HONEYWELL PERSPECTIVE ON MALAYSIA'S PATH TO NET ZERO

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **2**

INTRODUCTION **5**

Climate Aspects and Impacts 5
The Paris Agreement 5
Malaysia's Emissions Profile and Implications 6
Key Low Carbon Transitions towards Net Zero 7

THE POWER AND UTILITIES SECTOR **9**

Microgrids and Net-Zero Economic Zones: Honeywell Forge™ Power Manager 10
Energy Storage for Grid Stability: Honeywell Ionic™ modular BESS 13
Low Emissions Dispatchable Backup Power 14
What should the Government of Malaysia be doing now to accelerate decarbonization of the electric power sector? 14

THE TRANSPORTATION SECTOR **16**

Surface Transportation 16
Air Transportation 17
What should the Government of Malaysia be doing now to accelerate decarbonization of the transport sector? 20

URBANIZATION AND BUILDING EFFICIENCY **22**

Convert the 'Smart Cities' Program to 'Sustainable Cities' Program 24
Increase reach of Core Smart Cities to Suburbs and nearby Townships via a hub & spokes model 25
Strengthen green & sustainable buildings standards: Insights from Singapore, Europe & Japan 25
Battery Energy Storage Systems (BESS) for buildings 27
Low GHG Building Materials: Solstice refrigerants and blowing agents 28
What should the Government of Malaysia be doing now to accelerate the decarbonization of the buildings sector? 28

HARD TO ABATE INDUSTRIALS **31**

Hydrogen 31
Carbon Capture Utilization and Storage 32
Methane emissions 34
Manufacturing 35
What should the Government of Malaysia be doing now to accelerate decarbonization of the Industrial sector? 36

CONCLUSIONS **37**

APPENDICES **38**

Glossary and terminology 38
Malaysia's Emission Inventory 40

REFERENCES **41**

EXECUTIVE SUMMARY

The world is grappling with climate induced events as manifested in the form of extreme heat, wildfires, flash floods, glacial loss and associated biodiversity and material impact.

Despite unequivocal pledges by countries in Paris in 2015 in pursuing efforts to limit the temperature rise to 1.5 °C above pre-industrial levels, the recent global stock take reports reveal otherwise. Instead of the targeted 8% annual GHG emissions cut in 2021-22, the world has emitted 1.2% more. If emissions remain unabated, in all likelihood the world is staring at a warmer planet by the turn of the next century. Malaysia has unleashed multi-sectoral decarbonization efforts by the combination of mitigation and adaption measures to accelerate the energy transition, while meeting national goals for carbon equity and aspirational socio-economic transformation.

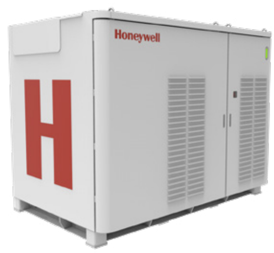
Given Malaysia's 2050 net zero pledge, the complexity of energy transition, the long gestation timelines for massive scale energy investments and infrastructure, and Malaysia's unique opportunities, the time is ripe "now" for bolder actions and climate leadership. Malaysia, due to its unique geographic location and geopolitical neutrality, is bestowed with abundant tree cover, subsea geology suitable for carbon sequestration, and greener energy sources, such as: solar, hydro and biomass. These attributes can enable Malaysia to lead in the export of green energy and low carbon intensity goods like cement and steel, services, such as CCS as a service, and fuels and at scale for the global markets and emerge as a low carbon intensity energy export hub. Malaysia launched an ambitious National Energy Transition Roadmap (NETR) and Hydrogen Economy and Technology Roadmap (HETR) in 2023 to guide the national policy and industry development towards Net Zero. These roadmaps come in the context of increased interest in Malaysia as a China Plus One investment destination, and a re-envisioning of Malaysia's growth model through the National Industrial Masterplan 2030 (NIMP). This white paper recommends the following holistic actions for Malaysia's path to net zero, what can be done "now", and what Malaysia's role in shaping global policy and market dynamics could be:

- **Net Zero Special Economic Zones (NZ-SEZs):** Encourage the formation of net zero special economic zones in geographically favourable areas for renewable power generation through the adoption of micro grids. This can transform the economy through inclusive growth, low-carbon, world-class infrastructure and enable production of low carbon intensity products for exports and domestic consumption. This will enable Malaysia to participate more competitively in global supply chains.

- **Carbon Capture:** Malaysia's unique subsea geological structures off the coast of Sarawak and extensive experience with offshore gas operations can enable the capture and long-term sequestration of carbon. This enables the creation a market for carbon storage services both domestic and trans-border markets – a potential game-changer for regional decarbonization. By building infrastructure that enables the capture and transport of carbon from industrial zones to storage terminals to be shipped to sequestration hubs, Malaysia can create greener manufacturing opportunities.

- **Reduced Emissions Surface Transport:** Surface transport is the major GHG emission source in the transportation sector for Malaysia at more than 85% of transport emissions. Malaysia plans to reduce the GHG emissions by improving efficiency, increasing public transportation, promoting EVs and switching to alternative fuels. With EV expected to have increase in adoption with time, it is poised to achieve the target of low carbon mobility.

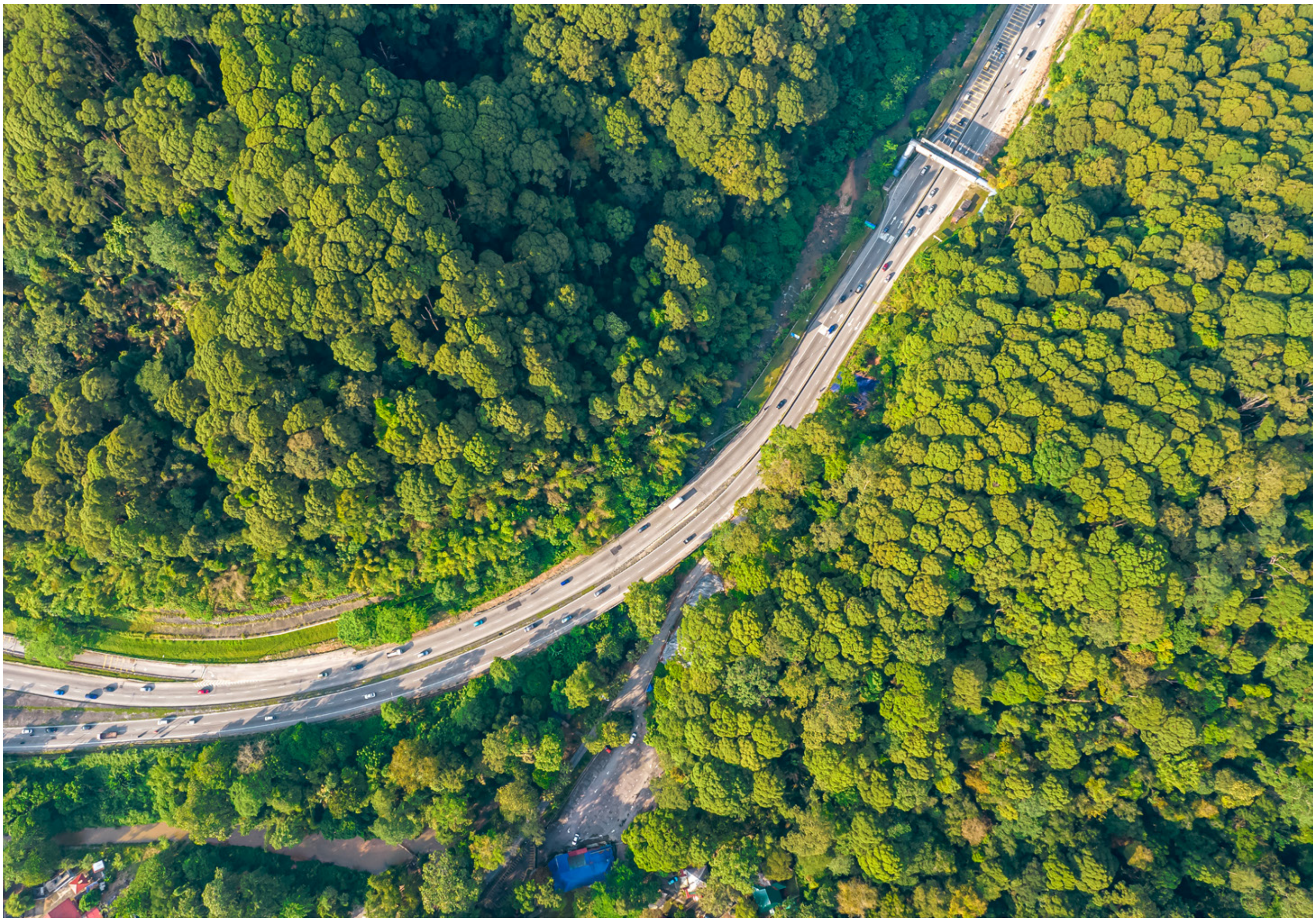
- **Sustainable Aviation Fuel:** Palm oil has one of the highest yields per hectare when converted to SAF compared to other biofuel sources[55], Malaysia can therefore position itself as a major contributor to global SAF supplies not just as a refiner but also as a feedstock provider considering the vast reserves of palm oil, if it can be verified that palm oil can be cultivated and used with the highest sustainable forestry practices, and without negative impacts on land use, forest cover or food supply. Malaysia has successfully implemented the Malaysia Sustainable Palm Oil Certification to address the concerns of sustainability around palm oil sourcing and has an opportunity to position its expertise and sustainable harvesting standards where global standards are being developed. In the short term, considering that regional traffic to and from Malaysia constitutes more than 70% of overall Malaysian aviation, there is an opportunity to promote up to 10% palm-oil SAF blending in intra-ASEAN/ domestic flights with like-minded countries to support decarbonization of Malaysia's aviation sector and demonstrate that this feedstock can be applied at the highest sustainable standards to produce low GHG intensity SAF.
- **Smart and Low Carbon Cities:** Convert 3 to 5 major urban conurbations into smart and low carbon cities that are built on the pillars of environmental, economic, and social awareness by incorporating cutting edge technologies and digital infrastructure that can reduce environmental footprint, boost economic growth, and enhance quality of life for the residents.



- **Hubs and Spokes Model for Smart Cities:** Deploy hub and spoke model to increase reach of the smart cities program to suburbs and surrounding townships by leveraging the integrated command control centre (ICCC) that has been already put in the core cities of Kuala Lumpur, Johor Bahru, Penang, Putrajaya. This can drive more environmentally friendly outcomes in water, waste and emissions management and build robust resilience against abrupt weather events resulting in floods.
- **Battery Energy Storage Systems (BESS):** Deploy BESS to replace diesel back-up generators, improving energy quality and availability in isolated communities, and green micro-grids for buildings, critical infrastructure, and industrial hubs.
- **Low Global Warming Refrigerants:** Advance the phase down of Hydrofluorocarbons (HFCs) in Malaysia, especially in the production of heating and cooling equipment, much of which are exported to developed markets such as the US, EU and Middle East. In addition, promoting the sector specific 100% adoption of LGWP refrigerants such as in automobiles or supermarket refrigerators can demonstrate a phased and graded approach towards carbon neutrality.

- **Hydrogen:** Malaysia govt has declared target of 1 hydrogen hub by 2030 (and 3 hubs by 2050) along with 2.5 Mt/y green hydrogen by 2050. Sarawak's unique proposition of Hydro + Solar positions Malaysia to take an early lead in SE Asia in green hydrogen production and capturing export markets. Govt has also decided to convert all grey hydrogen to blue hydrogen by 2050. Accelerated utilization of Malaysia's dominant position in gas production and massive carbon capture capacity is a must to meet blue hydrogen goals.

Overall, Malaysia can implement sectoral decarbonization policies to help reduce emissions at scale. Sectors such as energy, chemicals, power, cement, steel, transportation, aviation, and other carbon intensive industries carry a high potential to reduce their emissions by adopting technologies to decarbonize existing production and integrated clean technology for new capacity. Sector-wise policies having time-bound and implementation targets for both medium and long term will help in resolving complex industry-specific issues. Special emphasis on benchmarking of sector-specific resource consumption, developing standards for various emissions, sector-specific mandates for emissions abatement, and reporting can reorient the Malaysian manufacturing sector as a shining example of sustainable business practices.



INTRODUCTION

The world is recovering from the pandemic. Nevertheless, geopolitical instability, supply chain disruptions, high inflationary headwinds, and frequent climate change-induced events are impeding the pace of economic recovery.

In this milieu, Malaysia is clocking a moderate but consistent economic growth, evidenced by GDP growth recovering to between 4 and 6% in 2024. Malaysia is located in a strategic geographic location of the Indo-Pacific, straddling the sea routes between the great economies of East Asia and India. Sixty percent of global maritime trade passes through the Straits of Malacca[1]. Malaysia's climate and geography confer unique advantages for production of biomass and renewable energy and allow Malaysia to emerge as a leading exporter of low carbon-intensity energy and products throughout the region.

CLIMATE ASPECTS AND IMPACTS

Science has overwhelmingly established that the anthropogenic emissions are causing climate change resulting in extreme climate events that are more frequent and severe. Every year, the world adds 37 giga tons of carbon dioxide (Gt CO_2) to the atmosphere[2]. The concentration of the Green House Gases (GHGs) has continued to increase in the atmosphere, reaching an annual average of 415 parts per million (ppm) for carbon dioxide (CO_2), 1896 parts per billion (ppb) for methane (CH_4) and 335 ppb for nitrous oxides (N2O). This has resulted in global mean surface temperature increase in the range of 0.8 to 1.3 °C since 1850[3]. This has led to heat stress, water shortages, soil drying, ocean acidification, intense cyclones, sea level rise, among other impacts. It is essential to limit temperature rise to less than 1.5- 2 °C to moderate the consequences of climate change.

Climate change impact is affecting every region on the planet in different ways. Malaysia is no exception. Over the past decade, Malaysians have endured hazardous peat fire haze, wildfires, heat waves, catastrophic floods, intense drought and monsoon seasons, and more recently, falling trees due to very strong winds in cities leading to deaths and injuries, property losses and disruption in the economy. These extreme weather events are expected to become more frequent due to climate change[4,5]. This underscores the need for scale and urgency in action through global cooperation to mitigate climate risks.

THE PARIS AGREEMENT

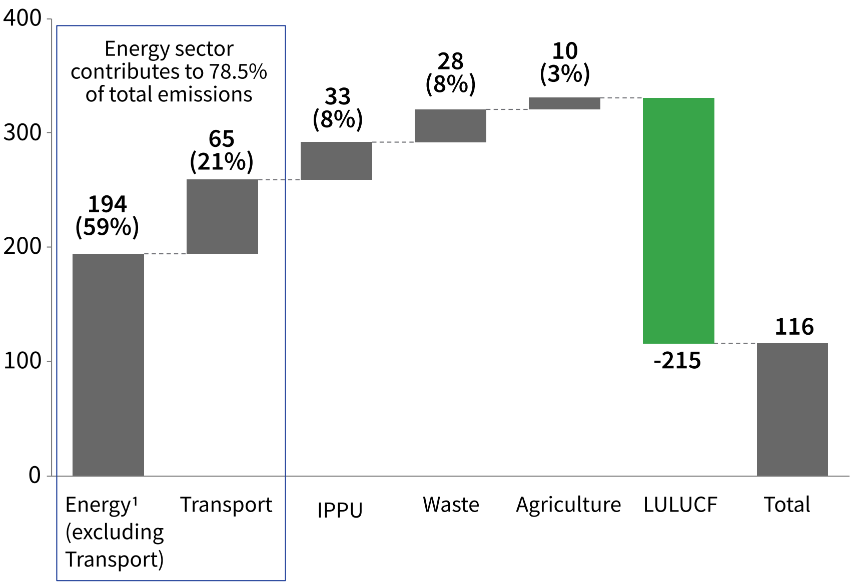
The Paris Agreement on climate change was adopted by 196 countries at the Conference of Parties (COP 21) in Paris in 2015. The main goal of the agreement is to limit global warming to well below 2°C, preferably less than 1.5°C compared to pre-industrial levels, review countries commitment every five years, provide financing to mitigate climate change, strengthen resilience and adapt to climate impact[6]. Malaysia's ratification of the Paris Climate Agreement on 16th November 2016 is the first step towards combating the effects of climate change.

