An Input–Output Analysis of Total Requirements of Energy and Greenhouse Gases for All Industrial Sectors in Thailand

by

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Thailand’s Outstanding Energy Problems

- Limited fossil energy reserves
- Energy consumption per GDP projected to hit 2.1 trillion Baht by 2017 at economic growth rate of 5% per year with corresponding increase in dependency on imported energy
- Contributions from main indigenous energy resource (Nat. Gas) to the country’s energy demand cannot be increased.
- Renewable energy sources appear to have high potential, but current contributions to country’s commercial energy are not significant
- Rising oil prices having severe adverse effect on the country’s economy (In 2005 energy import/GDP >10%)
Thailand Energy Situation

Primary Energy Consumption (PEC)

Total Thailand Primary Energy Consumption in 2004: 98.1 Mtoe

Thailand Energy Situation

Final Energy Consumption (FEC)

Biomass, 17.1%
Electricity, 16.1%
Fossil Fuels, 66.8%

Thailand’s energy efficiency policies and programs

- Energy Conservation Act of 1992
- Energy conservation in factories-designated factories
- Energy conservation in large buildings-designated buildings
- Efficiency standards for appliances, building materials and control systems-producers and distributors of energy appliances, equipment, and machineries
- Energy Conservation Program
- ENCON Fund
- Demand-Side Management (DSM) Program
Why is Energy such an Issue?

- Air pollution
- Water pollution
- Climate change
- Soil contamination
- Landscape/Topography alterations
Methodology: Input-Output Analysis

• Provides a description of a local economy
• Predictive model to estimate impacts
• Can help identify sectors where significant reductions in energy and environmental burdens can be achieved
What are Input-Output (IO) Models?

• Static and linear models of the entire economy
• Can be used to estimate the impacts of shocks and changes to an economy
• Limitations of approach:
  – product /sector aggregation
  – technology and purchasing patterns fixed over time
Input-Output Model

• Is centered on the idea of inter-industry transactions:
  – Industries use the products of other industries to produce their own products.
  – For example - automobile producers use steel, glass, rubber, and plastic products to produce automobiles.
  – Outputs from one industry become inputs to another.
  – When you buy a car, you affect the demand for glass, plastic, steel, etc.
Environmental impacts have been correlated with commodity outputs

\[ c = [C][I - A^d - M]^{-1} \]

c = total impact
C = matrix of environmental impacts I = Identity matrix,
\(A^d\) = The inter-industrial transaction of n industries
M= Import matrix
I = Unity matrix
**Input-Output Theory: the Environmental Equation**

\[ f^* = [F][I - A^d - M]^{-1} \]

\[ EI^T = [ConversionFactor_{f \times 1}]^T \times [f^*_{f \times n}] \]

- \( f^* \) = The total energy content including effect of import commodities to the economy
- \( F \) = Energy consumption matrix
- \( I \) = Identity matrix,
- \( A^d \) = The inter-industrial transaction of \( n \) industries
- \( M \) = Import matrix
- \( EI \) = energy intensity
Database of IO

• 180 Industrial sector economic input-output data
• 180 Industrial sector energy input-output data
• Energy conversion factors (fuels)
## Results

### Table 1 Top 10 sectors from total energy intensity (2000)

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector Name</th>
<th>TJ/ M Baht</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Petroleum Refinery &amp; Gas Separation Plant</td>
<td>8.43</td>
</tr>
<tr>
<td>(2)</td>
<td>Road Freight Transport</td>
<td>3.10</td>
</tr>
<tr>
<td>(3)</td>
<td>Electricity</td>
<td>2.98</td>
</tr>
<tr>
<td>(4)</td>
<td>Cement</td>
<td>2.64</td>
</tr>
<tr>
<td>(5)</td>
<td>Ocean Transport</td>
<td>2.43</td>
</tr>
<tr>
<td>(6)</td>
<td>Coastal &amp; Inland Water Transport</td>
<td>2.11</td>
</tr>
<tr>
<td>(7)</td>
<td>Route &amp; Non route of Road Passenger Transport</td>
<td>2.05</td>
</tr>
<tr>
<td>(8)</td>
<td>Basic Chemicals</td>
<td>1.88</td>
</tr>
<tr>
<td>(9)</td>
<td>Agricultural Services</td>
<td>1.87</td>
</tr>
<tr>
<td>(10)</td>
<td>Iron and Steel</td>
<td>1.80</td>
</tr>
</tbody>
</table>
Discussion

