Cre8Sustainability Competition:

Proposed Design Improvements for Frasers Tower to achieve lower Carbon Footprints

School: Temasek Polytechnic

Registration No. : IHL032

Building: Frasers Tower

Names of Group Members:

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I. Introduction

The objective of this project is to seamlessly integrate sustainability principles into the urban design framework of Frasers Tower, with a primary focus on lowering carbon footprints through innovative solutions. Comprising three distinct areas, the project aims to revolutionize the environmental impact of Frasers Tower by enhancing energy efficiency, waste management, and water conservation practices. By conducting thorough research and analysis, along with leveraging data-driven insights, this project seeks to identify areas in need of improvement and propose actionable strategies to attain measurable carbon reduction targets. Embracing sustainability as a foundational principle, Frasers Tower is positioned to establish pioneering standards in environmentally conscious urban development, leading the charge towards a more sustainable and eco-friendly future.

II. Overview

3 Areas working on **Energy Efficiency, Water Management and Waste Management**

The Goals are to achieve desired carbon reduction target and to design, innovate and reimagine sustainability through landscapes and architecture.

Recommendations

1. Sustainability Awareness Campaign
2. FraSaver's Challenge
3. DCI System for Cooling Tower
4. Bubble90 Nozzle
5. Bin-E
6. NOVENCO AHU Fans
7. PIR Light Sensor
8. Wind Energy Harvester by NTU
9. Photovoltaic Solar Film Sticker

III. Consumption Data

Electricity Consumption:

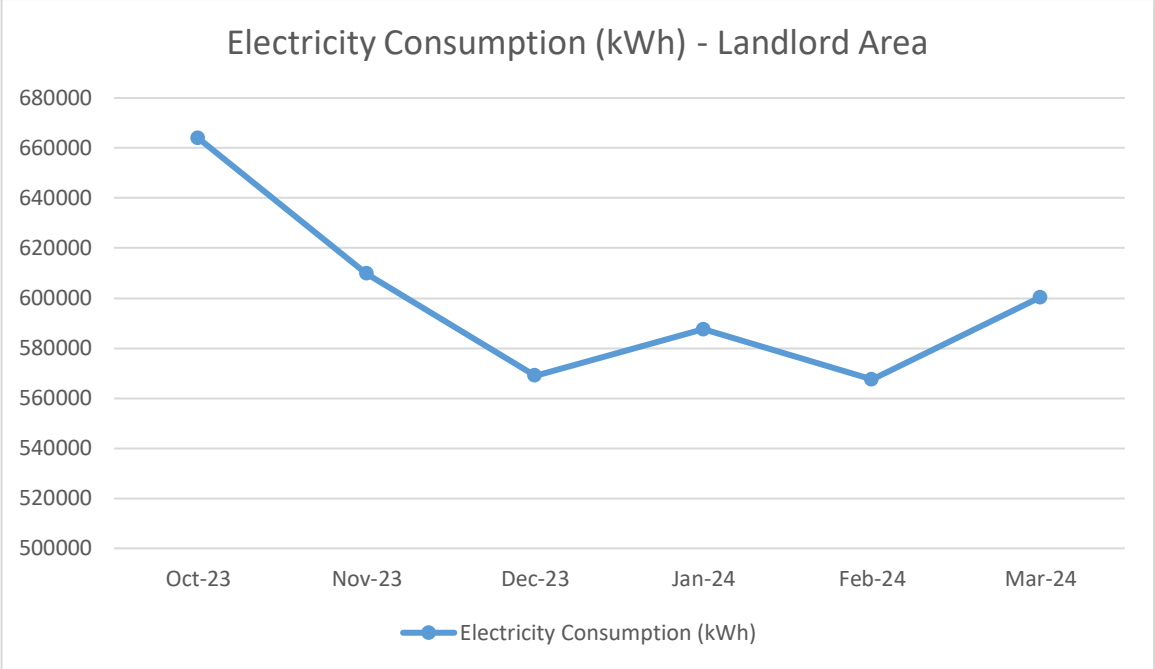
- **Monthly Electricity Consumption – Landlord Area – kWh**

Month	Electricity Consumption (kWh)	Carbon Emission (kgCO2e)
Oct-23	663,900	269,344.23
Nov-23	609,800	247,395.86
Dec-23	569,000	230,843.30
Jan-24	587,600	238,389.32
Feb-24	567,500	230,275.32
Mar-24	600,400	243,582.28
Total	3,598,200	1,459,830.31
Average	599,700	243,305.052

- **Emission Factor**
  The Emission Factor for waste is 0.4057 kg CO2e per kwh (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Electricity Consumption: 3,598,200 kWh
  Total Carbon Emissions: 1,459,830.31 kg CO2e
  Average Monthly Electricity Consumption: 599,700 kWh
  Average Monthly Carbon Emissions: 243,305.052 kg CO2e

- Oct-23: 663,900 kWh x 0.4057 kg CO2e per kWh = 269,344.23 kg CO2e
- Nov-23: 609,800 kWh x 0.4057 kg CO2e per kWh = 247,395.86 kg CO2e
- Dec-23: 569,000 kWh x 0.4057 kg CO2e per kWh = 230,843.30 kg CO2e
- Jan-24: 587,600 kWh x 0.4057 kg CO2e per kWh = 238,389.32 kg CO2e
- Feb-24: 567,600 kWh x 0.4057 kg CO2e per kWh = 230,275.32 kg CO2e
- Mar-24: 600,400 kWh x 0.4057 kg CO2e per kWh = 243,582.28 kg CO2e



Electricity Consumption – Landlord Area:

- The month with the highest electricity consumption is October 2023 with a number of 663,900 kWh. A possibility is due to pre-festive season activity like Deepavali preparations and high business activity periods.
- There was a sudden decrease of 54,100 kWh from October 2023 to November 2023. This may be due to the post-festive season, activities slow down which reduce electricity consumption.
- The month with the lowest electricity consumption is February 2024 with a number of 567,500 kWh. A possibility is due to festive season like Chinese New Year, which many would be celebrating it, reducing operational days.

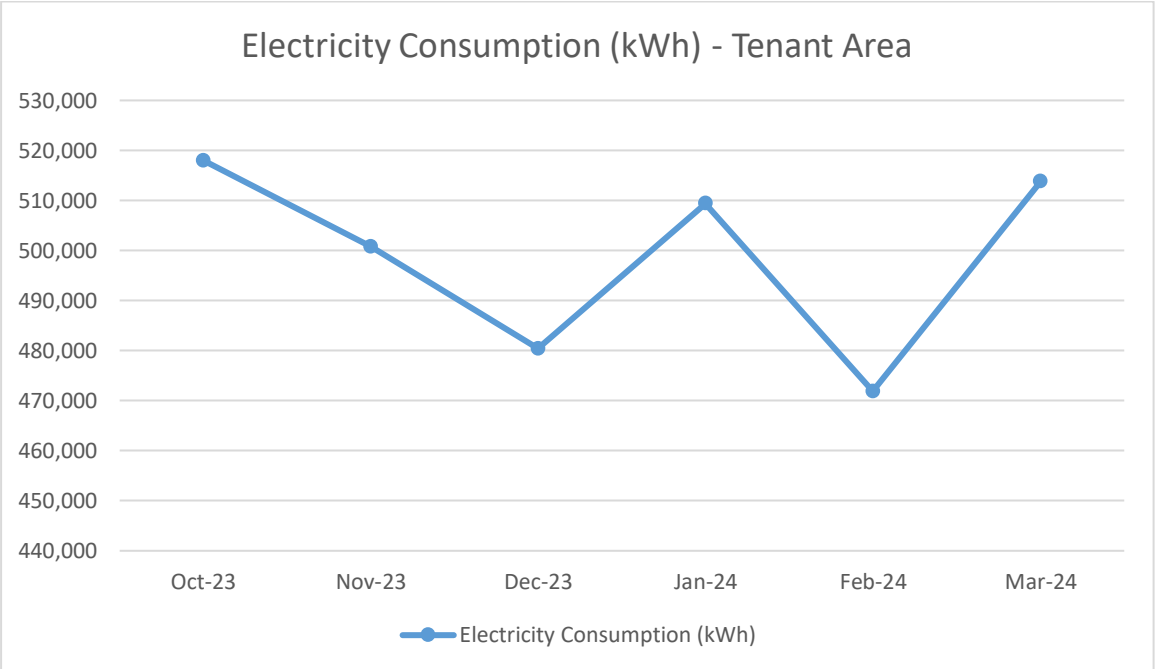
- **Monthly Electricity Consumption – Tenant Area – kWh**

Month	Electricity Consumption (kWh)	Carbon Emission (kgCO2e)
Oct-23	518,000	210,154.60
Nov-23	500,800	203,248.56
Dec-23	480,400	194,853.08
Jan-24	509,400	206,480.58
Feb-24	471,900	191,363.83
Mar-24	513,800	208,335.46
Total	2,994,300	1,214,436,11
Average	499,050	202,406.02

- **Emission Factor**
  The Emission Factor for waste is 0.4057 kg CO2e per kwh (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Electricity Consumption: 2,994,300 kWh
  Total Carbon Emissions: 1,214,436,11 kg CO2e
  Average Monthly Electricity Consumption: 499,050 kWh
  Average Monthly Carbon Emissions: 202,406.02 kg CO2e

- Oct-23: 518,000 kWh × 0.4057 kg CO2e per kWh = 210,154.60 kg CO2e
- Nov-23: 500,800 kWh × 0.4057 kg CO2e per kWh = 203,248.56 kg CO2e
- Dec-23: 480,400 kWh × 0.4057 kg CO2e per kWh = 194,853.08 kg CO2e
- Jan-24: 509,400 kWh × 0.4057 kg CO2e per kWh = 206,480.58 kg CO2e
- Feb-24: 471,900 kWh × 0.4057 kg CO2e per kWh = 191,363.83 kg CO2e
- Mar-24: 513,800 kWh × 0.4057 kg CO2e per kWh = 208,335.46 kg CO2e



Electricity Consumption – Tenant Area:

- The month with the highest electricity consumption is October 2023 with a number of 518,000 kWh. A possibility is due to pre-festive season activity like Deepavali preparations and high business activity periods.
- There was a sudden decrease of 15,116.75 kWh from January 2024 to February 2024. There might be reduction in business activities as festive season coming, Chinese New year, leading to a drop in electricity reduction.
- The month with the lowest electricity consumption is February 2024 with a number of 471,900 kWh. A possibility is due to festive season like Chinese New Year, which many would be celebrating it, reducing operational days.

Waste Combusted:

- **Monthly Waste Incineration (with Energy Recovery) Data - Whole Building (Landlord-controlled)**

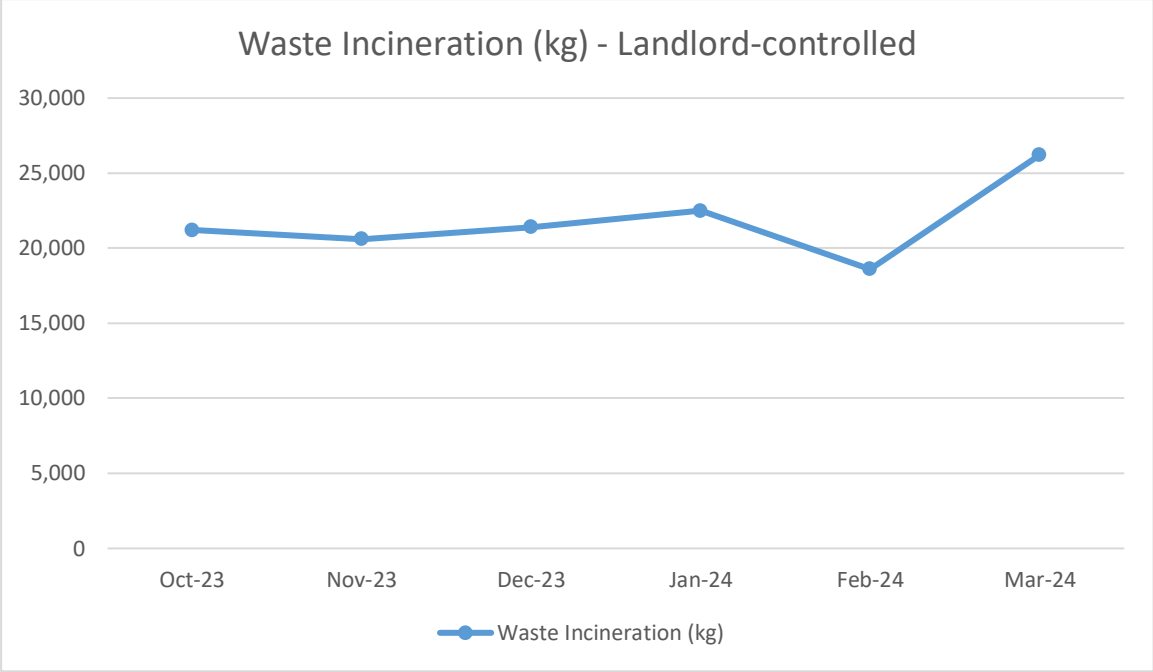
Month	Waste Incineration (kg)	Waste Incineration (tonnes)	Carbon Emission (kgCO2e)
Oct-23	21,200	21.2	451.1332
Nov-23	20,600	20.6	438.4186
Dec-23	21,400	21.4	455.3394
Jan-24	22,500	22.5	478.8225
Feb-24	18,600	18.6	395.8266
Mar-24	26,200	26.2	558.5622
Total	130,500	130.5	2776.1505
Average	21,750	21.75	462.39075

- **Emission Factor**
  The Emission Factor for waste is 21.281 kg CO2e per tonnes.
  (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Waste Incineration: 130,500 kg
  Total Carbon Emissions: 2776.1505 kg CO2e
  Average Monthly Waste Incineration: 21,750 kg

Average Monthly Carbon Emissions: 462.39075 kg CO2e

- Oct-23: 21.2 tonnes x 21.281 CO2e/tonne = 451.1332 kg CO2e
- Nov-23: 20.6 tonnes x 21.281 CO2e/tonne = 438.4186 kg CO2e
- Dec-23:21.4 tonnes x 21.281 CO2e/tonne = 455.3394 kg CO2e
- Jan-24: 22.5 tonnes x 21.281 CO2e/tonne= 478.8225 kg CO2e
- Feb-24:18.6 tonnes x 21.281 CO2e/tonne = 395.8266 kg CO2e
- Mar-24: 26.2 tonnes x 21.281 CO2e/tonne = 558.5622 kg CO2e



Waste Incineration – Landlord Area:

- The month with the highest waste incineration is March 2024 with a number of 26,200 kg. There is possible reason due to post-festive cleanup, there may be many waste as tenants and landlords clean up decorations and dispose of additional waste generated during the festive period.
- There was a sudden increase of 7,600 kg from February 2024 to March 2024. The businesses resuming normal operations after the festive break, leading to an increase of waste generation and incineration.
- The month with the lowest waste incineration is February 2024 with a number of 1,470 kg. During the Chinese New Year period, many businesses operate at reduced capacity or close entirely, leading to less waste generated.

