



Analysis of Implementation of GHG Mitigation Measures in Shandong's Iron and Steel Sector

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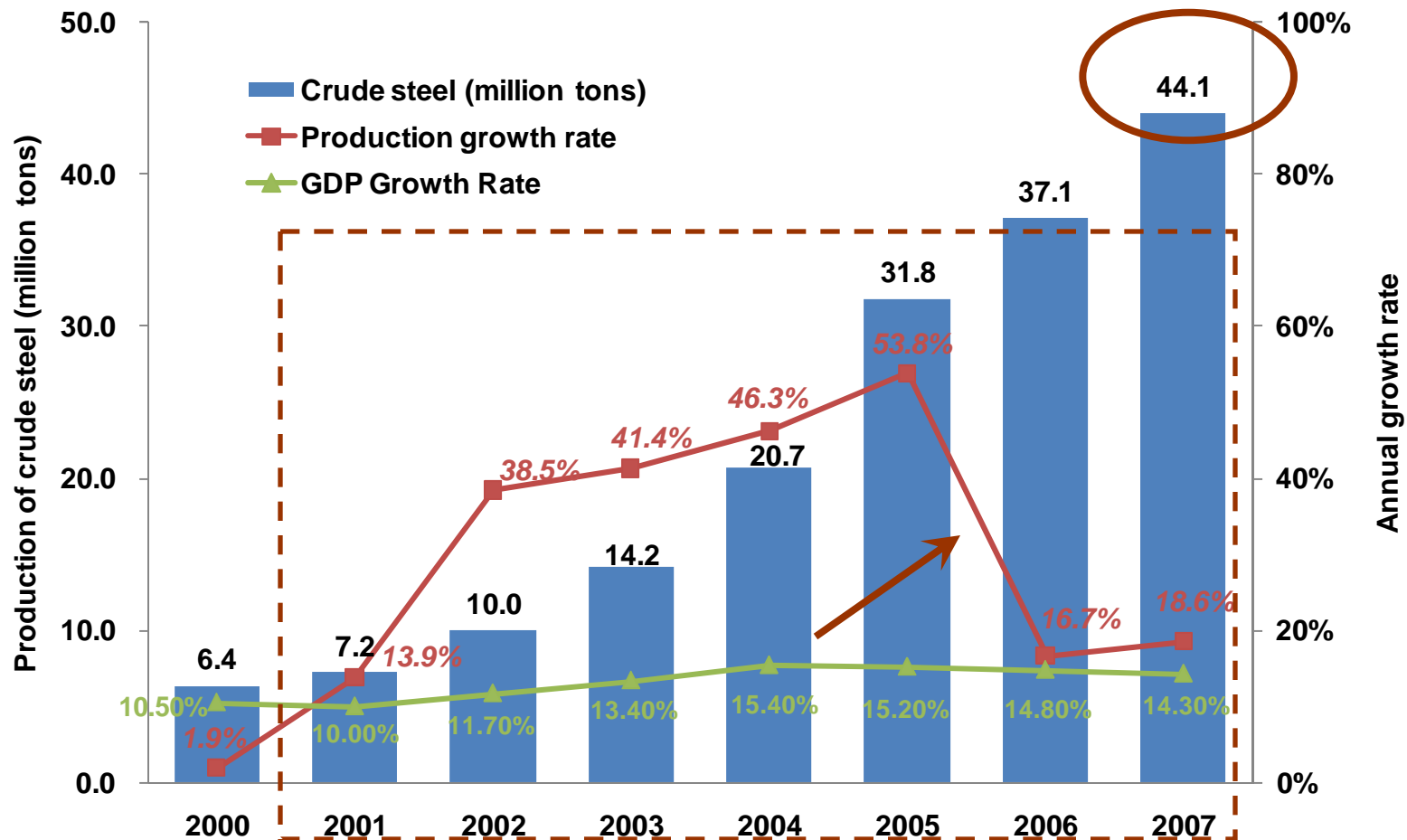
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Rapid development in Shandong's iron and steel

-- from 2005 to 2007, production in Shandong remained 4th in China, taking up 9% of China's production



CO₂ emissions in Shandong's iron and steel in 2007: around 75MT₃



Industrial concentration level

In 2006, Shandong crude steel production was 37.1 MT, among which,

JIGANG: 36%

LAIGANG: 29%

(65%)

