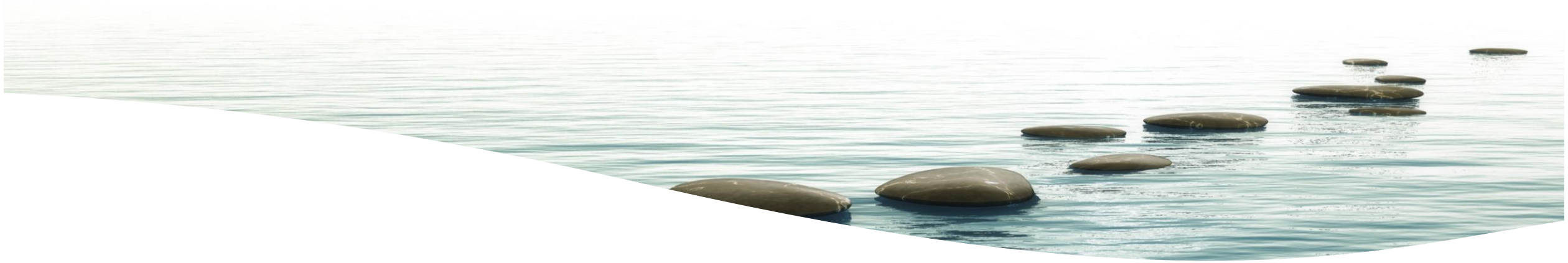

Market Dynamics in Singapore - Latest Development, Opportunities and Risks

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Topics

1 **The Latest Development in the Singapore Power and Energy Procurement Market**

2 **Experience of the Firm in the Singapore Market**

Singapore fuel mix

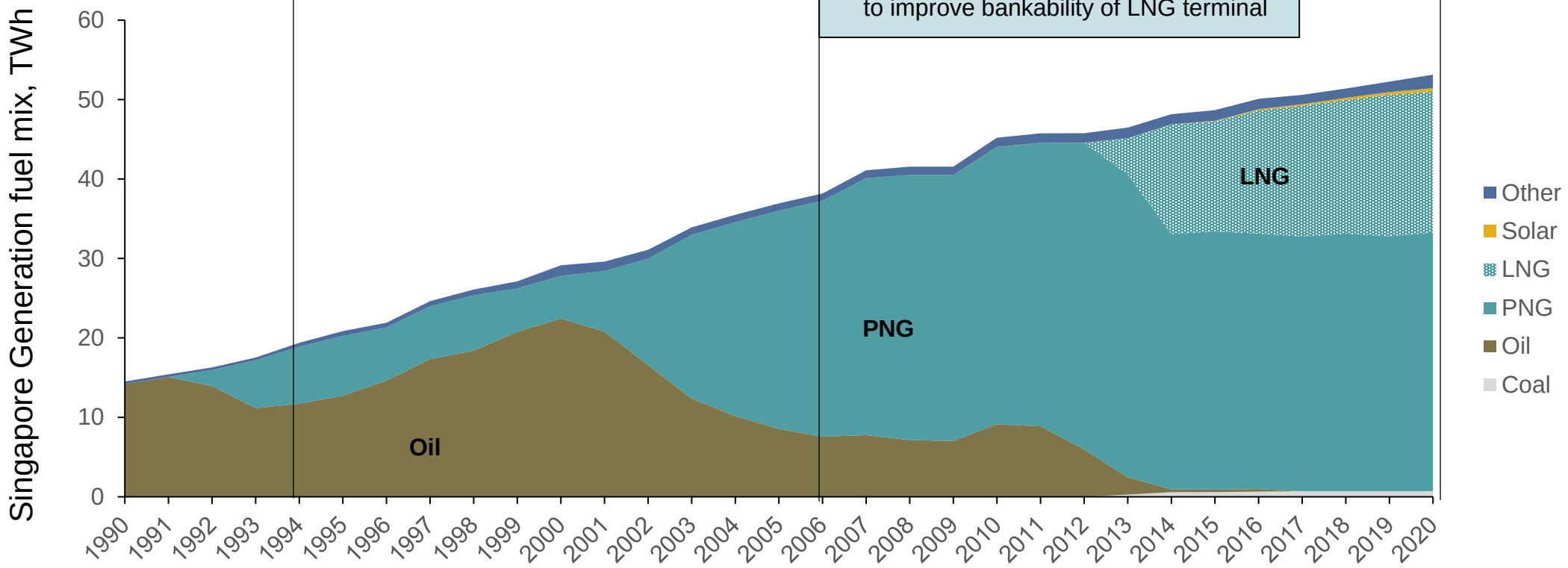
Pivotal policy decisions from the government have shaped Singapore fuel mix and its power sector in the past few decades

1 **To commit to Pipeline Natural Gas (PNG) take-or-pay contracts in late 1990s**

2

- PNG supply disruption and partial blackout in 2004 trigger concerns on energy security.
- Government is committed to develop LNG terminal in 2006; impose PNG moratorium and introduce LNG vesting to improve bankability of LNG terminal

