TLG on China: UHV

THE LANTAU GROUP
strategy & economic consulting

Slow progress but momentum is building

The approval progress of State Grid Corporation's Ultra-High Voltage (UHV) transmission development plans has been very slow not because the plans are unimportant, but because the plans are too important. The UHV plans will shape China's power supply for the next half-century and have enormous influence on China's future energy landscape and power sector development direction.

In this issue of ***TLG on China,*** we examine the latest development status of UHV projects and assess their impacts on the renewable energy development, building on our work in 2012 and 2013 analysing the economics of China's UHV AC and DC transmission system[1]. The environmental imperative for China to solve its power supply challenges has increased steadily.[2] All levels of China's government face enormous pressure to find solutions to China's worsening air haze problems, especially in the eastern provinces. These same eastern provinces are also the ones with the greatest supply stress and risk of brownouts. UHV solutions address both of these high priority challenges, but they also raise many others.

In 2013, State Grid announced its UHV construction targets for the eight-year period from 2013 to 2020. By 2015, it plans to achieve commissioning "two vertical and two horizontal" AC lines, the Yangtze River Delta UHV "loop", and seven DC lines. By 2017, it plans to achieve "three vertical and three horizontal" AC lines and 13 DC lines. By 2020, it plans to achieve "five vertical and five horizontal" AC lines and 27 DC lines. As we noted last month, pressure is on State Grid to keep up with the next phase of wind power capacity expansion and maintain or improve operating conditions of wind power generation.

So State Grid's UHV ambitions are a good sign from the point of view of wind power generation.

Progress, however, has been slow. There are only seven UHV lines in operation so far. Five of these are DC and two are AC. There is one UHV DC project (Xiluodu to Zhexi) and one UHV AC (Fuzhou to Zhebei) project under construction. The former is expected to be commissioned in mid-2014.

In 2013, State Grid reportedly planned to start construction on four UHV AC lines and three DC lines. It ended up only starting construction on one UHV AC line. In January 2014, State Grid reportedly targeted to start construction on six UHV AC lines and four DC lines. Those targets have since been revised downward. For 2014, State Grid is targeting to start construction on only two AC lines and two DC lines.

1 See: "China's UHV Highway Revisited", April 2013.

2 See GuoNengGuiHua [2014] No 38 , http://zfxxgk.nea.gov.cn/auto82/201401/t20140124_1756.htm

Should China's renewable energy sector be concerned of this?

In 2013, State Grid received preliminary approval (Lutiao in Chinese) for its two UHV AC and two UHV DC projects so it can start preparation of various permits applications and supporting documents for the final approval application. The two UHV AC projects are: Ya'an to Wuhan and Huainan-Nanjing-Shanghai (Ximeng to Nanjing received preliminary approval in 2012). The two UHV DC projects are Jiuquan to Hunan and Zhundong to Huadong. The UHV DC project of Ningdong to Zhejiang received preliminary approval in 2011.

In 2014, State Grid targets completing construction on one UHV AC line (Fuzhou-North Zhejiang), starting construction on two UHV AC lines (Huainan-Nanjing-Shanghai and Ya'an-Wuhan), and starting pre-construction preparation work on four UHV AC lines (Mengxi-South Tianjin, Jingbian-Weifang, Ximeng-Zaozhuang and Mengxi-Changsha). The company targets completing construction on one UHV DC line (Xiluodu-Zhejiang), starting construction on two UHV DC lines (Jiuquan-Hunan and Ningdong-Zhejiang), and starting pre-construction preparation on two UHV DC lines (Ximeng-Taizhou and Shanghaimiao-Shandong)[3].

As set out in its Guidelines for 2014 Energy Work[2], the NEA planned twelve power transmission corridors, most of which are UHV projects, including two UHV AC lines (Mengxi-South Tianjin and Ximeng-Shandong) and three UHV DC lines (Zhundong-East China, Ximeng-Jiangsu and Ningdong-Zhejiang).

Summary of UHV projects in operation, under construction and to be approved potentially shortly

