



REFRIGERANT MANAGEMENT BY USING IoT TECHNOLOGY AND CO-BENEFIT IN ENERGY SAVING AT MALAYSIA FOOD BASE SECTOR

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Introduction

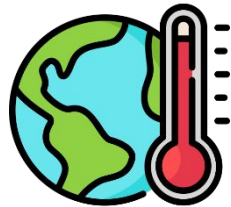


Fluorocarbons (HCFC, HFCs) are used as refrigerant for temperature exchange equipment

(Example: Refrigeration units, food showcases, unit coolers, air conditioner, chiller etc)



Ozone depletion potential (ODP) is measured relative to HCFC and it represents the amount of ozone destroyed by emission of a vapor over its entire atmospheric lifetime relative to that caused by the emission of the same mass of HCFC



Global warming potential (GWP) is the ratio of the warming caused by a substance to the warming caused by a similar mass of carbon dioxide.



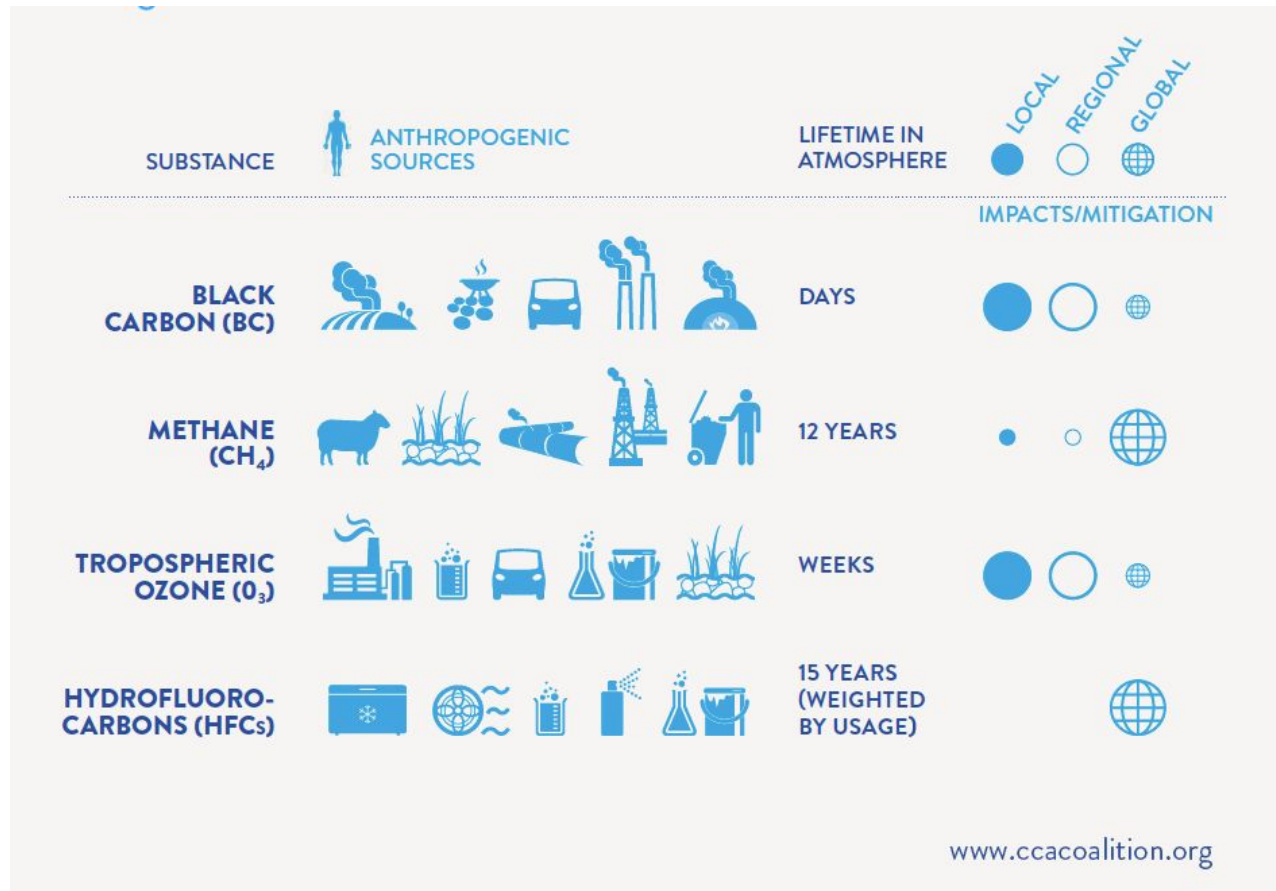
The demand of air conditioning and refrigerant is increasing as the world warms and as wealth increases

Country	Room AC Demand (thousand units)		Refrigerant
	2010	2015	
World Total	73,420	79,389	R-22 dominant (Other Asia Total)
Malaysia	751	789	R-22 dominant, R-32 (starting)
Indonesia	1493	2109	R-22, R-410A, R-32 (~33%)
Thailand	957	1268	R-22, R-32 (~50%)
Vietnam	670	1546	R-22 (~60%), R-32 (~20%)

Details of room AC demand and refrigerant used in 2015
(Shah et al., 2017)

Short-lived Climate Pollutants.

