THE STRATEGY ANALYSIS OF LIQUEFIED NATURAL GAS SECURITY IN TAIWAN

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Energy Challenges for the Next Decade

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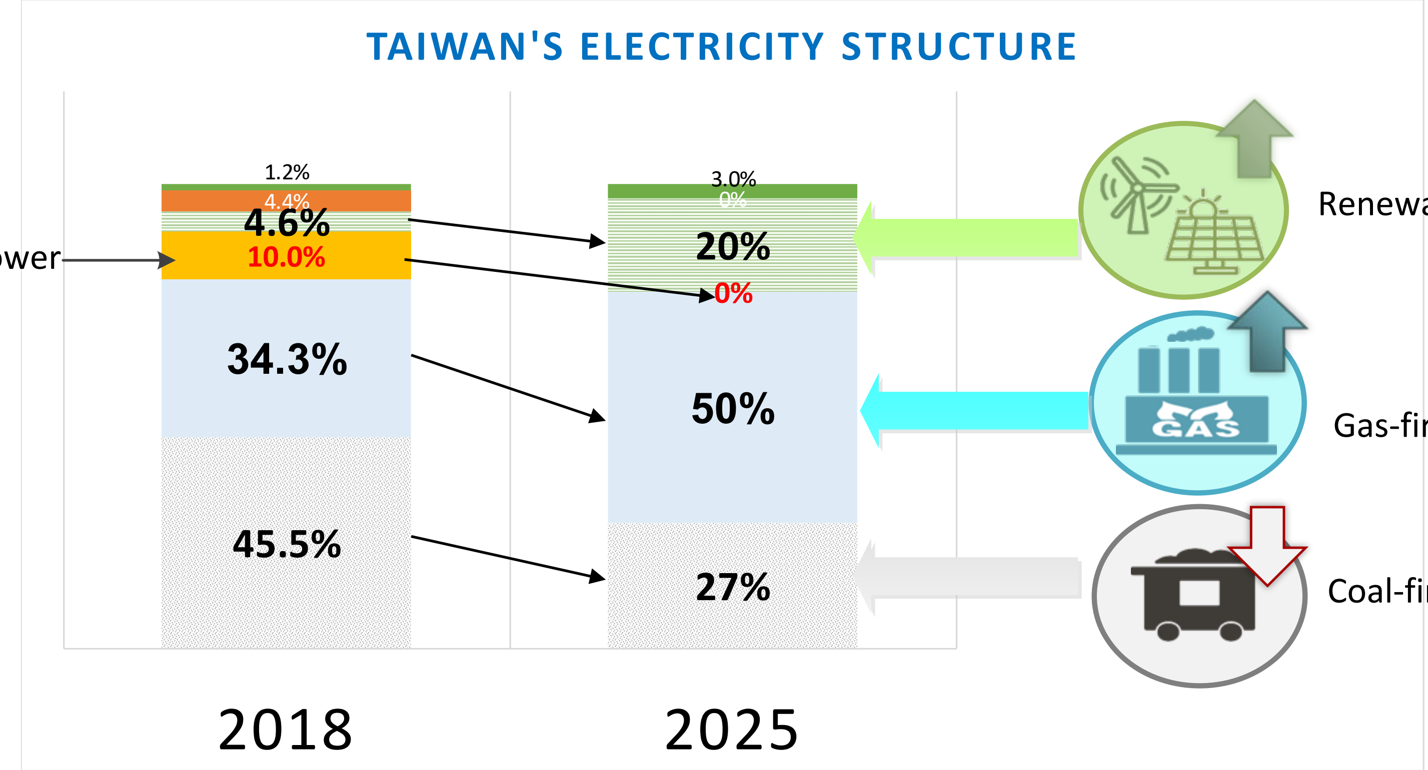
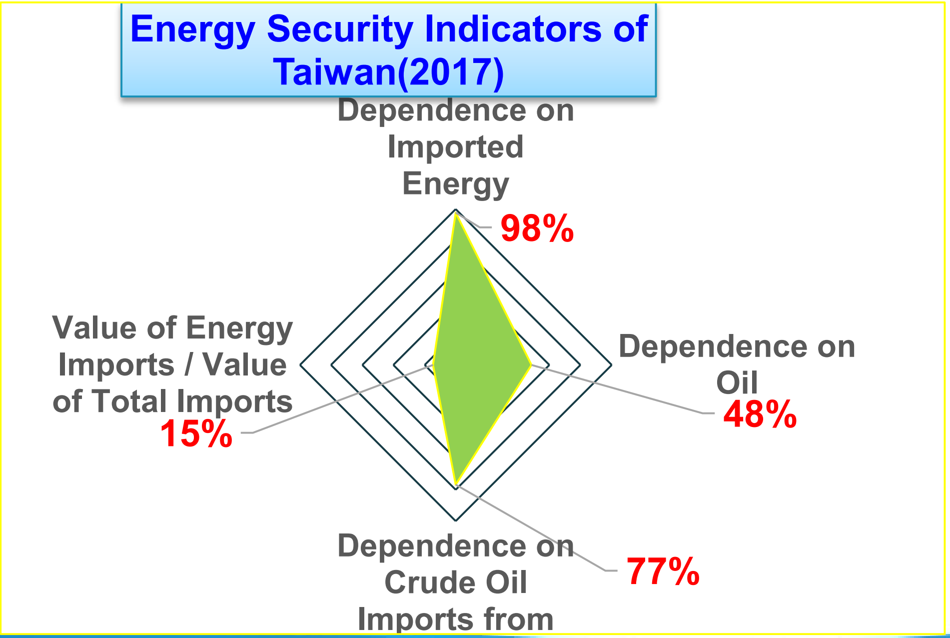
Vision of Taiwan's Energy Transition

