Grid Interconnection and Renewables Deployment related Air Quality and Human Health Benefits in Southeast Asia

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Introduction

Power sector scenarios

Models and methods

Air quality and health impacts

Analysis limitations and opportunities

Conclusions
Introduction
Air Pollution in Southeast Asia

• Energy sector contribution to air pollution caused mortality is 5th highest (~10%) in SE Asia, including:
  – 6% from coal-fired power generation and
  – 4% from other power generation sources

• 10,000–40,000 cases of excess mortality each year from PM$_{2.5}$ exposure
  – More than the excess deaths from transportation-related pollution

Adapted from McDuffie et al. (2021)
Geographic and Sectoral Scope of Analysis

- Our analysis focuses on power sector-related emissions.
  - Only direct emissions from combustion of fossil fuels are considered
  - Emissions from any upstream and downstream processing are not accounted for

10 ASEAN Countries

Image Source 5th ASEAN Energy Outlook, ACE
## ASEAN Interconnection Masterplan Study (AIMS) III Scenarios

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>Each country's existing PDP* is respected but extended beyond PDP period to 2040, without new interconnection considered</td>
</tr>
<tr>
<td>Optimum RE</td>
<td>Co-optimization of interconnection capacity and VRE &amp; conventional generation expansion</td>
</tr>
<tr>
<td>ASEAN RE Target</td>
<td>Renewables target of 23% is fixed in the plan, the remaining generation and interconnection capacity are optimized</td>
</tr>
<tr>
<td>Higher VRE</td>
<td>Explore the potential of having higher VRE for advancing multilateral power trade</td>
</tr>
<tr>
<td>Updated PDP</td>
<td>Updating the study with the latest PDPs</td>
</tr>
</tbody>
</table>

*PDP: Power Development Plan  
*Note: Many countries have updated their Power Development Plans (PDPs) since AIMS III, and these updates are not included in our analyses.*
Models and Methods
Global InMAP is described in Thakrar et al. (2022)
Air quality and health impact results
Estimated emissions of NO\textsubscript{x} by country and unit types in the three AIMS III modeling years for the Base scenario (Frame a) and for the ASEAN region as a whole (relative to the Base scenario) for the three AIMS III scenarios (Frame b)
## Results: Changes in Annual Average PM$_{2.5}$ Concentration

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
<th>Change in Population-weighted PM$_{2.5}$ Concentration Relative to Base Scenario (μg m$^{-3}$)</th>
<th>% of Population Breathing Cleaner Air (Relative to Base scenario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimum RE</td>
<td>2040</td>
<td>-0.08</td>
<td>91%</td>
</tr>
<tr>
<td>ASEAN RE Target</td>
<td>2040</td>
<td>-0.01</td>
<td>34%</td>
</tr>
<tr>
<td>High RE Target</td>
<td>2040</td>
<td>-0.50</td>
<td>99%</td>
</tr>
</tbody>
</table>

In Optimum RE and High RE Target scenarios, the vast majority of citizens in ASEAN countries would breathe cleaner air.
Results: Changes in Mortality Over Time

- All scenarios lead to projected increases in PM$_{2.5}$-caused mortality
- Distribution of projected increases in excess mortality reflects the spatial distribution of emissions increases across ASEAN countries, with the greatest increases in countries such as: Vietnam, Thailand, Indonesia, and the Philippines
Results: Changes in Projected Mortality Relative to “Base” in 2040

• All alternative AIMS III scenarios lead to decrease in regional, net PM$_{2.5}$-caused annual mortality relative to the Base scenario in 2040
• In the High RE Target scenario, PM$_{2.5}$-caused mortality declines in all countries relative to the Base scenario
• Other scenarios indicate a few countries experience an increase in mortality relative to the Base scenario in 2040
Limitations and Opportunities
Limitations & Opportunities for Improvement

• AIMS III scenarios reflect 2018-2019 power development plans.
  – Incorporating recent changes to PDPs would increase the relevance of this analysis.

• Country-level analysis
  – Power sector modeling was at country level (2 countries represented with 3 nodes)
  – Results should only be viewed at country or regional level

• Population, economic growth, and health status assumed static with 10,000–40,000 cases of excess mortality each year from PM$_{2.5}$ exposure
  – Incorporating these factors and resultant changes could further improve the analysis

• Biomass-based power excluded in AIMS III
  – In some countries, this could lead to large underestimation of emissions from power sector, but in others, relatively small underestimation of emissions

• Power sector considered in isolation
  – Electrification of transportation represents just one cross-sectoral linkage
  – Thus, this study doesn’t attempt to estimate absolute magnitude of concentrations and health in the future; the focus is relative differences in power sector emissions and health impacts between scenarios
Conclusions

• Power sector is (and is expected to remain) a prominent source of air pollution in SE Asia.
  – Mortality and other health effects from the power sector in SE Asia will only become more pressing in a region already with some of the highest air pollution levels in the world

• Alternative AIMS III scenarios yield net reductions in mortality compared to Base scenario
  – A few countries have increased estimated mortality in Optimum RE and ASEAN RE Target scenarios
  – All countries have decreased estimated mortality in High RE Target scenario (16,000 total avoided mortality annually in 2040)

• Study points to potential benefits of regional coordination of strategic power sector investments that could start to consider air quality and health
  – Air pollution is transboundary; changes in one country will affect others
  – Strategic utilization of renewable power; partnerships to locate emitting plants in lower mortality intensity regions; and the prioritization of emissions control equipment for certain units
Thank you

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