



SUSTAINABLE HOUGANG Mall PROJECT PROPOSAL

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01

Introduction



Team Members



Grace



Jayden



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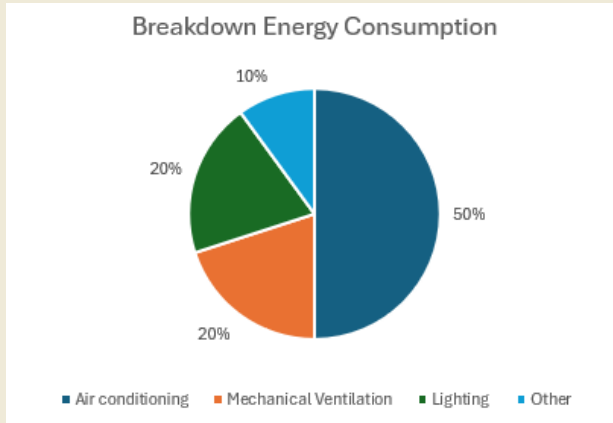
We are a team of Year 3 students currently pursuing a Diploma in Environmental and Marine Science in Republic Polytechnic. In this Challenge, we hope to contribute to a greener urban landscape and architecture through designing and reimaging the Sustainable Hougang Mall.

About Hougang Mall



Hougang Mall is a suburban retail mall located near Hougang MRT Station and Hougang Central Bus Interchange. It has a rather heavy foot traffic (12.7 million as recorded between October 2022 and September 2023), and a net lettable area of 15,393 sqm offering a wide variety of daily necessities and essential services, resulting in the mall consuming a significant amount of electricity and water, and producing tonnes of waste.

Energy Consumption Pattern



- According to a recent study conducted at Singapore Institute of Technology (SIT), heating, ventilation and air conditioning (HVAC) systems accounted for approximately **50% of the building energy consumption.**
 - This is due to the space cooling requirement all year long as Singapore has a tropical climate.
-
- Recent energy audits and surveys of commercial premises have also shown that lighting contributes to **20-30% of energy consumption** in a building.
 - HVAC systems and lighting are indeed among the major contributors to energy/ electricity consumption in commercial buildings in Singapore, including Hougang mall.
 - Hougang Mall attained the BCA Green Mark Platinum Building Certification in 2022. Frasers Centrepoint Trust, the owner of Hougang Mall, has upgraded its cooling systems and retrofitted more energy efficient LED lightings (based on Frasers Sustainability Report 2023).

Environmental Performance Data of Hougang Mall

Timeframe	Electricity Consumption (kWh)	Waste Incineration (kg)	Water Consumption (kL)
Sep 2023	373,200	76,810	7,420
Oct 2023	384,000	80,990	7,200
Nov 2023	361,500	77,460	6,630
Dec 2023	367,900	79,480	6,880
Jan 2024	366,000	79,800	5,410
Feb 2024	342,300	78,650	6,820
Consumption in 6 months	2,194,900	473,190	40,180
Emission factor	0.4168 kg CO ₂ e/kWh	0.635722 kgCO ₂ /kg	1.3 kgCO ₂ /m ³
Average for 1 month	152.47 tonnes CO ₂	50.14 tonnes CO ₂	8.71 tonnes CO ₂
Average for 6 months	914.83 tonnes CO ₂	300.82 tonnes CO ₂	52.23 tonnes CO ₂
Estimated for 1 year	1,829.67 tonnes CO ₂	601.63 tonnes CO ₂	104.47 tonnes CO ₂

- Electricity consumption has the highest carbon emissions, followed by waste incineration and water consumption.
- There has been a decline in electricity consumption from November 2023 to February 2024. This trend is typically attributed to changes in weather patterns, as November tends to be cooler due to increased rainfall and the cooler weather continues through February.
- Emission reduction in waste consumption and electricity consumption are targeted.

- **Electricity Emission factor:** Singapore energy statistics 2023 by Energy Market Authority (EMA)
- **Water Emission factor:** LCA of water supply in SG
- **Waste Emission factor:** Singapore's fifth national communication and fifth biennial update report 2022

Our Proposal



Environment Performance



People



Sustainability

Focus areas

Waste (BSF Composter)

At least **7% reduction in carbon emission** per month and **45 tonnes of waste diversion** from landfill per year

Energy (Retractable Solar Panels)

At least **2% efficiency improvement** in electricity consumption per month

Air Quality (Green Walls)

Strengthening resilience against air pollution and global warming effects

Community Engagement

Boost behavioural changes in residents to keep electricity, water consumption and waste management low

1) Waste

Implementation of smart and food recycling bins, food waste recycling lockers, fashion waste bins and collaboration with recycling companies

2) Electricity

Usage of electricity quotas and educational game booths

3) Sustainable Food Growth & Efficient Water Usage

Implementation of guided tours and rewards system

Food Sustainability

Achieve sustainable food management and efficient use of resources

1) Aquaponics

Combination of hydroponics and aquaculture

2) Community Garden

Educate residents about sustainable farming practices

Resource Sustainability Act

- Resource Sustainability Act (RSA) was enacted in 2019 to give legislative effect to new measures to address the priority waste streams (including food waste)
- Under the RSA, affected buildings are required to segregate their food waste for treatment and reporting which includes industrial and commercial buildings that generate large amounts of food waste

Types of Buildings		Threshold	
Commercial	Shopping Malls	F&B Area*	> 3,000 sqm
	Hotels	F&B and Function Area	> 3,000 sqm
Industrial	Single-user Factory (SUFs)	Large Food Manufacturers^	Operation area > 750 sqm
	Multi-user Factory (MUFs)	GFA and food tenants	GFA > 20,000 sqm and with > 20 food tenants
		At least one large food manufacturer^	Operation area > 750 sqm

Buildings covered under the food waste segregation and reporting framework



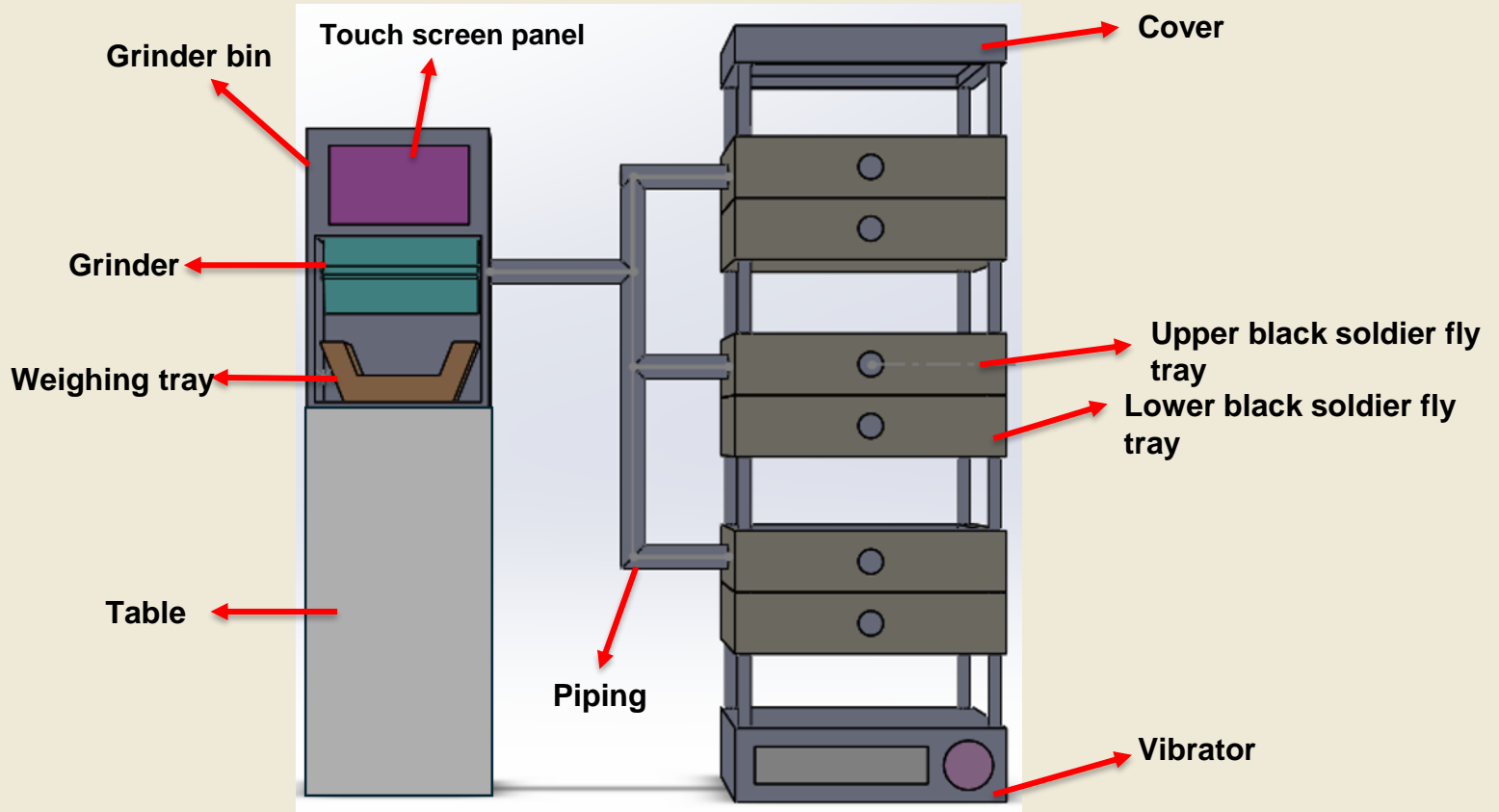
ORGANIC

ANIMAL FEED

**02: Black Soldier Fly
Composter**

FERTILISER FOR PLANTS

Overview of Black Soldier Fly Composter



Design Mechanism

- In the black soldier fly composter set up, a grinder bin is connected to black soldier tray through pipes
- Food waste is deposited into the top of the grinder bin, where it passes through the grinder, breaking down into smaller particles. These particles are weighed by a tray at the bin's bottom. Using the touch screen panel (in pink coloured) , a predetermined quantity of ground food waste is set in the bin. Subsequently, the grounded food waste is automatically conveyed from the grinder bin to the black soldier fly tray through pipes and automation.
- Each container depicted in the design component for black soldier tray comprises of two trays. The upper tray houses the black soldier fly larvae along with the ground food waste from the grinder bin and average contact time inside the composting tray is 2 hours. Positioned at the bottom of the upper tray is a sieve (shown at slide 11). The lower tray serves as a receptacle for the frass collected from the black soldier fly larvae. Frass can be collected 2-3 times daily depending on amount of food waste fed to the system.
- In the set-up, three containers were stacked on top one another, each separated by a small gap to ensure sufficient oxygen supply for the survival of the black soldier fly larvae. A cover was added to the top of the structure to create a shaded environment for the black soldier fly larvae, since they thrive in dark and moist conditions.
- At the bottom of the stacked containers, a vibrator is installed to introduce a gentle shaking motion to the structure. This serves to facilitate the collection of frass, a black soldier fly larvae byproduct, by assisting in the sieving process.

