



The opportunity for coal in the context of natural gas

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Outline

1. Coal vs natural gas

- Economics
- Environment
- Gas availability in China

2. Power vs non-power

- Emission characteristics
- Scale and efficiency advantages of power boilers
- Advanced clean coal technologies in power and heat sector

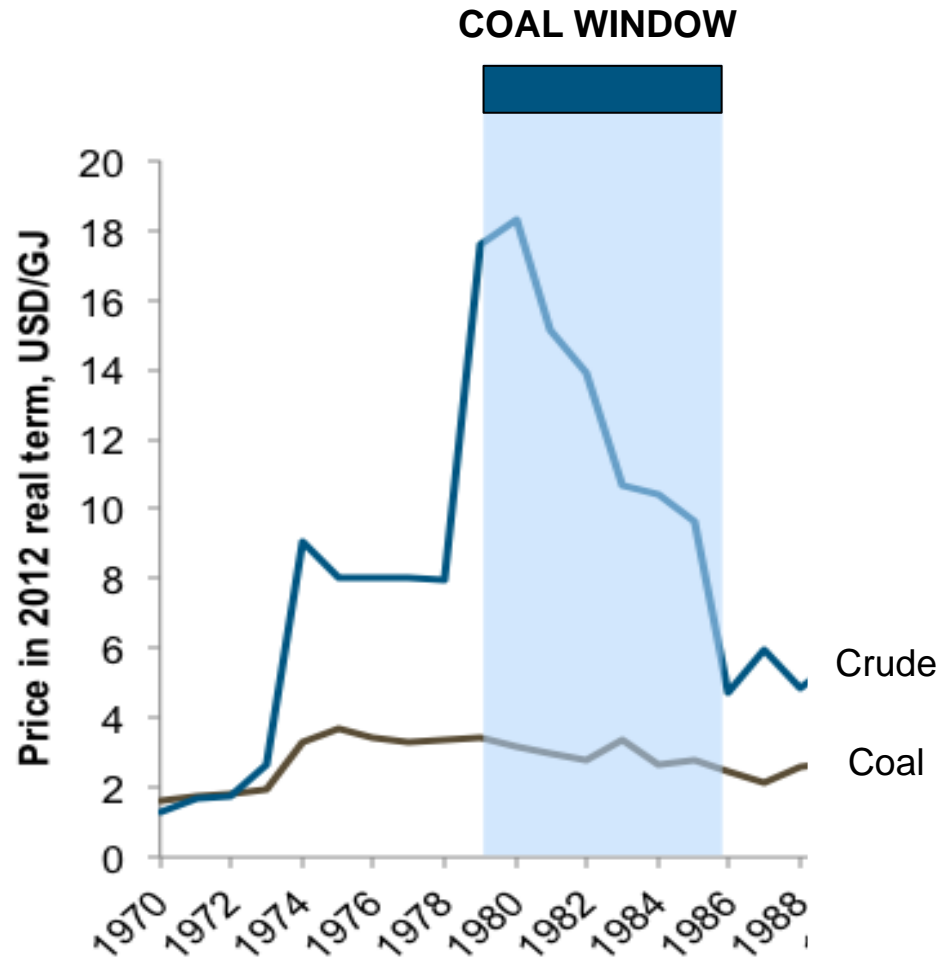


See:

“The Myth of Sisyphus China Style: Will Large Amounts of Domestic Gas Ever Get into Power?” December 2012
http://www.lantaugroup.com/files/pique_sisyphus.pdf

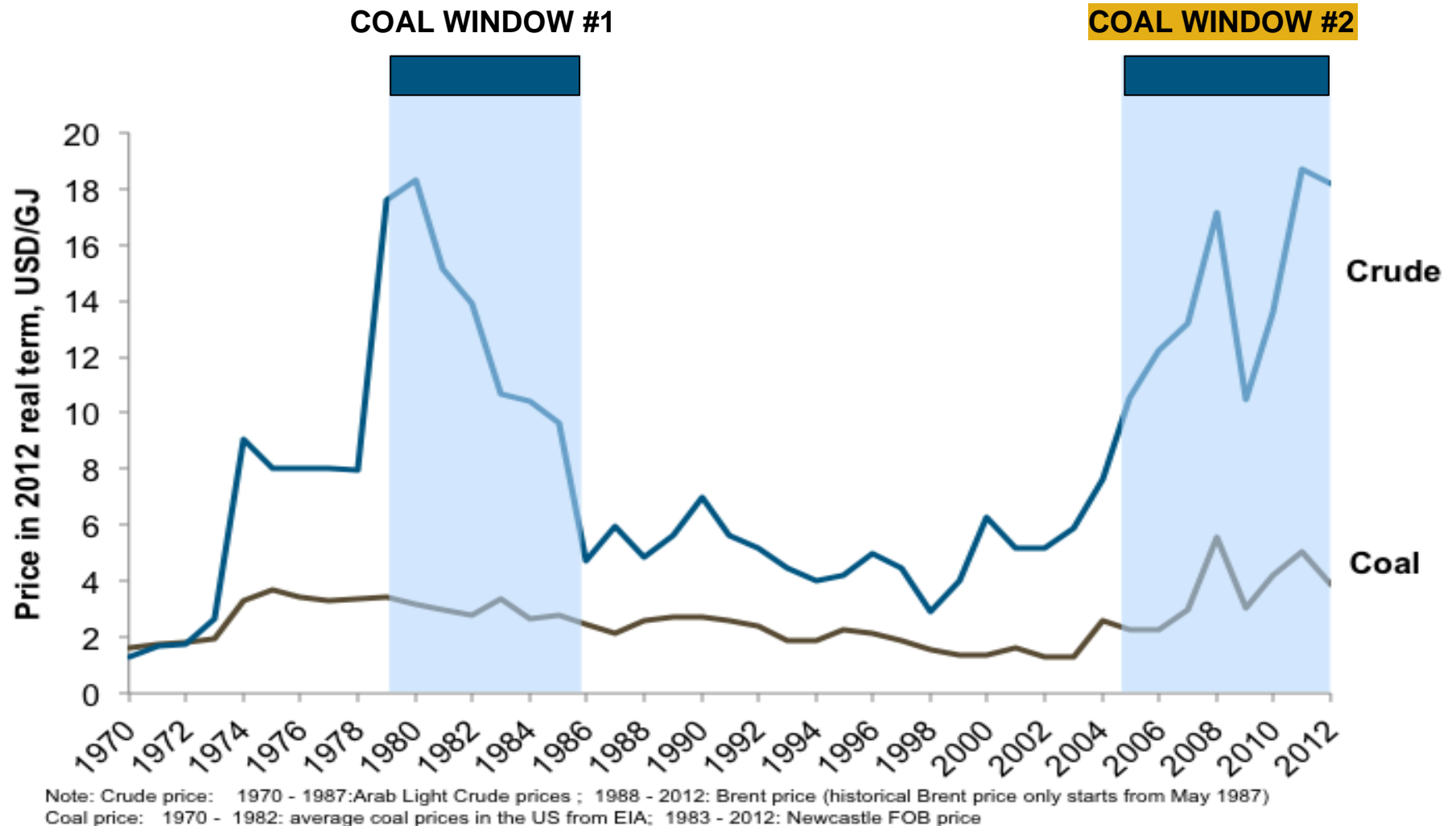
“China’s Air Quality Problem is Not Coal” November 2013
http://www.lantaugroup.com/files/pique_china_enviro.pdf

