SUSTAINABLE CITIES CHALLENGE

(PHASE- 2)

Hillview Community Club

REGISTRATION NO: IHL002

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Table of Content

Introduction

In this Phase 2 feasibility report is conducted in line with Hill view community club's Cyclical Maintenance Programme (CMP) in 2024. In this report our team will cover in depth analysis of the actual consumption saving, projected carbon emissions avoidance and building sustainability.

In this report we will be covering various improvement solutions to achieve lower carbon footprint in 3 main categories,

1. Energy Efficiency
2. Water Efficiency
3. Waste Management

Certain saving analysis is conducted based on assumptions will be indicated in the report.

1. Energy Efficiency

1.1 Basketball Court Lighting

Currently the basketball court is using Halogen floodlight to brighten up the space from 7pm to 9pm daily. According to People Association, it is using 8 nos of 150Watts Halogen light. We recommend replacing it with 80W LED floodlight, which provide the same equivalent lux capacity and uses lesser energy consumption. Total estimated carbon emissions avoided per annual is 170 kg CO_2e.

- Energy saved per unit: 150W- 80W= 70W
- Power consumption saved per annual = 70W x 2hr x 8 x 365days= 408.8KWh
- Carbon emissions avoided per annual* = 408.8KWh x 0.4168 = **170.38 kg CO_2e**

* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO_2/KWh


Fig 1.11: Basketball court halogen floodlight


Fig 1.12: LED floodlight

1.2 Daylight & Solar Analysis

Due to unique shape of Hillview community club building, it's longitudinal side is found to be East-West facing and exposed to sun rise and sun set solar heat radiation. This will cause building to have higher heat load from glazing and air conditioning will have high energy consumption. Refer Fig.1.2 show the solar sun simulation below.

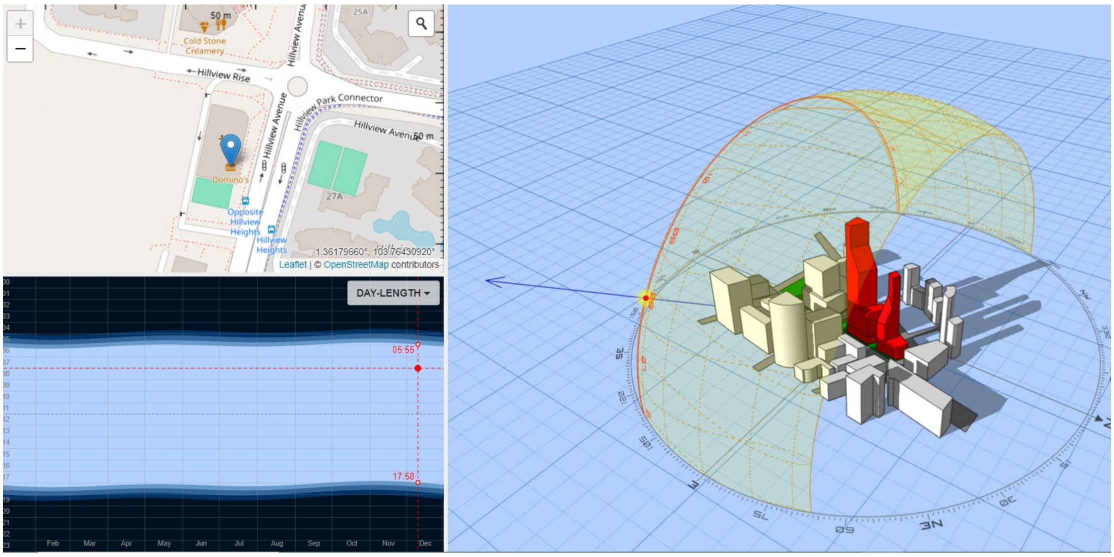


Fig. 1.2: Daylight Solar Analysis for Hillview Community Club
Source: https://drajmarsh.bitbucket.io/sunpath3d.html

It is proposed to implement low- U and low- E solar film at all the window facing the East-West direction (Fig. 1.21). Additional sun shading devices are also recommended to be installed at East-West facing window to block the solar heat from sun (Fig. 1.22). Current window curtain is not effective is reducing the solar heat from the sun.

Base on nonprofit International Window Film Association (IWFA) study, solar film can reduce energy consumption by as much as 30 percent^.

Assume all the room has windows and they are running 50% of the times and running on 50% part load condition. Base on 30% saving of the air conditioning power consumption from 9am to 5pm (8hrs) per day. Total estimated carbon emissions avoided per annual is 90,183.85 kg CO2e.

- Power consumes per annual = 988KW x 8hrs x 365days x 0.5= 1,442,480 KWh
- Power consumes based on 50% usage per annual= 721,240 KWh
- Power consumption saved per annual = 721,240 KWh x 30% = 216,372 KWh
- Carbon emissions avoided per annual* = 216,372 KWh x 0.4168 = **90,183.85 kg CO2e**

* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh

^ Source: https://www.solargard.com/ca/blog-ca/in-the-news-ca/new-study-reveals-window-film-as-the-most-cost-effective-answer-to-reducing-florida-homeowners-high-energy-costs/

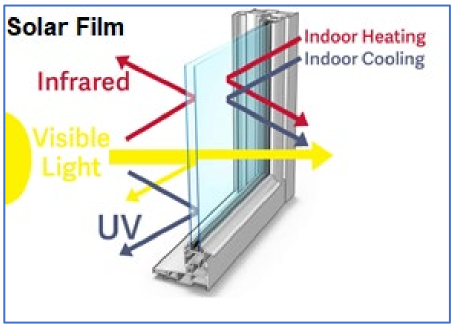


Fig 1.21: Low U-value & Low E solar firm

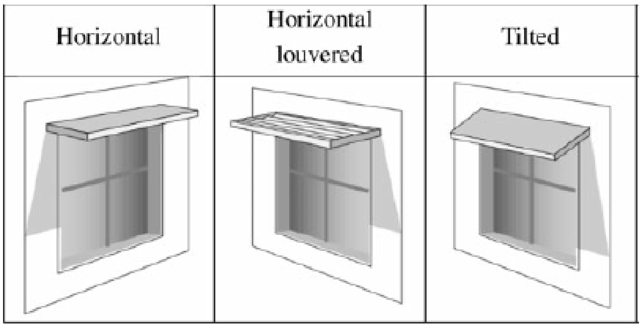
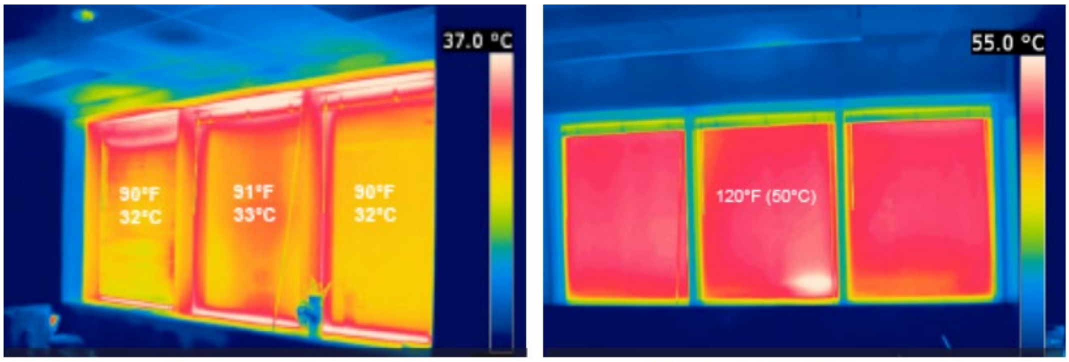


Fig 1.22 Sun shade



With Solar Film

Without Solar Film

Fig 1.23: Thermal scanning comparison between with and without solar film

Fig 1.24: Proposed Conference room & library solar film location

1.3 Air Conditioning Analysis

1.3.1 Level 3 Community Library

Library's front entrance is found to be exposed to outdoor air (Fig 1.31), this will cause air leakage and the air conditioning system difficulty to cool down the space and lead to high energy consumption. Curtain air conditioner is not effective to prevent outdoor air from entering, it also consume high energy to operate at 250Watts and running at full load all the time from daily 10am to 9pm (11hrs).

Proposed to install automatic sliding door (Fig 1.32) to prevent air-conditioned space to be exposed to outdoor air and consume lesser energy at 55Watts. Total estimated carbon emissions avoided is **2,922 kg CO2e**.

Fig 1.31: Level 3 Library front entrance

Fig 1.32: Proposed automatic sliding door

Air Curtain Carbon Emissions Saving Calculation

Removal of air curtain and install automatic sliding door

- Energy saved per unit: 250W- 55W= 195W
- Power consumption saved per annual = 195W x 11hr x 365days= 782.75 KWh
- Carbon emissions avoided per annual* = 782.75KWh x 0.4168 = **326 kg CO2e**

Air Conditioning Carbon Emissions Saving Calculation

Assume VRV-IV[##] and System 3 split unit[^^] serving the library and running at 70% part load conditions due to no leakage of outdoor air.