After committing to climate neutrality by 2050 in 2015 as part of Malaysia Climate Action Plan ahead of the Paris Agreement, Malaysia released the National Energy Transition Roadmap in 2023 and is now preparing its Long-Term Low Greenhouse Gas Emission Development Strategies (LT-LEDS) that will outline a broad contour of its emissions reduction plan. On the business front, the Paris agreement has paved the way for setting in motion a series of energy transitions and net zero commitments from corporations. Globally, more than 5,000 businesses have committed to net zero, 400 banks, insurers, and investors collectively representing $130 trillion of assets have allocated investments towards climate neutral portfolios and have created a sustainable marketplace for the next three decades[7].

MALAYSIA'S EMISSIONS PROFILE AND IMPLICATIONS

Although Malaysia's annual production of total GHG emission is low compared to major global economies at 290 Mt/y CO_2 equivalent (2019), the per capita emission was 8.23 tons CO_2 equivalent in 2022 which is above the global average of 6.76. Malaysia has underpinned its Net Zero strategy on maintaining 50% tree-cover, use of green power generation, transition to electric vehicles, and energy efficiency practices[8].

In Malaysia, the power, transport, and industry sectors represent the most significant sources (78.5%) of GHG emissions (Figure 1.1), while Industrial Processes and Product Use (IPPU) and waste represented 8% each, with agriculture only accounting for 3%. In terms of the type of GHG gases, CO_2 contributes most of the volume at 51.15 megatons, which is approximately 86% of total CO_2e emissions[9]. However, emissions of perfluorocarbons and methane also make substantial contributions to Malaysia's greenhouse gas footprint (see Figure 1.2). Because of Malaysia's tropical location and large area of virgin forest, land-use, land-use change and forestry (LULUCF) is considered to play a critical role in Malaysia's strategy to achieve net-zero emissions by 2050



1 Refers to emissions from energy industries, manufacturing industries and construction, other sectors and non-specified energy emissions, and fugitive emissions from fuels.

Source: Malaysia's Fourth Biennial Update Report submitted to the UNFCCC (2022)

Figure 1.1 Malaysia's GHG Inventory in 2019[8]

The energy demand of the economy is currently met mostly by carbon-intensive fossil fuels, though progress has been made to maximize lower carbon intensity fuels like natural gas (42.4%). Other sources still prevalent include crude oil (27.3%) and coal (26.4%). Significant opportunity exists to progressively convert the most carbon-intensive fossil sources to renewable energy (solar, hydro, wind) which still only represents 3.9% of energy supply. In GHG Economic Emission Intensity, a measure to track the energy used for producing a given amount of output (GDP), Malaysia stands at 0.368 kg CO_2 equivalent/$ per annum, based on GDP at Purchase Price Parity (GDP-PPP), versus a global average of 0.386 kg CO_2 equivalent/$ per annum. In its Nationally Determined Contributions (NDCs) submission for 2021, Malaysia committed to reduce the emission intensity against GDP by 45% in 2030 from 2005 levels[10].

Gases	Emissions	Units
Net CO_2	51155.4	Gigagrams
CH4	2029.2	Gigagrams
N20	24.41	Gigagrams
HFOs	973.53	CO_2 equivalents (Gigagrams)
PFCs	4976.28	CO_2 equivalents (Gigagrams)
SF6	483.76	CO_2 equivalents (Gigagrams)
Other Halogenated Gases	50.85	CO_2 equivalents (Gigagrams)
NOx	3.66	Gigagrams
CO	100.2	Gigagrams
NMVOCs	65.92	Gigagrams
SO2	3.49	Gigagrams

Figure 1.2 Malaysia's Greenhouse Gases Breakdown[9]

By 2050, Malaysia is expected to grow into a $2.8 trillion economy (PPP basis). This growth will trigger demand in key industrial sectors like power, steel, cement, semiconductors, data centres, logistics, chemicals and general manufacturing. As a result, the total power capacity is expected to double from 46 GW to 97 GW by 2050, of which 58% is expected to come from solar and 29% from natural gas in 2050[8]. This requires a significant increase in solar, energy storage, carbon capture, and energy efficiency initiatives to mitigate the increases in carbon footprint.

KEY LOW CARBON TRANSITIONS TOWARDS NET ZERO

The NETR published in 2023 provides a comprehensive view of the pathways for Malaysia to decarbonize and highlighted the key areas of focus and the required financing and investments[8]. The NETR also specified fifty initiatives and ten flagship catalyst projects in the first phase of implementation covering six transition levers: energy efficiency, renewable energy, bioenergy, hydrogen, green mobility and CCUS.

Honeywell is a leading player in providing sustainability-oriented technologies, which we define as those that improve safety, environmental impact and societal resilience for our customers and the communities they serve. Honeywell has a century-long track record of innovation to make our world a better place. The company invests approximately 60% of its R&D spend towards sustainability-oriented offerings[11]. Honeywell sustainability-oriented solutions are developed based on foundational pillars of Circular Economy, Energy Evolution, Environmental Transformation, Health and Safety, Security, Resilience, and Accountability. Honeywell has a strong legacy in Malaysia, built over the last four decades. Honeywell's Malaysia commitment is evident in locating our Asia Pacific (APAC) Headquarters in Kuala Lumpur, and in locating APAC's largest avionics production, gas separation membrane production, and an electrical products manufacturing site in Malaysia, with 1,000 staff overall.

Honeywell is committed to partnering with states & industry sectors to help them meet Malaysia's net zero ambitions. Some of the major emission sectors and their decarbonization pathways are covered subsequently.

THE POWER AND UTILITIES SECTOR

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The power and heat sector contributes up to 49% of Malaysia's total GHG emissions, and fossil fuels constitute 81% of Malaysia's input energy mix for electricity generation[12].

There is a pressing need to decarbonize this sector as it can positively contribute to GHG emissions reductions in homes, commercial buildings and other industrial sectors. Malaysia has an electricity generation capacity of 188,000 GWh (2023) with 19% of total generation contributed by solar, hydro, waste and bio-power. Malaysia has a relatively low adoption of variable renewable power (wind and solar) by global standards, with only 2.4% of power from these sources, despite Malaysia's very favourable location for solar intensity[12].

In Malaysia's path to low emissions development, the transition to renewable power is imperative. Solar, hydro, and biomass constitutes some of easiest to access sources of renewable energy at scale. Other potential sources such as geothermal, and nuclear power have been explored and may show potential in the longer term. Today, renewables are the fastest growing segment of power generation with a CAGR of 12.5%[12]; by 2050, they must constitute >70% of the energy mix to keep pace with Malaysia's economic growth ambitions[8]. Malaysia has planned to add 59 GW of solar energy capacity by 2050[8].

However, as renewables gain a larger share (35-45%) in the energy mix, energy supplies run the risk of intermittency and grid instability. Honeywell has ready-now technologies that can help Malaysia take advantage of the natural resources of renewable power while building a grid that reliably delivers power even when there are variations in renewable power output. Honeywell has three technologies that are key to this cleaner power transition: smart microgrids to enable load balancing; battery energy storage systems and technologies that can help reduce the greenhouse gas emissions from fossil-fired power plants; and generators for dispatchable power.

MICROGRIDS AND NET-ZERO ECONOMIC ZONES: HONEYWELL FORGE™ POWER MANAGER

A microgrid is a local electrical grid that acts as a single controllable entity. Most microgrids have the ability to operate in grid-connected or "island" mode, but some operate only in stand-alone mode with no connection to a broader utility grid (e.g., for geographical island communities, isolated rural areas, military bases and some large industrial sites). Honeywell has extensive experience of building microgrids that connect multiple energy sources and energy demands to help deliver stable and reliable electric power to users and ranging in size from large commercial buildings (1MW) to hospitals (15MW), universities (18MW), government centres (65MW) and even island nations (250MW).

Microgrids always operate their own local generation assets, often including a high proportion of variable renewable power such as solar panels. Microgrids usually incorporate energy storage systems such as batteries to provide backup power, regulate frequency and voltage, and mitigate variability in renewable power availability. All microgrids require an energy management system to maintain grid stability under varying demand and generation loads. Smaller microgrids may have a simple SCADA system, but larger microgrids often use hierarchical control under the IEEE 2030.7 standard (device level; local area control; SCADA; grid connection layer). Larger microgrids can also incorporate transformers and mid-low voltage transmission systems to transmit power over longer distances (e.g., when serving several communities on an island or villages near an isolated town).

Industrial sites (e.g., refineries) and larger commercial sites (e.g., ports, airports) that have their own generation assets and storage can operate as a microgrid. Mutually beneficial interactions between commercial and industrial sites and their distribution utility grid can be facilitated or optimised by Honeywell offerings or services and offer an opportunity for value sharing. While energy markets cover net import and export of energy between microgrids and the main grid, there are ancillary services that can be provided by microgrids to the utility grid (voltage regulation being the most useful one). Islanding operations can shed load as needed and can assist in grid formation when recovering from an outage (cold load pickup assistance) by soft or partial reconnection or by coordinating reconnection with other nearby microgrids.

A Virtual Power Plant (VPP) allows several microgrid owners to combine their energy generation and storage assets to create virtual resource groups with combined capacity to participate in wholesale electricity markets. Individual asset owners can join an existing VPP with other asset owners or combine their fleet of assets for their own private VPP, enabling asset owners to access additional revenue from resources that may otherwise be too small to participate in electricity markets.

Net-zero special economic zones (NZ-SEZ, also sometimes referred to as near-zero zones, eco-industrial business parks, sustainable industrial parks, etc.) are a special case of microgrid, with the additional constraint that the electric power supplied to the consumers cannot come from unmitigated fossil fuel combustion[40]. A NZ-SEZ that draws on grid power must be able to demonstrate that the power is sourced from non-fossil assets, which is obviously much easier if the NZ-SEZ is located in a region that already has ready access to clean energy. Net zero economic zones can also incorporate diesel or turbine generators for back-up power resiliency as long as the generators are fuelled with renewable diesel fuel or biogas.

Honeywell Forge™ Power Manager

Honeywell Forge™ Power Manager is a turnkey end-to-end solution for optimizing on-site supply side resources and power consuming assets from project design and execution to ongoing operation and maintenance. It enables orchestration and optimisation using AI/ML algorithms of demand side and supply side assets based on grid consumption, utility rates, and electricity demand. Supply side assets include onsite energy generation (Solar PV and traditional fuel generation) as well battery energy storage.

The Power Manager solution helps reduce operational and utility costs, increase site resiliency and uptime, and s meet customer environmental impact goals, as shown in Figure 2.1.

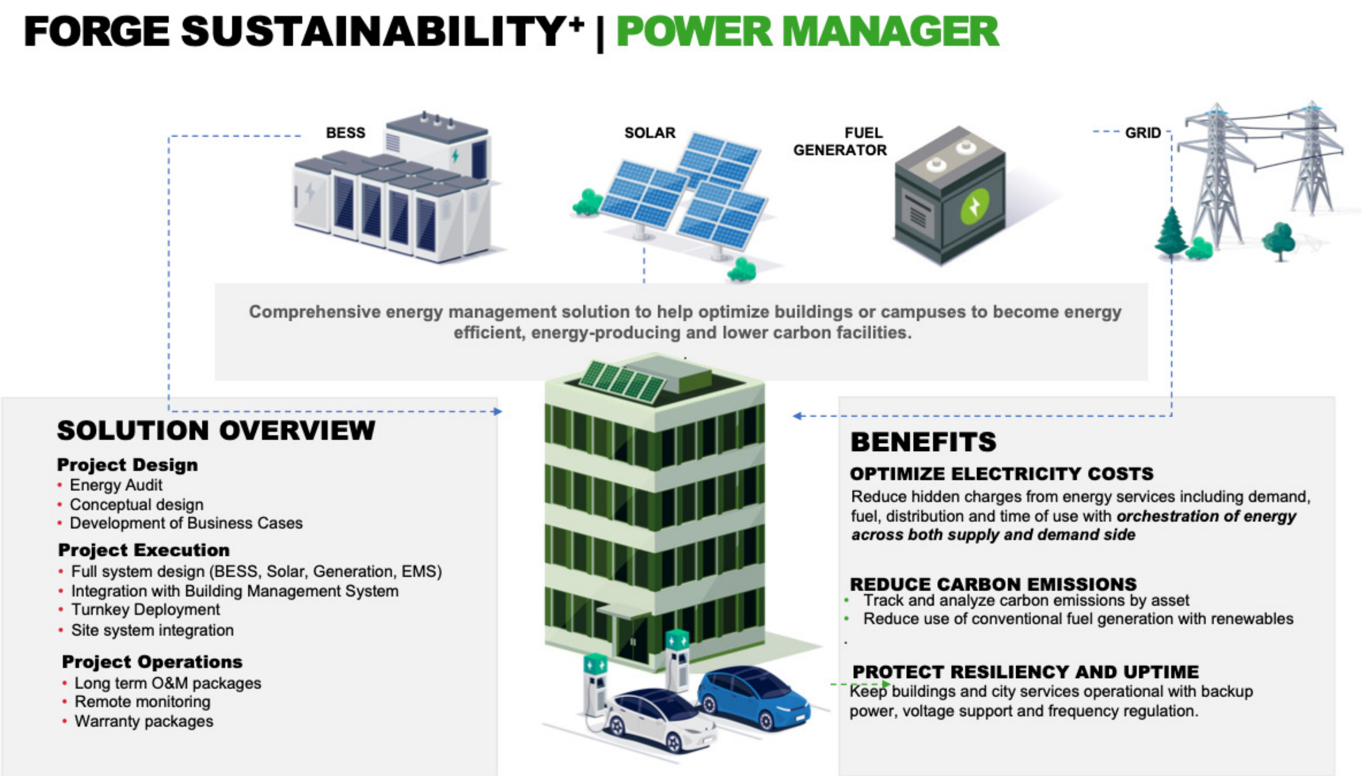


Figure 2.1: Honeywell Forge™ Sustainability+ Power Manager

Key Features of Honeywell Forge™ Power Manager include:

- Automated peak shaving, frequency and voltage regulation with Experion® Energy Control System, which optimises selection of energy sources based on priorities for generator efficiency curves, dynamic grid power pricing, start/stop maintenance costs, weather forecasts, and carbon footprint reduction. Honeywell's microgrid controls are based on the proven Control Edge™ RTU and PLC controllers, which are powerful, modular, and scalable devices capable of all remote automation and control applications. The Control Edge™ RTU and PLC come with an extensive library of control algorithms for renewable energy and can be configured to help provide stable high-availability edge control of assets during communication outages, while storing data in onboard memory for uploading when communications are restored. Cybersecurity is built into the Control Edge™ RTU and PLC with ISA Secure EDSA Level 2 certification helping to ensure the safety of the system, personnel, and data.
- Microgrid operational status and key KPI for solar PV, BESS, and backup fuelled generation
- Microgrid controls for cost optimisation, carbon optimisation, and microgrid islanding to enable grid load shedding.
- Real time building and user load demand forecasting with AI/ML algorithm, enabling load shedding of non-critical operations to help meet needs of the microgrid or allow increased export to the main grid, and reducing building demand-based power charges.
- Monthly and real time reporting on energy consumption, utility savings, and carbon emissions. Honeywell Forge™ Power Manager tells you how much carbon footprint has been generated by the microgrid and how much renewable power has been exported if the microgrid runs in VPP mode, enabling certification of Net Zero operations.