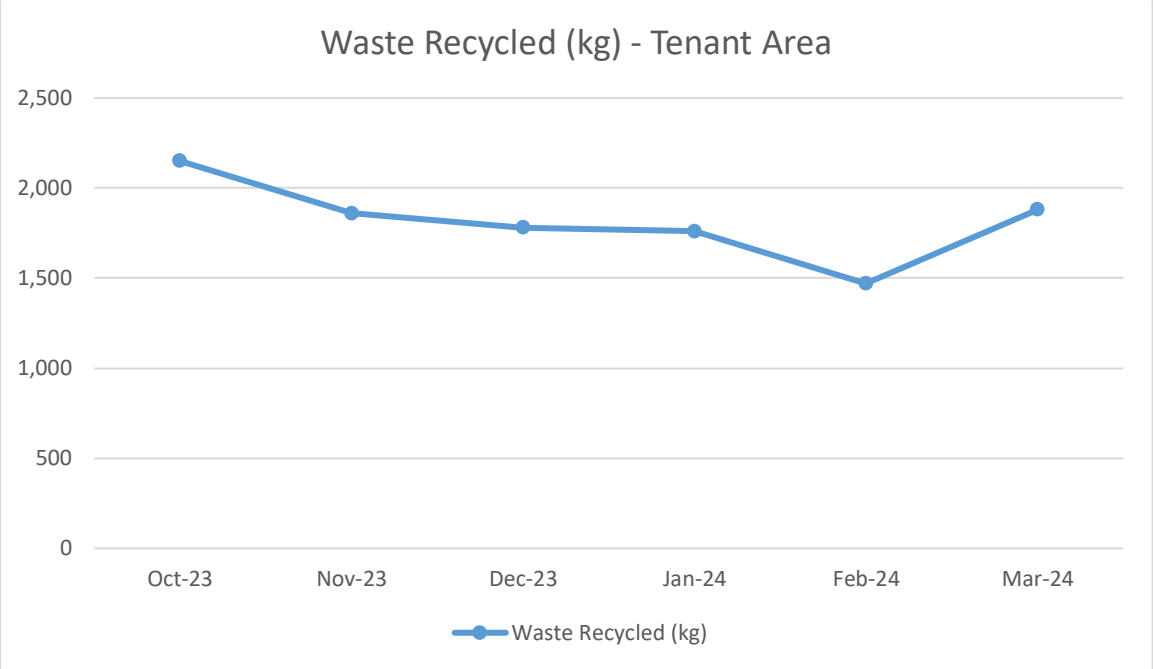
- **Waste Recycled Data: Operating Properties - Whole Building (Landlord-controlled)**

Month	Waste Recycled (kg)	Waste Recycled (tonnes)	Carbon Emission (kgCO2e)
Oct-23	2,150	2.15	45.75415
Nov-23	1,860	1.86	39.58266
Dec-23	1,780	1.78	37.88018
Jan-24	1,760	1.76	37.45456
Feb-24	1,470	1.47	31.28307
Mar-24	1,880	1.88	40.00828
Total	10,900	10.9	231.9629
Average	3,114.285	3.114285	38.66048333

- **Emission Factor**
  The Emission Factor for waste is 21.281 kg CO2e per tonnes.
  (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Waste Recycled: 10,900 kg
  Total Carbon Emissions: 231.9629 kg CO2e
  Average Monthly Waste Recycled: 3,114.285 kg
  Average Monthly Carbon Emissions: 38.6605 kg CO2e

- Oct-23: 2.15 tonnes x 21.28 kg CO_2e/tonne = 45.7542 kg CO2e
- Nov-23: 1.86 tonnes x 21.28 kg CO2e/tonne =39.58266 kg CO2e
- Dec-23:1.78 tonnes x 21.28 kg CO2e/tonne = 37.88018 kg CO2e
- Jan-24: 1.76 tonnes x 21.281 kg CO2e/tonne = 37.45456 kg CO2e
- Feb-24:1.47 tonnes x 21.281 kg CO2e/tonne = 31.28307 kg CO2e
- Mar-24: 1.88 tonnes x 21.281 kg CO2e/tonne = 40.00828 kg CO2e



Waste Recycled – Tenant Area:

- The month with the highest waste recycled is March 2024 with a number of 1,880 kg. There may be possible reasons such as post-festive cleanup and spring cleaning. The tenants may engage in extensive and spring cleaning so they may sort and recycle a larger amount of waste.
- There was a sudden increase of 410 kg from February 2024 to March 2024.
- The month with the lowest waste recycles is February 2024 with a number of 1,470 kg. A reason for low waste recycled is during Chinese New Year, many tenants might be on holiday, reducing the amount of waste generated and subsequently recycled.

Water Consumption:

- **Monthly Water Consumption Data- Tenant area -kL**

Month	Water Consumption Landlord (kl)	Water Consumption (ML)	Carbon Emission (kgCO2e)
Oct-23	950	0.95	167.965
Nov-23	1150	1.15	203.505
Dec-23	1140	1.14	201.138
Jan-24	810	0.81	143.187
Feb-24	890	0.89	157.863
Mar-24	1140	1.14	201.138

Total	6080	6.08	1,074.336
Average	1013.33	1.01333	179.056

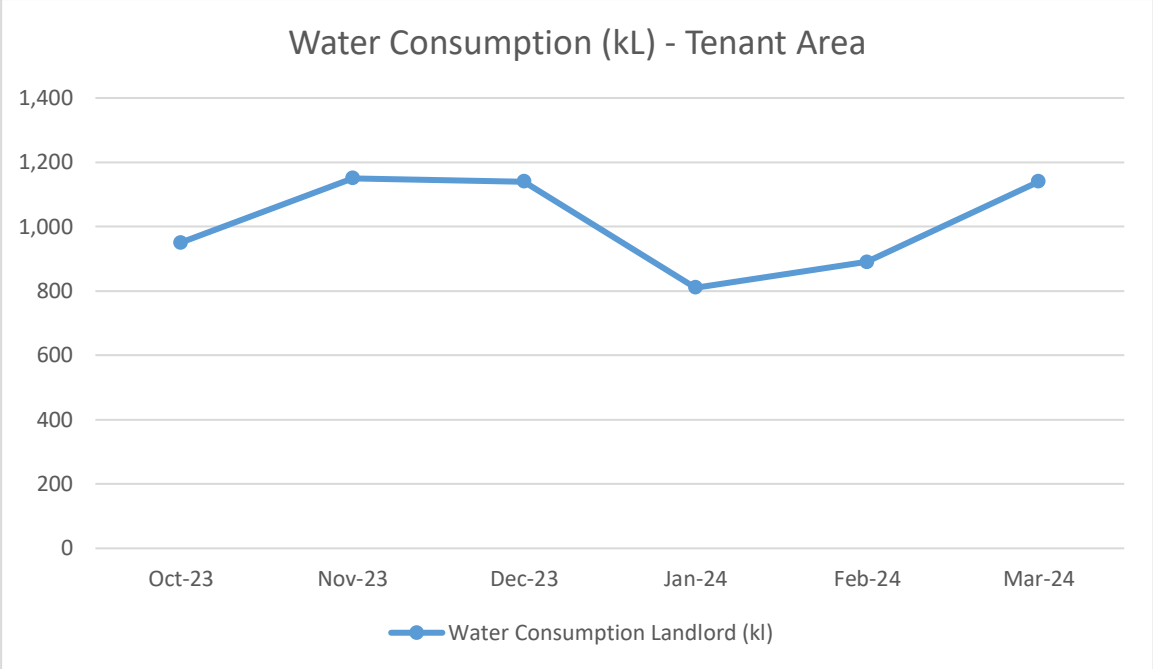
- **Emission Factor**

  The Emission Factor for water is 176.7 kg CO2e per million litres.

  (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Water Consumption: 6080 kL
  Total Carbon Emissions: 1,074.336 kg CO2e
  Average Monthly Water Consumption: 1013.33 kL
  Average Monthly Carbon Emissions: 179.056 nkg CO2e

- Oct-23:
  Water Consumption (ML) = 950 kL / 1000 = 0.95 ML
  Carbon Emission = 0.95 ML x 176.7 kg CO2e/ML = 167.865 kg CO2e
- Nov-23:
  Water Consumption (ML) = 1150 kL / 1000 = 1.15 ML
  Carbon Emission = 1.15 ML x 176.7 kg CO2e/ML = 203.205 kg CO2e
- Dec-23:
  Water Consumption (ML) = 1140 kL / 1000 = 1.14 ML
  Carbon Emission = 1.14 ML x 176.7 kg CO2e/ML = 201.438 kg CO2e
- Jan-24:
  Water Consumption (ML) = 810 kL / 1000 = 0.81 ML
  Carbon Emission = 0.81 ML x 176.7 kg CO2e/ML = 143.127 kg CO2e
- Feb-24:
  Water Consumption (ML) = 890 kL / 1000 = 0.89 ML
  Carbon Emission = 0.89 ML x 176.7 kg CO2e/ML = 157.263 kg CO2e
- Mar-24:
  Water Consumption (ML) = 1140 kL / 1000 = 1.14 ML
  Carbon Emission = 1.14 ML x 176.7 kg CO2e/ML = 201.438 kg CO2e



Water Consumption – Tenant Area:

- The month with the highest water consumption from the tenant area is November 2023 with a number of 1,150 kL. There are possible reasons like pre-festive activities where there is increased tenant activity and preparations for the festive season such as Deepavali and Christmas, could cause lead to higher water usage for cleaning and other activities. Another reason is high business activity. November is often a busy month for many businesses, meaning AC would be operating for longer hours, contributing to higher water consumption.
- There was a sudden decrease of 330 kL from December 2023 to January 2024 due to feastive season and preparation for Chinese New Year. The drop could be attributed to the aftermath of the festive season, with many tenants still on holiday and reduced operation hours.
- The month with the lowest water consumption from the tenant area is January 2024 with a number of 810 kL. A reason could be Chinese New Year preparation. Some businesses might start closing early for Chinese New Year, reducing water usage.

Water Consumption:

- **Monthly Water Consumption Data- Landlord area - Domestic Water - kL**

Month	Water Consumption Landlord (kl)	Water Consumption (ML)	Carbon Emission (kgCO2e)
Oct-23	3950	3.95	697.965
Nov-23	4690	4.69	828.423

Dec-23	4490	4.49	793.383
Jan-24	4350	4.35	768.645
Feb-24	3950	3.95	697.965
Mar-24	4100	4.10	724.47
Total	25530	25.53	4,511.851
Average	4255	4.255	751.975

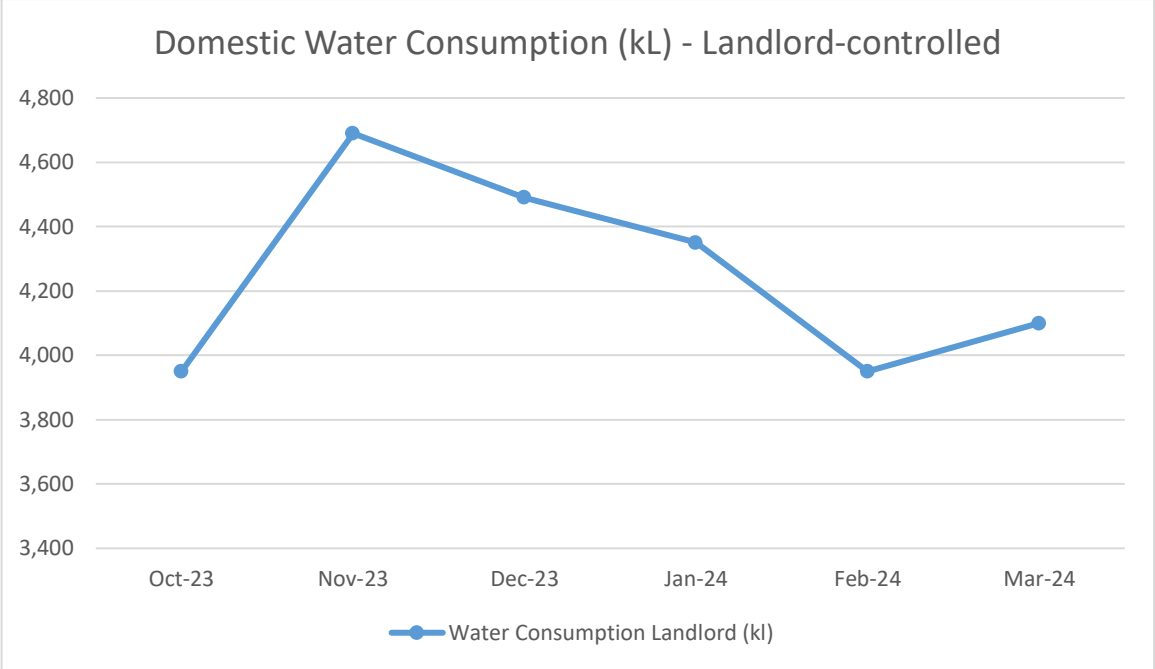
- **Emission Factor**

  The Emission Factor for water is 176.7 kg CO2e per million litres.

  (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Water Consumption: 25,530 kL
  Total Carbon Emissions: 4,511.851kg CO2e
  Average Monthly Water Consumption: 4,255 kL
  Average Monthly Carbon Emissions: 751.975 kg CO2e

- Oct-23:
  Water Consumption (ML) = 3950 kL / 1000 = 3.95 ML
  Carbon Emission = 3.95 ML x 176.7 kg CO2e/ML = 697.965 kg CO2e
- Nov-23:
  Water Consumption (ML) = 4690 kL / 1000 = 4.69 ML
  Carbon Emission = 4.69 ML x176.7 kg CO2e/ML = 828.423 kg CO2e
- Dec-23:
  Water Consumption (ML) = 4490 kL / 1000 = 4.49 ML
  Carbon Emission = 4.49 ML x 176.7 kg CO2e/ML = 793.383 kg CO2e
- Jan-24:
  Water Consumption (ML) = 4350 kL / 1000 = 4.35 ML
  Carbon Emission = 4.35 ML x 176.7 kg CO2e/ML = 768.645 kg CO2e
- Feb-24:
  Water Consumption (ML) = 3950 kL / 1000 = 3.95 ML
  Carbon Emission = 3.95 ML x 176.7 kg CO2e/ML = 697.965 kg CO2e
- Mar-24:
  Water Consumption (ML) = 4100 kL / 1000 = 4.10 ML
  Carbon Emission = 4.10 ML x 176.7 kg CO2e/ML = 724.47 kg CO2e



Domestic Water Consumption – Landlord Area:

- The month with the highest water consumption from the tenant area is November 2023 with a number of 4690 kL. There might be large events that was held which could lead to higher water usage.
- There was a sudden increase of 330 kL from October 2023 to November 2023. There may be scheduled maintenance activities such as HVAC system flushing or cooling tower cleaning that could contribute to higher water consumption.
- The month with the lowest water consumption from the tenant area is January 2024 with a number of 810 kL. A reason would be businesses may have extended holiday closure, leading to significantly lower water usage.