Benefits of The Black Soldier Fly Composter

Objective: To reduce the amount of food waste produced by the mall

- Use of black soldier fly (*Hermetia illucens*), a native fly in Singapore.
- Black soldier flies, in their larval stage, are recyclers that can efficiently convert large quantities of organic waste into useful products, such as animal feed and fertiliser.
- Black soldier fly larvae (BSFL) is a voracious eater that can decompose and break down various type of organic matter, including food waste into a nutrient rich substance called frass (black soldier fly larvae waste product)
- Frass → Rich in essential nutrients like phosphorus and nitrogen and can be repurposed as fertilisers for agricultural crops
- Black soldier fly composting → reduce the weight of food waste by 50% and operates at a faster rate as compared to conventional composting methods. Research have shown that 1 kg of black soldier fly larvae can process over 20,000kg of food waste that would otherwise be sent for incineration.
- Black soldier fly larvae are also rich in proteins and lipids, making them suitable to be used in food pellet ingredients for fish or chicken feed which helps to alleviate the strain on food production resources and contributes to meeting the food demands of Singapore's population.

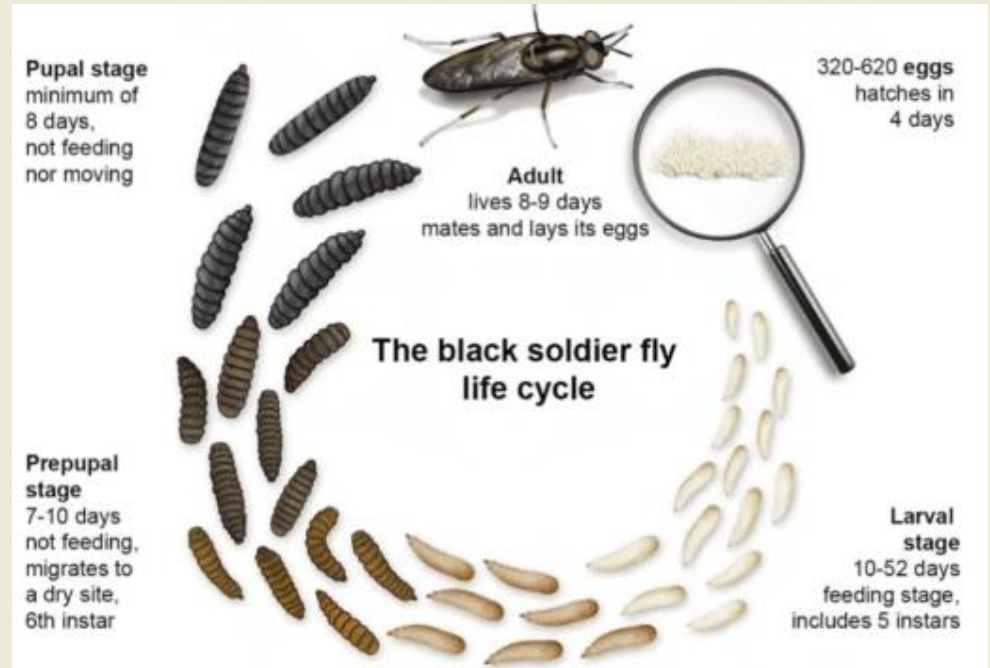
Black Soldier Fly



Black soldier fly larvae

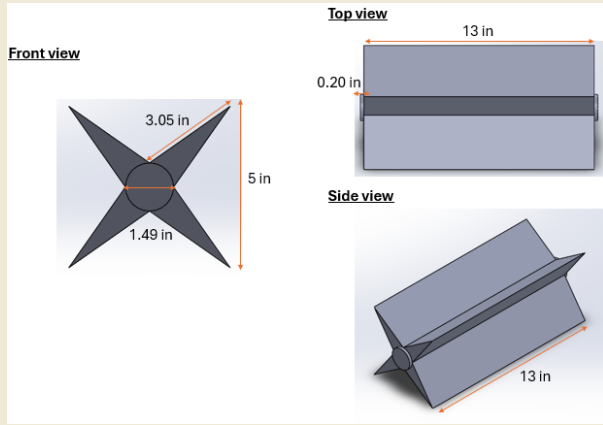


Frass produced by Black soldier fly larvae

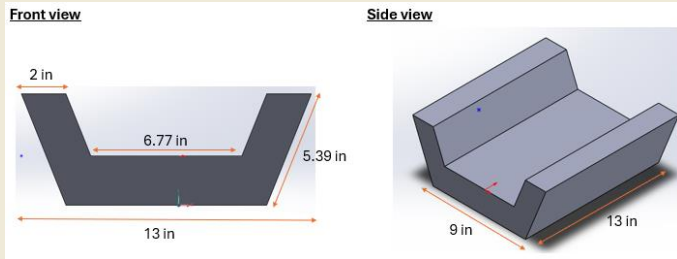


Black soldier fly life cycle

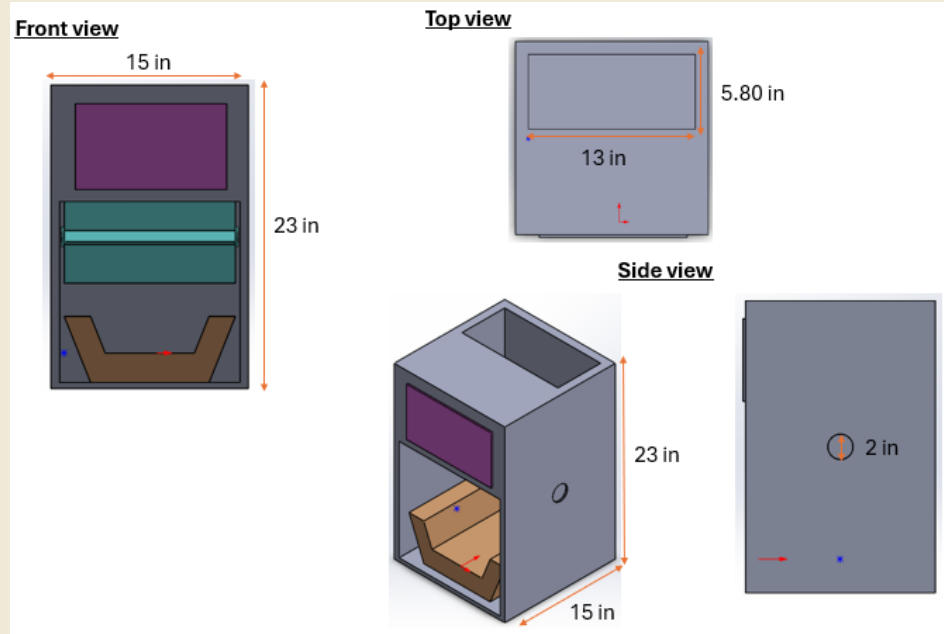
Design Components (Grinder Bin)



Grinder



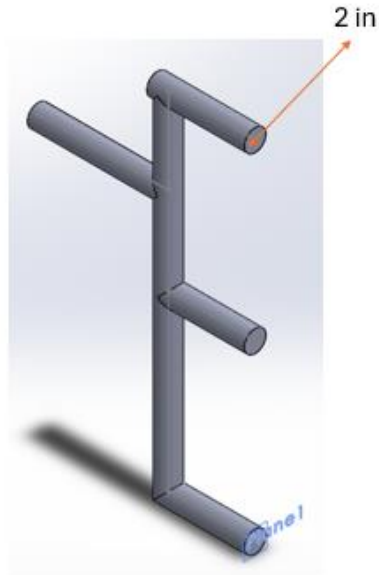
Weighing tray



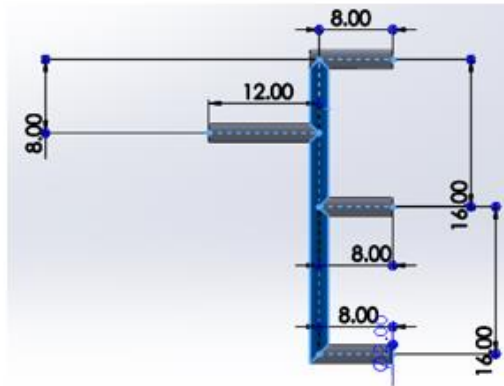
Overview of grinder bin

Design Components (Piping)

