Transfer and Adoption of Green Technologies: Lessons from Thailand

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Positioning of NSTDA

Research and Development

Universities

NSTDA

Death valley

Agriculture, Industry & Service (including public policy)

Basic Research

R & d

R & D

r & D

Technology Development & Commercialization

← bridging the gap →
Green Technologies in Thailand: Definition

- **Definition (generally used in Thailand):**
  1. A strategy (tool) for **enhancing productivity and environmental performance** for overall socio-economic development” *(source: APO)*
  2. The **continuous** application of an **integrated, preventive** environmental strategy (tool) **towards processes, products and services (organization)** in order to increase overall efficiency and **reduce damage and risks for humans and the environment**” *(Source: UNEP)*

- **Other terms (generally used in Thailand) with similar meaning:**
  Cleaner Technology-Clean Technology *(CT)*/ Cleaner Production *(CP)/ Green Productivity *(GP)/ Pollution Prevention *(P2)/ Eco-efficiency

- **Green Tools (well-known in Thailand):**
  GT-CT/ Life Cycle Assessment *(LCA)/ Eco-efficiency/ other ISO 14000 tools
Green Technologies in Thailand: History

- **1990** CT Pilot Projects in Thai industry
- **1994** Thai Green Label Scheme
- **1996** CT in Education, Research (Internship program)
- **1997** CT in other Sectors/ LCA Concept in Thailand
- **2001** Thai LCA Network/ LCA-EcoDesign Teaching
- **2002** National Capacity Building on 3R, LCA/ 1st LCA Database
- **2007** Thai Green Design Network/ Thai National LCA Database
- **since 2009** CT-LCA applications: Thai Carbon Footprint- C Reduction Label, CleanTech Programme for SME, Green GDP, etc.

Green National Plan in Thailand

- **2002** National Master Plan on Cleaner Production
- **2007** National LCI Database Project/ LCA-Ecodesign Policy-Plan
- **2008** Government Green Procurement Plan (3rd plan now)/ Strategy for Industrial Competitiveness (Environment & Trade)
- **since 2010** Several CT related plan: 3R Strategic Plan, Eco-Town Plan, SCP Roadmap (2017-2036), SEP for SDGs in 20Y Plan (2017-2036), etc.
Adoption & Transfer of Green Technologies (LC Thinking) in Thailand*

(Can be divided into 4 important phases: based on SD & Resource Efficiency)

1. Donors & Govt. Projects on GT (LCT)
   - GT/CT projects in Industry
   - LC Thinking (Thai Green Label)

2. Capacity Building, Networking & Infrastructure on GT (LCT)
   - Early stage of LCA
     - GT University Network
     - LCA Projects
   - EU White Paper Policy
     - Thai Govt. budget supported LCA database & EcoDesign (2008-2010)
   - Capacity Building with pilot projects
     - GMTAP (supported by Japanese Govt.)
     - 3R/ LCA/ Ecodesign
   - National LCA Database
     - MOU 5 org. (MOI-FTI-TEI-NSTDA-TRF)

3. Full Applications on policy & with stakeholders + international orgs.
   - GT/ LCA Applications
     - National Carbon Footprint Label (CFP&CFO)

4. GT (LCT) towards SDGs
   - 2015-present
     - Full GT/LCA for SDGs (SCP) – SEP
     - Sustainable Industry/ Agriculture/ Tourism/ City/....
     - Projects on GT/LCA for SD
     - Global LCA Network
     - Asia Carbon Footprint Network
     - Water Footprint, Env. Footprint, Sustainability assessment/ SCP/ SEEA

(*) Only projects/ activities involved by presenters)
Adoption & Transfer of Green Technologies (LC Thinking) in Thailand* (Can be divided into 4 important phases: based on SD & Resource Efficiency)

1. Donors & Govt. Projects on GT (LCT)
   - GT/CT projects in Industry
     - 1990
     - LC Thinking (Thai Green Label)

2. Capacity Building, Networking & Infrastructure on GT (LCT)
   - GT/LCA in Education & Research
     - 2000
     - LCA Curriculum
     - Thai LCA Network
   - Capacity Building with pilot projects
     - 2002
     - GMPAP (supported by Japanese Govt.)
     - 3R/ LCA/ Ecodesign
   - National LCA Database
     - 2009
     - MOU 5 org. (MOI-FTI-TEI-NSTDA-TRF)
   - EU White Paper Policy
     - Thai Govt. budget supported LCA database & EcoDesign (2008-2010)