- **Monthly Water Consumption Data - Landlord area - NEWater – kL**

Month	Water Consumption Landlord (kl)	Water Consumption (ML)	Carbon Emission (kgCO2e)
Oct-23	1370	1.37	241.079
Nov-23	1860	1.86	328.722
Dec-23	1689	1.689	298.4163
Jan-24	1580	1.58	279.306
Feb-24	1470	1.47	259.629
Mar-24	1870	1.87	330.369
Total	9839	98.39	1737.5213
Average	1639.833	1.639833	289.587

- **Emission Factor**

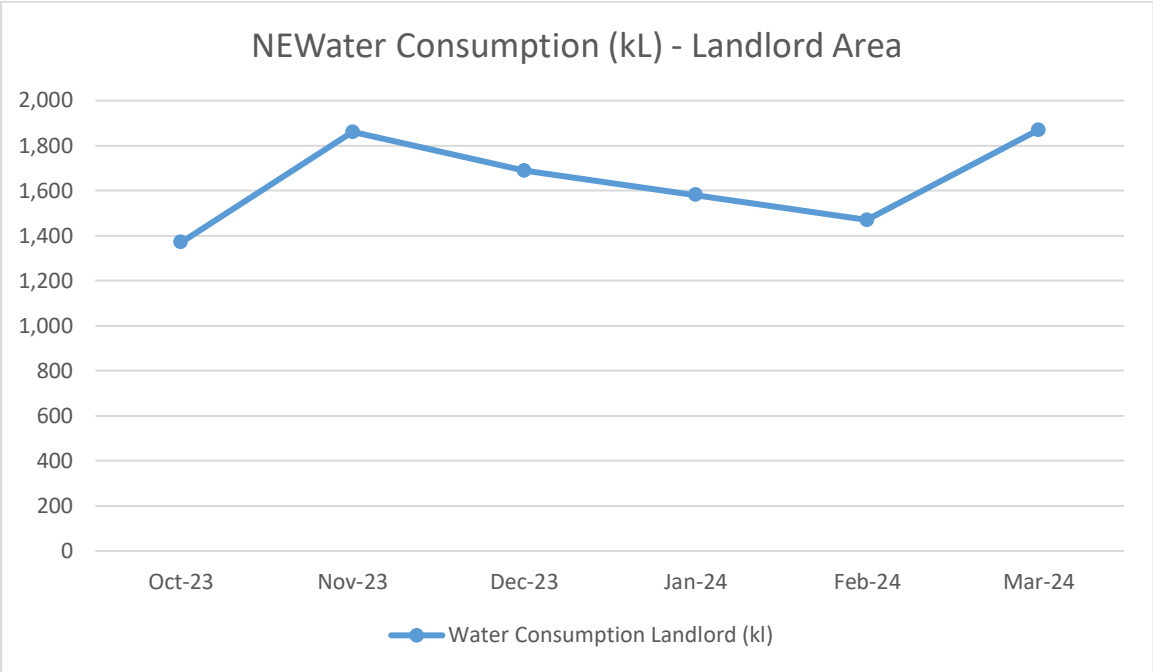
  The Emission Factor for water is 176.7 kg CO2e per million litres.

  (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023)

  Total Water Consumption: 9,839 kL
  Total Carbon Emissions: 1,737.5213 CO2e
  Average Monthly Water Consumption: 1,639.833 kL
  Average Monthly Carbon Emissions: 289.587 kg CO2e

- Oct-23:
  Water Consumption (ML) = 1370 kL / 1000 = 1.37 ML
  Carbon Emission = 1.37 ML x 176.7 kg CO2e/ML = 241.079 kg CO2e
- Nov-23:
  Water Consumption (ML) = 1860 kL / 1000 = 1.86 ML
  Carbon Emission = 1.86 ML x 176.7 kg CO2e/ML = 328.722 kg CO2e
- Dec-23:
  Water Consumption (ML) = 1689 kL / 1000 = 1.689 ML
  Carbon Emission = 1.689 ML x 176.7 kg CO2e/ML = 298.4163 kg CO2e
- Jan-24:
  Water Consumption (ML) = 1580 kL / 1000 = 1.58 ML
  Carbon Emission = 1.58 ML x 176.7 kg CO2e/ML = 279.306 kg CO2e

- Feb-24:
  Water Consumption (ML) = 1470 kL / 1000 = 1.47 ML
  Carbon Emission = 1.47 ML x176.7 kg CO2e/ML = 259.629 kg CO2e
- Mar-24:
  Water Consumption (ML) = 1870 kL / 1000 = 1.87 ML
  Carbon Emission = 1.87 ML x 176.7 kg CO2e/ML = 330.369 kg CO2e



NEWater Water Consumption – Landlord Area:

- The month with the highest water consumption from the tenant area is November 2023 with a number of 4690 kL. NEWater is often used for cooling towers so it may indicate that there is a demand for cooling due to the high temperature.
- There was a sudden increase of 330 kL from October 2023 to November 2023. A reason could be possibly a maintenance activities which requires water usage.
- The month with the lowest water consumption from the tenant area is January 2024 with a number of 810 kL. This may be caused by holiday period, reduce office hours and measures for conservation.

IV. Our Proposal

CAMPAIGNS

Recommendation #1: Sustainability Awareness Day Event with Energy Harvesting Floor System

Pavegen Harvesting energy flooring systems located at Citibank, London

During the team's site visit, one observation made is the high-traffic areas around the building and have come up with an idea to further enhance energy efficiency. A proposal of installing an energy harvesting flooring system around these high-traffic areas such as the lobby entrance and the corridors near the oasis. This system would harness the kinetic energy generated by human weight to produce electrical energy, providing sustainable power sources for low-power systems.

There are numerous benefits to offer in considering the installation of energy harvesting flooring. Each step on the energy harvested flooring creates renewable energy which helps to reduce the need for power transmission, devices can operate on low power, reducing the utility bill and reducing the environmental impact.

These floors harness the kinetic energy from footsteps and convert it into electricity, which can power low-level devices or contribute to the building's overall energy supply. By generating their own power, these floors reduce reliance on the traditional grid, promoting sustainability.

Additionally, certain systems can collect data on foot traffic patterns, providing valuable insights for building management and optimization. The harvested energy can also power interactive displays or other features, creating a more engaging environment.

Feasibility:

Examples of the application:

Soundpower's Generating Floor Mats located at Shibuya Station, Japan

Recommended System: Pavegen Tiles

Pavagen Tiles consists of three components, an electro-magnetic generator, a singular composite tile and people. These tiles convert the kinetic energy from footsteps into electrical power through a simple yet effective mechanism. When someone steps on the tile, it depresses vertically by 5mm to 10mm, compressing an electromagnetic generator inside. This compression creates a rotary motion that generates off-grid, clean energy. Each step on the triangular tile, with a surface area of 0.108 square meters, can produce between 2 to 4 joules of energy, equating to approximately 0.000555556 to 0.00111111 watts.

This innovative technology harnesses the energy from pedestrian movement, offering a renewable energy source suitable for powering low-energy applications and collecting data on foot traffic. Despites Pavegen generates a relatively small amount of electro-magnetic energy (3-5 joules per footstep), it is stated that it can still contribute to power low-energy applications and provides valuable public engagement, education, and awareness.

To increase community awareness of sustainability and net zero intent, for instance, kinetic energy may be used to irrigate green wall projects, charge tiny devices like mobile phones, and light up LED streetlights. Data from the floor is also presented on digital panels. Even if it might not be possible to feed this energy back into the grid on a large scale, Pavegen's true value is in its capacity to increase public awareness of sustainable lifestyle choices and motivate people to become involved in their local communities, where they both live and work.

In addition to installing the Pavagen Tiles, installing a battery pack would be ideal. This would reduce the dependence on the power and maximizing the utility of the generated power. The excess energy generated during peak foot traffic can be stored and used during off-peak hours.

For the recommendation, suggesting installation of Pavegen tiles with a dimension of 2m by 4m. That would require about 74 Pavegen tiles. However, based on the calculation of the cost analysis and ROI stated below, the installation of the Pavegen tiles is not the best feasible recommendation.

Cost Analysis; on assumption* calculation in annex

Initial Cost	
Tile Costs	$14,000
Installation Costs	$800
Component Costs	$160+$1,500+$160+$1,500
Operating Cost	
Maintenance	$300
Energy Storage	$500 per kWh
TOTAL	$18,920

ROI

Time of day	No. of steps	Energy Generated (kWh)	Energy considering 2 hours (kWh)
Start of the day	16,000	0.0155568	0.0311136
Lunch Break	25,600	0.024889	0.049778
End of the Day	16,000	0.0155568	0.1120052
TOTAL (Daily)		0.0550024	0.1120052

Payback Period and ROI

After calculating the cost analysis and the ROI, I have concluded that the payback period and ROI are not meaningful as there is a net loss annually. Thus, it is not feasible.

RECCOMENDATION 1:

So, with the feasibility of installing Pavegen tiles, I propose to have a sustainability awareness day event. The event would be called “Step into Sustainability Awareness Day”. The event would be held on the 4th floor of Frasers Tower.

The event was designed to highlight the importance of sustainability and demonstrate how the office tenants can actively contribute to sustainability. The main goal was to promote sustainability awareness by educating office tenants about the importance of sustainability and the impacts of their actions on the environment. The other objectives include fostering engagement, showcase innovation and to inspire

them to act sustainably. Through interactive and engaging activities, it will foster a sense of community and collective responsibility among office tenants through interactive and engaging activities. In addition, creating an event in collaboration with Pavegen, can highlight innovative technologies like Pavegen in offering solution to conserve energy and sustainable living. Lastly, this event would empower tenants with the knowledge and tools learnt from the workshops to implement further sustainable practices in their daily lives and workspaces. Frasers Tower

There would be 5 event highlights – Interactive Pavegen Walkway, Sustainability Workshops, Live Demonstrations and Tenant Participation.

1. Interactive Pavegen Walkway

By walking a specially constructed Pavegen path, participants can feel the impact of their footsteps. They will discover how this innovative technology may be used into everyday situations to capture kinetic energy as they observed how their footfall produced power in real-time.

2. Sustainability Workshops

The program included interactive sessions centered on workplace sustainability initiatives. Waste reduction, energy efficiency, and the significance of renewable energy sources were among the subjects covered. Experts shared useful advice and tactics that tenants may use in their workplaces.

3. Live Demonstrations

Participants can witness live demonstrations of Pavegen technology and other sustainable innovations. These demonstrations showcased how such solutions can reduce the carbon footprint of office buildings and contribute to a more sustainable future.

4. Tenant Participation:

The event encouraged tenants to take part in fun, interactive activities that promoted sustainability awareness. Activities included energy-saving challenges and eco-friendly office competitions, providing numerous opportunities for everyone to get involved and make a difference.

5. Networking Opportunities

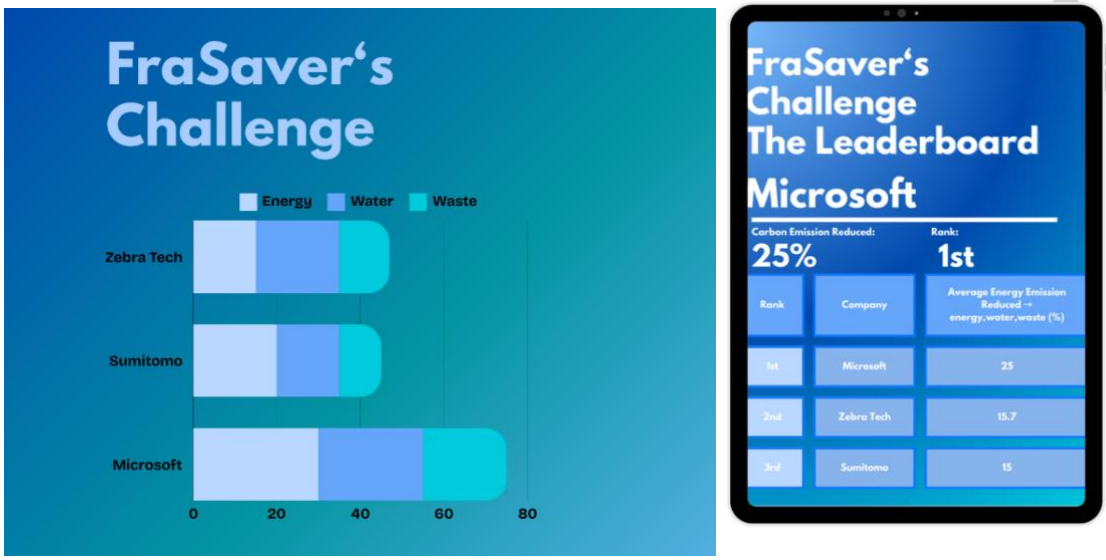
Participants connected with like-minded professionals and organizations dedicated to sustainability. They shared ideas, collaborated on projects, and explored potential partnerships that can drive positive change within the community.

Feasibility

Citi partnered with Pavegen and agency Salterbaxter to bring their net zero commitment to life and engage employees innovatively. Pavegen designed an interactive Kinetic Employee Engagement Experience centred around the campaign "Power Up Net Zero – Show Them What a Global Bank Can Do." Their aim was to educate and inspire employees and visitors alike about Citi's net zero ambition. Over the course of the campaign, thousands of participants generated over 50,000 joules of energy which is approximately 13.888889 watts-hour.

https://www.pavegen.com/hubfs/Citi%20Bank%203.png

Recommendation #2: FraSaver's Challenge Campaign



FraSaver's Challenge Leaderboard

Our team has come up with a campaign proposal, called FraSaver’s Challenge: Tenant Sustainability Initiative. The event is designed to enhance sustainability efforts within the building by actively engaging tenants in various environmental activities. These activities will coincide with global events, and progress will be meticulously tracked through participation and commitments. The campaign's primary objective is to reduce overall building consumption by 20% by the end of the year, with the help of tenant participation. Our slogans, "Green Starts with this Tower" and "Green is the New Blue," encapsulate our mission.

The programme is structured around quarterly themes and activities.

First quarter: The focus will be on measurement and establishing a baseline. This involves conducting an energy audit to determine current energy usage, distributing surveys to tenants to gather data on existing sustainability practices, and hosting a kickoff event to introduce the campaign and explain the points system.

Second quarter: Dedicated to increasing tenant awareness and engagement in sustainability. This will include a sustainability fair on Earth Day, with booths showcasing tenant initiatives and workshops on energy-saving practices and waste reduction. Additionally, a "Green Office Challenge" will be launched, providing incentives for reducing energy consumption and waste.

Third quarter: will focus on water conservation. Activities will include organizing a water conservation exhibition on Water Day, with interactive displays and tenant-led presentations. A building-wide water audit will be implemented, followed by recommendations for water-saving measures. Communication efforts will promote water-saving technologies and practices through newsletters and emails.

Final quarter: A time for review and recognition. The progress and efforts of the year will be summarized and reported, culminating in an end-of-year awards ceremony to recognize top-performing tenants. A major showcase event, led by a prominent tenant such as Microsoft or Sumitomo, will highlight the year's sustainability successes.

Throughout the year, tenants will earn points for participating in events, adopting sustainable practices, and achieving energy and water savings. Points will be tracked and reported quarterly, with top-performing tenants receiving recognition and rewards at the end of the year. To encourage daily sustainable actions, staff can earn points by buying coffee with their own bottles, tracked through an app connected to the Fraser app. Additionally, key members attending events will contribute points to their teams, maintaining high attendance metrics.

