

AIM/Enduse Model for Thailand: Effects of CO₂ Emission Constraints

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9th AIM International Workshop, Tsukuba, Japan

Presentation outline

- Improvements in the present analysis
- Energy use and CO₂ Emissions: Historical Trends
- Energy Mix and Emissions under base case
- Energy Mix and Emissions under CO₂ Reduction
- Conclusions

Major improvements in the present analysis

- AIM/Enduse model includes detailed modeling of iron & steel and cement manufacturing processes
- Service demand forecasts based on techno-economic approaches
- Use of more disaggregated and up to date data
- Planning horizon extended to 2030

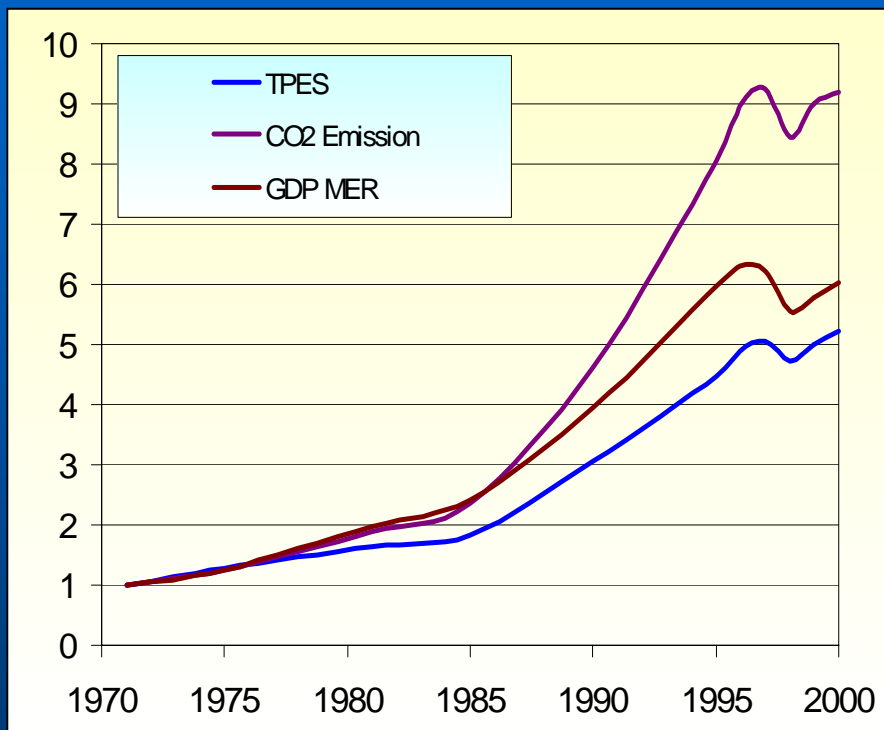
Energy use and CO₂ Emissions: Historical Trends and Status

Economic Growth, Energy Use and CO₂ Emission

- AAGR:

	1971-1996	1997-1999	1999-2000
TPES	6.64	-1.62	5.22
CO2 Emissions	9.35	-2.81	4.45
GDP MER	7.68	-6.11	4.26

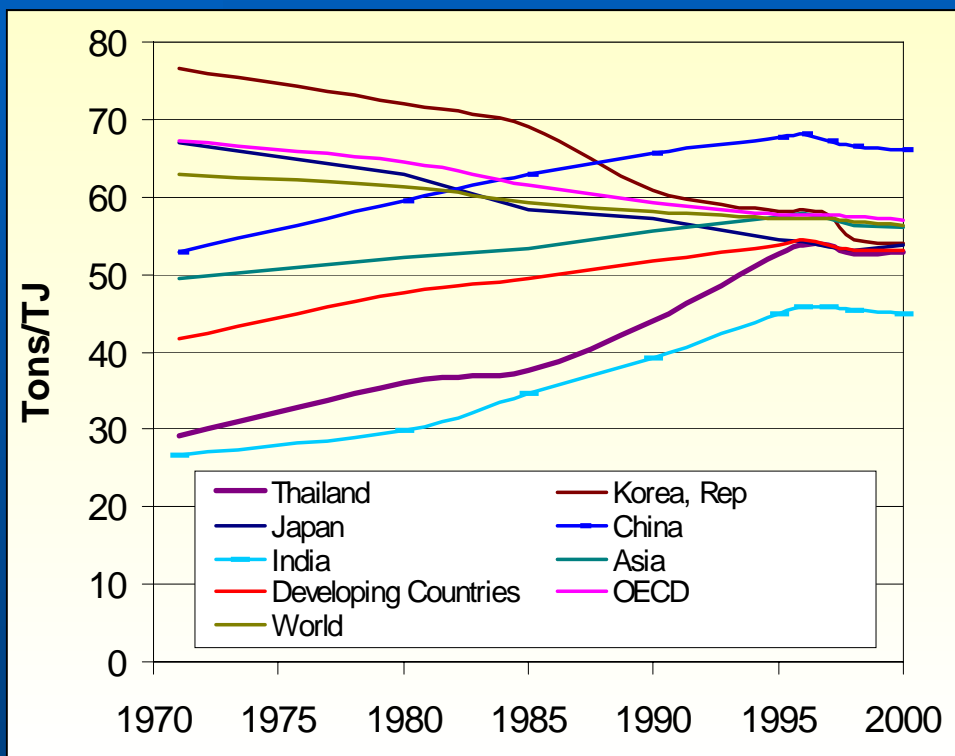
- CO₂ emission from energy use increased at a faster rate than TPES and GDP



Data source: IEA, 2002

CO₂ Intensity (tCO₂/TJ) in selected Countries and Regions during 1971-1999

- Relatively high growth of CO₂ intensity in Thailand.
- CO₂ intensity was increasing from 30 tons/TJ to 54 tons/TJ during 1971-1996 and decreased slightly thereafter.



AAGR:

Thailand:	2.1%
Asia:	0.4%
Developing:	0.8%
OECD:	-0.6%
World:	-0.4%

Data Source: World Resources Institute WRI, 2003.

CO₂ Intensity (tCO₂/GDP) in selected Countries and Regions in 1971-2000, tCO₂/10⁶US\$ PPP (1995 Prices)

Relatively high growth of CO₂ intensity in Thailand.

AAGR:

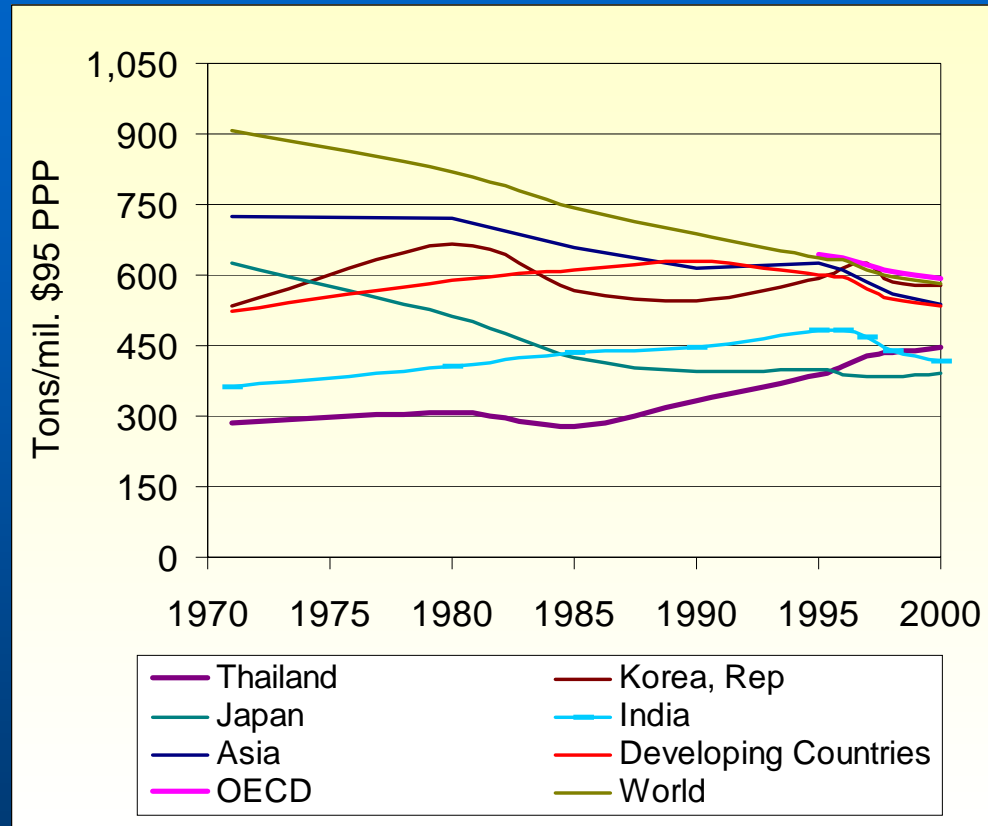
Thailand: 1.5%

Asia: -1.0% (mainly due to fall in China)

Developing Countries: 0.1%

OECD: -1.6%

World: -1.5%



Data Source: World Resources Institute WRI, 2003.

