Greenbacks from Greenhouse Gases: Carbon Sequestration and Nutrient Management

Prakasam Tata, Ph.D., QEP
Tata Associates International
1213 Stonebriar Court
Naperville, IL 60540

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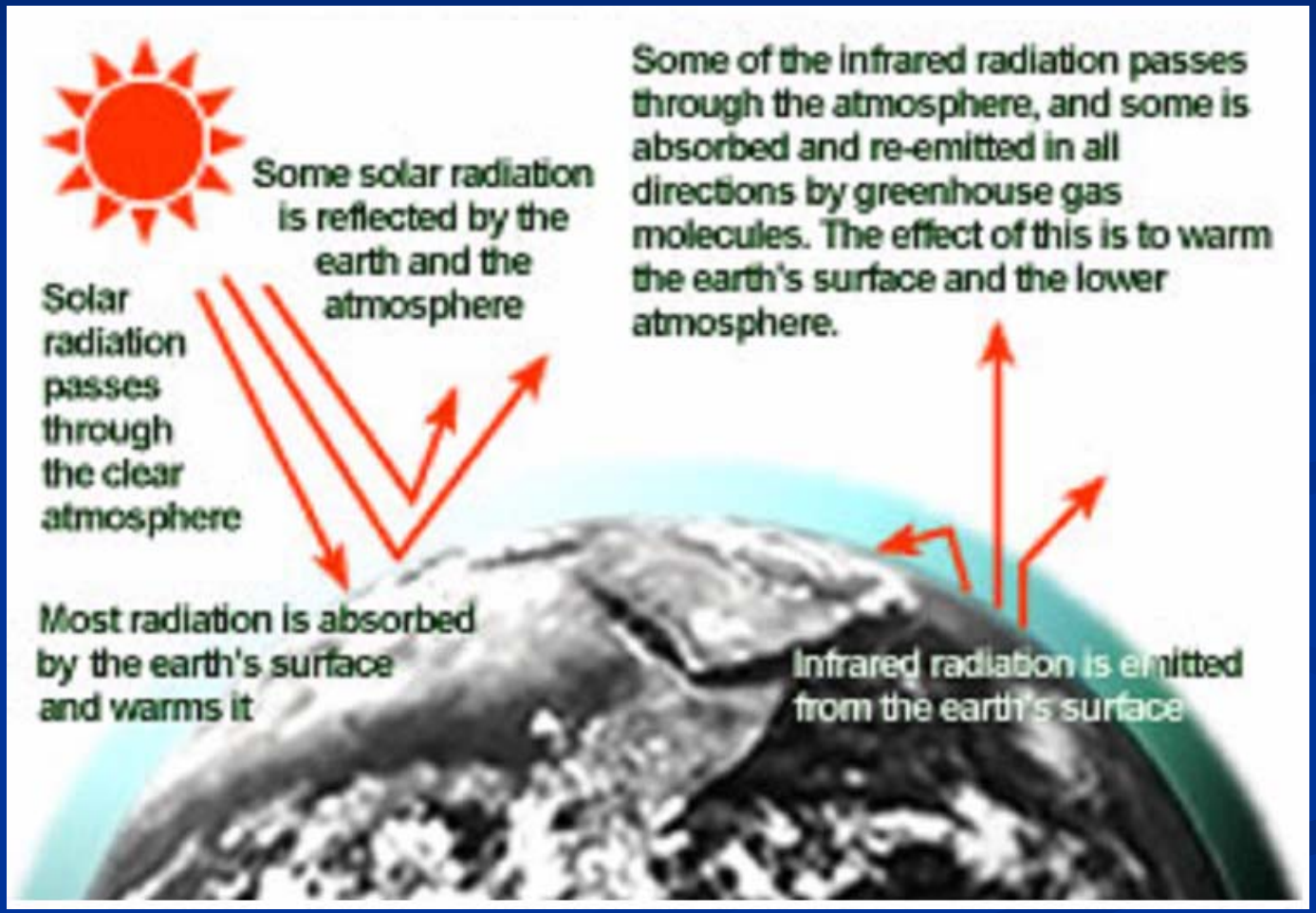
Definition of Green House Gases and Green House Effect

