Anaerobic Wastewater Treatment for Energy Recovery and Emission Reduction : TNPL Case Study

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Anaerobic Wastewater Treatment for Energy Recovery and Emission Reduction : TNPL Case Study

1. About TNPL
2. Anaerobic Digestion
3. Greenhouse Effect and Climate Change
4. Biomethanation & Climate Change
5. Biomethanation In TNPL

1. About TNPL

About TNPL

- Promoted by the Govt. of Tamil Nadu during early eighties to manufacture Newsprint & fine paper using bagasse as primary raw material
- The largest bagasse based paper mill in the World. Consumes one million MT of bagasse every year
- Commenced the commercial production with a capacity of 90,000 tpa in 1985
- Increased the capacity to 1,80,000 tpa in 1996 by installing the second paper machine.
- Capacity increased to 2,30,000 tpa in 2002 through upgrade of paper machines
- As continual improvement, TNPL embarked on a Mill development plan at a cost of Rs.565 Crores to become environmentally benign by implementing Elemental Chlroine Free (ECF) bleaching sequence in the inhouse pulping lines


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18 09 2004

UNLOADING OF BAGASSE (TIPPLER)

STACKING OF BAGASSE (BOOM STACKER)

FEEDING OF BAGASSE IN THE CONVEYOR BY FRONT END LOADER

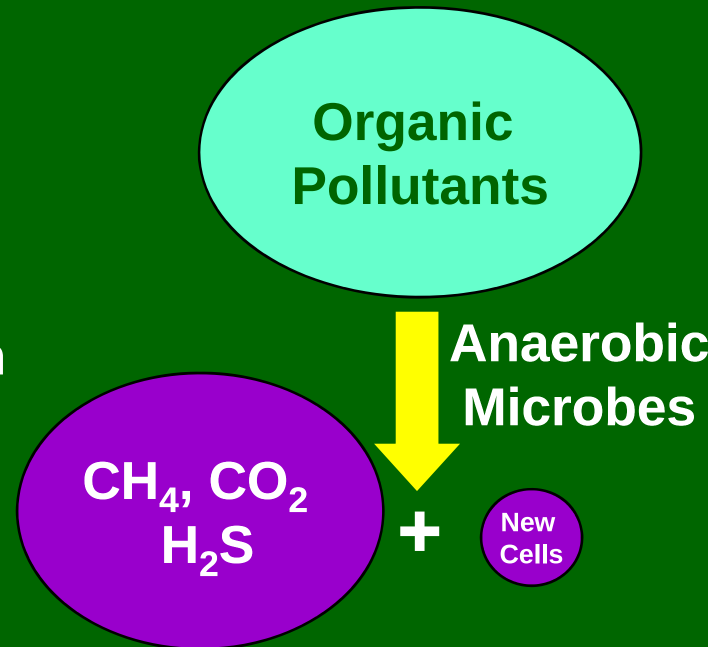
END PRODUCT OF PULP MILL

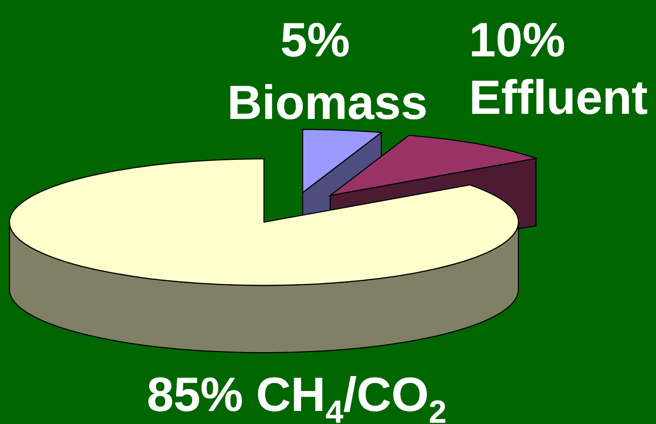
VIEW OF PAPER MACHINE - II (VOITH)

2. Anaerobic Digestion

Why Anaerobic Digestion !

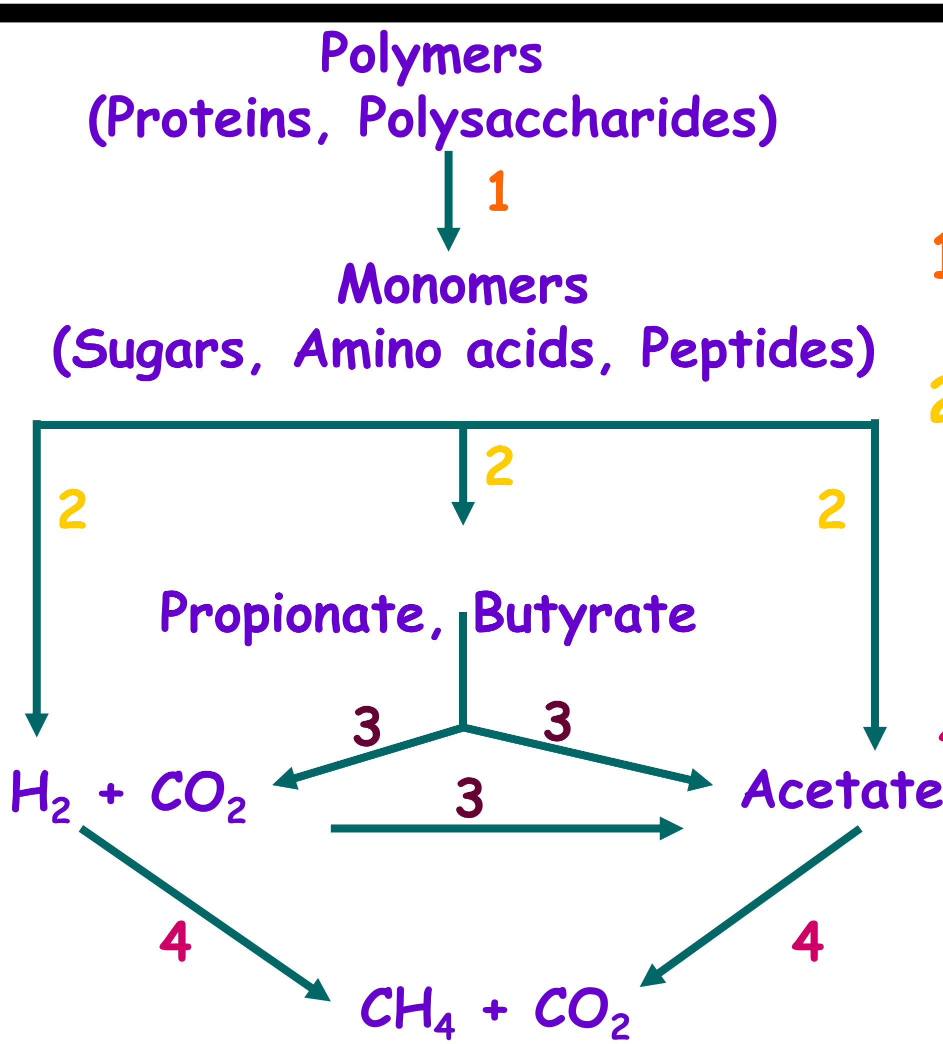
Biodegradable pollutants in the wastewater are converted to biogas containing methane, carbon dioxide and biomass (little) in the absence of oxygen by Anaerobic microorganisms





Net energy surplus is generated during AD in the form of CH_4 bearing biogas

Metabolic Stages of Anaerobic Digestion



1. Hydrolytic Bacteria
2. Fermentative Bacteria
3. Acetogenic Bacteria
4. Methanogenic Bacteria

Types of Anaerobic Reactors

Low rate anaerobic reactors

- Anaerobic Lagoon
- Septic tank
- Standard rate anaerobic digester

Slurry type bioreactor, temperature, mixing, SRT or other environmental conditions are not regulated. loading of 1-2 kg COD/m^3-day.

High rate anaerobic reactors

- Anaerobic contact process
- Anaerobic filter (AF)
- Upflow anaerobic sludge Blanket (UASB)
- Fluidized bed Reactor
- Hybrid reactor: UASB / AF

Able to retain very high concentration of active biomass in the reactor. Thus extremely high SRT could be maintained irrespective of HRT. Load 5-20 kg COD/m^3-d COD removal efficiency : 80-90%.

Upflow Anaerobic Sludge Blanket (UASB)

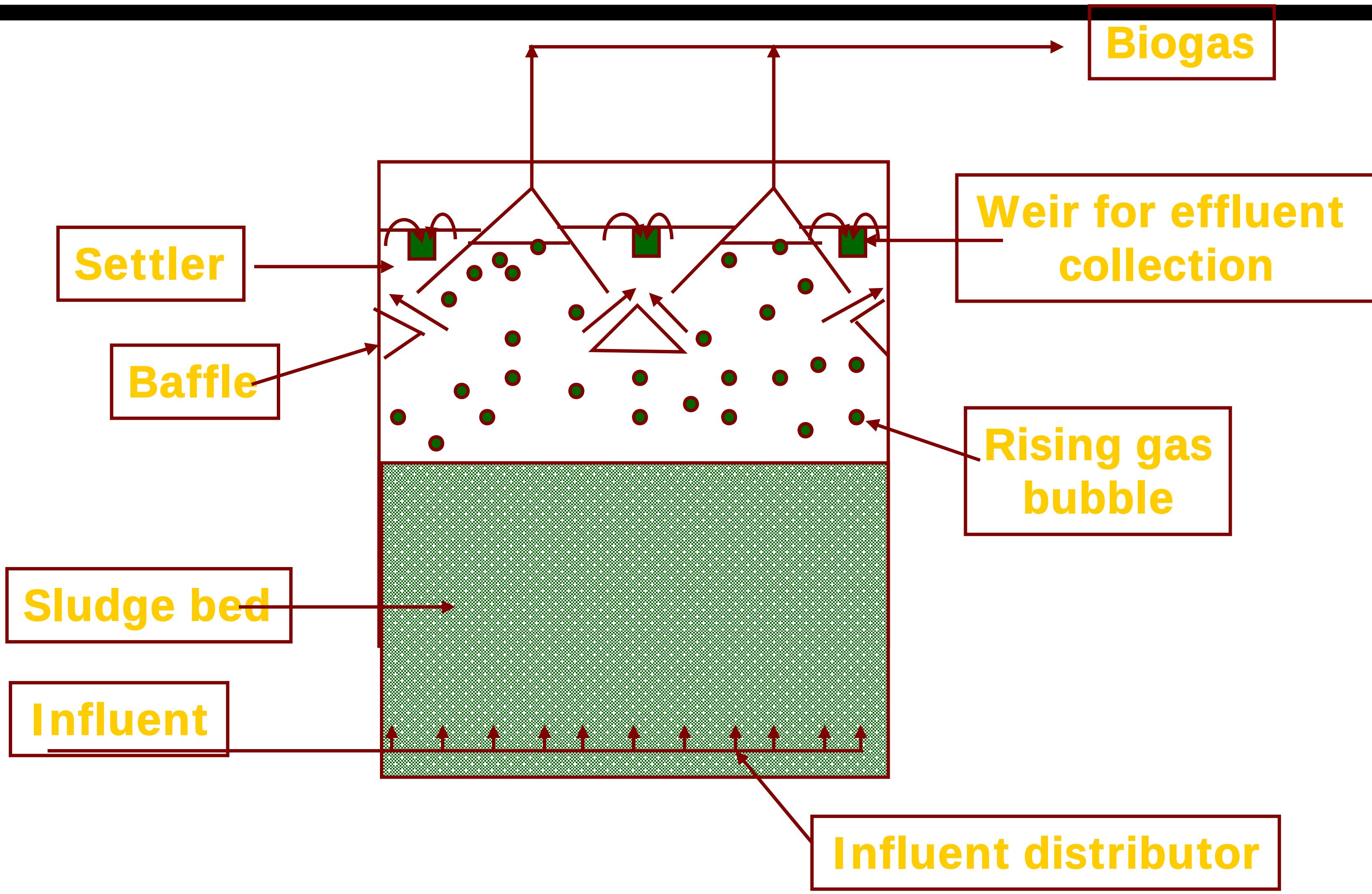
UASB was developed in 1970s by Dr. G. Lettinga in the Netherlands

It is a special kind of reactor concept for high rate anaerobic treatment of wastewater

It is essentially a suspended growth system in which proper hydraulic and organic loading rate is maintained in order to facilitate the formation of granules

The granules consist of hydrolytic bacteria, acidogen/acetogens and methanogens

UASB REACTOR



Essential Conditions for Anaerobic Treatment

1. No excessive air/O_2 exposure, pH (6.8 - 7.8), Temp. 30 to 38^oC, Alkalinity >1500 ppm
2. No toxic/inhibitory compounds in the influent
3. Enough nutrients (COD:N:P = 500:7:1) and trace metals especially, Fe, Co, Ni, etc.

