IT1394

Visual Analytics Project

Final Report

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Summary

The purpose of this project is to determine whether the hypothesis "Singapore is committed to implementing a sustainable future." is true. To do so, the five SG Green Plan Pillars (City in Nature, Energy Reset, Sustainable Living, Green Economy, Resilient Future) were researched by different group members. Key stakeholders of this project include sustainability specialists, policymakers and Singaporeans who are concerned about sustainable practices. They would like to measure sustainability in terms of carbon footprint, recycling rate, total greenery, factors contributing to energy production and food security.

After collecting related datasets and analysing them via data visualisation, it was discovered that Singapore is committed to planting more trees to mitigate the negative effects of global warming. Additionally, Singapore has been focusing on adopting solar energy as part of its sustainable future, setting the target of 2 gigawatt-peak solar energy deployment by 2030, which after analysis, seemed to have a high chance of meeting the target. The total carbon footprint of motor vehicles has remained relatively stagnant over the last 10 years and the general recycling rate of waste materials has increased slightly over the years. Furthermore, Singapore is committed to mitigating overall temperature increase through greenery provision through the process of evapotranspiration.

Some recommendations include identifying areas in which Singapore needs more green provision, speeding up the process of integrating electric vehicles into Singapore's transportation scene, increasing its network of energy imports and continuing to increase the quality of farms by increasing the investment in local production.

Project Plan

Each member was to research and perform data visualisations for their respective Green Plan Pillars to facilitate greater efficiency in producing results for this project.

Member	SG Green Plan Pillar
Brendon	City in Nature
Rui Hong	Energy Reset
Winston	Sustainable Living
Jia Hao	Green Economy
Derron	Resilient Future

Fig. 2.1: Delegation of Pillars

In the development stage, Excel was used to store datasets, which were then imported into Power BI for data visualisation.

The figure below depicts the project schedule and task allocation in this project.

• Approach & Timeline
  - Week 12-13
    - Collection of Business Requirements, Datasets required
  - Week 14
    - Data Cleaning, Data Modelling in Power BI
  - Week 15
    - Data Visualisation
  - Week 16
    - Making of Individual Data Preparation Report
  - Week 17
    - Preparation for Final Presentation + Integration
  - Week 18 - Completion of Final Report

Fig. 2.2: Project Scheduling

Data Understanding, Visualisation and Modelling

Datasets had to be chosen for data visualisation and modelling. The following table collates all the datasets chosen for each pillar.

Pillar	Datasets
City in Nature	• https://tablebuilder.singstat.gov.sg/table/TS/M870341 • https://www.nparks.gov.sg/portals/annualreport/facts-and-figures/index.htm • https://tablebuilder.singstat.gov.sg/table/TS/M890861 • https://www.nparks.gov.sg/about-us/annual-reports/nparks-annual-report-archives • https://tablebuilder.singstat.gov.sg/table/TS/M890191#

Energy Reset	• https://tablebuilder.singstat.gov.sg/table/TS/M890841
	• https://www.kaggle.com/datasets/ariohakhamanesh/singapore-building-energy-performance
	• https://www.ema.gov.sg/resources/singapore-energy-statistics
	  ○ 2.2
	  ○ 2.4
	  ○ 6.1

	○ 6.2
Sustainable Living	• https://www.nea.gov.sg/docs/default-source/default-document-library/waste-and-recycling-statistics-2¬017-to-2021.pdf • https://www.nea.gov.sg/docs/default-source/our-services/waste-management/wastestats-2003-20164197a3fd04d34770bafba09393d0fdf0.pdf • https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/statistics/pdf/PT_Ridership_Yearly_2015-2022.pdf • https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/statistics/pdf/MVP01-1_MVP_by_type.pdf • https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/statistics/pdf/Rail_Length_2021.pdf • https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=typical%20passenger%20vehicle%3F-,A%20typical%20passenger%20vehicle%20emits%20about%204.6%20metric%20tons%20of,8%2C887%20grams%20of%20CO2 • https://ourworldindata.org/travel-carbon-footprint • https://www.zemo.org.uk/assets/reports/Van%20CO2%20Final%20Report.pdf • https://www.researchgate.net/publication/289658304_Freight_transport_in_Singapore_-_Current_status_and_future_research#:~:text=The%20results%20suggest%20an%20average,230%20km%20for%20prime%20movers.
Green Economy	• https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter1 • https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter6 • https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter7
Resilient Future	• https://tablebuilder.singstat.gov.sg/table/TS/M890191 • https://www.nparks.gov.sg/about-us/annual-reports/nparks-annual-repor

	t-archives • https://www.sfa.gov.sg/docs/default-source/publication/sg-food-statistics/singapore-food-statistics-2021.pdf • https://www.sfa.gov.sg/docs/default-source/publication/sg-food-statistics/singapore-food-statistics-2022.pdf • https://tablebuilder.singstat.gov.sg/table/TS/M890721

Fig. 3.1: Datasets by Green Plan Pillars

Afterwards, dashboards and statistical models were made for each pillar.

City in Nature

The City In Nature pillar focuses on having harmonious integration between urban development and natural ecosystems. Instead of viewing cities and nature as separate entities, it promotes the idea of creating urban environments that coexist in balance with the surrounding natural world. This approach prioritises sustainability and green spaces, to enhance both human well-being and environmental health within urban areas.

There are 3 pages relating to City In Nature in the Power BI report - Climate Change, Healthcare and Greenery map. These pages will help prove or disprove the hypothesis and the sub-hypothesis, whether Singapore is committed to implementing a sustainable future.

Climate Change:

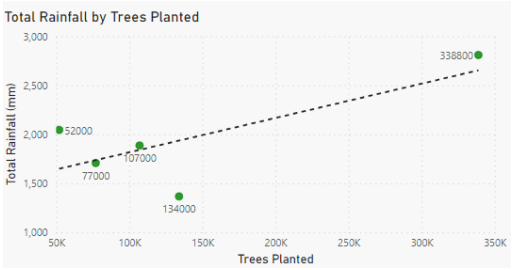


Fig. 3a.1

As seen in Fig 3a.1, the statistical model shows how having more trees will lead to an increase in rainfall. This is essential as it explains how when more trees are planted, there is more rainfall. After the green plan started, more than 200,000 trees were planted, greatly increasing the total rainfall. This is very positive and shows how Singapore is committed to implementing a sustainable future. More rainfall will help to regulate temperature by cooling the air and surfaces. During rainfall, heat is absorbed providing a cooling effect. Increased rainfall also supports the growth of vegetation. Plants absorb carbon dioxide during photosynthesis, this helps to reduce the concentration of greenhouse gases in the atmosphere, mitigating climate change which is an essential component of promoting sustainability. Additionally, having high rainfall helps to ensure crop growth, sustains livestock and supports food production. Increased agricultural productivity contributes to food security and economic sustainability. In Figure 3a.1, you can see there are about 30,000 more trees planted, from 107,000 to 134,000 but a lower rainfall. Climate systems are complex with various factors influencing precipitation patterns. Other factors which might have affected this anomaly are wind patterns,

temperature and geographical features that can counteract the positive effects of tree planting.

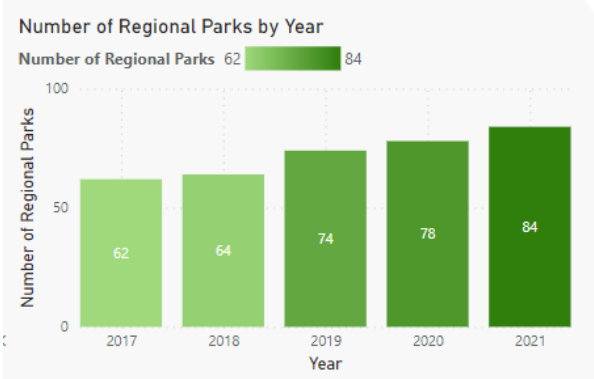


Fig. 3a.2

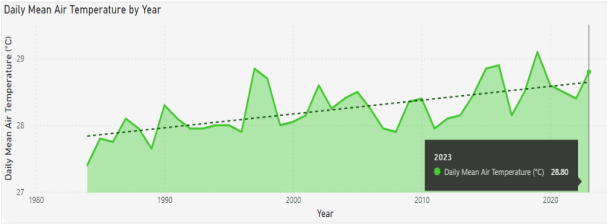


Fig. 3a.3

As seen in Fig 3a.2, the bar graph shows the number of parks that have been created over the years. Even though Singapore is a small country, the government still pushes the idea of always having more greenery and more parks around Singapore. In 2021, when the green plan started, most parks were created. Having more parks definitely will help slow down the increase in air temperature. More parks and greenery correlate with the slowing down in air temperature. With more parks and greenery, means more carbon dioxide can be taken in. Less carbon dioxide means the atmosphere is less warm, resulting in lower air temperatures. In Fig 3a.3, you can see only a gradual increase in air temperature. Trees can only do so much in helping to reduce carbon dioxide emissions, and can only slow down how much our air temperature increases. Industrial use will never stop and will only continue to increase. Thankfully, with more parks and greenery, our air temperature is not a steep increase but only a gradual one. With more parks and greenery created by Singapore, it will help slow down the increase in our air temperature, mitigating climate change which promotes sustainability.

