



ASIA PACIFIC
FOUNDATION
OF CANADA

CHINA ECO-CITY TRACKER

A series on China's commitments to environmental
protection and pollution control

INTRODUCTION

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China has made commitments to environmental protection and pollution control, to create cities with "a blue sky, clear water, green land and a beautiful environment." Not only did China declare "green development" as a priority in its 13th five-year plan, the message has recently been reinforced and reiterated by Chinese leaders at many major events, including the 19th CPC Party Congress and 2018 Davos Forum.

As a more practical step forward, China's National People's Congress, which ended March 20, 2018, established a new Ministry of Ecological Environment to replace the former Ministry of Environmental Protection. This grand ministry is expected to push forward China's environmental protection more efficiently by integrating related responsibilities and functions dispersed in several different ministries during the previous government.

The national government's environmental commitment has led to new political incentives, guidelines, and frameworks. Environmental protection is now a key performance indicator and officials who don't comply put their promotions at risk. Many are choosing to abide by the new rules. There is little mercy shown to polluting factories, which are at risk of being shut down overnight, despite the potential negative impact on the economy. Chengdu, Tianjin, Beijing, and Taiyuan closed the highest numbers of polluting factories (14,148, 9,081, 4,216, and 1,933, respectively) according to 2017 data.

In view of these developments, the demand in China for clean technologies to help achieve environmental protection objectives and commitments is likely to be high.

Canada has been a global frontrunner in environmental protection and has actively engaged in initiatives to combat climate change and build a sustainable environment. Collaboration on environmental issues has been one of Canada's top priorities in its relationship with China.

As the fourth ranked country in the 2017 Global Cleantech Innovation Index, Canada has a lot to offer China. Canadian companies, which excel in many clean technology areas, should take advantage of China's green development strategy and seek opportunities to expand trade and investment in China's cleantech market.

This new research series dives into the environmental protection performance of China's 31 provincial capital cities and central-governed municipalities by comparing air, water, and waste pollution data since 2013. The research also analyzes China's national and provincial policy structures and commitments to promoting clean technology development.

We hope this research series will help Canadians better understand environmental protection in China, and assist Canadian governments and businesses identify potential market opportunities in China's clean technology market.

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01

A CLEARING IN THE 'AIRPOCALYPSE' FOR CHINA

BY IRIS JIN, SANDY WAN



Reeling from the 'airpocalypse' of deadly air pollution that attracted global media attention and sparked public outrage beginning in 2013, Beijing has made international headlines once again, but this time for the blue skies that have begun to reappear over the capital in 2018. The transformation is indicative of the government's fresh focus on environmental protection instead of unblinkered economic growth. At the behest of President Xi's famous pet phrase, "lucid waters and lush mountains are invaluable assets," the government has taken drastic measures to lay down the law.

To draw a picture of China's air quality progress, we tracked air quality data from the country's 31 major cities (27 provincial capital cities and four direct-governed municipalities) since the Air Pollution Prevention and Control Action Plan was introduced in 2013. Using this data, we analyzed air quality changes over the years.

Connecting the Dots Across the Map

Along with a national plan to reduce air pollution, the Ministry of Environmental Protection (MEP), reorganized as the Ministry of Ecological Environment early this year, has adopted a new standard to measure air quality. The Air Quality Index (AQI) in China has six levels based on the amounts of six atmospheric pollutants. Up to level two, air quality is still considered acceptable: levels three and above are considered detrimental to public health (see Chart 1).

CHART 1
Air Quality Index Levels

1	0 - 50 EXCELLENT
2	51 - 100 GOOD
3	101 - 150 LIGHTLY POLLUTED
4	151 - 200 MODERATELY POLLUTED
5	201 - 300 HEAVILY POLLUTED
6	> 300 SEVERELY POLLUTED

SOURCE: MINISTRY OF
ECOLOGY AND ENVIRONMENT
OF THE PEOPLE'S REPUBLIC
OF CHINA

A common way to analyze overall AQI is by the number of days in a year that AQI is level two or better (chart 2). In 2016, Beijing still had a poor ranking in the bottom 10 with just over half of its days recording decent air quality. China has yet to publish its annual statistical yearbook for 2017, but the MEP has already praised Beijing for squeezing into the top ten earlier this year.

CHART 2

Days in a Year with Level 2 or Better AQI

RANK	2016		2013	
	CITY	DAYS	CITY	DAYS
1	Kunming	362	Fuzhou	343
2	Fuzhou	361	Haikou	342
3	Haikou	361	Lhasa	341
4	Guiyang	350	Kunming	329
5	Nanning	348	Guiyang	278
6	Nanchang	318	Nanning	275
7	Lhasa	313	Guangzhou	259
8	Guangzhou	310	Yinchuan	249
9	Changchun	291	Shanghai	246
10	Chongqing	289	Haerbin	239
11	Huhehaote	283	Changchun	230
12	Haerbin	282	Nanchang	230
13	Shanghai	276	Xining	216
14	Xining	271	Shenyang	215
15	Changsha	266	Huhehaote	213
16	Hangzhou	260	Hangzhou	212
17	Hefei	253	Chongqing	207
18	Yinchuan	252	Nanjing	198
19	Shenyang	249	Changsha	196
20	Urumuqi	246	Lanzhou	163
21	Lanzhou	243	Urumuqi	184
22	Nanjing	242	Hefei	180
23	Wuhan	237	Beijing	167
24	Taiyuan	232	Taiyuan	162
25	Tianjin	226	Wuhan	161
26	Chengdu	214	Xi'an	157
27	Beijing	198	Tianjin	145
28	Xi'an	192	Chengdu	139
29	Shijiazhuang	172	Zhengzhou	134
30	Ji'nan	168	Ji'nan	79
31	Zhengzhou	159	Shijiazhuang	49

SOURCE: CHINA STATISTICAL
YEARBOOK 2013-2016

There has been a gradual general improvement in other cities too. In 2013, only four cities had more than 300 days of acceptable air quality, increasing to 22 cities in 2016. On the flip side, 22 out of the 31 cities suffered hazardous air quality for at least a third of the year in 2013, decreasing to only 11 cities in 2016.

The city with the largest improvement between 2013 and 2016 is Shijiazhuang, capital of the northern province of Hebei, where air quality improved by 250 per cent. Other cities showing notable improvement include Ji'nan and Tianjin, where air quality improved 113 per cent and 56 per cent respectively over the same period. Despite the commendable improvement, Shijiazhuang and Tianjin, together with Beijing, are still among the bottom ten in 2016; China still has a long way to go before people in many of the urban centres will be able to breathe safely without facemasks.

Looking at the cities geographically, we see on Map 1 (below) that the top ten cities with the best air quality (indicated in blue) lie in the south and southwest regions of China with the sole exception of Changchun, the capital city of China's northern province of Jilin. At the same time, the bottom ten cities (indicated in red) with the worst air quality are, not surprisingly, concentrated in northern regions historically more reliant on primary industries which use coal as a main source for heating and energy generation. The national capital region, dubbed Jingjinji, is composed of Beijing, Tianjin, and Shijiazhuang. These highly industrialized cities, not surprisingly, find themselves in the bottom ten rankings for air quality. An outlier to the geographical cluster is Chengdu, the capital of southwestern province of Sichuan.

MAP 1

Top and Bottom 10 Cities in Terms of Air Quality



SOURCE: CHINA STATISTICAL YEARBOOK 2013-2016

The Invisible Assassins

China's economy has grown at an unprecedented pace over the past few decades, and it is widely accepted that economic growth came at the price of its environment and public health. One of the most direct dangers to public health is the 'airpocalyptic' smog. It is linked to nearly one-third of deaths in China.

The specific indicators tracked and analyzed for policy purposes are primary pollutants, substances directly emitted from a source, which include particulates (PM2.5 and PM10), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO) and carbon dioxide (CO₂), all directly generated by industrial and residential activities. Pollutants emitted by coal and oil-based heating and electricity generation, automobile exhaust, and construction and waste incineration go hand in hand with China's industrialization and urbanization efforts and are widely accepted as an unacceptable by-product of economic development. This makes the transition to renewable energy sources difficult. Moreover, to curb air pollution each city requires a unique scenario, tailored for its economic strengths and industry focuses.

New Perspective from the Eye of the Airpocalyptic Hurricane

After decades of GDP growth driven decisions, the Chinese government is now reflecting on the resulting environmental damage and destruction. More importantly, they are connecting environmental degradation to the health of China's citizens and economy. With the end of the Air Pollution Prevention and Control Action Plan in 2017, China implemented the Environmental Protection Tax Law on January 1, 2018, declaring air, water, solid waste and noise pollution a taxable emission. This tax not only designates 100 per cent of revenue to local government, it also increases the penalties for violating pollution standards.

These efforts signal to the world China's newfound commitment to environmental protection, however, air pollution is not a fight reserved for China alone. Last year South Korea launched a class action lawsuit against Beijing and Seoul, seeking compensation for its own worsening air quality. Even further across the ocean, China's smog has drifted to haunt the western states of the U.S. Researchers from Peking University found that the smog drifting to the U.S. from China is linked to Chinese exports destined for American consumers.

With Canada being a close neighbour to the U.S. and a likeminded outsourcer for manufacturing, Canada cannot escape the blame for China's air pollution either. In that sense, working with China to combat 'airpocalyptic' smog is not only good for China, but also good for Canada.

02

THE UPSTREAM BATTLE FOR DRINKABLE WATER

BY IRIS JIN, SANDY WAN



China faces a daunting challenge: it houses 20 per cent of the world's population while only having seven per cent of the world's water resources. In addition, only 67.7 per cent of China's surface water is deemed safe for human contact and over 75 per cent of its ground water is classified as poor or very poor. In fact, China's water pollution problem is just as serious as its hazardous smog. Adding to the challenge, the already scarce, useable water sources are unevenly distributed geographically, resulting in water shortages in over [half](#) of China's cities, especially in the northern regions.

In order to better understand China's water problems, we tracked the data of China's 27 provinces and four direct-controlled municipalities over a four-year period from 2013 to 2016 to identify China's performance trend and gaps.

Understanding the Raindrops Across China

China's water quality is divided into five grades depending on its environmental function and protection targets (Chart 1). Most often, water quality measurements are pooled into grades one to three, which is deemed drinkable, or grades four and above where it is deemed unsafe to drink.

