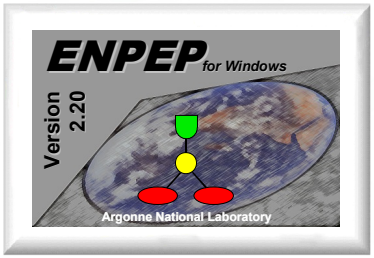
ENPEP-BALANCE: Up and Down Pass

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



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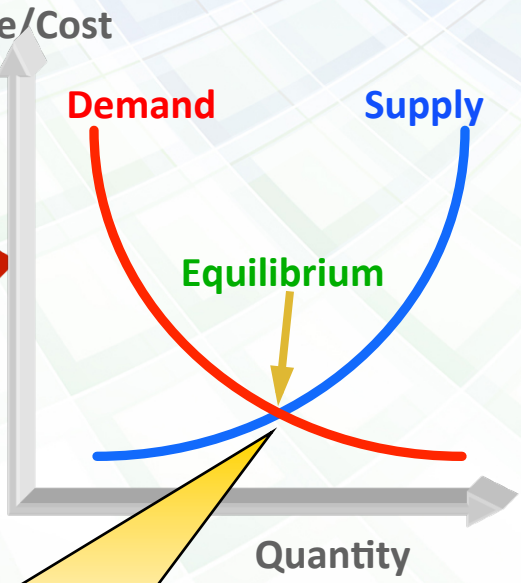
ENPEP-BALANCE Determines the Equilibrium Supply/Demand Balance of the Energy System

INPUT

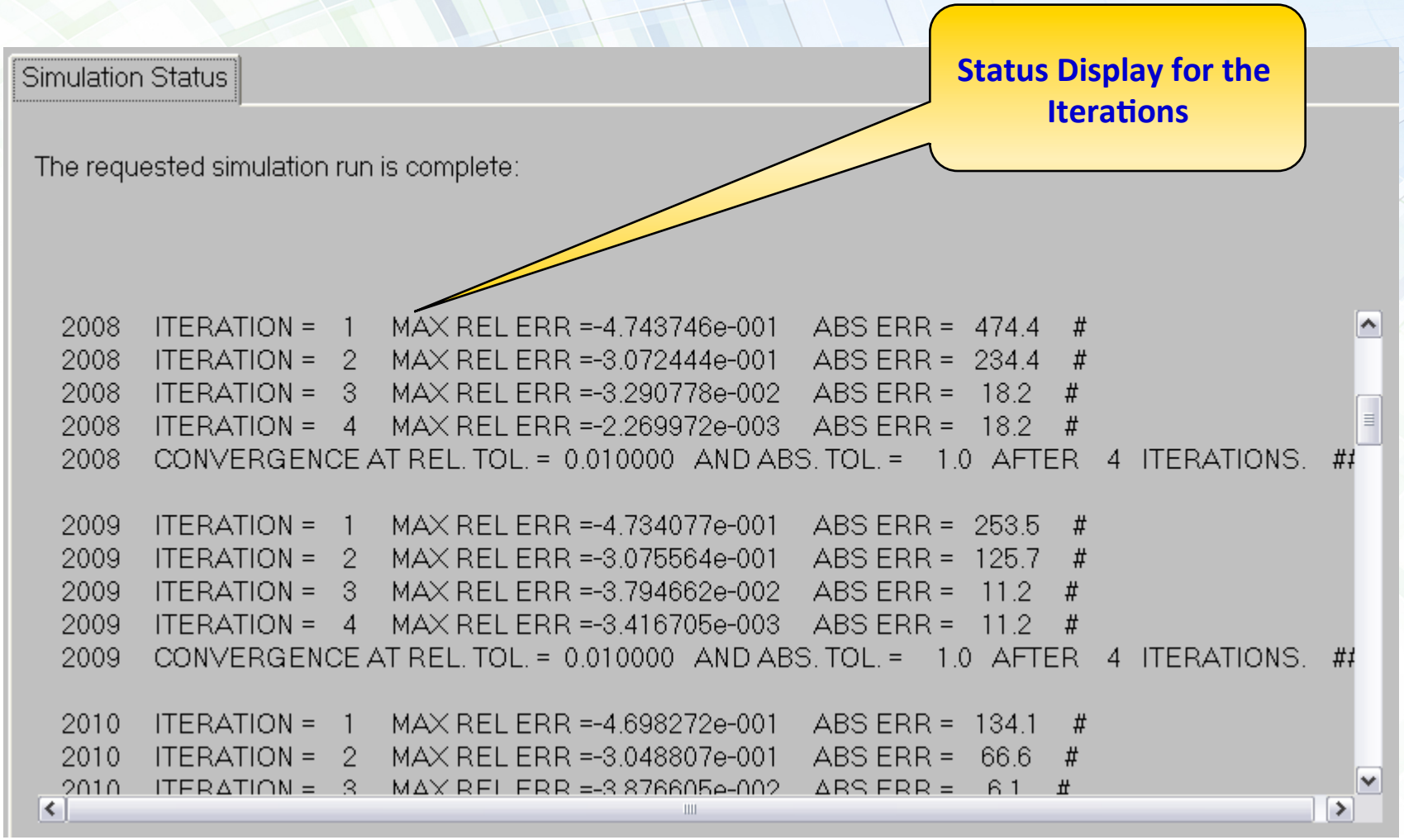
- Energy system structure
- Base year energy flows and prices
- Energy demand growth projections
- Technical and policy constraints

OUTPUT

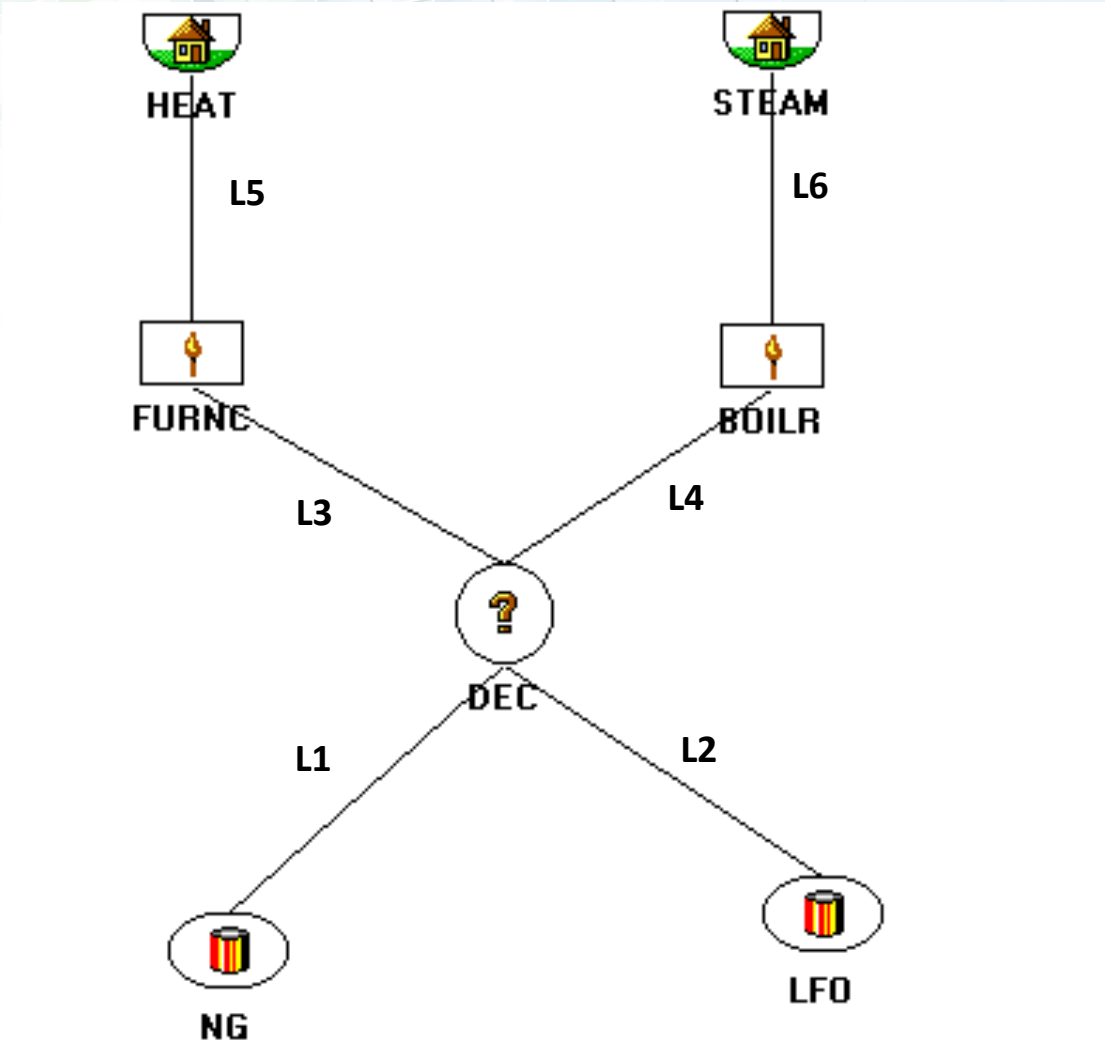


Jacobi Iterative Method Finds the Market Equilibrium Using Up and Down Passes

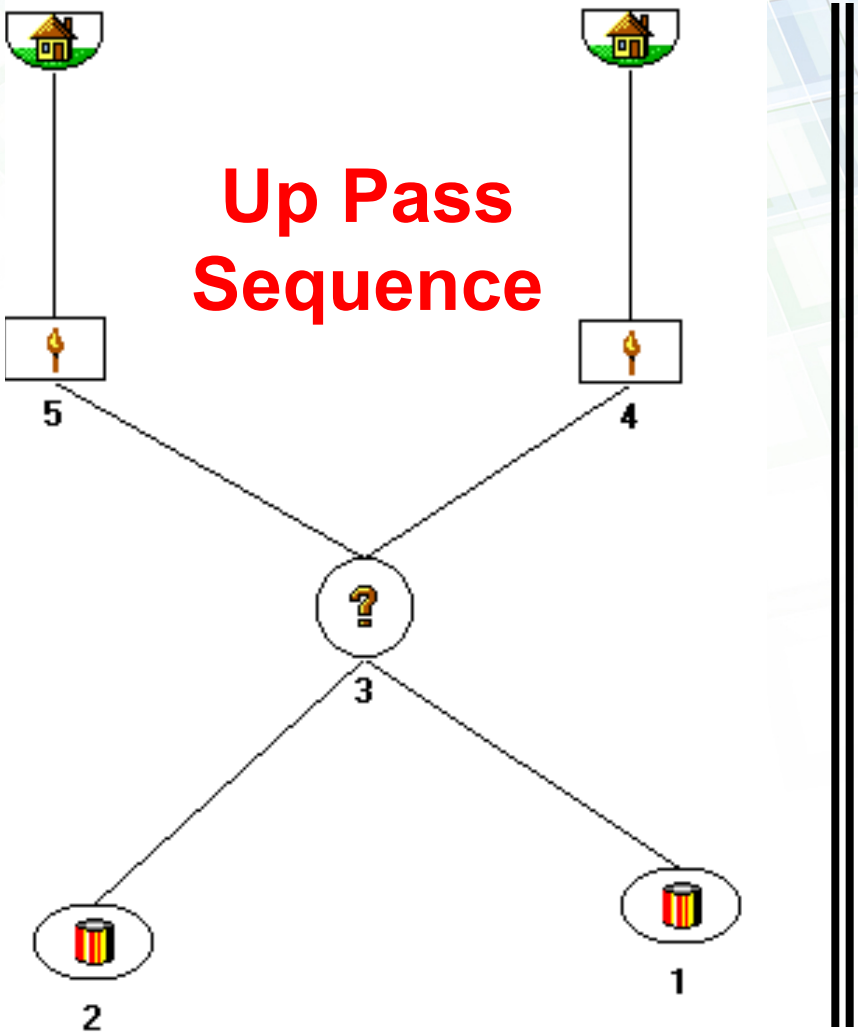
The Status of Iterations is Shown to the User as BALANCE Proceeds with Calculations

