Argus Media– Value in Use, Sulphur penalties and the impact of regulatory change

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Contents

- Argus Value in Use normalisation technique
- Valuing sulphur penalties in current environment
- Sulphur legislation in other regions – Japan, Europe and the U.S.A.
- How regulatory changes could impact higher non-mainstream ore imports into China

Price normalisation model development – steel plant modelling

- Objective is to replicate the decision-making process of the end-user
  - Why would I purchase a particular iron ore?
  - What does this ore do in my sinter plant?
  - Is the alkali content high or not?
  - This new ore contains Boron. Can I still use it?
- Vulcan Technologies operates a Value in Use model that is unique in its feature set and flexibility.
  - Multiple steel mills can be modelled, not just a generic mill
  - A full steel works is modelled, sinter plant, blast furnace, desiliconisation, dephosphorisation, vanadium recovery, desulphurisation, Basic Oxygen Furnace, ladle metallurgy, casting and rolling.
  - The thermodynamics and kinetics of each plant is understood and modelled.
- What sets the modelling apart?
  - Accurate modelling of the effect of large impurities like silica and alumina in the steel making process.
  - Accurate modelling of the effect of minor impurities like sulphur, alkalis, phosphorus, titanium and others.

Blast furnace 1 operated many years ago ($2500m^3$)

Operating a small blast furnace with a client ($0.15m^3$)

Integrated model – Decision making flow

Model calibration and runs

- Multiple types of mills modelled to account for different operating practices.
- Multiple calculations per element/compound like Fe or SiO_2

Develop equations

- General form to account for all raw material costs, scrap costs, alloy costs, steel prices and other economic indicators like natural gas price.
- Multiple of everything is good, but how do we get to a normalisation routine?
- Low alumina high alumina blast furnace slag practices settled on.
- Normalisation routines for various ore grades (52% Fe, 58% Fe, 62% Fe, 65% Fe).

Port and test results

- Extensive testing phase to verify that the equations predict market behaviour.

Developed equations consider all economic factors affecting steel mills

- Previous day normalised indices
- Coking coal
- Anthracite
- Coke conversion cost
- Limestone, dolomite, other sinter plant fluxes
- Granulation water cost
- Electricity cost (sinter plant fan operating cost)
- Lump and pellet price relativities to fines index.
- PCI
- Merchant coke if used in mill
- Hot metal pre-treatment agents like CaC_2 for desulphurising
- Heavy scrap
- Burnt lime
- Oxygen for BOF and blast furnace (electricity cost)
- Ferro-alloy costs to normalise liquid steel chemistry
- Semi-finished and finished steel product prices.

General form of equations for

- Fe
- SiO_2
- Al_2O_3
- P
- S
- K_2O
- TiO_2
- Mn

$$\begin{aligned} DeltaCost &= (\text{SPCokePrice x } A \\ &+ LPrem * \text{Argus62Price x} B \\ &+ PPrem * \text{Argus62Price x } C \\ &+ \text{BFCoke} * \text{D} + \text{CaC}_2\text{Price x } E \\ &+ (\text{ScrapPrice x F } + G)) \end{aligned}$$

$$Profitability = DeltaRevenue - DeltaCost$$

Integrated model – Decision making flow

Port and test results

- Extensive testing phase to verify that the equations predict market behaviour.
- The Contracts and Trading markets do not necessarily account for steel mill fundamentals when valuing the effects of chemistry.

ERROR!

We will closely look at sulphur as an example.
Why sulphur?

- The recent Beijing sinter plant closures around Beijing due to smog and associated health problems.
- Beijing recently declared war on smog.

The acid consequence of sulphur dioxide

Example plant

- 4.2 Mt p.a. steel output
- 70% sinter to the blast furnace
- 0.02% S ore
- Typical SO_2 emissions from sinter plant = 2800t p.a.

- With a 1% S ore, emissions increase to 89000t p.a.*

How do we address this?

