Electric vehicle demand implications for electricity cost and CO_2 emissions

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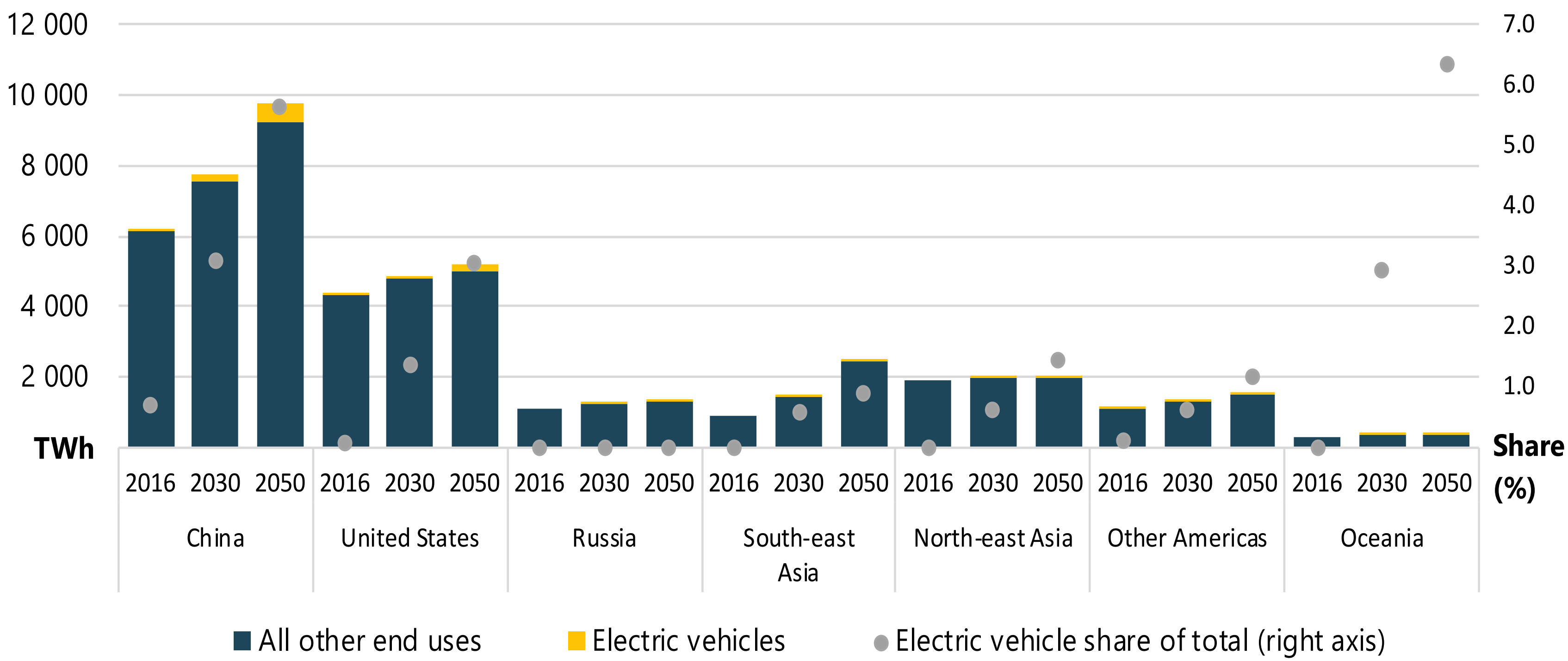
Gigih Udi Atmo, Ph.D., Senior Researcher, APERC

Strong growth of electricity demand from electric vehicles

Electricity demand for electric vehicles and other end-uses by subregion, 2016-50



Source: APEC Energy Demand and Supply Outlook 7th Edition, 2019.

APEC electricity demand for electric vehicles jumps from 49 TWh in 2016 to 805 TWh by 2050, driven mostly by China, United States, Australia, Chile, Indonesia, and New Zealand.