Status	Type	2012	2013	2014
Commissioned	AC	Jindongnan-Nanyang-Jingmen	Jindongnan-Nanyang-Jingmen	Jindongnan-Nanyang-Jingmen
			Huainan-Zhebei-Shanghai	Huainan-Zhebei-Shanghai
				Fuzhou-North Zhejiang
	DC	Yunnan-Guangdong	Yunnan-Guangdong	Yunnan-Guangdong
		Xiangjiaba-Shanghai	Xiangjiaba-Shanghai	Xiangjiaba-Shanghai
		Jinping-Sunan	Jinping-Sunan	Jinping-Sunan
			Nuozhadu-Guangdong	Nuozhadu-Guangdong
				Southern Hami-Zhengzhou
				Xiluodu-Zhejiang
Under construction	AC	Huainan-Zhebei-Shanghai	Fuzhou-North Zhejiang	Huainan-Nanjing-Shanghai
				Ya'an-Wuhan
	DC	Nuozhadu-Guangdong	Southern Hami-Zhengzhou	Jiuquan-Hunan
		Southern Hami-Zhengzhou	Xiluodu-Zhejiang	Ningdong-Zhejiang
		Xiluodu-Zhejiang		
Awaiting final approval	AC		Huainan-Nanjing-Shanghai	
			Ya'an-Wuhan	
	DC		Jiuquan-Hunan	
			Ningdong-Zhejiang	

Source: TLG research based on various reports and media news
Note: The four lines bounded by red in "2014 under construction" are in SGCC's wish list of construction in 2014

3 http://www.nmg.gov.cn/main/nmg/zfxxgk/jrnmg/jrnm/2014-03-22/2_385223/default.shtml

Three Observations

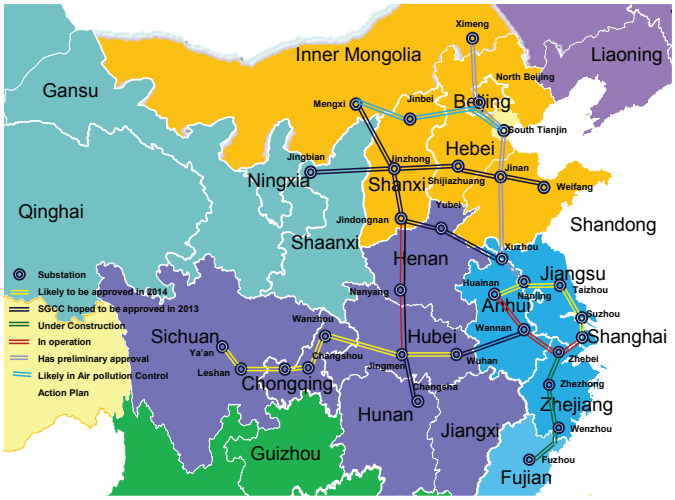
(1) Last year's developments indicate that China is less concerned about building out a specific UHV line and more focused on increasing and integrating renewable energy resources, and reducing curtailment risk.

Aside from not approving or delaying certain projects State Grid proposed, China actually granted preliminary approval for two other UHV DC lines that were not part of the original list of projects State Grid planned to start (the Jiuquan-Hunan line from Gansu and Zhundong-Huadong line from Xinjiang).

Both Xinjiang and Gansu are renewable-energy rich provinces that, without UHV transmission, would have few places to send their surplus energy. Neither of these two provinces is anywhere near regions of high demand. Xinjiang's existing HVDC inter-provincial transmission lines[4] connect into Qinghai and Gansu, while Gansu's lines connect into Qinghai, Ningxia and Shaanxi. As a result, Xinjiang and Gansu have historically not been able to export surplus power to energy short provinces in eastern or southern China.

National UHV DC Projects and Status

SGCC's 2015 UHV AC Plan and Status



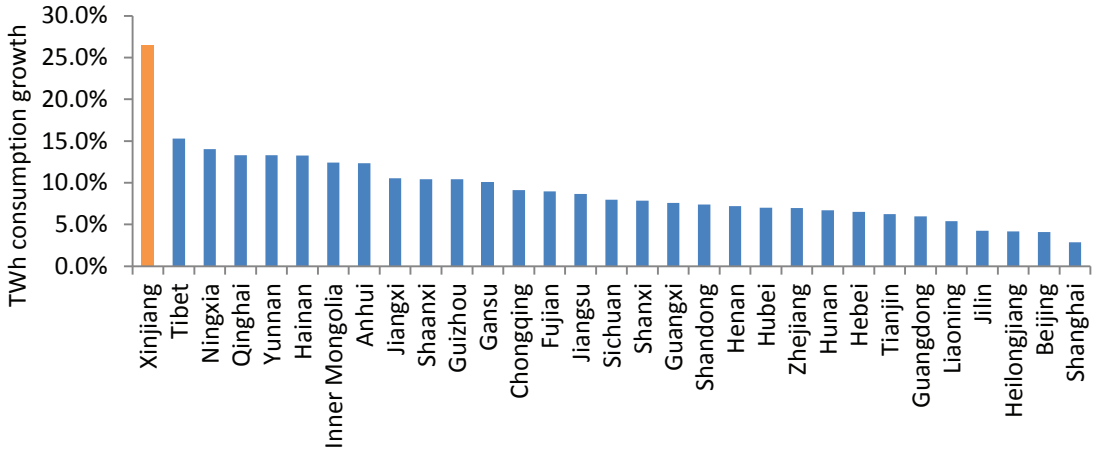
Source: TLG Research based on various sources

This situation has left wind farms built in Xinjiang and Gansu reliant on local consumption to absorb wind generation. In Xinjiang, where electricity consumption has grown at the fastest pace in China over the past three years, incremental electricity consumption has kept pace with additions of wind power capacity relatively well, minimizing curtailment in the province.

