

THE EFFECTS OF URBANIZATION ON ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS IN ASEAN COUNTRIES: A DECOMPOSITION ANALYSIS

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1. Introduction to ASEAN

ASEAN – Association of Southeast Asian Nations consists of 10 countries



	ASEAN	EU	World
Area <i>million km²</i>	4.4	4.4	
Population <i>million people</i>	625	508	
GDP annual growth rate %	4.9	1.9	3.5
% Urban population	52.2	71.3	60.2
Urban population annual growth rate %	3.0	0.9	2.1
Energy intensity <i>koe/\$</i>	0.174	0.111	0.157
CO ₂ emission annual growth rate %	6.1	-5.6	0.8

Resources: World Bank database – 2016, IEA - 2016

2. Motivation & Objectives

Literature review of the studies for relationship between Energy Consumption, Emission & Urbanization

Level	No. of studies	year			Results			Method			Variable				
		1989-2000	2000-2010	2010-now	+	-	~	Re	De	Other	GDP	EC	Em	El	Others
Multi-country	16	4	4	8	9	2	5	13	0	3	17	15	6	3	1
Country/Sector	26	3	9	14	13	4	9	19	3	10	23	22	1	4	9

Acronyms:

“+”: increase effect, “-”: decrease effect, “~”: unclear effect.

Re: Regression; De: Decomposition; EC: Energy consumption; Em: Emission, El: Energy Intensity

Issues:

1. Comparison between countries & sectors
2. Partly conflicting results
3. Methodology limitations
4. Variable selection : Urbanization definition, Emission & Energy intensity

Objectives:

1. Estimate the urbanization effect and other contributions effects on energy consumption & emission by new approach
2. Compare the effects in multi-level in ASEAN
3. Propose some suggestions for policy makers

3. Methodology

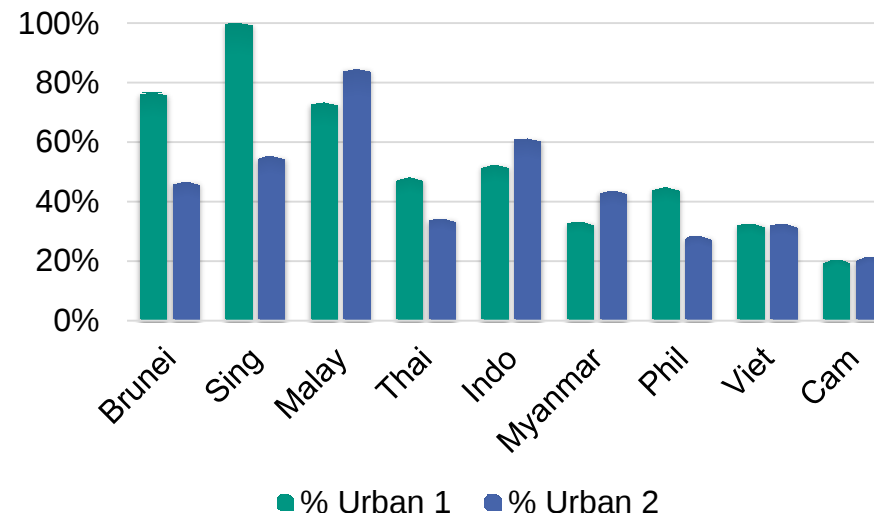
IDA – Index Decomposition Analysis

$$\Delta C_j = \Delta C_{emf} + \Delta C_{mix} + \Delta C_{int} + \Delta C_{str} + \Delta C_{act} + \Delta C_{de} + \Delta C_{rsd}$$

Effect	Emission-factor	Energy-mix	Energy intensity	Economic structure	Activity	Demographic
Symbol	$\Delta C_{emf} = \Delta \frac{C_{ij}}{E_{ij}}$	$\Delta C_{mix} = \Delta \frac{E_{ij}}{E_j}$	$\Delta C_{int} = \Delta \frac{E_j}{VA_j}$	$\Delta C_{str} = \Delta \frac{VA_j}{GDP}$	$\Delta C_{act} = \Delta \frac{GDP}{De}$	$\Delta C_{de} = \Delta De$

- C: Emission
- E: energy consumption
- VA: Value added
- De: Demographic
- i: fuel (oil, gas, coal)
- j: sector (commercial, industrial, transportation, residential)

Comparison the proportion of 2 types of urban



1st - Population

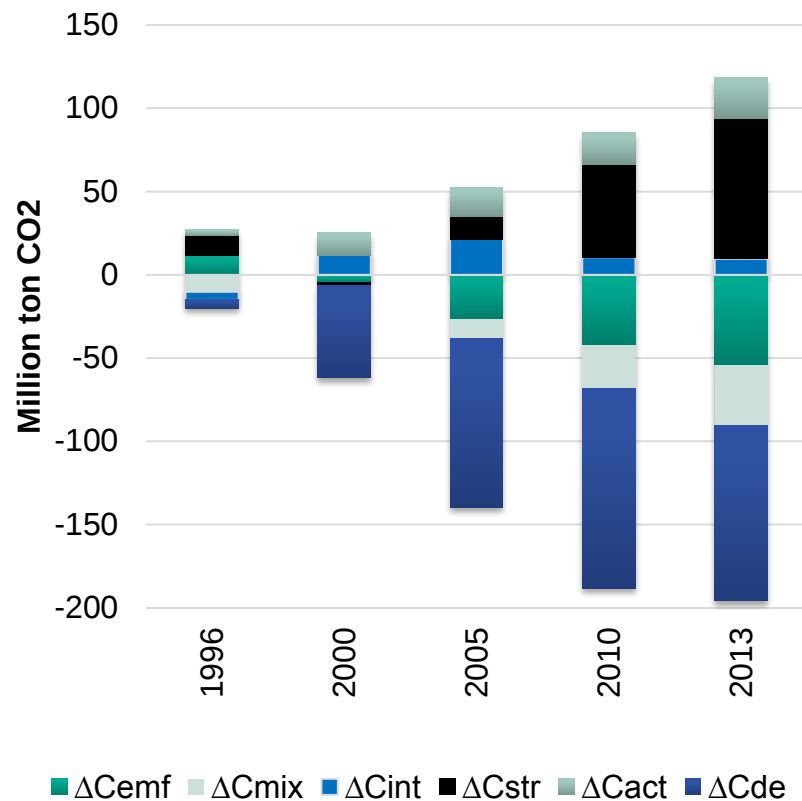
2nd - Urban 1 –
Population in urban areas