3 **How will the decarbonization push alter the future long-term fuel mix??**

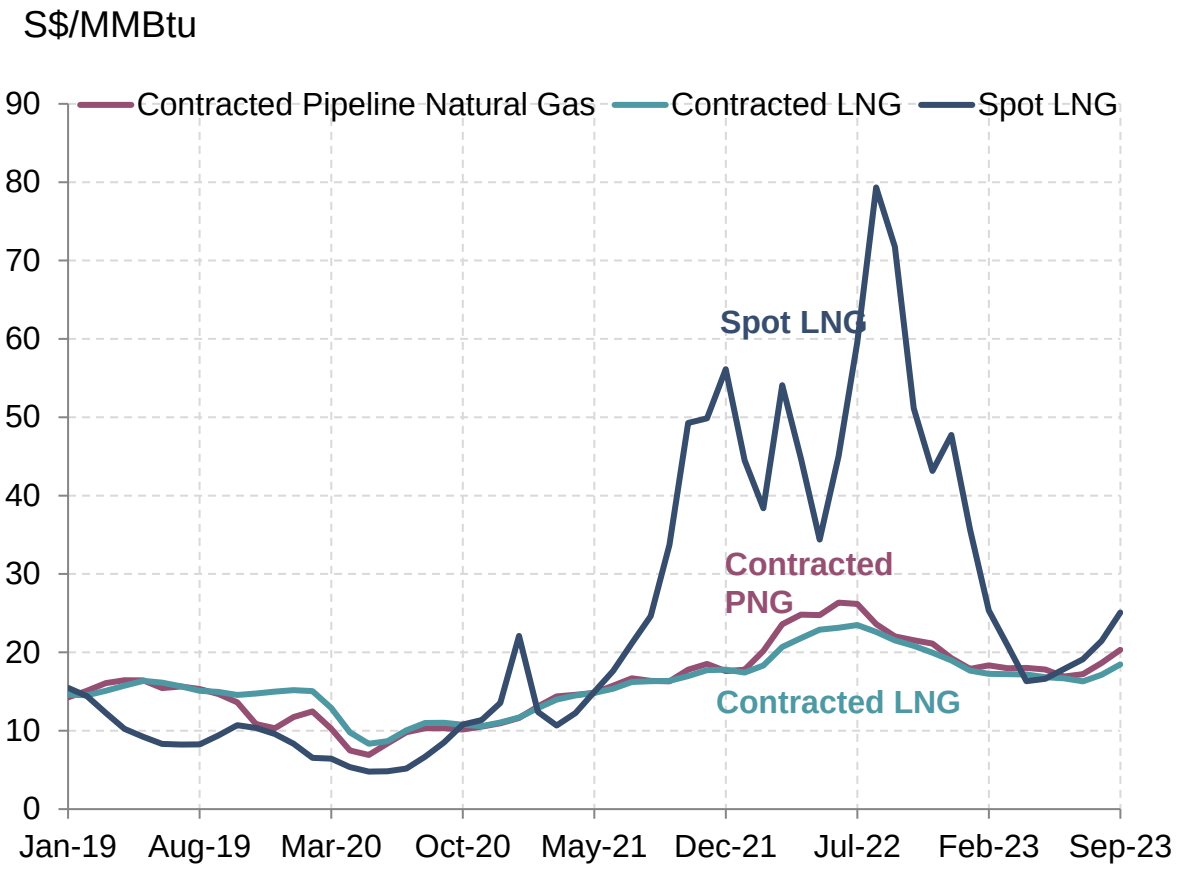


Note: Others are mainly waste-to-energy production from the incineration plants.
Source: IEA, EMC, WaterRock Energy Research and Analysis

Recent price shock

Marginal spot LNG prices have increased substantially in Singapore since Q3 2021, and end-users need to proactively manage cost

Singapore Gas Price



Contracted Gas Price

- Contracted delivered LNG and PNG prices to the CCGTs have increased from around S$14/MMBtu in H1 2021 to more than S$ 20/MMBtu since Jan 2022 due to the increase in Brent and fuel oil prices.

