Overview of Briefing on EMF21: Multigas-Mitigation and Climate Policy

Francisco de la Chesnaye, U.S. EPA

Energy and Economic Policy Models: A Reexamination of Some Fundamentals

November 15, 2006

Stanford Energy Modeling Forum

- Established in 1976 to provide a structured forum within which energy experts from government, industry, universities, and other research organizations could meet to study important energy and environmental issues of common interest
- Prof. John P. Weyant is EMF's Director
- Objectives:
  - Understand Model Differences
  - Communicate Insights to policy Makers
  - Identify Critical Research Needs
  - Help Fill the Gaps in Data/Research
- EMF-21: Multi-Gas Mitigation and Climate Change
  - Working Group Chairman: Francisco de la Chesnaye, USEPA
  - Study Objective: Compare and contrast CO2-only mitigation vs. multi-gas mitigation for given scenarios and targets
- More at www.stanford.edu/group/EMF/projects/projectemf21.htm

EMF 21 Working Group Objectives

1) Conduct a new comprehensive, multi-gas policy assessment to improve the understanding of the affects of including non-CO_2 GHGs (NCGGs) and sinks (terrestrial sequestration) into short- and long-term mitigation policies. Answer the question: *How important are NCGGs & Sinks in climate policies?*.
2) Advance the state-of-the-art in integrated assessment / economic modeling
3) Strengthen collaboration between NCGG and Sinks experts and modeling teams
4) Publish the results: Multi-Greenhouse Gas Mitigation and Climate Policy. *The Energy Journal*, Special Issue, F. de la Chesnaye and J. Weyant and (eds). 2006

Special Issue

Multi-Greenhouse Gas Mitigation and Climate Policy

THE ENERGY JOURNAL

de la Chesnaye and Weyant (eds.)

THE ENERGY JOURNAL

IAEE INTERNATIONAL ASSOCIATION *for* ENERGY ECONOMICS

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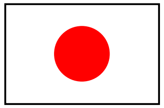
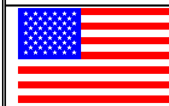
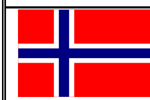
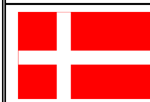
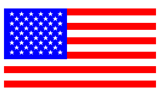
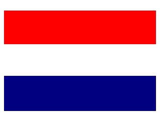
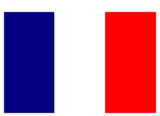
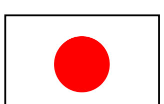
MULTI-GREENHOUSE GAS MITIGATION AND CLIMATE POLICY

(continued on inside front cover)

Special Issue IAEE
International Association for Energy Economics

Energy-economic Models in EMF- 21

	**AIM** Asian-Pacific Integrated Model	J. Fujino, R. Nair, M. Kainuma, T. Masui (National Institute for Environment Studies, Japan) and Y. Matsuoka (Kyoto Univ., Japan)
	**AIM/EU-India** AIM - End-Use Component Applied to India	P.R. Shukla (Indian Institute of Management), A. Garg (UNEP/RISO), M. Kapshe (Maulana Azad Inst.of Tech.), and R. Nair (NIES, Japan)
	**AMIGA** All Modular Industry Growth Assessment	D. Hansen (Argonne National Laboratory, U.S.), J. Laitner (U.S. EPA)
	**COMBAT** COMprenhensive aBATement	H.A. Aahaim, J.S. Fuglestvedt, and O. Godal (CICERO, Norway)
	**EDGE** European Dynamic Equilibrium Model	J. Jensen (TECA TRAINING ApS)
	**EPPA** Emissions Projection and Policy Analysis Model	J. Reilly, M. Sarofim, S. Paltsev, and R. Prinn (Massachusetts Institute of Technology, U.S.)
	**FUND** Climate Framework for Uncertainty, Negotiation, and Distribution	Richard Tol (Economic and Social Research Institute, Ireland and Hamburg, Vrije & Carnegie Mellon Universities)
	**GEMINI-E3/GEMWTrap** General Equilibrium Model of International Interaction for Economy-Energy- Environment	A. Bernard (Min. of Equipment, Transport, and Housing, France), M. Vielle (CEA-LERNA, France), and L. Viguier (HEC Geneva and Swiss Federal Institute of Technology)
	**GRAPE** Global Relationship Assessment to Protect the Environment	A. Kurosawa (Institute of Applied Energy, Japan)

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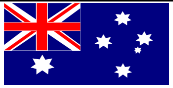
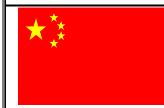
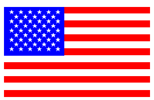
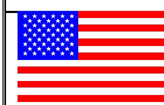
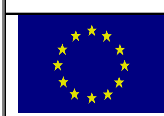
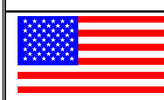
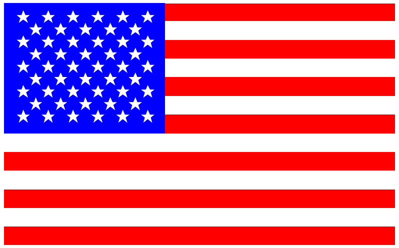
	**GTEM** Global Trade and Environment Model	G. Jakeman and B. Fisher (Australian Bureau of Agriculture and Resources)
	**IMAGE** Integrated Model to Assess The Global Environment	D.P. van Vuuren, B. Eickhout, P.L. Lucas and M.G.J. den Elzen (National Institute for Public Health and the Environment, The Netherlands)
	**IPAC** Integrated Projection Assessments for China	K. Jiang, X. Hu, & S. Zhu (Energy Research Institute, China)
	**MERGE** Model for Evaluating Regional and Global Effects of GHG Reductions Policies	A. Manne (Stanford University, U.S.) and R. Richels (Electric Power Research Institute, U.S.)
	**MESSAGE** Model for Energy Supply Strategy Alternatives and Their General Environmental Impact	S. Rao and K. Riahi (International Institute for Applied Systems Analysis, Austria)
	**MiniCAM** Mini-Climate Assessment Model	S. Smith (PNNL/Univ. Maryland, U.S.) and T.M.L. Wigley (National Center for Atmospheric Research, U.S.)
	**PACE** Policy Analysis With Computable Equilibrium	C. Böhringer, (University of Heidelberg), A. Löschel (Centre for European Economic Research – ZEW, and T. Rutherford (University of Colorado)
	**POLES-GEGS** Prospective Outlook on Long-Term Energy Systems-Global Emissions Control Strategies	P. Criqui (Institute of Energy Policy and Economics, France), Peter Russ (EC- Institute for Prospective Technological Studies, Spain), and Daniel Deybe (EC Environment DG)
	**SGM** Second Generation Model	A. Fawcett (U.S. EPA) and R. Sands (PNNL/Univ. Maryland, U.S.)
	**WIAGEM** World Integrated Applied General Equilibrium Model	C. Kemfert (German Inst. of Economic Research & Humboldt University), T. P. Truong (Univ. of New South Wales, Australia) and T. Bruckner (Institute for Energy Engineering, Tech Univ, Germany)

Non-CO_2 GHG Experts
Dina Kruger and Francisco de la Chesnaye, USEPA
John Gale, IEA Greenhouse Gas R&D Programme

Methane & N_2O
Ann Gardiner, Judith Bates, AEA Technology
Casey Delhotal, Dina Kruger, Elizabeth Scheehle, USEPA
Chris Hendriks, Niklas Hoehne, Ecofys

Fluorinated (HGWP) Gases
Jochen Harnish, Ecofys, Germany
Deborah Ottinger and Dave Godwin, USEPA



Sinks (Terrestrial Sequestration)
Bruce McCarl, Texas A&M
Ken Andrasko, USEPA & Jayant Sathaye, LBNL
Roger Sedjo, RFF & Brent Sohngen, Ohio State Univ
Ron Sands, PNNL-JGCRI

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Key Characteristics of EMF- 21 Models

Model	Model Type	Representation of non-CO_2 GHG Emissions Sector(s)	Non-CO_2 Gas Contribution Method	Solution Concept
AIM	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	Radiative Forcing	Recursive Dynamic
AMIGA	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
GTEM	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
GEMINI-E3	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
EU-PACE	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	Radiative Forcing	Intertemporal Optimization
EDGE	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
EPPA	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
IPAC	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
SGM	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
WIAGEM	Multi-Sector General Equilibrium	Reduced Form Adj. to Prod. Fcns.	GWPs	Recursive Dynamic
Combat	Aggregate General Equilibrium	Reduced Form MACs	Radiative Forcing	Intertemporal Optimization
FUND	Aggregate General Equilibrium	Reduced Form MACs	Radiative Forcing	Intertemporal Optimization
GRAPE	Aggregate General Equilibrium	Structural Models	Radiative Forcing	Intertemporal Optimization
MERGE	Aggregate General Equilibrium	Reduced Form MACs	Radiative Forcing	Intertemporal Optimization
IMAGE	Market Equilibrium	Structural Models	GWPs	Recursive Dynamic
MESSAGE	Market Equilibrium	Structural Models	GWPs	Intertemporal Optimization
MiniCAM	Market Equilibrium	Structural Models	GWPs	Recursive Dynamic
POLES/AgriPol	Market Equilibrium	Structural Models	GWPs	Recursive Dynamic

Developing Multgas Stabilization Targets

Key analytical issues:

- What constitutes a multigas stabilization scenario ? Stabilize concentrations, radiative forcing, temperature change, etc.?
- Should multigas stabilization still be defined in CO_2 concentration equivalents ? (The 100ppm CO_2 for other gases)
- How to handle NCGG ?
- How to handle sinks ?
- How to handle short-term, regional agents, e.g., BC/OC, O_3 ?
- What is the appropriate disaggregation of results across regions?
- How to best report results ?

EMF 21 Scenarios

Purpose: Model Development, Comparison, and Sensitivity Analyses

1) Modeler's Reference Case

2) Long-term, Cost-minimizing

Case A - achieved through CO_2 mitigation only, and

Case B - achieved through multi-gas mitigation.

- <u>Climate Change Target:</u> Stabilize radiative forcing at 4.5 W/m^2 relative to pre-Industrial times by 2150.
- <u>Time frame:</u> 2000 to 2100. From 2002 to 2012, Kyoto Protocol is *NOT* in reference scenario.
- <u>Emissions:</u> Based on meeting climate target at lowest global cost.

EMF 21 Scenarios:

3) Combined Decadal Rate of Change and Long-Term Cost-minimizing

Achieved through multi-gas mitigation.

- Climate Change Target: Hold global mean decadal rate of temperature change from 2010 to 2100 at 0.2ºC. (starting in 2030) and meet LT at 4.5 W/m2 by 2150.
- Time frame: 2000 to 2100. From 2002 to 2012, KP is *NOT* in reference scenario.
- Emissions: Based on meeting climate target at lowest global cost.

4) CO_2, Multigas + Sinks with selected price path(s)

Emission targets handoff

- Long-term models provided global total GHG emissions to Short-term models for early periods (to 2050) based on LT Stabilization. For global total need to use 100-yr GWPs.

Table 1: Global Anthropogenic GHG Emissions in 2000 and Beyond (MtCe)

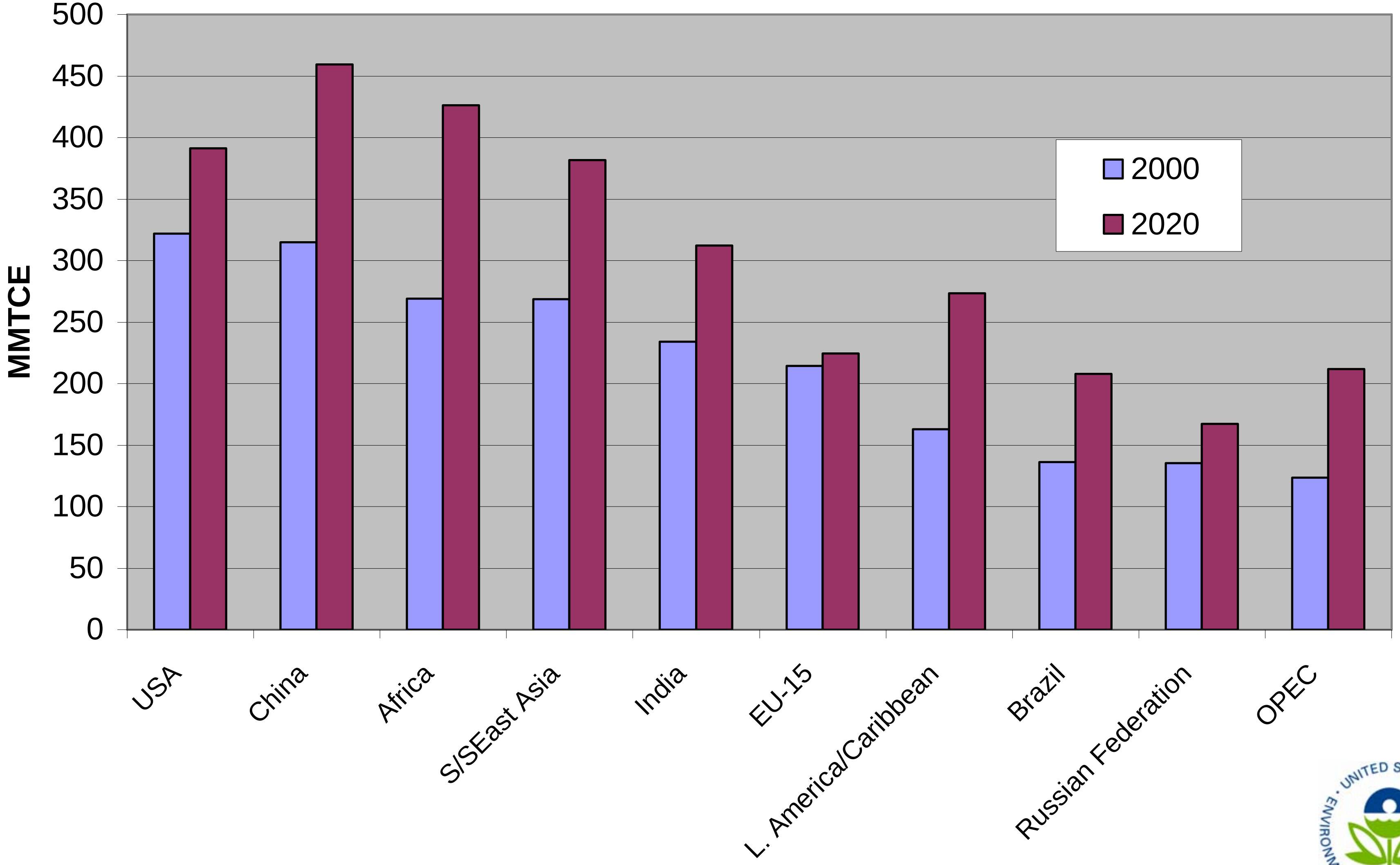
Sectors Detail for 2000					
Sector subtotal & Percent of Total	Sub-sectors	**CO_2**	**CH_4**	**N_2O**	**F-gases**
ENERGY 6,845 67%	Coal	2,218	123		
	Nat Gas	1,309	244		
	Petroleum Systems	2,857	17		
	Stationary/Mobile Sources		16	61	
LUCF and AGRICULTURE 2,608 25%	LUCF and Agriculture (net)	942			
	Soils			711	
	Biomass		134	51	
	Enteric Fermentation		476		
	Manure Management		61	56	
	Rice		177		
INDUSTRY 391 4%	Cement	226			
	Adipic & Nitric Acid Prd			43	
	HFCs				26
	PFCs				29
	SF6				15
	Substitution of ODS				52
WASTE 395 4%	Landfills		213		
	Wastewater		154	22	
	Other		3	3	
TOTAL GHG	10,239	7,552	1,618	947	122
Gas as percent of total		74%	16%	9%	1%

