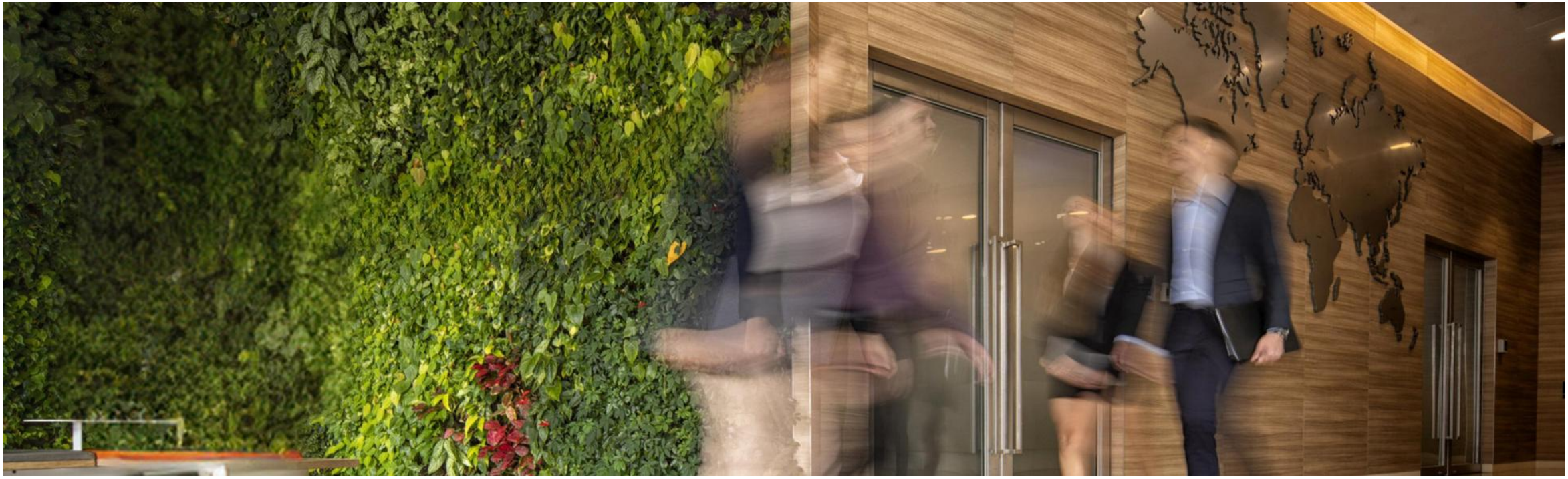
It’s Getting Hot in Here! 🔥

Overview of Global & SG Energy Landscape

Keppel

Content

1. Global & SG Climate and Energy Landscape
2. Renewable Energy Certificates (RECs) & Carbon Credits (CCs)
3. Power Purchase Agreements (PPAs)



01

Global & SG Climate and Energy Landscape

Global Efforts on Climate Change

IPCC Assessment Report: Chapter 6, Energy Systems

Roadmap for transforming global energy systems to limit warming to well below 2°C – not mandatory to follow, **reference for climate science used by governments**

- Urgent shift away from fossil fuels
- Renewables are slowly becoming affordable
- Global energy demand continues to rise
- Investments are moving toward low-carbon tech
- Integration of storage, grids, and clean fuels is essential

Scientific Findings

Carbon budget is **shrinking** to keep below 1.5°C

2°C has **higher risks** compared to 1.5°C

To stay below 1.5°C, must reach global net-zero **by 2050**

Lifecycle and infrastructure changes can cut emissions

Paris Agreement

IPCC Report supports the Paris Agreement by providing scientific assessments; Paris Agreement turns to global policy/structure

Legally binding international treaty on climate change, adopted by 195 countries in 2016; **countries to submit national climate action plans every 5 years since 2020**

- **SG to support the Paris Agreement through the SG Green Plan, over the next 10 years**
- Lack of efforts will hurt SG's reputation, reduce climate funding, and limit access to carbon markets

Paris Agreement Frameworks

Providing **climate finance** to developing countries

Guidance for tech development in reducing GHGs

Support for capacity building for developing countries

Source: [1]IPCC, [2]United Nations Climate Change

IPCC: Intergovernmental Panel on Climate Change: provide governments globally with climate and scientific information

