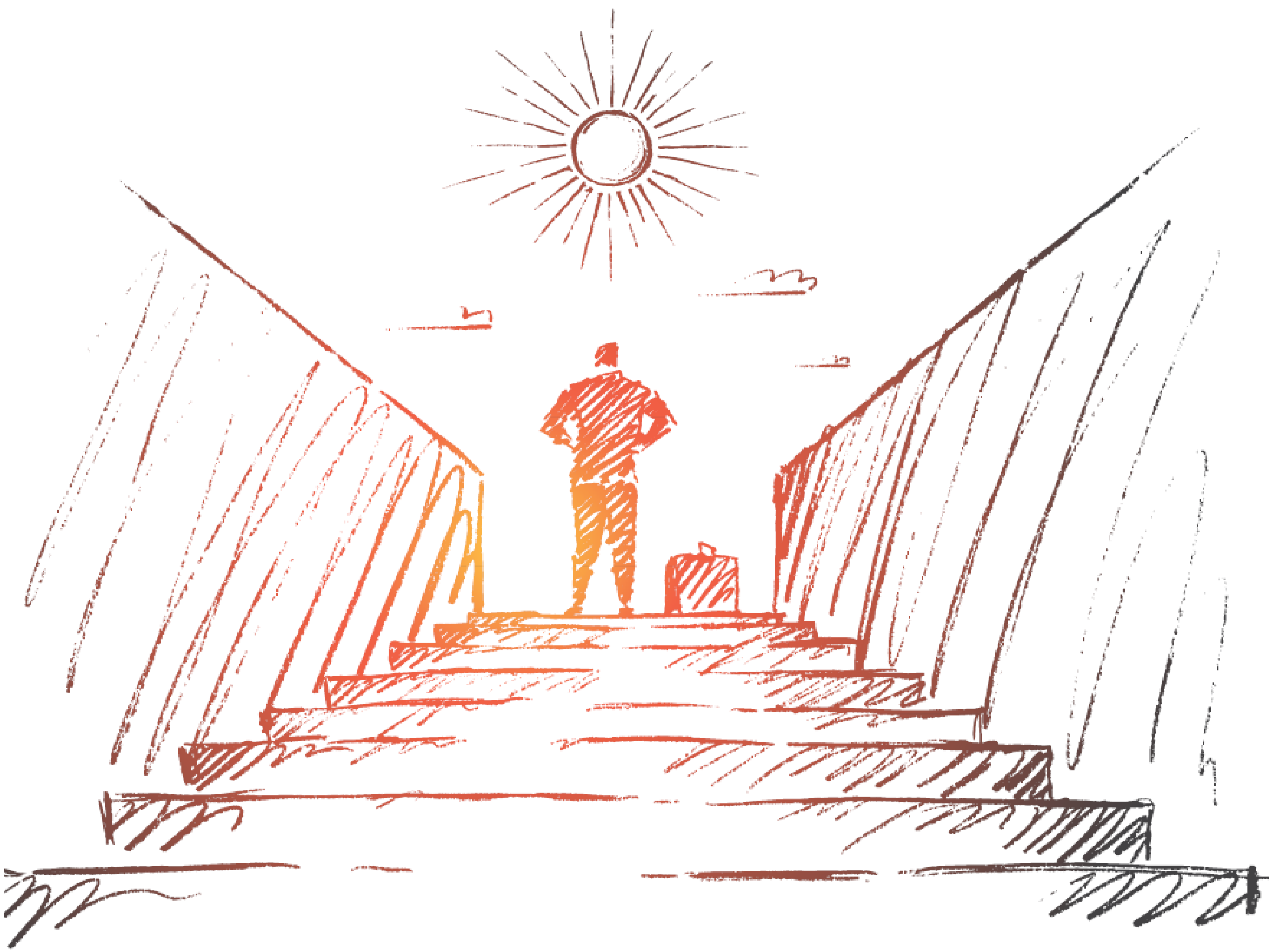
IChemE
Trinidad and Tobago
Members Group

THE VESSEL

OCTOBER 2022

A NEW BEGINNING...



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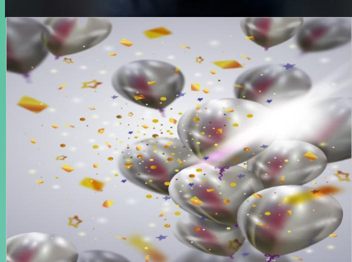

MESSAGE FROM OUR CHAIR

THE RESET

Pulling through the pandemic revealed a resilience we didn't know that we had. For many of us, it was an experience we wished we didn't have to endure, primarily due to the losses of people, jobs, finances, and even opportunities. But for many, in the same vein, it provided insights into what we wish to better prepare for – meeting new people, finding new jobs, welcoming finances, and creating new opportunities.

The reset that is upon us is as tangible as it is intangible. Intangibly, we must first sharpen our understanding of where we see ourselves fitting in to a dynamic society. The question is, is it as dynamic as we would like it to be? Who is responsible for making it more so? Tangibly, much of our efforts must be focused on positioning ourselves to fit in to this same changing global environment, occupying future jobs in the energy transition space, differentiating our skillsets, and developing entrepreneurial/ business acumen to serve our immediate local society and possibly, beyond.

It is for these reasons that this newsletter speaks to topics ranging from industry risk management, to waste management and aspects of climate change, such as carbon capture and storage and GHG abatement strategies. As a reminder, in 2019, IChemE launched its 5 year 'Strategy 2024' (IChemE Strategy 2024 - IChemE), which speaks to the below four (4) goals, and as a Members Group, we must acknowledge and progress our own contribution to make them a reality in Trinidad and Tobago:

- To be respected for professionalism and technical competence;
- To be recognised as a vibrant learned society that materially impacts on the Global Grand Challenges for Engineering;
- To be acknowledged as a peer-group leader in which an engaged membership which receives and adds value; and
- To be known as a high-performing organisation delivering significant value.

Of particular interest to the Trinidad and Tobago landscape is our role in addressing the (local and) global grand challenges for engineering which fall under the pillars of energy, water, food & drink and well-being. This has a direct bearing on our sustainability ambitions and what we leave behind for future generations.

As the current IChemE TTMG Steering and Management Committees prepare to pass the baton of responsibility to a new cohort of leadership at the upcoming Annual General Meeting (AGM) in November 2022, it is critical to keep these key focus areas at the forefront of our minds. We look forward to your attendance at the AGM, where you have the chance to interface with the outgoing team and other members of the IChemE TTMG community.

It has been a pleasure serving in the capacity of the Management Committee Chair for the past two terms and I do look forward to serving the committee, like many of you, in achieving our TTMG Strategy 2024 goals and beyond.

Do enjoy this 2022 issue of ***The Vessel***.

Monifa Graham

IChemE TTMG Management Committee Chairperson

FOOD WASTE: THE GHG BLIND SPOT

Author: Abigail Clarke, Process Engineer and Environmental Advocate

According to the World Wildlife Fund (WWF), food waste accounts for an estimated 10% of global greenhouse gas emissions (GHG). This is equivalent to nearly twice the emissions of all cars in the United States and Europe. While food waste is not commonly thought of when one discusses carbon emissions, its contribution to GHG emissions is so high that if *food waste* was considered a country, it would actually be the third largest emitter behind only China and the United States (Vox, 2017).

The carbon footprint of food products refers to the cumulative GHG emissions produced during its life cycle - production, processing, transportation, and waste disposal. The GHG emissions associated with food waste refer to the emissions generated during the life cycle of food that ends up being wasted. Food waste is defined as food that can be consumed but is discarded. This occurs at four levels: producer, distributor, retailer, and consumer, and does not only come from foods that have surpassed their shelf life, but also from consumable food which is simply now unwanted or even has production defects in color and appearance. The UN estimates that one third of the world's food, approximately 1.3 billion tonnes, is lost or wasted annually (United Nations, 2011). **Figure 1** shows the breakdown of food wastage by product type.

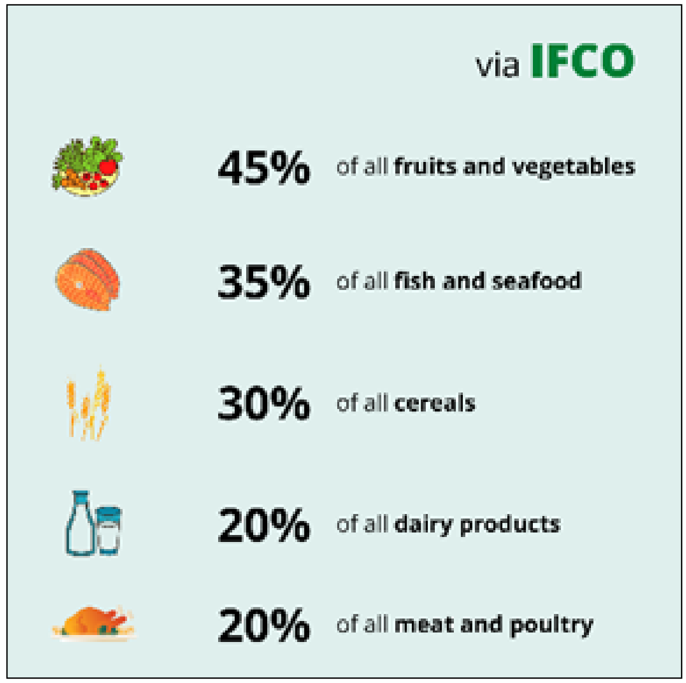

Figure 1: Global Food Waste by Product Type.

Food wastage has increased considerably over the years. **Figure 2** shows this increase for the US from 1960 to 2015. The increase is primarily due to two factors: the increasing population and the lack of correctional action toward food waste. This has consequential effects on the environment and the economy, both regionally and internationally.