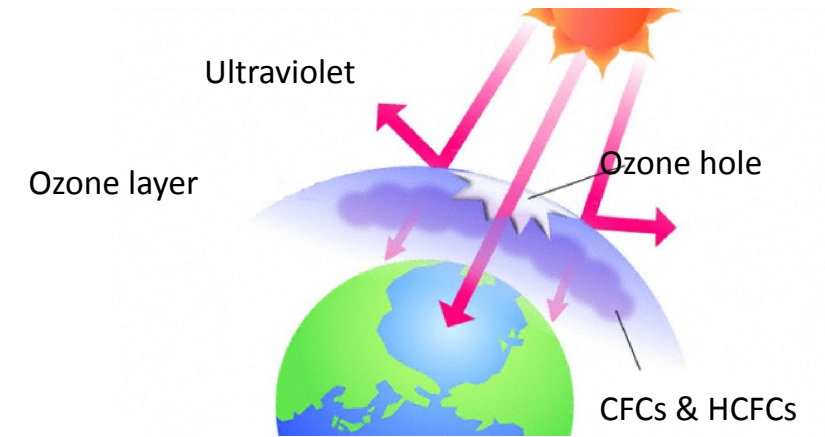
Powerful climate forcers that remain in the atmosphere for a much shorter period of time than carbon dioxide (CO₂), yet their potential to warm the atmosphere can be many times greater.



Greenhouse Gases	Global Warming Potential (GWP)
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous oxide (N ₂ O)	298
Hydrofluorocarbons (HFCs)	124 -14,800
Black Carbon	460-1,500

International Agreement in Controlling Production & Consumption

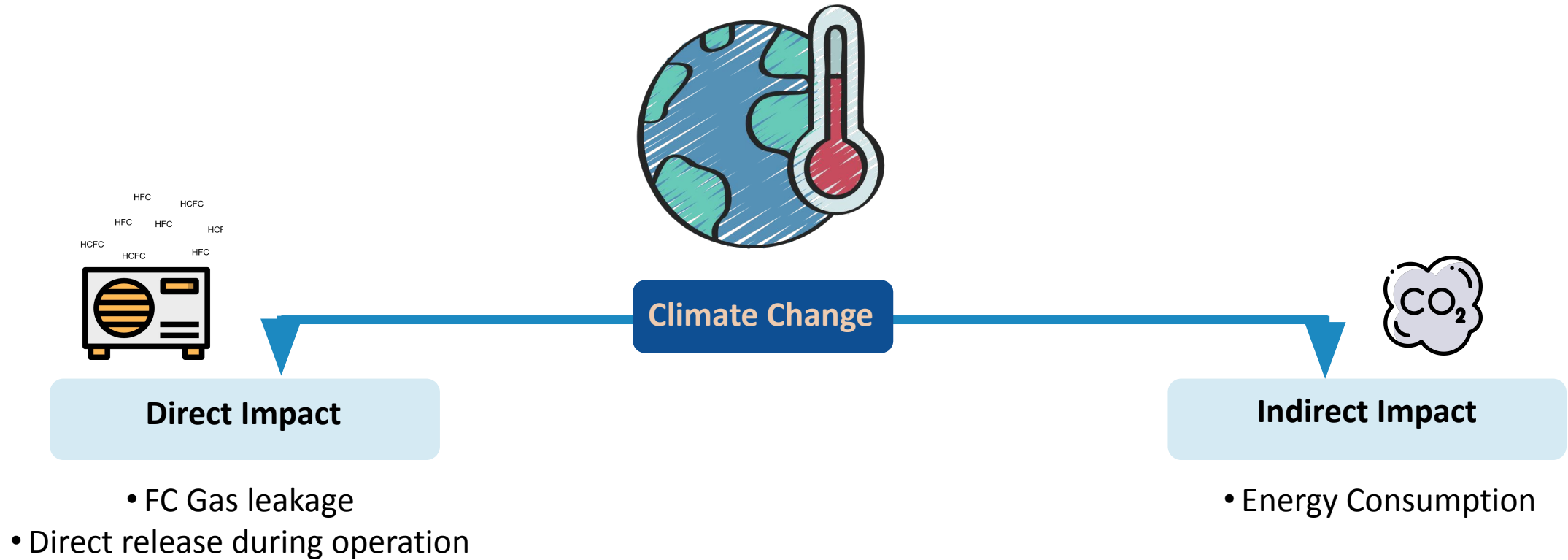
- F-gas (CFCs/HCFCs/HFCs) are used as refrigerants for equipment (e.g. refrigeration units, showcases, unit coolers, air-conditioner (AC), etc.).
- The Montreal Protocol entered into force on 1 January, 1989, initially restricted CFCs and HCFCs whose Ozone Depletion Potential (ODP) values are over zero. However, with the Kigali Amendment ratified in 2016, the Protocol will also restrict HFCs because of their high Global Warming Potential (GWP) values.