Projections: GHG Total & by Gas	**TOTAL**	**CO_2**	**CH_4**	**N_2O**
2025	14,403	11,102	2,325	976
2050	18,643	14,494	2,974	1,176
2075	21,411	16,874	3,419	1,118
2100	25,067	20,019	3,858	1,190

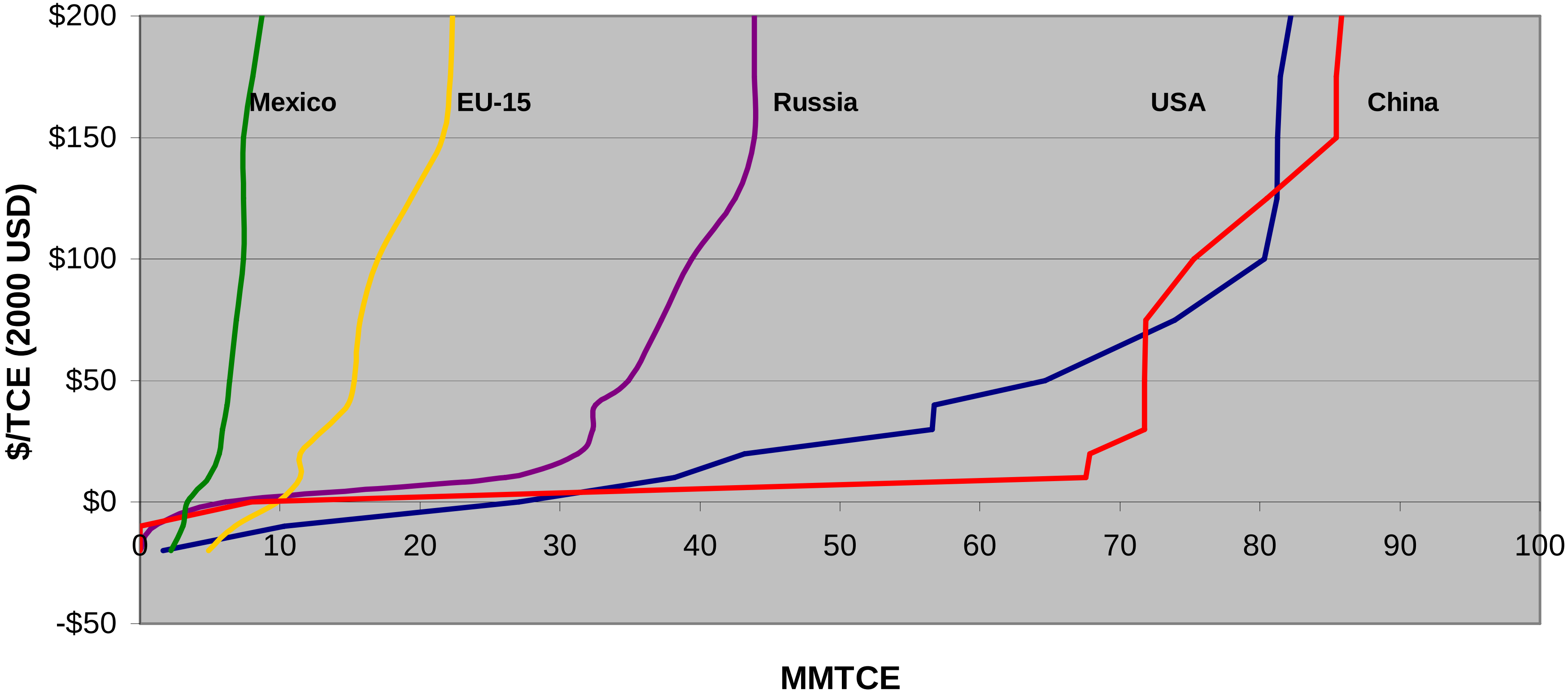
Non-CO_2 GHG & sequestration data requirements

- Global, consistent non-CO2 GHG emission baselines for 2000 and projections 2020 by region. And key emissions drivers.
- Comparable marginal abatement curves
  - by region, by gas, and by sector
  - sensitivities to energy, material prices
  - in MMTCE w/ 100-yr GWP & gas specific units
  - Various discount and tax rates
- Assessment of how marginal abatement curves vary over time, from 2010 to 2100 by decade.

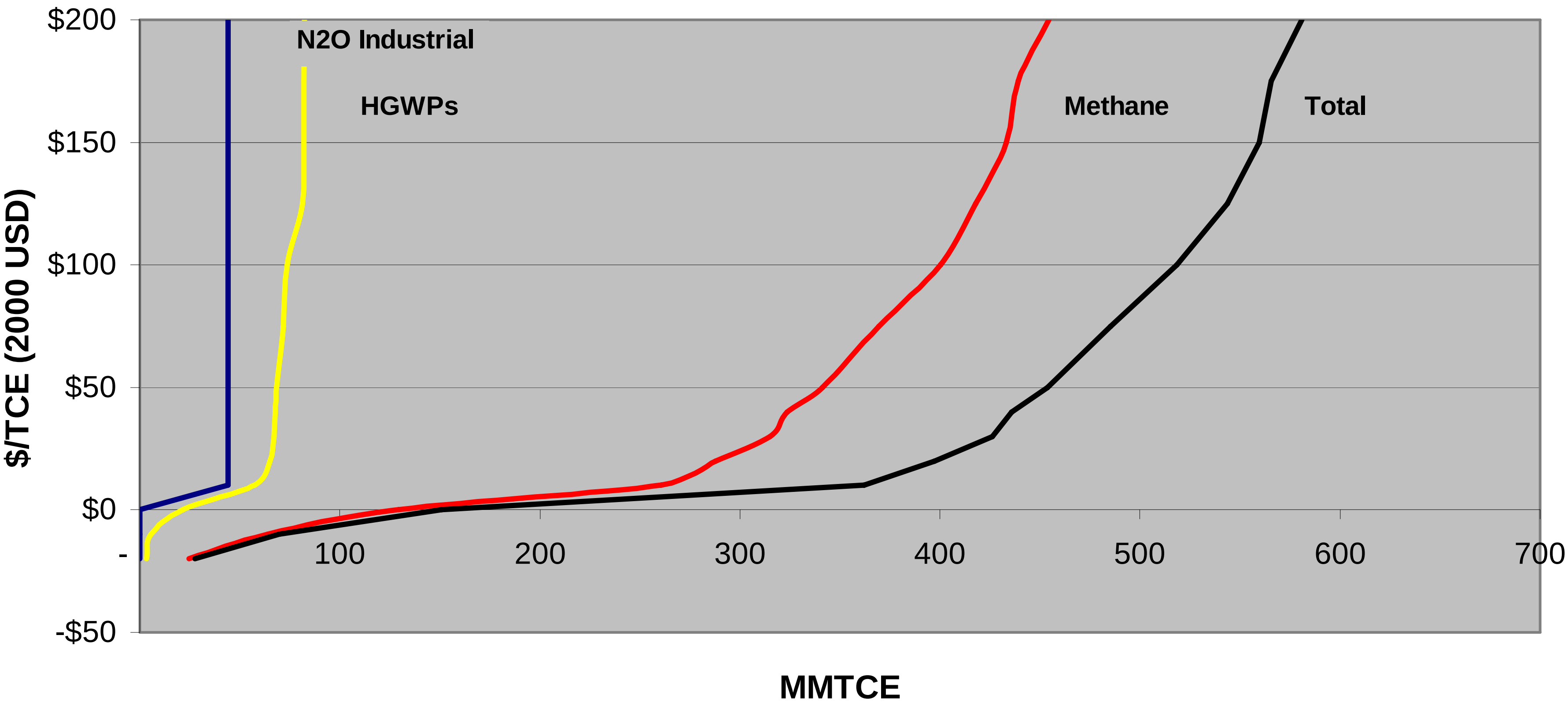
Total Emissions: CH4, N20 and F gases

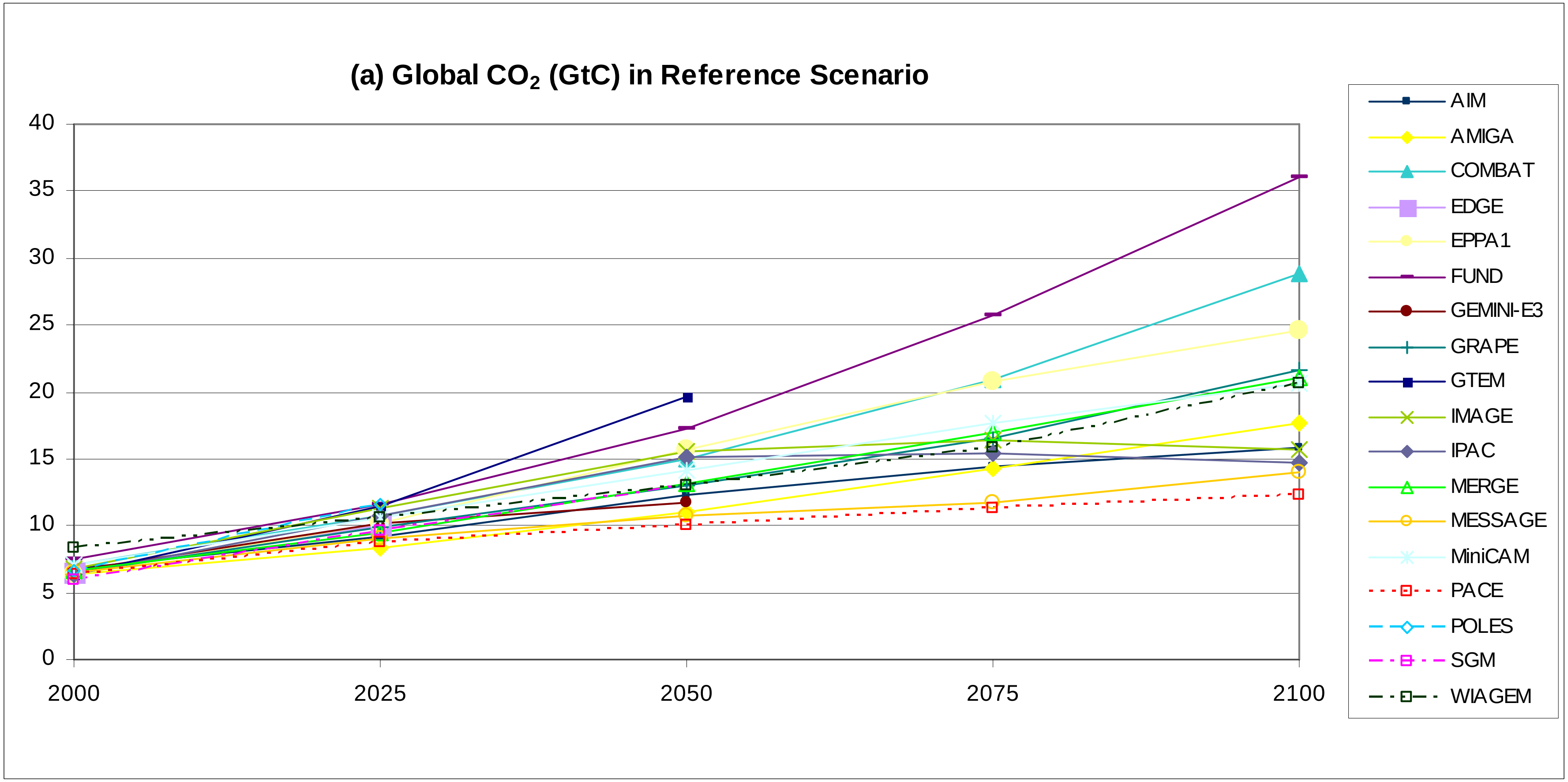


Regional Methane Marginal Abatement Curves for Energy & Waste Sectors: 2010

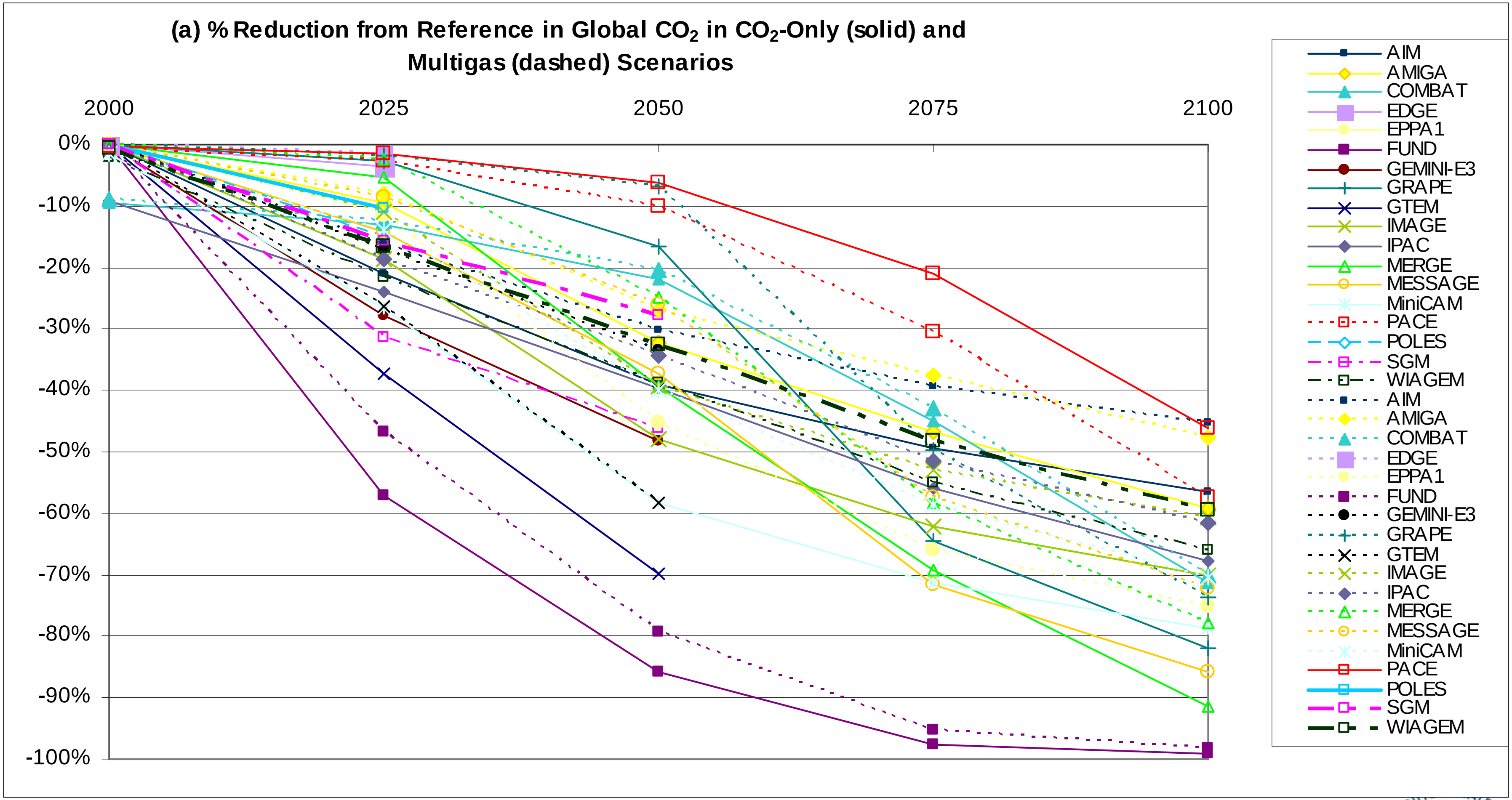


Global Non-CO_2 Marginal Abatement Curves for Energy, Industry & Waste Sectors: 2010





