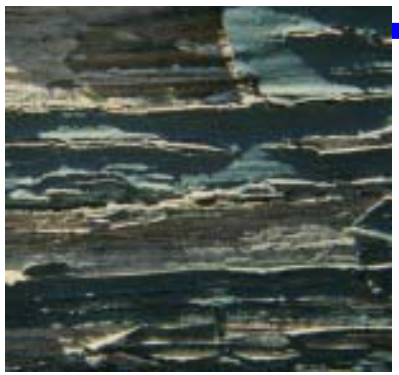

CarBen: A New Model for Assessing Cost-Effective GHG Emission Reduction Strategies

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INTRODUCTION

One of the most frequently asked questions during any greenhouse gas and climate change discussion is:

What Will It Cost?

The answer is never simple and depends on:

1. ***The baseline for GHG emissions.***
2. ***GHG emissions reduction scenario (e.g., the Administration's GCCI, Kyoto Protocol).***
3. ***GHG emission reduction options (e.g., CO2, methane, forestry)***
4. ***Nature of the policy and response mechanism(s) (e.g., cap and trade; incentives; R&D/technology)***

INTRODUCTION (Cont'd)

The CarBen (Carbon Sequestration Benefits) Model was built to answer the question - - *What Will It Cost?* - - *and to examine the set of options that would provide "least costs." It also addresses questions such as:*

- ***What are the benefits of pursuing a carbon capture and geologic storage technology option?***
- ***What levels of RD&D and market-based incentives would stimulate industry to broadly apply carbon sequestration technology?***