- System 3 air conditioning power consume per annual: 2,809 KWh
- Single VRV power consume per annual: 17,958KWh
- Power consumption saved per annual at 70% part load: (2,809KWh + 17,958KWh) x 0.3 = 6,230KWh
- Carbon emissions avoided per annual* = 6,230 KWh x 0.4168 = **2,596 kg CO2e**

Total carbon emissions avoided per annual= 326 kg CO2e + 2,596 kg CO2e = **2,922 kg CO2e**

##Daikin VRV-IV Model Name (RQQ6T)
^^Daikin System 3 Model Name (iSmileEco Series)
* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh

1.3.2 VRV System Migration

Hillview community club uses VRV-IV to cool down the entire building (Fig 1.322). The VRV-IV is older generation model and less energy efficient. To further reduce the energy consumption of air conditioning, it is proposed to migrate the existing VRV-IV to VRV-X. Refer to (Fig. 1.32) show the COP chart comparison of both VRV system, it is shown that VRV-X has higher COP and 20% lower annual power consumption.

Air conditioning consume 40-50%^^ of total building electricity, 20% lower consumption is very significant saving. This migration can also support the Green Mark Gold recertification requirements. Migration can still reuse the exiting refrigerant pipes.

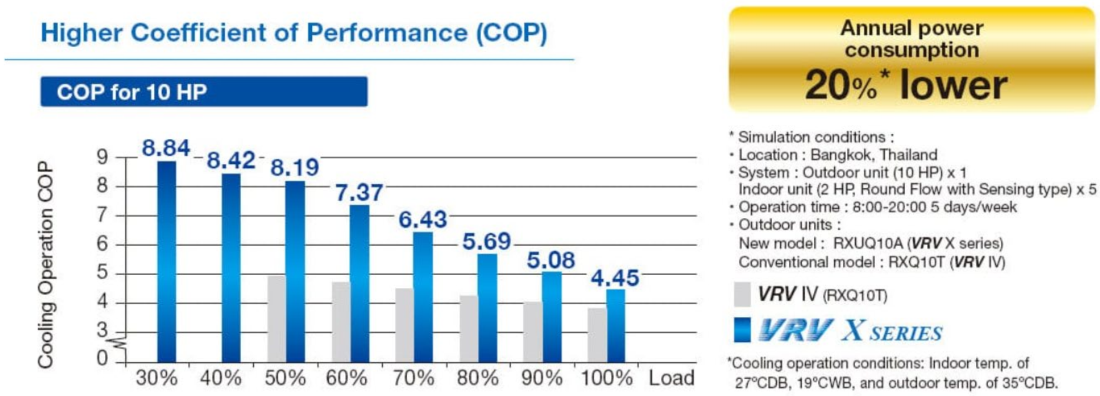


Fig 1.32: COP comparison between Daikin VRV-IV and VRV-X **

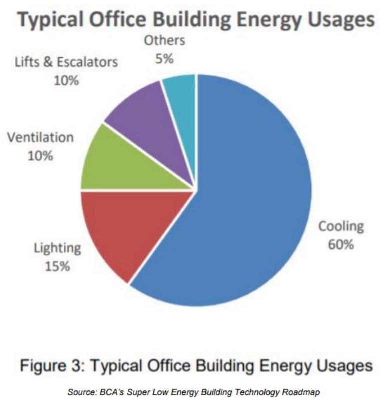


Fig 1.321: Building energy consumption

** Source: https://www.daikin.com.my/product/vrv-x-a-series/

^^ Source: https://secoe.seas.org.sg/assets/Workshops/95/48ee90c8ee/2.1-SGBC_Singapore-Case-Building-Energy-Efficiency.pdf

Fig 1.322: Exiting older generation VRV-IV in rooftop

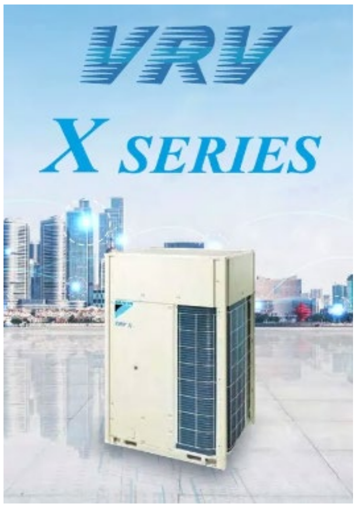


Fig 1.323: New VRV-X

Based on the ACMV equipment schedule provided from People Association, assume building operate daily (9am to 9pm). VRV consume total 988 KW, assume all VRV run 50% of all times and at 50% part load. After migrated to VRV-X, estimated carbon emissions avoided annually is 90,183.85 kg CO2e.

- Power consumes per annual = 988KW x 12hr x 365days x 0.5 x 0.5= 1,081,600 KWh
- Power consumption saved per annual = 1,081,600 KWh x 20% = 216,372 KWh
- Carbon emissions avoided per annual* = 216,372 KWh x 0.4168 = **90,183.85 kg CO2e**

* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh

1.3.3 R32 Spilt-Unit Air Conditioning Migration

In 2019, new refrigerant gas R32 was introduced to replace R410A due to R32's lower GWP (Global Warming Potential). R410A air conditioning system are also ban from selling in Singapore.

R410A air conditioning's spart part and refrigerant will be difficult to source in future as it is ban in Singapore, periodic maintenance will also be affected. Newer R32 air conditioning is 10% reduction of energy consumption and 30% reduction of global warming potential (Fig 1.331).

Inline with Green mark recertification and net zero carbon emission goal. People Association may consider this migration recommendation in CMP (cyclical maintenance programme).

Key Benefits of R32 low GWP refrigerant as below;

- R32 refrigerant with a GWP of 675, which is **30%** lower than that of R-410A and other commonly used refrigerants.
- R32 air conditioning system has approximately **10%** reduction of electricity consumption.
- R32 air conditioning system spare part and refrigerant can be source easily as compared to R410A air conditioning system in future.
- According to Daikin Singapore, R32 VRV system is currently sold in oversea and will be available in Singapore soon.

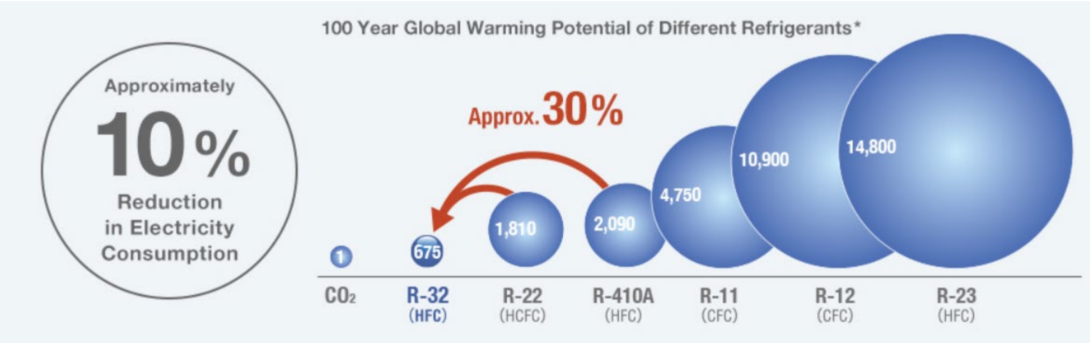


Fig 1.331: R32 Refrigerant provide lower GWP and energy reduction

Source: https://www.daikin.com/air/daikin_techknowledge/benefits/r-32#:~:text=Although%20there%20are%20various%20types,conditioners%20using%20refrigerant%20R%2D22.

Fig 1.332: R410A Air conditioning ban in Singapore

Source: https://www.nea.gov.sg/media/news/news/index/nea-introduces-measures-to-reduce-greenhouse-gas-emissions-from-refrigeration-air-conditioning

We believe R32 air conditioning system can reduce carbon emission in Scope 1 & 2. We do not have the exact quantity of existing R410A spilt unit air conditioning. Assume there is 50 Split unit AC system.

Carbon emissions avoided (Scope 1)

- Carbon emission per R410 AC per annual[^^^] = 2,090 kg CO2e
- Carbon emission per R32 AC per annual[^^^] = 675 kg CO2e
- Carbon emission saved per annual = (2,090 kg CO2e - 675 kg CO2e) x 50 = 70,750 kg CO2e

Carbon emissions avoided (Scope 2)

- Power consumes per R410 AC[###] per annual = 2,831KWh
- Power consumes 50 x R410 AC per annual = 2,821KWh x 50= 141,500 KWh
- Power consumption saved per annual = 141,500KWh x 10% = 14,105 KWh
- Carbon emissions avoided per annual* = 14,105KWh x 0.4168 = 5,878.96 kg CO2e

Estimated total carbon emissions avoided per annual= 70,500 kg CO2e + 5,878.96 kg CO2e = **76,378.96 kg CO2e**

[###] Daikin Split Unit Air Conditioning Model Name (RKS50G)

[^^^] Assume air conditioning system have 1kg of refrigerant charged, carbon emission factor IPCC Fifth Assessment Report, 2014 (AR5)

* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh

1.4 BMS (Building Management System)

Recommend to install BMS (Building Management System) to control all the air conditioning on/off, scheduling, temperature setpoints and also monitor all the equipment energy/water consumption. This will minimize unnecessary energy wastage and unauthorised usage from users.

BMS can be linked to facilities booking from public members.

