Transfer and Adoption of Green Technologies: Lessons from Thailand

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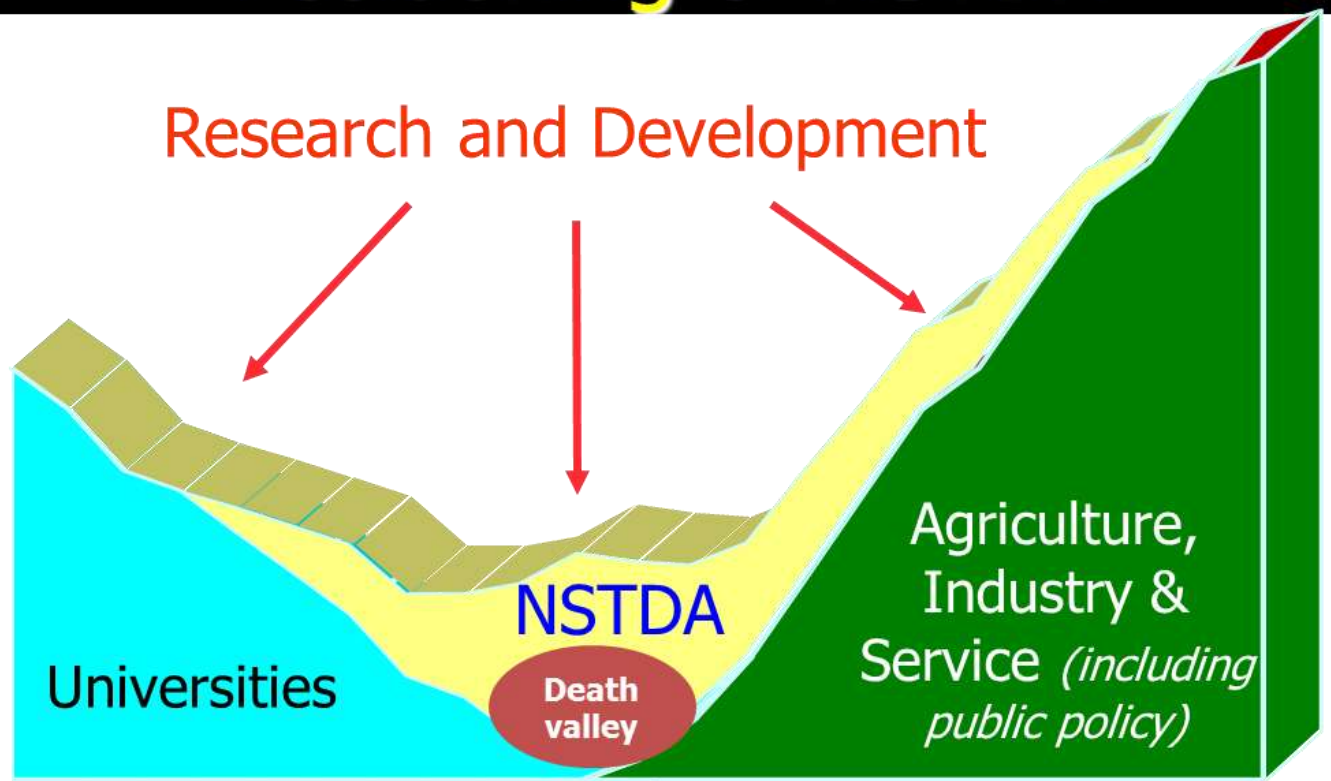
Positioning of NSTDA



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:**

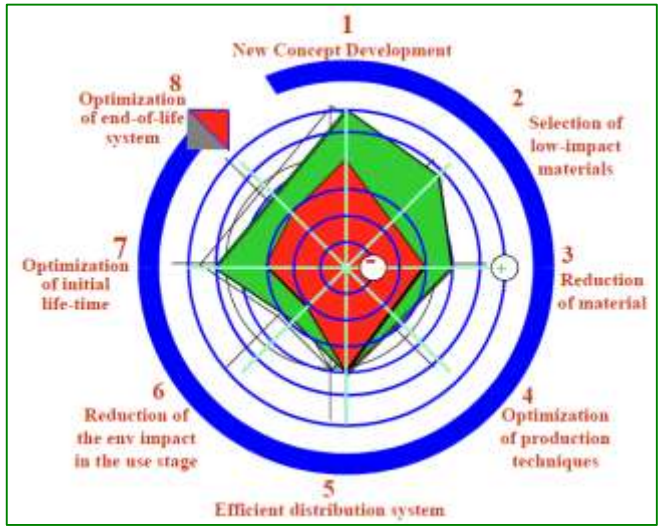
  Cleaner Technology-Clean Technology (**CT**)/ Cleaner Production (CP)/ Green Productivity (GP)/ Pollution Prevention (P2)/ Eco-efficiency

- **Green Tools (well-known in Thailand):**

  GT-CT/ Life Cycle Assessment (LCA)/ Eco-efficiency/ other ISO 14000 tools

Green Technologies in Thailand: History

Green Technologies with LC approach



- **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
- 2002 National Research Plan: CT/ LCA/ Ecodesign (2002-2006)
- 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)

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

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EU White Paper Policy
Thai Govt. budget supported LCA database & EcoDesign (2008-2010)

2007-2009 — National LCA Database
(MOU 5 org. (MOI-FTI-TEI-NSTDA-TRF)

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

2009 — GT/ LCA Applications
- National Carbon Footprint Label (CFP&CFO)

2012 — LCA Food Asia Network

2012-2015 — National LCI Database applications (phase 2)

2013-2015
- Projects on GT/LCA for SD
- Global LCA Network
- Asia Carbon Footprint Network
- Water Footprint, Env. Footprint, Sustainability assessment/ SCP/ SEEA

4. GT (LCT) towards SDGs

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

(* Only projects/ activities involved by presenters)

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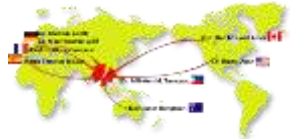

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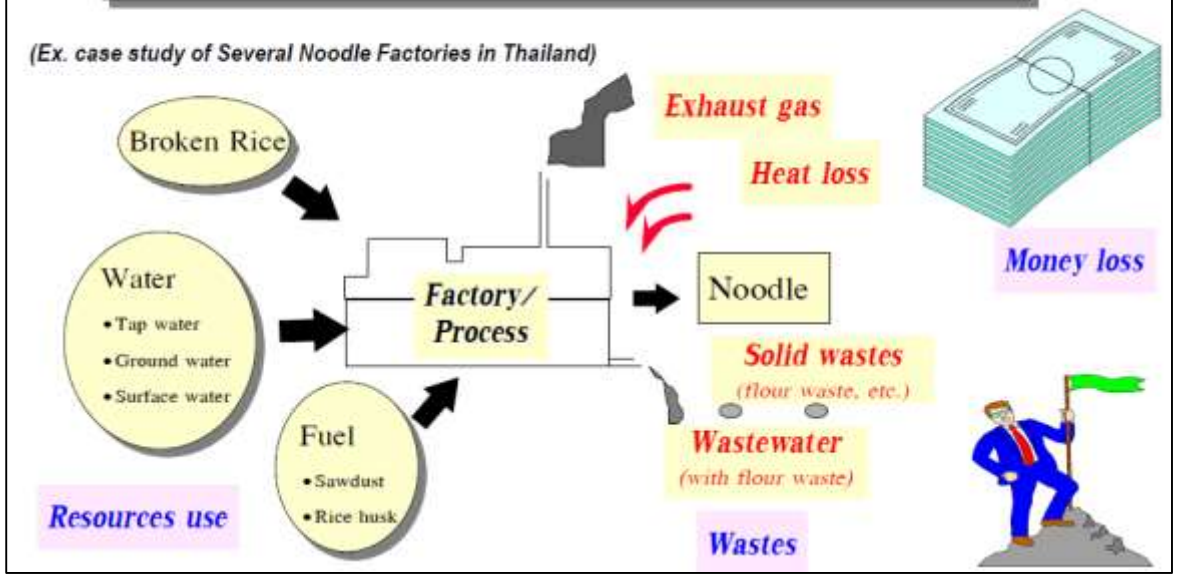
Green Technologies Promotion (donor's project with Local Thai experts): *1st Phase*

