TLG on

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Cutting the Gordian Knot:

China's High-voltage Super Grid Evolves

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TLG on is The Lantau Group's in-house journal addressing current energy issues, and their policy and economic implications, facing the Asia Pacific region.

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The ongoing expansion of China's ultra-high voltage (UHV) power transmission network continues to serve as one of the country's most complex and ambitious infrastructure projects. The regions richest in power generation resources, including coal but also solar, wind, and hydropower resources, are in relatively remote provinces in the North, West, and Southwestern parts of China. Meanwhile, the coastal regions in the South and East continue to serve as the primary load centres. Given the country's ambitious environmental targets, resolving this inherent imbalance is problematic. Creating a grid that works reliably and efficiently requires complex, technical planning and massive strategic investment in transmission network infrastructure.

Imbalances have long been the lingua franca of China's power system. It doesn't matter the source, the type, the structure, or the outlook, imbalances are the common problem that exists periodically at all levels of the system and in all locations. At times, demand has outpaced supply. At times, it has been the inverse. Regional imbalances have been the more challenging issue, with demand centres far from resource centres. And now, environmental considerations complicate reaching any semblance of steady state given China's enormous base of coal-fired capacity, much of which has been recently built. The process of developing market-like dispatch and commercial contracting processes and options is another way in which the impact of manifest imbalances are likely to play out. Imbalances cry out for trading and exchange – based on more systematic market processes, which China has been developing and testing and is gradually enhancing. However, with larger end users gaining options to secure market-based power at lower prices, the resulting lost revenue to the industry will still need to come from somewhere. Not all results of market trading are the product of pure efficiency. Much of what happens initially is simply a transfer of value as one shifts the sector from an old way of doing things to a new way. The scale of these imbalances, whether physical, commercial, or environmental, will drive China's sector evolution for some time.

TLG started following UHV developments in 2012 largely because of their projected magnitude but also because without such development curtailment would be inevitable (as it was anyway because change and transformation take time). Then, China's grid was much less developed and China was in the midst of shifting the focus of generation resource development to the west while incorporating more renewable energy resources. From even the early days of constraints and shortages, change was expeditious. There was little need to focus on economics when the magnitude of what was intended was so clearly exceptional. But eventually things catch up with themselves so to speak.

By 2017, TLG had published China's UHV Grid: Exporting Power in an Age of Overcapacity. In that update we noted that for every exported MWh, there must be an imported MWh. Excess capacity meant that many regions that had been expected to import electricity from other regions did not really need what was being offered. Supply

and infrastructure were being built out faster than demand was growing. Power systems eventually face challenges whenever supply and demand grow at materially different rates. Throughout an integrated grid, new capacity can be added, but this does not assure that it can or will be used as intended, that is, to enable electricity to flow to where it is needed. Thus, construction and sequencing are crucial.

In this edition of *TLG On*, we recognise the crucial importance UHV build-out status and expectations to a robust factual basis for interpreting changes and informing the outlook for renewables, battery storage, corporate sustainability efforts, as well as commercial transactions. We do not make many predictions or present additional analysis here, but we are always happy to discuss our views.

Key Points and Executive Summary

UHV development in China continues on its strong pathway; the balance of economics and technical adaption is complex. Some approvals have slowed, but the outlook is still one of growth and confidence.

- **China's UHV development continues robustly.** Whilst ambitious targets are not always met, there is no evidence of an underlying shift in planning or execution strategies. UHV development progresses with most proposed lines currently in the approval pipeline looking to be online by 2021-2022. The 14th FYP will likely set updated goals for *additional* UHV line capacity;

- **Regulatory approvals and economic (cost) considerations are starting to matter more.** Regulatory approvals have slowed somewhat suggesting an increasing focus on economic benefits and not just technical possibilities.

  Sequencing and timing will become a more important focal point. Excess capacity at the element or component or resource level is not the same as excess capacity at the overall system capability level. Local constraints will need more attention. As the system becomes more complex, so too must the process of evaluation and approval, suggesting increasing importance and possibly tension in coordination and planning at both the national and provincial level.

