



Impact of Renewable Portfolio Standards on China's power sector

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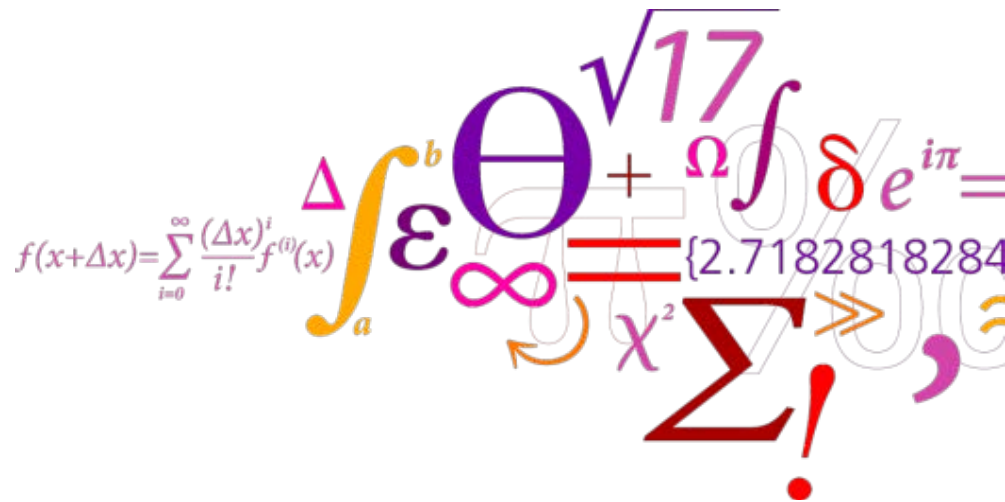
Impact of Renewable Portfolio Standards on China's power sector

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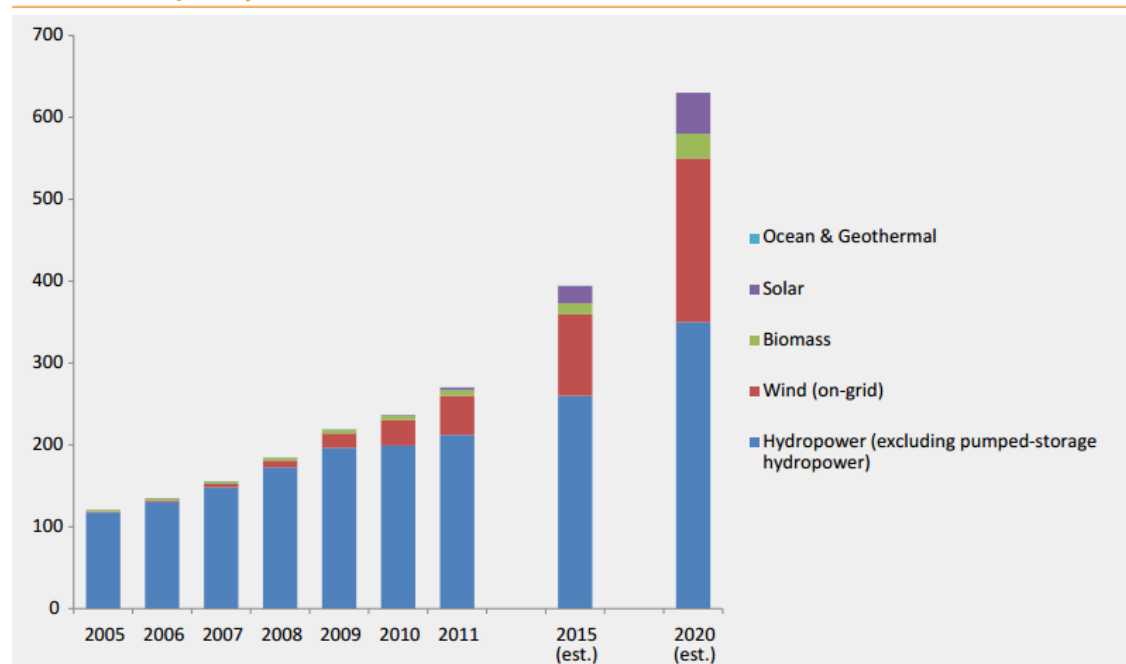
Overview

- **Background and challenge:**
 - uncertainty of contribution of the renewable energy quota system into China's power sector
- **Objective:**
 - analyzing the impact of renewable energy quota system on China's power sector
- **Methodology:**
 - Capacity expansion modelling tool (China Power Planning Model – CPPM)
- **Results and next steps:**
 - Supporting policies and decision making processes