City power resiliency: Honeywell City Suite Power Manager
Honeywell City Suite Power Manager module integrates a renewable microgrid powered by Honeywell's Energy Control System (ECS) and battery energy storage solution (BESS) to Honeywell's smart city platform Honeywell City Suite to provide resiliency for critical infrastructure. City suite can be applied in a wide range of multi-building sites such as a city, port, military base, industrial park or net-zero economic zone. For municipalities or communities, critical infrastructure such as the city's dispatch centre, emergency operations centre, police & fire station, water & wastewater treatment plants and shelters can be provided with power especially during severe weather events that lead to extended power outages affecting these critical city services. Cities have traditionally used diesel generators to address this problem. However, cities face significant challenges & unpredictability with diesel supply and transportation during times of crisis and relying only on diesel generators increases risk of availability of critical city infrastructure.

Using the Power Manager module for City Suite, city operations teams receive advance notification of upcoming severe weather events, parts of the city & city infrastructure that are likely to be impacted. With this advance information, city operations use City Suite to prepare for this potential outage by commanding the ECS to charge the BESS system, as shown in Figure 2.2. As severe weather arrives, city operations command the ECS to island and optimises operations and demand loads to sustain power to the critical operations for as long as possible. During blue sky operations, the Power Manager module is used to run the BESS system in cost optimisation & net carbon impact modes to reduce demand charges & minimize net carbon impact contributing to the city's sustainability goals. With the power manager module, city operations have a single city operations platform to help manage city operations and resiliency of critical city infrastructure.

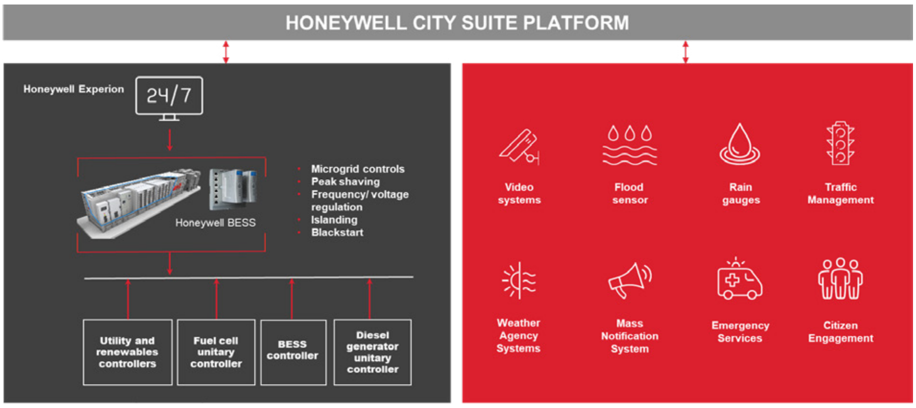


Figure 2.2: Honeywell City Suite Power Manager

ENERGY STORAGE FOR GRID STABILITY: HONEYWELL IONIC™ MODULAR BESS

Industrial energy storage systems with advanced energy management software are keys to assure grid reliability and reduce reliance on noisy and polluting diesel generators. The Honeywell team in Bengaluru has developed industry leading technologies such as Honeywell Ionic™, which is a compact, end-to-end modular battery energy storage system (BESS) and energy management tool that offers improved energy density compared to what's currently available on the market, while delivering a significant reduction of installation costs, see Figure 2.3. Honeywell's scalable modular architecture provides an optimised energy outcome, improves uptime, and allows electricity market participation to help our customers increase their use of renewable electricity and meet corporate environmental impact and efficiency goals. Honeywell IonicTM is currently available with (LFP type) lithium-ion-based batteries but can be configured to use other battery chemistries.

Honeywell Ionic™ includes Honeywell's Experion® Energy Control System and a chemistry-agnostic Battery Management System (BMS). Experion® helps users to manage and optimise energy use by improving uptime, maximizing arbitrage potential from peak shaving and providing the ability to create a Virtual Power Plant. The BMS provides insight into performance at the cell level, and is configurable with advances in battery chemistry, insulating the end user from future supply-chain risks.

Key features of the Honeywell Ionic™ BESS include:

- Scalable architecture allows you to right-size the system for both front of the meter and behind the meter use cases.
- Proven lithium-ion-based cell chemistry, with 730kWh modules scalable to any capacity.
- Compliant to energy storage standard UL95[40].
- Optional, industry-leading off-gas detection which can enable earlier mitigation actions to prevent thermal runaway and fires.
- Integrated Honeywell controls to support all use cases.
- Turnkey installation from utility engagement, engineering, procurement, construction, commissioning, start-up, operations, and maintenance. EPC scope is evaluated case by case.
- The batteries come pre-installed to reduce the on-site hours.
- The forklift-able design allows for fast installation without the use of expensive cranes.

LOW EMISSIONS DISPATCHABLE BACKUP POWER

One of the challenges of operating electricity grids at high levels of variable renewable energy (VRE = wind and solar power) is that there can be seasonal variations in levels of wind and sunshine. Daily variation in wind and solar power output and differences between maximum production (in the middle of the day) and maximum demand (in the evening) can be easily managed using batteries. If the batteries are charged and discharged every day, then they achieve 365 cycles per year. But a battery that is charged in the summer and discharged in the winter achieves only 1 cycle per year and so is 365 times more expensive per unit of electric energy stored. This makes batteries a very expensive option for longer term energy storage.

Given the relative costs of energy storage and new VRE capacity, we believe that utilities will deploy a range of solutions to meeting grid stability at high levels of VRE:

- Battery energy storage systems (BESS) with power capacity at least 50% of average power demand and storage duration of > 10h, but probably not > 20h unless the marginal cost of stored energy per MWh becomes very low.
- Overcapacity of wind power (and to a lesser extent solar) and expansion of high voltage grids to allow transmission over greater distances and facilitate regional balancing. This will lead to higher curtailment levels and lower ROI for the VRE assets but will be lower cost and higher ROI than adding marginal BESS capacity.
- Maintenance or expansion of dispatchable non-fossil, non-VRE generation sources such as nuclear power and conventional hydroelectricity.
- Conversion of dispatchable fossil fuel power generation assets to low-carbon intensity GHG abated power generation by addition of carbon capture and storage (CCS).
- Conversion of dispatchable power generation assets to low GHG power generation by fuel switching to hydrogen, biogas or renewable diesel fuel.

While it has been argued that a grid supplied with power solely from wind, solar and hydroelectricity is technically feasible[13], there is now a considerable amount of literature suggesting that 80% VRE probably represents a practical upper limit and other approaches are required to achieve a fully decarbonized electricity supply[14,15]. Sepulveda et al.[16] showed that energy capacity capital costs need to fall to < 1 $/kWh to fully displace firm low-GHG generation technologies.

Honeywell has a range of technologies that can be applied to help generate low carbon intensity electricity from conventional fossil fuel power generation equipment:

- Renewable diesel fuel for use in back-up diesel generators (see Chapter 3.1)
- Technologies to upgrade and meter biogas for use in gas turbines
- Advanced Solvent Carbon Capture technology to capture CO_2 from coal-fired power plants for sequestration or conversion to chemicals (See chapter 5.3)

WHAT SHOULD THE GOVERNMENT OF MALAYSIA BE DOING NOW TO ACCELERATE DECARBONIZATION OF THE ELECTRIC POWER SECTOR?

Malaysia will still rely on coal-fired power for some years, with current plans aiming to retire all coal power by 2045[8]. Access to cleaner burning natural gas represents an opportunity for Malaysia to systematically replace coal generation with natural gas power generation capacity and further reduce emissions by taking advantage of Malaysia's carbon capture and storage (CCS) potential and potential application of carbon capture and utilization (CCU). By means of an example, Honeywell's Advanced Solvent Carbon Capture process can help efficiently capture >95% of CO_2 from low CO_2 concentration sources like Combined Cycle Gas Turbine emissions, effectively abating CO_2 from this already cleaner, and fully dispatchable energy source. Additionally, the low cost of new renewable capacity like solar power means that distributed power generation is increasingly attractive. Honeywell believes that the Government of Malaysia can accelerate positive environmental impact, create jobs and stimulate development of disadvantaged regions by encouraging the private sector to expand the availability and reliability of renewable power, while leveraging cleaner burning fossil sources and advanced CO_2 capture technology to mitigate the impact of fossil generation while it is still required. We think the following actions by the government would improve Malaysia's competitiveness in attracting foreign investment as well as meeting Malaysia's goals for low-emissions sustainable development:

- Leading 'carbon storage as a service' model and aggressively developing CCUS to decarbonize power sector. It will have twin impact of decarbonizing domestic power sector as well as generate revenue which can be further reinvested to develop CCUS sector. As the government has already identified CCUS as a key driver in decarbonization journey, it needs to accelerate implementation.
- Malaysia has decided to not invest in any additional coal generation, which ensures that current >20% GHG emission (from coal) will be reduced once existing plants are retired. This needs to be balanced with investment in upstream gas production (combined with CCUS) to support the government's decarbonization commitments while supporting grid stability as Malaysia progressively transitions to renewable energy.
- Encourage the formation of net zero special economic zones in geographically favourable areas for renewable power generation through the adoption of micro grids. This can transform the landscape through inclusive growth, low-carbon world-class infrastructure and enable the production of sustainable net zero products for export markets. This will enable Malaysia to proactively play in the high value emerging global sustainability supply chains.
- 4. Promote the coprocessing of waste-, and agriculture-derived organic sustainable feedstocks along with conventional fuels for power production that can accelerate decarbonization and champion the creation of a circular economic model.

THE TRANSPORTATION SECTOR

THE TRANSPORTATION SECTOR

SURFACE TRANSPORTATION

Transportation remains a prominent contributor to GHG emissions in Malaysia, primarily driven by the emissions from internal combustion engine (ICE) vehicles. The land transport segment is a key driver of these emissions, accounting for 55 $MtCO_2eq$, constituting >85% of total transport emissions (see Figure 3.1)

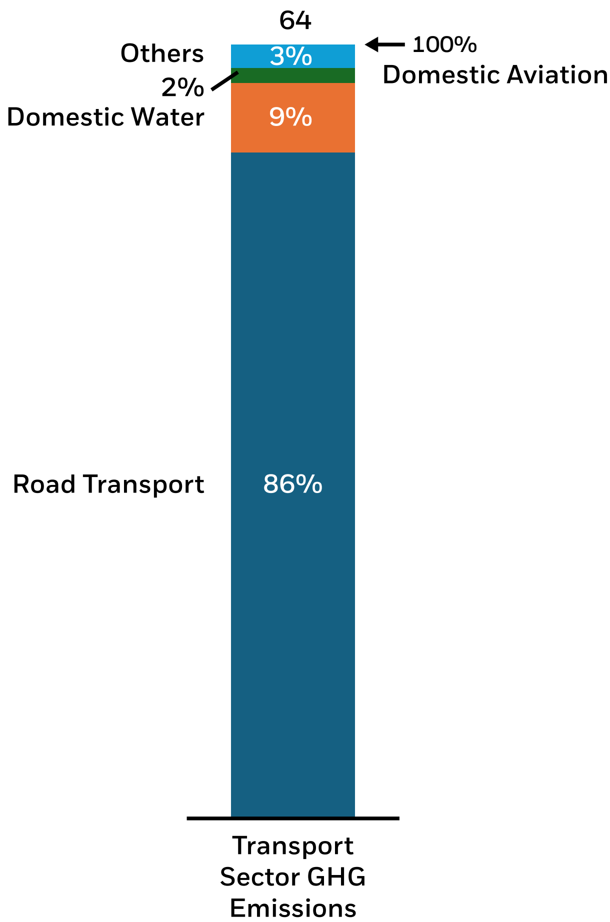


Figure 3.1: Malaysia Transport Sector GHG Emissions[8]

The National Energy Transition Roadmap (NETR)[8] released by the Malaysia Government builds on existing targets outlined by LCMB and National Energy Policy (DTN), by 2050 (Figure 3.3) it aims to:

- Elevate the public transport modal share to reach 60%
- Accelerate the penetration of xEV (4W) share of the vehicle fleet to 80%
- Accelerate the penetration of electric two-wheelers' (E2W) share of the vehicle fleet to 80%
- Foster robust local EV manufacturing capabilities to achieve 90% local xEV manufacturing
- Continue improvements in ICE fuel economy
- In 2023, 96% of electric vehicles sales was attributed to 2 wheelers and 3 wheelers.

In 2018, the ministry commissioned a study leading to Low Carbon Mobility Blueprint 2021-2030[17] (LCMB). Focus Areas (FAs) of the LCMB call for GHG emission and energy reduction via fuel economy and emission improvement, via electric vehicle adoption, via alternative fuels (Biofuels) adoption and mode shift adoption (improve public transportation, traffic flow etc.). Referring to the current rate of growth and no. of cars in Malaysia, it is estimated that Malaysians will make an estimated 131 million daily trips in 2030, a significant increase from the 40 million trips in 2010. Malaysia already has one of the highest levels of car ownership in East Asia, see Figure 3.2.

