Asian Institute of Technology

Implications of carbon tax and energy efficiency improvement on Thai economy: Application of AIM/CGE

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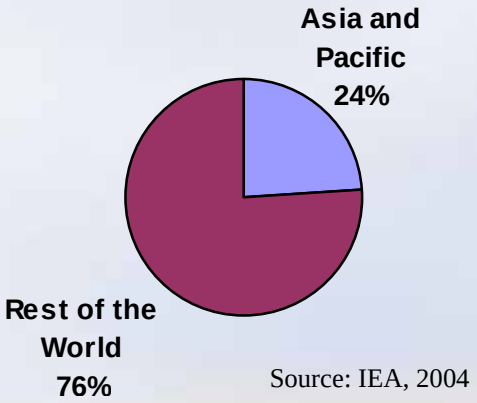
AIM based Integrated Assessment Model Development and Applications at AIT

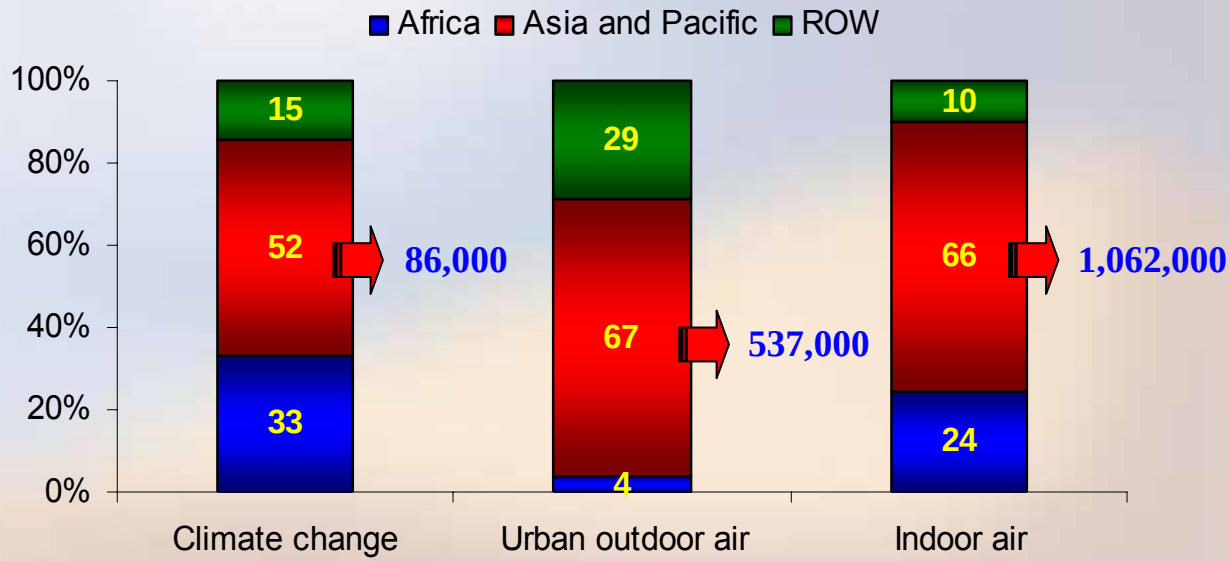
Air Pollution and Mortality

CO_2 emissions from fuel combustion, 2000



Source: IEA, 2004

Excess deaths due to selected environmental risks in 2000 (%)



Source: WHO, 2004

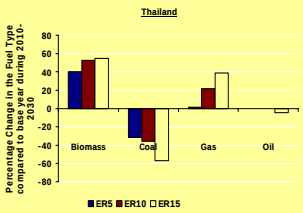
In developing countries of Asia, GHG and other local pollutant emissions are expected to increase at relatively higher rate than in industrialized countries over the next decade or so.

Integrated Assessment Framework

AIM/Bottom-up
A bottom-up technology

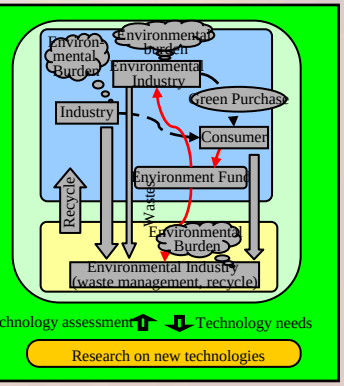
AIM/Top-down
A general-equilibrium-type world economic model

AIM/Enduse
A bottom-up technology selection model of energy use and emissions at country and local level

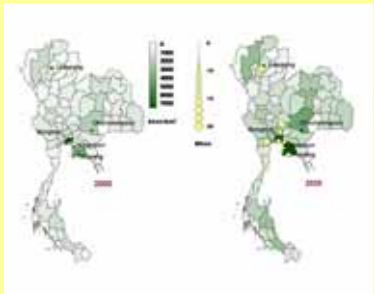


Integrated Assessment

AIM/CGE
A environment-economy integrated country model



AIM/Local
Spatial bottom-up Technology model



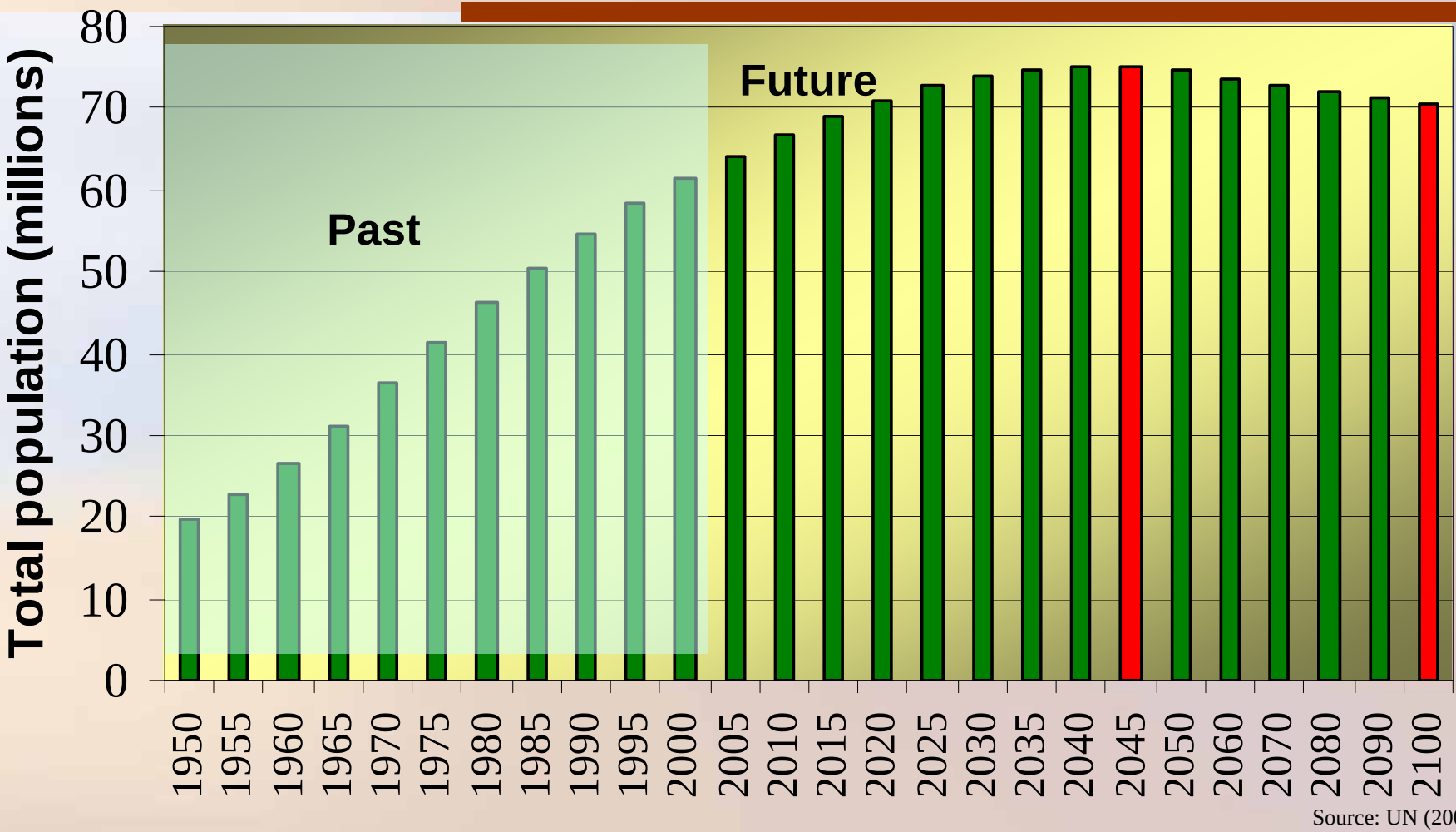
AIM/Air
Assessment of city specific air quality

Integrated Assessment Modeling Activities on Thailand and Other Asian Countries at AIT

Type of Model	Country	Issues analyzed
I. AIM/Enduse	Indonesia Sri Lanka Thailand Vietnam	***Common (all countries):*** Fuel-mix and technology-mix for projected service demands in future years Estimation of CO_2, NO_X and SO_2 Emissions associated with the energy use Implications of applying CO_2 and SO_2 emission reduction targets ***Country specific:*** Energy, environmental and cost implications of limitations on natural gas availability in Thailand Energy and environmental implications of biomass energy use for cooking and electricity in Sri Lanka Implications of applying carbon tax and sulfur tax in Thailand
II. AIM/Local	Thailand Vietnam	Carbon tax and sulfur tax on energy systems CO_2 and SO_2 emission reduction targets
III. AIM/CGE	Thailand	Implications of C-tax on Thai economy (Preliminary)

Selected AIM based Models Applications Specific to Thailand (AIM/Enduse and AIM/Local)

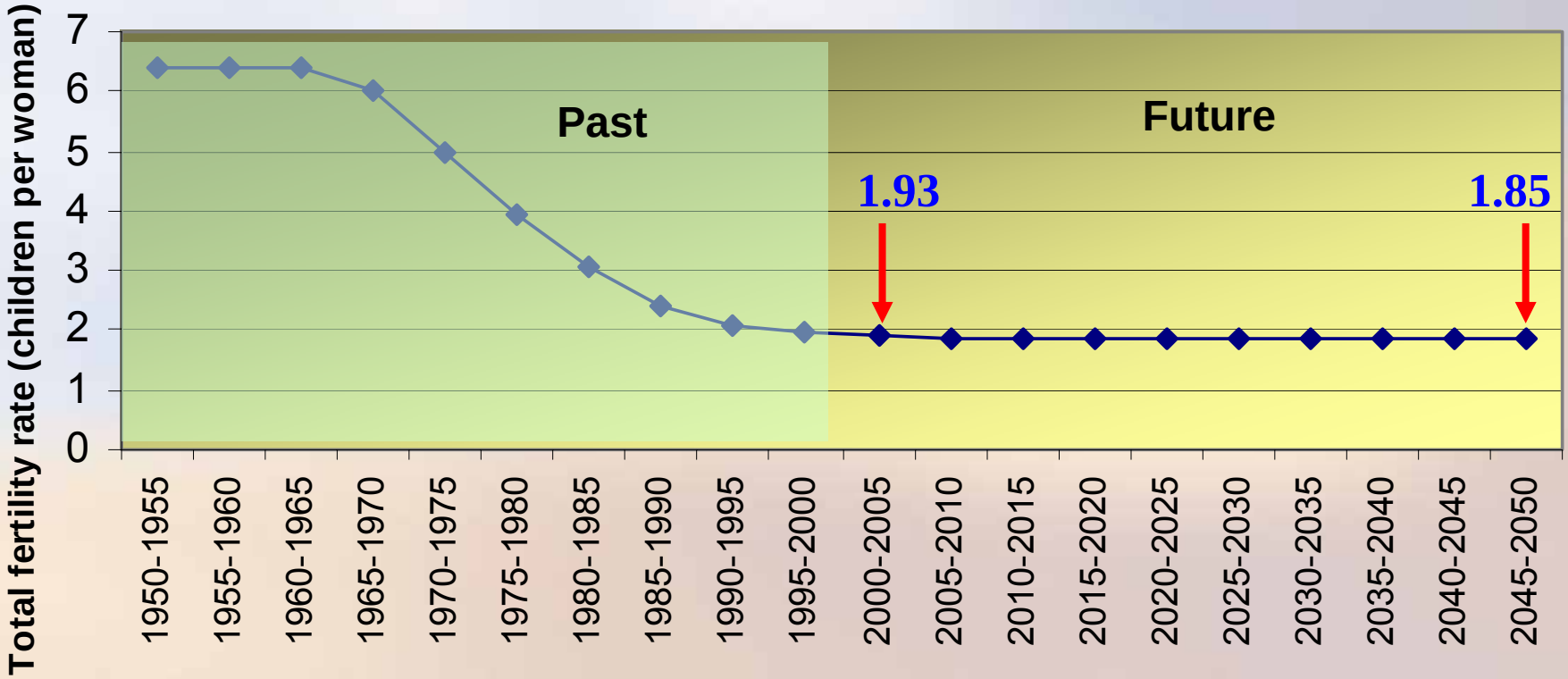
Total Population (millions)



