Streamlining the Green House Gases Reporting using Matlab
For Aluminium Smelter

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Dissertation submitted to HBMeU in partial fulfillment of the requirements for the degree of Master of Sciences: Excellence in Environmental Management program

Fall_2013
I have read the HBMeU regulations relating to plagiarism and certify that this dissertation is all my own work and do not contain any unacknowledged work from any other sources.

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Abstract

Environmental reporting has moved very fast in the last decade. Large corporations report their performances on a more frequent basis, looking to enhance and showcase their performance using different tools to stay up to date with changes internally and globally.

Optimization of the reporting process through minimizing time and manpower is the aim of this research. Performance Reporting is considered a key process to ensure the compliance with legal requirements or even going further to benchmarking. Streamlining any report is a means to eliminate time and resource wastages or to make the report process a lean process, and using software such as Matlab is an option considering that there is other software available in the market which can be customized to meet simpler environmental reporting systems, but when it comes to a complex site with a huge database, Matlab is recommended. DUBAL environmental database was built on excel sheets making data processing more challenging due to the huge number of variables. This paper looks at the application of using Matlab as reporting software.

The application of Matlab in reporting is negligible and even in the reporting of Aluminum smelter environmental performance, since it is more commonly used for engineering designs. However, it is a powerful tool for computing, simulation, and graphical design for dynamic and embedded systems.

Keywords: Environmental reporting, Matlab, GHG reporting, ISO14001, DUBAL.
Acknowledgements

This thesis is the end of my journey in obtaining my Master’s degree and the new beginning for my next phase. This thesis has been completed with the support and encouragement of many people including my family, my friends, colleagues, HBMeU and Dubai Aluminium (DUBAL). At the end of my thesis I would like to thank all those people who made this thesis possible and it is pleasant to express my thanks to all of them who had contributed in many ways to make this study a successful journey.

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Special thanks to e-School of Health and Environmental Studies for providing such an interesting master’s program here in Dubai for us. Finally, I would like to thank Dubai Aluminium top management for approving the DUBAL environmental monthly report as a case for this study as well as for their understanding and support throughout my studies.

Muna A. Alamoodi
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1. Introduction

A great deal of time and money is spent on the activities and systems involved in collecting and analyzing data, yet there remain a lack of satisfaction from the end user. As increasing reliance is placed on data analysis tools and assessment systems, the need to demonstrate that the underlying data is reliable has become more critical in the decision making process.

DUBAL's environmental database was built using Microsoft Excel software which makes data processing more challenging; as the amount of data is enormous in order to produce the comprehensive report that DUBAL management is looking for without any errors and within the time limit. More data means better analysis, which leads to more confident decision making.

1.1 Scope of the Study

DUBAL was established in 1979, under the leadership of H. H Sheikh Rashid Bin Saeed Al Maktoum, the late ruler of Dubai. Dubai Aluminium ("DUBAL") owns and operates one of the world's largest Aluminium smelters. Built on a 480-hectare site in Jebel Ali, the complex's major facilities comprise a one million metric ton per year primary aluminium smelter, a 2,350 megawatt power station (at 30°C), a large carbon plant, casting operations with a capability of more than 1,276,000 metric tons per year, a 30 million gallon per day seawater desalination plant, laboratories, and port and storage facilities. Figure 1: Aluminum Smelting Process At DUBAL
The smelter produces ingots, billet, and high purity Aluminium, which is the major supplier to the automotive industry, construction markets, and electronics industry. The company is certified with ISO 9001, ISO/TS 16949, ISO/IEC 27001, ISO/IEC 20000, ISO 14001, and OHSAS 18001. DUBAL currently employs around 4,000 skilled operators, administrative staff, technicians, professionals, and managers, collectively representing 15 different nationalities.

The environment is an important aspect of business at DUBAL. The company plays a major role in protecting and sustaining the environment. Systems and procedures are in place to ensure proper control and mitigation plans of the company's environmental impact. DUBAL management is well aware of the inherently large environmental footprint associated with the production of primary aluminium. The company is always seeking to enhance production performance, increase process efficiency, and improve environmental performances, which include the environmental reporting as well. DUBAL's environmental monthly report contains the following sections:

1. Executive Summary
2. Environmental Initiatives
3. Environmental Performance:

Figure 1: Aluminium Smelting Process At DUBAL
a. Air: Fluorides, Oxides of Nitrogen (NOx), Sulphur Dioxide (SO$_2$) and Greenhouse Gas Emission (CO$_{2eq}$)
b. Solid Waste and Recycling: Solid Waste Disposal, Spent Pot Liner (SPL) Disposal and Dross Generation
c. Waste Water: Water Quality
d. Raw Materials Consumption: Anode Carbon Consumption, Aluminium Tri-Fluoride Consumption and Site Water Consumption

The environment report is generated on the tenth working day following the reporting structure that was described earlier. The process started with data collection since the report parameter is well defined as a part of the Environmental Management system ISO 14001 requirement. Environmental Management Systems provide a solid foundation for environmental reporting because it defines what shall be considered a significant aspect or pollutant that the company shall keep an eye on and regularly monitor and control. The report is released to top management via email and it's also available to all employees on DUBAL's intranet in Portable Document Format (PDF).

Most of the environmental raw data comes from operational areas, as they are responsible for monitoring their environmental aspects. The areas issues a monthly report of their performance in excel format or other formats which are then shared with the Environment department. The environment team is responsible for collecting the performance data of each area and issuing a complete report about the site’s environmental performance.

The environmental report is one of the important references that will be used by the top management to make business decisions. Managing and reporting environmental performance can lead to significant business benefits as well as benefits for the environment, for example by saving resources and cutting costs. Preparation of the monthly environmental report requires three to four days of data collection and two days of calculation/verification, so the report is usually ready by the tenth working day of the month or later, as it depends on data availability.
DUBAL operates five major operational areas which have different processes, inputs, and outputs. The five different operational areas considered in the Environmental performance report are: Power Station, Desalination plant, Reduction Material, Potrooms and Casthouse. The last three areas are also known as the Smelter. Green House Gas (GHG) was selected as a case study for this paper, and an example of the GHG emissions data is displayed in Table (1): Raw Data of Total GHG Emissions. With such complex sites, the number of variables or reported parameters, or area’s environmental KPI is enormous as we can see in the GHG table (in area level not units), over 30 variables to report total site GHG emissions and that is only one aspect of the report.

