MW wind portfolio from the Mexican government. China's outbound investment in renewable energy has extended far beyond wind and solar industries. Thus it is possible that Alberta and China could find some common ground in bilateral investment in renewable energy and clean-tech markets in the future.

By and large, China is a fast-growing market with huge opportunities in the fields of renewable energy and clean technology. However, a number of challenges faced by foreign firms must be carefully considered before developing business in China. First, as a newly emerging market, China still lacks a unified structure for efficient governance within the renewable energy and clean-tech market. Policies and legal institutions in the field are still in their infancy in China and relevant laws and regulations are still vague and poorly defined, thus more clarity, professionalism and enforceable mechanisms are essential. For foreign investors in China, intellectual property protection is among the top concerns. Many companies still perceive that the lack of efficient intellectual property rights protection is one of the main barriers when investing in China.

Second, China's renewable energy industry also requires a coordinated system with strong support through public participation. Unlike a well-developed civil society found in developed countries, China heavily relies on government policies, bureaucratic channels and financial incentives to implement its development agenda. Due to the lack of information transparency, China's clean-tech market is still far from being mature and public participation remains very low. Large-scale, state-owned enterprises enjoy unequal advantages in terms of their relationship with governments, banks, and accessing contracts. Intensive competition drives prices down, making profit minimal for many enterprises. Under these circumstances, it takes time, finance and human resources for foreign companies to prosper in China's renewable energy and clean-tech industry.

Finally, China is a very large country with great regional disparities, thus regional differences in economic infrastructure, cultures, as well as policy variations among different levels of governments may create formidable obstacles for new foreign investors. It is necessary to keep in mind that China actually is a collection of varied sub-markets that consist of distinctive economic, demographic and cultural characteristics. For instance, electricity prices, tax benefits and development funds for the renewable energy industry are often set locally, leading to confusion for foreign investors. Therefore, for Albertan firms that seek new business access to China, it might be useful to work with a local partner for information, advice and consulting.

THE MAJOR PLAYERS

Major Companies in Renewable Energy and Clean-Tech Industry

This section will introduce major players (domestic and international) in China's renewable energy and clean-tech markets in selected sectors.

HYDROPOWER CORPORATIONS IN CHINA

Some Chinese large hydropower corporations are China Three Gorges Corporation, China Yangtze Power, Sinohydro Corporation, Longtan Hydropower Development, Guangdong Meiyan Hydropower Corporation and Dongfang Electric Corporation. The Three Gorges Project is the world's largest hydropower plant, which is owned and operated by China Three Gorges Corporation. The Xiluodu dam is China's second largest power station and it is operated by China Yangtze Power. The Longtan Hydropower plant is owned and operated by Longtan Hydropower Development, and designed by Hydrochina Zhongnan Engineering and built by Sinohydro Corporation. China's large hydropower corporations are state-owned enterprises, and many Chinese government institutions (such as the State Council) are involved in approving hydropower projects. Said projects are mainly funded by Chinese banks and other financiers (for instance, the World Bank).

Many international companies are also involved in China's hydropower projects. For instance, in the Three Gorges Projects, companies from Brazil (Sade Vigesa), Canada (Acres International, BC Hydro International, Dominion Bridge Inc, GE Canada, Hydro-Quebec, SNC-Lavalin Group, Teshmont Consultants), the US (Atkinson Construction, Bechtel Enterprises, Caterpillar, Rotec Industries, Voith Hydro, CS Johnson, General Electric, Harza Engineering, United States Army Corps of Engineers, etc.), France, Germany and other countries also supplied equipment and services.[69]

[68] Steve Blume, "Global Energy Storage Market Overview & Regional Summary Report (2015)", *Energy Storage Council*, page 12.

