ENPEP MODEL AND CO_2 EMISSIONS IN MEXICO

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Mexico - US Economic, Environmental
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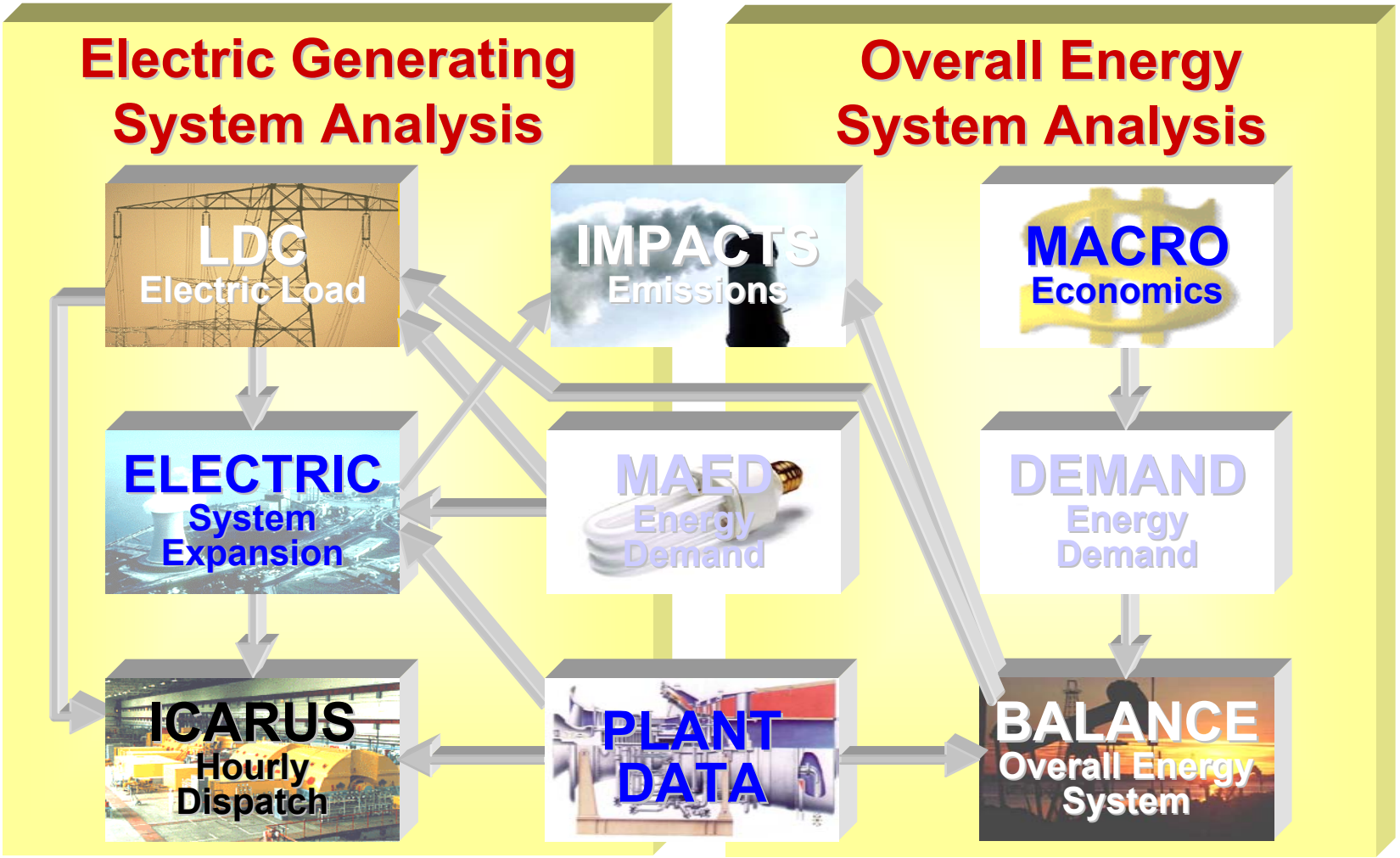
21-22 November 2002

ENPEP PURPOSE

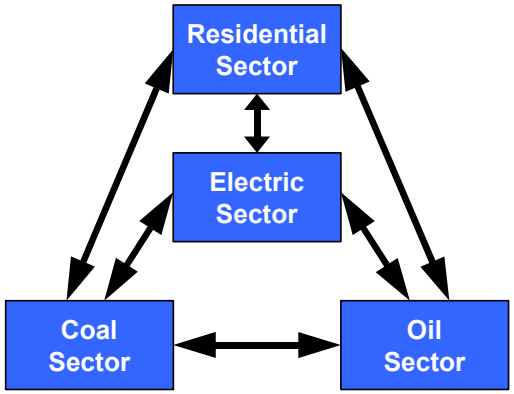
The ENergy and Power Evaluation Program (ENPEP) is a set of microcomputer-based analytical tools for conducting integrated energy and environmental planning.

ENPEP is a Tool to Address Critical Energy and Environmental Issues

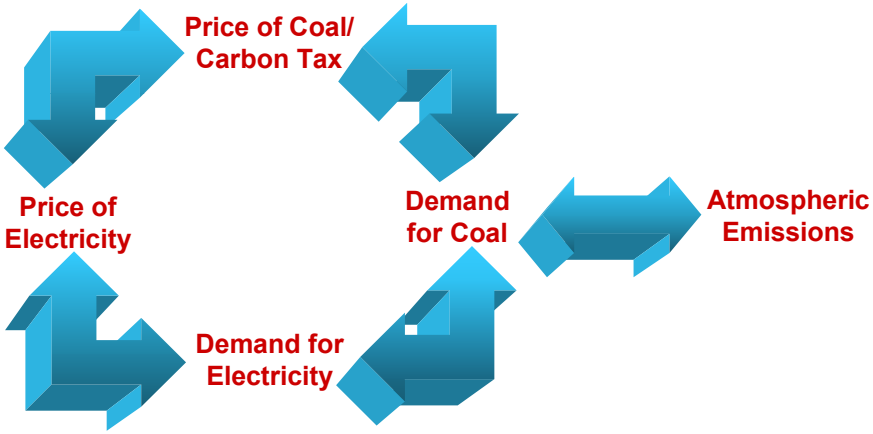


ENPEP is Designed to Analyze the Entire Energy System in an Integrated Framework

- Integrated framework reveals cross-sectoral effects; demand side measures may affect energy supply requirements



- Integrated framework allows evaluation of feedback effects



Technical modules and their functions are:

LDC: Characterizes the electrical load over time for use in other modules

IMPACTS: Estimates environmental residuals and resource requirements for the energy system determined by BALANCE and/or ELECTRIC

MACRO: Allows the user to specify macroeconomic growth (global or sectoral) that will be the drivers of energy demand

ELECTRIC: The microcomputer version of WASP-III, determines the minimum cost expansion plan for the electrical generating system