In the late 1970, oil prices shot up, creating a “coal window”

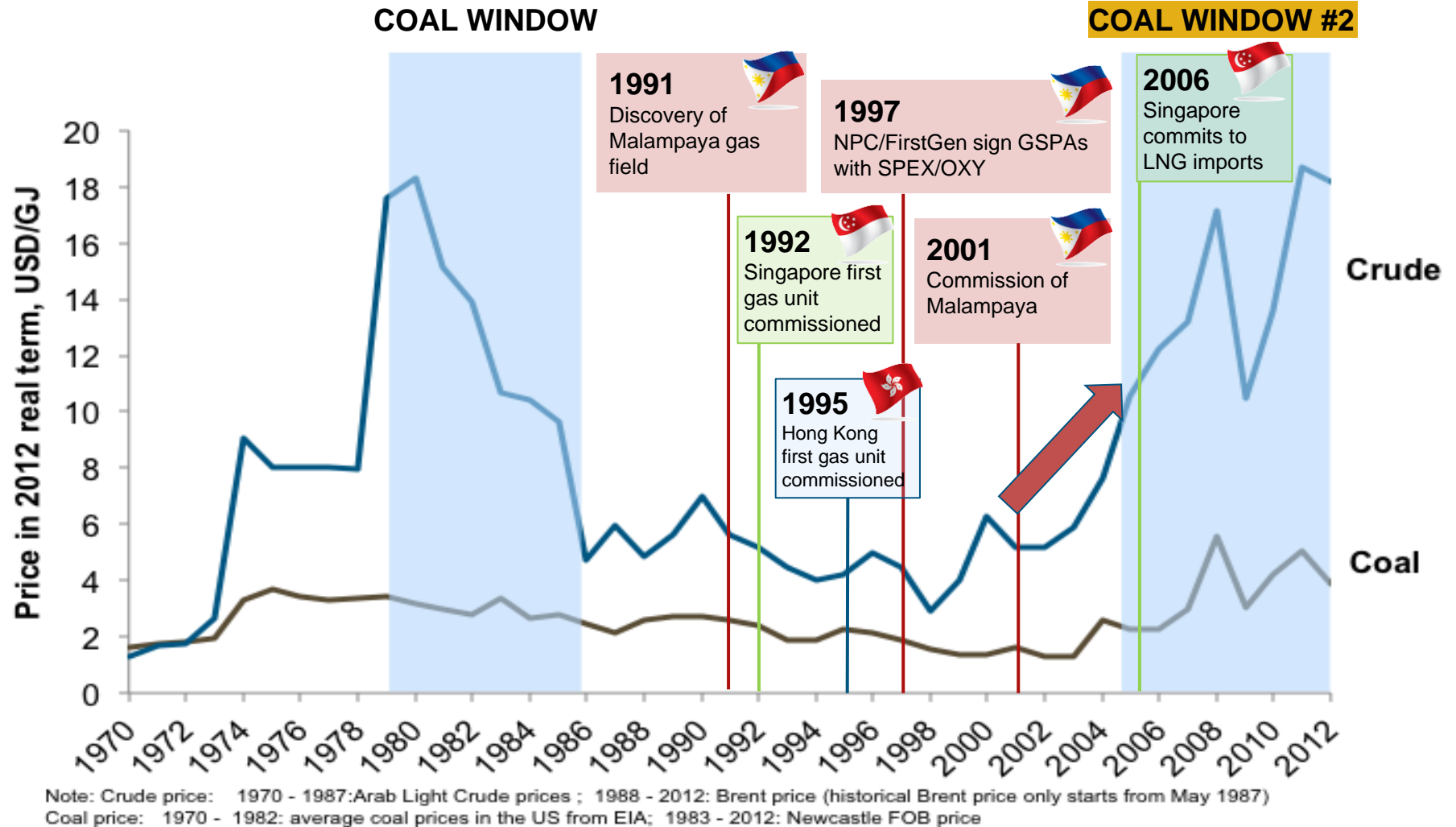


Note: Crude price: 1970 - 1987: Arab Light Crude prices ; 1988 - 2012: Brent price (historical Brent price only starts from May 1987)
Coal price: 1970 - 1982: average coal prices in the US from EIA; 1983 - 2012: Newcastle FOB price

