Reducing CO2 Abatement Costs – the Importance of Learning by Doing

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MERGE 4.5

- Model has nine regions (5 of which comprise Annex B and 4 of which comprise non Annex B)
- For technologies, which benefit from “learning by doing”, costs decrease by 20% for every doubling of capacity (dynamic cost component)
- One carbon-free LBD technology for electric and one for nonelectric
- There is global diffusion of learning
- There is a limit to cost reduction associated with learning by doing (static cost component)
- There is an autonomous factor, which contributes to decline in technology costs
- There are introduction constraints on new technologies and decline constraints on existing technologies

Table 1. Electricity Generation Technologies Available to US [a]

Technology name	Identification/Examples	Earliest possible introduction date	Costs in 2000 [b] (Mills/kWh)	Potential cost reduction due to learning by doing (Mills/kWh)	Carbon emission coefficients (Billion tons per TWH)
HYDRO	Hydroelectric, geothermal and other renewables	Existing	40.0		0.0000
NUC	Remaining initial nuclear	Existing	50.0		0.0000
GAS-R	Remaining initial gas fired	Existing	35.7		0.1443
OIL-R	Remaining initial oil fired	Existing	37.8		0.2094
COAL-R	Remaining initial coal fired	Existing	20.3		0.2533
GAS-N	Advanced combined cycle	2010	30.3		0.0935
GAS-A	Fuel cells with capture and sequestration – gas fuel	2030	47.7		0.0000
COAL-N	Pulverized coal without CO2 recovery	2010	40.6		0.1955
COAL-A	Fuel cells with capture and sequestration – coal fuel	2040	55.9		0.0068
IGCC	Integrated gasification and combined cycle with capture and sequestration – coal fuel	2020 [c]	62.0		0.0240
ADV-HC	Carbon-free technologies; costs do not decline with learning by doing	2010	95.0		0.0000
LBDE-HC	Carbon-free technologies; costs decline with learning by doing (high cost)	2010	95.0	40.0	0.0000
LBDE-LC	Carbon-free technologies; costs decline with learning by doing (low cost)	2010	95.0	60.0	0.0000

[a] Introduction dates and costs may vary by region.
[b] Except for oil and gas costs and the learning by doing component, we assume that the costs of all technologies decline at a rate of 0.5% per year beginning in 2000.
[c] IGCC is currently available; however, without capture and sequestration.

Table 1. Electricity Generation Technologies

Technology name	Identification/Examples
HYDRO	Hydroelectric, geothermal and other renewables
NUC	Remaining initial nuclear
GAS-R	Remaining initial gas fired
OIL-R	Remaining initial oil fired
COAL-R	Remaining initial coal fired
GAS-N	Advanced combined cycle
GAS-A	Fuel cells with capture and sequestration – gas fuel
COAL-N	Pulverized coal without CO2 recovery
COAL-A	Fuel cells with capture and sequestration – coal fuel
IGCC	Integrated gasification and combined cycle with capture and sequestration – coal fuel
ADV-HC	**Carbon-free technologies; costs do not decline with learning by doing**
LBDE-HC	**Carbon-free technologies; costs decline with learning by doing (high cost)**
LBDE-LC	**Carbon-free technologies; costs decline with learning by doing (low cost)**

Figure 1. Initial Costs for Carbon-free LBD Technologies in the Electric Sector

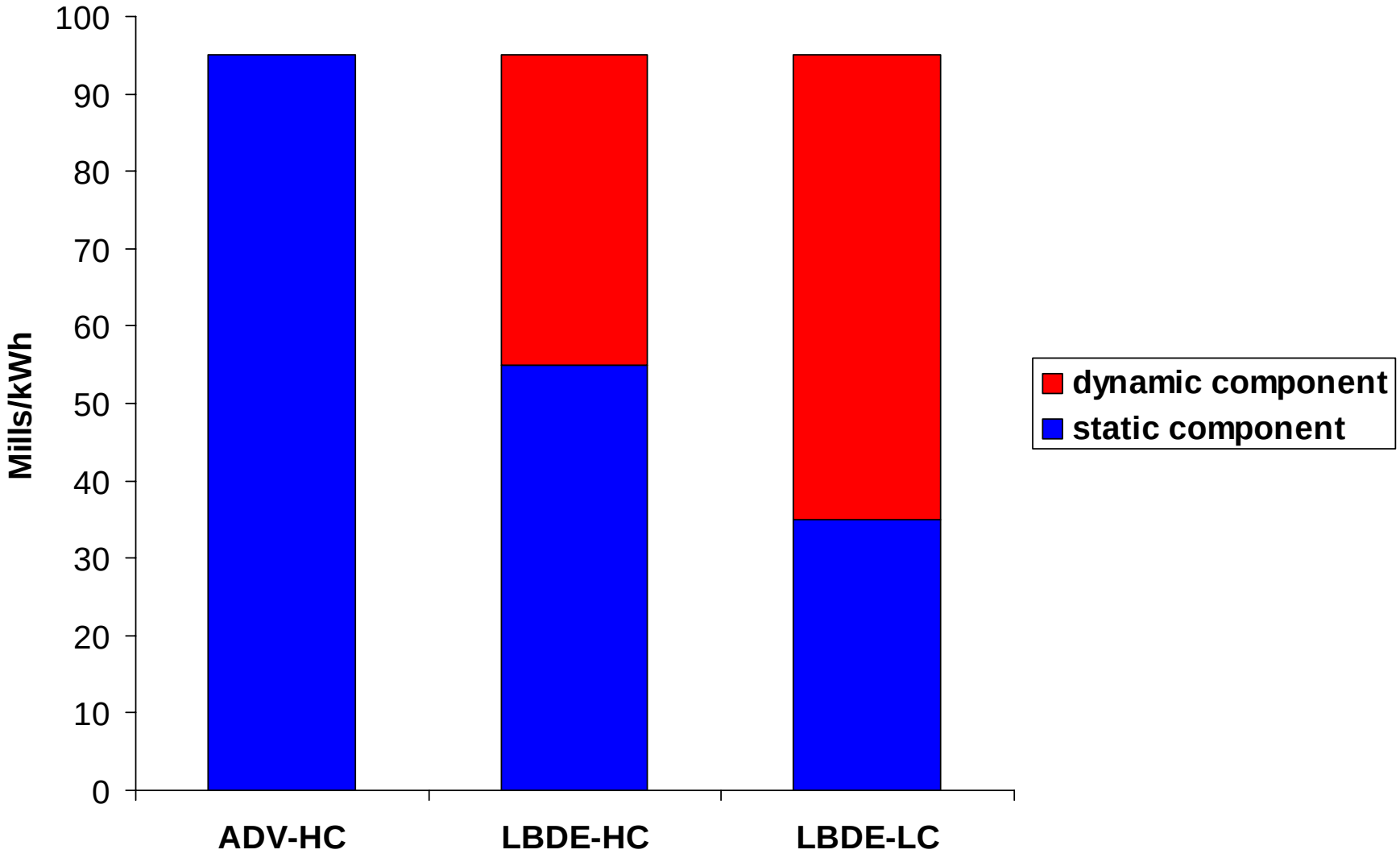

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Figure 2. Electricity Generating Costs for Four Technologies in the Absence of a Carbon Constraint