(a) Global CO_2 (GtC) in Reference Scenario
40
35
30
25
20
15
10
5
0
2000
2025
2050
2075
2100
AIM
AMIGA
COMBAT
EDGE
EPPA1
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MERGE
MESSAGE
MiniCAM
PACE
POLES
SGM
WIAGEM


(a) % Reduction from Reference in Global CO_2 in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
AMIGA
COMBAT
EDGE
EPPA1
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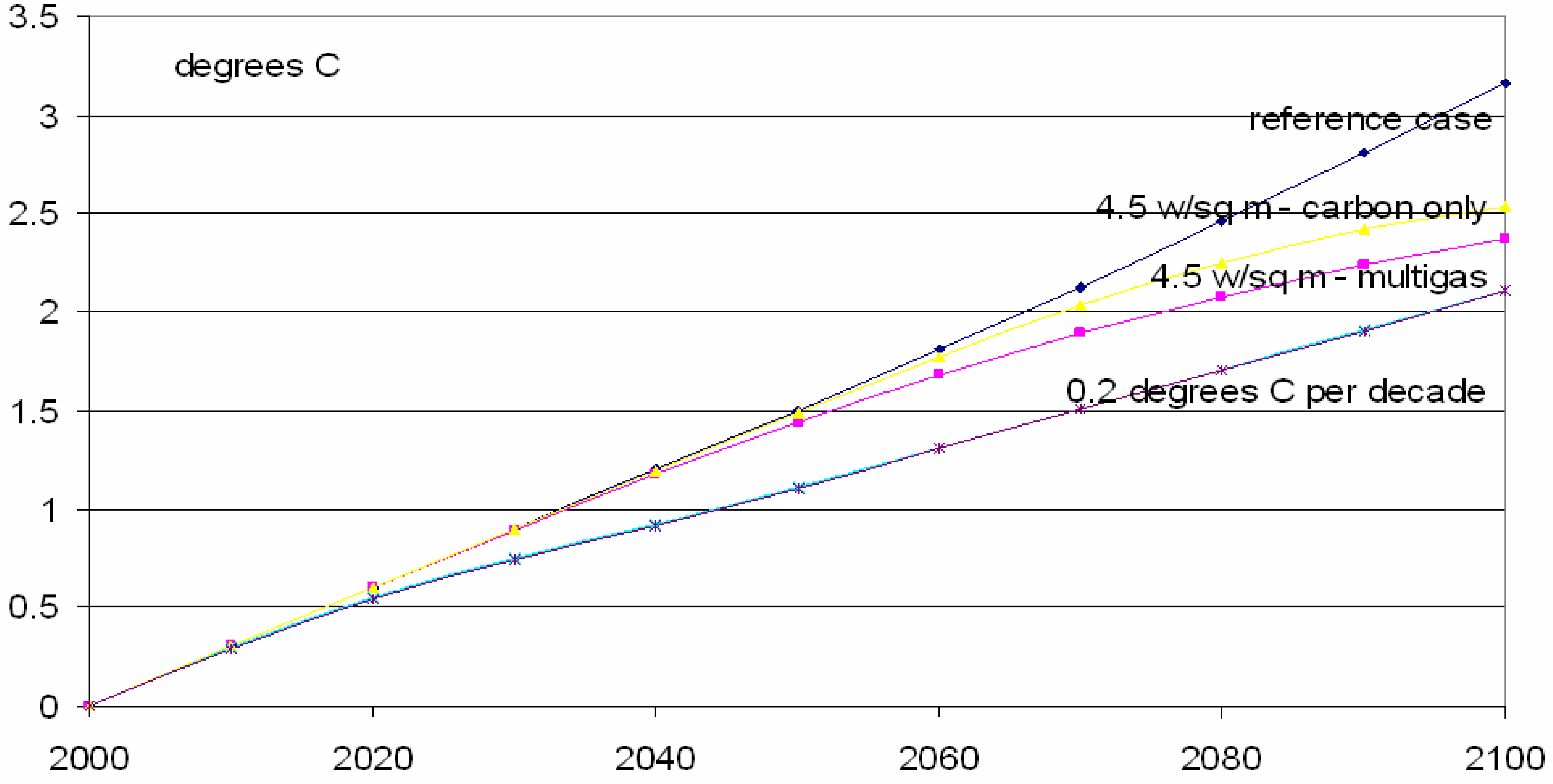
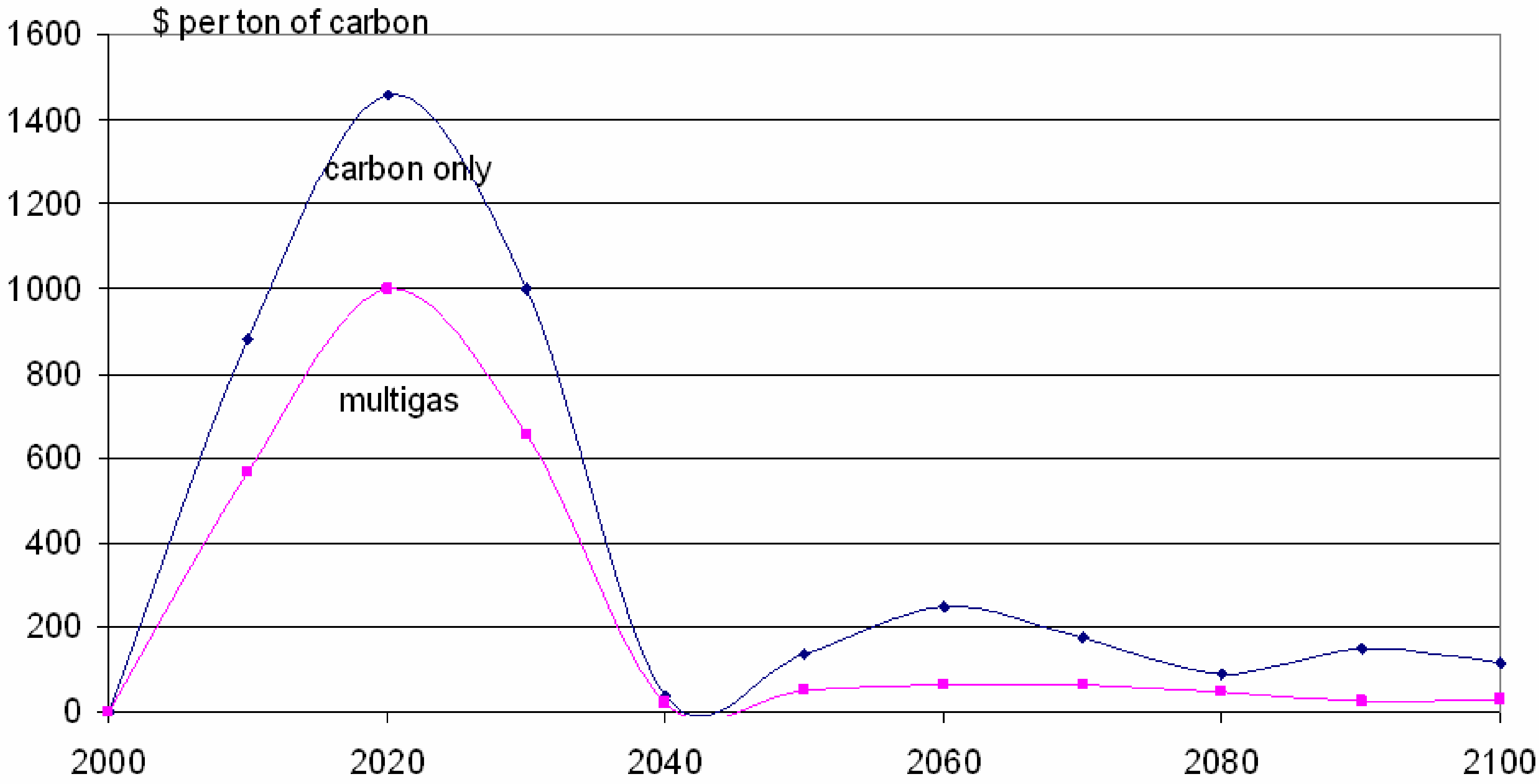
Temperature Increase from 2000



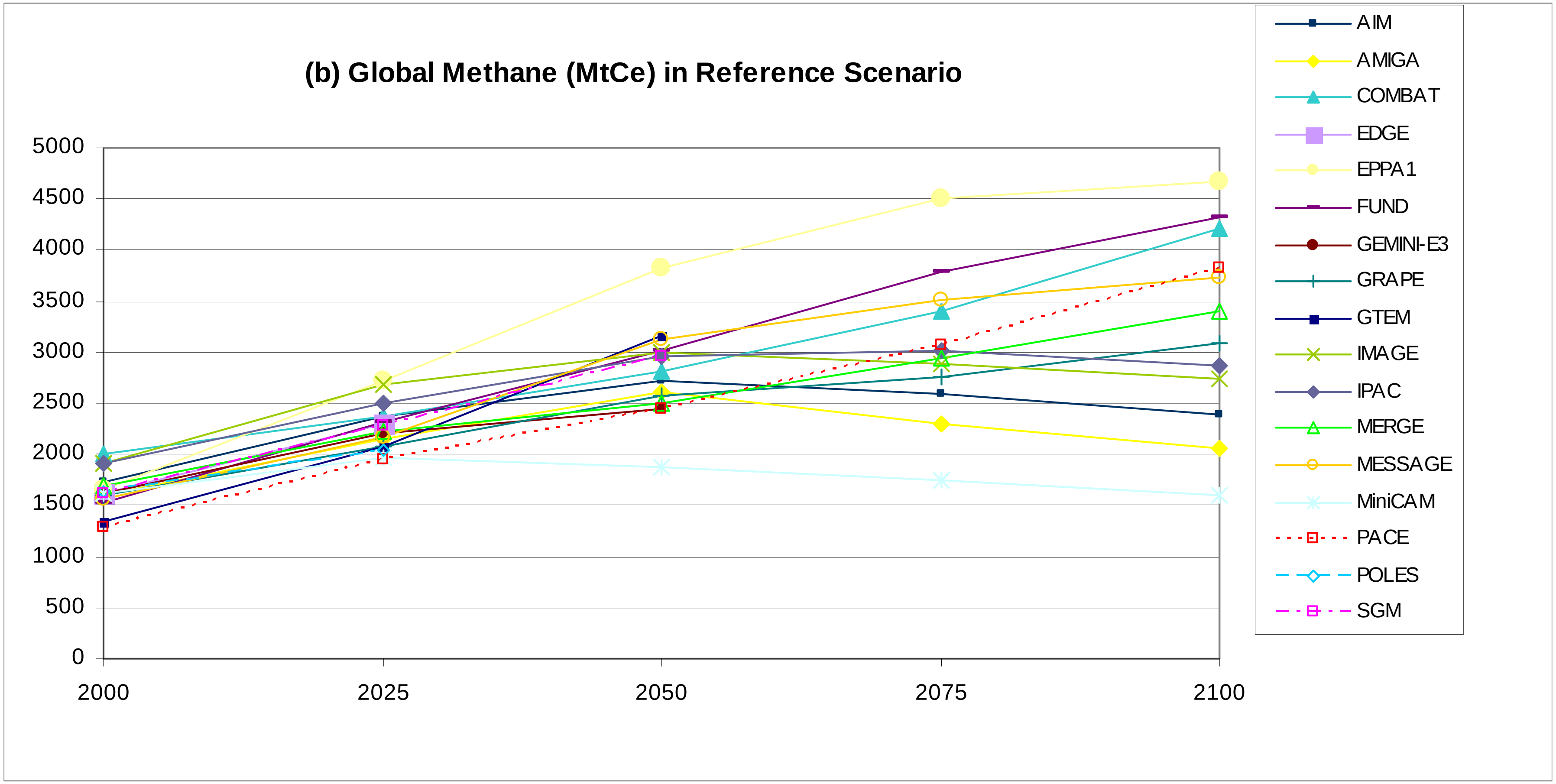
Source: MERGE Model, EMF-21

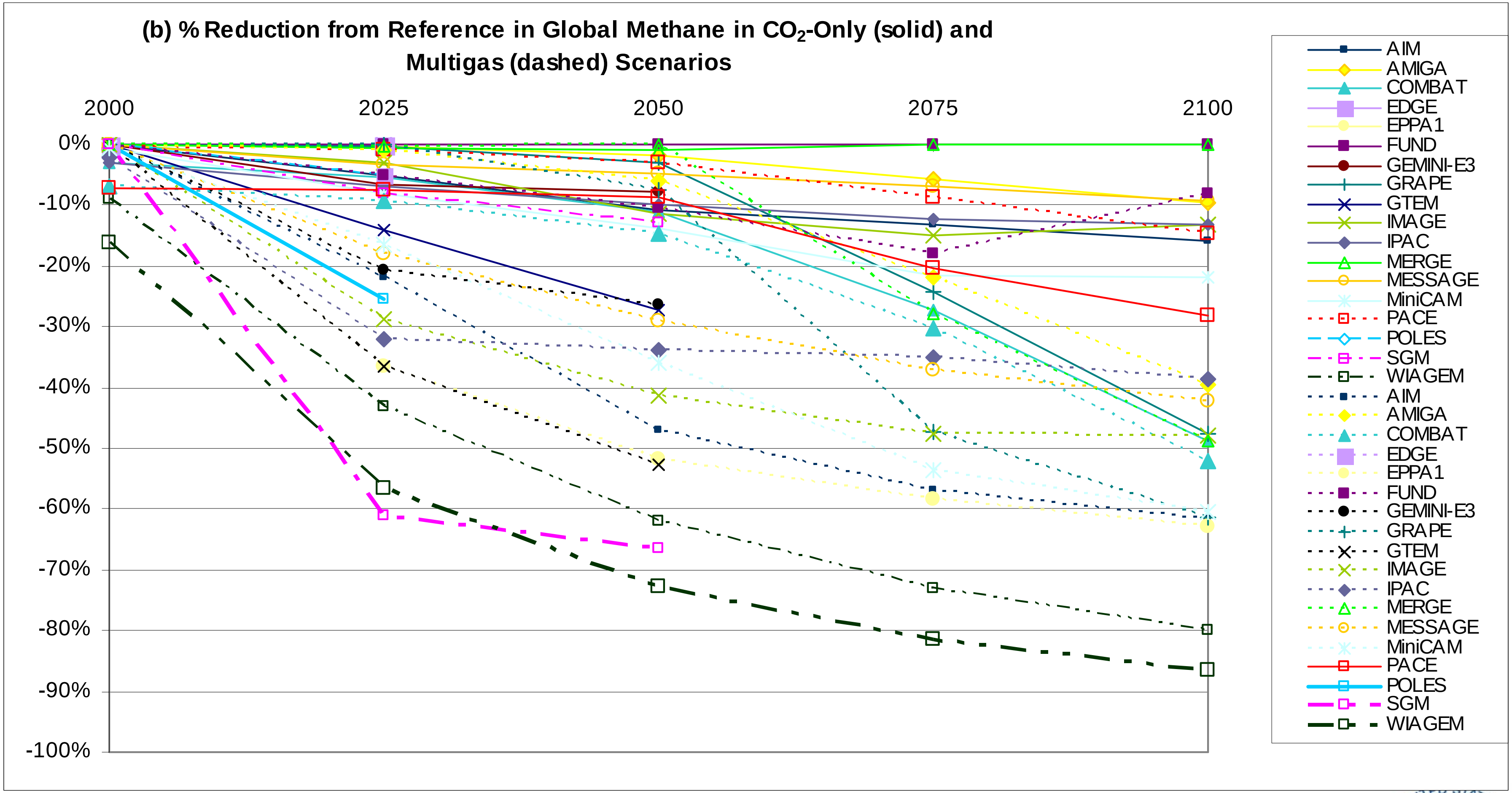
RR12020G.12

Efficiency price of carbon – 0.2 degrees C per decade



Source: MERGE Model, EMF-21


(b) Global Methane (MtCe) in Reference Scenario
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2000
2025
2050
2075
2100
AIM
AMIGA
COMBAT
EDGE
EPPA1
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MERGE
MESSAGE
MiniCAM
PACE
POLES
SGM


