Impacts on Emissions and Air Quality of alternative fuel mixes in Spain

EUROPEAN ENERGY MARKETS 2010

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OUTLINE

1.- Introduction

2.- Scenario without Natural Gas

3.- Future scenarios (up to 2020)

4.- Conclusions

1.- INTRODUCTION

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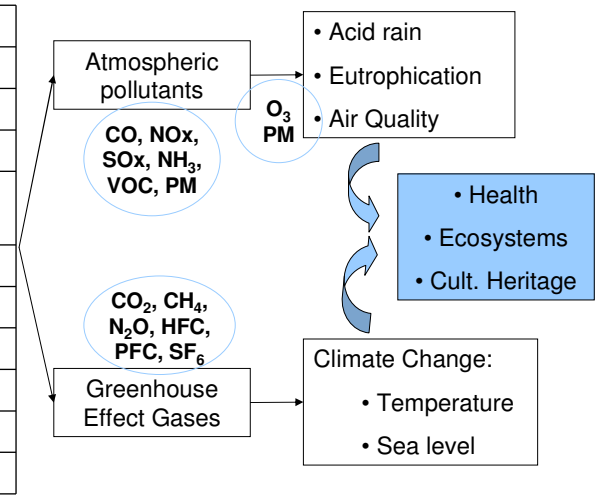
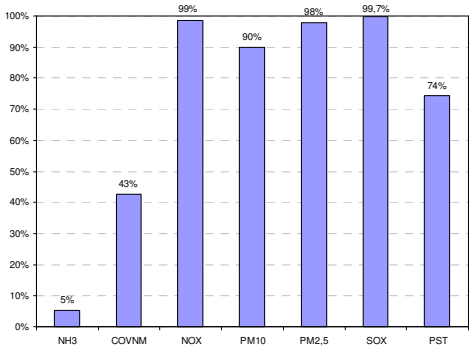
Emission → **Transport/chem. react.** → **Effects/impacts**

Electricity generation
Non-industrial comb. plants
Industrial Combustion
Production processes
Extraction and distrib. of fossil fuels
Solvent use
Road transport
Other mobile sources
Waste treatment
Agriculture
Other sources and sinks

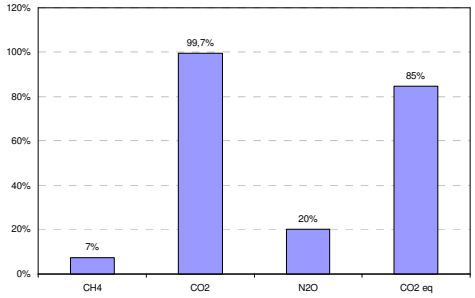


Emissions from energy sector vs. Spanish total (MARM, 2008)



Percentage of energy sector emissions from total Spanish emissions for 2006

- Energy and transformation industries
- R&C&I
- Industry
- Transport



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2.- SCENARIO WITHOUT NATURAL GAS

Reference scenario (2006 official) vs. scenario without Natural Gas

Assumptions under scenario without Natural Gas :

- Energy & transformation: fuel/gas to the historic maximum and coal growth
- RCI: substitution by petroleum products, mainly diesel
- Industry: dependant on the activity and technology:
  - co-generation: petroleum derivatives
  - process kilns and boilers: petrol products, coal and waste fuels.
- Transport: without any change

Industrial sector	D	FO	LPG	PC	Coal	CG	C	W
Iron and steel	X	X	X		X	X		
Non-ferrous metal industries	X	X		X	X		X	
Lime production		X		X				
Glass production		X						
Bricks and tiles	X	X		X				
Fine ceramic materials		X						
Pulp and paper		X						X
Chemistry	X	X	X		X			X
Wood	X	X						X
Textile	X	X	X					
Food, drink and tobacco	X	X						X
Machinery and transport equipments	X	X	X	X				

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Emissions:

Sector	CO_2 equiv.	SO_2	NO_X	NMVOC	$PM_{2,5}$
Energy and transformation industries	+32%	+69%	+38%	+10%	+63%
Non-industrial combustion	+10%	+90%	+7%	-1%	+7%
Industrial combustion	+16%	+168%	+18%	-17%	+64%
TOTAL	**+13%**	**+77%**	**+12%**	**-1%**	**+14%**
NG segment	**+23%**	**+81%**	**+27%**	**-5%**	**+38%**

