LONG ROAD FORWARD

Reducing Energy Sector GHG Emissions Through China-US Partnerships

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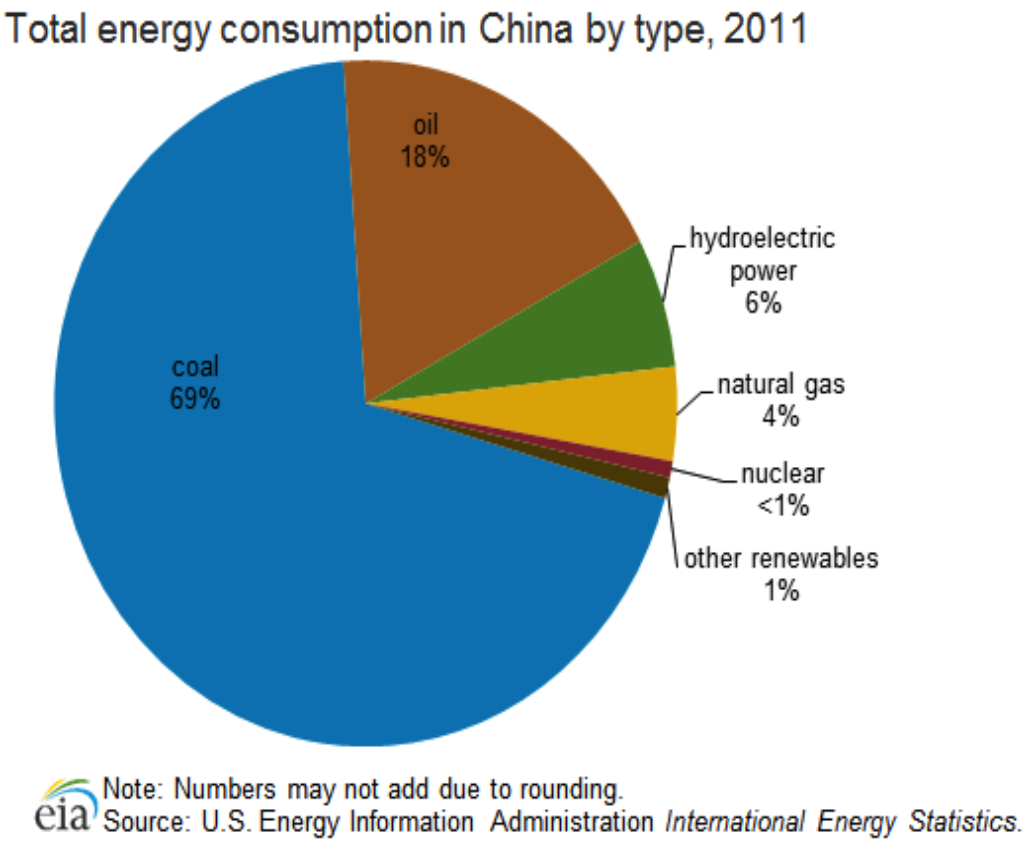
Chief Asia Representative-Clean Air Task Force

China Environment Forum | March 2014

China's energy and climate challenge

- China's energy use is dominated by coal
- While growing rapidly, nuclear and non-hydro renewables remain minor energy sources
- Only about 50% of China's coal consumption is used to produce grid electricity
- Most of the remaining coal use is for industrial production
- Substantial coal to natural gas development is beginning to move forward
- New low-carbon energy sources are unlikely to "grow" China out of coal dependence any time soon

