Accelerating power system decarbonization in China – An analysis based on SWITCH-China Model

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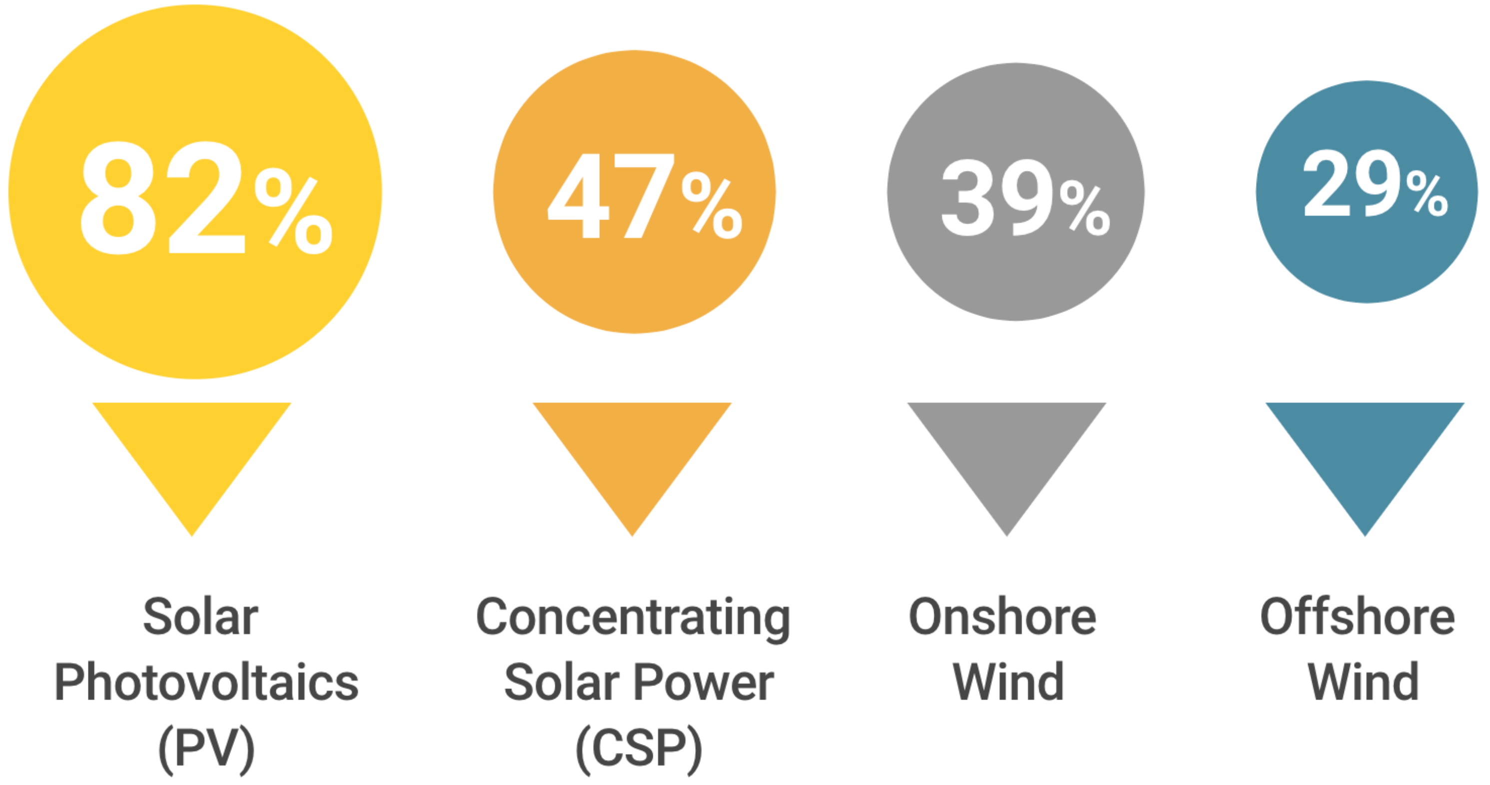
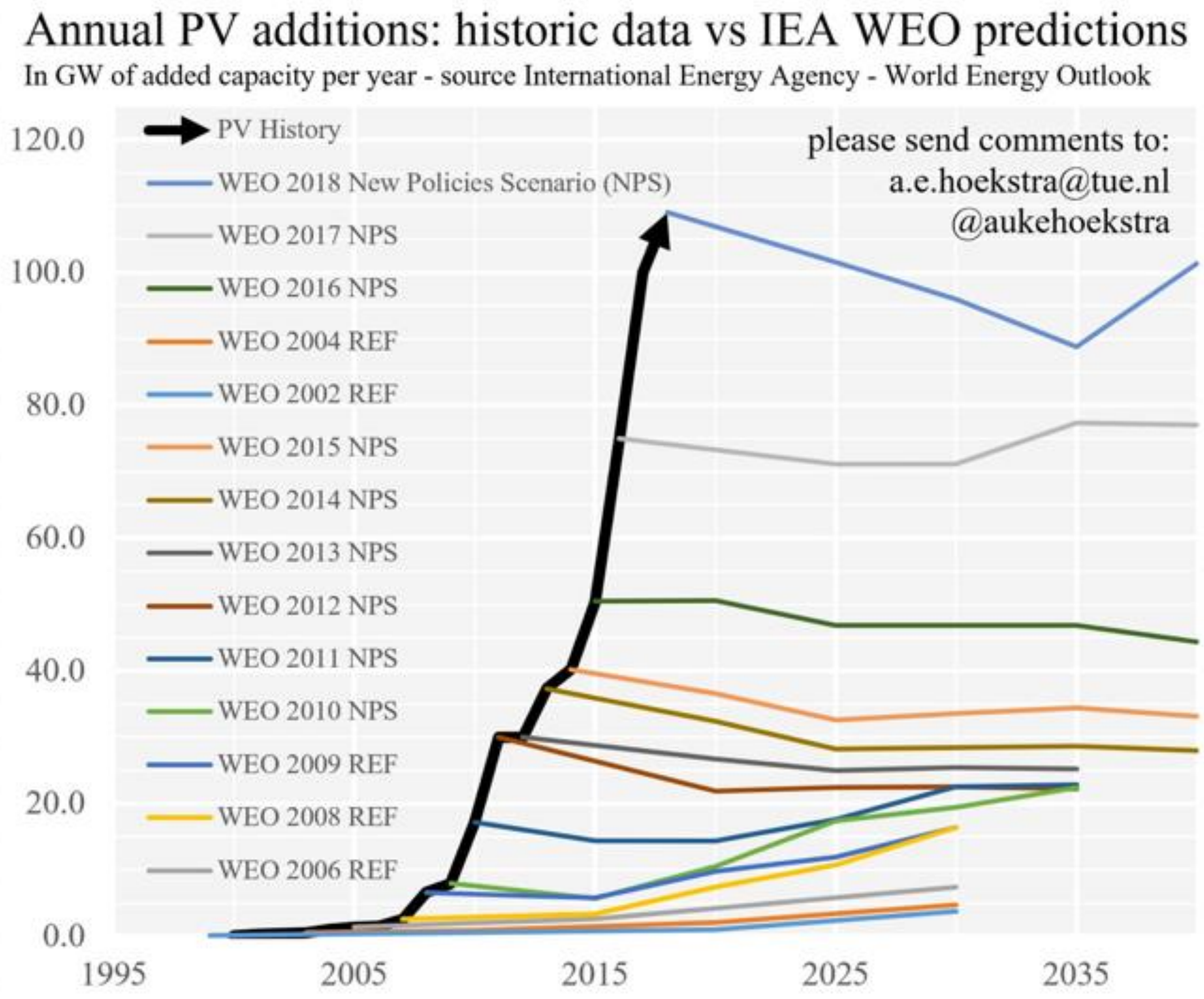
FALLING POWER GENERATION COSTS