Source: UN (2004)

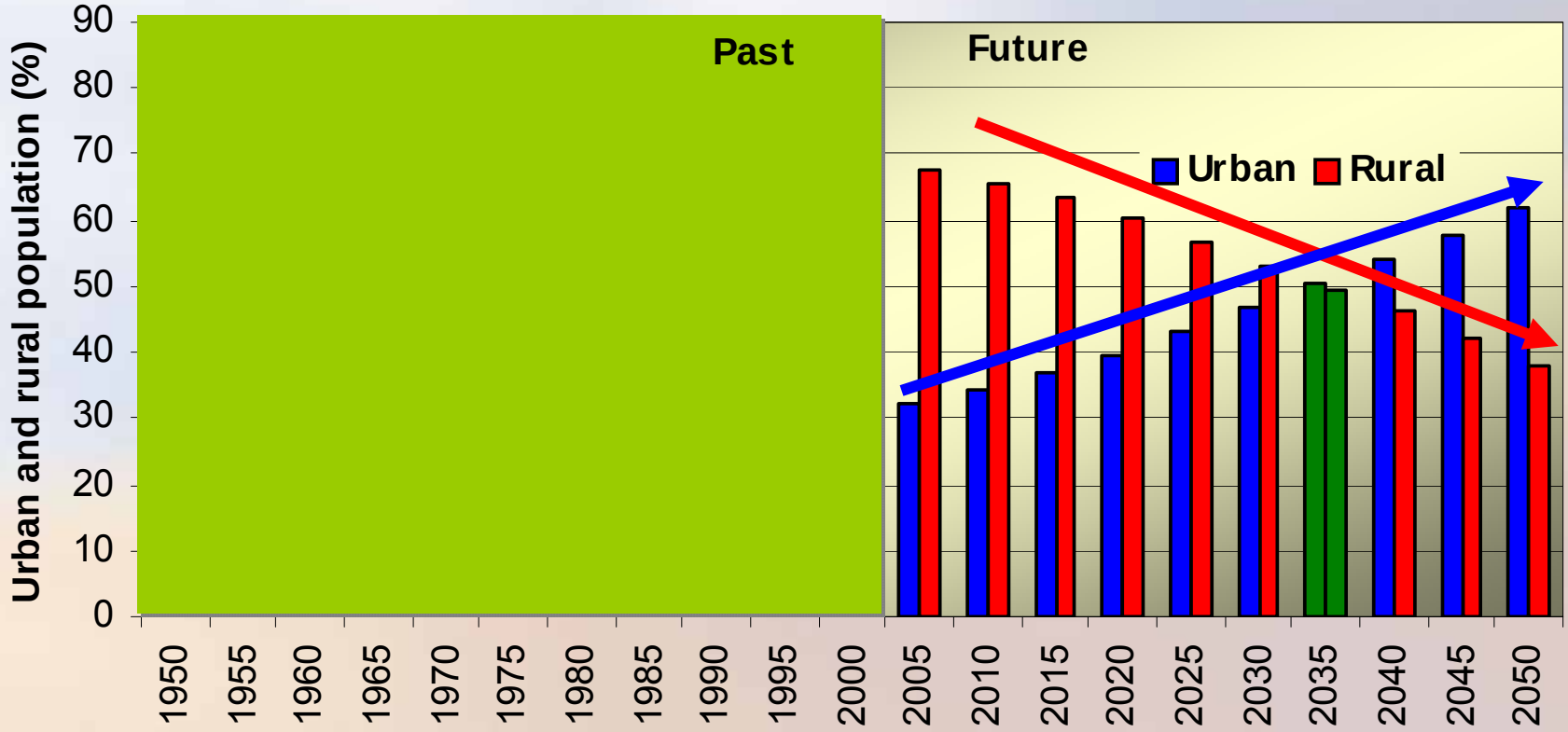
- Peak by 2045 (74.9 million) before it turns down by 4.5 million by 2100 (70.4 million)
- Three factors: Decline in total fertility rate; Negative net migration; and life expectancy improvement

Total Fertility Rate (children per woman)



- **TFR is expected to fall from 1.93 children per woman between the period of 2000-2005 to about 1.85 children per woman by the period of 2045-2050.**

Urban-Rural Population



- Urbanization rate is 31% in 2000 and it is projected to double by 2050 (62%).
- By 2035, the share of both urban and rural population reach about 50%.

Energy Strategy

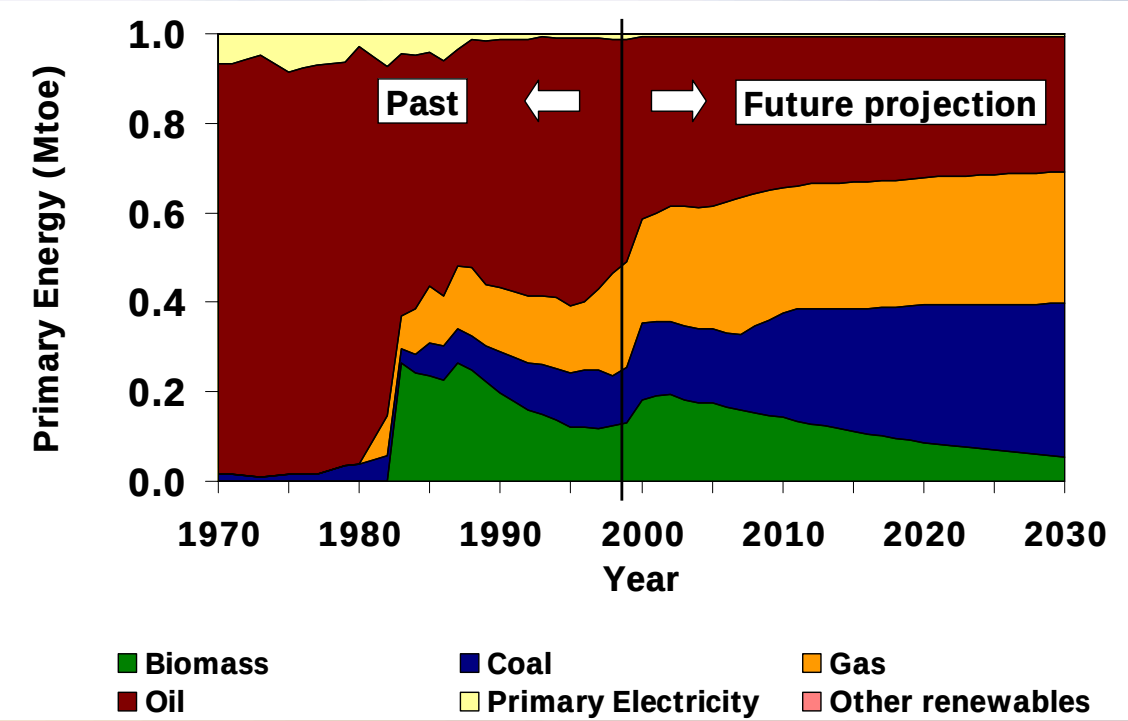
Thailand's Ministry of Energy's 5 strategies (Source: Annual Report 2003):

- Enhancing Efficiency of Energy Conservation in Transport Sector
- Enhancing Efficiency of Energy Conservation in Industrial Sector
- Enhancing National Energy Security (Reduce Energy Import Dependency)
- Enhancing Overall Capability in Energy Management and Integration
- Becoming a Regional Energy Hub

Notable actions taken/initiated:

- Establishment of Energy Conservation Promotion Act (1992): ENCON Fund
- Strategic plan for energy conservation (2002)
  - Bio-fuel Program
  - Renewable Portfolio Standards (5% by 2011)
  - Target of reducing the value of energy to GDP elasticity ratio from the current 1.4 : 1 to 1 :1

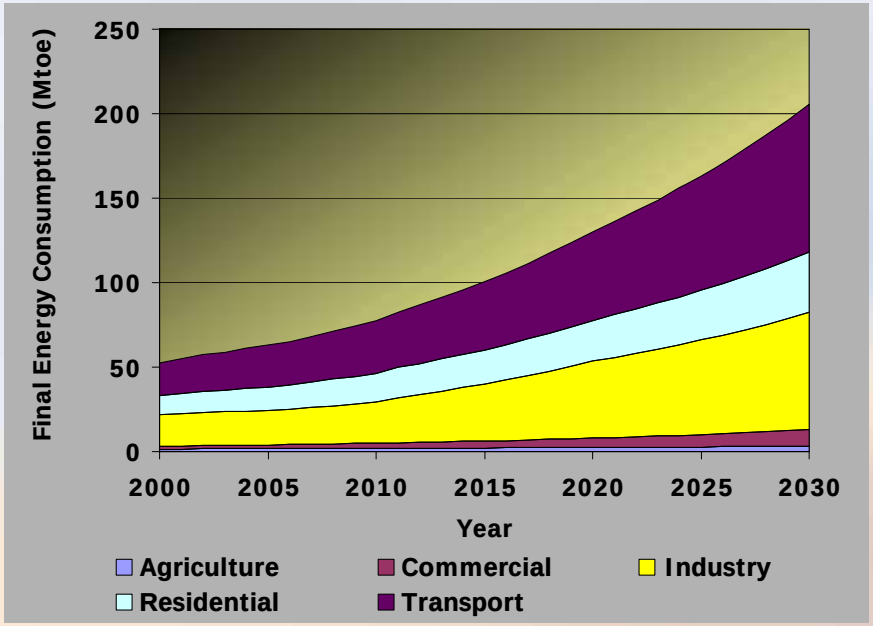
Primary Energy Mix (Based on AIM/Enduse)



From 2000 to 2030 shares of,

- Oil: ↓ 41% to 30%
- Coal: ↑ 17% to 34%
- Gas: ↑ 23% to 29%
- Biomass: ↓ 18% to 5%

Final Energy Demand



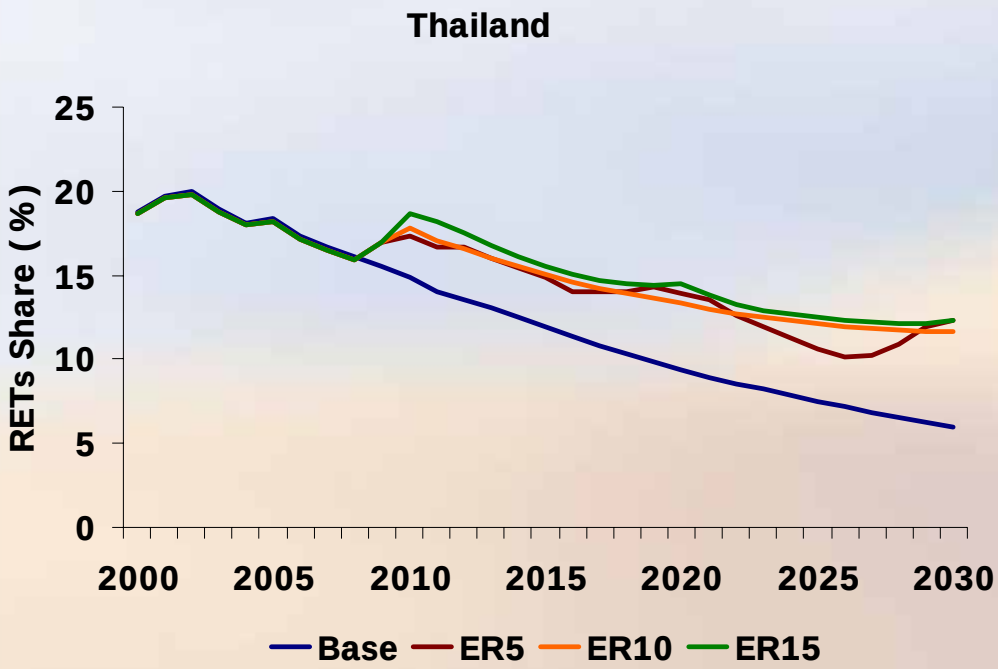
- Final energy demand:

  53 Mtoe (2000) to 206 Mtoe (2030)

- AAGR: 4.7%.

