Curbing Air Pollution and Greenhouse Gas Emissions From Industrial Boilers in China: an analysis and implementation roadmap

解决工业锅炉，减少大气污染及应对气候变化：中国工业锅炉能效提升及燃料替代的技术经济分析及实施路线图

Bo Shen 沈波
Lawrence Berkeley National Laboratory 美国劳伦斯伯克利国家实验室

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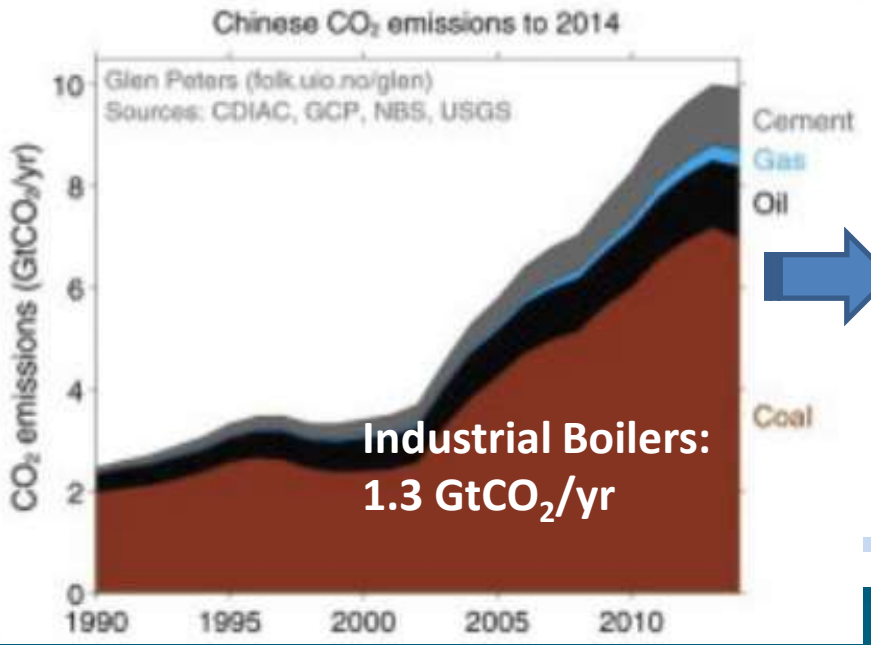
Why industrial coal-fired boilers?
解决工业燃煤锅炉的重要性

- Largest coal-consuming single industrial system最大的单一工业耗能设备
- 18% of China's total coal use
- 33% of total soot emissions
- 27% of total SO_2 emissions

Heavy air pollution near the China Central Television headquarters building in Beijing, 2014. Photo Credit: The Guardian.



Country	Total CO_2 emissions from Energy Use (Gt CO_2/yr), 2012
Japan	1.26
Australia	0.42
U.K.	0.49
Germany	0.79
Canada	0.55
India	1.83
U.S. 2025 goal	1.85~1.99

Boiler Opportunities Assessment Project Background and Scope 锅炉评估研究的背景和内容

- Chinese central and city governments actively taking actions to mitigate air pollution and GHG emissions related to industrial boilers: ***Boiler Action Plan*** announced in October 2014
- The U.S. and China are working together on industrial boiler under the framework of U.S. – China Climate Change Working Group