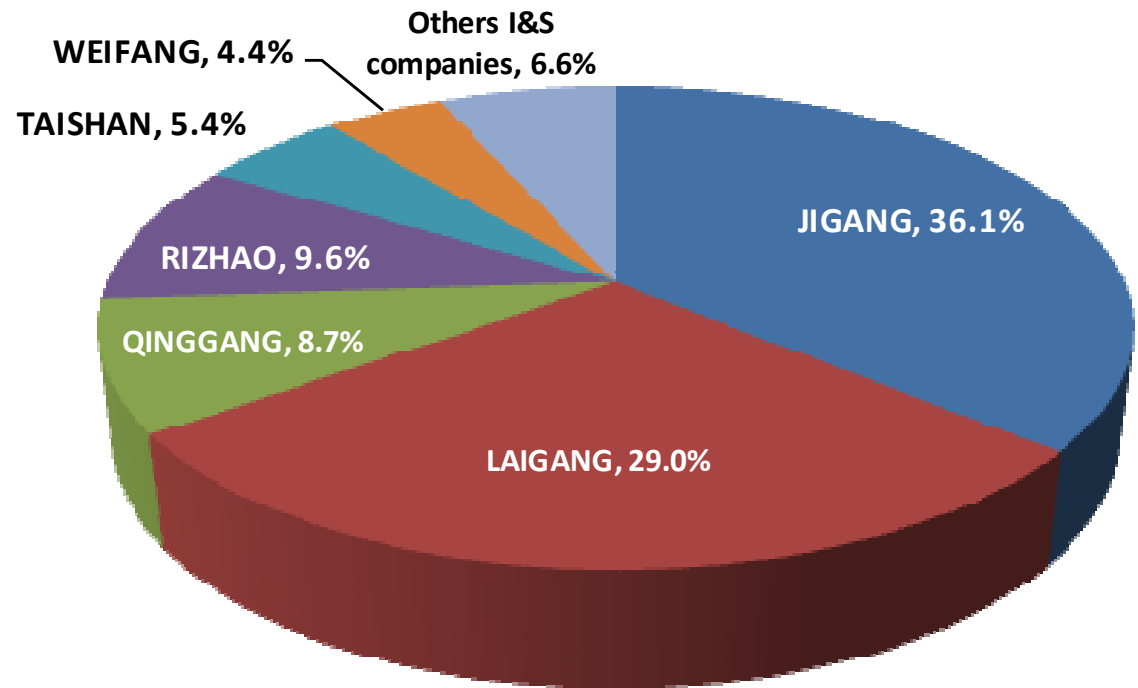


Figure 1. Share of crude steel production in Shandong in 2006

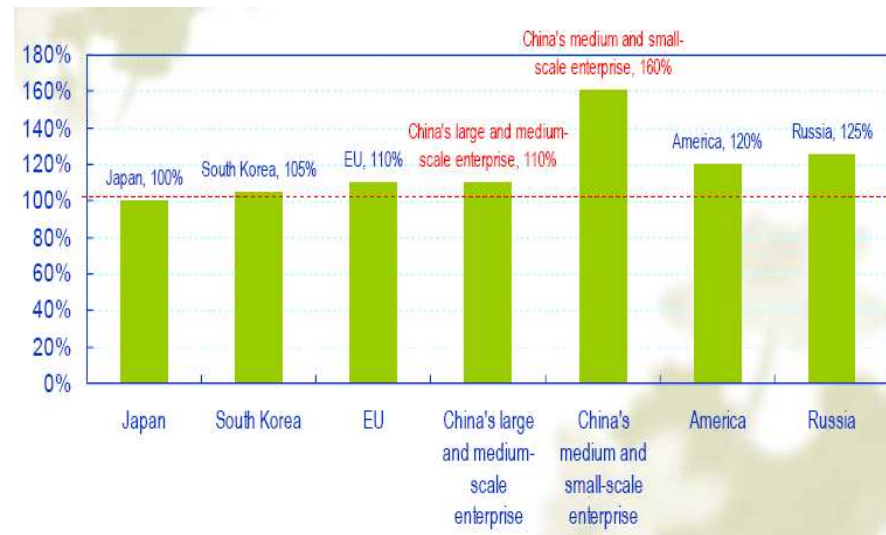
Source: China Iron and Steel Statistics 2007

It is very hard to know how many iron and steel plants there are in Shandong.



Energy efficiency gap between Shandong and international advanced level

	Comparable energy consumption per ton of steel production (kgce)
Thyssenkrupp AG (2003)	603.6 ^a
China (2006) Big and medium plants	623.04 ^b ↑↑ 3.2%
Shandong (2007) Big and medium plants	667 ^c ↑ 10.5%



Note: The figures are based on 100% of energy consumption of Japan ton steel.

