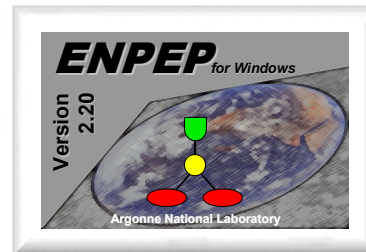


# ENPEP-BALANCE: Simple Case

**ENPEP-BALANCE Training Course**  
Singapore  
December 5-9, 2011



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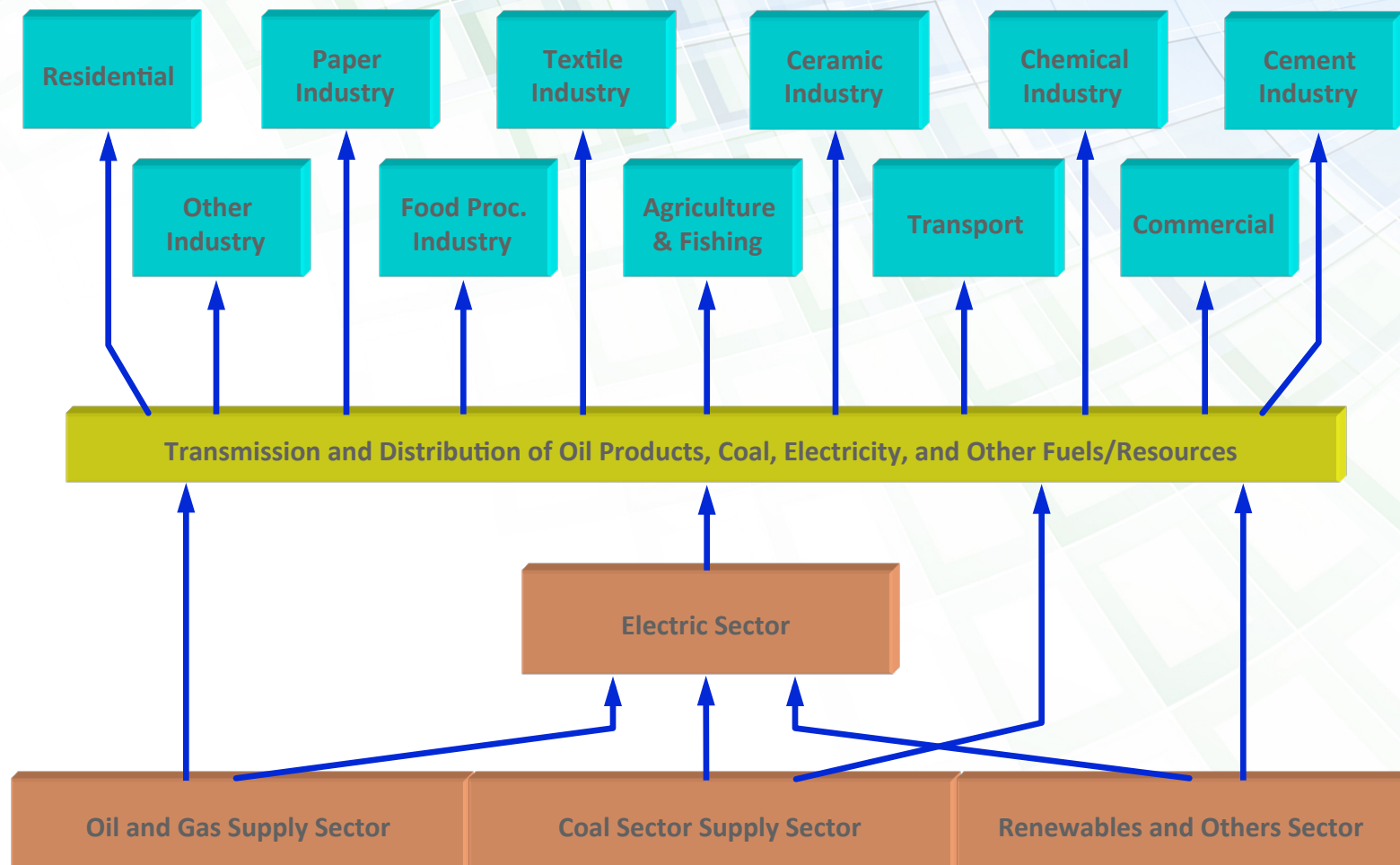
# ***Purpose of Simple Case is to Illustrate some of the Basic Calculations in BALANCE***

**Lecture will cover the following:**

- Simple Case definition & node input description
- Example of network development
- Testing the sensitivity of model results to various model parameters



# *The Basic Starting Point in BALANCE is the Energy Network that Simulates Energy Markets*



# The Following Node Types are Available to Construct Cases

- Demand



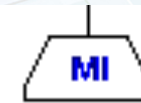
- Conversion Processes



Single In-/Output



Multi Output



Multi Input



Transport

- Resource Processes



Depletable



Renewable

- Economic Processes



Decision/Allocation

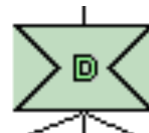


Pricing



Stockpile

- Electricity Dispatch and Thermal and Hydro Units



Central Dispatch



Thermal Unit



Hydro Unit



# *Steps in Network Development*

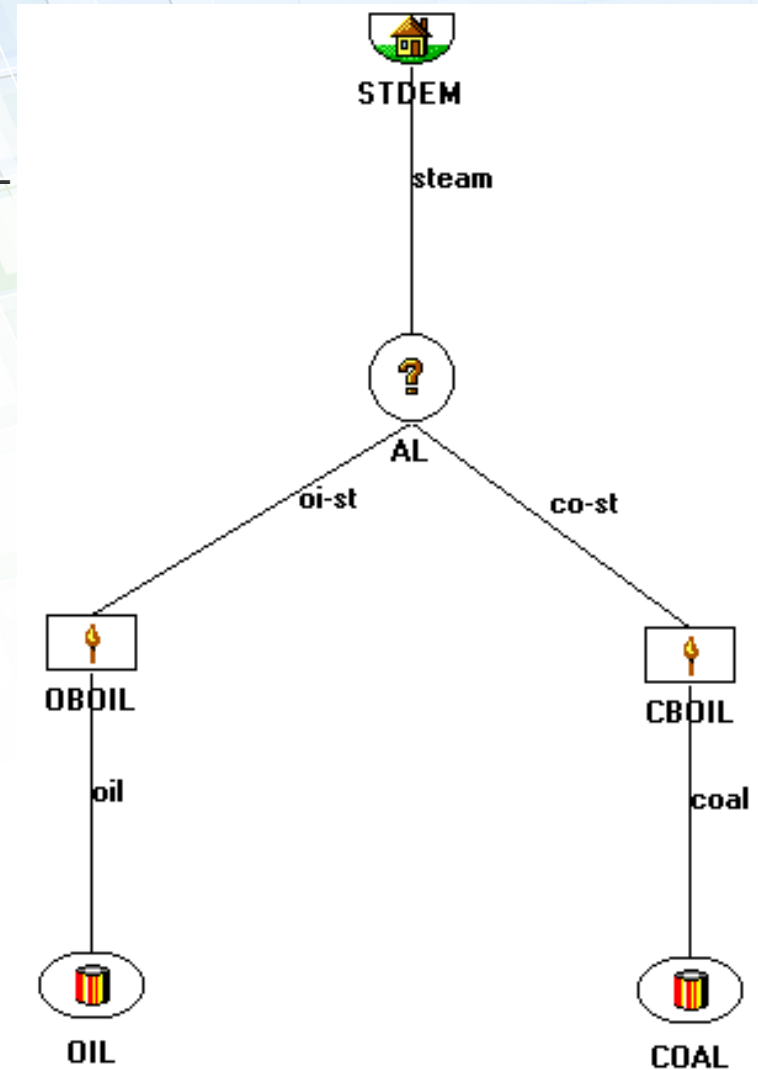
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- Prepare the network structure
  - Draw the network
  - Label the network (each link and node has a name and abbreviation)
- Prepare the input data
- Prepare (run/check) the node visitation sequence (Up/Down-Pass)
- Run BALANCE
- Check/printout the results (tables, graphs, text files)

