Indicators for Sustainable Energy Development: Thailand Case Study

Jessie L. Todic
Monaliza Todic
Prof. Thierry Lefevre
Centre for Energy Environment Resources Development (CEERD)
Bangkok, Thailand

International Atomic Energy Agency (IAEA)
Third Research Coordination Meeting/Workshop
13-16 September 2004
UNDESA, United Nations
New York, U.S.A.
Contents

- Overview of Thailand energy situation (using ISED)
- Energy data capability
- Major energy priority areas
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- Summary and conclusions
Fast increasing indigenous energy production
Fast increasing share of natural gas in the indigenous energy mix

- Combustible renewables
- Hydropower (including non-combustible renewables)
- Gas
- Oil
- Coal
...but energy imports dependency, particularly on oil, remains high
High share of oil in the primary energy mix
Indigenous natural gas, the main fuel for power generation
Imported oil dominates final energy demand
...due to high growth in transport and manufacturing final energy demand
Successful rural electrification program...
...resulted in high electrification level even in rural areas

Note: Thailand provincial administration is divided into municipal, sanitary, and non-municipal areas.
High (energy and other) data capability...

### Demographic and Socio-economic data
- National Statistical Office (NSO)
  - Population and Housing Census
  - HSES
  - HECS
  - Other surveys

### Industrial statistics
- NSO
  - Industrial Census
  - Manufacturing Industry Survey
- Office of Industrial Economics of Thailand
  - Semi-annual statistics

### Transport statistics
- Ministry of Transport and Communications (MOTC)
  - Annual data on all transport modes
- Department of Land Transport
- State Railway of Thailand (SRT)
- Royal Irrigation Department
- Department of Customs
- Department of Aviation

### Energy and environment data
- Department of Alternative Energy Development and Efficiency (DEDE)
  - Power in Thailand
  - Oil and Thailand
  - Thailand Energy Situation
- Energy Policy and Planning Office
  - National Load Forecast
- EGAT
  - Power Development Plan
- Annual Report
- PEA
  - Annual report
- MEA
  - Annual report
...but still some data are not available

- NSO census and survey do not include statistics on production of various industries
- Office of Industrial Economics of Thailand’s semi-annual report on industrial statistics (production, sale and sales values) covers only few industries, and publication of these statistics started only in mid-1990s
- No data available on passenger-kilometer for road and urban transport
- No pipeline transport statistics available in the country
- Energy data do not give detailed information beyond the sectoral level
  - energy consumption of road transport is not classified into passenger or freight
  - energy use of cement, glass, and other non-metallic products industries are lumped together
International sources of data on Thailand

- ADB’s *Key Indicators*
- United Nations’ various statistics
- World Bank’s *World Development Indicators*
- IEA/OECD’s *Energy Balances and Statistics for Non-OECD Countries and Energy Prices and Taxes*
Major energy priority areas: *energy strategies for competitiveness*

- **Increase energy efficiency**
  - reduce country’s energy elasticity from the current 1.4:1 to 1:1 by 2007

- **Develop renewable energy**
  - increase the share of renewable energy from 0.5% of the commercial primary energy in 2002 to 8% in 2011

- **Enhance energy security**
  - enhance security of electricity supply and energy supply from indigenous fossil fuels
    - expand the availability of domestic energy reserves from 30 years to 50 years

- **Develop Thailand as regional energy center**
  - to shift its role from being an energy buyer to energy trader
Focus on energy efficiency

- Thailand has been a good example in terms of energy conservation efficiency policy implementation;
- The policy has been introduced since the 1990s so programs are already in full-scale implementation;
- Energy data is well-established at the aggregate and sectoral level; and
- It is expected that the analytical framework developed in this study can be applied to other countries.
Thailand energy efficiency policy 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
Energy Conservation Program

- NEPO
  - Voluntary
    - Renewable Energy and Rural Industries
    - Research and Development
    - Industrial Liaison
  - Complementary
    - Human Resource Development
    - Public Awareness Campaign
    - Management and Monitoring
- EPPO
  - Voluntary
    - Renewable Energy and Rural Industries
    - Research and Development
    - Industrial Liaison
  - Complementary
    - Human Resource Development
    - Public Awareness Campaign
    - Management and Monitoring
- DEDP
  - Compulsory
    - Energy Efficient Buildings
    - Building Code
- DEDE
ENCON Fund

- General support
- 30% subsidy and Standard Measures program
- Energy Efficiency (EE) Revolving Fund

