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Analysis on Energy Cost of LCET-CN based on ERIA Energy Outlook Models 2024

Edited by

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Foreword

Currently, the national pathway to achieve carbon neutrality by 2050 or later is a key focus. Optimisation approaches such as the Linear Programming method are commonly applied to select zero-emission fuels and technologies under cost-minimisation conditions. ERIA began exploring national pathways to achieve carbon neutrality by 2050 or later in 2019–20 under the EAS Energy Outlook framework. However, it used an econometric approach to select traditional renewable energy sources (hydro, geothermal, and biomass), variable renewable energy sources (solar and wind), nuclear power, CCS for thermal power plants, and hydrogen use for industry, transport (road), and thermal power plants (known as cofiring) manually.

ERIA has newly produced LCET-CN (Low Carbon Energy Transition – Carbon Neutral) scenarios for the 17 EAS countries in addition to the BAU (Business as Usual) and APS (Alternative Policy Scenario), which reflects aggressive EEC and RE targets. This LCET-CN scenario does not guarantee a cost-minimum pathway due to the application of the econometric approach. However, using the energy outlook results until 2050, we can conduct a cost comparison analysis between BAU and LCET-CN. In other words, we compare the future energy costs of a fossil fuel society and a clean energy society.

Energy costs consist of the following items:

a. Fossil fuels, which include coal, oil, and gas,

b. Power investment costs,

c. Hydrogen costs,

d. CCS costs.

The BAU scenario requires significant fuel costs for coal, oil, and gas, and thermal power investment. In contrast, the LCET-CN scenario requires renewable energy, nuclear power, hydrogen, and CCS. Energy consumption and power generation by all power sources come from the EAS Energy Outlook for both BAU and LCET-CN, but fuel prices (including hydrogen), unit investment costs of all power sources, and CCS costs are assumptions. Thus, if we change the assumptions, the cost comparison results will also change.

This report includes:

a. Revised LCET-CN results, and

b. The cost comparison results for the 17 EAS countries.

However, both the LCET-CN and the cost comparison analysis do not cover all low or zero-carbon fuels and technologies. These include thermal power generation with cofiring hydrogen, ammonia, and biomass; the necessary capacity of battery electric storage

systems (BESS) for solar PV; demand and supply of e-fuels and e-methane; and DACCS (Direct Air Carbon Capture and Storage) and BECCS (Bioenergy with Carbon Capture and Storage).

ERIA primarily uses an econometric model, which has limitations in reflecting all low and zero-carbon fuels and technologies. Nonetheless, ERIA, in collaboration with ERIA Working Group members for the EAS Energy Outlook and Energy Saving Potential in the East Asia Region, is dedicated to incorporating these fuels and technologies as much as possible.

We hope this report will provide valuable discussion points regarding the achievement of carbon neutrality to energy policymakers, academia, and private/public companies in the EAS region.

Tetsuya Watanabe

President of ERIA (Economic Research Institute for ASEAN and East Asia)

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Introduction

EAS Energy Outlook Update and Analysis

The EAS Energy Outlook, which includes 17 EAS countries excluding Russia, has been updated every 2 years. The last update occurred in 2021–22, with the next update planned for 2023-24. Based on the updated models from 2021–22, ERIA conducted two studies in 2022–23:

1. Review of the Existing LCET-CN Scenario: This involved improving the Low Carbon Energy Transition – Carbon Neutral (LCET-CN) scenario where possible.
2. Cost Comparison Analysis: This compared the Business as Usual (BAU) scenario with the revised LCET-CN scenario.

To support these efforts, ERIA, with assistance from IEEJ, held two working group meetings for the EAS Energy Outlook and Energy Saving Potential in January and May 2023.

Review of the Existing LCET-CN Scenario

ERIA requested working group members to review several aspects:

- Energy-saving policies in the LCET-CN compared to BAU and the Alternative Policy Scenario (APS).
- Policies for electric vehicle (EV) penetration.
- Increased use of renewable energy, particularly solar PV and wind power.
- Hydrogen demand and supply perspectives.
- Availability of Carbon Capture and Storage (CCS).