GHGs: Gaseous Components of the Atmosphere that Contribute to the Green House Effect

GREEN HOUSE EFFECT: The phenomenon whereby the earth's atmosphere traps solar radiation, because of the atmosphere containing gases that allow incoming sunlight to pass through but absorb heat radiated back from the earth's surface.

The Green House Effect



History of Global Warming

- 1827: Jean-Baptiste Fourier proclaimed that Earth's atmosphere traps heat like a "glass vessel." Later becomes known as Greenhouse Effect.
- 1896: Svante Arrhenius was the first one to quantify the degree of warming of Earth due to CO_2. "We are evaporating our coal into the air."
- 1985: Hole in the Ozone Layer Discovered by American and British Scientists. Global Warming becomes prominent in politics
- 1988: Intergovernmental Panel on Climate Change (IPCC) formed by the UN. In the US, half of the Bill aimed at reducing global warming by Rep. Claudine Schneider passes
- 1990: First IPCC Report: 0.5° C rise in earth's temp, in the last century

History of Global Warming – Contd.

- 1992: UN Framework Convention on Climate Change – Reverse Warming by Cutting Emissions down to 1990 Level by 2000
- 1997: Kyoto Protocol proposed. Pres. Clinton signs the treaty but never submitted it to the Senate; first see meaningful participation of developing nations before ratifying.
- 2005: Kyoto Protocol takes effect. USA and Australia are not signatories.
- 2006: "Inconvenient Truth" released – a documentary on Gore's campaign on Climate Change
- 2007: IPCC Report – 90% certainty that global warming is man-made. Another report predicts that global temperatures and sea levels will rise

7/27/ 2007: Tata, a retired MWRD Employee says that Municipal Agencies can help minimizing global warming and can possibly make money through the sale of carbon credits earned through offsets, conservation of energy, careful nutrient management, and afforestation