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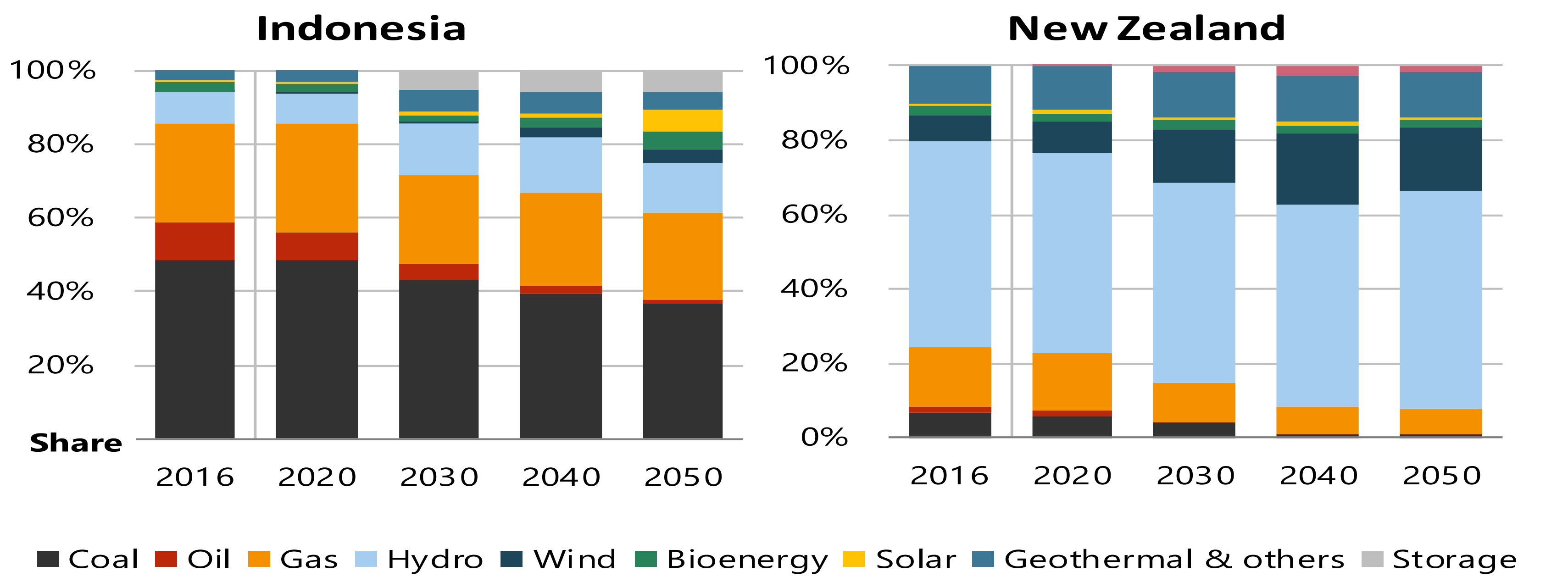
Research objective

- This study uses General Algebraic Modeling System (GAMS) to analyse the implications of increased demand from EV charging on the cost and emissions of electricity generation.
- It extends the 7th edition APERC electricity model to calculate NO_x volume from the electricity generation (in addition to the CO_2 emission calculation).
- The analysis focuses on two APEC economies in Asia and Oceania: Indonesia and New Zealand.

Renewables electricity generation continues to expand over the Outlook

Share of electricity generation by fuel in Indonesia and New Zealand, 2016-50



Source: APEC Energy Demand and Supply Outlook 7th Edition

Indonesia's electricity generation mix is currently dominated by fossil fuels, but consumption gradually shifts towards renewables and natural gas. Renewables are the primary energy source used in New Zealand's electricity.