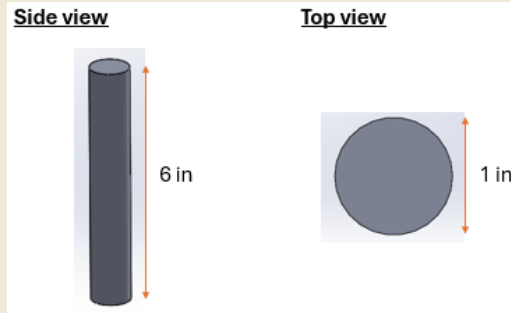
Side view



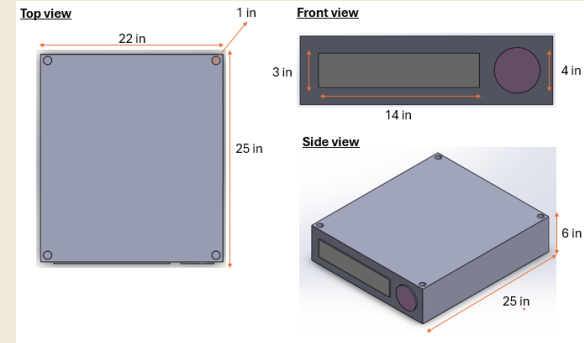
Front view



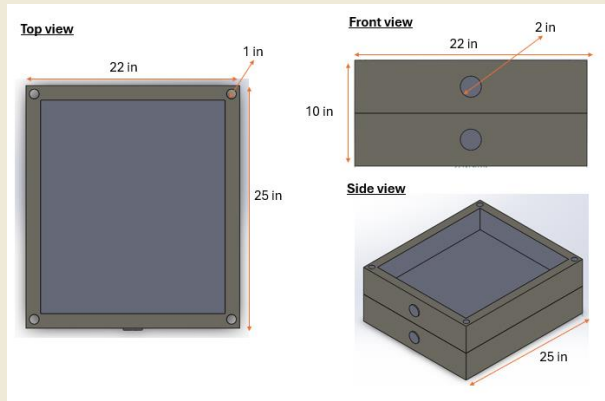
Design Components (Black Soldier Fly Tray)



Column



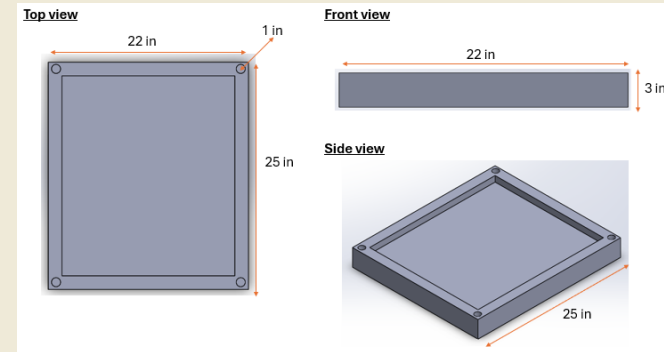
Vibrator



Container



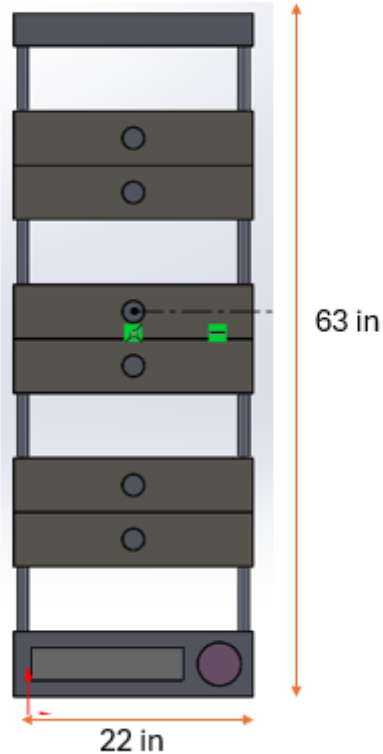
Illustration of a sieve at the bottom of top layer tray



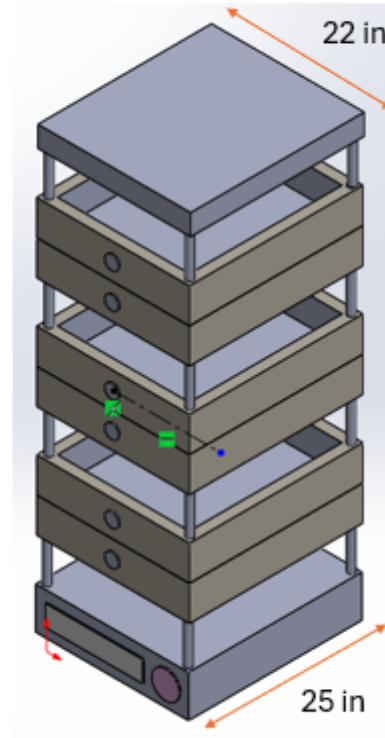
Cover

Overview: Black Soldier Fly Nursery Tray

Front view



Side view



Real-Life Application: Sustainability @ Tampines Park

1 WASTE SOURCING

- Food waste such as vegetable cuttings, fruit peels, carbohydrates and meat are collected from residents.
- Volunteers will sort them out to remove items such as watermelon rinds and durian husks as these are not digestible by the black soldier fly larvae.



2 WASTE PROCESSING

- The food waste is then processed with other by-products such as okara, which is a waste product from soya beans.
- This can help to manage the consistency of the food waste and to optimise its processing rate.



Real-Life Application: Sustainability @ Tampines Park

3 FEEDING THE LARVAE

- This is then fed to the black soldier fly larvae, which take a few days to convert the food waste into a by-product known as frass.
- Frass, which is rich in nutrients such as phosphorus and nitrogen, can then be used as fertiliser for plants.
- Each batch of larvae is fed with food waste for two weeks before it is harvested.



4 A LARVAE FOR FISH FEED

- The larvae, which are high in protein and fats, are then harvested and frozen so that they can be used as fish feed at the tilapia pond.



Frozen larvae



4 B FRASS FOR VEGETABLES FARMING

- The frass is then separated from the insect larvae, where it is converted into fertiliser to be used for the vertical vegetable farm owned by Neta Tech.
- This can be used to grow local vegetables such as nai bai, cai xin and bayam.



Frass



Vegetables & Fish for residents

Calculation

Timeframe	Waste Incineration (kg)
Sep 2023	76,810
Oct 2023	80,990
Nov 2023	77,460
Dec 2023	79,480
Jan 2024	79,800
Feb 2024	78,650
Consumption in 6 months	473,190
Emission factor	0.635722 kgCO ₂ /kg
Average for 1 month	50.14 tonnes CO ₂
Average for 6 months	300.82 tonnes CO ₂
Estimated for 1 year	601.63 tonnes CO ₂

- Average amount of waste generated by month: $473,190 \text{ kg} / 6 = 78,865 \text{ kg} = \underline{\underline{80 \text{ tonnes of waste}}}$

It is estimated that our black soldier fly composter can treat **0.2 tonne of food waste (200kg) per day**

- Total amount of food waste treated by BSF composter per month: $0.2 \text{ tons} \times 30 = \underline{\underline{6 \text{ tons}}}$
- Total percentage of waste diverted from incineration per month: $6/80 \times 100\% = \underline{\underline{7.5\%}}$
- Total emission reduction per month: $6000 \text{ kg} \times 0.635722 \text{ kgCO}_2/\text{kg} = 3814.33 \text{ kgCO}_2 = \underline{\underline{3.814 \text{ tonnes CO}_2}}$
- Total emission reduction per year: $3.814 \text{ tonnes CO}_2 \times 12 = \underline{\underline{45.77 \text{ tonnes CO}_2}}$
- Percentage of emission reduction per month: $(3.814/50.14) \times 100\% = \underline{\underline{7.61\%}}$



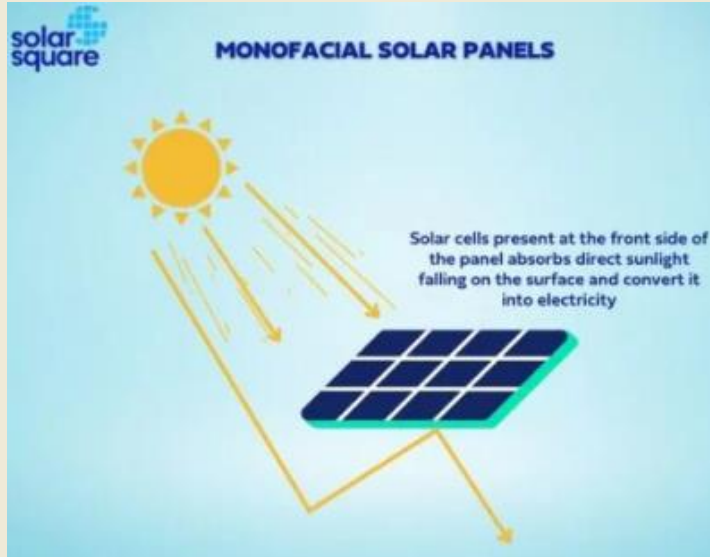
03: Retractable Solar Panels

Benefits of Retractable Solar Panels

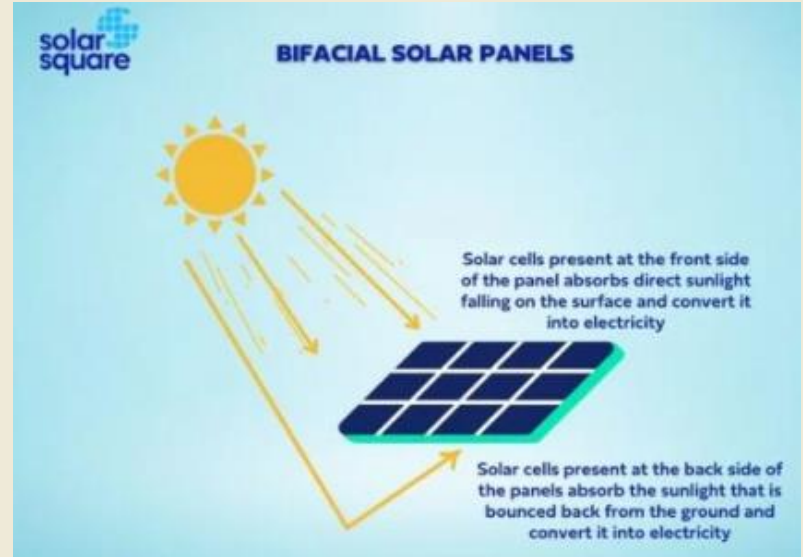
Objective: To improve overall energy efficiency of the mall

