Integrated assessment of Climate Change and Air quality policies in Korea

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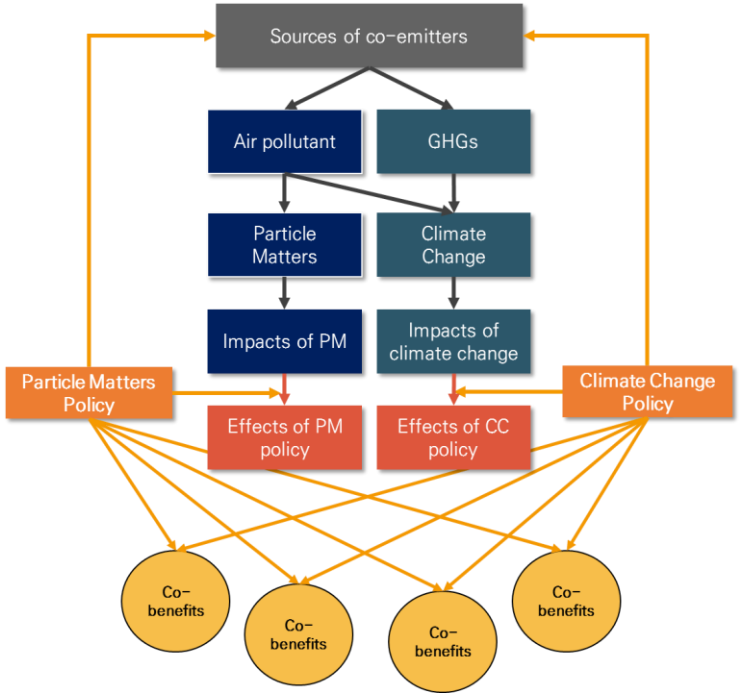
Importance of Co-benefit

▪ Concept and framework of co-benefit

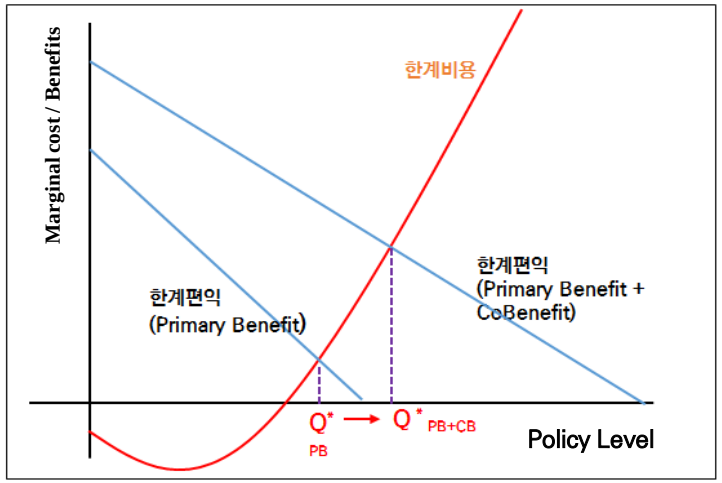
- Co-benefit

  - The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. (IPCC AR5)

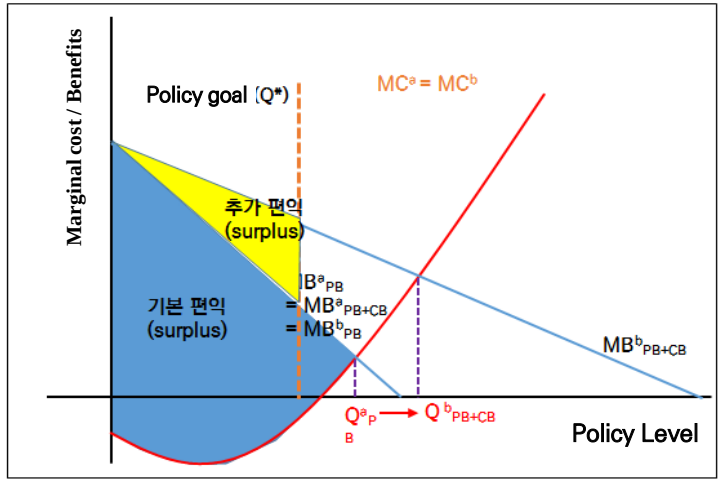
  - AQ-Climate policy of a country shares various social goals with neighboring countries



<Change of optimal policy level and policy mix by estimation of co-benefits>



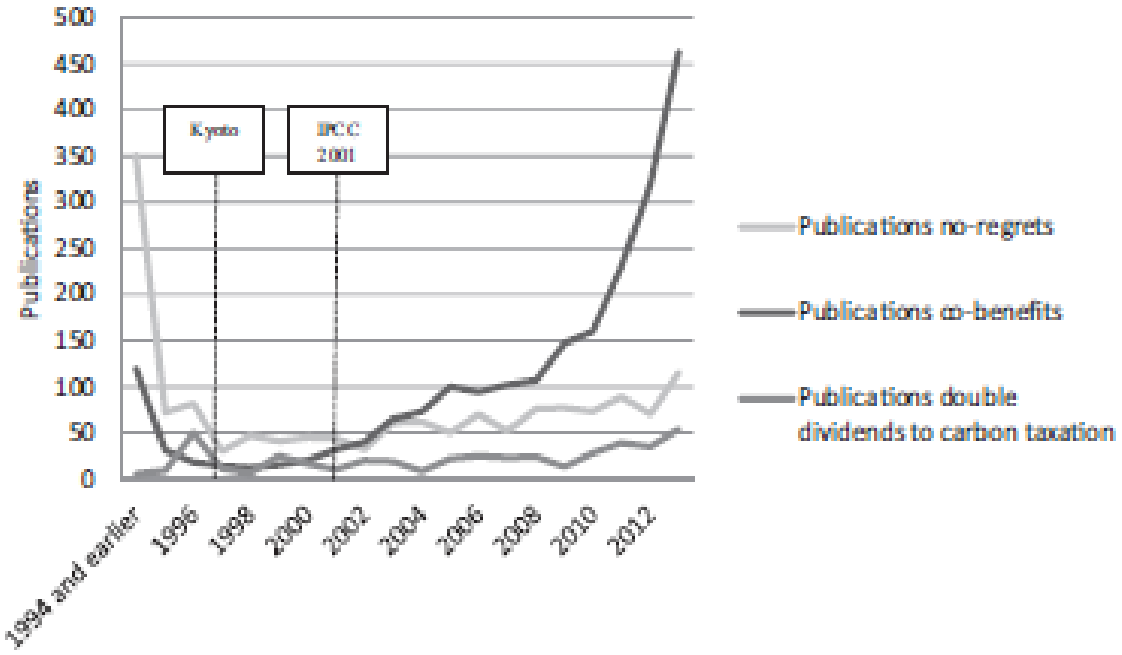
- 정책에 대한 비용편익 분석시 공편익(Co-Benefit) 혹은 공비용(Co-Cost)를 고려하였을 경우와 그렇지 않은 경우 사회적 적정 감축 수준이 달라짐(Q^*_{PB} → Q^*_{PB+CB})
- 각 감축사업별 주편익(primary benefit)도 다른 뿐더러 공편익 및 공비용 역시 달라짐



- 정책조합 (a, b)
  - 한계비용은 같다고 가정
  - 정책조합 a의 공편익은 0라고 가정
- 다른 제약 조건이 존재없을 경우 사회적 최적 감축 수준 Q^b_{PB+CB}
- 사회적으로 합의된 감축수준(Q*)이 존재하는 경우에도 정책조합 a보다 추가편익을 발생시키는 정책조합 b가 최적

Increased interest in co-benefit

<Publications using co-benefits and related concept in ScienceDirect database>



Source: Mayrhofer, 2016

- The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. (IPCC AR5 WGIII, 2014)

- Climate policy intersects with other societal goals creating the possibility of co-benefits or adverse side effect. […] Mitigation and adaptation can positively or negatively influence the achievement of other societal goals, such as those related to human health, food security, biodiversity, local environmental quality, energy access, livelihoods, and equitable sustainable development; and vice versa, polices toward other societal goals can influence the achievement of mitigation and adaptation objectives. (IPCC AR5 WGIII SPM, 2014)

Questions for better policy decision

What are synergy and trade-off between AQ policy and GHG mitigation policy?

What is optimal policy mix to achieve goals of AQ and GHG mitigation policy?

Hypothesis: Co-benefit policy (GHG + AQ) < GHG policy +AQ policy

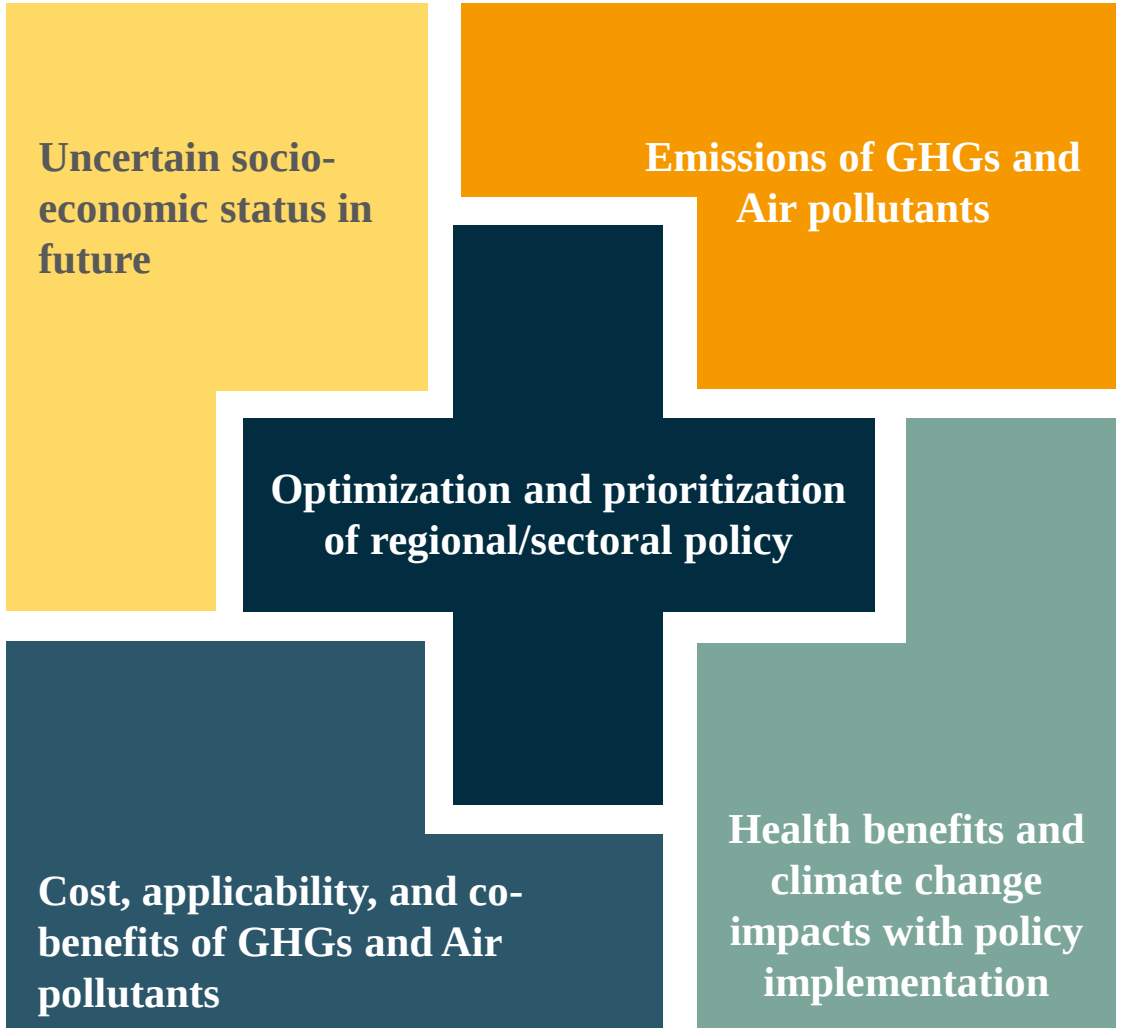
What are the prioritized order of policies by region/sector?