3rd - Urban 2 –
No. of non-agriculture
employees

4. Results: different effects

Different effects on CO2 emission from 1995-2013

Philippines



	Emission-factor	Energy-mix	Energy intensity	Economic structure	Activity	Demographic
Brunei	-	-	-	-	+	+
Cambodia	+	+	+	+	+	+
Malaysia	+/-	+/-	+	-/+	+	+
Myanmar	-	-	-	+	+	+
Philippines	-	-	+	+	+	-
Thailand	-	+/-	+	-/+	+	+
Vietnam	-	+	-	+	+	+

“+”: increasing effect, “-”: decreasing effect,

“+/-”: change from increasing to decreasing

“-/+”: change from decreasing to increasing

4. Results: different effects by sector

Different effects on CO₂ emission by sectorial in Philippines from 1995-2013

	Emission-factor	Energy-mix	Energy intensity	Economic structure	Activity	Demographic
Commercial	+	+	-	+	+	-
Industrial	-	-	+/-	+	+	-
Transportation	-	/	+	+	+	-
Residential	+	-	+	/	+	-

“+”: increasing

“-”: decreasing

“+/-”: change from increasing to decreasing

“-/+”: change from decreasing to increasing

4. Results:

Normalized effect of Urban 1 on Energy Consumption

EC	Brunei	Cambodia	Malaysia	Myanmar	Philippines	Thailand	Vietnam
Commercial	+	+	+	+	+	+	++
Industrial	++	++	+++	++	++++	++	+++
Residential	++++	++++	++++	++++	++	+++	++++
Transportation	+++	+++	++	+++	+++	++++	+

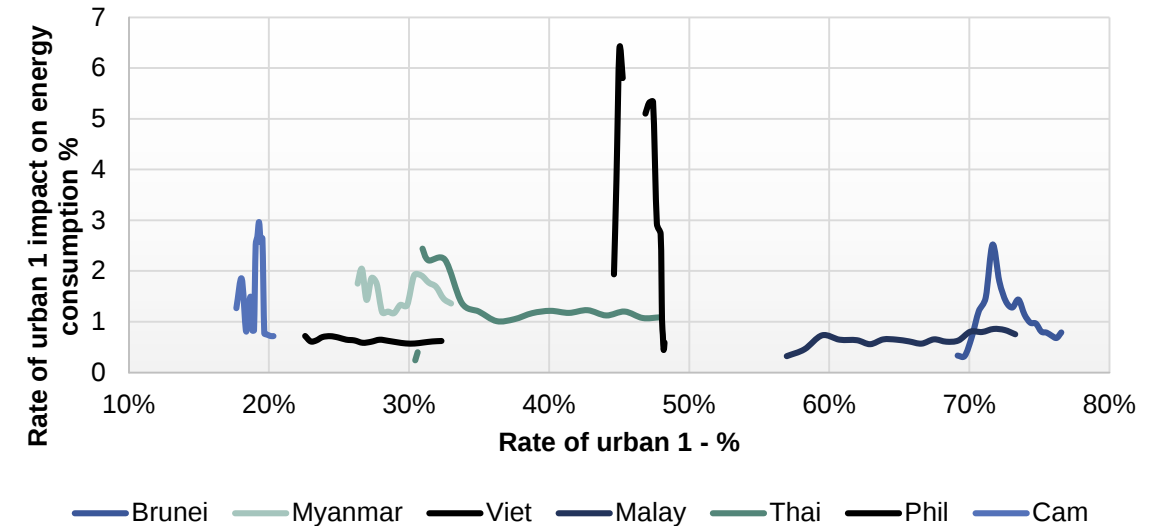
4. Results: demographic effects

Average demographic effect on Energy Consumption
from 1995-2013

	Population	Urban 1	Urban 2
Brunei	1.00	1.33	1.40
Cam	1.00	1.48	3.53
Malay	1.00	1.81	1.55
Myan	1.00	2.24	3.41
Phil	1.00	0.82	1.86
Thai	1.00	3.49	3.25
Viet	1.00	2.57	4.66

Multi-country comparison

- **Urban 1 & 2** effect more than **Population**
- Notable effect in Cambodia & Philippines
- Constant effect in Vietnam & Malaysia
- Urban 1 & 2 increase their effects in the first phrase and decrease gradually after that
- Urban factors co-variate with energy consumption



Sectorial comparison across countries

On Energy consumption

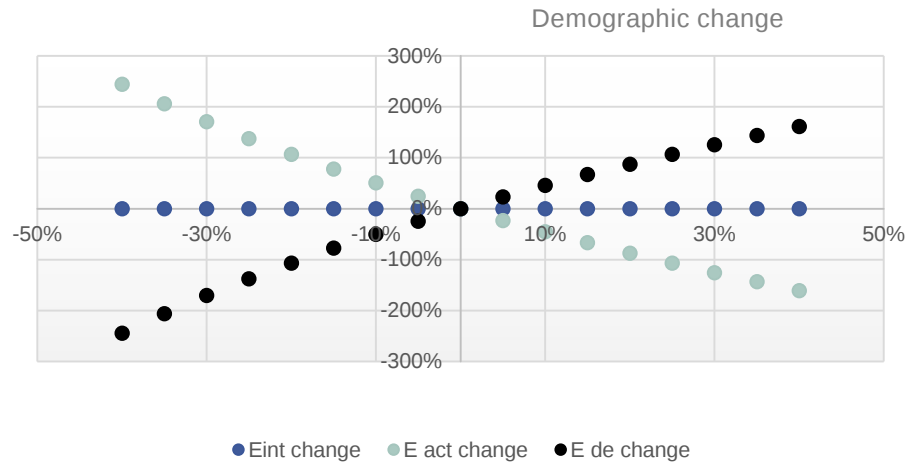
- Strongest effect in residential sector
- Weakest effect in commercial sector

