

Climate Change
September 2012

No water, no power

Is there enough water to fuel China's power expansion?

China plans to add more than the total installed power capacity of the US, the UK and Australia by 2030

Consequently, industry faces more water and electricity shortages

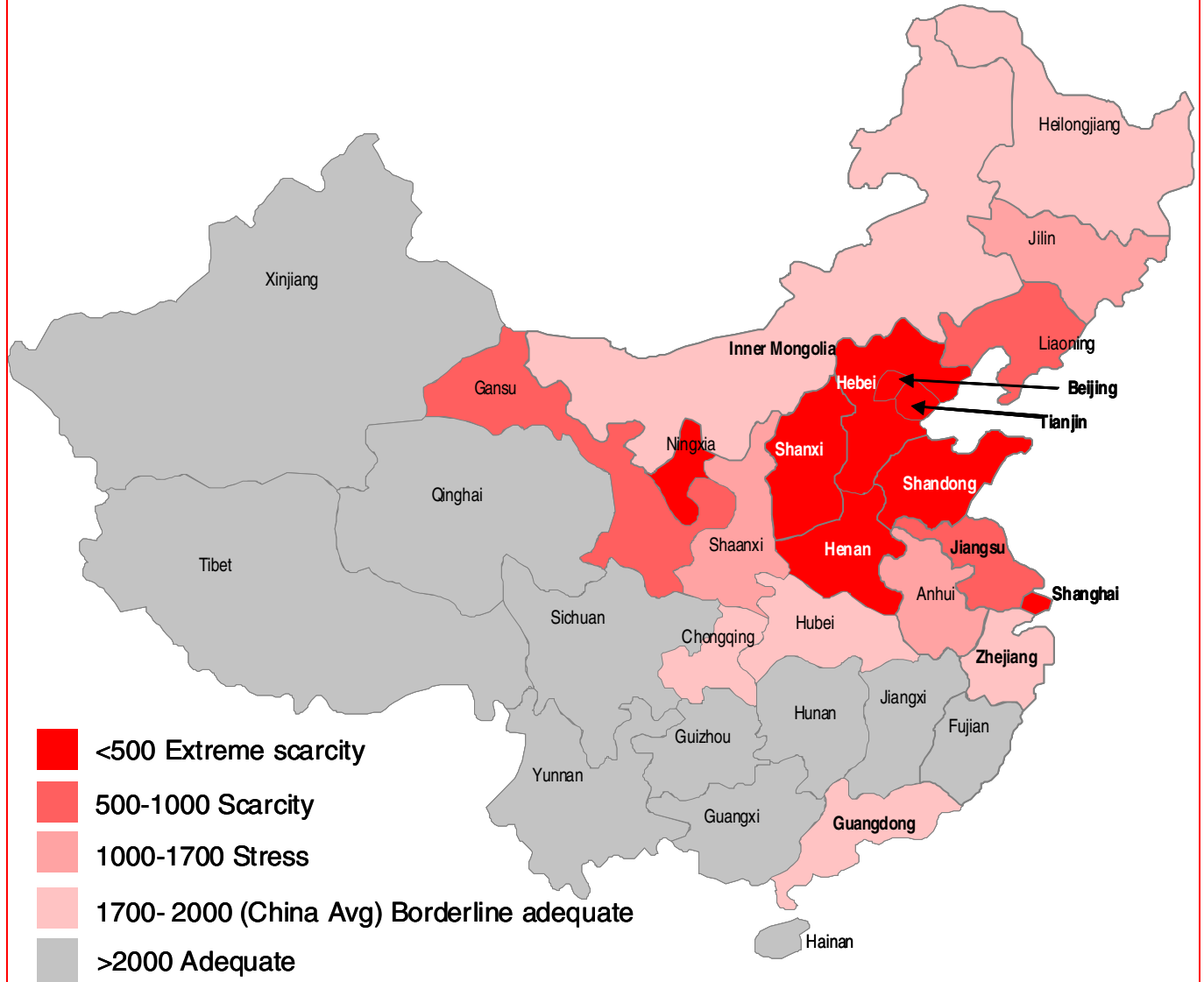
Project financiers, investors and companies should consider resource shortages and more efficient options before funding, investing and expanding

HSBC Climate Change Centre commissioned China Water Risk to research and analyse the findings which form the basis of this report

By Wai-Shin Chan, Nick Robins, Zoe Knight

Disclosures and Disclaimer This report must be read with the disclosures and analyst certifications in the Disclosure appendix, and with the Disclaimer, which forms part of it

China's annual water resources per capita (m³) by province, 2003-10 average



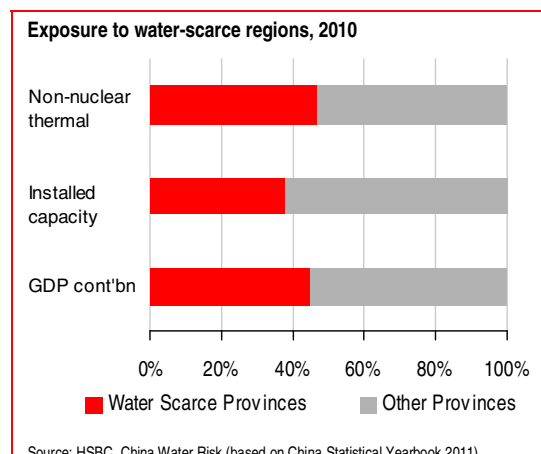
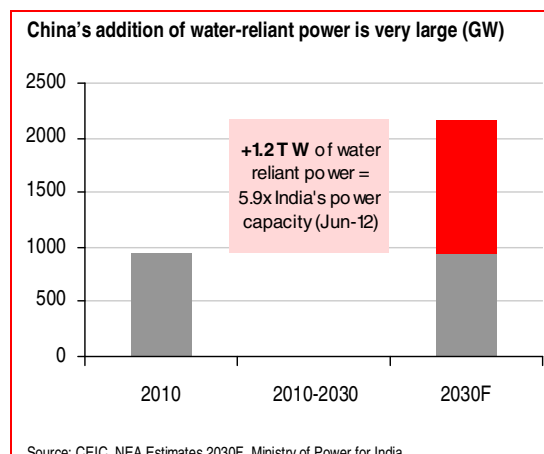
Source: China Water Risk (based on National Bureau of Statistics)

Summary

- ▶ Nearly half of China's GDP is earned in water-scarce provinces
- ▶ Looking ahead, ambitious expansion plans for power capacity could face real water constraints
- ▶ This is expected to drive an increased focus on water and energy efficiency in the power, industry and mining sectors

China has limited renewable water resources; 11 provinces are already water scarce ($<1,000\text{m}^3$ per capita per year) and climate change exacerbates existing water stresses. The government recognises this issue and has responded by setting tough new water quotas, as well as pollution reduction targets. We believe that three sectors will be most affected: power, industry and coal mining.

The power sector is heavily reliant on water for cooling purposes, as well as driving steam turbines. We estimate China's power sector uses approximately 10% of the nation's water, relatively low compared to the UK's 34% and 49% in the US. China plans to add 1.2TW of water-reliant power capacity by 2030, equivalent to 5.9x India's current installed generation capacity. Coal-fired power remains in the vanguard: in the decade to 2020, China plans to add 453GW of coal-fired power capacity, equivalent to double Russia's entire 2009 power generation capacity. This aggressive build-out takes China's installed capacity per person (0.66kW/person) towards the G20 average of 1.5kW/person. Water reliance is expected to remain high through to 2030 despite a change in fuel mix, with 87% of power capacity still requiring water for cooling and generation, down from 97% currently. We believe this expansion will further stress water resources unless efficiency is greatly improved. Hydropower is also at risk from changing water availability such as more frequent and more extreme droughts and floods. The



damming of rivers in China is also becoming a geopolitical risk, generating tensions with countries further downstream.

Energy efficiency is as important as water efficiency because using less energy would reduce demand for more power, which could lead to less capacity, alleviating some of the water stress. China has improved both water and energy efficiency in recent years, although more needs to be done in order to achieve national targets. Stricter energy efficiency targets have already been imposed on the industrial sector since they missed 2011 targets. We think industrial water targets could follow suit. Marginal water efficiency gains in the power sector will likely be harder to achieve since many smaller, inefficient plants have already been shut down.

The industrial sector is doubly exposed since it consumes well over 80% of all electricity. The metals & mining, utilities production & supply, and manufacturing segments are at risk, especially since no water means no electricity and no raw materials. Moreover, since agriculture is of prime importance to China in terms of food security, competition for water should become fiercer.

China's power capacity expansion will involve an increase in coal mining. We estimate that 47% of coal reserves are located in water-scarce regions, further increasing the competition for water. Coal itself requires an abundance of water for extraction and processing. Water scarcity could be an additional factor, leading to a greater reliance on coal imports; 30% of China's ensured coal reserves are in Shanxi, a province suffering from extreme water scarcity.