International Agreement	Montreal Protocol		Kigali Amendment
Fluorocarbon Gas	CFC	HCFC	HFC
	Restriction of Production and Consumption		
Phase out/phase down plan	Complete phase out by: 1996 (developed ctys) 2010 (developing ctys)	Complete phase out by: 2030 (developed ctys) 2040 (developing ctys)	Phase down (-80%) by: 2034 (developed ctys) 2045 (developing ctys)*
Ozone Depletion Potential (ODP)	1 to 0.5	0.5 to 0.005	0
Global Warming Potential (GWP)	380 to 8100 (R12=8100)	90 to 1800 (R22=1700)	140 to 11700 (R404a=3943)

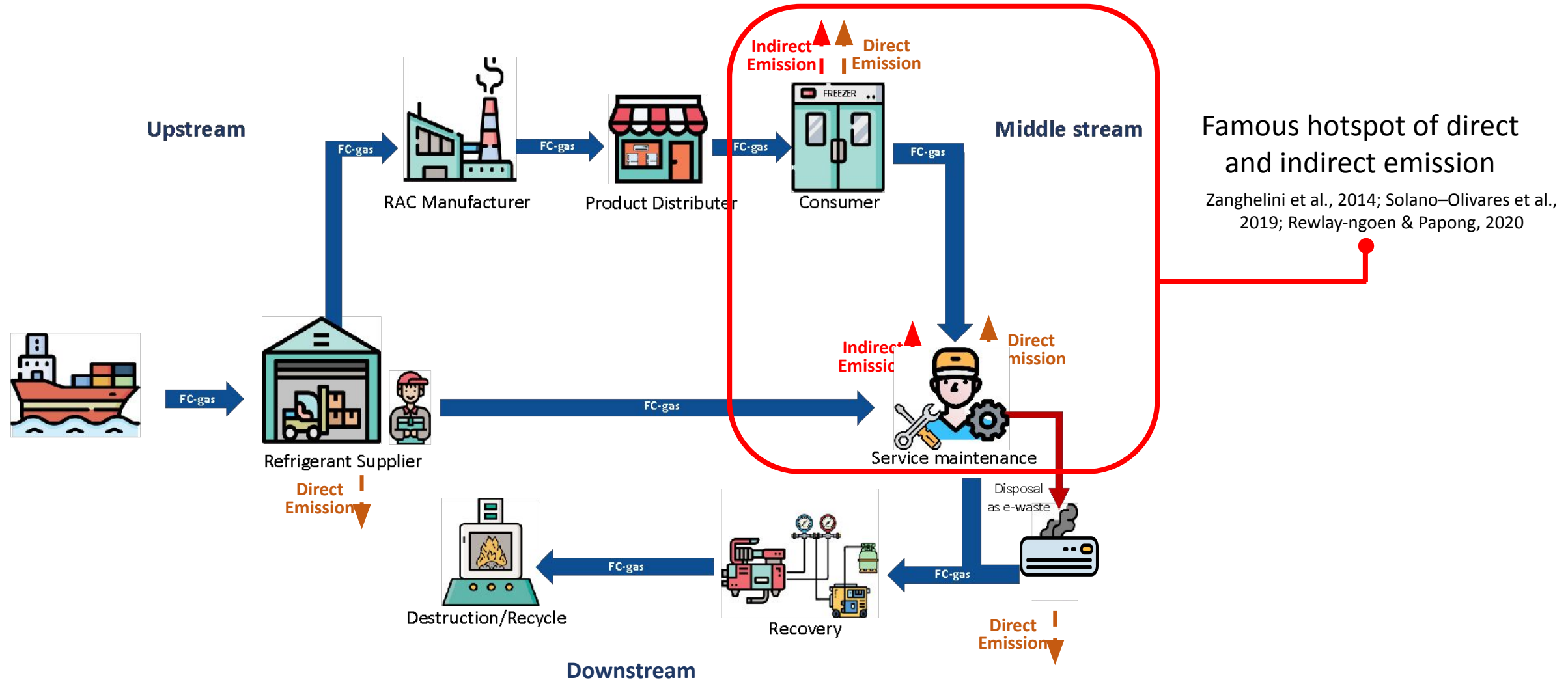
*Except for India, Pakistan, Iran, Iraq, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE.

