Analysis of the effects of the Thai Power Development Plan 2015 on air quality from 2016 to 2036 using GAINS and CAMx

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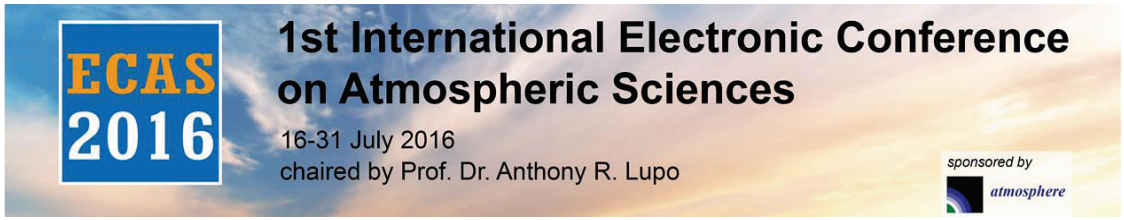

Abstract: Air pollution is a serious issue that affects many parts of the world, Southeast Asia in particular. Nitrogen dioxide, particulate matter, sulfur oxides, and other emissions have negative impacts on human health as well as overall environmental quality. The major sources in Thailand are open burning and fossil fuel combustion, both in vehicles and power generation. Given increasing actual and projected GDP growth, subsequent increases in energy consumption are inevitable. The power generation system must grow and expand as well to meet changes in demand from industrial, commercial, and residential customers. The Ministry of Energy of Thailand has published the Power Development Plan 2015 (PDP 2015) to outline policies and goals of the growing power generation and transmission systems throughout the nation. Notably, the plan involves increasing the use of coal-fired generation. Using both the Greenhouse Gas and Air Pollution Interactions and Synergies Model (GAINS) and the Comprehensive Air Quality Model with Extensions (CAMx), we have compared two different emissions scenarios: one with standard emission control technology, and another with maximum emission controls. The effectiveness of emission control technology varied by region and pollutant. The greatest increase in air quality was located around Rayong province of the eastern region. For PM10 in the north, however, emission control technologies did little to increase air quality because the main source of pollutant, biomass burning, was left unabaited. This forecast of air quality can show possible impacts from future air quality in Thailand and regions that may benefit from added emission control technology in the future.

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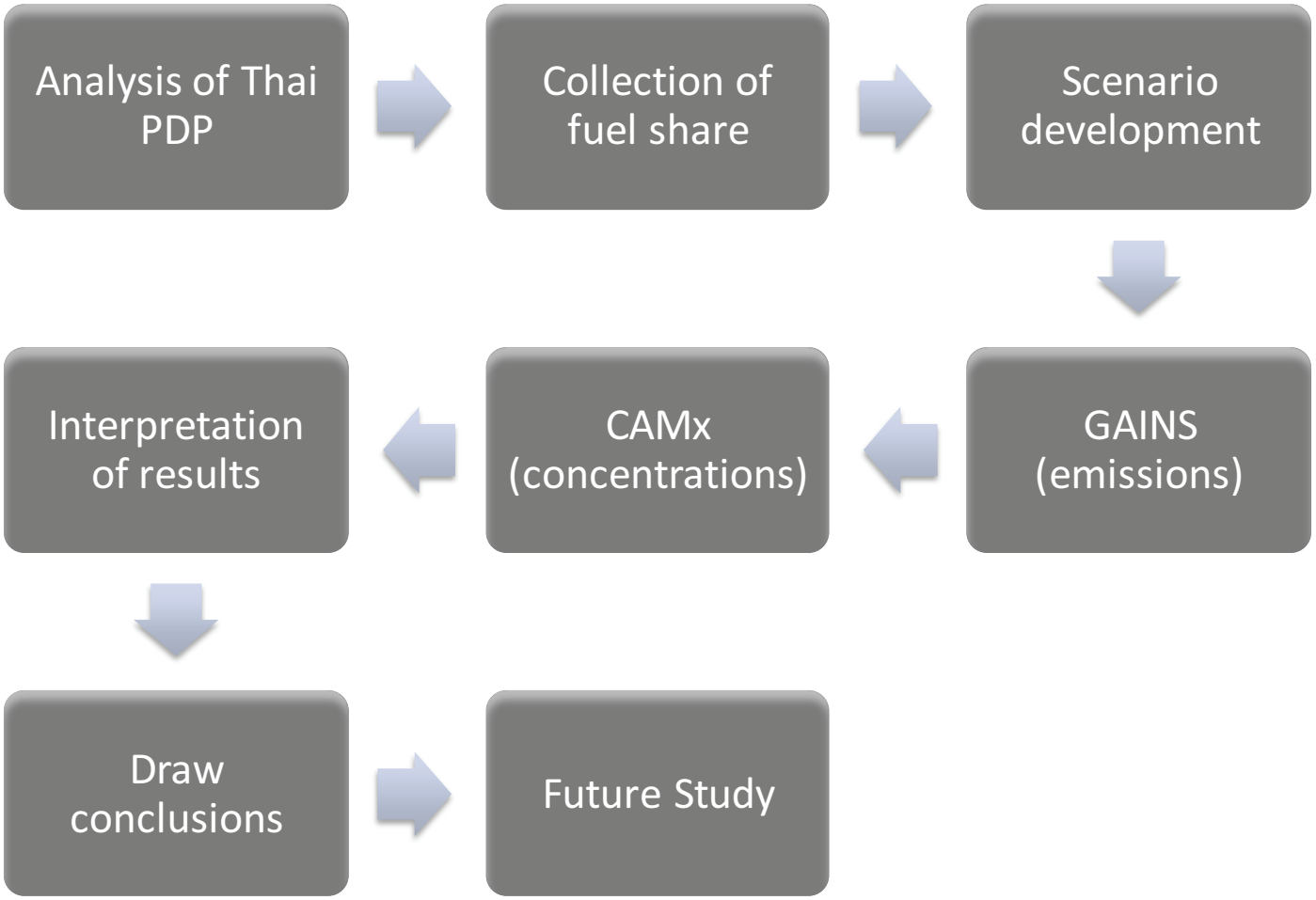
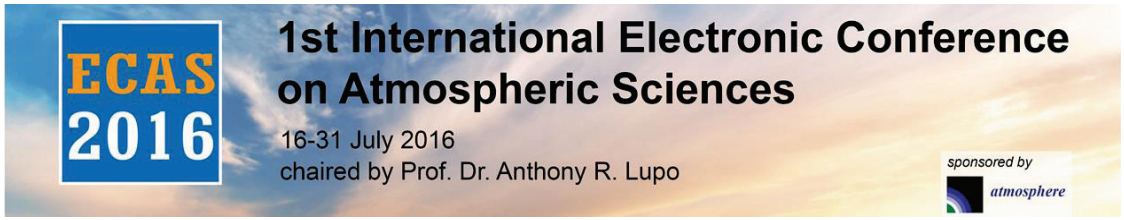
Methodology





Thai Power Development Plan 2015

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PDP
GAINS
Fuel Data
Scenario Development
GAINS Results
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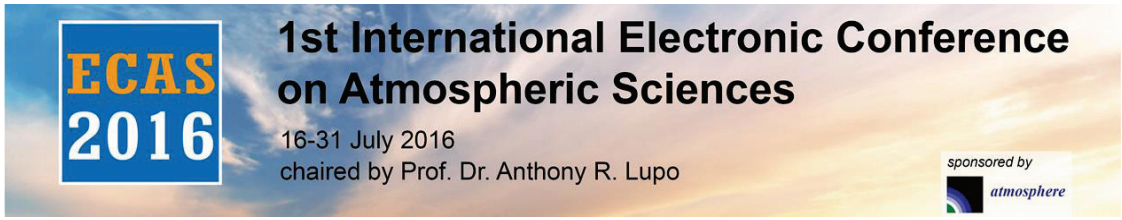
CAMx Results
Discussion
Conclusion

- Published in 2015, projected growth of power sector to 2036
- Highlights changes in fuel share (coal, natural gas, etc.)
- 3 mains goals
  - Increase energy security
  - Maintain reasonable cost to consumer
  - Reduce Greenhouse Gas emissions



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PDP 2015 Revision

- Methodology
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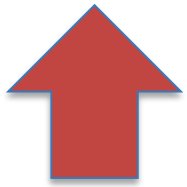
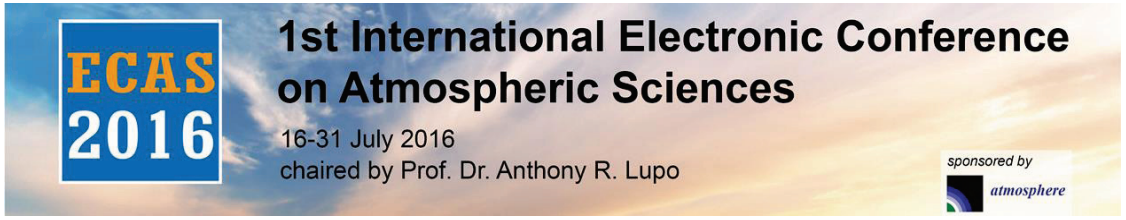
Year	PDP2010 Rev3		PDP2015		Change	
	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak %	Energy %
2016	32,000	211,000	30,000	198,000	-6	-6
2026	46,000	305,000	41,000	268,000	-11	-12
2030	52,000	347,000	44,000	292,000	-15	-16
2036	-	-	50,000	326,000	-	-





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PDP net capacity

- Methodology
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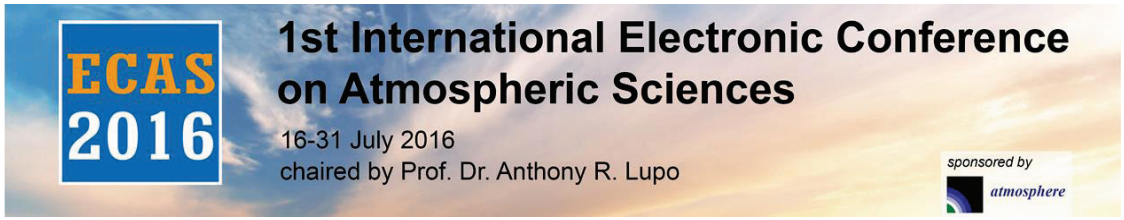
Generating Capacity contributors during 2015-2036	(MW)
~~Existing capacity as of December 2014	38,000
≈≈New capacity during 2015-2036	**57,000**
~~Retired Capacity during 2015-2036	-25,000
~~Total Capacity in 2036	70,000