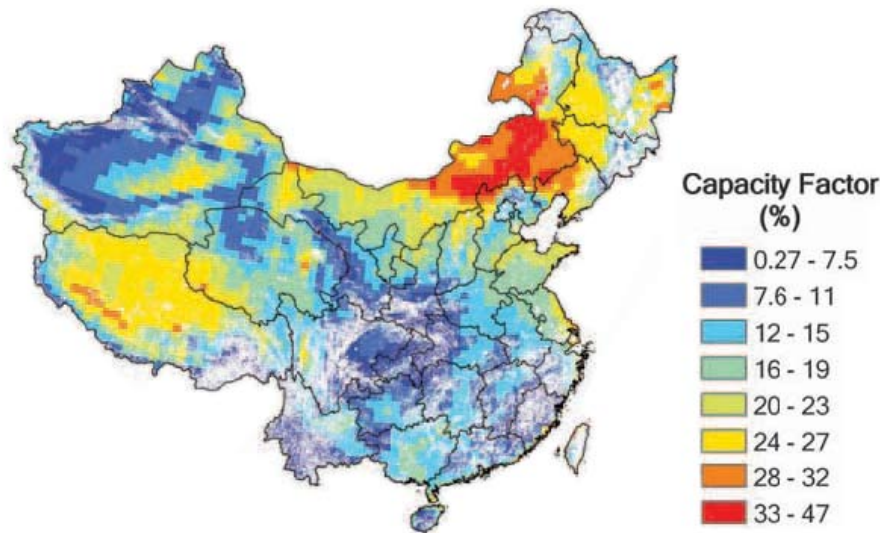
Renewable energy deployment in China

- China is the world leader of renewable energy development:
 - Rapid installation and increasing penetration in energy supply
 - Ambitious national target: **600 GW in 2020**
- This target has led to two issues for China: (i) roadmap for RE development and (ii) policies to support implementation



Regional heterogeneity of renewables in China

- Large **heterogeneity** of renewable energy resource and electricity load in China
 - Grid integration issues in renewable energy resource-rich regions have occurred in recent years (example onshore wind integration)
- **Regionally heterogeneous supporting policies are needed**



Wind capacity factor estimation in China

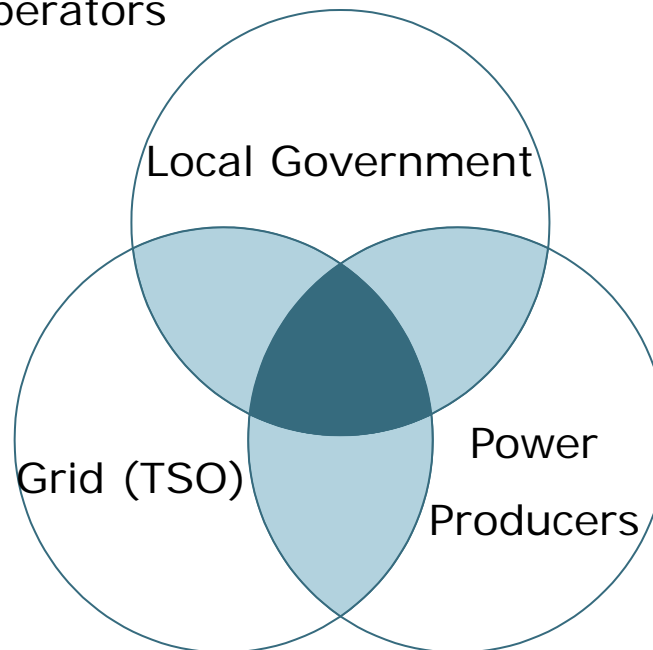


Light pollution from China's cities



How to implement a renewable energy quota system for China's power sector?

- Renewable quota system is being considered as main policy tool to guide renewable energy development in China after 2015
 - Requires grid companies to transmit up to 15% of their power from renewable sources
- Renewable energy targets will be set for provincial governments, power companies and grid operators





What results do existing studies provide for RE policy modelling on China's power sector?

- **Bottom up modelling**
 - Impact of carbon tax policy on power mix to 2050 (Zhang, 2012)
 - Critical effects of CCS on emission to 2030 (Chen, 2010)
 - Reduction potential of IGCC (Cai, 2007)
- **Top-down economic modelling**
 - Impact of renewable portfolio standards on energy security (Fan, 2005)
 - CCS investment risk by real option modelling (Zhu, 2011)
 - Interaction between electricity/coal price by CGE (He, 2010)
- **Research gap:**
 - **Technical-rich bottom up model including various renewable energy (resource heterogeneity, variation, technology improvement...)**
 - **Muti-regional definition to describe China's power sector**



Our research questions

- There is a need to analyse and discuss potential impact of renewable quota policy on China's power sector
- Research questions:
 - **What's the potential impact of renewable quota system on emission, generation, installation and transmission for different regions in China?**
 - **What are potential synergies between renewable energy quota and other implemented or on-going policies like carbon cap or feed-in-tariffs?**



