CDM Potential of Electric Power Sector and Energy-intensive industries in China

Outcome of 5-Year Joint Study of Keio University/Tsinghua University

Sponsored by NEDO (New Energy and Industrial Technology Development Organization) Japan

Members of Joint Research Team

- Keio University

Mitsutsune YAMAGUCHI, Professor, Faculty of Economics
Osamu KAWAGUCHI, Professor, Faculty of Science and Technology
Minoru FUJII, Senior Technical Advisor, Hitachi Engineering Co., Ltd.
Yasuhiro KONNO, Senior Technical Advisor, Hitachi Engineering Co., Ltd.
Kuniyuki NISHIMURA, Research Director, Mitsubishi Research Institute, Inc.
Shuta MANO, Staff Researcher, Mitsubishi Research Institute, Inc.

- Tsinghua University

Lu Yingyun, Professor, 3E Research Institute
Liu Deshun, Professor, Institute of Nuclear Energy Technology
Ma Yuqing, Professor, 3E Research Institute
Zhao Yong, Associate Professor, 3E Research Institute
Zhou Sheng, Lecturer, 3E Research Institute
Tong Qing, Assistant Professor, 3E Research Institute

- Members of the 3E CDM Committee in Japan
- Various staffs in Electric Power Companies in China

Purpose of the study

- Contribute sustainable development of China through promoting CDM activities
- Establish a methodology of estimating CO_2 emission reduction potential
- Provide reliable figures of emission reduction potentials and costs of CDM in China to prospective investors worldwide