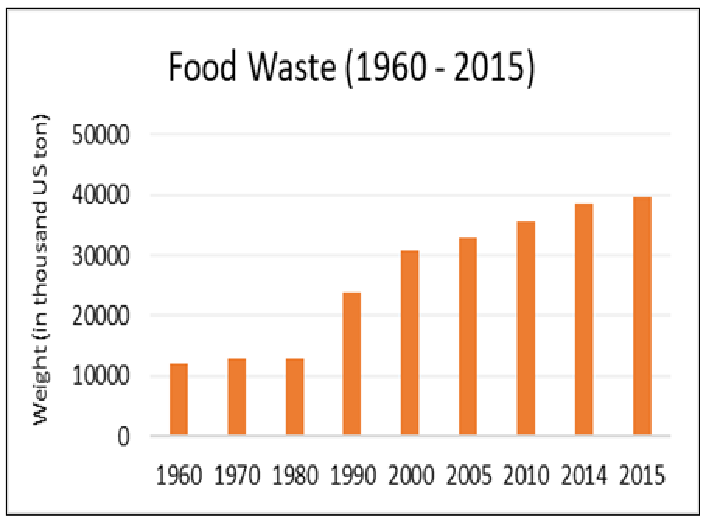

Figure 2: Food waste in the US from 1960 to 2015.

Food waste is typically disposed of via one of three methods: composting, combusting or landfill. A growing portion of food waste is combusted for energy production while a smaller portion is composted, usually in residential settings. The majority of food waste however, ends up in landfills as shown in **Figure 3**.

Food waste is the largest component of municipal waste, amounting to 21% (Harvard, N/A). In addition to the carbon emissions, the wasted food is left to decompose at these landfills. The decomposition process produces methane, which is one of the most potent greenhouse gas based on its Global Warming Potential, and further contributes to accelerated warming. Apart from increased emissions, in Trinidad and Tobago, landfills are currently being overwhelmed by the amount of waste produced. SWMCOL, a leading local waste management company, intends to replace the existing overfilled landfills with one new engineered site and has indicated that a 50% reduction in waste generation is necessary for this proposed site. A reduction in food waste ending up at landfills can complement efforts in recycling to achieve this goal (Douglas, 2019).

From an economic standpoint, simply put, when food is wasted, money is also wasted. Similar to the environmental impact, it is not solely the physical food that is being thrown away, but the capital and resources behind the production, transportation, and subsidies of food that need to be considered. It is estimated that as much as US$ 1 trillion is lost annually due to food wasted globally (Food and Agriculture Organization of the UN, 2014). Additionally, a reduction in food waste can directly impact food prices. It is expected that reduced production and transportation costs will likely result in lower food prices and benefit consumers.

Reducing food waste is important as it will be part of a strategic plan to reduce global greenhouse gas emissions through various mediums and sectors. This is keeping with the Paris Agreement and adopting good practices with respect to the environment and sustainability. These collective actions to reduce GHG emissions will hopefully reduce the effects of global warming to a more acceptable level before a critical climate threshold is reached.

What can we do?

- Donate extra food to charities, and elderly and youth homes, or to the less fortunate in your area.
- Sort and recycle food to use as compost heaps, natural fertilizers, or even to feed animals.
- Prepare or purchase a suitable quantity of food that can be consumed, which will reduce the amount of food left uneaten and subsequently wasted.
- Educate the public on the consequences of wasting food and best practices on how to properly store food, and how to utilize the food after it is inedible.
- Encourage local businesses such as groceries, restaurants, markets, and cafeterias to conduct evaluations of the amount of food waste that occurs and use that data gathered to identify causes of wastage and devise appropriate solutions.
- Understand the difference between "best before" and "use-by" dates.
- Don't criticize food by its appearance because even if it may be slightly bruised or weirdly shaped, it is still good for consumption.

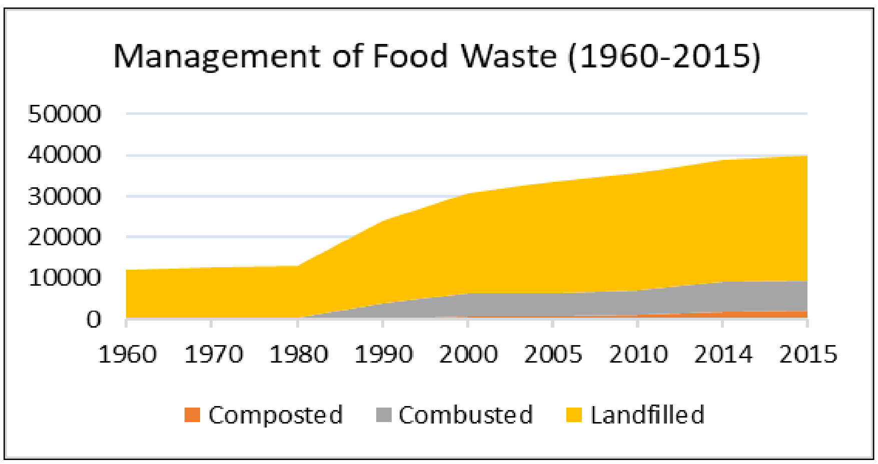

Figure 3: Graph showing how food waste is handled.

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2021 EVENTS RECAP

STUDENT MEMBERSHIP DRIVE

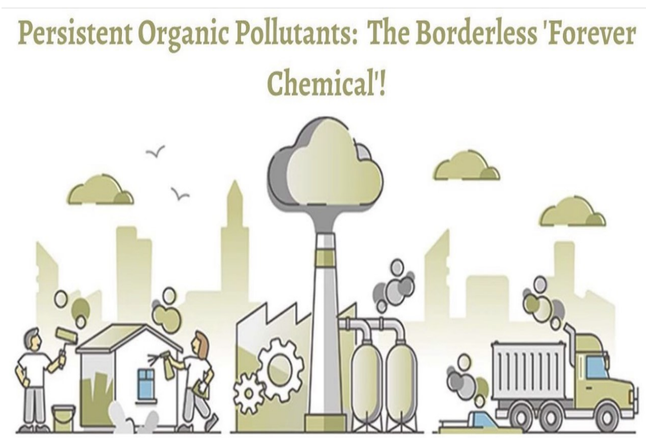
On Thursday 28th November 2021, IChemE TT's Assistant Treasurer, Dr. Keeran Ward, and Networking, Fundraising, Sponsorship and Recognition Committee Lead, Renisha Hercules, conducted a Student Membership Drive for Year 1-3 Chemical & Process Engineering students of the University of the West Indies. In this session, students were introduced to IChemE, the benefits of membership, and how to register for Student Membership. As well, students were invited to volunteer with the local IChemE Chapter - the Trinidad and Tobago Member Group. From this session, 13 new student members registered for IChemE membership.

ENGINEERS IN BUSINESS PANEL DISCUSSION

On Thursday 28th November 2021, the Engineers in Business Panel Discussion was held with esteemed presenters Ian Walcott, Managing Director at Nutrien; Leiselle Harripersad, Manager, Commericla and Stakeholder Relations, Methanex; Maurice Massiah, IChemE Senior Ambassador; Andre Perseval, IChemE TTM Committee Lead, and Monifa Graham, IChemE Management Committee Chair (Moderator). This event aimed to assist today's Chemical Engineers, and by extension all Engineers, in leveraging their existing talents and creativity into tangible Entrepreneurial or Intrapreneurial practices.

2021 EVENTS RECAP

STOP THE POPS!...
PERSISTENT ORGANIC POLLUTANTS



On the 23rd September, 2021, IChemE TTMG welcomed Keima Gardiner, Waste Management Specialist at the Ministry of Planning and Development, for an engaging presentation on Persistent Organic Pollutants. Keima holds an MSc in environmental studies and sustainability science from Lund University in Sweden, with distinction, a BSc double major in environmental and natural resources management and geography (first class honours) from the University of the West Indies, St. Augustine, and Project Management Professional (PMP) certification. Webinar participants gained knowledge on the key characteristics of POPS, as well as potential sources of exposure. During the session, Keima discussed the threats posed by and measures to reduce the impact of toxic, ubiquitous persistent

Congratulations!

PROFESSOR EMERITUS WINSTON A MELLOWES

RECIPIENT OF THE CHACONIA MEDAL GOLD

IChemE TTMG recognizes and celebrates Professor Emeritus Mellowes, on being a recipient of his 2022 Chaconia Medal Award Gold!

After receiving a scholarship from his home land of Barbados, in 1962 to attend the University of the West Indies, Professor Emeritus Mellowes, was amongst the second batch of graduates from the UWI St. Augustine Campus' Faculty of Engineering.

Winston A Mellowes is a Professor Emeritus in Chemical Engineering of the University of the West Indies (UWI) who has served as Head of Department, Assistant Dean for Undergraduate and as Deputy Dean for Postgraduate Students and Research for eight years. His major teaching courses have been in Transport Phenomena, Biochemical Engineering, Environmental Engineering and Food Engineering. He is a Chartered Engineer of the IChemE and currently serves in the capacity of UWI & Board of Engineering of Trinidad and Tobago (BOETT) Representative for IChemE Trinidad and Tobago Members Group.

Professor Mellowes is currently Chairman of BOETT and a Member of the Board of the Accreditation Council of Trinidad & Tobago. He also serves on the Trinidad & Tobago Group of Professional Organisations (TTGPA). He is a Fellow of the Association of Professional Engineers of Trinidad and Tobago and is a recipient of their Career of Excellence Award. He is also a Fellow of the Caribbean Academy of Sciences (CAS) and is currently Foreign Secretary and Immediate Past President of CAS and Focal Point for Science for the CAS.