Table (1): Raw data of total Green House Gas (GHG) Emission

<table>
<thead>
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<th>Area</th>
<th>Raw Data (variable)</th>
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<tr>
<td>Potline</td>
<td>Hot Metal Production</td>
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<tr>
<td>Potline</td>
<td>Anode Effect Frequency</td>
</tr>
<tr>
<td>Potline</td>
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<td>Potline</td>
<td>Net Carbon Consumption</td>
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<td>Reduction Material</td>
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<td>Reduction Material</td>
<td>Green Anode Weight</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Baked Anode Weight</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>No. of Baked Anodes Supplied</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Pitch In Green Anode</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Tar Emission KFTP</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Total Purchased Anodes Supplied To Potrooms</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>No. of Baked Anodes Rejected</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>H₂ In Pitch</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Petroleum Coke</td>
</tr>
<tr>
<td>Reduction Material</td>
<td>Baked Anode Production</td>
</tr>
<tr>
<td>Potline</td>
<td>Soda Ash Consumption (Plant)</td>
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<td>Potline</td>
<td>Purity Soda Ash</td>
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<td>Reduction Material</td>
<td>Resister Coke Consumption</td>
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<tr>
<td>Potline</td>
<td>Number of Pots Bathed-Up</td>
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<td>Reduction Material</td>
<td>Petroleum Coke Sulphur</td>
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<td>Reduction Material</td>
<td>Petroleum Coke Ash</td>
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<tr>
<td>Power</td>
<td>Nat Gas fuel (Power)</td>
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<tr>
<td>Power</td>
<td>Gross Cal Value of Nat Gas</td>
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<td>Power</td>
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<td>Power</td>
<td>Nat Gas fuel (Smelter)</td>
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<tr>
<td>Power</td>
<td>Gross Cal Value of Nat Gas</td>
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The ISO 14001, which is the EMS adopted by DUBAL since 1999, has been designed with the Plan-Do-Check-Act (PDCA) cycle which underlies all ISO management systems standards. The explanation of the Plan-Do-Check-Act (PDCA) cycle is based on the operating principle of ISO’s management system standards for the environment (ISO 14000) and quality (ISO 9000), illustration in Figure 2:

1. Plan – establish policy, objectives, target and make plans,
2. Do – implement your plans (Plan execution),
3. Check – measure your results or the progress (measure/monitor) and
4. Act – correct and improve your plans and how you put them into practice.

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<tr>
<td>Potline</td>
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<td>Equipment</td>
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</tr>
<tr>
<td>Camp</td>
<td>SF6 Consumption</td>
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<td>Refrigerant Consumption kg (each type)</td>
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In the reporting, we follow a similar process which is to start with planning through defining the reported parameter-like aspects. Each process is then assessed to define the environmental aspect and impact as part of the initial environmental risk assessment and this gives a solid foundation for environmental reporting. After defining the aspect, each area will set the measurement methods such as lab sampling and analysis, as well
as the online monitoring system for point sources, or even using process data to estimate the pollution level. Regardless of the method, the company will ensure that the measurement and monitoring systems are established for the significant aspect as it is required by EMS.

The next stage will be collection of the data from different systems to report the total site impact. All raw data both environmental and processed will be fed into one database which is basically a spreadsheet interlinked through macros. The verification stage will start as soon as data entry is completed to ensure data accuracy and normalization, as the last two stages are really important in our process of streamlining environmental reporting.

![Data Flow Diagram](image)

**Figure 3: Data Flow Into Main Sheets In The DUBAL Environment Database and Interlinked Between The Sheets.**

Generally any defined reporting system will include the following steps, check the below Figure (3):
The following are more details about each step:

1. **Measurement**: In this step environmental monitoring and measurement of different pollutants are considered and which are already defined in the EMS. The area will specify the measurement system if the environmental agency, such as Dubai municipality, didn’t require to adopt certain systems.

2. **Data Collection**: The output of the measurement systems will be extracted into a common location such as a file, server, or database where all reporting input will be stored. This process can be automatic especially if the company adopts online measurement system. On the other hand, manual sampling, using emission factors, or estimation will be more challenging when compared to automation. Sometimes this step is combined with data verification to ensure that the collected data is accurate and abnormal data is identified.

3. **Calculation**: The requirement or the objective of the reporting will be considered in this step since the input will go through conversion or transition in order to be in the format (output) that is required by the company management; things such as the total mass of the discharge, emission per production, or even simpler things such as conversion between units.

4. **Analysis**: Interpretation of the data, the relation between the process and the process control systems. Also the impact of process modification or expansion shall be considered as it will affect the environmental performance. This and other factors shall be considered here since the good EMS system will require that the company adopts control systems to prevent the reoccurring of such effects again. This part is really important for the management decision making process.

5. **Reporting**: The final output will be represented in the required report format (ex. graph and tables). The generation of the report can be as simple as clicking
on a button which will collect the data, calculate, and then report it in the desired format via software, if the system is automated. However, semi-automated systems can be slower when compared to a previous system; for example, a reporting system with an online measurement system but still uses manual data collection and reporting, or vice versa.

1.2 Problem Statement

The problem of my research can be summarized as the following:

The Dubai Aluminium environmental monthly report is generated from the raw data of different measurement systems, which are fed into spreadsheets manually or extracted from the areas' database or reporting system. The process of data collection will take a minimum of two to four days followed by another two to three days for calculation and verification by Microsoft Excel. The process of generating this report considers the bottleneck in the checking phase of the EMS. Several options were discussed to enhance the reporting process such as looking for readymade software in the market.

DUBAL was in the process of adopting software known as SAP X Emission Management (SAPXEM), but the project was stopped due to the high investment cost, lack of experts of this software also due to the complexity of environment calculation, and huge amount of raw data used to get one aspect. In 2009, the program was tested for one aspect from one area, which took around 10 months to write and get the program running correctly. DUBAL's IT department had also contacted different vendors for the same purpose of enhancing the environment reporting system, and there was no outcome nevertheless. Currently, DUBAL is still searching for software which can manage the environmental reporting system.

It is may that the application of Matlab application is null in the environmental reporting field, base my limited knowledge and research, but it is well known for its capability of handling a large set of data, as well as for interfacing with other programs including Excel.
1.3 MATLAB Application

Cleve Moler who is considered to be the chairman of the computer science department of University of New Mexico started developing this program or system in the late 1970’s. He outlined and designed MATLAB to provide his students the access of LINPACK and EISPACK without them needing to learn FORTRAN.