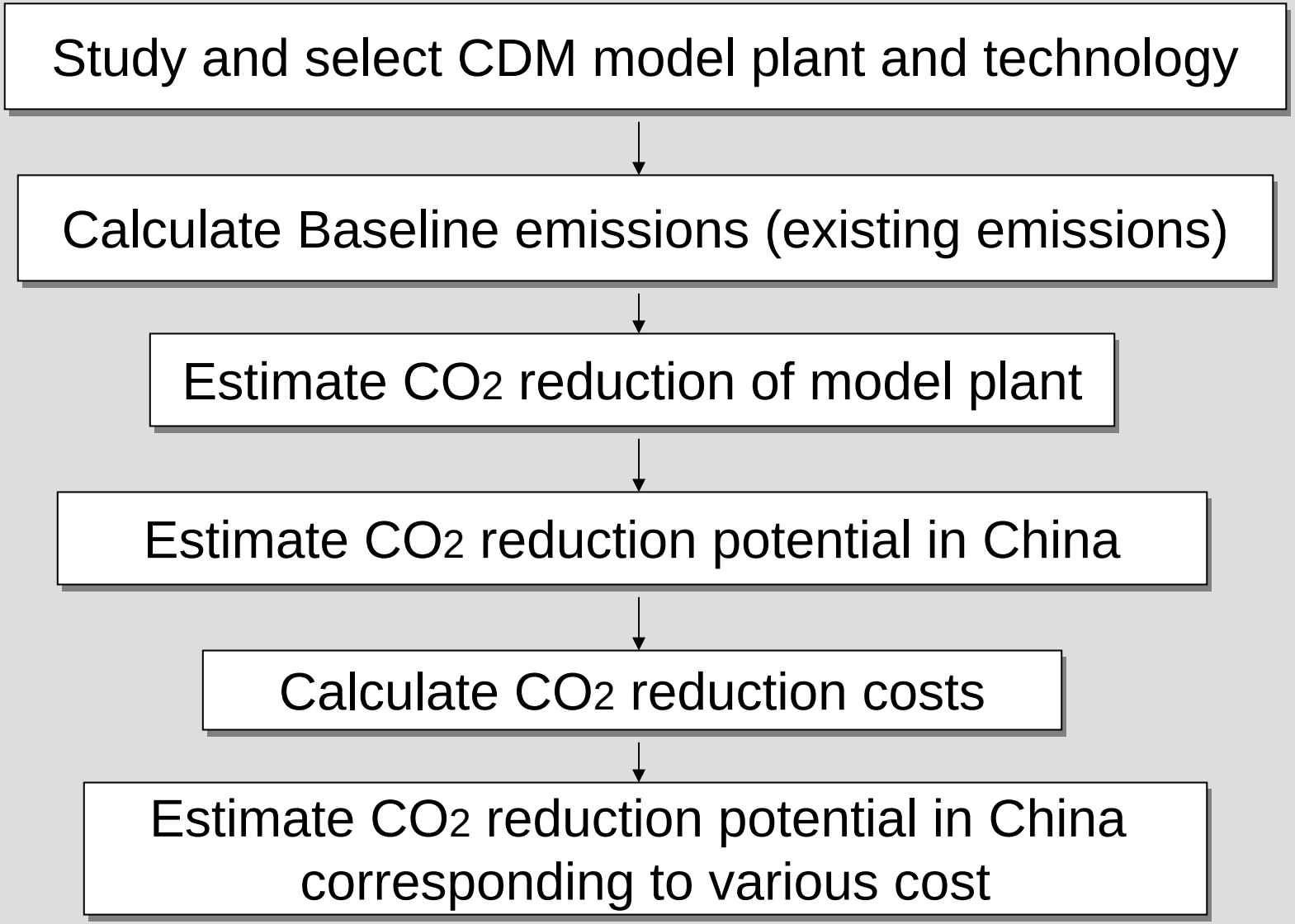
Characteristics of our study

- Thorough bottom-up approach
- Technology-based
- Based on the actual data (especially in electric power plant cases)
- Intense cooperation of Keio-Tsinghua Universities as well as Academia, Industry and Governments
- Best mix of climate and technology experts, mechanical engineers, research institute, business society of both countries

Targeted sectors and reason

- Targeted sectors
  - Power Generation
  - Iron & Steel
  - Paper & Pulp
  - Cement
  - Oil Refinery and Chemicals
- Reason
  - Major CO_2 emitters

Process of analysis



CDM potential in electric power plants (Keio & Tsinghua U.)

- Collection of basic data of all power plants in North China (Tsinghua University and power plants in North China)
- Classification of power plants

Group 1：50 MW units	Scrap & Build Option
Group 2：100，200 MW units	Modification
Group 3：300 MW units	Fuel switching

The above 3 groups account for 75% of total capacity in North China

- Selection of model units/technologies, collection of detailed data, thereafter implementation of site survey
- Price of fuel (gas price is about 8 times higher than coal)

Estimation of CO_2 reductions

- Calculate baseline emissions

  "Existing actual emissions" are used as baseline

- Estimate CO_2 emission reductions of model units by applying state-of-the-art Japanese technologies (with some exception)

- Apply model units' reduction to all others units

Summary of CO_2 emission reduction potential (Power Plants)

50 MW Scrap & Build(50MW to 200MW)	100MW Retrofit	200MW Retrofit	300MW Fuel switching from coal to natural gas	Total
11,695	7,180	9,004	45,550	73,429