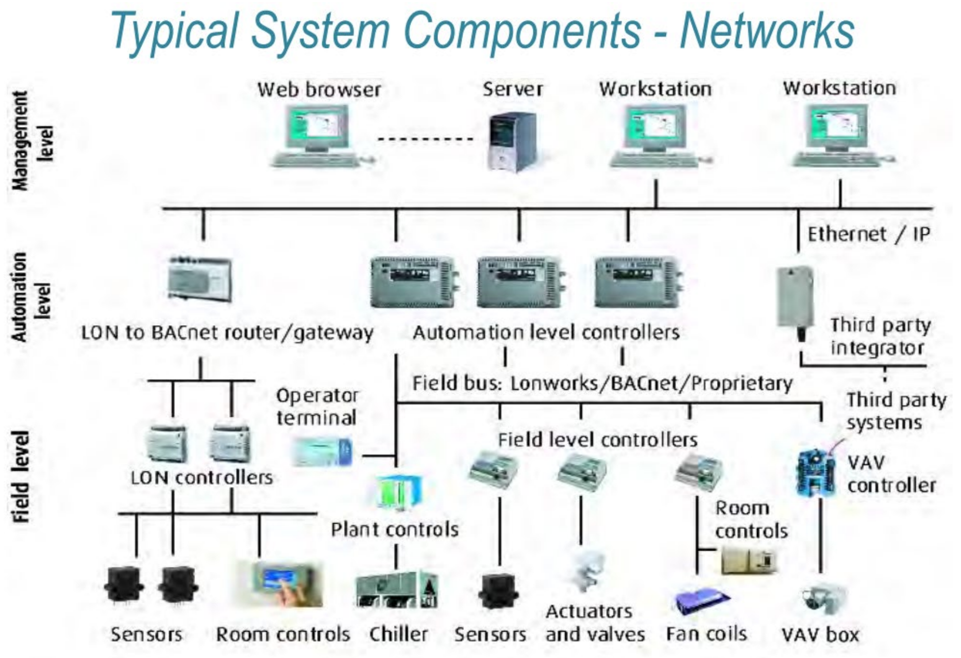


Fig. 1.4: BMS Architecture Network Diagram

2. Water Efficiency

2.1 Rainwater Harvester

Rainwater can be collected from roof gutter and stored into a rainwater harvester tank. The rainwater collected can be used for irrigation purposes. Purposed rainwater harvester tank will be located at level 1, drawing of rainwater harvester tank connection to the building rainwater drainpipe can be found in Appendix B**.**

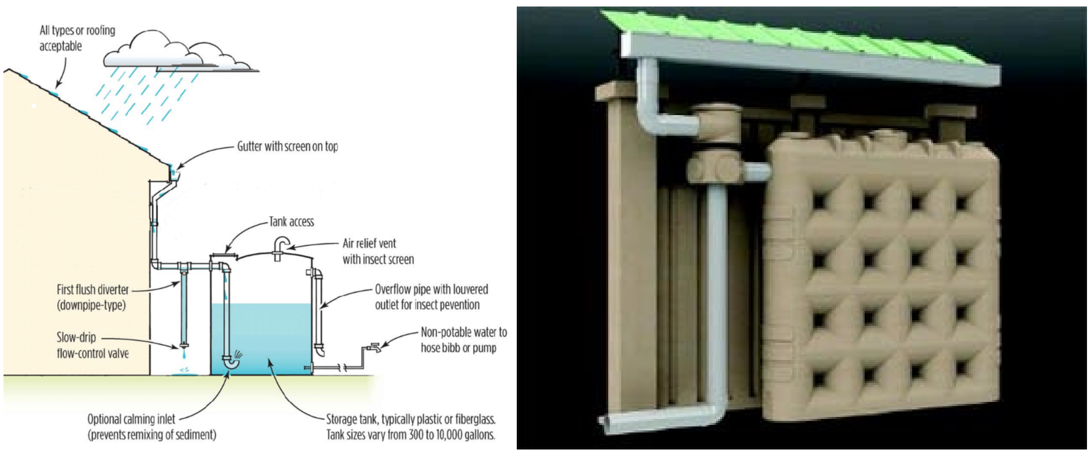


Fig 2.1: Rainwater Harvester System

As provided from People Association, the current irrigation tank at roof top is 0.75m3 or 750L. Assume the irrigation uses 80% of the water tank daily to water all the plants.

- Water consumption per day= 0.75 m^3 x 0.8= 0.6m^3
- Water consumption per annual= 0.6m^3 x 365= 219 m^3
- Carbon emissions avoided per annual^ = 219m^3 x 0.149 = **32.63 kg CO2e**

^ UK Government GHG Conversion Factors for Company Reporting (2022), water supply conversion factor per m3 carbon emission 0.149 kg CO2e.

2.2 Remote Water Meter Monitoring

Check any water leak detection, identify high-water consumption and monitor the monthly water usage data analysis. The system is designed to monitor water flowing through a pulse water meter.

Fig 2.21: Remote water/energy meter monitoring

Currently facility management monitor the main incoming water meter and the tenant's water meter on monthly basis. Any abnormal usage or leakage cannot be captured in between the period. In scenario of large leakage of water either at roof top of culinary studio, facility management will be uninformed, therefore minimize undetected wastage and leaks from sanitary fittings and supply pipework.

- Proposed remote energy and water meter monitoring at different level and zone

Remote Energy Meter	Remote Water Meter
1. Multi-purpose hall	1.Basement
2. Conference Room	2. Level 1
3. 3 x Activity Room (Combine)	3. Level 2
4. 2 x Dance Studio (Combine)	4. Level 3
5. Culinary Studio	5. Level 4
6. Hillview Heritage Alley	
7. Library	

Table 2.2: Proposed remote energy and water meter location

2.3 Basement Transfer Water Tank

Currently Hillview community club water supply is under indirect mode of supply, there is basement transfer water tank and transfer pump (Fig 2.31) to supply water to the roof top water cistern storage tank. Basement water transfer tank has an effective capacity of $5.4m^3$ or 5,400 litres, which is significant large amount of water storage.

Fig 2.31: Basement transfer water tank and transfer pump

Referring to Appendix A building layout, building height of Hillview Community Club from basement to roof top is 21.95m. Base on SS636 (Fig 2.32), building height below 25m require only direct water supply from PUB main. If building height below 37m does require low level transfer tank, indirect transfer pump to rooftop cistern tank is sufficient. However, we require Professional Engineer (PE) to verify this water supply configuration. Unless this is intent design during construction stage due to some unknown building constraint.

Below are some disadvantages of indirect system mode of supply:

- Higher maintenance cost
- Higher power consumption
- Higher water consumption
- Higher replacement cost due to aging
- Risk of water leakages
- Risk of water tank level sensor malfunction lead to overflow
- Risk of transfer pump break down and disruption of water supply

People Association may consider to check with Professional Engineer during CMP (cyclical maintenance programme), either to keep it or convert to direct mode of water supply.

	Height of Highest Fitting (Above Mean Sea Level)	Mode of Supply
a	Not exceeding 25 m	Direct supply to fittings from PUB mains.
b	Above 25 m but not exceeding *37 m	Indirect supply through high level water storage tank.
c	Above 37 m	Indirect supply through low level water transfer tank with pumping to high level water storage tank.
(* Refers to height of inlet pipe to high level water storage tank.)		

Table 2.32: Singapore Standard SS636

Based on the water consumption given from People Association, assume it is seasonally adjusted. As water transfer tank is related to building water consumption, total estimated carbon emissions avoided is 1,151.47 kg CO2e.

- Average monthly water consumption= (566+ 591+ 757+549+692+709)/6= 644m3
- Water consumption per annual= 644m3 x 12= 7,728 m3
- Carbon emissions avoided per annual* = 7,728m3 x 0.149 = **1,151.47 kg CO2e**

^ UK Government GHG Conversion Factors for Company Reporting (2022), water supply conversion factor per m3 carbon emission 0.149 kg CO2e

3. Waste Management

3.1 Food Digester and Composting

Encourage F&B tenant to collaborate with waste vendor to send their food waste to recycle in food digestor (Fig 3.1) to produce fertilizer. Provide each F&B tenant with individual waste bin to dispose their food waste for recycling.

Available off-site or on-site food waste treatment systems will segregate food waste collected from various premises. Treatment with used water sludge at a co-digestion demonstration facility, it has potential to produce biogas production. This can reduce 10% of overall waste at estimated 3,804.19 kg CO_2e.

Fig 3.1: Food Digester

- Average waste consumption per month= (5,700+ 5,950+ 6,020+ 4,950+ 4,860+ 5,490+ 210+ 120+ 160+110+160+150) / 6 = 5,646.66 Kg
- Waste consumption per annual= 5,646.66kg x 12= 67,759.92 Kg
- Waste consumption reduced per annual= 67,759.92Kg x 10% = 6,775.99 kg
- Carbon emissions avoided per annual[@] = 6,775.99kg x 0.5614225 = **3,804.19 kg CO2e**

[@] National Environment Agency (2018) Singapore's Fourth National Communication and Third Biennial Update Report. 1kg of general waste carbon emission 0.5614225 Kg CO2e.

3.2 Re-usable item corner

Purposed to create a corner in Hillview community club for public to donate usable item like clothing, shoe and other useable items, to give the product a 2nd life instead of throwing them away (Fig 3.21). Shoe can also be donated to dedicated bin collected by waste vendor, send for processing and used for sports surfaces (Fig 3.22).