Best Candidates of Industrial Wastewater for Anaerobic Treatment

- Alcohol production & Brewery
- Sugar processing
- Starch (barley, corn, potato, wheat, tapioca) and desizing waste from textile industry.
- Food processing & Slaughter house
- Pulp and paper
- Petrochemical waste

Process Advantage

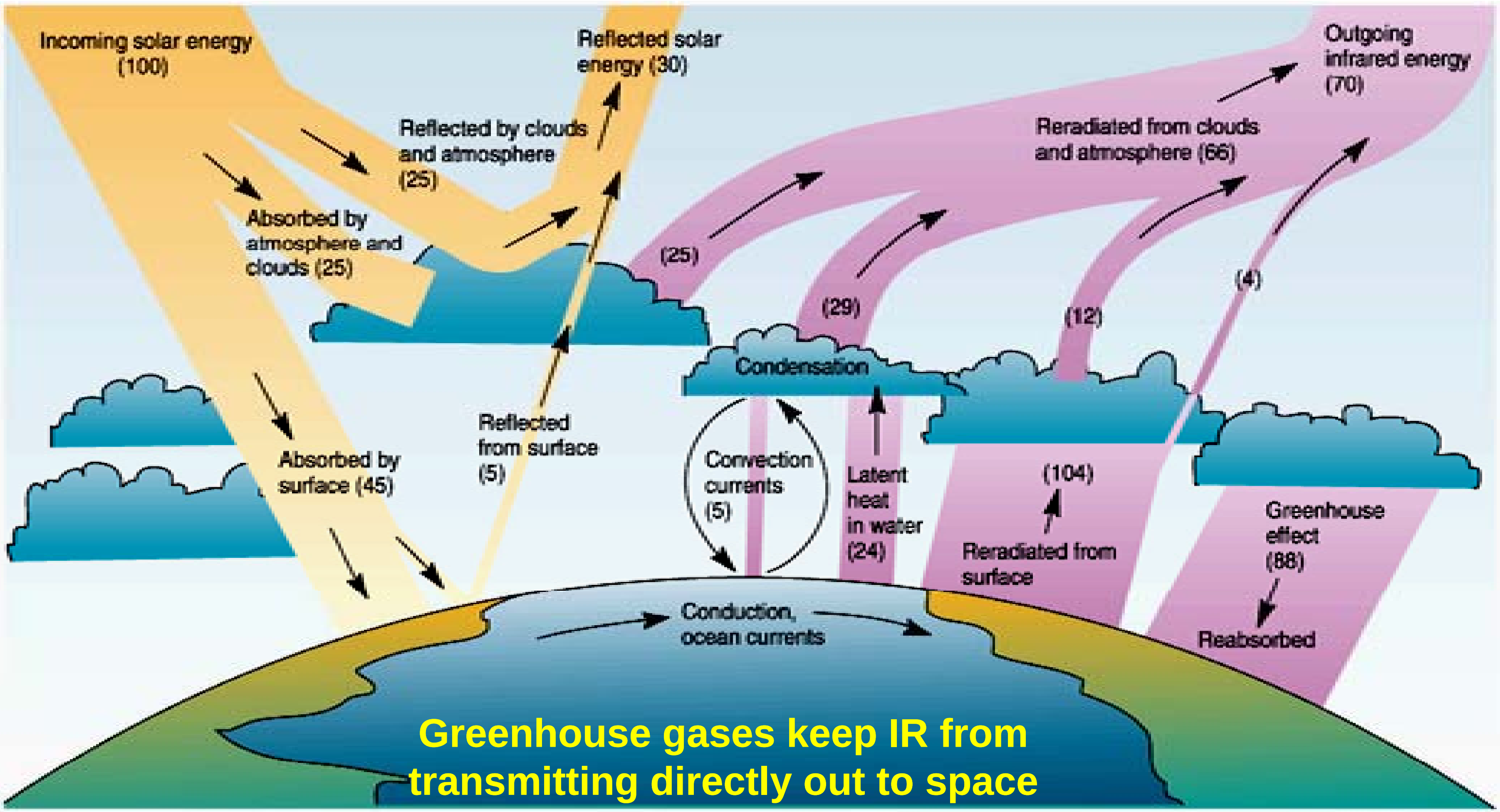
1. Less energy requirement, because no aeration is needed
2. Energy generation in the form of methane gas
3. Less biomass (sludge) generation
4. Less nutrients (N & P) requirement because of low biomass
5. Higher organic loading rate
6. Space saving due to high organic loading

Limitations of Anaerobic Process

1. Long start-up time due to low biomass yield
2. Long recovery time due to low biomass yield
3. Specific nutrients/trace metal requirements
4. More susceptible to pH, temperature and redox potential
5. Quality of treated wastewater

3. Greenhouse Effect and Climate Change

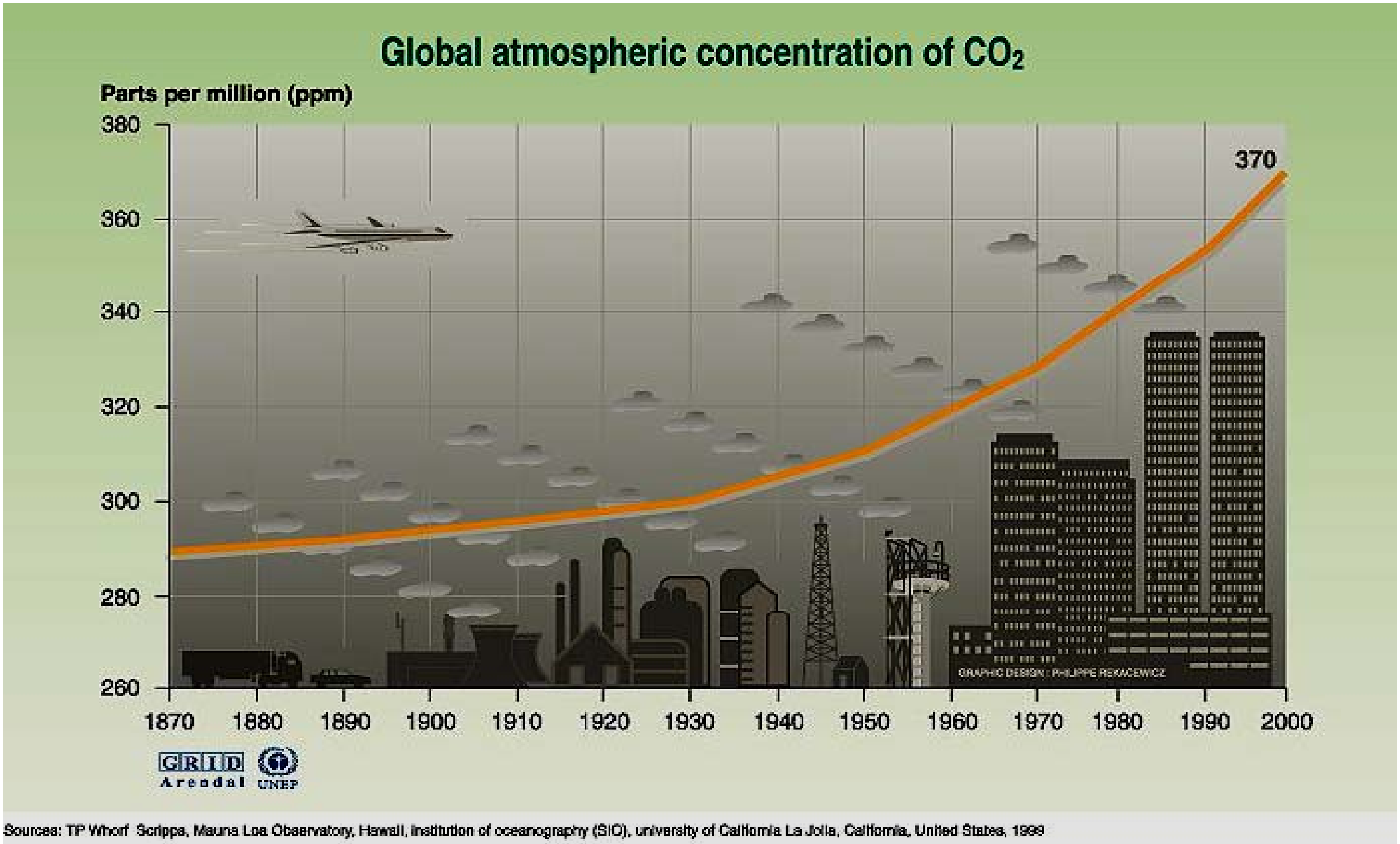
Greenhouse Effect



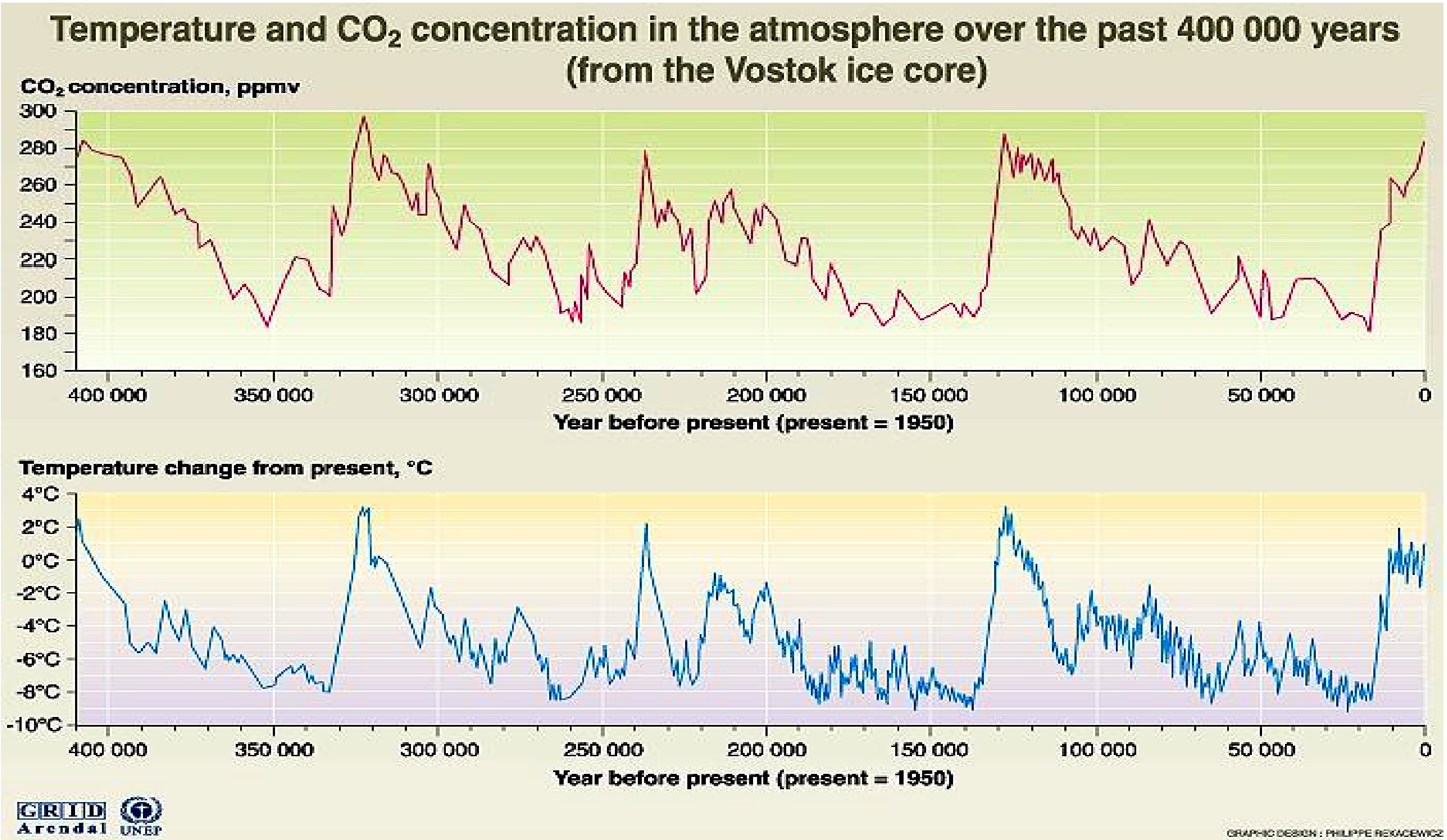
GHG in Atmosphere

GHG Name	Pre-industrial Concentration	Concentration in 1994	life time (years)	GWP
Carbon –di- Oxide	278 ppmv	377 ppmv	Variable	1
Methane	700 ppbv	1783 ppbv	12.2	21
Nirous Oxide	275 ppbv	318 ppbv	120	310
CFC-12	0	0.503 ppbv	102	6200-7100
HCFC-22	0	0.105 ppbv	12.1	1300-1400
Perfluromethane	0	0.070 ppbv	50000	6500
Sulphur hexa-fluride	0	0.032 ppbv	3200	23900