Data source: Iron and Steel Institute of Japan



Development trends in Shandong's iron and steel sector

- Production capacity control
- Regional production capacity adjustment
- Regrouping
- Products structure upgrade
- Technology innovation
- Decrease resource consumption and pollution



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Phase I Study Summary – Abatement potential and corresponding cost information of mitigation options

No.	Mitigation Options	Marginal mitigation cost (US\$/tCO ₂)	Total emission reduction (MMt CO ₂)
1	Establish energy management center	-3.57	3.64
2	Advanced coke oven	Advanced blast furnace tech. 使用更先进的高炉炼铁技术	
3	Advanced blast furnace technology	5.36	24.63
4	Adjust ratio of iron/steel	Advanced sinter and coke oven 使用更加先进的烧结机、焦炉	
5	Dry coke quenching	30.36	3.52
6	Advanced sinter machine	Advanced EAF 使用更加先进的电炉	
7	Advanced direct steel rolling machine	34.88	4.43
8	Smelt reduction technology	Smelt reduction technology 使用熔融还原等先进技术	
9	Advanced converter	60.96	7.59
10	What is the technology and equipment status in Shandong's iron and steel sector?		5.68



Classification of production equipments

	To be eliminated	Entry Point	Encouraged Scale
Coke oven	Height of coke chamber < 4.3m ^a	Height of coke chamber ≥ 6m	--
Blast furnace for iron making	Effective capacity ≤ 300m ³	Effective capacity ≥ 1000m ³	Effective capacity ≥ 3000m ³
Oxygen blown converter for steel making	Capacity ≤ 20t	Capacity ≥ 120t	Capacity ≥ 200t
Electric furnace for steel making	Capacity ≤ 20t	Capacity ≥ 70t	--

^a except for tamping coke oven with height > 3.2m



Main production equipments status in SD

	Number of production equipments	<i>Number of equipments to be eliminated</i>	<i>Number of equipments below the entry point</i>	<i>Number of equipments above entry level but not as good as the encouraged levels</i>	<i>Number of equipments above the encouraged scale</i>
Blast furnace for iron making	62	15			
Share		24%	58%	18%	0%
Oxygen blown converter for steel making	24	0	15	9	0
Share		0%	63%	38%	0%
Electric furnace for steel making	7	0	6	1	0
Share		0%	86%	14%	0%

• Most-energy consuming process
• Comparatively laggard equipment status



The specific key mitigation options

- Coke Dry Quenching (CDQ) 干熄焦
- Blast Furnace Top-pressure Recovery Turbine (TRT) 高炉炉顶煤气余压回收透平发电装置
- Combined Cycle Power Plant (CCPP) 燃气蒸汽联合循环发电
- Residual heat utilization in sintering 烧结环冷机余热回收
- Negative energy steel-making of converter 负能炼钢
-



Name of option	Cost	Effectiveness	Reference
CDQ	150-300 million Yuan	It can save 50-60 kgce per ton of coke made. It accounts for 50% of total energy saving in iron-making systems ^[1] .	《National Key Sectors' Clean Production Technology Directory》 (Part One)
TRT	30-50 million Yuan	It can save 10-20 kgce per ton of iron made ^[2] .	《National Key Sectors' Clean Production Technology Directory》 (Part Two)
CCPP	300-1000 million Yuan (may be higher according to scale)	It can supply 30-40% or more of total electricity demand in iron and steel factory ^[3] .	Internet sources ^[4]
Residual heat utilization in Sintering	40-50 million Yuan (if the sintering machine is around 90 m ² *2 large)	It can produce steam 16.5t/h.	《National Key Sectors' Clean Production Technology Directory》 (Part 1)
Negative energy steel-making of converter	20 million Yuan ^[5]	It can save 90m ³ gas and 80kg steam per ton of steel made. For each ton of steel made, it can save energy of 23.6kgce.	《National Key Sectors' Clean Production Technology Directory》 (Part 3)



A simplified comparison matrix of the key mitigation options in Shandong's iron and steel sector

	Cost	Effects on CO ₂ mitigation	"Technical" deployment potential
CDQ	**	****	*
TRT	****	***	***
CCPP	*	*****	*****
Residual heat utilization in Sintering	***	*	****
Negative energy steel-making of converter	*****	**	**