~~New capacity during 2015-2036	57,000

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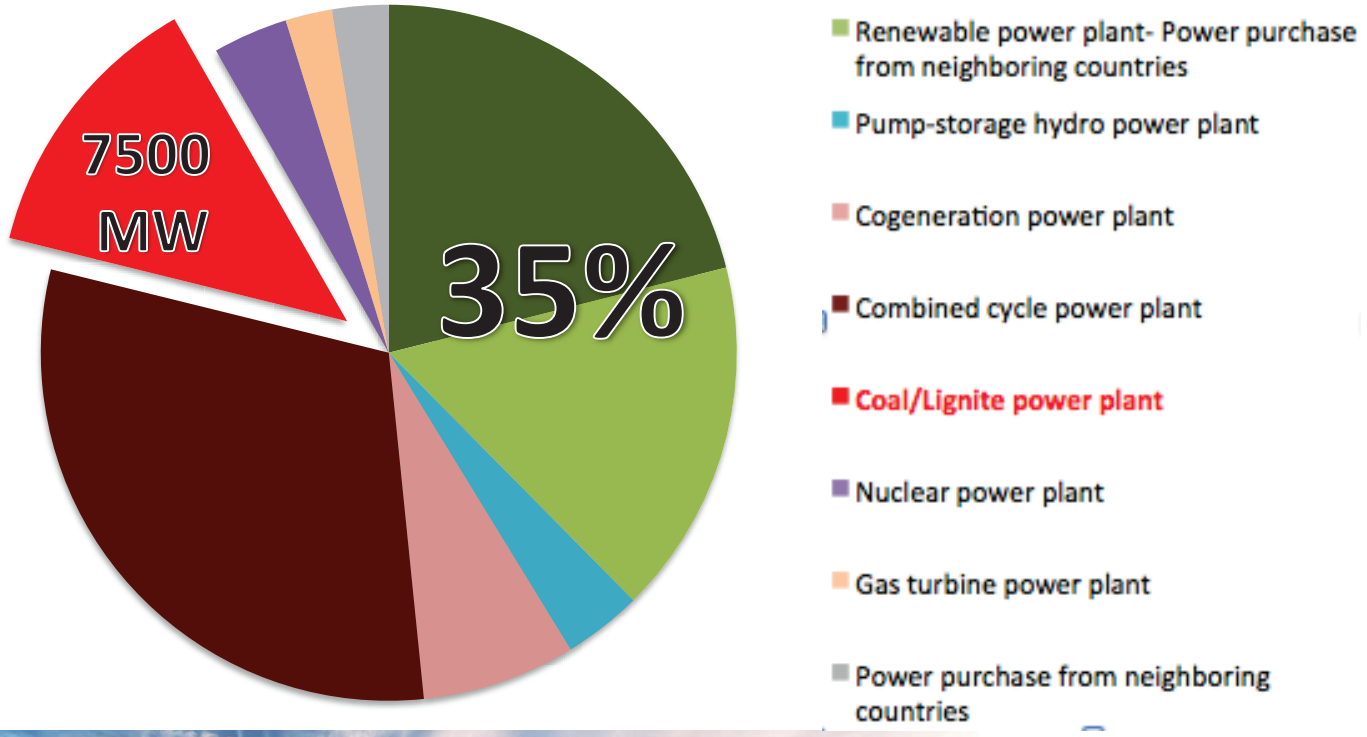
Breakdown of capacity to be added during 2015-2036 (Total=57,000 MW)



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GAINS model

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Raw fuel data

Analyze ETP and TCAP project

Input scenarios into GAINS

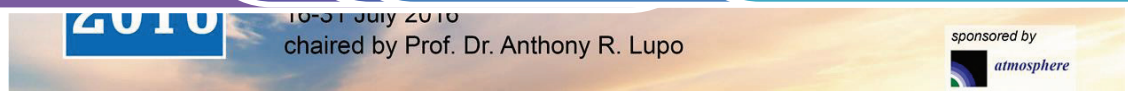
Ran model for specified time scale

Obtained emissions output

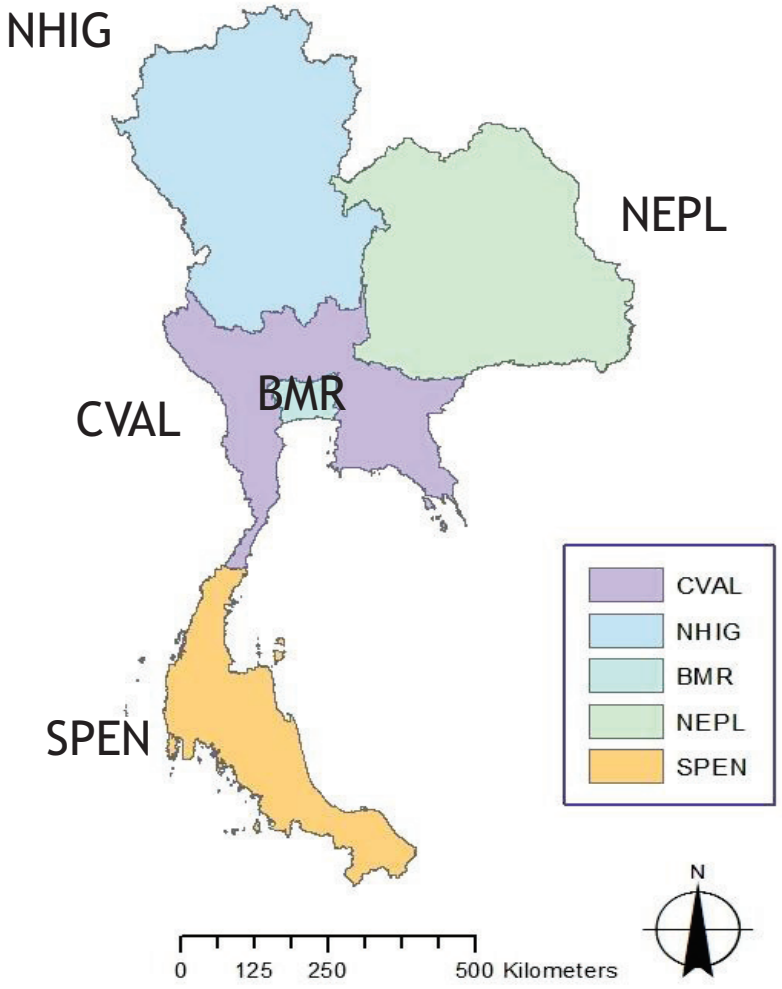
Analyze to GAI

On al species regior 2016 a five ye

Used as input to CAMx model



GAINS Regions



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Input Fuel Data to GAINS

- Methodology
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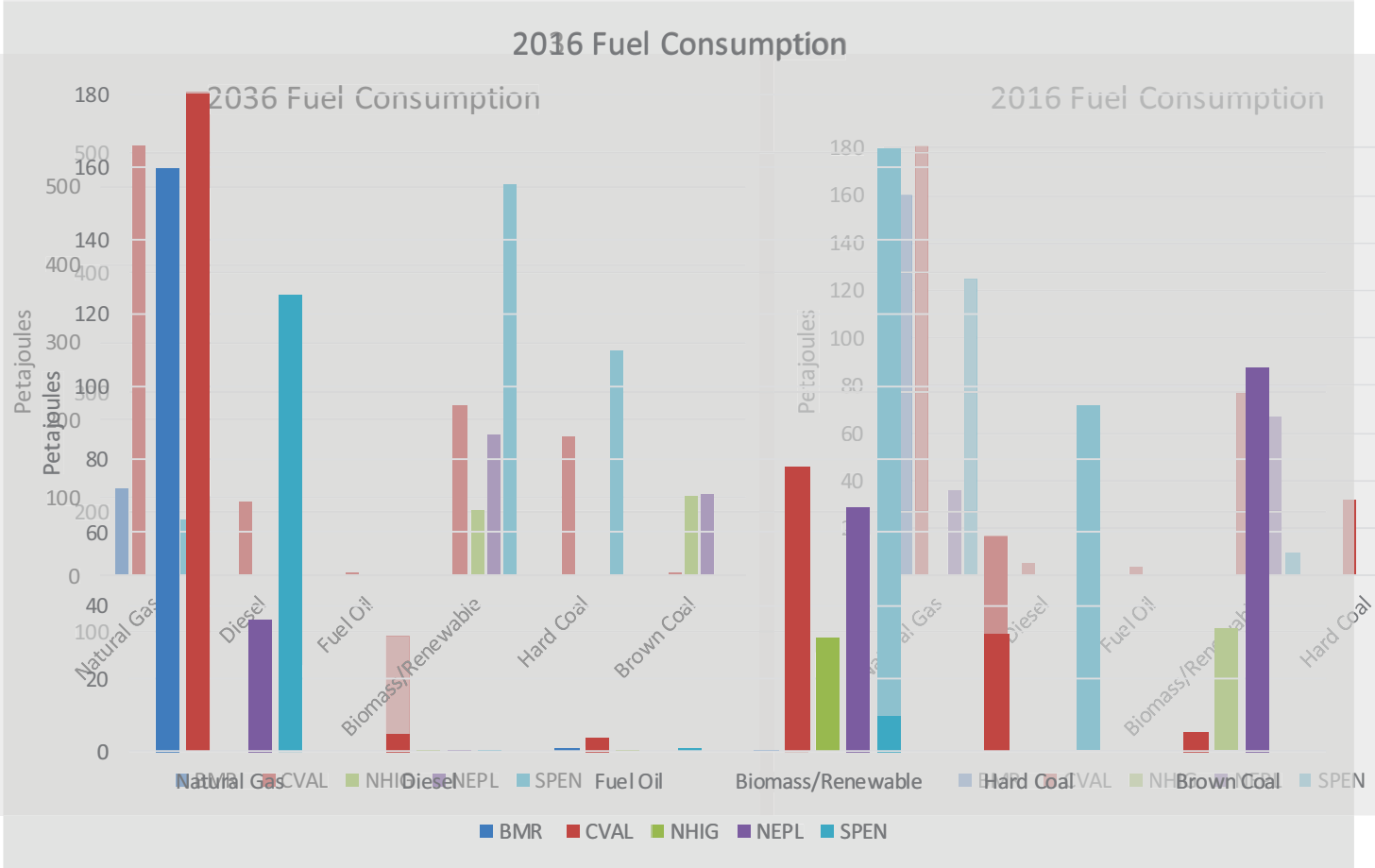