The overall scale of investment initially envisioned remains immense. China's 2060 commitment to a carbon-neutral China is still far off, but replacing approximately one terawatt of coal-fired capacity over 40 years will require around 50 GW of new solar and wind capacity additions each year just to cover replacement generation, plus additional resources to accommodate the imbalances that arise due to factors such as when the sun shines and when the wind blows versus when electricity is needed. It becomes clear that the scale of transformation, even to meet a seemingly distant 2060 target, is notably larger than it might first appear. There is no doubt that significant grid development will be needed. However, it should also be clear that getting and keeping everything in reasonable balance will continue to be the biggest challenge of all.

Where We Left Off: Reviewing Key Points from 2017 Whitepaper on China's UHV Development

In our previous report, we noted that whilst China's UHV development had been impressive, it was lagging well behind the aggressive targets set in the 13th FYP from 2016.

1. The pause in new UHV project approvals in 2017 reflected poor market fundamentals across China, specifically a persistent state of oversupply nationwide that left UHV projects lacking suitable provinces to receive surplus electricity;

2. A super grid is a national project requiring much greater coordination across importing and exporting regions. Provinces, however, often had different preferences;

3. Growth in electricity demand had slowed and new coal build-out also slowed, changing both the need and the expected future locations of generation investment;

4. The larger hydro projects that naturally require massive transmission export capacity had lost favour.

Accordingly, we argued that UHV grid development would need to adapt to changing circumstances, reflecting:

1. **Slower Economic Growth:** Slower GDP growth would continue to underpin slower power demand growth, potentially slowing the need for large scale UHV capacity increases until regional and inter-regional supply vs demand was rebalanced;

2. **The Need to Curtail Curtailment:** We identified reduction of wind, solar, and hydropower curtailment, especially in the North, Northwest, and Southwest parts of the country, as an important but narrower and more specific driver for adding more UHV lines under 2017 market conditions;

3. **Greater Focus on Renewables Development and Integration:** The main support for more UHV lines would eventually need to shift away from more flexibly located thermal generation capacity towards renewable energy resource areas, thus dependant on further policy development;

4. **Reconcile Provincial vs National Priorities.** A national UHV grid has significant provincial impacts. Optimising these is both important and, at times, challenging.

UHV grid development is susceptible to change, but adaptable. China's transition economy, from ultra-growth to power capacity additions now having to match demand harmoniously.

China's economy is now in transition. From a period in which it was previously growing so quickly that nearly any additional infrastructure could immediately be used or absorbed, to now; a period in which power capacity additions must be timed more strategically to match demand growth. This is a problematic transition in any economy. Chinese power planners have been taking increasingly assertive steps to keep GDP growth and capacity expansion aligned. This has aligned well with our predictions for power supply and the necessity for Chinese planners to shift focus towards smarter prioritisation, tighter coordination and sequencing, and increased focus on economic costs and benefits.

Analysing the Predictions of 2017

In 2017, China's UHV industry was amidst a new-build freeze for UHV lines that would last for nearly two years.[1] At the time, some speculated that this may reflect a loss of appetite for UHV lines on the part of government planners.[2] The reality was more that the underlying economics and priorities were shifting to focus on more severe supply-demand imbalances.

Since 2017, power curtailment rates have decreased dramatically. This is primarily due to regional new-build moratoriums that came into effect in 2018, part of the Clean Energy Consumption Action Plan 2018-2020.[3] The reductions in renewable curtailment were realised, not just in the 'Three Norths', (the Northwest, North, and Northeast Grids) where wind and solar power traditionally experienced offtake challenges, but also in the hydro-rich South West. These efforts culminated in YoY curtailment reduction by nearly

1 UHVAC lines (May 2015 to July 2017) and UHVDC lines (Jan 2016 to Nov 2018) respectively

2 https://chinadialogue.net/en/energy/10376-sparks-fly-over-ultra-high-voltage-power-lines/

3 https://www.ndrc.gov.cn/xxgk/zcfb/ghxwj/201812/W020190905495739358481.pdf

50% last year.[4] These regions also serve as origination points for the UHV line buildout. The slowdown on new capacity additions applied to coal as well. This was due to the central government's reassumed responsibility for new plant approvals, their first action being to delay and defer construction at multiple sites that had been previously been approved during a flurry of provincial government overindulgence from 2014-2016.

