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Case study of the constraints and potential contributions regarding wind curtailment in Northeast China

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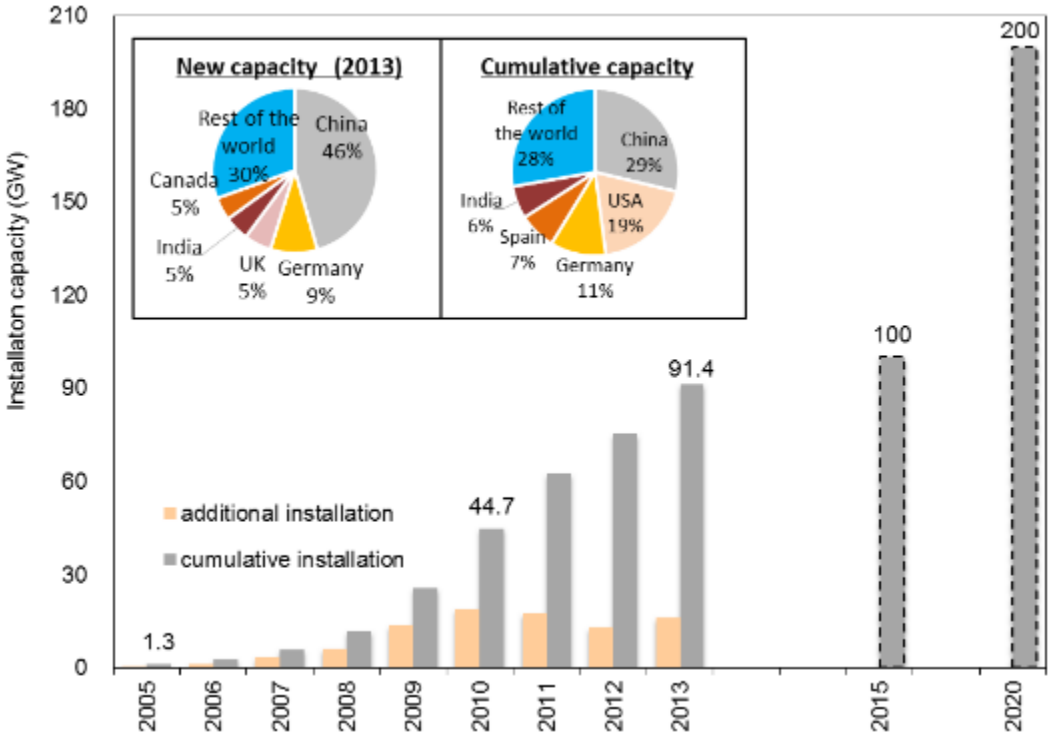
Outline

1. Background & Motivations
2. Methodologies and Data
3. Results
4. Conclusions & suggestions

Background

- Wind power has seen a significant progress in China.
- High rate of wind curtailment
  - 20 GWh of undispatched wind power
  - 17% of total available wind power generation in China



