UNIVERSITY OF CAMBRIDGE | Electricity Policy Research Group

INTERNATIONAL SUPPORT FOR DOMESTIC CLIMATE POLICIES

Domestic Climate Policy for the Steel Sector, India

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To effectively communicate insights into climate change policy, Climate Strategies works with decision-makers in governments and business, particularly, but not restricted to, the countries of the European Union and EU institutions.

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Abstract

This paper examines the introduction of suitable domestic sectoral climate policies by emerging economy governments to address rising greenhouse gas (GHG) emissions using the example of the Indian iron and steel sector. The current industry structure, drivers and performance indicators are examined to set the scene for policy analysis. This study suggests that in order to realise significant reductions for GHG emissions, the individual circumstances of the sector must be recognised and climate policy designed accordingly. Through analysis of possible policy outcomes the paper suggests various objectives policy makers should consider to develop a long-term and integrated domestic policy. Additional support through international cooperation would help provide additional political support, stabilise the policy environment and facilitate substantial sectoral abatement.

1 Introduction

The industrial sector accounts for a significant share of greenhouse gas (GHG) emissions in emerging economies (EEs) like China and India from fossil fuel combustion and various chemical processes (IEA 2007a). High rates of economic growth are expected to continue in EEs, suggesting that demand for industrial products will remain high and emissions from this sector will rise rapidly. However, there are very few examples of targeted domestic policy mechanisms introduced by EE governments to holistically address the issue of rising industrial GHG emissions. This paper discusses how focused domestic policy interventions could help achieve this objective, using the rapidly expanding Indian iron and steel sector as an example.

The iron and steel sector of India is currently growing at over 7% per annum (MoS 2008) and accounts for nearly 10% of the country's CO_2 emissions (Garg et al 2006). Analysis of the sector shows that energy efficiency and CO_2 emission intensity levels are still exceeding the OECD average for primary steel making by 50% (IEA 2007b). Several reasons have been identified for this poor performance. For one, the historic influence of low demand and regulated markets has led to a lack of profitability and competitiveness in the sector. The resulting smaller plant size of most operating integrated steel units, which use the conventional blast furnace route, implies that retrofitting with the latest technologies such as coke dry quenching (CDQ) and top recovery turbines (TRTs) are still technologically and economically unviable. Secondly, the recent trend of rising prices for international coking coal and steel scrap has led to the emergence of an alternative cheaper, but inefficient, coal based direct reduced iron (DRI) process in the country. This process requires significantly lower capital investment and exploits the local advantage of cheaper low-grade raw materials, while employing unskilled labour. This alternative process accounted for 26% of the country's crude steel output in 2007 and is growing at an alarming rate of over 15% per annum (MoS 2008).

The government's role in inducing national action to address climate change through specific policies and directives is paramount. The Indian scenario, however, shows that the government has so far adopted a rather laissez-faire approach in dealing with CO_2 emissions, and has still not mainstreamed climate change mitigation into planning and policy guidelines for sectoral expansions. In order to meet the growing demand for steel, the Indian government continues to approve new steel units without due consideration of process type or efficiency standards, which could eventually lead to lock-in effects. Although some efforts are underway to help build technical capacity through the Energy Conservation Act 2001 and ban very small size coal DRI units, much of the planning information shows little or no emphasis on tackling the serious issue of rising industrial CO_2 emissions (Planning Commission 2006; MoS 2008).

On the global front, in order to address the energy performance of industries in EEs, a number of novel sectoral schemes have been suggested for the post-2012 climate regime. While some researchers discuss trans-national technical cooperation (Asia Pacific Partnership (APP) 2007; Baron 2006) others propose no-lose policy with a sectoral Clean Development Mechanism (CDM) incentive (CCAP 2007, 2008). However, given the peculiar dynamics of a fast growing sector in a free market, these approaches may not be able to address the fundamental issue: the lack of factoring CO_2 externality costs into investment decisions undertaken both at the individual firm and government approval level. Thus, initiatives by firms will continue to be voluntary and without specific timelines for abatement and, consequently, climate benefits will remain an afterthought in investments decisions.

The Bali Roadmap[1] also makes reference to "c*onsideration of cooperative sectoral approaches and sector specific actions"*, and *"various approaches including use of market opportunities to promote mitigation actions bearing in mind the national circumstances of countries"* in order to enhance implementation of the Convention's objectives (UNFCCC 2008). In line with this thought, this paper evaluates various domestic policy options for intervention to lower the rising GHG emissions trajectory from the Indian steel sector.

Manufacturing and use of steel is a resource intensive and socio-economically complex activity, creating a deeply entrenched supply chain system. This implies that a holistic consideration of both production and consumption is required when proposing any climate policy for this sector. The broader policy objective should clearly be to help integrate climate change mitigation at the decision making stage to facilitate the improvement of energy efficiency levels of all production units. However, since climate protection efforts eventually call for progressively larger sectoral abatement, policies should evolve to create step-changes towards the most efficient metallurgical processes, while keeping in mind that end-user requirements could also be met by enabling substitution with other less carbon-intensive materials.

Policies focusing on efficient technologies alone typically help promote specific abatement projects, while leaving the overall sectoral emissions unchecked. For example, the existing CDM design aims to reduce marginal emissions (like the waste energy recovery projects), but fails to limit proliferation of inefficient small coal DRI and blast furnace units in the first place. This type of project-based mechanism also fails to promote the modernisation of entire industrial units with high-energy demand, which could deliver maximum climate benefits.

Conversely, providing project-based incentives makes climate policies politically acceptable while generating minimum opposition from important industrial lobbies.

[1] Action Plan 1/CP.13 Section 1(b) (iv) and (v) FCCC/CP/2007/6 (UNFCCC 2008)

This play-it-safe position is further emphasised by a lack of adequate information in EEs on the cost-benefits of reducing domestic emissions and meeting end-user demand needs through the shortest conversion paths. Hence, policies planning to achieve marginal abatement through energy efficiency improvements will have to be re-evaluated to avoid incentivising suboptimal processes or plant sizes. Lastly, acknowledging that steel is inherently a carbon-intensive material, policies in the long-term should promote the substitution of other low-carbon materials. Figure 1 depicts the different climate policy outcome scenarios for the Indian steel sector.