<u>Healthcare:</u>

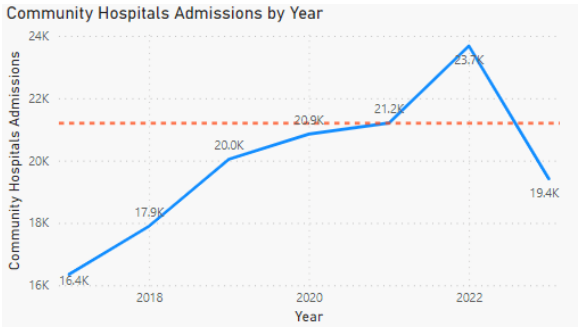


Fig. 3a.4

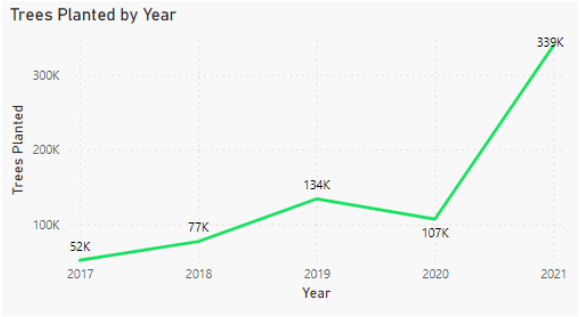


Fig. 3a.5

Fig. 3a.4 and Fig. 3a.5 are linked together to explain the whole picture. From Fig 3a.4, you can see the number of community admissions per year. From Figure 3a.5, you can see the number of trees planted per year, notably in 2021 when the tree plan started, and how much of an increase there is. Trees take time to fully develop and only after a few years will we begin to see the true benefits of the trees. After

2021, about 2 years later, do we see the true benefits of how trees help with people's health? In Fig 3a.4, you can see how from 2021 to 2022, there is a steep increase in admissions, but do not be alarmed as that is when there was a rise/increase in COVID-19 cases causing this increase. However, you can see that not only in 2023 is there a sharp decrease, but comparing 2021, before the rise of COVID-19 cases, and 2023, you can see there were fewer cases in 2023 than in 2021, about 2000 fewer cases. Instead of the cases being around the same as in 2021, there was a much further decrease through my visuals, you can see after the 2 years of development in the trees from 2021, the trees help with people's health, making them less prone to visit the hospitals. When more people are healthier, living healthier, and visiting hospitals less frequently, it places less strain on healthcare systems, reducing resources and contributing to sustainability. Moreover, healthier individuals will mean more productivity in the workforce and enhanced productivity supports economic sustainability by fostering stable and thriving communities.

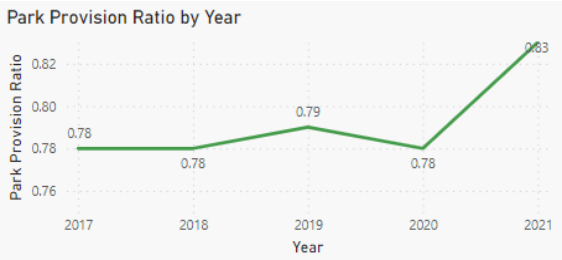


Fig. 3a.6

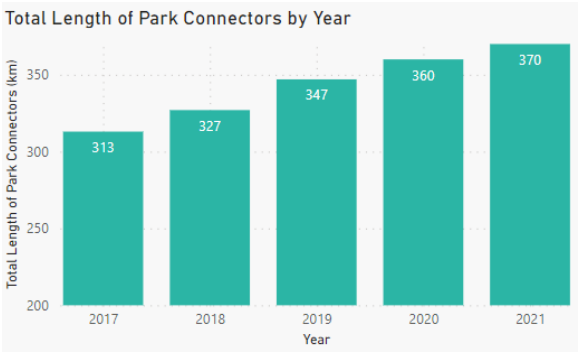


Fig. 3a.7

As seen in Fig. 3a.6, it shows the park provision ratio each year. Park provision ratio refers to the measurement or calculation used to assess the availability and accessibility of parks and green spaces within an area relative to the land size area or population. After the green plan started, there was a big increase in the park provision ratio, from 0.78 to 0.83. This shows how Singapore is committed to having more green spaces around Singapore. With a higher park provision ratio, it also explains why there is a decrease in hospital admissions. With fig. 3a.7 further proves that having more park connectors, increasing the lengths of park connectors, and more greenery in Singapore all help in a sustainable future. Since more people will have access to greenery, parks, and park connectors, more people will be able to also use these green provisions to exercise and foster healthier living. This not only places less strain on healthcare systems, reducing healthcare resources with the lowering of hospital admission due to the increase in healthier Singaporeans, but it also fosters a long-term perspective on societal well-being. Singapore can then prioritise investments in education, infrastructure and social services that promote health and sustainability over the long term.

Greenery map:

Fig 3a.8

As seen in Fig 3a.8, shows a map of the parks which are in bubbles colour-coded by their respective regions. This map shows how many parks there are in Singapore, and how much Singapore is committed to having more parks and greenery around Singapore. With how there are so many parks scattered around Singapore, more people will have access to parks for them to exercise or even just be around, and this promotes healthier living and better air quality too. This will help them to live a healthier life, making them less prone to visiting hospitals, placing less strain on healthcare systems which reduces healthcare resources, ultimately contributing to sustainability.

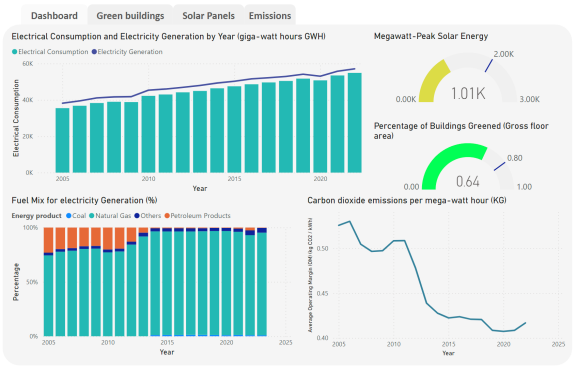
Energy Reset

The energy reset pillar focuses on using cleaner energy sources across all sectors by employing methods such as adopting solar renewable energy and increasing energy efficiency by reducing emissions.

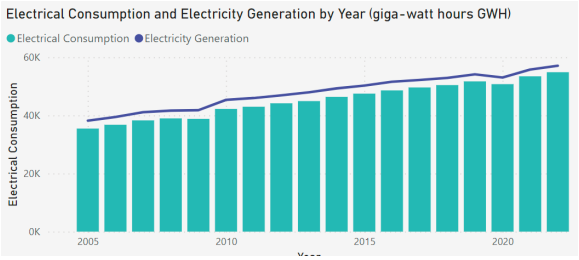
The methodology involves using directly quoted goals in the energy reset pillar and utilising key metrics to measure the current progress and even future possible outcomes of the goal. These metrics will determine if Singapore will meet their desired target within a specific timeframe. Additionally, other visualisations that may not be directly quoted in the green plan, but briefly mentioned will also be considered in decision-making as they also play a part in implementing a sustainable future.

Given the sub-hypothesis for the Energy Reset Pillar, 2 key goals were highlighted for analysis, one is at least 2 giga-watt peak energy deployment by 2030, and another is greening 80% of buildings by gross floor area by 2030.

There are 4 pages dedicated to this pillar - dashboard, green buildings, solar panels and emissions.

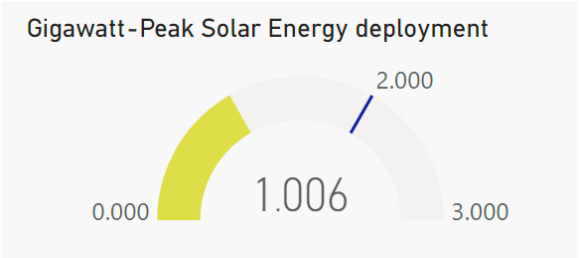


Dashboard: The dashboard shows key insights and important data points across multiple pages or reports. By compiling information into a single page, the dashboard allows viewers to quickly grasp the most relevant and impactful aspects of the data without needing to navigate through each page.