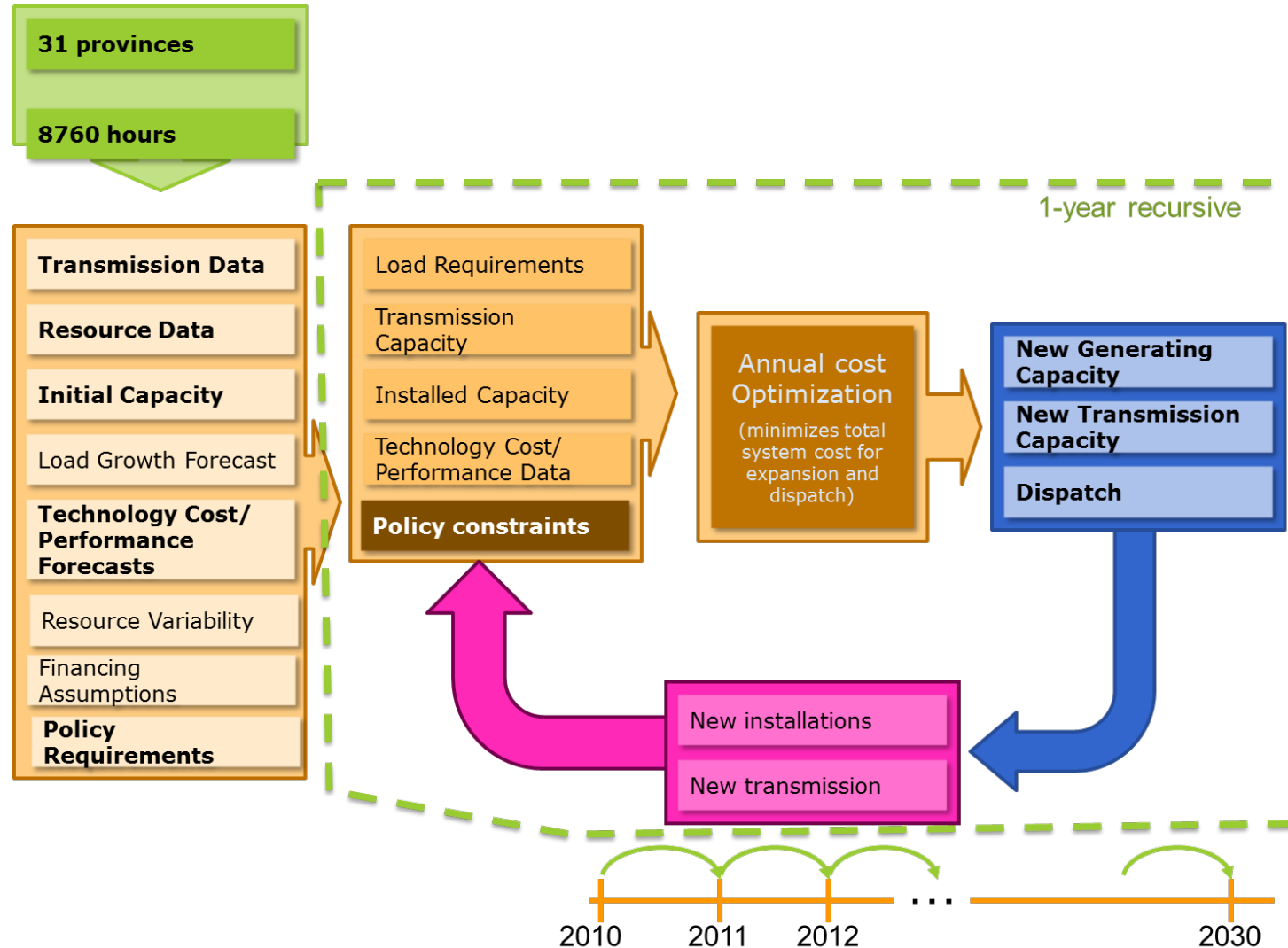


Methodology: Capacity expansion modelling tool

- Capacity expansion model for China's power sector based on open-resource model **Balmorel** was developed
 - Balmorel is widely used in Scandinavian countries
 - 31 provinces for China with updated Chinese data for existing power system
 - Resource potentials for renewables
 - **Finds the minimized-cost solutions for generation and transmission capacity expansion in different regions in China**
- This model can provide information for:
 - Deployment (quantity and location) of each technology/ transmission capacity
 - Cost and emission of each scenario
- ... but it can't give details about:
 - Dynamic (frequency, voltage stability, etc.) issues
 - Individual power plant analysis/ distribution level requirement



Methodology: Capacity expansion modelling tool





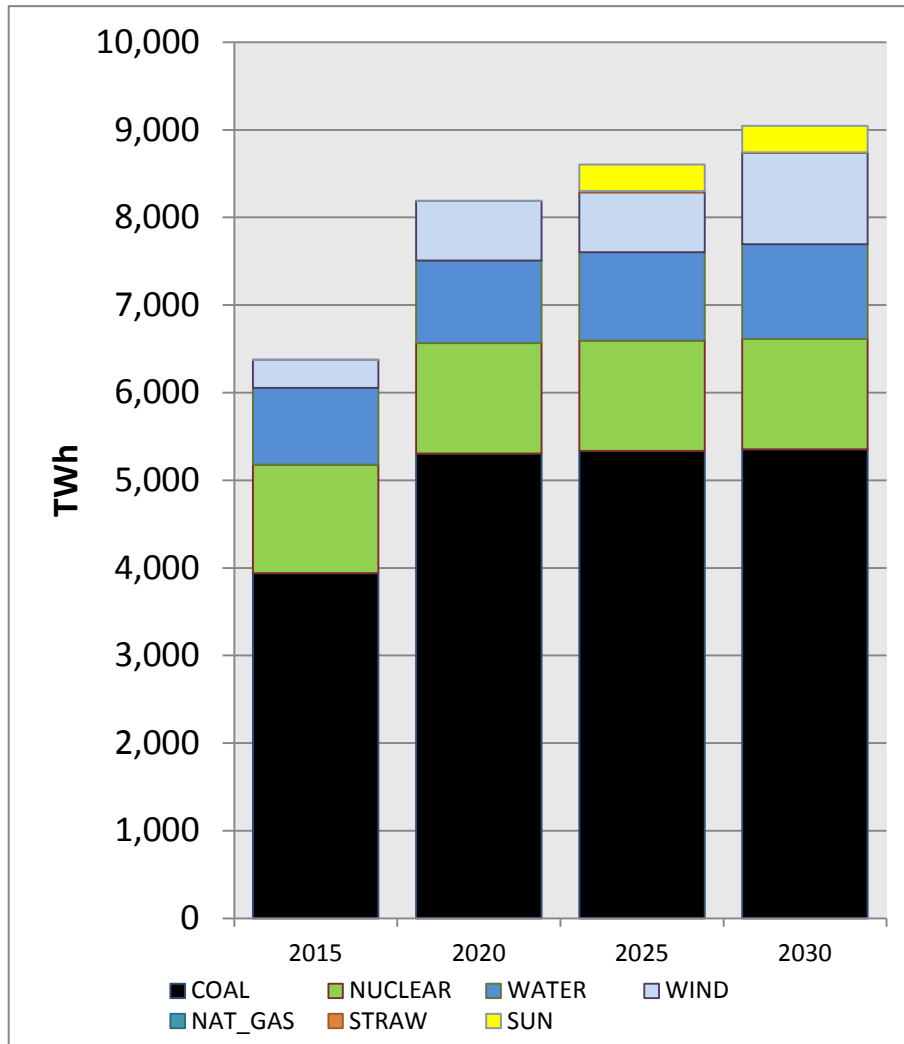
Methodology: Capacity expansion modelling tool