MAED: Portrays the electrical demand as part of overall energy demand

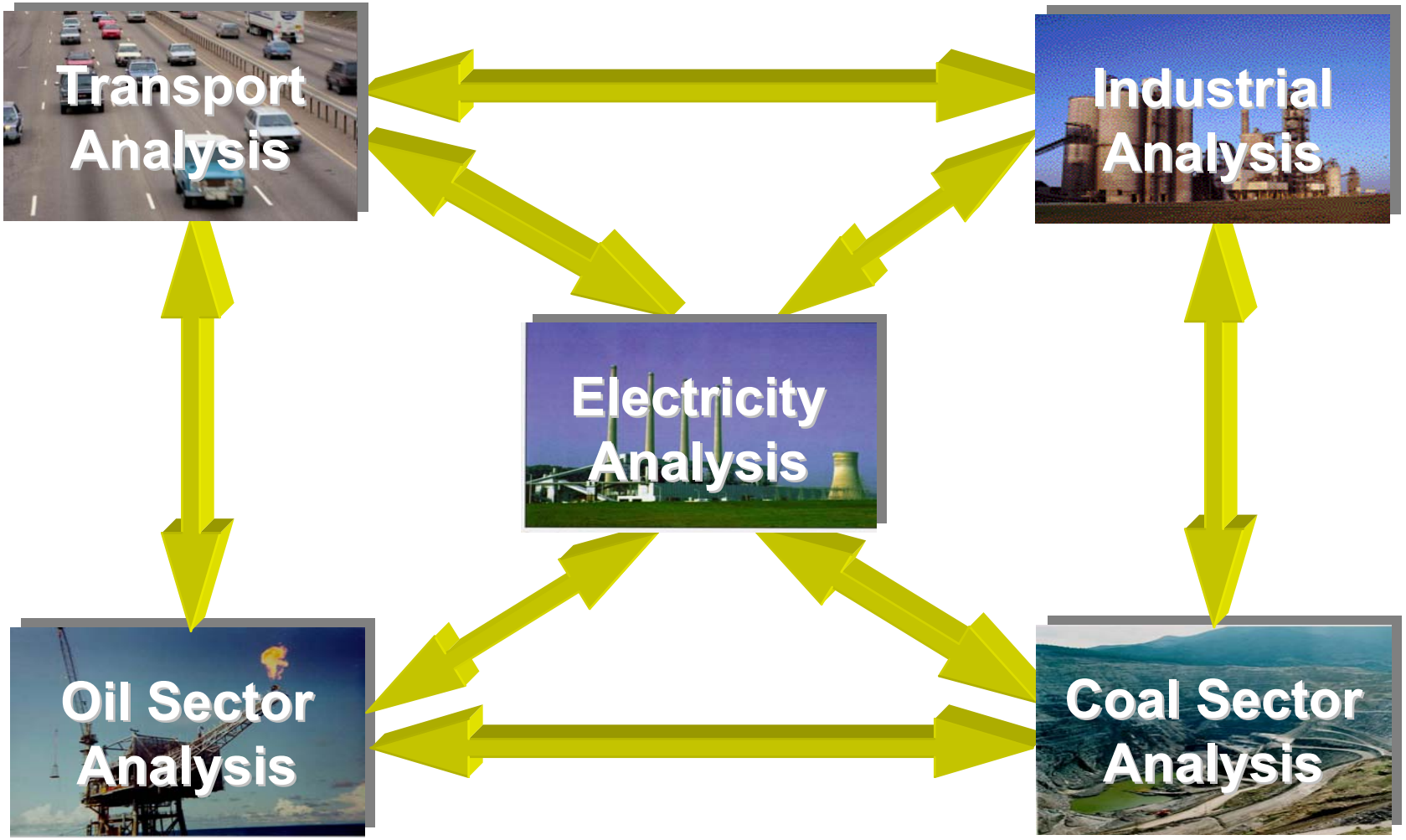
DEMAND: Projects energy demand based upon the macroeconomic growth information provided in MACRO

ICARUS: Performs detailed production cost and reliability calculations for a specified electrical generating system

PLANTDATA: Provides, for use in other modules, a library of technical data on electric generating plants

BALANCE: Computes equilibrium energy supply/demand balances over the study period

An Integrated Model Can Provide the Structure for a Consistent Energy Planning Program



The Most Frequently Used ENPEP Modules Include:

ELECTRIC (WASP-III+)
Power System Analysis

ICARUS
Least-Cost Dispatch, Environmental Dispatch, Emissions Trading

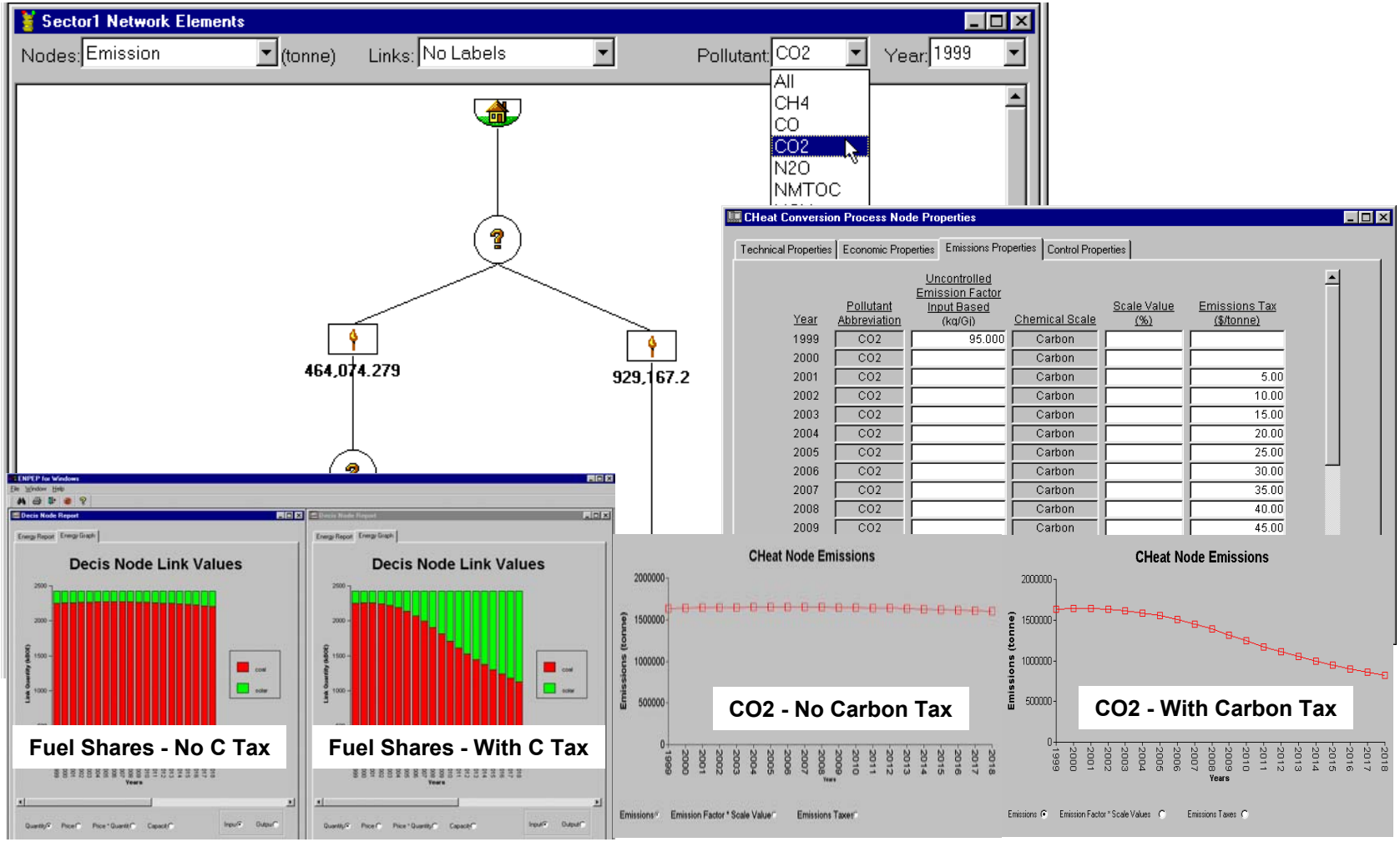
IMPACTS
Emissions Projections

MAED
Energy/Electricity Demand Analysis

Please note that the new ENPEP for Windows combines BALANCE and IMPACTS into one model

BALANCE
Overall Energy System Analysis

The New ENPEP for Windows Combines the BALANCE and the IMPACTS Model in a Windows Environment

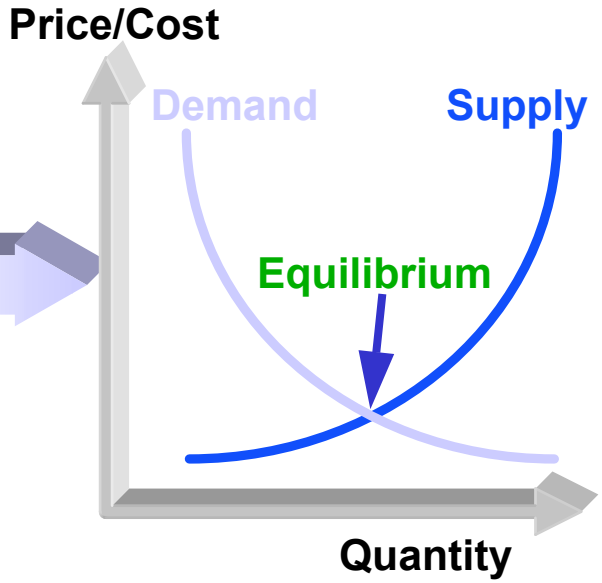


BALANCE Determines the Equilibrium Supply/Demand Balance of the Energy System

INPUT

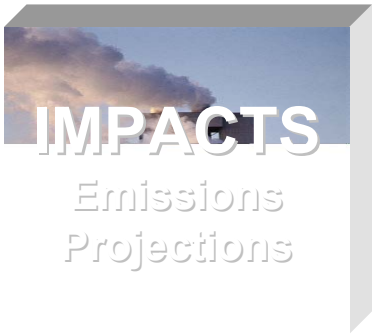
- Energy system structure
- Base year energy flows and prices
- Energy demand growth projections
- Technical and policy constraints