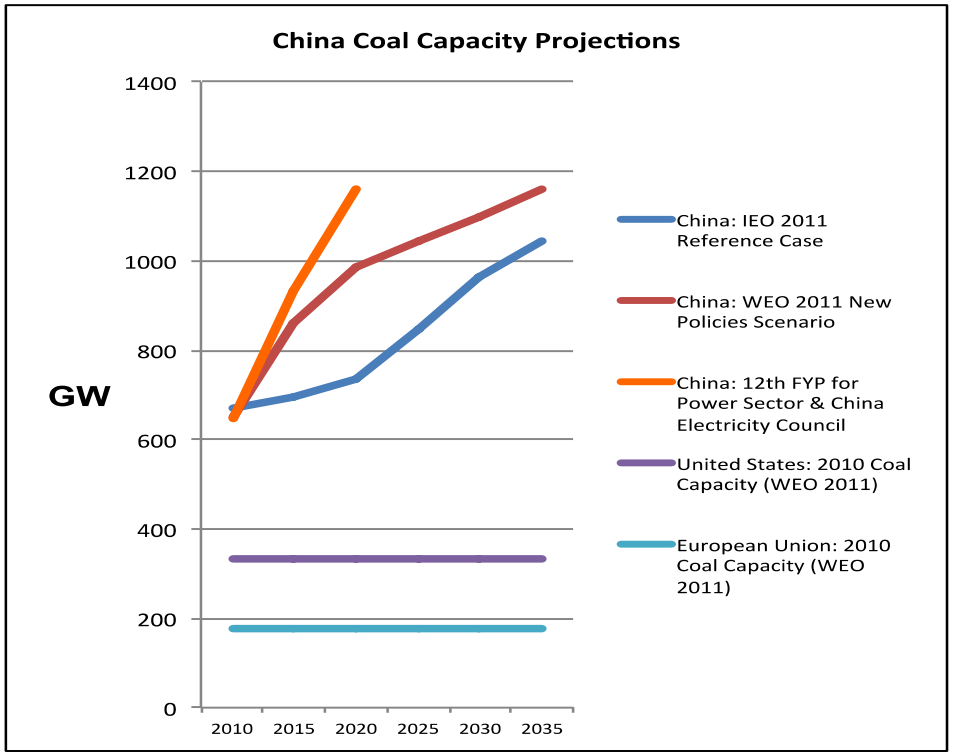


COAL: Remains the dominant energy, necessitates CO2 capture/use/storage

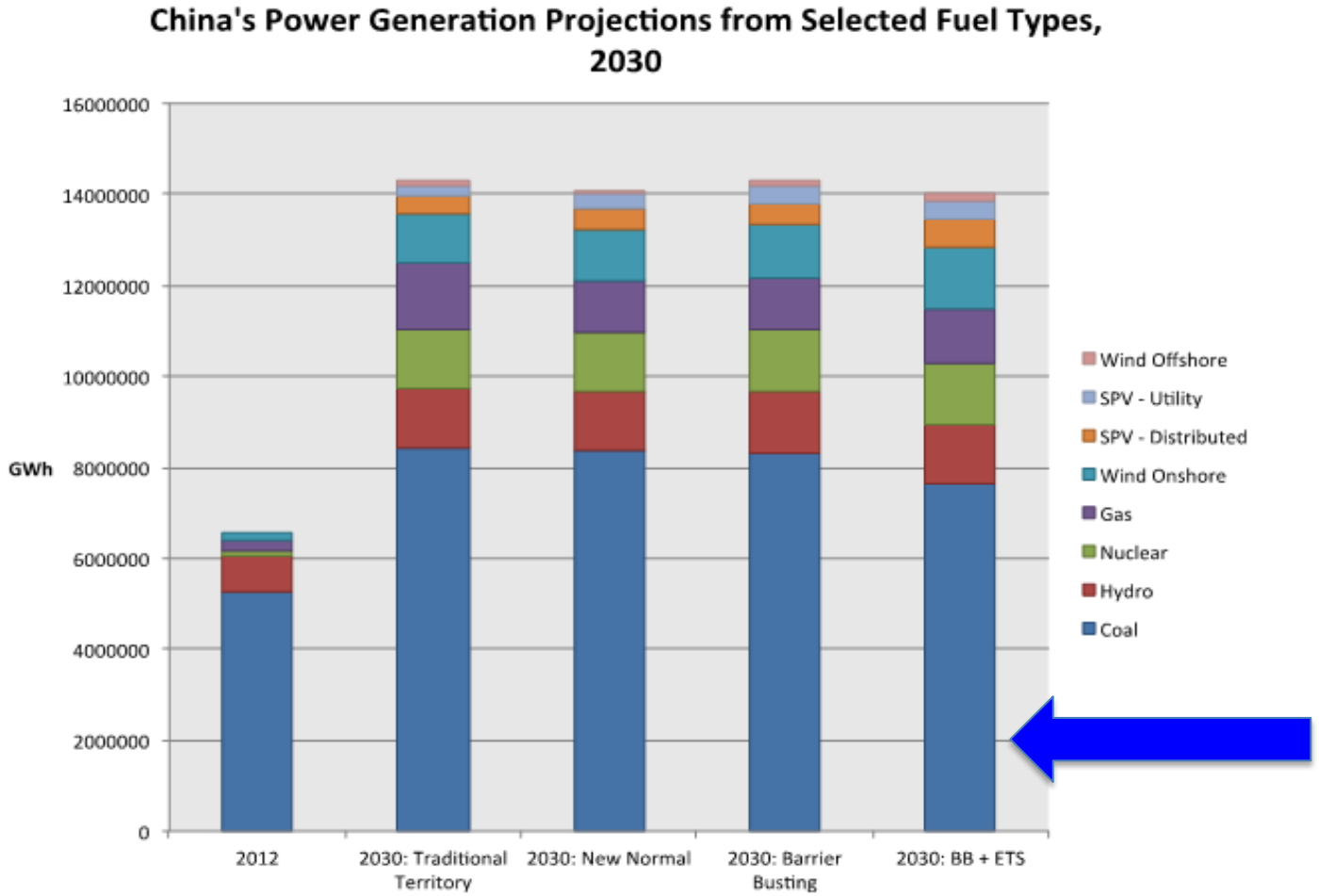
The massive build-out of China's coal fleet is still underway and is projected to continue for decades.