- Multi-scenario analysis:
 - Two renewable quotas scenarios: 15% and 25% non-hydro renewable energy penetration in 2030
 - Two associated carbon cap scenarios with same emission mitigation effect as in 15% quota and 25% quota scenarios
- Key assumptions and database:
 - Coal (sub-critical, super-critical, ultra_supercritical, IGCC), coal with CCS, natural gas (turbine, engine, IGCC), renewable energy (wind onshore, wind offshore, solar PV, CSP, hydro, small hydro, pump hydro)
 - Technology performance and cost: investment cost, O&M cost, efficiency...
 - Electricity demand: **provincial forecast from CAS and State Grid**
 - Grid connections: aggregation of transmission capacity among provinces, cost matrix for new connections

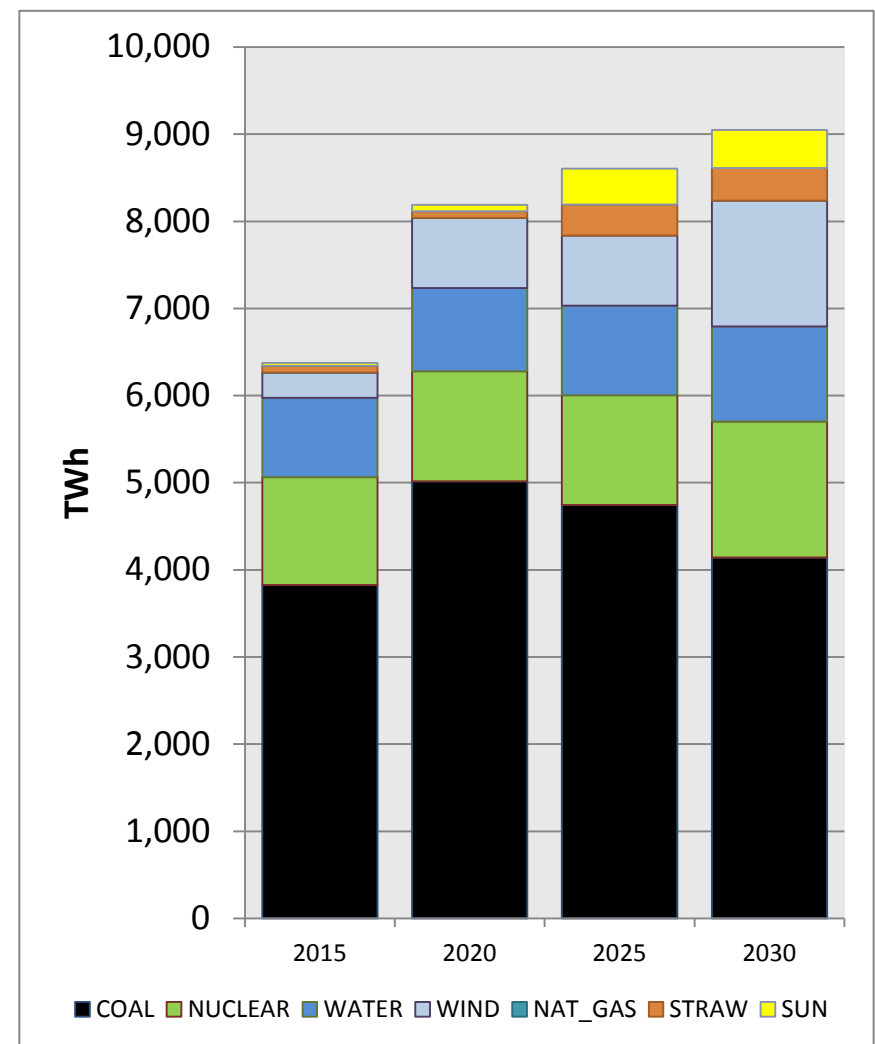


Results: Future electricity generation under different RE quotas

