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Effects of Carbon Tax on CO_2 Emission and Energy Security in Sri Lanka

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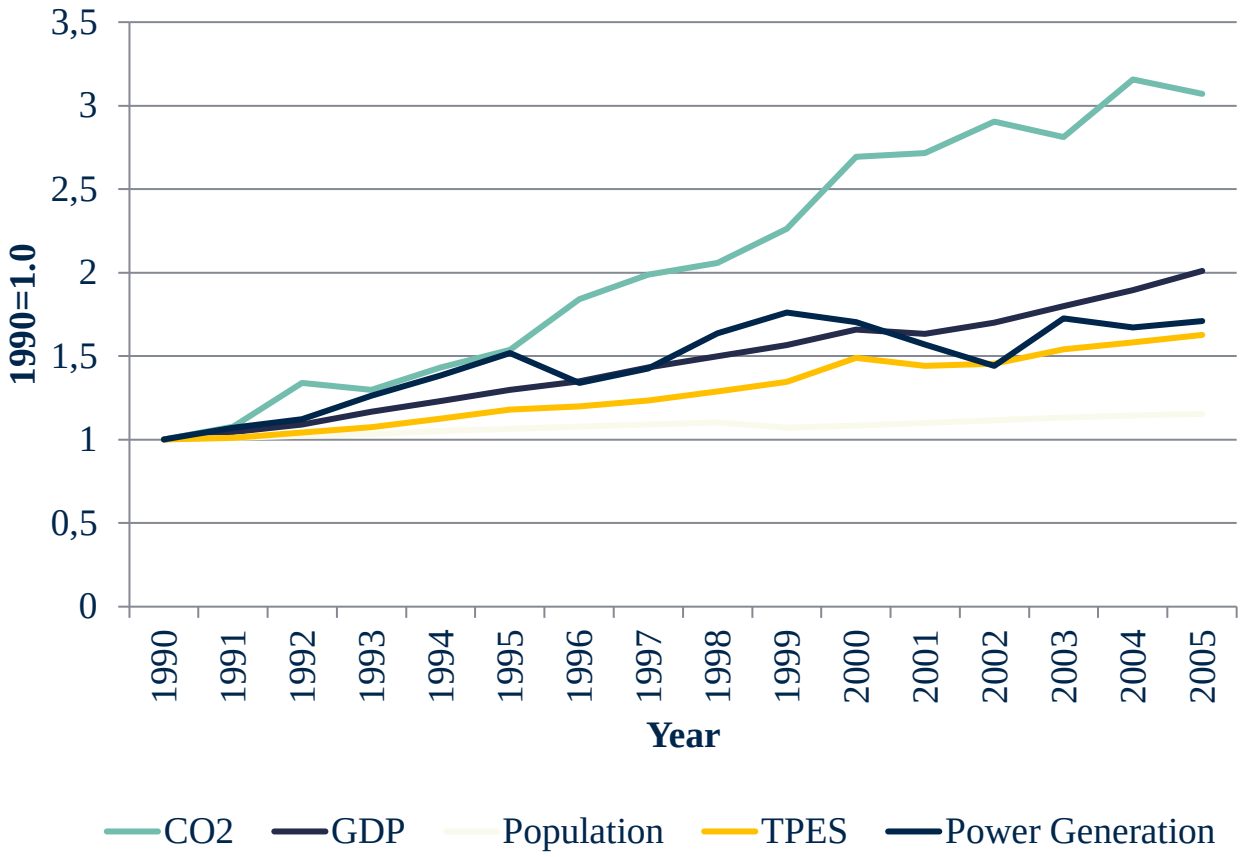
Outline

- Background
- Total primary energy consumptions, Energy resources mix in power generation and CO_2 emission
  - Base case
  - Carbon tax case
- Effects on energy security
- Concluding remarks

Background

Power Generation, GDP, Population, Energy related CO_2 emission in Sri Lanka during 1990-2005



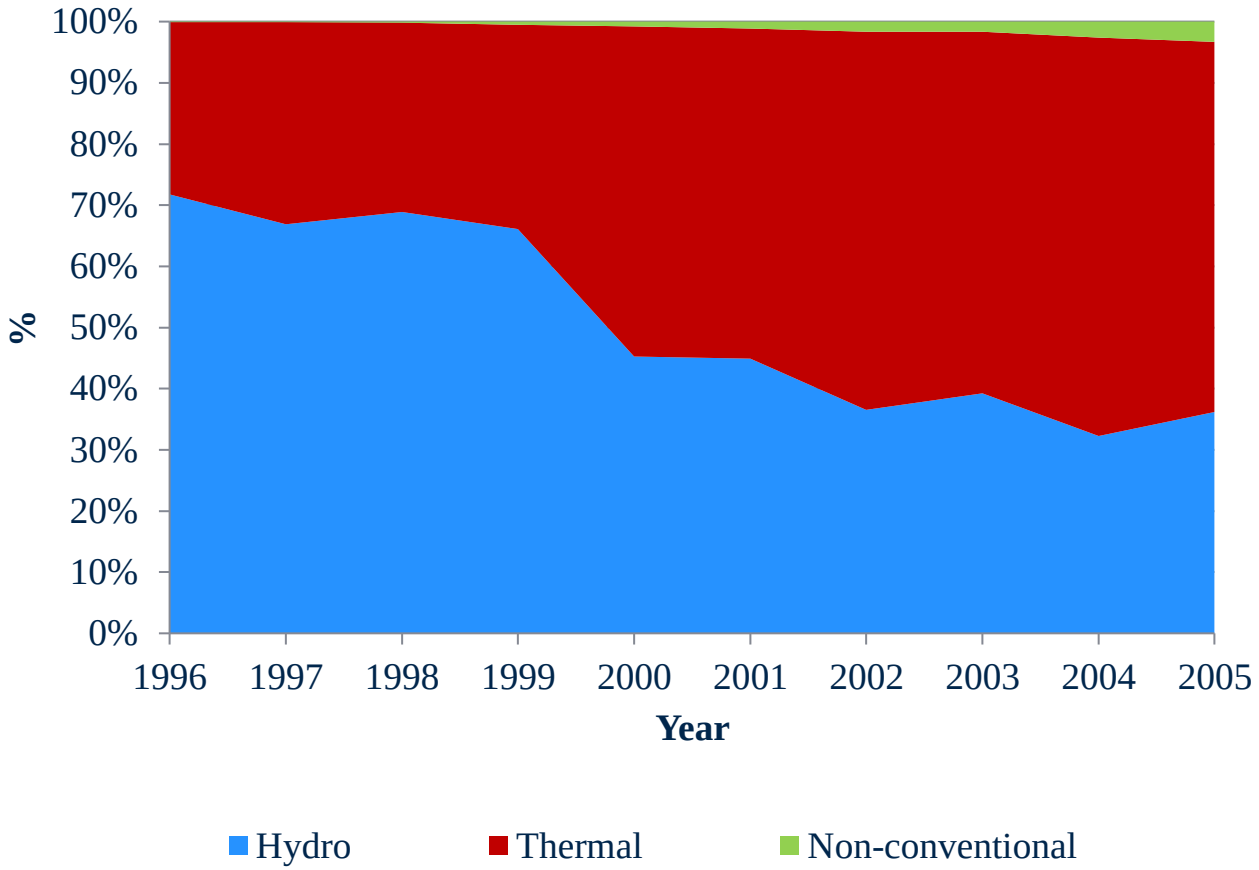
Sources: SEA 2006, Oak Ridge National Laboratory 2009

