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NRMP-IEA Input-Output Working Paper No. 16

# CASE STUDY OF THE BASIC IRON & STEEL SECTOR

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# Preface

## NRMP-IEA Technological Scenarios

The Natural Resources Management Project (NRMP) assisted by USAID in association with the Institute for Economic Analysis (IEA) at New York University is carrying out a modelling exercise to project the economic, employment and environmental consequences of different development paths for the Indonesian economy. The purpose is to provide advice to the Indonesian National Planning Agency (BAPPENAS) to assist in the development of the next five-year plan (Repelita VI) and the next Long-Term Development Plan. The first stage of this work has already been completed with the support of the Environmental Programming Support Services Project of CIDA.

The analysis, of which the present paper is a component, will provide advice on the trade-offs and complementarities between the growth of income and employment on the one hand, and the levels of natural resource depletion and degradation of the natural environment on the other. For instance, it is important for policy makers to know how the development of the pulp and cement industries over the next 20 years is likely to affect air and water pollution and how costly or cost-saving it will be to adopt cleaner technologies than are being used now.

The analytical framework includes a dynamic input-output model covering all economic activities. The model is dynamic in two senses. First, it incorporates a representation of investment in which levels of sectoral investment depend on expected growth of output, the technology in use and levels of capacity utilisation. Secondly, the model is dynamic in that it explicitly incorporates projections of changes in technology for a range of sectors in the economy, including agricultural sectors, forestry, energy sectors and key manufacturing sectors.

Technological scenarios are developed for each of these sectors using detailed information about likely technological and institutional changes obtained from technical experts. They include expected changes in intermediate inputs, notably energy and raw materials, capital stocks and human resources of different skill types as well as expected changes in natural resource usage and environmental degradation associated with current and alternative future technologies.

This paper is one of a series of working papers prepared by NRMP and IEA researchers in collaboration with industry experts. The papers will form a vital part of the data base for the numerical computations. In addition, they will be valuable as stand-alone analyses of technological futures for a range of important industries in Indonesia.

It should be noted, however, that some of these working papers (especially those on manufacturing sectors) were prepared under severe time limits and should not be taken to represent the last word on technological change in the industries in question.

## 1 Introduction

This case study describes current and future technologies in the Indonesian basic iron and steel production sector (Sector 17.5 in the NRMP-IEA 30-sector classification system).[1]

Large-scale iron and steel production in Indonesia is still a relatively new industry - initiated with the establishment of PT Krakatau in 1969 - and is almost wholly dependent on imported equipment and technology. In addition, Indonesia possesses no domestic sources of iron ore, so that raw material must be imported. However, Indonesia currently has adequate domestic resources of natural gas and coal for 'direct reduction' of iron ore pellets to sponge iron, using relatively modern production technology.

The state-owned PT Krakatau Steel (located in West Java) is Indonesia's only fully-integrated producer of iron and steel, and the sole producer of steel slab. All other domestic steel producers use crude steel (slab and billet) and scrap steel (both domestic and imported) to produce steel billets and hot and cold rolled products (e.g. steel plate and reinforcing rods). These smaller producers, of which there were some 13 in 1991, are commonly called 'mini-mills' (capacity ranging from 12,000 to 500,000 tonnes p.a., and total capacity of about two million tonnes p.a.) which focus on producing a small range of products for the domestic market (commonly steel reinforcing rod for road and building construction). It is thought likely that the proportion of domestic steel demand met by mini-mills will markedly increase during the next decade.

Despite the rapid increase in domestic production since the mid-1980s (16 per cent p.a. over 1985-90), Indonesia still imported nearly two million tonnes of crude steel and steel products in 1990. In addition, imports of scrap steel have continued to increase, as scrap is the main raw material input for the growing number of mini-mills and domestic supply is inadequate both in quantity and quality. However, the most modern of these mini-mills use combinations of technology that were common in Europe, America or Japan in the late-1970s or early-1980s.

Table 1 presents data on the production of sponge iron, and steel slab, billet and ingots for 1985-90. It should be noted that some differences exist between data sources regarding steel production, imports and consumption, as a comparison of Table 1 and Table 2 reveals.