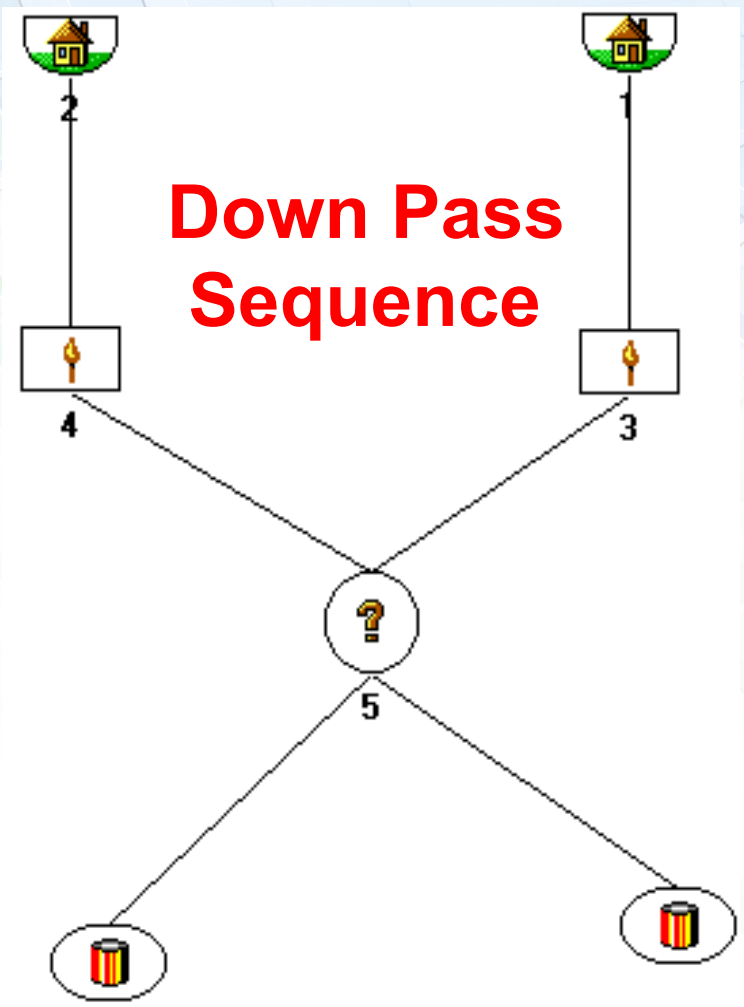


The Up and Down Pass Calculations to be Performed on a Simple Network

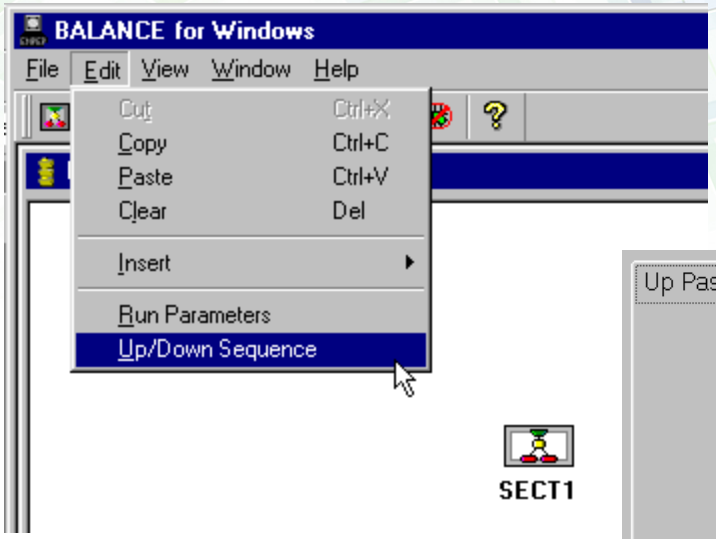


Up and Down Pass Sequences Used for Calculations





You Can View and Edit the Up and Down Pass Sequences



Up Pass Sequence | Down Pass Sequence

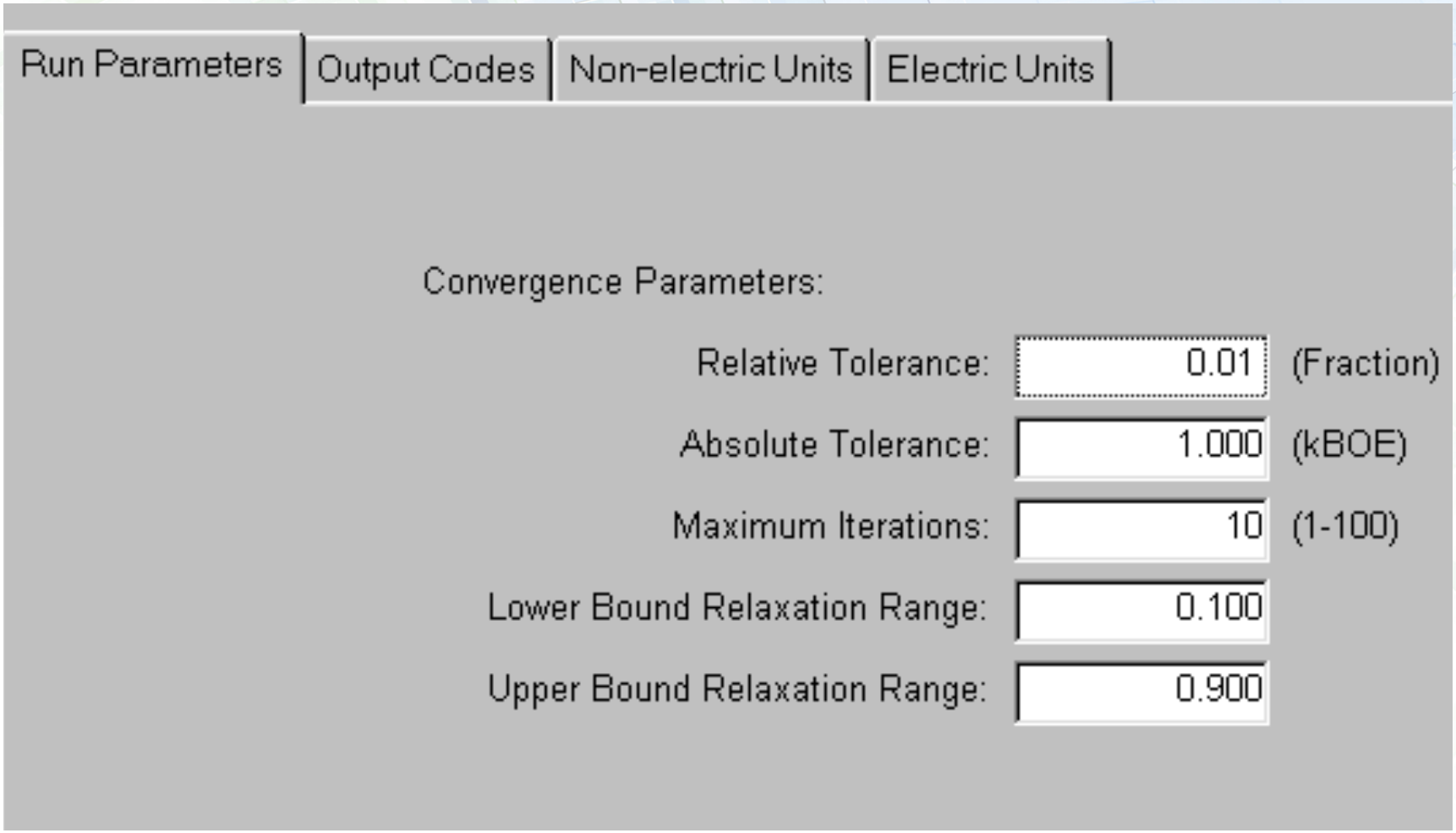
Node Type	Node Abbreviation	Node Name	Sector Abbreviation	Sector Name	Up Sequence
RS	COAL	Coal resource	SECT1	Sector	1
RS	OIL	Oil resource	SECT1	Sector	2
PR	CBOIL	Coal Boiler	SECT1	Sector	3
PR	OBOIL	Oil Boiler	SECT1	Sector	4
AL	AL	Allocation Node	SECT1	Sector	5

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.

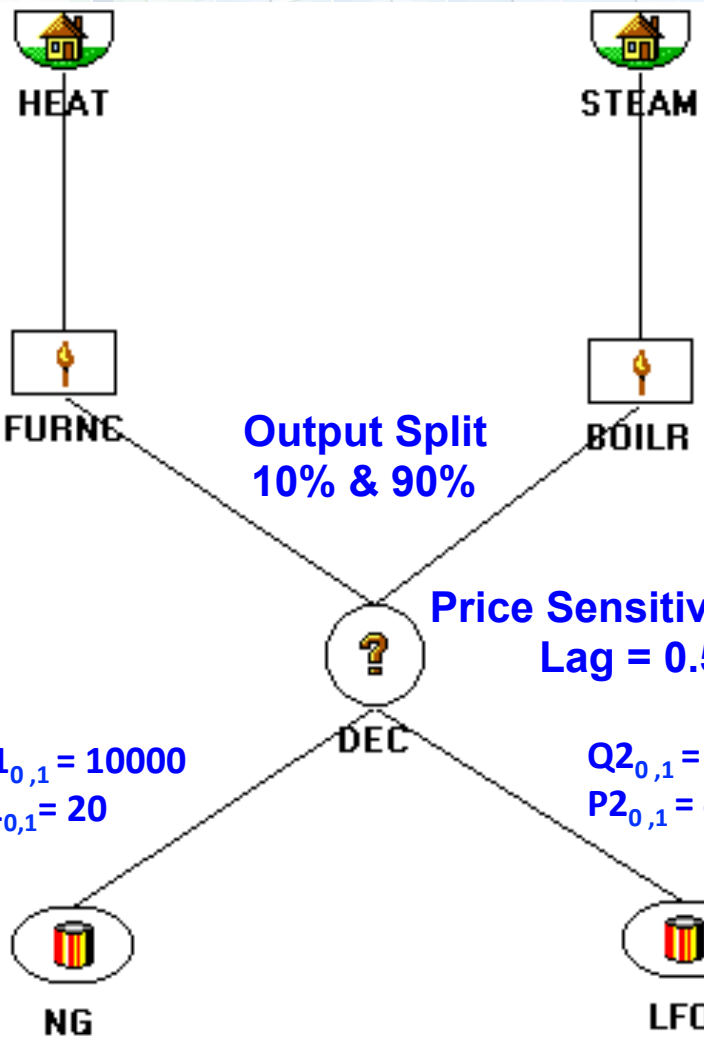
Up Pass Sequence | Down Pass Sequence

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

Convergence Parameter Specifications



User-input Data for the Network (Base Year Values)