Fig 3.21: Reuseable item corner

Fig 3.22: Recycling Shoe Project

3.3 Green packaging for F&B business

Choosing products with less packaging or green packaging. Products that have reduced packaging carry this eco-label (Fig 3.31). Avoiding single-use carrier bags, bottles, takeaway cups. Encourage customers to bring own reusable bags, containers and utensils (Fig 3.32).

From bring personal container for takeaway food and using green carrier bags at Hillview community club's F&B tenants, this can potentially reduce 3% of overall waste consumption annually.

Fig 3.31: Eco recycle carrier bag

Fig 3.32: Bring your own container

- Waste consumption reduced per annual= 67,759.92Kg x 3% = 2,032.79 kg
- Carbon emissions avoided per annual[@] = 2,032.79 kg x 0.5614225 = **1,141.25 kg CO2e**

[@] National Environment Agency (2018) Singapore's Fourth National Communication and Third Biennial Update Report. 1kg of general waste carbon emission 0.5614225 Kg CO2e.

3.4 Donation of the excess food

Work with food distribution organizations (i.e. Foodbank, Food from Heart, Fei Yue Community service or Willing Hearts) donate unwanted food products that are still good for consumption, instead of discarding them. This can potentially reduce 3% of overall waste consumption annually.

Fig 3.4: Food Distribution Organisation

- Waste consumption reduced per annual= 67,759.92Kg x 3% = 2,032.79 kg
- Carbon emissions avoided per annual[@] = 2,032.79 kg x 0.5614225 = **1,141.25 kg CO2e**

[@] National Environment Agency (2018) Singapore's Fourth National Communication and Third Biennial Update Report. 1kg of general waste carbon emission 0.5614225 Kg CO2e.

3.5 Redesign Menu with F&B business

Collaborate with F&B tenant to re design their menu to offer different portion sizes options and indicate serving sizes, helps reduce food wastage due to overbuying. This can potentially reduce 2% of overall waste consumption annually.

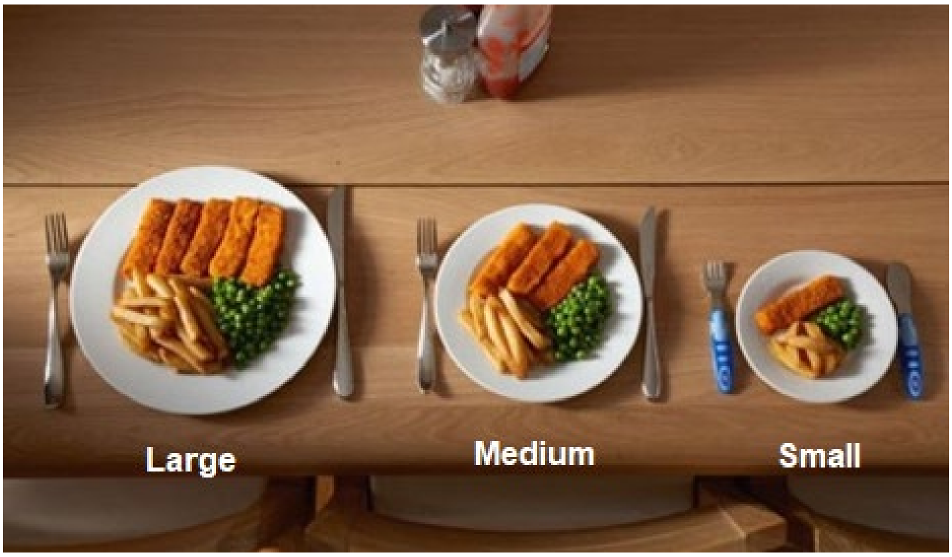


Fig 3.5: Different option sizes menu

- Waste consumption reduced per annual= 67,759.92Kg x 2% = 1,355.19 kg
- Carbon emissions avoided per annual[@] = 1,355.19 kg x 0.5614225 = **760.83 kg CO2e**

[@] National Environment Agency (2018) Singapore's Fourth National Communication and Third Biennial Update Report. 1kg of general waste carbon emission 0.5614225 Kg CO2e.

4. Renewable Energy and Net Zero Carbon Solutions

4.1 Solar PV above 4th Storey roof top

We proposed to install solar PV above 4th storey roof top of size 48200 x 9600. The solar power generated can reduce the carbon emissions from electricity supply. Total estimated carbon emission avoided per annual by 27,425 kgCO2e.

There are some vendors provides zero capex installation and maintenance of the solar PV on buildings but requires the contract agreement of power generated to be shared among building owner and vendor.

For this feasibility study of solar PV installation at Hillview community centre's roof top is supported by local Solar PV vendor. Total 81 solar panels will be installed, total installation cost including submission to authorities, testing and commissioning is estimated $195,000.

- Solar PV Area= 48.2m x 9.6m= 462.72m^2
- Power Generated per annual^ = 65.8 MWh
- Carbon emissions avoided per annual* = 65.8MWh x 0.4168 = **27,425kg CO2e**

* Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh

^ Estimated power generation from solar PV is provided from Solar PV vendor

As checked with People Association, the roof RC loading is 5.0KN/m^3 which is above the 1.5KN/m^3 minimum loading requirement to install the solar PV. The proposal is based on assumption there is connection point at switch room located at 1st storey and available roof access point.

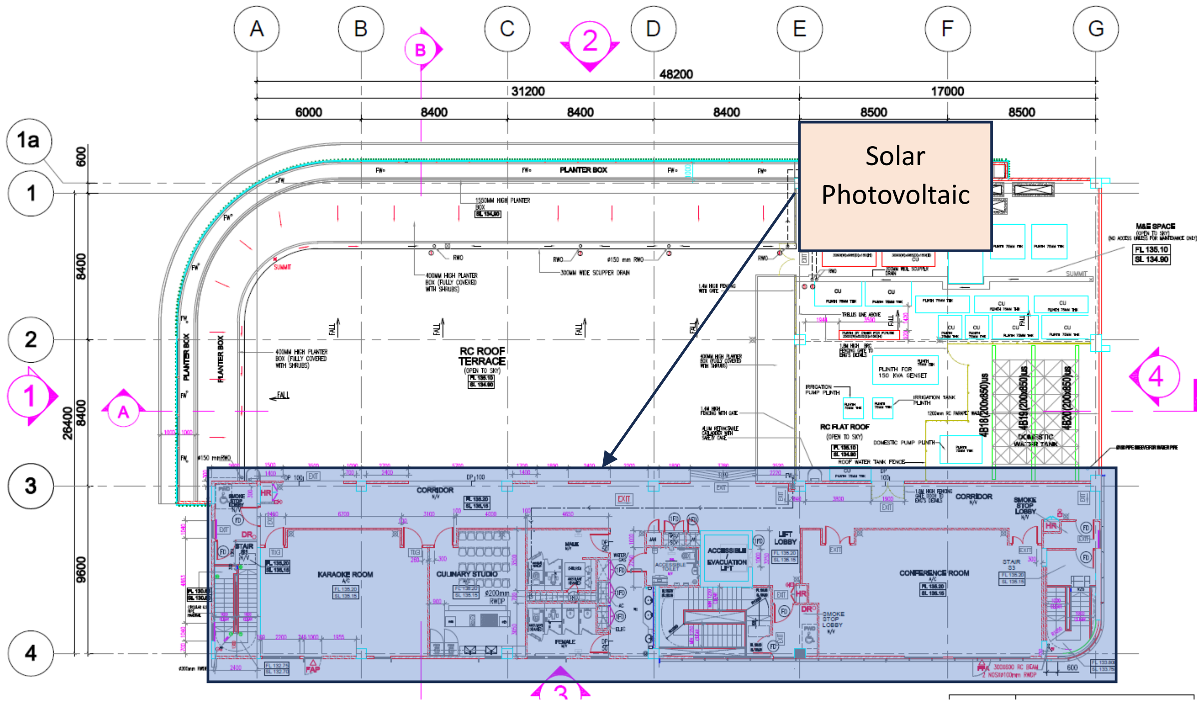


Fig 4.1: Plan view of 4th storey

1 Hillview Rise, Singapore 667970

Nb Modules	Nb Inverters	System Size	Production y1
81	50	50.6	65.8
JA Solar 625Wp	*SUNGROW -SG50CX-P2*	*kWp*	*MWh in year 1^*

