North Eastern China

Energy Integration System

National Renewable Energy Laboratory

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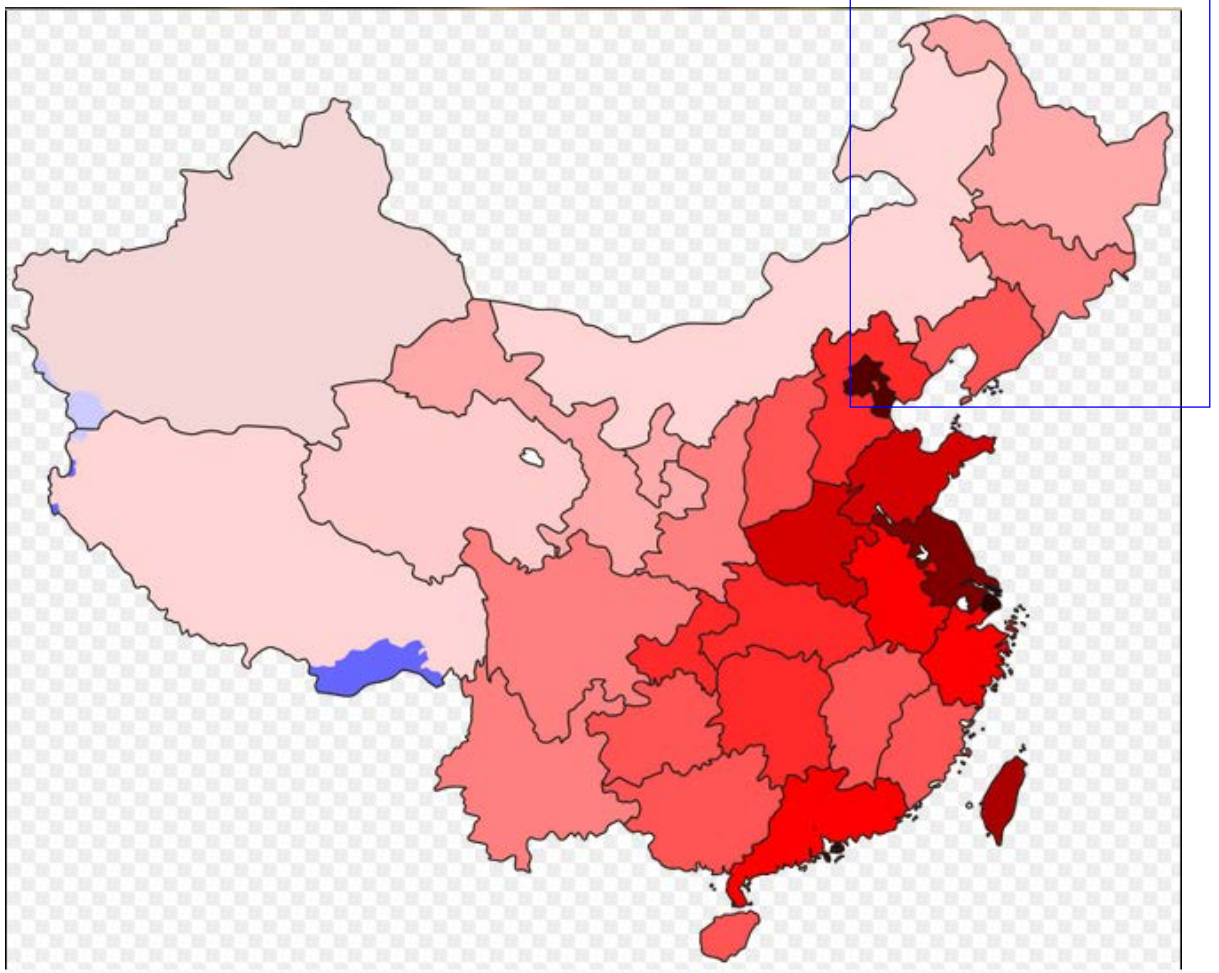
Abdulelah Habib Raja Timihiri Roshi Nateghi

Our Region of Interest

http://www.szscada.com/en/info.asp?cid=610

Population Density



SVG Map of China's population densities by province. No Labels. Legend: (in people per square kilometers) > 900 800–900 700–800 600–700 500–600 400–500 300–400 200–300 100–200 50–100 0–50

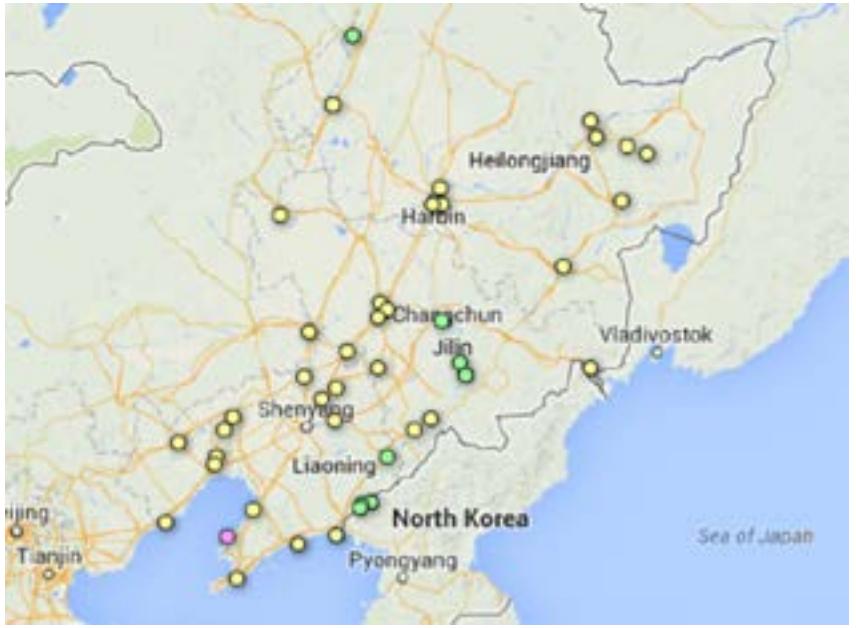
http://en.wikipedia.org/wiki/Demographics_of_China

Population Vs Energy

Energy

People

Power plants map



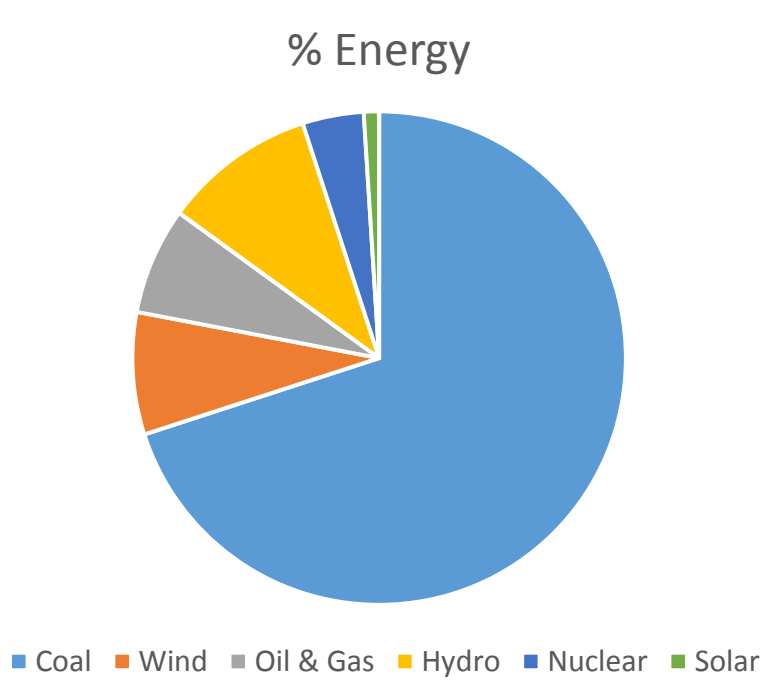
Yellow: Coal
Green: Hydro % pump
Pink: Nuclear