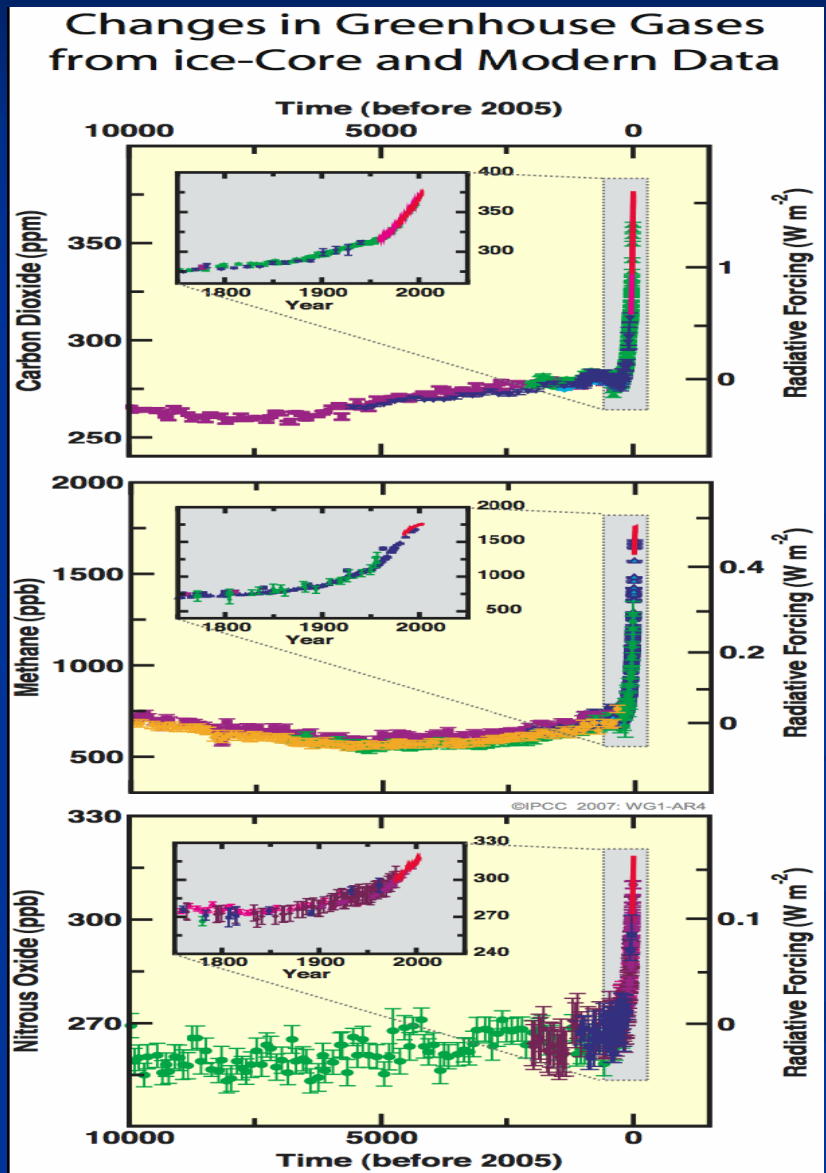
Green House Gases and Origin

Gas	Origin
CO_2	Oxidation of Carbon
CH_4	Anaerobic Decomposition, Combustion
N_2O	Denitrification, Combustion
HFCs	Man made
PFCs	Man made
SF_6	Man made

The Units

Gas	Global Warming Potential
CO_2	1
CH_4	21
N_2O	310
HFCs	1.5- 260
PFCs	6,500 – 9,200
SF_6	**23,900**

Changes in GHG Emissions With Time



Increases in Ambient GHG Concentration

	N_2O	CO_2	CH_4
Pre Industrial Revolution	280*	715**	270**
Current Levels	370	1,774	319

*ppmv
**ppbv

Let us See What The World Is Doing About Climate Change

KYOTO PROTOCOL

- Article 3: "---- to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012."

Annexe I Parties and Emission Targets

Annexe I Parties	Emission Target*
Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK, Northern Ireland	-8 %
USA**	-7 %
Canada, Hungary, Japan, Poland	-6 %
Croatia	-5 %
New Zealand, Russian Fed., Ukraine	0 %
Norway	+1 %
Australia**	+8 %
Iceland	+10 %

**Compared to Base Year (usually 1990)*

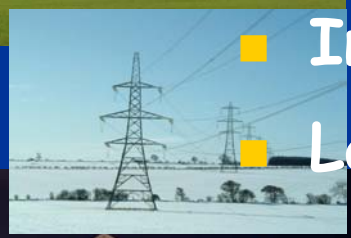
*** Countries which haven't ratified the KP*

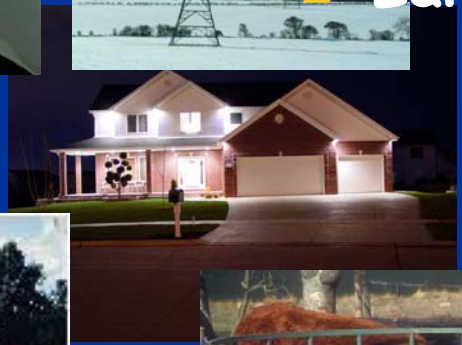
Mechanisms Proposed in Kyoto Protocol to Achieve Goals