- 6 sub-programs: Residential Program, Commercial/Governmental Building Program, Industrial Sector Program, Load Management Program, Energy Conservation Attitude Promotion Program, and Program Monitoring and Evaluation
- first three programs focused on energy-efficient appliances, particularly lighting equipment, high-efficiency refrigerators and air-conditioners, and high-efficiency motors
- Total budget of US$189 million, of which GEF = US$15.5 million, OECF = US$25 million in concessional loans, and EGAT

<table>
<thead>
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<tbody>
<tr>
<td>238 MW peak demand</td>
<td>468 MW peak demand</td>
</tr>
<tr>
<td>1,427 GWh generation</td>
<td>2,194 GWh generation</td>
</tr>
<tr>
<td>1.16 million tons of CO\textsubscript{2} emissions</td>
<td>1.64 million tons of CO\textsubscript{2} emissions</td>
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</table>
DSM phase II (2002-2006)

- 13 sub-programs
- 330 green learning rooms to create awareness of energy conservation in the curriculum
- 632 MW peak demand saving
- 2,508 GWh energy saving
- 1.85 million tons of CO2 emissions
- Program will cost Baht 2,155 million (USD 53.875 m): Baht 1,700 million (USD 42.5 m) for the 13 DSM programs and Baht 455 million (USD 11.375 m) for the attitude creation programs
ISED framework to assess energy efficiency performance
ISED framework for Thailand

INSTITUTIONAL DIMENSION
Promotion of Energy Efficiency and Conservation

STATE OF ECONOMIC DIMENSION
Aggregate final energy intensity by GDP
Sectoral energy intensity:
Manufacturing; transport; residential; commercial
Sub-sectoral energy intensities:
freight energy intensity; specific energy/electricity intensity of energy intensive industries; commercial sector energy intensity by floor area; commercial sector electricity intensity by employee; traditional energy intensity per capita household; per capita residential electricity intensity; modern fuel energy intensity per capita household

Sectoral energy mix

Sectoral quantities of greenhouse gas emissions:
• CO₂
• CO
• NOX
• CH₄
• SO₂
• SPM

STATE OF SOCIAL DIMENSION
Fraction of disposable income/private consumption per capita spent on fuel and electricity by:
• average
• population, group of 20% poorest population

STATE OF ENVIRONMENTAL DIMENSION
Ambient concentration of pollutants in urban areas

 Fraction of households: heavily dependent on non-commercial energy: without electricity

Distance traveled per capita
Floor area per capita
Transport structure and modal mix
Car ownership

Share of sectors in GDP value added
Structure of manufacturing value added of energy-intensive industries

GDP per capita
Demographic data

Economic dimension
Social dimension
Environmental dimension
Institutional dimension
Response indicator

Energy prices

Indirect driving force
Direct driving force
State indicator

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ISED Indicators Used

1 Population
2 GDP per capita
3 **End-use energy prices w/ and w/o tax/subsidy**
4 Sectoral share in GDP (sectoral GVA)
5 Distance traveled per capita
6 Freight transport activity
8 Manufacturing value added by selected energy intensive industries
9 **Sectoral energy intensity**
10 Final energy intensity of selected energy-intensive products

Note: In bold are ISED core indicators.
ISED Indicators Used (cont.)

20 Ratio of daily disposable income/private consumption per capita of poorest 20% of population

21 Fraction of disposable income

22 Fraction of households heavily dependent on non-commercial energy

23 Quantities of air pollution emissions

24 Ambient concentration

26 Quantities of GHG (CO2) emissions

Note: In bold are ISED core indicators.
Key Derived Indicators

- Employment population
- Commercial area per employee
- Car/motorcycle ownership
- Per capita transport energy consumption
- Service sector specific energy consumption per unit of floor space
- Service sector specific electricity sector consumption per employee
- Floor area per capita
- Residential sector energy and electricity intensity by private consumption
- Proportion of households using traditional and modern fuels by type of fuel
- Pollutants and GHG emissions from manufacturing and residential/commercial sectors
- Sectoral CO2 intensity
Energy efficiency indicators

The Energy Efficiency Indicator Pyramid

Data Aggregation Level

International statistics
National statistics
Individual plant data

Efficiency Analysis Level

National energy intensity (MJ/$ GDP)
Sectoral energy intensity (MJ/$ VA)
(sub)sectoral efficiency (GJ/tonne product or MJ/$)
Individual plant efficiency (GJJ/tonne)
Unit operation efficiency (GJ/tonne)
Economic Dimension

