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Energy Sources and Carbon Emissions in the Iron and Steel Industry Sector in South Asia

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ABSTRACT: This paper examines CO_2 emissions from electricity and fuel consumption of different energy sources consumed in the Iron and Steel Industry sector (non-ferrous included, also known as basic metal) in five South Asian countries including Bangladesh, India, Nepal, Sri Lanka and Pakistan. The study finds that about 30% of the total energy in the manufacturing industry is used in this sector, which is about 11% of total industrial input, contributing approximately 13% to the Manufacturing Value Added (MVA). Electricity, on the other hand, shares almost 60% of total energy consumption in the five countries in South Asia, followed by natural gas, coal, kerosene and diesel. The study also finds that CO_2 emissions vary across sectors in countries in which the study was conducted. For instance, while in Bangladesh CO_2 emissions are primarily caused by electricity generation, in India the majority of CO_2 emissions are originated from coal. On the contrary, CO2 emissions in Nepal are mostly generated through other fuels such as Charcoal, Diesel and Kerosene. This study provides some policy recommendations, which could help reduce CO2 emissions in the Iron and Steel Industry sector in the South Asian region.

Keywords: CO_2 Emissions, Iron & Steel Industry, South Asia
JEL Classifications: L61; Q40; Q51

1. Introduction and Background of the Study

Industry accounts for an estimated 12 gigatonnes (Gt) CO_{2_e} and approximately 25 percent of all greenhouse gas emissions from all sources globally in 2004. Roughly 85 percent of the industrial sectors' energy use in 2004 was in the energy-intensive industry (Bernstein et al. 2007). The trend of carbon dioxide emissions is rising alarmingly in developing countries because of credit crunch during 2008, which caused a recession and led to a 7 percent (800 million tonnes) drop in the combined emissions in developed countries (UNIDO, 2011). The report also suggests that this decline compensated for the continuing strong rise in emissions in developing countries, such as India, by six percent (during this period). In addition, India is one of the top six emitting economies in 2009, together accounting for some two-thirds of carbon dioxide emission. Through the use of modern infrastructure and information technology, developing countries are fast becoming competitive in the production of energy-intensive manufacturing commodities. For this reason, developing countries accounted for 42 percent of Iron and Steel production in 2003 (Bernstein et al. 2007) and shared 30% of direct industrial carbon dioxide emissions in 2006 (UNIDO, 2011). These statistics are burning issues in the context of global warming, climate change, industrial energy efficiency and carbon trading.

So far, it is known that global greenhouse gas (GHG) emissions are rising due to human activities. The most significant GHG emissions grew by about 80% between 1970 and 2004 (Climate Change, 2007). Now, focusing on the future, the target is fixed in reducing the energy related carbon emissions. The international agreement known as the Kyoto Protocol, linked with the United Nations Framework Convention on Climate Change (UNFCCC), sets binding target for industrialized countries for reducing GHG emissions. The amount set is an average of 5 percent against 1990 levels over the five-year period 2008-2012 (UNFCC, 2012). To monitor emission reduction targets, 'Parties' (Annex I Parties; signatories of Kyoto Protocol) conduct reporting by way of submitting annual emission inventories and national reports under the protocol at regular intervals. In order to do this, *'Parties shall use the methodologies provided in the 2006 IPCC Guidelines, unless stated otherwise in the UNFCCC Annex I inventory reporting guidelines on annual GHG inventories…'* (IPCC, 2012)

As an energy intensive industry, the Iron and Steel industry has the potential of being one of the highest carbon emitters sectors. As such, it also offers high mitigation potentials. Zahan and Upadhyaya (2012) developed a working paper, which dealt with industrial energy efficiency measurements in the manufacturing industry in South Asia. However, this work analyses the sources of fuel consumed in the Basic Metal Industry (Iron and Steel together with non-ferrous) and reports the carbon emissions from such energy sources.

1.1 Basic Metal Industries in South Asia

In this section we are discussing the overall manufacturing sectors, which includes the metal industry in particular of the South Asian region.

1.1.1 Manufacturing Sectors

According to the national bureau of Statistics of South Asian countries**,** Basic Metal industries generally consists of sub-sectors of basic iron and steel, basic precious and non-ferrous, as well as casting of metal. We also find that the United Nations Industrial Development Organization (UNIDO) has database (INDSTAT2) at the two-digit level; International Standard of Industrial Statistics (ISIC 2) where Basic Metal, described as ISIC 27, is one of the 23 manufacturing sectors. This is also important to state that 'corresponding industry groups, UNIDO and IEA databases, ISIC revision-3' described ISIC 27 as Basic Metal for UNIDO and Iron and Steel as well as Non-ferrous metals by IEA (UNIDO, 2010).

1.1.2 General Status of the Industry

India, the gigantic producer in South Asia, has emerged as the fifth largest producer of steel in the world and the second largest producer of crude steel, as well as Direct Reduced Iron (DRI) in recent years (ASA & Associate, 2012). In addition, the ASA & Associate (2012) also states that in the year 2009-10, India exported about 7.296 million tonnes of carbon steel. Some of the leading India steel producers such as Tata Steel, SAIL, Bhushan, Mittal etc. are the biggest players of the Iron and Steel industry, with competitive status worldwide.

Likewise, Bangladesh's low production cost and high quality items have become a challenge to other major steel producing countries. The country exports mainly corrugated iron (CI) and galvanized plain (GP) sheets, cast iron articles, carbon rod, etc. (Export Promotion Bureau, Bangladesh)[1].

