Renewable energy futures in China: application of GCAM

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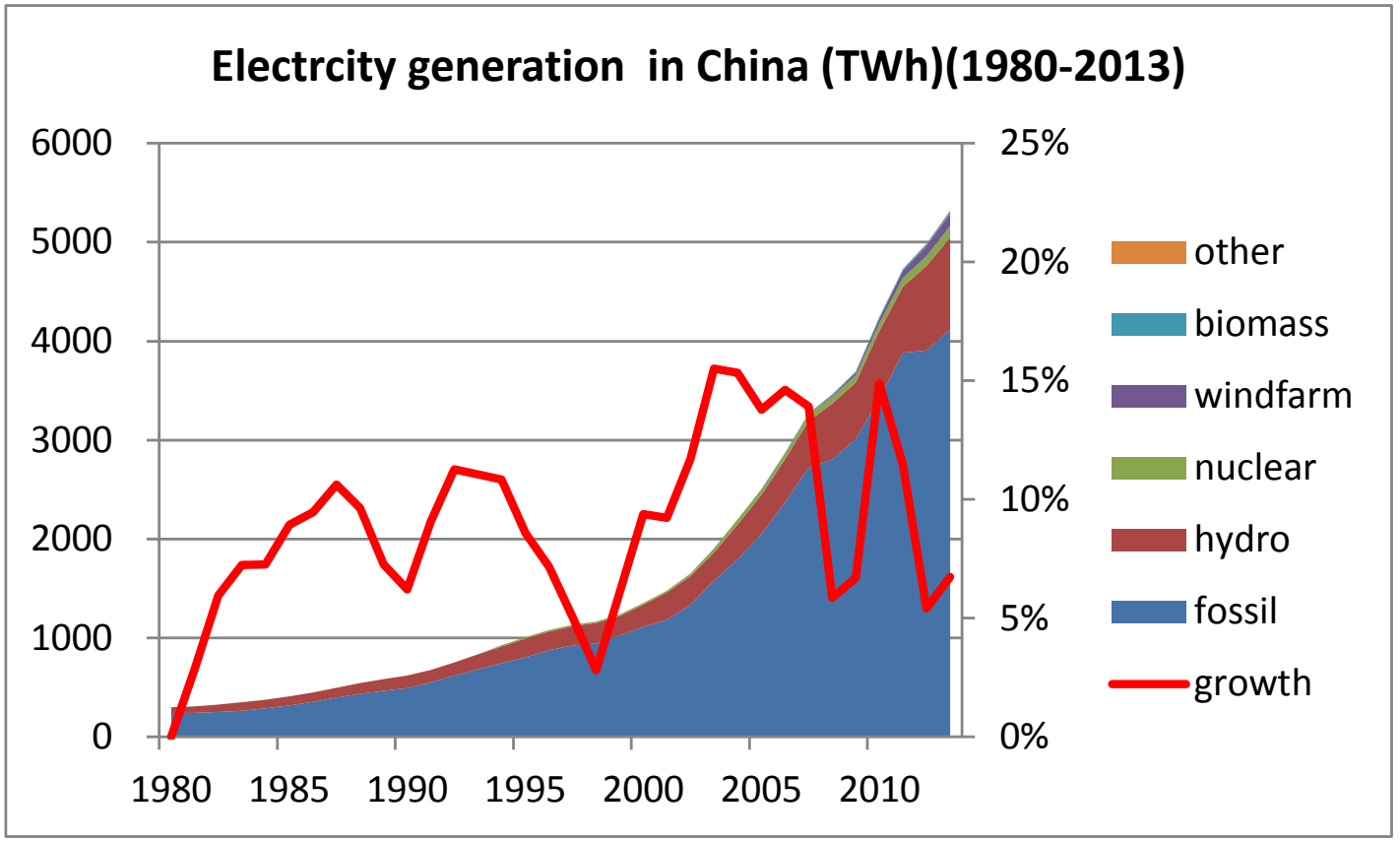
Outline

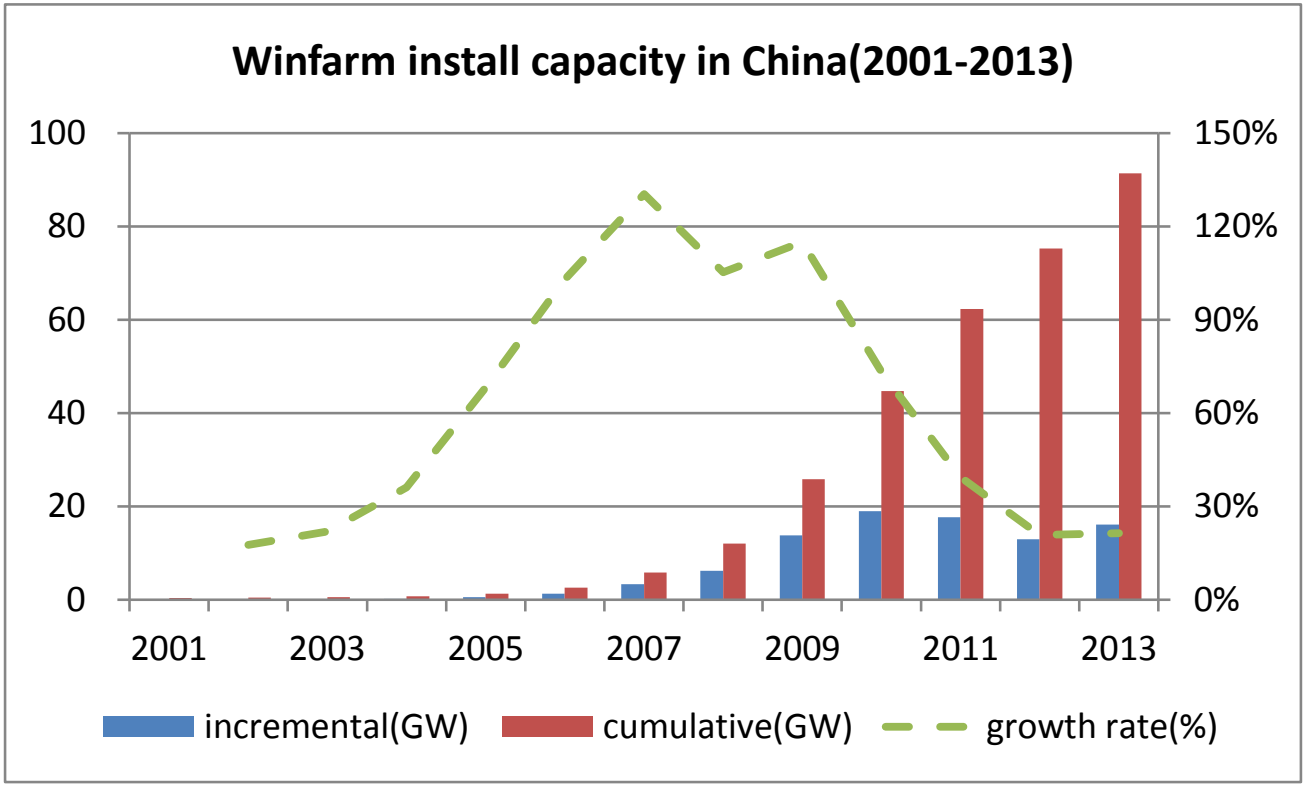
- Back ground
- Method
- Result
- Conclusion