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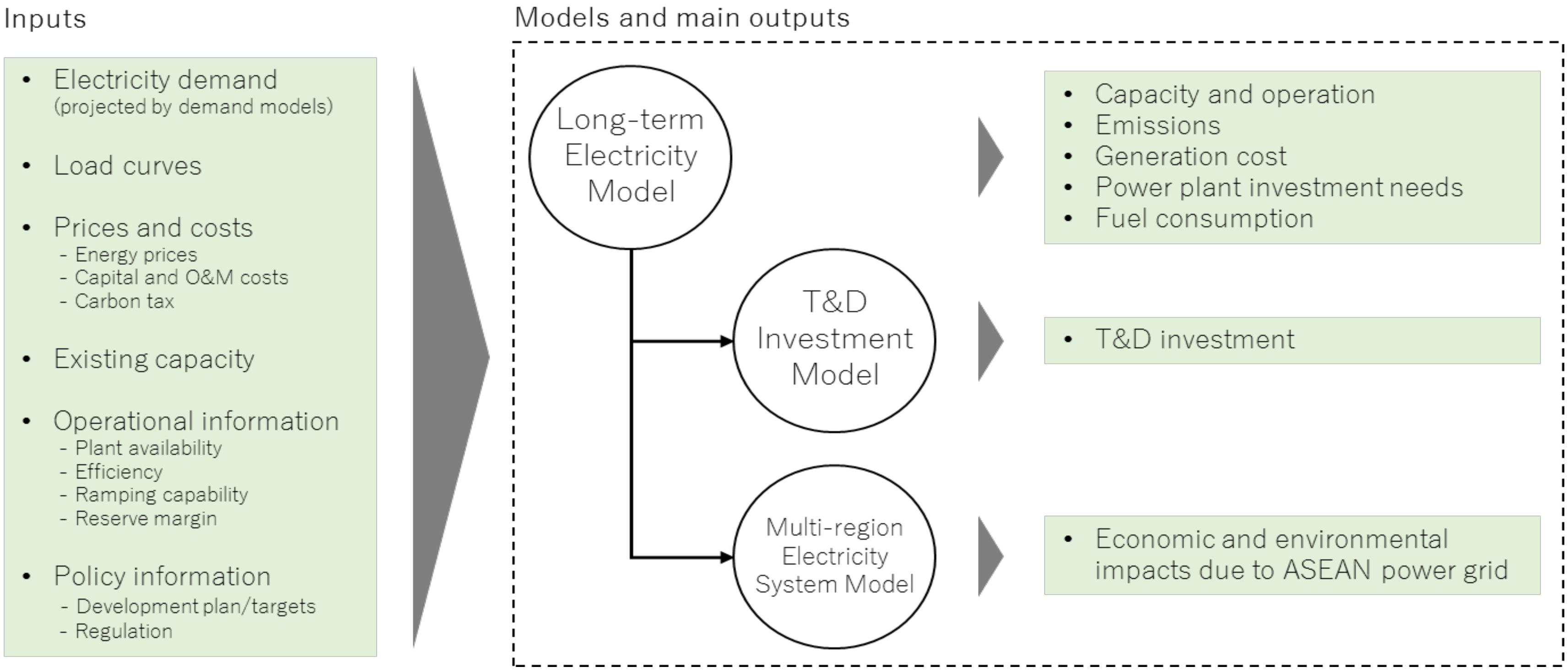
Long-term electricity supply model

Electricity projection system for APEC Electricity Supply Outlook 2016-2050



Source: APERC, 2019

The long-term electricity projection system aims to calculate electricity and emissions from power plants to meet the demand including EV charging.

Key assumptions and data

- Electricity demand for EV charging in the BAU scenario is taken from *the BAU Scenario* and *the APEC Target Scenario* of APEC Energy Outlook 7th Edition.
- NO_x properties for each fuel category (i.e. coal, natural gas, oil and biomass) were derived from a report published by the Intergovernmental Panel on Climate Change (IPCC).
- Daily load curves of electricity supply in Indonesia and New Zealand were obtained from PLN (2018) and Transpower (2019), respectively.