AAGR

CO_2: 8.0% TPES: 3.3%

GDP: 4.8% Population: 0.98% Power Generation 4.0%

Energy resources mix in power generation



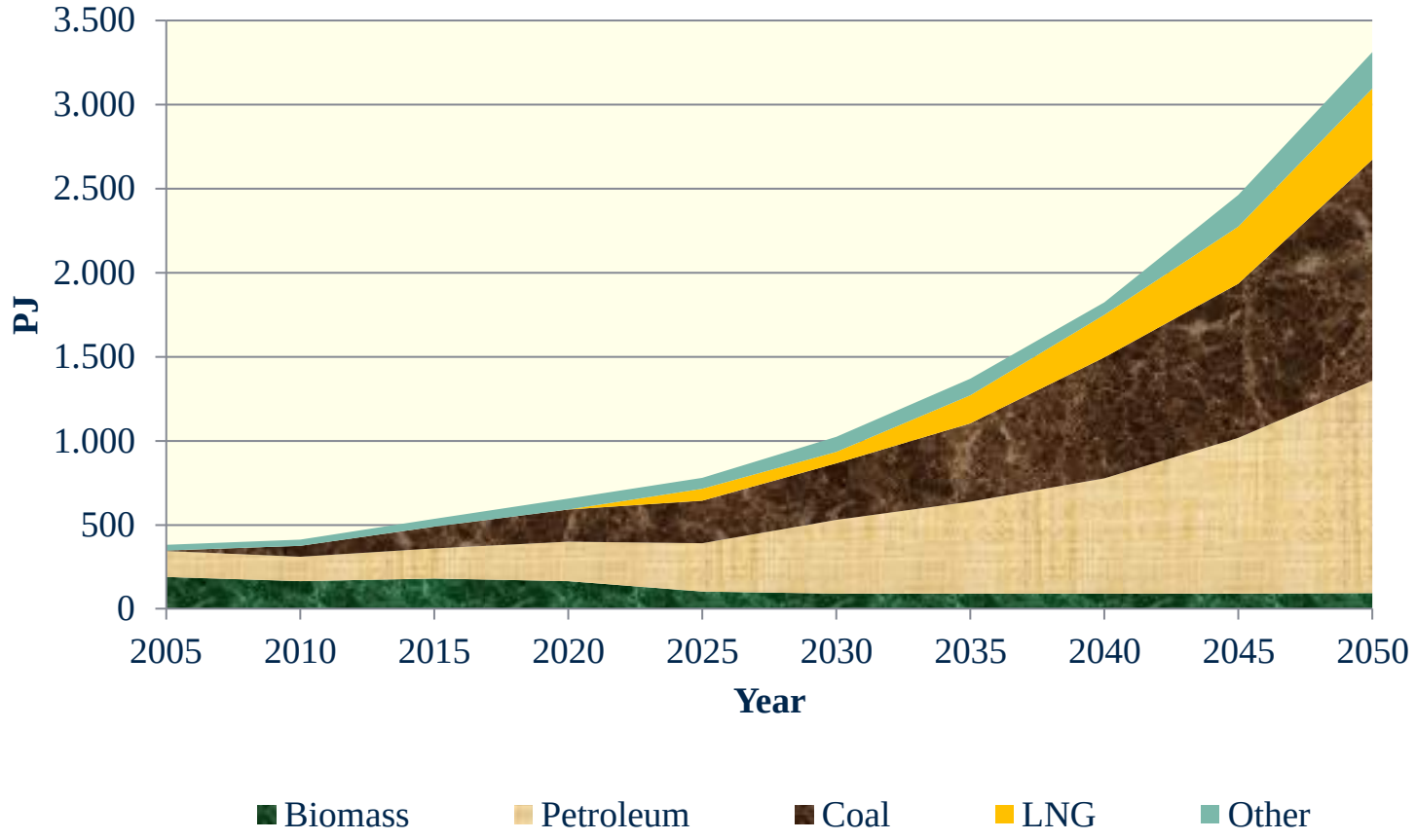
Share of thermal power generation
28% in 1996
65% in 2005

Model

- Bottom up cost minimization model of Sri Lanka using the MARKAL Framework.
- Detailed characterization of energy conversion (power generation, refining), industrial, transport, residential (rural and urban), commercial and agriculture sectors.
- 462 technology options considered (61 in power sector incl. coal and gas based CCS)