We think provincial water caps could force a change in the economic mix since 45% of China's GDP is produced in water-scarce provinces. Facilities may have to relocate because arable land cannot be moved, and water quotas and pollution reduction targets could be enforced more strictly than in the past. We believe five provinces (**Hebei, Shanxi, Shandong, Henan and Jiangsu**) and three municipalities (**Beijing, Shanghai and Tianjin**) are most at risk of water shortages. Three borderline stressed provinces (**Guangdong, Zhejiang and Inner Mongolia**) are also at risk, as they fluctuate in and out of water stress.

Water and power risks need to be considered by financiers, investors and companies as a core feature of capital expenditure plans. Project financiers should consider these resource shortages before funding assets; investors should examine the effects of potential water shortages on facilities located in water-scarce provinces; and companies should be more conscious of water quotas and pollution targets as they strive to make operations more efficient. Finally, we believe that water constraints will provide an additional driver for industrial energy efficiency, already a priority of the 12th Five-Year Plan (12FYP). Without upfront action now, we believe the risk remains and future assets could be left stranded high and dry.

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HSBC Climate Change Centre commissioned China Water Risk (CWR) to research and analyse the findings which form the basis of this report. Based in Hong Kong, CWR is a non-profit initiative dedicated to addressing business and environmental risks arising from the country's urgent water crisis. It aims to foster efficient and responsible use of China's water resources by engaging the global investment and business communities, civil society and individuals in understanding and managing China's water risk.



China's water problem

- ▶ Water resources vary widely across China's 31 provinces, with key provinces suffering from extreme water scarcity
- ▶ The government has responded to the problem with water quotas
- ▶ Certain industry sectors will require more water as they expand; growth in industrial water use is met by a decline in agricultural use

Water resources are stressed

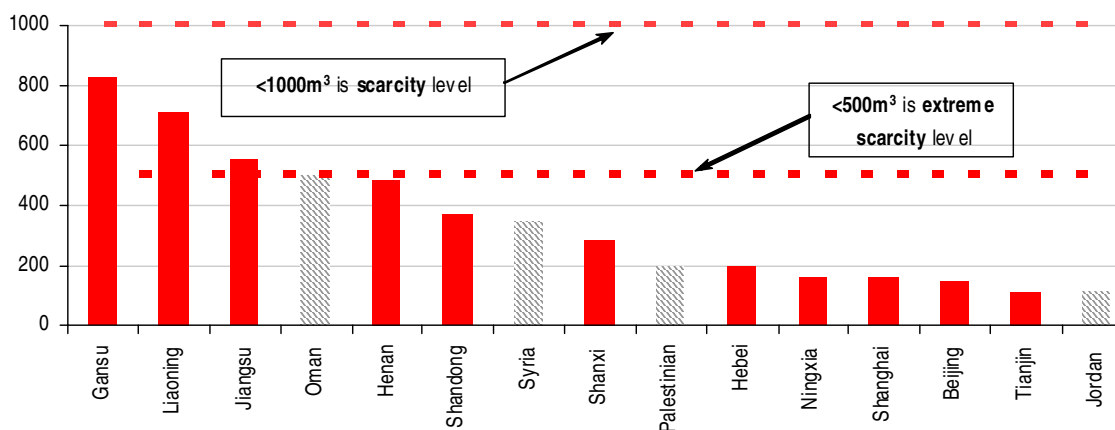
In HSBC's report [China's rising climate risk](#), 6 October 2011, we highlighted China's vulnerability to resource stress and how climate change exacerbates these risks. Water scarcity was a key risk, potentially affecting all aspects of China's economy.

China has limited water resources; its national annual renewable water resource per capita averaged slightly over 2,000m³ in 2003-10, just above the water stress level of 1,700m³. Upon closer examination, however, this water is not evenly distributed throughout its 31 provinces and

municipalities and the South-North Water Diversion Project is an example of the government's attempt to even out China's water availability.

In 2003-10, eleven provinces were, on average, water scarce (<1,000m³) with eight of these defined as extreme scarcity (<500m³), putting them on par with Jordan, Syria and Palestine (Chart 1). At these levels, the lack of water becomes a severe constraint on economic development, food production and the protection of the natural environment.

Chart 1: Water-scarce provinces (total water resources in m³ per capita), 2003-10 average



Source: National Bureau of Statistics, FAO AQUASTAT 2012

Moreover, six regions (Beijing, Tianjin, Shanghai, Jiangsu, Hebei and Ningxia) are already running water deficits – they are withdrawing more water than can be replenished naturally.

The government recognises water problems impede economic growth

The central government recognises the importance of water resources and has addressed the issue in various Five-Year Plans (FYP) and especially in 2011's No. 1 Document (Table 1). It has committed RMB4trn (cUSD600bn) to water infrastructure through to 2020 and has imposed a series of national water caps to be met in 2015, 2020 and 2030. These measures are designed to slow water demand growth and encourage more efficient use of water.

Table 1: Key points in China's No. 1 Document on water, 2011

	Details of targets and dates to be achieved
Investment	Total investment of RMB4trn into water projects through to 2020, or about RMB400bn per year
Consumption	An annual consumption cap on water of 670bn m ³ is expected to be achieved by 2020 (Note: in 2010, consumption was 602bn m ³)
Efficiency	The efficiency rate for rural irrigation should be improved to at least 55% by 2015 (current c48%)
Irrigation	Increase the area of irrigated land by 2.7m ha by 2015
Construction	Build effective flood control and drought relief systems by 2020

Source: Chinese Government website, 30 January 2011

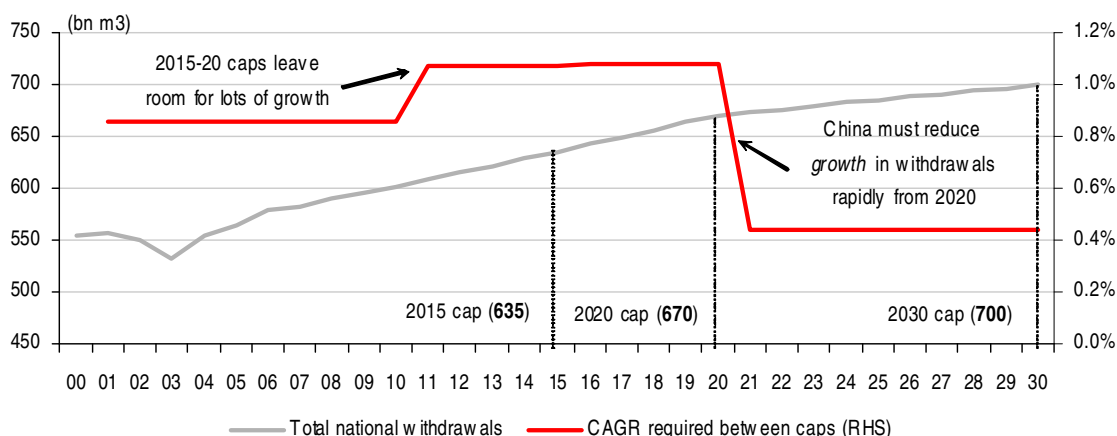
Quality before quantity

In [Quality before quantity](#), 4 July 2012, we examined the interaction between China's caps on water and its desire to improve water quality. We estimate that China can increase the rate of growth of total water withdrawal volumes annually until 2020 and still stay within total water withdrawal caps (Chart 2).

We believe the increase in withdrawals by the industrial sector should be largely met by a decrease of withdrawals from agriculture through improved irrigation and higher yielding processes – the focus of 2012's No. 1 Document.

Our analysis suggests that this would give industry as a whole almost a decade to prepare for water efficiency, which is expected to begin in earnest in 2020. However, certain segments within industry will require more quantities of water as part of planned expansion. We believe the electric power industry is one such segment where water scarcity could hamper growth. We examine the power sector's interaction with water in the next section.

Chart 2: China's planned total water withdrawals and associated caps



Source: CEIC, China State Council, HSBC estimates

Industry's double exposure to power and water

- ▶ We estimate the power sector uses 10% of China's water, much less than that used in the UK (34%) and US (49%)
- ▶ China's aggressive power capacity build-out will further stress water resources, unless efficiency is greatly improved
- ▶ Manufacturing and industry are at risk since no water means no electricity and no raw materials

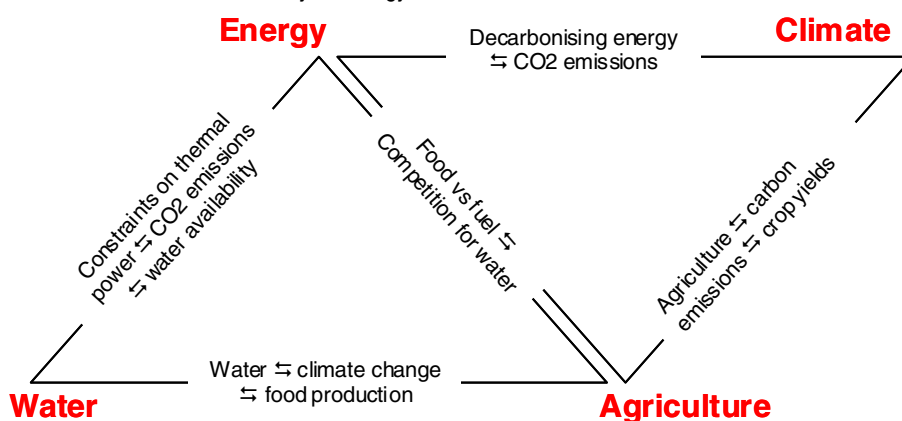
Power relies on water

Climate change, caused mostly by carbon dioxide emissions, changes the availability of water (Chart 3). However, water in turn is essential for thermal power production as it is required for cooling purposes, as well as in steam-drive turbine generators. Water is even more critical to production at hydropower stations. In 2010, thermal power represented 74% of China's total installed capacity, with hydropower representing a

further 22%. These numbers combined mean that almost 97% of China's total power generation capacity is reliant on water for production.