Data: Wikipedia , Maps: Fusion Tables

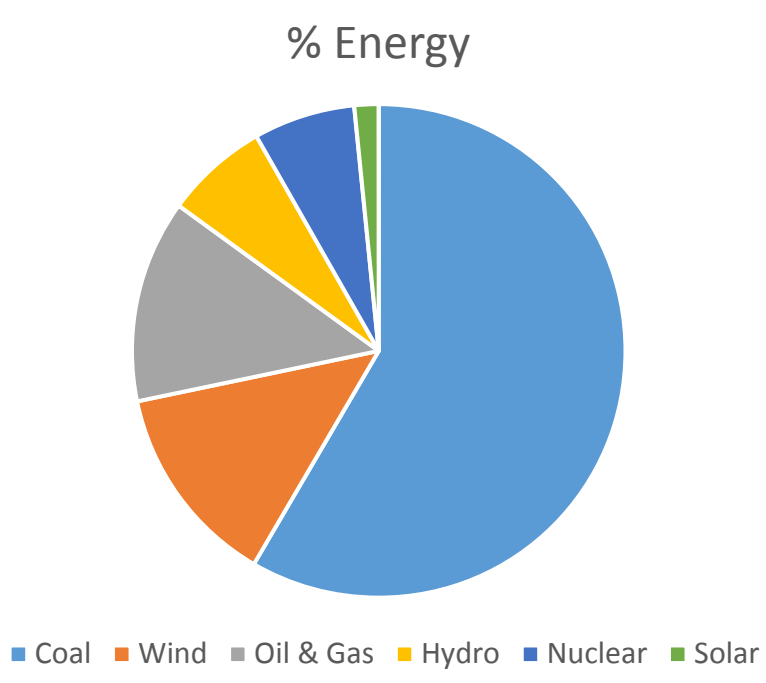
Projection of the Energy Mix by 2030-2050

- Some increase in:
  - Wind power
  - Hydro
  - Nuclear
  - Natural gas
- Slight increase in:
  - Solar power
- Some decrease in Coal