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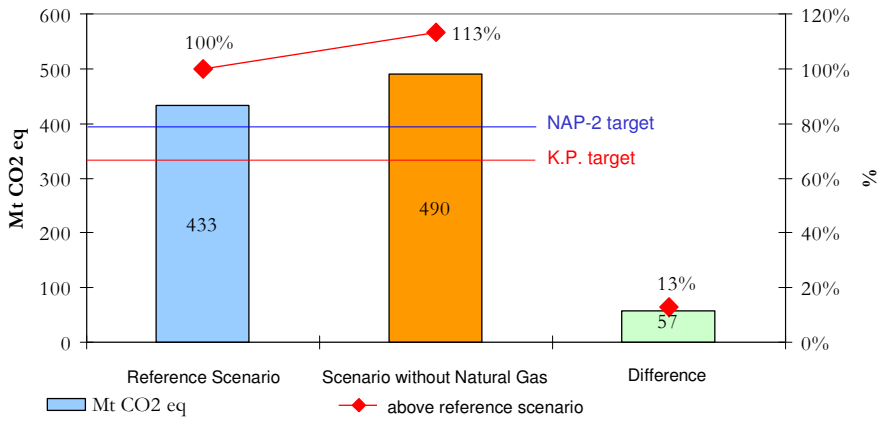
Comparison with Kyoto Protocol target



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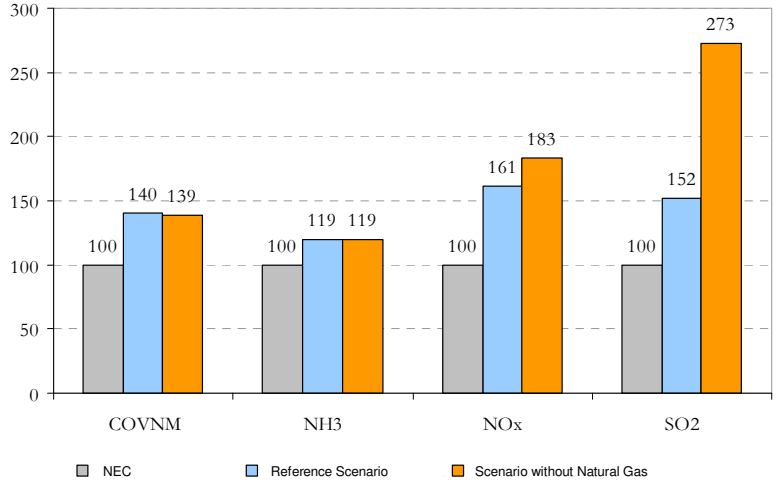
Co-benefits on air pollutants



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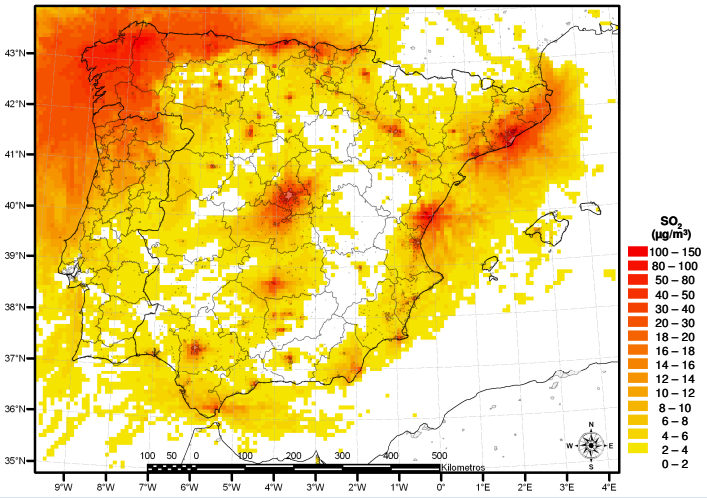
Co-benefits on air quality (sulphur dioxide, SO_2)

Difference between reference scenario and scenario without NG for the SO_2 daily percentile