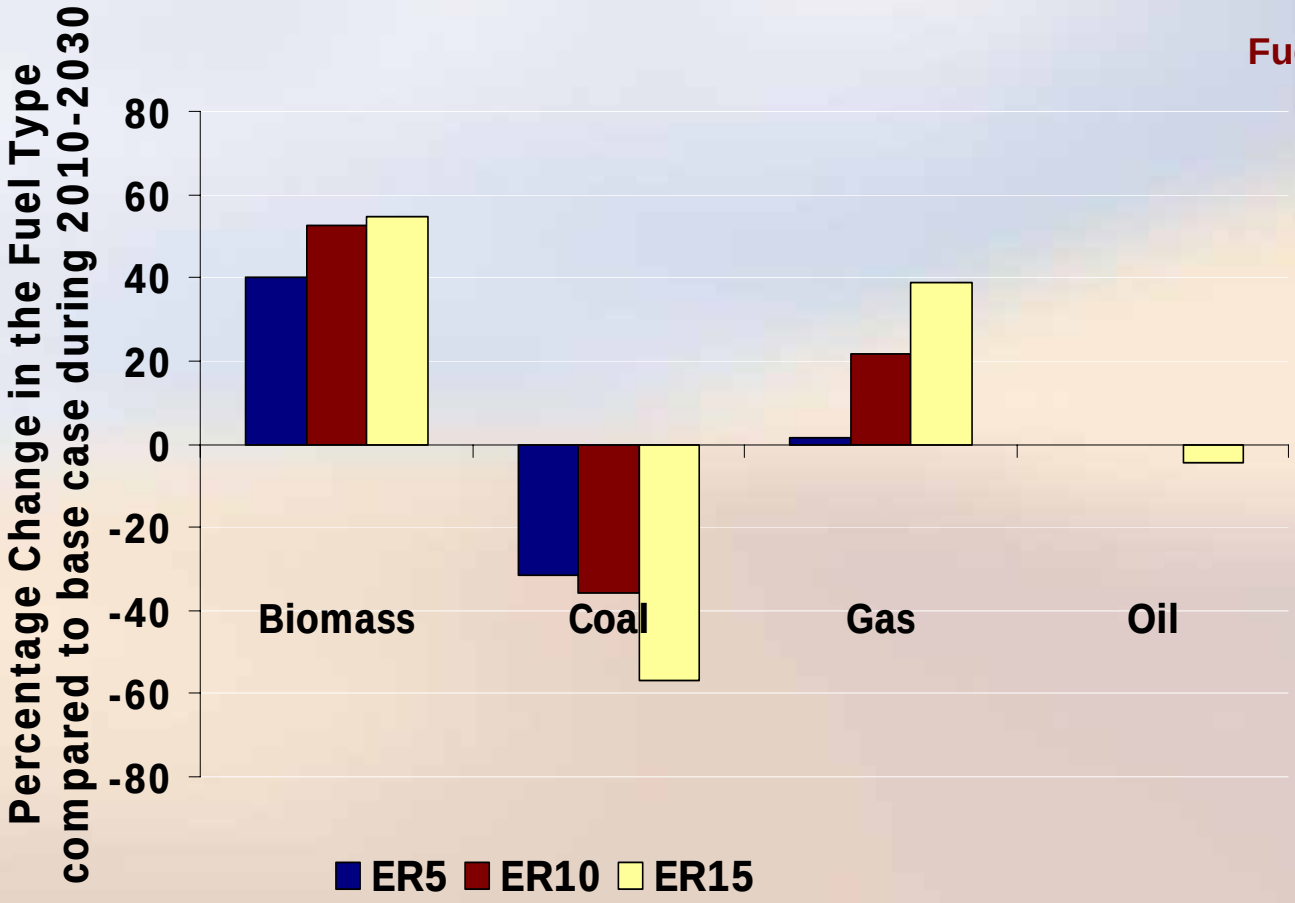
- Sectoral shares from 2000 to 2030,
  - Transport: ↑ 37% to 43%
  - Industry: ↓ 36% to 34%
  - Residential: ↓ 21% to 18%
  - Others: *small*

Role of Renewable Energy Technologies under CO_2 Emission Reduction Targets in Thailand



- In base case, the share of Renewable Energy Technologies (RETs) will reduce from 20% in 2000 to 6% in 2030.
- In 2030, the RETS share increases from 6% in base case to 12% in ER cases
- The RETs share reduces over time due to limitation of availability in agricultural residue to meet the increasing energy demand.
- Plantation based biomass is used in ER cases

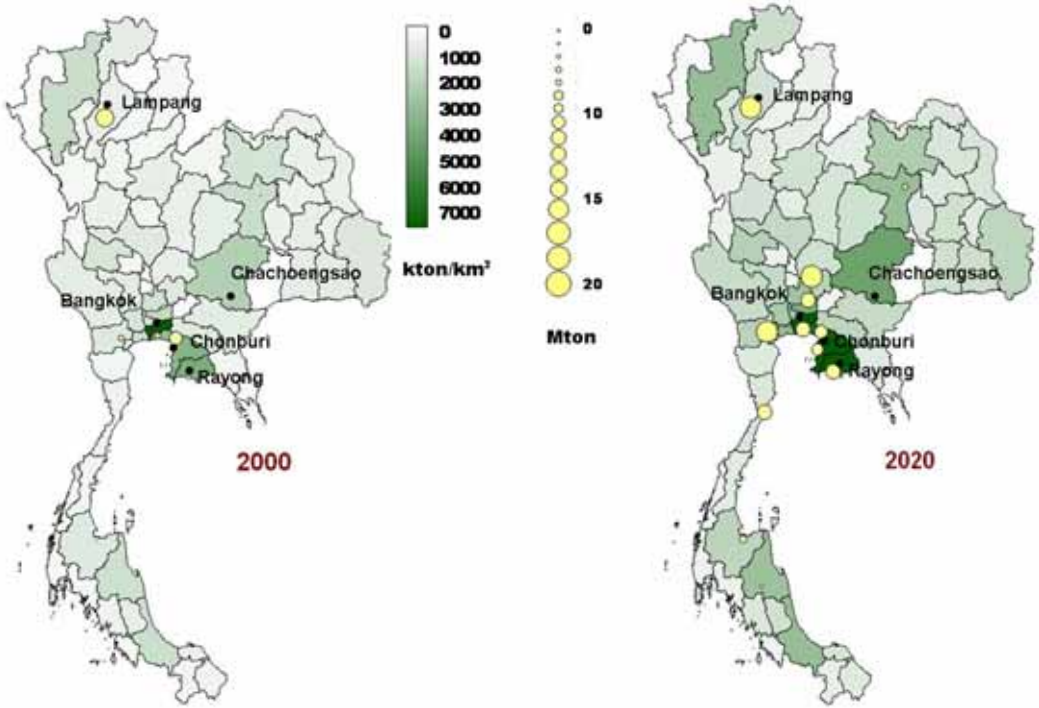
Changes in Primary Energy Supply Structure due to CO_2 Emission Reduction Targets in Thailand



Fuel substitution under ER targets:

Shift from coal to biomass and natural gas

Spatial distribution of CO_2 emissions in 2000 and 2020 (based on AIM/Local: Reference Case)



- **In 2020**

  LPS > 18 million ton,

  Lampang (Northern Thailand)

  Saraburi (Central Thailand)

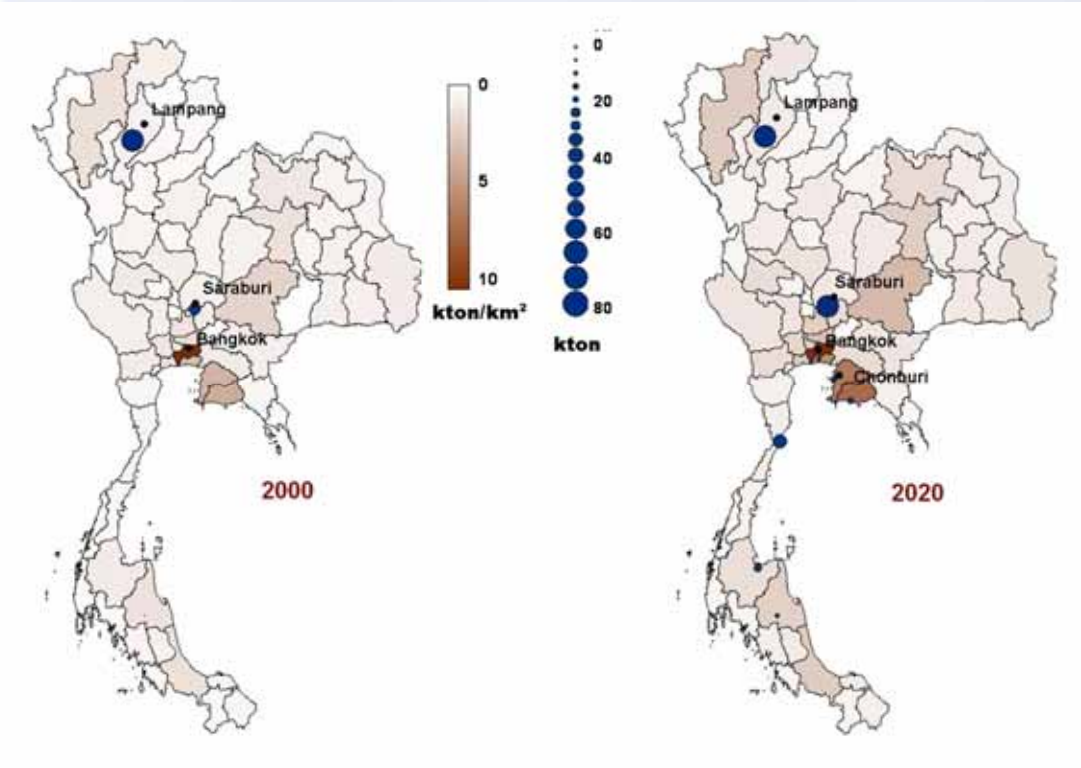
  Area sources > 6000 kton/km^2

  Bangkok

  Rayong (Eastern Thailand)

  Chonburi (Eastern Thailand)

Spatial distribution of SO_2 emissions in 2000 and 2020 (based on AIM/Local)



- **In 2020**

  LPS > 70 kilo ton,

  Lampang (Northern Thailand)

  Saraburi (Central Thailand)

  Area sources > 7 kton/km^2

  Bangkok

  Samut prakan (Central Thailand)

  Rayong (Eastern Thailand)

  Chonburi (Eastern Thailand)

AIM Based Models Application Workshop at AIT

Workshop on Energy System Development and Greenhouse Gas Emissions: Analyses of Selected Options in Thailand in June 2005

http://www.serd.ait.ac.th/ep/esdgge/

Application of AIM/CGE

Implications of carbon tax and energy efficiency improvement on Thai economy

- Sunil Malla and Ram M. Shrestha

Market-based instruments such as carbon tax is one of the policy options of mitigating GHG emissions because of its cost-effectiveness.

Thailand as a case study.

Presentation Outline

- Introduction
- Profile of GDP, energy and CO_2 emissions in Thailand
- Model description
- Scenario description
- Results
- Conclusions

Introduction

- Timilsina and Shrestha (2002) : CGE analysis of carbon tax in Thailand
  - Based on static CGE analysis.
- Wattanakuljarus (2004): CGE analysis of nationwide economic and environmental impacts of tourism in Thailand
  - Based on static CGE analysis specific to tourism sector.
- Chung-I Li (2004): CGE analysis of carbon tax with emphasis on local health
  - Dynamic CGE analysis with local health feedback
  - Study period: 1998 - 2010
- **In this paper:**
  - **Use of Dynamic recursive CGE approach based on AIM/CGE**
  - **No. of sectors: 27 sectors including eight energy sectors**
  - **Study period: 1998-2030 (short-term)**

Economy, energy use and CO_2 emissions in Thailand and selected countries of the world (2002)

Indicators	Thailand	Philippines	Indonesia	Japan	USA
Population (million)	62	80	212	127	288
GDP/capita (constant 1995 US$)	3,000	1,209	1,060	45,029	31,891
TPES/capita (kgoe)	1,344	526	736	4,070	7,953
CO_2 emissions (million tons)	179	70	303	1,207	5,652
CO_2 intensity (kg CO_2 per 1995 US$)	0.97	0.72	1.35	0.21	0.61
Net energy import (% of commercial energy use)*	47	53	-54	80	25