15%_quota generation



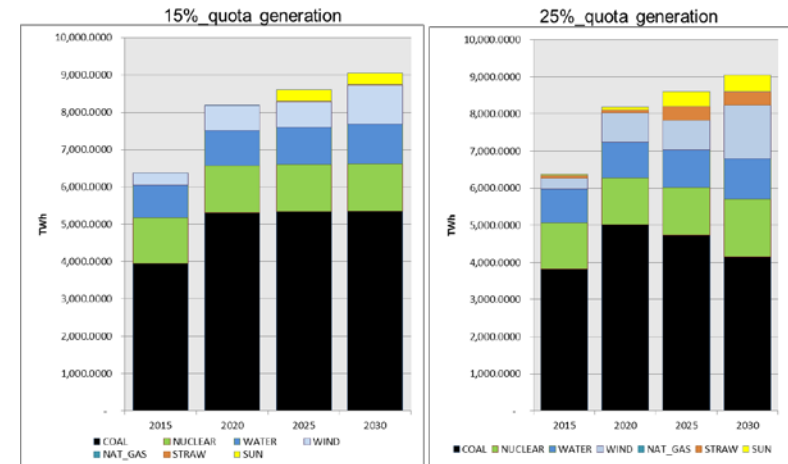
25%_quota generation



Results: Future electricity generation under different RE quotas

In the short term (2010-2020)

- No significant differences between two scenarios
- No large scale biomass and solar energy deployment



In the long term (2020-2030) → differences between scenarios increase

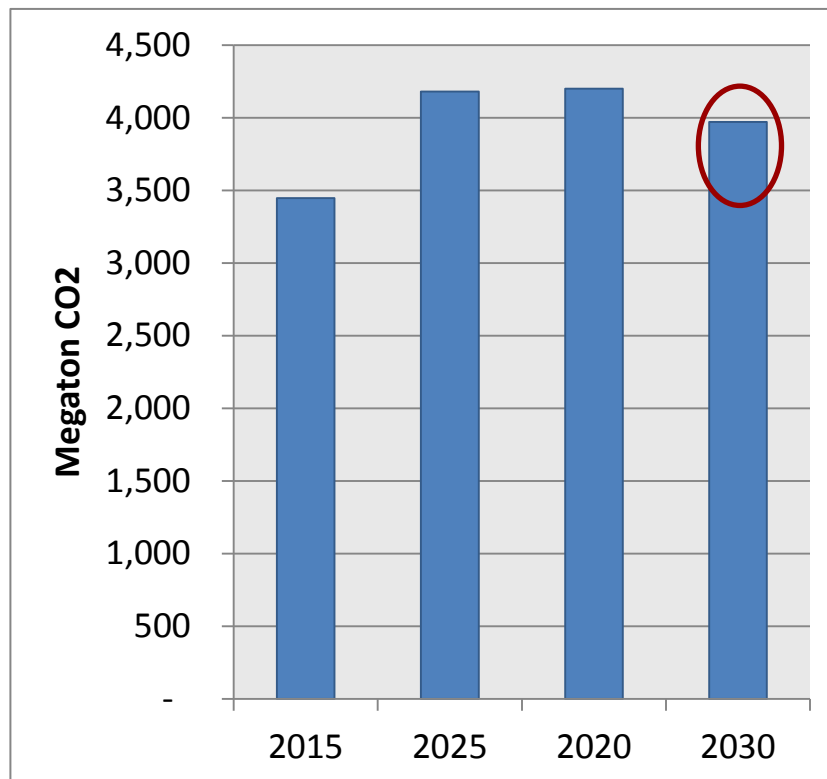
- The coal remains major fuel for power generation in 15%_quota scenario --- but **coal generation decreases very rapidly in 25% scenario after 2015**
- There is no obvious development of biomass energy and solar energy in 15% scenario ----but **the 25% quota scenario drives significant renewable generation**, particularly for wind power, after 2020.



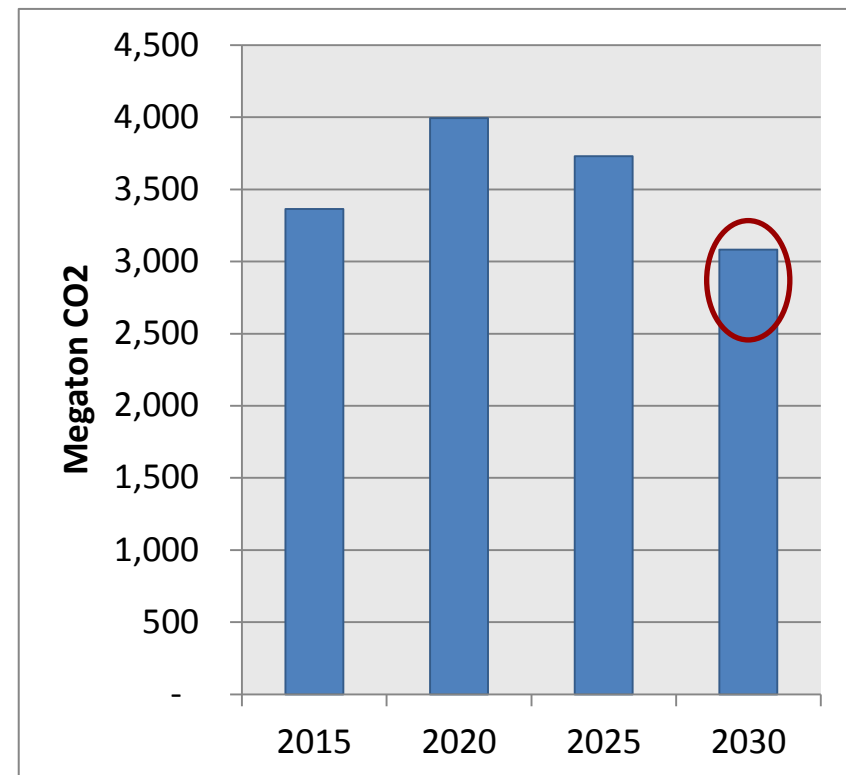
Results: CO₂ emission mitigation under different RE quotas