3. Full Applications on policy & with stakeholders + international orgs.
   - 2007-2009
   - GT/ LCA Applications
     - 2009
     - National Carbon Footprint Label (CFP&CFO)
   - National LCA Database applications (phase 2)
     - 2012
     - LCA Food Asia Network

4. GT (LCT) towards SDGs
   - 2015-present
   - Full GT/LCA for SDGs (SCP) – SEP
   - Sustainable Industry, Agriculture, Tourism, City,....
   - Projects on GT/LCA for SD
     - 2013-2015
     - Global LCA Network
     - Asia Carbon Footprint Network
   - Water Footprint, Env. Footprint, Sustainability assessment/ SCP/ SEEA

(* Only projects/ activities involved by presenters)
Green Technologies Promotion (donor’s project with Local Thai experts): 1st Phase

Starting in 1990 → 1999

At the earlier phase: Promotion of GT/CT in Industry

Exhaust gas
Heat loss
Money loss
Solid wastes (flow waste, etc.)
Wastewater (with flour waste)

Resources use

Analysis of Losses/Wastes

Broken Rice

Water
• Tap water
• Ground water
• Surface water

Fuel

Noodle

Factory/Process

Wastes

Key Performance Indicators Before & after CT implementation

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>before CT</th>
<th>after CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (MJ/ton product)</td>
<td>1,018</td>
<td>373</td>
</tr>
<tr>
<td>Broken Rice (kg/ton product)</td>
<td>109.90</td>
<td>46.02</td>
</tr>
<tr>
<td>Water (m³/ton product)</td>
<td>3.75</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Generate CT Solutions

Rinsing tank
Broken Rice
Rinsing water
Rinsing Tank
Waste water

Innovation

Losses of Water & Flour in Rice Vermicelli Process

15% 41%
5%
17% 11%
16% 4%
10% 3% 9%
GT Promotion (Governmental support → COP): 1st Phase – 2nd Phase

**CT Manual – Code of Practice (COP) by Department of Industrial Works**

1. Dairy Products
2. Natural Rubber
3. Pineapples in Can
4. Frozen Seafood
5. Rice Noodle
6. Tapioca Flour
7. Fish in can
8. Metal Finishing
9. Kha-nom-jeen Flour
10. Wood Furniture
11. Rice Mill
12. Meat Processing (meat ball & sausage)

**CT: Key Factors for Meat Processing Sector (Env. Performance Indicators: EPI)**

<table>
<thead>
<tr>
<th>Key Performance Indicators (average)</th>
<th>Factory Size</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. รายงานจำนวนการผลิตสินค้าในแต่ละเดือน</td>
<td>1,649</td>
<td>1,637</td>
<td>1,616</td>
<td></td>
</tr>
<tr>
<td>2. รายงานสถานการณ์การผลิตสินค้าในแต่ละเดือน</td>
<td>1,500</td>
<td>1,497</td>
<td>1,495</td>
<td></td>
</tr>
<tr>
<td>3. รายงานผู้บริโภคสินค้าในแต่ละเดือน</td>
<td>50.4</td>
<td>51.1</td>
<td>61.4</td>
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<tr>
<td>4. รายงานการขายสินค้าในแต่ละเดือน</td>
<td>45.4</td>
<td>46.7</td>
<td>51.4</td>
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<tr>
<td>5. รายงานการขายสินค้าในแต่ละเดือน</td>
<td>28.6</td>
<td>22.6</td>
<td>13.8</td>
<td></td>
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<tr>
<td>6. รายงานการขายสินค้าในแต่ละเดือน</td>
<td>15.3</td>
<td>10.4</td>
<td>6.4</td>
<td></td>
</tr>
</tbody>
</table>

**CT Solutions**

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>Factory Size</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Contents**

1. Executive Summary
2. Technical Part
   2.1 Major CT Aspects (resource use/ waste generation/ productivity: KPI)
   2.2 CT Solutions (productivity enhancement & pollution prevention)
   2.3 Case Studies
   2.4 How to start
   2.5 Appendices (all supportive documents)

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**CT-Solutions**

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>Factory Size</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>84,900</td>
<td>126,374</td>
<td>160,438</td>
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<td>2. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>8,000</td>
<td>384,720</td>
<td>160,438</td>
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<tr>
<td>3. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>1,200,000</td>
<td>4,155,637</td>
<td>407,394</td>
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<tr>
<td>4. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>340,000</td>
<td>294,978</td>
<td>27,296</td>
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<tr>
<td>5. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>206,000</td>
<td>86,951</td>
<td>-</td>
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<tr>
<td>6. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>200,000</td>
<td>93,152</td>
<td>-</td>
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<td>7. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>67,850</td>
<td>16,888</td>
<td>-</td>
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<td>8. รายงานผลผลิตเปรียบเทียบกับเป้าหมายของบริษัท</td>
<td>65,000</td>
<td>781,260</td>
<td>-</td>
<td></td>
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</tbody>
</table>