- Legislation
- Emissions trading
- Abatement

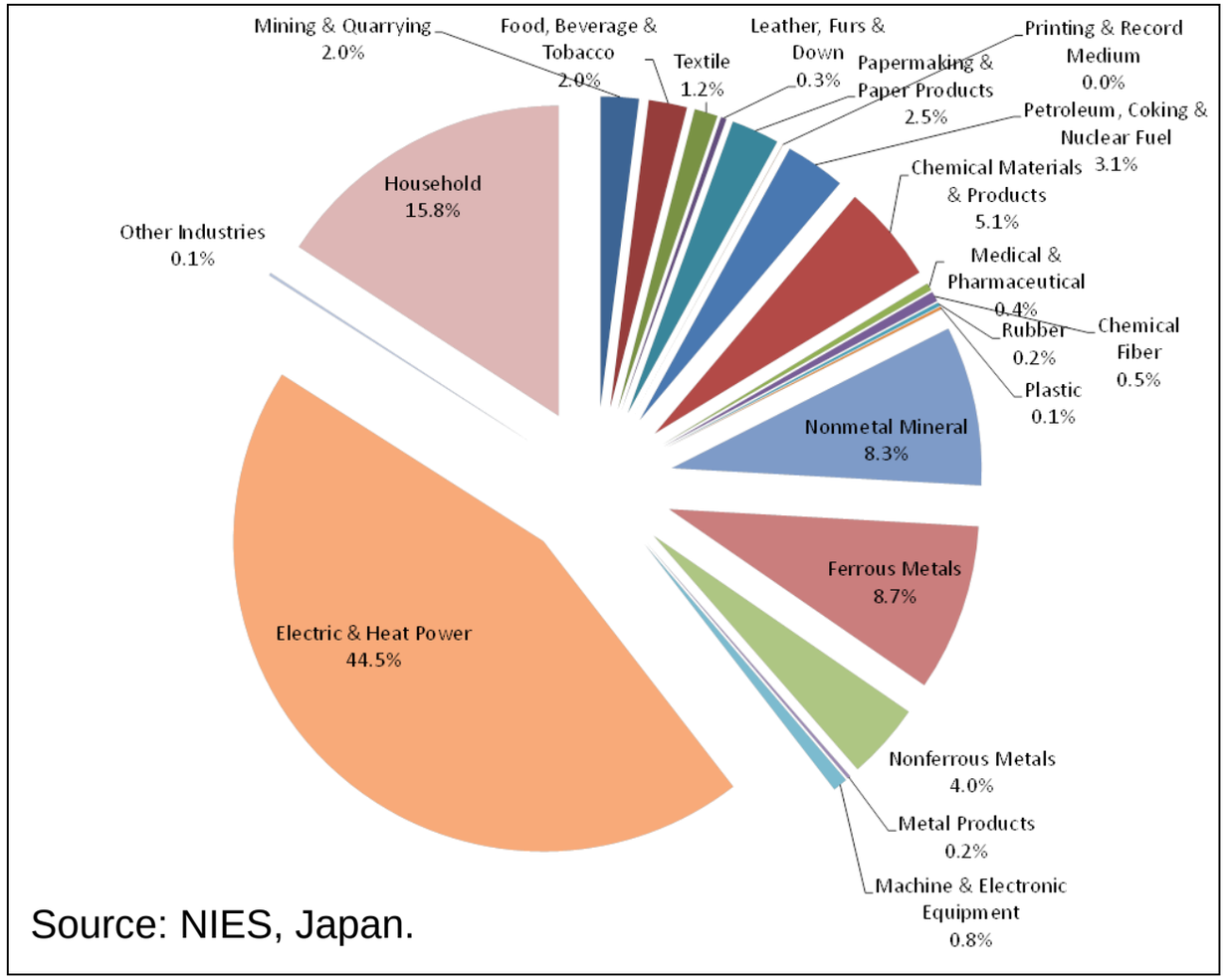
Picture AP

*Including SO_2 from extra fuel due to lower Fe.

Sulphur makes the world go round – the issue is not new

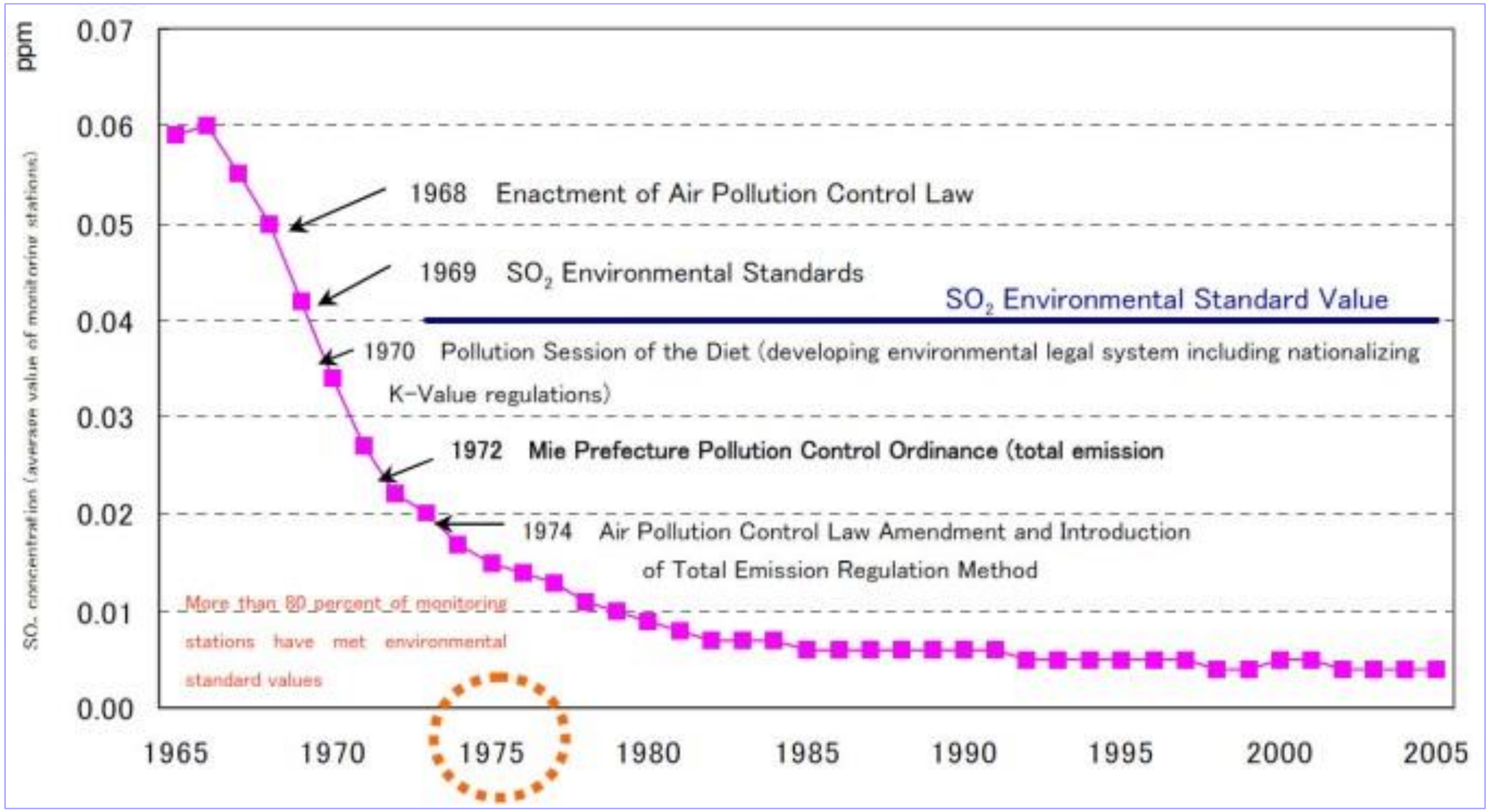
- Japan, the European Union and U.S.A. have all dealt with this issue before.
- Chinese legislation is in some respects more advanced than in the above regions.

- The largest culprit is coal-fired power stations. High sulphur coal is burned and SO_2 exits into the atmosphere **together with particulate emissions**.
- First solution is to burn low-sulphur coal; and if you can't find low sulphur coal,
- Install offgas treatment facilities for your power station. Or sinter plant. Or pellet plant.