Spot LNG Price Shock

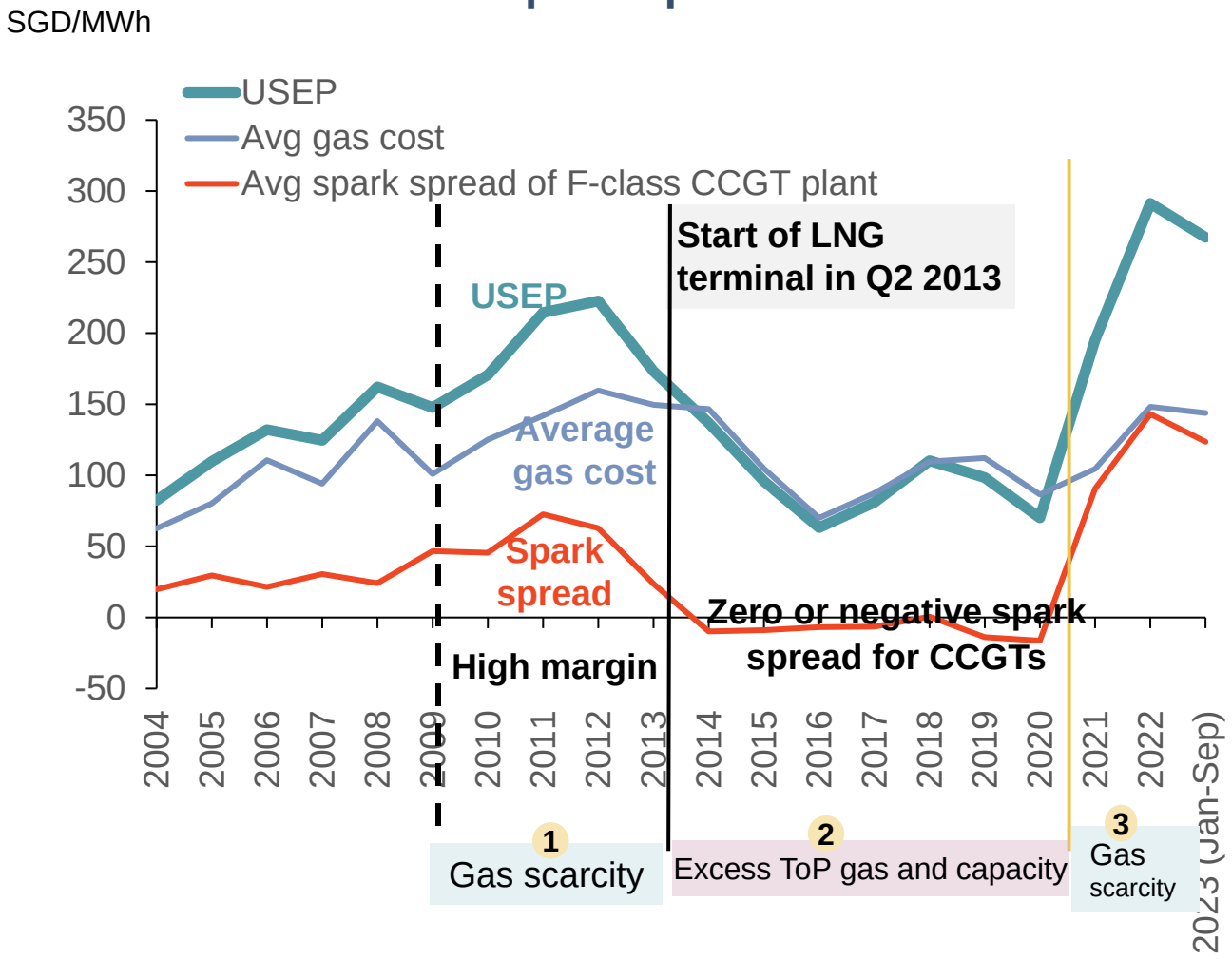
- Due to the pipeline gas supply curtailment from Indonesia, Singapore Gencos have to import spot LNG cargos via the SLNG terminal.
- However, Asian spot LNG prices have been trading at very high prices and are volatile since Q3 2021. This has materially increased the marginal fuel cost, which in turns increases Singapore wholesale electricity price (USEP) and retail prices.

Source: ICE, WaterRock Energy Research and Analysis

Historical USEP and Retail Prices

USEP and retail prices have increased materially since Q3 2021, driven by pipeline gas curtailment in Indonesia and high spot LNG prices

Market Prices and Spark Spread



- **2010-2012:** The high spark spreads in 2010-2012 were largely due to **gas shortages**, leading to a high opportunity cost of gas
- **2014-2020:** The market was over-supplied with both capacity and gas, leading to very low or negative spark spread in 2014-2020.

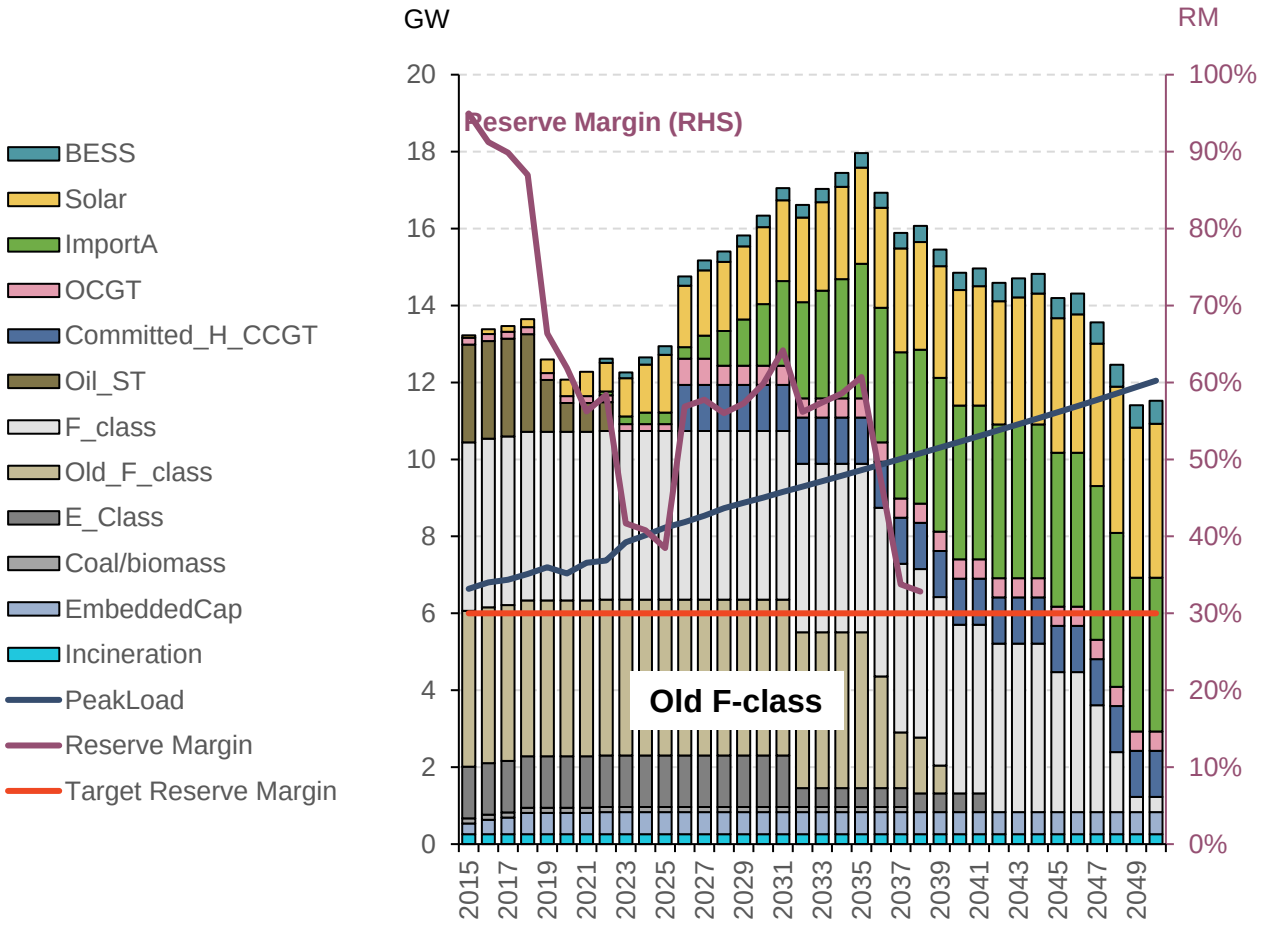
- **Since Q3 2021,** pipeline gas supply disruption/curtailment from Indonesia has led to the need to import spot LNG, but Asian spot LNG prices have increased materially to USD 20-50/MMBtu. This has led to high marginal gas price, causing USEP prices to spike.
- The gas cost of the Gencos is still largely based on oil-linked gas contracts, so average gas cost only increases slightly. Thus, the generation spark spread has increased materially for the Gencos.
- We understand that Gen-tailers have offered retail contracts based on fuel cost plus SGD 200/MWh in recent months. Partly due to the recent price/tariff spike.