OUTPUT

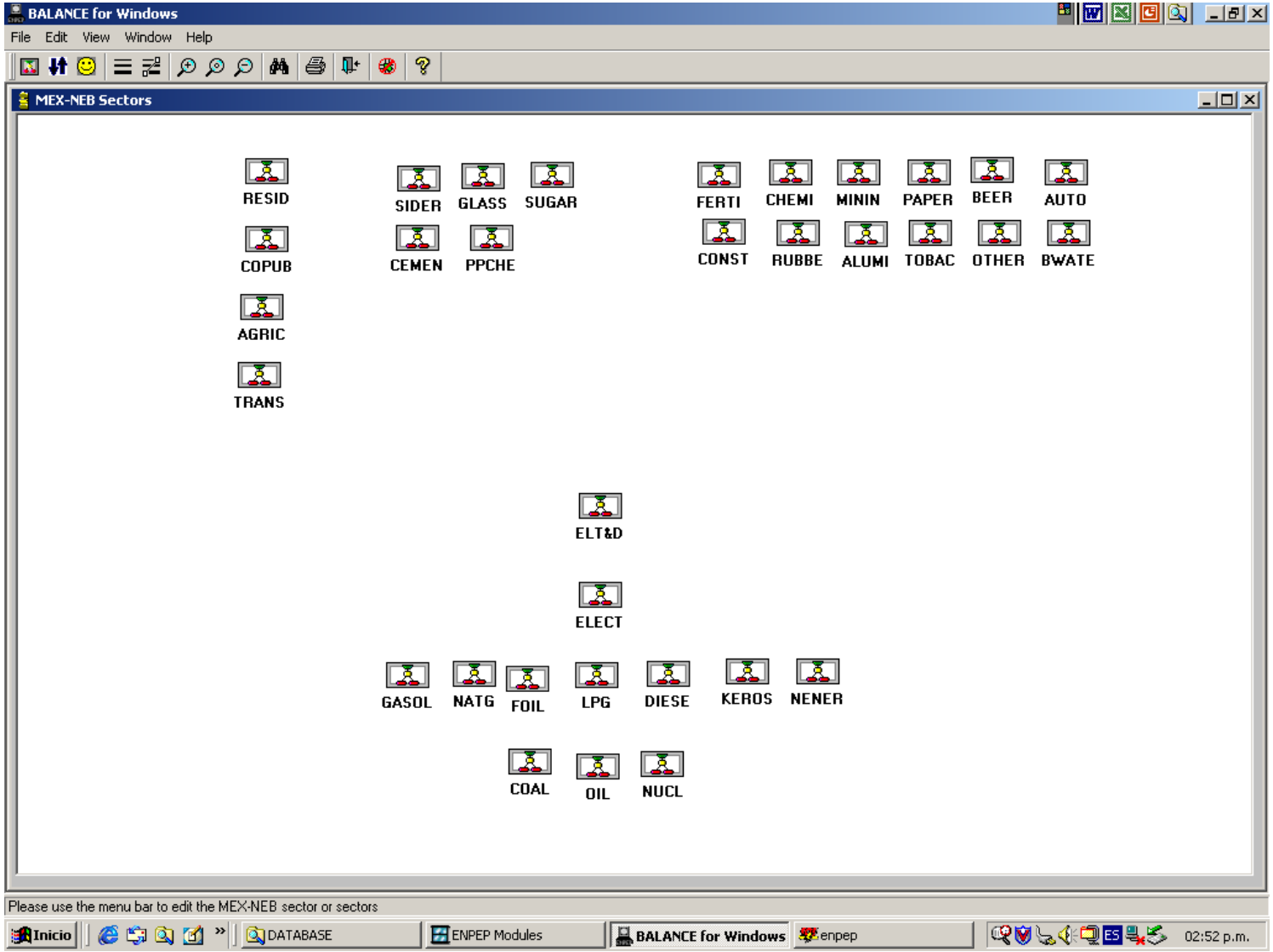


IMPACTS is Used Together with ELECTRIC, MODEMA and BALANCE to Project Future Environmental Burdens

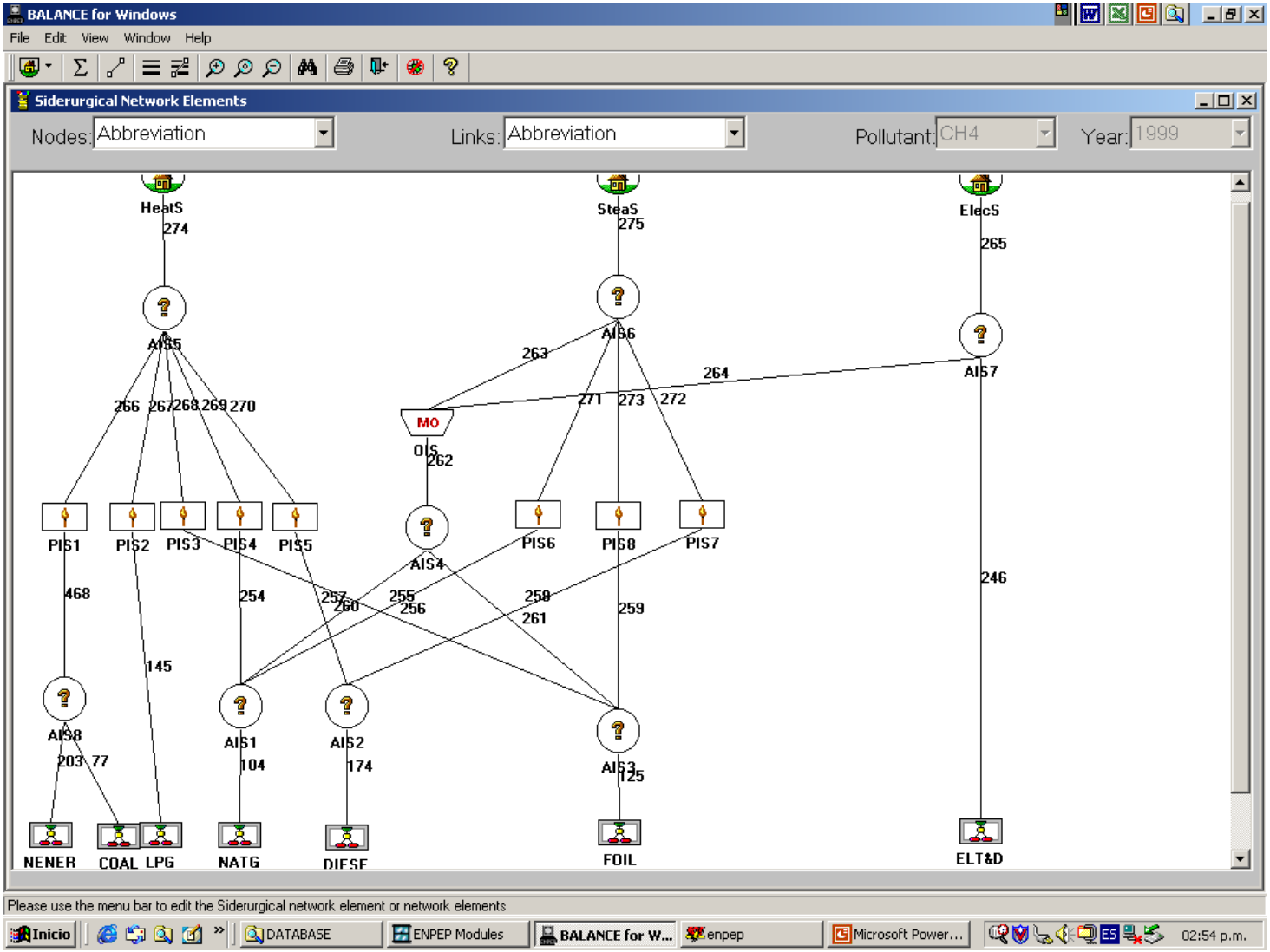
MODEMA: Projects energy demand and growth rates based upon the structural macroeconomic and population growths