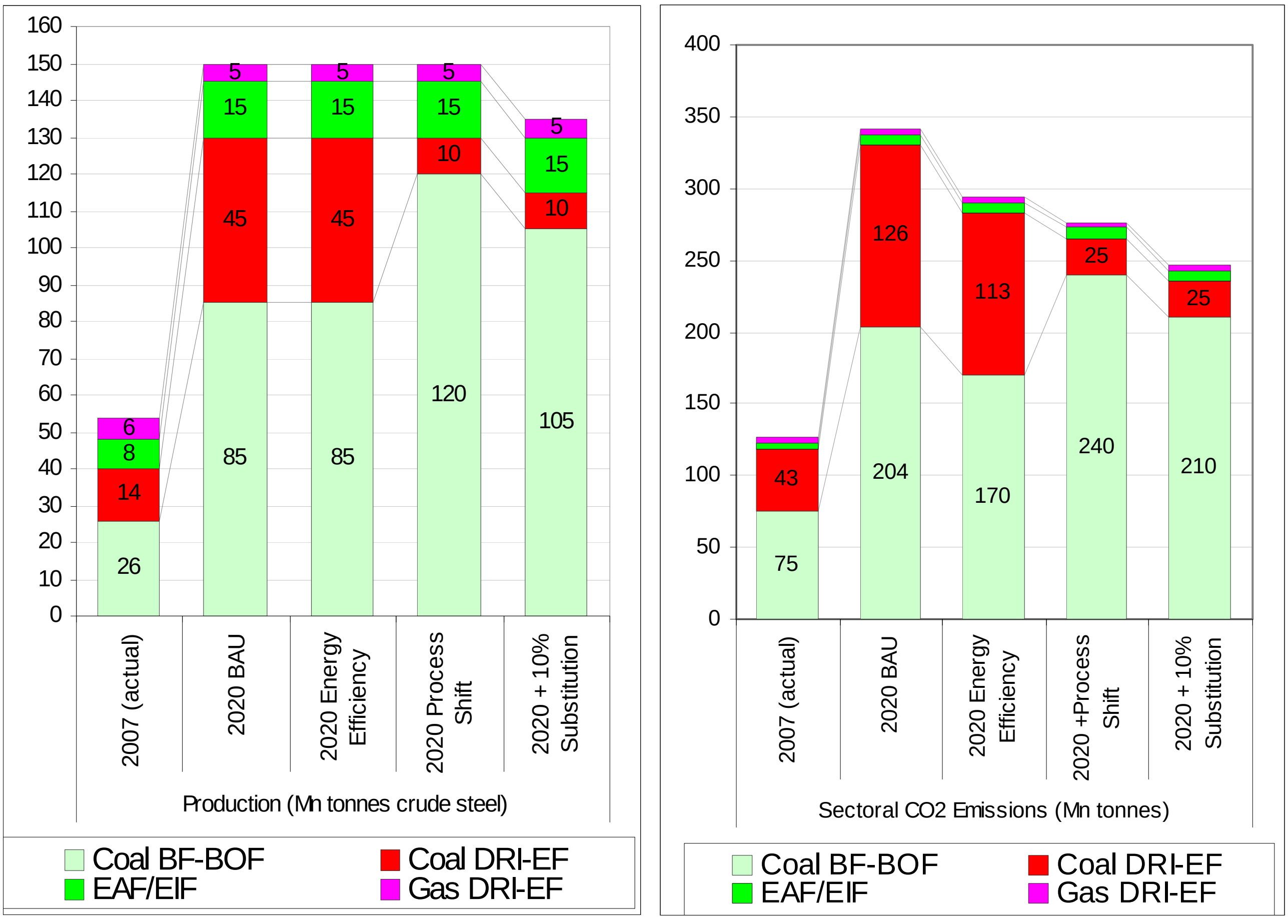


Fig1: Different outcomes possible from climate policies in the Indian steel sector (assuming steel substitutes have limited emissions and conservative production forecast).

As observed from the figure, an energy efficiency improvement policy could deliver noteworthy emission reductions by 2020. However, the inefficient coal DRI process would continue to contribute a higher share of sectoral emissions (37%) than sectoral output (30%; tonnes of crude steel). Looking forward to 2030 and beyond, achieving additional sectoral abatement could well lead to tougher bargaining positions due to lock-in effects. On the other hand, shifting the process to the most efficient large BF-BOF units would allow the industry to meet the same market demand and yet achieve further emission reductions by 2020. Finally, any additional substitution efforts could help to achieve drastic emission reductions.

Certain co-benefits from long-term sectoral planning to address climate concerns can also be expected. These could include reduced demand for coal (a key natural resource in India), lower local pollution levels, increased firm competitiveness, and the stimulation of local research and development activities in the steel supply chain.

Based on the policy outcome scenarios discussed above, table 1 shows a qualitative representation of evaluating criteria for various climate policy options. While the overall effectiveness measure takes into account the evolution of a policy over time, governance is also crucial when considering potential institutional capacities and the number of steel making units operating in India.

+++ = Very good; --- = Worst; NA = Not applicable

	Criteria for Policy Evaluation	Existing CDM	Proposed Policy 1 Harmonised tax	Proposed Policy 2 Incremental Emissions Tax*	Proposed Policy 3 Administered Standards
SYSTEM LEVEL EFFECTIVENESS	1. Short term - Improving Efficiency and CO_2 intensity of coal DRI and BF-BOF units over business-as-usual (BAU)	+	+ +	+	+ +
	2. Medium Term - Encourage shift from coal DRI and small BF to large efficient BF units	- - -	+	- -	+ +
	3. Long term – Encourage substitution of steel with low carbon intensive materials	- - -	+	-	NA
	4. Overall Effectiveness	- -	+ +	-	+ +
GOVERN-ANCE	5. Ease of Implementation	+	+ +	- -	+
	6. Ease of Monitoring and Verification	+ +	+	- -	+

Table 1: Policy evaluating criteria Note:* The proposed National Action Plan scheme of India has a similar policy design.

The table above shows that although CDM and Policy 2 (incremental emissions tax) can deliver marginal emission reductions in the short term, they continue to promote inefficient processes and plant sizes. Policy 3 (administered manufacturing standards) would, on the other extreme, be an ideal scheme, and can be incorporated gradually into sectoral expansion plans. Policy 1 (harmonised tax) appears to be a good option with varying benefits at different stages, this policy also supports the free-market characteristics of Indian business. Enhanced abatement could further be achieved by combining Policies 1 and 3, thus creating a real impact by incentivising firms while setting guidelines for minimum performance standards.

Although the above policy analysis is not complete, it still highlights the kind of shortcomings and distortions that different policies could deliver by considering a too short time horizon. Climate change concerns require urgent action; however, it is crucial that these policies evolve in the right direction. Therefore, it is vital to have a fully integrated, long-term and well-planned domestic policy approach which will take into account the aforementioned implications. Furthermore, even though the above policies would essentially be nationally driven, close international cooperation from Annex 1 parties would be required to support suitable domestic policy choices and deliver enhanced emission reductions. One such area is technology transfer and cooperation, where domestic policies need to be complemented by increased access to technology for firms. Similarly, capacity building programmes for low-skilled workers belonging to coal DRI units would increase their employability in larger and more efficient steel making units. Nevertheless, further research is required on how international support could balance the needs for implementing ambitious domestic climate policies.

In the next section the industry structure, key indicators, capacity addition plans until 2020, emission scenarios for different approaches of energy efficiency improvement, process shift and reduced demand through substitution are discussed[2]. Various policy options are then briefly described in Section 3 and benefits that they could deliver are defined in Section 4. Section 5 discusses domestic drivers and barriers. Finally, in Section 6 the importance of international support required to promote a domestic sectoral policy is briefly discussed.

2 Industry Structure and Emission Scenarios

Industry Structure

The iron and steel industry profile of India consists of public and private integrated steel units using the Blast Furnace-Basic Oxygen Furnace (BF-BOF) process; gas based Direct Reduced Iron (DRI) units; coal based DRI units and small electric arc/induction furnace (EAF/EIF) units (Fig 2). Coal is expected to be the dominant primary energy source for the conversion of iron ore, considering problems of availability and rising prices of natural gas (mJunction2008). A distinctive feature of the sector is the presence of a large number of small-scale coal based DRI units with capacities ranging from 0.03 to 0.3 million tonnes per annum (MTPA). DRI is used as a substitute for steel scrap; India has been the largest producer of coal-based DRI globally with an estimated 350 small units currently under operation (mJunction 2008).

