Sustainability Initiatives SP MAE Workshops

Speaker 1: Mr Saw Tun

- Senior Lecturer, School of Mechanical & Aeronautical Engineering, Singapore Polytechnic
- Course Manager for CET Specialist Diploma for Air-Conditioning & Energy Sustainability
- Course Coordinator for Short Courses related to Building Information Modelling (BIM) applications in BE industry
- Lead for MAE's Focus Group: Energy & Sustainability

MAE's Motivation

Why Sustainability?

- Sustainability targets
- Influence and enabler of green efforts

- 60-30 Vision, 5% energy reduction challenge
- Reduce Waste Disposal Index by 30% by FY2030
- Reduce Water Efficiency Index by 10% by FY2030

- Industry Trends
- Prepare our learners
- Journey with companies

Singapore's Sustainability Vision

GreenGov.SG - Targets for public sector

	Focus Area	Target
	Greenhouse Gas Emissions	Net zero emissions around 2045, after peaking emissions around 2025
	Energy	Reduce energy use by 10% from the baseline by 2030
	Water	Reduce water use by 10% from the baseline by 2030
	Waste	Reduce waste disposed of by 30% from the baseline by 2030

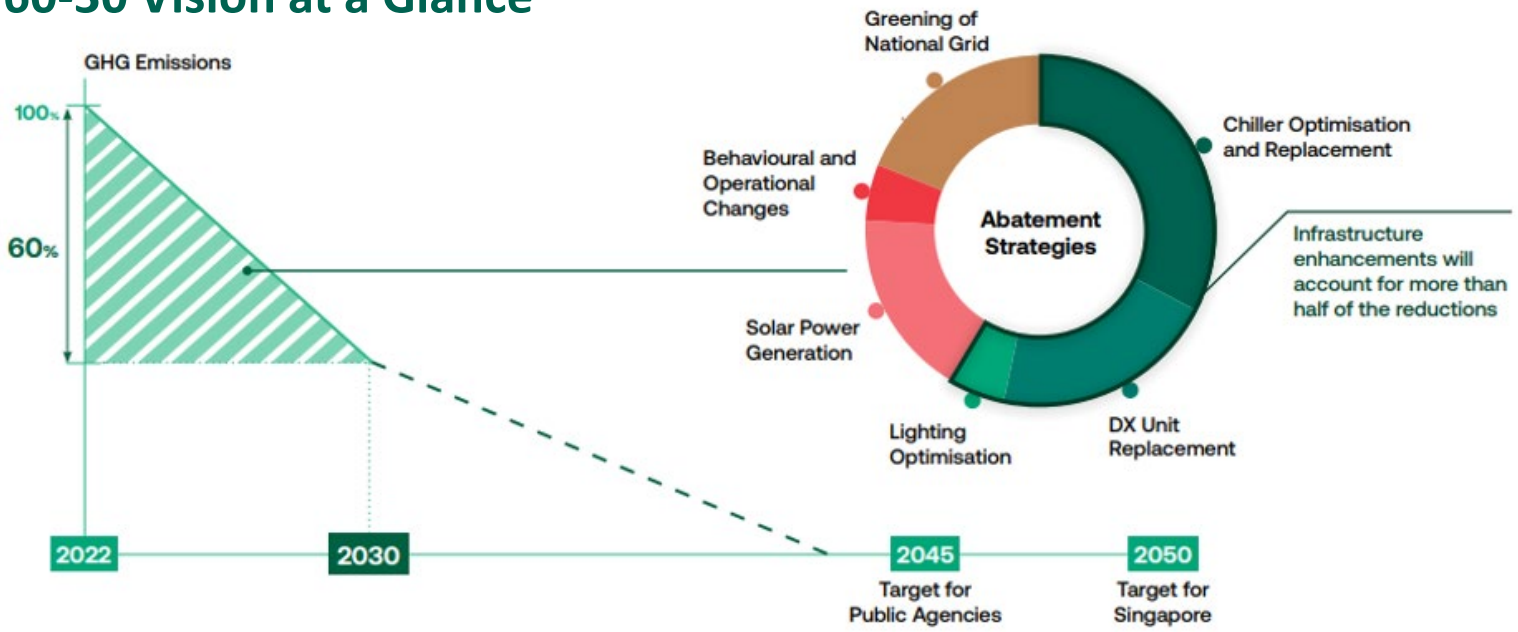
Singapore's Sustainability Vision

GreenGov.SG - Targets for public sector

Focus Area	Target
Greenhouse Gas Emissions	Net zero emissions around 2045, after peaking emissions around 2025

SP's Sustainability Vision

60-30 Vision at a Glance



PCEO's challenge to **further reduce 5% of EUI by 2025.**

Source: https://www.greenplan.gov.sg/key-focus-areas/green-government/

What are the industry trends?

Carbon tax: Singapore's carbon tax steadily increases to drive decarbonization and incentivize low-carbon technologies.

Sustainability disclosures (Scope 1 and 2): From FY2025, SGX-listed companies must report direct and indirect emissions, enhancing transparency and climate accountability.

Scope 3 disclosures in FY2026: From FY2026, listed firms will need to disclose Scope 3, covering value chain impacts and pushing broader climate responsibility.

Large Non-Listed Companies (FY2027): From FY2027, large private firms must adopt similar sustainability disclosures, aligning them with public company standards.

Regulations beyond Singapore: Global sustainability regulations are tightening, pushing companies to adopt consistent climate reporting across jurisdictions.