TRT development in Shandong

Year of operation	Name of Plant	Single dynamo capacity	Number of units
2004	JIGANG	8000kW	1
2005	LAIGANG	15000kW	2
		4350kW	1
		4160kW	1
	JIGANG	15000kW	1
		8000kW	1
2006	LAIGANG	8000kW	2
	QINGGANG	6800kW	1
	YONGFENG	8000kW	1
2007 (till end of May)	TAIGANG	6800kW	1
Sum		107110kW	12

JIGANG: 3 LAIGANG: 6 QINGGANG: 1
YONGFENG: 1 TAIGANG: 1



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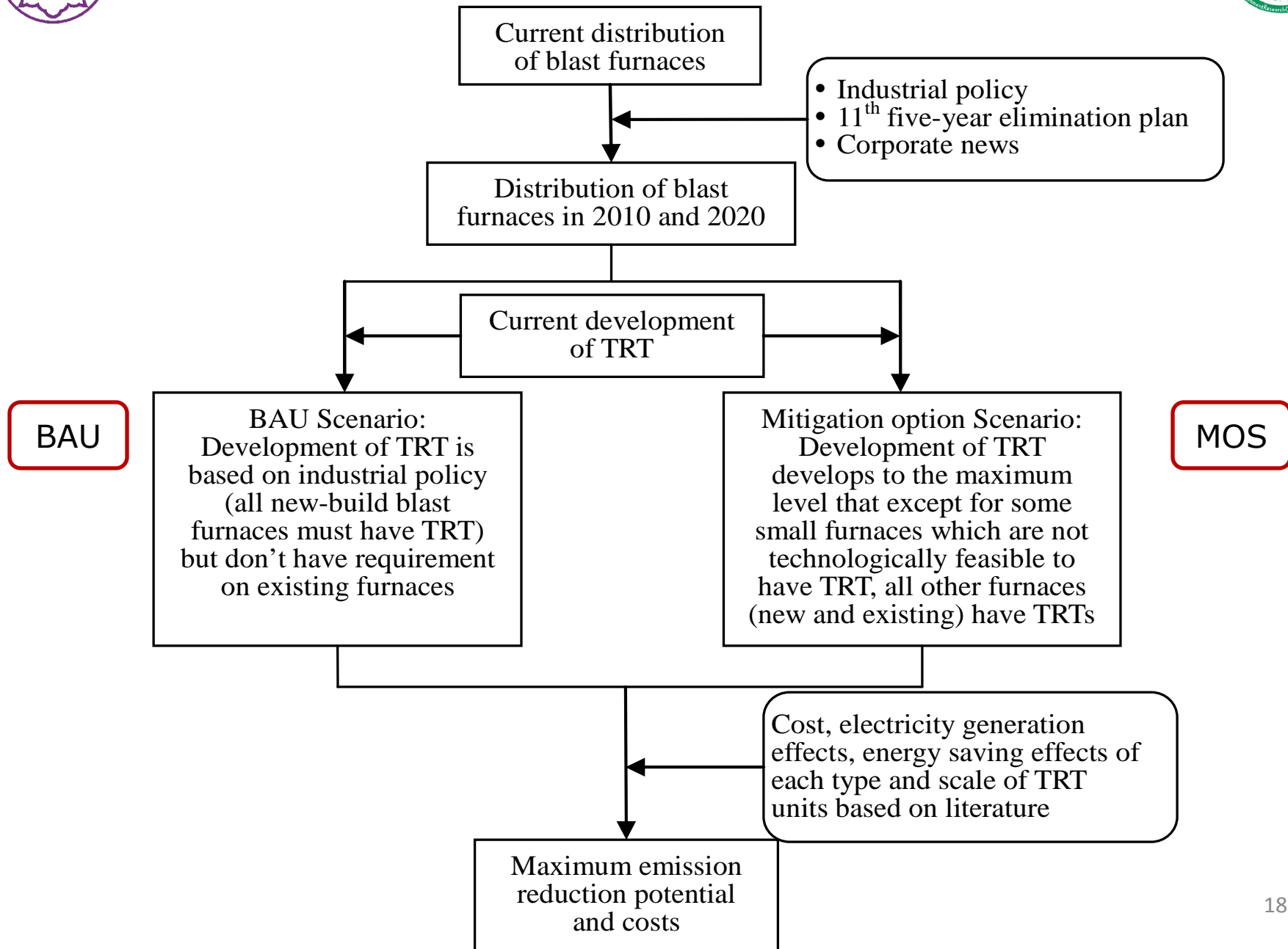
Review of general policies in iron and steel sector