As a result, some members successfully improved their LCET-CN scenarios.

Cost Comparison Analysis

ERIA asked working group members to estimate the energy costs for both the BAU and LCET-CN scenarios to determine which would incur higher costs. Energy costs included:

- Fuel costs (fossil fuels and hydrogen).
- Power investment costs per power source.
- CCS costs.
- Energy-saving costs (though this was omitted due to insufficient data).

Fuel Costs Estimation Process

1. Calculate the increased amount of each fuel between 2019 and 2050.
2. Multiply the assumed unit cost of each fuel by the increased amount in 2050.
3. Compare the estimated fuel costs between BAU and APS.

Assumed unit costs for 2050 (2019 constant price) were:

	2019/2020		2050 (2019 Constant Price)	
Coal	80.03	US$/ton	98	US$/ton
Oil	41	US$/bbl	100	US$/bbl
Gas	7.77	US$/MMBTU	7.5	US$/MMBTU
Hydrogen	0.8	US$/$Nm^3$	0.1	US$/$Nm^3$
CCS	-	US$/$CO_2$ ton	70	US$/$CO_2$ ton

Power Capital Cost Estimation Process

1. Calculate the increase in power generation per source from 2019 to 2050.
2. Calculate additional power capacity needed, considering the capacity factor of each power source.
3. Multiply the assumed unit capital cost by the necessary increase in power capacity.
4. Compare the estimated power capital costs between BAU and LCET-CN.

Assumed capacity factors and unit capital costs for 2050 were:

	2019		by 2050	
Coal	75	%	75	%
Oil	75	%	75	%
Gas	75	%	75	%
Hydrogen	-	%	75	%
Nuclear	80	%	80	%
Hydro	60	%	60	%
Geothermal	75	%	75	%
Solar	15	%	17	%
Wind	25	%	30	%
2Biomass	75	%	75	%

And the assumed unit capital cost of each power source were:

	2019		by 2050	
Coal	1,500	US$/KW	1,525	US$/KW
Oil	-	US$/KW	-	US$/KW
Gas	700	US$/KW	700	US$/KW
Hydrogen		US$/MW	700	US$/KW
Nuclear	4,500	US$/KW	3,575	US$/KW
Hydro	2,000	US$/KW	2,223	US$/KW
Geothermal	4,000	US$/KW	4,256	US$/KW
Solar	1,600	US$/KW	307	US$/KW
Wind	1,600	US$/KW	1,235	US$/KW
Biomass	2,000	US$/KW	3,019	US$/KW

BAU will basically increase thermal power plants; on the other hand, LCET-CN will increase renewable, nuclear, and hydrogen power plants.

For CCS cost, ERIA requested the members to estimate CCS treatment costs. Theoretically CCS consists of following three activities: capture CO_2, transport CO_2 and Store CO_2. But this analysis assumes CCS running cost of CO_2 defined as US$/$CO_2$ ton. The estimation process is shown below:

CCS Cost Estimation Process

1. Obtain CO_2 emissions for coal and gas in 2050 from the EAS Energy Outlook.
2. Calculate the share of coal and gas consumption in power generation.
3. Calculate CO_2 emissions by the power sector.
4. Multiply the CCS share of coal and gas power generation by the CO_2 emissions.
5. Multiply the unit cost of CCS by the CO_2 emissions treated by CCS.

Cost Comparison Results

The comparison considered:

- Fuel Costs: Higher for BAU due to reliance on fossil fuels.
- Power Capital Costs: Higher for LCET-CN due to increased renewable and hydrogen power plants, which have lower capacity factors than thermal plants.
- CCS Costs: Applicable only to the LCET-CN scenario.

Generally, the fuel costs for LCET-CN are much lower than for BAU. However, power capital costs are higher for LCET-CN due to the need for substantial renewable energy capacities. This analysis provides valuable insights for policymakers, academia, and private/public companies in the EAS region regarding the pathway to carbon neutrality.