He has been instrumental in organizing the many workshops and seminars for this body for primary and secondary school teachers in the "Hands on Teaching of Science Methodologies" part of the Inquiry Based Science Education (IBSE) programme. He has been honoured as a Caribbean Icon in Engineering by the National Institute for Higher Learning Education and Technology (NIHERST). He is also the immediate Past Chairman of NIHERST.

Professor Mellowes has a joint USA patent in Xanthan gum production from sugarcane juices. This is in addition to many regional and international publications in the area of Sugar Technology, and related environmental matters, biomass utilization and transport phenomena.

To this list, he has now been added as a recipient of the Chaconia Medal Gold Award.

Professor Mellowes, we at IChemE TTMG are proud of you and honoured that Trinidad and Tobago has become your second home! Thank you for your stellar legacy!

BRIDGING THE GAPS FOR INDUSTRIAL RISK ASSESSMENT AND EMERGENCY RESPONSE PLANNING

Authors: A. Perseval, Shamrock HSE Consultancy and M. Baldeo, Arkulus Solutions, Project Management Consultancy

Summary

The Process Industry evolution and experience has led us to develop formulated processes for 'Risk Assessments' and to ensure the appropriate safeguards, mitigations and elements of contingency planning/emergency response plans are in place to protect our workplace activities on any industrial site. This article addresses why some gaps in the risk assessment processes still occur and identifies areas for improvement in implementing emergency response plans during a Major Accident Hazard (MAH) event.

Key words: Risk Assessment, Major Accident Hazard, Process Safety, Process Safety Management.

Introduction (Identifying Issues)

International Standards such as IEC 61882 HAZOP Studies[1], ISO 31000:2018 Risk Management[2], IEC 31010:2019 - Risk Management - Risk assessment techniques[3] have been developed as safety pillars in our approach to risk management across industry. Risk Assessments processes and procedures reference these applicable standards to provide a structured methodology for many organisations to effectively manage risk exposure during site operations. These risk assessment systems ensure the appropriate safeguards, mitigations and elements of contingency planning are in place to protect our workplace activities on any industrial site to as low as reasonably practicable - ALARP Principle[4] illustrated below in Figure 1.

Risk Assessments are essential tools in decision making processes and play an integral role in the success of health and safety management systems. However, shortfalls in risk assessment processes or even the routine approach taken to conduct assessments can increase the severity of hazardous events or omit vulnerable areas in a planned activity that may contribute to an unforeseen hazardous event. This article addresses why shortcomings in the risk assessment process still occur, identifies human factors and risk management system gaps and discusses how they can affect emergency response during a Major Accident Hazard (MAH).

<u>Conducting Risk Assessments</u>

Risk Assessment is the process of identifying applicable hazards and estimating the likelihood of occurrence of undesirable events and the severity of the harm or damage caused, along with a value judgement relating to the significance of the results. When choosing a risk assessment method, factors such as the type of industrial process, identification of hazard types, levels of associated risk and the stage of the project life cycle, project activity should all be considered. Risk assessments can be qualitative, semi-quantitative or quantitative processes. Qualitative Risk Assessments approaches include What-if Analysis, Hazard and Operability (HAZOP) studies, Failure Mode and Operability Analysis (FMEA), and are dependent on level of judgement, experience and knowledge while Quantitative Risk Assessment approaches include Quantitative Risk Assessment (QRA), Probability Risk Analysis (PRA), Quantitative Scenario Analysis (QSA), and are derived from the quantification of potential hazard consequence and relevant risks (Desai 2008).

Though the purpose of conducting each type of risk assessment is ultimately the same, that is identifying and reducing the

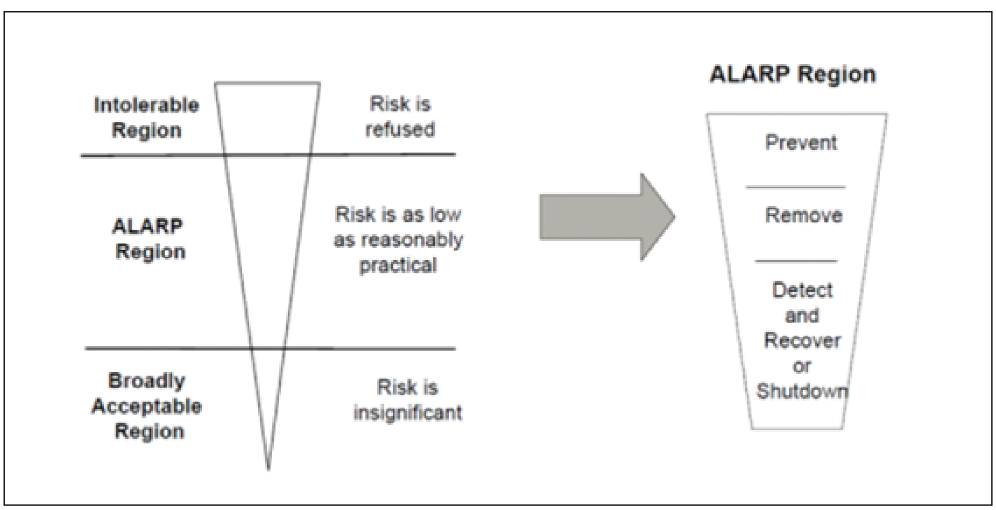


Figure 1: The ALARP Principle (HSE, 1988c). Source: Courtesy of HM Stationery Office.

risks of potential hazardous events to as low as reasonably practicable, a common shortfall when conducting risk assessments is the selection of the appropriate risk assessment type or approach to be used. Essentially, the degree of detail in the risk assessment should be commensurate to the level of the intrinsic hazard. That is, as the severity of consequence of the hazards under consideration and the complexity of the systems being assessed increases, the robustness of the risk assessment should also increase (Gadd et al 2003). Selection of the most appropriate risk assessment approach based on the degree of consequence of a particular hazard scenario prevents against the use of generic risk assessments when more site or work specific assessments may be required.

Another common pitfall when conducting risk assessments is the failure to involve a team in the assessment process or, if a team is involved, the lack of technical expertise of team members or the absence Subject Matter Experts (SMEs) due to competing work priorities. Appropriate team selection for the risk assessment process is crucial in adequately assessing the potential outcomes of hazardous operations. The expertise of team members should be relevant to the risk assessment problem statement or enhancement requirement and study context. Questions like, “What type of expertise and subsequent degree of competency would best contribute to the risk assessment study?”, should be considered when determining the best suited members for the team (Brady 2018). Additionally, organizations may have to outsource members to participate in the risk assessment study, for example in cases of work carried out by external contractors. The involvement of parties actually involved in the potentially hazardous events being analysed, is essential to the risk assessment study as the assessment scope may require the expertise of individuals who are more familiar with the nature of work to be carried out.

Team members’ attitude toward risk management can also determine the success or failure of the risk assessment process. This shortfall is related to the influence of human factors on accident causation. Usually, the direct effect of human factors as contributors to major accidents would be considered such as the increased likelihood of occurrence of accidents when organizations lack or do not enforce safety rules and regulations thereby reducing the level of safety awareness of employees (Xuecai and Guo 2018). However, organizational safety awareness may not necessarily translate to individual competence at all times. If employees feel that the risk assessment process is becoming repetitive or monotonous, employee complacency in tasks may arise, potentially decreasing awareness of or desensitizing persons to glaringly hazardous scenarios as they emerge (Flight 2021).

For site operations it may be desirable to quantify and rank the risks arising from human failures. A number of methods exist for quantifying the contribution made by human action or inaction to the overall risk from a system. These approaches, known as Human Reliability Assessment (HRA[5]) include the process of task analysis which helps with the identification of all points in a sequence of operations at which incorrect human action, or the failure to act, may lead to adverse consequences (Hurst, 1998). Procedural HAZOPs may well be applicable in high risk, manual/semi manual site operations and should be implemented to capture the human factor element and provide a quantitative risk assessment.

<u>The importance of Emergency Response Planning.</u>

An Emergency Response Plan (ERP) is a detailed program of action to control and/or minimize the effects of an emergency requiring prompt corrective measures beyond normal procedures to protect human life, minimize injury, to optimize loss control, and to reduce the exposure of physical assets and the environment from an accident. Emergency response plans are purposed to develop a state of readiness such that the response to any emergency is prompt, orderly and effective. The emergency response planning procedure should have the objectives of understanding the type and extent of consequence of potential emergencies, establishing a high level of emergency preparedness, ensuring well-organized and timely decision-making response processes and providing incident management with clear goals and actions by the appropriate lines of authority.

Risks arise when hazards are realized, and hazards can be presented as a result of work activities involving hazardous substances, machinery/processes and work organisation. Emergencies fall under the scope of non-routine activities in the risk assessment workflow. Therefore, emergency preparedness planning should be included in the mitigative/ prevent response section of the risk assessment. A gap with this approach is that in referring to the ERP as the answer to a Mitigation, stakeholders of the Risk Assessment may take the ERP for granted as a document that exists as a ‘silver bullet’ solution, but not necessarily effective in responding to a site specific hazardous event.

It is important that an experienced safety member, who is familiar with the ERP, confirm that effective credit can be taken from the plans identified in the ERP. This test may prompt an action to create a site or project specific ERP.

Effective emergency management implies that plans are put in place for all identified emergency scenarios prior to site operations. Subsequently, based on the outcome of the risk assessment, emergency plans can be further developed, and resource and knowledge gaps can then be addressed prior to the occurrence of the emergency scenario.

<u>The Risk Assessment Workflow.</u>

A dynamic approach should be taken to the Risk Assessment process by considering four (4) phases of risk assessment during the project activities: Pre-works, Site works and Mitigative/Preventive Response and Post-works. Figure 2 illustrates this below.