Article 6 of the Paris Agreement

Enables international cooperation to tackle climate change and unlock financial support for developing countries, main components include:

Article 6.2 – provide accounting & reporting guidance for countries to use internationally transferred mitigation outcomes (RECs, CCs) to meet nationally determined contributions (NDCs) – through bilateral or multilateral agreements

Article 6.4 – Establishes a new United Nations Framework Convention on Climate Change (UNFCCC) mechanism which can be used to trade high-quality CCs

Article 6.8 – Provide opportunities for non-market-based cooperation for enhancing climate action

Main Goals

Create a **basis** for trading carbon instruments

Establish framework for **trading emissions cross-border**

Recognize and research non-market approaches to **promote mitigation of emissions**

Limitations

Lack of transparency especially due to bilateral agreements

Lack of structured framework on the double-counting of emission reductions

No clear framework on handling temporary carbon offset initiatives

Relation to SG & Keppel

SG aspires to be a carbon trading hub by tapping on its ecosystem and locality in SEA, one of the largest carbon credit sources

Article 6 enables international CC transfers, helping alternative energy disadvantaged countries (e.g. SG) meet climate targets, **but requires strong bilateral agreements**

SG signed bilateral agreements with Papa New Guinea, Ghana, Bhutan, Peru, Rwanda, Paraguay and Chile for the buying of CCs**, also eyeing other suppliers such as Malaysia for carbon credit supply**

Keppel's Efforts on Article 6

Involved in retiring coal-fired power plants in SEA to generate CCs by retiring and replacing them with clean energy solutions

Source: World Bank, Carbon Markets, Keppel

Overview of SG Energy Landscape

Growing electricity consumption, with **limited** renewable supply in SG

Increasing consumption

- **Digital economy** drives rising electricity consumption[1]
- Mainly from **commerce & services and industrial sectors (e.g. manufacturing and data centres)**
- With the *SG Green Plan*, SG has been shifting to **renewable power sources**

Stagnating production in SG

- **SG primarily relies on solar power** for generation of renewable power, which is **constrained by land scarcity**
- Subsea cables and networks to be developed supporting the *ASEAN Power Grid (APG)*[2]
- **SG to import up to 6GW of low carbon energy from ASEAN countries by 2035**

SG Green Plan

Initiative to achieve long-term zero emissions by 2050 supported by carbon offsets and "4 switches" to renewables

Key Targets[3]

- Increase solar energy deployment to meet 3% of projected electricity demand by 2030
- Green 80% of SG buildings
- New investments supporting carbon efficiency

Example	**Equinix to launch Green DC, awarded MW by IMDA**[4] • Announced investments in Equinix DC featuring rainwater harvesting, naturally ventilated corridors, and solar panels • Rewarded through DC-CFA 1, 20MW – RFS in 2027 SG Green Plan sets ambitious targets but is **NOT mandatory** to follow. However, efforts to follow gives an advantage in obtaining more MW capacity in future investments

[1]Evident, [2]CCarbon, [3]Green Plan, [4]Equinix

Four Switches of SG Energy Strategy

To ensure a reliable, affordable and sustainable energy supply for Singapore

Note:
- Brown Power: ●
- Green Power: ●

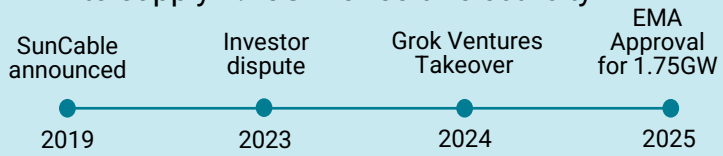
Current Supply

Natural Gas ●

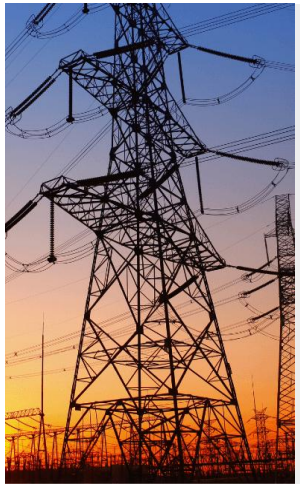
- Cleanest fossil fuel, producing least amount of carbon emissions, however, still releases GHG emissions contributing to climate change
- Mainly composed of methane
- **Contributed to 94% of SG total electricity in 2024**, piped from Malaysia and Indonesia[1]