**Payback period (yr)**

- 6.7
- 10 days
- 0.3
- 1.2
- 2.0
- 3.1
- 3.2
- 6.1
GT Promotion (GUI model → Education & Research Consortium): 1st Phase – 2nd Phase

The Model of CT Internship Program
(Tri-party format: G-U-I)

- Interns-Mentors and Enterprise
  - To point the problems out and apply the CT concept to handle them

- Government
  - NSTDA
  - To bring the training of CT concept to all participants
  - Enterprises-NSTDA
  - To monitor and evaluate the projects

- Factory Coordinators
  - To support the process data
  - To solve the problems together with the interns and mentors

- University
  - Mentors
  - To create the CT research and development concepts

Starting in 1997 → 2009

Industrial Sectors Involved in CT Internship Program (2005 - 2009)

Output of CT Internship Program (1998-2004)

Output of the Project (2005-2009)

<table>
<thead>
<tr>
<th></th>
<th>Year 2005</th>
<th>Year 2006</th>
<th>Year 2007</th>
<th>Year 2008</th>
<th>Year 2009</th>
<th>Year 2010</th>
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</thead>
<tbody>
<tr>
<td>No. of University nodes</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>No. of industrial companies</td>
<td>102</td>
<td>106</td>
<td>111</td>
<td>67</td>
<td>55</td>
<td>59</td>
</tr>
<tr>
<td>No. of Students involved</td>
<td>204</td>
<td>222</td>
<td>236</td>
<td>142</td>
<td>131</td>
<td>139</td>
</tr>
<tr>
<td>No. of Faculty Members Involved</td>
<td>165</td>
<td>153</td>
<td>153</td>
<td>99</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>No. of Industry Staff</td>
<td>102</td>
<td>106</td>
<td>98</td>
<td>67</td>
<td>55</td>
<td>139</td>
</tr>
<tr>
<td>No. of CT-options proposed</td>
<td>&gt;102</td>
<td>&gt;122</td>
<td>317</td>
<td>202</td>
<td>160</td>
<td>203</td>
</tr>
<tr>
<td>No. of CT-options implemented within the 2-month intern period</td>
<td>-</td>
<td>-</td>
<td>139</td>
<td>69</td>
<td>69</td>
<td>87</td>
</tr>
<tr>
<td>Expected Savings M/Bt/year</td>
<td>&gt;152</td>
<td>&gt;172</td>
<td>106</td>
<td>&gt;32</td>
<td>&gt;53</td>
<td>&gt;56</td>
</tr>
<tr>
<td>Actual Savings M/Bt/year</td>
<td>-</td>
<td>40.47</td>
<td>23.33</td>
<td>25.98</td>
<td>26.60</td>
<td>26.60</td>
</tr>
<tr>
<td>No. of Research Projects</td>
<td>20</td>
<td>21</td>
<td>41</td>
<td>24</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>GHGs reduction, ton CO2e/year (proposed)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>GHGs reduction, ton CO2e/year (actual)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2,555</td>
</tr>
</tbody>
</table>
Adoption & Transfer of Green Technologies (LC Thinking) in Thailand*
(Can be divided into 4 important phases: based on SD & Resource Efficiency)

1. Donors & Govt. Projects on GT (LCT)

2. Capacity Building, Networking & Infrastructure on GT (LCT)

3. Full Applications on policy & with stakeholders + international orgs.

4. GT (LCT) towards SDGs

* Only projects/ activities involved by presenters
Master Plan on GT/ LCA → Green Growth

1. Capacity Building & Networking
   (2000-2002)

2. Thai LCA/ GHGs EF Database
   (National Infrastructure)

3. Applications of GT/ LCA/ Eco-design
   (Carbon/ Water/ Env. footprints, Green GDP, Eco-efficiency, ...)
   (2009-....)

4. Collaboration ASEAN+
   (2008-....)

5. Govt. green procurement
   (2008-2011)

Thai Sustainable Society

Sustainable Consumption
(PCA/DEQP/TISI/TEI/etc.)

Sustainable Production
(MTEC/FTI/MOI/TEI/TRF)

Thai Industry
(Green Process/ Product/ Org.)