CO_2 in Atmosphere

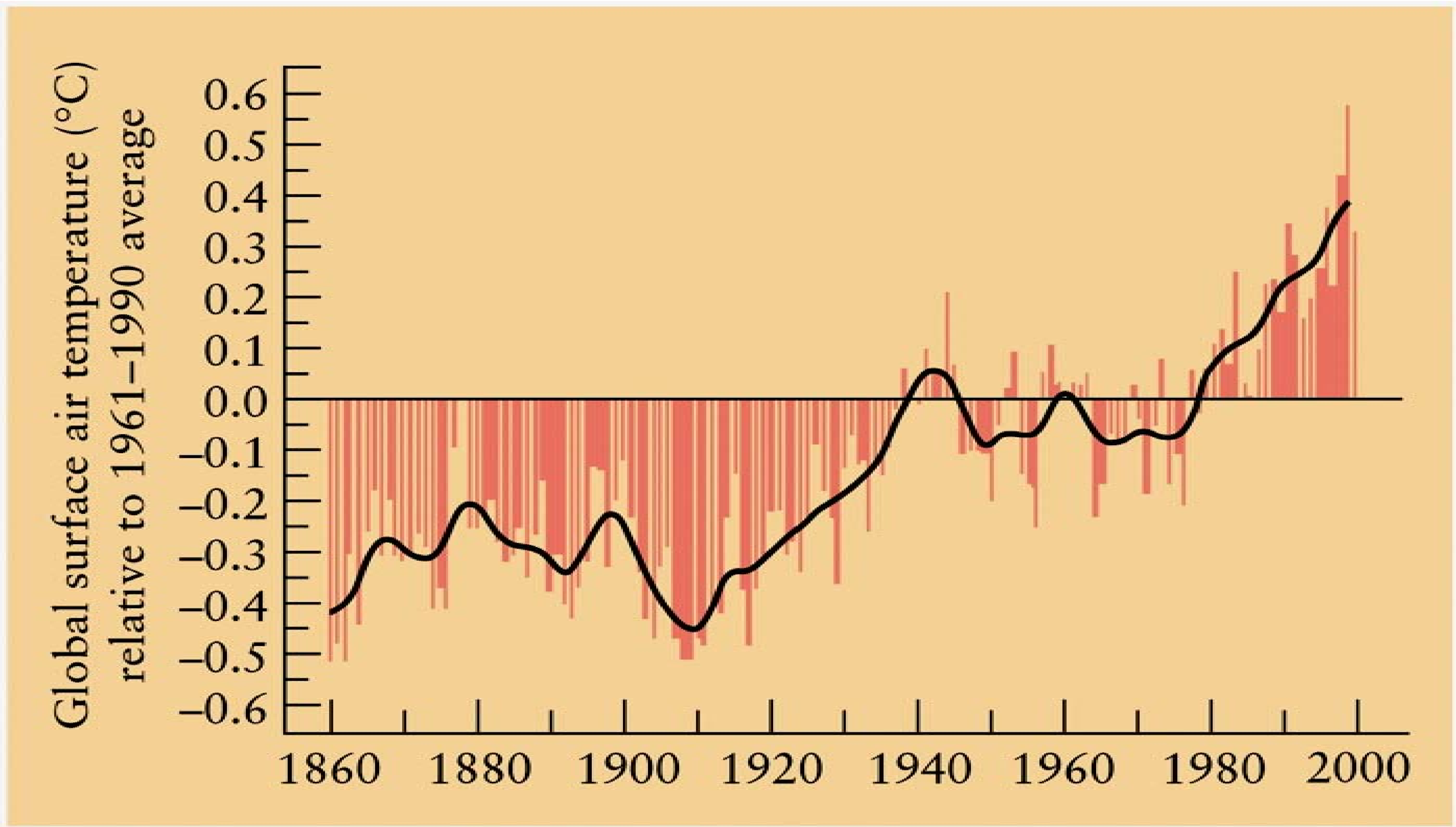


GHG and Global Warming

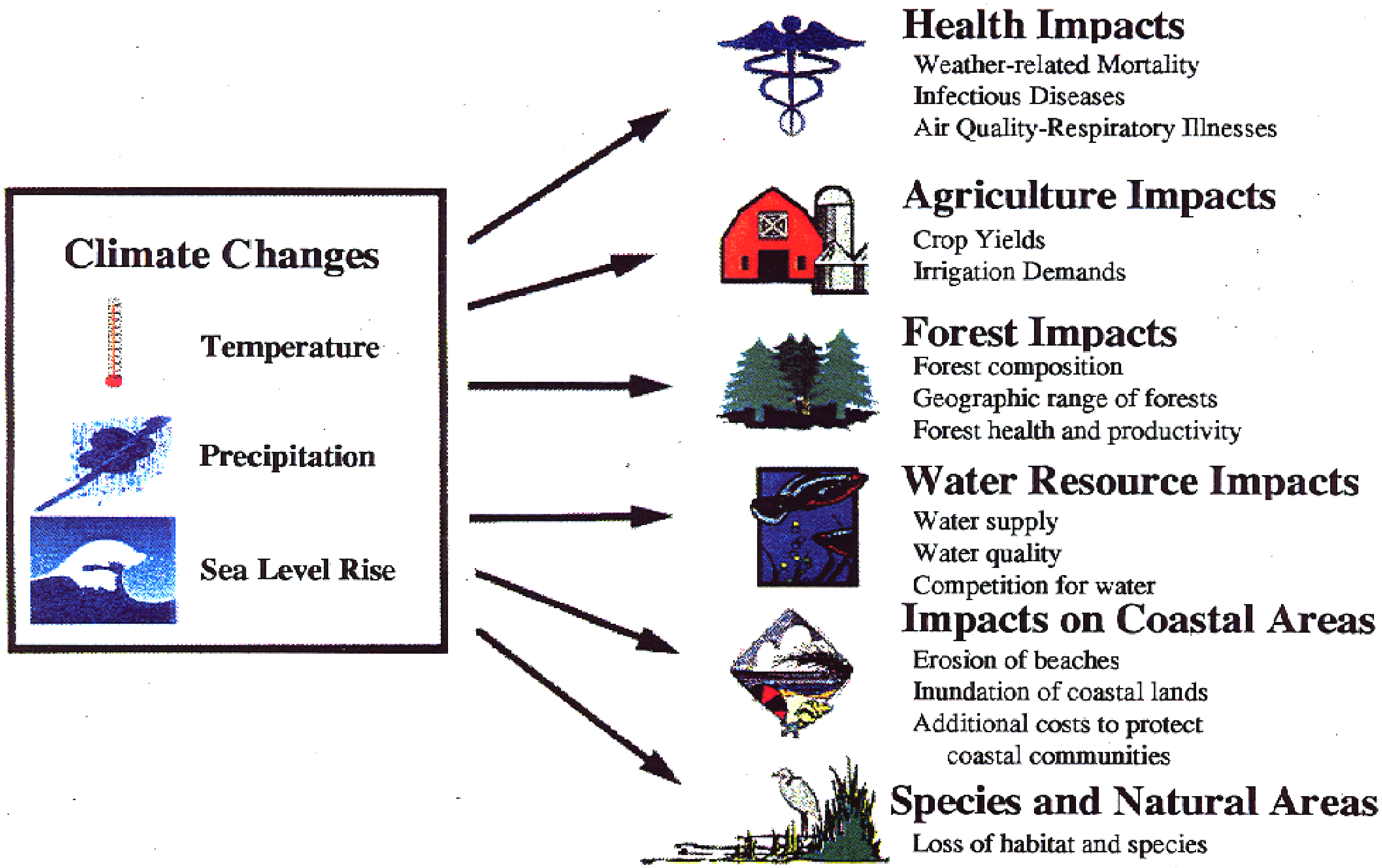


Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

Atmosphere is warming ?



Impacts



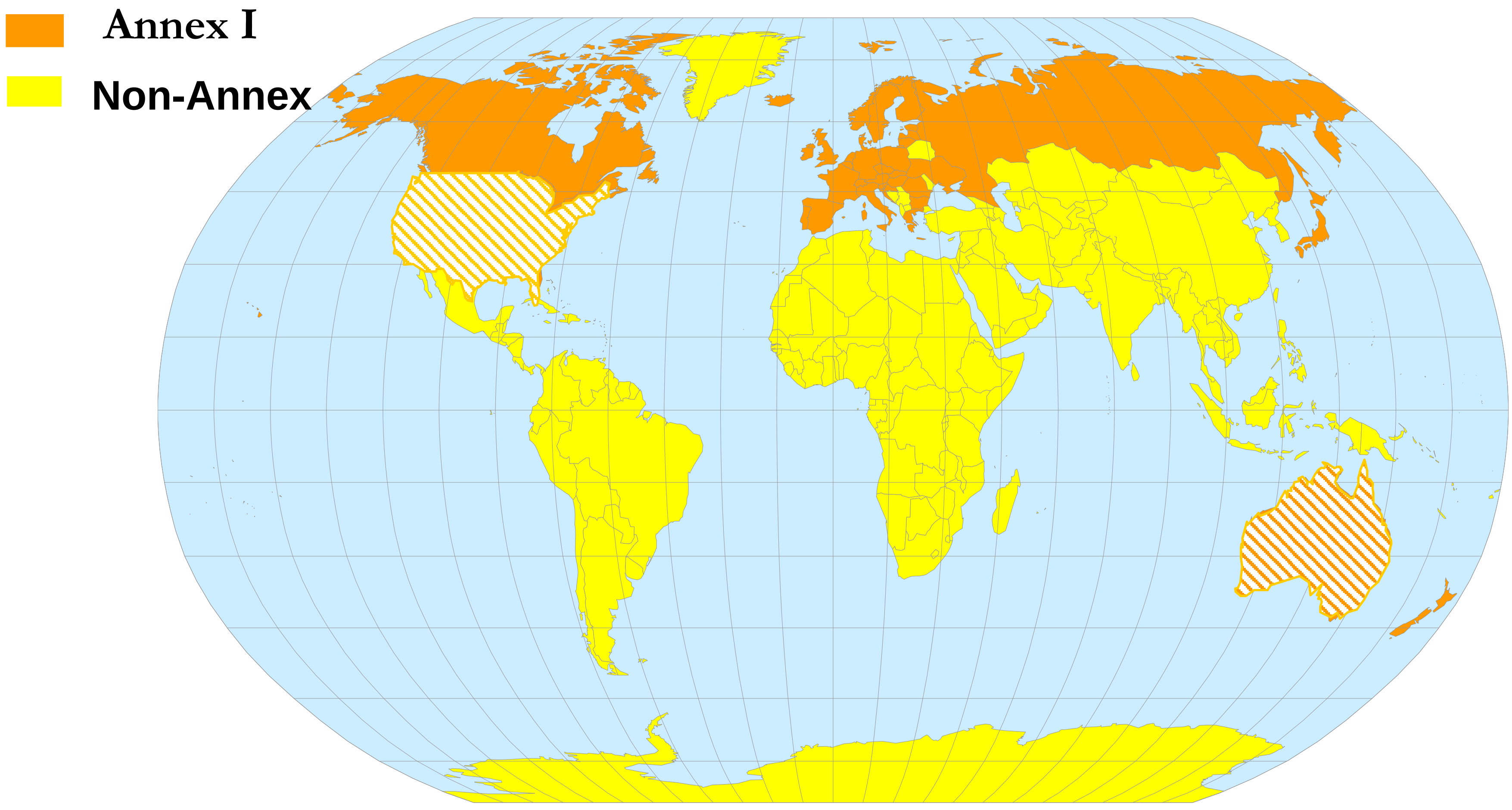
Climate Changes
Temperature
Precipitation
Sea Level Rise
Health Impacts
Weather-related Mortality
Infectious Diseases
Air Quality-Respiratory Illnesses
Agriculture Impacts
Crop Yields
Irrigation Demands
Forest Impacts
Forest composition
Geographic range of forests
Forest health and productivity
Water Resource Impacts
Water supply
Water quality
Competition for water
Impacts on Coastal Areas
Erosion of beaches
Inundation of coastal lands
Additional costs to protect coastal communities
Species and Natural Areas
Loss of habitat and species

International Efforts

United Nations Framework Convention on Climate Change (UNFCCC)

- **Ultimate objective of stabilizing global greenhouse gas concentrations in the atmosphere**
- **Developed countries (Annex I countries) *aim to restore GHG emissions to 1990 levels and less***
- **Support capacity building in, and facilitate technology transfer to developing countries to mitigate, and to adapt to climate change**

Polluter Should Pay



Promises Made

Kyoto Protocol: 36 Developed Countries and Economies in Transition (namely Canada, Japan, European Union and most East European countries) agree to:

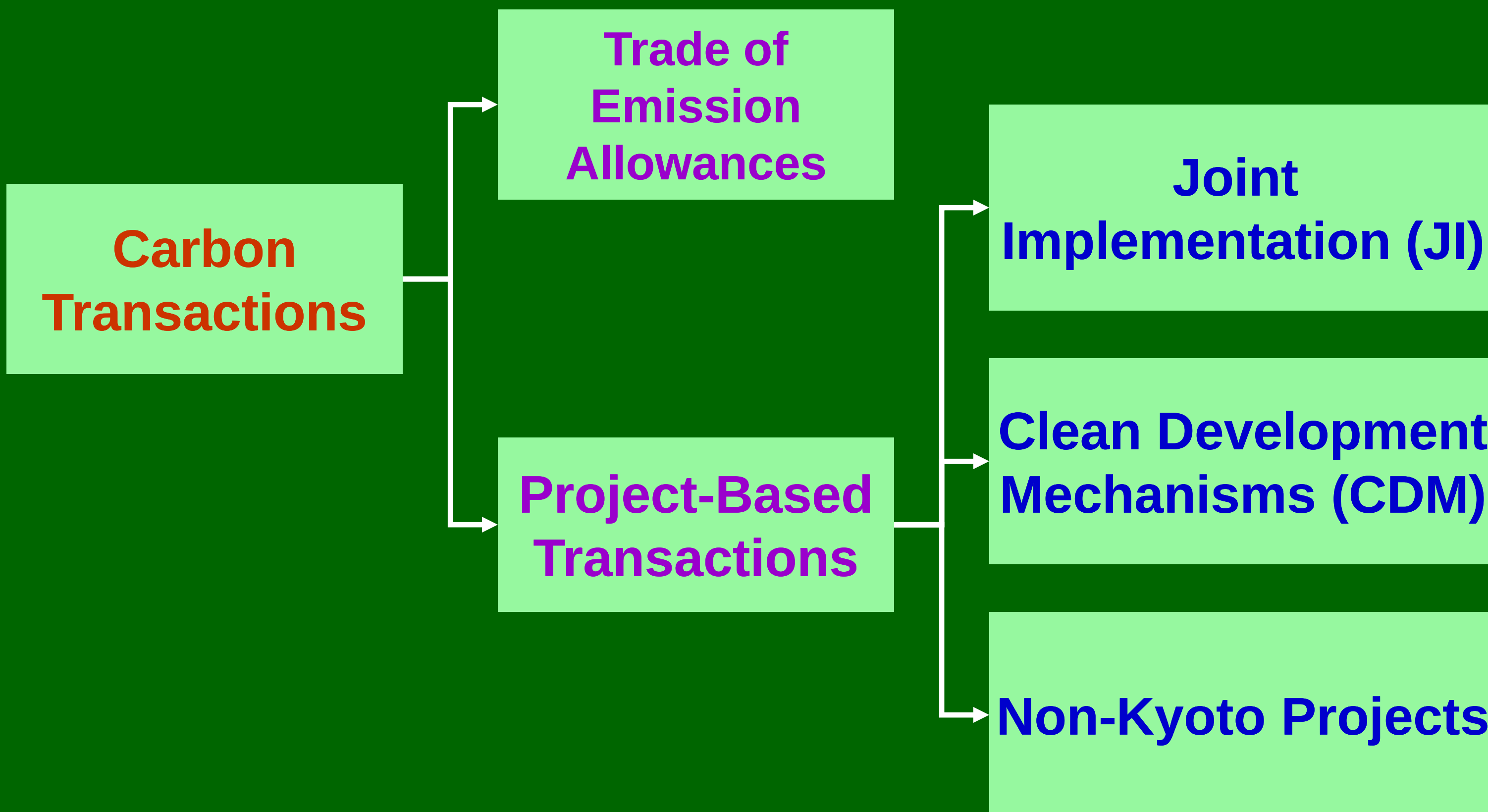
- **Reduce GHG emissions by 5.2 % below 1990 levels in the commitment period 2008-2012**
- **Marrakech Accord: agreed in Nov 2001 sets rules of implementation**
- **Required ratification of 55 Parties to UNFCCC representing 55 % of CO_2 emissions from developed countries**
- **Came into force February 16, 2005**
- **As of February 2006, 162 states ratified representing 66.1% developed countries emission**

Solutions !