Fig 4.2: Proposed Solar PV power generated

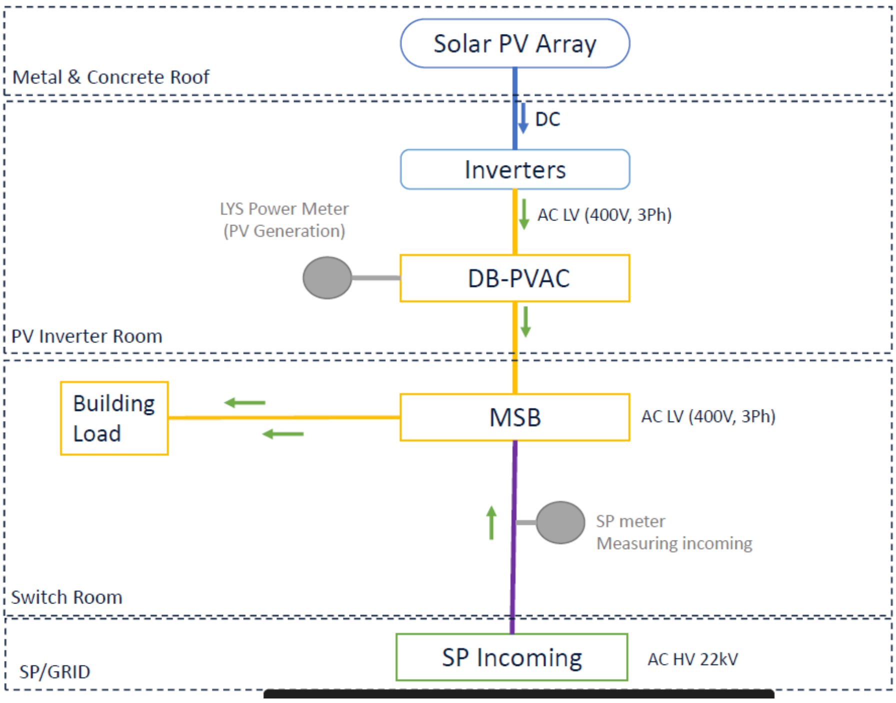


Fig 4.3: Solar PV On-Grid Configuration

The proposed solar PV is an on-grid system is designed to first allow solar energy to be consumed by the customer. Should the customer needs any excess power, it is can drawn from the grid. If the customer's energy requirement is lower than power generated from the solar system, excess solar units are exported to the grid. Further details of the solar PV system can be found in Appendix C.

4.2 EV Charger

Switching to electric vehicles are just a few of the ways that can reduce carbon emissions in operation. Proposed to install 2 EV (Electric Vehicles) Charger outlet in basement carpark to encourage occupants to use electric vehicles instead of ICE (Internal Combustion Engine) vehicles to reduce carbon emissions from petrol or diesel. According to US EPA each ICE vehicle emits about **4.6 T CO2e per annual** and EV vehicle emit net zero CO2.

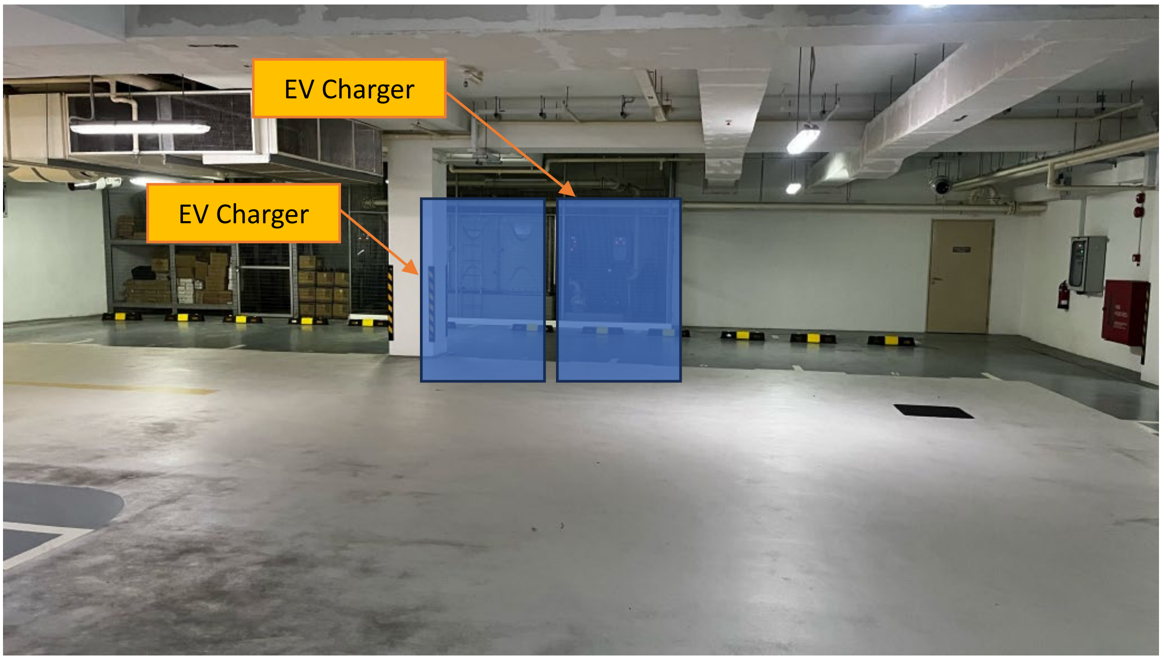


Fig 4.21: Proposed EV chargers in carpark

Currently in the market there are 2 types of EV charger, mainly the AC and DC charger (Fig 4.22). The key difference between both, DC charger is fast charger and AC charger is slow charger. The duration of charging are below.

- AC Charger's charging time: 3-8hour
- DC Charger's charging time: <1-2hour

Fig 4.22: AC and DC Charger

In term of payment, EV vehicle owner can use mobile app to make payment thru Stripe (similar to PayPal) or Visa/Master directly. There is also POS machine function where people can tap their debit/credit card to activate charging.

Payment Activation Mode:

1. POS machine
2. Mobile Application

Some profit can be generated from EV charger, EV vehicle owner will be bill at market rate of $0.60-$0.70/kWh (following SP Power and Shell), backend system can also set any amount the building owner wishes. Building owner pay at $0.32/kWh on their electrical bill. Further details of proposed EV charger can be found in Appendix D.

4.3 Bicycle Rack

Install bicycle rack to encourage occupants to ride bicycle instead taking inter combustion engines (ICE) vehicles to reduce carbon emission.

Fig 4.3: Bicycle Rack

5 Carbon Footprint Calculation

People Association has provided the actual monthly electrical, water bills and waste disposal record. Below table shows the estimate amount of CO2 emissions reduced from implementing the proposed ideas at Hillview Community Club.

5.1 Carbon Footprint Saving Per Annual

Scope 1	**Direct emission from source**	**Quantity**	**Unit**	**Conversion Factor**	**Carbon Equivalent (KgCO2e)**
Transportation (Mobile Combustion)	EV Charger	2	Pcs	4,600	9,200 kg CO2
Refrigerants#	R410A AC removal	50	Kg	2,090	- 104,500 kg CO2
Refrigerants#	R32 AC installation	50	Kg	675	33,750 kg CO2
Scope 2	**Indirect Emissions from purchased energy**	**Quantity**	**Unit**	**Conversion Factor**	**Carbon Equivalent (KgCO2e)**
Electricity*	VRV-X replacement (Less 20% Power)	216,372	KWh	0.4168	90,183 kg CO2e
Electricity*	R32 AC replacement (Less 10% Power)	14,105	KWh	0.4168	5,878.96 kg CO2e
Renewable Energy*	Solar PV (4th Storey)	65,800	KWh	0.4168	27,425 kg CO2e

Electricity*	Library Sliding Door (Remove Air curtain)	782.75	KWh	0.4168	326 kg CO2e
Electricity*	Library Sliding Door (reduce air con Power)	6,230	KWh	0.4168	2,596 kg CO2e
Electricity*	Solar Film	216,372	KWh	0.4168	90,183 kg CO2e
Electricity *	Basketball Court LED replacement	408	KWh	0.4168	170 kg CO2e
Scope 3	**Indirect Emissions**	**Quantity**	**Unit**	**Conversion Factor**	**Carbon Equivalent (KgCO2e)**
Water Consumption^	Rainwater Harvester System	219	m3	0.149	32.63 kg CO2e
Water Consumption^	Basement Transfer Water Tank removal	7,728	m3	0.149	1,151.47 kg CO2e
Waste Disposal - General Waste[@]	Food digester	6,775.99	Kg	0.5614225	3,804.19 kg CO2e
Waste Disposal - General Waste[@]	Food donation & minimise food wastage	2,032.79	Kg	0.5614225	1,141.25 kg CO2e
Waste Disposal - General Waste[@]	Green packaging for F&B business	2,032.79	Kg	0.5614225	1,141.25 kg CO2e
Waste Disposal - General Waste[@]	Redesign menu for F&B business	1,355.19	Kg	0.5614225	760.83 kg CO2e
Total CO2e (Scope 1, 2 & 3) avoided per annual:					**304,744 kg CO2e**

Note: * Grid Emission Factor, a published figure by the Energy Market Authority (EMA) on a yearly basis. The GEF (2024) is 0.4168kg CO2/KWh.

[#] Assume air conditioning system have 1kg of refrigerant charged, carbon emission factor IPCC Fifth Assessment Report, 2014 (AR5)

^ UK Government GHG Conversion Factors for Company Reporting (2022), water supply conversion factor per m3 carbon emission 0.149 kg CO2e.

[@] National Environment Agency (2018) Singapore's Fourth National Communication and Third Biennial Update Report. 1kg of general waste carbon emission 0.5614225 Kg CO2e.