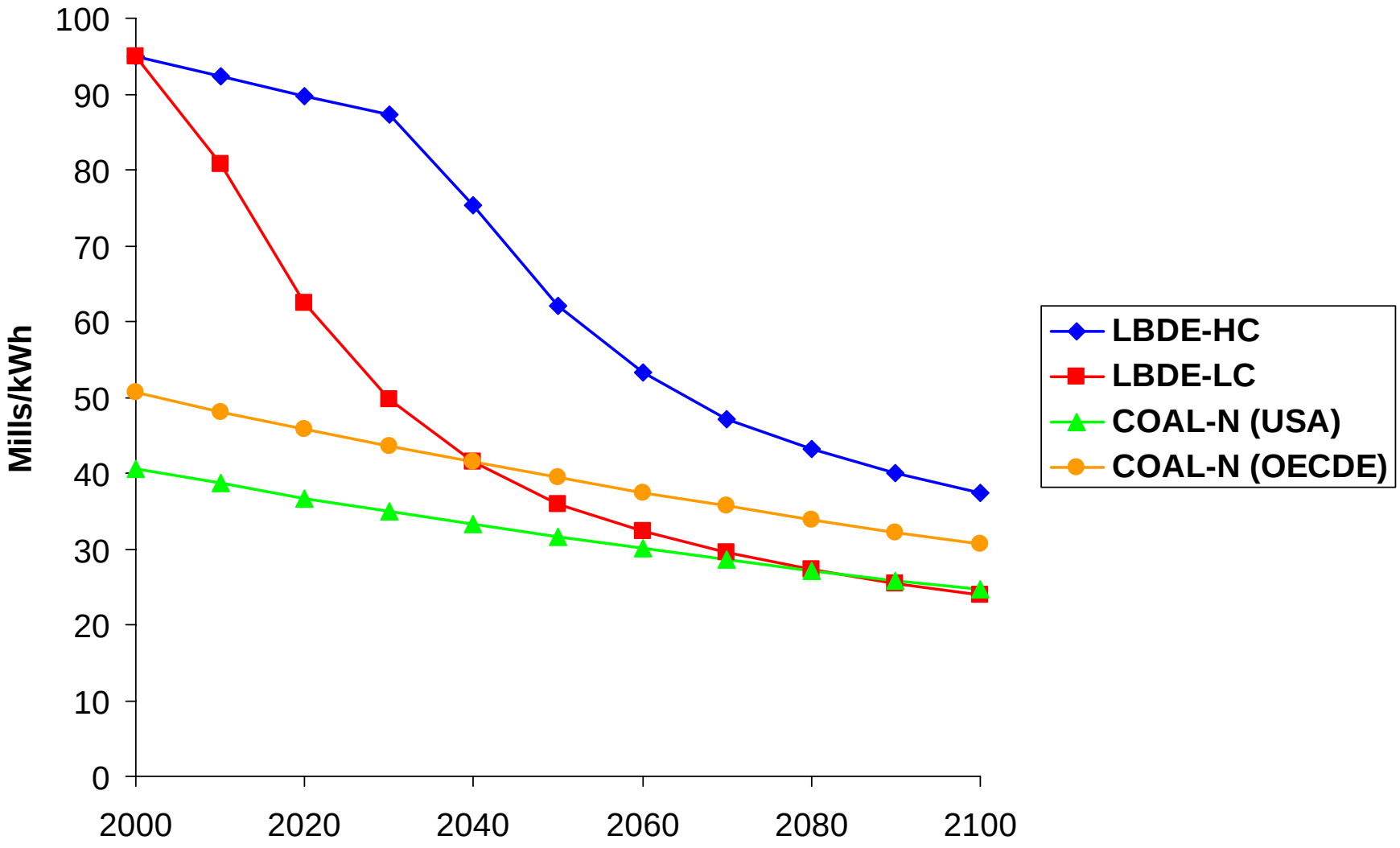

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Table 2. Nonelectric Energy Supplies Available to US [a]

Technology name	Description	Cost in 2000 ($/GJ) [b]	Potential cost reduction due to learning by doing ($/GJ)	Carbon emission coefficients (tons of carbon per GJ)
CLDU	Coal – direct uses	2.50		0.0241
OIL-1-10	Oil – 10 cost categories	3.00-5.25		0.0199
GAS-1-10	Gas – 10 cost categories	2.00-4.25		0.0137
RNEW	Renewables	6.00		0.0000
NEB-HC	Nonelectric backstop	14.00		0.0000
LBDN	Carbon free technologies; costs decline with learning by doing	14.00	6.00	0.0000

[a] Costs may vary by region.
[b] Except for the learning by doing component, we assume that the costs of all technologies decline at a rate of 0.5% per year beginning in 2000.

Table 2. Nonelectric Energy Supplies

Technology name	Description
CLDU	Coal – direct uses
OIL-1-10	Oil – 10 cost categories
GAS-1-10	Gas – 10 cost categories
RNEW	Renewables
NEB-HC	**Nonelectric backstop**
LBDN	**Carbon free technologies; costs decline with learning by doing**