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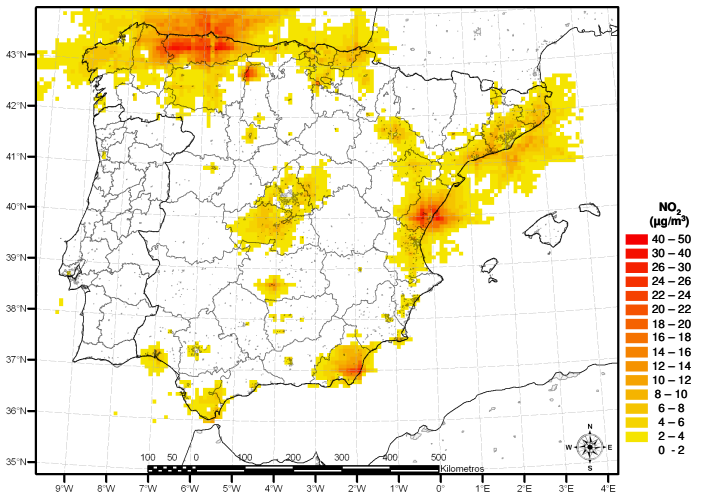
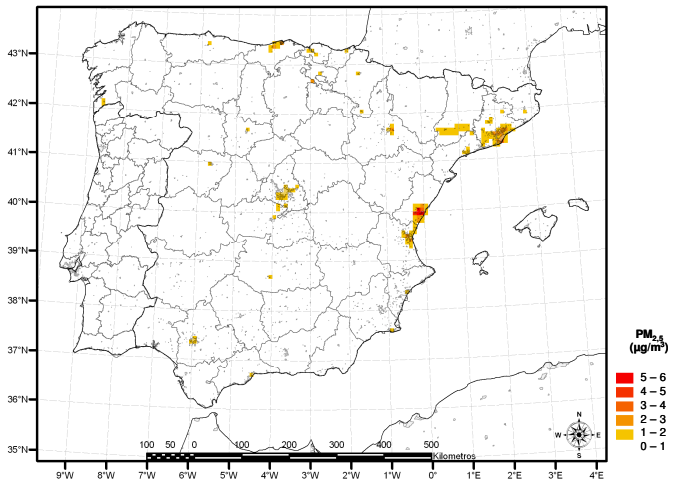
Co-beneficios on air quality (nitrogen dioxide, NO_2)

Difference between reference scenario and scenario without NG for the NO_2 Hourly 99.8 percentile



Co-benefits on air quality (fine particulate mater, $PM_{2.5}$)

Difference between reference scenario and scenario without NG for the $PM_{2.5}$ annual average



