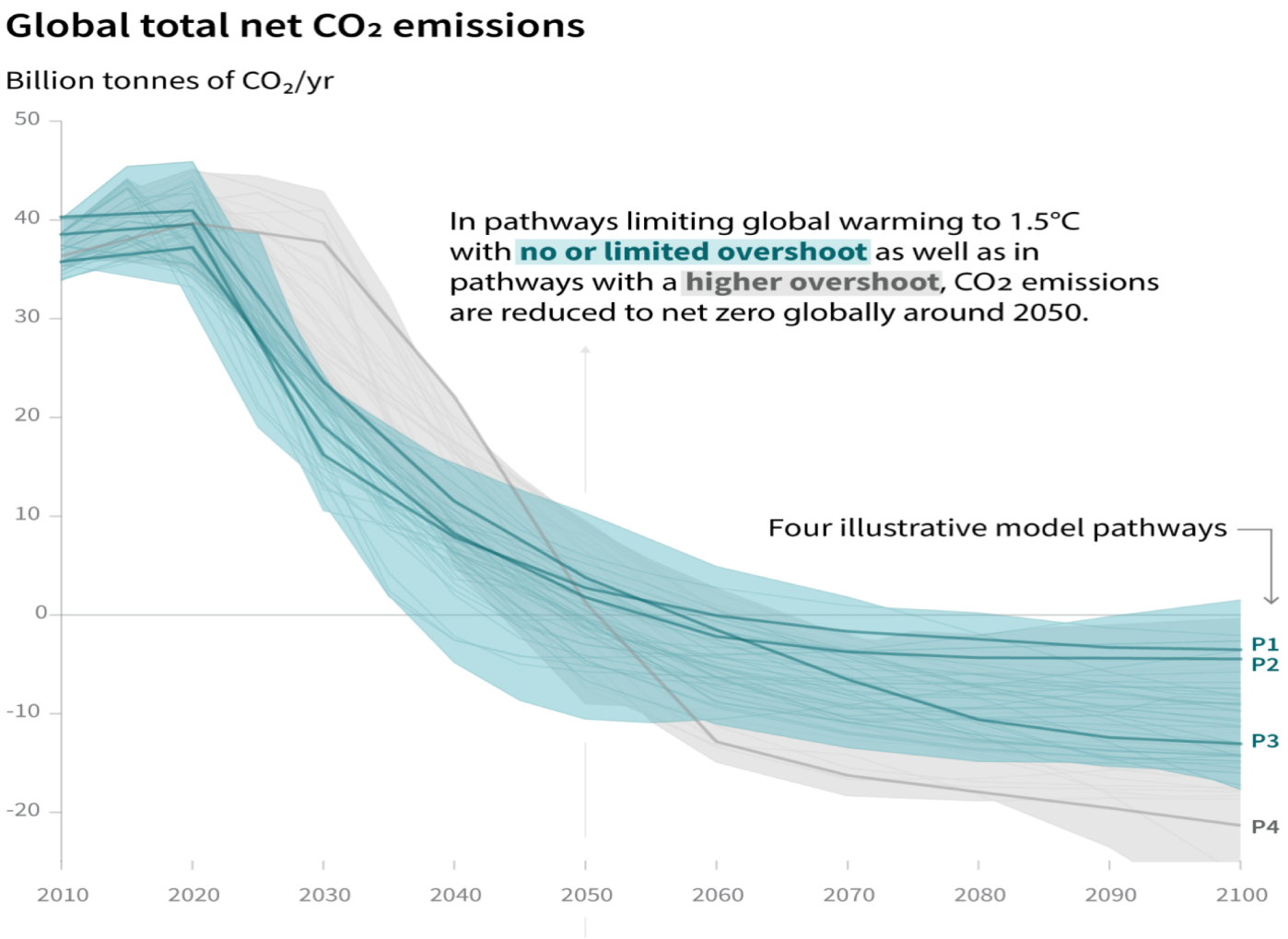
Sunsetting Coal Power in China

Jiang Lin

Lawrence Berkeley National Laboratory
University of California, Berkeley

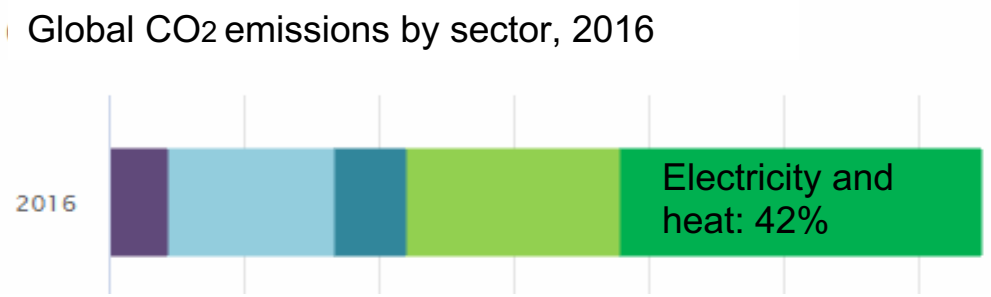
F Kahrl, J Lin, X Liu, and JF Hu, 2019, "Sunsetting coal power in China," IEAD Working Paper 007

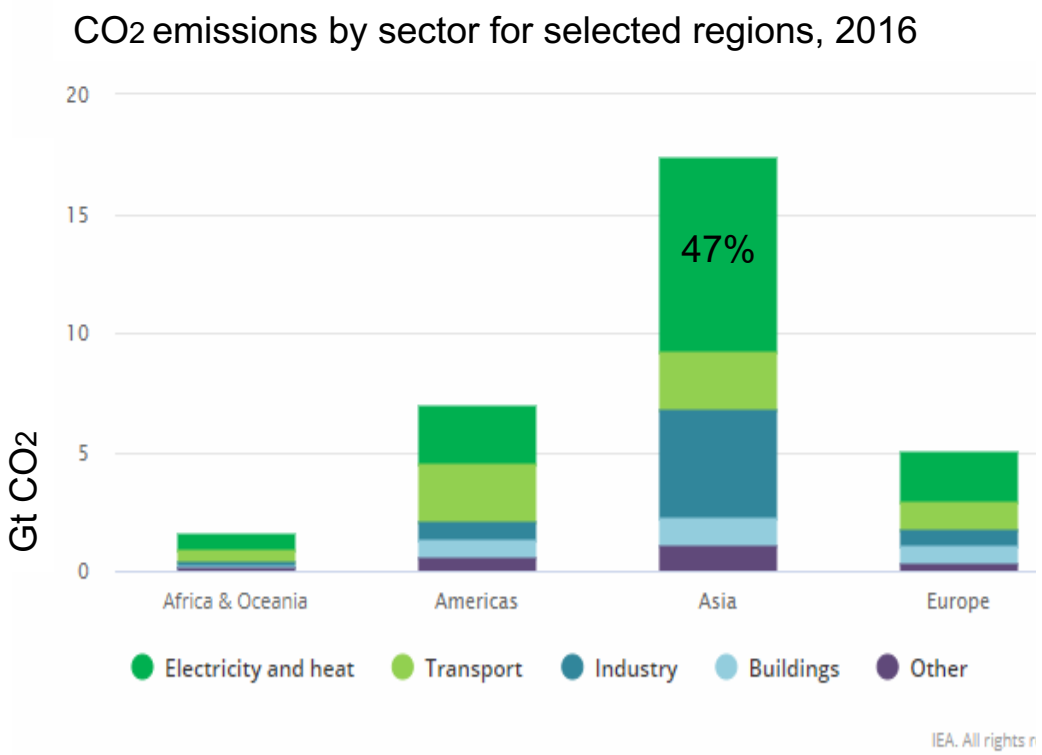
Net zero emissions by 2050 to achieve the 1.5 degree C goal