- Key results:
 - **15% quota scenario fails to reduce carbon emissions drastically** and emission peak is one decade later than in the 25% quota scenario
 - **25% quota shows less emissions in 2030 compared to 2015**

15%_quota carbon emission



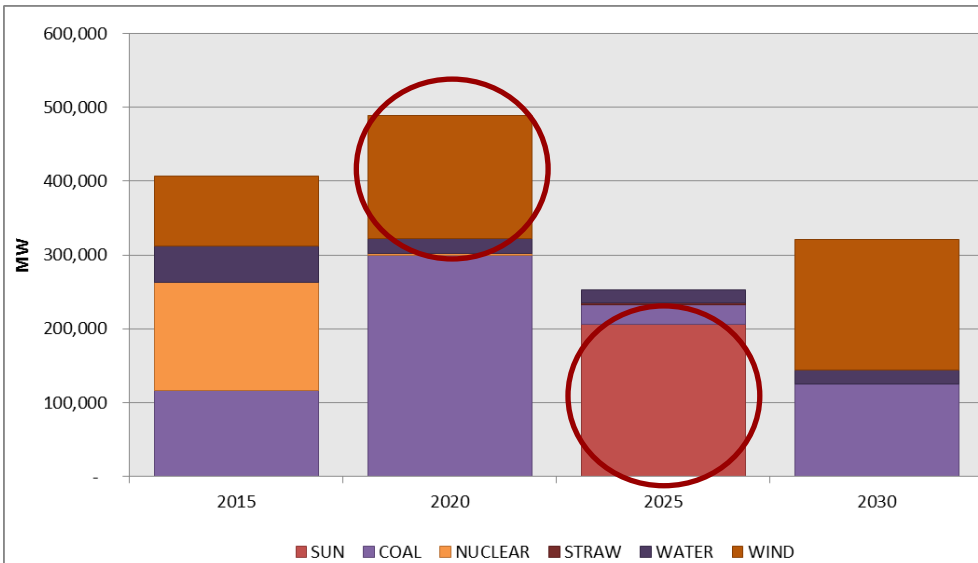
25%_quota carbon emission



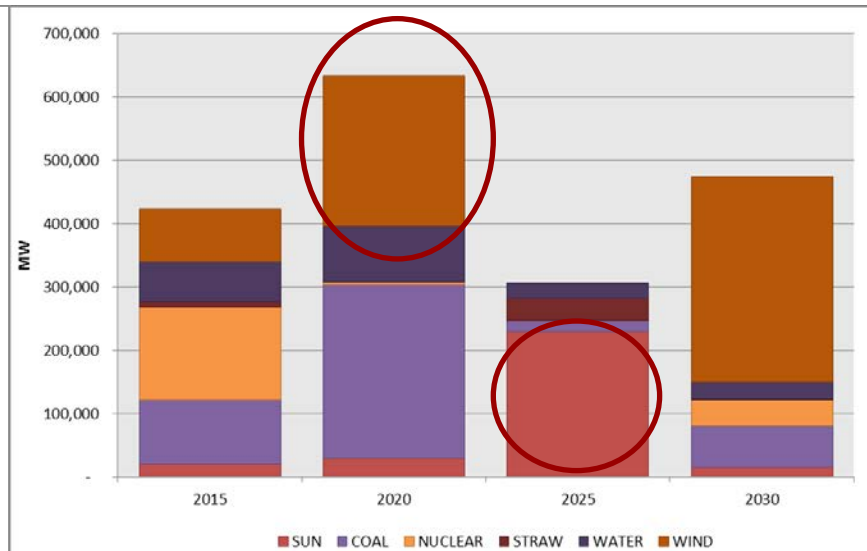


Results: New investments in power generation capacity under RE quota scenarios

- High quota needs more investment capacity on renewable energy,
- especially wind energy in short term and
 - solar energy in the long term



