Role of Other Greenhouse Gases - Response

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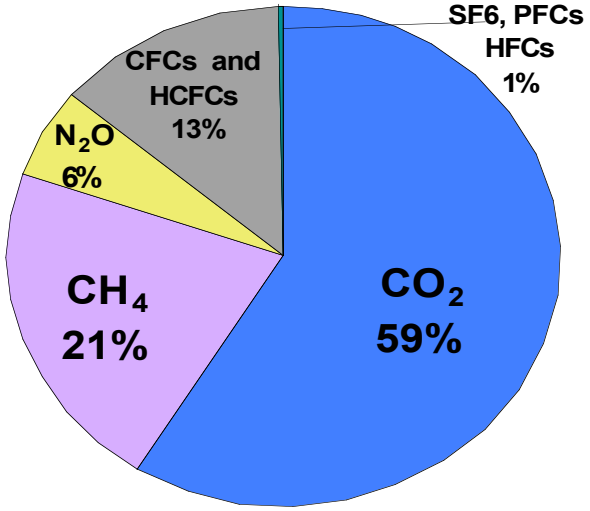
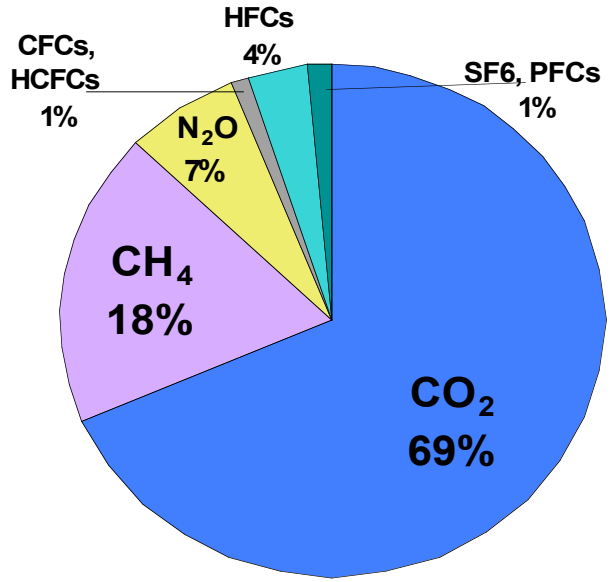
Main Conclusion

- CO_2 will be the main contributor to the future total radiative forcing and temperature change.