None of this had so much to do with the technical feasibility of UHV or even the economic desirability of increasing the scale and complexity of China's supergrid. It was more a case of economic realities and the fact that grid elements abide by the laws of physics in terms of where and how electricity flows (or does not flow) over those elements at a point in time. Limitations attributable to local grid capacity as well as a lack of need in importing regions all demonstrated that timing and sequencing matter.

Looking ahead, the shift to renewable energy is the likely to become the most robust driver of increased grid development. Although the generous on-grid subsidies offered circa 2017 have receded and grid-parity offtake will become mainstream in 2021, the promulgation of Renewable Portfolio Standards for all Chinese provinces and major power consumers bode well for RE development the coming years. Additionally, a significant but highly uncertain transformational opportunity lies with the potential to expand local and regional wholesale power markets.

Where Are We Now?

China's UHV system build-out has reached over 40,000 km, impressive, but far behind the original goal of 89,000 km. Even so, 2,700 km of UHVAC and 11,500 km of UHVDC lines have been added in just the last two years. In our view, these specific goals almost no longer matter. It should be more about the process of evaluation and approval; not just the simplicity of continual building.

Though hesitation remains over the viability of exclusively-renewable UHV lines, China has a considered, dedicated effort in ensuring its UHV intentions are met.

Nevertheless, there are reasons to expect a robust uptick in UHV build out activity:

- As part of China's COVID19 economic recovery plan via the 'New Infrastructure' initiative, which includes accelerated UHV investment;
- Redoubled initiatives to even out supply and demand imbalances, ensuring that capacity additions are aligned with the needs of the (slowing) economy;
- Continued transition to a more market-oriented power trading system;
- Continued transition to using more economic dispatch protocol; and
- Heightened, specific focus on ensuring renewables offtake, even at the expense of coal projects, in accordance with the newly announced objective to achieve carbon neutrality by 2060.

In our 2017 paper, we noted the uncertainties over the economic viability of UHV lines being supported exclusively by renewable energy. Our concerns remain, but it is noteworthy that on 29 August 2020, the Zhangbei-Xiong'an UHVAC line completed 72 hours of trial operation and formally entered commercial operation, and in doing so, became the latest building block in China's growing inter-regional high-voltage grid as well as the first powered dedicated to transporting power generated from wind resources. The line stretches 315 kilometres, working north to south, across northern China's Hebei Province. It runs from Zhangjiakou to Baoding, sitting north and south of Beijing respectively. The line is China's shortest UHV line to date, purpose-built to supply the Xiong'an New Area with green electricity. Xiong'an, a name familiar to followers of Chinese megaprojects, is a planned economic zone southwest of Beijing that is to be entirely green powered.

4 http://energy.people.com.cn/n1/2020/0307/c71661-31621377.html

The completion of the Zhangbei-Xiong'an UHV line provokes the notion of a new Chinese UHV development era, one in which UHV lines may be strategically constructed to benefit green energy. Zhangbei-Xiong'an is first UHV line in China that was purpose-built to exclusively carry electricity generated by wind and solar. The nearly complete Qinghai-Henan UHVDC will be the next example (and the first DC line). Begun in November 2018, the line stretches nearly 1600 km, traversing four provinces, and today remains the only UHV line in China built to transfer solar and wind power across such a significant distance. It entered limited operation in August 2020. Its full operationality was expected by December 2020, but Q1 2021 now appears more likely. At least five more renewable energy generation bases and directly associated UHV line systems are now planned (see table).