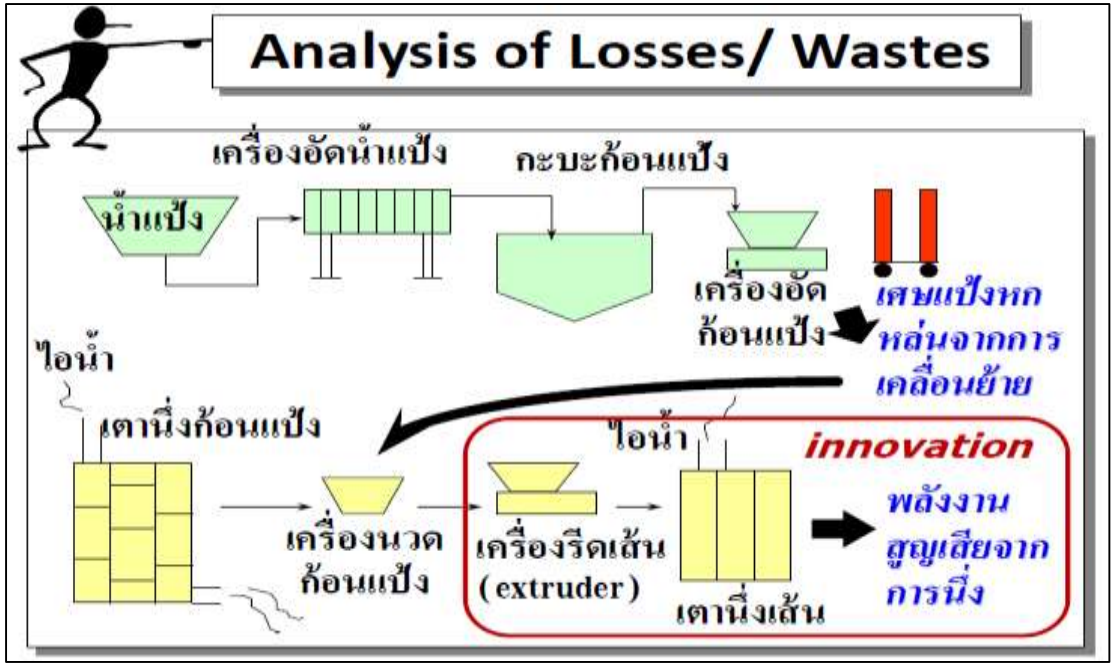
Starting in 1990 → 1999

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

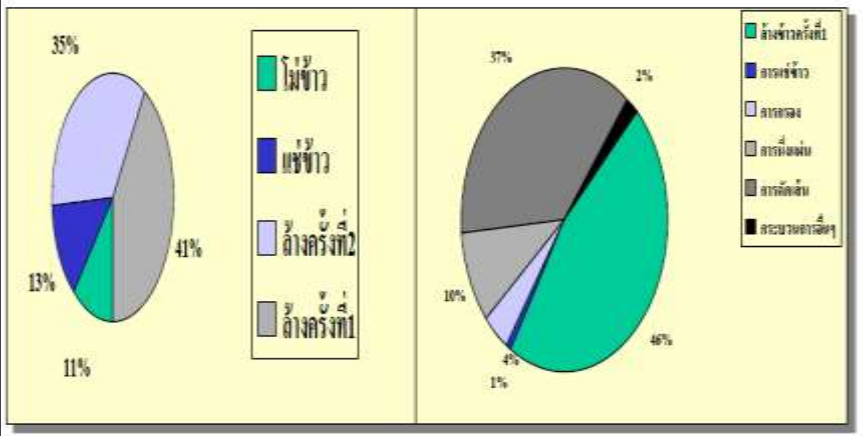
(Ex. case study of Several Noodle Factories in Thailand)



Analysis of Losses/ Wastes



Losses of Water & Flour in Rice Vermicelli Process



Generate CT Solutions

Key Performance Indicators Before & after CT implementation

Key Performance Indicator	before CT	after CT
Energy (MJ/ton product)	1,018	373
Broken Rice (kg/ton product)	109.90	46.02
Water (m3/ton product)	3.75	1.90

GT Promotion (Governmental support → COP): *1st Phase – 2nd Phase*

Starting in 1999 → 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 Manual: Code of Practice (COP) (Ex. Meat Processing: meat ball & sausage)

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)*



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

Factory Size	Small	Medium	Large
Key Performance Indicators (average)			
1. ปริมาณไฟฟ้า (กิโลวัตต์-ชม.ต่อตันผลิตภัณฑ์)	1,610	302	419
2. ปริมาณเชื้อเพลิง (ลบ.ม.ต่อตันผลิตภัณฑ์)	12,960	1,197	2,495
3. ปริมาณการใช้น้ำ (ลบ.ม.ต่อตันผลิตภัณฑ์)	50.4	9.1	6.8
4. ปริมาณน้ำเสีย (ลบ.ม.ต่อตันผลิตภัณฑ์)	44.7	7.7	7.2
5. ความสกปรกของน้ำเสีย (กก.บีโอดีต่อตันผลิตภัณฑ์)	21.0	4.6	4.4
6. การใช้แรงงาน (กก.ผลิตภัณฑ์ต่อคน-ชั่วโมง)	4.2	16.2	16.0
CT Solutions: 1. Energy			
1.1 การฉีดโฟมฉนวนป้องกันการสูญเสียความเย็นจากใต้พื้นห้องเย็น	◉	◉	●
1.2 การปรับอุณหภูมิห้องผลิตโดยระบบ Save mode	◉	◉	●
1.3 การหุ้มฉนวนหม้อต้ม	●	●	●
1.4 การนำคอนเดนเสทกลับมาใช้ผสมน้ำป้อนหม้อไอน้ำ	◉	●	●
1.5 การปรับเปลี่ยนขนาดของหม้อแปลงให้เหมาะสมกับภาระงาน	○	◉	◉
1.6 การนำความร้อนเหลือทิ้งจากเครื่องปรับอากาศมาทำน้ำร้อน	◉	◉	●
1.7 ปรับเปลี่ยนบัลลาสต์ขดลวดเป็นบัลลาสต์อิเล็กทรอนิกส์ความถี่สูง	◉	●	●
1.8 การปรับปรุงประสิทธิภาพความร้อนของหม้อไอน้ำ	●	●	●

CT-Solutions	Investment (Baht)	Savings (Baht/yr)	Environment Benefit (Unit/yr)	Payback period (yr)
1. การฉีดโฟมฉนวนป้องกันการสูญเสียความเย็นจากใต้พื้นห้องเย็น	84,500	126,374	ลดการใช้ไฟฟ้าได้ 43,131 กิโลวัตต์-ชม./ปี	0.7
2. การปรับอุณหภูมิห้องผลิตโดยระบบ Save mode	8,000	304,720	ลดการใช้ไฟฟ้าได้ 104,000 กิโลวัตต์-ชม./ปี	10 days
3. การหุ้มฉนวนหม้อต้ม	1,200,000	4,155,637	ลดการใช้น้ำมันเตา 407,807 ลิตร/ปี	0.3
4. การนำคอนเดนเสทกลับมาใช้ผสมน้ำป้อนหม้อไอน้ำ	340,000	294,978	ลดการใช้น้ำมันเตา 27,960 ลิตร/ปี	1.2
5. การปรับเปลี่ยนขนาดของหม้อแปลงให้เหมาะสมกับภาระงาน	206,000	80,951	-	2.6
6. การนำความร้อนเหลือทิ้งจากเครื่องปรับอากาศมาทำน้ำร้อน	290,000	91,152	ลดการใช้ไฟฟ้าได้ 31,110 กิโลวัตต์-ชม./ปี	3.2
7. ปรับเปลี่ยนบัลลาสต์ขดลวดเป็นบัลลาสต์อิเล็กทรอนิกส์ความถี่สูง	62,850	19,888	ลดการใช้ไฟฟ้าได้ 6,788 กิโลวัตต์-ชม./ปี	3.2
8. การปรับปรุงประสิทธิภาพความร้อนของหม้อไอน้ำ	65,000	781,360	ลดการใช้น้ำมันเตา 53,335 ลิตร/ปี	0.1

GT Promotion (GUI model → Education & Research Consortium): *1st Phase – 2nd Phase*

Starting in 1997 → 2009

The Model of CT Internship Program

(Tri-party format: G-U-I)

