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An Integrated Carbon Accounting and Mitigation Framework for Greening the Industry

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Abstract

Greenhouse gases (GHG) emission from industry is one of the potent contributors to the global warming. In industry, the source of carbon emissions related to an industry premise can be categorized into two major types, i.e., direct carbon emission source related to the on-site carbon emission, for instance the emission due to fuel combustion within the premises itself and indirect carbon emission source that is related to the carbon emission at external premises, due to the resource consumption within the business premises. For instance, electricity, fuel consumption, water consumption, solid waste and waste water will lead to the carbon emission at the power plant, due to the power generation requirement to treat and handle these resource and waste. Therefore, all these five main criteria, i.e., electricity, fuel consumption, water consumption, solid waste and waste water will be selected as carbon performance indicators (CPI). In this study, an integrated carbon accounting and mitigation (INCAM) framework is developed and may serve twofold purposes, tracking of emission in onsite specific area and identify potential emissions reduction strategy in a holistic manner. The systematic steps to develop INCAM includes (1) Define carbon accounting centre (CAC) (2) Establish carbon emission indicators (CEI) for each CAC and CPI (3) Identify the hot spot for each CAC (4) Propose emission reduction strategies and rank emission mitigation measures according to cost effectiveness. INCAM provides relevant information that makes carbon profiling visible to various levels of an organization, enabling industry to plan, make decisions and take effective action to reduce emission towards greening the industry.

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Keywords: carbon accounting, carbon profiling, carbon emissions, green industry cost effectiveness

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1. Introduction

There are several green industry definitions from different point of view. According to UNIDO (United Nations Industrial Development Organization [1], green industry can be defined as economies striving for sustainable pathway improvement, undertaking green public investments, implementing public policy initiatives that encourage environmentally responsible private investments. In other definition, green industry in a view of green energy is defined as clean energy with high environmental protection and free of pollution. The process of energy production and consumption are also free or less of pollution. In other explanation, the green energy can be naturally produced with almost free pollution [2]. The implemented of green industry continuously enhance the environmental performance of all industries regardless of sector, size or even location. The economic profit is not the main issue regarding the implementation of green industry but more to the sustainable development of the enterprise in the future. In addition, green industry implementation will improve the condition of the environment, promotes economic development stability, create more jobs to the community, energy reliability and human wellbeing [3]. Presently, there are various types of techniques or tools used for environmental performance assessment in various types of greening activities but integrated framework to quantify the level of green industry performance that include five main emission contributors in electricity, fuel consumption, water consumption, solid waste and waste water is not available. The green house gas (GHG) Protocol is the closest to a global standard for emissions measurement and disclosure, while industry-specific guidelines from the American Petroleum Institute (API) provide details on measurement and statistical calculation methods relevant for oil and gas industry. In the absence of systematic framework for carbon accounting and reporting, industry interprets differently. The industries have to determine what to include and how to define the emissions, including the boundaries for carbon accounting. In this study, systematic framework for carbon accounting and mitigation (INCAM) is established to enable comparison of carbon performance indicators (CPI), carbon accounting centre (CAC), industry to industry and against appropriate benchmarks It is envisaged that by using this tool, the industry can quantify the carbon emission, monitor carbon emission profiling and take effective action to reduce emission of its premises.

2.0 Methodology

The key component of carbon accounting is the determination of carbon performance indicators. In this study, five main emissions contributors in industry includes electricity, fuel consumption, water consumption, solid waste and waste water are selected as CPI. The systematic methodology includes (1) defining Carbon Accounting Centre (CAC), where the premise and process is divided into smaller scoping unit for monitoring. (2) Carbon checklist is the developed to identify carbon emission sources for each activity in each CAC and perform the plant audit. This is important to prepare relevant documents for data collection as well as method to quantify indirect CO_2 emission. (3) In this step, carbon emission index (CEI) for each CPI and CAC will be established, by using the emission factor to calculate carbon emissions from all the predetermined sources. The hotspot for CPI as well as CAC is determined by the highest Carbon Emission Profile (%) of each CEC. (4) After that, the options screening for carbon emission reduction strategy will be identified. The later stage involved carbon monitoring and targeting (CMT) and carbon mitigation to reduce emission.