Renewable energy costs declined rapidly over the last 10 years (2010-2019)



Source: IRENA 2020

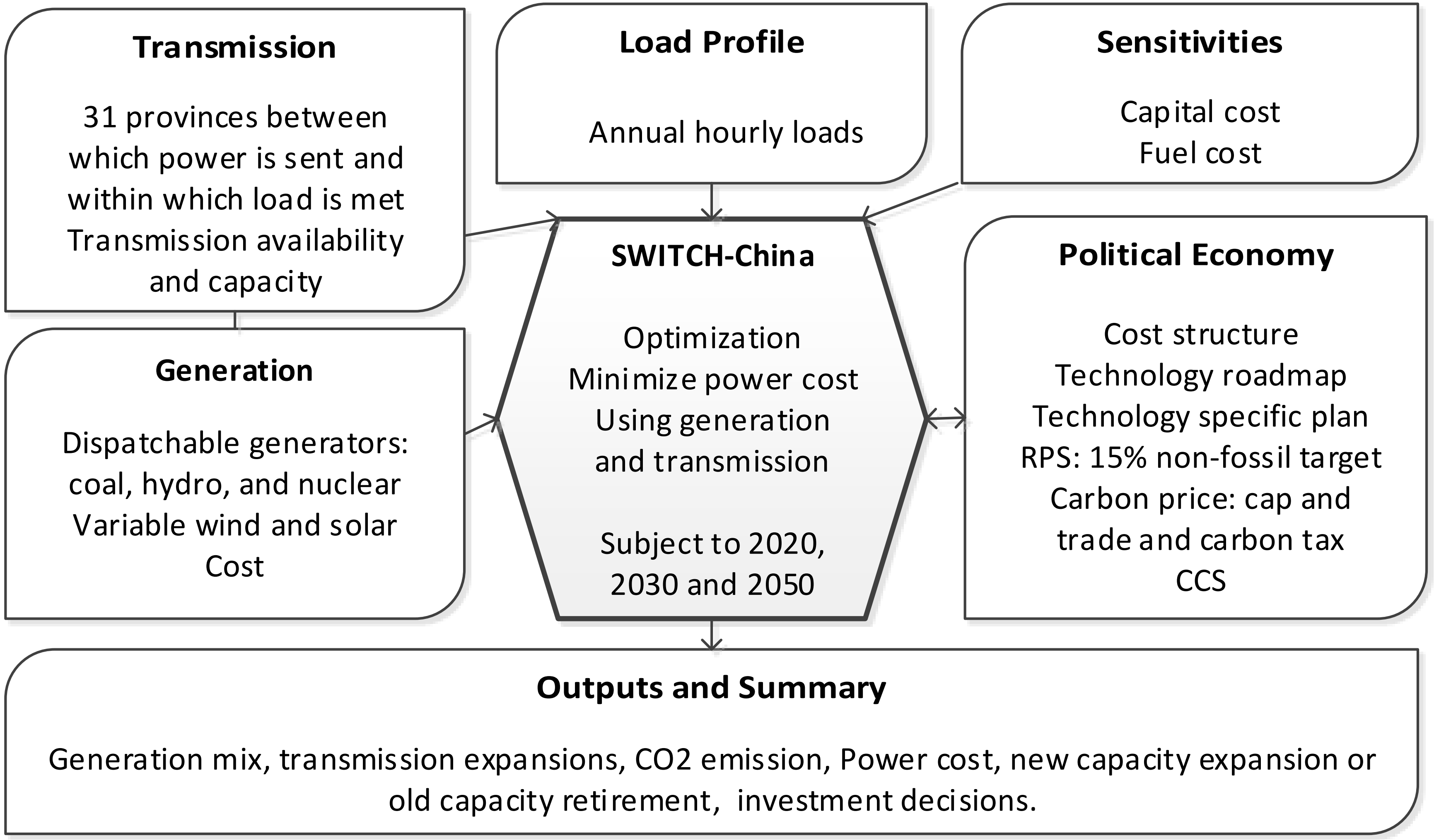
IEA has been ALWAYS underestimated PV installation