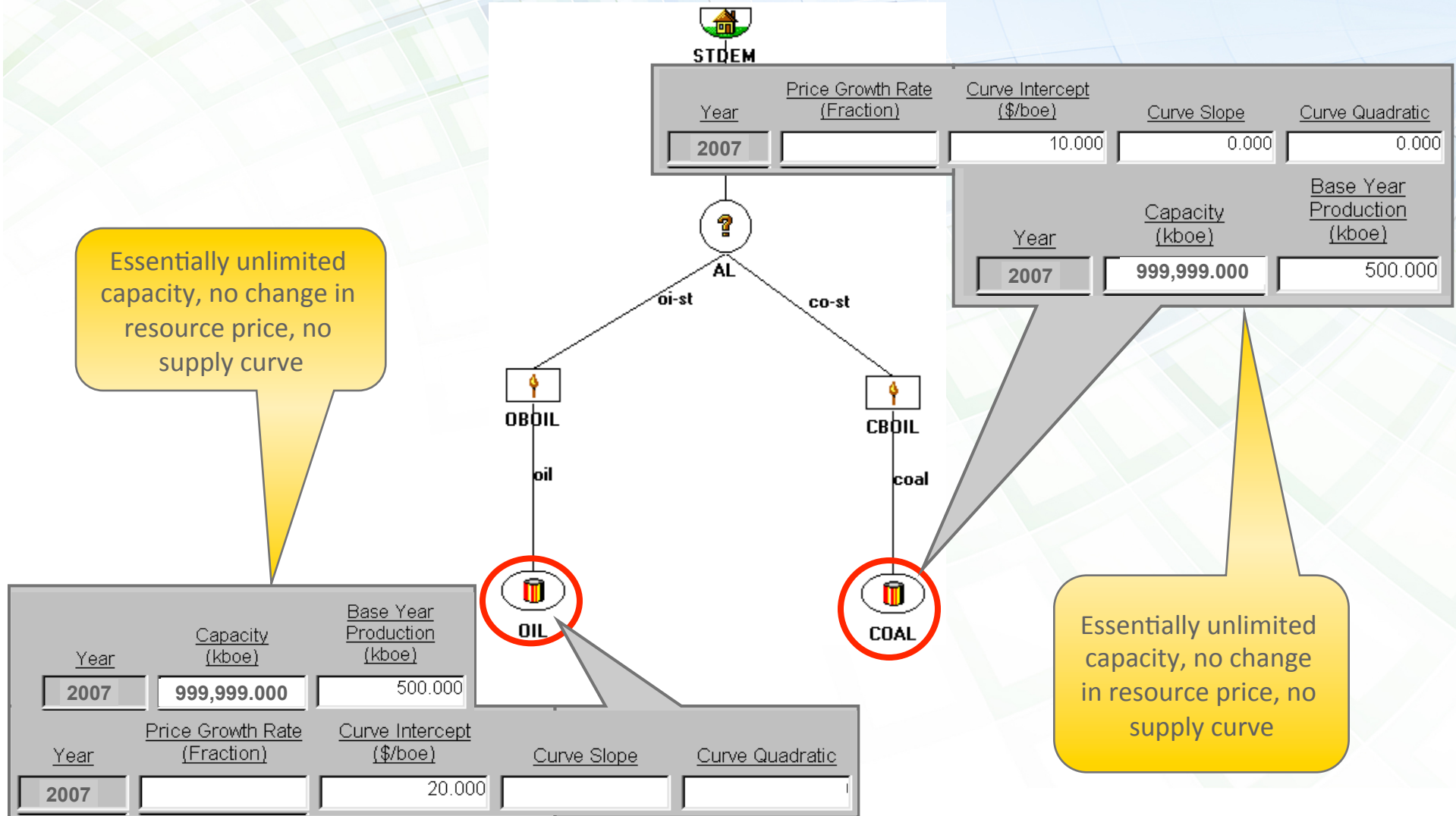


# Structure of Simple Network

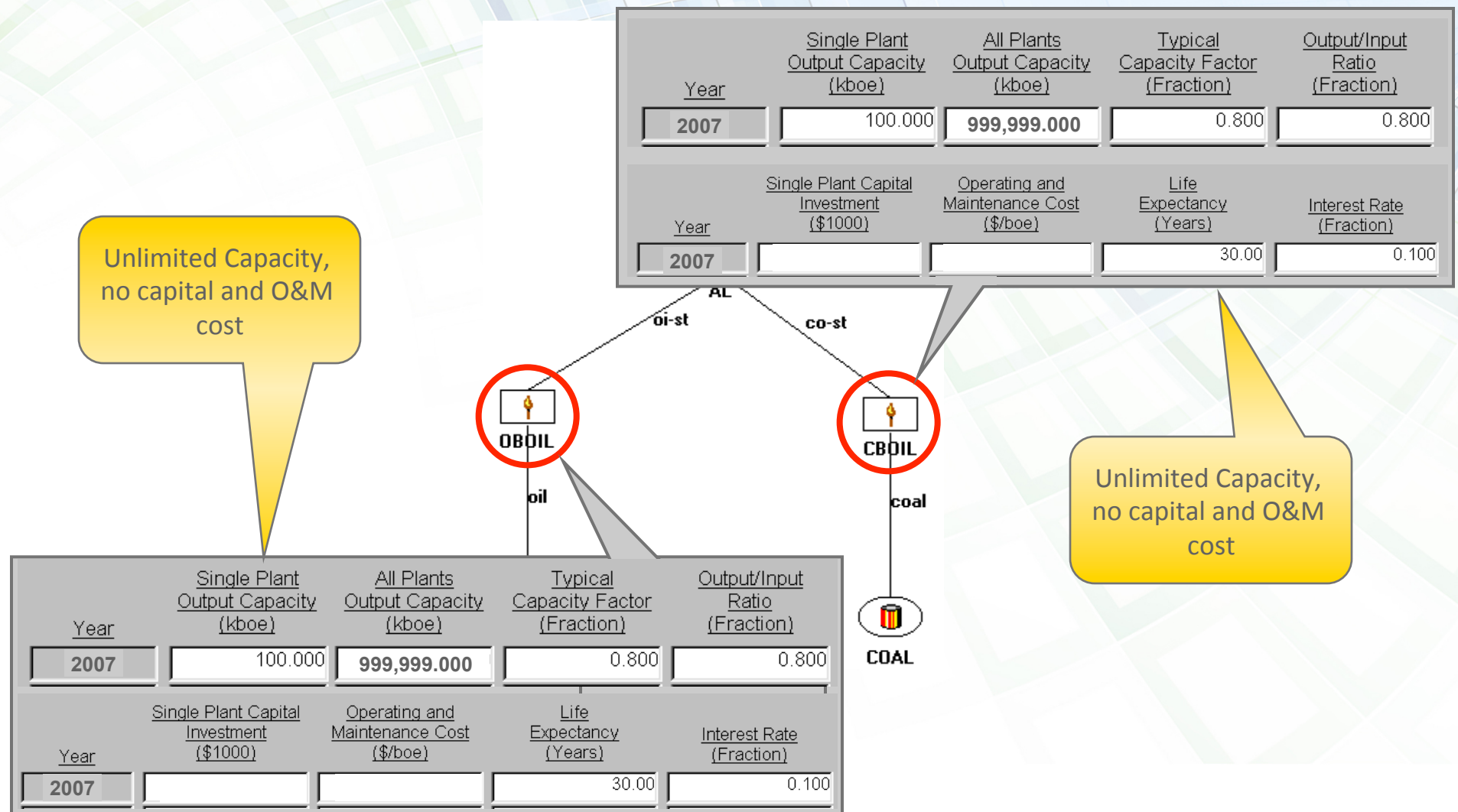
- Two resource nodes: OIL and COAL
- Two conversion processes or boilers: OBOIL
- One decision node: AL
- One demand node: STDEM (steam demand)
- Study period: **2007-2026**



# Resource Node Input Data (Case 1)



# Conversion Process Node Input Data (Case 1)





# Allocation Node Input Data (Case 1)

No priority, no premium multipliers

Year	Input Link Abbreviation	Priority	Premium Multiplier
2007	co-st		
2007	oi-st		

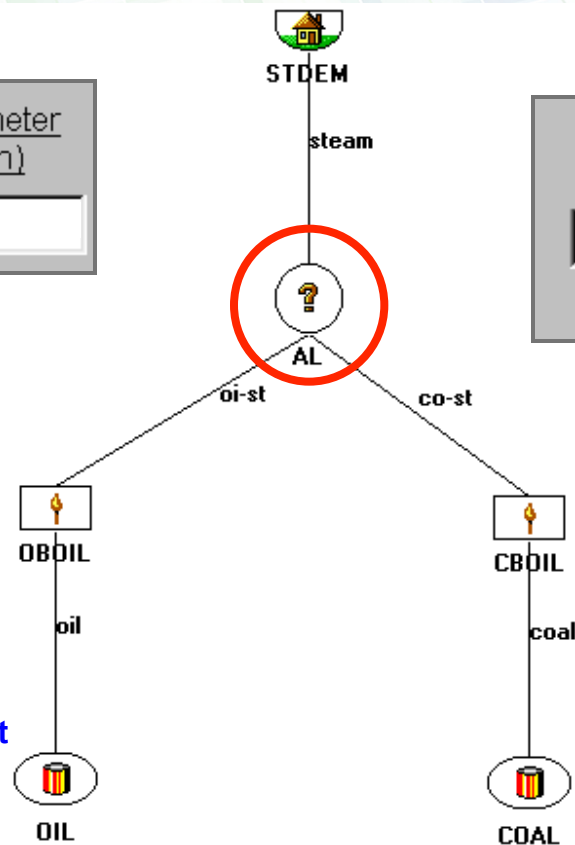
Year	Price Sensitivity	Lag Parameter (Fraction)
2007		

Blank means 0:  
Decision is not sensitive to prices (sensitivity of 0);  
Market cannot respond to price signals (lag of 0)