1) *Pre-works Phase:* Also known as the Planning Phase, this is where all relevant information and documentation necessary to execute the site operations is identified and prepared in advance. The risk assessment is conducted in a calm frame of mind as the team identifies and assesses the hazards using the appropriate formalized risk assessment methodology. At this stage, the selection of the team both from technical experience and technical applicability would be performed. Experience refers to the individuals' competence and years' experience in the industry in relation to the work site activity. Applicability refers to the composition of the team ensuring the right cross section of team members are selected for the type of activity. For example, considering a hot work type activity on a pipeline, the core team should have adequate representation from Mechanical, Process, Construction, HSE, Pipeline Subject Matter Expert, Operations team, and a Project Manager, but unlikely to include Civil or Electrical representatives. If, however, as the Risk Assessment progresses, discipline risk areas are discovered requiring assessment, the respective discipline technical representatives must be added to the core team or called upon to make an intervention.

Contractor experience is also key as the party experienced in undertaking the activity and can provide great insight and approaches to the work activity. An experienced executing contractor will most likely possess the practical knowledge for a technical work scope. It is important to emphasize that during this phase, the mood of the Team is most calm, and the team, led by the Project Manager, that has the ability to be most strategic to identify and plan for all resources, (personnel and equipment), and establish a sense of gravitas in developing contingency or project specific emergency response plans as necessary.

Cascade risks are a type of risk characterized by a 'domino effect' of one risk impacting on another, this risk type that should be identified in the planning stage where possible. The order of the risks impacting each other may happen in series or parallel with a compounding effect leading to a major catastrophe or major accident hazard event. Most organizations only consider individual risks and the impact of those on the organization, they miss out the abridged effect of multiple risks impacting on different areas of site or operational activities.

2) *Site Works Phase*: After the electronic or paper-based Risk Assessment is approved to commence work, the process parameters and environment must be continuously assessed. Regular audits should be conducted by the Project team with active assessment by key team members such as the Construction Supervisor, HSE tag and Project Manager, to assess and identify new variables such as new information or changes to process conditions. Introductions to new hazards also may arise such as Simultaneous Operations (SIMOP) activities that can impact the method of execution of the project activity. Depending on the changes, safety stand downs or revisits to the previous Risk Assessments may be warranted. Monitoring of parameters is key at this stage, as it provides indicators of variance, a sign that what was previously assessed, may be now obsolete. The use of technology can be of great benefit here as it can effortlessly and accurately track data, trigger alarms, identify values outside of acceptable limits and provide trends for future activities of similar nature.

3) *Mitigative/Preventative Response Phase:* This occurs when the incident is taking place on the work site. The mood will now be a lot different to the previous phases and this is where all parties must remain calm in order to roll out contingencies, as individuals must now make quick decisions based on experience and the information available at hand. Organizations must have a robust Business Continuity Plan (BCP) and an Emergency Response Plan (ERP) ready to follow. These plans must be developed and tested/drilled from the Planning Phase to ensure they will add great value and play a critical role in re-stabilizing the work activity in play.

The focus during this phase should be following procedures outlined by a tested plan, rather than trying to develop one. Similar to the Ability to Influence a Project vs Cost graph (Figure 3), and the Ability to Remain Calm vs Project Conse-

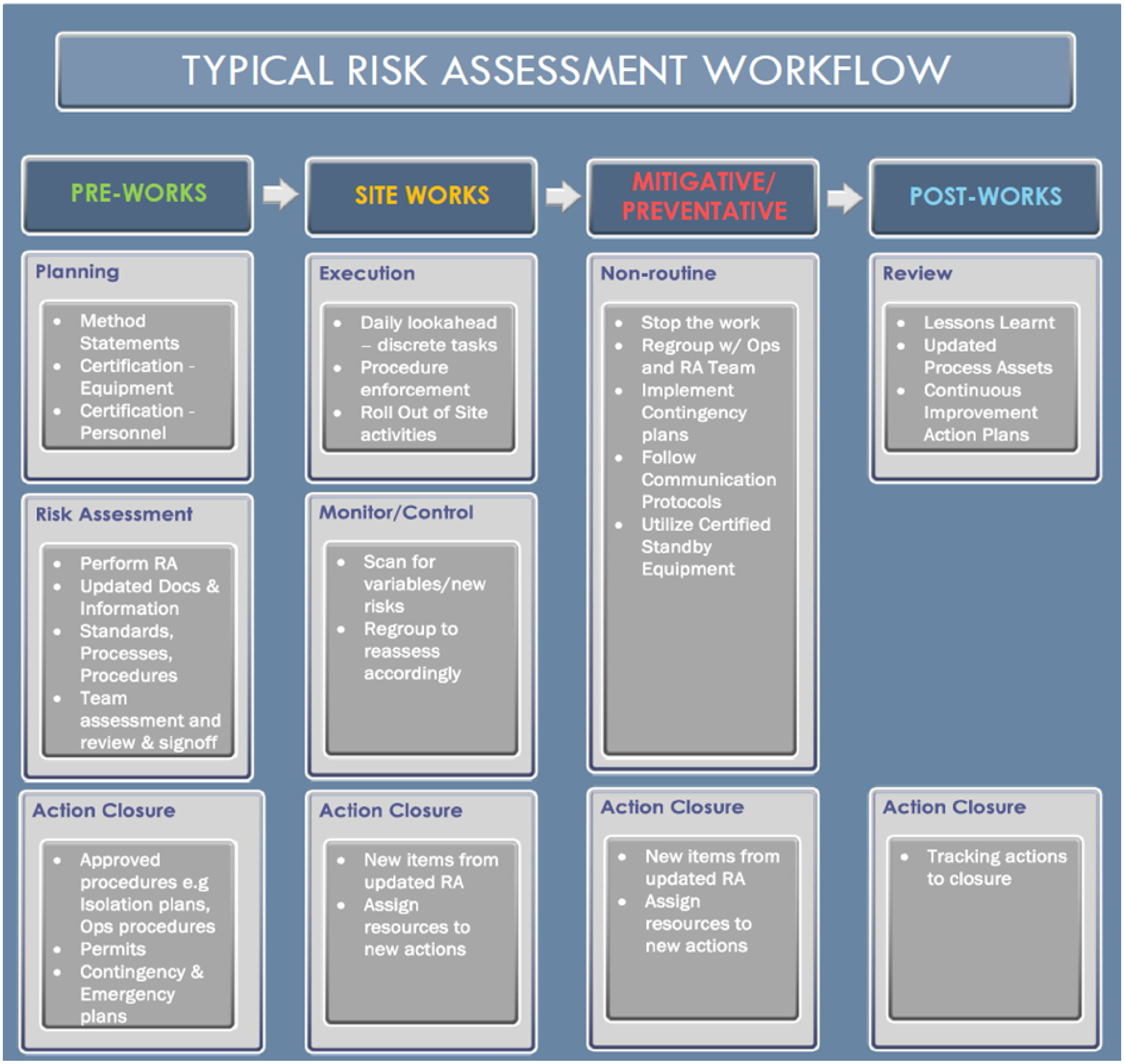


Figure 2: The Risk Assessment Workflow.

quence curves (Figure 4) repel each other as time moves along.

All items identified in contingency planning during the Pre-works phase, must be available on site, prior to the start of the work activity. This includes approved procedures, clear ERP identified for use, key personnel and equipment ready and available for use. If it is not practical to stage all the solutions, adequate emergency plans for each scenario to stabilize the situation can be prepared and time taken to mobilize said resources must be factored in. For example, most site work usually carries a degree risk of injury depending on the work activity, however it is not practical to have an ambulance on site for a job spanning say five (5) or more days, but instead having a trained HSE officer can provide necessary support to stabilize and Injured person (IP) until the professional medical response arrives.

At this stage, if the incident revolves around a Safety or Environmental consequence, every hour, minute, second counts, so upfront planning is critical to successful mitigation. The main focus of this phase is trained reacting, to be executed as calmly and quickly as possible, so as not to contribute to worsening the situation.

In many project activities, we may never experience this phase. This does not necessarily mean that excellent mitigation measures were in place, but instead, simply means a hazard event did not occur leading to a potential consequence, whether it be Safety, Environmental or Production impacting.

4) *Post-Works Phase*: This is a last phase of the workflow where the site operations are completed, and any incidents have been dealt with in the most effective way possible using best practice from the planning phase. The mood is reflective, and the mindset is how could have the team improved on what was done, what lessons can be captured and taken forward for continuous improvement to reduce risks and provide future reference. This includes updates of all relevant process assets of the organization. There is valuable information in this stage and documenting the learnings while it is still fresh in the Team's minds can be vital for future projects.

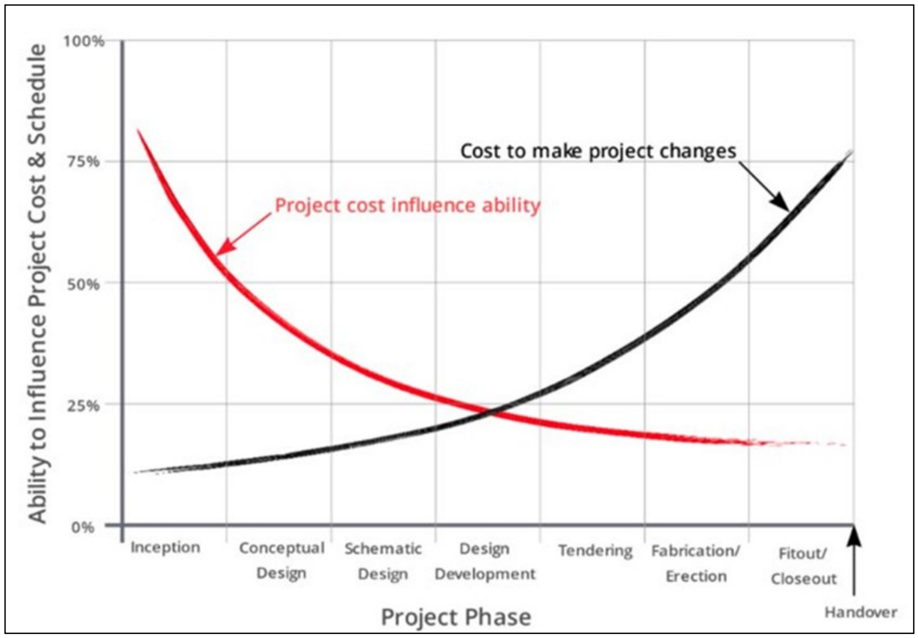


Figure 3: Ability to Influence Project vs. Project Cost.