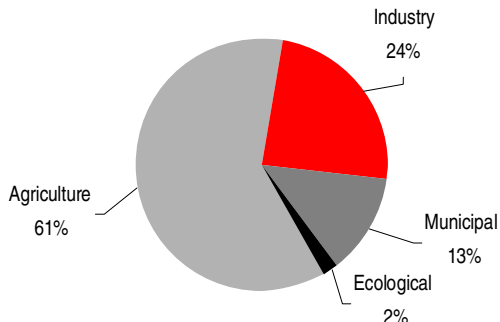
The industrial sector as a whole is second only to agriculture in water usage (Chart 4). We estimate the power sector accounts for 40% of that, or just under 10% of total national usage in 2010.

Chart 3: Climate factors affect water availability and energy



Source: HSBC

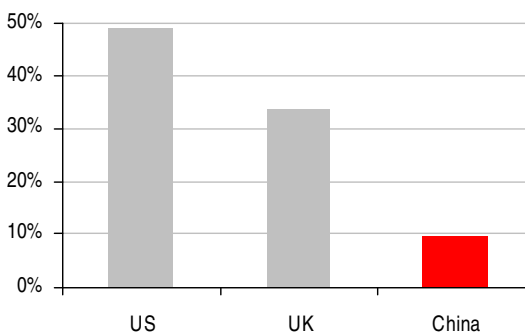
Chart 4: Water use by sector in China, 2010



Source: National Bureau of Statistics, China

This 10% share is relatively low when compared to developed countries such as the UK (34%) and the US (49%) where the power industry is the largest overall user of national water (Chart 5).

Chart 5: Estimated use of water by the power industry



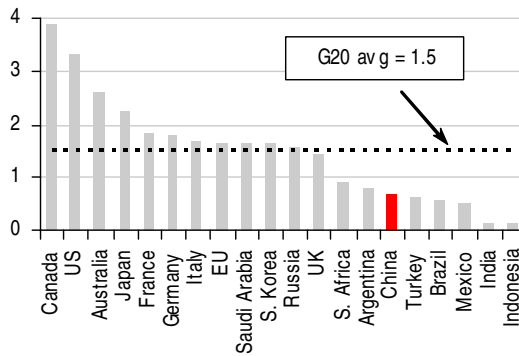
Source: UK DEFRA, US DOE, USGS, China Water Risk estimates
Note: UK figures (2008), US (2005)

Industrialisation, urbanisation and rising affluence will increase demand for electric power and, with it, depletion of already scarce water resources.

Installed capacity per capita is low

As China continues its modernisation, it will need to grow its installed capacity appropriately. On a per capita basis, installed capacity is towards the low end of countries in the G20 (Chart 6).

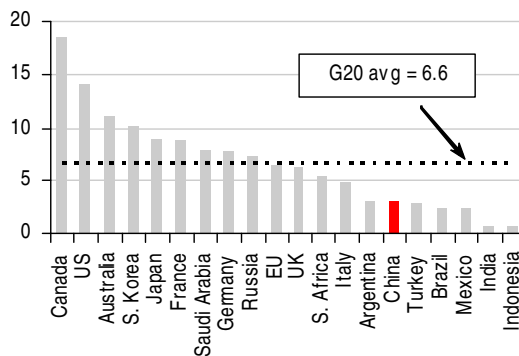
Chart 6: G20 installed capacity per capita (kW/person), 2009



Source: EIA, World Bank

There is also a gap to be bridged before China is on a par with the G20 average for actual power generated (Chart 7).

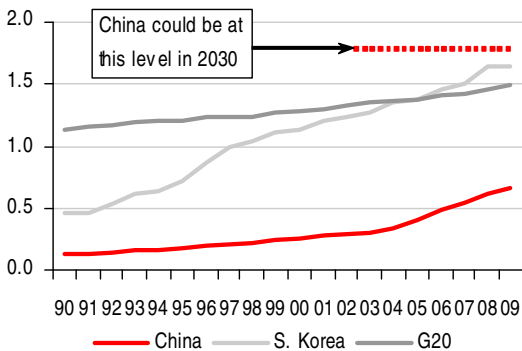
Chart 7: G20 generation per capita (MWh/person), 2010



Source: BP Statistical Review of World Energy June 2011, World Bank

China's desire to modernise will give rise to large growth in installed capacity per capita, similar to the rapid development of capacity in South Korea since 1990 (Chart 8). Based on UN-projected population figures, (0.2% CAGR for 2010-30e), we think China's installed capacity per capita could rise to 1.77kW by 2030, bringing it more in line with the current G20 average.

Chart 8: China's aggressive installed capacity growth

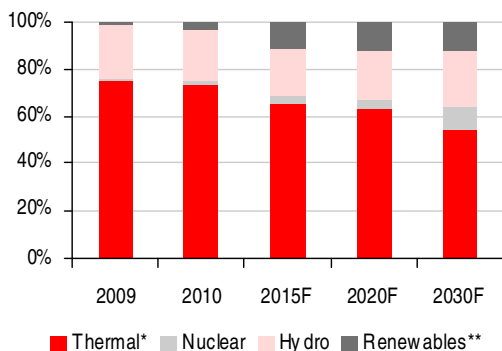


Source: NEA, EIA, World Bank, UN population estimate

Aggressive build-out plans to 2030

According to the National Energy Administration (NEA), China intends to more than double (2.56x) its power generation capacity from 967GW in 2010 to 2,470GW by 2030. The NEA expects nuclear power to grow by over 20.1x and renewable energy by 10.7x by 2030. This growth is in line with the 12FYP, as China strives to meet its energy intensity and greenhouse gas (GHG) emission targets. The overall growth in capacity as planned by the NEA is expected to cause a change in energy mix (Chart 9). Thermal generation (primarily coal) should fall from 74% to 55% by 2030.

Chart 9: Breakdown of China's installed capacity



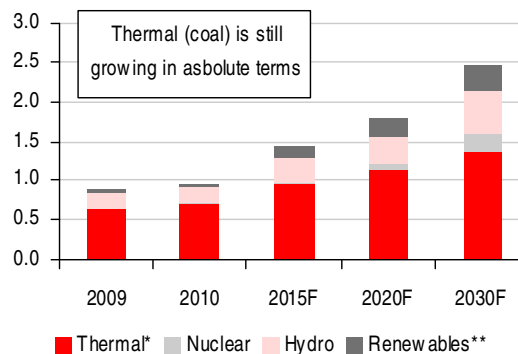
Source: 2009 & 2010 CEIC, 2015F & 2020F China Water Risk estimates (based on CEC), 2030F NEA estimates.

Note: *Thermal includes coal, gas and liquid fired plants

** Renewables include solar, wind, biomass and other renewable energy

However, thermal would still be the mainstay of power generation capacity. Indeed, the absolute installed capacity from thermal would still grow through to 2030 in tandem with overall capacity growth (Chart 10).

Chart 10: China's total installed capacity (TW)



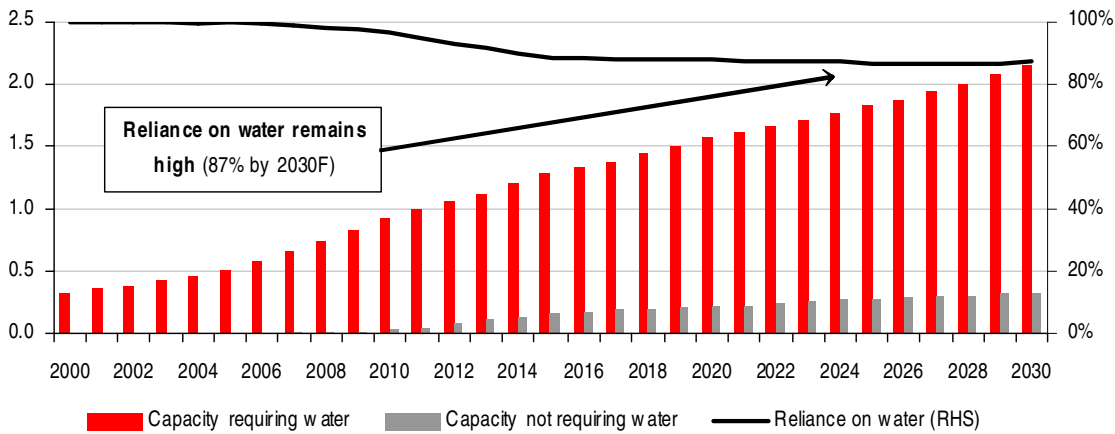
Source: 2009 & 2010 CEIC, 2015F & 2020F China Water Risk estimates (based on CEC), 2030F NEA estimates

Note: TW = terawatt or one trillion watts

Reliance on water remains high

Currently, 97% of China's electricity requires water to generate. Regardless of the change in energy mix, China will remain highly reliant on water. As discussed above, thermal (coal, gas and liquid-fired) and hydropower generation all require water. Our analysis shows the proportion of installed capacity that relies on water would fall a mere 10% to an estimated 87% in 2030 (Chart 11).