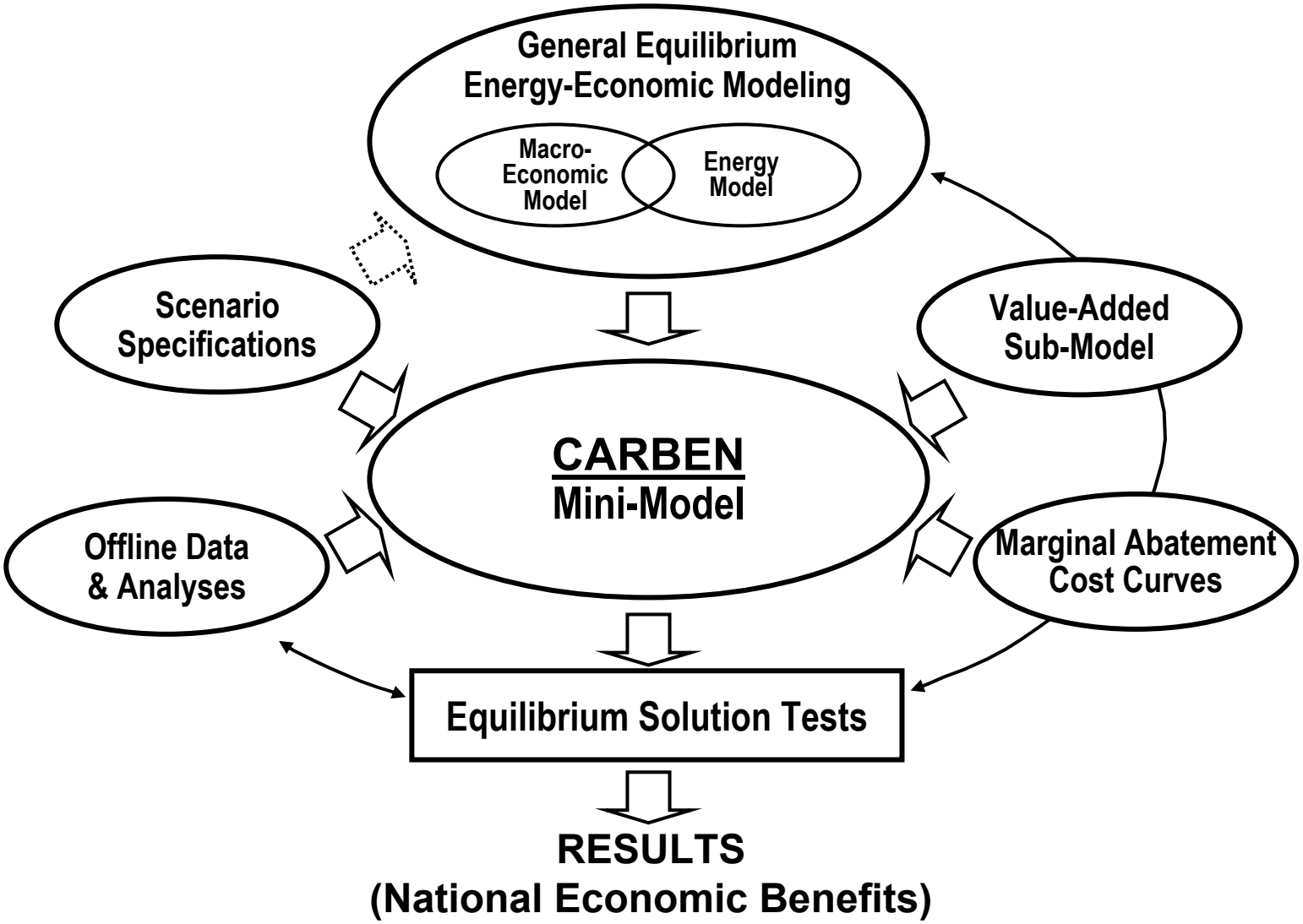
The CarBen Modeling System

The CarBen Modeling System is founded on the general equilibrium results from EIA's National Energy Modeling System (NEMS) and includes:

- ***Energy efficiency and renewables***
- ***Non-CO2 GHGs***
- ***Value-added geologic sequestration***
- ***Advanced sequestration technology***

CarBen contains "dynamic" marginal cost emissions reduction supply functions, incorporates a shadow-price for carbon, and projects results to year 2050.

The CarBen Modeling System



1. BASELINE FOR GHG EMISSIONS

Under the Reference Case, U.S. carbon emissions are projected to double from 1,928 million metric tons equivalent (MMtC) in 2000 to 3,880 MMtC(e) in 2050:

	U.S. GHG Emissions (MMtC(e))		
	2000	2012	2050
CO2 from Energy Use	1,565	1,850	3,234
Other CO2	32	40	66
Non-CO2 GHG's	330	379	580
TOTAL	1,928	2,269	3,880

The Reference Case incorporates data from EIA, EPA and other sources for the initial years. CarBen projects these emissions trends through 2050.

EXAMINATION OF BASELINE CASE

The EIA Reference Case is not a "frozen technology" case. It assumes significant progress in technology, increased use of recoverable and improvements in energy efficiency for the next 25 years:

- ***55% increase in use of wind for power generation***
- ***100% increase in solar thermal heating systems***
- ***9% increase in fuel efficiency for light duty vehicles***
- ***45% increase in use of CHP for electricity generation***

The Reference Case also assumes natural gas provides the bulk of new power generation. CarBen assumes that these positive trends continue to 2050.

2. REDUCED EMISSIONS SCENARIO

For example purposes, we have assumed a three-phase carbon emissions reduction scenario:

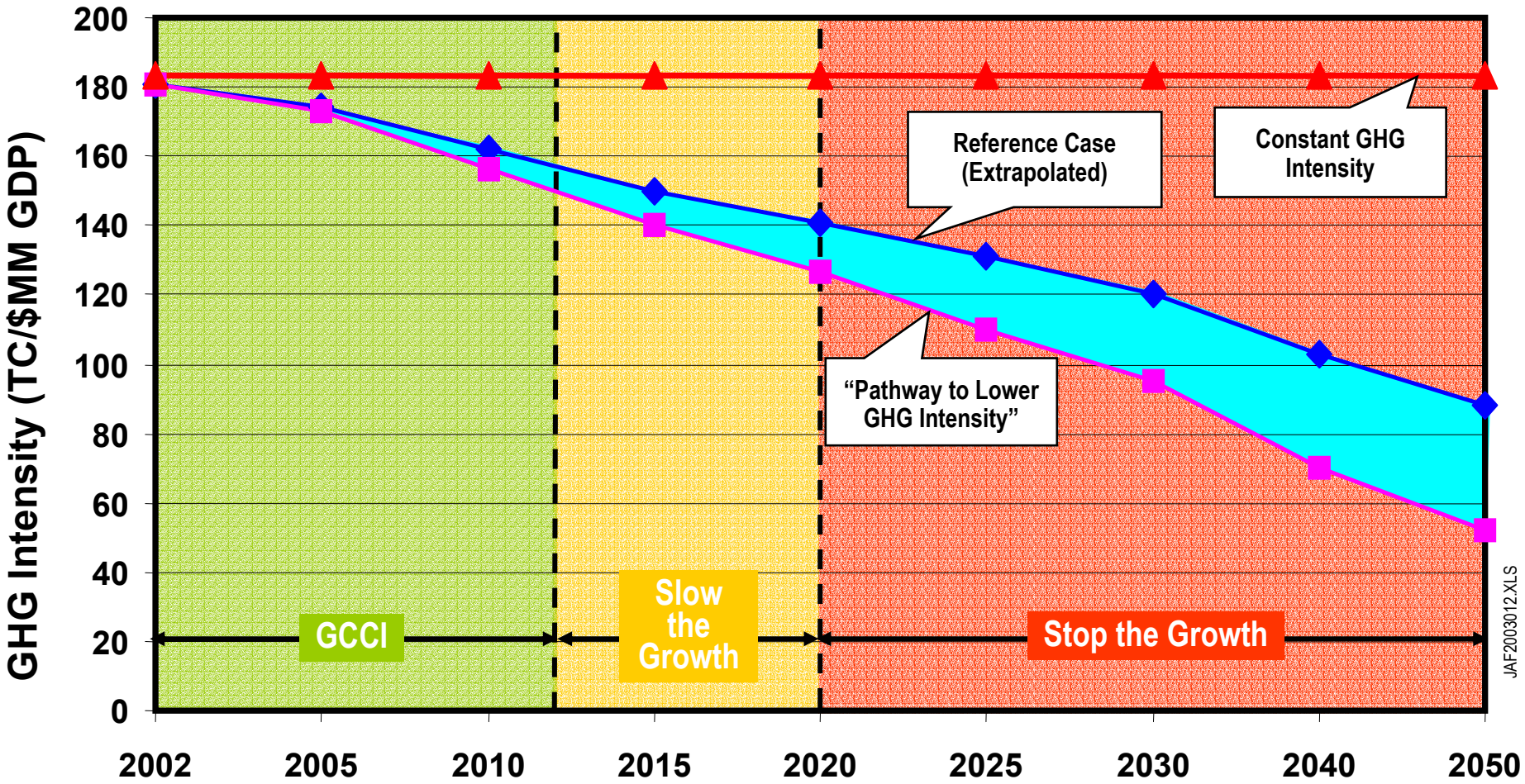
- ***From 2002 – 2012: Administration's GCCI: GHG intensity of 150 TC per million $GDP in 2012, 18% below year 2002.***
- ***From 2013 – 2020: Slow the Growth: Annual GHG emissions growth rate is reduced by 50%.***
- ***From 2021 – 2050: Stop the Growth: Annual GHG emissions are assumed stabilized at year 2020 levels.***

This scenario requires the following annual reductions:

2012 - -	***100 MMtC***
2020 - -	***240 MMtC***
2050 - -	***1,570 MMtC***

Alternative emission reduction scenarios, including ones that reverse the growth in carbon emissions can also be assessed with CarBen.