HEAT has no demand growth

STEAM has a demand growth rate of 0.05

Efficiency=0.9
O&M=10

Efficiency=0.7
O&M=30

Output Split
10% & 90%

Price Sensitivity = 6
Lag = 0.5

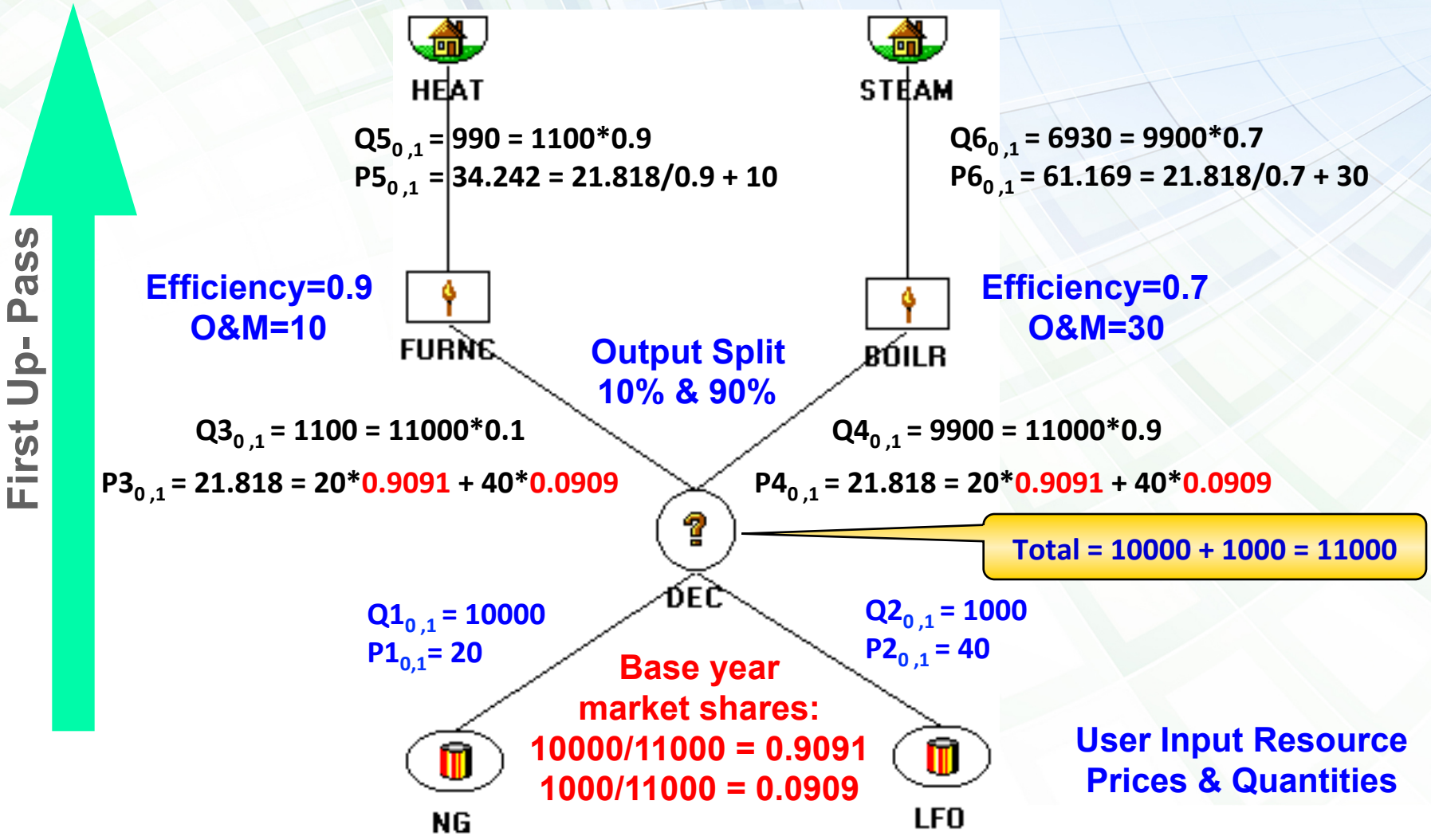
$Q1_{0,1}$ = 10000
$P1_{0,1}$ = 20

$Q2_{0,1}$ = 1000
$P2_{0,1}$ = 40

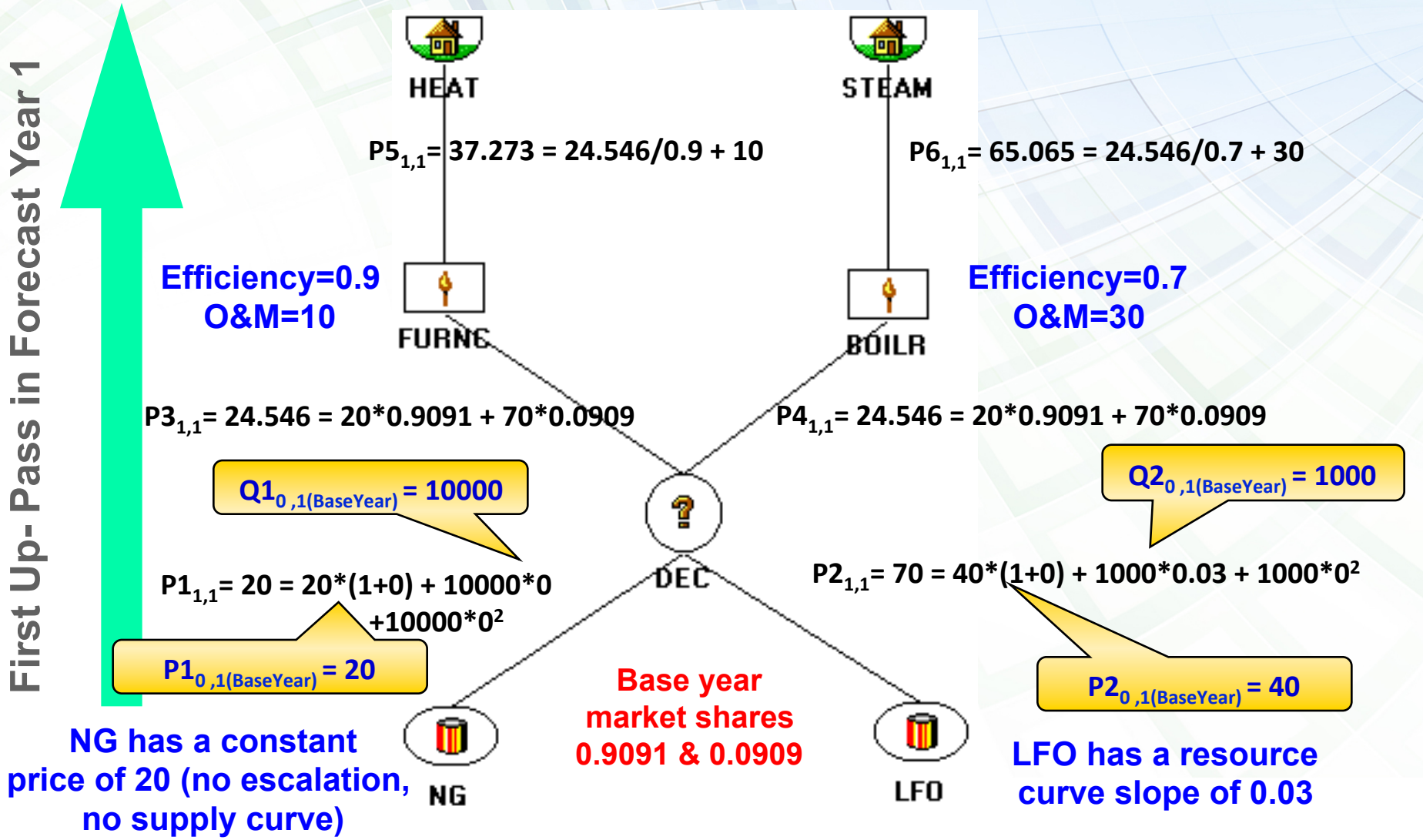
NG has a constant price of 20

LFO has a resource curve slope of 0.03

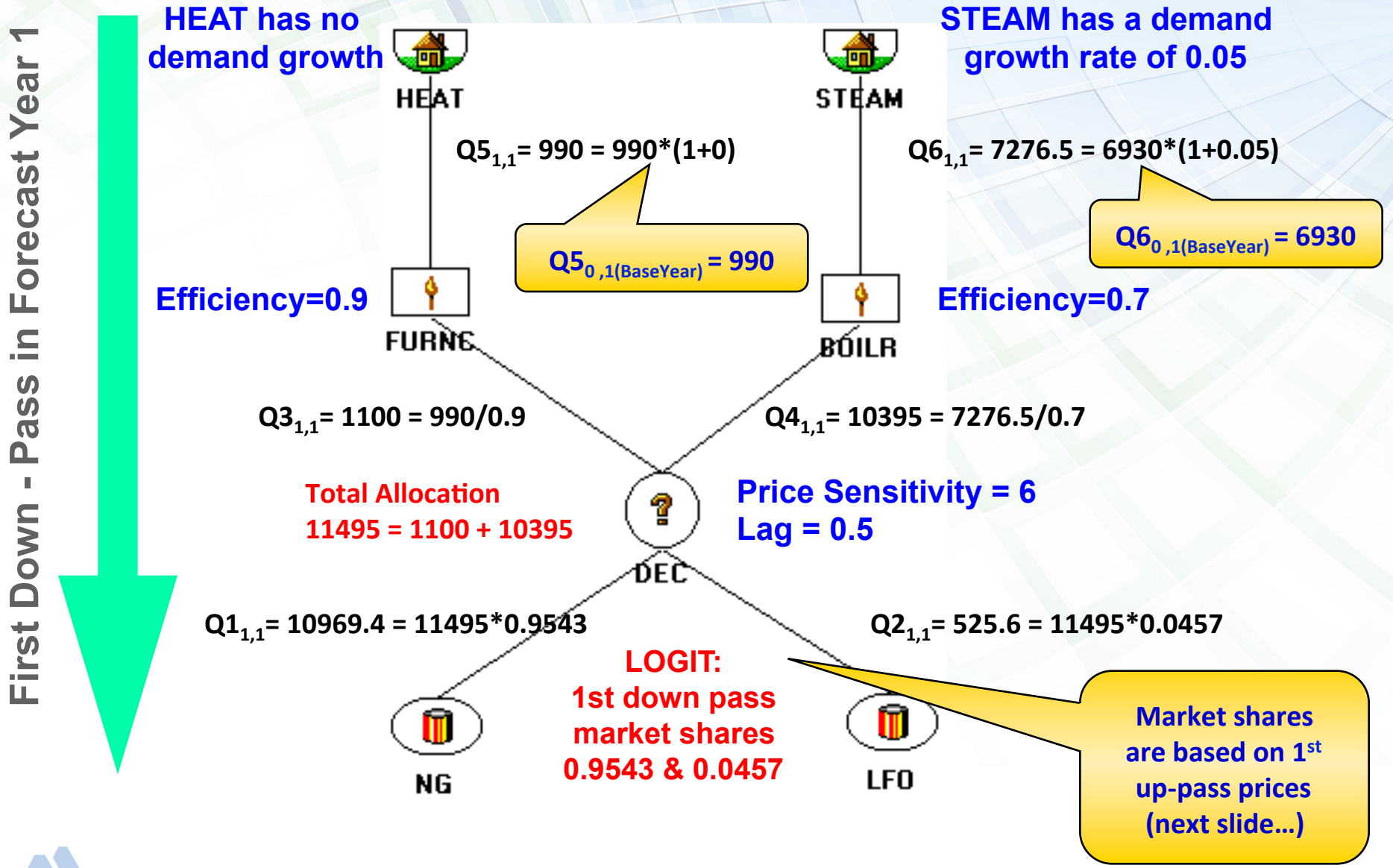
BASE YEAR: The First Up-Pass Is Performed to Determine Base Year Prices and Quantities on Every Network Link



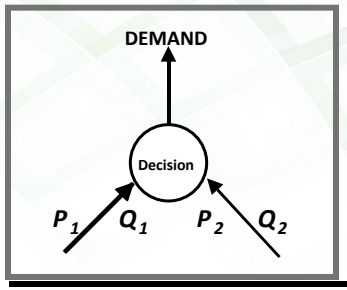
YEAR 1, ITERATION 1: The First Up-Pass Is Performed to Determine Prices for the First Forecast Year



YEAR 1, ITERATION 1: The First Down-Pass Is Performed to Make an Initial Guess For Quantities For First Forecast Year



YEAR 1, ITERATION 1: Market Share Calculation



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

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

Initial market shares

$$MSL\,1_{1,1} = 0.999 = \frac{\left[\frac{1}{20}\right]^{6}}{\left[\frac{1}{70}\right]^{6} + \left[\frac{1}{20}\right]^{6}}$$

g = 6

$$MSL\,2_{1,1} = 0.001 = \frac{\left[\frac{1}{70}\right]^{6}}{\left[\frac{1}{70}\right]^{6} + \left[\frac{1}{20}\right]^{6}}$$

Price from 1st year in 1st up-pass

Market Shares are Adjusted for System Lags Using Lag Equation

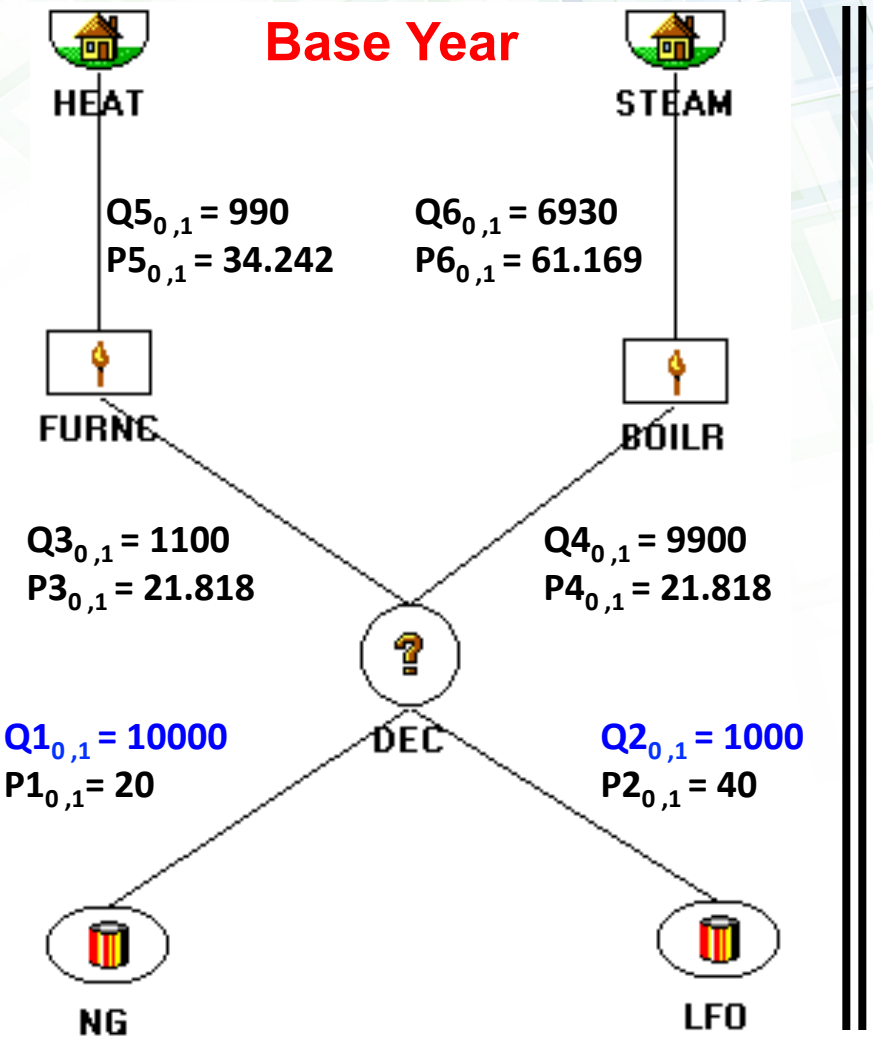
$MSL\,1_{1,1} = 0.9543 = 0.90909 + ((0.999 - 0.90909) * 0.5))$

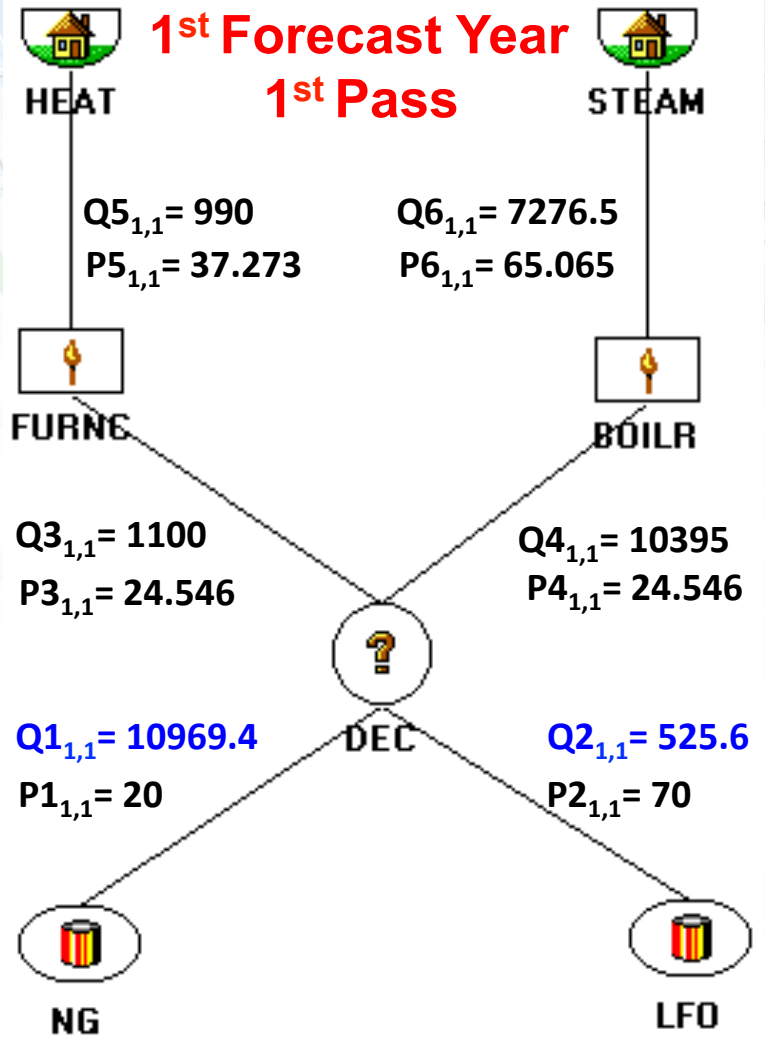
$MSL\,2_{1,1} = 0.0457 = 0.09091 + ((0.001 - 0.09091) * 0.5))$

Previous (Base Year) Market Shares

Lag = 0.5

YEAR 1, ITERATION 1: Prices and Quantities Have Changed from the Base Year





YEAR 1, ITERATION 1: BALANCE Checks for Convergence After the First Iteration

Convergence report:

$Q1_{0,1} = 10000$ $Q1_{1,1} = 10969.4$ RERR = 9.7 % ABERR = +969.4

$Q2_{0,1} = 1000$ $Q2_{1,1} = 525.6$ RERR = - 47.4 % ABERR = -474.4

Errors are relative to the base year (the quantity used to estimate the prices in Year 1 first up-pass)