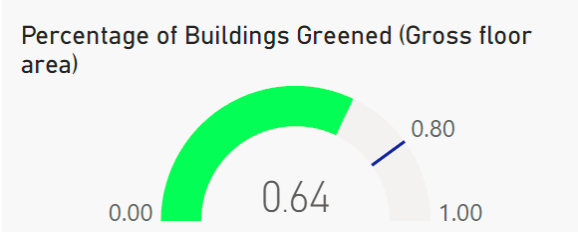


This visual shows the electrical consumption and generation across the years. This gives viewers a quick understanding of Singapore's current energy usage, and assesses its sustainability and effectiveness as they compare this against other visuals

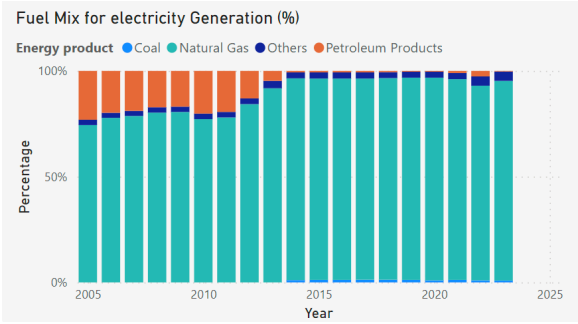
This chart shows a stable increase in electrical consumption and generation, which is to be expected due to the growing population of Singapore. This stability is noteworthy during the Circuit Breaker, whereas a significant portion of the population remained at home in 2020. The absence of anomalies during such a period highlights sustainable energy infrastructure in Singapore.



Quoted from the Singapore Green Plan 2030, one of the proposed goals in the energy reset pillar is: "Our aim is at least 2 gigawatt-peak of solar energy deployment by 2030, which can generate enough energy to meet the annual electricity needs of around 350,000 households. This gauge shows Singapore's current gigawatt-peak solar energy deployment. As seen from the gauge, Singapore is at the halfway mark on reaching its desired target of "at least 2 gigawatt-peak of solar energy deployment by 2030".Further analysis on this would be done under the solar panel page to measure the possibility of reaching their desired goal.



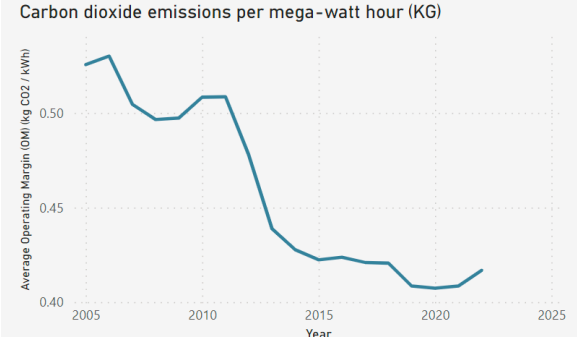
Quoted from the Singapore Green Plan 2030, another proposed goal under green buildings in the energy reset pillar is:" Stepping up the pace to green 80% of our buildings (by gross floor area) by 2030".This gauge shows Singapore's current progress in greening its buildings, with 64% of the gross floor area having been greened.This shows that Singapore is close to meeting its desired target of 80%, and more information will be shown under the green buildings page.



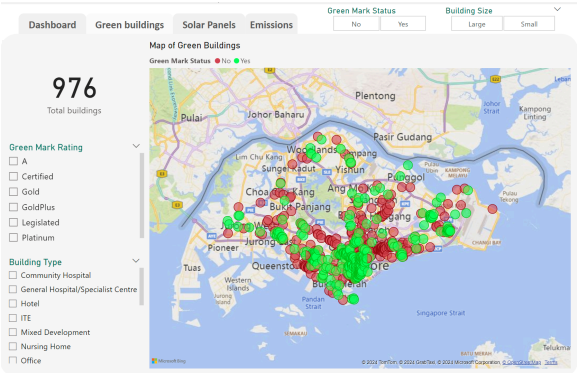
This visualisation shows the fuel mix for electricity generation, intending to significantly increase the utilisation of natural gas, which is considered a cleaner energy source. Over the years, there appears to be a consistent trend towards the predominant use of natural gas as a primary fuel for electricity generation.

In 2022, Natural Gas accounted for 92.0% of Singapore's fuel mix. Although the natural gas fuel mix in 2022 decreased due to tighter worldwide supply, supported by the IEA(International Energy

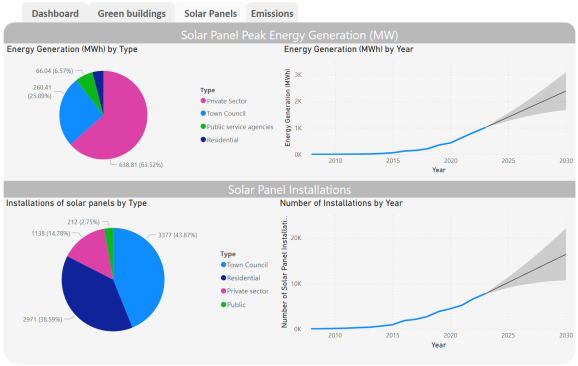
Agency), it rebounded to represent 94.3% of the fuel mix in 2023.



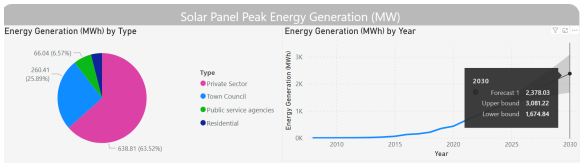
The operating margin (OM) grid emission factor (GEF) measures the average CO2 emissions per unit of net electricity generation in the system by all grid-connected power units. The operating margin grid emission factor includes generation technologies from main power producers (e.g. combined cycle power plants, waste-to-energy) and auto producers*(e.g. embedded co-generation plants and solar). Overall, it seems that the emissions have decreased overall over the years, however increasing slightly from 2020 to 2022. This highlights the energy efficiency of Singapore's electricity generation. This goes hand in hand with the fuel mix electricity generation, where the natural gas fuel mix decreased in 2022, therefore increasing carbon dioxide emissions in 2022. This means that natural gas plays a pivotal role in energy production, reducing emissions and increasing energy efficiency.



This visualisation shows a map of Singapore's recorded buildings. Building types include hospitals, education centres, and office buildings. The visualisation does not include residential areas. Viewers can use the filters however they like to gain more insight into particular areas. Filters include green mark status, building size, green mark rating and building type. From the visual, the key takeaway point viewers can see is that the amount of large buildings that are green (233) is more than small green buildings (67). However, 676 out of 976 buildings do not have a green mark, while only 300 buildings have a green mark. This means that there is more to be done, as the majority of the buildings are not green, despite the gauge from the dashboard showing *64% of buildings green by gross floor area.*



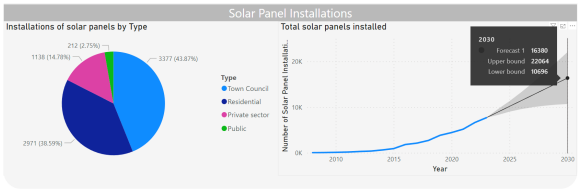
This is the page about solar panels, where there is more information on solar energy and statistical modelling done as a key metric to measure future performances.



Under the solar panel peak energy generation, there is a pie chart showing the distribution of solar energy generation for the year 2023. It seems that the Private sector accounts for the majority of solar

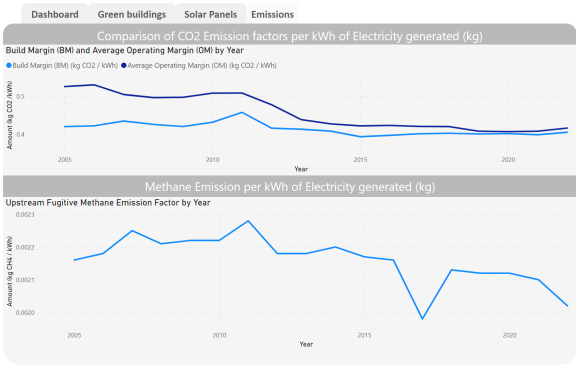
energy generation, followed by the residential sector.