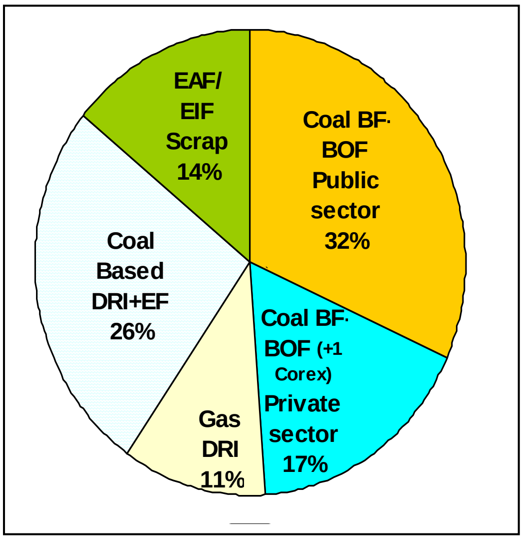


Fig 2: Steel Industry Structure, India – Output 53.9 million (mn) tonnes of crude steel (tcs) for year 2007-08 (MoS 2008).

Figure 3 compares the current Indian primary crude steel production energy efficiency and CO_2 emission intensity with the OECD average, where the BF-BOF route is predominantly used (IEA 2007a). A major reason for the poor performance of BF

[2] Although a slow-down in the Indian steel sector is witnessed from October 2008 onwards due to the global financial crisis and related slackening of international steel demand, the paper looks at long term demand and capacity addition scenarios in India, where this policy analysis could be of an important consideration.

units in India is the small plant size, which makes them inherently less productive and techno-economically impractical for retrofitting using the latest energy efficient technologies. A second reason is the use of locally available high ash (>20%) coking coal, due to higher costs of imported coking coal (SAIL 2008). Thirdly, there is a large presence of public sector units, which are still inefficient due to governmental controls, political patronage, bureaucratic delays and consequent lack of competition.

The alternative route of small-scale coal DRI processes, though inefficient, has several advantages including significantly lower capital cost requirements; the ability to directly use the cheaper high ash non-coking coal (35 to 40% ash content) and low quality iron ore (including fines); the ability to manage operations with cheaper unskilled labour and catering to the low-end housing markets (Saluja, 2008). As a result, a number of small entrepreneurs are setting up DRI units and this sub-sector is growing rapidly at over 15% per annum (MoS 2008).

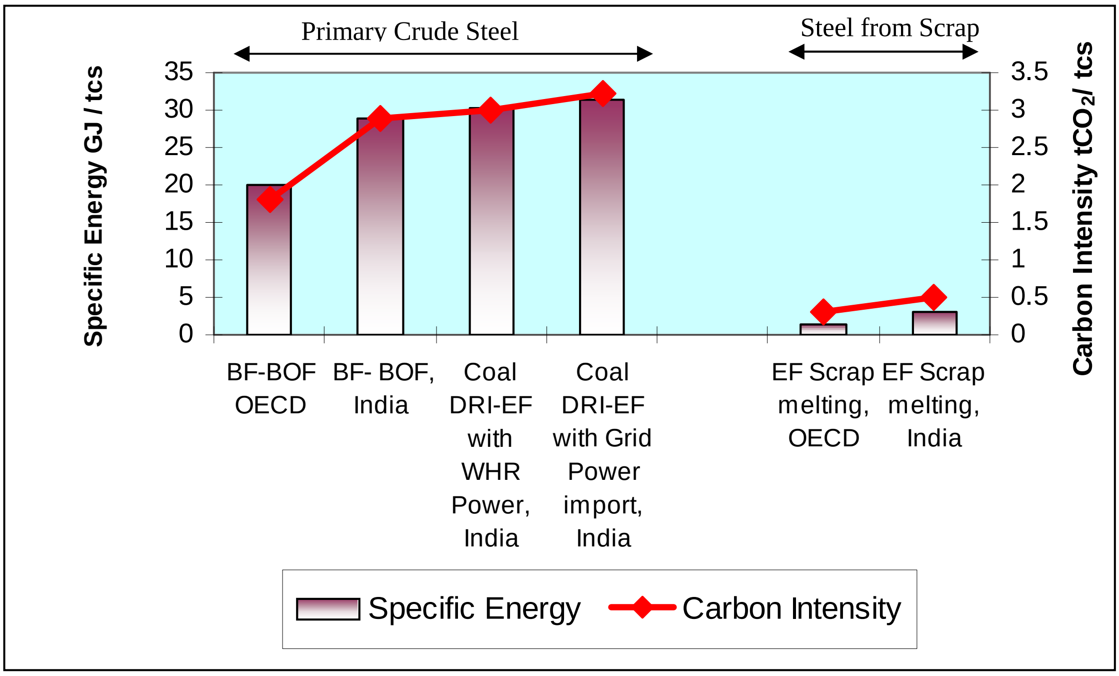


Fig 3: Performance comparison of major steel making processes of India with OECD, average figures (Source IEA 2007b, Planning Commission 2006, Saluja 2008 and own estimation) Note: 1) Steel units importing grid power would have further losses of primary energy during Transmission losses and Generation of power. 2) WHR= Waste Heat Recovery, EF = Electric Arc/ Induction Furnace units, tcs = tonne of crude steel.

Institutional Framework

Legislation, directives and government policies play a key role in guiding energy efficiency in industries. In India, two relevant pieces of legislation for the sector are the Environment Protection Act of 1986 (with several amendments) and the Energy Conservation Act of 2001. The latter has enabled the establishment of the Bureau of Energy Efficiency (BEE) in collaboration with the German Technical Cooperation (GTZ). Over the last three years, BEE has developed good capacity through knowledge sharing and certification of energy managers and energy auditors (GTZ 2008). Further, the Central and State Pollution Control Board’s (PCB) norms and its

Corporate Responsibility for Environment Protection (CREP) guidelines help control industrial pollution. However, all the above laws and guidelines still do not discuss enforceable minimum energy efficiency or CO_2 performance standards for the industrial sector (CPCB 2008).

A dedicated ministry under the national government oversees the iron and steel sector. The Ministry's latest National Steel Policy (2005) and the Planning Commission's 11th Plan (2007-12) report on steel do not mention targets for energy efficiency or CO_2 emission levels (Planning Commission, 2006).

In June 2008, India released its National Action Plan for Climate Change (NAPCC 2008). As per the document, a National Mission of Energy Efficiency is envisaged, which would formulate energy efficiency initiatives for large industries. The plan considers an initiative of mandated energy consumption reductions and subsequent trading of certificates from any excess energy savings achieved by firms. However, the plan is still under discussion and has no mention of specifying norms or guidelines for granting approvals to new builds in energy intensive sectors.

Thus, on the institutional front, apart from the recently conceived NAPCC all existing policies are essentially advisory or consultative in nature; therefore, definite norms, targets, or external incentives for energy efficiency as yet do not exist. As a result, firm managers are largely oblivious to the extent of carbon emission externalities of their operations.

Rising inflation as witnessed recently in the national economy has led to the government holding the steel industry partially responsible for profiteering from scarcity effects and urging producers to restrain pricing (The Hindu, 2008). In response, large steel firms have complied due to fear of increased regulation, however, this has affected their capacity expansion and modernisation plans due to reduced profits (mJunction 2008). This is a conflicting concern at both government and industry levels and could hamper sectoral climate policies, which might impose additional costs on companies.

Investment Drivers at Corporate and Government Levels

Energy efficiency, technology and process upgrading projects in the steel sector are capital intensive with long gestation periods (NSP 2005). Efforts undertaken by firms so far have essentially been voluntary with the primary aim (or motivation) to reduce operational costs and enhance energy security. In a few cases, firms have applied for Clean Development Mechanism (CDM) funds for selective GHG abatement projects. However, when viewed on a macro level, CDM revenue or climate concerns are not among the primary investment drivers in the sector. As shown in Table 2, high local demand and a favourable global situation (demand from China) are both expected to continue in the short to medium term, therefore both Indian and foreign steel firms have lined up substantial investments for capacity addition and to secure raw material supplies at competitive prices (mJunction 2008). This indicates that firms constantly expect higher returns for investments, which energy efficiency and modernisation measures may not deliver.