"China approved the construction of more than 100 million tonnes of new coal production capacity in 2013 – six times more than a year earlier and equal to 10 percent of U.S. annual usage . . . The scale of the increase, which only includes major mines, reflects Beijing's aim to put 860 million tonnes of new coal production capacity into operation over the five years to 2015, more than the entire annual output of India."

REUTERS (Jan 2014)



Coal dominates in 2030 even under the most aggressive renewable and carbon price scenarios



CATF, from Bloomberg New Energy Finance, "The Future of China's Power Sector" (August 2013)

China power sector de-carbonization options

Given China's continued reliance on fossil fuel, how can power sector GHG emissions be *significantly reduced* from today's levels?

- Expanded development of *new* low-carbon power generation
  - Nuclear
  - Wind and solar
  - Natural gas (properly produced and transported)
  - Carbon capture, utilization, and sequestration (CCUS) at fossil-fired generation, most notably coal

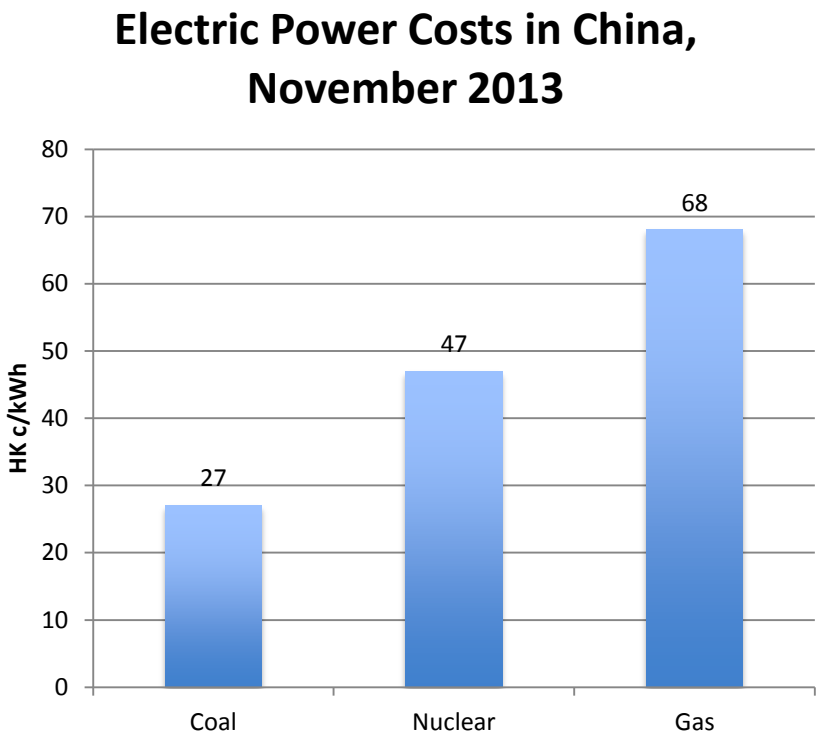
- Eventual retrofitting today's modern coal power plant "fleet" in China with CCS or nuclear technology