In Nepal, on the other hand, Iron and Steel are the tops most export earners, growing by 1.2% in 2011 from the previous year 2010. Iron rod, steel rod, stainless steel, cast iron pipe, tin sheet etc., are some of the export items of this industry (Trade and Export Promotion Center, Nepal).

Pakistan has experienced an increased demand of metal items in automobile industry, construction and re-construction. Production in 2004-05 equated 1.125 million tones. The demand is higher than its production capacity, with 60 percent of its total demand met by Pak Steel and scrap smelters, and the remaining quantum filled by imports and ship breakers (Pakistan Planning Division, 2006). Iron and Steel casting are important sectors in Sri Lanka. The industry consists of arc furnace and rolling mill facilities (Asia Institute of Technology (AIT), 1997). Data source shows its contribution to the manufacturing value-added being limited.

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1 Abul Khair Steel, Chittagong Steel, Apollo Ishpat etc. are some of the leading Steel companies in Bangladesh.

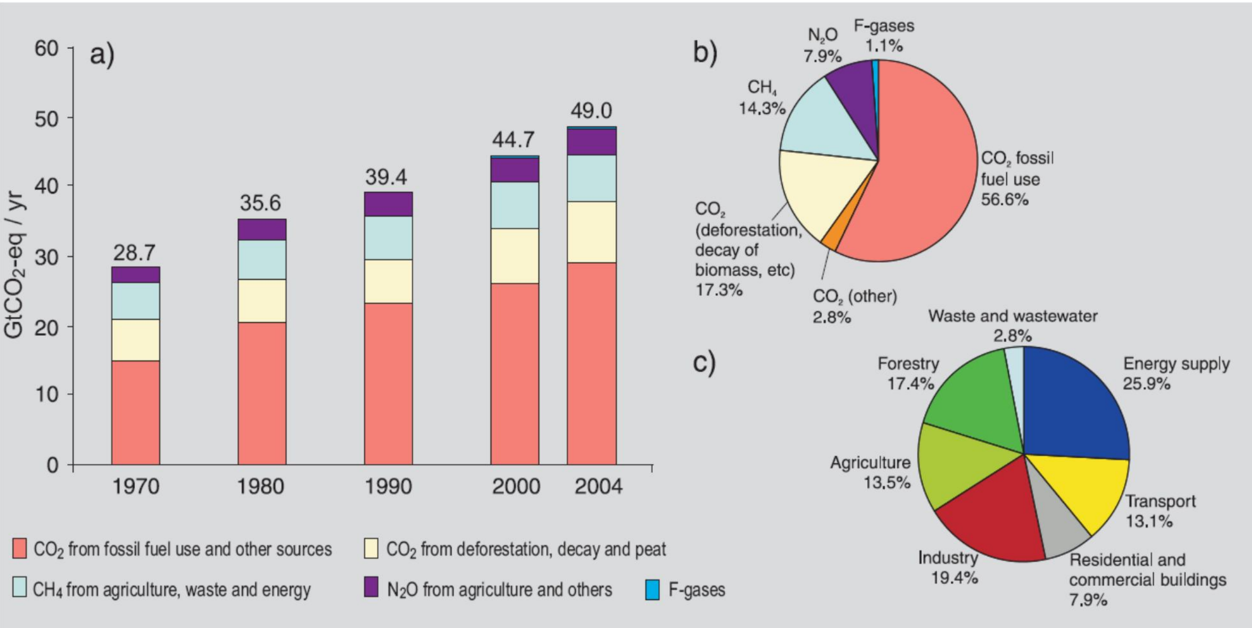
1.2 Steel Manufacturing and CO2 Emission

Steel is manufactured by the chemical reduction of iron ore, using an integrated steel manufacturing process or a direct reduction process. In the conventional integrated steel manufacturing process, the iron from the blast furnace is converted to steel in a basic oxygen furnace (BOF). Steel can also be made in an electric arc furnace (EAF) from scrap steel and, in some cases, from direct reduced iron. BOF is typically used for high-tonnage production of carbon steels, while the EAF is used to produce carbon steels and low-tonnage specialty steels. Emerging technology produces steel directly from iron steel. The steel making process with general air emission targets for India is discussed in a number of studies including the World Bank Group (1998) and Chatterjee (1996). The reports suggest that carbon dioxide emissions from steel production, ranging between 5% and 15% of total country emissions in key developing countries (including India) will continue to grow. This is particularly true in developing countries where outdated, inefficient technologies are still in use to produce iron and steel' (Price et al. 2001). Therefore, energy consumption and efficiency and/or intensity reduction has much more value to control emissions from manufacturing Iron and Steel.

1.3 CO_2 and its Impacts Upon the Environment

Carbon Dioxide increases the surface temperature and changes physical and biological systems. There is a scientific consensus that the main reason for carbon dioxide concentration is due to the burning of fossil fuels. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years. However, continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century. These changes will more than likely be larger than those observed during the 20th century (Climate Change, 2007). Figure 1 shows us the trend of carbon emissions. The share of fossil fuel burning in CO_2 emissions is almost 30 percent, and the sole contribution of carbon from fossil fuel use is almost 60 percent.

Figure 1. Global Emissions-(a) Global annual emissions of anthropogenic GHG from 1970 to 2004, (b) Share of GHGs in total emissions in 2004 in CO_2_e, (c) Share of emission different sectors in 2004



Source: Climate Change Synthesis Report, 2007.

