Overview of Environmental Calculations in ENPEP for Windows

Main Design Characteristics for Environmental Calculations in ENPEP for Windows

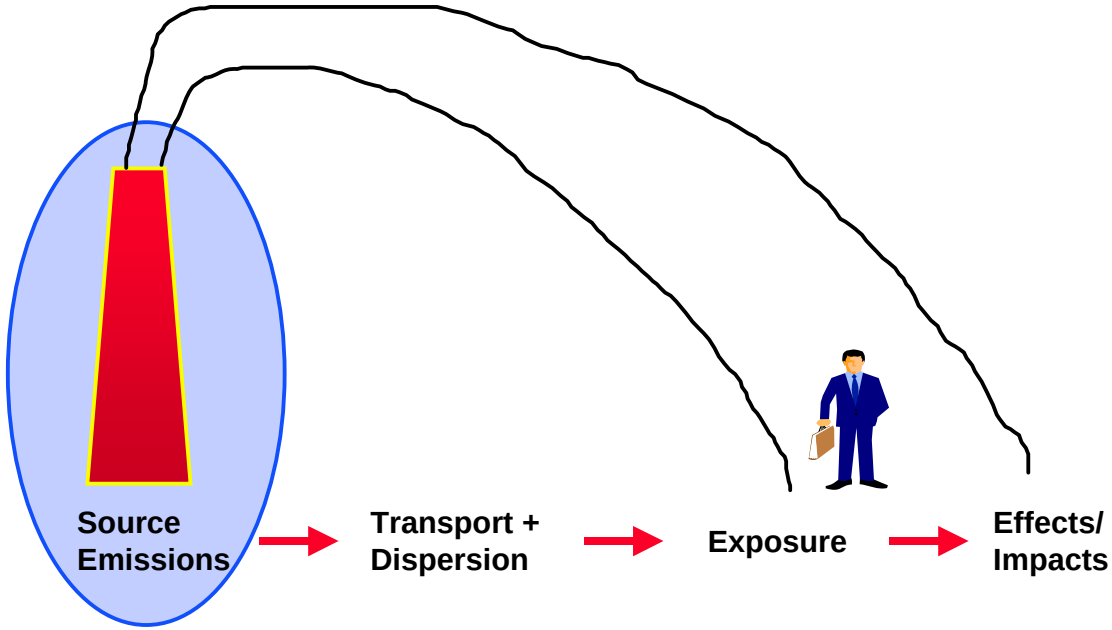
- **Compute annual levels of environmental burdens (e.g., air pollutant emissions, water effluents, solid waste generation) from energy production, conversion, and consumption**

- **Allow the user to introduce emissions taxes into the model (e.g., carbon tax) and examine the resulting changes in the energy supply mix and associated environmental burdens**

Emissions are Assumed to be a Function of the Following General Parameters

- Level of fuel consumption
- Type of fuel (e.g., coal versus oil versus gas, high sulfur coal versus low sulfur coal)
- Type of combustion technology (steam turbine versus gas turbine, pulverized coal versus stoker furnace, etc.) and pollution control equipment

ENPEP Uses a Standard Methodology to Determine the Uncontrolled Source Emissions

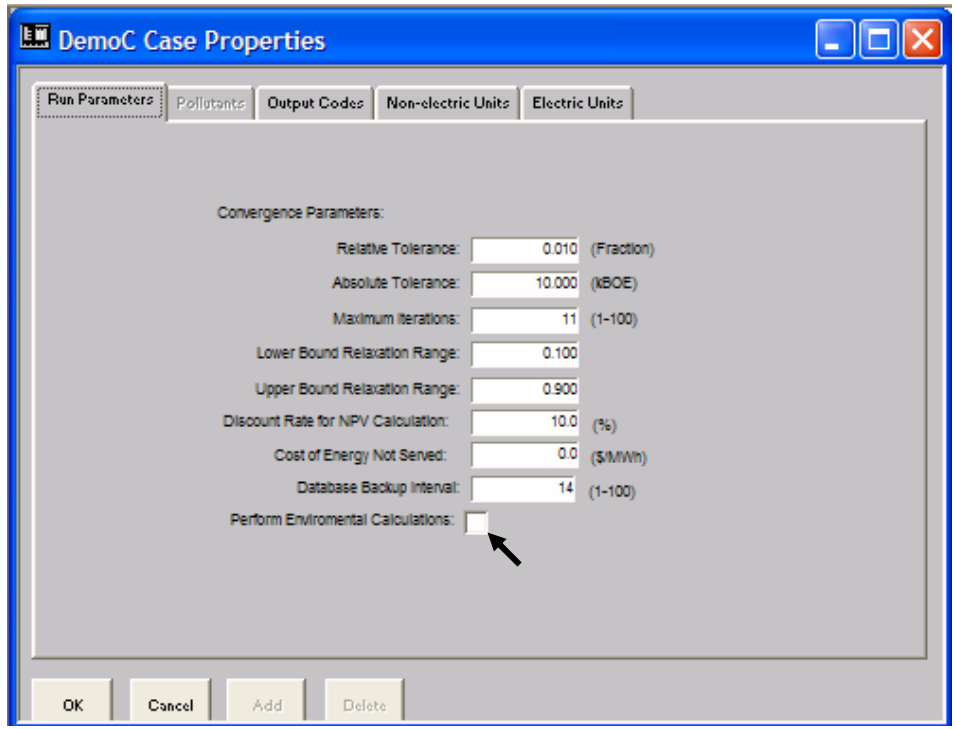


Uncontrolled Emissions = Fuel Consumption x Emission Factor x Chemical Scale

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

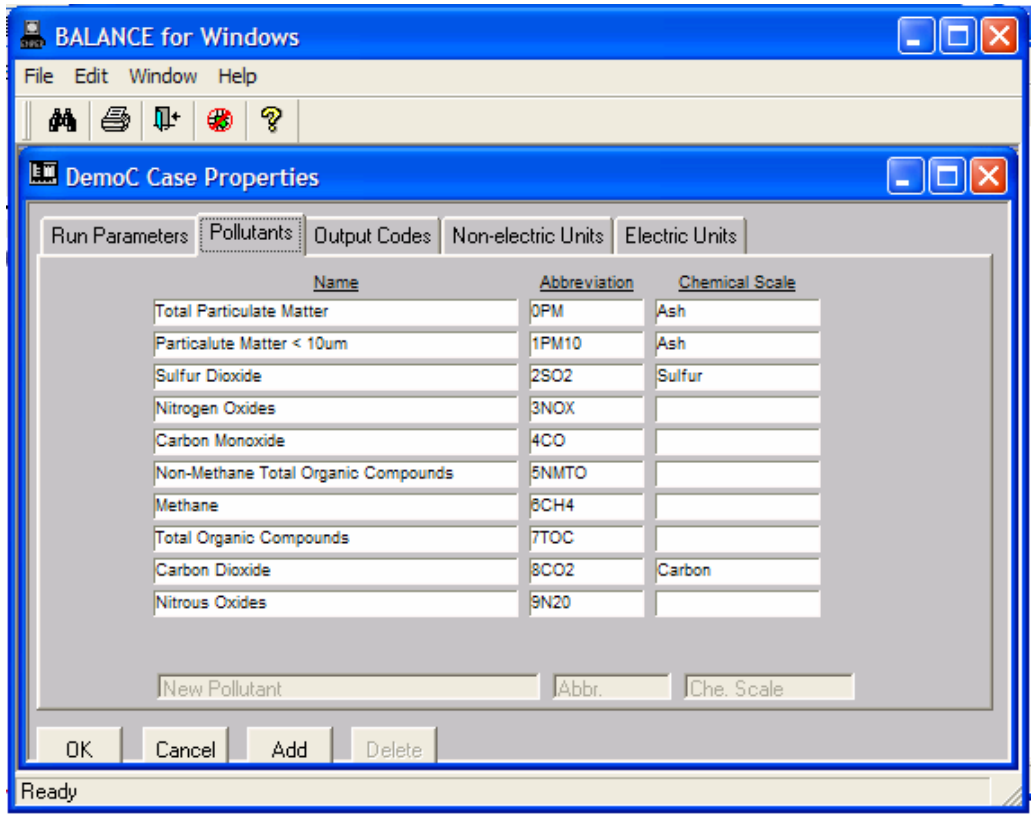
The Environmental Calculations Can be Activated under Run Parameters

- **Checking the "*Perform Environmental Calculations*" box will activate the environmental routines**
- **It also allows access to the environmental input data screens as well as the output screens**
  - the environmental input/output screens are "grayed-out" to indicate they are not activated