Unit 1000 t/y

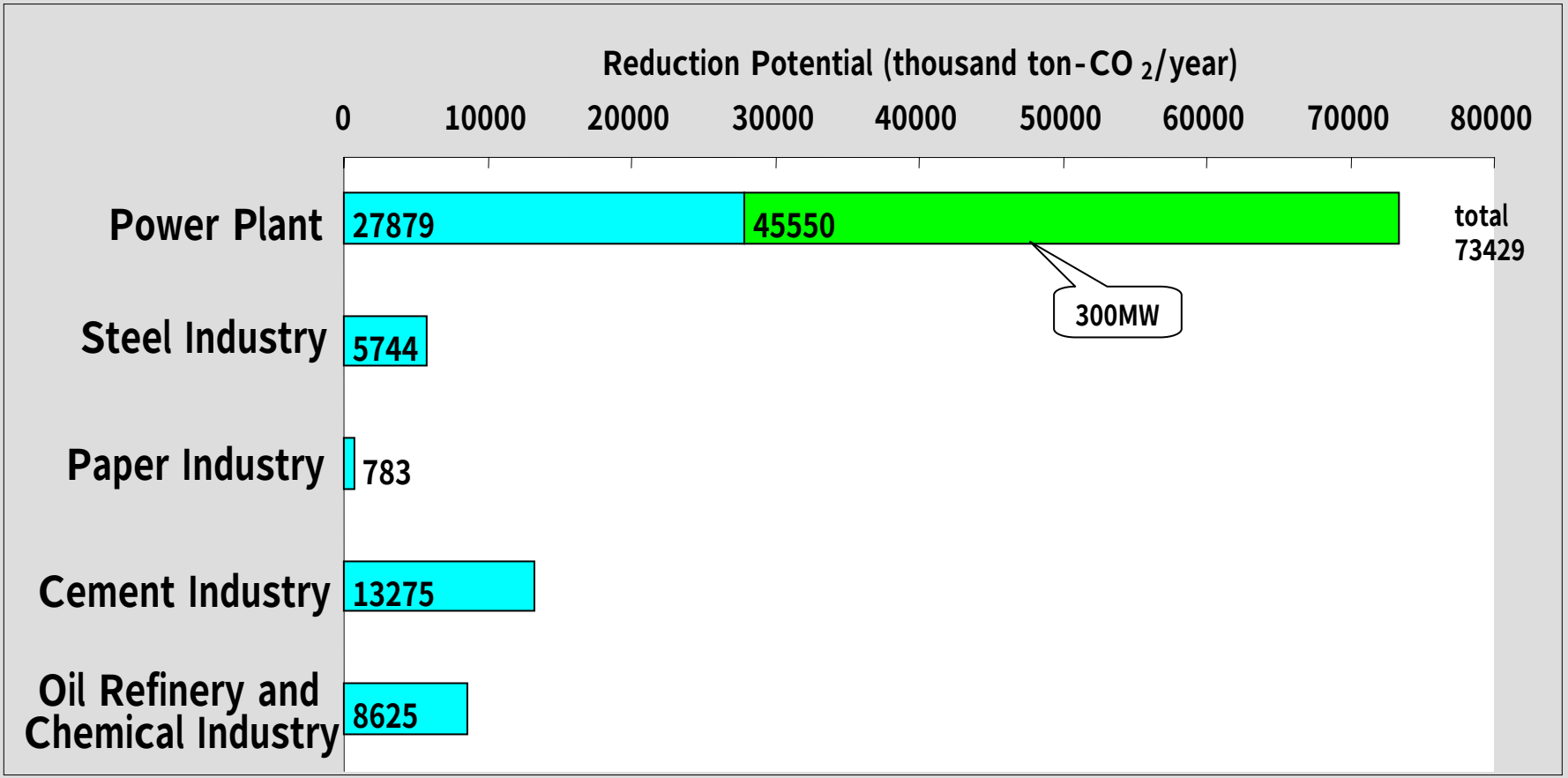
Other energy intensive industries (Iron & steel)

Technologies Japanese state-of-the-art technology	Targeted plants
Coke Dry quenching (CDQ)	Plant capacity bigger than 1 Mt of Pig Iron, but excludes plants already installed them
Top Pressure Recovery Turbine (TRT)	Blast furnaces exceeding 1000 M3, but excludes plants already installed them

Other energy intensive industries (Cement, Chemicals and Paper)