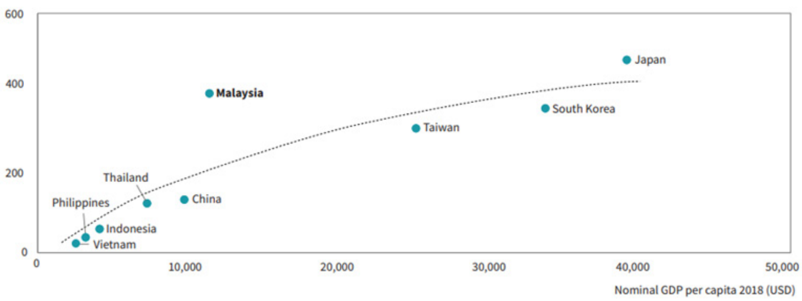
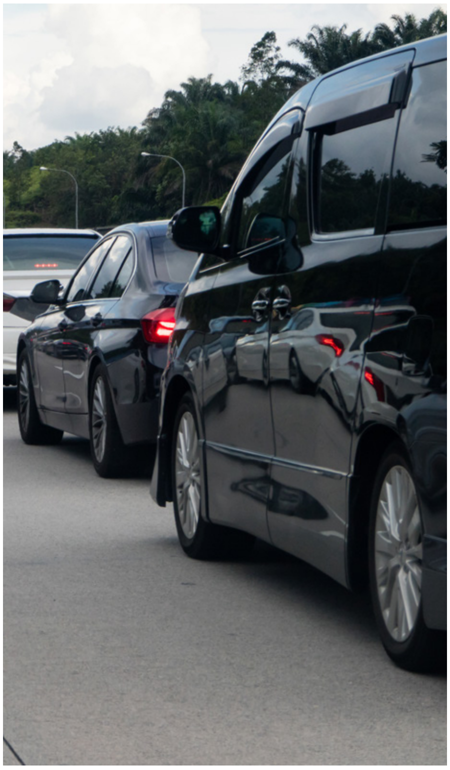


Figure 3.2: Car Ownership in East Asia, 2018 (per 1000 people)



AIR TRANSPORTATION

The NETR also proposed adoption of International Civil Aviation Organization's (ICAO) Long Term Aspirational Goal (LTAG) of net-zero carbon emissions by 2050 for international aviation and up to 47% sustainable aviation fuel (SAF) blending mandate by 2050. The Malaysian government has therefore recently released the Malaysia Aviation Decarbonisation Blueprint.[18]

SAF represents a valuable low-carbon opportunity in Malaysia's journey towards reducing aviation emissions. Within SAF's production framework, two primary sources were identified as key alternatives; biofuels and synfuels. Hydroprocessed esters and fatty acids (HEFA) emerged as the front-runner technical pathway in the near term, while alcohol-to-jet (ATJ) and gasification-integrated Fischer-Tropsch (GFT) are some of the technologies being considered in Malaysia.

Sarawak has abundant hydroelectric potential that can be used to create e-SAF, as an alternate route for carbon utilization. E-SAF combines CO_2 with Green Hydrogen into methanol and further processed into SAF with Honeywell's e-Fining technology.

Malaysia will need to address concerns around sustainability of palm oil as a SAF feedstock due to concerns related to indirect emissions, land use change and other sustainability criteria as this impacts the life cycle emissions values in the sector's pursuit of sustainable aviation.

Palm Oil as a feedstock for SAF:

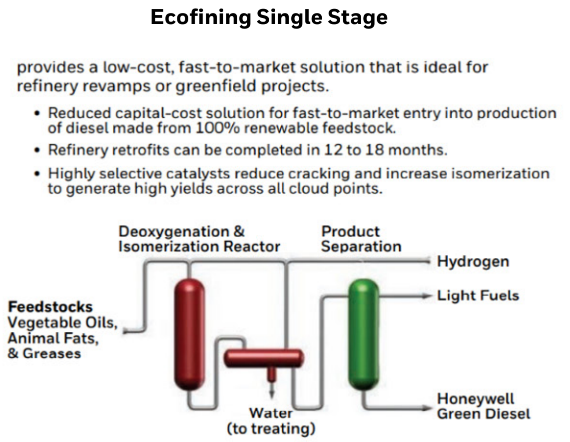
- Palm oil, which is widely grown in Malaysia, is one of the highest potential feedstocks for SAF / renewable diesel production in the ASEAN region. If sourced sustainably, palm oil has the potential to meet up to 40% of the world's aviation fuel demand by 2050, according to a report by the International Renewable Energy Agency (IRENA)[19]
- Palm plantation offers the best area specific yield for SAF versus other biomass sources at about 176 GJ/hectare/year.[20]
- Malaysia's position has been that use of palm oil to make sustainable aviation fuel would provide more flexibility to producers in terms of feedstocks, however sustainability concerns due to the impact of deforestation in tropical regions are a major impediment to its use.

Citing perceived misconceptions from the EU on the deforestation risks in Indonesia and Malaysia, the two largest palm oil producers in the world, Singapore's acting transport minister recently said *"We should take a pragmatic approach based on science and evidence, instead of an ideological approach based on pre-conceived bias and dogma"*.

- To counter the sustainability concerns, Malaysian Government has launched its own initiative Malaysian Sustainable Palm Oil (MSPO) which is a nationally mandated scheme and is backed by penalties and sanctions in case of non-adherence.
- Recently the Malaysian Government declared that 87% of palm oil plantations in Malaysia have been certified under MSPO standard as of April 2024. This feat has been lauded by major palm oil importing nations and the EU, which is confident of Malaysia's success in sustainable palm oil production[33].

Ecofining™ Technology

With the right collection, logistics and infrastructure, waste fats, oils and greases, as well as palm oil can be used for producing sustainable aviation fuel (SAF) / renewable diesel. Honeywell's Ecofining technology enables the production of sustainable aviation fuel / renewable diesel that can be a drop-in replacement, requiring no changes to fleet technology or the fuel storage and delivery infrastructure (Figure 3.4). The process chemistry is based on the hydrodeoxygenation, hydrodecarboxylation and hydrodecarbonylation of the triglycerides and/or free fatty acids[20]. The resulting normal paraffins are hydroisomerized and hydrocracked to yield drop-in liquid fuels that exhibit superior properties in terms of energy density, cetane number, sulfur and oxidative stability. Malaysia, with its unique advantage of having access to a basket of renewable feedstocks, can tap into the vibrant international biofuels market for export provided there is trust developed on sourcing the palm oil sustainably. For instance, financially attractive incentives for producing SAF from sustainably sourced Palm oil can help bring investments to make Malaysia the hub for SAF supplies in the region. Honeywell UOP has Licensed more than 53 Ecofining units globally, with some units processing up to 35,000 barrels of feed per day (bpd), a scale that represents a significant portion of the total Malaysian jet fuel demand of up to +-70,000 bpd[34,35].



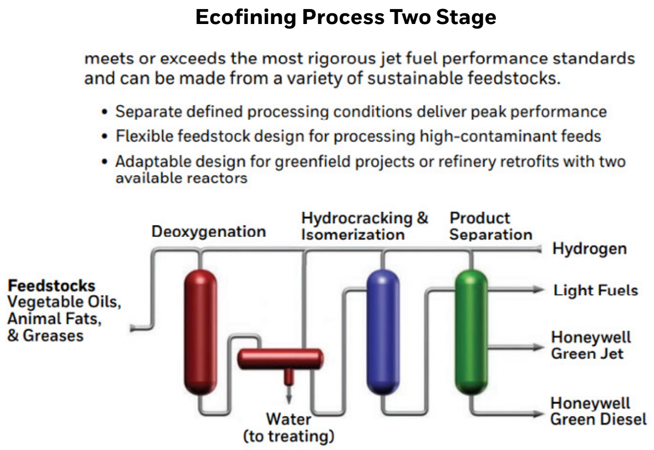


Figure 3.3 Renewable Diesel/ Jet Distillates Production Technology

eFining™

To reconcile the growing demand for air travel with increasing calls for decarbonization, the world needs greater and faster access to sustainable aviation fuel. While renewable oils derived from biomass can supply part of the demand, fuels developed using captured carbon dioxide and green hydrogen can also expand the available options for sustainable aviation fuel production. Honeywell UOP eFining™ technology shown in Figure 3.5 enables rapid access to one of the most abundant renewable feedstocks on earth: CO_2 and produces such eFuels[21].

eFuels, also known as electro fuels, are a class of synthetic fuels that displace conventionally produced fossil fuels. This process starts with renewable power from sources like wind, solar, and geothermal energy. Green hydrogen is produced using an electrolyzer powered with renewable energy to turn water into hydrogen and oxygen. The hydrogen is then combined with recycled CO_2 to produce e-Methanol, which is the feedstock for a wide range of renewable fuels including SAF, gasoline and diesel alternatives. E-SAF can be blended with the traditional aviation fuel used today for drop-in-use in existing jet engines without any modifications.

eFINING KEY FEATURES AND BENEFITS

- Low carbon intensity jet fuel
- High SAF yield and selectivity
- Minimized CapEx and plot space
- Scalable process with high operational reliability
- Highly integrated design
- High-efficiency equipment
- Modular units available to accelerate execution
- Unmatched commercial and R&D experience

Figure 3.4 e-SAF

WHAT SHOULD THE GOVERNMENT OF MALAYSIA BE DOING NOW TO ACCELERATE DECARBONIZATION OF THE TRANSPORT SECTOR?

As Malaysia continues to grow and expand its economy, people and freight movement are set to increase significantly. Electrification and renewably-sourced fuels will be the keys to sustainable transportation. The pace of decarbonization will vary according to the different transportation modes with road transport and aviation needing to be the focus due to their overwhelming share of overall transport emissions. The mass segment of small passenger vehicles can achieve net zero within the next decade through the concurrent adoption of batteries and charging infrastructure. Heavy duty trucking and aviation sector need a credible roadmap for graded emissions reduction. Malaysia can leverage equipment and standards from amongst others the USA, Brazil and Indonesia where renewable diesel has been widely adopted. Our key recommendations are noted below:

- Consider the use of easily accessible, scalable feedstock, including feeds such as palm oil and POME, for an ambitious 10% SAF blends for flights within ASEAN (e.g., Indonesia, Singapore, Thailand routes).
- Improve the carbon intensity of diesel fuel by adopting a B20 biodiesel mandate and increase the supply to include both FAME and HEFA routes to renewable diesel fuel. This can help meet demand for biofuels in ASEAN, which is projected to grow fastest up to 2050, with an annual CAGR of 4.7%[36].
- Accelerate low carbon intensity electrification of light duty 2-wheel and 4-wheel vehicles by deploying charging infrastructure using renewable energy combined with battery energy storage systems in microgrids.
- Foster regional cooperation for enhancing feedstock and biofuel trade among ASEAN countries. It is crucial that ASEAN's strategy extends beyond merely increasing feedstock production, as relying solely on this method is not sustainable.
- Create multidisciplinary Research and Development capabilities and pilot plants to improve SAF or biofuel feedstock availability and quality, gain insights into actual deployment costs and address challenges of biofuels supply and adoption in the region.

URBANIZATION AND BUILDING EFFICIENCY

URBANIZATION AND BUILDING EFFICIENCY

Malaysia's Unique Advantages and Opportunities in the Built Environment

- Malaysia has 3 urban conurbations with population more than 2 million[22]
  - Klang Valley (9 million, density of 3,000 per square kilometer)
  - George Town (2.8 million, density 760 / km^2)
  - Johor Bahru (2.5 million, density 500 / km^2)
- These are followed by 2 smaller conurbations:
  - Kinta Valley (0.98 million, 495 / km2)
  - Greater Kuching (0.93 million, 460 / km^2)
- Cities also drive greater impact from policies and innovations for decarbonization and operational efficiency, given the larger density of population.
- Currently, 5 cities are involved in the Smart City pilot projects: Kuala Lumpur, Johor Bharu, Kulim, Kota Kinabalu, and Kuching. Other cities with Smart City development are Putrajaya, Cyberjaya, Melaka, and Penang[23].

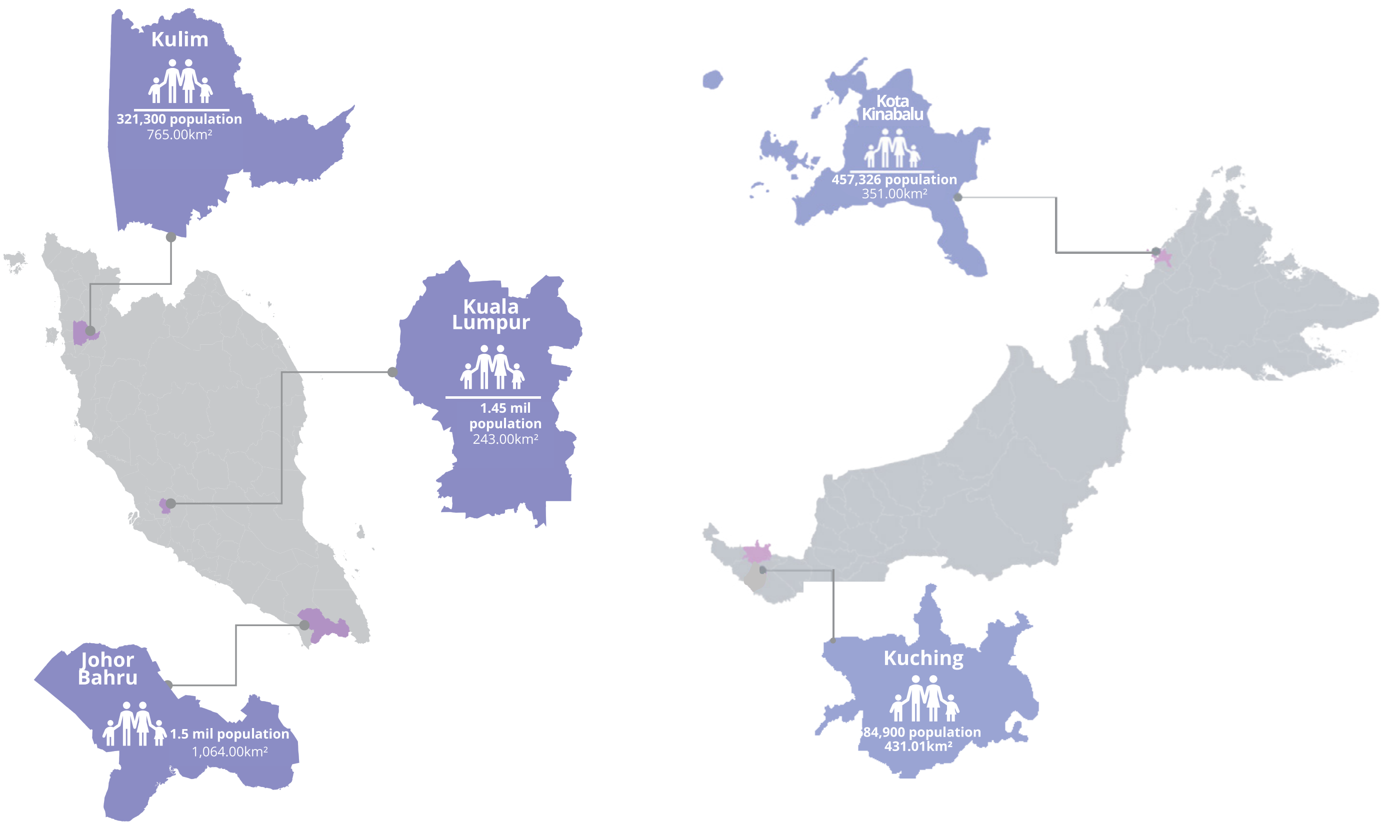


Figure 4.1 Major urban centres in Malaysia[37]

Malaysia's urban population with large aspirational needs is driving new investments in public infrastructure, transportation, municipal services, education, public health, safety and security, giving Malaysia the opportunity to plan the urban environment, promote climate-responsive and resilient building design, construction and operation, and ensure that Malaysian cities are designed to alleviate the vulnerabilities of urban poor.

Malaysia is, by and large, an urbanized country, with a national urbanization rate of 77.7% on a population of 33.5 million. 75% of the nation's GDP is currently generated in cities. Furthermore, Malaysia is projected to have an urbanization rate of 81.8% by 2030. The challenges of managing Malaysian cities include urban sprawl, a lack of sufficient and affordable housing, poor urban mobility, traffic congestion, waste management, high flood risk, and a lack of green spaces[24].