China's action plans on air pollution control and protection by provinces in the eastern coastal region propose to cap and then gradually reduce total coal consumption beginning from 2015 or so. To achieve these targets, many provinces would need to increase power imports from other provinces. For example, Shandong Province plans to import of 16,000 MW from other provinces by 2015 according to its 2013-2015 Action Plan. This level of import capacity can easily absorb the power transmission capacity of two UHV DC lines. Zhejiang Province plans to import 20,000 MW by 2015 and 30,000 MW by 2017 according to its Action Plan. The situation may increase pressure on the main UHV project approval authority (NEA) to speed up the approval process.

4 Excluding the Hami-Zhengzhou UHV DC line commissioned in January 2014

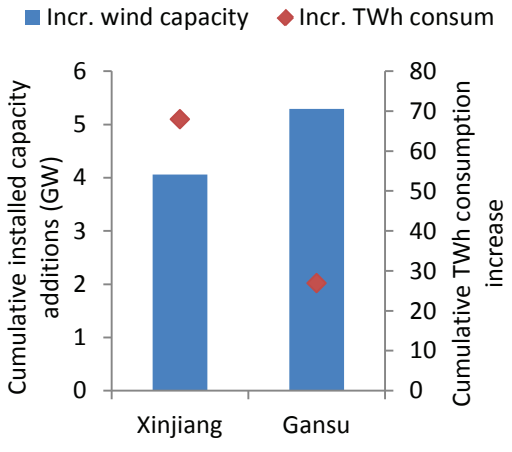
China electricity consumption growth by province (2010-13)



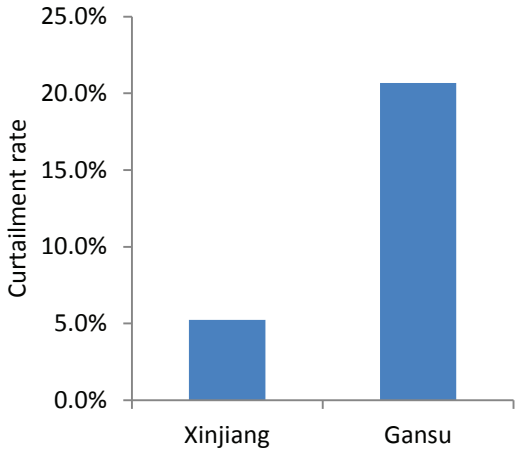
Source: Government and press releases, TLG analysis. The western and inland regions have higher percentage demand growth rates due to smaller user base and more foccused efforts to increase economic growth under China's development plan for western provinces.

In Gansu, where electricity demand growth has been more moderate, additions of wind power capacity have outpaced incremental electricity consumption, causing higher grid curtailment than in Xinjiang.

Incremental wind capacity and electricity consumption in Xinjiang and Gansu (2010-13)



Wind generation curtailment rate in Xinjiang and Gansu (2013)



Source: CWEA, government releases, TLG analysis

The acceleration of the Jiuquan-Hunan and Zhundong-East China UHV DC lines therefore shows that China recognizes that it cannot simply rely on local consumption but also needs to add export transmission capacity to absorb that growth in renewable energy supplies in areas that without UHV-connection are relatively isolated within the grid[5]. This also recognizes the priority need of the receiving ends that otherwise face supply shortages and worsening environmental problems.

(2) China's UHV construction has only begun its transition into tapping wind and solar energy and coal sources in northern China.

Based on a list of seven commissioned, two under construction and 17 planned UHV lines we have identified, China's UHV construction has only begun its transition into tapping wind and solar energy sources and coal-fired generation from the planned coal-power bases in northern China, reflecting SGCC's "YiTeSiDa" (One Ultra and Four Big) version of China's future power system[6].

- Of the seven commissioned UHV lines, only the Hami-Zhengzhou UHV DC line commissioned in January 2014 starts from northern China's wind and solar energy-rich region.
- Of the two under construction UHV lines, neither starts from northern China.
- But of the 17 planned lines, there are three UHV AC and seven UHV DC lines planned from northern China, including two UHV AC and three UHV DC from Inner Mongolia alone.