At the government level, due to high inflation fears, approvals for new build plants are being granted easily to many large and small private investors without definite planning of future energy efficiency and GHG emission patterns. For its own public sector units, the government has prepared investment plans in order to gradually modernise their projects with the latest energy efficient technologies (MoS 2008; Planning Commission 2006).

Capacity Addition Plans

Iron and steel is a major input to infrastructure and development projects. Currently, per capita consumption of steel in India is a tenth of the industrialised country average of 400kg (MoS 2007). Due to rising domestic demand from the infrastructure, housing and manufacturing segments over the last five years, growth of steel consumption has stretched to a record high of 9% per annum, resulting in the country becoming a net importer from 2006 (MoS 2008).

The Indian steel sector has a competitive advantage in its access to abundant iron ore, non-coking coal (used in coal DRI) and low labour costs (Planning Commission 2006). With demand expected to grow at over 7% per annum till 2020, coupled with an opportunity for exports, both public sector and private large and small players have planned huge capacity additions, as shown in Table 2. Even though the actual realisations may be lower, the figures suggest the pattern of preferences for different process routes of primary crude steel production.

Producer(s) and type	Process for Primary Crude Steel production	Current Capacity 2007	Total (Brownfield + Greenfield) Capacity	
			2012	2020
SAIL (Public Sector, Large)	BF-BOF	12.84	24.84	60
RINL (Public Sector, Large)	BF-BOF	2.9	6.80	10
Tata Steel (Private, Large)	BF-BOF	5.0	13.00	33.5
Essar Steel, (Private, Large)	Gas DRI and BF-BOF	4.6	14.50	20.5
JSW (Private, Large)	BF-BOF	4.1	11.00	31
JSPL (Private, Large)	Coal DRI and BF-BOF	2.4	10.45	26.5
Ispat Industries (Private, Large)	Gas DRI + BF	3.0	5.0	17
Posco (Private, Large)	BF-BOF	-	-	12
Arcelor Mittal (Private, Large)	BF-BOF	-	-	24
Bhushan Power and Steel (Private Medium)	Mini BF and coal DRI	1.8	10.0	16
Others and Secondary (medium and small scale units)	Includes mostly coal DRI	22	28.47	42
Total		**58.64**	**124.06**	**292.5**

Table 2: Capacity Addition Plans - in Mn tonnes of crude steel (Source: MoS 2008).

Emission Scenarios

Recognising the complex structure, dynamics and trends of the Indian steel industry as described above, different outcome scenarios are analysed to show the influence of policy options on production output and CO_2 emission trends. Since the realisation of capacity addition plans depends on emerging global and local market circumstances, a conservative estimate of nearly 50% of forecasted 2020 output is assumed. This would imply around 10% growth in both BF-BOF and coal DRI routes. Table 3 shows the proportion of output contributed by different processes in the business-as-usual (BAU) scenario.

Break-up – Process wise	Total Output - Mn Tonnes of Crude Steel(tcs)		Assumption
	2007 (actual)	2020	
Gas DRI	6	5	No growth
Coal DRI	14	45	around 10% growth per annum
Coal BF-BOF	26	85	around 10% growth per annum
EAF/EIF	8	15	Modest growth
Total	**54**	**150**	

Table 3: Production forecast in the BAU scenario.

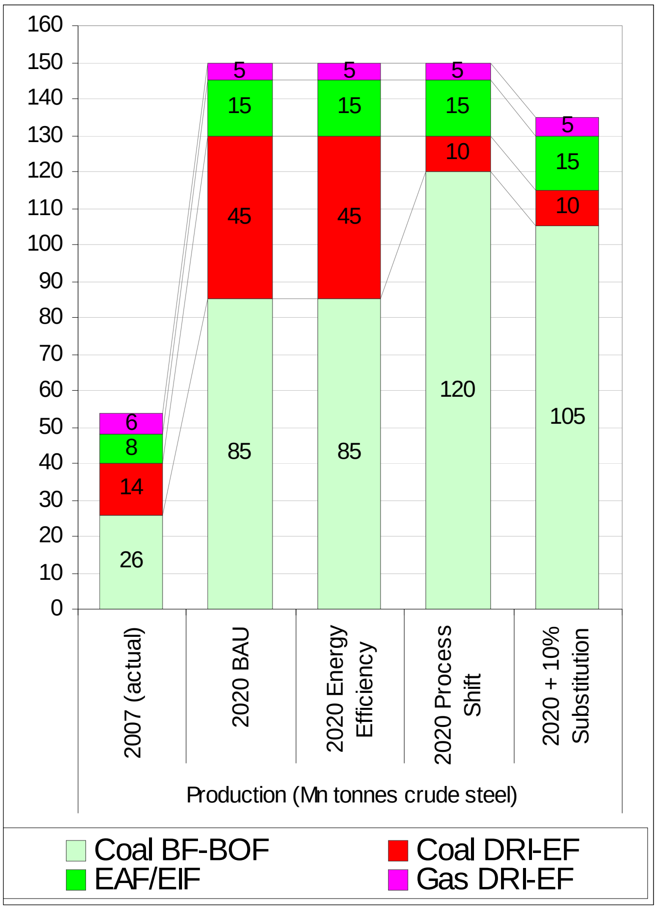
At present, the only operating climate and energy policy in the sector is the CDM of the Kyoto Protocol. Although the mechanism offers certain project-based incentives, it does not help drive overall modernisation nor does it provide guidelines to the sector expansion as a whole. Three major indicators are analysed for the influence of a policy option over business-as-usual: the 'energy efficiency improvement' scenario, the 'process shift' scenario and the possibility of reduced demand through substitution.

Emission scenario calculations: For capacity addition in the BF-BOF route, both public and private sector units are assumed to achieve a reasonable amount of reductions in emission intensity levels in the BAU. In the 'energy efficiency improvement scenario', emission intensity levels are assumed to reach closer to the current OECD levels (Table 4). A similar approach is followed for the coal DRI route, however, the reduction in 2020 is assumed to be modest, given its metallurgical limitations and potential for reductions yet to be proven (IEA 2007b). No change is assumed in emission intensity levels for the gas DRI and EAF/EIF processes. Details of calculations are provided in Appendix – I.

Process	Current and projected average emission intensity tCO_2/ tonne of crude steel (tcs)			
	2007 India*	2007 OECD Best practise*	2020 BAU	2020 Energy Efficiency**
BF-BOF	2.9	1.7	2.4	2.0
Coal DRI	3.1	NA	2.8	2.5

Table 4: Assumptions for Emission intensity levels for major processes in 2020. (Note: * Source: IEA 2007b); **Identical values considered for 'process shift' and 'substitution' scenarios.

Energy efficiency improvements for the BF-BOF process can be undertaken by investing in clean technologies like CDQ and TRT, by maximising pulverised coal injection and by process waste energy recovery. For the coal DRI process, approaches include waste energy recovery, raw-material beneficiation (like pelletisation of ore) and using a higher grade of non-coking coal. In the 'process shift' scenario, production would primarily move from small coal DRI and BF units to the large (> 4 MTPA) efficient BF units and other upcoming proven iron making processes. Finally, substitution efforts with sustainable and low-carbon materials would reduce, albeit in a small way, the high demand for steel products.