The line chart shows the solar energy generation over the years, with a forecast to measure the energy generation in 2030.As seen from the line chart, during 2030, the mean of the energy generation is 2378 megawatt-hours, which converted into 2.378 gigawatts surpassing Singapore's quoted goal of 2 gigawatt-peak solar energy deployment by 2030, with an upper bound of 3.081 and lower bound of 1.674 gigawatts respectively, with a 95% confidence level.This means that Singapore has a *high chance* of meeting its quoted target of 2 gigawatt-peak energy deployment by 2030, showing that *Singapore is committed to implementing a sustainable future.*



This visualisation contains additional information on solar panels, with a pie chart containing the distribution of solar panel installations. In this pie chart, it seems that the town council is now the main area with the most installation of solar panels, followed by the residential areas.The pie chart distribution is vastly different from the pie chart of energy generation, where the private sector takes part in the majority of solar energy generation. This means that the dominance of the town council in solar panel installations indicates a proactive approach by local governance towards renewable energy adoption. On the other hand, the predominance of the private sector in solar energy generation suggests that private entities, likely businesses and industries, are driving solar energy generation, indicating a focus on economic viability and profitability.

This line chart shows the total number of solar panels installed over the year.The line chart follows an exponential increase in solar panels installed, indicating that Singapore is putting consistently increasing effort into solar panel installations, and has no plans on stopping or halting it. Using the forecast, it seems that the estimated total amount of solar panels installed will be 16380, with an upper bound and lower bound of 22064 and 10696 respectively with a 95% confidence level.



This page shows more detailed information on emissions from electricity generation. The first line chart shows a comparison of build margin (BM) and average operating margin (OM) of carbon dioxide emissions per kWh of electricity generated quoted by the energy market authority, "The Operating Margin (OM) Grid Emission Factor (GEF) measures the average CO_2 emissions emitted per unit of net electricity generation in the system by all grid-connected power units.", and "The Build Margin (BM) Emission Factor refers to the average CO_2 emissions emitted per unit of net electricity generation by the most recently built power units." As seen from the graph, Singapore's BM emission factor trends lower than the OM emission factor as the most recently built power plants are generally more efficient as compared to the older plants, and over the years there seems to be a slight decline of carbon dioxide emissions.

The 2nd line chart shows the methane emissions per kilowatt-hour(kWh) of electricity generated. The chart highlights the unstable movement of the values, with years increasing emissions and some years decreasing emissions. However, it seems that from 2020 onwards, there has been a consistent slight decrease in methane emissions until 2023. Only time will tell if the methane emissions will decrease to improve energy efficiency and reduce emissions.

Sustainable Living

In the SG Green Plan, recycling and transportation are aspects which make up sustainable living. As such, there are 4 pages relating to Sustainable Living in the Power BI report - Recycling, Recycling Details, Transportation and Transportation Details.

Recycling

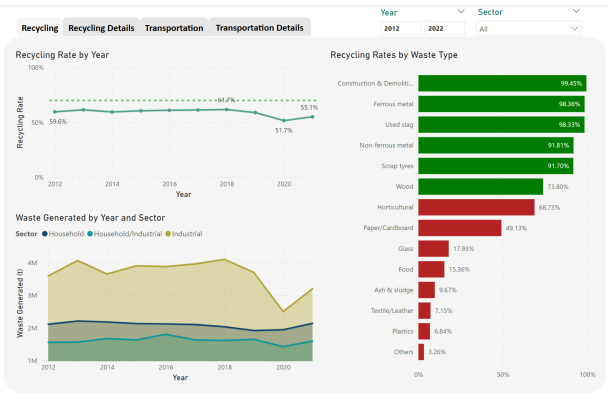


Fig. 3c.1: Recycling Page

As seen in Fig. 3c.1, food and plastic have a low average recycling rate of 15.36% and 6.84% from 2012 to 2021, respectively. Regarding the general recycling rate, it experienced a slight increase from 59.6% in 2012 to 61.7% in 2018 before dipping by 3% in 2019 and 7% in 2020.

The COVID-19 pandemic may contribute to the notable dip in recycling rate in 2020, where healthcare has a larger priority than sustainable practices. Note the decrease in industrial waste by 1.2 million tonnes in 2020 is also attributed to the COVID-19 pandemic, as non-essential services halted during the circuit breaker held in Singapore in the same year.

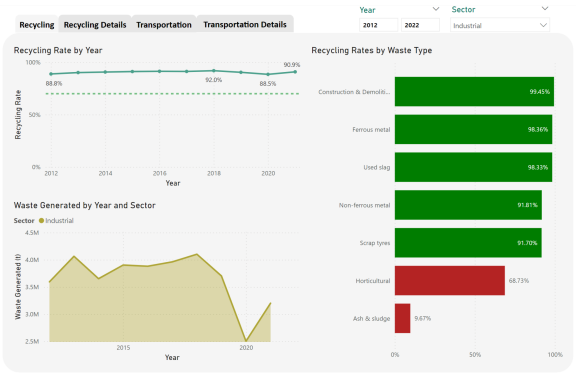


Fig. 3c.2: Recycling Page, filtered by Industrial

It is pivotal to know that the recycling rate of industries exceeds the Green Plan target of 70% by a large margin. As seen in Fig. 3c.2, the recycling rate of industries consistently remains above 88%, having its lowest recycling rate of 88.5% in 2020, showing that the government's policies in enforcing and developing recycling habits in industries are effective to a large extent.

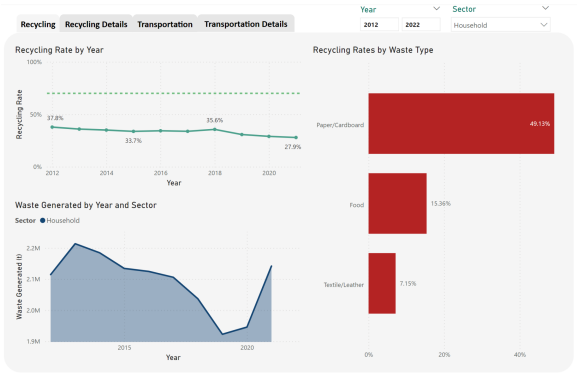


Fig. 3c.3: Recycling Page, filtered by Household

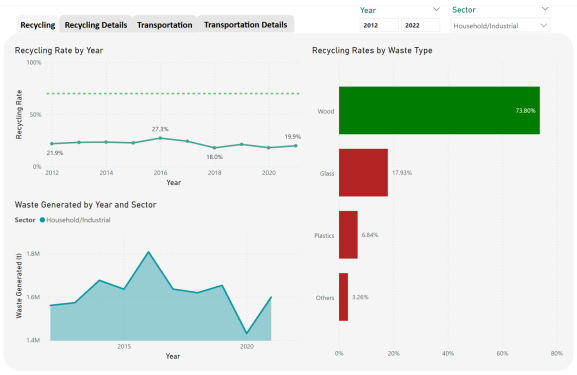


Fig. 3c.4: Recycling Page, filtered by Household/Industrial

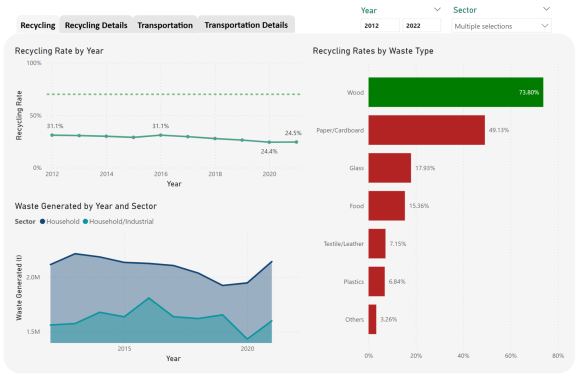


Fig. 3c.5: Recycling Page, filtered by Household/Industrial

However, as seen in Fig. 3c.3, Fig. 3c.4 and Fig. 3c.5, the recycling rates for materials produced by households and those produced by both households and industries have a large room for improvement, excluding Wood which meets the Green Plan target of 70%, suggesting the National Environmental Agency has to focus more on these waste types in its sustainable policies.

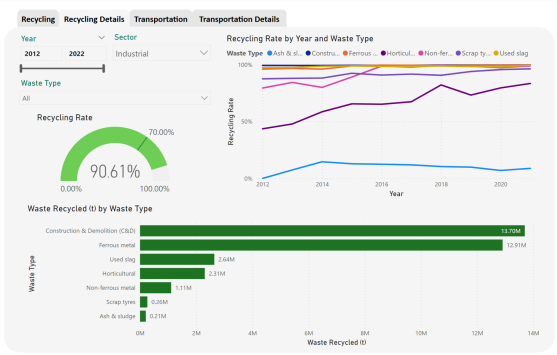


Fig. 3c.6: Recycling Details Page

The Recycling Details Page serves as a user interface for stakeholders to know more about the details relating to waste generated and recycling. In the gauge chart, one can view the average recycling rate over the years specified in the Year slicer. Aside from filtering by Sector, the user may also filter by Waste Type and view the changes in the recycling rates of the different waste types over the years, as seen in the line chart.