Chart 11: Reliance on water of planned installed capacity (TW)

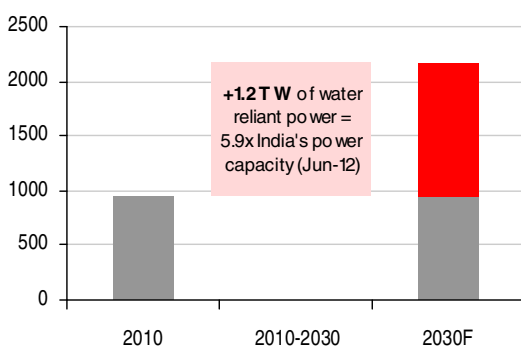


Source: China Water Risk (based on 2000 & 2005 NBSC, 2010 CEIC, 2015F & 2020F CEC Estimates, 2030F NEA estimates)

China will add 5.9x India's capacity

To put this growth into perspective, China will add 1,212GW or 1.2TW of water-reliant power by 2030, which is equivalent to adding 5.9x India's total installed capacity – 205GW as of June 2012 (Chart 12). 1.2TW is also more than the combined total installed capacity of the US, the UK and Australia.

Chart 12: China's addition of water-reliant power (GW)



Source: CEIC, NEA estimates 2030F, Ministry of Power for India

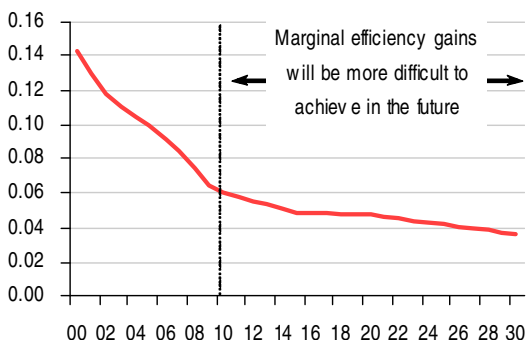
almost 77GW of installed capacity was shut down as part of this efficiency drive. However, almost 400GW of new capacity, albeit more efficient, was added, demonstrating the magnitude of the stress imposed upon water resources.

We think marginal efficiency improvements going forward to 2030 will be even more difficult to achieve given that many smaller, inefficient plants have already been shut down. Moreover, without a vast improvement in the water efficiency of power capacity, some power plants potentially run the risk of becoming stranded assets. This could be remedied by possibly upgrading, retrofitting or diverting, but these options require expenditure. More efficient expansion may also require more upfront capital expenditure.

Water efficiency is paramount

China has made good progress in improving the water efficiency of its power production facilities (Chart 13). This was achieved through a combination of higher efficiency, larger facilities and a deliberate phasing out of older, inefficient capacity. During the 11th Five-Year Plan (11FYP),

Chart 13: Intensity of water use by installed capacity (m3/W)



Source: HSBC estimates based on NEA, NSB

Note: This chart is not a forecast, it presents the intensity of water withdrawals by industry against planned capacity expansion.

Power growth is greater than water growth

Based on NEA plans, we estimate the annual allowed growth (CAGR) for water-reliant power for 2010-30 to be 4.2%. This is much more than the 0.8% CAGR growth afforded within national water withdrawal caps during these two decades.

We think institutions financing these capacity additions should take into consideration the constraints on water resources, especially given the water caps. More water efficient technology may be worth investing in, but these would likely require more initial capital outlay.

Energy efficiency is imperative

In conjunction with water efficiency, China has a strong energy efficiency directive. It plans to reduce its energy intensity (energy consumed per unit of GDP) by 16% during the 12FYP.

Reducing energy intensity – that is improving energy efficiency – would result in less growth in electricity demand, hence less need for new power capacity. In theory, this would help to alleviate some of the stress on China's water resources.

However, this is easier said than done. In [Is China too big to filter down?](#), 21 March 2012, we highlighted that China missed its 2011 energy intensity reduction target. Achieving a mere -2% decline instead of the targeted -3.5% decline,

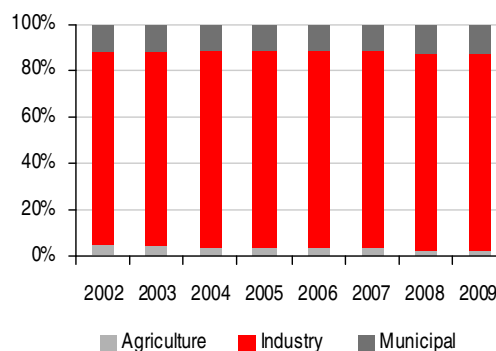
which was necessary to stay on track with the 12FYP target. In response, the Ministry of Industry and Information Technology (MIIT) set the industrial sector an energy reduction target of 21%, higher than the national 16% target.

A lesson learned during the 11FYP was to check on the progress of targets annually instead of at the end of FYP periods. We believe that if energy intensity and water withdrawal/pollution targets are not more or less on track on an annual basis, then the authorities will become stricter in their enforcement – a break from the past. Hence, annual checkpoints will be important to watch.

The double exposure of China's industrial backbone

In 2009, industry used almost a quarter of the nation's water and also consumed 84% of all power (Chart 14). We think direct exposure to water scarcity, coupled with indirect exposure (97% of electricity generation is water-reliant) poses risks for the industrial sector – a double exposure.

Chart 14: China's electricity consumption by broad sector

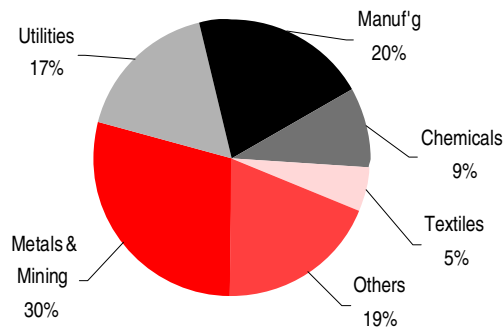


Source: National Bureau of Statistics

Within industry, metals and mining consume around 30% of electricity generation. The elements produced become raw materials for manufacturing, which consumes a fifth of electricity. The manufacturing process requires utilities (electricity, gas, water), which in turn consume another 17% for production and supply

(Chart 15). Taken in aggregate, manufacturing and industry are especially at risk since no water also means no electricity and no raw materials.

Chart 15: Breakdown of industrial electricity usage, 2009

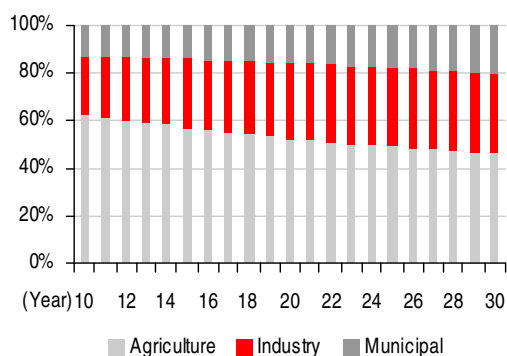


Source: China Statistical Yearbook 2011

Industry caps in earnest from 2020

As the economy shifts further from its agricultural roots, we expect industrial and municipal usage will continue to be the main drivers of water demand growth (Chart 16).

Chart 16: Share of water use by segment in China



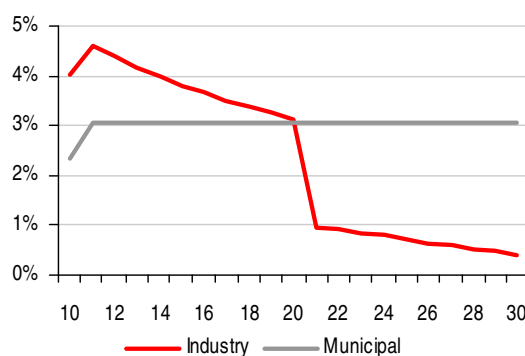
Source: HSBC estimates

In order to stay within government water withdrawal caps, we expect the rate of growth of industrial water to decline gradually ahead of the 2020 cap. Realistically, a step-shift from 2020 is unlikely, but the caps to 2030 leave little room for the continuation of the 2010-20 growth trajectory. China's secondary industry must either become

more efficient or shift towards tertiary services, which are less water intensive.

Moreover, continued urbanisation and rising affluence will cause municipal water use to grow. A crossover in growth is likely around the end of this decade, with municipal growth outpacing that of industrial growth, in our view (Chart 17).