MAE Sustainability Journey

1. Build Capabilities

- **Assign dedicated team**
- **Build knowledge**
- **Engage industry and solution providers**

2. Planning & Baselining

- **Conduct energy audit & baselining**
- **Implement energy monitoring system**

3. Implement & Improve

- **Prioritise and implement sustainability measures**
- **Replace the old AC equipment with more energy efficient equipment**

MAE Sustainability Journey

1. Build Capabilities

- **Assign dedicated team**
- **Build knowledge**
- **Engage industry and solution providers**

Build Knowledge

- Green Compass (Sep 2022)
- Masterclass in Sustainability by SMF (Sep 2023)
- Leading the Manufacturing Sustainability by SMF (Feb 2024)
- Carbon Management & Strategies in Driving Net Zero (Feb 2024)
- Sustainable Manufacturing Awareness (SIRI & COSIRI) (Mar 2024)
- ISO 50001: Energy Management System Implementation (Sep 2024)



Engage Industry





Engage Solution Providers


MAE Sustainability Journey

Energy Audit & Baselining

2. Planning & Baselining

Energy Audit @W1411 & W1412B

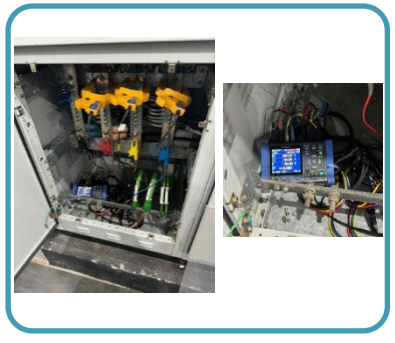
- **Conduct energy audit & baselining**

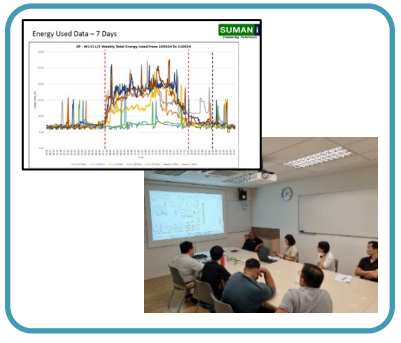
Pre-audit site survey

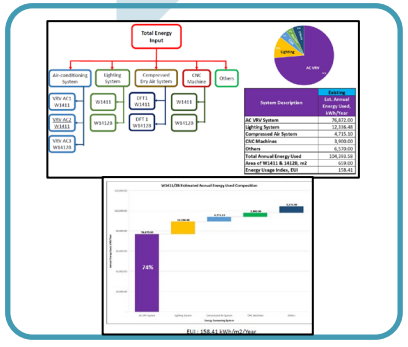
Instrumentation and Data Logging (1 week)

Post survey discussions

Audit Report







- To establish an energy baseline by assessing energy consumption breakdown and identifying energy-saving opportunities.
- Level 2 energy audit was performed.

MAE Sustainability Journey

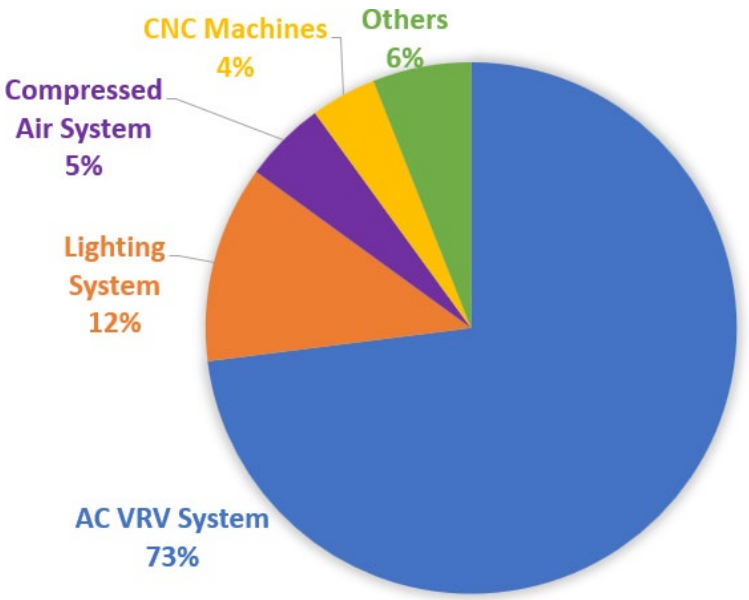
Energy Audit & Baselining: Energy Consumption Breakdown

2. Planning & Baselining

- **Conduct energy audit & baselining**

Energy Audit @W1411 & W1412B

System	Est Annual Energy Consumption (kWh/Year)
AC VRV System	76,872.00
Lighting System	12,336.48
Compressed Air System	4,715.10
CNC Machines	3,900.00
Others	6,570.00
Total Consumption:	**104,393.58**
GFA (m^2)	**659.00**
Energy Utilization Index, EUI (kWh/m^2)	**158.41**



Energy Audit & Baselining: Energy Consumption of AC system

2. Planning & Baselining

- Conduct energy audit & baselining

Energy Audit @W1411 & W1412B

Energy (kWh) = Energy Efficiency (kW/RT) x Cooling Load (RT) x Time (h)

Location	Area (m2)	Weighted Cooling Load, RT	Cooling Load Intensity, m2/RT
W1411	507.58	23.23	21.85
W1412B	151.42	13.25	11.43
Total	659	36.47	18.07

System	Weighted Cooling Load (RT)	Weighted input power (kW)
VRV CU	36.47	28.28
VRV FCU		6.88
Total	36.47	35.16
TSE	0.964	kW/RT

Energy Audit & Baselining: Energy Saving Opportunities

2. Planning & Baselining

- **Conduct energy audit & baselining**

Energy Audit @W1411 & W1412B

System	Proposals	Est. Reduction from Total Consumption (%)
AC VRV System	• W1411: Operate half the VRV fan coil units to achieve a cooling load intensity between 30 and 40 m^2/RT. • W1412B: Operate half the VRV fan coil units during the peak and operate only 1 fan coil unit during off-peak.	22.49%
Lighting System	• Use more energy efficient lightings, reducing lighting budget from 5 W/m^2 to 3.5 W/m^2.	4.92%
Compressed Air System	• Reduce operating pressure from 8 bars to 6 bars. • Install variable speed drive (VSD) for the compressor to operate at lower speed and pressure.	1.15%
	Est. total reduction (%) = 29% Est. total energy reduction = 29,820 kWh Potential EUI reduction to **113.16 kWh/m^2**/year from 158.41 kWh/m^2/year	