It shows our concern that industry contributes almost 20 per cent of the emissions. Rising sea levels, changing wind patterns, extreme temperatures and heat waves are some of the consequences of global warming. It is also worth referring to the projection of effects of rising carbon emissions in

Asia, such as:

■ By the 2050s, freshwater availability in Central, **South,** East and South-East Asia, particularly in the large river basin, is projected to decrease.

■ Coastal areas, especially heavily populated mega-delta regions in **South**, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some regions, flooding from rivers might also occur.

■ Climate change is projected to heighten the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development.

■ Endemic morbidity and mortality due to diarrheal diseases associated with floods and droughts are expected to rise in East, **South** and South-East due to projected changes in the hydrological cycle.

The above arguments indicate that rising CO_2 emissions violates industrial sustainability and deteriorate the environment by contributing to global warming. For the sake of sustainable industrial development and emissions reductions, learning about industrial emissions sources and emissions volume is a crucial need. The aim of this analysis is to further explore ways in which major emissions reductions can be achieved.

In the next sections, we will discuss the purpose of this study in detail, along with a literature review, data sources and protocols of carbon emissions, plus an analysis of energy sources and emissions resulting from the metal industries. The study will finally provide an ending conclusion.

2. Purpose, Scope and Limitations of the Study

In order to reduce cost and emissions, reporting Carbon dioxide and other greenhouse gases is a key issue to achieve industrial energy efficiency. The result can be used to improve the competence and streamline process altering energy type. Complying with risks, liabilities, and environmental legislation is also a must. The declining trend of energy emissions could specifically attract social investment and responsible capital, agency and regulators. This will help the industry to achieve competitive advantages. Industry thus needs to diversify their business by also trading carbon emissions. An energy intensive industry such as the Iron and Steel industry are legally required to report their emissions to the EU Emission Trading System (EU ETS)[2]. Other large organizations are required to do so under the terms Carbon Reduction Commitment Energy Efficiency Scheme (CRC; Cognizant, 2011)[3]. In addition, 'credits are currently granted under the CDM (Clean Development Mechanism) in a one-to-one ratio: 1 unit of emissions reduction=1 ETS emission reductions credit' (Stewart et al. 2009). The global uniform rate for transfer payment is also estimated. Hence, OECD countries would currently have to transfer US$ 27 billion per year to compensate the rest of the world for implementing a global carbon price of $\$35/tCO_2$ (Landis and Bernauer, 2012). Therefore, we need to analyze the major sources of energy used in the metal production process. This information would help to decide adaptation measures to sources that contribute less emission, such as renewable energy (solar, wind). Additionally, such information can alter existing fossil fuel systems (coal, petroleum products etc.) and measure the volume of emissions based on our existing energy system.

2.1 The reason to select emissions of CO2

Industrial energy consumption not only emits carbon dioxide into the atmosphere, but also nitrous oxide, methane and other greenhouse gases. Estimating emissions from fuel combustion requires country specific emissions factors and suitable activity data that can ultimately lead to a proper approach. The non-CO_2 emissions are strongly dependent on the technology, the operating

2 The EU Emissions Trading System (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. Being the first and biggest international scheme for the trading of greenhouse gas emission allowances, the EU ETS covers some 11,000 power stations and industrial plants in 30 countries (for details: http://ec.europa.eu/clima).

3 The CRC Energy Efficiency Scheme (CRC) – formerly known as the Carbon Reduction Commitment – is a mechanism which started in April 2010 and is designed to improve energy efficiency in large, 'low energy-intensive' organisations not already covered by UK Climate Change Agreements and the EU ETS. It is a cap and trade scheme, like the EU ETS, thereby providing a financial incentive to reduce energy use by putting a price on carbon emissions. (For details: www.decc.gov.uk or www.cognizant.com /insights)

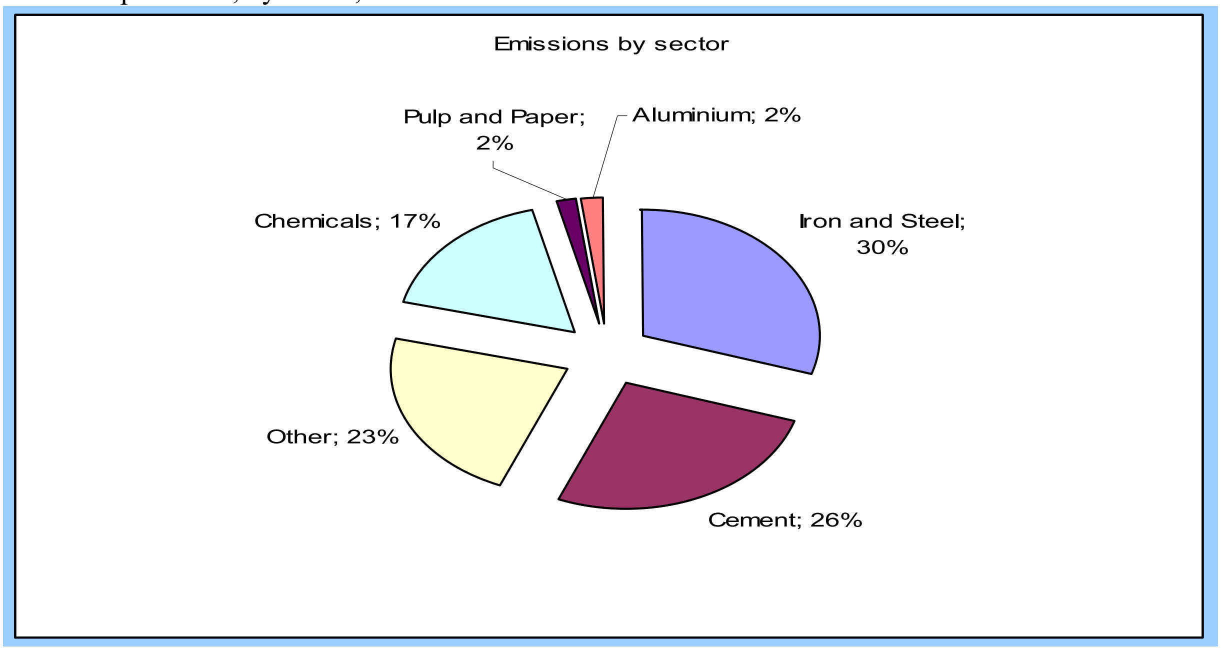
conditions and the individual plant level data. However, in order to make a fairly accurate estimate based on the available total amount of data for fuel and electricity consumption and average carbon content, only CO_2 was selected for the purpose of this study.