- Uses solar energy → renewable & clean source of energy that does not produce any greenhouse gas emission during operation. This helps to mitigate climate change and reduce reliance on fossil fuels. They also have relatively low operating and maintenance costs as compared to traditional energy sources
- Mounted on elevated poles → maximizing land utilization through dual land use.
- Lightweight construction facilitates easy movement and eliminates the need for extensive vertical supports.
- Can be folded in an accordion-like manner without compromising the structural integrity of the solar roof → optimizing space efficiency.
- Can be adjusted to optimize their angle and orientation towards the sun throughout the day, maximizing energy production as compared to fixed solar panels.
- Serve as a shelter for aquaponics, black soldier fly composter, community garden
- Use of bifacial solar panels (solar cells on both sides, front captures incident sunlight & back absorbs reflected light)
→ A 2018 study by LONGi Solar showed that bifacials can increase efficiency by 11% as compared to a conventional solar panel system

Monofacial Vs Bifacial Solar Panels



Monofacial Solar panels



Bifacial Solar panels

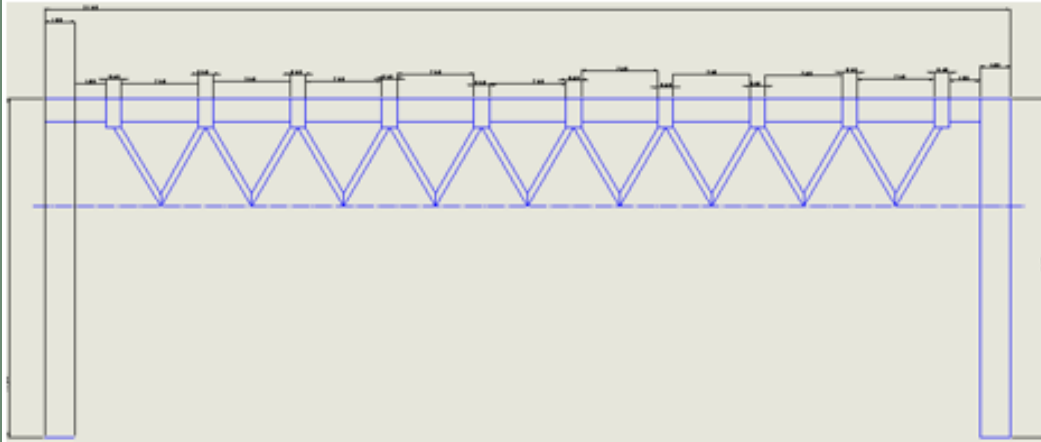
Differences In Solar Cell Efficiencies

Monofacial Solar Panels	Bifacial Solar Panels
<ul style="list-style-type: none"> • More affordable • Lighter weight • Work on all surfaces 	<ul style="list-style-type: none"> • Higher efficiency • Higher durability & heat resistant • Lesser space required • Panels can be set at any angle

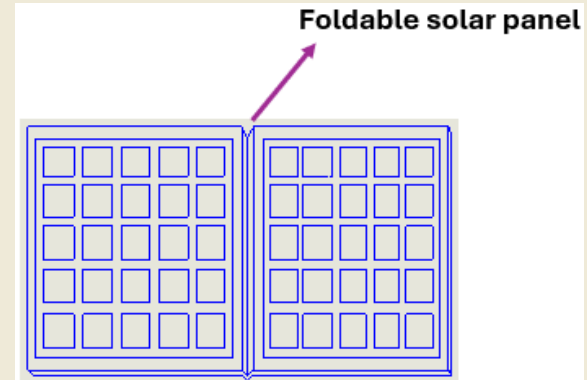
Type of Solar Panel	Total Solar Cell Efficiency
Monofacial Monocrystalline	18% +
Monofacial Polycrystalline	15–17%
Monofacial Thin-Film	11–15%
Bifacial Monocrystalline	20% +

Retractable Solar Panel Design

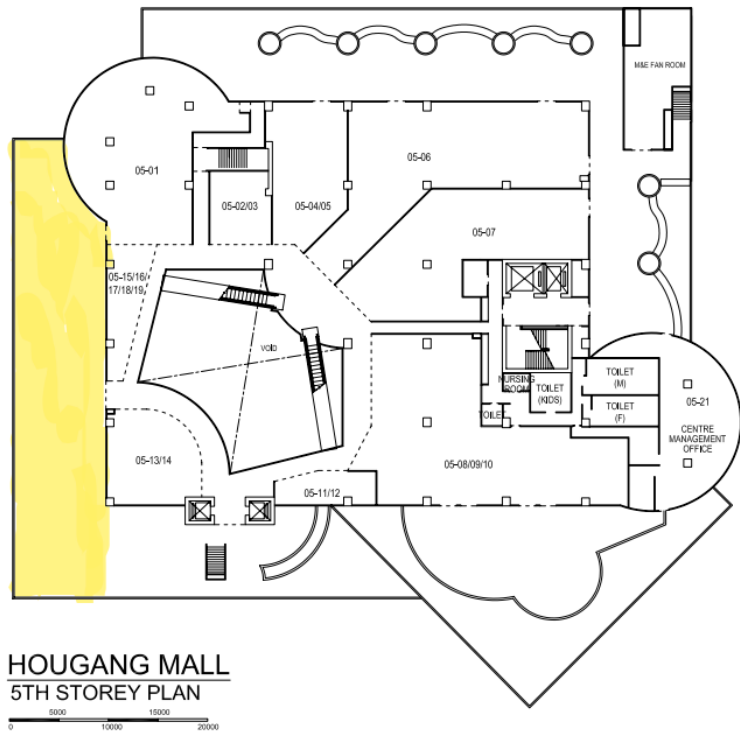
Side view



Foldable solar panel



Proposed Location : Rooftop



Estimation area of shaded yellow area:

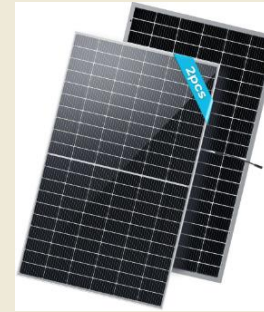
- Breadth: 2cm \rightarrow 10m
 - Length: 8cm \rightarrow 40m
- Total area: 10m x 40m = 400m²

Calculation

Timeframe	Electricity Consumption (kWh)
Sep 2023	373,200
Oct 2023	384,000
Nov 2023	361,500
Dec 2023	367,900
Jan 2024	366,000
Feb 2024	342,300
Consumption in 6 months	2,194,900
Emission factor	0.4168 kg CO₂e/kWh
Average for 1 month	152.47 tonnes CO₂
Average for 6 months	914.83 tonnes CO₂
Estimated for 1 year	1,829.67 tonnes CO₂

Dimensions of PV:

1.909m x 1.134m x 0.035m



Estimated area of 1 PV: 2.16m²

Average amount of electricity consumed by month: 2,194,900 kwh / 6 = **365,816.66 kwh**

It is estimated that using Renogy's bifacial monocrystalline panels would produce up to **450 watts per panel**

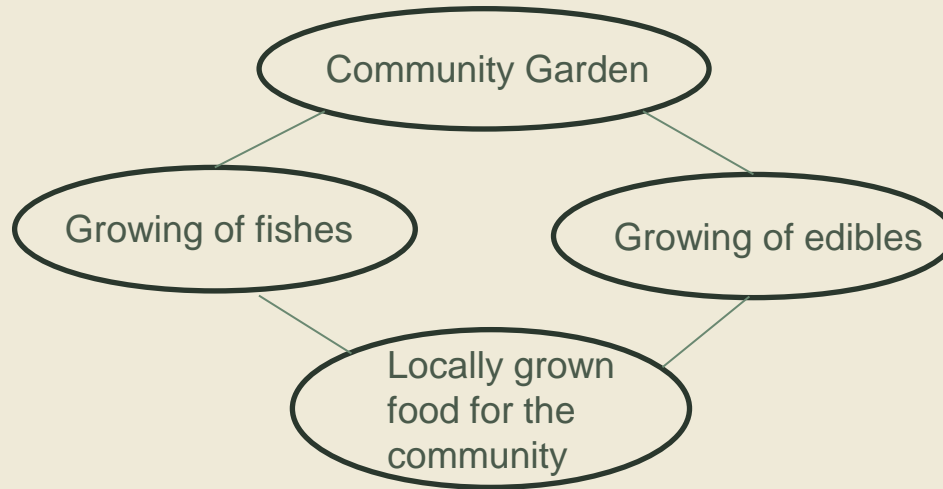
- **Average peak sun hours per day in Singapore:** 5 hours
- **Efficiency of PV = 75%**
- **Number of PVs installed:** 200 panels
- **Solar output per day:** Wattage x Peak Sun hours x 0.75 → 0.45kW x 5 x 0.75 = **1.687 kWh per day**
- **Total solar output per month (200 panels are installed):** 1.687 kwh x 30 days x 200 panels = **10,122 kwh**
- **Total emission reduction per month:** 10,122 kwh x 0.4168 = 4218.85 kg CO₂e → **4.219 tonnes CO₂**
- **Total emission reduction per year:** 4.219 tonnes CO₂ x 12 = **50.63 tonnes CO₂**
- **Percentage of electricity offset per month:** (10,122/365,816.66) x 100% = **2.77%**

04: Community Garden



Community Garden Objectives

- The current purpose of the rooftop area is to act as a community space for the community. We aim to upgrade this space into an educational and recreational space that teaches interested members of the community more about sustainable farming practices and gives them hands on experience in growing their own food.
- The goal is to ensure that anyone who is interested to help out, can join and feel included and contribute towards the community garden.
- The produce (edible greens and fish) can be given out to needy members and volunteers of the community garden.