CHART 1
Water Grade Levels

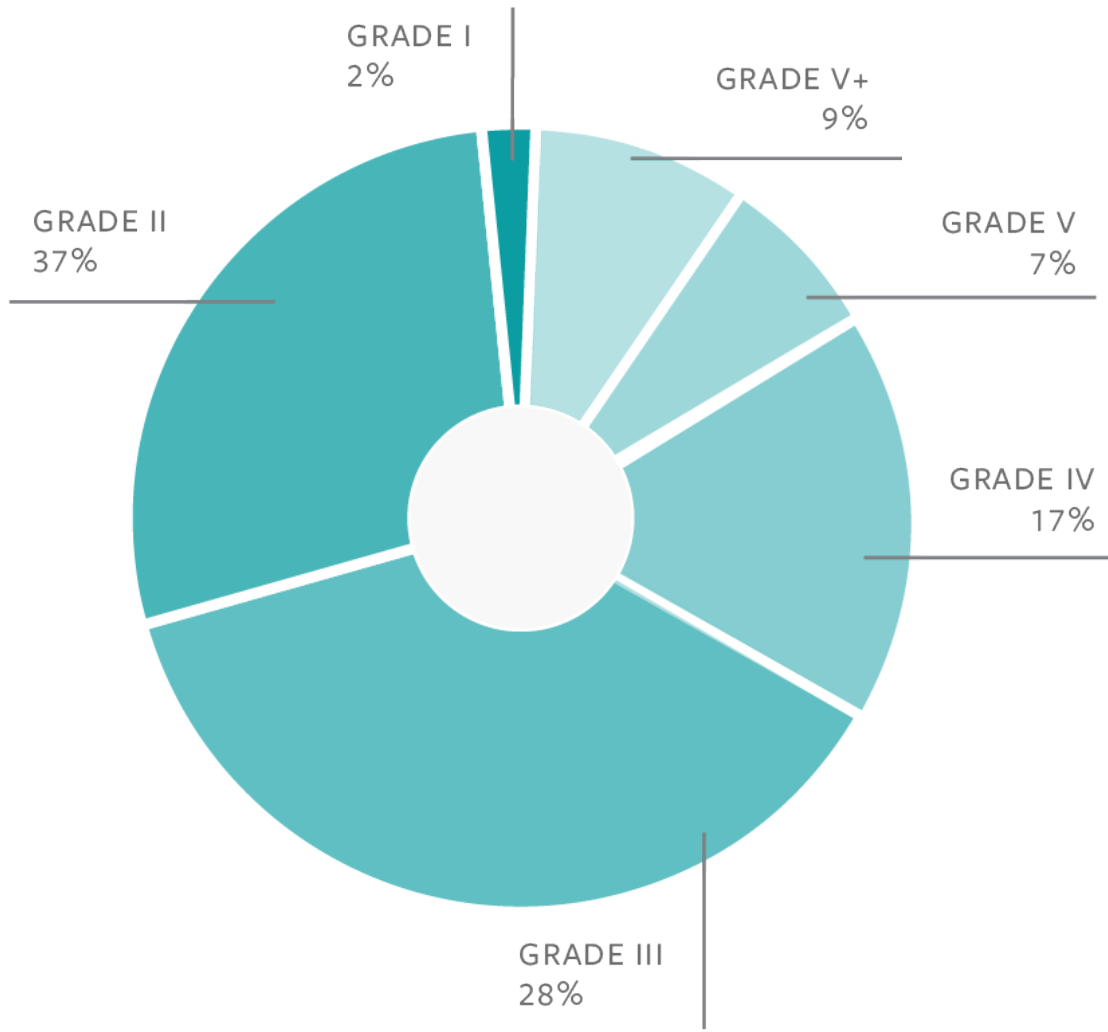
GRADE	DESCRIPTION
I	EXCELLENT <i>main water source for population use, national protected</i>
II	EXCELLENT <i>for human drinking and living, rare aquatic life habitation, fish and shrimp spawning grounds and young fish feeding ground purposes</i>
III	GOOD <i>for human drinking and living, fish and shrimp species hibernation, migration, aquatic life cultivating and swimming purposes</i>
IV	LIGHTLY POLLUTED <i>for industrial and entertainment purposes without direct human contact</i>
V	MODERATELY POLLUTED <i>for agricultural and display purposes</i>
V+	HEAVILY POLLUTED

SOURCE: MINISTRY OF ECOLOGY AND ENVIRONMENT OF THE PEOPLE'S REPUBLIC OF CHINA

China gets most (63 per cent) of its drinking water from surface water sources. And according to 1,940 surface water monitoring stations surveyed in China's 2016 environmental report, almost a third of China's surface water is polluted to the point that it is unsafe for human contact (Chart 2).

CHART 2

Surface Water Quality of China 2016



SOURCE: ENVIRONMENT STATUS BULLETIN 2013-2016 OF ALL 31 PROVINCIAL-LEVEL ADMINISTRATIVE REGIONS

To break this chart down even more, we ranked all 31 data points according to the percentage between grades one and three and grades four and above (Chart 3). At first glance, we see 100 per cent of surface water is safe to drink in the provinces of Tibet and Ningxia, both located in the less populous and less wealthy northwestern region of China. Conversely, more than half of the surface water is undrinkable in the worst performing provinces and cities (Beijing, Shanxi, Tianjin, Liaoning and Shanghai). Perhaps not coincidentally, these more populous areas are concentrated in the economic epicentres of eastern and northeastern China.

CHART 3
Surface Water Quality Ranking 2016

RANK	CITY	I-III	IV-ABOVE
1	Tibet Territory	100.00%	0.00%
2	Ningxia Territory	100.00%	0.00%
3	Xinjiang Territory	97.60%	2.40%
4	Fujian Province	96.50%	3.50%
5	Guizhou Province	96.00%	4.00%
6	Gansu Province	95.59%	4.44%
7	Guangxi Territory	94.80%	5.20%
8	Hainan Province	91.80%	8.20%
9	Hunan Province	89.70%	10.30%
10	Hubei Province	86.60%	13.40%
11	Yunnan Province	82.30%	17.70%
12	Qinghai Province	81.80%	18.20%
13	Jiangxi Province	81.40%	18.60%
14	Chongqing	80.60%	19.40%
15	Guangdong Province	78.20%	21.80%
16	Zhejiang Province	77.40%	22.60%
17	Anhui Province	69.60%	30.40%
18	Jiangsu Province	68.30%	31.70%
19	Jilin Province	67.00%	32.90%
20	Heilongjiang Province	64.50%	35.50%
21	Sichuan Province	63.20%	36.80%
22	Inner Mongolia Territory	57.80%	42.20%
23	Hebei Province	54.27%	45.73%
24	Shaanxi Province	54.20%	45.80%
25	Henan Province	51.10%	46.80%
26	Shandong Province	50.50%	49.50%
27	Beijing	48.60%	51.40%
28	Shanxi Province	48.00%	52.00%
29	Tianjin	20.00%	80.00%
30	Liaoning Province	18.00%	82.00%
31	Shanghai	16.20%	83.80%

SOURCE: ENVIRONMENT
STATUS BULLETIN 2013-2016
OF ALL 31 PROVINCIAL-LEVEL
ADMINISTRATIVE REGIONS

The Upstream and Downstream Battle Since 2013

While a few notable provinces have made strides in improving water quality since 2013, the rest of the country is stagnant (Chart 4). The northwestern provinces of Qinghai and Shaanxi have been most successful, increasing the number of monitoring stations registering potable water by 36 and 23 per cent, respectively. On the opposite end of the scale, a few provinces are failing to keep their heads above the polluted water. Water quality in Hainan, Inner Mongolia Territory, Jilin and Liaoning has actually worsened since 2013. As for Shanghai, its water quality worsened by more than 34 per cent in just one year from 2015 to 2016.

CHART 4
Changes in Grade I-III 2013-2016

RANK	PROVINCE / CITY	CHANGE
1	Qinghai Province*	36.33%
2	Shaanxi Province	23.20%
3	Tianjin	12.60%
4	Guizhou Province	10.80%
5	Zhejiang Province	9.50%
6	Gansu Province	6.53%
7	Shandong Province	6.00%
8	Beijing	4.20%
9	Shanxi Province	4.00%
10	Yunnan Province	3.30%
11	Anhui Province	3.00%
12	Henan Province	2.90%
13	Hebei Province	2.86%
14	Sichuan Province	1.20%
15	Hubei Province	1.20%
16	Chongqing	1.00%
17	Heilongjiang Province	0.70%
18	Fujian Province	0.60%
19	Xinjiang Territory	0.55%
20	Jiangsu Province	0.50%
21	Jiangxi Province	0.00%
22	Hunan Province	0.00%
23	Guangdong Province	0.00%
24	Guangxi Territory	0.00%
25	Tibet Territory	0.00%
26	Ningxia Territory	0.00%
27	Hainan Province	-1.80%
28	Inner Mongolia Territory	-4.70%
29	Jilin Province	-7.00%
30	Liaoning Province	-9.40%
31	Shanghai**	-34.41%

SOURCE: ENVIRONMENT
STATUS BULLETIN 2013-2016
OF ALL 31 PROVINCIAL-LEVEL
ADMINISTRATIVE REGIONS

Wastewater: The Carrot and the Stick

In addition to surface water quality, another key indicator of water pollution is wastewater. Wastewater is an unintended outcome of industrialization and urbanization (Chart 5). Among the 31 major cities, the top five for wastewater discharge volumes are, not surprisingly, the most economically developed and densely populated areas of Shanghai, Beijing, Guangzhou, Chongqing, and Tianjin. Those five cities alone discharged over 7.6 billion m³ of wastewater in 2016. That is enough to fill Lake Superior, the world's third-largest freshwater lake, 633 times over. And that is only 16 per cent of China's total wastewater discharge volume. This begs the question: is the country capable of solving such a daunting problem?

CHART 5
Changes in Grade I-III Water 2013-2016

RANK	VOLUME OF WASTE WATER DISCHARGED 20126 (10,000 M ³)		% OF WASTE WATER TREATED 2016	
1	Shanghai	236,248	Zhengzhou	99.8%
2	Beijing	169,540	Hefei	99.7%
3	Guangzhou	150,867	Guiyang	97.6%
4	Chongqing	104,129	Wuhan	97.4%
5	Tianjin	99,693	Ji'nan	97.2%
6	Nanjing	99,272	Changsha	96.9%
7	Chengdu	94,747	Chongqing	96.8%
8	Wuhan	89,110	Shijiazhuang	96.1%
9	Shenyang	74,921	Nanjing	96.0%
10	Hangzhou	57,916	Lanzhou	95.4%
11	Xi'an	54,500	Yinchuan	95.2%
12	Changsha	54,210	Hangzhou	95.1%
13	Hefei	50,342	Haikou	95.0%
14	Kunming	49,296	Shenyang	94.9%
15	Haerbin	42,832	Huhehaote	94.6%
16	Shijiazhuang	42,728	Chengdu	94.3%
17	Nanning	40,217	Shanghai	94.3%
18	Ji'nan	35,978	Guangzhou	94.3%
19	Zhengzhou	35,397	Kunming	94.1%
20	Nanchang	30,705	Nanchang	93.5%
21	Changchun	28,930	Changchun	93.4%
22	Taiyuan	28,415	Fuzhou	93.2%
23	Fuzhou	28,386	Xi'an	92.4%
24	Guiyang	26,228	Haerbin	92.2%
25	Urumuqi	21,484	Tianjin	92.1%
26	Lanzhou	18,008	Beijing	90.6%
27	Yinchuan	15,955	Urumuqi	90.4%
28	Haikou	15,862	Nanning	89.5%
29	Huhehaote	14,060	Lhasa	89.5%
30	Xining	11,578	Taiyuan	86.9%
31	Lhasa	6,019	Xining	74.1%

SOURCE: CHINA URBAN
CONSTRUCTION STATISTICAL
YEARBOOK 2013-2016

Building the Dam on Water Pollution, Branch by Branch

While the scale of the problem is difficult to fathom, there is a glimmer of hope when looking at the percentage of wastewater treated in the 31 major cities (chart 5). In 2016, all cities treated more than 90 per cent of their wastewater with four exceptions, Nanning, Lhasa, Xining and Huhehot. However, these numbers can misguide us as treatment quality and methods differ across the country, making these numbers cause for further investigation.