Errors exceed both convergence criteria of 1% and 1 kBOE

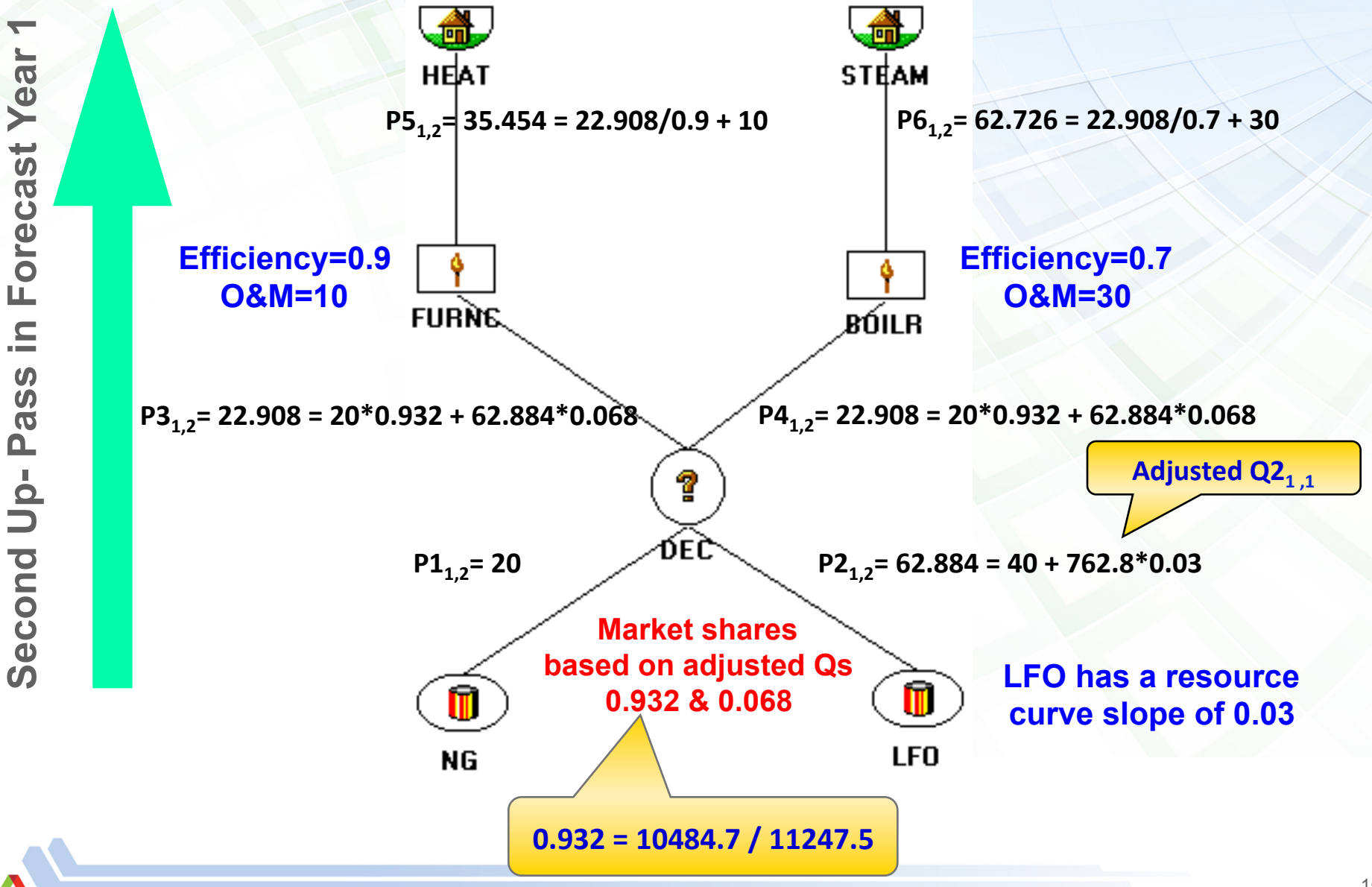
BALANCE makes quantity adjustments for the 2nd up pass:

$$Q1_{1,1,adj} = 10484.7 = (Q1_{0,1} + Q1_{1,1}) / 2$$
$$= (10000 + 10969.4) / 2$$

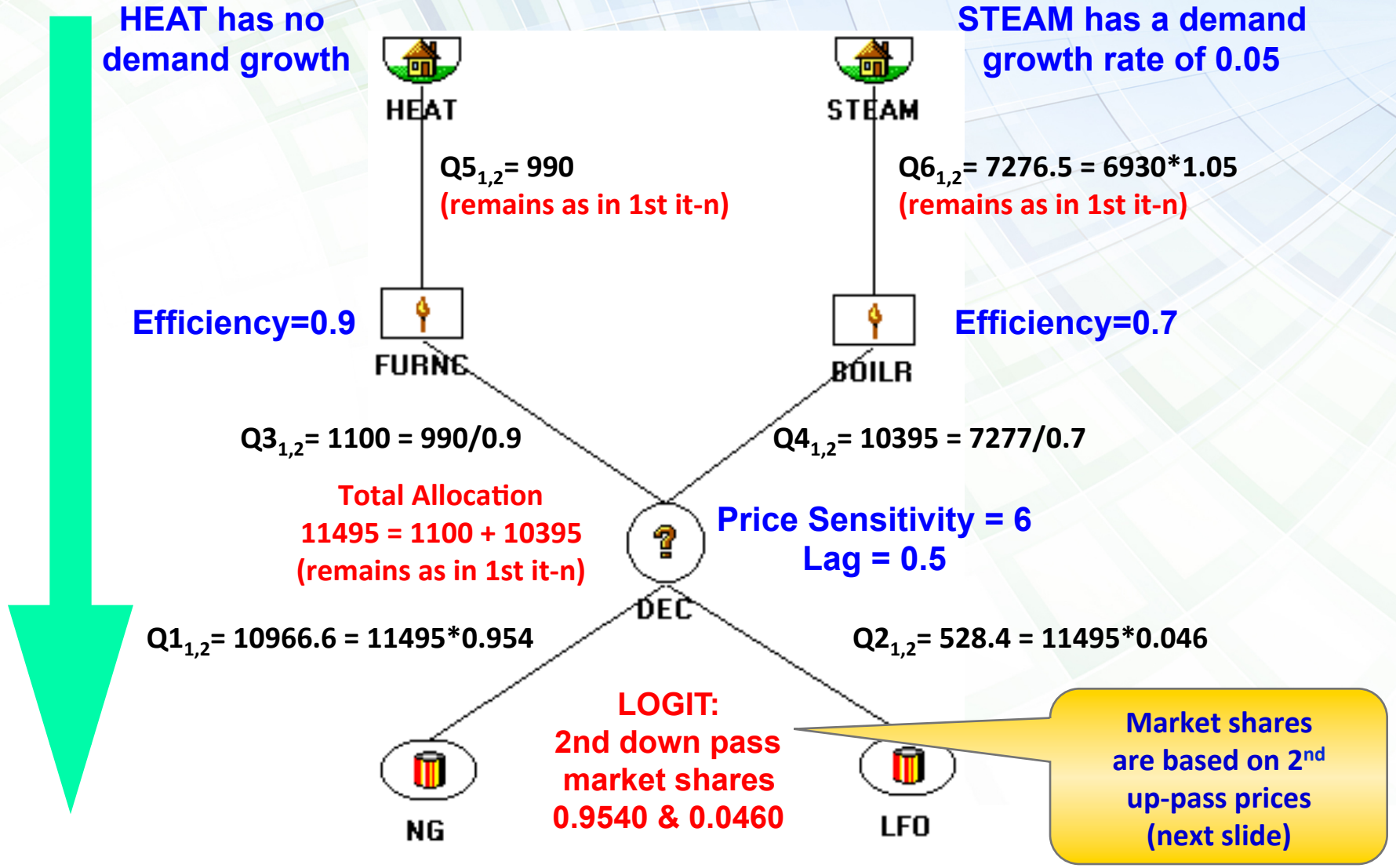
$$Q2_{1,1,adj} = 762.8 = (Q2_{0,1} + Q2_{1,1}) / 2$$
$$= (1000 + 525.6) / 2$$

As a 2nd guess, an average is used

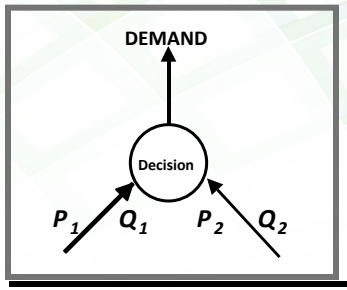
YEAR 1, ITERATION 2: A Second Up-Pass Is Performed for the First Forecast Year



YEAR 1, ITERATION 2: A Second Down-Pass Is Performed to Re-compute Quantities for the First Forecast Year



YEAR 1, ITERATION 2: Market Share Calculation



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

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

Initial market shares

$$MSL\ 1_{1,1} = 0.998\ 9 = \frac{\left[\frac{1}{20}\right]^{6}}{\left[\frac{1}{62.9}\right]^{6} + \left[\frac{1}{20}\right]^{6}}$$

g = 6

Slight change from 1st iter-n

$$MSL\ 2_{1,1} = 0.001 = \frac{\left[\frac{1}{62.9}\right]^{6}}{\left[\frac{1}{62.9}\right]^{6} + \left[\frac{1}{20}\right]^{6}}$$

Price from 1st year in 2nd up-pass

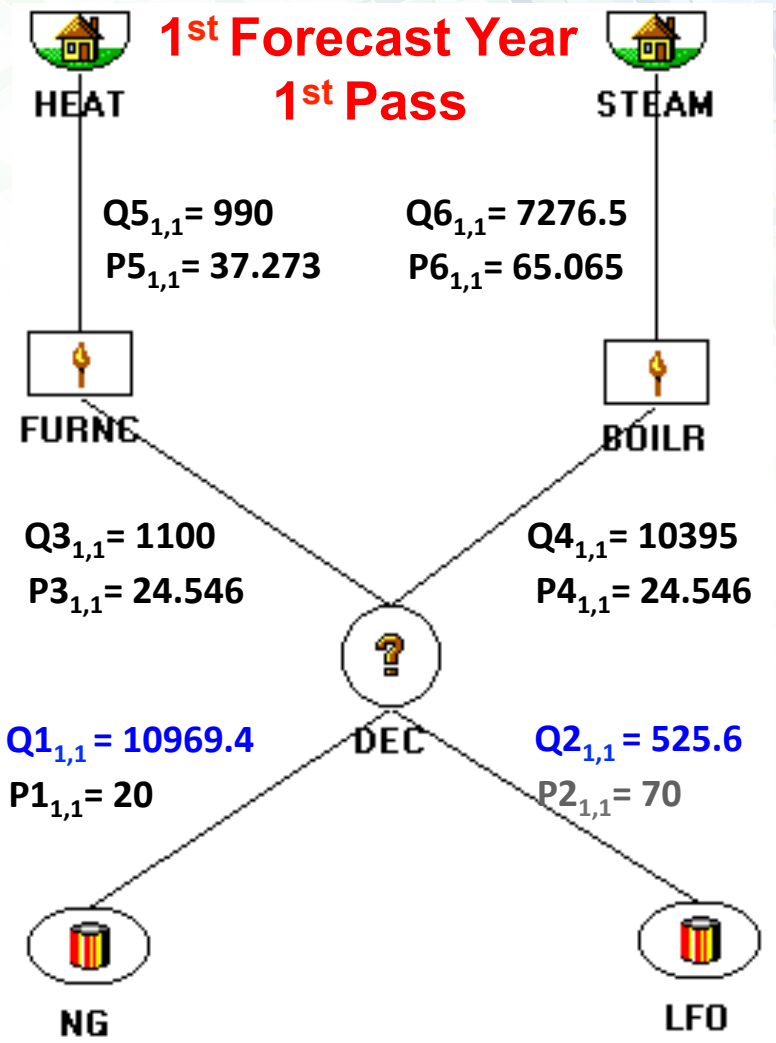
Market Shares are Adjusted for System Lags Using Lag Equation

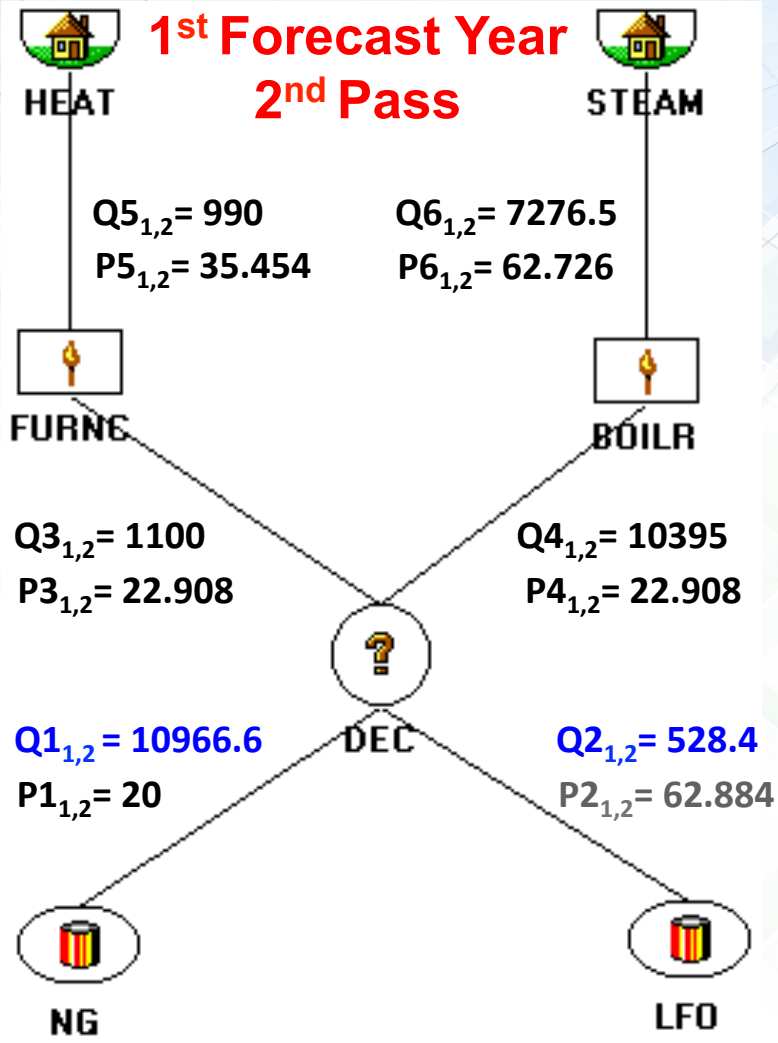
$MSL\ 1_{1,1} = 0.9540 = 0.90909 + ((0.9989 - 0.90909) * 0.5))$