Summary of China's UHV projects

Status	Type	Project	Start province	End province	Grid company	Start year
Commissioned	AC	Jindongnan-Nanyang-Jingmen	Shanxi	Hubei	SGCC	2009
		Huainan-Zhebei-Shanghai	Anhui	Shanghai	SGCC	2013
	DC	Yunnan-Guangdong	Yunnan	Guangdong	CSG	2010
		Xiangjiaba-Shanghai	Yunnan	Shanghai	SGCC	2010
		Jinping-Sunan	Sichuan	Jiangsu	SGCC	2012
		Nuozhadu-Guangdong	Yunnan	Guangdong	CSG	2013
		Southern Hami-Zhengzhou	Xinjiang	Henan	SGCC	2014
Under construction	AC	Fuzhou-North Zhejiang	Fujian	Zhejiang	SGCC	2015
	DC	Xiluodu-Zhejiang	Sichuan	Zhejiang	SGCC	2014
Planned	AC	Huainan-Nanjing-Shanghai	Anhui	Shanghai	SGCC	>2015
		Mengxi-South Tianjin	Inner Mongolia	Tianjin	SGCC	>2015
		Jingbian-Weifang	Shaanxi	Shandong	SGCC	>2015
		Ya'an-Wuhan	Sichuan	Hubei	SGCC	>2015
		Ximeng-Nanjing	Inner Mongolia	Jiangsu	SGCC	>2015
		Zhangbei-Nanchang	Hebei	Jiangxi	SGCC	>2015
		Mengxi-Changsha	Inner Mongolia	Hunan	SGCC	>2015
	DC	Jiuquan-Hunan	Gansu	Hunan	SGCC	>2015
		Zhundong-East China	Xinjiang	Anhui	SGCC	>2015
		Ximeng-Taizhou	Inner Mongolia	Jiangsu	SGCC	>2015
		Ningdong-Zhejiang	Ningxia	Zhejiang	SGCC	>2015
		Zhundong-Sichuan	Xinjiang	Sichuan	SGCC	>2015
		Humeng-Shandong	Inner Mongolia	Shandong	SGCC	>2015
		Mengxi-Hubei	Inner Mongolia	Hubei	SGCC	>2015
		Northern Hami-Chongqing	Xinjiang	Chongqing	SGCC	>2015
		Baoqing-Tangshan	Heilongjiang	Hebei	SGCC	>2015
		Longdong-Xinyu	Gansu	Jiangxi	SGCC	>2015

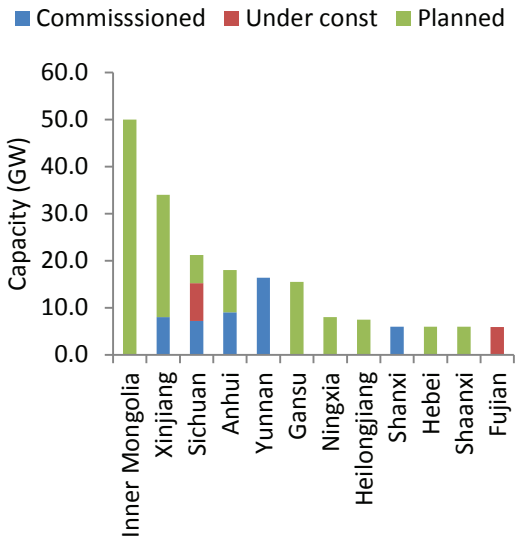
Source: TLG Research

5 From the demand side, a major factor for the two UHVs is that fuel transportation to inland provinces such as Hunan, Sichuan is costly. For Sichuan, an additional factor is the seasonality of hydropower generation causing sharp shortage and surplus during the dry and wet seasons.

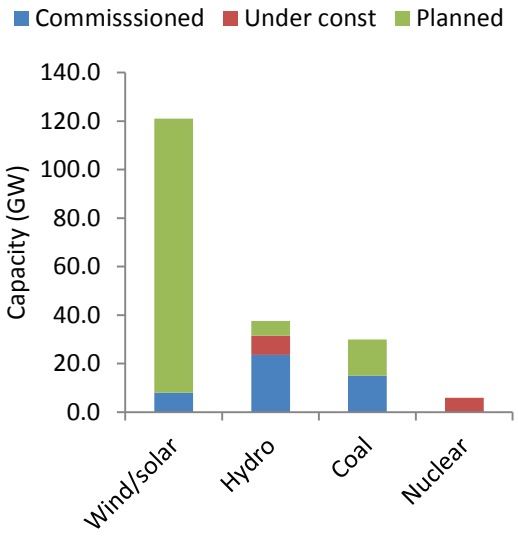
6 YiTe is referred to the UHV systems and "SiDa" is referred to "Big Hydro", "Big Coal Generation", "Big Nuclear Power" and "Big Renewable Power". Recent Action Plans for Air Pollutant Control may add foundation to the need of the UHV systems.