Regular communication will be maintained through emails, quarterly newsletters, and a dedicated campaign page on the building's intranet, ensuring tenants stay informed and engaged.

The FraSaver's Challenge: Tenant Sustainability Initiative promises continuous engagement and progress in sustainability, leveraging the participation of major tenants to lead and inspire the entire building community. This comprehensive programme is designed to foster a culture of sustainability and drive significant environmental impact.

WATER MANAGEMENT

Recommendation #1: Integrating DeCalon System (DCI)

DeCalon System

With Frasers Tower having 3-storey podium with roof garden surrounded by lush planting and cooling water features, based on their website, they have a cooling tower water treatment system achieving 7 or better cycles of concentration. To further improve the reduction of water usage in Frasers Tower, a DeCalon System (DCI) would be beneficial.

A DCI system reduces water usage by over 50% by altering the cooling tower's water chemical balance through electrolysis. This eliminates the need for chemicals for water treatment, reducing water usage costs. The system also reduces operation costs and maintenance by eliminating the need for anti-scalent and corrosion inhibitors chemicals. Additionally, it increases the equipment's operating life without requiring plant shutdown.

Feasibility

Keppel Bay Tower – Green mark Platinum (zero energy)

Notable result of Keppel bay's Tower significant changes implementing the DCI system:7% chiller energy savings and 81% blow down water reduction.

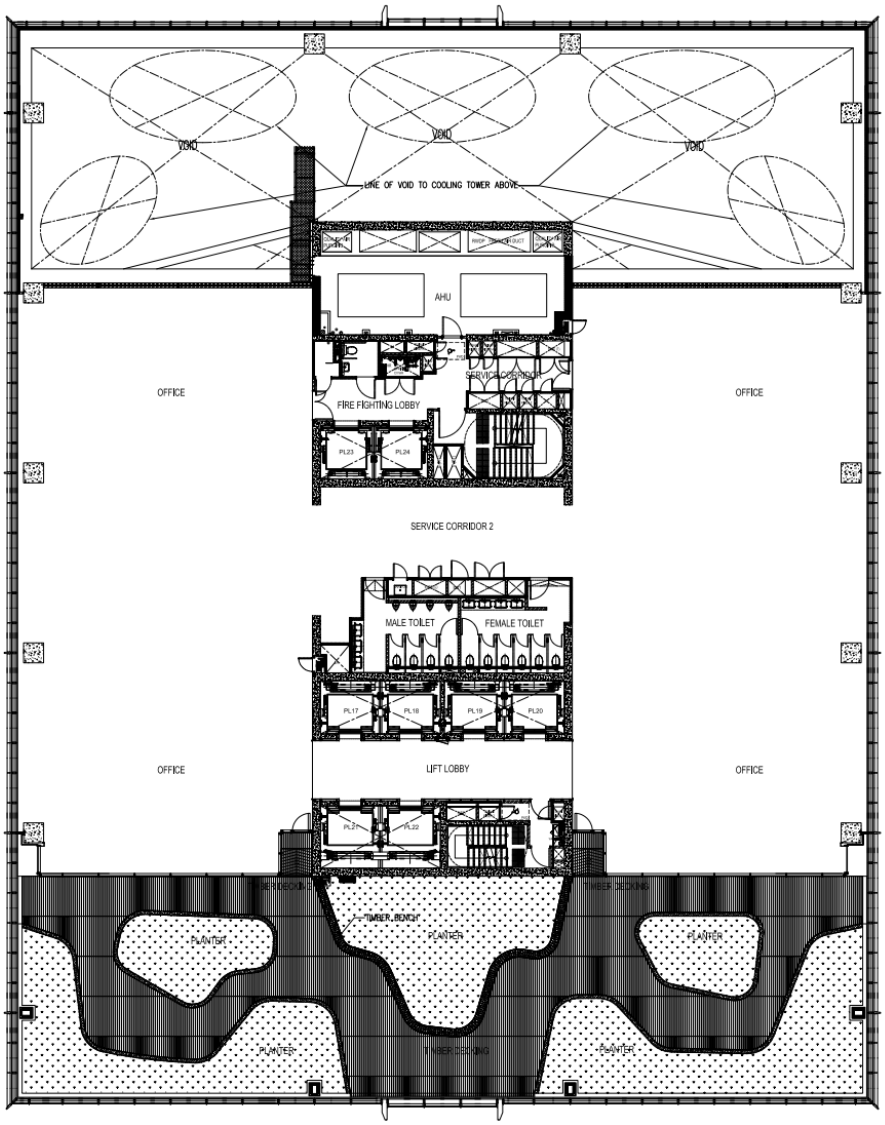
Implementation Plan:

The installation of the DCI system is a straightforward and feasible one. With just enough space for its device, it can be implemented as standalone or integrated with the current plant. Furthermore, Fraser's cooling tower setup is likely compatible with the DCI system as the building's infrastructure is considered new.

1. Connect source pipe from cooling tower to DCI system.
2. Connect service pipe from DCI system to cooling tower.
3. Prime the pump.
4. Connect DCI system to single phase system power supply and turn on system.

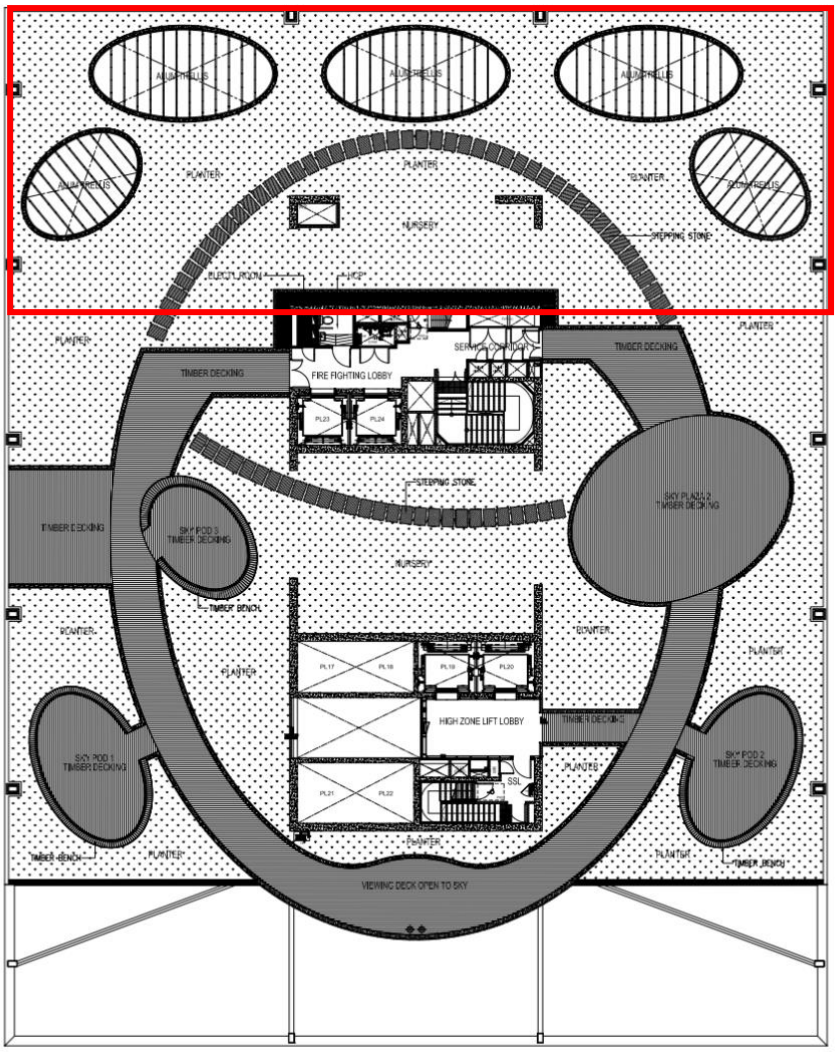
The DCI system's relevance to Frasers Tower is grounded in its alignment with the building's sustainability goals. As a modern commercial building in Singapore, Frasers Tower is likely focused on environmental stewardship and efficiency. The DCI system can enhance the building's green credentials and position it as a leader in sustainable practices.

Suitable Area: Area near the Cooling Tower



Area that is for Cooling Tower = Area to put DCI System

38TH STOREY PLAN



39TH STOREY PLAN

Cost Analysis:

DCI unit cost is not published and can vary depending on the cooling tower capacity or refrigeration tonnage (RT). To get a rough estimation on one unit and Fraser's ROI, SIN10 Digital Realty Singapore a data centre is used as benchmark. Capabilities of a DCI system may vary and can treat different amount of water. It is published on a website that it may cost around $33000 per unit. https://www.datacenterdynamics.com/en/news/digital-realty-singapore-uses-electrolysis-to-clean-its-cooling-water/

Taking into consideration the cooling capacity or refrigeration tonnage of Fraser's Tower is not provided.

1. Calculate Water Savings with 2 DCI Units

Each DCI unit achieves a 50% water saving. The cooling tower currently uses 1900 kL per month.

Water saved per month per DCI unit

=50%×1900 kL

= 950kL

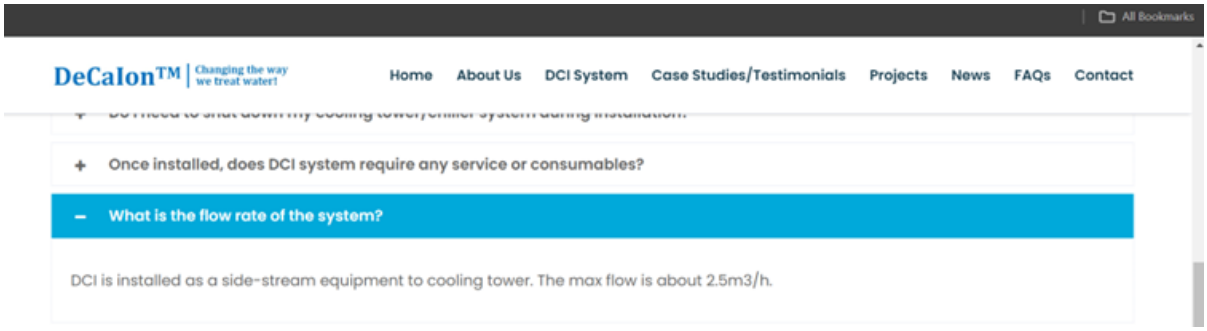
For 2 DCI units:

Total water saved per month

= 2×950 kL/month

=1900 kL/month

2. Calculate Number of DCI Units Needed



Each DCI unit has a maximum flow of **2.5 m³/h**.
Converting meters per hour to Litres per hour:
2.5 m³/h=2500 L/h

To match the water saving needed for 2 DCI units:

Water usage per hour
=1900 kL/month30 days/month×24 hours/day
=1900×1000 L720 hours
≈2638.89 L/h

Number of DCI units
=2638.89 L/h ÷2500 L/h per unit
≈1.056 L/h

Since we are unable to have a fraction of a unit, we would need at least 2 DCI units. Having one more for would also be for redundancy and would disrupt the water treatment operation in case one of the units is on maintenance.

3. Calculate Return of Investment (Roi) For 2 DCI Units

To calculate ROI, consider the cost savings from reduced water usage:
Current water cost per month:
1900 kL/month×$2.50/1000 L
=$4,750

Water cost after installation of 2 DCI units (50% savings):
950 kL/month×$2.50/1000 L
=$2,375

Total Investment:

- Cost of 2 DCI units = 2 × $33,000 = $66,000
- Installation cost = $5,000
- Total Investment = $66,000 + $5,000 = $71,000

Annual Savings:

- Monthly savings = $2,375
- Annual savings = $2,375 × 12 = $28,500
- ROI=Total Investment/Annual Savings ×100%

ROI=28,50071,000×100% ≈40.14%

Therefore, the Return on Investment (ROI) for installing 2 DCI units, considering an installation cost of $5,000 and each unit costing $33,000, is approximately **40.14%**. This means you would recover your investment in approximately ***2.49 years and approximately 3 years.***

5. *Calculate Annual Carbon Reduction for 2 DCI Units*

	Non-Domestic NEWater Prices (per cubic metre)		
	Before 1 April 2024	From 1 April 2024	From 1 April 2025
Tariff	$1.28		
Water Conservation Tax (% of Tariff)	$0.13 (10% of $1.28)		
Waterborne Tax	$0.92	$1.00	$1.09
Total Price	$2.33	$2.41	$2.50

To find the annual carbon reduction with 2 DCI units:

- Calculate monthly water consumption reduction due to 2 DCI units: ***1900 kL/month.***
- Convert to annual reduction:
  1900 kL/month×12 months= ***22,800 kL/year***

Carbon reduction using the Singapore carbon grid emission factor:

Annual carbon reduction = 22,800 kL/year×0.4057 kg CO2/L

Annual carbon reduction ≈ 9,249.96 kg CO2/L

Recommendation #2: Bubble90 Nozzle

Bubble90 Nozzle

Based on Frasers Tower's website, it was stated that Frasers Towers' water fittings are certificated with two or more "ticks" under the Water Efficiency Labelling Scheme. With great water fittings for sustainability, there is another water fitting that is even greater. It is the Bubble90 nozzle.

The Bubble90 nozzle, developed by the Japanese company DG Takano, is a water-saving technology that uses pulsation flow to deliver water in quick, controlled bursts instead of a continuous stream. This innovative design reduces water usage while maintaining the functionality of regular taps. They have 3 different types of fittings, Bubble 90 extreme, classic, and light. All of these has its different unique features that would improve the water flow with pressure. More details about this nozzle would be in Annex F.

Installation of the Bubble90 Nozzle is beneficial as the existing toilet faucet in Fraser's Tower lobby can be significantly reduced by 80-90% using the bubble90 nozzle, which uses pulsation tech flow technology to save 1.5-2L per minute, resulting in up to 90% less water usage.

Bubble90 blue nozzles are universally fit, cost-effective, and easy to install, requiring only removing the current nozzle and attaching it with a wrench. As well as additional customization options available.

Feasibility

Flemington Market in Sydney, Australia

Fish markets on a regular day uses a lot of water for their daily needs. With just only 20 faucets changed to the bubble90 nozzle, bills costing has significantly reduced by thousands of dollars due to less water usage. This can be applied at Fraser's Tower common toilets and possibly the restaurant in the building to aid in saving water.

"We had huge water usage at Sydney Markets in Flemington and could not find a suitable solution to reduce this and save costs. We came across Bubble90 and have installed it on 20 of our faucets. This has helped us save $10k in water and achieve our sustainability KPI's," said Con Kapellos, the Sustainability Manager of Sydney Markets.

Source: https://asiafoodjournal.com/japan-water-saving-technology-sydney-fish-market/

Implementation Plan

The Bubble90 extreme would be proposed to be fitted in common toilets at the lobby and on level 2. These are the targeted places with higher human traffic reaping the most benefits from this water saving tool. Faucet of existing toilet in Fraser's Tower lobby (Right in between Fraser's Tower lobby and restaurant).

