# LCA/LCM 2004

INTERNATIONAL CONFERENCE ON LCA AND LCM

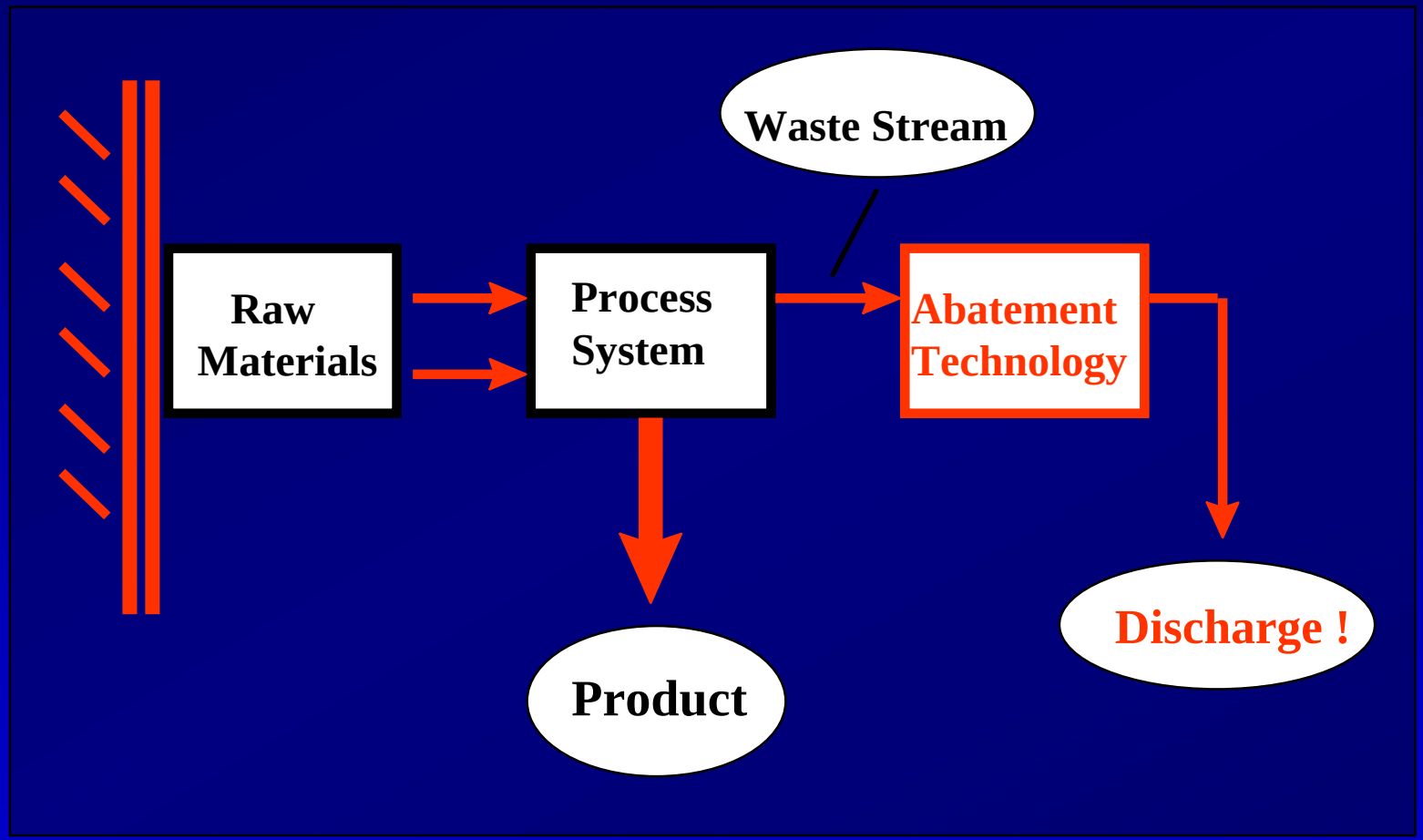
# APPLYING LIFE CYCLE TOOLS AND PROCESS ENGINEERING TO DETERMINE THE MOST ADEQUATE TREATMENT PROCESS CONDITIONS. A TOOL IN ENVIRONMENTAL POLICY.

**Dr. Omar Romero-Hernandez**
**oromero@itam.mx**


**Instituto Tecnológico Autónomo de México**
**Department of Industrial Engineering and Operations**
**México D.F., MEXICO**

# CONTENTS

# BACKGROUND
## Process Design and Discharge Regulations




Dr. Omar Romero
oromero@itam.mx



ITAM EXCELENCIA ACADEMICA

# PROBLEM STATEMENT
## Economic and Environmental Impact of Wastewater Technologies

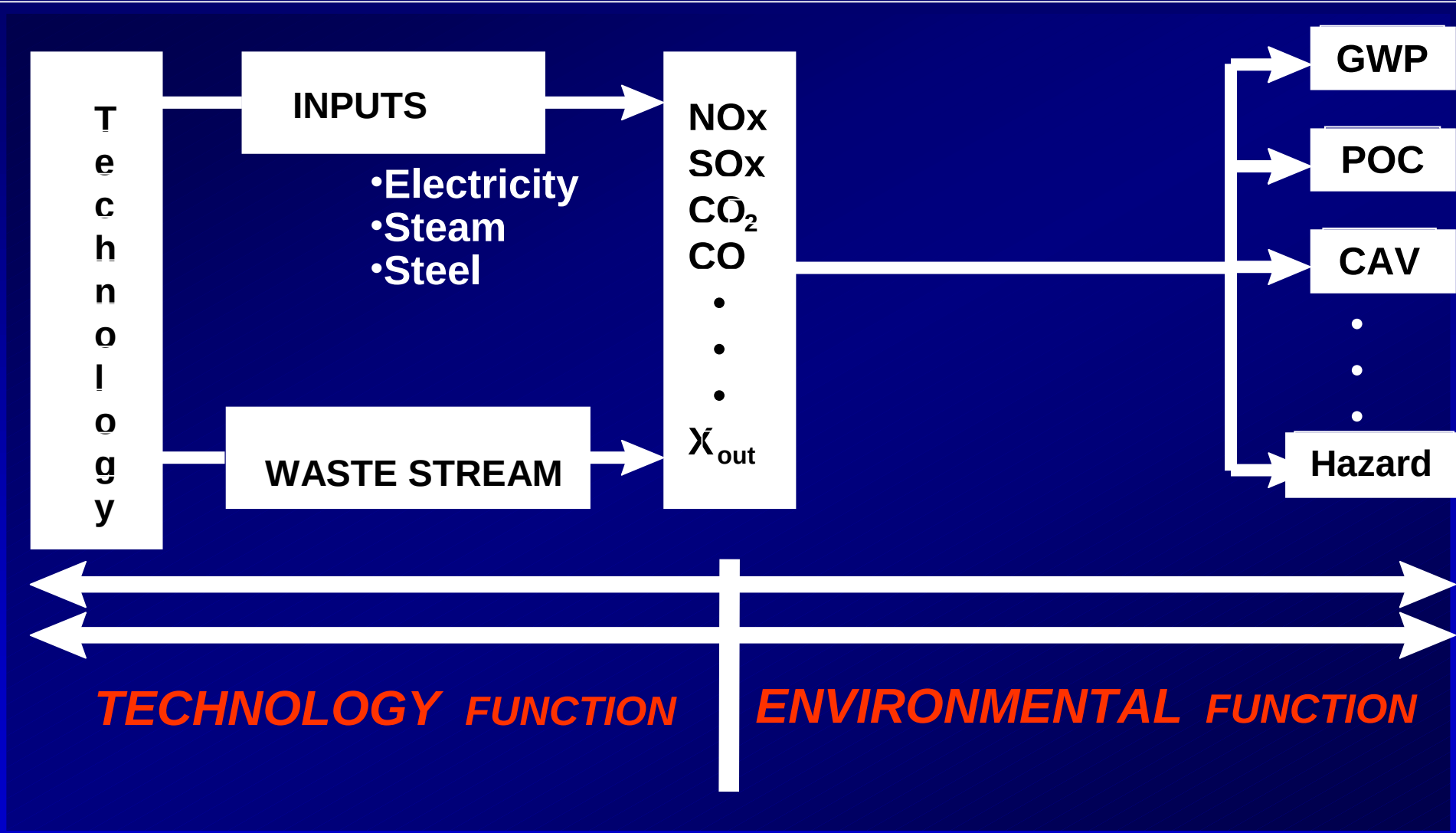
- HOW TO DECIDE BETWEEN DIFFERENT OPERATING CONDITIONS ON A GIVEN TECHNOLOGY, IN ORDER TO:
  - MINIMIZE ENVIRONMENTAL IMPACT?
  - AVOID EXCESIVE TREATMENT COSTS?
- HOW TO INCORPORATE THIS INSIGHT AS A TOOL FOR ENVIRONMENTAL POLICY ?