How can Developed Countries/EITs meet their obligations under Kyoto?

- **Domestic Emission Reductions**
- **Carbon Sinks: Direct human-induced land use change and forestry activities (limited to ~330 Mt/CO_2e)**
- **International Emissions Trading**
- **Project Based: Joint Implementation**
  Clean Development Mechanism

Market Based Mechanism !



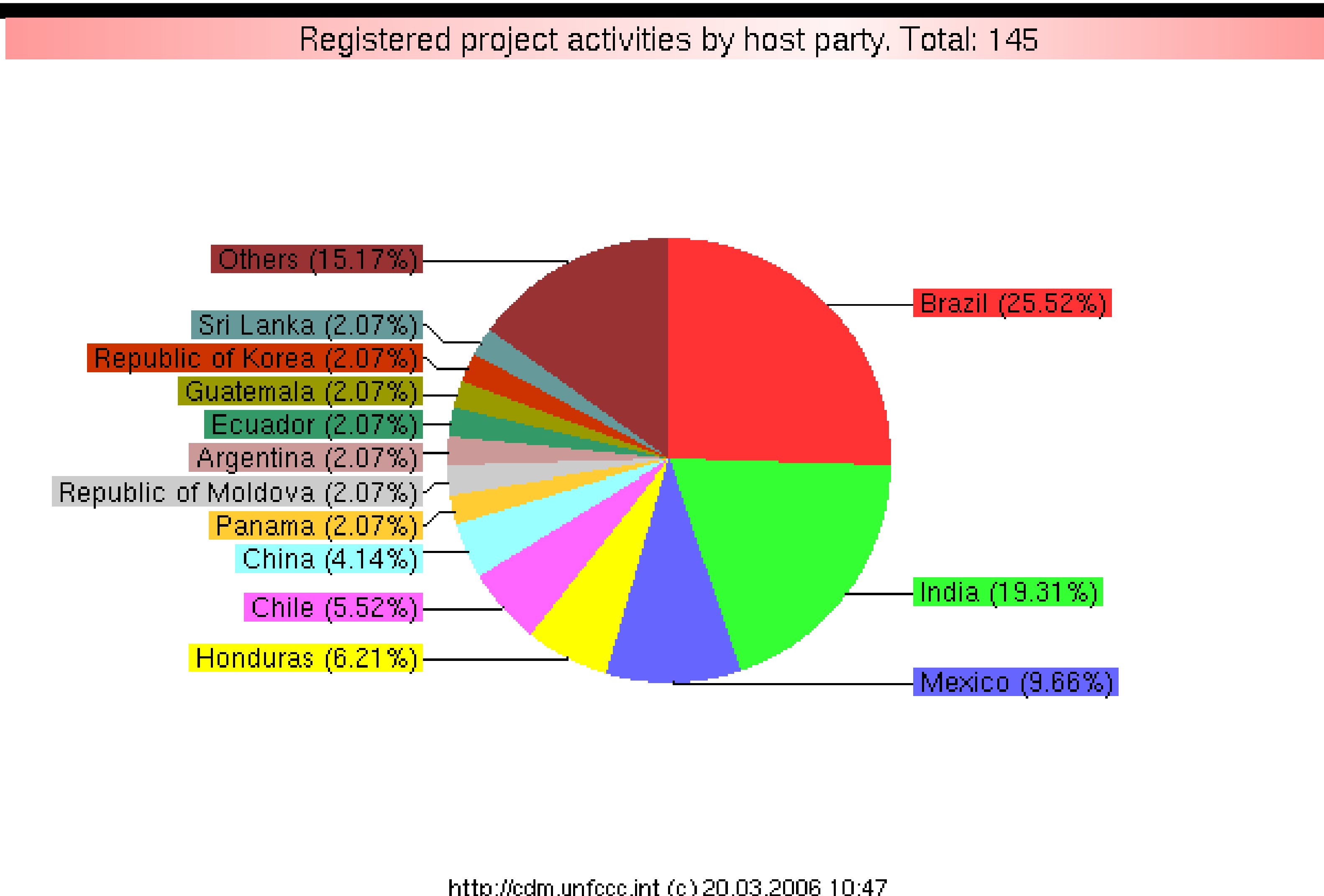
Type of Projects

1. Installations based on renewable energy (Geo thermal, wind, solar, biomass, small hydro etc.)
2. Fuel switch to lower carbon intensive fuels (electricity, heat sector)
3. Combined heat and power projects
4. Transport sector
5. Land fills gas recovery (methane emission avoidance & use)
6. Waste & Wastewater handling (methane emission avoidance and use)
7. Reforestation and Afforestation (A/R) projects (carbon sequestration).

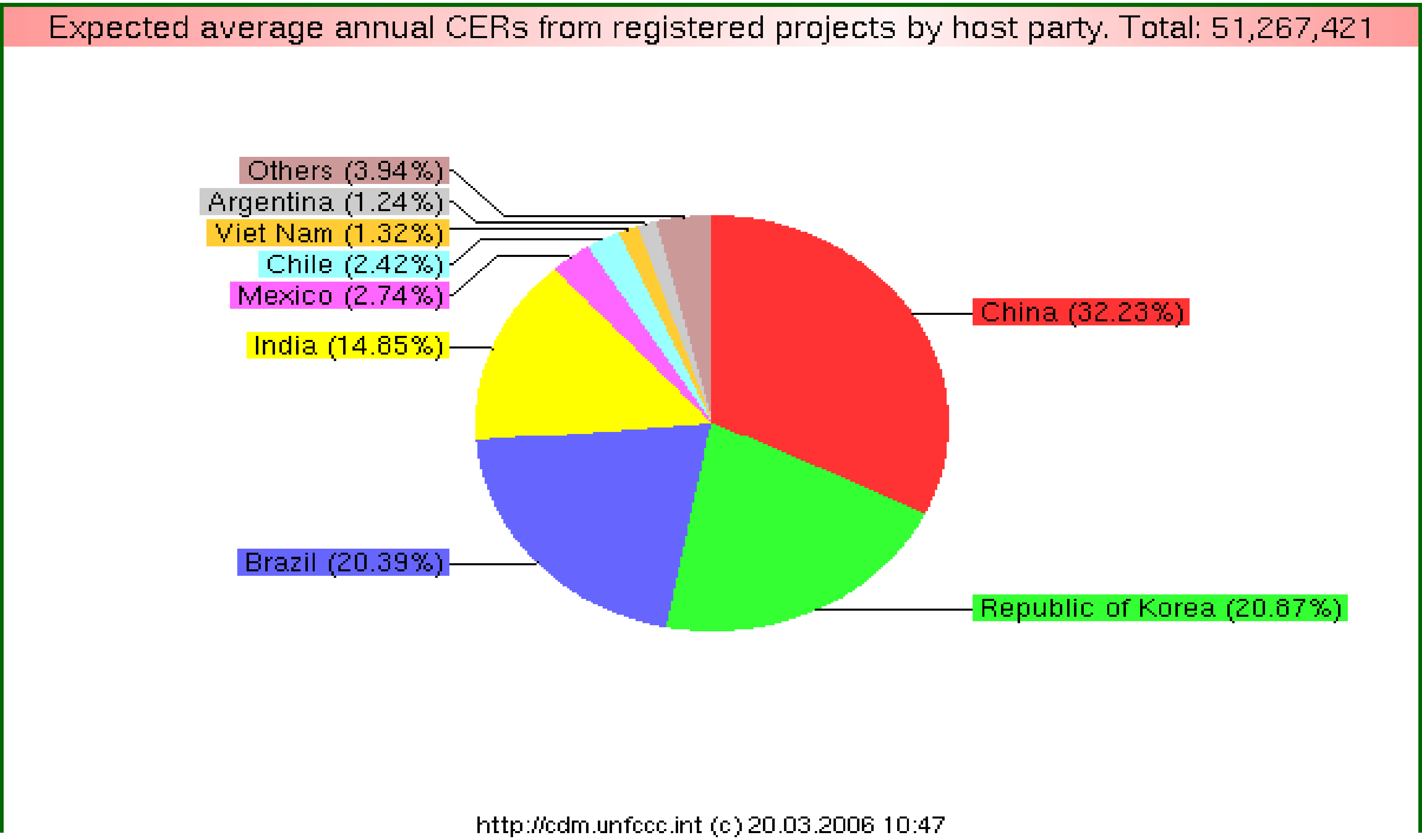
Project Cycle

• Project Design	Project Participant (PP)
• Validation /	Designated Operating Entity (DOE)
• Registration	Executive Board
• Monitoring	Project Participant (PP)
• Verification / Certification	Designated Operating Entity (DOE)
• CER Issuance	Executive Board (EB)