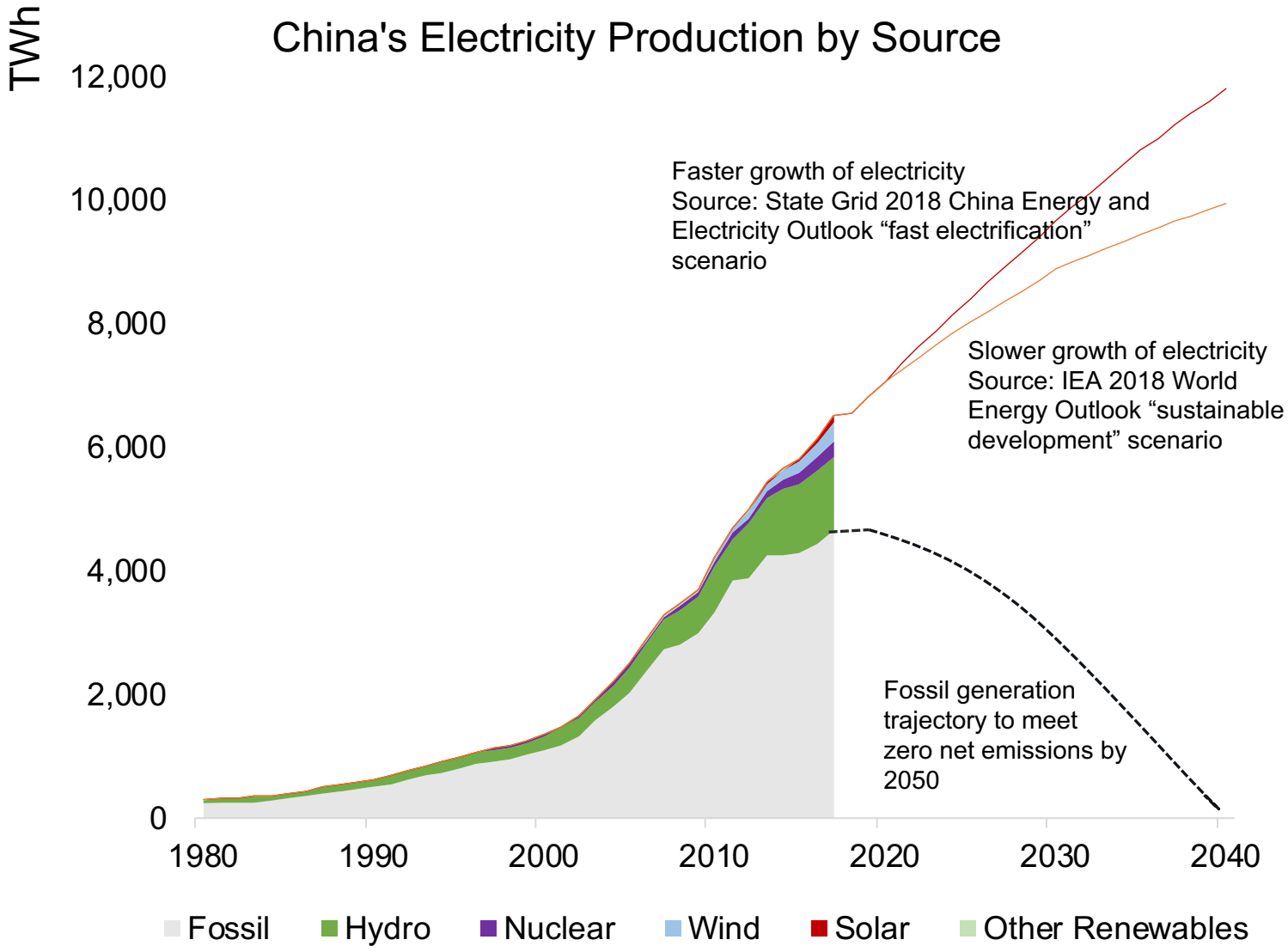
Source: IPCC (2018) Summary for Policymakers. In: Global Warming of 1.5°C.

All unabated coal generation needs to go to zero





Source: IEA (2019)



Research Questions

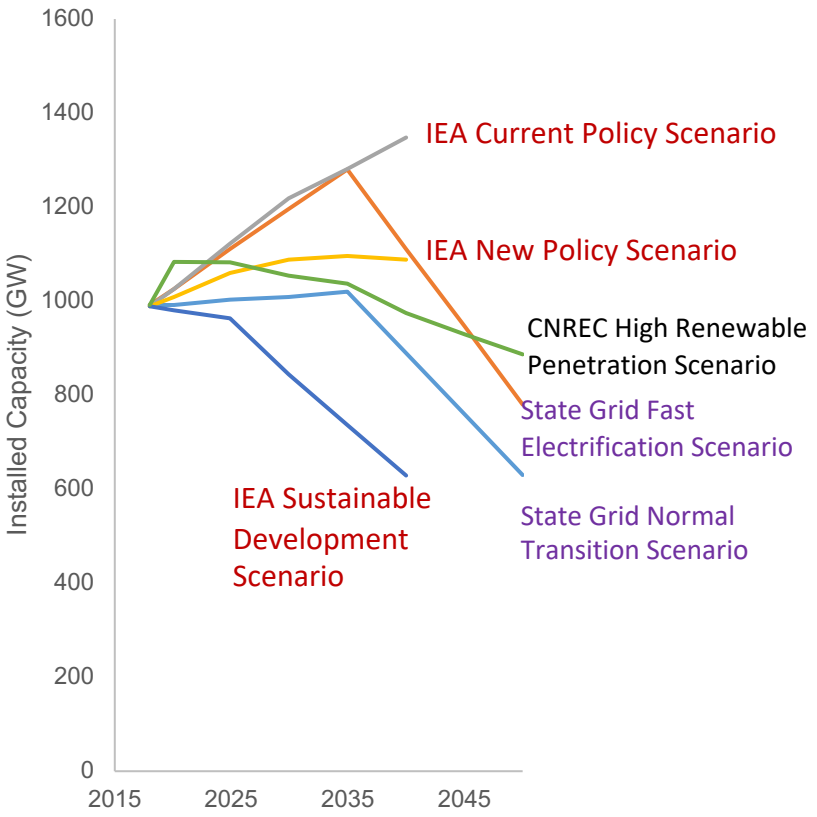
- Can coal generation in China be substantially reduced or completely replaced by 2040?
  - Under what conditions would make this coal generation phase-out possible, while meeting reliability needs, and without significant stranded assets?
  - What institutional changes are needed to support the transition to the condition above?

Importance of China’s Power System

- China’s power sector accounts for roughly 13-15% of global energy-related CO_2 emissions
- Rapid decarbonization of China's power system is one of the most significant actions that can be taken to address global climate change
- Zero-emissions power system is essential to decarbonize China’s industry, building, and transportation sectors through electrification
- A clean power system also supports China’s development goals such as *Ecological Civilization* and the vision of *A Beautiful China*