Scenario Development

Scenario Development - CLE

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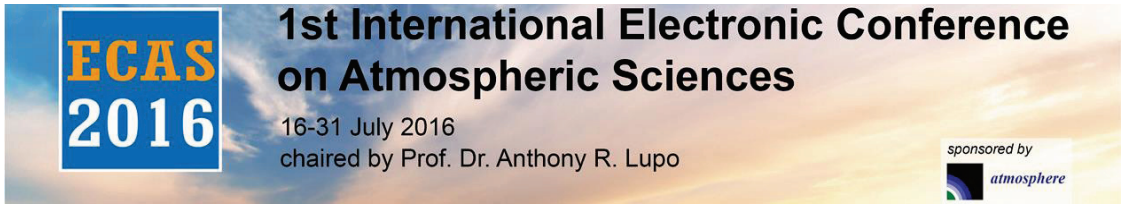
				2016	2021	2026	2031	2036
Emissions	**Technology**	**Efficiency**	**Fuel Type**	**% share of penetration of emission control technology**				
NOx	PBCCSC	80	Brown Coal	0	0	0	0	0
	PBCSCR	80	Brown Coal	0	0	0	0	0
	PHCCSC	80	Hard Coal	0	0	0	0	0
	PHCSCR	80	Hard Coal	89	0	0	0	0
PM	ESP1	93	All coal	0	100	100	100	100
	ESP2	96	All coal	100	0	0	0	0
	HED	99	All coal	0	0	0	0	0
SO2	PWFGD	95	All coal	0	87.5	87.5	87.5	87.5
	RFGD	98	All coal	0	0	0	0	0



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Scenario Development - MFR

- Methodology
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				2016	2021	2026	2031	2036
Emissions	**Technology**	**Efficiency**	**Fuel Type**	**% share of penetration of emission control technology**				
NOx	PBCCSC	80	Brown Coal	80	100	100	100	100
	PBCSCR	80	Brown Coal	80	100	100	100	100
	PHCCSC	80	Hard Coal	80	100	100	100	100
	PHCSCR	80	Hard Coal	80	100	100	100	100
PM	ESP1	93	All coal	20	0	0	0	0
	ESP2	96	All coal	40	50	50	50	50
	HED	99	All coal	40	50	50	50	50
SO2	PWFGD	95	All coal	80	100	100	100	100
	RFGD	98	All coal	80	100	100	100	100

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GAINS Results - NOx

- Methodology
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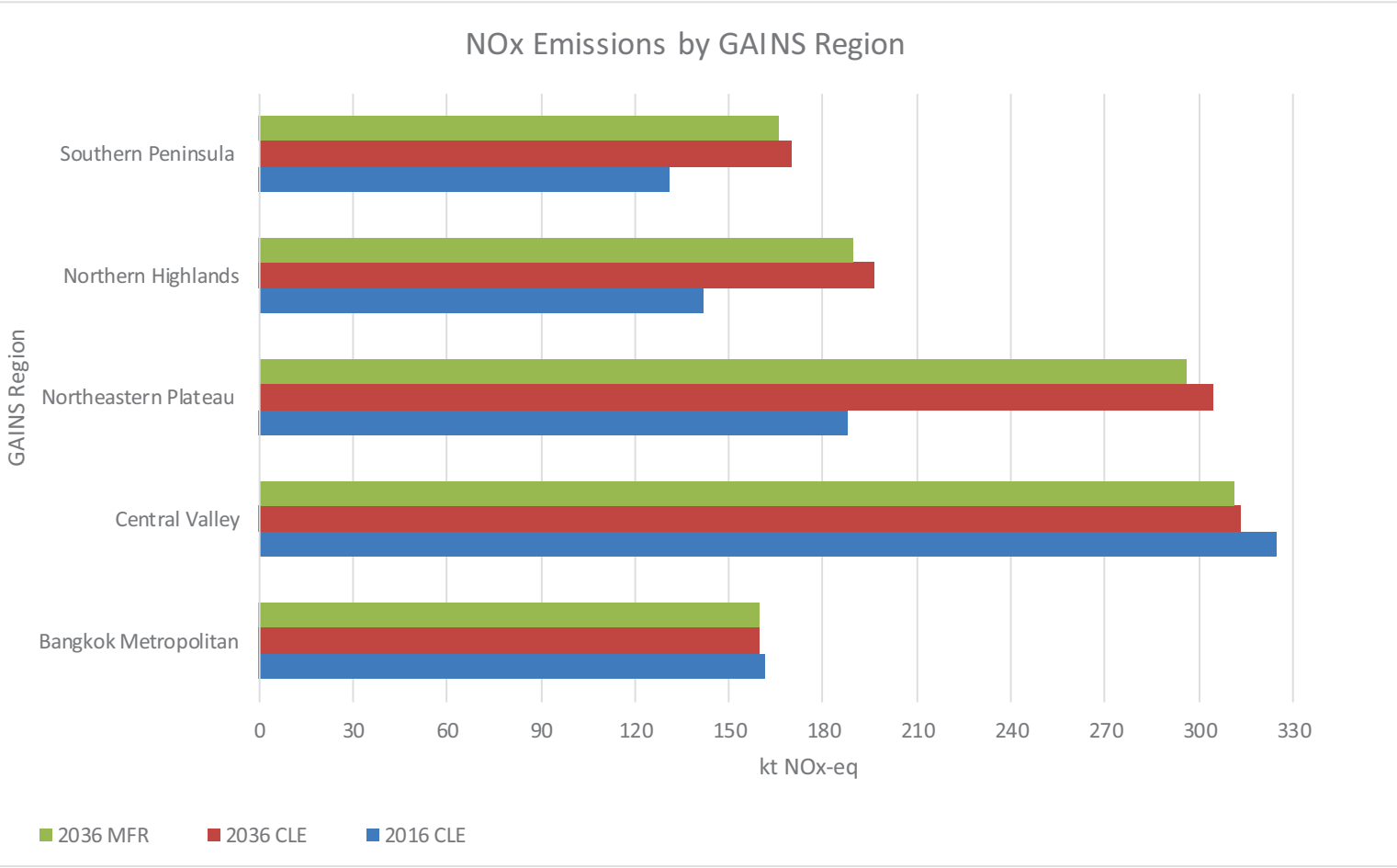

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GAINS Results – SO_2

- Methodology
- PDP
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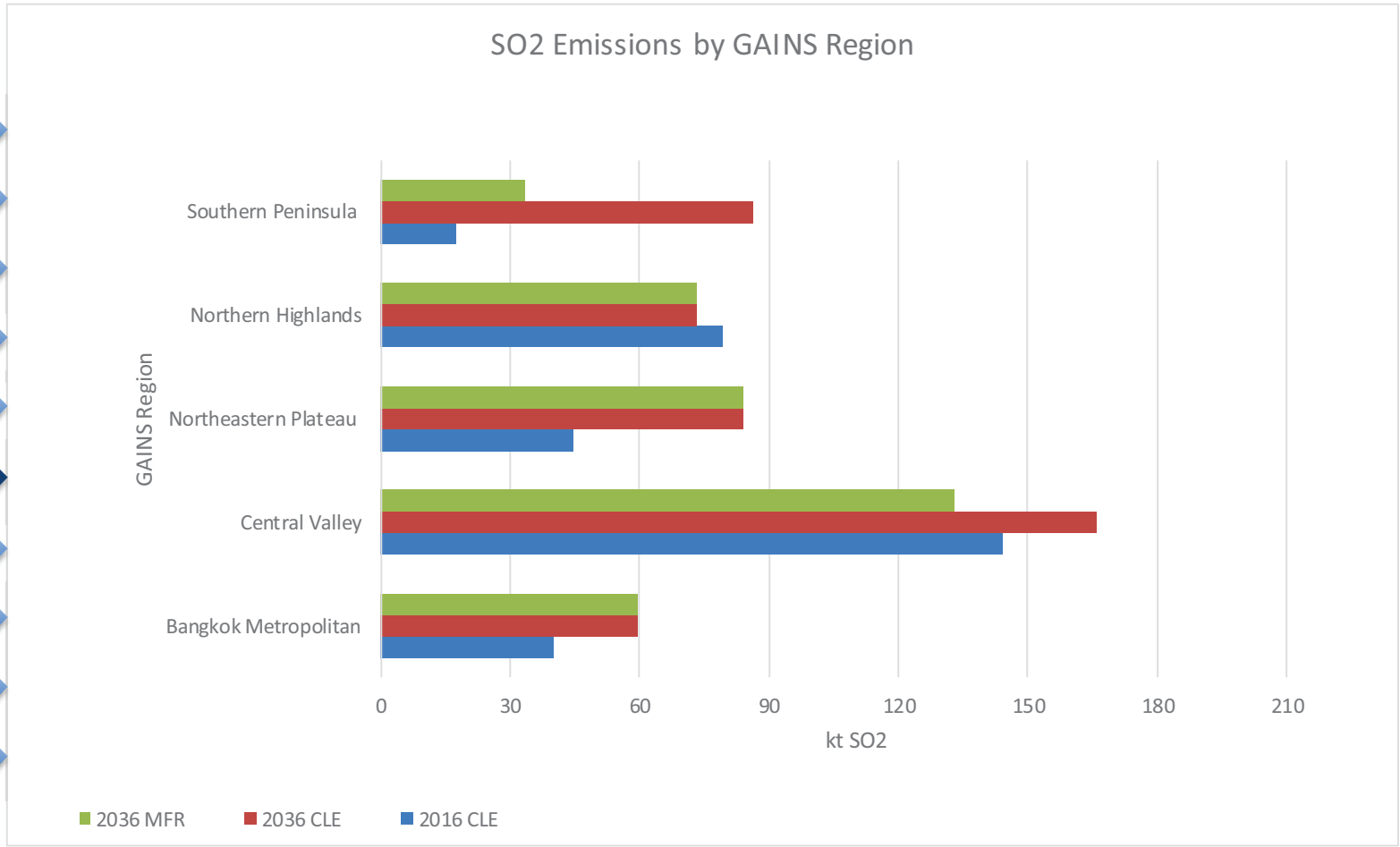