Frasers Tower's female toilet

Cost of Analysis

Price per unit of the bubble90 nozzle is not reflected in any sources. However, there is only one source stating the price of one of the bubble90 nozzle proposed. Which suggest that contact directly between Fraser's and DG Takano is needed to get the accurate prices.

Assuming there are 2000 people using the toilets and each using around 12 seconds.

Number of People: 2000
Usage Time per Person: 12 seconds = 0.2 minutes
Flow Rate: 2 liters per minute (Fraser's has 3 water fixtures with 3 ticks)
Daily water usage per person= 2liters /minute × 0.2minutes = 0.4liters/day *Total daily water usage for 2000 people=0.4 Liters/day × 2000=800 Liters/day*

Reduction: 90%

Daily water usage per person with new nozzle
= 0.4 Litres/day x 0.10
= 0.04 Litres/day
Total daily water usage for 2000 people with new nozzle
=0.04 Litres/day×2000
= 80 Litres/day

Daily water savings
= 800liters/day−80liters/day
=720liters/day Annual water savings
= 720 liters/day×365 days/year
= 262,800 litres/year

Cost saving
Annual water savings
= 262.8cubic meters/year

Cost savings
=262.8 cubic meters/year × $3.24 per cubic meter
= $851.47 per year

Carbon Reduction
Annual carbon reduction
= 262,800liters/year × 0.4057kg CO2/litre
= 106,617kg CO2/year

Cost of new nozzles
= 16nozzles × $160.62per nozzle
= $2,569.92
Payback period= $2,569.92 / $851.47 per year **≈ 3.02 years**

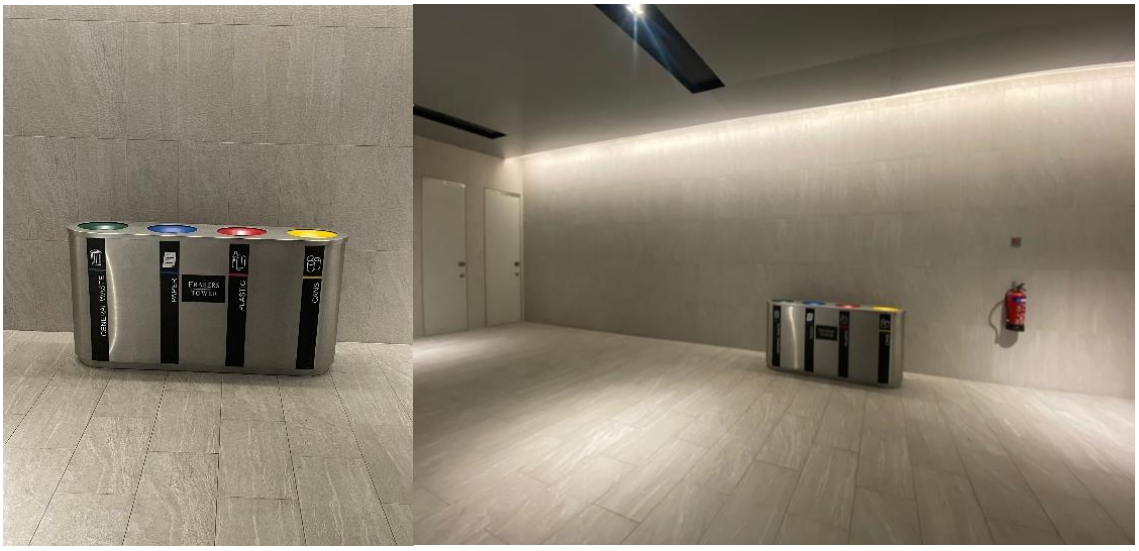
Annual Water Savings: 262,800 Liters
Annual Cost Savings: $851.47
Annual Carbon Reduction: 109,982 kg CO2
ROI (Payback Period): 3.02 years

Return of investment would be approximately in 3 years and this is only assuming the number for time of usage and amount of water dispensed which is relatively great while achieving reduction in carbon targets.

WASTE MANAGEMENT

Recommendation #1: Bin-e

Based on the observation during the site visit, Frasers Tower uses the traditional recycling bin, and the bin is placed at an area where it's secluded from the restaurants.



Nearby Level 2's Oasis Exit

One suggestion is to place a Bin-e (smart waste bin). Bin-e is a smart waste bin that utilises AI and image recognition technology to recognise waste being thrown into the bin.

https://www.waste360.com/waste-recycling/bin-e-creates-contactless-smart-bin

Bin-e promotes efficiency by reducing the need for manual labour and minimizing contamination of recyclable materials. It utilizes sensor data to optimize waste collection routes, ensuring trucks only service bins that require emptying, thereby lowering fuel consumption and carbon emissions.

By precisely sorting waste into categories such as organic, recyclables, and general waste, Bin-e boosts recycling rates and decreases landfill waste. This system leads to significant cost savings for Frasers Tower through efficient sorting and optimized collection, reducing labour and trip frequency. It can decrease waste collection costs by 80% and waste management costs by 70%.

Environmentally, Bin-e supports sustainability by promoting recycling, conserving resources, and lowering greenhouse gas emissions. It provides valuable data insights on recycling rates, fill levels, and waste generation patterns, aiding in the optimization of waste management strategies and enhancing sustainability for Frasers Tower.

The user-friendly interface offers feedback to users, encouraging correct waste disposal and increasing engagement in recycling programs. Bin-e is scalable and easily integrates into various environments, from public spaces and office buildings, with its modular design allowing flexible deployment.

Another benefit is that you can customize the choose different designs of the bin to match according to the building's interior design. This will help the bin blend in with the place and not stand out. The video display screen on the bin can be managed by creating playlists and uploading them on the bin.

https://bine.world/
https://blogs.nvidia.com/blog/bin-e-smart-recycling-bin/
https://www.smithsonianmag.com/innovation/smart-recycling-bin-could-sort-your-waste-you-180964848/

Feasibility

Dell Technologies in Poland

By implementing Bin-e in their office, Dell Technologies were able to enhance internal sustainability initiatives by progressively improving waste segregation in their office environment.
https://bine.world/

Carbon Emission Reduction

The total trip between Fraser Towers and KL Enviro is 62km. Assuming that the weight of the truck is 26 tonne and the average fuel efficiency is 3.5km/l,

Fuel Consumed = Distance (km) / Fuel Efficiency (km/l)
= 62km / 3.5km/l
= 17.71 litres
CO2 Emissions = Fuel Consumed x Emission Factor
= 17.71 litres x 2.86kg Co2/l
= 50.65 kg CO2

Before implementation of Bin-e, recycling truck comes to Fraser Tower 3 times a week, 10 times a month.

10 x 62 = 620km

Fuel Consumed = Distance (km) / Fuel Efficiency (km/l)
= 620km / 3.5km/l
= 177.14 litres
CO2 Emissions = Fuel Consumed x Emission Factor
= 177.14 litres x 2.86kg Co2/l
= 506.63 kg CO2

After implementation of Bin-e,

5 x 62 = 310km

Fuel Consumed = Distance (km) / Fuel Efficiency (km/l)
= 310km / 3.5km/l
= 88.57 litres
CO2 Emissions = Fuel Consumed x Emission Factor
= 88.57 litres x 2.86kg Co2/l
= 253.32 kg CO2

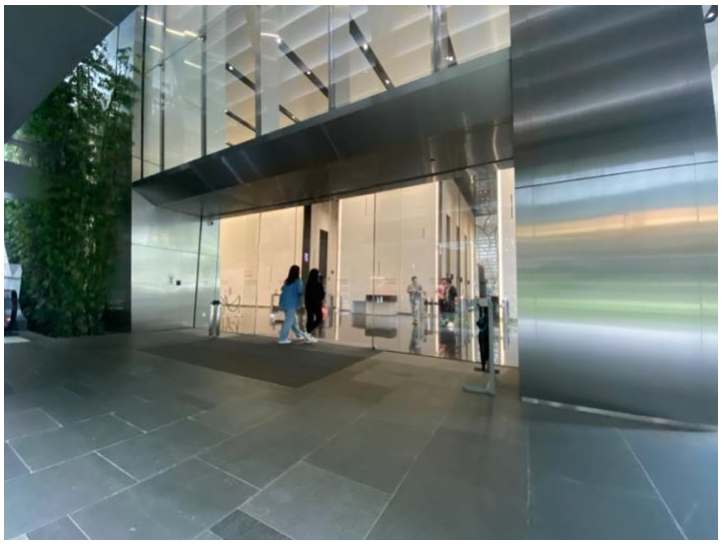
Total CO2 Emissions saved = 506.63 – 253.32 = 253.31kg CO2

2.86kg Co2/l derived from NEA
https://www.nea.gov.sg/docs/default-source/our-services/climate-change/m-r-appendix-(ver-14-feb-2018).pdf

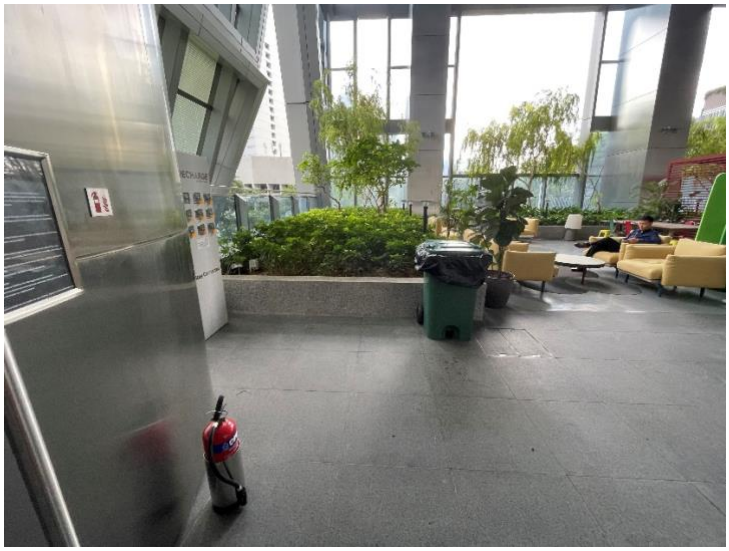
Implementation Plan:

Suitable Areas:

1. Outside the lobby

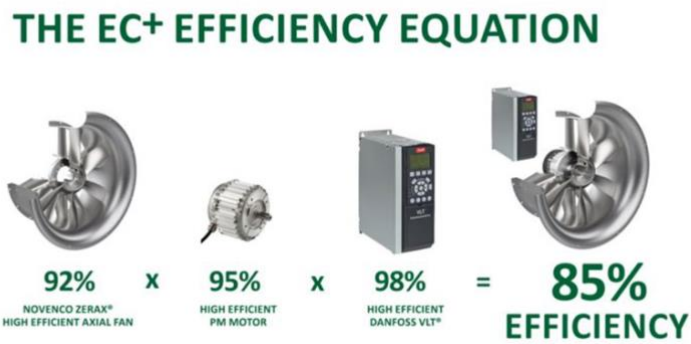


2. The Terrace (Level 4)



ENERGY EFFICIENCY

Recommendation #1: NOVENCO AHU fan system



NOVENCO AHU Fan System

One of the highest total AHU fan systems that guarantees 85% efficiency. The NOVENCO Zerax highly efficient axial fan which produces significantly lower noise than most in the market right now. Unlike most HVAC systems, which only uses static pressure, this setup utilizes both the dynamic and static pressure which just simply means it does not let any airflow go to waste. Their cutting-edge designs allow higher efficiency which results in lower energy consumption, thus reducing operating costs.

Implementation

NOVENCO offers a complete plug-and-play solution for HVAC system upgrades. A site study is conducted for free to analyse current installations and identify potential improvements. Estimations are provided outlining energy savings and ROI. A Proof of Concept is done to validate estimates. Site upgrades are efficient and completed quickly for effective implementation.

Feasibility

Installing the NOVENCO Total AHU Fan System at Fraser Tower is a feasible project due to superior energy savings of up to 50%, a quick ROI of as low as 1-year, compact design for easy integration, environmental benefits through reduced carbon footprint, and proven performance. A feasibility study and validation further support the benefits, making it an appealing choice for enhancing energy efficiency at Fraser Tower.

Cost Analysis

Assuming about 40% of energy is going into ACMV system. We are going to assume that 5% is going into the ahu fans.

Taking one of the highest electricity usages in the month of October 2023 which is 663900kwh.

40% to ACMV
= 663900kwh x 0.4
= 265560kwh

5% to AHU
= 265560kwh x 0.05
= 13278kwh

Energy savings due to 50% reduction
= 13278 kWh x 50%
= 6639 kWh

Carbon emissions without energy savings
= 13278 kWh x 0.4057 kg CO2/kWh
= 5388.7 kg CO2

Carbon emissions with energy savings
= (13278 kWh - 6639 kWh) x 0.4057 kg CO2/kWh
= 2694.35 kg CO2

Cost Before
= 13278 kWh x $0.3257/kWh
= $4,321.39

Cost After = 6639 kWh * $0.3257/kWh = $2,161.76
Savings = $4,321.39 - $2,161.76 = $2,159.63

Reduction in carbon emissions: 5388.7 kg CO2 - 2694.35 kg CO2 = 2694.35 kg CO2

Case Study

Before Improvement	After Improvement	Achieved Savings
0.533 W/CMH 13.53 kW	0.230 W/CMH 6.96 kW (Jan-Dec 2019)	46.8%

Keppel Bay tower integrated the NOVENCO total ahu fan system and have achieved great results resulting in 46.8% in energy saving. It has recorded a significant drop in noise level up to 17%. It is now using for all 22 AHU and is continuing to produce results for the building, up to 20500 kwh saved, resulting in massive carbon reduction.

Recommendation #2: Passive InfraRed Motion sensors

Passive InfraRed Motion sensors

A passive infrared sensor, abbreviated as PIR sensor, detects movement through changes in infrared radiation emitted by objects within its range, commonly used in security systems and automatic lighting control. Fraser Tower has an existing photocell sensor which are used for office perimeter lighting and staircase. Photocell sensors are great in helping to turn off current lighting when it senses natural light but further saving can be achieved when these two technologies is coupled.

Energy conservation: The office building maximizes energy efficiency by utilizing PIR and photocell sensors to control lighting based on occupancy and natural light availability. Consequently, there is a clear decrease in the energy consumption for lighting in both daytime and unoccupied areas.
User Comfort: Well-lit workspaces that adapt to their presence and keep the best possible lighting throughout the day are advantageous to employees. The smooth transition between artificial and natural lighting improves both productivity and comfort.

Operational Efficiency: By minimizing the need for manual intervention, the integrated sensor system enhances operational efficiency and lowers lighting management maintenance expenses.