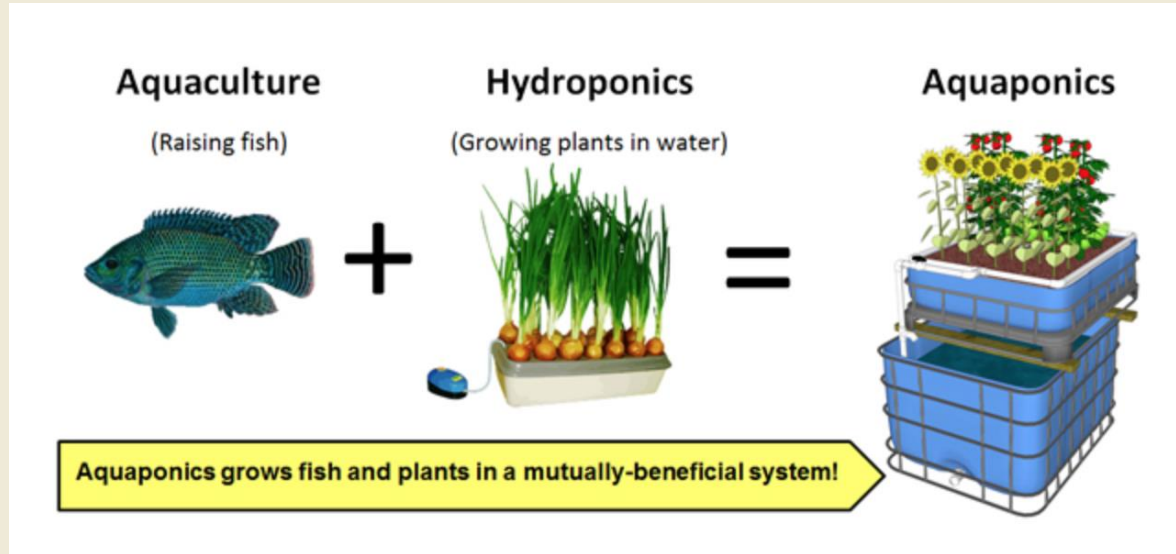


05: Aquaponics

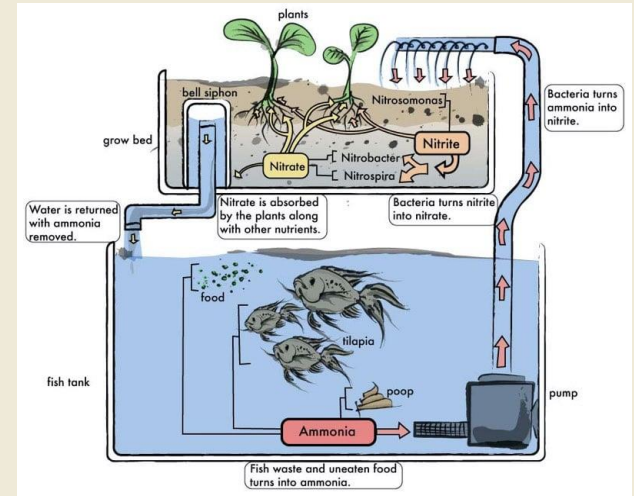
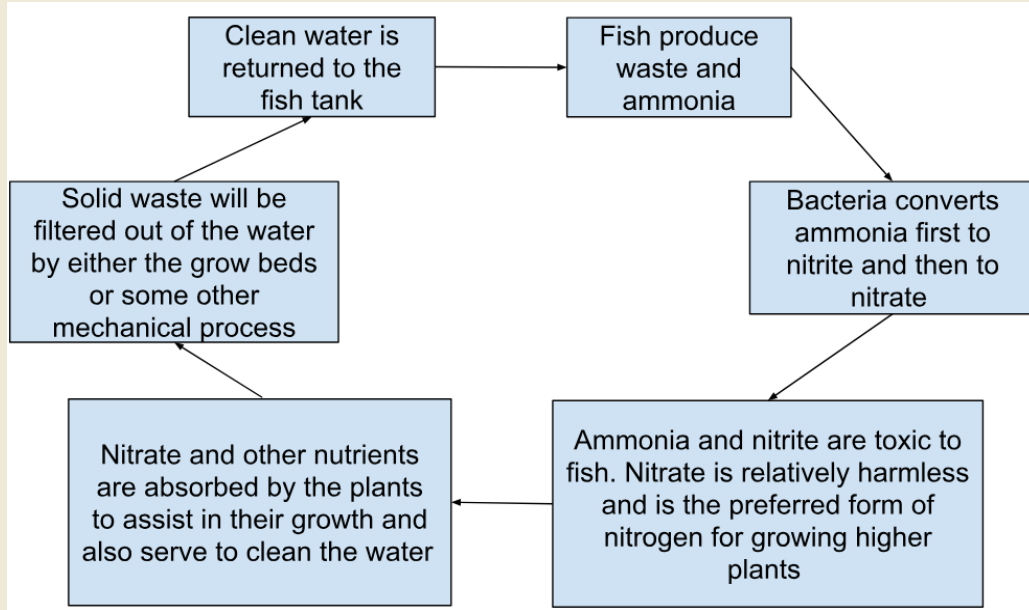
The image shows a multi-level aquaponics system. It consists of several long, white, curved tanks filled with clear blue water. In the foreground, a tank contains numerous small, blue fish swimming. Two rectangular floating beds are positioned in the tank, each densely packed with bright green, leafy plants. A white rectangular panel with a small black display is attached to the side of the tank. In the background, another similar tank is visible, also containing fish and floating plant beds. The entire system is set on a light-colored tiled floor.

What is Aquaponics?

- An aquaponic system creates a recirculating, symbiotic system for sustainable food production by combining the hydroponic growing of plants with the husbandry of fish.
- The aquaculture system's waste discharge is decreased since plants can use the water and nutrients from the tanks which are broken down bacteria.

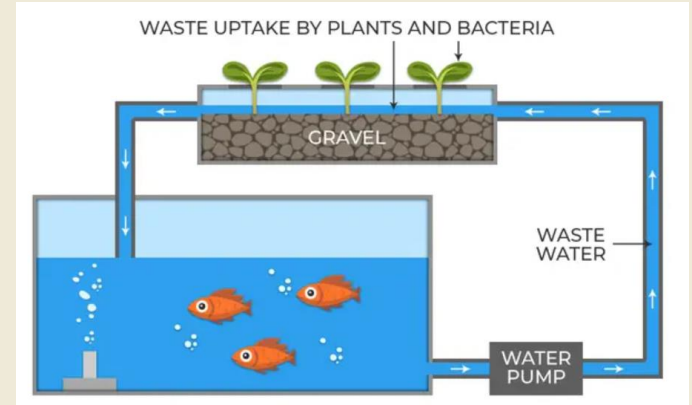


The Aquaponic Cycle



Recommended Aquaponics Type: Continuous Flow Media System

Advantages	Disadvantages
<ul style="list-style-type: none">• Beginner friendly• Easy to Set-up• Provides good aeration and nutrient dynamics	<ul style="list-style-type: none">• Flow interruption can result in the entire system getting disrupted



The continuous flow media system is the aquaponics system which is the easiest to use and set up while still providing the plants with all the necessary conditions to thrive. This is ideal for a community garden which aims to allow all interested members of the community be involved. The only major precaution that needs to be taken would be to barricade the pumps and water pipes to reduce the chances of flow interruptions occurring.

Required Water Quality Parameters

- The fish and plants should have similar needs as far as **temperature** and **pH**.
- **pH**
 - The best average pH: 7.0 – 7.5 (neutral to slightly alkaline)
 - Add calcium (coral chips) or potassium hydroxide to increase pH and restore to recommended levels
 - Add sulfuric, phosphoric, nitric or hydrochloric acid to reduce pH to recommended levels if necessary
- **Oxygen**
 - Oxygen levels: 5 ppm or higher
 - Flowing water or aerator to deliver oxygen to the system and remove wastes
- **Ammonia**
 - Ammonia levels: 1 ppm (mg/L) or less
- Other Parameters such as **nitrite**, **nitrate** and **phosphate** are used by the plants in the aquaponics, so they are kept at safe levels

swissôtel THE STAMFORD
SINGAPORE

Aquaponics Case Study 1



- Swissôtel and Fairmont Singapore are In an attempt to satisfy the growing demand from visitors for high-quality, fresh produce and to help Singapore achieve its target of providing **30% of its nutritional needs locally by 2030**, The Stamford opened the first urban aquaponics garden in the sector.
- The aquaponics system at Fairmont Singapore and Swissôtel The Stamford is the outcome of months of meticulous study, examining the best approach to satisfy customer and guest demand for fresh food, maximize the little area available for growing produce, conserve water, and reduce water waste.
- It is a sustainable technique that allows for the cultivation of an entire meal in a single system. Fish waste is converted to nitrates, which the vegetables use as fertilizers; in turn, the vegetables filter and clean the fish's water, using less water overall than when farming in soil. Fish and vegetables grow together in an integrated system.
- The 450 square metre aquaponics farm will provide enough food each month to meet the hotels' expected demands for 100% of nasturtium and tilapia, 60% of Swiss Chard, 52% of mixed salad leaves, 30% of micro-greens and 20% of basil. Produce cultivated in phases is utilized in meals and drinks at The Stamford Brasserie, CLOVE, Prego, JAAN by Kirk Westaway, Asian Market Cafe, and Skai.