- Non-nuclear homeland and low-carbon economic development.
- Establishing **a new national electricity structure by 2025**.



Correlation between Energy Security and Energy Transition

- **The energy security is linked to national security.**
  - ✓Depending on imported fossil fuel as high as **98%.**
  - ✓**15%** of national import expenditures is spent on energy.
  - ✓Domestic energy price is fluctuated by **international energy prices**.
  - ✓**Crude oil from Middle East accounted for 77% which are affected by geopolitics**.
- Implementing low-carbon energy transition should base **on a stable and affordable energy supply system.**



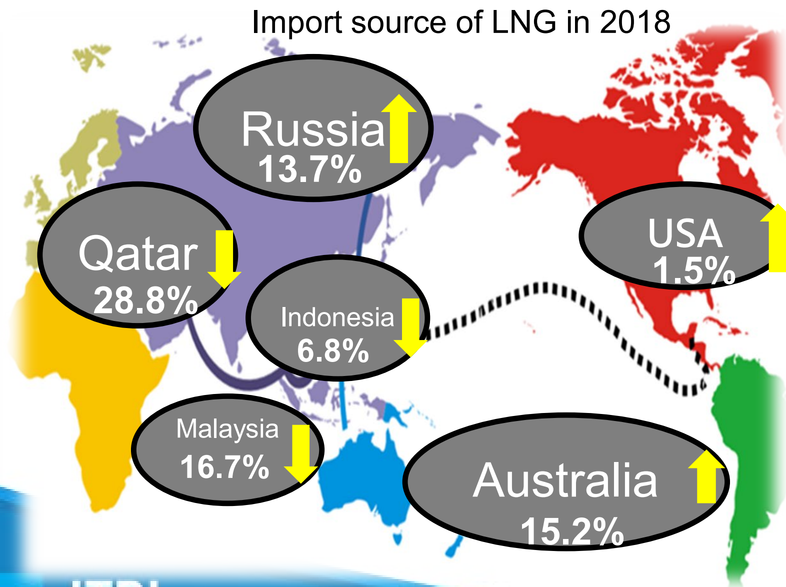
Policies for LNG Security in Taiwan

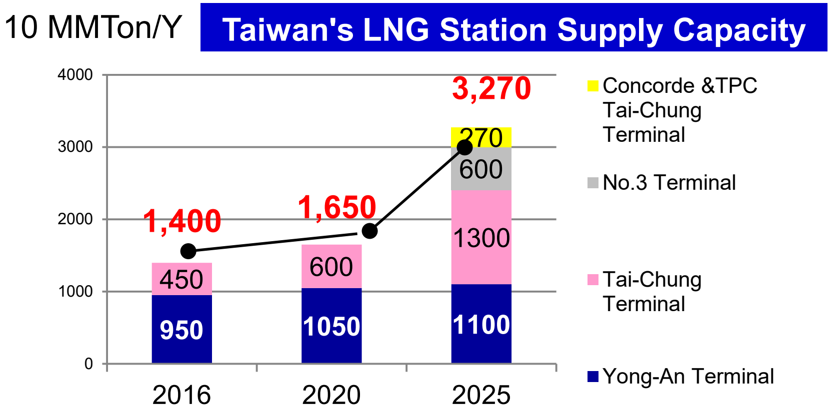
- 80% of gas is used in the power sector in the last five years.
- The importance of LNG for low-carbon energy transition in Taiwan：
  - ✓ Assistting the dispatch of variable renewable power.
  - ✓ Stabilising air quality by increasing gas in place of coal.

■ Two policies to secure LNG supply：

(1)Diversifying the import sources of natural gas.

(2)Expanding the storage tank capacity and raising LNG legal days of stock.





legal days	2019	2022	2025	2027
storage tank capacity	15	16	20	24
safety stock	7	8	11	14

Purpose of this Study....

- National energy security is constructed with **interrelating multi-dimensions, including 4As(Availability, Accessibility, Affordability, Acceptability)**, proposed by APERC in 2007.
- This study established a **system dynamic model of natural gas** to assess policy impact and identify risk factors during the energy transformation.

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Methods of Energy Security Analysis

- Indicator is a prevailing method for measuring energy security.
- Comparing the two types of **energy security indicators** as follow:

This study use the ***system dynamic model*** as a research method.