Climate Change Impact



Emission throughout Fluorocarbon Lifecycle Stages

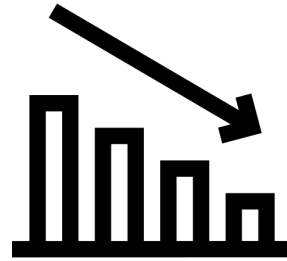
The emission of FC-gas occurs over the whole life cycle



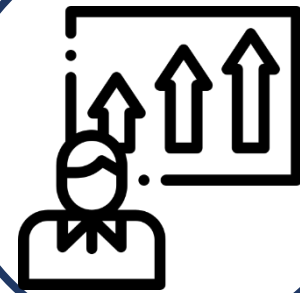
Objective



To determine the scenario of fluorocarbon gas leakage management




To estimate reduction potential of carbon & GHG emission also co-benefit in energy saving



To suggest improvement in fluorocarbon gas management in Malaysia

Methodology



IoT


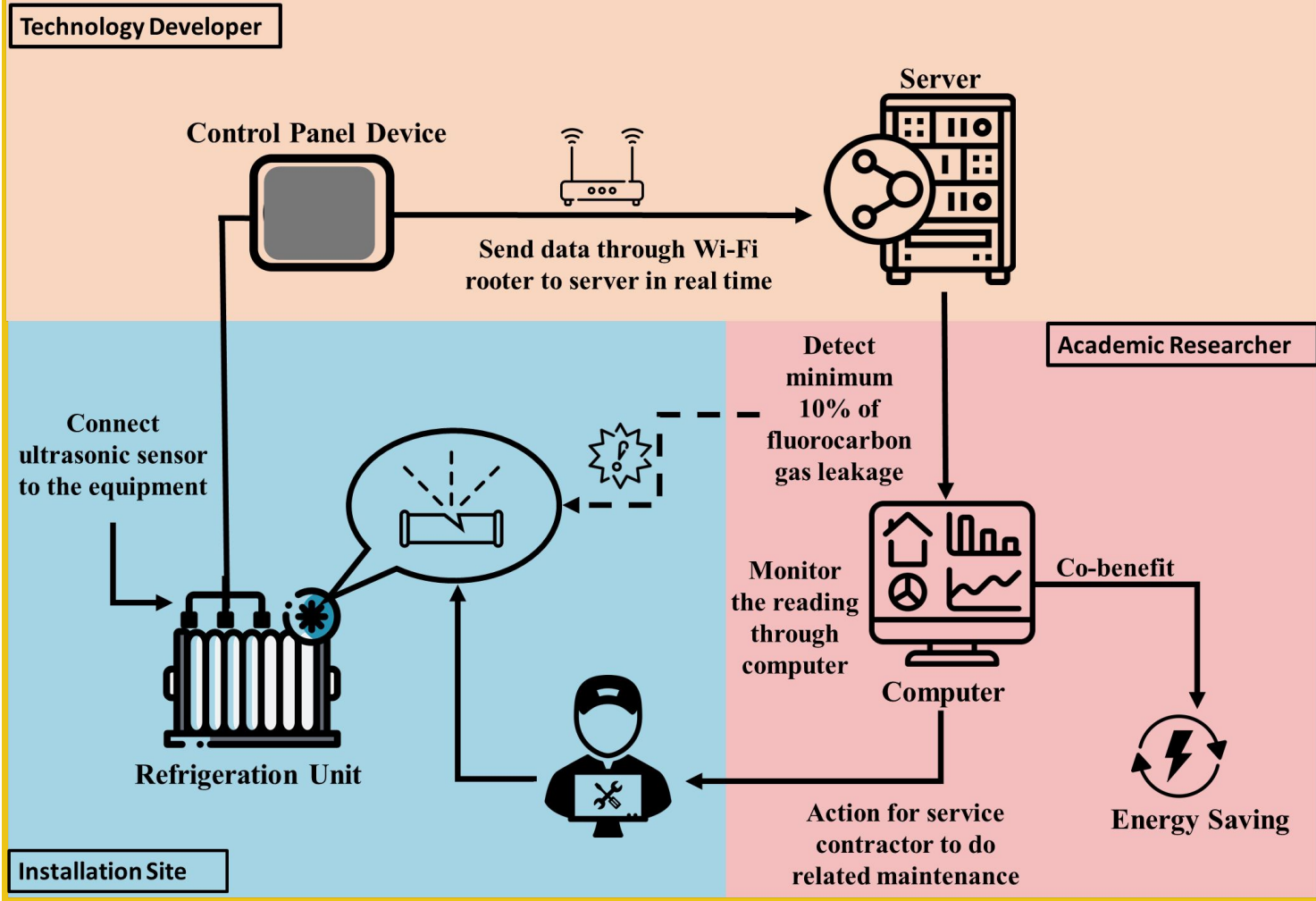
Collect various data from inside of refrigeration system