- Highest total energy intensity is for Petroleum refinery & gas separation plant sector.
- Products from this sector utilized in power and electricity generation sector and also in 156 industrial sectors.
- Trend expected to continue as projections estimate Thailand’s economy to be driven by increased natural gas consumption as percentage of Natural Gas utilized for electricity generation has increased from 57.6% in 1999 to 76% in 2006
- Energy requirements for these sectors generated mainly from combustion of fossil fuels
## Results

Table 2 Top 10 sectors from environmental burdens view point

<table>
<thead>
<tr>
<th>No.</th>
<th>Sector</th>
<th>t- CO$_2$-eq / M Baht</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electricity</td>
<td>386.831</td>
</tr>
<tr>
<td>2</td>
<td>Ocean Transport</td>
<td>305.822</td>
</tr>
<tr>
<td>3</td>
<td>Cement</td>
<td>283.087</td>
</tr>
<tr>
<td>4</td>
<td>Coastal &amp; Inland Water Transport</td>
<td>224.140</td>
</tr>
<tr>
<td>5</td>
<td>Road Freight Transport</td>
<td>220.490</td>
</tr>
<tr>
<td>6</td>
<td>Fluorite Ore</td>
<td>186.996</td>
</tr>
<tr>
<td>7</td>
<td>Railways</td>
<td>171.224</td>
</tr>
<tr>
<td>8</td>
<td>Ocean And Coastal Fishing</td>
<td>167.636</td>
</tr>
<tr>
<td>9</td>
<td>Agricultural Services</td>
<td>163.762</td>
</tr>
<tr>
<td>10</td>
<td>Distilling &amp; Blending of Spirit</td>
<td>156.004</td>
</tr>
</tbody>
</table>
Discussion

• Highest CO\textsubscript{2} emission intensity from electricity sector
• Attributed to 76% of its direct energy requirement sourced from Natural Gas and also to its indirect energy requirements (fossil fuels.
• The high emissions of the top ten emitters also result from the combustion of various types of fossil fuels for production processes
## Discussion

Comparison of energy and emission intensities (sectoral classification system)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy intensity (TJ/ M Baht)</th>
<th>GHG emission Intensity (t- CO$_2$-eq / MBAht)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a (This study )</td>
<td>b (Limm et al )</td>
</tr>
<tr>
<td>Agriculture</td>
<td>13.08</td>
<td>10.27</td>
</tr>
<tr>
<td>Industry</td>
<td>78.39</td>
<td>76.81</td>
</tr>
<tr>
<td>Transportation</td>
<td>13.06</td>
<td>8.84</td>
</tr>
<tr>
<td>Commercial sector</td>
<td>11.7988</td>
<td>10.88</td>
</tr>
<tr>
<td>Energy sector</td>
<td>15.4790</td>
<td>7.00</td>
</tr>
<tr>
<td>Total</td>
<td>131.81</td>
<td>113.80</td>
</tr>
</tbody>
</table>
Discussion

• Energy intensity has increased in all sectors.
• Increase in CO$_2$ sectoral emission intensity for all sectors except commercial and industrial.
• Sectoral emission changes indicate probable changes in energy consumption pattern of these sectors. Also other factors like lower capacity utilization, fuel switching, etc.
• Reductions in total amount of GHG emissions could result from changes in technologies, fuel switching, and improvement in end-use efficiencies.
• Energy conservation and energy efficiency programs of government successful?
**Conclusion**

- Most of the greenhouse gases attributable to Thailand originate from the demand for electricity, generated from a combination of fossil fuels, by almost all sectors of the economy.
- Industrial and transportation sectors of Thailand’s economy are still the most energy intensive sectors.
- Comparison of study result with a similar one shows reduction in Thailand’s total energy intensity.
- Diverse energy efficiency programs for designated factories and large commercial buildings introduced can be said to be effective.
THANK YOU
Energy sector

- Comprised of: Coal and Lignite, Crude Oil and Natural Gas, Petroleum Refinery and Gas Separated Plant, Other Coal and Petroleum Products, Electricity, as well as Pipeline
Energy Sources for Electricity Generation

1999

- Fuel oil: 18.8%
- Natural gas: 57.6%
- Hydro: 4.3%
- Coal & lignite: 18.7%

2004

- Natural gas: 76.0%
- Diesel: 3.0%
- Fuel oil and others: 1.0%
- Coal & Lignite: 17.0%
- Hydro: 3.0%

: Thailand Energy Statistics, DEDE, 2004