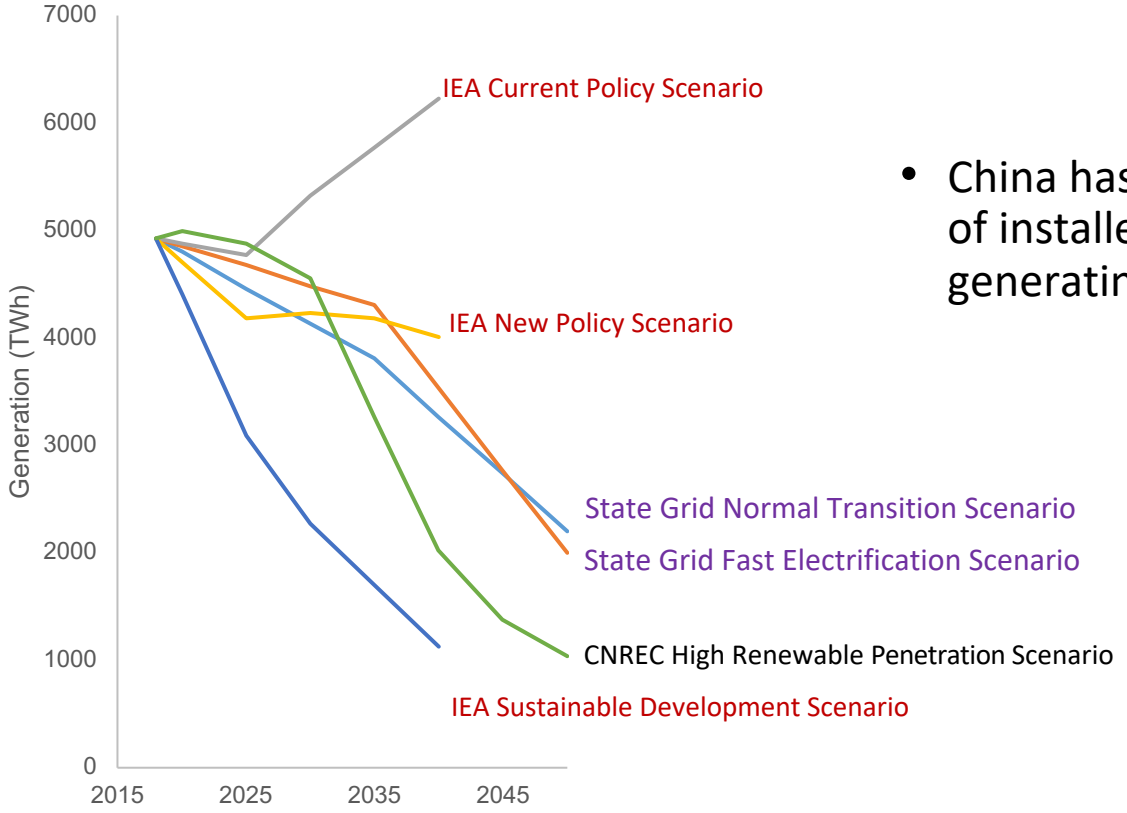
Many Studies Show Significant Levels of Coal Power Generation Requirements in China in 2040 and 2050

Installed Coal Capacity



Annual Coal Generation

in Studies of China's Long-Term Electricity Needs

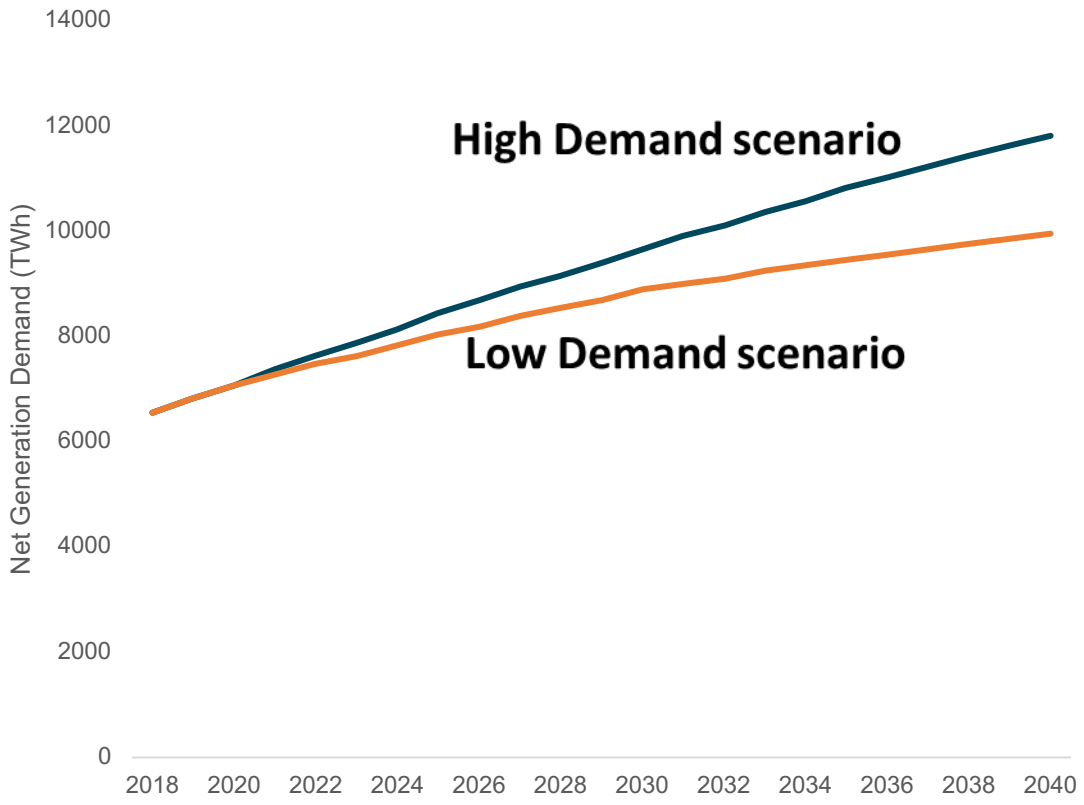


- China has more than 1 TW of installed coal generating capacity

Scenario Analysis of Our Study

- Four Scenarios in total: Two demand scenarios X Two renewable scenarios
  - HDHR – high demand high renewables
  - HDLR – high demand low renewables
  - LDHR – low demand high renewables
  - LDLR – low demand low renewables

China Power Demand Assumptions



High Demand scenario

- 11,811 TWh of total net generation in 2040
- Based on State Grid 2018 China Energy and Electricity Outlook “fast electrification” scenario

Low Demand scenario

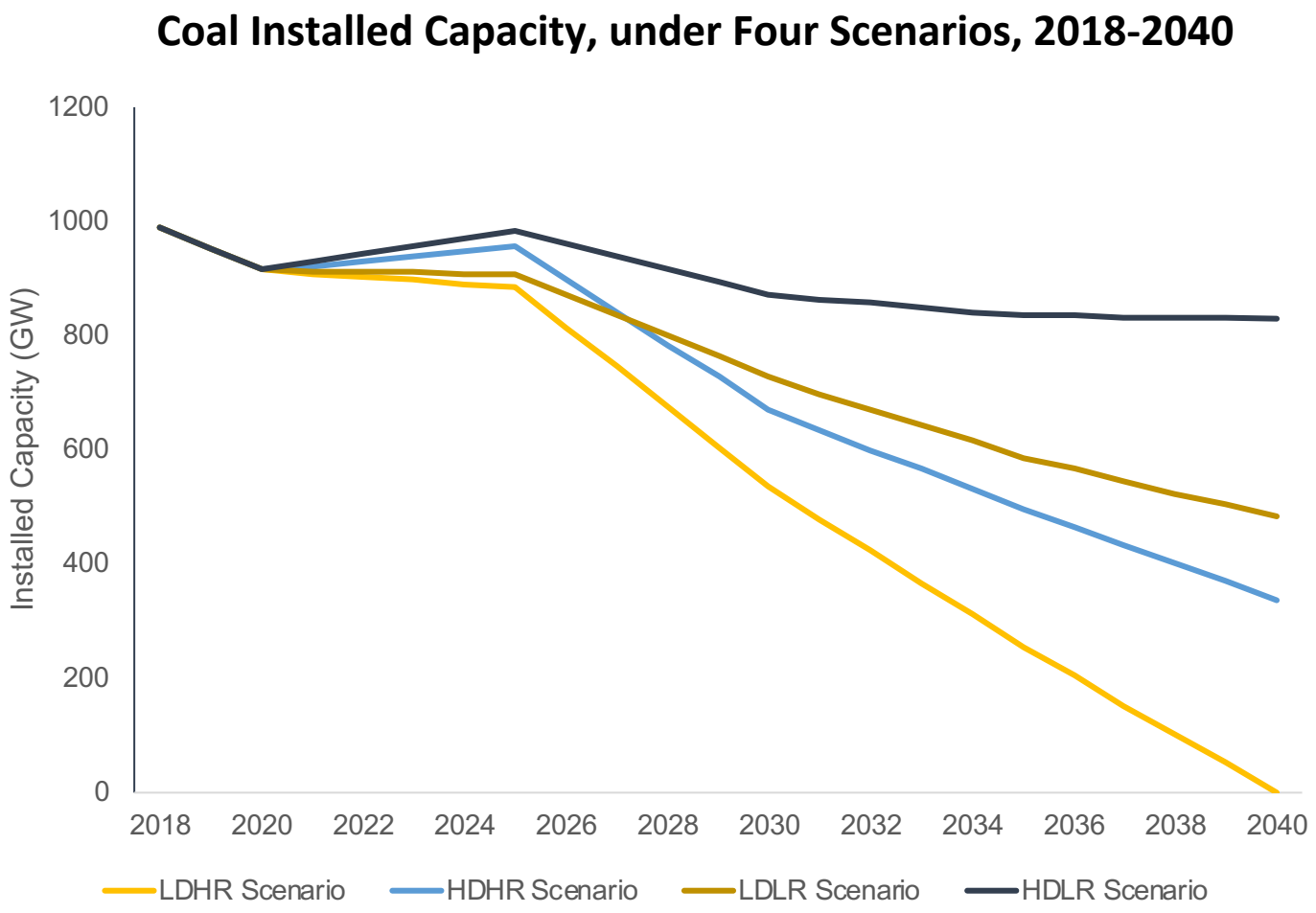
- 9,952 TWh of total net generation in 2040
- Based on IEA 2018 World Energy Outlook “sustainable development” scenario