Research questions:

- How would China’s power system change if the renewables and storage cost trend continue?
- What are the costs to achieve those changes?
- How those changes would affect China’s regional pattern power system development?

SWITCH-China model structure

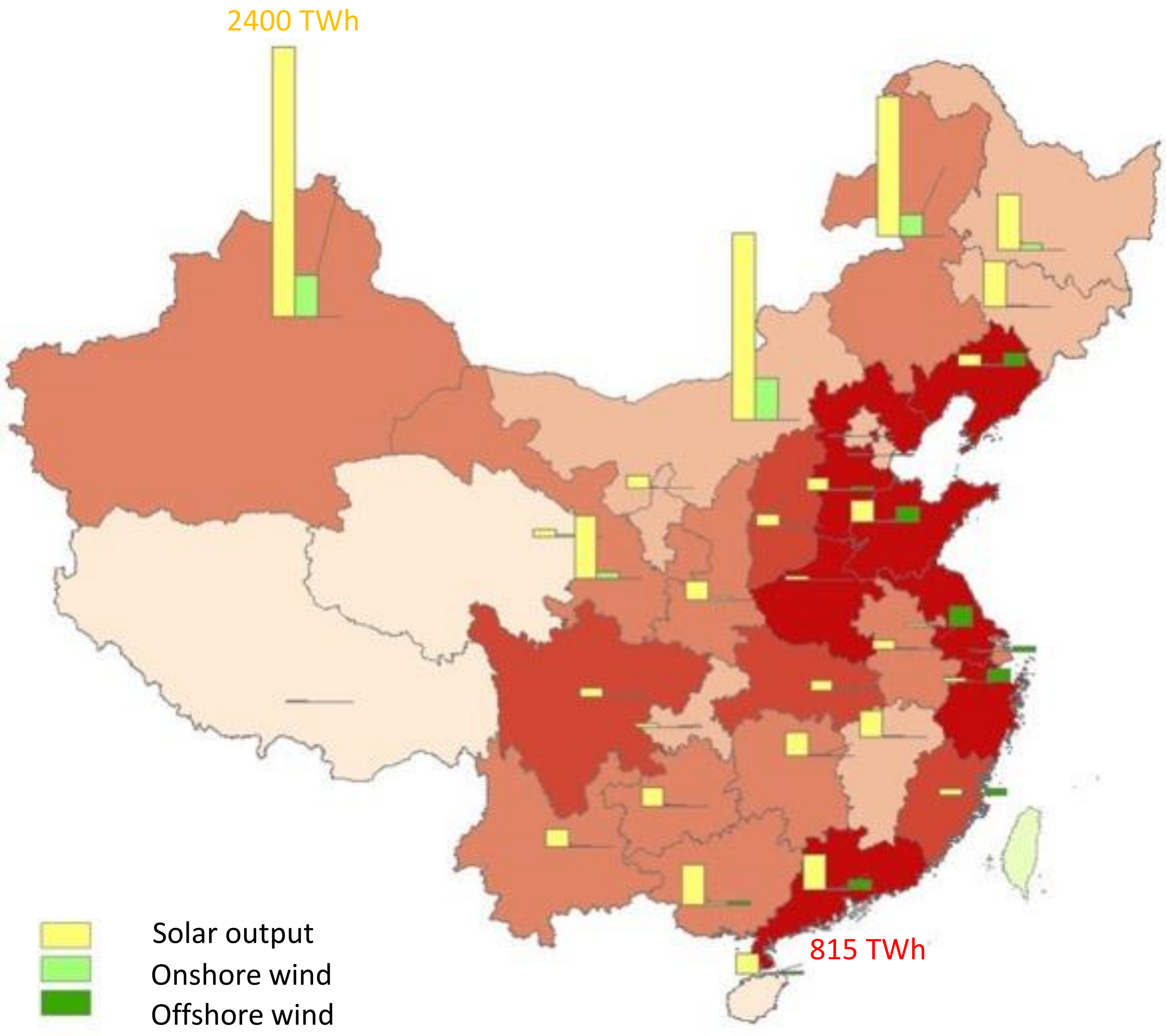


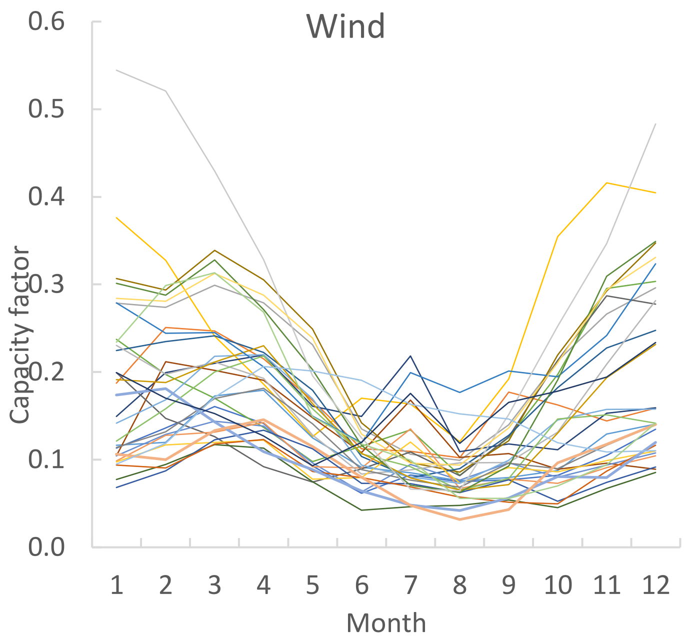
Objective function and constrains

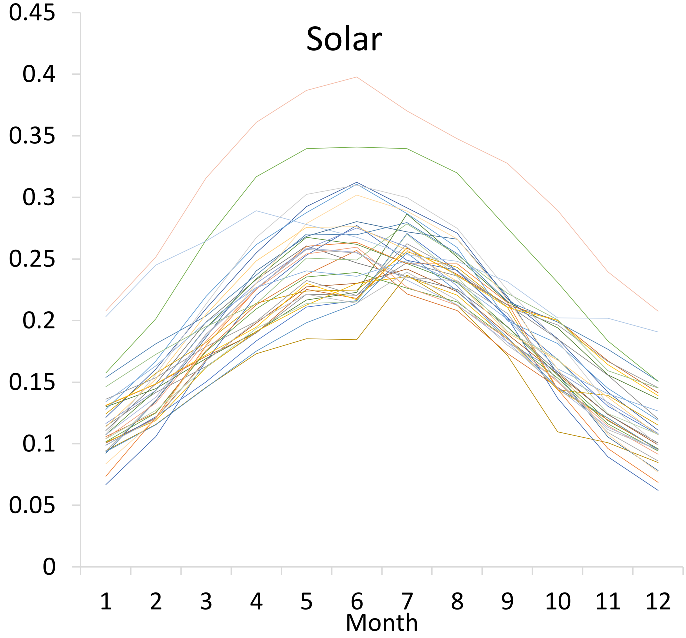
$$\min C = \sum_{T,i} G_{T,i} \cdot c_{T,i} + \sum_{g,i} G_{g,i} \cdot x_{T,i} + \sum_{T,i} O_{T,t} \cdot \left(m_{T,t} + f_{T,t} + c_{T,t}\right) \cdot hs_t + \sum_{a,a',i} T_{a,a',i} \cdot l_{a,a'} \cdot t_{a,a',i}$$

Constrains:

- Load meeting
- Reserve margin
- Operating reserve
- Non-fossil/RPS
- Carbon targets
- Operational







Source: He and Kammen, 2014. Where, when and how much wind is available? A provincial-scale wind resource assessment for China. Energy Policy. 74:116-122; He, Gang, and Daniel M. Kammen. 2016. “Where, When and How Much Solar Is Available? A Provincial-Scale Solar Resource Assessment for China.” Renewable Energy 85: 74–82.