Aquaponics Case Study 2

- The aquaponics was built on the rooftop of a Malaysia Mall, 1 Utama, which allows customers to select their own vegetables that are grown in the aquaponics system
- They sold red tilapia fish, fresh basil and many other vegetables for visitors to choose and purchase
- The greenhouse conditions needed by the plants were easily given as the aquaponics was built at the rooftop which had strong sunlight but is covered to mitigate the impacts of heavy rain
- This was the first aquaponics built in a mall in Malaysia and it managed to attract many visitors to take home some of the fresh greens



Proposed Fish Criteria

- Fish is able to tolerate Singapore's temperatures to reduce costs since no cooling system is required.
- Fish must have low feed-conversion ratio (FCR = Feed given/Animal Weight gain) to reduce costs on feed needed for the fish because the lower the FCR, the less feed is needed for the same number of fish which makes it more efficient as the fish grows faster as well.
- Fish must be able to tolerate a wide range of water quality conditions (Like Tilapia or Barramundi) so that they do not die easily and do not require frequent maintenance.

Name of Fish	Type of Fish	Picture of Fish
Tilapia	Food Fish	
Trout	Food Fish	
Catfish	Food Fish	
Salmon	Food Fish	
Barramundi	Food Fish	
Koi Fish	Ornamental Fish	
Goldfish	Ornamental Fish	
Gourami	Ornamental Fish	

Proposed Fishes

Food Fishes

- Tilapia (*Oreochromis niloticus*)
 - They are suitable for small-scale aquaponics
 - They grow in warm temperatures which is easily a given due to Singapore's weather
 - They are easy to breed and fast growing
 - They can also withstand very poor water conditions
 - They are omnivores
- Barramundi (*Lates calcarifer*)
 - They grow very fast
 - They are a resilient species so they can tolerate a wide range of water parameters
 - They have a low FCR at around 1.5 to 1.7 so they are efficient to produce
 - They are omnivores

Ornament Fish

- Goldfish (*Carassius auratus*)
 - They are one of the best options for a small-scale aquaponics
 - They are attractive to many pet lovers
 - They are omnivores
- Koi Fish (*Cyprinus rubrofuscus*)
 - Great for outdoor ponds like the roof terrace space at Hougang mall
 - Visually appealing to look at
 - They are omnivores

		TILAPIA Suitable for small scale Aquaponics
		KOI Better in outdoor ponds
		GOLDFISH Best for small-scale Aquaponics
		CHANNEL CATFISH Tank of atleast 250 gallons
		JADE PERCH Suitable to raise in tanks
		MURRAY COD Only suited for tanks at high density
		LARGEMOUTH BASS Ponds or Large tanks of 1200 gal
		RAINBOW TROUT Better in ponds or large tanks
		BLUEGILL SUNFISH Good for small-scale Aquaponics
		STURGEON Better in large ponds
WATER TEMP	 WARM  COOL  COLD	FISH DIET  CARNIVORE  OMNIVORE

Application to Hougang Mall

- The design is suitable for outdoor spaces such as the rooftop terrace at Hougang Mall
- Water is recirculated which reduces the discharge of wastewater despite growing both fish and plants
 - This further reduces operating costs because water treatment is minimized
- Only a one-time set up is required as it is self-sustaining and requires very minimal maintenance
- Higher growth rates and yields of both the seafood and the plants
- It is more Earth friendly and can be easily used in small, urban areas like the roof terrace
- The larvae of the Black soldier fly can be used as the protein component for the fish's feed which also helps to save costs



Benefits to Hougang Mall

- Be the first mall in Singapore to have an aquaponics system which can make the mall unique and attractive to investors
- The system of growing sustainable seafood and vegetables can allow vendors in the mall to potentially rely on the food supply grown in the aquaponics system
- The mall will have a distinctive feature for those interested in agri-tourism
- The aquaponics system can be profitable to the mall when the fish are grown and sold



Proposed Plants Criteria

- Plants should be well adapted to Singapore's climate to grow well outdoors.
- Plants should also not be easily susceptible to pests in Singapore as pesticide use should be limited to avoid causing harm to the fishes in the aquaponics system.
- Plants should prefer more water as there will be a constant flow of water from the tank that the fishes are living in to the plant growing areas of the aquaponics system.
- Plants should be relatively easy to grow to allow residents that lack gardening experience contribute to maintaining the plants.
- Fast growing plants preferred to allow more frequent harvesting.

Proposed Plant: Lemongrass

Pest resistance	Benefits	Precautions	Treatment
Relatively pest resistant when the plant is healthy	Lemongrass grows extremely fast, this allows the leaves of the plant to be continuously harvested to make mulch or to be used as organic mosquito repellent all year round	Prone to root rot in substrates with poor flow, as such aquaponics system needs to be constantly running. Root rot can decrease pest resistance.	Prune infested parts of the plant



Proposed Plant: Thai Basil

Pest resistance	Benefits	Precautions	Treatment
Relatively pest resistant when the plant is healthy	<p>Rapid growth in high nitrogen content from aquaponics</p> <p>Multiple harvesting periods through harvesting some leaves and stems using a method known as cut-and-come-again</p>	Should be watered regularly in hot weather to prevent heat stress which can reduce pest resistance.	<p>Prune any infested parts of the plant</p> <p>Any signs of wilting, indicate that the plant is heat stressed. Increase amount of water given to the plant</p>



Proposed Plant: Xiao Bai Cai

Pest resistance	Benefits	Precautions	Treatment
<p>Prone to pests such as caterpillars and leaf miners</p>	<p>Rapid growth in high nitrogen content from aquaponics</p> <p>Relatively quick harvest of 3 to 4 months after sowing</p>	<p>Seedlings are vulnerable to high heat and heavy rain, as such seedlings should be placed in semi-sheltered areas.</p> <p>Vulnerable to sun burn and prefers indirect sunlight.</p> <p>Netting is required to prevent pests from getting to the plant</p>	<p>Manually remove caterpillars, worms or slugs observed around the plant</p> <p>Remove leaves infested with leaf miners</p> <p>If plants appear long and skinny, with weak stems and small leaves, the plant is etiolating. To resolve this, expose the plant to more sunlight and space for growth</p>



Proposed Plant: Kang Kong

Pest resistance	Benefits	Precautions	Treatment
<p>Resistant to most pests and diseases when healthy but can be devoured by snails and slugs when young</p>	<p>Rapid growth occurs with high nitrogen content from aquaponics</p> <p>Fast harvest of around 3 weeks to a month after sowing</p> <p>Multiple harvesting periods through harvesting young leaves and stems using a method known as cut-and-come-again</p>	<p>Netting of plants to prevent being eaten by pests such as snails or slugs.</p> <p>Can wilt due to heat stress. Increase watering and apply mulch to the plant's base when this occurs</p>	<p>If plants appear long and skinny, with weak stems and small leaves, the plant is etiolating. To resolve this, expose the plant to more sunlight and space for growth.</p> <p>Pest infestation: remove any worms or slugs observed around the plant</p> <p>Signs of wilting indicate that the plant is heat stressed. Increase amount of water given to the plant</p>



Proposed Plant: Brinjal

Pest resistance	Benefits	Precautions	Treatment
<p>Relatively pest resistant</p>	<p>Relatively quick harvest of 3 to 4 months after sowing</p> <p>Potassium & phosphorus from aquaponics increases flower production</p>	<p>Netting of plants to prevent being eaten by pests such as snails or birds, however holes should be big enough for pollinators</p> <p>Wrapping of fruits to prevent fruit flies from laying eggs on them</p>	<p>Pruning of infested part of the plants</p> <p>Signs of wilting indicate that plant is heat stressed. Increase amount of water given to the plant</p> <p>Increase watering if sunken blotches at the end of the fruit are observed</p>

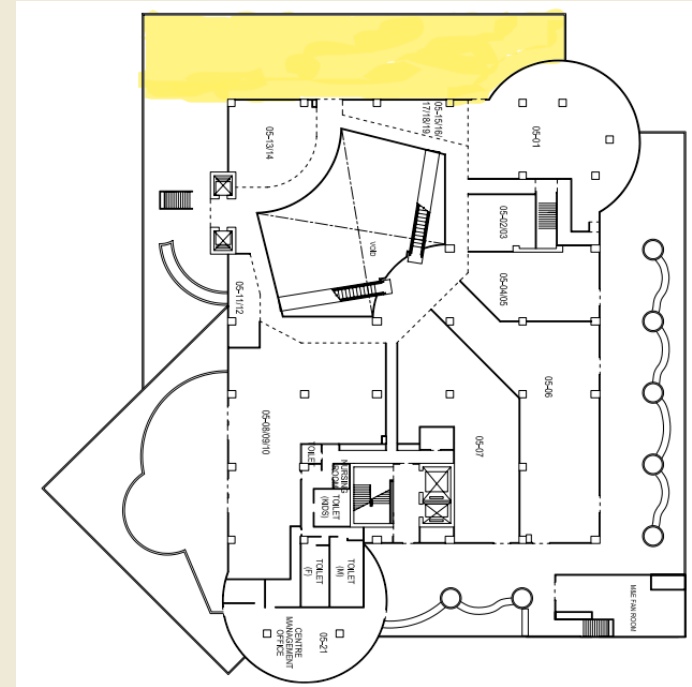


Maintenance of Aquaponics

Example of checklist

Tasks for Aquaponics Maintenance	Tick if task is completed for entire month (✓)
Prepare antibiotics and formalin in case of any bacteria or parasite infections respectively to avoid mass mortalities every month	
Daily visual inspection throughout the week to check the water quality and if there is any odd fish behavior (E.g. If moving very little or not eating as much)	
Weekly water parameters testing to check the levels for ammonia (<1.0ppm), nitrite (<0.75ppm), nitrate (<80ppm), salinity, dissolved oxygen (at least above 3 ppm) and temperature	
Overall, practice good hygiene procedures to prevent any introduction of pathogens	