On CO2 Emission

- Strongest effect in transportation
- Weakest effect in residential sector

4. Critique of the methodology

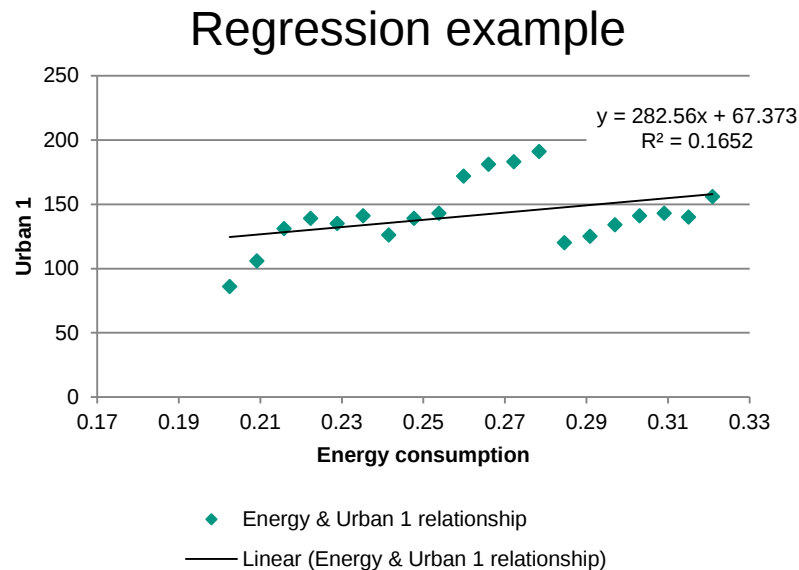
Sensitivity analysis



Every 1% variation in the input could change

- Activity effect: about -5.5%
- Demographic effect: 5.5%
- Energy intensity effect: 0%

Pros & Con of the method



Advantages of decomposition:

- Deal with non-linear relationship
- Comparison in multi-level across countries
- Assess the hidden effects as energy structure & economic structure

Disadvantages of decomposition:

- Collecting & synchronizing data
- Choosing appropriate decomposition analysis
- Problem with 0 value in datasets

5. Conclusion & Outlook

Demographic effect:

- The effects on Energy Consumption & Emissions: Urban 2 > Urban 1 > population
- Urbanization increases Energy Consumption & Emissions
- Urbanization has the greatest impact on
 - Transportation emission
 - Residential energy consumption

Other effects on Energy & Emissions:

- Increasing factors: Activity, Economic Structure
- Decreasing factors: Energy intensity: most progress in industrial

Suggestions for Policy-makers:

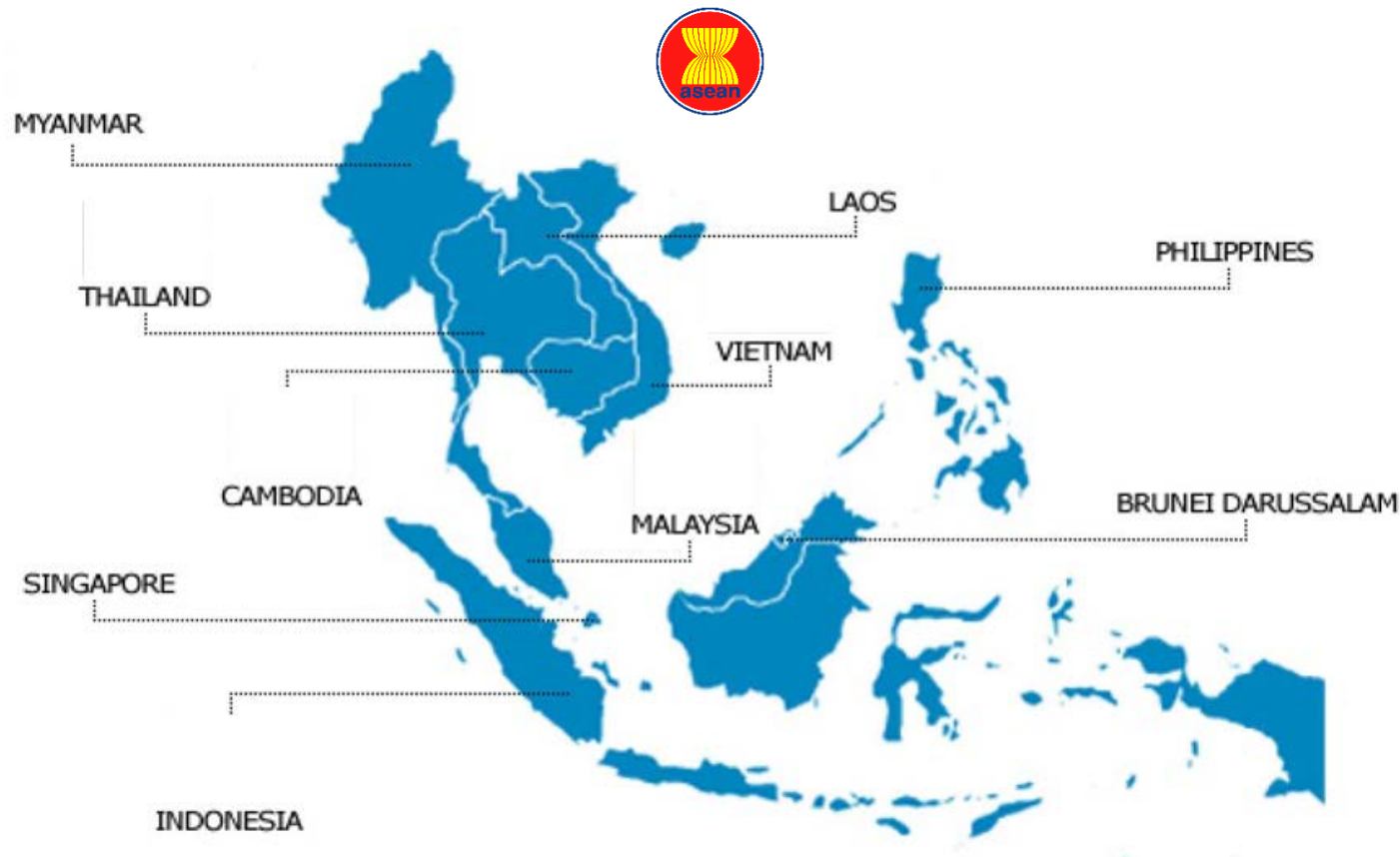
- Consider urbanization instead of population as a energy consumption & emission problem
- Focus efforts on finding an optimal solution to decentralized, efficient energy system for urban cities
- Focus efforts on decreasing transportation emission