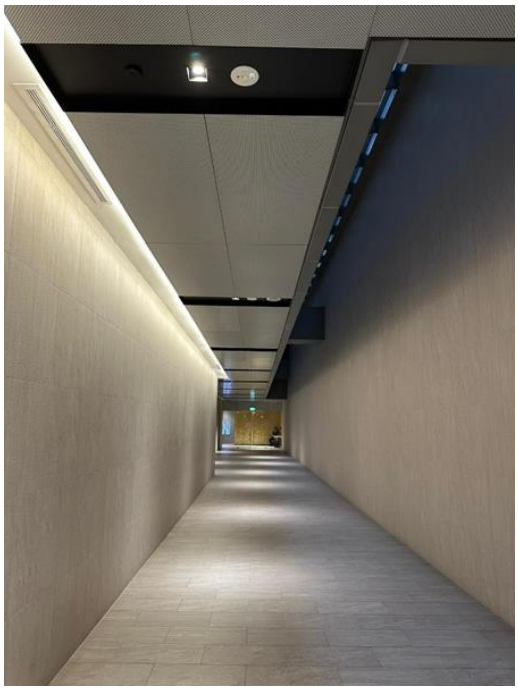
Feasibility
Setting up and upgrading:

Limited Disruption: Utilizing wireless sensors and adhesive mounting solutions lessens the requirements for extensive wiring and retrofitting, decreasing disturbances to office activities in progress.
Flexibility: Sensors can be added either outside of normal working hours or gradually in different sections of the building, enabling a step-by-step deployment without significant disruptions.
Initial Cost: Though sensors and control system upgrades require an initial investment, the energy savings over time usually exceed these upfront costs.

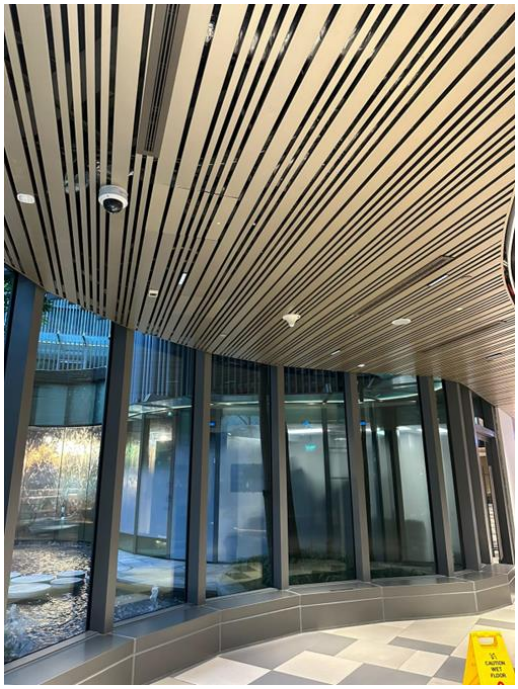
Potential Return on Investment (ROI): The possible savings in energy costs and maintenance expenses can lead to a positive ROI during the sensors' operational lifespan.

Implementation:

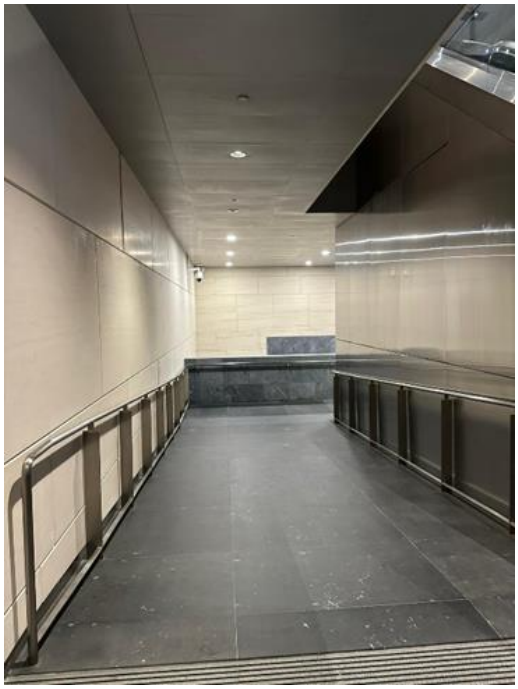
1. Lighting near level 2 towards Ya Kun



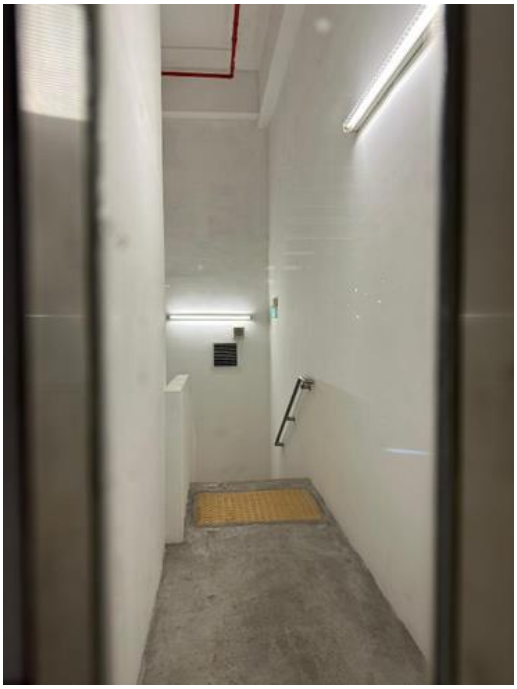
2.Lighting located at Oasis level 2 lift lobby



3.Access for wheelchair



4.Emergency exit near the wheelchair access at entrance of Fraser Tower near the MRT



Areas such as in the pictures can be further explored for greater potential saving. There is natural light coming in during daytime and does not require as much light. With the PIR sensors and building management systems, the PIR sensors can detect the light coming in this area, hence determining the light luminosity to be emitted. This requires the LED lights to be adjustable and able to be set to dim mode when. Additionally, when there is low traffic of people but sufficient natural lighting, some lights can even be set to only on at a lower luminosity.

Case Study:

Busy Mode:
Switches to the upper dimming level when high activity level is detected

Sensor Mode:
The dimming level fluctuates between upper and lower levels in response to the triggers of the PIR sensors

Silent Mode:
When there is no activity detected for a while, the lights are switched off

Lumani Pte Ltd Projects with Keppel Bay Tower.

Lumani installed a thorough smart lighting system throughout their buildings. This system comprised of:

PIR sensors are placed in every office and workspace to sense occupancy and automatically control lighting brightness. These sensors made sure that lights were activated only when required, leading to a notable decrease in energy consumption when the building was not in use.

Smart Lighting Controls are linked with the building's management system, enabling centralized supervision and management of lighting in various zones. This functionality allowed for automatic lighting changes according to occupancy trends and natural light levels.

Energy conservation: Installing PIR sensors and intelligent lighting controls resulted in a notable decrease in energy usage for lighting purposes. Lumani was able to cut down lighting energy use by as much as 30% by turning off lights in areas that are not being used and by adjusting brightness levels depending on the amount of natural light available.

Recommendation #3: Wind Energy Harvester by NTU

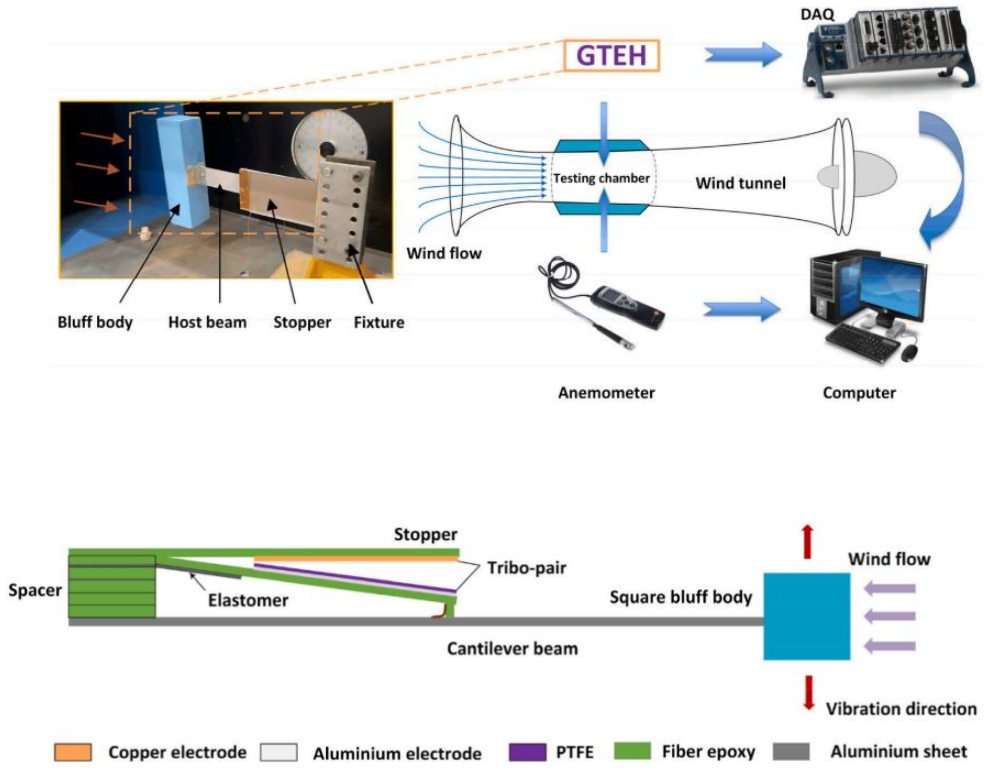


Fig. 1. Schematic diagram of the top view of the proposed GTEH.

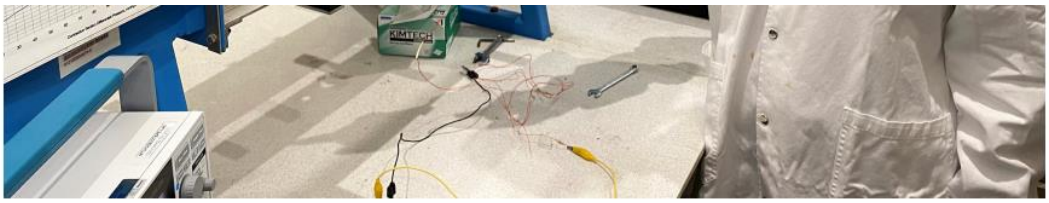
A wind energy harvester that turns flow-induced structural vibration into electricity uses the galloping effect in conjunction with triboelectric energy conversion. The proposed harvester comprises a host cantilever beam, a stopper, and a middle plate with one rotation degree of freedom. The electrodes and triboelectric layers are positioned in between the middle plate and the stopper's surface. The middle plate comes into contact with the free end of the host beam towards the bluff body creating galloping vibrations with the stopper periodically, causing the triboelectric-based conversion mechanism to produce electricity.

[redacted]. The harvester achieved a very low cut-in wind velocity of 1.4 m/s, and the voltage output could reach 200 V. [redacted]

Feasibility

Singapore on average produces 2- 3 m/s of wind speed which is relatively low for a substantial amount of energy to be produced through a wind energy harvester. However, at a low wind speed this revolutionary design can capture the win through its Y shape cantilever and generate electricity through the movement of the triboelectric.

Cost Analysis:



Scientists at the Nanyang Technological University (NTU) in Singapore have developed a cheap wind turbine that produces electricity even in very light winds.

Professor Yang Yaowen from Nanyang Technological University, who is developing a wind harvester

With an air flow speed of up to 2 meters per second, the installation generates a voltage of three volts and generates power up to 290 microwatts. This is enough to activate the sensor or provide power to the LED lamp.

Screenshot from Website (>>>>)

Wind energy harvester that uses cantilever vibro-impact triboelectric. This product is currently still in its research stage and does not have a price tag. However, Fraser's can partner with NTU to gain access to this invention. This energy wind harvester in its report by the researcher, states that they have managed to "developed a low-cost device that can harness energy from wind as gentle as a light breeze and store it as electricity." To give it a comparison, a small wind turbine box would at least cost minimally $500 and would stretch as far as above $40000 excluding installation cost.

This Wind energy harvester that uses cantilever vibro-impact triboelectric is only **15cm by 20cm** which is relatively small but able to produce enough energy to power an IoT sensors in Fraser's tower. In the report published by NTU, their research consists of testing different material for this technology to not only lower cost but also to reduce maintenance work. Wind energy is free and is throughout the day. Energy produced that is not used can be stored in battery where the building can use for different purposes.

Assuming one wind harvester can generate enough to power an LED lamp, we assumed 5 watts per hour.

Annual Energy generated=5 Wh×24 hours/day×365 days

Annual Energy Generated =43,800 Wh Annual Energy Consumption=43.8 kWh

Carbon Reduction=43.8 kWh×0.5 kg CO2/kWh

Carbon Reduction=21.9 kg CO2

Number of units proposed= 20

- Annual energy generated per harvester: 43.8 kWh
- Carbon intensity of electricity: 0.4188 kg CO2/kWh

Total Annual Energy Generated for 20 LED Lamps:

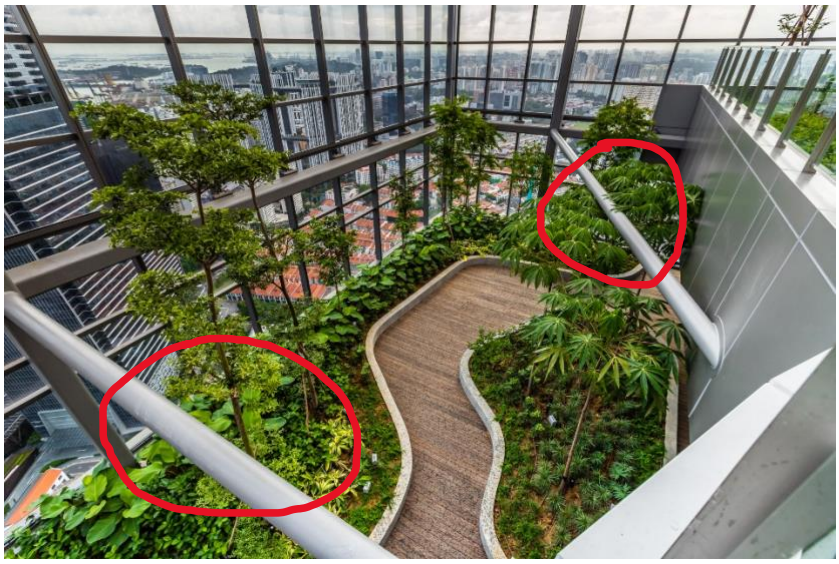
Total Annual Energy Generated = 43.8 kWh/lamp×20 lamps = 876kw/h

Total Carbon Reduction:

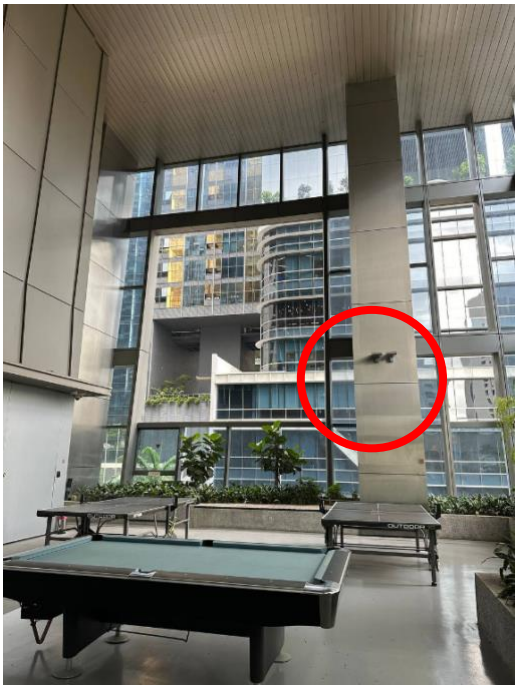
Total Carbon Reduction = Total Annual Energy Consumption x Carbon Intensity
Total Carbon Reduction = 876 kWh x 0.4188 kg CO2/kWh = 367 kg CO2

Savings = 876kw/h x 32.57cents = $285.40

Implementation

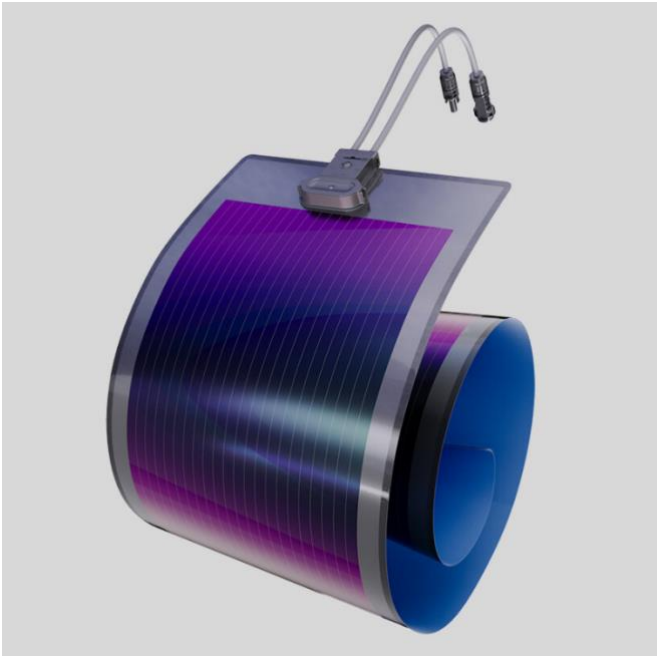


Can be placed on top of this beams where to catch the air flowing freely.



