Modeling Energy Demand and Deforestation Measures for a Sustainable Future

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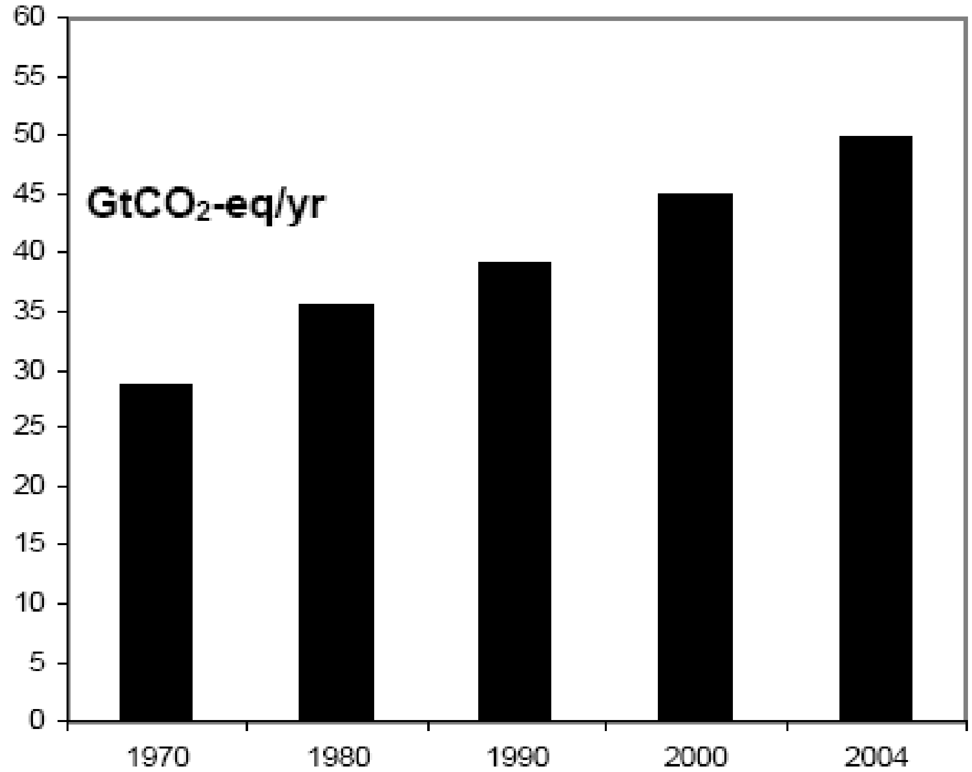
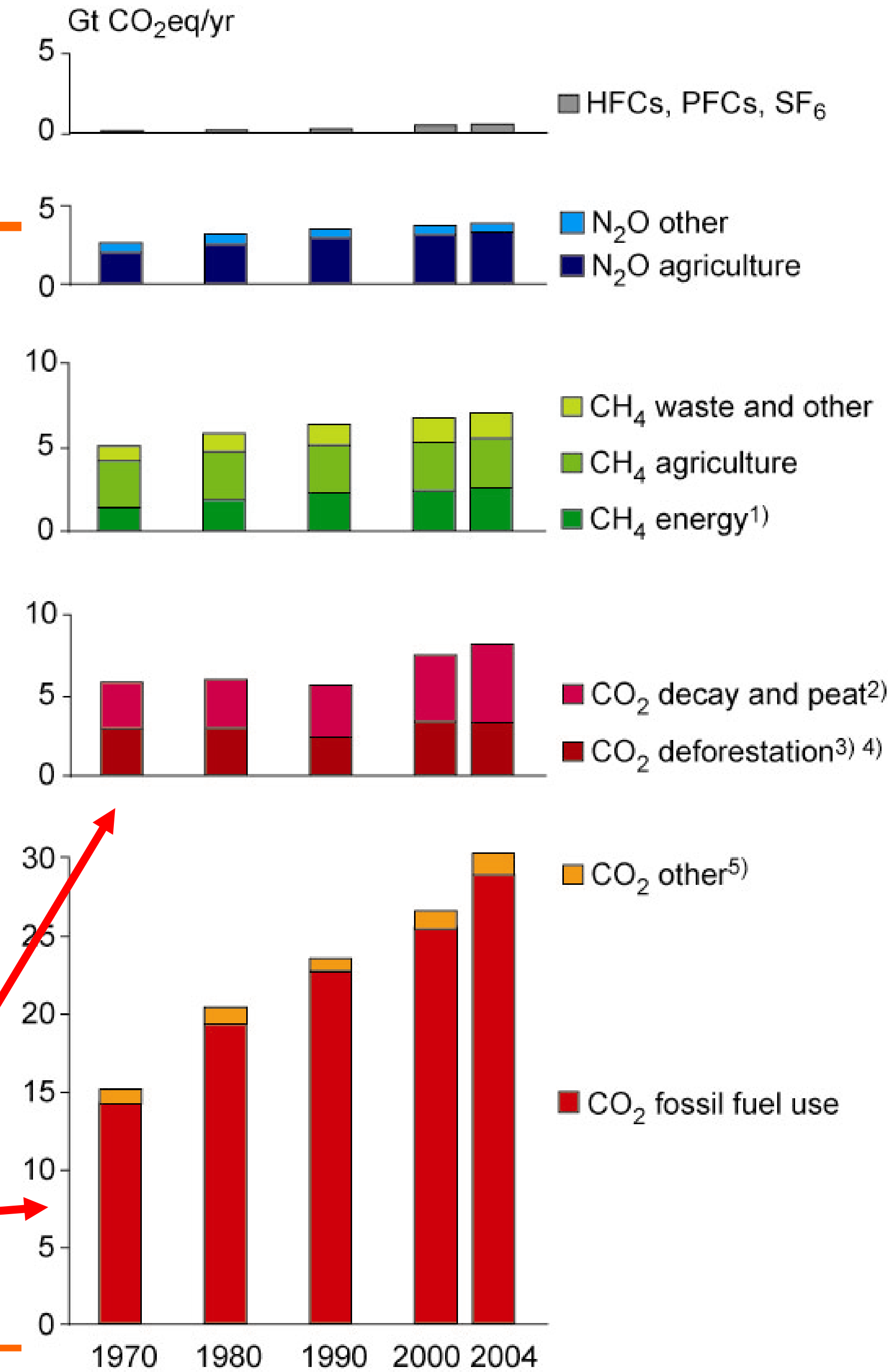
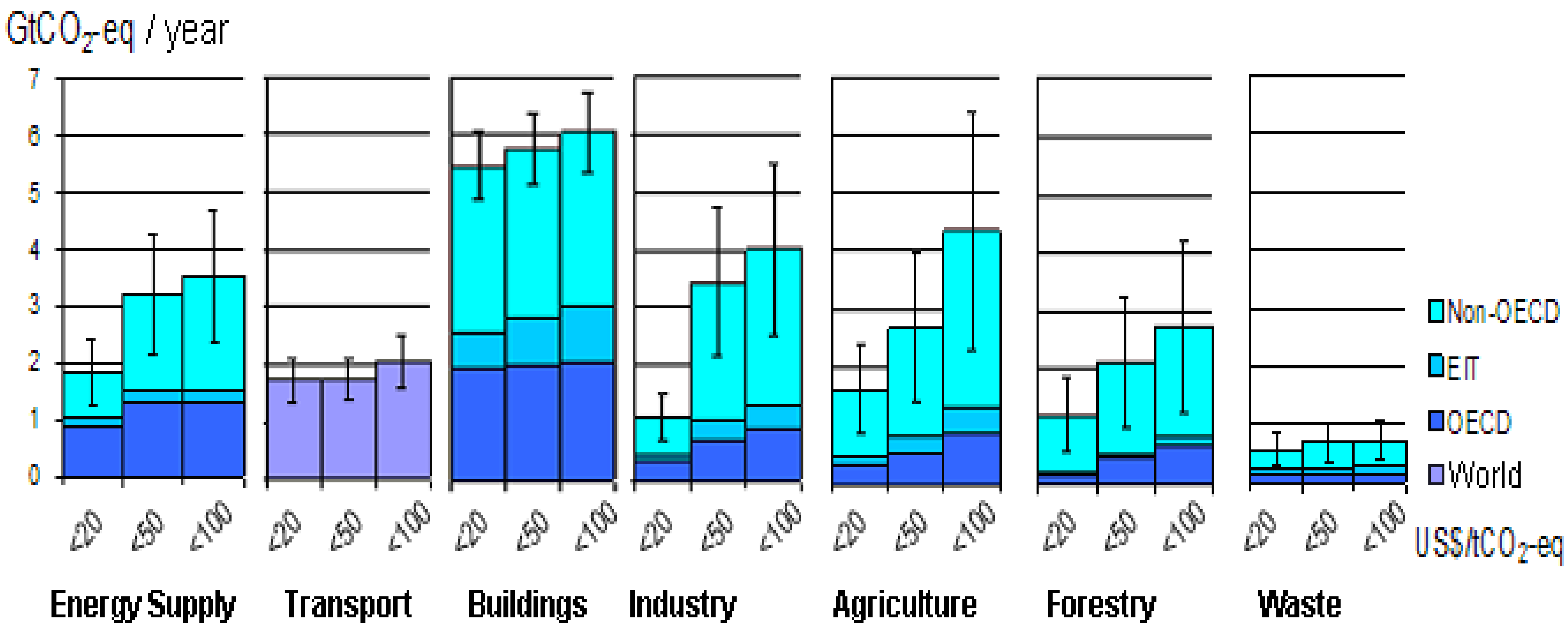
Total Global Greenhouse Gas Emissions Increased by 70 % (1970 – 2004)