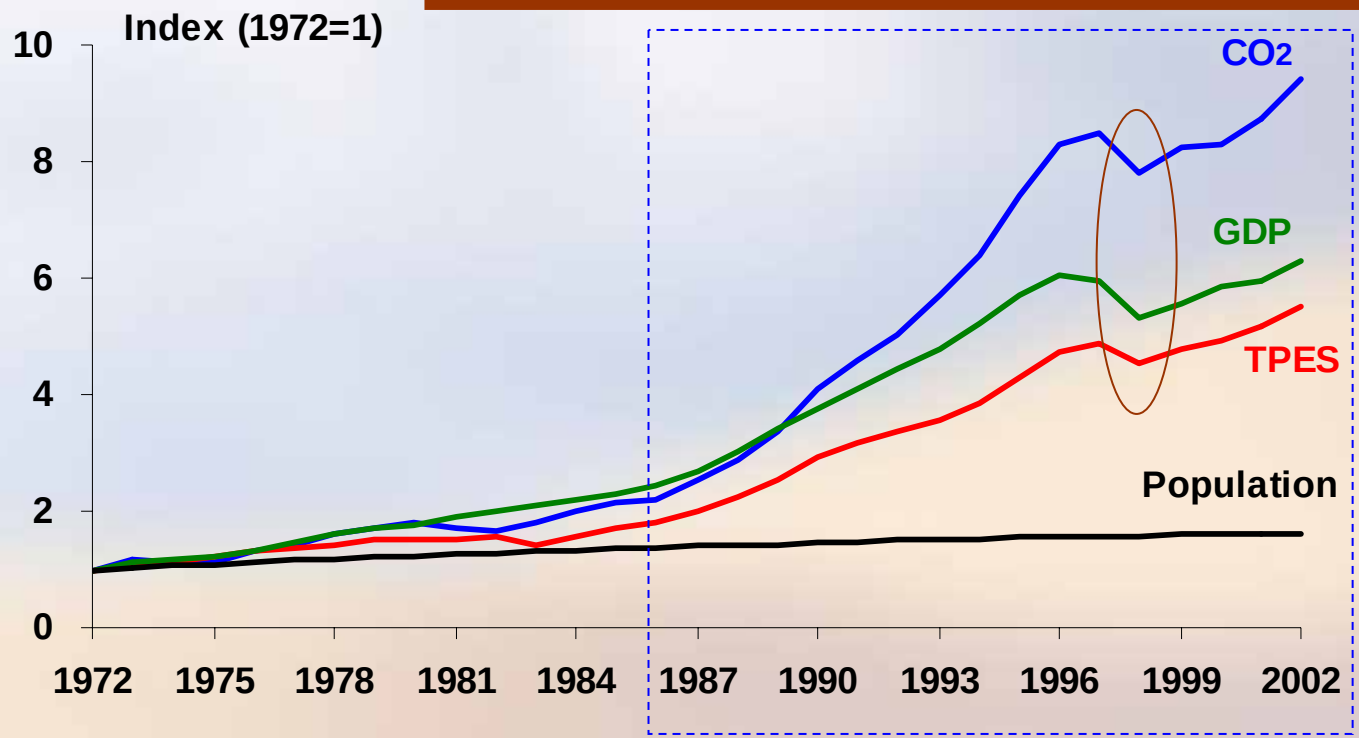
* Data for 2001

Source: WDI (2004) and IEA (2004)

In Thailand:

- **Both GDP/capita and TPES/capita are highest among the Southeast Asian economies but lower compared to industrialized nations.**
- **CO_2 emission was about 179 million tons in 2002.**
- **CO_2 emissions intensity is much higher compared to most of the industrialized nations.**
- **Net energy import is quite high and increasing over the past two decades (33% in 1985 to 47% in 2001). In 2004, about 13.5 billion US$ was spent on oil import alone.**

Historical trends of GDP, energy use and CO_2 emissions in Thailand (1972-2002)



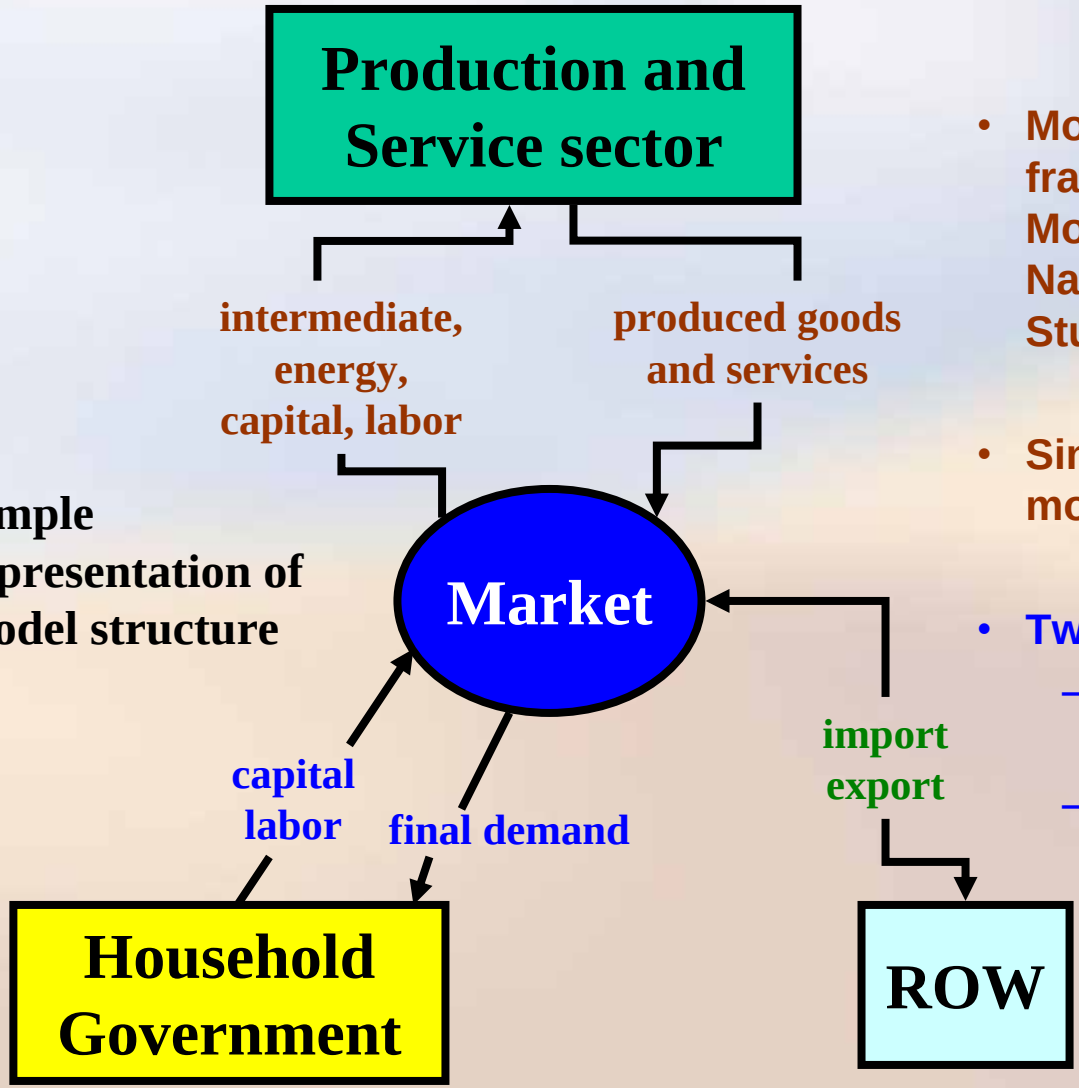
AAGR (1972-2002):

- CO_2 emission: 7.8 %
- GDP: 6.3 %
- TPES: 5.9%
- Population: 1.5%

- CO_2 emission from energy use accounted for more than 70% of the total CO_2 emissions in 2002.
- Per capita CO_2 emission increased by about 6 times over 1972 - 2002 period.

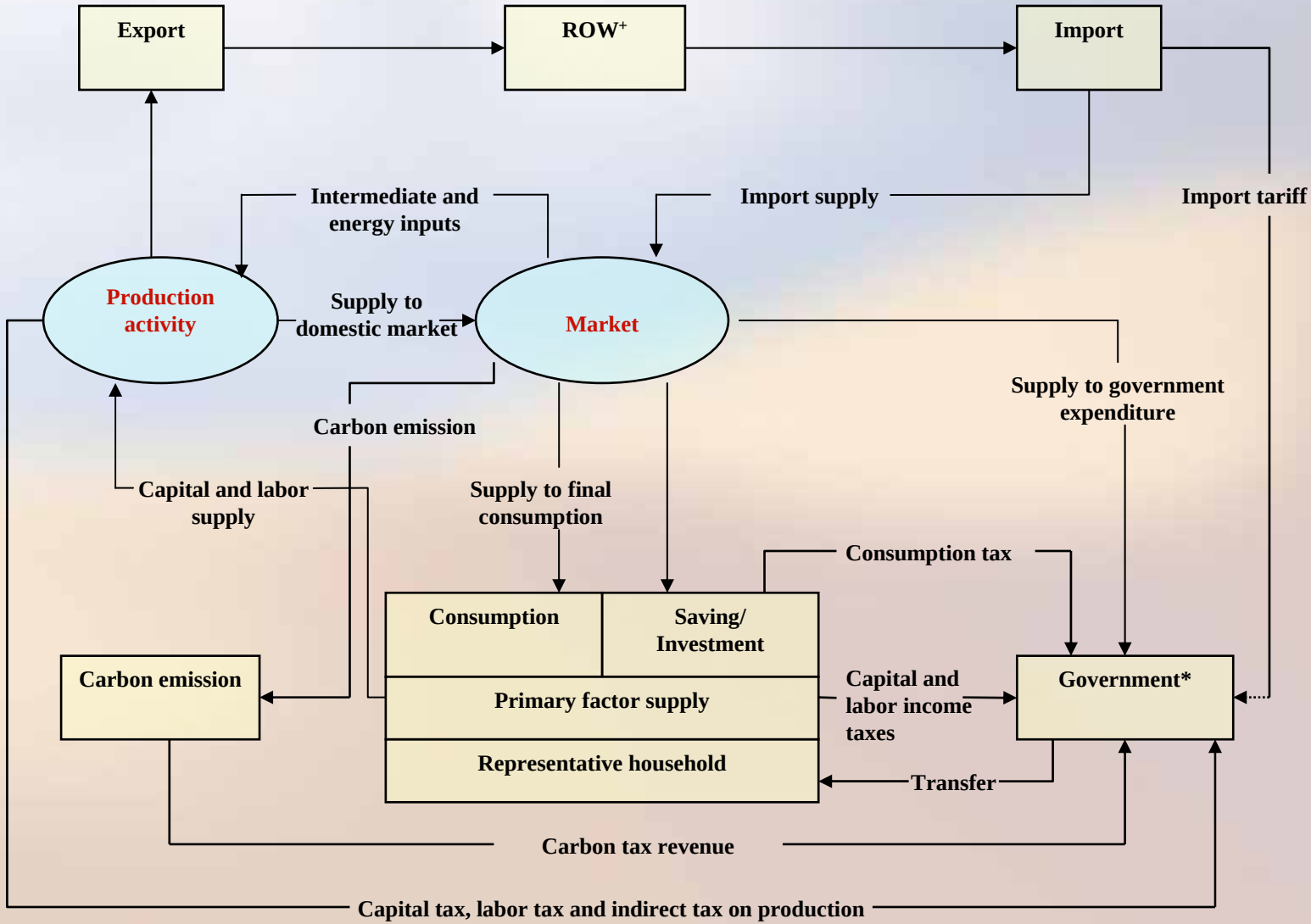
Model Description

Simple representation of model structure



- Model used in this study follows the framework of Asia Pacific Integrated Model (AIM)/CGE model developed by National Institute for Environmental Studies (NIES), Japan.
- Single country dynamic recursive model
- Two specifications are defined:
  - Within-period specification (static part of the model)
  - Between-period specification (dynamic part of the model)

THAI ECONOMY
Flow of goods, factors and taxes in the model



Model assumptions

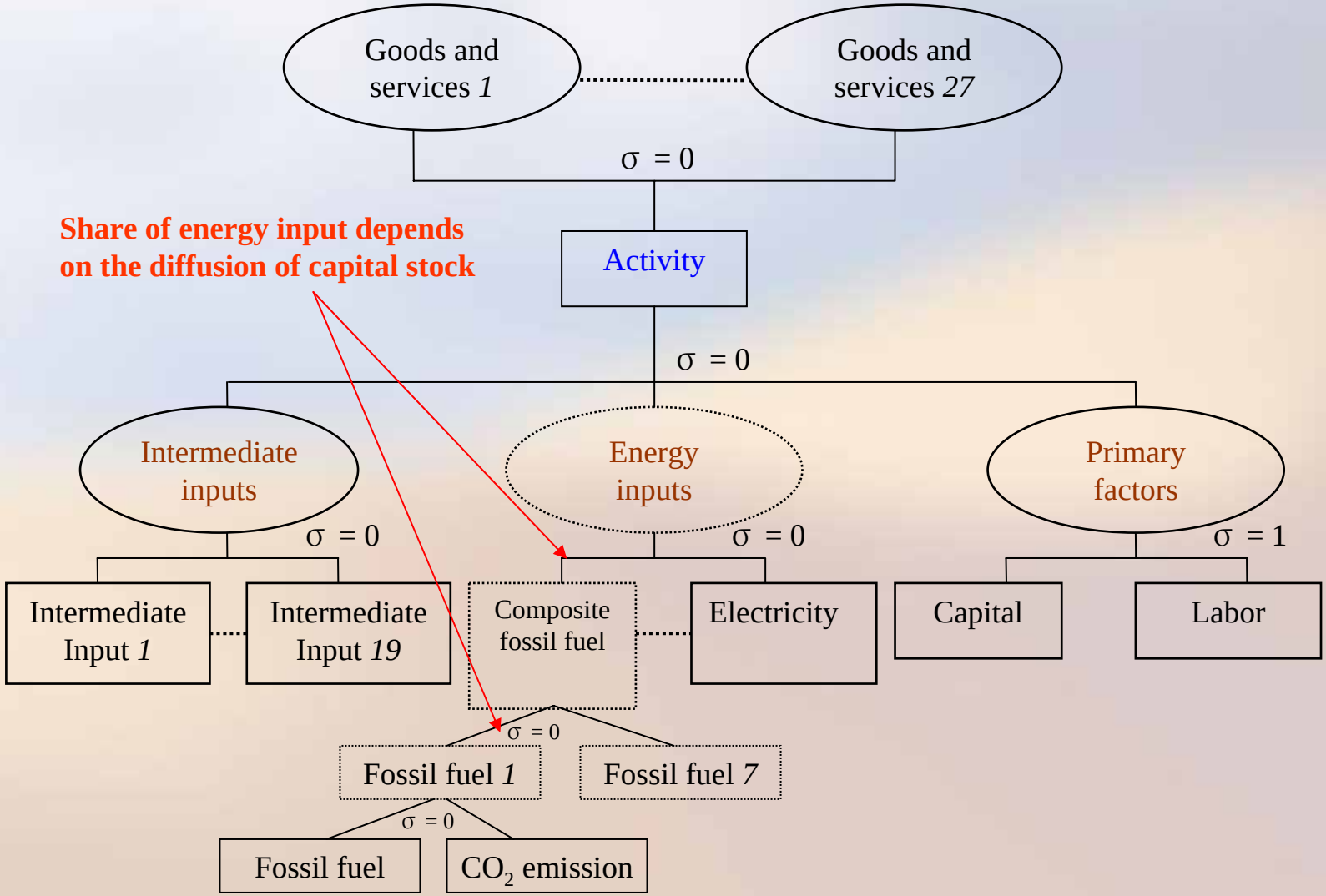
Within period specification:

- Elasticity of substitution (σ) between import and domestic is assumed zero for non-energy goods and infinity for energy goods.
- σ between export and domestic is infinity.
- Investment is calculated exogenously.
- Capital is assumed to be immobile across the sectors while labor is assume to be perfectly mobile across the sectors.