Figure 3. Initial Costs for Carbon-free LBD Technology in the Nonelectric Sector

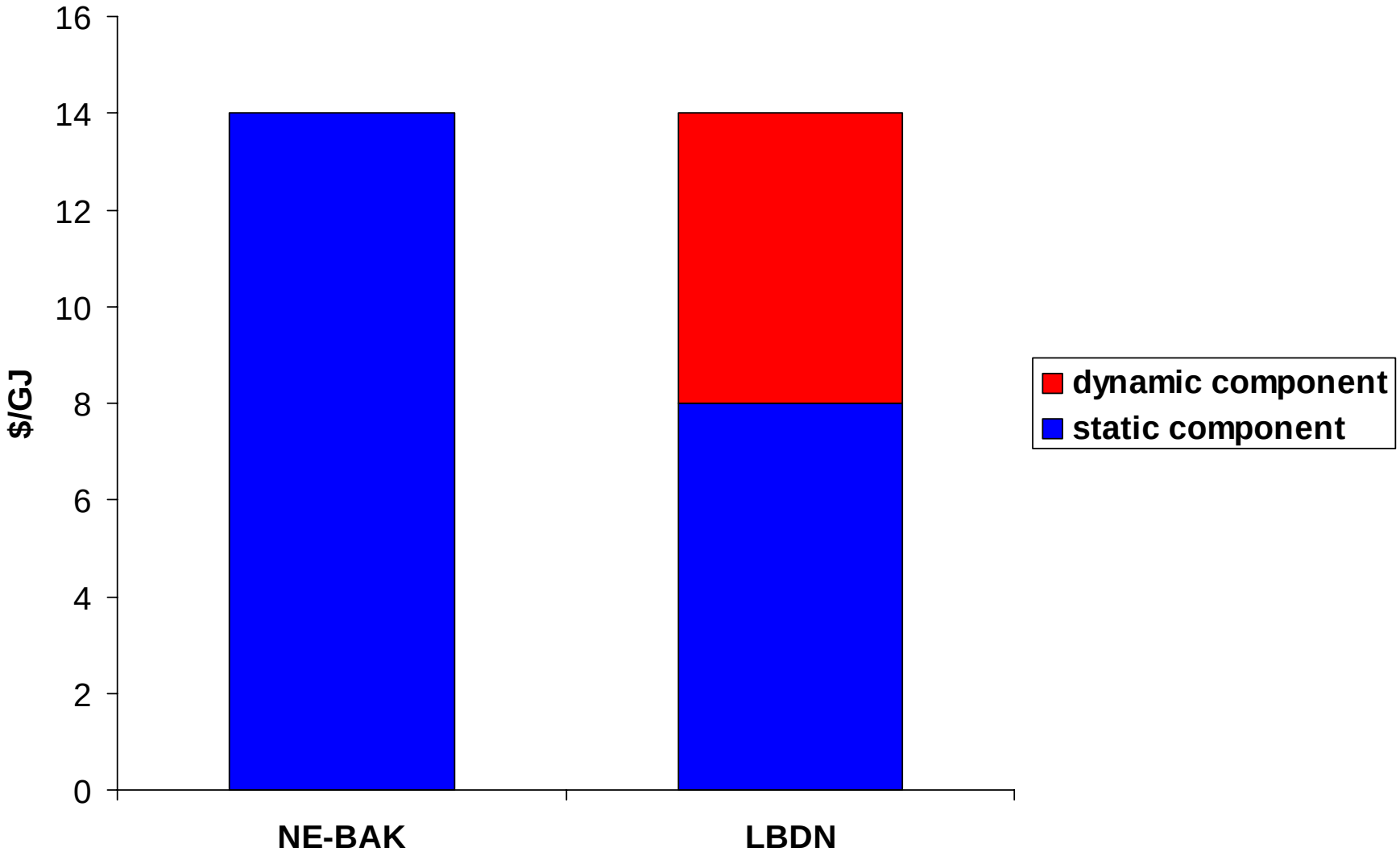

Figure 4. Global Carbon Emissions – no carbon constraints

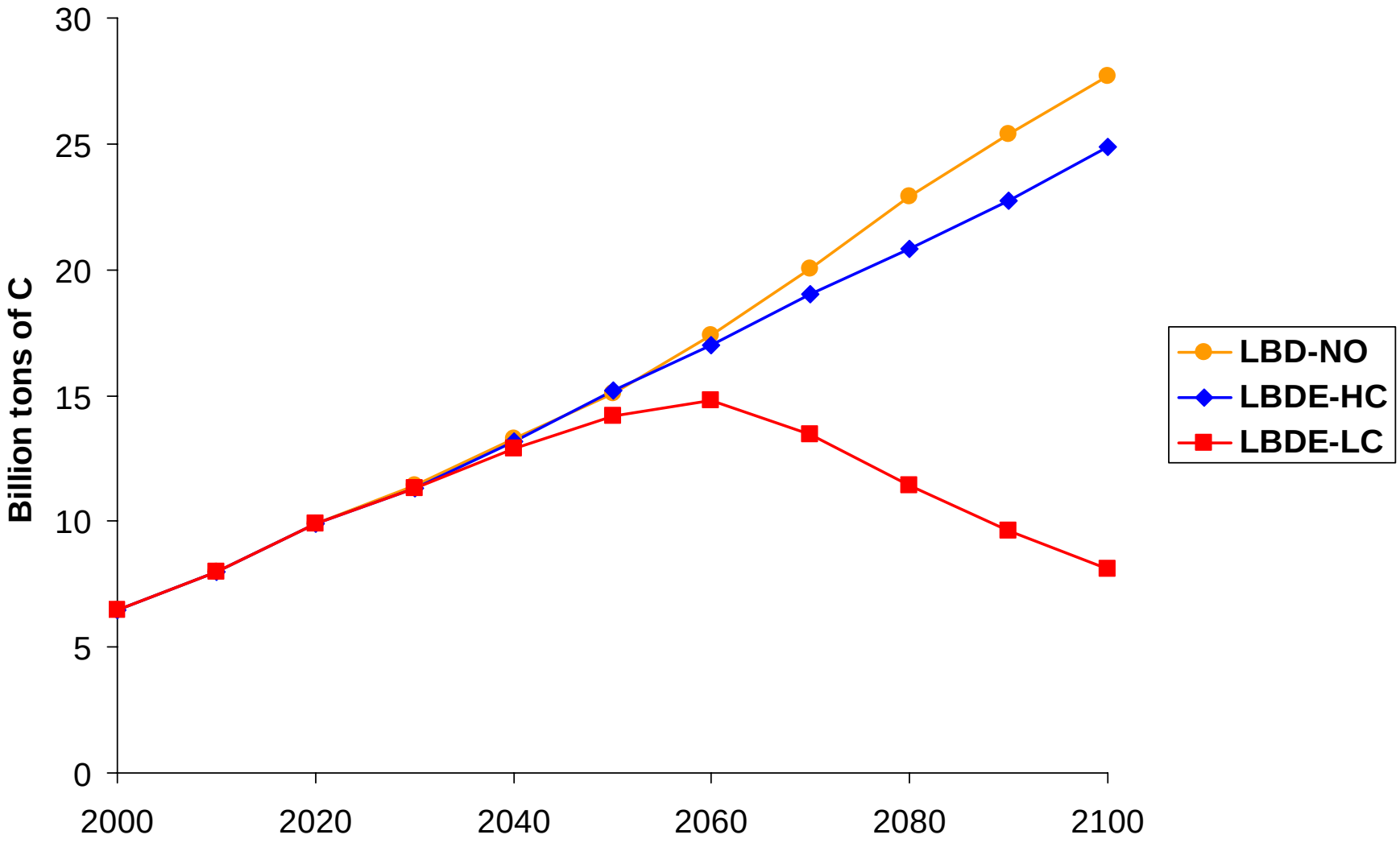

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Figure 5. Global Carbon Emissions – reference case and two control scenarios (LBDE-HC)

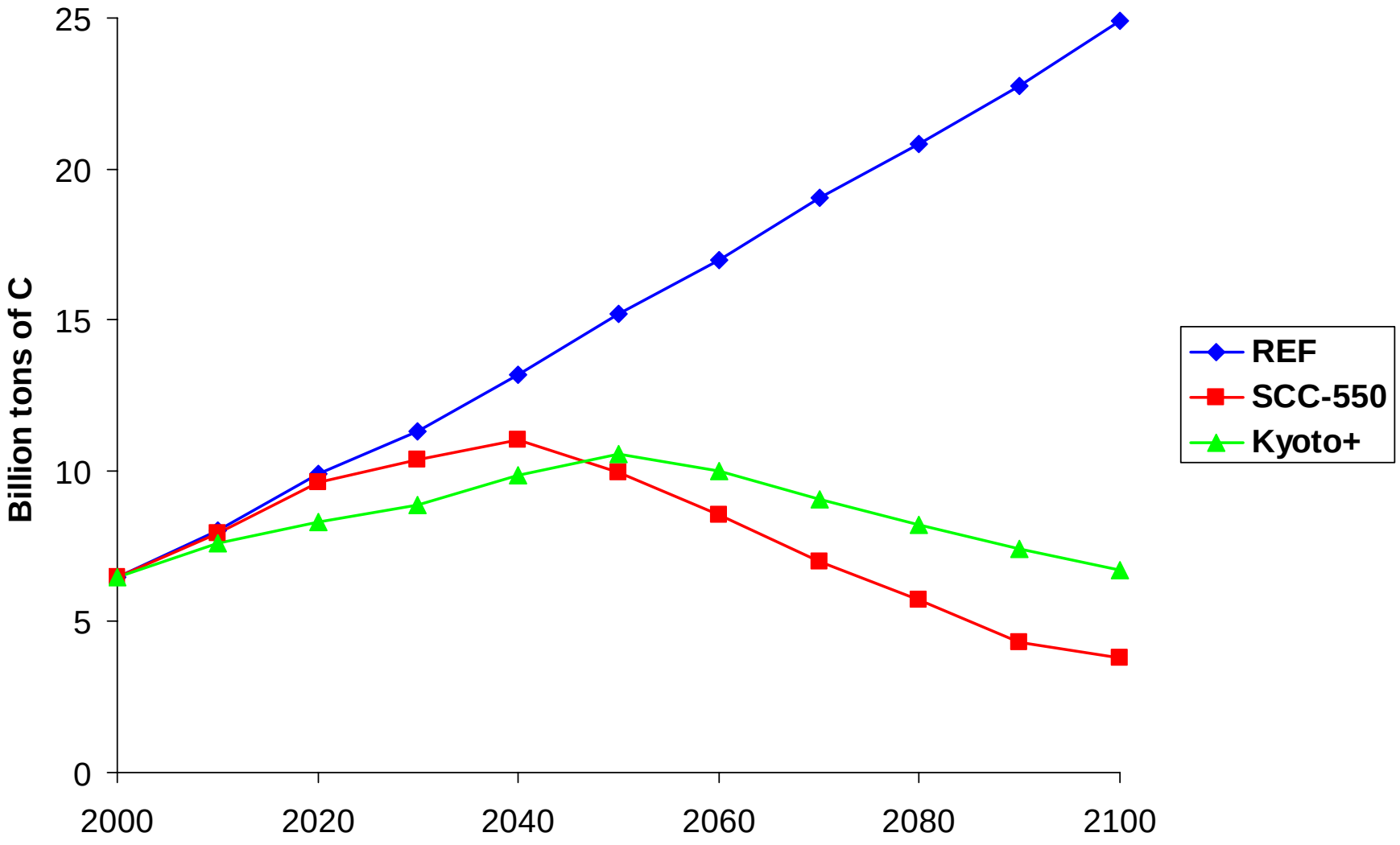

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Figure 6. Global Carbon Emissions – reference case and two control scenarios (LBDE-LC)