“With air, you stop pollution at the source, and the blue skies come back instantly,” said Ma Jun, director of the Institute of Public and Environmental Affairs. But unlike [air](#), water has its own cycle, which in a way makes the problem much more resistant to short-term and small-scale solutions. Mitigating the lethal pollution that flows throughout China’s entire water system will require a comprehensive solution.

The backbone of China’s water improvement aspirations is the 2015 *Action Plan on Water Pollution Prevention and Control*, also commonly referred to as the “Water Ten Plan.” Ambitious goals of this [plan](#) include making at least 93 per cent (currently at 67 per cent) of all urban drinking water sources to actually provide potable water by 2020. In 2014, Premier Li Keqiang [set aside US\\$330 billion](#) to tackle the issue of water pollution specifically. Following the national movement, provincial and city governments are also investing in cleanup efforts.

China’s water quality problems are not confined to its own borders, but reach far beyond the Great Wall into the world’s oceans, seafood and eco-systems. With the advancements made this decade, there is no better time for China, and the rest of the world, to ride the tidal wave of development in renewable energy, clean tech and environmental stewardship to improve water quality. With Canada’s expertise in these areas, especially water remediation and treatment technologies from British Columbia and Ontario, this provides a perfect opportunity for Canadians clean-tech firms to meet China’s need.

03

TACKLING TRASH TROUBLES WITH NEW POLICIES, PENALTIES

BY SANDY WAN, IRIS JIN

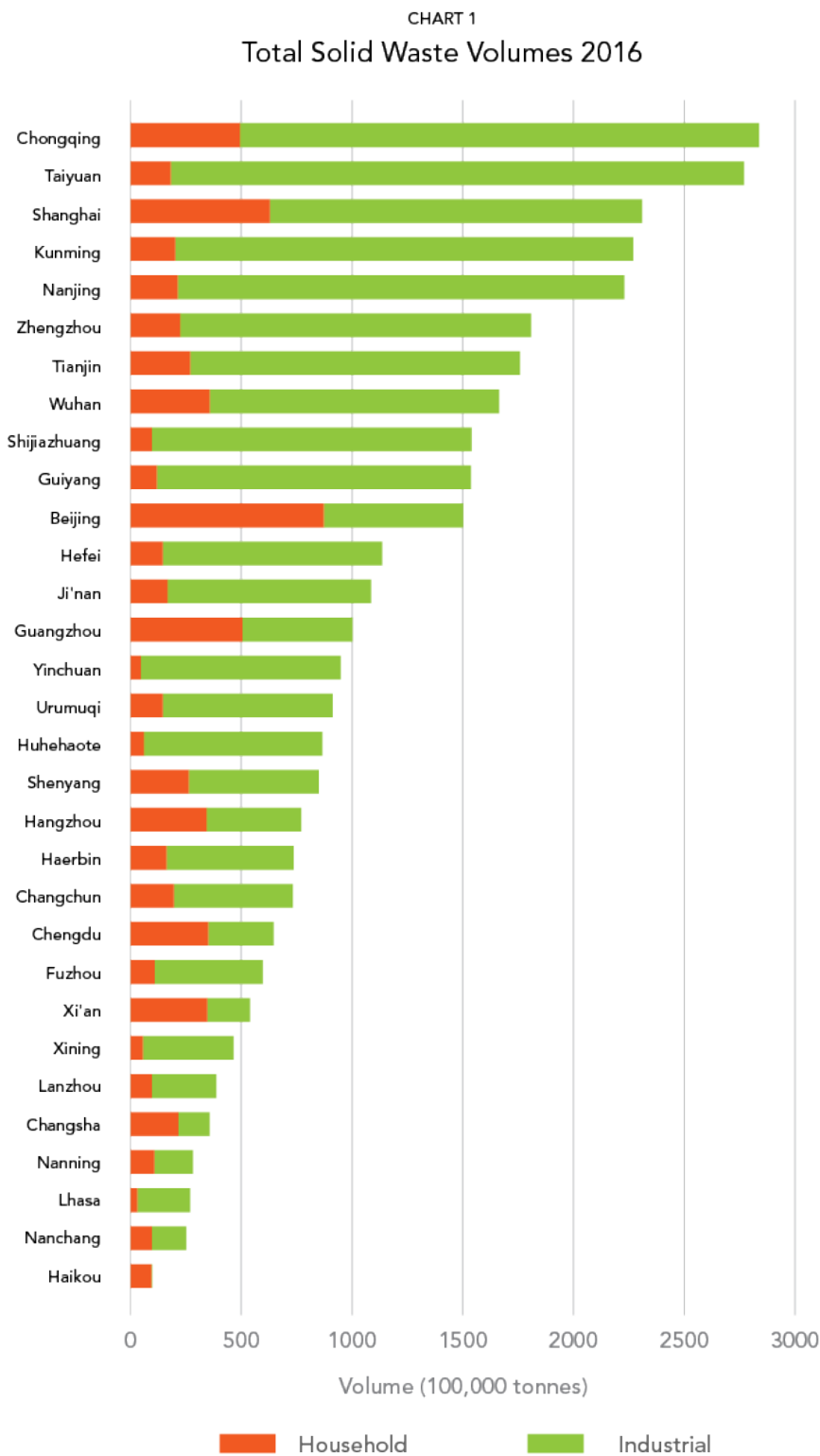


As China surges forward as the world's second largest economy, it comes as little surprise that it is the world's largest solid waste generator, surpassing the U.S. in 2004. The World Bank predicts China will produce twice as much municipal solid waste as the United States by 2030. With the last official number tipping the scales at almost 3.3 billion tonnes in 2016, China is producing solid waste at an unprecedented rate.

To better grasp the larger picture, we looked at 31 major cities (27 provincial capital cities and 4 direct-governed municipalities) and explored the data for patterns and credible indicators in cities tackling China's garbage overflow.

China's Mountain Range of Garbage by the Numbers

Organized in descending order by total waste volumes on Chart 1 (household and industrial waste combined), we see the cities producing the most waste are Chongqing, Taiyuan, Shanghai, Kunming, and Nanjing. To better understand the rankings, we can further segregate the numbers.



SOURCE: CHINA STATISTICAL YEARBOOK 2013-2016, CHINA URBAN CONSTRUCTION STATISTICAL YEARBOOK 2013-2016

For analysis purposes, solid waste is commonly split into two streams depending on the mode of production – household (in red) and industrial (in green). From Chart 1, we see that industrial waste volumes dwarf household waste in almost all cities. The five exceptions are Beijing, Chengdu, Xi’an, Changsha, and Haikou, which have a higher percentage of household than industrial waste.

Door to Door: Household Solid Waste

Household solid waste volumes often reflect the size of the residential population. Looking at Chart 2 below, many of the cities were repeated in the top 10 lists for both household solid waste volumes and residential population in 2016 – likewise for the bottom 10 ranked cities. For example, seven out of the top 10 cities for household solid waste production also landed a spot within the top 10 for residential population. Along the same lines, seven out of the bottom 10 cities for household solid waste also scored a spot within the bottom 10 for residential population.

CHART 2
City Rankings 2016

RANK	BY HOUSEHOLD SOLID WASTE	BY RESIDENTIAL POPULATION
1	Beijing	Chongqing
2	Shanghai	Shanghai
3	Guangzhou	Beijing
4	Chongqing	Chengdu
5	Wuhan	Tianjin
6	Chengdu	Guangzhou
7	Xi'an	Shijiazhuang
8	Hangzhou	Wuhan
9	Tianjin	Haerbin
10	Shenyang	Zhengzhou
11	Zhengzhou	Hangzhou
12	Changsa	Xi'an
13	Nanjing	Shenyang
14	Kunming	Nanjing
15	Changchun	Hefei
16	Taiyuan	Changchun
17	Ji'nan	Changsha
18	Haerbin	Fuzhou
19	Urumuqi	Ji'nan
20	Hefei	Nanning
21	Guiyang	Kunming
22	Fuzhou	Nanchang
23	Nanning	Guiyang
24	Lanzhou	Taiyuan
25	Nanchang	Lanzhou
26	Shijiazhuang	Urumuqi
27	Haikou	Huhehaote
28	Huhehaote	Xining
29	Xining	Haikou
30	Yinchuan	Yinchuan
31	Lhasa	Lhasa

SOURCE: CHINA URBAN
 STATISTICAL YEARBOOK
 2013-2016, STATISTICAL
 COMMUNIQUE OF ECONOMIC
 AND SOCIAL DEVELOPMENT
 2013-2016 OF ALL 31
 PROVINCIAL-LEVEL
 ADMINISTRATIVE REGIONS

While most cities follow this pattern, there are a few outliers suggesting other factors are at play in their jurisdictions. The most compelling example is Shijiazhuang. As the capital and largest city of northern China's Hebei province, it has a low amount of household solid waste, despite its high residential population.

It is interesting to observe that from 2013 to 2016, despite zero or slight population growth in Shanghai, Nanjing, and Lanzhou, household solid waste volumes in those cities actually decreased over the same period. It is also worthwhile to point out that Shanghai and [Nanjing](#) are actively educating citizens on recycling, and enforcing residential recycling programs. In 2015, Shanghai even vowed to become a [zero landfill city](#) by 2018 by curbing household waste and diverting it to waste energy facilities. Government policies and initiatives play a large role in greening cities, and with the 2015 revision of the Prevention and Control of Environmental Pollution by Solid Waste policy now in place, more cities may follow the lead of Lanzhou, Nanjing, and Shanghai.

Despite its enormous volumes of household solid waste, China fares quite well in terms of treatment. Twenty of 31 major cities treated all their solid waste in 2016, an addition of five cities since 2013. The remaining 11 cities are also treating more than 90 per cent of their solid waste.

However, it is misleading to take these numbers at face value without further analyzing the quality and level of treatment. Treatment processes may vary from city to city and some may need to improve in order to meet sustainability thresholds. This is where clean technologies from Canada could come into play.