MAE Sustainability Journey

Energy Monitoring System: Implementation

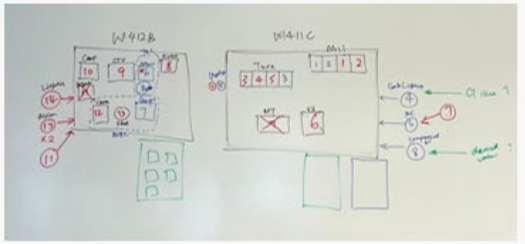
2. Planning & Baselining

- Conduct energy audit & baselining
- **Implement energy monitoring system**

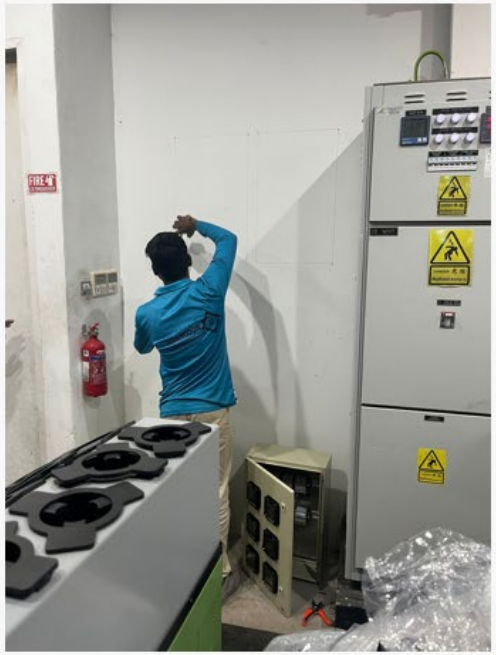
- Purpose: Gather data to review energy efficiency implementation and continuously monitor systems for sustained performance.

1) Site Survey and SLDs

2) Determine what to monitor



3) Start of Installation on 4 Oct



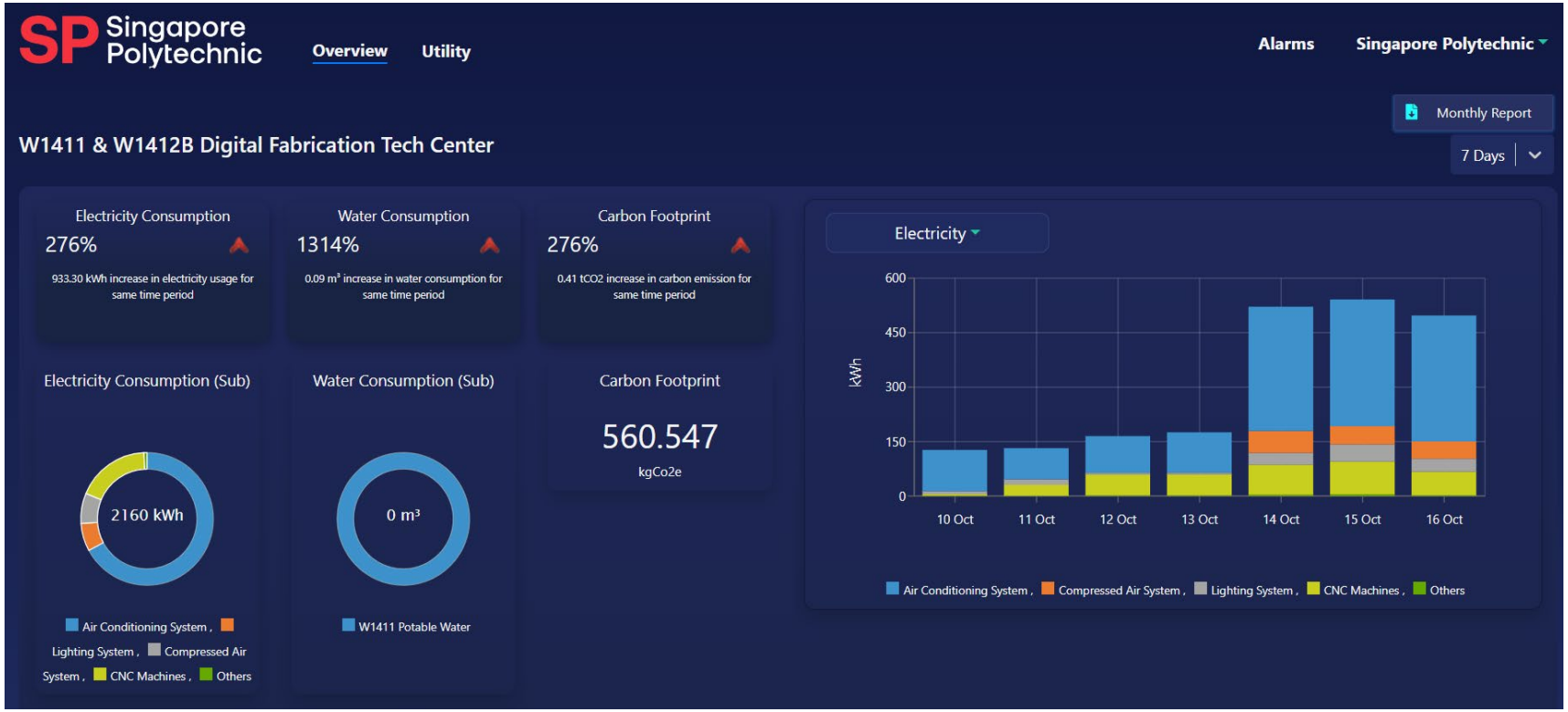
MAE Sustainability Journey

2. Planning & Baselining

- Conduct energy audit & baselining
- **Implement energy monitoring system**

Energy Monitoring System: Dashboard

- Installed 15 new power meters, 1 water meter, and set up a dashboard incorporating our existing power meters for near real-time monitoring.