2.2 The reason to select Iron and Steel Industry

Basic Metal Industry (ISIC 27) is one of the most energy intensive sectors. A single source data is used to develop a classification of manufacturing sectors by the energy input ratio[4]. This classification is based on the ranking of manufacturing branches at the 2-digit level of ISIC Rev 3. Once results of two different exercises of manufacturing branches are compared, they are classified into three categories (UNIDO, 2010). Hence Basic Metal falls into the high energy-intensive industry class[5]. This class contributes more in the MVA; 40% for Bangladesh, 55% for India, 39% for Nepal, 60% for Pakistan and 24% for Nepal (Zahan and Upadhyaya, 2012). The sole contribution of the Basic Metal for different countries can be found in the analysis section.

This is not only a high energy-intensive industry but it is also a major source of carbon dioxide. The key energy statistics of International Energy Agency shows (Figure 2) that, as of 2006, the Iron and Steel Industry was the major source of carbon emissions among the high-intensive industry sectors, accounting for 30 percent of emissions contributions.

Figure 2. Share of Direct industrial carbon dioxide emissions from fossil fuel use and industrial processes, by sector, 2006



Source: Energy Statistics, IEA 2009, adapted from UNIDO Report, 2011

To analyze energy sources and report on carbon emissions, this study has selected a sector that is highly energy-intensive and has the potential to emit the highest emissions. Finally, there are four aims to this study. These are:

- To rank the energy sources by source cost in the Basic Metal Industries;
- To calculate the share of energy sources from this industry in relation to total sources cost in the manufacturing industry;
- To report carbon emissions; and
- To advance the industry into carbon trading.

The study therefore analyses the major sources of energy while also calculating carbon emissions by fuel sources for the energy consumption within the Basic Metal Industry for South Asian countries.

[4] Energy input ratio is calculated as relation of energy cost to the total input of manufacturing activities.

[5] This class includes Textiles (ISIC 17), Paper and paper products (ISIC 21), Coke and Petroleum products (ISIC 23), Chemical products (ISIC 24), Non-metallic Minerals (ISIC 26), Manufacture of Basic Metals (ISIC 27)

Other areas that are explored include the general status of the industry, its position in relation with energy consumption by sectors, its MVA contribution and share of industrial input. The primary factors that the industry needs to consider are: efficiency investment within the industrial system, reducing energy intensity during the metal production process, acknowledges the recent volume of carbon emissions, trade on the 1 unit emission reduction, learning share of energy sources as well as measuring the emissions. All these factors are explored within this paper.

2.3 Limitations of the study

The share of cost of various types of energy is studied. Efficiency investment, energy intensity, decomposition or generation of fuel or electricity in the establishment is beyond the scope of this study. Limited data of energy volume is used to measure only carbon dioxide gas (CO_2) emissions followed by stationary combustion.

3. Literature Review

3.1 IPCC protocols in the literature

Price et al. (2001), Guma et al. (2009), Tam et al. (2011), UK Greenhouse Gas Inventory Report, 1990-2002 of Baggott et al. (2004), Worrell et al. (Energy Efficiency, 2009), Kharel (2006), Li et al.(2001), and Fu and Brown-Santirso (2008) used the guidelines of IPCC for the purpose of carbon measurement and other analyses.

3.2 Carbon emission in Iron and Steel industry

Several valuable works have been identified, that deal with carbon emissions measurements reduction/mitigation prospects, and industrial energy efficiency, specifically regarding the Iron and steel industry in relation with climate change. Marland et al. (2010) most elaborately deal with the emissions report for global, regional and national levels. Time series data for national carbon emissions are available through sources of energy such as solids, liquids, gases, flaring, and cement for different South Asian countries. However, regional basis as South Asia in carbon emissions is not present.

Emissions reduction potential is a very dealt with phenomenon for the Metal Industries and it includes a range of factors such as fuel mix, energy process and status of the technology used. Price et al. (2001) assessed technical potential to reduce emissions based on the best practice. The main focus was India, along other key developing countries. Worrell et al. (2009) explored reduction of emissions based on efficiency improvement. Taking secondary emissions data for different geographical areas (developing Asia referred), the study discusses the potential contribution of industrial energy-efficient technologies and policies to reduce greenhouse gases within the iron and steel industry. Similar analyses are also found in Martin et al. (1999). Details of steel plant route, its modification, reporting and reduction of emissions in changing processes are all explored in Larsson et al. (2008). Route based (BF/BOF/EAF) emissions are also reported and analyzed in the study of De Beer et al. (2000), and Birat et al. (1999), as well as emissions reduction using Life Cycle Assessment (LCA) in Losif et al. (2008).