BACKGROUND

Electricity consumption increase 17.7 times from 1980 to 2013, faster than primary energy consumption increase rate (6 times)



Wind farm increase dramatically more than 200 times since 2001

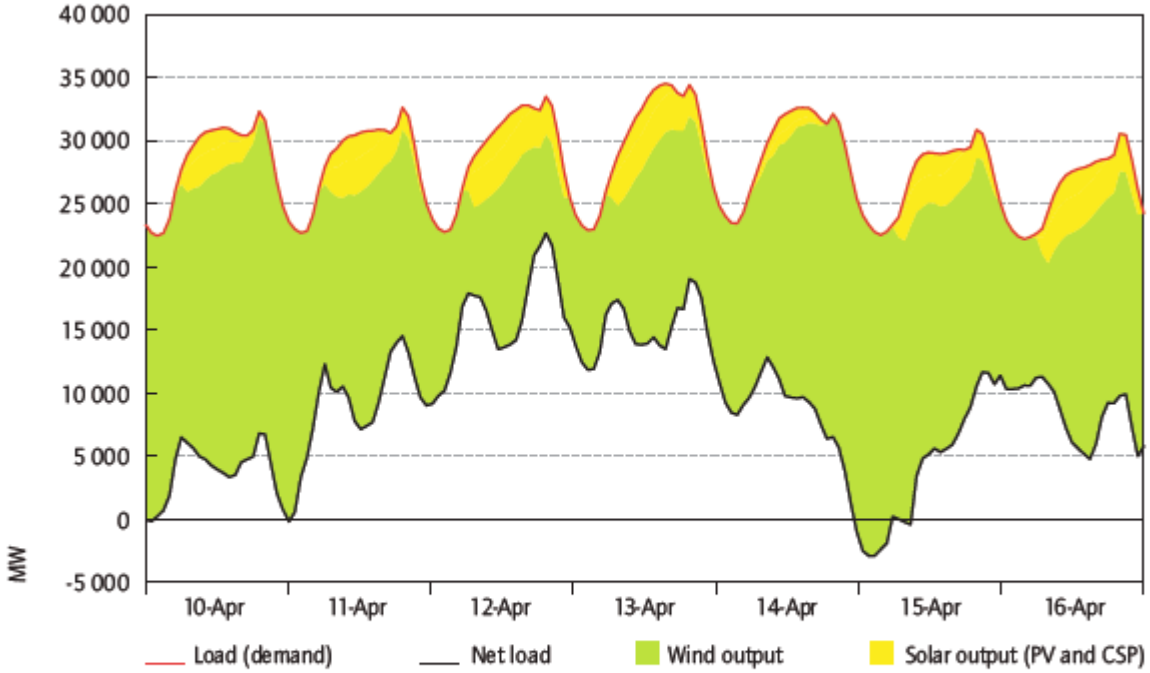


In 2013, more than 15% wind farm can not sell to grid?
wind farm can not provide the stable output (intermittency issue)

Supply fluctuation

Variability is not a new phenomenon in power system management, but high VRE penetrations will pose significant additional challenges

Figure 3 • Variability in demand (upper line), and in net load (lower line) in a challenging week



Source: GE Energy, 2010.

Key point • *Variability is not a new phenomenon in power system management, but high VRE penetrations will pose significant additional challenges. Only the additional variability in the* net load *is germane (not the variability of VRE power plants in isolation).*

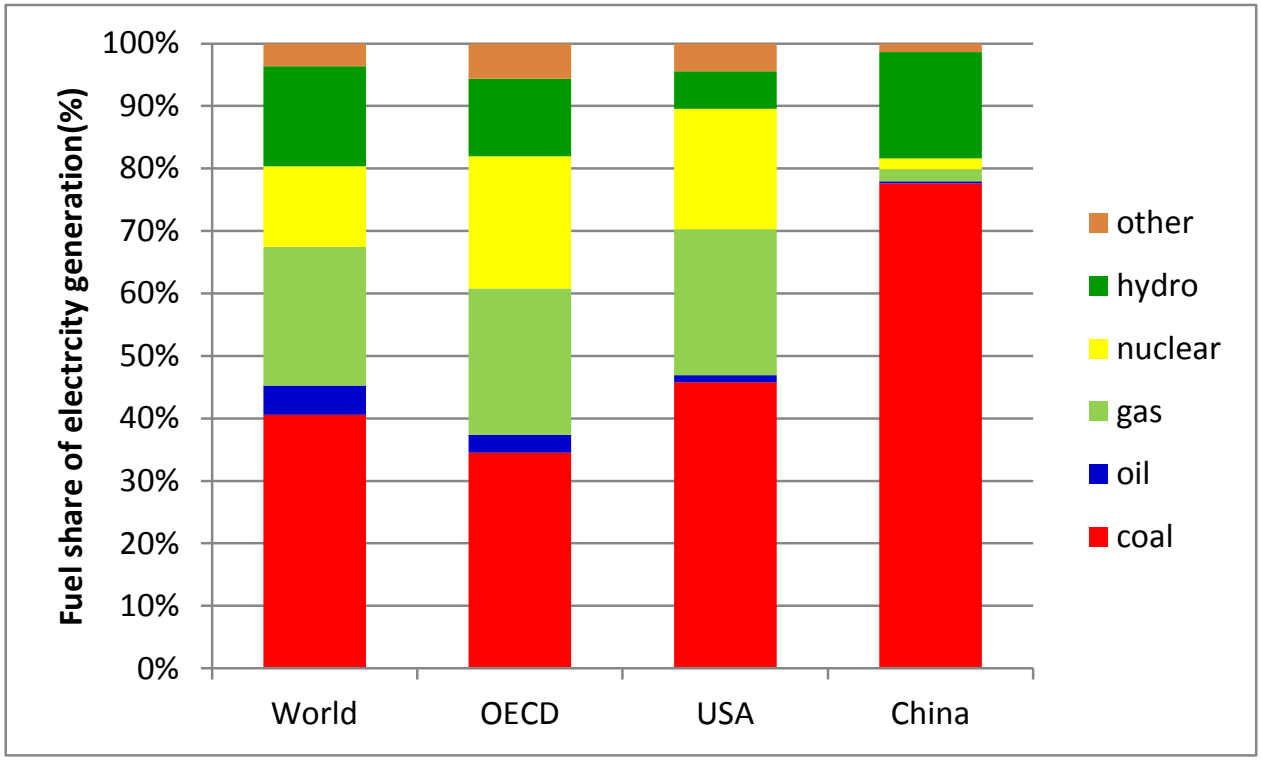
Lack of inter-regional grid connections in China

Electricity exchange among regional grids about 4.5% in 2013. source: CEC.