Chart 17: Growth trajectory of industry vs. municipal use



Source: HSBC estimates

The result of this crossover would be even less water for the power sector – in the midst of its ambitious expansion – meaning planning for improved efficiencies, better technologies and even energy use itself must be conducted now, rather than blind expansion, which just expects there to be enough water in the future.

We discuss the expansion of power and the location of coal reserves in different provinces in the next section.

Provincial matters

- ▶ Water-scarce provinces contributed to 45% of national GDP
- ▶ Provincial water caps may force authorities to rebalance the economic mix as different segments compete for less water
- ▶ Investors with assets in provinces at risk should consider future water availability before going ahead with expansion plans

Not all provinces are equal

China's vast geographic area is diverse in climate and in resources. The 31 provinces and municipalities have different economic make-ups. For a detailed analysis of provinces, see [Inside the growth engine](#), December 2010.

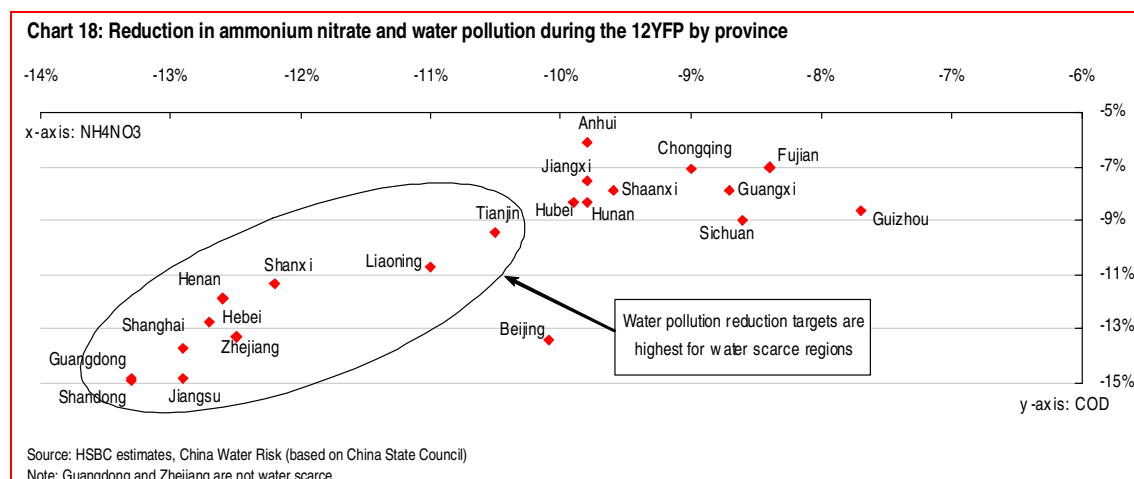
Agricultural remains important

Some 40% of China's total agricultural output value is produced in water-scarce regions, mainly in the North. At the same time, many of these provinces are top industrial producers. We previously highlighted China's desire for safeguarding food security in [China's rising climate risk](#). The need for improvement in

agricultural technology and yields, water efficient irrigation, and research into grains, which use less water and seed strains that are drought, flood and pest resistant, is clearly discussed in 2012's No. 1 Document. Also, climate change will affect the productivity of agriculture, see [Agriculture: Double trouble](#), 12 December 2011.

In [Quality before quantity](#), we highlight the issue of water quality improvement. The introduction of new reduction targets such as ammonium nitrate (NH₄NO₃) and chemical oxygen demand (COD) will affect the agriculture sector.

Whilst water pollution reduction measures differ from province to province, we note that the



toughest targets have been imposed mostly on water-scarce regions (Chart 18). We think these provinces could break with the loosely enforced past in light of this additional pollution dimension. In turn, power and industry must consider these regulations before expansion.

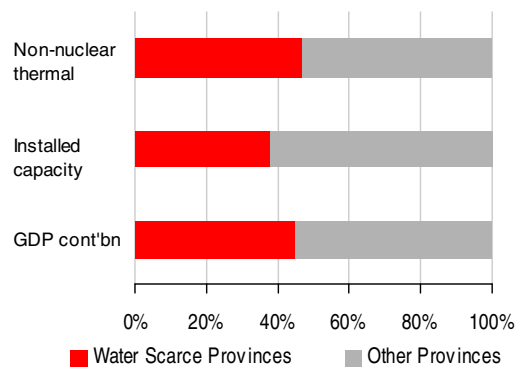
Arable land cannot be moved

Industrial facilities can be moved (eventually), but the location of arable land and coal reserves are fixed. In our view, the challenge will be for central and local governments to balance agriculture and industrial output within and between provinces.

Up to 45% GDP could be affected

Water-scarce provinces contributed to 45% of national GDP and also 51% of China's industrial output by value in 2010, further highlighting how limited water resources could be a bottleneck for economic development.

Chart 19: Exposure to water-scarce regions, 2010



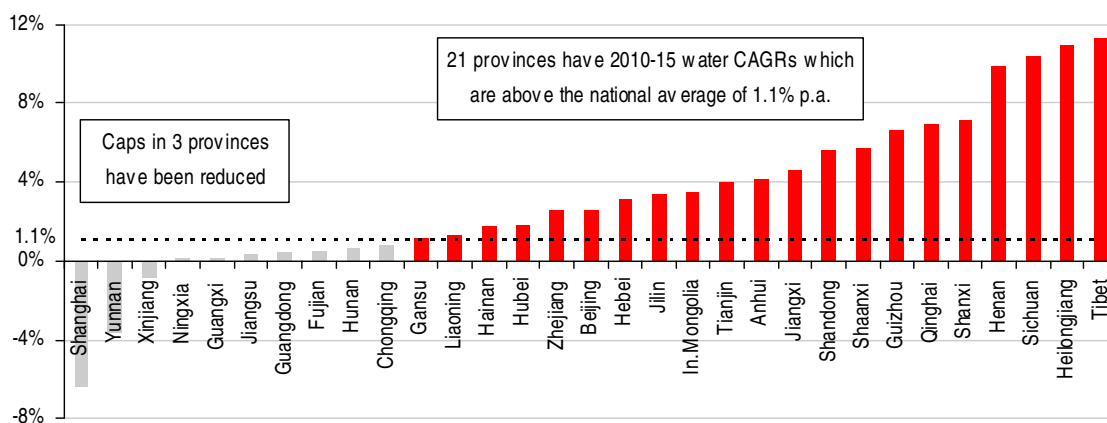
Source: HSBC estimates, China Water Risk (based on China Statistical Yearbook 2011)

Water-scarce regions are home to 38% of the nation's installed capacity (Chart 19) and this is expected to remain broadly the case in 2015, according to provincial 12FYP energy forecasts.

Enter provincial water caps

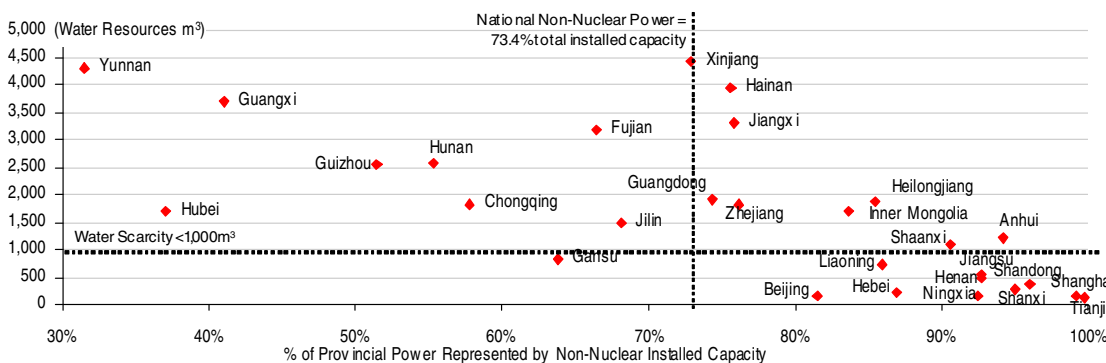
Provincial governments have now set and released 2015 water caps in response to the national water management decree issued in March 2012, which introduced national quotas for 2015, 2020 and 2030. The allowed annual growth (2010-15 CAGR) of these water caps vary from a decline (-6.4% p.a.) for Shanghai to substantial growth (+11.3% p.a.) for Tibet (Chart 20).

Chart 20: Proposed annual growth in provincial quotas largely exceed national goals



Source: HSBC estimates, China Water Risk (based on provincial government websites and China Water Risk estimates)

Chart 21: Water-scarce provinces are most reliant on non-nuclear thermal power (bottom right quadrant)



Source: China Water Risk (based on 2011 China Statistical Yearbook, CEIC and State Electricity Regulatory Commission and provincial government information, 2010)

Shanghai, Yunnan and Xinjiang have actually had their total cap reduced from 2010 levels. Twenty one other provinces have been allowed annual growth figures (CAGR), which exceed the national average of 1.1%; of these, eight are water-scarce provinces.