(b) % Reduction from Reference in Global Methane in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
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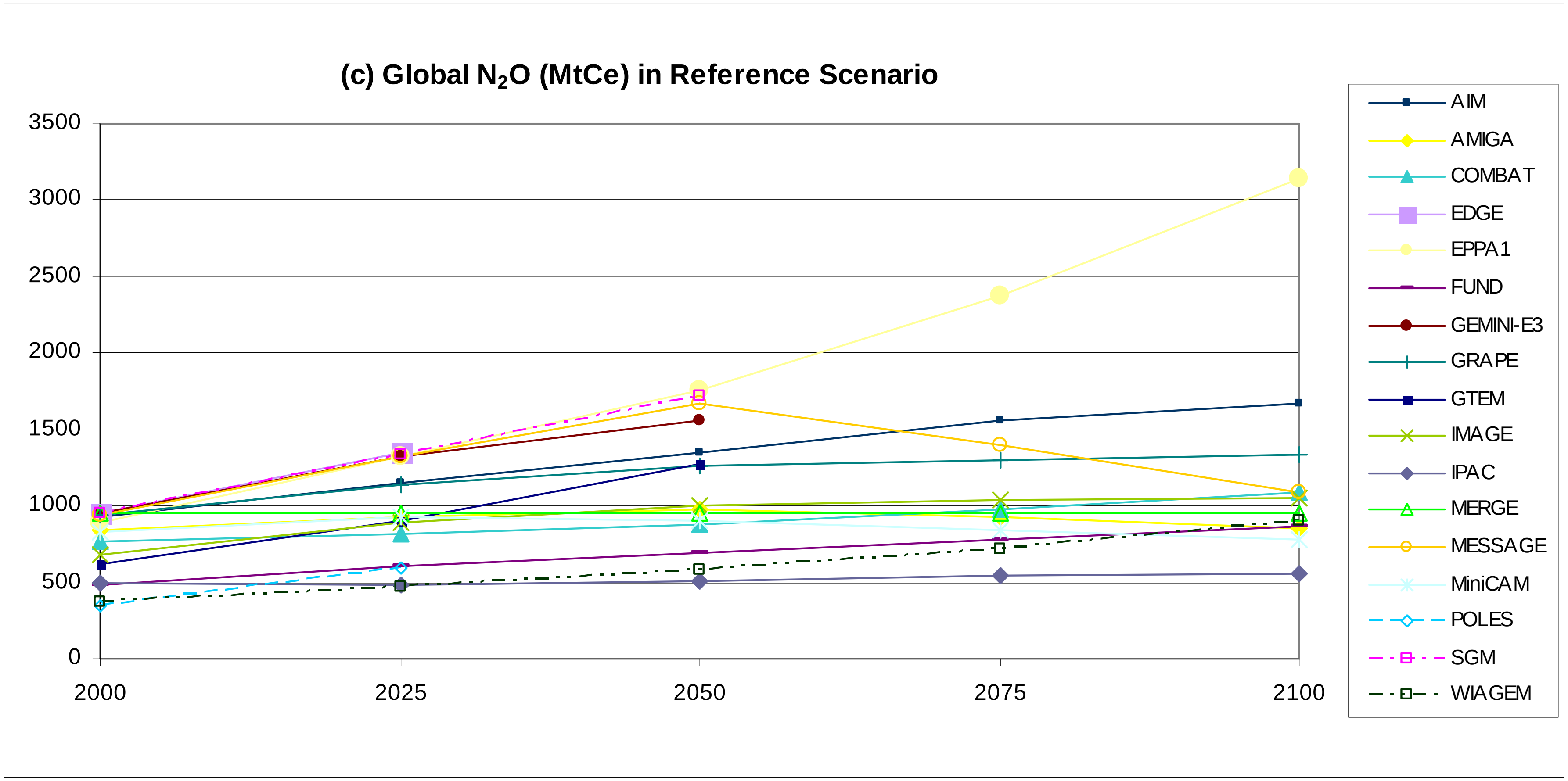
(c) Global N_2O (MtCe) in Reference Scenario
3500
3000
2500
2000
1500
1000
500
0
2000
2025
2050
2075
2100
AIM
AMIGA
COMBAT
EDGE
EPPA1
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
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MERGE
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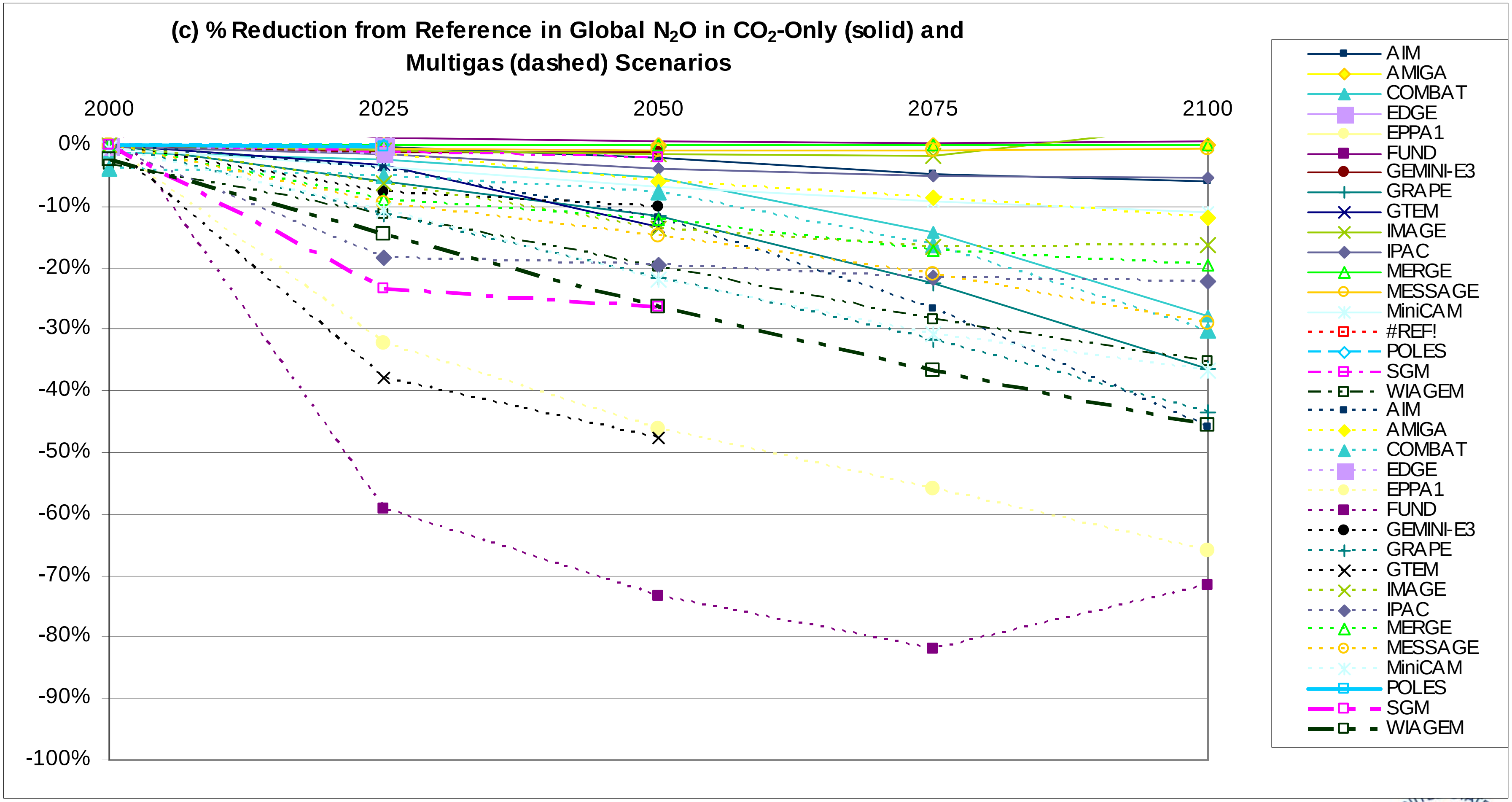
MiniCAM
POLES
SGM
WIAGEM


(c) % Reduction from Reference in Global N2O in CO2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
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AIM
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FUND
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COMBAT
EDGE
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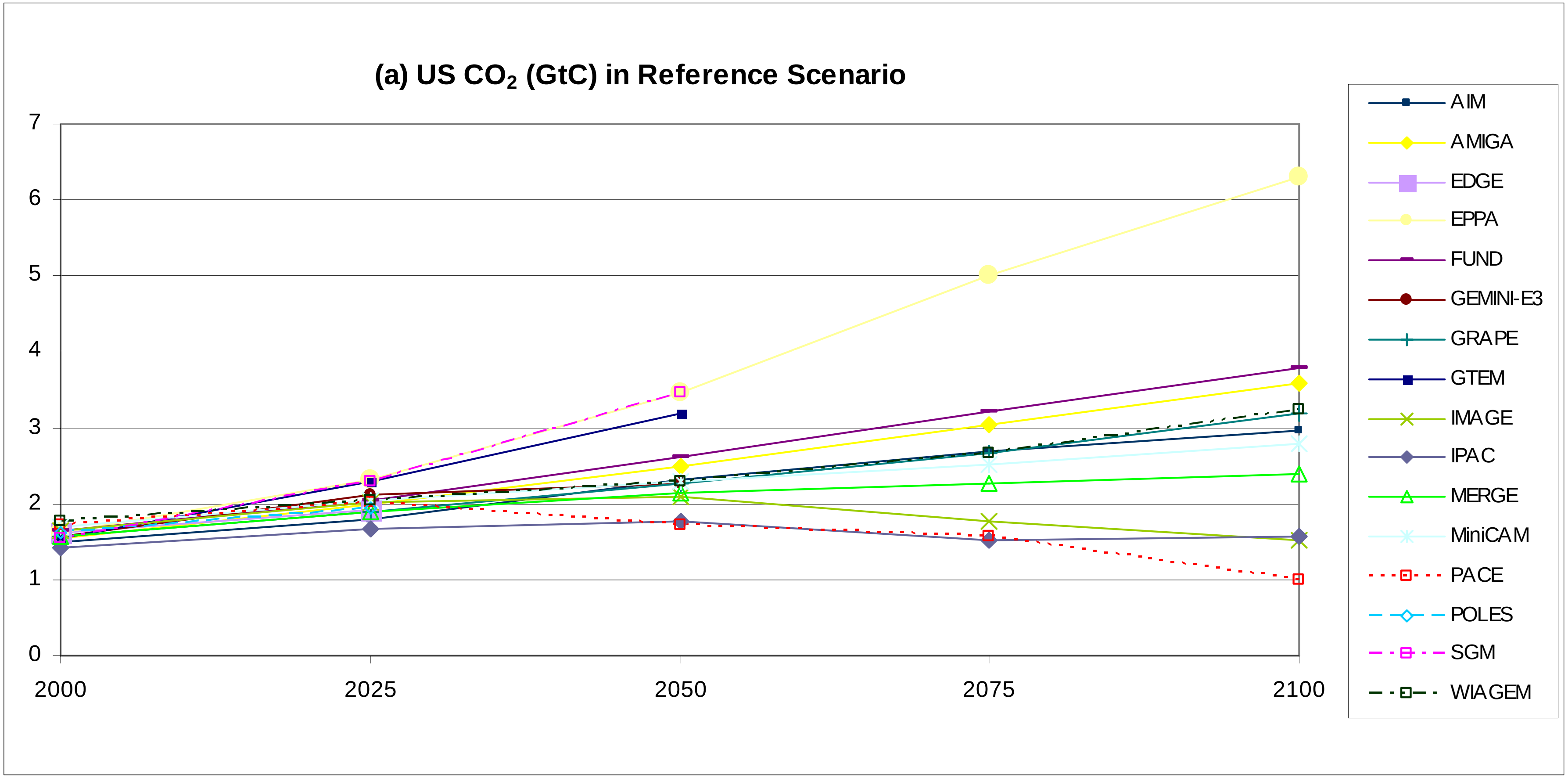

(a) US CO2 (GtC) in Reference Scenario
0
1
2
3
4
5
6
7
2000
2025
2050
2075
2100
AIM
AMIGA
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MERGE
MiniCAM
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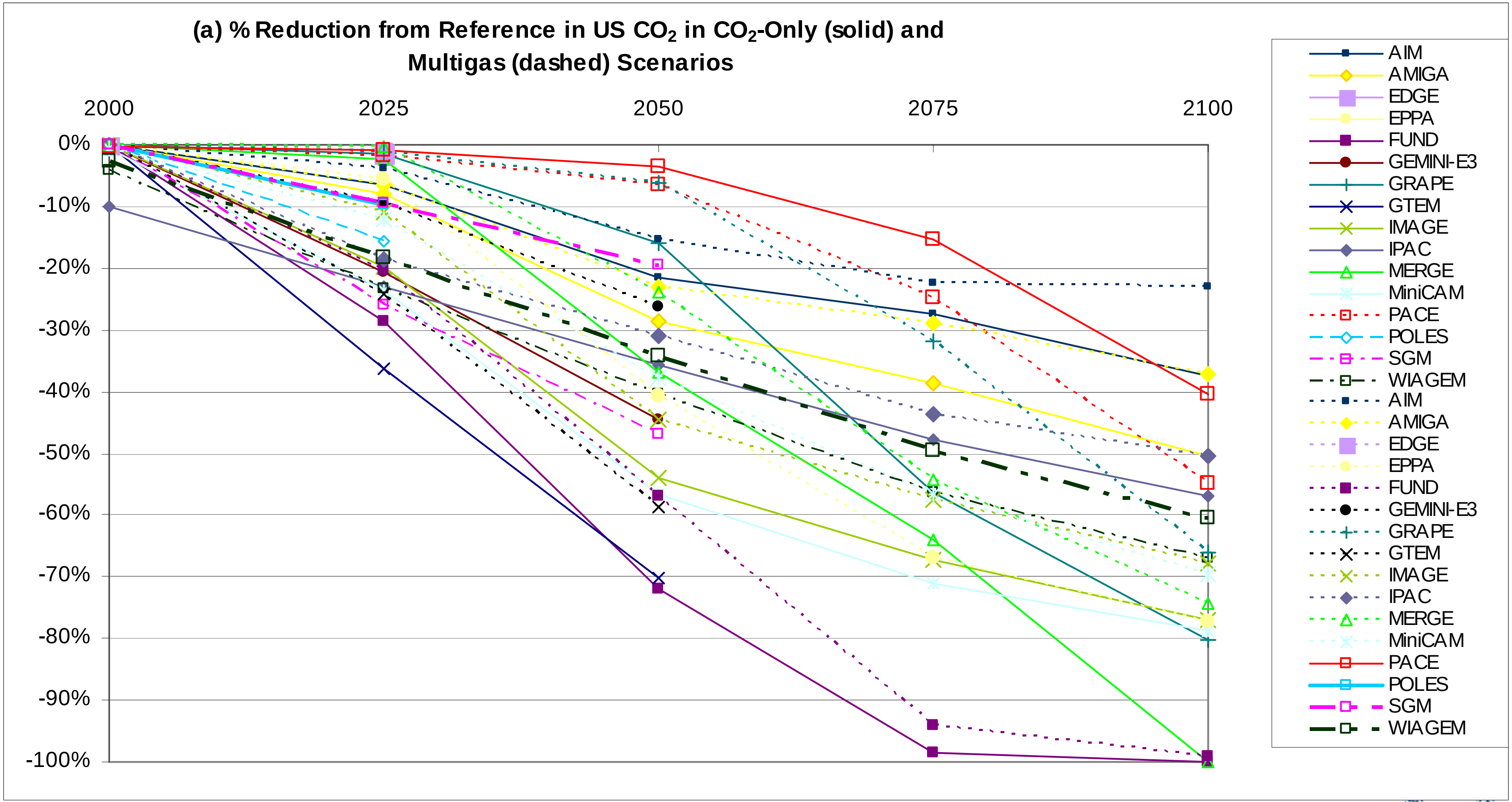
POLES
SGM
WIAGEM