How to maximize benefits with limited budget?

How the policy effects would change with uncertainties in future?

How much does the integrated management curtail the net-cost?

Decision-making factors for integrated management



Major concerns in Korea

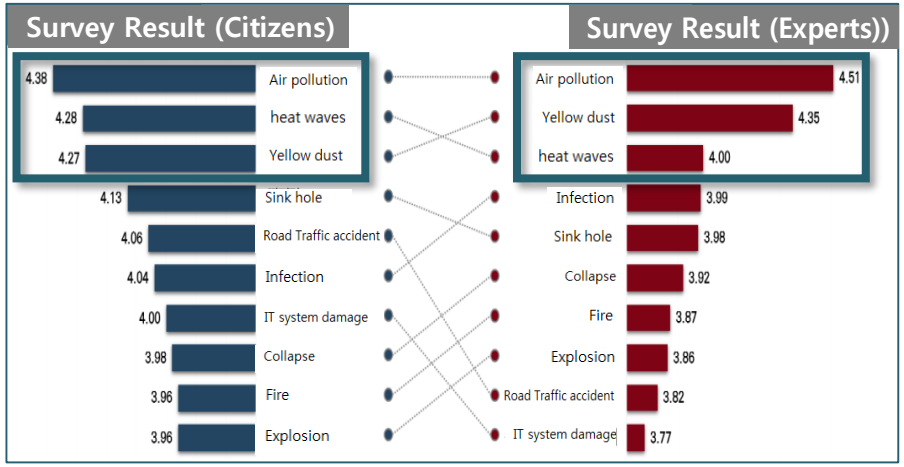
Disaster risk perception of citizens and experts in Seoul

- Present
  - → Citizens & experts: Air pollution (#1)
  - → Heat waves ranked: Citizens #2, Experts #3
- Future
  - → Heat waves: #1 from citizens, #2 from experts
  - → Air pollution: #2 from citizens, #3 from experts

Level of interest and perception of risks

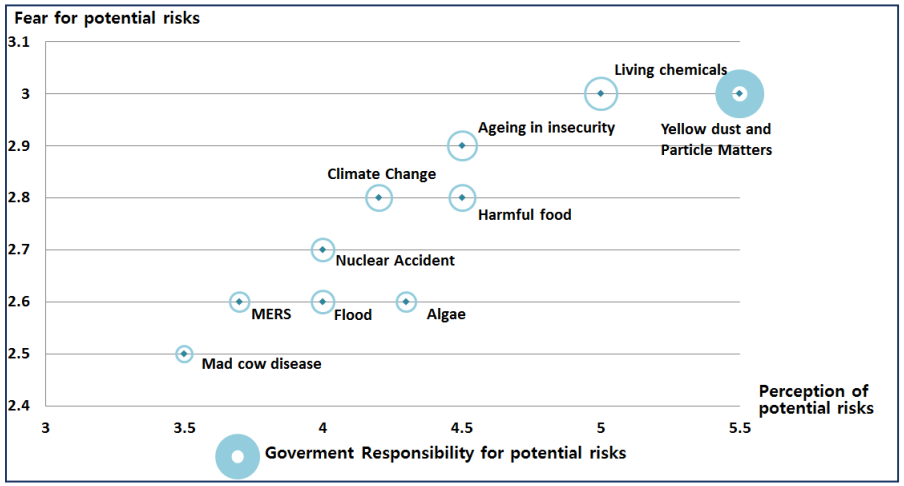
- Interests in PM and AQ, increased
  - → Interests and concerns about yellow dust and PM are higher than any other issue
  - → The levels of the fear for the potential risks and the government responsibility are similar

The most risky disasters (Present)



Source: The Seoul Institute (’16, 10. 17.)

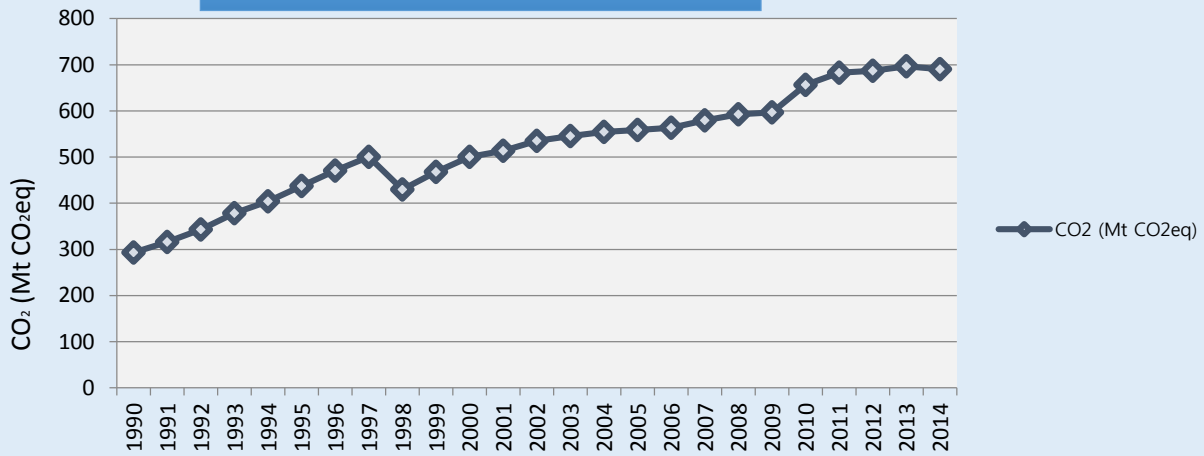
Level of interest and perception of risk factors



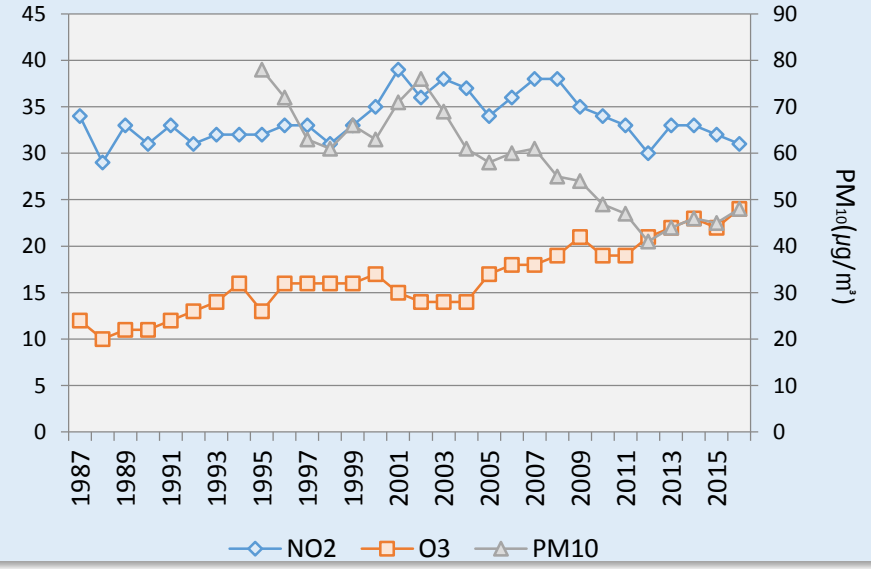
Source: reconstructed based on Han(2016)

Air Pollutants & GHGs

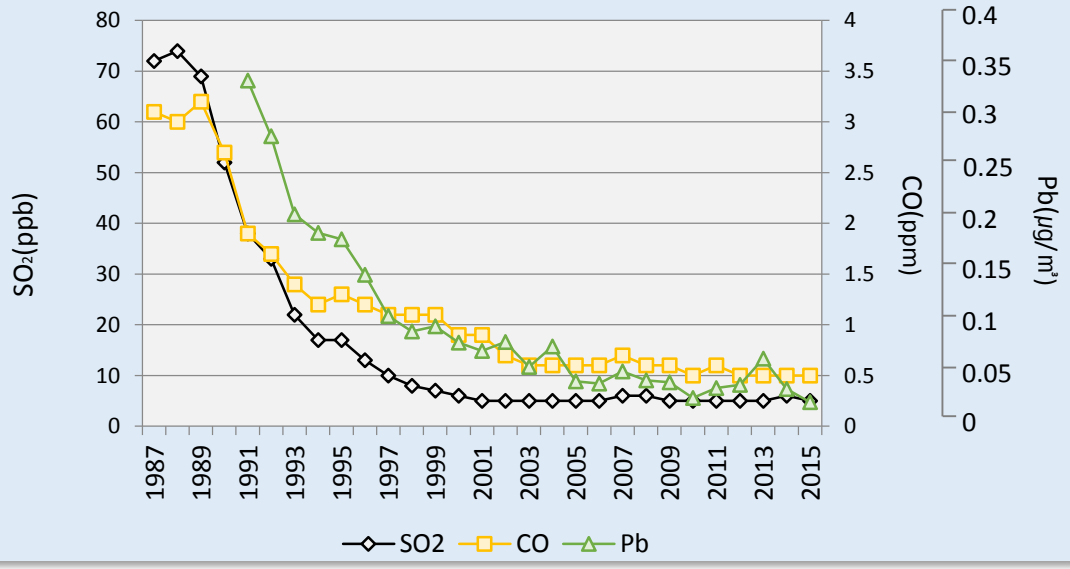
CO_2 concentration trend



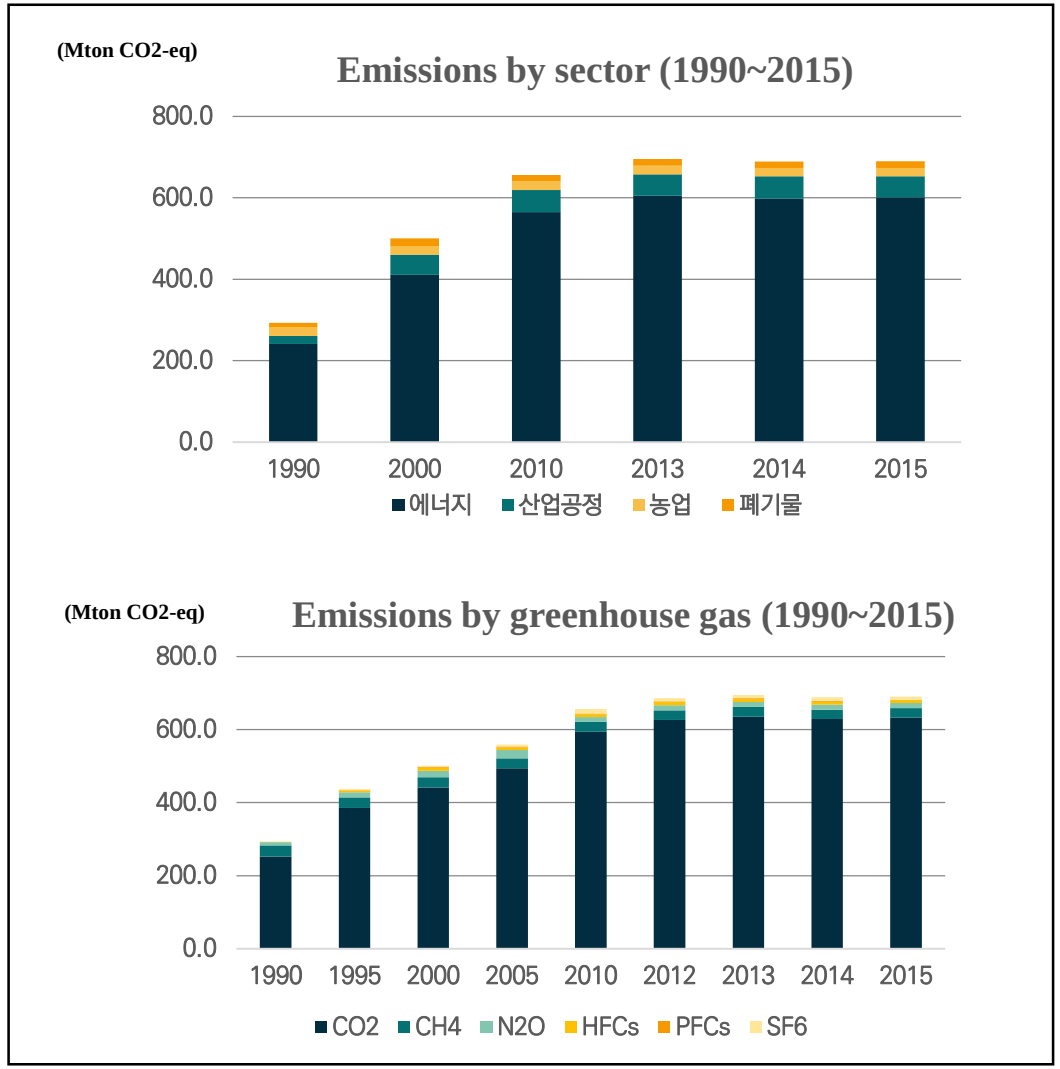
NO_2, O_3, and PM_{10} concentration trend