15%_quota capacity investment



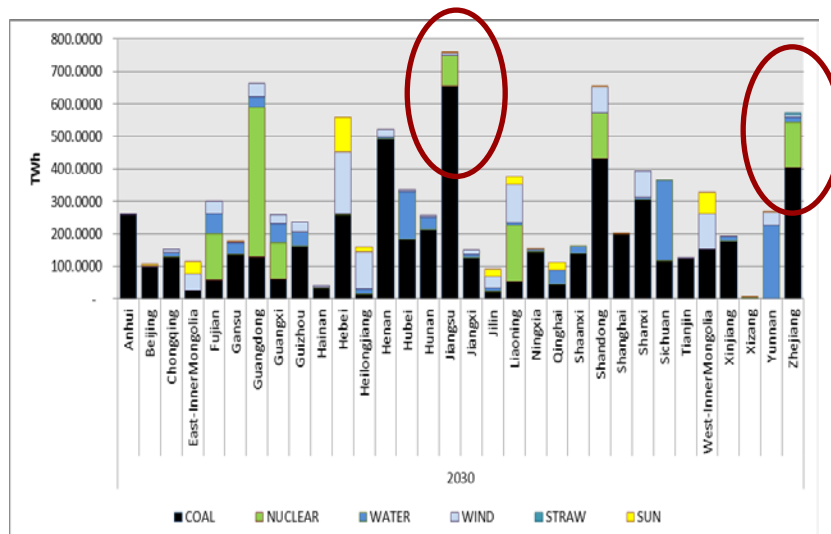
25%_quota capacity investment



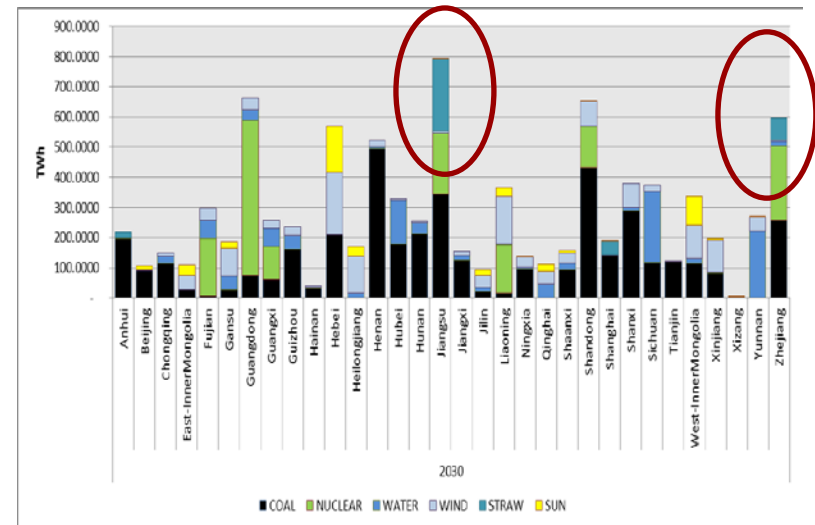
Results: Provincial heterogeneity of RE deployment under different RE quota scenarios

- Share of renewable energy varies among provinces in both scenarios
- The renewable energy penetration has strongly relationship with renewable resource and domestic fuel prices, especially coal price
- High quota is needed for biomass energy