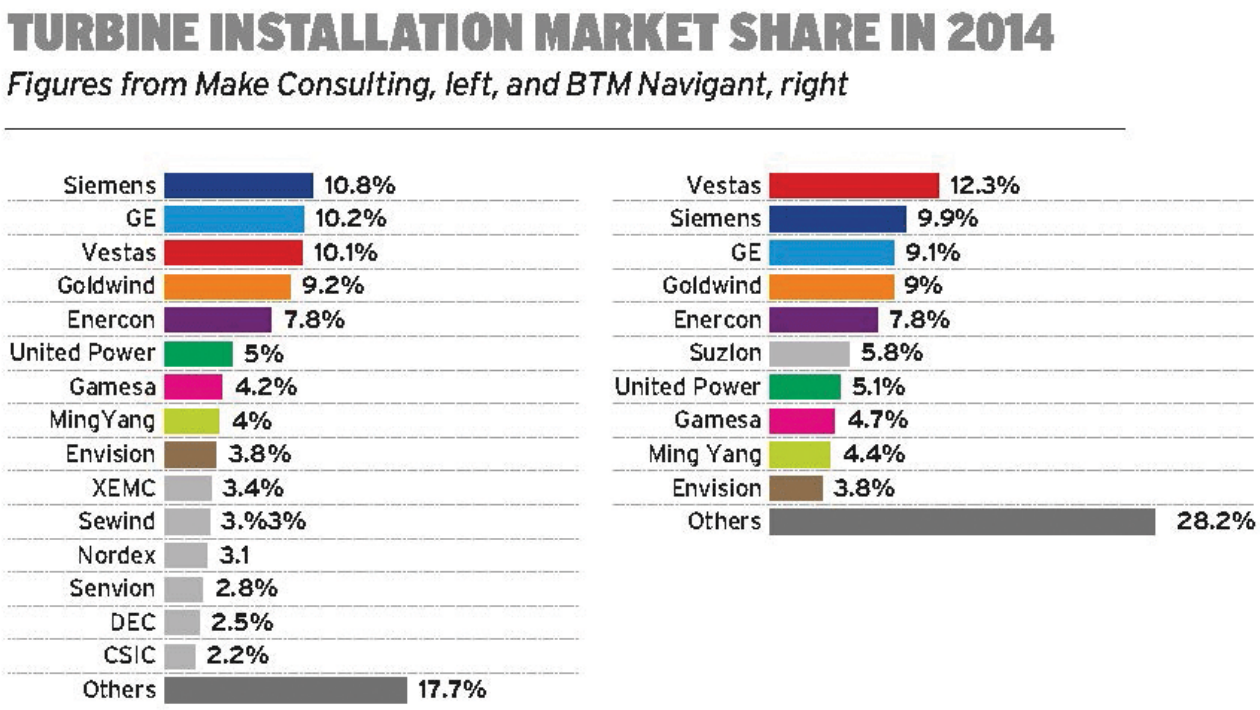
[69] "Who is behind China's Three Gorges Dam", *Probe International*, February 22, 2016, http://journal.probeinternational.org/three-gorges-probe/who-is-behind-chinas-three-gorges-dam/

WIND POWER MANUFACTURERS AND COMPANIES IN CHINA

Among domestic companies, Golden Wind from Xinjiang Province is the largest domestic wind turbine manufacturer in China. It was established in 1998 and owned 35% of the Chinese market in 2006, 19% in 2012 and 19% in 2014. In the latter year, Guodian United Power's market share was 11%; Minyang Wind Power was 9%. Sinovel overtook Golden wind in 2010 as the top turbine company, but it has been facing a steep decline in sales turnover. In wind farms, Longyuan Electric Power Group was an early pioneer which once operated 40% of China's wind farms.[70]

Among international companies, Danish turbine maker Vestas, Spain's Gamesa, America's GE and Germany's Simens have turbine sales and services in China. In recent years, Western turbine manufacturers have steadily lost their market share in China. In 2014, Gamesa, GE and Vestas collectively claimed only 1.7% of the market.[71] Also, in 2006, two major European turbine manufacturers, Vestas (Denmark) and Gamesa (Spain), together accounted for 44% of the Chinese wind-turbine market. Since 2010, Chinese turbine manufacturers have become increasingly competitive in the global market – European companies' market share shrank to 13% in 2010. Today, many of China's turbine manufacturers are among the world's top exporters.[72]