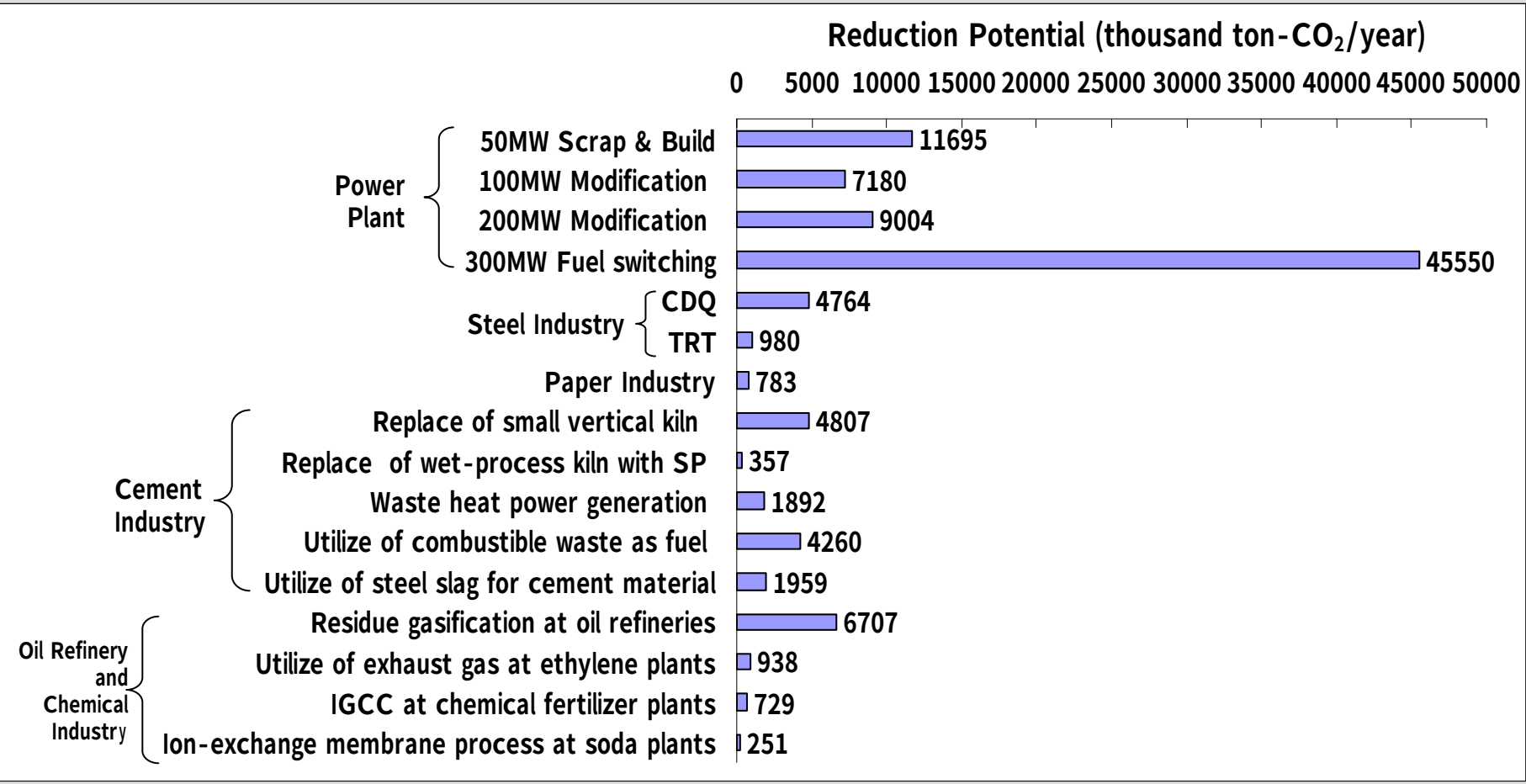
- Cement Japanese state-of-the-art technology
  - Replacement of small vertical kiln with fluidized bed kiln
  -Replacement of wet-process kiln with suspension preheater
  -Waste heat power generation
  -Utilization of combustible waste as fuel
  -Utilization of steel slag for cement material
- Oil refinery and chemical industry Japanese state-of-the-art technology
  -Oil refinery (Gasification of oil residue and power generation)
  -Ethylene (Gas turbine installation and utilization of exhaust gas for cracking furnace)
  -Chemical fertilizer (Coal gasification combined power generation)
  -Clor-alkali (Replacement of diaphragm process with ion-exchange membrane process
- Paper Japanese state-of-the-art technology
  -Replacement of main motors/main auxiliary motors with variable speed motors
  -Installation of closed type dryer hood and waste heat recovery equipment for dryer and other remodeling

Comparison of CDM reduction potential by industry



Paper industry：Reduction potential is 394～1172 thousand ton-CO_2. 783 thousand ton-CO_2 showed above is average.