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

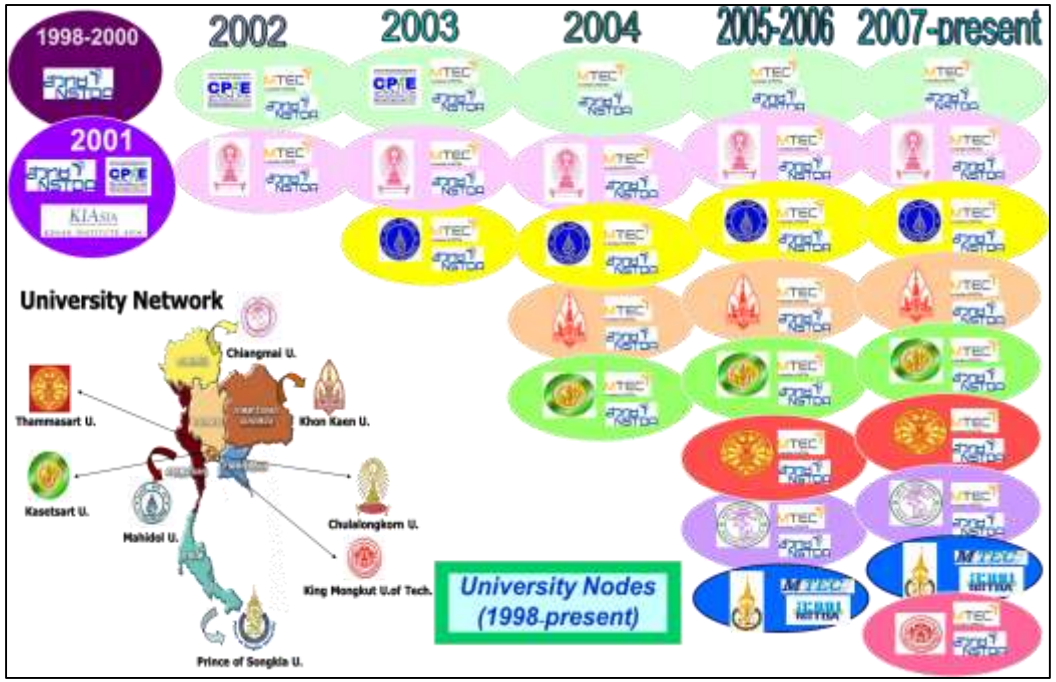
Government

NSTDA
- To bring the training of CT concept to all participants

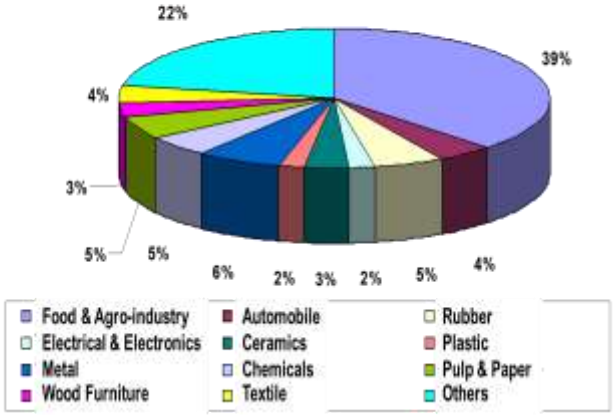
Enterprisers-NSTDA
- To monitor and evaluate the projects

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

Mentors
- To create the CT research and development concepts



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



Output of CT Internship Program (1998-2004)

Number of	Year 1998	Year 1999	Year 2000	Year 2001	Year 2002	Year 2003	Year 2004	Total
Industrial Sectors	3	5	5	4	8	10	-	10
Factories	16	8	15	7	17	40	65	158
Trained Students	32	19	30	16	34	82	133	346
Universities	11	5	7	5	5	11	14	19
Mentors	8	8	20	13	27	73	105	241
Central Advisors	0	0	8	6	5	15	-	27
CP Options	> 40	> 32	> 50	24	53	142	226	567
RD&E Concept Papers	–	8	13	8	20	42	>55	146
Proposed Saving	> 10	> 4.6	> 28	> 5	> 22.4	> 23	>107	> 197 MB/yr

Output of the Project (2005-2009)

Output \ Year	2005	2006	2007	2008	2009	2010
No. of University nodes	7	7	8	8	7	7
No. of Industrial companies	102	106	111	67	55	59
No. of Students involved	204	222	238	142	131	139
No. of Faculty Members involved	165	153	153	99	75	75
No. of Industry Staff	102	106	98	67	55	139
No. of CT-options proposed	>102	>123	317	202	169	203
No. of CT-options implemented within the 2-month intern period	-	-	139	89	69	87
Expected Savings (M Bt/year)	>153	>172	106	>53	>56	71.59
Actual Savings (M Bt/year)	-	-	40.47	23.33	25.69	29.69
No. of Research Projects	20	21	41	24	18	12
GHGs reduction, ton CO2e/year (proposed)			-	-	-	25,000
GHGs reduction, ton CO2e/year (actual)			-	-	-	2,565

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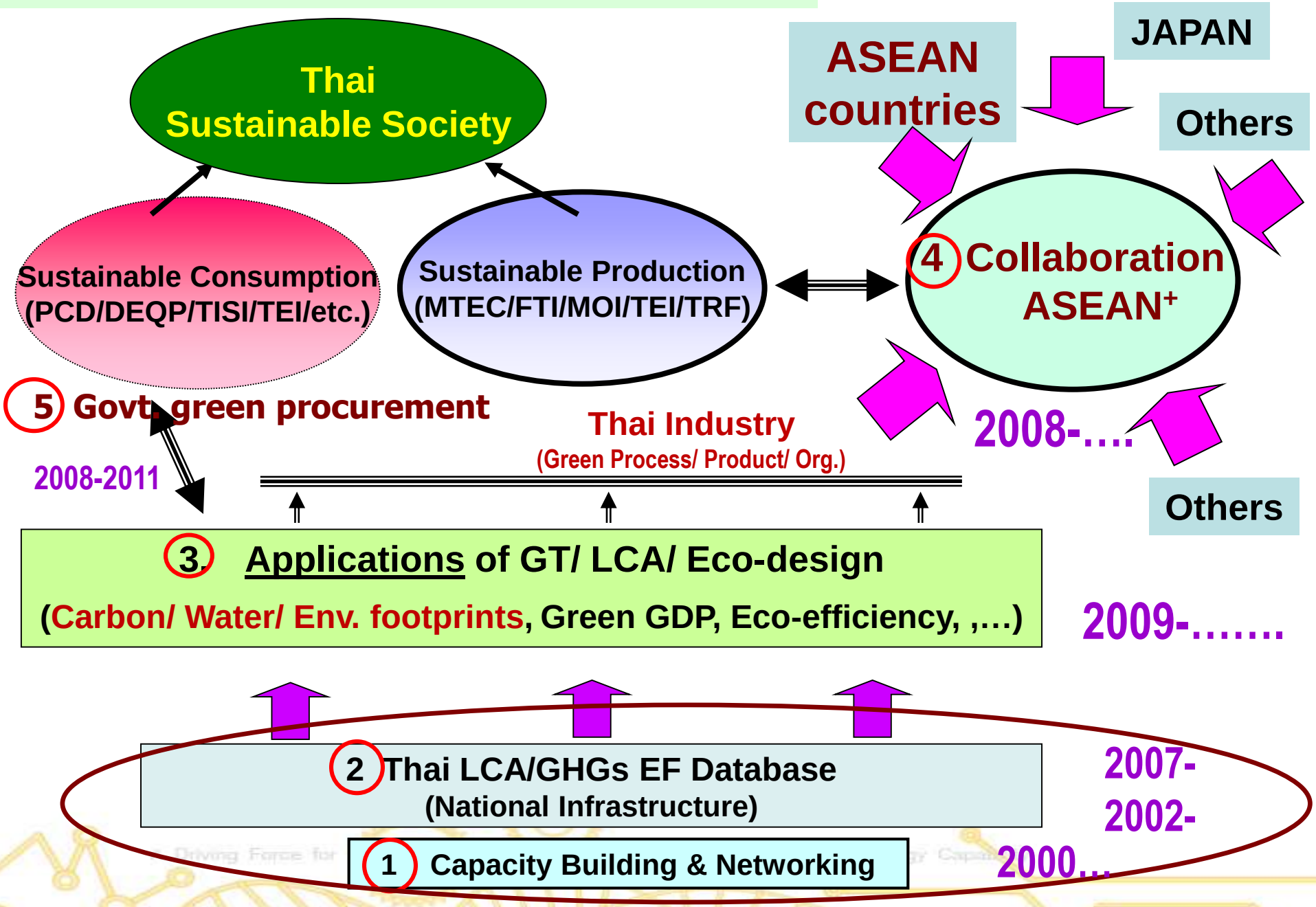
Master Plan on GT/ LCA → Green Growth



1. Capacity Building & Networking

(build core team to link with govt. & private orgs.)