$MSL\ 2_{1,1} = 0.0460 = 0.09091 + ((0.001 - 0.09091) * 0.5))$

Lag = 0.5

YEAR 1, ITERATION 2: Prices and Quantities Have Changed from the First Pass





YEAR 1, ITERATION 2: BALANCE Checks for Convergence after the Second Iteration

Convergence report:

Errors exceed both convergence criteria of 1% and 1 kBOE but are smaller than in the 1st pass

$Q1_{1,1,adj}$ = 10484.7 $Q1_{1,2}$= 10966.6 RERR = 4.6 % ABERR = 481.9

$Q2_{1,1,adj}$ = 762.8 $Q2_{1,2}$= 528.4 RERR + -30.7 % ABERR = -234.4

Errors are relative to the 1st pass adjusted quantities (the quantity used to estimate the prices in the up-pass)

BALANCE makes quantity adjustments for the 3nd up pass:

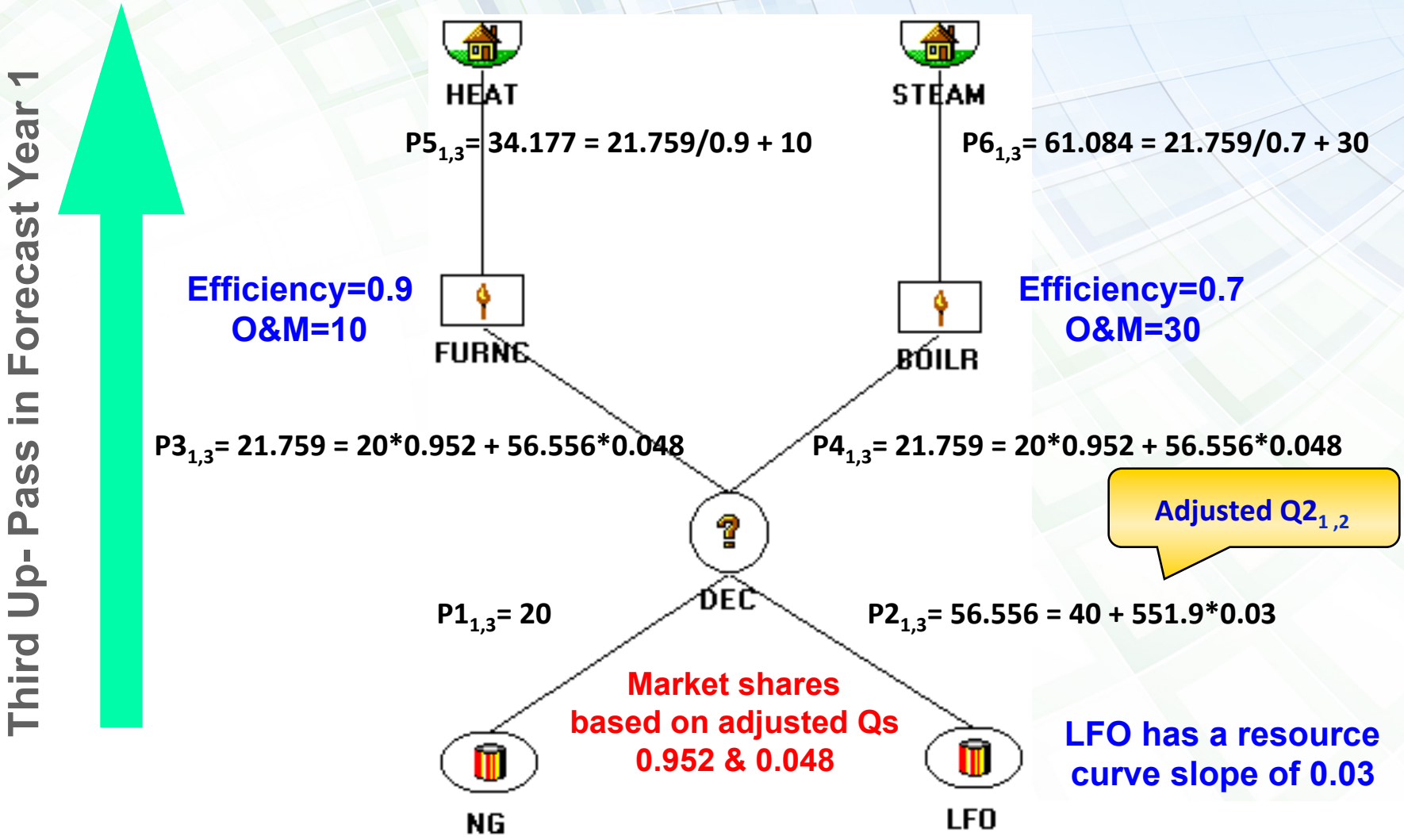
$$Q1_{1,2,adj} = 10918.4 = (Q1_{1,1} * 0.1) + (Q1_{1,2} * 0.9)$$
$$= (10484.7 * 0.1) + (10966.6 * 0.9)$$

$$Q2_{1,2,adj} = 551.9 = (Q2_{1,1} * 0.1) + (Q2_{1,2} * 0.9)$$
$$= (762.8 * 0.1) + (528.4 * 0.9)$$

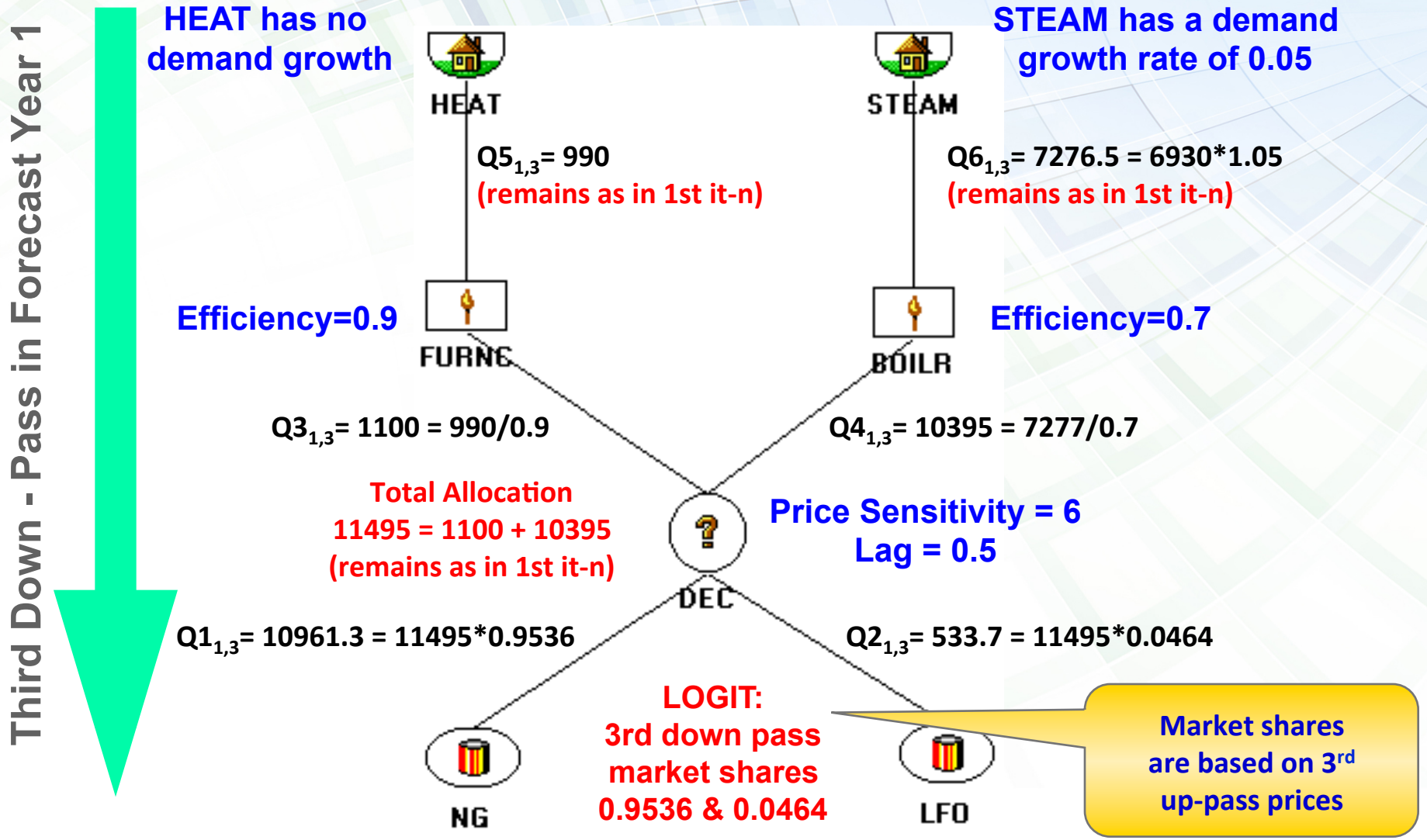
Lower relaxation

Upper relaxation

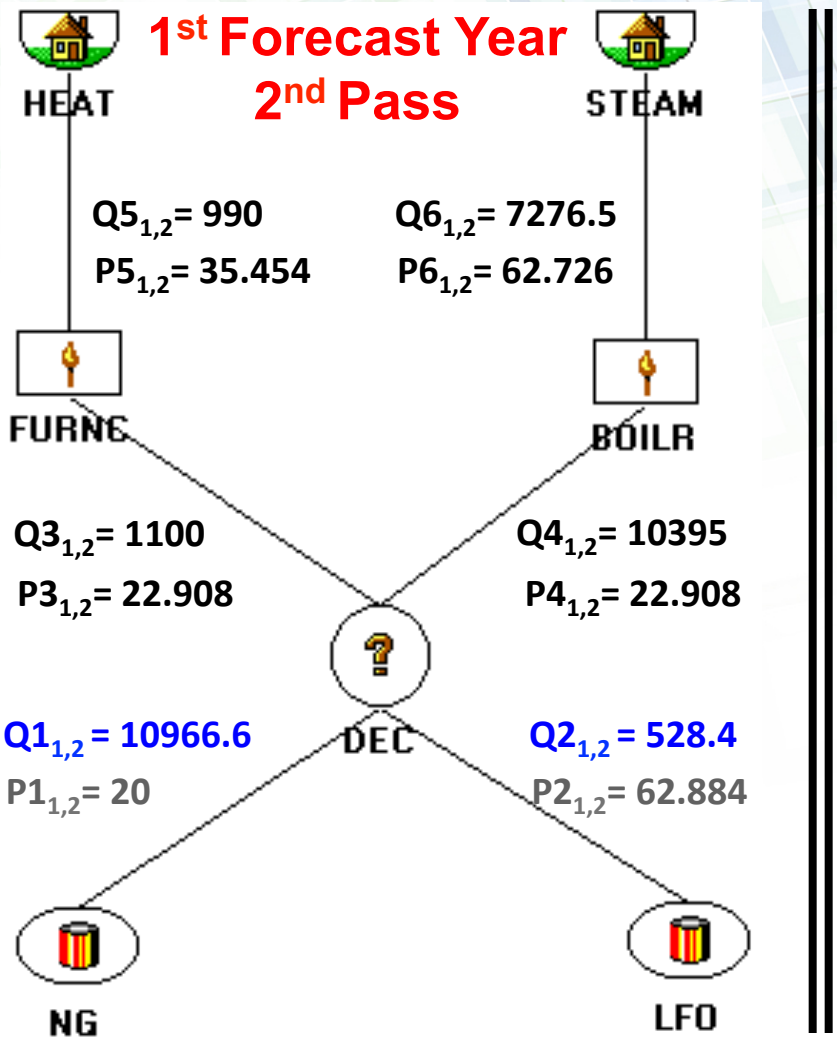
YEAR 1, ITERATION 3: A Third Up-Pass Is Performed for the First Forecast Year

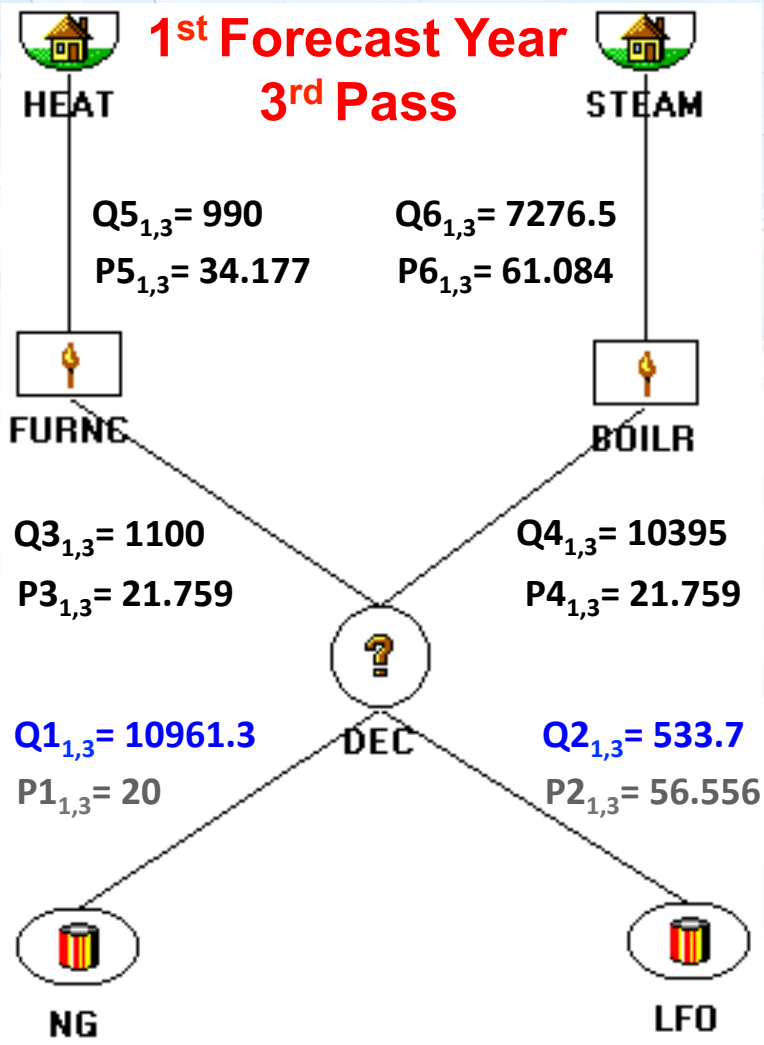


YEAR 1, ITERATION 3: A Third Down-Pass Is Performed to Re-compute Quantities for the First Forecast Year