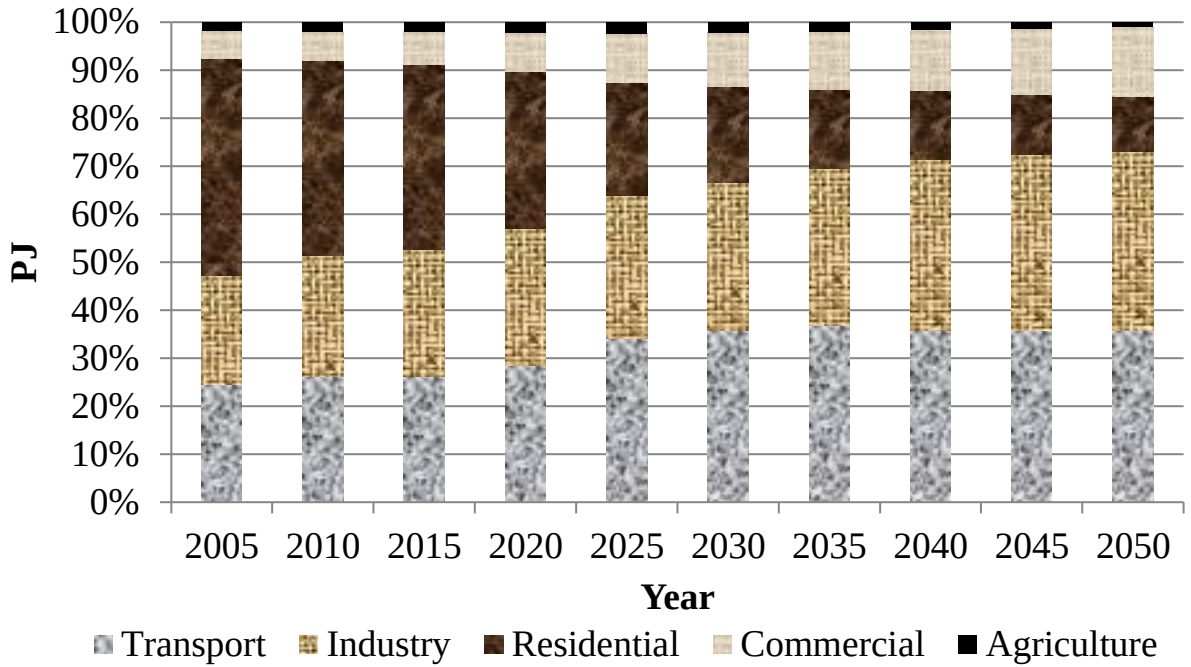
Base Case Analysis

Total primary energy supply mix 2005-2050



Total primary energy supply would increase by 8.7 time. AAGR 4.92%

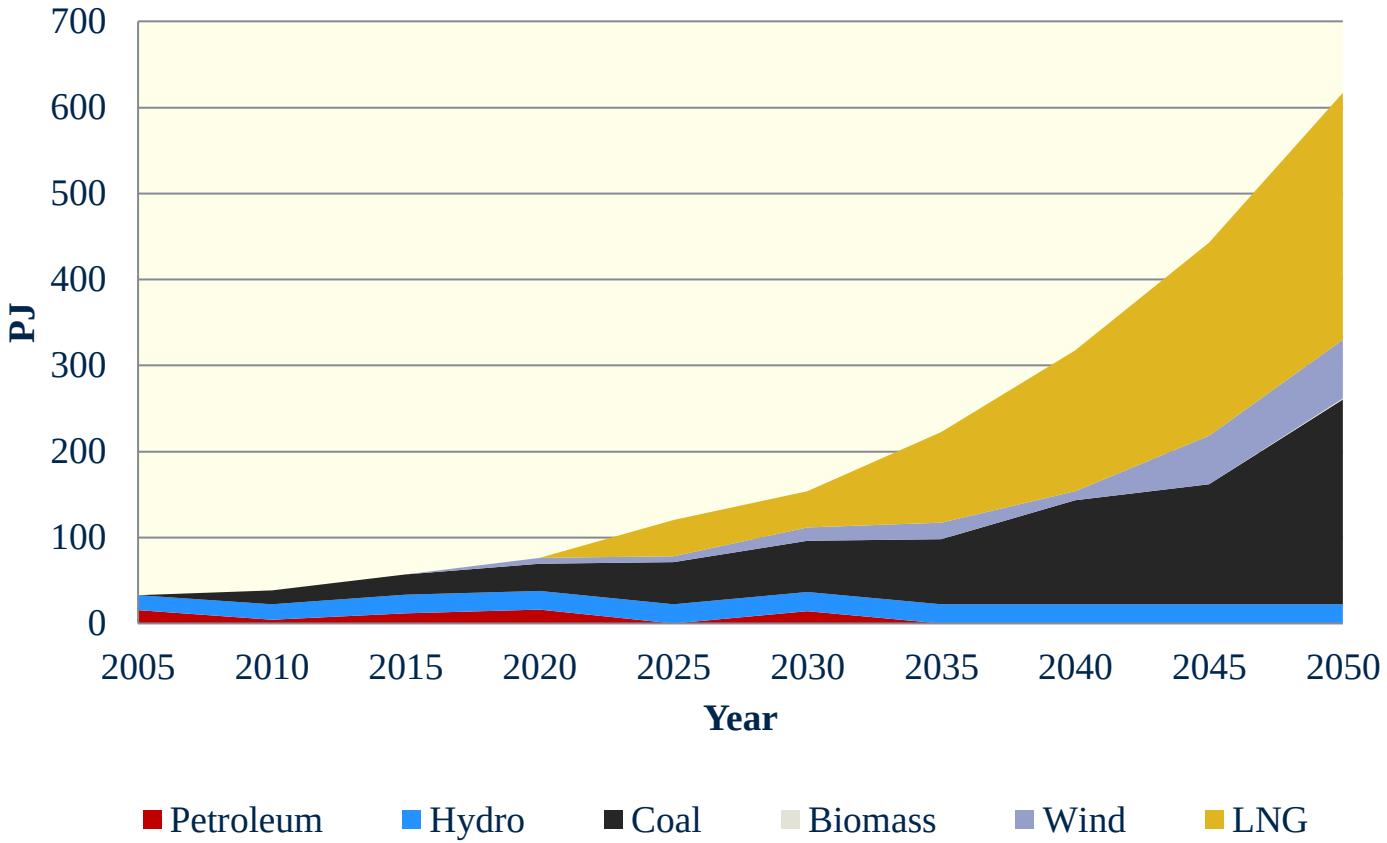
Sectoral Final Energy Consumption



AAGR
Residential sector : 1.6%, Transport sector: 5.7%, Industry sector: 5.9%
Commercial sector: 6.9%, Agriculture sector: 3.5%

- Till 2020 residential is the largest energy consuming sector.
- Thereafter till 2040, the transport sector is the most significant sector.
- After 2040 Industry sector would have the highest share in final energy demand.