Proposed Location : Rooftop








Proposed Layout : Rooftop



Mall entrance

Legend:

-  : Fish rearing area
-  : Community garden area
-  : Black soldier fly rearing area
-  : Aquaponic pipes
-  : Shop areas (cannot be used)



06: Green Wall



Illustration of Green Walls



Benefits of Green Walls

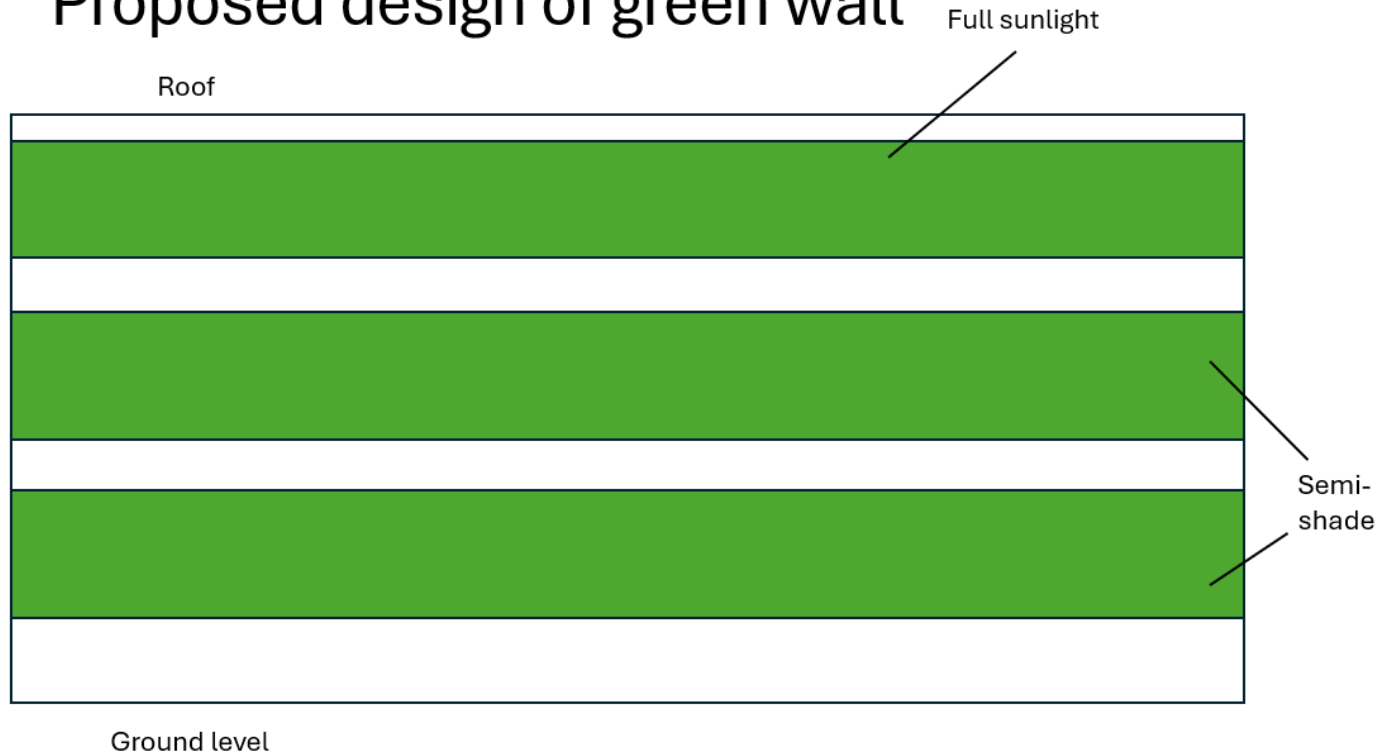
- **Eliminate air pollution**
 - Green wall are natural filter. Pollutants in the air, such carbon dioxide and carbon monoxide, are changed into oxygen by plants. As a result, the air quality and general well-being of the local population are improved due to the large reduction in CO2 in the atmosphere.
- **Lower the city's temperature**
 - Unlike most cities' hard surfaces, plants are better at absorbing sunlight than reflecting it, hence trapping considerable quantity of heat.
- **Acting as a buffer against rainwater**
 - Vertical green walls have the capacity to both retain and evaporate some rainwater in addition to slowing it down. Some systems even harvest rainfall surpluses for use in irrigation, essentially making green walls self-sufficient!
- **Decrease stress and enhance wellbeing**
 - Building exteriors with natural components are a terrific method to instantly lift your spirits and brighten the surrounding region

Proposed Green Wall Location

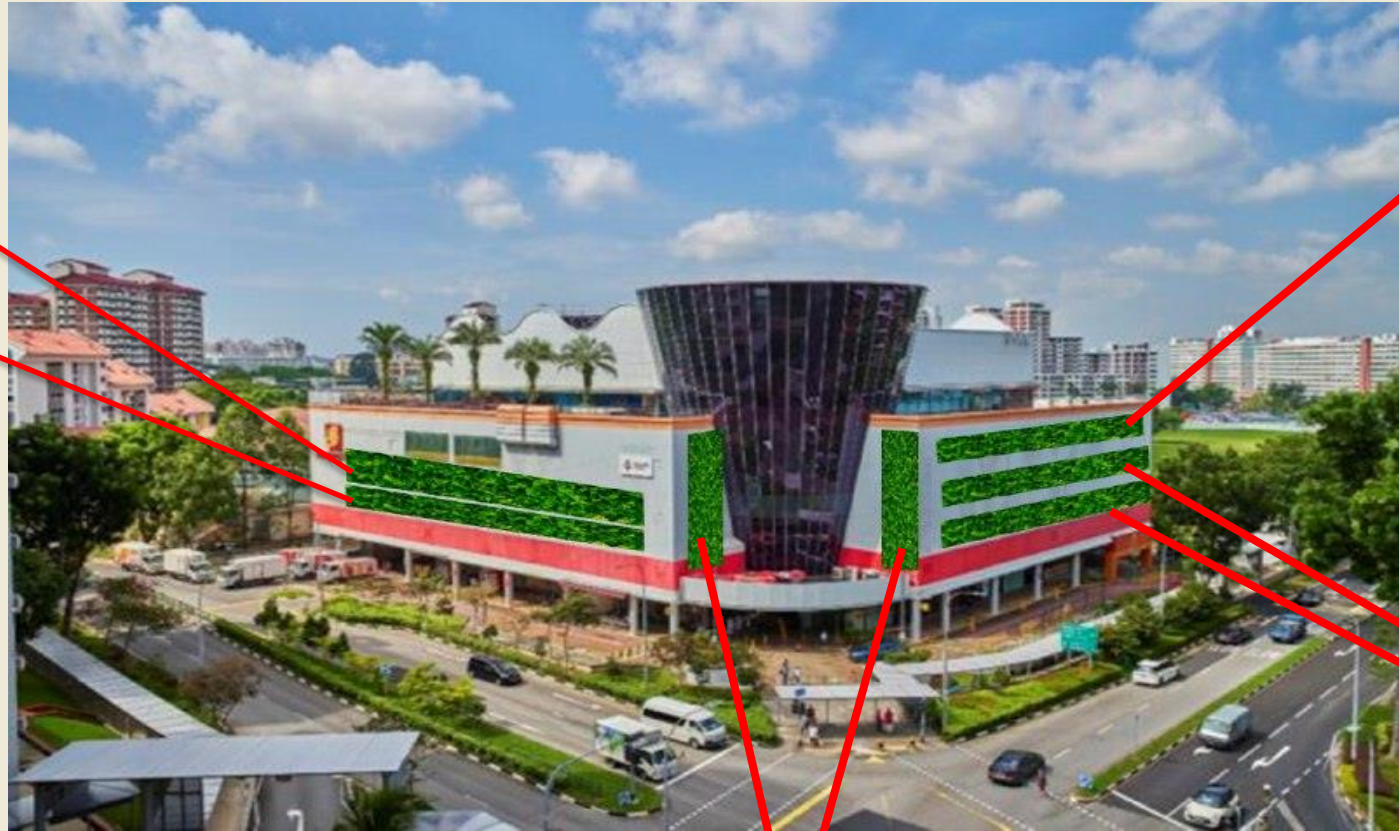


Design of The Green Wall

Proposed design of green wall



Ideal Green Wall Design



Full Sunlight

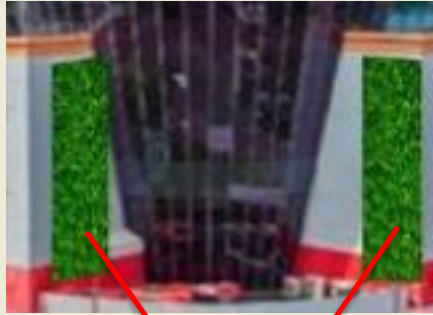
Full Sunlight

Moderate Sunlight

Moderate Sunlight

Moderate Sunlight

Sunlight Level Estimations



Moderate Sunlight

Due to the green walls facing inwards and towards each other, they will not receive direct sunlight, as such only plants that can grow well with moderate sunlight can be planted here to ensure optimal plant growth.

