Wind power in North Asia:
International project finance for Mongolia

Aare Sweden – 9 February 2015
Winterwind

Sebastian Meyer
Director of Research & Advisory, Azure International Beijing
Director, Clean Energy (Mongolia)

Disclaimer

- This presentation is for attendees of “Winterwind 2016” held in Aare Sweden over 8-10 February 2016. The report may not be distributed, viewed or used by any other party without the express written agreement of Azure International.
- Azure International has exercised due and customary care in developing this report and where possible verifying information provided by others. This work has been undertaken in accordance with Azure International Quality System. No other warranty, express or implied is made in relation to the contents of this report. Therefore, Azure International assumes no liability for any loss resulting from errors, omissions or misrepresentations made by others.
- This report is the product of primary research conducted by Azure International’s team of analysts in China and is the unique and independent result of said research. This report is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. This report presents trends, and analysis based on public industry domain knowledge of activity. Any trend or relationship presented must be interpreted in light of other reliable sources of market knowledge and cannot be relied upon independently.
- Any recommendations, opinions or findings stated in this report are based on circumstances and facts as they existed at the time Azure International performed the work. Any changes in such circumstances and facts upon which this report is based may adversely affect any recommendations, opinions or findings contained in this report.
- No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the express prior written consent of Azure International. Azure International does not authorize the redistribution of our research without permission.

Representing

Azure International

Director of Research & Advisory

Azure is a clean energy technology advisory, research, development, and investment firm based in Beijing with networks and presence in the US and Europe

Power Market Research

Strategy & Advisory

Engineering & Sourcing

BD, Investment & Partnering

Founded in 2003 as one of China's earliest commercial clean energy tech development companies, we are focused on facilitating the growth and commercialization of cleantech solutions globally

We assist clients, partners, and portfolio companies with market strategy, market entry, sourcing, and business development in China

Clean Energy

Independent Director

Developer and operator of Salkhit – the first wind farm in Mongolia.

- Installed capacity 50 MW
- Annual production 168.5 mln kWh
- Average wind speed 8.2 m/s
- Operations since June 2013
- Total investment cost 122 Million USD

A renewable energy company developing and operating the first wind farm in Mongolia

Established in 2004 as part of Newcom Group

Investors:

- Newcom LLC
- General Electric Pacific PTE Ltd (GE)
- European Bank for Reconstruction and Development (EBRD)
- Netherlands Development Finance Company (FMO)

Video detailing development and construction:

https://www.youtube.com/watch?v=aygmUfsEi6U

This is a CDM project and CERs are purchased under ERPA by Swedish Energy Agency

Wind power in North Asia
- contents

Continental North Asian Wind Cluster
- resource

Continental north Asian regional wind cluster

2004 CREIA study assessed China wind potential at 253GW on-shore and 750GW offshore (capacity)

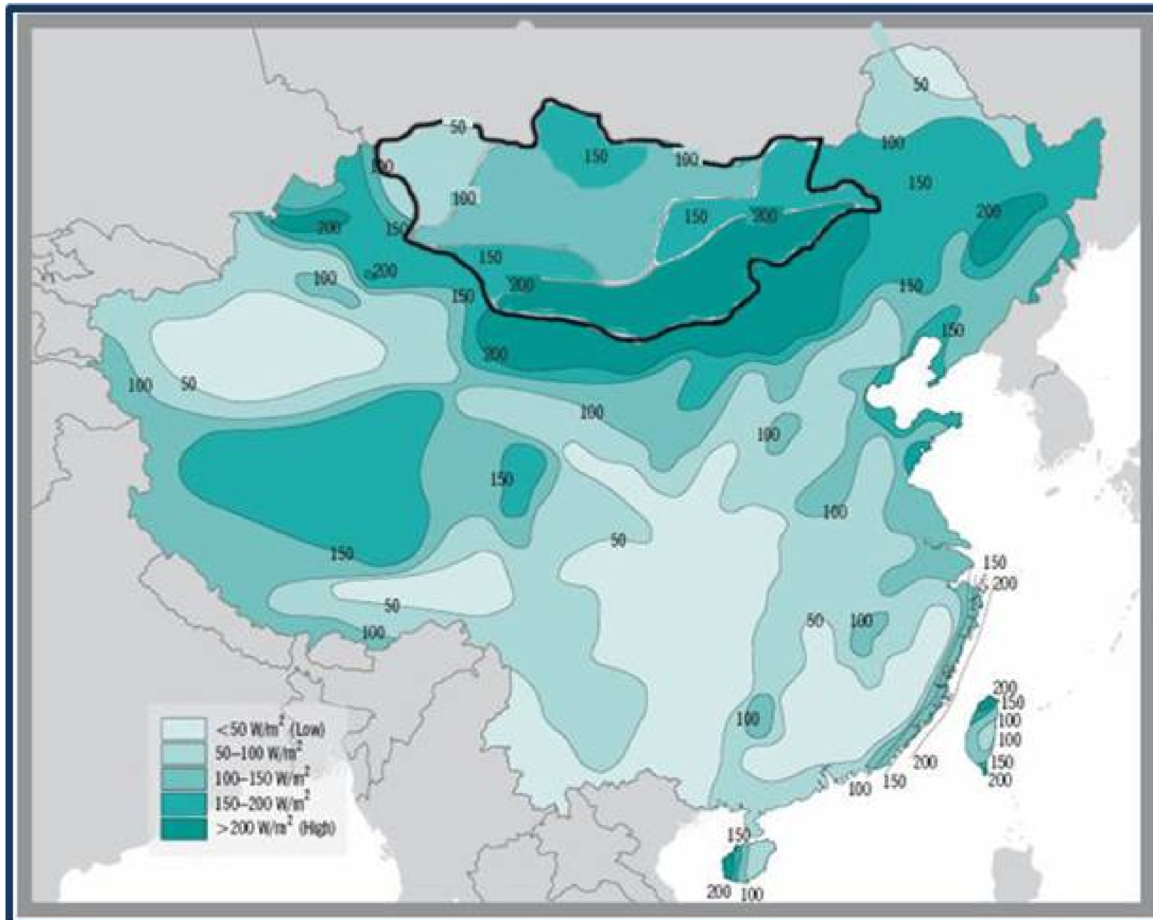
Study by Michael B. McElroy (Harvard), Xi Lu, Chris P. Nielsen, Yuxuan Wang (Tsinghua), finds All additional power needed by China to 2030 (800GW) could come from the wind resource based on reasonable geographical limitations – implies 3200GW of wind capacity

Onshore 25Pwh p.a. (7x current demand)
Offshore 2Pwh p.a. (200+ GW in 0-20m)

Note: also NREL/Black & Veatch 6600GW, 18Pwh p.a. @50% to total

Mongolia along has enough wind resource to supply 40% of the world's power generation