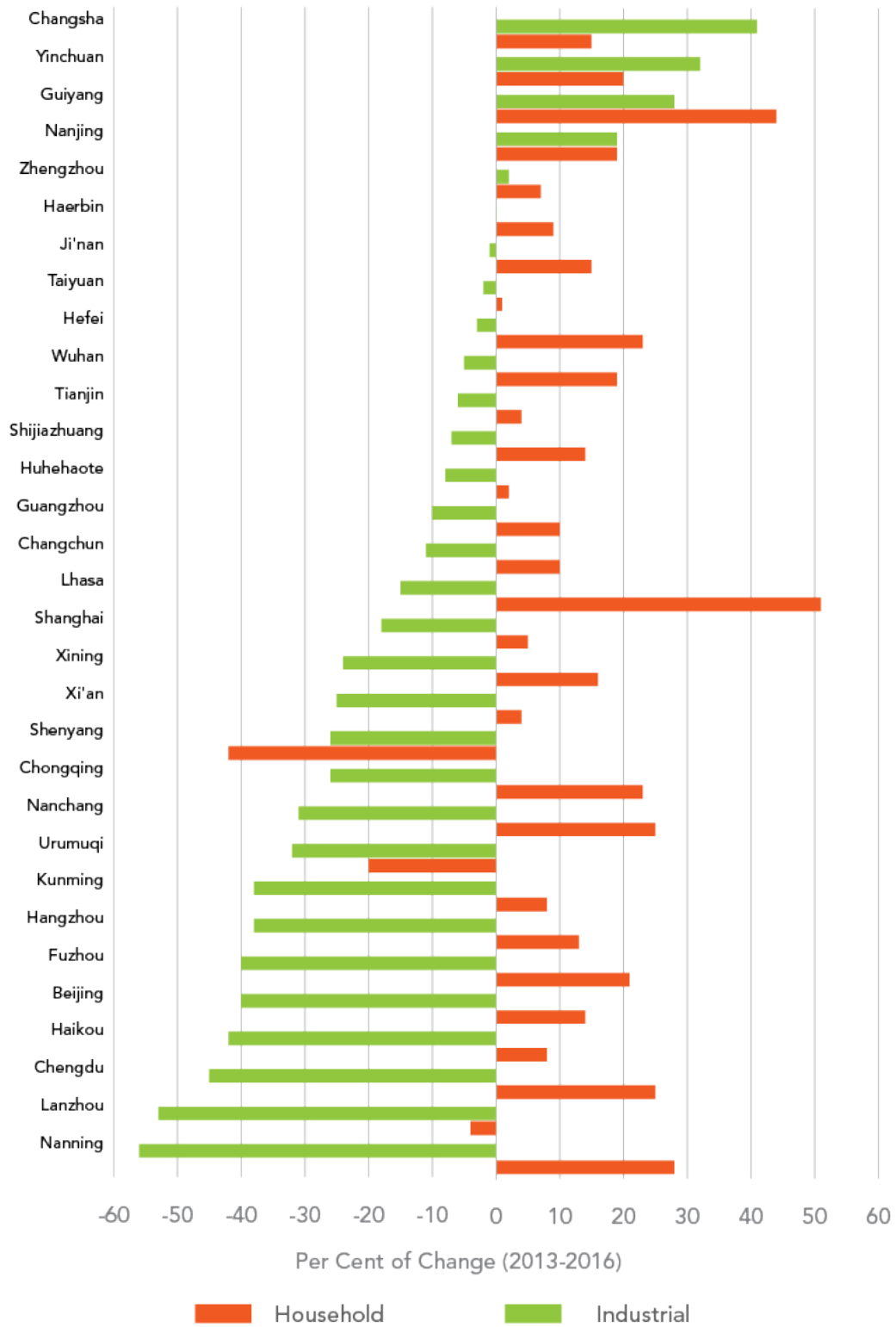
Between the Skyscrapers: Industrial Solid Waste

Industrial waste is generally accepted as a reflection of economic development. Economic growth, especially in countries with a growing secondary manufacturing sector, might be expected to create a more noticeable trail of industrial waste. However, the data tells a different story.

In 2016, cities with the largest volume of industrial solid waste were Taiyuan, Chongqing, Kunming, Nanjing, and Shanghai with just over 258, 234, 206, 201, and 168 million tonnes, respectively. Since 2013, industrial waste volumes in most cities have generally decreased, as shown by the green bars reaching below zero (Chart 3). The cities lagging, as represented by green bars on the left of Chart 3, include Changsha, Yinchuan, Guiyang, Nanjing, and Zhengzhou. On the flip side, the superstar trendsetters include Nanning, Lanzhou, Chengdu, Haikou, and Beijing. These five cities have had the greatest success in curbing industrial solid waste, decreasing volumes by 56, 53, 35, 42, and 40 per cent, respectively, since 2013.

Over the same period, all the cities except Shenyang also achieved positive GDP growth. More impressively, industrial waste volume reductions were achieved despite soaring increases in secondary industry, depicted by the red bars above zero (Chart 3). This shows most major cities in China have been able to achieve a more sustainable, green growth in the past several years.

CHART 3
 Change in Industrial Solid Waste vs. Change in
 Secondary Industry GDP



SOURCE: CHINA STATISTICAL
 YEARBOOK 2013-2016

One reason for this could be China's new found environmental protection policies. Over the past three years, China has mounted an unprecedented crackdown on polluting factories to meet environmental targets. Estimates suggest as many as [40 per cent](#) of China's factories have been temporarily closed for environmental reasons and officials in more than 80,000 factories have been charged with criminal offenses related to infringing on public and environmental health. This revolution may have, over the last few years, helped reduce industrial waste volumes as well as other types of pollution, including [air](#) and [water](#).

Despite all its efforts, China overall has only realized a mere six per cent decline in industrial solid wastes between 2013 and 2016. A sobering indication of the ongoing challenges is the realization that industrial sources make up an overwhelming 94 per cent of all solid waste in China.

A Balanced Approach for the Future

From initial movements to curb solid waste by setting industrial solid waste targets in the 11th Five Year Plan to the most recent initiative of defining accountable parties under the Law on Prevention and Control of Environmental Pollution by Solid Waste (2015 revision), China has come a long way – but the work has only just begun. Not only is this problem mounting domestically, on the international stage China has also traditionally been a depository for waste from other countries. The bold move to [ban many types of recyclables](#) at the beginning of this year sends a message to the world: the health of China's environment, people and economy will be prioritized.

04

LESSONS FROM THE DANES AND FINNS

BY DONGWOO KIM



The global market for clean technology is now estimated to be around US\$1 trillion and is expected to surpass US\$2.5 trillion by 2020. For Canada, a country with an economy largely reliant on resource exports, the performance of its companies in a new, rapidly growing sector is welcome news. Today the Canadian cleantech market consists of approximately 850 firms valued at C\$13 billion, and plays an important role in the country's economy, employing more than 55,000 skilled workers. Earlier this year, a record 13 Canadian companies were named to Cleantech Group's 2018 [Global Cleantech 100 List](#), which highlights top enterprises in the sector.

And yet, the record-shattering performance of Canadian cleantech enterprises last year fails to present the full picture. Experts in the sector are warning stakeholders about serious structural problems, which, unaddressed, might harm Canadian competitiveness in the global market. To thrive, Canadian companies must increase their share of the international market because the domestic market is so limited. For the past few years, the world market share for Canadian cleantech companies actually dropped from 1.6 per cent of the total in 2008, to 1.4 per cent in 2015.¹

¹ *Analytica Advisors, 2017 Canadian Clean Technology Report*

Cleantech and Why Asia Matters

In this context, the Asian market is particularly important for Canadian cleantech entrepreneurs. While in the past policy-makers frequently argued that there was a trade-off required between economic growth and environmental protection, today that assumption may not hold true. Increasingly, policy-makers point to the need for “green growth,” advancing technologies and development strategies that both stimulate economic growth while protecting the environment.

A good example is India’s ‘Smart Cities Mission,’ which aims to develop 100 “smart cities” by 2022 using clean technology. The Government of India plans to invest approximately C\$39.42 billion in the project during the 2018-2019 fiscal year alone. This presents enormous opportunities for Canadian cleantech entrepreneurs who have world-class expertise and recognition.

China also presents opportunities for Canadian cleantech companies. Within the past few years, China has emerged as a key player in international environmental politics, taking leadership in tackling climate change, both domestically and internationally. Beijing made bold commitments to pursue a “dramatic energy revolution” in its latest five-year plan. To that end, it has changed foreign investment policies and upped investment in cleantech research and development. As a result, there was a 1,600 per cent increase in investment in the Chinese cleantech sector between 2016 and 2017. Today, the Chinese cleantech market accounts for 21 per cent of global market share, a number likely to rise even higher.

What is the Challenge?

Canadian companies have struggled in their efforts to penetrate the Asian market. As part of an initiative to address this challenge, Innovation, Science, and Economic Development (ISED) Canada and the Asia Pacific Foundation of Canada launched a [Federal-Provincial-Territorial Assistant Deputy Ministers Meeting in October 2017](#). Cleantech stakeholders and government officials gathered to discuss their ‘China Strategy,’ starting from the implicit consensus that there is a barrier for Canadian cleantech entrepreneurs in relation to China.

In the end, while the language varied, there was agreement that market conditions and the scale of projects in China often make it difficult for a single Canadian cleantech company, usually an MSME (Micro, Small and Medium Enterprise), to be successful. The complex regulatory landscape in China, dominated by the long-term ‘relationship’ (guanxi) culture, adds a further layer of complexity. One strategy that may prove to be effective is for Canadian MSMEs to team up to increase their footprint and resources.

Industry stakeholders and government officials alike noted the ‘Canada Brand’ is gaining prominence in Asia. Last year, the Nation Brands report ranked Canada as the seventh most valuable brand in the world. ‘Canada Brand’ power is especially valuable in Asia and the cleantech industry, as it is associated with keywords such as ‘healthy,’ ‘trustworthy,’ and ‘clean.’ However, meeting participants noted this advantage has so far, not yet been fully leveraged.

To help Canadian cleantech companies gain greater access to Asian market, government and industry may want to look to Scandinavian countries like Denmark and Finland, which have been quite successful in increasing their international competitiveness.

What are the Danes and Finns Doing?

In 2017, Canada was ranked fourth in the Global Cleantech Innovation Index, which measures the national competitiveness of 40 countries in the cleantech sector. Denmark topped the list, and Finland ranked second. These two Scandinavian states invested in the cleantech sector early on and, as a result, now have world-class cleantech industries. Each government has established a specialized cleantech hub to assist companies to take their businesses abroad – especially to Asia.

The Danish hub, [State of Green](#), is a public-private partnership founded by the Danish Government, Confederation of Danish Industry, Danish Energy Association, Danish Agriculture & Food Council, and Danish Wind Industry Association to connect international clients with Danish cleantech solutions. The website is accessible in four languages (English, German, Japanese, and Mandarin Chinese) and presents Danish cleantech solutions by sectors, highlights success stories, and keeps visitors apprised of industry updates. By adopting the name ‘State of Green,’ Denmark effectively leverages its country’s brand to maximize opportunities for its cleantech industry.

[Cleantech Finland](#) is the Finnish equivalent of Denmark’s State of Green. This hub has in-person operations in China, India, and Russia to connect Finnish industry with international clients. Cleantech Finland also ran a program called ‘Beautiful Beijing’ in collaboration with the Chinese Ministry of Environment. The program ran between 2015 and 2017, before it was discontinued due to changes in government policy in China, with the goal of creating 300 new jobs for the cleantech sector and achieving 10 per cent growth of Finnish MSMEs’ annual turnover. Cleantech Finland secured projects on winter sports infrastructure for the Beijing 2022 Winter Games, as well as the construction of the Sino-Finnish Economic, Trade and Cultural Cooperation and Exchange Centre in Nanjing. The ‘Beautiful Beijing’ initiative shows how valuable the role of government as co-ordinator and introducer can be to help companies tackle the ‘scale’ challenge in China.

These two programs provide excellent examples for the Canadian Government as it moves forward to support Canadian cleantech companies abroad. Late last year, the federal government launched the [Clean Growth Hub](#), which seeks to up both domestic and international competitiveness of the Canadian cleantech sector.