ASEAN countries

JAPAN

Others

ASEAN countries

Others

2007-2002
1. Capacity Building & Networking
(build core team to link with govt. & private orgs.)

ThaiLCA.net
ThaiGDN.net

Since 2000

GT-LCA-ecodesign Experts > 100
(mostly registered as CF Consultants & Verifiers)

Universities (across the country)

Prince of Songkla
Chiangmai, Payao
Khonkaen Mahasarakam
Chulalongkorn
Mahidol
Silpakorn
JGSEE-KMUTT Etc.

GUI = Govt., Univ. and Industry
Thai National LCA Database (Master Plan, Dec. 2004)

Infrastructure
- Energy, Utilities and Transportation
  - Coal, Natural Gas
  - Petroleum (gasoline, diesel, jet fuel, gas oil, etc.)
  - Biofuels
  - Electricity grid
  - Transportation system
  - Water supply (surface/ground)
- Recycle and Waste Management
  - Recycle
  - Landfill
  - Anaerobic digestion
  - Incineration

Industrial Materials
- Plastics (PS, PE, PP, etc.)
- Non-ferrous metals
- Ferrous metals
- Aluminum, Copper
- Fibers
- Synthetic rubber (SBR, BR)
- Pulp & Paper
- Petrochemicals (7)

Agriculture
- Cassava
- Rice
- Sugar cane
- Corn
- Cotton
- Natural rubber
- Vegetable oil
- Livestock
- Animal feed

Commodity/Chemicals
- NaOH
- H2SO4
- HCl
- CI2
- Lime
- Na2CO3
- Sulfur
- Fertilizer/ Pesticide

Building and Construction Materials
- Steel/ Gypsum
- Cement
- Glass
- Wood
- Tiles

Recycle and Waste Management
- Recycle
- Landfill
- Anaerobic digestion
- Incineration

MOU on 30 March 2007
- MOU with JRC/EU 22 Aug. 2007
- Join UNEP/SETAC LC initiative
- Technical Support by Japanese Government through GPP
- Financial Support by Thai Government

Supported by several Universities

WEBSITE
Thai LCA Software
Thai LCI Data for Research
LCI Databases exchange with other Countries

NATIONAL LCA DATABASE

1,400 Thai National LCI Data for Research

Supported by several Universities
• Food vs. Feed vs. Fuel?
• Green GDP/Green Industry (Eco-Factory/Eco-Industrial Park/Eco-Industrial Town)
• Eco-efficiency/ Factor X
• Economic instruments
• SDGs
• etc.

3 GT/LCT Applications for Green Growth

3.1 Carbon Footprint - Low C policy (since 2009)

3.2 Eco-Products Eco-Factory Promotion policy (since 2009)

3.3 Green Public Procurement - SPP policy (since 2012)

3.4 Sustainability improvement (Biofuels, Agri-Food,..) Policy (since 2012)

3.5 Water/Environmental Footprint (resource eff.-EU policy) (since 2011)

3.6 LCT for other Policy Support (since 2012)
3.1/3.2 GT (+LCA) applications for Eco-products

Different Products/Services have Env. Impact on different stages of Life Cycle

Type a: short-lived, material-intensive product (e.g., single-use package)

Type b: manufacturing-intensive product (e.g., luxury computer, paper products)

Type c: long-lived, energy and resource consuming product (e.g., cars, mobiles, airplanes, buildings)

Type d: product with special end of life or disposal characteristics (e.g., single-use disposable)

Eco-products from Thailand Ecodesign Award

Engine Oil Collector
Degradable Plastic Bags
Food Tray with Multilayer Film
Edible package

From coffee grounds
Eco Battery

Thailand Eco-products Directory
1st Eco-Products Directory (2009)

GHGs from each LC stages for 1 kg pork meat
GT/3R can play an important role to reduce GHGs emission

3.5 tonnes CO2 eq. per kg

3R opportunity
- Reduce grain use (improve meat exchange rate)
- Recycle/Utilization of manure (biogas, etc.)
- Reduces use of manure

Eco-Products
Total 452 → (1) Materials 28 (2) Components 42 (3) Products 232 (4) Services 145

2nd Eco-Products Directory 2011 (1,108 products/services)
3rd Eco-Products Directory 2013 (6,094 products/services)
4th Eco-Products Directory 2015 (9,686 products/services)
3.1/3.2 GT (+LCA) applications for Eco-products (appropriate technology)