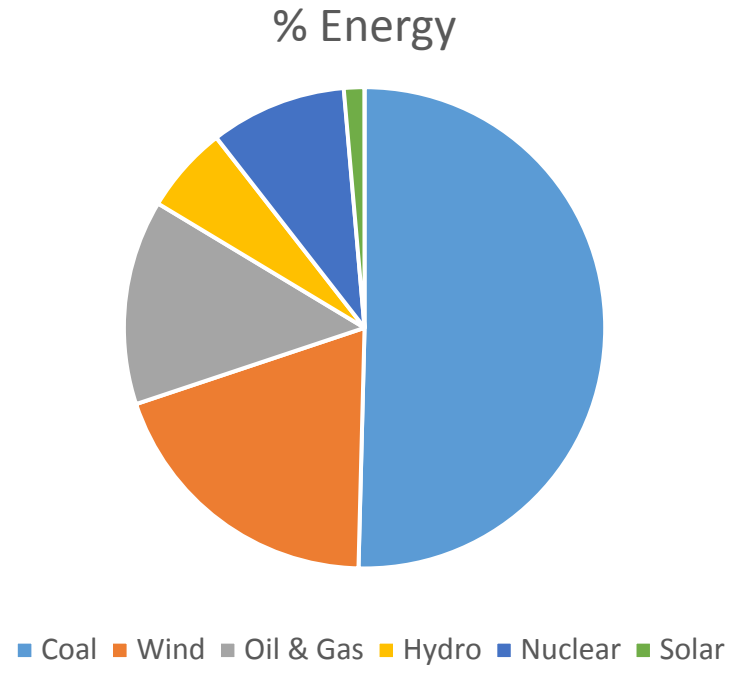
Current Mix



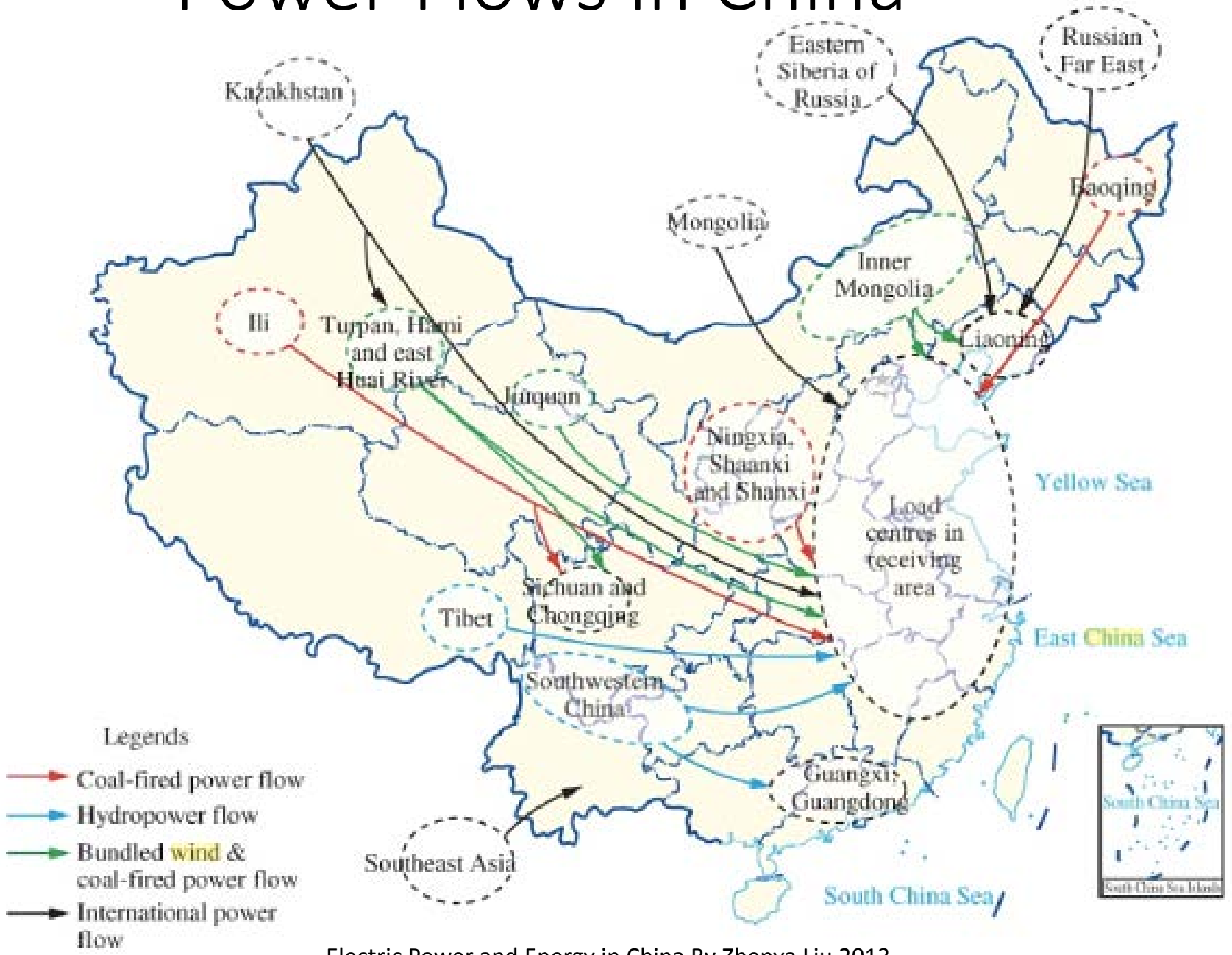
Energy Mix 2030



Energy Mix 2050

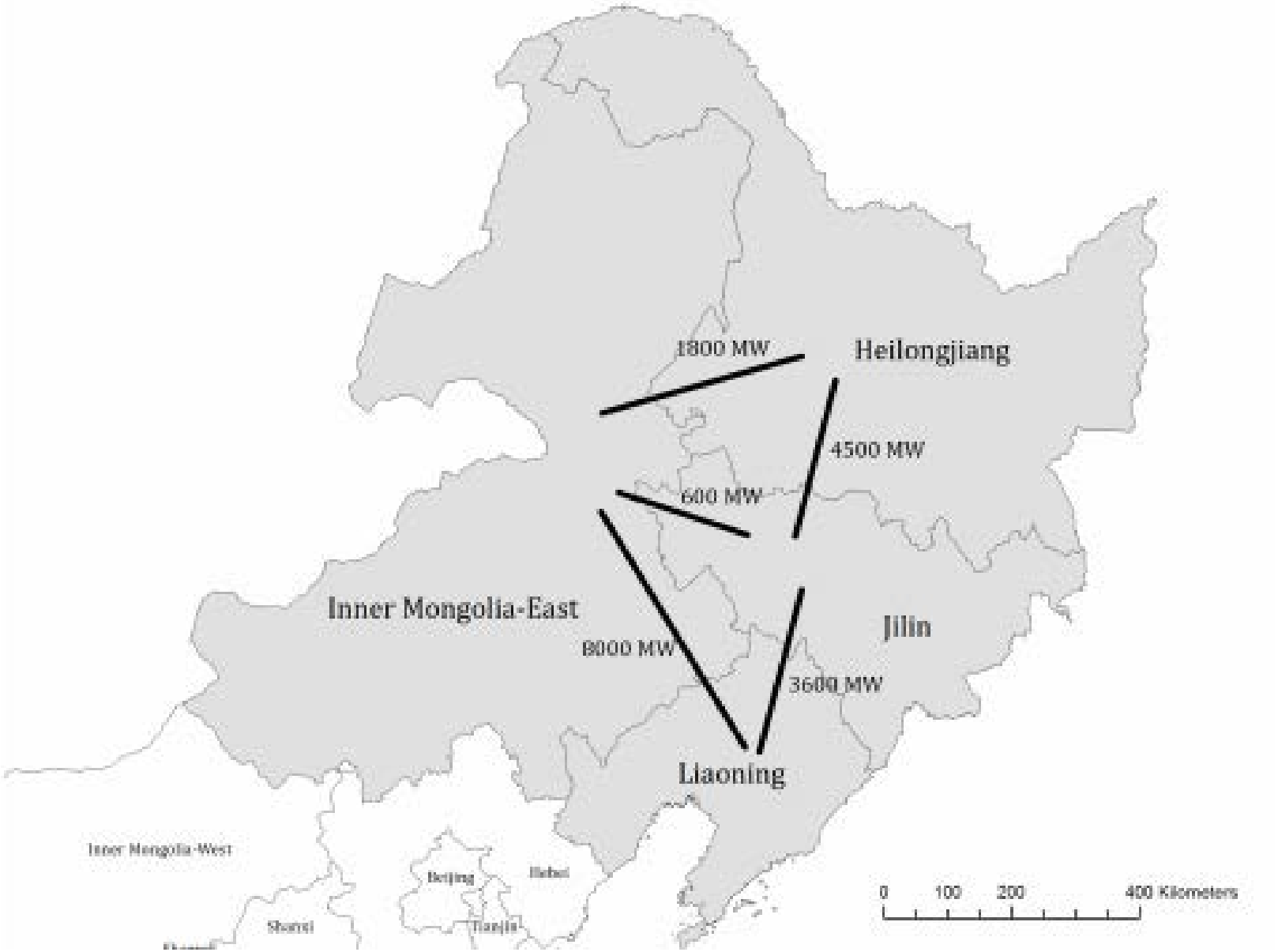


Power Flows in China



Electric Power and Energy in China By Zhenya Liu 2013

Inter-provincial Transmission Capacities



http://globalchange.mit.edu/files/document/Davidson_MS_2014.pdf

The Carbon Emission Flow

http://www.nature.com/srep/2012/120629/srep00479/fig_tab/srep00479_F2.html

Fossil Fuels

Coal

- The primary fuel behind China's economic growth over the last decade; providing three quarters of the nation's primary energy supply
- But coal plants only generate about 40% of their capacity
- Less integration space for renewables
- Associated with environmental and health damages

Policy for Coal

- The Small Plant Closure Program:
  - Small mines are being closed down or bought out by large energy groups
- Coal caps
- Consolidation, mostly into the hands of state-owned enterprises

Oil Fields

- Liaohe, one of China's largest heavy oil fields, produced 200,000 bbl/d in 2012.
- CNPC began using more advanced EOR methods such as steam flooding and polymer flooding on a large scale, the company hopes to restore production to around 241,000 bbl/d by 2020.
- CNPC has used hydraulic fracturing and CO_2 injection at the Jilin field to mitigate further declines in hydrocarbon output.

http://www.energy-pedia.com/news/china/annual-oil-and-gas-output-of-changqing-oil-field-exceeds-30-million-tons

Challenges

- Gas
  - Development is geologically and technically challenging; mostly tight gas (characterized by low permeability and low pressure and usually requiring hydraulic fracturing for commercial production).
- Oil
  - They are mature fields; heavily exploited since the 1960s, and their output is expected to decline

Solutions

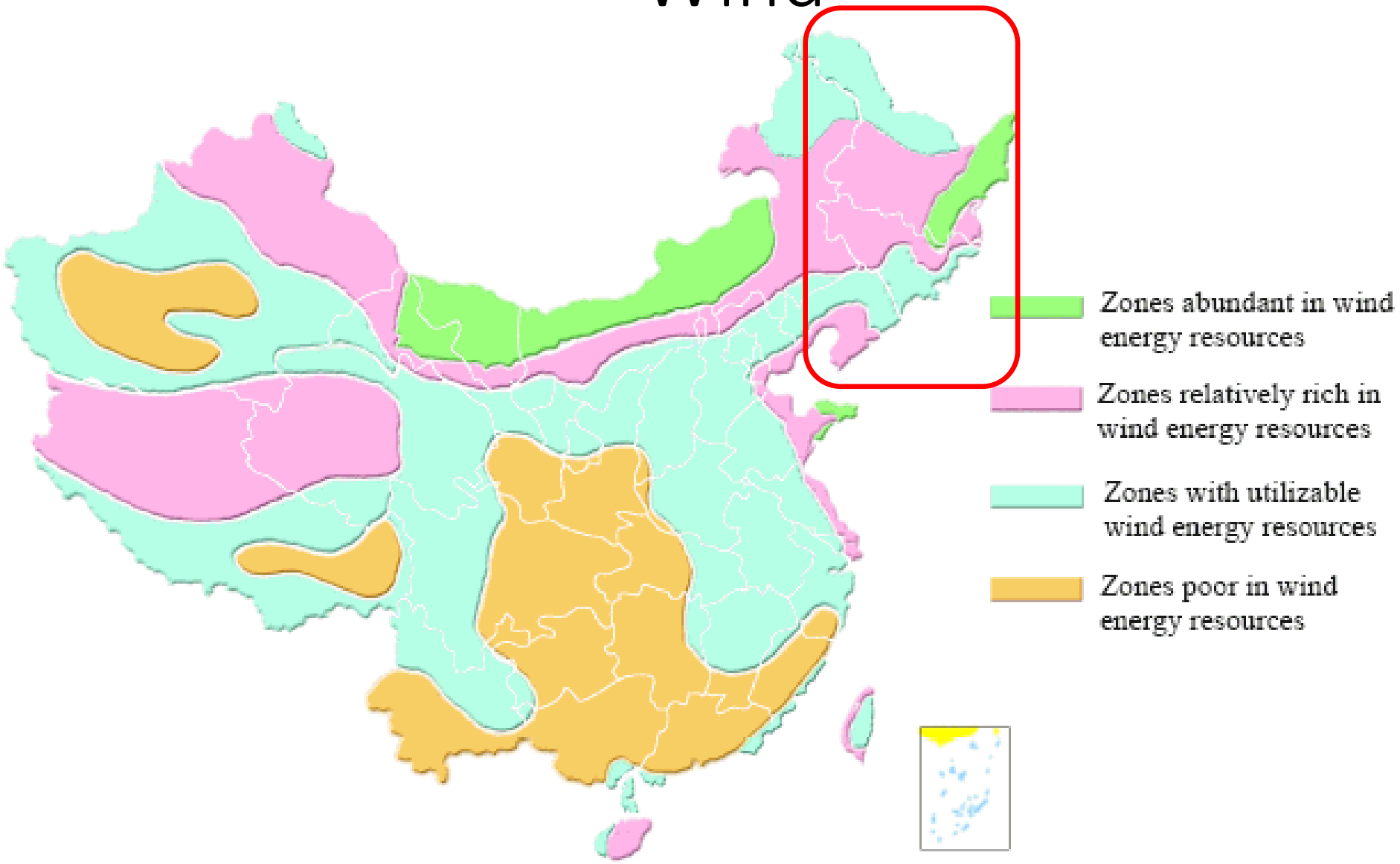
- Effectively using advanced drilling techniques and recovery methods to retrieve natural gas
- Increased gas import from Russia
- Use CO_2-EOR techniques to enhance recovery rates for the mature fields in this area, e.g. the Jilin oil field