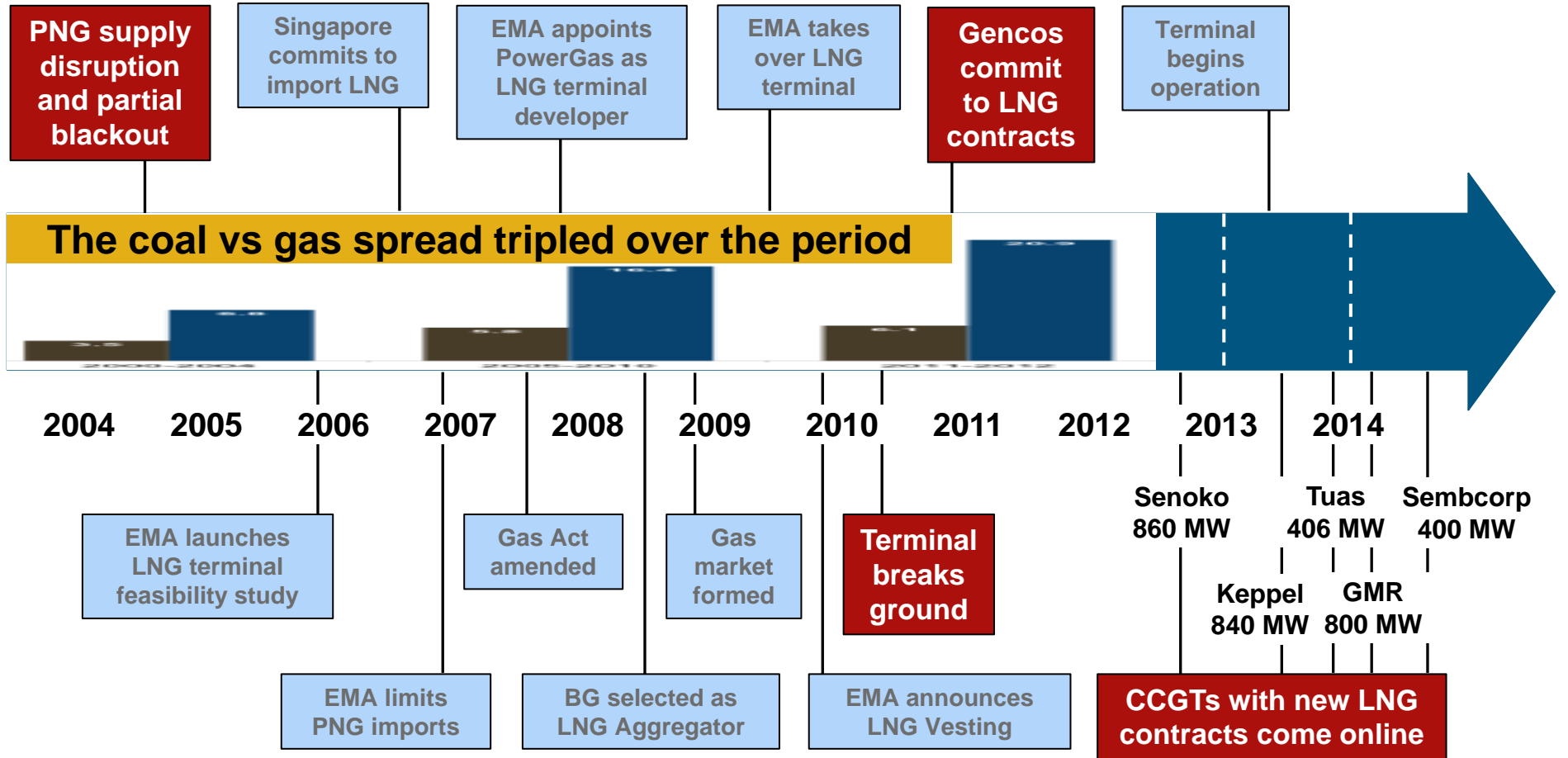
Around 2005, a second coal window opened and continues to this day



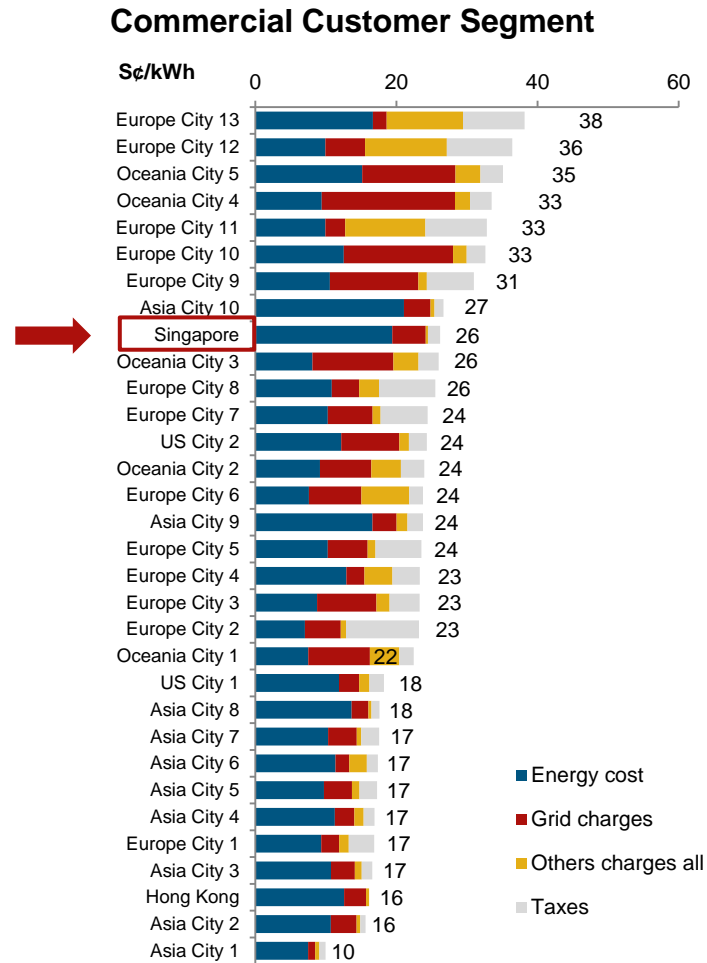
Asian gas prices are linked to oil – so many Asian countries developed gas-based strategies in between the two coal windows....



For example, Singapore studied LNG and then commissioned a terminal



Singapore has some of the highest electricity prices in Asia as a result of high dependency on imported gas and fuel oil



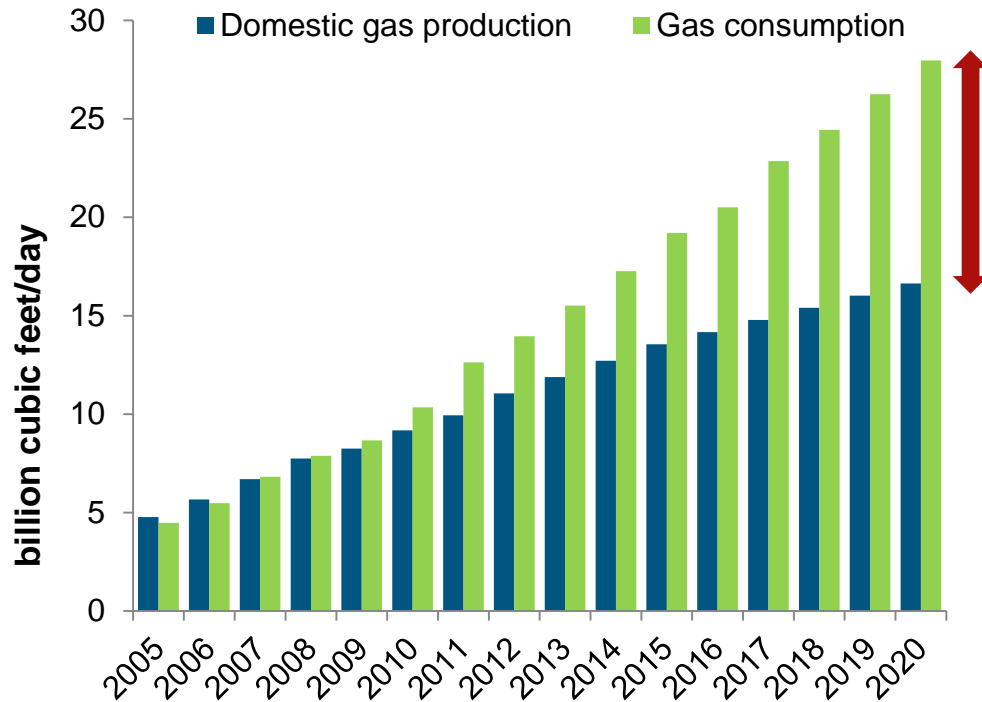
Coal has been key to keeping tariffs reasonable in Asia and other developing countries