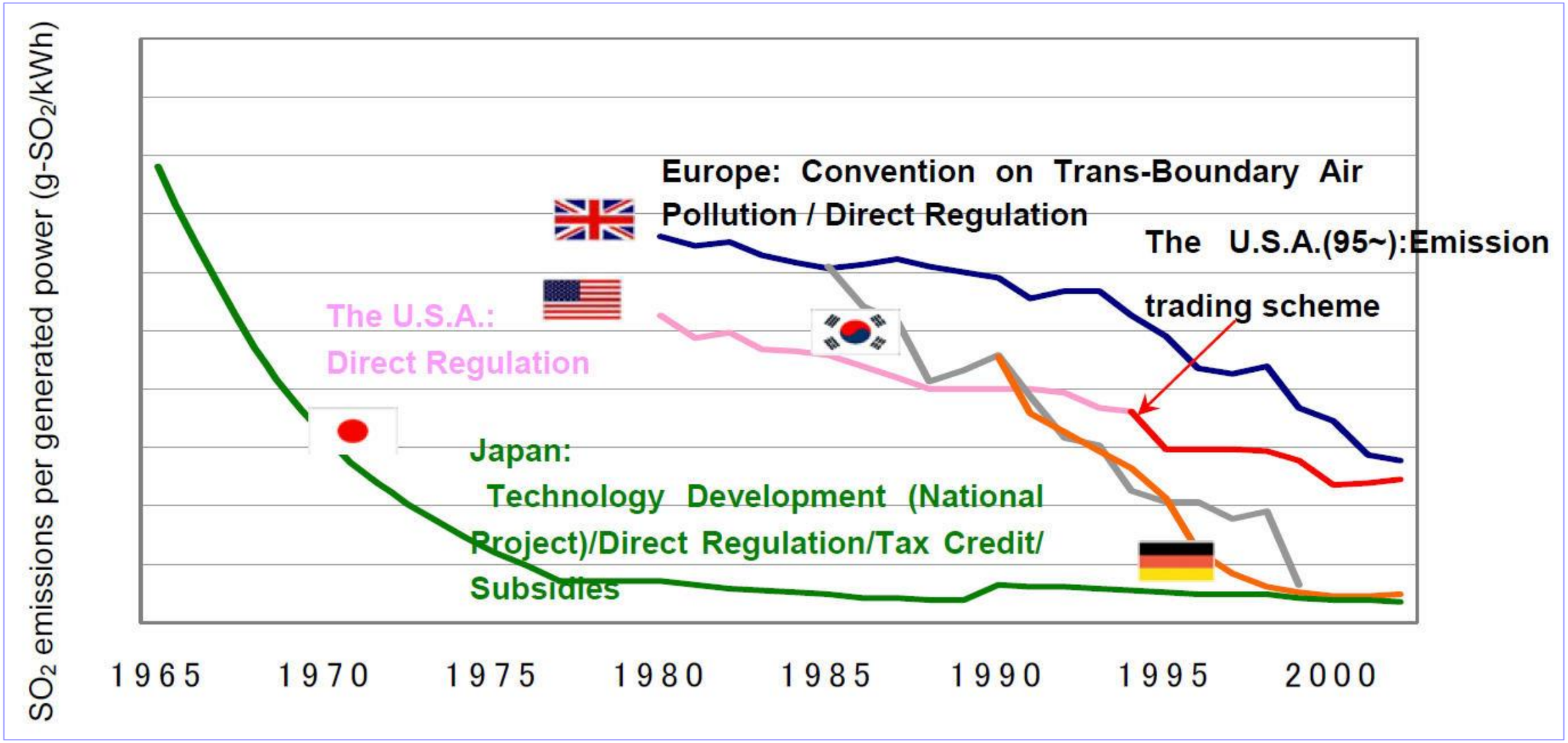
Source: NIES, Japan.

The effect of legislation – Japan's rapid implementation.



Source: Learning from Japan's Experience in Energy Conservation – T Sugiyama

The effect of legislation – other regions were slower to adapt.



Source: Learning from Japan's Experience in Energy Conservation – T Sugiyama

- It seems that any single control method is not sufficient.
- Strict legislation with Government assistance seems to be most effective, though.

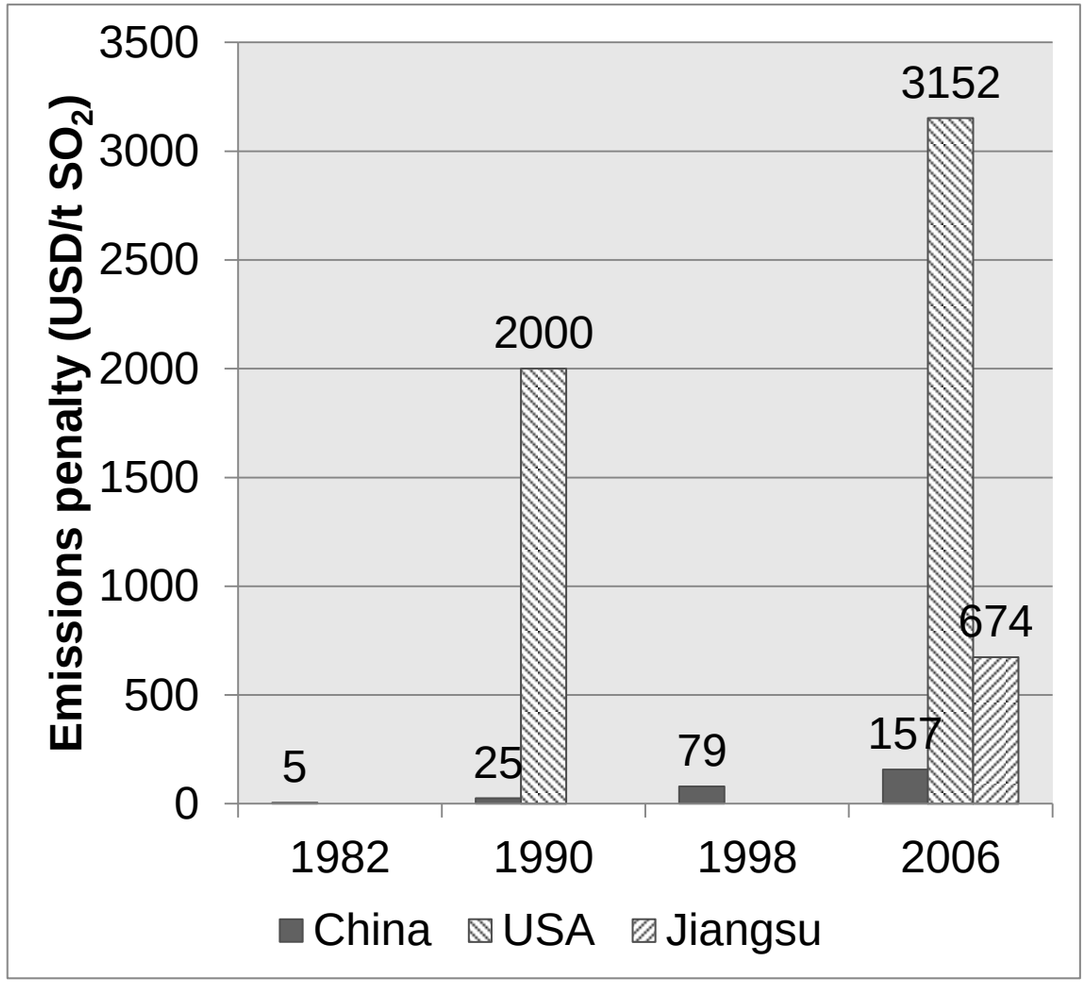
Current Chinese legislation

- Emission penalties generally low at USD160/t.
- Two trading pilot schemes (Taiyuan and Jiangsu)
- Penalties for non-compliance capped at RMB4000 per offence.
- SO_2 reduction targets and results in previous five-year plans:

	10th (2001-2005)	11th (2006-2010)
SO_2 reduction targets	10% below 2000 levels	10% below 2005 levels
SO_2 reduction results	27.8% above 2000 levels	14.3% below 2005 levels
Industrial emissions meeting discharge standards	79.4%	97.9%
Industrial desulfurization rate	33.5%	66.0%

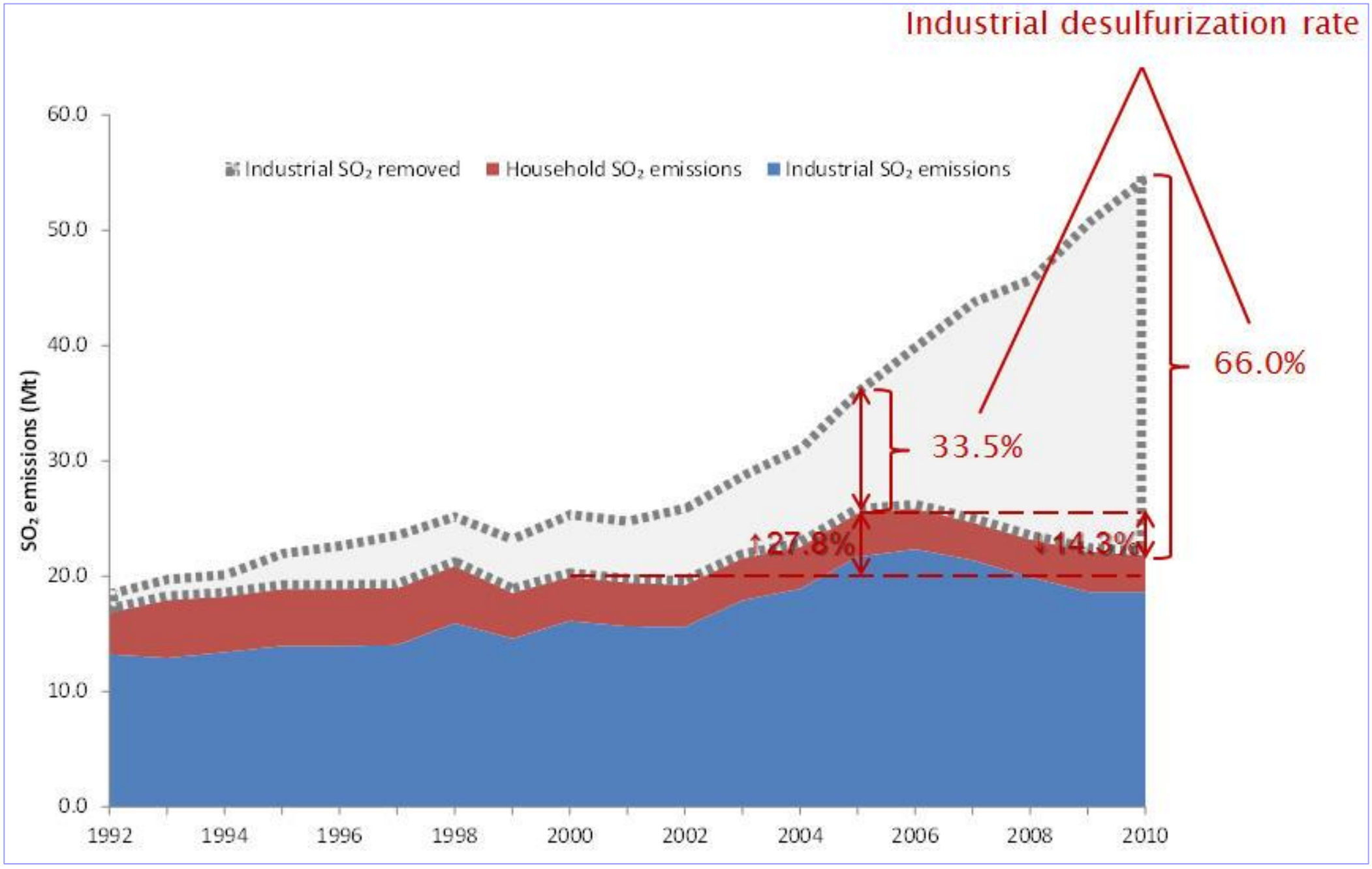
Source: NIES, Japan

- In China all emissions are penalised from zero upwards versus other regimes where only excess emissions are penalised.
- Industries have to report emissions at a certain time, free reign at all other times…



Source: CARE, US EPA,

Current Chinese performance



Source: NIES, Japan.

