"Comprehensive Analysis of Fugitive GHG Emissions: Assessing and Mitigating the Environmental and Economic Impact"

***Disclaimer**: The data utilized for this analysis was provided by the hiring team specifically for the purpose of skill assessment.*

Objective:

- To analyze and evaluate the levels of fugitive greenhouse gas (GHG) emissions from various facilities of Huanle Noodles between January 1, 2021, and December 1, 2023. The primary aim is to identify the main contributors to fugitive emissions, assess which gases contribute the most to the total emission volume, and understand the financial implications of these emissions as energy losses or inefficiencies. Additionally, the objective is to recommend strategies to mitigate emissions, reduce energy waste, and minimize financial losses.

Goal:

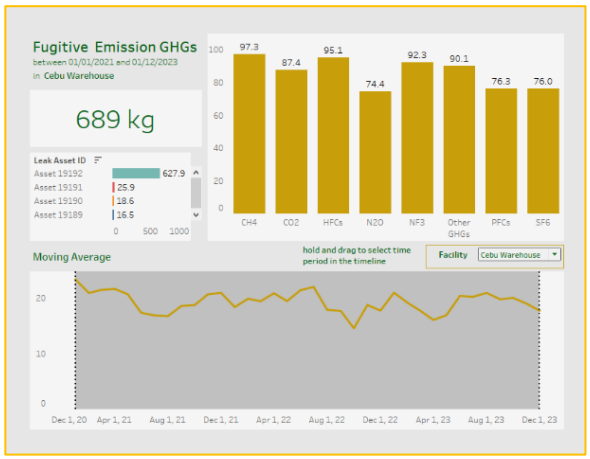
- Identify the total fugitive GHG emissions across all Huanle Noodles facilities.
- Pinpoint the specific leak assets that contribute the most emissions and potential financial losses.
- Analyze the composition of GHGs per facility to determine the most problematic gases and estimate the associated energy and financial losses.
- Provide actionable recommendations to reduce overall emissions and inefficiencies, focusing on major emission contributors to improve both environmental performance and operational cost efficiency.

Analysis Summary:

1. **Cebu Warehouse**

- Total fugitive emission GHGs: 689 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 627.9 kg (91% of the total).
- Top 3 highest GHGs:
    - CH4 (Methane): 97.3 kg
    - HFCs (Hydrofluorocarbons): 95.1 kg
    - NF3 (Nitrogen Trifluoride): 92.3 kg

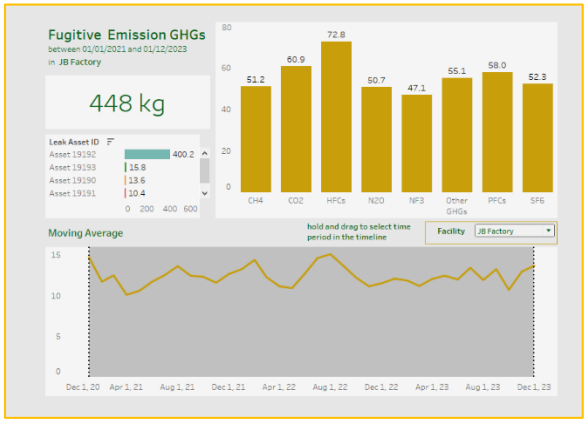
screenshot



2. **JB Factory**

- Total fugitive emission GHGs: 448 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 400.2 kg (89% of the total).
- Top 3 highest GHGs:
    - HFCs: 72.8 kg
    - CO2 (Carbon Dioxide): 60.9 kg
    - PFCs (Perfluorocarbons): 58 kg

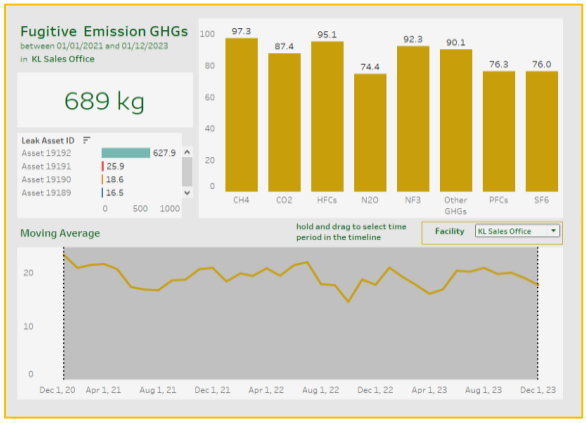
screenshot



3. **KL Sales Office**

- Total fugitive emission GHGs: 689 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 627.9 kg (91% of the total).
- Top 3 highest GHGs:
    - CH4: 97.3 kg
    - HFCs: 95.1 kg
    - NF3: 92.3 kg