This soon spread to different universities and it was discovered by many individuals who were interested in the program, which led to the involvement of the applied mathematics community with its development. In 1983, an engineer named Jack Little was exposed to the system during a visit Moler made to Standford University. By acknowledgement and recognition to its commercial potential, the engineer joined with Moler and Steve Bangert. Later on they were able to upgrade the program in C and were able to establish it in 1984 to continue its development and processes. These rewritten libraries were named as JACKPAC.

In the year 2000, MATLAB was rewritten to utilize a newer set of libraries for matrix manipulation which was named as LAPACK. MATLAB as a program was first adopted by researchers and scientists in engineering control; however it quickly spread to numerous different sectors and domains. This system spread to numerous areas and sectors of different practices including the academic field. MATLAB is now also being utilized in the teaching of linear algebra and numerical analysis, and now it’s popular amongst scientists who use image processing (Originlab Corporation, n.d)

Improved by Mathworks, this program permits various framework controls, matrix manipulations, and the functioning and plotting of data and information. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic motor, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems. In the year 2004, this system had about one million users across various industries and universities, with users from diverse backgrounds such as engineering, science, and economics. This program or system is widely utilized in academic and scholarly institutions that are based on research, as well as various sorts of industrial enterprises as was mentioned earlier.
Matlab is one of the greatest tools used to analyze huge data sets delivering the same output but is much quicker. Most of the industrial applications of Matlab are more related to engineering designs, so using Matlab for data processing and the reporting of Aluminium smelter environmental performances would be for the first time. DUBAL never used Matlab before until recently when one of the trainees used Matlab in one of the projects to improve the unloading process. Even with the first application of Matlab in DUBAL, it was used for designing engineering systems.

The research is explained over seven sections including the introduction, followed by a literature review which is divided into the environmental management system, the importance of GHG reporting, and the operation management system. The research objective is the next section explaining how the above three concepts work to meet the research objective. The aim is to streamline the Dubal GHG reporting system using Matlab in the place of Excel. In the methodology which is in the fourth section, we explain the conversion process of GHG reporting from Excel to Matlab. The output of the conversion process was discussed in the results section with comparison to the current system. Discussion includes the finding of this study as well as the limited findings of other studies in EMS and OM. In the last section, the study will conclude with remarks showing the benefits of Matlab and the concerns of its use. Further studies are needed to cover the Matlab visualization feature and the ability to interface with other programs.
2. Literature Review

In this section we look into previous studies related to the environmental management system (2.1), the importance of GHG reporting (2.2) in the context of four areas of cost saving (2.2.1), opportunity and risk management (2.2.2), requirement of stakeholders (2.2.3), and branding and communication (2.2.4). In the last part we cover the operation management and Matlab (2.3). Starting from EMS as reporting is part of the checking phase, into its importance, and finally using Matlab in operation management to enhance the reporting system.

2.1 Environmental Management System

An Environmental Management System (EMS) is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency (EPA, 2011) or it can be also described as a system that helps businesses to evaluate, manage, and reduce their environment impacts by providing a methodology to integrate environment management into business operations in a systematic manner.

Since the first EMS standard (BS 7750) developed by the British Standard Institute (BSI) in 1992, different organizations have developed their own EMS’s. Probably the most famous two among them are the international standard ISO 14001 developed by the International Organization for Standardization (ISO) and the European union (EU) regulation the Eco-Management and Audit Scheme (EMAS). However, in 2003 the BSI published their new British standard, BS 8555, which provides a staged approach for the UK businesses, especially the small and medium-sized enterprise (SME) to implement the EMS (Chen, 2004).

The ISO 14001 standard is a specification for an environmental management system that can be assessed by external bodies. The standard also provides an umbrella for the rest of the ISO14000 series which covers a wide range of environmental management issues including auditing, labeling, life-cycle assessment, etc. The use of ISO 14001 is voluntary, but is often cited as a requirement of commercial tendering processes and
legal compliance. ISO 14001, one of ISO’s most successful management system standards, in its second revision ensures that it remains relevant over the next two decades. Since it was first published in 1996, ISO 14001:2004, Environmental management systems – Requirements with guidance for use, has been adopted by well over 250,000 certified users in 155 countries worldwide (ISO, n.d).

EMS can be a powerful tool for organizations to both improve their environmental performance, and enhance their business efficiency. EMS combines government intervention tools, such as regulatory/enforcement programs, managing resources and pollution, to attain environmental goals of value to the environment and the public, and EMS assures that resources are allocated to manage the impacts (EPA, 2011). With that the company will be able to reduce liability, improve compliance, improve public image, and enhance customer trust. Environmental Key Performance Indicators (KPIs) provide businesses with a tool for measurement. They are quantifiable metrics that reflect the environmental performance of a business in the context of achieving its wider goals and objectives. KPIs help businesses to implement strategies by linking various levels of an organisation (business units, departments, and individuals) with clearly defined targets and benchmarks. The impact of environmental matters on business performance is increasing and will continue to do so. Generally environmental risks and uncertainties affect investment decisions, customer behaviour and Government policy. For example, poor management of energy, natural resources, or waste can affect current performance, and failure to plan for a future in which environmental factors are likely to be a significant risk for the long-term value and future of a business. Businesses will need to use environmental KPIs to adequately capture the link between environmental and financial performance.

2.2 Importance of GHG Reporting

According to research, our planet Earth is warming and the average temperature has risen over the past century. Minor changes in the average temperature of the planet can cause a large potential danger to the climate and weather of earth, and henceforth it is considered to be a disaster. As a fact, due to the temperature rise of the planet, the water level of earth is increasing which means that it is covering the land of various countries when compared to past centuries.
Evidently it is clear that the temperature rise of the planet is causing changes to the climate and weather, various regions were able to experience rainfall which resulted to floods, droughts or intense rain; as well as severe heat waves. Due to the reason of increase in temperature, the ocean temperature has risen which is causing an acidic effect to the ice caps that are located in the poles, and changes have occurred such as the sea level rising. These changes are predicted to cause a negative impact to the living things in the world and will likely present challenges to our society and our environment (Ministry of the Environment – Ontario, 2011).

One of the fundamental achievements in order to have a sustainable growth and ensuring stable shareholder returns would be by administrating and managing carbon emissions and protecting the organization or the business operation from the potential effects of the ecological changes. A large portion of organizations administers, manages, and reports their GHG, which is known as Green House Gases emissions, in this type of report or in environmental sustainability reports. Such organizations consider the imperativeness and importance of measurement or estimations, and administer them in order to disclose the GHG emissions in the standards of their business operations.