NATURAL GAS: Not a near-term "game changer" for China

- China has the world's greatest technical potential for unconventional gas, which include shale gas, coal bed methane, and tight gas.
  - Natural gas supplies only 4% of China's energy presently (EIA).
  - Unconventional gas resource estimate (IEA, 2013): 33 TCM (1,115 TCF) (technical, economic much less). Current utilization about 169 BCM. NDRC shale targets: 6.5 BCM/2015, 80BCM/ 2020.
  - Sinopec and PetroChina successes in 2013 in Sichuan basin.
  - Still, commercialization will be comparatively slow. E.g.,
    - Risk from lack of technical experience (150 wells in past 3 years, compared to 30,000 in US 2013) and lack of subsurface data.
    - Inadequate open-access pipeline infrastructure
    - Resource concentration. Sichuan and Tarim (remote) basins have marine shales; other basins have continental shale, hard to frac.
- Lacking reduced emissions well completions (RECs) and CCUS on gas power plants, the climate advantage of gas will go unrealized.

NUCLEAR: Steady development that needs to be accelerated

- Mainland China has 20 nuclear power reactors in operation, 28 under construction, and more about to start construction.
- China's nuclear is typically cheaper than gas, more expensive than coal.
- Targets:
  - 58 GWe by 2020
  - 150 GWe by 2030




Sanmen site Mar, 2013

Extensive nuclear RD&D in China

HTR-PM: First *commercial* high temperature gas reactor
-Follows the HTR-10 prototype
-50-month construction goal
-75% localized content

CEFR: Chinese Experimental Fast Reactor
-Grid-connected in 2011
-1000 MWe CFR to be demonstrated, with construction beginning in 2017, commissioning in 2023

Molten Salt Reactor (MSR) program
- Very promising advanced nuclear technology developed by the US at Oak Ridge National Lab
-China has established a large, long-term MSR R&D program
- $400 million investment, 300 engineers on the project

CEFR UNDER CONSTRUCTION

HTR-PM UNDER CONSTRUCTION

CATF APPROACH: China-US Partnerships

- CATF works as an “Honest Broker” to accelerate the development/deployment of CCUS, advanced nuclear and clean unconventional gas, by bringing together utilities, technology companies, financiers, academics, government.
- Key commercial parties trust CATF and give access.
- Steps: initial match-making; project conceptualization; deal coaching; government liaison where necessary.


CLEANAIR TASK FORCE
Statoil
AEP AMERICAN ELECTRIC POWER
国家电网公司 STATE GRID CORPORATION OF CHINA
POWERSPAN Clean Energy Technology
Duke Energy
CHINA HUANENG
ENN
EmberClear™
ZEEP ZERO EMISSION ENERGY PLANTS
KBR
CLEANAIR TASK FORCE
Mitchell GROUP
GreatPoint ENERGY
SUNTRACING CLEAN ENERGY
Dongguan Tianming Electric
萬向集團 WANXIANGGROUP
HTE PURenergy

COAL/CCUS: What CATF is doing

- **Support energy company collaborations**, e.g. Duke-Huaneng/CERI (feasibility study of Huaneng CCS technology at Duke Gibson ($68/ton); Duke-ENN (CO2-fed algae-fuel technology demo).
- **Facilitate investment in key technologies**, e.g. Sinopec's stake in Summit's Texas Clean Energy Project
- **Technical workshops**, e.g. CATF Oct 2013 and Feb 2014 EOR Workshops in Beijing featuring US-based experts in enhanced oil recovery. Attended by PetroChina, Sinopec, CNOOC, YanChang, Huadian, Huaneng, CAS.

UNCONVENTIONAL GAS: What CATF is doing to help China develop capability

- **Technical Exchanges**
  - Organized and hosted a US tour of US shale gas sites for senior technical staff of key Chinese companies to view and learn about shale gas development best practices.
- **Workshops**:
  - Convinced the US Trade and Development Agency to fund a series of technical workshops on shale gas development best practices conducted by the Gas Technology Institute (GTI). CATF provided input to the environmental best practices workshop and have presented on this topic at three symposia in 2013 and 2014.
- **Promoting Advanced Practices**:
  - Working with the National Energy Administration (NEA), National Development and Reform Commission (NDRC), US DOE, EPA and State Department to facilitate informal dialogue on shale gas best practices and managing shale gas development.

NUCLEAR: What CATF is doing

- Working with innovative nuclear energy companies that are considering China as a first market

- Examining others ways to speed up US/China cooperation and technology diffusion:
  - Modify US export controls as appropriate
  - Company to company collaboration
  - Explore potential for staged pilot reactor development by US companies in China