Table 1: Planned Renewable Energy Bases with Directly Associated Transmission Projects

Location	Wind (GW)	PV (GW)	Related UHVDC	Related UHVAC
Xinjiang	31	9	Zhundong-Chengdu 1100kV; Zhundong- Wannan 1100 kV	
Western Inner Mongolia	24	4	Ximeng-Taizhou 800 kV Ximeng-Wuhan 800 kV	Ximeng-Shandong 1000 kV; Ximeng-Tianjin 1000 kv; Ximeng-Changsha 1000 kV
Gansu	20	9	Jiuquan-Hengyang 800 kV	
Hebei	17	3	Zhangbei 500kV four-terminal VSC-HVDC grid	Zhangbei-Nanchang 1000 kV
Eastern Inner Mongolia, Jilin, Heilongjiang	25		Zhalute-Qingzhou 800 kV	

Source: Huang Qili, State Grid Corporation of China

The UHV Build-out Will (and Must) Continue

China's transformative UHV grid will only continue to express its prominence within the country's power infrastructure system. As part of its Covid-19 response, China is likely to press even harder to develop UHV projects, suggesting that long term expectations remain robust and perhaps even strengthened by China's 2060 carbon neutrality pledge.

China's COVID19 response includes a dedication to UHV projects. While some previous projects have withered in comparison to their lofty initial plans, it seems China now has a more expressed determination in the building and going live of UHVDC/UHVAC projects.

To support the inter-region UHVDC lines, bolstering the UHVAC regional networks will be paramount to useability. This is especially prudent in Central China, a geography in which multiple UHVDC lines will intersect. Original plans for UHVAC construction called for a Central China Ring Network comprising seven separate UHVAC lines, effectively integrating the North China Grid and East China Grid. The first line of this network was completed in 2009 (Jindongnan – Nanyang – Jingmen) with the following six highlighted as Key National Projects in a 2018 NEA release. The construction schedule has not matched expectations, however, with only one additional line constructed since the release (Zhumadian – Nanyang was completed in June 2020). The other five lines still exist only on paper. Despite a State Grid work plan released in March 2020 indicating approval would be sought for all remaining lines by the conclusion of this year, only one (Nanchang – Changsha) has succeeded in gaining approval. The regulatory authority expressed concerns about the necessity for these lines and their economic feasibility, saying: 'the owner must optimise their design according to generation capability and the actual demand. However, at this time, this UHVAC project has not met the bar for approval.[5]

5 China Energy News Network (www.china5e.com)

Figure 1: China's UHVDC Networks

Source: TLG Research

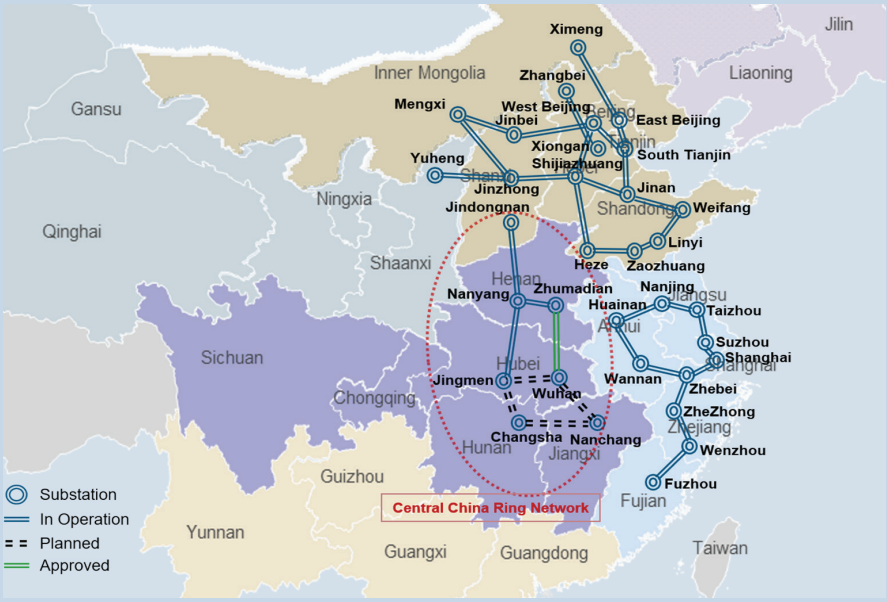
With UHVAC infrastructure lagging, UHVDC lines have had to accept lower utilisation rates. Without adequate regional UHVAC infrastructure, these grids in central China may be limited by fault risk on various UHVDC lines and thus cannot securely access their full available capacity. For example, the transmitting capacities of the South Hami-Zhengzhou and Jiuquan-Hunan UHVDC lines have been throttled under 5400 MW and 5500 MW respectively, less than 70% of their designed capacity. The situation in the 'Three Norths' provinces is even more severe. The ten UHV lines originating in this region were theoretically capable of delivering 520 TWh of power in 2019 but the real figure was 207.9 TWh; only 40% of their designed capacity. All ten lines had capacity factors lower than 50%, while Ximeng-Taizhou, Ximeng-Jinan, and the West Inner Mongolia-South Tianjin lines were as low as 20%.[6] While part of this is due to insufficient grid infrastructure, dispatch protocols that prioritize local generation have also played a role. In many provinces that still use a 'fair dispatch rules' dispatch protocol, including most of State Grid's area of jurisdiction, local coal generation that is assigned quota-guaranteed dispatch will enter the grid first, even if cheaper or cleaner power is available via UHV line. These issues will only be resolved following dispatch reform and stricter implementation of the Renewable Energy Law, but the entrenched coal industry has a powerful lobby.