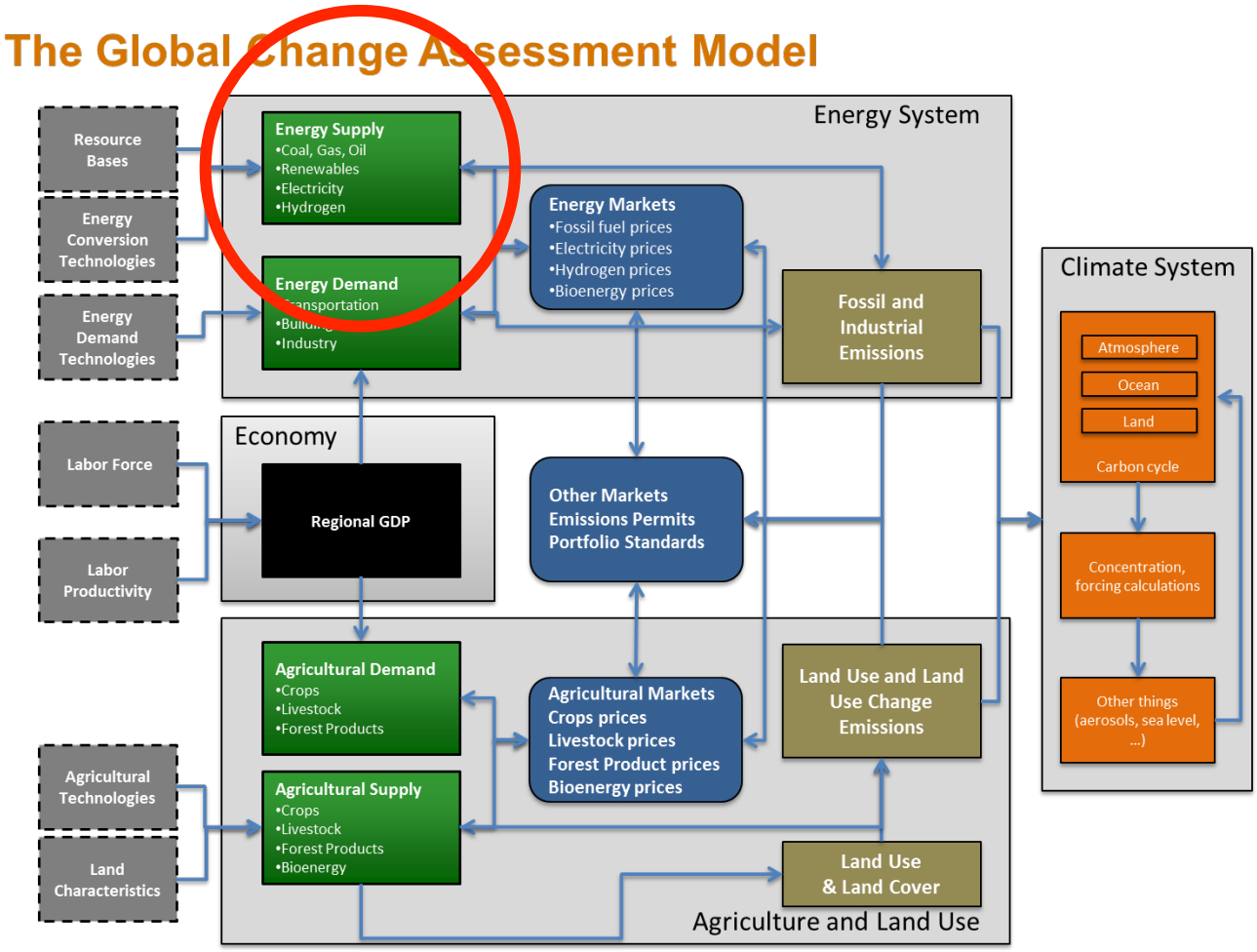
Grid has no ability to match the intermittency issue in regional level

Integration cost and remote transmission not clear and uncertainty

Electricity structure by fuel in 2010



Technologies competing in electricity sector



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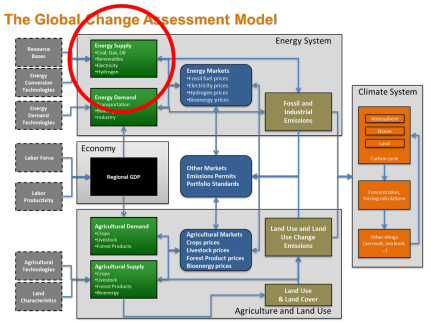
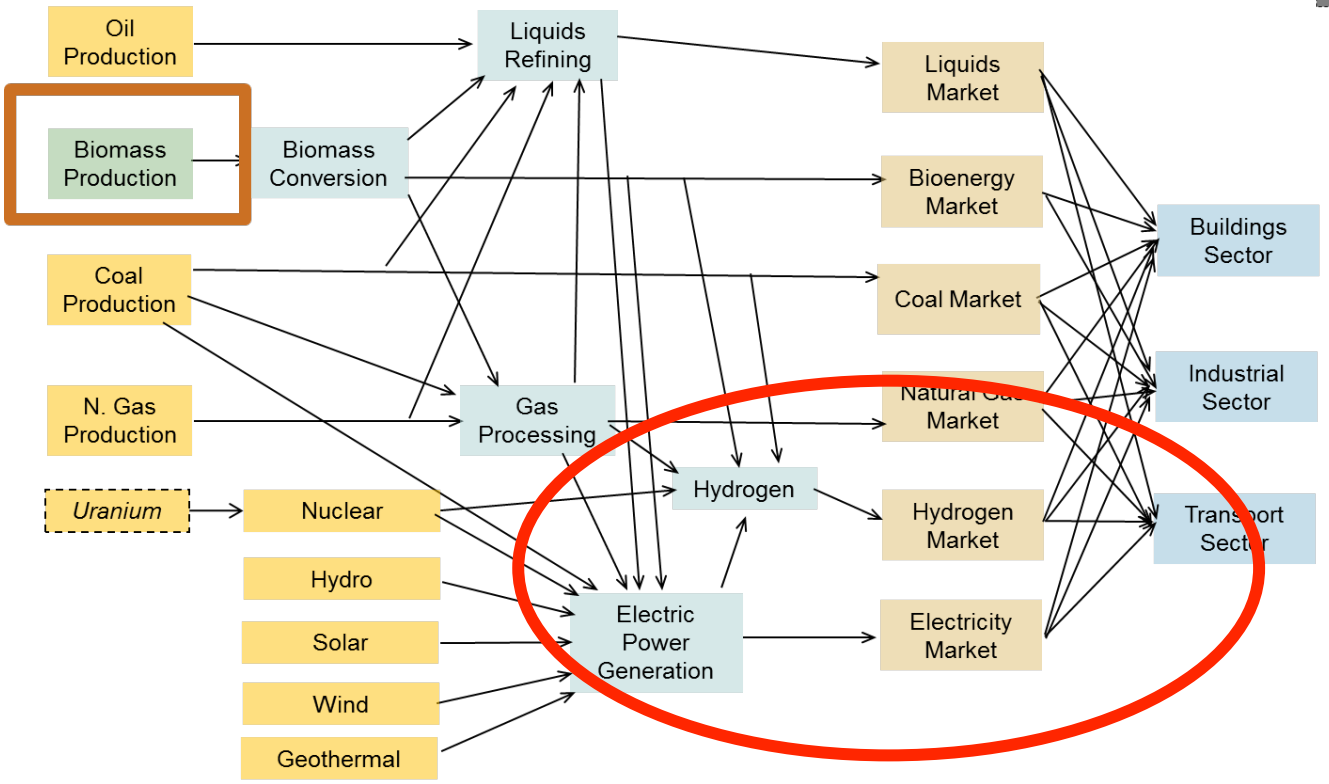