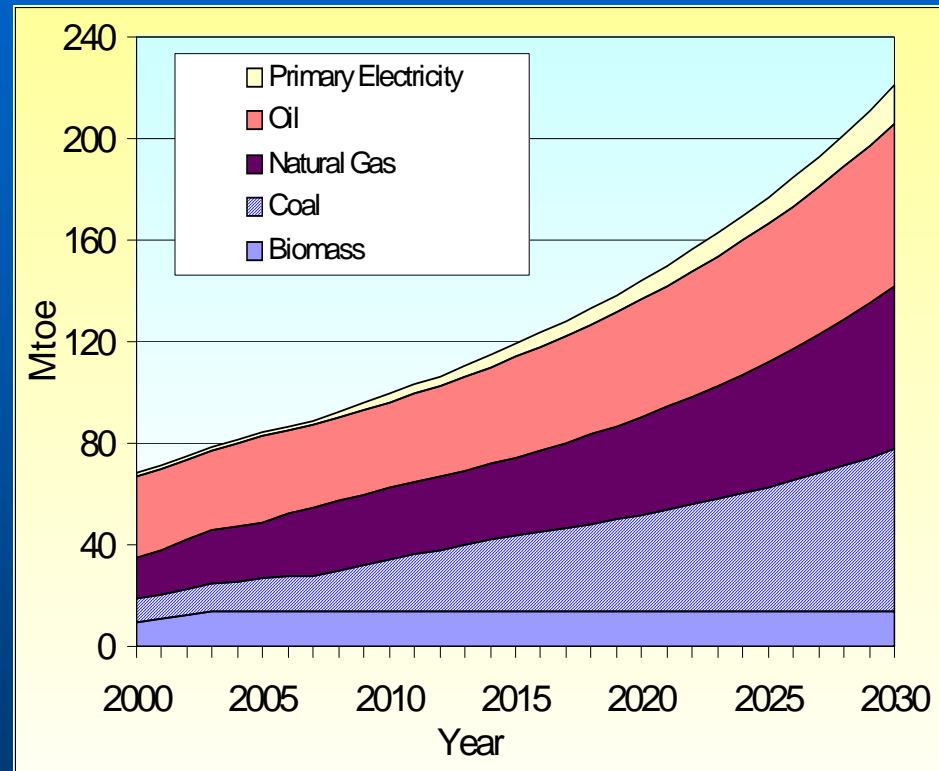
Description of Scenarios

- ✓ Base Case during 2000-2030.
- ✓ CO₂ Emission Reduction Cases: CO₂ emissions of 5%, 10% and 15% from that of the Base case. (hereafter denoted as ER5, ER10 & ER15 respectively)

Energy Mix and Emissions during 2000-2030

Primary Energy Supply-Base case

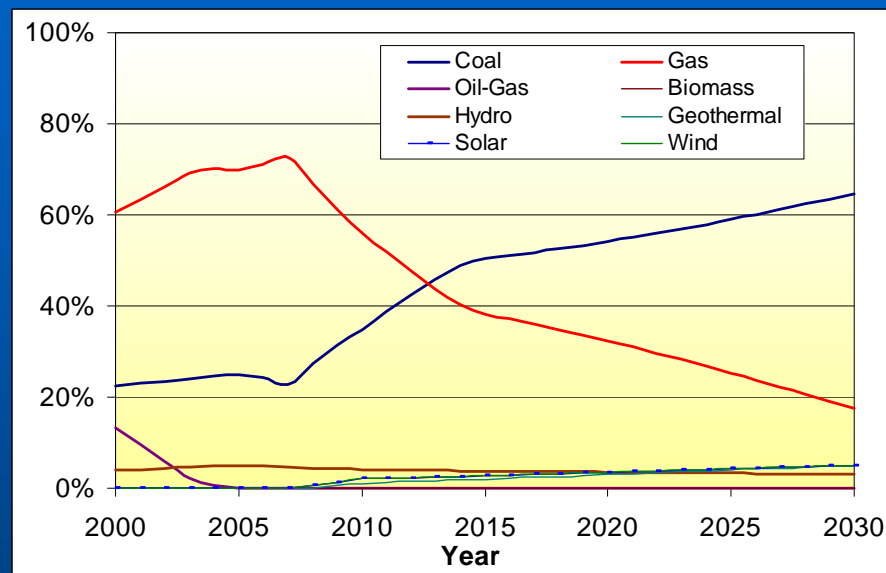
- ✓ AAGR of TPES during 2000-2030 is 3.4% as compared to 6.0 % 1971-2000
- ✓ Oil and biomass shares to **decrease** from 2000 to 2030
- ✓ Coal and gas share to **increase** from 2000 to 2030



Primary Energy Supply by Fuel Type, Mtoe

Power Generation Share by Energy Type in Base case

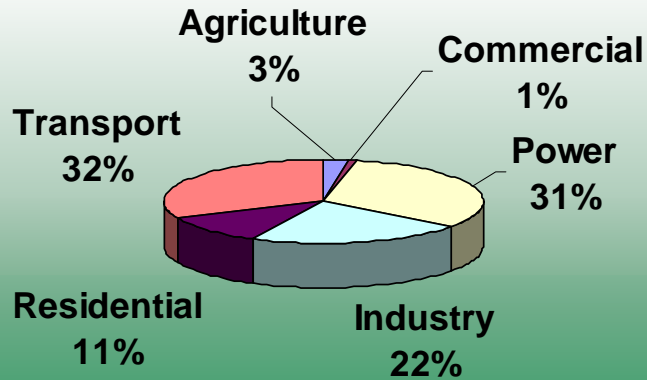
- ✓ **Coal** share to **increase** from 22.5% in 2000 to 64.6% in 2030
- ✓ **Gas** share to **decrease** from 60.5% in 2000 to 17.4% in 2030
- ✓ **Oil** share to **decrease** from 13.1% in 2000 to 0% in 2030
- ✓ Non-hydro **Renewable** share to **increase** 0% in 2000 to 15.0% in 2030



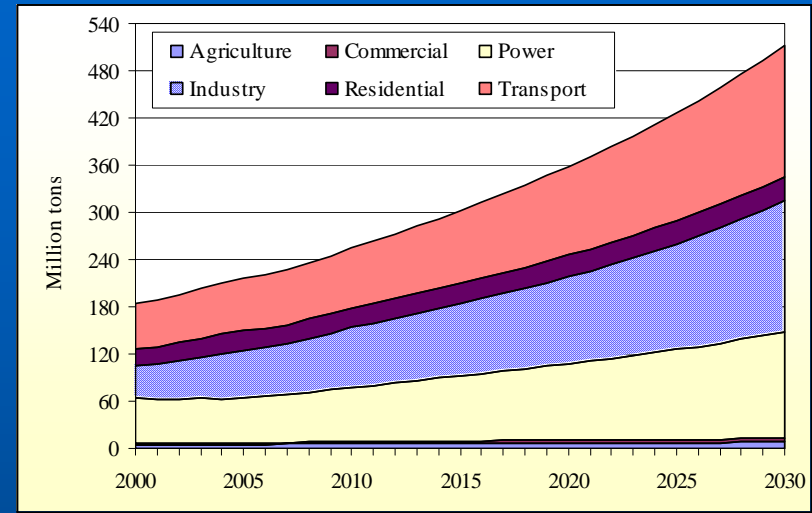
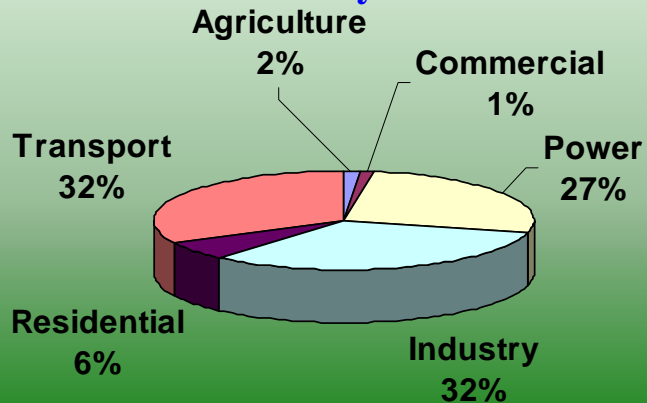
Electricity Generation Share by Energy Types (%)