Installation

Food Manufacturing

Commercial Complex




Monitoring

Phase 1:
Actual scenario of fluorocarbon gas leakage

Phase 2:
After counter measure

Phase 3:
Final monitoring



Reduction Potential

Direct & indirect emission, electricity consumption and energy saving

Adopted from JRAIA

Data Monitoring Portal

Top

4. Time interval for Display

5. Search

6. Graph

7. Power

3. Range of Date to display

計測日時	外気温度	冷媒液温度	吐出温度	吸入温度	高圧圧力	低圧圧力	電力	フラッシュガス
2018-10-11 14:39:00	18.4	22.6	60.5	13.6	1.321	0.101	0.0	300
2018-10-11 14:38:00	18.4	22.4	Suction temp.		1.322		Power	300
2018-10-11 14:37:00	18.4	22.5	67.6	11.8	1.394	0.117	46.1	300
2018-10-11 14:36:00	18.4	23.1	65.3	12.6	1.439	0.144	91.3	300
2018-10-11 14:35:00	18.4	23.7	57.8	14.6	1.370	0.287	43.8	300
2018-10-11 14:35:00	18.4	23.9	59.2	14.1	1.315	0.105	0.0	300
2018-10-11 14:32:00	18.4		Liquid refrigerant temp.	13.0	1.316	0.104	0.0	300
2018-10-11 14:31:00	18.3	22.9	67.7	11.8	1.320	0.102	0.0	300
2018-10-11 14:30:00	18.4	22.6			1.444	0.135	92.7	300
2018-10-11 14:29:00	18.4	23.2						
2018-10-11 14:28:00	18.4	22.8						

Insert the Long in ID & password that has been set by the Master Controller

The monitoring data also can be observed in Graph Form

Login ID

Password

Login

Server shown the real time monitoring data of the refrigeration



Type of Facilities

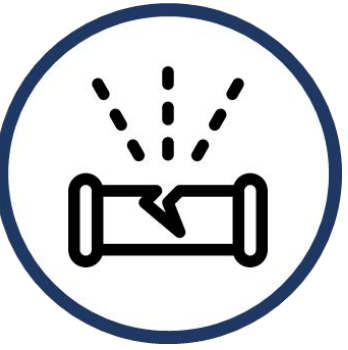
	FACILITY A	FACILITY B
Type of Business	Food Manufacturing	Commercial Complex
Type of Fluorocarbon	R-22	R-507A HFC
Ozone Depletion Potential (ODP)	0.055	0
Global Warming Potential (GWP)	1810	3985



