

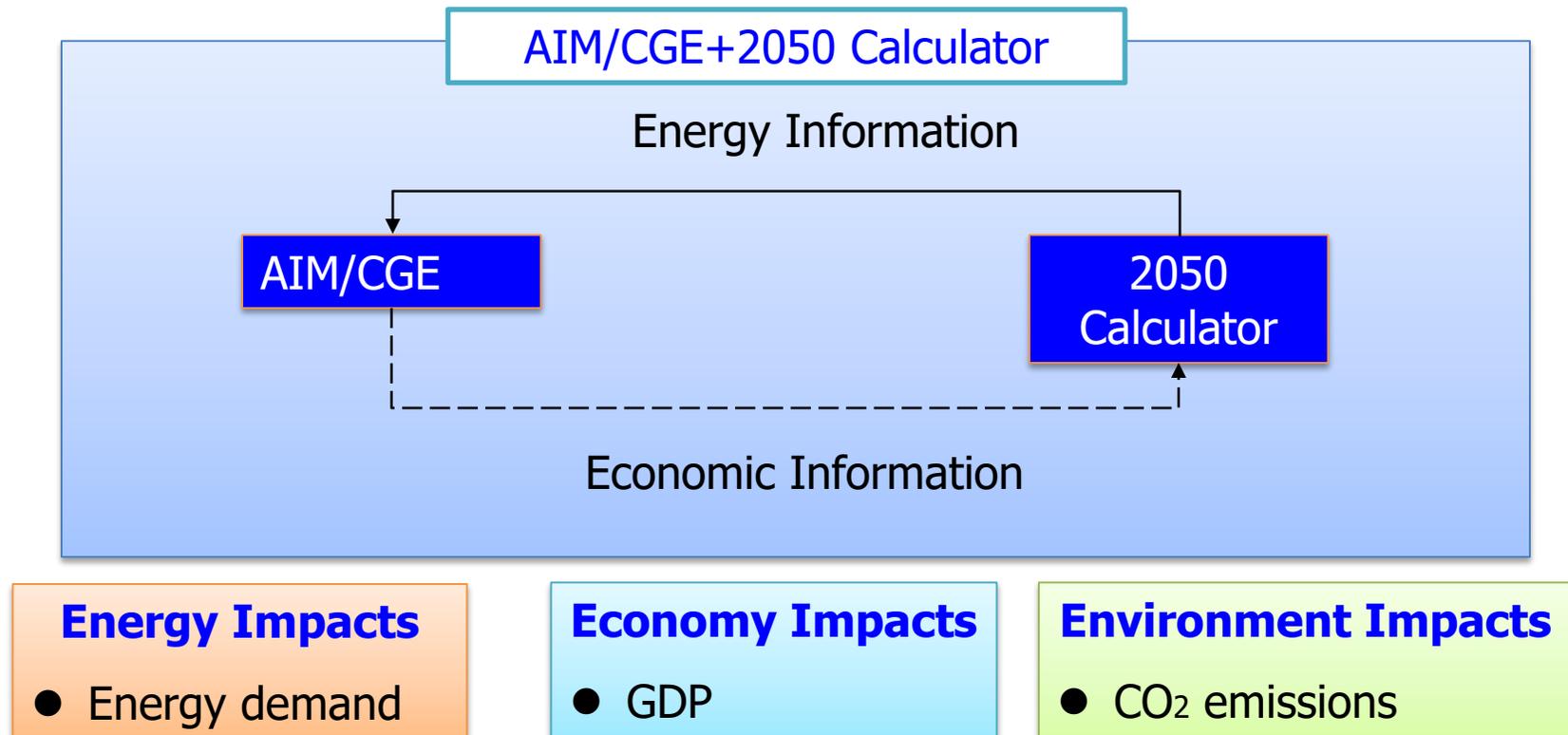
The Power Generation Mix and 3E Consequence: The Implications for Taiwan

Yi-Hua Wu, Chia Hao Liu, Hancheng Dai and Toshihiko Masui

Introductions

Purpose

- Investigate the impacts of various **power generation mix**
- Use an integrated model, **AIM/CGE** and **2050 Calculator**, to study such an issue



Introductions

Taiwan Relies on Energy Import

- **98%** of Taiwan' s energy is imported in 2016

Nuclear Fuel



Oil



Gas



Nuclear Fuel

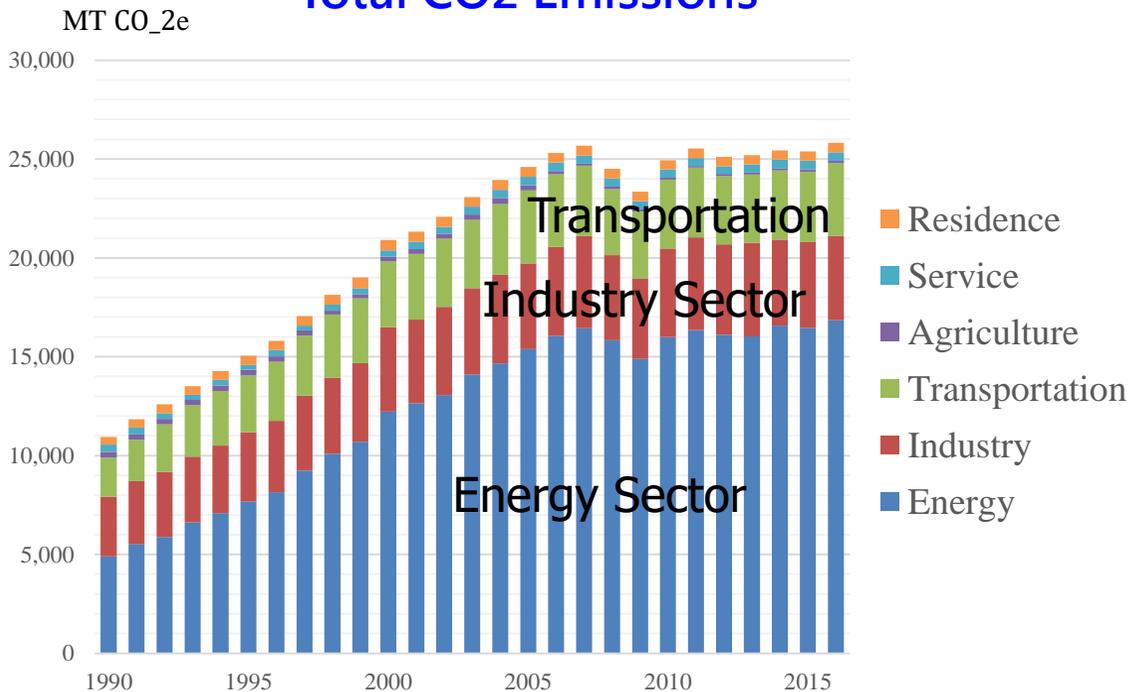


Introductions

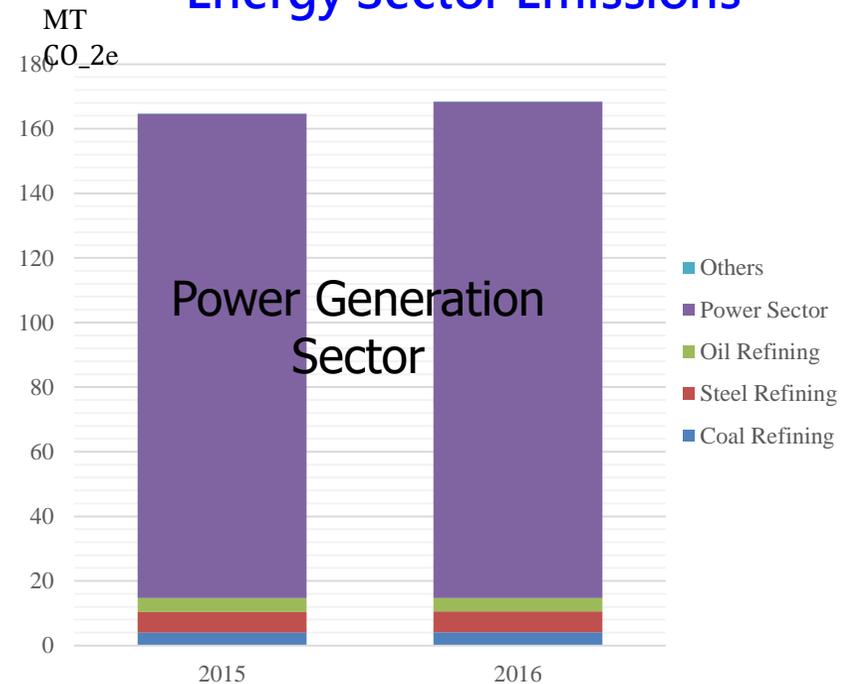
Why Power Generation Mix is Important?