Increase in Radiative Forcing from pre-industrial times



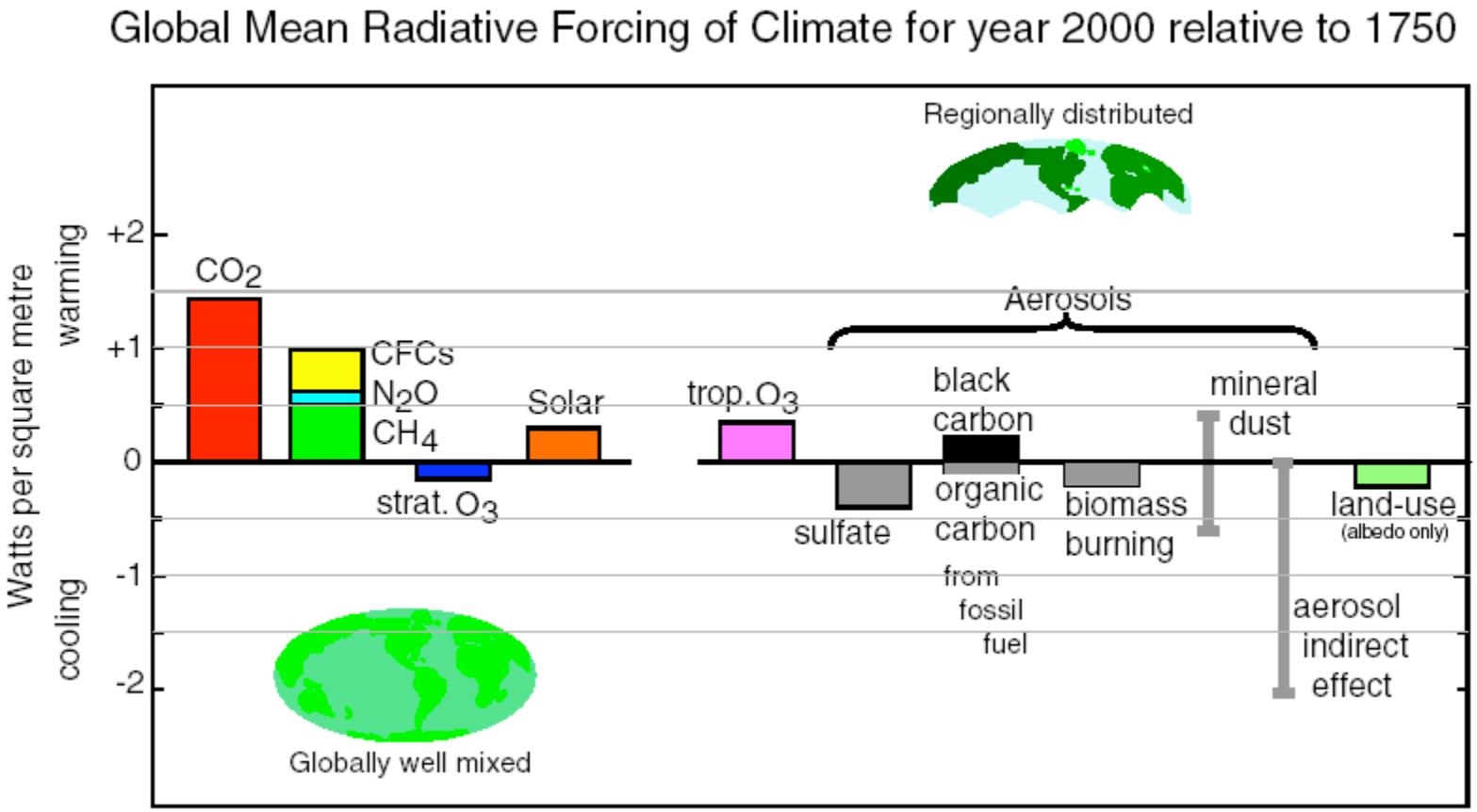
(1765-2000) = 2.45 Wm^{-2}

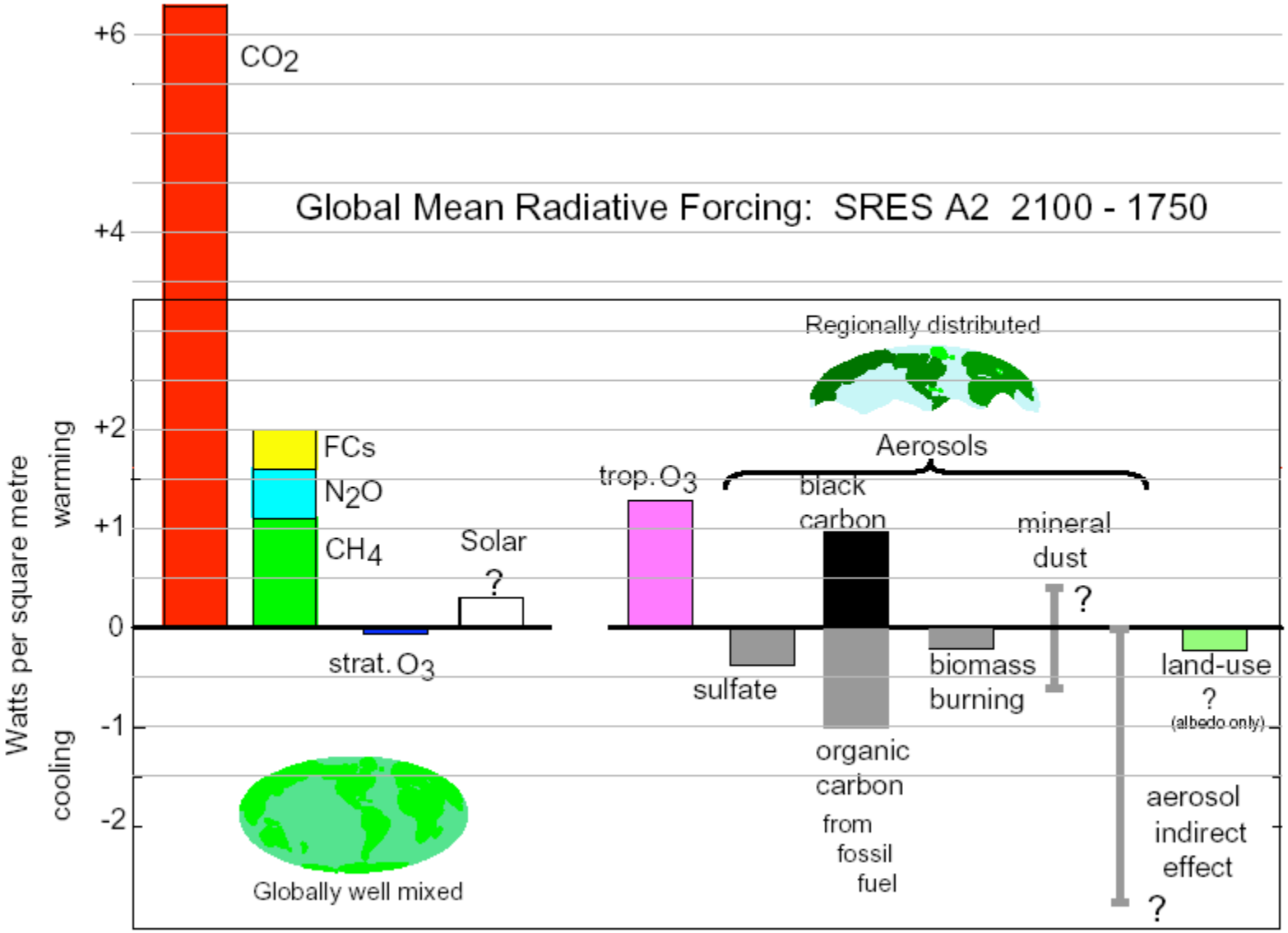


(1765-2100) = 5.05-8.31 Wm^{-2}

Based on Jain et al.2000

What Other Greenhouse Agents are Forcing Climate?




Global Mean Radiative Forcing: SRES A2 2100 - 1750
Watts per square metre
warming
cooling
+6
+4
+2
+1
0
-1
-2
CO2
FCs
N2O
CH4
Solar
?
strat. O3
Globally well mixed
trop. O3
Regionally distributed
Aerosols
black carbon
mineral dust
?
sulfate
biomass burning
land-use
?
(albedo only)
organic carbon
from fossil fuel
aerosol indirect effect
?

Non-CO_2 Greenhouse Gases (GHGs) & Climate Change

***Non-CO_2 Greenhouse Gases** include the gases listed under the Kyoto Protocol (CH_4, N_2O, HFCs, PFCs, and SF_6), as well as other fluorinated compounds already listed under Montreal Protocol and its Amendments.*

- **Why is it so important to study the contribution of non-CO_2 GHGs to climate change and mitigation?**

Why are Non-CO_2 Gases Important ?

- Non-CO_2 GHGs are major Contributors to increase in *radiative forcings* on climate since 1750.
- Non-CO_2 GHGs effect the *lifetimes* of many greenhouse gases. As a GHG's lifetime changes, its climate forcing and Global Warming Potential (GWP) will also change.