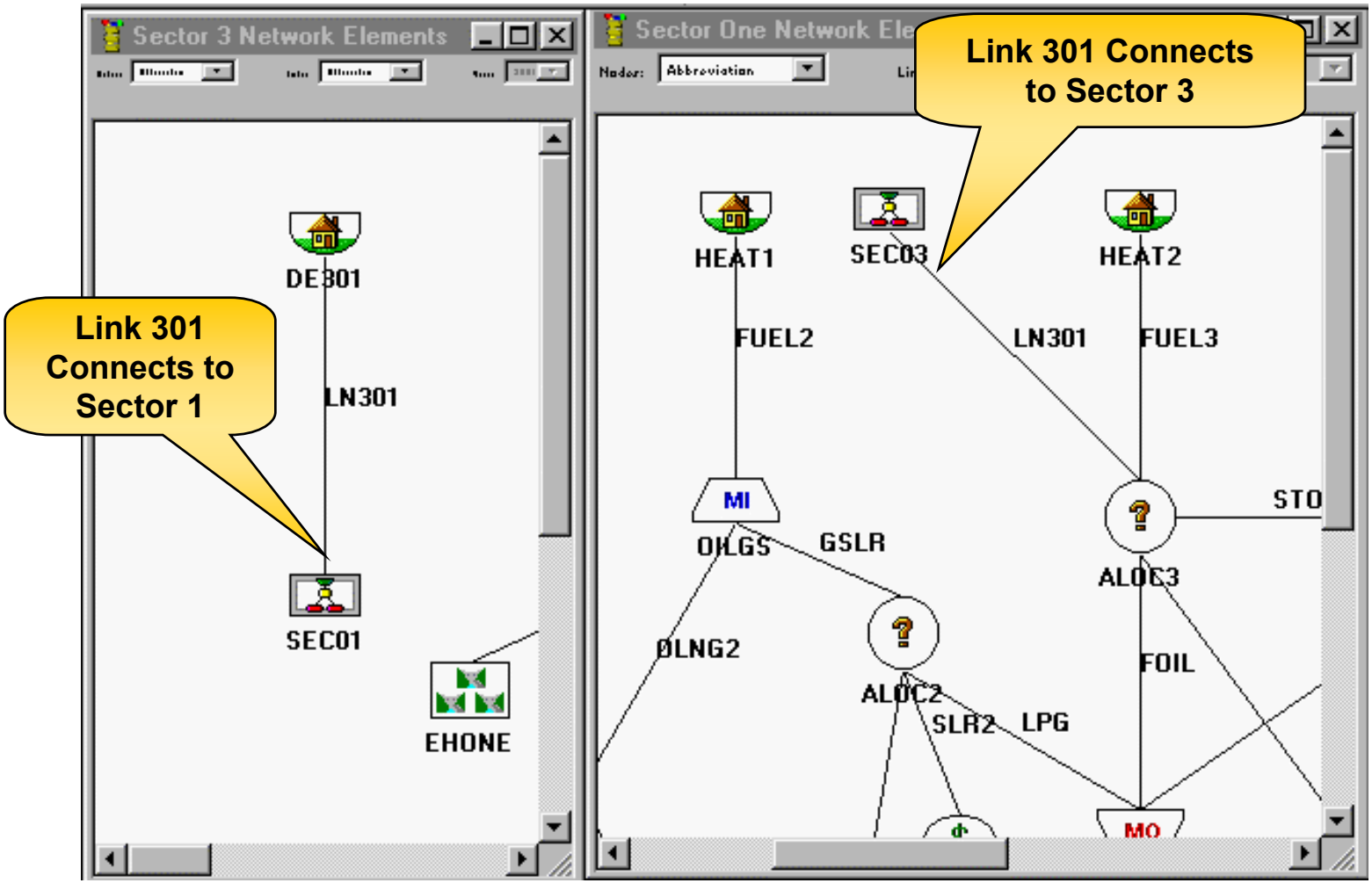
In the Model, a Network Implementation May Look as Follows:



The User Designs the Sector Networks Using Nodes and Links Right on the Screen



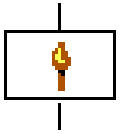
Different Sectors Can be Connected using Cross-Sectoral Links



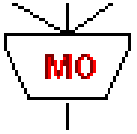
The Following Set of Node Conventions Has Been Adopted

- Demand

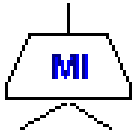
- Conversion Processes



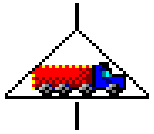
Single In-/Output



Multi Output



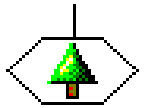
Multi Input



Transport

- Resource Processes

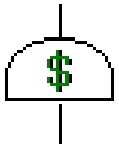
Depletable



Renewable

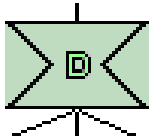
- Economic Processes

Decision/Allocation



Pricing

- Electricity Dispatch and Thermal and Hydro Units



Central Dispatch

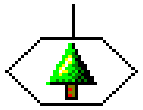
Thermal Unit

Hydro Unit

Nodes Available in the BALANCE Module

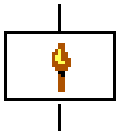
Depletable resource

Simulates depletable resources such as crude oil, coal, natural gas.



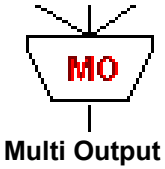
Renewable resource

Simulates renewable resources such as solar, biomass.



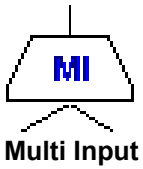
Conversion In-Output 1

Simulates technologies that convert one form of energy to another (e.g., electric power stations).



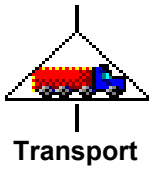
Conversion Multiple Output

Simulates technologies that produce two or more forms of output energy for one form of input energy (e.g., refineries, cogenerators).



Conversion Input

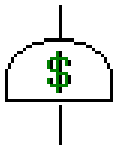
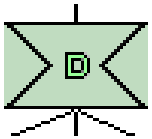
Simulates technologies that require two types of energy input to produce one form of energy output (e.g., solar water heater with electric backup).



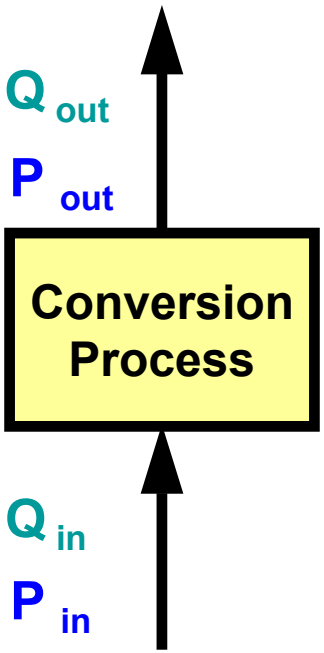
Transport

Simulates technologies for transportation of fuels (e.g., oil and gas pipelines).

Nodes Available in the BALANCE Module (continuation)

Decision/Allocation	Economic process (decision/allocation)	Simulates market decisions that choose among energy alternatives.
 Pricing	Economic process (pricing)	Simulates pricing policies that change the price but not the quantity of an energy form.
 Central Dispatch	Electricity dispatching	Simulates the dispatching of electrical generators according to the load duration.
Thermal Unit	Thermal unit	Simulates the specific thermal unit.
Hydro Unit	Hydro unit	Simulates the specific hydro unit.
	Demand (sectoral/subsectoral)	Simulates the final demand for energy o energy services.

Nodes Are a Series of Simple Sub-Models, Each With a Set of Quantity and Price Equations



- $\text{Quantity}_{output} = f(\text{Quantity}_{input})$
  - Example conversion process