MAE Sustainability Journey

Prioritise and Implement Sustainability Measures

3. Implement & Improve

- **Prioritise and implement sustainability measures**

Energy Saving Measures

System	Proposals	Est. Reduction from Total Consumption (%)
AC VRV System	• W1411: Operate half the VRV fan coil units to achieve a cooling load intensity between 30 and 40 m^2/RT. • W1412B: Operate half the VRV fan coil units during the peak and operate only 1 fan coil unit during off-peak.	22.49%
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MAE Sustainability Journey

3. Implement & Improve

- **Prioritise and implement sustainability measures**

Prioritise and Implement Sustainability Measures

Energy Saving Measures

System	Proposals	Actual Reduction from System Consumption (%)
AC VRV System	• W1411: Operate half the VRV fan coil units to achieve a cooling load intensity between 30 and 40 m^2/RT. • W1412B: Operate half the VRV fan coil units during the peak and operate only 1 fan coil unit during off-peak.	Oct – Dec 2024: 27,154.2kWh Jan – Mar 2025: 19,466.5 kWh **28% reduction**
Lighting System	• Use more energy efficient lightings, reducing lighting budget from 5 W/m^2 to 3.5 W/m^2.	4.92%
Compressed Air System	• Reduce operating pressure from 8 bars to 6 bars. • Install variable speed drive (VSD) for the compressor to operate at lower speed and pressure.	Oct – Dec 2024: 3961.8 kWh Jan – Mar 2025: 3010.2 kWh **24% reduction**

Energy reduction over 3 months = 8,639.3 kWh

Cost reduction over 3 months (based on $0.3 per kWh) = $2,591.79

MAE Sustainability Journey

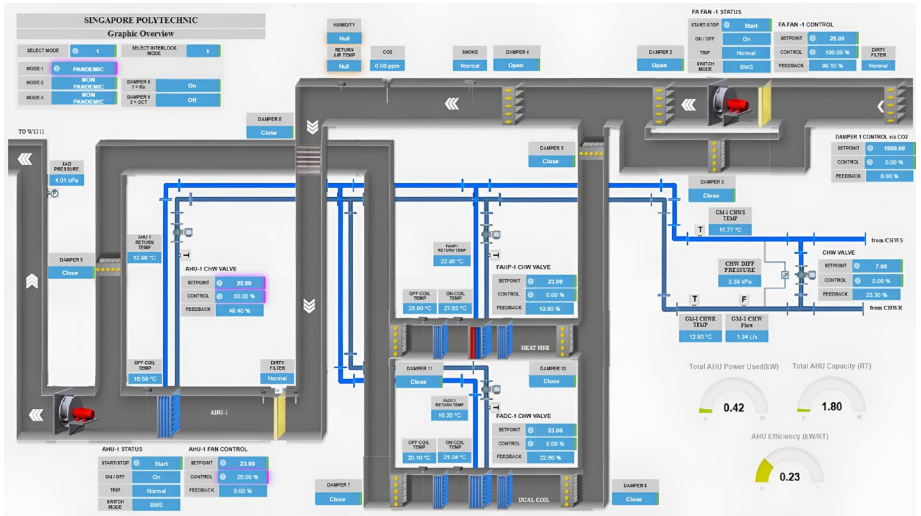
3. Implement & Improve

- Prioritise and implement sustainability measures
- **Replace the old AC equipment with more energy efficient equipment**

Replace the old AC equipment with more energy efficient equipment

Upgrading energy efficient air handling system at W1311-RAC Lab

- Air Handling Unit (AHU) system used in our Refrigeration & Air-Conditioning RAC lab was ageing and there is no energy monitoring and energy efficient features.
- Upgraded to a new air handling system equipped with energy-saving technologies.



New AHU installed in RAC Lab

MAE Sustainability Journey

3. Implement & Improve

- Prioritise and implement sustainability measures
- **Replace the old AC equipment with more energy efficient equipment**

Replace the old AC equipment with more energy efficient equipment

Upgrading energy efficient air handling system at W1311-RAC Lab

Energy (kWh) = Energy Efficiency (kW/RT) x Cooling Load (RT) x Time (h)

Case 1: Before the AHU Upgrade													**Room Condition**	
Chiller Power =	12	kW											Temp (deg C):	20
AHU Power =	3	kW											RH (%):	85
Total Power =	15	kW												
Cooling Load =	5.57	x	4.2	(	14	-	11	) =	70.182	kW	=	20.0	RT	
COP =	70.2	/	15	=	**4.6788**									
kW/RT =	**0.75**													
Energy per day =	20.0	x	0.75	x	8	=	120	kWh						

Case 2: After the AHU Upgrade													**Room Condition**	
Chiller Power =	12	kW											Temp (deg C):	24
AHU Power =	0.53	kW											RH (%):	55
Total Power =	12.5	kW												
Cooling Load =	0.37	x	4.2	(	17.50	-	9.60	) =	12.277	kW	=	3.5	RT	
COP =	12.3	/	12.5	=	**0.98**									
kW/RT =	**3.59**													
Energy per day =	3.5	x	3.59	x	8	=	100	kWh						

Energy reduction per year = 4,800 kWh (more than 16% saving from air side system)

Cost reduction per day (based on $0.3 per kWh) = $1,440

MAE Sustainability Journey

3. Implement & Improve

- Prioritise and implement sustainability measures
- **Replace the old AC equipment with more energy efficient equipment**