GAINS Results – PM10

Methodology
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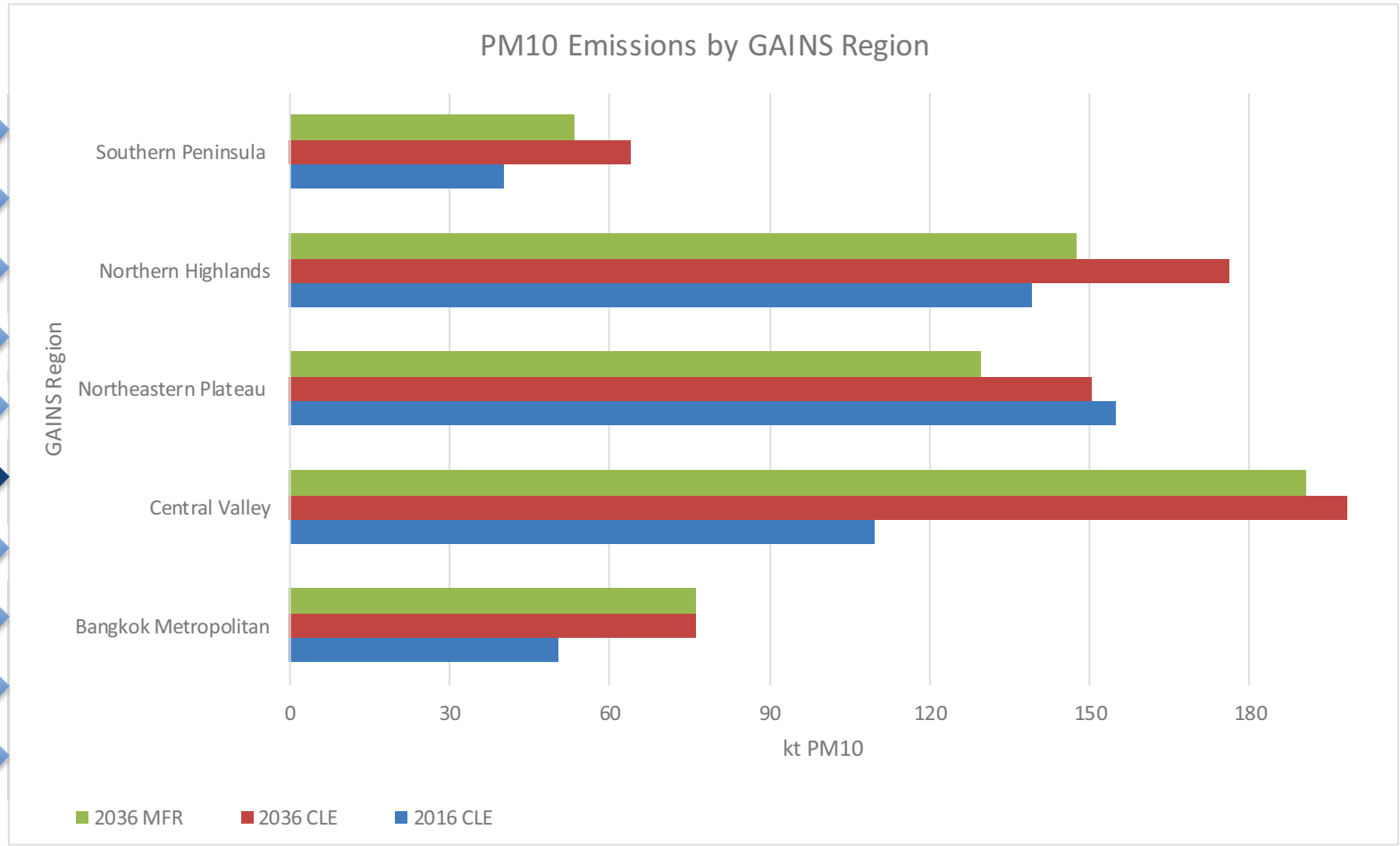

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CAMx model

- Methodology
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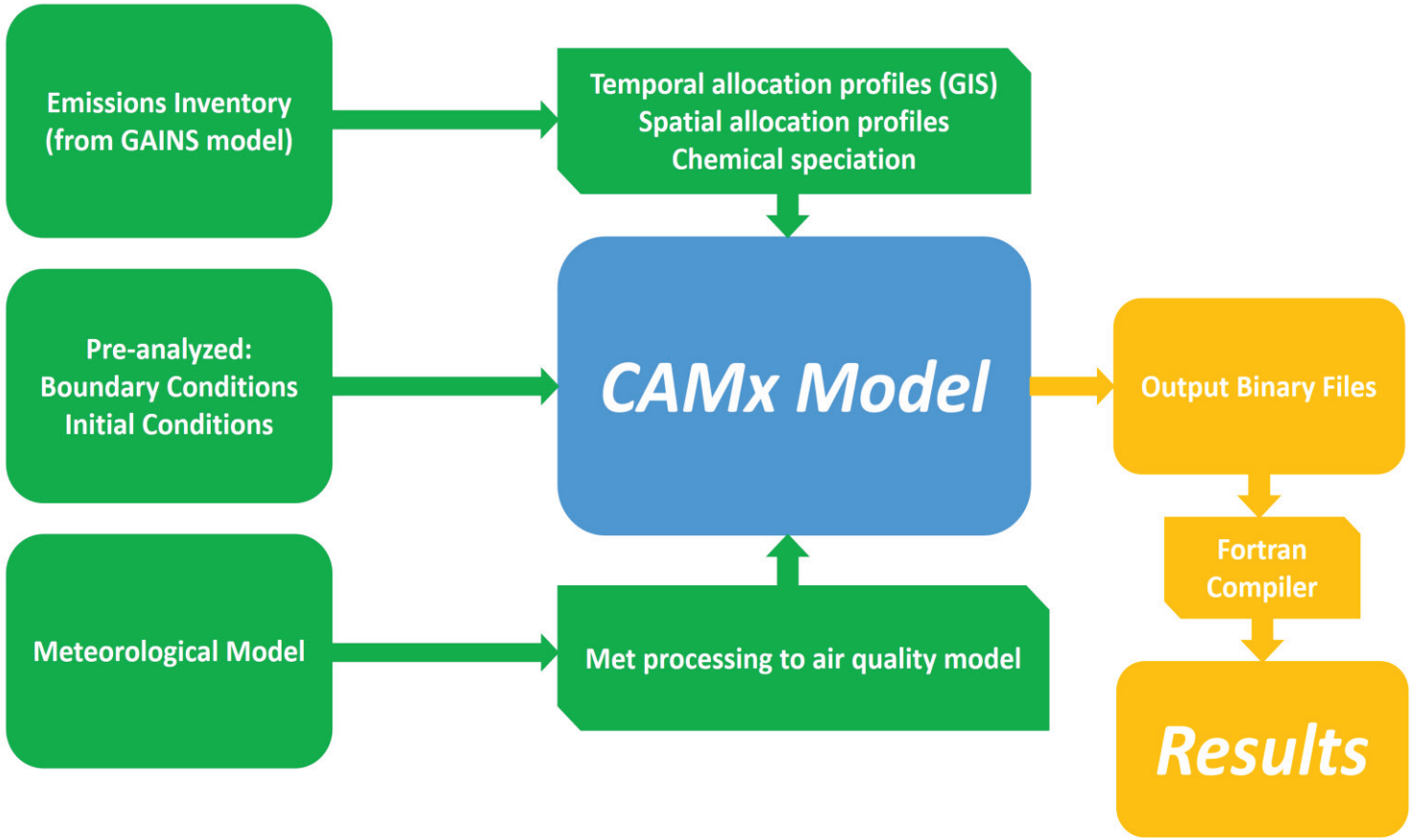