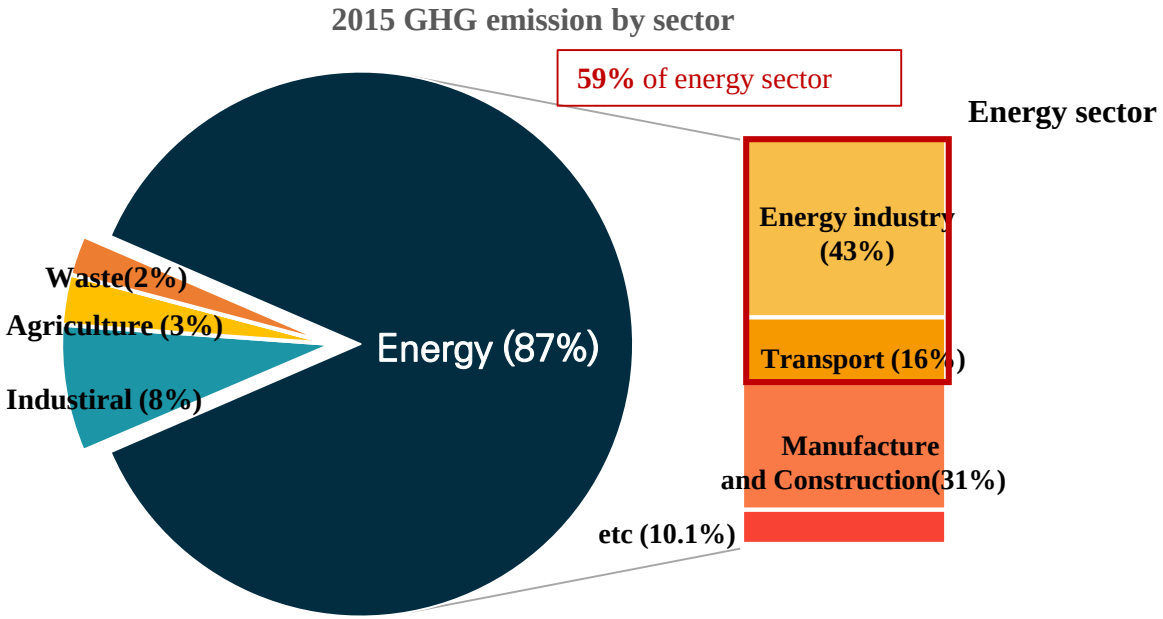


SO2, CO, and Pb concentration trend in Seoul



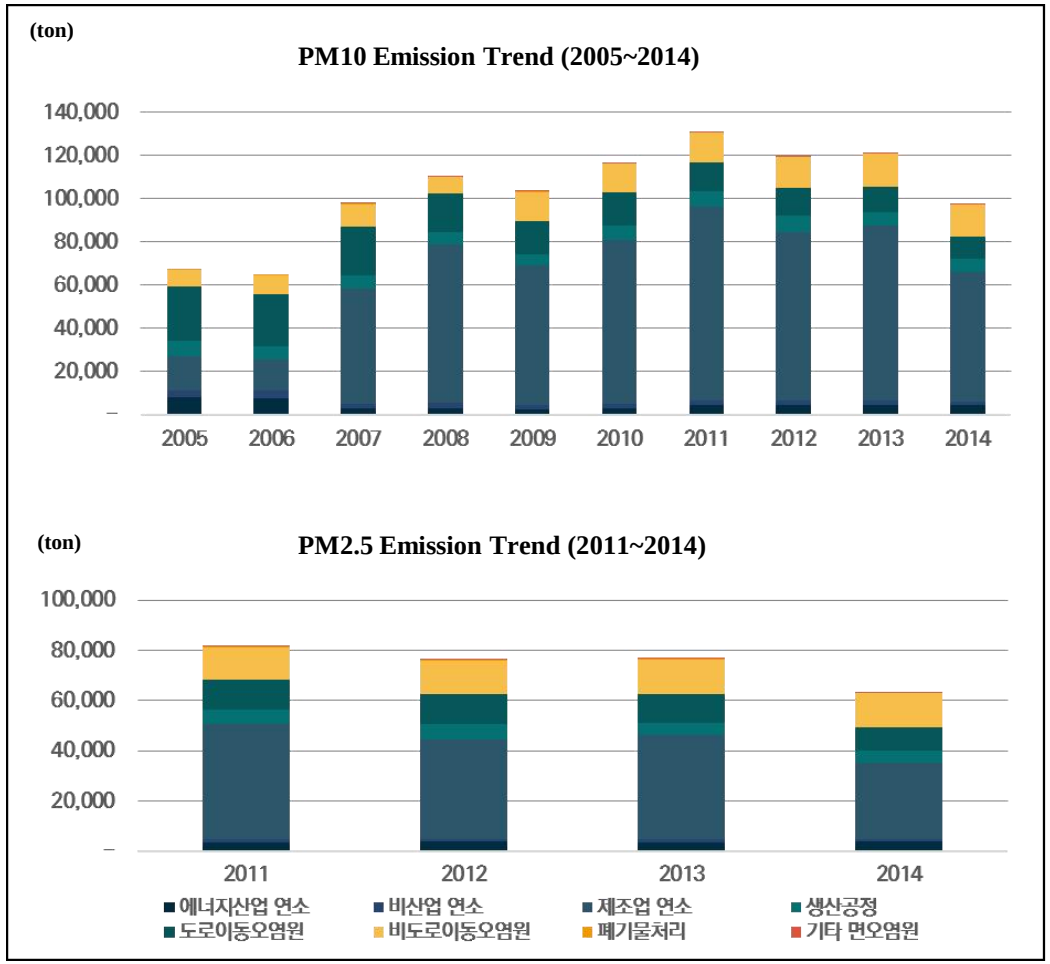
Korean Context: GHG emissions

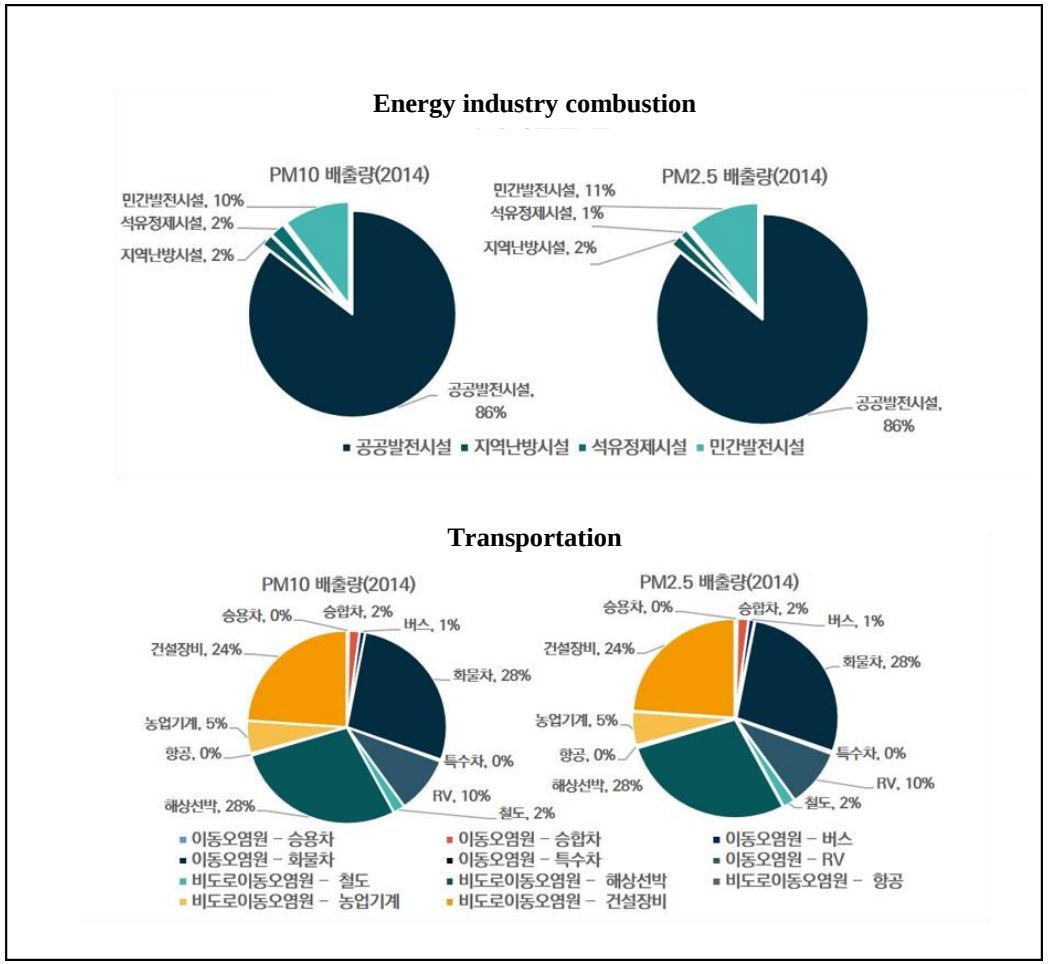




Source: GIR(2018)