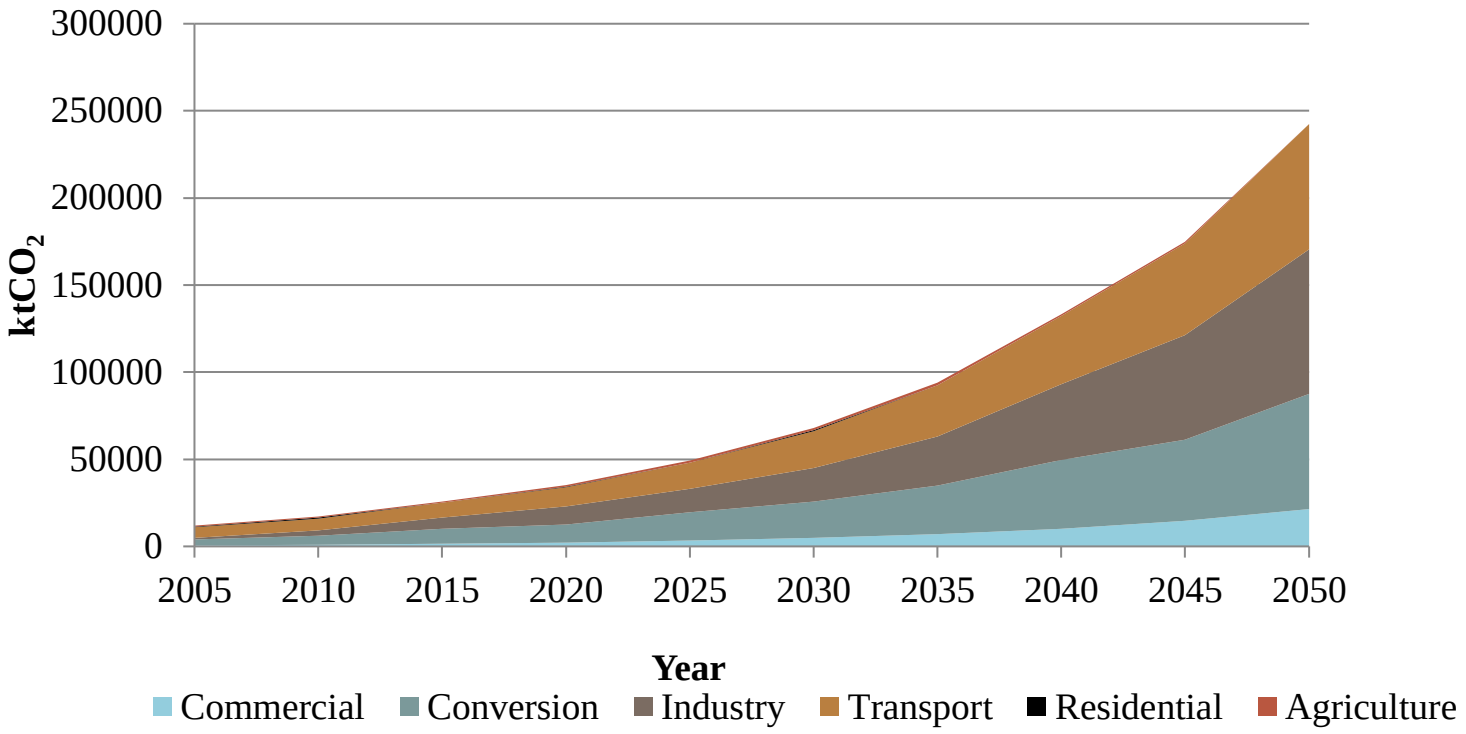
Power generation in base case



AAGR of power generation

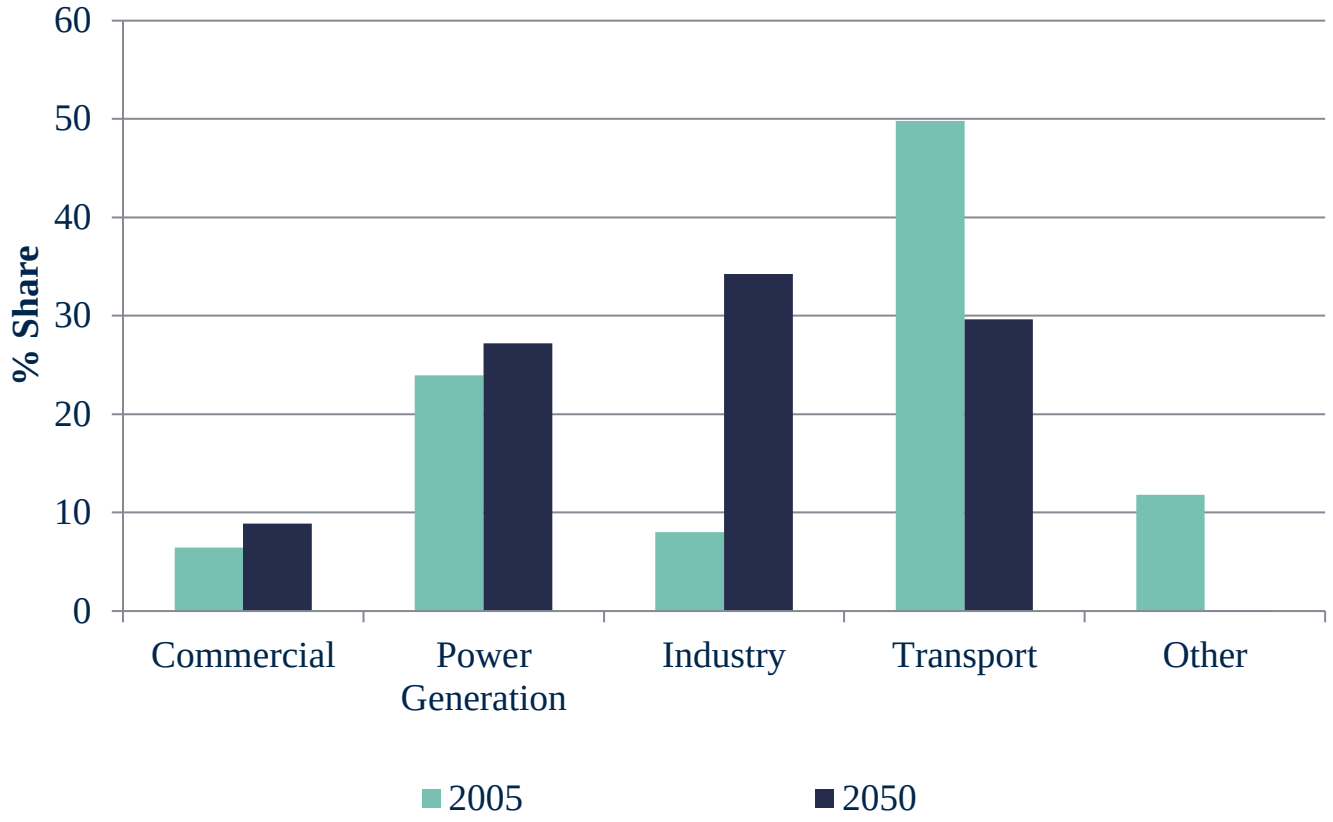
6.3% during 2005-2030
7.2% during 2030-2050

CO_2 Emission in the Base Case



- AAGR of total CO_2 Emission is 6.94%
- The transport sector accounted for 50% of the total emission in 2005. However, it would decline during the planning horizon and reach to 30% in 2050.
- The energy conversion sector is the second largest contributor to the total CO_2 emission with its share being 30% on the average during 2005-2050.
- The share of industrial sector in CO_2 emissions would increase from 8% in 2005 to 34% in 2050.