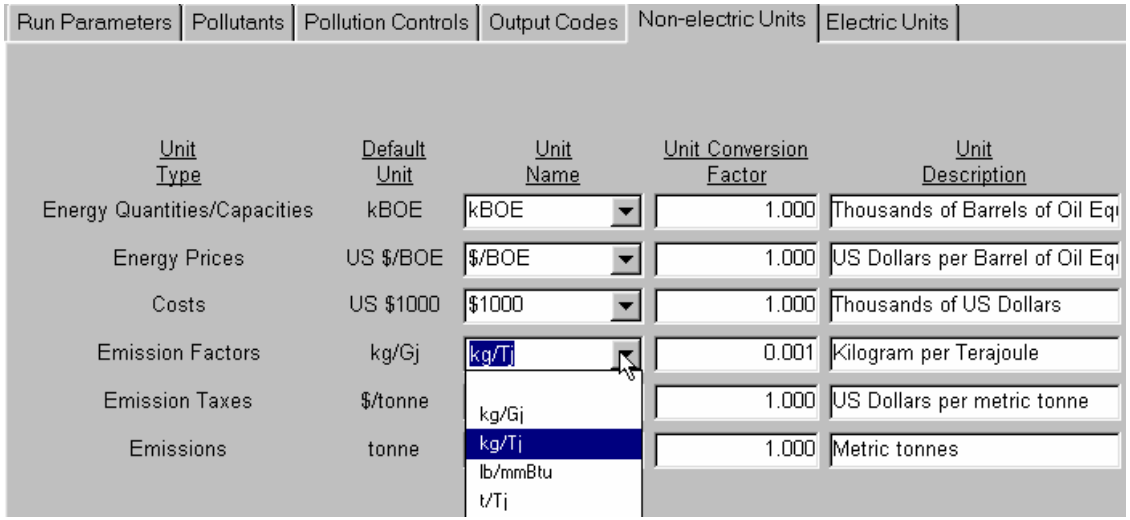
- **After you enter all environmental information and run the case, if you wish, you can turn the environmental calculations off again by un-checking this box**
  - environmental information is maintained but no calculations are performed
  - you can turn the environmental calculations back on again by simply checking the box

The User Can Add or Delete Pollutants to the Current Default List



- ***Name*** **indicates the name of the pollutant**
- ***Abbreviation*** **is the 5 character abbreviation for the pollutant**
- ***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.**

The User May Specify the Units Used for Environmental Inputs and Outputs



- Units may be defined for both Non-Electric and Electric (if electric sector is used)
- The ***Default Unit*** is the unit that the model uses internally
- The pull-down menu under ***Unit Name*** provides the user with a choice of alternative units; the user may add to (select blank field) or delete items from the list
- The ***Unit Conversion Factor*** is a factor that the model uses internally to convert the user-selected unit back to the default unit

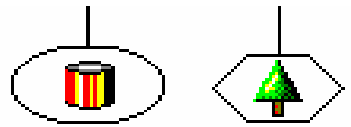
Default Unit = New Unit * Unit Conversion Factor

example: kg/GJ = kg/TJ * 0.001 TJ/GJ

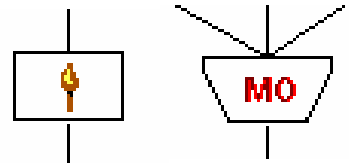
- Note that the environmental units can only be selected if the "Perform Environmental Calculations" checkbox in Run Parameters is checked

Emissions Are Calculated and Reported by Node

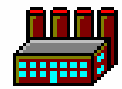
- **For depletable and renewable resources, emissions are calculated based on the resource *output***



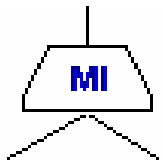
- **For single input/single output and multiple output processes emissions are calculated based on process fuel/energy *input***



- **For thermal electric generating units, emissions are calculated based on fuel *input* or fuel consumption**



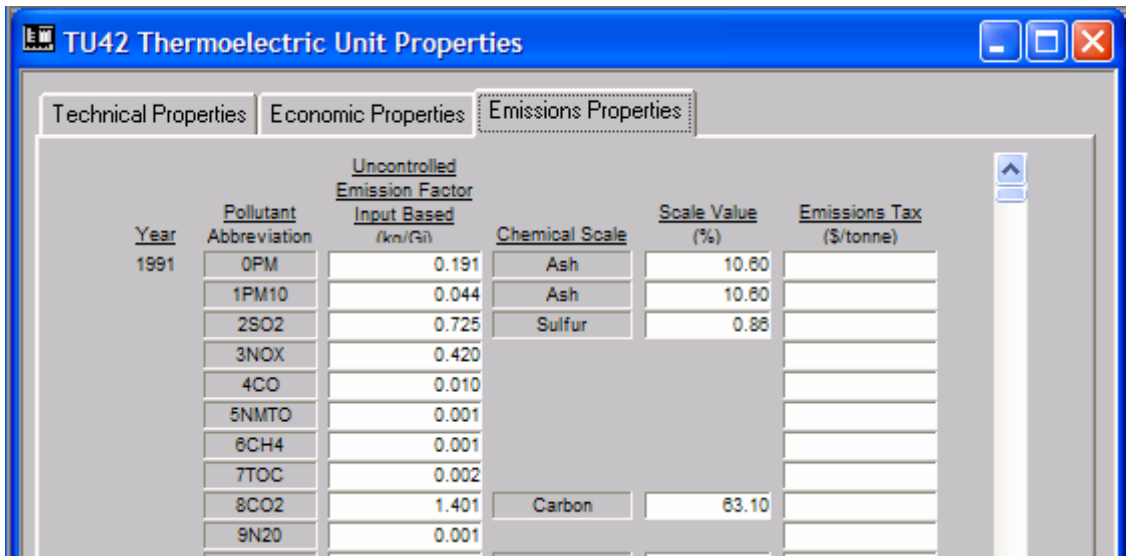
- **For multiple input nodes, emissions are calculated based on process *output***
  - output based emission factor needs to be calculated and input as weighted average across all fuel inputs



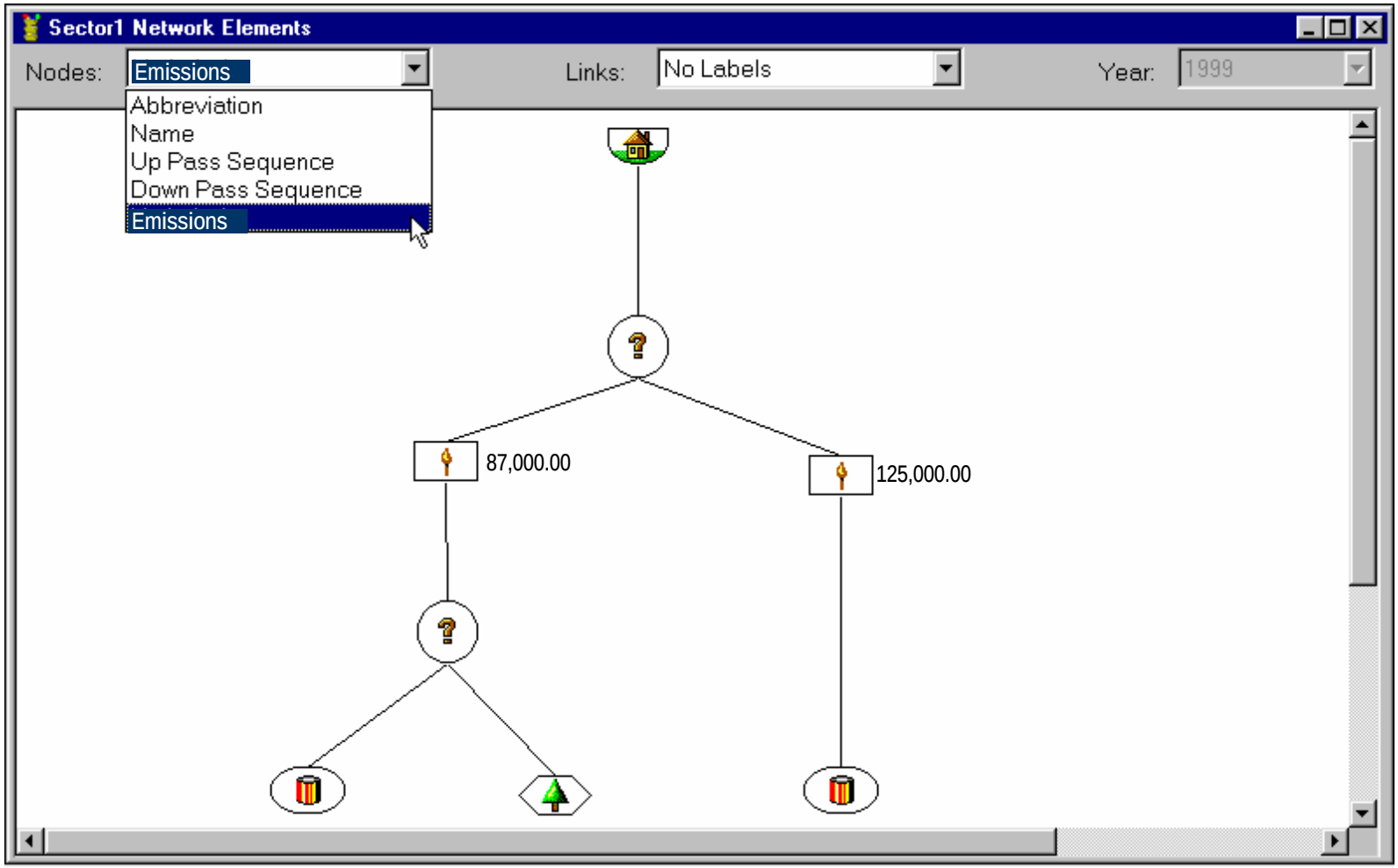
- **For demand nodes, emissions are calculated based on process *input***
  - demand nodes should only be used for situations where sectors are modeled in terms of final energy