Dr. Omar Romero
oromero@itam.mx



ITAM
EXCELENCIA ACADEMICA

# FRAMEWORK
## Analysis of Abatement Technologies

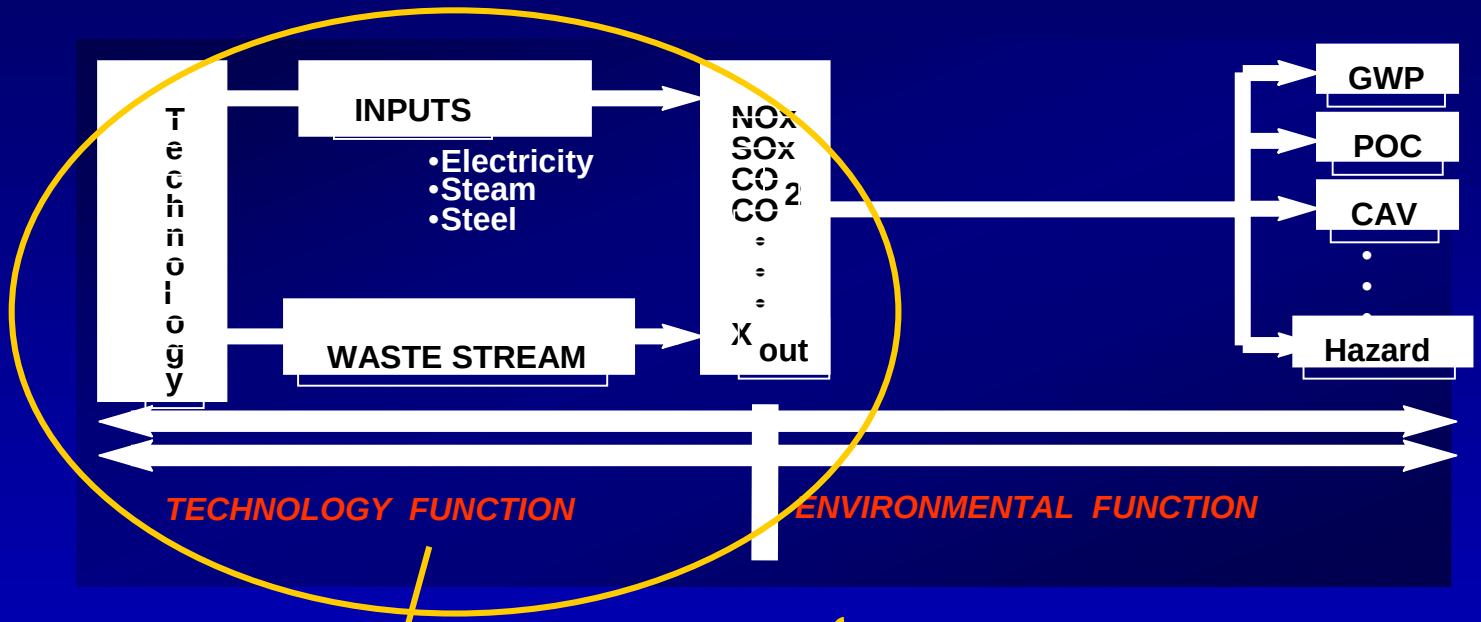



Dr. Omar Romero
oromero@itam.mx



ITAM EXCELENCIA ACADEMICA

# FRAMEWORK
## Technology Function:




**Technology Function:**

- Mass and Energy Balances
- Equipment Size
- Operating conditions
- Inputs Requirements
- Cost Estimation


Dr. Omar Romero
oromero@itam.mx




ITAM EXCELENCIA ACADEMICA

# FRAMEWORK
## Environmental Function

**Environmental Impact (EI):**

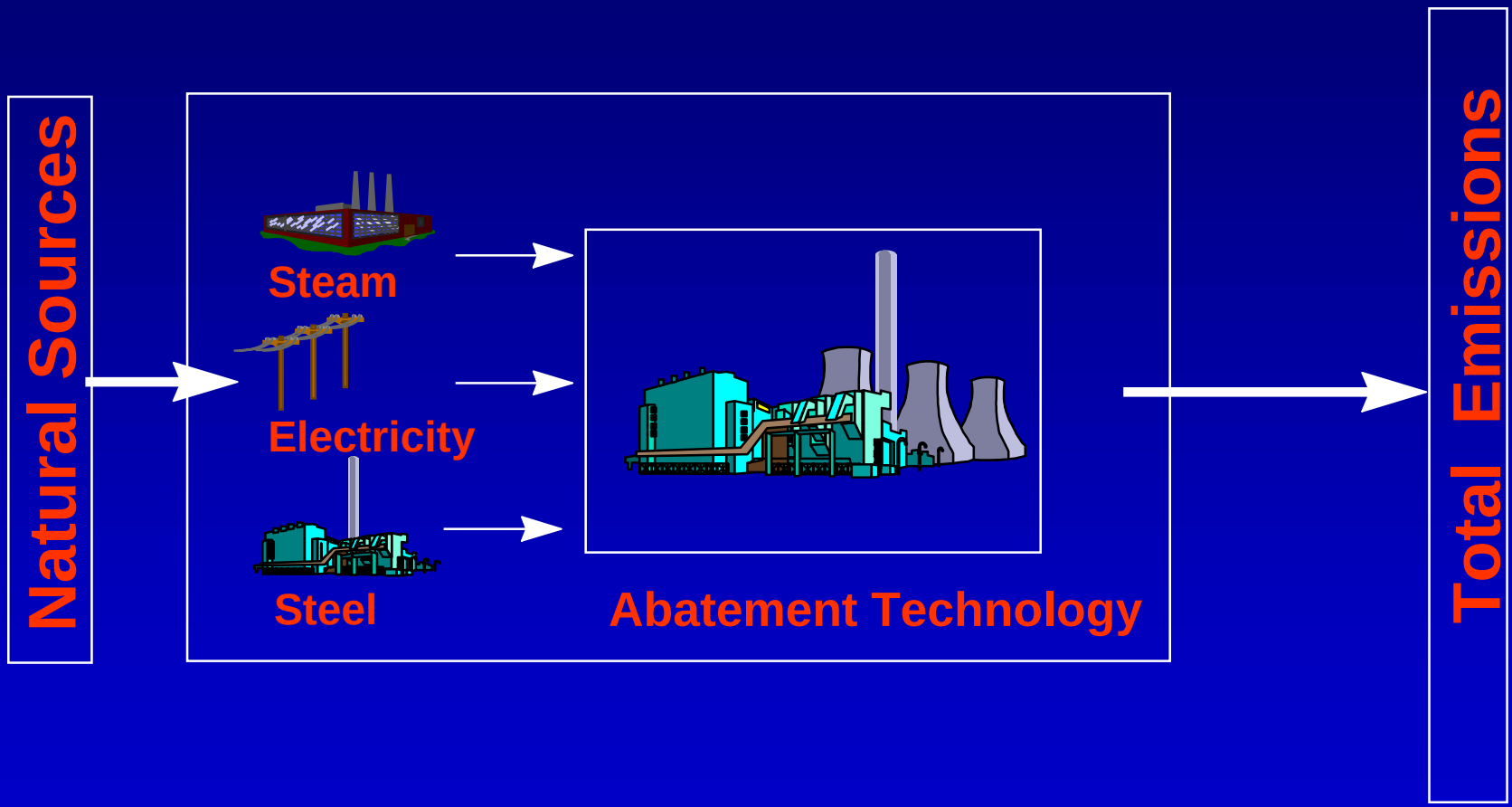
$$EI = \left[ EI_{HC}, EI_{NO} \cdots \right] \left[ \begin{matrix} E_{HC} \\ E_{NO} \\ \vdots \end{matrix} \right]$$