Overall, planned UHV capacity from wind and solar resource regions is expected to far surpass that of other regions, yet at this point most existing UHV lines are in Southwest China's hydro rich regions.

China UHV capacity by start province



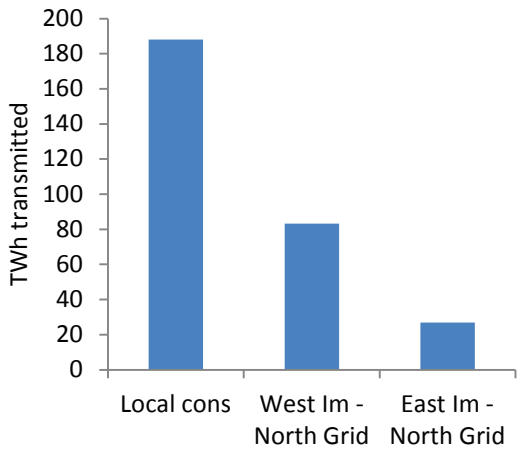
China UHV capacity by energy source



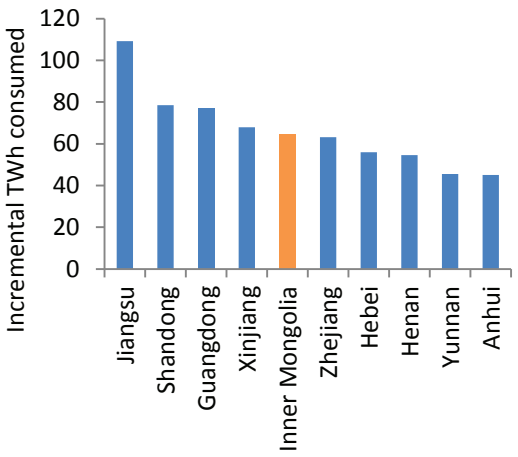
Source: Government and press releases, TLG analysis

As resource development continues, Inner Mongolia may need to find long-term solutions to its projected surplus generation. The region is currently able to export electricity using non-UHV transmission infrastructure to the neighbouring energy-short Beijing-Tianjin-Hebei region in the North China Grid. The province has also enjoyed strong electricity consumption growth, reducing the level of exports from what it would otherwise have been. So far grid improvements at the local level have kept pace and limited curtailment. This is why Inner Mongolia's wind power sector has been able to grow to a scale close to its 2015 target without the need of UHV construction.

Inner Mongolia electricity consumed and transmitted (2011)



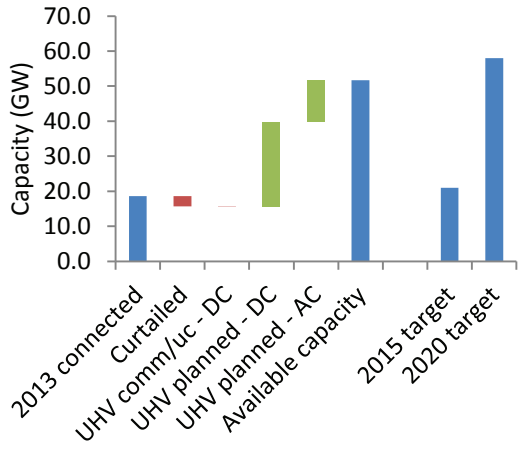
Top 10 incremental electricity consumption provinces (2010-13)



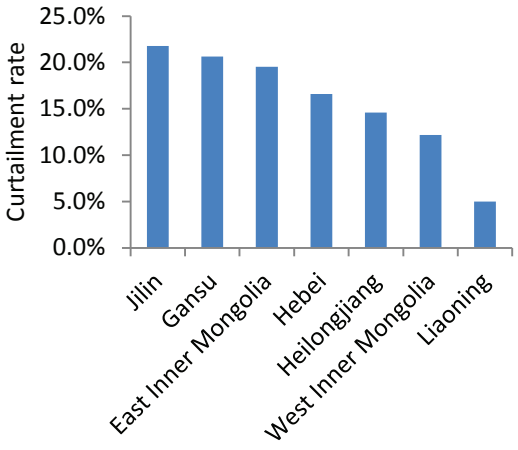
Source: Government and press releases, TLG analysis

But in the longer term UHV transmission will be needed to more fully tap China's best wind resources in Inner Mongolia and send them to areas beyond the Beijing-Tianjin-Hebei region. In 2013, wind curtailment in East Inner Mongolia remained at about 20 percent and curtailment in West Inner Mongolia remained at about 12 percent. Hebei, meanwhile, is currently tackling its own grid curtailment problems. Wind curtailment in Hebei increased to over 16 percent in 2013 due to increased wind generation capacity, and the province is currently building transmission lines to send more wind power from its wind farms in Zhangjiakou to Beijing, Tianjin and the rest of Hebei.