Outlook:

- Consider different urbanization indicators (population and/or urban density)
- Improve database by applying bottom-up approaches
- Using decomposition combined with regression to forecast energy demand

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Resources: World Bank database – 2016, IEA - 2016

Thank you for attention

Feedback & Questions

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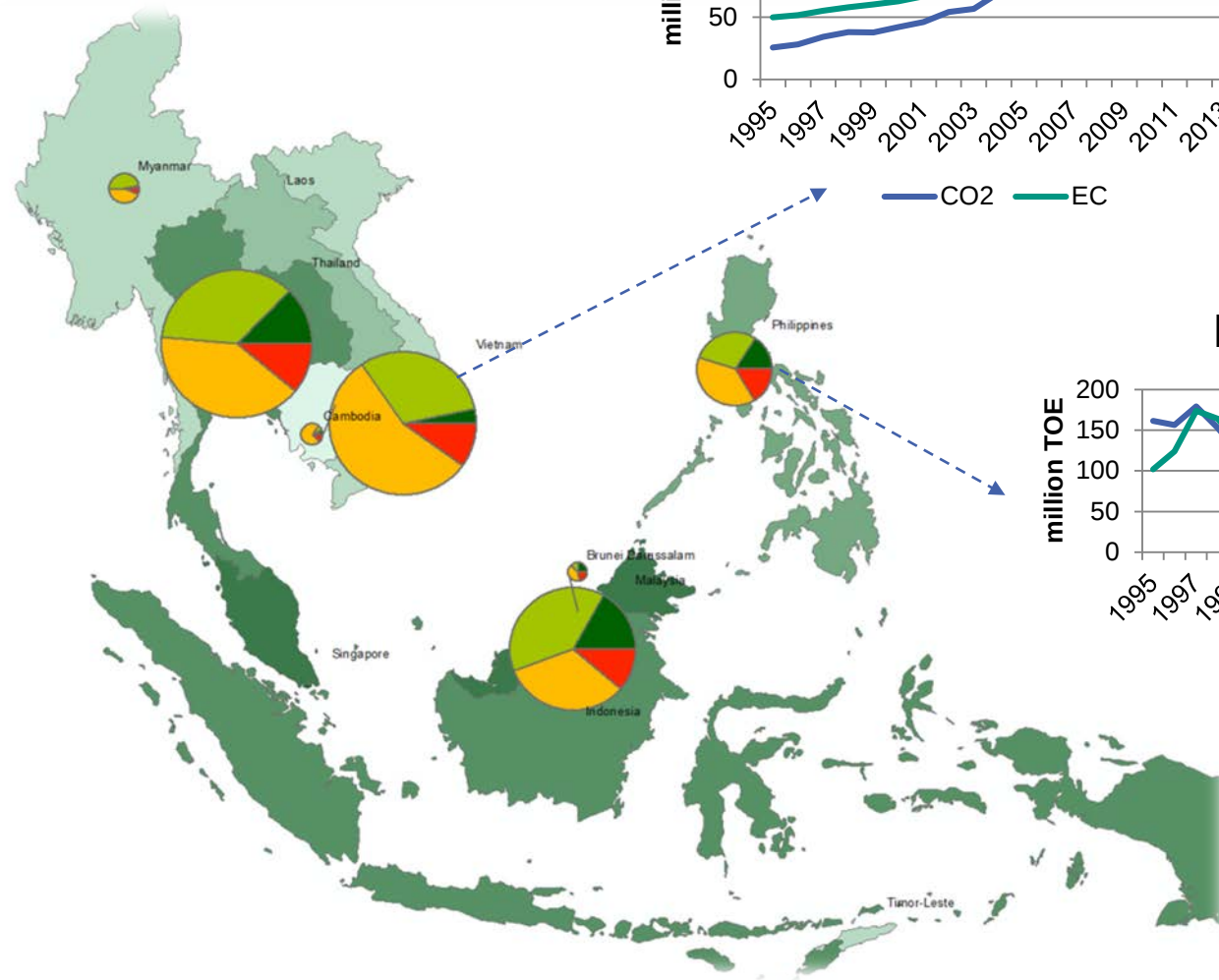
1. Introduction to ASEAN

CO2 emission from 1995 to 2013.
Unit: million ton CO2

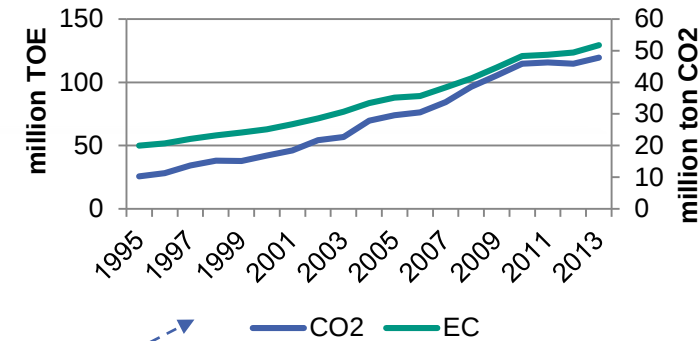
- CO2 – Commercial
- CO2 – Industrial
- CO2 – Transportation
- CO2 – Residential

