

# **Stabilizing Long-Term Temperature: The Issues of Uncertainty, Timing, Costs and Technology**

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Workshop on Economic and Environmental Modeling

U.S. Environmental Protection Agency &

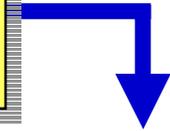
The Indian Ministry of Environment and Forests

New Delhi, India

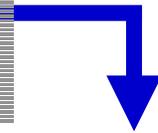
19-20 January 2004

# Causal Chain Between Human Activity and Damages

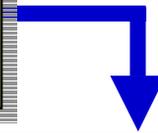
Demographic/  
Socio-economic/  
Tech. futures



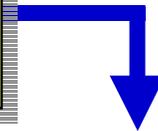
Emissions



Concentrations



Climate change



Impacts

# Issues

1. What is the range and likelihood of temperature change over the 21<sup>st</sup> century in the absence of climate policy?
2. What is the impact of technological expectations on the least-cost emission pathways for stabilizing global-mean temperature?
3. What is the impact of technological expectations on the near-term price of carbon?
4. What is the potential value of a technology rich energy future?
5. Why focus on stabilizing temperature rather than concentrations?

# MERGE

- An intertemporal CGE Model
- 9 geopolitical regions
- 150 year time horizon
- Multiple greenhouse gases
- Aerosol cooling
- Tradeoff among gases based on relative prices, not GWPs
- Bottom-up representation of energy sector
- Learning-by-doing (LBD)
- Top-down representation of rest of economy

# Electricity Generation Technologies

Identification/ Examples	Availability - Pessimistic Technology Scenario	Availability - Optimistic Technology Scenario
Hydroelectric, geothermal and other renewables	yes	yes
Existing nuclear and fossil	yes	yes
Advanced combined cycle	yes	yes
New coal without CO2 recovery	yes	yes
Fuel cells with capture and sequestration	no	yes
Integrated gasification and combined cycle with capture and sequestration	no	yes
Carbon-free technologies; costs do not decline with LBD	yes	yes
Carbon-free technologies; costs decline with LBD	no	yes

# Nonelectric Energy Supplies

Description	Availability - Pessimistic Technology Scenario	Availability - Optimistic Technology Scenario
Coal-direct uses	yes	yes
Oil	yes	yes
Gas	yes	yes
Coal-based synthetic fuels	yes	yes
Renewables	yes	yes
Carbon-free technologies; costs do not decline with LBD	yes	yes
Carbon-free technologies; costs decline with LBD	no	yes