Scenario development

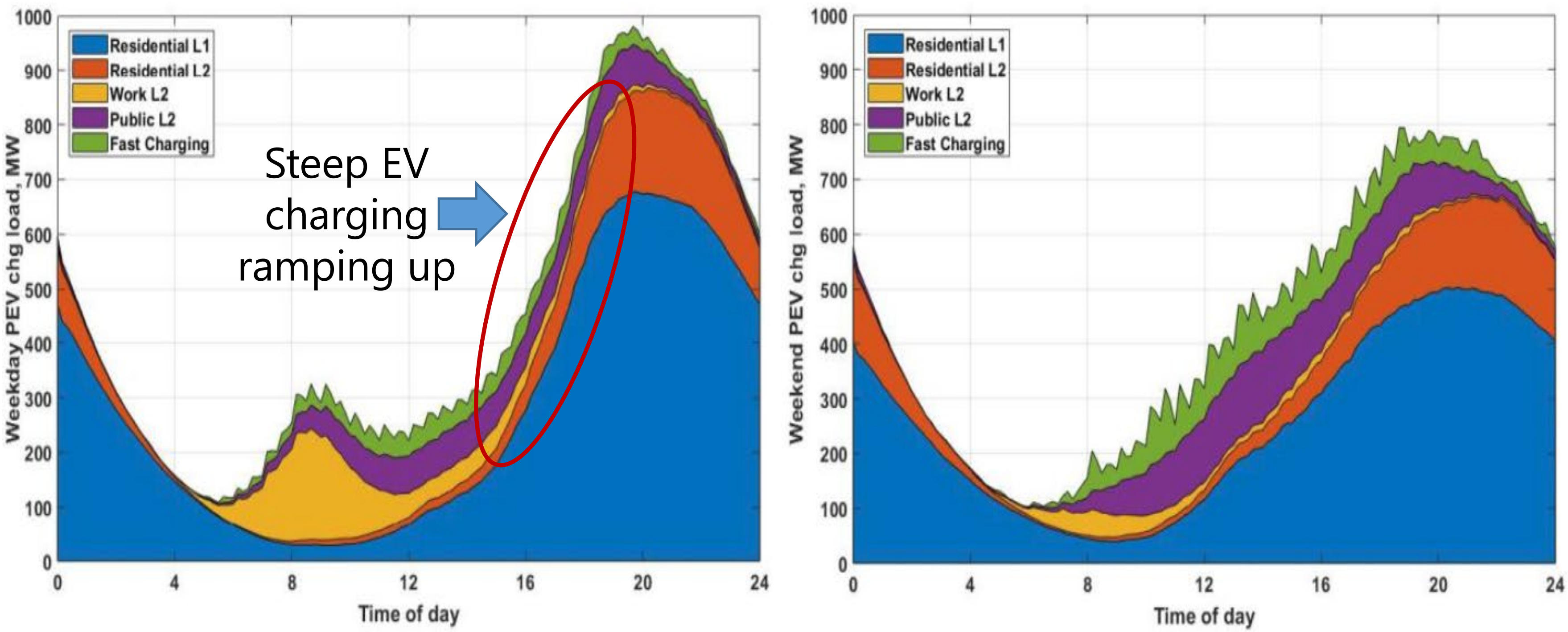
- Two EV scenarios were investigated in this study: the Business-as-Usual (BAU) and the High EV share (HEV) scenarios.

Scenario	Indonesia		New Zealand		Charging Profile
Year	2020	2050	2020	2050	
BAU	0.87 TWh (0.31% of the total electricity demand)	12 TWh (1.3%)	0.28 TWh (0.71%)	3.0 TWh (5.9%)	Unregulated charging
HEV	2.0 TWh (0.73%)	25 TWh (2.7%)	0.57 TWh (1.4%)	5.6 TWh (9.9%)	Unregulated and Managed charging

Source: APEC Energy Demand and Supply Outlook 7th Edition (2019)