YEAR 1, ITERATION 3: Prices and Quantities Have Changed from the Second Pass





YEAR 1, ITERATION 3: BALANCE Checks for Convergence after the Third Iteration

Convergence report:

Errors for at least one resource exceed both convergence criteria of 1% and 1 kBOE but are smaller than in the 2nd pass

$Q1_{1,2,adj}$ = 10918.4 $Q1_{1,3}$= 10961.3 RERR = 0.4 % ABERR = 42.9
$Q2_{1,2,adj}$ = 551.9 $Q2_{1,3}$= 533.7 ERROR = -3.2 % ABERR = -18.2

Errors are relative to the 2nd pass adjusted quantities

BALANCE makes quantity adjustments for the 3rd up pass:

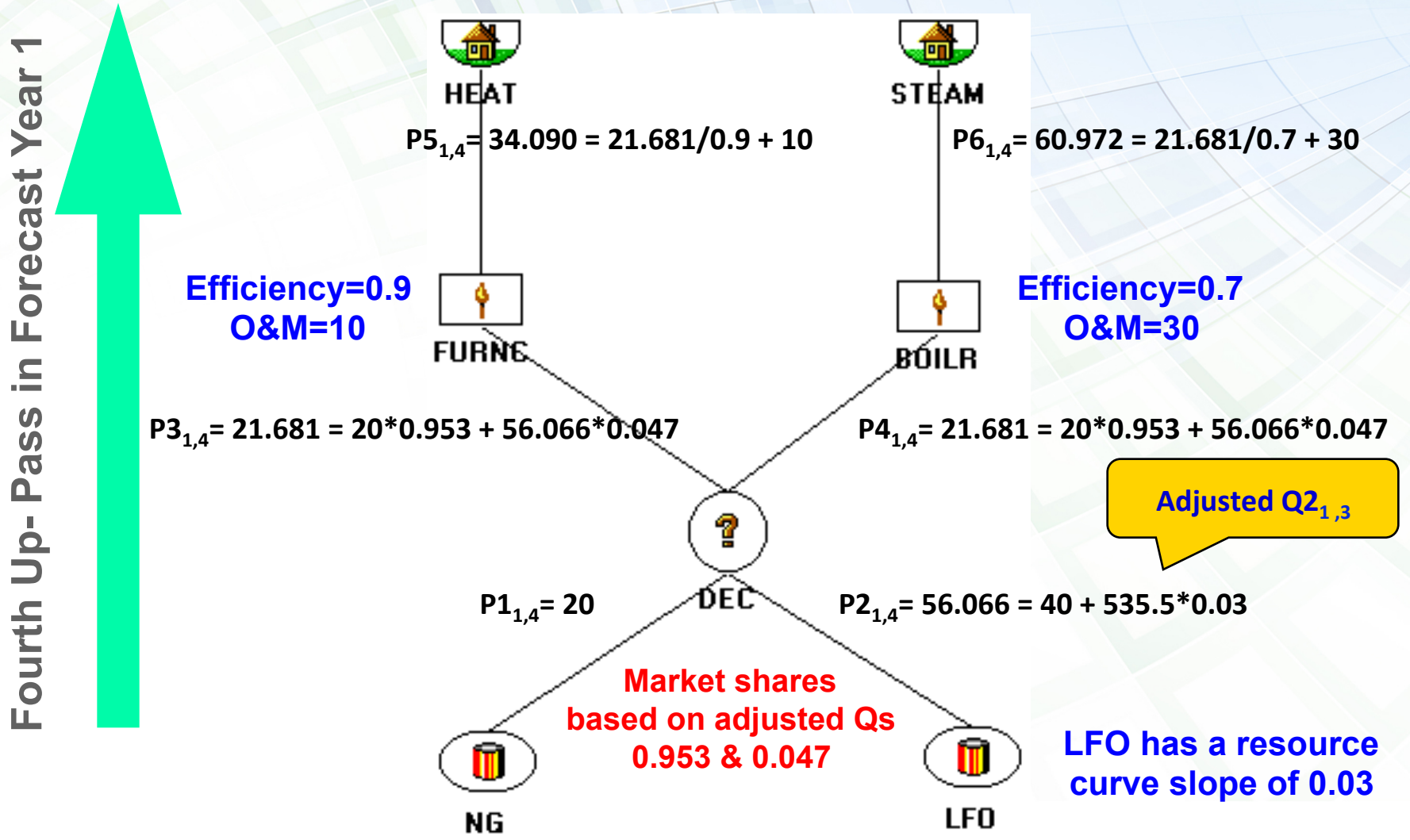
$$Q1_{1,3,adj} = 10957.0 = (Q1_{1,2} * 0.1) + (Q1_{1,3} * 0.9)$$
$$= (10918.4 * 0.1) + (10961.3 * 0.9)$$

$$Q2_{1,3,adj} = 535.5 = (Q2_{1,2} * 0.1) + (Q2_{1,3} * 0.9)$$
$$= (551.9 * 0.1) + (533.7 * 0.9)$$

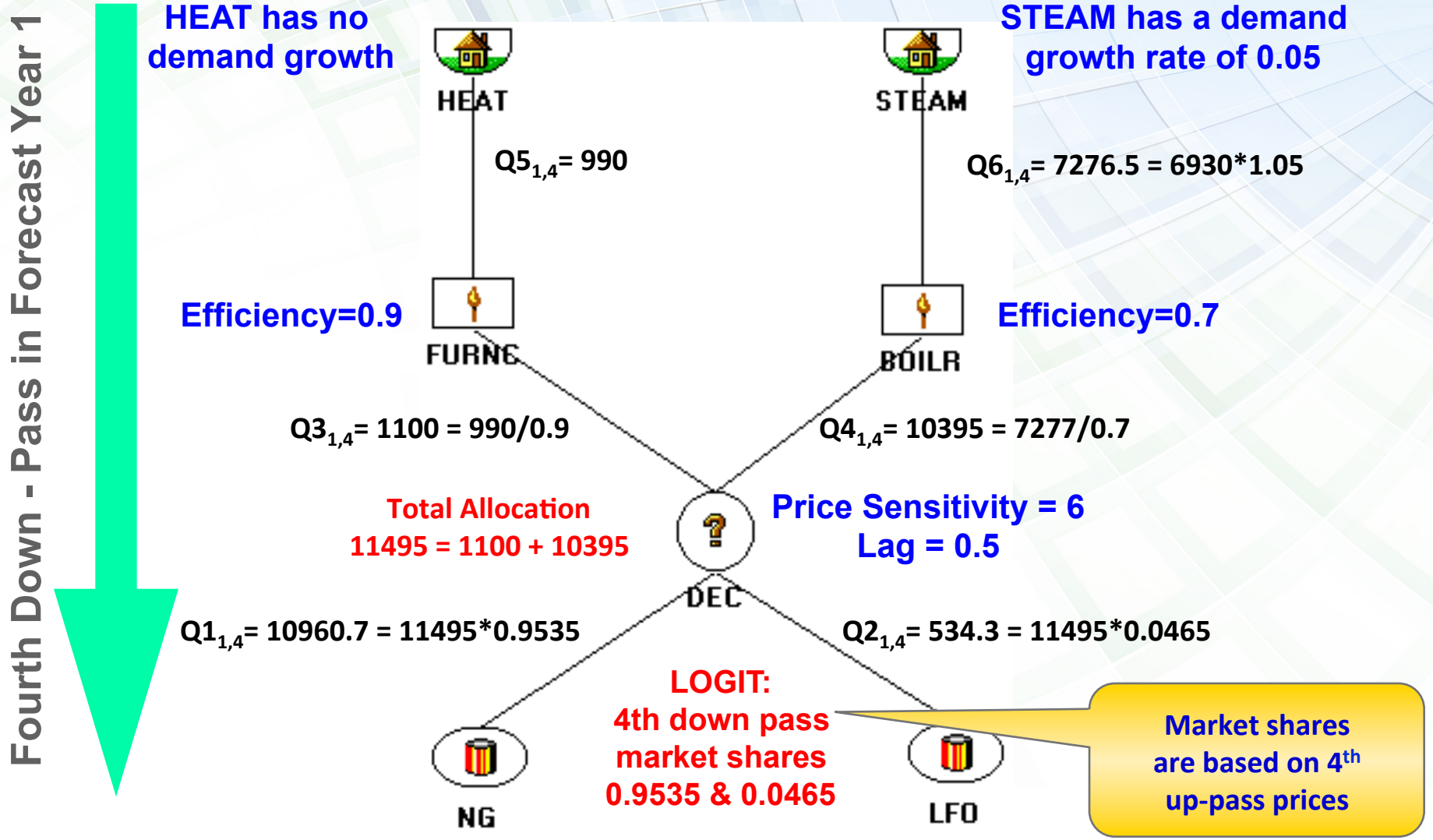
Lower relaxation

Upper relaxation

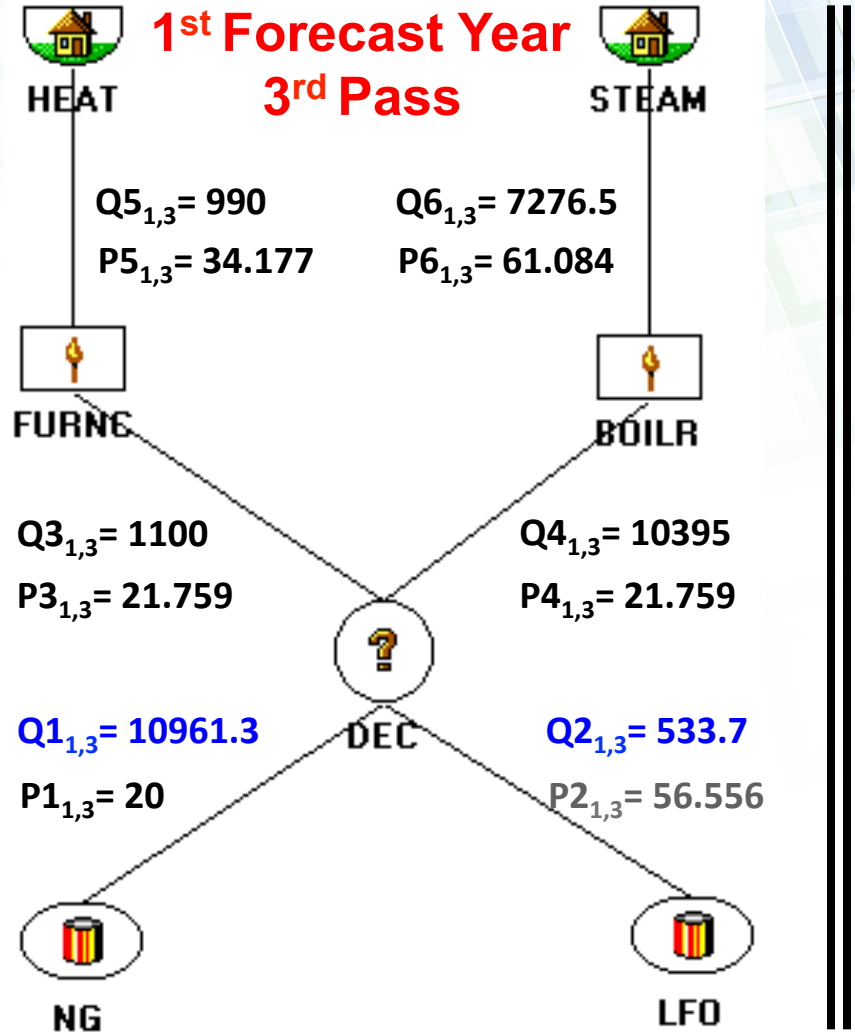
YEAR 1, ITERATION 4: A Fourth Up-Pass Is Performed for the First Forecast Year

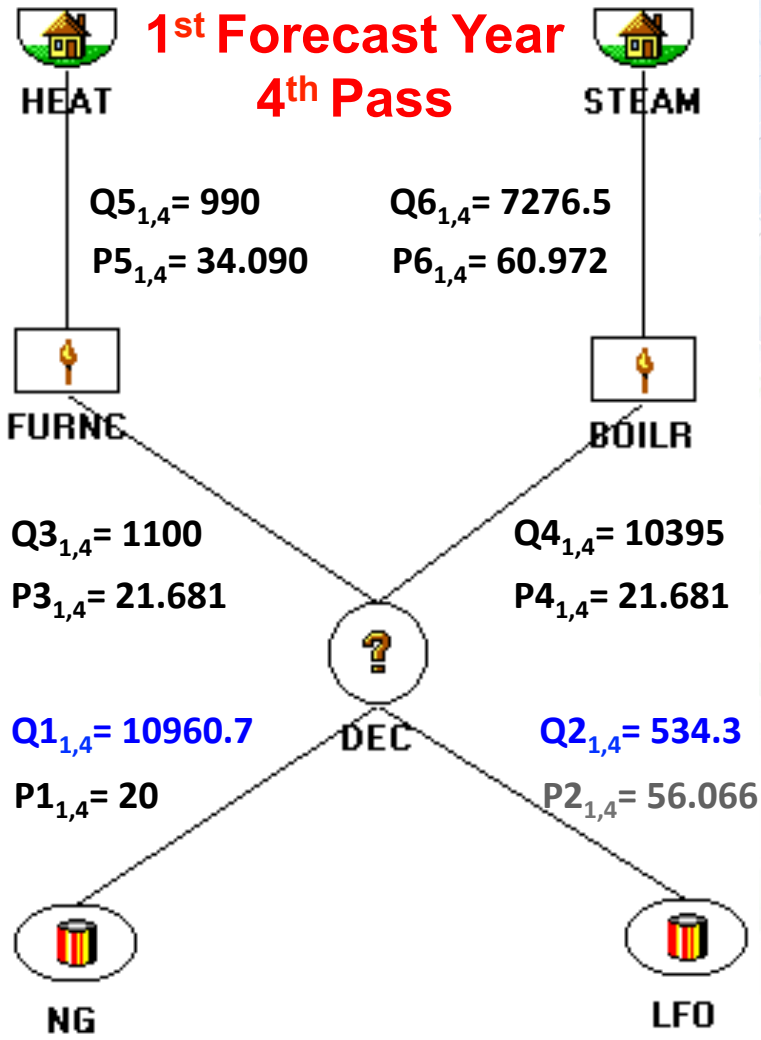


YEAR 1, ITERATION 4: A Fourth Down-Pass Is Performed to Re-compute Quantities for the First Forecast Year