(a) % Reduction from Reference in US CO_2 in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
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-50%
-60%
-70%
-80%
-90%
-100%
AIM
AMIGA
EDGE
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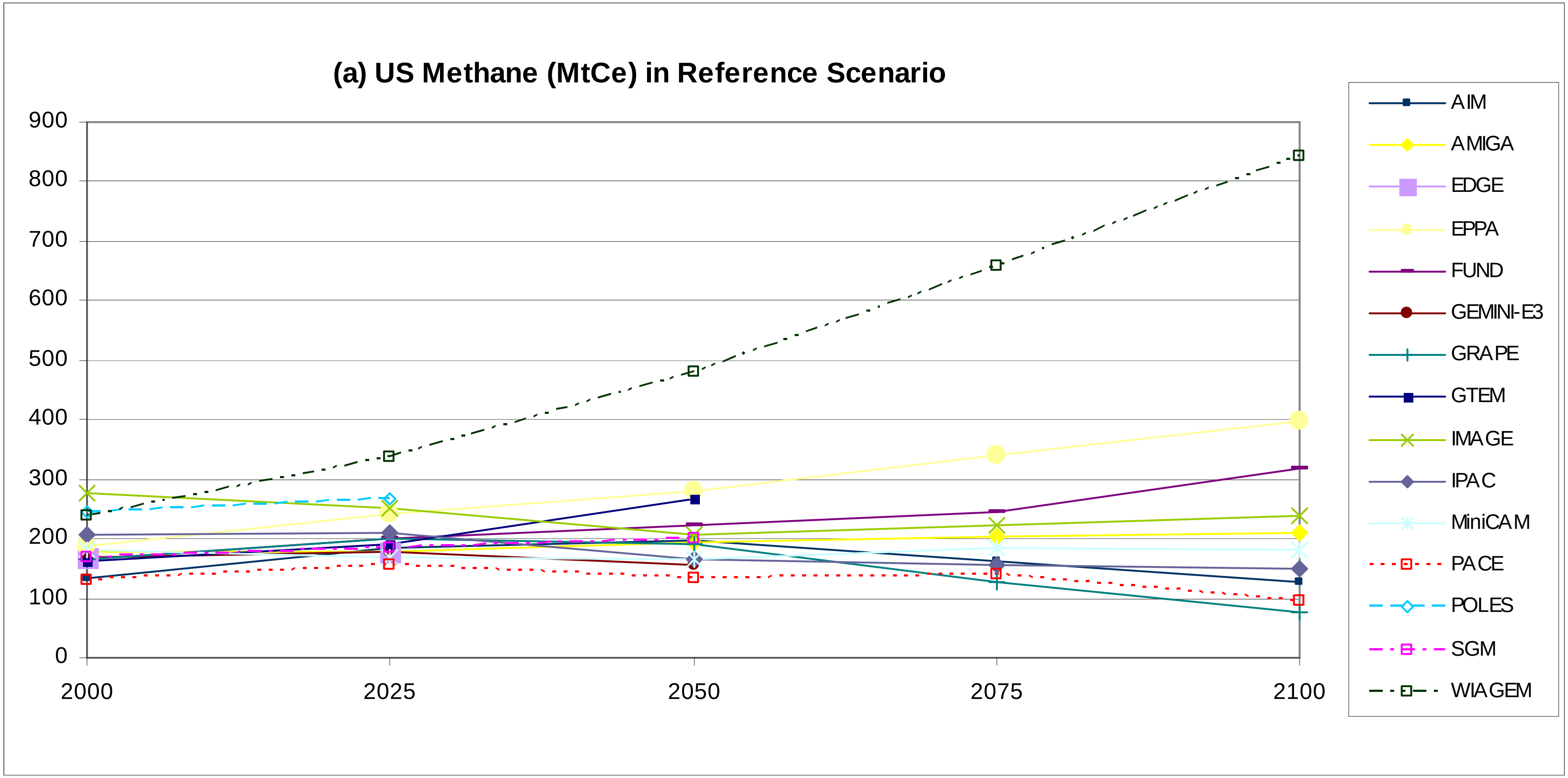
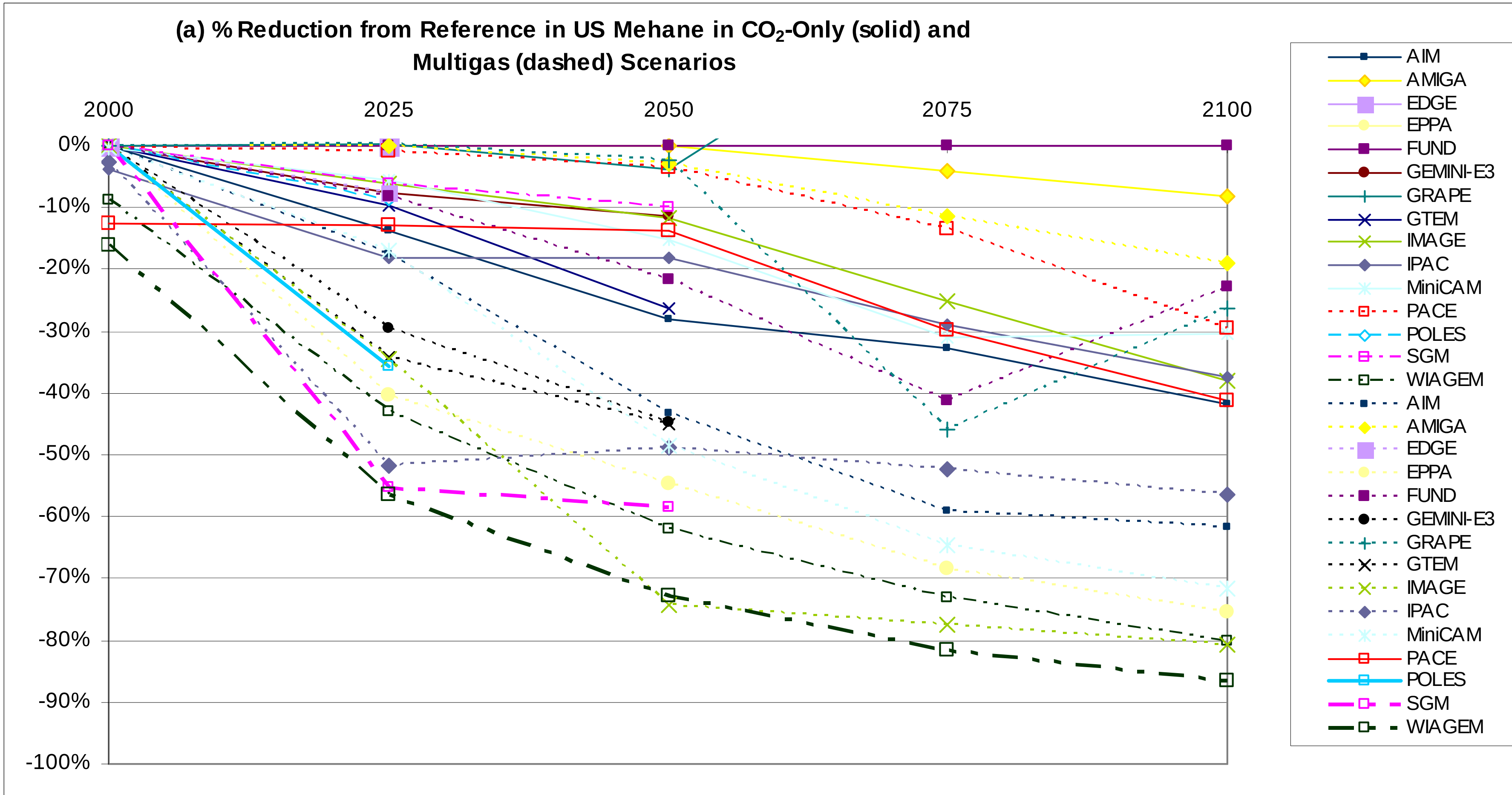
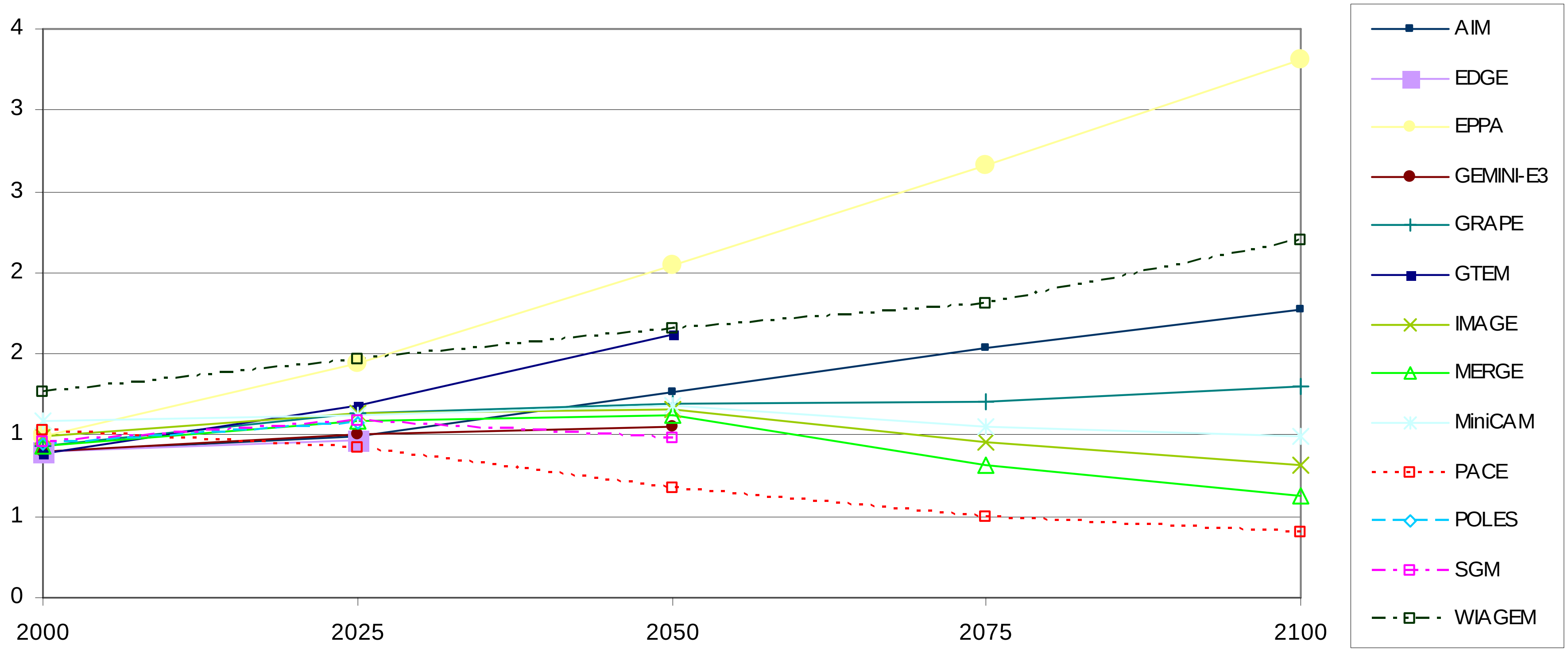
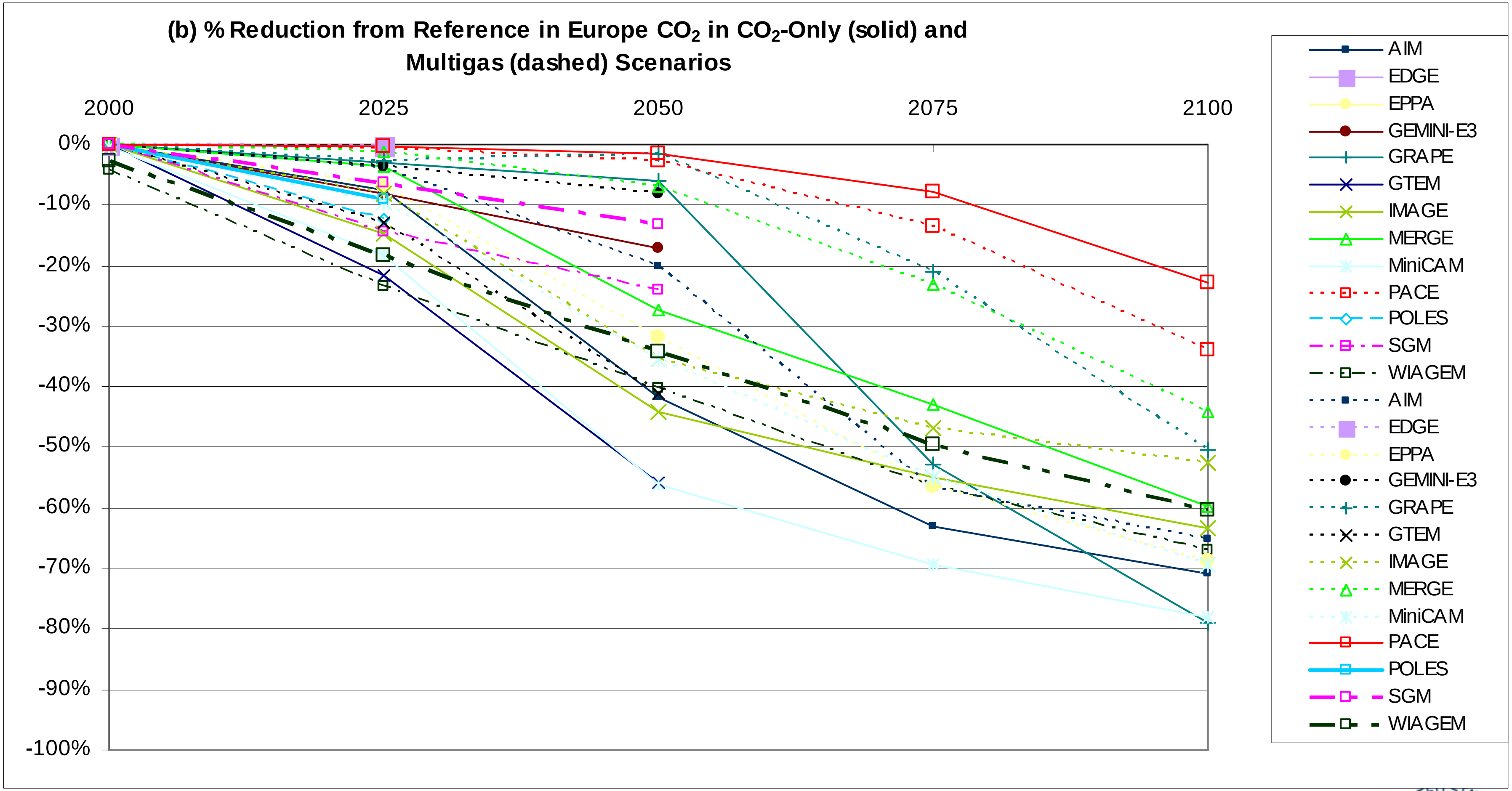
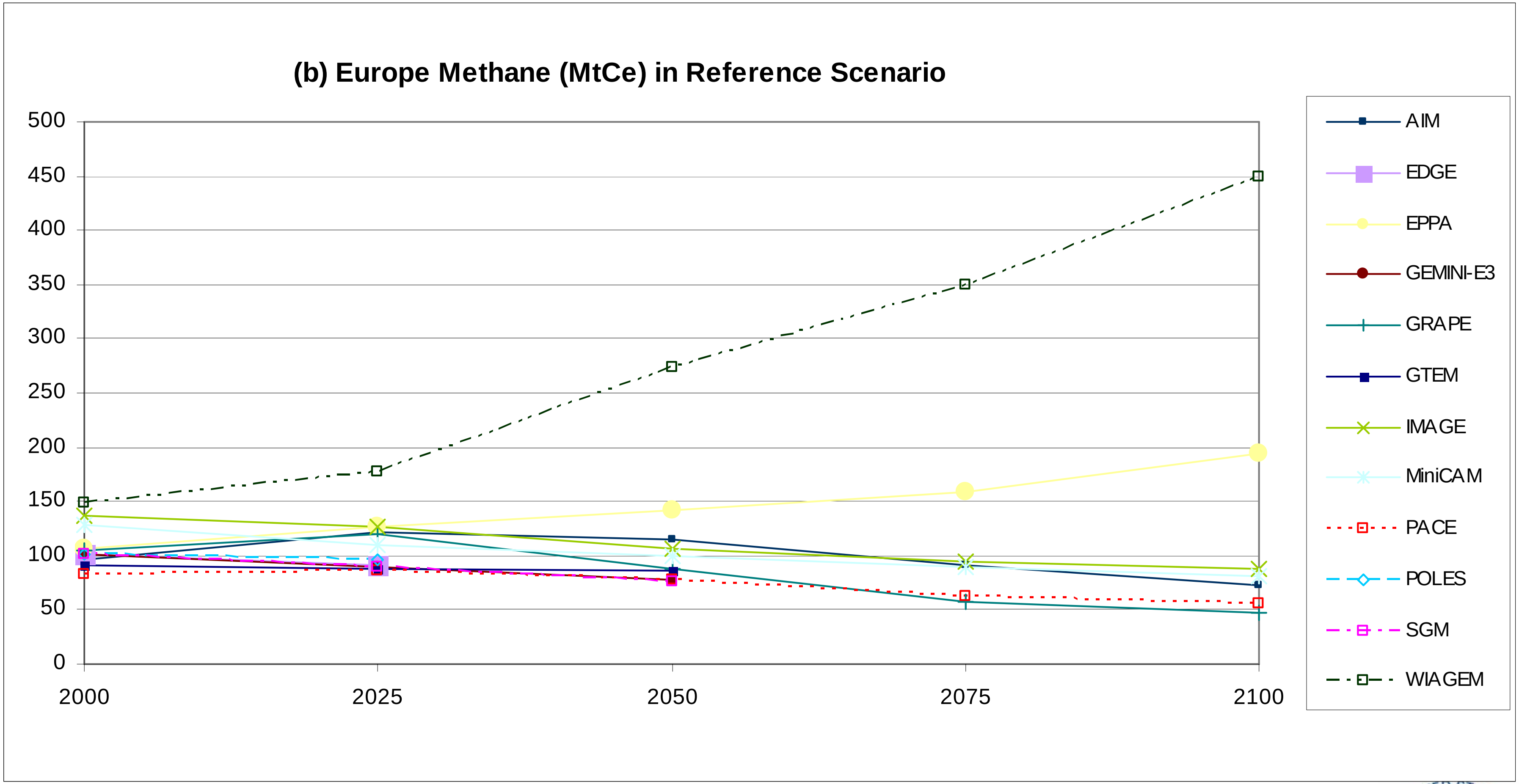