Renewables

- They provide more than a quarter of China’s electricity generating capacity

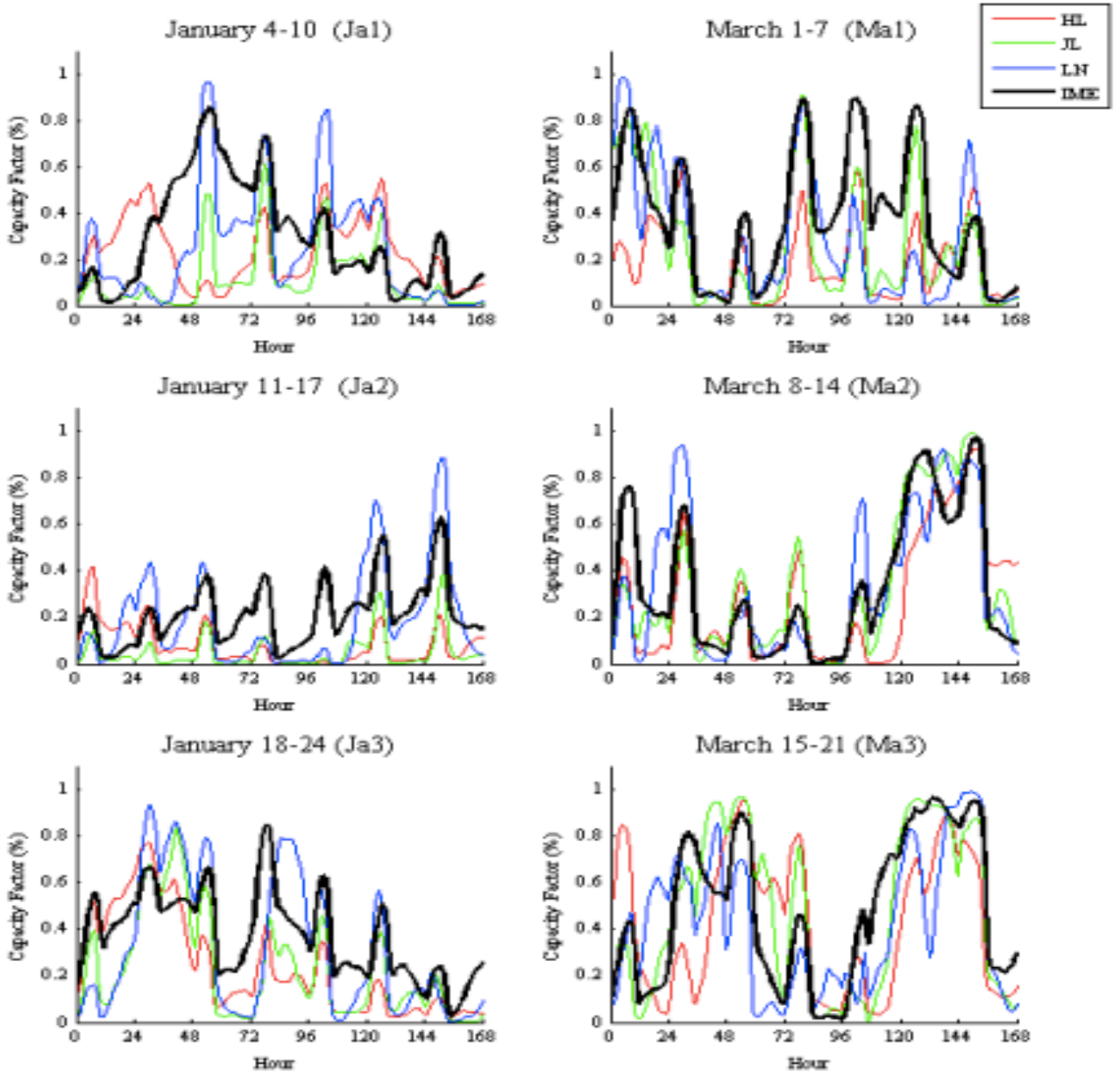
- Steady increase in investments in renewables over the last decade

Wind



http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/wind-asia/wind-china.shtml

Wind Profiles by Province



http://globalchange.mit.edu/files/document/Davidson_MS_2014.pdf

Wind Power

- The fastest growing renewable energy resource
- In 2013 wind accounted for 2.7% of national generation while the curtailment rate reached 12%. (77 GW installed capacity-137 TWh annual energy generation)
- It is largely concentrated in China’s northern region

Future Wind Energy in North Eastern China

Table 10. Wind power development targets and distribution (GW)

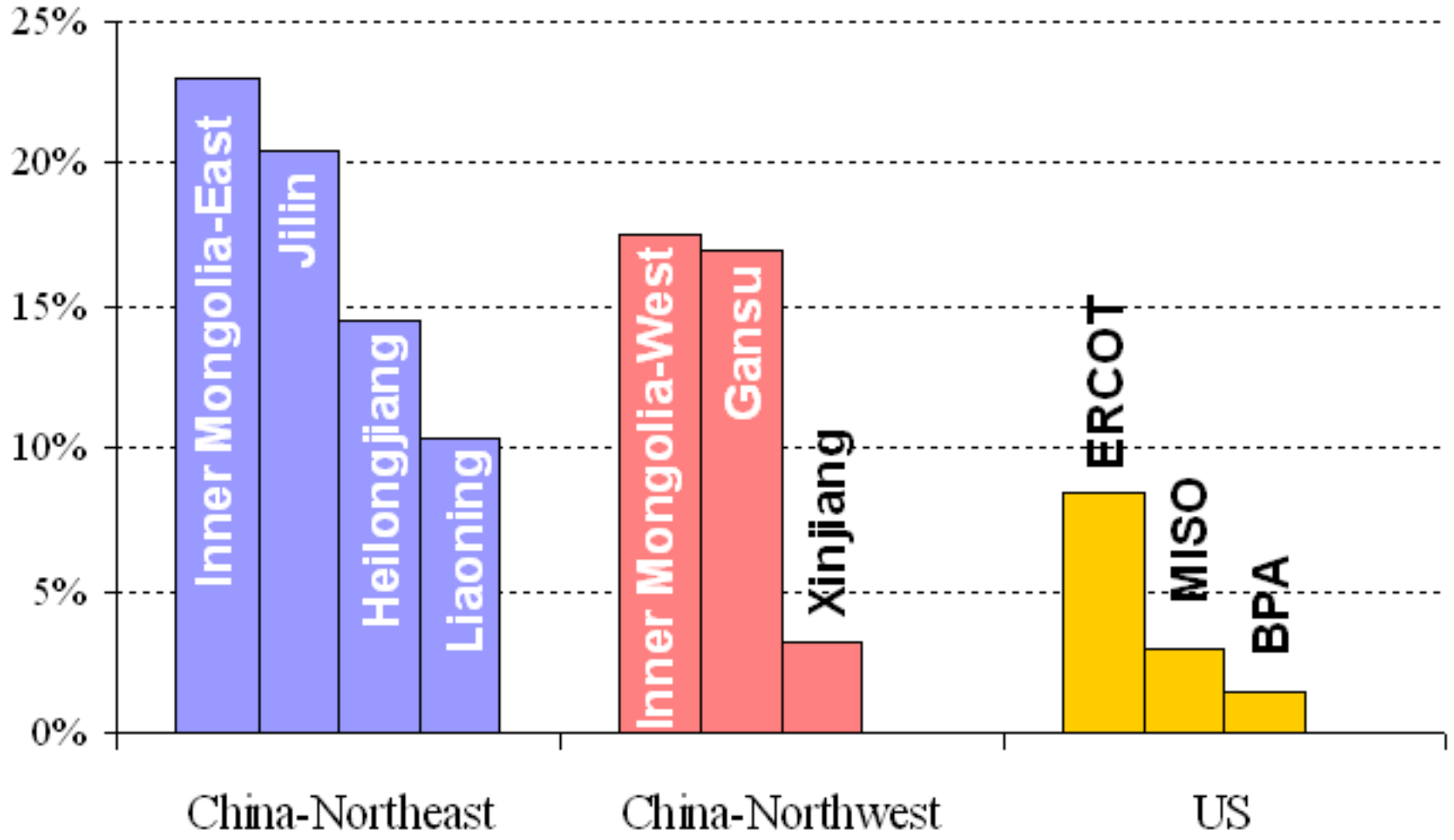
Regions	2010	2020	2030	2050
West Inner Mongolia	6.50	40	100	300
East Inner Mongolia	3.62	20	40	90
Northeastern China provinces	7.31	30	38	60
Hebei Base	3.78	15	27	60
Gansu Base	1.44	20	40	120
Xinjiang Base	1.13	20	40	100
Distributed land-based wind in Eastern and Central China and other areas	7.43	25	50	70
Near offshore wind	0.10	30	60	150
Far offshore wind	0	0	5	50
Total	**31.31**	**200**	**400**	**1 000**

http://www.iea.org/publications/freepublications/publication/china_wind.pdf

Biggest Challenge: Wind Curtailment

- Wind curtailment occurs due to technical, economic and institutional reasons; The curtailed energy is equivalent to burning 3.3 million tons of coal, (equivalent 10 million tons of CO_2 emissions)
- Reasons:
  - Insufficient transmission investments –need to invest in transmission and Construction of distributed and small-scale wind farms closer to load centers
  - Wind variability and unpredictability-need for forecasting improvements
  - Inflexibility in operation of coal plants and CHPs
  - Policies incentivizing construction over grid architecture
  - Incomplete market transition

Wind Curtailment in China, US (2011)