Solar ●

- SG is solar dense with high solar irradiance, **supplying 1% of SG's total energy consumption**[2]
- Aim to supply **10% of projected total energy demand by 2050**
- Investments in Australia's Future Sun Cable to supply 1.75GW of solar electricity[4]



Future Supply



Regional Power Grids ● ●

- Import from regional countries with abundance of renewable resources, enhancing energy security (e.g. Indonesia, Australia and Vietnam)
- Aim to import **6GW of low-carbon electricity via regional grids by 2035**[1]

Low-Carbon Alternatives ●

- R&D underway on emerging tech (e.g. hydrogen, geothermal, nuclear, and carbon capture and storage)
- Aim to supply **50% of total energy demand by 2050**[3]

[1]EMA, [2]International Trade Association, [3]MTI, [4]EDB

SG Regional Power Grids

Key Targets[3]

- Import 6GW of clean energy by 2035 from near countries like Indonesia, Vietnam, Laos (2024)
- Invest in transmission lines and substations
- Challenges with **mixed energy in the grid**

Large-Scale Electricity Imports *(In Development)*

- EMA has awarded conditional approvals and conditional licenses to import low carbon electricity regionally (before import licenses and commercial operations)
- Planned energy imports include:
  - Vietnam – Wind (1.2GW),
  - Cambodia – Solar and Hydro (1GW by Keppel),
  - Indonesia – Solar (3.4GW – 300MW by Keppel)
  - Australia - Solar (1.75GW – Sun Cable)
- EMA to consider awarding more licenses to boost progress on the grid - mixing solar, hydro, and wind power

Import Trials
(Supporting ASEAN Power Grid Vision)

LTMS-PIP	**Phase I - 2022 to 2024** • Up to 100 MW of hydropower from Laos to Singapore via Thailand and Malaysia • 1st renewable energy import into SG • Keppel was issued electricity importer license for 2 years from 2022 **Phase II - 2024 to 2026 *(Not yet started)*** • Aim to increase electricity traded up to 200 MW, additional power from Malaysia • Keppel's electricity importer license extended 2 years to 2026
Malaysia ENEGEM Pilot	**2024 to 2026** • Sembcorp to import 50 MW of renewable electricity from Malaysia's TNB to SG for 2 years starting Dec 2024 • Supplied via Energy Exchange Malaysia Platform (ENEGEM) – For cross border green electricity sales to neighbouring countries

Source: EMA

Enegem Project: Malaysia's flagship project to modernize its electricity grid and support the integration of low-carbon energy sources.
TNB (Tenaga Nasional Berhad): Malaysian multinational electricity company and is the only electric utility company in Peninsular Malaysia

Low Carbon Alternatives

Hydrogen

- Created through electrolysis with water as by-product; **ammonia** used to store and transport – to supply 50% of SG energy Natural gas CCGTs are in use; 100% hydrogen-compatible systems by 2030
- High cost of low-carbon hydrogen due to reliance on imports and new pipe structures or liquification

Ammonia

- Carrier for hydrogen, easier to transport due to higher energy density, and established infrastructure
- Can be used directly or converted back to hydrogen to be used in CCGTs (better energy efficiency)
- **To develop ammonia power generation in Jurong Island,** ongoing discussions on lead developer
- Leakage and toxicity concerns

Nuclear

- Low-carbon, high output energy using uranium or plutonium
- SG Budget 2025 to focus on Small Modular Reactors (SMRs) – better safety than conventional plants
- SG inked agreements with US, France, UAE and Sweden to **build nuclear energy capabilities in SG** – *No deployment decisions yet*
- EMA highlighted that SMRs to power DCs
- Safety, land, waste, and cost concerns

Carbon Capture and Storage (CCS)

- CCS captures CO_2 during pre- and post-combustion of natural gas and stores them underground –*to use existing gas infrastructure*
- SG exploring CCS tech:
  1. EMA co-funding R&D with corporates
  2. **Jurong Island trial to aggregate CO_2 produced for export. Target operational date of 2030**
- Leakage, environmental, cost concerns

Source: EMA, OCBC

CCGT: Combined Cycle Gas Turbines transform hydrogen to power

02

Renewable Energy Certificates (RECs) & Carbon Credits (CCs)