Urban percentage

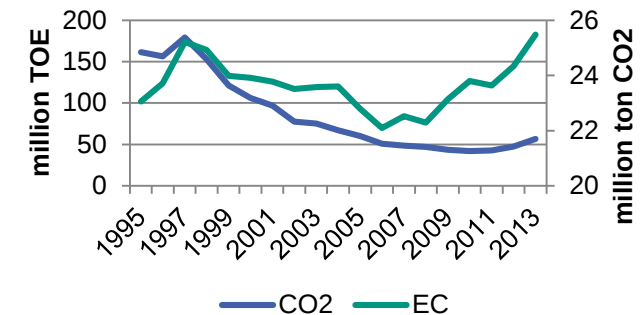
- 21
- 22-34
- 35-38
- 39-44
- 45-54
- 55-77
- 78-100



Vietnam



Philippines



3. Methodology & Database

Database: 7 countries from 1995 - 2013

Sector	Activity	Energy data	Emission data	Demographic
Residential	Number of households – <i>National population censuses report</i>	Fuel, renewable, electricity - <i>IEA 2015</i>	CO2 emission from fuel combustion - <i>IEA, 2016</i>	Population, Urban 1, Urban 2 – <i>World Bank 2015</i>
Commercial	Added Value, GDP – <i>World Bank 2015 & ADB database 2015</i>	Fuel – <i>IEA 2015</i>		
Industrial				
Transportation				

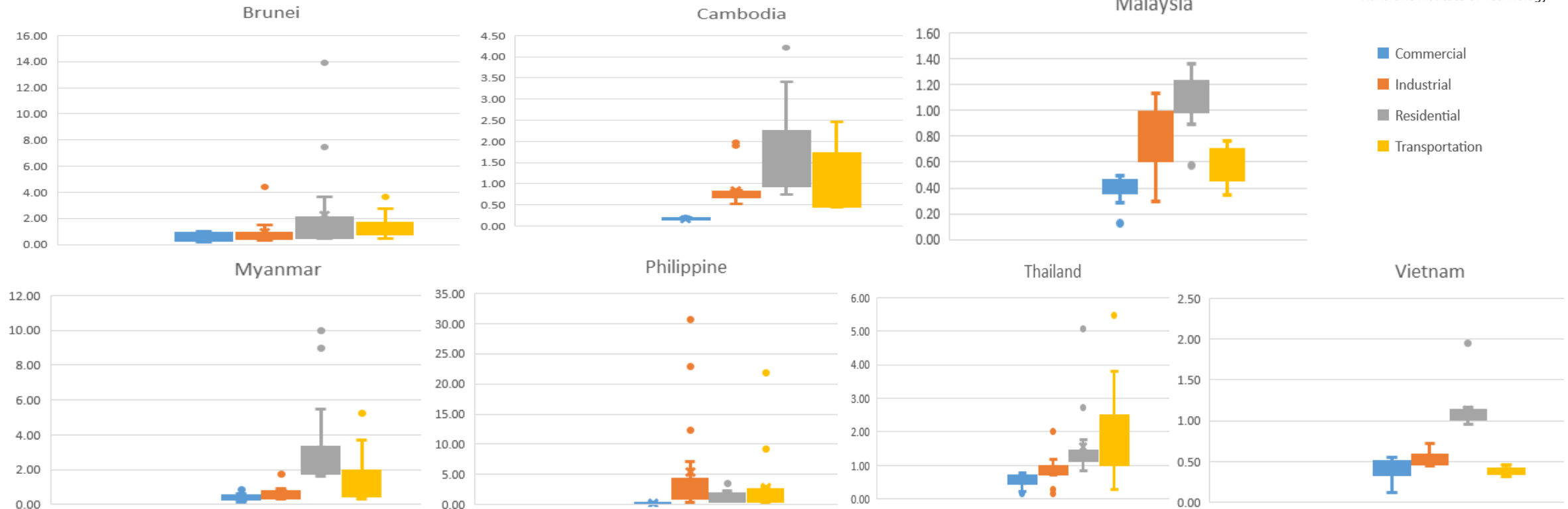
4. Results:

Normalized effect of Urban 1 on Emissions



	Brunei	Cambodia	Malaysia	Myanmar	Philippines	Thailand	Vietnam
Commercial	+++	++	++	+	+++	++	+
Industrial	++++	+	++++	+++	+	+++	++++
Residential	++	+++	+	++	++	+	++
Transportation	+	++++	+++	++++	++++	++++	+++

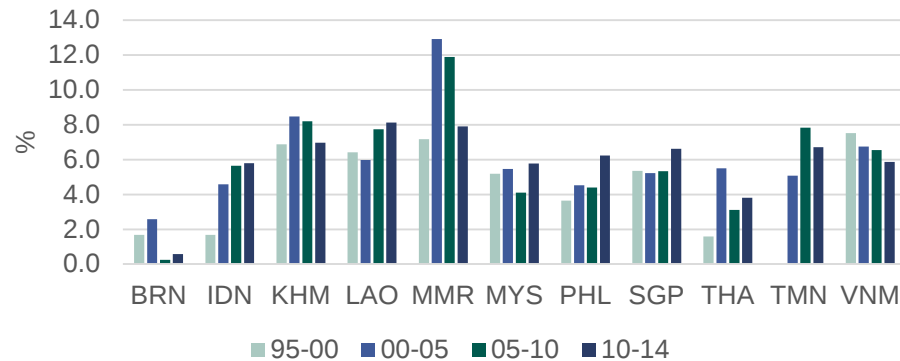
Energy consumption



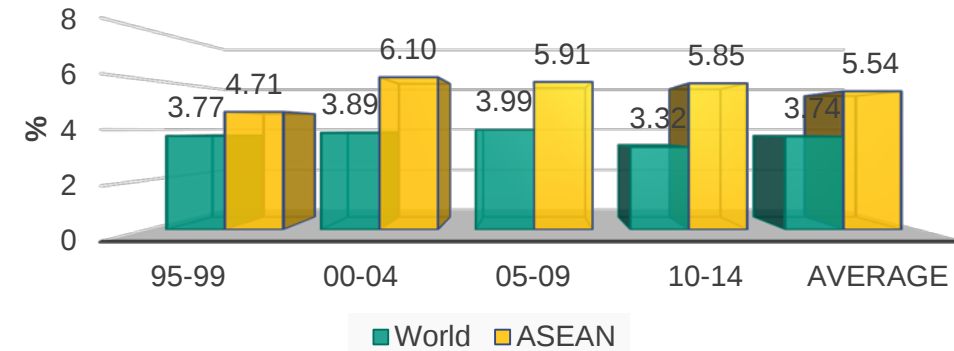
EC	Brunei	Cambodia	Malaysia	Myanmar	Philippines	Thailand	Vietnam
Commercial	+	+	+	+	+	+	++
Industrial	++	++	+++	++	++++	++	+++
Residential	++++	++++	++++	++++	++	+++	++++
Transportation	+++	+++	++	+++	+++	++++	+