Korean Context: PM emissions

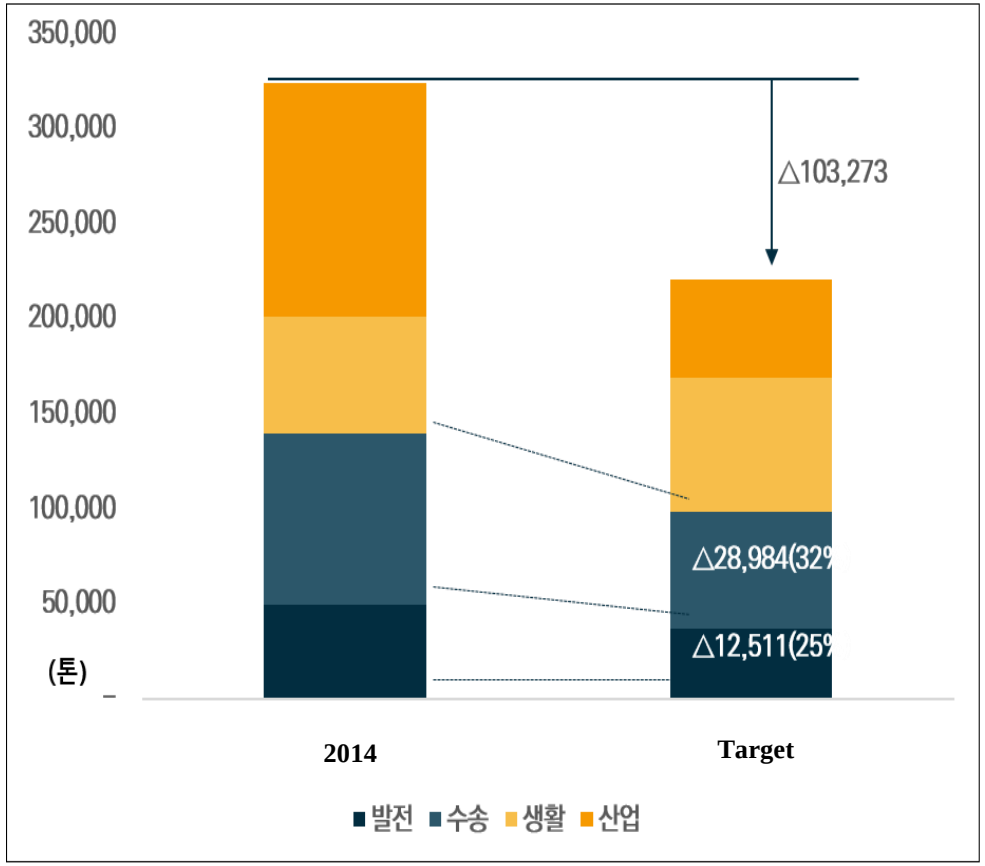




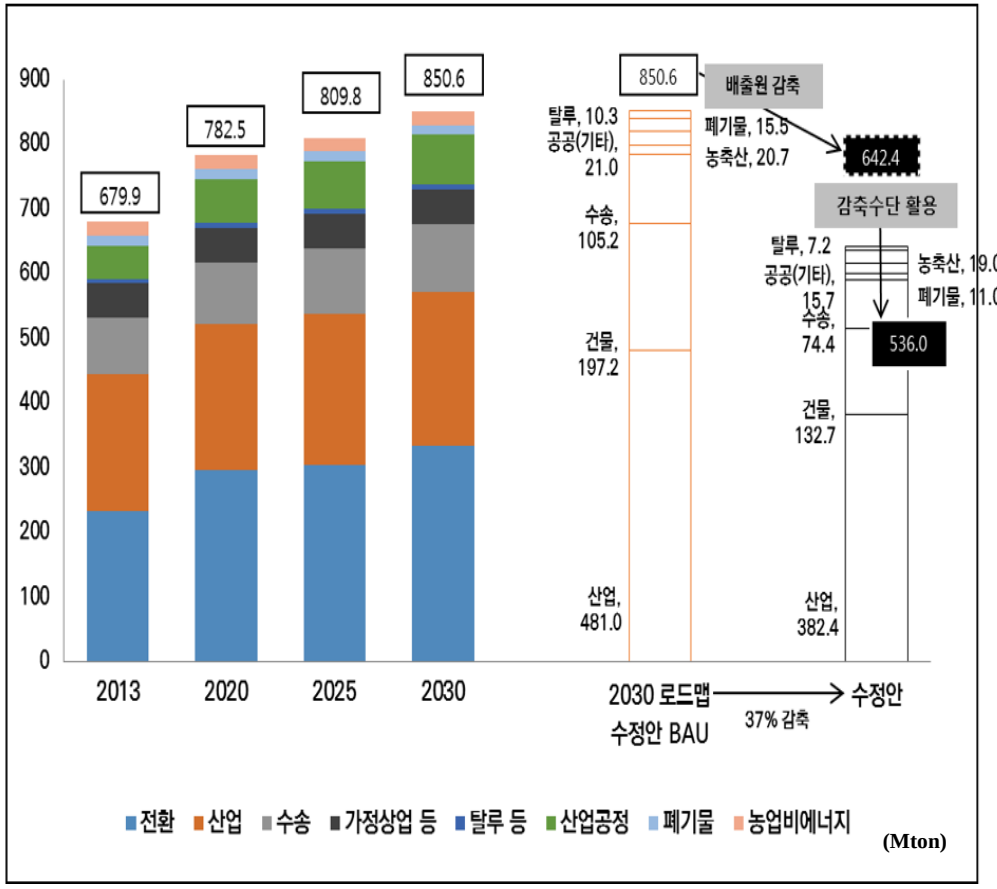
Source: National Institute of Environmental Research(2017)

Policy objectives of GHG and PM emission reduction

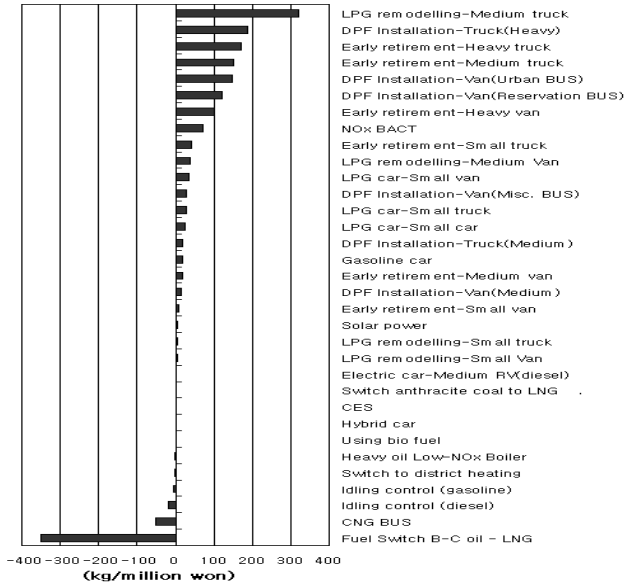
PM Reduction Target
<Fine dust master plan>