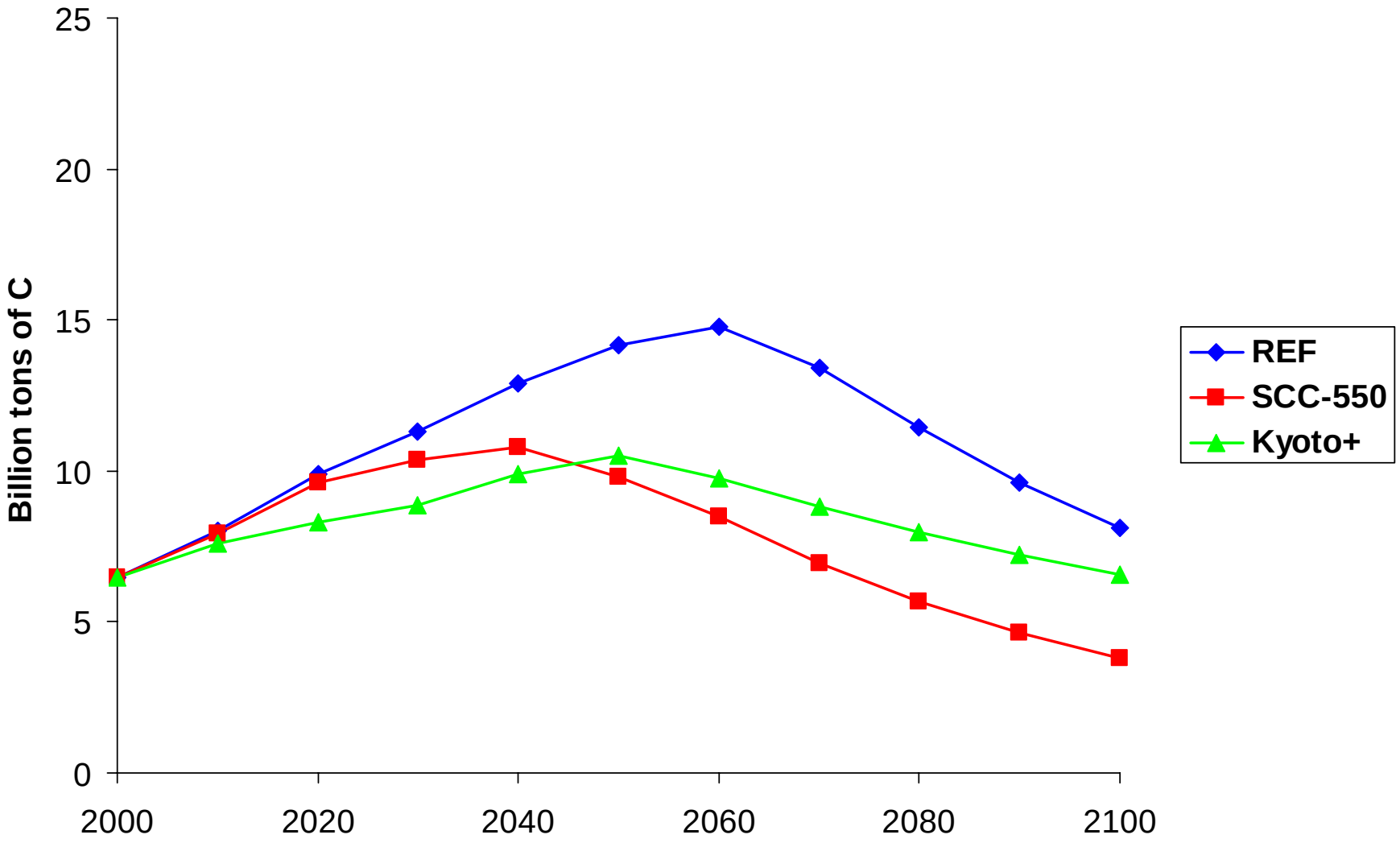

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Figure 7. Incremental Value of Carbon Emission Rights (SCC-550)

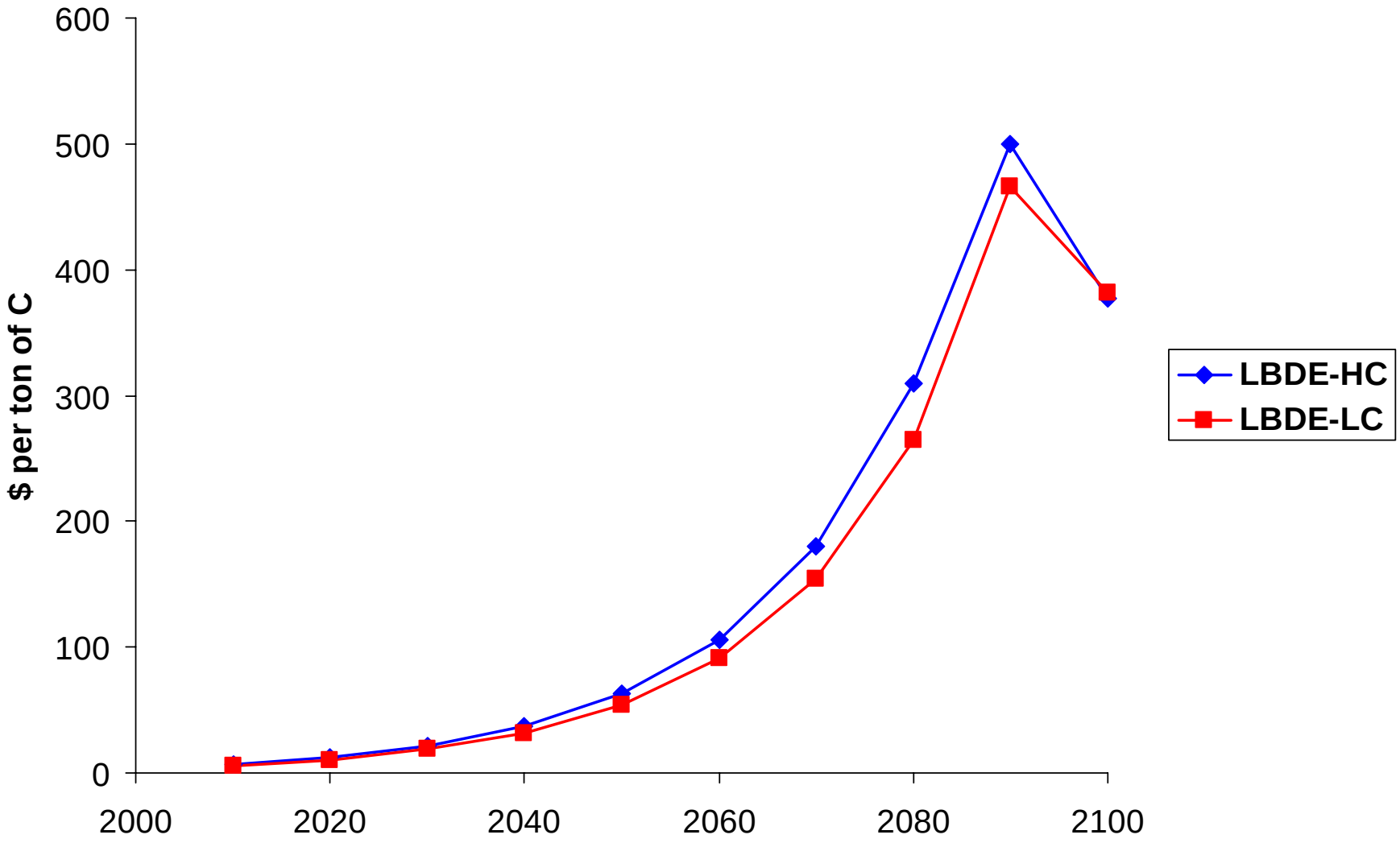

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Figure 8. Incremental Value of Carbon Emission Rights (Kyoto+)