Giving already scarce provinces a higher cap is likely to lead to even further scarcity, in our view. We think this highlights the difficulties central and local authorities face in managing water resources. We do note, however, that some inter-provincial planning or collaboration will have to take place since the sum total of the 31 provincial caps actually exceeds the national total for 2015. We believe this further highlights the problem of enforcement in China.

Water-scarce provinces rely on coal-fired power plants

Interestingly, 47% of existing coal-fired power plants capacity lies in water-scarce provinces. The scatter diagram in Chart 21 shows that water-scarce provinces are often those that rely most on thermal power. Local governments may find it difficult to balance the economic needs of their provinces given the need for more growth and hence more power, but limited water.

Adequate planning and appropriate investment into more water-efficient power capacity means a

balance can be achieved within the various targets. The 2015 water caps were issued this year, leaving just enough lead time for thermal power plant capacity additions by 2015, since the build-out time for a plant in China is 12-18 months.

Competition for water

We think there could be increased competition for water resources from the high value-added industries, which contribute to gross regional product (GRP is provincial GDP). The need to power these industries means that provinces, which tend to be the higher contributors to GDP, also have a higher reliance on coal-fired power plants.

Provincial vulnerability

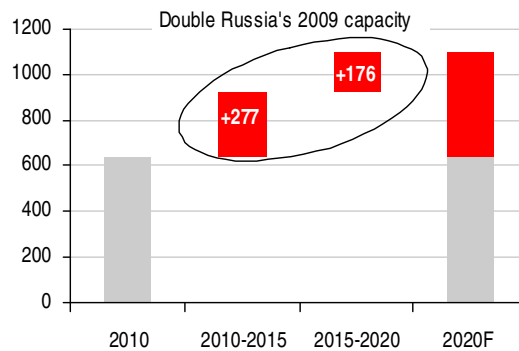
We analyse the power build-out by province, mapped against available water resources in map 1 overleaf. Jiangsu, Shandong, Hebei, Henan and Shanxi are the most vulnerable given their water scarcity, aggressive power build-out and water pollution reduction targets. Moreover, Jiangsu and Hebei are already running water deficits.

Trading water for coal

Coal remains the vanguard

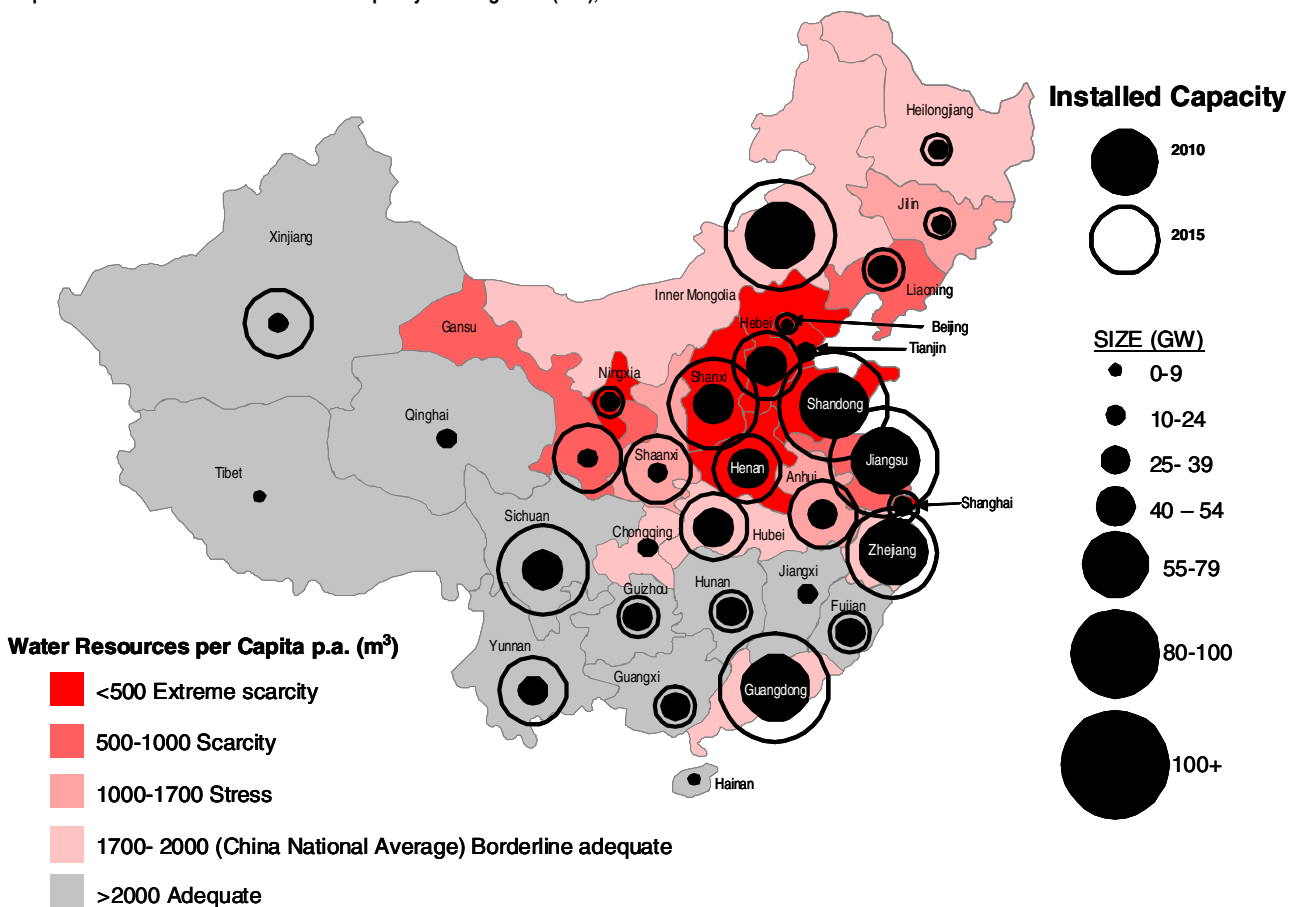
Non-nuclear thermal generation reliance is set to remain through to 2030, and of this, the lion's share is and will remain coal. China expects to add approximately 277GW of coal-fired power capacity in 2010-15, and a further 176GW by 2020. In aggregate, China intends to add a total of 453GW of coal-fired power within the decade (Chart 22), equivalent to twice Russia's 2009 power generation capacity.

Chart 22: China's coal-fired power plant expansion (GW)



Source: HSBC estimates, China Water Risk (based on 2010 CEIC, 2015F & 2020F CEC estimates, EIA)

Map 1: Location of China's total installed capacity and its growth (GW), 2010-15e



Source: China Water Risk (based on China Electricity Council, China Statistical Year Book and Provincial 12FYPs)

Will there be enough coal to burn?

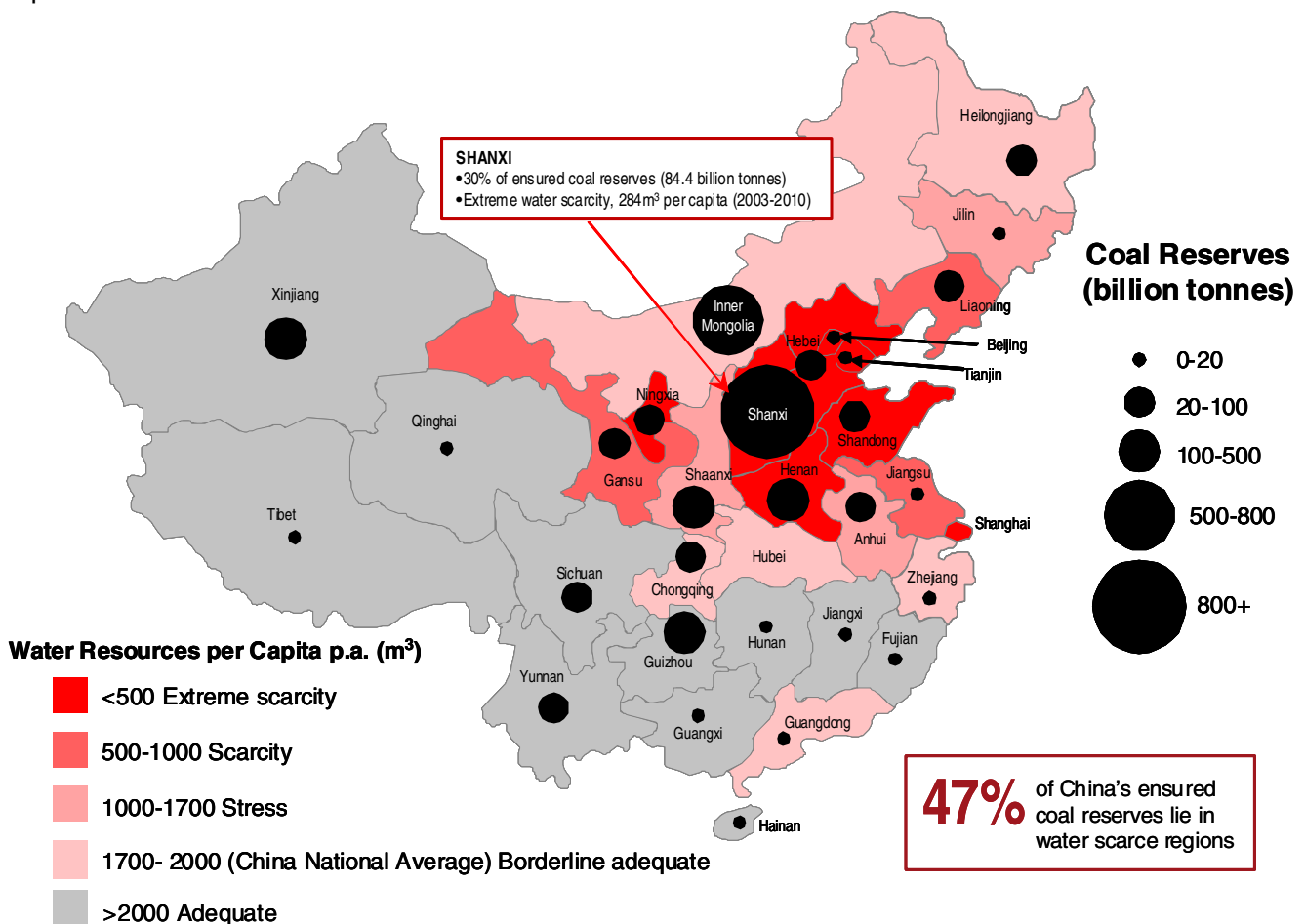
We briefly look upstream to see where China intends to obtain the coal to burn in these new power plants. Some 47% of China's ensured coal reserves are located in water-scarce provinces (map 2). The bulk (30%) is located in Shanxi, which is classified as extreme water scarce. Inner Mongolia, which houses 28% of national coal reserves, is a borderline water stress province, hovering around the 1,700m³ mark in different years (2010 was stressed).