General view of resource: wind power density



Source: China Meteorological Administration

Continental North Asian Wind Cluster
- resource

Continental north Asian regional wind cluster

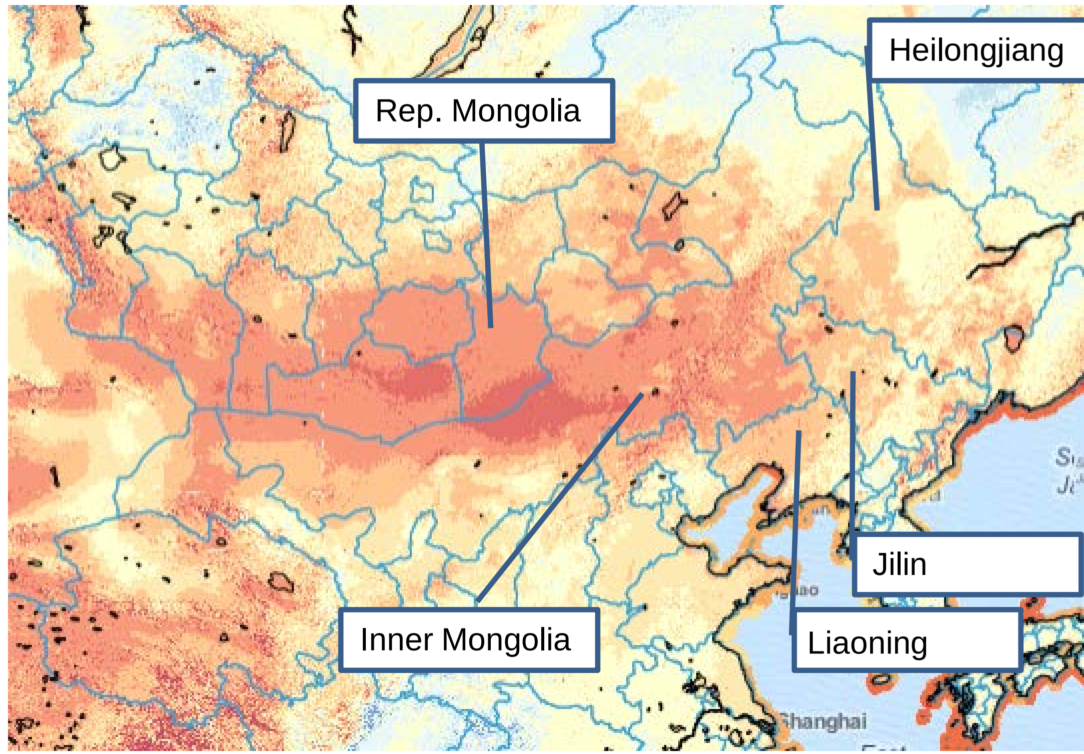
Region defined:
- Lat 31-58 deg
- Lon 88-134 deg
- Concentrating east

Regional cluster includes:
- Mongolia (MN), 2.8m
- Inner Mongolia (CN), 25m
- Heilongiiang (CN), 38m
- Jilin (CN), 27m
- Liaoning (CN), 44m

These are major power markets each similar to European countries.

Inner Mongolia: 104GW (ESP)
Liaoning: 43GW (SWE)
Heilongjiang: 26GW (VN/RO)
Jilin: 26GW (EGY)
Mongolia: 1GW (CY/LUX)

General view of resource: wind power density



Source: DTU, http://globalwindatlas.com/index.html

Continental North Asian Wind Cluster
- project concentration

Status:

China now has 143GW of wind power installed after adding 30.5GW in 2015

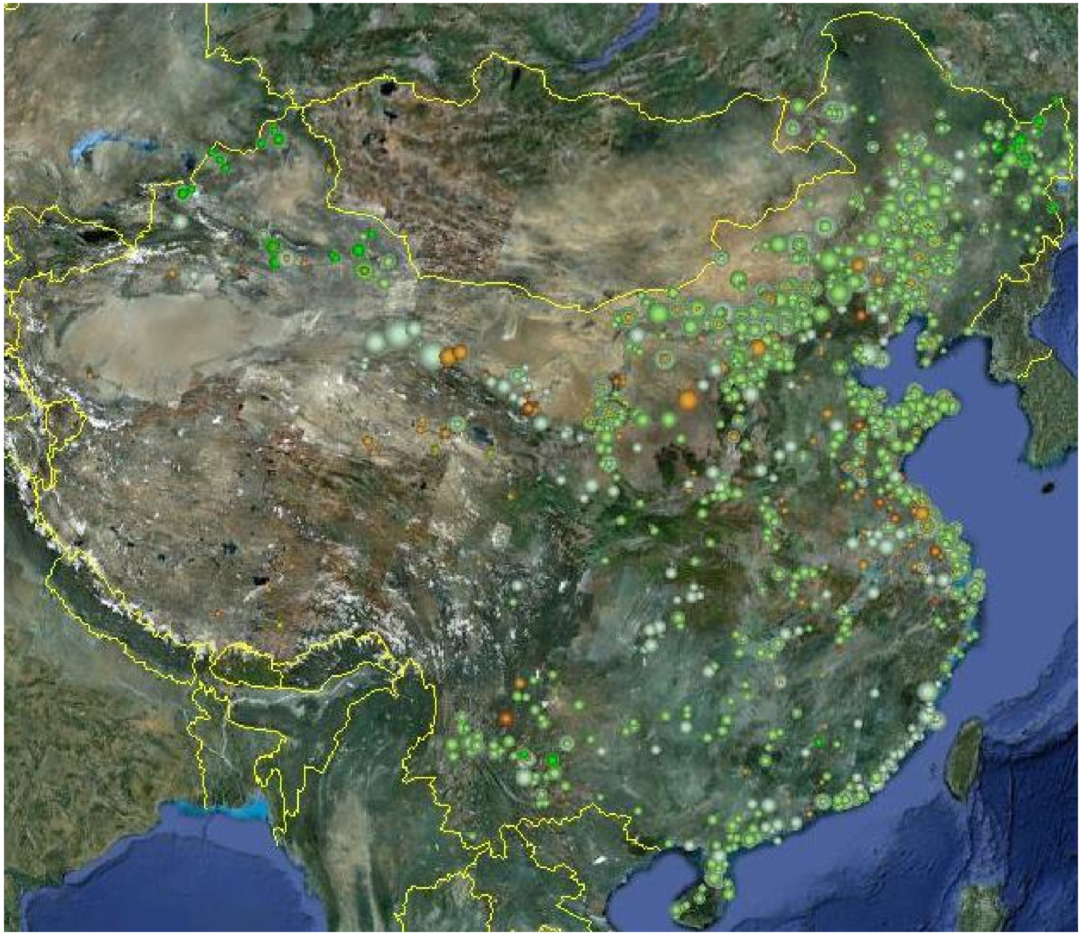
The cluster has
•Mongolia: 50MW
•Inner Mongolia: 24GW
•Heilongjiang: 5GW
•Jilin: 4.4GW
•Liaoning: 6.4GW

Capacity newly connected for the region was 5GW in 2015

capacity penetration for wind is about 25%

China plans 200GW wind 2020, we expect 250GW based on development activity

Operating projects and future pipeline projects



Source: Azure International

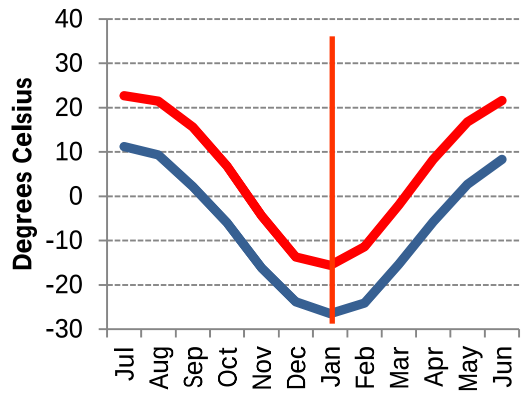
Continental North Asian Wind Cluster - cold weather

Meteorological statistics:

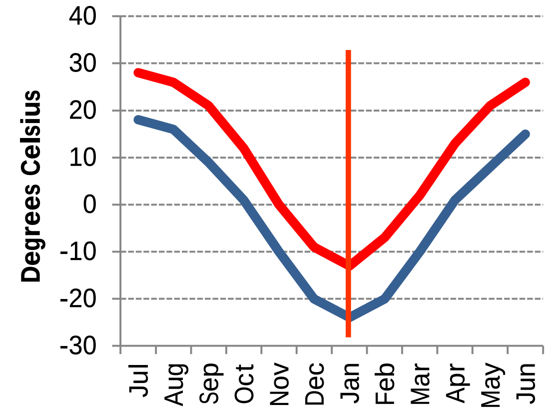
Region is adjacent to Siberia, and is known for cold winter temperatures