Inner Mongolia potential wind capacity including UHV



Wind generation curtailment rate in grid curtailed regions (2013)

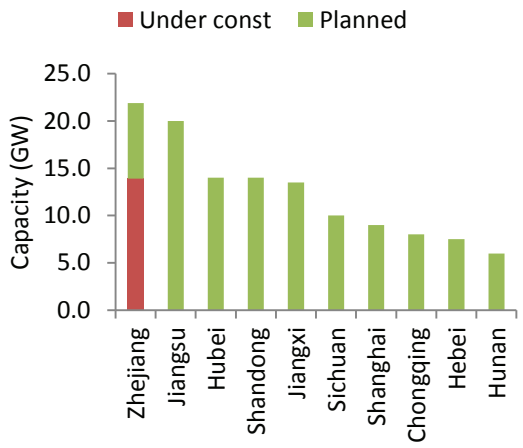


Source: Government and press releases, TLG analysis

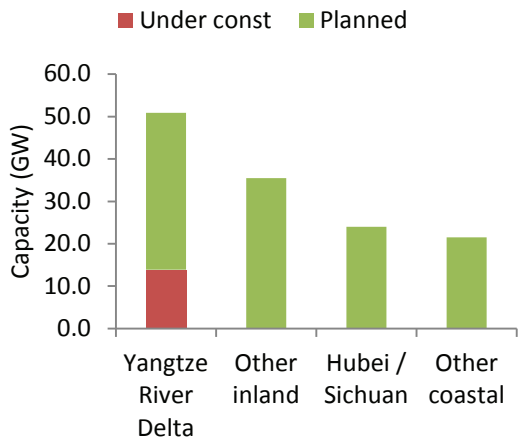
(3) Continued demand growth in coastal and inland China will underpin the need for UHV transmission of wind and solar energy from northern China

From the demand side, areas with the greatest need for more electricity imports includes, the Yangtze River Delta region's Zhejiang and Jiangsu, other coastal provinces such as Shandong, hydropower provinces such as Hubei and other inland provinces such as Hunan.

China UHV capacity by end province



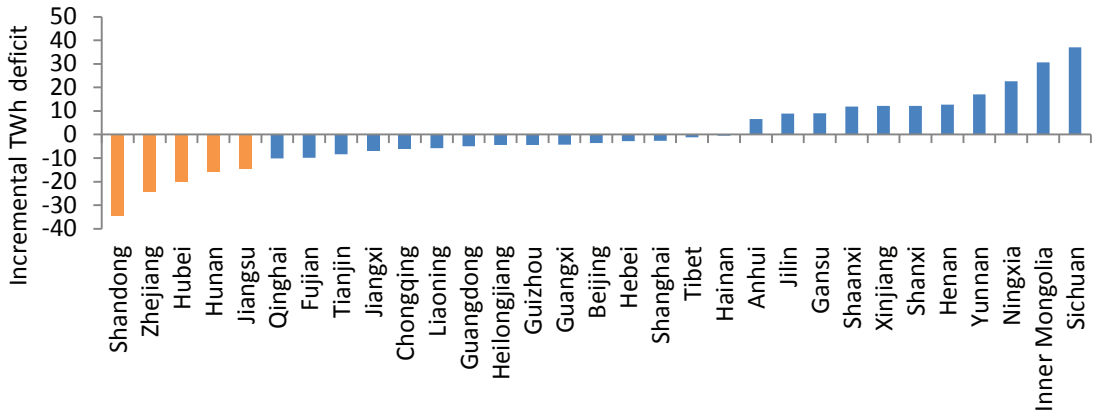
China UHV capacity by end region



Source: Government and press releases, TLG analysis

Over the past three years, these provinces have experienced the widest increase in their electricity deficits, as local electricity supply in these regions has been unable to keep pace with electricity demand growth.