Renewable Energy Assumptions

- High Renewable (HR) scenario: significantly increase wind, solar PV, and energy storage capacity to allow coal capacity to be fully retired by 2040
- Low Renewable (LR) scenario: increase wind, solar PV, and energy storage capacity to allow installed coal capacity to initially decline by 2030, then to flatten out after that
- Both scenarios contain the same amount of conventional hydropower, natural gas, and nuclear generation capacity

Results

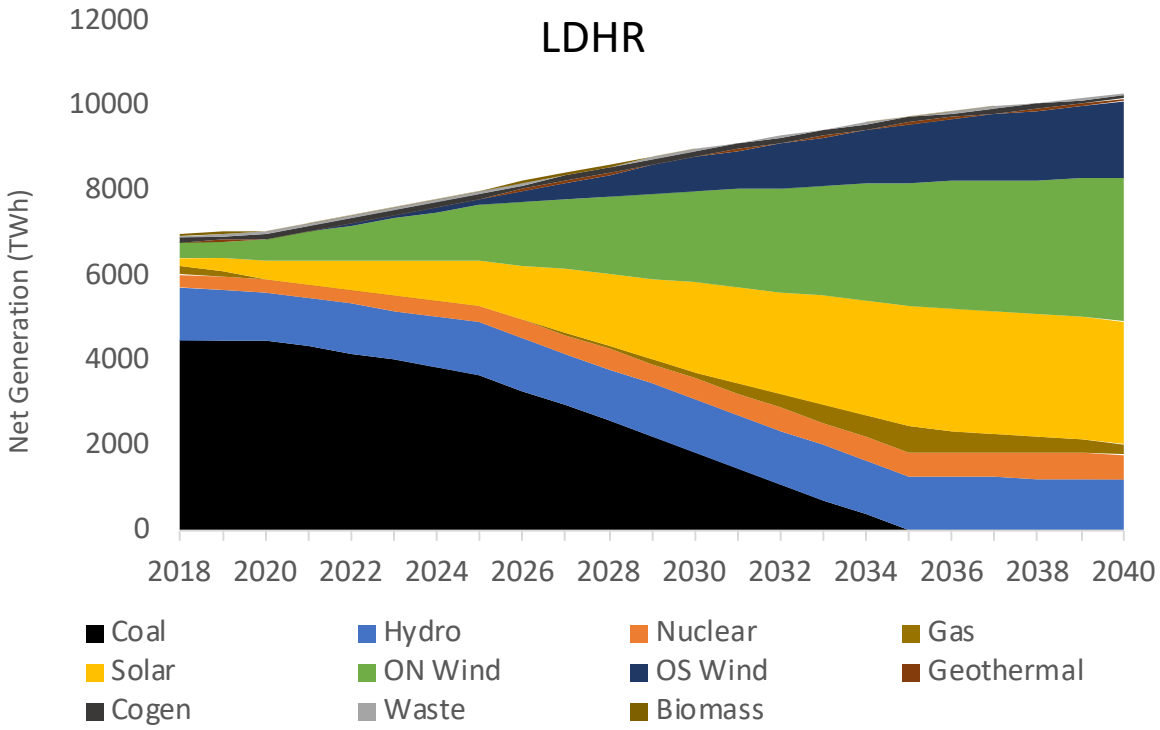
Coal capacity in LDHR scenario falls to zero by 2040

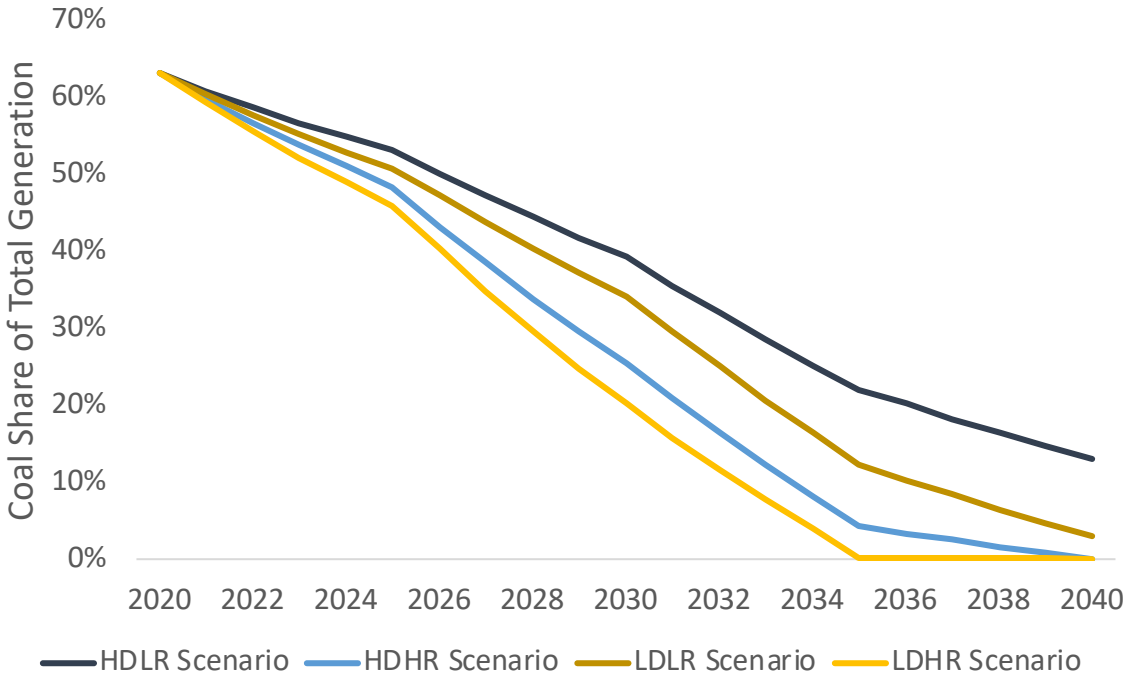


- LDHR scenario: no coal capacity by 2040
- HDHR scenario: around 340 GW of coal capacity for reliability needs by 2040
- LR scenarios: 500 – 800 GW of coal capacity by 2040

No coal generation in HR scenarios, and less than 15% of total generation in LR scenarios by 2040