Carbon Dioxide Is the Largest Contributor

IPCC AR4, 2007: WG III Summary for Policy Makers
Singificant Potential for Demand-side Efficiency Improvement: Largest Potential is in the Buildings Sector



Note:

- Sectoral estimates are based on bottom-up studies
- Estimates do not explicitly include non-technical options, such as lifestyle changes.

Selected Models that Represent Energy Demand Technologies

- **AIM** *(Asia Pacific Integrated Model)* **-- Bottom-up/Hybrid**
- **AMIGA** *(All-Modular Industry Growth Assessment Modeling System)* **-- Hybrid**
- **BEAR** *(Berkeley Energy and Resources -- California)* **-- Top-Down/Hybrid**
- **CIMS** *(Canada)* **– Hybrid Model**
- **COBRA -- LBNL** *(Global)* **-- Bottom-up**
- **DNE21+** *(Global) –* ***Top-down/Hybrid***
- **MARKAL** *(MARKet Allocation)* **-- Bottom-up Hybrid**
- **MiniCAM** ***(****US)* **-- Bottom-up model/structure (OBJECT) integrated into a Top-Down (MiniCAM) Integrated Assessment Model**
- **NEMS** *(US)* **– Bottom-up Hybrid**

- **Review based on secondary information and interviews with some modelers in April 2007**

Representation of end-use technologies: Some key issues

- **An advantage of bottom-up and hybrid models is that they permit evaluation of non-price policies and programs**
  - **Standards and labels for appliances for example**
- **Policy and programmatic costs, however, are not explicitly considered in most models**
  - **Quantification of market failures**
  - **Transaction costs**
    - LBNL study shows that these are less than \$4 / t CO_2 for CDM type projects
- **Further most such models do not evaluate**
  - **Non-energy benefits**
  - **Analyze life cycle (LCA) costs and benefits**

Quantification of Market Failures:
IEA Report -- Mind the Gap
(US, Japan, Netherlands, Norway, Australia+)

- **% of US households and energy use affected by split incentives and asymmetric information that are characteristics of a Principal Agent Problem**
- ***Two transactions (Jaffe and Stavins, 1994):***
  - ***Tenant and landlord***
    - *Landlords may not be able to recover all of the value of efficiency investments in the form of higher rents, where renters pay fuel bills, and tenants who make these investments in cases where the landlord pays the energy bill may not be able to get reduced rents*
  - ***Builder and buyer***
    - *Home builders may have difficulty conveying the benefits of energy efficiency technologies to prospective buyers because these technologies and their future energy use consequences are not observable*
- **Consequence is that some markets or portions thereof may be isolated from energy price signals**

Classification of End Users for US Residential Sector

End-User	Can Choose Technology	Cannot Choose Technology
Direct Energy Payment	Case N: No Problem	Case E: Efficiency Problem
Indirect Energy Payment **(Utilities incl. in rent or a flat fee)**	Case U&E: Usage and Efficiency Problem	Case U: Usage Problem

Primary Data Sources: Residential Energy Consumption Survey, American Housing Survey, National Association of Home Builders, Energy Star, etc.