ThaiLCA.net
ThaiGDN.net

2

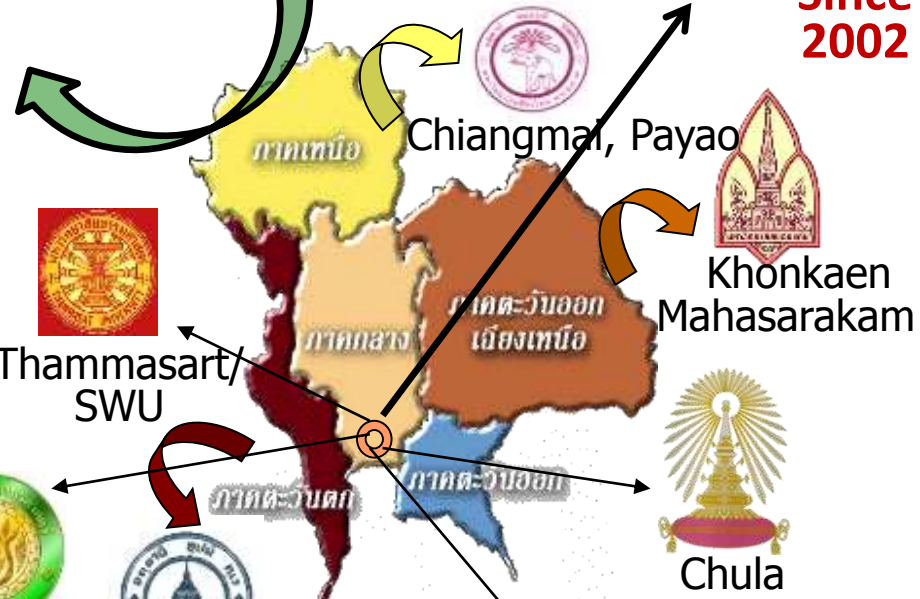
Since 2000

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

1

MTEC LCA Lab/ EcoDesign Lab

Since 2002



Chiangmai, Payao

Khonkaen Mahasarakam

Thammasart/ SWU

Chula

Kasetsart KMTNB

Mahidol Silpakorn

JGSEE-KMUTT Etc.

Prince of Songkla

1

Universities (across the country)

Since 1996

Government

NSTDA

students

Industry

FTI, THTI, ect.

University

GUI = Govt., Univ. and Industry

2 Thai National LCA Database (National Infrastructure)

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

CommodityChemicals
- NaOH
- H2SO4
- HCl
- Cl2
- Lime
- Na2CO3
- Sulfur
- Fertilizer/ Pesticide

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

National LCI Database (@ Feb 2015) → GHG emission factor

WG1: Natural Gas	6
WG2: Refinery	8
WG3: Petrochemical	19
WG4: Ferrous & Non-ferrous	
Ferrous	9
Non-ferrous	5
WG5: Infrastructure/Transportation	
Electric Grid Mix	1
Water	6
Road Transportation: Truck	188
Transportation: Ship & Rail	21+22
WG6: Construction Materials	
Ceramics	7
Glass & Mirror	7
Alternative Materials for Wood	3
Construction Materials	8
WG7: Agriculture/Agro-products	
Feed mill	15
Livestock & Products Agriculture Machinery	19 33
Rubber	7

WG7: Agriculture/Agro-products (Cont)	
Rice	17
Pulp & Paper	9
Wood (Para-wood)	17
Cassava + Cassava Products	2+13
Longan + Food & Agriculture	4+43
Pineapple + Vegetables & Frozen Fruits	1+10
Plantation of Plants (from literature)	80
Oil Palm → Bio-diesel	24
Others (UHT coconut milk/ Curry paste)	3
WG8: Basic chemicals	
Paints + Industrial gases	6+3
Basic chemicals + Chemical products	14+2
Fertilizers and Herbicides	47
WG9: Recycle/Waste Management	
Incinerations	8
Landfills + Recycle	8+12
Wastewater Treatment	9
WG10: Others (Textile 30, EE Parts 80, Automotive Parts 3, Vanish oil 3)	116
TOTAL (G-t-G 846, C-t-G 552)	1,398
(G-to-G by MTEC 711)	

1,400

MOU on 30 March 2007

Supported by several Universities

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

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

3 GT/LCT Applications for Green Growth

- **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.

3.1 Carbon Footprint- ***Low C policy*** (since 2009)

GHG emission factors

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)

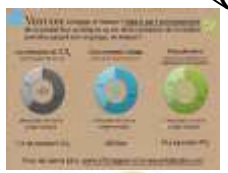
Experts & Networking — LCA, Eco-Design

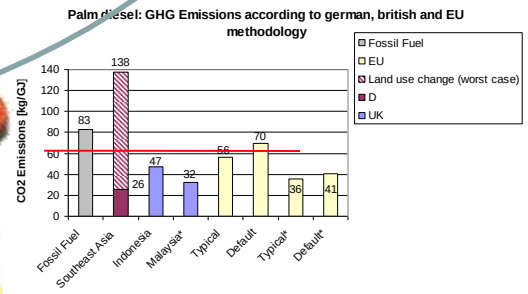
LCA Inventory data

Life Cycle Thinking

CO_2 UPCYCLE

Since 2015

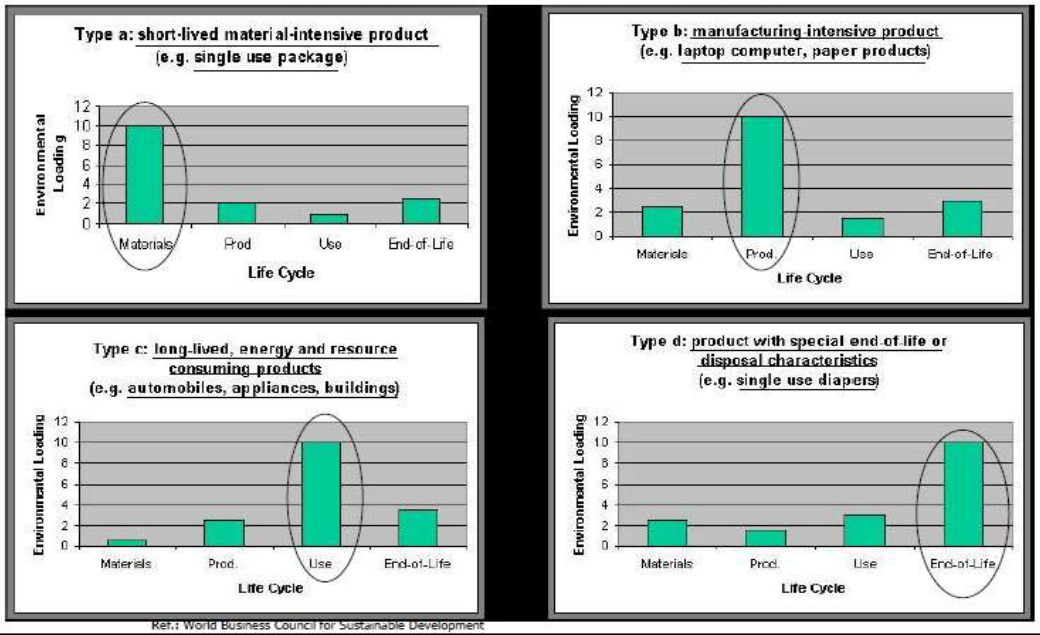




Sugar cane/ Molasses/ Cassava/ Oil palm/ Jatropha

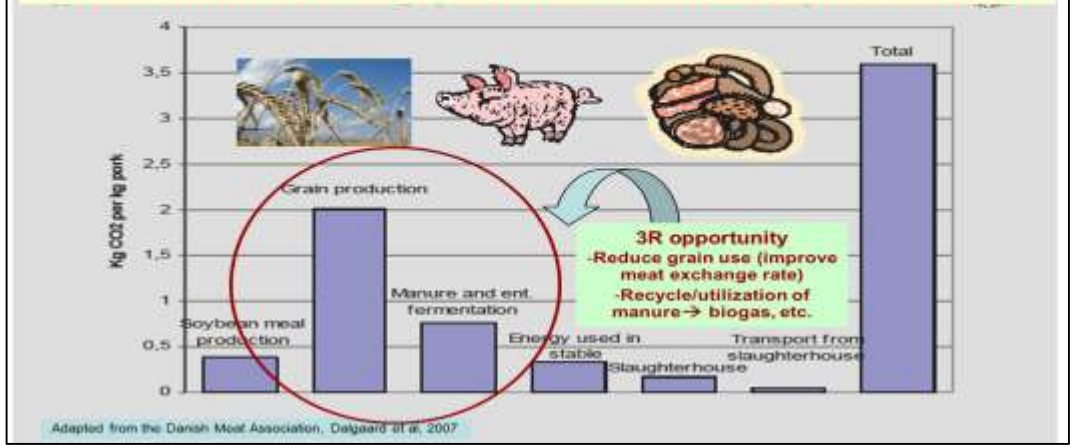
3.1/3.2 GT (+LCA) applications for Eco-products

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



Ref.: World Business Council for Sustainable Development

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



Adapted from the Danish Meat Association, Dalgaard et al., 2007

Eco-products from Thailand Ecodesign Award

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

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)

MTEC a member of NSTDA

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

Type of Rice	Energy saving	Electricity saving* (M Baht/yr)
Thai Jasmine	39%	104
Brown Jasmine	61%	332
White Rice	34%	154