2. REDUCED EMISSIONS SCENARIO



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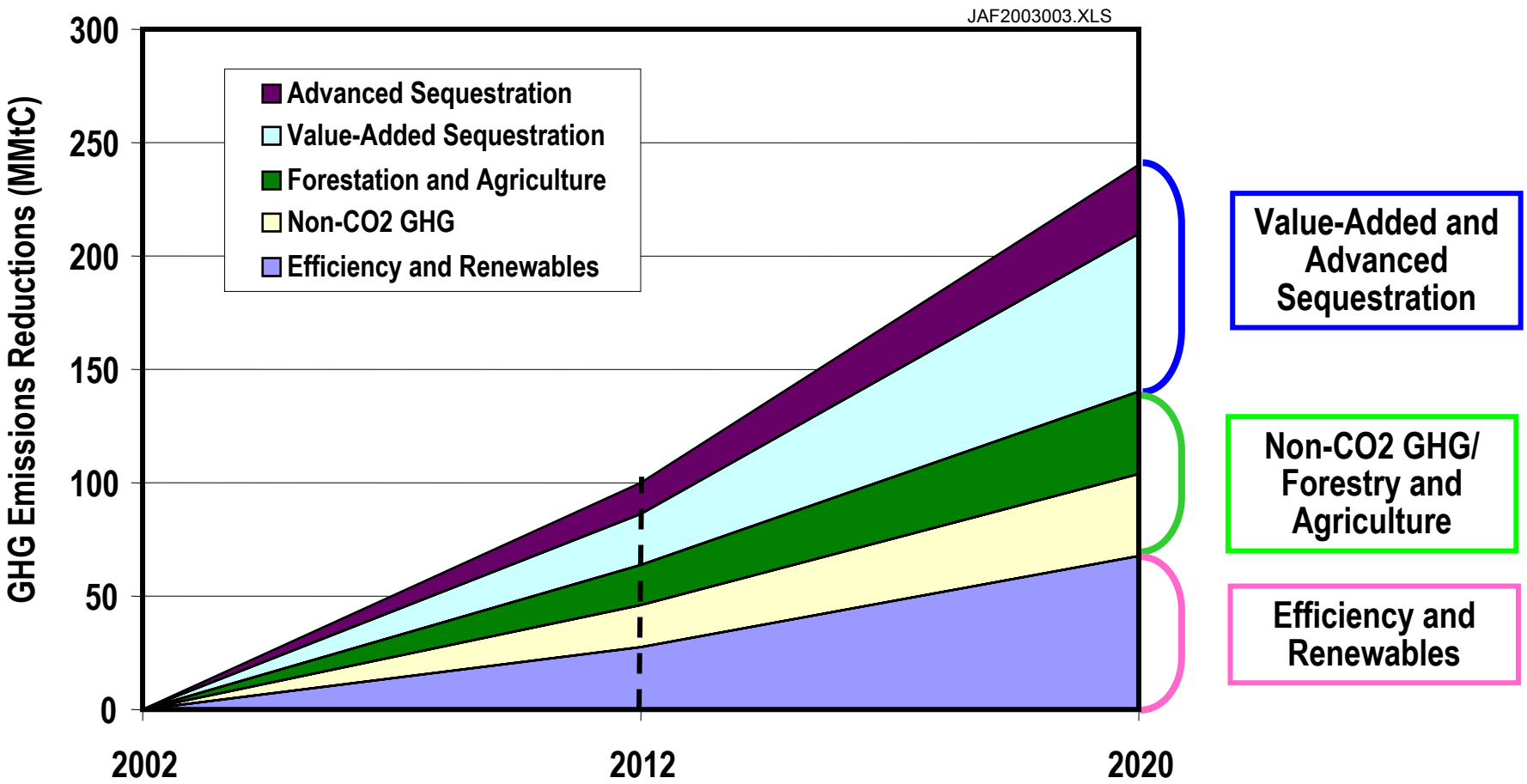
3. GHG EMISSION REDUCTION OPTIONS

The CarBen Model shows that using a combination of R&D investment and a shadow price of $50 per metric ton of carbon will enable the U.S. to meet the posed missions reduction scenario.

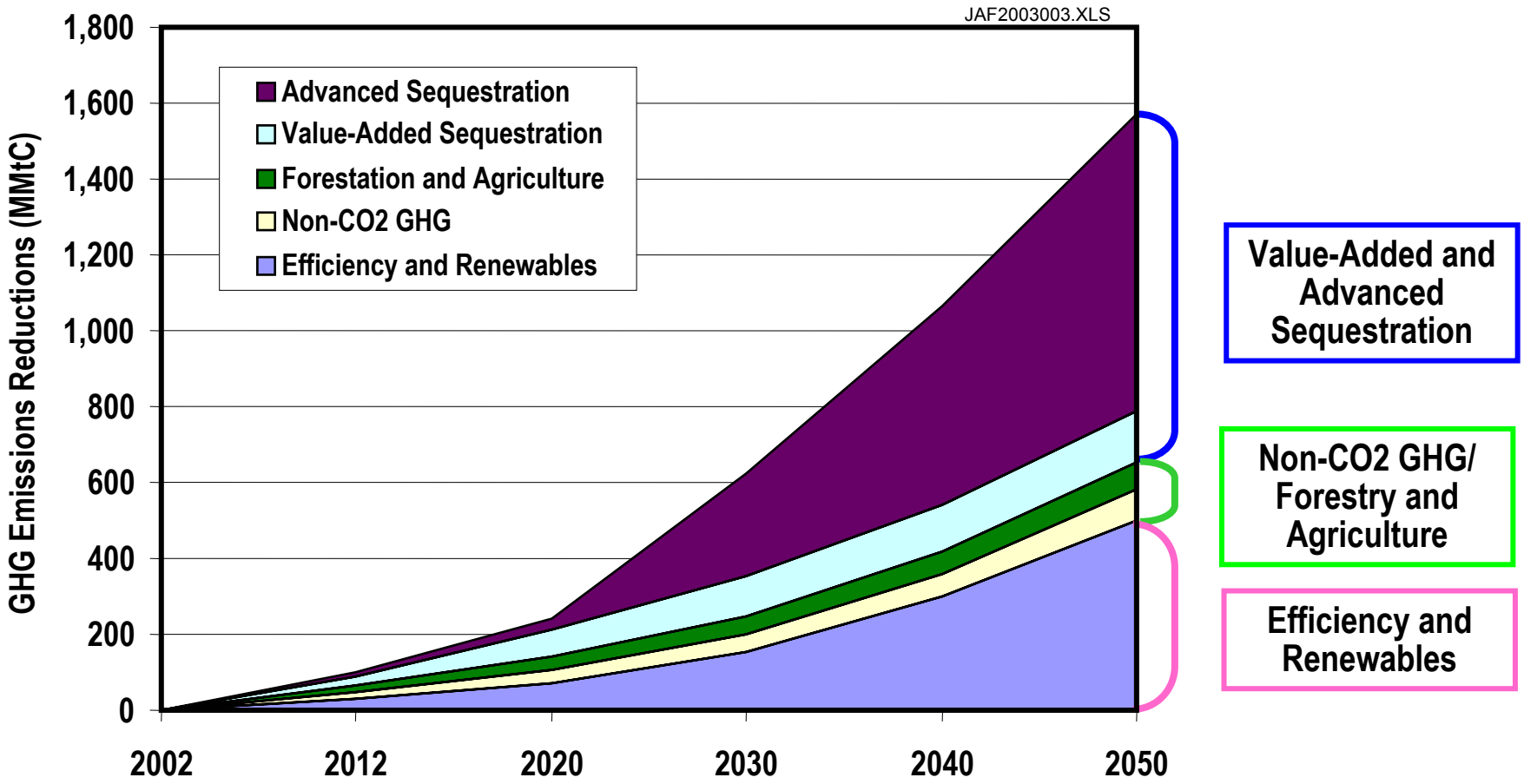
		2012	2020	2050
Annual U.S. GHG Emission Reduction Needs (MMtc)		**100**	**240**	**1,570**
Contributions Toward Reductions	High Technology Energy Efficiency and Renewables	28	68	500
	High Technology Reductions in Non-CO2 GHGs Emissions	18	36	80
	High Technology Forestry & Land Use Changes	18	36	70
	Early Value-Added Geologic Sequestration	23	70	140
	Target for Advanced Sequestration Technology	13	30	780
	TOTAL (MMtc)	100	240	1,570