Background

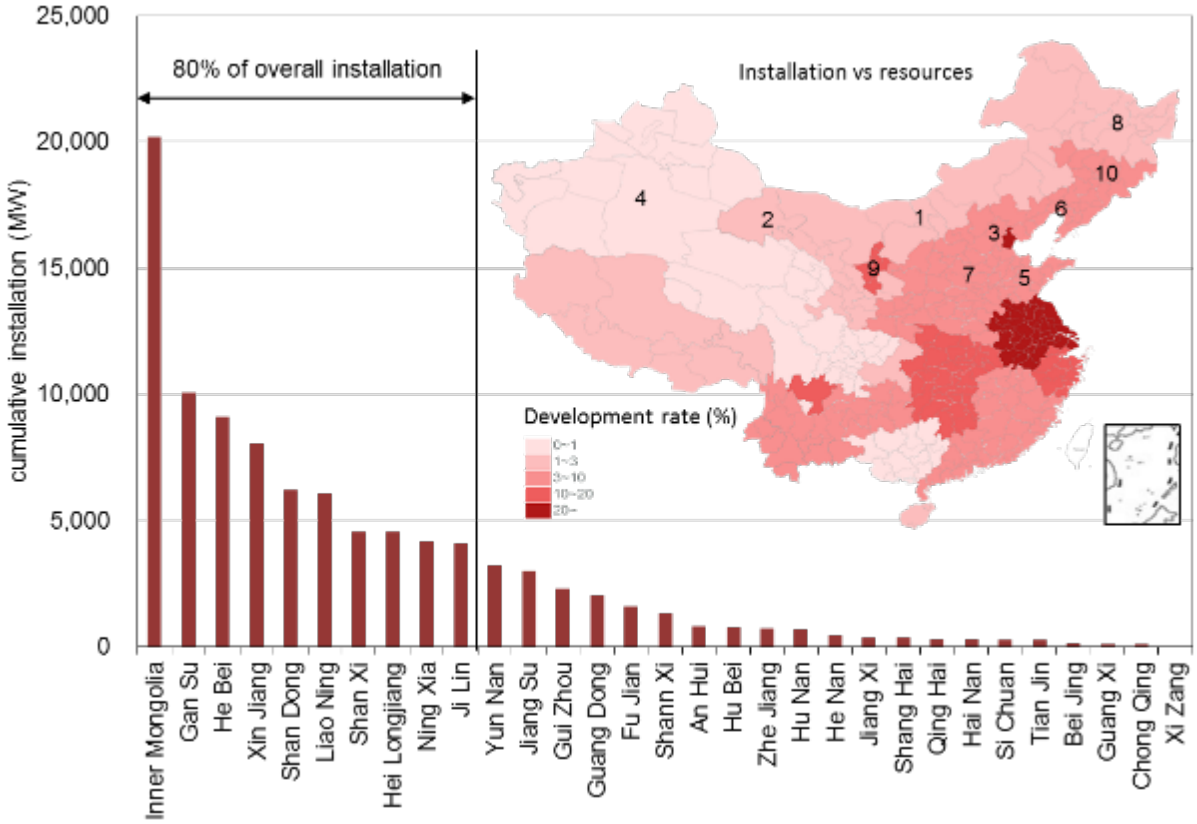
Why this happened?

Inflexible generation structures	Coal dominated Large-scale extraction units above 100 MW
Weak regulation	Generation quotas policy
Conflicts between the electricity and heat sectors	CHP units are dispatchable with limited range of flexibility after the requirement for the minimum load for heat production is reached during the heating period

Questions

- Is it possible that large-scale integration of fluctuating wind power?
- Is it possible to identify the energy balance in both the electricity and the heat sector?

Case study– Northeastern China



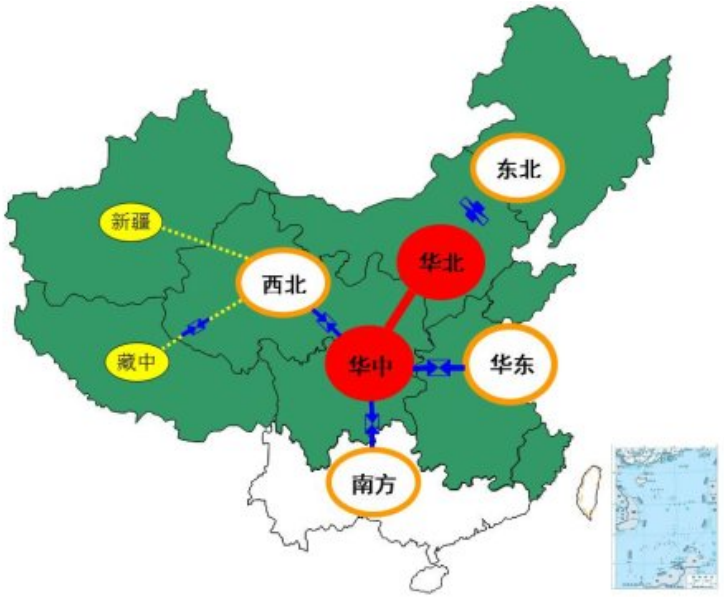
The Northeast Grid region accounted more than 30% of China's total wind capacity, but contributed almost 50% of total wind power curtailment.