Demographic data

- GDP per capita
- Share of sectors in GDP value added
- Structure of manufacturing value added of energy-intensive industries
- Distance traveled per capita
- Transport structure and modal mix
- Car ownership
- Floor area per capita

Structure of manufacturing value added of energy-intensive industries

- Energy prices

Environment Dimension

STATE OF ECONOMIC DIMENSION

Aggregate final energy intensity by GDP

Sectoral energy intensity
- manufacturing
- transport
- residential
- commercial

Sub-sectoral energy efficiency indicators
- freight energy intensity
- specific energy/electricity consumption of energy-intensive industries
- commercial sector specific energy consumption by floor area
- commercial sector specific electricity consumption per employee
- traditional energy consumption per capita household
- per capita residential electricity consumption
- modern fuel energy consumption per capita household

Social Dimension

Sectoral energy mix
Aggregate and sectoral energy intensity
Energy intensity of manufacturing

Manufacturing energy intensity

Energy intensity:
- 1980: 0.0250 toe/000 Baht
- 1981: 0.0200
- 1982: 0.0150
- 1983: 0.0100
- 1984: 0.0050
- 1985: 0.0000

Percentage changes:
- 1980 to 1981: -8.03%
- 1981 to 1982: 10.42%
- 1982 to 1983: 10.18%
- 1983 to 1984: 13.36%
- 1984 to 1985: 1.36%
- 1985 to 1986: -0.96%
Energy intensity of manufacturing subsectors
Energy intensity in non-metallic minerals manufacturing

- Non-metallic minerals consumption increased significantly from 1980 to 1997.
- The energy consumption grew at an annual rate of 11.62% in the early years.
- A significant decrease of 6.36% was observed from 1997 to 1998.
- From 1998 to 2000, the energy consumption decreased further by 7.46%.

Energy consumption data is presented in million baht 1988 prices and kToe.
Transport sector energy intensity

- Freight transport specific energy consumption (mtoe/ton-km)
- Total final energy intensity
- Freight energy intensity

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Service sector energy efficiency indicators

Energy intensity by floor space (toe/m²)

Service sector final energy intensity

Energy intensity by floor space

Residential sector energy and electricity intensity

Electricity intensity (kWh/baht)
Energy intensity (toe/000 baht)
Residential sector electricity intensity

Million baht 1988 prices

GWh

Private consumption expenditures
Residential electricity consumption

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Residential sector energy intensity

- Energy consumption
- Private consumption expenditures
Household energy consumption

Kgje/hh

KWh/hh

- Residential sector final energy intensity
- Residential electricity intensity
- Traditional fuel energy intensity
- Modern fuel energy intensity
Decomposition of aggregate energy intensity

- Structural effect
- Pure intensity effect
- Aggregate energy intensity
The economic driving forces

- GDP per capita
  - Demographic data
  - Share of sectors in GDP value added
    - Structure of manufacturing value added of energy intensive industries
      - Distance traveled per capita
      - Transport structure and modal mix
      - Car ownership
      - Floor area per capita
      - Energy prices
  - Sectoral energy mix

STATE OF ECONOMIC DIMENSION
Structure of GDP

[Diagram showing the structure of GDP from 1980 to 2000, with categories such as Manufacturing, Transport (including communication), Services, Agriculture, and Others.]
Car and motorcycle ownership

- Cars per 100 persons
- Motorcycle per 100 persons

[Bar chart showing the increase in car and motorcycle ownership from 1983 to 2000.]
Floor area per employee
The social dimension

- Fraction of disposable income/private consumption per capita spent on fuel and electricity by:
  - average population
  - group of 20% poorest population

- Fraction of households: heavily dependent on non-commercial energy; without electricity

- Ratio of daily disposable income of poorest 20% household to price of: electricity, main fuel used for cooking, kerosene used for lighting

Economic Dimension

Environmental Dimension

Energy Prices
Household structure for cooking

% household using modern fuel
% household using traditional fuel
Proportion of households using each type of fuel for cooking

Kerosene | Gas | Electricity | Charcoal | Wood | Others

Structure of residential energy consumption
Fraction of households electrified

- % of household without electricity
- % of household with electricity

Daily kWh consumption of the poorest 20% population

![Graph showing daily kWh consumption from 1986 to 2000 for household and household per capita.](image)
Daily consumption of LPG

Gigajoule/day/household & household per capita

Gj/day/household  Gj/day/household per capita
Fraction of disposable income spent on fuel and electricity