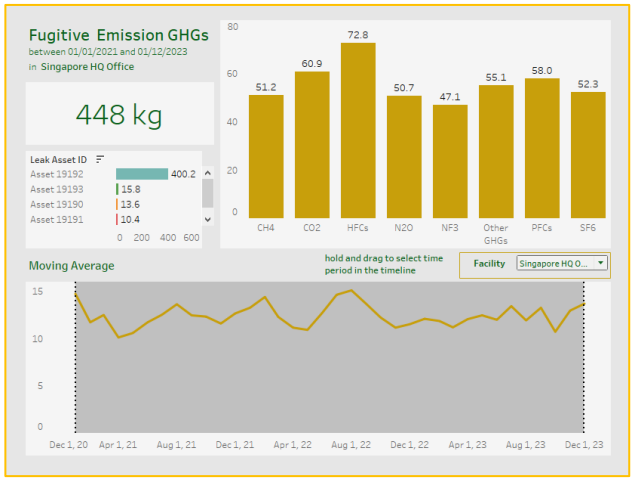
screenshot



4. Manila Sales Office

- Total fugitive emission GHGs: 448 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 400.2 kg (89% of the total).
- Top 3 highest GHGs:
    - HFCs: 72.8 kg
    - CO2: 60.9 kg
    - PFCs: 58 kg

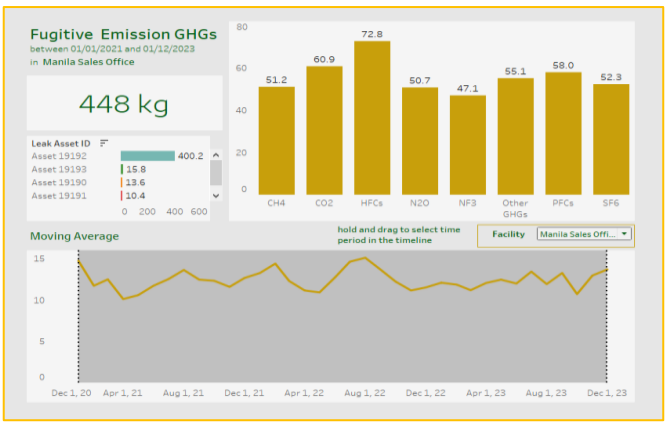
screenshot



5. Singapore HQ Office

- Total fugitive emission GHGs: 448 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 400.2 kg (89% of the total).
- Top 3 highest GHGs:
    - HFCs: 72.8 kg
    - CO2: 60.9 kg
    - PFCs: 58 kg

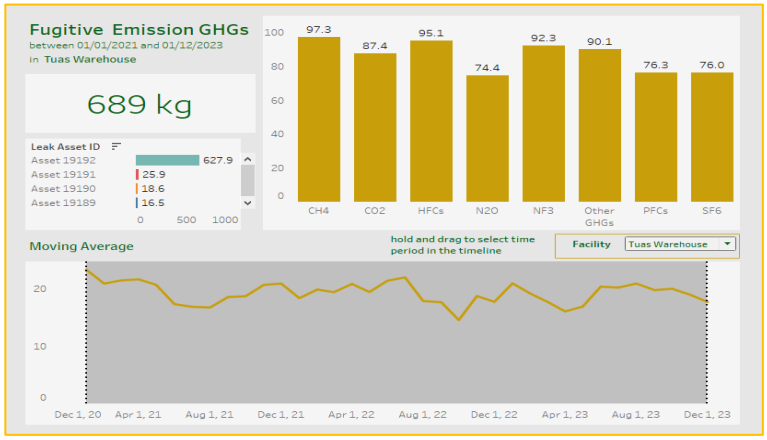
screenshot



6. Tuas Warehouse

- Total fugitive emission GHGs: 689 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 627.9 kg (91% of the total).
- Top 3 highest GHGs:
    - CH4: 97.3 kg
    - HFCs: 95.1 kg
    - NF3: 92.3 kg