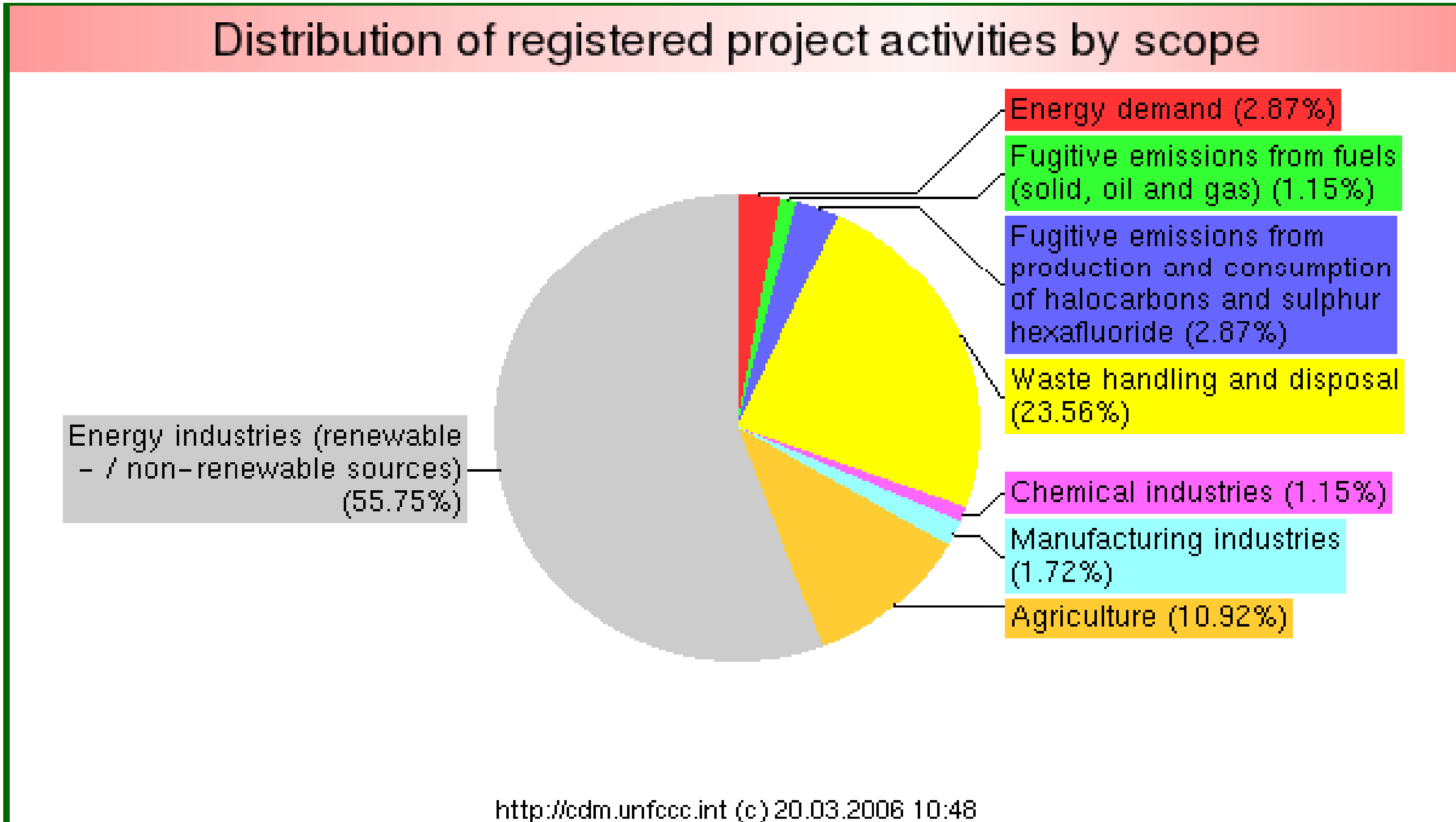
Registered Projects by Country



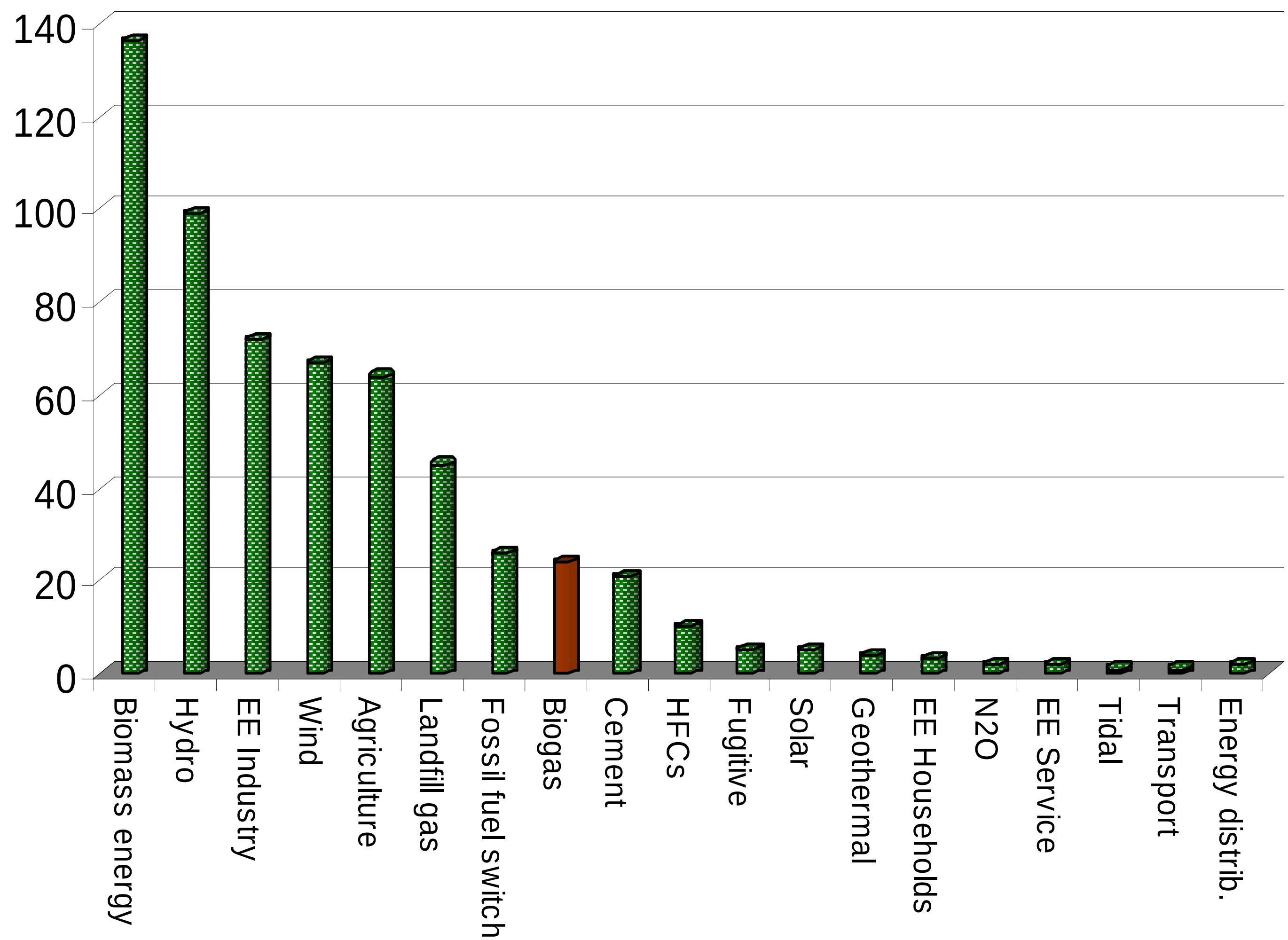
CERs from Registered Projects by Country



Registered Projects by Sector



CDM Projects in Pipeline



4. Biomethanation & Climate Change

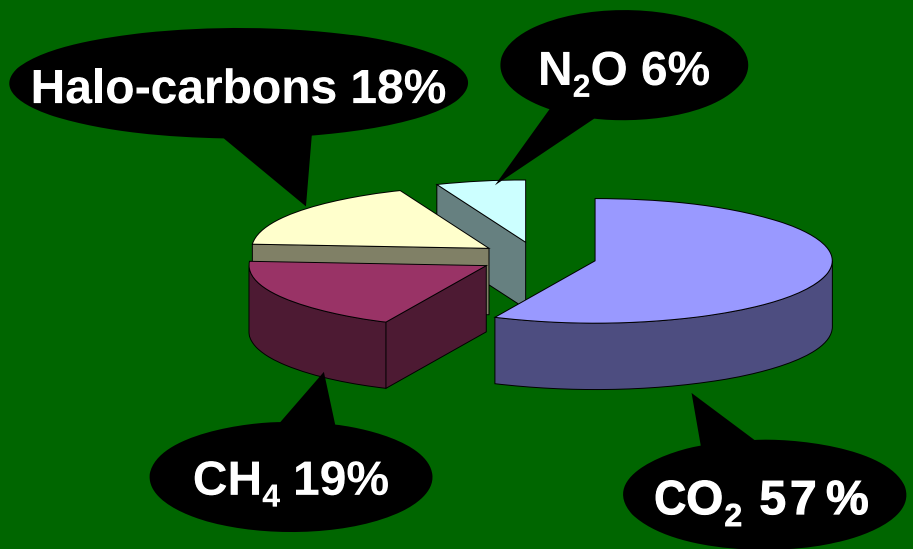
Methane and Climate Change

Methane:
Most abundant greenhouse gas after CO_2 in the atmosphere

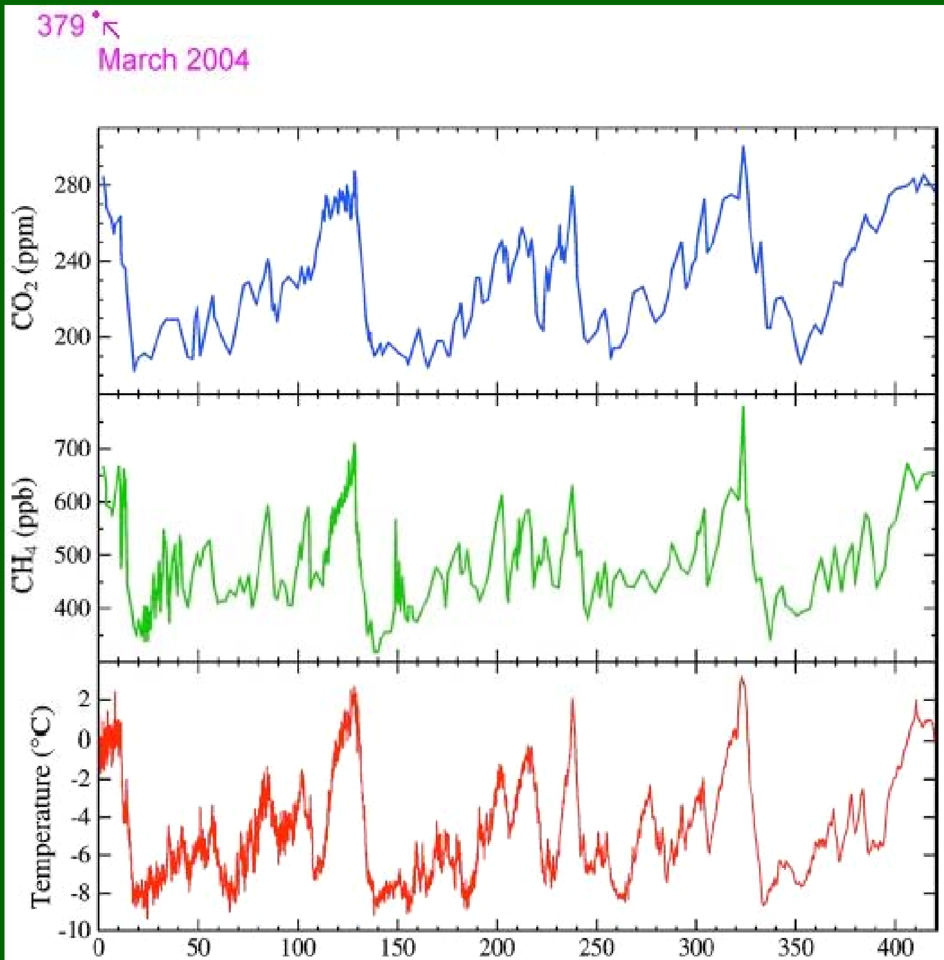
Concentrations is increasing from pre -industrial times (now :1783 ppbv)

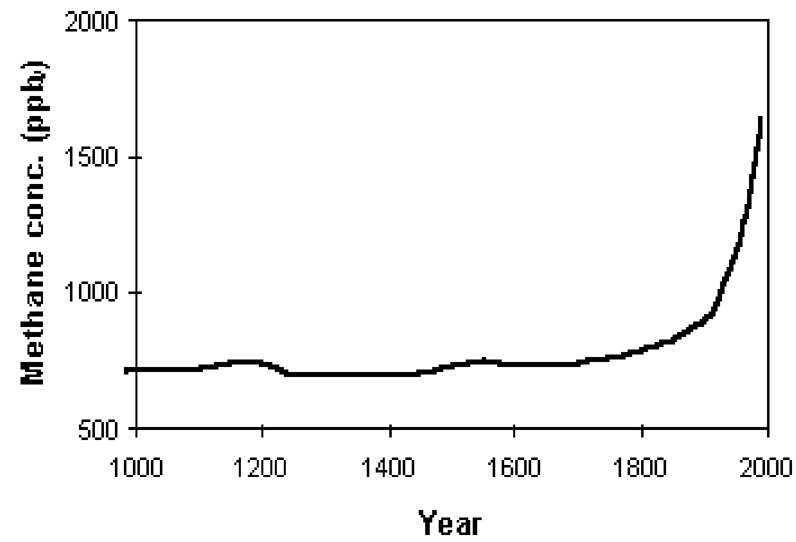
23 times more Global warming potential than CO_2

Contribution to Global Warming



Methane in Atmosphere





GHG Increase From 1750

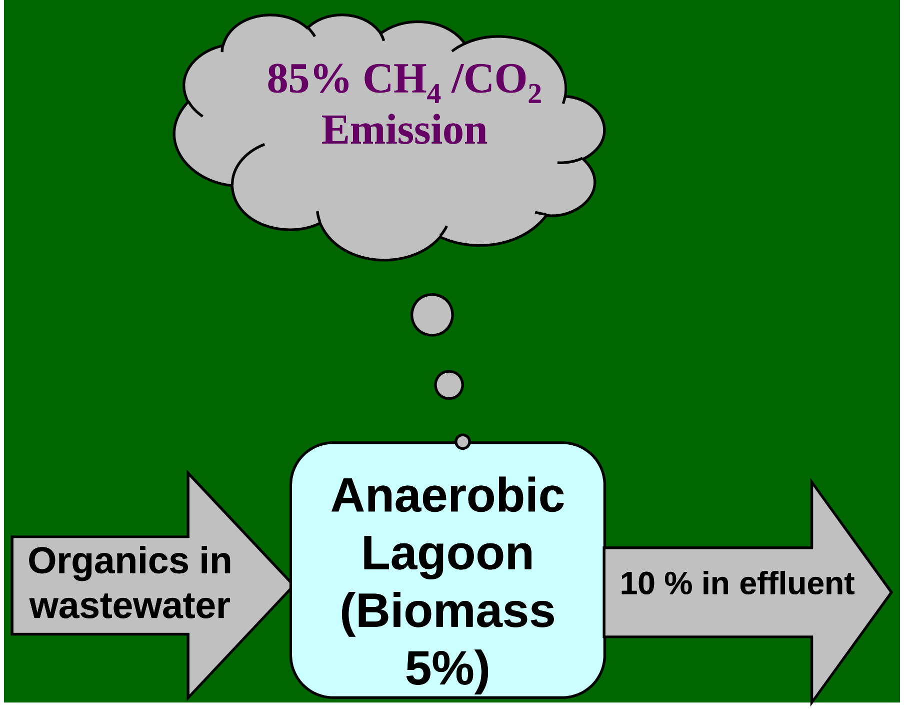
CO_2 :35%

CH_4 :155%

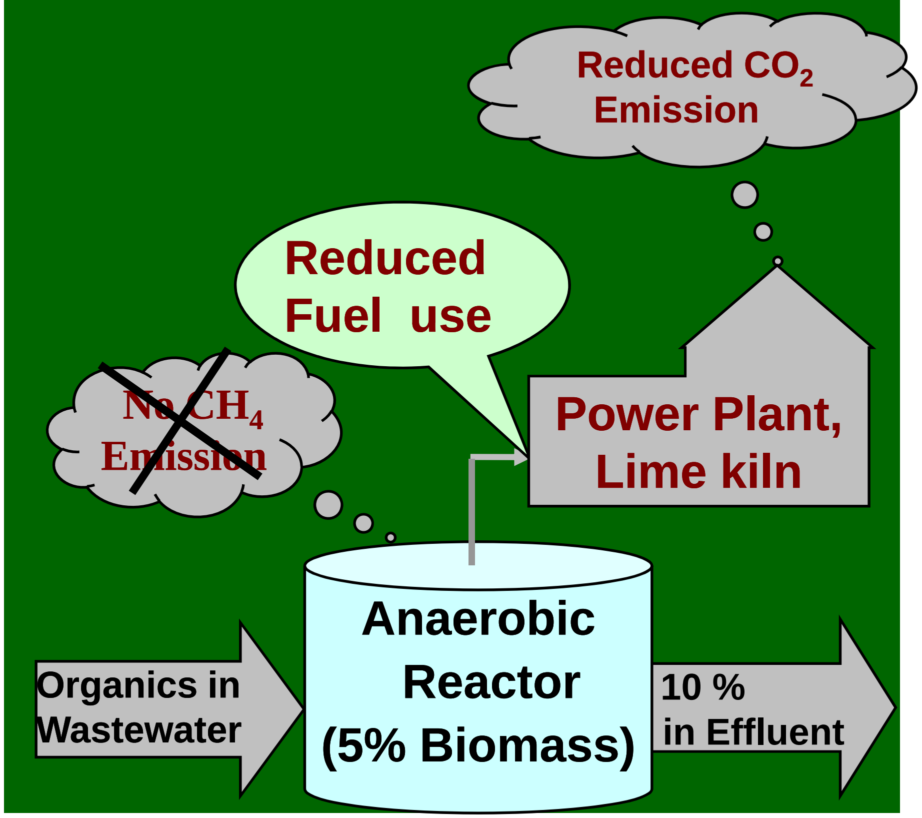
N_2O :18%

Anaerobic Treatment for Emission or Energy ?