    $Q_{out} = Q_{in} \times \eta$

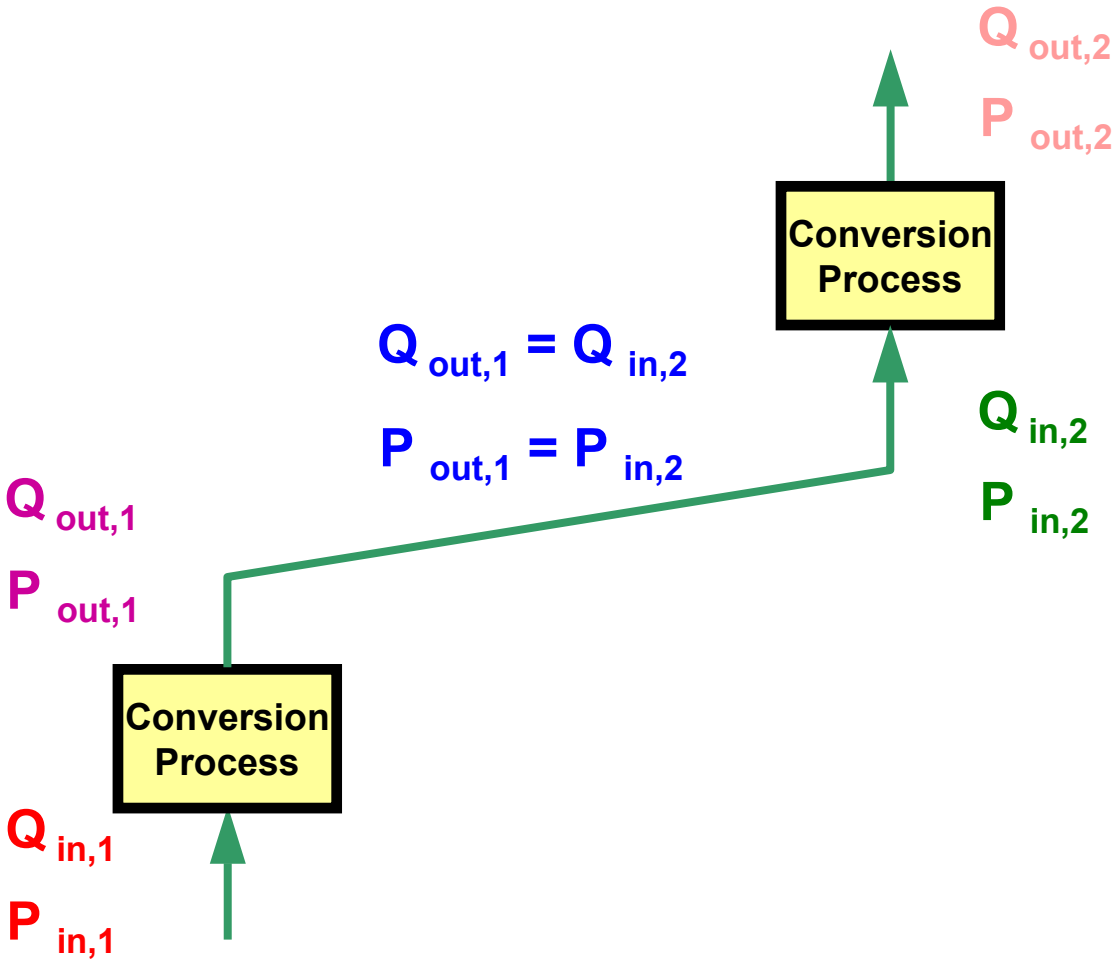
    η: conversion efficiency

- $\text{Price}_{output} = f(\text{Price}_{input})$
  - Example conversion process

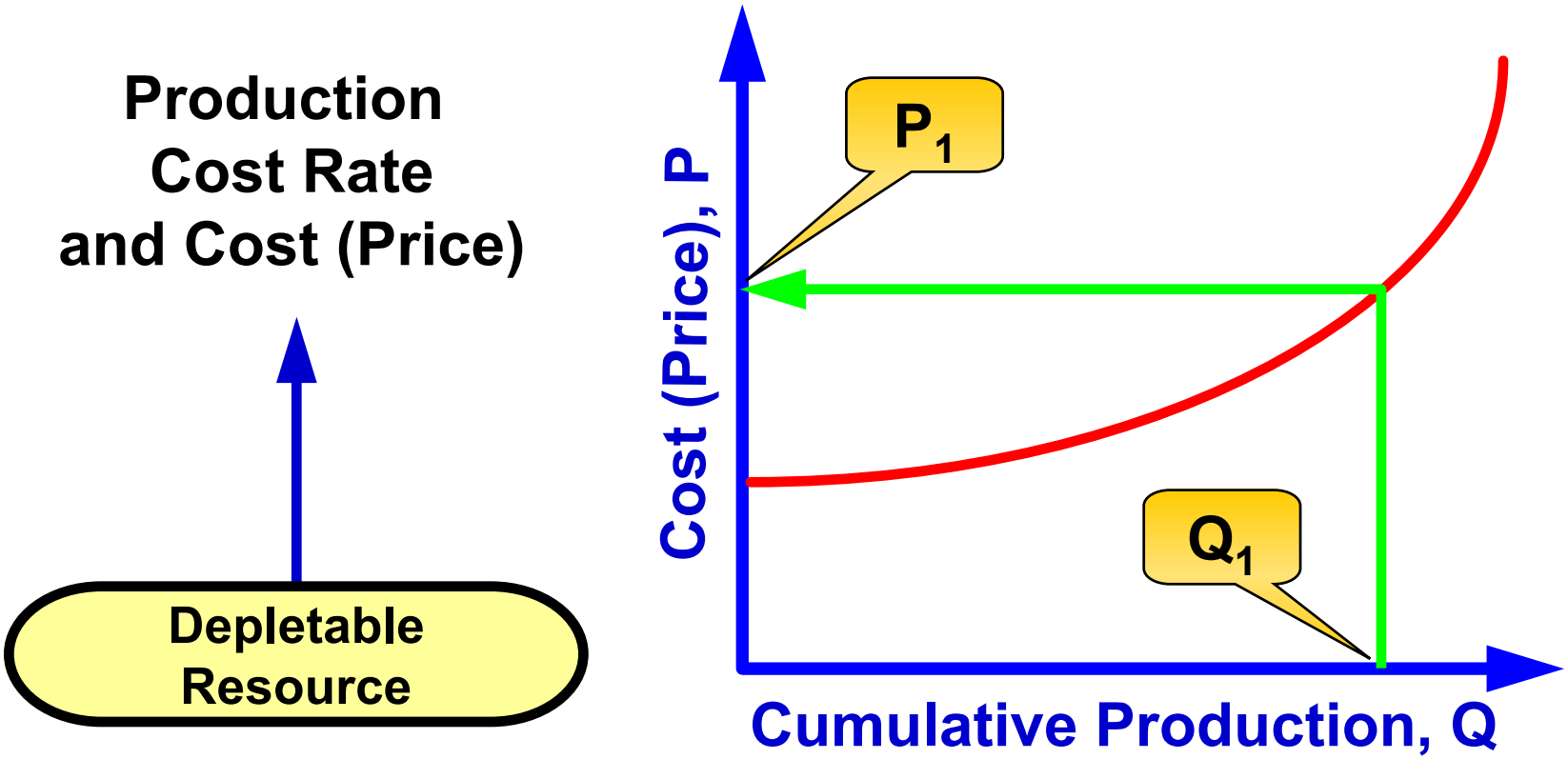
    Revenue = Cost

    $Q_{out} \times P_{out} = Q_{in} \times P_{in} + O\&M + \text{Capital Recovery}$

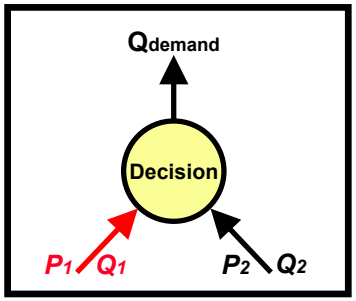
The Links Connect the Nodes and Pass Information from One Node to Another



The Resource Process Represents Primary Energy Production with Resource Supply Curve

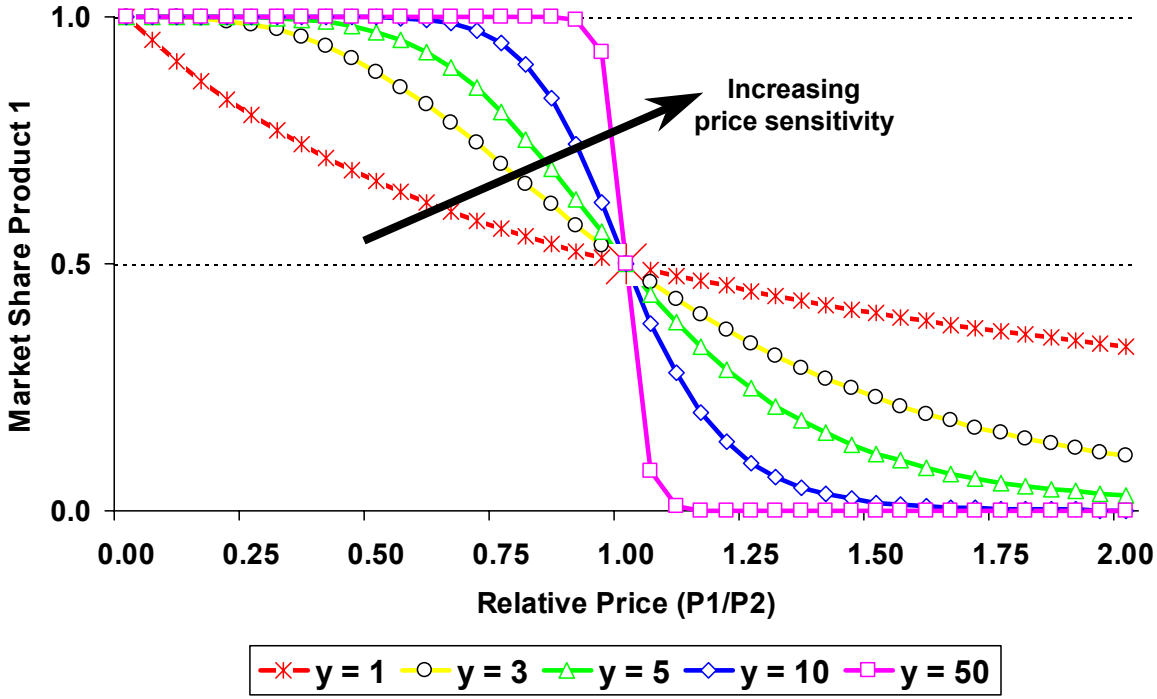


BALANCE Uses a Logit-Function to Estimate Market Shares of Competing Commodities at the Decision Node



$$MS_1 = \frac{Q_1}{Q_1 + Q_2} = \frac{\left[\frac{1}{P_1 \times PM_1}\right]^{\gamma}}{\left[\frac{1}{P_1 \times PM_1}\right]^{\gamma} + \left[\frac{1}{P_2 \times PM_2}\right]^{\gamma}}$$

