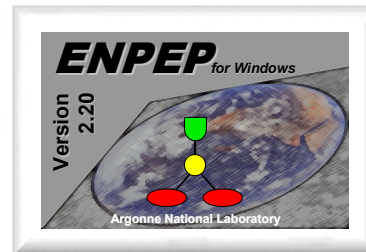


ENPEP-BALANCE: Simple Case Results

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



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Center for Energy, Environmental, and Economic Systems Analysis
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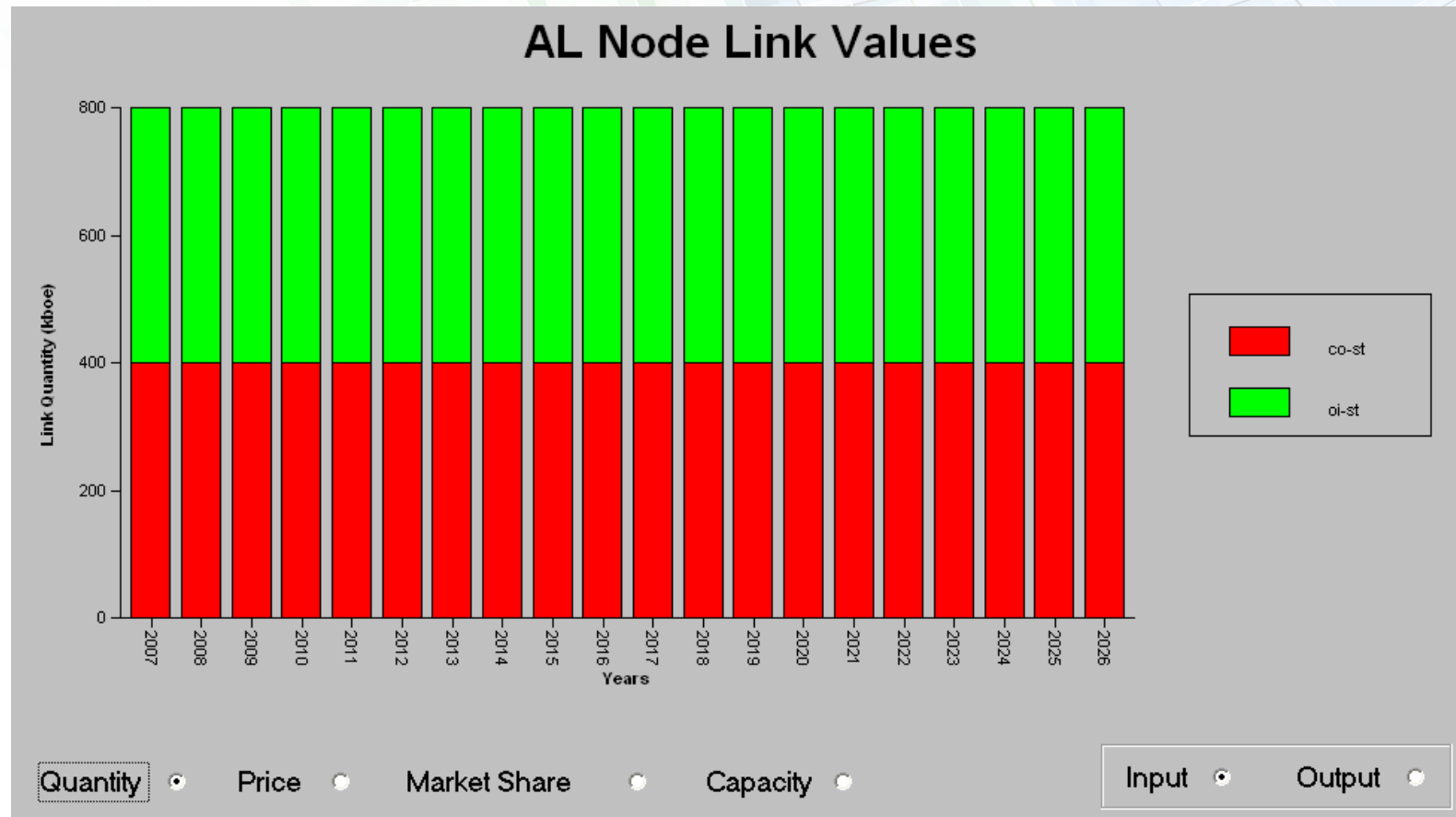
Changes in Input Variables: Cases 1 to 8