*Metrics:*

- *Photochemical Ozone*
- *Global Warming*
- *Ozone Depletion, etc.*

# FRAMEWORK

## *Traditional* Analysis of Abatement Technologies



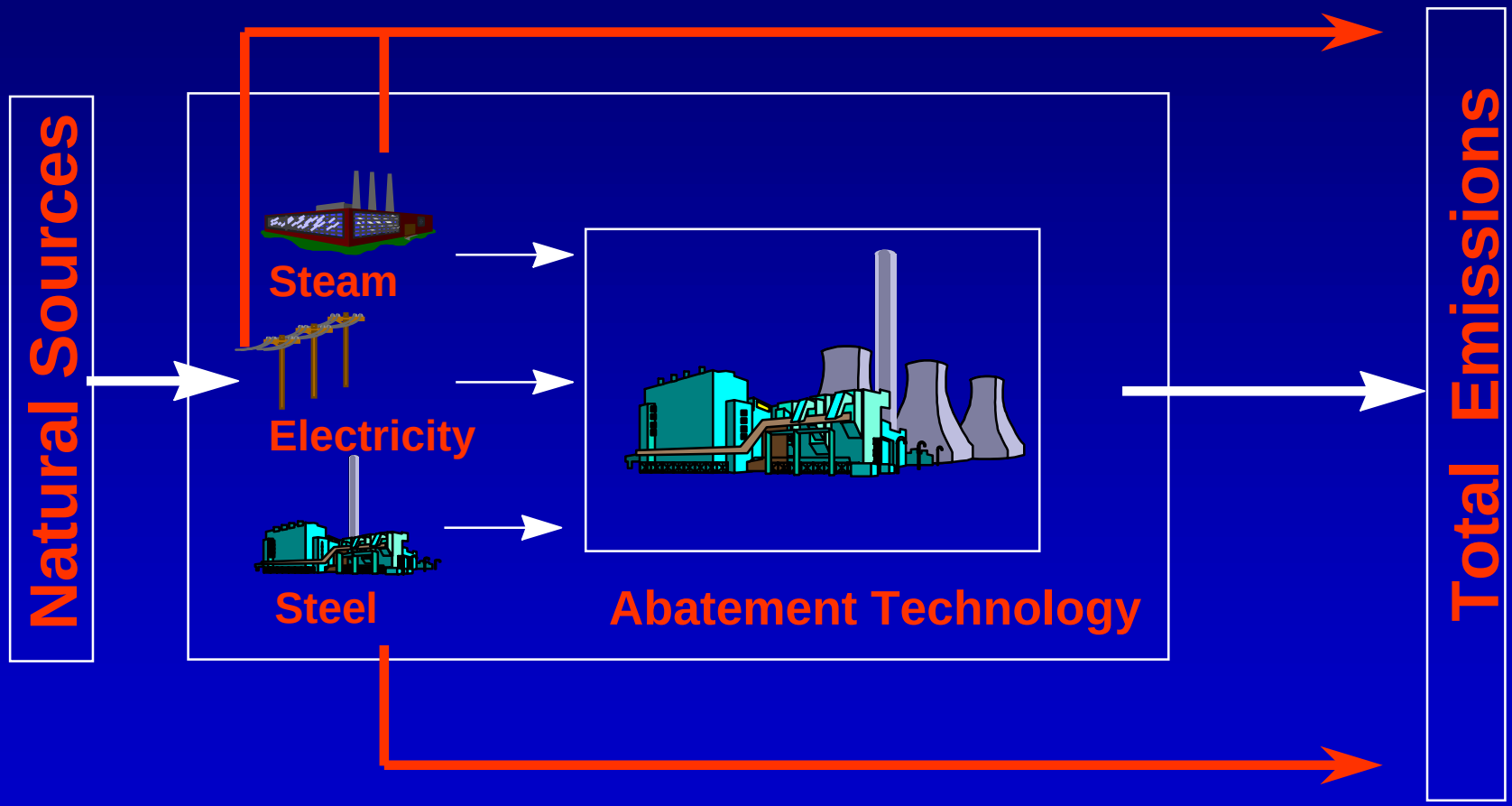

Dr. Omar Romero
oromero@itam.mx



ITAM
EXCELENCIA ACADEMICA

# FRAMEWORK

## *Life Cycle Analysis* for Abatement Technologies




Dr. Omar Romero
oromero@itam.mx

LCA/LCM 2004
Seattle, USA

ITAM
EXCELENCIA ACADEMICA

# CASE STUDY

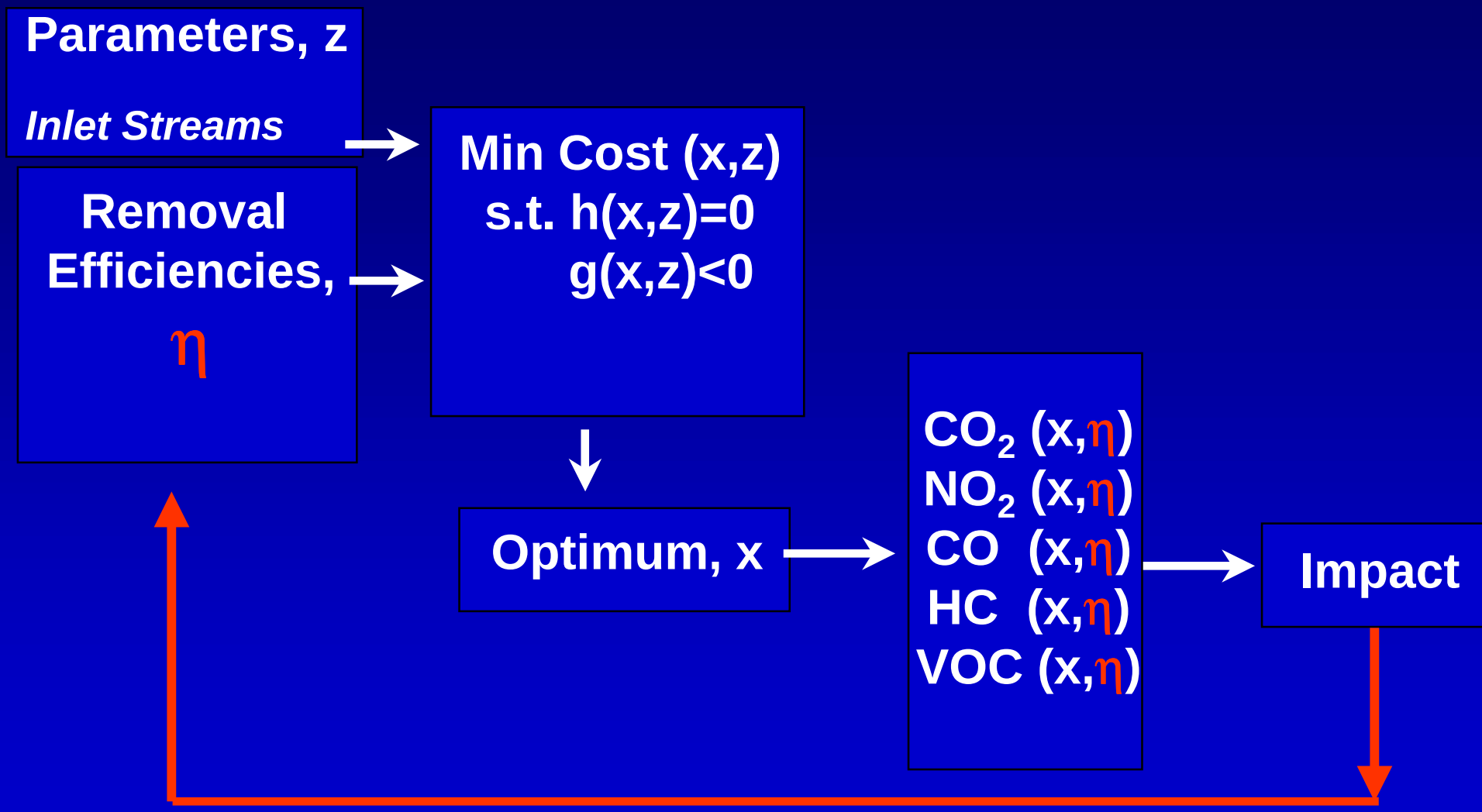
## 2 WASTEWATER STREAMS:

- 10 $m^3$/hr and 1,000 ppm of 1-2 Dichloroethane (DCE)
- 10 $m^3$/hr and 1,000 ppm of Bencene

## 1 TECHNOLOGY:

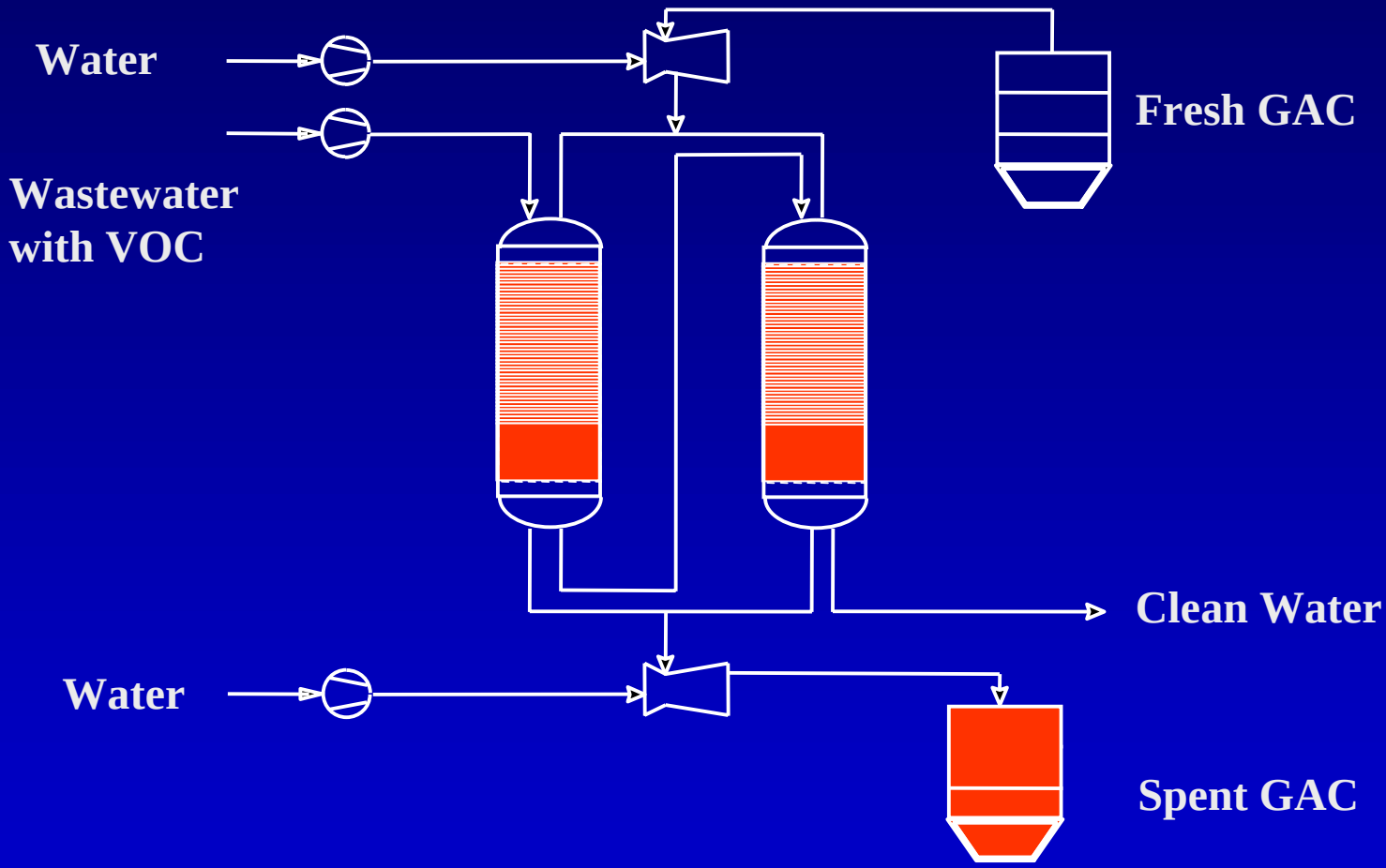
- Granular Activated Carbon Adsorption (GAC)

# CASE STUDY
## Mathematical Model




Dr. Omar Romero
oromero@itam.mx

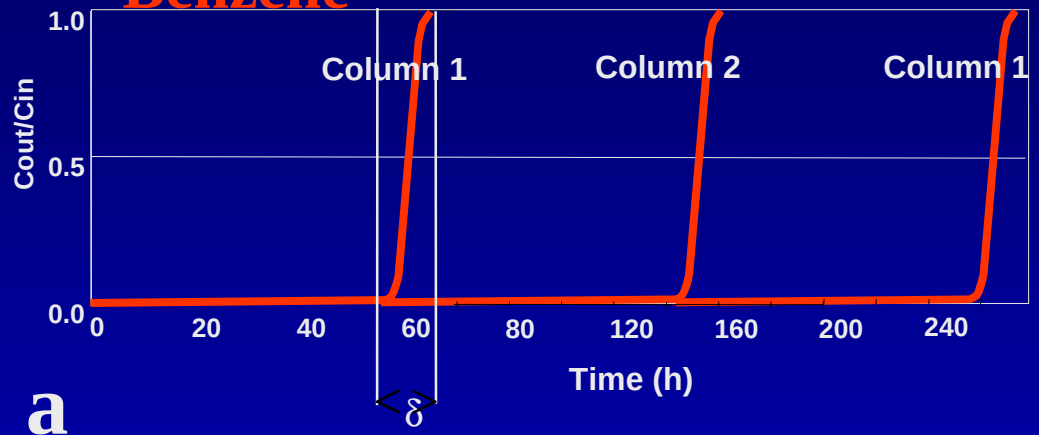
# GRANULAR ACTIVATED CARBON (GAC)