The major fact that emerges from Table 1 is that the rate of growth in the shortfall - between crude steel production and the manufacture of steel products - is growing faster than either the rate of growth in production of crude steel or the rate of growth of manufactured steel products. This trend suggests that Indonesia could well become increasingly dependant on

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1 Agus Sutiardi is thanked for his assistance in data collection.

imports of steel. The same trend is apparent in Table 2, although the data only cover the period 1985-89.

**Table 1:**
**Basic Iron and Steel Production - 1985-90.**

| ('000 t) Product | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1985-90 Growth % p.a. |
|---|---|---|---|---|---|---|---|
| Sponge Iron | 1,052 | 1,323 | 1,027 | 985 | 1,210 | 1,422 | 6.2 |
| Steel | | | | | | | |
| Slab | 358 | 652 | 721 | 722 | 800 | 890 | 20.0 |
| Billet/Ingot | 1,016 | 1,124 | 1,337 | 1,360 | 1,608 | 1,988 | 14.4 |
| Basic Steel | 1,374 | 1,776 | 2,058 | 2,082 | 2,409 | 2,878 | 15.9 |
| Steel Prod's | 1,965 | 2,353 | 2,989 | 3,392 | 4,106 | 4,546 | 18.3 |
| Shortfall | 591 | 578 | 931 | 1,310 | 1,698 | 1,668 | 23.1 |

Notes: Shortfall is equal to total production of manufactured steel products less total basic steel production.
Source: Departmen Perindustrian, pers.comm..

Given that Indonesian steel production is considered inefficient by world standards in terms of energy use, labour productivity and quality (Data Consult 1993), reliance on imports may well be more efficient (in economic terms) than an overly-rapid expansion of domestic capacity using outmoded technology.

**Table 2:**
**Steel Production, Imports, Exports and Consumption 1985-89.**

| '000 t Item | 1985 | 1986 | 1987 | 1988 | 1989 | 1985-89 Growth % p.a. |
|---|---|---|---|---|---|---|
| Production | 1,328 | 1,747 | 1,983 | 1,859 | 2,303 | 14.8% |
| Imports | 693 | 1,001 | 1,310 | 1,673 | 1,783 | 26.6% |
| Total | 2,021 | 2,748 | 3,293 | 3,532 | 4,086 | 19.2% |
| Exports | 170 | 292 | 804 | 814 | 814 | 47.9% |
| Consumption | 1,851 | 2,456 | 2,489 | 2,718 | 3,272 | 15.3% |

Source: Jurnal Industri. Edisi Khusus, Juli-Augustus 1990.

## II Intermediate Inputs

Table 3 lists the 10 main intermediate inputs to Iron and Steel production in 1985 according to the BPS Input-Output table, the value of these 10 inputs accounts for over 85 per cent of total intermediate inputs (for a complete listing see Annex 1). Intermediate inputs to the sector are dominated by those coming from within the sector, because sponge iron, in particular, is a major input to the steel production processes. However, it is unclear from the I-O table under

what heading the substantial inputs of scrap iron and steel are classified, unless they are included in the inputs from within the sector itself (Sector 45 in the 75-sector classification).

**Table 3:**
**Main Intermediate Inputs to Iron and Steel Production in 1985.**

| Sector Name | Sector | % of total inputs |
|---|---|---|
| Basic iron and steel | 45 | 37.87 |
| Unspecified sector | 66 | 10.39 |
| Chemicals | 40 | 7.60 |
| Electricity, gas and water supply | 51 | 7.29 |
| Petroleum refinery | 41 | 5.22 |
| Machinery & electrical machinery | 48 | 4.57 |
| Road transport | 56 | 3.72 |
| Restaurant and hotels | 54 | 3.30 |
| Financial intermediaries | 61 | 3.12 |
| Fabricated metal product | 47 | 2.54 |
| Share of Total Intermediate Inputs | | 85.62 |

Source: BPS I-O Tables, 1985.

Table 4 lists the ten most important consuming sectors for the production of iron and steel in 1985, almost all of the value of the sector's output is consumed by these ten sectors (for a complete listing see Annex 2). It is noteworthy that the construction sector dominates consumption of output, and probably accounts for the rapid growth in the number of mini-mills producing reinforcing rod and bar. The relatively large consumption for production of fabricated metal products (Sector 47) is mainly used for the production of office equipment and consumer durables. Also worthy of note is the fact that only about one tenth of output is used by the two sectors manufacturing transport and other machinery (Sectors 49 and 48).