Quantification of PA Market Failures

- **Results:** ***% of US households and energy use affected by the Principal Agent Problem***

  Refrigerators – 33% and 25%

  Space heating – 52% and 48%

  Water heating – 69% and 66%

  Lighting – 5% and 2.3%

- **The affected four end-uses account for about 25% of US primary residential energy use**
- **Energy savings may be a lower percentage if regulatory policies (standards for instance) already require higher efficiency levels**

Representation of PA Market Failure in a Model

- ***Suggested approach:--***
  - ***Quantify impact of principal agent and lack of information problems***
  - ***Isolate the segment of energy use by each end-use that is affected by the above problems***
    - ♦ *Particularly important for sector-focused policies in transition scenarios*
  - ***Change model parameters for this segment***
    - ♦ *Elasticity values, discount rates, policy and program costs, other transaction costs*
- ***Currently exploring approach for US NEMS and MARKAL models***

Cost of Conserved Energy: Accounting for Changes in Capital, Labor and Material Costs

$$CCE = \frac{I \cdot q + M}{S}$$

$$q = \frac{d}{(1-(1+d)^{-n})}$$

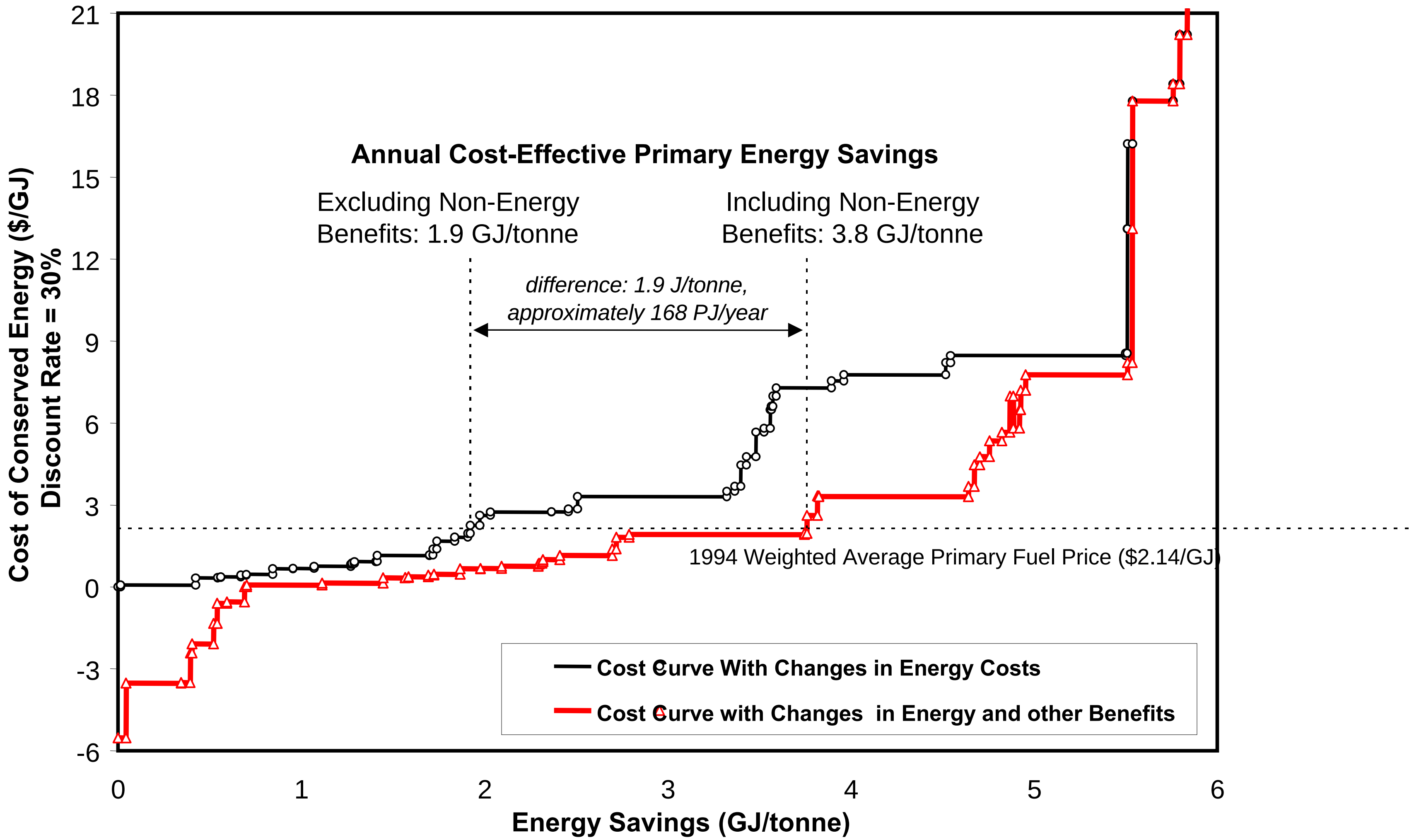
where:

CCE = Cost of Conserved Energy for the energy efficiency measure, in $/GJ
I = Capital cost ($)
q = Capital recovery factor
M = Annual change in labor and material costs ($)
S = Annual energy savings (GJ)
d = discount rate
n = lifetime of the conservation measure (years)

US Steel Industry Cost of Conserved Energy: Other Benefits

Waste	Emissions	Operation & Maintenance
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction		Reductions in labor requirements
Production	**Working Environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased Reliability in Production	Improved air quality	Improved worker morale

US Steel Industry Supply Curves: Accounting for Changes in Four Categories of Benefits (previous slide)



Effect of Accounting for Changes in Other Benefits on Cost-Effectiveness and Ranking of Measures

	With Energy (E) Benefit Only			*With Other* Benefits		
Measure	**CCE ($/GJ)**	**Rank (of 47)**	**Cost-Effective?**	**CCE ($/GJ)**	**Rank (of 47)**	**Cost-Effective?**
Inj. of NG – 140	3.1	19	NO	-0.5	8	YES
Coal inj. – 225	3.9	22	NO	1	23	YES
Coal inj. – 130	4.4	23	NO	0.1	11	YES
DC-Arc furnace	5	26	NO	-1.3	6	YES
Process control	5.6	27	NO	-2.1	5	YES
Scrap preheating	6.7	31	NO	-0.6	7	YES
Thin slab casting	8.5	35	NO	1.9	27	YES
Hot charging	8.9	36	NO	5.3	35	NO
FUCHS furnace	12.7	37	NO	-3.5	3	YES
Adopt cont. cast	14.3	39	NO	-3.5	2	YES
Twin shell	16.6	40	NO	3.3	30	NO
Oxy-fuel burners	17.4	41	NO	-5.5	1	YES
Bottom stirring	20.5	45	NO	-2.4	4	YES
Foamy slag	30.1	46	NO	7.2	40	NO

NOTE: These cost of conserved energy (CCE) and cost-effectiveness calculations are based on a discount rate of 30% and an average primary energy price of $2.14/GJ.