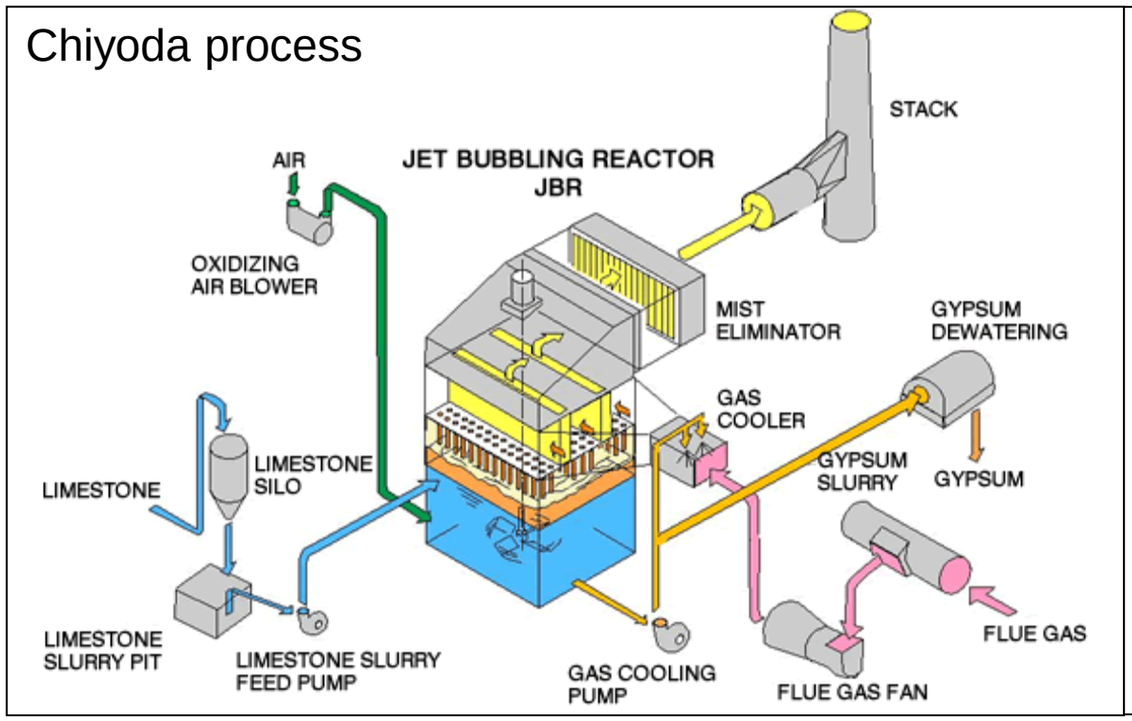
Abatement technologies

Name	Description	Efficiency SO_2	Efficiency Particulates	Cost (USD/t SO_2, 15 years life)
Lime slurry duct injection	Atomised spray into stack, SO_2 + particulates	50%	90%	140 - 180
Chiyoda Flue gas desulphurisation	Jet bubbling reactor, SO_2 + particulates	90-99%	90%	220-450
Limestone forced oxidation	Air bubbled through product slurry after sprays	95	90	230-320
Lime Spray Dryer	Low sulphur coal only	90	90	390-460
Low sulphur coal		Variable	0	0-600

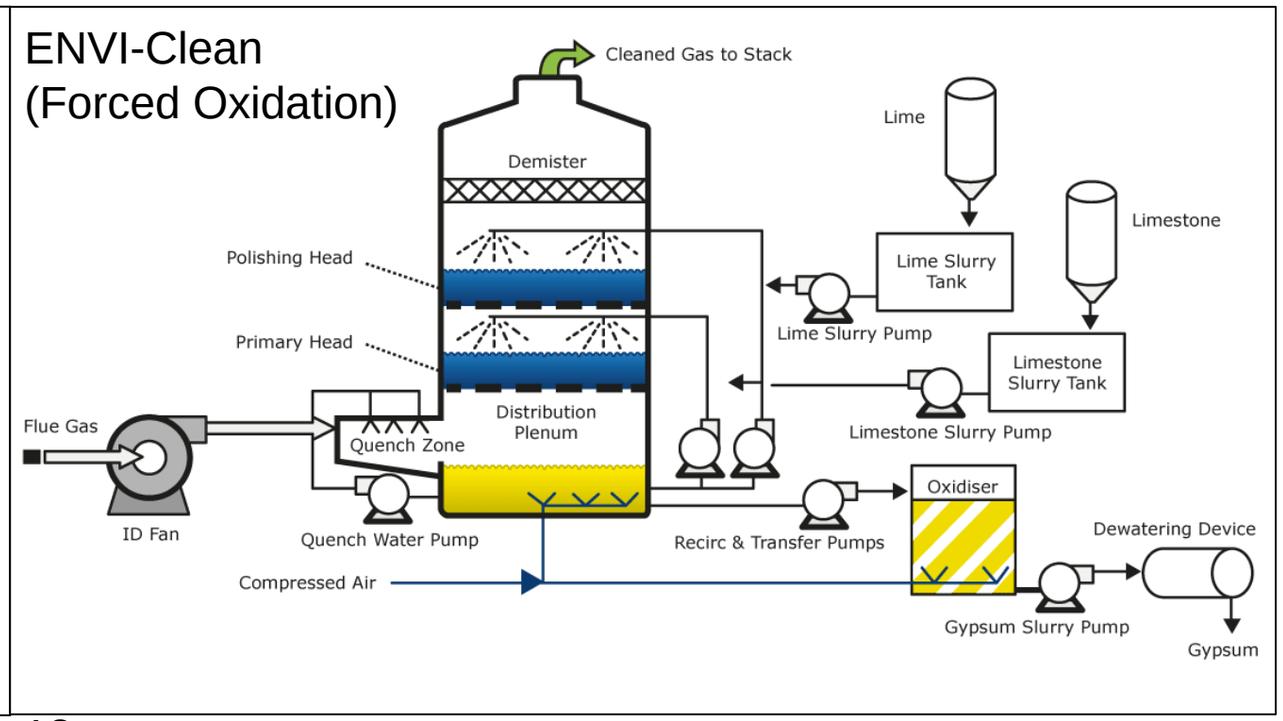
Source: SO_2, NO_x and Particle control technologies for the Mexican Electricity Sector, J Islas et.al.

Caution: Costs increase substantially for shorter payback periods.