For the Indian Iron and Steel Industry, CO2 emissions and mitigation potentials through the adoption of energy efficiency measures are explored in the paper of Shatya and Schumacher (1998). It argues that energy consumption is the single largest source of carbon dioxide emissions in the iron and steel sector, which contribute to global environmental problems. Gas based and petroleum based energy consumption and emissions are calculated. Emissions are based on best practice energy consumption and is calculated using weighing factors, not the actual consumption data. To evaluate the eco-efficiency of the Iron and Steel Industry in Nepal, the study of Kharel (2008) considered carbon emissions and reported the emissions in equivalent[6] measure of one individual Manufacturer[7] to represent the whole industry. On the other hand, analysis of energy sources, regionally or locally, is fairly limited. Another one of the useful references is the Environmental Protection Agency (EPA) Final Report, USA, 2007, which examines the energy trends in the sector levels that include the Iron and Steel industry.

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[6] Equivalent measures include indirect carbon and non-carbon gases with direct carbon dioxide.

[7] Rajesh Metal Crafts Limited, Jeetpur, Nepal.

So far, we find that none of the above studies analyzed sources of energy consumption and reported carbon emissions. However, this is a complete feature of the status of energy consumption and carbon emissions reporting by fuel type in the Iron and steel industry of South Asia.

4. Data Sources and Methodology of Calculation

4.1 **Data Sources**

The National Energy Consumption data selection is based on the most recent available census of industrial energy use in Basic Metal (Manufacturing sector of Basic Metals; ISIC 27 of UNIDO INDSTAT 2)[8] is taken from the National Bureau of Statistics for all five countries i.e., Bangladesh (2005-06), India (2008-09), Nepal (2006-07), Pakistan (2005-06) and Sri Lanka (2008). It is noteworthy that value is taken for consumption analysis rather volume. Electricity and other energy sources in Ktoe are used to evaluate the emissions. The data of 'energy use by sources' in the Iron and Steel Industry is from IEA database for India and Pakistan, and refers to the year 2008 and 2006 respectively. The year in reference is close to the year of census for each particular country. The later data is to get an elaborate and complete picture of the emissions for India and Pakistan. (Volume of energy consumption is not available for Pakistan and Sri Lanka in the data source of National Bureau of Statistics)

4.2 **Protocol of Carbon Emissions**

To measure the emissions (and describe the process as well), the document '2006 IPCC Guidelines for National Greenhouse Gas Inventories' is followed. There are three Tiers presented in the *2006 IPCC Guidelines* for estimating emissions. The purpose is to produce a first order estimate of national greenhouse gas emission if only very limited resources and data structures are available to the inventory compiler.

The *Guidelines* estimate carbon emissions in terms of the types of gases that are emitted. During the combustion process, most carbon is immediately emitted as CO_2. However, some carbon is released as carbon monoxide (CO), methane (CH_4) or non-methane volatile organic compounds (NMVOCs). In the case of fuel combustion, the emissions of these non-CO_2 gases contain very small amounts of carbon compared to the CO_2 estimate and at Tier 1, it is more accurate to base the CO_2 estimate on the total carbon in the fuel. This is because the total carbon in the fuel depends on the fuel alone, while the emissions of the non CO_2 gases depend on many factors such as technologies, maintenance etc. Since CO_2 emissions are independent of combustion technology, stationary and default emission factors[9] for CO_2 due to combustion are considered in this paper.

Although the details of the protocol for reporting and measuring carbon emissions is mentioned above, it is still important to briefly state the following, regarding the Tiers.

Tier 1

The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated on the basis of the quantities of fuel combusted (usually from national energy statistics) and average emission factors. Tier 1 emission factors are available for all relevant direct green house gases. The quality of these emissions factors differs between gases. For CO_2, emissions factors mainly depend upon the carbon content of the fuel. Combustion conditions (combustion efficiency, carbon retained in slag and ashes etc.) are relatively unimportant. Therefore, CO_2 emissions can be estimated fairly accurately based on the total amount of fuels combusted and the average carbon content of the fuels.

Tier 2

In the Tier 2 method for energy, emissions from combustion are estimated for similar fuel statistics, as used in the Tier 1 method. However, country-specific emissions factors are used in place of the Tier 1 defaults. The emissions from electricity consumption are measured here following this approach.

4.2.1 **Choice of Method**

In general, emissions of each greenhouse gas from stationary sources are calculated by multiplying fuel consumption by the corresponding emission factor. Fuel consumption in mass or volume units is first converted into the energy content of these fuels. Different tiers can be applied for different fuels

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[8] Details can be found in the website of UNIDO; www.unido.org.

[9] IPCC, 1996, Carbon emission factors are used to analyse the relation between Carbon intensity and Energy intensity trends (Price et al. 2001)

and gases, consistent with the requirements of *key category* analysis and avoidance of double counting.

4.2.1.1 **Tier 1 Approach**

Applying a Tier 1 emission estimate requires the following for each source category and fuel:

► Data on the amount of fuel combusted in the source category

► The default emission factor come from the default values provided.