Life-Cycle Analysis: Energy Use and GHG Emissions for 50 Products Manufactured in California

Life-Cycle Energy Consumption and GHG Emissions of Two Generic PC Systems

Life-Cycle Stage	Primary Energy (MJ/PC)		GHG (kg CO_2/PC)	
	CPU+CRT	CPU+LCD	CPU+CRT	CPU+LCD
Raw Materials Acquisition	1964	2231	139	289
Manufacturing	22595	5735	533	570
Use	7544	5125	330	224
End-of-Life	-633	-277	-39	-18
Total	**31470**	**12814**	**963**	**1065**

High manufacturing energy consumption of PC with CRT monitor due primarily to CRT glass manufacturing.

Manufacturing GHG emissions of PC with LCD exceed those of PC with CRT monitor due primarily to SF_6 emissions during LCD module manufacture.

Life-Cycle Energy Consumption and GHG Emissions Occurring within California

Life-Cycle Stage	Primary Energy (MJ/PC)		GHG (kg CO_2/PC)	
	CPU+CRT	CPU+LCD	CPU+CRT	CPU+LCD
Raw Materials Acquisition	18	18	1	1
Manufacturing	257	257	17	17
Use	7544	5125	330	224
End-of-Life	22	10	1	0.6
Total	**7841**	**5410**	**349**	**243**

Energy consumption and GHG emissions for PC manufacture in California are low due to offshore production of CRT monitors, LCDs, and many CPU components.

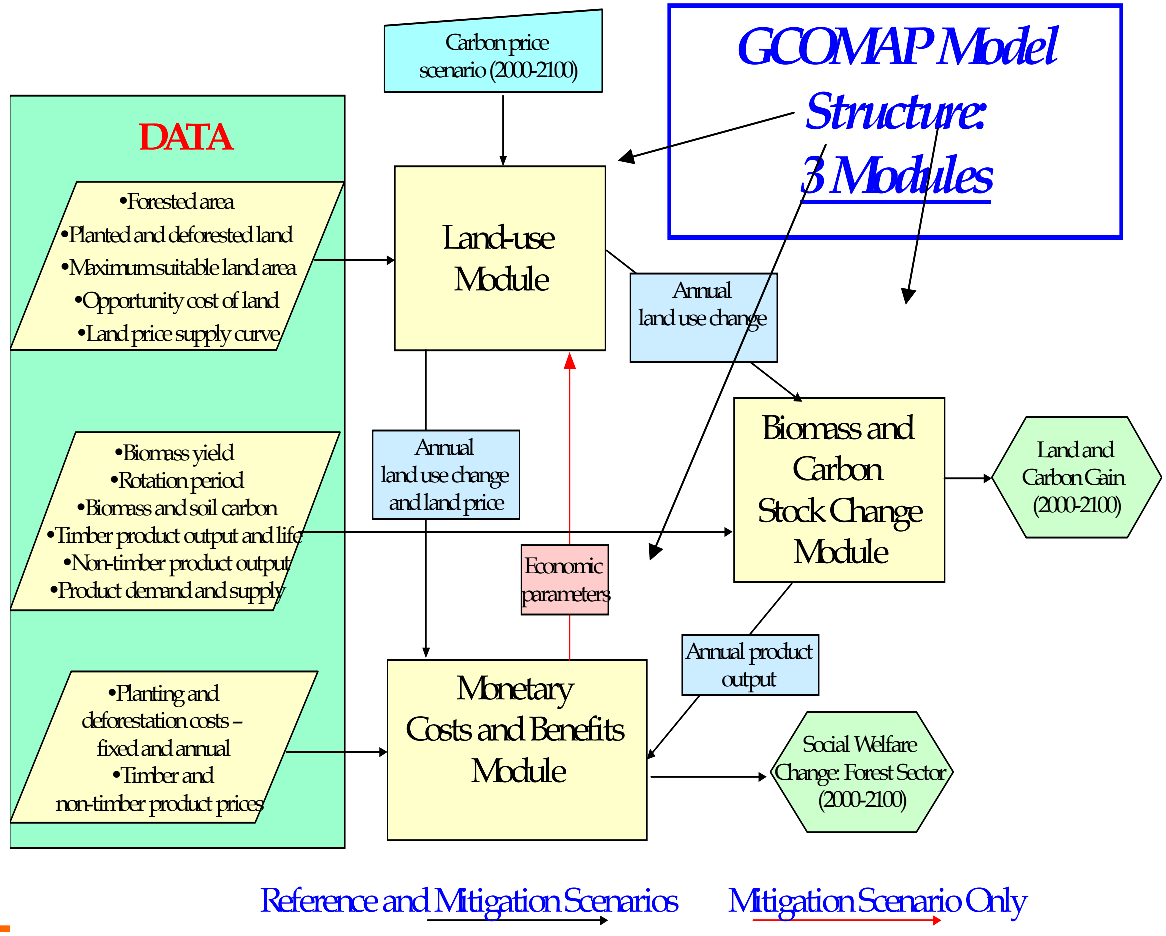
At end-of-life, PC landfilling and PC demanufacturing occur in California but recycling "credits" occur elsewhere.

Primary sources: 1) Masanet E., Price L., de la Rue du Can S., Brown R., and E. Worrell. 2004. *Optimization of Product Life Cycles to Reduce Greenhouse Gas Emissions in California.* California Energy Commission, PIER Energy-Related Environmental Research. 2) U.S. EPA. 2001. Desktop Computer Displays: A Life-Cycle Assessment.

How much additional land area will be planted or avoided from being deforested in response to C price path?