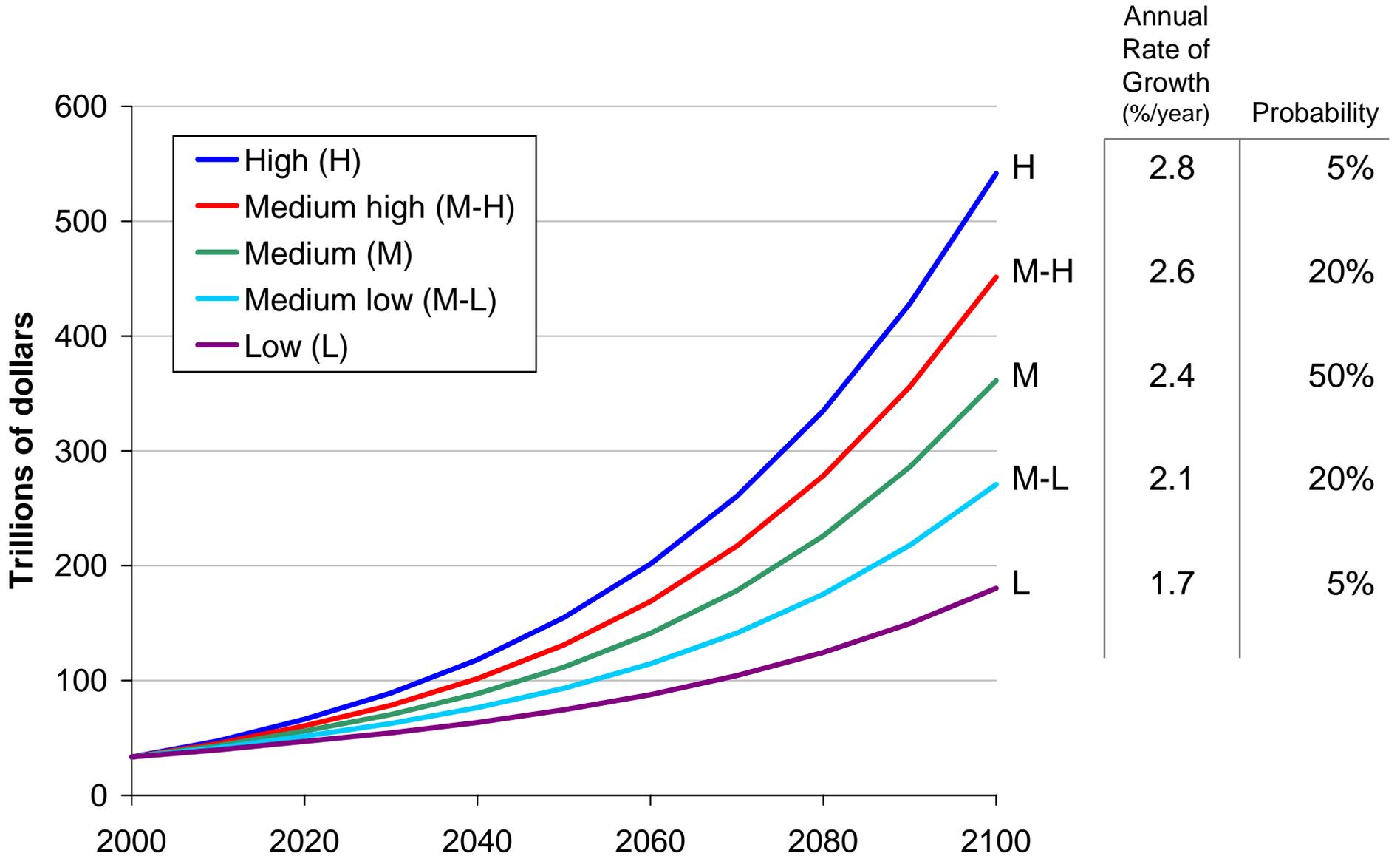
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