- Non-CO_2 GHGs, since they arise from a variety of sources, offer the potential to increase flexibility and lower the cost of meeting emission targets relative to CO_2 abatement alone

Anthropogenic Control of the Major GHGases

CH_4 emissions (600 Tg-CH_4/yr)

fossil fuels	17%
biomass burning	5%
landfills	7%
ruminants	14%
rice	9%
pollution (lifetime)	***??%***

N_2O emissions (16 Tg-N/yr)

industrial processes	7%
biomass burning	3%
agriculture	24%
cattle/feedlots	12%

CFC & HCFC emissions (<< 1 Tg/yr)

refrigeration, foam, propellant, cleaning

phased out under Montreal Protocol

Anthropogenic Control of the Other GHGases

PFCs = CF_4 + ... (13 Gg/yr ++)

anthropogenic*** 100%

aluminum, industrial

SF_6 emissions (6 Gg/yr ++)

anthropogenic 100%

insulation, electrical switches

HFC emissions (100 Gg/yr ++)

anthropogenic 100%

CFC partial replacements

Anthropogenic Control of the Pollution gases

CO emissions (2800 Tg-CO/yr)

fossil & domestic fuel	32%
biomass burning	25%

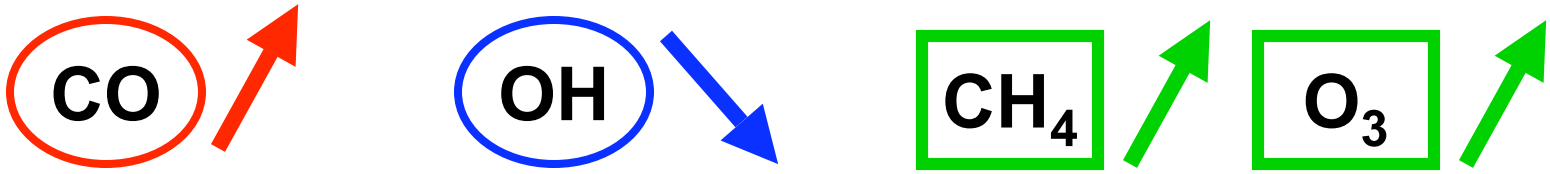
NO_X emissions (52 Tg-N/yr)

fossil fuels	65%
biomass burning	14%
agriculture/soils	12%

VOC emissions (600 Tg-C/yr)

fossil fuel	28%
biomass burning	6%

CO is an indirect greenhouse gas



CO emissions are effectively equivalent to CH_4 emissions:

100 Tg-CO = 5 Tg-CH4

(IPCC, TAR)

Anthropogenic Impact through Reactive Pollutants 1750 - 2000

1800⇨2000	$\triangle O_3$	$\triangle OH$
CH_4	+4.6 DU	- 30 %
NO_X	+4.1	+ 14
CO	+1.2	- 11
VOC	+0.5	- 5
sum	*+10 DU*	*- 32 %*
"observed"	*+9 (±4)*	*??*

Effective Reactive Pollutant Contribution to CH_4

CH_4	320 Tg(CH_4)/y = direct emission	
NOx	40 Tg(N)/y	⇨ **-** 80 Tg(CH_4)/y
CO	1000 Tg/y	⇨ **+** 50 Tg(CH_4)/y
VOC	250 Tg/y	⇨ **+** 30 Tg(CH_4)/y

(IPCC TAR)

Example: CH4 mitigation in the U.S.

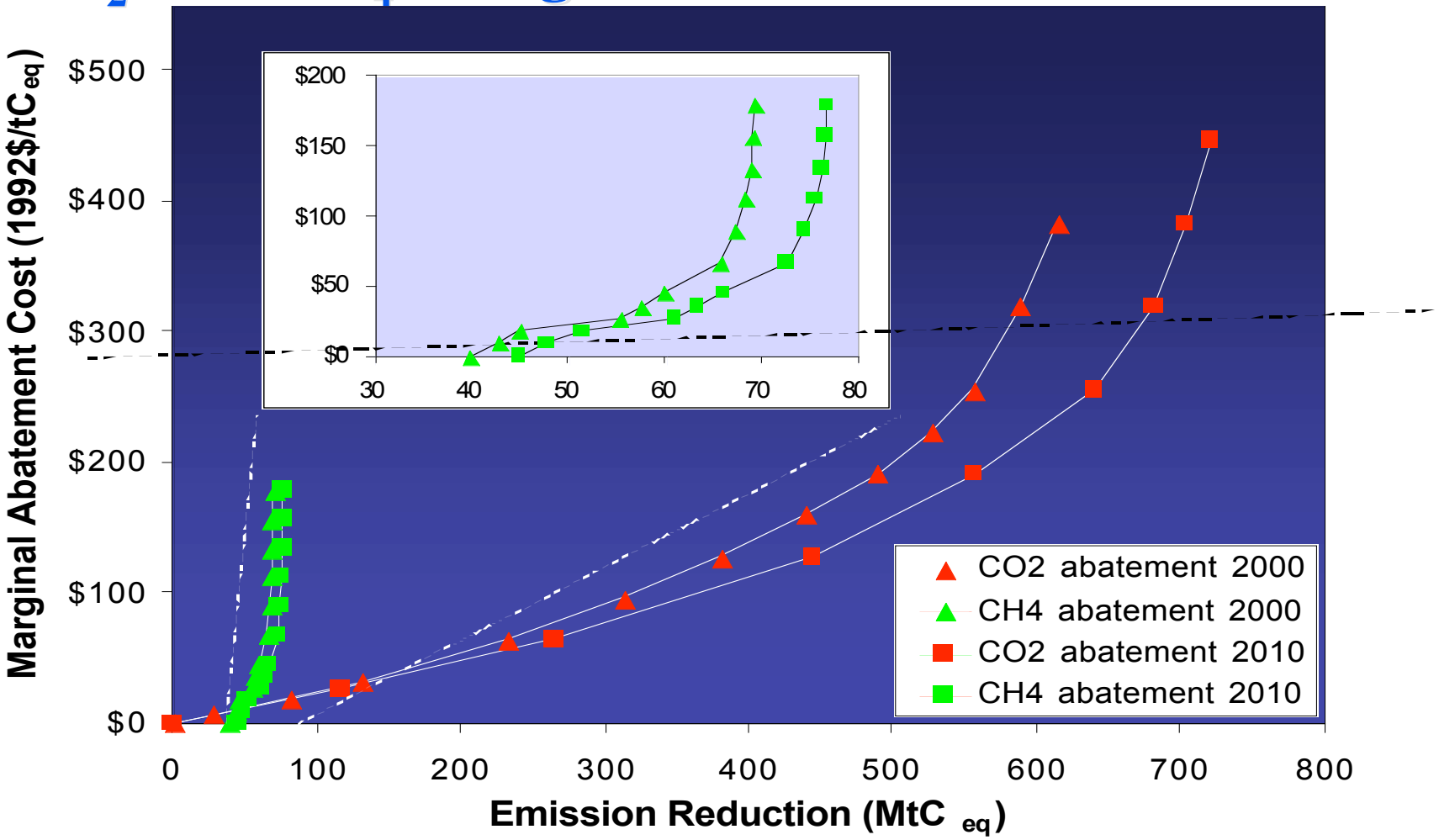
Science Article

(29 October 1999, Vol 286, pp. 905-906)

Hayhoe et al.

A significant amount of CH_4 emissions for the United States can be reduced with economically justified options with no reduction costs. Based on the latest abatement costs, we estimate that for short-term targets, CH_4 can offset CO_2 reductions and reduce U.S. costs by more than 25% relative to strategies involving CO_2 alone.

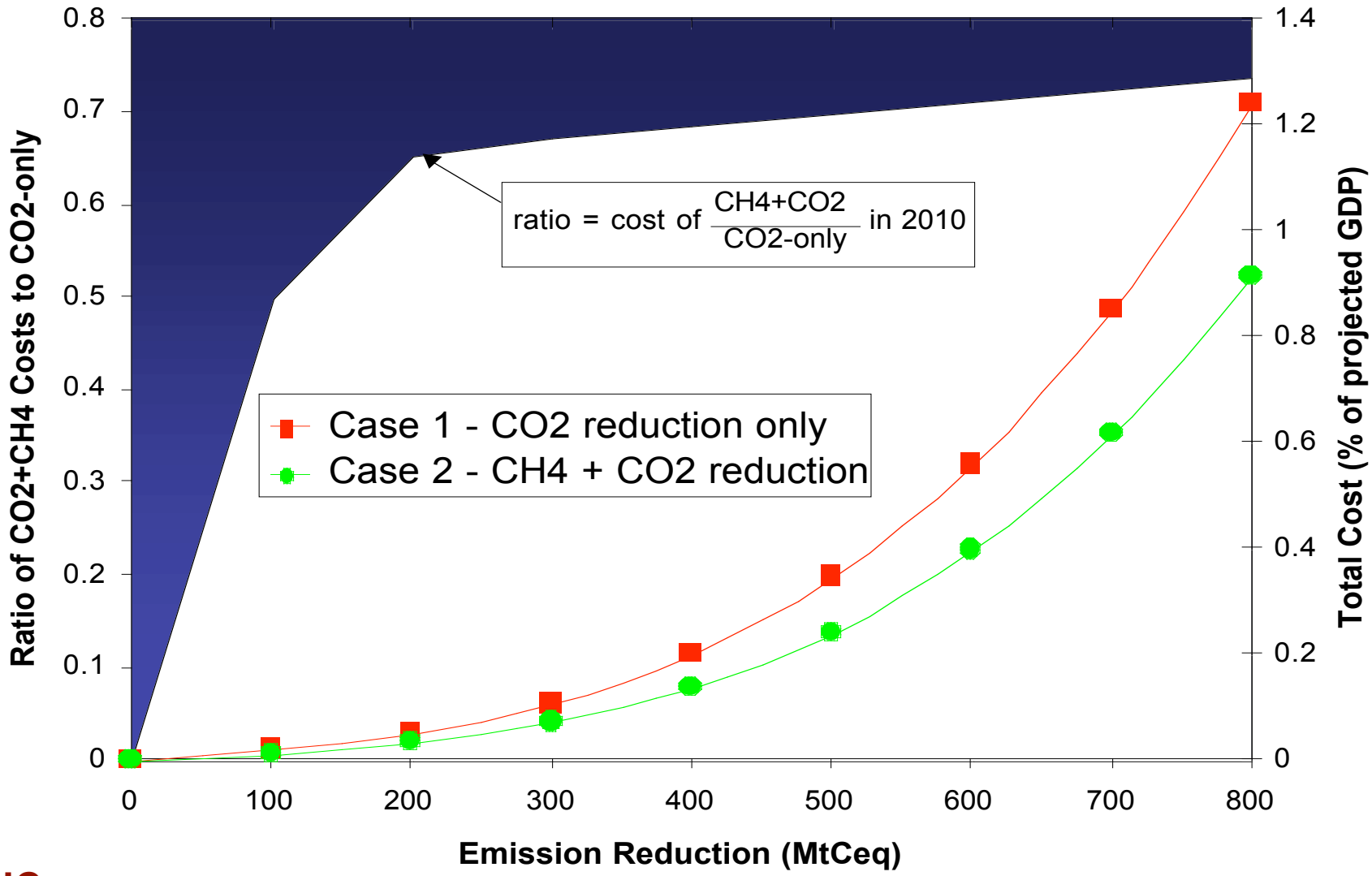
CO_2 and CH_4 Marginal Abatement Cost Curves