**Energy Saving Rice Cooker**

*Save energy 34-61%*

**Principle:** minimize water use to reduce water vaporization by step-wise temp. control

<table>
<thead>
<tr>
<th>Type of Rice</th>
<th>Energy saving</th>
<th>Electricity saving (M Baht/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thai Jasmine</td>
<td>39%</td>
<td>104</td>
</tr>
<tr>
<td>Brown Jasmine</td>
<td>61%</td>
<td>332</td>
</tr>
<tr>
<td>White Rice</td>
<td>34%</td>
<td>154</td>
</tr>
</tbody>
</table>

**High pressure LPG stove (very popular in Thailand)**

Production > 800,000 stoves/yr

Average efficiency ~ 47%

If $\eta$ ↑ 1% → save LPG 2%

→ saving LPG ~ 40,000 ton/yr

~ 1,200 cu.m./yr

**Improvement on the Performance of High pressure Gas Stove Project**

**Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Platon turbine (high head)</th>
<th>Blade turbine (low head)</th>
<th>Flow turbine (water flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small water turbine for Rural Electricity</td>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Cost</td>
<td>30,000 Baht</td>
<td>36,414 Baht</td>
<td>29,500 Baht</td>
</tr>
<tr>
<td>Import</td>
<td>140,000 Baht</td>
<td>110,000 Baht</td>
<td>75,000 Baht</td>
</tr>
<tr>
<td>Efficiency</td>
<td>52 %</td>
<td>50 %</td>
<td>5 %</td>
</tr>
<tr>
<td>- Our product</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Import</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table:**

- Production > 800,000 stoves/yr
- Average efficiency ~ 47%
- If $\eta$ ↑ 1% → save LPG 2%
- Saving LPG ~ 40,000 ton/yr
- ~ 1,200 cu.m./yr
GT/ LCT towards Eco-products/ Low C in Industry

Vision of CEOs: PTT, SCG and others

Sustainable Development: Perspective of Industry

ECONOMIC Profit
-
Sustainable
-
ENVIRONMENTAL Planet
-
Social
-
People
-
Good Governance

Private Sector
-
Public Sector

Now
-
Private & Public together

Then

Proactive Practice: Product stewardship

Activity planning

<table>
<thead>
<tr>
<th>Milestone</th>
<th>2011</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable chemistry product</td>
<td>Carbon footprint /Life cycle analysis for every product</td>
<td>Using resource efficiency to minimize footprint</td>
<td>Improve GHG emission through carbon footprint reduction</td>
</tr>
<tr>
<td>Responsible management of products throughout their life cycle</td>
<td>Improved life cycle performance and design of product</td>
<td>Implement eco-labelling system for products</td>
<td>Implement of product stewardship</td>
</tr>
<tr>
<td>Chemical management policy</td>
<td>Better management of end-of-life plastics</td>
<td>Bio-plastics, Bio-solvent based on naturally occurring molecules</td>
<td>Develop lighter plastics or high efficiency and high tension plastics</td>
</tr>
</tbody>
</table>

Source: PTT Scil, Feb 2010

Cool Roof
-
CARBON NEUTRAL COMPANY
-
Zero Net CO2 Emission

Idea Green
-
PE 100+
-
Green Logistic

Activ – Flow
-
 så ialkemical, natural products

Sustainable chemistry product
-
Life cycle analysis
-
GHG emission
-
Eco-labeling
Adoption & Transfer of Green Technologies (LC Thinking) in Thailand*
(Can be divided into 4 important phases: based on SD & Resource Efficiency)

1. Donors & Govt. Projects on GT (LCT)
   GT/CT projects in Industry
   1990
   *LC Thinking (Thai Green Label)*

2. Capacity Building, Networking & Infrastructure on GT (LCT)
   GT/LCA in Education & Research
   1997-1999
   - LCA Curriculum
   - Thai LCA Network

3. Full Applications on policy & with stakeholders + international orgs.
   2000
   - EU White Paper Policy
   - Thai Govt. budget supported LCA database & EcoDesign (2008-2010)
   2002
   - Capacity Building with pilot projects
     - GMTAP (supported by Japanese Govt.)
     - 3R/ LCA/ EcoDesign
   2007-2009
   - National LCA Database
     - (MOU 5 org. (MOI-FTI-TEI-NSTDA-TRF)
   2009
   - GT/ LCA Applications
     - National Carbon Footprint Label (CFP&CFO)

4. GT (LCT) towards SDGs
   2015-present
   - Full GT/LCA for SDGs (SCP) – SEP
   - Sustainable Industry/Agriculture/Tourism/City/....