Two case studies were undertaken to determine details of production technology, labour and natural resource requirements and environmental impacts. The first case study examined the production processes of the only integrated iron and steel manufacturer in Indonesia, PT Krakatau Steel, located in the rapidly expanding industrial complex at Ciligon, West Java. The second study examined the production processes of a medium-sized mini-mill, PT Budidharma, located in North Jakarta, whose sole products are a range of steel reinforcing bar and rod for use in the construction industry.

**Table 4:**
**Main Consuming Sectors for Iron and Steel in 1985.**

| Sector Name | Sector | % of Total Output |
|---|---|---|
| Construction | 52 | 58.02 |
| Fabricated metal product | 47 | 16.84 |
| Basic iron and steel | 45 | 12.20 |
| Transport equipment and repair | 49 | 7.98 |
| Machine, electrical machinery | 48 | 2.33 |
| Other services | 65 | 1.24 |
| Nonferrous basic metal | 46 | 0.81 |
| Petroleum refinery | 41 | 0.15 |
| Crude oil and natural gas | 25 | 0.13 |
| Other product, nec | 50 | 0.12 |
| Share of Total Consumption | | 99.73 |

Source: BPS I-O Tables, 1985.

## Case Study 1: PT Krakatau Steel

PT Krakatau Steel was established in 1969 and started operations in the early 1970s with production of sponge iron from imported iron ore pellets. Over the period 1976-86 it expanded and integrated its facilities to begin producing steel billet, slabs and ingots, and began production of steel rod, wire and hot and cold rolled steel sheet and coils, including coated steels.

*Production Processes*

The sponge iron production process uses direct reduction technology, where iron ore pellets are reacted directly with carbon monoxide (CO) and hydrogen ($H_2$, reformer gas) at high temperatures (800-900$^{o}$C). The process uses natural gas (mainly $CH_4$) as both the heat source and the source of carbon and hydrogen, the speed and yield of the reaction is enhanced by using a nickel catalyst. The current production process has two direct reduction units, with a combined annual capacity of 1.5 million tonnes of sponge iron.

The sponge iron from this process is combined, in a separate process using an electric arc furnace, with steel scrap (30 per cent) and limestone (used as a flux) in an inert atmosphere (nitrogen or argon gas) to produce crude steel. During this smelting process (which operates at a temperature of about 1,700$^{o}$C) alloys are added to the melt to obtain the required qualities. The molten steel is then cast into billets or into steel slabs, using a continuous casting process. PT Krakatau currently have eight electric arc furnaces and six continuous casting units, with a combined annual capacity in 1992 of 0.550 million tonnes of steel billet and 1.2 million tonnes of steel slab.

Steel billets and slabs are reheated to about 1,200°C prior to further processing. The billets are rolled into a range of bar and rod products, while slabs are used for producing steel sheet. Annual production from crude steel billets in 1992 was 0.150 million tonnes of plain and deformed (patterned) reinforcing bars, 0.200 million tonnes of reinforcing rods, 0.045 million tonnes of steel sections and angles, and 0.018 million tonnes of zinc coated wire and nails. Annual capacity in 1992 for sheet steel was 1.2 million tonnes of hot rolled steel coils and 0.850 million tonnes of cold rolled coils and black steel sheet.

*Material and Energy Requirements*

It is not possible to satisfactorily separate all the inputs to the iron and steel production process, because they are integrated within one complex at PT Krakatau; also no data were available on production inputs, energy in particular, for rolling billets and slabs into semi-finished and finished products. Production inputs of materials and energy into the process - from sponge iron production (direct reduction) to billet and slab production (smelting) - are summarised in Table 5.

**Table 5:**
**Material and Energy Inputs for Crude Steel Production - 1992.**

| Inputs | per tonne of steel |
|---|---|
| Iron ore pellets | 766 kg |
| Scrap steel | 528 kg |
| Ferro alloys | 12 kg |
| Limestone | 46 kg |
| Electrodes | 4 kg |
| Additives | 11 kg |
| Refactories | 24 kg |
| Electricity | 874 kWh |
| Natural gas | 673,361 $m^3$ |
| Oxygen | 0.55 $m^3$ |
| Nitrogen | 6.60 $m^3$ |
| Argon | 0.61 $m^3$ |
| Water | 5.57 $m^3$ |

Source: PT Krakatau Steel, pers. comm.