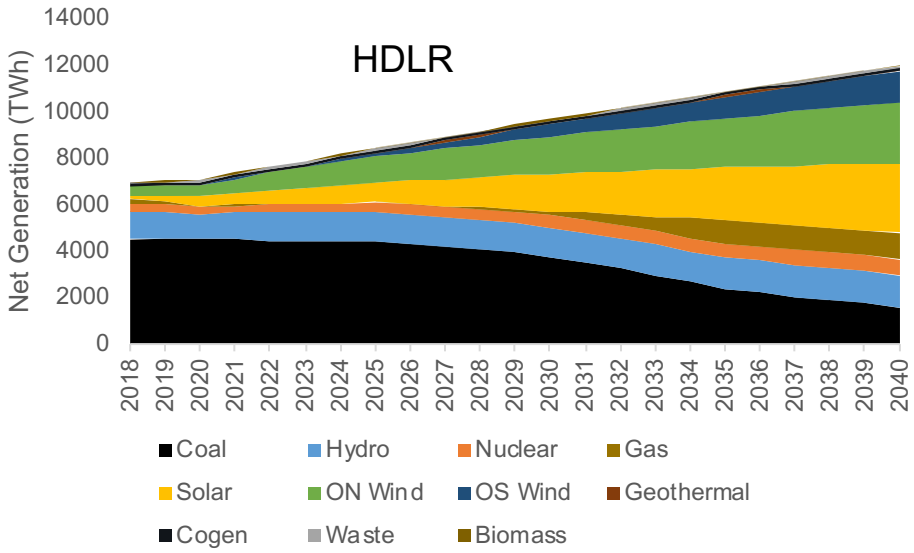
Generation Fuel Mix under LDHR and Share of Coal Generation Under Four Scenarios, 2018-2040

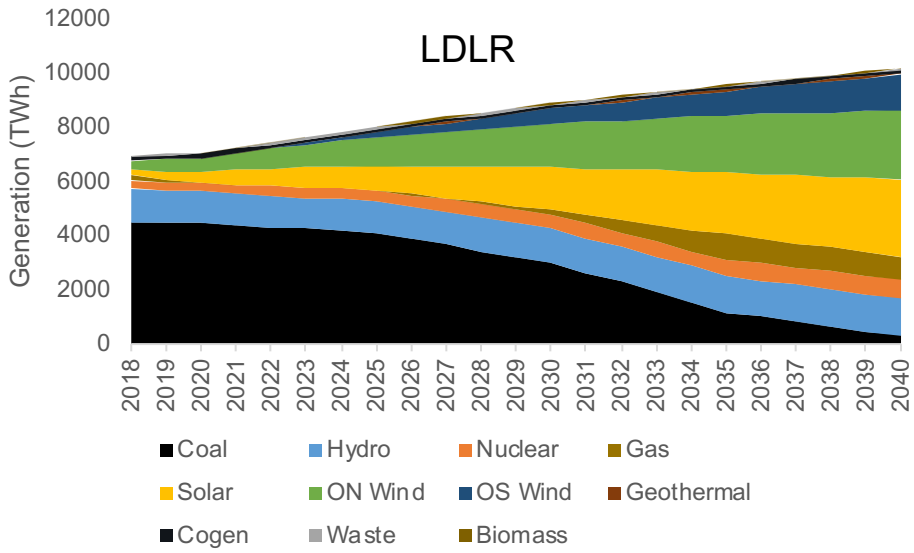


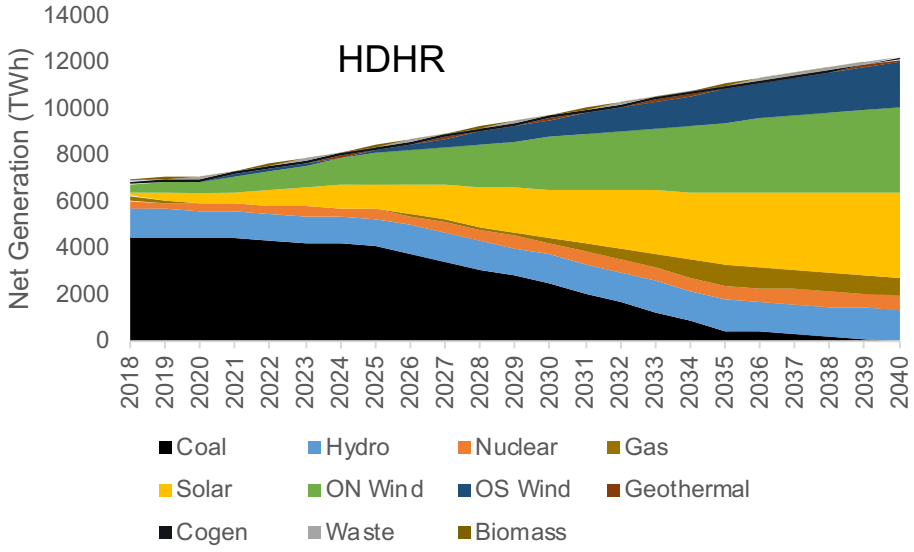


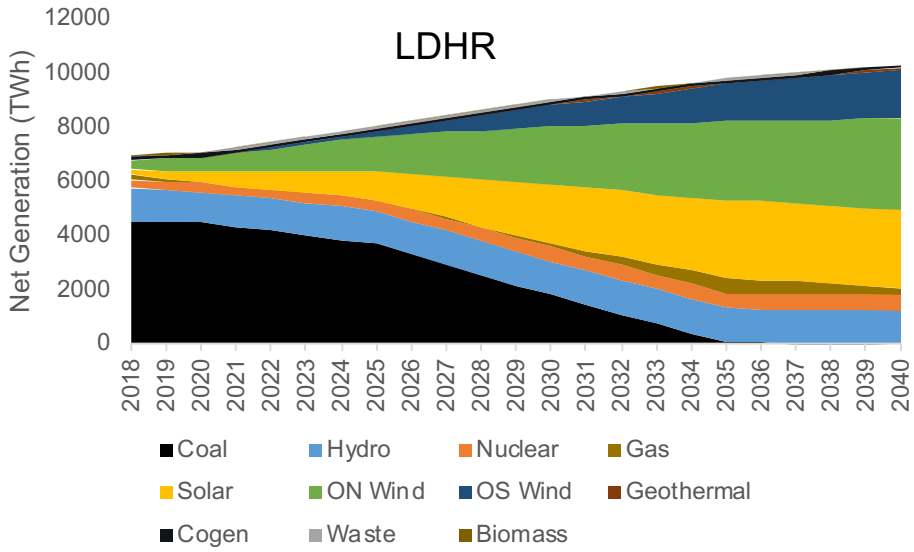
- Both HR scenarios: no coal generation by 2040
- LDLR scenario: 300 TWh yr^{-1} of coal generation by 2040
- HDLR scenario:1,600 TWh yr^{-1} of coal generation in 2040