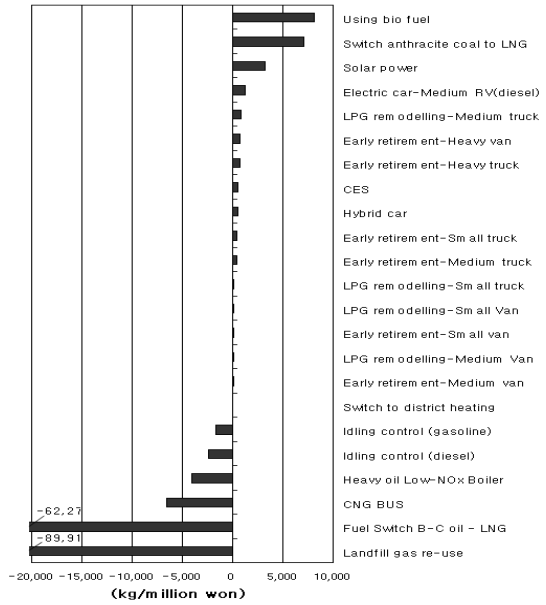


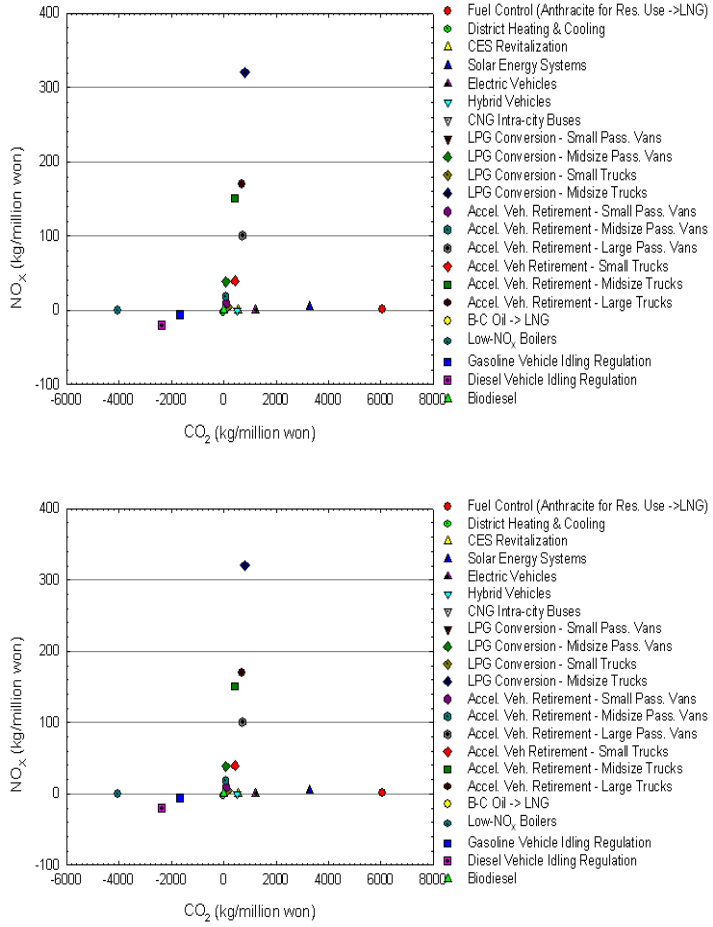
GHG Reduction Target
<2030 GHG roadmap>

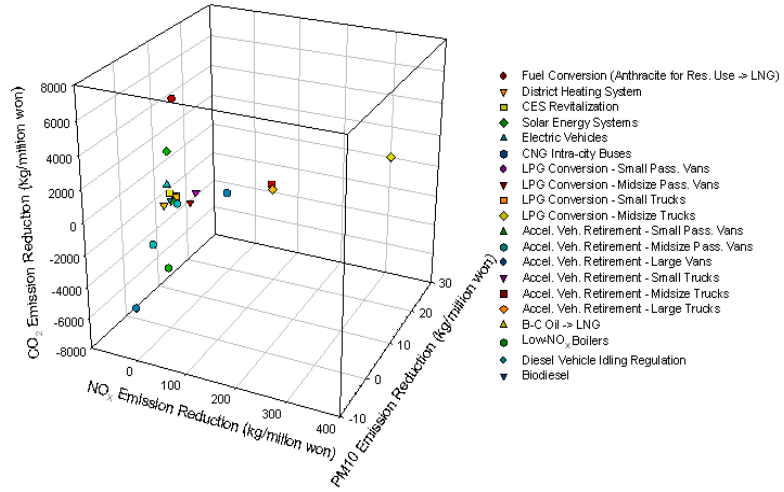


Evolution of policy analysis for GHG and air pollutant mitigations



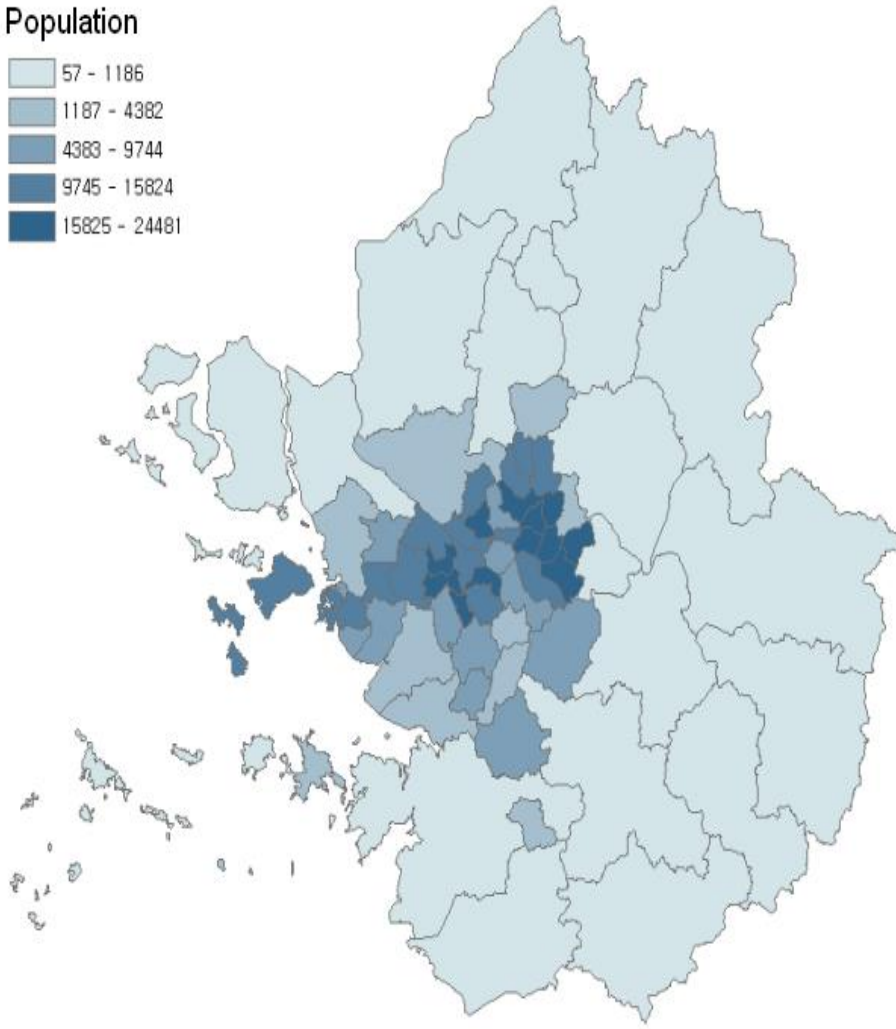




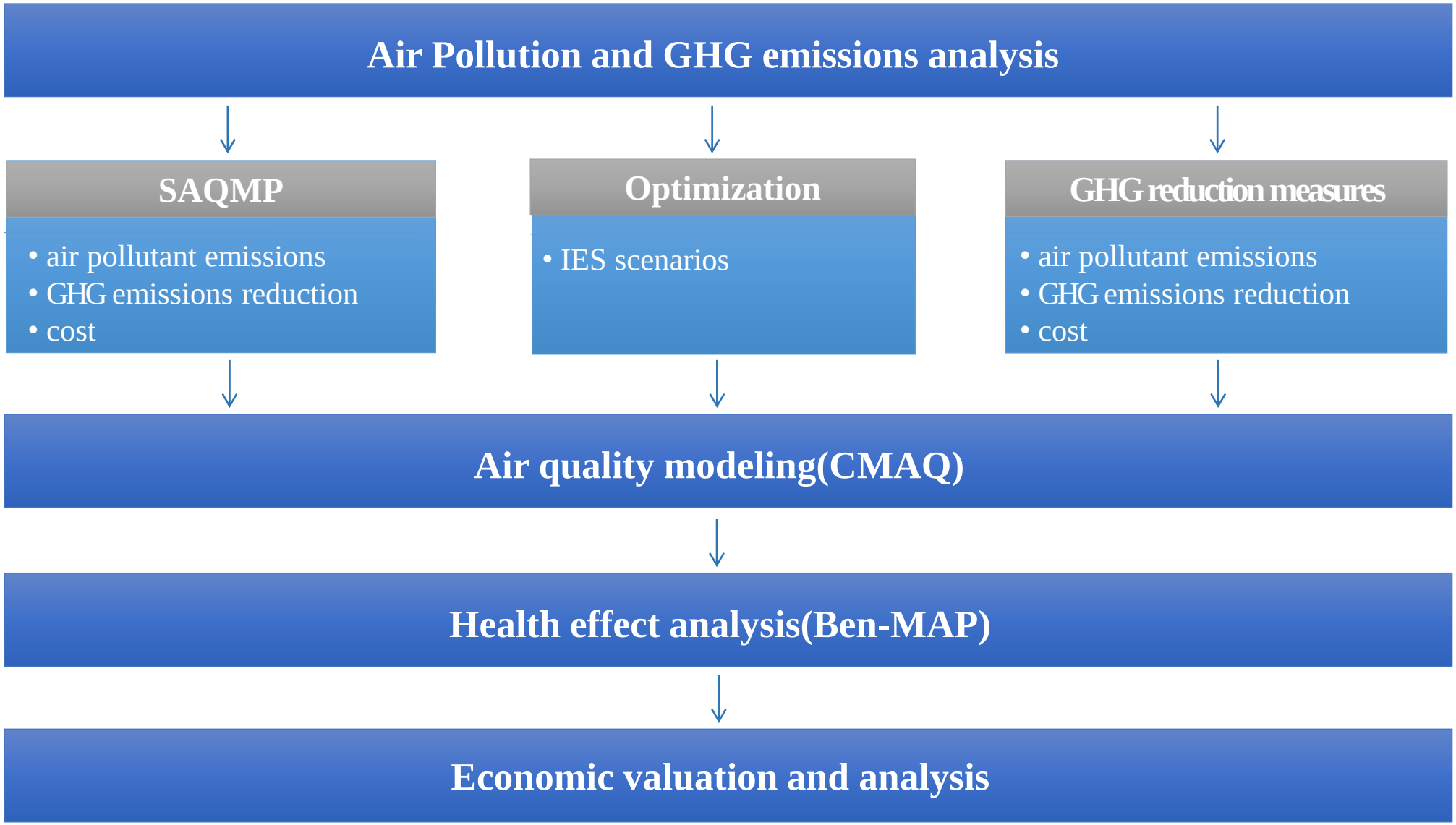


Seoul Metropolitan Area

Category	Unit	National	Seoul Metropolitan Area			
			Total	Seoul	Incheon	Gyeonggi
Area	Km^2	99,852.0	11,700.5 (11.72%)	605.5 (0.61%)	958.0 (0.96%)	10,137.0 (10.15%)
Population	Thousand	48,289	22,525 (46.65%)	10,331 (21.39%)	2,582 (5.35%)	9,612 (19.91%)
Population Density	Person/km^2	483	1,925 (4 times)	17,062 (35 times)	2,634 (5.5 times)	948 (20 times)
Gross Regional product	Billion Won	561,789	251,220 (44.72%)	114,153 (20.32%)	25,513 (4.54%)	111,554 (19.86%)
Company	Number of Company	3,051,482	1,381,566 (45.28%)	725,569 (23.78%)	147,081 (4.82%)	508,916 (16.68%)
Employee	Person	14,336,604	7,175,802 (50.05%)	3,878,833 (27.06%)	699,233 (4.88%)	2,597,736 (18.12%)
Manufacturing Company	Number of Company	331,762	170,079 (51.27%)	76,017 (22.91%)	20,507 (6.18%)	73,555 (22.17%)
Vehicle	Thousand	12,914	5,983 (46.33%)	2,550 (19.75%)	697 (5.40%)	2,736 (21.19%)