The mining of this coal is potentially at risk because there may not be enough water to extract it. Coal requires water to extract, transport, process (wash), store and dispose. According to China Water Risk,

an estimated 3,000-11,500 litres of water is used to produce one tonne of coal.

China's reliance on coal, coupled with the location of coal in water-scarce provinces, could lead to a greater reliance on coal imports, which in turn might affect coal prices. China's hunger for resources could also fuel further acquisitions of coal mines abroad, in our view.

Map 2: Location of China's ensured coal reserves in 2010



Source: China Water Risk (based on 2011 China Statistical Year Book, FAO AQUASTAT 2012)

Hydropower at risk

Sensitivity to droughts and floods

The viability of hydropower also comes into question as droughts and floods diminish hydro capacity. We touched on this in [China's rising climate risk](#). Although hydro capacity tends to be built in areas that are rich in water resources, the effects of shortages can be felt more quickly in the event of a drought.

Some hydropower stations have operated at below capacity during summer months in recent years due to droughts in Southern China. Power shortages not only affect power producers, but also disrupt businesses. The authorities in some

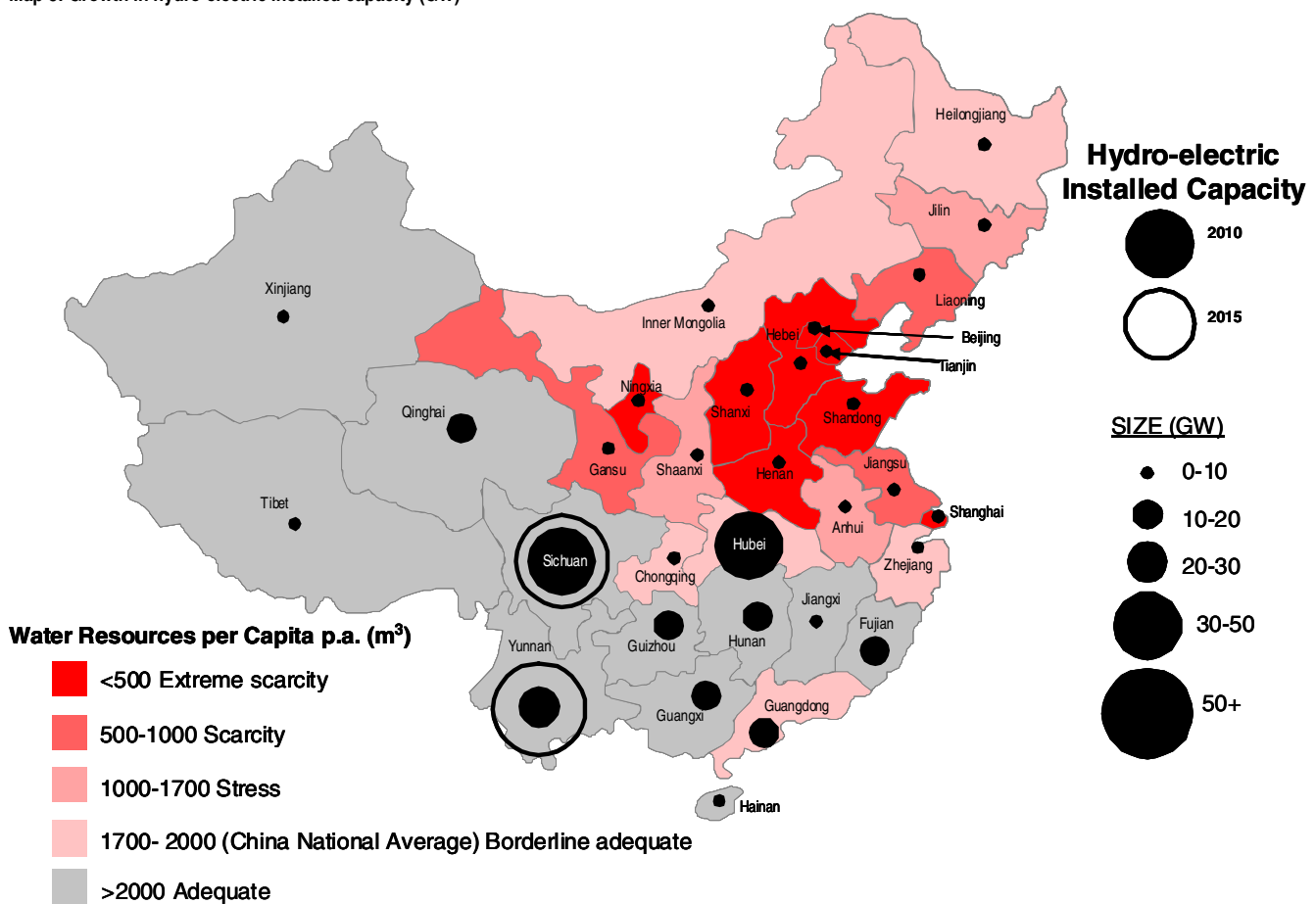
regions of China have occasionally increased retail prices in order to lessen demand on the grid; certain sectors have also had to pay higher prices for power, especially during seasonal demand; or at worst forced suspension of factories.

Geopolitical risk may be unavoidable

As shown in map 3, many of China's hydropower facilities are located in the relatively water-rich south west provinces. Hubei, Sichuan and Yunnan accounted for 40% of the installed hydro capacity in 2010.

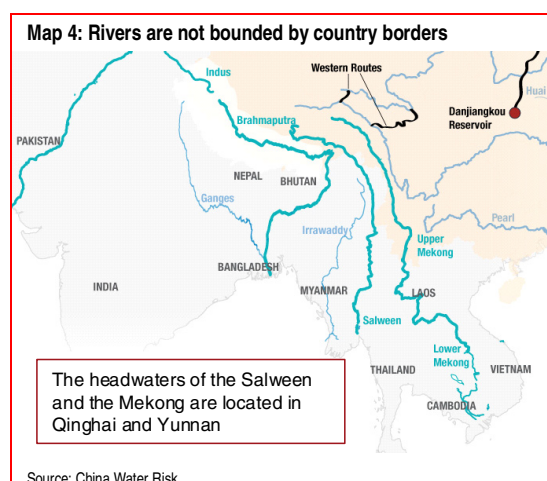
The government plans to expand hydropower from 216GW in 2010 to 568GW by 2030 – an increase equivalent to Japan's and Australia's total installed capacity as of 2009. Even within the

Map 3: Growth in hydro-electric installed capacity (GW)



Source: China Water Risk (based on State Electricity Regulatory Commission, China Statistical Yearbook & Provincial 12 FYPs)

12FYP, hydropower capacity is expected to increase by 32% to 285GW. Approximately 80% of this additional 12FYP hydro capacity will be located in Yunnan and Sichuan



The rivers suitable for hydropower in these two provinces are the ones that feed the Mekong River and Salween River, which run through Cambodia, Laos, Myanmar, Thailand and Vietnam (Map 4). Energy security and emissions reductions may be reasons for China to dam these rivers, but geopolitical tensions in the region may counter these reasons as water scarcity spills over into neighbouring countries. China is already constructing eight dams along the Lancang section of the Mekong River – to the irk of downstream nations.