But many countries are unsure about the role of coal in their fuel mix

- Poor experience with older or high-polluting existing power stations
- Belief that gas is cheaper (or will be) than it currently is (relative to coal)
- Belief that there needs to be a future “fuel mix”
- Concern about greenhouse gas emissions

The role of coal in Asia's power sector is complicated

Partly in response to environmental concerns, China is increasing its use of natural gas, but most new gas has to be imported



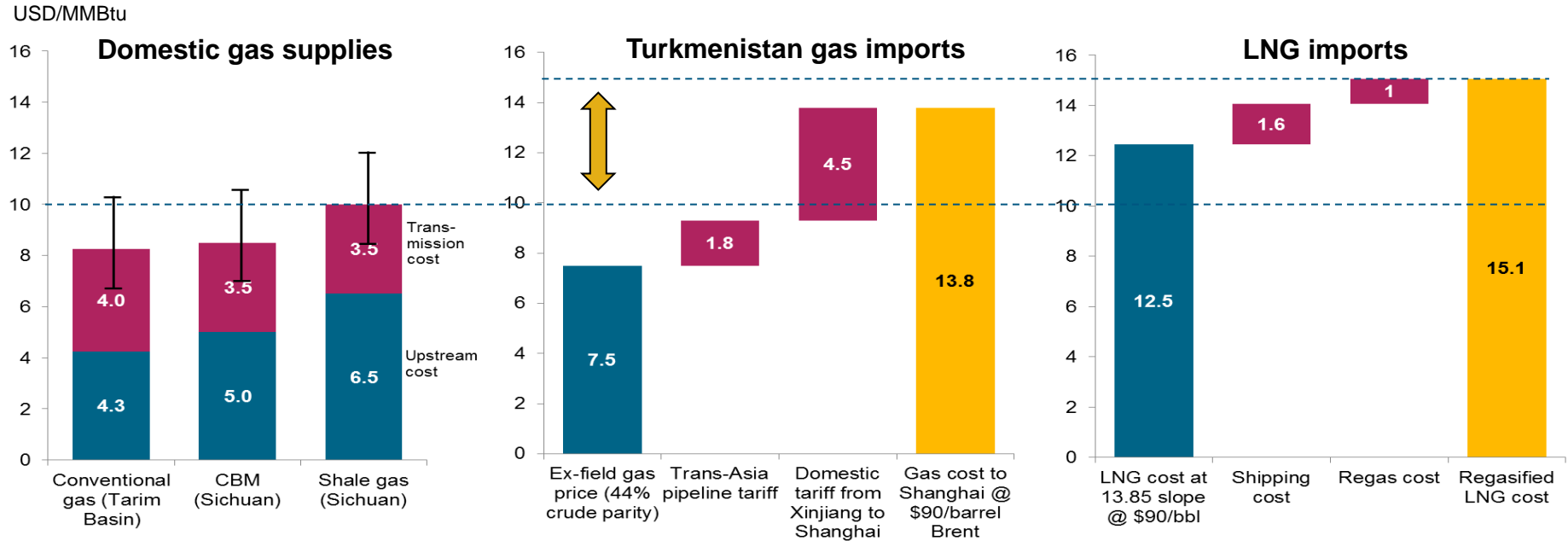
Source: 2005-2011 – data are from China Annual Statistical Book; 2012-2013 data estimated by TLG; 2014-2020 are forecasted by TLG

- Domestic production growth lags much behind the demand growth. Development in CBM and shale gas is slow due to policy, engineering and cost factors.
- Development of coal to gas projects is also slow due to concerns of environmental issues themselves and water constraints and lack of clear regulations.
- China natural gas import sources:
 - Liquefied natural gas (LNG): CNOOC, PetroChina and Sinopec have signed a total of 12 Sale and Purchase Agreement (SPA) with total contracted amount of about 37 million tonnes/year.
 - Pipeline gas imports: Central Asia – signed 30 billion cubic meters/year SPA contract; Myanmar – signed 5 billion cubic meters/year SPA contract; may sign more contracts from Central Asia and Russia.

Imported piped gas and LNG are much more expensive than domestic production

China's imported gas has much higher costs than existing domestic gas

Comparison of costs for different sources of gas supplies to Shanghai



Source: Annual reports, China Custom Statistics, news sources and TLG Analysis

The very low shale gas prices in the US are almost impossible to replicate elsewhere

To develop new domestic gas, China's gas infrastructure needs much more investment and development