The following equation is used:

Equation 1

GREENHOUSE GAS EMISSIONS FROM STATIONARY COMBUSTION

$$Emissions_{GHG,\ fuel} = Fuel\ Consumption_{fuel} * Emission\ Factor_{GHG,\ fuel}$$

Where:

$Emissions_{GHG,\ fuel}$ =emissions of a given GHG by type of fuel (kg GHG)

$Fuel\ Consumption_{fuel}$ =amount of fuel combusted (TJ)

$Emission\ Factor_{GHG,\ fuel}$ =default emission factor of given GHG by type of fuel (kg gas/TJ). For CO_2, it includes the carbon oxidation factor, assumed to be 1.

To calculate the total emissions by gas from the source category, the emissions is calculated in the following equation as summed up over all fuels:

Equation 2

TOTAL EMISSIONS BY GREENHOUSE GAS

$$Emissions_{GHG} = \Sigma_{fuels}\ Emissions_{GHG,\ fuels}$$

4.2.1.2 Tier 2 Approach

Applying a Tier 2 approach requires:

■ Data on the amount of fuel combusted in the source category;

■ A country-specific emission factor for the source category.

Here, the default emission factors are replaced by country specific emission factors.

4.2.2 Choice of Emission Factors

Default emission factors are used for emissions estimate. Emission factors for CO_2 are in units of kg CO_2/TJ on a net calorific value basis and reflect the carbon content of the fuel and the assumption that the carbon oxidation factor is 1. The table for default emission factors for stationary combustion is given in the annex.

4.2.3 Choice of Activity Data

The activity data for all tiers consist of the amounts and types of fuel combusted. Most fuels consumers (here the Iron and Steel manufacturers) normally pay for the solid, liquid and gaseous fuels they consume. Therefore, the masses or volumes of fuels they consume are measured. National statistics or energy statistics agencies are good sources where the amount consumption data is collected, as mentioned in the sources before.

5. Analysis of Energy Consumption and Sources in the Basic Metal Industry, and Resulting Emissions

5.1 Industry Contribution and share of energy

The Basic Metal industry in South Asia stands as one of the most energy intensive and important contributors to the MVA for the whole manufacturing industry; 23 sector category. Its contribution to the MVA of India is the highest among other South Asian countries; 13%.

Table 1. Basic Metal Industry contribution to MVA and energy consumption percentage

Country	Share of MVA	Share of Total Energy	Energy Share of Total Industrial Input
Bangladesh	6%	8%	3%
India	13%	30%	11%
Nepal	5%	5%	4%
Pakistan	4%	7%	13%
Sri Lanka	1%	0.5%	1%

Source: Authors' own calculation

The analysis of this paper shows that this sector also consumed a major portion of energy in relation with total energy consumption in the manufacturing industry; 30% and 11% share in the context of total industrial input in the Indian manufacturing industry. On the other hand, the Basic Metal Industry contributes 6% to the MVA, shares 8% of total energy, and 3% to total Industrial Input in the manufacturing Industry of Bangladesh. The percentage share is depicted in Table 1 for five countries. It is seen that the sector has minimum contribution to the Manufacturing Output in Sri Lanka. Also, it consumes little amount of energy and input there. Table 1 also shows that MVA contribution and share of total energy in Pakistan are only 4% and 7% respectively, however the Industrial Input share is about 13%, which is significantly higher as compared to other South Asian countries.

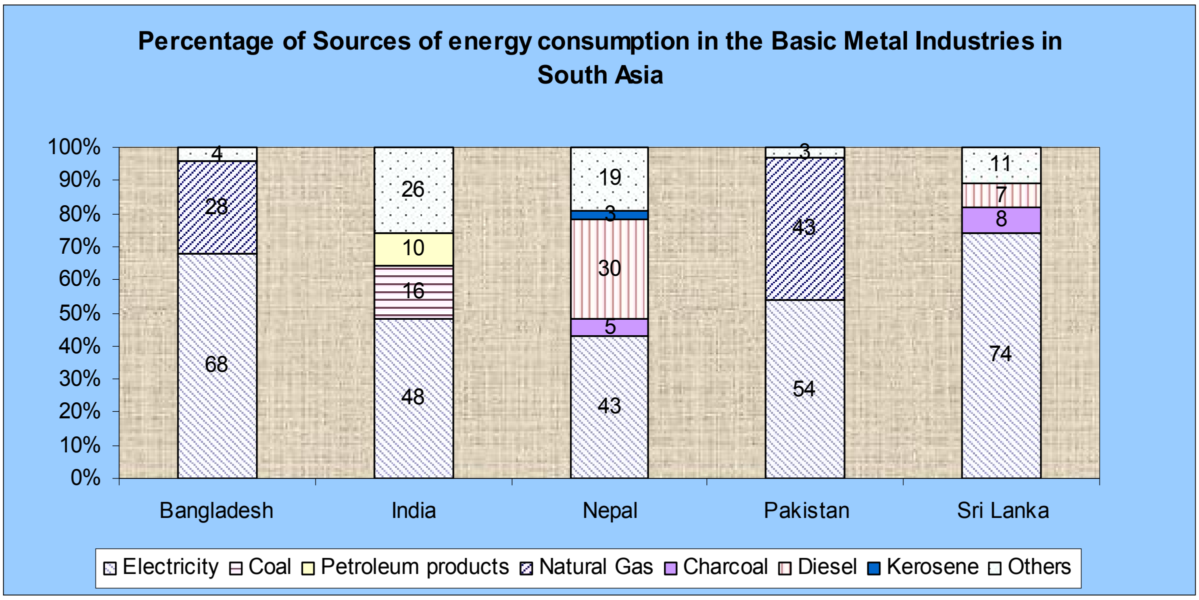
5.2 Energy consumption by sources in the Basic Metal Industry