Three Scopes of Emissions in SG

	Scope 1	Scope 2	Scope 3
Type of Emissions	Direct	Indirect	Indirect
Phase of production cycle	During production	Upstream	Upstream and Downstream
Activities	Manufacturing, direct services	Off-site energy (electricity, heating, cooling) when a company makes a purchase from a 3rd party	Activities prior to production Use/disposal of products or services
Estimated Share in SG	~5%-10%	~10%-15%	~75%-90%
Examples	Fuel combustion in company-owned vehicles, boilers, furnaces	Emissions from off-site power plants generating electricity for the company	Employee commuting, transportation, leased assets, distribution
Mandatory in SG?	Companies to report Scope 1 emissions starting 2025	Companies to report Scope 2 emissions starting 2025	No current plans to make Scope 3 reporting mandatory
Common Carbon Instrument	**Carbon Credits**	**Carbon Credits AND RECs**	**Carbon Credits**

Relation to Keppel

- Aim to halve Scope 1 and 2 emissions by 2030, compared to 2020
- Achieve net zero Scope 1 and 2 emissions by 2050
- Achieved reduction of 70% in Scope 1 and 2 emissions compared to 2020 by 2023

*Allows Keppel to **reduce carbon tax**, align with **SG green plan***

Scope 3 emissions were slightly lower compared to 2022 by 2023

Source: McKinsey

Carbon Offsets and Carbon Credits in SG

Carbon Offsets

- Voluntary **actions** to balance CO_2 emissions (e.g. investing in renewables, tree planting, etc.)

Key Characteristics

Quantifiable
Based on the amount of CO_2 mitigated

Voluntary
Driven by environmental goals

Flexible
Non-exhaustive list of initiatives that offset CO_2

Credible
Verifiable through 3rd party registries (Verra, Gold Standard in SG)

Carbon Credits

- **Digital** certificates that represent emissions **based on Carbon Offsets**

1 CC = 1MT of CO_2

Key Characteristics

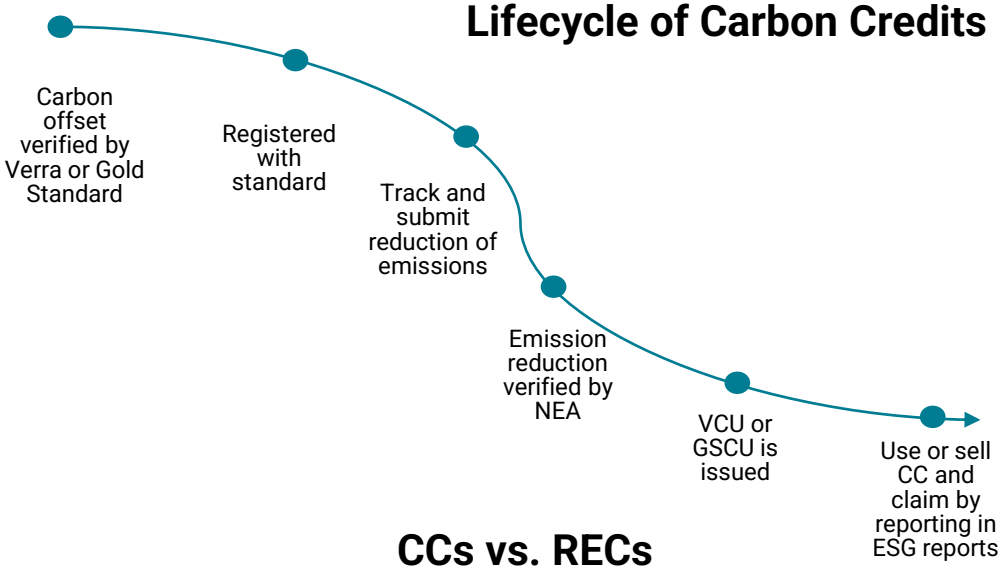
Unique
One-time serial number used once

Tradable
Companies can buy and sell CCs

Project-Based
Must prove importance to a project

Emission-Based
Represent the reduction of GHG, not renewable generation

Lifecycle of Carbon Credits



CCs vs. RECs

	CCs (Common for Scope 1&3)	RECs (Common for Scope 2)
Purpose	Offset emissions	Increase renewables
Project Scope	Broad	Narrow – only renewables
Additionality	Yes, must prove importance to a project (CC to push project development)	Some buyers prefer additionality for measurable impact, but it is NOT a requirement for reporting
Vintage Effects	Tracked and matters less	Tracked and matters