Climate change affects water availability

We have previously discussed how climate change is expressed through the availability of water – too much or too little – in certain locations, which is likely to make water resource stress more acute in many countries, including China (see [Scoring climate change risk](#), 9 August 2011). Over the long term, hydropower may not be a reliable source of power, leaving authorities with tough choices when it comes to powering the economy.

Provinces at risk – PAR 11

The economies of five provinces and three municipalities are particularly at risk due to their water scarcity, with a further three provinces on the borderline for water stress. These eleven provinces include the top four agricultural producers by value; the top three industrial producers; the top two coal reserves and the top five installed power capacities (Table 2).

Five water-scarce provinces

Hebei, Shanxi, Shandong, Henan, Jiangsu

Jiangsu, Shandong, Hebei and Henan collectively contributed 28.4% to national GDP in 2010. Between them, they are the top three agricultural producers and the top and third industrial producers. We expect these provinces to continue to drive the economy, further straining already scarce water resources.

Table 2: Ranking of output and capacity in water scarce provinces, 2010

Province	Cont'nbn to GDP	Water Resources (m ³ /capita/yr)	Water Deficit	Industrial Output Value	Agriculture Output Value	Installed Capacity	Non-Nuclear Thermal	Hydro-electric Capacity	Ensured Coal Reserves
Tianjin	2.1%	Extreme scarce (113)	Yes						
Beijing	3.2%	Extreme scarce (146)	Yes						
Shanghai	3.9%	Extreme scarce (162)	Yes	#8					
Hebei	4.7%	Extreme scarce (201)	Yes	#7	#3	#10	#8		
Shanxi	2.1%	Extreme scarce (284)				#8	#7		#1
Shandong	9.0%	Extreme scarce (372)		#3	#1	#4	#1		#8
Henan	5.3%	Extreme scarce (486)		#6	#2	#6	#5		#6
Jiangsu	9.5%	Scarce (554)	Yes	#1	#4	#2	#2		
In. Mongolia	2.7%	Borderline (1705)				#3	#3		#2
Zhejiang	6.3%	Borderline (1806)		#4		#5	#6	#10	
Guangdong	10.5%	Borderline (1902)		#2	#7	#1	#4	#7	

Source: China Water Risk analysis (based on CEIC, CEC, SERC, NSBC)

Shanxi only contributed 2.1% to 2010 GDP, but as China progresses with its substantial coal build-out, Shanxi's importance in supplying coal should grow. We feel it is at risk from water shortages given its prevalence in coal resources, 30% as discussed above.

From targets to tariffs

We expect local governments to focus more closely on the mix of industries operating in these provinces, especially in light of energy intensity and water pollution targets, as well as water quotas. We also expect relatively stricter enforcement of water quotas on a sector or company/facility basis – a possible break with the past.

Furthermore, we think local authorities will explore other means to stay within water quotas. These include increases in water tariffs, improved water efficiency and alternate water solutions such as full potable water recycling/reuse and desalination. We believe the operational risk of increased tariffs is much lower than that of water shortages. Inefficient facilities may feel the pinch, but these options could be beneficial to companies willing to explore and develop solutions.

Three extremely water scarce cities

Beijing, Tianjin and Shanghai

Beijing, Shanghai and Tianjin are already running water deficits and consistently fall in the extreme scarcity range of below 500m³. Beijing's annual growth in installed capacity (10.6%) for the 12FYP period is four times its allowed annual growth in water withdrawals (2.6%); Tianjin is three times. Shanghai plans to grow installed capacity by 6.1% p.a. to 2015, whilst at the same time *reducing* water use by -6.4% p.a.

Industry at risk

We think Shanghai is even more at risk due to its industrial base. Despite similar populations, Shanghai (19.2m people) withdrew more than triple the water of Beijing (17.5m) in 2010. Around two-

thirds of Shanghai's water is withdrawn for industrial purposes. We think Shanghai's negative water quota could lead to the relocation or closure of industrial facilities, and we expect to see stricter enforcement in this megacity.

What lies beneath

Running a water deficit brings other problems such as groundwater depletion. This over-extraction of groundwater not only brings about falling water tables, but also an increased risk of subsidence. The Chinese Academy of Geological Sciences warned earlier this year of a subsidence threat to 170,000km² of land and excessive annual withdrawal of 4bn m³ of groundwater in Northern China. Beijing has seen well-documented ground collapses this year, leading the local government to close 800 wells within the 5th ring-road in an effort to rein in groundwater extraction.

Three borderline stressed provinces

Guangdong, Zhejiang and Inner Mongolia

A further fifth of national GDP comes from Guangdong, Inner Mongolia and Zhejiang. The eight-year average water availability from these provinces is on the borderline of water stress (1700m³) and hence at risk from further stress, due to climate change or otherwise, in our view. The water resource per capita fluctuates from year to year, with all three provinces having touched lows well into the water stressed zone in the past decade.

Guangdong is the top contributor (10.5%) to GDP and has the second largest industrial output. Inner Mongolia is rapidly becoming the mining capital of China – housing not only 28% of China's coal reserves, but also the lion's share of its rare earth resources.

Zhejiang and Guangdong also have some of the toughest greenhouse gas reduction targets during the 12FYP. The annual growth in power build-out is more than three times the water cap growth in these provinces. In our view, these combined

issues could change the economic make-up of Zhejiang and Guangdong – pushing industry out; bringing services in. As for Inner Mongolia, water is already being blamed for driving out agriculture, perhaps it could be a stranded province when the mining resources run dry.

Listed utilities exposure

The exposure of power companies to vulnerable regions may limit growth and even, in the worst cases, cause stranded assets. Listed utilities' coal-fired power generation assets in 2010-11 show that many companies have exposure to one or more provinces that are water scarce or stressed. We list this exposure in Table 3.

We do not assess the level of assets exposed, merely the location of assets as disclosed in company reports.

Conclusion

China's planned economy is taking water and other resource stresses into account, however, the growth profiles of power and water in certain provinces seem to show a planning mismatch.

Efficiency is crucial

Although both industry and the power sector have seen efficiency improvements in recent years, more needs to be done if the power expansion plans are to be met.

The water resource situation could add to the pressure to improve energy efficiency since reducing energy demand could alleviate some of the strain on water. Energy intensity targets have already gone up, and we think water targets could be more strictly enforced than in the past.

Although water tariff hikes are a concern, we believe the greater risk lies with water shortages. Improving both the water and energy efficiency of operations is crucial.

Other high and dry options

We believe project financiers and providers of capital should ensure that water availability has been fully taken into account before a project receives funding, otherwise certain assets could become stranded, halting capital payback.

The more efficient option may involve higher capital expenditure up front, but this would be worth it if it lowers the longer term exposure to water shortages, in our view.

Table 3: Exposure of assets to water-scarce/stressed provinces in 2010-11

Regions	Water resources (m ³ /capita/yr)	Huadian (1071 HK)	Huaneng (902 HK)	Datang (991 HK)	CPID (2380 HK)	CRP (836 HK)	Guodian (600795 SSE)
Tianjin	Extreme scarcity(113)		Yes	Yes			
Beijing	Extreme scarcity(146)		Yes			Yes	
Shanghai	Extreme scarcity(162)		Yes				Yes
Ningxia	Extreme scarcity(163)	Yes		Yes			Yes
Hebei	Extreme scarcity(201)	Yes		Yes		Yes	Yes
Shanxi	Extreme scarcity(284)		Yes	Yes	Yes		Yes
Shandong	Extreme scarcity(372)	Yes				Yes	
Henan	Extreme scarcity(486)	Yes	Yes		Yes	Yes	
Jiangsu	Scarcity (554)		Yes	Yes	Yes	Yes	Yes
Liaoning	Scarcity (716)			Yes		Yes	Yes
Gansu	Scarcity (823)		Yes	Yes			Yes
Hubei	Borderline (1702)				Yes	Yes	
Inner Mongolia	Borderline (1705)		Yes	Yes		Yes	Yes
Zhejiang	Borderline (1806)	Yes	Yes	Yes		Yes	Yes
Guangdong	Borderline (1902)	Yes	Yes	Yes		Yes	
Company exposure to provinces		8	12	10	6	11	9

Source: China Water Risk (based on various 2010/2011 annual reports, social responsibility reports and company websites)

Alternatively, financiers might explore relatively more water efficient power options such as wind or solar.

The water supply chain

Investors should also be aware of the locations of facilities, especially in these PAR 11 provinces since potential water shortages could affect the supply of both water and electricity, which could impact operations and earnings.

We think companies and their investors should be conscious of enforced water quotas, on top of the new emissions and pollution quotas, which may affect their operations, as well as those of their supply chains, see [The water hole in the supply chain](#), 29 November 2011. This should aid companies to disclose more operating data related to resource use as they strive to become more efficient and hence more profitable.

As previously discussed in [China's rising climate risk](#), water and electricity shortages could affect companies operating in, sourcing from, and even selling to China. We think it is important to ask all companies about these issues.

Notes

Disclosure appendix

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