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



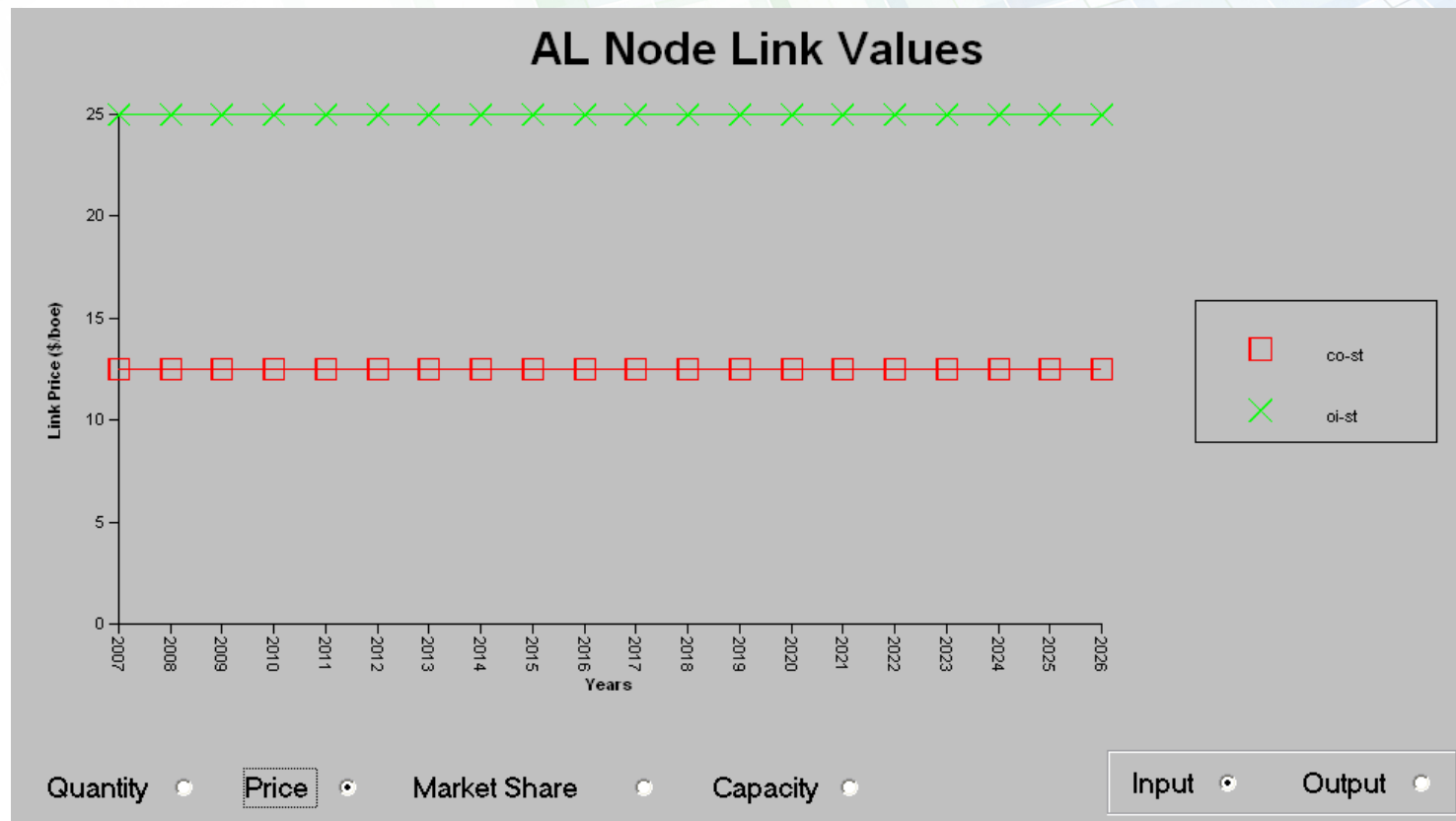
Case 1 Results: QUANTITIES at the Allocation Node

- 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)