Comparison of CDM reduction potential by technology



Cost estimation methodology

$$\sum_{i=1}^{n} \frac{(SB_i - EB_i - MB_i)}{(1+r)^i} - \sum_{i=1}^{n} \frac{(SC_i - EC_i - MC_i)}{(1+r)^i} - I_0$$

(Baseline emission) **(Emission after CDM project)**

$$= \sum_{i=1}^{n} \frac{(EC_i - EB_i)}{(1+r)^i} + I_0$$

--- (Numerator means saved fuel)

$$\frac{\sum_{i=1}^{n} \frac{(EC_i - EB_i)}{(1+r)^i} + I_0}{\sum_{i=1}^{n} Y_i}$$

(Denominator means CO_2 reduction in year i)

(Carbon reduction cost per ton)

***SB_i*: revenue, *EB_i*: fuel cost, *MB_i*: maintenance cost of Baseline case**

***SC_i*: revenue, *EC_i*: fuel cost , *MC_i*: maintenance cost of CDM case**

***I_0*: initial investment cost of the project**

Reduction potential and cost (1)

Power Plant	Reduction Potential 1,000t- CO_2/y	Cost, $/t - CO_2 7 year crediting period	Cost, $/t - CO_2 14 year crediting period
50 MW Scrap & Build	11,695	8.3	2.5
100 MW Retrofit	7,180	19.4	8.0
200 MW Modification	9,004	28.3	12.7
300 MW Fuel switching	45,550	61.4	41.4
Total	73,429		

Reduction potential and cost (2)

Iron & Steel	Reduction Potential 1,000t- CO_2/y	Cost, $/t - CO_2 7 year crediting period	Cost, $/t - CO_2 14 year crediting period
CDQ	4,764	1.6	-15.3
TRT	980	0.5	-15.6
Total	5,744		

Reduction potential and cost (3)

Paper & Pulp	Reduction Potential 1,000t- CO_2/y	Cost, $/t - CO_2 7 year crediting period	Cost, $/t - CO_2 14 year crediting period
Replacement of main motors etc.	394 - 1,172	21.1	0.91