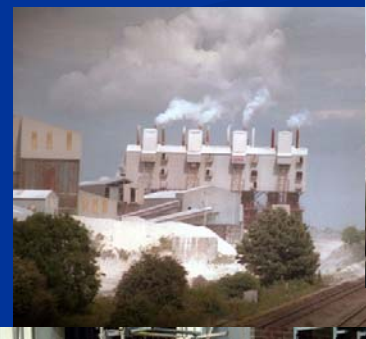
- CAP and TRADE: International Emissions Trading of Emission Permits (EPs) Measured by Assigned Amount Units (AAUs)
- Joint Implementation (JI) Crediting of Emission Offsets From Projects Among Developed Countries Measured by Emission Reduction Units (ERUs)
- Clean Development Mechanism (CDM): Crediting Emission Offsets Resulting from Developing Countries Project to Developed Countries

GHG Emission Categories

- Energy
- Agriculture
- Wastes (Agricultural and Municipal)
- Industry
- Land Use







Greenhouse Gas Emission Sources

Sources

Fossil Fuel Combustion (CO2, N2O, CH4)

Natural Gas Systems (CH4)

Agricultural Soils (N2O, CO2)

Manure Management (CH4, N2O)

Domesticated Animals (CH4)

Burning of Field Wastes (CH4, N2O)

Solid Waste Disposal (CH4, CO2, N2O, CH4)

Wastewater Treatment (CO2, CH4, N2O)

Industrial Processes (CO2, N2O, HFC, PFC, SF6)