Wind curtailment rate:

- Heilongjiang: 12%
- Jilin: 15%
- Liaoning: 6%
- Inner Mongolia: 9%

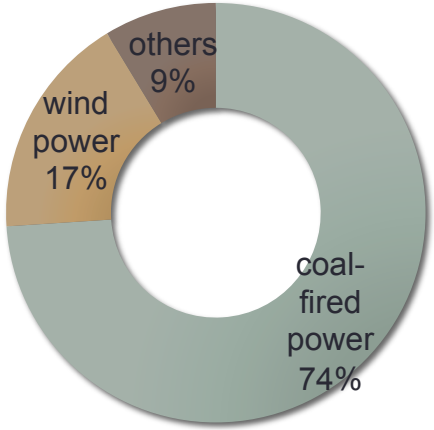
Provincial accumulative on-grid wind capacity by the end of 2014

Situation of Northeastern China

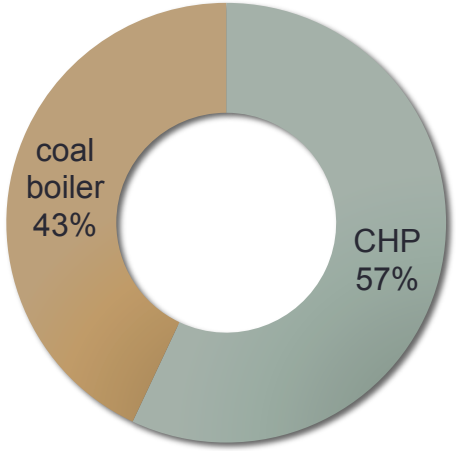


- 12.5% of national land
- 8% of national population
- 10.7% of national GDP

Electricity capacity: 106 GW



Heat supply: 275 TWh



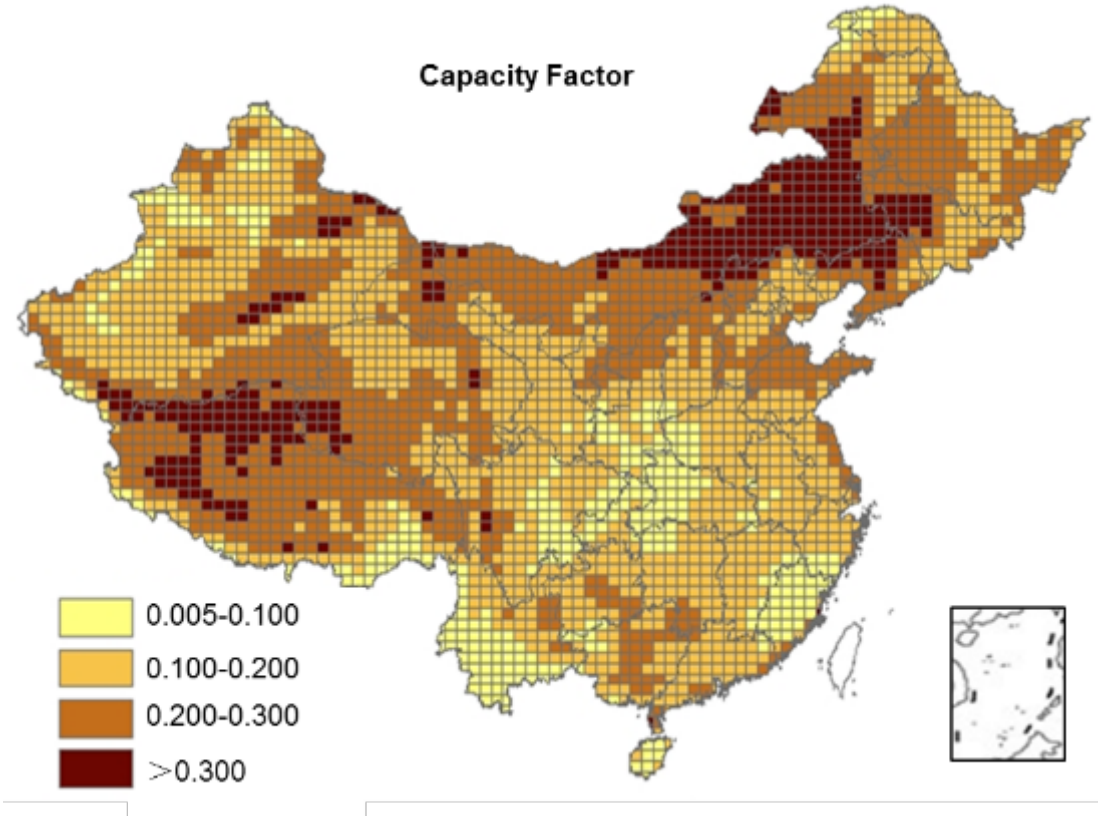
A large number of coal-fired extraction-mode CHP units are operated during the heating season