	Simplified	systemic
Temporal	Static	Dynamic
Spatial	Assembled	Integrated with **interaction**
Functional	Outcome-based indicators (ex-post)	Evaluated-based indicators (**ex-ante**)
Meaning	Measuring the current state of energy supply chain	Assessing the **potential risks** and vulnerability of energy system
Advantage	Simple and Easily communication	**Clarification of causality** brings meaningful dialogue
Disadvantage	Incomplete thinking may convey contradictory messages	Complex on data collection and model operation

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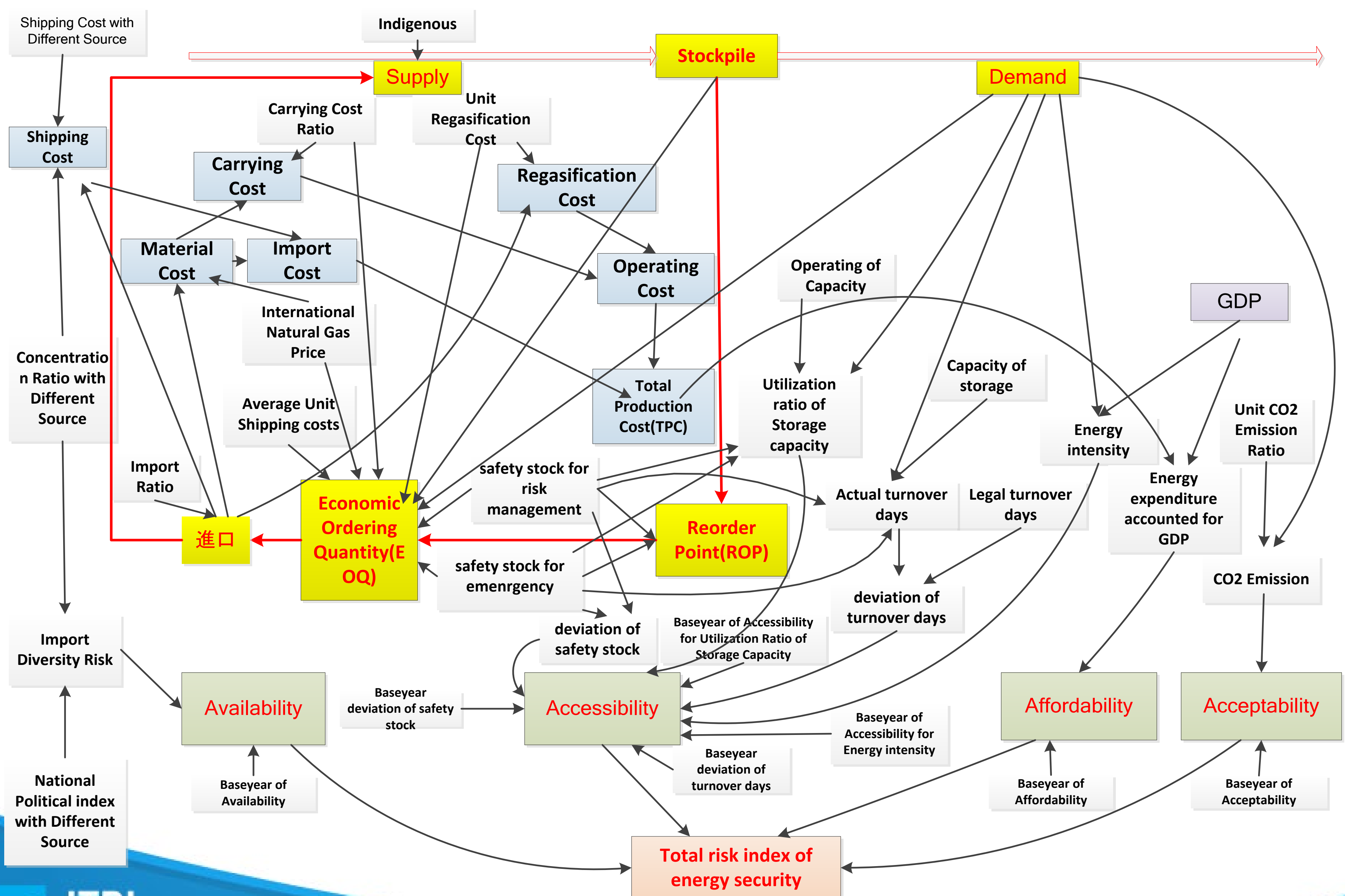
Introduction for System Dynamic Model

- System dynamic(SD) model was created by **Jay W. Forrester In 1956**.
- **The main characteristics as follow:**
  - ✓ To analyze the dynamic behavior of complex systems.
  - ✓ Qualitative visualization ：A feedback causality of factors are represented in SD as a causal-loop diagram(CLD).
  - ✓ Quantitative analysis：The CLD is formulated the equations to simulate the value of all stocks and flows (stock-flow diagram, SFD)over time under certain conditions and assumptions.
- **The steps of building a SD as follow:**