Source: SP Group, Straits Times

Recent Developments on Carbon Credits

Present

Trust issues, lack of verifiable credits slowing investment in Singapore's carbon market: study Sept 2024

Singapore looking to buy nature-based carbon offsets to meet 2030 climate target Mar 2025

Singapore signs implementation agreements on carbon credits collaboration Apr 2025

SG facing shortage of CCs that meet registry's criteria due to difficulties **proving additionality, lack of standards and shortage of talent leading offset initiatives**

SG signed bilateral agreements with Papa New Guinea, Ghana, Bhutan, Peru, Rwanda, Paraguay and Chile for the buying of CCs ***– supporting article 6 of Paris Agreement***

Future

(Closed on 20 July 2025) Public Consultation on the Draft Voluntary Carbon Market Guidance SG based

Singapore and Japan Set New Rules for Carbon Credits and How They Shape Asia's VCM Jun 2025

Lack of standards to facilitate the trade of CCs locally and internationally – making companies concerned about risks

Future Frameworks:
Local: NCCS, MTI, SSFA and Enterprise SG to create framework to guide CC buy, sell, and use; key initiatives include requiring the disclosure of CCs in companies' decarbonization strategy, etc.

International: Asian Governments to align with CC guidelines; Japan and SG to collaborate on a standardized criteria for quality CCs

Source: Eco Business, Straits Times, Allen & Gledhill, NCCS

What are Renewable Energy Certificates (RECs)?

Renewable Energy Certificates (RECs)[1]

- Digital assets validating renewable electricity **to offset non-renewable electricity consumption,** claiming environmental benefits of renewable energy

1 REC = 1MWh

Motivation to procure/generate RECS

- Corporate sustainability commitments
- Regulatory requirements
- Green building standards
- Government support

Key Characteristics

Unique
One-time use serial number that is redeemable once

Tradable
Companies can buy and sell RECs

Vintage
Year which renewable energy was generated, older vintages (beyond 2 years) are not favoured

Tangible
Evidence that energy was produced from renewables

Financially Motivating
REC sales revenue finance renewable projects

Types of RECs

Bundled RECs
Certificate sold together with physical electricity

Unbundled RECs
Certificates sold without physical electricity

[1]SP Global, Resource Solutions[2]

REC Standards and Compliance in SG

Global REC systems **collaborate with local issuers such as national grid and energy operators** to register and issue RECs

Singapore Standard SS673 (Launched in 2021)

- Clear framework for measurement, reporting and verification (MRV) requirements for issuance and management of RECs
- **Covers guidelines from production, tracking, management, to the usage of RECs for energy claims in Singapore**
  - Defines types of qualifying renewable energy sources
  - Process of registration and verification of renewable energy facilities
  - Recommendations on renewable energy consumption claims

Corporates to pick **ONE** registry to follow

THE INTERNATIONAL REC STANDARD

Local Registry: SP Group

- *By I-TRACK Foundation* in Europe[1]
- Manages ***in* 60 countries;** most issuances in China, Brazil, and Turkey[3]
- **Global reach in many countries, low cost**

TIGRs

Tradable Instruments for Global Renewables

Local Registry: APX

- Developed by *APX* in USA[2]
- Online platform for RECs in **12 countries**
- **Tech-integrated, real-time tracking**

General Requirements of SS 673

- ✓ Grid connected
- ✓ Source of electricity from SG or SEA (Facilitating future renewable imports into SG)
- ✓ Consistent metering systems (smart meters, SCADA)
- ✓ Verifiable through audits & inspections