Lowest temperatures occur over Dec – Feb

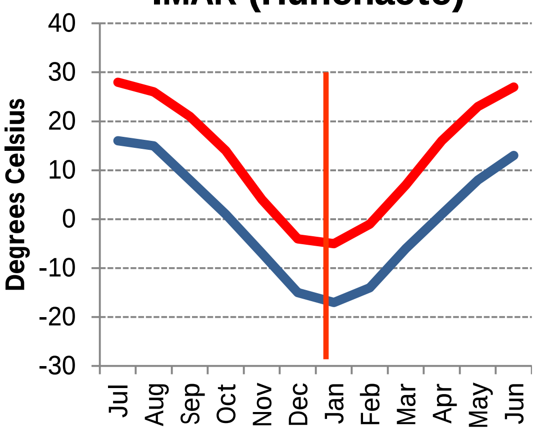
Mongolia (Dzumond / UB)



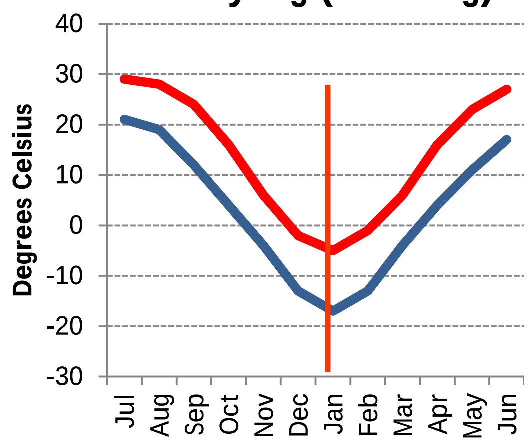
Heilongjiang (Harbin)



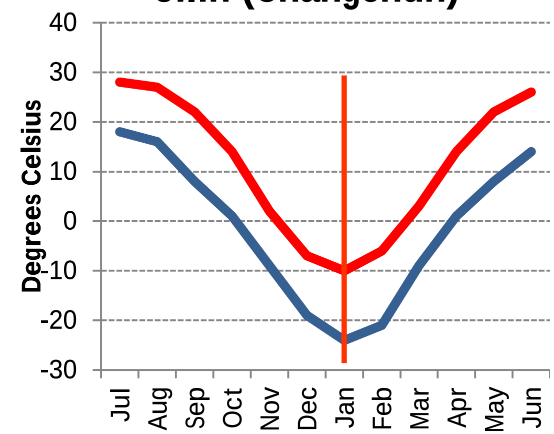
IMAR (Huhehaote)



Shenyang (Liaoning)



Jilin (Changchun)



Source: China Meteororlogical Associaiton, Mongolian Statistics Bureau

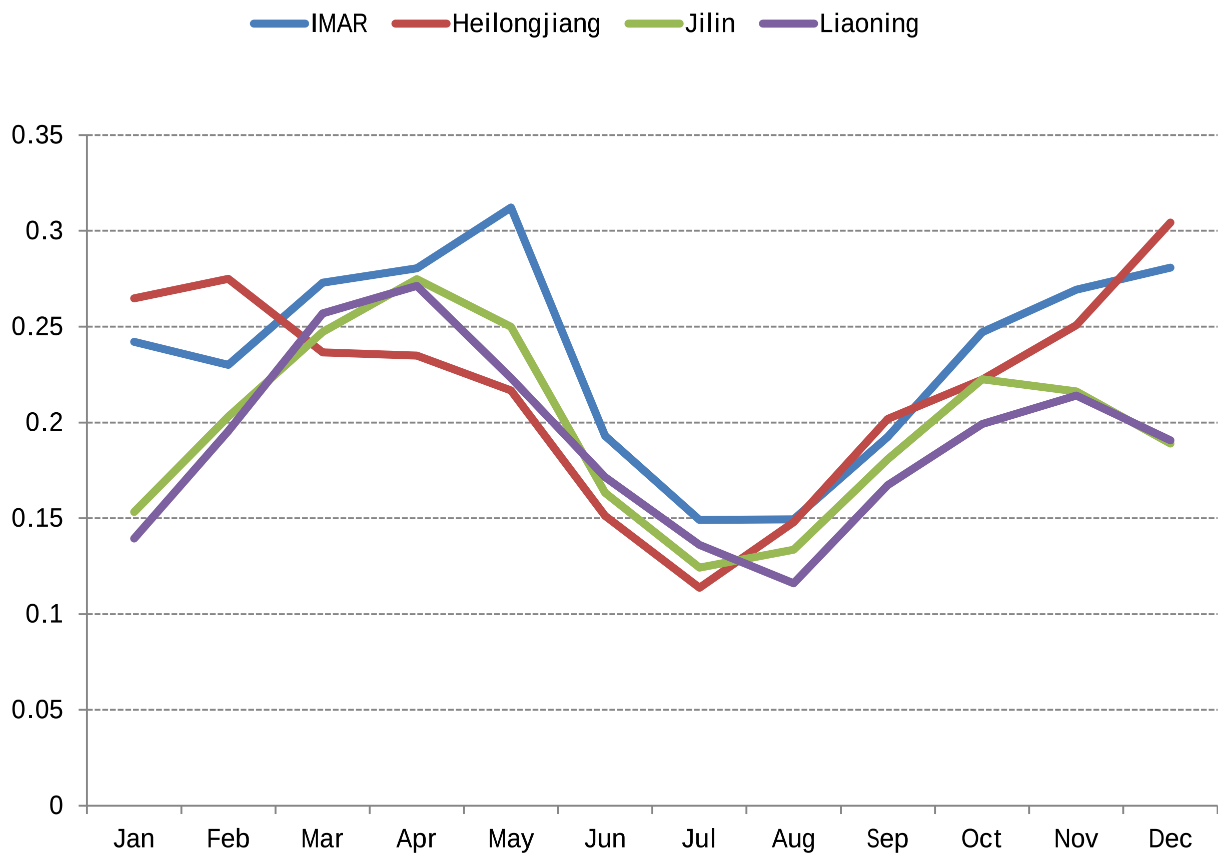
Continental North Asian Wind Cluster
- China operating data

Status:

Seasonality: Best months for production are March – May

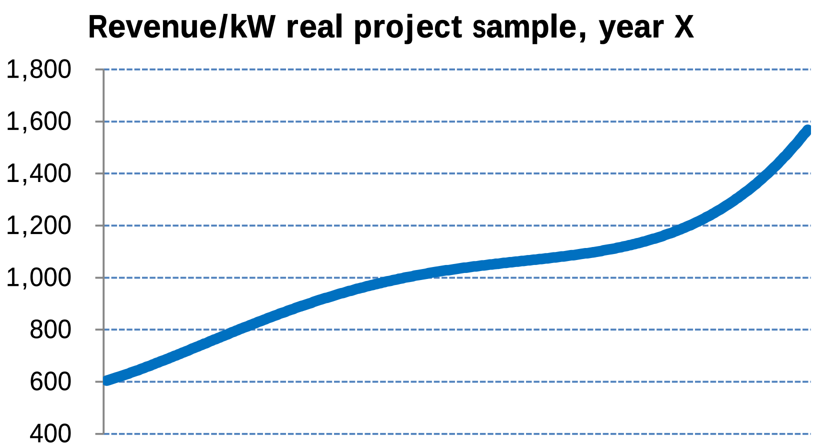
Fall and winter also strong, but more affected by curtailment especially in Jilin and Liaoning

5-year average NCF results (net power deliveries ex- curtailment)

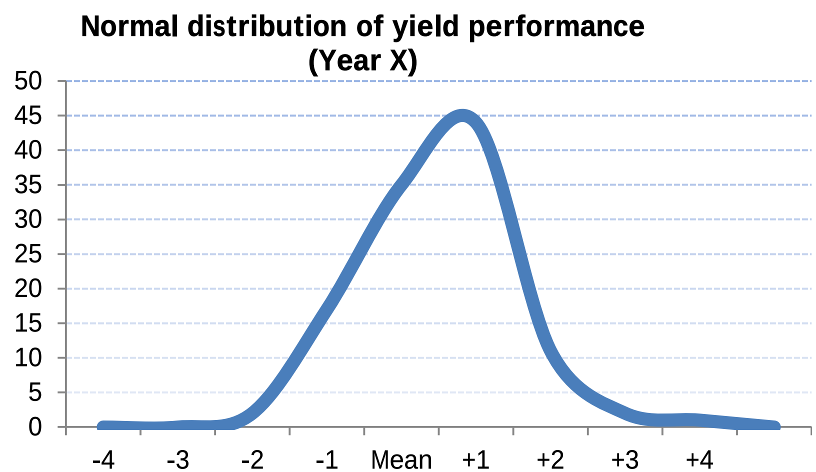


Source: Azure International

Continental North Asian Wind Cluster
- China operating data, project yield



Source: Azure International



Source: Azure International

Yield distributions

China FIT is higher for lower wind resource regions

Yield defined as kWh/kw * FIT over calendar year

Focus on understanding financial returns and cash flow

Distribution for one 12-month calendar data year only for all projects

Distribution exhibits year-to-year variation based on resource and operational differences