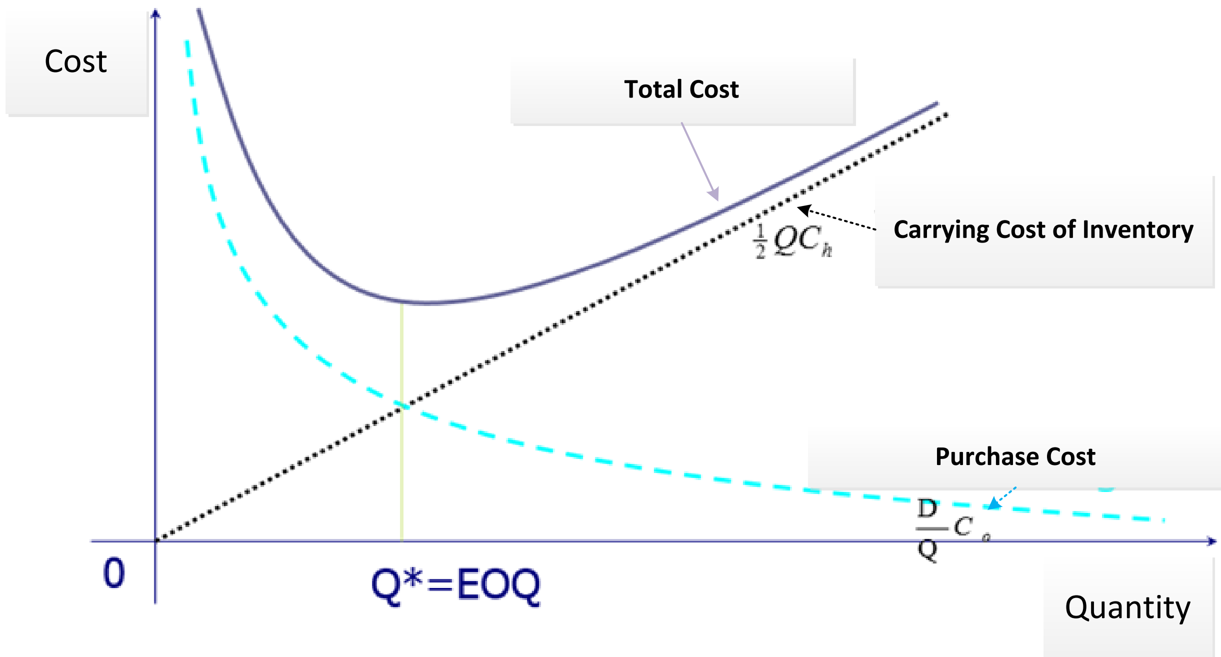
1. Understanding system
2. Identifying problems
3. building models
4. Establishing baseline
5. Simulating policy scenarios

Modeling for LNG Supply Security



Features of LNG Supply Security Modelling

- Introducing **inventory management theory** into SD model is in line with **cost-benefit decision-making and supply-demand equilibrium of economics.**
- Inventory management theory was proposed by Ford W. Harris in 1915.