Note: Spark spread is based on the difference between USEP and average contractual fuel cost of a F-class CCGT plant
Source: EMC, WaterRock Energy Analysis

Power Market Dynamics in Singapore

Even with expansion of green imports and local solar PV capacity, new local firming generation is still needed in the medium term

Singapore Power Supply and Demand



- The power market fundamental will become more balance with reserve margin at 30-40% from 2023 onwards.
  - The two steam units owned by Seraya are likely to be retired; potentially some old CCGT units might be retired or refurbished.
  - Near-term demand growth is relatively strong with commissioning of committed data centres and relatively healthy economic growth.
- **If the implementation of import projects are delayed, reserve margin may go below 27% for some years, leading to resource adequacy issues.**
- Even with expected material increase in base-load green imports and local solar PV capacity, **new local firming capacity is required in the medium term.**
- **In Singapore, new local firming capacity is CCGTs and/or OCGTs that can run on gas and H2. Thus, long-term market prices will need to be increased to reflect the long-run marginal cost of building and running new gas capacity. The key uncertainties of USEP prices are LNG price and carbon tax.**
- Singapore aims to reach net carbon zero in the power sector by 2050, so H2 will likely need to be introduced. H2 price is higher than LNG price, and we expect that special policy support will be provided for its adoption.

Note: When calculating the capacity contribution of solar PV to reserve margin, a de-rated rate of 21% is used for DC-rated solar capacity.

Source: EMA, WaterRock Energy Research and Analysis

Key Retailers

Due to the volatile prices, many independent retailers have existed the market, making the retail market (much) less competitive

Gentailers (Retailers with Thermal Assets)

- Seraya Energy Pte Ltd
- Senoko Energy Supply Pte Ltd
- Tuas Power Supply Pte Ltd
- Keppel Electric Pte Ltd
- Sembcorp Power Pte Ltd
- PacificLight Energy Pte Ltd

Retailers with Solar and/or Other Clean Offerings

- Sunseap Energy Pte Ltd
- Cleantech Solar Singapore Assets Pte Ltd
- Diamond Energy Merchants Pte Ltd
- ENGIE South East Asia Pte Ltd

Other Retailers

- Union Power Pte Ltd
- Just Electric Pte Ltd
- MyElectricity Pte Ltd
- LHN Energy Resources Pte Ltd
- Greencity Energy Pte Ltd
- MA Energy (SG) Pte Ltd
- Bioenergy Pte Ltd
- Flo Energy Singapore Pte Ltd

Retailers (Failed/Exited)

Energy Supply Solutions	Failed in May 2018
CHARIS ELECTRIC	Failed in Dec 2018
RedDotPower	Failed in Jan 2019
SUN ELECTRIC	Failed in Nov 2020
iswitch	Ceased operation in Oct 2021
Qhm.	Failed/Exited in Oct 2021
Union Power	Dropped 850 accounts in Q4 2021
BEST ELECTRICITY	Exited residential sector in Oct 2021

Note: SP Services is the supplier of last resort. When the retailers failed, their customers were automatically transferred to SP Services with prices set at the regulated tariff.
Source: EMA, Public News, WaterRock Energy Research and Analysis

Green Premium

The green premium varies materially across Gentailers, and it is worthwhile to proactively manage green procurement