Figure 16: Top Turbine Manufacturers in the Global Market in 2014[73]



Source: Wind Power Monthly

[70] "Wind Power in China", *EcoWorld Magazine*, July 15, 2006, http://www.ecoworld.com/energy-fuels/wind-power-in-china.html

[71] "Sign of Uptick for Foreign Wind OEMs as China Talks about Cooperation", *Global Wind Energy Council*, http://www.gwec.net/signs-of-uptick-for-foreign-wind-oems-as-china-talks-co-operation/

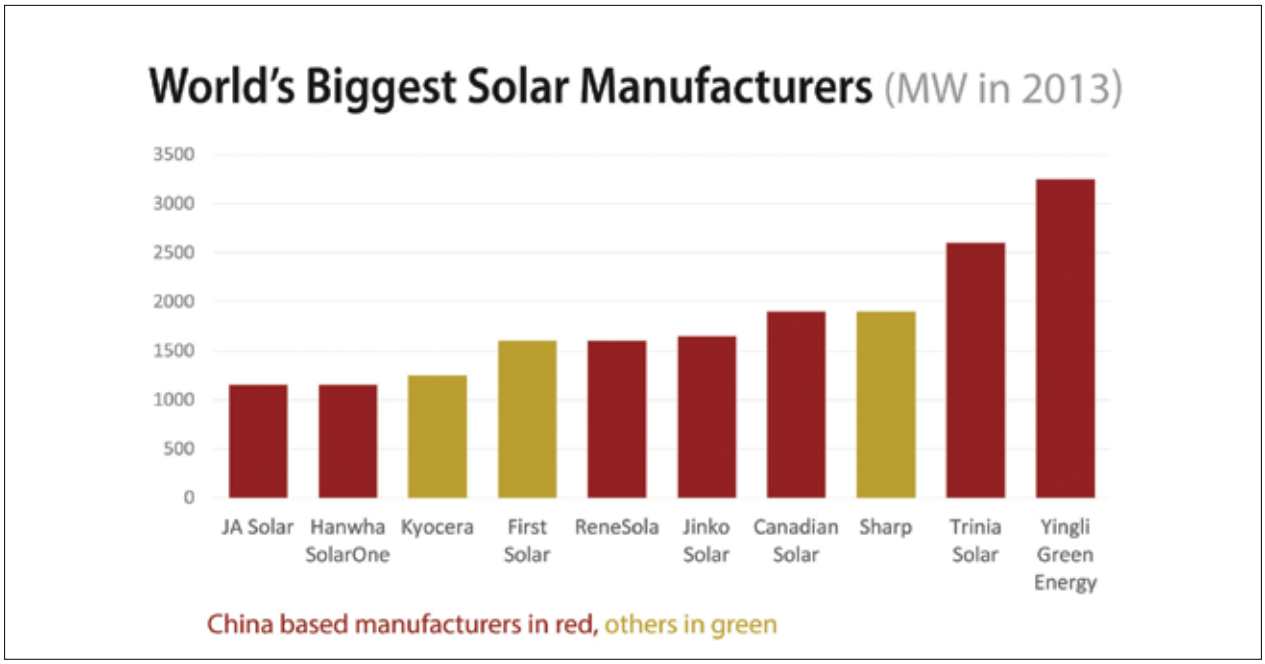
[72] "China's Shift to Clean Energies", *European Parliament*, Briefing May 2015, page 7, http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2015)556981.