- **65%** of CO₂ emissions come from **Energy Sector** in 2016
- **Power Generation Sector** is the major source of energy emissions.

Total CO2 Emissions



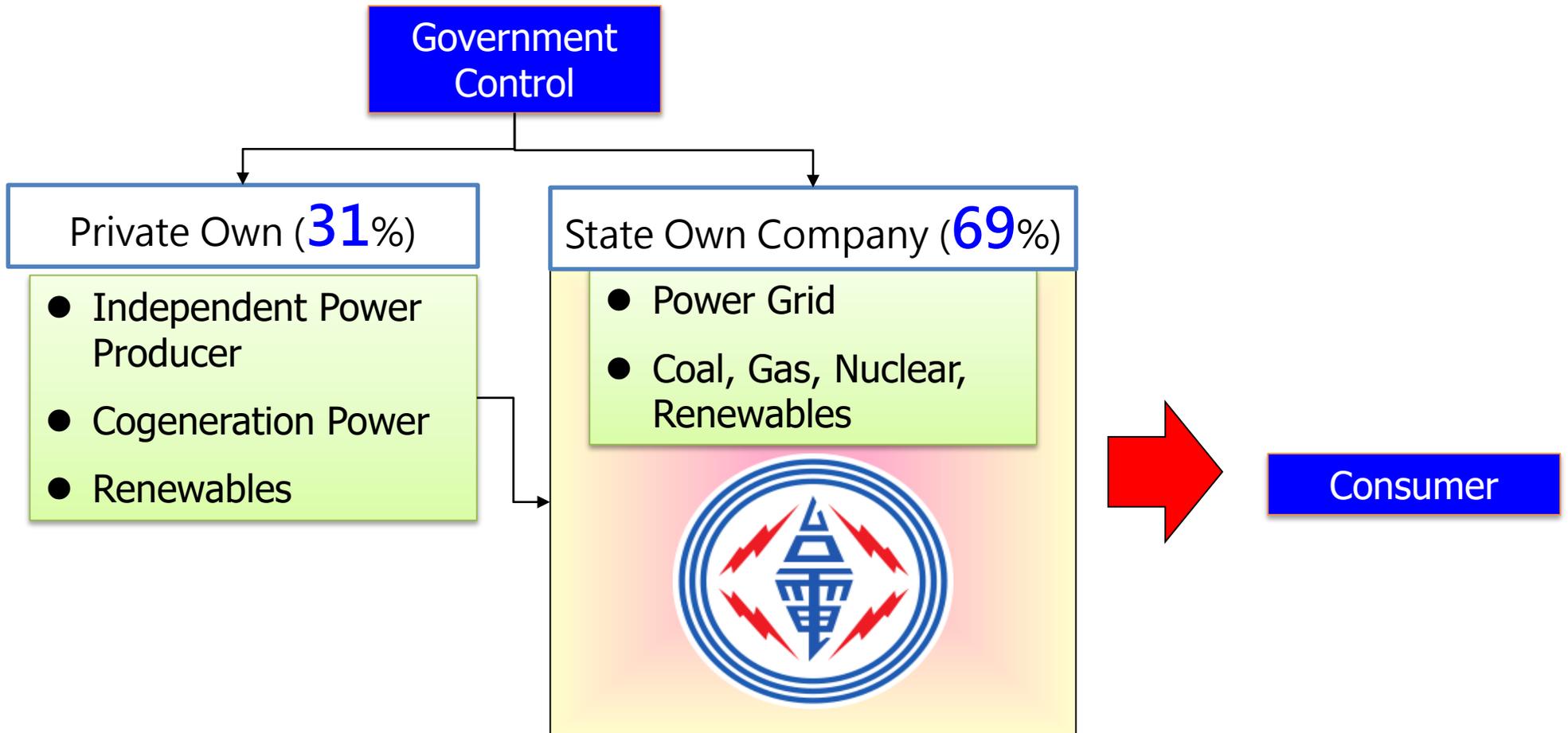
Energy Sector Emissions



Introductions

Power Generation is Controlled by Government

- Power Market is controlled by Government in Taiwan



Introductions

Protest against Nuclear Power

- People protested nuclear power in Taiwan



Source: <http://news.ltn.com.tw/news/life/paper/759872>

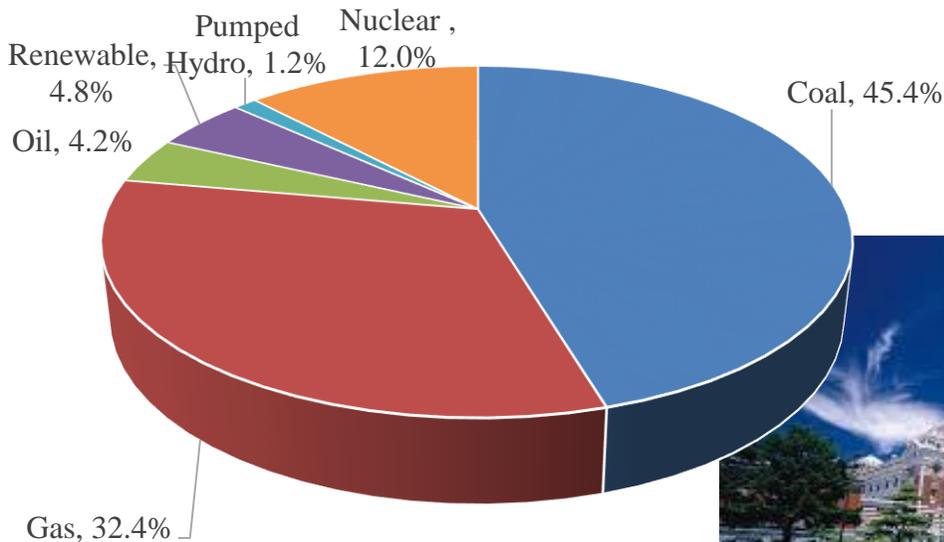
Source: <http://www.peoplenews.tw/news/13366fd0-a3c5-49c8-bce2-baa9c1519c85>