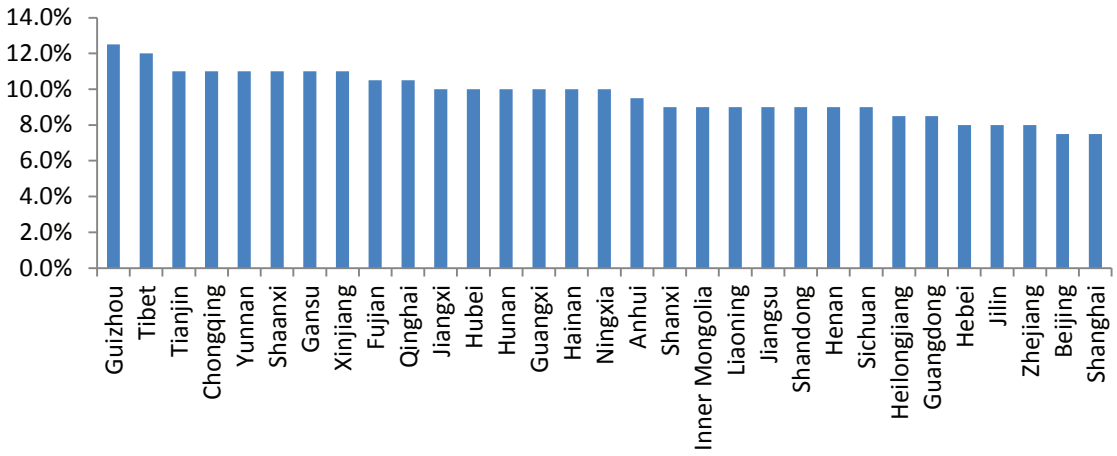
China incremental electricity deficit by province (2010-13)



Source: Government and press releases, TLG analysis

This trend of in growing electricity deficits in both coastal provinces and parts of inland China is likely to continue if the provincial economies grow as planned. Even with deceleration in China's previously stratospheric growth rates GDP growth in traditional demand centres in coastal China is targeted to reach at least 8 percent in 2014. Meanwhile, GDP growth in most inland provinces is expected to grow at higher rates than the more developed coastal provinces.

Ambitious provincial GDP growth targets for 2014

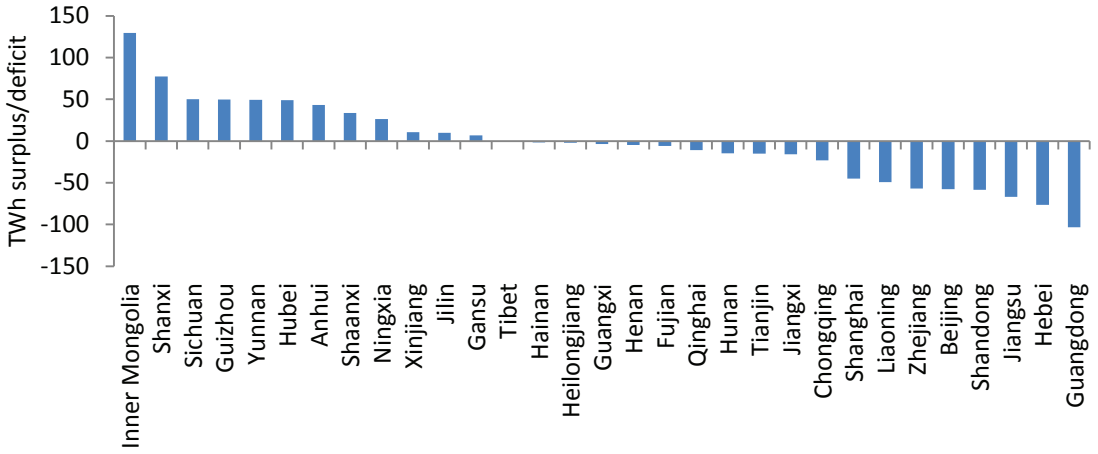


Source: Government and press releases

And as these provinces continue to grow, many of them will need to look to UHV connection from the north if they wish to import clean energy rather than burning fossil fuel to generate power locally coal-fired power. Of the provinces with electricity surpluses, only Shanxi and Anhui are located in near coastal China, yet both are primarily coal-producing provinces. Yunnan and Guizhou are hydropower provinces located in southern China, and traditionally supply electricity to Guangdong.

Hubei and Sichuan are hydropower provinces located in central China, but after the completion of the Xiluodu-Zhejiang line, there are no other hydro-based UHV lines planned.

China electricity surplus/ deficit by province (2013)