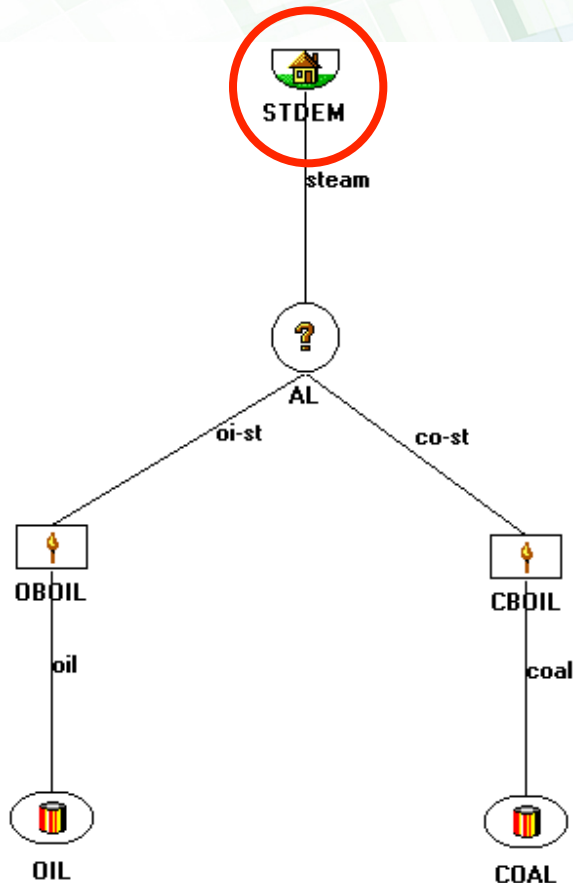
Lag of 1.0: Entire market can potentially shift  
Lag of 0.5: Half the market can potentially shift  
Lag of 0: No change in market shares

Output Link Abbreviation	Base Year Split (Fraction)
steam	1.0000
<b>Sum:</b>	<b>1</b>

Sum of the base year splits has to equal 1.0; Note that this is **OUTPUT SPLIT**; this input is used only in the base year calculations



# Demand Node Input Data (Case 1)

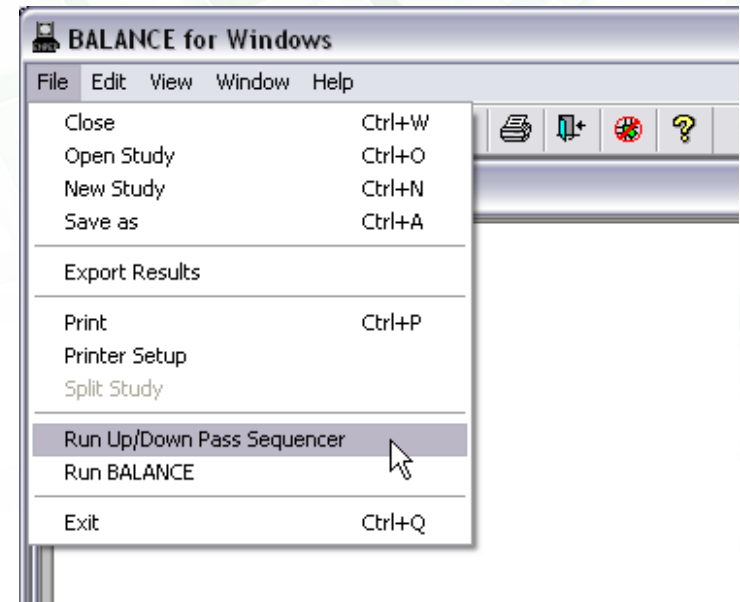
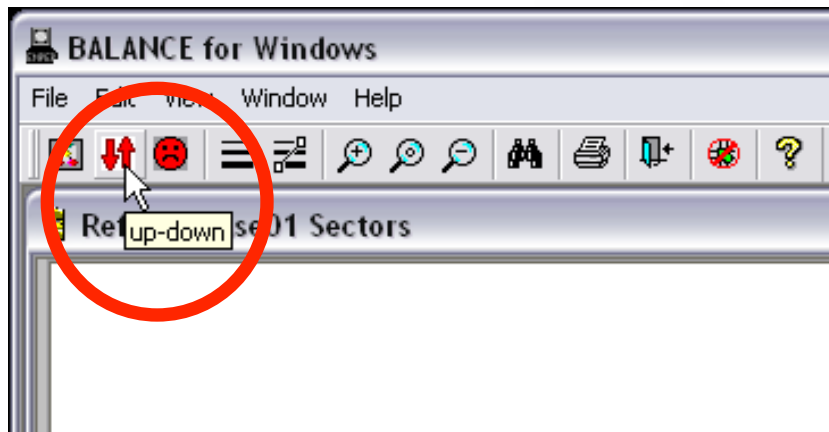


Year	Growth Rate (Fraction)	Elasticity	Type
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			
2021			
2022			
2023			
2024			
2025			
2026			

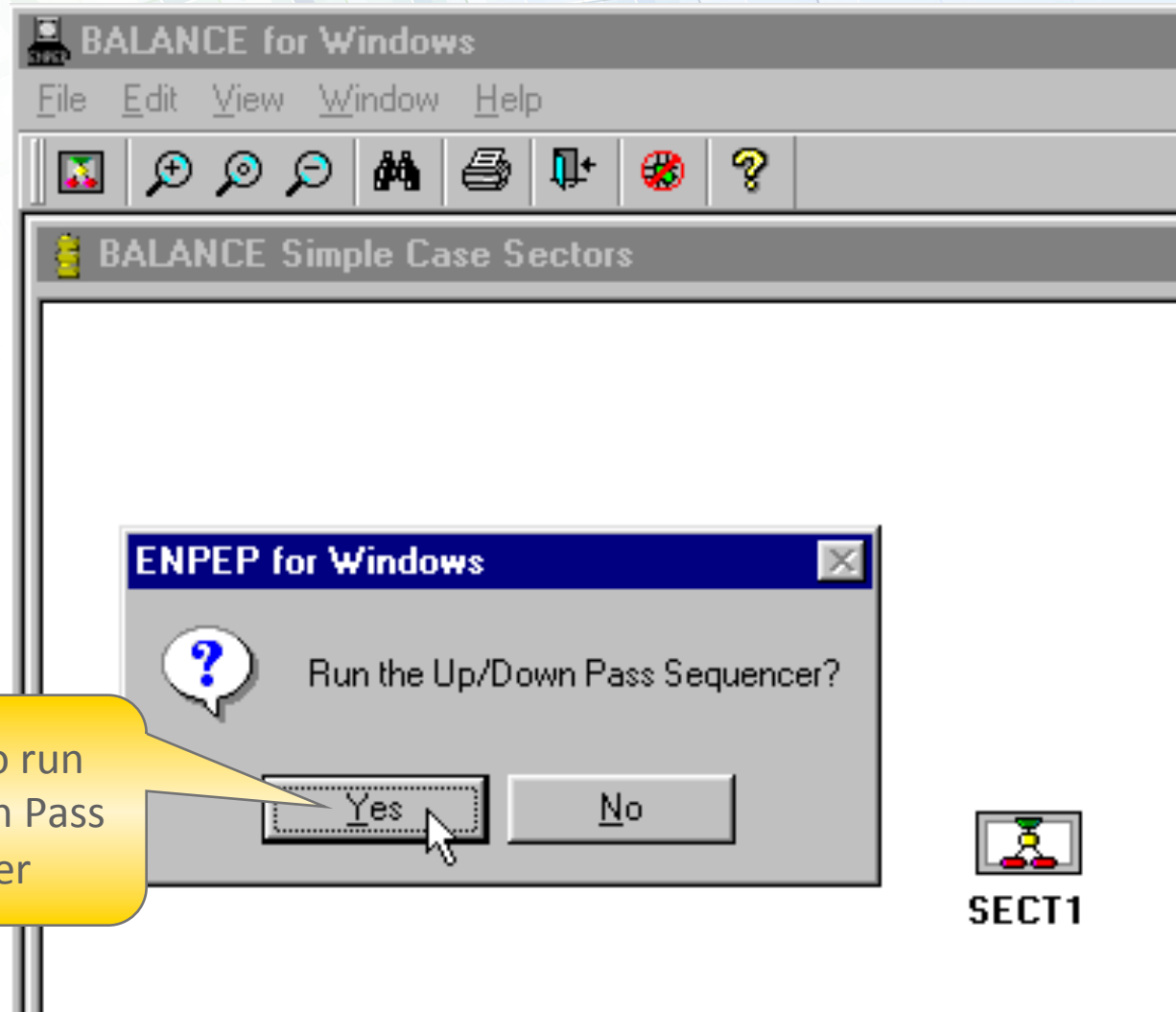
Demand stays constant:  
A **Blank** growth rate means  
growth rate of 0 in that year

# Before Running BALANCE, the Node Visitation Sequence Has to be Determined

- Before running BALANCE for the first time it is necessary to execute the Up/Down Pass program to determine the node visitation sequence
  - Up-down tells the model in which sequence to do the node calculations during the simulations
- Later, the Up/Down Pass has to be executed only if there has been a change in the structure of the energy network
  - add/delete node
  - add/delete link
- If the up-down icon is red, you should click it to run the sequencer