Example: Emission Factors for a Thermal Power Plant Process

- ***Uncontrolled Emission Factor Input Based*** **represents the emission factor for this specific process without using any pollution control technology; factor is based on the process input or fuel consumption**
- ***Scale Value*** **is the chemical content in percent that will be used to linearly scale the emissions**
  - the scale value may be left blank if already included in the emission factor
  - for example CO_2: enter 104.68 kg/GJ (1.349 * 77.6) and leave scale value blank (default is 1.0) instead of 1.349 kg/GJ and 77.6% carbon
- ***Emissions Tax*** **represents the tax imposed on a process for a specific pollutant**
- **All three parameters above can be changed year by year**

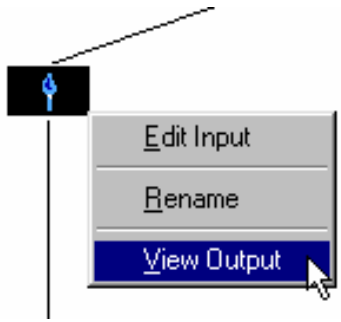


Environmental Results Can be Viewed Directly in the Network Using the Node Overlays



Environmental Reports and Graphs Can be Accessed for Each Node Using "View Output"

- **Results can be viewed for each pollutant individually by using the *Selected Pollutant* pull-down menu or for all pollutants at the same time**
- **The pollutant selection in this screen will influence what will be displayed in the environmental graph screen**



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
N20
NMTOC
NOX

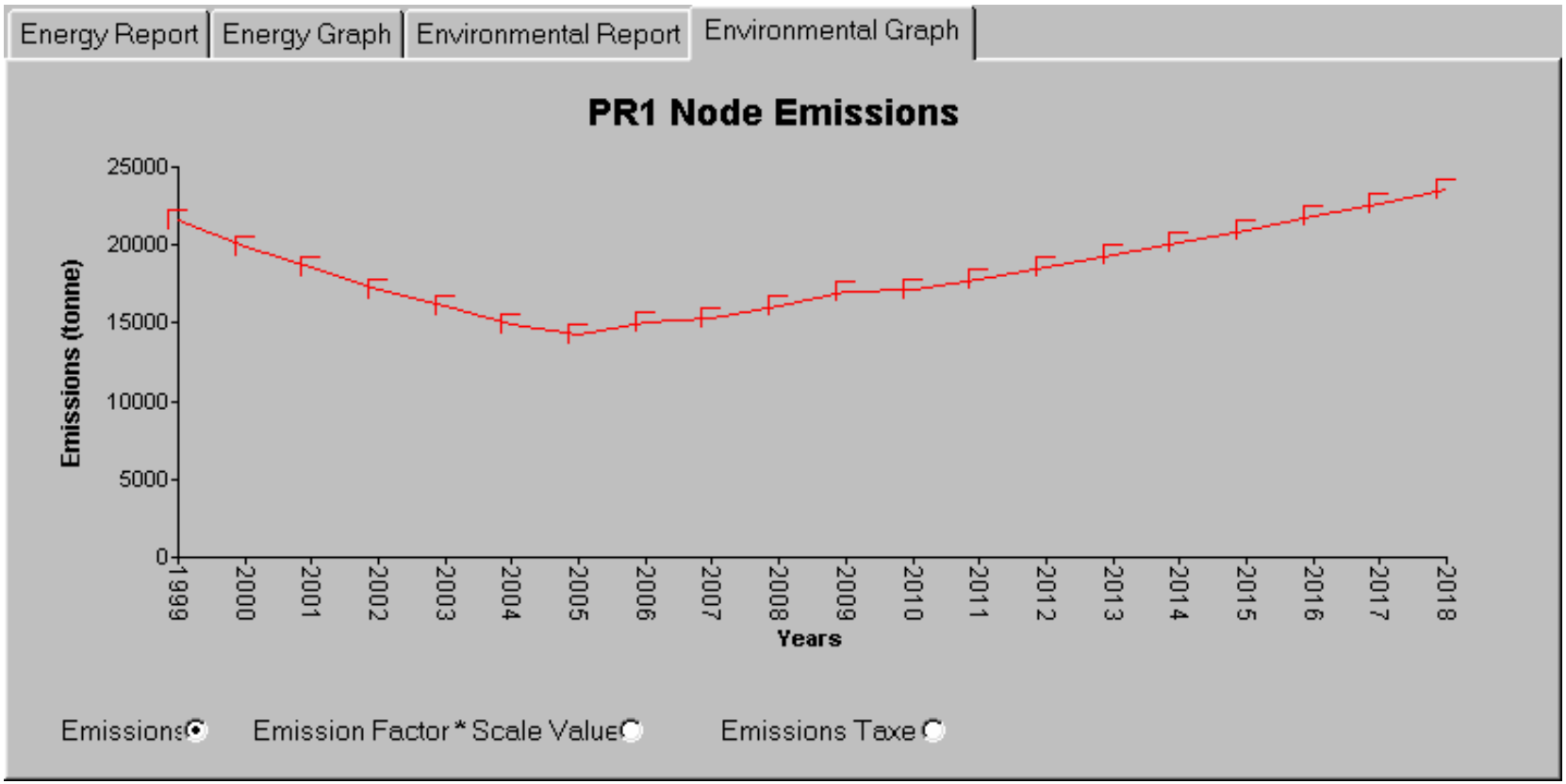
OK

Environmental Reports and Graphs Can be Accessed for Each Node Using "View Output" (cont'd)

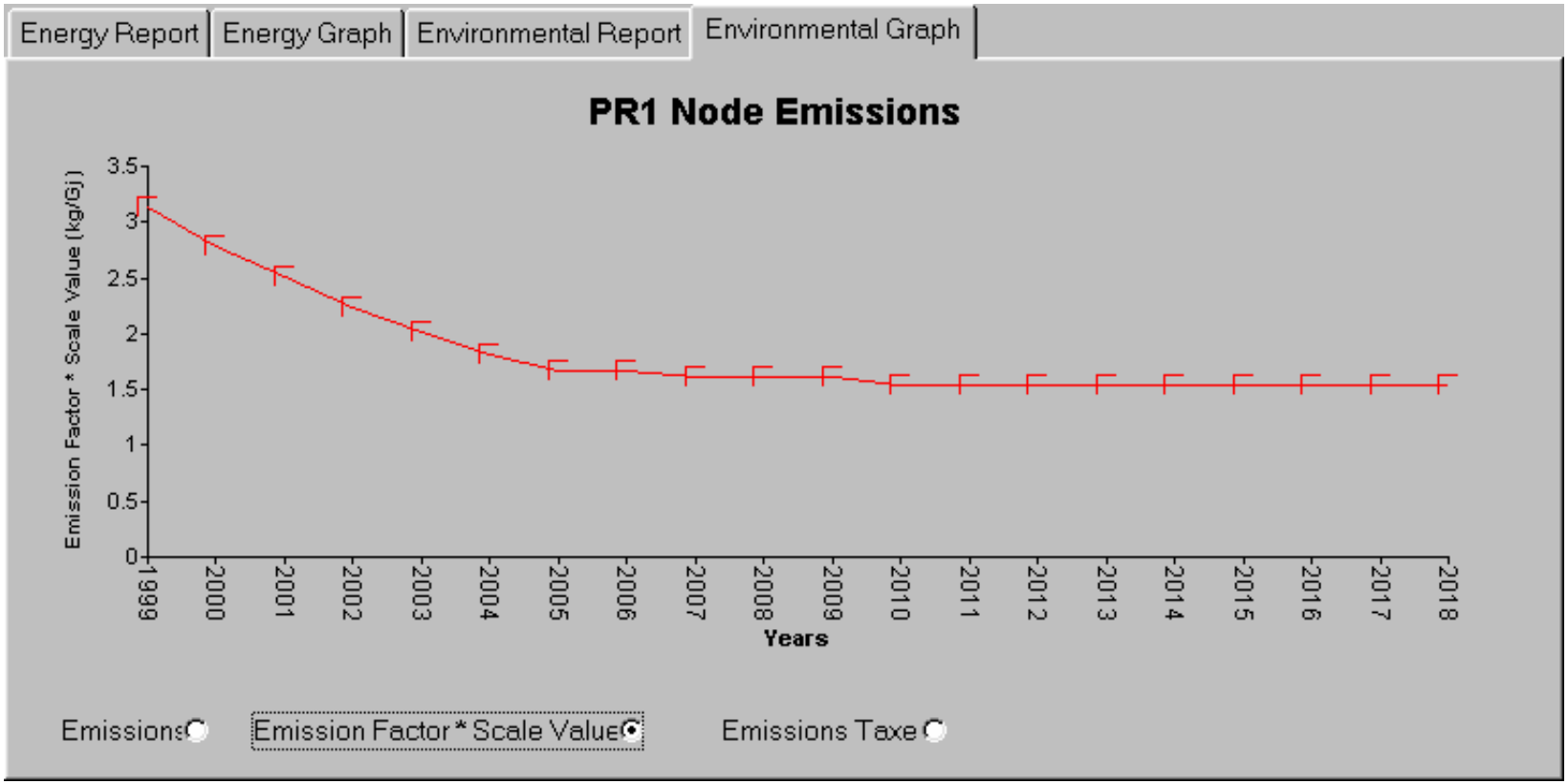
- ***Input Quantity*** **reports the annual fuel consumption for this process**
- ***Pollutant Abbreviation*** **indicates which pollutant you are viewing**
- ***Emission Factor Times Scale Value*** **displays the combined or aggregate emission factor including the chemical scale for the selected pollutant**
- ***Emissions*** **reports the annual atmospheric emissions for this process for the selected pollutant**
- ***Emission Taxes*** **displays the annual pollution taxes incurred by this process for this pollutant**
  - there may be taxes on more than one pollutant
  - taxes are calculated using the following equation