Ultimately, local governance is the key driver in the green lighting of projects. Reform, preexisting relationships with other energy sources, current laws, and protocol systems are all major elements in the hold-up, and future signing-off, of UHV line operation.

Lagging UHVAC infrastructure may also be related to push back from local stakeholders unenthused about seeing the already-complex T&D fee determination process exacerbated by adding another huge infrastructure investment. While connection of the regional grids via UHVAC in the Central China Ring Network is still likely the ultimate destination, we anticipate that the concerned parties are all waiting for a clear signal from the 14th FYP to move forward with project approvals (and subsequent construction).

6 Global Energy Interconnection Development and Cooperation Organization (GEIDCO)

Figure 2: China's UHVAC Network



Source: TLG Research

Curtailment Unlikely to Plague Future RE Generation

At the very least, widespread solar and wind curtailment across the Three Norths circa 2016-2017 is at low risk to return. The successful operation of purpose-built renewable energy-carrying UHV lines from Western China to Central China (such as the Qinghai-Henan line, due to enter full commercial operation in December 2020) will pave the way for UHV-connected RE bases in China's generation bases in remote regions of the North and West to become the 'new normal.' As long as RE projects have access to the UHV grid, their likelihood to encounter severe, loss-making curtailment issues should be greatly reduced.

As these planned RE + UHV projects demonstrate, our concerns stated in the 2017 edition of this paper, that renewable generation may be insufficient to exclusively serve as an energy source for a UHV project, are clearly not shared by Chinese power planners.

Energy Storage Capacity is Set to Expand and Support UHV

Early prototype-style projects being successful, such as the Qinghai-Henan line that runs from Western to Central China, will work as sterling examples to incentivise provincial governments.

China's energy storage industry has seen exponential growth since 2017 when the NEA released its *Guiding Opinions on Energy Storage Technology Industry and Development*. Although energy storage's role in optimising power costs for large industrial users (user-side storage) is often at the forefront of the discussion, utility-scale energy storage on the grid side and generation side also has role to play. We anticipate energy storage in 'PV + storage' and 'wind + storage' applications to increase notably as energy storage can be used for frequency regulation on UHV lines that would otherwise be potentially endangered by intermittent renewable generation. We expect more provinces and regions to adopt policies requiring all new capacity to be designed with some percentage of their nameplate capacity being covered by onsite energy storage. In Southern Xinjiang, for example, this requirement is 15% for 2 hours[7], while

7 China Energy Storage Alliance (CNESA)

other provinces such as Hunan are as high as 20%[8]. These policies have been notably unpopular with developers who have protested their impact on CAPEX and the lack of regulatory support for higher on-grid tariffs.

Developers are also unlikely to see much relief, however, with the promotion of RE + storage appearing to become a priority for policymakers, while being dually beneficial for UHV development as well. Regardless of it being covered explicitly in the Five-Year Plan on Energy, or promulgated piecemeal via provincial decree, requirements for energy storage will likely become a normal feature of newbuild solar and wind from 2021 onward. Whether the associated rise in CAPEX has a stunting effect on RE deployment remains to be seen. In Southern Xinjiang at least, the PV stations with paired energy storage that operate as a single generating unit receive the same on-grid price as PV plants with no storage, negatively impacting the economic case for these projects. Critics of the policy point out that while the energy storage industry is delighted by these positive developments, the thermal industry is likely to be the ultimate beneficiary of the associated rise in RE CAPEX.