Government and project owner sources of performance feedback do not present this spread including under performing and out-performing assets

Distribution exhibits year-to-year variation based on resource and operational differences

Cold & performance at Salkhit
- conditions & challenges

Mongolia project example - Salkhit

Safety First! – wind chill effect

Temperature & wind chill safety threshold limit values

km/h	0.0	7.2	14.4	16.2	21.6	28.8	32.4	36.0	43.2	48.6	50.4	54.0
m/s	0.0	2.0	4.0	4.5	6.0	8.0	9.0	10.0	12.0	13.5	14.0	15.0
	4.0	3.1	-1.0	-2.1	-4.8	-7.2	-8.1	-8.5	-9.4	-10.1	-10.3	-10.8
	-1.0	-2.8	-7.8	-9.1	-11.8	-14.8	-16.1	-17.0	-18.4	-19.1	-19.3	-19.8
	-7.0	-8.8	-14.6	-16.1	-18.8	-21.8	-23.2	-24.5	-26.8	-28.1	-28.3	-28.8
	-12.0	-13.8	-21.2	-23.1	-26.5	-30.4	-32.1	-33.0	-34.8	-36.1	-36.3	-36.8
Effective	-12.2	-14.0	-21.4	-23.4	-26.8	-30.6	-32.3	-33.3	-35.1	-36.3	-36.6	-37.0
Deg C	-15.0	-17.3	-24.7	-26.6	-30.4	-34.1	-35.6	-36.8	-38.8	-40.1	-40.5	-41.1
	-18.0	-20.7	-28.2	-30.2	-34.2	-37.8	-39.2	-40.5	-42.8	-44.2	-44.6	-45.5
	-20.5	-23.2	-30.7	-32.7	-37.4	-41.6	-43.2	-44.8	-47.3	-48.7	-49.1	-50.0
	-23.0	-25.7	-33.2	-35.2	-40.6	-45.4	-47.2	-49.0	-51.8	-53.2	-53.6	-54.5
	-23.3	-26.0	-33.6	-35.6	-41.0	-45.8	-47.6	-49.4	-52.2	-53.6	-54.0	-54.9
	-26.0	-28.7	-37.0	-39.2	-44.3	-49.2	-51.2	-53.0	-56.0	-57.6	-58.0	-58.6
	-29.0	-31.7	-40.8	-43.2	-47.9	-53.0	-55.2	-57.0	-60.2	-62.1	-62.3	-62.8
	-31.5	-34.7	-44.2	-46.7	-51.1	-56.6	-59.2	-61.0	-64.2	-66.1	-66.5	-67.1
	-32.0	-35.2	-44.9	-47.4	-51.7	-57.3	-60.0	-61.8	-65.0	-66.9	-67.3	-68.0

- Caution: Freezing to exposed flesh in 1 hour
- Danger: Freezing to exposed flesh within 1 minute
- Extreme danger: Freezing to exposed flesh within 30 seconds

Source: Clean Energy

Cold & performance at Salkhit
- conditions & challenges

Generally dry continental environment

Dry powder snow drifts across the ground and needs frequent clearing

Source: Clean Energy

Cold & performance at Salkhit
- conditions & challenges

Generally dry continental environment

Dry powder snow drifts across the ground and needs frequent clearing





Source: Clean Energy

Cold & performance at Salkhit
- conditions & challenges

January 2016

Ice formation on blades is a rare - 7 events last year where WTG stopped due to ice on blades, operation resumed after sunrise

Generally, we start to see down rating starting to affect output when temperatures reach -14 and below.

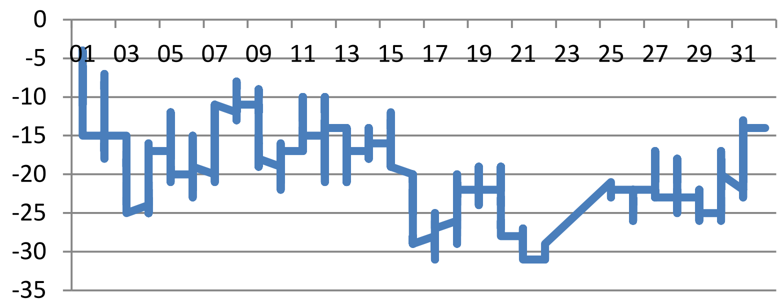
Shut down occurs when nacelle temperatures reach -30 for one minute and resume when temperature reaches -25 for ten minutes.

For a few days in January, the temperature cooled to -35 over night. Causing the first cold temperature shut downs seen at the project.

Turbines started to power down in the evening with temperature dropping. By late morning after sunrise, turbines were once more operating.

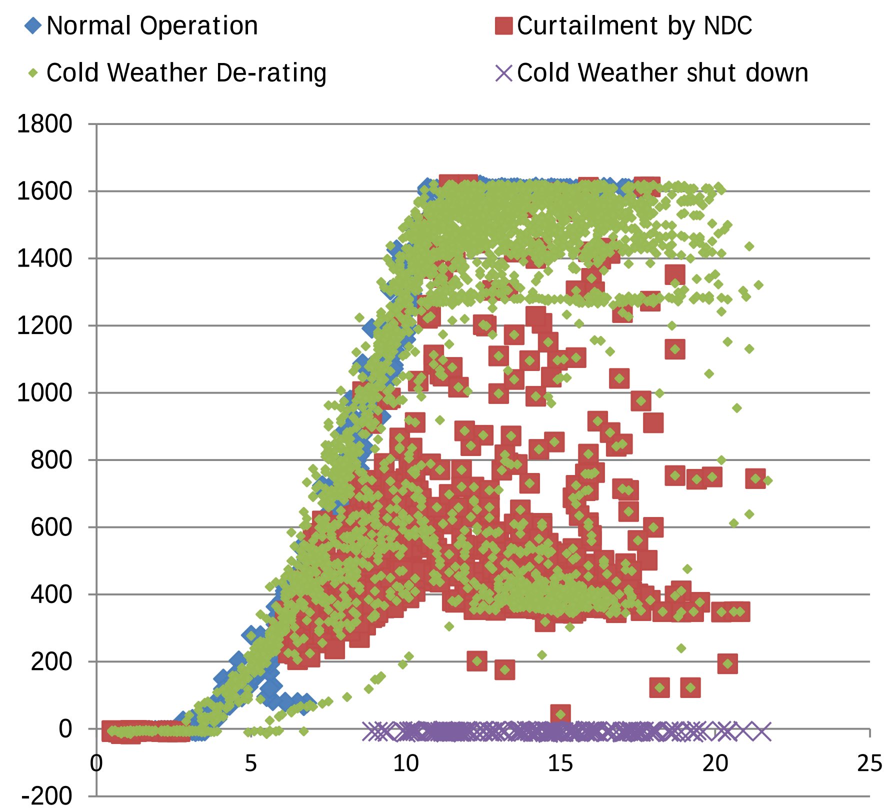
Jan 2016 was still a good year for production as P50 was surpassed.