There are different sorts of benefits that can be considered when GHG management is consulted by the organizations (Environment Canada, 2013). The points below are some of the major common paybacks to manage their green house gas emissions:

2.2.1 Cost Saving

By managing the GHG emission rates that occur due to business operations, it enables the departments to analyze and evaluate the energy usage of particular sources. Larger amounts of GHG emissions are considered to be linked to the most energy intensive process, and therefore the administration and management of reporting systems enables the identification and recognition of GHG emissions reduction projects internally which can result to the organization in cost cutting or cost saving.

An example than can be concluded would be the usage of renewable energy sources such as solar would provide cost beneficial factors instead of utilizing coal/fossil fuel as a source of energy.
2.2.2 Opportunity and Risk Management

By increasing the emission rate it establishes risks and opportunities to businesses and organizations which can lead and affect the revenue of the business. It also may cost the reputation of the company which will be a negative factor to the organization. By managing and reporting these GHG emissions, it will assist the organization to administer the various threats and risks and will enable them to reap opportunities. Due to the fact of increasing climate changes, governments across the world are making rules and regulations in order to restrict the rates of emissions. Generally the most affected areas are the sectors that are based on energy, such as the transportation or heavy manufacturing and industrialized businesses such as DUBAL. By creating the GHG emission accounting, managing and reporting systems enables companies to create and produce a suitable environment in order to be ready for such rules and regulations that have been passed by the laws. By practicing this managing system, it will create an opportunity for organizations for cost saving due to the optimization of energy sources and then the organization can carefully select the best energy efficiency sources, measures, and innovations in energy technologies which will benefit both the organization and the environment (Ricoh Company, 1995).

2.2.3 Requirements of Stakeholders

Investors are interested in the operation of the business and obtain information and reports regarding the effort the organization is taking towards the carbon emission reduction. This is done by practicing the Carbon Disclosure Project which is also known as CDP reporting. Thusly, quantification of the inventory that is based on GHG consistent with ISO 14064-I will help an organization to meet current and future administrative necessities and stakeholder's desires. Organizations such as the International Aluminium institute (IAI), International Trade Center (ITC), Wipro and other numerous companies have successfully managed and engage their stakeholders on carbon management which resulted to enhancing the reputation and brand image of the organization (Carbon action, 2013).
2.2.4 Branding and Communication

In order to make a strong statement to the stakeholders and potential investors, the company publishes status reports and carbon emissions alongside with the annual report/sustainability report which basically outlines how the business is managing their operation responsibly. These reports could be displayed at various discussions or forums depending on the business’s target shareholders for instance, shareholders such as Investors, Lenders, Government, and Customers, etc.

By practicing and generating such reports, it assists the organization to analyze their performance of the business operation towards emissions as well as enhancing the brand image and organization position in the market (EPA, 1990).

2.3 Operational Management With Excel and Matlab

Operation Management (OM) is required for the environmental reporting process. The operational management concept is mostly relevant to improve industrial application and processes. OM looks for efficient utilization of resources (manpower, equipment, energy, time, etc) in the process of converting the input to output (product or service) with less wastage and still maintain a high quality product or service (Angell, 1999).

The same concept applies with the environment report as a process which required input such as area’s raw data (process or environmental KPI) to be processed and converted into an environment report for management, total quality management system, Lean, and six sigma process, and others which work around the same concept of OM. Applying the OM concept to the Environmental reporting process will identify the bottleneck process and where exactly we have issues with reporting processes through using different tools and performance indicators to evaluate each process and step or activity.

Both Matlab and Excel can be used as tools to achieve operational efficiency considering the environmental reporting as process with input such as raw data (GHG) and output like final report. However the features of both programs will define which is to be used by the end user. Excel can take up to 15,000 rows of data set in numerical format, alternatively Matlab can manage more than that plus other formats of data, ex. descriptive.
MATLAB is known as the matrix laboratory; this software or system is a numerical figuring or computing environment and fourth generation programming language. It was developed by the Linpack and Eispack projects for matrix computation. Matlab is well known for it is programming-oriented solutions, developing new mathematical algorithms, and high computational speed while dealing with massive data sets where Excel may break down at a certain point. MATLAB is also able to interact with other programs such as excel itself or C/C++ or Java (Matlab, 2012).

The program will streamline the production of the environmental monthly report in general and particularly the GHG aspect of it. Matrix Laboratory will allow operational efficiency through better utilization of manpower, resources, and time.
3. Research Objectives

Optimization of the reporting process through minimizing the time and manpower needed to generate the environmental reports is the aim of this research. The reporting process falls under the environmental management system (EMS) which requires a regular checking or monitoring to ensure the compliance with legal requirement or operational targets. Nevertheless the process of the reporting is an important part of checking, that is considered a critical phase due to the time taken to produce the report, such an output that is needed for the next phase "Act" for management review.

Streamlining any report will mean eliminating time and resource wastages or to make the reporting process a lean process, and using software such as Matlab is an option considering that there are other software available in the market which can be customized to meet simpler environmental reporting systems but when it comes to such a complex site with a huge database, Matlab could be an option. Matlab is used in the field of applied mathematics, research, and in this primary industry. Matlab is an interactive system built around vectors and matrices, and is considered one of the greatest tools for solving algebraic and differential equations and numerical integration. The software is well known with its powerful graphic tools which can produce pictures in different dimensions, ex. 2D and 3D. Useful tool boxes for signal processing, image processing, and mathematical function, and more features are also part of Matlab’s package. Automation can be an option to meet our objective, and Matlab can solve many technical computing problems in a fraction of the time. Time that we are trying to save in the process of environment reporting, through eliminating double data entry and reducing the time for data verification and calculation process.

The study will be focused on the conversion of the GHG emission reporting system from excel base to Matlab to confirm the effective use of Matlab for reporting environmental performance in the smelter industry. The report will contain details of the current reporting system in DUBAL, Matlab and GHG reporting, the importance of effective reporting systems, and the link with Environmental management systems and operation efficiency.
4. Methodology

4.1 Overview of Methodology

The methodology consists of the extraction of formulas which is based on the process on site (4.2), followed by the development and approval of area templates following the GHG scope 1 calculation (4.3), ending with the coding using Matlab (4.4). Figure (5) showing an overview of the methodology.