Introductions

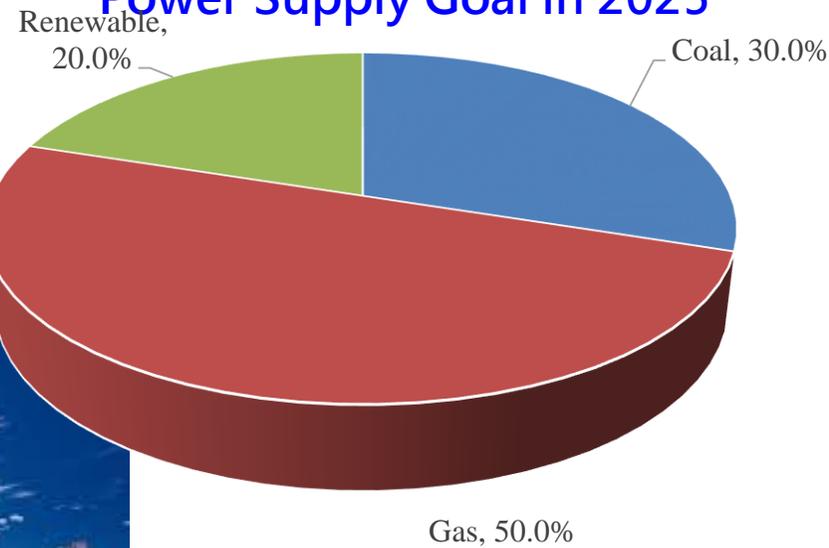
Policy Goal: Transition to a Cleaner Power Mix

- In 2016, **Gas (32.4%)** and **Coal (45.4%)** are major source of power supply
- In 2017, Taiwan' s authority announced clean power goal:
 - The **2025** Target: **Gas (50%)** and **Coal (30%)** and **Renewables**

(20%)
Power Supply in 2016



Power Supply Goal in 2025



Designed by 長野宇平治

Introductions

Outline of this Study

- Mission: Transition to **low-carbon** in the future
- Policy Goal: **Gas (50%), Coal (30%), and Renewables (20%)** in **2025**.
- Impacts on **3 E (Energy, Environment, and Economy)**



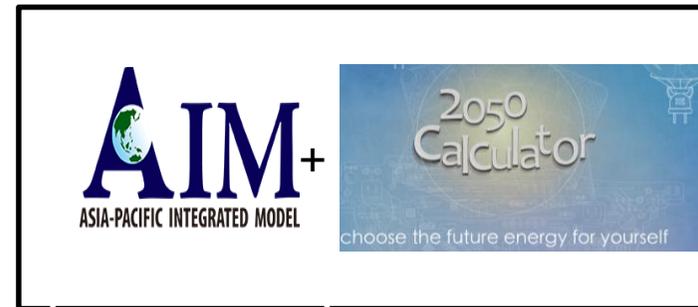
Main CO₂ Source

- Power Generation Sector



Policy Goal

- 20% of Renewable
- 30% of Coal Fire
- 50% of Gas Fire



This Study

- Energy Impacts
- Environment Impacts
- Economic

Models

Build of Taiwan 2050 Calculator

- Built since 2013 by Industrial Technology Institute Research (ITRI)

Built of 2050 Calculator
for Taiwan

2050 Calculator
Conference in Taipei

Interaction with
AIM/CGE-Taiwan

2013

2015

2017

Attendance of 2050 Calculator
Conference in Taipei

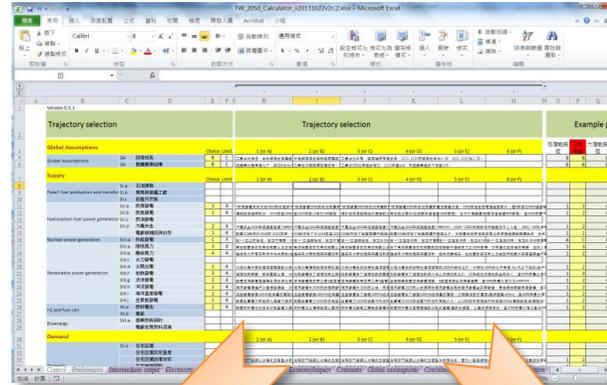
Dr. Nishioka as a Keynote



Models

2050 Calculator is Open to the Public

- Every one can choose their scenarios

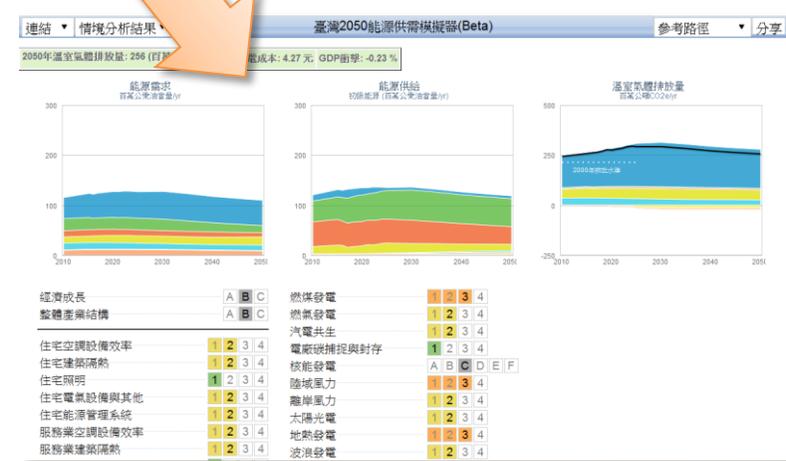


Excel-based
Core Model

Interactive Version



Advanced Version



<http://my2050.twenergy.org.tw>

<http://2050.twenergy.org.tw>

Models

Build of Taiwan 2050 Calculator

- Based upon Experts' Views

The public

Online

Taiwan 2050 Calculator

Construct

Experts' input

Determination of development scenarios
of supply and demand-side techs

MACC
database

MARKAL
database

Inner experts of ITRI provide
possible development scenarios
of low-carbon technologies

Based on solid R&D
experiences of ITRI

Results

Comprehensive analysis
of energy supply
and demand-sides of
energy system

Energy-saving potential,
costs, land use, and etc.

More than 100
consultation
workshops

Reviewed by more
than 100 experts

Models

Level	Meaning	Definition
1	Little or no attempt	assumes little or no attempt to decarbonise or change or only short run efforts
2	Ambitious	describes what might be achieved by applying a level of effort that is likely to be viewed as ambitious but reasonable by most or all experts.
3	Very ambitious	describes what might be achieved by applying a very ambitious level of effort that need a significant breakthroughs from the current system.
4	heroic	describes a heroic level of change that could be achieved with effort at the extreme upper end of what is thought to be physically plausible by the most optimistic credible observer. This level pushes towards the physical or technical limits of what can be achieved.