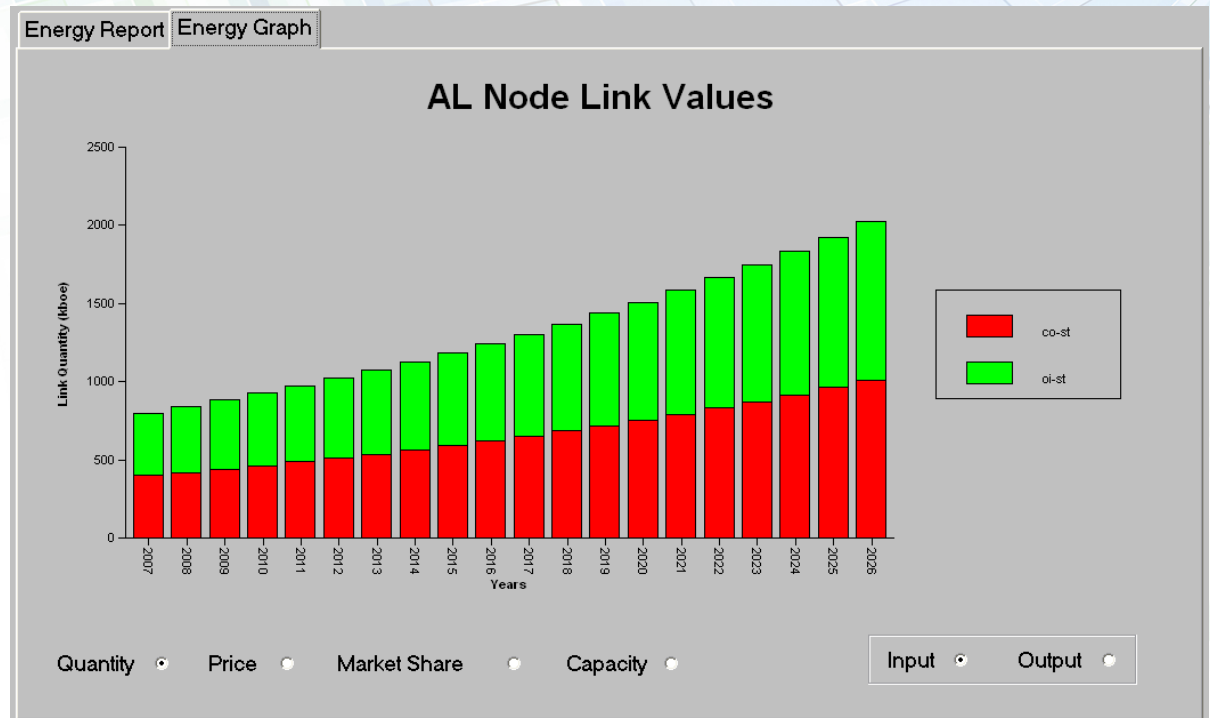
Case 1 Results: *PRICES* at the Allocation Node

- 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)