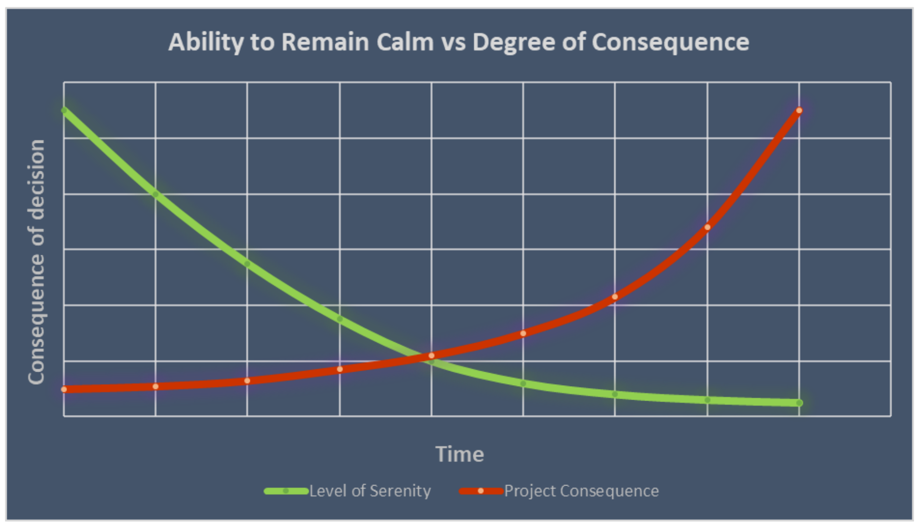


Figure 4: Ability to Remain Calm vs. Degree of Consequence.

Conclusions

Solutions to improve the methodology of risk assessing activities, strategies that could have reduced the 'gaps' in risk assessment include: Process safety management tools and processes including Safety Critical Task Analysis, Human Factors Risk Assessment, methodology for contractor capability assessment, procedure for issuing permits for emergency response, Emergency Drills, Safety Critical Equipment listings/deployment etc. can be used and referenced to ensure risks are ALARP. Regular reviews and audits by 3rd parties also assist in identifying gaps to updated international standards and assisting an organisation to follow best practices.

Technologies including spatial modelling, thermal/laser imaging inspections, unmanned vehicles and others, pressure/temperature/flow monitors, may be used to mitigate risks in day-to-day operations by facilitating comprehensive and timely analyses and diagnoses.

A robust communication plan can also help provide closer feedback and may help prevent personnel from exposure to potential hazards being created by changing variables.

Devices that track employees' movements in high-risk areas can save time in locating people during emergencies. Wearable devices that collect data to predict how long they can be in a work situation, especially those that are high-stress, before becoming fatigued, may be able to reduce the risk of human factors leading to a safety incident. New intrinsically safe trackers with heart rate monitors, locations and communication can be synced to a central system and provide real time feedback to a remote support team.

Use of mobile devices as tools that can provide meaningful information in a timely manner while also increasing employee engagement; collection of incident data, near-miss reporting, audit report findings etc.

New technologies exploited such as Big Data, analytics, mobile applications, cloud computing, enterprise resource planning, Governance, Risk, and Compliance (GRC) systems, are very important for risk management. There are also a number risk visualization apps/programs, social media, data integration to the internet to gather real-time data, digital image processing and artificial intelligence to assist in decision making.

An Enterprise Wide Risk Management (EWRM) system will aid organizations in accessing cascade risks. It covers many different aspects of strategy /operations/ projects/unforeseen risks including the interlinkages between the different risk levels and the strength of those interlinkages. EWRM systems can be tailored to an organizations risk appetite, to the extent of its risk capacity, i.e. how well it can control the risk and the duration of the risks are functional inputs (internal and external risks). As many risks are happening dynamically, it provides a framework whereby they can be captured and effectively managed, even if the unforeseen or unforeseeable risks happen, they will be able to be analysed, monitored and controlled thereafter. It is important to note the number of indicators: Key Performance Indicators (KPIs), Critical Success Factors (CSFs) and other metrics, in the EWRM help reduce the chances of unforeseen or unforeseeable hazards escalating into a Major Accident as risk identification is greatly improved.

A resource such as a 'Risk Engineer' can greatly help reduce the gaps in industrial risk assessment through all the four (4) phases of risk assessment: Pre-works/ Planning, Site works, Mitigative/ Preventive Response, and Post works, which is usually performed by the over extended Project Manager. Having a dedicated role to monitor the workflow, can help ensure governance and monitoring of the risk management processes.

In most project lifecycles, we may never experience the third phase, Mitigative/ Preventative Response Phase, much like safety drills at home or the office and safety videos in an aircraft before take off. Significant contingent and response planning should not be taken for granted and due diligence must be placed early on in the project development.

Our Closing Quote: "An ounce of prevention is worth a pound of cure." — Benjamin Franklin

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2022 EVENT RECAP

ANNUAL KICK-OFF EVENT

On the 31st March, 2022, IChemE TTMG hosted the annual kick off event virtually. During the event, Steering Committee Chairperson, Maurice Massiah, provided a comprehensive recap of the previous year's activities, after which, a short video compilation was shared showcasing the many challenges overcome in 2021. There was an exciting round of trivia, where three members were awarded prizes for displaying their knowledge of chemical and process engineering culture. A few lucky members also received door prizes. The Technical Training and Mentorship committee lead, Andre Perseval, then presented feedback from members on the performance of IChemE TTMG. The evening ended on a light note with musical entertainment provided by Jay Caplin.

FOOD TECHNOLOGISTS IN MANUFACTURING AND PROCESSING - A CHEMICAL ENGINEER'S PRESPECTIVE

On April 7th 2022, esteemed presenter Jamillah David (MEng, MSc, CFSQA), Food Technologist Consultant, shared her outlook on Food Technology and Chemical Engineering, as well as how the skillsets learnt in one support the other. Topics such as Chemical Engineering career paths within the Food industry as well as various challenges faced by Chemical engineers within this sector were discussed. Jamillah also shared her views on how the professional community can prepare for the future of food manufacturing, touching on important factors such as sustainability. Attendees gained key insight into the local Food Industry, as well as how various historical and economic policy factors have impacted the industry.

2022 EVENT RECAP

ENTREPRENEURSHIP COACHING & MENTORSHIP WEBINAR

PRESENTER: JULIAN HENRY

In this session, Mr. Julian provided an introduction to entrepreneurship, innovation and building a network. He defined entrepreneurship as the process of identifying a market gap or opportunity, investing in a new venture of innovation, making personal sacrifice and taking financial risks, and owning the financial rewards or failures of the risks taken. Entrepreneurship success factors were highlighted; these included developing an entrepreneurial mindset, setting milestone targets and planning the steps to get there, innovation (either a product or process), developing a reliable business support network, knowing the industry, and having a plan. The main steps associated with entrepreneurship were discussed: (i) basic research (discovery), (ii) business model (iii) applied research (proof of concept and prototype), (iv) market exploration and analysis, (v) implementation/business plan, (vi) implementation team, (vii) business incorporation (or IP licensing), (viii) seed capital (typically self-funded), and (ix) start-up and beta-testing. Next, Mr. Henry delved into the importance of creating systems or mechanisms that facilitate innovation and identified the main factors for success in innovation: value of the idea, market scope, and expertise for implementation. In terms of building a network, Mr. Henry emphasized the importance of establishing a network comprising of your team, the market, investors, and governments/regulators. Finally, he discussed the coaching and mentorship services of The UWI Entrepreneurship Unit and The UWI Ventures Limited.

ICHEME TTMG MENTORSHIP PROGRAMME

In February 2022, the Technical Training and Mentorship a sub-committee, led by Andre Perseval, launched the IChemE TTMG. In total, twenty three (23) members expressed interest in becoming mentees under the programme. Thirteen (13) experienced professionals volunteered their time to coach and provide valuable insight to mentees. The mentees were assigned a suitable mentor based on experience and interest areas.

IChemE

Trinidad and Tobago
Members Group

ICHEME TRINIDAD AND TOBAGO MEMBERS GROUP

ANNUAL GENERAL MEETING & MINGLE

Details
Date: Saturday 5th November, 2022
Time: 10am-12pm
Venue: To Be Confirmed

Voting for Management Committee 2022-2024

Voting for candidates to occupy the following voluntary positions on the Management Committee will occur:

1. Chairperson
2. Secretary
3. Assistant Treasurer
4. Technical Training and Mentorship (TTM) Lead
5. Applied Research (ARC) Lead
6. Networking, Fundraising, Social and Recognition (NFSR) Lead

Nominations are to be submitted via email.