[73] "Ten of the Biggest and the Best Manufacturers", *Wind Power Monthly*, June 30, 2015, http://www.windpowermonthly.com/article/1352888/ten-biggest-best-manufacturers

SOLAR POWER MANUFACTURERS AND COMPANIES IN CHINA

China's solar companies include photovoltaic manufacturers in silicon, cells, modules, panels and service companies. Some notable companies are Suntech, JA Solar (the world's largest solar cell producer), Yingli Green Energy Holding (the world's largest solar module producer), China Sunergy, Hanergy (the world's largest thin-film solar power producer), Trina Solar, Jinko Solar, GCL-Poly (the largest supplier of polysilicon), CHINT Group and Jinniu Energy. The top Chinese firms are remarkably similar in present output capacity: the major solar power developers in China are almost all either large state-owned enterprises or large renewable energy players.[74] Chinese solar panel manufacturers are highly competitive in the global market. More than 90% of panels made in China are for exports. Famous foreign companies, such as Canadian Solar and American First Solar have their manufacturing bases in China. Canadian Solar has substantial manufacturing facilities in China; for instance, at the Suzhou Golden Sun project, Changshu Factory and Guanghua Industrial Park.

Figure 17: Chinese Solar Manufacturers in the Global Market in 2013[75]



Source: IHS Technology Inc.

[74] Anders Hove, Guo Hong, Xue Shan, and Emiel van Sambeek, "Opportunities for Dutch Clean Energy Companies in China", *Azure International*, December 2013, page 21.

[75] "It's not where your solar panels came from that matters, it's where they are going that counts", *Shrink That Footprint*, http://shrinkthatfootprint.com/solar-panel-origin

MAJOR PLAYERS IN NUCLEAR POWER

China's nuclear energy industry is strictly administrated by different levels of government agencies. Among them, the China Atomic Energy Authority oversees the development of nuclear energy in China. China National Nuclear Corporation (CNNC) is the largest player in China's nuclear energy. As a state-owned enterprise, CNNC has major investments across the nuclear supply and development chain, with more than 100 subsidiaries. It operates existing nuclear facilities in Zhejiang and Jiangsu and will lead planned projects in those provinces as well as in Fujian and Hunan. China Guangdong Nuclear Power Corporation (CGNPG) is another leading nuclear company in China, managing the Daya Bay and Ling'ao reactors as well as planned projects.[76] China has granted equity of nuclear projects to China's big five power corporations: Huaneng Group, Huadian Group, Datang Group, China Power Investment Group and Guodian Group.

China has established technological cooperation in nuclear energy with many countries such as France, Russia, Japan, South Korea, Finland, etc. The cooperation between China and France (Electricite De France) in nuclear energy dates back to more than thirty years ago when the two sides worked together to build Daya Bay nuclear power station. China's cooperation with other countries in nuclear energy also includes Russia (Rosatom, Atomstroyexport, the institute Atomenergoproekt, Gidropress and Kurchatov Institute), the United States (Westinghouse and GE), and Japan (Toshiba, Hitachi and Mitsubishi). China and Canada have greatly increased nuclear cooperation after 2008. In Stage II and Stage III of the Qinshan nuclear plant in Zhejiang province, Babcock & Wilcox supplied steam generators and Candu provided two heavy water reactors. In November 2014, Candu Energy and China National Nuclear Corporation (CNNC) agreed on further nuclear cooperation. Candu has also been working with China Nuclear Power Engineering Company, Ltd. (CNPEC) in the construction of CANDU Units 3 and 4 at the Cernavoda Nuclear Power Plant in Romania.[77]

SOLID WASTE MANAGEMENT COMPANIES IN CHINA

Everbright International is one of the largest solid waste management enterprises in China. By the end of 2014, the company invested in over 122 environmental projects with approximately RMB 30 billion (about USD 4.9 billion), which included 36 waste-to-energy projects and 10 industrial solid waste and hazardous waste treatment projects in China. In September, Everbright International signed an investment agreement that would build Zibo Hazardous Solid Waste Landfill Project, with the investment around RMB170 million (about USD 28 billion).[78] At present, Beijing Chaoyang Green Power Station is the largest waste-to-energy plant in China, with daily waste incineration of 1,300 tons and annual power generation of 136 million kW/h. The second phase of the power station, scheduled to be completed at the end of this year, is expected to increase the facility's annual power generation to 225 million kW/h.[79] China's other well-known solid waste management enterprises are Jiangsu Welle Environmental Corporation, Ltd., Tianjin TEDA Environmental Protection, Wefang Jinsida and Shanghai Environment Group.