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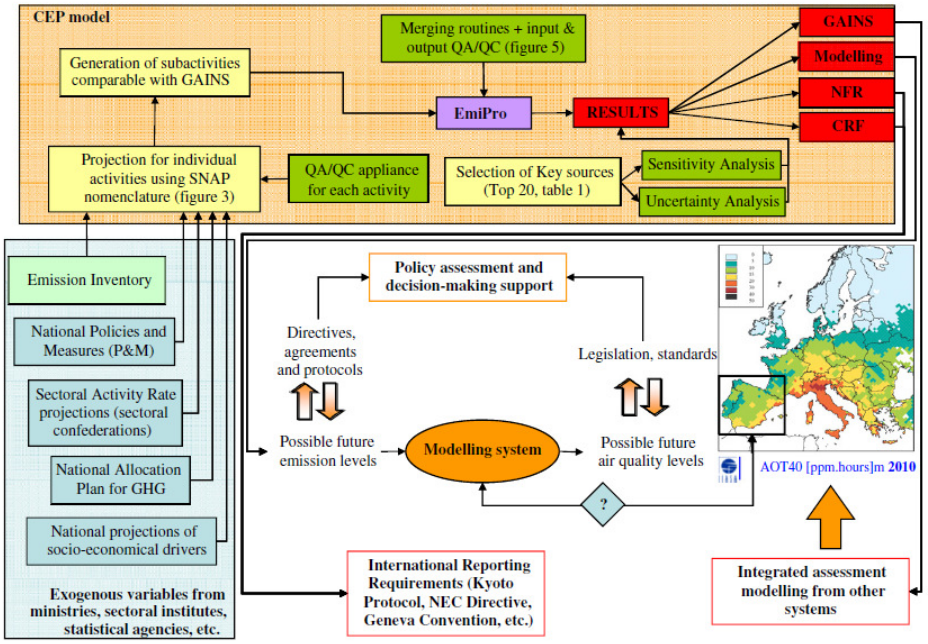
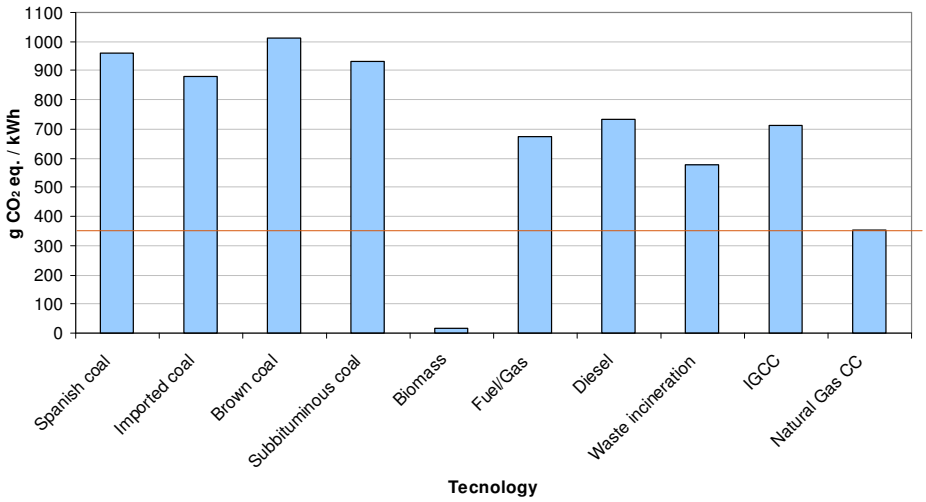
3.- FUTURE SCENARIOS (up to 2020)

Consistent Emission Projection (CEP) Model applied to Spain

• 2010. Kelly, A., Lumbreras, J., Maas, R., Pignatelli, T., Ferreira, F., and Engleryd, A. Setting national emission ceilings for air pollutants: policy lessons from an ex-post evaluation of the Gothenburg Protocol. Environmental Science and Policy 13, 28-41.
• 2009. Lumbreras, J., García-Martos, C., Mira, J., Borge, R. Computation of uncertainty for atmospheric emission projections from key pollutant sources in Spain. Atmospheric Environment 43, 1557–1564.
•2008. Lumbreras, J., Borge, R., de Andres, J.M., Rodriguez, M.E. A model to calculate consistent atmospheric emission projections. Application to Spain. Atmospheric Environment, 42/21, 5251-5266.
• 2008. Borge, R., Alexandrov, V., Vas, J.J., Lumbreras, and J., Rodríguez, M.E. A comprehensive sensitivity analysis of the WRF model for air quality applications over the Iberian Peninsula. Atmospheric Environment 42, 8560–8574.
• 2008. Lumbreras, J., Valdés, M., Borge, R. and Rodríguez, M.E. Assessment of vehicle emissions projections in Madrid (Spain) from 2004 to 2012 considering several control strategies. Transportation Research Part A 42, 646-658
• 2008. Borge, R.; Lumbreras, J. and Rodríguez, E. Development of a high-resolution emission inventory for Spain using the smoke modelling system: A case study for the years 2000 and 2010. Environmental Modelling & Software 23, 1026-1044.



CO_2 eq. emission factors for electricity generation



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Future scenarios:

- Reference scenario: most likely considering official energy prospective from the Ministry for Energy including sectoral and national legislation and planning
- Fossil scenario without NG: energy demand increase with respect to 2006 is satisfied by fossil fuels different than NG (assuming NG total consumption as in 2006)
- Natural Gas scenario: same energy demand as in the reference scenario but assuming higher NG penetrations

Natural Gas scenario assumptions (up to 2020):

- Energy and transformation industries: coal substitution with NG
- RCI:
  - co-generation with NG,
  - increase of solar/gas solutions to $15 \cdot 10^6$ m^2 of solar panels
  - domestic use of NG in every town of more than 10.000 inhabitants
- Industry: co-generation with NG
- Transport:
  - CNG used in 5% of mileage from passenger cars and buses
  - 13% LNG consumption in the national fishing fleet