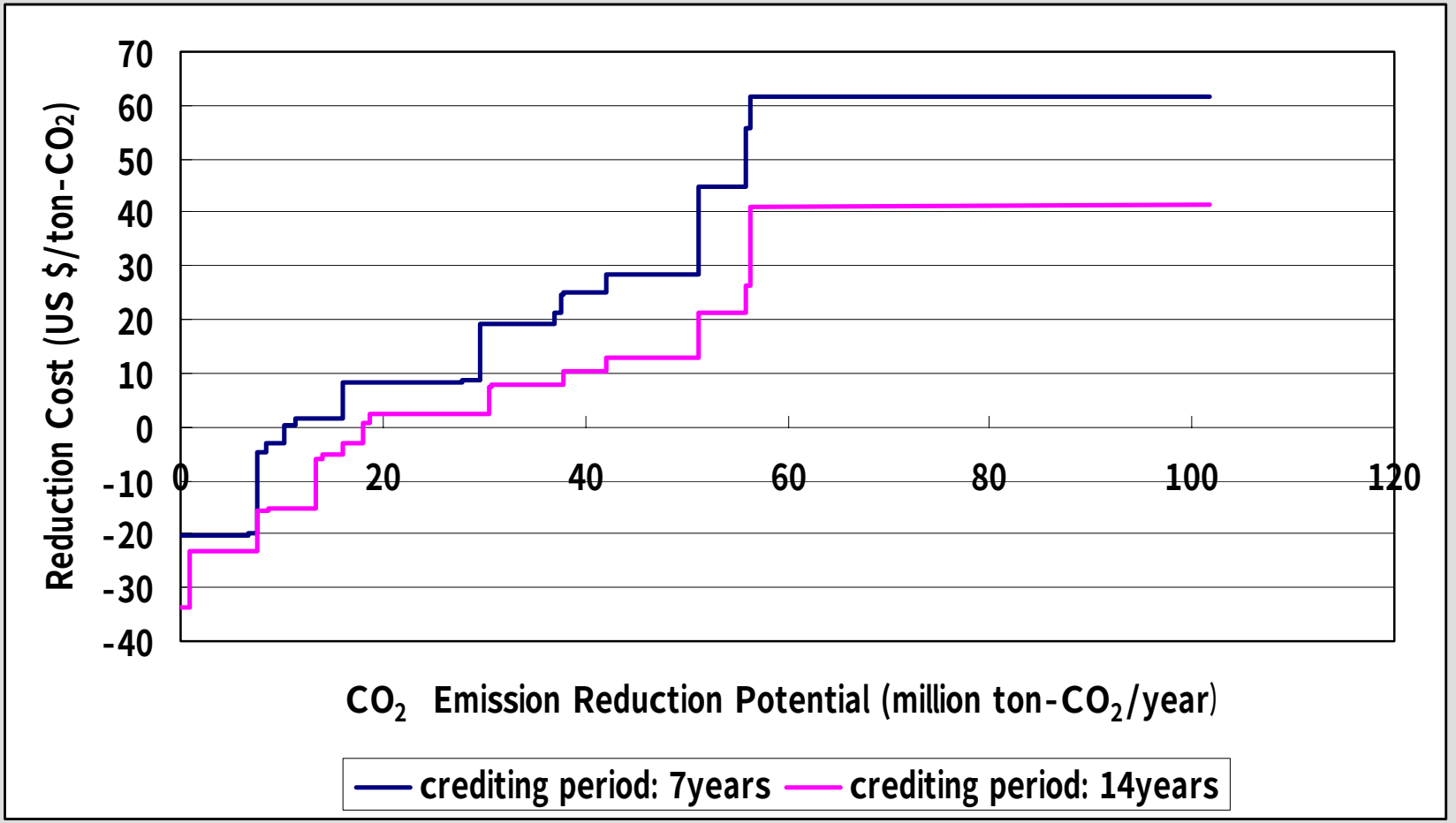
Reduction potential and cost (4)

Cement	Reduction Potential 1,000t- CO_2/y	Cost,$/t - CO_2 7 year crediting period	Cost, $/t - CO_2 14 year crediting period
Replace of small vertical kiln with fluidized bed kiln	4,807	45.0	21.4
Replace of wet-process kiln with Suspension Pre-heater	357	55.9	26.2
Waste heat power generation	1,892	8.9	-5.2
Utilize of combustible waste as fuel	4,260	25.0	10.2
Utilize of steel slag for cement material	1,959	-2.9	-3.1