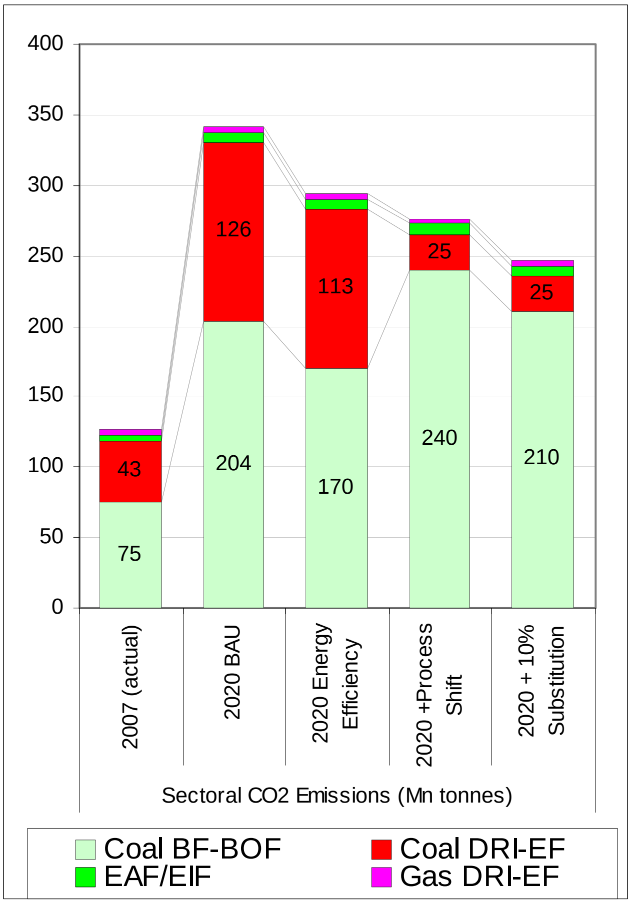


Fig 4: Different outcomes possible from climate policies in the Indian steel sector (assuming no emissions from substitution and conservative production forecast).

Figure 4 shows that a policy focused on energy efficiency improvements alone could deliver substantial abatement, but the inefficient coal DRI process would continue to contribute a disproportionately high share of sectoral emissions compared to output (tonnes of crude steel). Looking forward to 2030 and beyond, achieving additional sectoral abatement could well lead to tougher bargaining positions due to increased dependency on the coal DRI process. On the other hand, further process shift to large BF-BOF would allow meeting the same market demand and yet achieve further abatement by 2020. Finally, acknowledging that steel is a carbon intensive product, suitable substitution efforts could help deliver substantial emission reductions.

3 Description of policy

An important feature of the Indian business system is that private, and an increasing number of public firms, are largely dynamic and entrepreneurial in nature. If policies are enforced with clear guidelines, then firms tend to innovate and maximise individual benefits; for example CDM success of India (CII 2008). This paper discusses how policies could help address sectoral GHG emissions by leveraging this behaviour in the Indian context.

3.1 Policy Objectives

Given current state of affairs of Indian steel sector, as discussed in the sections above, the broader policy objective should be to incorporate CO_2 externality effects in decision making, especially in primary crude steel production processes. This broader objective should then translate into improving sectoral energy efficiency performance by revamping the existing stock of steel making units. Furthermore, as emerging economies ramp-up capacity to meet their growing consumer demand, it is essential that conversion paths with minimum resource requirements in new builds are chosen to avoid lock-in effects.

To achieve these objectives would require a fundamental attitude shift both in the government, which can supply a robust national policy framework; and firms, which can make the difference at the unit level. In particular, policy should help India fulfil its domestic climate mitigation responsibility, thus shifting away from its current stance of shunning commitments while seeking Annex-I assistance. Appropriately designed policy instruments can help achieve this multi-dimensional objective and initiate the desired behavioural shift.

Policy instruments need to demonstrate credibility and stability to be seriously considered by investors at large. Enforcement of policy should create monitoring, reporting and verification systems, which would allow analysis of sectoral emissions, evaluation of policy performance and help develop future policies. Finally, policies could deliver co-benefits such as improved environmental performance, increased capacity (manpower and technology/equipment providers) and encourage firms to transform themselves into a '*knowledge-based*' manufacturing sector, by boosting innovation.

3.2 Policy Mechanisms

The following section discusses likely economic policy options appropriate to Indian circumstances and briefly explains how they influence decision making.

Clean Development Mechanism – Currently CDM is the only major climate policy operating in the sector. The CDM is a bottom-up approach, which provides incentives for project based abatement activities through the sale of emission reduction credits to Annex-I parties, who in turn use them for meeting their Kyoto compliance targets. The firm voluntarily initiates energy efficiency projects in its facility and seeks CDM financing to minimise project risks. Details of the scheme's operating procedures, current status and opportunities have been discussed in Michaelowa (2008). A number of Indian steel industry projects have qualified to obtain emission credits, especially projects relating to waste energy recovery in coal DRI and BF-BOF units (Bhattacharya et al 2007; UNCTAD 2006).

On the other hand, due to the inherent complexities involved in satisfying additionality criteria, determining baseline, extensive monitoring and verification requirements and the high transaction costs involved, most industrial firms are not motivated enough to apply for this scheme especially when they are considering modernisation or thermal energy efficiency projects (Hayashi et al 2007; Parthan et al 2007). Thus, while CDM promotes easy-to-monitor project-based activities, it does not provide incentives for abatement through complex modernisation activities, choice of plant size or the process-type adopted.

Proposed Policy 1: Harmonised Carbon Tax

Under this scheme, the government levies a charge to the firm for every unit of carbon emission (tonne of CO_2). In response to the tax imposed, firms then seek opportunities to minimise their overall current and future tax liabilities by investing in cleaner technologies or extensive modernisation plans. For new build units, firms would also evaluate their carbon tax liability as part of the decision-making process, while deciding on process type, plant size or technology choice.

On a more practical level, the influence of such a policy was analysed for a few technologies; Pulverised Coal Injection (PCI), Coke Dry Quenching (CDQ) and Top Pressure recovery Turbines (TRT). Without a carbon tax liability, the rate of return of the technology (internal rate of return (IRR)) is less than the discount (or benchmark) rate; therefore the firm desists from investing in the project. This is representative of the existing scenario, where investments in such technologies in India are highly capital intensive and generally uneconomical. Table 5, shows the shift of economic attractiveness of technologies when a carbon tax of \$5/ tCO_2 is imposed.

Influence of Carbon tax	TRT	CDQ Plant	PCI
Technology specification	7MW for a 2300m^3 BF	24MW for a 300 tonne per hour coke capacity	140 kg coal per tonne hot metal
Approximate Investment (mn \$)	8.60	50.0	18.7
Internal Rate of Return(IRR) Without Carbon Tax	11.73%	8.60%	12.49%
IRR With Carbon Tax of \$ 5/ tCO_2	15.38%	10.23%	17.07%

Table 5: Illustration of carbon tax influence on a few low-carbon technologies (Estimates based on data from CDM projects and MoS Budget Outcome 2006).

The higher the tax imposed, the more attractive it will be for the firm to invest in such technologies. Thus, a harmonised carbon tax can act as a good policy incentive for the firms to invest in improving their energy performance.

If the firms decide to absorb the entire carbon tax liability, then the profitability of the firms is affected. To evaluate these impacts, balance sheet analysis of various firms was undertaken. It was found that a tax of \$5/ tCO_2 would range from 1.5% to 2.4% as percentage turnover and 2.3% to 2.9% as percentage expenditure for BF-BOF and coal DRI firms respectively. The impact on net profit is found to be severe in the case of small DRI firms where profit margins are notably low (Table 6).