Famous foreign companies such as Waste Management Inc. and Covanta have developed businesses in China. Waste RE-Solution, an Edmonton enterprise, will develop a waste management business opportunity in Lichuan city in China. Shenzhen will build the world's largest waste-to-energy plant, with six firms – Arup, Atkins, AECOM, Gerber Architekten, Schmidt Hammer Lassen with Gottlieb Paludan Architects, and local firm Tanghua Architects – having been shortlisted for its design. Beijing Enterprise Group recently won a bid to purchase German incineration group EEW Energy-from-Waste.

[76] Ryan Ong, "A Boost for Nuclear Power", *China Business Review*, May 1, 2010, http://www.chinabusinessreview.com/a-boost-for-nuclear-power/

[77] "Qinshan Nuclear Power Plant, Haiyan County, Zhejiang, China", *Power-Technology.com*, http://www.power-technology.com/projects/qinshan-nuclear-power-china/

[78] "Business Overview", *Everbright International*, http://www.ebchinaintl.com/en/business/business.php

[79] Liu Yuanyuan, "Chinese Waste to Energy Market Experiences Rapid Growth during Last Five Years", Renewable Energy World.com, April 28, 2015, http://www.renewableenergyworld.com/articles/2015/04/chinese-waste-to-energy-market-experiences-rapid-growth-during-last-five-years.html

SMART GRID AND ENERGY STORAGE COMPANIES IN CHINA

In terms of electric utility companies, the State Grid Corporation of China is the world's largest; two other, large electric utility companies are China Southern Power and Chint Group Corporation. In China, domestic suppliers dominate the UHV transmission, transformation and smart meter markets. Some notable companies are Wasion Group (smart meters), Huawei (communication equipment), XJ Electric (transmission and distribution equipment) and BYD (electric vehicle and energy storage markets). International companies have actively participated in transmission and generation infrastructure and the network software market.

Some famous companies are ABB (transmission and distribution equipment), Siemens (smart logistics services, building energy management systems and distribution level grid infrastructure) and GE (wireless smart meters, residential demand-side energy management, automated outage management system, network software and EV management system). Some foreign companies such as Atos Origin, Echelon, ZBB Energy, Siemens and ABB also have formed joint ventures to enter the areas of information management, smart metering and energy storage.[80]

Selected Resources in Renewable Energy and Clean-Tech Markets

The following table summarizes the main resources available in the renewable energy and clean-tech markets in China. It consists of four parts: laws, regulations and policies; industrial exhibitions and forums held in China; bureaucracies, research institutes, associations and websites in China; and research institutes, organizations, associations and websites outside China.

1. Laws, Regulations and Policies

(1) Renewable Energy Law of People's Republic of China (2005 and 2009)
http://english.mofcom.gov.cn/article/policyrelease/Businessregulations/201312/20131200432160.shtml

(2) Energy and Climate Goals of China's 12th Five Year Plan (2010-2015)
http://www.c2es.org/international/key-country-policies/china/energy-climate-goals-twelfth-five-year-plan

(3) Energy Conservation Law of People's Republic of China (1997)
http://www.asianlii.org/cn/legis/cen/laws/eclotproc501/

(4) Medium and Long Term Development Plan for Renewable Energy in China (2007)
http://www.martinot.info/China_RE_Plan_to_2020_Sep-2007.pdf

(5) China's Energy Policy White Paper (2012)
http://news.xinhuanet.com/english/china/2012-10/24/c_131927649.htm

[80] Anders Hove, Guo Hong, Xue Shan, and Emiel van Sambeek, "Opportunities for Dutch Clean Energy Companies in China", *Azure International*, December 2013, pages 25-26.