05

NAVIGATING THE ‘VALLEY OF DEATH’: FINANCING AND COMMERCIALIZING CANADA’S CLEANTECH INDUSTRY

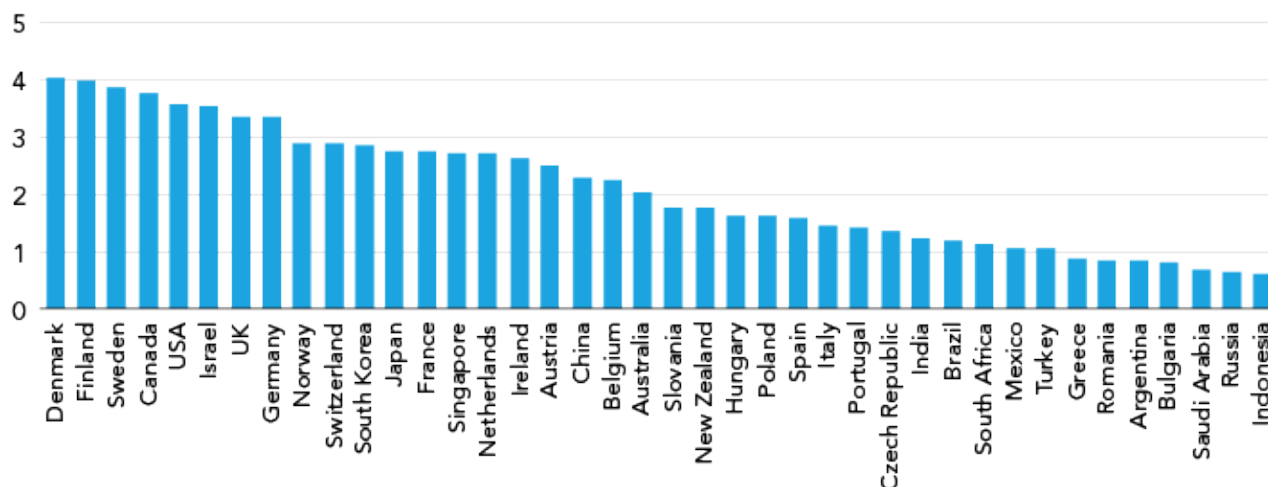
BY DONGWOO KIM

In the start-up community, the biblical-sounding term ‘Valley of Death’ refers to the precarious intermediate stage between Research and Development (R&D) and product commercialization. This gap is especially pronounced within the cleantech sector, which requires greater R&D investment and is heavily reliant on government regulations and policies to launch products and services. Joseph Lassiter from Harvard Business School, contrasts this particularity in the cleantech sector with the well-funded Internet industry and argues that “[public policy support in the form of subsidies and mandates is required.](#)” According to industry accounts, many Canadian cleantech firms languish in the ‘Valley of Death.’ A closer at the sector reveals structural problems – especially with financing – and highlights the need for the Government of Canada to assist in this area.

Has Canadian Cleantech Left Behind the Valley of Death

The 2017 Global Cleantech Innovation Index, which compares the cleantech innovativeness of 40 countries, ranked Canada in fourth place. The Index attributed Canada's strength to its "relative advantage in providing start-ups with access to private capital via cleantech-focused funds and domestic investors," which has tripled "the number and value of cleantech funds and domestic investors targeting cleantech." The report further notes that Canada ranked first in making funding available for early entrepreneurship, a ranking that considers the amount of venture capital invested in cleantech companies as a proportion of GDP between 2014 and 2016. The Index assessment, together with [Canada's C\\$2.2-billion investment in the cleantech sector in its 2017 federal budget](#), paints a rosy picture. However, domestic observers and stakeholders have concerns about the health of the industry and are calling for changes to ensure Canada doesn't lose its competitive edge in the global market.

Cleantech Countries Innovation Index



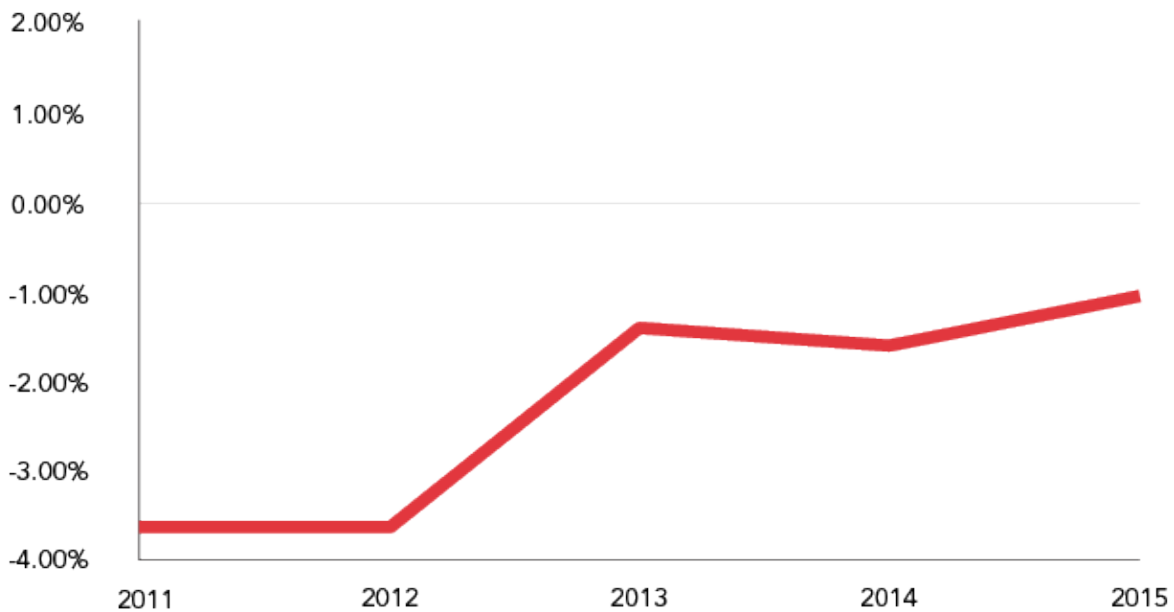
SOURCE: IMAGE COURTESY GREENHOUSE COMPETITIVENESS AND INNOVATION INITIATIVE (GCII)

Canadian Cleantech on the Ropes?

Analytica Advisor's 2017 Canadian Clean Technology Industry Report assessing Canada's cleantech sector tells a different story from the Index. Financing challenges, especially access to growth capital, have been cited as the primary barrier for Canadian cleantech firms. Céline Bak, the CEO of Analytica Advisors, points out that some of the leading companies in the sector are "on the ropes" and that "Canadian firms do not have access to financing enabling them to meet demand." Mike Monteith, a representative from the Council of Canadian Innovators, notes that accessing capital is too difficult under the current business model that traditionally requires a two-to-five year business plan, and suggests that a longer view – 20 years, perhaps – would be a more appropriate framework to fund firms working with disruptive technologies like cleantech.

These contrasting views on access to capital suggest the greatest challenges exist in the commercialization stage. As noted by the Index, there is an abundance of early stage venture capital funds, which further the emergence of promising, innovative new firms. However, as the Advisor report notes, Canadian cleantech firms have not been profitable since 2011, causing apprehension among domestic investors. During the federal-provincial-territorial assistant deputy ministers meeting on Developing a Collaborative Approach to Exporting to China hosted by the Asia Pacific Foundation of Canada on October 12, 2017, industry representatives also mentioned additional support for “scaling-up” ventures in markets like China that demand larger-scale projects. Financing problems were identified at the post-R&D stage, which heightens the threat of innovative firms – along with their technical expertise – being hijacked by foreign capital in a desperate attempt to exit the Valley of Death.

Canadian Clean Technology Industry Return on Sales 2011-2015



SOURCE: IMAGE COURTESY
ANALYTICAL ADVISORS

The Government that Must Act

In this context, the case is strong for the federal government to play a more active role in furthering the growth of the cleantech sector. The introduction of specialized funds for cleantech industry is a positive step. However, the federal government could also leverage existing interest in the market by adjusting financial regulations to accommodate the special needs of cleantech firms, such as a longer timeframe for business plans. As noted by Harvard's Lassiter, cleantech R&D and commercialization take more time because the environmental sector requires government collaboration. The slow adjustment of the Canadian financial sector to this new, disruptive innovation model, has further challenged Canadian cleantech entrepreneurs. The Government of Canada's 2017 budget promise to invest C\$700 million in the industry through the Business Development Bank of Canada makes perfect sense.

There are other ways the government could help expand market opportunities within and outside Canada. The Advisor Analytica report notes current Canadian regulatory policies, which do not punish carbon pollution very harshly, dis-incentivize other countries and potential clients from setting environmental performance standards. This in turn reduces interest in the services of cleantech firms.

Government assistance is needed to grow Canada's cleantech market, where only slightly more than half (51 per cent) of revenues come from outside Canada and of that an even smaller portion (18 per cent) originate from non-U.S. markets. If the federal government can help get more cleantech firms to Asia, it could help spark a virtuous cycle where increased profits could in turn attract greater investment.