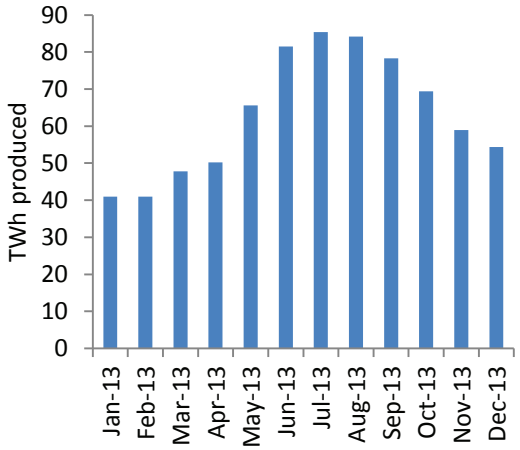


Source: Government and press releases, TLG analysis

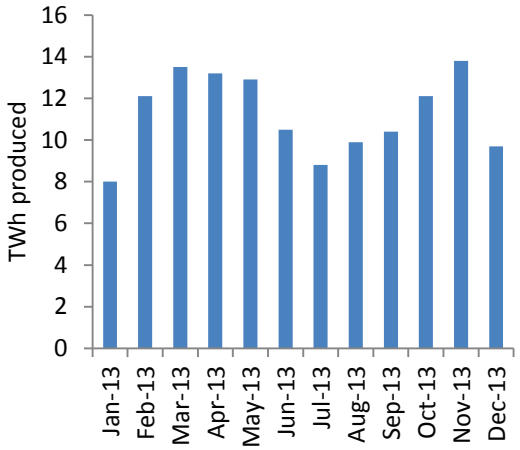
Instead, UHV lines from North or Northwest China to Hubei and Sichuan are constructed or planned. This is because the seasonality of hydropower and of wind power in China are complementary to each other, enabling the use of wind rather than coal as a source of electricity when these provinces encounter energy deficits during periods of low precipitation.

Hydropower generally peaks during the summer when the rainy season provides about 50 to 60 percent of annual rainfall. Wind power is generally most plentiful during the spring and winter, and troughs during the summer.

Monthly hydropower generation in 2013



Monthly wind power generation in 2013



Source: CEC, NBS, TLG analysis

Summary

The drivers of China's UHV system infrastructure development have shifted from being seemingly driven mainly by broad ideas concerning the very best overall grid structure and strategy to being driven by the practical needs of ensuring adequacy of supply and promoting cleaner air. As previously noted, significant local grid strengthening has been a priority as well, often creating enough additional capacity to keep curtailments risk within limits. China's decelerated growth has provided some breathing room as well.

But going forward, construction of UHV transmission infrastructure is likely to be particularly intensive in 2014 to 2017 due to the need to export large amount of power from the resource rich areas to the eastern and central regions which are deficit of energy resources and are facing serious environmental pressures. Availability of transmission capacity has the potential to stimulate another major round of investment in renewable energy in Xinjiang, Shaanxi, Gansu and Inner Mongolia. However, all is not yet smooth sailing. The UHV AC projects have not made it through the full approval process, especially those projects that cross regional boundaries. If the past is any guide, the final UHV AC systems are likely to differ from SGCC's version. China is moving beyond State Grid's original vision of a UHV AC systems that would integrate the three regional grids: North China Grid, East China Grid and Central China Grid. A more practical approach, with targeted development, is emerging.

About the Authors

Dr Xinmin Hu

Manager

xhu@lantaugroup.com

+852 9381 6938

Xinmin is an expert in the Chinese power sector and energy economics having advised clients on generation, transmission and energy supply issues as well as regulatory developments and cost trends. He is a former lecturer at Jilin University in Changchun and at Zhongshan University in Guangzhou. He combines his knowledge of China's power sector with over a decade of experience as a consultant in the Australian and other power markets and as an associate director of RepuTex (AU) focusing on environmental and greenhouse gas emission issues. He is a regular reviewer for several international energy, operations research and optimization journals. He holds a PhD in operations research with a minor in economics from the University of Melbourne and an MSc in Applied Mathematics from Jilin University of Technology, China. Xinmin is fluent in both English and Mandarin.

Mike Thomas

Partner

mthomas@lantaugroup.com

+852 9226 2513

Mike has advised energy sector stakeholders on sensitive regulatory, commercial, and strategic matters for over 25 years. He is an expert in the rigorous analysis of energy sector decisions including: how or whether to regulate; how and when to rely on market forces; and what value to place on opportunities and risks. Prior to co-founding The Lantau Group in 2010, he headed the Asia Pacific Energy & Environment practice of a global consulting firm. Mike has an MPP from Harvard Kennedy School and a BA in economics from Carleton College.

Liang Zhang

Consultant

liangzhang@lantaugroup.com

+852 9226 0307

Liang joined our team from Sanford Bernstein in Hong Kong, where he advised institutional investors on stock selection in the Asia Pacific region. He brings with him experience across a broad range of sectors including energy and finance, with particular expertise in quantitative analysis and financial modelling. Liang holds a B.S. cum laude in Economics and Biomedical Engineering from Yale University. He is fluent in both English and Mandarin.

Subscribe

This newsletter is available to our China power and gas service subscribers.

For more information, please contact Dr Xinmin Hu at **TLGonChina@lantaugroup.com**

For more information about The Lantau Group, please visit **www.lantaugroup.com**