# Evaluation of Eco-efficiency of Iron and Steel Industries in Nepal

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## ABSTRACT

This paper presents the eco-efficiency of energy intensity, material consumption, water use, waste generation, and $CO_2$ emission in terms of production sales value in (US$) per environmental influences. Many iron and steel industries have been significantly contributing to Nepal by manufacturing infrastructural products as well as also imposing a burden on the environment [1]. The concept of evaluating eco-efficiency and its application [2] is not still implemented, thereby loosing the opportunity of creating more value with fewer resources and less possible environmental impact [3]. A case study on eco-efficiency evaluation of Rajesh Metal Crafts Limited, Jeetpur, manufacturing Black and GI pipes (herein after called iron pipe industry) located at Bara district in southern part of Nepal, have been carried out [1]. This study evaluated eco-efficiency of energy intensity, material consumption, water use, waste generation, and $CO_2$ [4] emission using provision of eco-efficiency indicators empirically, considering only production process boundary of this industry [5] [6]. Evaluation of eco-efficiency tried to couple the economic and environmental influences [7] of industry in terms of both physical unit (mass production per environmental influences) as well as economic unit (sales value of production per environmental influences) to know economic and environmental excellence [8]. Eco-efficiency of iron pipe industry was quantitatively analyzed that determined the energy, material (only in unit of T/T), and $CO_2$ emission eco-efficiency trends were decreasing. However, eco-efficiency of material consumption (only in unit of US$/T), water use, and waste generation trends have been increased gradually as production increased during analysis of eco-efficiency for past five years from 2001 to 2005.

**Results**

Quantitative analysis confirmed the overall existing situation of iron pipe industry that helps to substitute prevailing practices of traditional technologies, working standards, and guide to lessen environmental influences through improving present know how and processes. The analyzed results provide tangible feedback to decision level to formulate better option for wise utilization of energy, material, and water with less possible waste and $CO_2$ emission to ensure sustainability in industrial ecology of this industry [8]. It is recommended that evaluation of eco-efficiency should be implemented in other industries. It is high time to augment the concept of eco-efficiency in existing industrial policy and to link existing relevant legislation in Nepal [1].

Comparison of eco-efficiency of each year of iron pipe industry indicated that energy and $CO_2$ emission eco-efficiency trends in terms of economic unit were different and uneven despite trying hard to increase these trends during the same period. This study has considered $CO_2$ emission from utilization of purchased electrical energy in the industry [7] including $CO_2$ emission from fuel consumptions. Evaluations of $CO_2$ emission have been carried out in accordance with $CO_2$ emission conversion factors concerned with electricity as well as fuel oils from UNCTAD, 2004 [9] and IPCC, 1996b [10]. This evaluation provided feedbacks to lower the energy, material, water intensity in addition to waste and $CO_2$ emission by improving necessary means to increase the

overall eco-efficiency of iron pipe industry and extending the access to live in a pleasant and sound environment to the entire population [11].