1990-1994
- Projects on GT/LCA for SD
- Global LCA Network
- Asia Carbon Footprint Network

2002-2009
- Projects on GT/LCA for SD
- Global LCA Network
- Asia Carbon Footprint Network
- Water Footprint, Env. Footprint, Sustainability assessment/ SCP/ SEEA

2012-2015
- National LCI Database applications (phase 2)
- LCA Food Asia Network

(* Only projects/ activities involved by presenters)
2016 is the warmest in 137-year record (0.94°C above 20th century average of 13.9°C)

Paris Agreement (196 members)
_global av. T rise \leq 2°C_ (CO₂ \leq 450 ppm).... 12/15, 11/16
(Thailand: 20-25% GHGs by 2030)

Major Drivers for 4th Phase

Unsustainable Earth

2 Global Agreements

Global SD Goals (193 members)
17 goals, 169 targets
(2016-2030)..... 25 Sep. 2015
(Thailand: National SDGs committee)
GT/ LCT towards SDGs

1. Cleaner production in **manufacturing**
2. Energy efficiency and renewable **energy**
3. Water efficiency and integrated **water** management
4. Sustainable **transport**
5. Sustainable **buildings**
6. Sustainable **agriculture** and sustainable **food systems**
7. Eco-labelling and consumer **information**
8. Sustainable **lifestyles**
9. Sustainable **tourism**

**Survey by WEF**: Top 3 SDGs 3 for CEOs are
- **SDG13**: Climate Action
- **SDG8**: Decent work and economic growth
- **SDG12**: SCP

Group 1 **Peace**: goal 16
Group 2 **Planet**: goal 6,7,12,13,14,15
Group 3 **People**: goal 1,2,3,4,5
Group 4 **Prosperity**: goal 9,10,11
Group 5 **Partnership**: goal 17

* Bhaskar Chakravorti, 17 June 2016 (World Economic Forum)
Case Study 1: Green Technology (+ LC) to ensure “Sustainable Biofuels”

1. Select methodology

- Regulatory framework
- Voluntary standards

Sustainability Indicators (+good governance)

<table>
<thead>
<tr>
<th>Economic</th>
<th>Environment</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>- To monitor and enhance production efficiency</td>
<td>- To monitor and encourage the reduction of environmental impacts along the life cycle of sugarcane production system</td>
<td>- To encourage the decent livelihood and fair trading</td>
</tr>
<tr>
<td>- To create economic security of farmers and producers</td>
<td>- Climate change</td>
<td>- To promote the human safety and health</td>
</tr>
<tr>
<td>Productivity</td>
<td>Eutrophication</td>
<td>Wages paid</td>
</tr>
<tr>
<td>Processing efficiency</td>
<td>Acidification</td>
<td>Income generation in the value chain</td>
</tr>
<tr>
<td>Net Energy Ratio (NER) of bioenergy products</td>
<td>Water use impact</td>
<td>Employment generation</td>
</tr>
<tr>
<td>Product cost</td>
<td>Energy use</td>
<td>Working conditions and standards</td>
</tr>
<tr>
<td>Net income</td>
<td>Agrochemical used</td>
<td>Land tenure (farmer)</td>
</tr>
<tr>
<td>Value added</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Public-Private-People-Partnerships (4Ps)

Advisory Committee
- National Federation of Sugarcane Planters
- Thai Ethanol Manufacturing Association
- Thai Sugar Millers Association
- Office of Agricultural Economics
- Ministry of Industry/Ministry of Energy
- Etc.

Technical Committee
- Department of Agriculture
- Sugarcane, Sugar and Ethanol Experts
- Experts on Economic and Social Aspects
- Etc.

Study Team (Sugarcane value chain)

3. Data collection (sugarcane molasses/ cassava/ palm)

Statistical coverage: **whole country and all value chains**
(Cultivation → Production mills → Biofuel production)
4 Study results (Ex. Bio-Ethanol)