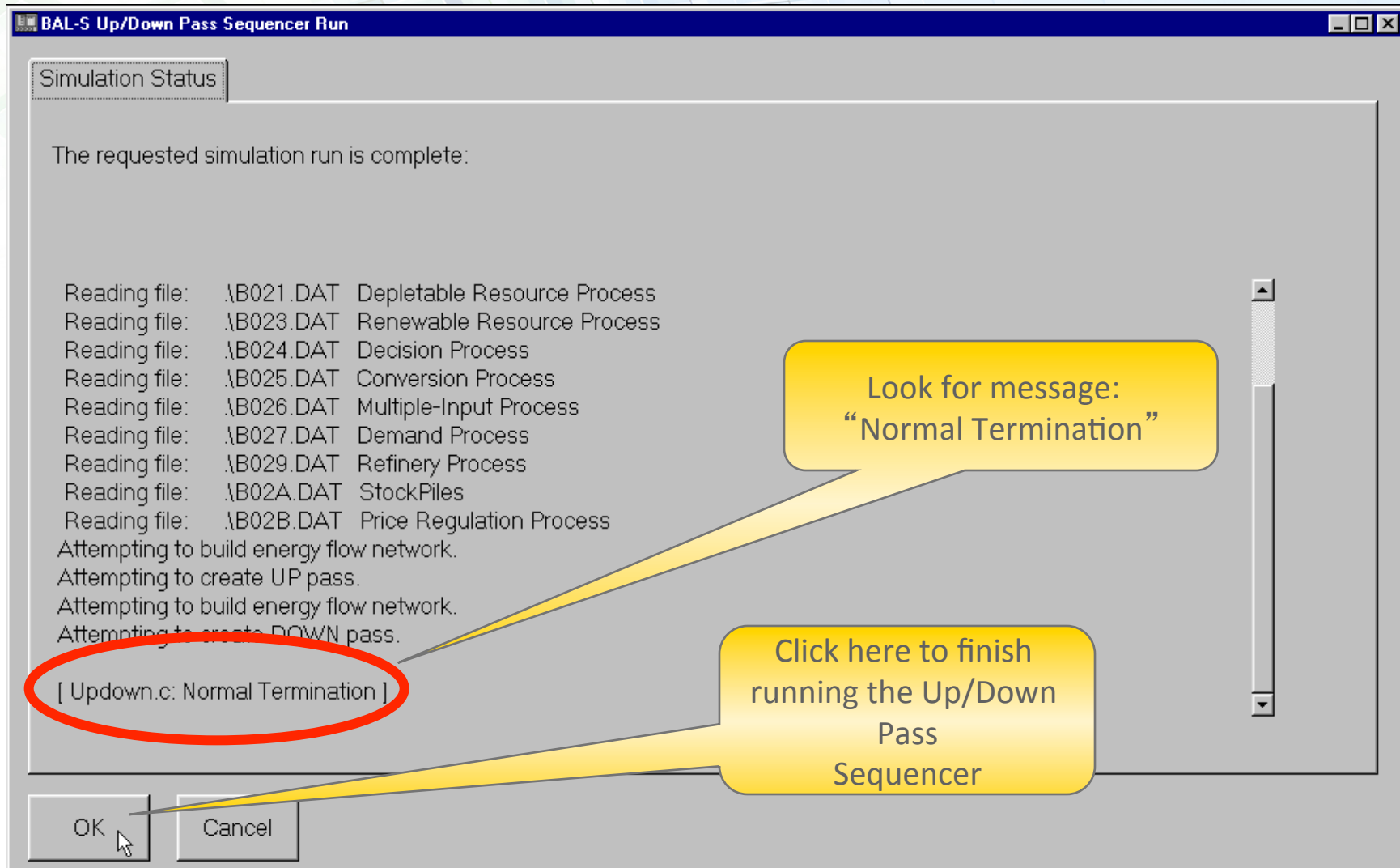


# ***BALANCE Asks for User Confirmation to Run the Routine***

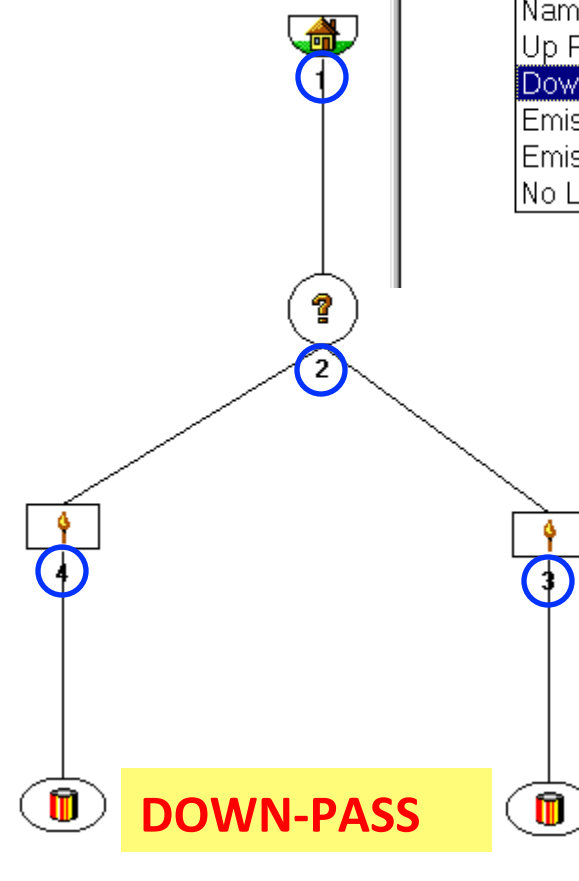
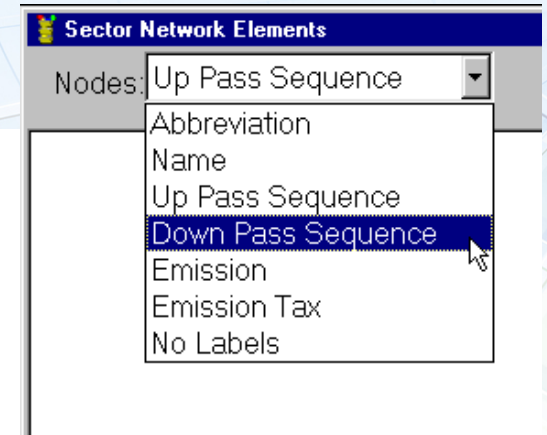
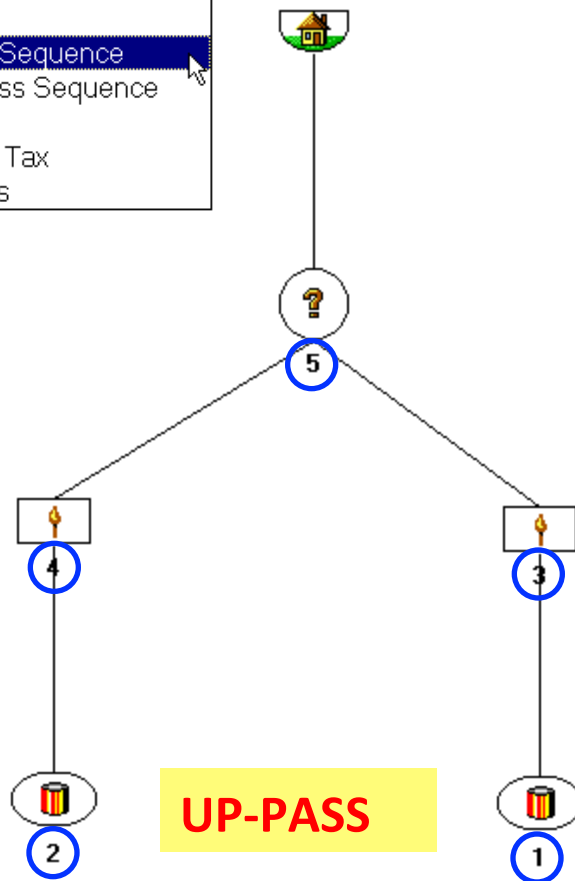
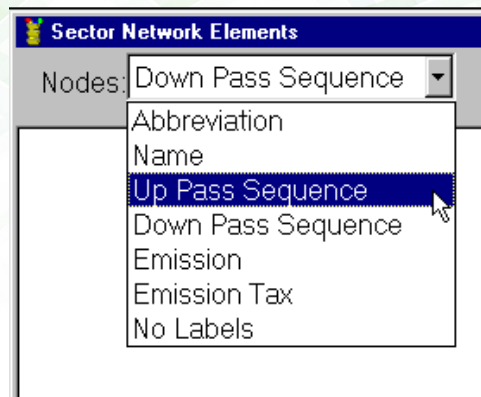