Improvement on the Performance of High pressure Gas Stove Project

Burner A Burner B Burner C

High pressure LPG stove (very popular in Thailand)

Production > 800,000 stoves/yr

Average efficiency ~ 47%

If η ↑ 1% → save LPG 2%

→ saving LPG ~ 40,000 ton/yr

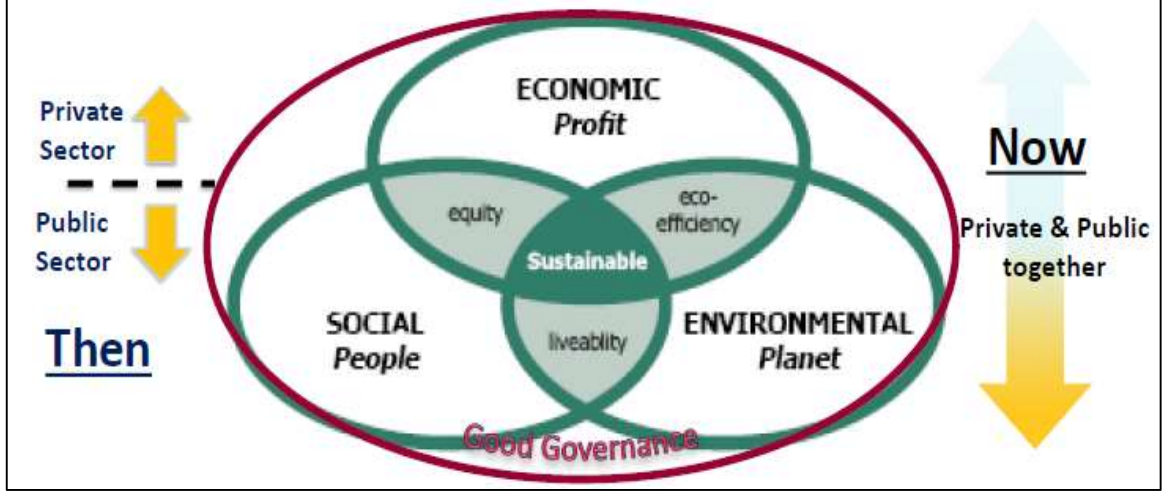
~ 1,200 cu.m,/yr

Parameter	Platon turbine (high head)	Blade turbine (low head)	Flow turbine (water flow)
Small water turbine for Rural Electricity			
Cost			
Our product	30,000 Baht	36,414 Baht	29,500 Baht
Import	140,000 Baht	110,000 Baht	75,000 Baht
Efficiency			
- Our product	52 %	50 %	5 %
- Import	50 %	40 %	1 %

GT/ LCT towards Eco-products/ Low C in Industry

Vision of CEOs: PTT, SCG and others

Sustainable Development: Perspective of Industry



ตัวอย่างแผนงาน eco ของ PTT Global Chemical

ptt GLOBAL CHEMICAL

Proactive Practice : Product stewardship

Activity planning

Milestone	2011	2015	2020
Sustainable chemistry product	Carbon footprint /life cycle analysis for every product		
	Using resource efficiency to minimize footprint		
	Improve GHG emission through carbon footprint reduction		
Responsible management of products throughout their life cycle	Improved life cycle performance and design of product		
	Implement eco- labeling system for products		
Chemical management policy	Implement of product stewardship		
Innovation the plastic for tomorrow	Better management of end-of – life plastics		
	Bio-plastics, Bio-solvent based on naturally occurring molecules		
	Develop lighter plastics or high efficiency and high- tension plastics		

Source: PTTGC, Feb. 2556

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)

1990 — GT/CT projects in Industry

1994 — LC Thinking (Thai Green Label)

1997-1999 — Early stage of LCA
- GT University Network
- LCA Projects

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

2000 — GT/LCA in Education & Research
- LCA Curriculum
- Thai LCA Network

2002 — Capacity Building with pilot projects
- GMTAP (supported by Japanese Govt.)
- 3R/ LCA/ Ecodesign

EU White Paper Policy
Thai Govt. budget supported LCA database & EcoDesign (2008-2010)

2007-2009 — National LCA Database
(MOU 5 org. (MOI-FTI-TEI-NSTDA-TRF)

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

2009 — GT/ LCA Applications
- National Carbon Footprint Label (CFP&CFO)

2012 — LCA Food Asia Network

2012-2015 — National LCI Database applications (phase 2)

2013-2015
- Projects on GT/LCA for SD
- Global LCA Network
- Asia Carbon Footprint Network
- Water Footprint, Env. Footprint, Sustainability assessment/ SCP/ SEEA

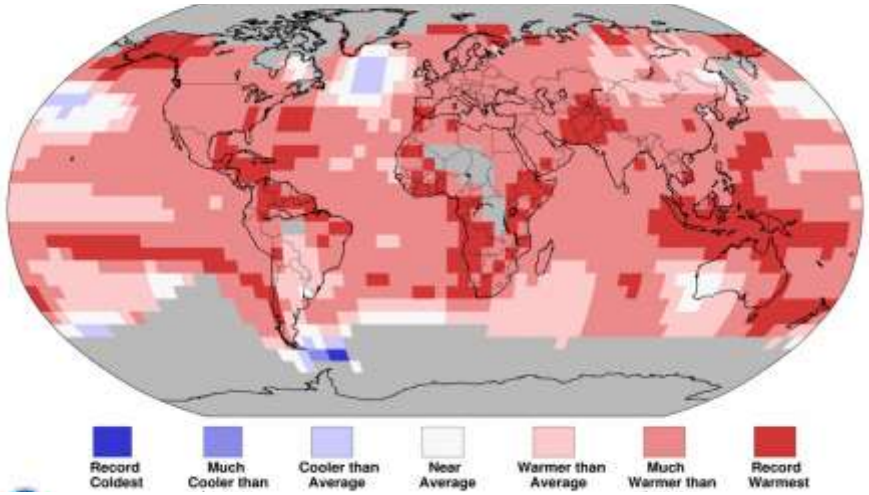
4. GT (LCT) towards SDGs

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

(* Only projects/ activities involved by presenters)

2016 is the warmest in 137-year record

(0.94 ^{0}C above 20th century average of 13.9^{0}C)



Source: National Centers for Environmental Information, NASA GISS, CO2Now.com (Temp. percentiles Jan-Dec 2016)

1 **Paris Agreement** (196 members)
global av. T rise ≤ 2^{0}C
(CO_2 ≤ 450 ppm).... *12/15, 11/16*
(Thailand: 20-25% GHGs ↓ by 2030)

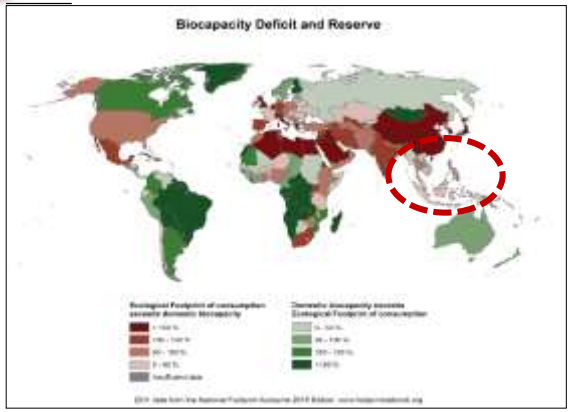
Major Drivers for 4th Phase

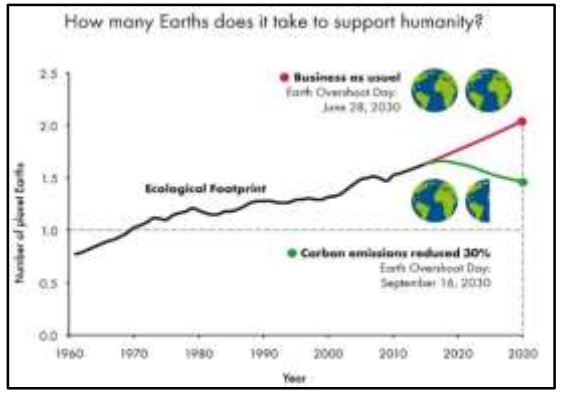
Unsustainable Earth

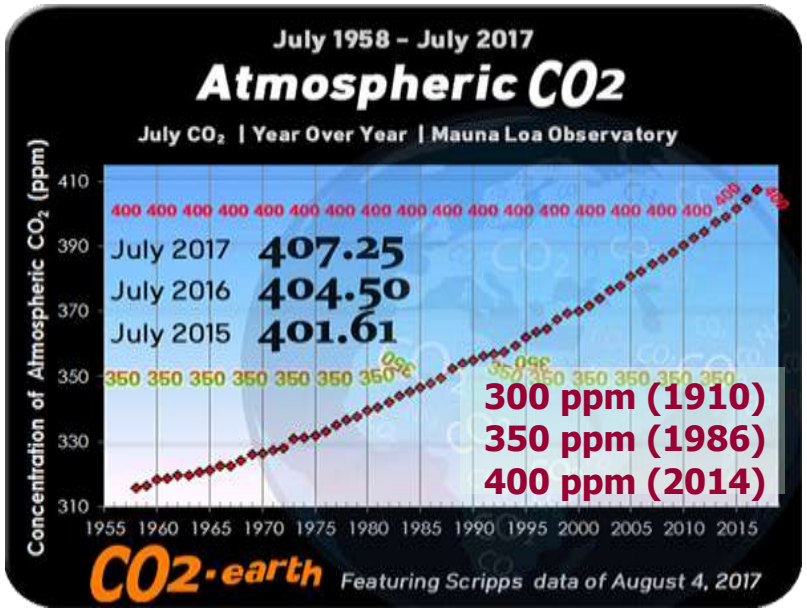
and

2 Global Agreements

Source: footprintnetwork.org







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

GT/ LCT towards SDGs

17 UN-SDGs divide into 5 group

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 8,9,10,11
Group 5 Partnership: goal 17