Malaysia has developed the Malaysia Smart City Framework in 2018 by the Ministry of Housing and Local Government). This is followed by the National Low Carbon Cities Masterplan (NLCCM) in 2021 by the Ministry of Environment and Water. Both documents aspire to drive infrastructural improvements, promote the digitalization of municipal services and data gathering, and reduce carbon emissions significantly. The 12th Malaysia 5-year Plan Mid-Term Review in 2023 emphasized the goals of developing 5 Smart Cities and that 12 Local Authorities developed smart city action plans by the end of 2025.

Given Malaysia's high urbanization, carbon emissions in Malaysia mainly relate to urban settings, where the energy sector (including electricity and transportation) makes up around 80% of total emissions[25]. Hence, optimizing building energy use, decarbonizing public and private transportation systems, and driving energy efficiency in commercial and industrial operations can greatly support the reduction of CO_2 footprint in Malaysian cities.

Honeywell has proven technologies for smart city management, building energy efficiency, indoor air quality (IAQ), and low GHG building materials. Honeywell technologies are used in over ten million buildings worldwide, and Honeywell has guaranteed $9.2 billion USD of energy savings across 3400 energy efficiency projects, spanning schools, universities, hospitals, airports, military bases, commercial and government buildings.

Highlights of the Malaysia Smart City Framework

Level 1: Core Criteria for Smart Cities

- Comprehensive primary and basic infrastructure

Comprehensive primary and basic infrastructure should be in place in order to advance smart city agenda. Basic infrastructure in this context refers to the fundamental physical facilities and systems serving a city which includes roads, bridges, tunnels, water supply, sewers, electrical grids and telecommunications.

- Connected and modern digital infrastructure

Smart city anchor on the concept that everything is connected and intelligent. Shared digital infrastructure will help cities correlate data from multiple sources to generate new value and efficiencies

- Initiatives aligned with the needs of the city

By using digital technology, smart city initiatives should align around the needs of the city based on identified urban challenges – e.g. government efficiency, sustainability, health and wellness, mobility, economic development, public safety and quality of life

Level 2: Data and Information protection

Robust information and data protection are necessary for stakeholders buy-in and support for the smart city agenda. A secure technology infrastructure and information collection system ensures stakeholders confidence in using smart solutions. Information collected must be protected, and used in accordance to its owners' wishes. Policies, legislation and technology should continually be adapted to achieve a balance of protection, privacy, transparency and utility.

Level 3: Plus Points

- Low carbon city and green lifestyle
- Introduce the concept of green cities in Malaysia, thereby helping to reduce carbon emission in cities and townships as well as provide guidance towards green solutions for their cities and townships

CONVERT THE 'SMART CITIES' PROGRAM TO 'SUSTAINABLE CITIES' PROGRAM

Malaysia has developed various Smart Cities Frameworks over the past two decades, focused on digitalizing and automating city services, emergency responses, crime surveillance and traffic management. Various urban and state authorities in Malaysia have embarked on Smart Cities transformation programmes (Kuala Lumpur, Putrajaya, Johor Bahru, Penang, Selangor). Substantial progress was made in developing infrastructure and integrating several siloed systems (e.g., traffic management, surveillance etc.) using an integrated command and control centre. However, there is an opportunity to convert these Smart Cities into Sustainable Cities – addressing economic, social and environmental sustainability and generating savings that will fund operations and maintenance while even further modernizing the infrastructure. Malaysia could benefit from a nationally defined approach to sustainable cities built on a scalable platform that can be efficiently replicated across cities and townships around the nation, while optimizing design and implementation lead times.

PILLARS OF SUSTAINABILITY FOR CITIES

A sustainable smart city is built on the pillars of environmental, economic, and social sustainability. By incorporating cutting-edge technologies into urban infrastructure, cities can reduce their environmental footprint, boost economic growth, and enhance the quality of life for their residents.

Economic Sustainability	Environment Sustainability	Social Sustainability
Integrating revenue-generating methods is crucial for the financial sustainability of smart cities which can reduce dependence on government funding for further development. • Advertising Rev • Parking Fees & Mgt • Traffic Violation Rev • Demand Response Program • Pay-As-You-Throw Program • Sale of Recyclables • Data Analytics Services	Sustainable cities focus on conservation of energy, water & recycle waste to reduce carbon footprint and enable Malaysia's net zero goals. • Smart grids/microgrids • Energy-efficient buildings • Integration of renewable power • Integrated Transportation • Waste Mgt, Circular economy • Water Management	Social sustainability focuses on fostering an inclusive and equitable environment where all citizens can thrive. Leveraging cutting-edge technologies, smart cities can weave this intangible fabric more effectively by fostering digital inclusion. • Inclusive Citizen Governance • Citizen Awareness • Citizen Engagement Platforms

A) Economic Sustainability: Specific strategies to generate revenue for smart cities in Malaysia while promoting sustainability

- **Advertising Revenue:** Utilize digital screens and smart infrastructure for targeted advertisements.
- **Parking Fees & Management:** Implement smart parking systems with variable pricing based on demand. Revenue can be generated through parking fees and fines for violations.
- **Traffic Violation Revenue:** Implement advanced systems of Red-Light violation detection (RLVD) and Automatic number-plate recognition (ANPR) cameras.
- **Demand Response Program:** Introduce programs that encourage industries to reduce energy consumption during peak hours, providing financial incentives.
- **Pay-As-You-Throw Program:** Charge residents and businesses based on the amount of waste generated. This incentivizes waste reduction and recycling.
- **Recyclables Sale:** Selling recyclable materials to industries engaged in recycling.
- **Data Analytics Services:** Offer data analytics services to businesses & research institutions using the vast amount of data collected through IoT devices.

By implementing these revenue-generating methods, smart cities in Malaysia can achieve financial sustainability while promoting environmental, social, and economic well-being.

B) Environmental Sustainability: Specific Solutions

- **Energy Efficiency & Renewables:** One of the primary focuses of a sustainable city a is energy efficiency. Smart grids/microgrids, energy-efficient buildings, and the integration of renewable energy sources contribute to a substantial reduction in carbon emissions. The Integrated Command Control Centre plays a pivotal role in monitoring & optimizing energy consumption across the city, ensuring a seamless balance between demand & supply.
- **Integrated Transportation Systems:** Efficient transportation is crucial for any city's success. An Integrated Command Control Centre oversees the coordination of various modes of transportation, including buses & feeder transport vehicles. Real-time traffic monitoring and smart traffic management systems contribute to reduced congestion, lower

emissions, and enhanced mobility for residents. Using advanced data & video analytics we can optimise the inflow & outflow of vehicles into cities thus giving impetus to data-driven infra development.

- **Waste Management and Circular Economy:** Sustainable cities prioritize waste management through innovative technologies. Integrate smart waste bins and sensors to optimise waste collection routes, reduce operational costs, and promote recycling efforts also optimizing landfills. The command control centre facilitates the monitoring of waste collection, recycling processes, landfills, and the implementation of a circular economy. Implement Waste-to-Energy with Carbon Capture program to optimise the use of waste as a source of energy while conserving land space and ensuring the process minimizes pollution footprint. By minimizing waste and maximizing resource efficiency, these cities contribute to a healthier environment.
- **Water Management:** Implement IoT devices to monitor water consumption, detect leaks, and manage water distribution more efficiently, contributing to water conservation efforts

C) Social Sustainability: Specific Solutions

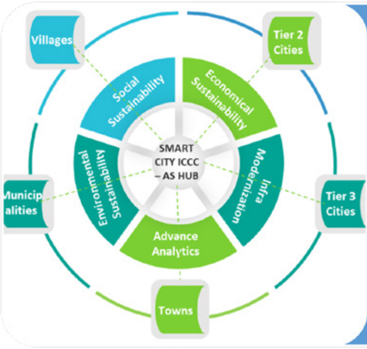
- **Advanced Infrastructure for Enhanced Living:** Smart infrastructure encompasses intelligent buildings, smart street lighting, and advanced water management systems. The command control centre ensures seamless integration and efficient management of these systems, leading to improved living conditions for residents. Smart sensors and data analytics enable predictive maintenance, optimizing resource use, and reducing overall operational costs.
- **Community Engagement and Social Inclusivity:** The social aspect of sustainability is equally crucial. A sustainable smart city promotes community engagement through digital platforms and citizen-centric applications. The command control centre acts as a hub for gathering and analyzing data on citizen preferences, feedback, and needs, fostering a sense of inclusivity and responsiveness in urban governance.

INCREASE REACH OF CORE SMART CITIES TO SUBURBS AND NEARBY TOWNSHIPS VIA A HUB & SPOKES MODEL

In the ever-evolving landscape of urban development, the emergence of a few key large smart cities programs in Malaysia has ushered in a new era of efficiency, connectivity, and sustainability. Among the pioneering examples is the **Integrated Command Control Centre (ICCC)**, which serves as the nerve centre for managing and optimizing various aspects of city life. What sets these smart cities apart is not only their intrinsic capabilities but also their potential to influence and uplift smaller cities in their periphery, creating a hub-and-spoke model of progress with minimum investment and a public-private partnership model.

Smart Devices, Sensors & IOT to integrate T2/3 cities using ICCC:
At the heart of this transformation lies the smart devices, intricate web of IoT sensors and various other sensors, weaving a tapestry of technological advancement that not only propels the city forward but also fosters sustainability on a profound scale. Integrating cities on the periphery into an existing Integrated Command Control Centre (ICCC), involves deploying a network of sensors and smart devices strategically. Some of the sensors and smart devices that can enable these transformations are Digital Screens, Smart and advanced cameras, Smart Infrastructure Sensors, Environmental Sensors, Waste Management sensors, IoT devices to manage end-to-end water management systems, Smart City Apps, and Citizen feedback systems. By implementing these strategies, cities on the periphery can effectively leverage the advantages of an already established integrated command control centre, contributing to a more connected, efficient, and sustainable urban ecosystem.

We need to compelling narrative of a smart city with an already established integrated command control centre, exploring how these urban behemoths can first become sustainable themselves and then act as catalysts, shaping the future not just for themselves but for the smaller cities in their gravitational pull.



Leverage Hub and spoke model to increase reach of 100 Smart Cities program to Tier 2 and 3 cities and convert Smart into Sustainable.

This can be achieved by leveraging the ICCC infrastructure that has already been put up in the Tier 1 city. T2/3 cities could be connected with sensors to ICCC and analytics on top could drive outcomes focused on sustainability agenda (Water/Waste water, Emissions etc).

STRENGTHEN GREEN & SUSTAINABLE BUILDINGS STANDARDS: INSIGHTS FROM SINGAPORE, EUROPE & JAPAN

Malaysia stands at the cusp of a transformative journey toward net-zero emissions. In pursuit of a net-zero emissions future, inspiration could be drawn from the experiences of other countries. Much planning and strategic work has been done through the NETR, HETR and Energy Efficiency and Conservation Act 2023 (EECA). Insights from Singapore's Green Plan 2030[26], the EU 2050 Long Term Strategy[27] and Japan's Roadmap to Beyond Zero Carbon[28] strategies can further contribute to Malaysia's vision for a sustainable and resilient future.

Strengthening Malaysia's Approach:

- **Green Building Certification Mandate:** Build on the EECA by setting ambitious energy reduction targets incorporating a mandatory green building certification requirement for new infrastructure projects and existing floorspace of qualified buildings. This ensures that all new buildings and qualified existing buildings meet stringent environmental standards, fostering a culture of sustainability and maintainability in the construction sector.
- **Upgrade to Smart Building Technologies:** Set five yearly targets for per-capita reduction in overall building energy use through the adoption of smart IOT based building technologies
  - Upgrade 60% of existing HVAC systems with smart, efficient alternatives by 2030
  - Provide grants or low-interest loans for the installation of smart building systems
  - Collaborate with Energy Performance Contracting companies to offer energy savings
  - Implement AI powered SMART IoT Analytics platform to control and manage buildings systems
- **Green Building Tax Incentives:** Introducing tax/ incentives for commercial real estate developers adhering to green building standards. These incentives could include reduced property taxes or accelerated depreciation for eco-friendly features, encouraging sustainable practices in the commercial real estate sector.
- **Renewable energy integration:** To reduce energy related emissions, Malaysia should pass new regulations to mandate more than 50% RE integration for every commercial building of size more than 50,000 sqft.
- **Environmentally-friendly refrigerants:** Establish or update regulations and standards that explicitly mandate the use of environmentally friendly refrigerants in HVAC and Split AC systems. This can be achieved through amendments to existing building codes, energy efficiency standards, incentives, or the creation of a new set of regulations specific to refrigerants.
- **Sustainable Campus Initiatives:** Expanding on Singapore's model, Malaysia should launch Sustainable Campus Initiatives, encouraging schools and educational institutions to adopt eco-friendly practices, such as solar installations, waste reduction programs, and sustainable landscaping.
- **Industry-Specific Emission Reduction Targets:** Malaysia should set up industry-specific emission reduction targets under the new Energy Regulations. This incentivizes industries to invest in green technologies, innovate sustainable processes, and transition towards a low-carbon footprint.

By incorporating these recommendations, Malaysia can accelerate its decarbonization journey at par with international leaders and with proven approaches and technologies.

Key Learnings from Singapore Green Plan 2030

- Comprehensive Urban Planning integrating sustainable design principles into building & infra incorporating green spaces within urban landscapes
- Commercial Real Estate sustainability integrating green building certifications, incentivizing energy-efficiency and promoting the use of RE in commercial spaces
- Greening Educational Spaces making of 20% schools' and educational institutions carbon neutral and 1/3rd emission reduction by 2030
- Industry-specific targets to enable decarbonization at scale for hard-to-abate sectors through sectoral emission reduction goals along with incentives for adopting green tech

Key Learnings from European Nations:

- Circular Economy emphasizing, & incentivizing resource efficiency, waste reduction, and the recycling of materials.
- Emission reduction targets & penalties for industries & buildings, coupled with penalties & market-driven incentives; periodic energy audits
- Green trade agreements that prioritize sustainable practices, incentivizing adherence to environmental standards while fostering economic growth

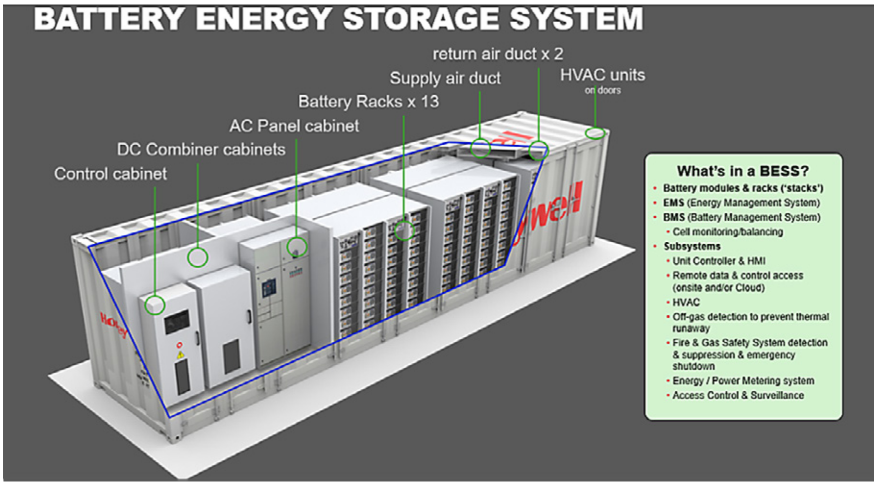
Key Learnings from Japan's Beyond Zero 2050 Initiatives:

- Incentives for Beyond Zero Achievements for industries surpassing net-zero targets. This fosters a culture of continuous improvement and innovation in emission reduction
- Technology-Driven Innovation Hubs focused on developing & implementing cutting-edge technologies for achieving net-zero targets through subsidies and tax credits
- Collaborative Research Partnerships between research institutions, businesses, and government to accelerate the development & implementation of innovative solutions

BATTERY ENERGY STORAGE SYSTEMS (BESS) FOR BUILDINGS

The deployment of Battery Energy Storage Systems (BESS) within commercial real estate transcends conventional energy management paradigms, offering a multifaceted solution that extends beyond peak demand mitigation. Beyond the alleviation of peak loads and associated demand charges, BESS represents a technologically advanced alternative to traditional Diesel Generator (DG) sets, addressing both environmental and operational concerns. By seamlessly integrating with the existing infrastructure, BESS serves as a cleaner, quieter, and more efficient backup power source during grid outages or peak demand scenarios, negating the need for DG sets and their associated emissions.