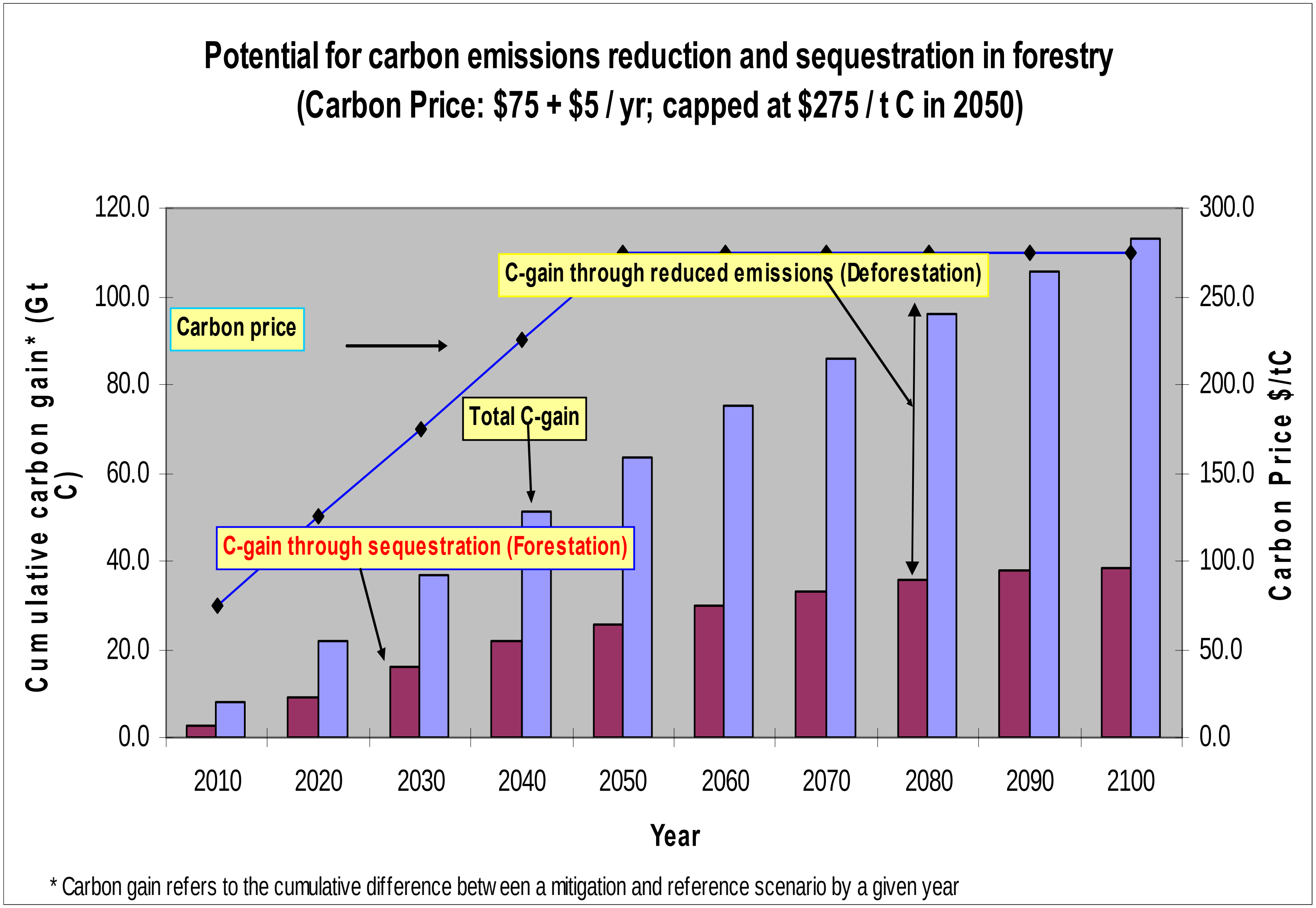
GCOMAP: A Dynamic Partial Equilibrium Economic Model

- Since 1990, LBNL has developed bottom-up forestry sector models
- GCOMAP was developed using this expertise and data combined with global and OECD data
- Model represents forest sector market dynamics; based on investment theory, and assumes perfect foresight
- Includes 10 regions, a deforestation and 2 forestation options, and tracks carbon in 6 pools annually



Sathaye et al. *The Energy Journal Special Issue* 2006

Global Net Sequestered Forestry Carbon and Reduced Deforestation Emissions (Cumulative to date)



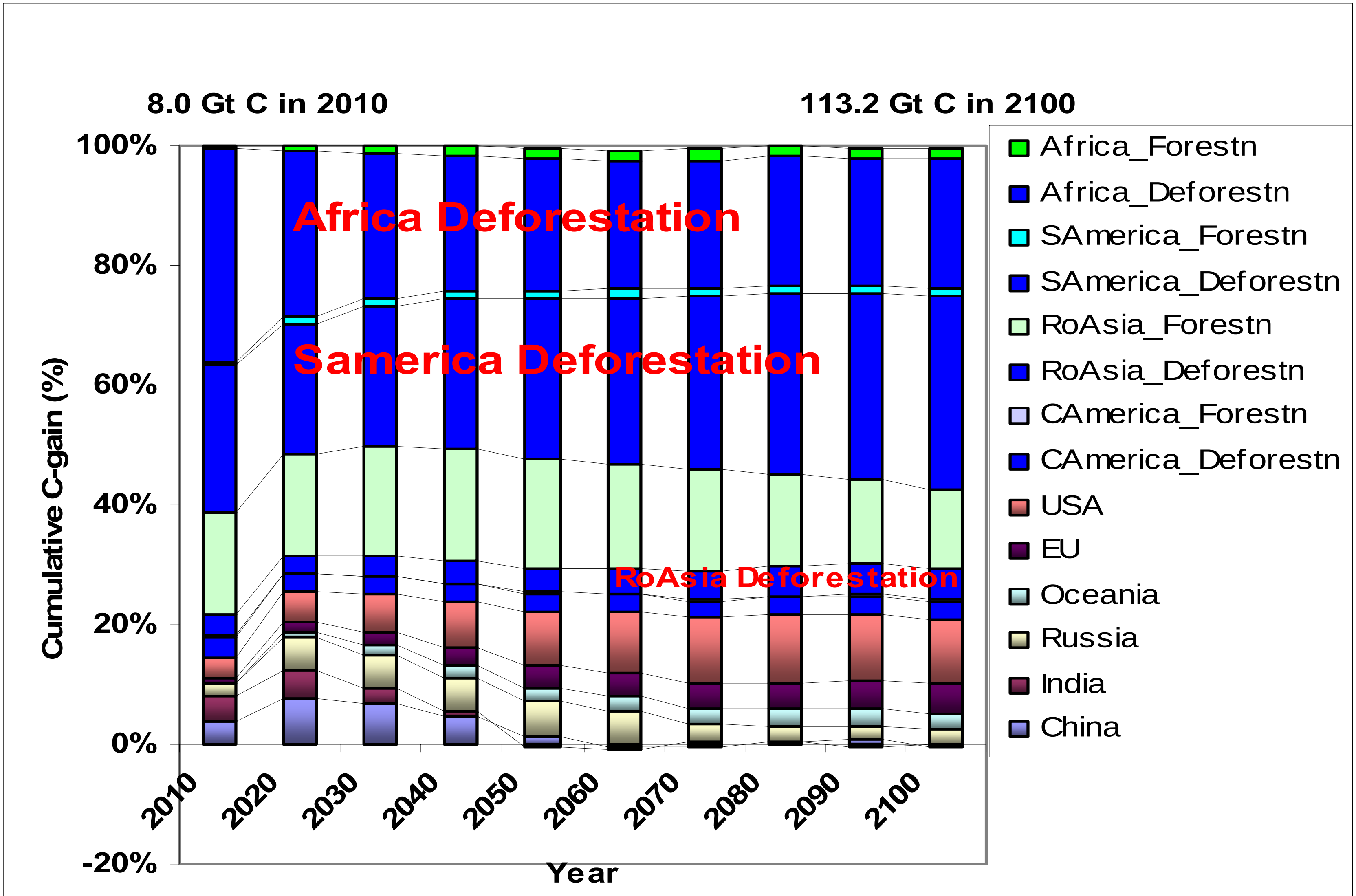
Carbon choke price to theoretically stop deforestation (i.e., C price > opportunity cost) varies across regions