CO₂ Emission during 2000-2030 - Base case

CO₂ Emissions by sector in 2000



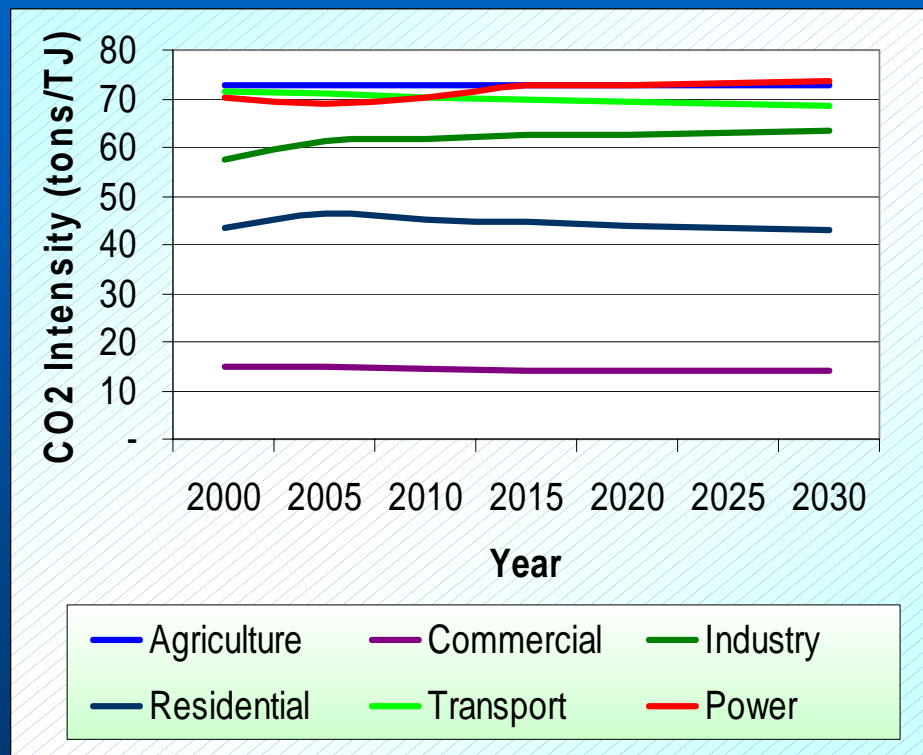
CO₂ Emissions by sector in 2030



✓ Total emissions during 2000-2030: 9,838 million tons

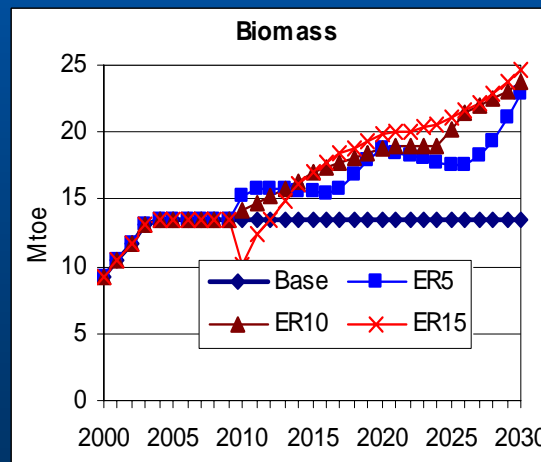
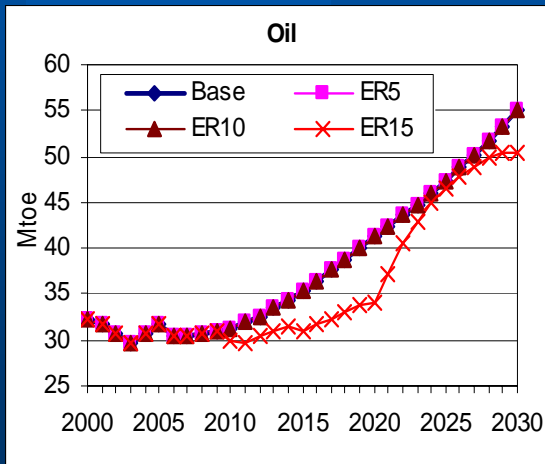
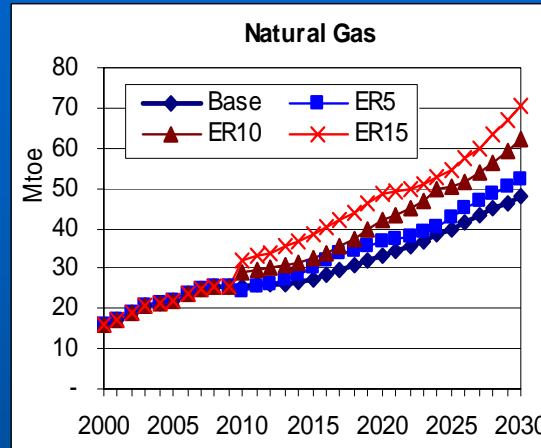
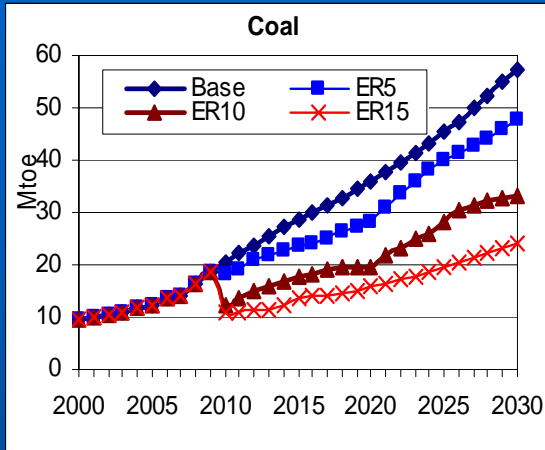
CO₂ Intensity (tCO₂/TJ) by Sector in Base case

- ✓ Overall CO₂ intensity during 2000-2030 almost constant around 62-63 tons/TJ
- ✓ Intensity Ranking:
 - 1.Agriculture, 2.Power,
 - 3.Transport, 4.Industry,
 - 5.Residential & 6.Commercial.
- ✓ The CO₂ intensity would be **decreasing** in all sectors except power and industry.