Generation Fuel Mix under Four Scenarios

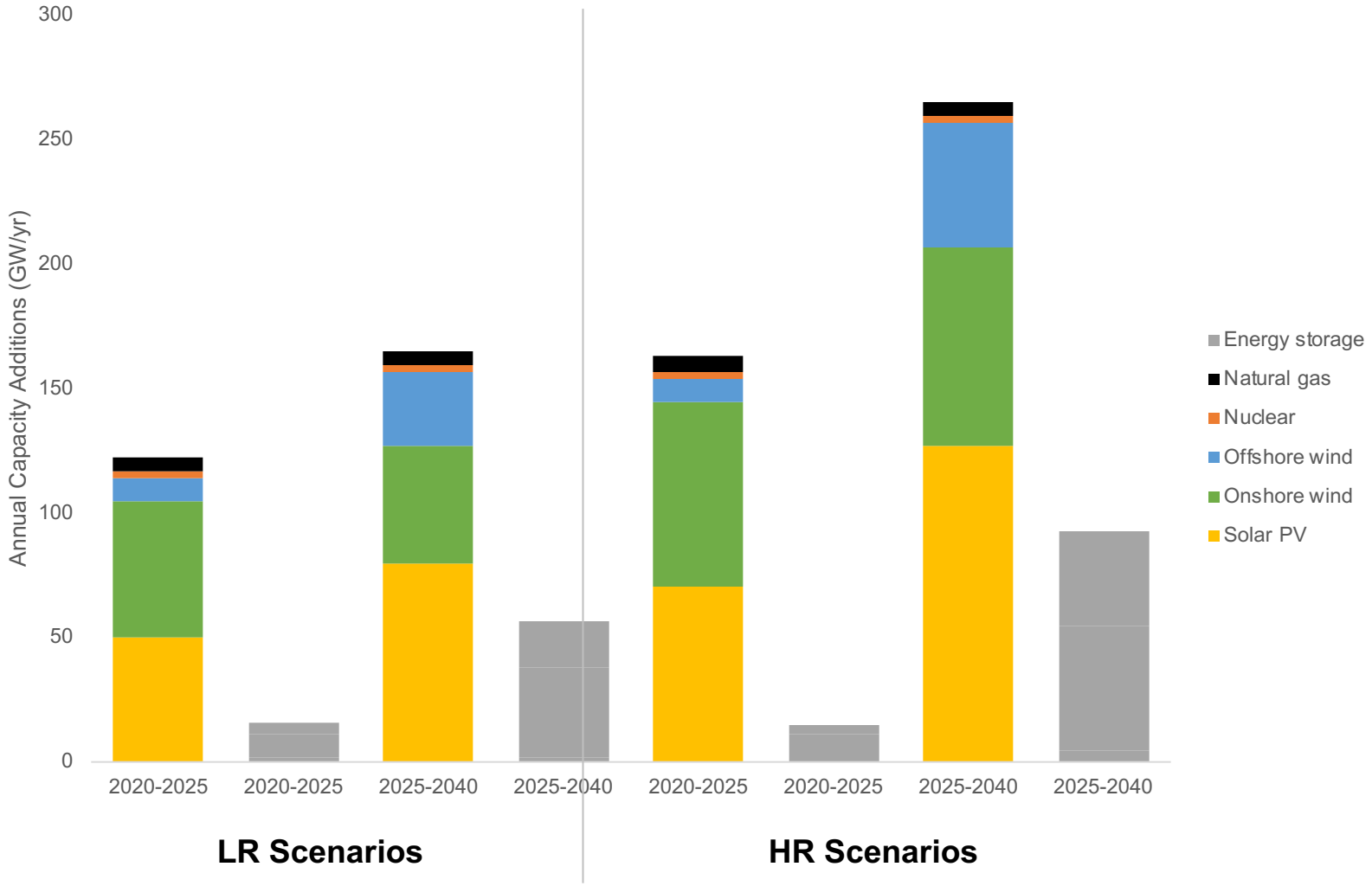








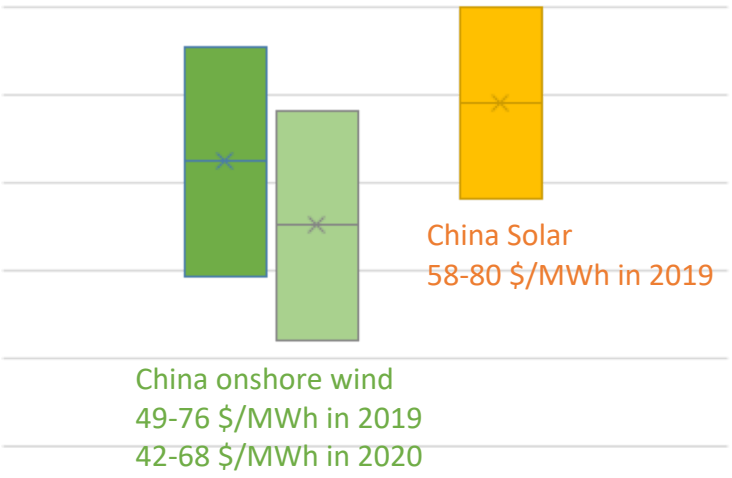
Capacity additions: >doubling solar and wind capacity from 2020-2025



- Significant solar, wind, battery additions needed in both the HR and LR scenarios from 2020-2025
  - ~50-70 GW/yr of solar
  - ~64-84 GW/yr of wind
  - ~16GW/yr of storage
- Significant shift in power system economics from (capital + fuel) costs to mostly capital costs

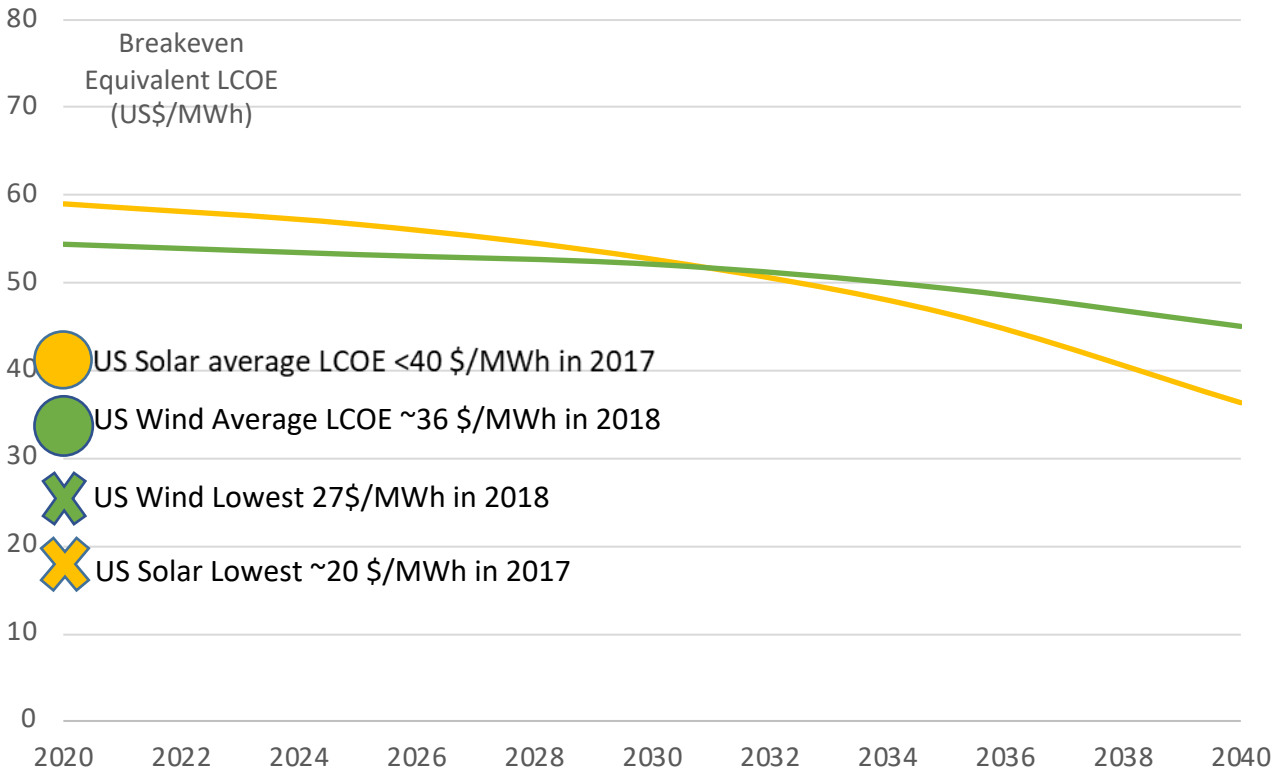
Continued declines in solar PV and wind costs are needed to make LDHR cost-effective

China Current Solar and Wind Cost (2018 US$/MWh)