There are different types of energy sources found in the Basic Metal Industry. Electricity is the most common and mostly used energy sources. Others are Natural Gas, Coal, Coke, Firewood, Furnace Oil, Diesel, Kerosene, Petrol, Lubricant Oil, LPG, and Charcoal etc. Petroleum products are found as broad sources for India and Water as a source for Sri Lanka. Energy sources are analyzed in two separate sections; one is percentage of sources solely consumed by the Basic Metal and the second is the share of total sources of particular energy in the manufacturing energy consumption of the Basic Metal industry.

5.2.1 **Percentage of sources of energy consumed by Basic Metal Industries**

Electricity shares the highest cost of total energy value in the Basic Metal Industry for particular country. It costs 68% in Bangladesh, 48% in India, 43% in Nepal, 54% in Pakistan and 74% in Sri Lanka in relation to the total value of other energy sources. The second highest value bearing specific energy sources are a bit different. Natural Gas stands as the second highest for Bangladesh and Pakistan; 28% and 43 % respectively, though Coal is the second for India; 16%. Diesel is used as a second major value of sources; 30% as well as Charcoal the second for Sri Lanka 8%. Figure 3 shows other percentage of sources thereafter.

Figure 3. Percentage of sources of energy consumed by Basic Metal Industries



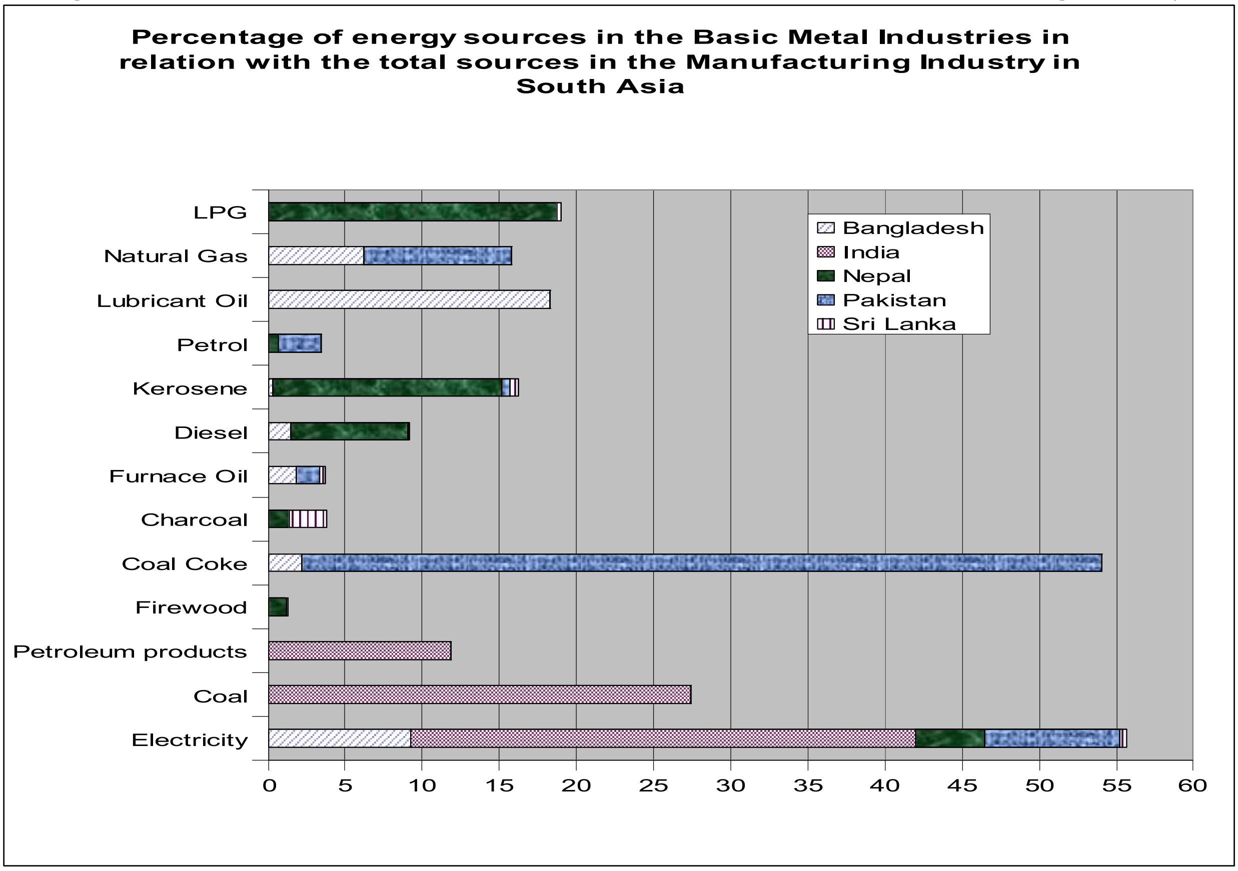
Source: Authors' own calculation

5.2.2 **Percentage of sources consumed by Metal Industries in relation with total value of sources in the manufacturing industry**

Some sectors or some countries are particularly energy intensive. Though in the previous section it was found that electricity is the major contributor source for the Basic Metal Industry, when considering the total value of sources in the manufacturing industry, the share of costs of energy sources vary.