Energy Mix and Emissions under CO₂ Emission Reduction Targets

Primary Energy Mix under CO₂ Emission Reduction Targets (1)



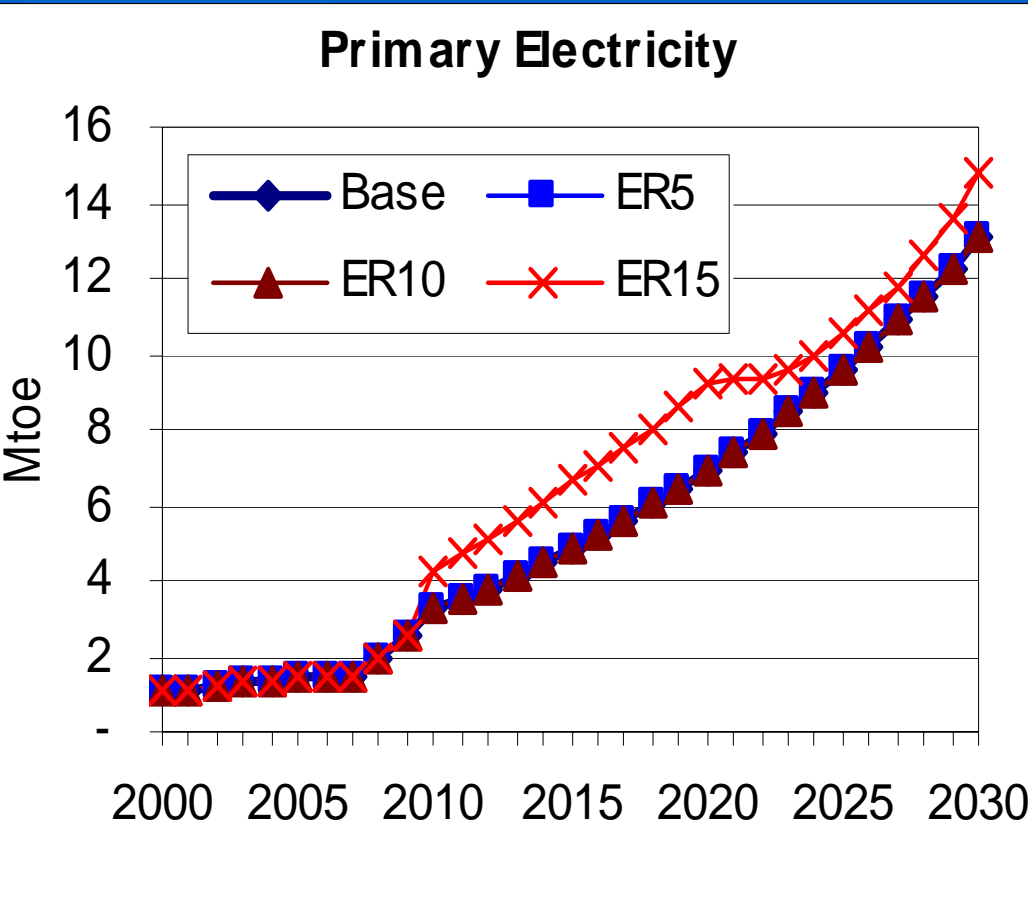
✓ **Coal use** ↓ **under ER15**

✓ **Noticeable** ↓ **in Oil use under ER15.**

✓ **Natural gas share** ↑

✓ **Significant Biomass use** ↑ **at all ER target**

Primary Energy Mix under CO₂ Emission Reduction Targets (2)



- In ER5 and ER10 cases, primary electricity use remain at Base Case levels
- In ER15, Primary Electricity generation would increase

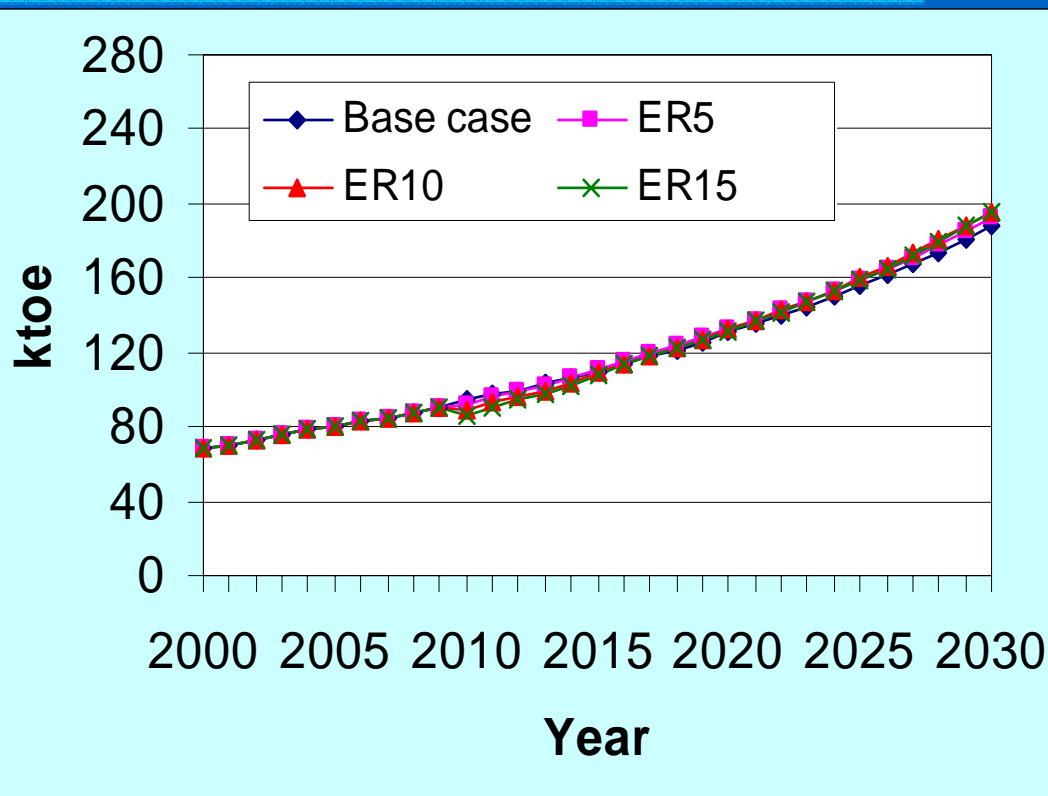
Use of Renewable Energy for Power Generation to meet the Emission Reduction Targets

Renewable based power generation in Base and ER cases, Mtoe

	Basecase		ER5		ER15	
	2010	2030	2010	2030	2010	2030
Solar	0.72	3.62	0.72	3.62	1.52	4.48
Wind	0.72	3.62	0.72	3.62	0.76	3.96
Geothermal	0.36	3.62	0.36	3.62	0.38	3.96
Biomass	-	-	2.34	9.4	2.48	11.12

- ✓ Non-Hydro renewable power generation account for only 11.4 % and 29.8% in ER15 in years 2010 and 2030 respectively.
- ✓ Biomass based power generation would play a greater role

Total Primary Energy use under ER Targets

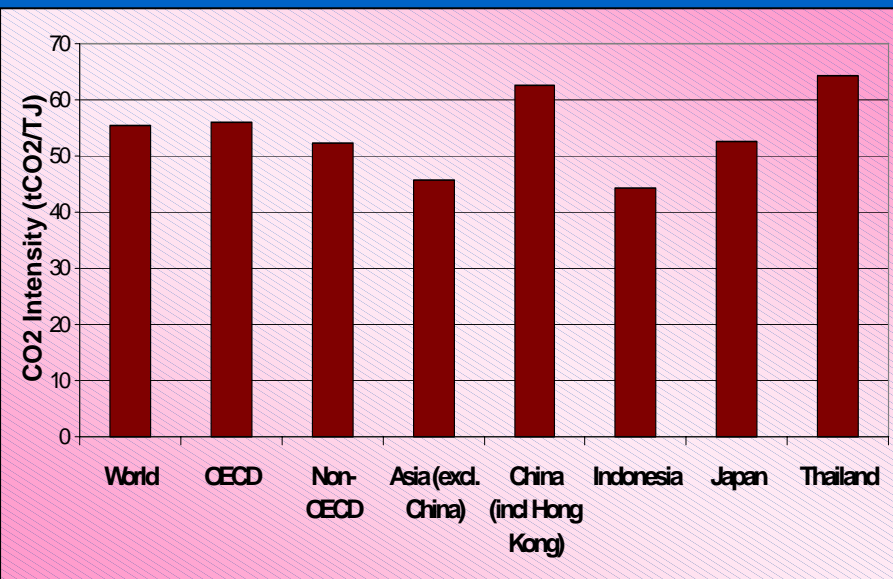


Total Energy Use, ktoe

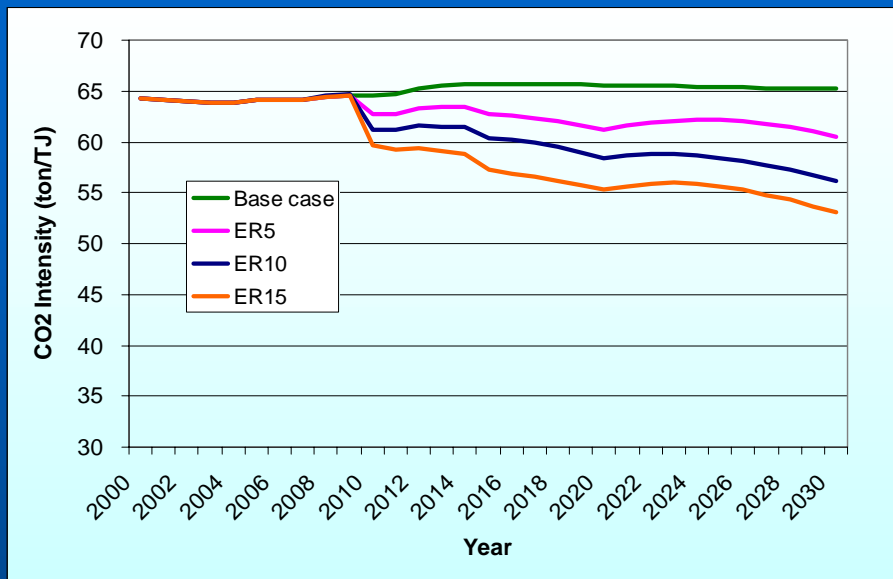
- CO₂ emission reduction targets are found to have little effect on total primary energy requirement during the period

- Emission reductions achieved mainly through fuel switching.