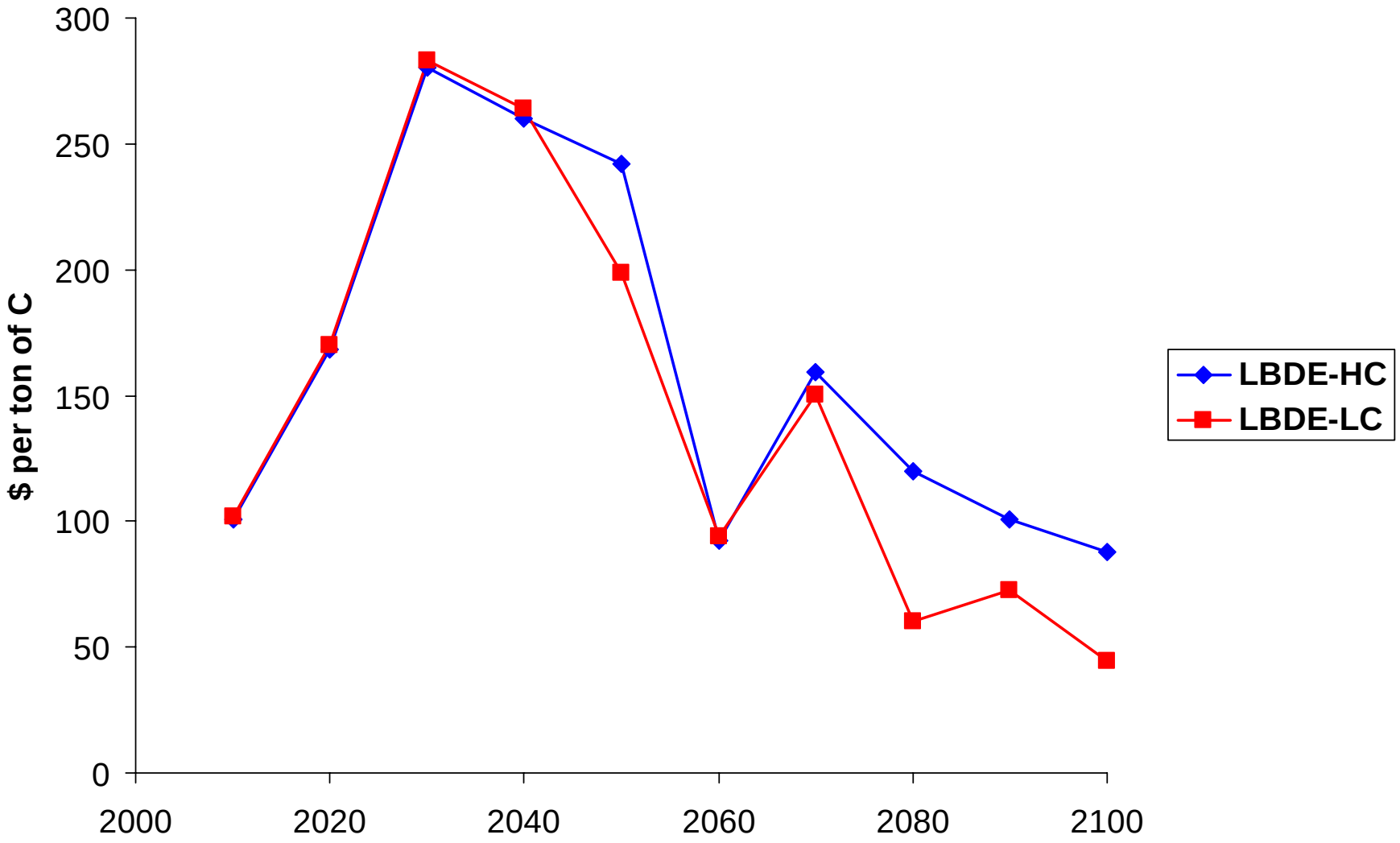

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Figure 9. Global Losses for Two Carbon Control Scenarios (discounted at 5% from 2000 through 2100)

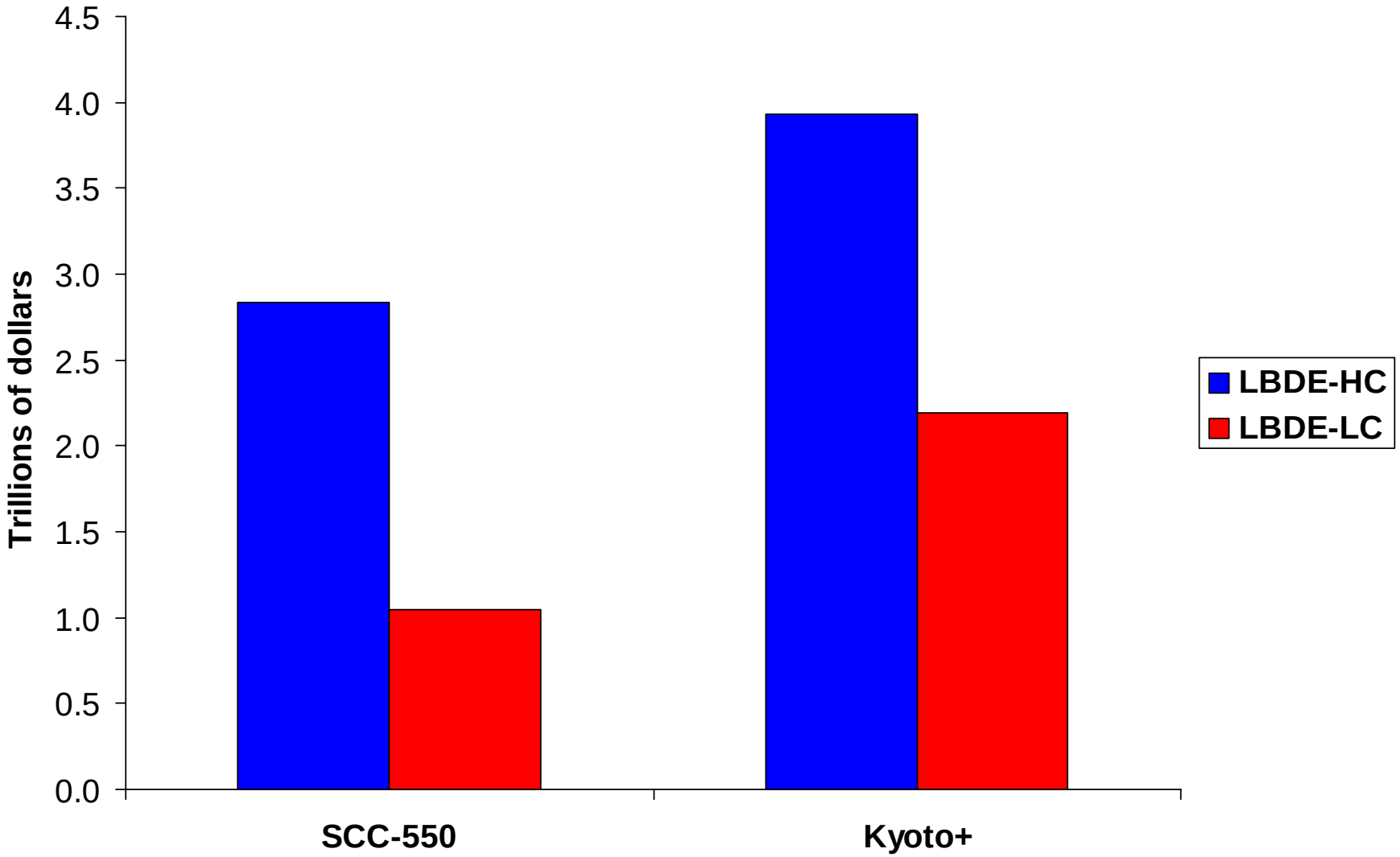

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Figure 10. US Losses for Two Carbon Control Scenarios (discounted at 5% from 2000 through 2100)