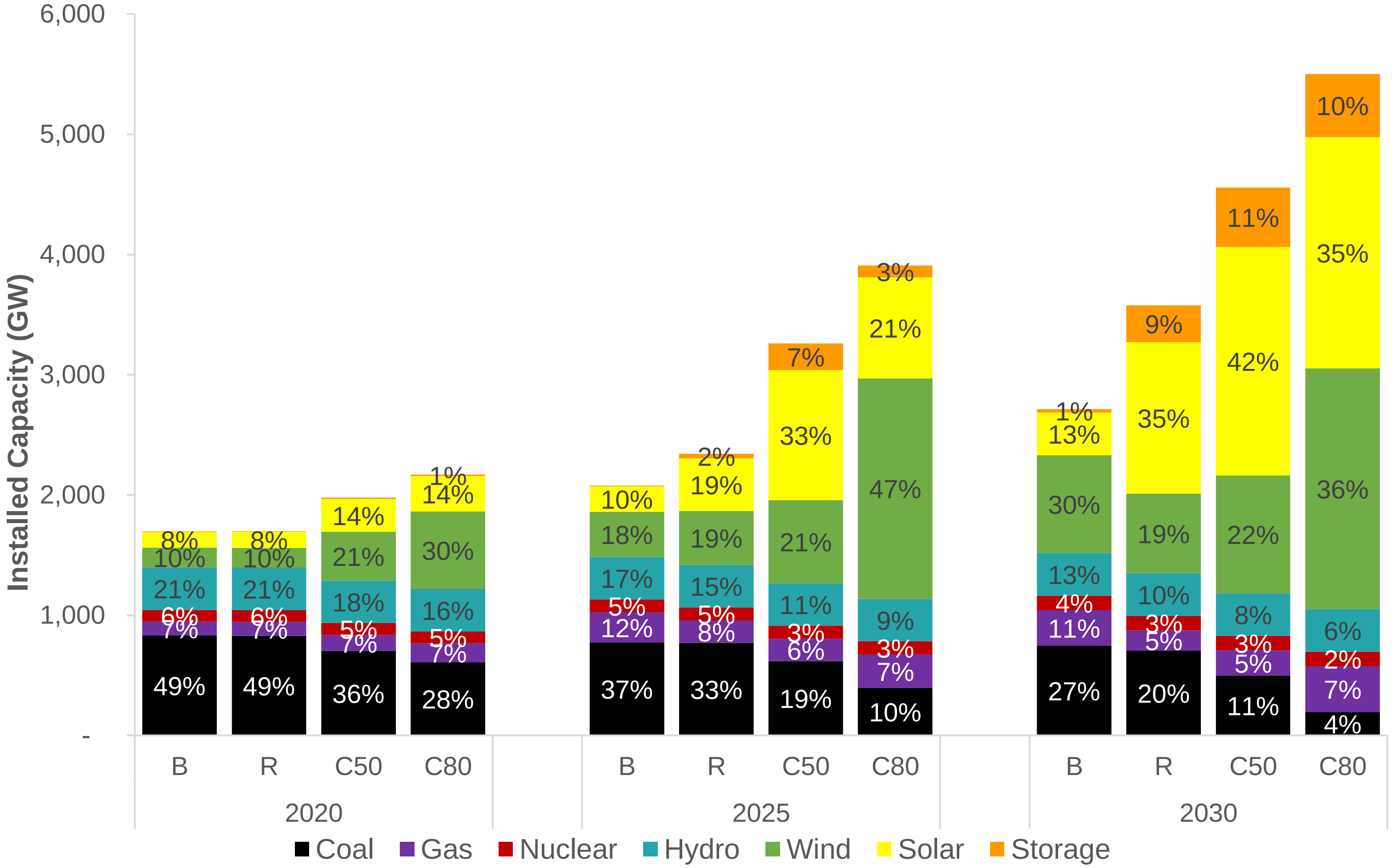
This Study: Scenarios

	Business as usual (B)	Low-cost renewables (R)	Carbon constraints (C50)	Deep carbon constraints (C80)
Base year	2015			
Existing Policies	Continuation of current policies and no new coal plants after 2020 because of tight regulations on air pollution and institution of carbon mitigation measures[11]			
Future Renewable Costs Assumptions	Utilizing conventional models for future renewable costs	Rapid decrease in costs for renewables and storage continues: dramatic decreases in wind, solar, and storage costs as projected by Lawrence Berkeley National Laboratory (LBNL) and the National Renewable Energy Laboratory (NREL)		
Carbon constraints	No	No	50% reduction in power sector CO_2 from 2015 level by 2030	80% reduction in power sector CO_2 from 2015 level by 2030