RESULT & DISCUSSION

Scenario of Fluorocarbon Gas Leakage

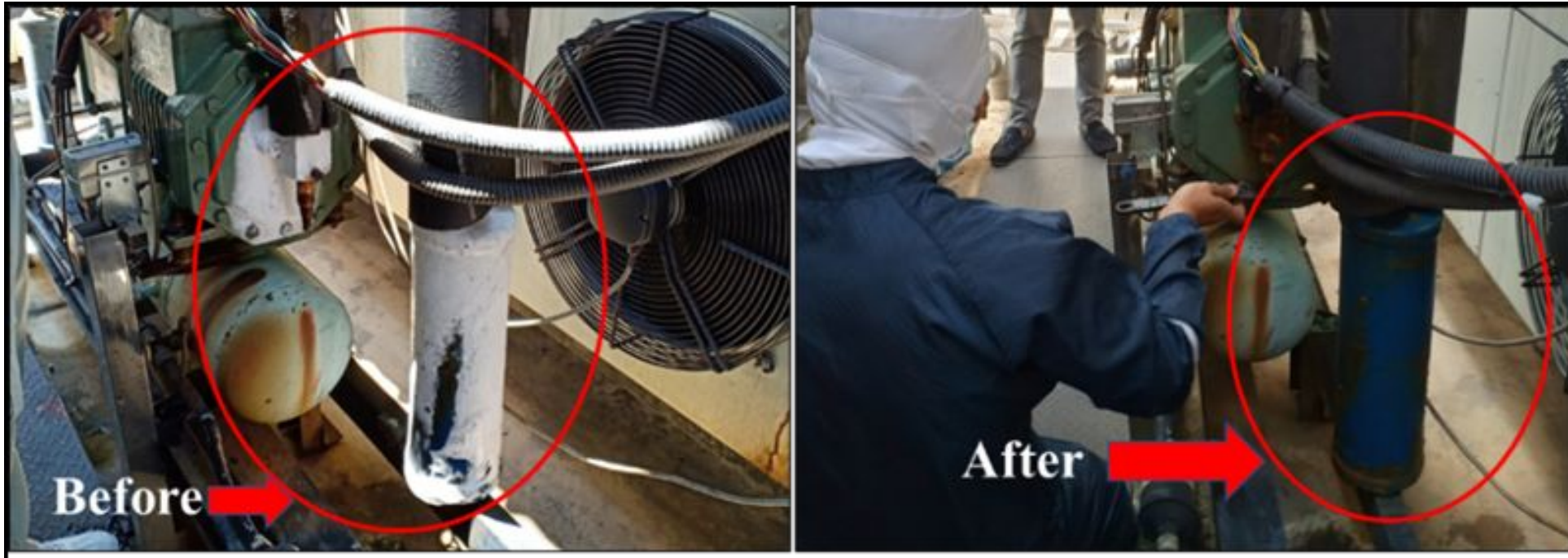
	FACILITY A	FACILITY B	FACILITY B
Response Time (as early as)	FREEZER ROOM	FREEZER ROOM	SHOWCASE
	Week 1	Week 6	N/A
Phase 1	<p>33.9%</p> <ul style="list-style-type: none"> Service contractor proposedly release & recharge 7.3kg fluorocarbon gas 	<p>60.6%</p> <ul style="list-style-type: none"> High amount of fluorocarbon gas leakage 	<p>21.3%</p> <ul style="list-style-type: none"> Amount of fluorocarbon gas in sufficient level
Phase 2	<p>0.7%</p> <ul style="list-style-type: none"> Recharged 16.3 kg of fluorocarbon gas Electricity consumption increase (112.3 kWh to 137.7 kWh) 	<p>27.0%</p> <ul style="list-style-type: none"> Repaired and recharge 45kg of fluorocarbon gas 6.8% reduction of electricity consumption 	<p>31.8 %</p>
Phase 3	<p>1.9%</p> <ul style="list-style-type: none"> Reoccurrences of fluorocarbon gas leakage Identify and repair leakage point 	<p>43.1%</p> <ul style="list-style-type: none"> Reoccurrences of fluorocarbon gas leakage Electricity consumption significantly increase (1072.7 kWh to 1307.5 kWh) 	<p>37.4%</p> <ul style="list-style-type: none"> Abnormality of this unit continuing until Phase 3 Electricity consumption increase (1030.1 kWh to 1320.6 kWh)