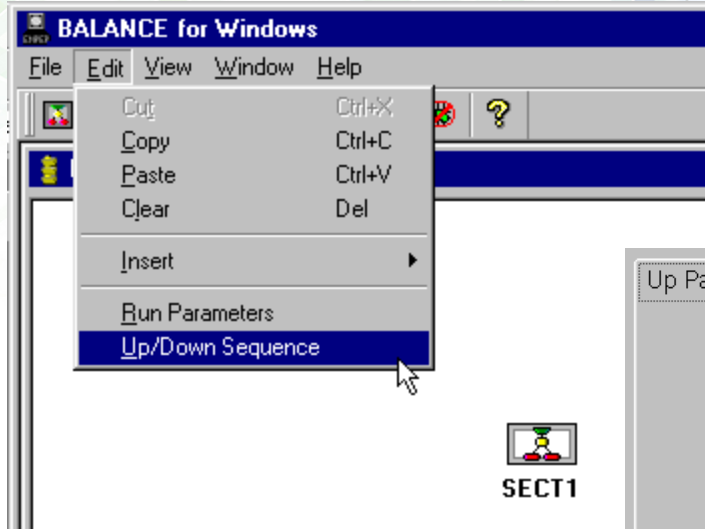
# ***BALANCE Produces a Simulation Status Report for the Up/Down Pass Sequencer***



# Case 1: Definition of Node Visitation Sequences



# You Can View and Edit the Up and Down Pass Sequence



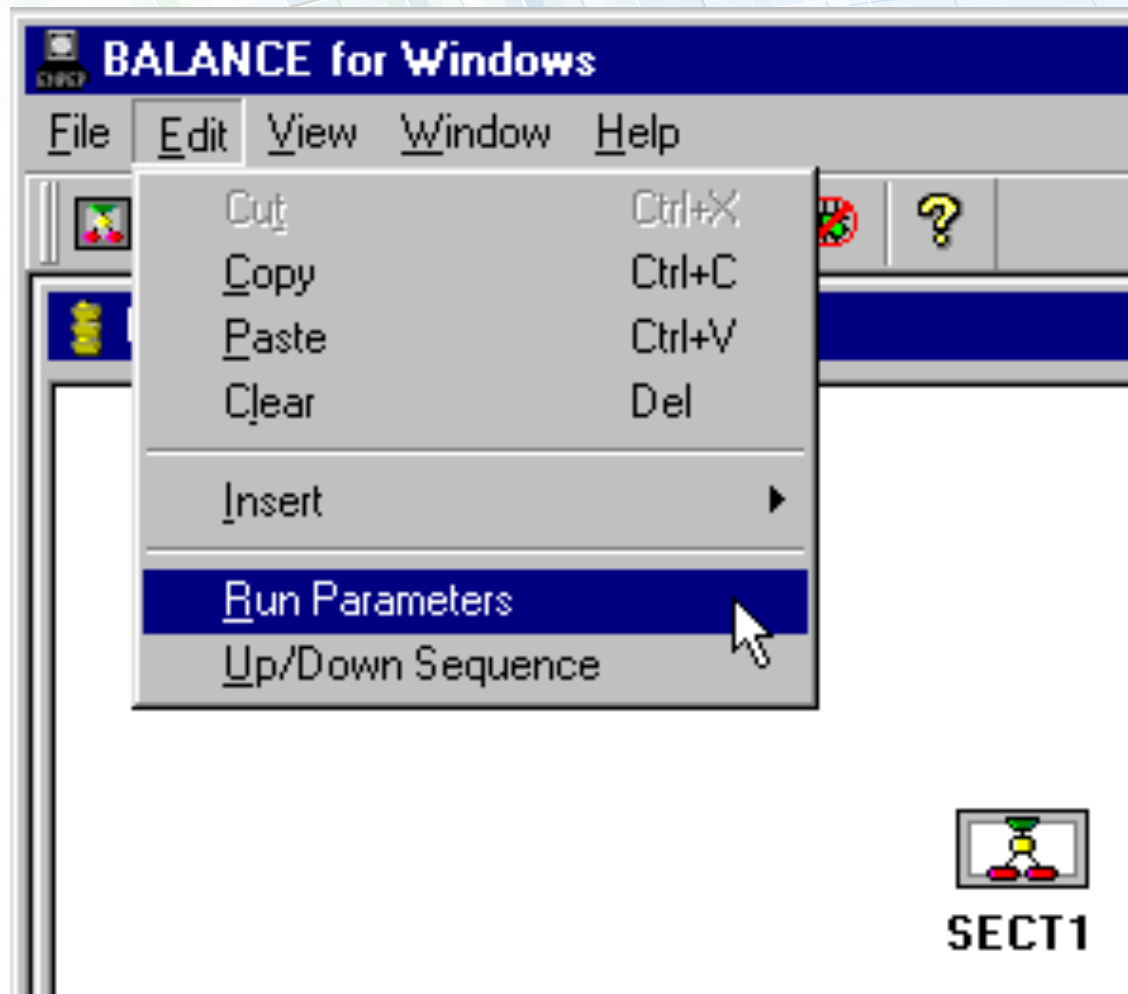
You usually need to edit the sequence only if you have **COGENERATION** in the network. Also it may be necessary in some situations with the oil refinery.

Up Pass Sequence					
Node Type	Node Abbreviation	Node Name	Sector Abbreviation	Sector Name	Up Sequence
RS	COAL	Coal resource	SECT1	Sector	1
RS	OIL	Oil resource	SECT1	Sector	2
PR	CBOIL	Coal Boiler	SECT1	Sector	3
PR	OBOIL	Oil Boiler	SECT1	Sector	4
AL	AL	Allocation Node	SECT1	Sector	5

Down Pass Sequence					
Node Type	Node Abbreviation	Node Name	Sector Abbreviation	Sector Name	Down Sequence
DE	STDEM	Steam demand	SECT1	Sector	1
AL	AL	Allocation Node	SECT1	Sector	2
PR	CBOIL	Coal Boiler	SECT1	Sector	3
PR	OBOIL	Oil Boiler	SECT1	Sector	4



## *You May also Want to View/Modify some of the Run Parameters*





# Run Parameters Allow the User to Specify Convergence Parameters and Discount Rate

Run Parameters	Pollutants	Output Codes	Non-electric Units	Electric Units
<b>Convergence Parameters:</b>				
The model will stop running after the specified number of iterations in a year				
Input tolerance level in both percent and absolute terms				
Relaxation parameters for adjusting values between iterations (discussed in up-down pass lecture)				
Discount rate and cost of energy not served used in the economic system cost calculations (NPV)				
Automatic backup interval (days). The model will remind you to backup after each interval passes (in this case 14 days)				
Turn on/off environmental calculations				

Convergence Parameters:

Relative Tolerance:	0.100	(Fraction)
Absolute Tolerance:	10.000	(kboe)
Maximum Iterations:	10	(1-100)
Lower Bound Relaxation Range:	0.100	
Upper Bound Relaxation Range:	0.900	
Discount Rate for NPV Calculation:	10.0	(%)
Cost of Energy Not Served:	0.0	(\$/MWh)
Database Backup Interval:	14	(1-100)
Perform Enviromental Calculations:	<input checked="" type="checkbox"/>	

# The User Can Change the Units for Energy, Costs, Prices, and Environment

Run Parameters | Pollutants | Output Codes | Non-electric Units | Electric Units

**Default units**

Unit Type	Default Unit	Unit Name	Unit Conversion Factor	Unit Description
Energy Quantities/Capacities	kboe	kboe	1.000	Thousands of Barrels of Oil Eq
Energy Prices/O&M Costs	US \$/boe	\$/boe	1.000	US Dollars per Barrel of Oil Eq
Costs	US \$1000	\$1000	1.000	Thousands of US Dollars
Emission Factors	kg/GJ	kg/GJ	1.000	Kilogram per Gigajoule
Emission Taxes	US \$/tonne	\$/tonne	1.000	US Dollars per metric tonne
Emissions	tonne	Gg	1,000.000	Gigagram

**The factors are used to convert values from the default value to the user specified unit**

**Select a predefined unit or define a new one**

- Gg
- kg
- tonne
- User Unit 1
- User Unit 2
- User Unit 3
- User Unit 4
- User Unit 5

# Units Can be Changed for both Electric and Non-Electric Processes

Run Parameters		Pollutants	Output Codes	Non-electric Units	Electric Units
Unit Type	Default Unit	Unit Name	Unit Conversion Factor	Unit Description	
Base Year Production	kboe	kboe	1.000	Thousands of Barrels of Oil Equivale	
Thermal Capacity	MW	GJ	1.000	Megawatt	
Hydro Capacity	MW-year	kboe	1.000	Megawatt-year	
Electricity Generation	MWh	tce	1.000	Megawatt-hour	
Capital Cost	\$/kW	TJ	1.000	US Dollars per Kilowatt	
Fixed O&M Cost	\$/kW-year	toe	1.000	US Dollars per Kilowatt-year	
Variable O&M Cost	\$/MWh	User Unit 1	1.000	US Dollars per Megawatt-hour	
Opt. Loading Order	\$/MWh	User Unit 2	1.000	US Dollars per Megawatt-hour	
Heat Rate	Btu/kWh	\$/MWh	1.000	British Thermal Units per Kilowatt-hc	
Emission Factors	kg/GJ	Btu/kWh	1.000	Kilogram per Gigajoule	