**Table 1: Eco-efficiency of Iron Pipe Industry, Comparison, and Their Percentage Change within Consecutive Years**

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | Comparison of Eco-efficiency Between (2001 & 2005 only) |
|---|---|---|---|---|---|---|
| Production Net Sales (US$ per year) (a) | $ 8660864 | $ 9415973 | $ 9047947 | $ 8263638 | $ 11631044 | |
| Energy Consumption (GJ) (b) | 7719 GJ | 13826 GJ | 12132 GJ | 7842 GJ | 14513 GJ | |
| Energy Eco-efficiency ($/GJ) (a/b) | 1112 US$/ GJ | 681 US$/ GJ | 746 US$/ GJ | 1054 US$/ GJ | 801 US$/ GJ | |
| Comparison Of Eco-efficiency | - | (2001-2002) - 39 % (?) | (2002-2003) 9.5 % (?) | (2003-2004) 41 % (?) | (2004-2005) - 24 % (?) | (2001-2005) - 28 % (?) |
| Material Consumption (T) (c) | 23086 T | 23771 T | 19021 T | 11834 T | 18000 T | |
| Material Eco-efficiency ($/T) (a/c) | 375 US$/T | 396 US$/T | 475 US$/T | 698 US$/T | 646 US$/T | |
| Comparison of Eco-efficiency | - | (2001-2002) 5.6 % (?) | (2002-2003) 20 % (?) | (2003-2004) 47 % (?) | (2004-2005) - 7.45 % (?) | (2001-2005) 72.26 % (?) |
| Water Consumption ($m^3$) (d) | 1911 $m^3$ | 1815 $m^3$ | 1365 $m^3$ | 792 $m^3$ | 861 $m^3$ | |
| Water Eco-efficiency ($/ $m^3$) (a/d) | 4532 US$/ $m^3$ | 5188 US$/ $m^3$ | 6628 US$/ $m^3$ | 10434 US$/ $m^3$ | 13509 US$/ $m^3$ | |
| Comparison of Eco-efficiency | - | (2001-2002) 14.47 % (?) | (2002-2003) 27.75 % (?) | (2003-2004) 57.42 % (?) | (2004-2005) 29.47 % (?) | (2001-2005) 198 % (?) |
| Waste Generation (T) (e) | 795.4 T | 675.4 T | 498 T | 294 T | 422.18 T | |
| Waste Eco-efficiency ($/T) (a/e) | 10889 US$/T | 13941 US$/T | 18168 US$/T | 28108 US$/T | 27550 US$/T | |
| Comparison of Eco-efficiency | - | (2001-2002) 28 % (?) | (2002-2003) 30 % (?) | (2003-2004) 54.71 % (?) | (2004-2005) - 2 % (?) | (2001-2005) 153 % (?) |
| $CO_2$ Emission (T $CO_2$ eq.) (f) | 279 T $CO_2$ eq. | 749 T $CO_2$ eq. | 689 T $CO_2$ eq. | 453 T $CO_2$ eq. | 890 T $CO_2$ eq. | |
| $CO_2$Emission Eco-efficiency $/T $CO_2$ (a/f) | 31042 US$/$CO_2$ | 12571 US$/T $CO_2$ eq. | 13132 US$/T $CO_2$ eq. | 18242 US$/T $CO_2$ eq. | 13068 US$/T $CO_2$ eq. | |
| Comparison of Eco-efficiency | - | (2001-2002) - 59.5 % (?) | (2002-2003) 4.46 % (?) | (2003-2004) 39 % (?) | (2004-2005) - 28.36 % (?) | (2001-2005) - 58 % (?) |

(?)(?) Signs Indicate Increasing and Decreasing

**Eco-efficiency of Different Indicators in Economic Term**

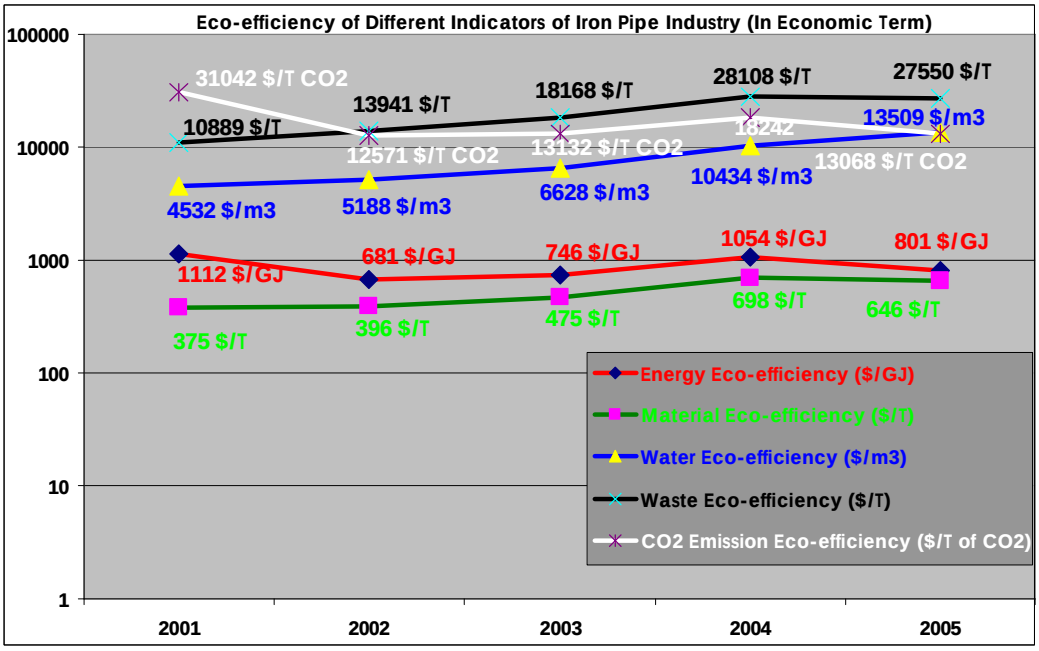


**Figure 1**: Eco-efficiency of Different Indicators in Economic Term ($/Environmental Influences) and itsTrend from 2001 to 2005