Chiyoda process

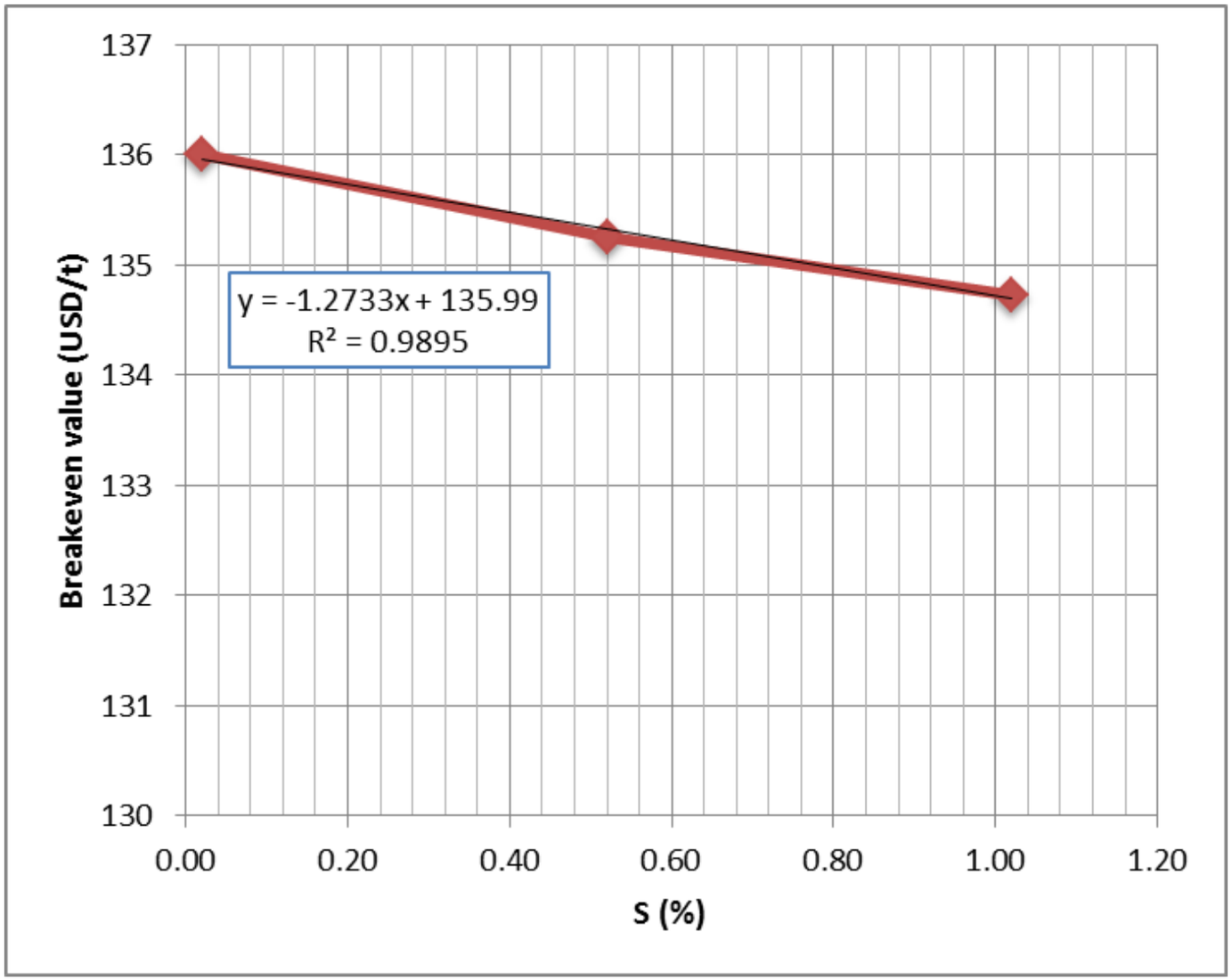


ENVI-Clean
(Forced Oxidation)



The impact of sulphur in steel making

- Sinter plant - ~80% of sulphur entering sinter plant exits through offgas stream.
- Pellet plant - ~90% exits through offgas stream.
- These offgas streams needs to be treated to remove SO_2 if required.
- Coke making – Some sulphur reports to coke, rest to byproducts plant where sulphur is removed. Coke facilities without byproduct plants burn all the gas…
- Blast furnace - ~95% of all sulphur from coke, coal, sinter, pellets and lump ore exits through slag (very efficient).
- Remaining 5% is removed from hot metal with burnt lime (CaO), powder magnesium (Mg) or calcium carbide (CaC_2).
- Most these things cost money.



1% sulphur in the ore costs USD1.27 to remove **excluding** sinter plant offgas SO_2 emissions (USc1.27/0.01%S).

The market typically does not value sulphur in mainstream ores (No bonuses/penalties)

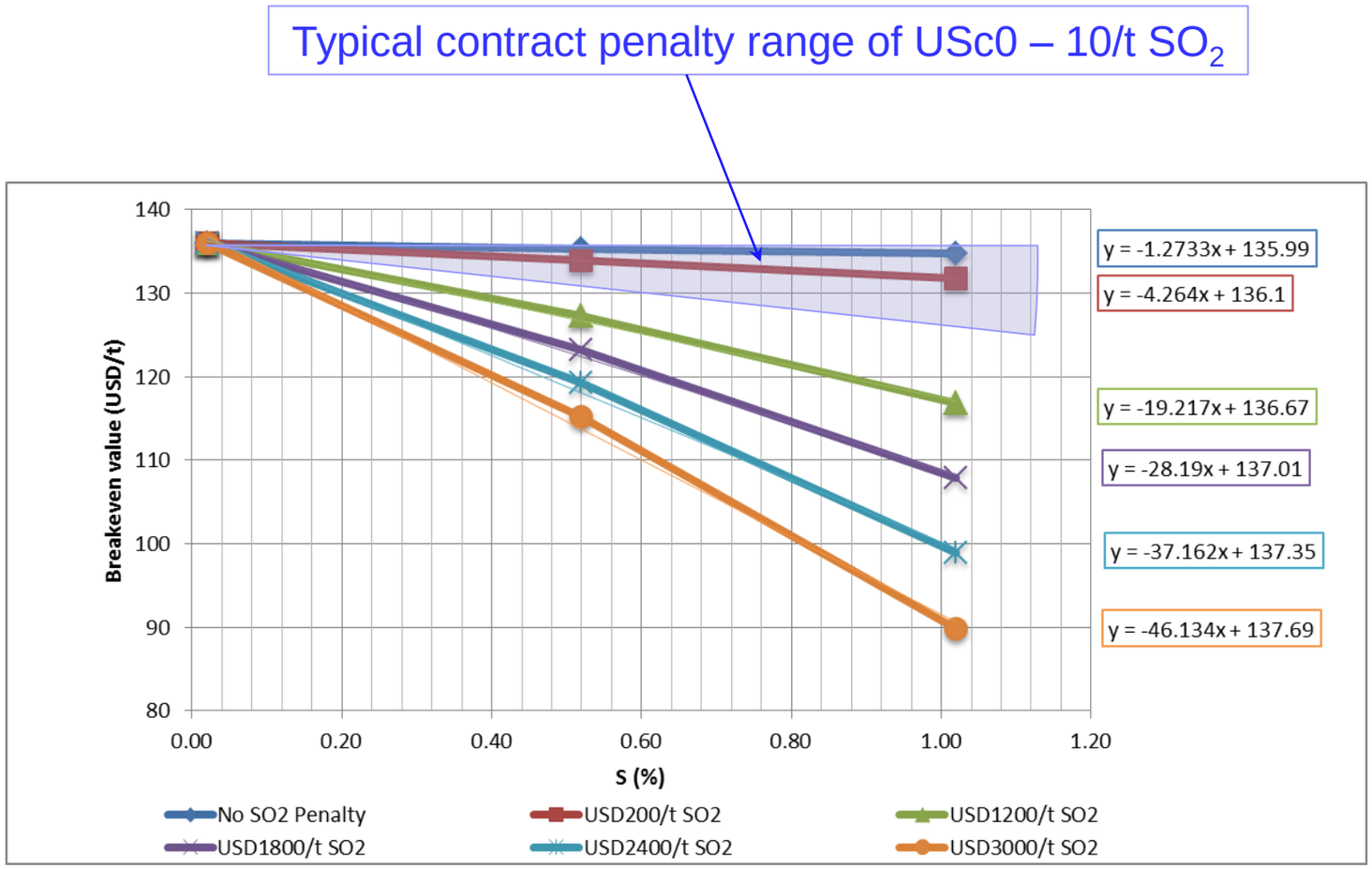
Market implications of sulphur dioxide

China will have to implement multiple measures rapidly to follow Japan, Korea and Germany in short timeframe to solutions.