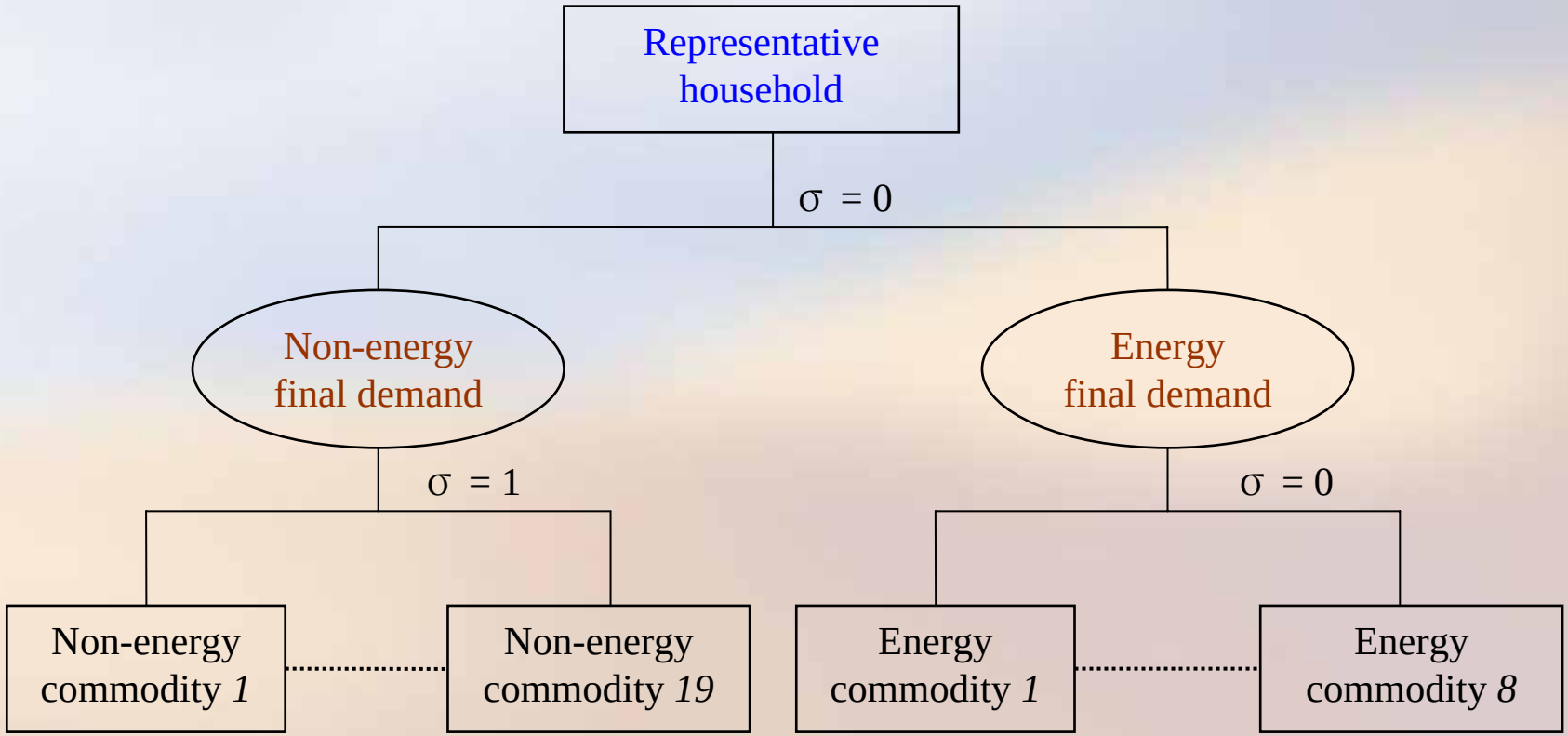
Between period specification:

- Capital stock in each sector is estimated from investment.
- Investment to each sector is distributed by the expected capital income in each sector.
- Efficiency change (energy efficiency and labor productivity) is given in new investment.

THAI ECONOMY (Production structure)



THAI ECONOMY: (Consumption structure)



Sectors/commodities in Thailand

27 Sectors/commodities with 8 energy sectors

1	Agriculture, livestock, forestry, fishery	23	Construction
4	Other non-energy mining	24	Trade
5	Food, beverage and tobacco	25	Hotels & Restaurants
6	Textile, leather, and the products	26	Transport & Communications
7	Timber and wooden products	27	Services
8	Pulp, paper and printing		8 Energy sectors
9	Chemical products	2	Coal and lignite
14	Plastic and rubber products	3	Crude oil
15	Non-metallic mineral products	10	Gasoline
16	Metal products	11	Diesel
17	Machinery	12	Aviation fuel
18	Transport equipment	13	Fuel oil
19	Other manufacturing products	20	Electricity
22	Water	21	Gas distribution

- Original 1998 SAM has 61X61 sectors [obtained from International Food Policy Research Institute (IFPRI)]
- Based on modified SAM (i.e., 27x27 sectors), U-, V- and capital formation- matrices are prepared .

Base case and Alternative Policy Scenarios

(Benchmark year: 1998 and Study period: 1998-2030)

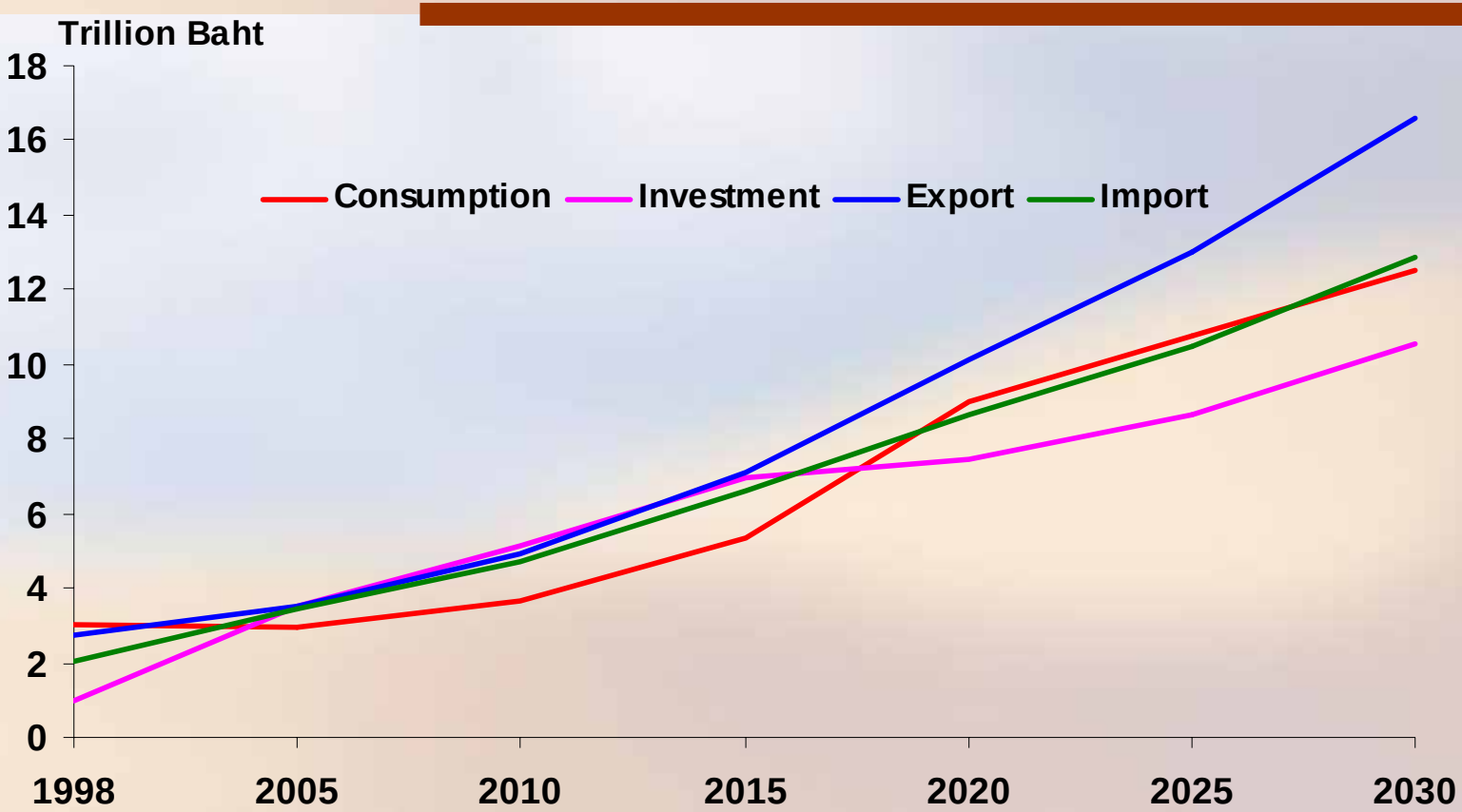
Base case	❖ No carbon tax ❖ Same commodity-, import-, capital-, and labor- tax rates of 1998 throughout the simulation period ❖ Depreciation of capital stock is 5% ❖ Differentiated labor productivity improvement
Carbon tax case (from 2008 onwards)	❖ Base case Plus ❖ Carbon tax (4 different tax rates: CT5, CT150, CT100 and CT200) (CT5 is carbon tax of US$ 5 per ton of carbon)
Energy efficiency case	❖ Base case Plus ❖ Average energy efficiency improvement (three cases: 0.5%, 0.75% and 1.0% per year)

Results

Base case

Changes in components of GDP (1998-2030)

Base case



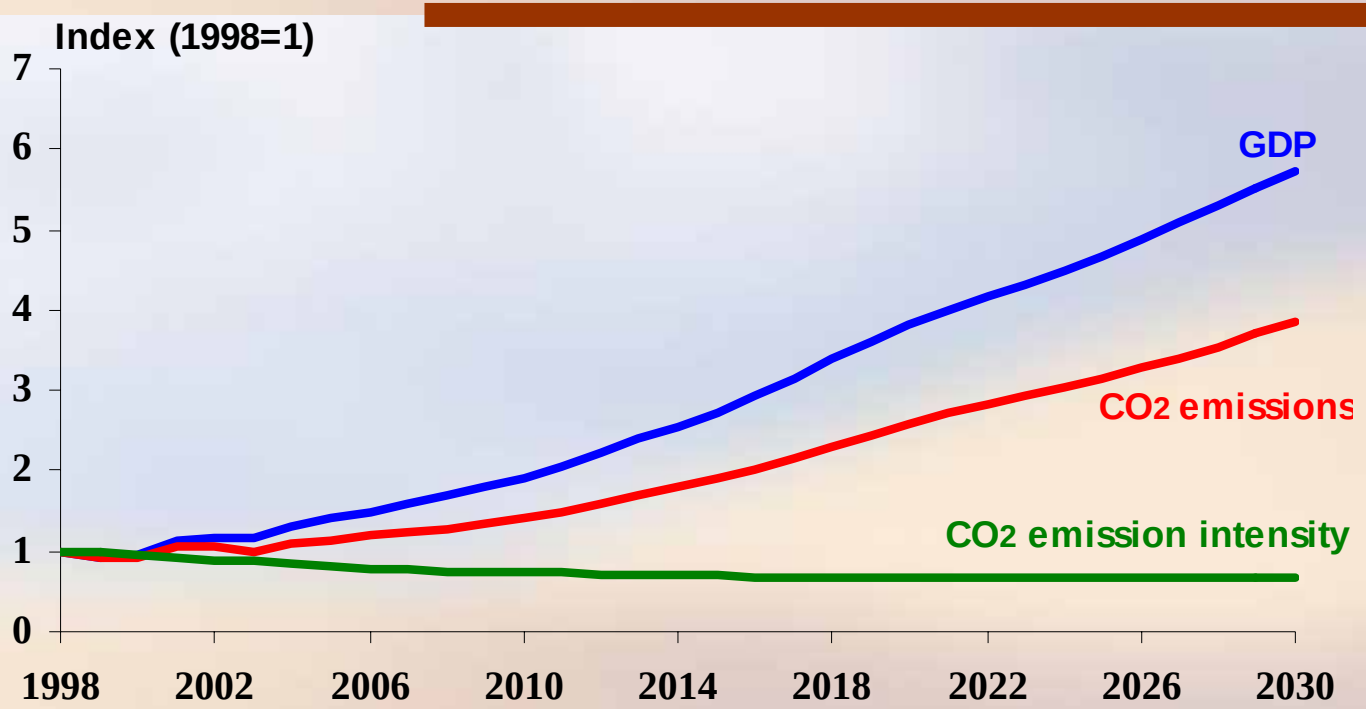
By 2030:

Consumption: ↑ 4 folds
Investment: ↑ 11 folds
Export and Import: ↑ about 6 folds

Share in GDP(%)	1998	2030
Consumption:	64	46
Investment:	21	39
Net export:	15	15

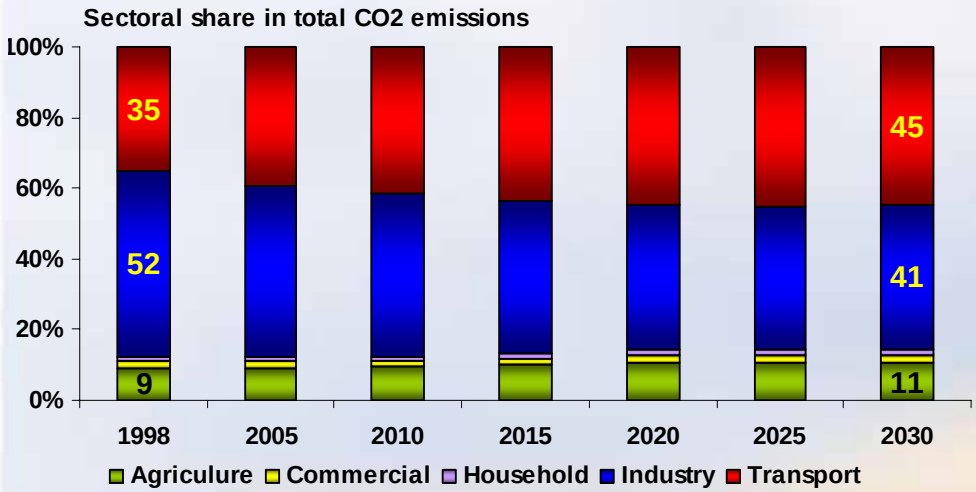
GDP, CO_2 emissions and carbon intensity (1998=1)

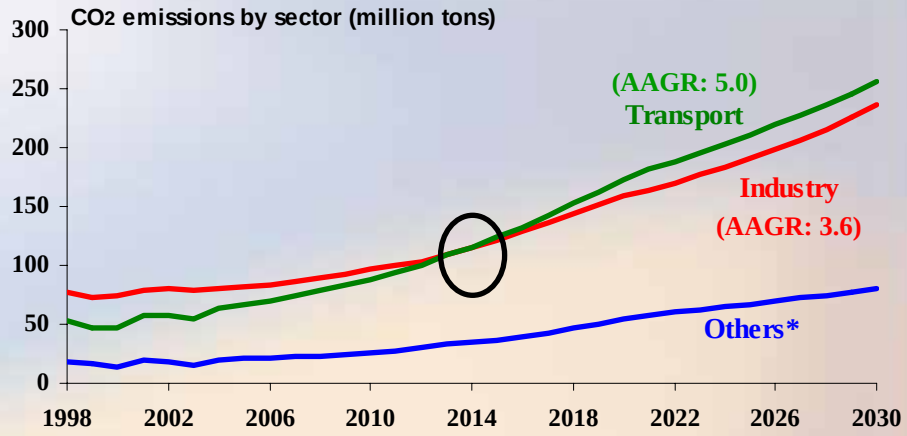
Base case



- Total GDP is expected to increase by about six folds by 2030 (671 billion US$).
- Total CO_2 emissions is expected to increase by about 4 folds in 2030 (573 million tons).
- Increase in GDP is much larger compared to increase in CO_2 emissions, hence a decline in overall carbon intensity. This is mainly due to structural change (from energy-intensive sectors to non energy-intensive sectors) and labor productivity improvement in Thai economy.

Sectoral CO_2 emissions
Base case





* Others include agriculture, household and commercial sectors

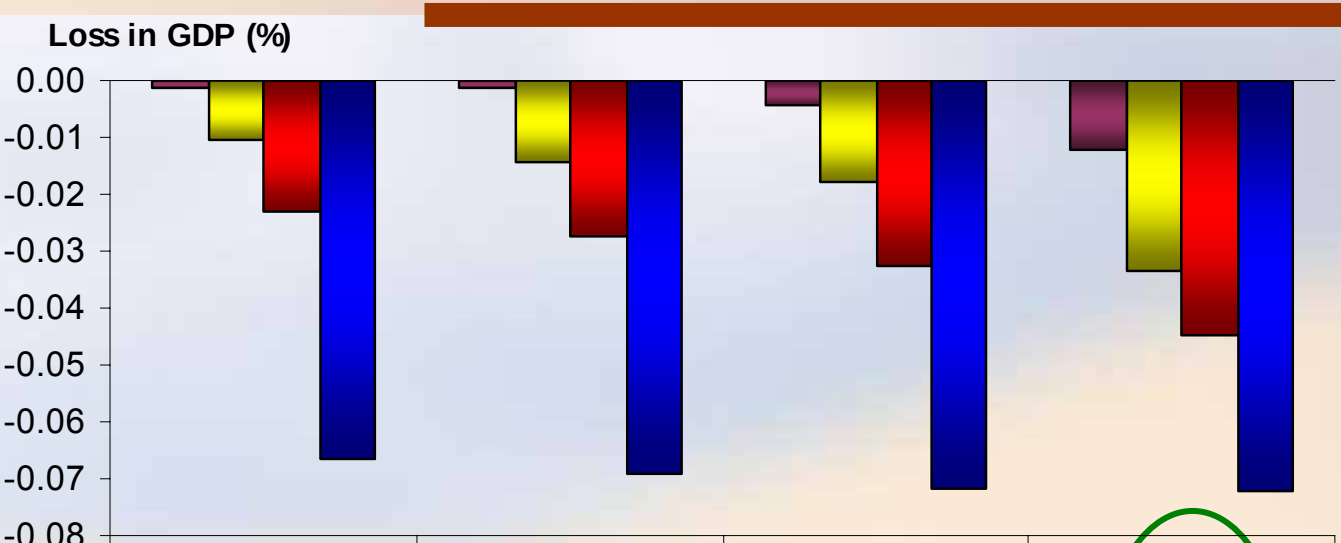
- Industry and transport sectors combined would contribute about 87% of total CO_2 emissions (498 million tons) in 2030 compared to 86% (128 million tons) in 1998.
- Although 41% of total CO_2 emissions (235 million tons) comes from industry in 2030, the sector's share in total CO_2 emissions would decrease over time while the share of transport sector would increase (35% in 1998 to 45% in 2030).

Results

Carbon tax case

Loss in GDP compared to base case (%)

Carbon tax case

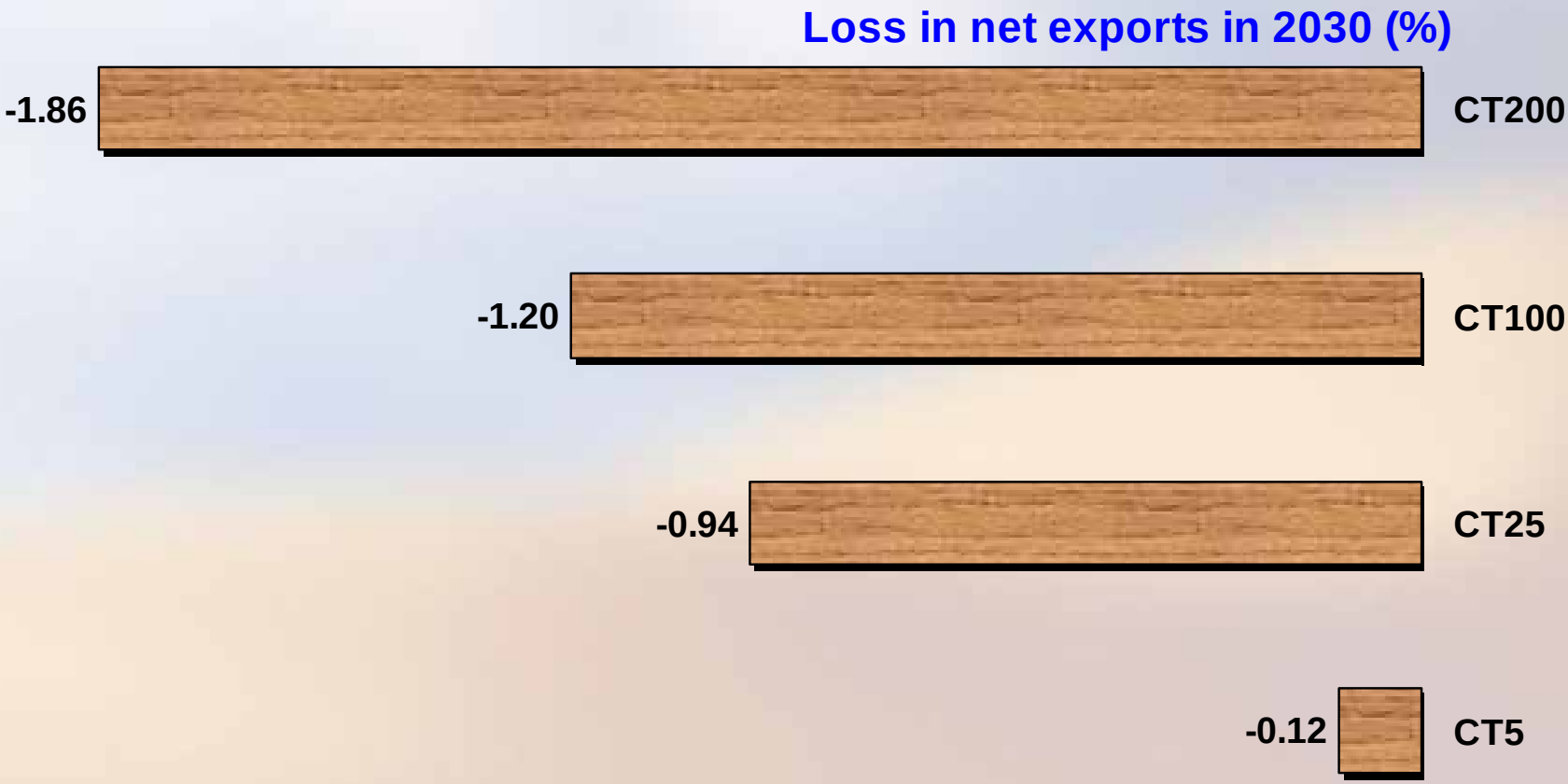


	2015	2020	2025	2030
CT5	-0.001	-0.002	-0.005	-0.012
CT50	-0.011	-0.014	-0.018	-0.033
CT100	-0.023	-0.027	-0.033	-0.045
CT200	-0.067	-0.069	-0.072	-0.072

- GDP loss due to carbon tax would vary from 0.012% (8 billion US$) at CT5 to 0.072% (48.5 billion US$) at CT200 in 2030.
- The loss is mainly due to increased cost of energy inputs in the production process resulting in decreased output.