These estimates of inputs per tonne of steel production are for 1992 production technology. According to information obtained from interviews with staff, material inputs to the iron and steel production process have remained unchanged since 1985. However, there has been a 67

per cent reduction in the quantity of energy (natural gas) required for direct reduction of iron ore to sponge iron since 1985.

*Labor Requirements*

Detailed data on employment at PT Krakatau Steel for 1985 was not available, only an estimate of a total workforce of about 4,500 persons. By the end of 1992 total employment had doubled to 9,062 persons (Table 6). However, according to interviews with company staff, the educational composition of the workforce remained similar to that in 1985.

Based on the assumption that labour productivity has changed little between 1985 and 1992 (an assumption borne out by interviews with company staff), in 1985 5.31 person-years of labour were required to produce 1,000 tonnes of crude steel. By 1992 output had doubled over 1985 levels and staff numbers had also doubled, resulting in serious over-staffing, according to company officials.

**Table 6:**
**PT Krakatau Steel Employment by Educational Level - 1993.**

| Education | non-tech'l | tech'l | total |
|---|---|---|---|
| not completed elem. school | 11 | 0 | 11 |
| elementary school | 505 | 0 | 505 |
| junior high school | 833 | 322 | 1,155 |
| senior high school | 1,253 | 4,629 | 5,882 |
| diploma | 340 | 378 | 718 |
| university | 227 | 561 | 788 |
| post-graduate | 0 | 3 | 3 |
| Total | 3,169 | 5,893 | 9,062 |

Source: PT Krakatau Steel Pers. comm.

In the next few years, the company plans to approximately halve the size of the workforce, as part of its plans for increasing automation and use of computer-based control systems, and replace most un-skilled and semi-skilled workers with technical high school and college graduates. Assuming this goes ahead, it will result in a 50 per cent reduction (minimally) in labour inputs per unit of production. Labour saving technology is discussed in more detail below.

*Environmental Impacts*

There is only fragmentary information from a 1981 study available from the company on water pollution and no useful standardised information available on the air pollution impacts of this large iron and steel complex. More recent data collected and analysed for evaluating the environmental impacts of the iron and steel complex have yet to be made public.

Water requirements for iron and steel production have been estimated as 5,600 litres per tonne (Table 5). Little or no water remains to be discharged from the plant, as a result of rapid evaporation during production and rolling operations, according to company staff. Despite this assertion, the following data on discharge water quality were provided by the company (Table 7). We were unable to gain access to recent or complete environmentaal impact assessment documents, and this evaluation is based on fragmentary information provided by PT Krakatau, and a partial environmental impact assessemnt conducted by Padjadjaran University in 1982.

**Table 7:**
**Quality of Discharge Water from PT Krakatau Steel.**

| Parameter | Pollutant |
|---|---|
| BOD | 32 mg/l |
| COD | 68 mg/l |
| $CO_2$ | 28 mg/l |
| $HCO_3$ | 231 mg/l |
| pH | 7 |

Source: Padjadjaran 1983.

In addition to general water pollution, the waste water also contains heavy metal compounds (Table 8).

**Table 8:**
**Heavy Metal in Discharge Water from PT Krakatau Steel (mg/l).**

| Sample | Zn | Cd | Cr | Cu | Pb |
|---|---|---|---|---|---|
| 1 | <0.01 | nd | 0.0052 | 0.0286 | <0.03 |
| 2 | <0.01 | nd | 0.0052 | 0.0128 | <0.03 |

Notes: Units mg/l of waste water. nd = non detected; 1 = waste water from billet plant; 2 = waste water from sponge iron plant.
Source: Padjadjaran 1983, supplied by PT Krakatau Steel.

## Case Study 2: PT Budidharma

This mini-mill at Cilincing in the north east of the Jakarta metropolitan area has been in operation since 1972, and current production is about 130,000 tonnes/annum of steel reinforcing rod. The plant uses an electric arc furnace, continuous casting unit and semi-automated rolling mill. The bulk of its raw material input is scrap steel (150,000 t/annum, of which 100,000 t is imported from Holland), supplemented by pig iron (22,500 t/annum). In general, European and Japanese technology for electric arc furnaces, steel rolling and process control of 1970s vintage is employed.