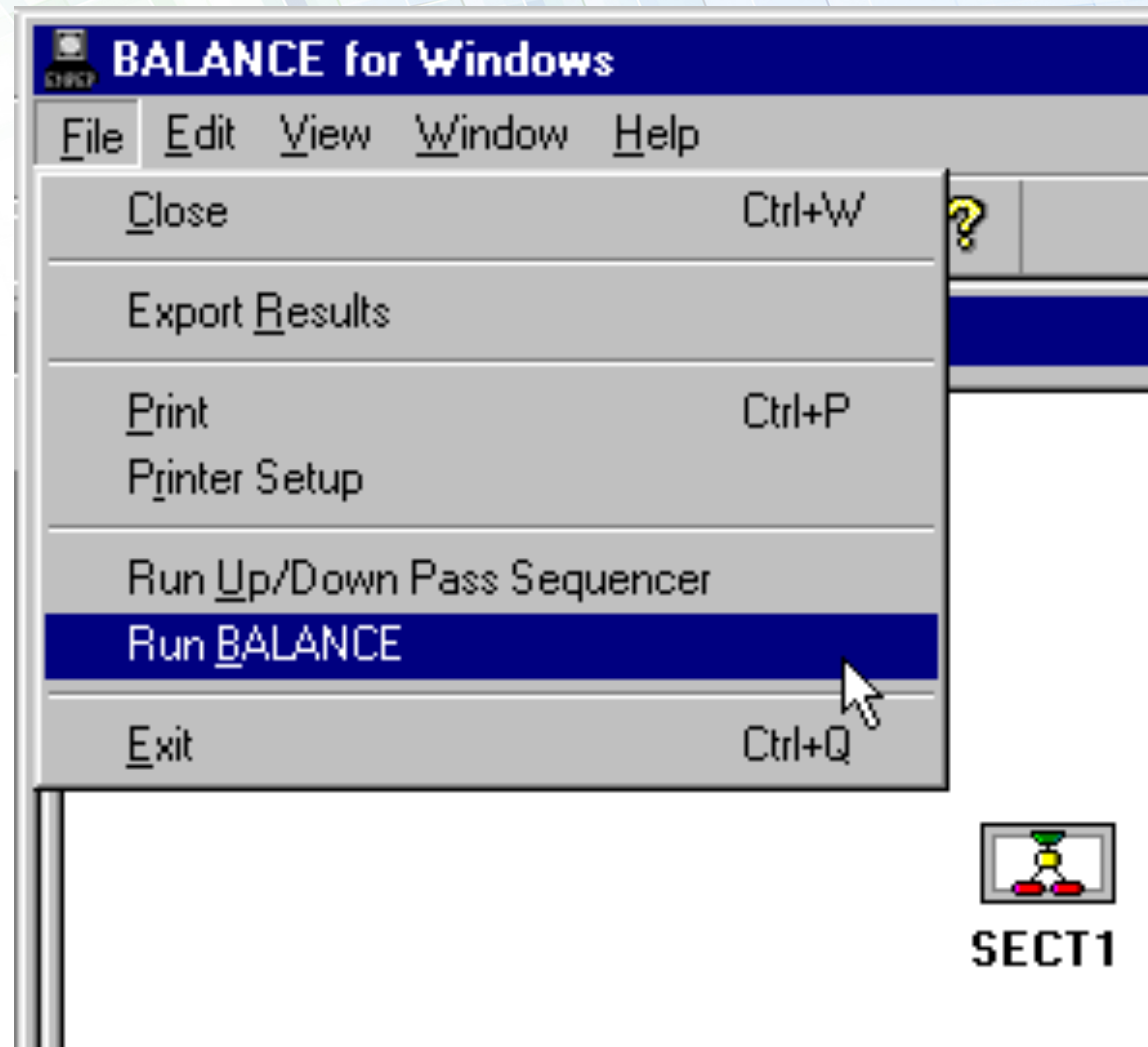
## *Under “Output Codes” Options for Standard Reports Can be Modified; These Reports are mostly useful for Debugging*

Run Parameters	Pollutants	Output Codes	Non-electric Units	Electric Units			
			<u>Start Year</u>	<u>End Year</u>	<u>Step</u>	<u>Start Iteration</u>	<u>End Iteration</u>
Converged Price/Quantity Results:			2007	2026	1		
Converged Electric Sector Results:			2007	2026	1		
Diagnostic Price/Quantity calculations:			2007	2026	1	1	10
Diagnostic Electric Sector Calculations:			2007	2026	1	1	10
Diagnostic Output to be Generated:							
Non-electric:		Node Sequence	<input checked="" type="checkbox"/>	Node Calculations	<input checked="" type="checkbox"/>	Market Share	<input checked="" type="checkbox"/>
Electric:		Detailed Electric Sector Iteration Calculations					<input checked="" type="checkbox"/>
Input Data:							<input checked="" type="checkbox"/>





# *To Run the Model Select “Run BALANCE” Under the File Menu When You Are in the Sector Window*



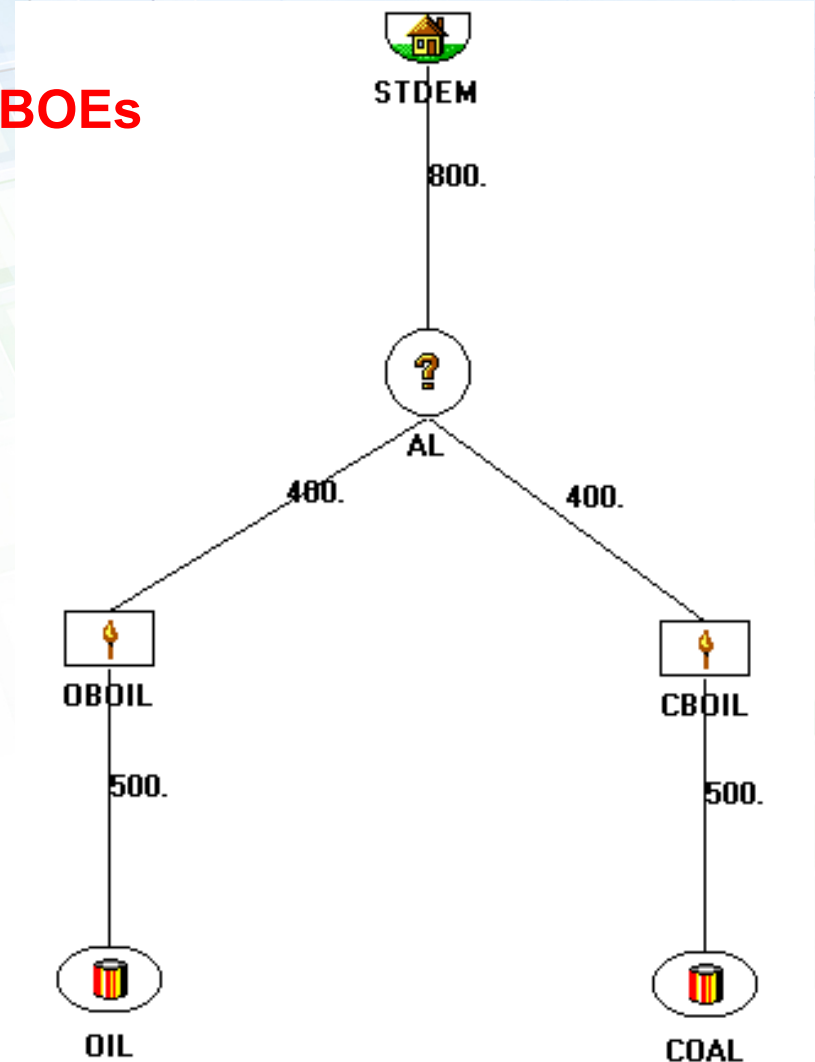
# Case 1: Check of Base Year Energy Flows