Sectoral CO_2 Emission Share in 2005 and 2050



- Share of power generation is significant both in 2005 and 2050.
- Industry sector shows the highest increase of CO_2 emission over the time

Effects of the Carbon Tax

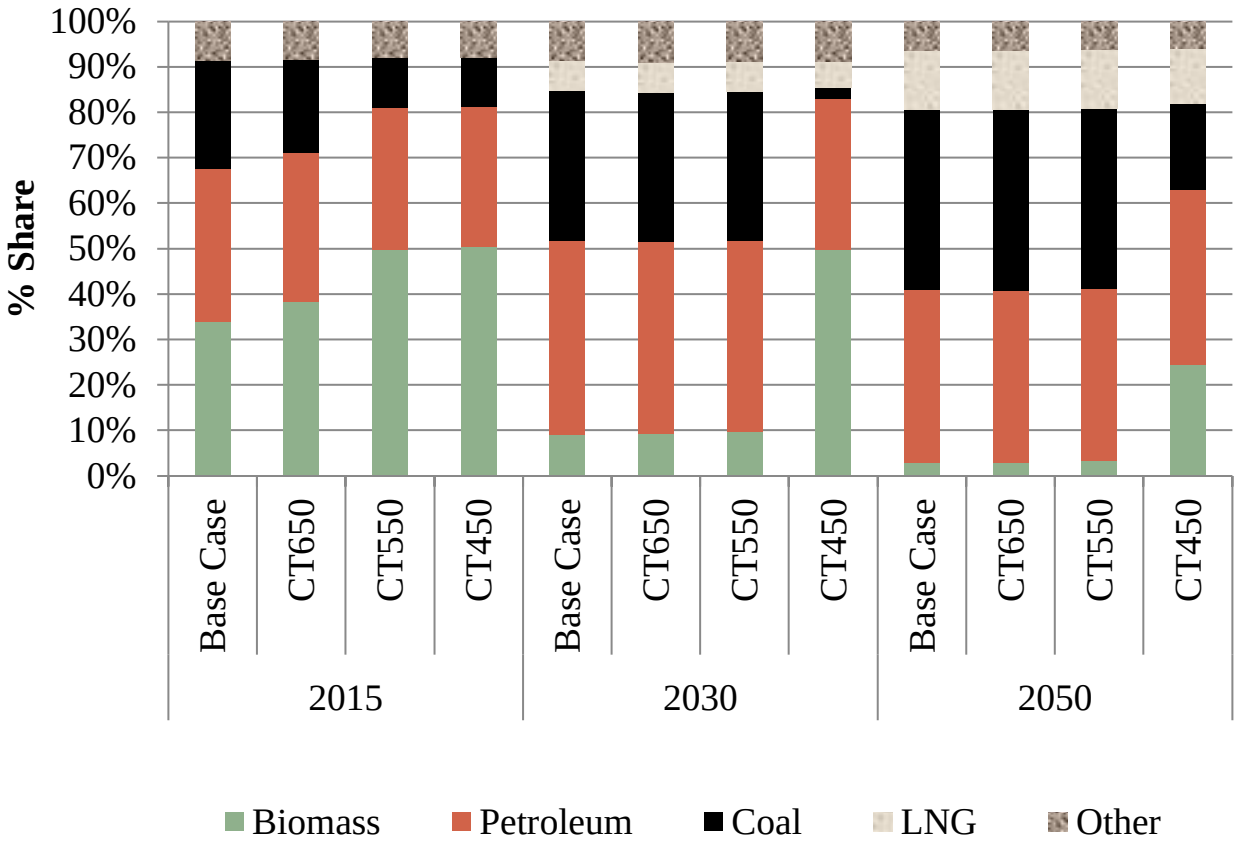
Carbon Tax Cases

CT 650:
Using carbon tax of 0.7US$/t$CO_2$ in 2010 and increase up to 10.1US$/t$CO_2$ by 2050. This is the carbon tax level required to achieve the 650ppm stabilization target

CT550:
Using carbon tax of 1.5US$/t$CO_2$ in 2010 and increase up to 20.7US$/t$CO_2$ by 2050. This is the carbon tax level required to achieve the 550ppm stabilization target.

CT450:
Using carbon tax of 8.3US$/t$CO_2$ in 2010 and increase up to 111.6US$/t$CO_2$ by 2050. This is the carbon tax level required to achieve the 450ppm stabilization target

Primary Energy Supply Mix



- In 2015, all the carbon tax cases increase the biomass consumption and reduce the coal consumption.
- In 2030 and 2050, coal is replaced considerably by biomass only under CT450.