Agenda

Review of 2020-2022 Term

Chairperson's Report
Events and Accomplishments
Mentorship Programme

Feature Speaker Address

Mix & Mingle

Networking and refreshments

JOIN US VIA LIVE STREAM ON OUR FACEBOOK PAGE

For further information or to request nomination forms, contact us at trinidadtobago.ichememember@gmail.com

Connect with us: @icheme_tt | IChemE Trinidad and Tobago Member Group | IChemE Trinidad and Tobago

DIRECT AIR CAPTURE (DAC) METHOD OF CARBON CAPTURE AT THE POINT LISAS INDUSTRIAL ESTATE

Author: Jaden Brereton, BSc. Chemical & Process Engineering

Introduction

Carbon Capture is an important technology used in the reduction of emissions that can be employed throughout energy system (IEA, 2021). In this method, the carbon dioxide (CO_2) captured can either be utilized for purposes such as feedstock material or stored underground in permanent geological formations. This form of technology is necessary due to a climate crisis, i.e., global warming, which has been accelerated due to increased levels of greenhouse gases (GHGs) in the atmosphere, of which CO_2 is one of the most common. The effects of this climate crisis have already been observed, in cases of higher global temperatures, rising of sea levels and erratic weather patterns. These effects pose a direct threat to both human and animal life as the environment in which they inhabit is changing.

A major site of CO_2 emissions in the country is the Point Lisas Industrial Estate (PLIE). Typically, CO_2 is produced as a by-product at this site and is sent for usage in the downstream sector in various processes. However, this method of reducing CO_2 emissions does not ensure that all of the CO_2 is eliminated, resulting in the remainder being released to the atmosphere. In recognition of this, another form of carbon capture/removal, the Direct Air Capture Process (DAC), can be examined. This method involves the extraction of CO_2 directly from the atmosphere. In essence, the process can be looked at as an enhanced photosynthetic reaction, as plants perform this removal process every day, but DAC performs it a faster rate (Carbon Engineering, 2015).

Background and Objective

<u>Emissions at the Point Lisas Industrial Estate</u>

The PLIE consists of many industrial plants in the sectors of power generation, petrochemicals, oil and gas and soft manufacturing. These commodities often produce CO_2 as a by-product of their operations and have been found to contribute to Trinidad & Tobago's yearly emissions figure of 21 MMT of CO_2 respectively in the environment (methanol and ammonia figures combined). This figure contributes to Trinidad and Tobago being considered as one of the top emitters of CO_2 in the Caribbean region.

<u>The Direct Air Capture Method</u>

This method pulls in atmospheric air, and extracts CO_2 through a series of chemical reactions before returning the air to the environment. These DAC facilities can be set up in areas where CO_2 emissions are considered to be peak, namely in highly industrialized areas, such as the PLIE. In the interest of bringing this new type of technology into existence, facilities can be set up on already existing plants to assist in their carbon removal, or as a stand-alone type plant. Both initiatives can assist companies on the PLIE, and by extension Trinidad and Tobago, in its stride to achieve net-zero goals set forth by 2050. Modes of carbon capture at industrial sites follows three main steps: capture, transportation and storage. Upon capture of the CO_2, it is compressed and deeply chilled into fluid form, and then transported to a storage site through pipelines. In the final step, it is injected into underground geological formations to be stored for long term, to prevent its release into the atmosphere. Examples of these storage sites are former oil and gas reservoirs, deep saline formations and coal beds. This stored CO_2 can also be put into use in the manufacture of products such as synthetic fuels, to allow for more gas captured than released.

The DAC process can be designed to utilise a liquid sorbent or a solid sorbent for application (IEA, Direct Air Capture, November 2021).

1. Liquid Sorbent Method

This method makes use of a chemical solvent to absorb CO_2. Typically, the solvent used is sodium hydroxide (NaOH), which binds to the carbon molecules, allowing for the return of clean air to the environment.

2. Solid Sorbent Method

This method makes use of solid sorbent filters which bond easily with the CO_2. Upon the binding of the molecules, the filters are subjected to heat to release concentrated CO_2 to be captured and stored.

The DAC method generally makes use of four major pieces of equipment: an air contactor, a pellet reactor, a calciner and a slaker, as shown in **Figure 1** (David W. Keith 2018).

1. Air Contactor

This is a large structure that is modelled off of an industrial cooling tower. A giant fan is responsible for pulling air into the contactor, where it will pass over plastic surfaces that have either a liquid sorbent or solid sorbent flowing over them. This compound binds with the CO2 molecules, removing them from the air, trapping them in liquid form in a carbonate salt.

2. Pellet Reactor

The function of this reactor is to separate the salt from the carbonate solution into small pellets., a method utilized in water treatment technology.

3. Calciner

In this equipment, the pellets are heated to release the CO2 into a pure gas form. This equipment holds similarity to one utilized in the ore processing the mining industry.

4. Slaker

In the calciner process, often some processed pellets are left behind. These pellets are hydrated in a slaker and recycled back into the system to produce the original capture chemical.

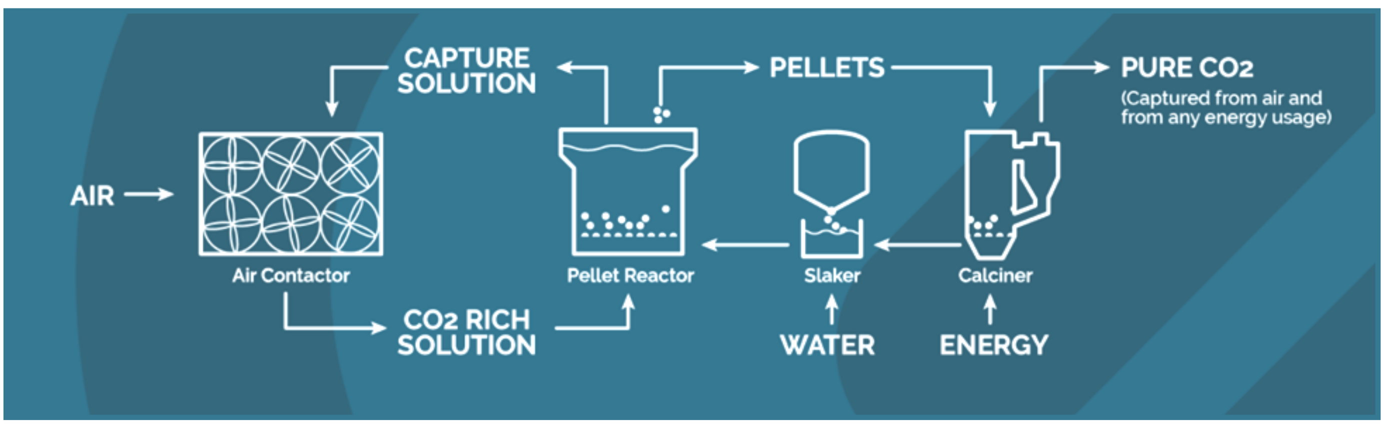

Figure 1: Process Flow Diagram of Direct Air Capture (DAC) Process.

Objectives

- The research project was conducted to ascertain the feasibility of introducing a 1MT/yr DAC facility at the Point Lisas Industrial Estate. This pilot facility will exist on site at the ammonia producing company Nutrien, to further assist in their CO_2 removal method, aiding in their stride to decarbonization.
- This idea can be sold to petrochemical companies at the Point Lisas Industrial Estate, with the main premise being achieving decarbonization goals by 2050. In recognition of their efforts already established for this purpose, the DAC facility will enhance these efforts.
- This initiative can shine light on activity at the PLIE, an industrial centre in need of restructuring, to drive the shift for a more sustainable manufacturing industry.
- In addition to this, invitations can be extended for pre-purchasing of carbon dioxide for removal from the atmosphere. This incentive can be offered to potential investors and multi-national entities in Trinidad and Tobago, who share the common goal of eliminating more carbon dioxide than they emit.
- Extension of the initiative to the average citizen who is passionate about climate change and would like to help out in decarbonization efforts. With the assistance from the Government of Trinidad and Tobago, or private entities, for subsidization of the cost, these individuals can have a chance to contribute to efforts.

Site Location and Environment

It is proposed that the DAC facility be set up in the vicinity of Nutrien, at the PLIE. The chosen site borders Nutrien's ammonia plants. Thus, this pilot DAC facility would be used to assist the company in bringing carbon emissions in the area surrounding the plant to a minimum. **Figure 2** shows the sitelocation.

There are no specific environmental considerations for the construction of the carbon capture facility. These sites can be placed at any location, provided that a sufficient power source is available, and storage sites exist, to carry on its operations. Particularly, at the PLIE, power can be obtained from the area's T&TEC Power Station. However, power obtained in this manner utilizes the burning of natural gas, a counter-productive step, when trying to accomplish net-zero emissions. As a result, investigations can be done into the use of steam for powering of the facility.

Carbon Dioxide obtained at this facility, can be processed and then stored underground or utilized for the manufacture of products such as synthetic fuels. Storing of the carbon emissions underground allows for its reduction in the atmosphere, resulting in the amount of gas being captured being more than the amount released. Its use for the production of synthetic fuels assists in keeping a balance of CO_2 in the atmosphere, preventing its increase.

Figure 2: Proposed Location for Direct Air Capture (DAC) Facility in the Point Lisas Industrial Estate.

Method

Simulations were performed on two main equipment of the DAC process, the Air Contactor and the CO_2 Compression System using the Aspen Plus software. These equipment play instrumental roles in capturing and removing CO_2 from atmospheric air and were modelled based on guidance provided in a project by (Andrea Lanzini, 2018), demonstrating a complete model of the DAC process. These two components don't possess templates on the Aspen Plus software and hence were modelled making use of common process equipment to mimic their operation and achieve the desired results.

Results

In the financial aspect of this proposal, some notable costing figures that were drawn up were: Capital Investment ($446.5 M USD), Utility Cost ($22.0 USD/hr), Maintenance Cost ($ 182.8 M USD) and Total Project Cost ($1.1 B USD). These figures were quoted in US currency as relevant pricing data, for factors such as equipment and raw materials, were obtained from a research paper titled, "A Process for Capturing CO_2 from the Atmosphere" by (David W. Keith 2018). Due to a high estimated project cost, a profit and loss forecast was devised after one year of operation, adding credibility to the facility's potential to be profitable and feasible. The forecast was performed making use of figures of US $600 – $775 per ton for removal of CO_2, and highlighted an increase in profit as the plant's operation progressed, a trend seen in the Net Profit and Net Profit Margin graphs, **Figure 3** and **Figure 4** respectively. This observation showed a direct relationship to the demand for removal of carbon from the atmosphere, highlighting the project's profitability and feasibility.