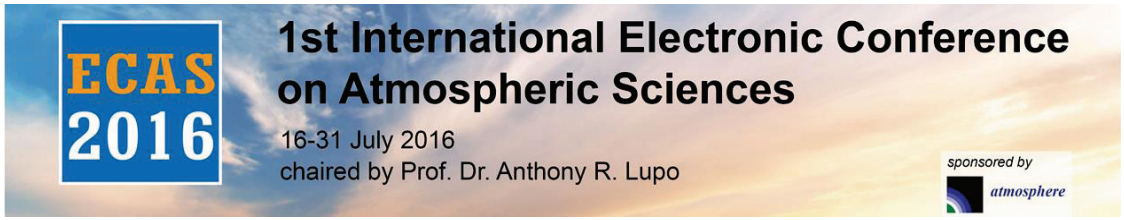

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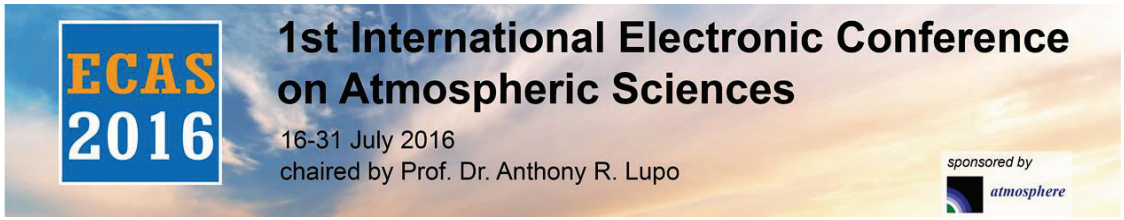
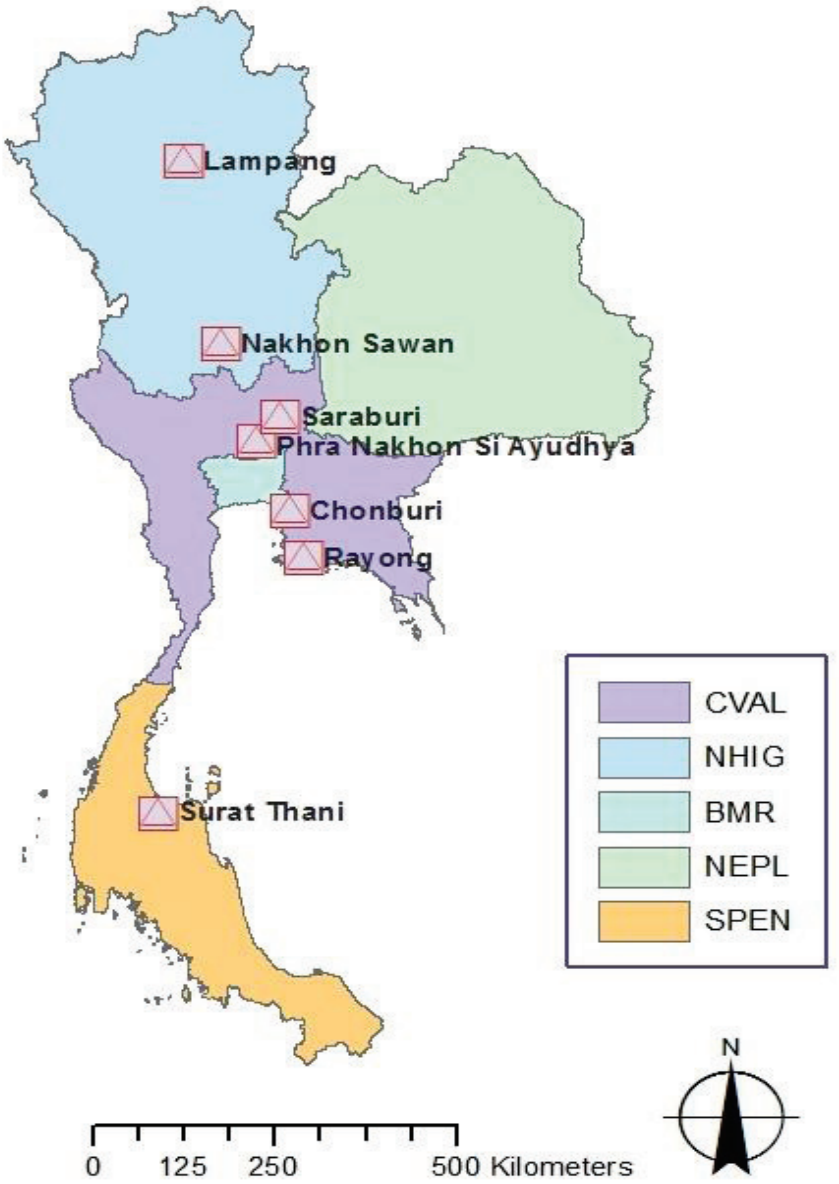
CAMx Input Requirements

- Emissions Inventory
  - GIS and spatial allocation
  - Chemical speciation
- Meteorological Model
  - WRF
- Boundary and Initial Conditions
  - MEGAN-MACC and GFEDs database
- Shipping emissions survey



CAMx monitoring stations



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CAMx Results - NOx

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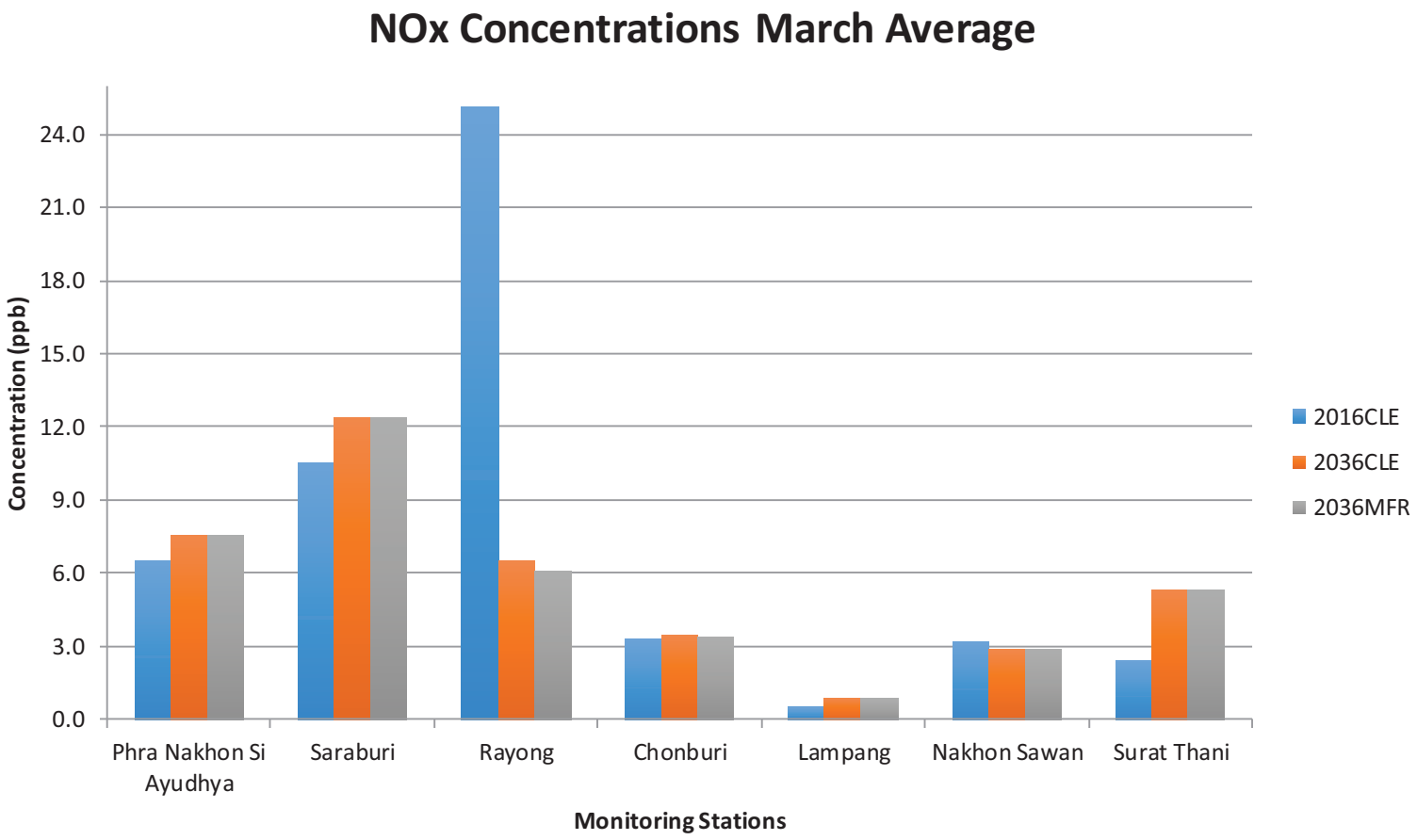

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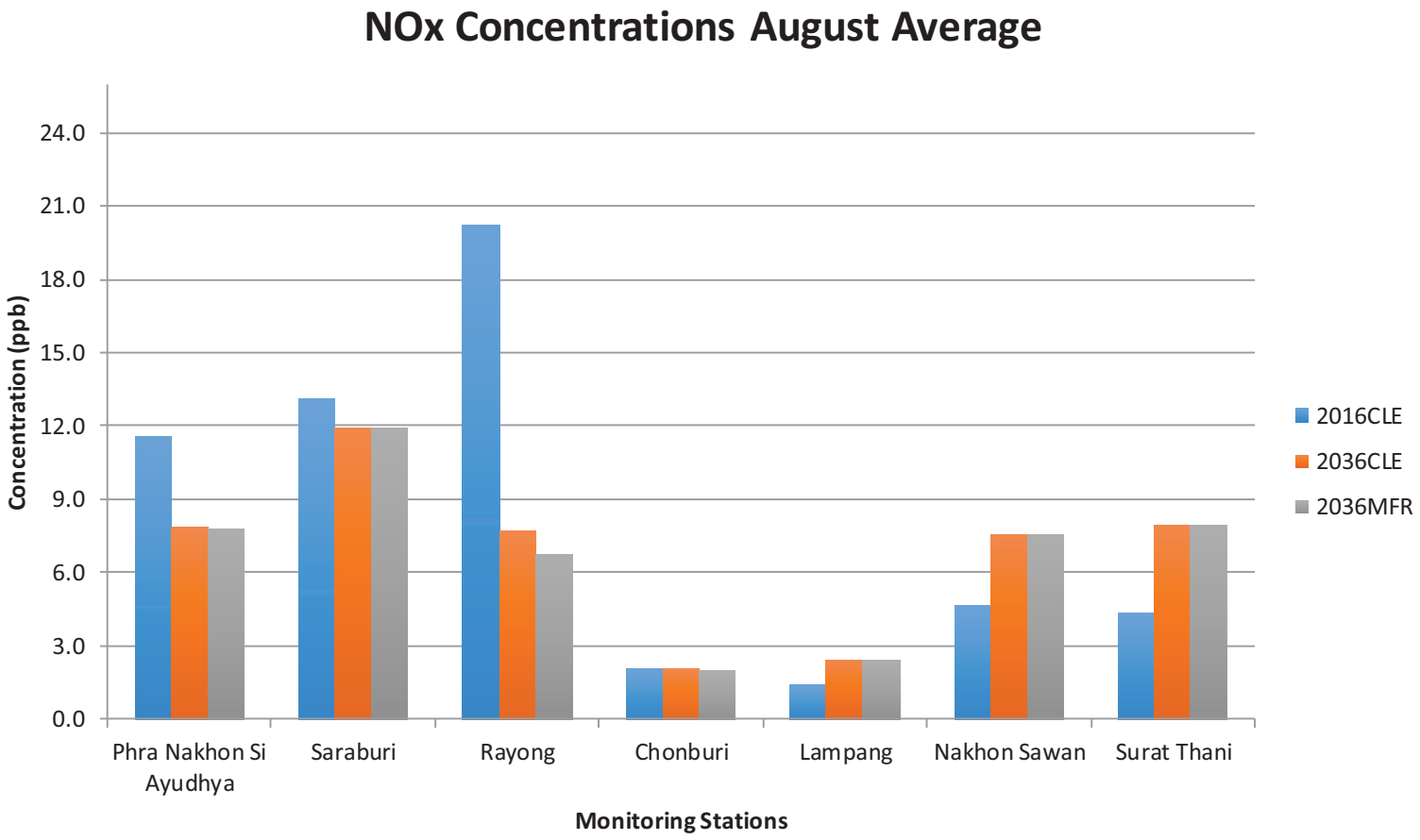