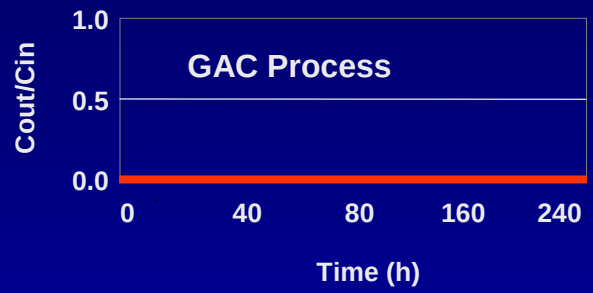

Dr. Omar Romero
oromero@itam.mx

# PROCESS ENGINEERING:
## MODELLING AND SIMULATING GAC PERFORMANCE

**Benzene**

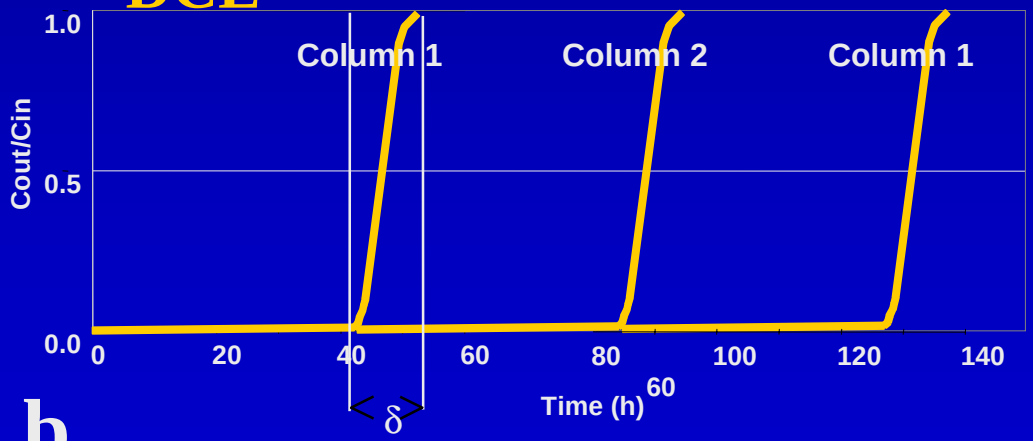



a

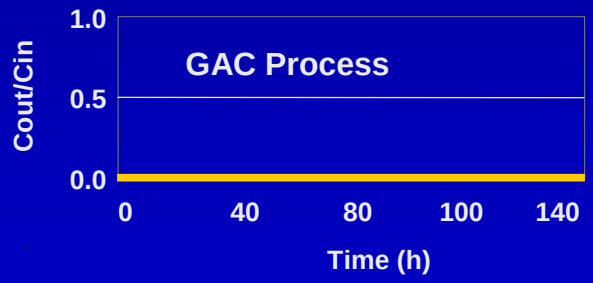



a'

**DCE**




b




b'


Dr. Omar Romero
oromero@itam.mx

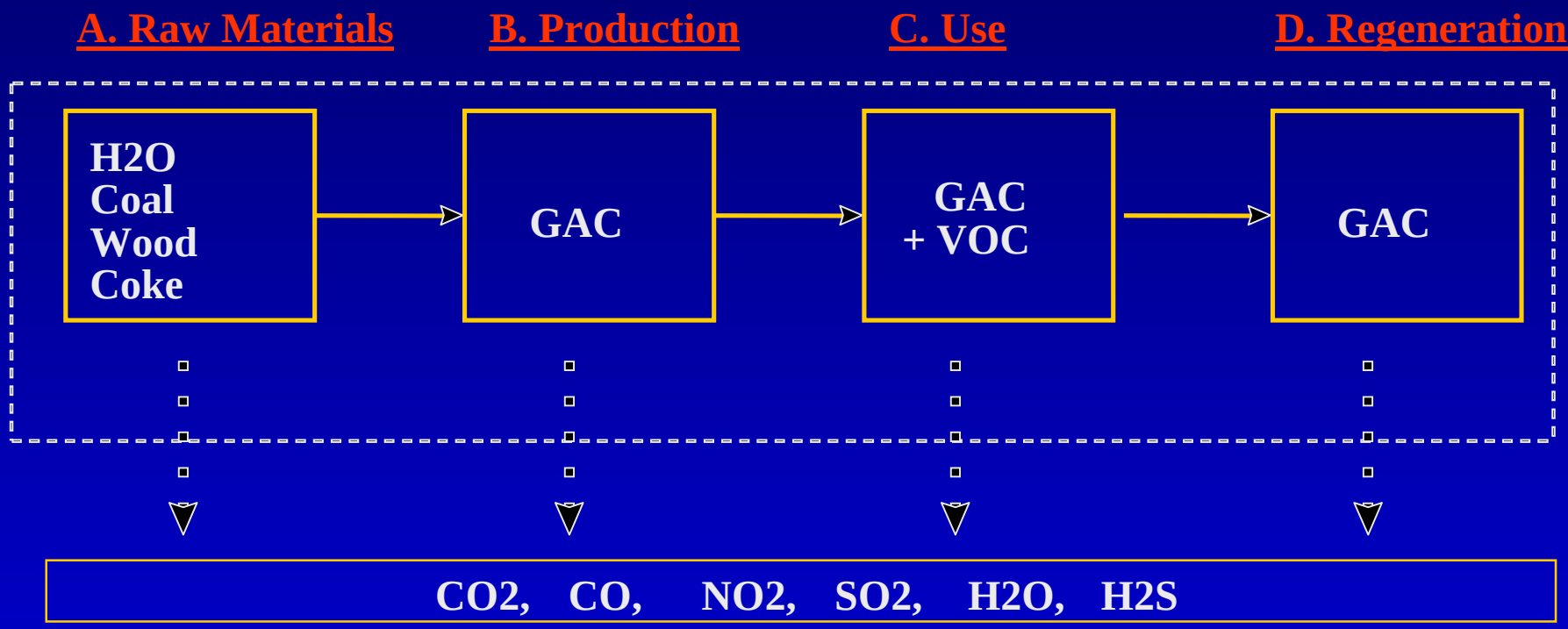

LCA/LCM 2004
Seattle, USA

ITAM
EXCELENCIA ACADEMICA

# PROCESS ENGINEERING:
## COST MODEL OF THE GAC PROCESS

| | Benzene | DCE |
|---|---|---|
| **Total Cost (£/yr)** | **459,120** | **511,470** |
| **Capital Cost (£/yr)** | **103,550** | **100,730** |
| **Operating Cost (£/yr)** | **355,560** | **410,740** |
| | | |
| **Cost of Adsorbers (£/yr)** | **30,640** | **27,235** |
| Height (m) | 2.617 | 2.267 |
| Diameter (m) | 1.614 | 1.614 |
| **Cost of Storage Tanks (£/yr)** | **57,198** | **58,947** |
| **Cost of Feed Pump and Eductors (£/yr)** | **6,825** | **6,646** |
| **Cost of GAC (£/yr)** | **352,580** | **407,500** |
| GAC (kg/yr) | 248,296 | 286,971 |
| Load Ratio $kg_{VOC}/kg_{GAC}$ | 0.328 | 0.284 |
| **Cost of Electricity (£/yr)** | **2,721** | **2,852** |
| Electricity (kw.hr/yr) | 54,420 | 57,040 |
| **Cost of Water (£/yr)** | **260** | **384** |