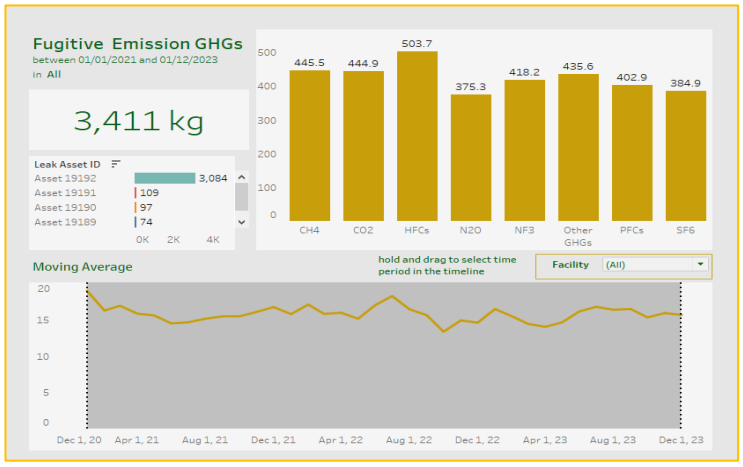
Screenshot



7. All Facilities

- Total fugitive emission GHGs: 3,411 kg
- Highest leak asset:
    - HVAC leak asset no. 19192 contributing 3,084 kg (90% of the total).
- Top 3 highest GHGs:
    - HFCs: 503.7 kg
    - CH4: 445.5 kg
    - CO2: 444.9 kg

Screenshot



Environmental Impact Analysis

- Fugitive emissions pose a substantial threat to the environment due to their contribution to global warming and ozone depletion. In particular:
    - HFCs (Hydrofluorocarbons) are potent GHGs with a high global warming potential (GWP), making them a major contributor to climate change.
    - CH4 (Methane) is also a highly potent GHG that contributes to the warming of the atmosphere.
    - Emissions of CO2, while less potent per unit than HFCs or CH4, are still a significant contributor to overall climate change given their quantity.

Insights:

1. Consistent Asset Leakage Across Facilities:

- The HVAC leak asset no. 19192 consistently accounts for around 90% of the fugitive emissions across all facilities. This suggests a critical need for maintenance or replacement of this specific asset. Reducing leakage from this source can significantly lower overall emissions.

2. Top GHG Contributors:

- Across the facilities, the highest contributors to emissions are HFCs, CH4, and CO2. This implies that the company needs to focus on reducing emissions from these gases, especially HFCs, which are potent GHGs with high global warming potential.

3. Facility Performance:

- Some facilities, like Cebu Warehouse, KL Sales Office, and Tuas Warehouse, have higher total emissions than others. Targeting these higher-emitting facilities for improvement could lead to the most significant emission reductions.

4. Emission Reduction Focus:

- HFCs have emerged as the largest contributor across all facilities (503.7 kg), followed by CH4 (445.5 kg). This suggests that replacing or upgrading cooling systems that use HFCs and improving containment of methane emissions could provide the most substantial benefit in emission reductions.

Recommendations to Mitigate Environmental Impact:

1. Immediate Inspection and Repair of HVAC Systems:

- Given that HVAC leak asset no. 19192 is the highest source of emissions, conducting an immediate inspection and repair (or replacement if necessary) across all facilities should be prioritized.

2. Adoption of Low-GWP Alternatives:

- For HFCs, the company should consider transitioning to low-GWP (global warming potential) refrigerants or other cooling technologies that produce fewer GHG emissions.

3. Methane Containment:

- Since CH4 emissions are a significant contributor, better containment strategies for methane leaks should be explored. Regular inspection and maintenance of equipment responsible for methane leaks could help reduce overall emissions.

4. Focus on High-Emission Facilities:

- Targeting emissions reduction efforts in the highest-emitting facilities (Cebu Warehouse, KL Sales Office, Tuas Warehouse) would yield the greatest reduction in total GHG emissions.

Economic Impact Analysis

- Fugitive emissions not only contribute to environmental degradation but also have direct financial impacts on a company's operations. These emissions often result from energy inefficiencies, leaks, or poor equipment performance, all of which translate into financial losses due to wasted resources and energy.

Insight:

1. Energy Wastage Due to Fugitive Emissions:

- Fugitive emissions, particularly from HVAC systems (such as leak asset no. 19192), signify inefficiency in energy usage. For example, the refrigerants used in HVAC systems, like HFCs, leak into the atmosphere, resulting in both energy loss and the need for more frequent refrigerant refills or maintenance. This inefficiency drives up operational costs.