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CAMx Results – SO_2

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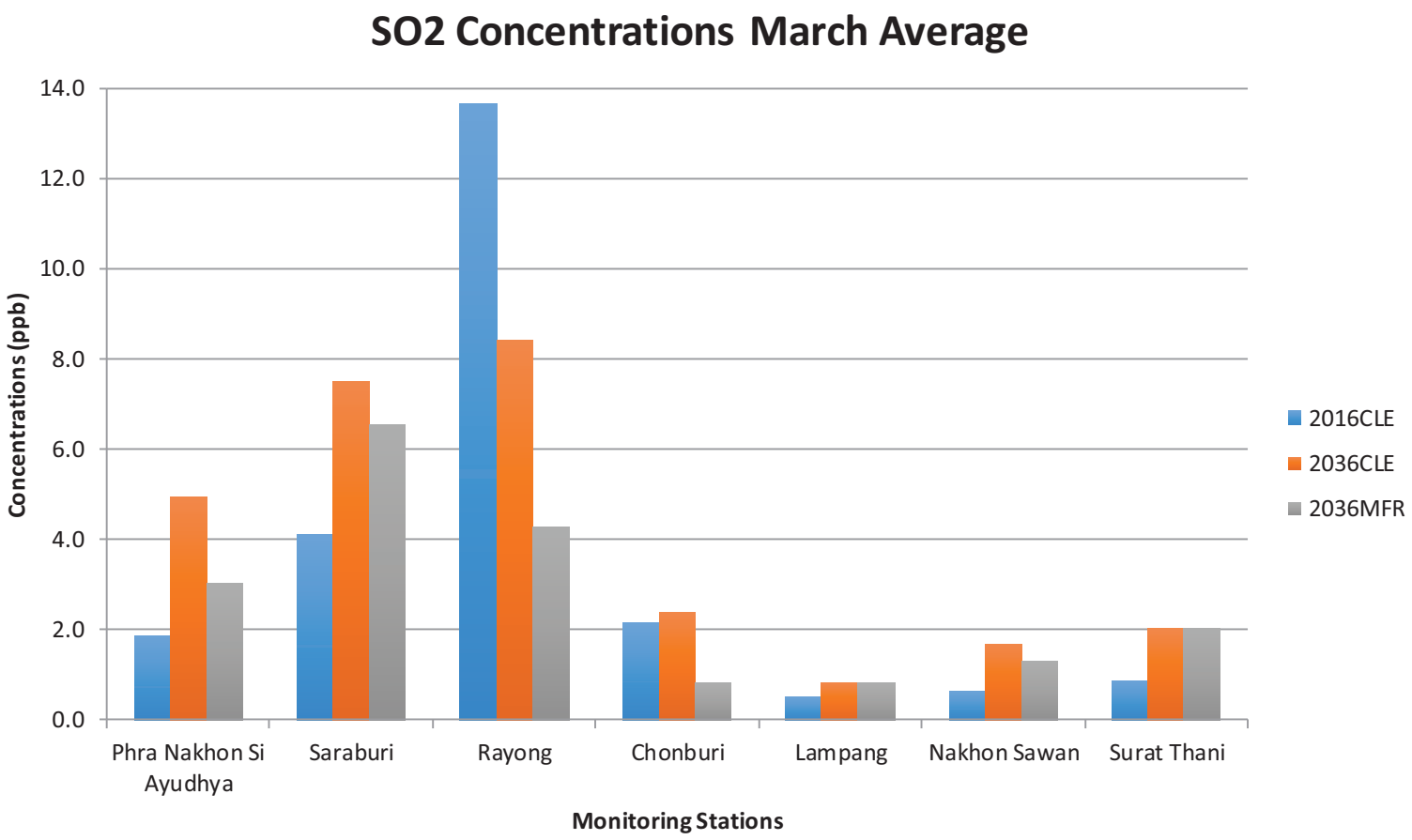

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CAMx Results – SO_2

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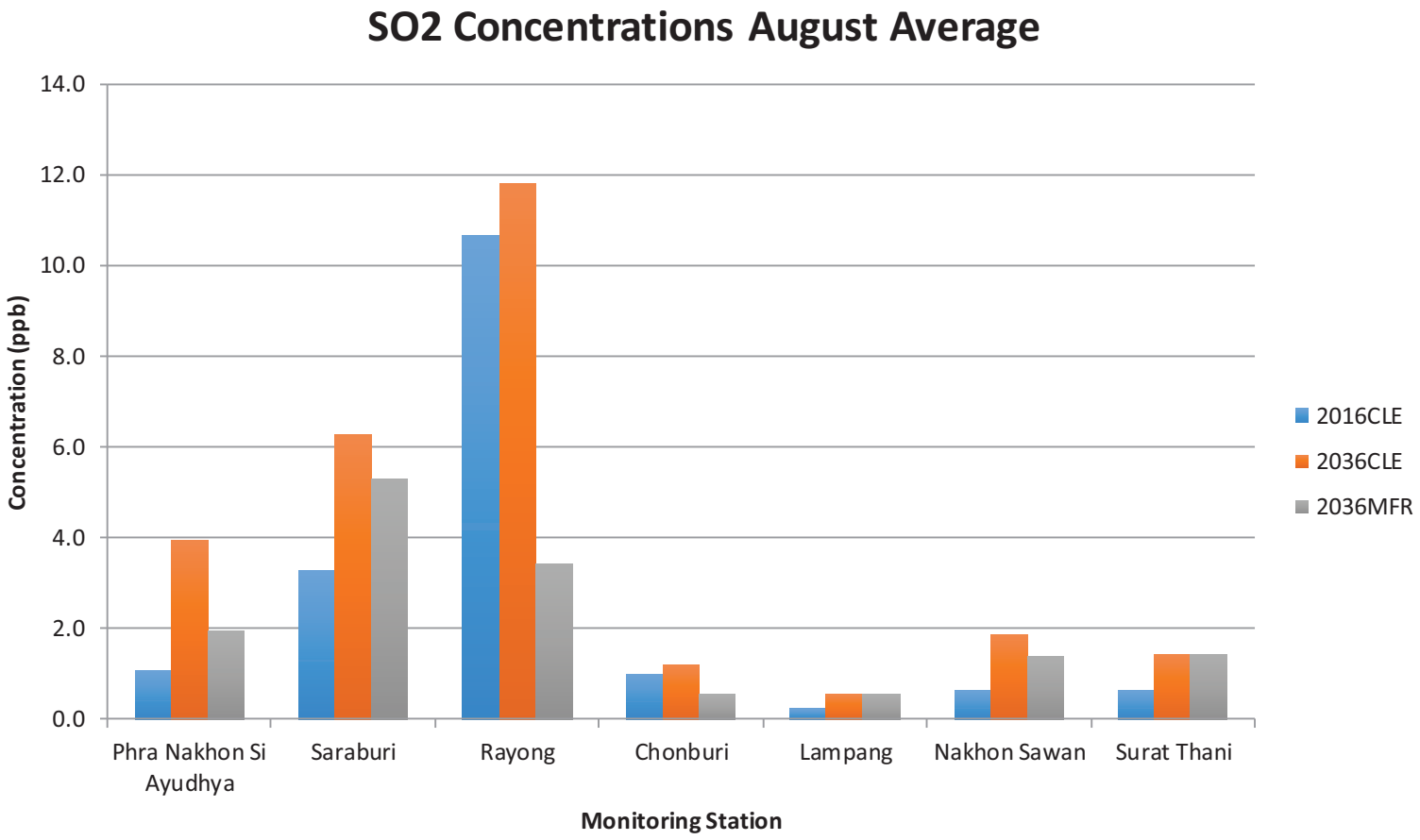
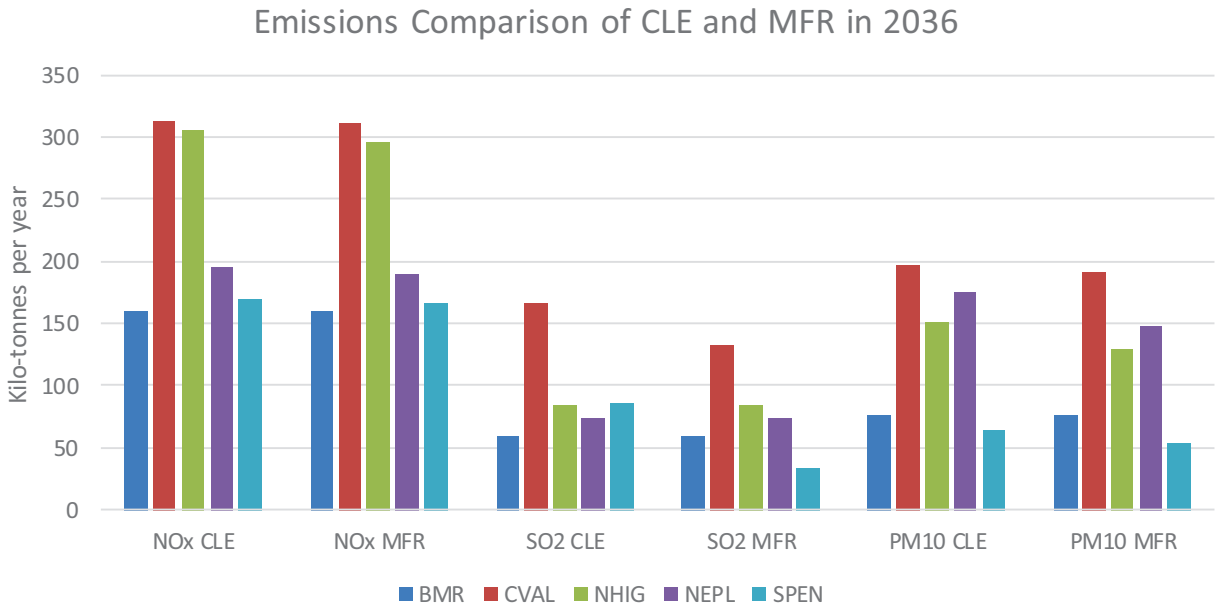
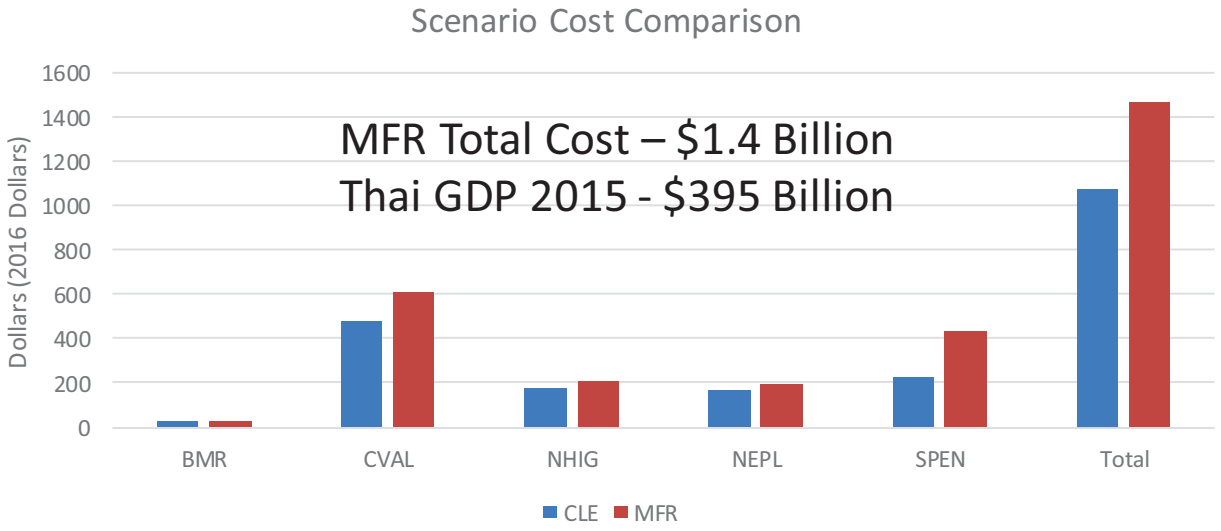