The bar chart has a unique feature. If a user hovers above the bar, he/she may view the percentage of waste recycled of the waste type in comparison with the total waste recycled in that particular section. As such, this helps the user determine the composition of the amount of waste recycled by sector without the need for a pie chart.

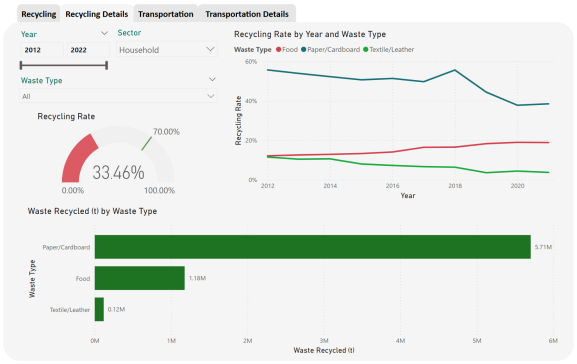


Fig. 3c.7: Recycling Details Page, filtered by Household

Based on the line chart, the recycling rate for food has increased while that for paper/cardboard has decreased, suggesting the government's efforts in implementing food-recycling policies have improved while efforts in increasing the recycling rate of paper/cardboard can be better.

Transportation

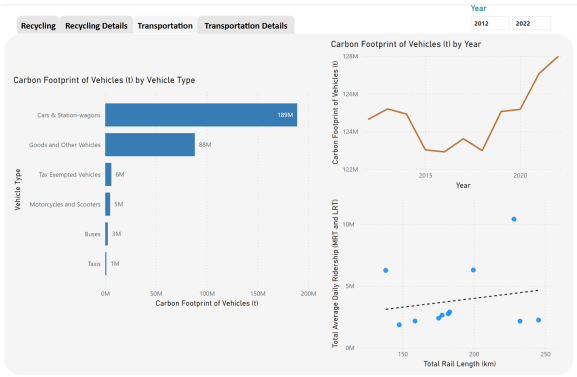


Fig. 3c.8: Transportation Page

Based on Fig 3c.8, cars, station wagons and goods vehicles contributed to the majority of carbon footprint produced by motor vehicles from 2012 to 2022s. This explains why the government implemented the Certificate of Entitlement (COE) to control the number of vehicles on Singapore's roads, in a bid to reduce the incentive to utilise cars as private transport and encourage its residents to take public transportation.

However, the rise in total carbon footprint from 122.9 million tonnes to 128 million tonnes in 2016-2022 suggests that there may be some failure in reducing total vehicular carbon footprint. Despite this, the fact that the increase is less than 5% of the total carbon footprint in 2016 and that there was a slight decrease in the total carbon footprint from 2013 to 2016 by <1% suggests a possible fluctuation in the data. As such, it is not too concerning for stakeholders who are monitoring the total vehicular carbon footprint.

Based on the small gradient of the trend line in the scatter plot in Fig. 3c.8, it seems that there is a weak positive correlation between rail length and average daily ridership, signifying that rail length does encourage people to commute via rail, though it is not a significant factor.

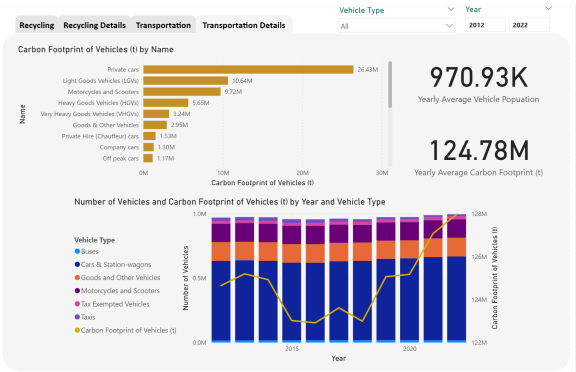


Fig. 3c.9: Transportation Details Page

The Transportation Details Page is a way for stakeholders to find out more about the data which makes up the previous Power BI page (Fig. 3c.6). Using the slicers, users can filter by Vehicle Type and Year and view the carbon footprint of vehicles in the bar chart (note that Fig. 3c6 only shows the

total carbon footprint by vehicle type, which provides a more generalistic view of the data).

Since the population of motor vehicles affects the total carbon footprint of motor vehicles, data on motor vehicle population was visualised via a card showing the yearly average vehicle population and a stacked column chart showcasing the composition of the number of vehicles by vehicle type over the years. In addition, the yearly average carbon footprint is shown to the user using a card and depicted in the same stacked column chart mentioned above using a line chart. Doing so enables the stakeholder to view the population and total carbon footprint of different vehicle types over time - all in one combo chart.

Green Economy

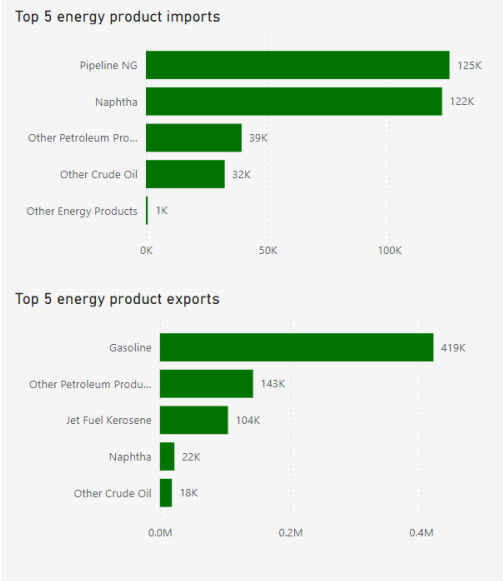


Fig. 3d.1 Energy Import and Exports

The bar charts for the top five energy product imports and exports provide a clear picture of Singapore's energy trade profile. The strategic import of cleaner fuels and the diversified export base support the Green Plan 2030's objectives to facilitate Asia's transition to a low-carbon economy. Singapore's role as a trading hub for sustainable energy products is essential for catalyzing regional green initiatives and promoting sustainable development.

Fig.3d.2 Import and export value trends

The line charts show the historical and current trends in energy product import and export values, reflecting Singapore's evolving energy trade strategy. The fluctuations and overall trends highlight the nation's responsiveness to global market shifts while maintaining a focus on sustainability. These trends are indicative of Singapore's efforts to balance economic growth with the Green Plan 2030's environmental objectives, signalling a transition towards a more sustainable and green economy.

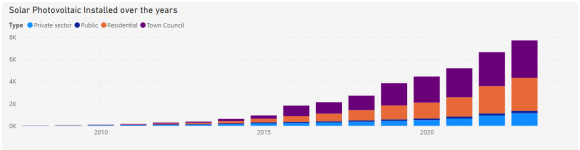


Fig.3d.3 Solar Photovoltaic Installed over the years

The bar chart reflects a commendable upward trend in the adoption of solar PV systems across various sectors over the years. This consistent growth aligns with the Green Plan 2030's aim to ramp up the use of clean energy and reduce reliance on fossil fuels. The chart indicates that investments in solar technology are bearing fruit, positioning Singapore to meet its green energy goals and contribute to regional and global sustainability efforts.

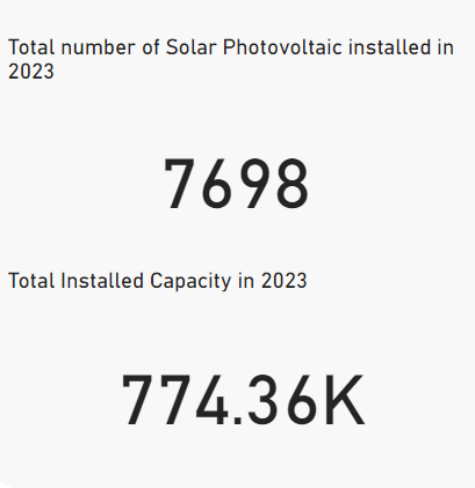


Fig.3d.4 Total number of Solar Photovoltaic installed and Total Installed Capacity in 2023

The figures on solar PV installations and the total installed capacity as of 2023 reveal significant milestones in Singapore's green journey. These numbers show the tangible outcomes of policies and initiatives aimed at boosting renewable energy usage. The data indicates a trajectory that will not only meet but potentially exceed the renewable energy targets of the Green Plan 2030, reinforcing Singapore's commitment to a sustainable and low-carbon future.