Sinks & Negative Emissions

Carbon Sequestration

Forest Management

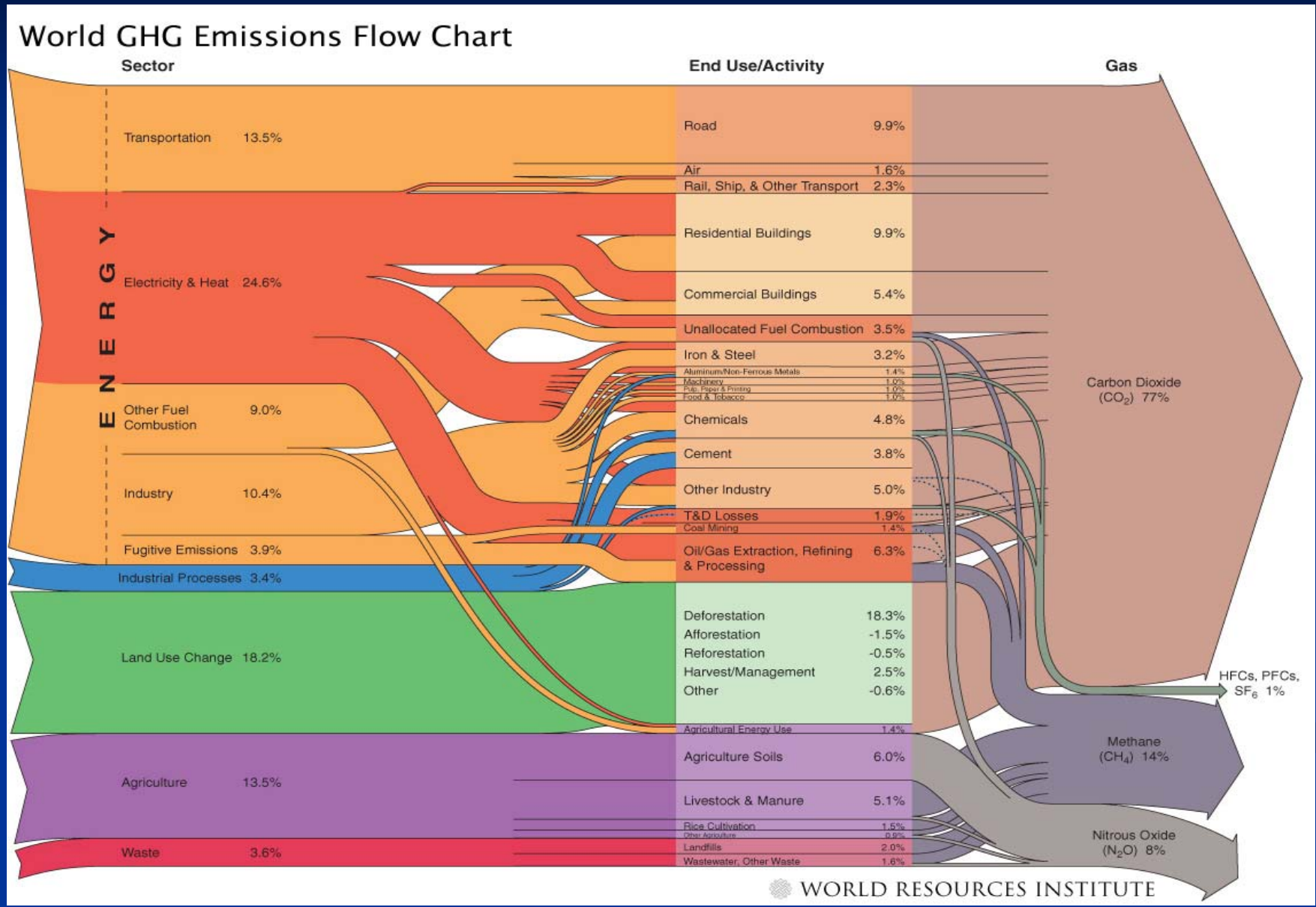
Agriculture Land Use

Methane Recovery & Flaring

Landfills

Wastewater Treatment

CO_2 Emissions from Various Sources



Now Let Us Turn Our Attention to:

Our Own Business of Wastewater Treatment & Explore How We Can Make Some Green Backs Out of the GHGs Emitted From Wastewater Treatment Processes.

GHGs of Importance and Concern in Wastewater Treatment Processes

- Carbon Dioxide
- Methane
- Nitrous Oxide

Where Do GHGs Come From In Wastewater Treatment Processes?

- From the Same Carbon and Nitrogen Cycles That Guide Aerobic, Anoxic, and Anaerobic Wastewater Treatment Processes
  - **Aerobic Process End Product:** CO_2
  - **Anaerobic Process End Products:** CH_4 and CO_2
  - **Anoxic Process End Products:** N_2, N_2O, and CO_2

How Money Can be Made from Controlling GHG Emissions

Mechansims Available For Revenue Generation

- Emissions Trading : CAP and TRADE
- Generation of Carbon Offsets

CAP AND TRADE

- A Regulator Establishes a CAP on Designated Polluters, e.g. Power Plants, To a Lower Level of Emissions than Their Level of Current Emissions
- These New Limits Are Divided Among Polluters and Individual Permits Issued
- Polluters who Emit Less Than What is Allowed Can Sell the Emissions That They Did Not Emit to Others who Cannot Reduce Their Emissions, but it is Economical for Them to Buy Credits Rather Than Reducing Emissions Themselves at a Higher Cost

Emissions Trading

- Involves Earning Validated and Verified Carbon Credits Through Implementation of Cost Effective Technologies and Practices to Offset GHG Emissions

- Removal of GHG Emissions by Cost Effective Methods is Essential for Making Money by Selling Carbon Credits

Chicago Climate Exchange (CCX)

- CCX is the only Exchange in the USA that Does Trading in Carbon Credits
- The Baseline (BL) Year is 2000 or the Average Emissions of 1998 to 2001
- The Reductions are Fixed
  - Phase I: For 2003 to 2006 - 4% compared to BL
  - Phase II: For 2007 to 2010 - 6% (additional 2%)

Emissions Trading Prices

- Carbon Emissions Trading Prices Although Started Low are now Trading Higher on CCX Than What They Were at the Beginning ($~3.50 vs. <$1.00/ton in 2003, went as high as ~$4.50/ton)
- Many Companies Are Members of the CCX and Are Already Trading
- The Price of Carbon Sequestered Trades at a Considerably Higher Price in European Union Carbon Trading Market

CCX

- Members Include:
  - State of Illinois
  - State of New Mexico
  - Various Municipalities, including Chicago
  - King County, Sacramento County
  - American Electric Power
  - Various Universities
  - Various Major Industries, and
  - Many Others

Breaking News!