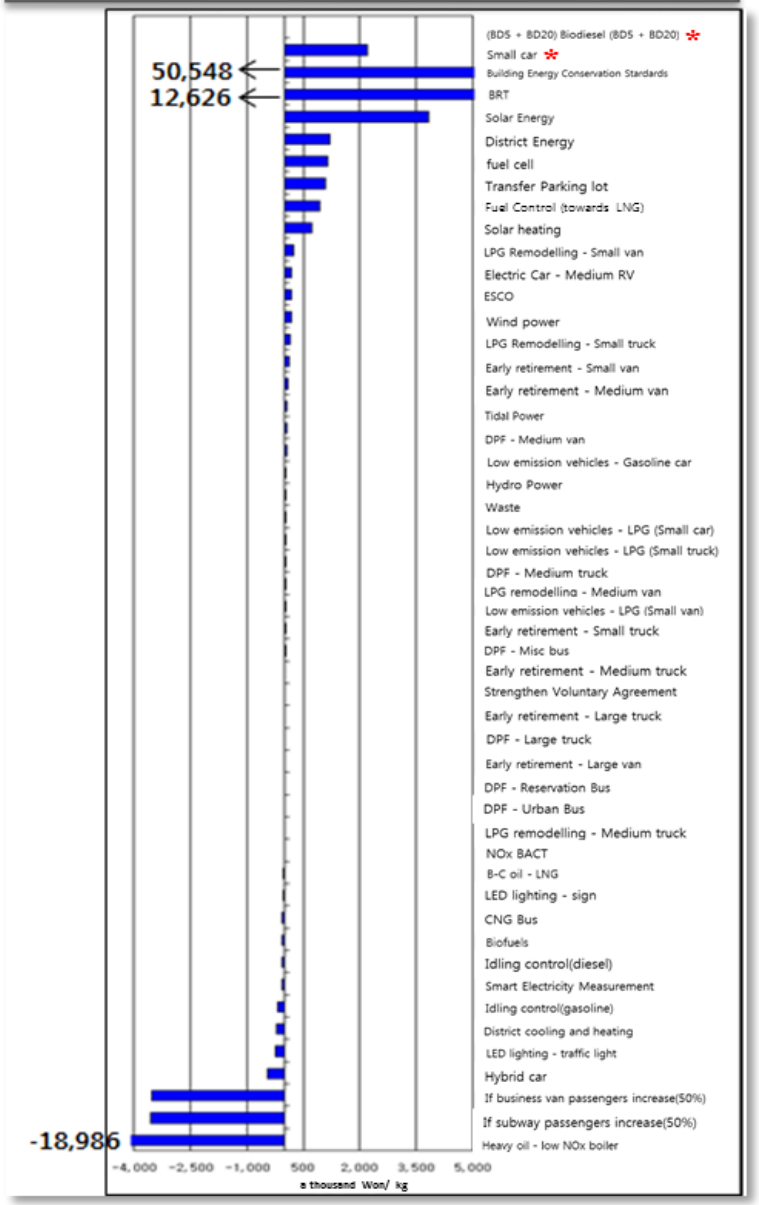


Research Structure

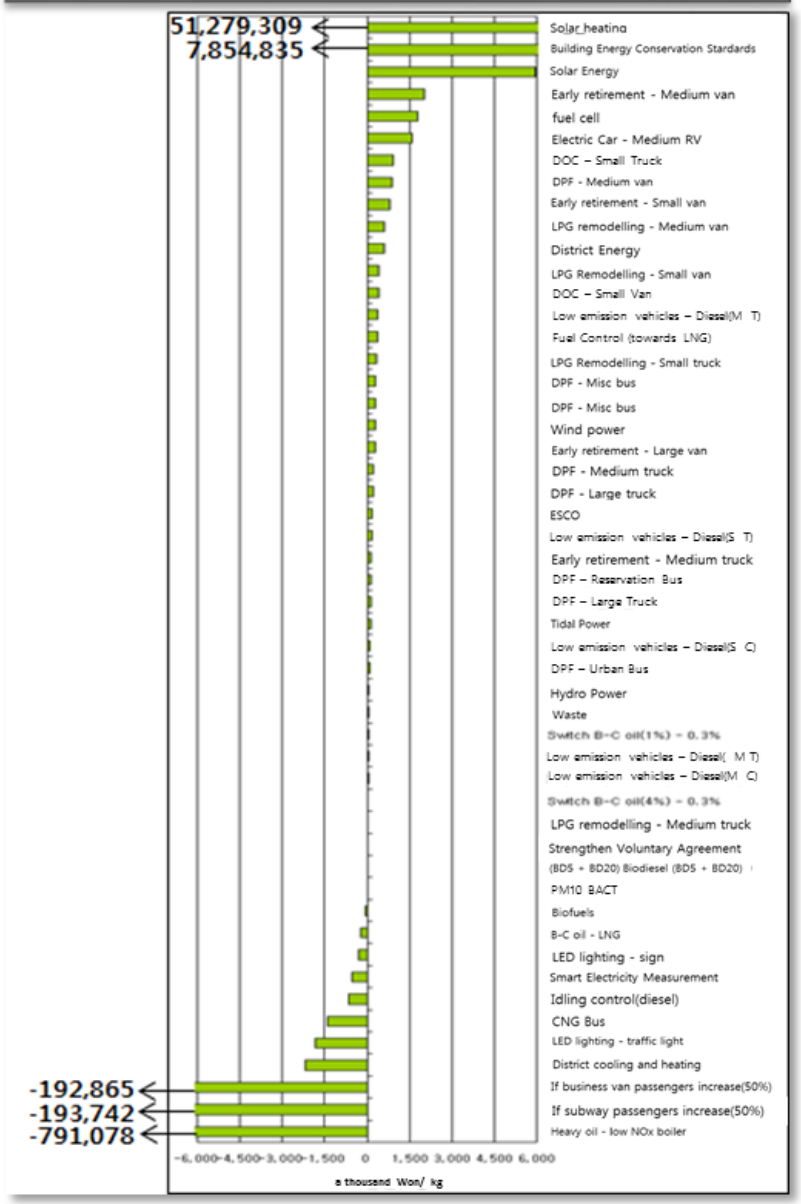


Cost Effectiveness of Air Pollution Policies

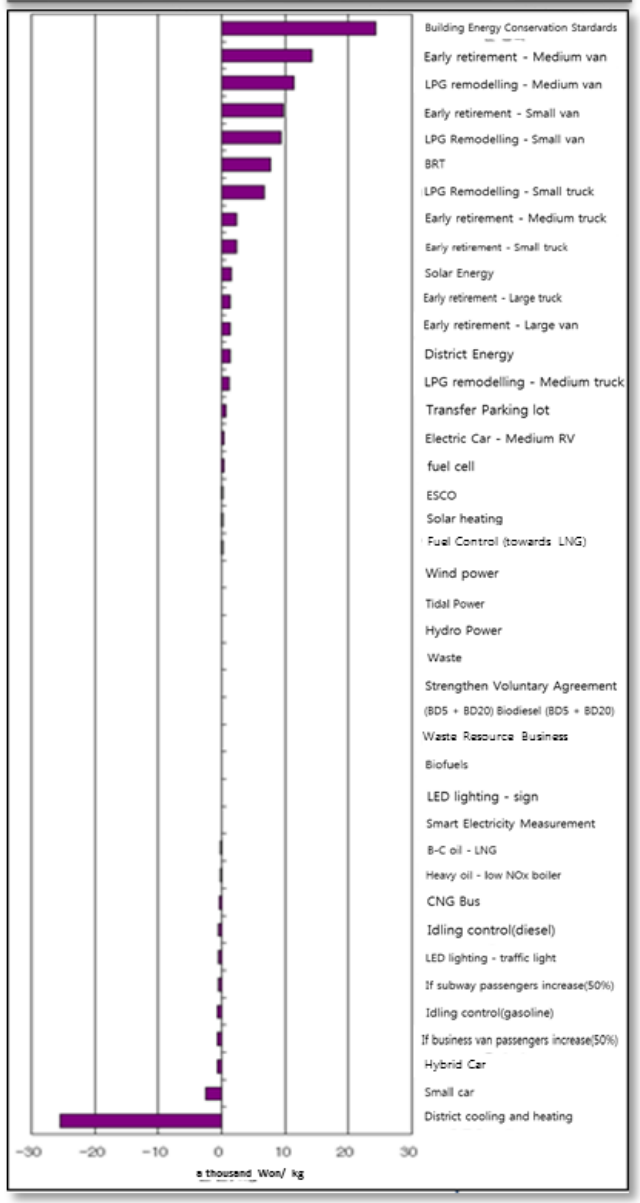
Cost Effectiveness of NOx Reduction



Cost Effectiveness of PM_{10} Reduction

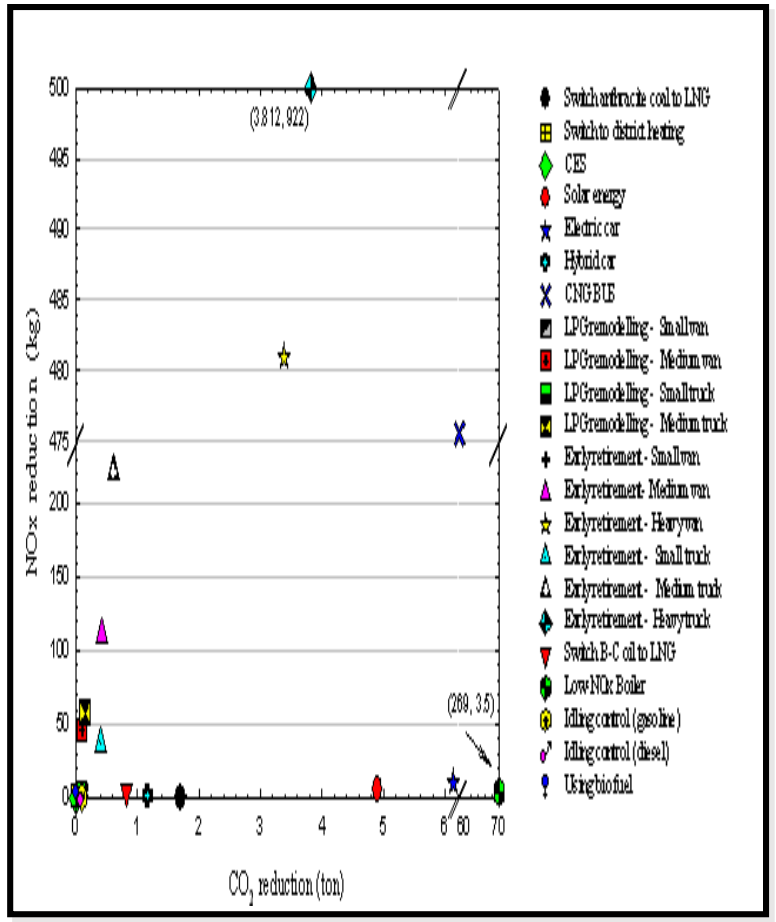


Cost Effectiveness of CO_2 reduction

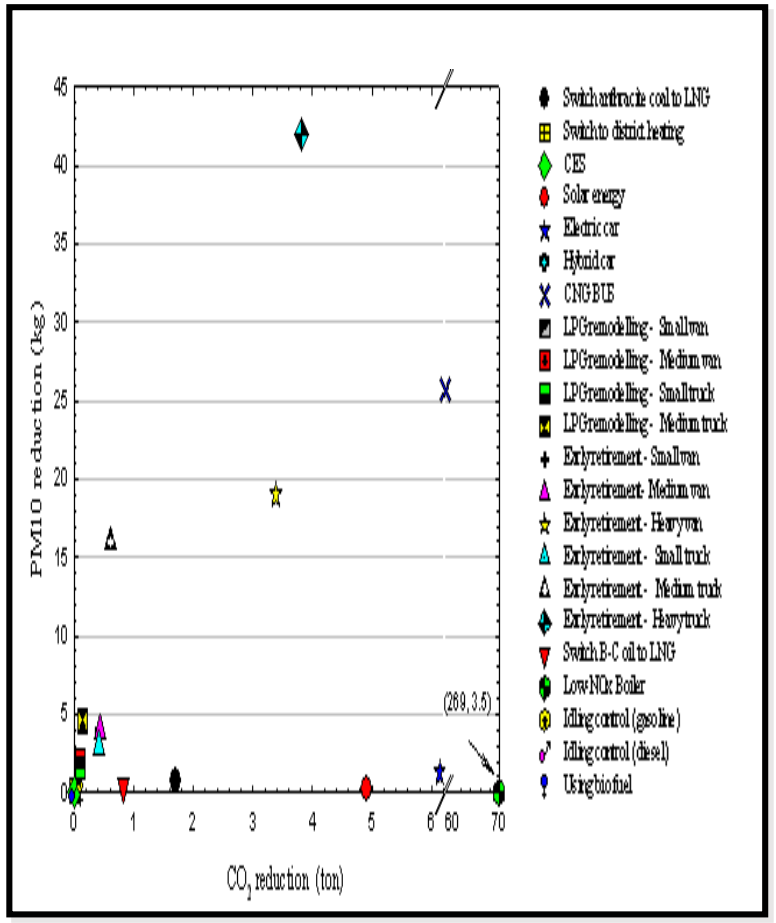


Relationship between NOx, CO_2, PM_{10} emission reduction from each measures

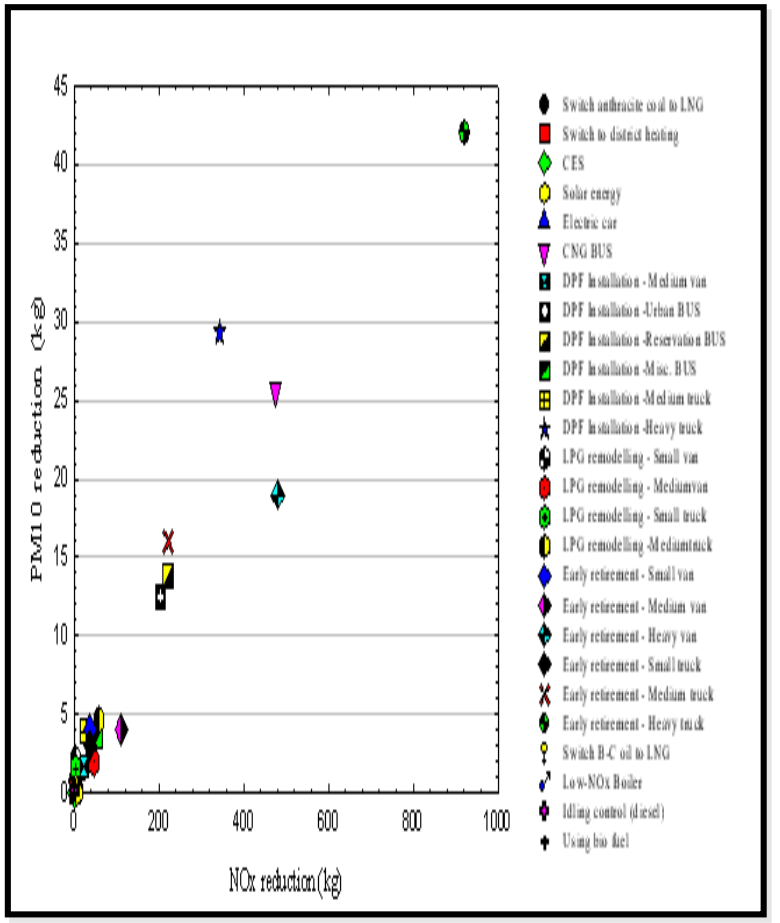
NO_X - CO_2



PM_{10} - CO_2



PM_{10} - NO_X



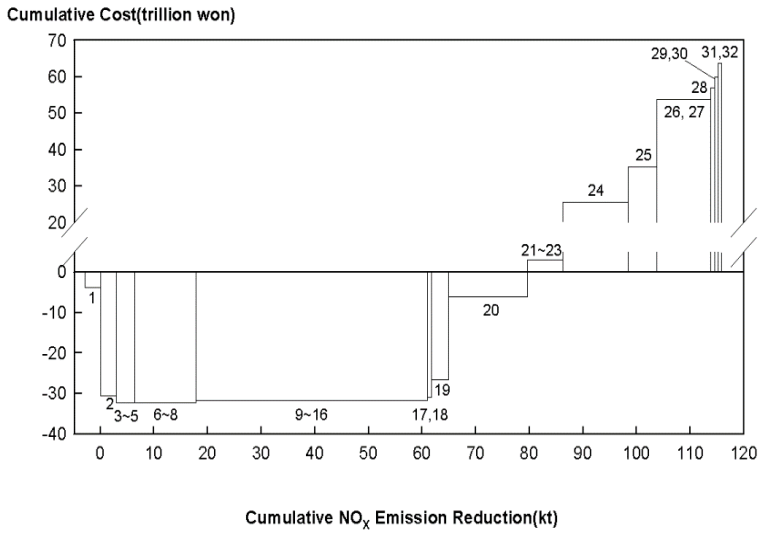
Co-benefit of Seoul Air Quality Management Plan: CO_2 Emission Reduction(2014)

KEI 한국환경정책·평가연구원 Korea Environment Institute

	Measure		Amount of CO_2 Reduction (ton/year)
Area source	Fuel Control	Switch anthracite coal to LNG	22,010
	Switch to district heating		25,308
	CES		5,191
	Alternative energy	Solar power	225,400
	Total		277,909
Mobile source	Low Emission Car	Electric car	80,329
		Hybrid car	164,034
		CNG BUS	425,869
	LPG Remodeling		1,936
	Early Retirement		29,908
	Total		702,076
Industry	Fuel Switch	B-C oil->LNG	2,042,097
	Low-NOx Boiler		4,303,933
	Total		6,346,030
Total			**7,326,015**