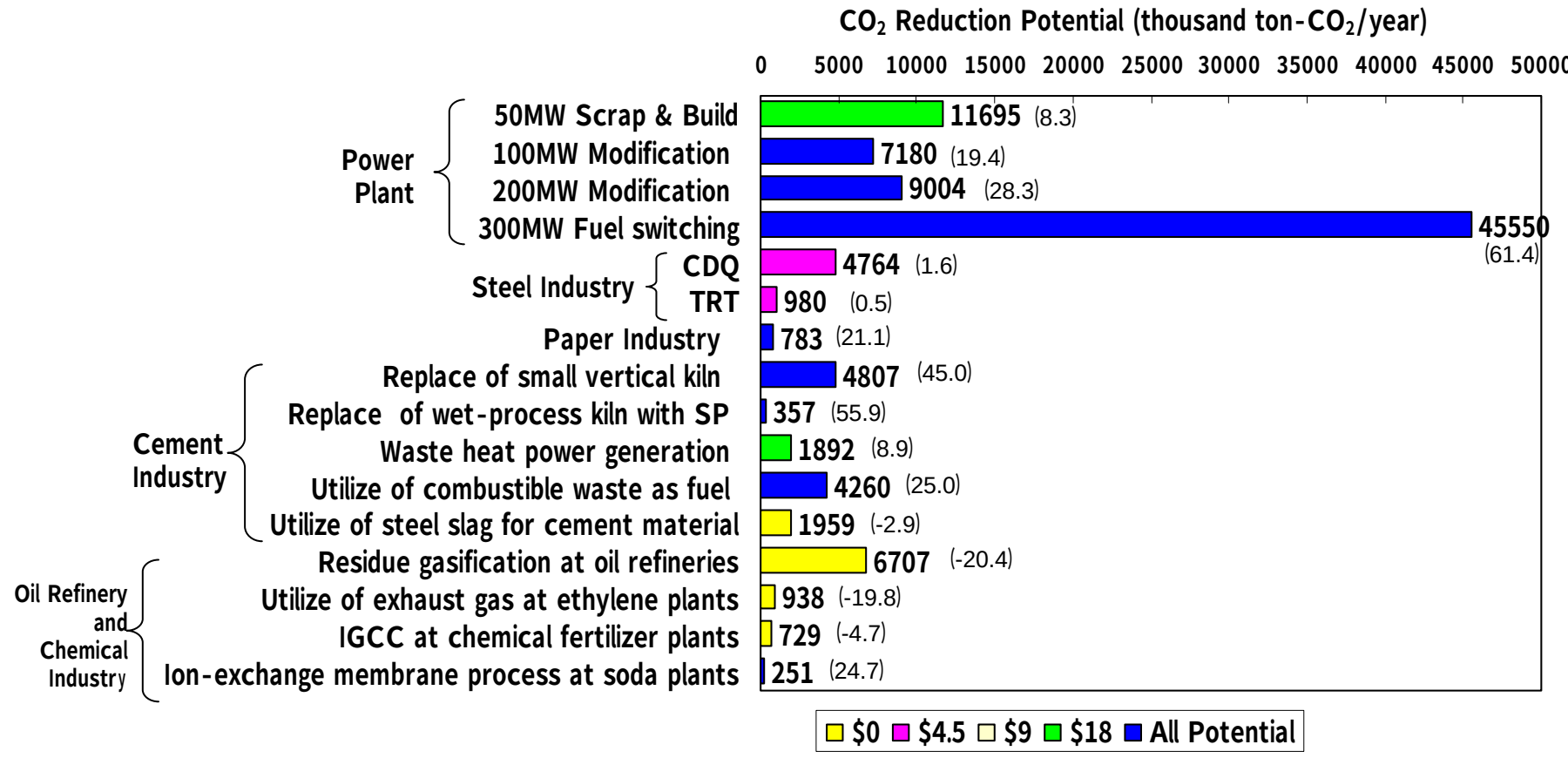
Reduction potential and cost (5)

Oil refinery, Chemicals	Reduction Potential 1,000 CO_2 t/y	Cost, $/t 7 year crediting period	Cost, $/t 14 year crediting period
Oil refinery (Gasification of oil residue and power generation)	6,707	-20.4	-23.3
Ethylene (Gas turbine installation and utilization of exhaust gas for cracking furnace)	938	-19.8	-33.5
Chemical fertilizer (Coal gasification combined power generation)	729	-4.7	-5.8
Clor-alkali Replacement of diaphragm process with ion-exchange membrane process	251	24.7	7.5

Marginal Cost Curve of CDM in China



Reduction Potential corresponding to credit prices



Tentative Conclusion

- Potential CO2 emission reduction in five major sectors is around 100 Mt (Physical potential)
- Among them, power generation sector is the largest (especially at 300 MW units)
- When considering cost, picture changes drastically
- Very few commercially viable projects exist (at zero cost, total reduction will be only 10 Mt, at $4.5, still 16 Mt even under our baseline emission figures)
- Fuel switching projects in power sector will not be feasible due to high cost of natural gas
- Public funding is essential for promotion of CDM projects in China

Further works

- Elaborate baseline emissions in view of discussions at the Executive Board
- Revisiting selection of model plants
- Improve data quality (other than power plants)
- Compare with other top down models
- Take into consideration of transaction costs
- Explore applicability of our methodology to other developing countries