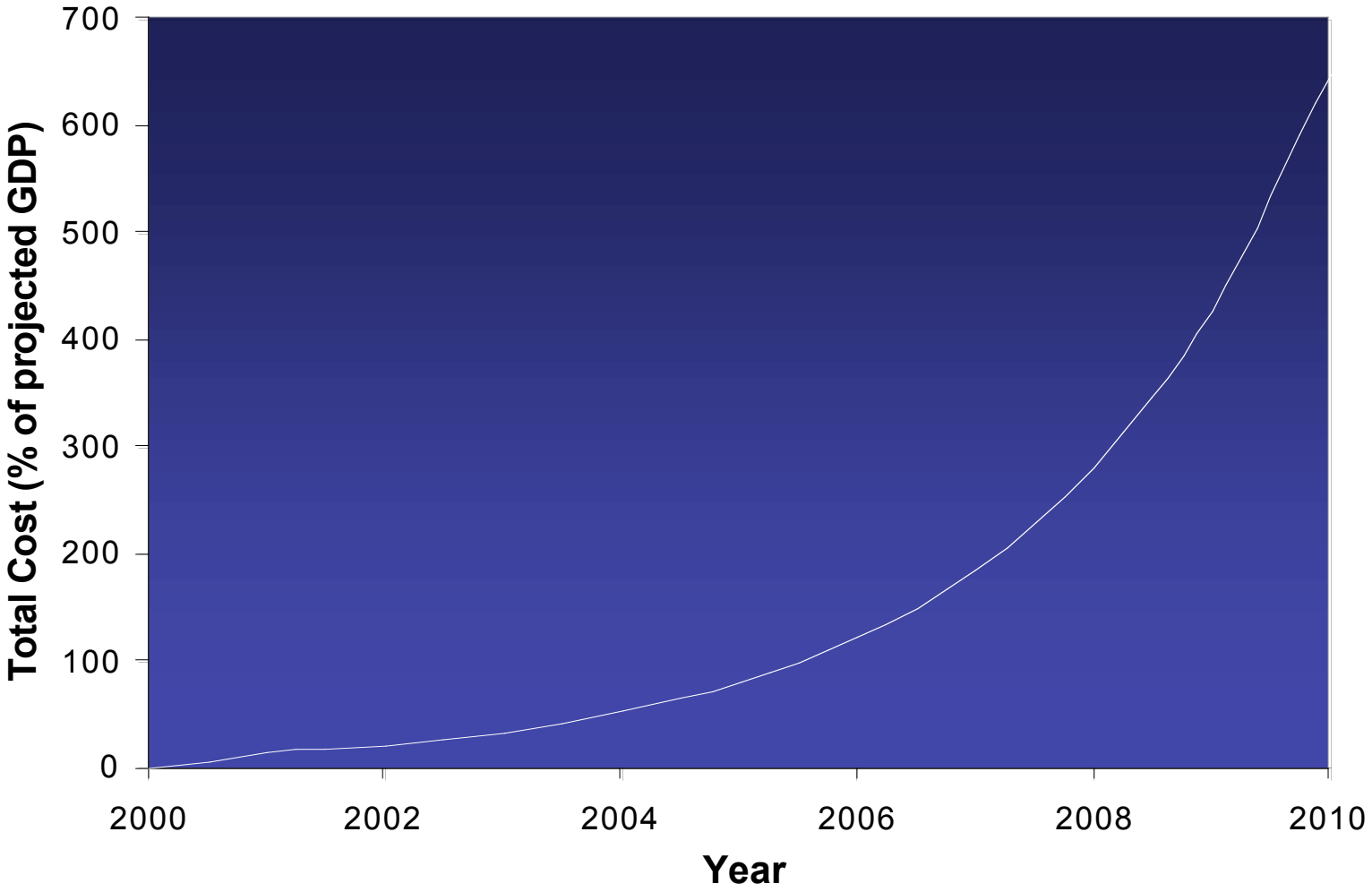
Abatement costs for CH_4 increase gradually up to 75 MtC_{eq}, or 40% of projected CH_4 emissions