2. Industrial Exhibitions and Forums Held in China

(1) International Wind Energy Expo. Conference, Beijing, Oct 14-16, 2015, http://www.huodongjia.com/event-1251653.html
(2) Energy Storage China, Beijing, May 10-12, 2016, http://www.escexpo.cn/
(3) International Green Building System and Technology Exhibition, Shanghai, Nov 13-15, 2016 http://www.vnuexhibitions.com.cn/en/Cases/chinaExhibitionsContent?id=6
(4) The Sixth International Storage Conference, Shenzhen, April 24-26, 2016, http://www.huodongjia.com/event-5632397.html
(5) The 10th China (Shanghai) International Wind Energy Exhibition and Conference, Shanghai, May 24-26, 2016, http://www.china-wpower.com/en/index.php?ac=article&at=list&tid=32
(6) The 8th Guangzhou International Solar Photovoltaic Exhibition, Guangzhou, Sept 20-22, 2016 http://www.pvguangzhou.com/index.php?lang=en
(7) The 15th China International Electric Power and Power Engineering Equipment and Smart Grid Exhibition, May 13-15, 2015, http://eventegg.com/epower-china/
(8) The 8th Chinese Renewable Energy Conference and Exhibition, Wuyi, Nov 3-5, 2016 http://www.enfsolar.com/event/profile/exhibition/1649/the-8th-chinese-renewable-energy-conference-exhibition
(9) The 9th Clean Energy Expo China, Beijing, March 29-31, 2016, http://www.cleanenergyexpochina.com/
(10) The 6th International Conference on New Energy and Sustainable Development, Suzhou, July 25-27, http://eventegg.com/nesd-2016/

3. Bureaucracies, Research Institutes, Associations and Websites in China

(1) China National Energy Administration, http://www.nea.gov.cn
(2) Ministry of Environmental Protection of PR. China, http://www.mep.gov.cn
(3) China National Renewable Energy Centre, http://www.cnrec.org.cn
(4) China Renewable Energy Industry Association, http://www.chnreia.org/
(5) China Energy Technology Information Network, http://www.etiea.cn/index.php
(6) China New Energy Network, http://www.newenergy.org.cn/
(7) China National Development and Reforms Commission: Energy Research Institute, http://www.eri.org.cn/jgsz.php?aid=230&cid=61
(8) China Clean Coal Technology, http://www.cct.org.cn/
(9) Chinese Wind Energy Association, http://www.cwea.org.cn/
(10) China Photovoltaic Industry Association, http://www.chinapv.org.cn/
(11) China Nuclear Energy Association, www.china-nea.cn
(12) China Electricity Council, http://www.cec.org.cn/
(13) China Solid Waste, http://www.solidwaste.com.cn

4. Research Institutes, Organizations, Associations and Websites outside China

(1) International Renewable Energy Agency (IRENA), http://www.irena.org
(2) REN21: Renewable Energy Policy Network for the 21st Century, http://www.ren21.net/
(3) International Energy Agency (IEA), http://www.iea.org/
(4) Bloomberg New Energy Finance, http://about.bnef.com/
(5) CleanTechnica, http://cleantechnica.com/
(6) Renewable Energy World, http://www.renewableenergyworld.com/index.html
(7) International Hydropower Association (IHA), http://www.hydropower.org/
(8) World Wind Association, http://www.wwindea.org/
(9) International Solar Energy Society, http://www.ises.org/home/
(10) International Atomic Energy Agency (IAEA), https://www.iaea.org/
(11) International Solid Waste Association, http://www.iswa.org/
(12) EU SME Centre, http://www.eusmecentre.org.cn/about-centre
(13) Europe-China Clean Energy Center, http://www.ec2.org.cn

CONCLUSION

In conclusion, we will summarize the main characteristics of China's renewable energy and clean-tech markets' development trends in the near future. Accordingly, some suggestions for Alberta's clean-tech firms that seek out business expansion in the Chinese market will be provided. In general, five main development trends will shape the Chinese renewable energy and clean technology market activities of tomorrow.