China gas infrastructure, 2012
45,000 km

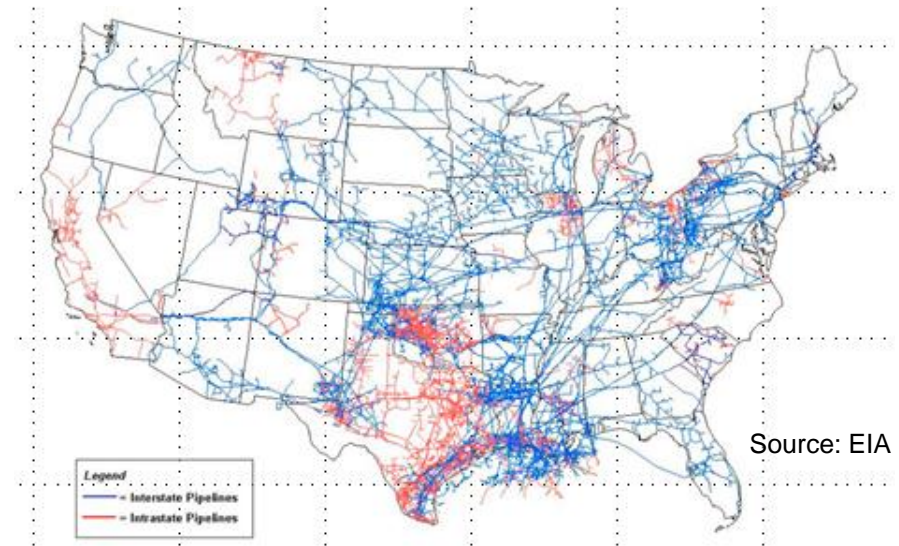
← ~4,500 km →



Source: PetroChina, news reports and TLG analysis

US gas pipeline infrastructure
Inter-state pipeline length – 360,000 km

← ~4,000 km →

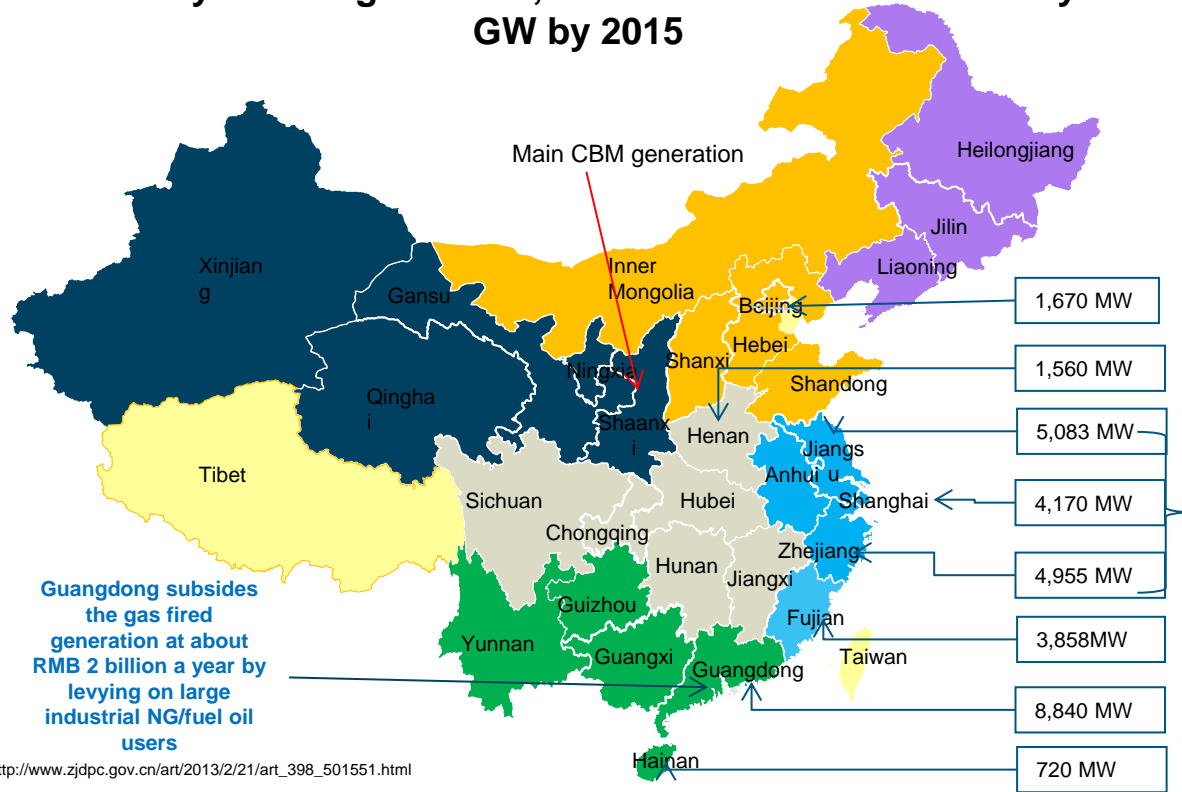


Source: EIA

China's gas network is still in a very early stage

The power sector has not been a driver of China's gas demand as gas-based generation on-grid prices are too low

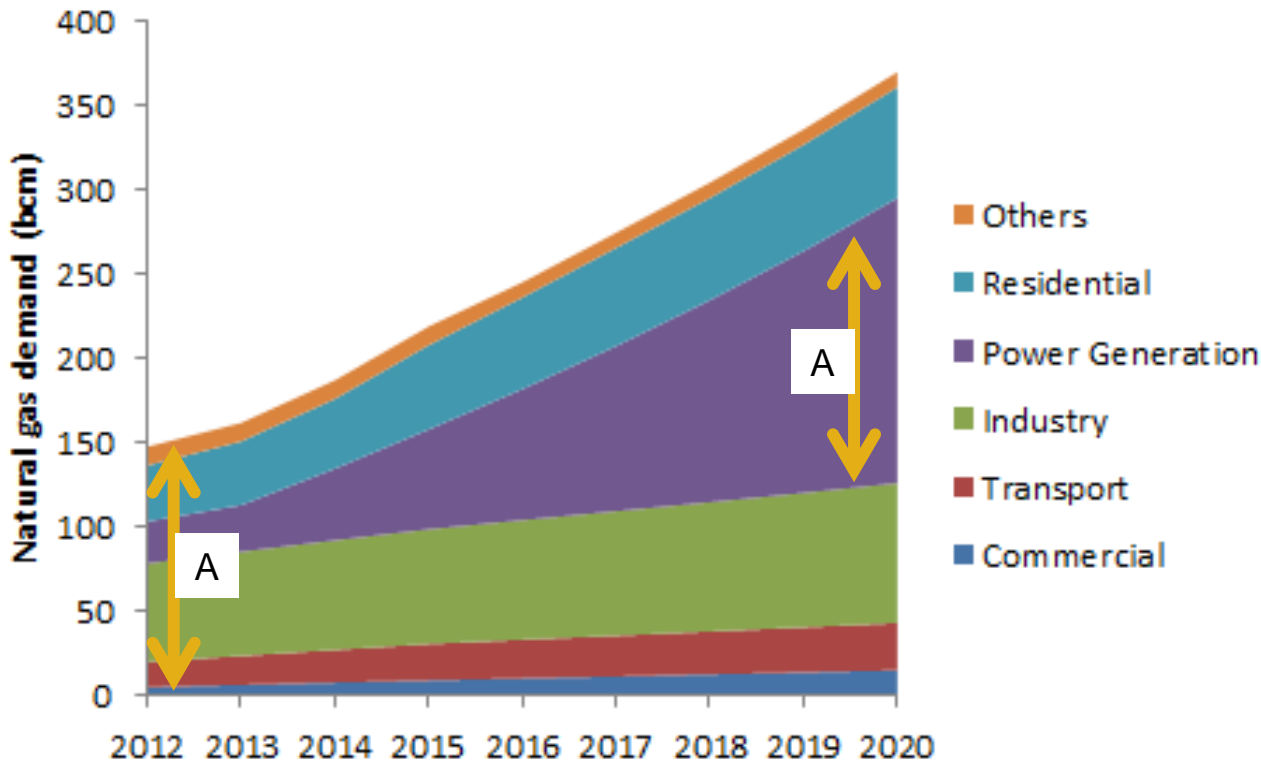
China has very little (only about 32 GW) of gas fired generation out of a system larger than 1,000 GW and aims to have only 56 GW by 2015