Replace the old AC equipment with more energy efficient equipment

Upgrading energy efficient air handling system at W1311-RAC Lab

Case 2: After the AHU Upgrade													Room Condition				
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COP =	12.3	/	12.5	=	**0.98**												
kW/RT =	**3.59**																
Energy per day =	3.5	x	3.59	x	8	=	100	kWh									

- From the air system upgrade, able to reduce more than 16% of the energy consumption
- Still have great potential to further reduce the energy by upgrading the water side
- Will include upgrading the existing chilled water and condenser water pumps and cooling tower with variable speed drive (VSD)
- Target to stretch the energy saving more than 40%

MAE Sustainability Courses

Specialist Diploma in Air-Conditioning & Energy Sustainability (1-Year Programme)

- Air-Conditioning & Energy Sustainability
  - Air-Conditioning System
  - Green Mark & Energy Sustainability
- Energy Modelling & Management
  - Integrated Building Management System
  - Information & Energy Modelling of Facility

Specialist Diploma in Sustainable Digital Manufacturing (1-Year Programme)

- Manufacturing Digitisation
  - AI-Driven Data Analytics for Sustainable Manufacturing
  - Essentials of Advanced Manufacturing
- Monitoring and Reporting for Sustainability
  - Sustainability Reporting and Strategies
  - Energy Monitoring and Auditing

MAE Sustainability Courses

Short Courses

- **[SSG approved]** Driving Sustainability in Manufacturing Through ISO 50001 Energy Management Approach (co-developed with TUV SUD)
- **[SSG approved]** Performing Fundamental Greenhouse Gas Accounting Based on ISO 14064 – A Manufacturing Perspective (co-developed with TUV SUD)
- **[SSG approved]** Sustainability Roadmap Implementation for Manufacturing Industry (co-developed with SMF)

MAE Sustainability Courses

Programme Benefits

Foundations of Sustainable Manufacturing

Gain insights into the core principles, benefits, and impact of sustainable manufacturing on SMEs.

Structured Implementation

Understand the three-stage sustainability journey and apply Phase 1 (Planning) by setting objectives, identifying KPIs, and engaging stakeholders.

Practical Application

Identify a Proof-of-Concept (POC) focus area for mentoring and validation with HP Singapore at Phase 2.

Applicable Industries

SMEs with manufacturing facilities in aerospace, electronics, food and beverage (F&B), fast-moving consumer goods (FMCG), general manufacturing, pharmaceutical, and precision engineering

Phase 1	Phase 2	Phase 3
2-Day Business Needs Analysis in Sustainable Manufacturing Workshop	4-Hour Proof of Concept Mentoring Programme with HP	Evaluation and Implementation

Speaker 2: Mr Ahmad Sulaiman B. Sumani, CEng

- Adjunct Lecturer, School of Mechanical & Aeronautical Engineering, Singapore Polytechnic
- Practicing BCA Energy Auditor and Energy Efficiency Opportunities Assessor
- 40 Years Experience In The Field of Air-conditioning
- Holders of 2 patent On Data Analytics

Misconception On Environmental Sustainability

1. Which Come First ? Environmental Sustainability Or Design In-built Environmental Objectives
    a. Environmental Sustainability – Energy Savings, Cost Savings, Carbon Reduction
    b. Design In-built Environmental Objectives – Space Temperature, Humidity and CO2 concentration

2. Can Be Done In Isolation?
    a. Yes or No ?

Energy Savings & Energy Cost Savings

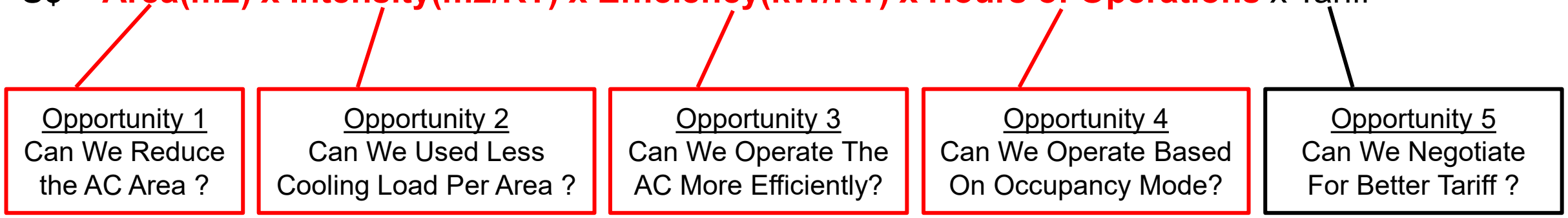
Singapore Polytechnic

S$ = **kWh** x Tariff

S$ = **kW** x **Hours of Operations** x Tariff

S$ = **Load(RT) x Efficiency(kW/RT) x Hours of Operations** x Tariff

S$ = **Area(m2) x Intensity(m2/RT) x Efficiency(kW/RT) x Hours of Operations** x Tariff

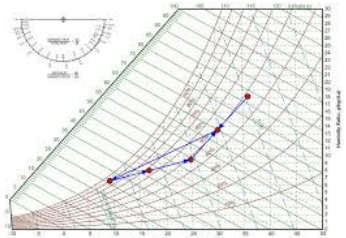


Concept of Energy Efficiency and Savings

1. **Conceptualised and Delivered**
    a. Computation Must Accurate and Conservative
    b. Finance Director and the Housewives Must Saw It In Their Utilities.
2. **Get Your Priorities/Objectives In The Right Order**
    a. **Primary Objectives – Space Temperature, Relative Humidity and CO2 Concentration**
        i. Keep It Simple – Make Sure The Operators Could Operate It With Ease
        ii. Follow Through – Simplify Your Performance Metrics For The Operator
    b. **Secondary Objectives – Energy Efficiency and Savings**
        i. Know Your Daily Load, RT and Efficiency Target, kW/RT
        ii. Track Your Operating Performance Hourly – initial Stage – On-The-Job-Training
        iii. Follow Through – Hourly – Daily – Weekly – Monthly Efficiency Target
        iv. Make your Achievement Visible
        v. Final Litmus Test – The Savings Must Be Visible In The Monthly Utilities Bill