- Emission penalty regimes will range from USD200 to USD3000/t SO_2.
- How do you get someone to spend USD600/t SO_2 to abate? Penalise them USD2000/t SO_2 for non-compliance.

Typical contracts may assign reasonable value to sulphur, but as it applies to values above an agreed limit, it is seldomly enforced.

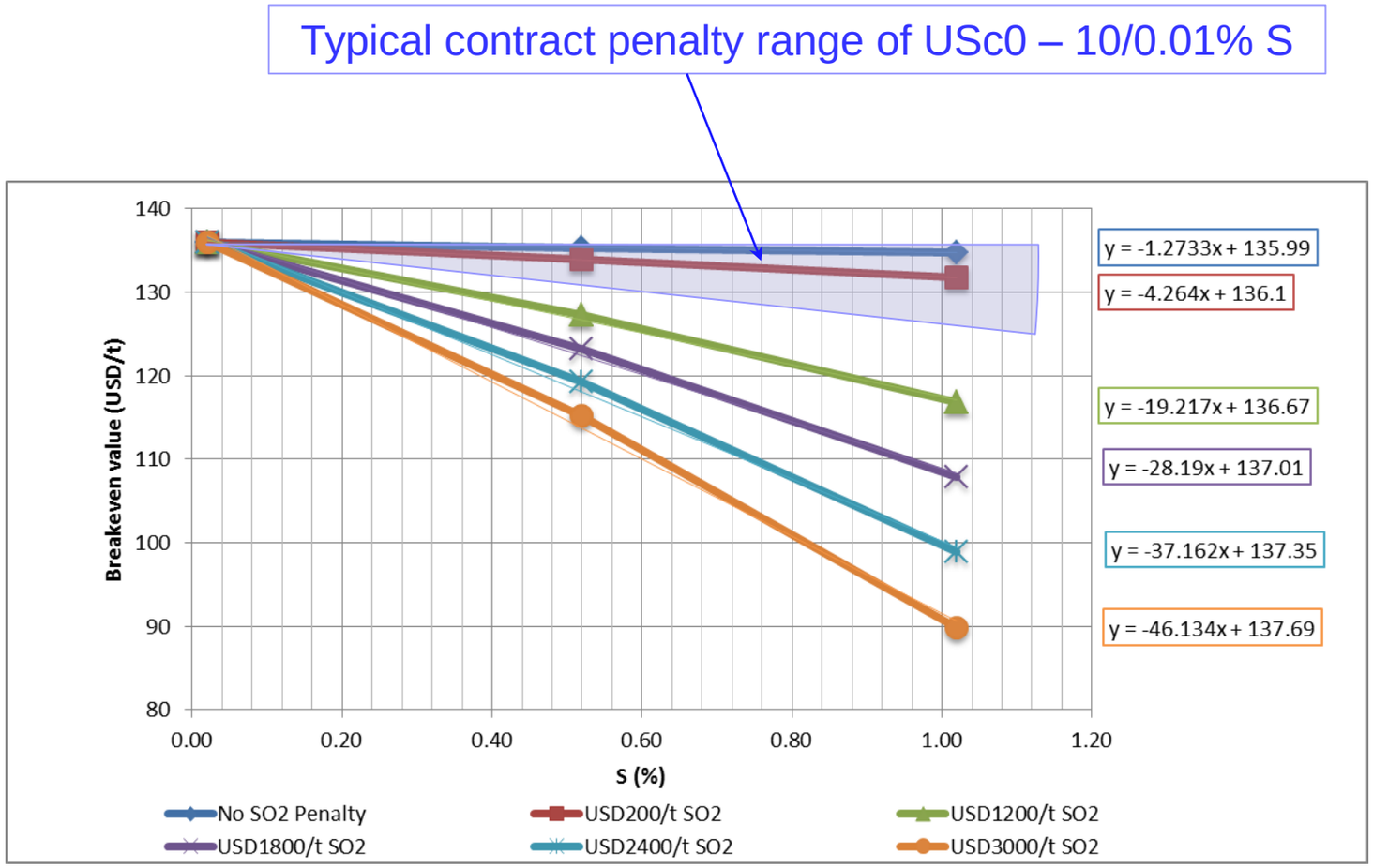
- A 1% sulphur fine ore should lose USD5 – 45/t of value due to sulphur content based on SO_2 emissions penalty regime.



Impact of sulphur dioxide penalties on VIU models

If SO_2 emissions penalty increases to reasonable levels as per below table, the value of high sulphur ores will decrease substantially.

SO_2 penalty (USD/t SO_2)	Sulphur penalty (USD/0.01% S in ore)
0	0
200	3.0
1200	17.9
1800	26.9
2400	35.9
3000	44.9



NB: The difference between graph and table is the slope of other sulphur penalties (No SO_2 penalty slope)

Impact of sulphur dioxide penalties on ore value

Traded ore 29 April 2014

- Handy size vessel
- Magnetite
- 57% Fe
- Size 0-30mm (Unscreened lump + fines)
- 1.5% S
- 0.15% P
- USD60/DMT FOB Bandar Abbas (2% moisture)

Handymax freight = USD25/t excluding handling/port charges

CFR price = USD60/DMT + USD25/WMT +USD5.60/WMT (RMB35/t) = USD88.80/WMT CFR.

Indices for day were 62% = USD107/DMT CFR and 58% = USD89/DMT CFR, so a 57% Fe ore could have sold at as low as USD87.50/DMT before any negotiated discounts and phosphorus penalties.