CO₂ Intensity (tCO₂/TJ) during 2000-2030 in Base and ER cases



CO₂ Intensities of the World and some Selected Countries in year 2000 (source: IEA 2002)

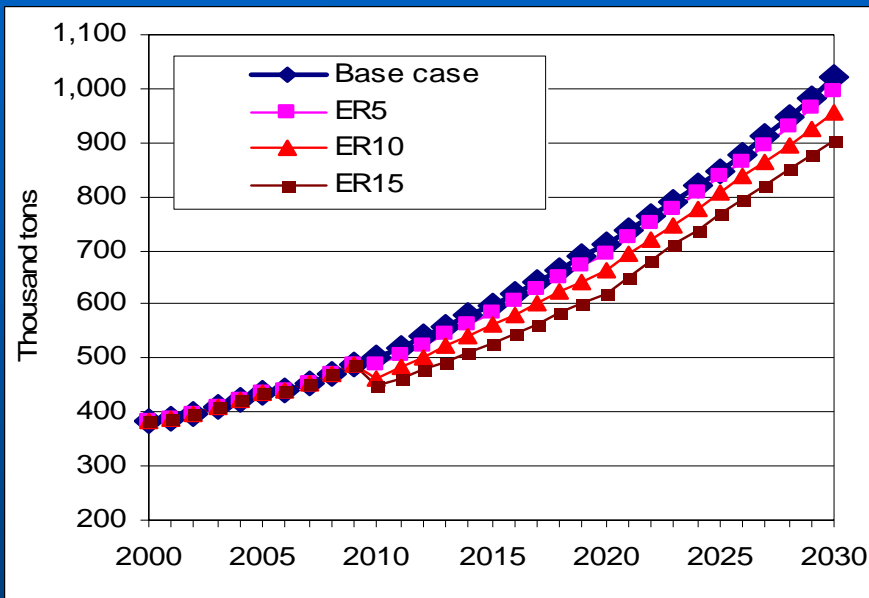


CO₂ Intensities for base and ER cases

- CO₂ Intensity of Thailand is higher than that of world average and many other countries in 2000
- The CO₂ Intensity of Thailand by year 2030 under ER15 would be close to the OECD CO₂ intensity in 2000

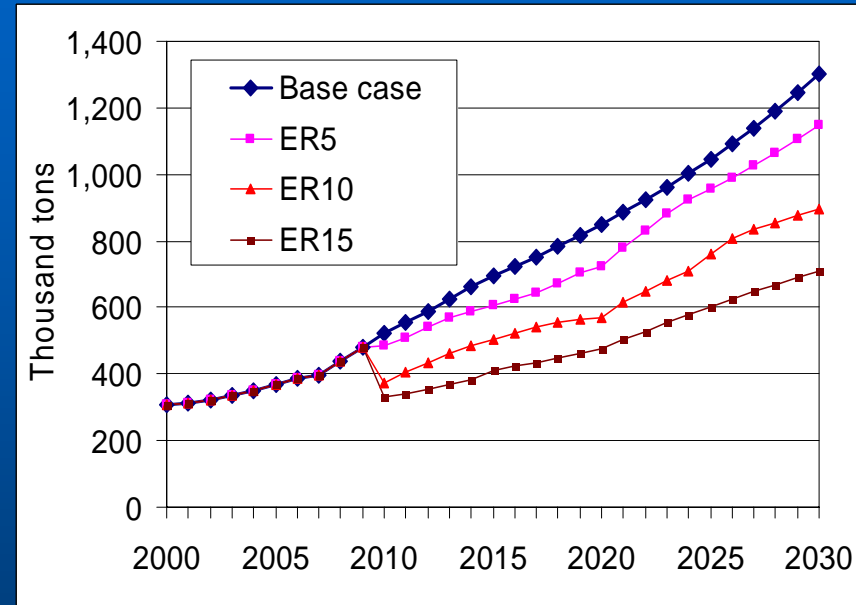
NO₂, SO₂ under CO₂ Emission Reduction Targets

Total NO_x Emission under Base and Emission Reduction Cases (ERs)



Total cumulative NO₂ emission in ER15 8.6% less than in Base case during 2000-2030

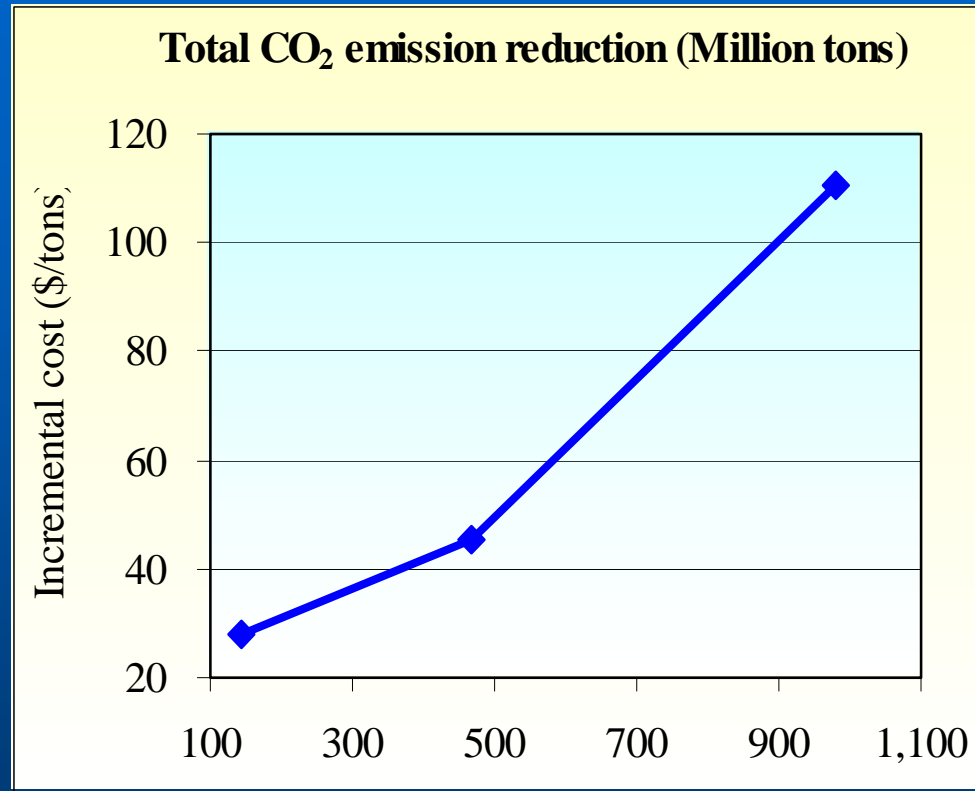
Total SO₂ Emission under Base and Emission Reduction Cases (ERs)



- Total cumulative SO₂ emission in ER15 35.4% less than in Base case during 2000-2030
- SO₂ reduction higher than NO₂

Incremental CO₂ Abatement Cost (\$/ton CO₂)

- The average incremental cost of CO₂ abatement (IAC) would increase from \$28 per ton of CO₂ in ER5 case to \$111 per ton of CO₂ in ER15 case.
- At IAC of 28 \$/tCO₂, about 142 million tons of CO₂ could be mitigated (cumulative) during 2010-2030.
- At IAC of \$46/ tCO₂ and \$111/tCO₂, 468 and 978 million tons of CO₂ (cumulative) could be reduced respectively.