Energy supply



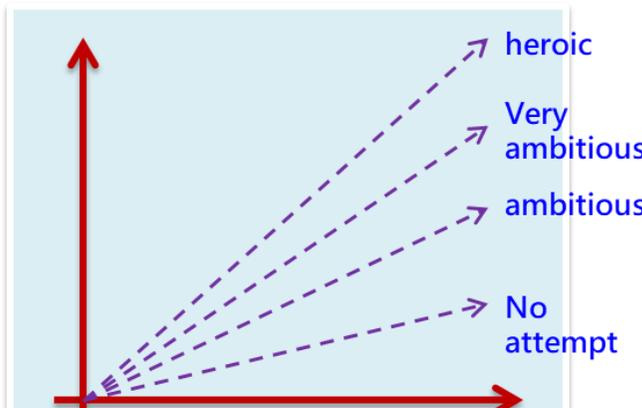
Domestic and commercial



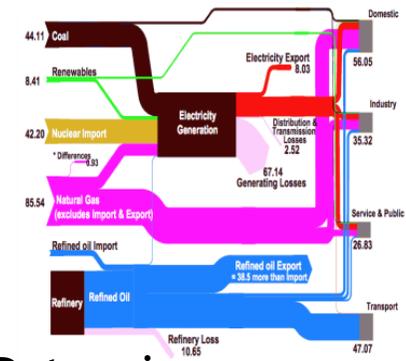
Industry



Transportation



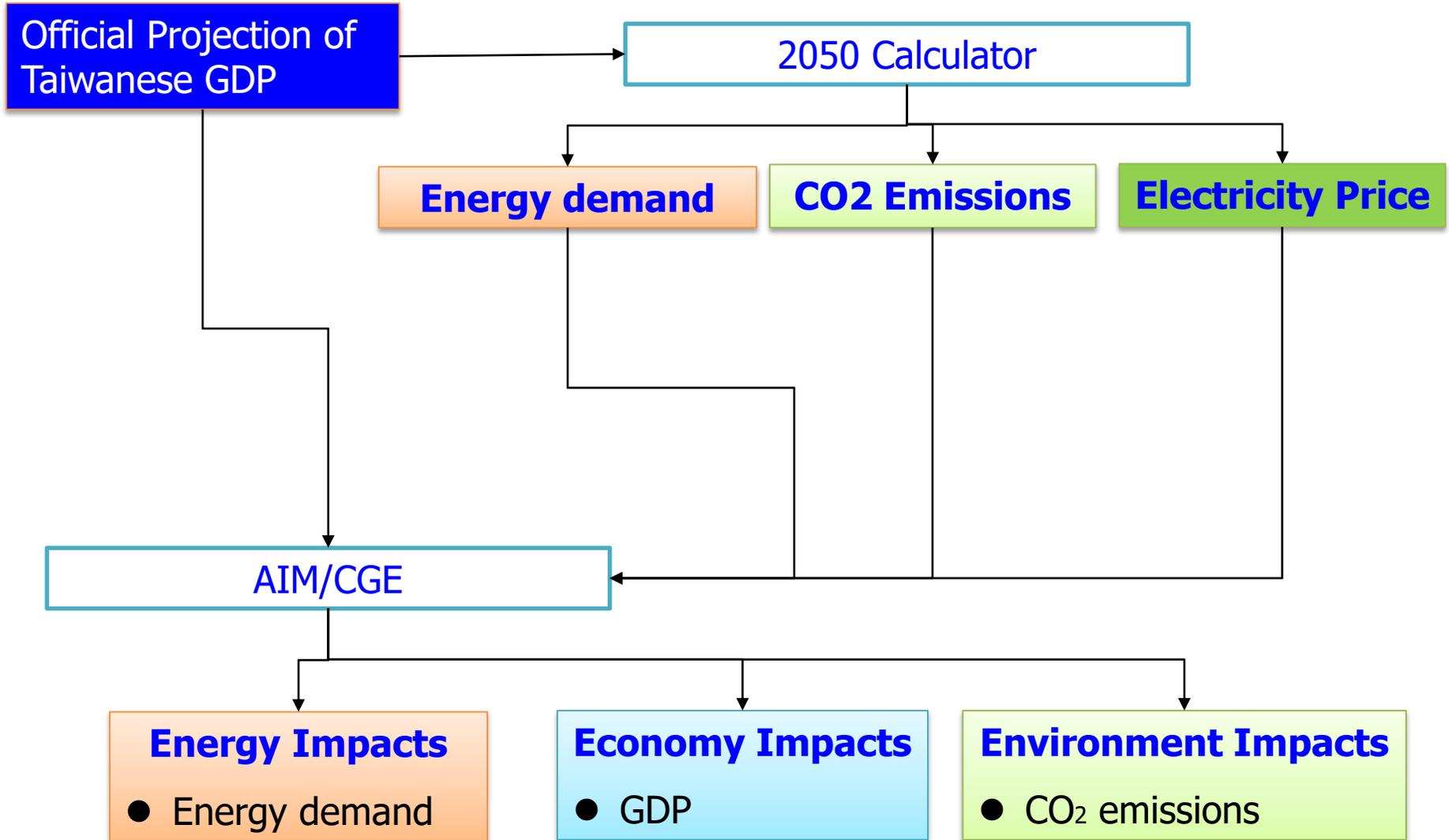
Choose level of each of 35 tech choices



Determine energy flow of the system

Models

Structure of Interaction

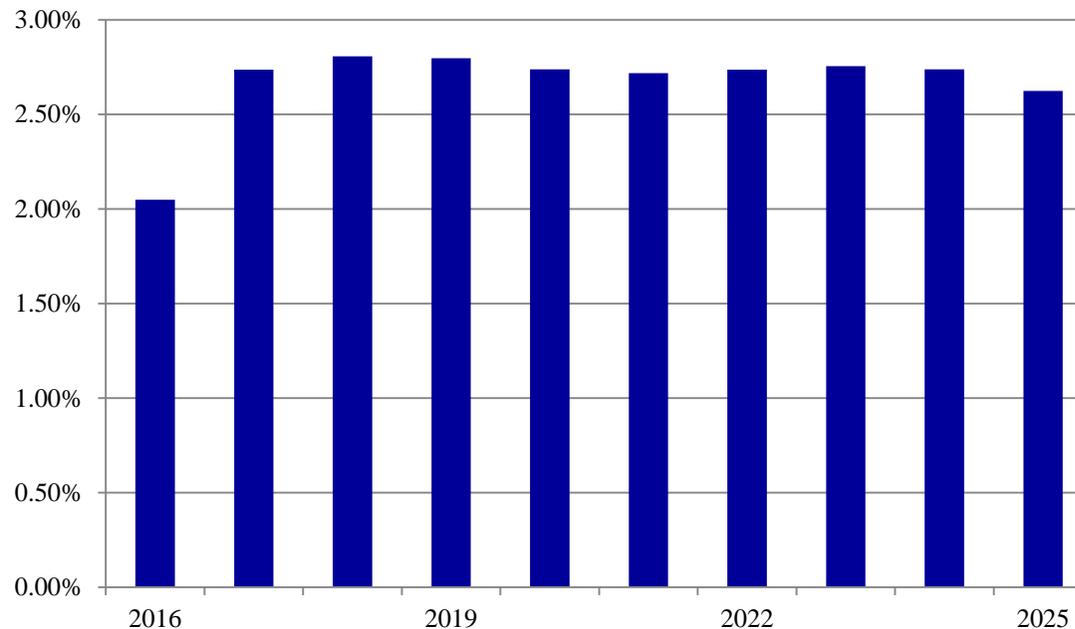


Scenarios

GDP Growth in Taiwan

- In July 2017, National Development Council in Taiwan announced the future GDP growth in Taiwan
- Taiwan' s GDP growth is expected to stabilize.