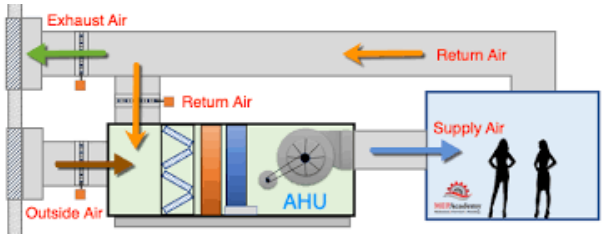
Setting Up and Delivering Your Primary Objective

1. Understand Your HVAC Psychrometric Plan
   a. Temperature Controls
   b. Relative Humidity Controls
   c. CO2 concentration Controls



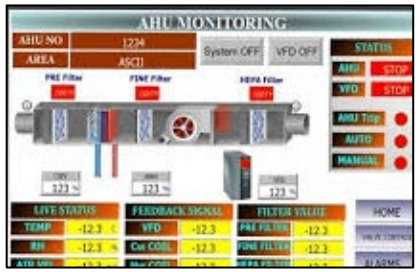
a. Designed Space Temperature
b. Designed Relative Humidity – Dew Point
c. Designed Air Change – CO2 Concentration

2. Set Up Your Installation As Per Item 1
   a. Temperature Controls
   b. Relative Humidity Controls
   c. CO2 concentration Controls
   d. Airside Efficiency



a. Space Temperature – RA Thermostat
b. Relative Humidity – Dew Point Sensor
c. CO2 Concentration – CO2 Sensor
d. Airside Efficiency – Digital Power Meter

3. Synchronise Your Control And Its Algorithm
   a. Temperature Controls
   b. Relative Humidity Controls
   c. CO2 concentration Controls
   d. Airside Efficiency



a. RA Thermostat – Fan Speed
b. Dew Point Sensor – Modulating CHW Valve
c. CO2 Sensor – FA Damper
d. Airside Efficiency – Digital Power Meter

4. Monitor, Track and Deliver The Performance
   a. Temperature Controls
   b. Relative Humidity Controls
   c. CO2 concentration Controls
   d. Airside Efficiency
   e. Load Reduction

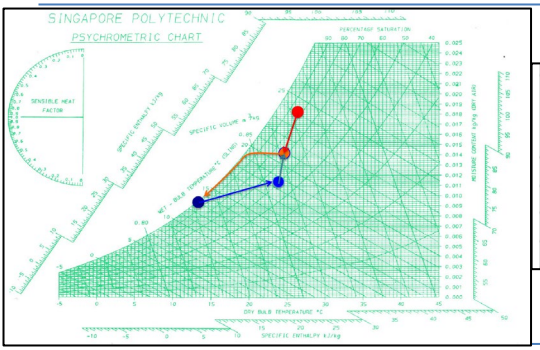
a. RA Thermostat – Fan Speed – Space Temperature
b. Dew Point Sensor – Modulating CHW Valve – Relative Humidity
c. CO2 Sensor – FA Damper – CO2 Concentration
d. Airside Efficiency – Digital Power Meter – kW/RT
e. Load Reduction – Cooling Load Intensity – < m2/RT

Plan and Set Up

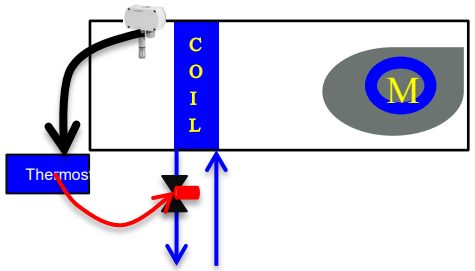
Existing

Objectives:

1. Temperature: 24 – 26°C
2. Relative Humidity: 65 ± 5%
3. CO2 Concentration: < 1,100 ppm

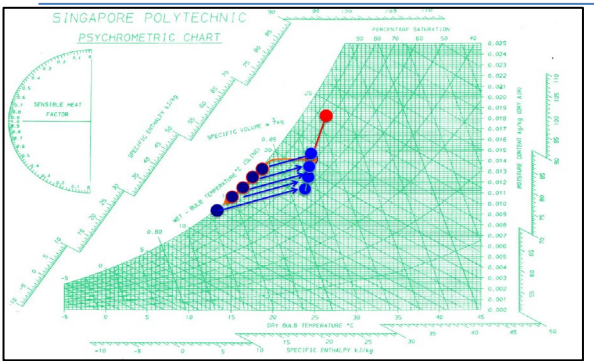


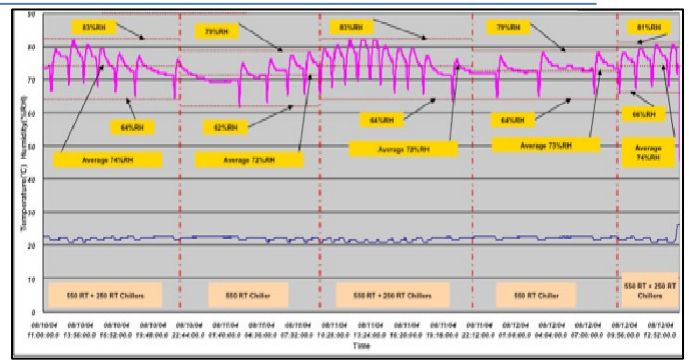
NO.	UNIT. NO.	MODEL	LOCATION		Qty	AIR FLOW (L/S)	TOTAL CAPACITY (KW)	TOTAL SENSIBLE HEAT (KW)	OUTSIDE AIR FLOW (L/S)	ENTERING AIR TEMP.		LEAVING AIR TEMP.		WATER FLOW RATE (l/s)	EXTERNAL STATIC PRES. (Pa)	POWER		
			FLOOR	ROOM DESIGNATION						DB (OC)	WB (OC)	DB (OC)	WB (OC)			Volt	ph	kW
1	AHU-C-FC-01	DM2TB-1519B	CONCOURSE	FOOD COURT	1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
2	AHU-C-FC-02	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
3	AHU-C-FC-03	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
4	AHU-C-FC-04	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11



Controls Logic

1. Fan Speed Constant
2. RAT regulate the CHW valve opening
3. Room Temperature achieved, the CHW valve closed.
4. CO2 sensor/damper not included.
5. Result ????