One of the key contributions of BESS lies in its ability to integrate renewable energy sources such as solar and wind, seamlessly. The modularity and scalability of BESS also ensure adaptability to varying energy needs, enhancing overall operational flexibility. Additionally, BESS's ability to provide rapid response and frequency regulation contributes to grid stability, reinforcing the resilience of commercial real estate. By storing excess energy during low-demand periods and releasing it during peak demand, BESS aids in peak shaving. This not only reduces strain on the grid but also helps manage electricity costs. Businesses and utilities can optimise their energy consumption, leading to more efficient use of resources and reduced reliance on traditional, often fossil-fuel-based, peak power plants. From a cost-efficiency standpoint, the declining costs of battery technologies coupled with potential incentives for clean energy adoption position BESS as an economically prudent choice. In essence, Battery Energy Storage Systems emerge as a transformative force within commercial real estate, offering a synergistic blend of technological advancement, environmental stewardship, and economic viability.



Regulations and Mandates:
To accelerate the widespread adoption of energy storage, the Malaysian government can institute regulatory mandates requiring new commercial buildings and major renovations to integrate BESS as an integral component of their energy infrastructure. This would involve amendments to building codes, making BESS integration a prerequisite for project approvals. Simultaneously, the government can implement a phased approach, mandating existing buildings to retrofit BESS within a defined timeframe.

- **Incentives:** To spur widespread adoption, the government must institute a robust system of incentives. Financial incentives such as tax credits, accelerated depreciation, and subsidies can be extended to developers and building owners embracing BESS. Additionally, concessional financing programs and grants can be established to ease the initial capital burden. Special incentives may be offered to early adopters, encouraging a rapid and widespread transition.
- **Penalties:** In parallel, penalties for non-compliance or continued reliance on DG sets beyond the stipulated transition period can be introduced. These penalties can range from higher tariffs on electricity for buildings using DG sets, environmental fines, or even limitations on obtaining necessary permits for non-compliant buildings.
- **Financial Viability:** From a financial perspective, the adoption of BESS can be positioned as a sound investment. The government can work with financial institutions and Energy Performance Contracting (EPC) companies to develop innovative financing models, such as Energy Services Agreements (ESAs), where the upfront costs of BESS installation are borne by third-party investors who then recoup their investment through a share of the energy cost savings over time.
- **Technical Viability:** To address technical considerations, the government can facilitate R&D collaborations between industry and research institutions to enhance the efficiency, reliability, and scalability of BESS. Standardized guidelines and best practices for BESS integration in different building types can be developed to streamline the adoption process. Moreover, capacity-building programs and technical training initiatives can be launched to equip professionals with the skills needed for BESS design, installation, and maintenance.

As technology advances and regulatory frameworks evolve, BESS is poised to play a crucial role in the global transition to cleaner and more resilient energy systems. A holistic approach combining regulations, incentives, and penalties can effectively steer the widespread adoption of BESS in Malaysian buildings, concurrently phasing out DG sets. A related safety consideration on the proliferation of Lithium-based BESS in buildings, data centres and utility-scale green energy plants, is the regulation and enforcement of Lithium offgas detection system to pre-empt catastrophic thermal runaway incidents. Such systems can detect and pre-empt thermal runaway incidents by enabling the automatic shutdown or isolation of the defective BESS.

By aligning financial attractiveness with green considerations, BESS can pave the way for a resilient energy infrastructure with reduced environmental impact, propelling Malaysia towards a cleaner and more secure energy future.

Example: Achieving Renewable Powered Microgrid in Tapah

This illustrative example shows how a village can use green hydrogen and capacitor to get fully renewable green energy. A Malaysian village 'Orang Asli' was totally off-grid, relying on candles and kerosene, till 2019

- 100 inhabitants faced various challenges due to lack of power
- Unique solution for the situation was thought, combining solar power with hydrogen and supercapacitors (for storage)
- During daytime, the grid uses its solar power directly, with excess energy charging the supercapacitors and then converting to hydrogen.
- Night-time demand is first supplied by the supercapacitors, with a fuel cell converting hydrogen to supply remaining energy requirements.
- Project details:

- Electrolyzer (AEM single-core)	1 x EL 2.0
- H_2 storage	0.5 m3, 20 kWh of useable energy
- Storage pressure	35 bar
- Photovoltaic (PV)	4.7 kWp
- Fuel cell	1.1 kW
- Supercapacitor	10 kWh

LOW GHG BUILDING MATERIALS: SOLSTICE REFRIGERANTS AND BLOWING AGENTS.

The Kigali amendment to the Montreal Protocol added Hydrofluorocarbons (HFCs) to the list of controlled substances and approved a timeline for their gradual reduction by 80-85% by the late 2040s. Malaysia will freeze its HFC baseline on 2024 and reduce in 4 steps: 10% reduction from base by 2029, followed by 30% in 2035, 50% by 2040 and 80% by 2045[29]. This calls for the reliable supply and availability of Low Global Warming Potential (LGWP) molecules for use as refrigerants and as blowing agents for insulation. LGWP molecules such as the Solstice® products developed by Honeywell find widespread applications in air conditioning, commercial refrigeration and as blowing agents to create insulation materials that reduce energy consumption of appliances.

Malaysia is a major production and export hub of 3.4 million units residential AC and other cooling and heating products which consume imported HFCs, 70% which are exported to Europe, North and South America and the Middle East[29]. Malaysia stands to derisk export revenue, reduce domestic consumption of HFC (industrial consumption of HFC for export is considered as official in-country consumption by the Montreal protocol), and position herself as a responsible player in global GHG reduction through the adoption of HFO and HFC alternatives in an accelerated roll-out program. In addition, promoting the sector specific 100% adoption of LGWP refrigerants such as in automobiles or supermarket refrigerators can demonstrate a phased and graded approach towards carbon neutrality.

WHAT SHOULD THE GOVERNMENT OF MALAYSIA BE DOING NOW TO ACCELERATE THE DECARBONIZATION OF THE BUILDINGS SECTOR?

As Malaysia's cities continue to expand and the Government continues to upgrade the infrastructure of schools, hospitals, airports, universities and government buildings, Honeywell believes there is an opportunity to design for sustainability reduced environmental impact and create a built environment that will be resilient to the impact of climate change. We think the following actions by the government would be consistent with Malaysia's goals for low-emissions sustainable development and would lead to more efficient buildings and cities that provided people with comfortable living and working spaces:

- Convert all key cities and state capitals into sustainable cities that are built on the pillars of environmental, economic, and social sustainability by incorporating cutting edge technologies and digital infrastructure that can reduce environmental footprint, boost economic growth, and enhance quality of life for the residents.
- Deploy hub and spoke model to increase reach of the smart cities program to surrounding townships by leveraging the integrated command

control centre (ICCC) that has been already put in place in the key cities. This can drive sustainable outcomes in water, waste and emissions management and build robust resilience against abrupt weather events resulting in floods.

- Strengthen green and sustainable building standards through wider adoption of green building certification mandates that are focused on continuous energy audits and monitoring, implementation of smart building technologies, expansion of renewables in the building's energy mix and adoption of industry specific emission standards.
- Phase out diesel generators for stationary power back up in rural and island settings with battery energy storage systems. This is a transformative force within commercial real estate offering a synergistic benefit of technological advancement, environmental stewardship and economic viability.
- Advance the phase down of Hydrofluorocarbons (HFCs) in Malaysia by promoting the sector specific 100% adoption of LGWP refrigerants in heating and cooling equipment manufacturing, in automobiles, and in supermarket refrigerators, commercial buildings can demonstrate a phased and graded approach towards carbon neutrality for the nation and for Malaysia's export markets

HARD TO ABATE INDUSTRIALS

HARD TO ABATE INDUSTRIALS

Industrial manufacturing, excluding heat production, contributes 15.5% of Malaysia's total GHG emissions[10], yet the long-term economic growth of Malaysia depends heavily on growth in domestic industrial manufacturing. Malaysia which saw decline in industrial growth during financial crash early in the century has now embarked on the path of reimagining the industry. Other than steel, cement, key sectors such as refining and petrochemicals, Electrical and Electronics, semiconductor, specialty chemicals, advanced materials, aerospace etc. are driving industrial growth.

From an energy perspective, this sector is switching to natural gas networks for its energy needs. Expanding the industrial fuel basket by including bio-based fuels such as biodiesel, biogas, biomass briquettes, and refuse-derived oils can play a pivotal role in hastening the energy transition. In the long term, green hydrogen can emerge as an alternative low-carbon fuel platform and as an industrial reducing agent promoting the manufacturing of low-carbon steel, cement, and other industrial intermediates.

At the same time, energy efficiency and emissions management is critical to reduce the carbon footprint of industry and reduce the cost of transitioning to greener energy sources. Honeywell's wide array of Process, Environment, and Industrial Control Systems and Solutions can play a critical role in the transition of the hard-to-abate sectors to a lower emissions footprint. Honeywell's Forge Sustainability+ Emissions Management provides enterprise wide GHG emissions accounting, visualization, and reporting. Honeywell Versatilis™ Signal Scout™ helps identify methane leaks in near real time to help reduce emissions, reduce product loss and improve safety for gas-based sectors.

HYDROGEN

Hydrogen (H_2) is an emerging fuel that can replace natural gas for industrial heating applications. Honeywell Blue H_2 solutions is a ready-now suite of proven carbon capture technologies to help meet stringent emission goals and gain fast entry into the growing hydrogen economy. The Malaysian government has set a target of up to 2.5 Mt/y (million metric tons per year) local green hydrogen production capacity by 2050 and plans to completely phase out the use of grey hydrogen as a feedstock by 2050. Honeywell has case studies of projects where state of the art technology will be applied to meaningfully decarbonize hydrogen production from fossil sources at scales of up to 7 Mt/y CO_2 removal, helping decarbonize whole industrial sites.

For green hydrogen, Honeywell is accelerating the development of Catalyst-Coated Membranes that help in reducing the cost of green hydrogen production by enabling greater electrolyzer performance.

Malaysia currently produces grey H_2 for primary use in refineries, fertilizers and chemicals. By combining the conversion of existing grey hydrogen to blue hydrogen, investing in world class low-carbon intensity hydrogen production and producing green hydrogen or derivatives, Malaysia's 2050 targets can be supported for hydrogen production and this low carbon molecule can be effectively leveraged to decarbonize heavy and hard to abate sectors. Additionally, as Malaysia is a key energy provider to Northeast Asia, hydrogen could represent a viable export product by leveraging hydrogen derivatives and hydrogen carriers, like the Liquid Organic Hydrogen Carriers.

Honeywell has also developed technologies that can aid in the long-distance transport of H_2 using novel liquid organic carriers. By leveraging existing refining and petroleum infrastructure this technology pathway represents a scalable, reliable and cost-effective lever for the import and export of low carbon hydrogen to energy importing countries such as Japan, Korea and Singapore.

HYDROGEN ECONOMY

MALAYSIA'S UNIQUE ADVANTAGES	HOW CAN HONEYWELL HELP IN GREEN H_2 ECONOMY
• Malaysia is the 16th largest natural gas producer in the world. It was 5th largest exporter of LNG, exporting ~27 million metric tons in 2023. • Malaysia has ~13 billion metric tons of CO_2 storage capacity, which provides it with unique advantages for producing blue hydrogen and decarbonizing electricity generation (Malaysia generates 43% of electricity from coal 37% from natural gas). • Malaysia is second largest producer of palm oil, which means large palm oil biomass for bioenergy. It has plans to increase biorefinery capacity to 3.5 billion litres by 2050 • Presence of Hydropower in Sarawak, combined with Solar & Wind, gives Malaysia an edge in producing and capturing initial growth in green hydrogen production and supply to Japan (key green hydrogen demand centre). From internal Honeywell study, green H_2 in fertilizer can reduce 30% CO_2 per ton of N in fertilizers such as ammonium nitrates. • Malaysia is utilizing its geographic proximity to Singapore (leader in green hydrogen demand in Southeast Asia) to develop hydrogen hub in Johor to meet Singapore hydrogen demand • In long term, green hydrogen can become an energy source for long haul transportation and seasonal energy storage.	• Decarbonizing refineries, biorefineries, fertilizer and chemical plants involve the deployment of low carbon and green hydrogen. Hydrogen can be deeply decarbonized right now with Honeywell's blue hydrogen solutions and the future green hydrogen industry can take advantage of Honeywell developments in catalyst and membrane technologies. • Honeywell is accelerating the development of a catalyst-coated membrane that helps to reduce the cost of green hydrogen by enabling 55% higher current density compared to commercially available CCM equating to 55% higher hydrogen production per area for proton exchange membrane (PEM) water electrolysis and 35% reduction in Electrolyser stack cost versus commercially available PEM CCM (based on Honeywell UOP lab testing and validated by OEM customers). • Purification of green hydrogen is critical for reliable, safe and cost-effective operation of the chemical plants. Honeywell's PolybedTM PSA and PolysepTM membranes provide enhanced hydrogen recovery with high product purity levels enabling faster payback and higher monetization of green hydrogen. • Honeywell's process measurement and control, grid injection solutions help assure quantity and quality of green hydrogen in the pipeline mix. • Honeywell's novel and innovative liquid organic hydrogen carriers help in the export of hydrogen and enables an efficient, effective and safer way to ship hydrogen using existing infrastructure

CARBON CAPTURE UTILIZATION AND STORAGE

As an energy producing country, there is pressing need for Malaysia to balance economic interests, energy security and environmental sustainability. CCUS can help Malaysia in meeting net zero aspiration by reducing carbon emissions, especially in hard to abate industries like steel and cement. Carbon Capture, utilization and storage (CCUS) is an important energy transition lever in the National Energy Transition Roadmap8. As per the plan, CCUS can bolster the GHG emission reduction in Malaysia by 32%, and CCUS implementation with storage capacity of between 40 to 80 Mt/y is reported to enable reduction of emissions to 176 $MtCO_2e$ by 2050 from 259 $MtCO_2e$ baseline in 2019.