In contrast to CH_4 costs, the carbon permit fees needed to provide an economic incentive for CO_2 reduction increase gradually

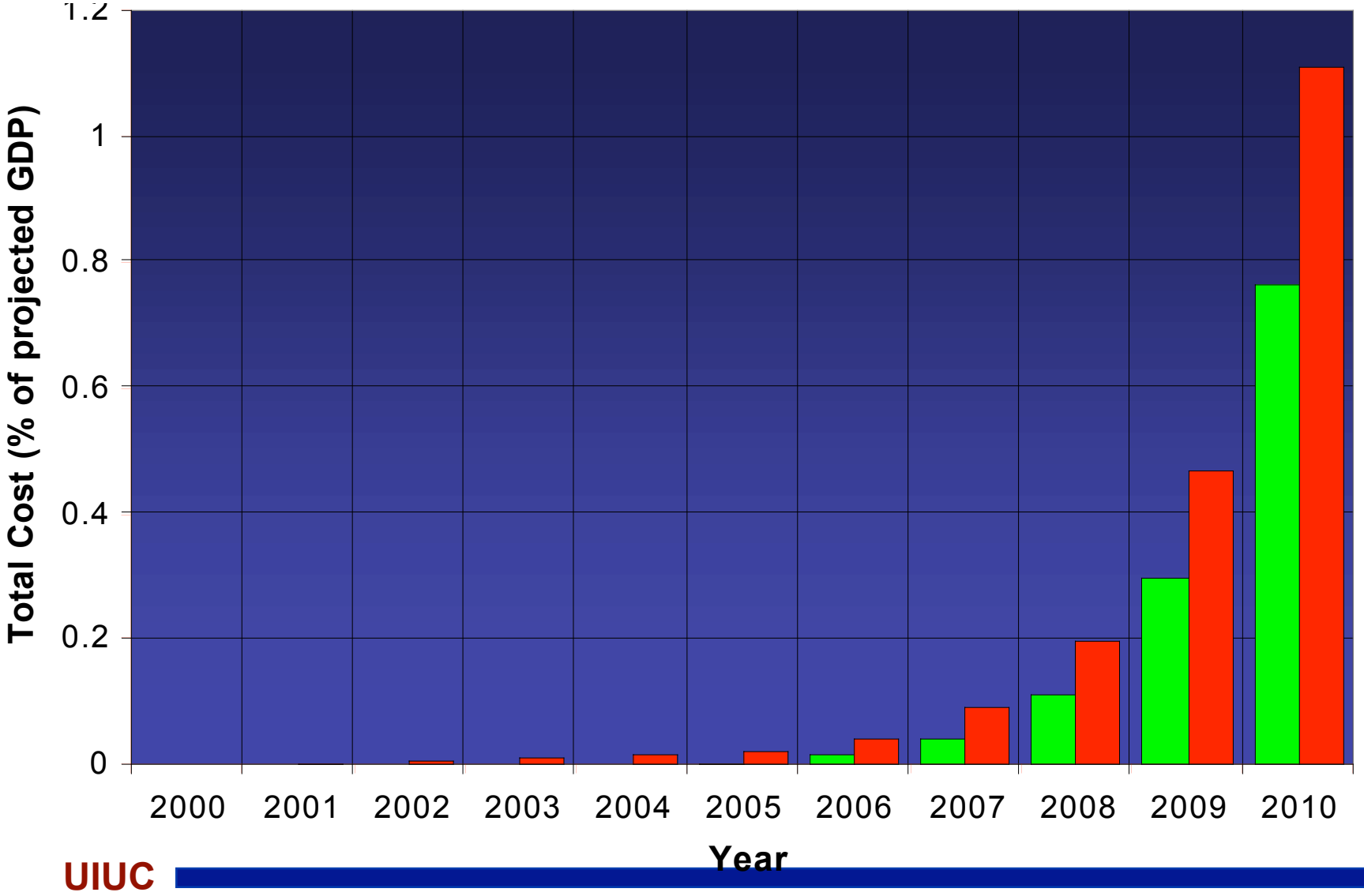
Comparison of Emission Reduction Costs (Year 2010)



Illustrative emission pathway



Cost of Illustrative Emission Scenario with CH_4 (green) vs. without CH_4 (red)