YEAR 1, ITERATION 4: Quantities Have Converged but Prices Changed from the Third Pass





YEAR 1, ITERATION 4: BALANCE Checks for Convergence after the Third Iteration

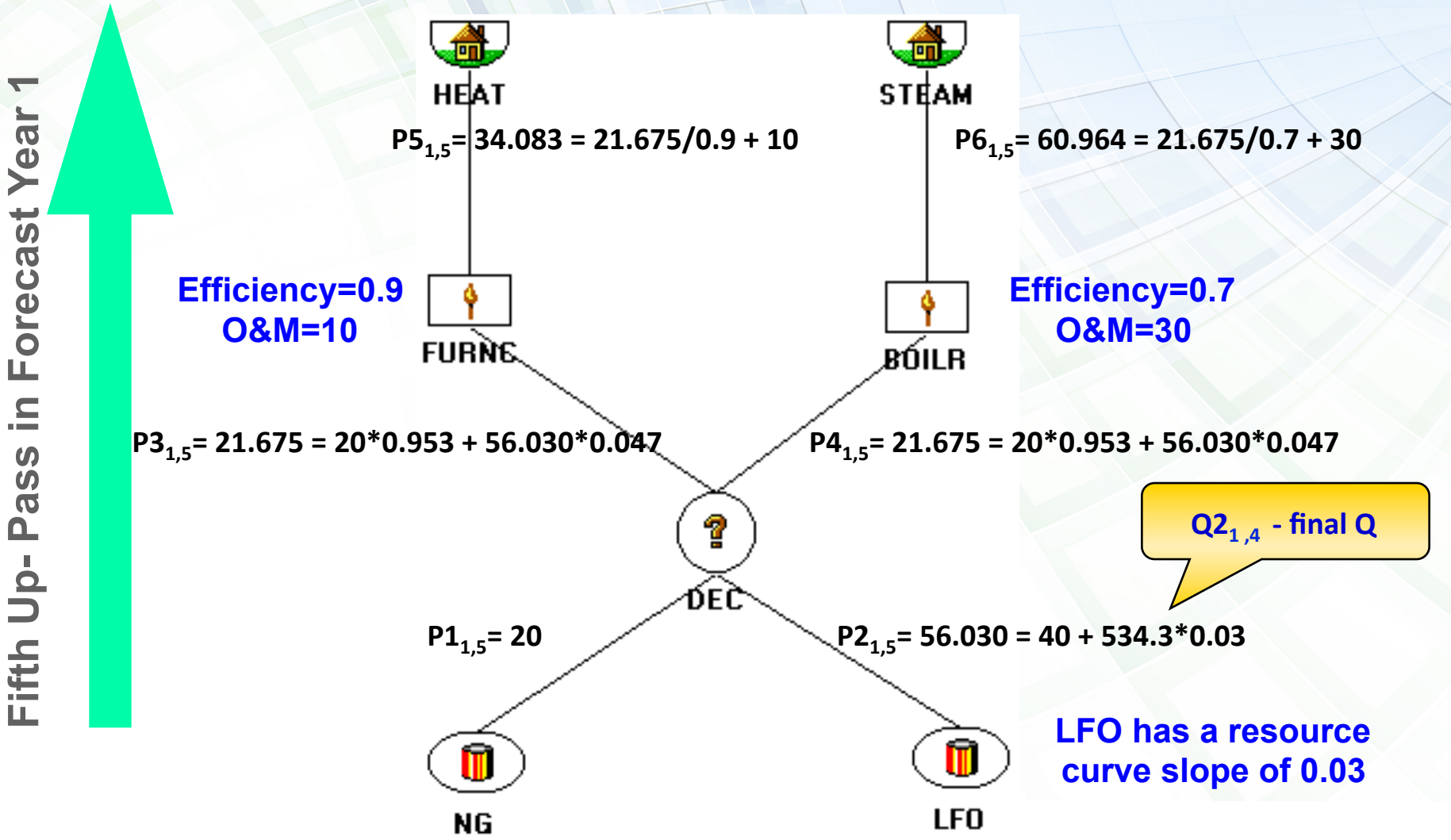
Convergence report:

$Q1_{1,3,adj}$ = 10957.0 $Q1_{1,4}$= 10960.7 RERR = 0.03% ABERR = 3.7
$Q2_{1,3,adj}$ = 535.5 $Q2_{1,4}$= 534.3 ERROR = -0.2% ABERR = -1.2

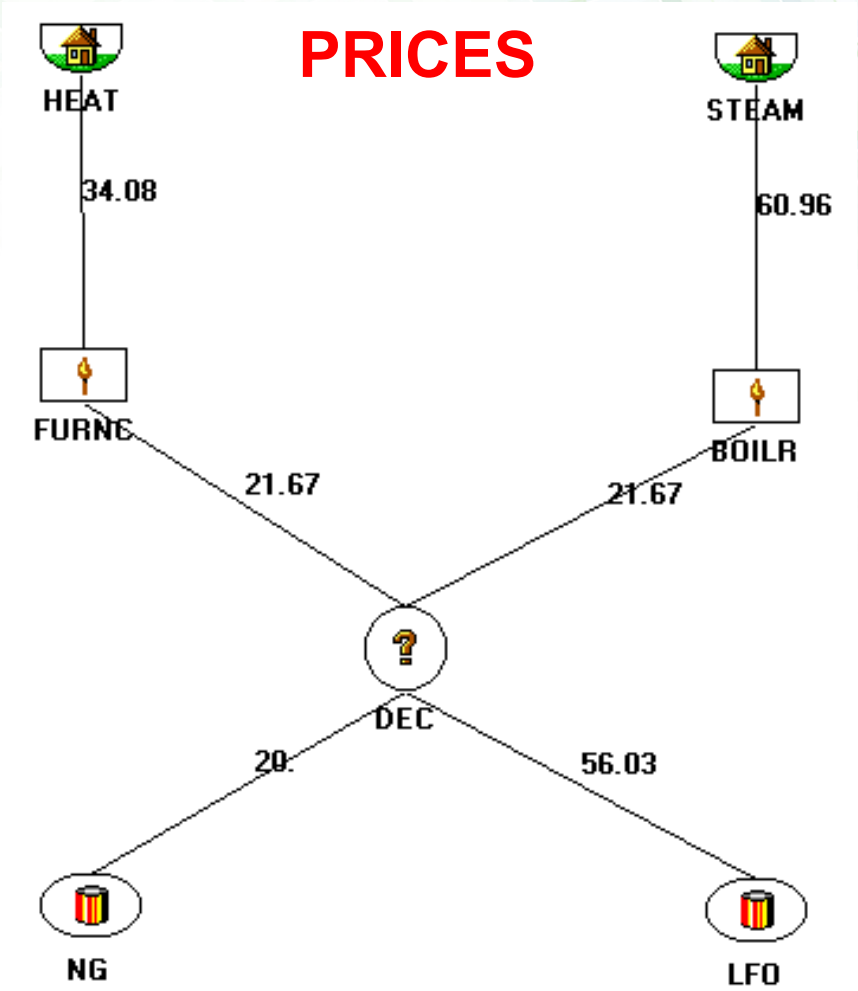
Errors are relative to the 3rd pass adjusted quantities

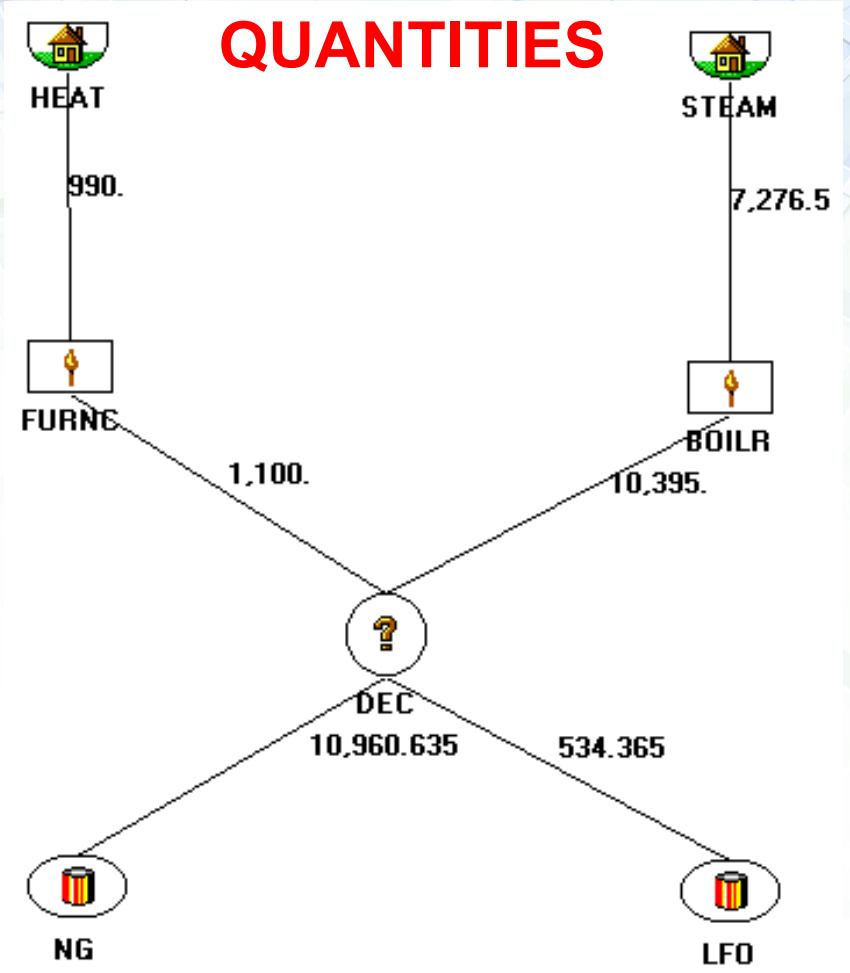
Errors on all resources meet at least one convergence criteria, in this case, the relative convergence criteria of 1%

YEAR 1, ITERATION 4: After Convergence, One Last Up-Pass is Performed to Compute Final Energy Prices