- "US dominates booming voluntary carbon market." Environmental Finance, 19 July 2007

The US is leading the rapidly growing market for voluntary carbon credits in terms of both supply and demand, according to a report from Ecosystem Marketplace and analysts New Carbon Finance.

Emission reductions equivalent to approximately 23.7 million tonnes of carbon dioxide were traded in 2006, at a volume-weighted average price of $4.10 a tonne, giving the market a value of $91 million.

Let Us See How Carbon Dioxide Can be Captured and Stored to Slow Down Climate Change

- Through Carbon Sequestration
- Through Earning Carbon Credits

What is Carbon Sequestration?

- Carbon sequestration is the process through which carbon containing emissions are lowered and permanently stored and/or removed either directly from their source or from the atmosphere.

- Can be directly or indirectly achieved by:
  - Modifying industrial and energy production operations and treating waste gas streams
  - Capturing and storing emissions in geological formations
  - Capturing and storing by biological means

Carbon Sequestration Technologies

- Geological Sequestration
  - Injection into Oil and Gas Reservoirs
  - Injection into Unmineable Coal Seams (Coal Bed Methane)
  - Injection into Deep Saline Reservoirs
- Capture Technologies
  - Absorption
  - Adsorption
  - Low Temperature Distillation
  - Gas Separation Membranes
  - Mineralization and Biomineralization
- Terrestrial Sequestration
  - Forest Lands
  - Agricultural Lands
  - Biomass Crop Lands
  - Degraded and Desert Lands
  - Wet Lands and Peat Lands

What is Terrestrial Carbon Sequestration?

- Terrestrial carbon sequestration is the process through which carbon dioxide (CO2) from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils

Potential Level of Carbon Sequestration by Afforestation and Reforestation

- 1 to 3 GT C/ Year

  -US DOE, 2000

- 1 Tree will sequester CO2 from:
  - air travel of 4 hrs.
  - Car travel of 1242 miles
  - Train/coach travel of 6210 miles

    - Carbon Bank, USA

Carbon Offsets

- Wind
- Biomass
- Solar
- Alternative Fuels
- Recycling
- Afforestation and Reforestation

WIND

Technology

Wind Energy is Converted into Electrical Energy. Energy derived from Carbon Fuels can be offset by the energy derived by wind,

Biomass

Fuels

- Wood
- Mill Residues
- Forest Residue
- Urban Wood Waste
- Agricultural Residue
- Grasses

Technologies

- Co-fire with coal
- Gasification

Biomass

- CH_4 Recovery
  - Livestock
  - Sewage
  - Landfill

Solar

- One Square Meter of a Conventional Solar Panel Can Produce 0.5 to 1 KWh/day depending on Length of Day and Brightness of Sun
- Installation of Solar Panels on Roof Tops of Single Family Homes Offsets GHG Emissions

Recycling

Landfill Reduction

= MTCE in Avoided Emissions

Summary of Reduction Strategies to Reduce GHG Emissions by Offsets

Strategy	Offsets Achievable
Wind	
Biomass – Vegetative	
Biomass – Biogas	
Solar	
Other Alternative Fuels	
Recycling	
Carbon Sequestration	

Potential for Carbon Sequestration through Land-use Management

- Agriculture
  - No till
  - Biomass
    - Grasses
    - Woody trees
- Reforestation & Afforestation
  - Acres available

Estimate Potential million $MTCO_2$ due to Offsets or Reforestation and Afforestation