The Energy System



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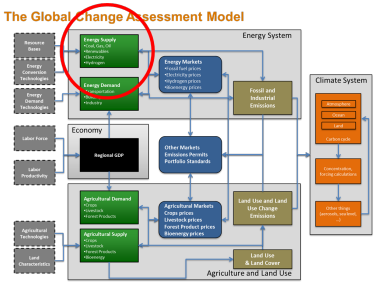
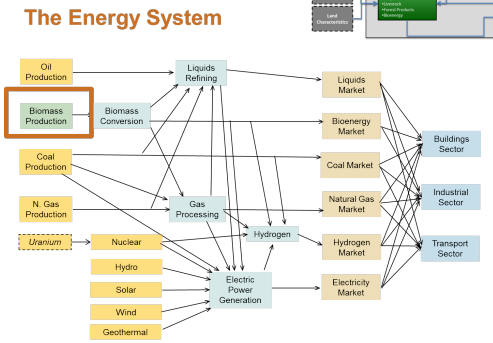




sector

subsector

technology

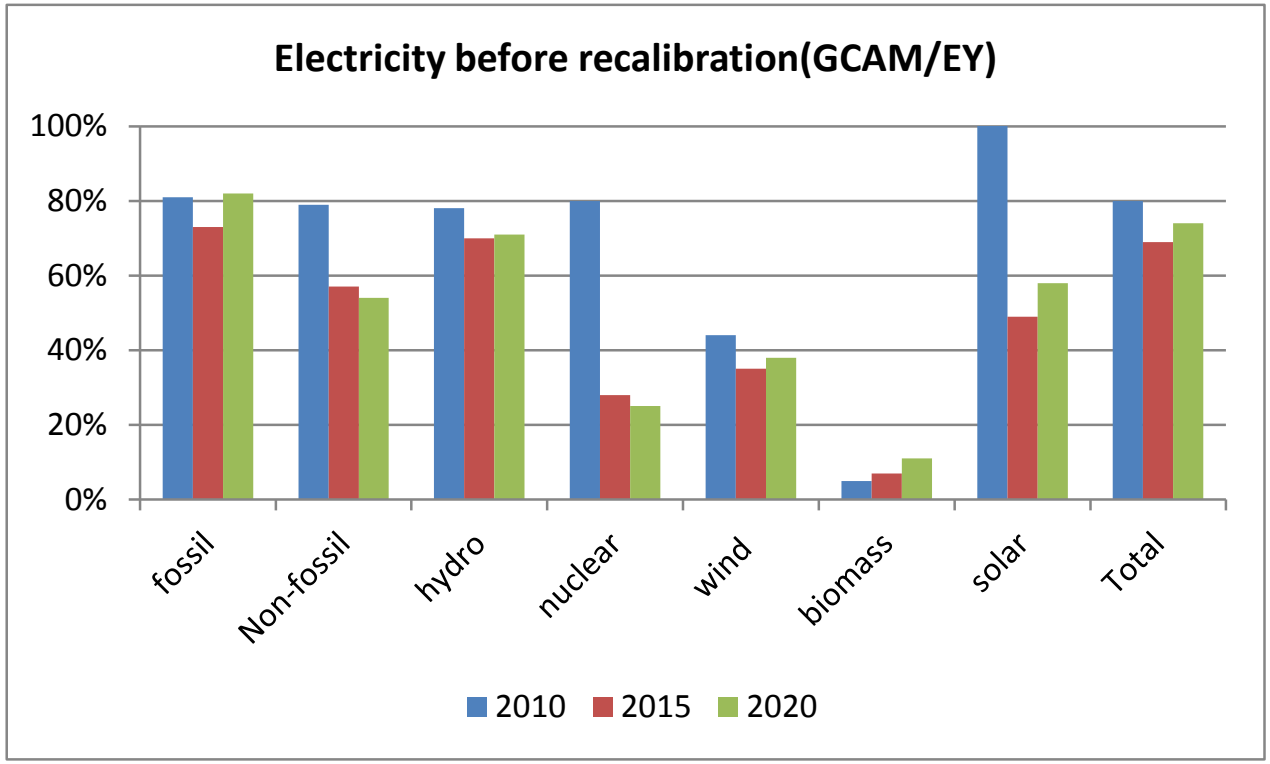
GDP

electrcity demand

coal | gas | oil | hydro | nuclear | wind | solar | biomass | geothermal

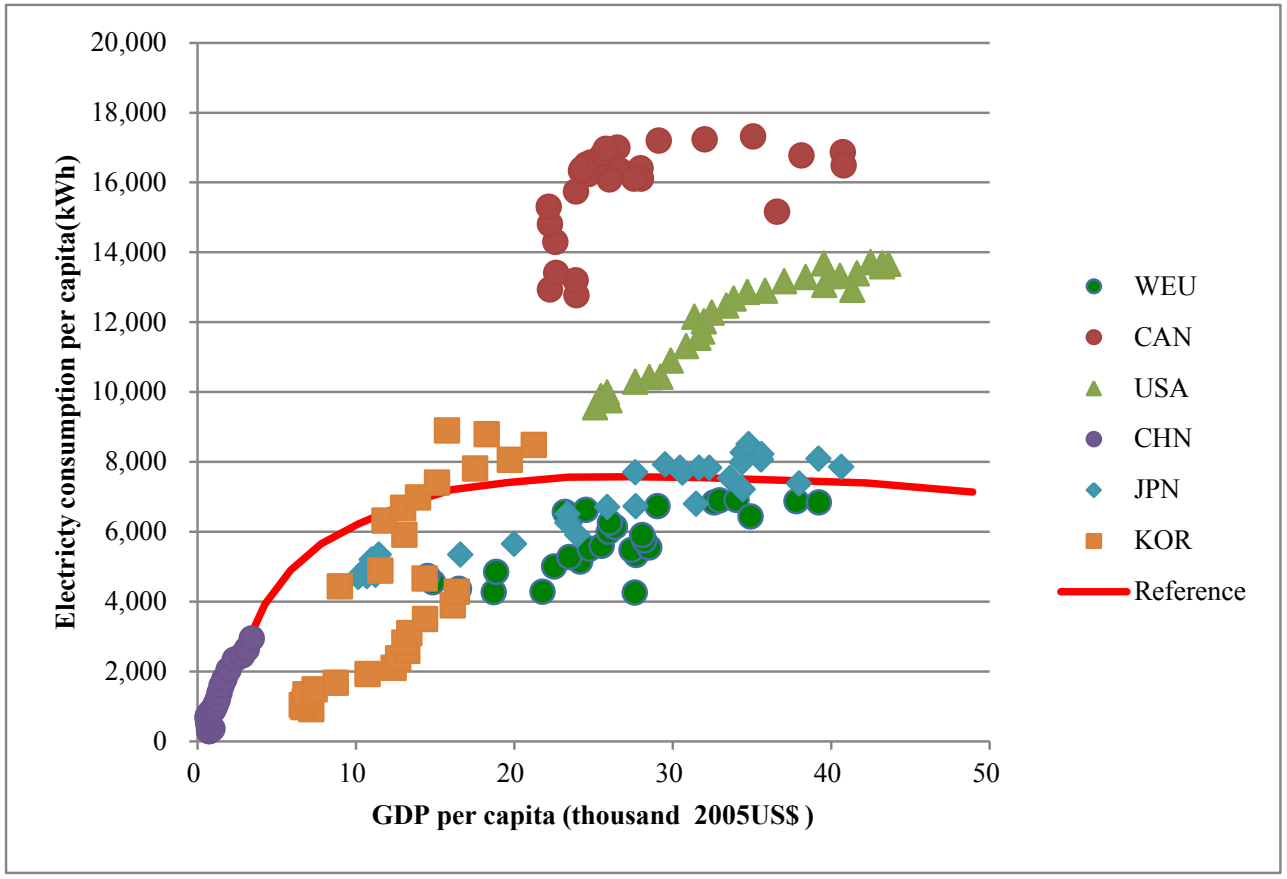
coal conv | coal igcc | coal ccs | wind | wind w/storage | solar | solar w/storage

Recalibration electricity generation in GACM based on Chinese data