Loss in net exports compared to base case (%)

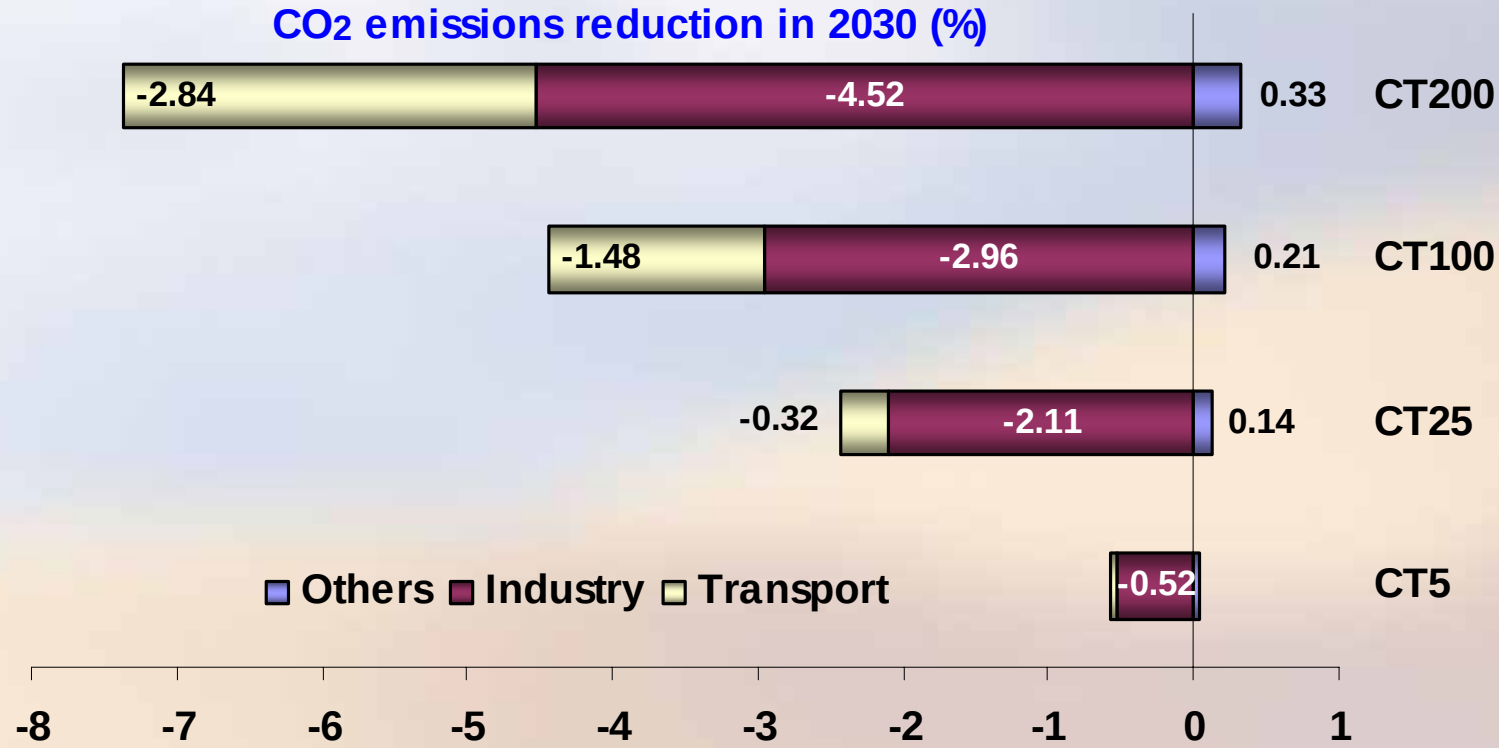
Carbon tax case



- By 2030, the net exports loss would range from 0.12% (0.1 billion US$) with CT5 to about 1.9% (1.7 billion US$) with CT200.

Reduction in sectoral CO_2 emissions compared to base case (%)

Carbon tax case

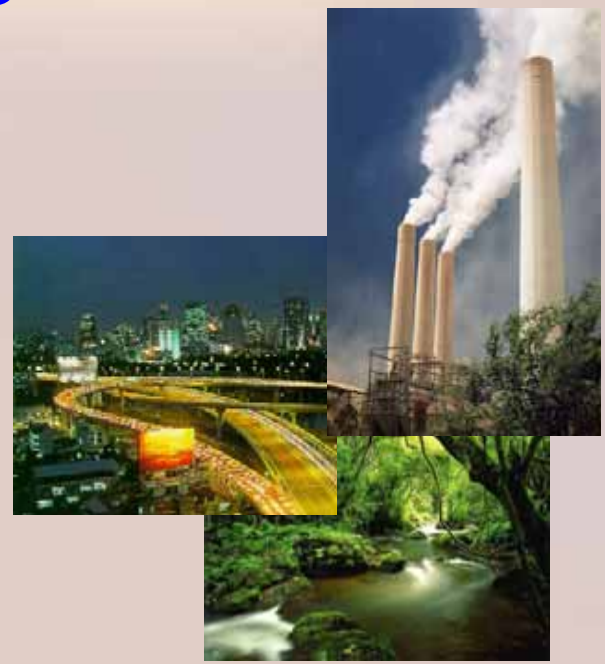


- Within industry sector, the range of CO_2 emission reduction varies from about 0.5% (3 million tons) with CT5 to 4.5% (26 million tons) with CT200.

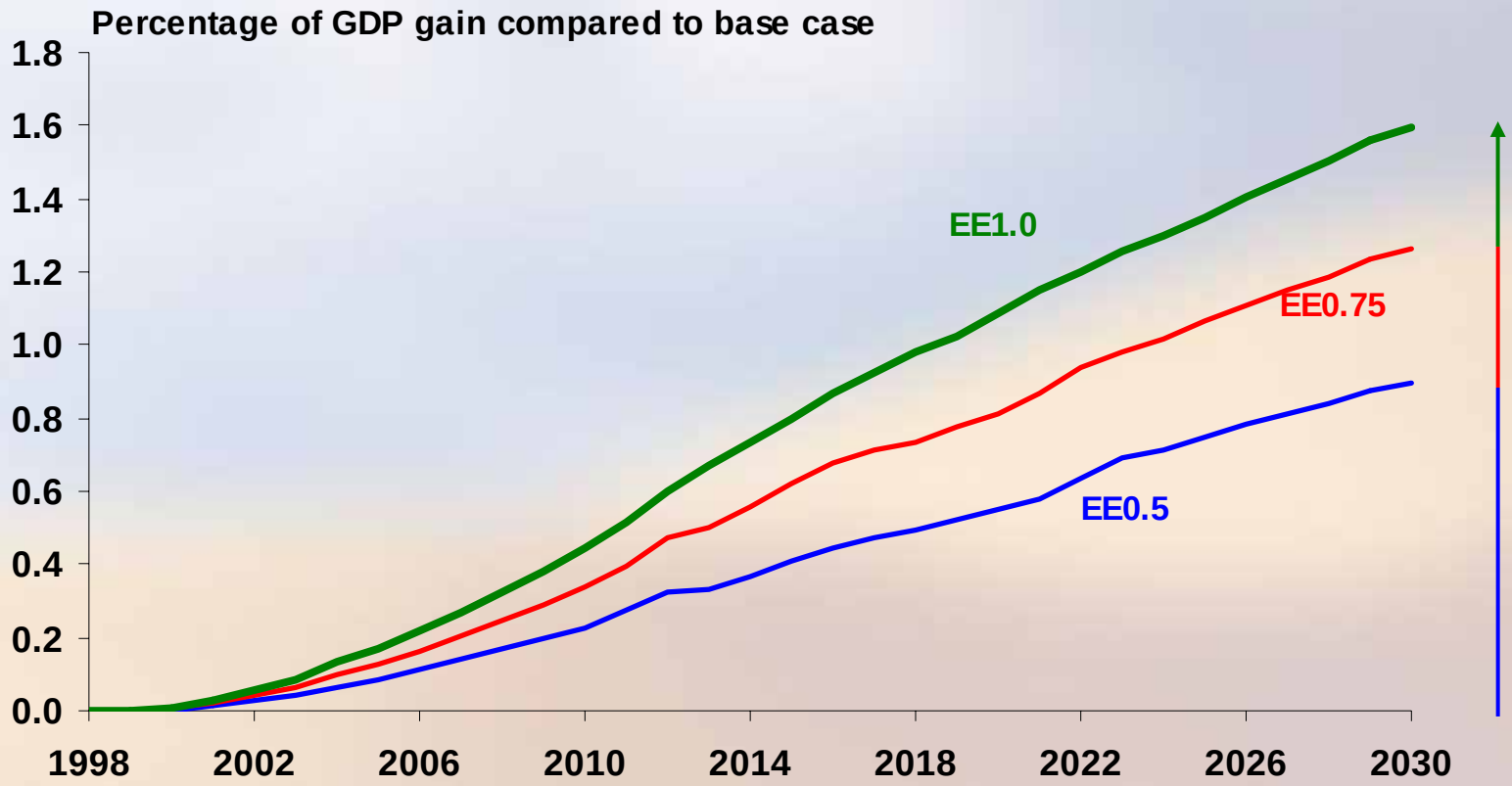
- Reduction in CO_2 emissions mainly comes from fuel switching (coal to oil and gas) and reduction in energy consumption in the industry sector through structure change.

Results

Energy efficiency case

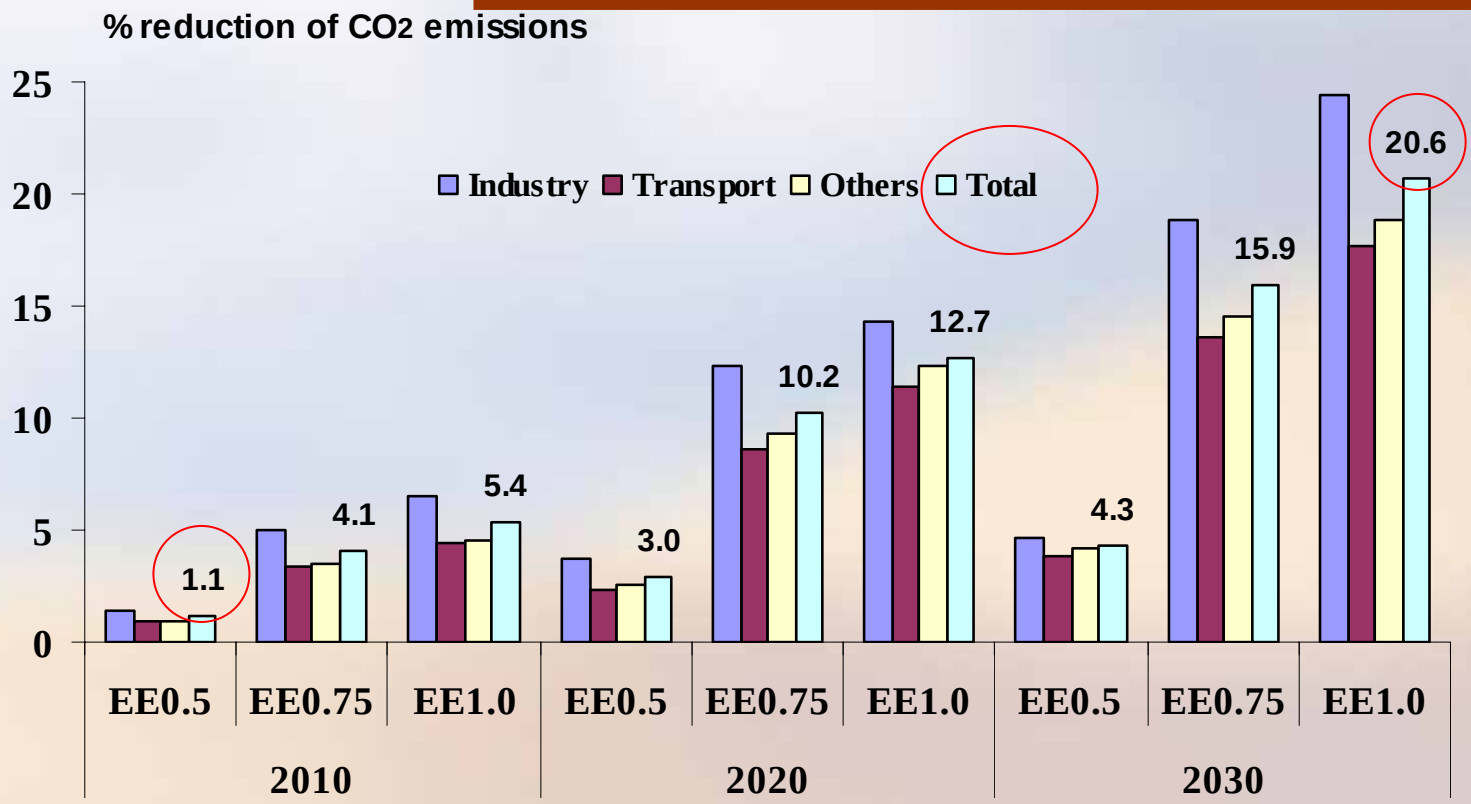


GDP gain compared to base case (%)
Energy efficiency case



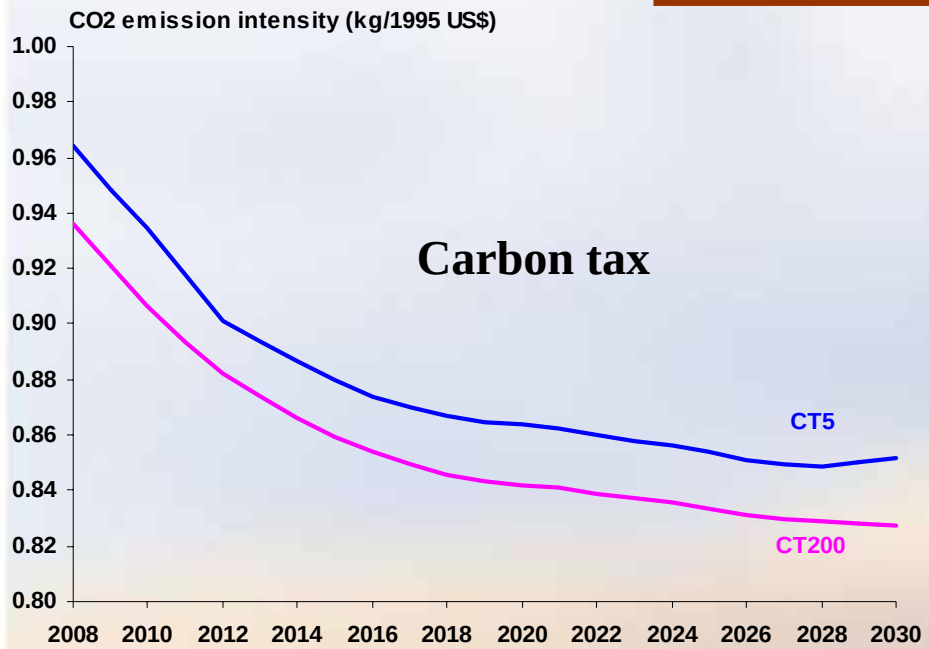
- EE0.50: 0.01% (14 million US$) in 2001 to about 0.89% (239 billion US$) in 2030.
- EE0.75: 0.02% in 2001 to about 1.26% in 2030.
- EE1.00: 0.03% in 2001 to about 1.60% in 2030.