06

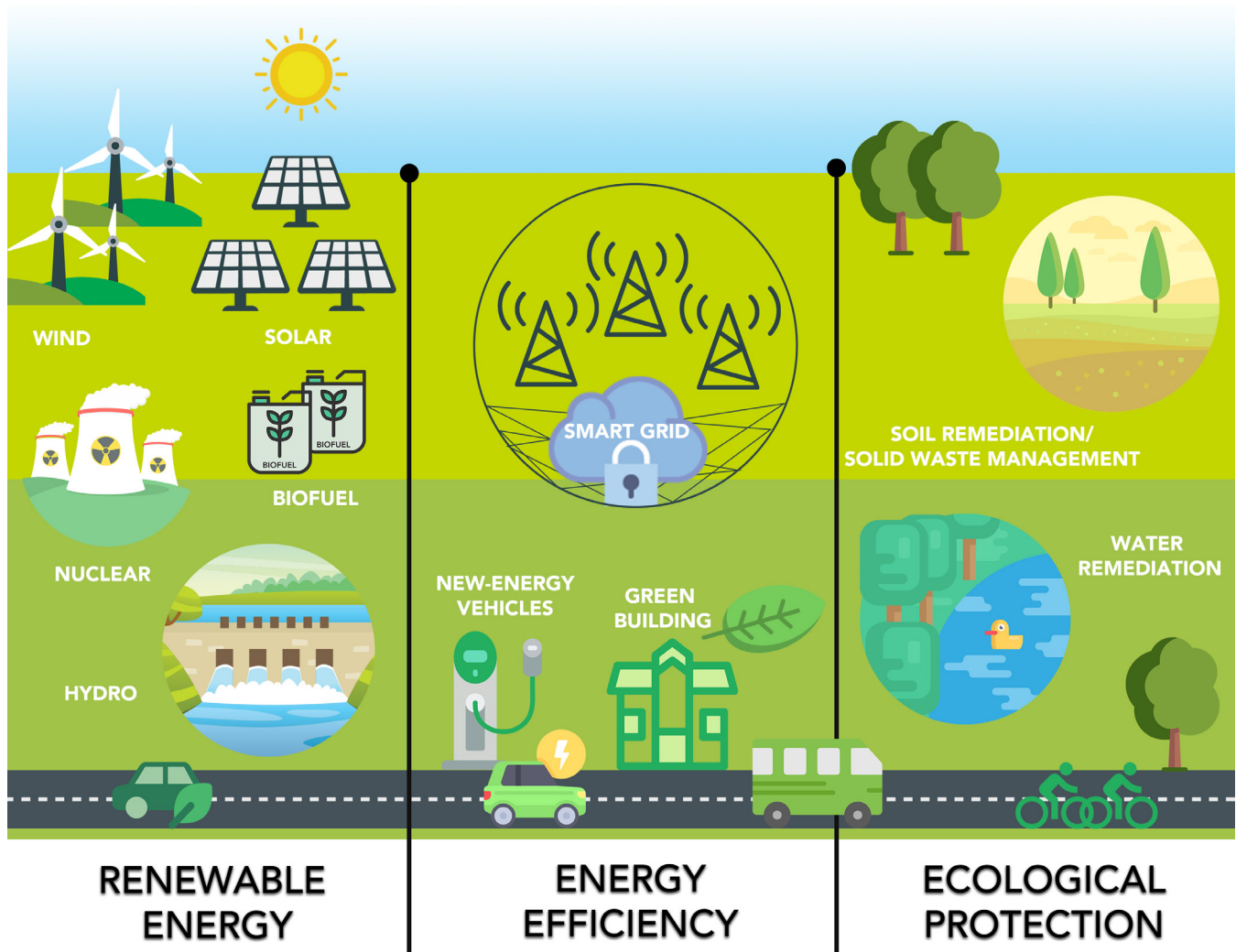
CHINA'S CLEANTECH COMMITMENT

BY YINGQIU KUANG



It should come as reassuring news to the international community that China appears genuinely committed to addressing climate change and promoting clean-tech innovation. China's 13th five-year plan lays out one of the world's most anticipated and far-reaching blueprints for green development. Its 'Belt and Road Initiative' sets 'ecological civilization' as a primary goal: the modern Silk Road would foster the flow of clean technologies between borders and promote global collaborations for a low-carbon economy. Last year, China also broke the international takeover record of large, clean-tech projects, the total value of which exceeds US\$44 billion.

China's ambitions for its low-carbon future has huge, but complex, export and investment potential for international participants, especially for Canadian clean-tech companies. By visualizing China's commitments in clean technologies and comparing these commitments to the country's current status in developing its clean-tech industry, an interesting picture emerges.



1. Renewable Energy

China is leading the world's renewable energy revolution. Since 2013, severe air pollution and climate change fears have driven the smog-ridden country away from fossil fuels. Renewable energy development is key to reducing green-house gas (GHG) emissions from coal which is burned to generate power. Chinese political leaders view renewable energy as the way of the future and a powerful engine for job creation. At the start of 2017, they announced an investment of US\$ 360 billion in renewable energy by 2020, a move which will create 13 million additional jobs in the sector.

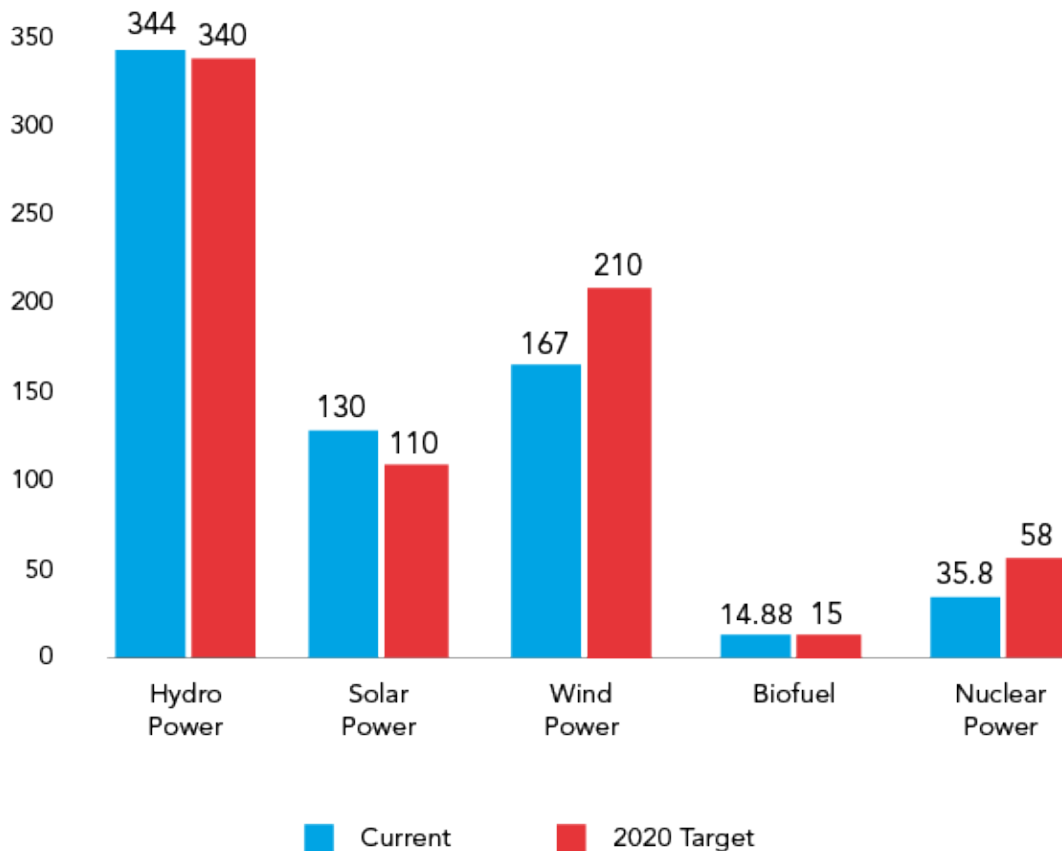
TARGETS. Beijing has identified two important targets in renewable energy development:

- Increase the use of non-fossil fuels: increase the share of non-fossil fuels in primary energy consumption from 11.4 per cent in 2015, to 15 per cent by 2020, and to about 20 per cent by 2030.
- Increase domestic production to ensure energy security: increase the share of installed non-fossil fuel generation capacity from 30 per cent in 2015 to about 39 per cent by 2020.

CURRENT TREND. China appears to be ahead of schedule in meeting these goals. Official figures show coal consumption in China fell in 2017 for the fourth straight year. And by the end of 2013, the share of installed non-fossil fuel generation capacity (30.6 per cent) had surpassed the goal set for 2015 (30 per cent); As a result, the National Energy Administration (NEA) adjusted the 2014 goal to 32.7 per cent. And given that by 2017 the share of installed non-fossil fuel generation capacity had already hit 38.7 per cent, it seems likely the country will reach its 2020 goal by next year.

Hydro continues to be the leading renewable power source in the country, but growth is greatest in solar and wind energy. On the solar front, solar power generation capacity grew more than 700% over the past 5 years; the country now accounts for 60% of world's solar cell production. By 2017, China had already met its 2020 target of installing 110 GW of solar, causing the Chinese National Renewable Center to increase the target to 200 GW. The estimated installed capacity of wind by 2020 is now set at 264 GW, far surpassing the original target of 210 GW set in the five-year plan.

Installed Generation Capacity (GW)



By contrast, the development of biofuels and nuclear power is moderate. The most recent five-year plan makes limited mention of biofuels, implying that biofuels will likely play only a minor role in China's decarbonisation of its transport sector. While there are 21 nuclear power plants now under construction, regulators in China have not approved any new nuclear energy projects since the 2011 Fukushima disaster in Japan. The 2020 target to reach 58 GW nuclear power capacity is therefore, unlikely to be met. Chinese regulators are now very cautious of having a big nuclear program; and are searching for advanced technologies to ensure future projects meet the highest possible safety standards.

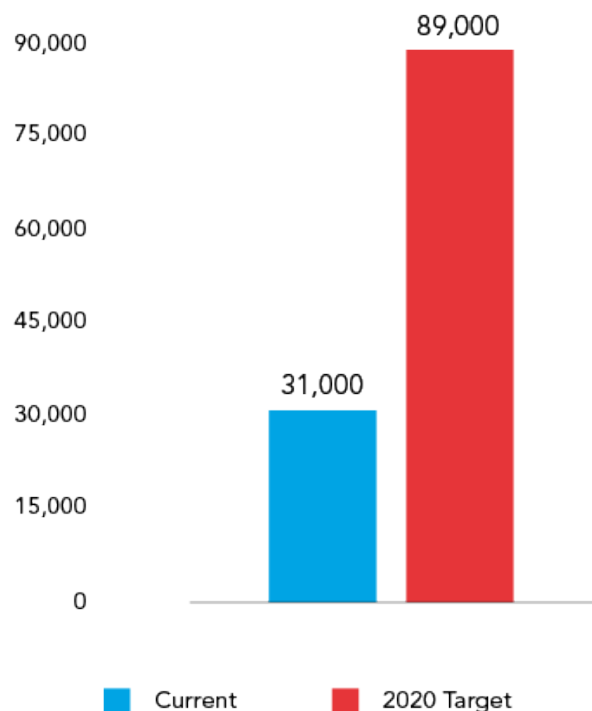
2. Energy Efficiency

Besides the renewable energy revolution, energy efficiency and conservation are also high on China's political agenda. The 13th five-year plan commits to a 15 per cent decline in energy consumption per unit of GDP by 2020, and a reduction of the carbon intensity of its GDP from 40 to 45 per cent by 2020 (relative to 2005). To achieve that, Chinese government policies focus on three sectors: smart grid capabilities, green building technologies, and the adoption of new-energy vehicles.

SMART GRID

Smart grid stands for advanced technologies for highly-efficient and cost-effective energy storage. It can help enhance the reliability of electricity supply by integrating intermittent renewable power sources and using control systems to ensure energy efficiency. In 2009, State Grid, China's state-owned electricity utility, announced plans to invest over US\$ 285 billion to construct a 'unified strong and smart grid' project by 2020.

Length of Ultra-High Voltage Lines Under Construction (km)



TARGETS. The focus of the smart grid plan in China is to build an ultra-high-voltage (UHV) transmission grid, a key technology that ensures efficient integration of renewable energy power over long distances. China is the first country to set the development of ultra-high-voltage power lines as a government priority. State Grid aims to construct 4200 km UHV transmission grid by 2010, 40,000 km by 2015, and eventually 89,000 km lines by 2020. Beijing also committed to having smart meters in widespread use by 2020.

CURRENT TREND. The smart electric meter market is currently the most mature in China. The number of households with installed smart meters grew from 191 million in 2013 to 447 million in 2017, a penetration rate of 99 per cent. Due to the near-saturation of this market, further growth will mainly come from newly-built residential buildings. The growth rate is expected moderate as the 13th five-year plan has significantly lowered the real estate growth goal in the country.

The annual growth rate of ultra-high-voltage transmission grid construction has also shown a marked slowdown over the past five years. There are two reasons for this. First, construction costs are hefty and current technological constraints limit the actual transmission of intermittent renewable energy power. Second, the National Energy Administration and State Grid appear to have different priorities. The NEA seems to prefer strengthening regional grids, whereas State Grid's UHV plan calls for inter-connection between regional grids. The future development of smart grid projects in the country are highly dependent upon further technological advancement and political coordination among state agencies.

GREEN BUILDINGS

Improving energy efficiency of buildings is crucial for China to realize its national green development strategy. Over the past several years, government policies have created building codes that set minimum construction standards for energy efficiency. The Ministry of Housing and Urban-Rural Development in 2008 also implemented a National Green Building Evaluation Label certification. They aim to cut energy use of buildings in all cities by 50 per cent by 2010 and 65 per cent by 2020.