2010, 2015 and 2020, can not reflect Chinese data (GCAM used IEA). Default GCAM underestimates Chinese historical and near-term energy estimates. Most energy use is underestimated, but solar is overestimated.

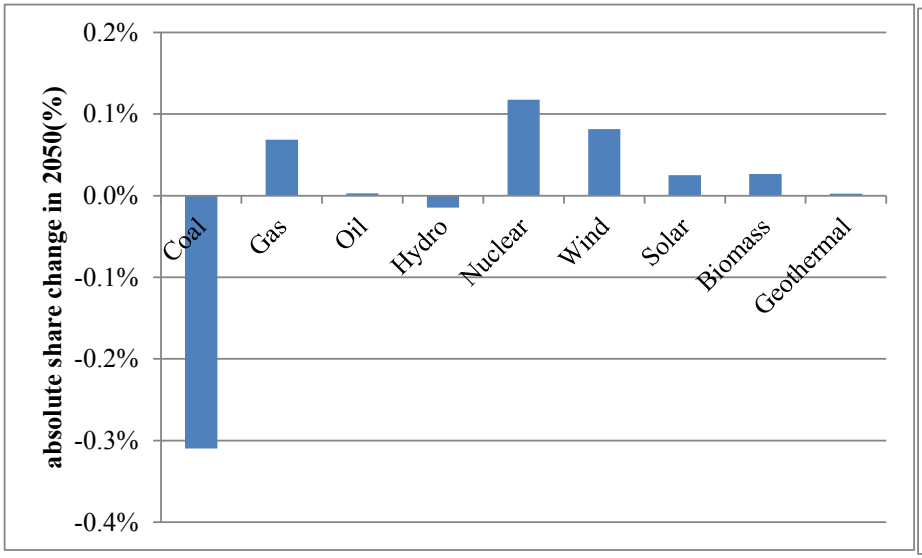
Pathway of electricity demand per capita in the future

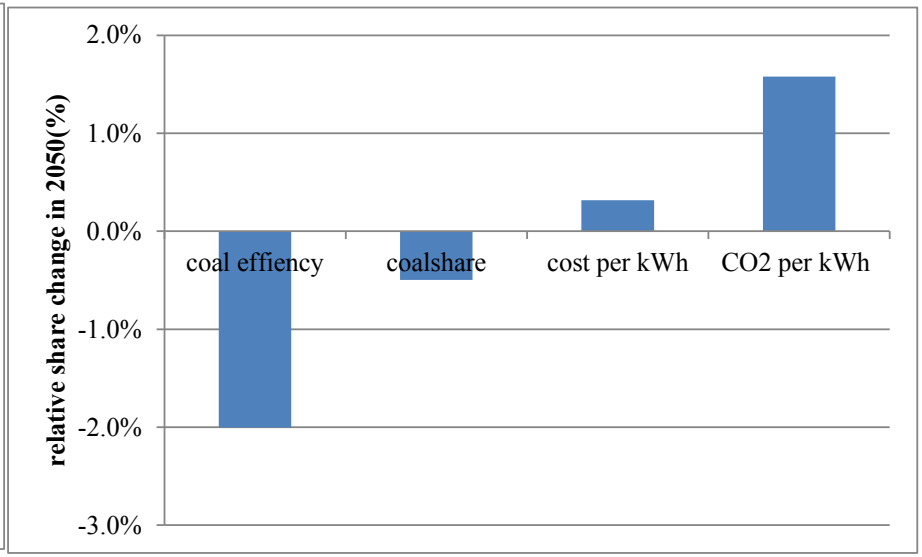


In 2013, per capita is 3910kWh, total 5322 TWh

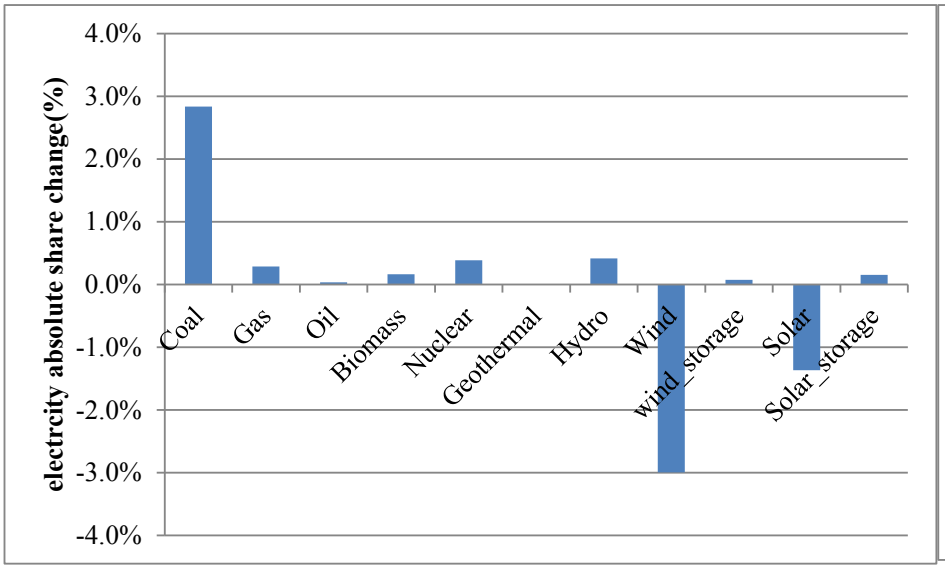
To 2050, per capita is 7550kWh, about 1.9 times of 2013