Case 2: Demand Growth Rate Specified at 5%

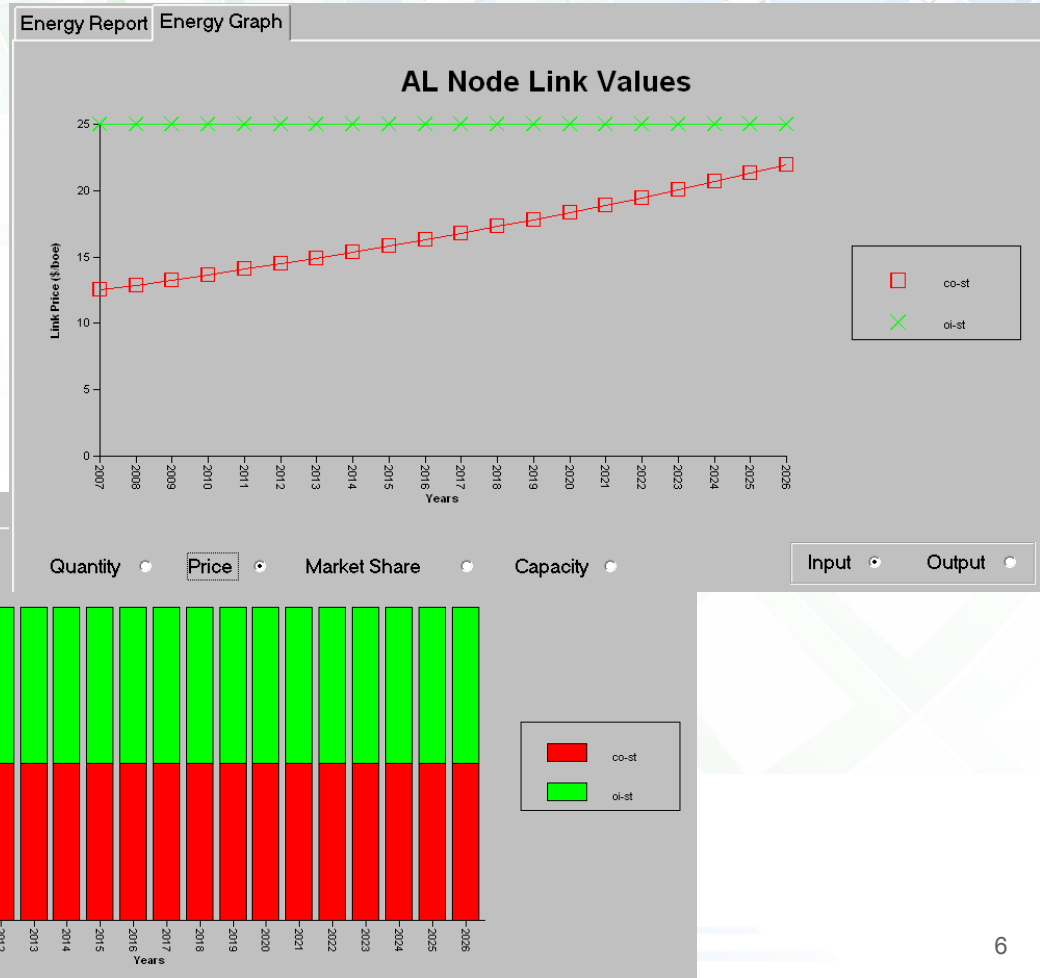
STDEM Demand Node Properties	
Economic Properties	Emissions Properties
Year	Growth Rate (Fraction)
2007	0.050
2008	0.050
2009	0.050
2010	0.050
2011	0.050
2012	0.050
2013	0.050
2014	0.050
2015	0.050
2016	0.050
2017	0.050
2018	0.050
2019	0.050
2020	0.050



Case 3: Coal Price Increase 3% Per Year; No Demand Growth

- Coal price increases 3% per year (and so does coal steam), oil price remains constant
- The quantities of heat produced from both fuels (market shares) remain constant because there is no price sensitivity specified

COAL Depletable Resource Node Properties		
Technical Properties	Economic Properties	Emissions Properties
Year	Price Growth Rate (Fraction)	Curve Intercept (\$/boe)
2007	0.030	10.000
2008	0.030	
2009	0.030	
2010	0.030	
2011	0.030	
2012	0.030	
2013	0.030	
2014	0.030	
2015	0.030	
2016	0.030	
2017	0.030	



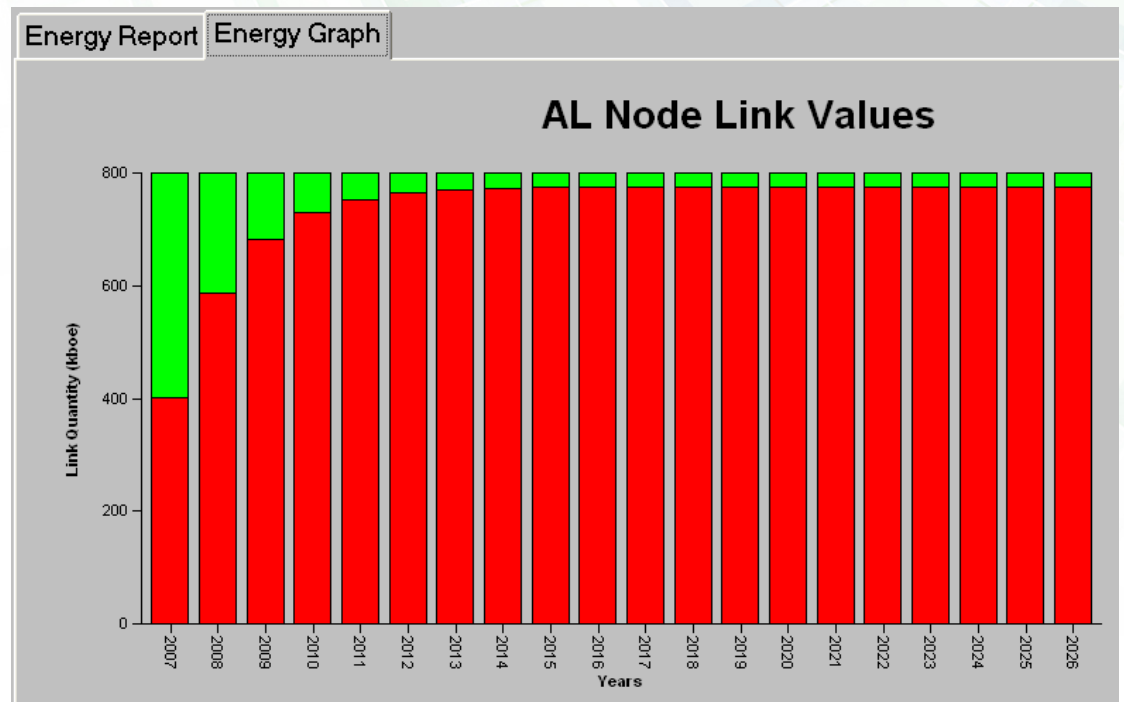
Case 4: Price Sensitivity = 5 Lag Parameter = 0.5