Comparison of Green Electricity Plans for Household as of May 2022

Electricity retailer plan	Price (per kWh), excluding GST	Contract Duration
Sunseap – 1 Sunseap - 100	0.390 (1% solar) 0.420 (100% solar) **0.030 green premium**	6 months
Sembcorp	0.27925 (fixed price contract) 0.3166 (Sunshine green plan) **0.03735 green premium**	12 months
Senoko	0.2691 (3% certified solar) 0.2732 (100% certified solar) **0.0041 green premium**	24 months
Geneco Power	0.2701 (no RECs) 0.2801 (100% RECs) **0.01 green premium**	12 or 24 months

- There are local and international RECs. Depending on the green requirement of the large end-users, different types can be used, with different cost implications.
- Singapore is also looking to import renewable energy in the coming years. RECs generated from the RE import projects can potentially bundle with the imports and are sold to the large end-users in Singapore. However, there is policy risk that the host countries may ban the sale of RECs across border.
- Based on retail contracts with and without renewable generation offered by the large retailers to the household in Singapore (table on the right), the green premium is S$ 0.004-0.03/kWh (i.e. S$ 4-30/MWh).
  - This indicate that the green premium could vary materially across different Gen-tailers. .

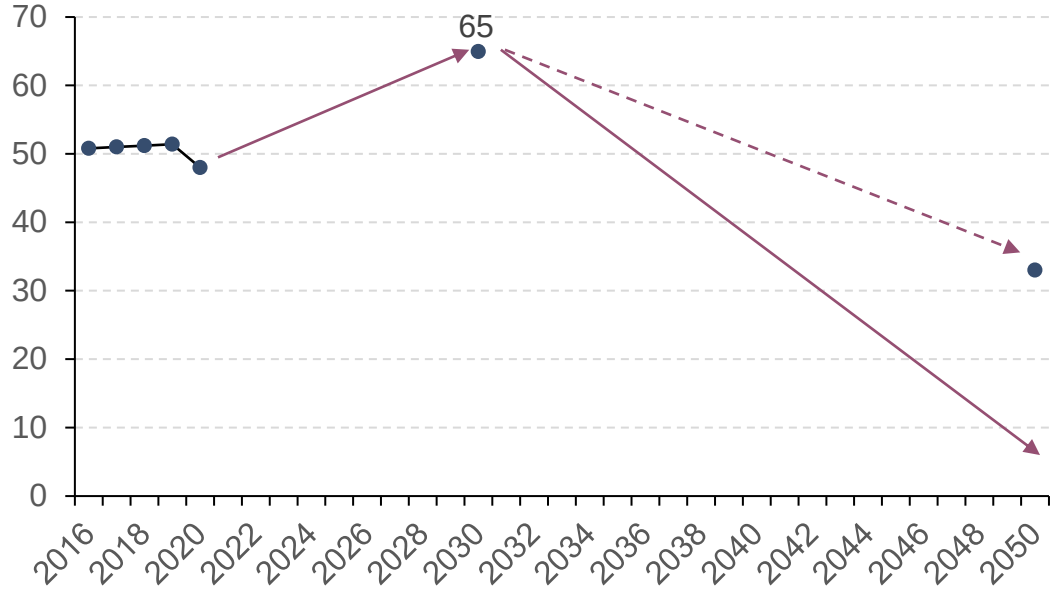
Source: Price plans from Sunseap, Sembcorp, Senoko and Geneco Power.

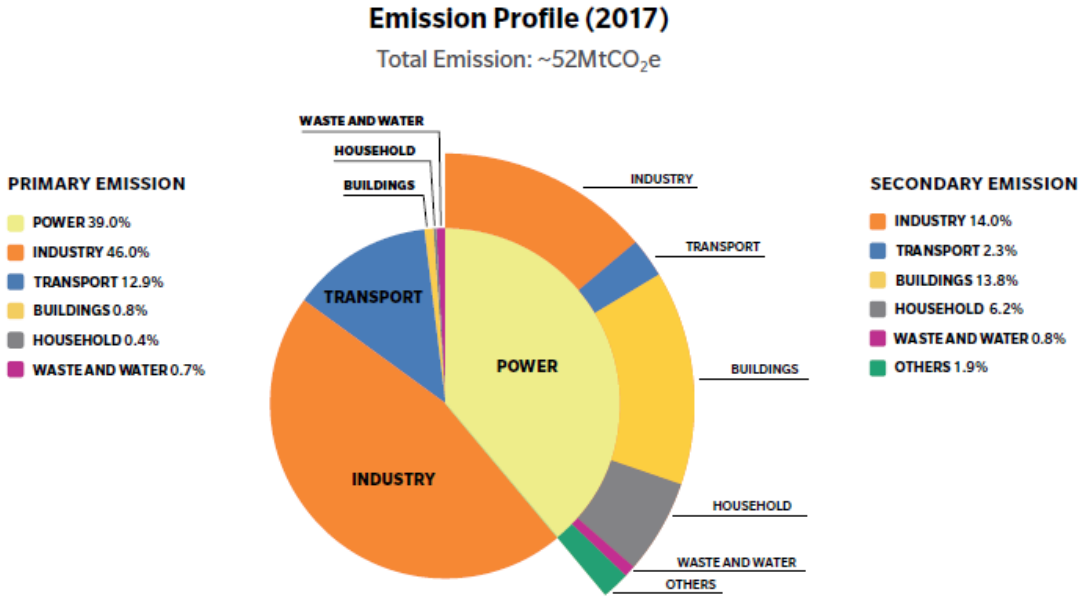
Singapore Long-term CO2 Emission Plan

Singapore plans to introduce imports, hydrogen and maybe CCS to help meet its carbon emission target in the power sector