2. Increased Operating and Maintenance Costs:

- The HVAC leak asset no. 19192 alone contributed up to 90% of the total emissions across all facilities. This suggests significant inefficiencies in the HVAC systems, leading to increased costs for energy consumption, repair, maintenance, and regulatory compliance (e.g., environmental penalties). Regular leaks, such as those of HFCs, also incur additional costs associated with refrigerant refills and heightened maintenance cycles. The refrigerants themselves are expensive, and recurring leaks can cause a financial strain.

3. Regulatory and Compliance Costs:

- Many governments are tightening regulations related to GHG emissions. Fines and penalties can be imposed on companies that exceed emission thresholds, particularly for high-GWP gases like HFCs. Thus, companies with fugitive emissions risk incurring regulatory fines or additional carbon tax liabilities, further inflating the economic impact.

4. Decreased Equipment Lifespan:

- Equipment, such as HVAC systems, that frequently leaks or performs inefficiently due to fugitive emissions is prone to faster wear and tear, reducing the overall lifespan of critical machinery. This not only leads to increased capital expenditure for new equipment but also causes downtime and disruptions to operations, impacting productivity and profitability.

5. Energy Inefficiency and Increased Energy Bills:

- Fugitive emissions are often indicative of poor energy efficiency. Leaks of gases such as methane (CH4) or refrigerants (HFCs) contribute to excessive energy use since the systems have to work

harder to maintain their performance levels. This results in higher utility bills as more energy is consumed to compensate for the inefficiencies.

Recommendations to Mitigate Economic Impact:

1. Invest in Energy-Efficient Technologies:

- Replace outdated HVAC systems and other equipment prone to leaks with energy-efficient models that reduce both emissions and energy consumption. Using low-GWP alternatives to HFCs can lower costs associated with refrigerant loss and refills. For example, transitioning from HFCs to more sustainable alternatives (e.g., natural refrigerants) can provide long-term financial savings by lowering energy usage and reducing environmental impact.

2. Perform Energy Audits:

- Regular energy audits should be conducted to assess the energy efficiency of each facility. By identifying where energy is being wasted, the company can take steps to optimize processes, reduce operational costs, and improve equipment performance. Optimizing HVAC usage and implementing proper maintenance practices can reduce energy bills, saving thousands annually across multiple facilities.

3. Predictive Maintenance and Monitoring:

- Deploy predictive maintenance systems to monitor the health of critical systems, especially HVAC equipment. These systems use real-time data and analytics to predict when equipment is likely to fail or require maintenance, minimizing downtime and reducing both operational and capital expenditures. Predictive systems reduce the need for emergency repairs and extend the lifespan of equipment, further reducing costs.

4. Training and Awareness Programs:

- Training staff on the importance of minimizing emissions and improving energy efficiency can lead to better equipment usage, early detection of leaks, and faster response times. An engaged workforce can reduce overall energy consumption and limit financial losses. Regular training sessions on the maintenance of energy-intensive equipment, leak detection, and proper energy management practices should be prioritized. Leverage Renewable Energy:

Conclusion:

- The data analysis reveals that addressing fugitive emissions in specific assets and gases can lead to significant reductions in overall GHG output. By prioritizing the HVAC systems and focusing on high-emitting GHGs like HFCs and CH4, the company can achieve its sustainability goals more effectively and reduce its environmental impact. Future efforts should involve continuous monitoring, maintenance, and adopting more environmentally friendly technologies to minimize the company's fugitive GHG footprint. furthermore, By addressing fugitive emissions through modern equipment upgrades, proactive maintenance programs, energy audits, and leak detection systems, the company can mitigate significant financial losses associated with energy inefficiencies. Not only will this improve environmental compliance, but it will also enhance the bottom line by reducing operational and maintenance costs, improving equipment longevity, and ensuring overall energy efficiency across all facilities.

Appendices

Technology Used:

- This analysis has been accomplished using Pandas for data manipulation and exploratory data analysis (EDA), and Tableau for visualization.

Resources:

- https://www.thermofisher.com/blog/identifying-threats/what-are-fugitive-emissions-why-do-they-matter/
- https://www.climate-chance.org/wp-content/uploads/2019/03/new-fugitive-emissions-a-blind-spot-in-the-fight-against-climate-change.pdf
- https://www.climate-chance.org/wp-content/uploads/2019/03/new-fugitive-emissions-a-blind-spot-in-the-fight-against-climate-change.pdf
- https://www.sciencedirect.com/science/article/pii/B9780323919289000013