Possibility of placing outside this façade where wind generation outside is higher.

Recommendation #4: Photovoltaic Solar Film Stickers



https://www.designboom.com/technology/solar-films-ultra-flexible-and-adaptable-renewable-energy-solution-12-11-2022/

Fraser Towers do not have much rooftop area/surface for implementing photovoltaic solar panels as the garden occupies the rooftop.

By installing these PV solar film stickers on the building's façade, it can receive as much sunlight from a greater height of the building. The films have 40% - 50% opacity, making it semi-transparent and it generates 85W/sqm. This can create a more pleasant and natural working environment, which can enhance occupant comfort and well-being.

Because OPV films are flexible and lightweight, they are easy to integrate into current window designs and constructions. OPV technology works reasonably well in low light, such as interior lighting or cloudy days, which increases its usefulness in a range of weather circumstances. Compared to conventional silicon-based solar cells, OPV films have a lower temperature coefficient, which means that at high temperatures, their efficiency decreases less. OPV films are produced using non-toxic ingredients and require less energy, making them a more environmentally friendly product.

The thermal and acoustic insulation offered by double-glazed windows is already exceptional. The total performance can be enhanced when paired with OPV stickers, which significantly reduce the amount of sunlight that enters the building. Double-glazed windows and OPV stickers work together to provide an extra layer of glare prevention. The OPV film and the outer glass layer can work together to disperse and filter light, lowering the possibility of glare.

Carbon Reduction

Carbon Emission (Before implementation) = 600400kWh x 0.4057 = 243,465.88 kg CO2

Carbon Emission (After implementation) = (600400 – 9052.5)kWh x 0.4057 = 239,813.64 kg CO2

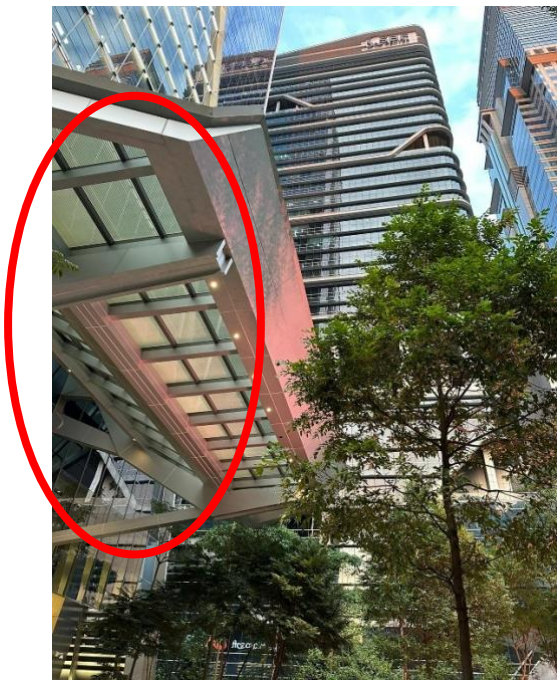
Carbon Reduction = 243,465.88 kg CO2 - 239,813.64 kg CO2 = 3,652.24 kg CO2.

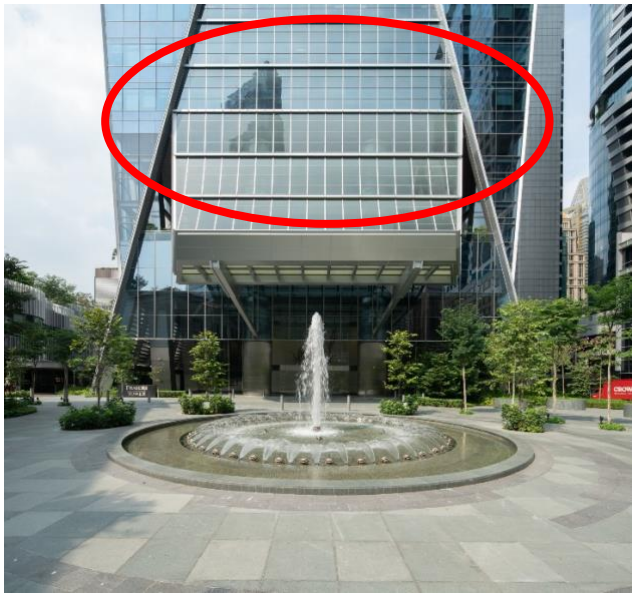
Implementation Plan

Suitable Areas:

1. The east and west side of the building where it receives most sunlight during afternoon and when the sun is setting

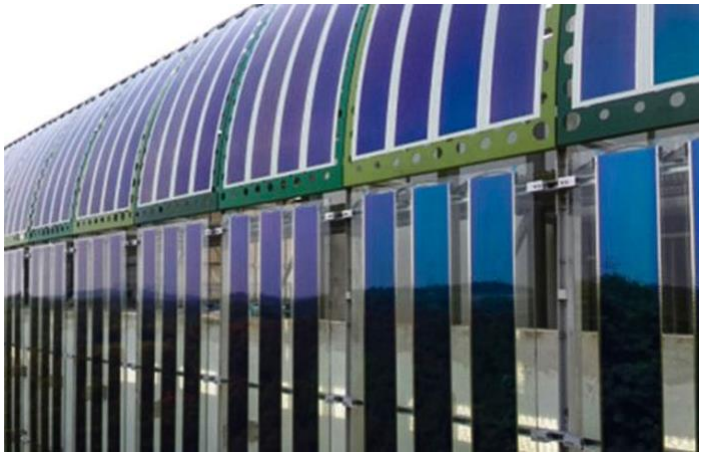
2. Canopy at the entrance of the building





https://archello.com/project/frasers-tower

Feasibility



https://www.heliatek.com/en/references/

JTC Cleantech Park I and II, Singapore

With a total area of 44 square meters and 64 films, the system has a capacity of 1.9 kWp.

https://www.glasstec-online.com/en/Media_News/Heliatek_Successfully_Implements_Second_Phase_of_BIOPV_Pilot_Project_in_Singapore_1

V. Our Proposal From Phase 1

WATER MANAGEMENT

Recommendation #1: Greywater Recycling System

Greywater Microfiltration system

Frasers Tower, and many other buildings, uses the toilet wash basins, but where does the water all go? The water is called greywater. It is untreated used water which has not come into contact with toilet waste. It is collected from showers, wash basins, bathtubs, bathroom/toilet wash basins. It does not include used water from urinals, toilet bowls (water closets), kitchen sinks or dishwashers.

Frasers Tower could potentially reuse the greywater for sanitary facilities uses such as flushing toilets. This would reduce the amount of potable water demand, making Greywater recycling system more sustainable.

Recycling treated greywater provides several benefits including reducing Potable water and NEWater demand. It also decreases the volume of used water discharged into the sewerage system, water bills which all contributes to the sustainability of Frasers Tower.

System Recommended: Microfiltration with Ultraviolet (UV) Disinfection

Microfiltration with Ultraviolet (UV) Disinfection is the suggested system.

Microfiltration is an efficient technique that can be used to either clear liquids or remove germs, protozoa, and minute suspended particles, feature 0.1 micron-sized pores that holds onto bacteria, because it efficiently eliminates particles that can protect viruses from UV light when used with UV post-filtration disinfection.

Ultraviolet radiation does not leave behind any byproducts that could be harmful to people or the surrounding area. Including the UV dosage, it will start a photochemical reaction that breaks down the DNA molecule in microorganisms, UV disinfects by preventing cell division and, as a result, multiplication. The dosage of UV radiation that the microorganisms absorb, and their UV resistance determine how much cell damage occurs. This would ensure that any remaining microorganisms are harmless.

This suggested system is relatively low maintenance and cost-effective over time. In addition, this system ensures that the occupants in Frasers Tower are safe and cost-efficient to use the reusable treated water and maintaining the health of theirs, making it a suitable option for the long-term use for Frasers tower.

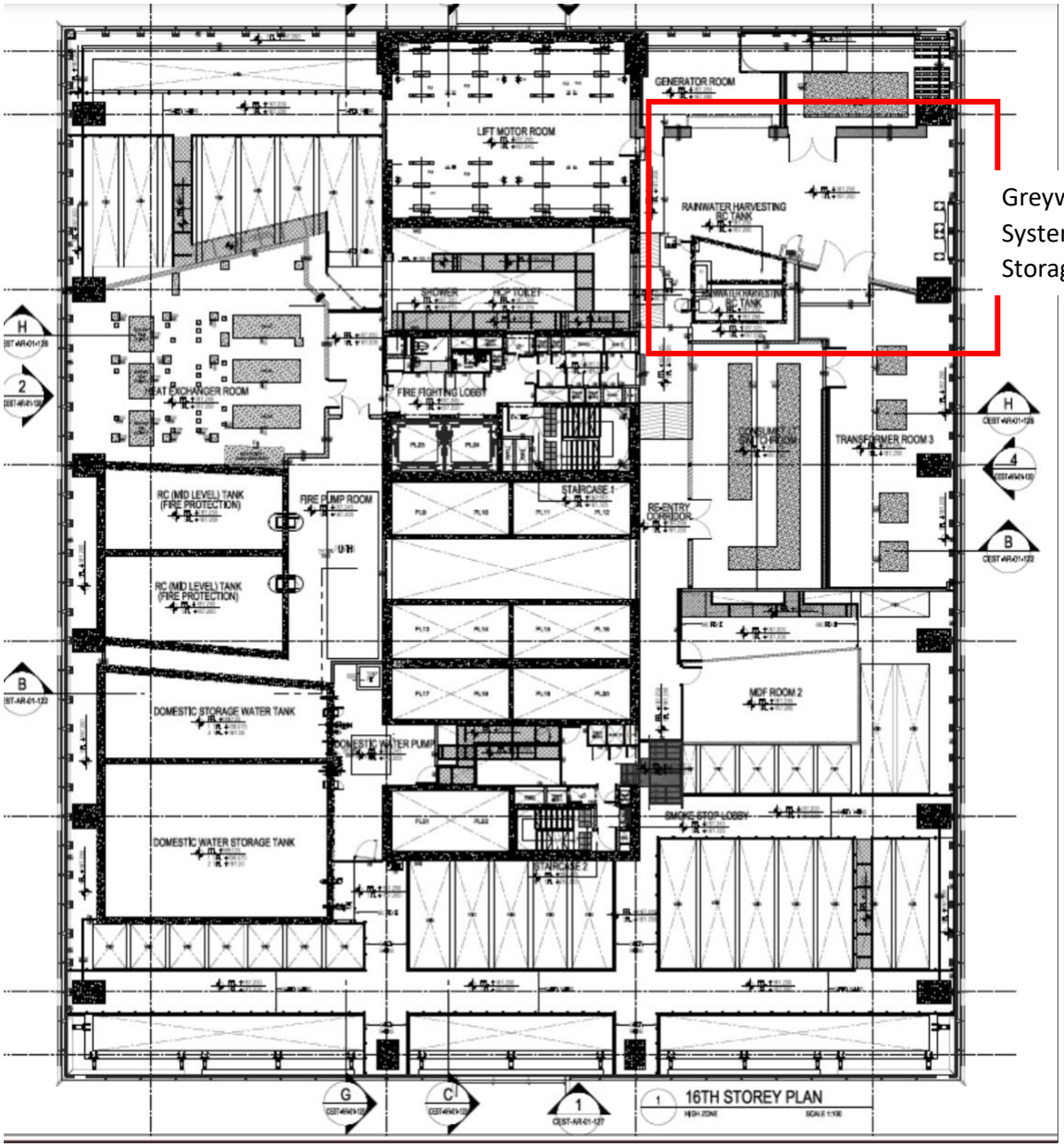
Feasibility

Standard Chartered Bank (SCB), Changi Business Park

https://www1.bca.gov.sg/docs/default-source/docs-corp-news-and-publications/publications/for-industry/sustainable-construction/sa022009.pdf

Implementation Plan:

Suitable Areas:



Greywater System & Storage Tank

Recommendation #2: Food Composter

Leftover food scraps can be transformed into something valuable. Frasers Tower could install a food composter. It is a machine that will take your compostable waste such as food scraps, to recycle into a valuable fertilizer that can enrich soil and plants.

Based on the observations made, there are no trash bins around Frasers Tower. Introducing a food composter for the restaurant could be a great solution to manage food waste effectively and promote sustainability.

Installing a food composter has several benefits that would contribute to Frasers Tower. Firstly, it helps to reduce methane emissions from landfills. Secondly, it helps to reduce waste. Lastly, It helps to helps to recycle organic materials into a valuable soil and improve the plants quality. https://www.epa.gov/sustainable-management-food/composting

Feasibility:

Temasek Polytechnic, School of Engineering's Short Circuit Canteen

IMPLEMENTATION PLAN:

Suitable Area: Center area that the restaurants around the Oasis can walk to dispose the food scraps in the middle

RECOMMENDED SYSTEM: Liquid Food Composter

A liquid food composter would be beneficial for Frasers Tower as it enhance both sustainability and operational efficiency. With a composter, it would reduce the volume of food waste, minimising the landfill contribution. The liquid which was produced can be use for Frasers Tower's lush greenery. This would improve Frasers Tower's landscape, soil quality as well as contributing to greater sustainability. By composting food waste on-site, the areas' odours would be better, improving overall hygiene and making it convenient for the tenants around Frasers Tower's the Oasis.