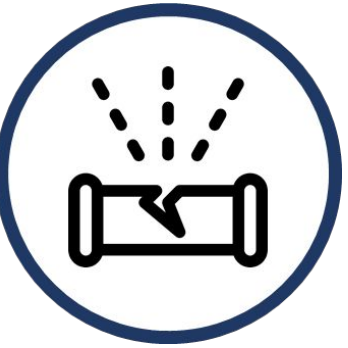


Scenario of Fluorocarbon Gas Leakage

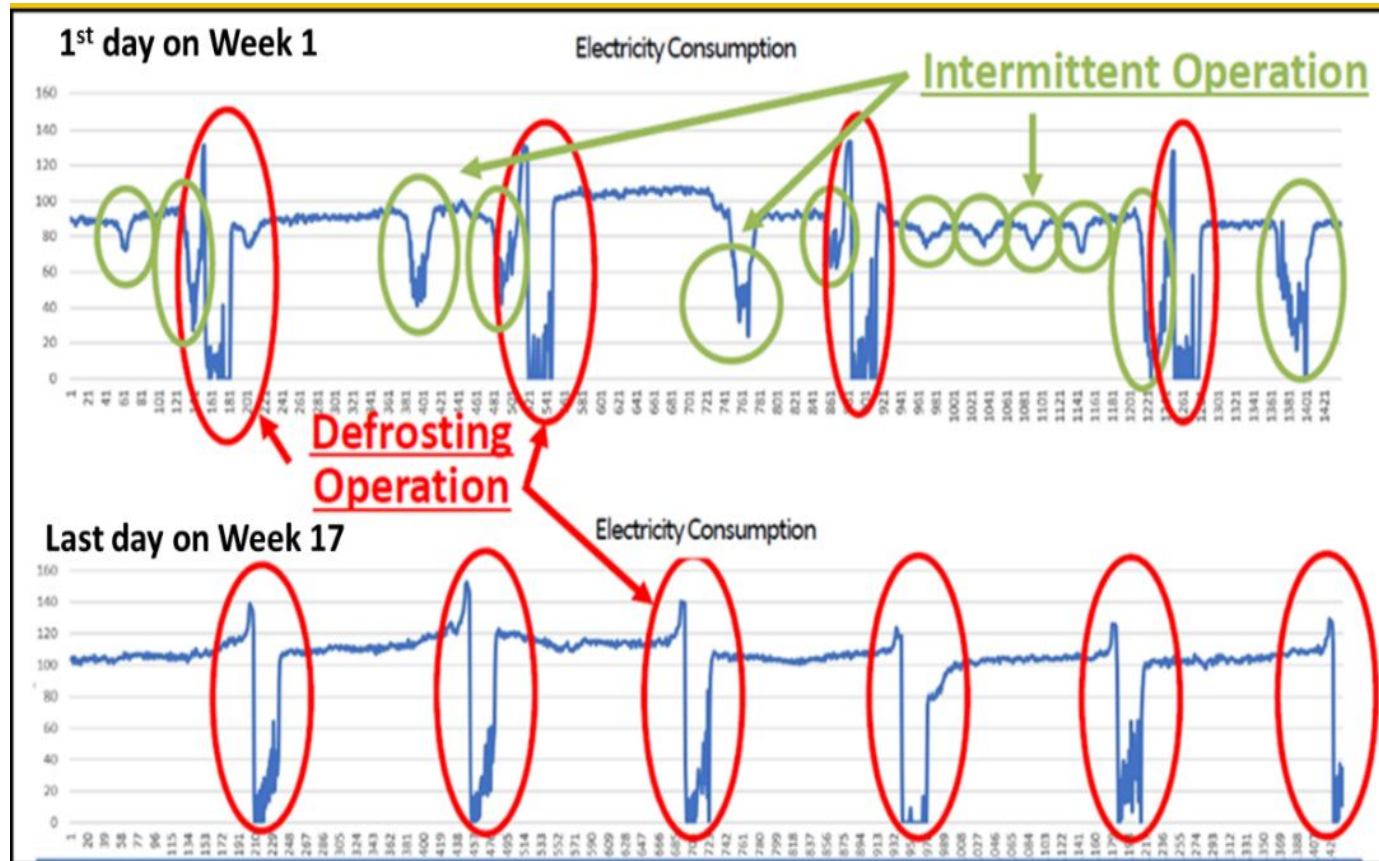
FREEZER ROOM

FACILITY A





Scenario of Fluorocarbon Gas Leakage



- Extremely shortage of fluorocarbon gas in refrigeration system can cause intermittent operation
- After recharge fluorocarbon gas, operation rate of this refrigeration system has been optimized and possibly caused increase in electricity consumption.
- It takes 17 weeks to achieve normal defrosting operation