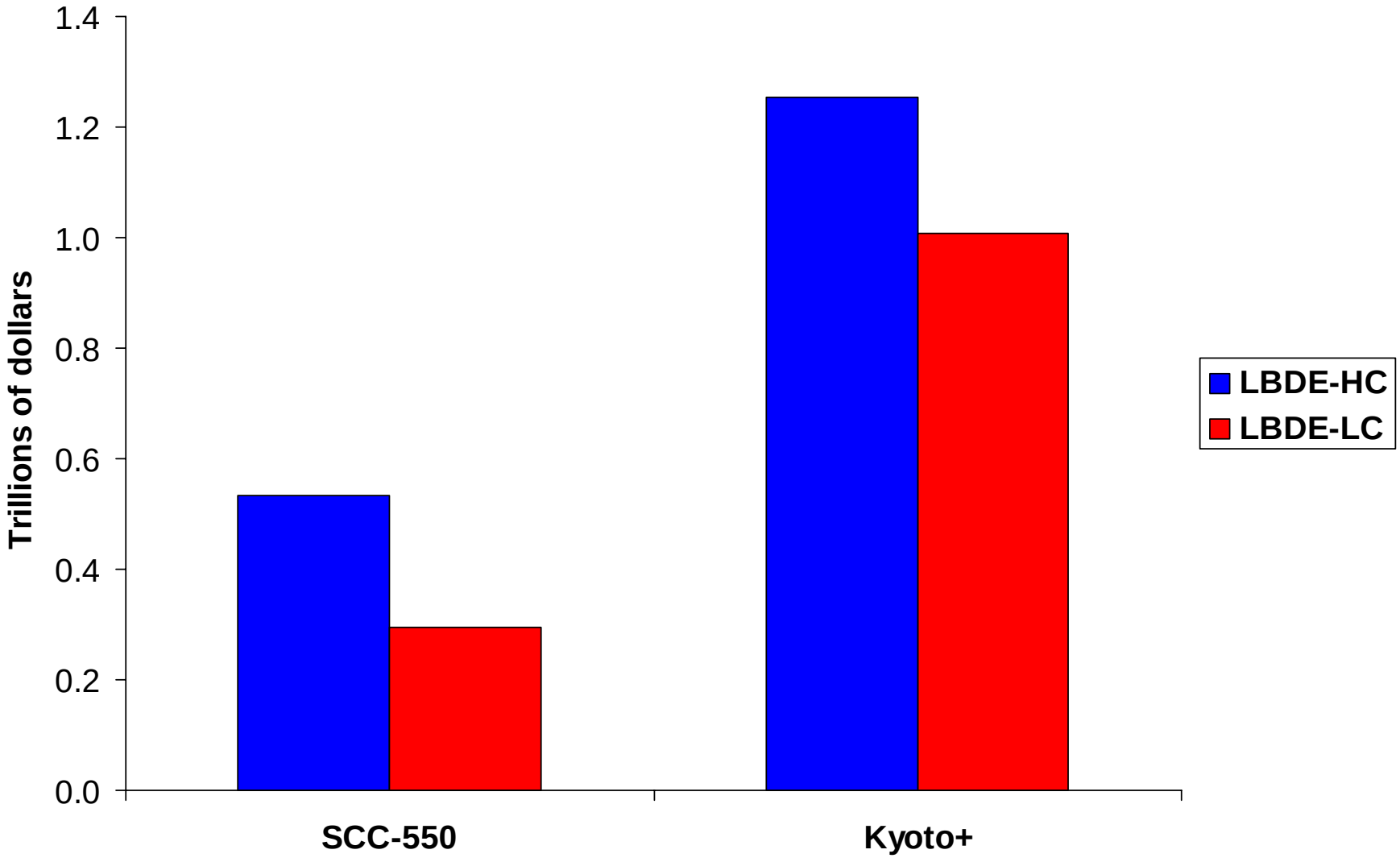

Figure 11. Global Carbon Emissions for Alternative Concentration Limits (LBDE-HC)

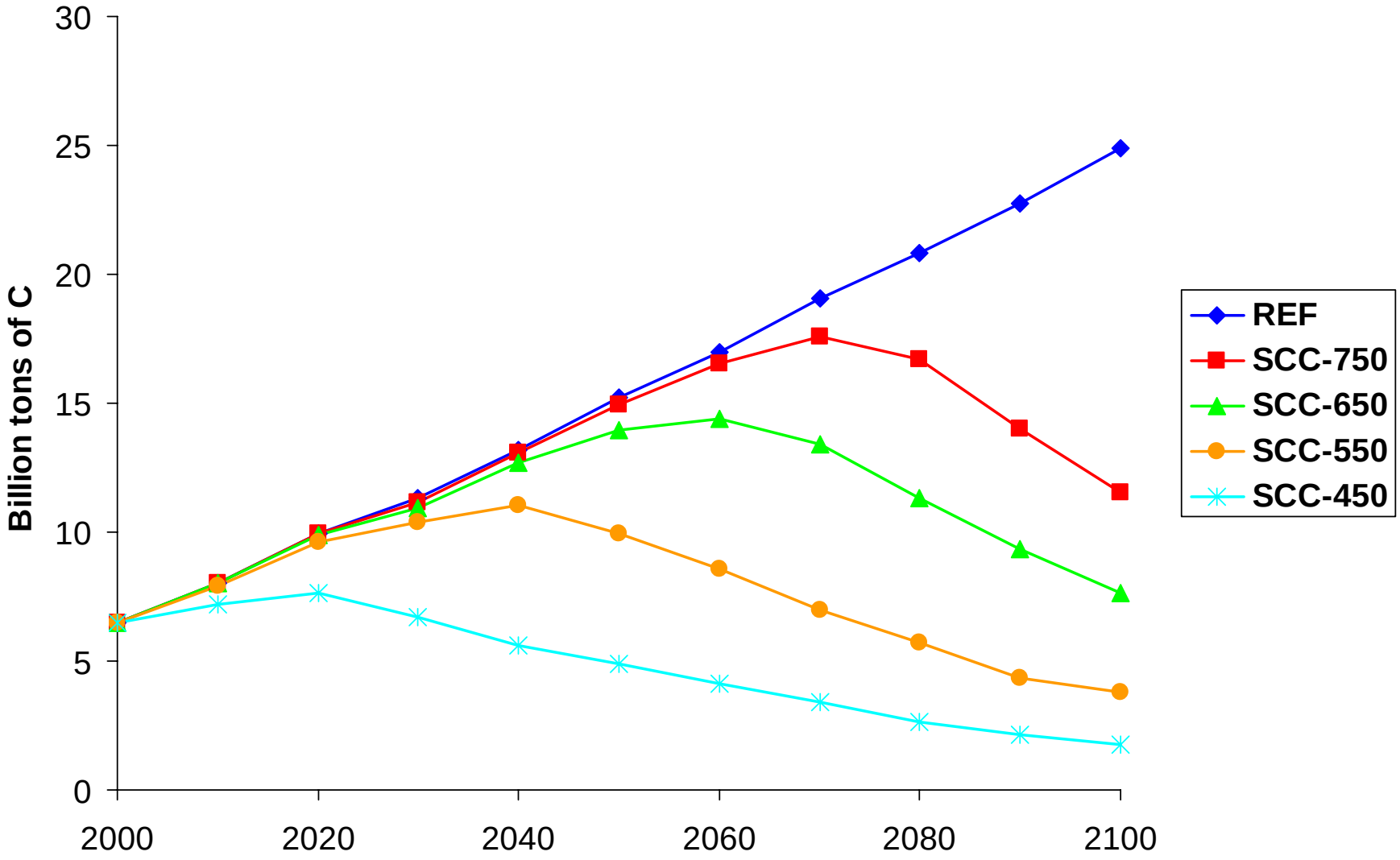

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Figure 12. Global Carbon Emissions for Alternative Stabilization Ceilings (LBDE-LC)