- With a price sensitivity of 5, the decision between coal-steam and oil-steam is responsive to the (fairly large) price signals
- The model switches heavily to the lower-cost coal steam
- The pace at which the switch occurs is based on the lag parameter; with a lag parameter of 0.5, the response to the price signal is very quick; after about 7-8 years it reaches equilibrium for the constant price signal it receives

AL Allocation Node Properties

Technical Properties Economic Properties

Year	Price Sensitivity	Lag Parameter (Fraction)
2007	5.000	0.500



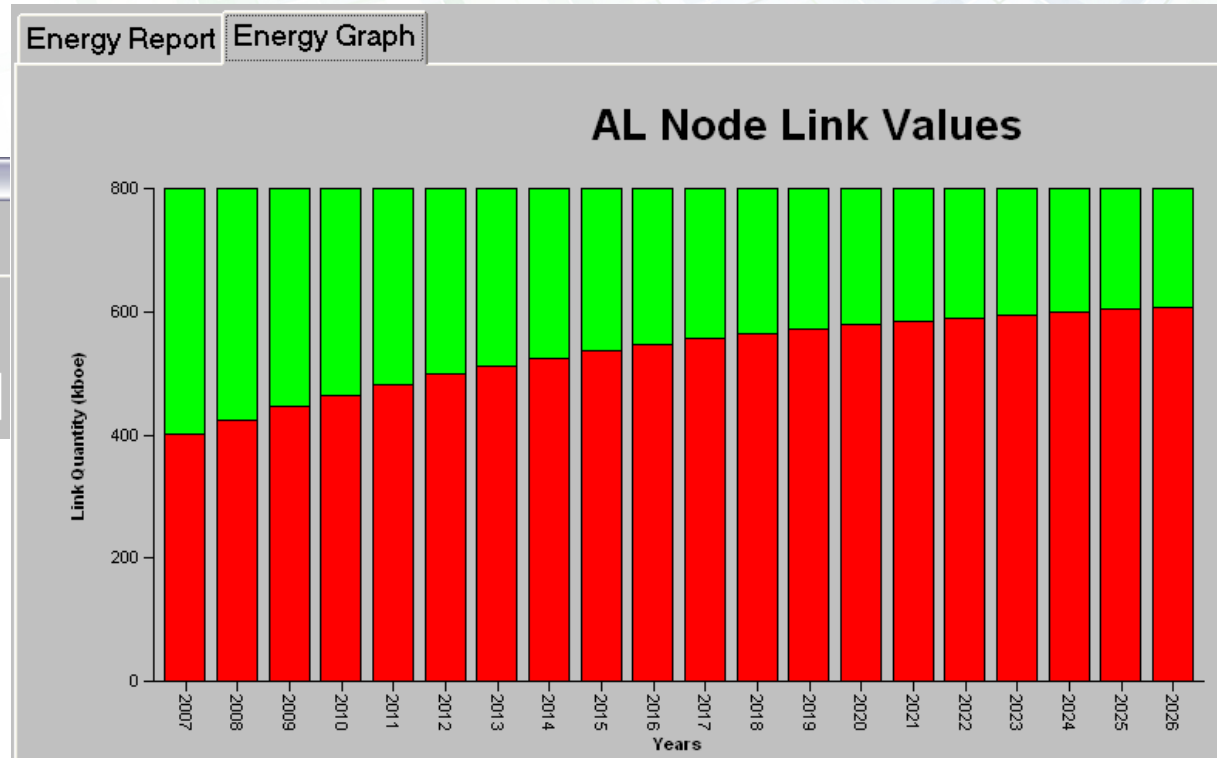
Case 5: Price Sensitivity = 2 Lag Parameter = 0.1