Trees conducive for Carbon Sequestration*

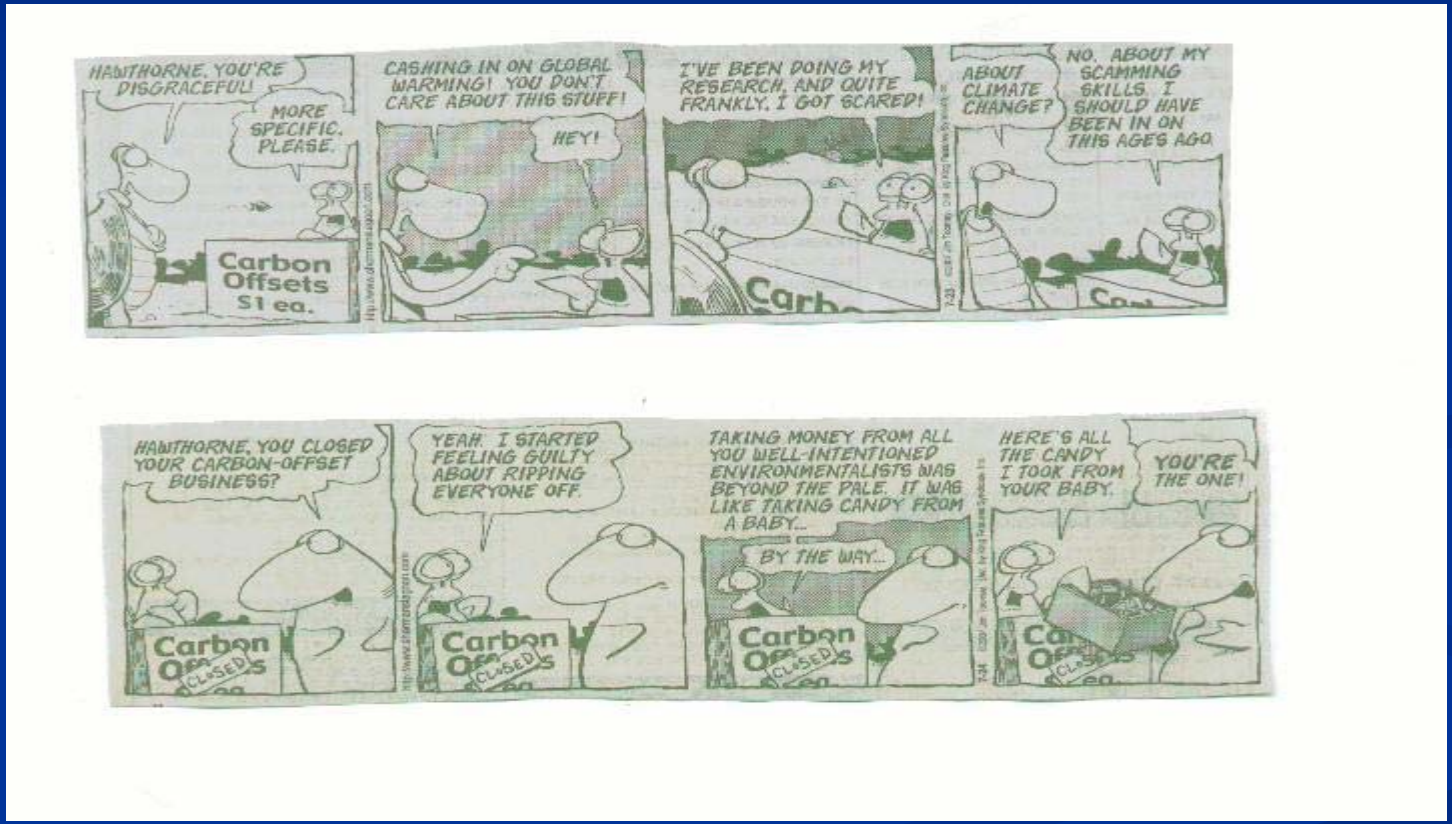
- Common Horse-chestnut
- Black Walnut
- American Sweetgum
- Ponderosa Pine, Red Pine, White Pine,Hispaniolan Pine
- London Plane
- Douglas Fir
- Scarlet Oak, Red Oak, Virginia Live Oak
- Bald Cypress