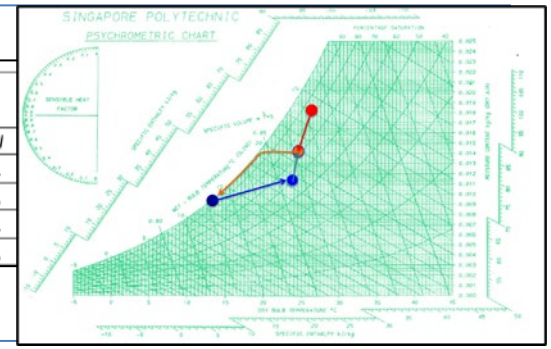


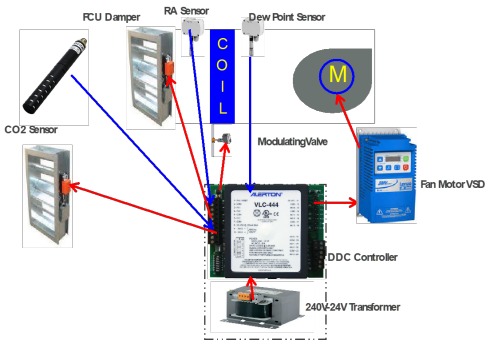


Proposed

Objectives:

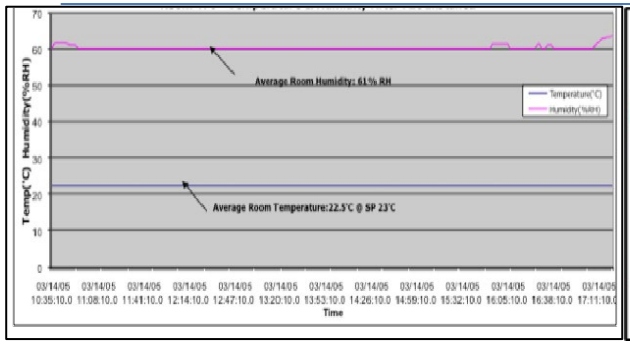
1. Temperature: 24 – 26°C
2. Relative Humidity: 65 ± 5%
3. CO2 Concentration: < 1,100 ppm

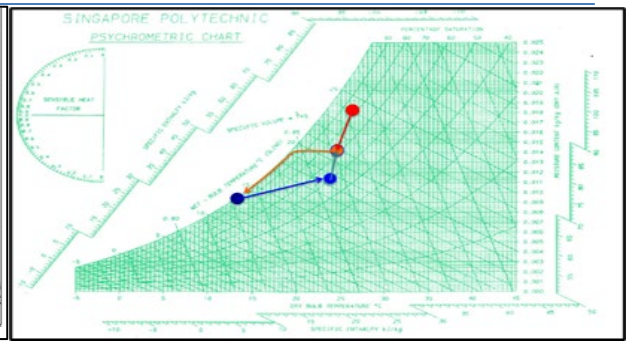




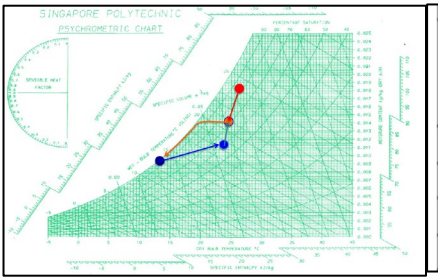
Controls Logic

1. Fan Speed Variable
2. RAT regulate the fan speed
3. DPT regulate the CHW valve opening to maintain a preset DP Temperature
4. CO2 sensor regulate FA damper
5. Result ????

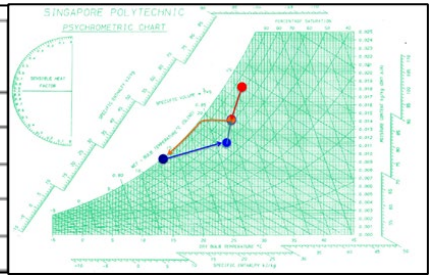


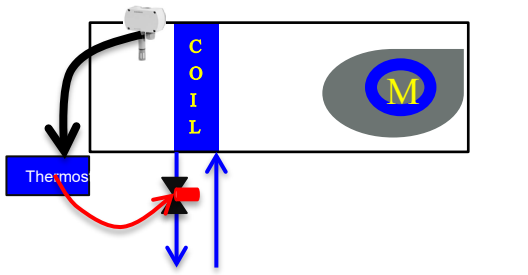


Set Up, Performance and Efficiency



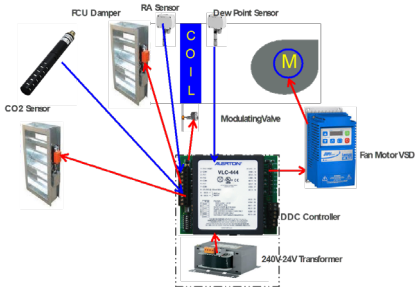
NO.	UNIT. NO.	MODEL	LOCATION		Qty	AIR FLOW (L/S)	TOTAL CAPACITY (KW)	TOTAL SENSIBLE HEAT (KW)	OUTSIDE AIR FLOW (L/S)	ENTERING AIR TEMP.		LEAVING AIR TEMP.		WATER FLOW RATE (l/s)	EXTERNAL STATIC PRES. (Pa)	POWER		
			FLOOR	ROOM DESIGNATION						DB (OC)	WB (OC)	DB (OC)	WB (OC)			Volt	ph	kW
1	AHU-C-FC-01	DM2TB-1519B	CONCOURSE	FOOD COURT	1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
2	AHU-C-FC-02	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
3	AHU-C-FC-03	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11
4	AHU-C-FC-04	DM2TB-1519B	CONCOURSE		1	6,395	170	101	3,386	25.00	19.50	11.41	11.35	5.21	500	400	3	11