- National
 - Iron and Steel Industrial Development Policies (2005)
 - National Industrial Structure Adjustment Reference Catalogue (Year 2005 version)
 - Economic measures (Discriminated electricity price policy, Decrease the export tax rebates, Export license management for part of steel products)
 - Environmental regulations
- Provincial
 - The Guidance on Speeding Up the Structural Adjustment of Iron and Steel Industries (2006)
 - Energy consumption limits (executed since 2008)



Policies related to TRT

- Iron and Steel Industrial Development Policies (2005) 《钢铁产业发展政策》
 - “*New blast furnaces must install TRT.*”
- The Guidance on Speeding Up the Structural Adjustment of Iron and Steel Industries (2006) 关于加快钢铁工业结构调整的指导意的通知 (鲁政办发〔2006〕118号)
 - “*Big blast furnaces must build TRT at the same time.*”





Current status and detailed settings in scenarios

		$\leq 1000\text{m}^3$	$\leq 1250\text{m}^3$	$\leq 2300\text{m}^3$	$\leq 4000\text{m}^3$
2006	Distribution of blast furnaces	51	3	8	0
	Number of TRT in operation	3	2	6	0
2010	Distribution of blast furnaces	34	4	8	0
BAU	Number of TRT in operation	9	3	6	0
MOS	Number of TRT in operation	17	4	8	0
2020	Distribution of blast furnaces	8	6	9	2
BAU	Number of TRT in operation	8	5	7	2
MOS	Number of TRT in operation	8	6	9	2



Effects and cost information of TRTs

Scale of blast furnaces		$\leq 1000\text{m}^3$	$\leq 1250\text{m}^3$	$\leq 2300\text{m}^3$	$\leq 4000\text{m}^3$
Top-pressure/kPa		110-120	120-150	150-200	200-250
Annual operation fee /thousand Yuan	Dry	960	1460	2360	5170
	Wet	3100	4220	6750	14620
Annual recovered electricity /GWh	Dry	24	38	64	140
	Wet	17	26	44	100
Annual recovered electricity expense /million Yuan	Dry	12.79	20.26	34.12	74.63
	Wet	9.06	13.86	23.45	53.31
Annual net Income /million Yuan	Dry	11.83	18.80	31.76	69.46
	Wet	5.96	9.64	16.70	38.69
Total investment /million Yuan	Dry	24	30.5	48	74
	Wet	25.5	32	51	82
Payback time/a	Dry	2.03	1.62	1.51	1.07
	Wet	4.28	3.32	3.05	2.12
Annual energy saving/tce	Dry	8736	13832	23296	50960
	Wet	6188	9464	16016	36400



Equations

- $\Delta ELE = \sum ELES_i \cdot (N_{i2} - N_{i1}) \quad (i=1,2,3,4)$
- $\Delta E = \sum ES_i \cdot (N_{i2} - N_{i1}) \quad (i=1,2,3,4).$
- Where:
 - ΔELE : total reduction in electricity usage by TRT
 - $ELES_i$: annual electricity saving made by different scales of blast furnaces installed by TRT
 - i : the different scales of blast furnaces ($i=1,2,3,4$)
 - N_{ij} : number of TRTs in operation ($j=1,2$; 1 means BAU ; 2 means MOS).
 - ΔE : total reduction in energy usage by TRT
 - ES_i : annual energy saving made by different scales of blast furnaces installed by TRT



Effects on Energy and GHG Reductions

	Maximum total reduction in electricity usage by TRT (GWh)	Maximum energy saving by TRT (tce)	CO ₂ emission reduction by TRT* (tons)	
2010	358	130,312	401,246	0.5% of 2010 emissions
2020	166	60,424	186,053	0.3% of 2010 emissions

*Emission factor of north China region = 1.1208 tCO₂/MWh (average number for 2003-2005)



Changes in energy and carbon intensities

		BAU	MOS
Energy Intensity of iron making (kgce/t)	2006	497	497
	2010	488	483
	2020	448	446
Carbon Intensity of iron making (tCO2/t)	2006	1.34	1.34
	2010	1.31	1.30
	2020	1.20	1.20

		BAU	MOS
En	2006	667	667
	2010	658	653
	2020	618	616

Results of equipment scaling up and the TRTs required to installed in new blast furnaces

Results of further utilization of TRTs

7.7% decrease in total by MOS in 2020. Nearly finishes the 8% energy intensity decrease goal in Medium and Long-term Energy Saving Plan



To achieve this:

- Need to build:
 - 8 TRTs in blast furnaces less than 1000 m³
 - 1 TRT in furnace less than 1250 m³
 - 2 TRTs in furnaces less than 2300 m³
- Investment costs:
 - 318.5 million Yuan (46.2 million USD)
- Operation costs:
 - 13.86 million Yuan per year (2 million USD) (prices in 2007 except the operation costs)
- Other related and indirect costs:
 - The precondition of installing TRT is the scaling up of blast furnaces. Investment cost of each m³ of blast furnace is around 0.4 million Yuan. A 1000m³ needs an average 0.4 billion Yuan.
 - Scaling up of blast furnaces will bring in higher production efficiency and result in a smaller demand for work labors and increase the demand for more educated and skilled labors. Around 30% of labors in blast furnace session will be off-duty. This will cause a lot of social problems.