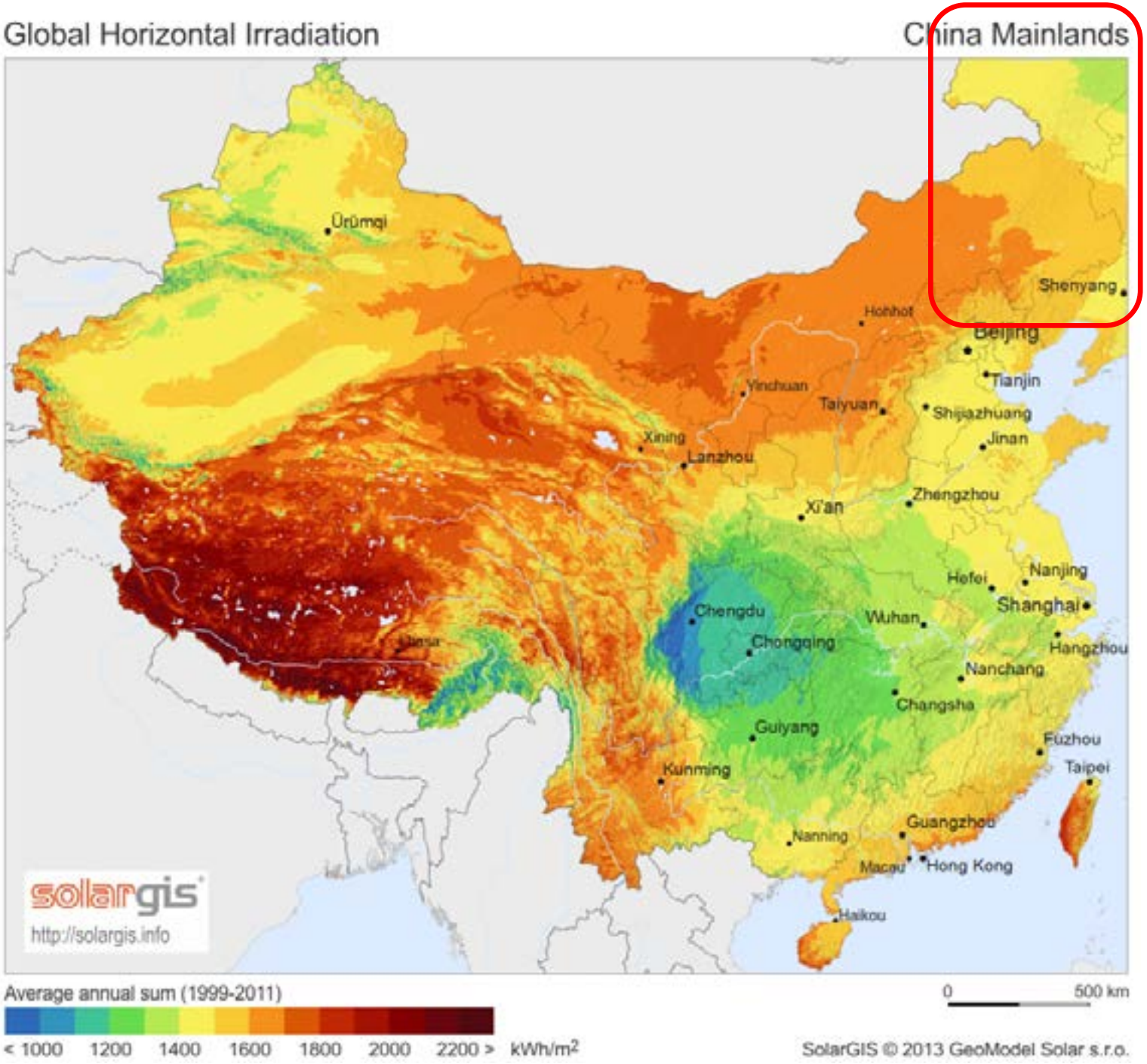


Source: CREIA Wind Power Outlook 2012, DOE Wind Technologies Market Report 2011

Solar

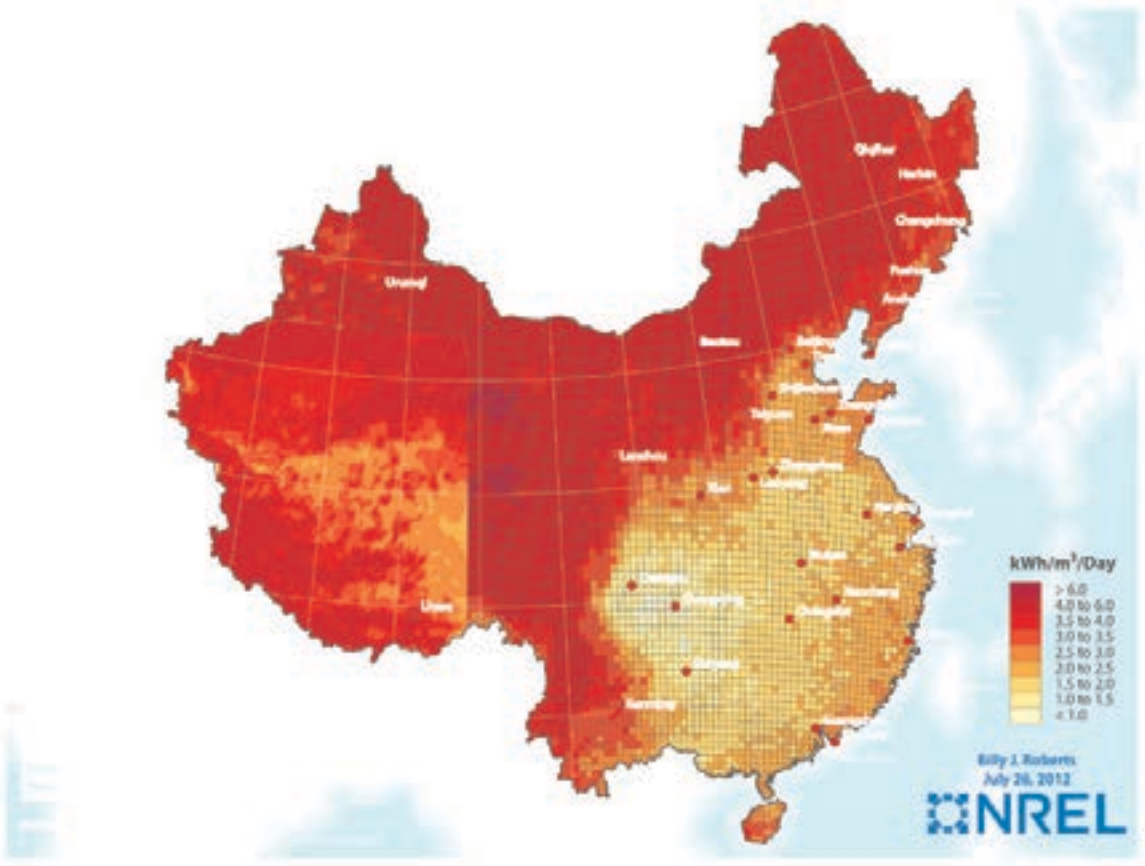
- 70% of the growing global market in solar panels
  - aggressive pricing
  - the collapse of three U.S. competitors in the last two months

- "The days of China's PV (photovoltaic) production being purely for export are coming to an end," GTM Research said, referring to solar power technology.