(a) US Methane (MtCe) in Reference Scenario
900
800
700
600
500
400
300
200
100
0
2000
2025
2050
2075
2100
AIM
AMIGA
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MiniCAM
PACE
POLES
SGM
WIAGEM

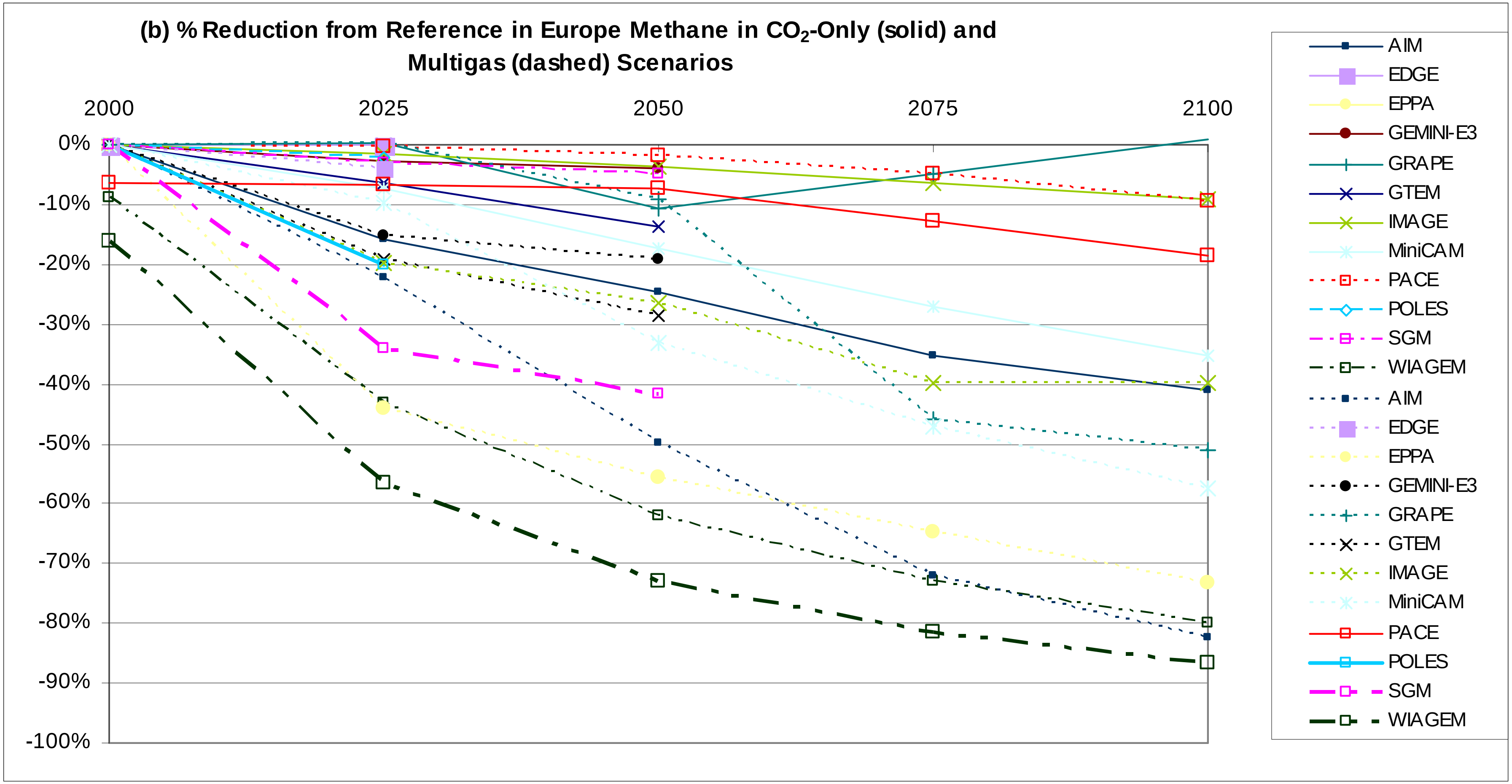

(a) % Reduction from Reference in US Mehane in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
AMIGA
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MiniCAM
PACE
POLES
SGM
WIAGEM
AIM
AMIGA
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MiniCAM
PACE
POLES
SGM
WIAGEM

(b) Europe CO_2 (GtC) in Reference Scenario

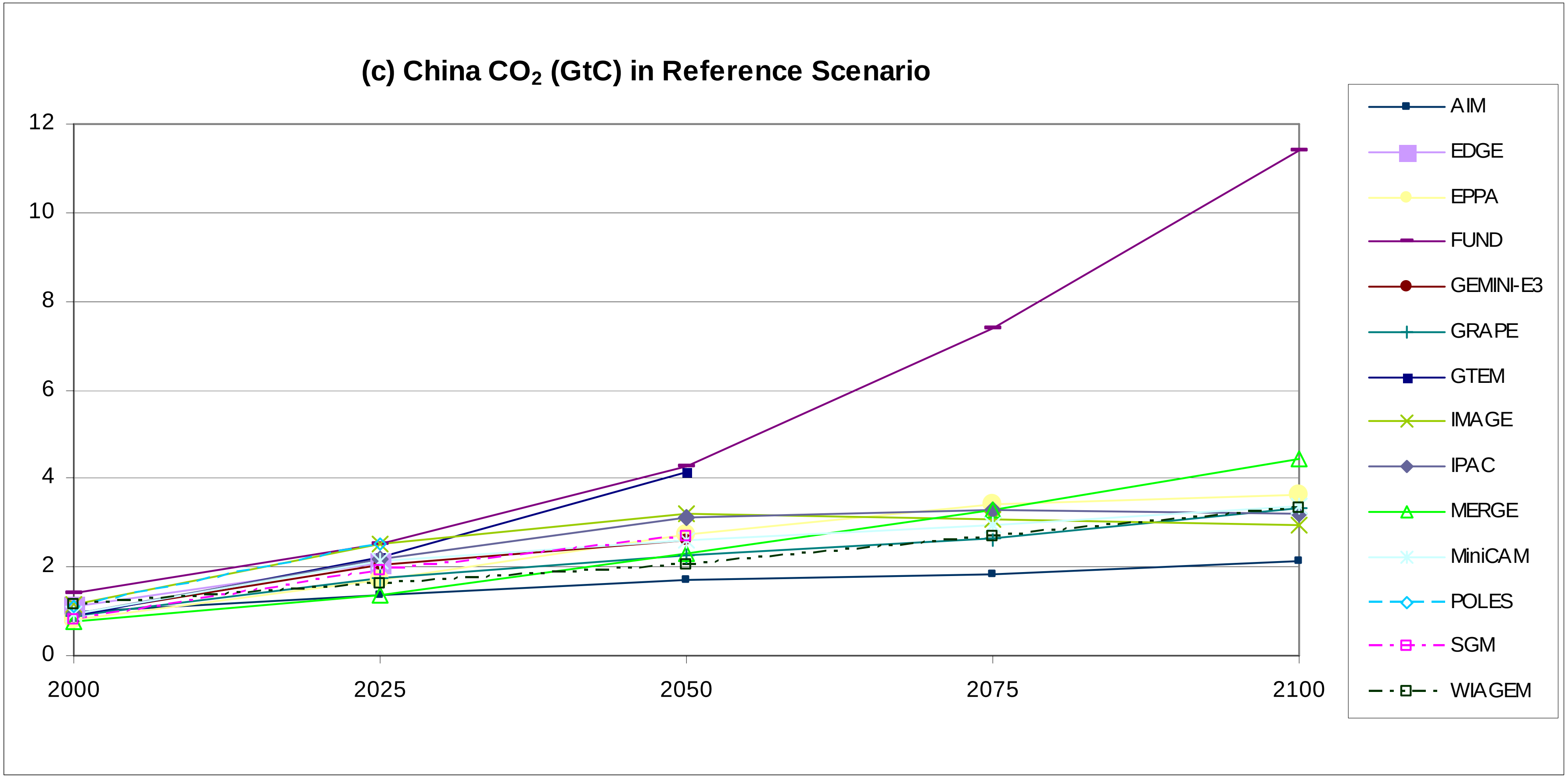


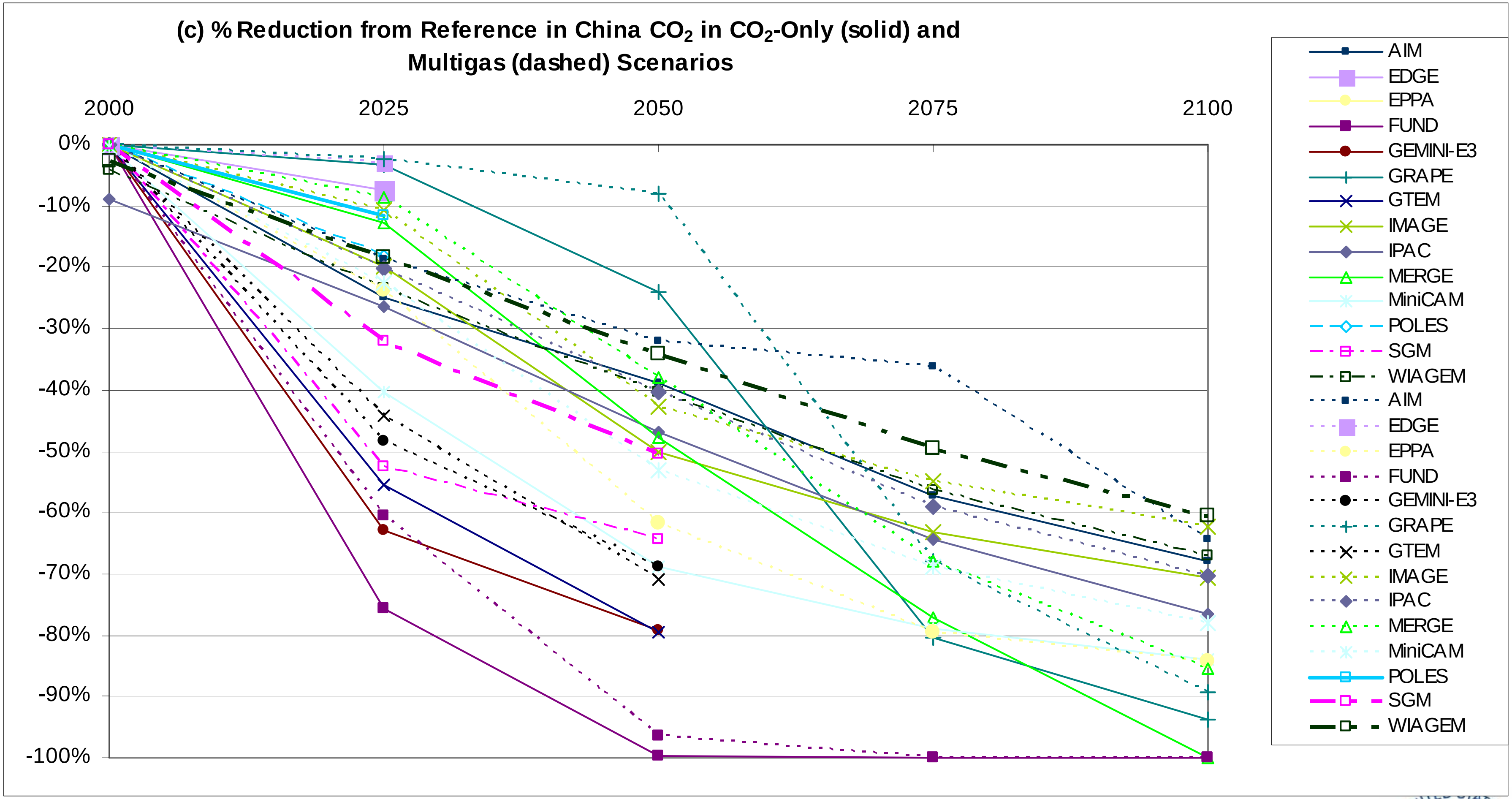

(b) % Reduction from Reference in Europe CO_2 in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
EDGE
EPPA
GEMINI-E3
GRAPE
GTEM
IMAGE
MERGE
MiniCAM
PACE
POLES
SGM
WIAGEM
AIM
EDGE
EPPA
GEMINI-E3
GRAPE
GTEM
IMAGE
MERGE
MiniCAM
PACE
POLES
SGM
WIAGEM