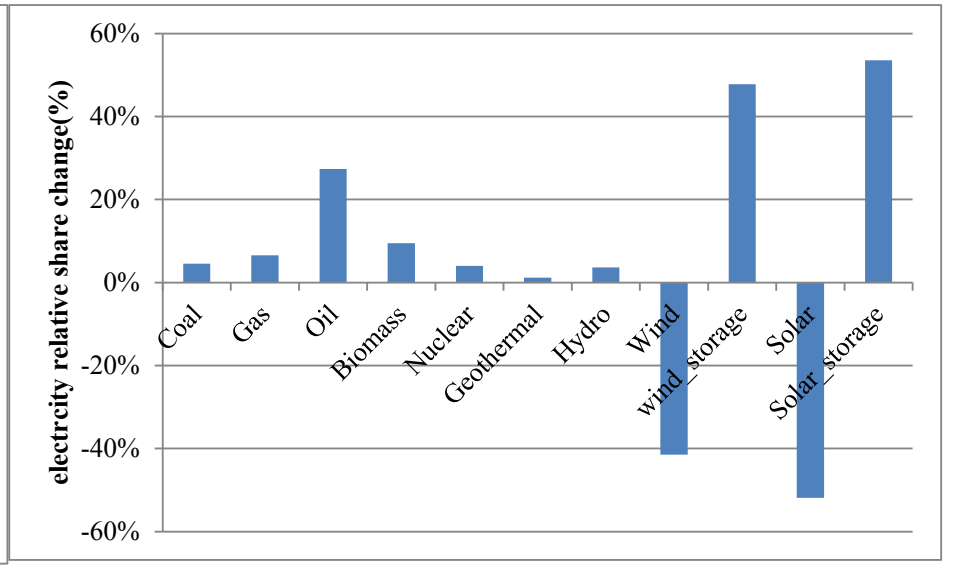
Coal generation efficiency penalty impact





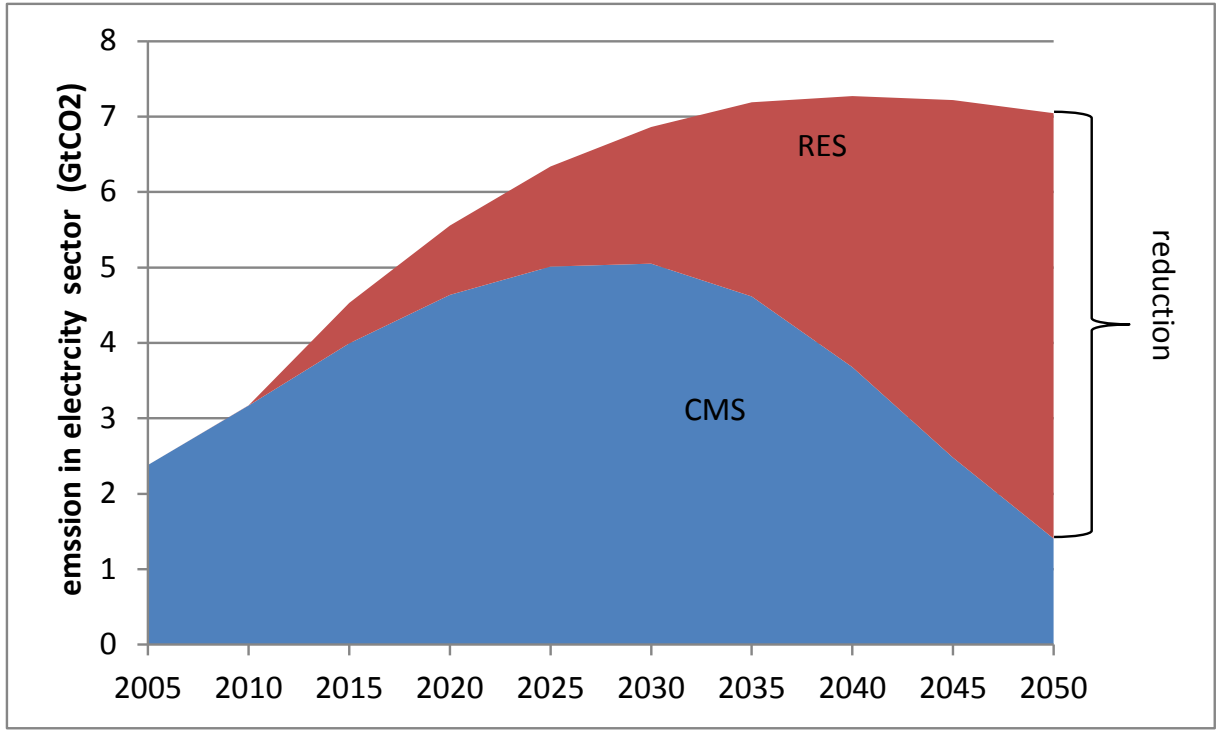
Integration cost impact
Wind farm and Solar without storage capability share will decrease by 40% and 50% in 2050