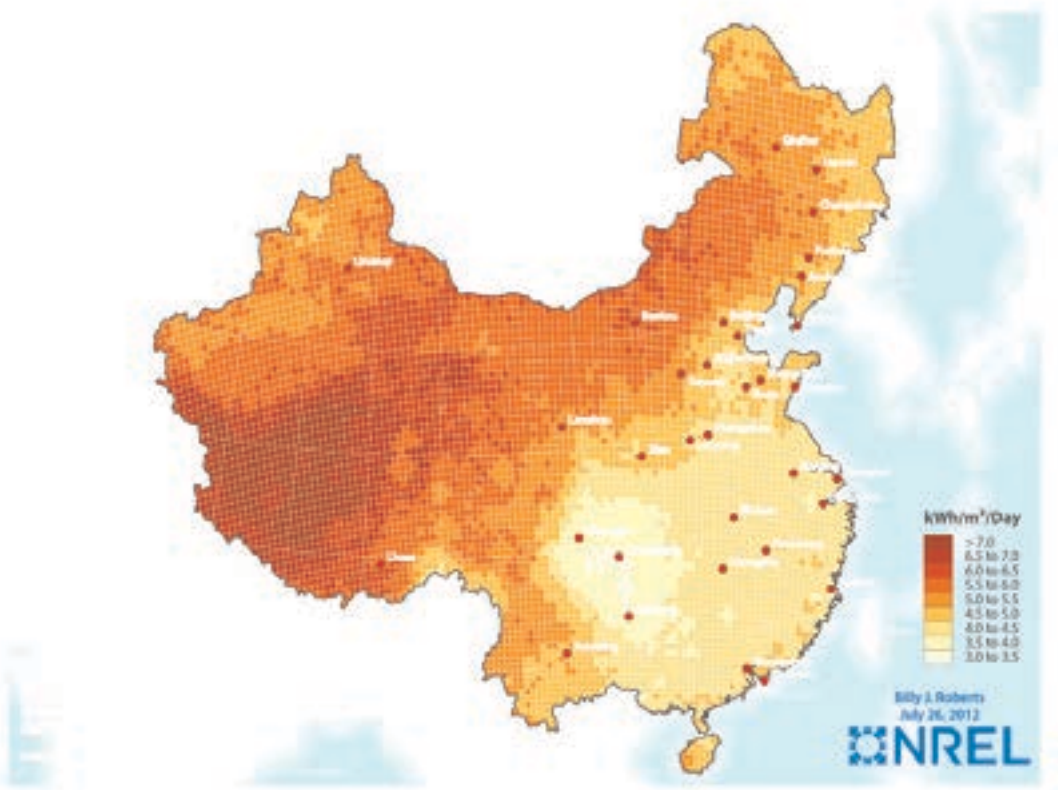


Northeastern China

CSP



PV



Potential heat map for different solar technology

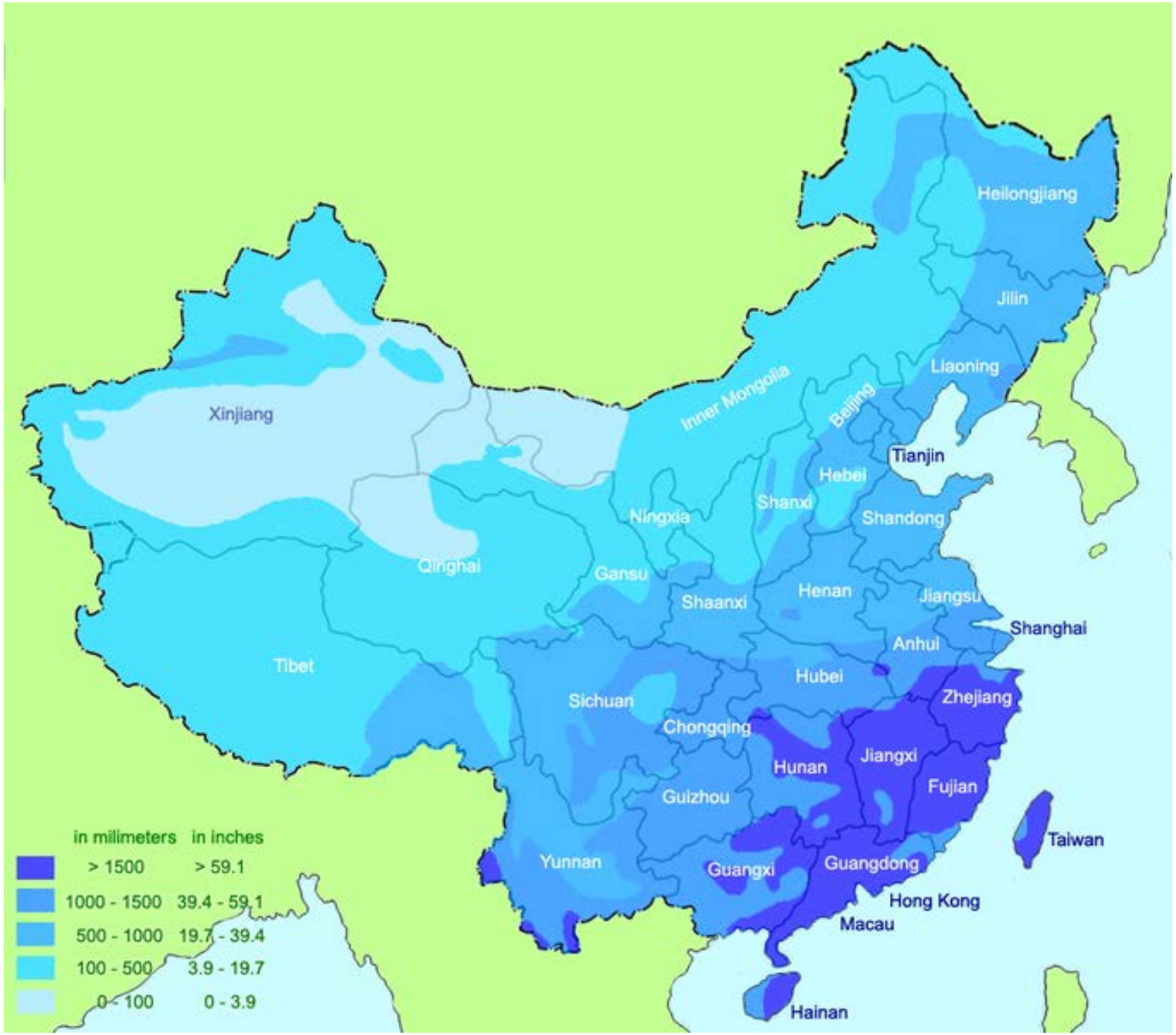
CHP

- Proposed reduction in energy by 20 % → second largest country in terms of installed CHP capacity
- During the cold winters several centers are equipped with coil boilers constructed or retrofitted with CHP plants
- These plants face additional operating constraints to satisfy demand on local district heating grids, constraining the space for renewables
- They are typically smaller (each technology limited to 50 MW or less)

Water

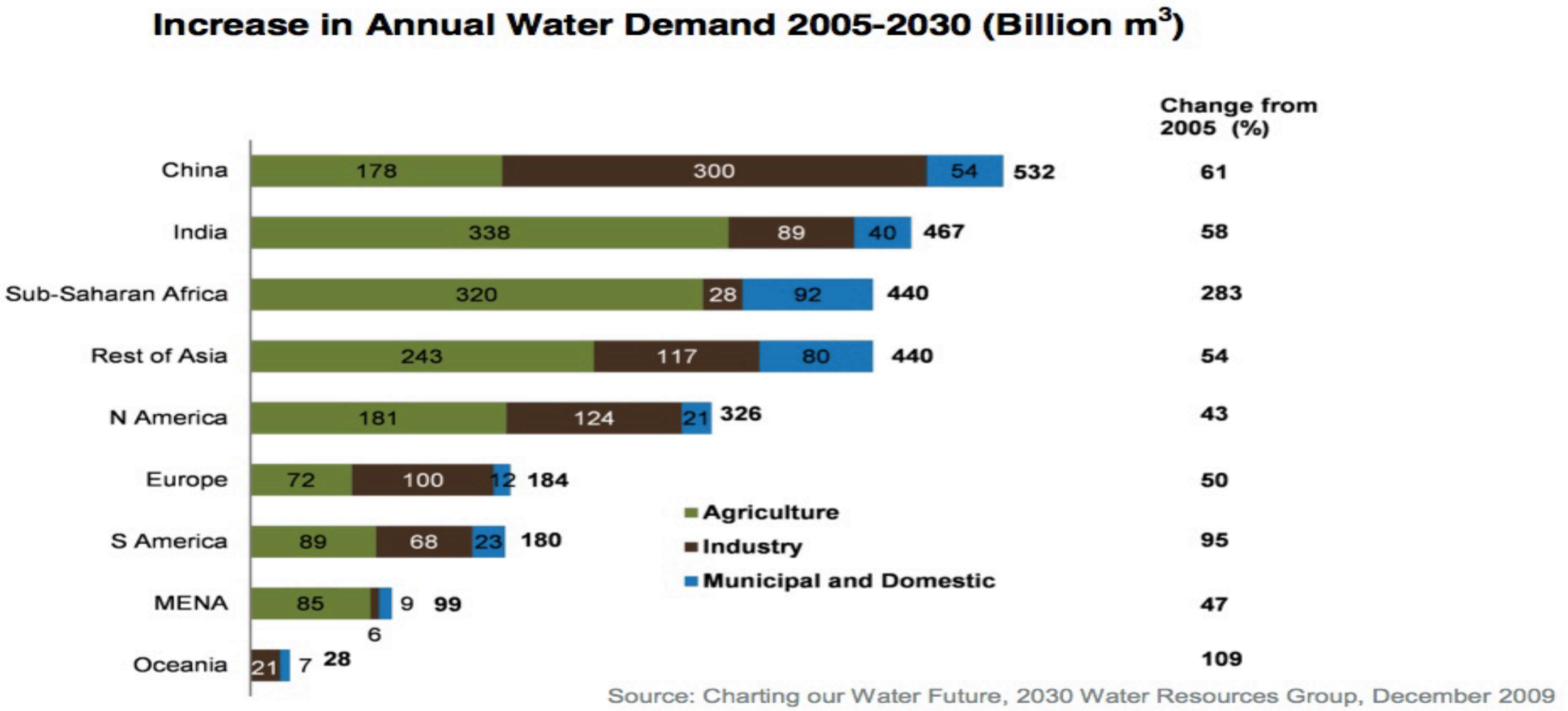
- Water crisis is thought to worsen; the Chinese economy has grown by more than 9.5% annually over the pas 3 decades (four times the rate of first world economy)