ASEAN status

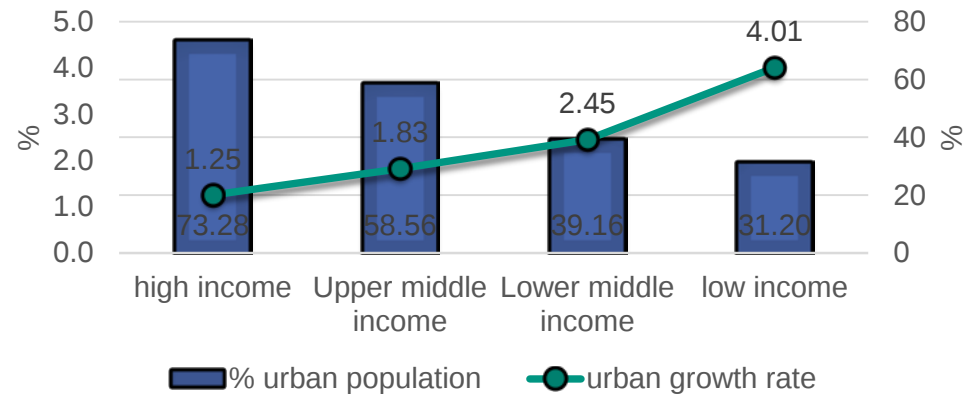
Average GDP growth rate in ASEANs



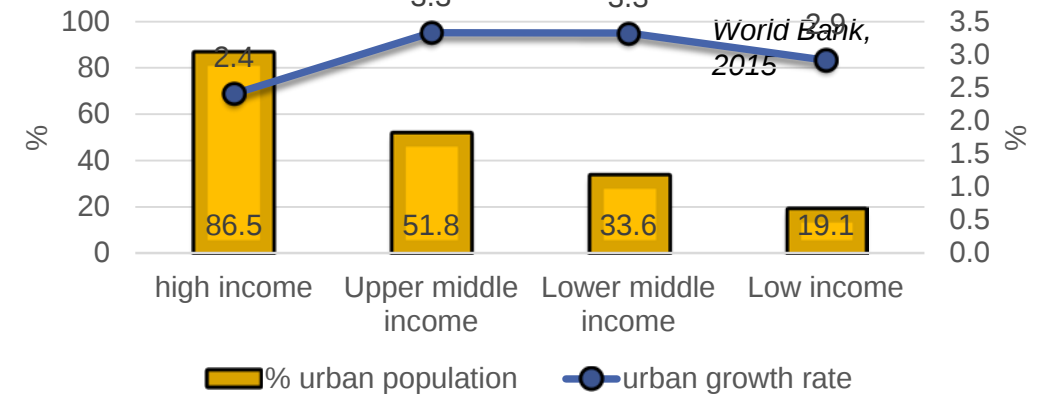
Average GDP growth rate over the World & ASEAN from 1995-2014