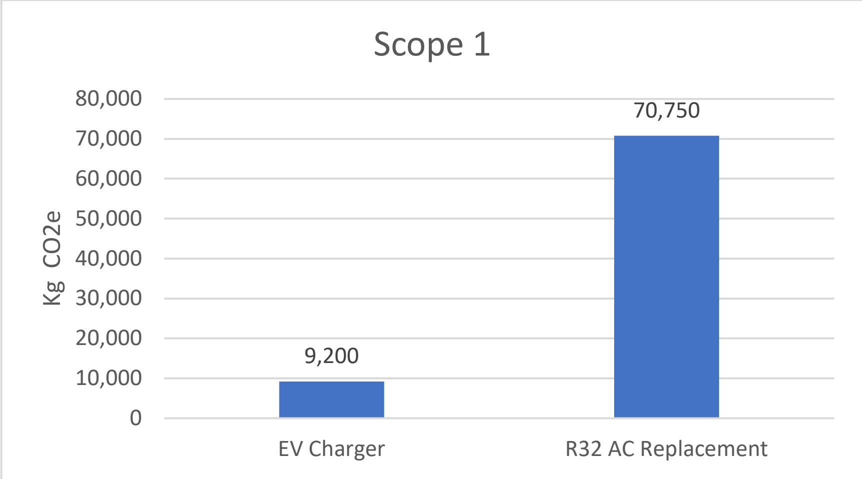


Chart 5.1: Scope 1 Chart

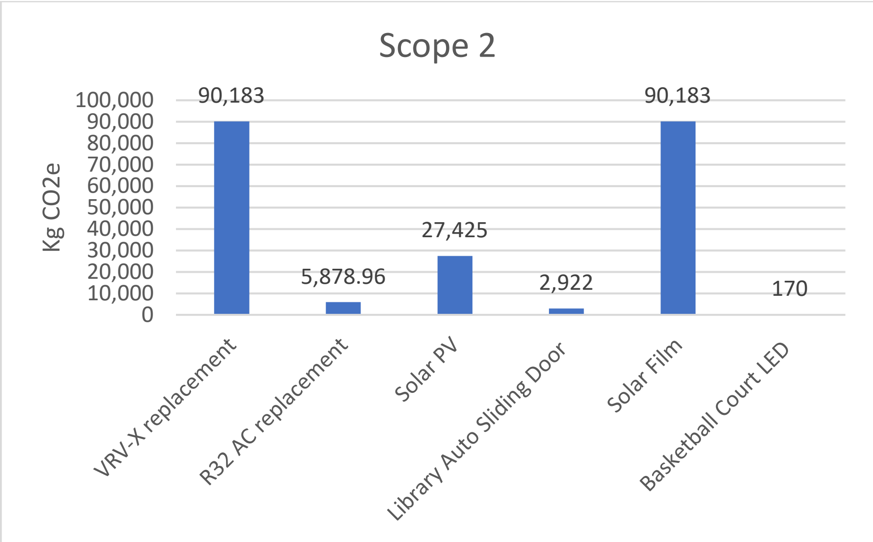


Chart 5.2: Scope 2 Chart

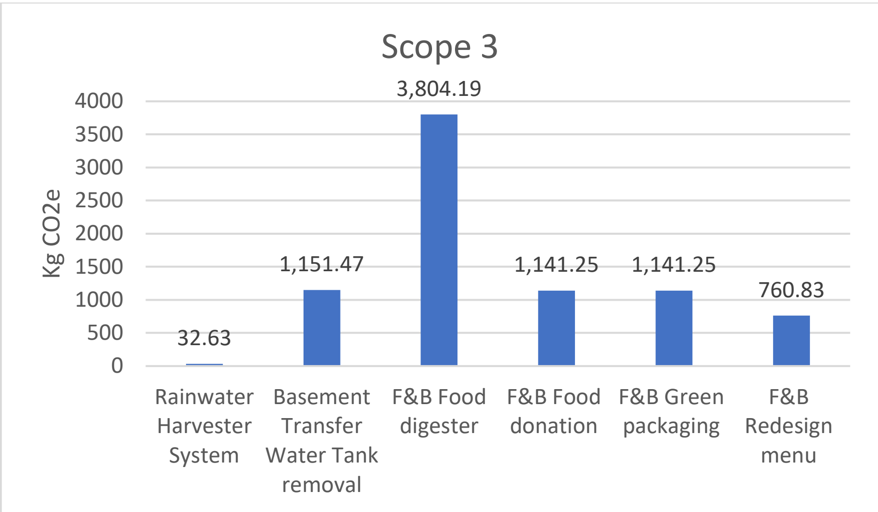


Chart 5.3: Scope 3 Chart

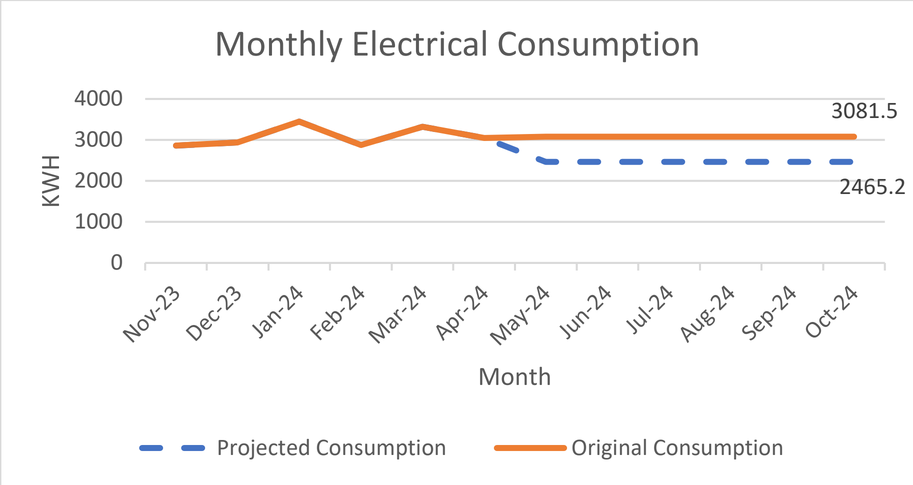


Chart 5.4: Energy consumption projected reduction based on VRV-X (- 20%), R32 AC (- 10%) and Solar Film (- 30%)

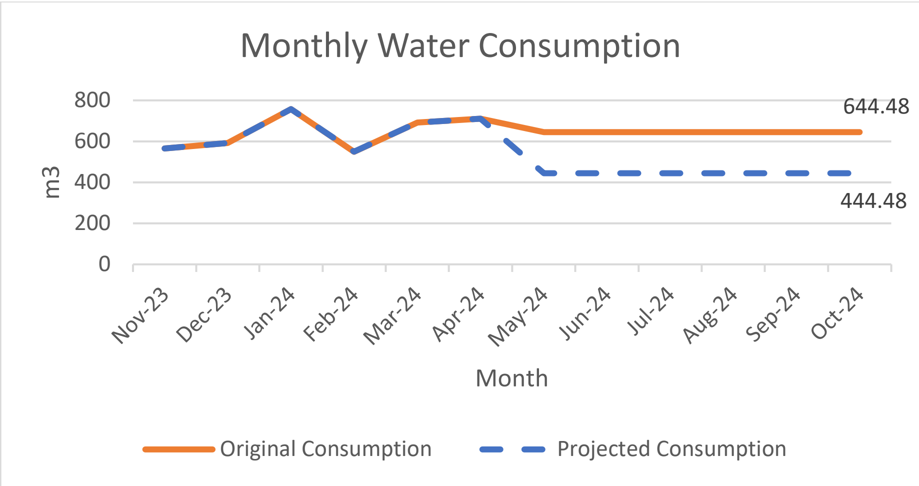


Chart 5.5: Water consumption projected reduction based on rainwater harvester (-200m^3)

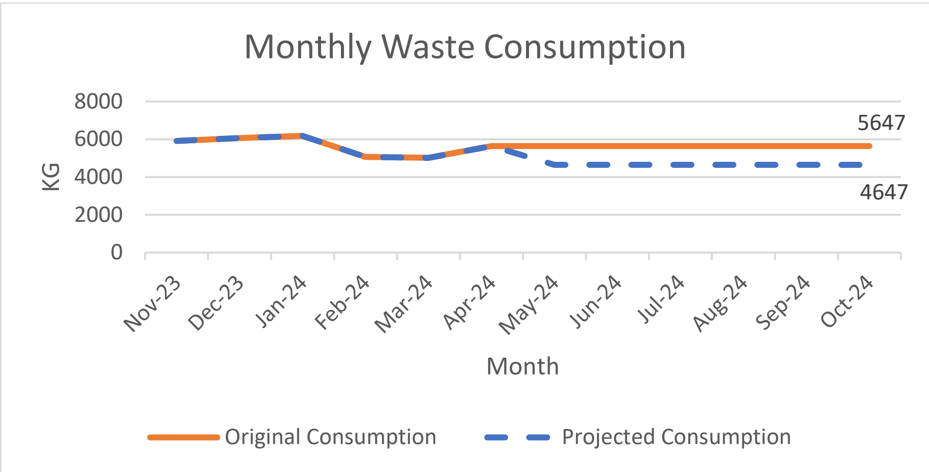


Chart 5.6: Waste consumption projected reduction based on Food Digester (-10%), Food Donation (-3%), Green Packaging (-3%) and Redesign Menu (-2%)

Total projected CO_2 emissions avoided (Scope 1, 2 & 3) per annual after implementing the proposed solution is **304,744 Kg CO2e.**

Conclusion

The ideas and proposals are done by the students of ITE and they are still developing it. Students hoped to implement the proposed ideas and apply it to wider range of residential and commercial building to see more saving of more carbon emissions and consumption.