- Main causes of resource depletion: increased water demand, overuse and systematic inefficiencies, persistent pollution



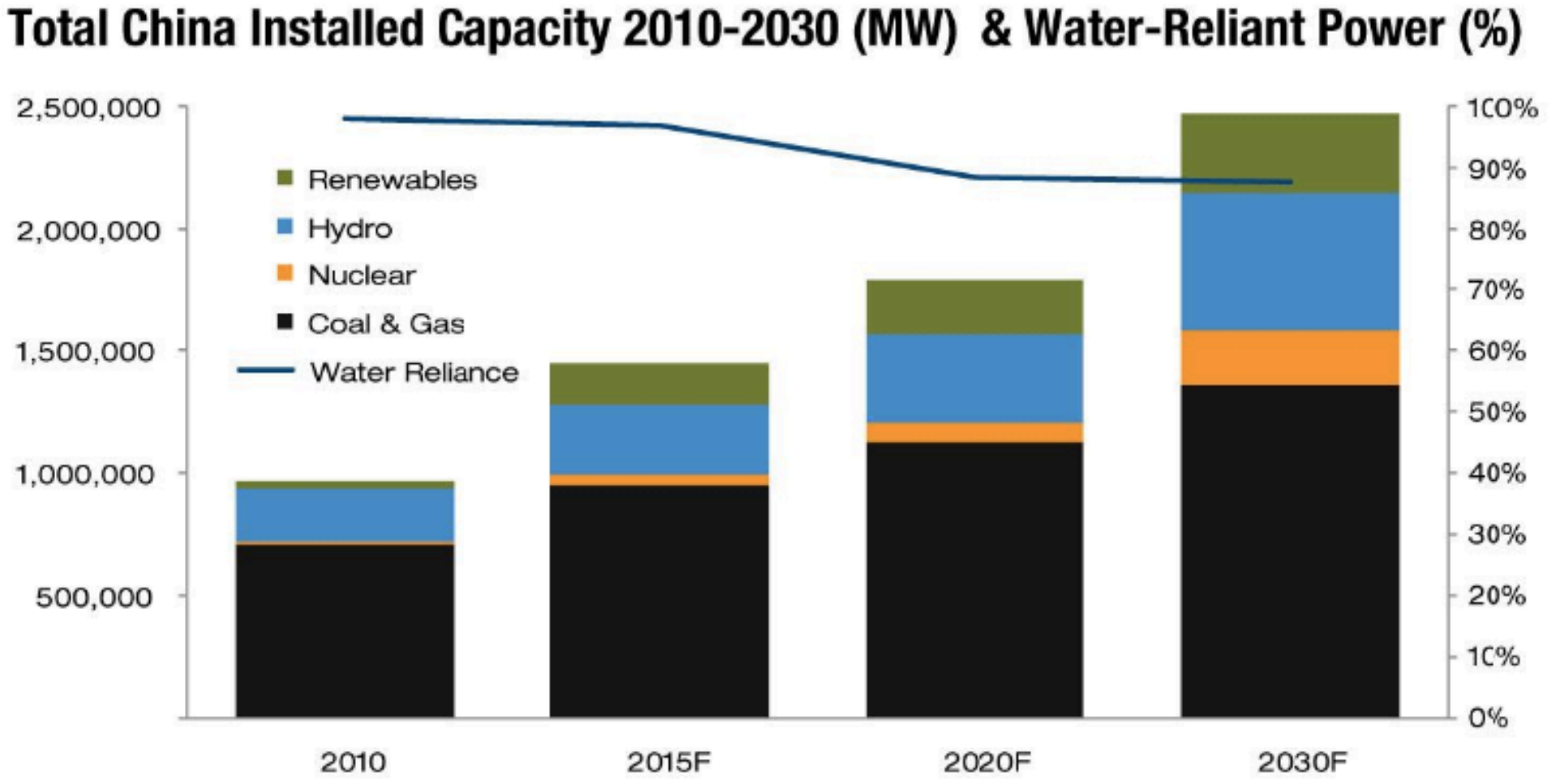
From Wikimedia Commons, the free media repository