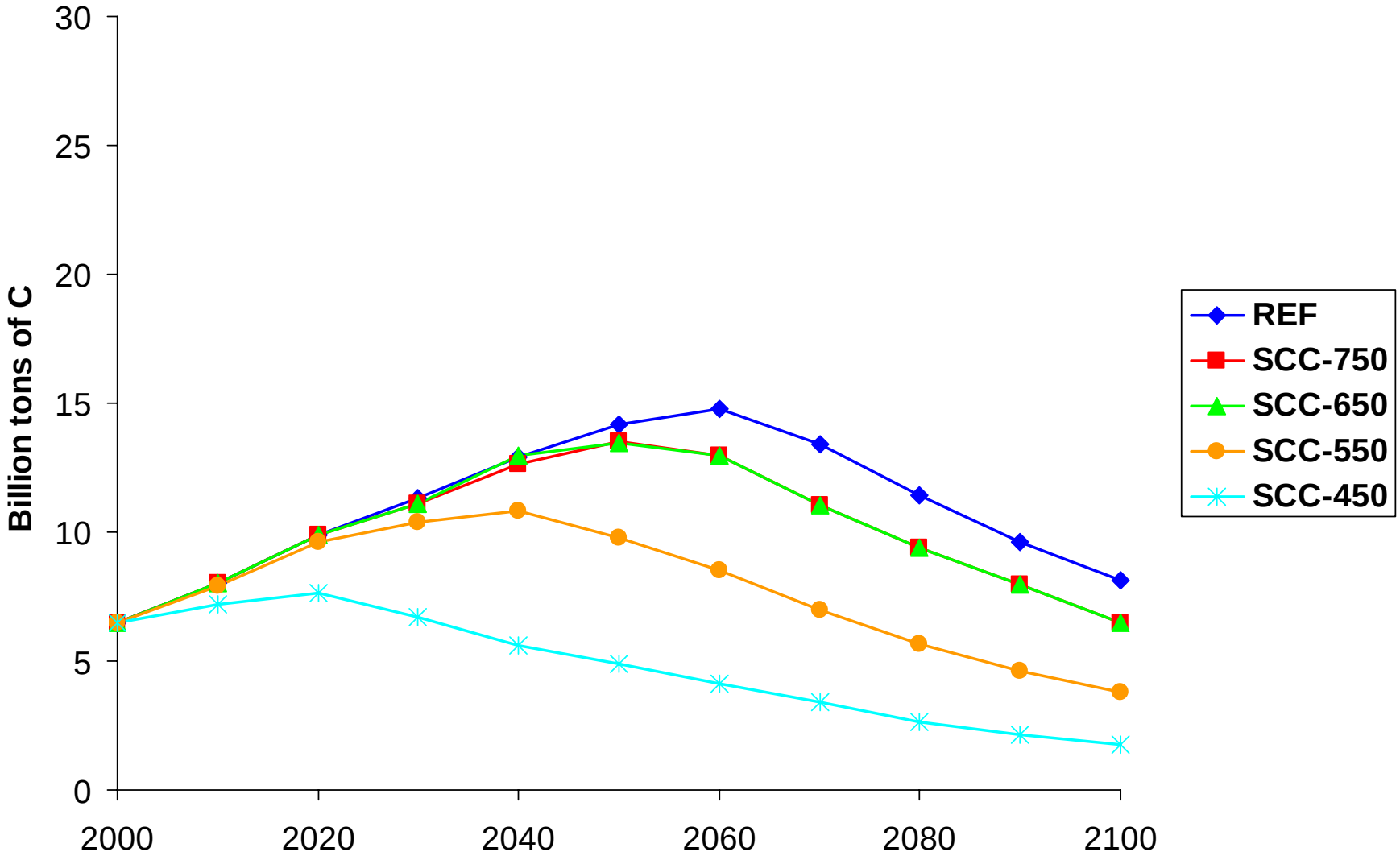

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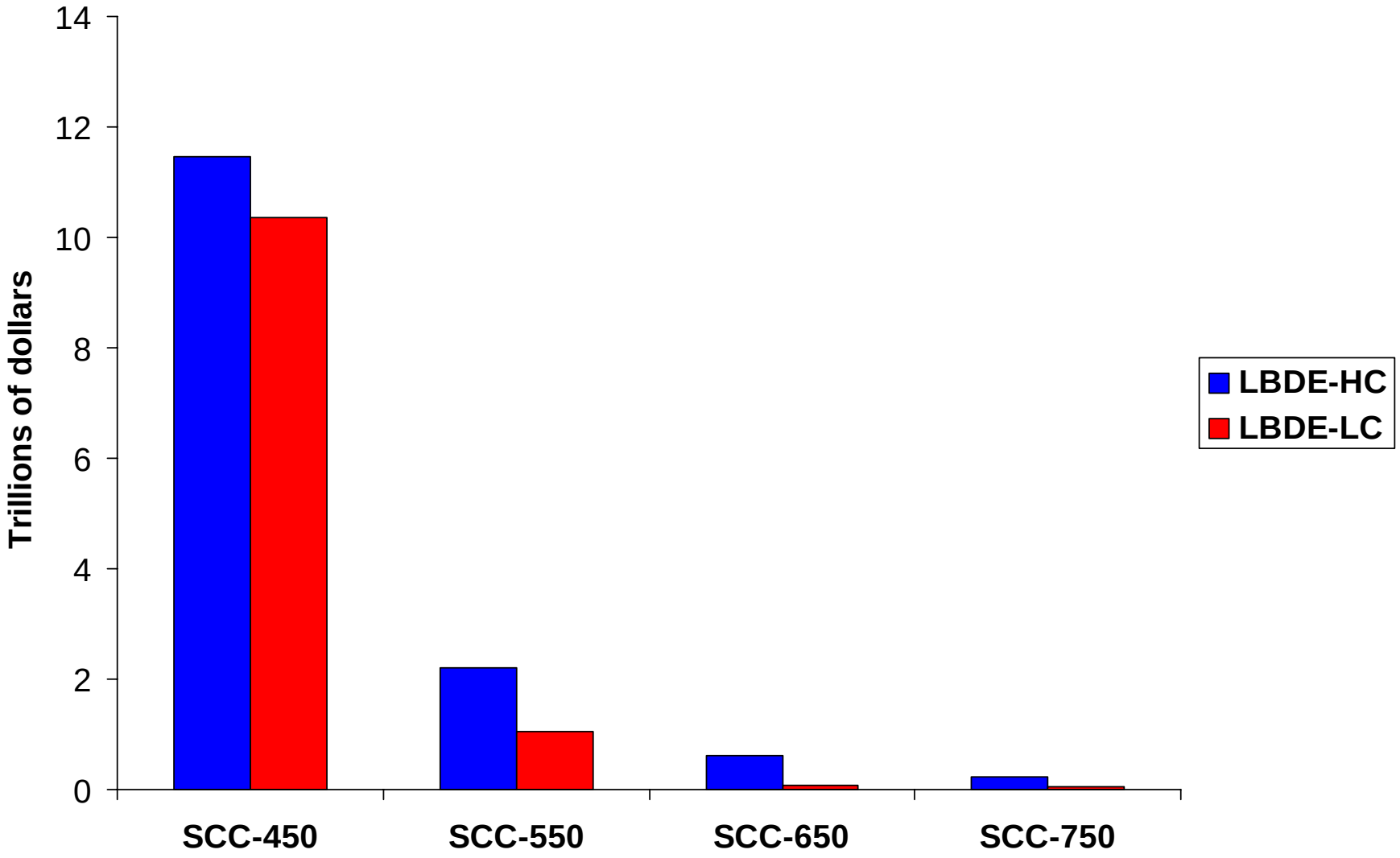
Figure 13. Cumulative Discounted Global Abatement Costs – discounted at 5% from 2000-2100



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Some Candidates for Sensitivity Analysis

- Expansion and decline constraints
- Rate of learning
- Ultimate costs achievable with learning
- Costs of other technologies
- Environmental goals