Figure 5: Process Flow Showing an Overview of The Methodology

4.2 Extraction and Defining variables

Primary aluminium is produced in two steps. Firstly, the bauxite ore is ground, purified and calcined to produce alumina (also called aluminium oxide, \( \text{Al}_2\text{O}_3 \)). Secondly, the alumina is electrolytically reduced to aluminium in large electrolytic cells (pots). These cells contain alumina dissolved in a molten cryolite bath (sodium aluminium fluoride). The electrolyte bath is contained in a carbon-lined steel shell, the lining of which acts as the cathode for the electrolytic reaction. Anodes may be either pre-baked in a separate process and attached to connecting rods for immersion in the bath (prebaked cells) or may be formed through self-baking from a paste of pitch and coke that fed into the top of a steel casing above the cell (Soderberg design cells). The electrolysis of the
aluminium oxide produces molten aluminium that deposits on the cathode, and carbon dioxide from oxidation of the carbon anode.

DUBAL produces aluminium in second steps using prebaked anodes. There are four main sources of Direct GHG emission (Scope 1 GHG emission) produced by DUBAL are explained below. In DUBAL all the GHG calculation and data are maintained in a well designed excel file. The file also contains macros that run to transfer the input data, into a summary of results and all results into a relevant historical data sheet. The DUBAL GHG emission inventory has been designed as per the guidelines set by the World Business Council for Sustainable Development (WBCSD) and the World Resource Institute (WRI) in their Greenhouse Gas Protocol. Calculation methods are taken from the guidance documents published in the GHG protocol. (Ombustion, S. T. C., 2005)

**DUBAL – Process Emission From:**

- **Electrolysis (Prebaked anodes)**
  Most of the CO₂ emissions result from the reaction at the carbon anode (electrolytic reduction of the carbon anode with alumina).

\[
2\text{Al}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Al} + 3\text{CO}_2
\]

Some CO₂ is also formed as the anode reacts with air at elevated temperatures. This occurs during cell operation.

\[
\text{C} + \text{O}_2 \rightarrow \text{CO}_2
\]

Carbon dioxide also formed as a result of the *Boudouard* reaction where CO₂ reacts with the carbon anode forming Carbon monoxide, which is then oxidised to form CO₂.

\[
2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2
\]
Equation for calculation of Carbon dioxide emissions from Prebake anode consumption during electrolysis:

\[ \text{Eco}_2 = [\text{NCC} \times \text{MP} \times (100 - S_a - \text{Ash}_a - \text{Imp}_a)/100] \times [44 / 12] \]

Where:

\( \text{Eco}_2 \) = CO\(_2\) emissions in tones per year  
\( \text{NCC} \) = Net carbon consumption, tonnes per tonne aluminium.  
\( \text{MP} \) = Total metal production, tonnes aluminium per year.  
\( S_a \) = Sulphur contained in baked anode, wt\%  
\( \text{Ash}_a \) = Ash contained in baked anode, wt\%  
\( \text{Imp}_a \) = Impurities contained in baked anode, wt\%  
\( 44 / 12 \) = CO\(_2\) molecular mass: Carbon atomic mass ratio, dimension less.

Electrolysis (PFCs)

Two PFCs, CF\(_4\) and C\(_2\)F\(_6\), are emitted from primary aluminium production. They are formed during brief upset conditions known as “Anode Effect” (AE), when alumina levels drop too low and the electrolytic bath itself undergoes electrolysis. This results in the reactions shown below. PFC emissions increase with frequency, duration and intensity of AEs.

\[ 4\text{Na}_3\text{AlF}_6 + 3\text{C} = 4\text{Al} + 12\text{NaF} + 3\text{CF}_4 \]

\[ 4\text{Na}_3\text{AlF}_6 + 4\text{C} = 4\text{Al} + 12\text{NaF} + 3\text{C}_2\text{F}_6 \]

Calculation Method (Slope Method):

The Slope method is being used in DUBAL for calculating PFCs emissions. In the slope method a slope factor is used for the PFCs emission calculation. The slope factor is calculated from the ratio of emissions in kg PFC per metric ton aluminium to anode effect minutes per cell day.
Equation:

\[ \frac{Kg \ CE_4 \ or \ C_2E_6}{metric \ ton \ Al} = slope \ * \ AEF \ * \ AED \]

\[ E_{CO2\-eq} = MP \ x \ \{[EF_{CE4} \ x \ GWP_{CE4}] + [EF_{C2E6} \ x \ GWP_{C2E6}]\} \]

Where:

- **Slope** = ratio of kg PFC per metric ton aluminium to anode effect minutes per cell day
- **AEF** = Anode effect frequency.
- **AED** = anode effect duration
- \( E_{CO2\-eq} \) = Carbon dioxide equivalent emissions tonnes per year
- **MP** = Total metal production, tonnes aluminium per year.
- **EF_{CE4}** = Emissions of tetra-fluoro-methane, kg \( CE_4 \) per year
- **EF_{C2E6}** = Emissions of hexa-fluoro-methane, kg \( C_2E_6 \) per year
- **GWP_{CE4}** = Global Warming Potential of \( CE_4 \)
- **GWP_{C2E6}** = Global Warming Potential of \( C_2E_6 \)

**Pitch coking (Anode Baking)**

Additional \( CO_2 \) results from the oxidation of organic volatile materials during the baking of anodes for prebake cells.

Equation:

\[ CO_2 \ from \ pitch \ coking \ (t) = [GAW \ - \ BAP \ - \ HW \ - \ (RT/1000)] \ x \ [44 \ / \ 12] \]

Where:

- **GAW** = green anode tonnage (t)
- **BAP** = Baked anode production (t)
- **HW** = weight of hydrogen from pitch (t)
- **RT** = recovered tar (t)
- \( 44 \ / \ 12 = CO_2 \) molecular mass: Carbon atomic mass ratio, dimension less.
• **Bake Furnace Packing Material**  
Additional CO₂ results from the combustion of baking furnace packing material.  
Equation:

\[ CO₂ \text{ from baking coke (t)} = [\text{PCC} \times (100 - \text{Ash}_{pc} - \text{S}_{pc})/100] \times \frac{44}{12} \]

Where:
- \( \text{PCC} \) = packing coke consumption per ton of baked anode (t coke/ t anode)
- \( \text{Ash}_{pc} \) = ash content in packing coke (wt %)
- \( \text{S}_{pc} \) = sulphur content in packing coke (wt %)
- \( \frac{44}{12} \) = CO₂ molecular mass: Carbon atomic mass ratio, dimension less.

• **From Soda Ash used in Aluminium Production Process**  
Additional CO₂ results from the use of soda ash, associated with aluminium production.  
Equation:

\[ \text{Eco}_2 = [Q_{soda} \times (P_{soda}/100)] \times \frac{44}{106} \]

Where:
- \( \text{Eco}_2 \) = CO₂ emissions in tones per year
- \( Q_{soda} \) = quantity of soda ash (Na₂CO₃) consumed, tonnes soda ash per year
- \( P_{soda} \) = Purity of soda ash consumed, decimal fraction
- \( \frac{44}{106} \) = CO₂ molecular mass: Na₂CO₃ molecular mass ratio, dimension less.