## Base Year (2007) Energy Flows in kBOEs

AL:  $Q_{out_t} = \sum Q_{in_{(t,l)}} = 400 + 400 = 800$

PR:  $Q_{out_t} = Q_{in_t} \times f = 500 \times 0.8 = 400$

RS:  $Q_{out_0} = \text{user-specified} = 500$



# Case 1: Check of Base Year Prices

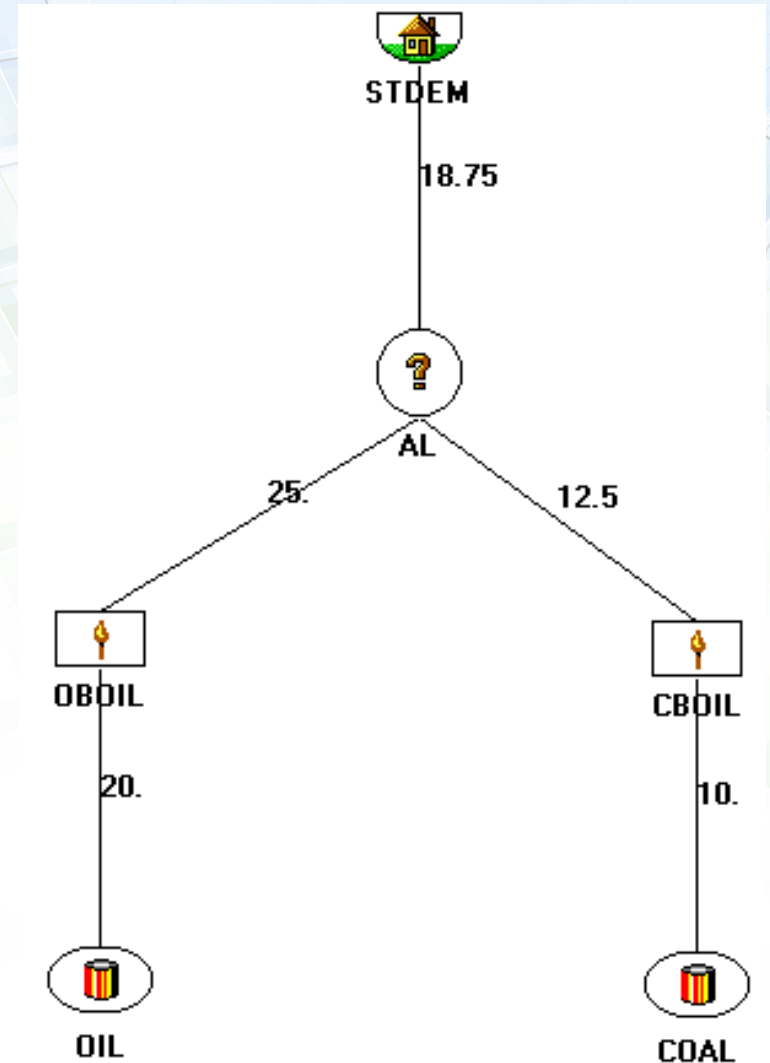
## Base Year (2007) Energy Prices in \$/BOE

AL:  $P_{out_t} = \sum [P_l \times S_l]$

$$= 25 \times 0.5 + 12.5 \times 0.5 = 18.75$$

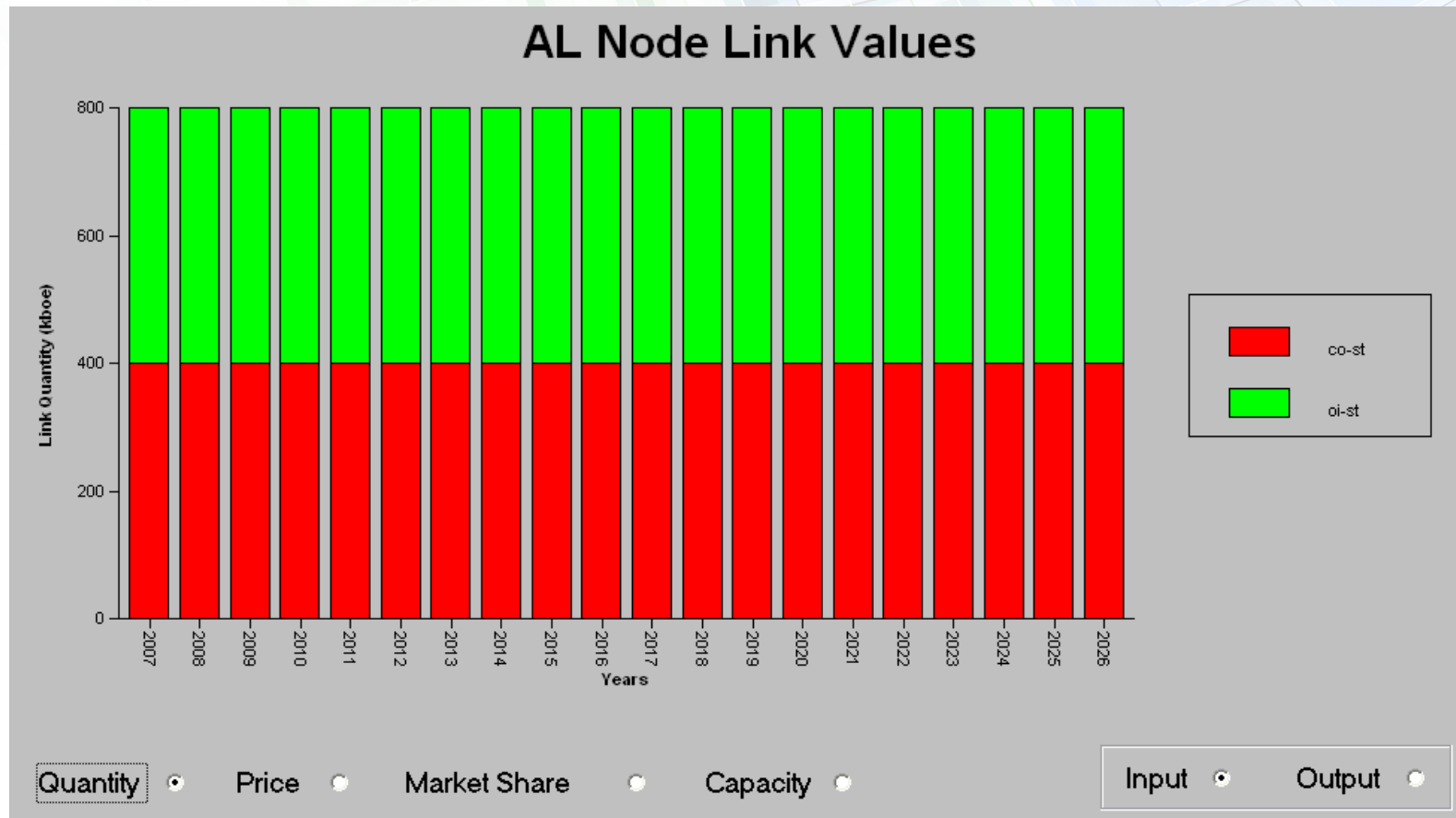
PR-OBOIL:  $P_{out_t} = P_{in_t}/\text{eff} + \text{OM} +$   
 $+ [TCL/(CAP \times CF)] \times CRF(i,n)$   
 $= 20/0.8 + 0 + 0 = 25$

RS-OIL:  $P_{out_t} = A(Q_{out_{t-1}}) \times (1+R_t) + B \times Q_{out_t}$   
 $+ C \times Q_{out_t}^2$   
 $= 20 \times (1+0) + (0 \times 500)$   
 $+ (0 \times 500^2) = 20$



## Case 1 Results: Check of the *QUANTITIES* at the Allocation Node

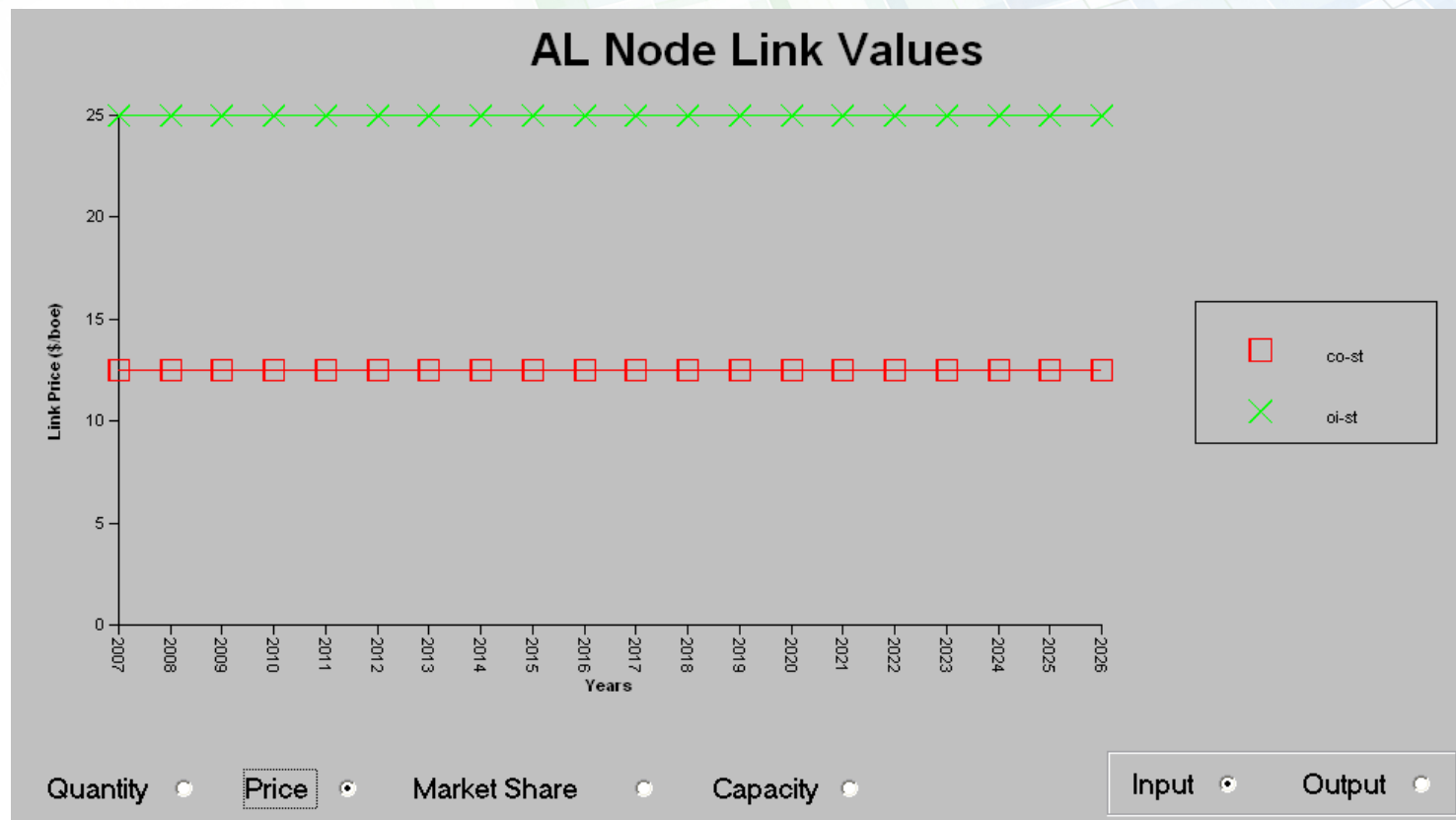
- No demand growth specified over the study period
- The quantities are equally distributed on input links (equal market shares) because of inputs for price sensitivity (0) and lag parameter (0)