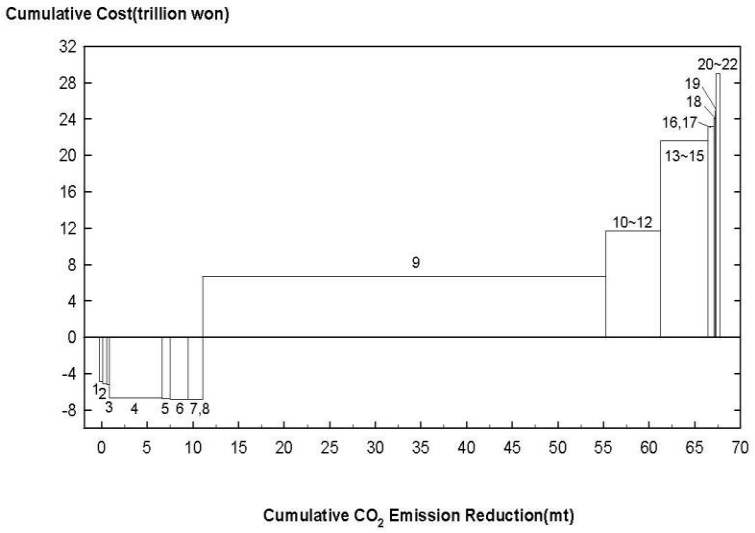
NOx, CO_2, PM_{10} emissions reduction effect and costs

NOx



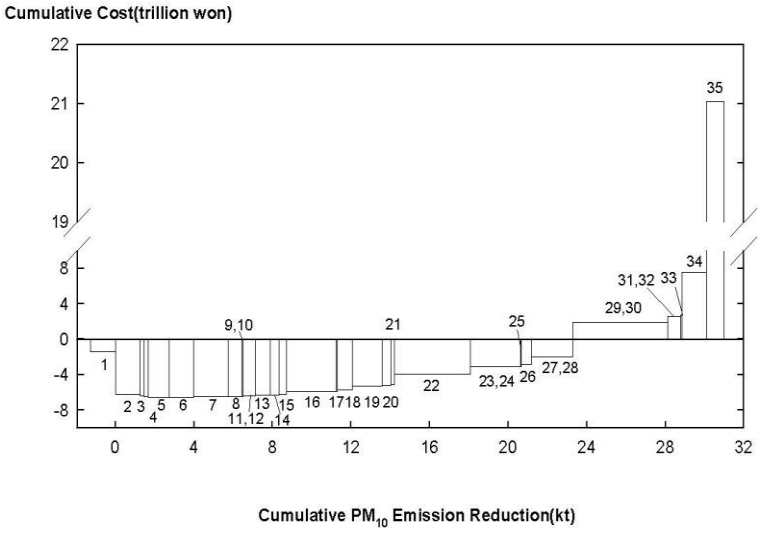
1. Heavy Oil Low-NO_X Boiler	2. CNG BUS	3. Switch to District Heating	4. Idling Control (Gasoline)
5. Idling Control (Diesel)	6. Fuel Switch B-C Oil - LNG	7. CES	8. Gasoline Car
9. NO_X BACT	10. LPG Car-Small Car	11. LPG Car - Small Vans	12. LPG Car - Small Trucks
13. LPG Conversion - Medium Trucks	14. Switch Anthracite Coal to LNG	15. LPG Conversion – Small Trucks	16. LPG Conversion – Small Vans
17. Early Retirement – Small Trucks	18. LPG Conversing – Medium Vans	19. DPF Installation – Medium Vans	20. DPF Installation-Vans (Urban BUS)
21. DPF Installation – Medium Trucks	22. Early Retirement – Medium Trucks	23. Solar Power	24. DPF Installation-Vans (Reservation BUS)
25. DPF Installation – Vans (Misc. BUS)	26. DPF Installation – Heavy Trucks	27. Hybrid Car	28. Early Retirement – Small Vans
29. Early Retirement – Heavy Vans	30. Electric Car – Medium RV (Diesel)	31. Early Retirement – Heavy Trucks	32. Early Retirement – Medium Vans

CO_2



1. Switch to District Heating	2. Idling Control (Gasoline)	3. Idling Control (Diesel)	4. Heavy Oil Low - NO_X Boiler
5. CNG BUS	6. Fuel Switch B-C oil - LNG	7. Landfill gas re-use	8. Switch anthracite coal to LNG
9. Solar Power	10. Electric Car – Medium RV (Diesel)	11. LPG Conversion -Medium Trucks	12. Early Retirement -Heavy Vans
13. Early Retirement -Heavy Trucks	14. CES	15. Hybrid Car	16. Early Retirement -Small Trucks
e17. Early Retirement -Medium Trucks	18. LPG Conversion -Small Trucks	19. LPG Conversion -Small Vans	20. Early Retirement -Small Vans
21. LPG Conversion -Medium Vans	22. Early Retirement -Medium Vans		

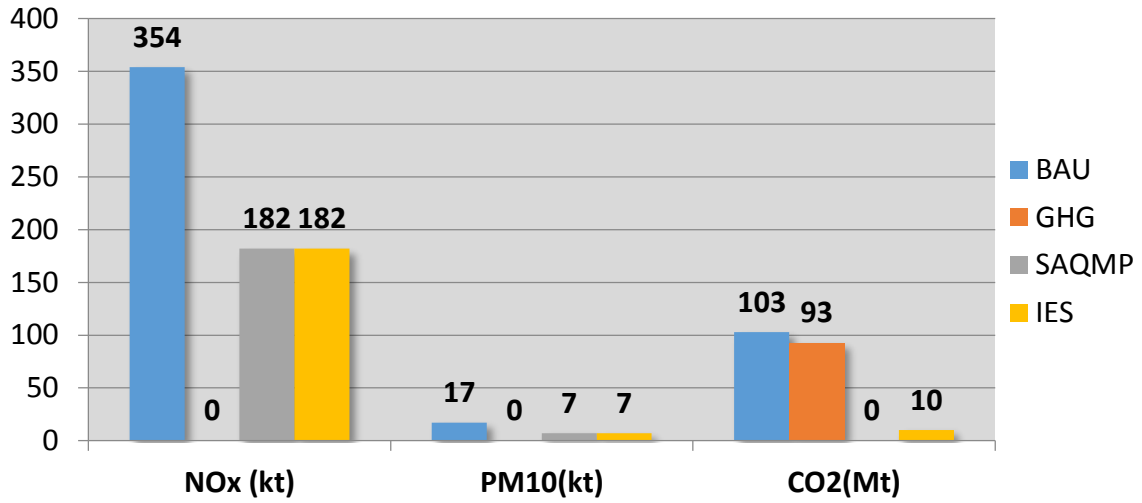
PM_{10}



1. Heavy Oil Low-NO_X Boiler	2. Switch to District Heating	3. CNG BUS	4. Idling Control (Diesel)
5. Fuel Switch B-C Oil - LNG	6. PM_{10} BACT	7. LPG Conversion – Medium Truck	8. Switch B-C Oil (4%) - 0.3%
9. Diesel Car-Large Vans	10. Diesel Car – Heavy Trucks	11. Switch B-C Oil (1%) - 0.3 %	12. DPF Installation – Vans (Urban BUS)
13. Diesel Car-Small Trucks	14. DPF Installation – Heavy Trucks	15. DPF Installation – Vans (Reservation BUS)	16. Early Retirement – Medium Trucks
17. Diesel Car – Medium Trucks	18. Early Retirement – Heavy Trucks	19. DPF Installation – Trucks (Medium)	20. Early Retirement – Heavy Vans
21. DPF Installation - Vans (Misc. BUS)	22. Early Retirement – Small Trucks	23. LPG Conversion – Small Trucks	24. Diesel Car – Medium Vans
25. Switch Anthracite Coal to LNG	26. DOC Installation – Small Vans	27. LPG Conversion – Small Vans	28. LPG Conversion – Medium Vans
29. Early Retirement -Small Vans	30. DPF Installation – Vans (Medium)	31. DOC Installation – Small Trucks	32. CES
33. Early Retirement – Medium Vans	34. Electric Car – Medium RV (Diesel)	35. Solar Power	

Emission Objectives for scenarios

- GHG scenario: 10% GHG reduction compared to BAU
- SAQMP scenario: Air pollutants emission reduction to meet AQ target
- IES scenarios : GHG+SAQMP with minimum cost (optimized)



<Co-benefits of each scenario>

	CO_2 emission	NO_X emission	PM_{10} emission	Fuel saving (trillion won)
BAU	103	354	17	
SAQMP	96	182	10	3.12
GHG	92	322	14	8.28

Benefit Estimation

- Human health benefit

Air quality modeling(CMAQ)

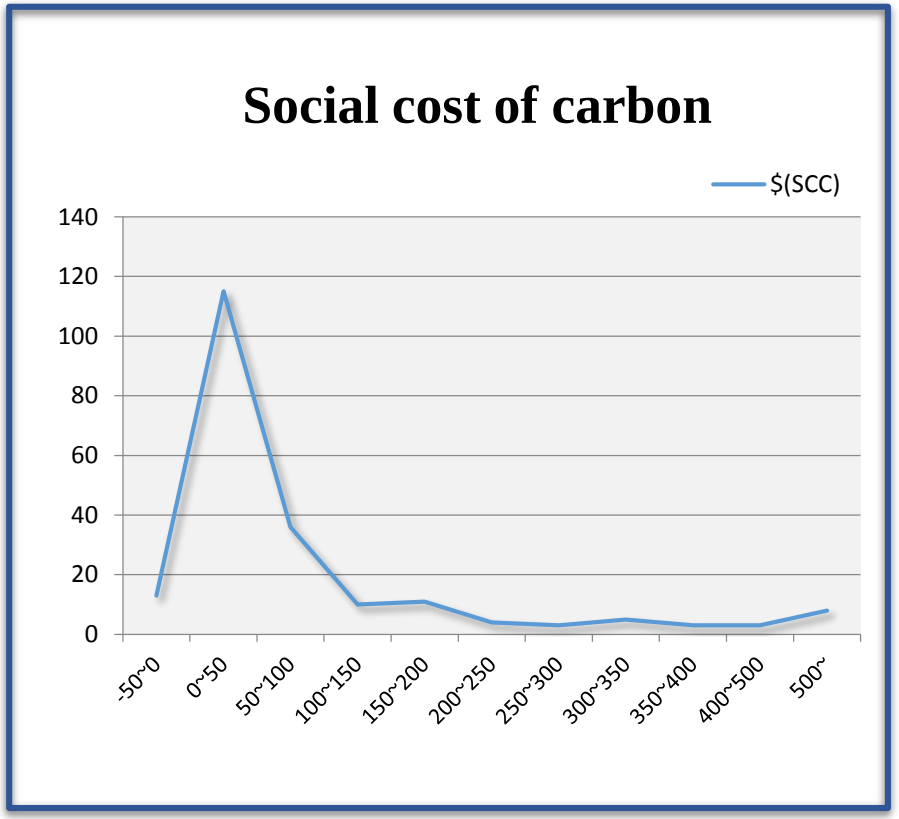
↓ Dose-response function (BenMAP)