• **From Use of Resistor Coke For Pre-Heat**  
Extra CO₂ generation from using resistor coke for preheating of new pot cathode lining.
Equation:

\[ \text{Eco}_2 = \left[ N_{\text{B/up pots}} \times \text{Net}_{\text{rcc}} \right] \times \left\{ \left[ 100 - \text{Ash}_{\text{rcc}} - \text{S}_{\text{rcc}} \right] / 100 \right\} \times \frac{44}{12} \]

Where:

- \( \text{Eco}_2 \) = CO\(_2\) emissions in tones per year
- \( N_{\text{B/up pots}} \) = New bath-pot (new pot started), in number
- \( \text{Net}_{\text{rcc}} \) = Net resistor coke consumed, tonnes per year
- \( \text{Ash}_{\text{rcc}} \) = ash content in resistor coke (wt %)
- \( \text{S}_{\text{rcc}} \) = sulphur content in resistor coke (wt %)

**DUBAL – Emission From Stationary Combustion Sources**

DUBAL having an in-house power station installed capacity of 2,400 MW at 30°C which satisfies the energy requirements of DUBAL and is also a main stationary combustion source. The other main stationary combustion sources are the Cast house, Pot Repair and Anode Baking Plant. All the mentioned sources are owned by DUBAL and are within the organisational boundary. The approach “GHG Protocol Scope 1: Direct greenhouse gas emissions” is being used in DUBAL to calculate the CO\(_2\) emission from fuel combustion.

There are two basic approaches for estimating direct (scope1) CO\(_2\) emissions from stationary combustion

1. Direct measurement of the mass of CO\(_2\) in the exhaust gas
2. Calculation of CO\(_2\) emission based on activity data.

Second approach is being used in DUBAL for estimating CO\(_2\) emission.

Equation: Calculation based method for CO\(_2\) emission.

\[ \text{Eco}_2 = \frac{\text{EF}_{\text{CO2}} \times \text{HHV} \times F_g}{1000} \]
\[ \text{Eco}_2 = \frac{\text{EF}_{\text{distillateCO2}} \times F_{\text{distillate}}}{1000} \]
Where:

\[ \text{Eco}_2 = \text{CO}_2 \text{ emissions in tones per year} \]
\[ \text{EF}_{\text{CO}_2} = \text{Default CO}_2 \text{ Emission Factor (EF}_{\text{CO}_2}), \text{ kg/million Btu fuel} \] (Natural gas) used
\[ \text{F}_g = \text{Quantity of fuel burned, mscf} \]
\[ \text{EF}_{\text{distillateCO}_2} = \text{Default CO}_2 \text{ Emission Factor (EF}_{\text{distillateCO}_2}), \text{ kg/Imperial gallon of distillate (Type 2) used.} \]
\[ \text{F}_{\text{distillate}} = \text{Quantity of distillate burned, IG} \]
\[ \text{HHV} = \text{Default High Heating Value (HHV) for Natural gas, Btu/scf} \]

**DUBAL – Emission From Mobile Combustion Sources**

Mobile sources includes the DUBAL owned vehicle (Direct emission) which operates within the boundary of organisation and the hired transport vehicle (Indirect Emission) used for the transportation purpose of the employees. Direct and Indirect emissions are classified according the norms defined in the GHG protocol

Equation: Calculation based method for CO\(_2\) emission.

\[ \text{Eco}_2 = \frac{\text{EF}_{\text{dieselCO}_2} \times \text{F}_{\text{diesel PR}}}{1000} \]
\[ \text{Eco}_2 = \frac{\text{EF}_{\text{petrolCO}_2} \times \text{F}_{\text{petrol PR}}}{1000} \]

Where:

\[ \text{Eco}_2 = \text{CO}_2 \text{ emissions in tones per year} \]
\[ \text{EF}_{\text{dieselCO}_2} = \text{Default CO}_2 \text{ Emission Factor (EF}_{\text{dieselCO}_2}), \text{ kg/Imperial gallon of diesel used} \]
\[ \text{EF}_{\text{petrolCO}_2} = \text{Default CO}_2 \text{ Emission Factor (EF}_{\text{petrolCO}_2}), \text{ kg/Imperial gallon of petrol used} \]
\[ \text{F}_{\text{diesel PR}} = \text{Quantity of diesel consumed, IG} \]
\[ \text{F}_{\text{petrol PR}} = \text{Quantity of petrol consumed, IG} \]
DUBAL – Emissions From Fugitive Sources

Fugitive CO₂ emissions generate due to use of SF₆ in power plants and refrigerant in both domestic and industrial air conditioners. These fugitive emissions of CO₂ are estimated using the following equations.

\[
\text{ECO}_2 = [ Q_{SF6} \times \text{GWP}_{SF6} ]
\]
\[
\text{ECO}_2 = [ Q_{Refr} \times \text{GWP}_{Refr} ]
\]

Where:

\text{Eco}_2 = \text{CO}_2 \text{ emissions in tones per year}

\text{Q}_{SF6} = \text{Quantity of SF}_6 \text{ used, kg}

\text{Q}_{Refr} = \text{Quantity of refrigerant used, kg}

\text{GWP}_{SF6} = \text{Global Warming Potential of SF}_6

\text{GWP}_{Refr} = \text{GWP of Refrigerants}

4.3 Development and Approval of Area Template

The above four classes of GHG emissions were also considered while converting the report from excel to Matlab. The process of data collection was started with the preparation of the template for each area contributing to GHG emission. Templates were in excel format which provides the raw data (variables) used to calculate the GHG emissions. The final templates were approved by the areas considering future application.

GHG classification eight template sheets were developed to record the raw data of month of March. Below are the templates names for each area:

- Anode plant: The file includes raw data of Reduction material area. The file contains four tables which are: Fume treatment plant data, Process material, raw material, and anode supply to potlines.