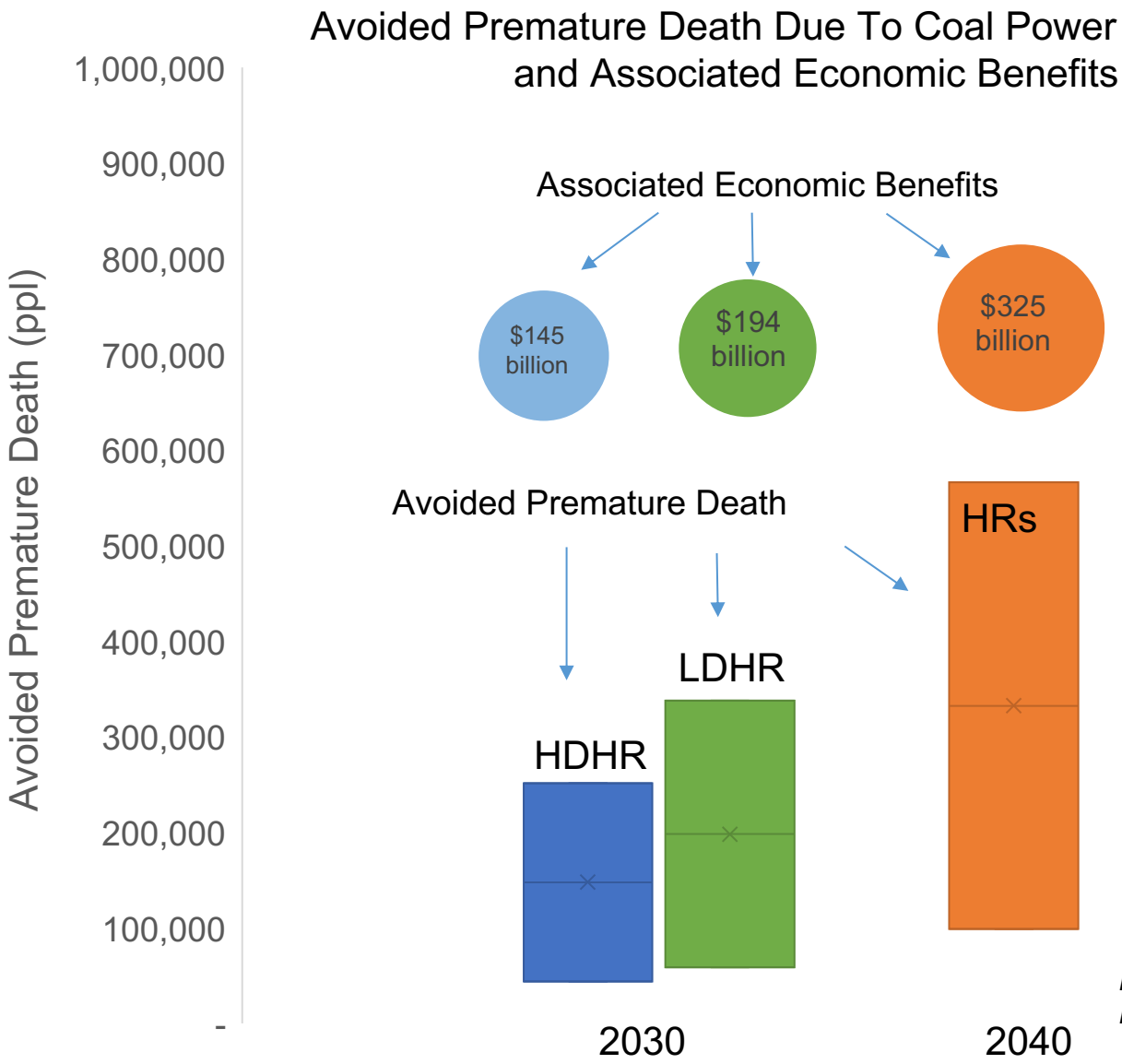
Source: Data are from NDRC website (2019)

Implied Breakeven Costs (2018 US$/MWh) for Solar PV and Wind Over Time, LDHR Scenario

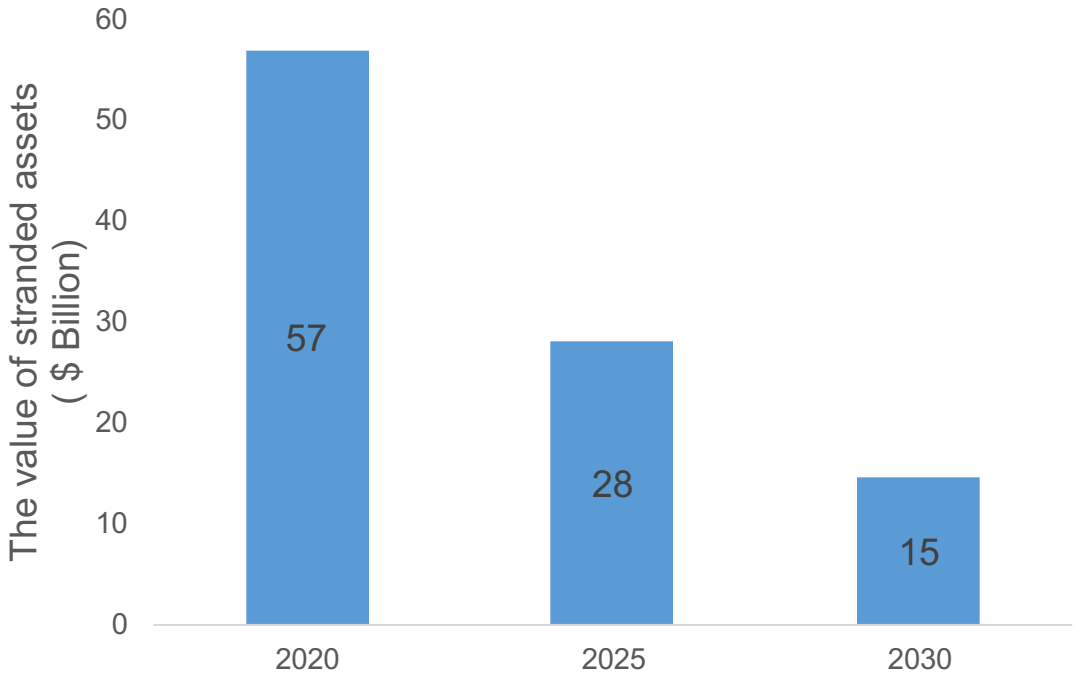


Source: Data are from LBNL (2019). Utility-Scale Solar 2018 Edition Report and LBNL (2019). The Wind Technologies Market Report.

Over 44,000 – 338,000 premature death could be avoided with more than $145 billion economic benefits under HR in 2030