Figure 14. Percent of Global Electricity Generation Supplied by LBDE (with and without expansion constraints)

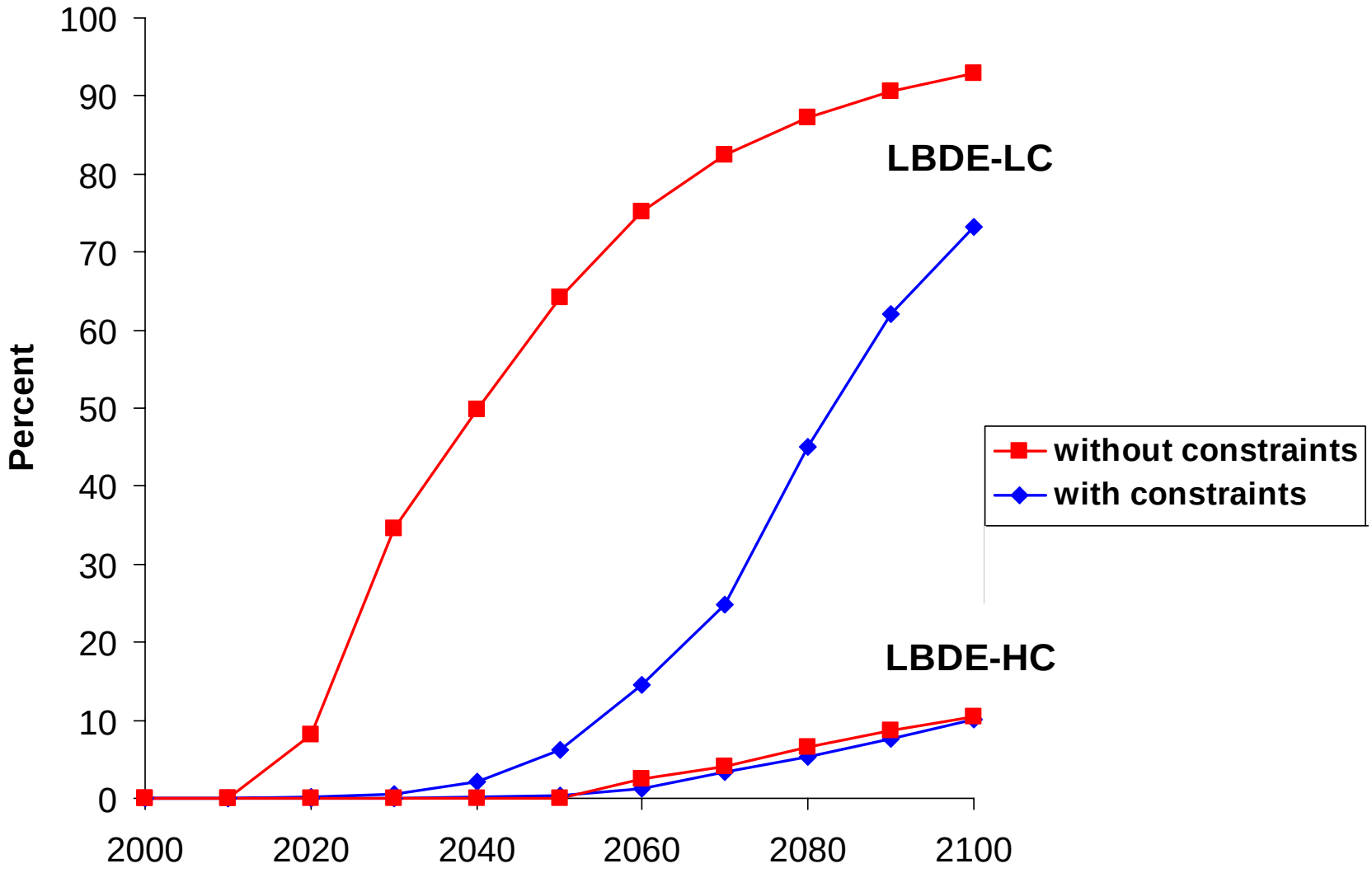

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Figure X. Global Carbon Emissions – LBDE-HC

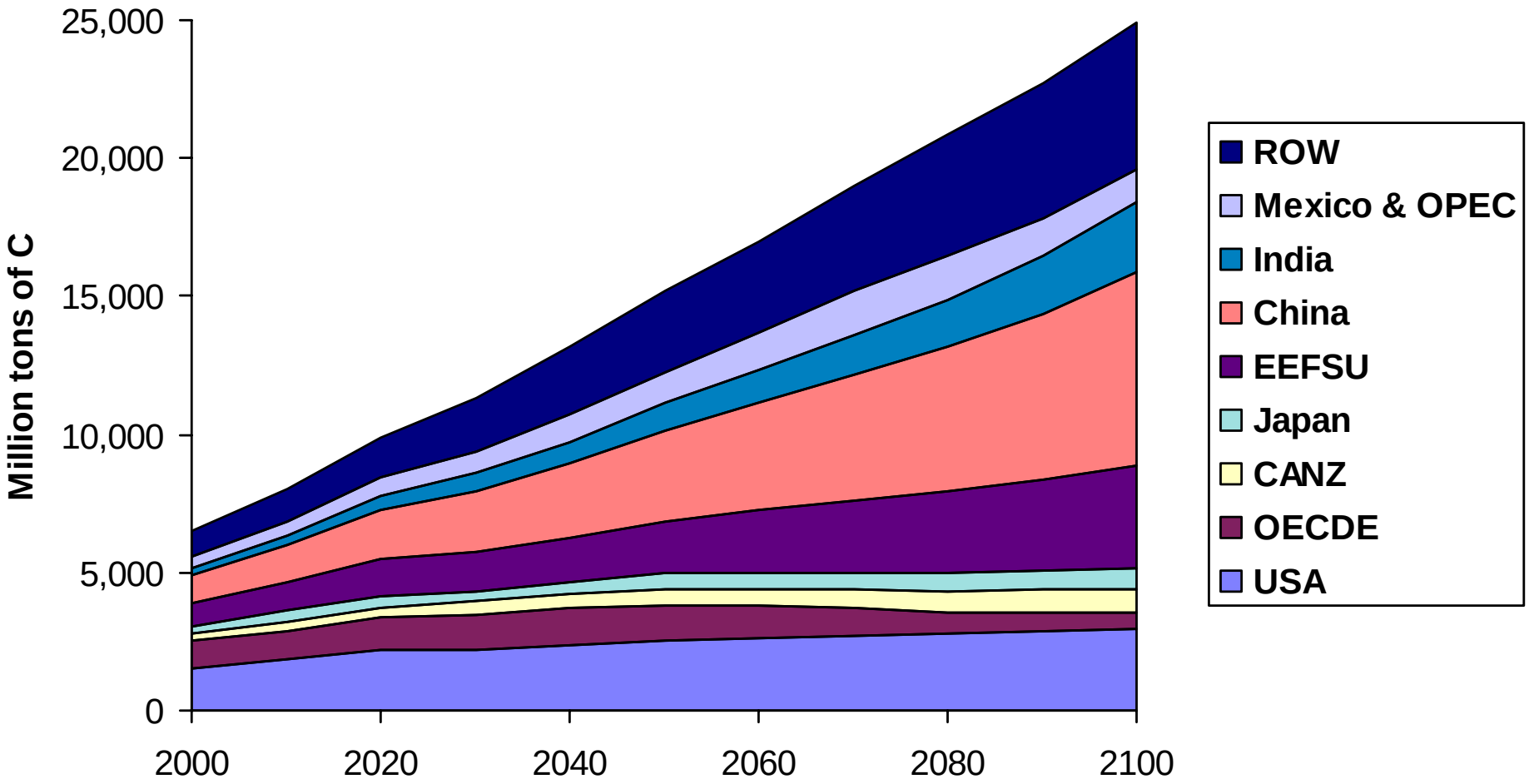

Figure Y. Global Carbon Emissions – LBDE-LC