*Material and Energy Requirements*

Pig iron, steel scrap and alloys are smelted in an electric arc furnace (using older Alternating Current rather than the newer Direct Current method) at about 1670oC. Oxygen is also added during smelting to reduce the carbon content of the melt and provide additional reaction energy for heating. The molten steel from the furnace is transferred by ladle directly to the four-strand continuous casting unit for casting billets. Table 9 provides details of the material and energy inputs required to produce one tonne of finished steel bar.

Billets are either taken directly into the rolling mill (after cooling) or stored for later processing (after reheating). The roughing and rolling mill can manufacture plain or deformed reinforcing bar in sizes from 12mm to 32mm.

**Table 9:**
**PT Budidharma Inputs to Steel Production and Processing.**

| Inputs | per tonne |
|---|---|
| *Raw Materials* | |
| Steel scrap | 1,150 kg |
| Pig iron | 170 kg |
| Ferro Alloys | |
| Si - Mn | 15.86 kg |
| Fe - Si | 0.99 kg |
| Fe - V | 0.12 kg |
| *Other Inputs* | |
| Oxygen | 27.1 $m^3$ |
| Calcium silicate | 0.06 kg |
| Carbon | 7.48 kg |
| Fluorspar | 1.02 kg |
| Burnt lime | 58.14 kg |
| Chromite sand | 0.20 kg |
| Silica sand | 11.57 kg |
| Water glass | 0.09 kg |
| Rice husks | 0.74 kg |
| *Energy Consumption* | |
| Electric furnace (electric) | 575 kWh |
| Rolling Mill (electric) | 40 kWh |
| LPG | 0.49 kg |
| IDO Furnace | 8.42 ltr |
| IDO Ladle | 1.33 ltr |
| Water input | 556 litres |

Notes: The plant operates 24-hours per day and 360 days/annum. Steel production is approximately 360 tonnes/day; all alloys and refractory materials are imported.
Source: PT Budidharma, pers.comm.

Company technical staff anticipate that electric energy consumption by the electric arc furnace could be reduced to about 400 kWh/t, by increasing the amount of oxygen injected during

smelting. Reducing energy consumption requires major investments in upgrading the smelting gas injection control system, which the company has not been will to make. According to company officials, a major replacement programme (amounting to almost a complete replacement of smelting and rolling equipment) would be required if the company aimed to achieve production efficiencies comparable to those current in the US, Europe or Japan. At present it is unclear whether the company plans such to make an investment of this scale at the present plant site.

*Labour Requirements*

The company currently employs 513 workers in their plant and head office in Cilincing. The approximate distribution of educational achievements for early 1993 is given in Table 10. According to their technical staff, the size and educational composition of the labour force has been stable since 1985. On this basis, and with an annual production of 130,000 tonnes, it requires 0.252 person-years to produce 1,000 tonnes of steel products; this is approximately one-twentith PT Krakatau's labour input per unit of steel production (5.31 person-years/1,000 t).

**Table 10:**
**PT Budidharma - Labour Force Educational Qualifications 1993.**

| | |
|---|---|
| Elementary school | 117 |
| Junior high school | 118 |
| Senior high school (general and vocational) | 250 |
| Academy/Polytechnic | 16 |
| University/Post-graduate | 12 |
| Total | 513 |

Source: PT Budidharma, pers. comm.

The explanation for this great differnce in labour requirements lies in the fact that PT Krakatau produces both sponge iron and steel products (and we were unable to obtain detailed data on the labour required for steel production only and is grossly over-staffed), while PT Budidharma only produces steel from recycled scrap (for which we have detailed data). Despite the apparent labour efficiency of PT Budidharma (in comparison to PT Krakatau) the company's technical staff are of the opinion that the labour force could be halved (with current technology) without affecting the quantity of output.

*Environmental Impacts*

Company technical staff claim that the company discharges no waste water, as all water evaporates during the production process or from settling ponds. The solid waste from the settling ponds, which are located within the factory boundary, is sold to the construction

industry as solid fill. Data on air pollution for early October 1992 was collected and analysed by a private environmental monitoring company (Table 11).