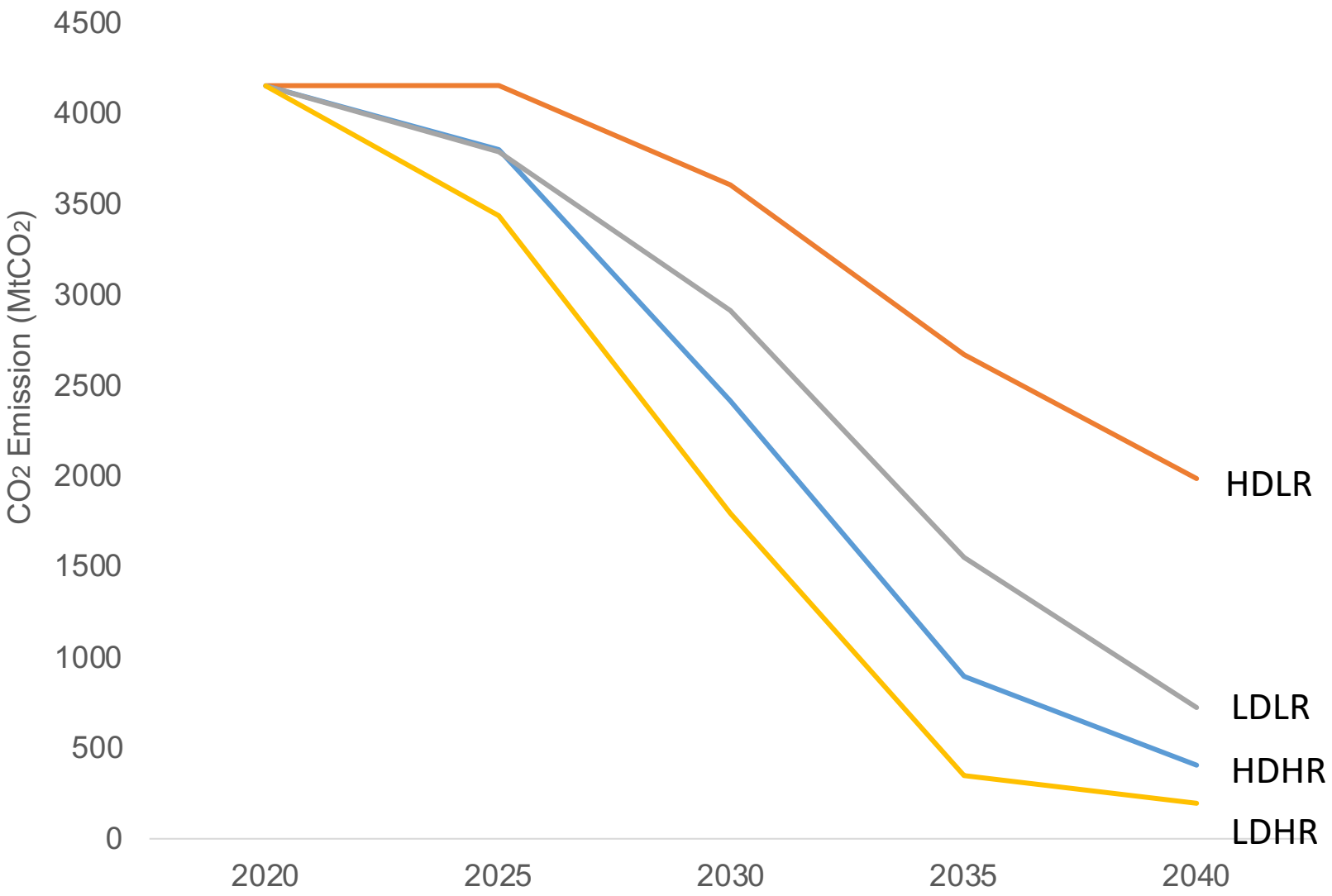
About 10 times of estimated stranded assets in 2030



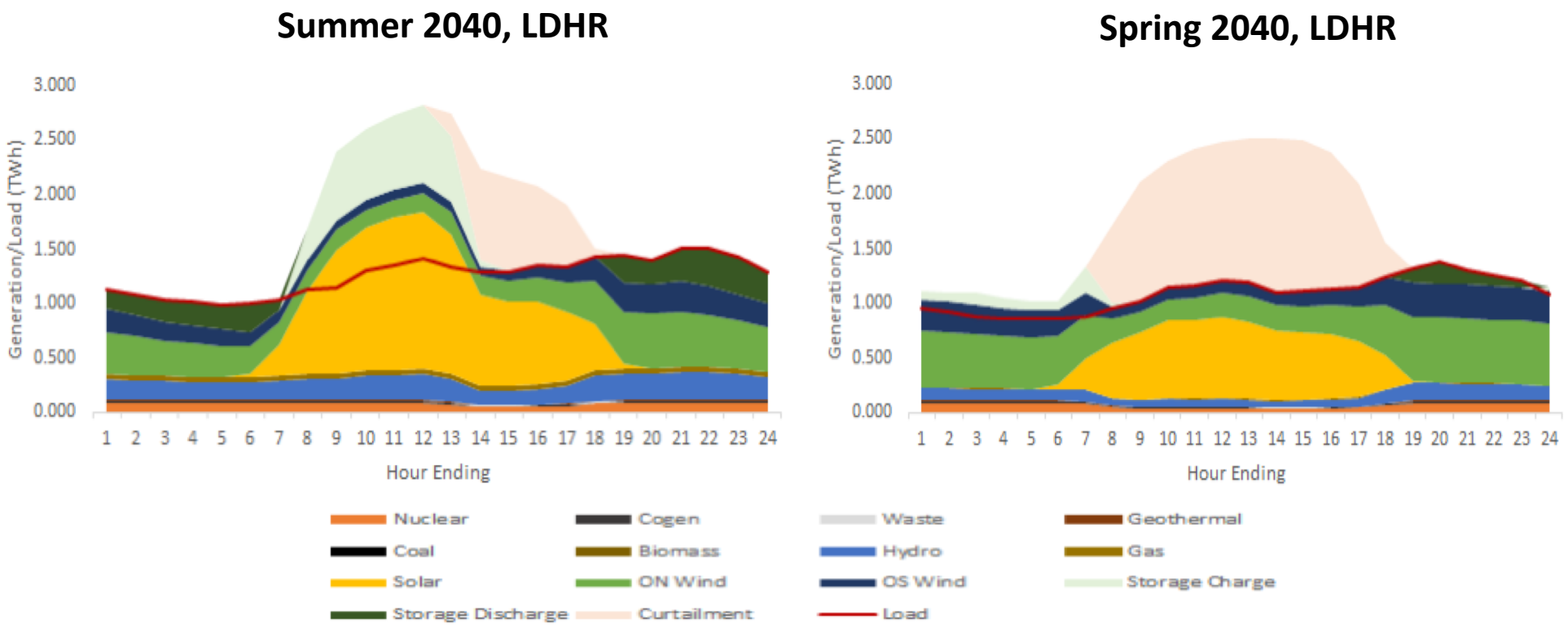
Estimated based on Yuan et al, 2019.

Estimated based on Gao et al., 2018. Rohde and Muller, 2015, Hausfather, 2018. and HEI, 2016.

CO_2 emissions drop to near zero in LDHR



Solar, storage, and wind overbuilt to meet summer peak needs



- Significant curtailment and low utilization of storage in spring
- Significant changes in system operations and economics by 2040
- These changes are consistent with long-term studies in the U.S.

Main Findings

- Reducing and ultimately retiring all of China's coal generation capacity by 2040 are technically and economically feasible
  - A combination of solar, wind, and storage can **reliably** meet future demands
  - A rapid scale-up in solar and wind generation and battery storage deployment
    - 50-70 GW/yr of solar, 64-84 GW/yr of wind, 14GW/yr of storage from 2020 to 2025
    - about 250 GW yr^{-1} of solar and wind and 90 GW yr^{-1} of storage from 2025 to 2040
    - relaxing the retirement date to 2050, solar and wind additions could be reduced to 175 GW yr^{-1} between 2035 and 2050 and total energy storage additions could be reduced to 50 GW yr^{-1}.
  - **Continued cost declines** in solar and wind, and significant cost reductions in battery storage
  - No new unabated coal generation
  - **All existing coal generation be retired** at least by the end of its original depreciation schedule
  - Significant changes in electricity system operations, transitioning to economic curtailment of solar and wind generation
  - Significant changes in the planning, procurement, and financing of electricity generation

Main Findings

- What policies and institutional changes are needed?
  - Policy efforts to restrain growth in electricity demand in China
  - Restrictions on new unabated coal generation
  - Transitioning to an electricity system dominated by solar PV and wind

    1) continued efforts to develop wholesale electricity markets

    2) a shift to planning for electricity system reliability

    3) Aligning electricity planning with land use regulation
- Transition issue with existing coal generation facilities
  - None of the scenarios indicates coal stranded assets issue under two conditions

    1) new investments in coal generation are not made after 2020

    2) historical depreciation schedules for coal generating facilities are maintained, which may be challenging

Thank you!

Jiang Lin

LBNL

J_lin@lbl.gov