Examples of Qualifying Renewable Energy Sources

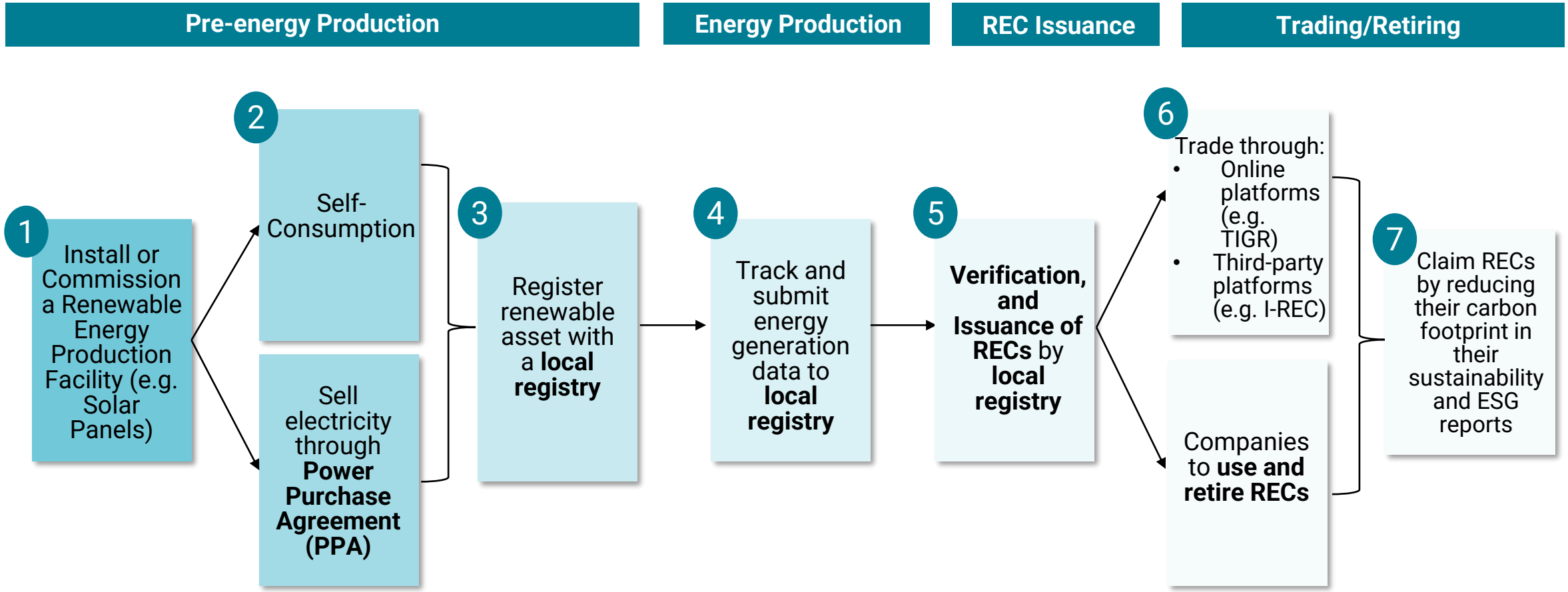
1. **Solar**
   Generation standards
2. **Biogas and Biomass**
   - Third party reports to prove sourcing and emissions

[1]Evident, [2]Association of Issuing Bodies (AIB), [3]S&P Global, [4]Saxon Renewables

I-Track Foundation: Governance and standard-setting role for RECs
APX: Created the tradable instrument for global renewables, an online platform for tracking and transferring RECs

Lifecycle of SG RECs

Process from energy production to trading or retirement of RECs



Source: Dentons Rodyk, GetSolar

Recent Developments on RECs

Countries follow the same standards (I-REC, TIGRs), yet have different local guidelines

Present

- Local guidelines in nearby countries make it difficult for RECs to be recognized cross-border
- In SG, mostly trading unbundled RECs cross-border
- Malaysia investing into renewable trade through the 'Enegem' project, to supply 50MW of solar and hydro generation in end 2025, potential supply of RECs

Future

Singapore develops framework for RECs in cross-border electricity trade

Jan 2025

Singapore seeks experts to work on global framework for cross-border renewable energy certificates

Oct 2024

- SG collaborating with Malaysia to build a new REC framework for bilateral trade to standardize code of practices, ensure proper verification, support REC market development, and integrate with power grids for physical electricity trade
- Prevent greenwashing in cross-border trade

However, proven to be challenging because of:

- Potential **to mix renewable and non-renewable energy sources in the local grid**
- Different financial constraints cross-border
- Regional governance

Sources: CNA, MTI, EcoBusiness, Business Times, Petra MY, ArgusMedia

Enegem Project: Malaysia's flagship project to modernize its electricity grid and support the integration of low-carbon energy sources.