Scenario Cost Comparison





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Human health impacts

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- Determined using WHO standards
  - Thai standards are out of date
  - Intended for international use
- Most pollutants had small improvements
- SO2 witnessed most improvement
- PM10 overshadowed by biomass burning

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Concentrations vs. standards

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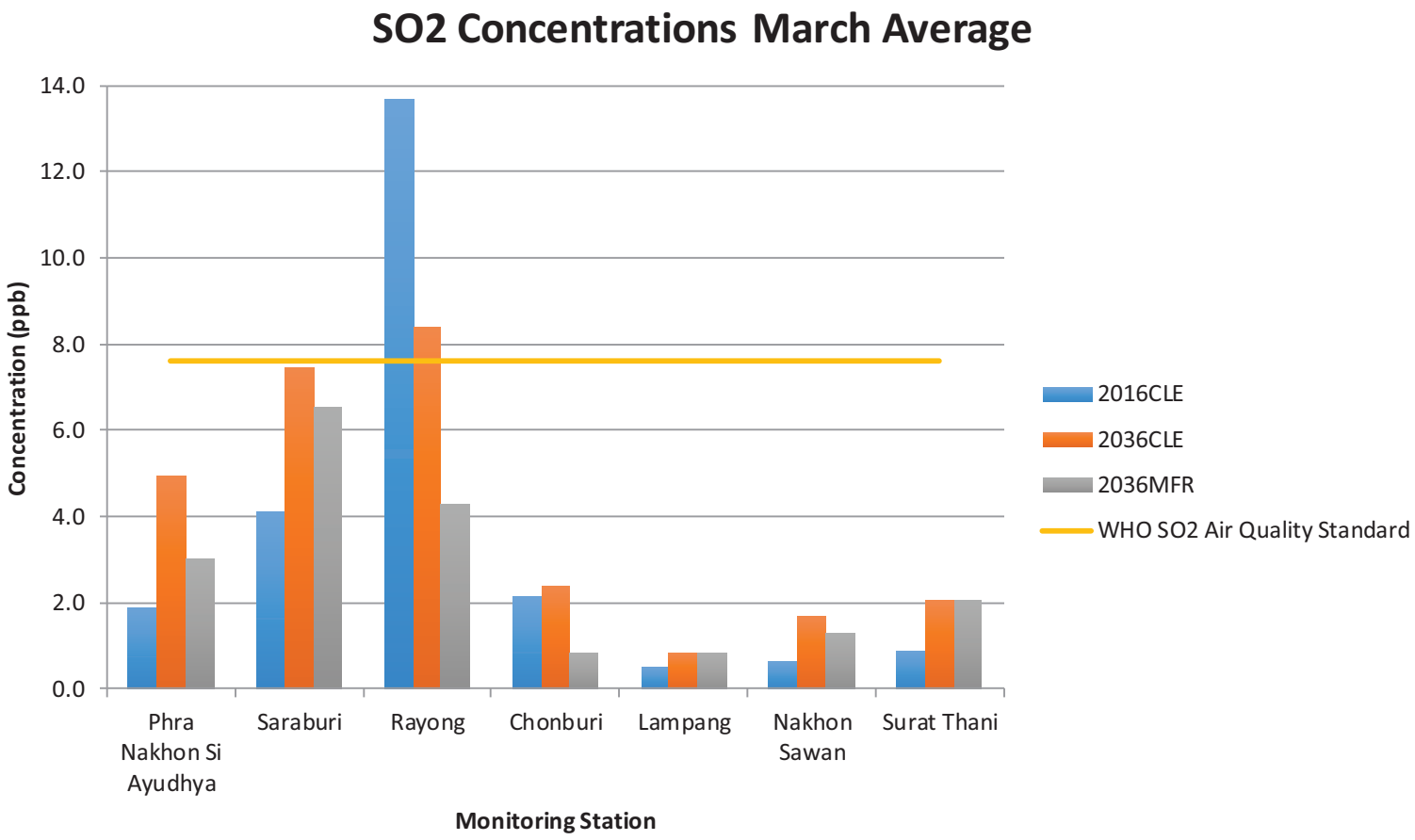

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Concentrations vs. standards

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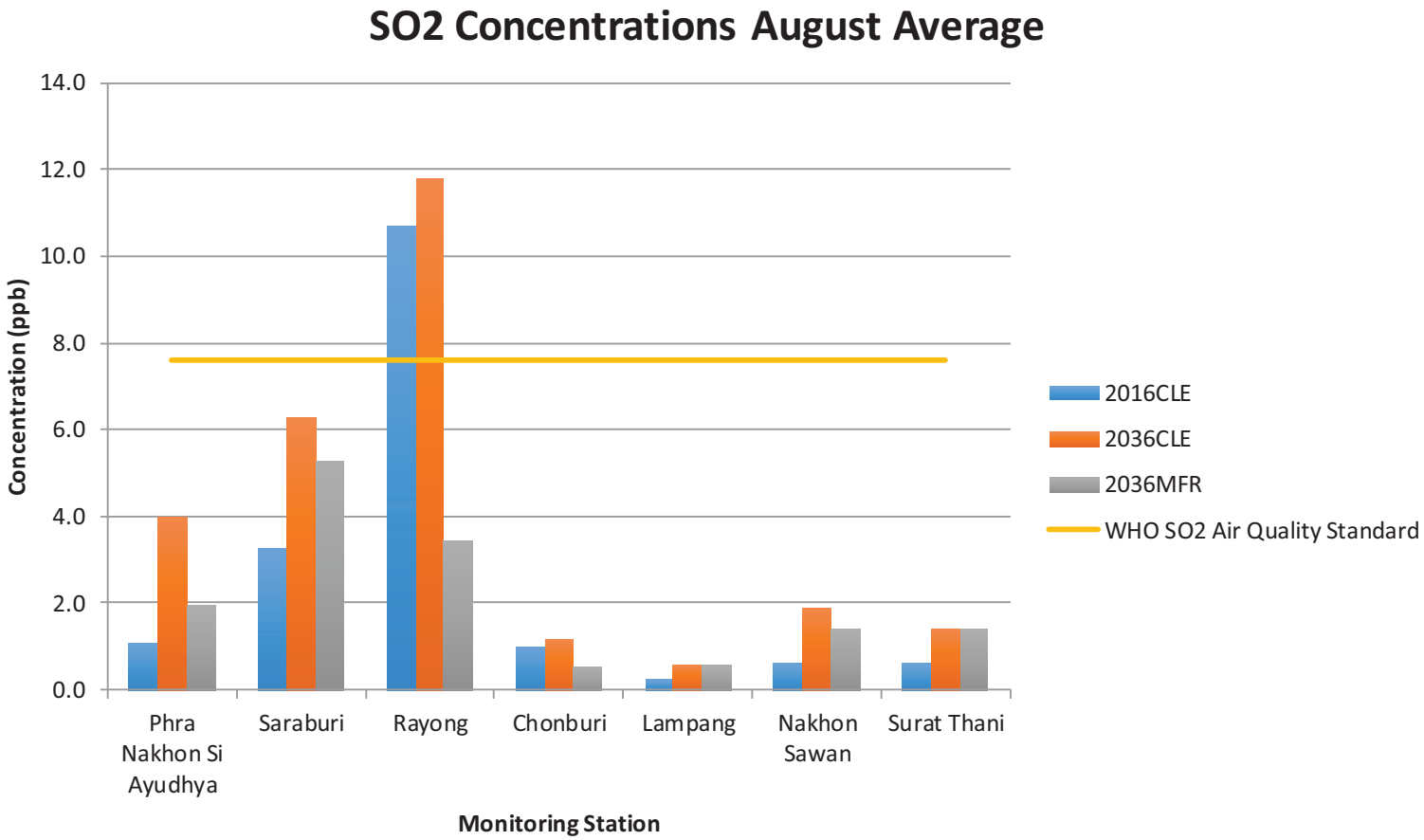