- Feasibility of stopping deforestation complicated by many barriers.
- Carbon choke price to theoretically halt deforestation depends on opportunity cost of land and products
  - Timber and agricultural products fetch higher prices than land or other products
  - Higher the timber and agricultural revenue higher the carbon price required to reduce or avoid deforestation

Region	Carbon choke price to theoretically stop deforestation ($/ t C)
Africa	$ 39
Central America	$ 127
South America	$ 147
Rest of Asia (Asia without China and India, incl. PNG)	$ 281

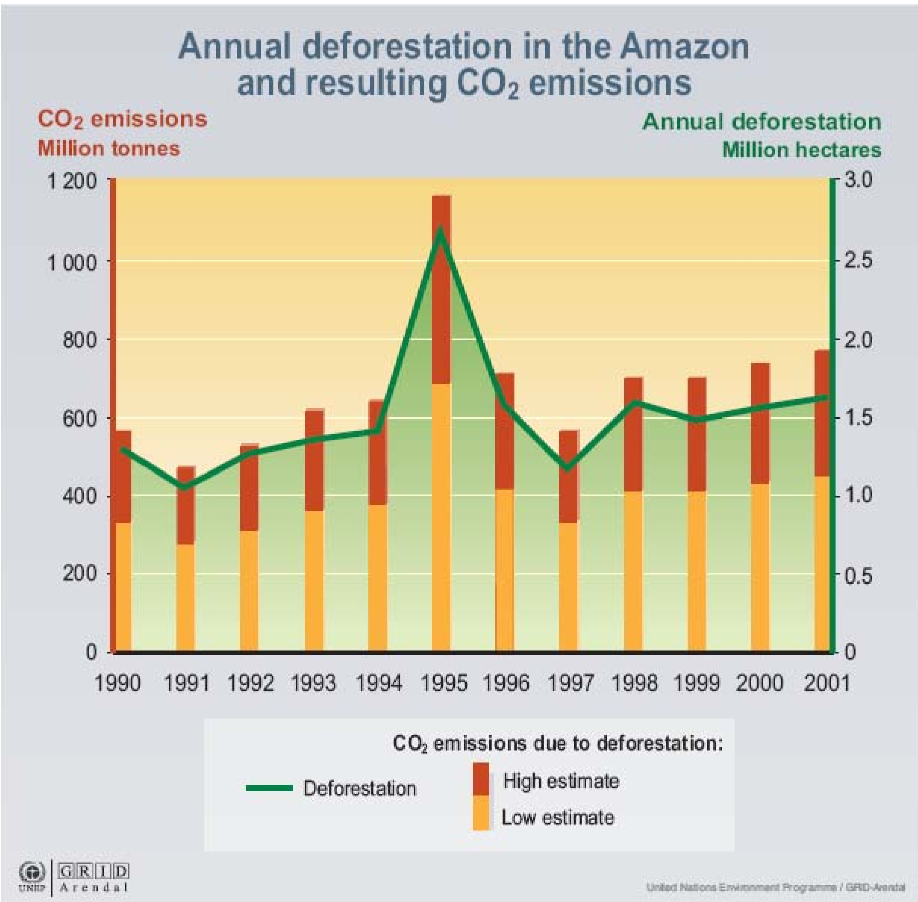
Net Sequestered Forestry Carbon and Reduced Deforestation Emissions by Region

(Cumulative to Date)