Conventional Uncontrolled Anaerobic Digestion

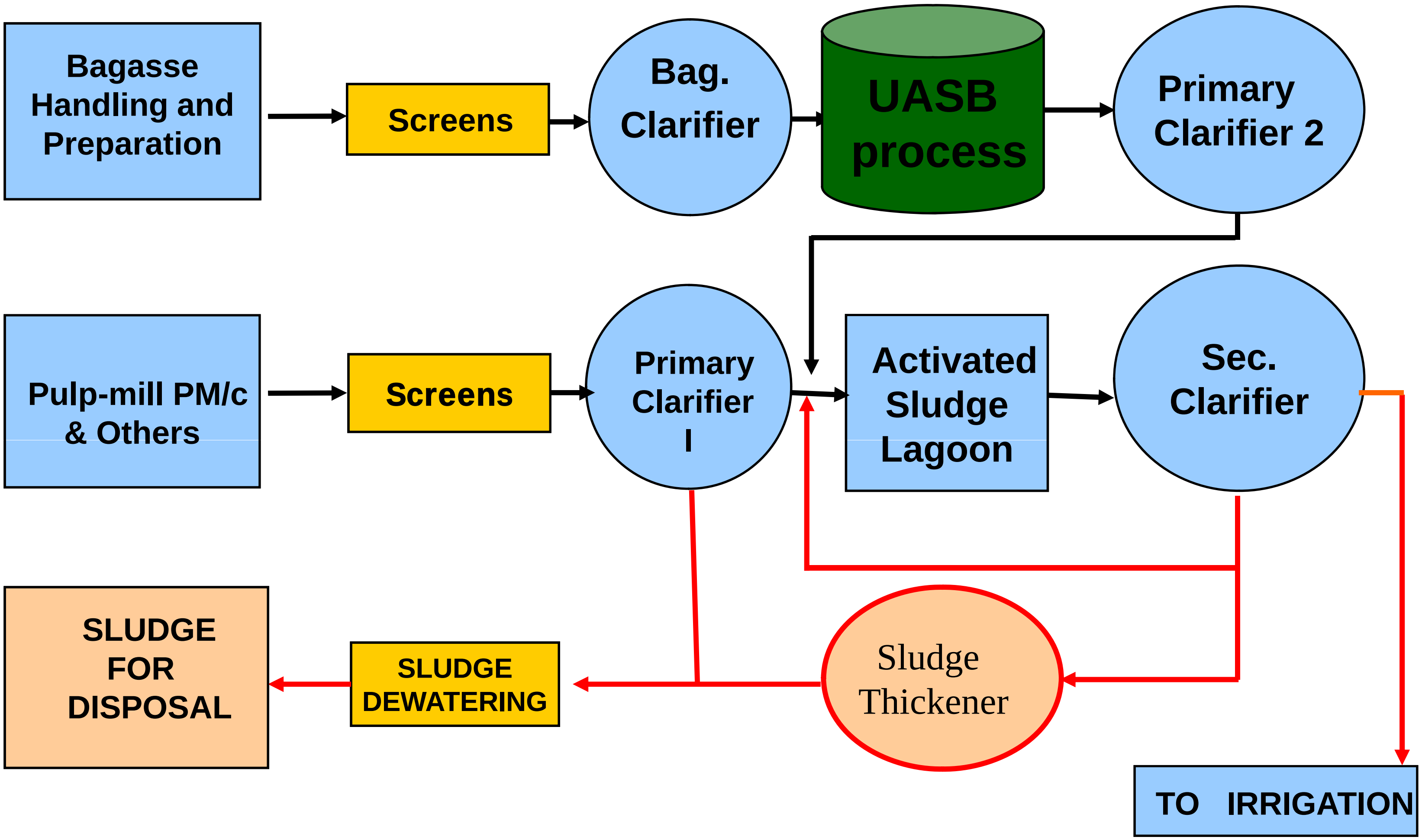


Controlled Anaerobic Digestion (UASB)