Unregulated EV Charging increases electricity peak demand

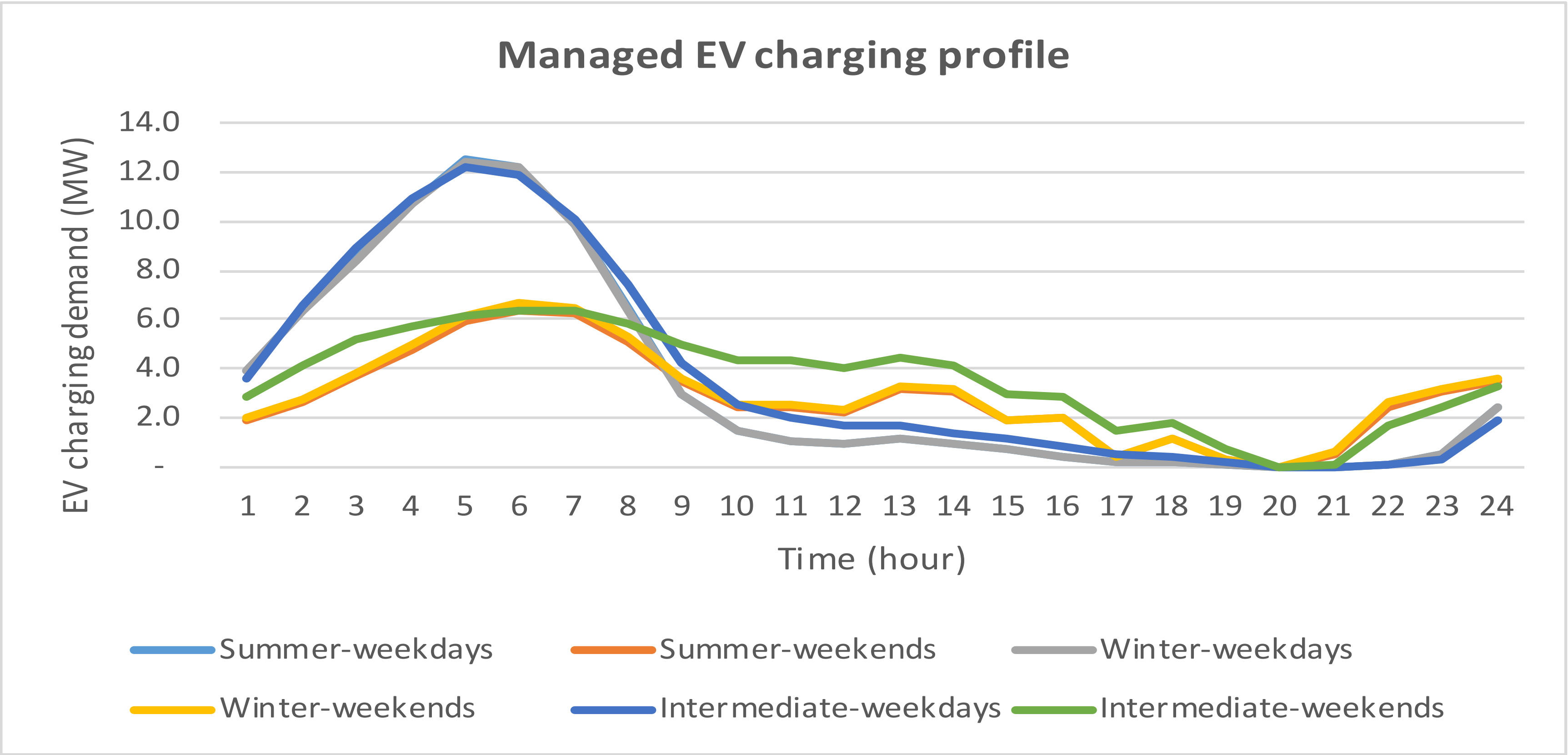
Daily profile of electric vehicle charging for uncontrolled charging profile, weekdays (left) and weekend (right)



Source: Bedir et al. (2018)

EV owners tend to charge the vehicles at both workplaces and at home during the weekdays; and at both home and public charging facilities during the weekend.

EVs in managed charging are incentivised to charge beyond electricity peak hours



Source: Alexey, Atmo, Otsuki (2019)

For the managed charging strategy, electricity demand from EVs is spread in a gradual charging pattern from mostly 10 pm to around 6 am the following day.

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Unregulated EVs charging increases costs but reduces NOx emissions from electricity generation

NO_x emissions from electricity generation, BAU and HEV Scenarios

NO_x emissions	Indonesia		New Zealand	
Period	2016 – 2030	2031 – 2050	2016 – 2030	2031 – 2050
Average emissions (g/kWh) in the BAU scenario	1.83	1.57	0.146	0.026
Average emissions (g/kWh) in the HEV scenario	1.83	1.51	0.149	0.025
Change (+/-)	0.0%	-4.1%	2.0%	-3.3%

Source: own analysis

In the HEV scenario, the average NO_x emissions between 2020-2050 are reduced in Indonesia but marginally increase in New Zealand, albeit from a very low level.