Ambient temperature Jan 2016 (deg C, Jan 2016)



Source: Clean Energy

10 minute interval sample turbine output (Jan 2016)



Source: Clean Energy

Cold & performance at Salkhit
- Mongolia vs. Inner Mongolia comps

Projection vs. performance comparison

Mongolian resource relatively strong

We indirectly compared wind resource estimated for Salkhit as presented in AEP estimations published in CDM PDD documents to those of a sample of nearby Chinese projects

We review the sample of 196 projects which submitted PDDs with distances from Salkhit ranging from 574 – 998 Km

For the sample, average expected kWh per kW deployed over 12 months is 2295. (MIN = 1685, MAX = 2827)

In Salkhit's PDD, an annual expected generation value of 168,499 MWh is presented ,which converts to 3397 kWh/kW p.a. This is the P50 Estimate produced by Sgyurr Energy.

The Salkhit result is 48% above the sample mean and 20% above the highest value in the China sample

Salkhit expected outcome is just over 5 standard deviations form the mean of the China peer sample !

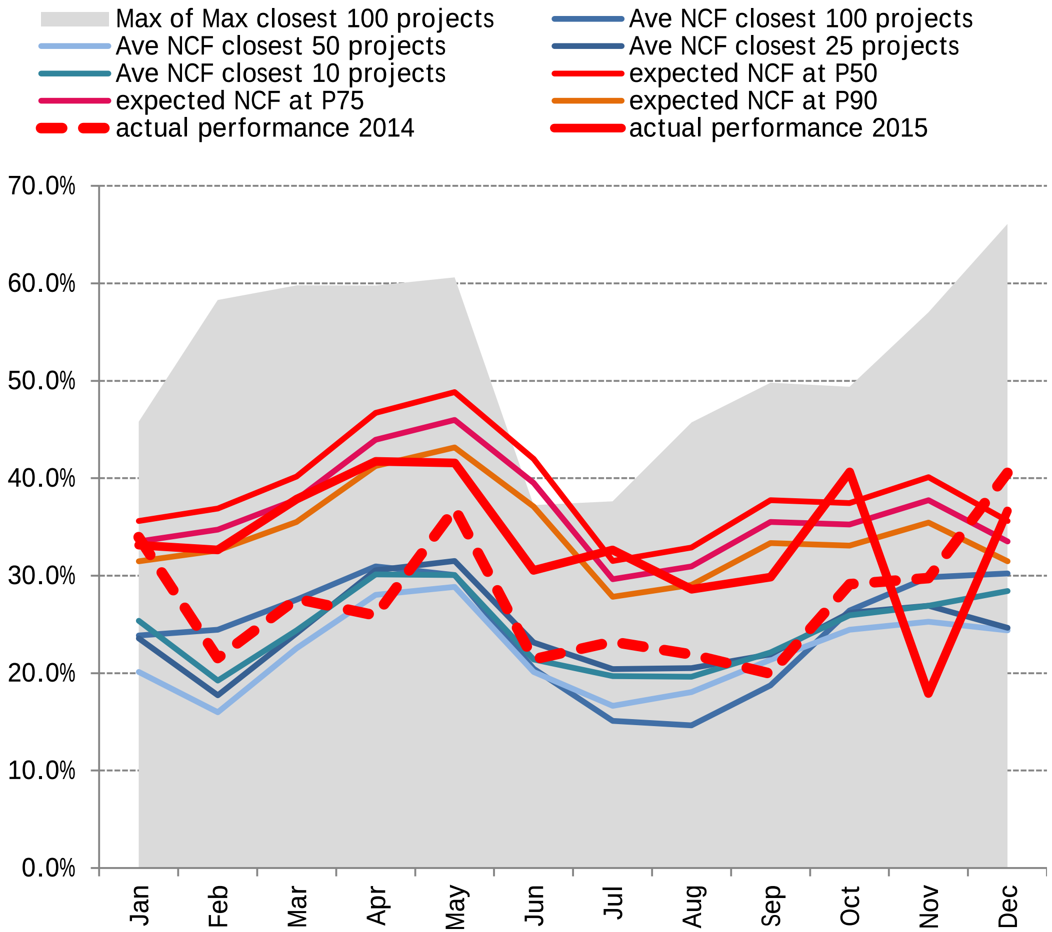
Better AEP expectation is a function of both resource and state-of-the-art equipment

Sample projects distribution

Source: Azure International

Cold & performance at Salkhit
- operating performance

Benchmark average monthly NCF (closest data projects, mean)



Source: Azure International, Clean Energy

Projection vs. performance comparison

The chart is comparing wind resource assessment for Salkhit vs. multi-year average monthly output of power deliveries (not counting curtailment) of a sample of 100 closest peer projects in Inner Mongolia

2014 (only Salkhit data) was a poor wind resource year

Also in 2014 performance was negatively impacted by incorrect settings relating to ultrasonic anenometers on a number of turbines

Regional curtailment challenge
- curtailment defined

Wind Curtailment

- **blades** are **adjusted** to cut output in order to **lower overall** production
- Turbines may be **idled**
- **Grid operators** may provide a **max** production **target** by regional dispatch, **impacting** curtailment levels

Solar Curtailment

- **Advanced inverters** control power export by changing **voltage** and **current** (related to MPPT capability)
- If advanced inverters **not present**, there may be a **less efficient method**, such as physical disconnection of solar array

Regional curtailment challenge
- curtailment & resource

When does curtailment happen?

Stronger resource seasons tend to face more curtailment

Absolute wind power sales are higher in high curtailment times than in low curtailment periods

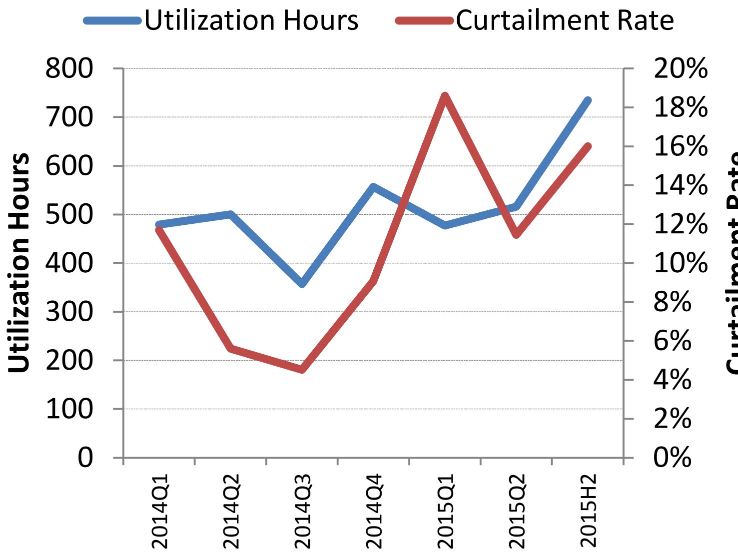
Headlines from China claiming improved curtailment (usually in the summer) without fundamental policy improvements are premature

District heating decreases operational flexibility for the coal thermal plants over colder months the plants must maintain higher minimum utilization rates

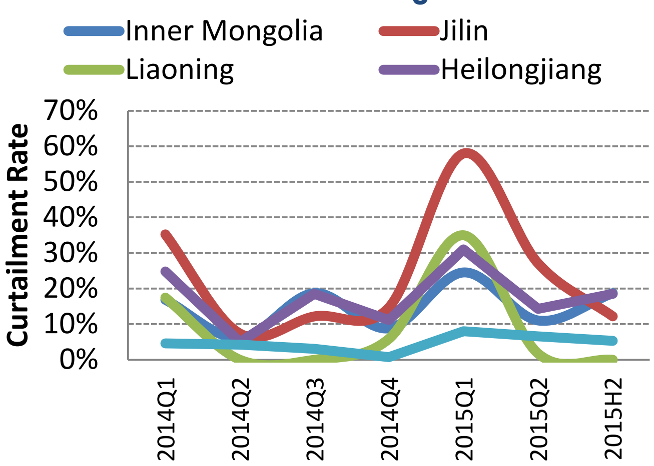
In north China and Mongolia coal thermal power supplies district heating to cities. District heating penetration is high – roughly 40% for the region; effectively 100% for Mongolia

Annual dispatch planning for coal thermal producers establishes minimum generation levels, so slowing or declining general power demand will increase pressure to curtail renewable sources