# LCA AND PROCESS ENGINEERING:
## GENERATING INVENTORY OF EMISSIONS FROM THE GAC PROCESS MODEL

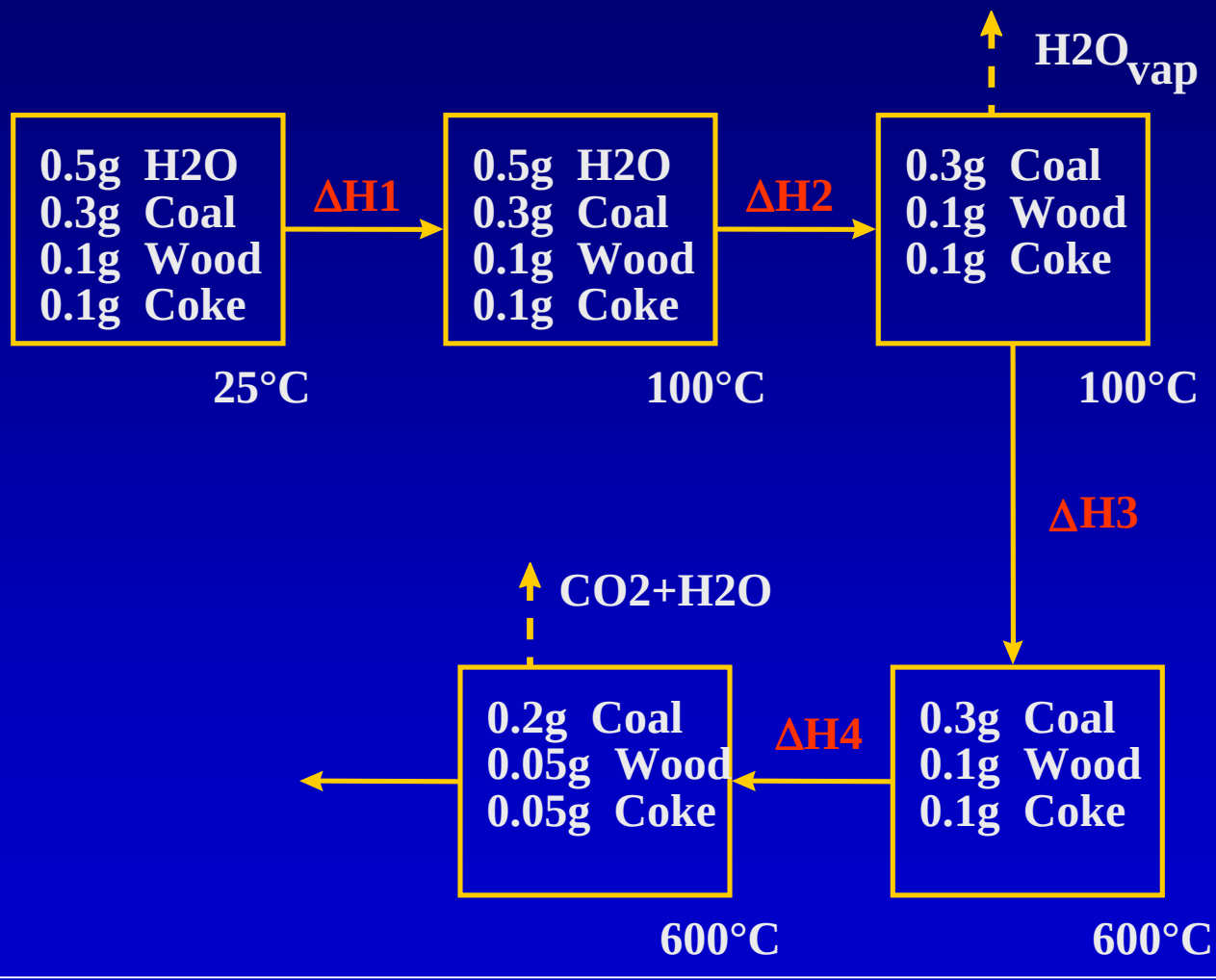



Dr. Omar Romero
oromero@itam.mx



ITAM
EXCELENCIA ACADEMICA

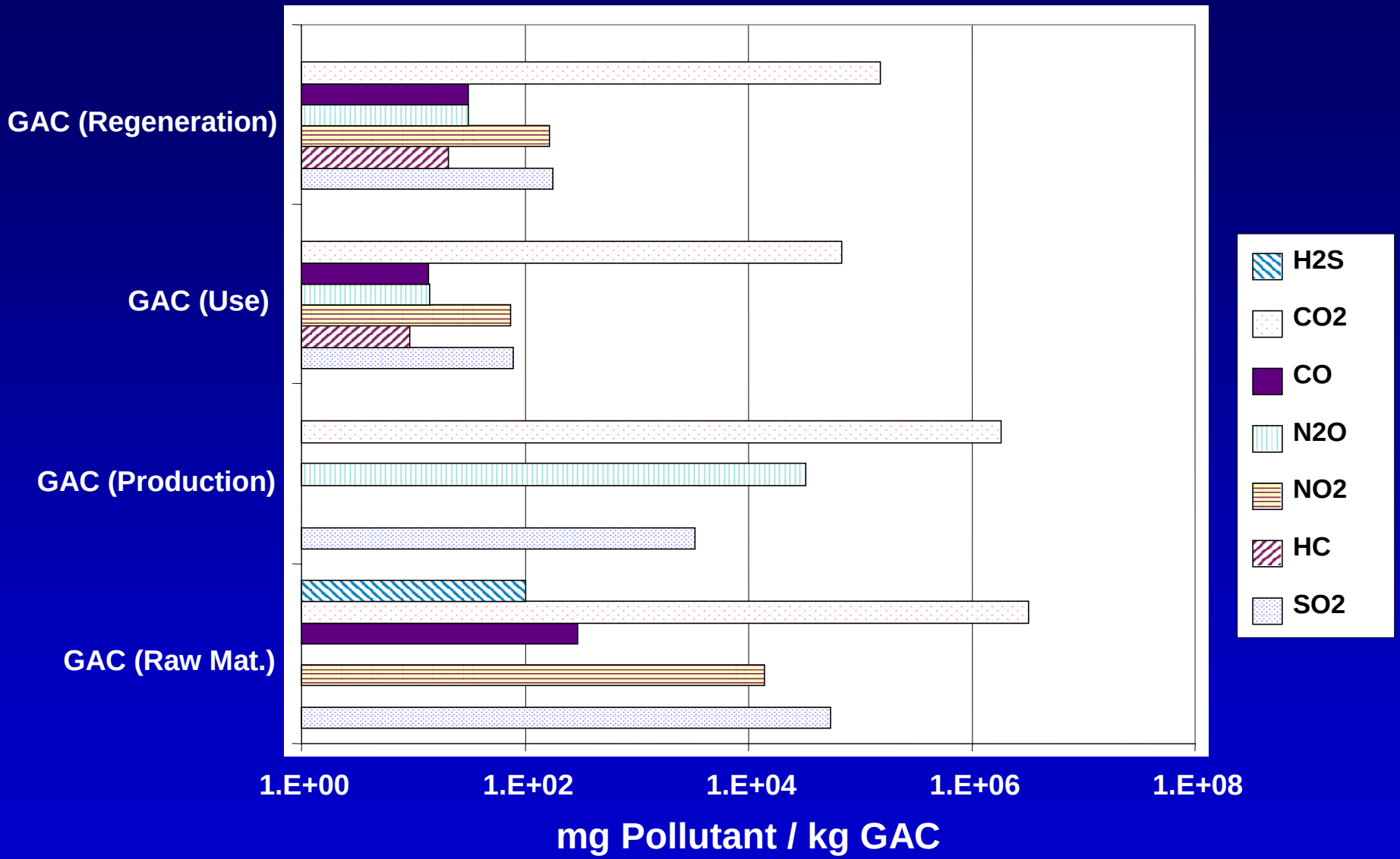
# LCA AND PROCESS ENGINEERING:
## PRODUCTION OF GAC AT 30% CONVERSION OF RAW MATERIALS
## - MASS AND ENERGY BALANCES -