GDP growth in Taiwan

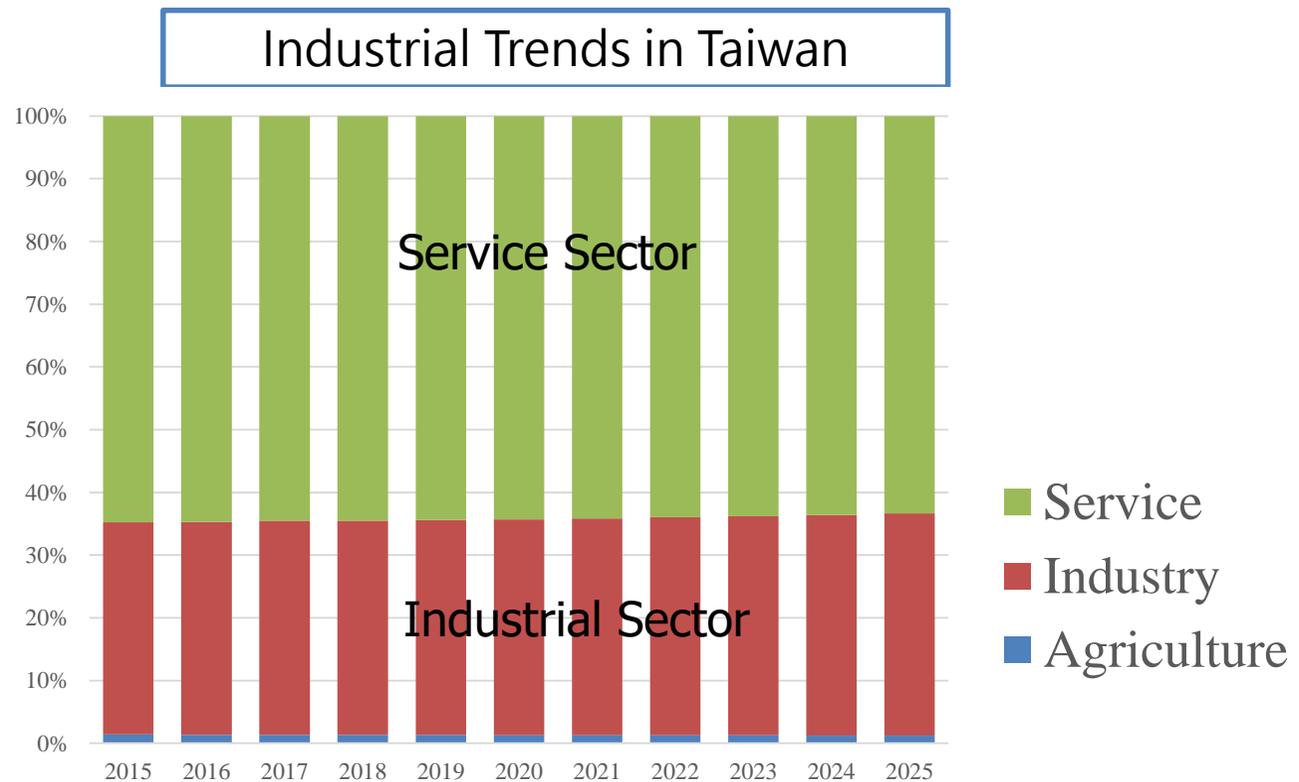


Source: National Development Council in Taiwan

Scenarios

Industrial Trends in Taiwan

- A large share of value added is composed of the service sector
- Industrial structure is stable



Scenarios

Scenarios of 2050 Calculator

- Energy demand: **Ambitious** (Level 2) energy saving
 - **Reasonable** and **achievable** scenario for energy saving
- Three scenarios for Energy supply:
 - **20%** of Renewable (High RE)
 - **6%** of Renewable (Low RE) **37%** of Gas-fired (High Coal-Fired and Low RE)
 - **7%** of Renewables and **54%** of Gas-fired (High Gas-Fired and Low RE)

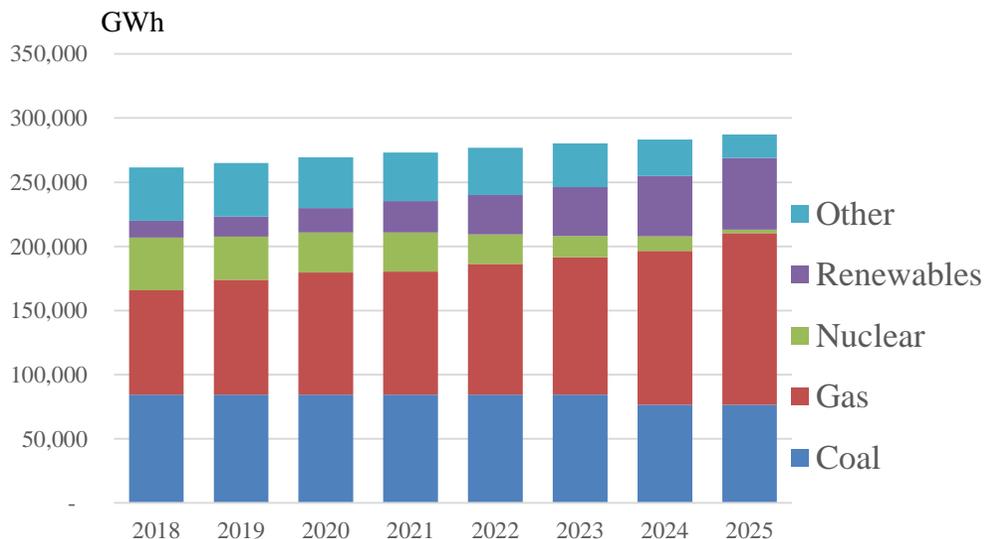
	Energy Demand	Energy Supply
Scenarios	<p>Energy Saving Level 2</p> <ul style="list-style-type: none">● Applying a level of effort that is likely to be viewed as ambitious but reasonable by most or all experts	<p>Power Share in 2025</p> <ul style="list-style-type: none">● 20% of Renewables (BaU)● 6% of Renewables and 37% of Gas● 7% of Renewables and 54% of Gas-fired

Simulation Results (1): BaU

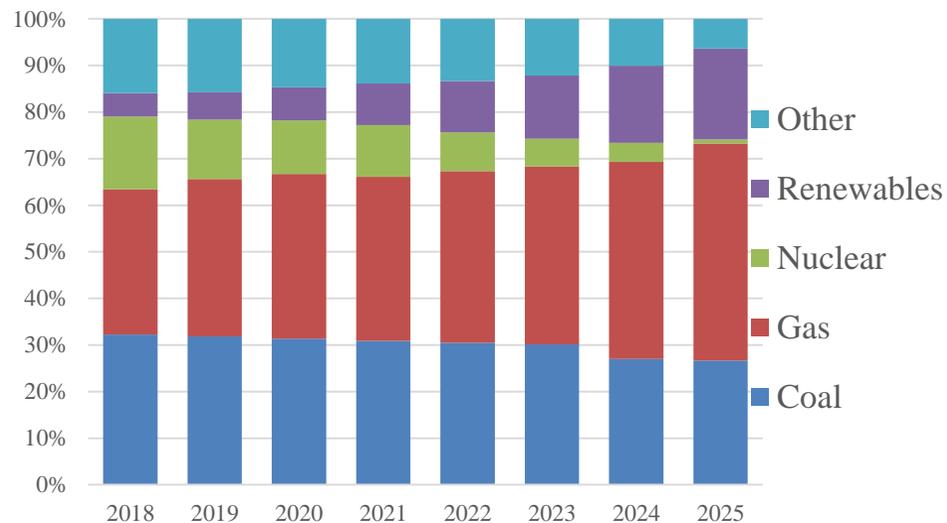
Power Generation in Taiwan

- BaU: **20%** of renewables are expected in 2025
- Gas-fired: **47%**. Others: **33%**. (Coal, CHP, and IPP)
- Nuclear power **disappears** in 2025