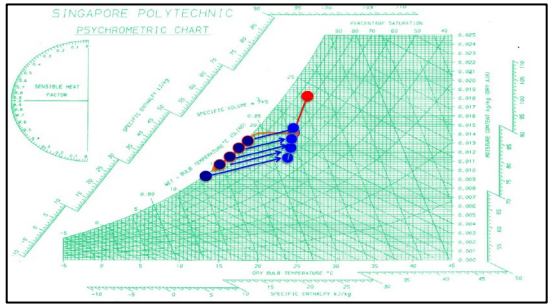
Controls Logic

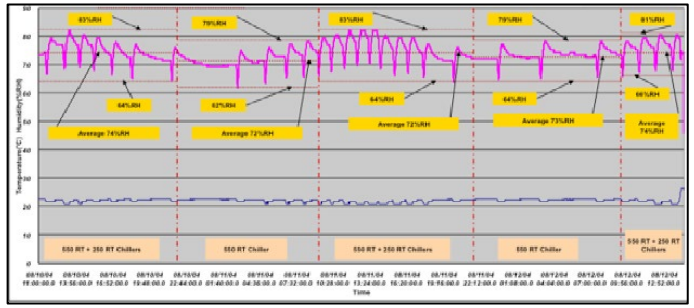
1. Fan Speed Constant
2. RAT regulate the CHW valve opening
3. Room Temperature achieved, the CHW valve closed.
4. CO2 sensor/damper not included.
5. Result ????

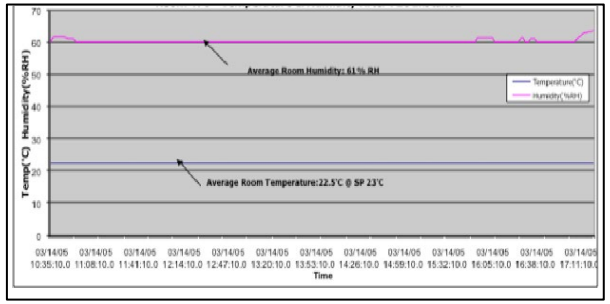


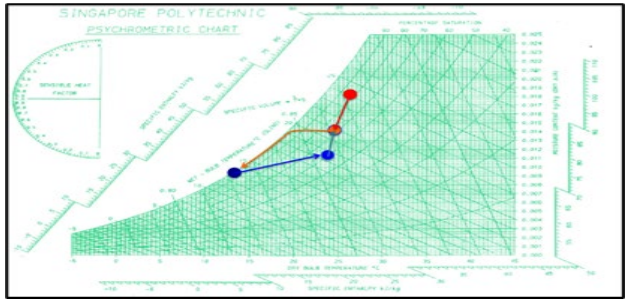
Controls Logic

1. Fan Speed Variable
2. RAT regulate the fan speed
3. DPT regulate the CHW valve opening to maintain a preset DP Temperature
4. CO2 sensor regulate FA damper
5. Result ????









Loading 100%	**Cap: 48.3RT**	**ikW: 11kW**	**ASE: 0.228 kW/RT**
Loading 90%	**Cap: 43.5RT**	**ikW: 11kW**	**ASE: 0.253 kW/RT**
Loading 80%	**Cap: 38.6RT**	**ikW: 11kW**	**ASE: 0.285 kW/RT**
Loading 60%	**Cap: 29.0RT**	**ikW: 11kW**	**ASE: 0.379 kW/RT**
Loading 40%	**Cap: 19.3RT**	**ikW: 11kW**	**ASE: 0.570 kW/RT**

Loading 100%	**Cap: 48.3RT**	**ikW: 11kW**	**ASE: 0.228 kW/RT**
Loading 90%	**Cap: 43.5RT**	**ikW: 8.0kW**	**ASE: 0.184 kW/RT**
Loading 80%	**Cap: 38.6RT**	**ikW: 5.6kW**	**ASE: 0.145 kW/RT**
Loading 60%	**Cap: 29.0RT**	**ikW: 2.4kW**	**ASE: 0.083 kW/RT**
Loading 40%	**Cap: 19.3RT**	**ikW: 0.7kW**	**ASE: 0.036 kW/RT**

Setting Up and Delivering Your Secondary Objective Energy Savings & Energy Cost Savings

Singapore Polytechnic

i. Know Your Daily Load, RT and Efficiency Target, kW/RT **(RT & kW/RT)**
ii. Track Your Operating Performance Hourly – initial Stage **– On-The-Job-Training**
iii. Follow Through – Hourly – Daily – Weekly – Monthly Efficiency Target **(RT & kW/RT)**
iv. Make your Achievement Visible **(RT & kW/RT)**
v. Final Litmus Test – The Savings Must Be Visible In The Monthly Utilities Bill **(kWh & S$)**

Conclusion

1. Design, Built and Operation In Totality – As An Eco-System
2. Design For The “Real” Operator To Operate
3. Make It Simple For Operations, Performance and Efficiency
4. Know Your Real-Time, Hourly, Daily, Weekly, Monthly and Annual Operating Efficiency
5. Continuous Training On Operations Performance and Efficiency
6. Include Your Operators In Your Monthly Operations Meeting.
7. Practice Create Habits, Good Habits Create Performance

Discussion