Singapore Long-term Carbon Emission Plan

Million Tonnes of CO2





Source: National Climate Change Secretariat Strategy Group, Singapore, Charting Singapore's Low-Carbon and Climate Resilient Future, WaterRock Energy Research and Analysis

- **CO2 Emission Target**: To peak CO_2 emissions of no higher than 65 million tonnes of carbon dioxide equivalent (MtCO2e) around 2030 and to potentially reach net carbon zero by 2050.
- **Singapore government plans to introduce imports, hydrogen and maybe carbon capture and storage (CCS) to help meeting its carbon emission target.**

Investment Opportunities

With expected tightening market fundamentals and changing regulatory structure, there are opportunities to invest in the Singapore power market

Opportunities	Details
To meet growing demand and displace old capacity	▪ New capacity will be required to meet its target reserve margin and carbon emission target: – **Imports**: Power import is one of the key strategies that Singapore government has adopted to meet its CO2 emission target in the long term. It is looking to import 3.5-4.0 GW of base-load green power from other countries by 2035. – **Local investment**: The government is actively seeking to get investors to plant local capacity. – **New technologies**: The government is mulling to provide special incentives for pilot hydrogen (H2) facilities before rolling out big scale hydrogen infrastructure.
M&A Opportunities	▪ Merger & acquisition opportunities are likely to increase as some players in the market may seek to exit the market. There may be more government intervention on private M&A activities due to energy security concerns.
Special projects	▪ Cost of renewable technologies (such as solar and battery energy storage) continues to fall, and thus they are likely to be economical for more applications in the power sector.

Even with the identified procurement opportunities, there are many hurdles to overcome for power procurement

? Many Questions Remain to be Answered

- What are the **Risks** embedded in the commercial procurement contracts?
- What are the **Opportunities** to take advantage of flexibility given?
- Who are the **Competitors** and are there ways to reduce prices?
- Does the procurement decision **Create Future Options** which may become valuable?
- What are the **Exit Options**?

We can work closely with you to address these questions one-by-one

Source: WaterRock Energy Research and Analysis

Topics

1 The Latest Development in the Singapore Power and Energy Procurement Market

2 Experience of the Firm in the Singapore Market

Our key strengths to support power procurement, transaction, quantitative modelling and regulatory work in the Singapore electricity market

Long and deep experience in the electricity market in Singapore

- We are leading or are involved in studies related to several detailed de-carbonization studies for EMA since April 2021, including commercial evaluation of import proposals and long-term technology mix.
- In Feb 2019 – early 2021, WaterRock Energy (led by Liutong and sub-contracted to The Brattle Group) have helped the Energy Market Authority (EMA) of Singapore on the detailed design of Forward Capacity Market.
- In 2018-2023, WaterRock Energy (led by Liutong) has completed several detailed market studies and power pool modelling exercise for existing and potential new investors. Key scope includes detailed analysis of government policies; gas and power market supply and demand balance; power pool modelling to forecast wholesale power prices; impacts of regulatory changes and M&A on market prices and investment opportunities for thermal and renewable investors.
- In 2011-2018, Liutong worked with EMA on many regulatory issues, including the review of vesting contract regime, the setting of vesting contract level in 2014-2018, regulation on intermittent generation sources, fuel mix and carbon pricing policies etc. He also provided modelling support for one of the existing Generators in Singapore, and managed multiple due-diligence and market studies for large end-users, existing Gencos, renewable investors and infrastructure funds.

Robust quantitative tools with extensive data-base

- WaterRock Energy have created and refined our in-house NEMS Power Optimization Model, and used it for multiple studies to project Singapore wholesale energy prices.
- We have been closely following the development of the Singapore market, including gas contractual renewals/extensions, fundamental supply and demand dynamics and latest regulatory changes. The pool model is also well calibrated for immediate use. This can help to save time and cost for new market studies.

Our past work in Singapore

We have excellent understanding and experience in both renewable energy (solar, wind & hydro) and fossil fuel (gas, fuel oil and coal)

Selected Projects for Energy Market Authority (EMA)

April 2022 – now
Commercial Evaluation of Renewable Import Proposals
EMA

April 2021 – 2023
Long Term Fuel Mix and decarbonization Study (carbon pricing)
EMA

Feb 2019 - 2021
Development of a Forward Capacity Market
EMA

2018
Market Structure for Gas and Electricity Sector
EMA

2012, 2014, 2015-16
Fundamental Review of Vesting Contract Regime
EMA

2013-2014
Carbon Policy and Regulation
EMA

Selected Projects for Commercial Players

Apr 2021 – Mar 2022
Market and strategy study for H2 adoption in Singapore
New Investors

Oct 2020 - 2021
Detailed Review of Singapore Electricity Market Design
A Research Institute

2019-current
Singapore power market study & price forecast (2020-2045)
Existing and New Investors

H2 2018
Detailed Analysis of Singapore Electricity Market
An Asian utility company

2014-18
Retail Contract Negotiation Strategy
Large end-users

2017
Strategy Paper on NEMS Reset
A consortium of International Gencos

2014-18
Pool Power Modelling Support
An existing Genco in Singapore

2013, 2016
Commercial Market Studies and USEP Price Forecast
Existing Gencos

2015
Market Entry Strategy for Rooftop Solar
International Solar Player

Our Services for End-users

Strategic Review

- Employ discipline in understanding of electricity market operation, sourcing of electricity supply and REC contracts;
- Identify the risks, opportunities and flexibility resided in the contracts;
- Manage best practices with aim of risk mitigation and value creation for our clients.