Annual Emission Tax	**=**	**Annual Emissions**	**x**	**Emission Tax per tonne**

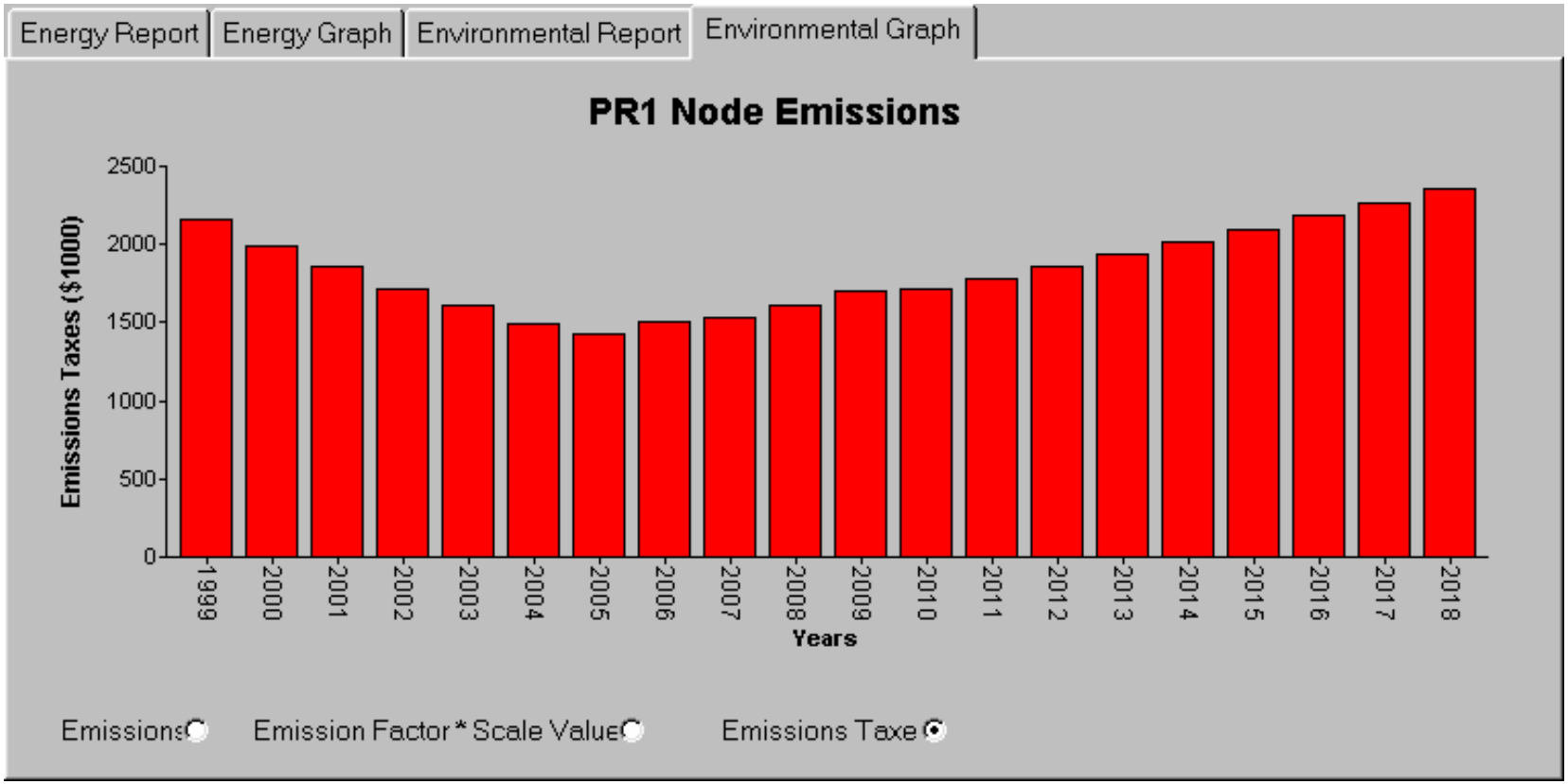
The Environmental Graph Shows Emission Results for the Pollutant(s) Selected in the Environmental Report



The Environmental Report Can Also be Used to View the Change in Emission Factor over Time

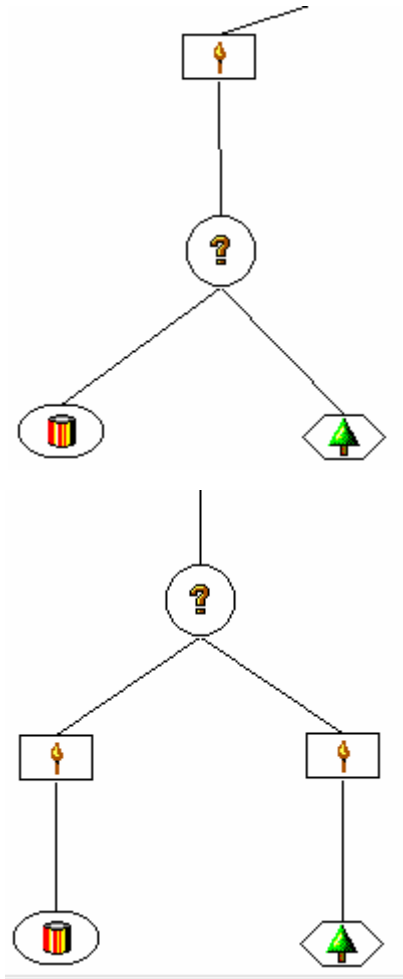


The Environmental Report Can be Used to Display the Annual Emissions Taxes Incurred by this Process



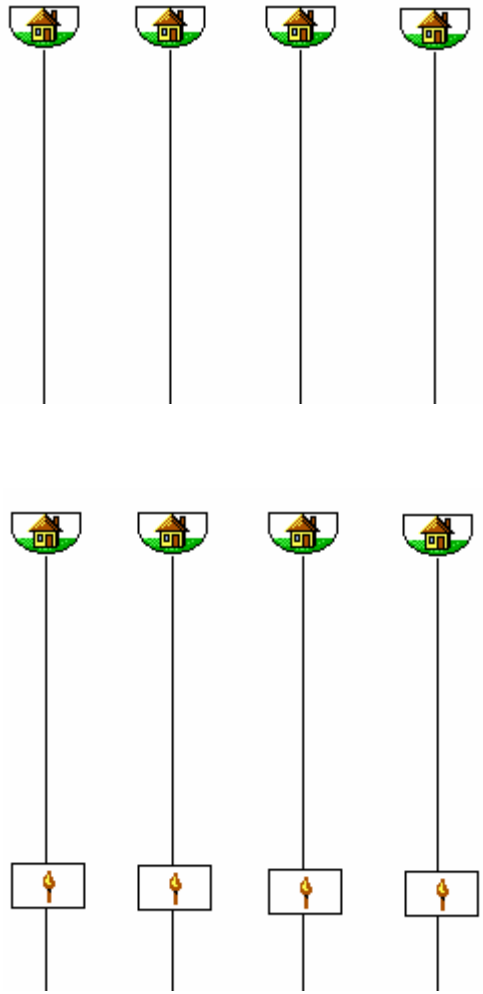
Some Modeling Issues

- If your process is using a mix of fuels that changes every year (e.g., oil and gas), your average emission factor also changes every year
- The fuel mix, and thus the average emission factor may be different in each scenario
- This version of the model does not track this information
- User needs to ensure consistency
- One way to do this is to compute an average emission factor year-by-year and enter the values into the model (this may have to be done for each of your scenarios)
- A better way to do this is by modifying the network structure
- The modified structure would make sure that each process uses just one type of fuel