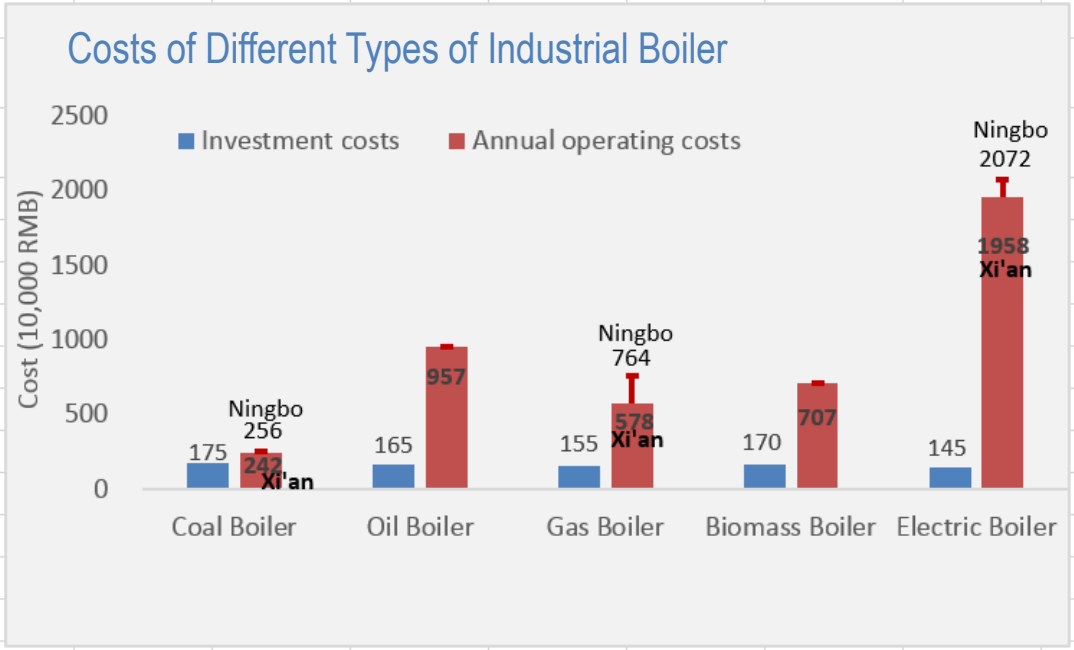
- To understand the landscape and issues related to industrial boilers
- To conduct a comprehensive techno-economic assessment of various options of addressing industrial boilers
- To develop an implementation roadmap with the goal to maximize boiler efficiency improvement and fuel switching opportunities
- To identify potential areas for U.S.-China further collaboration

Three Options Assessed 三种解决方案

1. Fuel switch: replacing coal with natural gas, biomass, oil, or electricity 燃料替代
2. Retrofitting existing boilers to improve energy efficiency 提升现有锅炉能效
3. Replacing scattered boilers with a community-scale system 以分布式能源中心取代企业自营小锅炉提供服务

1 Fuel switch: replacing coal with natural gas, biomass, oil, or electricity 方案一：燃气、生物质、燃油、电锅炉替代煤锅炉

- The fixed costs do not differ much but operation costs differ significantly due to distinctive fuel prices
- Electric boilers are the most costly option mainly due to the energy conversion losses and higher electricity prices for industrial customers in China.
- Natural gas can be a viable option if its price can be kept competitive
- Biomass can be a good fuel switching option but the focus on biomass-based electrification can make it hard to bring biomass boilers to scale



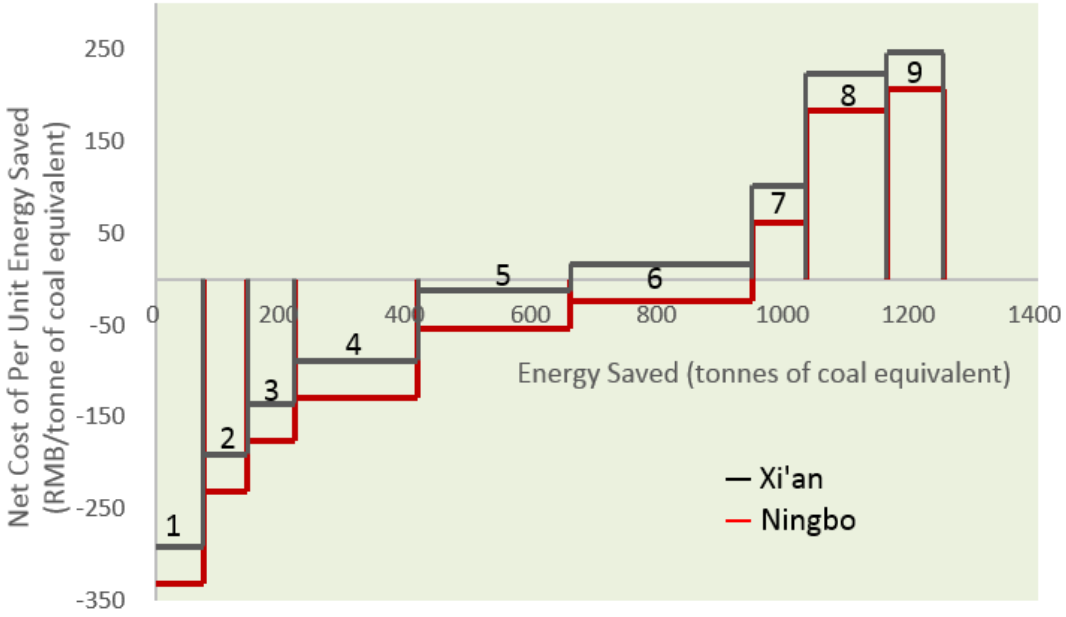
Electricity Prices to Make Electricity Competitive to Other Fuels