γ	price sensitivity for this decision process
MS:	market share
P:	price
PM:	premium multiplier
Q:	quantity

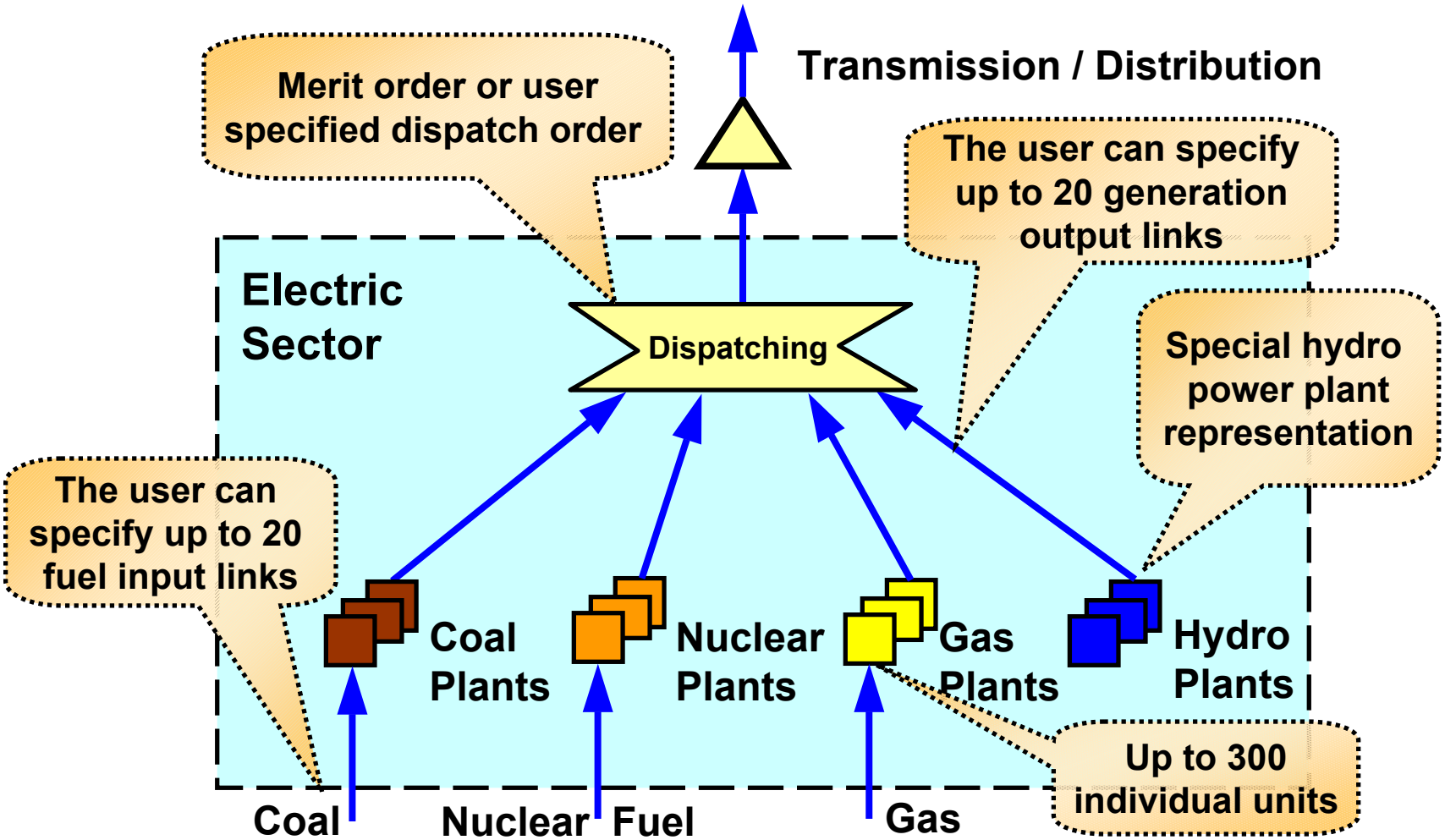


The Up-Pass and Down-Pass Sequences Are Repeated Until Convergence Has Been Achieved

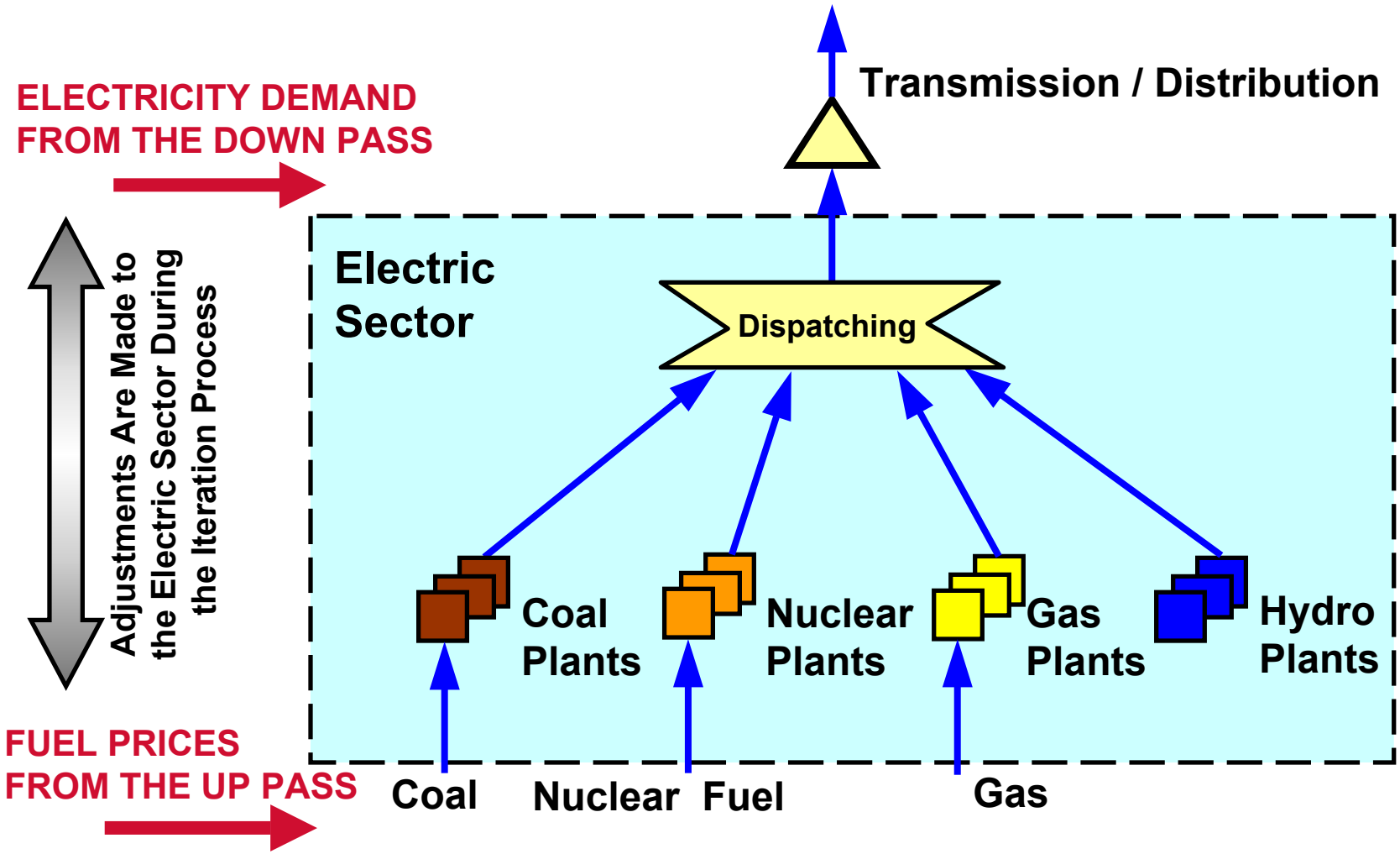
CONVERGENCE IS ACHIEVED WHEN:

- **Q1 (down) = Q1 (up) +/- Tolerance Level**
- Q2 (down) = Q2 (up) +/- Tolerance Level
- The final result is a converged solution
- The solution is in equilibrium across the whole network

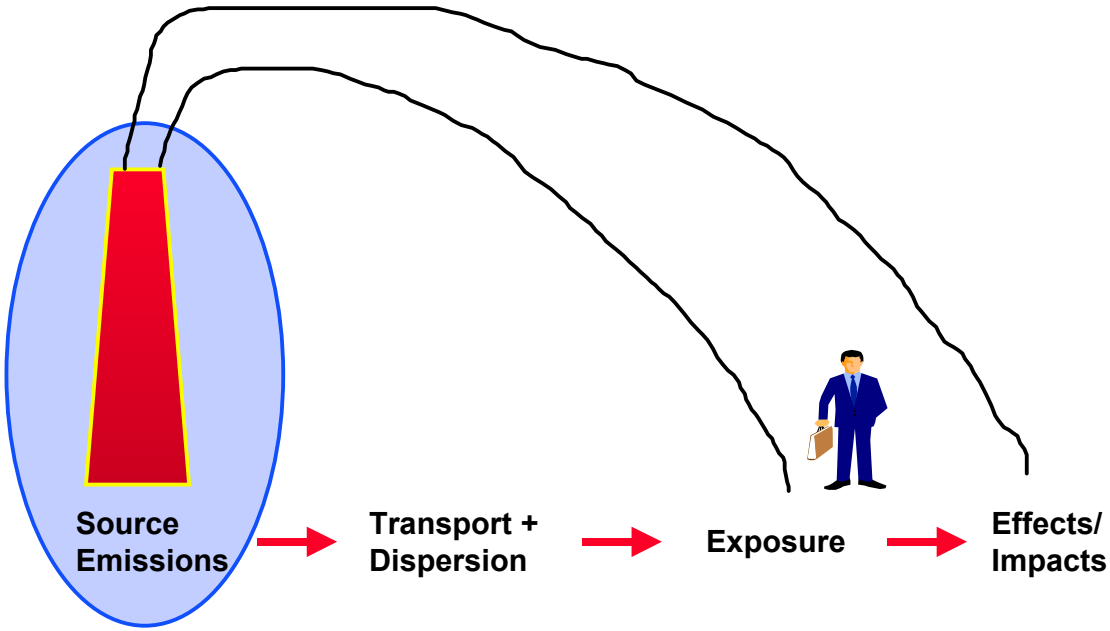
The Electricity Dispatch Node Handles the Electric Sector in a Special Way



Electricity Demand and Fuel Prices Are Received from the Network



ENPEP Uses a Standard Methodology to Determine the Uncontrolled and Controlled Source Emissions



Uncontrolled Emissions	=	Fuel Consumption	x	Emission Factor	x	Chemical Scale

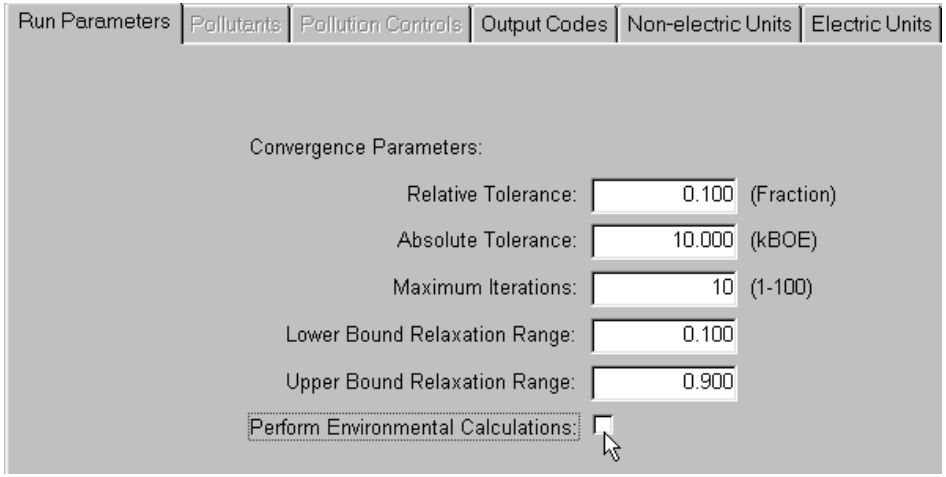
Controlled Emissions	=	Uncontrolled Emissions	x	(100 - Control Efficiency) / 100

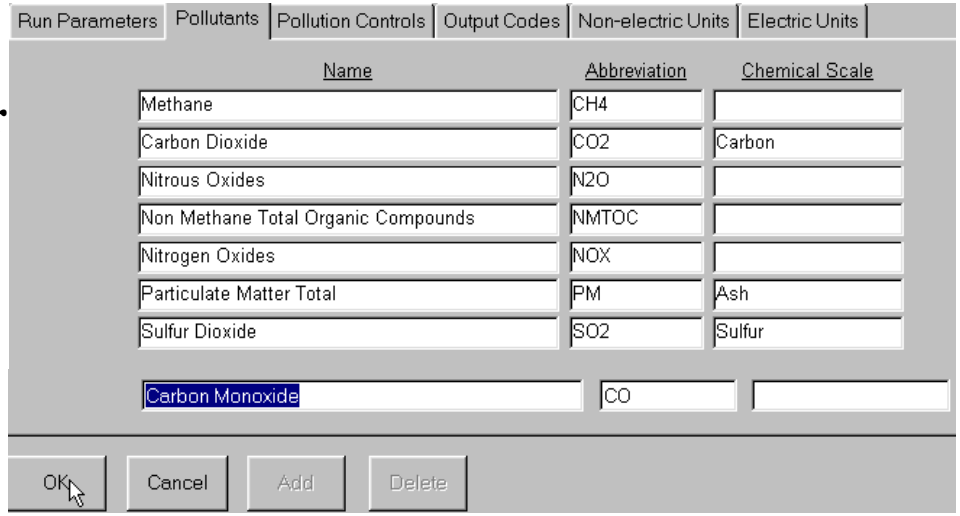
Environmental Calculations Need to be Activated; User Can Define the Pollutants

- Checking the "*Perform Environmental Calculations*" box will activate the environmental routines