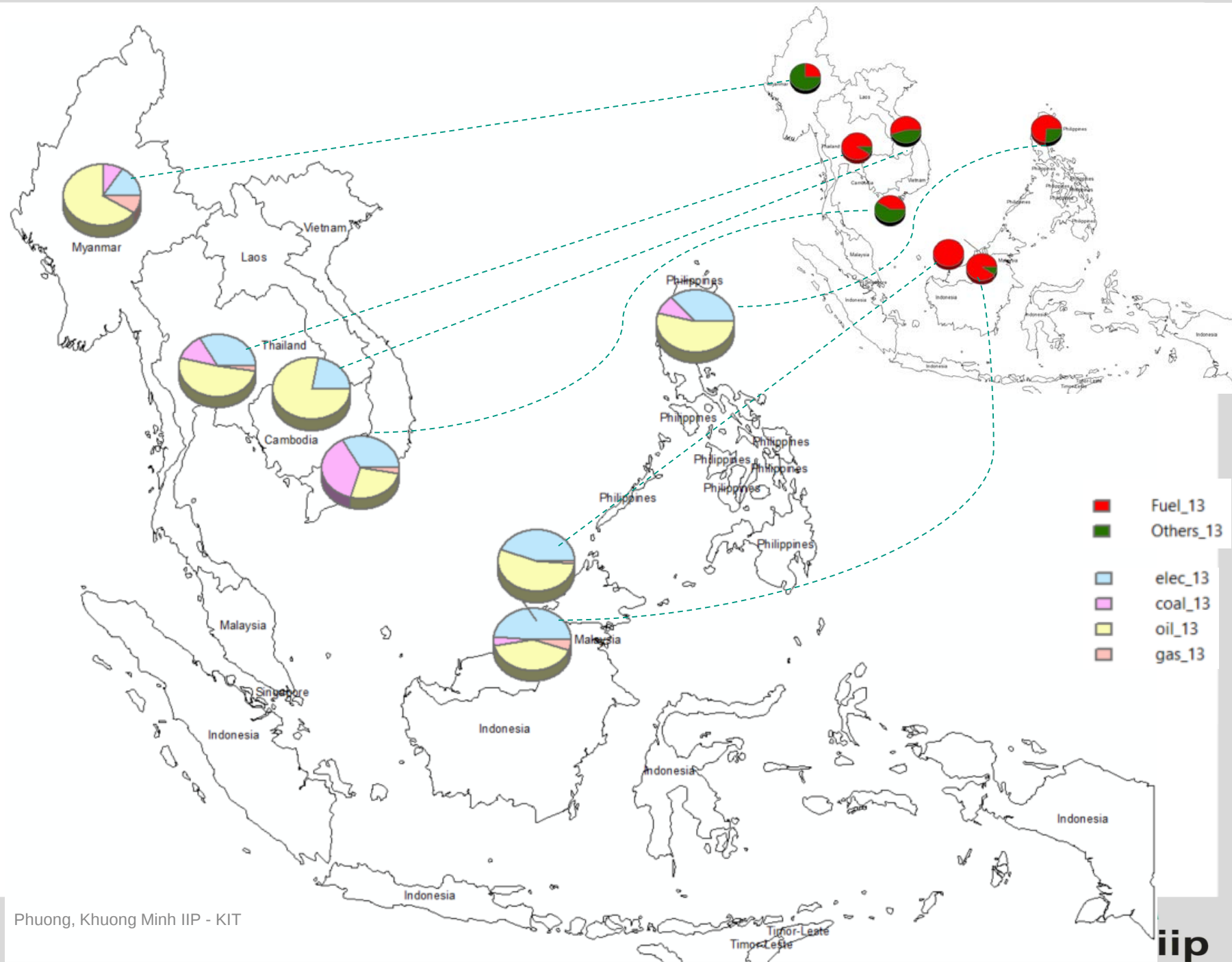
The World

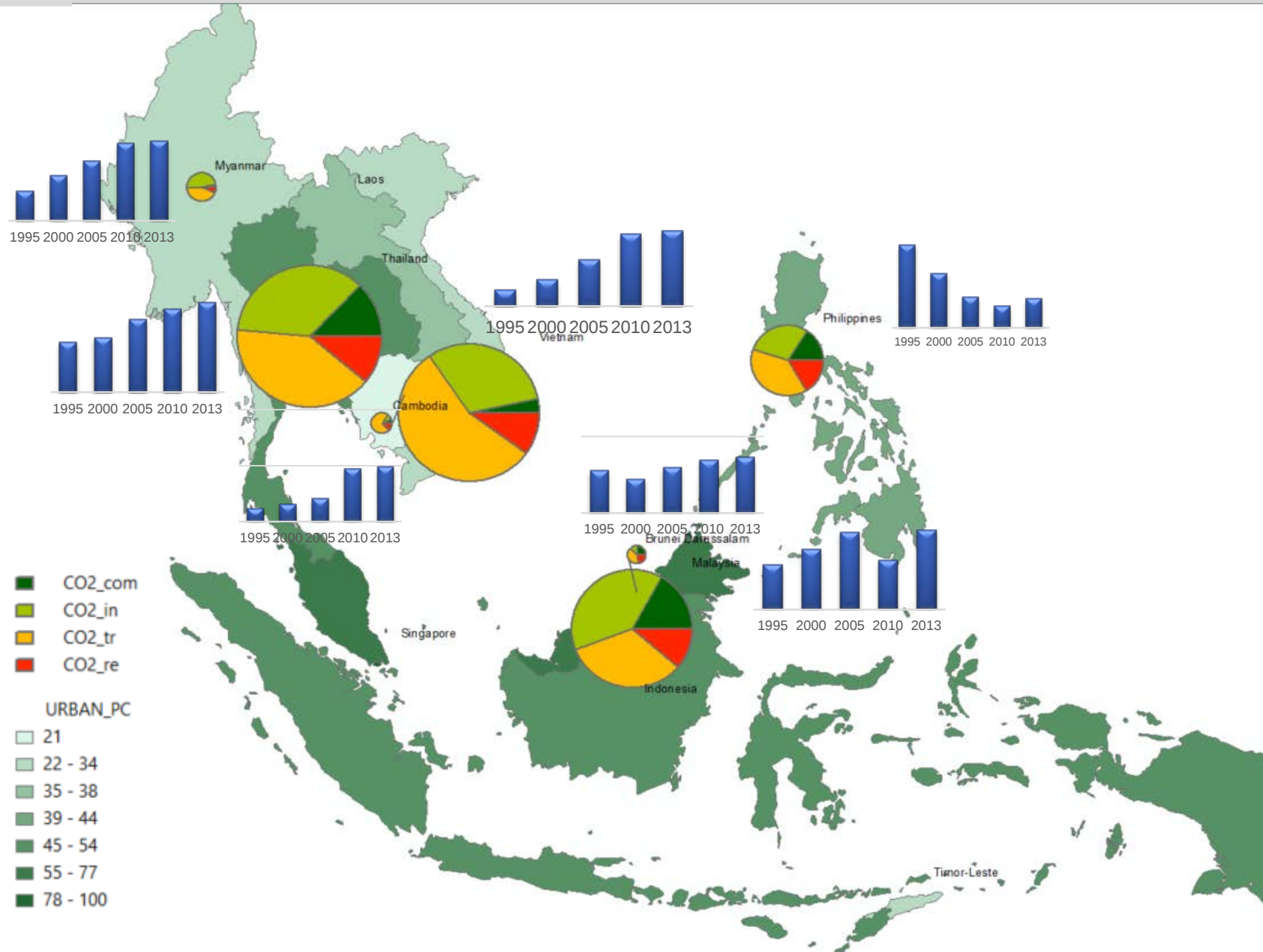


ASEAN

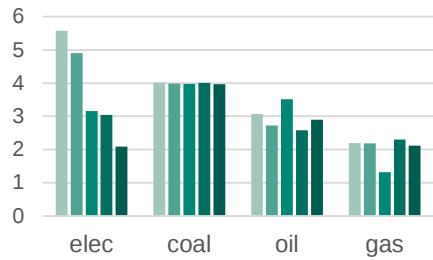


World Bank, 2015

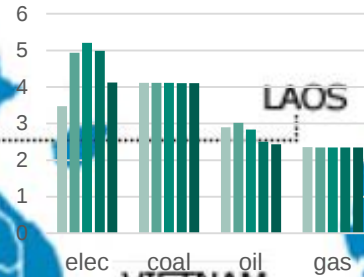




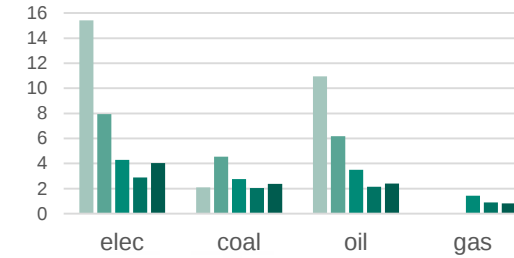
CO2 intensity 1995-2013. Unit: kgCo2/Toe