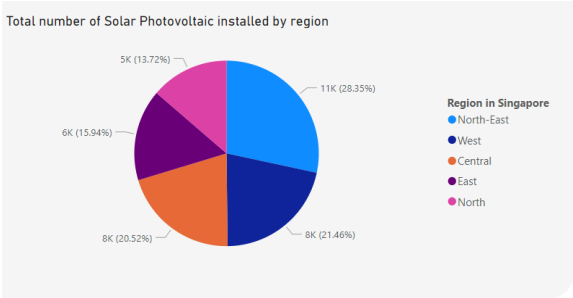


Fig.3d.5 Total number of Solar Photovoltaic installed by region

The pie chart presents the distribution of solar PV installations across Singapore, suggesting a strategic and equitable approach to renewable energy implementation. The chart reveals how each region contributes to the national objective of clean energy adoption, an integral part of the Green Plan 2030. It is a reflection of community engagement in green initiatives, which is vital for the holistic development of Singapore into a leading regional centre for developing new sustainability solutions.

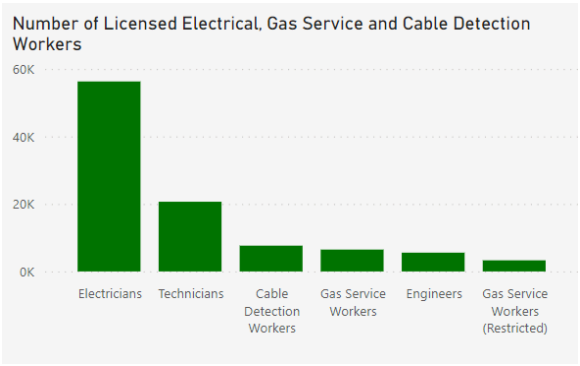


Fig.3d.6 Licensed Electrical, Gas Service and Cable Detection Workers

This visualization of licensed workers in key technical fields highlights the depth of Singapore's commitment to building a capable and comprehensive green workforce. The substantial number of licensed electricians and other specialists is crucial for maintaining the reliability and efficiency of Singapore's green infrastructure,

thereby contributing to the nation's reputation as a sustainable tourism destination and a hub for cutting-edge sustainability solutions.

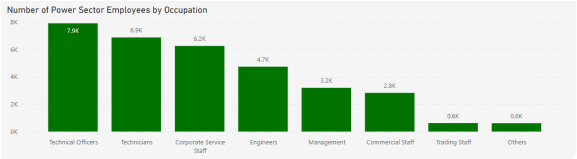


Fig.3d.7 Power Sector Employees by Occupation

The bar chart categorizes the power sector workforce by specific roles, with a strong emphasis on technical and engineering skills. This detailed breakdown underscores the strategic focus on cultivating a workforce that is not only sizable but also highly skilled and specialized. Such a workforce is critical for the execution of the Green Plan 2030, which includes complex projects like transforming Jurong Island into a sustainable energy and chemicals park and establishing Singapore as a leader in green finance and services. The chart indicates a strong foundation for ongoing and future initiatives.

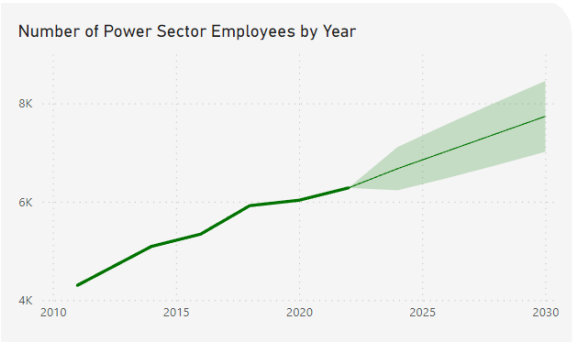


Fig.3d.8 Power Sector Employees by Year

The line chart illustrating the growth in power sector employees from 2010 and projecting through 2030 reflects a robust and sustained commitment to developing a green workforce. This increase is indicative of Singapore's proactive efforts to ensure that the workforce keeps pace with the rapid advancements in green technologies. The Green Plan 2030 envisions harnessing this human capital to foster innovation and growth within the sustainable energy sector, suggesting that the nation is on track to meet its employment goals in the green economy.

Resilient Future

The Resilience Future Pillar of the Green Plan 2030 focuses on national resilience for the future by preparing to mitigate the impacts of climate change, specifically:

- Global warming which is a threat to overseas agriculture instability, food imports which Singapore heavily depends on and the overall risk of food security instability within the country.
- Global warming which causes increased climate temperature to the already hot and humid Singapore, is unfavourable to the nation and its people.

In response, the Resilient Future Pillar of the Green Plan 2030 focuses on:

- Making food supply more resilient by setting a Goal of 30% of food locally by 2030 (30 by 30 Goal), less dependency on imports.
- Mitigating the overall temperature increase by mitigating the Urban Island Heat Effect through increased greenery provision.

In the Power BI Report, 4 pages have been allocated to Resilient Future - Food Security, Food Security Drillthrough, UHI Mitigation, and UHI Mitigation Analysis. 2 pages for Food Security, and 2 pages for Urban Heat Island Effect Mitigation.

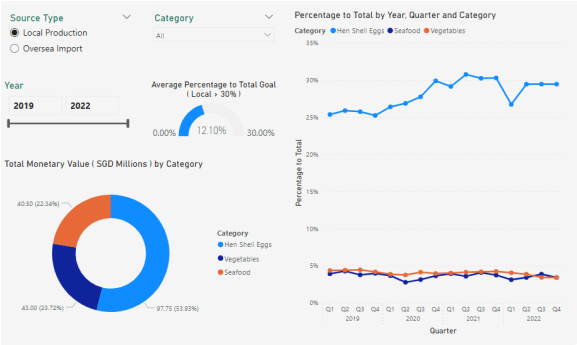


Fig. 3e.1: Food Security Page

The first page of Resilient Future - Food Security shows a general overview of the food categories focused on and the composition of each category by its source type, either locally produced or imported. At the top right, there are three filters given to the user, a time dimension filter by year, a source type and a food category filter. Due to the limitations of the datasets available online, the three most predominant food categories of Hen Shell Eggs, Seafood, and Vegetables have been chosen.

The right line visualisation allows stakeholders to see the trend and changes in produce composition by the source type throughout the quarterly periods. With the Source Type filter on "Local Production", it can be inferred that the local production of "Hen Shell Eggs" is generally increasing and nearly consistently achieving the 30% goal set in the Green Plan. However, this could not be said for the other two categories "Seafood" and "Vegetables" having a general decrease and constantly below 5%. Such a general slight decrease in "Seafood" and "Vegetables" could be attributed to COVID-19 which caused delays in building and upgrading of farms, as well as ceasing existing farm operations due to outbreaks[RF.1].

From 2021 Q4 to 2020 Q1, there was a significant dip in the local production percentage of locally produced "Hen Shell Eggs" to total from 30.28% to 26.72%. This could be also attributed to a Newcastle disease outbreak in one of the few local hen shell egg farms in Singapore[RF.2], such incident.

The bottom left doughnut chart allows stakeholders to view the overall revenue in the food market for either the local production or food import depending on what filter the Source Type visual is on. It can be inferred that the local produce market is still relatively small compared to the food import market for Singapore, with local production and food imports having a total market value of 60.42 SGD million and 573.85 SGD million respectively. The main purpose of this visual is to act as a stepping stone for users of the drill-through on the specific category and source type.

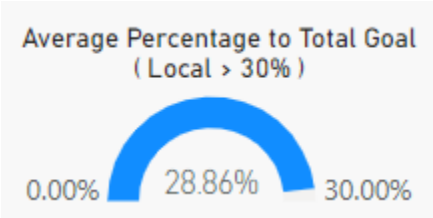


Fig. 3e.2: Food Security Goal Gauge Visual, filter on "Hen Shell Eggs" and "Local Production"

The gauge visual above is added to the page as a quick way to visualise Singapore's local production goals, the gauge visual also has an added filter to take Top N (3) years. *Food security requires food stability suggesting that the local food production should not only reach the 30% Goal once but be consistently around the 30% Goal.* This visual gives a more detailed percentage of local production to total for "Hen Shell Eggs", "Seafood" and "Vegetables" and overall local produce with an

average local production percentage of 28.86%, 3.53%, 3.92% and 12.10% respectively. This shows that among these three categories, *the progress has achieved one-third progress towards the 30% goal*.