- Many gas fired plants rely on the financial subsidies from local governments, except those with gas supply from earlier LNG contracts or West-East Gas Pipeline I
- Recent increases for gas fired generation on-grid prices are not sufficient to induce more gas penetration in the power sectors
- Given high gas fired on-grid prices, grid operators do not have financial incentives to dispatch more gas fired generation.
- More stable and robust financial and dispatch mechanisms are required to support gas fired power generation.

China's power sector will need to pay much higher prices before gas becomes a more significant fuel for power generation

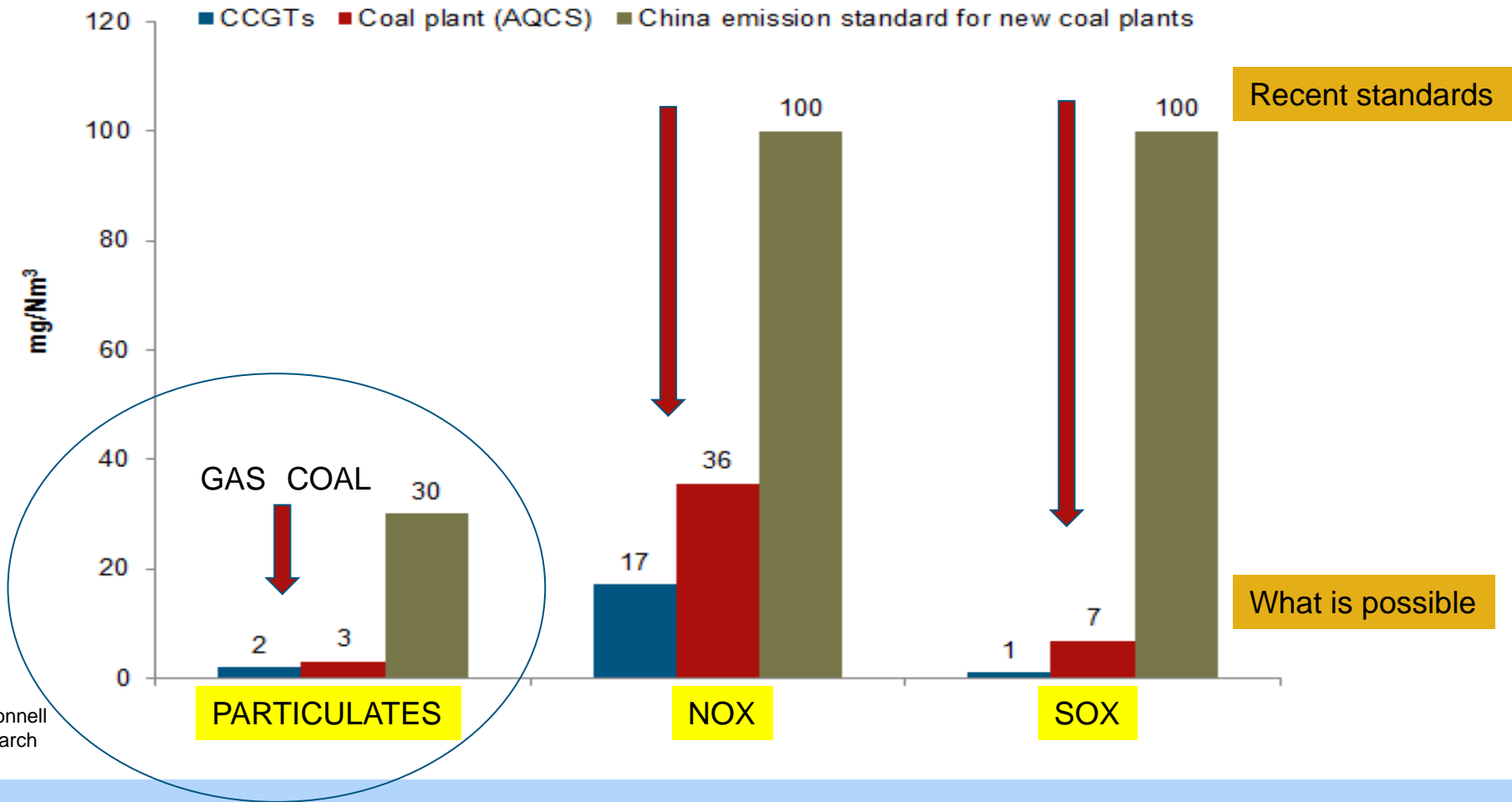
The amount of natural gas needed by the power sector to achieve a merely 10 percent generation share is almost as much what China currently uses



• China's power sector alone would consume more than China's 2013 consumption by 2020, creating huge stresses on the already stressed gas supply sector if gas fired power generation catches 10% of generation share by 2020

The power sector has been the major enabler of gas in other countries, but the economics and infrastructure are not in place in China at this time to support displacement of coal by gas