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Total results:

Sector	Scenario comparison	2020				
		CO_2 eq	SO_X	NO_X	NMVOC	$PM_{2,5}$
National Total	Fossil vs. Ref.	**4,0%**	53,3%	5,8%	-0,5%	5,3%
	Natural Gas vs. Ref.	**-8,2%**	-29,2%	-4,5%	0,1%	-5,1%
	Natural Gas vs. Fossil	**-11,8%**	-53,8%	-9,8%	0,6%	-9,9%
NG sector	Fossil vs. Ref.	**7,1%**	57,3%	11,2%	-2,3%	13,4%
	Natural Gas vs. Ref.	**-13,6%**	-31,3%	-8,0%	0,7%	-12,7%
	Natural Gas vs. Fossil	**-19,4%**	-56,3%	-17,2%	3,1%	-17,2%
Energy sector	Fossil vs. Ref.	**4,7%**	53,8%	5,9%	-1,8%	5,5%
	Natural Gas vs. Ref.	**-9,6%**	-29,4%	-4,6%	0,3%	-5,3%
	Natural Gas vs. Fossil	**-13,7%**	-54,1%	-9,9%	2,1%	-10,2%

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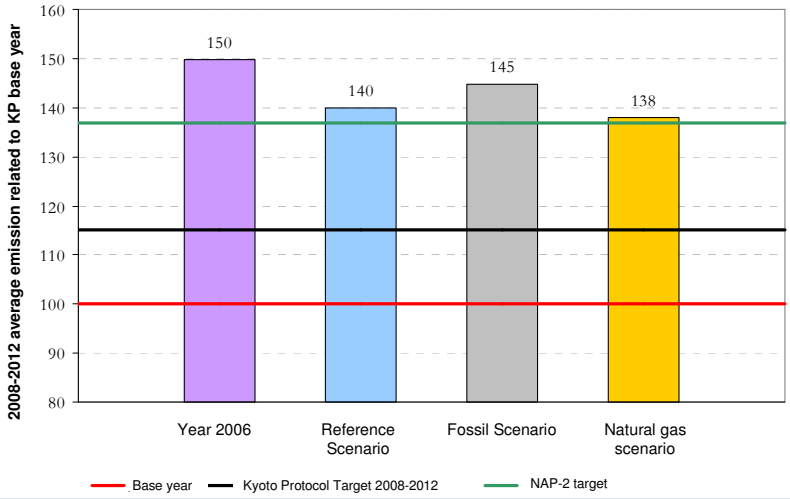
Kyoto Protocol accomplishment



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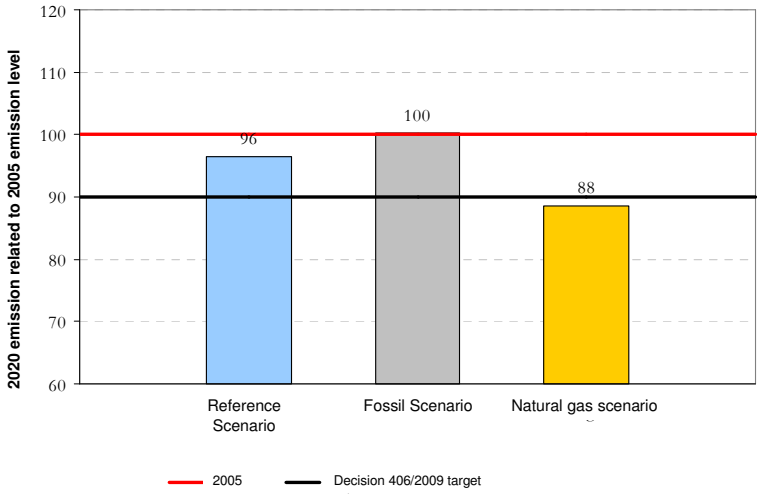
2020 targets



Sectoral results:

Sector	Scenario comparison	2020				
		CO_2 eq	SO_x	NO_x	NMVOC	$PM_{2,5}$
Energy and transformation industries	Fossil vs. Ref.	**4,3%**	19,4%	21,2%	6,1%	9,4%
	Natural Gas vs. Ref.	**-32,8%**	-42,3%	-36,0%	0,0%	-49,6%
	Natural Gas vs. Fossil	**-35,6%**	-51,6%	-47,2%	-5,7%	-53,9%
RCI	Fossil vs. Ref.	**7,0%**	72,7%	7,3%	0,2%	5,8%
	Natural Gas vs. Ref.	**-10,5%**	-50,8%	-7,0%	-0,3%	-3,8%
	Natural Gas vs. Fossil	**-16,4%**	-71,5%	-13,3%	-0,5%	-9,1%
Industry	Fossil vs. Ref.	**9,3%**	139,5%	8,9%	-8,9%	24,2%
	Natural Gas vs. Ref.	**-0,3%**	-3,7%	-0,5%	1,5%	-1,9%
	Natural Gas vs. Fossil	**-8,8%**	-59,8%	-8,6%	11,4%	-21,0%
Transport	Fossil vs. Ref.	**0,0%**	0,0%	0,0%	0,0%	0,0%
	Natural Gas vs. Ref.	**-2,2%**	-1,0%	-0,8%	-1,0%	-0,2%
	Natural Gas vs. Fossil	**-2,2%**	-1,0%	-0,8%	-1,0%	-0,2%

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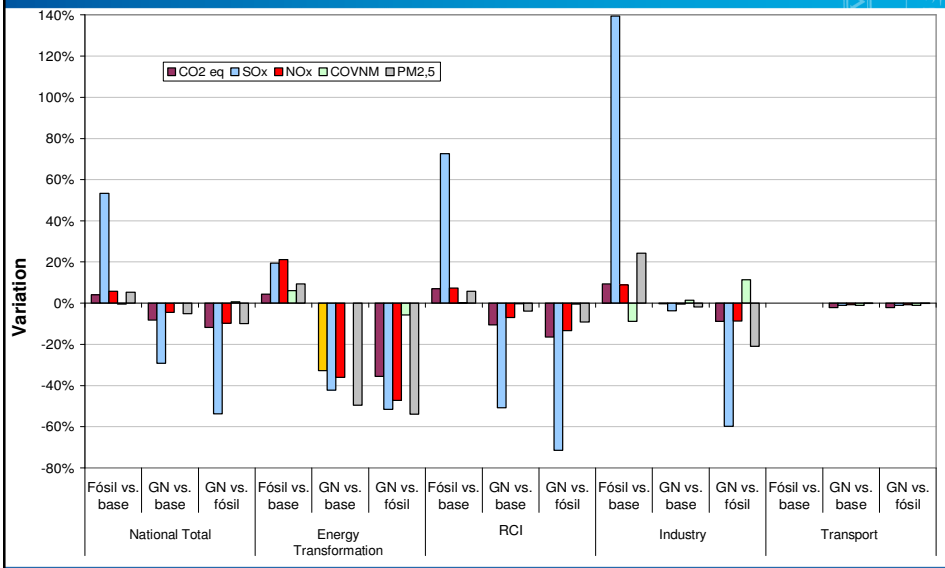

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4.- CONCLUSIONS

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- GHG emissions are lower for NG versus other fossil fuel:
  - electricity production: 47%-63%
  - RCI: 17%-53%
  - industry: 14%-49%
- There are important co-benefits:
  - SO_2 emission reductions: less acid rain
  - NOx emission reductions: lower effects on vegetation, crops, eutrophication, acid rain, etc.
  - Fine PM emission reduction: less mortality and morbidity
- These benefits are shown for a hypothetical situation for 2006 without NG:
  - GHG emissions would have increased in a 13%
  - Other emissions would have raise: SO_2 (77%), $PM_{2,5}$ (14%) y NO_2 (12%)
  - Annual average $PM_{2,5}$ concentrations would have augmented in urban areas
  - NO_2 concentration would be higher than AQ limit values for some regions (Asturias, Comunidad Valenciana and Cataluña)

- Future scenarios show that:
  - a greater NG penetration would:
    - close KP fulfilment
    - reach 2020 targets
    - reduce SO_2, NO_X and $PM_{2,5}$ emissions
  - an increase in fossil fuels with the same NG consumption would:
    - prevent KP fulfilment
    - distance 2020 targets
    - increase air pollutant emissions

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