NETR PROPOSED BELOW TARGETS FOR CCUS DEVELOPMENT IN MALAYSIA:

BY 2030	BY 2050
• Develop 3 CCUS hubs (2 in Peninsular Malaysia, 1 in Sarawak) • Total storage capacity up to 15 Mt/y	• Develop 3 carbon capture hubs • Total storage capacity between 40 to 80 Mt/y

While Malaysia is yet to develop a policy and regulatory framework for CCUS, Budget 2023 has introduced tax incentives for CCUS projects. Both companies undertaking in-house CCS activity and those providing CCS services qualify for an investment tax allowance of 100% of capital expenditure for a period of 10 years. Companies are also exempt from sales tax on equipment used for CCUS projects between 2023 to 2027. This approach highlights the role of CCS as a new source of economic growth and in achieving net-zero GHG emissions.

Globally, there is a growing trend towards building a robust CCUS ecosystem using a cluster or hub strategy. This method encourages emitters within the same geographic region or cluster to invest and utilize shared CCUS infrastructure, such as CO_2 pipelines and storage facilities and thereby reduce the overall cost of CCUS[41].

In Malaysia, National Oil company Petronas seeks to capitalize on its depleted offshore oilfields to position Malaysia as an international carbon storage hub. Japanese and South Korean companies have shown interest in developing cross-border projects with Petronas. Currently there are two projects in discussion: Kasawari Offshore CCUS project which is expected to be commissioned in 2025 and Lang Lebhas CCUS project for which FID is expected before end of year.

Malaysia is yet to accede to regulations such as the London Protocol and the EU CCS Directive to enable the transboundary transport and storage of CO_2. Although transboundary transport and storage of CO_2 is a potential source of growth, Malaysia has not developed its domestic policy on CCUS to allow for the integration of international regulations into domestic regulatory framework. For the seamless import and storage of CO_2 within Malaysian borders, aligning with these established international regulations is paramount.

Honeywell CCUS Technologies

Pre-Combustion: Honeywell UOP gas separation technologies have been deployed in pre-combustion CO_2 capture for more than 70 years in hydrogen plants, natural gas plants and oil refineries, with over 4000 units licensed. These technologies are described in Figure 5.1 and include Chemical Solvents (Amine & Benfield), Physical Solvents (SeparALL™ Process), Polybed™ Pressure Swing Adsorption (PSA) System, Separex™ Membrane Systems and Ortloff CO_2 Fractionation and can enable cost effective, scalable production of low carbon intensity hydrogen

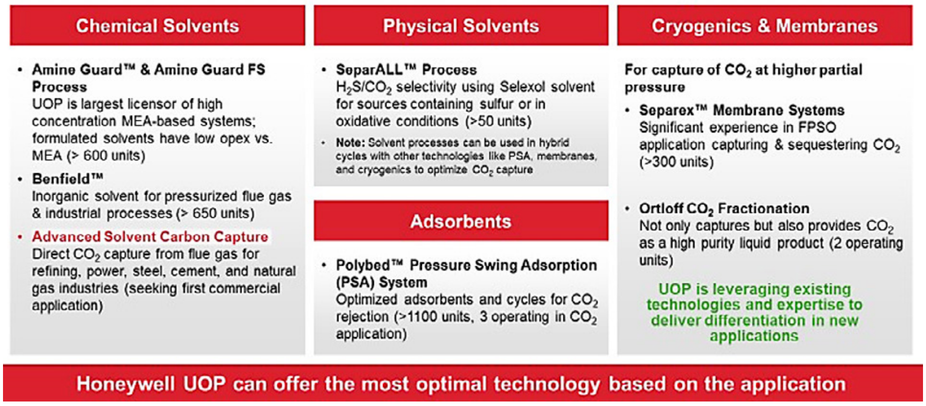


Figure 5.1 Honeywell CO_2 Solutions

Post Combustion: Honeywell UOP's Advanced Solvent for Carbon Capture technology can be applied to any fuel combustion emission point and is shown in Figure 5.2. This proprietary solvent-based CO_2 capture system, developed in partnership with the University of Texas in Austin in the United States, is specifically designed to address these streams with high volume, low pressures, low CO_2 concentrations (anywhere from 4% to 20%), and high oxygen concentrations.

Post-combustion carbon capture is harder and more expensive than pre-combustion capture from large, concentrated sources of carbon dioxide such as blue hydrogen plants, ammonia plants and ethanol plants, but has several unique benefits:

- Can be applied to natural gas fired turbines to deliver low carbon-intensity dispatchable electric power for peak use.
- Can be applied to coal-fired power plants to extend the life of major capital assets.
- Can be applied to biomass-fired power plants and industries to achieve net-negative CO_2 emissions.
- Can be applied to cement plants and steel plants to address both process and heating emissions.
- Can be deployed across multiple smaller sites using a hub and pipeline system.

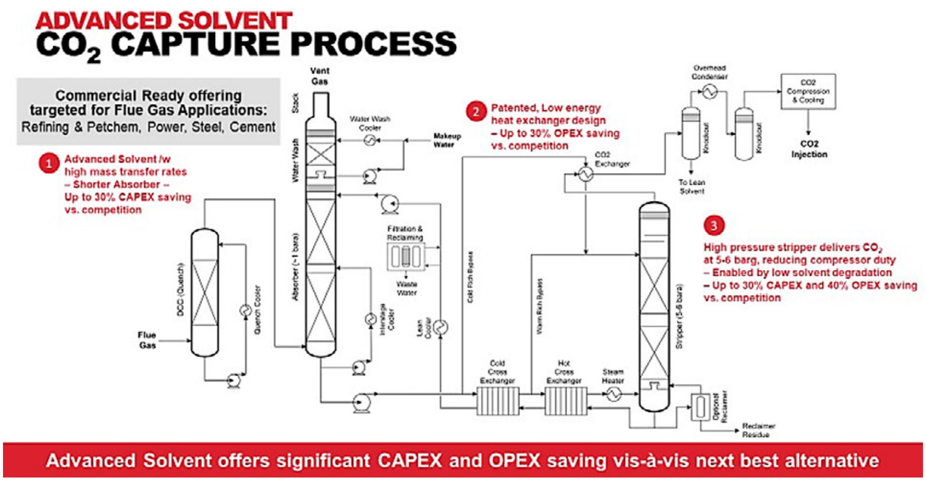


Figure 5.2 Honeywell UOP Advanced Solvent Carbon Capture

METHANE EMISSIONS

There is a growing recognition that methane plays a critical role in global warming due to its high greenhouse gas equivalency compared to carbon dioxide. Releasing 1 kilogram of methane is equivalent to releasing 84 kilograms of CO_2, on a 20-year Global Warming Potential basis. It is estimated that Methane has contributed up to a third of net warming since the Industrial Revolution[42]. During COP[26] in 2021 the Global Methane Pledge (GMP) was therefore jointly launched by the European Union and the United States. Many countries have joined this pledge, either immediately or subsequently, with the latest number of participants reported as 158 in March 2024[42].

Malaysia was an early signatory to the GMP in 2021, and its commitment to reducing methane emissions has been reaffirmed since, including by the Prime Minister YB Anwar Ibrahim during the Energy Asia event in June of 2023[43]. As noted herein, Malaysia has strategic resources, including natural gas as a transition fuel and palm derived products as a sustainable feedstock, which form an integral part of its decarbonization strategy. To ensure that these resources can be applied most optimally to reduce the carbon intensity of Malaysia's economy, addressing potential methane impacts remains critical.

Furthermore, to leverage growth in the production of more environmentally conscious products and energy as a key export vector, Malasia should consider the emphasis being placed on methane as part of the embedded carbon of such products, most recently demonstrated by inclusion in the proposal for a Delegated Act on Low Carbon Fuels in Europe. As a major producer and exporter of natural gas, Malaysia also benefits from addressing methane emissions because the saved methane can be used or sold for profit. Tackling methane emissions is thus one of the most economically attractive ways Malaysia can reduce its carbon footprint.

Implementing a methane emissions control plan for industrial and gas production sites involves:

- Reporting credible methane measurement data.
- Managing emissions levels for flaring, combustion, venting, and fugitive sources.
- Taking action to address continuous leak sources or when emissions events occur.
- Ensuring compliance to evolving regulatory and voluntary disclosures.

When these steps are implemented, gas producers and processors can validate the integrity of their assets and prove that they are not contributing to methane emissions.

Honeywell Emissions Management Suite

Honeywell has developed a portfolio of offerings to help our customers address methane emissions (see Figure 5.3). We have technologies that measure, monitor, report and reduce greenhouse gas emissions. Our approach to continuous measurement supports data accuracy, early detection and remediation, stakeholder transparency, and actionable insights. Once a baseline is firmly established, operators can measure meaningful progress toward reduction goals at site, source, region or enterprise level.

Our methane measurement system begins with sensors for active and passive detection of GHG leaks. Honeywell Versatilis™ Signal Scout™, is a new innovative gas leak detection technology for methane emissions monitoring across industries. Versatilis sensors can be mounted around a plant or site and will activate whenever a leak is detected. Communication is based on LoRaWAN® protocol for large area coverage. The compact and aerodynamic design is coupled with easy installation and commissioning for quick deployment in the field and has HAZLOC Area Certification.

Rebellion Gas Cloud Imaging Cameras (GCI) can then be used to accurately pinpoint the source of leaks as well as quantify the leakage rate. Honeywell has a decade of experience in advanced hyperspectral gas imaging systems for the oil and gas, petrochemical and power industries. Rapid visual verification of gas leaks, as well as the size and direction of the plume, provides the visualization of data needed to help with environmental monitoring efforts. Rebellion cameras provide wide area/ site level coverage and can monitor 20+ greenhouse gases including methane.

The Honeywell Forge Sustainability+ for Industrials | Emissions Management software platform is an enterprise-level Software-as-a-Service (SaaS) platform that integrates both Honeywell and third-party measurement devices, or other data sources, to give rapid reconciliation or comparisons between measurement methods for verification, ensuring auditability for mandatory and voluntary reporting disclosures.

Once a site or business has established a baseline emissions profile, the operator can measure progress towards reduction goals at the source, site, region, or enterprise level. Honeywell offers a range of products that help optimise processes and reduce emissions, including combustion control and systems solutions, proactive leak management, energy efficiency through Advanced Process Control (APC), Asset Performance Management (APM) and process optimisation, and outcome prediction with Digital Twin technology.

PETRONAS has been an early adopter and demonstration partner in deployment of several of these technologies[38] and has demonstrated their potential to track methane emissions in real time[39].

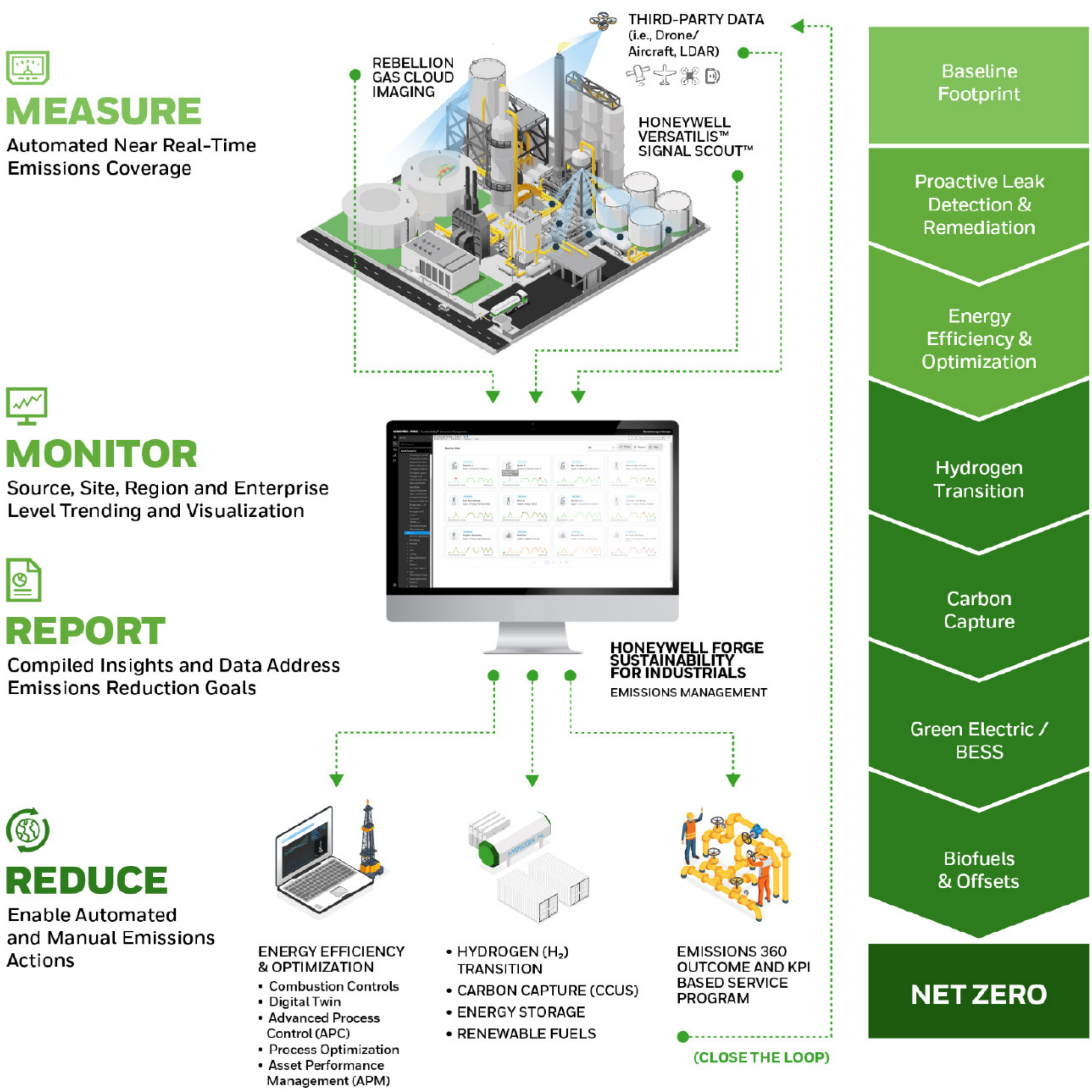


Figure 5.3 Honeywell Emissions Management Suite

MANUFACTURING

Malaysia maintains a healthy net export balance of trade and manufacturing of goods and commodities plays a significant role in supporting these exports. Integrated circuits and electronics, machinery, refined petroleum and gas, palm oil and aluminum are just a few examples of top exported products and commodities. However, the onset of regulations in these sectors pertaining to sustainability and shift towards net zero economy (e.g., the EU Green Deal, EU Taxonomy, EU Carbon Border Adjustment Mechanism, European Sustainable Products Registry, US IRA etc.), is incentivizing product imports with lower carbon footprint. Over and above the need to ensure decarbonization of industry to meet its own obligations, it is critical for Malaysia to develop an actionable roadmap to decarbonize the manufacturing sector and ensure its competitiveness in the export of sustainable products and goods. There are already several Green Industrial Parks and Net Zero Industrial Zones under development in Malaysia. The challenge is to make these zones viable and impactful, so as to move from traditional real estate plays to sustainability value-add plays.