Develop Synergies

- Introduce strategic opportunities
- Optimize deal opportunities and access to alternative solution
- Allow customers' to benefit from the timely execution of the contracts as well as execution of hedges.

We have worked for large power and gas end-users for more than 10 years in Asia

Business Sectors

Technology / data centers
[to help them understand regulation and energy cost in different Asian market for site selection

Manufacturers
[to help them track energy cost, optimize production plans, energy procurement etc]

Consumer goods
[to help them track energy consumption and reach their sustainability goals]

Key Services

- **Energy Procurement**
- **Regular Energy Market Development Updates**
- **Energy Price/Tariff Forecast**
- **RECs and Carbon Price/Cost**
- **Supports on Ad-hoc Tariff and Energy Procurement Issues**

Our Robust Approach

1. **Data/information collection and analysis**
2. **Review of key regulatory trends**
3. **Use robust tools to forecast energy tariff, REC and carbon price/cost**
4. **Assist clients plan/mitigate/respond**

Source: WaterRock Energy

Our service offerings for large power and gas end-users

- Detailed tariff benchmark studies
- Energy price projections
  - Wholesale
  - Retail
- Quarterly, Semi-Annual, or Annual briefings and projections
  - Tailored to industrial sites
  - Address key issues / clarify regulatory and policy developments
  - Review of REC policies
  - Review of latest carbon policies
  - Review and project fuel cost trends
  - Major regulatory radar issues.
- Short-term (1yr) and Medium-Term (5yr) energy budgets
  - Forecast of prices and spend by site (monthly or annually)
  - Focus on detailed charges and performance improvement opportunities (load factor, power capacity factor, etc)
- Invoice tracking (and translation where necessary) for reporting, validation, and trend analysis
- Special projects (e.g. preparation for contract negotiation, analysis of on-site generation options).

Source: WaterRock Energy

Forecasting USEP

Forecast of wholesale electricity market price USEP will be one of the key items that end-users need to do robustly to understand procurement risk

Modelling Specifics for NEMS Power Market

1 System Characteristics

- Unit-based modelling of every unit in the NEMS.
  - Reflect unit-specific cost and bidding behavior based on extensive data and knowledge accumulated over the years.
- Model main Island, Jurong Island and Tembusu areas to reflect transmission constraint before 2019
- Load duration curve approach to represent half-hourly load to increase model flexibility and adaptability.

2 Gas Contracts

- Thorough representation of pipeline natural gas (PNG) and liquefied natural gas (LNG) contracts, including fuel quantities [take-or-pay (ToP), ACQ, PNG banking and LNG re-profiling etc] and price linkages.

3 Markets

- Co-optimization of energy and ancillary services is represented
- Price caps for energy, reserves and regulation are imposed.

4 Bidding Strategy

- Game theoretic modelling of major Genco's incentives and ability to exercise market power and raise half-hourly prices above short-run marginal cost (SRMC).

5 Long-term decarbonization

- Different contractual frameworks could be adopted for low/zero carbon options, such as import, hydrogen and carbon capture and storage.
- We have modelling tools to incorporate different contractual frameworks and evaluate their impact on the spot market prices, USEP

Proprietary Power Optimization Model

We have robust and proven power optimization tool to model the Singapore electricity market

Key input and output structure of NEMS Power Optimization Model

Modelling Inputs

Demand-related	Supply-related	Fuel-related	Policy-related
Load duration curve (20 blocks per quarter)	Existing and committed fleet characteristics	Fuel prices and characteristics	Policy related constraints (such as price caps)
Demand growth by region	Operating, fixed & investment costs	Fuel contractual constraints	System wide constraints (like carbon emission level)
T&D loss and auxiliary use	New technology characteristics	Fuel-related infrastructure cost	**Carbon tax and REC policy**
Demand of ancillary services	Transmission Constraints	Fuel availability	System reliability (via required reserve margin)

Inputs

Process

Energy Dispatch Simulator (based on short-run marginal cost)