First, China's policy development has clearly demonstrated that the country will continue to invest heavily in renewable energy and clean technology in the near future. Despite its recent economic slow-down, China still remains one of the world's major engines for global economic growth. In order to meet energy demand and mitigate impacts on environment, it is especially apparent that China will seriously promote renewable energy sources and dramatically develop clean technology in the longer term. In this context, China's renewable energy sectors are expected to generate strong economic and social impacts worldwide. According to the International Renewable Energy Agency (IRENA), China today is the world's undisputed renewable energy leader, with 3.4 million renewable energy workers. In this regard, China's renewable energy and clean-tech market has great job-creating potential for Albertan firms that are dedicated to the industry.

Second, Chinese manufacturers in renewable energy will become increasingly competitive in the global market. For example, in the past, China's wind industry was once dominated by foreign companies; however, in recent years, they have significantly lost their market shares to their Chinese domestic competitors. This phenomenon is not isolated to the wind industry – many renewable energy sectors such as solar energy, nuclear energy and green transportation all indicate that Chinese manufacturers have been extremely successful in technology transfers, localizations and market strategies. Therefore, China is a highly competitive market that can be difficult for Albertan firms that are not well-prepared. It is necessary to conduct a comprehensive study of China's renewable energy and clean-tech market; make a subjective assessment of Albertan firms that are specializing in renewable sources and technology, analyzing Alberta's strengths and weaknesses; choose several potential industrial sectors, conducting in-depth market analysis with recommendations; and set up market development plans in the short-, medium- and long-terms.

Third, subsidies, preferential policies and tax benefits will likely continue to support the development of China's renewable energy industry; however, the Chinese government has ambitions to build new industries around green sectors as the foundation for China's future role in the global economy. In other words, upgrading China's renewable energy industry through strengthening domestic innovation, as opposed to using subsidies, preferential policies and tax benefits, has risen to the top of the government's agenda. For instance, China plans to remove green vehicle subsidies in 2020 with the intention of making China's manufactured green vehicles more competitive in the international market; China's renewable energy enterprises have been encouraged to invest overseas and conduct foreign acquisitions to access technology. China intends to move its renewable energy and clean technology from the early pilot development period to a future leadership development period. In the meantime, China's investment in renewable energy is rapidly diversifying into new sectors of clean technology. Thus, for the benefit of Albertan firms, Alberta needs to evaluate how to fit well within the opportunities created by China's shifting roles in the renewable energy industry. In some particular industrial sectors such as waste management, smart grids, energy storage, energy efficiency, carbon capture and green buildings, Albertan firms may have good prospects in cooperating with China in the near future.

Fourth, after nearly a decade of rapid growth, China's renewable energy and clean technology sectors will conceivably enter a period of policy adjustment. As mentioned above, in just a few years, because of attractive government subsidies, some Chinese renewable energy sectors such as solar and wind have undergone massive expansion, leading to serious overcapacity. At present, many large solar and wind manufacturers in China face great price competition and might go bankrupt. Concurrently, many wind power stations are unable to connect to the grid due to the lack of

transmission capacity. As a result, in recent years, the Chinese government has made great efforts to establish a thorough evaluation system for renewable energy development, implement a renewable energy quota system and improve renewable energy subsidies, taxation and financial policies. In this respect, Albertan firms should keep well informed about the most recent developments in China's renewable energy and clean-tech market.

Finally, the future development of China's renewable energy and clean-tech market will witness continued regional disparities and segmented marketization. Because China is a very large country, with great regional differences, in addition to China's macro-policy on renewable energy industry, most provinces and cities have their own sub-national policies and targets. Moreover, China's high-tech manufacturers and R&D are clustered in Eastern, coastal regions, while China's Northern and Western regions have rich energy resources such as solar, wind and hydropower. In this regard, China's renewable energy and clean-tech market should be viewed as a conglomeration of multiple sub-markets across different regions and industrial sectors. The point here is to emphasize that noticeable regional disparities in China might pose difficult barriers for Albertan firms to enter in the beginning, but they can present opportunities as well – as China's renewable energy industry expands, they should leave room for Albertan firms with skills in renewable energy and clean technology to target their business activities beyond the already well-exploited sectors and regions.