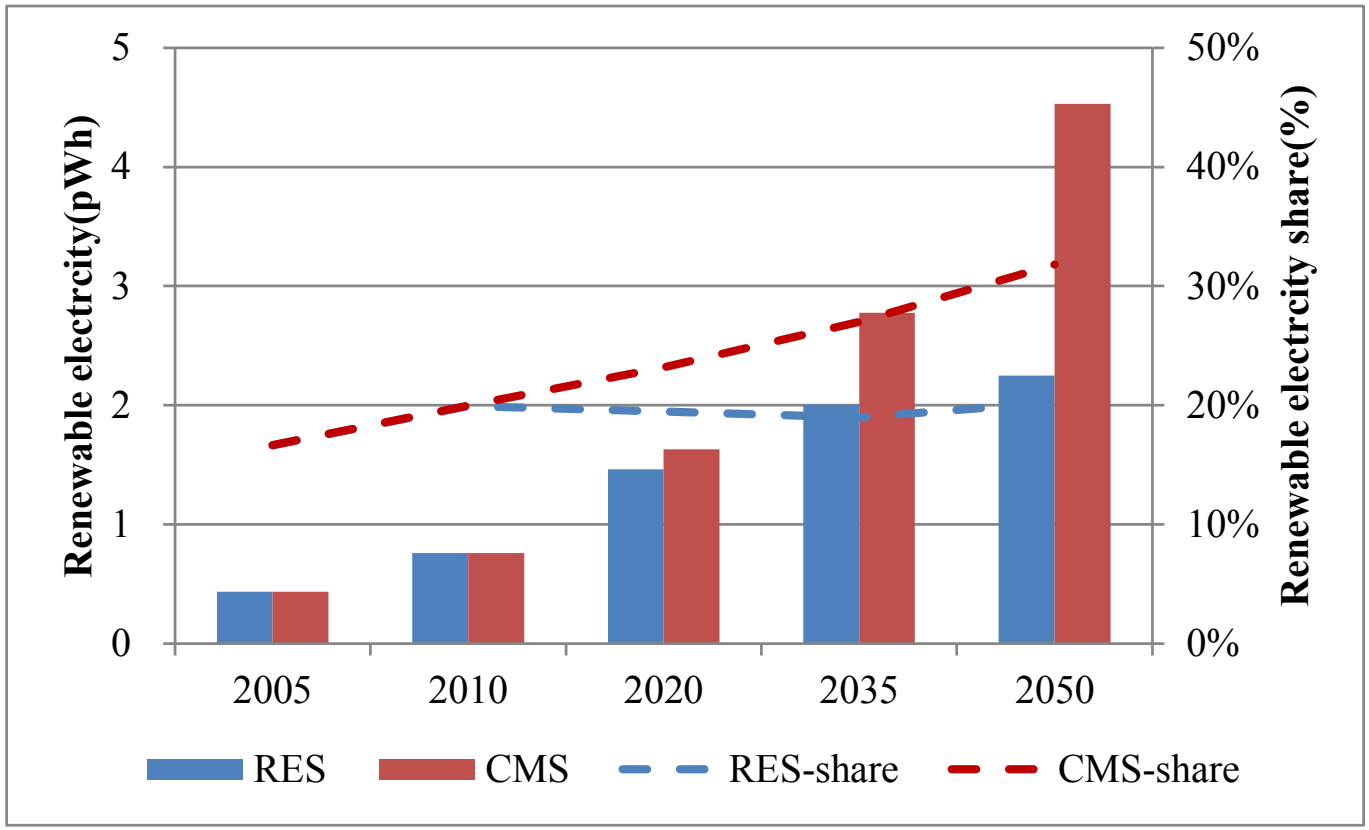


- Integration cost in China is expected to be more expensive and have a stricter capacity limit.
- Assumed integration cost is 20% for VRE electricity and
- Capacity limit is about 12.5%.

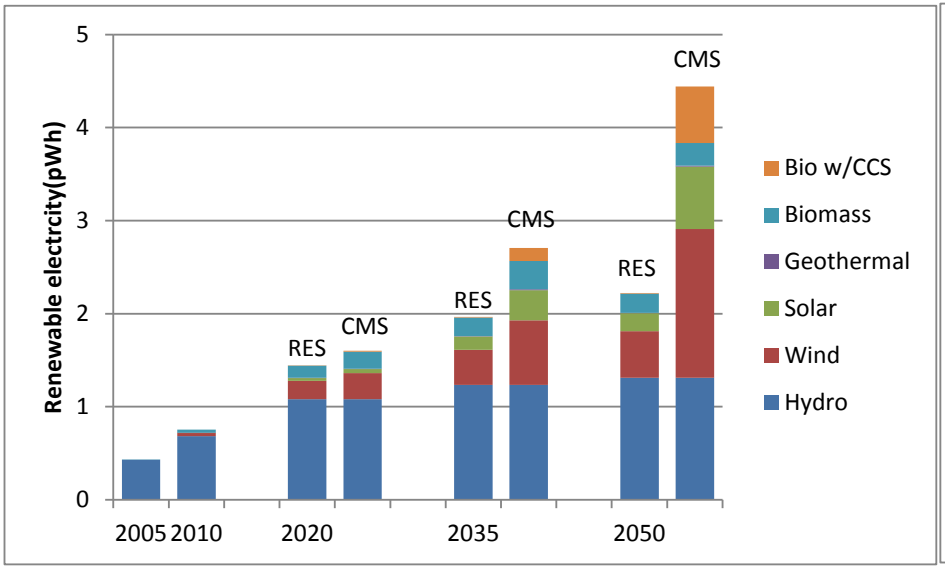
Carbon emission for two scenarios
Reference Scenario (RES)
Climate Mitigation Scenario (CMS; 450ppm-e)