TARGETS. Recognizing the importance of 'green buildings', Chinese regulators set ambitious targets for the sector:

- Construct 1 billion square meters of green buildings by the end of 2015;
- Ensure 20 per cent of new construction meets green building standards by 2015, and increase this share to around 50 per cent by 2020.

CURRENT TREND. The Chinese green building revolution is relatively young; available data only dates from 2013 to the end of 2016. By the end of 2016, China had constructed over 1.25 billion square meters of green buildings and 29 per cent of new construction met the green building standards. Despite ambitious national policies and strong local examples, China still focuses on specified pilot programs, many of which are located on the coastal area. Inland cities still face several green-building challenges such as: comprehensive urban planning, policy and regulatory implementation, and the deployment of available energy efficient technologies. While multinational corporations have taken the lead in promoting green buildings in China, local developers and companies lag behind. Only 19 per cent of landlords in the country have expressed plans to incorporate green building standards in their existing projects.

NEW-ENERGY VEHICLES

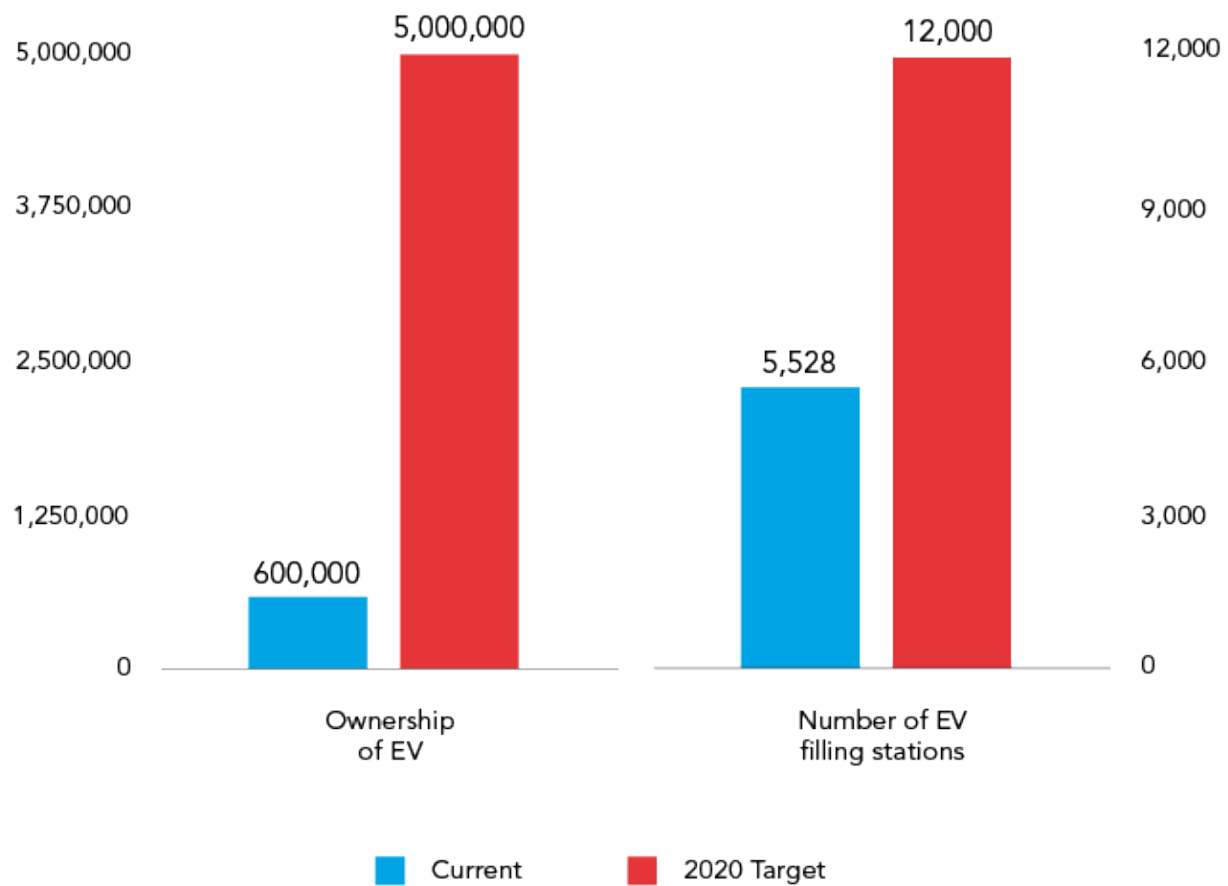
New-energy vehicles, especially electric vehicles (EVs), are key to China's green transportation program, as the country tries to curb petroleum demand and GHG emissions in the road transport sector. This program began in 2009 when Beijing launched the 'Ten Cities, Thousand Vehicles' program, to stimulate EV development through large-scale pilots in 10 cities, a program which was later expanded to 25 cities.

TARGETS. The Chinese government has identified two important targets to leap-frog current automotive technology:

- Increase the use of EVs: increase targeted ownership (including production and consumption) of battery-electric vehicles and plug-in hybrid-electric vehicles from 500 thousand in 2015 to five million by 2020.
- Ensure infrastructure construction: increase the amount of inner-city EV filling stations from 2,000 in 2015 to around 12,000 by 2020.

CURRENT TREND. Over the past five years, China has become the EV industry's global leader. In 2015, the country achieved record sales of over 200,000 EVs, surpassing markets in Europe and the United States. In 2017, more than 600,000 thousand EVs were sold, up 71 per cent over 2016. China produces roughly half the number of EVs sold worldwide and attracts 40 per cent of global investment in the sector.

Electric Vehicles



Despite the technological advantage China enjoys in this sector, the Chinese EV market does not seem to be too enthusiastic to meet Beijing's ambitions. By 2017, the original state targets for EV market share were far from being met, despite generous government subsidy schemes. Beijing had to reset the target to one million units by 2018 and two million units by 2020. Meanwhile, the domestic market is highly protected and almost all EV purchased within the country are locally produced; foreign brands represent only 4 per cent of EV sales.

3. Ecological Protection

In addition to renewable energy development and the energy efficiency revolution, ecological conservation and environmental protection also stand out as national priorities. The 13th five-year plan has set some serious targets in order to address water and soil pollution in China.

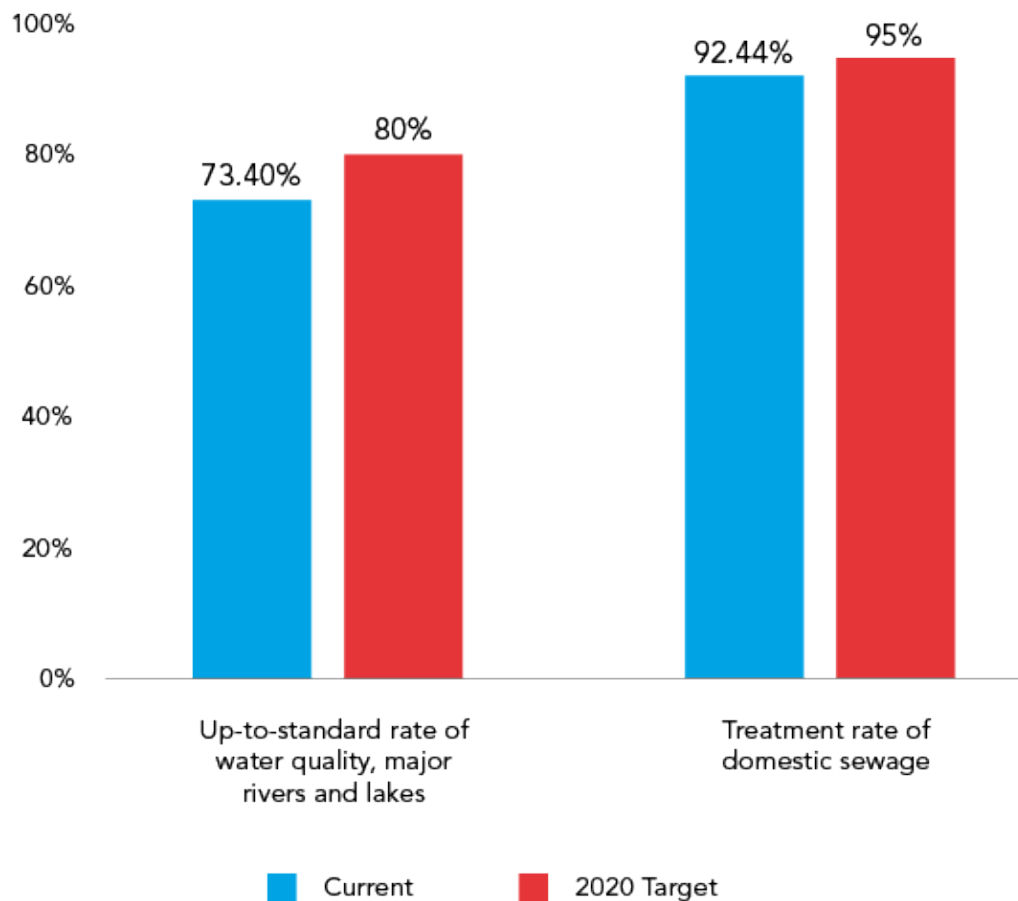
WATER REMEDIATION

Issued by the State Council in 2015, the new Water Plan is essentially a complete reset of China's water use and treatment program. This ambitious plan includes 10 key measures and 38 sub-measures with clearly defined timelines and government department responsibilities.

TARGETS. There are two targets for water remediation in China:

- Improve the up-to-standard rates of water quality at water function zones of major rivers and lakes from 55 per cent in 2010, to 60 per cent in 2015, and to about 80 per cent in 2020.
- Increase the treatment rate of domestic sewage from 70 per cent in 2010, to 85 per cent in 2015, and 95 per cent in 2020.

Percentage Rate of Quality and Treatment



CURRENT TRENDS. The current progress of water remediation, however, is quite slow. By last year, the Chinese government had nearly 8,000 water clean-up projects underway at 343 contaminated sites, for a projected total cost of US\$ 100 billion. Though treatment rates at major rivers and lakes and domestic sewage treatment has risen to 73.4 per cent and 92.4 per cent respectively, a Beijing-based NGO points out only 35 per cent of 12,226 monitored sites across the country have good quality water. Another 32 per cent are suitable as a water supply, 20 per cent are suitable for industrial or agricultural use – but not for human contact – and 13 per cent are useless. In this context, China is expected to seek out more technology supply and wastewater treatment assets from international companies.