Barriers to adopt TRT

- Technical ? No
- Administrative and legal ? No. Actually greatly encouraged by government.
- Financing ? Yes
 - A big concern for small and medium-sized plants
 - Example: Qinggang: 2*350m³, 1*400m³, 3*500m³, 169 million Yuan's profit in 2005
 - 2 TRT installation in 2006, 59% of profit in 2005 (What if the smaller plant who need to build new blast furnace? Where could the 0.4 billion Yuan investment for blast furnace come from?)
 - inflation, deposit reserve ratio, price of ores and energy, export control. It also explains why although TRT is so attractive to be paid back technically in 2-4 years, still in 2006 in Shandong, we can only see 11 out of 62 blast furnaces installed with TRTs.



Barriers to adopt TRT (cont.)

- Operative ? Yes
 - Difficult to get on electric grid
 - Best situation: use the electricity produced by itself and buy extra from public electric grid
 - Fact: the power grid company requires JIGANG to sell its own electricity to the grid, and then buy electricity from the power grid companies again (MONOPOLY); too complex approval process (takes at least half a year or even more than a year)



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Key promotion policy for TRT

Barrier	Possible path to overcome	Evaluation of feasibility
Difficult to get on grid	Break down the monopoly framework and restructure the approval processes	Not easy and effective (according to the difficult reformation on China's electricity sector)
Financing problems	Enhance the financial support of energy saving technologies, esp. at the investment phase, by domestic government, or by international cooperation	Easier and more practical