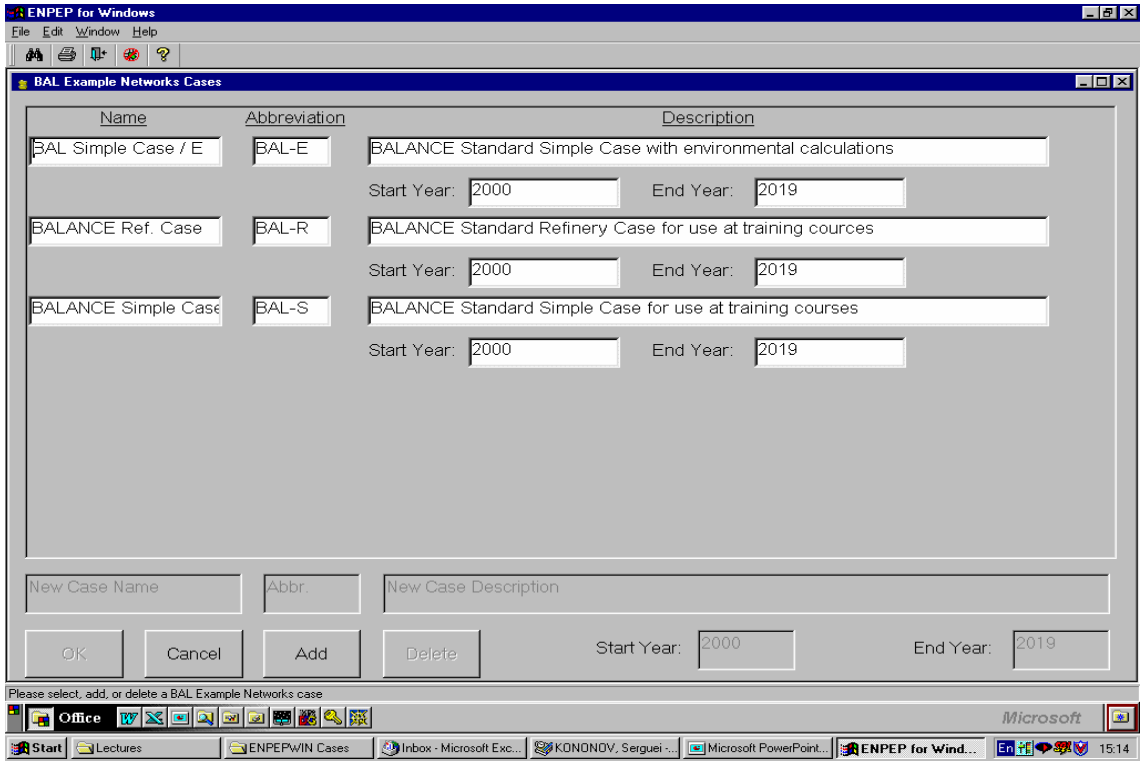


Some Modeling Issues (cont'd)

- **If your end use sectors are mostly in the final energy structure without any conversion processes, some emissions will not be accounted for**
- **One way to deal with this is to include emission factors into the demand nodes**
  - please make sure the demand nodes are not projecting a mix of fuels but only one fuel each
  - when converting the sector into useful energy demand by inserting conversion processes, the emission factors in the demand nodes should be deleted
- **Another way to deal with this is to include so-called "dummy" processes**
  - single input/single outputs
  - efficiency 1.0, no cost, no change in energy flows
  - only to obtain emissions for sectors with final energy

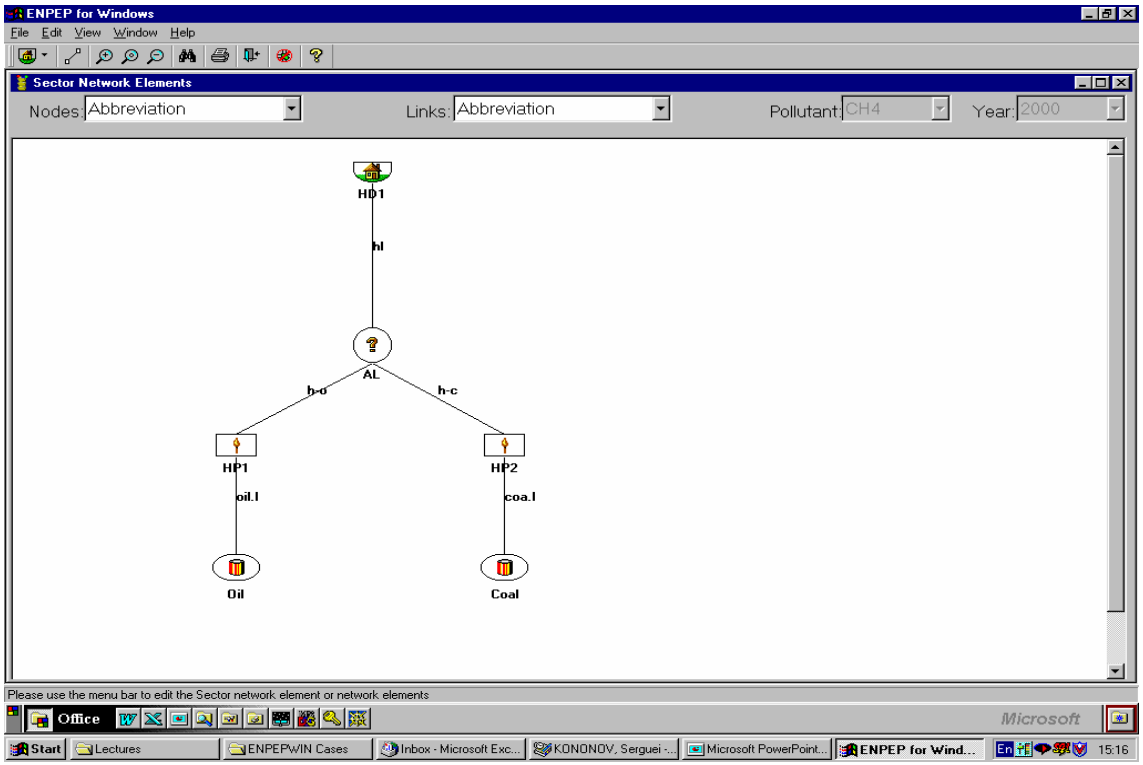


Example: Simple Network with Emissions



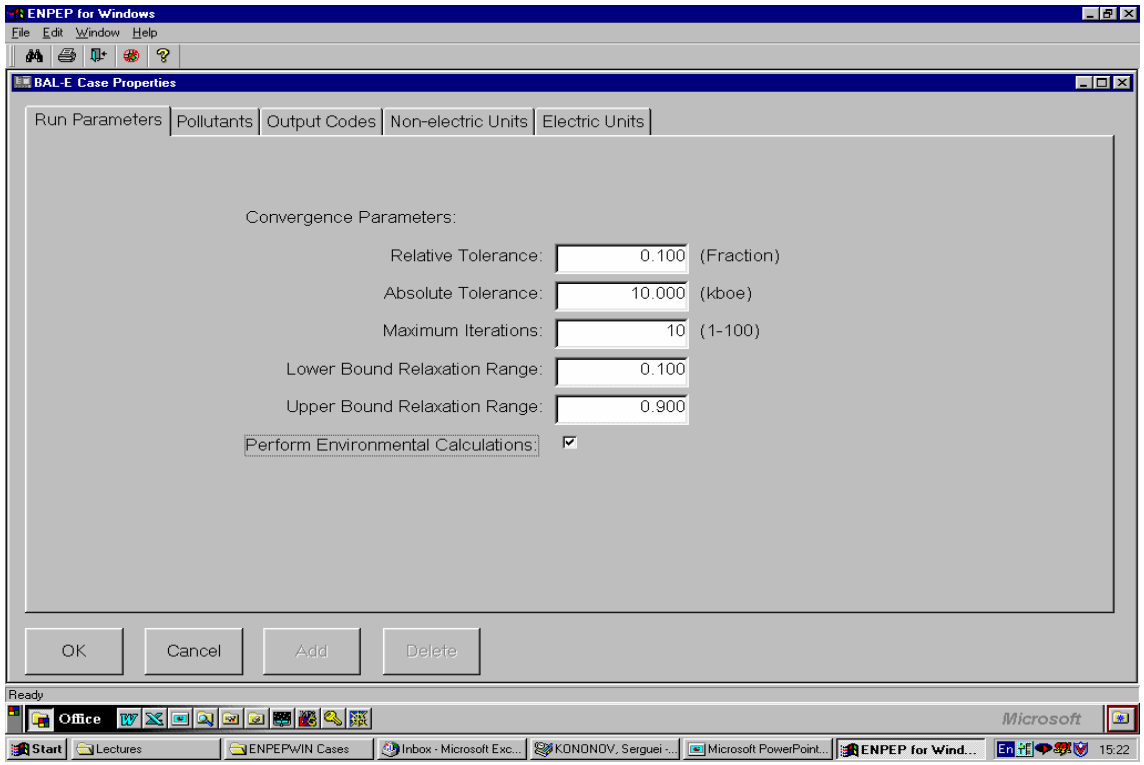
BALANCE simple case will be modified to include environmental calculations