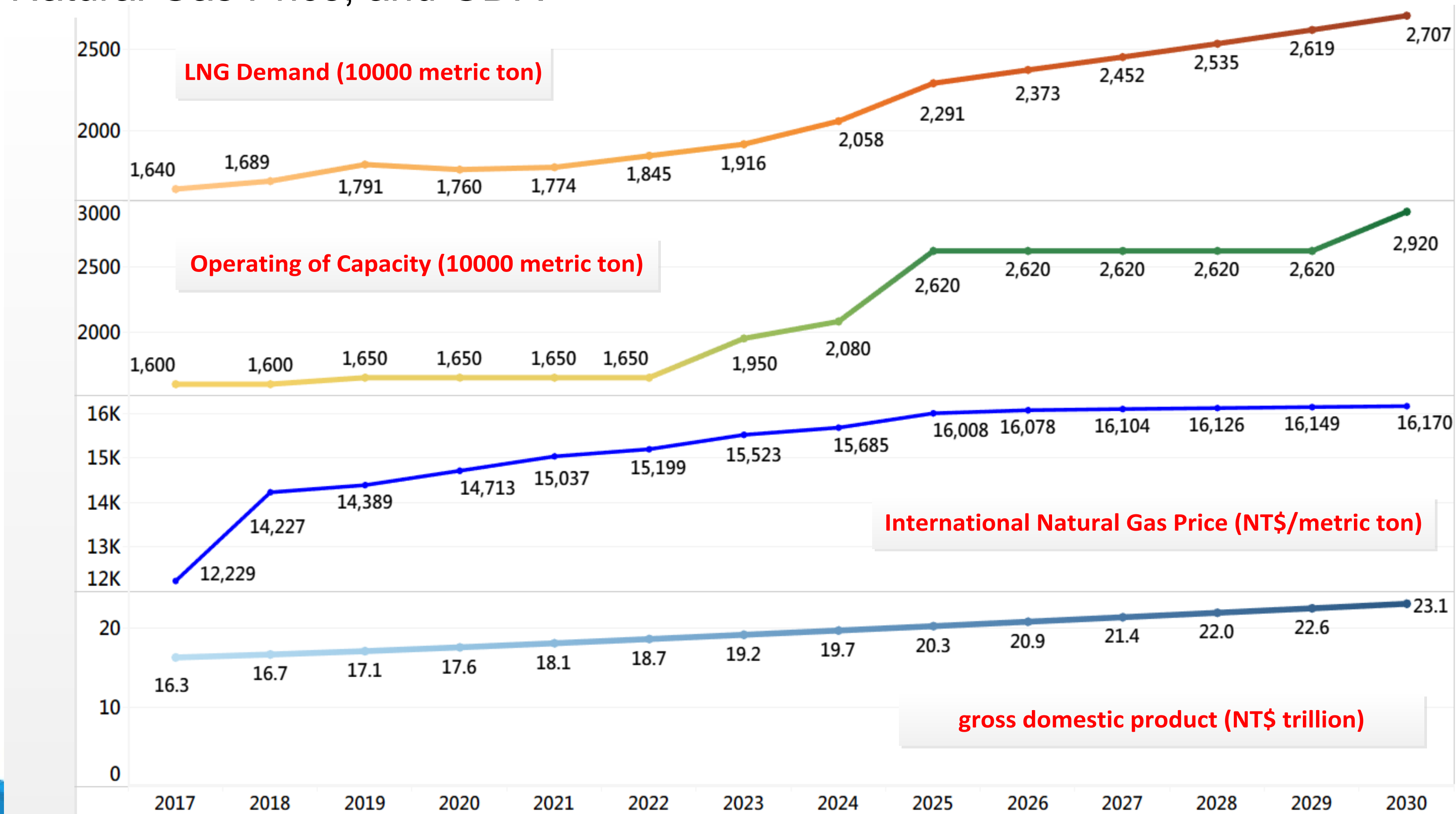


$$Q^* = \sqrt{\frac{2DC_o}{C_h}}$$

Q^* : Economic Ordering Quantity (EOQ)
C_0 : Carrying Cost
C_h : Purchase Cost
D : Demand

Assumptions of This Study

- **Four forecasting exogenous parameters** from 2017 to 2030 were used in this study, including LNG Demand, Operating of Capacity, International Natural Gas Price, and GDP.



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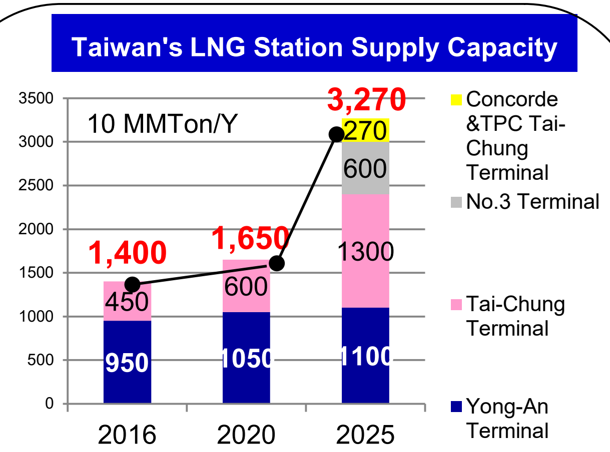
Scenarios of This Study….

- **Two scenarios were created to assess the policy impacts. SCEN scenario measured risk situation while safety stock policy was implemented. BASE scenario was used as a comparable benchmark related to SCEN scenario.**
- All analytic results were based on **the scenarios difference between SCEN and BASE**.