# of premature death

↓ VOSL

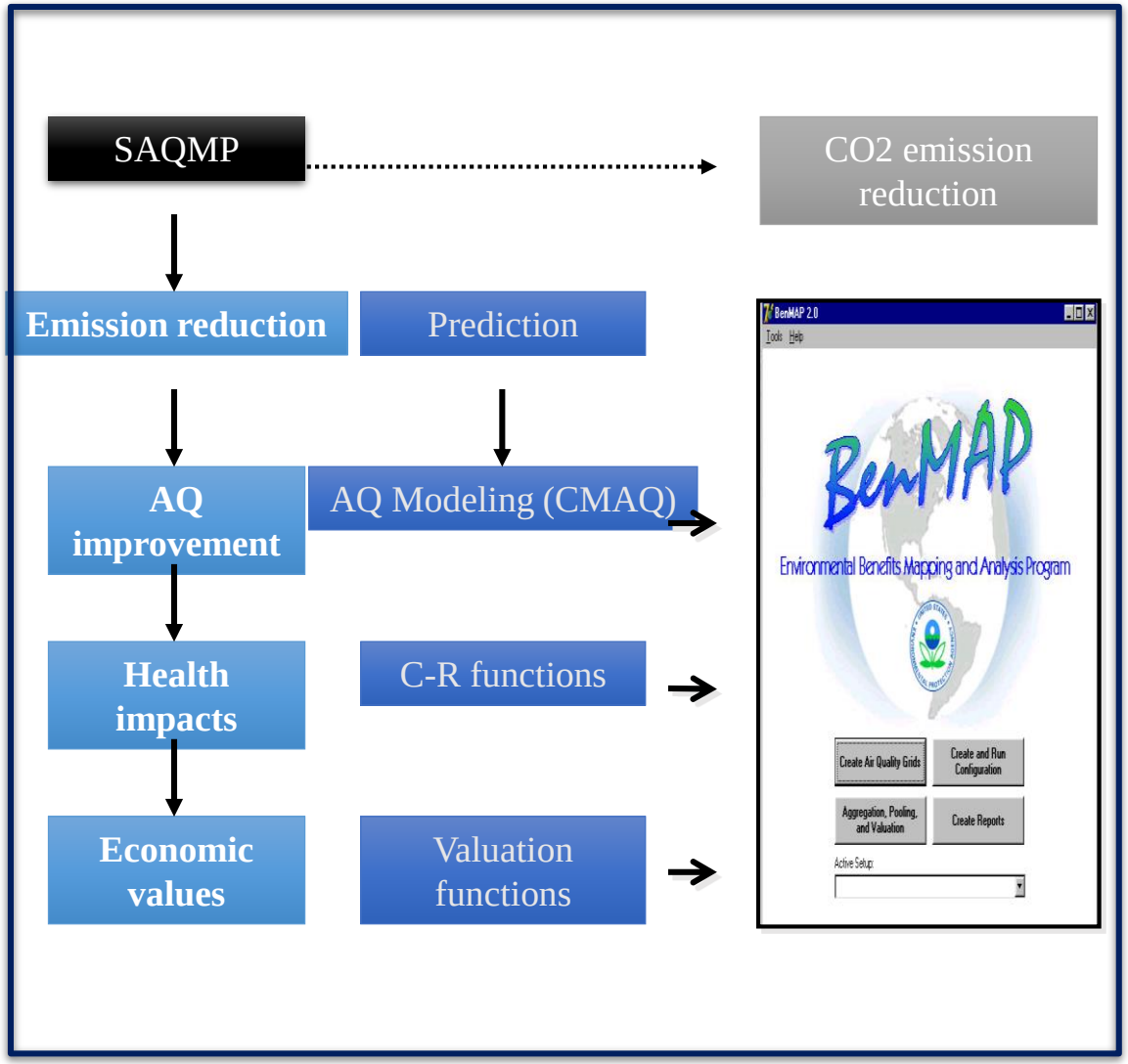
Economic valuation

- Climate change benefit



Benefit Estimation

Estimation of human health effects



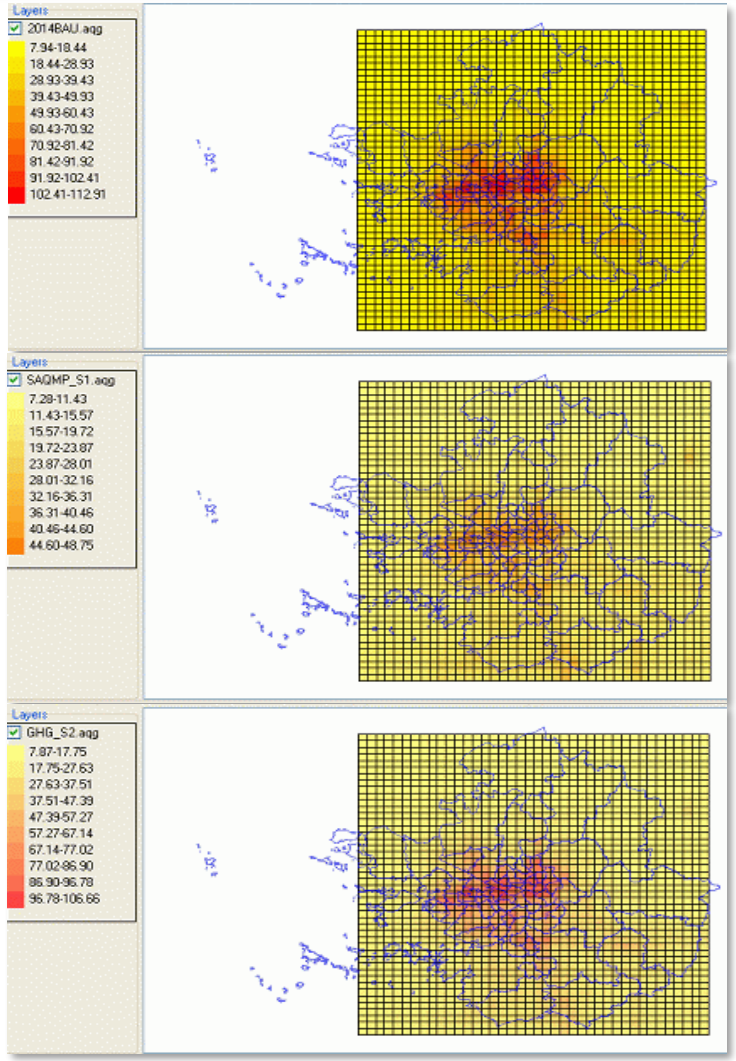
Estimation of human health effects: Materials

GIS files (the Seoul Metropolitan Area)	• Grid – the levels of political boundaries for the SMPA
Population Data	• Hamilton-Perry method
Air pollution modeling data	• MM5/CMAQ model or the widely accepted air quality modeling method • Pollutants – PM_{10}, NO_x • Scenario – BASE 2004, BAU 2014, SAQMP 2014, GHG 2014 • Result – Hourly concentrations under each Scenario

→ BenMAP

Air Quality Modeling: CMAQ

CMAQ-modeled PM_{10} concentration level
By district (2014)



(a) BAU scenario
Ranged from 8 to 113$\mu g/m^3$

(b) SAQMP scenario
Ranged from 7 to 50$\mu g/m^3$

(c) GHG scenario
Ranged from 8 to 107$\mu g/m^3$

Health Damage Estimation

<Estimated annual health benefits of deaths avoided from implementing the SAQMP>

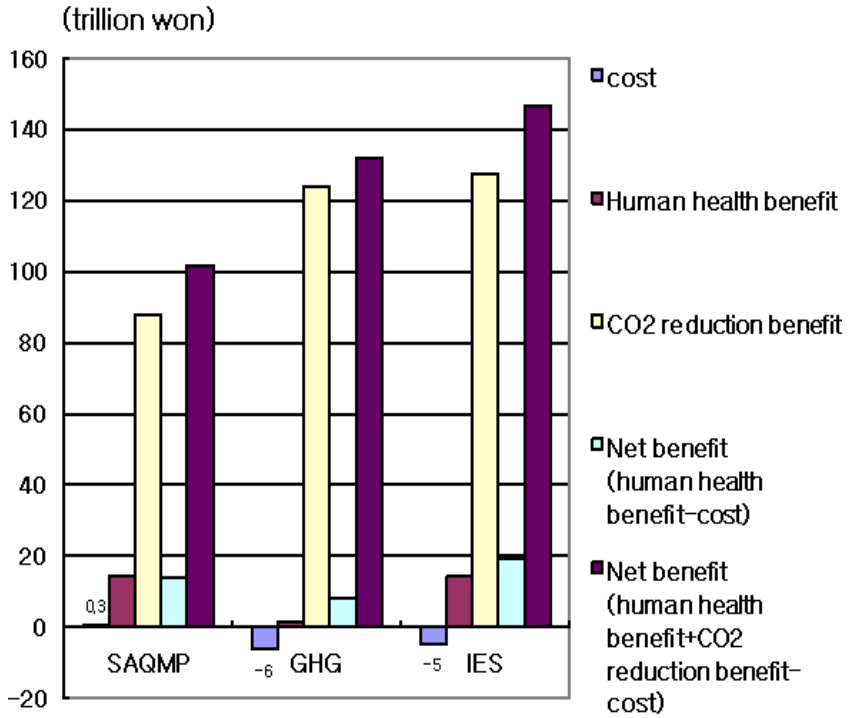
Area		Lives saved (95% Confidence Interval)
Sub Area	Seoul	**3,508 (1,774~5,140)**
	Incheon	**524 (263~776)**
	Gyeonggi	**1,663 (830~2,461)**
Seoul Metropolitan Area		**5,695 (2,867~8,377)**

<Estimated annual health benefits of deaths avoided from implementing the GHG>

Area		Lives saved (95% Confidence Interval)
Sub Area	Seoul	**358 (177~540)**
	Incheon	**56 (28~84)**
	Gyeonggi	**175 (82~260)**
Seoul Metropolitan Area		**589 (287~884)**

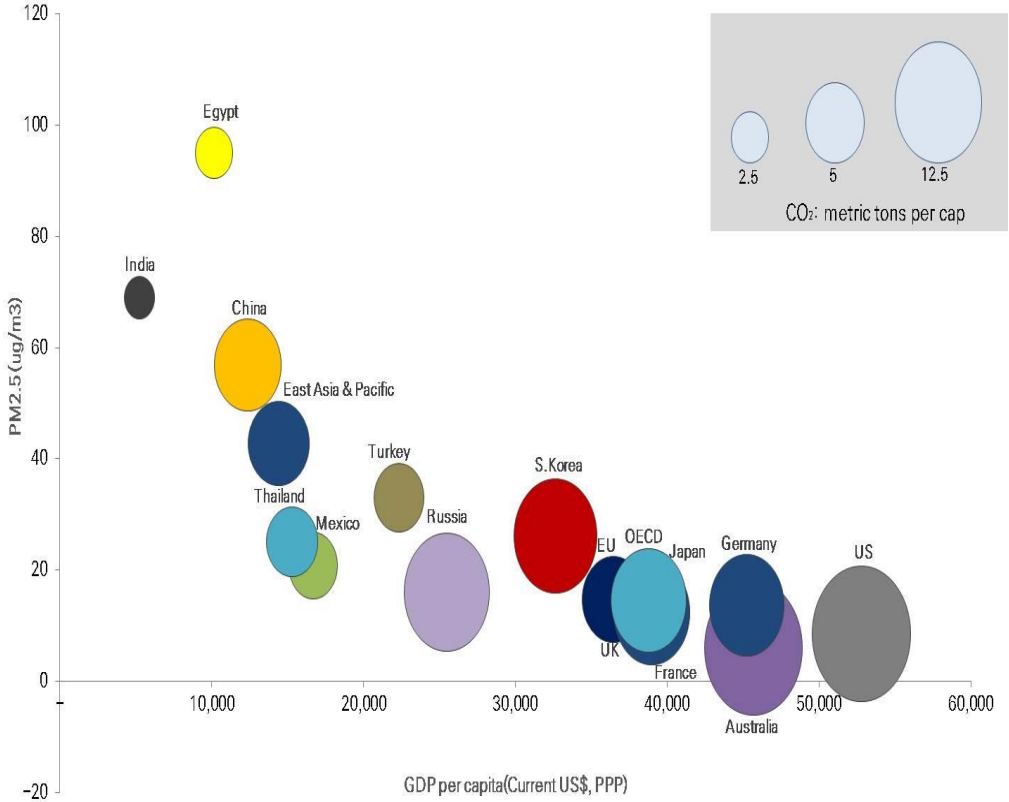
Emissions Reduction Effects and Costs of each scenario

	NO_X emission	PM_{10} emission	CO_2 emission	Cost	Human health benefit	CO_2 emissions reduction benefit
BAU	354	17	103,085	0	0	0
SAQMP	182	10	95,758	295	14,260	87,912
GHG	322	14	92,745	-6,419	1,474	124,075
IES	182	7	92,441	-3,568	14,260	127,718



What need to do?

- Development of the inter-country policy analysis model to manage GHGs and Air quality
  - To update the relevant policies, plans of neighboring countries in order to achieve the policy goals of each country
  - To develop optimal policy mix considering co-benefits and mutual benefits
- Development of Social cost of GHGs and APs in NEA
  - Social cost needs to be developed reflecting NEA context.
- Development of win-win policy in NEA context



Source: World Development Indicator