Power Generation by Fuel



Power Generation by Share

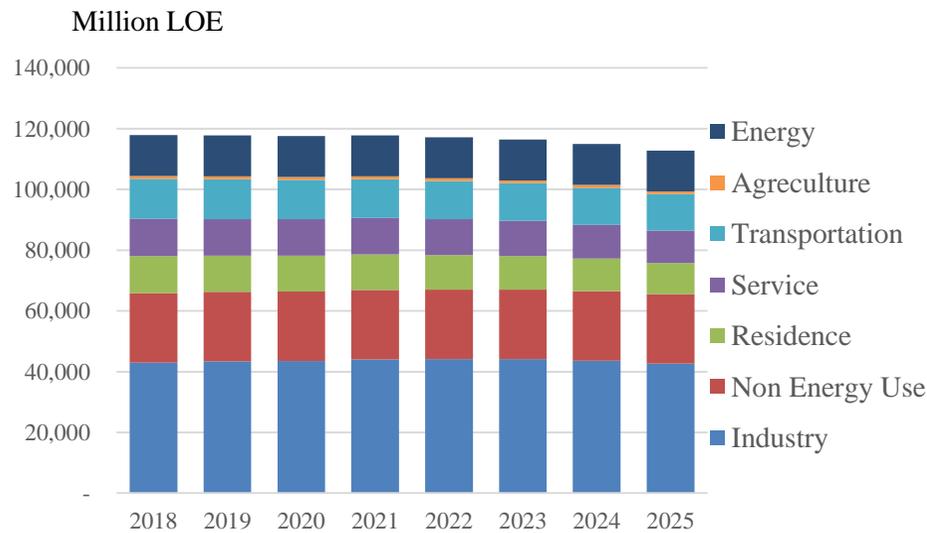


Simulation Results (1): BaU

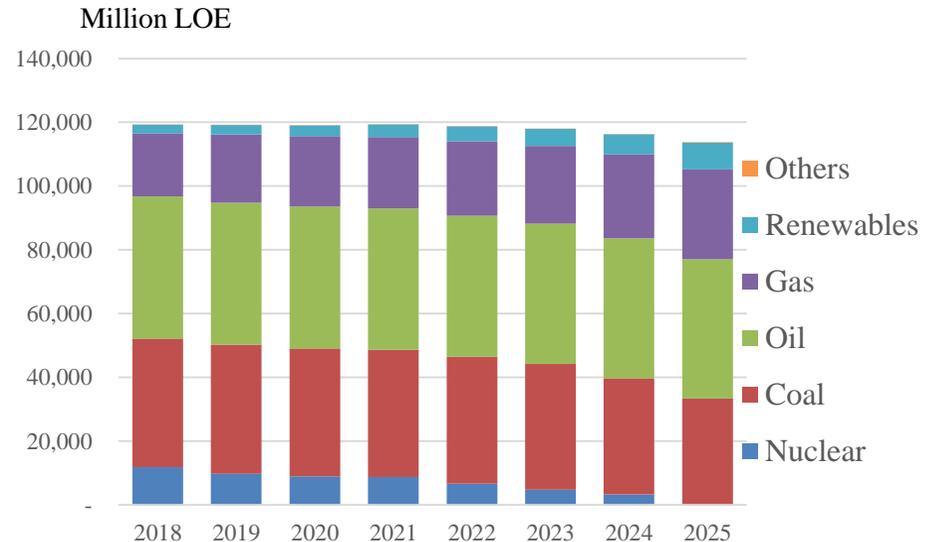
Energy Demand and Supply in Taiwan

- With ambitious (Level 2) energy saving, future **energy demand** is going to **decline**
 - **Industry sector** is the major demand for energy
- Energy supply is also going to decline
 - Coal and oil **decline** while gas **increases**
 - **No nuclear power** in the future

Energy Demand



Energy Supply



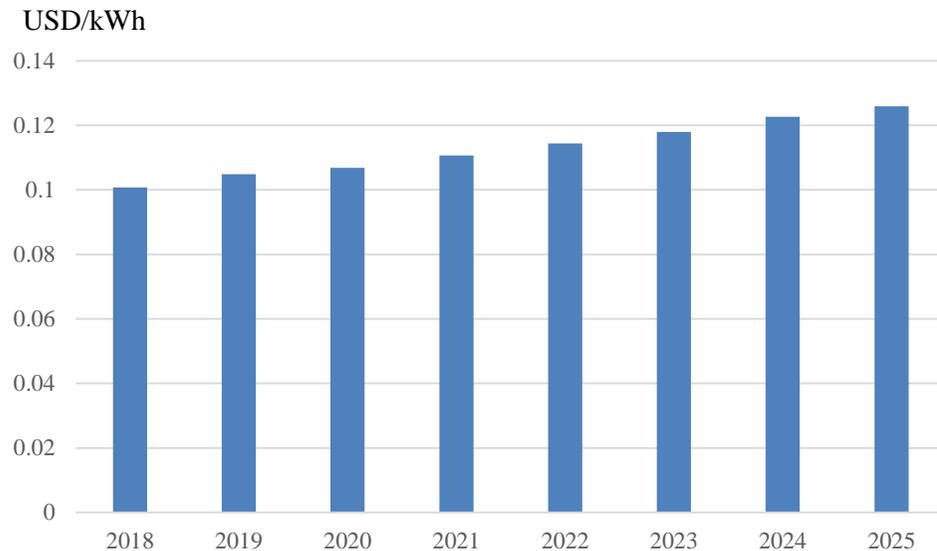
Note: LOE, Liter Oil Equivalent

Simulation Results (1): BaU

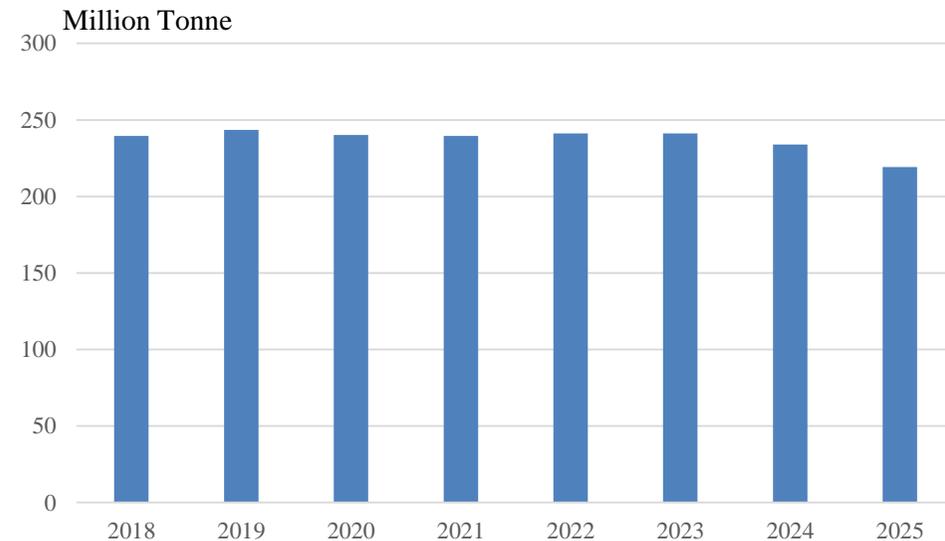
Electricity Price and CO₂ Emissions

- Power price is expected to increase from **0.10** USD/kWh in 2018 to **0.12** USD/kWh
- CO₂ emissions are expected to decline from **239** million tonne in 2018 to **219** million tonne in 2025