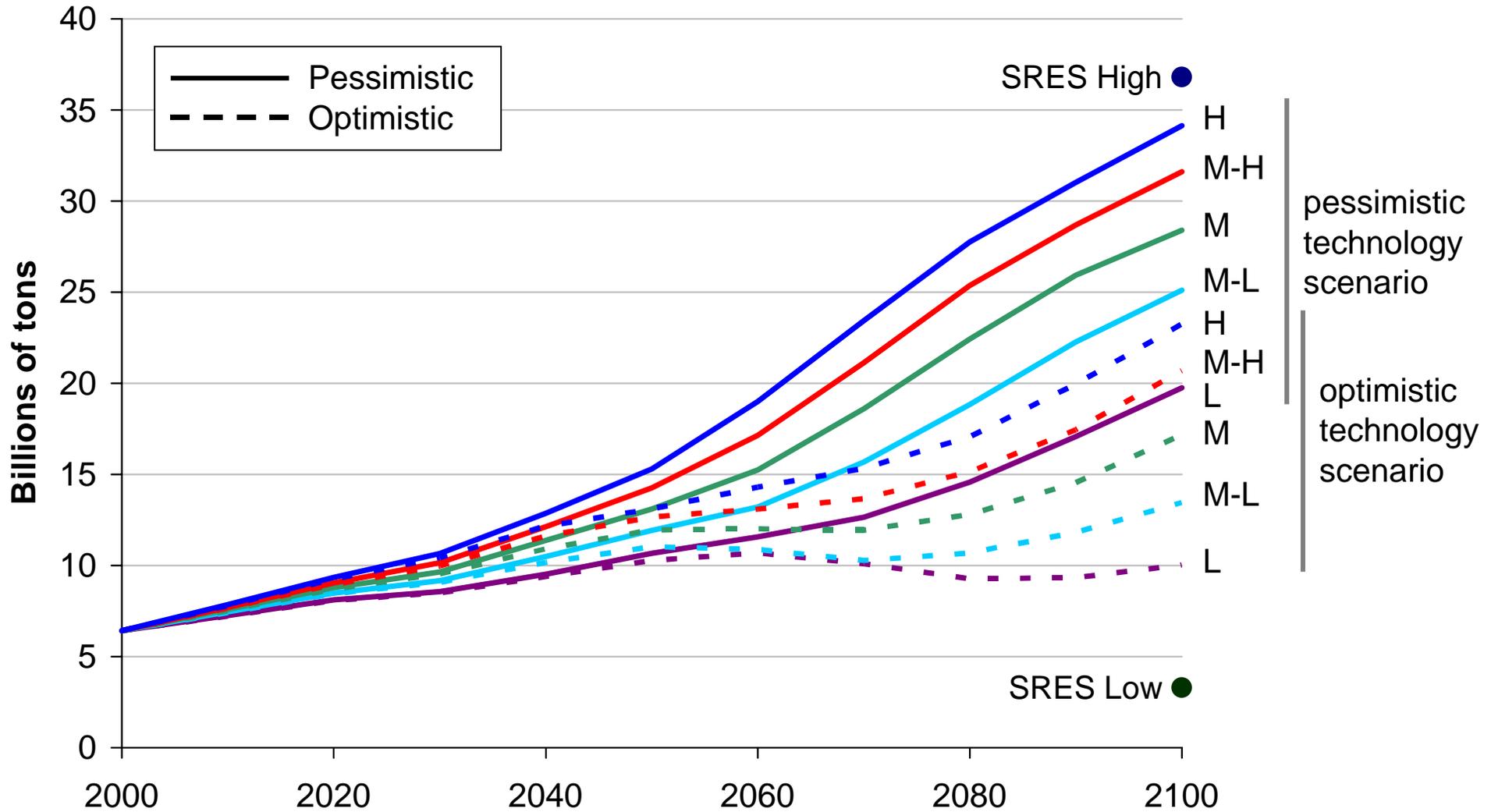
# Three Uncertainties