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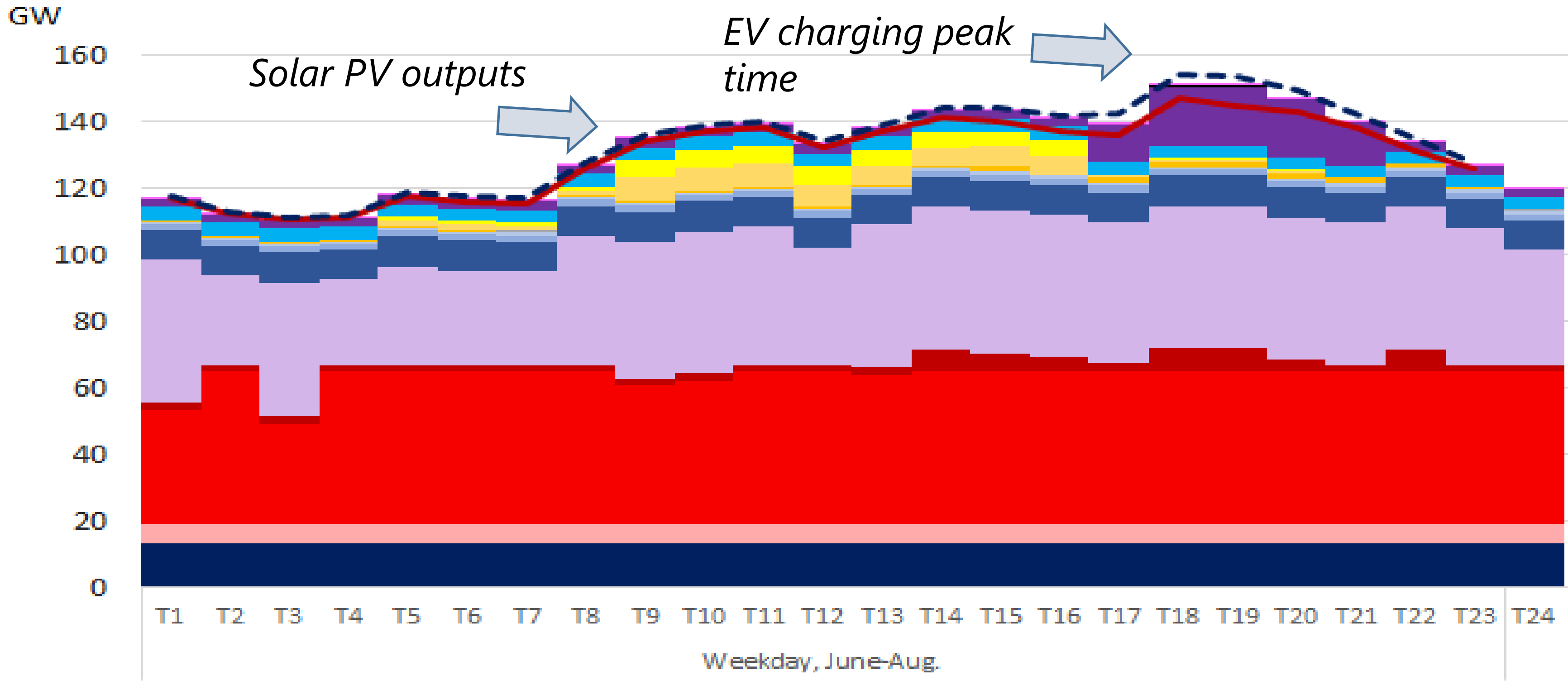
Electricity supply dispatch curve in Indonesia

Electricity supply dispatch in Indonesia for unregulated EV charging, 2050



Source: own analysis

Generation from natural gas power plants is higher to meet EV charging during peak hours at night; solar PV outputs increase to meet EV charging during daytime.

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Managed EV charging implication for Indonesia's electricity generation