(b) Europe Methane (MtCe) in Reference Scenario
500
450
400
350
300
250
200
150
100
50
0
2000
2025
2050
2075
2100
AIM
EDGE
EPPA
GEMINI-E3
GRAPE
GTEM
IMAGE
MiniCAM
PACE
POLES
SGM
WIAGEM



(b) % Reduction from Reference in Europe Methane in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
EDGE
EPPA
GEMINI-E3
GRAPE
GTEM
IMAGE
MiniCAM
PACE
POLES
SGM
WIAGEM
AIM
EDGE
EPPA
GEMINI-E3
GRAPE
GTEM
IMAGE
MiniCAM
PACE
POLES
SGM
WIAGEM


(c) China CO_2 (GtC) in Reference Scenario
0
2
4
6
8
10
12
2000
2025
2050
2075
2100
AIM
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MERGE
MiniCAM
POLES
SGM
WIAGEM



(c) % Reduction from Reference in China CO_2 in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MERGE
MiniCAM
POLES
SGM
WIAGEM
AIM
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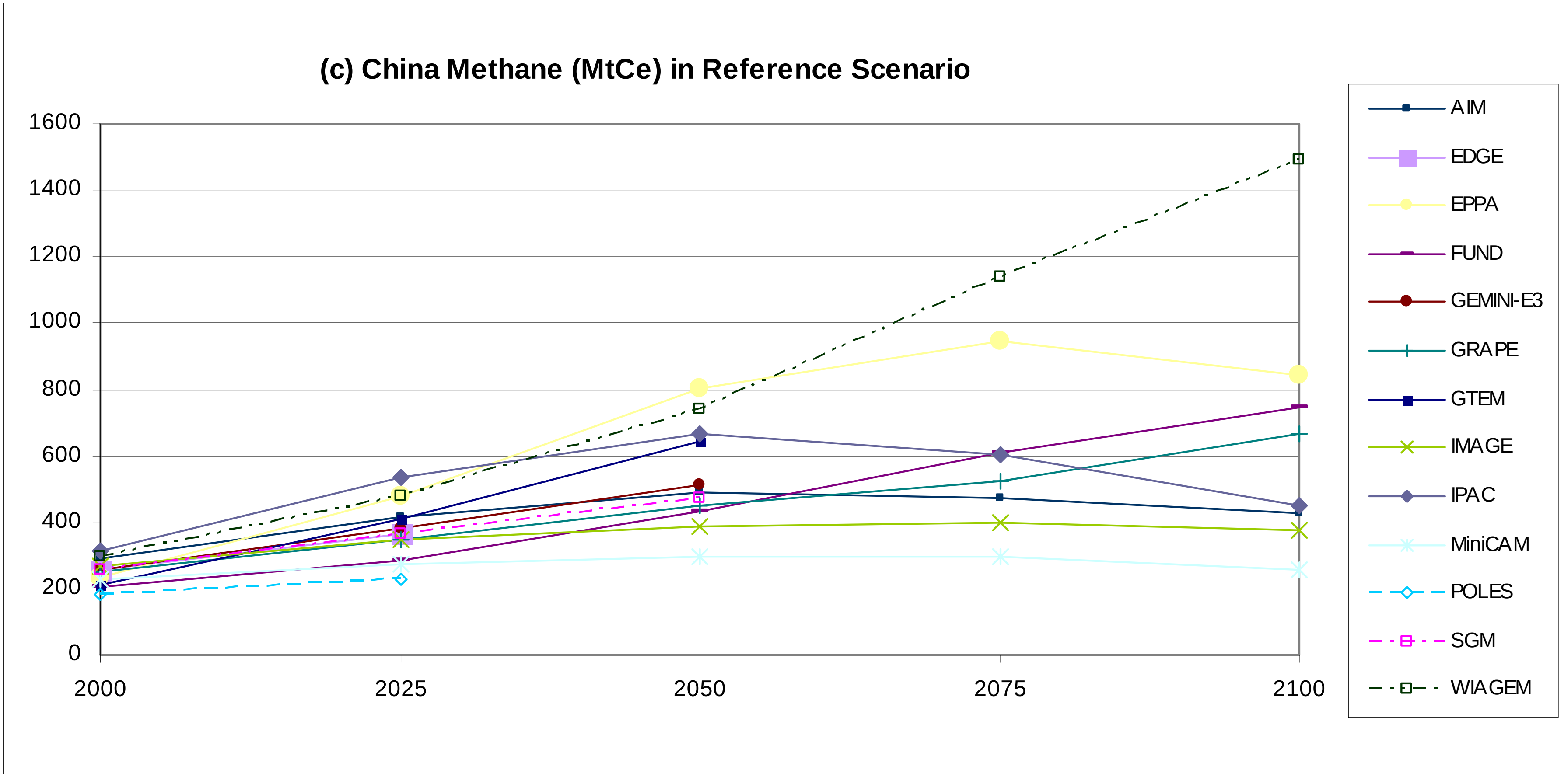
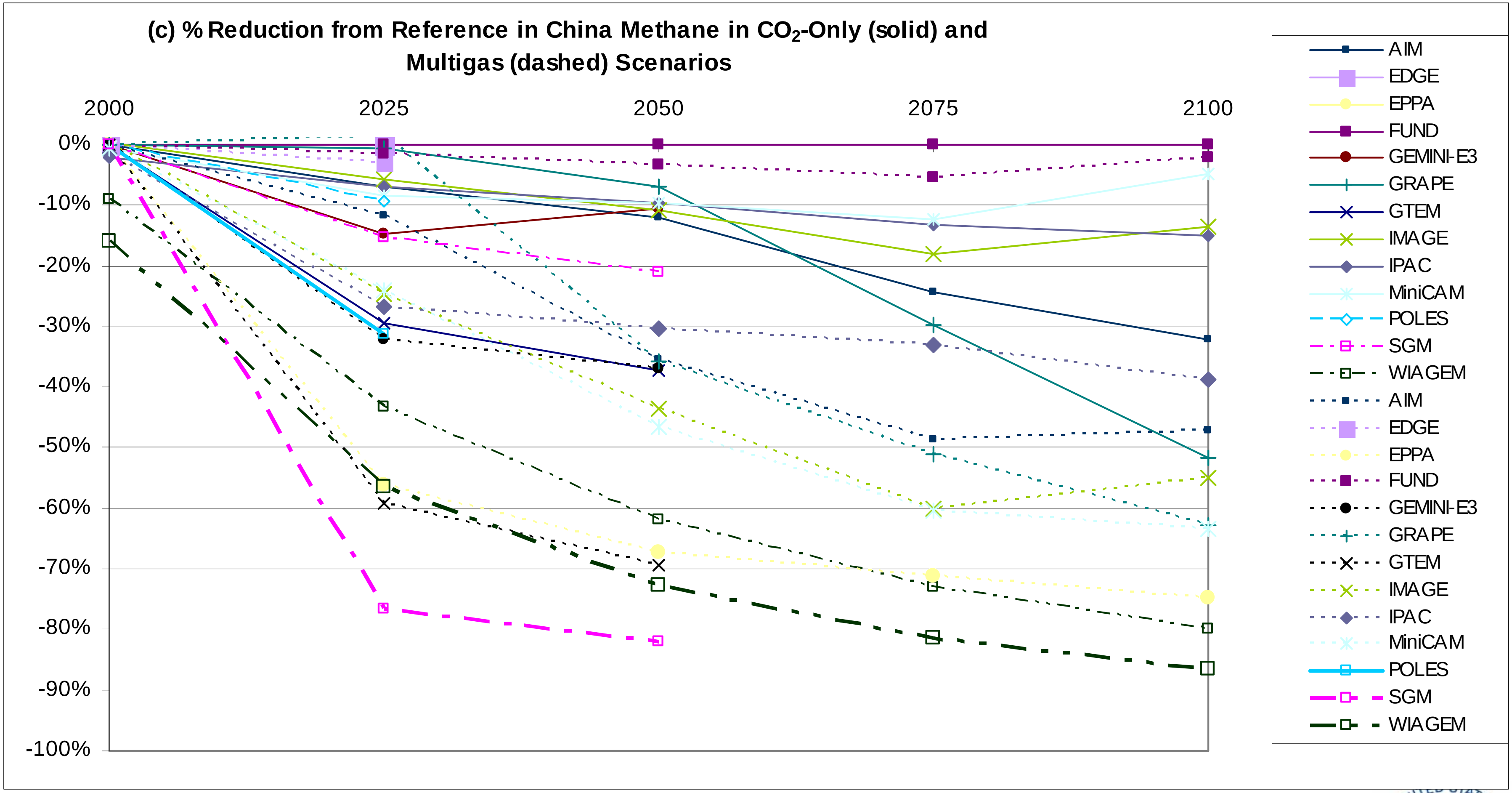
GTEM
IMAGE
IPAC
MERGE
MiniCAM
POLES
SGM
WIAGEM


(c) China Methane (MtCe) in Reference Scenario
1600
1400
1200
1000
800
600
400
200
0
2000
2025
2050
2075
2100
AIM
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MiniCAM
POLES
SGM
WIAGEM


(c) % Reduction from Reference in China Methane in CO_2-Only (solid) and Multigas (dashed) Scenarios
2000
2025
2050
2075
2100
0%
-10%
-20%
-30%
-40%
-50%
-60%
-70%
-80%
-90%
-100%
AIM
EDGE
EPPA
FUND
GEMINI-E3
GRAPE
GTEM
IMAGE
IPAC
MiniCAM
POLES
SGM
WIAGEM
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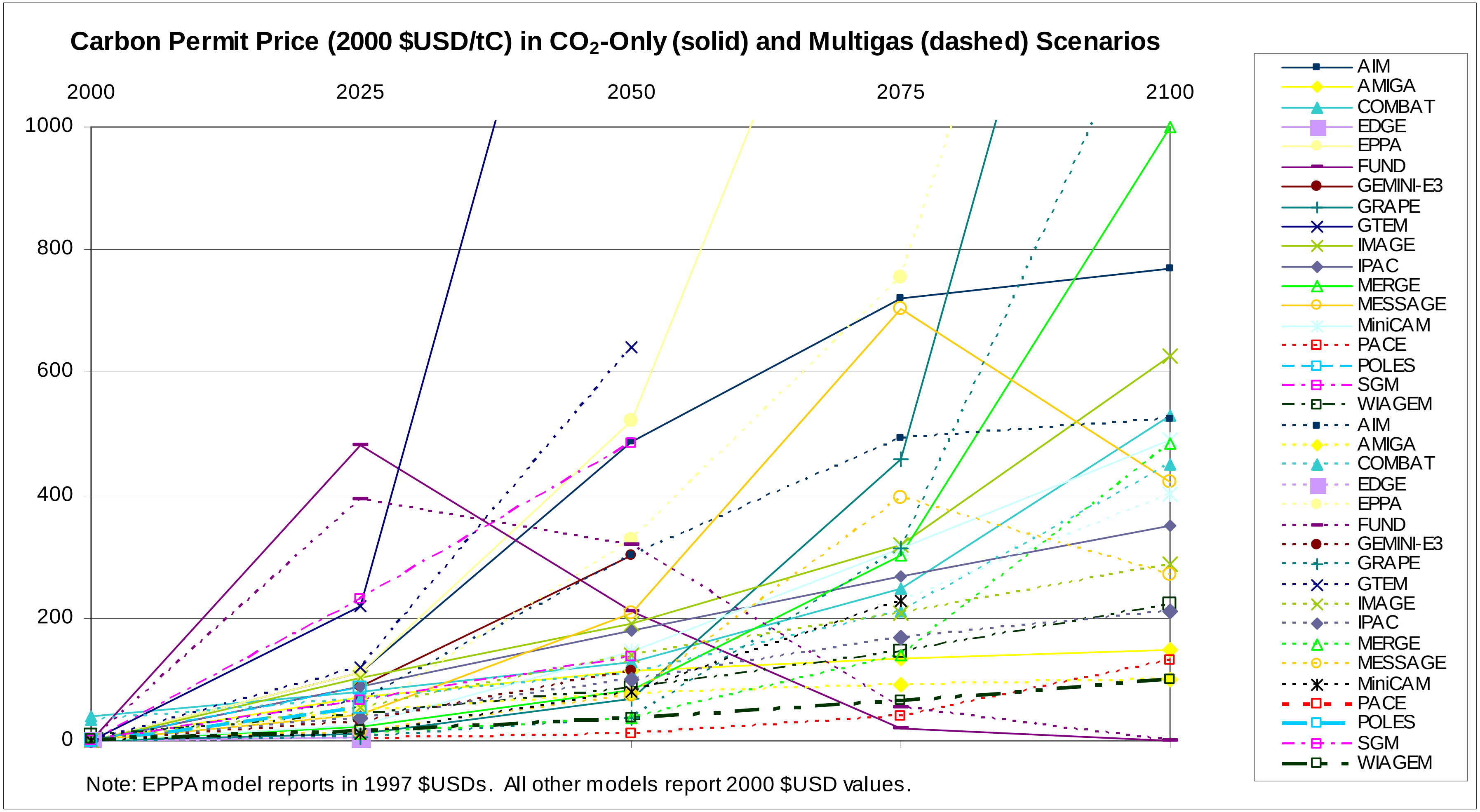
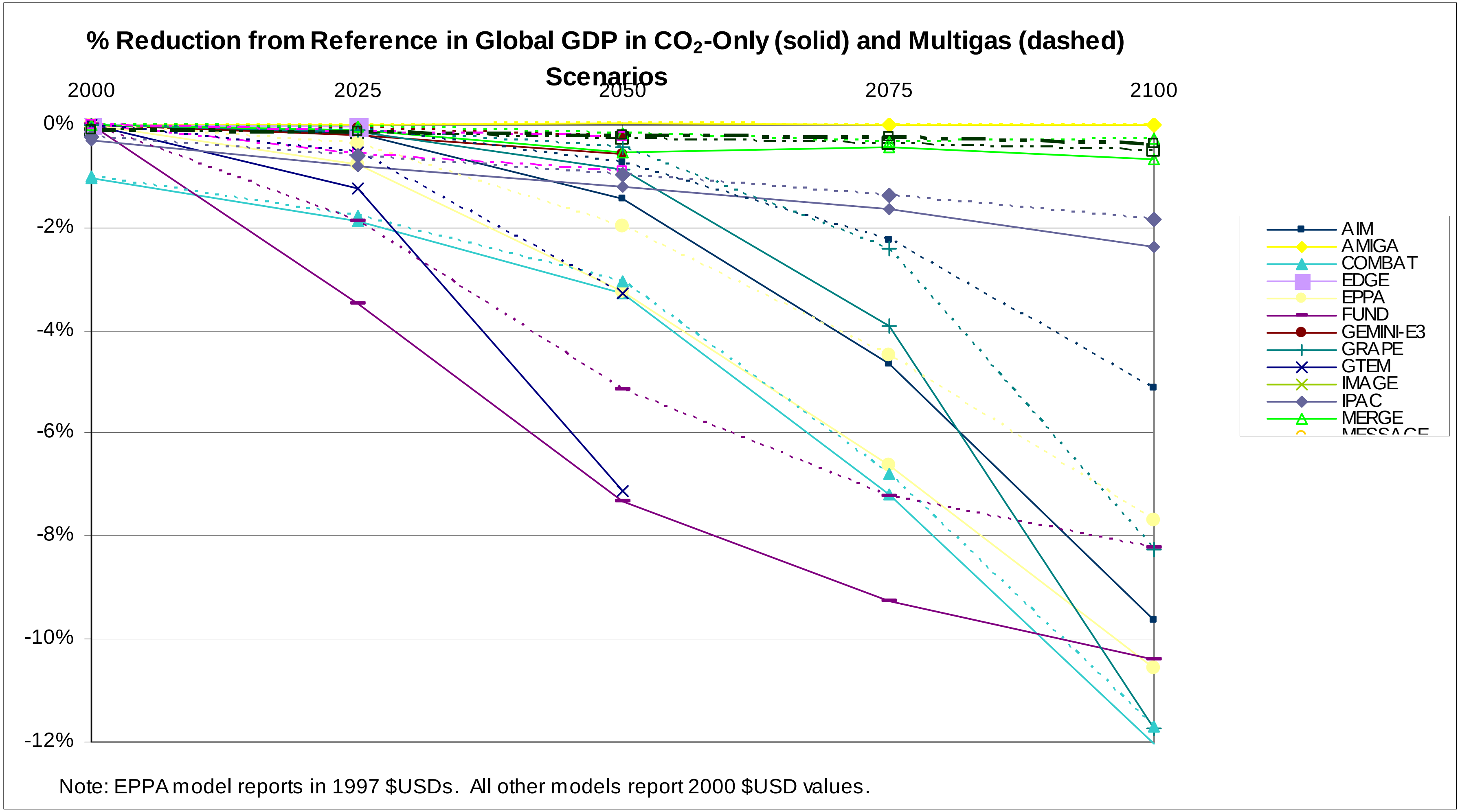
POLES
SGM
WIAGEM