Changes in power generation

- Renewable energy share in power generation

  Base case: 19%, CT650: 21%
  CT550: 23%, CT450: 37%

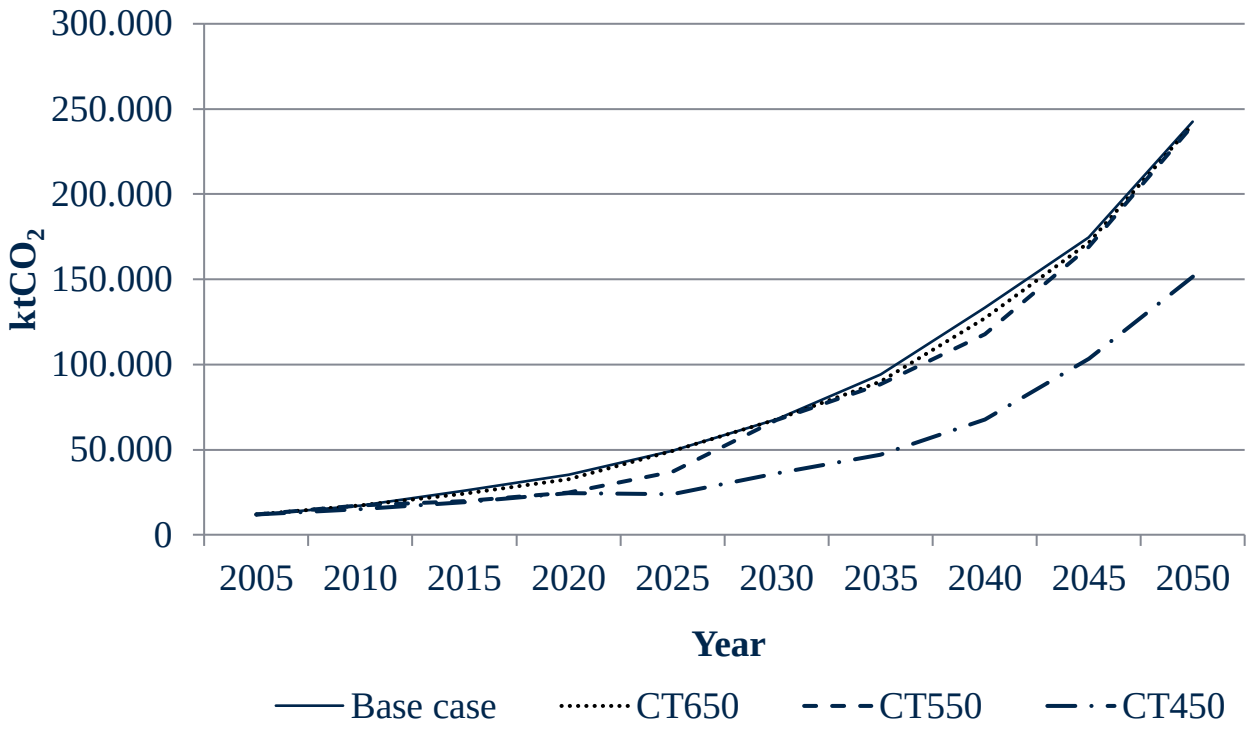
- Share of coal power generation (conventional and super critical)

  Base case: 36%, CT650: 34%,
  CT550: 31%, CT450: 4%

- Share of clean coal power generation (IGCC and Pulverized coal with CCS)

  Base case: 0%, CT650: 0%,
  CT550: 1%, CT450: 14%

Changes in total CO2 emission



Cumulative total emission reduction
CT650: 2%, CT550: 7%, CT450: 41%

- In the low carbon tax cases of CT650 and CT550, there significant emission reduction would take place only after 2015
- while under the CT450 case, significant reduction would start occurring before 2015 as well

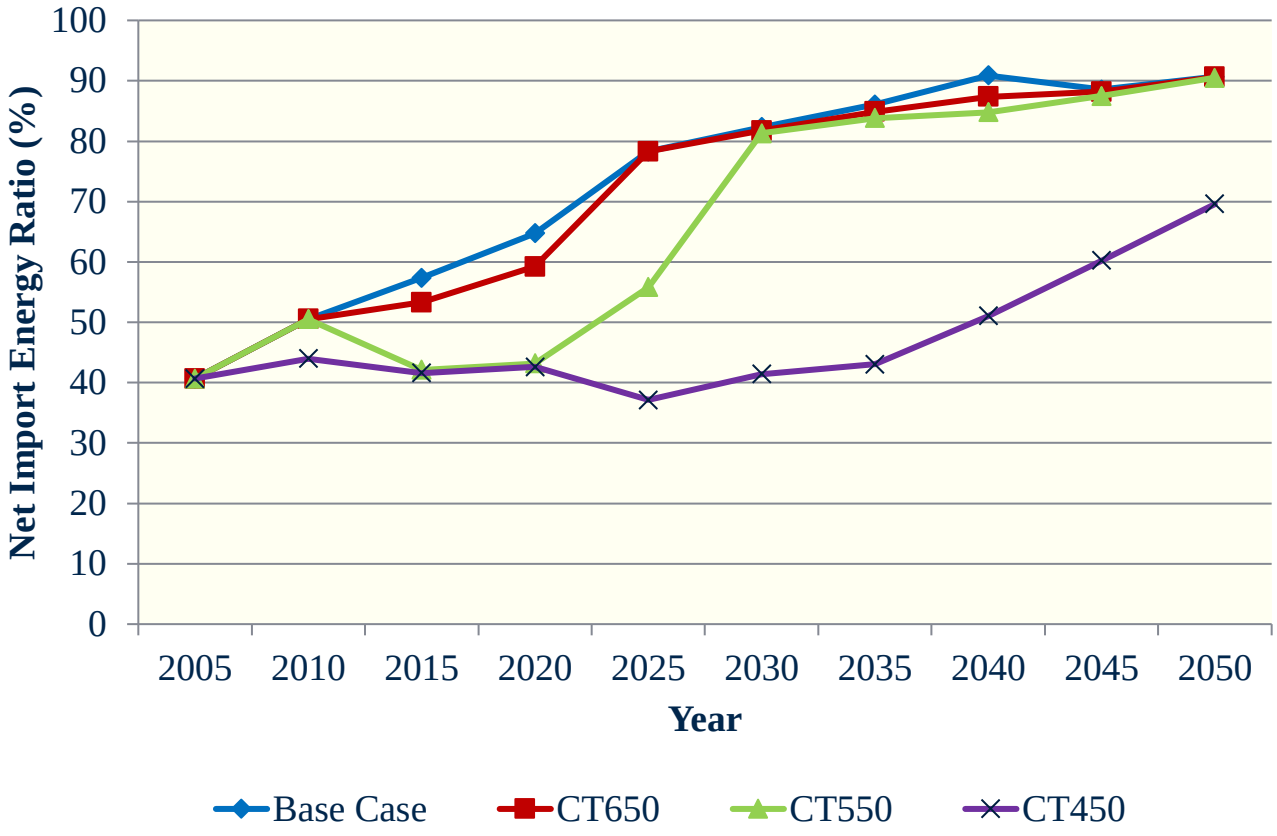
Emission Reduction under the Carbon Tax

Sectors	Base case cumulative CO_2 emission, $MtCO_2$	Cumulative Emission Reduction from the base case emission level under different carbon tax cases, $MtCO_2$		
		CT650	CT550	CT450
Agriculture	42	(4)	(8)	(7)
Commercial	338	0	0	0
Power Generation	1,213	47	102	682
Industry	1,342	27	175	1,058
Residential	12	(1)	(2)	(4)
Transport	1,305	25	25	26
Other	8	0	0	0
Total	4,252	94	292	1,755

Note: The figures in parenthesis denotes an increase in CO_2 emission from base case

- Power sector accounts for the largest share in CO_2 reduction at the low tax case (CT650),
- Industry sector plays the most significant role in emission reduction under the higher tax cases of CT550 and CT450.
- The cumulative emission reduction from the transport sector remains almost unchanged with higher carbon tax.