→ Plants suitable: Blue Pea, Fragrant Pandan and Rabbit's Foot

Sunlight Level Estimations

Full
Sunlight

Moderate
Sunlight



Full
Sunlight

Moderate
Sunlight



Both of these green walls are similar in structure, with the green walls being largely unobstructed.

- **Green walls at higher part of wall will receive full sunlight**
→ Plants suitable: Kock's Bauhinia, Fragrant Pandan and Rabbit's Foot
- **Green walls at lower part of wall will receive partial sunlight**
→ Plants suitable: Blue Pea, Fragrant Pandan and Rabbit's Foot

Greenwall Maintenance


Maintenance area	Regular/ Reactive	Action taken
Growth of weeds that compete with Greenwall plants for space	Regular	Regular weeding
Dead and dying plants	Reactive	Occasionally replacing dead plants with healthy new plants
Overgrown and dying Greenwall vegetation	Reactive	Pruning of Green wall plants
Damage to Greenwall support structure	Reactive	Regular maintenance and repair of Green wall support structure

Since the green wall is proposed to be on the sides of the malls, maintenance can be tricky due to the falling hazard. As such it is recommended that Green wall maintenance should be carried out by a third-party contractor occasionally along with the external maintenance work of the mall.


Plant Selection Criteria

- **Plants should be commonly found in Singapore** to avoid the accidental introduction of invasive alien species into the local ecosystem and to benefit the local fauna in the area by providing more potential habitats and food sources.
- **Plants selected must be hardy with a preference for low to moderate amounts of water** due to the difficulty and danger of maintaining a green wall, as such **plants must be able to survive long periods without water as well as large amounts of water** in a short span of time due to Singapore's unpredictable weather patterns with long dry spells and rainy seasons.
- **Plants should prefer full sunlight or semi-shade**, with the amount of sunlight required varying with the placement of the plants. Plants that are placed higher up should prefer full sun light while plants that are placed lower should prefer semi-shade as they are being partially blocked by the plants above them.
- Due to the green walls being present in a highly visible area of the building and playing a part in the buildings brand, **plants used for the green wall must have aesthetic value**.


Proposed Plants & Selection Rationale

Plant	Selection rationale
<p data-bbox="198 401 359 437">Blue Pea</p> 	<ul data-bbox="672 405 1798 757" style="list-style-type: none">• Hardy plant & requires moderate amount of water• Often found in local parks and has long been used in traditional South-East Asian cuisine.• Adds aesthetic value to the landscape with their blue ornamental flowers.• Requirements: full sun• Location: Place in upper layers where they can receive the necessary sunlight for growth.


Proposed Plants & Selection Rationale

Plant	Selection rationale
<p data-bbox="198 372 498 410">Fragrant Pandan</p> 	<ul data-bbox="672 372 1843 681" style="list-style-type: none">• Hardy plant & requires moderate amount of water• Can often be found in local parks.• Adds aesthetic value to the landscape with their ornamental leaves and give of a pleasant scent which is relief from the smell of engine exhaust from the nearby roads and carpark.• Requirement: full sunlight or semi-shade.• Location: Versatile in placement.

Proposed Plants & Selection Rationale

Plant	Selection rationale
<p data-bbox="198 383 436 416">Rabbit's Foot</p> 	<ul data-bbox="672 383 1760 645" style="list-style-type: none">• Hardy plant & requires moderate amount of water• Often found in local parks and growing prominently in the wild.• Adds aesthetic value to the landscape with their ornamental leaves.• Requirement: full sunlight or semi-shade.• Location: Versatile in placement

Proposed Plants & Selection Rationale

Plant	Selection rationale
<p data-bbox="198 396 488 431">Kock's Bauhinia</p> 	<ul data-bbox="672 396 1721 704" style="list-style-type: none">• Hardy plant & requires moderate amount of water• Can be found in local parks.• Adds aesthetic value to the landscape with their ornamental flowers.• Requirement: full sun• Location: Place in upper layers where they can receive the necessary sunlight for growth.



07: Community Engagement

Waste Reduction

1) Food recycling bin

- Collaboration with The Food Bank Singapore (NGO) to set up Bank Box
- Collect unwanted and unexpired packaged food to help the needy & reduce food wastage.

2) Setting of fashion waste bin

- Collect unwanted clothes from residents
- Conduct fashion upcycling event in the mall on weekends
- Collaborate with town council to give needy families vouchers to come to the event to collect the donated clothes they want.

3) Collaboration with Cloop textile recycling bins

- Operated by Life-Line Clothing Pte Ltd recycling company
- Collects old clothing and textiles (Eg: pillows, towels, fabric, linens) & sort them into 500 categories for various purposes including overseas, markets, fabrics for upcycling fashion and cleaning rags
- Implemented in areas such Ang Mo Kio, Bedok, Hougang, Jurong East, Marina One



Waste Reduction

4) Implementation of smart recycling boxes

- Reward residents for sorting waste through supermarket vouchers
- Residents must download an app to register an account to use the smart boxes. The app generates a personalized QR code that user must scan at the recycling boxes, before selecting the category of recyclable items they wish to deposit.
- The boxes are equipped with weighing scales & residents earn points based on the type & weight of materials recycled
- Eg: Every kg of glass, paper and aluminum deposited can earn the user 5, 15 and 80 points respectively. Accumulation of 1000 points → redeem \$10 supermarket voucher

→ A trial in Bishan and Sin Ming to collect recyclables using smart boxes managed to cut contamination rate by 5%, lower than the national average of 40%

5) Implementation of food waste recycling lockers

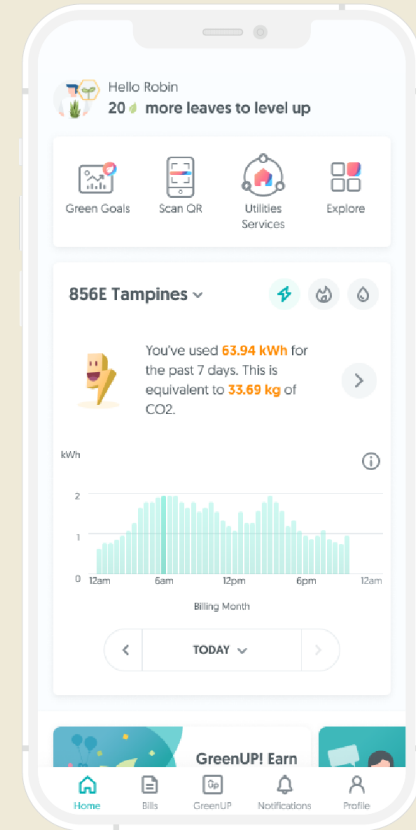
- Residents can put food scraps like fruit peel, fish and meat trimmings in airtight containers provided and weigh them before placing them into the locker
- Eg: 5 points awarded for every 500g of food waste collected
- Collected food waste can be sent to the black soldier fly facility



Electricity Reduction

1) Electricity Usage Quotas

- Usage of SP App by Singapore Power Digital (SP Digital), a smart meter or Advanced electricity (AMI) meters that is a digital meter which tracks and displays electricity usage at half-hourly intervals
 - This app helps Singaporeans to reduce their electricity consumption by providing recommendations and can measure the electricity used per month
- The mall can set quotas for residents so if they hit the quota, they can get a \$20 electrical shop voucher at the end of each year, quotas are as follow
 - For Landed Properties
 - For Private Condominiums:
 - For HDB flats:
 - These are based on the average monthly consumption for electricity was 1,257 kWh, 568.8 kWh, and 375.9 kWh in 2020 for households living in (i) landed properties, (ii) private condominiums, and (iii) HDB flats respectively.



Electricity Reduction

2) Educational Game Booths

- Use the space beside the escalator on the 1st floor of Hougang Mall to set up 4 or 5 game booths for both adults and children to participate
- Each booth to give a stamp so when all stamps are collected, the visitors can redeem one of few attractive prizes at the end by drawing from a box at a counter
- This is to invite visitors to learn more about what they can do in their own homes to save electricity because not everyone is sure which solution is more suitable for them
- This not only benefits the environment, but also helps them to save money which makes them more willing to implement such measures in their homes



Encouraging Sustainable Food Growth & Efficient Water Usage

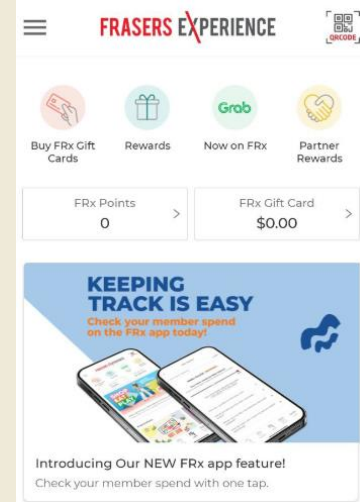
1) Guided tours

- Have 1 or 2 staff managing the aquaponics system to bring Primary & Secondary school students on guided tour of the aquaponics system
- To educate them on the importance of growing our own food sustainably while minimizing wastewater discharge and water treatment
- The guide can share how the fish and plants are fresher as compared to buying from supermarkets to encourage their parents to visit Hougang Mall to support the aquaponics



2) Rewards systems

- Volunteers helping out with the community garden can get bonus points on Frasers Experience app.



08

Conclusion



Conclusion

With the incorporation of the above sustainability features,

- the carbon footprint of the mall arising from food waste management would be significantly reduced by at least 7%.
- renewable electricity from solar panel would further offset the carbon footprint with an improvement in electricity efficiency of at least 2%.
- the mall will be more well-known for its greenery and sustainable food growth innovations that play a vital role in conserving the environment.



THANKS!!

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