- Average population
- Group of 20% poorest population
The Environment Dimension

States of Economic and Social Dimensions

Sectoral quantities of green house gas emissions:
- CO2
- CO
- NOX
- CH4
- SO2
- SPM

Sectoral carbon dioxide intensity per capita

STATE OF ENVIRONMENTAL DIMENSION
- Ambient concentration of pollutants in urban areas

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Ambient concentration of pollutants

- CO concentration
- TSP (road side air quality)
- TSP (Ambient air quality)
Sectoral CO2 emissions
Sectoral CO$_2$ intensity

CO2 Intensity

- Manufacturing
- Transport
- Residential-Commercial
Synthesis: energy efficiency achievements

- Manufacturing energy intensity
- Transport energy intensity
- Commercial energy intensity
- Residential energy intensity
- Agriculture energy intensity

Data for 1990 and 2000.
Synthesis: progress towards economic sustainability

- GDP per capita
- KWh per household
- Share of energy intensive industries to total industrial GVA
- Share of manufacturing to GDP
- Car ownership

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Synthesis: progress towards social sustainability

- Share of households using modern fuels for cooking
- Share of households with electricity
- GJ of LPG by 20% poorest pop/day
- KWh use by 20% poorest pop/day
- Fraction of disposable income of 20% poorest/private consumption spent on fuel & electricity
Synthesis: progress towards environment sustainability
Overall assessment of sustainable energy development

Aggregate energy intensity

GDP per capita

Aggregate carbon energy intensity

Fraction of disposable income of 20% poorest/private consumption spent on fuel & electricity

1990 — 2000

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Strategies for improvements in priority areas

<table>
<thead>
<tr>
<th>Programme/Sector</th>
<th>2006</th>
<th>Target</th>
<th>Units</th>
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<tbody>
<tr>
<td><strong>A. Energy Conservation in Factories, Buildings, and Households</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total energy saved</td>
<td>1142.21</td>
<td>1862.8</td>
<td>ktoe/yr</td>
</tr>
<tr>
<td>Total value of energy saved</td>
<td>20574.55</td>
<td>32509.97</td>
<td>M baht/yr</td>
</tr>
<tr>
<td><strong>B. Energy Conservation in Transportation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total energy saved</td>
<td>2792.28</td>
<td>7094.65</td>
<td>ktoe/yr</td>
</tr>
<tr>
<td>Total value of energy saved</td>
<td>51304.35</td>
<td>129563.55</td>
<td>M baht/yr</td>
</tr>
<tr>
<td><strong>C. Renewable Energy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total value of energy saved</td>
<td>1645.17</td>
<td>5068.89</td>
<td>ktoe/yr</td>
</tr>
<tr>
<td></td>
<td>33005.39</td>
<td>89691.87</td>
<td>M baht/yr</td>
</tr>
<tr>
<td><strong>D. Grand Total Energy Saved</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total value of energy saved</td>
<td>5579.66</td>
<td>14026.34</td>
<td>ktoe/yr</td>
</tr>
<tr>
<td><strong>E. Grand Total Value of Energy Saved</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total value of energy saved</td>
<td>104884.29</td>
<td>251765.39</td>
<td>M baht/yr</td>
</tr>
</tbody>
</table>
**Strategies for improvements in priority areas??**

<table>
<thead>
<tr>
<th>C. Renewable Energy</th>
<th>Percentage of total energy demand</th>
<th>Savings by type of NRSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1645.17</td>
<td>5068.89 ktoe/yr</td>
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<tr>
<td></td>
<td>3.52</td>
<td>9.39 %</td>
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| solar                | 24.16                             | 71.61 ktoe/yr           |
| wind                 | 0.87                              | 2.64 ktoe/yr            |
| biogas               | 37.86                             | 125.32 ktoe/yr          |
| **biomass**          | **630.14**                        | **1098.56** ktoe/yr     |
| hydro                | 19.22                             | 22.82 ktoe/yr           |
| geothermal           | 0.39                              | 3.06 ktoe/yr            |
| fuel cells           | 0.22                              | 0.38 ktoe/yr            |
| **biodiesel/ethanol**| **877.51**                        | **3678.67** ktoe/yr     |
| others (waste-to-energy) | 55                              | 66 ktoe/yr              |

Total value of energy saved: 33005.39 M baht/yr, 35.63%
Conclusion: value of ISED framework

- Analysis of policy effectiveness
- Environmental and social “implications” of energy policy
- Future policy responses
- Methodology compatible with other frameworks
- Offers flexibility to derive more indicators when necessary