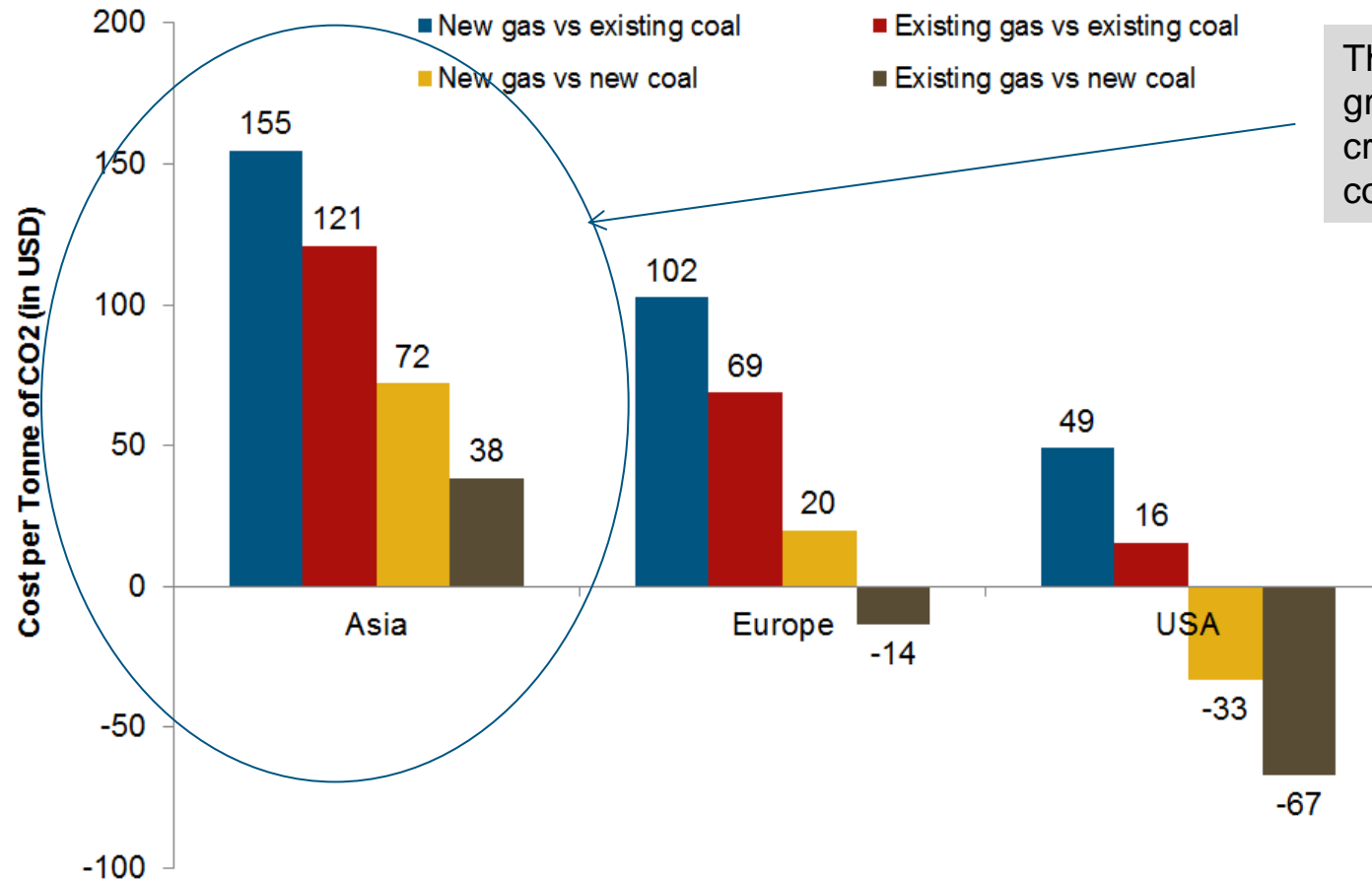
Technically, gas-fired generation is not a materially better solution to China's air quality problem (provided they are properly fitted with advanced AQCS)....



Data source:
Burns & McDonnell
and TLG research

Coal-fired boilers can achieve almost the same low levels of air non-carbon emissions as natural gas

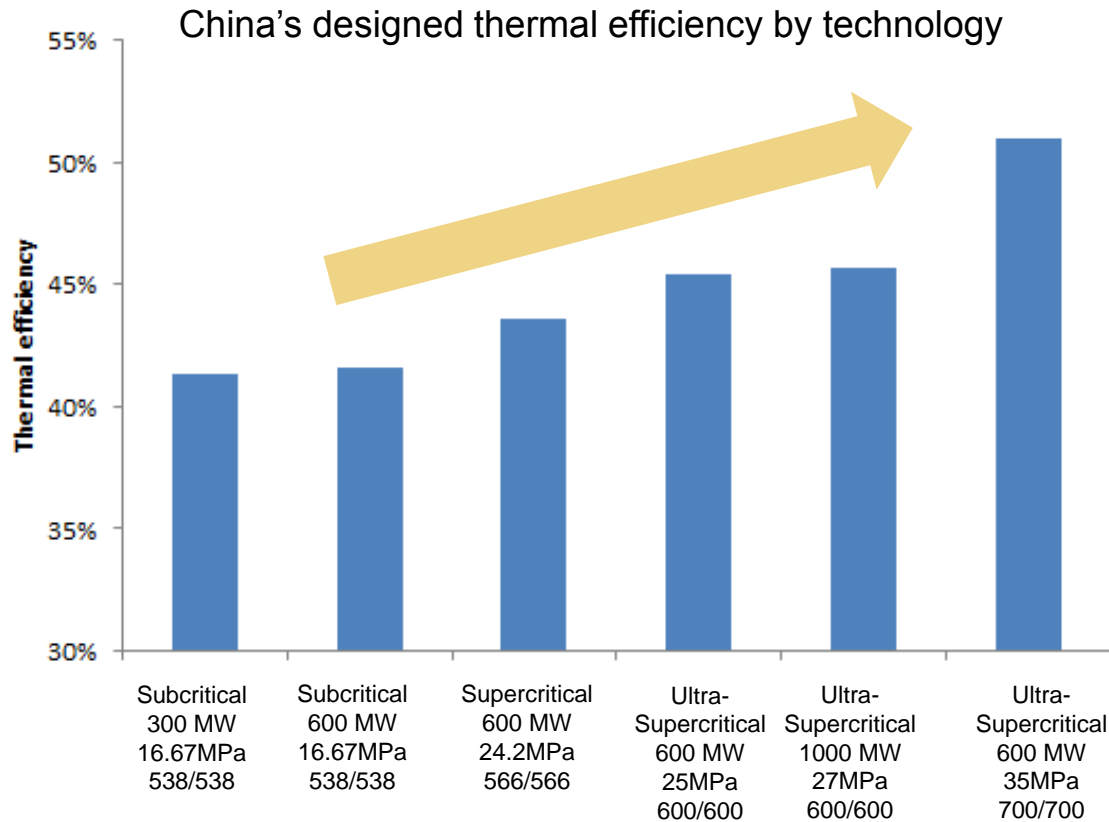
Switching from coal to natural gas for CO₂ involves exceptional costs in Asia compared to the rest of the world



These values are much greater than the cost of CO₂ credits traded in other countries

Much more cost-effective to stay with coal and participate in global carbon trading arrangements, than for China to switch from coal to natural gas for power generation at this time

China's use of coal in power generation is emerging as the most efficient in the world – reducing potential emissions per kWh generated