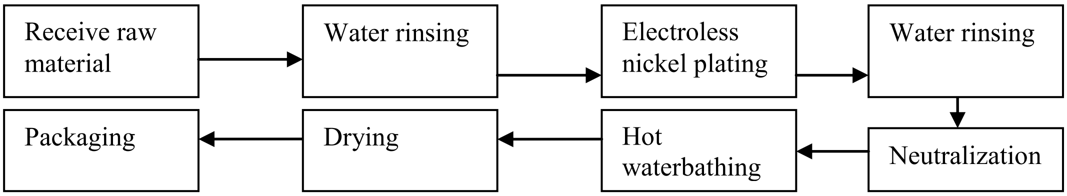
3.0 Case study

The effectiveness of INCAM methodology is demonstrated on Innovalues Precision Sdn. Bhd. case study. This company was located at Pasir Gudang Johor, Malaysia. Innovalues Precision Sdn. Bhd. specialises in the manufacture of customised precision machine parts and components. These include printer rollers, mechanical devices, rubber compounding and moulding services as well as surface treatment services. The production output for the company is 10,261 t/mth. The products are mainly surface treatment services such as electroless nickel plating, zinc phosphating and hard anodizing which used in automotive, office automation equipment and oil and gas industries.

3.1 Process description

Nickel electroplating is a process of depositing nickel on a metal part. Parts to be plated must be clean and free of dirt, corrosion and defects before plating can begin. To clean and protect the part during the plating process water rinsing technique is apply. Once the piece has been prepared it is immersed into an electrolyte solution and is used as the cathode. The nickel anode is dissolved into the electrolyte in form of nickel ions. The ions travel through the solution and deposit on the cathode. After that, the part will be once rinse to remove residue before go to neutralization process. Finally, the parts will undergo the hot water bathing process and drying process in the dryer. Finally, they will be sent to packaging department before distributed to the customer.

Process flow diagram :



3.2 Assessment of Carbon in Innovalues Precision Sdn. Bhd.

STEP 1: Define Carbon Accounting Centre (CAC)

For this case study, 2 breakdowns CAC is created, CAC1 represents the process production comprises of 4 sub CACs and CAC 2 represents warehouse, comprises of 3 sub CACs.

STEP 2: Develop Carbon Checklist and Perform Plant Audit

In this step, sources of emissions in each CAC will be identified as shown in Table 1. To gather the relevant information, the audit process had been done involves site visit to the plant and data collections. The data collections were based on utility bills, procurement reports and domestic waste reports. Meanwhile, monthly consumption/generation of 5 CPI is gathered as shown in Table 2 for emission analysis in the next step.

Table 1. Carbon Checklist for Innovalues Precision Sdn. Bhd.

Carbon performance indicators (CPI)	CAC1 Production				CAC2 Warehouse		
	Water rinsing	Acid	Forklift	Heat	Forklift	Air Conditioner	Document
Electricity				√		√	
Fuel consumption			√		√		
Water consumption	√						
Solid waste							√
Waste water	√						

Table 2. Monthly consumption/generation for each CAC

Carbon performance indicators (CPI)	Emission Factor (CO_2e/unit) [4]	Monthly consumption/generation						
		CAC1 Process Production				CAC2 Warehouse		
		Water rinsing	Acid	Forklift	Heating	Forklift	Air Condition	Document
Electricity	11700	0	0	0	37,129 kWh	0	30,000 kWh	0
Fuel consumption (Diesel)	1670	0	0	835 litre		835 litre	0	0
Water consumption	300	3,997 m^3	0	0	0	0	0	0
Solid waste	700	0		0	0	0	0	700 kg
Waste water	1670	200 m^3	0	0	0	0	0	0

STEP 3 : Establish Carbon Emission Index (CEI) and identify hotspot

Details data for CPI for each subsection in CAC1 and CAC2 is shown in Table 3 and Table 4. From Table 3, the highest total monthly CO_2e (tCO2e) for the CAC which is the heating process in the production area is identified as the hotspot.

The Monthly Carbon Emission Equivalent (tCO_2e) is determined by multiplying monthly consumption/generation of each CAC with the emission factor of each CPI. The Carbon Emission Profile (%) is calculated by divided the total monthly CO_2e (tCO_2e) of each CAC with total monthly CO_2e (tCO_2e) of each CPI and multiply by 100%. The Carbon Emission Index for each CAC is determined by dividing total monthly CO_2e (tCO_2e) for each CAC with total production amount (t) for a month and multiply by 100%.

Table 3. Carbon Emission Profile (%) and CEI for Each CEC

Carbon performance indicators (CPI)	Monthly carbon emission equivalent (t CO_2e)						
	CAC1 Production				CAC2 Warehouse		
	Water rinsing	Acid	Forklift	Heating	Forklift	Air Condition	Document
Electricity	0	0	0	4.34×10^8	0	3.51×10^8	0
Fuel consumption (Diesel)	0	0	1.39×10^6	0	1.39×10^6	00	0
Water consumption	1.19×10^6	0	0	0	0	0	0
Solid waste	0	0	0	0	0	0	4.90×10^5
Waste water	3.34×10^5	0	0	0	0	0	0
Total monthly CO_2e (tCO_2e)	$1.53 X 10^6$	0	1.39×10^6	4.34×10^8	1.30×10^6	$3.5 0x 10^8$	4.90×10^5
Carbon Emission Profile (%)	0.19	0	0.18	54.97	0.18	44.42	0.06
CEI for CAC (tCO_2e)	149.41	0	135.90	4.23×10^4	135.90	3.42×10^4	47.75