Curtailment is correlated with resource



Curtailment is higher in winter



Source: Azure International, NEA, Clean Energy

Regional curtailment challenge
- inflexible generation mix dominated by coal

Curtailment and the energy mix

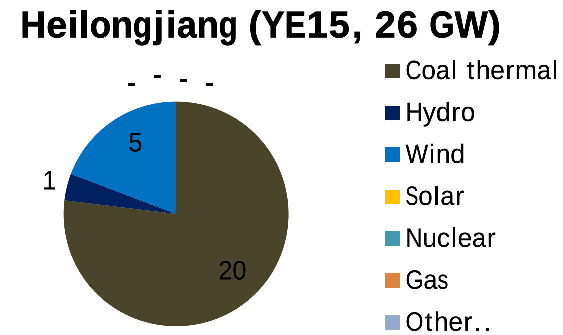
The dispatch flexibility of coal is more limited than other generation technologies like hydro or gas but more flexible than nuclear

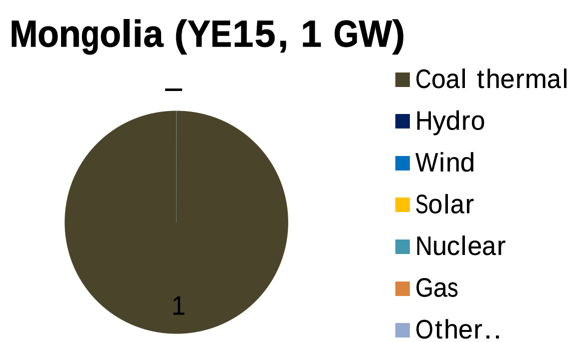
Of the total generation capacity 202 GW in the region , 143 GW is coal thermal power and a large portion of that is district heating

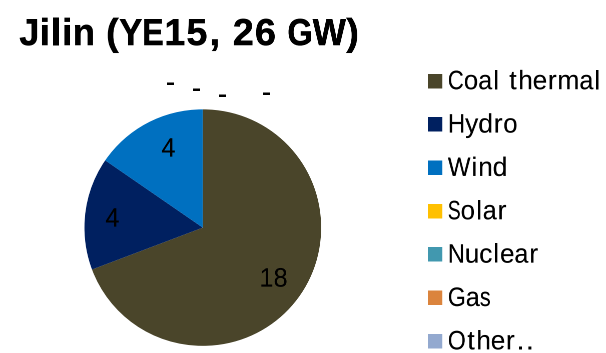
China's North East reason has not managed power sector planning very well

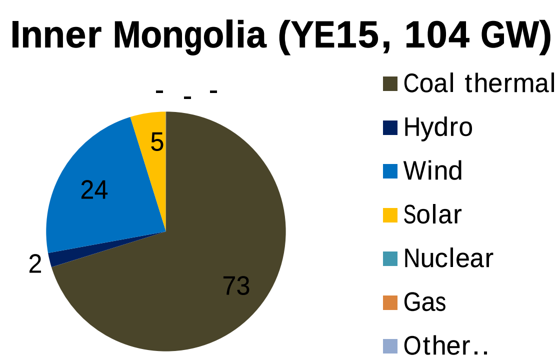
At present, Heilongjiang, Jilin and Liaoning together have approximately 20 GW of excess power generation capacity

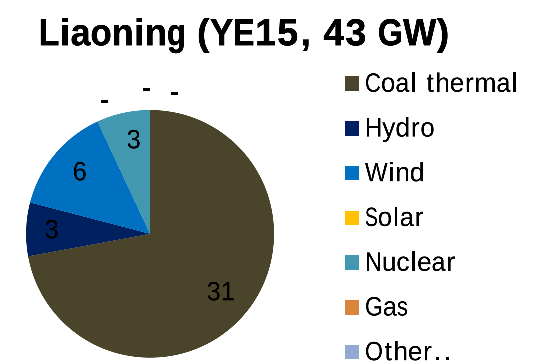
Planners continue to approve new projects, meaning that the situation may get worse over the next 3-5 years despite slowing economy (and demand growth for power)











Source: NEA, Mongolia ERC

Regional curtailment challenge
- curtailment drivers

azure international

Institutional	• Conflicting or miss-aligned market incentives and limited oversight can lead to inefficiencies in the generation planning and dispatch process • China has a mixture of conflicting policies that are the result of an incomplete transition to a market-driven electricity system • The decentralization of dispatch management to the provincial level and minimum generation rights quotas for coal thermal generators are significant contributors to power system operational inflexibility.
Economic	• Transmission systems are often undersized relative to installed wind capacities as the portion of time that wind farms are operating at maximum output is relatively low and does not justify the additional costs of a larger transmission system • The cost of cycling thermal plants, particularly large coal fired plants can be high relative to the lost revenues from power curtailment
Technical	• Generation flexibility due to availability, ramping, minimum output and stop/start constraints. CHP significantly limits generation flexibility • Local consumption is often insufficient to absorb all wind power generated • High reserve capacity requirements • Transmission may be insufficient or portion of transmission available to renewables may be limited, leading to stranded power

Never under-estimate the impact of power market frameworks; the playing field is extremely important in promoting efficient utilization and minimizing curtailment

Regional curtailment challenge
- dispatch model example

Collect provincial or regional level curtailment, generation and transmission data

↓

For wind, solar and demand, develop or simulate 1 year hourly profile. Develop transmission schedules.

↓

Develop dispatch model, verify or calibrate results against historical curtailment values

↓

Build generation, demand and transmission forecasts for area of interest

↓

Run model over forecast period. Verify soundness of results, sensitivity analysis.

Develop and run dispatch flow model for a multi-province regional grid with areas of concentration of renewables and load

Key inputs

- Yearly and historical curtailment data
- Historical generation capacities and utilization levels
- Transmission data
- Future electricity consumption
- Future generation plans
- Seasonal demand profiles
- Wind and solar generation profiles
- Other key operating parameters

Regional curtailment challenge
- curtailment drivers (dispatch flow model)

Factors Contributing to Generation Curtailment (Used in Our Model)

Generation

- Unit Commitment
- Coal utilization target ~5000 hours annually for ROI
- Winter Combined Heat and Power Unit ramp capacities and limitations
- Operating capacity levels for coal thermal and ramping characteristics
- Renewables Resource & Production over time including seasonal patterns
- Other technologies with flexible regulation properties: Hydro, PHS, gas, storage…
- Future view based on planning targets and market evolution for all technologies
- Operating & spinning Reserve levels and other dispatch practices and constraints