* Bhaskar Chakravorti, 17 June 2016 (World Economic Forum)

ที่มา: ปรับจาก SD Focus (Mar. 2016)

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

Case Study 1: Green Technology (+ LC) to ensure "Sustainable Biofuels"

1 Select methodology

Regulatory framework

Renewable Energy Directive EU

USA Renewable Fuel Standard

Voluntary standards

RSPO, BONSUCRO, GBEP, RTRS, RSB, FSC FORESTS FOR ALL FOREVER, ISCC

Sustainability Indicators (+good governance)

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

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

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

NSTDA ⇕ Coordination

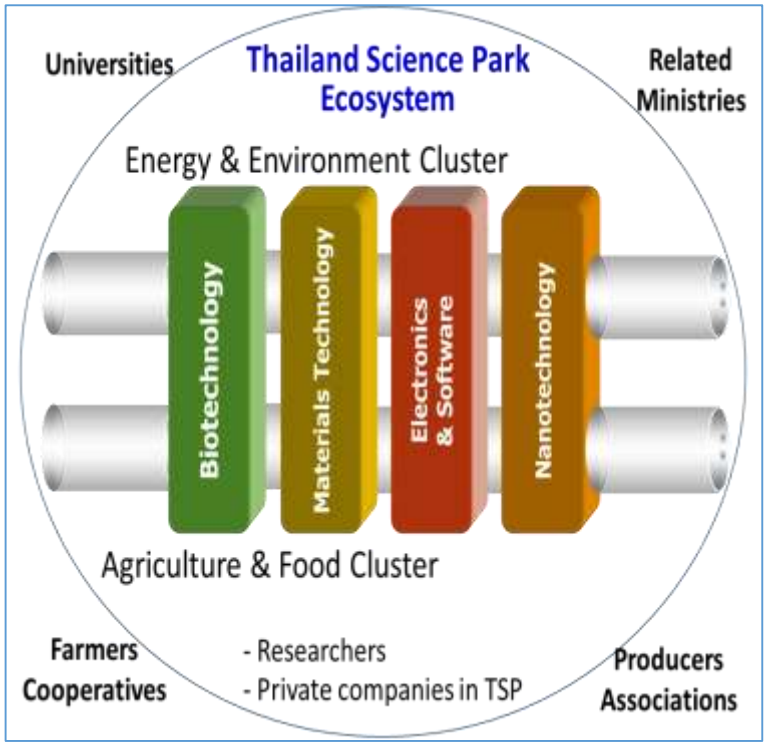
Technical Committee (MTEC)
- Department of Agriculture
- Sugarcane, Sugar and Ethanol Experts
- Experts on Economic and Social Aspects
- Etc.

Research Team Leader ⇕ Coordination

Study Team (Sugarcane value chain)

JGSEE, CEE-PERDO, ETDI, Factories

Biofuels Innovation System



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

	unit	cassava	Sugarcane
Net GHG emission	kg CO_2/t root-cane	46 (39 - 55)	37 (33 - 39)
	t CO_2/t starch-sugar	0.49 (0.40-0.59)	0.3 (0.2-0.4)
	g CO_2/MJ ethanol*	30 (26 - 55)	29 (27-31)
Acidification potential	kg SO_2/t root-cane	0.23 (0.19-0.26)	0.23 (0.1-0.3)
	kg SO_2/t starch-sugar	1.38 (1.1-1.82)	1-3
	g SO_2/MJ ethanol	0.10 - 0.42	0.03 - 0.10
	g SO_2/kWh bioelectricity	-	0.01 - 0.03
Net water	t water/t root-cane	0 - 30	20 - 130
	t water/t starch-sugar	18	28
Agrochemical applied	kg A.I./ha/yr	3 - 9	4 - 8
Net primary energy used	kJ/kg starch-sugar	2200-3750	2800-4700

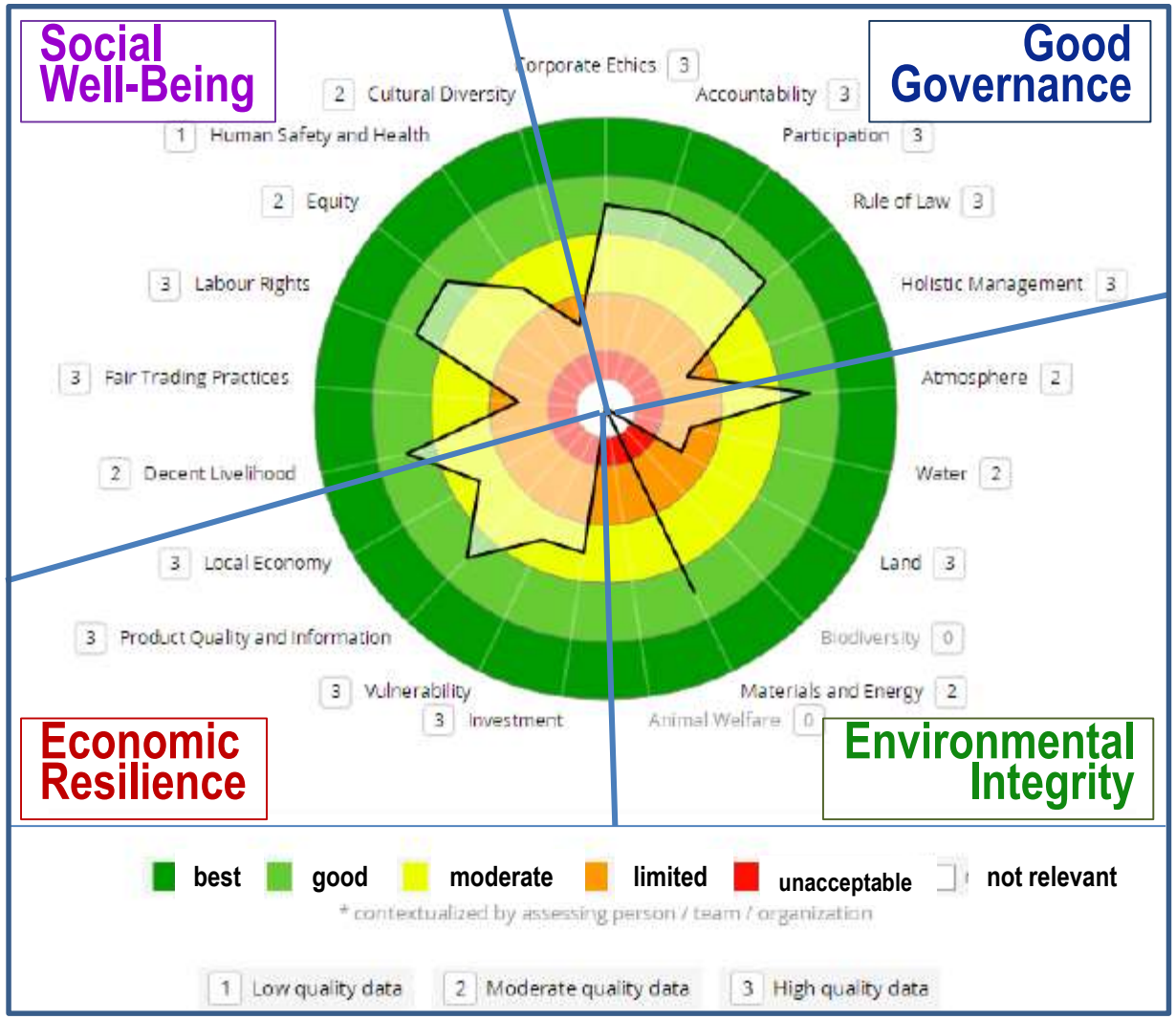
* Gasoline: 78.6 g CO2/MJ

Economic sustainability indicator

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

Social sustainability indicator

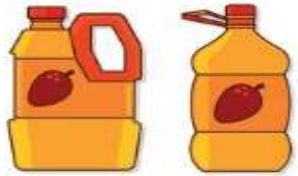
Wage paid	Income	Employment generation	Incident rate