Key promotion policy : Discount loan

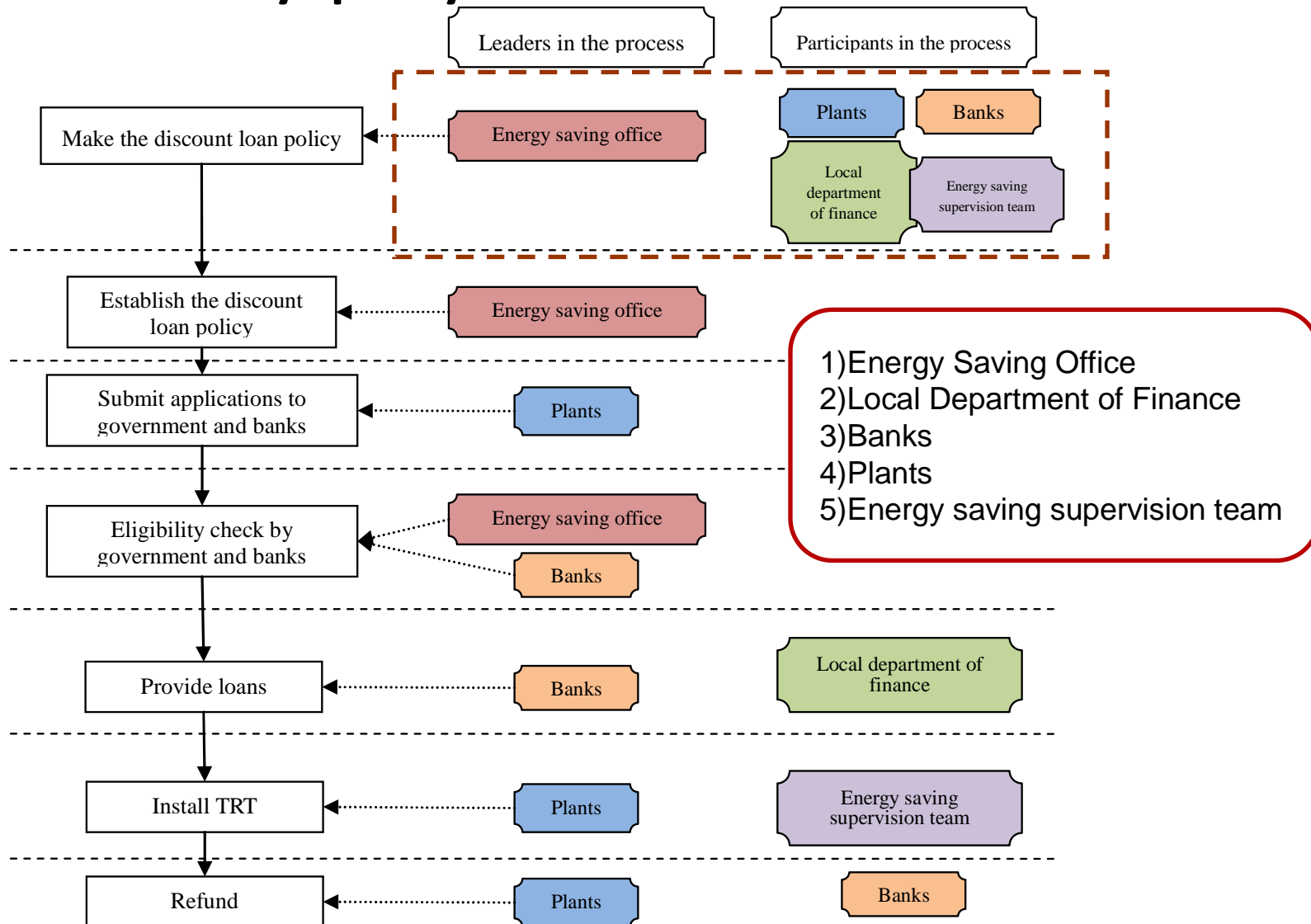


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Key players to be involved





Promotion policy barrier analysis

- Lack of fiscal money
 - Macro: Worsen local fiscal environment – a study made by ERI
 - Micro: Look into the use of “specific energy saving and emission reduction fund”



The Specific Energy Saving and Emission Reduction Fund

- 2.13 billion Yuan in 2007
 - 0.3 billion: energy saving and water saving, provincial
 - 0.81 billion: emission reduction, provincial
 - 1.023 billion: energy saving and emission reduction, city and county
- 0.3 billion was especially provided by the provincial department of finance
 - 0.1 billion – support 50 energy saving projects in enterprises
 - Three “100 projects” (100 energy saving technologies / 100 equipments / 100 pilot projects) (each item will relate to hundreds of plants)
 - Bounty Method for Energy Saving to encourage the best performers in energy saving this year – usually go to the big plants but not the ones who really need help !

An estimated 0.58 billion specifically for energy saving and water saving, both provincial and city level

How limited the money for each plant will be!



- In promotion policy scenario, total investment needed to use TRTs would reach 270.5 million Yuan.
- Assume
 - Half come from plants
 - Half come from loan
- Then, 135 million Yuan from banks
- For each percent of interest rate that government is paying for the plants, government would need an expense of fiscal income of 13.5 million Yuan!



Possible ways to overcome policy barrier

- Increase the budget for promoting energy saving technologies
 - Difficult. The conflicts between so many existing good technologies and such a big financial support demand from plants
- Improve the financial system for private investment
 - Easier. Develop a multi-level financial system to fit the need of private investment; allow private investment to apply for loans or grants from foreign government and international financial institutes; build up and improve the financial system for the private investment, and provide the supporting services to plants.



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Co-impacts analysis

Improved water quality	★	Improved air quality	★★★★★
Enhancement in economic productivity and performance	★★★★★	Technology innovation, research, development and transfer	★★
Job creation and poverty alleviation	★	Education, learning and training	★
Contributions to national development efforts and sustainability	★★★	Infrastructure development	★★★
Health benefits	★★★★★	Protection of biodiversity	★