Carbon Permit Price (2000 $US/tC)

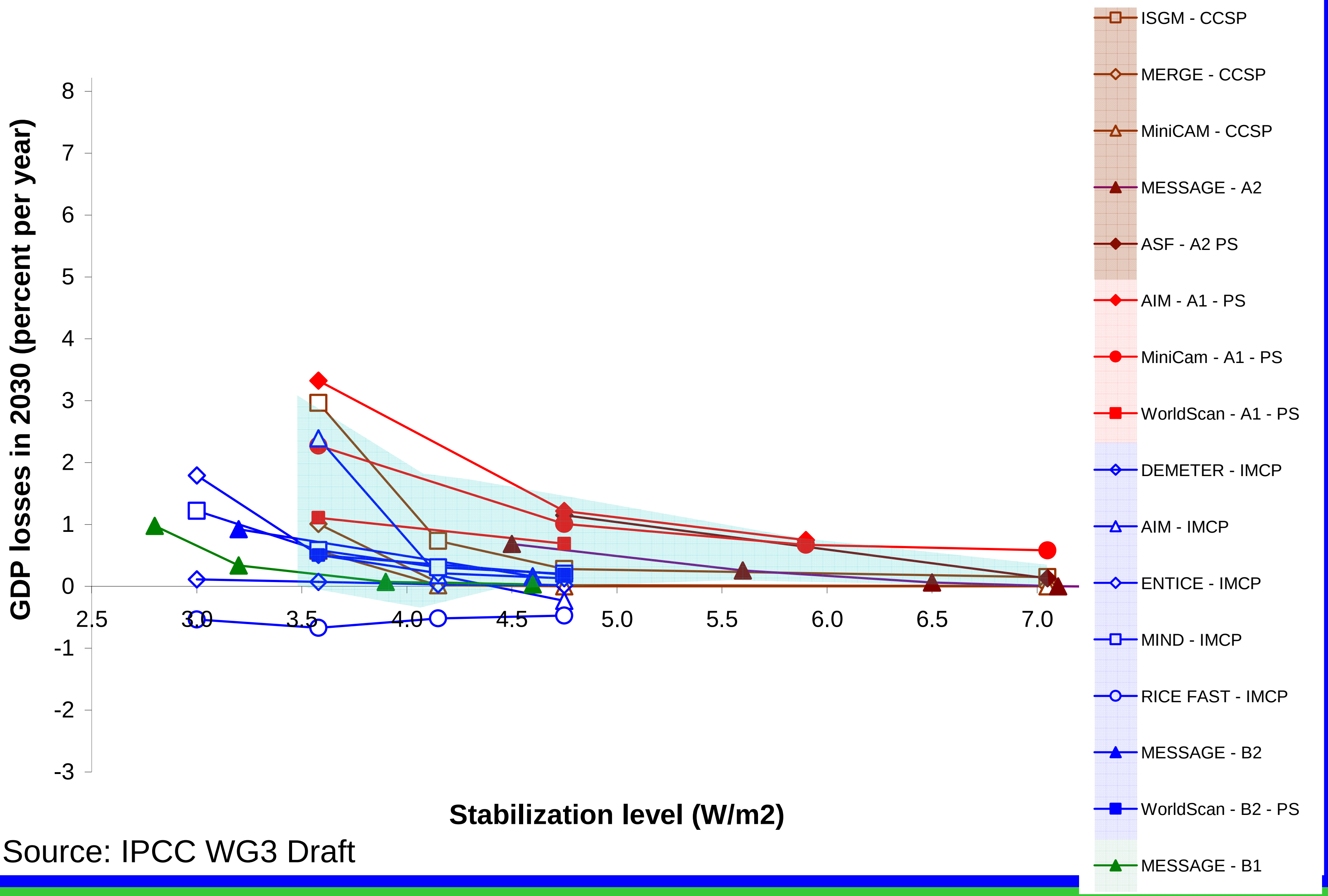
Model	Scenario	2000	2025	2050	2075	2100
Mean	CO_2 Only Scenario	2.7	101.3	314.2	406.2	877.0
	Multigas Scenario	2.0	57.8	158.7	241.8	480.3
	% Reduction	44%	48%	41%	23%	39%



Global GDP (2000 $US Trillions)

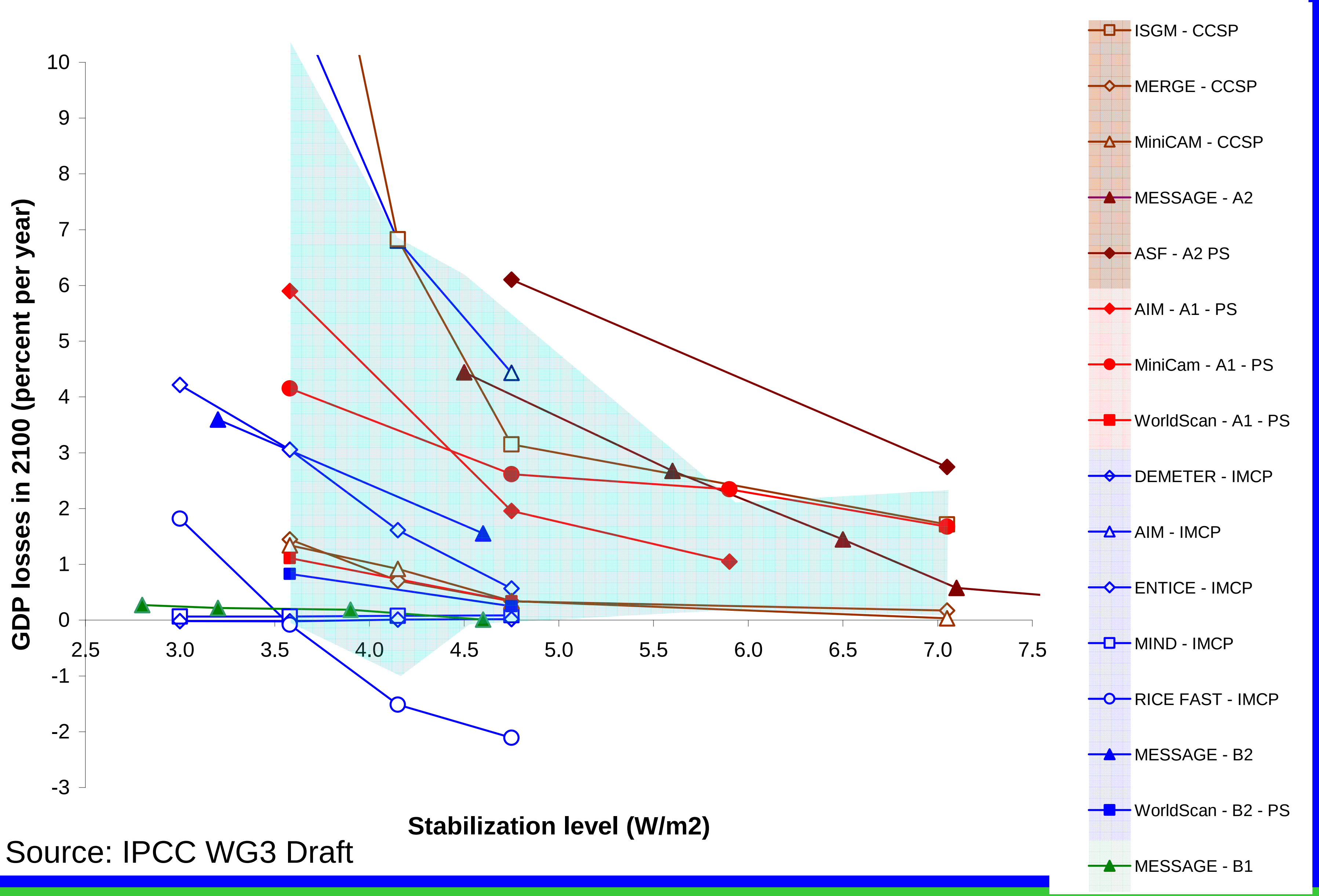
Model	Scenario	2000	2025	2050	2075	2100
Mean	Reference Case	33.0	65.8	116.7	194.4	295.4
	% Reduction GDP in CO2 Only Scenario	-0.1%	-0.7%	-2.2%	-3.8%	-6.4%
	% Reduction GDP in Multigas Scenario	-0.1%	-0.4%	-1.4%	-2.8%	-4.8%

Relationship between cost of mitigation (% loss of GDP)



Source: IPCC WG3 Draft

Relationship between cost of mitigation (% loss of GDP)



Source: IPCC WG3 Draft

Table 3.16: *Global Emission Reductions from Top-Down Models in 2030 by Sector for a Range of Stabilization Targets*

		POLES	IPAC	AIM	GRAPE	MiniCAM	SGM	MERGE	IMAGE 2.3	WIAGEM	MESSAGE
odel											
abilization Category		**Category C Stabilization Targets**						**Category B Stabilization Targets**			
abilization Target		550 ppmv	550 ppmv	4.5 W/m^2 from preindustrial	4.5 W/m^2 from preindustrial	4.5 W/m^2 from preindustrial	From MiniCAM Trajectory	3.4 W/m^2 from preindustrial	3.0 W/m^2 from preindustrial	2 degrees C from preindustrial	B2 Scenario, 1.5 degrees C from preindustrial
arginal Cost in 2030 hown in 2000 U.S. $/tCO2eq)		$ 57	14	$ 29	$ 2	$ 12	$ 21	$ 192	$ 112	$ 9	$ 115
eference Emissions 2030 otal All Gases (MtCO_2eq)		53.0	55.3	49.4	57.0	54.2	53.5	47.2	59.7	43.1	57.8
Sector Mitigation Estimates in 2030 (Total All Gases MtCO_2eq)	Energy Supply: Electric	9.5	6.4	5.2	0.5	7.3	3.0	9.5	8.7	7.0	4.3
	Energy Supply: Non-Electric	3.0	0.6	1.1	0.0	1.5	1.7	3.2	3.7	1.7	2.2
	Transportation Demand	0.5	0.8	0.5	0.1	0.2	0.5[b]	Included in Energy Supply	2.8	Included in Energy Supply	2.2
	Buildings Demand	1.0	0.6	0.5	0.4	0.3	Included in Energy Supply	Included in Energy Supply	1.0	Included in Energy Supply	1.4
	Industry Demand	1.9	1.2	0.5	Included in another sector	1.7	Included in Energy Supply	Included in Energy Supply	3.2	Included in Energy Supply	0.8
	Industry Production	0.8	0.0	0.8	0.3	0.2[e]	1.6[b]	3.6[a]	2.0	3.6	0.8
	Agriculture	(0.2)	(1.0)	2.0	0.6	0.3	4.2		1.2	1.1	1.7
	Forestry	Included in another sector	Included in another sector	0.0	0	0	Included in Agriculture		0.2	0.0	0.6
	Waste Management	Included in another sector	0	Included in another sector	0.0	0.3	0.8		1.1	Included in another sector	0.9
	Global Total	16.4	8.7	10.6	1.9	11.9	14.0[c]	16.3	24.0	15.5[d]	15.0
itigation as % Reference nissions		31%	16%	21%	3%	22%	26%	35%	40%	36%	26%

Table 11.3: *Estimated economic potentials for GHG mitigation at a sectoral level in 2030 for different cost categories using the SRES B2 and IEA World Energy Outlook (2004) baselines*

Sector (in brackets 2030 emissions WEO/SRES B2 scenario)	Mitigation option	Region	Economic potential < 100 US$/t$CO_2$eq		Economic potential at different cost categories in US$/t$CO_2$eq			
			Low	High	<0	0 - 20	20 - 50	50 - 100
			Mton CO_2eq					
Energy supply (n.a.)	All options in energy supply excluding electricity savings in other sectors	OECD	200	1400	100	200	290	200
		EIT	300	500	60	80	150	150
		Non OECD	1700	3100	700	700	1000	-
		Global	2200	5100	850	1000	[illegible]	[illegible]350
Transport (10.6 GtCO_2-CO_2 only)	Total	OECD	1700					
		EIT	150					
		Non OECD	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
		Global	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Buildings (15.0 GtCO_2-CO_2 only)	Electricity savings	OECD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
		EIT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
		Non OECD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20
	[illegible]	OECD	950	[illegible]	[illegible]	[illegible]	[illegible]	-
		EIT	500	[illegible]	[illegible]	[illegible]	10	-
		Non OECD	150	[illegible]	[illegible]	100	-	-
	[illegible]	OECD	1700	[illegible]	1500	100	150	-
		EIT	600	700	400	250	10	-
		Non OECD	1400	1700	1400	100	-	20
		Global	3700	4100	3200	450	150	20
Industry ([illegible] GtCO_2-CO_2 [illegible] GtCO_2 [illegible] non-CO_2 emissions in 2020)	[illegible]	OECD	400		100		100	200
		EIT	100		30		30	50
		Non OECD	900		200		200	450
	Other savings, including non-CO_2 GHG	OECD	300	900	300		200	50
		EIT	150	400	80		200	20
		Non OECD	900	2900	550		1300	70
	Total	OECD	700	1300	400		300	250
		EIT	300	550	100		250	80
		Non OECD	1800	3800	750		1500	500
		Global	2800	5600	1300		2100	850

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Table 11.8: Economic potential for sectoral mitigation by 2030 [a]: comparison of bottom-up and top-down estimates (mtCO_2 eq)

Chapter of this report	Sectors	<US\$20/tCO_2 eq central	<US\$20/tCO_2 eq	<US\$100/tCO_2 eq	<US\$100/tCO_2 eq maximum
		Bottom-Up	Top-Down	Bottom-Up	Top-Down
4	Energy supply and conversion (including electricity savings)	1800 (4200) [b]	566-8832	2200-5100 (5600 – 8500) [b]	15253
5	Transport	Not available	56-1318	3000	[illegible]
6	Buildings	1700 [c]	287-62[illegible]	1600-2[illegible]	[illegible]
7	Industry	900 [c]	47[illegible]	[illegible]	[illegible]549
8	Agriculture	2100	-1[illegible]-11[illegible]	[illegible]00	[illegible]915
9	Forestry	120[illegible]	0-[illegible]4	[illegible]700	[illegible]704
10	Wast[illegible]	70[illegible]	0-[illegible]	[illegible]550-[illegible]00	1186
11	To[illegible] ele[illegible]ic[illegible] [illegible]a[illegible]g[illegible]	[illegible]400		3400	
	[illegible]l a[illegible]ted [illegible]ffe[illegible] [illegible]n ene[illegible] [illegible]or	82000	1875-15531	18000-25000	23848
	IMCP potentials with induced technological change (9 models)		17000		27200

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