Capacity Expansion Simulator

Outputs

Output

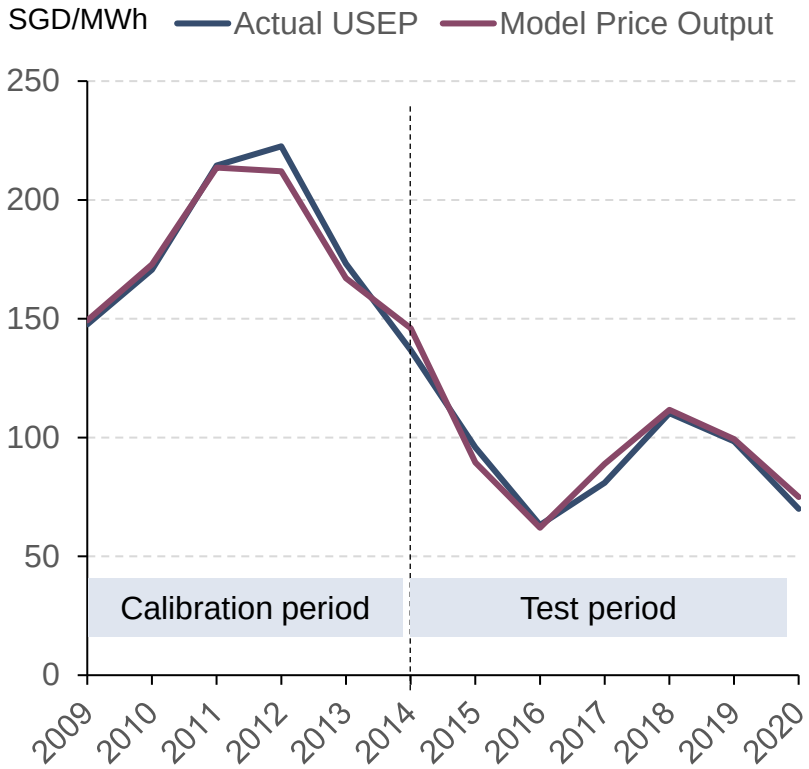
- New Capacity Expansion by Technology
- Generation by Unit
- Fuel Mix / Renewable share
- Market prices
- Profitability by Generation Unit
- Merit order curves
- System cost etc

New Builds & Retirements

Prices (marginal cost and system cost)

Our NEMS Power Optimization Model is an integrated generation dispatch and capacity expansion modelling tool that incorporates state-of-the-art optimisation theory grounded in proven techniques

Calibration and Test Period



Our NEMS Power Optimization Model reflects historical outcomes from bottom-up back-cast relatively well after taking into account actual demand, fuel prices and fuel contractual constraints.

Source: WaterRock Energy Research and Analysis

Thanks and Contact

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Energy Economics

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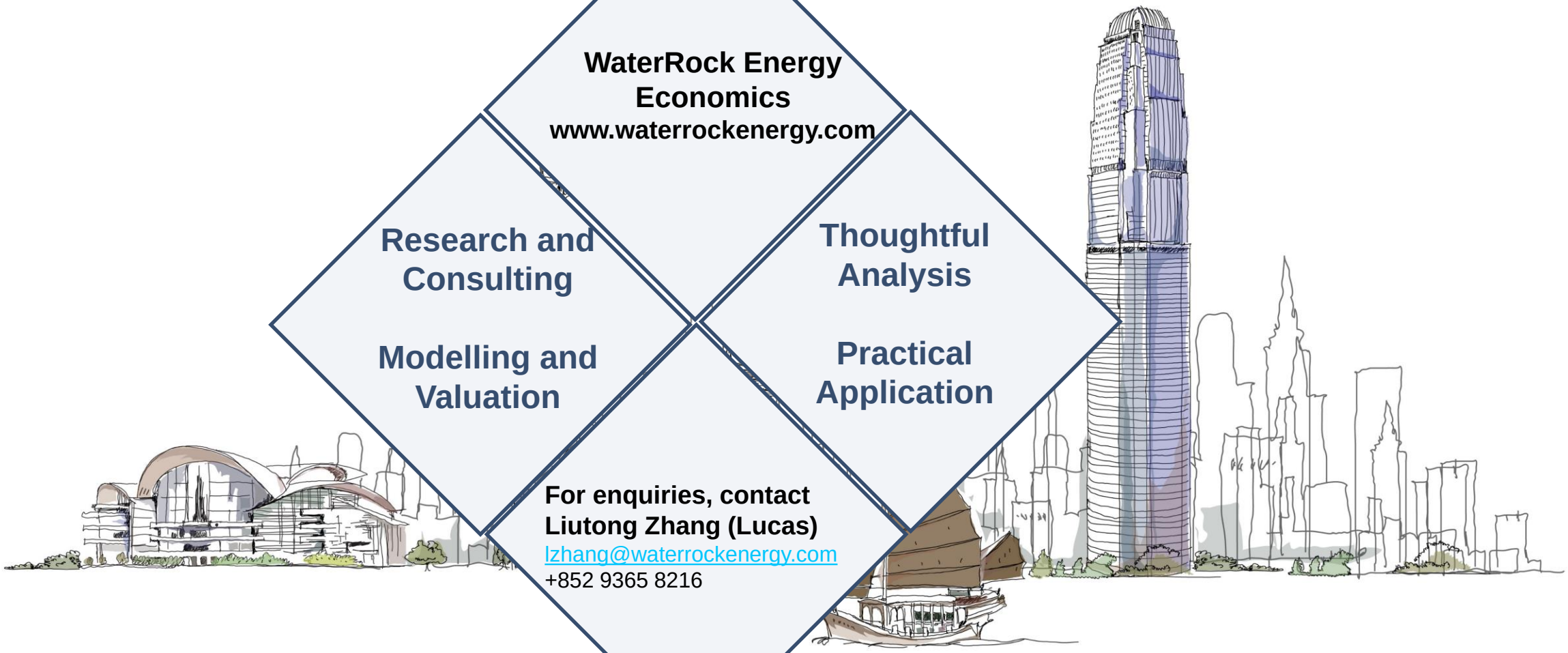
Research and Consulting

Modelling and Valuation

Thoughtful Analysis

Practical Application



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Commercial and Regulatory Support

RE energy imports to SG, REC market, Carbon pricing, Energy procurement, Transaction support, Market analysis, Regulatory support, Tariff benchmark,

Strong client base

Regulators, grid companies, utilities, PE funds, financial institutions, gas suppliers and importers

Our Key Clients (since July 2018)