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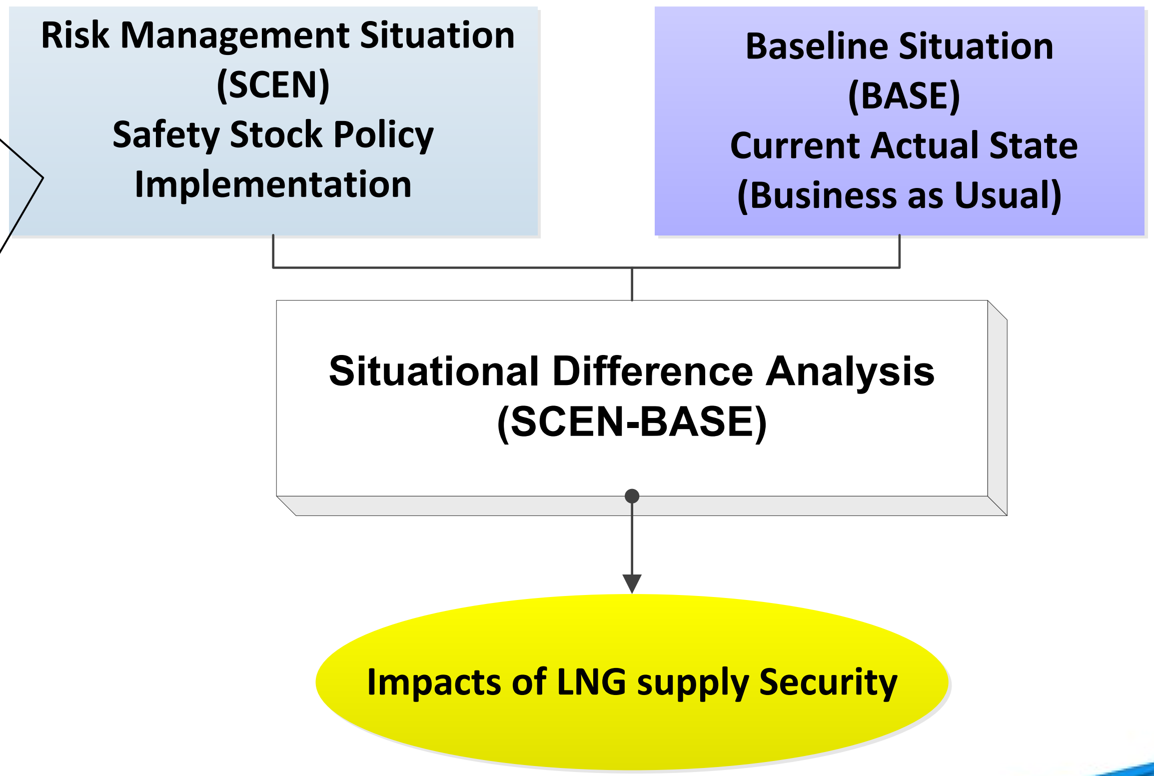
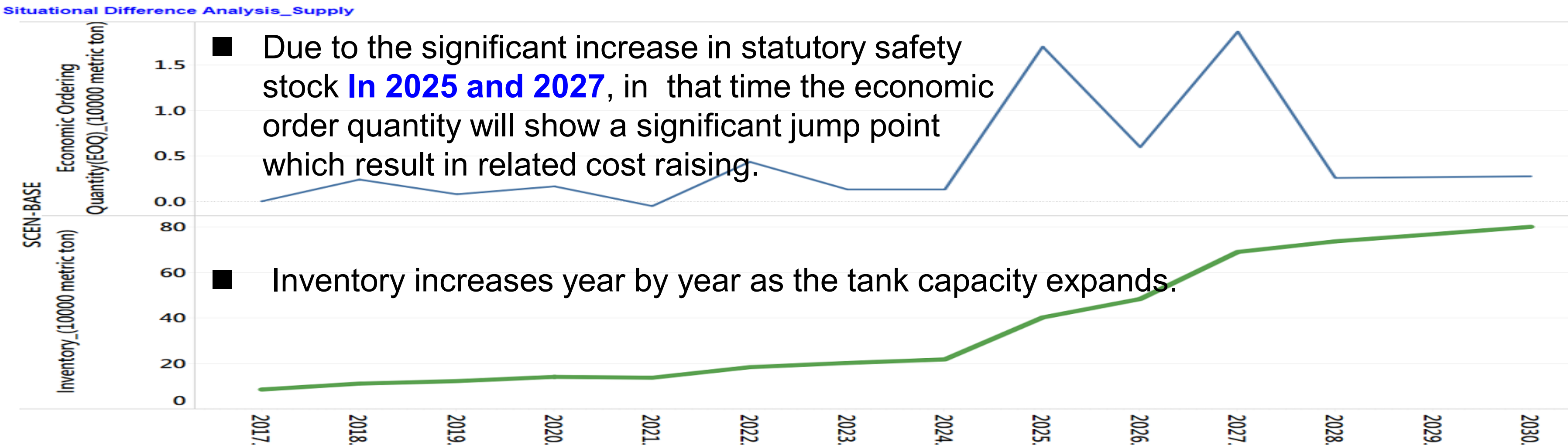
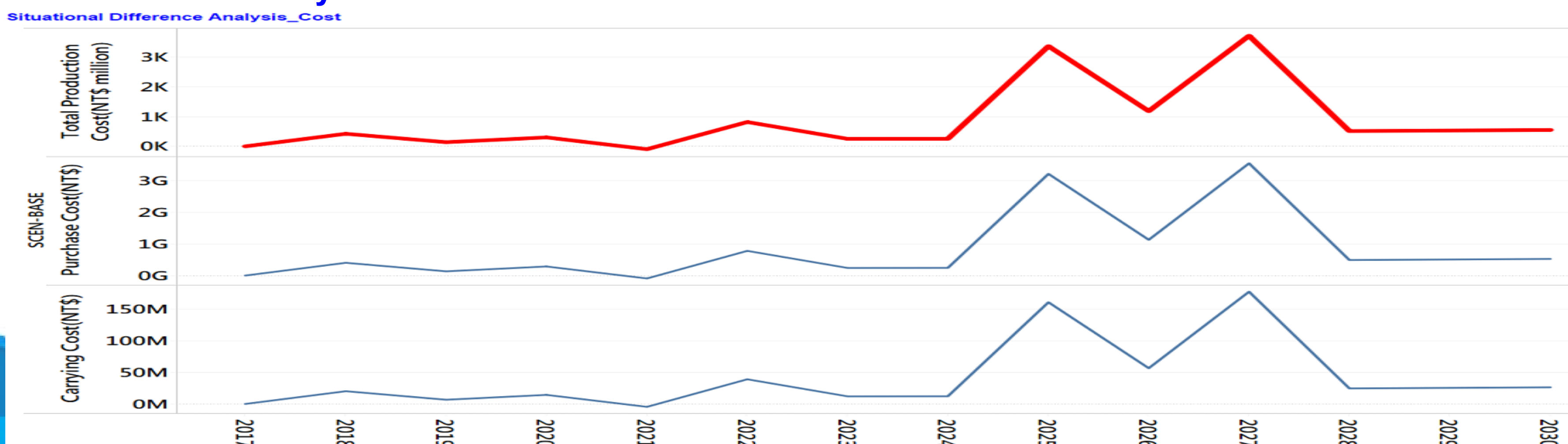