LCOE comparison between the BAU, R and C scenarios, and LBNL studies

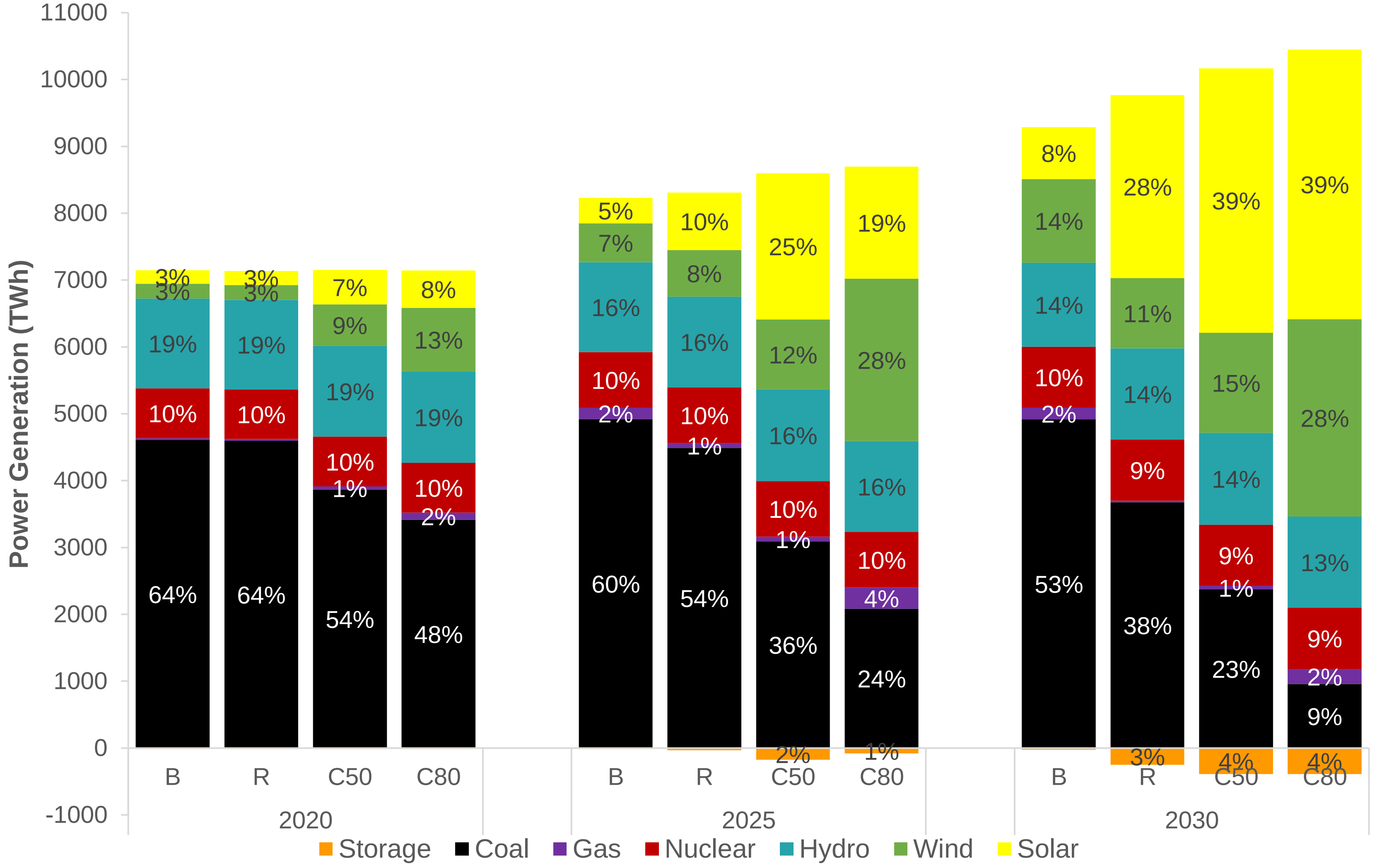
Source: He, Gang, Jiang Lin, et al. 2020. "Rapid Cost Decrease of Renewable Energy and Storage Offers an Opportunity to Accelerate the Decarbonization of China's Power System." *Nature Communications* 11(1).