Example: Simple Network with Emissions



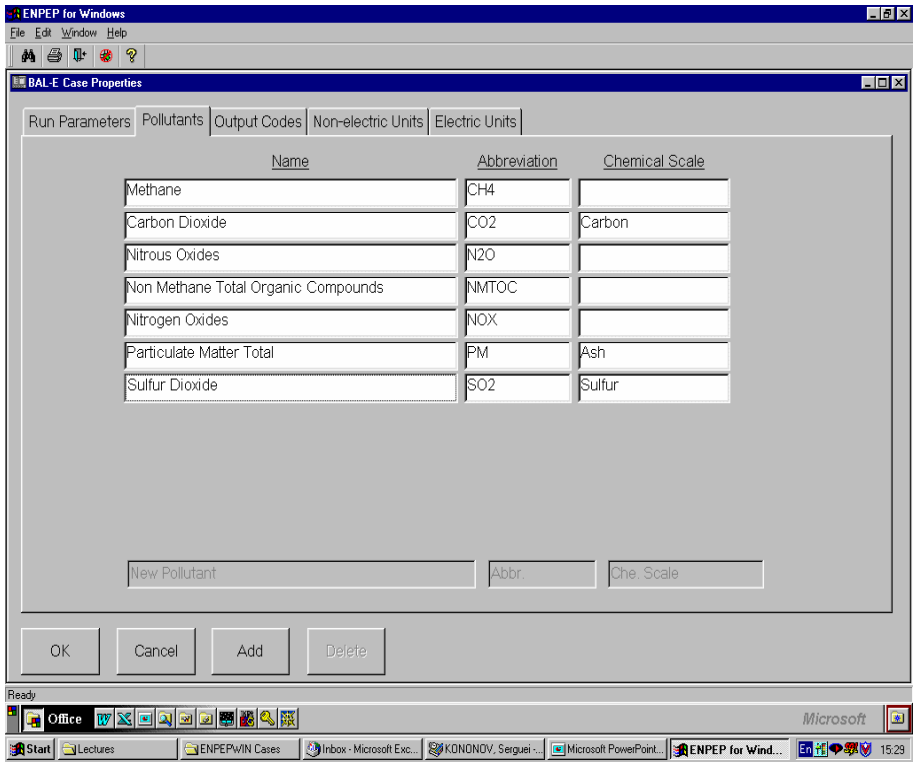
The outlook of the network is the same as in the standard BALANCE simple case

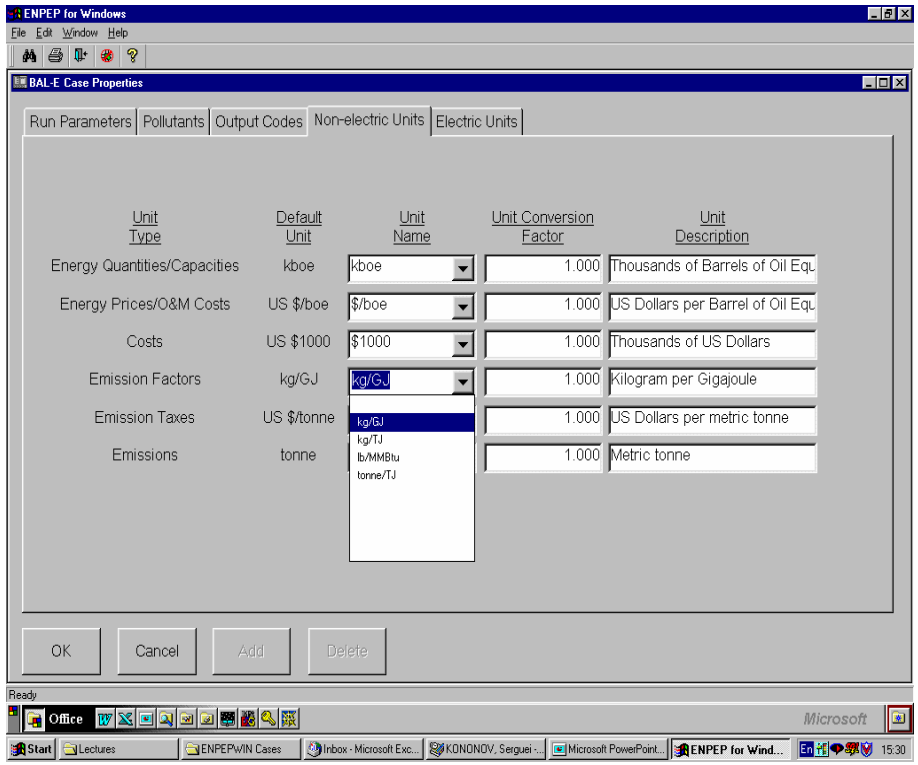
Example: Simple Network with Emissions



‘Perform Environmental calculations’ must be activated

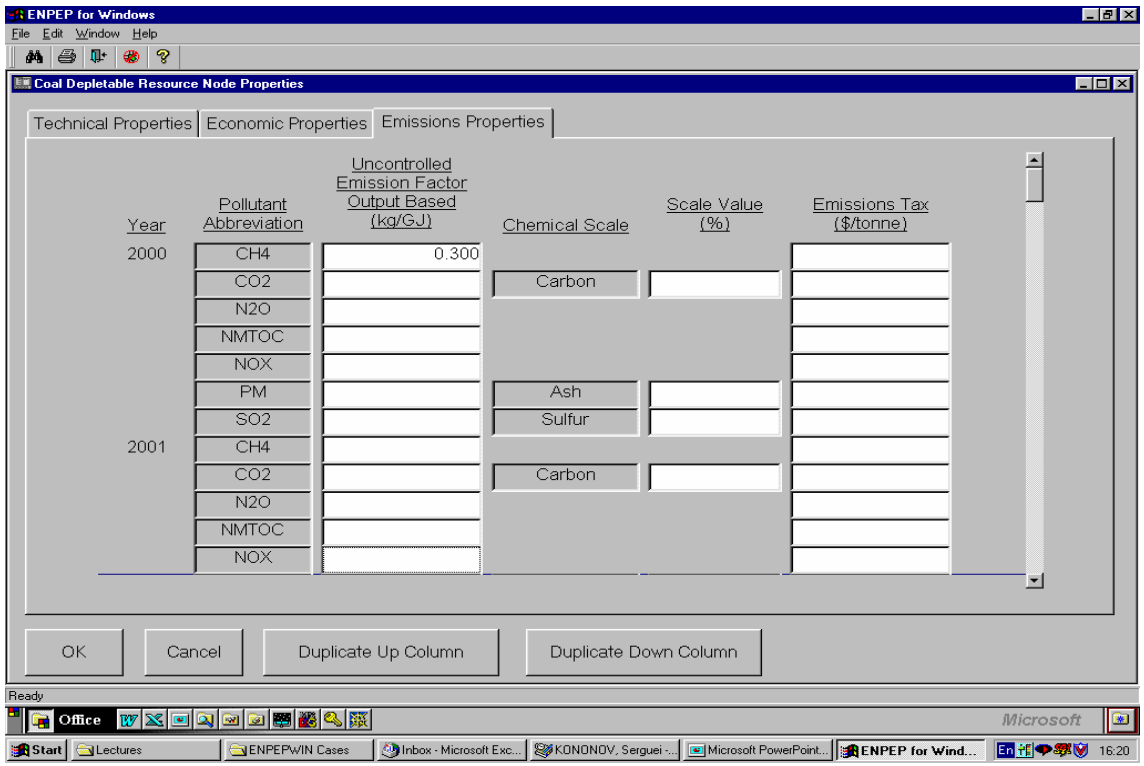
Example: Simple Network with Emissions





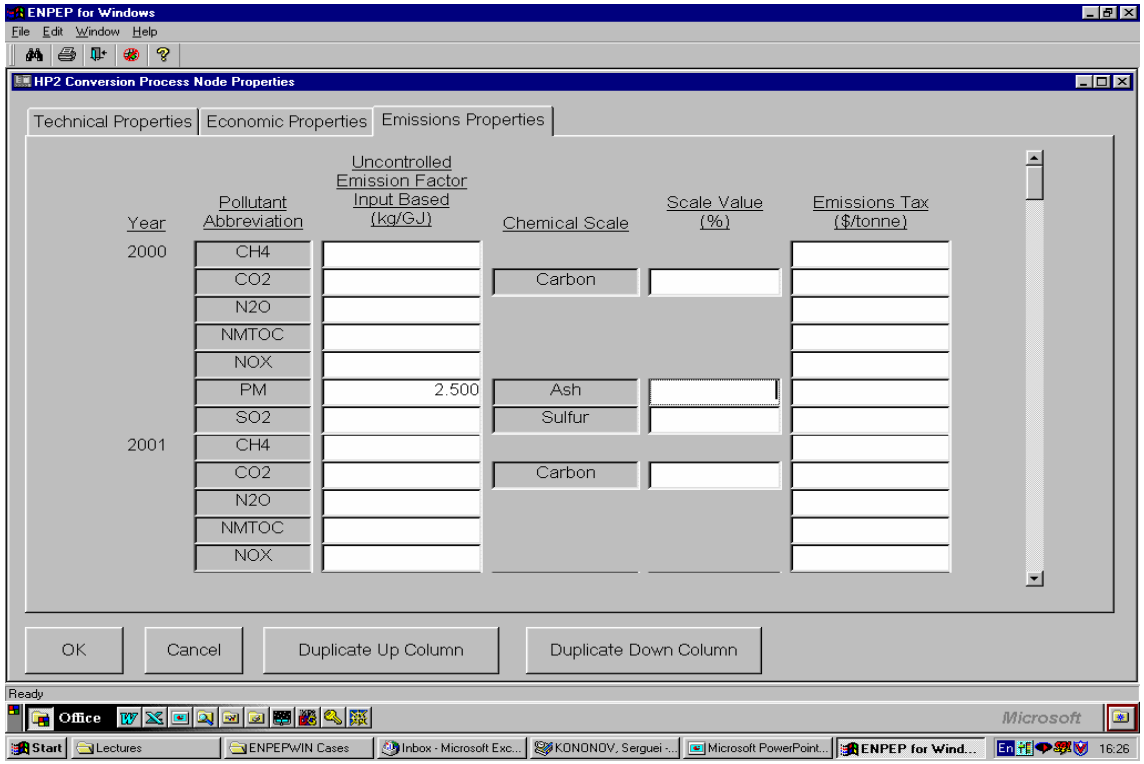
Check / modification of the pollutant list and units of measurement may be required