15%_quota generation mix



25%_quota generation mix



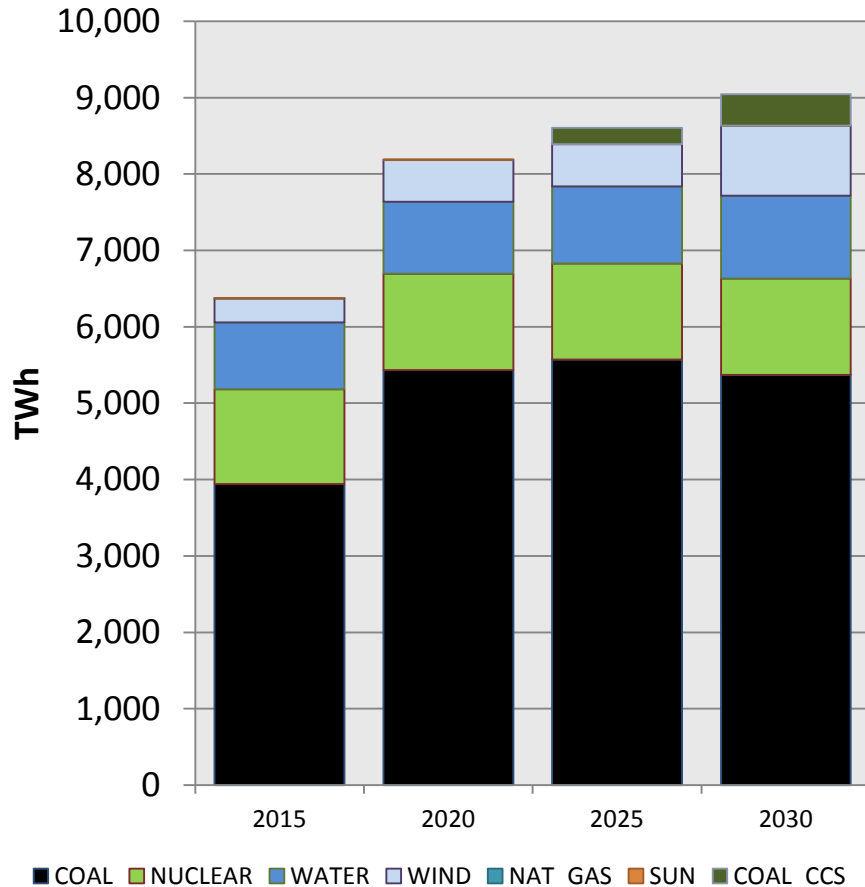


Results: High and low carbon cap scenarios

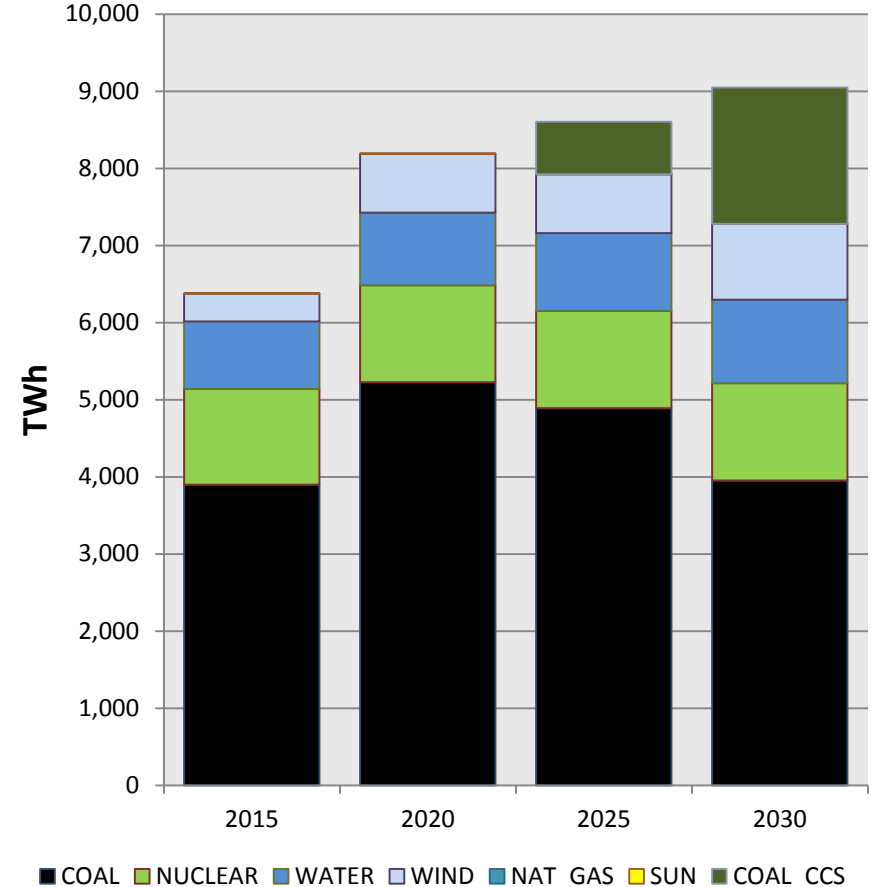
High cap scenario: same carbon emissions set as in 15% quota scenario

Low cap scenario: same carbon emission set as in 25% quota scenario

High cap generation



Low cap generation

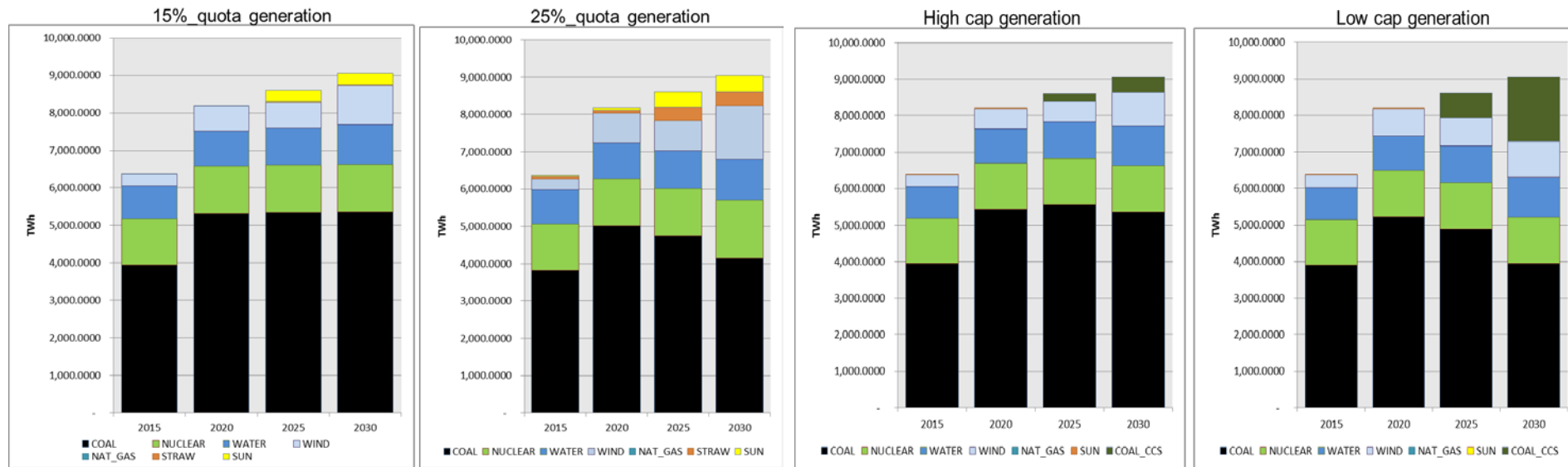




Results: Comparison of RE quota and carbon cap scenarios

the power generation mix in the short term (2010-2010) is similar in quota scenarios and cap scenarios

technology neutral carbon cap scenarios stimulate the development of CCS rather than biomass and solar energy



Key conclusions

- Renewable energy quota could drive the development of renewable energy in China very significantly
- **Different quotas have obvious discriminative influence on different renewable energy technologies**
- Carbon cap policy could reach the same target of emission mitigation while **coal+CCS** would be the key mitigation option than renewable energy in the long term
- **The optimal renewable energy penetration modelled varies among provinces**
→ regional targets or green certificates trading are needed in China's quota policy





Next steps

- Data improvements for different regions, Integration of more experts' forecast
- Sensitivity analysis of key parameters
- Development of the current model into a standard modelling platform to discuss China's policies for the power sector
- Model innovation in the future:
 - Renewable energy resources: integration with high-resolution GIS analysis
 - Supply curve of renewable energy resource and fossil fuels
 - Reflect the impact of wind/solar intermittences on the overall power sector



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