Table 4. Total Monthly CO_2e and CEI for CPI

Carbon performance indicators (CPI)	Total monthly CO_2e (t CO_2e)	Carbon Emission Profile (%)	CEI for CPI (t CO_2/ t product)
Electricity	7.80×10^8	99.39	7.60×10^4
Fuel consumption (Diesel)	2.79×10^6	0.35	272.00
Water consumption	1.19×10^6	0.15	117.00
Solid waste	4.90×10^5	0.06	48.00
Waste water	3.34×10^5	0.04	33.00
Total monthly CO_2e (t CO_2e)	7.90×10^8		

STEP 4: Options Screening for Carbon Emission Reduction Strategy

It was found that significantly emission in Innovalues Precision Sdn. Bhd. was contributed by electricity usage due to heating process and air conditioning unit. Therefore in order to reduce the energy consumption, implementation of higher efficiency heating tools that require less energy with better heating performance is recommended as mentioned in Table 5. The other alternative will be replacement of inverter type air conditioning unit. As for forklift, emission reduction can be achieved by switching the diesel type of forklift to the natural gas forklift. In addition, effort to reduce waste water usage can done by reuse the rinse water. By adopting this method, the usage of fresh water can be reduce significantly. Details data for CPI for each subsection in CAC1 and CAC2 after reduction strategy implementation is shown in Table 6 and Table 7. Substantial CO_2 emission reduction is achieved up to 20.3%.

Table 5. Carbon Emission Reduction Strategy and CPI Reduction Percentage

CPI	CAC	Emission reduction strategy	CPI reduction percentage [4]
Electricity	Heating process of CAC 1	High efficiency equipment	20%
Fuel consumption (Natural Gas)	Forklift usage of CAC1 and CAC2	Natural gas powered forklift	99%
Water consumption	Water rinsing activities of CAC1	Recycle water for rinsing activities	25%
Solid waste	Warehouse documentation waste of CAC2	Implementating reduce, reuse and recycle activities	20%
Waste water	Waste water generated from water rinsing of CAC1	Recycle water for rinsing activities	25%

Table 6. Carbon Emission Profile (%) and CEI for Each CEC After Reduction Strategy Implementation

Carbon performance indicators (CPI)	Emission Factor (CO2e/unit)	Monthly carbon emission equivalent (t CO_2e)						
		CAC1Production				CAC2Warehouse		
		Water rinsing	Acid	Forklift	Heating	Forklift	Air Conditioner	Document
Electricity	11700	0	0	0	3.47×10^8	0	2.24×10^8	0
Fuel consumption (Natural Gas)	1.92	0	0	1603	0	1603	00	0
Water consumption	300	8.99×10^5	0	0	0	0	0	0
Solid waste	700	0	0	0	0	0	0	3.92×10^5
Waste water	1670	2.50×0^5	0	0	0	0	0	0
Total monthly CO_2e (t CO_2e)		1.14×10^6	0	1603	3.47×10^8	1603	2.80×10^8	3.92×10^5
Carbon Emission Profile (%)		0.198	0	0	55.17	0	44.58	0.06
CEI for CAC (tCO_2e)		112.06	0	0.16	3.38×10^4	0.16	2.73×10^4	38.20

Table 7. Total Monthly CO_2e and CEI for CPI After Reduction Strategy Implementation

Carbon performance indicators (CPI)	Total monthly CO_2e (tCO_2e)	Carbon Emission Profile (%)	CEI for CPI (t CO_2/ t product)
Electricity	6.28×10^8	99.75	6.12×10^4
Fuel consumption (Natural Gas)	3206	0	0
Water consumption	8.99×10^6	0.14	88
Solid waste	3.920×10^5	0.06	38
Waste water	2.50×10^5	0.04	24
Total monthly CO_2e (tCO_2e)	6.29×10^8		

5.0 Conclusions and Recommendations

In this study, new carbon accounting and mitigation method known as INCAM has been developed and demonstrated to Innovalues Precision Sdn. Bhd case study. Application of this method revealed that the industry can successfully reduce their expenses on the electricity and water consumption and contribute for 20.3% of CO_2 emissions reduction simultaneously. However, the analysis of economic is will be discuss in upcoming journal. Energy efficiency is an example where value is already created within the existing commercial environment for consumers and businesses, providing cash flows that can make these investments attractive.In addition, the industry CEI can be reduce significantly and help to promote low carbon activities and reduce carbon footprints in industry.

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Biography

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