Scenarios Difference Analysis： Supply and Cost



- Due to the significant increase in statutory safety stock **In 2025 and 2027**, in that time the economic order quantity will show a significant jump point which result in related cost raising.
- Inventory increases year by year as the tank capacity expands.
- When the inventory in 2027 is raised to 700,000 metric tons, the total production cost will increase to NT$3.72 billion. Compared to 2018, **while inventory increased by 6.4 times, total production costs will increase by 8.7 times.**



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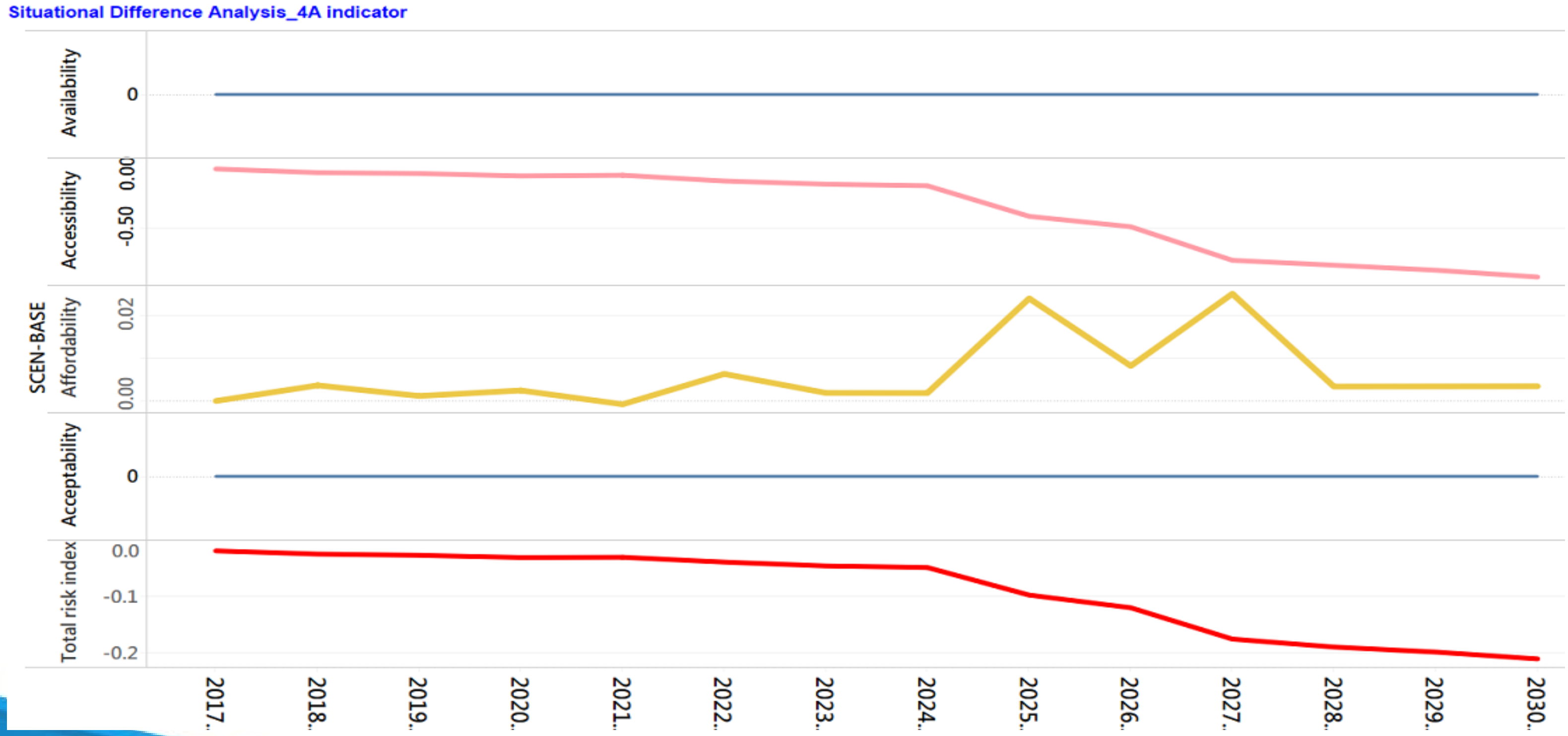
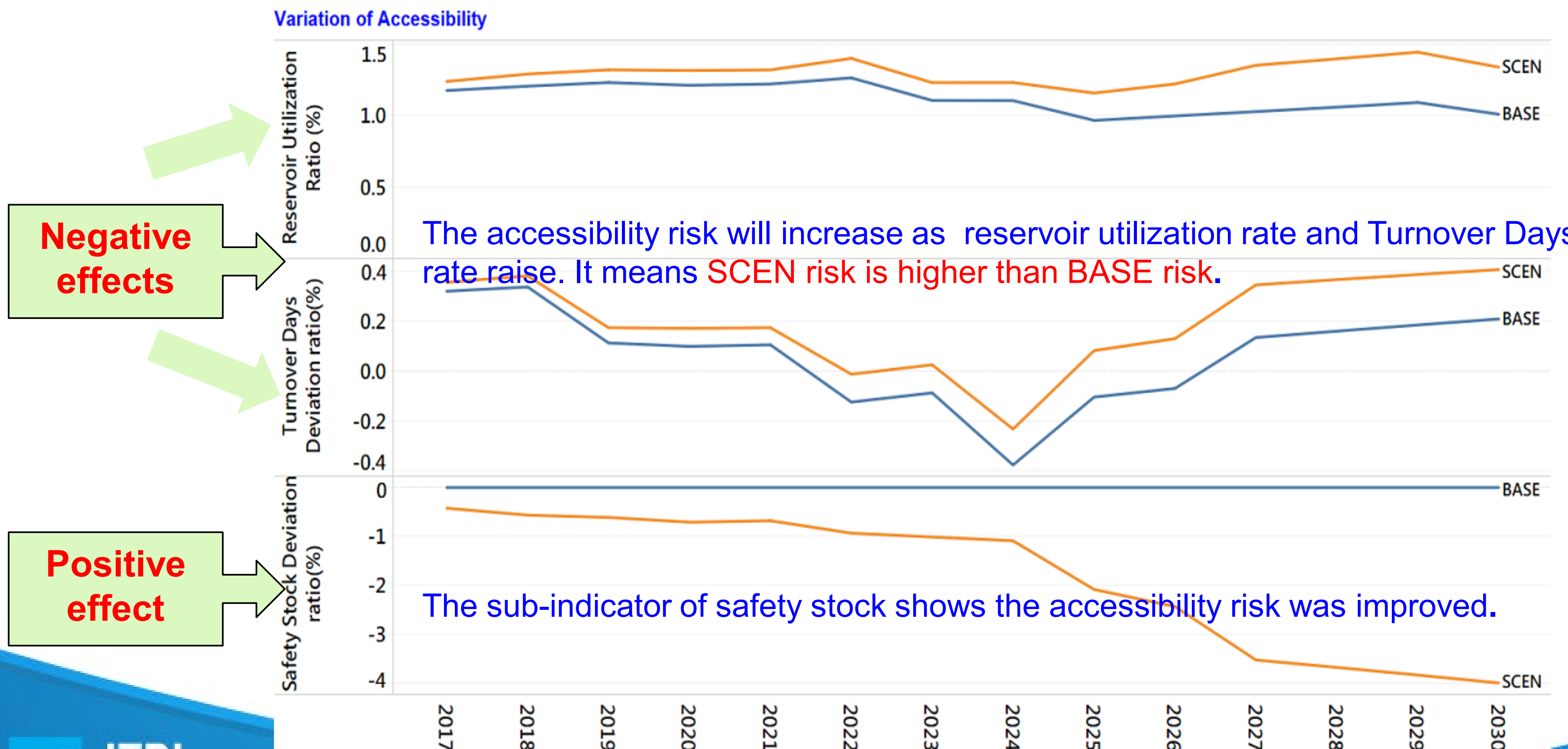
Scenarios Difference Analysis：4 A Indicators