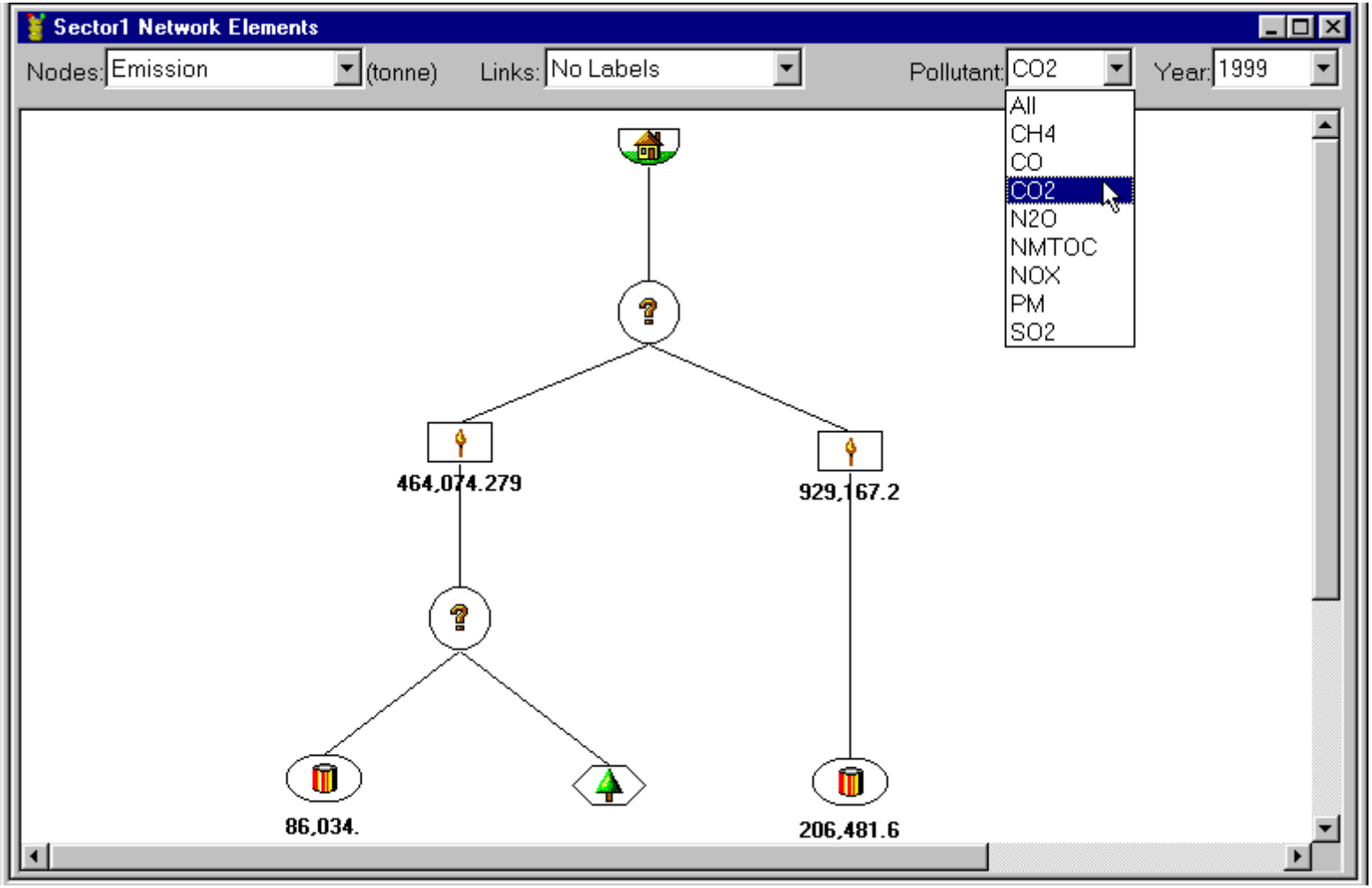
- Environmental input/output screens are "grayed-out" unless they are activated

- *Chemical Scale* indicates whether the emissions are considered to be a linear function of a certain fuel characteristic, such as fuel carbon content for CO_2 emissions, fuel sulfur content for SO_2 emissions, etc.





Environmental Results Can be Viewed Directly in the Network Using the Node Overlays



Results Can Also be Viewed as Tables, Simple Graphs, or Exported to EXCEL

Microsoft Excel - ENPEP Demo Case Emis Emissions.txt

File Edit View Insert Format Tools Data Window Hel

Arial 10

A1 = DemoC Export to TXT No

	A	B	C	D	E	
1	DemoC Export to TXT Nodes emissions				13-Feb-(	
2						
3	Base	Nb of	Nb of	Nb of		
4	Year	Years	Nodes	Pollutants	Unit	
5						
6	1991	30	79	10	tonne	
7						
8						
9	Sector	Node	Type	Pollutant	199	
10	AG	DE23	DE	0PM	1658.29	
11	AG	DE23	DE	1PM10	0	0
12	AG	DE23	DE	2SO2	14.31514	15.0309
13	AG	DE23	DE	3NOX	282.5357	296.6624
14	AG	DE23	DE	4CO	2563.163	2691.322
15	AG	DE23	DE	5NMTO	0	0
16	AG	DE23	DE	6CH4	0	0
17	AG	DE23	DE	7TOC	41.43856	43.51049
18	AG	DE23	DE	8CO2	414586.8	435316.1
19	AG	DE23	DE	9N20	0	0
20	AG	DE24	DE	0PM	4.230636	4.442168
21	AG	DE24	DE	1PM10	4.230636	4.442168
22	AG	DE24	DE	2SO2	6.345954	6.663252
23	AG	DE24	DE	3NOX	141.3032	148.3684
24	AG	DE24	DE	4CO	16.71101	17.54656
25	AG	DE24	DE	5NMTO	3.384509	3.553734

ENPEP Demo Case Emis Emissions

Ready

Energy Report | Energy Graph | Environmental Report | Environmental Graph

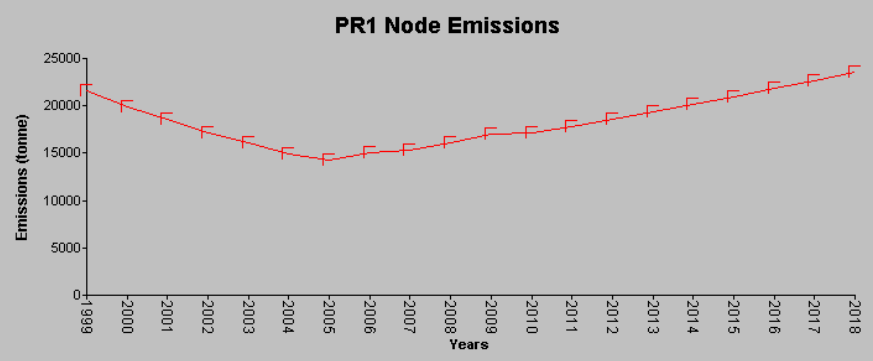
Year	Input Quantity (kBOE)	Pollutant Abbreviation	Emission Factor Times Scale Value (kg/Gj)	Emissions (tonne)	Emissions Taxes ($1000)
1999	1200	CO2	104.64515	720,243.281	14,404.866
2000	1245.777588	CO2	104.64515	747,719.114	14,954.382
2001	1292.328003	CO2	104.64515	775,658.800	15,513.176
2002	1340.535767	CO2	104.64515	804,593.232	16,091.865
2003	1389.497192	CO2	104.64515	833,980.013	16,679.600
2004	1439.415039	CO2	104.64515	863,940.841	17,278.817

Selected Pollutant: CO2

CH4
CO2
N2O
NMTOC
NOX

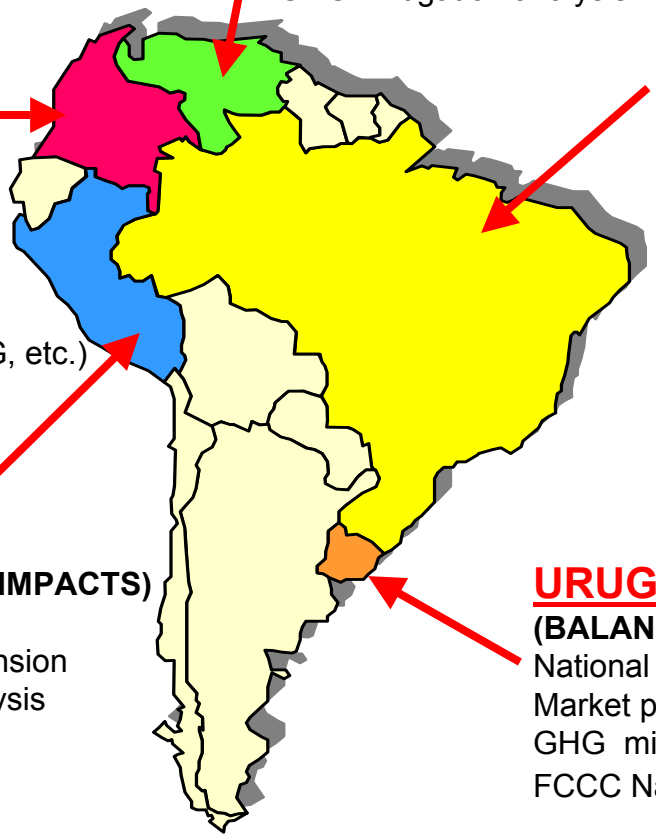
OK

Energy Report | Energy Graph | Environmental Report | Environmental Graph



Emissions Emission Factor * Scale Value Emissions Taxe

Current/Recent ENPEP Applications in South America



VENEZUELA
(WASP, BALANCE, IMPACTS)
National energy analysis
GHG mitigation analysis

COLOMBIA
(MAED, WASP, BALANCE, IMPACTS, VALORAGUA)
National energy analysis
Natural gas expansion
Electric system development
Air pollution (PM, SOX, NOX, GHG, etc.)
PM + SOX control cost analysis

BRAZIL
(WASP, BALANCE, VALORAGUA, IMPACTS)
State energy analysis
State electric system development
Air pollution analysis
Land use analysis
Decision analysis

PERU
(WASP, BALANCE, IMPACTS)
Load forecasting
Electric system expansion
National energy analysis
Air pollution analysis
GHG mitigation

URUGUAY
(BALANCE, IMPACTS)
National energy analysis
Market penetration of natural gas
GHG mitigation analysis
FCCC Nat Com (submitted)