Conclusions

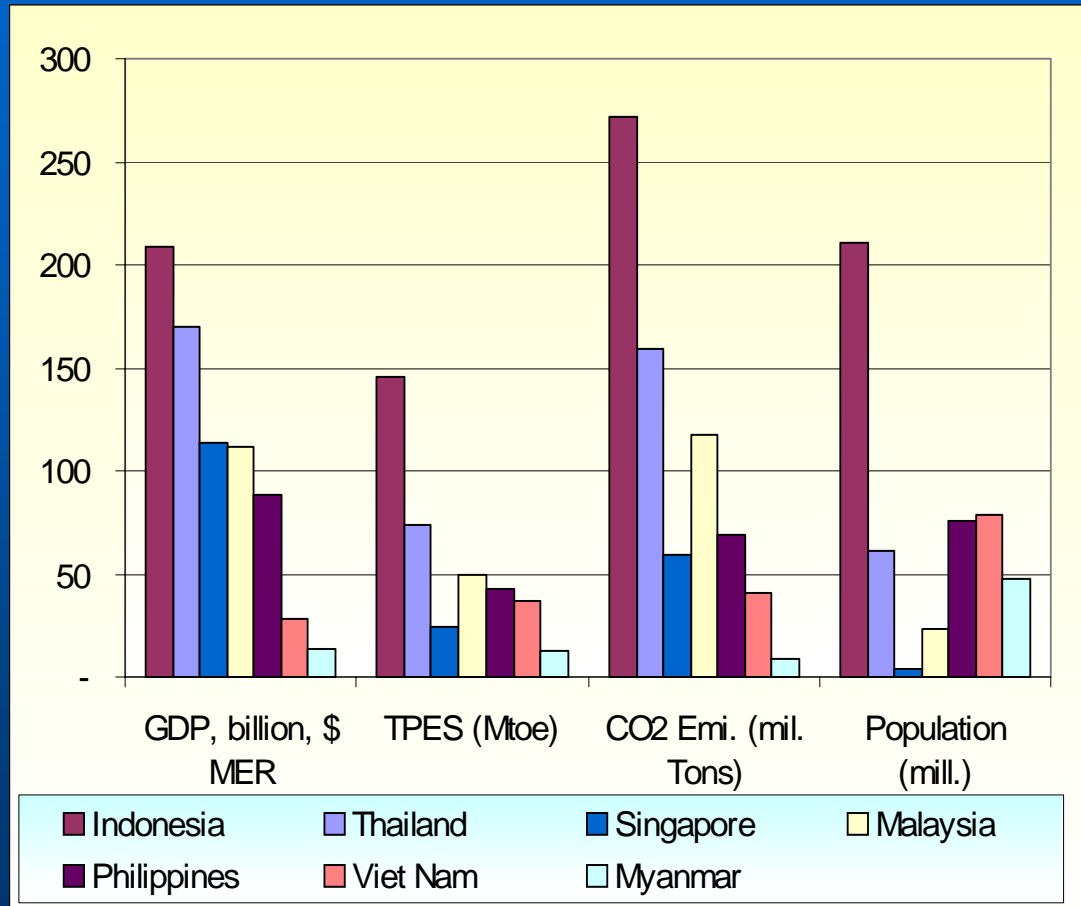
- CO₂ intensity in Thailand has been growing at a higher rate than most countries in Asia. It continues to remain high during 2000-2030.
- CO₂ intensity of Thailand in 2030 under ER15 case, would be almost the same as that of OECD (about 55 tCO₂/TJ) in 2000
- Fuel switching (mainly to natural gas and biomass energy) would be the major cost effective CO₂ mitigation options.
- Biomass based power generation would account for 15% of total power generation in 2030 under ER10 and ER15 cases.
- IAC of CO₂ ranges for \$28 to \$111/ton CO₂ in ER5 to ER15 cases

Thank You

GDP, Total Primary Energy Supply and CO₂ Emission in 2000

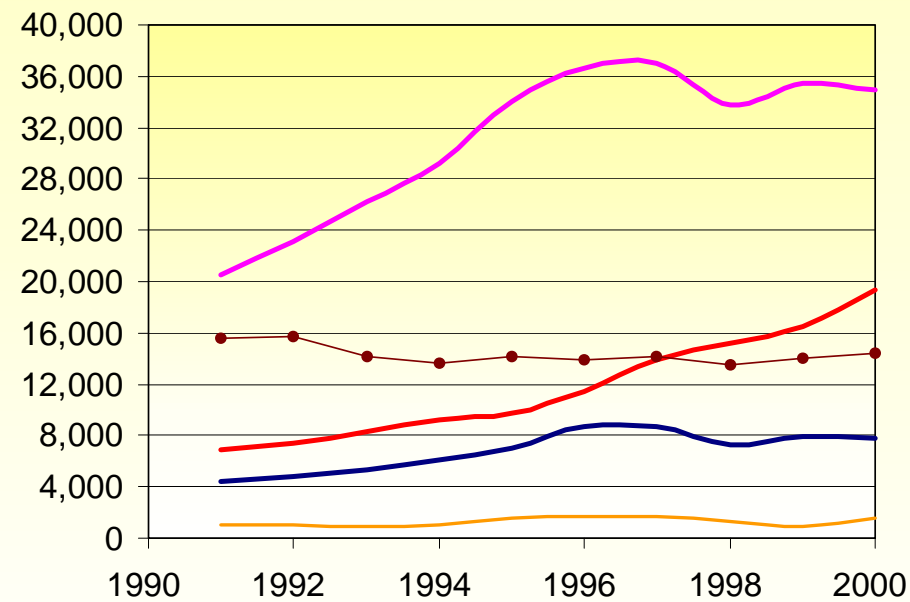
- GDP: 170.34 x 10⁹ US\$
- TPES: 73.6 Mtoe
- CO₂: 158.9 x 10⁶ tons
- Population: 60.7 million

Thailand: 2nd largest economy in South & South East Asia

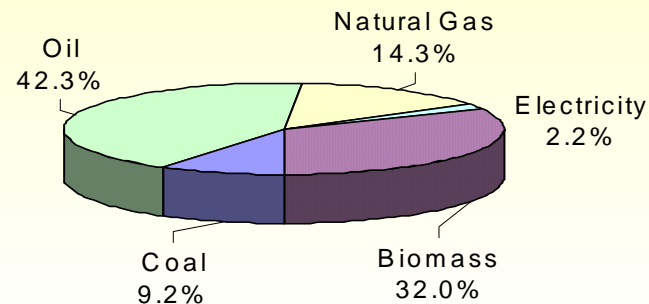


Data source: IEA, 2002

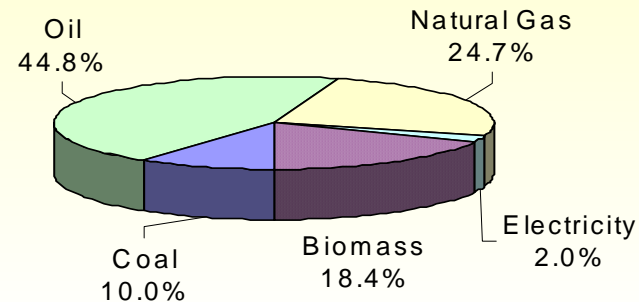
Total Primary Energy Supply (TPES) 1991-2000, Mtoe