Methodology & data

- EnergyPLAN
  - Annual production– installed capacities for each electricity and heat technology in terms of coal-fired, wind, hydro, coal CHP, and coal boiler units
    - China Electricity Council & State Electricity Regulatory Council
  - Annual demand– demand for space heating from coal-fired CHP plants and coal boilers
    - Most urban buildings are connected to the district heating grid
  - Hourly distribution profiles
    - Wind speed data: Hourly ground climatological database from China Meteorological Administration
    - Heat demand: the difference between the hourly indoor and outdoor temperatures
    - Electricity demand: database of CREAM-EDO MODE

Methodology & data

- **Wind resources analysis**
- Annual capacity factor for each grid cell is calculated by averaging capacity factors from 1979 to 2009, in order to eliminate yearly variation

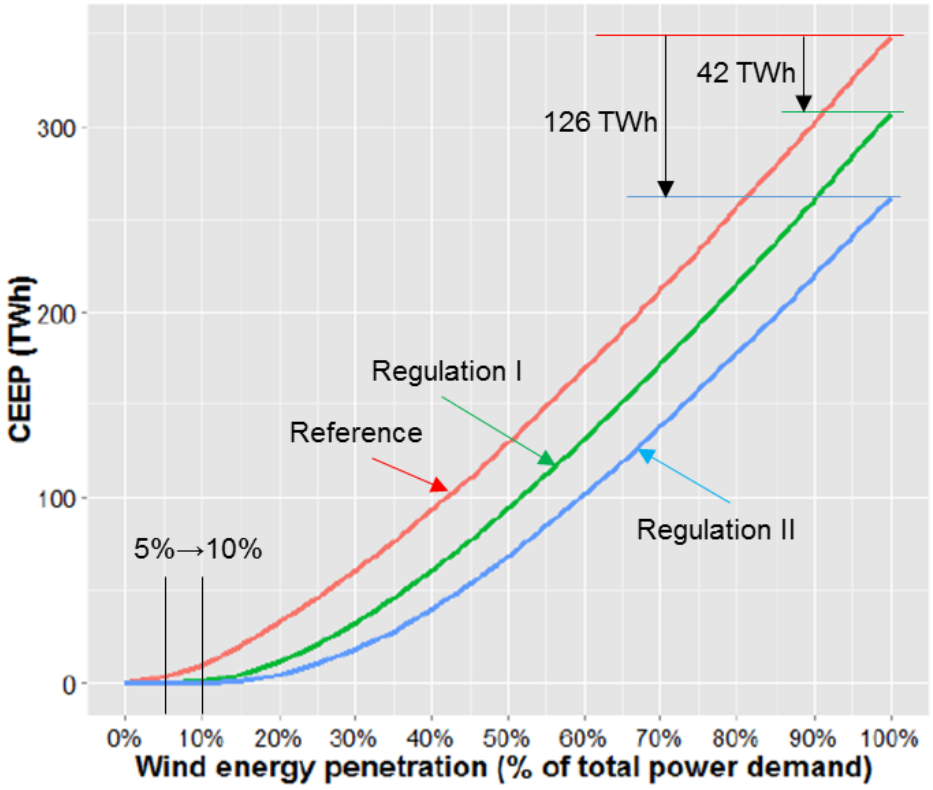


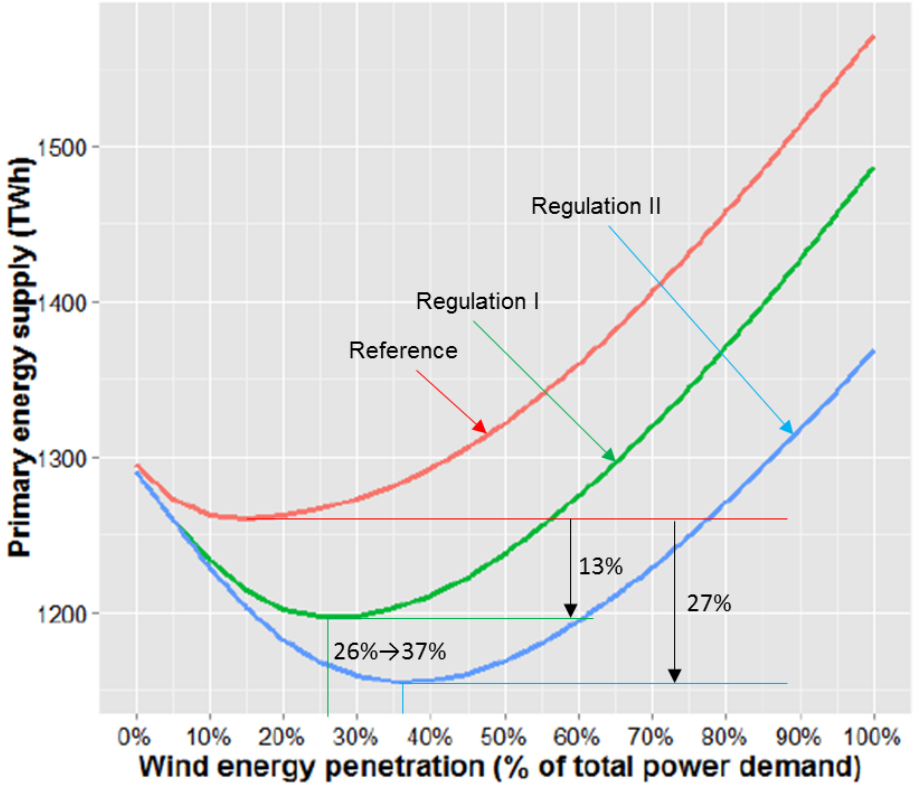
Scenarios

- Reference scenario:
  - The minimum annual operating capacity of coal-fired power plants is 26.8 GW, accounting for 34.2% of the total power plant capacity in the northeast China
- Regulation I scenario:
  - A minimum 20 GW of power plants operate over 8760 hours in one year and a minimum 35% of the hourly electricity production must be produced from grid-stabilizing plants
- Regulation II scenario:
  - A minimum 15 GW of power plants operate over 8760 hours in one year and a minimum 30% of the hourly electricity production must be produced from grid-stabilizing plants

Results

- Flexible limitations on hourly regulations have positive effects on wind integration