- Fuel Consumption for mobile equipment, this file contains the raw data of fuel (diesel or petrol) consumption for the transportation on site.
- Fuel Consumption for Residential Area, this file contains the raw data of fuel (diesel or petrol) consumption for the transportation in the Residential Area which is also on site.
- MP is the file which has the raw data for metal production and Soda Ash Consumption of the potlines.
- NCC stands for net carbon consumption; this file includes the consumption of carbon anode in Potrooms.
- PD file is the Power and Desalination (PD) raw data file. Natural gas consumption and Distillate or liquid fuel oil consumption are the main two parameters reported in this file and other parameters which used for GHG calculation.
- PFCs stands for Perfluorocarbon which is a unique gas released from Potroom during Anode effect, the file record Anode effect frequency (AEF) and anode effect duration (AED), in addition to other factors and parameters.
- The last template is for recording the site refrigerants consumption which is provided by Maintenance department which is basically Figure (6).

In excel the above GHG raw data will be entered into an input sheet which is one of eighteen sheets used in the environmental database. The data will be also saved into the monthly input and year to date (YTD) database using macros.

![Figure 6: Template For Recording The Site Refrigerants Consumption](image)
4.4 Matlab Code

The next step was to start writing Matlab codes to calculate the GHG emissions and compare the two types of software for GHG reporting. Raw data collection was done using the new templates and the data for the month of March was approved to be used for the demo to test the Matlab code. Matlab Coding consists of:

4.4.1 Part 1: Importing

This step covers data extraction from the templates, separating characters from numbers, saving numbers into myData and then naming every variable using the class diagram as in Figure (7). The templates were kept very simple and only with the required details for this demo.

![Figure 7: Class Diagram For GHG Variables](img)
4.4.2 Part 2: Calculation

This step includes multiplication of the raw data following the equations provided in the first section of the methodology. Factors and default values were fed directly into the Matlab code to support the calculations. Figure (8): Matlab code for GHG calculation from refrigerates consumption.

On the other hand, the current database uses the same formulas in the Excel spreadsheet called "Calculation". The results of the calculations sheet will be saved into the monthly results and year to date (YTD) database using macros.

4.4.3 Part 3: Visualization and Graphs

The results will be stored in the Matlab m. file; however different graphical format can be used to visualize the output. Figure 9: Showing Matlab results in the workspace.
The environmental database contains the report parameter sheet which includes all the data needed for the Environment Monthly Report, in addition to that another sheet is used to represent the data in graphical format such as a column or liner chart. These charts are used for the Environment Monthly Report along with data analysis, executive summary and environmental initiatives. Matlab can plot one (1-D), two (2-D) and three dimension (3-D) graphs. Similar to Excel one dimension includes line, bar, area, direction, and vector field, radial, and scatter graphs.

Figure 9: Workspace Showing Variables and Results From The Matlab Calculation
5. Results

The process of developing of Matlab code is parallel to writing macros in excel, which tells the program to do or to perform the required functions. The results of both programs were the same considering the point that Matlab is replacing excel to make the process effective and efficient.

Table (2): Excel and Matlab GHG Calculation Results

<table>
<thead>
<tr>
<th>March-2013</th>
<th>Excel</th>
<th>Matlab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct CO$_2$ from Anode Consumption, t/t</td>
<td>1.51</td>
<td>1.55</td>
</tr>
<tr>
<td>CO$_2$ equivalent from PFC, t/t</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Direct CO$_2$ from Anode Baking, t/t</td>
<td>0.072</td>
<td>0.071</td>
</tr>
<tr>
<td>Direct CO$_2$ from Packing coke during baking, t/t</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Direct CO$_2$ from soda ash in Potroom, t/t</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Direct CO$_2$ from resister coke in pot pre-heat (Potroom), t/t</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Stationary Combustion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct CO$_2$ from Power Generation by Gaseous Fuel, t/t</td>
<td>6.928</td>
<td>6.900</td>
</tr>
<tr>
<td>Direct CO$_2$ from Power Generation by Liquid Fuel, t/t</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Direct CO$_2$ from Gaseous fuel - Smelter, t/t</td>
<td>0.164</td>
<td>0.164</td>
</tr>
<tr>
<td>Source</td>
<td>March-2013</td>
<td>Excel</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>Direct CO₂ from</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel consumption Pot</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Repair, t/t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct CO₂ from</td>
<td></td>
<td>0.008</td>
</tr>
<tr>
<td>Diesel consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Equipment, t/t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct CO₂ from</td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Petrol consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Equipment, t/t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fugitive Sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂e from use of</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>SF₆ in Power Operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t/t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂e from use of</td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>refrigerants, t/t</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The minor variations between the two results are mainly due to the monthly accumulation in the environmental database and the correction in the fuel and raw material inventories.

The demo was limited to GHG data reporting rather than the entire environmental report due to the fact of information confidentiality and data sensitivity. However the results are listed in the above table covers both programs outputs. Looking at the Matlab application, this project uses a very small part of its computation capacity. The ability to read from other programs such as excels or a csv file was a good interface and is considered cost effective. The only part which wasn't used so we can have 100% transformation is the graphical representation of the results, something that Matlab is very strong at. The demo was for a single data set or one month only. In general the process of data collection and interlink with Matlab was swift, saving time and manpower. The exact savings weren't calculated; however we eliminated double data entry, reduced the time for data verification, saved three working days, reduced human error, and standardized data collection process.
6. Discussion

The Matlab program was done in six months since I had to learn the principles of software first, which was done through one to one meeting with my doctor or using online tutorials from Mathworks. The program was developed using a student version of Matlab. The Matlab code consists of three sections, and the first section is about data importing. Data is extracted from templates (csv. files) into myData. The second section defines each variable, and in the third section manipulation and calculation takes place. The actual coding process takes less time if the developer is familiar with Matlab; nevertheless the process was completed in two months part-time considering my basic skill and knowledge in Matlab.

The first part of the coding is replicable for each file or template. A function call that separates semicolons was developed for section 1 of every m. file, the function basically to open the required template, read the numerical data and then save them in myData. In the next section which is different from one file to another is due to the fact that the code shall link each variable name with the right number from myData. In the last part, the GHG calculation will be covered, the formulas from the methodology section were used for this section of the coding in the m. file. Five m. files were developed to cover the total GHG reporting.