Carbon Impact on Balance Sheet		**BF-BOF Firm 1**	**BF-BOF Firm 2**	**BF-BOF Firm 3**	**Large DRI-EF Firm 1**	**Small DRI-EF Firm 2**	**Small DRI –EF Firm 3**
Sales price	\$ / t steel	837.0	668.0	725.3	670.0	631.4	625.4
Total Expenditure	\$ / t steel	515.7	500.2	561.4	449.4	562.5	550.0
Net profit (after interests, depreciation and tax)	\$ / t steel	178.6	98.3	87.2	158.1	41.0	35.3
Carbon Tax	\$ / t CO_2	5.0	5.0	5.0	5.0	5.0	5.0
Existing CO_2 Intensity of steel	tCO_2/ t crude steel	2.6	3.0	2.6	2.6	3.0	3.0
Carbon Tax	\$/ t steel	13.2	14.8	13.1	13.2	15.2	15.1
Carbon tax cost as % turnover	%	**1. 57%**	**2. 21%**	**1. 80%**	**1. 96%**	**2. 40%**	**2. 41%**
Carbon tax % total expenditure	%	**2. 5%**	**2. 9%**	**2. 3%**	**2. 9%**	**2. 7%**	**2. 7%**
% drop in net profit if charge absorbed completely	%	**7. 36%**	**15. 01%**	**14. 97%**	**8. 32%**	**36. 9%**	**42. 6%**

Table 6: Implication of tax on balance sheet (publicly available company data for year 2007-08).

However, if the firms consider a carbon tax to be a negligible component of their product pricing and decide to pass on the entire cost of tax to customers, then it implies that the tax has been internalised (Bluffstone et al, 1999). This does not create the necessary incentive to invest in clean technologies or processes. In such a scenario, tax becomes a revenue raising mechanism for the government, which is not the desired intention of levying the tax. Therefore, determining the optimum level of harmonised carbon taxes is critical so as to create the necessary shift to low-carbon technologies.

Due to the larger burden effect from paying for emissions, firms may lobby and resist the scheme. Hence, different tax recycling options could be contemplated, provided that they avoid offering incentives to inefficient processes or plants. This scheme would also require monitoring plant level CO_2 inventories, which can be done on an aggregate level through collection of coal and electricity consumption data.

Proposed Policy 2: Incremental Emissions Carbon tax

A major drawback of harmonised taxes is that when tax levels are low, marginal costs are low and the firms can simply internalise or pass-on the added costs. Secondly, firms may object to the imposition of blanket taxes for all emissions. Therefore, another policy option is the incremental emissions tax (or the standards and charges approach) under this approach tax is levied on emissions over and above a specific emissions limit (Figure 5). Specific benchmarks for emissions can be determined based on ambitious targets agreed by stakeholders. Firms will eventually try to align their operations with the emission standard and may revamp or close down old plants. This policy mechanism also creates new physical benchmark guideline for technology providers, new entrants and steel plant designers.

This scheme has two advantages: First, the firm's burden (or cash outflow) will be significantly lower as it will not be required to pay for emissions below the specified level. Second, the tax can be fixed substantially higher than the harmonised tax level, so that the marginal cost of abatement is significantly lower (i.e. cost saving is higher) and creates a stronger incentive to industry to invest in capital-intensive clean technologies.

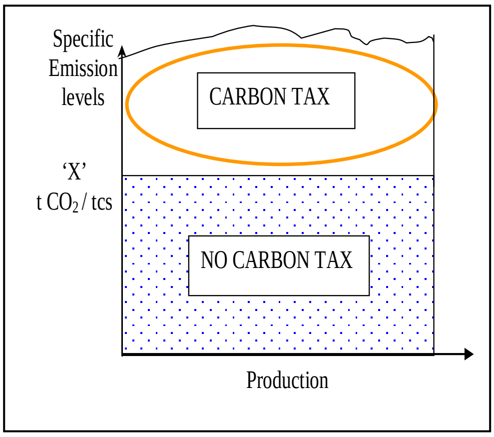


Fig 5: Concept of Incremental Tax.

However, such a scheme has some drawbacks. Defining benchmarks is quite complex given different process types, plant vintage and size, type of raw materials and scrap used and choice of system boundaries (Tanaka et al 2006, Eichhammer et al 2002). There may also be a risk of two or more benchmarks emerging from the political process, thus undermining a shift towards the most efficient production process.

The proposed National Action Plan scheme of India for mandated energy efficiency levels and subsequent trading of certificates also has a similar climate policy design.

Proposed Policy 3: Administered Standards

Regardless of imposing any of the above market based policies, highly inefficient processes like coal based DRI and old and/or small BF units may still continue to operate, given the huge market demand in India for iron and steel products. Providing market based incentives for such units to improve energy efficiency may only help to achieve minor abatement results and may not be enough to guide the sector to an overall lower carbon production path in the medium to long term. Hence, it may be necessary to incorporate and enforce certain standards for plant sizes and limits on capacity addition in inefficient processes. Norms can be stipulated and revised over time, making firms aware of the minimum plant performance levels required for sectoral expansion. The Asia Pacific Partnership Steel Task Force (APP 2008) and the International Iron and Steel Institute (IISI 2008) discuss such an approach, where inefficient plants are identified through benchmarking and eventually phased out.

The Indian government has taken some positive steps in this direction by recently imposing a ban on small coal DRI units below 100 tonnes per day capacity, as installing pollution control equipment proved to be uneconomical (CPCB 2007). The small units created severe air pollution problems for the nearby communities and agricultural lands and hence government was forced to take action. These restrictions were laid through the CREP guidelines. Further, the Central Pollution Control Board (CPCB) intends to develop Minimum National Standards (MINAS) for all types of industries with regards to key pollution parameters (CPCB 2008). CO_2 emission standards can also be included in this list to enable easy integration of GHG mitigation objectives with existing environmental policy.

4 Benefits

Short-Term and Long-Term Climate Benefits

Currently the institutional and business mechanisms in India do not account for the carbon emission externalities in investment decisions in the sector. A suitably designed policy (or combination of policies) as discussed above, would help price carbon effectively or provide appropriate standards. This would offer incentives and guidelines to decision makers to invest in low-carbon technologies and processes for the future. Introducing such a policy could also deliver co-benefits such as reducing fossil fuel related pollution, conserving natural resources and inducing innovative behaviour in firms as they continuously seek for cheaper carbon abatement opportunities. However, given the existing complex structure of the Indian steel industry, the policies should evolve over time to meet the following overall goals:

Short-term: As seen in Figure 3, low energy efficiency performance for primary crude steel production is exhibited in the existing stock of both BF-BOF and coal DRI processes. Hence, it is imperative that in the short-term, policies facilitate improvements in energy efficiency and modernisation of these facilities. Eventually, these changes should reflect in improved energy and CO_2 intensities from both the processes.

Medium-term: As explained in Section 2 above, due to inherent metallurgical limitations and poor raw material quality, coal based DRI and small BF-BOF units are highly inefficient and carbon intensive processes. Designing a policy, which merely encourages energy efficiency in these units, would help achieve marginal emission reductions, while still not lowering the overall sectoral emissions. Hence, it is important that in the medium term the policy should be able to limit the addition of inefficient processes and plant sizes. The policy should instead provide incentives to meet market demand through large integrated BF-BOF units (over 4 million tonnes per annum capacity) the efficiency levels of which can be higher, than current installations, by over a third (IEA 2007b).