- Income growth
- Climate sensitivity
- Temperature lag

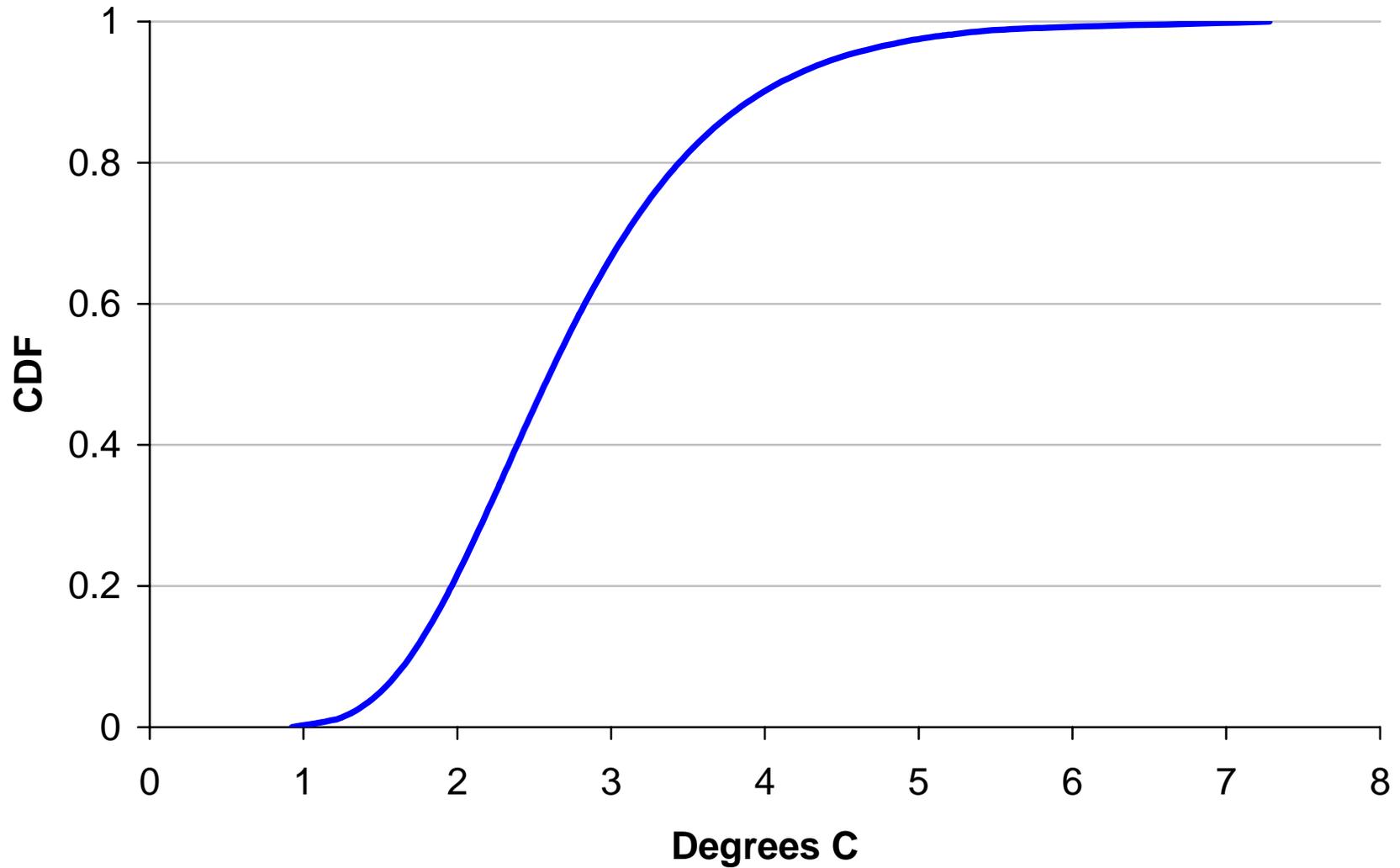
# Potential Gross World Product



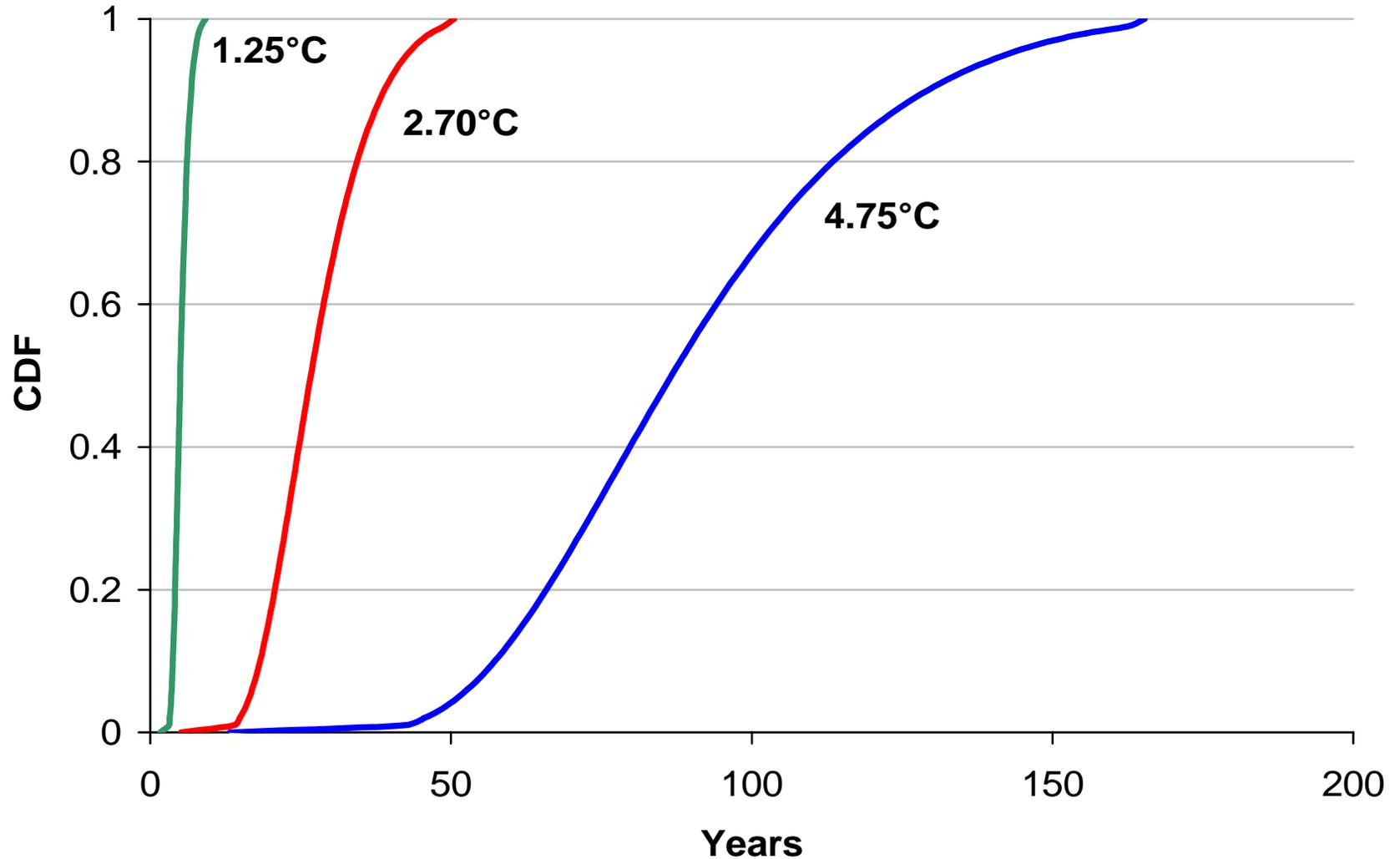
# Carbon Emissions Baseline



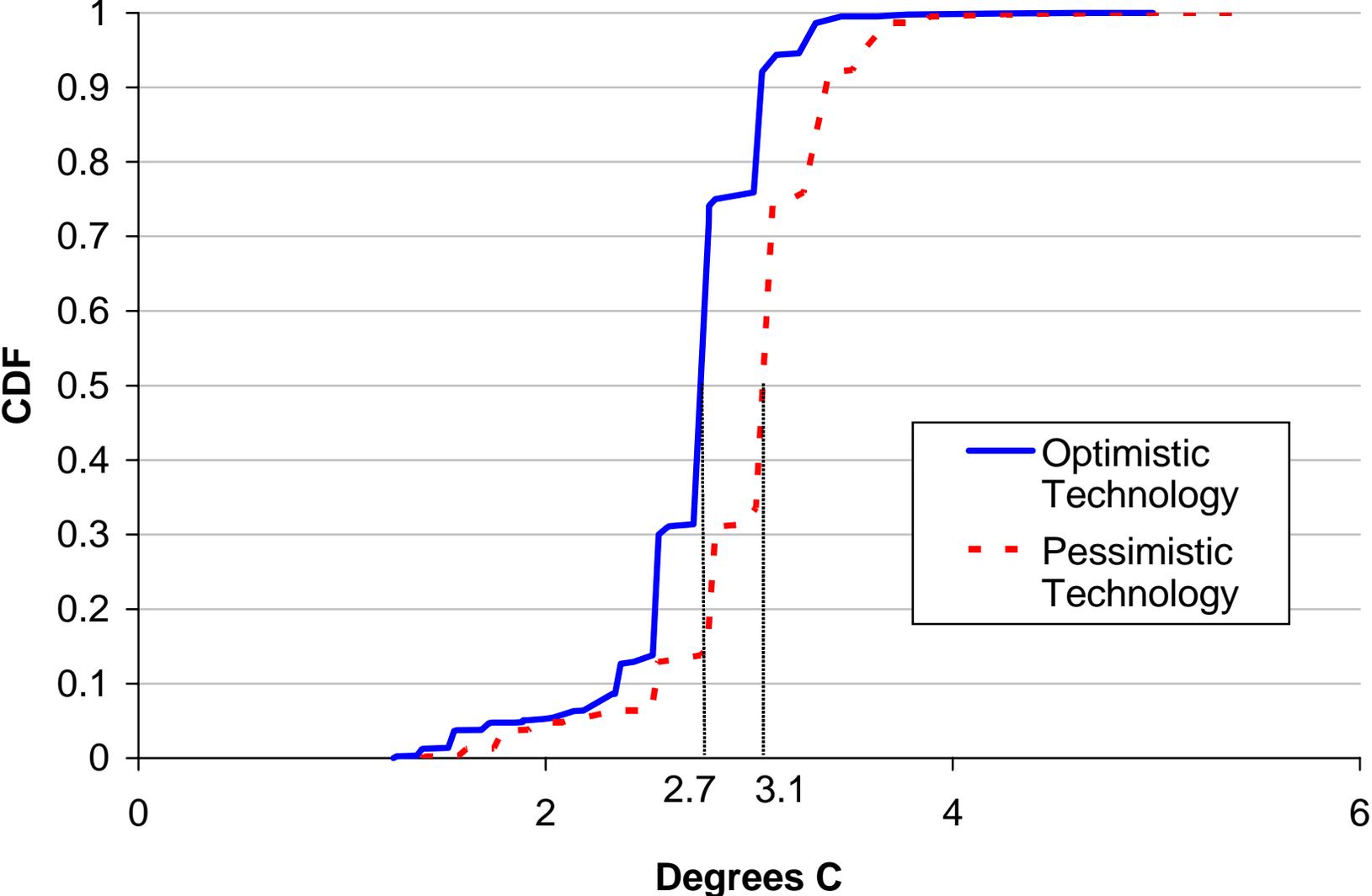
# Climate Sensitivity



# Response Time for Alternative Climate Sensitivities



# Temperature Increase During 21st Century In the Absence of Mitigation Policy



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# Percentage Reduction from the CO<sub>2</sub> Emissions Baseline (percent/year) for a 2°C Cap on Temperature Change