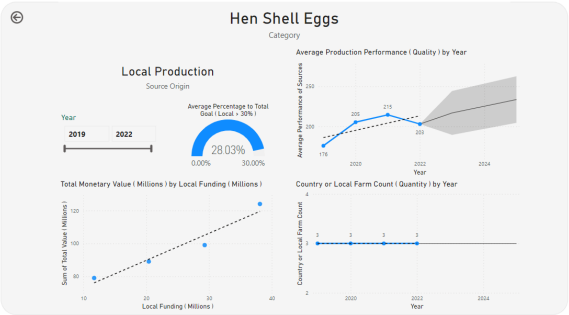


Fig. 3e.3: Food Security Drillthrough for "Hen Shell Eggs" and "Local Production"

The drill-through page's primary goal is to gain insights into what contributes to Food Security and gain insights on the causes of trends and changes seen on the first page. Drillthrough through the bottom left doughnut visual on the first page of Resilient Future would lead to the Food Security Drillthrough Page. The page contains 2 main visuals both on the right, two side visuals and two cards. The main visuals show a more in-depth view of each category and source by showing the factors that are composed together from the total produce, *local farm count multiplied by average local farm performance giving total produce*.

The bottom left visual shows the correlation between Singapore's amount invested into local production and the amount of produce locally, assessing the effectiveness of investment in enhancing local production and overall performance.

With the three visuals explained above, we can create a table to show the general details of each category.

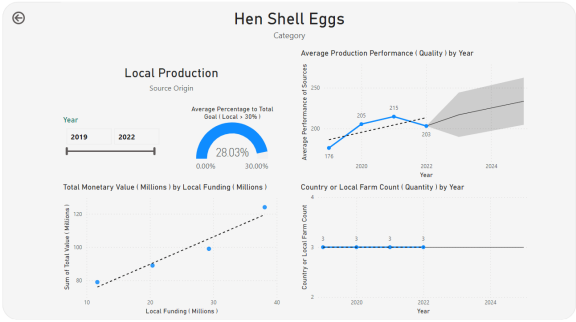


Fig. 3e.4: Food Security Drillthrough for "Hen Shell Eggs" and "Local Production"

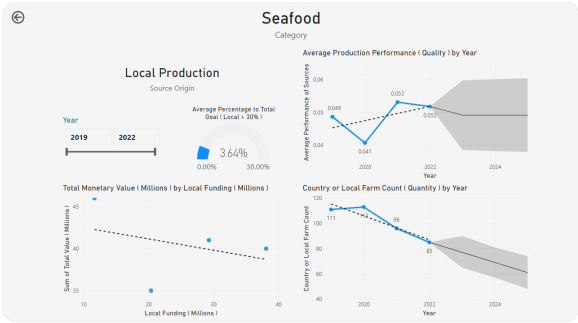


Fig. 3e.5: Food Security Drillthrough for "Seafood" and "Local Production"

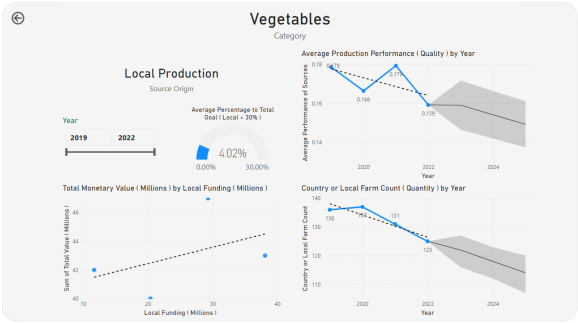


Fig. 3e.6: Food Security Drillthrough for "Vegetables" and "Local Production"

	Hen Shell Eggs	Vegetables	Seafood
Local Farm Count	stable trend at 3	slight decrease	slight decrease

		from 136 to 125	from 111 to 85
Local Farm Efficiency	strong increase from 176 to 203 million tonnes	slight decrease from 0.179 to 0.159 million tonnes	stable trend at 0.05 million tonnes
Singapore's Investment and Total Produce Correlation	strong direct correlation	strong direct correlation	weak inverse correlation

Fig. 3e.7: Food Security Drillthrough Summary Drillthrough Table for "Local Production"

From the table above, it can be inferred that generally, Singapore's investment is effective in increasing overall local production performance. Overall farm efficiency however usually decreases when the local farm count is high, this could be attributed to COVID-19 and disease outbreaks being more probable when the total local farm count for one's category is high. Another reason could be more diluted investment on each specific local farm as the investment would be more spread out when the local farm count increases.

However even categories with low farm counts have their cons, the local production of "Hen Shell Eggs" having a low farm count of 3 could explain why the Newcastle disease outbreak aforementioned could cause such a noticeable dip in total produce of "Hen Shell Eggs" from 2021 Q4 to 2022 Q1. *A low farm count means that the average dependency on each local farm (Local Farm Efficiency) is higher, meaning incidents like disease outbreaks have a more significant impact as total potential risk loss is higher on total produce and poses a threat to food stability.*

From these visuals, stakeholders can infer various strategies to enhance food security such as the local farm count for each category should be increased to decrease dependency on each local farm, the farm count also shouldn't be too high as the investment funds would be more spread out and investments would be less effective on each farm.

Singapore's approach, while direct and provisional, highlights that ***continuously increasing investments in local production is not a sustainable financial strategy in the long term.***

The solution is highlighted on the first page, indicating that more predominant local food produce categories correlate with higher revenue. By reinvesting a portion of revenue from categories that hit the 30% local production target, such as "Hen Shell Eggs," into those that haven't, naturally, those invested food categories would hit the 30% goal and a portion of their revenue will be reinvested. ***A self-sustaining cycle of investment and local production growth is created.*** *This all starts with the government's initial investment, fostering a self-reliant food supply and sustainable food security and future.*

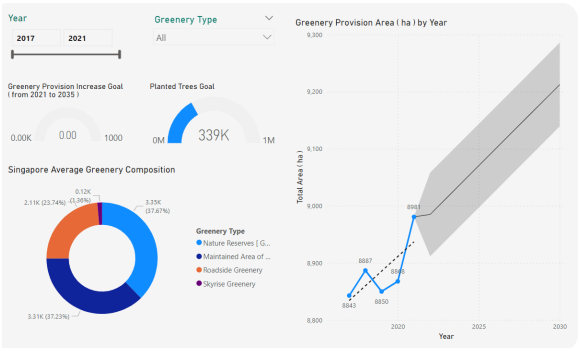


Fig. 3e.8: UHI Mitigation Page

The third page - the UHI Mitigation Page shows a general overview of Singapore's total greenery and its composition. As requested by stakeholders to have a convenient way of visualising Singapore's goal progress, the main right visual is used to project the expansion of total greenery across the country until 2030. Combined with the bottom left doughnut chart visual which shows the composition of the total greenery, stakeholders can forecast each greenery type till 2030. Currently, the forecast shows that Singapore will hit a total greenery of 9355 ha by 2035, roughly 40% of the 1000 ha increase target would be hit at this rate.

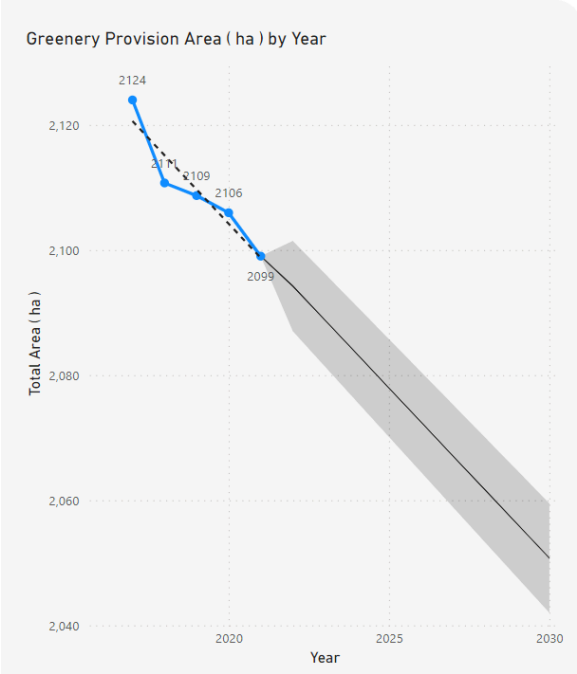


Fig. 3e.9: UHI Mitigation Page Forecast Visual with Greenery Type Filter on "Roadside Greenery"

There has been a general decrease of 5 ha of roadside greenery per year which could be attributed to urban development, infrastructure expansion and the overall limited space that Singapore has.