It must be noted that the figures utilized in the forecast were reference figures that companies such as Microsoft, Shopify and Stripe, were willing to pay for removal of CO_2. Shopify, for example, has made their purchase for 322.5 tons of CO2 at a rate of $775 per ton, at the Zurich-based company Climework's Orca facility (Clouse, 2021).

Conclusion

The Direct Air Capture method of carbon capture can be an asset to reducing greenhouse gas emissions at the PLIE. This is due to the existence of point sources of emissions, making it an ideal location for setting up of the pilot facility. In bringing forth this project, the site chosen for the construction of the facility was centered around the operations of the company Nutrien. However, to assist in the efficiency of future projects, site location can be chosen based on performing air quality tests, to confirm the need for a DAC facility to reduce CO_2 concentration in the air. The feasibility of the operations was determined by considering all requirements for the facility such as equipment, plant personnel, construction costs and other miscellaneous costs, to estimate the total project cost. At the end of the analysis, the estimated total project cost was high and the venture uneconomic. However, with the use of a profit and loss forecast, reflecting the plant's potential after a year of operation, will allow for the plant's viability to be recognized.

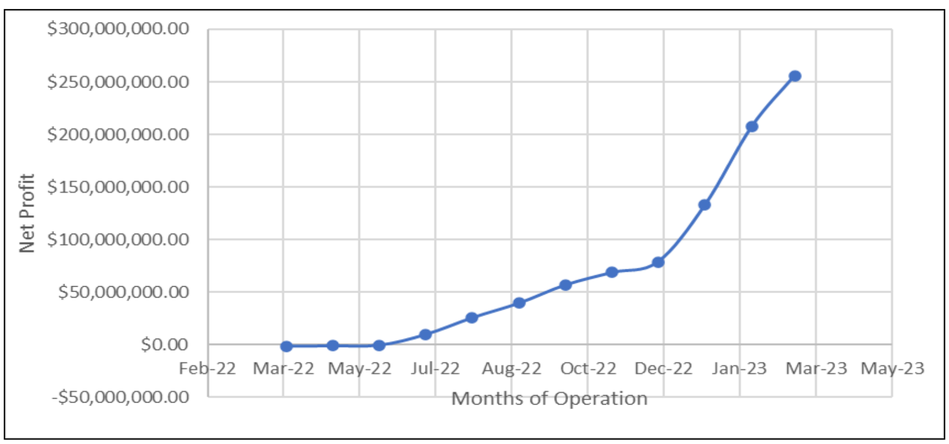

Figure 3: Net Profit for First Year of Operation of DAC Facility.

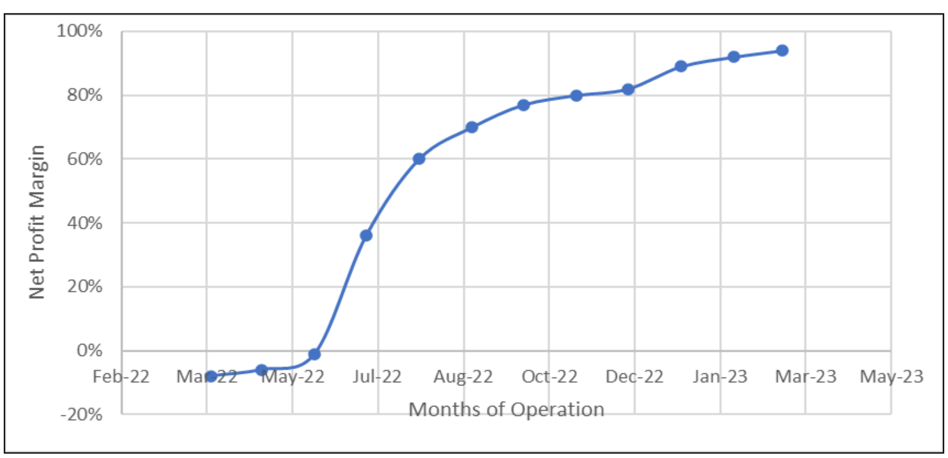

Figure 4: Net Profit Margin for First Year of Operation of DAC Facility.

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OH WHAT A FELLOW!

Canute Hudson

Technical Authority, Process Engineering

Canute Hudson has over 25 years' experience in the petrochemical and LNG industries, with approximately 20 years in the latter. He has a BSc. Degree in Chemical and Process Engineering, MBA in Oil and Gas Management and Diploma in Financial Management. He is also a Registered Engineer in Trinidad and Tobago as well as a Fellow at the Institution of Chemical Engineers (IChemE).

At Atlantic LNG, Canute has held discipline and supervisory process engineering, and project management roles with increasing seniority. Canute is currently Technical Authority – Process Engineering at Atlantic LNG. At IChemE, Canute has progressed over the last ten years from Associate Member to Chartered member status and now, Fellow. Canute also served as the Treasurer of the Trinidad and Tobago Members Group from 2015 to 2020.

Vasant Saith

Vice President, LNG Asset Solutions

Vasant has 19 years of experience in Engineering and Construction of which 16 years has been in integrated, specifically in the LNG sector. He provides execution oversight to portfolio and project managers on small to large standalone projects, portfolios of projects and strategic pursuits in the US. The scope of projects includes greenfield and brownfield EPC projects, debottlenecking and production optimization scopes, turnaround and maintenance management, provision of owner's engineering, operations readiness and decarbonization projects for most of the major LNG operators in the US. He also supports pursuits and provides execution guidance to key global gas and LNG Customers.

Vasant is regarded as an LNG subject matter expert in the Worley global organization. He provides technical and commercial guidance to both greenfield and brownfield projects across the globe as a designated project executive and project advisor. His involvement in LNG projects spans the full project lifecycle from early conceptual designs through to startup and operation. He has worked on over 20 LNG projects supporting owners and investors on projects that employ various liquefaction technologies, both onshore and offshore and for a wide range of production capacities.

Vasant has spent several years working with licensors, equipment manufacturers and LNG Customers on decarbonization solutions involving pre-combustion and post-combustion carbon capture, hydrogen production for fuel gas substitution, electrification and other carbon intensity reduction solutions for new and existing facilities. He regularly presents at international conferences to promote decarbonization initiatives in the LNG industry.

Volton Edwards

Process Safety Advisor

Volton Edwards holds a BSc degree in Chemical and Process Engineering from the University of the West Indies and an MBA from the University of Reading. He has over 24 years of experience in the Oil & Gas industry working in Refining, Midstream, Upstream and as a consultant in a wide range of activities including Process Operations, Engineering Design, Assurance, Process Safety and Risk Management.

Volton's career in Oil & Gas began as a process engineer at the PETROTRIN Refinery supporting various process units. He later specialized in the area of process safety and risk management working with Det Norske Veritas (DNV) and BHP Billiton. He has been employed at BP for the last 17 years where he has held several senior process safety roles including Process Safety Team Lead and Process Safety Technical Authority. For several years, he represented BP on the Technical & Operational Oversite Committee for Atlantic LNG and has been the Process Safety Subject Matter Expert on the assurance teams, for numerous BP major project startups. He is a trained and experienced Emergency Response Incident Commander. Once a teacher, he continues his love for teaching and mentoring through the delivery of numerous training courses including HAZID, HAZOP, LOPA, MAR and Process Safety Fundamentals.

Volton is a Senior Level Leader at BP and currently holds the position of Process Safety Advisor in BP's central Innovation and Engineering Team where he provides technical leadership for process safety engineering. His responsibilities include the development and implementation of process safety technical requirements, practices, and tools to be used across the company. He also represents BP on industry standards committees.

Over the years, Volton has progressed from Associate Member to Chartered Member and now a Fellow with the IChemE. He is also a registered Professional Process Safety Engineer with the IChemE and a Registered Engineer with the Board of Engineering of Trinidad and Tobago.

During his off time Volton enjoys spending time with his family and traveling to various locations. He is an avid DIYer so you can catch him working and lots of different projects. He also loves being outdoors where he relaxes by doing some gardening, golfing, jogging or just enjoying the scenery.

IChemE TTMG would like to extend a heartfelt

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METHANE MEASUREMENT AND REDUCTION BY MEASUREMENT OF FLARE COMBUSTION EFFICIENCY

Authors: Bhamini Matabadal-Charles & Sulana Chunilal

Introduction

Greenhouse gases (GHGs) absorb energy and reduce the rate at which it moves from the earth's atmosphere into space leading to warming of the earth's surface. Human activities such as industrial processes have altered the earth's natural balance of GHGs such that their concentrations in the atmosphere have intensified.

This has resulted in climate change as evidenced by the increase in global average air & ocean temperatures as well as the rising of the global average sea level (Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, Chapter 1 - Introduction 2014). In fact, climate models forecast that the global temperature will rise by circa 1 – 3.5 °C by the year 2100 if there is no abatement of GHGs (UNFCC Information Unit for Conventions (IUC) n.d.).

Therefore, global climate change frameworks are geared towards maintaining a global temperature rise of less than 2 °C by the year 2100, when compared to pre-industrial levels. Renowned climate change accords, polices and alliances include the following:

Paris Agreement

This treaty aims to intensify global response to changes in the climate in the aspect of sustaining development and eliminating poverty. All parties to the agreement (which includes the Republic of Trinidad and Tobago) agree to pursue efforts consistent with the following (United Nations 2015):

Holding the increase in the global average temperature to well below 2°C, preferably to 1.5°C above pre-industrial levels in order to limit the risks and impacts of climate change

Increasing ability to adapt to climate change and low GHG emissions development without negative impact on food production

Financing in line with low GHG emissions development.