SOIL REMEDIATION/SOLID WASTE MANAGEMENT

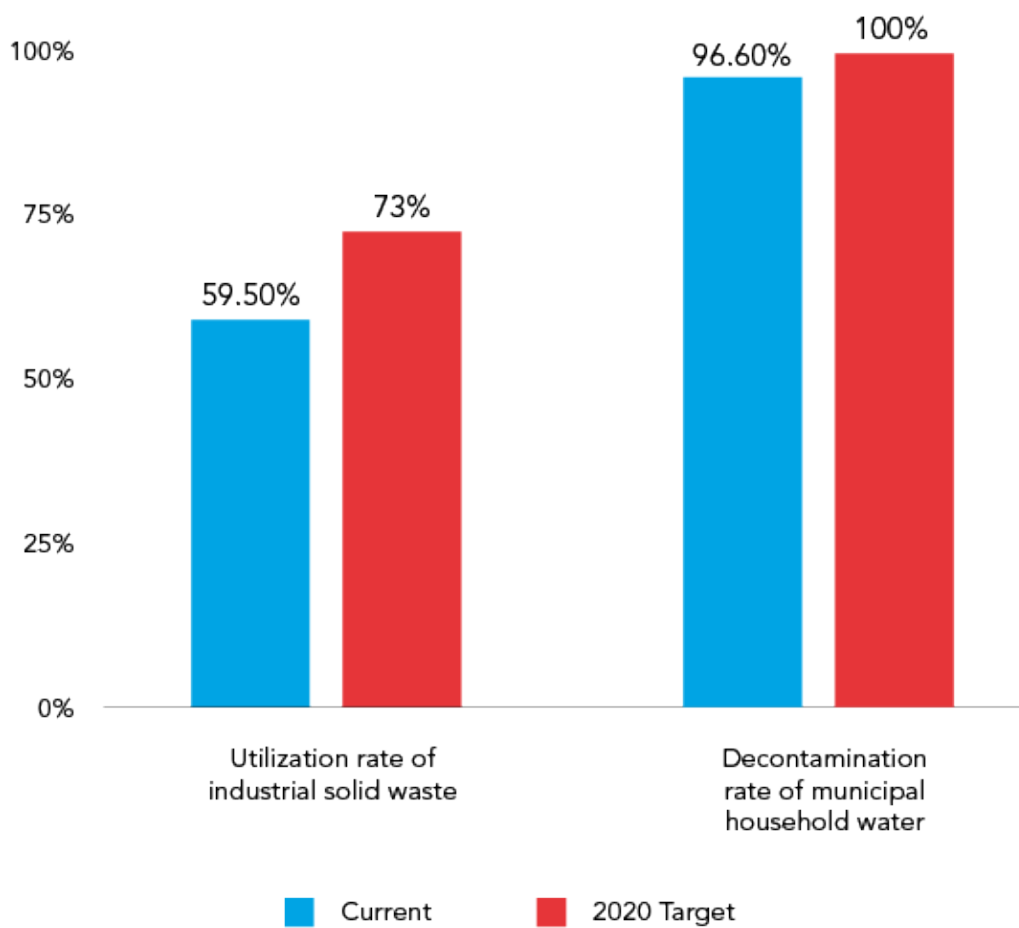
The surging volume of solid waste has been another key pollution concern for China. In 2005, Chinese regulators recognized and encouraged the use of municipal solid waste as a source of renewable energy. In July 2017, Beijing announced it would ban imports of 24 categories of recyclables and solid waste by 2018, reflecting the fact that China is generating more waste itself and needs to improve its own patchy recycling systems.

TARGETS. China has set two targets for industrial waste and municipal household waste.

- Increase the utilization rate of industrial solid waste from 62 per cent in 2010, to 72 per cent in 2015, and to about 73 per cent in 2020.
- Increase the decontamination rate of municipal household waste from 60 per cent in 2010, to 90 per cent in 2015, and eventually to 100 per cent in 2020.

CURRENT TRENDS. China's solid waste recycling industry still lags behind environmental demand. Whereas significant progress has been made to decontaminate municipal household waste during the past five years, the utilization rate of industrial solid waste was scaled back from 62.7 per cent in 2014 to 59.6 per cent in 2016. This is mainly because most of China's recycling industry is privately held and many firms are too small and have lax pollution controls. Some Chinese recyclers also believe the 2017 ban on foreign recyclables is an effort by the government to push out private players. Today in China, there is no complete, legal, regulated recycling system in place.

Percentage Rate of Quality and Treatment



China has demonstrated unwavering commitments to the Paris Climate Agreement. Its green development ambitions spell promising export and investment opportunities for Canadian companies. As they chart their course in the Chinese market, Canadians might face strong domestic competition in certain sectors like renewable energy development. In other areas such as energy efficiency and ecological protection, however, Canadian companies have much to offer. Canadian companies have the experience and technological expertise to help China further its commitments in these sectors, where domestic technology development still lags. A strong case can be made for enhanced international collaboration, and Canadian businesses should take the lead.

07

CHINA'S CLEANTECH DECISION-MAKING

BY YINGQIU KUANG



China is at the centre of a global clean technology transformation. The world's largest green-house gas emitter is attempting to reduce its dependence on fossil fuels, in what Chinese President Xi Jinping has termed the "energy revolution." Beijing has invested heavily in developing one of the world's largest clean-tech sectors. In particular, its planned US\$360 billion investment in renewables by 2020 has been lauded by the international community as a major commitment toward mitigating pollution and addressing climate change. And yet, the uncertain Chinese political and social structure makes it challenging for the country to honour its commitments. This blog in our China Eco-City Tracker web series highlights two important features of clean-tech policy-making in China.

The Central Government: Policy Co-ordination Calls for Administrative Reform

The process for drafting clean-tech policies within the Chinese central government requires unprecedented collaboration among a large number of ministries and cabinet-level departments. The State Council is the overall governing body for clean technologies and it designs, releases, and implements relevant clean-tech policies. Its main responsibility is to ensure strategies and policies developed through its ministries and departments are in line with the principles and guidelines set by the National People's Congress.

Under State Council leadership, China's decision-making in renewable energy development involves 15 ministries and departments and government action in energy efficiency and ecological protection depends on nearly 20 government agencies. The Chinese central government clearly maintains a strong role in planning, financing, and policy co-ordination, but the level of effectiveness and efficiency varies significantly among the country's clean-tech sectors.

In the renewable energy sector, policy co-ordination is concentrated and highly efficient. The National Energy Administration (NEA), a national vice-ministerial ministry under the administration of National Development and Reform Commission (NDRC), is the core of the Chinese regulatory framework for renewable energies.

The NEA has three important functions in renewable energy development: first, it ensures the overall planning of national renewable energy strategies and policies is in line with goals and principles set by top leaders and authorities; second, it promotes timely co-operation with other ministries and departments under the State Council; third, it supervises the implementation of national strategies at local governments and key state-owned enterprises (SOEs).

In the meantime, other ministries and departments have also developed specific roles:

- Ministry of Foreign Affairs and Ministry of Commerce: key decision-makers that determine China's plan for international cooperation in renewables;
- Ministry of Industry and Information Technology and China Development Bank: implement and support pilot programs in renewables;
- Ministry of Finance, State Administration for Industry and Commerce, and State Administration of Taxation: design and implement taxation and government procurement policies in renewables;
- China Banking Regulatory Commission and Certification and Accreditation Administration: establish investment and technology standards for renewables.

However, in energy efficiency and ecological protection, such policy co-ordination is not meeting the demands of the ambitious national strategy. In fact, the decision-making process in both sectors is fragmented and ineffective. No single government agency is endowed with the same centralized authority as the NEA; nor is there any clear definition specifying the roles of participating ministries and departments under the State Council.

This regulatory framework has delayed the ability of Chinese state actors to promote energy efficiency and ecological protection: Beijing needs to spend extra time and effort to achieve consensus among different government organizations before attempting to implement relevant policies. Due to the infighting, Chinese regulators were delayed two years before beginning 8,000 water clean-up projects.

Even though China has become the world leader in renewable energy production, its achievements in energy efficiency and ecological protection still fail to meet environmental demand. Smart grid technology projects are slower than planned, mainly due to the divergent levels of interest between the NEA and State Grid in inter-connecting regional grids. Success in water and soil remediation is sporadic, reflecting the fact that many cities in the country lack comprehensive urban planning capabilities and experience in policy co-ordination and implementation.

The new ministry will become the most powerful dedicated environmental regulatory body in the history of modern China.

The lack of policy co-ordination is raising calls for central government administrative reforms. On March 17, 2018, China formed a new Ministry of Ecological Environment. According to environment minister Li Ganjie, this is a major step to protect the environment and will help prevent the systemic destruction of China's ecology. The

new ministry has sweeping powers to curb pollution. First, it will replace the Ministry of Environmental Protection and take over all responsibilities; second, it will also take over major environmental protection responsibilities currently scattered across various government agencies and ministries.

These include:

- Climate change and emissions reduction policies under NDRC;
- Underground water pollution regulation under Ministry of National Land and Resources;
- Watershed protection under Ministry of Water Resources;
- Agriculture pollution control under the Ministry of Agriculture;
- Marine conservation under the State Oceanic Administration.

This administrative reform will help alleviate policy-making bottlenecks in energy efficiency and ecological protection. The new ministry will become the most powerful dedicated environmental regulatory body in the history of modern China. With its creation, Beijing is likely to expedite policy reforms in ecological conservation and protection which is in line with its global leadership ambitions in green development.

It remains to be seen whether the new institutional arrangement will be granted policy- and decision-making autonomy. Some analysts are pessimistic and believe the new regulatory framework might further marginalize the importance of ecological protection within China's national strategy. In the new institutional setting, the NDRC, the ultimate administrative and macroeconomic management agency in China, will no longer plan and control ecological protection. The new administration reform may create a new super-ministry in environmental protection. Unfortunately, the issue of ecological environment itself might end up enjoying less attention from top political leaders than in the past.

Central-Local Relations: Strong Policy Coordination

One of the fundamental concerns for Chinese political leaders today is the central government's perennial struggle to ensure local compliance with national policy. The second distinct feature of the China's recent clean-tech revolution is that Beijing has established an unprecedented level of policy co-ordination and compliance between central planning and local implementation.

An important policy innovation was to transform the wording in major central government documents. Over the past five years, Chinese regulators have dropped abstract and vague language from national strategies that broadly summarize economic and social development goals. In this clean-tech revolution, specific targets are set for different clean-tech sectors in every province and region, as well as practical timelines for pilot programs.

Simultaneously, the central government has implemented a series of supplementary government policies and regulations to confirm various landing policies that can facilitate the implementation of clean-tech projects. In addition, China has also strengthened the supervisory system in clean technology development. In 2013, Beijing restructured the NEA and vested the administration with institutionalizing supervision and feedback routines from the local government to the central government agency.

The creation of the new, super-ministry of ecological environment this year will significantly help China honour its own commitments for green development.

The other regulatory breakthrough is that, rather than delegating power to local governments to design pilot programs, the central government in China has once again centralized the decision-making. China's 13th national five-year plan and other supplementary government regulations have not only identified specific targets for various sectors in clean-tech industry, but provinces located in different regions are now required to meet certain quotas for the national strategy.

Under some circumstances, provinces are strictly prohibited from developing certain clean technologies and products. For example, Beijing promotes the development of distributed solar power generation, off-shore wind power, biofuels, and nuclear power in the coastal area, but both the northeast and northwest regions are prohibited from developing new wind power plants. In this context, local governments enjoy less policy autonomy and entrepreneurship than before, although this does help to ensure adherence to central policies.

The new clean-tech decision-making regime in China has great implications for Canadian political leaders and clean-tech business communities. First, the creation of the new, super-ministry of ecological environment this year will significantly help China honour its own commitments for green development. Stronger policy, coupled with China's national ambition, presents huge and stable market opportunities for Canadian clean-tech companies.

Second, the consolidated relationship between central planning and local implementation increases the importance of central-level planning and control. It is therefore imperative for Canadian political leaders to understand recent regulatory changes in China.