Electricity Price



CO₂

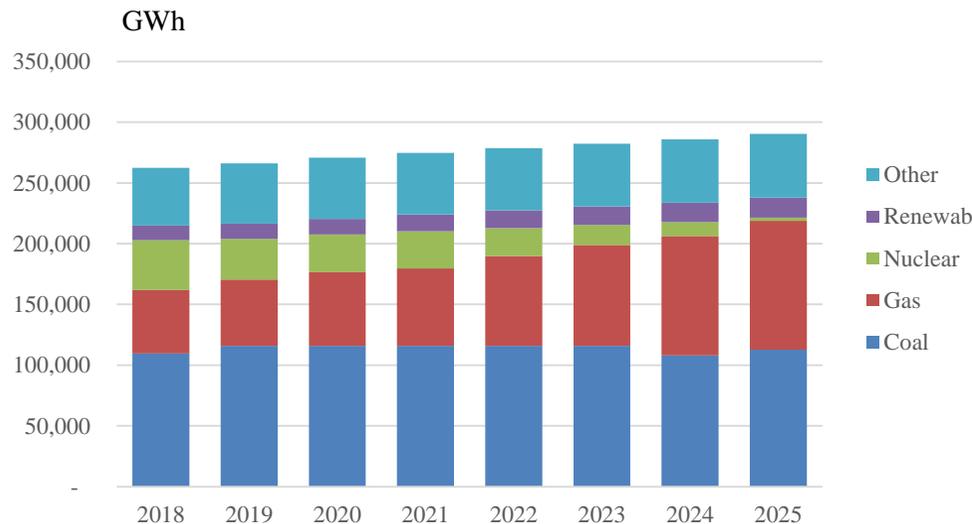


Simulation Results (2): Low REs and High Coal

Renewables Drop to 6% in 2025

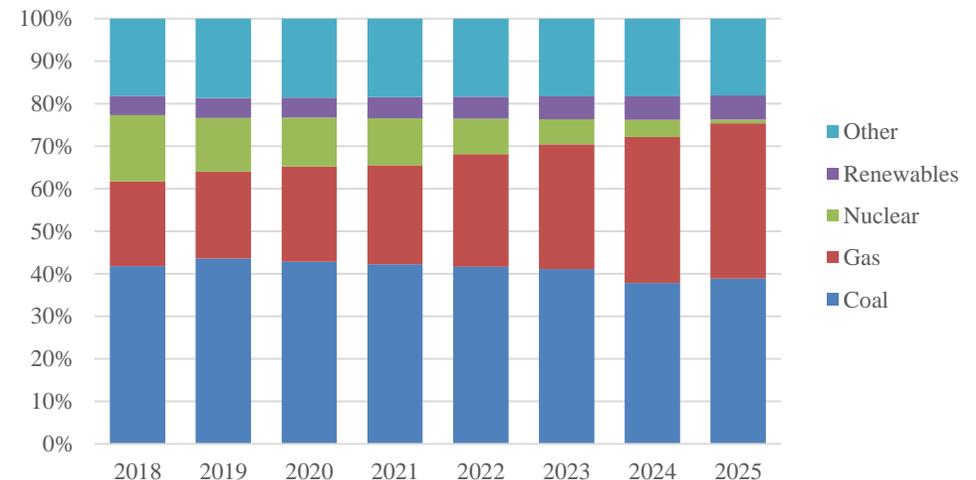
- No ambitious development of **renewables** (6% in 2025)
- **Gas-fired** declines to **37%** in 2025. Others: **57%** (Coal, CHP, and IPP)
- Nuclear still drops to **0** in 2025.

Power Generation by Fuel



Other includes CHP, oil, and other fuels

Power Generation by Share

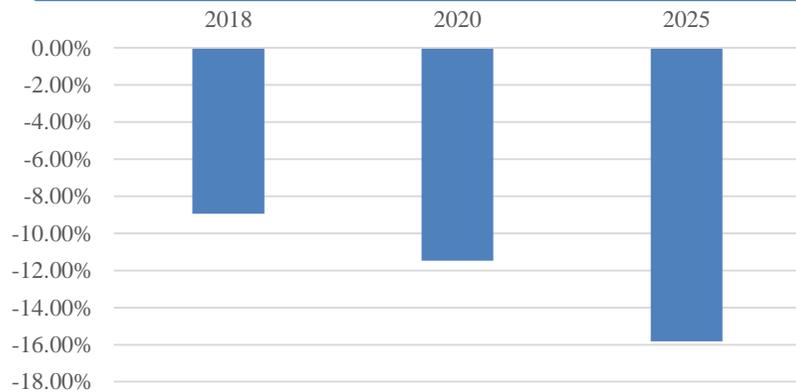


Simulation Results (2): Low REs and High Coal

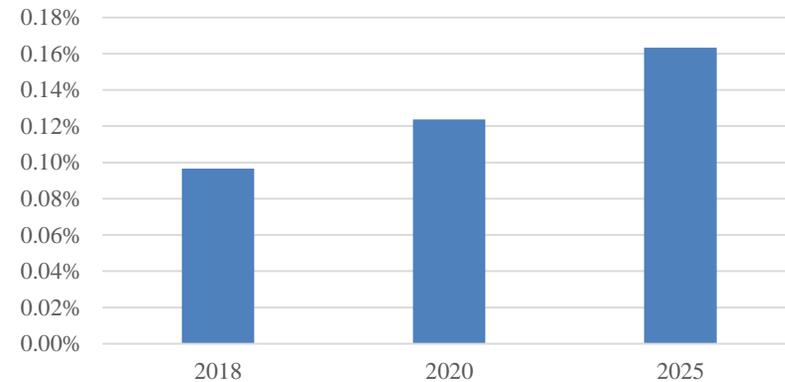
With High Coal-fired...

- Electricity price is **lower** (Scenario: 6% of RE) compared with **BaU** (Scenario: 20% of RE)
- GDP is **higher**, energy demand is **higher**, and CO₂ emissions are **higher**