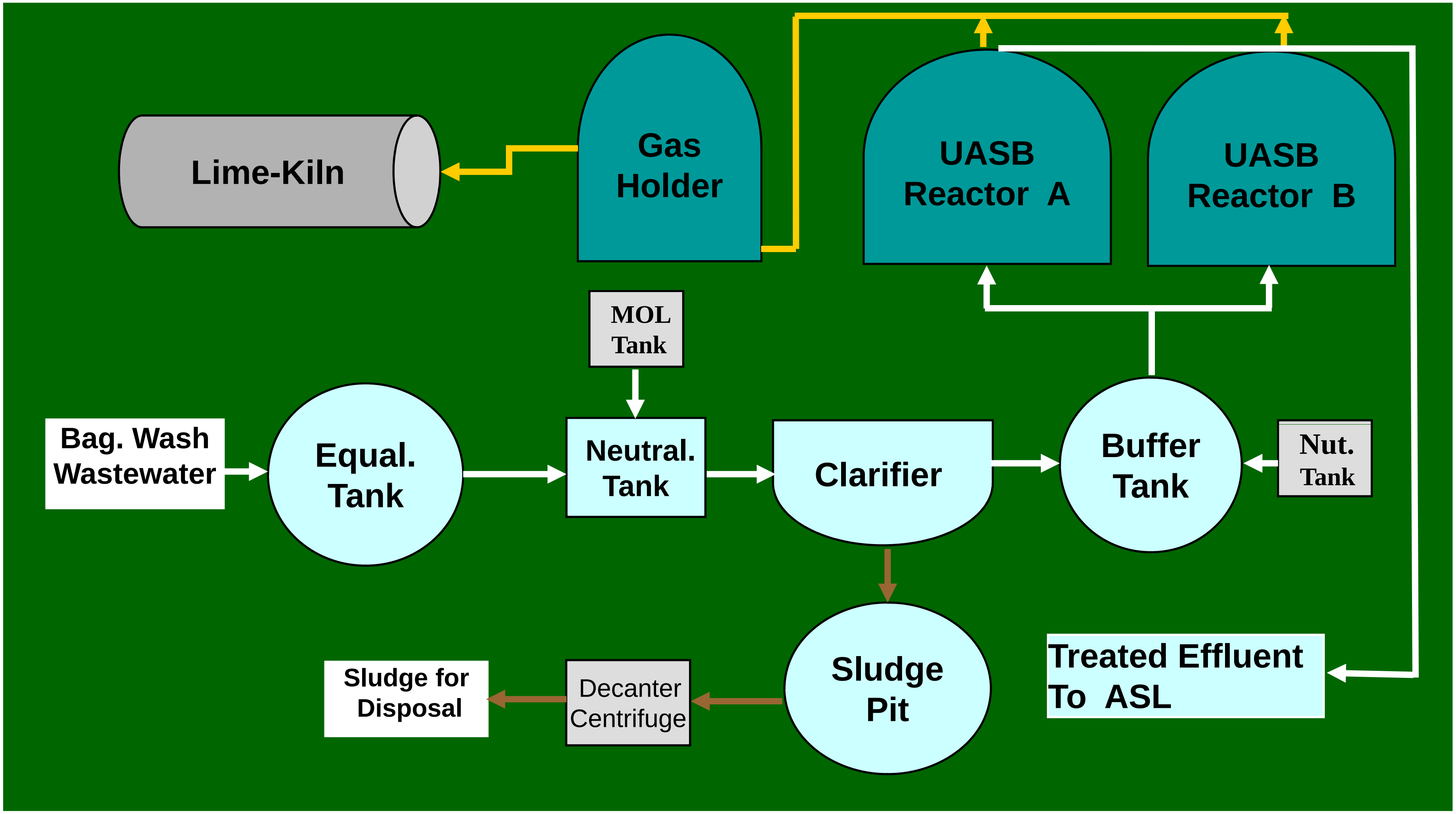


5. Biomethanation In TNPL

TNPL ETP Process Flow Diagram



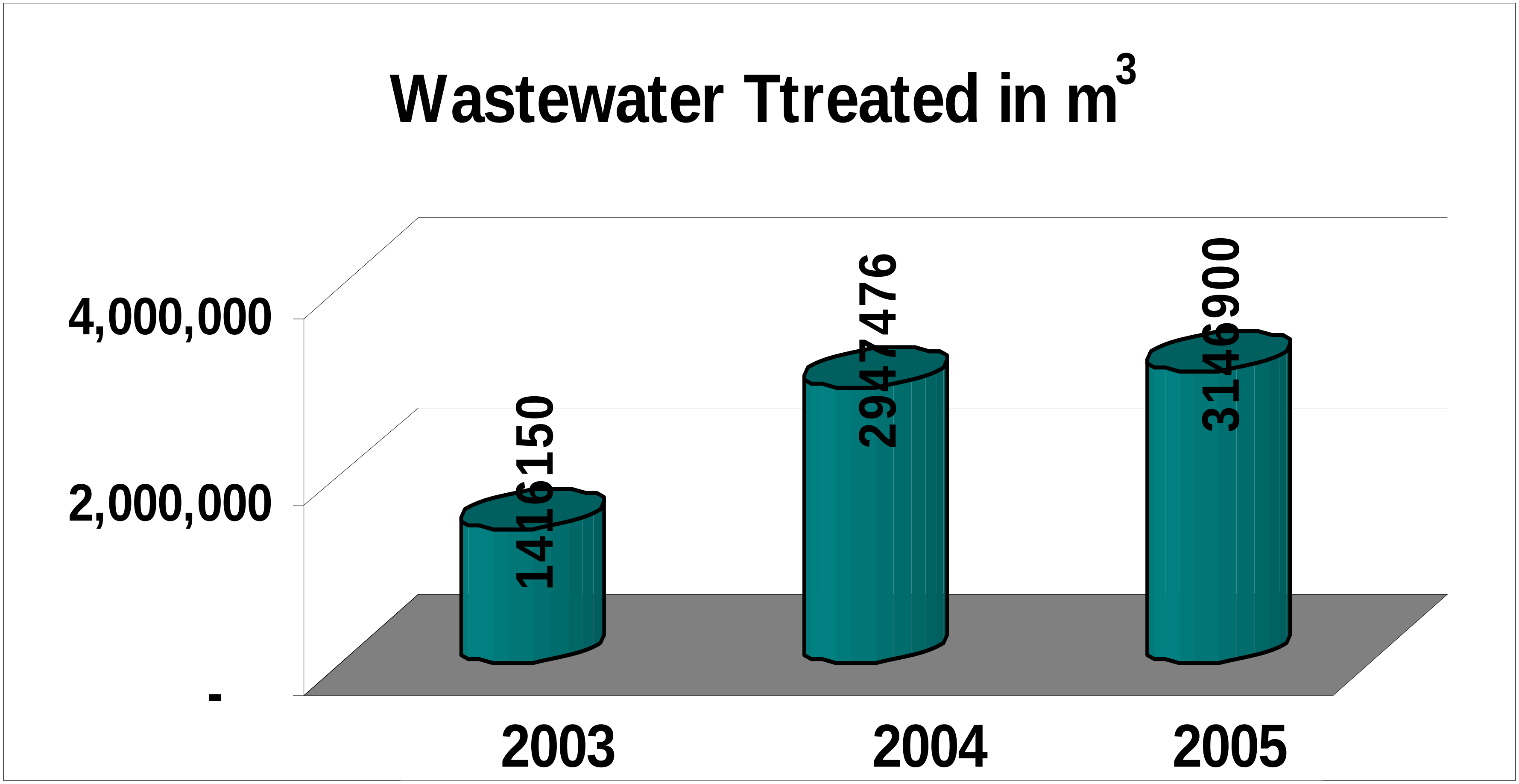
TNPL Biogas Process Flow Diagram



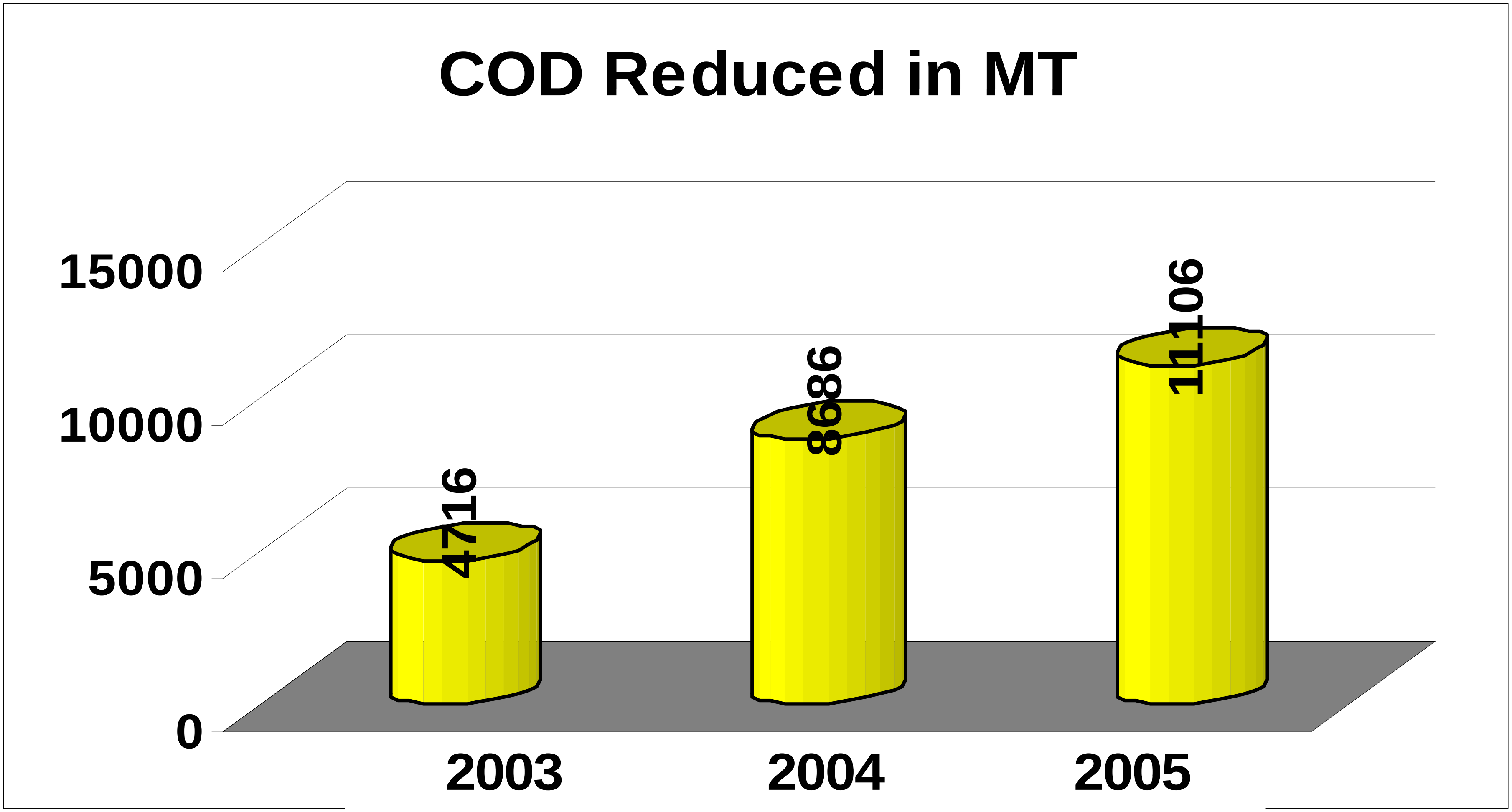
Biogas Plant Design

COD Load	: 57.6 T/Day
Hydraulic Retention Time	: 20 hrs
Reactor Volume	: 2 X 5,000 m^3
Volumetric Loading Rate	: 6.0 kg COD/m^3/Day
COD Reduction	: 85%
Gas Production Factor	: 0.47 m^3/kgCODr
Gas Production	: 23,000 m^3/Day
Flow	: 12,000 m^3/Day

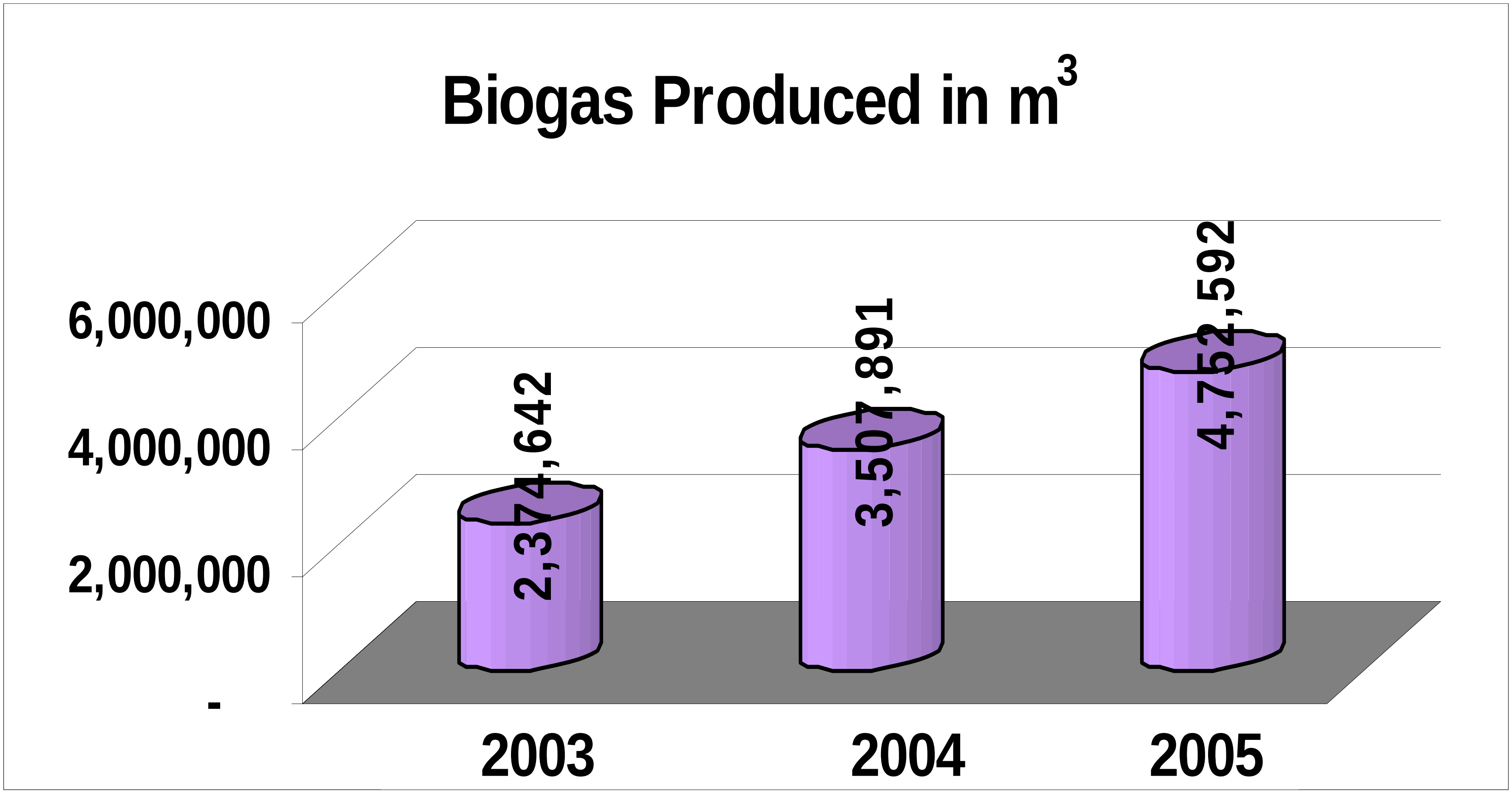
Biogas Plant Performance



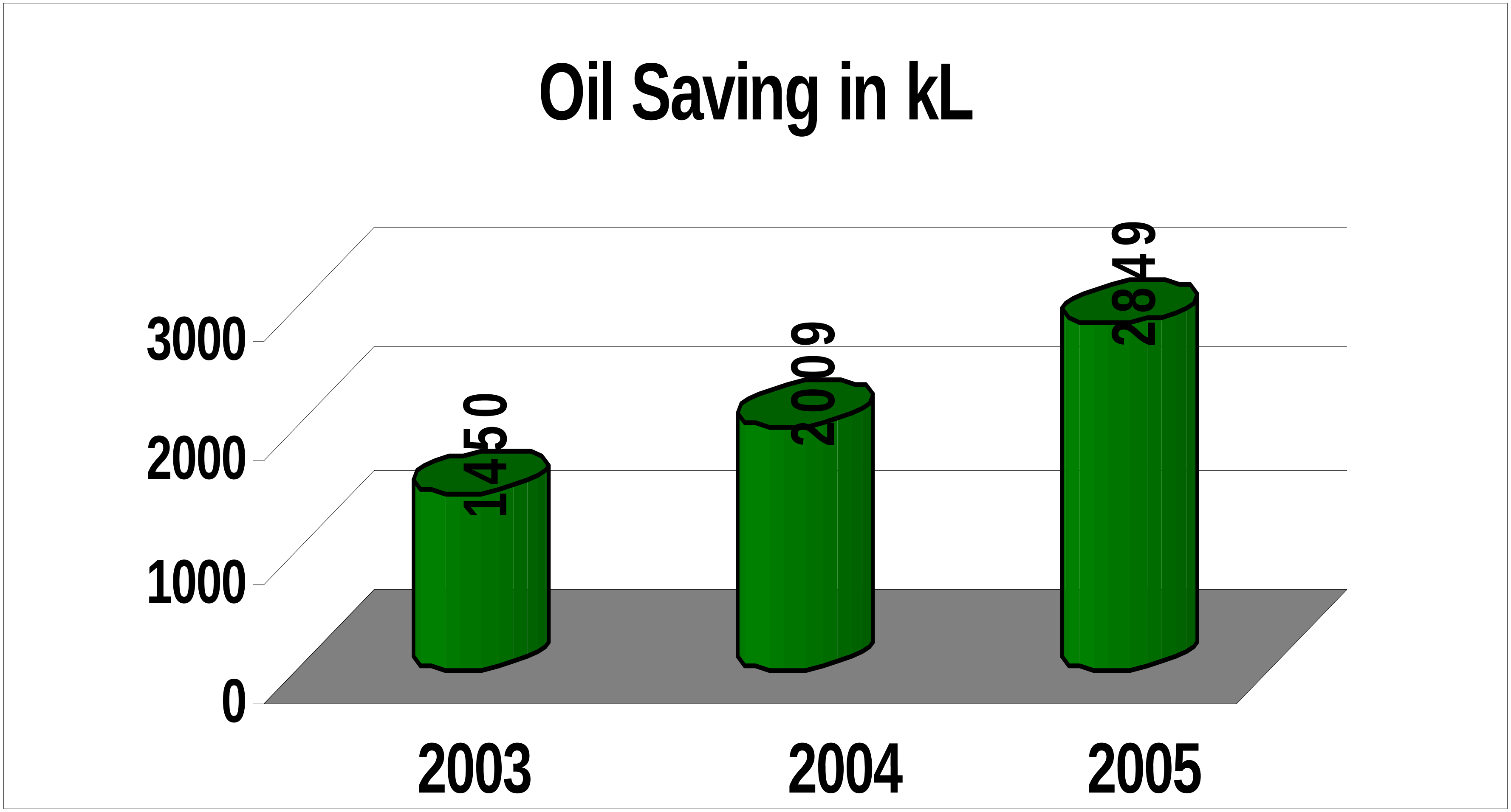
Biogas Plant Performance



Biogas Plant Performance



Biogas Plant Performance



CDM Project Status

Methane Extraction and Fuel Conservation Project (High rate Bio-Methanation)

- Estimated CERs Generation 37,000 t $CO_2e\ y^{-1}$

  Project Identification
  Project Design Document (PDD)
  Host Country approval (2nd May 2005)
  Validation
  Registration (14th January 2006)
  Verification
  CER trading

Emission Calculation

Methodology Adopted : AM0013 / Version 02

Emission Reductions t CO_2e → Baseline Emissions t CO_2e – Project Emissions t CO_2e

Baseline Emissions

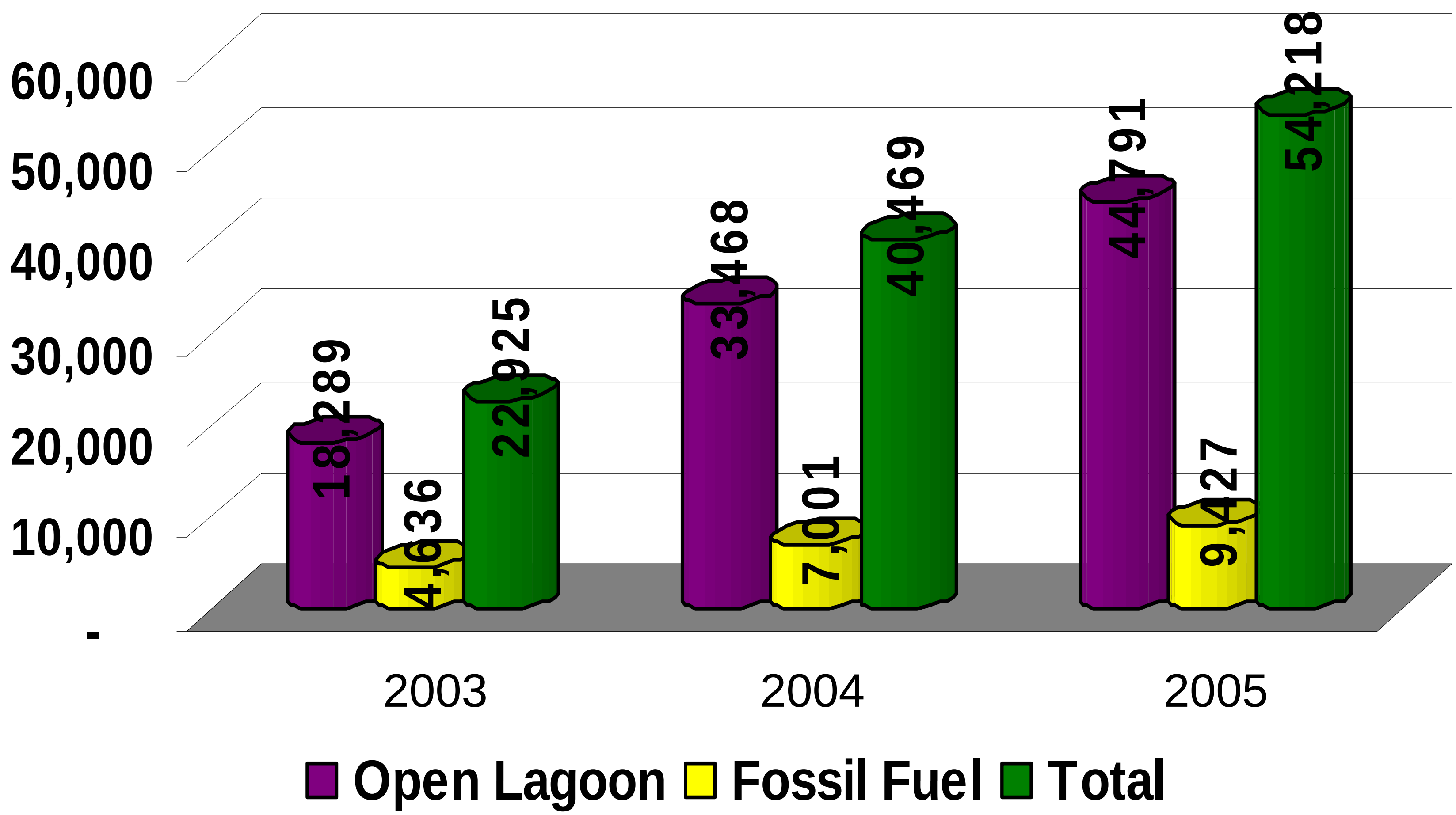
1. CH_4 emission from open anaerobic lagoons