VI. ANNEX

ANNEX A

COST ANALYSIS OF INSTALLING THE PAVEGEN TILES

1. The unit cost of Energy Generating Tiles can typically range from $1000 SGD to $2,500 SGD per square meter.

Assuming it costs $1750 per square meter,

Tile costs = $1,750 x 8 squared metres = $14,000

2. The Installation Costs are estimated at $50 to $150 SGD per square meter.
Assuming $100 SGD per square meter,

Installation Cost = 8 sqm × SGD 100/sqm

= $800 SGD

3. Surface Preparation are estimated at $10 to $30 SGD per square meter

Assuming $20 SGD per square meter,

Preparation Cost = 8 sqm × SGD 20/sqm

= $160

- Electrical Components and Integration
  Power Conditioning Equipment are estimated at $500 to $2500 SGD.

  Assuming $1,500 SGD,

  Total Equipment Cost = SGD 1,500

- Wiring and Connectors are stimated at SGD 10 to SGD 30 per square meter. Assuming $20 SGD per square meter,

  Total Wiring Cost = 8 sqm × SGD 20/sqm

  Total Wiring Cost = SGD 160

- Monitoring Systems sre stimated at SGD 500 to SGD 2,000. Assuming $1,500 SGD,

  Total Monitoring System Cost = SGD 1,500

5. Maintenance and Operational Costs

- Annual Maintenance are estimated at SGD 200 to SGD 500 per year. Assuming $300 SGD per year,
  Annual Maintenance Cost = SGD 300

ROI OF INSTALLING PAVEGEN TILES

Monthly and Annual Calculations

Total Energy Generated per Month:

0.1120052kWh/day x 30 days = 3.360156 kWh/month

Total Energy Generated per Year:

0.1120052 kWh/day x 365 days = 40.881898 kWh/year

Electricity Cost: Approx SGD 0.3257 per kWh

Annual Savings: 40.881898 kWh/year x 0.3257 SGD/kWh =13.309 SGD/year

Annual Maintenance Costs:

Estimated at SGD 300 per year

Net Annual Savings: 13.309 SGD/year – 300 SGD/year = -286.691 SGD/year

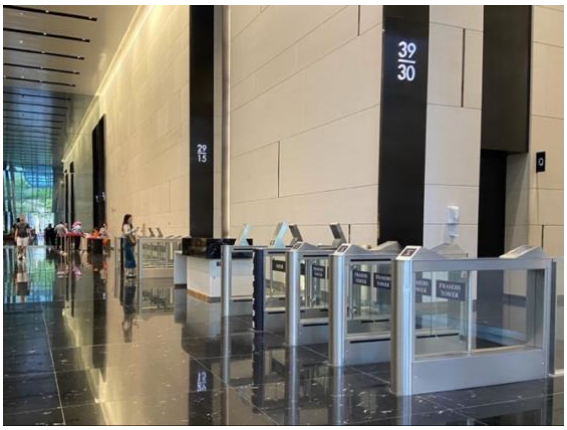
Implementation Plan:

Suitable Areas:

1. Lobby: High foot traffic areas like main lobbies and elevator entrances are key locations for energy harvesting.

2. High-traffic corridors: Corrodents connecting major area within the tower can generate significant amounts of energy.

3. In between the gantry to the building: Majority of the occupants will enter through the gantry



Annex B

Water Management: Integrating DeCalon System

What is DeCalon System?

DeCalon System just refers to removing calcium & ion scaling. In short, also known as DCI. The DCI is an innovative method for getting rid of scale in cooling water systems. Without the use of dangerous chemicals, DCI eliminates water hardness from cooling systems using applied electro-chemistry and a patented intelligent controller. The invention offers an environmentally friendly technological remedy for corrosion and scaling in industrial chiller circuits and HVAC systems in large buildings.

The DCI system catalyzes a non-spontaneous redox reaction that precipitates $Mg(OH)_2$ and $CaCO_3$ at the cathode, eliminating existing scale deposits and halting new scale formation. The recirculating cooling water can then be used to remove Ca^{2+} and Mg^{2+}, the main causes of scaling. Plus, SiO_2 is eliminated. The system runs continuously, eliminating the need for regular shutdowns for cleaning and always maintaining the design heat transfer efficiency.

How does installation of the DCI benefit Fraser Tower?

Reduced usage of water

Over 50% of blowdown water is reduced when a DCI is installed. This is achieved by electrolysis which alters the chemical balance of the cooling tower's water. Removing the need for chemicals to be induced for water treatment. As a result, the cost for water usage can be cut significantly.

Reduce operation cost & Maintenance

With its technology of basis electro chemistry, it is eliminating the need to induce anti-scalent and corrosion inhibitors chemicals. Cutting the cost for such products and maintenance. It has an inbuilt intelligent controller which removes scales at just the right amount to maintain heat transfer between water and air hence improving efficiency which results in lower energy consumption. In a nutshell, bills for energy consumption are reduced.

Increases operating life

Reducing corrosion this way is not only an eco-friendlier solution but increases the lifetime expectancy for this equipment. The DCI system does not need shutting down of plant to install which will affect the buildings operations.

Feasibility

Keppel Bay Tower – Green mark Platinum (zero energy)

The success of Keppel Bay Tower in implementing the DCI system provides strong evidence of its potential impact at Frasers Tower. Data from Keppel Bay Tower can demonstrate measurable improvements in energy efficiency and cost savings.

Notable result of Keppel bay's Tower significant changes implementing the DCI system:

7% chiller energy savings and 81% blow down water reduction.

Scope	Change
Chiller Power Consumption	8 – 12% reduction
Chiller Plant Power consumption	7.01% reduction at 70% Load
Blow down Water consumption	81.4% reduction
Make up water consumption	8.7% reduction
Cooling Tower water quality	Water Chemistry in DCI are kept within limits
Others	Bacteria in Cooling water are kept within NEA limits
Corrosion measured as Fe and Cu	Within industrial guideline limits

This data shows a strong argument for the implementation of the DCI system being effective in cutting several aspects. Since Keppel Bay Tower is roughly half the size of Fraser's Tower. This shows that the potential for savings and reduction in usage of water and energy can be greater if applied at Fraser's Tower.

Annex C

Water Management: Bubble90 Nozzle

What is the Bubble90 Nozzle?

The bubble90 nozzle is a water saving technology created by a Japanese company DG Takano, who specializes in product design. This revolutionary design of special nozzle uses pulsation flow technology which delivers water in quick, controlled bursts or pulses rather than a continuous stream. Resulting in less usage of water while performing the same function as regular taps.

Bubble 90 extreme: The Bubble90 Extreme provides maximum water savings and cost reduction. Its concentrated flow enhances cleaning power, making it ideal for washing smallware in restaurants and retail.

Bubble90 classic: The Bubble90 Classic balances water volume and conservation, boosting cleaning efficiency and reducing costs. It provides enough flow for tasks like filling a mug.

Bubble90 light: The Bubble90 Light is ideal for cleaning large dishes, providing a higher water volume for tasks like meeting flow rate requirements for water heaters.

The Bubble90 extreme would be proposed to be fitted in common toilets at the lobby and on level 2. These are the targeted places with higher human traffic reaping the most benefits from this water saving tool.

Annex D

Energy Efficiency: Photovoltaic Solar Film Stickers

It converts buildings into clean solar power plants for the production of green electricity. You can apply this ready-to-use solution on many types of building surfaces. Because the solar film contains integrated connection cables and an integrated backside adhesive, it may be connected and utilized right away after being simply adhered to the surface.

It can be applied to a wide range of substrates upon request, including bitumen, glass, metal, concrete, membranes, and other materials. Installing the films only takes a few simple steps and is easy.

Installation Steps:

1. Prepare the installation surface
2. Position the solar film on the installation surface
3. Remove the backside adhesive protection liner
4. Fix the solar film with a roller

ROI

Electricity Generation (Day)

= 85W x 300sqm x 5hr

= 127,500Wh

= 127.5kWh/day

= 127.5 kWh/day x 30 days = 3,825 kWh/month

Electricity Generation (Evening)

= 85W x 300sqm x 5hr

= 127,500Wh

= 127.5kWh/day

= 127.5 kWh/day x 30 days

= 3,825 kWh/month

Electricity Generation (Canopy)

= 85W x 55sqm x 10hr

= 46,750Wh

= 46.75kWh/day

= 46.75 kWh/day x 30 days = 1,402.5 kWh/month

Total generated in a month

= 3,825 kWh/month + 3,825 kWh/month + 1,402.5 kWh/month

= 9,052.5 kWh/month

Electricity Cost (before implementation)

= 600400kWh x 32.57 cents/kWh

= $195,550.28

Electricity Cost (after implementation)

= (600400 – 9052.5)kwh x 32.57 cents/kWh

= $192,601.88

Assuming that HeliaSol cost $727 per sqm (excluding installation costs),

Cost = 655sqm x $727 = $476,185

Initial Cost = 655 sqm × $727/sqm = $476,185

Monthly Savings = $195,550.28 − $192,601.88 = $2,948.40

Annual Savings = $2,948.40 × 12 = $35,380.80

Payback Period = $476,185 / $35,380.80 ≈ 13.46 years

ROI = ($35,380.80 / $476,185) × 100% ≈ 7.43%

Annex E

Waste Management: Bin-e

How does Bin-e (Smart waste bin) work?

When waste is thrown into the bin, it will be transported to the right fraction in the bin after the AI identifies the type of waste thrown. This process takes place immediately.

Plastic and paper thrown in the bin will get compresses to decrease to volume and reduce the frequency of waste management company coming in to empty the bin.

The bin has sensors that detect the fill level of the bin. This is to check if the bin needs to be emptied. Your phone/e-mail will be alerted if it is full.

All the data Bin-e collects is transferred onto a cloud and processed in real-time. There is an app that gives you information about the technical state of the bin, waste collection optimization data, and comprehensive statistics about the waste you collected.

Recommended System:

Smart Waste Bin: Place smart waste bins in strategic places to gather various waste kinds, including organic waste, non-recyclable waste, and recyclables. Bin-e bins use cameras and sensors to identify and categorize waste as it is thrown.

Sensor Technology: To precisely gauge the amount of waste inside the bins, incorporate sensors like weight sensors, infrared sensors, or ultrasonic sensors.

These sensors enable effective waste collection and management by giving real-time data on waste fill levels.

Connectivity: To send data to a central management system, make sure bins have connectivity choices like Wi-Fi, cellular, or LoRaWAN. The waste management system may be remotely monitored, data analyzed, and controlled thanks to this connectivity.

Central Management System: To collect and handle data from the bins instantly, put in place a central management system. To improve waste management operations, this system should have capabilities like predictive maintenance, route optimization, waste monitoring, and reporting tools.

Data Analytics: Apply data analytics methods to examine the information gathered from the bins and get important insights regarding fill-level trends, trash generation patterns, and operational effectiveness. Schedules for garbage collection can be improved, expenses can be decreased, and resource allocation can be improved with the use of this data.

Integration with Current Systems: The bins should be integrated with the current waste management infrastructure, which includes landfills, recycling centers, and garbage pickup trucks. The many elements of the waste management ecosystem are guaranteed to coordinate and communicate with one another seamlessly thanks to this integration.

User Interface: Create intuitive user interfaces, like web portals or mobile applications, so that facility managers, residents, and waste management staff can all access pertinent data and carry out tasks like booking pickups, reporting problems, and viewing analytics dashboards.

Smart Routing and Logistics: Based on real-time fill-level data from the bins, optimize garbage collection routes using cutting-edge algorithms and routing optimization approaches. This maximizes the effectiveness of waste collection operations while reducing travel time, fuel consumption, and emissions.

Security and privacy: Put strong security measures in place to safeguard private information that the system collects and to make sure privacy laws are followed. To protect data integrity and confidentiality, this also includes data anonymization methods, access controls, and encryption.

Durability and Suitability:

1. Durability: It is usually constructed from sturdy plastic or stainless steel, which guarantees endurance and resistance to wear and tear and adverse weather conditions. The architecture of the bin is made to resist repeated use and exposure to external conditions without suffering appreciable deterioration.

2. Sensor Technology: To precisely detect and quantify the amount of garbage placed, the bin is outfitted with a number of sensors, such as fill-level and weight sensors. These sensors add to the system's overall longevity because they are designed to be dependable and precise over lengthy periods of time.

3. Intelligent Features: Bin-e's intelligent features, like its data analytics and cloud-based software integration, make it more suited for today's waste management requirements. By enabling data-driven decision-making, predictive maintenance, and remote monitoring, these elements increase overall effectiveness and efficiency.

4. Adaptability: It is made to fit in with a variety of waste management settings, such as public areas, business buildings, and smart cities. It is appropriate for various waste streams and operational requirements because to its modular architecture and configurable features.

5. User Interface: To make communication between users and waste management staff easier, the bin frequently has an intuitive user interface, like a touchscreen or mobile app. These interfaces are made to be sturdy and user-friendly, which guarantees smooth functioning and little upkeep.

Aesthetics:

1. **Modern Design:** Bin-e has an elegant, cutting-edge style that appeals to current tastes. Its smooth surfaces, minimalist look, and clear lines all combine to create an aesthetically beautiful look that goes well with contemporary interior and architectural design themes.

2. **Compact Form Factor:** Because Bin-e is made to be small and space-efficient, it may be installed in a variety of locations without drawing attention to itself. Because of its small form factor, it can be perfectly integrated into the environment without taking over the room.

3. **Customized Finishes:** Bin-e may provide color choices or customizable finishes to enable customization and environment-friendly integration. Bin-e's aesthetic adaptability is enhanced by its ability to complement many color schemes and design concepts, thanks to this customisation option.

4. **Simple Interface:** Bin-e's interface, which includes both touch screens and LED indicators, is made to be simple to use and intuitive. The interface improves functionality and blends in smoothly with the garbage bin's general design, adding to its sleek, contemporary appearance.

5. **Concealed Technology:** Bin-e is a smart garbage bin featuring cutting-edge sensors and technology, yet it is made to blend in with its surroundings without drawing attention to itself. By keeping the waste bin tidy and uncluttered, this covert technology method improves its visual appeal.

6. **Distinctive Features:** The unique features of Bin-e, like smart fill-level monitoring, automatic garbage sorting, and IoT connectivity, not only increase the effectiveness of waste management but also give the waste bin's design a futuristic, cutting-edge look.

7. **Environmental Aspects:** Recycled materials, energy-efficient parts, or environmentally friendly production techniques are a few examples of design aspects that Bin-e may use to highlight its green attributes. The waste bin's overall attractiveness to ecologically concerned users is further enhanced by these environmental factors.

ROI

Cost for 2 bins: 12k Euro = $34,964 x 2 = $69,928

Assuming monthly waste management cost for Fraser Towers is $99,000,

Net Annual Savings = ($99,000 x 12) – 70% = $356,400

Payback Period = $69,928 / $356,400 = 0.196 years

Therefore, the payback period for the investment in the bins is approximately 0.196 years, or roughly 2.35 months.

ROI = [($356,400 - $69,928) / $69,928] x 100% = 409.73%