Water Demand 2030

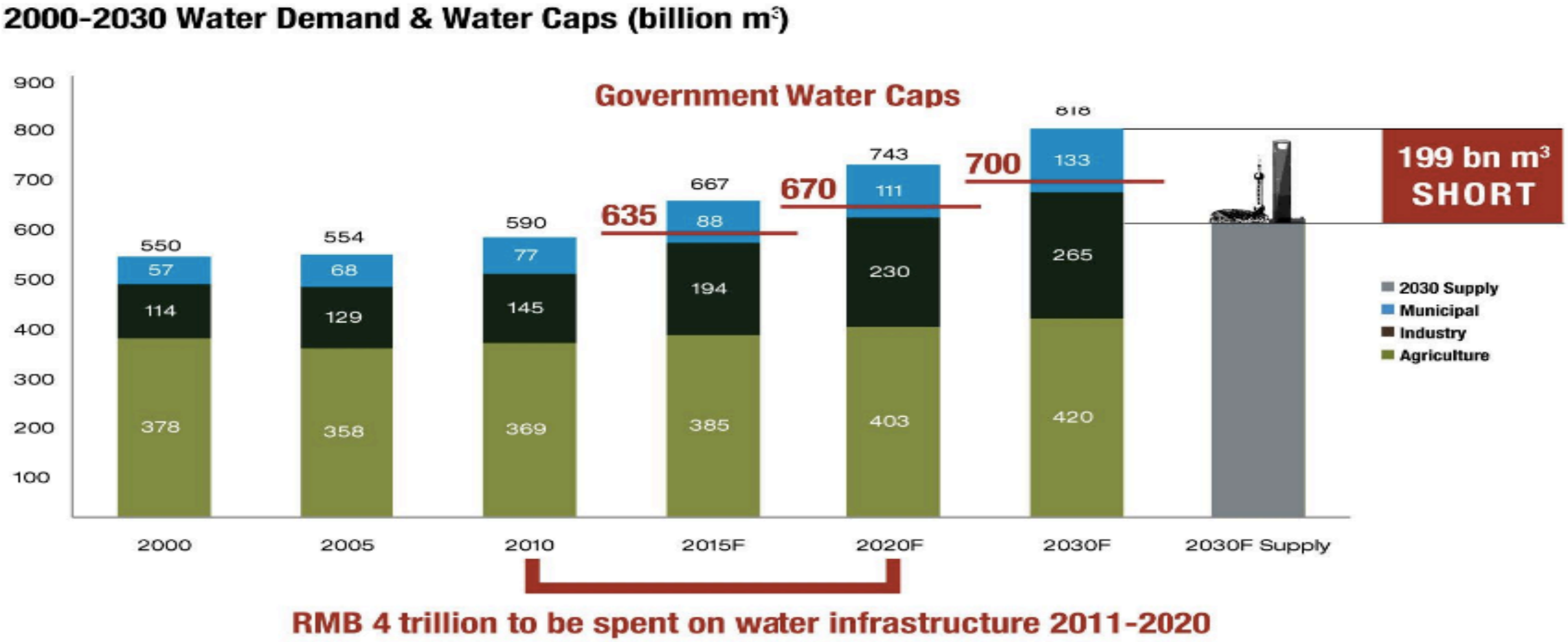


Water Energy Nexus

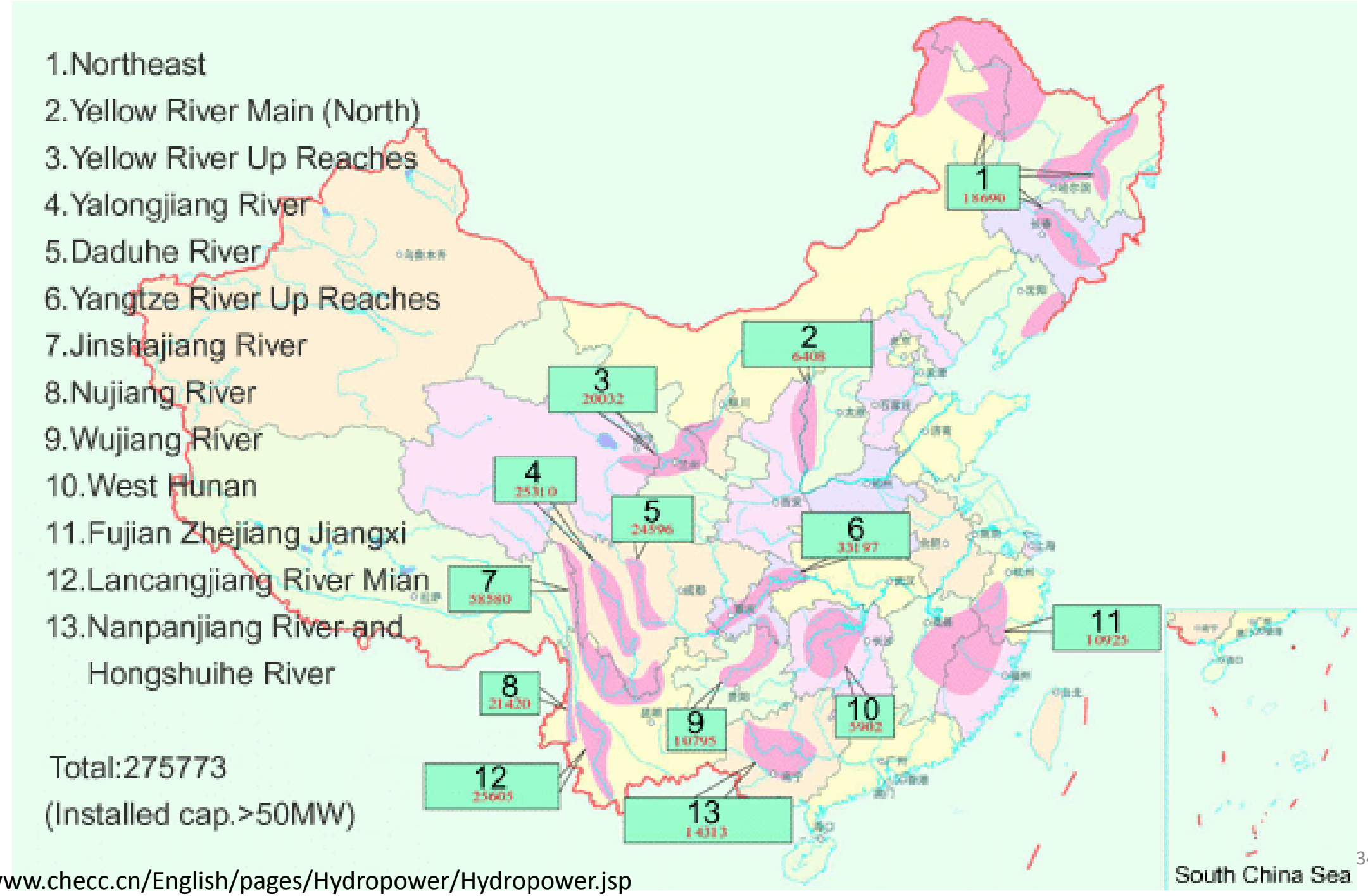
- China will remain highly reliant on water in 2030 with 87% of power requiring water to generate on a daily basis



Water Demand and Caps

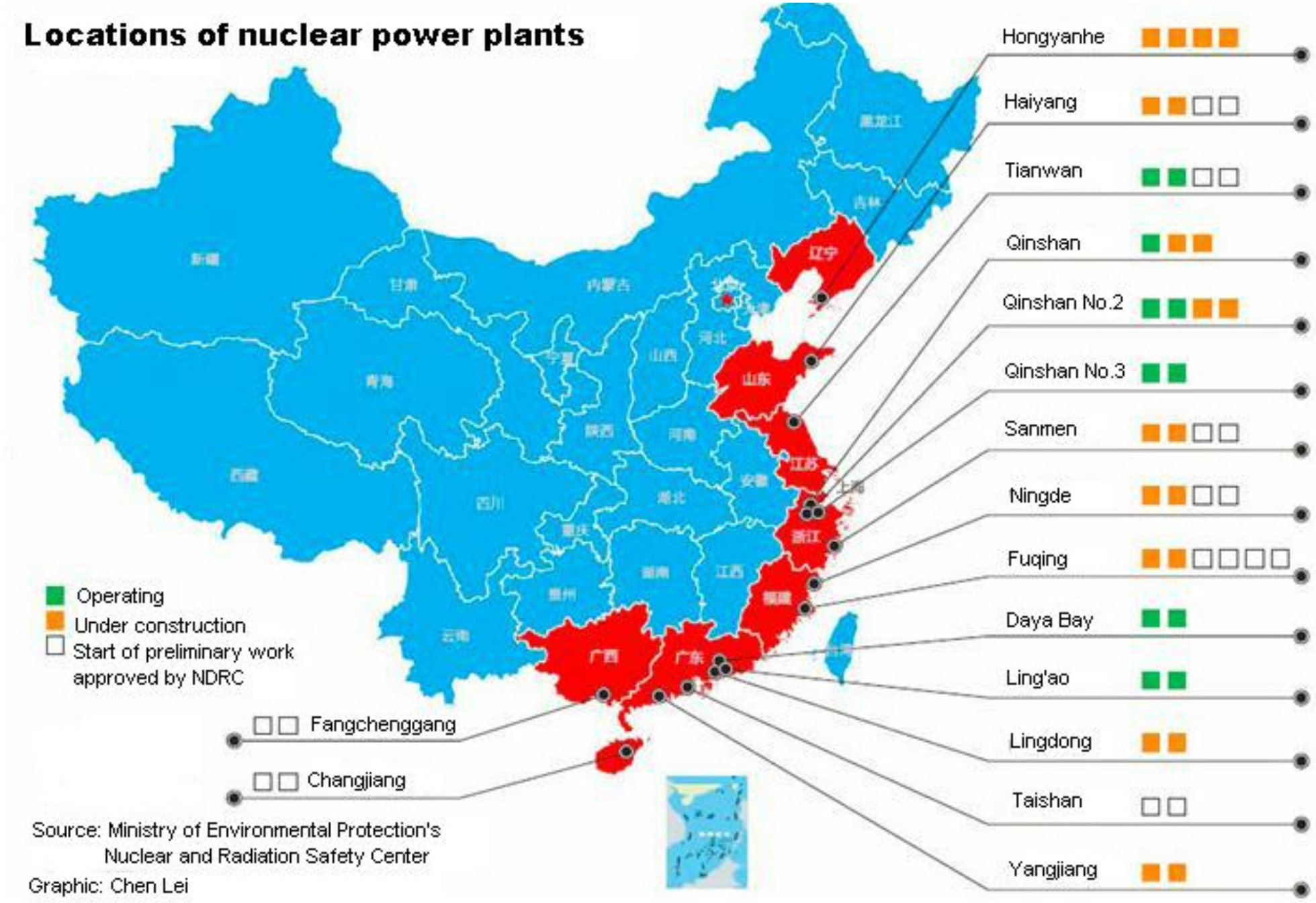


Hydropower



http://www.checc.cn/English/pages/Hydropower/Hydropower.jsp

Nuclear Power



1 reactor operational
Capacity 1,080 MW.

5 more reactors under construction

https://www.chinadialogue.net/article/show/single/en/5746-Drought-and-earthquakes-pose-enormous-risk-to-China-s-nuclear-plans

Integration Challenges

- Insufficient transmission infrastructure
- Lack of national grid (the Northeastern electricity suppliers are mostly state owned)
- Inflexible coal-fired plans and CHPs that limit renewable penetration (scheduled nuclear which adds to the flexibility)
- Slow transition into a market-based structure

Global Warming

- Sea level rise
- Wind shifts
- Droughts
- Altered precipitation patterns
- Heat waves

问题?

Backup Slides

Energy Integration

- Integrate renewables by building more transmission
- Build small wind farms closer to demand
- Export less solar power
- Use CO_2-EOR technique to enhance recovery rates for the mature oil fields

Oil &Gas Fields

- Backbone of the country's domestic production
  - In 2012, Daqing produced about 800,000 bbl/d of crude oil, according to FGE's most recent estimate, and has maintained this level for the past decade
  - Sinopec's Shengli oil field near the Bohai Bay produced about 550,000 bbl/d of crude oil during 2012: China's second-largest oil-producing field.
  - Changqing's production rose steadily this decade to 1,022 Bcf in 2012, and is anticipated to reach 1,236 Bcf by 2015.