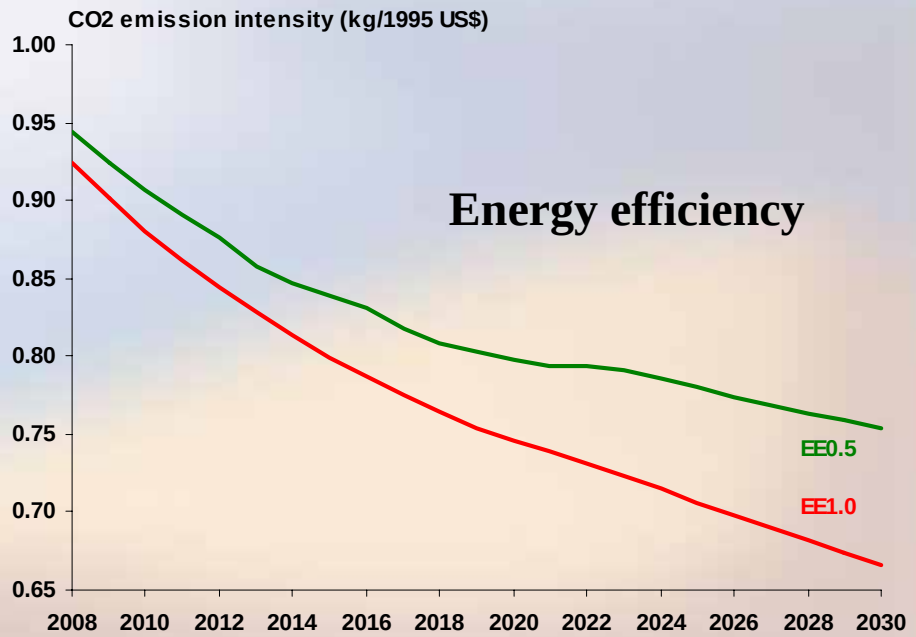
CO_2 emissions reduction (%)
Energy efficiency case



- The range of total CO_2 emissions reduction varies from 1.1% (2.3 million tons) under EE0.5 in 2010 to about 20.6% (118 million tons) under EE1.0 in 2030.
- Among the sectors, the CO_2 emissions reduction would be largest from industry sector followed by the others and transport sectors.

Carbon intensity of the economy
Carbon tax and energy efficiency cases





CO_2 intensity in 2000
(kg /US$ in 1995 prices)

Japan	0.37
OECD	0.51
World	0.56

Thailand: CO_2 intensity in 2030
(kg/US$ in 1995 prices)

Base case	0.86
Carbon tax	0.83 to 0.85
Energy efficiency	0.75 to 0.67

Conclusions

- Thai economy is expected to grow rapidly and so are energy demand and CO_2 emissions from the country. Total CO_2 emissions would increase from 147 million tons in 1998 to about 573 million tons in 2030 in the base case.

- Industry and transport sectors would continue emitting most of CO_2 emissions (86% in 2030) .

- With carbon tax in 2030:
  - GDP loss would vary from 0.012% at CT5 to 0.072% at CT200.
  - Loss in net export would vary from 0.117% at CT5 to 1.86% at CT200.
  - Total CO_2 emissions reduction ranges from 0.24% at CT5 to 3.09% at CT200

- Carbon intensity of the economy is expected to decline over time but it would still be higher than that of industrialized countries. In absolute term, carbon intensity of Thailand in 2030 even at CT200 would be higher than that of the OECD average value in 2000 (0.51 $kgCO_2$/US$ in 1995 prices).

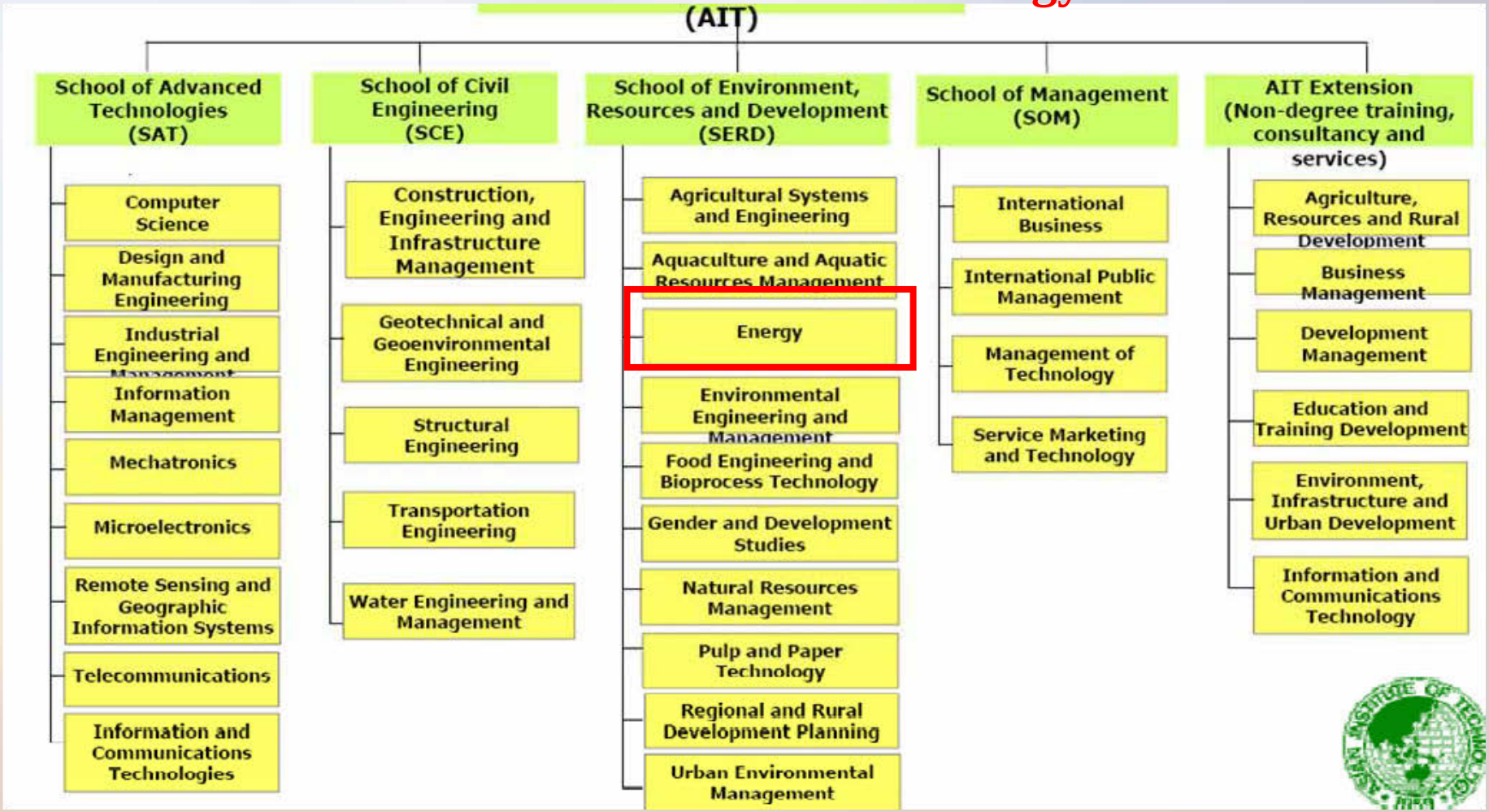
Extension of this study

- Revenue recycling schemes (distributional effects) of carbon tax on Thai economy by introduction of government and enterprise as separate institutions
- Co-benefits of CO2 emission reductions on other local air pollutants
- Emissions reduction targets
- Assessment energy efficiency improvements in energy sector as a potential CDM activities
- Assessment/incorporation of health benefits/impacts
- Domestic emission trading (C and S emissions)
- Renewable Portfolio Standards
- Medium term (2000-250) scenario development

Information about AIT

AIT ACADEMIC STRUCTURE
Schools and Extension

Asian Institute of Technology (AIT)



Key Numbers
August 2005

- 2,016 Students from 51 Countries/Territories
- 13,841 Alumni from 74 Countries/Territories
- 20,000 Short-term Trainees from 71 Countries/Territories
- 120 Faculty from 26 Countries
- 1,000 Research and Support Staff from 30 Countries
- 202 Sponsored Research Projects

DISTRIBUTION OF DOCTORAL & MASTER STUDENTS

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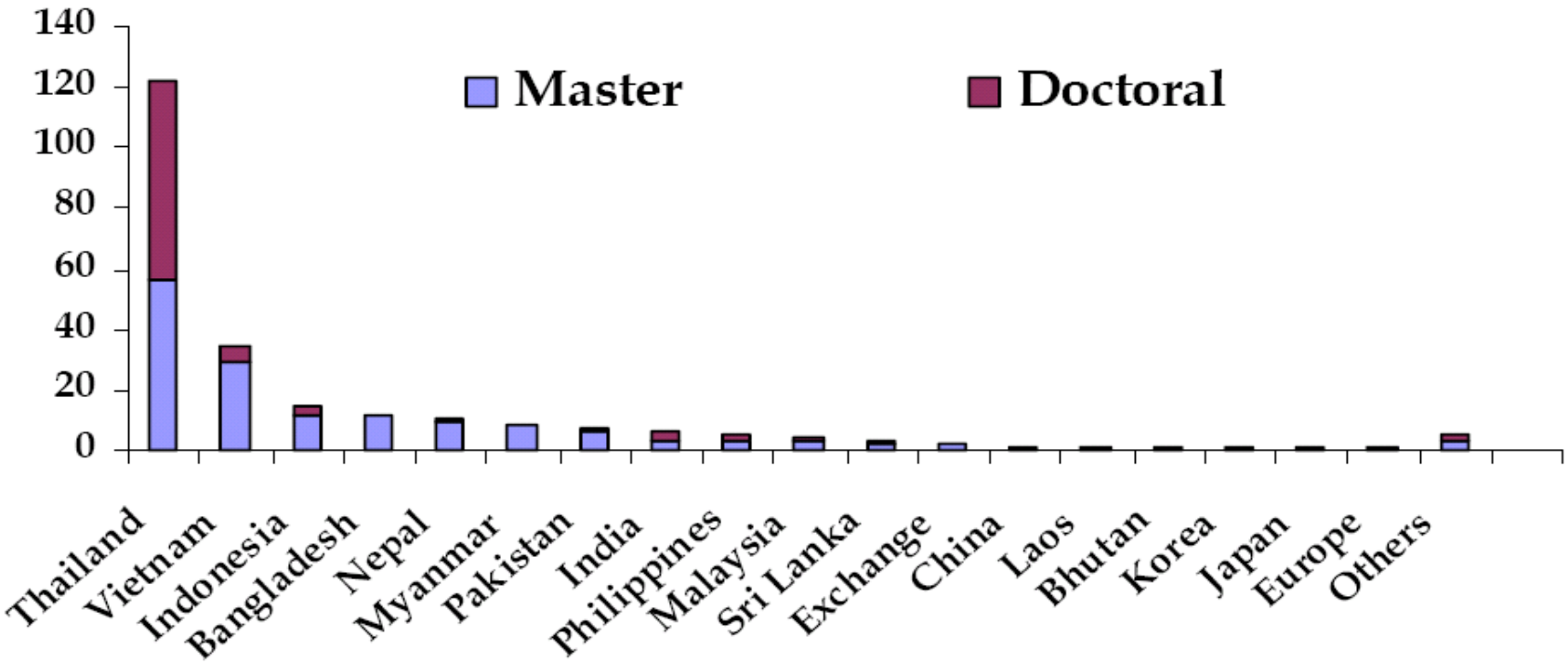

THANK YOU