However, Singapore's commitment to maintaining and increasing green spaces can be seen through other greenery categories despite urban development pressures.

Nature Reserves of Singapore have been reserved and untouched at 3347 (ha) of greenery for the past few years.

Skyrise Greenery has been constantly increasing with an average of 10 (ha) per year, such a stable trend could be attributed to multiple schemes like the Skyrise Greenery Incentive Scheme used to encourage the installation of green roofs and vertical greenery on buildings through financial incentives.

There's a general increase in the Area of Regional Parks of 24 (ha) per year, such an increase can be attributed to the urban planning of the Singapore Government. Regional Parks had the most increase out of all of the greenery categories as the increase of regional parks not only aligns with the Resilient Future pillar but also the City In Nature pillar.

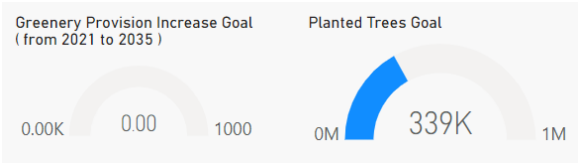


Fig. 3e.10: UHI Mitigation Page Gauge Visuals

The two gauge visuals showcase the goals mentioned in the Green Plan 2030, a greenery increase of 1000 ha by 2035 and 1 million trees planted by 2030. The greenery provision increase of 1000 (ha) has remained at 0 as the latest data was on 2021 and the goal was the increase of 1000 ha from 2021 to 2035.

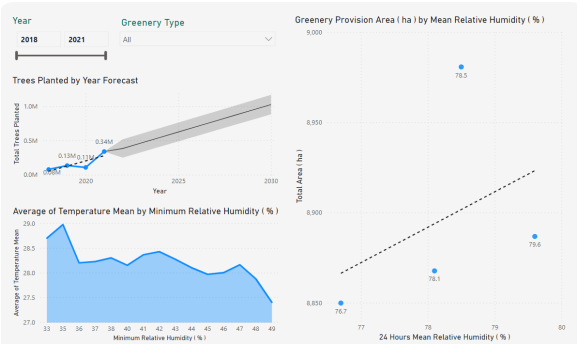


Fig. 3e.11: UHI Mitigation Analysis Page

The right main visual shows a strong positive correlation between greenery provision and mean relative humidity, a weak positive Pearson correlation coefficient of 0.345. The bottom left visual shows a general inverse correlation between relative humidity and temperature.

Given the negative correlation between temperature and relative humidity, coupled with the positive correlation between the presence of greenery and relative humidity, it can be inferred that the introduction of green spaces serves as an effective method to mitigate temperature increases. This linkage is further explained through the process of evapotranspiration, which naturally results from the introduction of vegetation.

Evapotranspiration is a key process in the hydrological cycle that combines two separate processes: evaporation and transpiration. In both evaporation and transpiration, heat energy is used to convert the water into water vapour. Such heat absorption is critical in urban environments where concrete, asphalt, and other surfaces absorb and retain heat, contributing to higher temperatures.

Such insights act as proof that Singapore's act of greenery provision can help mitigate the temperature increase and is contributing to the goal of sustainability.

Conclusion

After analysis via data visualisation, the following can be concluded:

The sub-hypothesis "Singapore's 'City in Nature' initiative contributes significantly to the enhancement of green infrastructure and is committed to mitigating climate change, fostering a sustainable and resilient urban ecosystem." is true. Through all my visuals, you can see how after the green plan, more parks, park connectors, and green provision, in general, all have a substantial increase, proving how the green plan and the City In Nature pillar enhance the development and improvement of green infrastructure within the urban landscape. Additionally, with all the green infrastructure created, through my climate change page, you can see how these green spaces and infrastructure help to slow down the increase of our air temperature in Singapore.

After performing analysis through data visualisation, it seems that the sub-hypothesis for the energy reset pillar "Singapore will meet their proposed plans and international goals for sustainability in the energy reset pillar" is true, where there are 2 accounts of directly quoted goals being used as a key metric to gauge Singapore's current efforts to their quoted goals. As seen in Powerbi, Singapore has a high chance of meeting 2 gigawatt-peak solar generation and greening 80% of their buildings. Furthermore, other visualisations such as the predominance usage of natural gas also play a part in showing that Singapore is committed to implementing a sustainable future. Hence, under

the energy reset pillar, Singapore is committed to implementing a sustainable future in the energy reset pillar.

The sub-hypothesis "Sustainability in transportation and recycling has improved in Singapore." is half-true. The recycling rate has made slight improvements to the Green Plan goal of 70% from 2012 to 2018 by 2.1%, dipping from 2018 to 2020 by 10% before increasing again by 4% in 2021. In contrast, the total carbon footprint of motor vehicles does not show significant improvement by decreasing drastically over the years. The next 26 years will determine if Singapore will make progress to net zero carbon emissions by 2050.

The sub-hypothesis "Singapore's energy economy and workforce have improved" holds. The presented visuals distinctly show an upward trend in renewable energy installations, specifically solar photovoltaic systems, and a bolstered workforce specializing in green energy sectors post-implementation of the Green Plan. This indicates a strategic shift towards a sustainable energy economy. Moreover, the diversification in energy trade with increased exports of cleaner energy products reflects a mature energy market pivoting towards sustainability. Collectively, these data points suggest that Singapore is successfully advancing its energy economy while simultaneously enhancing its workforce to support the nation's green transformation goals.

The sub-hypothesis "Singapore is committed to increasing food security and mitigating the Urban Heat Island Effect" *is true to a great extent.* It can be inferred from the first two pages of the "Resilient Future" Power BI pages that Singapore is committed to decreasing reliance on overseas imports by increasing dependency on local production and from the last two pages infer that Singapore is committed to mitigating overall temperature increase through greenery provision through the process of evapotranspiration. With that in mind, the pages have been taken one step further by allowing convenience for stakeholders to understand other factors that can contribute to temperature and food sustainability by going through in-depth analysis/views for each topic.

Recommendations

Based on the data for City In Nature, the government should continue to plant more trees, and find ways to build more green provisions around Singapore, especially in the West and North-East regions which have a lack of greenery compared to the rest of Singapore.

Based on the data for Sustainable Living, the government should speed up the process of integrating electric vehicles into Singapore's transportation scene, so that carbon emissions may be reduced by half.[R1] Furthermore, the government should continue cultivating the habit of food-recycling among its citizens. This would not only reduce the food waste generated but also enable Singaporeans to live more sustainably.

Based on data analysis on Energy Reset, here are my recommendations: As previously mentioned, there was a global issue that has affected Singapore's natural gas utilisation, which has increased emissions and ultimately decreased energy efficiency. Singapore has to step up and increase their energy security as since Singapore is a country that has no natural resources and relies heavily on

imports, energy security is a must by ensuring minimal impact from global issues. So Singapore can put more effort into increasing its network of energy imports or placing more emphasis on its solar energy adoption.

Based on the data for the Green Economy, stakeholders should focus on enhancing investments in clean energy technologies and upskilling the workforce to cater to the green sectors. With a demonstrated capacity for solar power generation, efforts to further incentivize and streamline the adoption of such renewable sources will bolster Singapore's energy self-sufficiency. Additionally, the government and industry leaders should collaborate to expand career pathways in green industries, ensuring that the workforce is prepared for a future where green jobs will be the norm. This dual approach of boosting green tech and workforce readiness will be pivotal in propelling Singapore towards its ambitious Green Plan 2030 objectives.

Based on data on the Resilient Future, Singapore should continue investing in local production to increase the quality of farms and overall produce to possibly start the self-sustaining cycle but also keep in mind a good balance of farm counts to not be too low to mitigate impacts of diseases outbreaks but not too high to not spread out investments. Singapore also continues encouraging greener provisions through financial means or policies to mitigate the overall temperature increase.

Issues

Finding the right datasets for analysis was a challenge. In some cases, the incompleteness of datasets would mean making assumptions on our part, thus compromising data integrity to some unspecified degree. However, we did minimise such compromise by applying statistical research methods to ensure our data remains accurate enough for analysis.

Future Enhancements

On the topic of Healthcare (City In Nature), more can be done to find more datasets that show the relationship of how greenery around Singapore, helps with Singaporeans' health, which greatly promotes sustainability.

Regarding, transportation (Sustainable Living pillar), more can be done to find more datasets to determine stronger recommendations to stakeholders.

For the “Food Security Drillthrough”, the average quality of each farm can be shown as the percentage of overall produce instead of the produced amount by tonnes. It can better show the average maximum potential of food instability Singapore may endure in the case of incidents like disease outbreaks in one of the farms.