03 Power Purchase Agreements (PPAs) for RECs

Overview of Power Purchase Agreements (PPAs)

Power Purchase Agreements (PPAs)[1]

- Long term agreements between energy producers and buyers
- Hedging instrument by locking in **prices**
- Determines **RECs ownership**

Key Characteristics[2]

Long Term
Typically 10-25 years commitment

Secure
Specifications of purchase is fixed (e.g. quantity, production date and price)

Risk Allocation
Outlines risks and responsibilities to be borne by different parties (e.g. grid and regulatory changes)

REC Ownership
Specifies owner of RECs

Types of PPAs

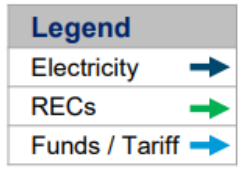
Private-Wire PPAs
Direct delivery from generator to buyer (mostly for bundled RECs)

Physical PPAs
Grid operator facilities delivery from generator to buyer (mostly for bundled RECs)

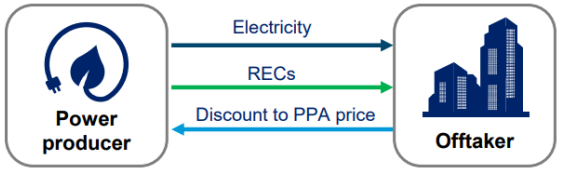
Virtual PPAs
Generator sells to the wholesale market (mostly for unbundled RECs)

[1]United Overseas Bank, [2]GetSolar

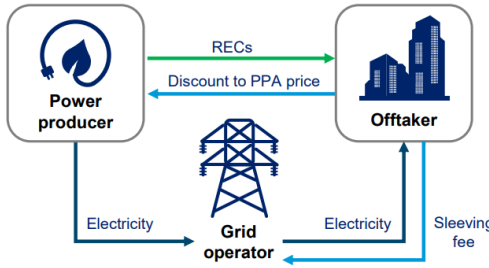
Overview of Power Purchase Agreements (PPAs)