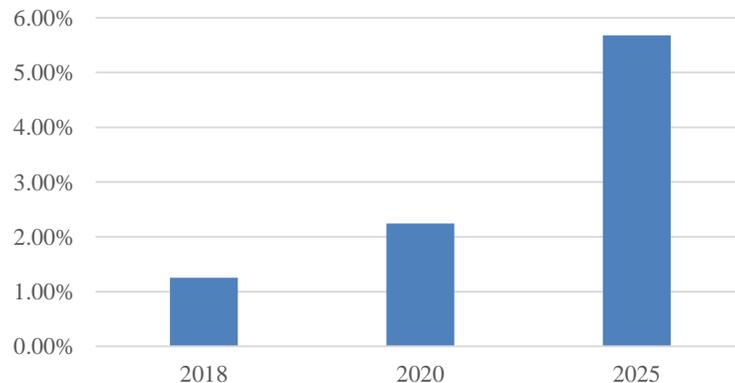
Electricity Price



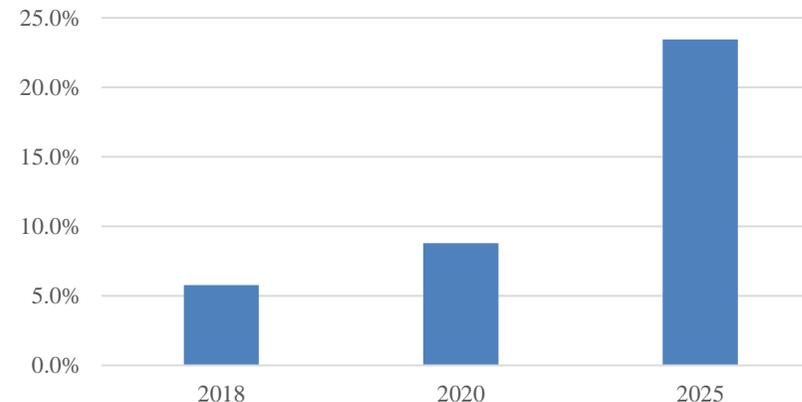
GDP Impacts



Energy Demand



CO₂ Emissions

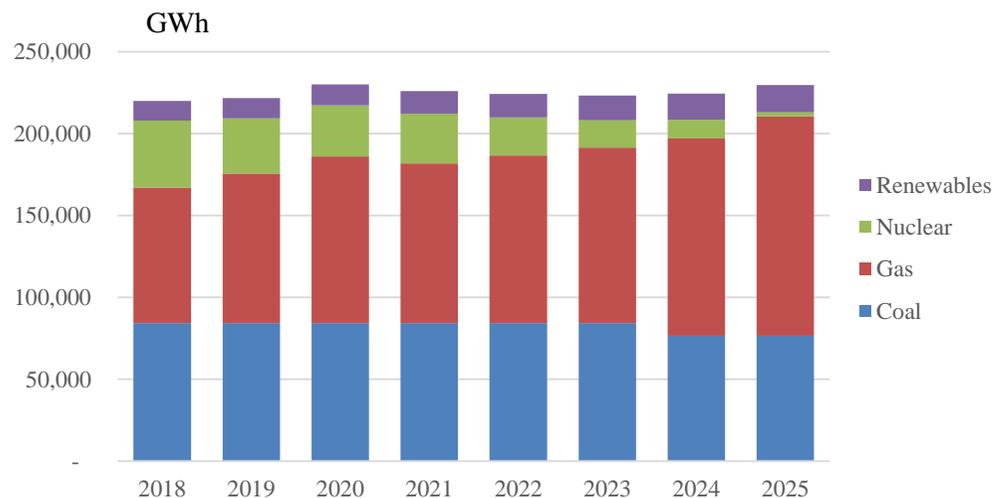


Simulation Results (3): Low REs and High Gas

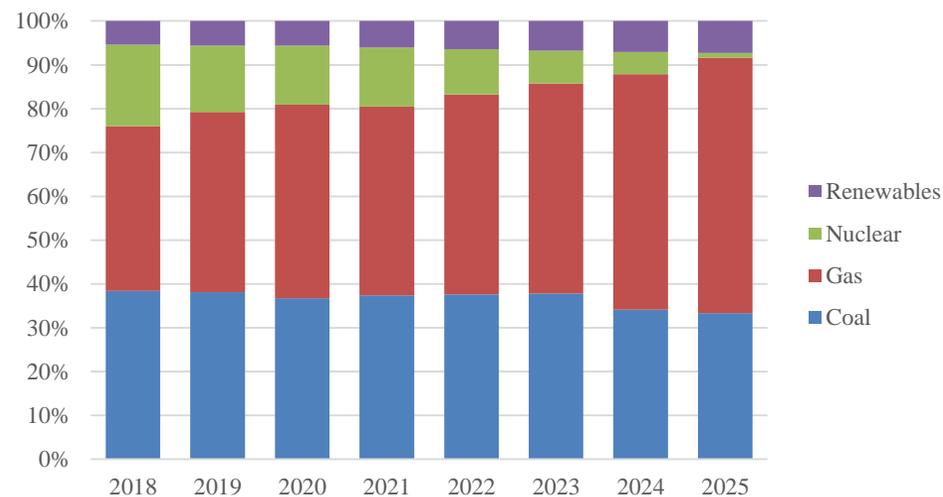
High Gas-fired and Low Renewables

- **Gas-fired** increases to **54%** in 2025, while **renewables** reach **7%** in 2025.
- **Nuclear power** still drops to almost **0** in 2025

Power Generation by Fuel



Power Generation by Share



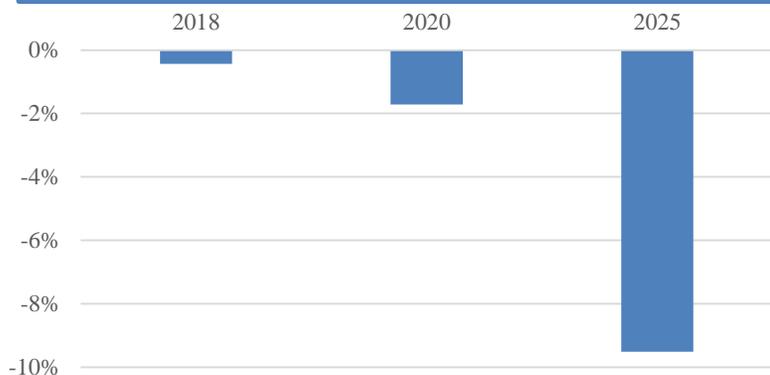
Other includes CHP, oil, and other fuels

Simulation Results (3): Low REs and High Gas

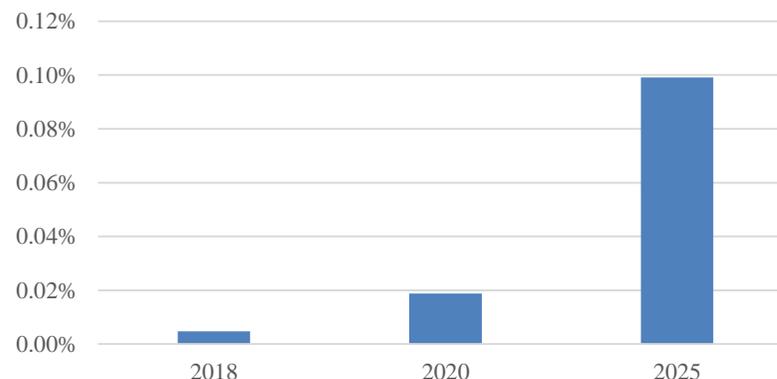
With high Gas-fired...

- Electricity price is **lower** (Scenario: 7% of RE and 54% of Gas) compared with **BaU** (Scenario: 20% of RE and 37% of Gas)
- GDP, energy demand, and CO₂ emissions **increase**.

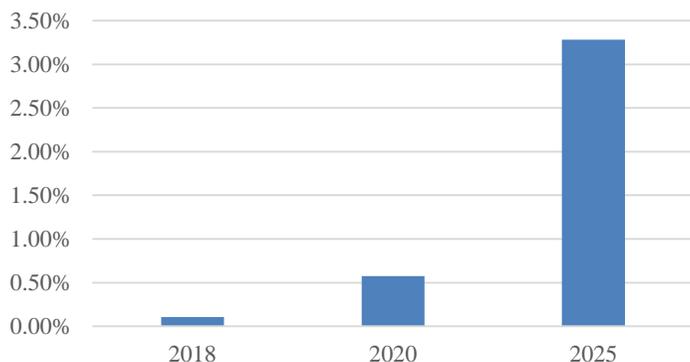
Electricity Price



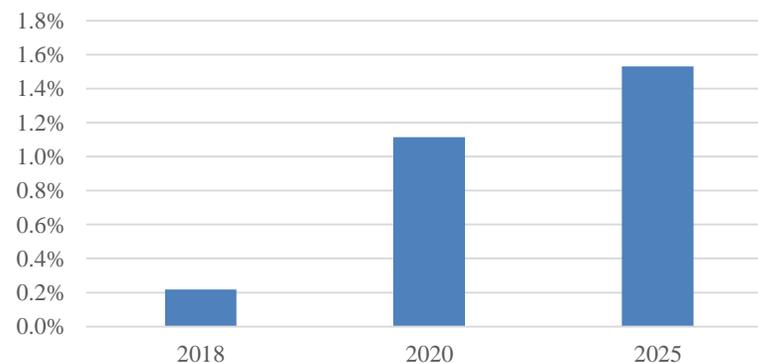
GDP Impacts



Energy Demand



CO₂ Emissions



Conclusions

More Renewables have the Lowest Emissions

- 20% of renewables have the **lowest** CO₂ emissions
- GDP is the **lowest** with 20% of renewables.
- CO₂ Emissions are **highest** with **low renewables** and **high coal-fired**, but this scenario has the **highest** GDP
- Future work: **further integration** between 2050 Calculator and AIM/CGE

	Energy Demand	Energy Supply	Compare with BaU
BaU	Energy Saving Level 2 ● ambitious but reasonable by most or all experts	Power Share in 2025 ● 20% of Renewables (BaU)	
Scenario (2)		Power Share in 2025 ● 6% of Renewables and 37% of Gas-fired	<ul style="list-style-type: none"> ● GDP increases 0.6% ● Energy increases 5.7% ● CO₂ increases 23%
Scenario (3)		Power Share in 2025 ● 7% of Renewables and 54% of Gas-fired	<ul style="list-style-type: none"> ● GDP increases 0.1% ● Energy increases 3.3% ● CO₂ increases 1.5%

Thank you for your attention!