Variation in net energy import dependency

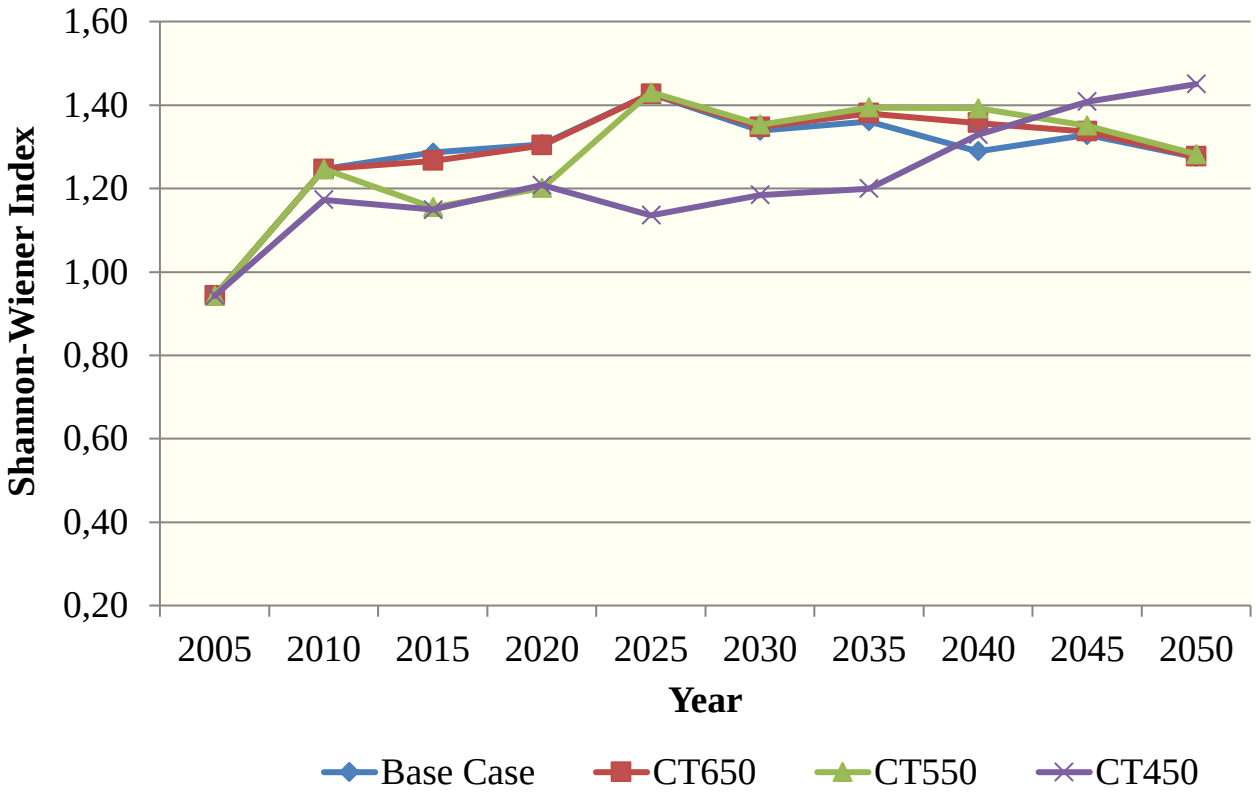


$$NEIR = \frac{NEI}{DS + NEI}$$

NEI = Net Energy Import,
DS = Domestic Supply of Energy

CT450 improve energy import dependency throughout the study period

Variation of energy resources diversification

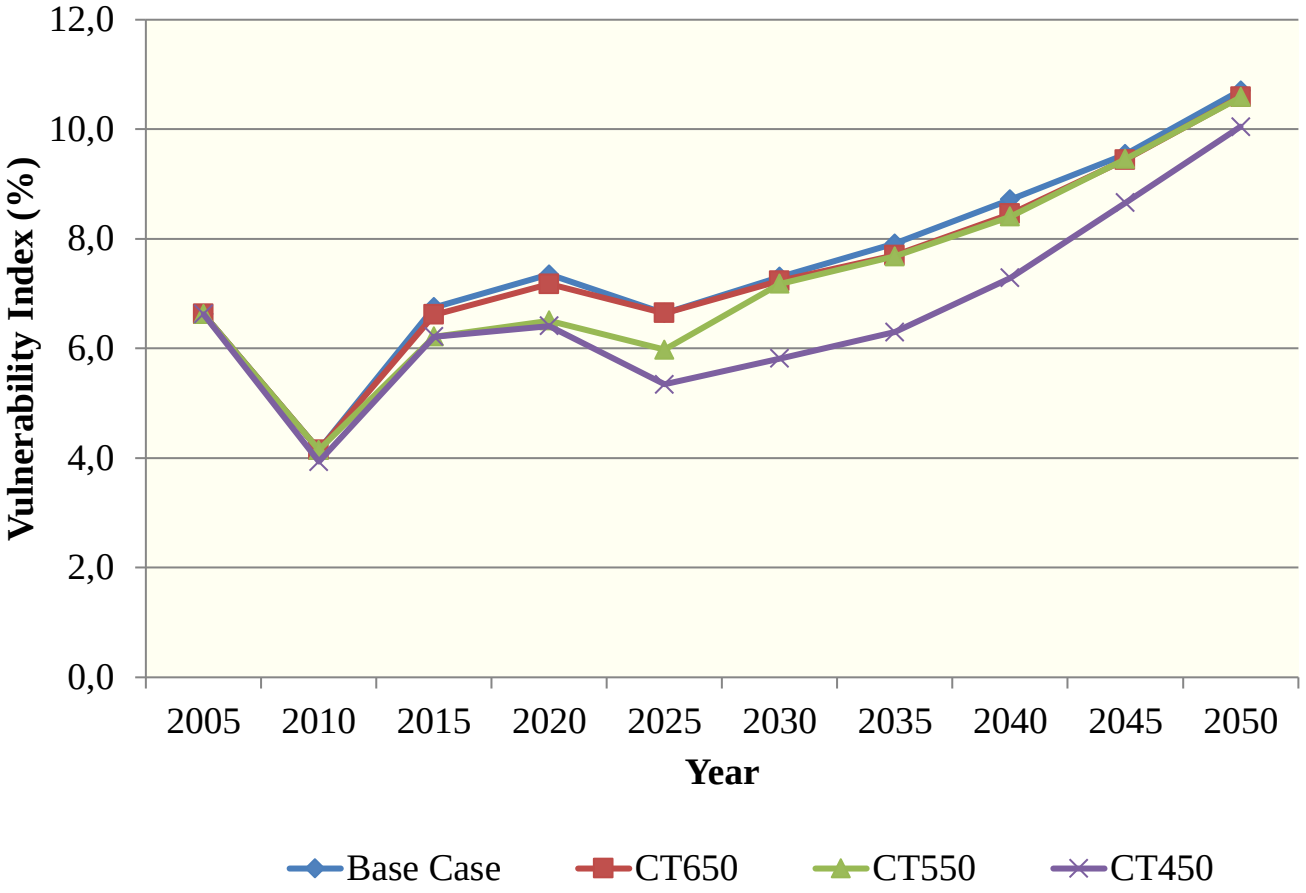


$$SWI = \sum_i -S_i \times Ln(S_i)$$

S_i = Share of primary energy sources i in primary energy supply mix

- Carbon tax fail to improve energy resources diversification throughout the study period.
- Till 2040 energy resources diversification deteriorates with the carbon tax.
- After 2040 it improves with the carbon tax

Variation of Economic Vulnerability



$$VI = \frac{EEI}{GDP}$$

EEI = Expenditure on energy imports
GDP = Gross Domestic Product

Economic Vulnerability is improved with the carbon tax but only CT450 tax shows considerable improvement

Total System Cost

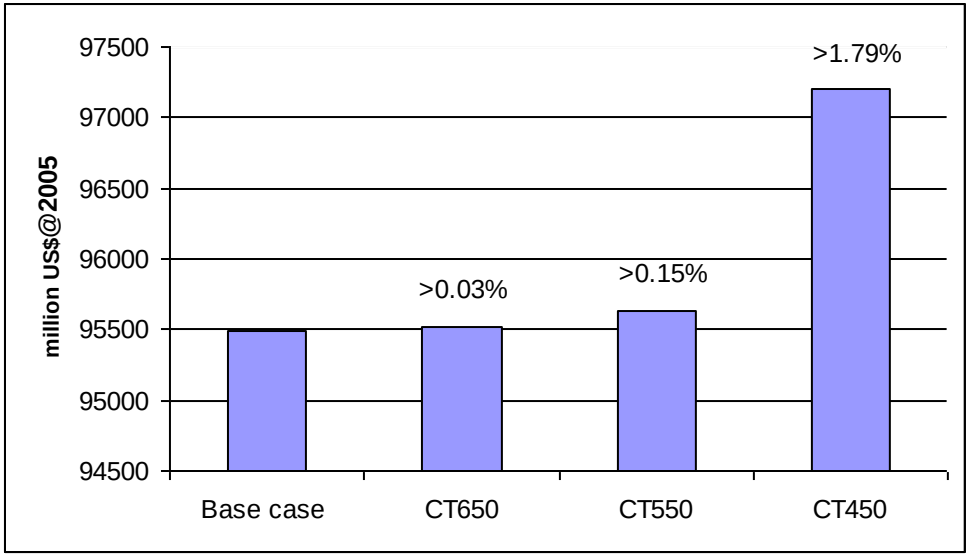
- **There would be a slight increase of total system cost under the carbon tax.**

- **The estimated increase of total discounted system cost is**

CT650 => 0.03%
CT550 => 0.14%
CT450 => 1.79%