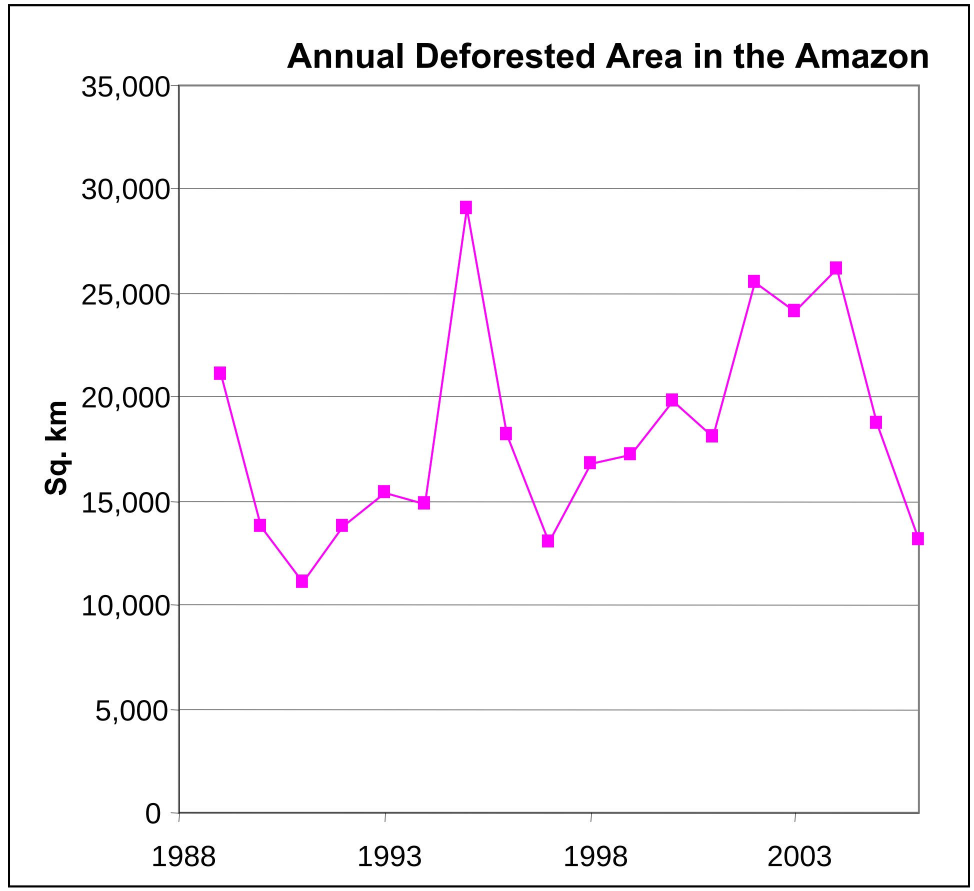


Baseline Setting:
How to model sharp fluctuations in base year deforested area?

Brazil Example



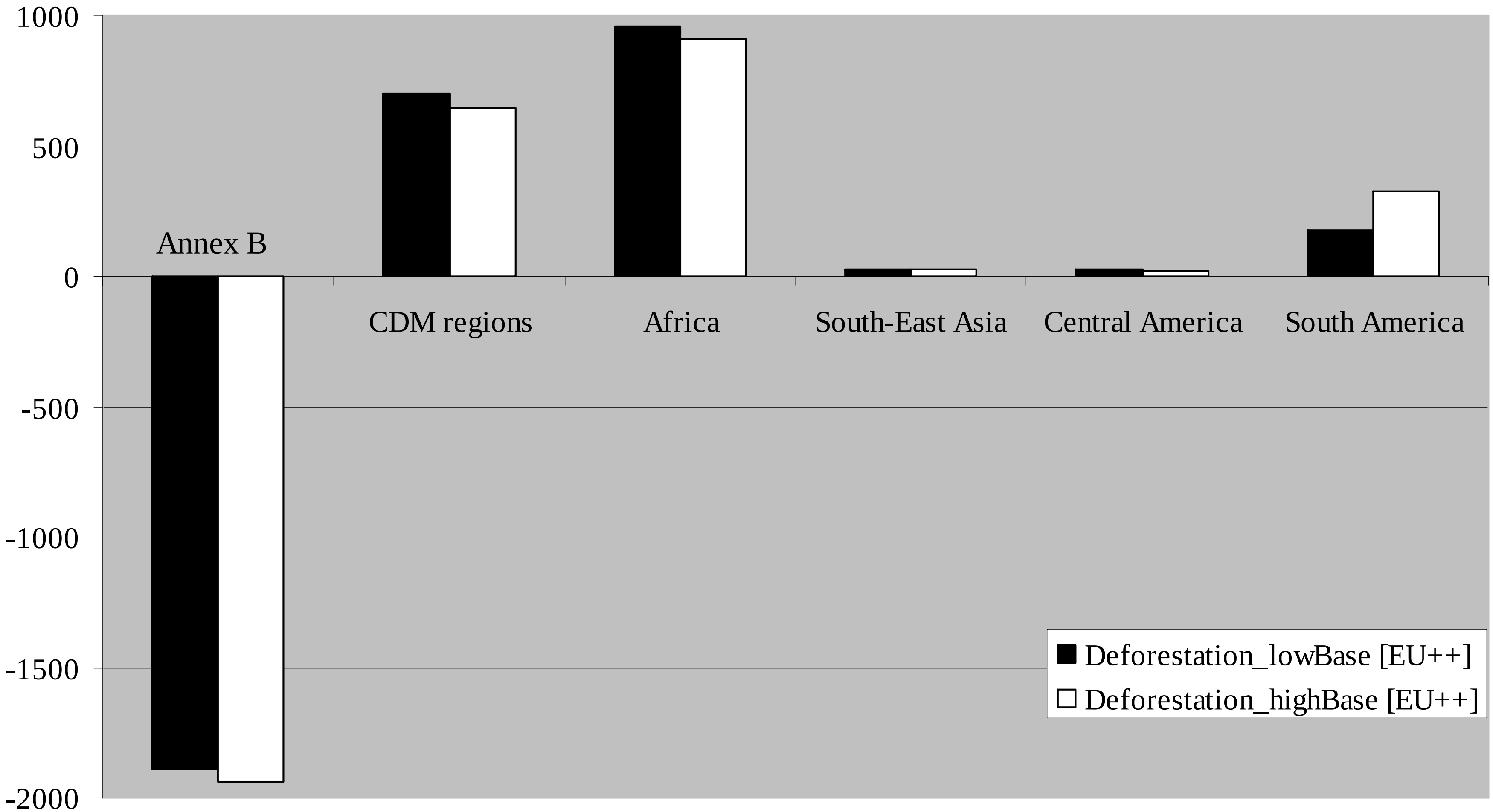
Sources: UNEP 1999; La Rovere 2000; Cramer 2004.



Source: INPE, Brazil

Offset credit exports (positive) and imports (negative) by region (Mt CO2)

In order to meet Annex I assumed 2020 emissions targets (EU, Canada, and Japan 20% and US 15% relative to 2020 Base Case)



Anger and Sathaye (2008)