**Nowak, D., US Forest Service (Northern Research Station, Syracuse, NY) 2002*

Agricultural Practices to Increase Carbon Sequestration and Reduce GHG Emissions

- Residue Management (Direct Seed and No-Till)
- Nutrient Management
- Methane Reduction from Live Stock and Lagoons
- Afforestation and Reforestation (forest, pasture, and croplands)
- Biogas Recovery

Some Are Still Skeptical!



Whether Climate Change is Real or Not,

- Probably, our lifestyles will be altered because of increased emissions.
- If we intend to prevent shifts in climate, we need to change the status quo.
- Since we produce more emissions than most people in the world, we stand to need the most change.
- As time is passing, even our Govt. is mellowing
- Several States even have voluntarily joined the efforts

Opportunities to Earn Carbon Credits for Municipal Agencies

- Carbon Sequestration by Afforestation and Reforestation
  - Explore In-House Opportunities
  - Explore Synergistic Opportunities with Forest Preserves and Park Districts
  - Explore Utilizing Final Effluent for Irrigation and Biosolids Growing Grasses, Native Plants, and Woody Trees on Open Land Owned
  - Explore using constructed or natural wetlands as media for sequestering carbon
- Carbon Credits Earned by Offsets
  - Explore In-house and Synergistic Opportunities

Potential Benefits Resulting from Carbon Sequestration Practices

- Water Quality Improvements
- Meeting Total Maximum Daily Load Targets
- Air Quality Improvement (Odor Abatement)
- Improvement in Public Relations

Steps to Determine Potential Carbon Credits

- Acres Available (MWRDGC: ~25,200 acres; Chicago Forest Preserves: 68,303 acres, Chicago Park District: 10,000 ac.)
- Aggregate Acreage with other Interested Parties (Park Districts, Forest Preserves, Arboretum, Golf Courses, Cemeteries in Cook, Du Page and other counties)
- Determine effluent irrigation requirements to grow corn and/or trees (36" p.a. per acre)
- Determine N Requirement for Fertilization through effluent and biosolids
- Determine C offsets due to N substitution for commercial N fertilizer (16.75 cu.ft of natural gas/lb anh. NH_3 used)
- Determine C fixed by crops and/or biomass planted above ground
- Determine C fixed in roots and soil
- Determine C fixed by wetlands (4.6 kg C/sq. m/yr.)
- Get C credits for overall C fixed

Other Factors to Be Considered

- Determine C offsets by changing all vehicles to Alternative Fuel Vehicles
- Determine C offsets by Energy Saving Mechanisms (e.g. Changing Light Bulbs from Incandescent Ones to others, etc.)
- Claim C offsets for every little effort made
- Employ a risk factor of 20% to cover contingencies as suggested by CCX unless justify a lower risk
- Consider transaction costs, brokerage fees, and legal fees, if any

Potential Annual Revenue for Landowners*

Acreage	@ $1.00/ton C sequestered
2000 -Morton Arboretum	$360,000
20,000 -DuPage Co. Forest Preserve	$3,600,00
35,000 -DuPage Co. Parks&Golf Courses,	$6,300,000

Assumption:

Plant 300 trees per acre X 60% increased growth rate = 180 tons of C/Year/acre (1 tree = 1 ton of carbon) (after J.V. Sheaffer, Personal Communication,2007)

Path Forward

- Every organization should voluntarily try to reduce GHG emissions to the atmosphere to promote a sustainable world.
- Recommend that the District also like several public and private organizations look into undertaking a study to reduce C emissions and perhaps make money, if it hasn't yet done so.
- Hopefully, there is a Potential for Saving Money to the Taxpayers.