Energy Supply in 1991



Energy Supply in 2000

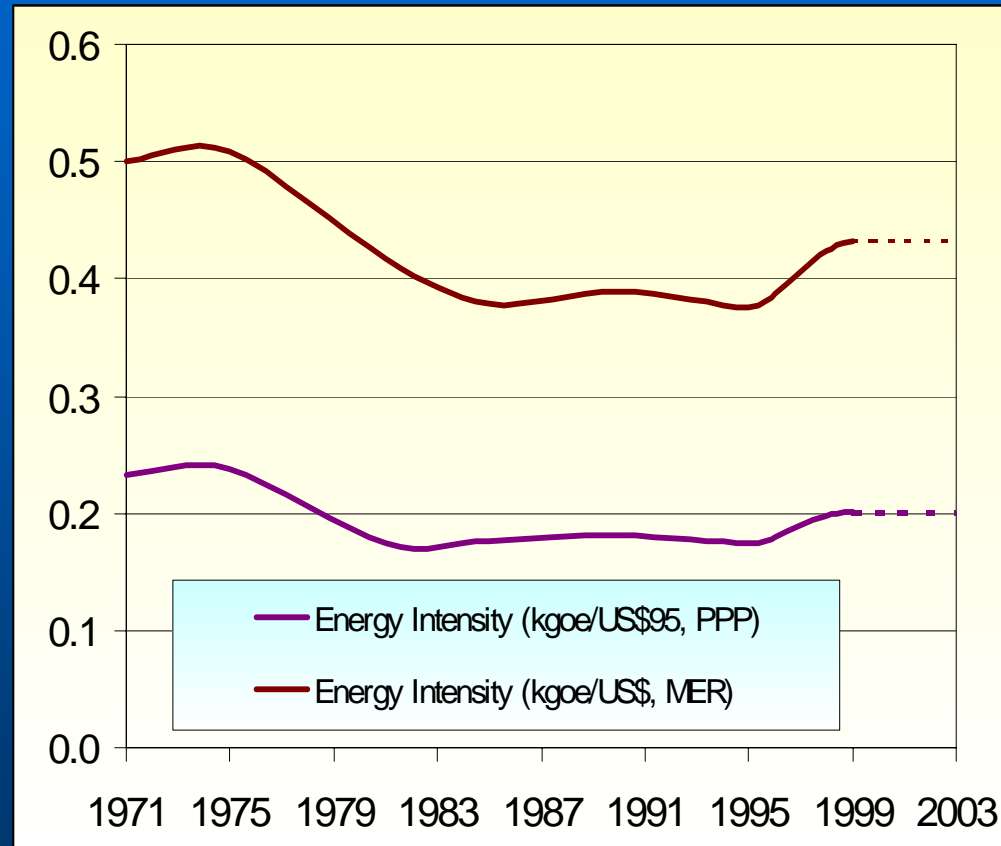


- TPES: 48.6 Mtoe in 1991 and 73.06 in 2000 (1.6 times that in 1991)
- Fossil fuel share increased from 68% to 81.6%

Data Source: IEA (2002), DEDP (2002)

Energy Intensity in Thailand in 1971-2000

- Energy intensity was decreasing from 0.24 in 1975 to 0.18 kgoe/US\$95 PPP in 1986, remaining at this level until 1996 and increasing thereafter.

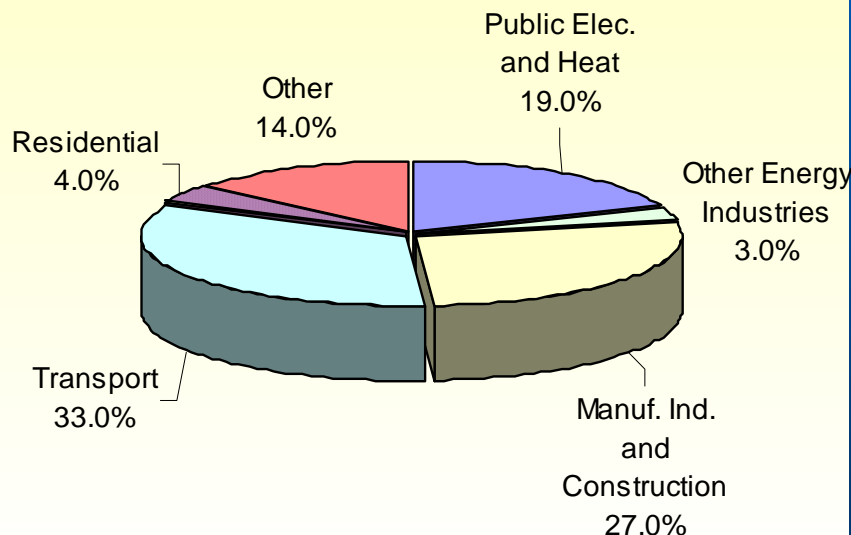


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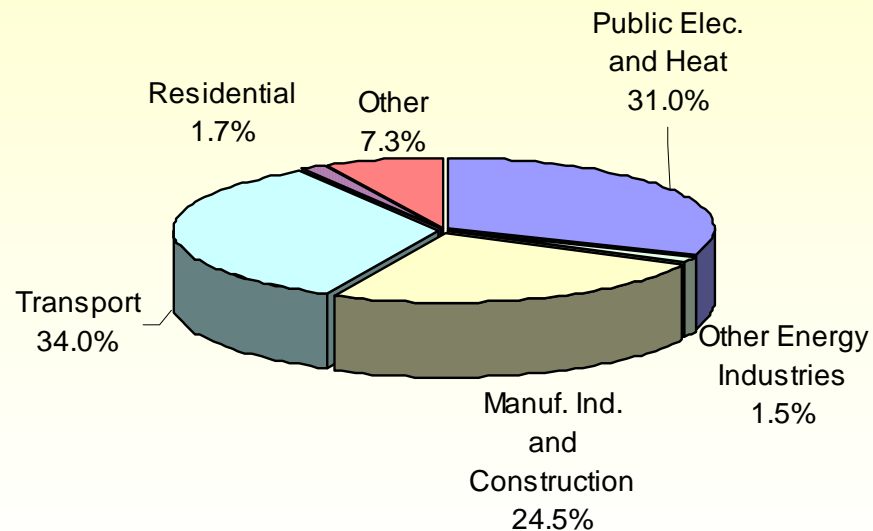
Sectoral CO₂ Emissions in 1972 and 2000

- Substantial increase of the power sector contribution
- Power, Transport and Industrial sectors were the three largest emission sources, accounting for over 80% of total CO₂ emission

Thailand CO₂ Emission by Sector in 1972



Thailand CO₂ Emission by Sector in 2000



• CO₂ emiss. in 1972: 18.6 mil. tons

• CO₂ emiss. in 2000: 159.0 mil. tons

Data Source: IEA, 2002

Sectoral CO₂ Intensities in Thailand during 1980-2000, tons/TJ

- CO2 intensity rising in all sectors
- Sec. Int. Ranking in 2000:
 1. Transport , 2. Power,
 3. Industry and 4. Res.&Com.

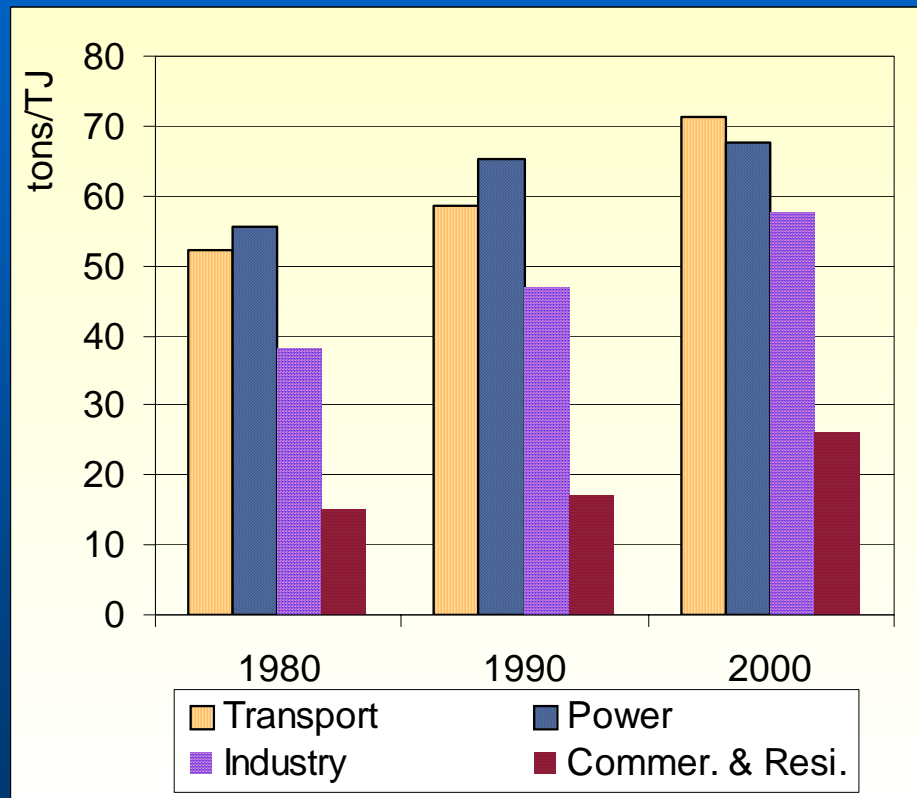
- AAGR:

Transport: 3.2%

Power: 2.0%

Industry: 4.2%

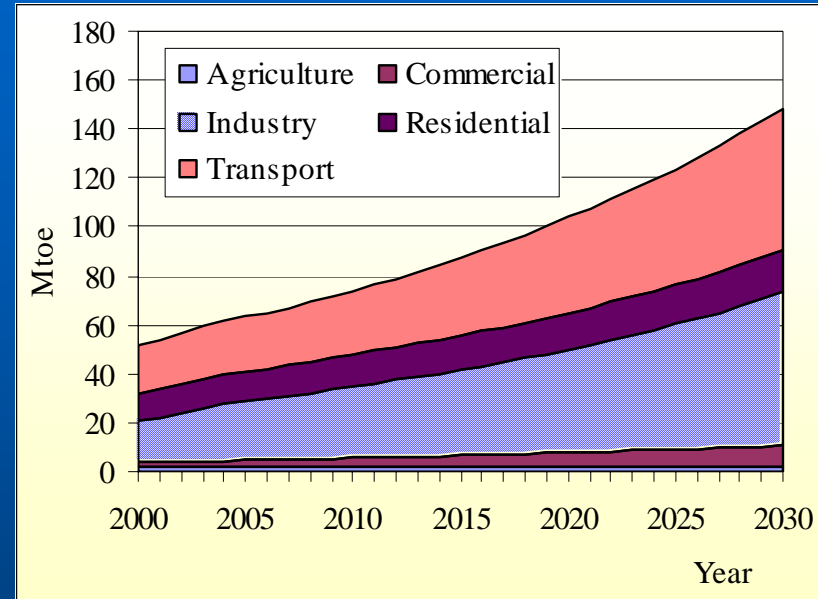
Res.&Com.: 5.5%



Data Source: IEA, 2003.

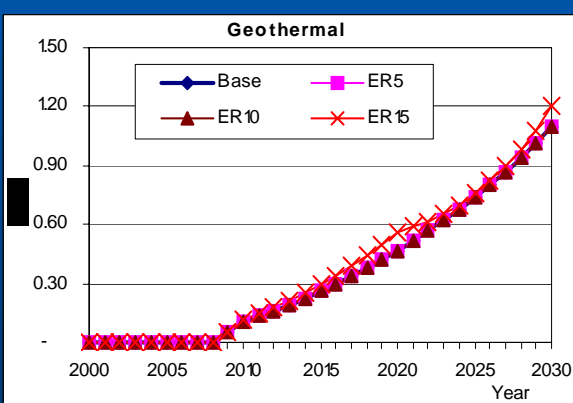
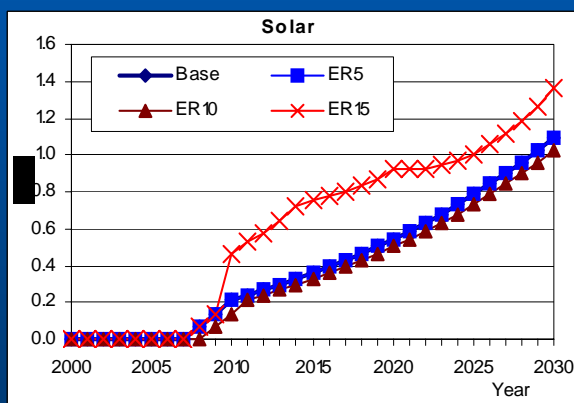
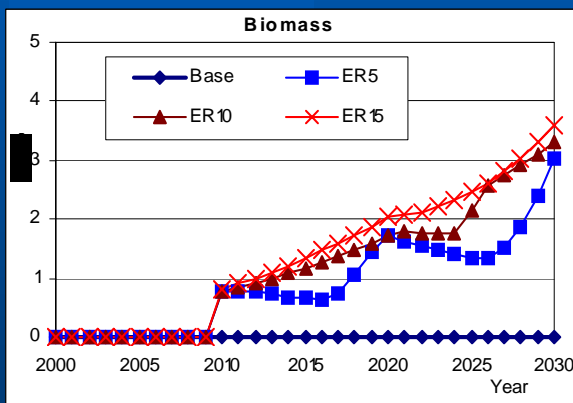
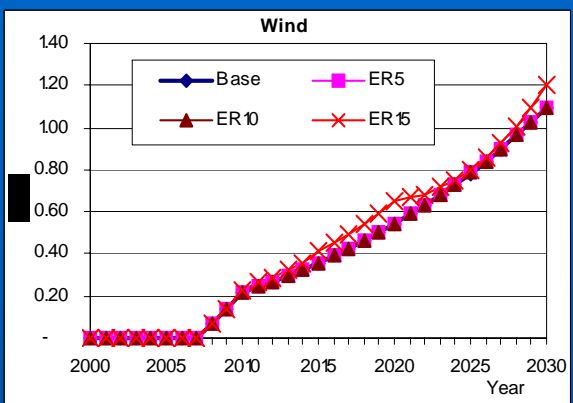
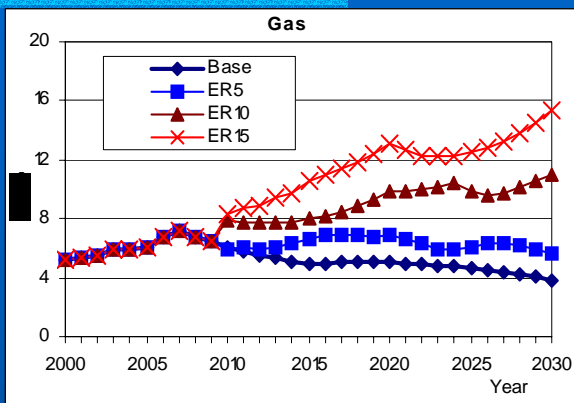
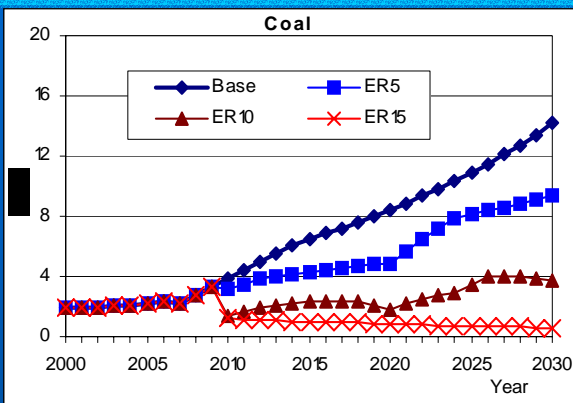
Final Energy Use by Sector-Base case

- ✓ **Agriculture** share to **decrease** from 2.9% in 2000 to 1.7% in 2030
- ✓ **Commercial** share to **increase** from 4.6% in 2000 to 5.5% in 2030
- ✓ **Industry** share to **increase** from 32.4% in 2000 to 42.1% in 2030
- ✓ **Residential** share to **decrease** from 22.1% in 2000 to 11.6% in 2030
- ✓ **Transport** share to **increase slightly** from 38.0% in 2000 to 39.1% in 2030



Energy Demand by Sector, Mtoe

Fuel Mix for Electricity Generation under CO₂ Emission Reduction Targets



- ER is achieved by a reduction in coal
- Gas, biomass and solar are substitutes for coal in electricity generation

Energy import dependency (EID) under CO₂ Reduction targets

- ✓ EID would be reduced from 76% in base case to less than 70% in all ER cases by 2030.
- ✓ Mainly due to decrease in imports of coal and oil.
- ✓ Increase in the use of Natural gas and domestic renewable energy resources (i.e., biomass, solar, wind and geothermal).
- ✓ Share of natural gas to increase by 231.0 Mtoe (29.8%) and biomass by 111.4 Mtoe (39.3% compared to the base case) to that from Base case to ER15 case.