	Pessimistic Technology Scenario			Optimistic Technology Scenario		
	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
2010	0	5	20	0	3	19
2020	1	9	37	0	7	40
2030	1	19	53	0	19	60

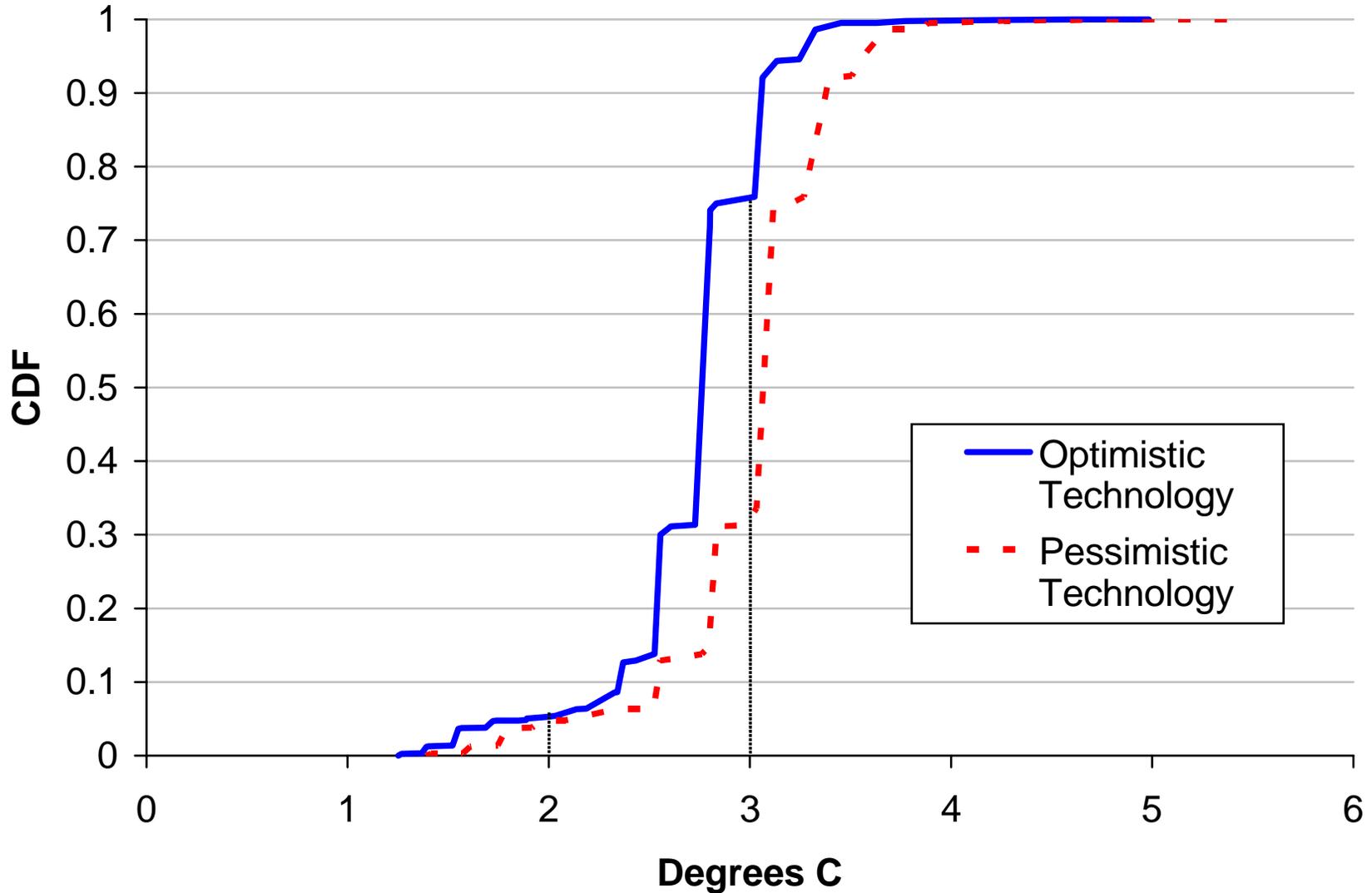
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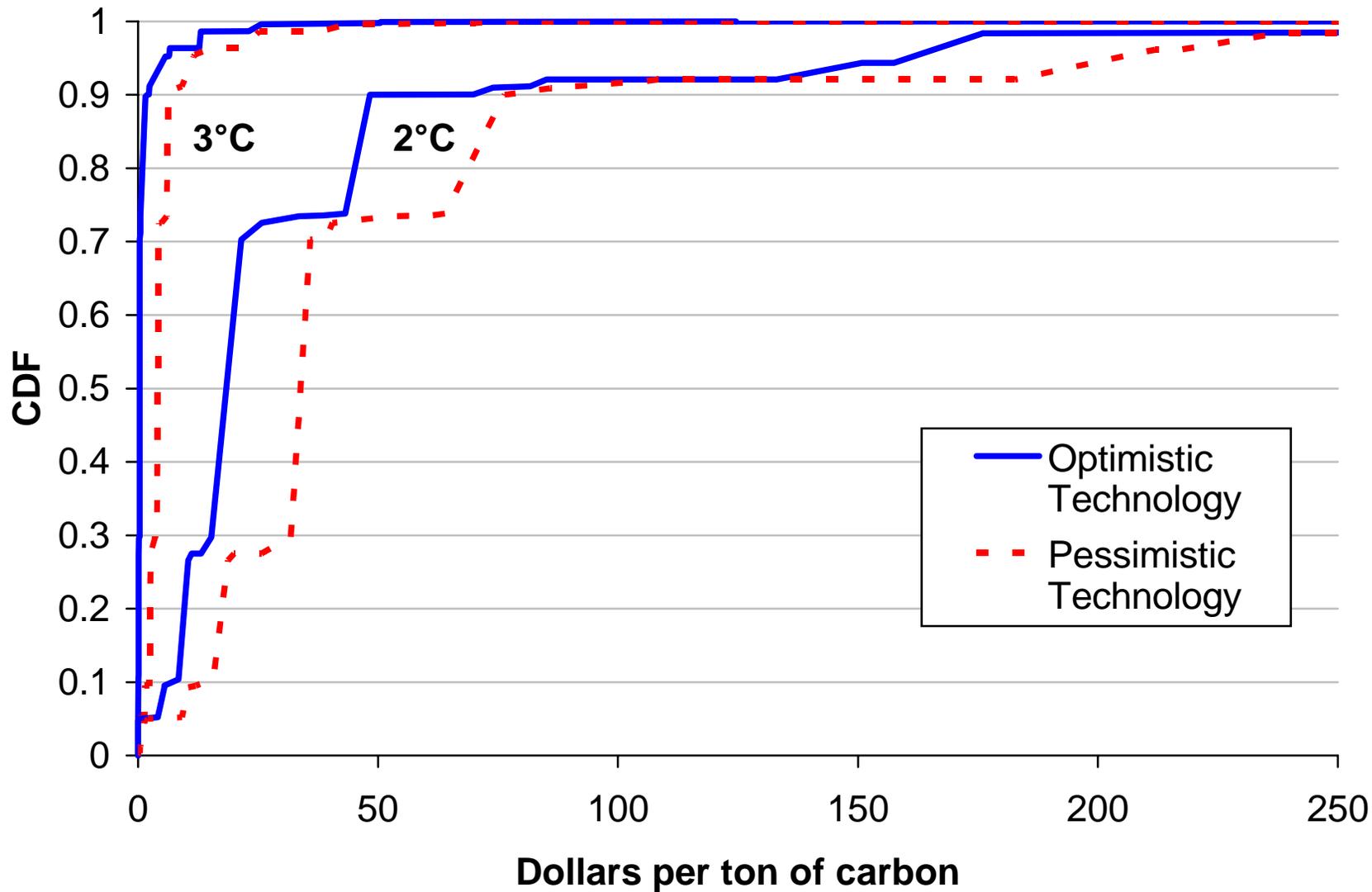
# Price of Carbon (\$/ton) with a 2°C Cap on Temperature Change