**At a carbon shadow price of $50 per metric ton.*

POTENTIAL NEAR-TERM OPTIONS FOR REDUCING GHG EMISSIONS



POTENTIAL LONG-TERM OPTIONS FOR REDUCING GHG EMISSIONS



4. INCENTIVES FOR CO2 STORAGE AND DOMESTIC ENERGY PRODUCTION

Market-based incentives could be structured to encourage industry to capture high CO2 concentration emissions for enhanced oil, natural gas and coalbed methane recovery:

- **Capture of CO2 emissions from high concentration vents**
- **Production of additional domestic energy**
  - **1 million barrels per day of oil production**
  - **Substantial potential for additional natural gas reserves**
- **A $50/tonne carbon ($13 to 14/tonne CO2) sequestration credit would be at least revenue neutral and may well be revenue positive.**

4. ADVANCED TECHNOLOGY

Advanced sequestration (in CarBen) is the "technology of last resort" to achieve required emissions reduction target and includes:

- ***Direct carbon capture options***
- ***Future "value-added" geologic sequestration (e.g., depleting gas fields, organic-rich shales)***
- ***Cost-avoided acid gas injection***
- ***Deep saline formations***
- ***Other long-term carbon storage options***

ADVANCED SEQUESTRATION TECHNOLOGY

Advanced Sequestration offers numerous options for cost-competitive responses:

- ***Additional "value-added" geologic storage (e.g., enhanced gas recovery, disposal of "total" emissions).***
- ***Gasification of petroleum residues (e.g., coke) and lower cost capture technologies.***

PC Boiler (w/coal)*	**$0.039/kwh**
Gasification (w/pet coke and CO2 recovery)*	**$0.056/kwh**
• CO2 Sequestration Incentive (@ $50/mtC)**	($0.011/kwh)
• Technology Progress (by 2012)	($0.006/kwh)
Net Costs	**$0.039/kwh**

**Based on SFA Pacific cost models.*
***High purity CO2 at 2,000 psi provided "free" at plant gate to "value-added" users.*

CONCLUDING REMARKS

A significant national effort will be required to achieve the GCCI carbon emission reductions for 2012 and beyond.

The CarBen Model demonstrates that a combination of options could lead to a "least cost" GHG emissions reduction response:

- ***R&D investment in lower cost CO2 capture technology,***
- ***Incentives for CO2 sequestration with energy production,***
- ***High technology accomplishments in energy efficiency and renewables,***
- ***Reductions in non-CO2 emissions and use of forestry and land use changes.***

For the longer term, carbon capture and storage will need to carry the dominant role.

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