CEEP: critical excessive electricity production

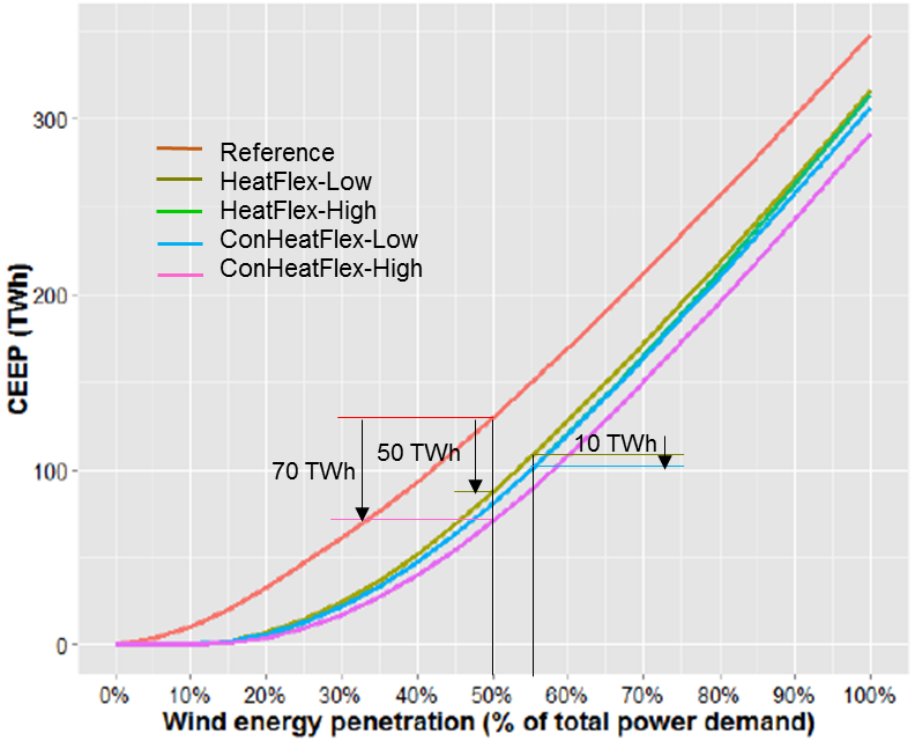
Scenarios

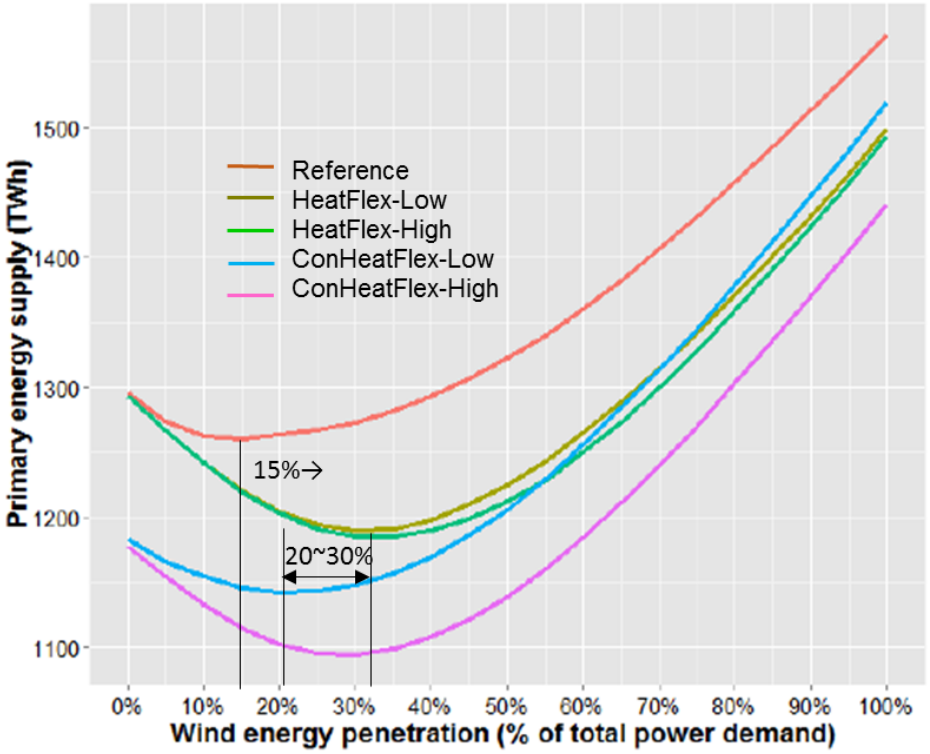
- To investigate the potential improvement for wind integration
- To address the intermittency of wind with extra flexibility introduced by heat pumps and heat storage

	Reference	HeatFlex-Low	HeatFlex-High	ConHeatFlex-Low	ConHeatFlex-High
Heat storage (GWh)	0	275	550	275	550
Heat pump (MW)	0	2866	5732	2866	5732
Connection between CHP system and boiler system	No	No	No	Yes	Yes