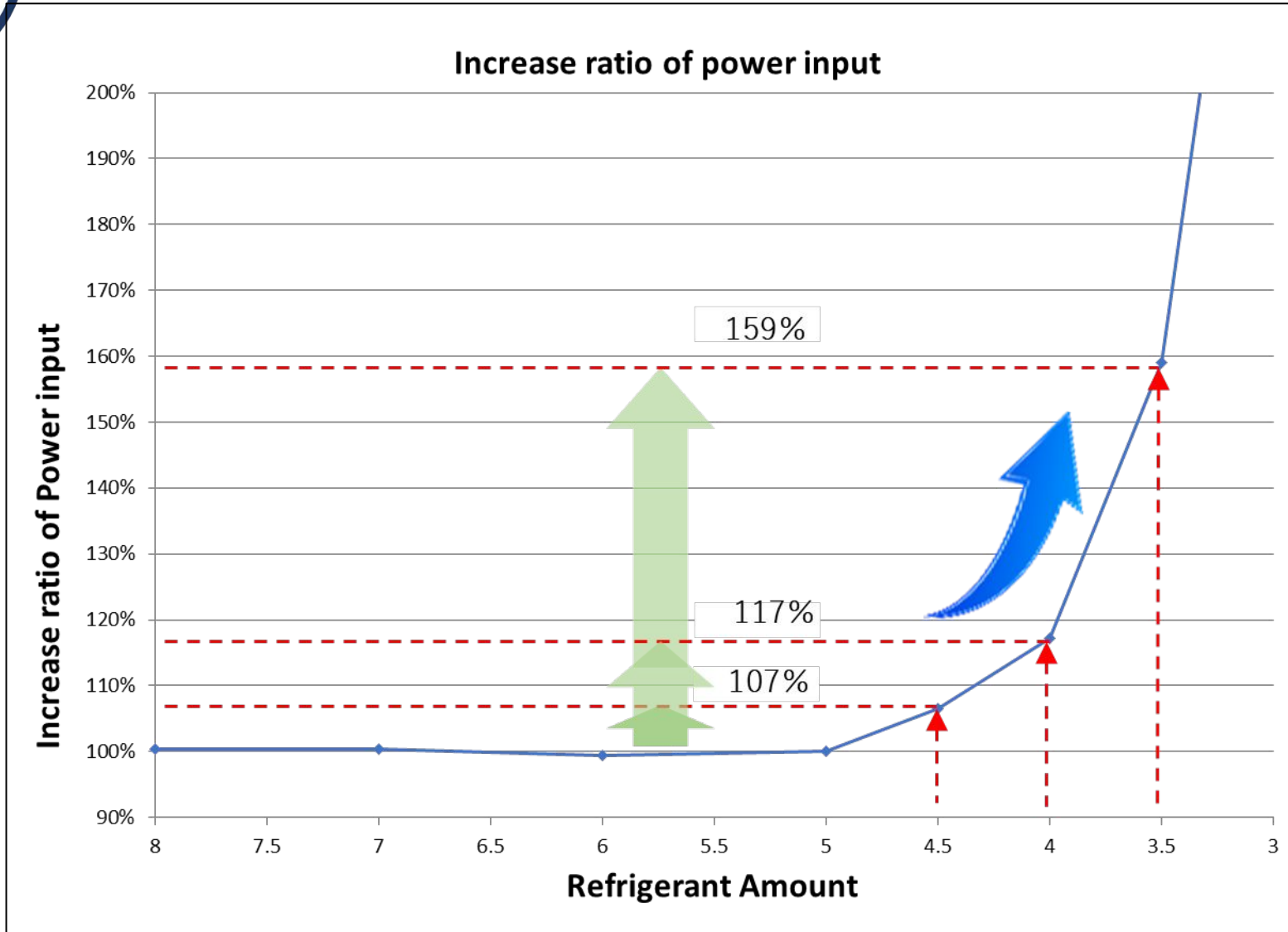


Reduction Potential

		FACILITY A	FACILITY B	FACILITY B
Recharge Amount		16.3 Kg	45 Kg	-
Actual Reduction	Direct Emission	-	180 t-CO2e/yr	280 t-CO2e/yr
	Indirect Emission	-	20 t-CO2/yr	50 t-CO2/yr
	Energy Saving	-	29 000 kWh/yr 10 000 RM/yr of cost cutting	70 000 kWh/yr 25 000 RM/yr of cost cutting
Reduction Potential	Direct Emission	30 t-CO2e/yr	460 t-CO2e/yr	460 t-CO2e/yr
	Indirect Emission	13 t-CO2/yr	90 t-CO2/yr	110 t-CO2/yr
	Energy Saving	1 500 kWh/yr 9,400 RM/yr of cost cutting	136 000 kWh/yr 49 000 RM/yr of cost cutting	161 000 kWh/yr 58 000 RM/yr of cost cutting



Correlation line of refrigerant leakage and power consumption increase



Power consumption rises sharply after the charged amount of refrigerant is reduced to below 5.0 kg level as cooling capacity decreased.

Source: Japan Refrigeration and Air Conditioning Industry Association

Key Issues in FC gas management

Human Resource

1

- Facility A: malpractice of service technician
 - Proposedly emit the FC gas to resolve the frost accumulation.
- Lack of effort from government to promote certified technician

2

Management & financial

- Facility B: Late response time
 - late approval from the top management due to budget
 - caused the condition of chiller become more severe
- These issues are facing by most of the Malaysia

Technical Part

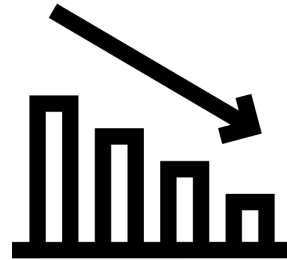
3

- Malaysia used direct method to detect FC gas leakage
- Not accurate as indirect method that used sensor to detect the fault of refrigeration system from inside and provide real-time data monitoring of the system
- This study shows, accurate and early response time of the refrigeration system

Conclusion



The scenario of fluorocarbon gas leakage at all facility is **different** in term of **condition of refrigeration & AC unit, response time** and fluorocarbon gas **leakage rate**.



Each facility can achieve huge reduction potential on carbon and GHG emission also co-benefit in energy saving



Crucial improvement in fluorocarbon gas management in Malaysia has been suggest

FUTURE STUDY:

There is a need to have proper inventory and capacity building

Acknowledgement

Special thanks to:



E&E Solutions Inc.



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