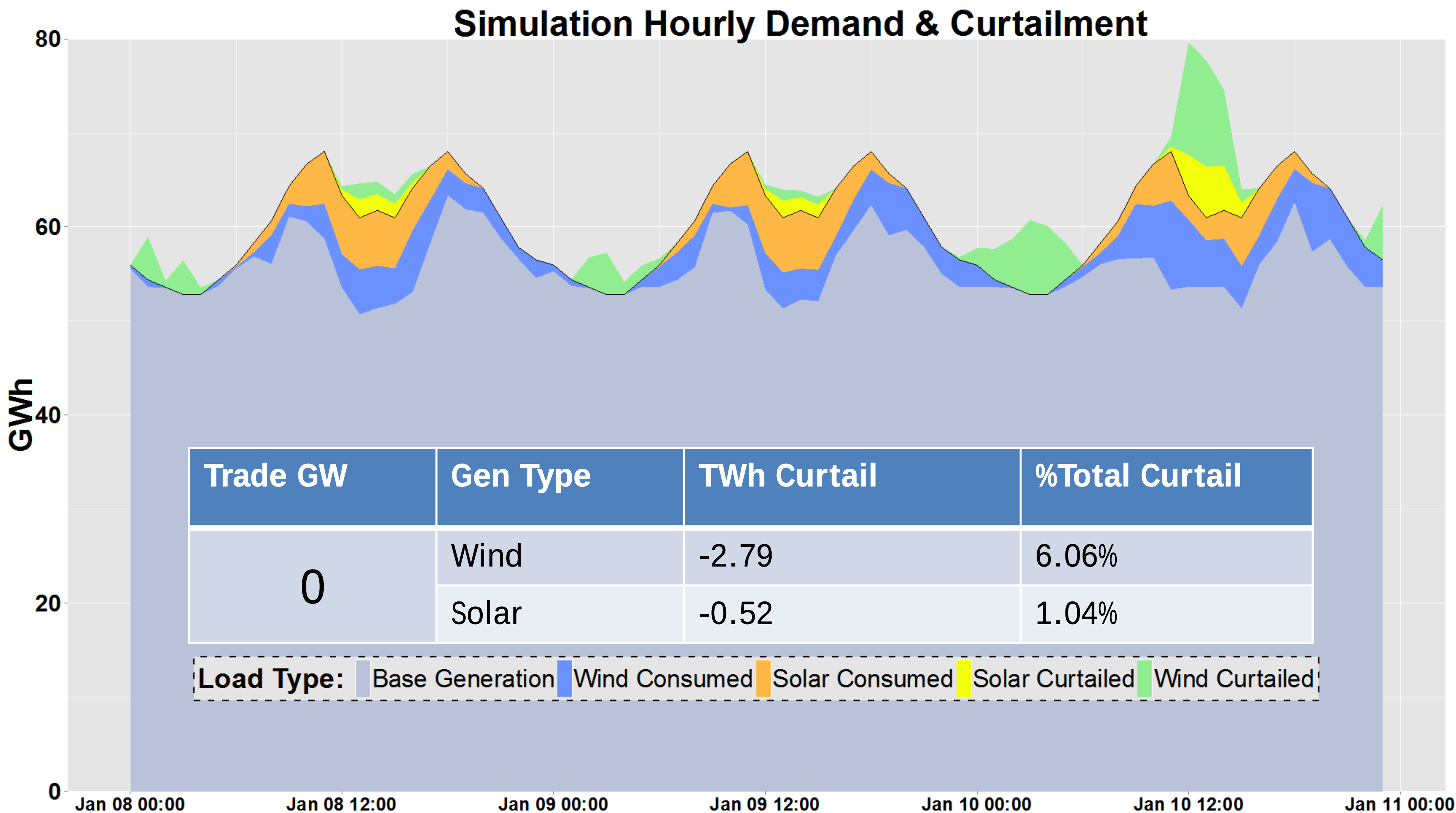
Demand

- Typical load curves growing over time by long-term economic development targets
- Demand versus Supply Ratio i
- Daily Load Profile Impacts Unit Commitment: 30% Swing in 6-12 hours
- Peak consumption during only a few hours a day
- Unpredictable daily load profiles: Increases reserve requirements
- Uncertain load growth: Generation installations may *outpace* demand growth

Transmission

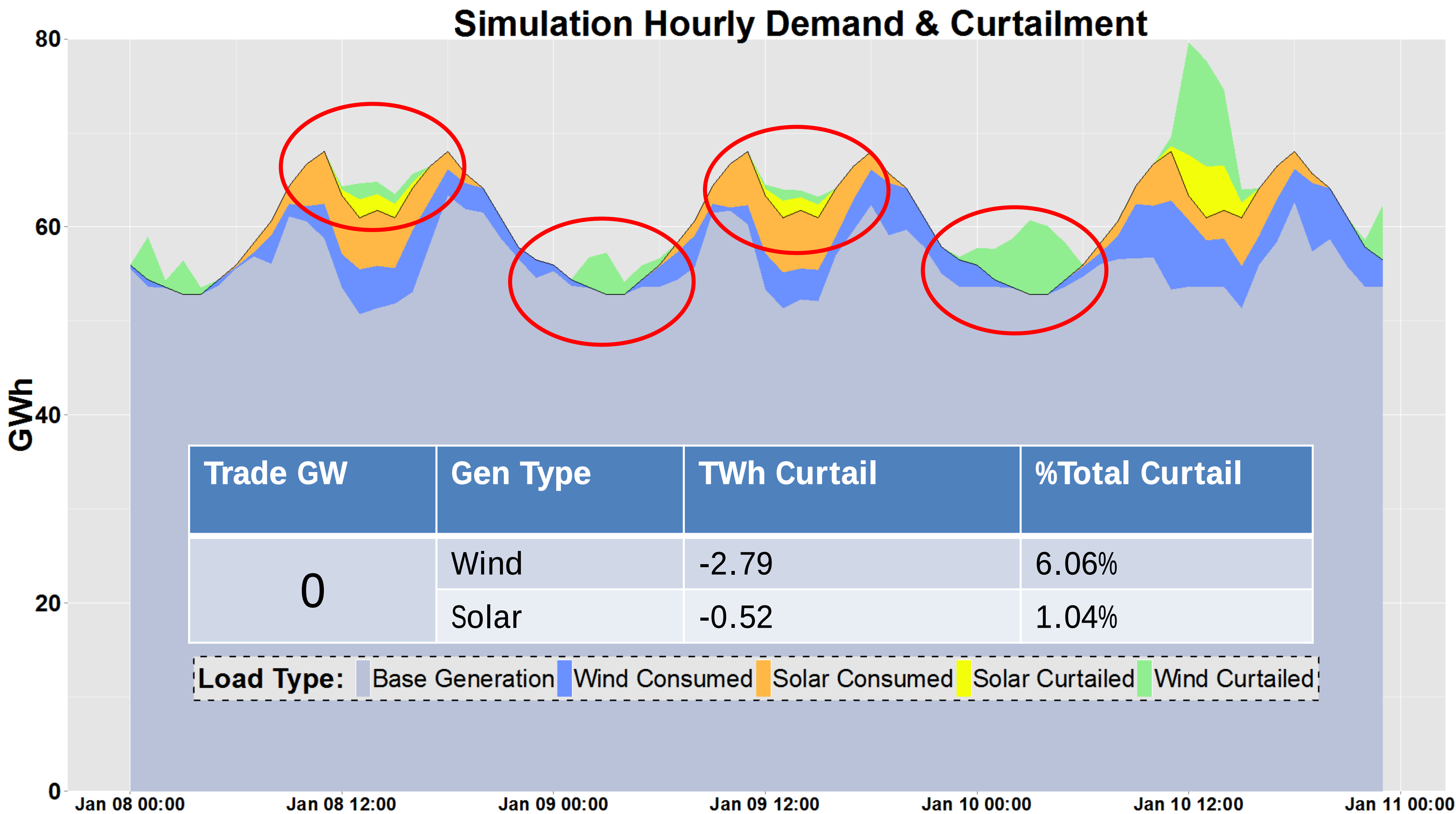
- T&D infrastructure and future development plans
- T&D operational constraints
- Insufficient export capacity
- Delays in transmission planning
- Changing consumption patterns for areas connected by UHV lines: power must be *exported* to regions with ability to *absorb* power during over-generation times
- Grid connection to low- versus high-capacity lines
- **Responsive (daily, hourly, weekly, monthly) planning and dispatch done mainly at provincial level and below**

Regional curtailment challenge
- dispatch model



Trade GW	Gen Type	TWh Curtail	%Total Curtail
0	Wind	-2.79	6.06%
	Solar	-0.52	1.04%

Regional curtailment challenge
- dispatch model



Trade GW	Gen Type	TWh Curtail	%Total Curtail
0	Wind	-2.79	6.06%
	Solar	-0.52	1.04%

Regional curtailment challenge
- dispatch model & power sector reforms

Some conclusions from the modeling exercise:

Curtailment forecasting assumes dispatch practices remain unchanged

Policy, operational and technical system improvements can have an important impact on future curtailment levels
In our models we generally see increasing curtailment for wind and solar power as penetration levels increase

Forthcoming power sector reform:

In China the power market is a centrally planned domain; pricing is set by planners instead of direct market input; In Mongolia, fixed prices and subsidies for coal and end use power emphasize health of coal thermal production as an industry