Example: Simple Network with Emission Calculations



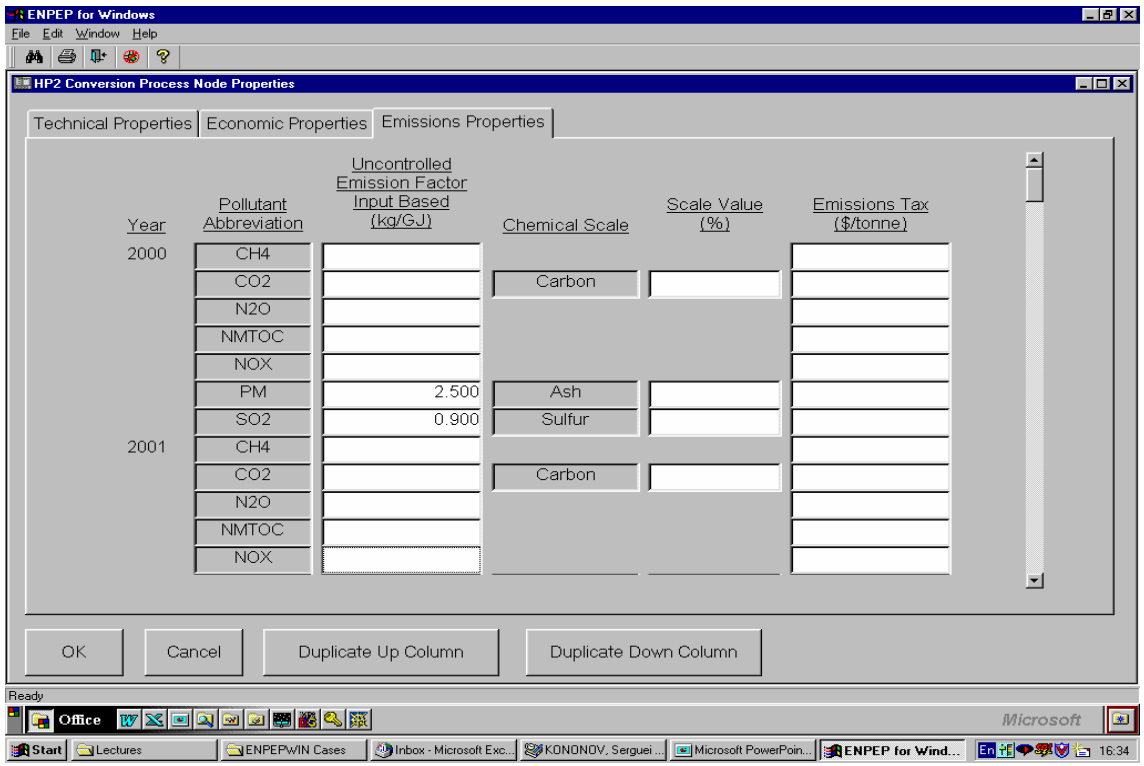
Coal mining: methane (CH_4) emissions = ~10 m^3/tonne of coal (range 0.3-24) = = ~0.5 m^3/GJ (1 tonne of coal = 20 GJ) = = ~**0.3 kg CH_4/GJ** (1 m^3 CH_4 = 0.6 kg)

Example: Simple Network with Emission Calculations



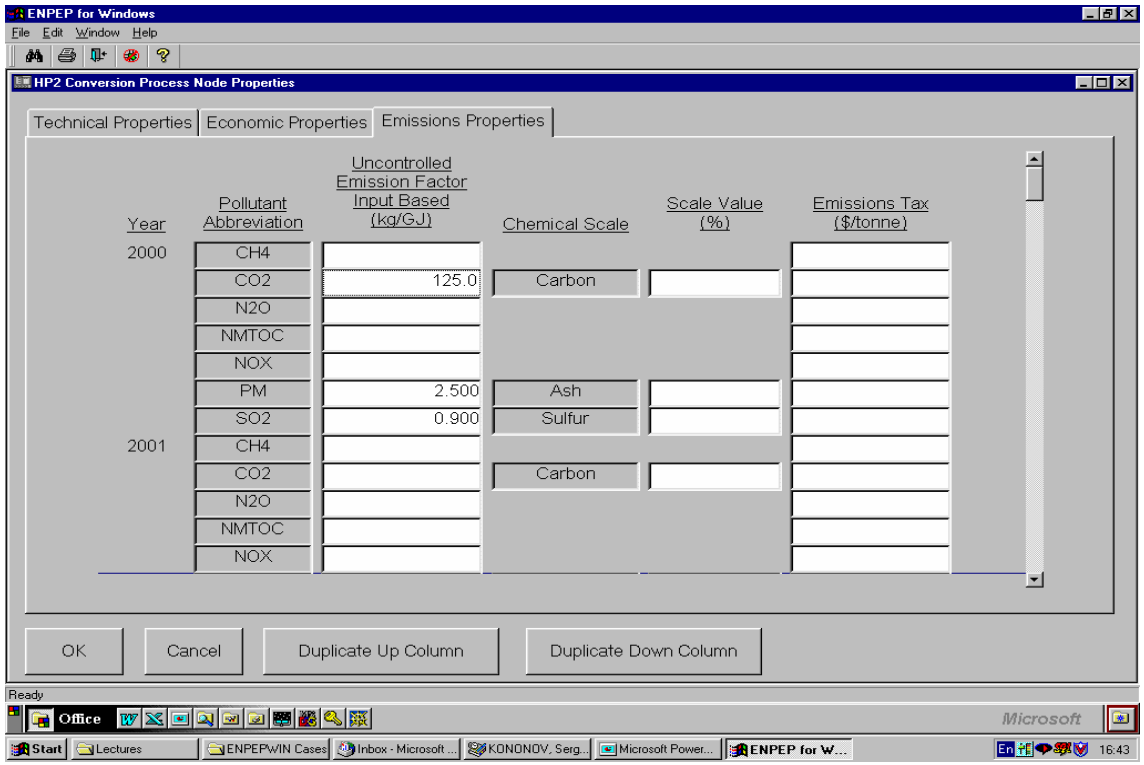
Coal combustion / ash: 1 kg coal with 10% ash = 0.1 kg ash generated = 0.05 kg bottom ash + 0.05 kg fly ash => 0.05 kg fly ash / kg coal = 50 kg/tonne = ~**2.5 kg ash /GJ** (1 tonne of coal = 20 GJ) - **uncontrolled** emissions;