Environmental sustainability indicator

<table>
<thead>
<tr>
<th></th>
<th>unit</th>
<th>cassava</th>
<th>Sugarcane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net GHG emission</td>
<td>kg CO₂/t root-cane</td>
<td>46 (39-55)</td>
<td>37 (33-39)</td>
</tr>
<tr>
<td></td>
<td>t CO₂/t starch-sugar</td>
<td>0.49 (0.40-0.59)</td>
<td>0.3 (0.2-0.4)</td>
</tr>
<tr>
<td></td>
<td>g CO₂/MJ ethanol*</td>
<td>30 (26-55)</td>
<td>29 (27-31)</td>
</tr>
<tr>
<td>Acidification potential</td>
<td>kg SO₂/t root-cane</td>
<td>0.23 (0.19-0.26)</td>
<td>0.23 (0.1-0.3)</td>
</tr>
<tr>
<td></td>
<td>kg SO₂/t starch-sugar</td>
<td>1.38 (1.1-1.82)</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td>g SO₂/MJ ethanol</td>
<td>0.10 - 0.42</td>
<td>0.03 - 0.10</td>
</tr>
<tr>
<td></td>
<td>g SO₂/kWh bioelectricity</td>
<td>-</td>
<td>0.01 - 0.03</td>
</tr>
<tr>
<td>Net water</td>
<td>t water/t root-cane</td>
<td>0 - 30</td>
<td>20 - 130</td>
</tr>
<tr>
<td></td>
<td>t water/t starch-sugar</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Agrochemical applied</td>
<td>kg A.I./ha/yr</td>
<td>3 - 9</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Net primary energy used</td>
<td>kJ/kg starch-sugar</td>
<td>2200-3750</td>
<td>2800-4700</td>
</tr>
</tbody>
</table>

* Gasoline: 78.6 g CO₂/MJ

Economic sustainability indicator

| Sugarcane yield | Sugar conversion efficiency | Value-added in the supply chain | Ethanol conversion efficiency |

Social sustainability indicator

| Wage paid | Income | Employment generation | Incident rate |

Main Outputs of This Study:
1. National sustainability baseline data
2. Sustainable biofuels & value chain
3. Areas for Green Tech. implementation
Green Innovation Created along Bioenergy Value Chain at NSTDA*

- **Breeding technology** for high yield cassava & oil palm
- **Simple analysis tools** for farmers (for measuring pH, % oil, etc.)
- **Precision farming technology** to increase yield and minimize resources use
  - Fertilizer mixing calculator
  - Fertilizer usage calculator by Soil Analysis
  - Optimum watering in Agriculture
  - etc.

- **Improving production efficiency** using various technologies
- **High yield- high rate Biogas technology** from wastewater

**Plantation**

- **Production of main product**
  - B10
  - B20

- **Production of biofuel**
  - H-FAME: for B10, B20 to support national target of 14 mL/day (by 2036) [start 2017]

**Sustainability improvement** (economic/ environment/ social/ good governance)

* Support the national biofuel policy (bioethanol 11.3 & biodiesel 14 MLPD by 2036) implemented by Ministry of Energy
## Main Outputs of Bioenergy Promotion Program

**support Energy Security, Climate Action and 6 (out of 17) SDGs**

<table>
<thead>
<tr>
<th></th>
<th>Ethanol</th>
<th>Biodiesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farmers’ Income Generation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethanol</strong></td>
<td>2015</td>
<td>150 M$</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>130 M$</td>
</tr>
<tr>
<td><strong>Biodiesel</strong></td>
<td></td>
<td>780 M$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>920 M$</td>
</tr>
<tr>
<td>(+ stabilize commodity prices &amp; employment)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CO₂ Mitigation (12.3 Mton)</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>from Ethanol</td>
<td>5.6 Mton CO₂</td>
<td></td>
</tr>
<tr>
<td>from Biodiesel</td>
<td>6.7 Mton CO₂</td>
<td></td>
</tr>
<tr>
<td>(for 2 years during 2015-2016)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Biofuels (RE) Utilization</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>2015</td>
<td>3.33 ML/d</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>3.67 ML/d</td>
</tr>
<tr>
<td>Biodiesel</td>
<td></td>
<td>3.90 ML/d</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.01 ML/d</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>NonR Resources (Import) Reduction</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>2015</td>
<td>857 ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(450 M$)</td>
</tr>
<tr>
<td>Diesel</td>
<td>2015</td>
<td>1,237 ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(570 M$)</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>937 ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(425 M$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,463 ML</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(565 M$)</td>
</tr>
</tbody>
</table>

**Estimation @ target year 2036**

- Ethanol (income) 11.3 ML/d (3,300 M$/yr)
- Biodiesel (income) 14.0 ML/d (4,800 M$/yr)

**Ref.:** Ministry of Energy
Ex. 2 Movement of Private Sectors towards SDGs

Bangchak Corp. PCL. (Petroleum, Biofuel, Renewable energy, etc.)
Carbon Intensity is one of corporate sustainability KPIs (Unit: Tons CO$_{2e}$/US$ 1 Million Revenue)