Results

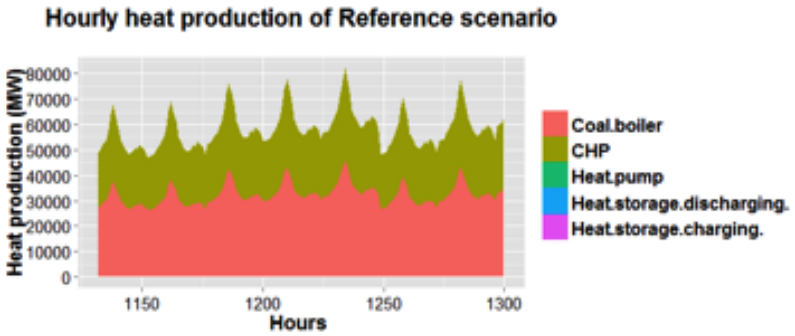
- CEEP reduced by merging the heat and electricity sectors
- With the assumed connections between the CHP and boiler-heated grids could increase the penetration with the lowest primary energy supply

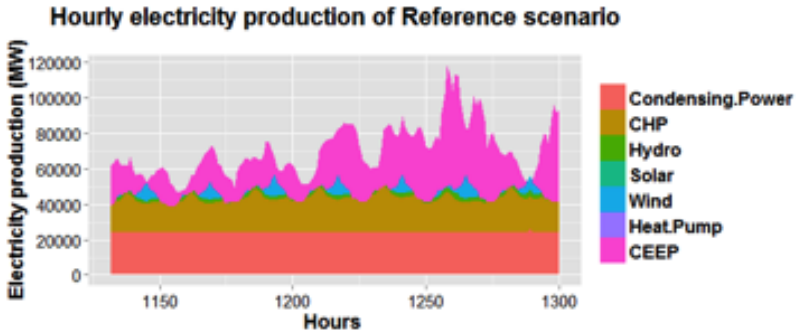


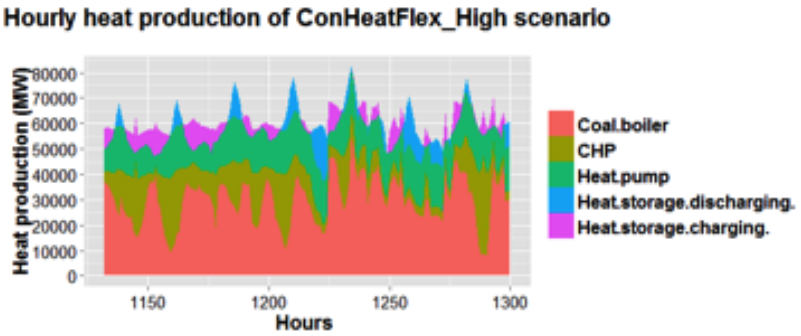


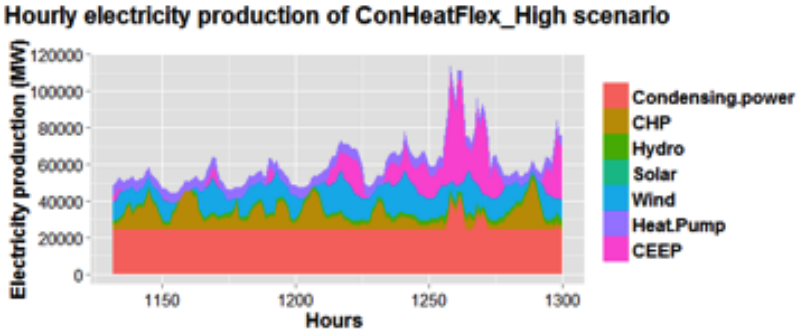
Results

- Wind curtailment and heat in Northeast
  - Suffering the inefficient integration of wind energy (Wind curtailment rate~25%)
  - Heat storage and flexible CHP dispatch could avoid wind curtailment