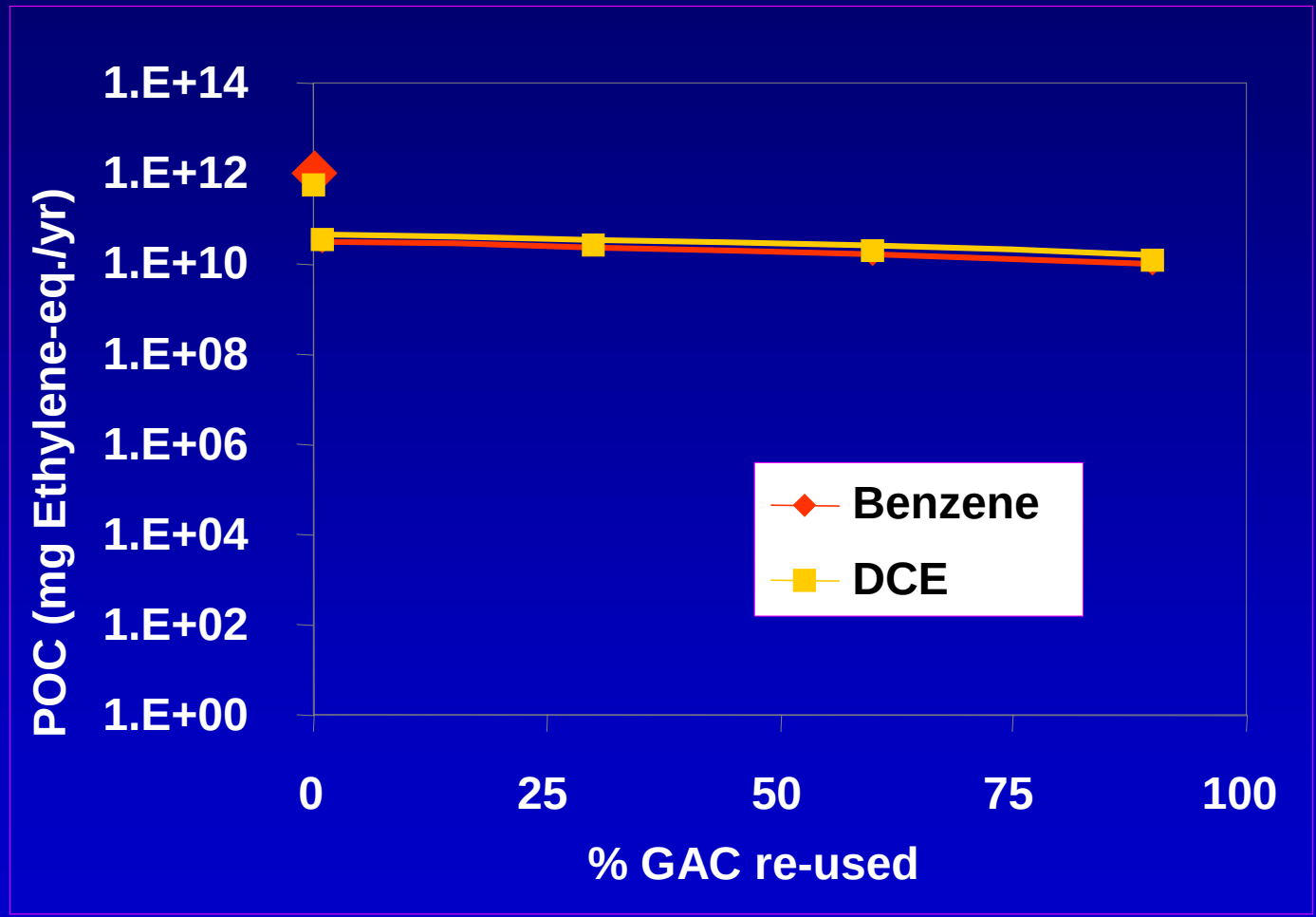
Dr. Omar Romero
oromero@itam.mx

# INVENTORY OF EMISSIONS




Dr. Omar Romero
oromero@itam.mx

# Environmental Impact
# POC as a function of % of re-used carbon (GAC)

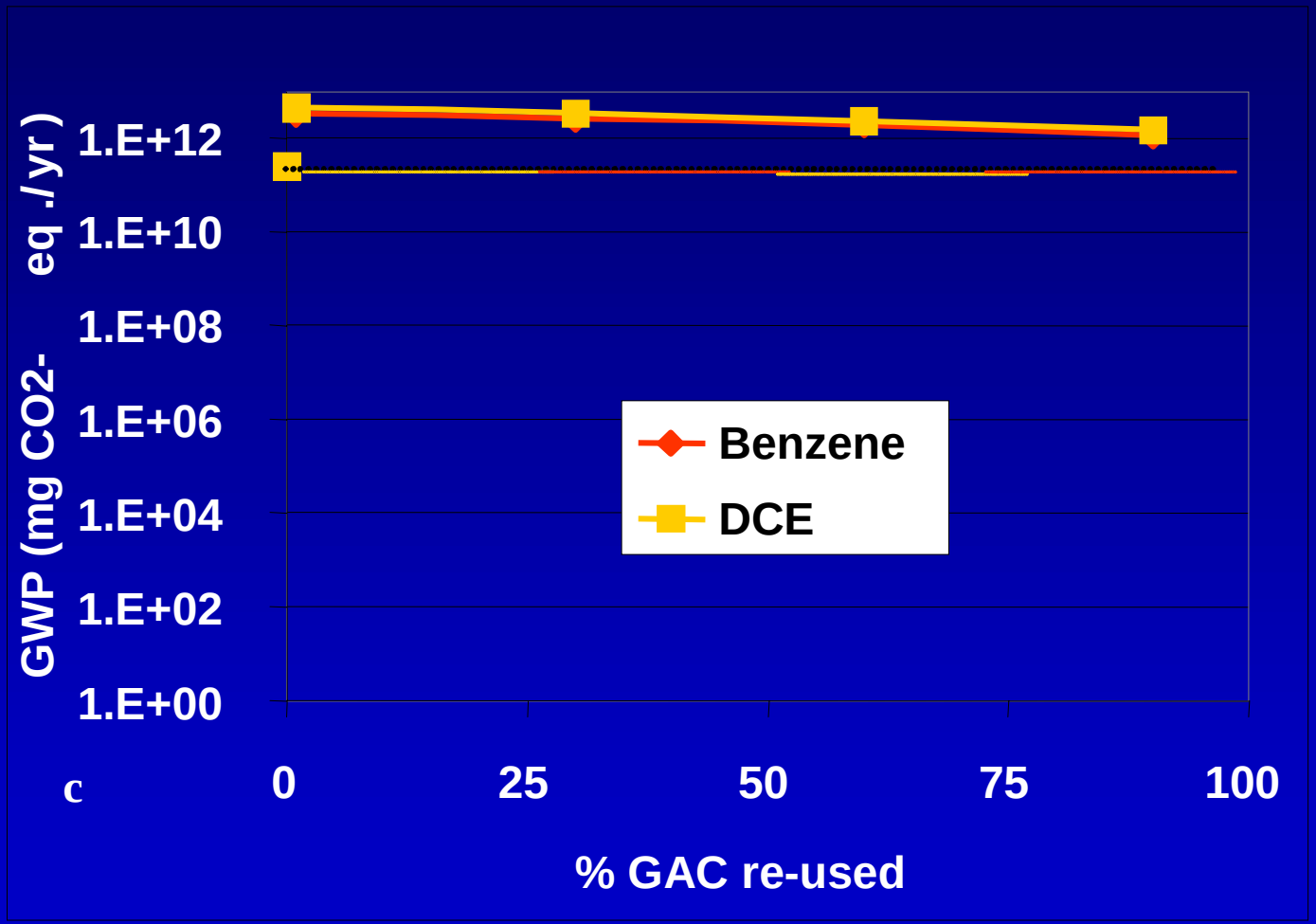



Dr. Omar Romero
oromero@itam.mx

LCA/LCM 2004
Seattle, USA

ITAM
EXCELENCIA ACADÉMICA

# Environmental Impact
# GWP as a function of % of re-used carbon (GAC)

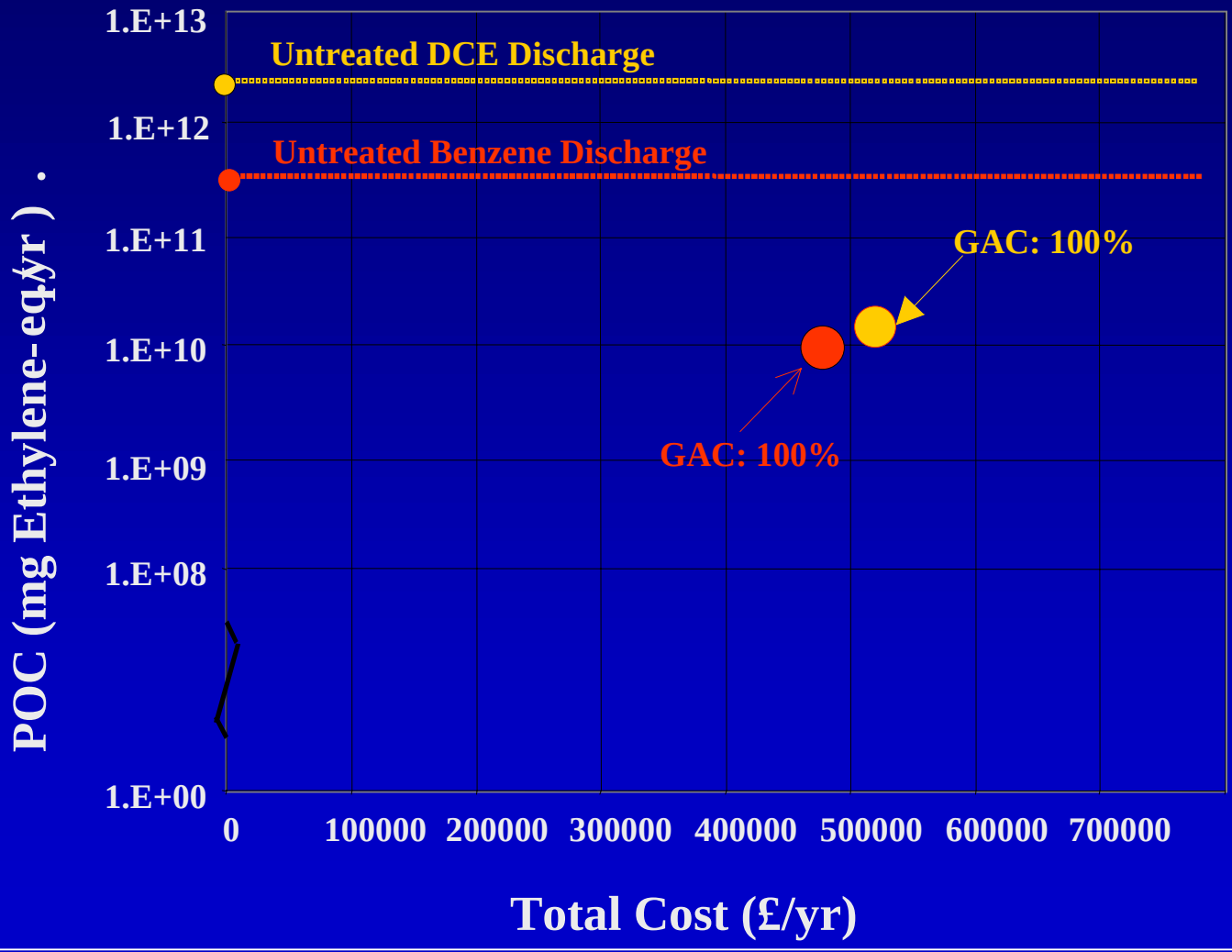



Dr. Omar Romero
oromero@itam.mx

LCA/LCM 2004
Seattle, USA

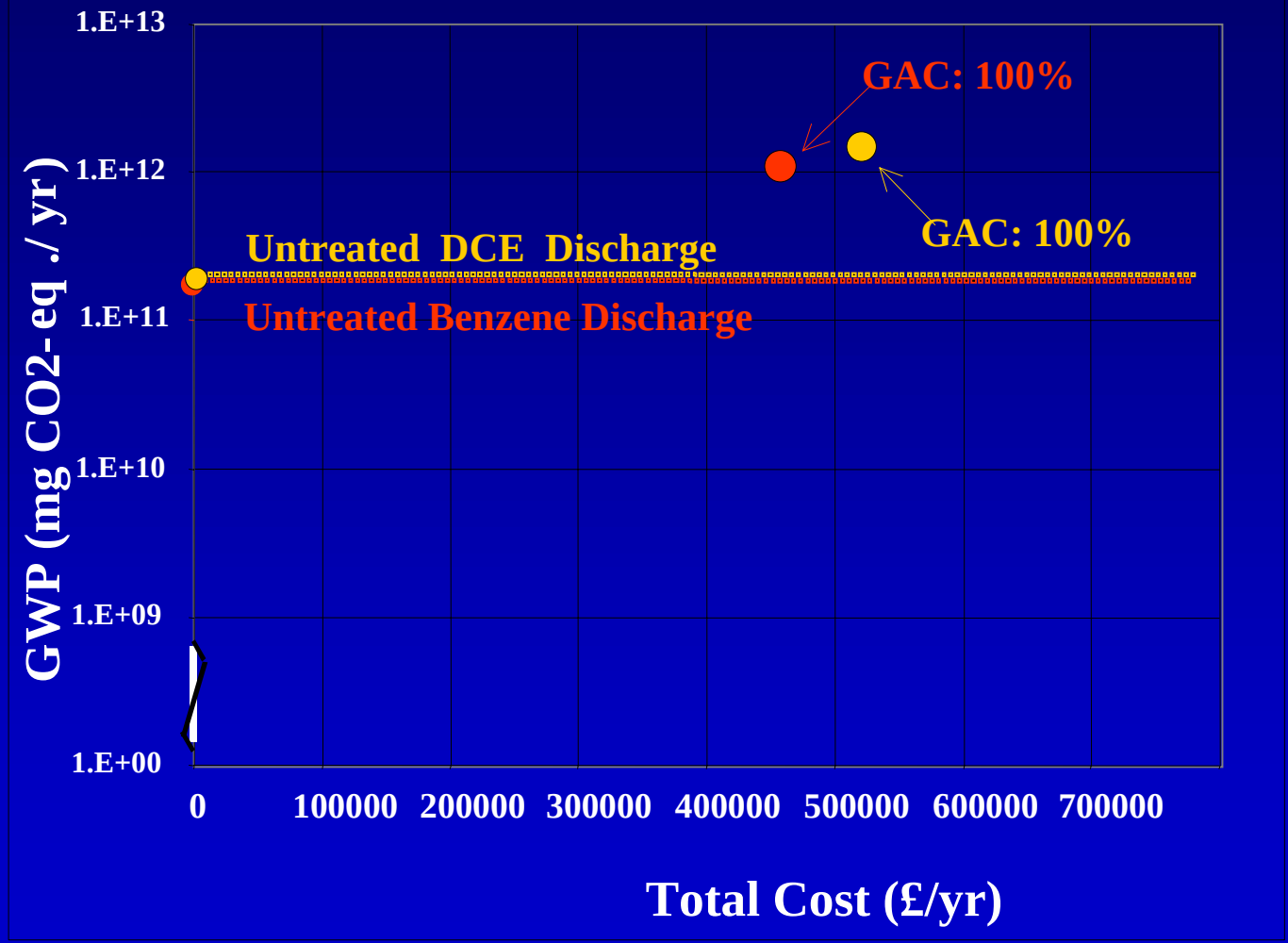
ITAM
EXCELENCIA ACADÉMICA

# ECONOMICS AND ENVIRONMENTAL IMPACT
## POC as a function of process cost




Dr. Omar Romero
oromero@itam.mx

# ECONOMICS AND ENVIRONMENTAL IMPACT
## GWP as a function of process cost




Dr. Omar Romero
oromero@itam.mx



ITAM
EXCELENCIA ACADÉMICA

# DISCUSSION

- FRAMEWORK
  - It is very case specific
  - Assumes a linear relationship between emissions and environmental impact
- PROCESS ENGINEERING?
  - A powerful tool to design cost effective and environmental concious processes
  - Comproimise between industry and legislators
- HOW TO DECIDE ON BEST OPERATING CONDITIONS?
  - Capital and Operating Costs
  - Environmental Impact
  - Simulation and case scenario analyses

# ACKNOWLEDGMENTS

**Financial support from CONSEJO NACIONAL DE CIENCIA y TECNOLOGÍA (CONACyT - MEXICO) through completion of this work is highly appreciated.**

**Comments and feedback from**
**Prof. Andrew G. Livingston and**
**Prof. Efstratios Pistikopoulos**
**from the Department of Chemical Engineering and Chemical Technology, Imperial College of Science and Technology, London, UK through this research are highly appreciated.**

# LCA/LCM 2004

INTERNATIONAL CONFERENCE ON LCA AND LCM

# APPLYING LIFE CYCLE TOOLS AND PROCESS ENGINEERING TO DETERMINE THE MOST ADEQUATE TREATMENT PROCESS CONDITIONS. A TOOL IN ENVIRONMENTAL POLICY.

**Dr. Omar Romero-Hernandez**
**oromero@itam.mx**


**Instituto Tecnológico Autónomo de México**
**Department of Industrial Engineering and Operations**
**México D.F., MEXICO**