The potential CO2e saving with the implementation of the proposed ideas is **304,744 Kg CO2e** annually. These solutions will reduce the cost of electricity bills (Chart 5.3), current average electricity consumption is 3,081KWh/mth, after implementation of the proposal the projected electricity consumption is 2,465KWh/mth. At tariff of $0.32 per KWh, potential electrical bill saving of $197.12 per month.

With implementation of the Solar PV, local vendor estimated it can potentially generating 65.8MWh/yr or 5,483KWh/mth, it has the potential to replace most of the building energy. But solar efficiency also depends on the weather, the proposed Solar PV is on grid, hence building can still received power supply from grid. Some vendor provide zero capex installations, depend on the building size and power consumption.

According to Daikin Singapore, R32 VRV will be available to Singapore soon. R32 air conditioning system based on the projected 20% energy saving in scope 1 and 30% carbon saving for scope 2, excellent part load performance, this is viable solution in term of scope 1 and 2 carbon emission reduction. Solar film can potentially reduce the energy up to 30% but depend on the quality of the solar film, range selection and efficiency of air conditioning system.

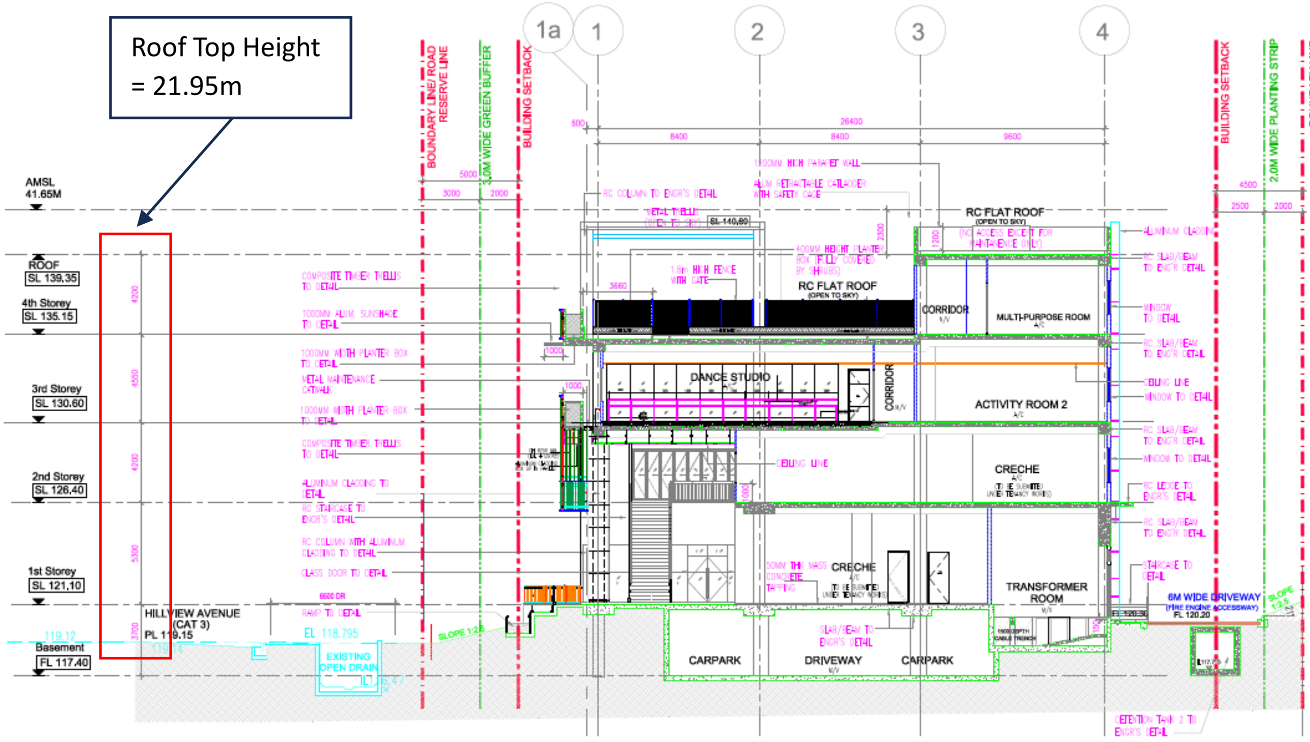
For water solution, rainwater harvester can significantly reduce the water consumption up to 30% based on current monthly water consumption (Chart 5.5). As for waste disposal, food digester can reduce up to 10% of the monthly waste but depend on the amount of waste generated from building and interest from waste vendor.

References

1. BCA Green Mark 2021 Certification Standard (2nd Edition)
2. Global Warming Potential Values IPCC Fifth Assessment Report, 2014 (AR5)
3. UK Government GHG Conversion Factors for Company Reporting (2022)
4. SS 636: 2018 Code of practice for water services
5. SS 553: 2016 Code of practice for air-conditioning and mechanical ventilation in buildings
6. SS 601-1: 2020 Photovoltaic (PV) systems
7. Daikin Air Conditioning Singapore Product Catalogue (2024)

Appendix-A

Hillview Community Club Building Height

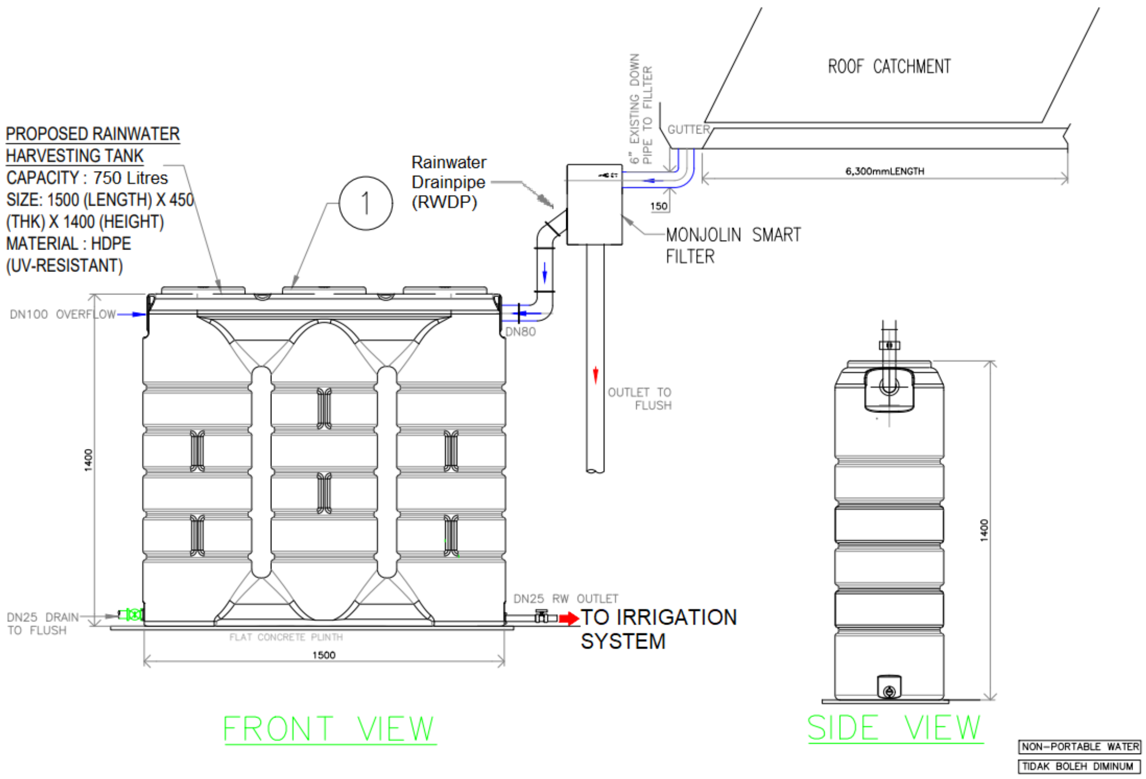


SECTION B-B

SCALE 1:100

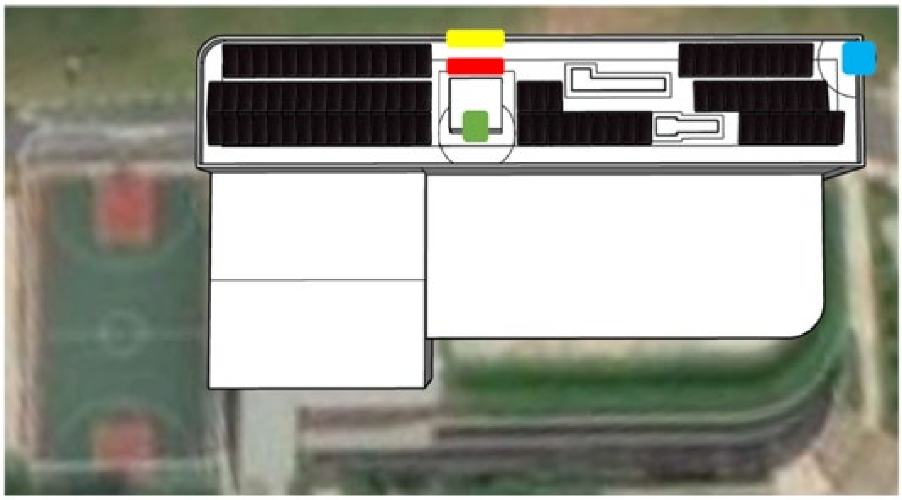
Appendix-B

Rainwater Harvester System

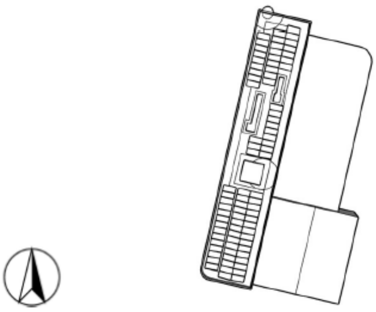


Appendix-C

Solar PV System



- Proposed inverter and DB-PVAC location (within 30m from the connection point)
- Assumed connection point at switchroom located at 1st storey
- Assumed existing roof access point
- Proposed roof access point with compliance to SCDF requirements