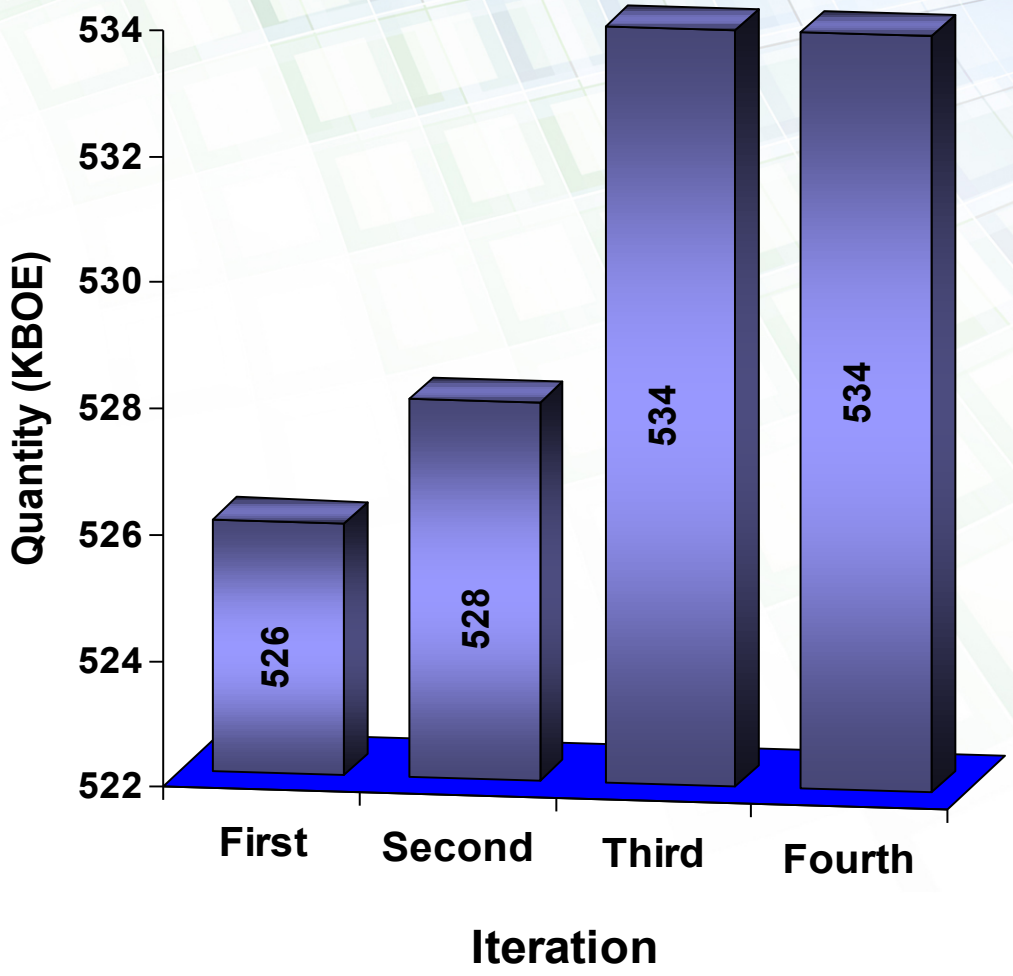


Year 1: Network Results for First Forecast Year

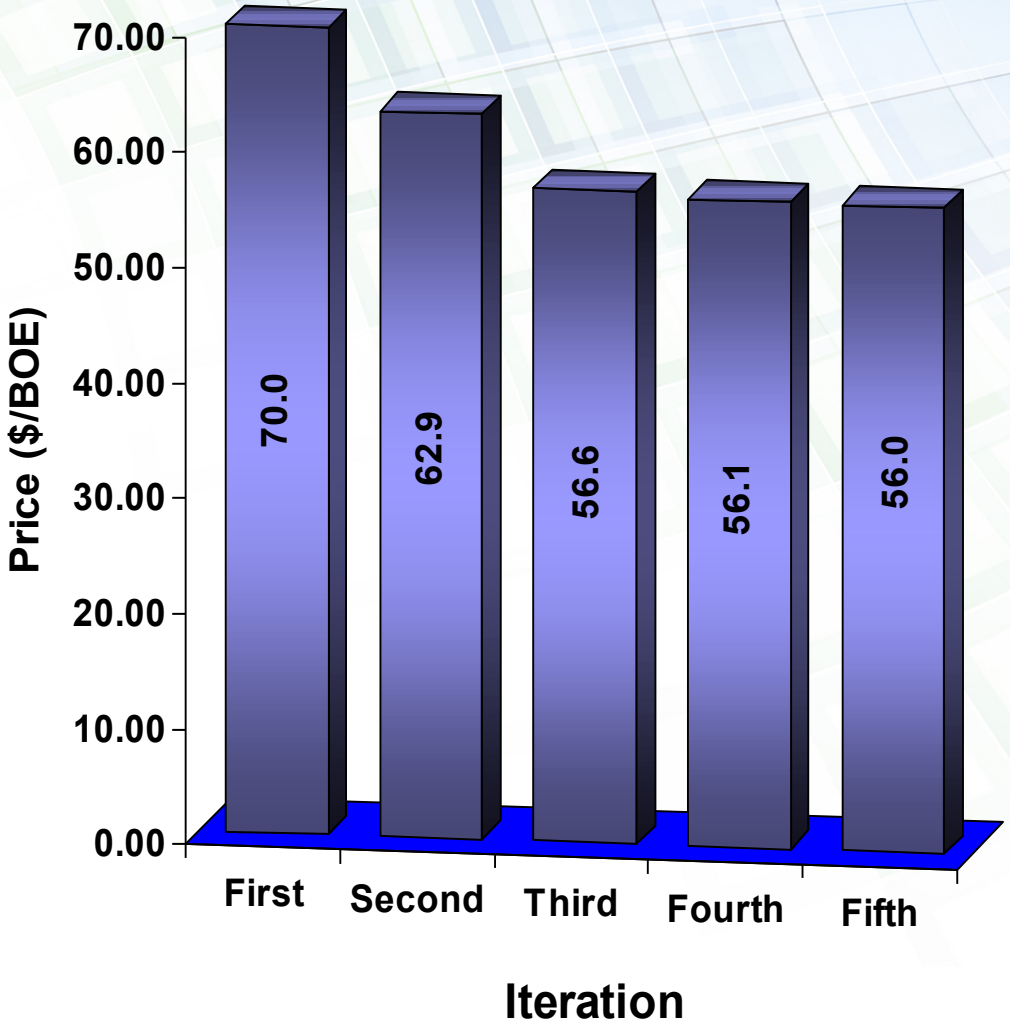




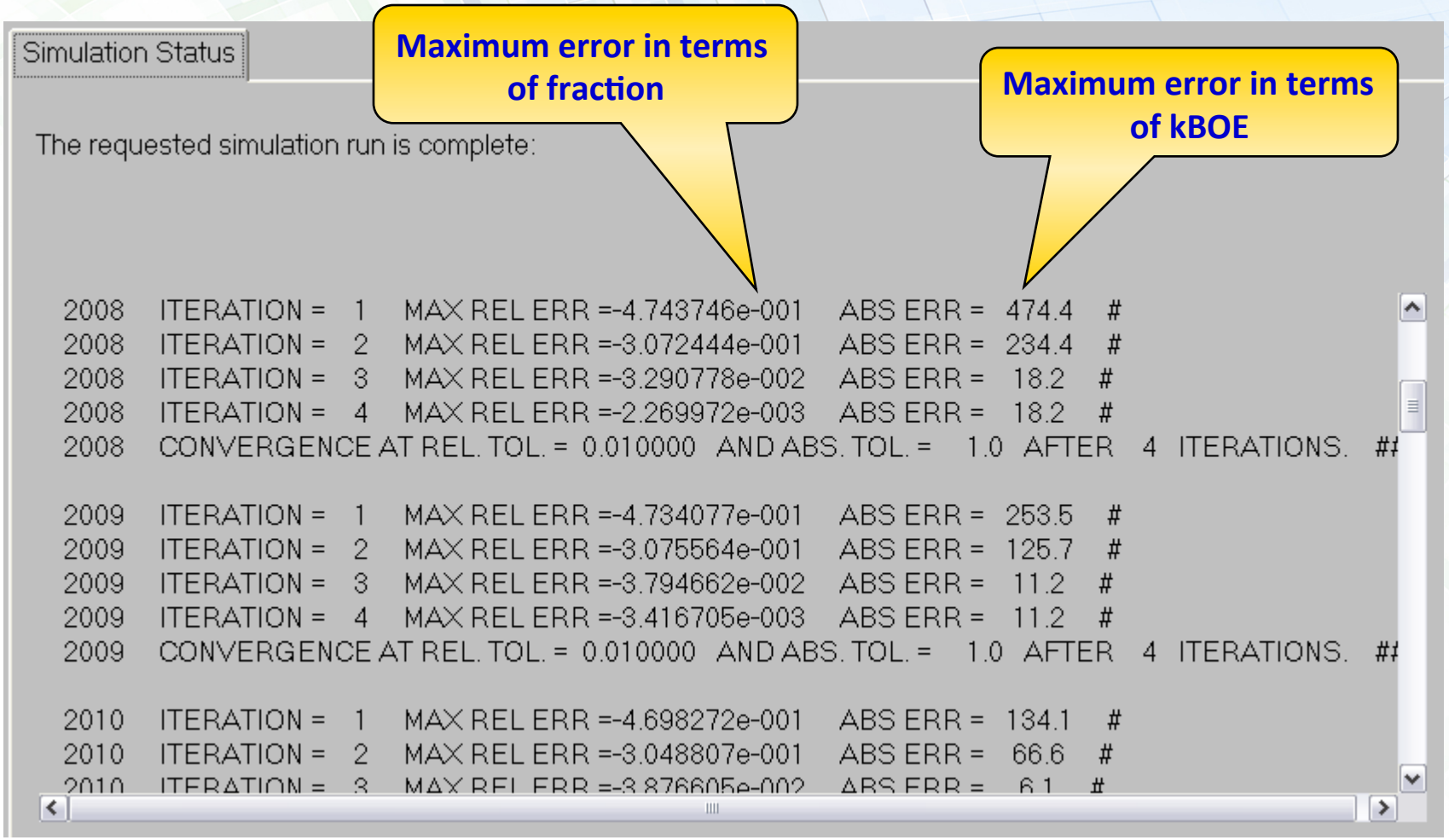
Evolution of Energy Quantities on Link 2



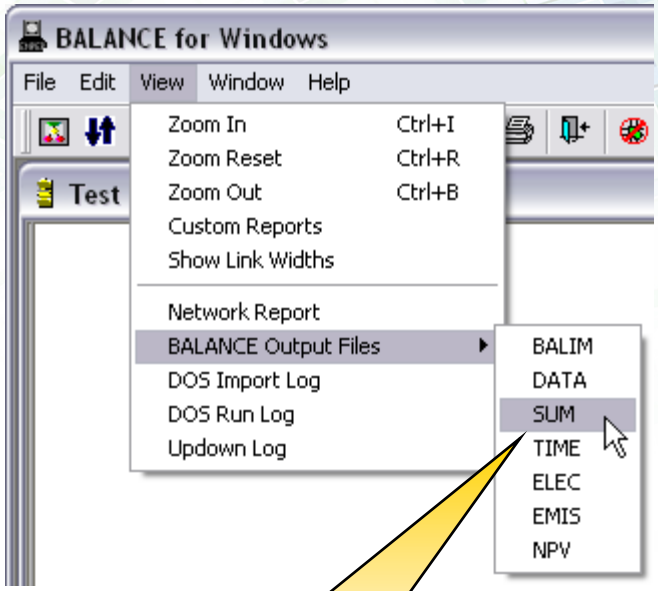
Evolution of Energy Prices on Link 2



The Simulation Status Folder Displays the Evolution of Quantities



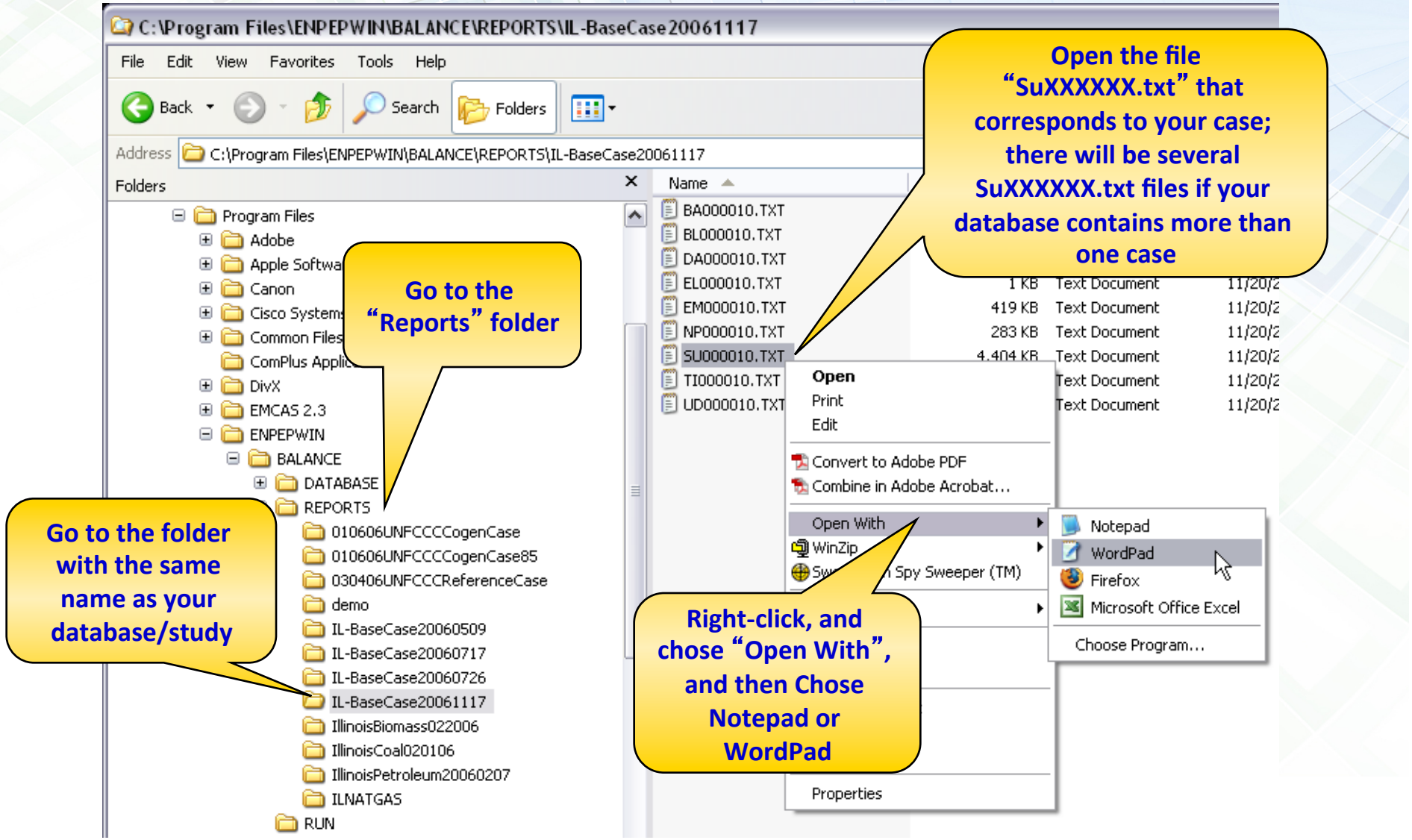
Detailed Results of the Iterations Can be Found in the BALANCE SUM.out File



Go to View – BALANCE Output Files - SUM

SU000095.TXT - Notepad

File Edit Format View Help

```
SIMULATION RUN ON:Sat Dec 09 11:27:35 2006
Baseyear: 1999  Number of Years: 20

Quantities are in TJ and Prices are in $/GJ

1ITERATION NO.     1          YEAR  1999
  UP-PASS :
  P      RS  Coal  (Sect1)     LINK  ln2       YEAR  1999    $    1.2900
  P      RN  Solar (Sect1)     LINK  ln1       YEAR  1999    $    0.0000
  P      PR  SHeat (Sect1)     LINK  solar     YEAR  1999    $    8.5768
  P      PR  CHeat (Sect1)     LINK  coal      YEAR  1999    $    4.5857
  P      AL  Decis (Sect1)     LINK  ln5       YEAR  1999    $    4.8737
  QB     AL  Decis (Sect1)     LINK  ln5       YEAR  1999      14098.837
1ITERATION NO.     1          YEAR  2000
  UP-PASS :
  P      RS  Coal  (Sect1)     LINK  ln2       YEAR  2000    $    1.3287
  P      RN  Solar (Sect1)     LINK  ln1       YEAR  2000    $    0.0000
  P      PR  SHeat (Sect1)     LINK  solar     YEAR  2000    $    8.5768
  P      PR  CHeat (Sect1)     LINK  coal      YEAR  2000    $    4.6373
  P      AL  Decis (Sect1)     LINK  ln5       YEAR  2000    $    4.9216




  DOWN-PASS :
  Q      DE  Heat  (Sect1)     LINK  ln5       YEAR  2000      14098.837
                        ALLOCATE=     14098.84
                MS=0.931  Q(coal )=     13120.87   NMS=0.956  OMS=0.928  LAG=0.100
                MS=0.069  Q(solar)=       977.97   NMS=0.044  OMS=0.072  LAG=0.100
  Q      AL  Decis (Sect1)     LINK  coal      YEAR  2000      13120.872  SHR=0.931   MS=0.931
  Q      AL  Decis (Sect1)     LINK  solar     YEAR  2000        977.965  SHR=0.069   MS=0.069
  Q      PR  SHeat (Sect1)     LINK  ln1       YEAR  2000       2794.186
  Q      PR  CHeat (Sect1)     LINK  ln2       YEAR  2000      17494.496

  CONVERGENCE REPORT:
  LINK=ln2       Q=  17441.860     HQ=  17494.496     ERROR= 3.0178e-003
  LINK=ln1       Q=   2906.977     HQ=   2794.186     ERROR=-3.8800e-002

  #      2000     ITERATION=    1     REL TOL= 0.1000     REL ERR MAX=-3.879986e-002
  UP-PASS :
```

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