Long-term: The importance of iron and steel as an input for infrastructure and development to enable economic growth is unquestionable. Taking into account this consideration, unrestrained consumption of carbon intensive resources, such as steel, will always lead to higher GHG emissions, even if all production plants are made highly efficient. Hence, it is important that the long-term incentives for alternate materials, which are less resource and carbon-intensive, are provided without compromising on safety, durability and other requirements of end use. Sedjo (2002), Reid et al (2004) and Werner et al (2006) discuss the viability of use of alternative materials like wood in some components of the construction sector. Policy designed with these objectives would support research and development, sustainable production and consumption of alternative materials and eventually reduce demand for steel products in the long term.

Measurements and Metrics for Policy Success

The existing Clean Development Mechanism (CDM) of the Kyoto Protocol is a project-based mechanism under which only marginal emission reductions are monitored. With the exception of CDM, no other target and time-bound domestic policy mechanisms are yet in place. Hence, the principal metric for intervention would be to have a suitable domestic policy mechanism in place to guide the sector towards overall low GHG emissions (i.e. an input based metric). Once implemented, success of a policy could be measured by the emergence of an effective domestic carbon price to regulate industry emissions.

For the iron and steel industry in particular, policy effectiveness could be gauged by monitoring energy efficiency and GHG intensity at the process (coal DRI/BF/gas DRI) and facility levels, i.e. outcome based metric. Policy performance should also assess the process type and plant size selected for new builds (i.e. input based metric). In the long-term, the metric should also indicate the extent of research and development efforts carried out for diffusion of alternative materials for steel. To enable regulators and stakeholders to evaluate policy impacts, it would be helpful to undertake periodic analysis of improvements over the BAU scenario.

For a long time, international evaluations by the OECD and developing countries have been proposing the removal of energy subsidies as a policy objective to achieve economic and energy efficiency (OECD 2003, Owen 2004). Hence, successful policies should also consider the removal of subsidies for commodities (like coal, steel products, etc.) that do not carry the cost of environmental externalities.

5 Domestic Drivers and Barriers

5.1 Stakeholders and Institutional Considerations

Carbon dioxide emissions are an inadvertent outcome of a deeply entrenched iron and steel production process. Designing policies to reduce sectoral GHG emissions would not only have financial and environmental implications for firms but also wider implications for social (employment), economic (market demand, financing), technological and political interests. Furthermore, the policy should also be compatible with any future international agreements on climate change and applicable trade laws. Thus, even though the national government would be the deciding authority on such a policy mechanism, it is essential that views from the following stakeholders are also taken into account, while deciding on the sectoral policy framework:

- Firms (large and small, public sector and privately owned, existing and planned, process types: BF-BOF, DRI coal, DRI gas, EAF/EIF units, etc)
- Various Ministries - Steel, Science and Technology, Environment and Forests, Finance, Commerce and the Planning Commission)
- Non-Governmental Organisations, environmentalists and Academic institutions
- Technology solution providers
- Industry Associations, Business Chambers, Trade Journals, etc.
- Joint Plant Committee (the nodal steel economic research unit)
- UNFCCC, Annex – 1 Parties, International Energy Agency/ OECD, International Iron and Steel Institute and the Asia Pacific Partnership

For implementing the policy, an Independent Steel GHG regulatory body would be necessary for laying out guidelines, coordinating monitoring and verification efforts, collecting emission liability costs, canalising revenue distribution schemes, performing the necessary checks and balances and reporting policy effectiveness.

Policy Benefits

By imposing emission cost liabilities and standards, firms would be motivated to take into account the carbon emission implications of their investment decisions. Investing in cleaner technologies would help reduce a firm's specific resource consumption, thus enabling it to enhance its long-term competitiveness. Investment would also encourage capacity building for employees and local technology providers, while inducing an innovative culture in the firms. Overall the policy can help to shift the sector and country towards an energy-efficient and low-carbon development trajectory, while reducing future costs from having to replace outdated steel manufacturing infrastructure.

Such long-term sectoral policies could also deliver a number of co-benefits. First, reduced pollution effects can be expected in the surrounding local communities, especially from small coal DRI and BF producers. Second, long-term policy would reduce the demand for coal thus helping to preserve the key natural resources. Finally, a well-designed policy could provide inputs for local research and development in abatement activities in the steel supply chain, while promoting appropriate low-carbon substitutes to meet growing end user demand.

Introducing a stringent domestic policy mechanism would make the country more participatory in international climate actions, allowing the country to play a proactive role in future negotiations. Overall, a suitably designed policy can be a win-win situation for the sector, government and the community, while addressing the larger global objective of climate mitigation.

Implementation Obstacles

The major difficulty for the implementation of such policies is the acceptability of the fundamental principles of climate change mitigation by both government and industry. So far, in international climate negotiations, the Indian government has resisted any attempt to take on emission caps and holds Annex-I countries responsible for bearing the costs of mitigation efforts. It can be argued that in coherence with this national position, the policies discussed above do not require any national or sectoral emission caps (or reductions in steel output), but would nevertheless show the country's commitment to act on climate mitigation.

Some concerns may arise that implementation of such policies would affect operational viability of many steel units and thus reduce supply at a period when demand for steel is high. Coupled with this fear, government is currently worried about record levels of inflation; holding steel firms partially responsible for their gains from the 'scarcity' effects (The Hindu, 2008). As a result, the government may be concerned that implementing any such climate policy would add to the cost of steel production, thus exacerbating inflationary conditions. However, as seen in Table 6, carbon emission liability costs are insignificant compared to production costs. Furthermore, it can be argued that as long as steel prices are determined by free market principles of national and global scarcity prices, an increase in production cost due to carbon pricing, would not completely feed through to product prices but may 'only' reduce profitability of the firms. Nevertheless such a policy creates the necessary economic incentives required for efficiency improvements and selection of low-carbon production process.

At the lower end of the sector, firms, especially smaller units, may lobby and oppose implementation of any such policy mechanisms, fearing risks to their survivability. In turn, firms may threaten job losses. As the medium and small-scale firms in the steel sector employ a large number of low or unskilled labour in India, this threat may create political patronage thus directly forcing government to reconsider any such ambitious schemes. As a result, political pressure could influence decision-making at the government level. These obstacles need to be overcome by initiating comprehensive stakeholder consultation and explaining the long-term sustainable benefits. One solution could be to provide capacity building to enhance the skill level of low and semi-skilled workers to enable employment at larger, more efficient plants. Nevertheless, given the entrenched socio-economic implications, further detailed research is required in this area.

As steel making is a capital-intensive process, debt financing required for shifts towards larger but cleaner production paths, could be a major hurdle. This is a particular problem in India, given the country's high cost of capital compared to developed countries and the challenging environment for doing business (World Bank, 2008; Drobetz, 2007).

Finally, the complexity of monitoring and verification of individual facilities to determine emission cost liabilities could be a major obstacle, especially as large numbers of small-scale DRI units are in operation. Overcoming such limitations require the creation of extensive independent monitoring capacities under the National Steel GHG regulator to collect plant level fuel consumption and production data. It also requires reporting and verification systems to be developed. Drawing system boundaries for allocating emission liability costs could also be a major policy design issue, and may require taxation policies aimed specifically at the upstream levels of the steel supply chain.

Criteria for Policy Selection

The major criteria affecting decision making for suitable policy choice are Effectiveness and Governance.

Effectiveness can be understood as the ability of a policy to limit the growth of sectoral GHG emissions over a business-as-usual (BAU) scenario. Since coal DRI and BF-BOF are the major processes contributing to sectoral GHG emissions, this implies reducing emissions specifically from these sub-sectors. In the medium-term, the policy should aim to not only reduce emissions at the firm level but also to introduce new efficient iron-making processes, encourage continuous innovation and facilitate overall sustainable development of the sector. Finally, in the long-term, policies should encourage substitution of steel with other low-carbon intensive materials.