Design comments and assumption:

- ✓ Roof dimension designed with reference to Google Stateline map/from roof drawings provided.
- ✓ Assume roof type is RC flat roof, in good condition and structurally sound to accommodate the proposed PV system load.
- ✓ Assume available inverter area within the building and connection to a LV switchboard within 30m from the DBPV
- ✓ A site visit is required to fine-tune the design & provide a detailed analysis.
- ✓ Assume no shading loss (if no 3D scene simulated in Pvsyst)
- ✓ Assume available roof access/lifeline

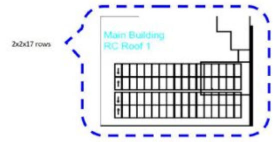
Location: 1.362, 103.764

Nb of inverters:	2	
DC output:	50.6	kWp
AC output:	50	kWac
Required Capacity:	100	A
Available Capacity:	TBC	A
Grid connection:	LT	

INSTALLATION DESIGN

Client roof type: Concrete

Typical mounting structure components for RC roof



Note: 1x2x17 rows per bay is used to calculate the proposed loading

Proposed Loads

Solar Components:	Weight per unit	Quantity	Weight	
Solar Module	29.0 kg/pcs	34	986	kg
Estimated Weight of Module accessories			1007	kg
Estimated Solar Component Weight including supports:			1993	kg
			19.93	**kN**

Designed Load

*Based on SS EN1991-1-1-2001(General actions-Densities, self-weight, imposed loads for buildings). It is assumed the existing design adopted imposed load for rc tile roof will not be less than **1.5kN/m²**.*

Conclusion

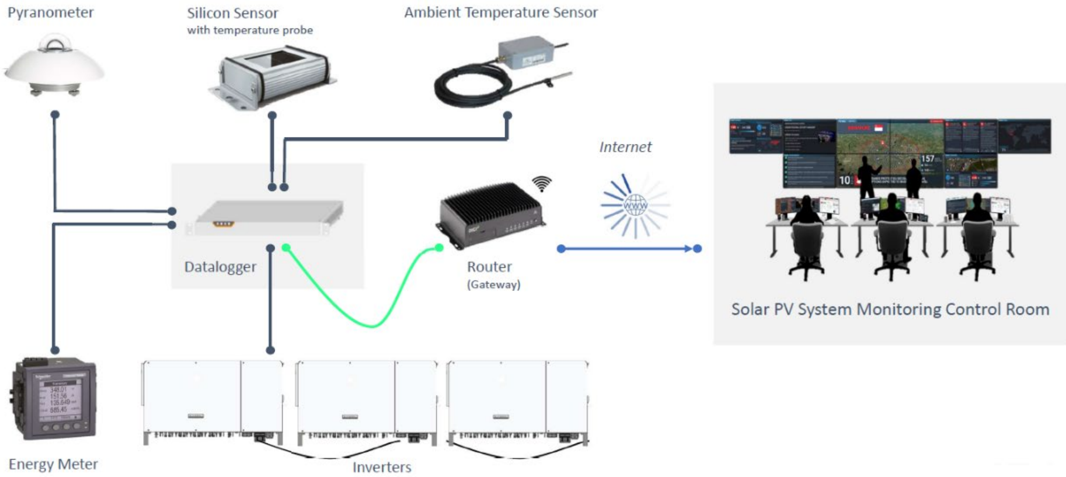
Designed load > Proposed load

Thus, the new proposed loads are within the estimated designed load.

Load assessment report extract

- ✓ The ballast system clamps offer a secure fastening without penetrating the roof, ensuring maximum stability and waterproofing protection.
- ✓ Before installation starts, a professional engineer will assess if the building structure can sustain the additional load from the PV system
- ✓ Typical additional load from the PV System is 60 kg/m.sq (0.60kN/m.sq)

Reliable Monitoring Connections



LATEST AND HIGHEST QUALITY KEY COMPONENTS

JA SOLAR | SUNGROW Clean power for all | KEYSTONE CABLE | Schneider Electric | mc meteocontrol

SOLAR PANELS

INVERTER

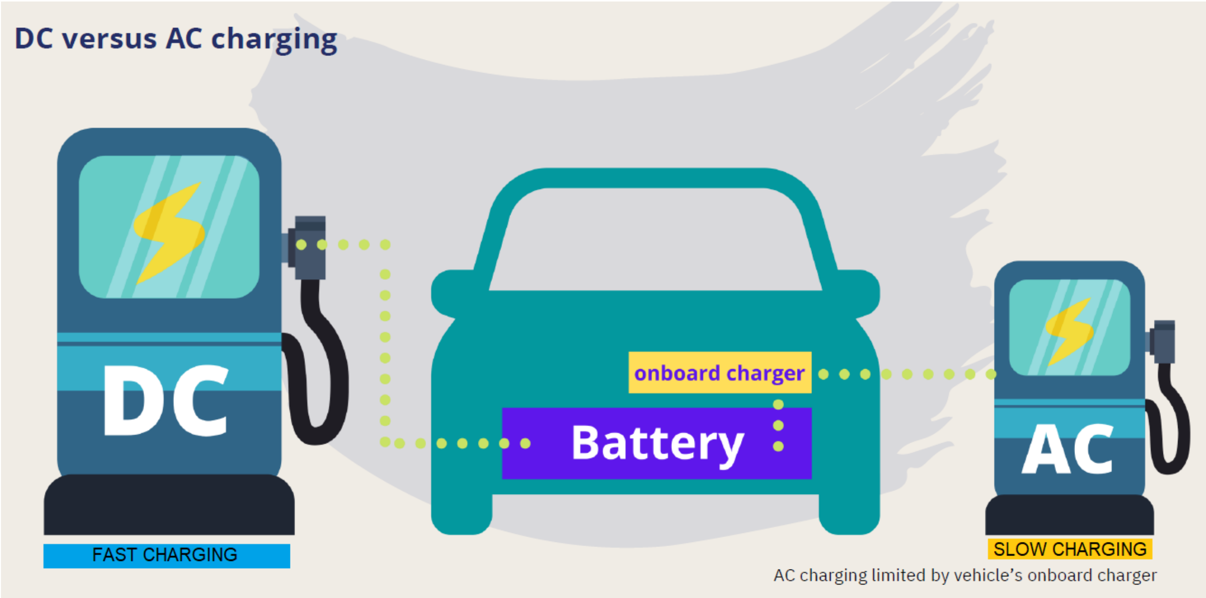
SOLAR CABLES

ENERGY METER

Datalogger

Appendix-D

EV Charger System



Power Input Requirements Summary

Input Current Rating for AC/DC Charger

Output Type	Charger Model	Output Power (kW)	Input Voltage (V)	Input Phase	Input Current (A)
AC	Mercury 7 ii	7.4	230	1-phase	32
	Artemis	7.4	230	1-Phase	32
		7.4	400	3-phase	16
	Aurora	7.4	230	1-Phase	32
		11	400	3-Phase	16
		22			32
DC	Venus	30	400	3-phase	50
	Titan	120			180
		150			225
		180			265
	Nova	360			2*265

VENUS SERIES (Fast charging)

Compact and Robust design for private and public application

Venus 30
- 30kW DC Charger
- 7" LCD Panel
- Compatible with EVs equipped with CCS2 connector
- CE, TR25:2016, Singapore LNO Certified (30kW)
- Outdoor and Indoor Use
- Wall or Column-Mounted
- Charge & Earn™ [Charge Point Operator (CPO)]

Activation Mode:
- RFID Key Card
- Plug and Charge
- Mobile Application

Great for Battery Capacity <100kW

<1-2hour Charging Time

AURORA SERIES (Standard charging)

Compact and modern design for private and public application

Aurora 7/11/22
- 7kW, 11kW, 22kW AC Wall Charger
- iF Design Award Winner
- Compatible with All EVs with Type 2 Connector
- CE, TR25:2016, Singapore LNO Certified
- Outdoor and Indoor Use
- Wall or Column-Mounted
- Charge & Earn™ [Charge Point Operator (CPO)]

Activation Mode:
- RFID Key Card
- Plug and Charge
- Mobile Application

Great for Battery Capacity <80kW

3-8hour Charging Time

Note: AC charging time dependent on vehicle's onboard charger