National Capacity mix



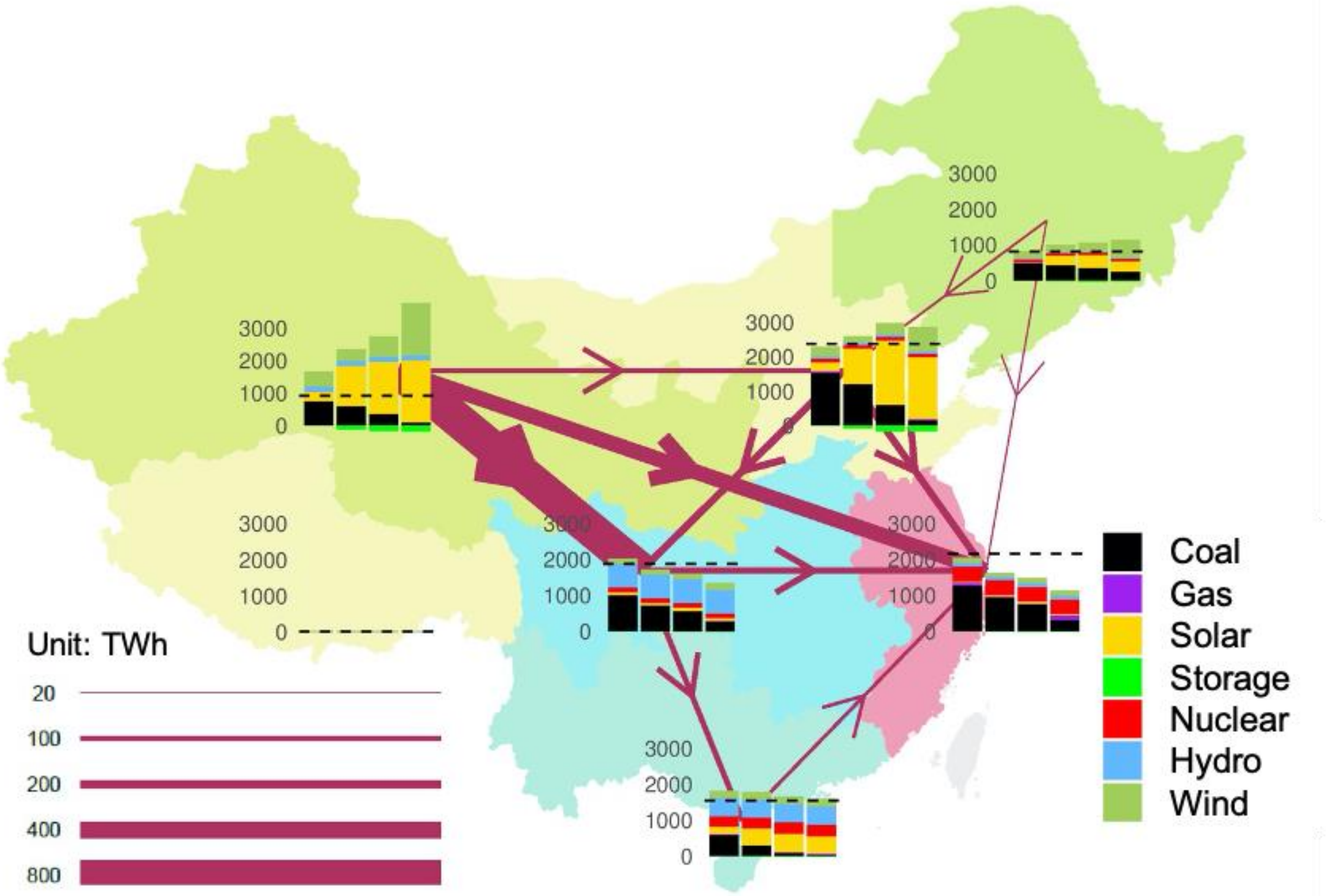
Source: He, Gang, Jiang Lin, et al. 2020. “Rapid Cost Decrease of Renewable Energy and Storage Offers an Opportunity to Accelerate the Decarbonization of China’s Power System.” *Nature Communications* 11(1).

National Generation mix



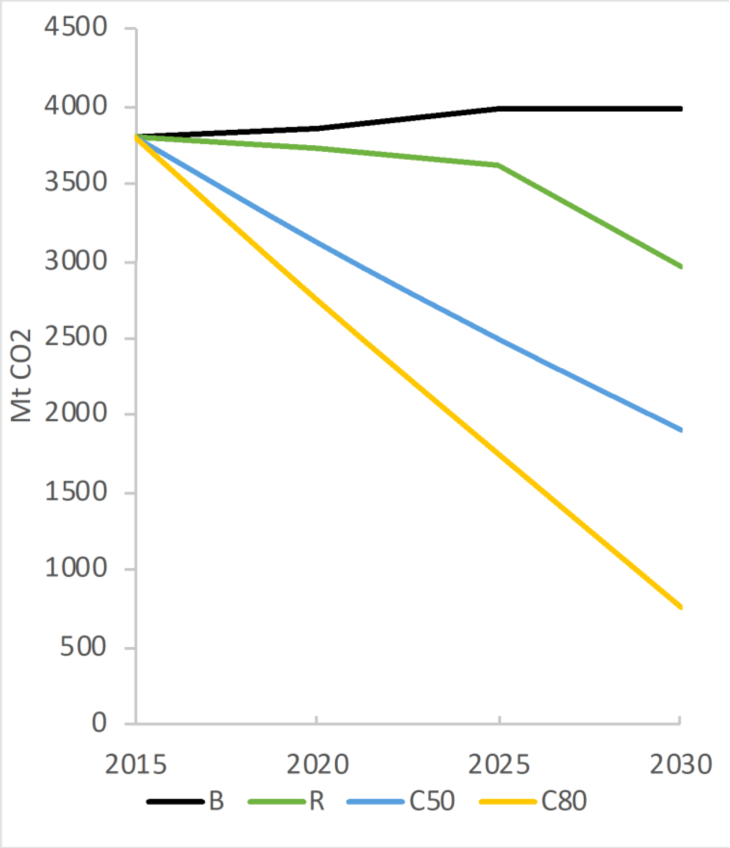
Source: He, Gang, Jiang Lin, et al. 2020. “Rapid Cost Decrease of Renewable Energy and Storage Offers an Opportunity to Accelerate the Decarbonization of China’s Power System.” *Nature Communications* 11(1).