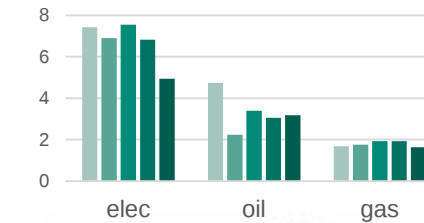
MYANMAR



LAOS



PHILIPPINES



BRUNEI DARUSSALAM

SINGAPORE

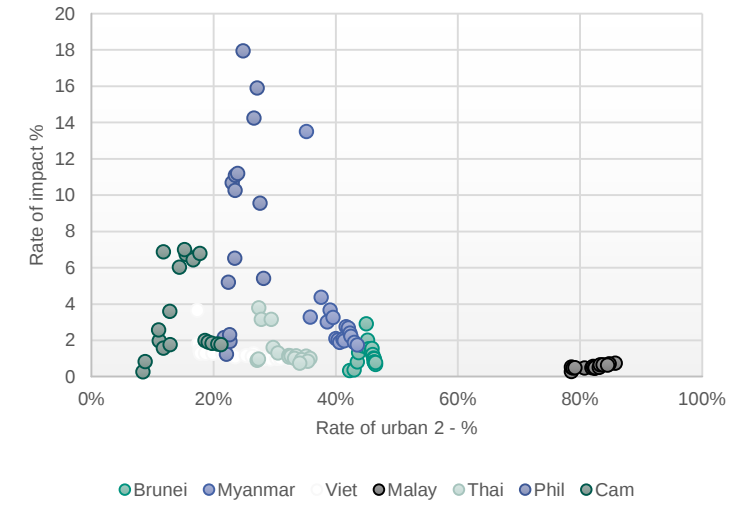
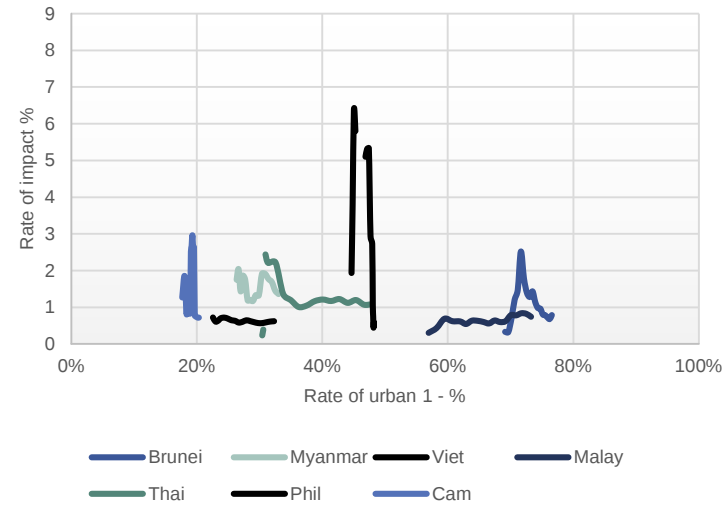
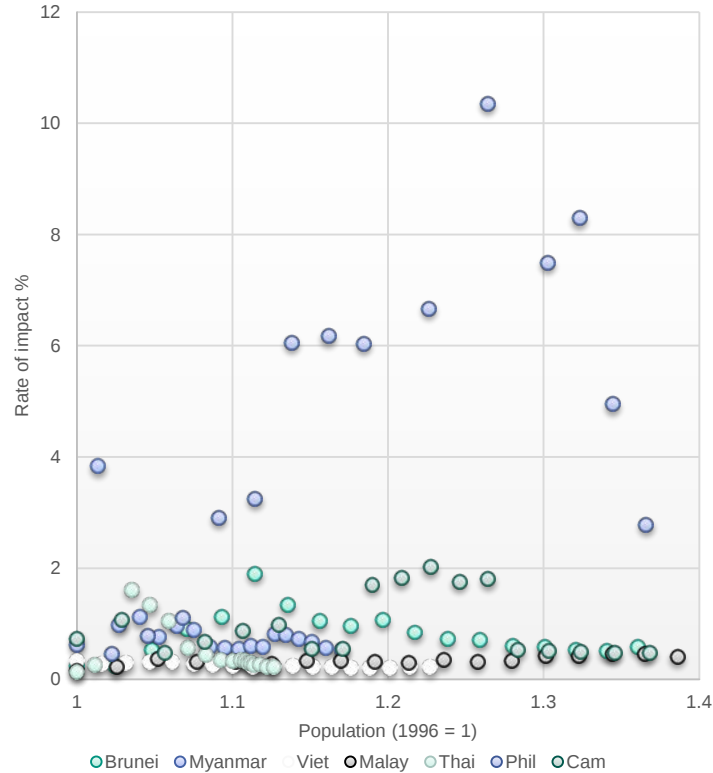
INDONESIA

CAMBODIA

MALAYSIA

VIETNAM

Urbanization effect on Energy Consumption



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3. Methodology selection

Limitation	Regression
Data	Require large data sets
	Difficult to deal with unbalanced data (missing data & different criterial)
Method	Complex in defining & considering the relationship between dependent and independent variables
	Not a strong tool in comparison
	Overlooks the effect of structure (i.e. energy structure & economic structure)

IDA – Index Decomposition Analysis

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Effect	Emission intensity	Energy mix	Energy intensity	Economic structure	Activity	Demographic
Symbol	ΔC_{emf}	ΔC_{mix}	ΔC_{int}	ΔC_{str}	ΔC_{act}	ΔC_{de}