Industrial Clusters: Malaysia has already set up industrial free trade zones (FTZ) and special economic zones (SEZ) across the country. This has brought in convergence in multiple models of development by central government and state governments including private sectors for driving cost efficiency. Furthermore, schemes such as Smart Automation Grants, Green Technology Financing Scheme, Investment Strategic Fund, and other similar schemes have ushered in continuous reforms through technology upgrades, sharing of advanced manufacturing practices, quality management and development of common infrastructure such as R&D labs and skill development centres. More specifically, there is a comprehensive roadmap for developing manufacturing as specified in the New Industrial Masterplan 2030 (NIMP)[30] and specific sector roadmaps in E&E and aerospace. Some of the well-known industrial clusters include E&E in Penang, Automotive cluster. Industrial clusters are connected to industrial corridors aimed for the development of futuristic industrial townships which can compete with best manufacturing and investment destinations in the world.

FTZ: FTZ are demarcated geographic areas that are subject to specific economic regulations including economic incentives and duty-free imports which make it easier for conducting manufacturing operations for export-oriented markets. Malaysia is home to 22 Free Industrial Zones (FIZ) and 24 Free Commercial Zones (FCZ). Some of the more renowned FIZs include the Bayan Lepas FIZ and Seberang Perai FIZ in Penang, the Pasir Gudang FIZ in Johor, the Port Klang Free Zone in Selangor. States with significant FIZ activities Penang, Selangor and Johor contributed 70% of Malaysia's exports[31]. Developing a clear path to net zero and implementing sustainability engineering practices in FTZs is critical to maintaining their attractiveness for investment and can also be a driver of high-value exports.

Medium and Small Manufacturing Enterprises (MSMEs): This has emerged as a vibrant and dynamic sector of the Malaysian economy contributing to the economic (RM150 billion worth of export) and social development (7.8 million workforce) of the country by promoting entrepreneurship and generating large scale employment opportunities at lower capital cost[32].

The next stage of Malaysia's industrial development will require increases in worker productivity, and value-add. These two objectives can be achieved with meaningful and sustained investments in automation and productivity, innovation, and, at the same time, increasing the use of renewable materials, energy and processes, circularity and decarbonization, as sustainable products are increasingly being mandated in export markets. It is critical for the government to support the ongoing advancement of the MSME sector by creating incentives for them to modernize their operations so that they maintain international competitiveness.

WHAT SHOULD THE GOVERNMENT OF MALAYSIA BE DOING NOW TO ACCELERATE DECARBONIZATION OF THE INDUSTRIAL SECTOR?

- Set Net Zero goals and timelines for Industrial clusters and FIZs with clearly defined and measurable interim milestones, ensuring the future competitiveness of Malaysia as a manufacturing centre.
- Setup sustainable parks akin to electronic and IT for manufacturing of components related to green hydrogen such as fuel cells, electrolyzer, etc. so as to maximize the "Made in Malaysia" components used in Malaysia's energy transition.
- Identify pilot industrial clusters and FIZs that have geographic advantages for access to renewable energy, industrial freight corridors and ports and that can show noticeable sustainability benefits and spur wider industrial adoption of technologies such as green hydrogen, liquid organic carriers and carbon capture.
- Mandates for introduction of low carbon-intensity hydrogen production by 2030 in refineries, fertilizer plants and applicable heavy industry to incentivize sustainability practices and accelerate the development of shared decarbonization infrastructure based on Malaysia's favourable geology and gas processing expertise.

CONCLUSIONS

Malaysia is committed to its ambition of achieving net zero by 2050. It plans to achieve this by an evolutionary and flexible strategy of international cooperation through climate funding, technology development and transfer while transitioning into a high-income economy, ensuring energy security, supporting economic and population growth and rationally using the bestowed natural resources. Though the path to net zero is daunting, it is achievable through a combination of impactful policies, their rigorous implementation and adoption of ready-now sustainable technologies. Malaysia has already developed meaningful policy documents such as the NETR, HETR, NIMP2030, Smart Cities Framework and others. As the country advances its net zero journey, the policies will take centre stage in driving the green energy transition. The challenge is in the doing.

With the right set of policies and synergies across sectors, the country can systematically speed up technology development, commercialization, and adoption of low-carbon goods and services across the economic value chain. A robust policy framework and its phase-wise implementation can be a key driver to building and deploying necessary infrastructure to enable wider social and economic impact. There are already a number of mature technology options that are ready now for deployment and can be leveraged to accomplish this, many of which are provided by Honeywell and discussed in this paper.

Malaysia has a geo-strategic advantage in terms of access to natural resources. Coupling this with ready now technologies such as carbon capture, utilization and / or storage, solar-powered micro grids, Hydrogen and renewable fuels can enable Malaysian manufacturing to be globally competitive while achieving world-leading low carbon intensity. By leveraging abundant palm oil resources, in conjunction with world class sustainable development and harvesting practices, Malaysia is uniquely positioned to produce low carbon fuels to drive deep decarbonization of transportation, including regional aviation, and to create value added export products. Conversion of smart cities into sustainable cities can aid in the delivery of low-carbon municipal services and build resilience in urban infrastructure. Finally, lifestyle choices that extend beyond personal well-being to include positive environmental choices and commitment towards energy conservation, water stewardship, sustainable foods and waste reduction can substantially reduce environmental impact.

Honeywell is well positioned to partner with the federal and state governments and industries to offer its broad portfolio of offerings to help drive the path to net zero at a faster pace in an economically viable manner. Honeywell has made substantial investments in development of sustainability-oriented technologies to reduce environmental impacts, such as in the areas of CO_2 capture, hydrogen, renewable fuels / SAF, energy storage and emissions management. In Malaysia, Honeywell has strong engineering expertise and market presence with 1,000 staff in Kuala Lumpur and Penang. Together we can enable the development of an ecosystem in Malaysia that is safer, healthier, more energy-efficient, more resilient and more economically viable.

APPENDICES

GLOSSARY AND TERMINOLOGY

The following terms are widely used (and misused) in discussions of climate change and climate modeling.

Anthropogenic greenhouse gas emissions: emissions of greenhouse gases due to human activity, i.e., excluding natural sources, but not excluding agriculture and land use impacts.

AR = Assessment Report: periodic reports issued by the Intergovernmental Panel for Climate Change (IPCC), summarizing the consensus state of scientific opinion on the extent, impact and potential mitigation of global warming.

Battery electric vehicles (BEV): electric vehicles that run solely on battery power and do not consume liquid transportation fuels. Often confounded with plug-in hybrid electric vehicles (PHEVs) that can consume significant amounts of liquid hydrocarbon fuel depending on how they are operated.

Carbon capture and storage (CCS): collection of carbon dioxide from any source and permanent sequestration of the carbon dioxide in geological storage so that it does not enter the atmosphere.

Carbon capture, utilization and storage (CCUS): collection of carbon dioxide from any source followed either by geological sequestration (CCS) or conversion of the carbon dioxide into durable materials that are not subsequently combusted with re-release of the carbon dioxide to the atmosphere.

Carbon dioxide equivalent (CO_2e): the equivalent amount of carbon dioxide that would cause the same global warming impact. This is a measure used to report other GHG emissions on a carbon dioxide equivalent basis and allows for the fact that other GHGs can have stronger warming effects or be more persistent in the atmosphere.

Carbon footprint: shorthand term used for carbon dioxide emissions footprint (more strictly GHG emissions footprint) – the carbon dioxide emissions associated with a given activity.

Carbon intensity of energy: shorthand for carbon dioxide intensity (or more strictly GHG intensity) of energy. The amount of CO_2 (strictly CO_2e, including actual carbon dioxide as well as other GHG on a carbon dioxide equivalent basis) emitted per unit energy consumed.

Carbon-negative technology: strictly, GHG emissions negative technology. Applies to any technology that permanently removes more GHG from the atmosphere than the entire carbon footprint associated with installation, operation and decommissioning of the technology over the entire service life of the technology.

Carbon-neutral: widely used but imprecise term, strictly meaning carbon dioxide emissions neutral. Since all activities that consume energy or materials have some emissions impact, the term carbon-neutral strictly applies only to systems that have offset all their GHG emissions footprint with an equivalent amount of permanent carbon dioxide sequestration from the atmosphere.

Clean hydrogen: defined in the US Federal Infrastructure bill and Clean Hydrogen Production Incentives Act of 2021 (S.1017) as "hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced". Note that steam methane reforming typically produces about 7 kg CO_2 per kg H_2, so the US definition of clean hydrogen requires at least 72% carbon capture and sequestration if applied to conventional hydrogen production.

Decarbonization: strictly, "removal of carbon from". Generally used in the context of decarbonization of the energy supply. Note that it is correct to say "decarbonization of the energy used for light duty transportation", implying the continued use of light duty transportation with energy sources that do not contain carbon, but it is incorrect to say "decarbonization of gasoline" as gasoline intrinsically contains carbon. Note also that decarbonization describes any level of removal of carbon. We therefore use the term "full decarbonization" to describe the complete removal of carbon from a particular energy supply.

Direct air capture (DAC): strictly, direct air capture of carbon dioxide. CCS or CCUS applied to carbon dioxide that is already in the atmosphere, thereby actually reducing the atmospheric concentration of carbon dioxide.

Energy efficiency: the proportion of energy consumed that is converted into useful mechanical work or required heat, as opposed to waste heat or other non-usable forms of energy.

Greenhouse effect: global warming caused by the accumulation of anthropogenic greenhouse gas emissions in the atmosphere.

Greenhouse gases (GHG): gas species such as carbon dioxide, methane, nitrogen oxides and some fluorinated gases that absorb infra-red radiation and consequently reduce the ability of the earth to cool itself by radiation to outer space.

Heavy goods vehicles (HGVs): large vehicles such as heavy trucks and locomotives used for freight applications, service and utility vehicles such as buses, garbage trucks, etc., and off-road special-purpose vehicles used in farming, construction, mining, forestry and other industrial activities.

Levelized cost of electricity (LCOE): cost of production of delivered electricity including capital and operating costs over the full life of an electricity producing or storage asset.

Light duty vehicles (LDVs): small vehicles such as cars, motorcycles, small vans, light trucks and SUVs, primarily used for personal transportation.

Low-carbon energy: strictly "lower carbon energy". Energy sources that have reduced GHG emissions when compared to conventional energy sources used in the same application.

Nationally determined contribution (NDC): the goal that a country that has signed the Paris Agreement on climate change sets for reducing its GHG emissions.

Net-zero emissions: strictly, net-zero GHG emissions. Somewhat stricter than carbon-neutral, a net zero GHG condition applies to a system that has offset all GHG emissions with an equal amount of carbon dioxide sequestration from the atmosphere.

Renewable energy: energy sources that are replenished by solar power or heat from the earth's core over non-geological timescales. This term can be used for wind power, wave power, solar power, hydroelectric power, geothermal power, ocean thermal power and energy from biomass sources that are grown sustainably.

SRES (Special Report on Emissions Scenarios): initial techno-economic modeling framework developed by IPCC Working Group 3 to predict the impact of economic and technical development on future GHG emissions. The SRES set of scenarios were used in IPCC AR3 and AR4 and subsequently replaced by SSP scenarios that allowed prediction of outcomes more consistent with the goals of the Paris Agreement.

SSP (Shared Socioeconomic Pathway): generically a term for any of a set of techno-economic scenarios that lead to similar final climate outcomes. More specifically used with a number (e.g., SSP3) to describe one of the five SSPs used by IPCC Working Group 4 to map future scenarios consistent with the goals of the Paris Agreement in IPCC AR5 and AR6. The IPCC SSP scenarios all allow for GHG removal from the atmosphere in the latter half of the 21st century using as yet undeveloped GHG-negative technology, to reverse the effect of GHG emissions to date.

Sustainable aviation fuel (SAF): strictly, a paraffinic jet fuel feedstock derived from sustainable biomass sources that can be blended 50% with conventional petroleum jet fuel to meet the Jet A specification for commercial jet fuel in accordance with ASTM D7566. More recently, the term "100% SAF" is being used to describe aviation fuels that are 100% derived from biomass sources, but still able to comply with the Jet A specification owing to the incorporation of an aromatic component derived from biomass in the blend so as to meet the aromatics and lubricity requirements of jet fuel.

Sustainable distillate fuel: a distillate range fuel (kerosene, jet or diesel) derived from sustainable biomass sources.

WG: Working Group refers to the three working groups of the IPCC climate change assessment. WG1 studies the scientific basis of global warming. WG2 addresses impacts on society and ecosystems and adaptation. WG3 addresses mitigation approaches.

Zero-emissions process: strictly, a technology that captures and sequesters an amount of GHG emissions sufficient to offset all the GHG emissions associated with installation, operation and decommissioning of the technology.

MALAYSIA'S EMISSION INVENTORY[9]

SECTOR	CATEGORY	EMISSION TYPE	% CONTRIBUTION
Energy	Main Activity Electricity and Heat Production	Combustion	33.3%
	Petroleum Refining	Combustion	2.5%
	Manufacture of Solid Fuels & Other Energy Industries (LNG)	Combustion	4.2%
Manufacturing, Industries and Construction	Iron and Steel	Combustion	2.9%
	Non-ferrous Metals	Combustion	0.1%
	Chemical	Combustion	1.1%
	Pulp, Paper and Print	Combustion	0.3%
	Food Processing, Beverages and Tobacco	Combustion	1.9%
	Non-Metallic Minerals	Combustion	2.4%
	Transport Equipments	Combustion	0.8%
	Machinery	Combustion	0.1%
	Wood and Wood Products	Combustion	0.1%
	Textile and Leather	Combustion	0.3%
	Non-specified industry	Combustion	0.2%
Transport	Domestic Aviation	Combustion	0.4%
	Road Transportation	Combustion	16.8%
	Railways	Combustion	0.0%
	Domestic water-borne Navigation	Combustion	1.7%
	Off road	Combustion	0.7%
Other sectors	Commercial / Institutional	Combustion	0.5%
	Residential	Combustion	0.5%
	Agriculture, Forestry,Fisheries, Fish farms	Combustion	0.8%
Non specified	Mobile	Combustion	0.1%
Fugitive emissions	Solid fuels	Fugitive	0.0%
	Coal mining and Handling	Fugitive	0.0%
	Oil and natural gas	Fugitive	6.8%
Mineral Industries	Cement production	Process	2.8%
	Glass production	Process	0.1%
	Other Process Uses of Carbonates	Process	0.1%
Chemical Industries	Ammonia production	Process	0.4%
	Petrochemical and Carbon Black Production	Process	1.4%
Metal Industry	Iron and Steel	Process	2.3%
	Ferroalloy	Process	0.5%
	Aluminum	Process	1.2%
	Integrated circuit or semiconductor	Process	0.1%
Electronics industry	Semi conductors	Process	0.4%
	Photovoltaics	Process	0.3%
Product Uses as Substitutes for Ozone Depleting Substance	Mobile Air Condition	Process	0.3%
Agriculture	Enteric Fermentation	Fermentation	0.4%
	Manure Management	Fermentation	0.2%
	Urea Application	Fermentation	0.1%
	Direct N20 Emissions from Managed Soils	Fermentation	1.1%
	Indirect N20 Emissions from Managed Soils	Fermentation	0.3%
	Indirect N20 Emissions from Manure Management	Fermentation	0.2%
	Rice Cultivation	Fermentation	0.7%
Wastes	Solid Waste Disposal Sites	Fermentation	3.5%
	Domestic Wastewater Treatment and Discharge	Fermentation	0.6%
	Industrial Waste Treatment	Fermentation	4.4%

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WPR-24-02-EN | 10/24

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