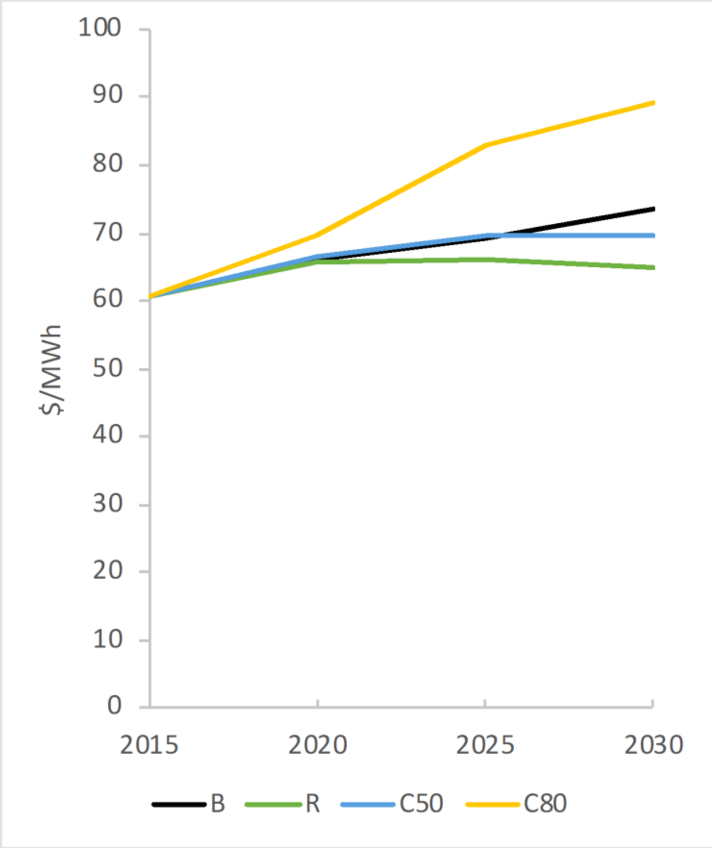
Regional transmission instruction needed



Source: He, Gang, Jiang Lin, et al. 2020. “Rapid Cost Decrease of Renewable Energy and Storage Offers an Opportunity to Accelerate the Decarbonization of China’s Power System.” *Nature Communications* 11(1).

Carbon emissions and power costs





Source: He, Gang, Jiang Lin, et al. 2020. “Rapid Cost Decrease of Renewable Energy and Storage Offers an Opportunity to Accelerate the Decarbonization of China’s Power System.” *Nature Communications* 11(1).

Conclusions & Discussions

- Global weighted-average cost of electricity of utility-scale solar PV, onshore wind, and battery storage in China plummeted by 82%, 39%, and ~88 %, respectively, between 2010 and 2019.
- If these trends continue, our results show that 62% of China's electricity could come from non-fossil sources by 2030 at a cost that is 11% lower than achieved through a business-as-usual approach...
- China's power sector could cut half of its 2015 carbon emissions at a cost about 6% lower compared to business-as-usual conditions, but 7% higher power cost than in the Low-cost Renewables Scenario.
- An 80% reduction on 2015 level by 2030 is technical feasible, with about 37% higher power cost than in the renewable scenario, and a \$21/tCO_2 cost of conserved carbon.

Contributions

- Reveals the implications of cost decrease on power systems and new perspectives on clean power transition.
- Demonstrates the impact of a fast cost decrease of renewable and storage source, a scenario that could apply to the United States.
- Reveals fast decarbonization is both technically feasible and economically beneficial, which offers the prospect of large emissions mitigation with a global environmental impact.

Uncertainties

- Can the price decrease sustain?
- Scale of the infrastructure
- Technology inertia and lock in
- Industry policy
- Power sector reform
- Storage: material, life cycle, etc
- Just transition, social economic impacts

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ARTICLE

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https://doi.org/10.1038/s41467-020-16184-x OPEN

Rapid cost decrease of renewables and storage accelerates the decarbonization of China's power system

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One Earth

Gold Standard for the Global Goals | 1 ton of CO_2 offset

CellPress

Perspective

Enabling a Rapid and Just Transition away from Coal in China

Gang He,[1,2,*] Jiang Lin,[2,3] Ying Zhang,[4] Wenhua Zhang,[1,5] Guilherme Larangeira,[1] Chao Zhang,[6] Wei Peng,[7] Manzhi Liu,[8] and Fuqiang Yang[9]

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Related Publications

- He, Gang, Jiang Lin, Froylan Sifuentes, Xu Liu, Nikit Abhyankar, and Amol Phadke. 2020. Rapid Cost Decrease of Renewables and Storage Accelerates the Decarbonization of China's Power System. *Nature Communications* 11 (1): 2486. https://doi.org/10.1038/s41467-020-16184-x.
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- Gang He, Anne-Perrine Avrin, James H. Nelson, Josiah Johnston, Ana Mileva, Jianwei Tian, and Daniel M. Kammen. 2016. SWITCH-China: A Systems Approach to Decarbonizing China's Power System. *Environmental Science and Technology*. 50(11):5467–5473.
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- Jianlin Hu, Lin Huang, Mindong Chen, Gang He, Hongliang Zhang. 2017. Impacts of Power Generation on Air Quality in China - Part II: Future Scenarios. *Resources, Conservation and Recycling*. 121:115–127.
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- Manzhi Liu, Meng Chen, and Gang He. 2017. The Origin and Prospect of Billion-Ton Coal Production Capacity in China. Resources, Conservation and Recycling 125: 70–85.

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Thank You!

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