Closing Thoughts

China's ambitions for its UHV network will continue, as they must be seen in tandem with its drive to increase the efficiency of, and reduction of the CO2 emissions from its power sector. The sweeping reforms currently underway regarding wholesale power markets, economic dispatch, and unbundled power pricing are all enhanced and empowered by China's UHV lines. Although concerns about economic feasibility have held up the approval of some of the UHVAC lines that comprise the proposed Central China Ring Network, such concerns have not been a sticking point for the bulk of the planned UHV projects. The inclusion of UHV lines in the post COVID19 'New Infrastructure' stimulus plan was expected to usher those lagging projects, taking them through the approval process, but this outcome has not yet materialized. The news of mid-December 2020, that Central China is now facing power rationing despite grid-wide oversupply, may serve as the catalyst needed to accelerate those sector reforms and see the regional AC interconnectors finally approved.

China's determination in its emission targets intersect importantly with UHV line development. Though it carries issues we have noted in this, and past editions of TLG On, the drive to reduce the country's carbon footprint will fasten important reform integral to UHV uptake.

The 14th Five Year Plan will reveal key details about the plan for UHV network development once. The overall direction is expected to remain, however. Considering the supporting role UHV plays for China's power sector reform, promoting renewables deployment, and improving the grid's robustness, the case for UHV lines goes beyond short-term economic feasibility. Chinese infrastructure is often planned out over many decades for mega-initiatives like high-speed rail, metros, power plants, or bridges and UHV is no different. As the world leader in large scale infrastructure development, China is also blazing a new trail for the practical application of UHV lines in a nationwide grid. The question is not ***whether*** China will eventually succeed in syncing up its regional grids with an UHV network with an economic dispatch protocol; it is how China's power sector will be transformed ***when*** it does.

8 China Energy News Network

Table 2: China's Intra-region UHVAC Network - Completed, Under Construction, and Planned

UHVAC Project	Construc-tion Start Date	Commis-sion Date	Voltage (kV)	Length (km)	Capacity (MW)	Dominant Fuel at Source
Jindongnan-Nan-yang-Jingmen (Central China Ring Network)	Aug-06	Jan-09	1000	650	5000	Coal
Huainan-Zhebei-Shanghai	Oct-11	Sep-13	1000	2x650	6000	Coal
Fuzhou-Zhebei	Apr-13	Dec-14	1000	2x603	6800	Nuclear
Huainan-Nanjing-Shanghai	Nov-14	Dec-16	1000	2x780	6000	Coal
Ximeng-Jinan	Nov-14	Jul-16	1000	2x730	9000	Coal + Wind
Mengxi-South Tianjin	Mar-15	Nov-16	1000	2x608	6000	Coal + Wind + Solar
Yuheng-Weifang	May-15	Aug-17	1000	2x1049	6000	Coal
Beijing West-Shiji-azhuang	Jul-17	May-19	1000	456	N/A	N/A
Shandong-Hebei	May-18	Jan-20	1000	816	N/A	N/A
Mengxi-Jinzhong	Nov-18	Sep-20	1000	2x304	N/A	N/A
Zhangbei-Xiong'an	Apr-19	Aug-20	1000	2x315	N/A	Wind
Zhumadian-Nanyang (Central China Ring Network)	Mar-2019	Jun-20	1000	187	N/A	N/A
Nanyang-Jingmen-Changsha (Central China Ring Network)	Planned	N/A	1000	635.5	6000	N/A
Zhumadian-Wuhan (Central China Ring Network)	Planned	N/A	1000	287	N/A	N/A
Wuhan- Jingmen (Central China Ring Network)	Planned	N/A	1000	240	N/A	N/A
Nanchang-Wuhan (Central China Ring Network)	Planned	N/A	1000	330	N/A	N/A
Nanchang-Changsha (Central China Ring Network)	Planned	N/A	1000		N/A	N/A
Ganzi-Tianfu South-Chengdu East	Planned	N/A	1000	N/A	N/A	N/A
Abei-Chengdu East	Planned	N/A	1000	N/A	N/A	N/A
Tianfu South – Tongliang	Panned	N/A	1000	N/A	N/A	N/A
Chengdu East - Changshou	Planned	N/A	1000	N/A	N/A	N/A
Tongliang - Changshou	Planned	N/A	1000	N/A	N/A	N/A