**Table 11:**
**PT Budidharma Air Pollution October 1992.**

| Parameter | Unit | Standard | Sample Location #94 | #95 | #96 |
|---|---|---|---|---|---|
| $SO_2$ | ug/m$^3$ (24 hrs) | 260 | 1.36 | 1.00 | 3.63 |
| CO | ug/m$^3$ (8 hrs) | 2,260 | 0.00 | 0.00 | 0.00 |
| NOx | ug/m$^3$ (24 hrs) | 92.50 | 2.82 | 0.29 | 6.42 |
| Dust | mg/m$^3$ (24 hrs) | 260 | 127.34 | 79.40 | 78.12 |
| Pb | ug/m$^3$ (24 hrs) | 60 | 0.81 | 5.04 | 7.63 |
| Fe | ug/m$^3$ (24 hrs) | | 16.00 | 3.01 | 8.02 |
| Cu | ug/m$^3$ (24 hrs) | | 1.07 | 0.00 | 0.00 |
| Zn | ug/m$^3$ (24 hrs) | | 5.04 | 0.00 | 0.00 |
| Cd | ug/m$^3$ (24 hrs) | | 3.47 | 0.00 | 2.11 |
| Ni | ug/m$^3$ (24 hrs) | | 0.00 | 0.00 | 0.00 |
| Si | ug/m$^3$ (24 hrs) | | 0.00 | 0.00 | 0.00 |
| Cr | ug/m$^3$ (24 hrs) | | 0.00 | 0.00 | 0.00 |

Notes: No.94: adjacent to furnace; No.95: about 100 m south of plant area; and No.96: about 100 m west of plant area.
Source: PT Consartha Indonesia, Jakarta.

The main source of air pollution, according to the company, is dust and combustion gases from the electric arc furnace. These are controlled by use of dust collecting equipment. The company is aware of the impact of dust and combustion gases on furnace worker's performance. Although the furnace was not in operation during a visit to the plant, the very minor build-up of dust in area surrounding the furnace suggests that their current dust control equipment is fairly effective.

**Summary of Technological Coefficients for 1985 and 2020**

The main changes expected in this sector are improvements in energy efficiency (some of which have already been achieved), reductions in labour requirements and a reduction in demand for water. As part of the government's overall energy strategy, there will be a shift from natural gas to coal as the main energy source for sponge iron production. Electricity from coal-fired generating plants (from PLN and/or own-generated) will remain the main source of energy for steel smelting at both PT Krakatau and mini-mills. The fragmentary data on water and air pollution provides no basis for making reliable estimates of reductions in environmental impacts.

Improvements in production technology will have interacting impacts on energy, and labour and raw materials requirements as follows:

1. *Energy Efficiency*: The adoption of the more efficient Correx direct reduction process by PT Krakatau for production of sponge iron. This will lead to major reductions in natural gas consumption per unit of production; and substitution of coal for natural gas.

2. *Energy and Labour requirements*: Reductions of electricity use in electric arc furnaces due to adoption of direct current smelting technology, and reductions in energy and labour use due to improvements in process control (smelting and rolling) from the adoption of computer-based control systems.

3. *Raw Materials and Energy*: There will be an increasing proportion of steel produced by mini-mills from recycled scrap steel (domestic and imported). This change will proportionately reduce the amount of iron ore (imported) required to meet total steel demand and reduce the amount of energy required per unit of production (recycling eliminates the energy-intensive iron-making step of production).

Reductions in labour requirements will result from a gradual improvement in the education level and skills of the workforce, coupled with the more widespread adoption of computer-based automation of production processes and control systems. The increasing proportion of steel produced by the more labour-efficient mini-mills will also result in a reduction in labour requirements.

Reductions in water use per unit of production will stem from the same sources: improved control of production processes and increasing importance of steel production coming from the more water-efficient mini-mills.

The technological coefficients for this sector for 1985 and 2020, based on the foregoing assumptions and estimations, are presented below in Table 12. Figures for 2020 are expressed as percentage changes on the 1985 coefficients.

**Table 12:**
**Changes in Technological Coefficients for Iron and Steel.**

| | | 2020 |
|---|---|---|
| **A MATRIX** | | |
| 7 | Coal | +50 |
| 19 | LNG | -75 |
| 20 | Electricity | -30 |
| **L MATRIX** | | |
| Total employment per unit output | | -50 |
| **B MATRIX** | | |
| Total new capital requirements | | 0 |
| 17 | Other manufacturing | 0 |
| 23 | Construction | 0 |

**N MATRIX**

| | Units | 1985 level | S1 |
|---|---|---|---|
| *Water pollution* | | | |
| Water input/output | l/t | 560 | -50 |
| Water output/output | l/t | 190 | -50 |
| BOD | mg/l | 32 | |
| COD | mg/l | 69 | |
| Chrome | mg/l | .0052 | |
| Lead | mg/l | .0300 | |
| *Air pollution* | | | |
| Dust | $mg/m^3$ | 80 | -90 |

**References**

BPS 1989 Tabel Input-Output Indonesia 1985, Volume 1. BPS, Jakarta.