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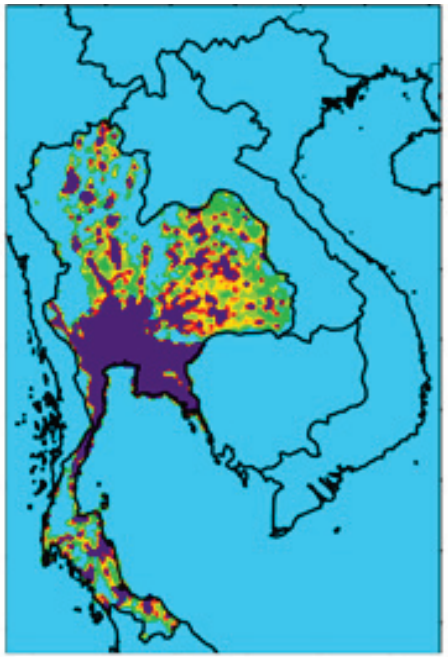
Discussion

SO2 Emissions: 2036 March



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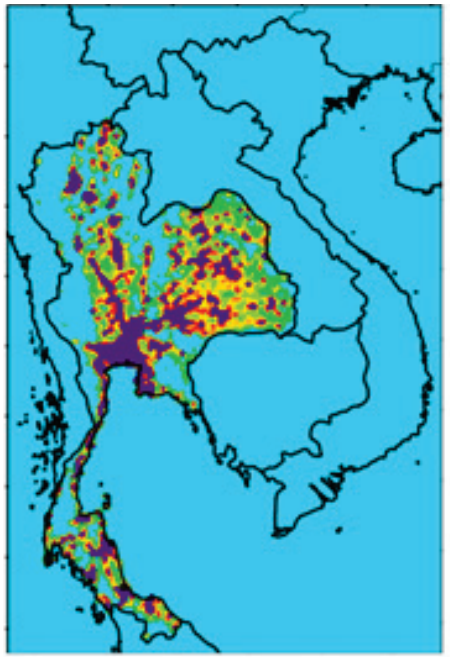
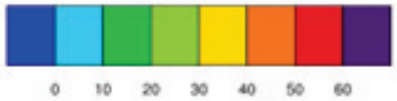
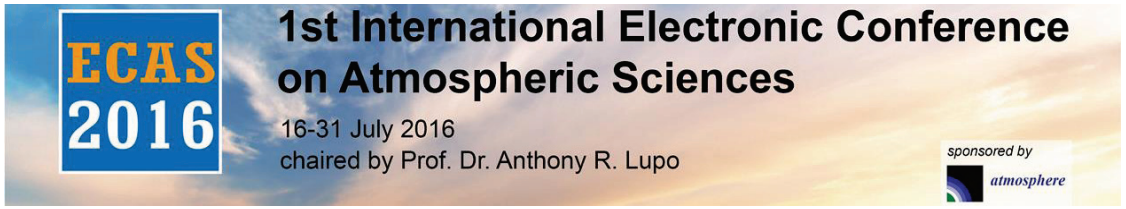


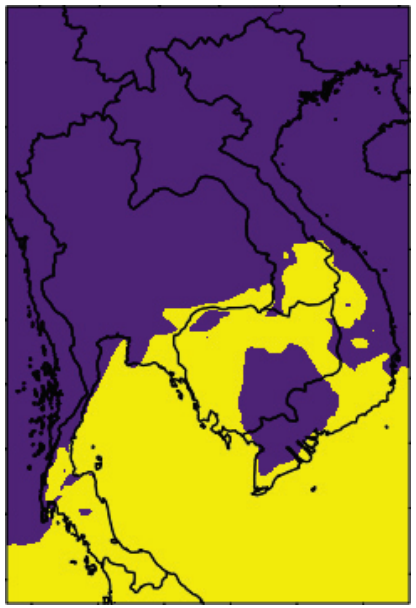
MFR



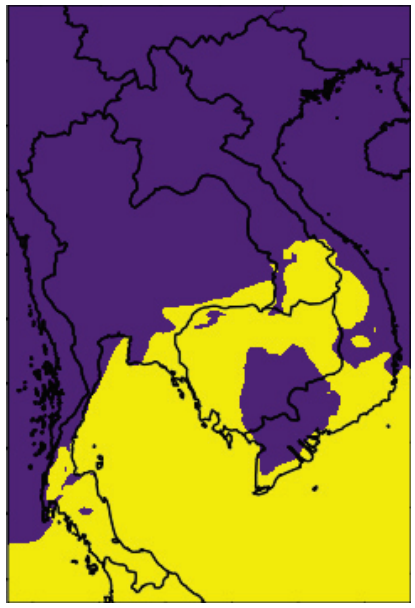


Discussion

PM10 Air Quality Standard Comparison



CLE 2036



MFR 2036

No Risk Risk to Health

Conclusions

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- NEPL and NHIG power plants emit the most PM10 out of all GAINS regions
- Biomass dwarfed coal in the NHIG and the NEPL GAINS regions
- Little difference observed between the CLE 2036 and the MFR 2036 for the SPEN region

Conclusions

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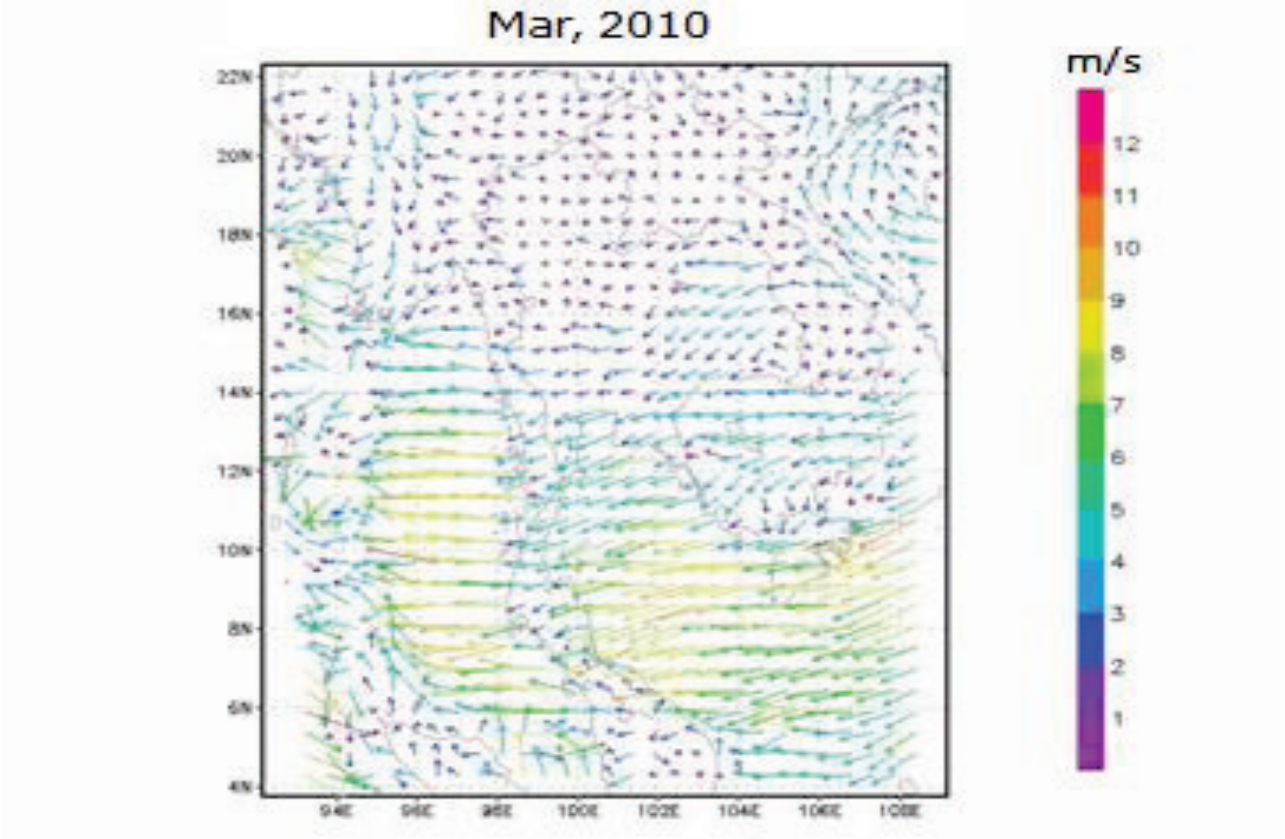
Wind Trajectory from TCAP ECLIPSE Meteorology Scenario



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Future Study

- Solve CAMx pollution modelling discrepancy in the SPEN region
- Conduct regional modelling with a resolution better than 12km by 12km
- Use BenMAP to predict DALY from concentrations
- Designing scenarios with wider ranges of emissions control technologies
- Interchanging fuel types for optimal air quality