## Case 1 Results: Check of the *PRICES* at the Allocation Node

- The prices of steam generated using coal (12.5 \$/BOE) and oil (25 \$/BOE) are different
- But because of price sensitivity and lag of 0, the model does not respond to this price signal and leaves the quantities/market shares the same (see previous slide)



# Changes in Input Variables: Cases 1 to 8

Case	1	2	3	4	5	6	7	8
Demand Growth (each year)	blank	0.05	blank	blank	blank	blank	blank	blank
Resource Price (Coal) Growth (each year)	blank	blank	0.03	blank	blank	blank	blank	blank
Price Sensitivity	blank	blank	blank	5	2	2	5	2
Lag Parameter	blank	blank	blank	0.5	0.1	0.9	0.5	0.9
Priority Link	blank	blank	blank	blank	blank	blank	blank	O: 2 C: 1
Premium Multiplier	blank	blank	blank	blank	blank	blank	O: 0.6 C: 1.0	blank



## Cases 9-17: *For Exercise*

- Prepare the network structure
  - Draw the network
  - Label the network (each link and node has a name and abbreviation)
- Prepare the input data
- Prepare (run/check) the node visitation sequence
- Run BALANCE
- Check/printout the results (tables, graphs, text files)



# Changes in Input Variables: Case 9 to 17

Case	9	10	11	12	13	14	15	16	17
Priority Link	blank	blank	blank	blank	blank	blank	blank	blank	Blank
Premium Multiplier	blank	blank	blank	blank	blank	blank	blank	blank	Blank
Price Sensitivity	5	5	5	5	5	5	5	5	5
Lag factor	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Resource Price Growth (every year)	blank	blank	blank	blank	blank	blank	blank	blank	<b>O: 0.02</b> <b>C: 0.04</b>
Conversion Process Capacity Factor	O: 0.8 C: 0.8	O: 0.8 C: 0.8	<b>O: 0.8</b> <b>C: 0.4</b>	<b>O: 0.8</b> <b>C: 0.4</b>	<b>O: 0.8</b> <b>C: 0.4</b>	<b>O: 0.8</b> <b>C: 0.4</b>	<b>O: 0.8</b> <b>C: 0.4</b>	O: 0.8 C: 0.8	O: 0.8 C: 0.8
Conversion Process O-I Ratio (efficiency)	O: 0.8 C: 0.8	O: 0.8 C: 0.8	O: 0.8 C: 0.8	<b>O: 0.8</b> <b>C: 0.6</b>	<b>O: 0.8</b> <b>C: 0.6</b>	<b>O: 0.8</b> <b>C: 0.6</b>	<b>O: 0.8</b> <b>C: 0.6</b>	O: 0.8 C: 0.8	O: 0.8 C: 0.8
Conversion Process O&M Cost	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	<b>O: 0</b> <b>C: 2</b>	O: 0 C: 0	O: 0 C: 0
Conversion Process Investment Cost (\$1000)	O: 0 C: 0	<b>O: 0</b> <b>C: 5000</b>	<b>O: 0</b> <b>C: 5000</b>	<b>O: 0</b> <b>C: 5000</b>	<b>O: 0</b> <b>C: 5000</b>	<b>O: 0</b> <b>C: 5000</b>	<b>O: 0</b> <b>C: 5000</b> (2007) 10000 (2012)	O: 0 C: 0	O: 0 C: 0
Conversion Process Lifetime	O: 30 C: 30	O: 30 C: 30	O: 30 C: 30	O: 30 C: 30	O: 30 C: 30	<b>O: 30</b> <b>C: 40</b>	<b>O: 30</b> <b>C: 40</b>	O: 30 C: 30	O: 30 C: 30
Conversion Process Interest Rate	O: 0.1 C: 0.1	O: 0.1 C: 0.1	O: 0.1 C: 0.1	O: 0.1 C: 0.1	<b>O: 0.1</b> <b>C: 0.05</b>	<b>O: 0.1</b> <b>C: 0.05</b>	<b>O: 0.1</b> <b>C: 0.05</b>	O: 0.1 C: 0.1	O: 0.1 C: 0.1
Capacitated Link (Steam Links)	O: blank C: blank	O: blank C: blank	O: blank C: blank	O: blank C: blank	O: blank C: blank	O: blank C: blank	O: blank C: blank	<b>O: blank</b> <b>C: blank</b> <b>C 200 (2012)</b> <b>C 300 (2017)</b>	O: blank C: blank

This entry means investment of \$5 million



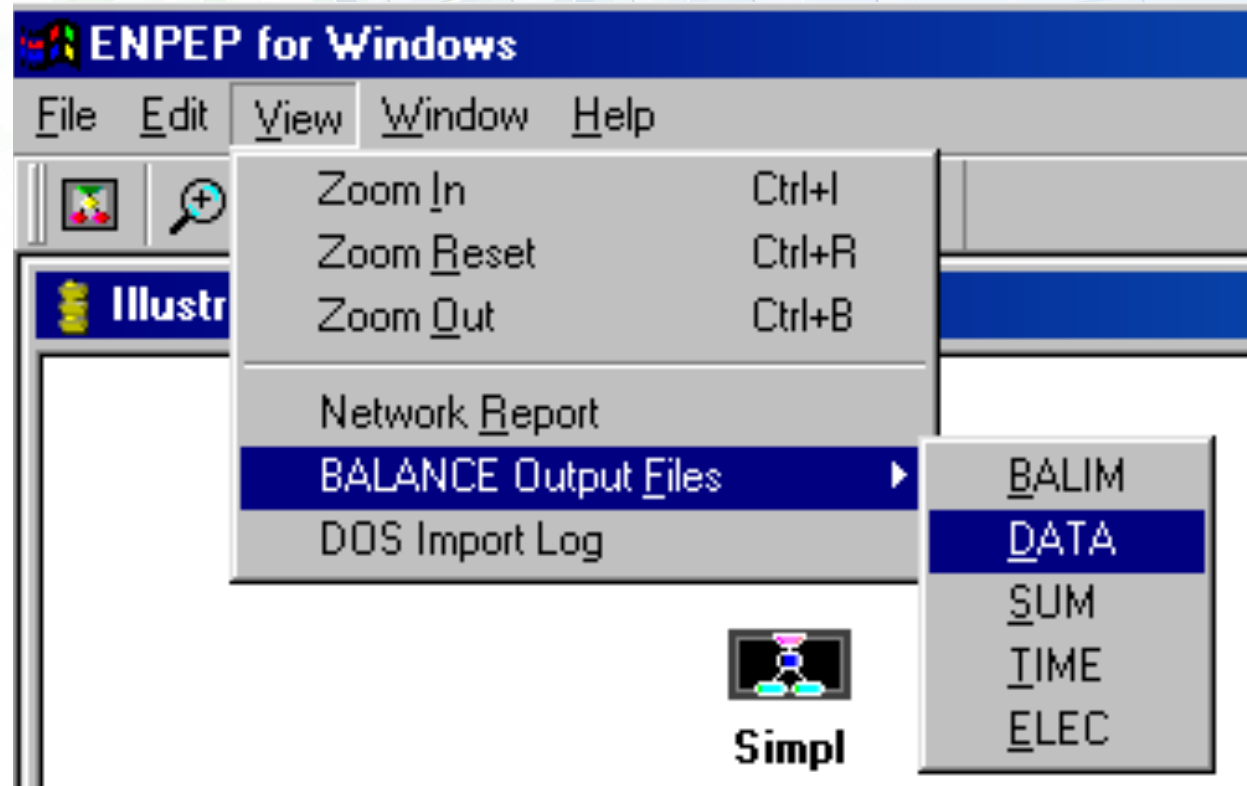
# ***There Are Several Ways to Look at Simulation Results***

- Output variables include
  - Prices
  - Quantities
  - Price X Quantity
- Results are displayed in BALANCE in the form of
  - Tables
  - Graphs
- Values are displayed
  - On the network for a specific sector & year
  - For all years for a single node or link
  - For all years for all links in a sector
- Results can be exported and viewed in another software package (e.g., Excel)





## *Invalid Input Data May Crash the Model: If this Happens, you can Use the Detailed Output Reports for Debugging*



- The **DATA file** will indicate invalid network data
- The **ELEC file** will indicate invalid dispatch data
- The **SUM file** will show detailed calculation results