Total COD to lagoon × Maximum CH_4 producing capacity × CH_4 conversion factor

2. Emission from Fossil fuel combustion

Biogas used × Energy Content of biogas × Carbon Content of Fuel × Mass conversion factor

Baseline Emission t CO_2e



Project Emissions

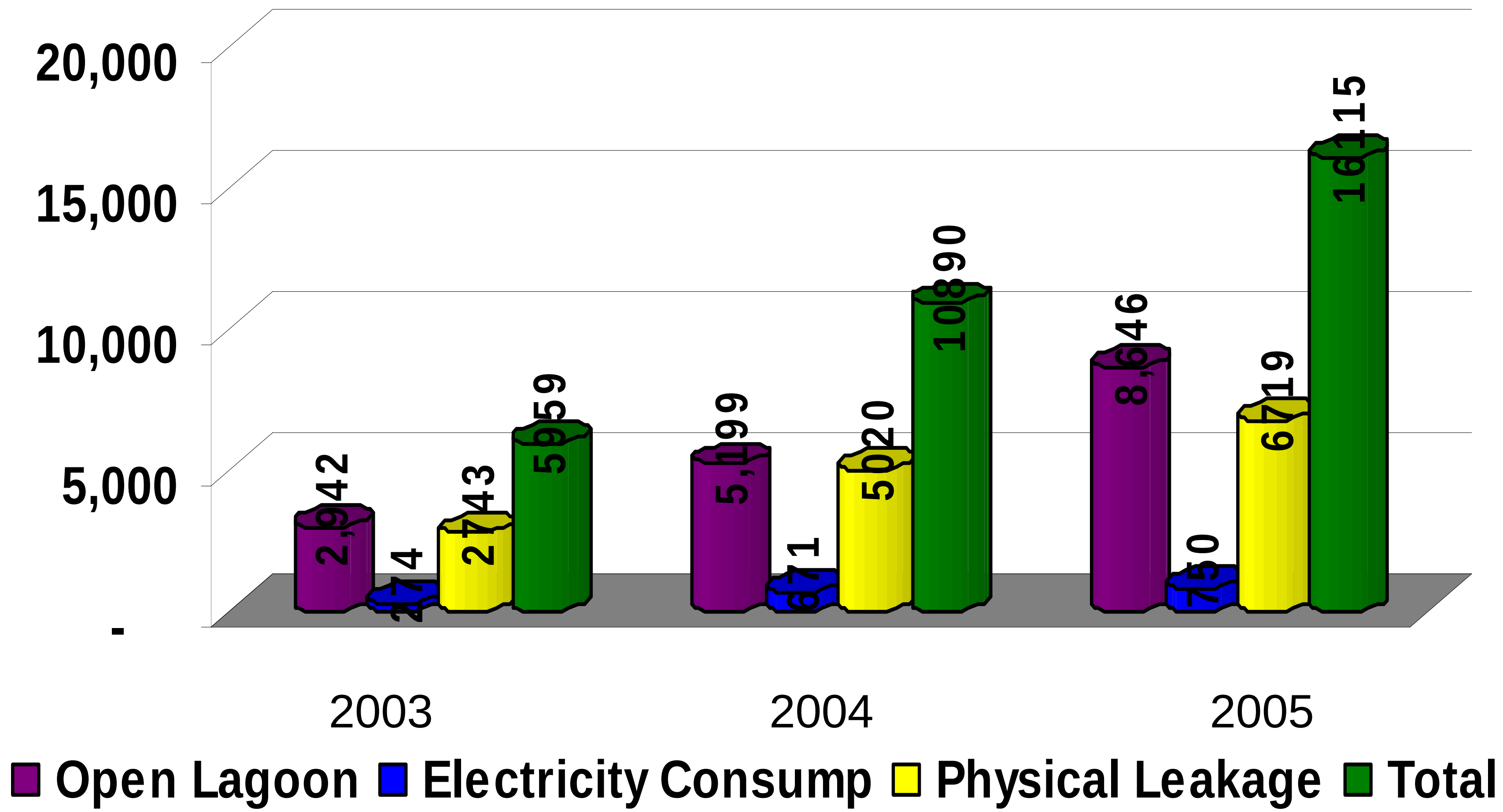
1. CH_4 emission from open anaerobic lagoons

Total undigested COD to lagoon × Maximum CH_4 producing capacity × CH_4 conversion factor

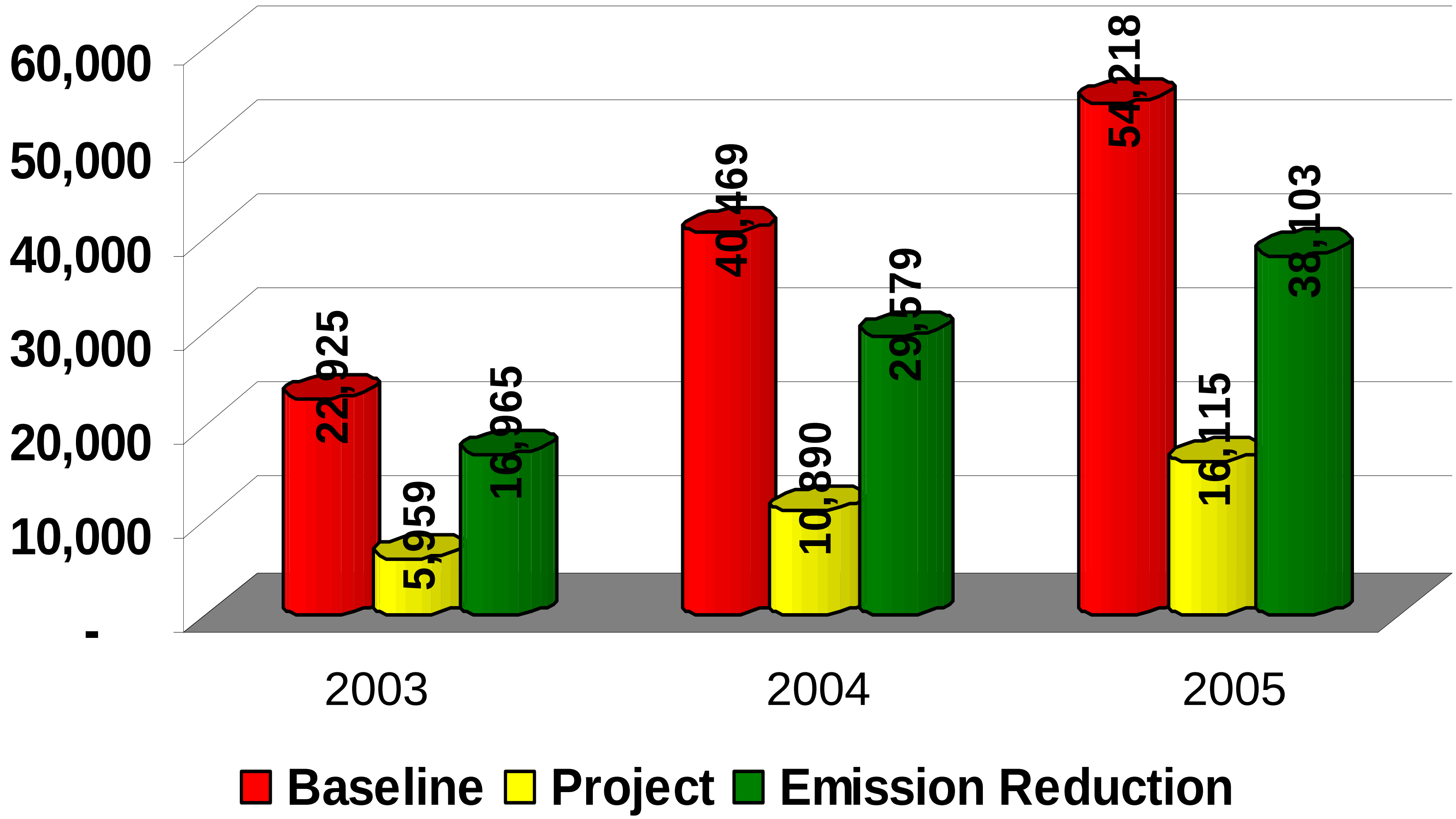
2. Emission due to leakage

Physical leakage from digester + Emission from electricity consumption

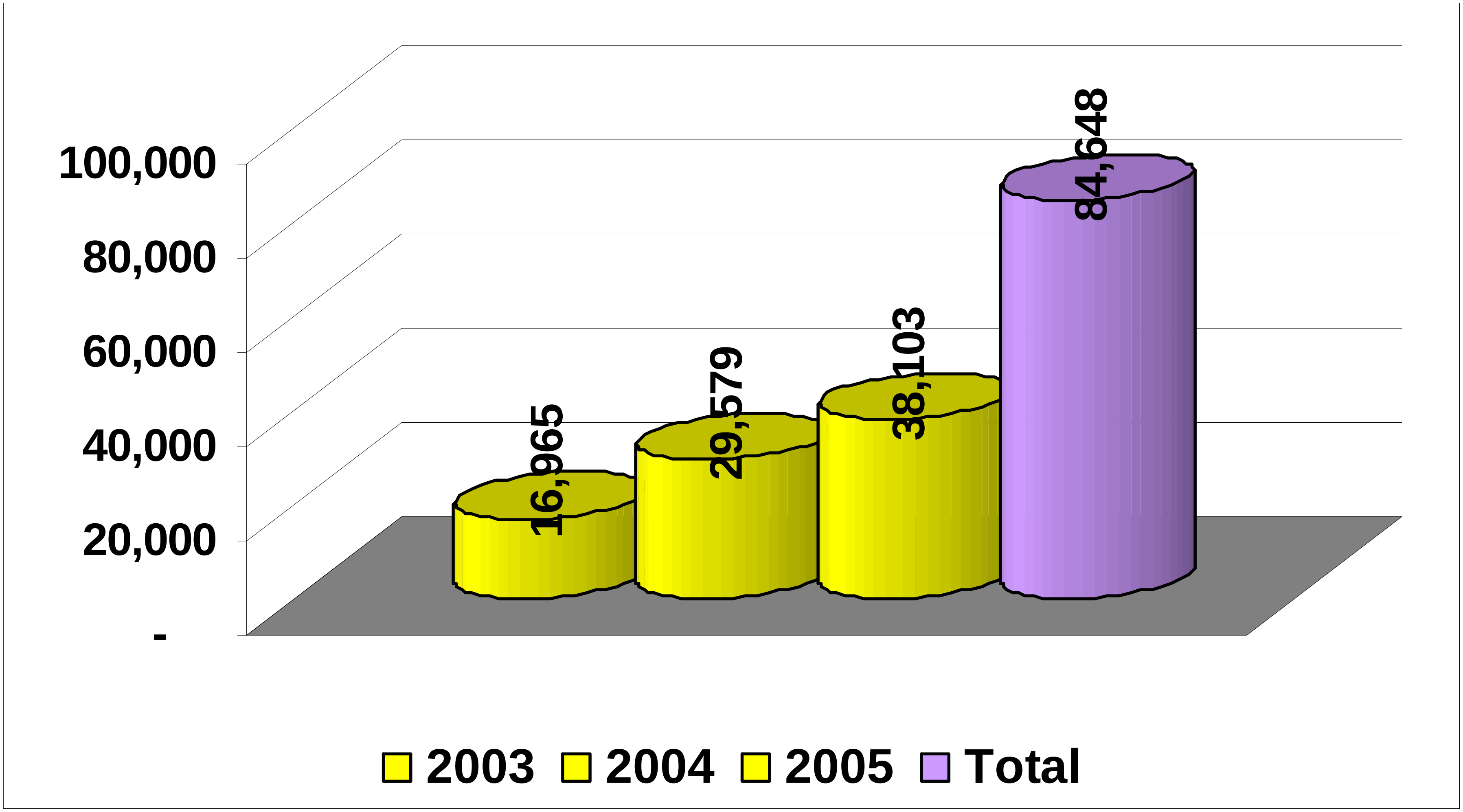
Project Emission t CO_2e



Emission Reduction t CO_2e



CER Generated from Aug. 2003 – Dec. 2005



Conclusion

The plant generates around 13,000 to 15,000 M^3 of biogas with COD reduction of around 83 - 85 %

I. Environmental Benefits from Aug. 03 to Dec. 05

- COD Reduced :24,500 t
- GHG Reduced :85,000 t CO_2e

II. Economical Benefits from Aug. 03 to Dec. 05

- Biogas generated :10.64 million m3
- Furnace oil Saving : 6308 t
- CERs generated :85,000

Thank You for Your Attention

Any Questions ?