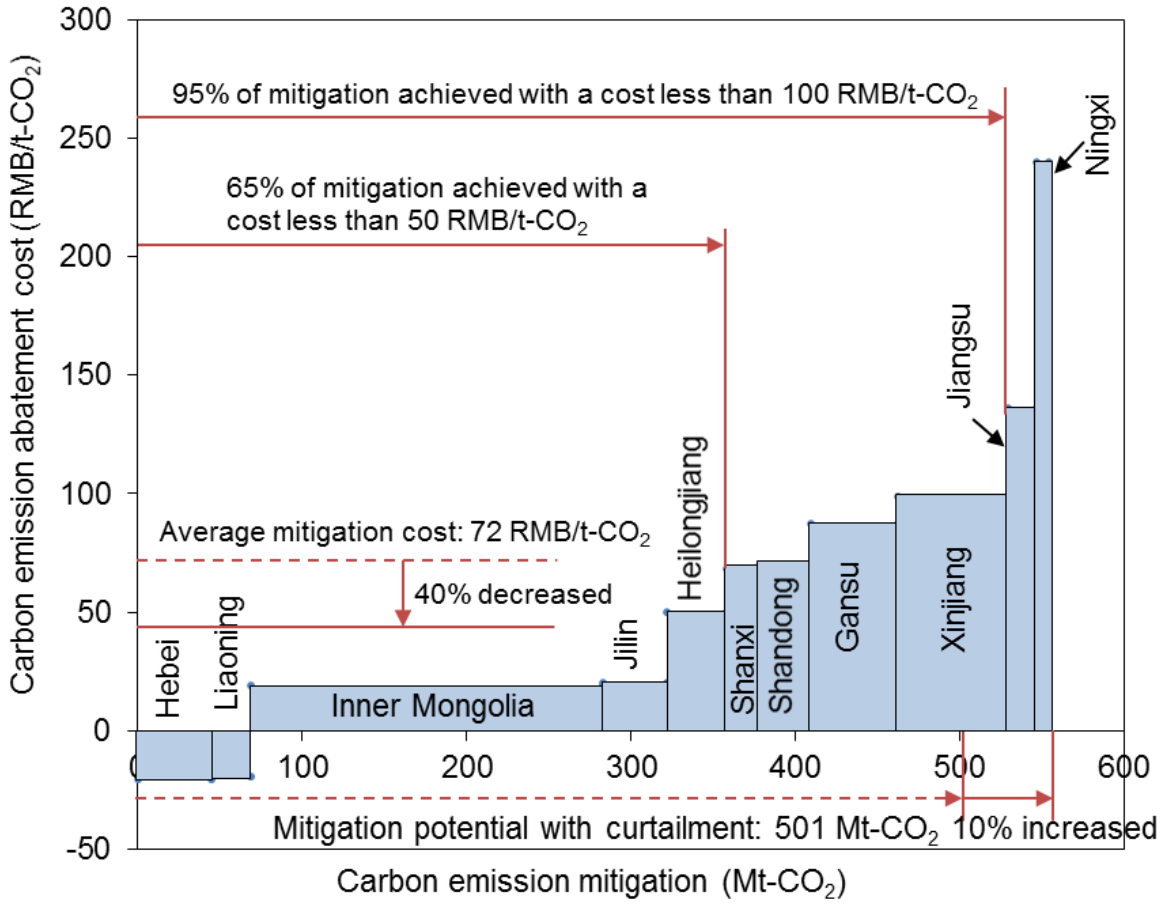


Excessive electricity goes to heat pump
Excessive heat goes to heat storage
CHP starts to reduce electricity output

Wind curtailment avoided
Excessive electricity consumed

Results

- The total abatement potential could reach 550 Mt-CO_2
- The averaged abatement cost could decreased to 44 RMB/t-CO_2.
- 95% of mitigation achieved with a cost less than 100 RMB/t-CO_2



CO2 mitigation potential and abatement cost without wind curtailments

Conclusion

- Is it possible that large-scale integration of fluctuating wind power?
  - Yes! Flexible regulation rules should be introduced.
  - More flexible dispatch rules should be promoted to take place the strict rules of minimum on-line capacity for coal-fired power plants.

- Is it possible to identify the energy balance in both the electricity and the heat sector?
  - Yes! To integrate heat and electricity sector by introducing heat pump and heat storage equipment.
  - The high penetration of coal-fired CHP in China has the potential to accommodate wind penetration rather than decreasing wind integration.

Thanks for your attention

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