Source: TLG research and analysis

Table 3: China's Intra-region UHVDC Network - Completed, Under Construction, and Planned

UHVDC Project	Construc-tion Start Date	Commis-sion Date	Voltage (kV)	Length (km)	Capacity (MW)	Dominant Fuel at Source
Yunnan-Guangdong	Aug-06	June-10	800	1438	5000	Hydro
Xiangjiaba-Shanghai	Dec-07	Jul-10	800	1907	6400	Hydro
Jinping-Sunan	Dec-09	Dec-12	800	2090	7200	Hydro
Nuozhadu-Guangdong	Dec-11	Sep-13	800	1451	5000	Hydro
Southern Hami-Zhengzhou	May-12	Jan-14	800	2210	8000	Coal + Wind+ Solar
Xiluodu-Zhejiang	Aug-12	Jul-14	800	1680	8000	Hydro
Ningdong-Zhejiang	Nov-14	Aug-16	800	1720	8000	Coal + Wind+ Solar
Jiuquan-Hunan	Jun-15	Jun-17	800	2383	8000	Coal + Wind + Solar
Jinbei-Jiangsu	Jun-15	Jun-17	800	1119	8000	Coal
Ximeng-Taizhou	Dec-15	Sep-17	800	1620	10000	Coal + Wind
Shanghaimiao-Shandong	Dec-15	Dec-17	800	1238	10000	Coal + Wind + Solar
Zhundong-Wannan	Jan-16	Sep-19	1100	3324	12000	Coal + Solar
Dianxibei-Guangdong	Feb-16	May-18	800	1959	5000	Hydro
Zhalute-Shandong	Aug-16	Dec-17	800	1234	10000	Coal + Wind
Qinghai-Henan	Nov-18	Jul-20	800	1587	8000	Wind + Solar
Wudongde-Guangdong-Guangxi	Dec-18	Aug-20	800	1452	8000	Hydro
Shaanxi-Hubei	Feb-20	2021	800	1137	8000	N/A
Yazhong-Jiangxi	Sep-19	2021	800	1711	8000	N/A
Baihetan-Jiangsu	Dec-20	2022	800	2088	8000	Hydro
Baihetan-Zhejiang	*Planned*	*N/A*	*800*	*N/A*	*N/A*	*Hydro*
Yunnan-Guizhou	*Planned*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Fujian-Guangdong	*Planned*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Zhundong - Chengdu	*Planned*	*By 2025*	*1100*	*N/A*	*N/A*	*Wind/ solar*
Zhundong-Wannan	*Planned*	*By 2025*	*1100*	*N/A*	*N/A*	*N/A*
Hami North-Chongqing	*Planned*	*By 2025*	*800*	*N/A*	*N/A*	*Wind/ solar*
Longdong - Shandong	*Planned (preliminary feasibility study)*	*N/A*	*N/A*	*N/A*	*N/A*	*Wind/ solar*
Hami-Chongqing	*Planned (preliminary feasibility)*	*N/A*	*N/A*	*N/A*	*N/A*	*Wind/ solar*

Source: TLG research and analysis

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David Fishman's areas of expertise cover regulatory and commercial intelligence for the Chinese energy sector, including its nuclear power, solar, wind, and distributed energy markets. His specific experience includes Chinese power market and policy intelligence and forecasting, solar and wind tariff policy, renewable asset transactional due diligence, China business matchmaking, and commercial support for foreign firms seeking to do business with Chinese state-owned enterprises (SOEs). Prior to joining TLG, David was a Managing co-director and shareholder of the nuclear energy-focused consultancy Nicobar Group in Shanghai. He holds a joint MA from Johns Hopkins University School of Advanced International Studies and Nanjing University in the field of International Relations and Energy Policy. He is a native English speaker and fluent in Mandarin Chinese.

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