Adding SO_2 emissions penalties changes the picture slightly…

SO_2 penalty (USD/t SO_2)	Sulphur penalty (USD/1% S in ore)	USD Penalties for 1.5% S (emissions only)
0	0	0
200	3.0	4.5
1200	17.9	26.9
1800	26.9	40.4
2400	35.9	53.8
3000	44.9	67.3

Higher sulphur ores will rapidly be priced out of the market.

Impact of sulphur dioxide penalties on ore value - Continued

What will happen to penalties and premiums for lower sulphur mainstream products?

- Contractual penalties are triggered when the ore chemistry exceeds agreed limits.
- These are seldomly triggered, so
- Even if penalties/bonuses change, not much will change in cash flow terms.

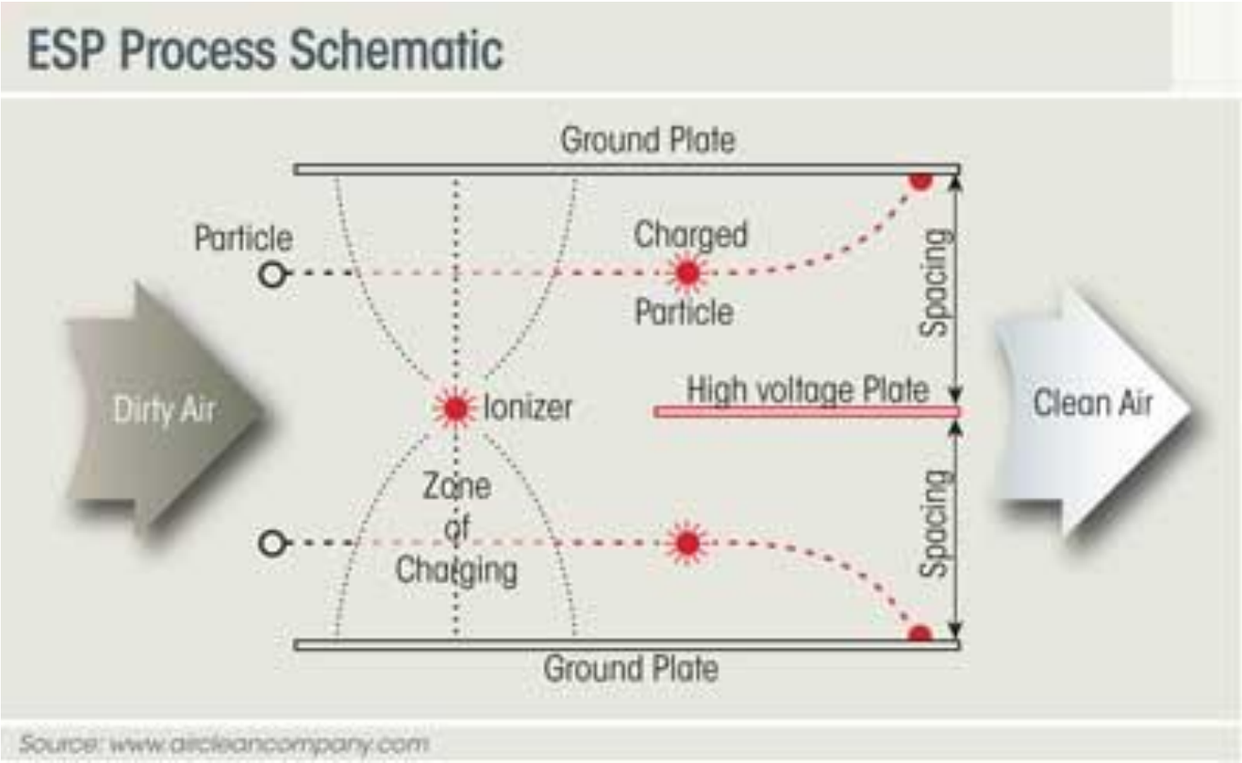
Will ores with sulphur content <0.05% command additional premiums?

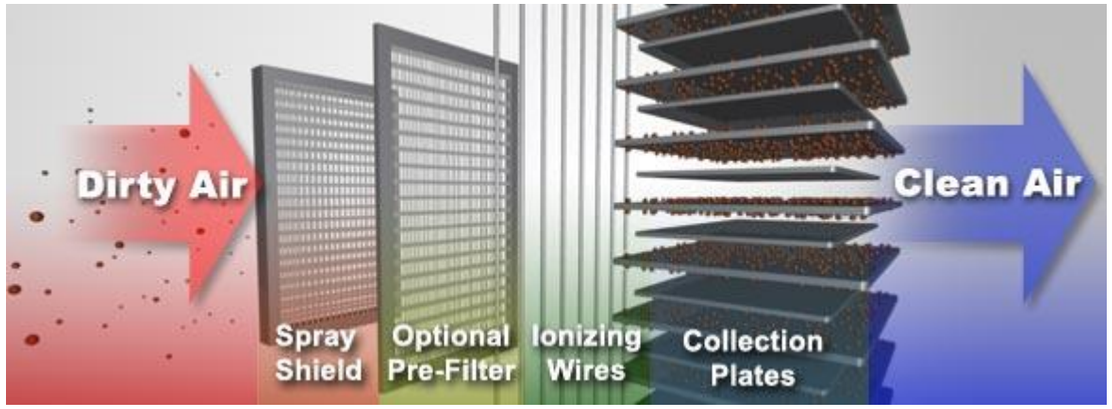
- Buyers have been unwilling to pay premiums for lower sulphur ores, but this may change in the future.
- High sulphur lump ore avoids **some of** these issues as it goes to the blast furnace (except for the undersize screen-outs that go straight to the sinter plant…

If China closes mills for exceeding sulphur emissions, SO_2 value could conceivably exceed USD2000/t.

One word on particulate emissions

- Maintenance…





- For an Electrostatic Precipitator at a sinter plant to work effectively the plates must be cleaned regularly and good start-up procedures followed.

Conclusions

- Argus price normalisation modelling is based on sound thermodynamics and operating experience.
- Multiple chemistry factors are taken into account to cater for boutique ores high in e.g. alkalis, titanium, manganese and sulphur.
- There is a disconnect between the cost of impurities in a steel mill and the way the market values impurities.
- We delved into detail in sulphur and saw
  - How the Chinese Government should tackle the smog problem
  - How the market should value sulphur.

Vulcan Technologies established in 2007

- Team of three
- Extensive experience in iron ore, steel making, manganese and phosphates.
- Services offered
  - Process modelling
  - Daily market data capture
  - Value in Use modelling
  - Metallurgical work
  - Study management
  - Economic modelling
  - Problem solving
  - Technical marketing
  - Steel making training

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