Effects of Carbon Tax on Cost: Sri Lankan Case

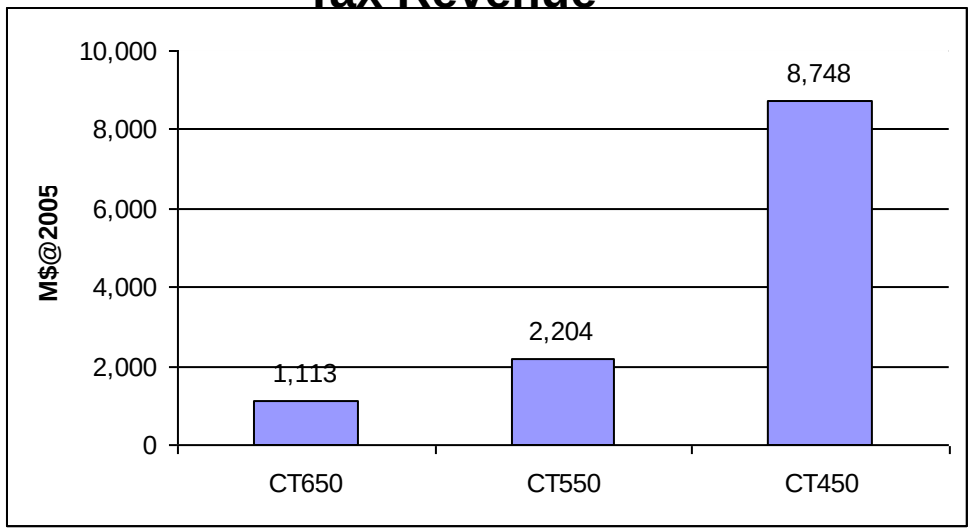
Total System Cost



The total system cost (net of C-tax) increases by 28 MUS$, 139 MUS$ and 1706 MUS$ in CT650, CT550 and CT450 respectively compared to the base case.

Tax as % of base case total system cost increases by 1.2%, 2.3% and 9.2% under CT650, CT550 and CT450 respectively.

Tax Revenue



Source: Shrestha and Opathella, 2009

Conclusions

- A significant decrease in the use of coal fired power generation is to take place under the carbon tax, while there would be an increase in biomass and wind based power generation.

- There would also be an increased use of cleaner coal technologies (with CCS) at higher carbon taxes.

- Significant reductions in net energy import dependency and economic vulnerability would occur with the application of the carbon taxes.

- The carbon tax below certain levels would not be so effective in reducing the CO_2 emission nor in improving the energy security.

- There would be a slight increase in total system cost under the carbon tax.

Thank You !

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Reference Energy System