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*



Plantation

Production of main product

Production of biofuel

- **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

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

Thailand

Japan

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

Biofuels (RE) Utilization

	Ethanol	Biodiesel
2015	3.33 ML/d	3.39 ML/d
2016	3.67 ML/d	4.01 ML/d

Farmer's Income Generation

	Ethanol	Biodiesel
2015	150 M$	780 M$
2016	130 M$	920 M$

(+ stabilize commodity prices & employment)

NonR Resources (Import) Reduction

	Gasoline	Diesel
2015	857 ML *(450 M$)*	1,237 ML *(570 M$)*
2016	937 ML *(425 M$)*	1,463 ML *(565 M$)*

CO_2 Mitigation (12.3 Mton)

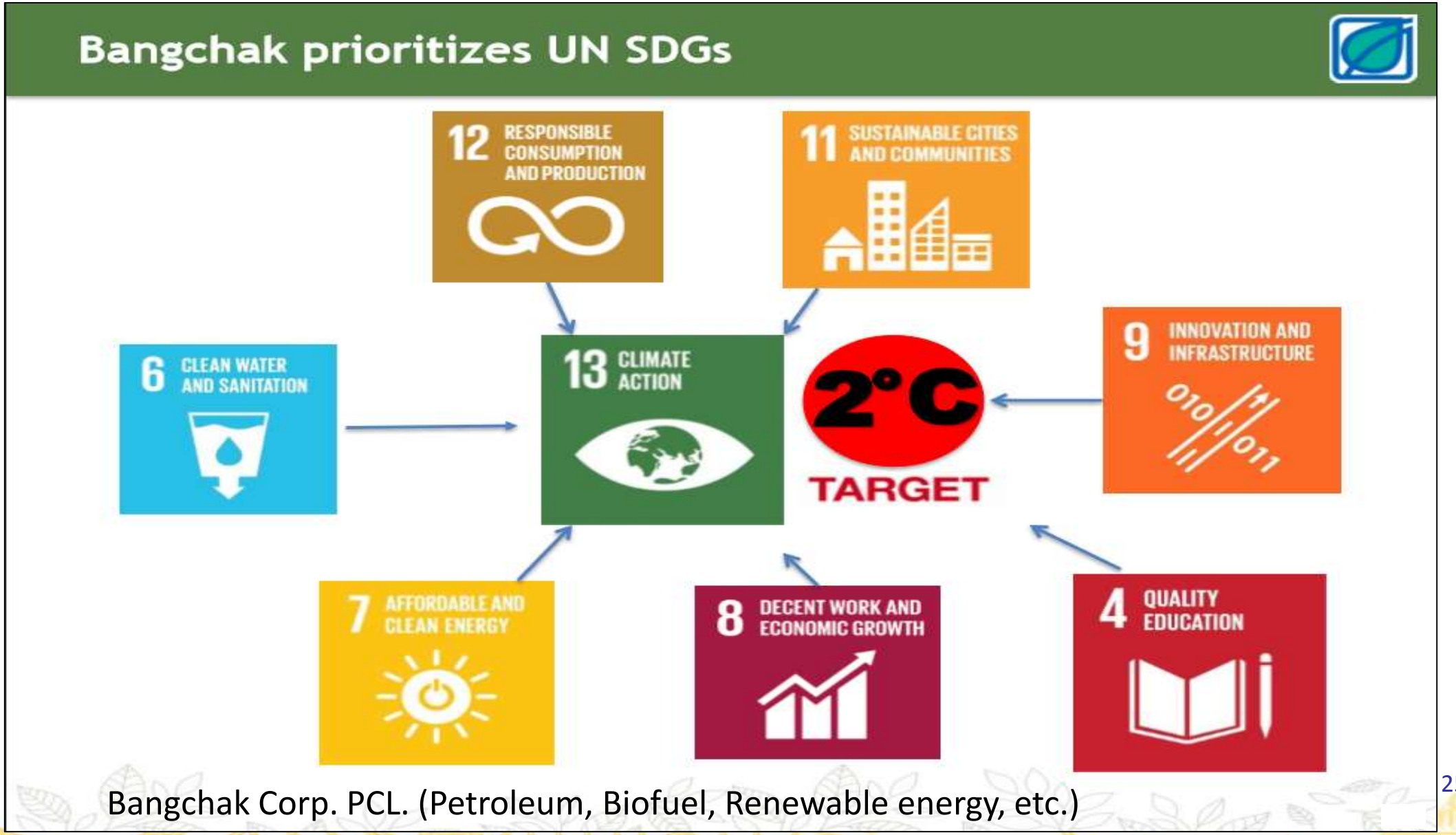
from Ethanol	5.6 Mton CO_2
from Biodiesel	6.7 Mton CO_2

(for 2 years during 2015-2016)

Estimation @ target year 2036	*Ethanol (income) 11.3 ML/d (3,300 M$/yr)*	*Biodiesel (income) 14.0 ML/d (4,800 M$/yr)*	*+ more employment & CO2 reduction*

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

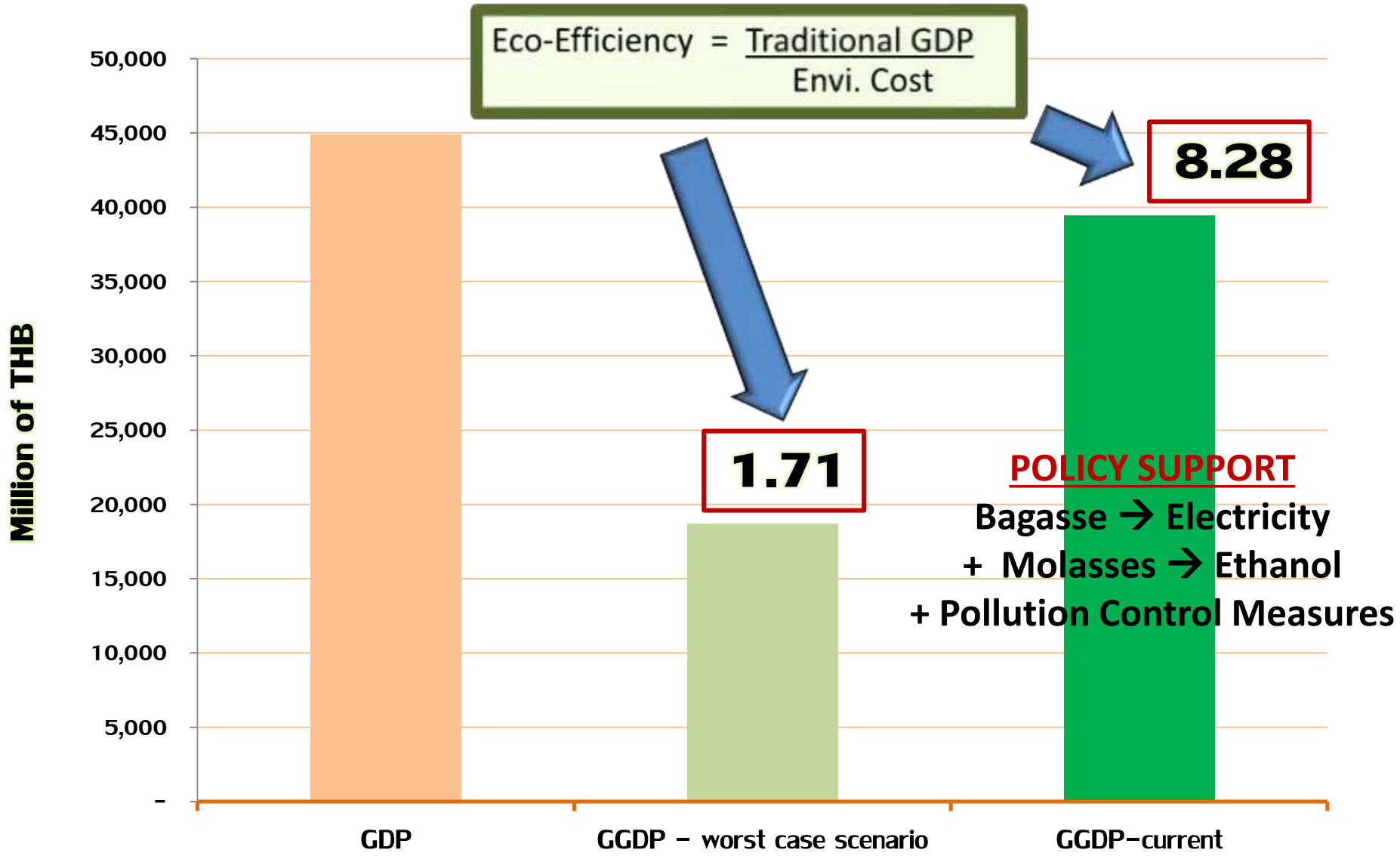
(Unit: Tons CO_{2e} / US$ 1 Million Revenue)