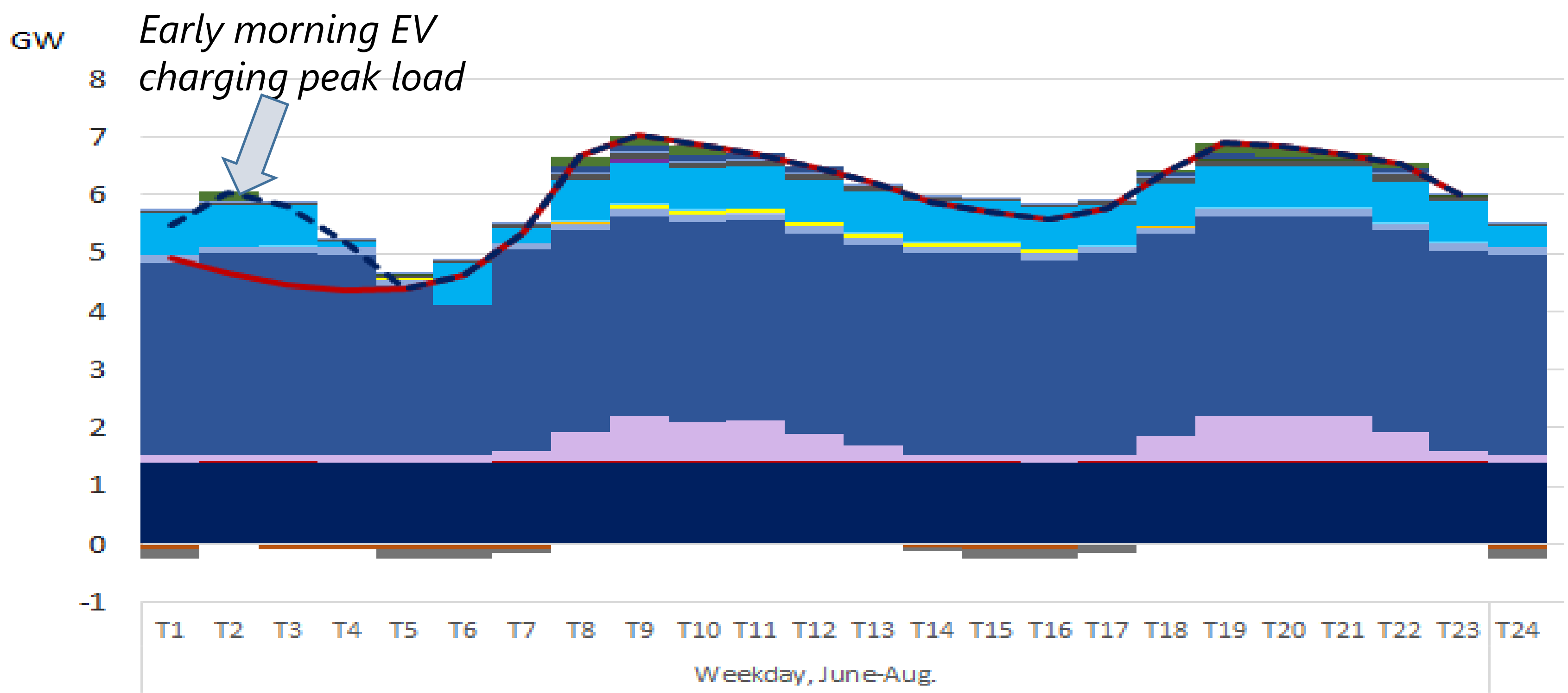
- Under the managed charging condition, EV charging can be served through increasing electricity generation from low-cost baseload power plants.
- The average cost of electricity production decreases 7.5% from 2025 to 2050, compared with the costs when charging is unregulated.
- Managed charging, however, generates higher emissions. Over the same period of comparison (2025-2050), CO_2 emissions rise 11% and NOx emissions increase by 20%.

Managed EV charging implication for New Zealand's electricity generation

- The average cost of electricity production increases 3.9% higher, mainly because of a slight increase in gas turbine peaker power plants (0.25 TWh higher).
- A new demand peak from EV charging is manly served through electricity discharge from pumped hydro and batteries. The utilisation of wind power increases by 10 TWh.
- Capital investment for batteries increases by 1.4 GW between 2020 and 2050.
- CO_2 emissions also slightly increase to 4.4% higher than in unregulated charging while there is no average reduction or increase on the NOx emissions.

Electricity supply dispatch curve in New Zealand

Electricity supply dispatch in New Zealand for managed EV charging, 2030



Source: own analysis

Batteries and pumped hydro play the important roles of storing excess wind-powered electricity produced during early morning and daytime hours and discharging it at night when demand peaks from residential electricity demand and EV charging.

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Summary

- Unregulated EV charging increases the average cost of electricity production, especially at the night peak hours time.
- Based on the managed charging case, shifting EV charging beyond peak hours and reducing the charging slope are important to reduce the necessity to operate higher operating cost power plants (oil or natural gas plants).
- While the managed charging approach decreases the average cost of electricity generation, CO_2 and NOx emissions are expected to increase, mainly from the increased generation from based-load power plants.
- EV charging can be directed to utilise low cost generation from solar PV during daytime charging. Energy storage has an important role to support higher utilisation of solar PV and wind power to meet EV charging demand at night.
- Policy action may be needed to align EV promotion program and renewable energy development to reduce the cost and emissions from power generation.

Thank you for your attention!

gigih.atmo@aperc.or.jp
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