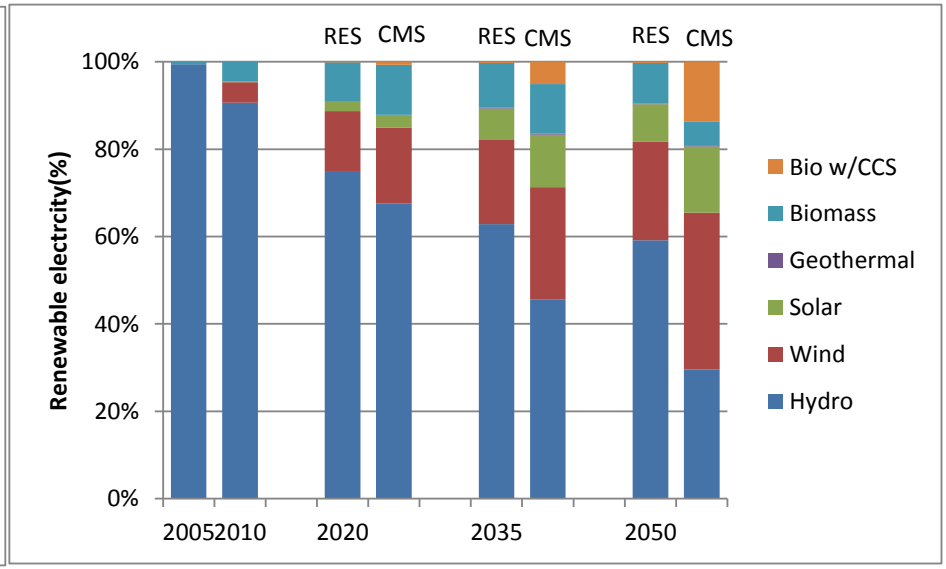


Renewable electricity and share

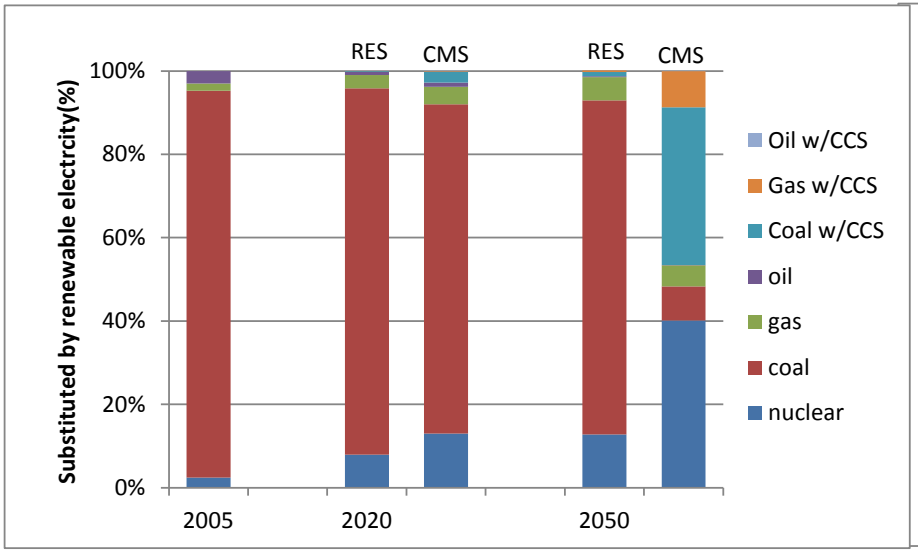


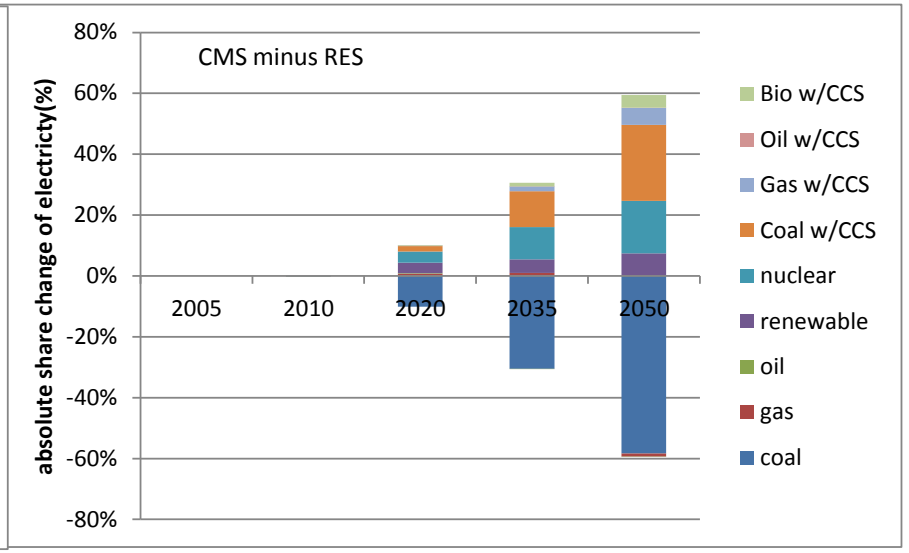
Renewable electricity by fuels



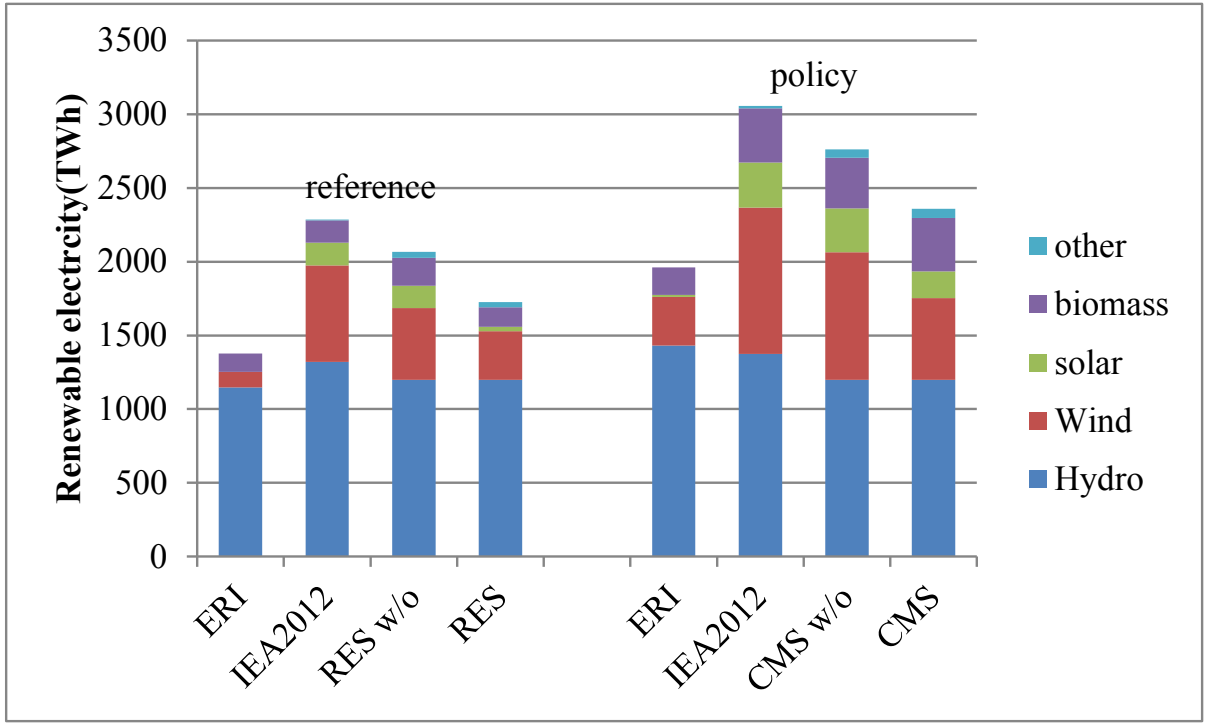


Substitution effect and share change





Comparison of renewable electricity in 2030, with other studies



Key Findings

This presentation explored the impact of intermittence in renewable power production on grid integration costs, coal electric power efficiency (penalty), structure change.

- Without carbon tax, renewable electricity in China continues to grow rapidly till 2035, reaches peak in 2050. But its share increase little till 2050. With carbon tax, renewable electricity is truly encouraged and keeps increasing in absolute amount and electricity share.
- Carbon tax does play the key role in encouraging renewable electricity development, especially for wind farm and solar. Compared to RES, wind farm and solar increase by 218% and 251% in 2050. Biomass with CCS more than 10 times.
- Before 2020, renewable electricity mainly substitutes electricity from coal generation in both scenarios. In the carbon policy scenario renewable electricity substitutes electricity more from nuclear and coal with CCS.

Conclusions

- Integration cost of VRE electricity does have important effect on RE competition in the future and reduce the economical attractiveness and competition. Due to coal efficiency penalty and integration cost, wind farm and solar without storage capability decrease by about 40% and 50% in 2050.
- CO2 emission reduction from renewable electricity in RES will be 1.81 GtCO2 in 2050. In CMS, 1.23 GtCO2 in 2050. In CMS, the total renewable electricity absolute amount is larger than that in RES, but the average emission factor is smaller and about 30% of RES level due to nuclear and CCS electricity share increase dramatically.

Further work

- What the future emission pathway in China ? (2020,2030,2050)
- High uncertainty
- Industry, transport and building sector emission path in the future?
- Feasibility for China contribution to 2 degree climate change target in 2050?

Your suggestions are welcome!