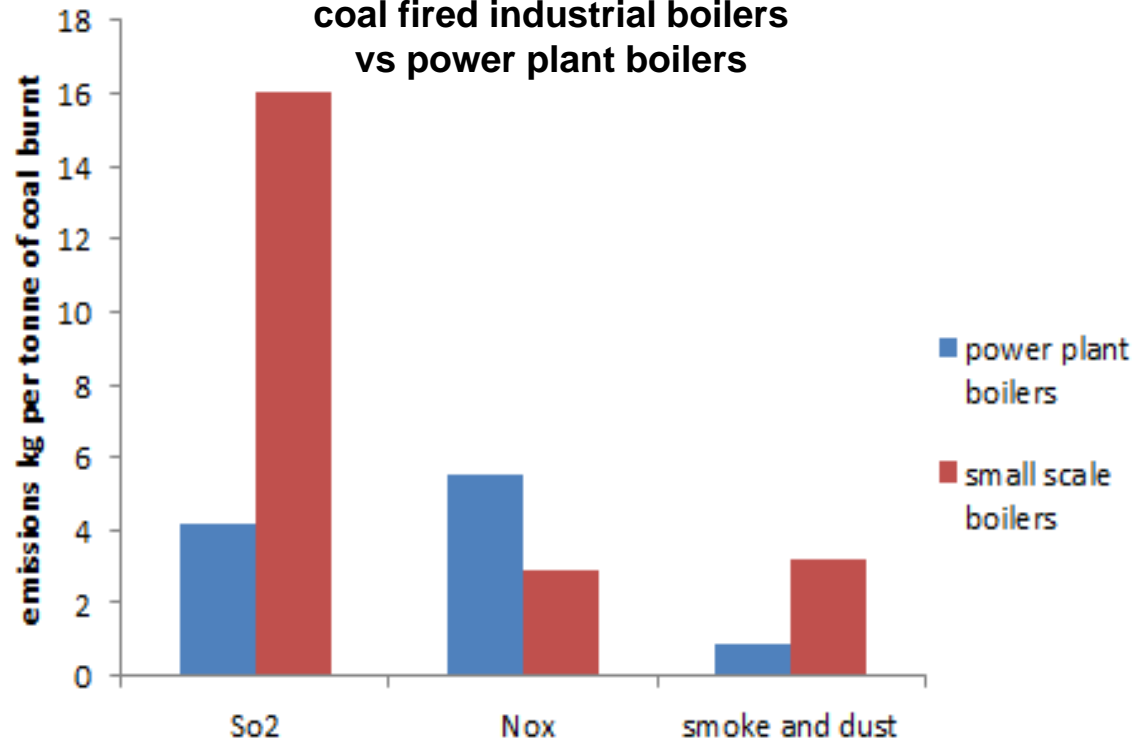


- If 300 MW units are replaced by an advanced USC, 72 million fewer tonnes of 5500 kcal/kg coal would be used for each 1,000 TWh generated
- With latest AQCS, emissions per MWh would approach the level of a gas fired CCGT
 - For example, dust removal efficiency rates (ESP, BH, ESP+BH)
 - ✓ 99.84% for 4 ESP
 - ✓ 99.968% for 5 ESP
 - ✓ 99.99% for 6 ESP

China is still building more efficient coal-fired generation to meet growth and to displace older less efficient generation (slowing or reducing emissions growth)

A key opportunity in China to improve air quality involves switching coal use from the non-power sector to the power sector (or from small to larger boilers)

**Emissions Comparison:
coal fired industrial boilers
vs power plant boilers**



Data source: YANG Jintian (2013), Chinese Academy for Environmental Planning

China 2012 data

China coal consumption
Total: ~3,700 million tonnes
Power and heat: 52.8%
Non-power boilers: 18%

China SO2 emissions
Total: 21.176 million tonnes
Power and heat: 37.6%
Non-power industry: 52.6%

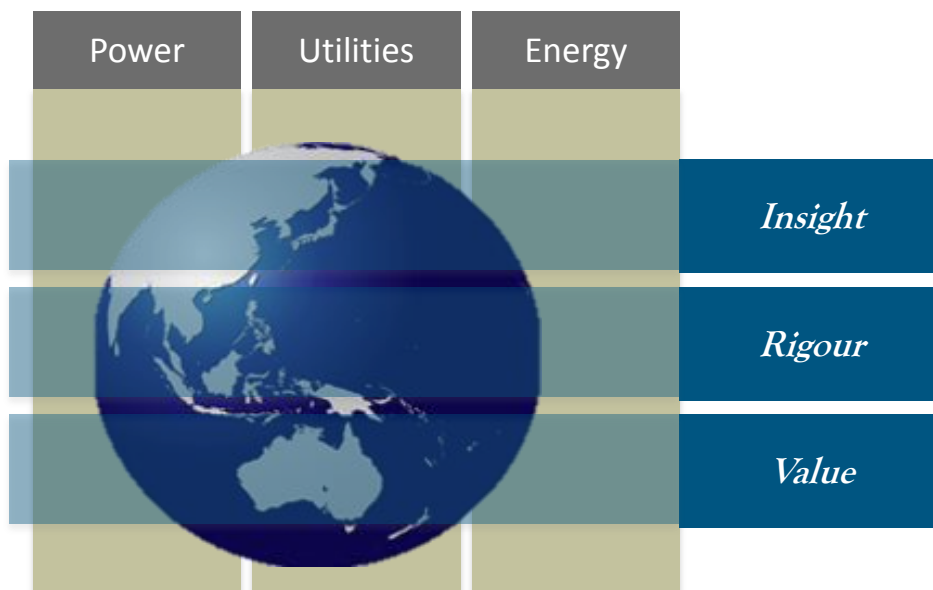
China NOx emissions
Total: 23.378 million tonnes
Power and heat: 43.6%
Non-power industry: 27.4%

China smoke and dust emissions
Total: 12.343 million tonnes
Power and heat: 18.1%
Non-power industry: 65.3%

China's latest boiler technology has the potential to greatly reduce emissions of all types

Coal-fired generation with technologically advanced AQCS systems can play a significant role in improving China's air quality

- China's coal-fired power generation is cleaner than coal combustion in China's non-power sector and cleaner than coal-fired generation in most developed countries
 - Higher boiler efficiency
 - Lower emissions
 - China can improve even more as it adopts the latest AQCS technology
- A key opportunity involves shifting away from smaller, less efficient, boilers, towards the most efficient larger boiler designs with AQCS emission control systems
- Aggressive switching from coal to natural gas is not cost-effective for China, even when considering CO₂ costs
 - Better options involve participation in global CO₂ trading regimes and development of non-emitting technologies (China's nuclear, hydro, and other renewable energy initiatives)



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