	Pessimistic Technology Scenario			Optimistic Technology Scenario		
	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
2010	2	36	212	0	22	176
2020	4	62	355	0	37	255
2030	6	106	637	0	64	409

# Temperature Increase During 21st Century In the Absence of Mitigation Policy



# Carbon Price in 2010 with 2° and 3°C Temperature Caps



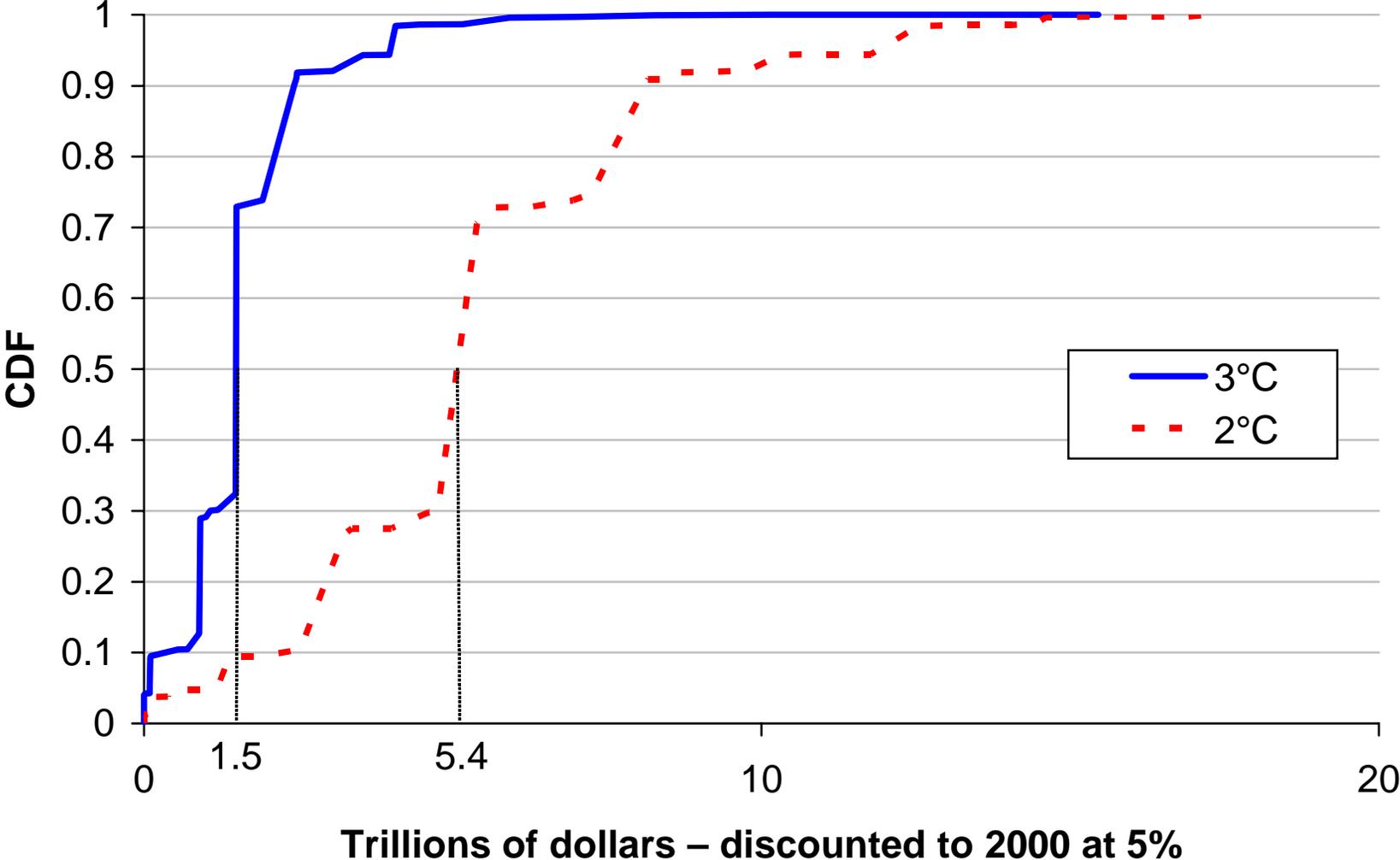
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# Difference in Consumption Losses (in \$ trillions) for Two Technology Scenarios Under a 2°C Temperature Cap – discounted to 2000 at 5%

	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
Consumption losses under pessimistic scenario	1.0	8.0	30.0
Consumption losses under optimistic scenario	0.0	3.5	17.7
Difference in consumption losses	1.0	5.4	12.3

# Gross Benefits Under Alternative Temperature Constraints



# Issues

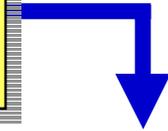
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# Stabilization of Atmospheric CO2 Concentrations (PPMV) for Alternative Temperature Caps

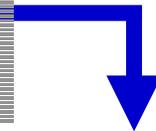
		5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
2°C	Pessimistic	417	472	743
	Optimistic	414	445	503
3°C	Pessimistic	535	574	669
	Optimistic	523	580	592

# Causal Chain Between Human Activity and Damages

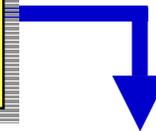
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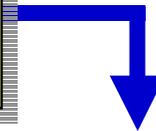
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