City	Chain-grate stoker coal boiler	Heavy oil boiler	Natural gas boiler	Biomass boiler
Ningbo	0.11	0.41	0.33	0.30
Xi'an	0.10	0.41	0.25	0.30

- Electric boilers are not an economical option for a complete replacement of coal-fired boilers, they can be used as a supplementary energy storage during electricity grid off-peak hours when electricity is inexpensive and the use of excess power (e.g., from wind) is desirable.

2 Retrofitting existing boilers to improve energy efficiency 方案2：提升现有锅炉能效

Fuel prices play an important role in affecting the economic potential of EE measures. Five and six are cost effective in Xi'an and Ningbo, respectively. adopting these measures could create more cost savings in Ningbo than in Xi'an



1. excess air management
2. boiler water treatment and descaling
3. insulation of steam piping, valves, fittings, and vessels
4. flue-gas thermal energy recovery
5. condensate recovery
6. compound combustion on chain grate boiler
7. boiler blowdown and recovery of heat from boiler blowdown
8. smart soot-blowing optimization and online slagging warning system
9. recovery of flash steam

Net cost is derived from annual avoided operating cost of using saved energy due to efficiency gains plus incentives received for pursuing the retrofit minus the annualized investment cost

3 Replacing scattered boilers with a community-scale system (Distributed Energy Center)
方案三：建立分布式能源中心取代企业自建小锅炉

Category	Indicators	1. Natural gas-based CHP	2. Community-scale coal-fired boilers	3. Community-scale natural gas boilers	4. Self-operated natural gas boilers
		Thermal to Electricity Ratio: 3.5: 1			
Cost (exclude the environmental compliance cost)	Net cost* (10,000 RMB)	6976.78	2552.64	6697.66	7515.51
	% of the cost of option 4: facilities self-operated natural gas boilers	92.8%	33.96%	89.12%	100%
Cost (include environmental compliance cost)	Net cost* (10,000 RMB)	7293.74	3435.33	6876.65	7698.56
	% of the cost of option 4: facilities self-operated natural gas boilers	94.74%	44.62%	89.32%	100%
Cost (with environmental compliance cost and a further reduction of natural gas price by 0.50 RMB/ m^3)	Net cost* (10,000 RMB)	4910.54	3435.33	5530.91	6322.23
	% of the cost of option 4: facilities self-operated natural gas boilers	77.67%	54.34%	87.48%	100%

Barrier to addressing the boiler challenge
解决工业燃煤锅炉的障碍

Barriers to improving energy efficiency 能效提升的障碍

- Lack of comprehensive efficiency standards
- Technologies focus less on boiler energy performance and lack of boiler system-wide solutions
- Lack of good operation practices and effective management for boilers
- Lack of technical capacity in operating boiler systems
- Lack of strong monitoring and enforcement

Barriers to fuel switching 燃料替代的障碍

- Lack of effective boiler phase-out compliance plan and strategies
- Lack of market competition and uncertainty in policies, fuel prices, market risks, and technologies
- Shortage of natural gas supply for industrial gas use and high natural gas prices

Roadmap to Capturing Opportunities
燃煤锅炉能效提升及燃料替代路线图

- Taking a holistic approach to addressing coal-fired industrial boilers
- Developing and deploying cost-effective compliance strategies
- Creating enabling policy
- Accelerating technology development and deployment via incentives
- Developing effective standards and guidelines
- Promoting advanced technologies and integrated solutions via implementation of pilots
- Stimulating greater investment via innovative business models and financing mechanisms
- Strengthening enforcement and enhancing its effectiveness via great flexibility
- Enhancing technical support and building strong capacity

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Thank you
Questions?

contact information
For more info, please contact

BoShen@lbl.gov