Data Consult 1992 IndoCommercial Newsletter. No.101, 1 June 1992, Jakarta

Padjadjaran 1983 Analisi Dampak Lingkungan Rencana Pengembangan Daerah PT Krakatau Steel, Ciligon. Universitas Padjadjaran, Bandung, Mei 1983.

**Annex 1:**
**Intermediate Inputs to Basic Iron and Steel Production - 1985.**

| Description | # | M Rp | % |
|---|---|---|---|
| Basic iron and steel | 45 | 173138 | 37.87 |
| Unspecified sector | 66 | 47518 | 10.39 |
| Chemicals | 40 | 34746 | 7.60 |
| Electricity, gas and water supply | 51 | 33313 | 7.29 |
| Trade | 53 | 30577 | 6.69 |
| Petroleum refinery | 41 | 23875 | 5.22 |
| Machine, electrical machinery | 48 | 20905 | 4.57 |
| Road transport | 56 | 17005 | 3.72 |
| Restaurant and hotel | 54 | 15107 | 3.30 |
| Financial intermediaries | 61 | 14250 | 3.12 |
| Fabricated metal product | 47 | 11600 | 2.54 |
| Nonferrous basic metal | 46 | 5076 | 1.11 |
| Service allied to transport | 59 | 5078 | 1.11 |
| Communication | 60 | 3409 | 0.75 |
| Other products nec | 50 | 3385 | 0.74 |
| Other services | 65 | 2697 | 0.59 |
| Other mining and quarrying | 26 | 2203 | 0.48 |
| Nonmetalic mineral product | 43 | 2062 | 0.45 |
| Construction | 52 | 2015 | 0.44 |
| Water transport | 57 | 1873 | 0.41 |
| Rubber and plastic wares | 42 | 1625 | 0.36 |
| Real estate and business service | 62 | 1128 | 0.25 |
| Coal and metal ore mining | 24 | 945 | 0.21 |
| Fertilizer and pestiside | 39 | 820 | 0.18 |
| Cement and limestone | 44 | 683 | 0.15 |
| Railway transport | 55 | 652 | 0.14 |
| Air transport | 58 | 647 | 0.14 |
| Paper, paper products and cardboard | 38 | 510 | 0.11 |
| Social and community services | 64 | 225 | 0.05 |
| Textile, leather and wearing apparel | 36 | 126 | 0.03 |
| Wood, bamboo and rattan products | 37 | 14 | 0.00 |
| Total | 457187 | | 100.00 |

Source: NRMDP-IEA 75-sector Input-Output Table for 1985.

**Annex 2:**
**Sectors Using Basic Iron and Steel Sector Output -1985.**

| Description | # | M Rp | % |
|---|---|---|---|
| Construction | 52 | 823449 | 58.02 |
| Fabricated metal products | 47 | 238991 | 16.84 |
| Basic iron and steel | 45 | 173138 | 12.20 |
| Transport equipment and its repair | 49 | 113266 | 7.98 |
| Machine, electrical machinery | 48 | 33142 | 2.33 |
| Other services | 65 | 17555 | 1.24 |
| Nonferrous basic metal | 46 | 11561 | 0.81 |
| Petroleum refinery | 41 | 2075 | 0.15 |
| Crude oil and natural gas mining | 25 | 1856 | 0.13 |
| Other products not elsewhere classified | 50 | 1725 | 0.12 |
| Nonmetalic mineral product | 43 | 1216 | 0.09 |
| Wood, bamboo and rattan products | 37 | 927 | 0.07 |
| Rubber and plastic wares | 42 | 174 | 0.01 |
| Textile, leather and wearing apparel | 36 | 152 | 0.01 |
| Paper, paper product and cardboard | 38 | 81 | 0.01 |
| Chemicals | 40 | 50 | 0.00 |
| Railway transport | 55 | 1 | 0.00 |
| Total | 1419359 | | 100.00 |

Source: NRMDP-IEA 75-sector Input-Output Table for 1985.