谢谢！

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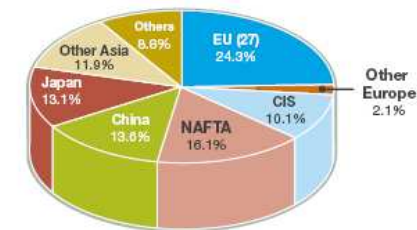
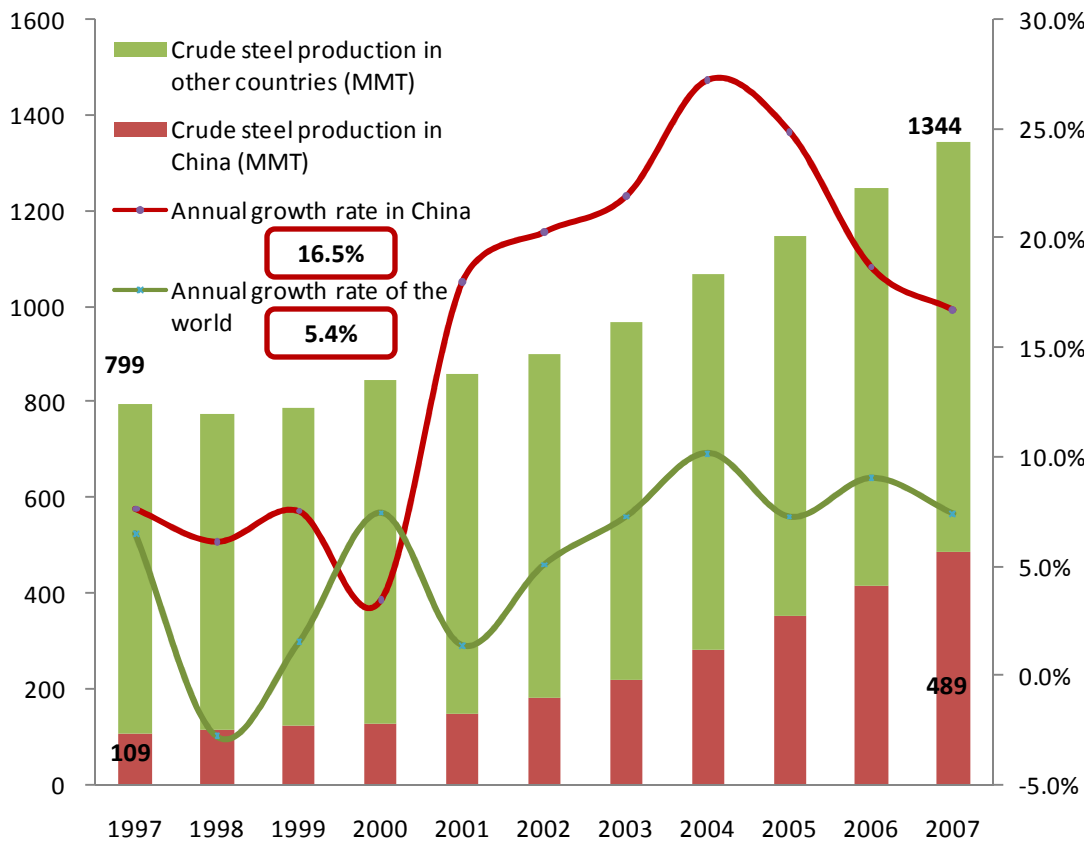
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Global crude steel production trends

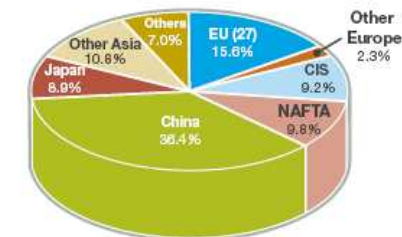
--China, one of the main contributors to the industry boom



Others comprise:

Africa	1.6%	Central and South America	4.8%
Middle East	1.2%	Australia and New Zealand	1.2%

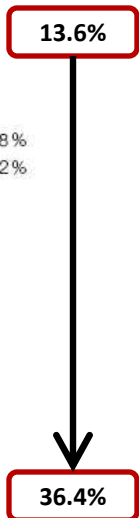
Steel production: geographical distribution, 1997



Others comprise:

Africa	1.4%	Central and South America	3.7%
Middle East	1.2%	Australia and New Zealand	0.7%

Steel production: geographical distribution, 2007



Source: International Iron and Steel Institute, 2008. World Steel in Figures 2008. CISA 2008. China Iron and Steel Statistics, 2007



Global and China's iron and steel emissions

	Iron and steel emissions (MtCO ₂)	Share of iron and steel in industrial GHG emissions	Share of iron and steel in global GHG emissions
WRI (2006) Data in 2000	1,319	15%	3.2%
OECD, IEA (2007) Data in 2004	-	24%	3%
IISI Data in 2006	2,100	-	-

Annual growth rate: 8%

“On average, 1.7 tonnes of carbon dioxide are emitted for every tonne of steel produced.”
 --- IISI “Sustainability Report of the World Steel Industry 2005”

Then, estimated China's emission in iron and steel in 2007: 831MMTCO₂e

We envision a larger emission than 831MMT due to the lower energy efficiency in China.

Source:WRI 2006. Navigating the number

OECD, IEA, 2007. Tracking Industrial Energy Efficiency and CO2 emissions

IISI data in 2006: <http://www.ecs.gov.cn/nsmb.asp?newsid=3123>