% Change 2010 - 2012	-21%	-8%	-14%	-10%

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

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)

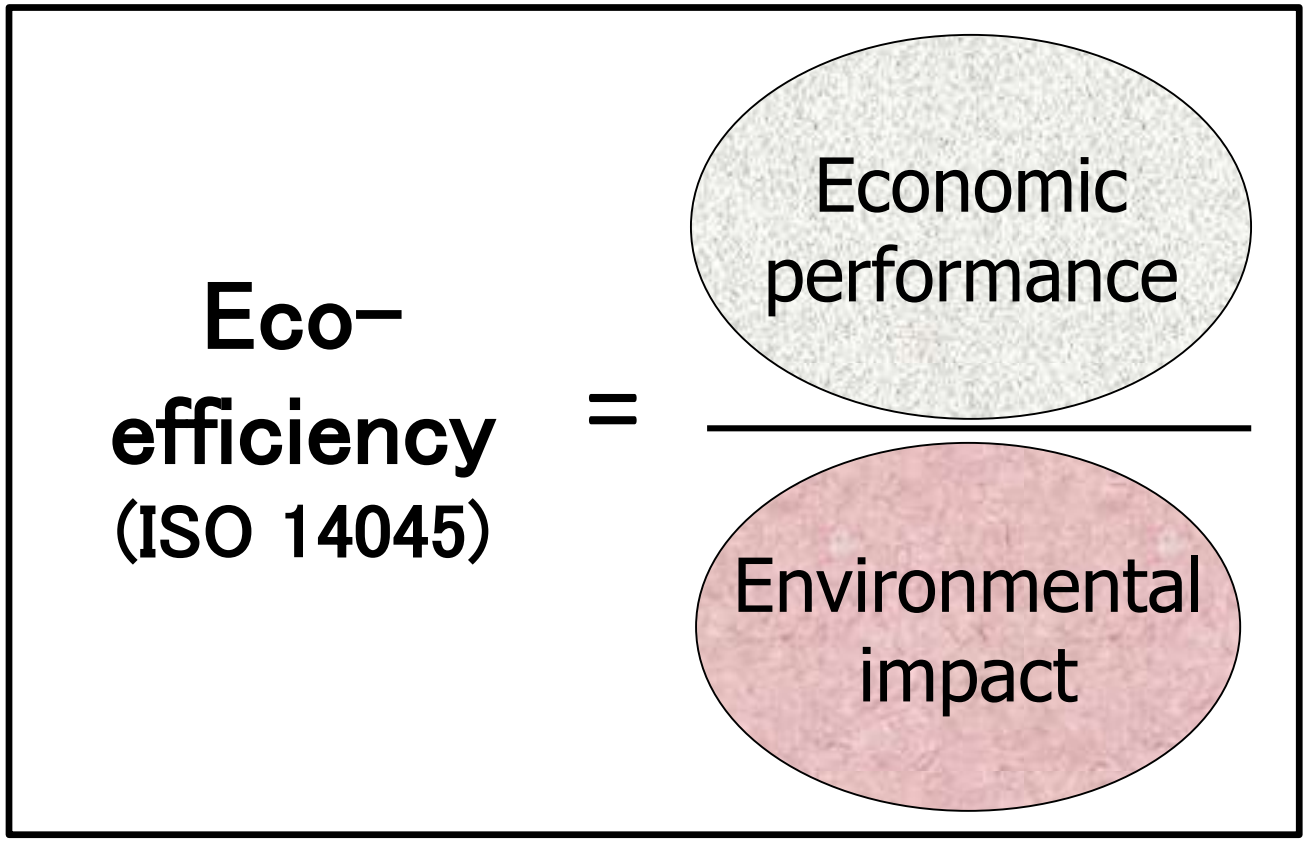


(@ current price, 2013)

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*



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

Resource use, Env. Impact (CO2,…)

Indicator

Factor X = Eco-Eff.$_A$/Eco.Eff.$_{ปีฐาน}$

Factor 4 → SD

SROI (Social Return on Investment)

* 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)

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

Tool to measure-improve performance of organization

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

zz.z

National level

GDP / Annual External Cost $_{\text{Thailand}}$

Sector level

Ex. State Enterprises, Eco-Factory, Green Hotel

yy.y

Organization level

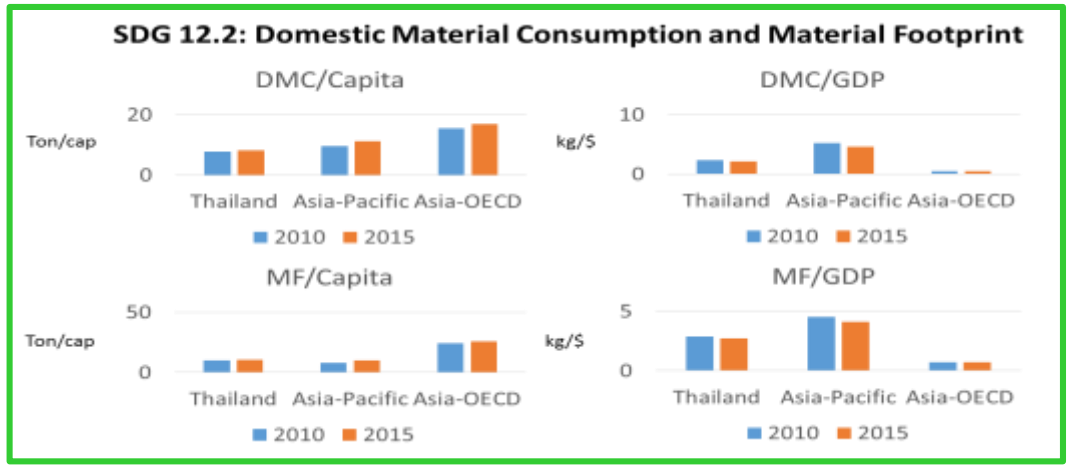
Value added / Annual External Cost $_{\text{Company}}$

xx.x

Ex. Green Label Scheme

Product/ service level

Value added / External Cost $_{\text{product}}$



Adated from: Norihiro Itsubo (AIST, Japan)

Summary: Green Technologies in Thailand

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.

SUMMARY

2°C THAILAND AGENDA –รับวิกฤติโลกร้อน–

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

1

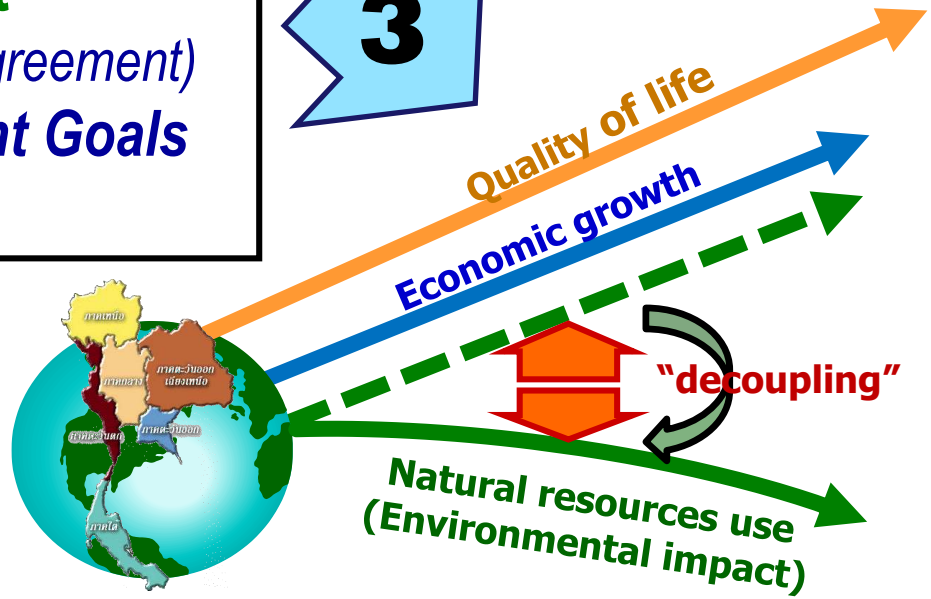
"Green Technologies" (with LCT):
help support **National target &**
Global commitment

1. ***GHGs reduction*** *(Paris Agreement)*
2. ***Sustainable Development Goals***
3. ***Decoupling***

2

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

3



4

4. Can be scaled-up & open for partnership!

Thailand → ASEAN → Asia Pacific