In China direct trading of power is now emerging. a pilot project in Inner Mongolia enabled a wind project to sell power directly to nearby industrial end users, reducing curtailment

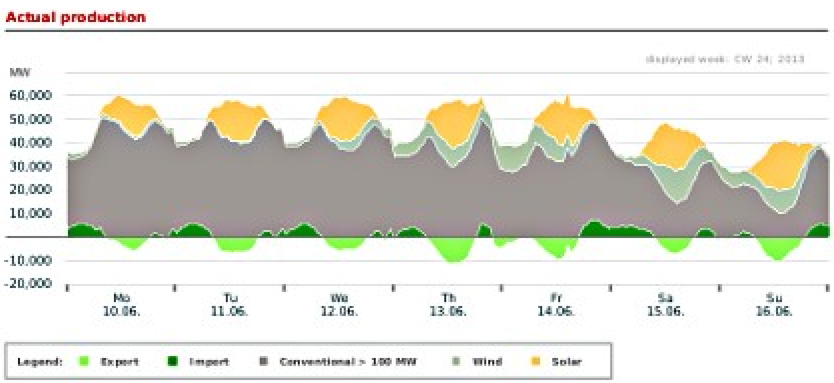
Power market trading and pricing has potential to transform the power market as it did with the independent power trading system created in India in 2002

Power market trading and incentives including markets for dispatch and related services have been important in reducing curtailment in the US in recent years

Way forward
- Market reform (country example)

German solar and wind penetration

Daily load curves for one week in summer 2013



Source: Fraunhofer

In 2013, Germany had 75 GW of non-hydro renewable capacity (of 178 GW total capacity); wind and solar supplied 24% of total energy

On one day in October 2013, wind and solar provided 47% of electricity; no grid problems resulted

Curtailment of German PV under 1% in 2013

Curtailment of all German renewable energy was under 0.5% in 2012, and 95% of curtailment was applied to wind

2012 EEG changes required PV owners to install equipment enabling grid operators to curtail them

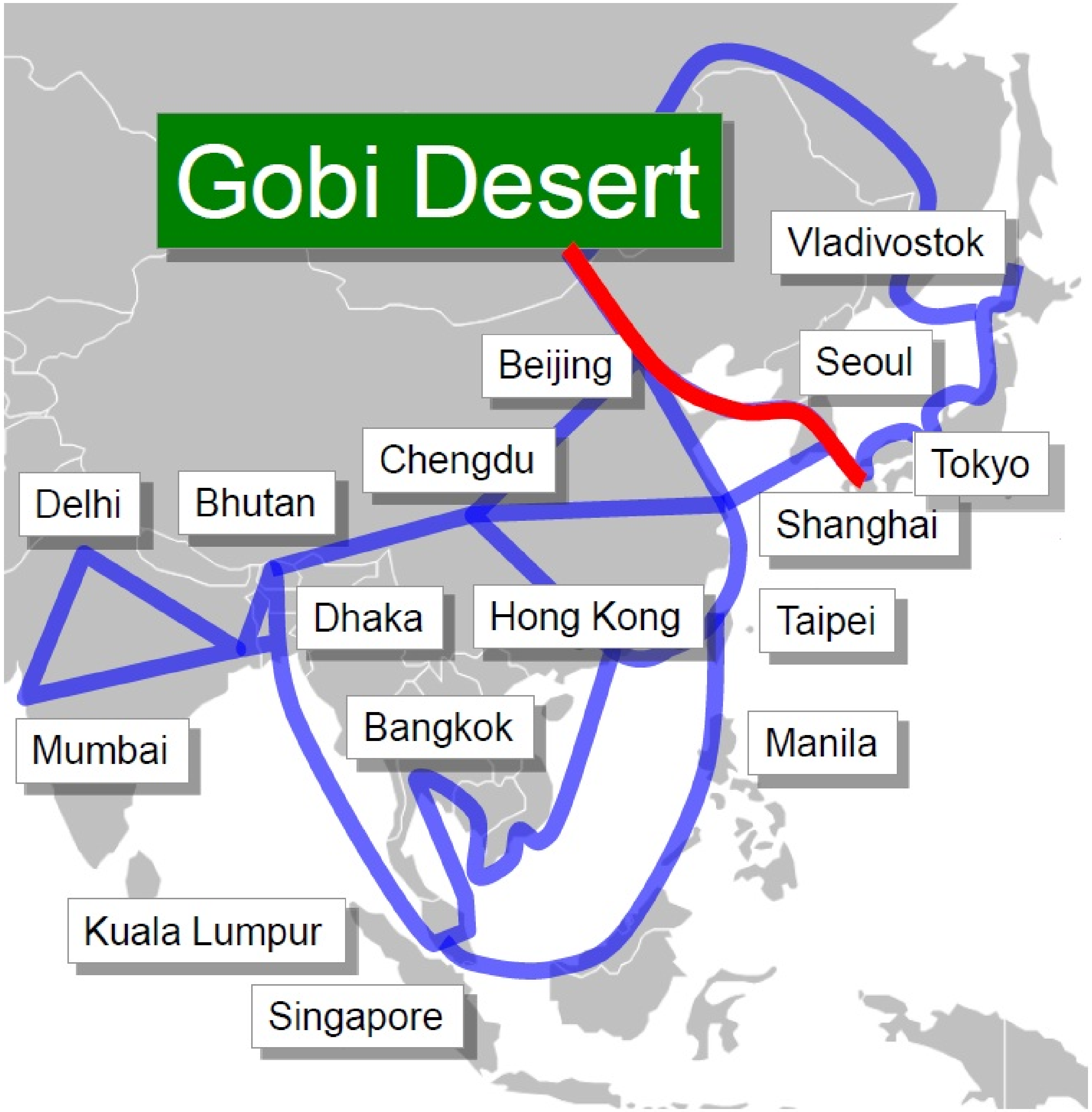
Curtailment allowed only for reasons of grid stability, not for negative power prices

Curtailed energy is compensated at 95% of the feed-in tariff rate, meaning the grid pays most of the cost of curtailment and has an incentive to avoid it

Generally power trades across European countries at spot prices. Solar produces valuable surplus power during peak load periods, which is exported

USA /Texas, Spain and other countries all additional examples of effectively minimizing curtailment

Way forward
- Super grid concept?



Idea behind Asia Super Grid

- **The Fukushima nuclear plant incident showed nuclear power is not cheap nor reliable**
- **Growing energy demand + reliance on fossil fuel → contribution to climate change**
- **Mongolia has vast amount of renewable energy resources**

Way forward

- **Private sector led initiative between Newcom and SoftBank and others**
- **Long term project involving multi-nations in the region**
- **Mongolian and Japanese governments support the initiative**
- **This project will make Mongolia the region's renewable energy leader**
- **200 GW clean power plant in Gobi by 2020**

Source: Clean Energy Asia, Softbank

Conclusion
- some conclusions

Conclusions

North Asia is a leading wind cluster region globally

Projects in the region face direct cold condition operating challenges

Regional power markets, and planning and dispatch frameworks are currently not as effective at incentivizing the minimization of curtailment as in other countries, and Curtailment has emerged as a leading risk issue for financial performance and returns

Minimizing curtailment will require a combination of technical and market based solutions:
- Regional integration (even international)
- Better planning including optimized generation mix and storage
- Market reforms including power trading and ancillary service markets

Due diligence and analysis using dispatch flow models:
- Curtailment forecasting
- Curtailment risk analysis including understanding regional and local drivers and bottle necks
- Curtailment risk analysis specifically addressing the impact of UHV expansion
- Market niche identification and sizing for generation and storage equipment
- General equipment and generation forecasts relating to actual local and national plans

Sebastian Meyer
Director of Research & Advisory
sebastian.meyer@azure-international.com
Tel: +86 10 8447 7053
Fax: +86 10 8447 7058

73 Ditan Park
100011 Dong Cheng District, Beijing
PR China
www.azure-international.com

新年快乐！
ШИНЭ ЖИЛИЙН МЭНД ХҮРГЭЕ!
HAPPY NEW YEAR!