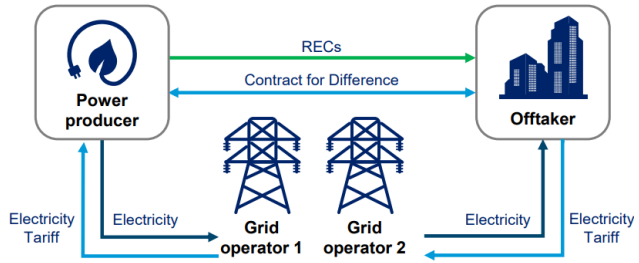
Private-Wire PPAs



Physical PPAs



Virtual PPAs



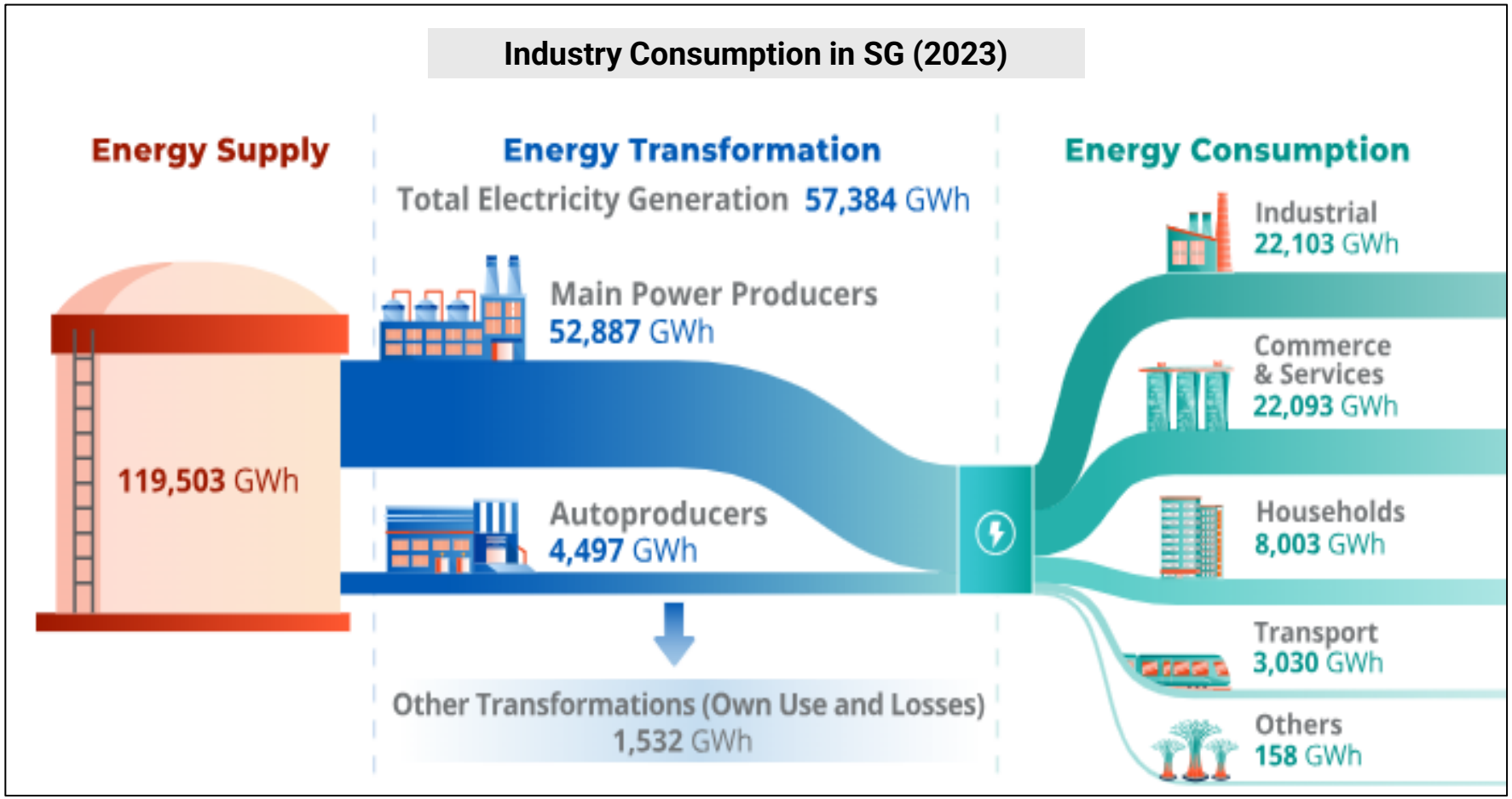
Electricity Delivery	Direct from generator to buyer via private wire	Direct from generator to buyer via public grid	Financial contract only
Grid Usage	No	Yes	No
Contract	Bilateral agreement	Bilateral agreement	Contract for Difference – Financial derivatives trading
Location Requirements	Generator and buyer in close proximity	Same market/region	No location restrictions
Grid Charges	No	Yes (transmission, distribution)	Yes – buyer's grid consumption
Use case	On-site generation in campuses, industrial sites	Corporate buyers with demand near plant location	Corporates seeking renewable attributes – unbundled RECs
Complexity	High – infrastructure and permits	Medium – grid connection	Medium -- financial derivatives only
Examples	Solar panels on-site powering factory	Wind farm supplying nearby data centre	Offsite wind farm financially linked to company's energy use

Source: United Overseas Bank

Thank you

04 Appendix

Overview of SG Energy Landscape *(per sector)*



Industrial sector:
Manufacturing, utilities, and construction companies

Commerce & Services:
Transport, healthcare, recreation, financial services

Excessive Energy Reasons
Industrial
- Extensive use of manufacturing, electronics, and transportation

Commerce & Services
- Operational processes and buildings

Source: EMA

Differences with I-REC and TIGR

I-REC

- Created in 2014
- Primary framework used in international REC transactions
- Certifies, and issues RECs through **local issuers**
- 199 million RECs issued in 2022
- **53 countries**

E.g. – I-REC appoints SP Group as one of the SG issuers. SP Group manages, issues, and facilitates trading of RECs

Similarities

- RE100 compliance

TIGR

- Created in 2016
- Simplifying tracking and trading of RECs worldwide through a central platform
- Issued 4 million RECs in Indonesia, out of the overall 10 million RECs issued in 2023
- **12 countries**

E.g. – RECs can be traded and transferred; or retired in the system for ESG claims

Source: Saxon Renewables