The report is based upon the term Matlab, which is considered as a system in which numerical data as well as environmental data is analyzed. In this paper, two different types of software are being utilized: Microsoft excels with spreadsheet application and Matlab with m. file (script) for GHG reporting. The Matlab program was tested and the results were compared with the Environment database report. Minor differences were noticed in direct CO$_2$ from anode consumption, direct CO$_2$ from packing coke during baking and direct CO$_2$ from power generation by gaseous fuel or natural gas. The variation as we mentioned before is due to correction in the fuel and raw material consumption.
Statically data that is contributed in the research and are computed in an easy manner, to arrange the numbers in a manner of rows and columns, such as in the template. In this method raw data was converted to structured raw data, which makes the processing leaner. Between data collection and calculation, verification is done to ensure all raw data were entered into right cell with the right value. Both data entry and verification are done manually consuming two to three working days and one manpower. Nonetheless human error is more likely to happen with the rush to get the report done as soon as possible. In Matlab, an area template will be directly used to feed the program, so we won't need double entry as the case in excel. The process of calculation is similar in both programs, the only difference is in constants and emission factors are saved in a separate sheet in excel, where in Matlab we feed it directly to the code or m. file. The plotting of the results can be completed by choosing the data then charts type in excel similarly in Matlab or writing script or code for that.

The only drawbacks that can be considered would be to any language how the fact is being analyzed such as there might be a difficulty in debugging the various errors. As well as there might be a present of limited set of statistical tools which might cause a problem in the program. Matlab help and online support were used to overcome the issue related to errors in the coding the GHG reporting program. In terms of large results being set, the Excel program is not able to handle large amounts of information and data. In DUBAL, the database is saved for every month to ensure that the data is maintained even if any part of the file is crushed.

Matlab is considered to be numerical based computing in terms of environments and in fourth generation programming languages. This program is developed by math works and it allows the manipulation of matrix plotting of functions and data where algorithms and different creations of user interfaces are involved. Although the program is intended to report the GHG performance, common function or scripts were used such as data importing code, reading numerical data and storing the required data for calculation. Developing the Matlab code was done systemically, as the Matlab doesn't allow moving forward to next step. Excel and Matlab time and output looks similar but Matlab has the advantage in eliminating the double entry of raw data, streamline the verification process, and still use less time and space.
To our knowledge, the literature hasn't reported the application of the operational management principle to environmental management system through the use of Matlab. Nevertheless, the streamlining EMS through automation was used in other applications such as the material safety data sheet (MSDS) system. This paper looks into the improvement of environmental management systems through data automation to maintain accurate records and eliminate time wasted in manual data entry. This paper will cover the benefits for businesses in short and long term, the Environmental specialist will have time to cover other activities which will reduce the environmental impacts, and contribute to the business long-term goals. Human error and standardization were also some of the benefits of applying such a concept in the EMS material reporting system (Your, A., & Data, M. n.d.).

MATLAB comes with a huge library of built-in functions that filter, organize, store different types of data, analysis, and graphically represent and model the data. On the other hand Excel uses mostly numeric data with manageable size, able to provide similar features but with a limited dataset. Also we need to state the Matlab ability to interface or interact with other programs. Below is a sample produce while testing Matlab graphical features. Figure (10): Showing Atmospheric pressure as illustration of Matlab graphical features.
7. Conclusion and Recommendations

Decision making processes for any business depend on data availability and accuracy. Prior to any decision, the general approach is to collect the required data and analyze them before jumping to conclusions. As successful businesses are built on that process, nevertheless the process will start to be more challenging with huge amount of data sets. Businesses will start looking into different tools to make the process of analyzing data easier.

While doing that businesses need to avoid inadequate data and knowledge gaps which are important problems for good management, including environmental management (EM), which measures the cumulative impact on the environment, and ensures that such impacts fell below the maximum allowable levels. Most of the environmental reports are generated from different measurement systems as raw data, fed into spreadsheets manually, analyzed, and then represented in form of tables, trends and graphs which are published in the final reports. The case could be as well that the company adopts the online system that captures the data from different measurement systems and then feeds into the common database where reports can be generated automatically. Nevertheless looking at the cost of transition, businesses will go with more cost effective options such as interface between both cases.

There are many aspects of the environment which have been inventoried and reported. Typically, these inventories are systematic and rich in data. Matlab can offer a good platform to process this data in a smooth way. The term Matlab is utilized as a tool mostly for engineering rather than reporting:

- It can be considered in simple mathematical manipulations and matrices for understanding the terms of mathematical and engineering concepts.
- The concept originally came from small and handy tools, and has later evolved to become an engineering workhorse.
- The method is now accepted in Matlab as well as various toolboxes where it can replace or enhance the usage of traditional simulation of tools for advance applications.
- Basically the study introduces the idea of using Matlab for reporting applications and integration with other programs.
- The advantages that can be considered would be the simulation manner, where it would be easy to analyze and evaluate the situation using historical or current data.

The Matlab program adds a value of cutting the verification process time and reducing the number of man hour work for manual data entry. Further applications can be found for organizations which are responsible for country GHG inventories, ex. the Ministry of Water and Environment (MOWE), or international organizations such as the International Aluminium Institute (IAI) who also collects and reports similar data for all Aluminium smelters in the world. The current program can be modified to meet the above applications, however further research is required to test the visualization features of Matlab compared to Excel as well as the interface with other programs. Matlab can act as an umbrella interacting with area’s different reporting systems to extract the raw data and compute GHG performance.
References


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Appendix
Appendix I

Appendix I: Abbreviation

- DUBAL: Dubai Aluminum
- GHG: Green House Gases
- ISO: International Standardization Organization
- HBMeU: Hamdan Bin Mohamed e University
- NOx: Oxides of Nitrogen
- SO$_2$: Sulphur Dioxide
- CO$_{2eq}$: Greenhouse Gas Emission equivalent
- SPL: Spent Pot Liner
- PDF: Portable Document Format
- KPI: Key Performance Indicator
- KFTP: Kiln Fume Treatment Plant
- Gross Cal Value: Gross Caloric Value
- EMS: Environmental Management System
- PDCA: Plan-Do-Check-Act
- SAPXEM: SAP X Emission Management
- BSI: British Standard Institute
- EU: European Union
- EMAS: Eco-Management and Audit Scheme
- BS: British Standard
- SME: Small and Medium-Sized Enterprise
- CDP: Carbon Disclosure Project
- IAI: International Aluminium institute
- ITC: International Trade Center
- OM: Operation Management
- 2D: Two dimensions
- 3D: Three dimensions
- Al$_2$O$_3$: Aluminium Oxide
- WBCSD: World Business Council for Sustainable Development
- WRI: World Resource Institute
- PFC: Perfluorocarbon
- AE: Anode Effect
- MW: Megawatt
- YTD: Year-to-date
- t: Tonne
- MSDS: Material Safety Data Sheet
- MOWE: Ministry of Water and Environment
Appendix II

Appendix II: DUBAL Environmental Monthly report.
Appendix III

Appendix III: DUBAL Environmental Raw data, sheets.
Appendix IV

Appendix IV: Matlab codes, m. files.