Figure 4 shows that only 9% of the total electricity costs in the manufacturing industry is shared by the Basic Metal industry in Bangladesh. In contrast, 33% in India, 4.5%in Nepal, and 9% in Pakistan are consumed in respect with total electricity cost. The industry consumes a good portion such as 6% and 18% in relation with the total cost of Natural Gas and Lubricant oil in the manufacturing of Bangladesh. In Nepal, it shares 19% of LPG and 15% of Kerosene use. The analysis also reveals that the metal industry of Pakistan is Coal, Coke (52%) and Natural Gas (10%) intensive. The industry shares 27% of the value of coal in India and 2.5% Charcoal in Sri Lanka, in relation to the total value of the respective energy in the whole manufacturing industry.

Figure 4. Sources in Basic Metal in relation with total value in the Manufacturing Industry



Source: Authors' own calculation

5.3 **Carbon emission by sources**

Emissions depend on the energy type consumed. Natural Gas and Firewood emits less, while coal and petroleum products emit greater volume of emissions. Producing electricity in the plant causes higher emissions as energy supply emits a high volume (corresponds to Figure 1). Regardless of the supply of industrial volume, the sources of energy are still used to measure the carbon emissions. Hence, the relative volume of carbon emissions in the Basic Metal Industry in South Asian countries is reported in Table 2.

Considering all available data for the energy volume (except volume of Natural Gas which shares 28% of total energy cost in this industry) consumed in the Basic Metal industries of Bangladesh, the measurement reports 183,474 tonnes of carbon dioxide emissions in the surveyed years of 2005-06. In India[10], Coal and Electricity shares 64% of total energy sources and those emit[11] only 110,823 tonnes

[10] Based on Indian data set: Fuel Consumed represent total purchase value of all items of fuels, lubricants, electricity, water (purchased to make steam) etc. consumed by the factory during the accounting year except those which directly enter into products as materials consumed. It excludes that part of fuels, which is produced and consumed by the factory in manufacture i.e., all intermediate products and also fuels consumed by employees as part of amenities. It includes quantities acquired and consumed from allied concerns, their book

of carbon dioxide for the industrial surveyed years 2008-09. On the other hand, the manufacturing industry in Nepal reports 22,344 tonnes of CO_2. Taking the IEA data for the Iron and Steel Industry in Pakistan, the measurement shows only 207 tonnes of CO_2 emissions using from using Coke and Gas.

Table 2. Carbon Emissions (CO_2) in the Iron and Steel Industries in South Asia

Data/Survey Year	Country	Type of Sources: Data availability on consumption of energy mix	Emission in tones of CO2 in two groups of sources	Total Emissions from stationary combustion (in tones of CO_2)
Data: National Bureau, 2005-06	Bangladesh	1) Electricity 2) Other Fuels: Coking Coal, Diesel, Furnace Oil, Kerosene, Lubricant, and Firewood	1) 178341.358 2) 5133.087	183474.445
Data: National Bureau, 2008-09	India	1) Electricity 2) Coal (Assuming bituminous)	1) 47075.842 2) 63748.161	110823.963
Data: National Bureau, 2006-07	Nepal	1) Electricity 2) Other Fuels: Charcoal, Diesel, Petrol, Kerosene, LPG, and Firewood	1) 37.952 2) 22306.479	22344.430
Data: IEA 2006	Pakistan	1) Other Fuels: Coke even Coke, Blast Furnace Gas, and Natural Gas	1) 207.442	207.442

Source: Authors' own calculation

6. Summary and Conclusions

Based on the cost of consumption, energy sources are analyzed and volume of consumption of energy carbon emissions is measured. It is found that electricity, natural gas, coal, coke and other petroleum products are used in the Iron and Steel industry in South Asian countries. About 30% of the total energy is used in this industry, in relation with the whole electricity and fuel use in the manufacturing industry of India. As another major source, electricity accounts for the second highest use of natural gas in Bangladesh and Pakistan, while accounts for in India, with diesel in Nepal and Kerosene in Sri Lanka. As a high-energy intensive industry, the Iron and Steel industry consumes major coal coke (52%) in Pakistan, LPG and Kerosene in Nepal, coal (25%) in India and Lubricant oil in Bangladesh, in comparison with the total particular energy used in the whole manufacturing industry. Additionally, the emissions from electricity (178341.358 Mt CO_2) are much higher when compared to other sources (5133.087 Mt CO_2) in Bangladesh. In Nepal, the amount of emissions from other fuels (22306.479 Mt CO_2) is higher. Coal has a very high potential of carbon emissions, emitting 63748.161 Mt CO_2 in India in the surveyed year. Emissions of electricity are less here because the data represents only the purchased electricity.

In conclusion, high volume of electricity is used in the Basic Metal Industry in South Asia. Plant generated electricity or other fuels should also be accounted for to get a complete representation of carbon emissions. Natural gases can also be a good source in lieu of fossil fuels to reduce the emissions of the Iron and Steel industry.

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value being taken as their purchase value and also the quantities consumed in production of machinery or other capital items for factory's own use. Page A 633: Annual survey of industries 2008-09. http://mospi.nic.in.

[11] Details IEA Energy consumption data for the Iron and Steel industry are taken, and analysed.. It shows less volume of emission what made to conclude that all metals sub-sectors are not included.

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