Example: Simple Network with Emission Calculations



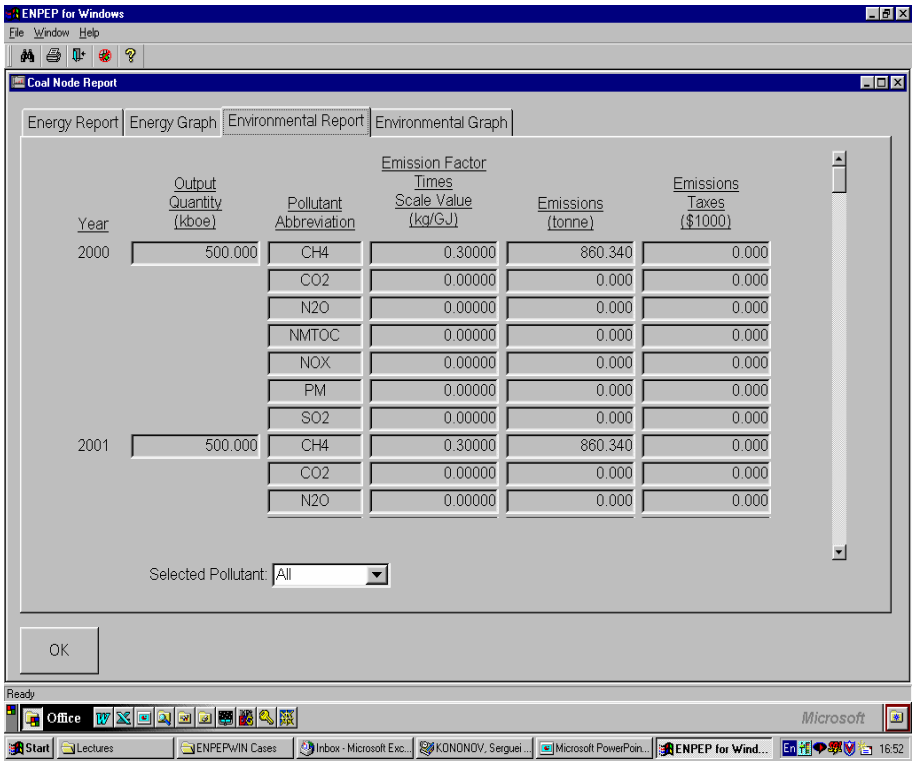
Coal combustion / SO_2: 1 kg coal with 1% sulfur = 0.01 kg S generated = 0.02 kg SO_2 (molar ratio SO_2/S = 64.06/32.06 = 1.998) generated = 0.018 kg emitted (inherent furnace control 10%) => 0.018 kg SO_2 / kg coal = 18 kg/tonne =
= ~**0.9 kg SO_2/GJ** (1 tonne of coal = 20 GJ) - **uncontrolled** emissions

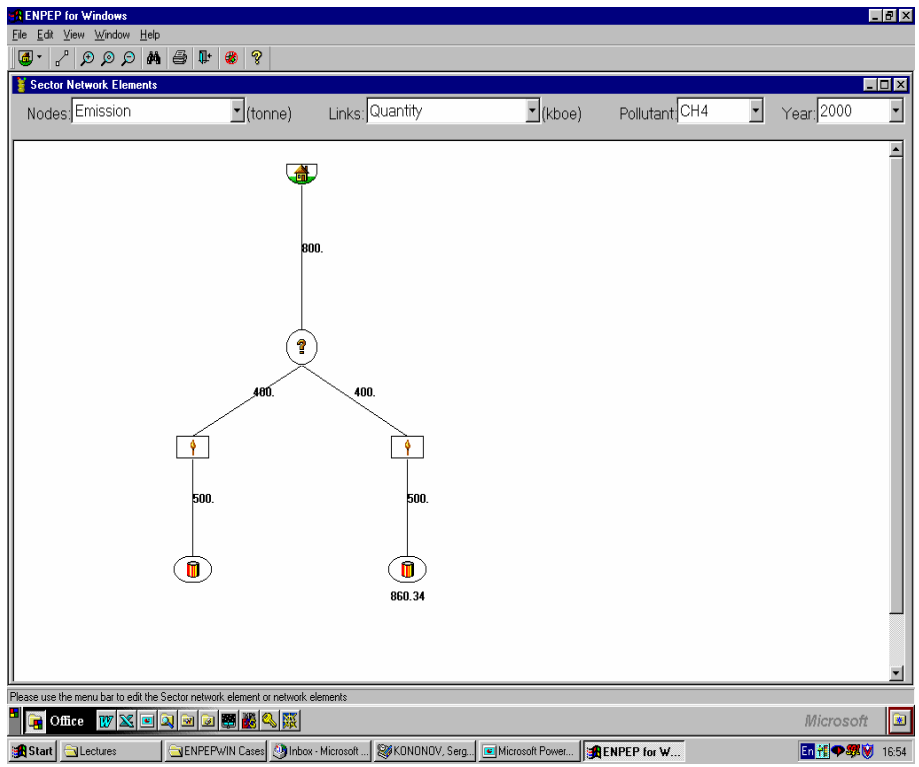
Example: Simple Network with Emission Calculations



Coal combustion / CO_2: 1 kg coal with 70% C = 0.7 kg C generated = ~2.5 kg CO_2 (molar ratio CO_2/C = 44.01/12.01 = 3.664) generated = 2.5 kg emitted (inherent furnace control 0%) => 2.5 kg CO_2 / kg coal = 2500 kg/tonne = = ~**125 kg CO_2/GJ** (1 tonne of coal = 20 GJ) - **uncontrolled** emissions

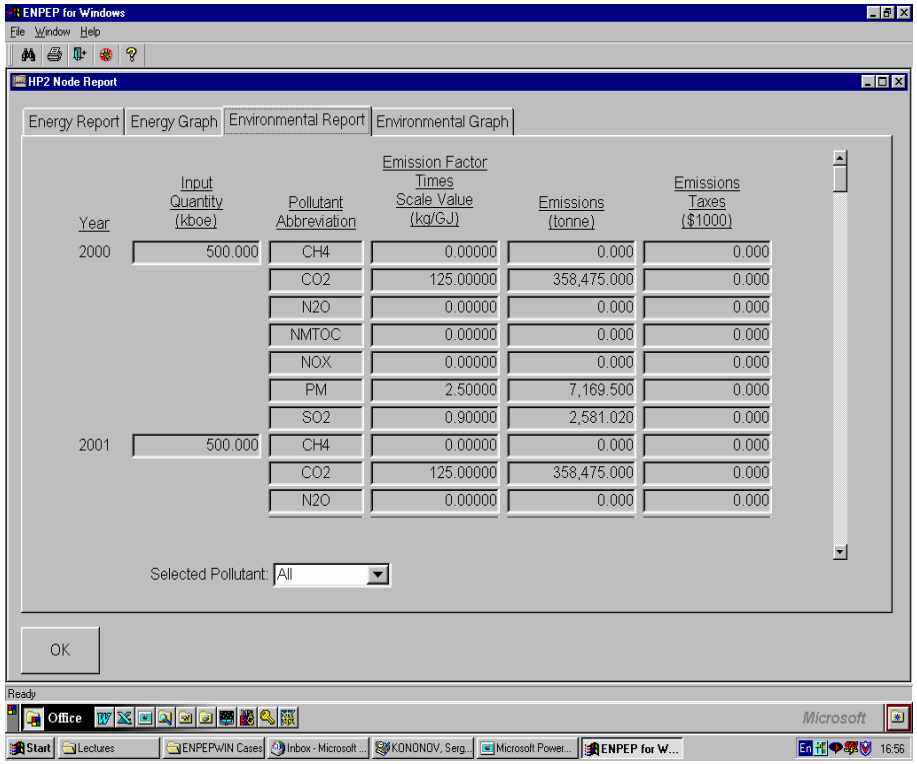
Example: Simple Network with Emission Calculations

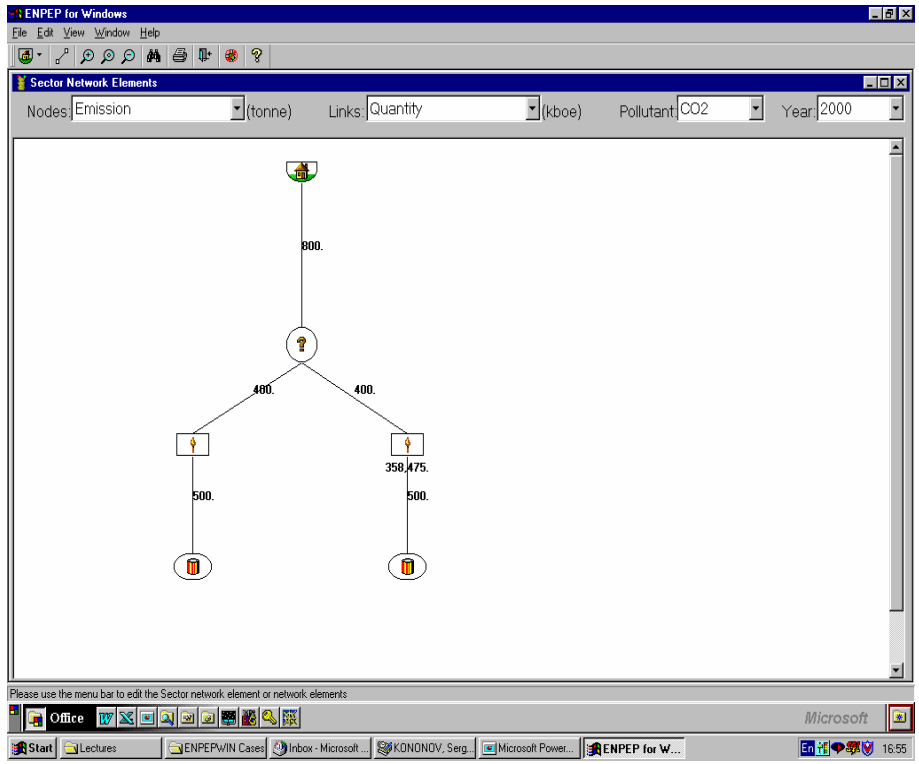




Results for coal mine: environmental report/graph & network info

Example: Simple Network with Emission Calculations





Results for coal boiler: environmental report/graph & network info