Governance related issues are important in policy-making decisions. Policies should be transparent for administration and interpretation by various stakeholders. This may require periodic monitoring, reporting and verification systems to be put in place. Therefore, the transaction costs and complexity involved should be considered. If it involves payments, firms may be concerned about the transparency of money directed. In particular, since there is a significant presence of public sector in the Indian steel industry, private firms may be worried about distortions created by a climate policy. Hence, the policy should be transparent and designed to create a level playing field for both private and public sector players.

A summary of this evaluation is presented in Table 7 below.

+++ = Very good; --- = Worst; NA – Not applicable

Criteria for Policy Evaluation		Existing CDM	Proposed Policy #1: Harmonised tax	Proposed Policy #2: Incremental Emissions Tax *(including the proposed NAPCC scheme)*	Proposed Policy #3: Administered Standards
SYSTEM LEVEL EFFECTIVENESS	1. Short term - Improving Efficiency and CO_2 intensity of coal DRI and BF-BOF units over business-as-usual (BAU)	+	+ +	+	+ +
	2. Medium Term - Encourage shift from coal DRI and small BF to large efficient BF units	- - -	+	- -	+ +
	3. Long term – Encourage substitution of steel with low carbon intensive materials	- - -	+ +	-	NA
	4. Overall Effectiveness	- -	+ +	-	+ +
GOVERN-ANCE	5. Ease of Implementation	+	+ +	- -	+
	6. Ease of Monitoring and Verification	+ +	+	- -	+

Table 7: Evaluation of policy selection.

The analysis in this table shows that though schemes like CDM and Policy #2 incremental emissions tax (or the proposed NAPCC scheme) can deliver marginal emission reductions in the short-term, they continue to promote inefficient processes over time. Policy #3, administered standards, would on the other extreme, be an ideal scheme which could gradually be incorporated into national planning mechanisms. Policy #1 'harmonised tax' appears to be a good option to tackle sectoral emissions with varying advantages in all stages and also goes well with the free market environment of Indian business. Enhanced abatement could further be achieved by combining Policies #1 and #3 which could provide the twin effect of incentives and minimum performance standards expected for existing and planned capacities.

6 International Cooperation

Although the policies discussed above are essentially domestically driven, close international cooperation with Annex – I parties would help garner more support for the choice of a suitable policy and would help to deliver enhanced emission reductions.

Technology transfer is one aspect that can be supported by international cooperation. The proposed domestic economic policies need to be complemented by easier access to technology by making it more affordable for firms. This would require more focused cooperation on patenting, licensing, business development and local adoption issues related to technology diffusion. Given constraints such as the use of low quality raw materials and old vintage plants in India, proven technologies like clean coal and ore-beneficiation are also extremely important.

Bilateral cooperation programmes, such as GTZ support during the formation of the Bureau of Energy Efficiency, have previously been successful for capacity building. It may also be necessary that advanced technical cooperation is made available to both large and small players, far beyond the level currently being discussed by APP and IISI (APP 2008, IISI 2008).

Another area of support required, is in development and improvement of standards for industrial machinery in order to aggressively promote the use of energy efficient equipment. Performance of this policy could be measured by an independent GHG regulatory system. This body would require considerable technical, advisory and institutional support through international cooperation.

Given the argument of the Indian government on Annex -I responsibility for leading mitigation actions, suitable financial incentives and other approaches can be thought of to appease concerns and facilitate early adoption of the policies. For example, finance could be provided for capacity building programmes for low-skilled workers in the small-scale coal DRI units, in order to make them employable in the larger more efficient plants. Policies are only successful and influence investment decisions, if industry believes they are robust and will be stable over the long term. Therefore, outside support schemes and international cooperation could help policy operation and provide the right decision-making environment for a move towards cleaner production efforts.

7 CONCLUSION

As scientific evidence and resulting climate change negotiations consistently demand increasing, proactive participation from developing countries in mitigation; it is essential that major emerging economies explore policy options that could achieve significant domestic carbon abatement, while complementing international agreements. One such solution could be to design sectoral policies to specifically target large GHG contributors from power and industry sectors without undermining the governments' priorities of socio-economic development.
The paper shows that unique circumstances and patterns exist in sectors of emerging economies and a single international policy for addressing climate change may not be able to take into account country specific situations. Further, shortcomings in the form of distortions may arise when policies are designed with a smaller time horizon in mind. As climate change concerns require urgent actions, but most importantly in the right direction, it is imperative to develop a fully integrated, long-term and well-planned domestic policy taking above criteria into account.

Based on the analysis of different policy outcome scenarios for the steel sector in India, it was found that an effective policy should be consistent at all stages of its implementation. This implies that in the short term the policy should evidently help in improving energy efficiency levels of existing units. However, as inefficient processes or plant sizes could continue to operate, the policy should evolve to encourage a process shift towards larger more efficient processes and thus avoid lock-in effects and tougher bargaining positions in the future. Finally, the policy should constantly promote substitution of steel with alternative zero or low carbon intensive materials to help achieve substantial abatement, while continuing to meet the end user demand. Further research is required into which policy mechanisms would be most effective and would have similar impacts to schemes like a harmonised sectoral carbon tax coupled with administered standards. These comprehensive polices would seek to achieve the objectives of enhanced abatement and sustainable production paths.

As an effective domestic sectoral climate policy may also need certain reconciliation in short to medium term, political and firm level acceptability may be a critical issue given that steel supply chain is deep-seated in India. Cooperation schemes like enabling a more simplified technology transfer and international financing for capacity building programs to upgrade the skill level of unskilled labour could go a long way in assuaging the political concerns. However, further research is required on how international cooperation could help in assuaging these concerns so as to enable stabilisation of a suitable domestic policy framework. This is particularly essential to establish the right business environment and give policy direction so that investors can make decisions to shift towards cleaner technologies and processes. Evidently, such a policy mechanism could also deliver substantial co-benefits for the country and thus a further study on the possible co-benefits would help decision makers better appreciate the policy impacts.

To conclude, it is possible to carefully design an ambitious domestic sectoral policy that can be a win-win situation for the sector, government and the community, while addressing the larger global objective of climate mitigation.

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APPENDIX – I Emission Scenario - Assumptions and Calculation

Break-up – Process wise	**Production output (Mn tonnes crude steel/ year)**				
	2007 (actual)	**2020 BAU**	**2020 Energy Efficiency**	**2020 Process Shift**	**2020 + 10% Substitution**
Coal BF-BOF	26	85	85	120	105
Coal DRI-EF	14	45	45	10	10
EAF/EIF	8	15	15	15	15
Gas DRI-EF	6	5	5	5	5
Total	**54**	**150**	**150**	**150**	**135**

Break-up – Process wise	**Emission Factors tCO_2/tcs**				
	2007 (actual)	**2020 BAU**	**2020 Energy Efficiency**	**2020 +Process Shift**	**2020 + 10% Substitution**
Coal BF-BOF	2.9	2.4	2.0	2.0	2.0
Coal DRI	3.1	2.8	2.5	2.5	2.5
EAF/EIF	0.5	0.5	0.5	0.5	0.5
Gas DRI	0.7	0.7	0.7	0.7	0.7

Break-up – Process wise	**Sectoral CO_2 Emissions (Mn tonnes/ year)**				
	2007 (actual)	**2020 BAU**	**2020 Energy Efficiency**	**2020 +Process Shift**	**2020 + 10% Substitution**
Coal BF-BOF	75	204	170	240	210
Coal DRI-EF	43	126	113	25	25
EAF/EIF	4	8	8	8	8
Gas DRI-EF	4	4	4	4	4
Total	**127**	**341**	**293.5**	**276**	**246**

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