European Green Deal

This strategy was presented in 2019 and aims to transform the European Union (EU) to climate neutral status by the year 2050. The European Commission has set out a number of policies for achieving emission reductions of at least 55% by 2030 relative to 1990 levels (European Commission 2020).

At this juncture, it should be noted that the United States of America (USA) is also considering carbon border adjustment taxes to help cut GHG emissions in global trade as indicated by the President Joe Biden at the Leaders' Summit on Climate in April 2021.

Impact of Methane

The Global Warming Potential (GWP) for substances are referenced to carbon dioxide (CO_2), which is assigned a value of 1. In this regard, the GWP of methane (CH_4) has been evaluated to be 29.8±11 over a 100-year timeframe (Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, Chapter 7 - The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity, 2021). Furthermore, the GWP for methane increases to 82.5±25.8 when evaluated for a 20-year period.

Methane's atmospheric lifetime is estimated to be approximately 11.8±1.8 years (IPCC Sixth Assessment Report) compared to centuries for carbon dioxide (CO_2). However, the immediate impact of methane to the environment is higher due to its GWP. This means that methane reduction will significantly slow the rate of global warming. In fact, the European Commission estimates that a 50% reduction in methane emissions over the next 30 years can prevent a 0.2 °C global temperature increase. Therefore, there is a global initiative to accurately report and reduce methane emissions.

Atlantic has been at the forefront of local climate change mitigation with the reporting of its GHG emissions which started in 2006 and subsequently by the issuing of its annual Greenhouse Gas and Energy Management Plan (GHG EMP), which commenced in 2017. The facility's GHG EMP provides an analysis of the facility's GHG inventory, reviews and updates the status of existing GHG abatement projects as well as outlines the plan for new opportunities for GHG reduction in accordance with Atlantic's corporate strategy.

One of the GHG projects currently being pursued is the installation of new technology for the measurement of Flare Combustion Efficiency. The project is intended to measure methane emissions from the facility's flares with the goal of improving reporting accuracy and ultimately reducing methane emissions from the flares.

Hydrocarbon Conversion at Flares

Flares are designed based on Destruction Efficiency (DRE). DRE is a measure of how much hydrocarbons are destroyed while combustion efficiency (CE) is a measure of the extent to which hydrocarbons burn completely to produce carbon dioxide and water vapor (EPA, 2012).

When post combustion gases can be accurately measured, CE is calculated as follows (Hydrocarbon Engineering , 2016):

$$CE(\%) = \frac{[C]_{CO2}}{\sum_i n_i[C]_{HCi} + [C]_{CO} + [C]_{CO2}} \times 100$$

Where:

CO_2: Volume concentration of carbon dioxide when combustion has stopped

CO: Volume concentration of carbon monoxide when combustion has stopped

HC_i: Volume concentration of hydrocarbon compound remaining when combustion has stopped.

However, since the concentration of CO is significantly smaller than CO_2 , CE is approximated as follows:

$$CE(\%) = \frac{[C]_{CO2}}{\sum_i n_i[C]_{HCi} + [C]_{CO2}} \times 100$$

It should be noted that the relationship between DRE and CE is not constant and changes for different compounds. CE is either equal to or less than DRE however, the estimation of 1.5% difference is a reasonable assumption (EPA, 2012).

Flaring Regulations

The Republic of Trinidad and Tobago does not currently have legislation for flaring and by extension, combustion efficiency, however, with the global and local focus on climate change, it would be prudent to anticipate future regulations for the local industry. A proactive approach for monitoring and control of flared emissions can be developed by considering the current USA Environmental Protection Agency's (EPA) Rule 40 CFR § 63.670 (Environmental Protection Agency, 2015), Sections (b) through (e), which require the following:

(b) – Presence of pilot flame
(c) – No visible emissions
(d) – Actual flare tip velocity (Dependent on the Maximum Allowable Control Technology Program for the respective Flare - Either maximum of 60 ft/s or 400 ft/s)
(e) – Minimum combustion zone net heating value of 270 Btu/scf.

Parameters (d) and (e) are surrogates specified by the EPA for control of CE, which is required to be a minimum of 96.5%. It must however be noted that research has proven that it is possible for some flares to meet the required CE (greater than 96.5%) with a combustion zone net heating value less than 270 Btu/scf (Providence Photonics, 2018).

Therefore, equipment which measures CE is valuable for accurate monitoring, control, and reporting of flare emissions.

Atlantic's Flare Combustion Efficiency Project

Facility flaring is a source of direct emissions at Atlantic and is therefore monitored and reported as part of Scope 1 GHG emissions in the facility's GHG and Air Emissions Inventory, annual corporate Sustainability Report and GHG Energy Management Plan.

The Atlantic 2021 GHG and Air Emissions Inventory indicates that emissions from flaring amounted to 239,809 tCO2e, of which 25,362 tCO2e were attributed to methane (CH4) flaring. However, it must be noted that the estimated flaring values are not measured and based on an assumed flare CE of 98% in accordance with IPCC and American Petroleum Institute (API) standards.

An appreciation of the potential error due to CE assumptions is represented in Table 1 below.

Table 1: Potential Impact of Assumed CE

	Sensitivity Analysis	
	98% CE[1]	**96.5%CE[2]**
Flared CH_4, tCO2e	25,362	44,383

Notes:

[1]Source: Atlantic 2021 GHG and Air Emissions Inventory

[2]Minimum Acceptable Flare Performance based on EPA Rule 40 CFR § 63.670

Flare Combustion Efficiency Measurement

The base method for determining Flare Combustion Efficiency is the Extractive Sampling test method (EPA 320). For this method, a probe assembly and pump are used to extract gas from the exhaust of the source and transport the sample to a Fourier Transform Infrared (FTIR) gas cell for analysis (URS Corporation, Texas Commission on Environmental Quality (TCEQ) 2004).

This Extractive Sampling method is not practical for continuous flare CE monitoring, therefore, technologies available on the open market were investigated for use at Atlantic.

The Atlantic project assessment has determined that the following two technologies can provide continuous CE measurements for DCS monitoring and historization:

- CE Algorithm (e.g., Baker Hughes Flare IQ)
- Video Imaging Spectral Radiometer (VISR) Technology (marketed by both Zeeco and Providence Photonics).

The Flare IQ software calculates CE. Inputs to the software include the following:

- Mass flow rate, molecular weight, velocity (these parameters can be provided by ultrasonic flowmeters)
- Flared Gas Heating value
- Wind speed.

The VISR technology directly measures the species in the flare combustion zone to determine CE. The technology is based on the use of a multispectral imager to measure the wavelengths of combustion products and unburned hydrocarbons in a three- dimensional image of the flare.

The project assessment at Atlantic is ongoing and a suitable technology will be for implementation at Atlantic.

Measurement of CE at Atlantic is intended to improve the accuracy of reported GHG emissions and is reflective of its efforts to proactively self-regulate. It also provides the added benefit of being in a state of readiness for potential future legislations.

Some considerations to guide the selection of an appropriate technology for use are shared in Table 2 below.

Table 2: Flare Combustion Efficiency Technology – Technical Selection Considerations.

Item	Deliberation
Accuracy	• Does the Facility operate with one or two flares per derrick? • Can the technology discern the individual combustion efficiency in scenarios where two (2) flares are installed on the same derrick? • Does the organization's strategy require the reporting of individual flare combustion efficiency? • Is the accuracy impacted by gas composition?
Constructability	Consider integration flexibility
Reliability	• Redundancy in communication (alternative communication (Ethernet, Modbus)) • Repeatability of value • Impact of Environmental factors (rain/wind speed and direction)
Maintainability	• Ease of Access to conduct maintenance • Frequency of Calibration
Safety	• Installation of equipment outside of flare radiation zone

<u>Recommended Additional Reading</u>

https://www.worldoil.com/magazine/2021/september-2021/features/flare-combustion-monitoring-system-for-upstream-flares

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Disclaimer:

This article represents the opinions of the authors and is the product of professional research. It is not meant to represent the views or official policy of Atlantic LNG Company of Trinidad and Tobago.

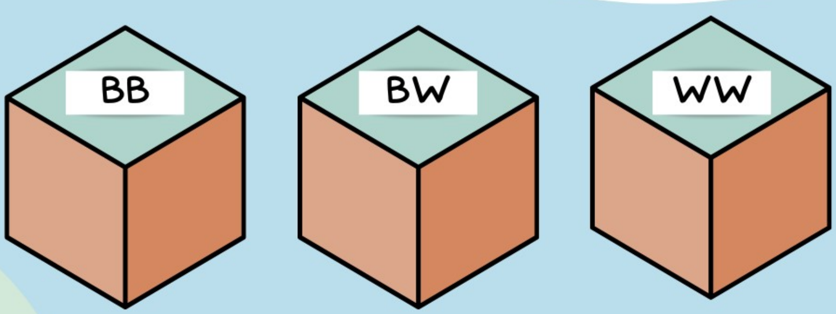
FUN SECTION

Have A Laugh!

To the optimist, the glass is half full.
To the pessimist, the glass is half empty.
To the engineer, the glass is twice as big as it needs to be.

Brainteaser

Imagine that you have three boxes, one containing two black marbles, one containing two white marbles, and the third, one black marble and one white marble. The boxes were labelled for their contents - BB, WW, BW - but someone has switched the labels so that every box is now incorrectly labelled. You are allowed to take one marble at a time out of any box, without looking inside, and by this process of sampling, you need to determine the contents of all three boxes. What is the smallest number of drawings needed to do this?



Answer: 1