Source: Estimated from data published in sustainability reports and CDP investor responses

% Change 2010 - 2012

- Carrefour: -21%
- 7 Eleven: -8%
- Tesco: -14%
- Walmart: -10%

ที่มา: คุณสมเจตนา ภาสกานนท์ (คณะกก.ทรัพยากรและสิ่งแวดล้อม หอการค้าไทย ในงาน Global Warming Forum ปีที่ 4 ครั้งที่ 2: ภูมิทัศน์ทางการเมืองในเวทีระหว่างประเทศด้านโลกร้อน)
Ex.3 Ministry of Industry: Sugar Industry Sector (Eco-Efficiency index)

Eco-Efficiency = Traditional GDP - Envi. Cost

Million of THB

<table>
<thead>
<tr>
<th>GDP</th>
<th>GGDP - worst case scenario</th>
<th>GGDP - current</th>
</tr>
</thead>
<tbody>
<tr>
<td>50,000</td>
<td>45,000</td>
<td>40,000</td>
</tr>
<tr>
<td>45,000</td>
<td>40,000</td>
<td>35,000</td>
</tr>
<tr>
<td>40,000</td>
<td>35,000</td>
<td>30,000</td>
</tr>
<tr>
<td>35,000</td>
<td>30,000</td>
<td>25,000</td>
</tr>
<tr>
<td>30,000</td>
<td>25,000</td>
<td>20,000</td>
</tr>
<tr>
<td>25,000</td>
<td>20,000</td>
<td>15,000</td>
</tr>
<tr>
<td>20,000</td>
<td>15,000</td>
<td>10,000</td>
</tr>
<tr>
<td>15,000</td>
<td>10,000</td>
<td>5,000</td>
</tr>
<tr>
<td>10,000</td>
<td>5,000</td>
<td>0</td>
</tr>
</tbody>
</table>

1.71

POLICY SUPPORT
Bagasse → Electricity
+ Molasses → Ethanol
+ Pollution Control Measures

8.28

(@ current price, 2013)

Work in progress, cannot be cited
Ex.4 Movement of Government towards SDGs: State Enterprise Policy Office (SEPO) use Eco-efficiency (+ GT+LCT) to measure SD performance of 56 Thai State Enterprises*

Factor X = Eco-Eff.\(_A\)/Eco.Eff.\(_B\) ปีฐาน

GDP, income, value added, service value, etc.
(Level: nation, organization, product/service, process)

Resource use, Env. Impact (CO2,...)

Indicator

Factor 4 \(\rightarrow\) SD

* starting 2018: start with 18 State Enterprises (in sectors: energy, transportation, industry, utility and agriculture)
New Movement: Green Technologies with Eco-efficiency
(benchmarking: product-process-service → organization → sector → nation)

Eco-efficiency$_i$ = \( \frac{\text{Value Added}_i}{\text{External Cost}_i} \) (Baht)

Resource 1 Baht (or 1 ton) can generate ??? Baht of income (value added)

Tool to measure-improve performance of organization

Sector level
Ex. State Enterprises, Eco-Factory, Green Hotel

Organization level
Ex. Green Label Scheme

Product/service level

Adapted from: Norihiro Itsubo (AIST, Japan)
BENEFITS of Green Technologies

- reduce pollution
- cost-saving thru reduced wastage of materials & energy
- improve operating efficiency and working condition (health & safety)
- better product quality and consistency
- compliance assistance
- improve corporate image
- better trade opportunity
- toward…. Green Label, ISO 14000 ,…..

...sustainable development

ORGANIZATIONS promoting GT

- CT Unit- Department of Industrial Works, MOI
- Federation of Thai Industries: Industrial Environment Institute (FTI-IEI)
- National Science and Technology Development Agency (NSTDA), MoST
- Pollution Control Department (PCD)
- Thailand Institute of Scientific and Technological Research (TISTR), MoST
- Thailand Network for Eco-efficiency and Cleaner Production (TNEC)
- Thailand Environment Institute (TEI)
- Universities
- etc.
“Green Technologies” (with LCT):
help support National target & Global commitment
1. GHGs reduction (Paris Agreement)
2. Sustainable Development Goals
3. Decoupling

National target: 30% RE by 2036 & Commitment: 20-25% GHGs↓ by 2030

SUMMARY

4. Can be scaled-up & open for partnership!
Thailand → ASEAN → Asia Pacific

Ex. Biofuel: support at least 6 out of 17 SDGs (2030)