- The impacts of statutory LNG safety stock will happen on **"Accessibility"** and **"Affordability"** of the 4A energy security dimensions.
- The accessibility risk is reduced, but the affordability risk rises.
- Averaging of the accessibility risk and the affordability risk, the overall risk indicator showed a downward trend, indicating that Taiwan's LNG safety stock policy has a positive effect on improving energy security.



Scenarios Difference Analysis：Variation of Accessibility

- Due to the LNG safety stock policy, two sub-indicators (reservoir utilization rate and turnover day rate) produced risk deterioration, but a safety stock resulted in a positive improving effect for emergency risk.
- Aggregating **the positive and negative effects of three sub-indicators, the overall accessibility risk improves.**



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Conclusion and Suggestion

- The energy security is mutual causality in different dimensions.
- It is necessary to consider positive and negative impacts of policies implementation by a systematic perspective.
- Some suggestions were proposed for further study as below：

    (1) Safety stock planning should consider the cost-effective inventory management. It is needed to collect the O&M detail cost data of LNG storage for more accurate assessment, including LNG maintenance under 162 ° C temperature, storage evaporation, etc. A more efficient inventory management system could avoid the loss of management costs due to excessive inventory, which could reduce the affordability risk.

    (2) It could reduce the fluctuation of Taiwan's electricity prices and consumer prices by diversifying the sources of LNG supply contracts, including long-term and short-term, which means Taiwan's natural gas management strategies not only ensure stable supply("Accessibility") but also pay more attention on "Affordability" and "Availability".

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Thank you for your attention!

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