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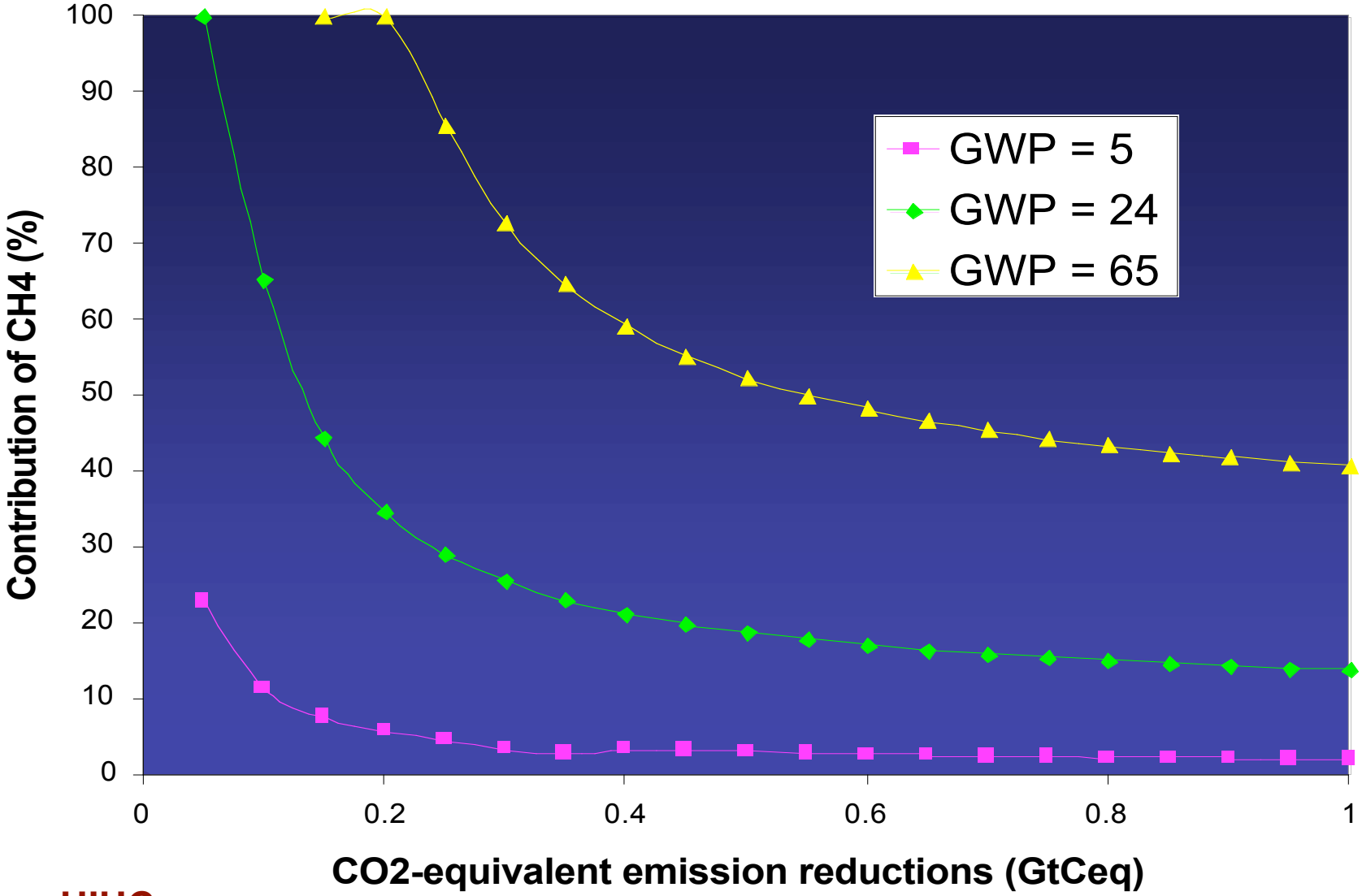
Contribution of CH_4 to Total CO_2-Equivalent Reductions



Conclusions

- Including non-CO_2 GHGs in emission reduction schemes has the potential to greatly reduce CO_2 controls and total costs, particularly in the short term
- CH_4 alone can reduce costs by over 25% relative to CO_2-only
- The contribution of CH_4 and other non-CO_2 GHGs to multi-gas reduction targets depends strongly on how the gases are weighted relative to CO_2.
- Due to the strong impact of atmospheric chemistry on CH4 concentrations, emissions of CO, NOx and NMHCs are likely to affect the contribution of CH_4 to a multi-gas reduction scheme.