Two-way Relationship Between Climate Change and Sustainable Development

A. Climate policy can have positive or negative effects on other factors

-- Ancillary benefits or co-benefits

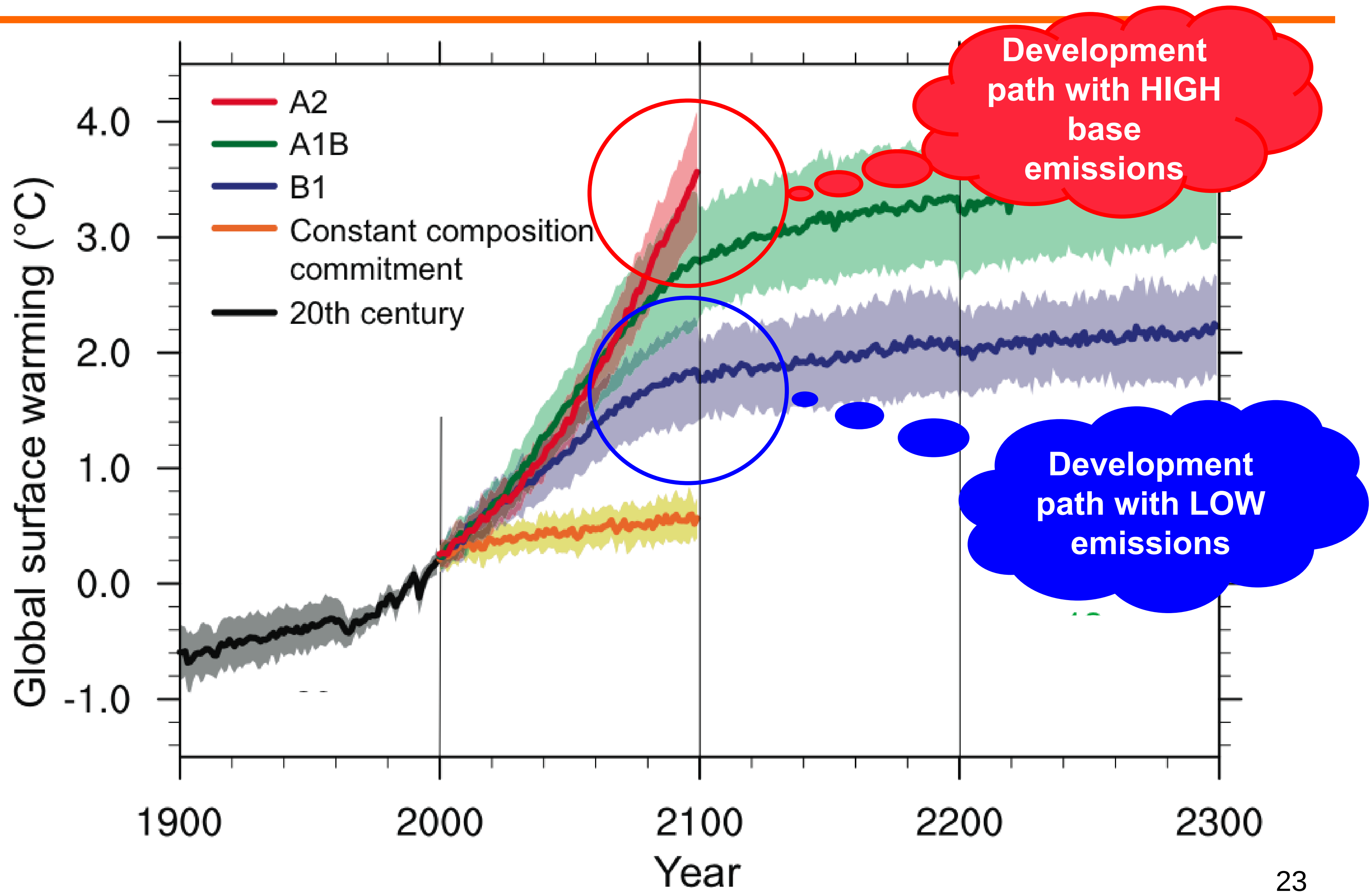
B. Non-climate development policies can influence GHG emissions as much as climate-specific policies

-- Requires mainstreaming climate change in decision-making

Other effects of climate mitigation (examples)

OPTIONS	*SYNERGIES*	*TRADEOFFS*
Energy: efficiency, renewables, fuel-switching 	• air quality • supply security • employment • costs (efficiency)	• particulate emissions (diesel) • biodiversity (biofuels) • costs (renewables)
Forestry: reduce deforestation, plant trees 	• soil protection • water management • employment • biodiversity (deforest.)	• biodiversity (plantations) • competition food production
waste: landfill gas capture, incineration 	• health & safety • employment • energy advantages	• ground water pollution • costs

Development path as important as specific climate mitigation policies



Non-climate policies can influence GHG emissions as much as climate-specific policies

Sectors	Non-climate policies -- Candidates for integrating climate concerns	Possible influence (% of global emissions)
Macro-economy	Taxes, subsidies, other fiscal policies	All GHG emissions (100 %)
Forestry	Forest protection, sustainable management	GHGs deforestation (7%)
Electricity	Renewable energy, demand management, decreasing losses transport,/distribution	Electricity sector emissions (20 %)
Oil-imports	Diversification energy sources/decrease intensity -> enhance energy security	GHGs from oil product imports (20 %)
Insurance buildings, infrastructure	Differentiated premiums, liability conditions, improved conditions green products	GHG emissions buildings, transport (20 %)
Bank lending	Strategy/policy, lending projects accounting for options emission limitations	Notably development projects (25%)
Rural energy	Policies promoting LPG, kerosene and electricity for cooking	Extra emissions over biomass (<2 %)

3 Ways to Broaden Climate Policies (Mitigation and Adaptation)

"Climate first" — from climate to development policy — **"Development first"**

International negotiations — from global agreement to local action — **Local and sector actions**

State — from government to governance — **All actors (state, market, civil society)**

Mitigation and adaptation: synergies and trade-offs

Mitigation→ **Adaptation↓**	Actions decreasing GHG emissions, increasing sinks, protecting C pools	Actions increasing GHG emissions, decreasing sinks, destroying C pools
Actions decreasing exposure and sensitivity to climate change	***Synergies, e.g. increased water efficiency, erosion control, cool roofs***	***Trade-offs adaptation ("adaptive emissions"), e.g., air conditioning, irrigation***
Actions increasing exposure and sensitivity to climate change	***Trade-offs mitigation ("new vulnerabilities"), e.g. climate-sensitive biofuels***	***Actions leading to non-sustainable development, e.g. deforestation***

Conclusions

- Detailed technology representation provides insight and understanding of technology and fuel mix choices
- Accounting for principal agent problems and other market failures is important and will provide better insights for types of climate policies that will be effective
- Inclusion of non-energy benefits reduces net costs, changes ranking of options, and increases emissions reduction potential
- Accounting for life cycle impacts is important for a comprehensive estimate of energy and GHG emissions
- Reducing deforestation can be achieved at a relatively modest cost, although the large baseyear uncertainty affects value of exported carbon credits
- Mainstreaming climate mitigation in development decisions with climate consequences is essential for a low-emissions path to emerge

Thank you

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Web Site: http://ies.lbl.gov