**Eco-efficiency of Different Indicators in Physical Unit**

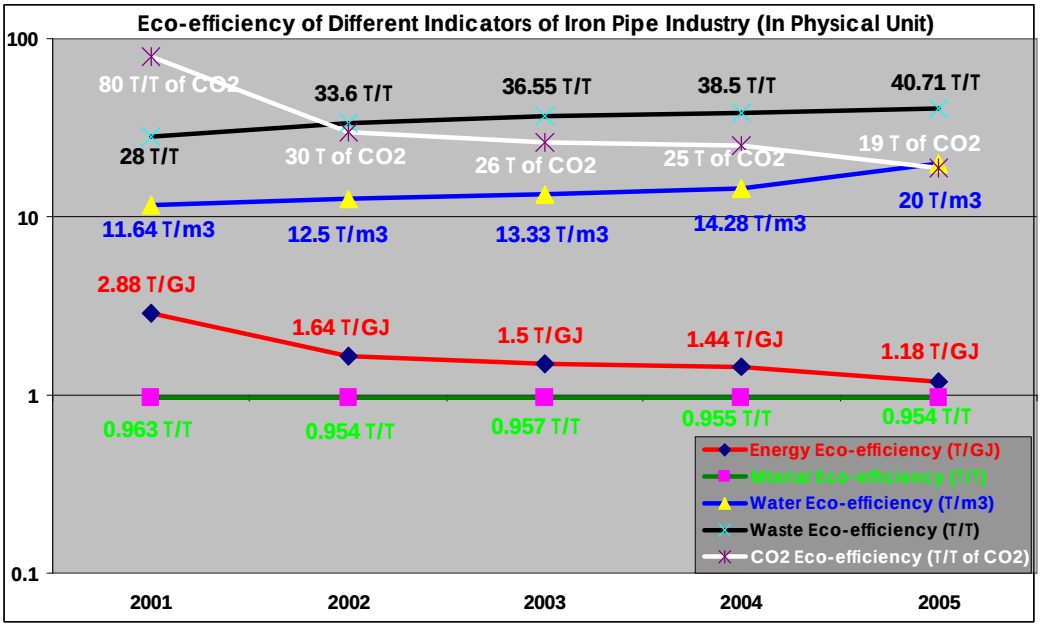


**Figure 2**: Eco-efficiency of Different Indicators in Physical Unit (T/Environmental Influences) and itsTrend from 2001 to 2005

**Stimulating Finding**

Consequent to the evaluation of eco-efficiency of different indicators (energy, material, water, waste, and $CO_2$ emission), this study has stimulated both factory owner and government to formulate $CO_2$ emission inventory of industries. This would be supporting component of Kyoto Protocol, 1997 [4], if industry can record $CO_2$ emission each year voluntarily that subsequently helps to curtail $CO_2$ emission of industry in future. Governments of developing countries can constitute $CO_2$ Emission Inventory Board and initiate either Carbon Tax Policy beyond the certain limit of emission or Emission Trading among industries. Board can fix exemption up to a certain limit of $CO_2$ emission and beyond this limit industry would be levied Carbon Tax. Thus, industry would be encouraged to maintain the tax exemption quantity of $CO_2$ emission, if government brings the policy of carbon-tax in future [1].

**Conclusion**

This study is useful moreover in applying tool of eco-efficiency that integrates ecological and economic excellence of industry from analysis to implementation. Comparison of each year eco-efficiency gives sparkling idea to design innovative products and processes including reducing the input of resources and emissions to management level. Curbing to greater extent of degradation on environment, reducing energy and resources consumption for manufacturing production enhances life cycle management with making complete loop of reducing, reusing, and recycling of waste released. This study is justified to contribute towards eco-innovation and exploring further improvements as well as environment. Thus, eco-efficiency is integrated environmental management strategy and subset of sustainable development that ensure the sustainability in industrial ecology. As a general statement of overall comparison and characterization of eco-efficiencies of five years duration, iron pipe industry was appreciably improving its eco-efficiencies of all parameters.

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