- With a price sensitivity of 2, the decision between coal-steam and oil-steam is less responsive to the price signals and the lower-priced coal steam takes less of the market
- A lag parameter of 0.1 means the market responds more slowly to the observed price signal

AL Allocation Node Properties

Technical Properties Economic Properties

Year	Price Sensitivity	Lag Parameter (Fraction)
2007	2.000	0.100



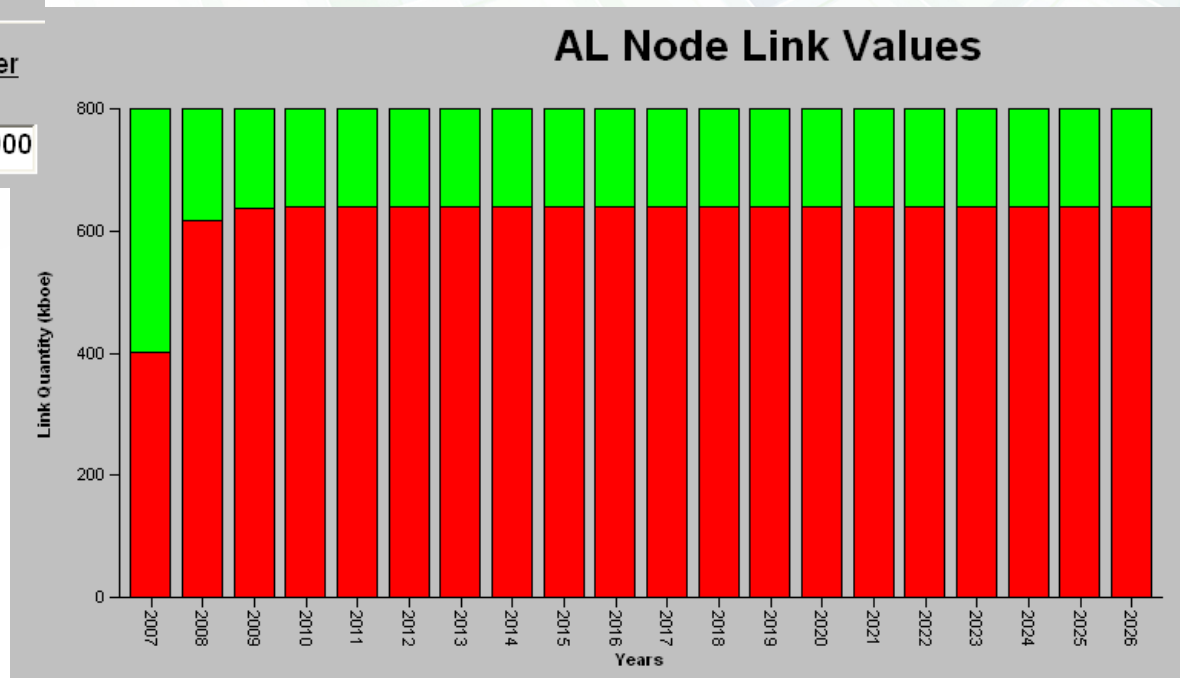
Case 6: Price Sensitivity = 2 Lag Parameter = 0.9

- If the lag parameter is closer to 1, the response to the price signal is almost immediate and the changes in the market share are achieved much more quickly
 - Equilibrium is reached after about 3 years
- Note that the shift is less than in Case 4 that uses a price sensitivity of 5

AL Allocation Node Properties

Technical Properties Economic Properties

Year	Price Sensitivity	Lag Parameter (Fraction)
2007	2.000	0.900



Case 7: Premium Multipliers for Coal = 1, Oil = 0.6; Price Sensitivity = 5, Lag Parameter = 0.5

- Because of the premium multiplier of 0.6 for oil steam, the allocation node looks at the oil steam as artificially lower priced ($0.6 * \$25 = \15) and uses that lower price in the market share calculations
- Note that the premium multiplier does **NOT** affect the price of the coal steam; only the way it is used in the market share calculations
- Oil now maintains a higher market share than under Case 4 which has the same price sensitivity and lag parameter as Case 7

AL Allocation Node Properties

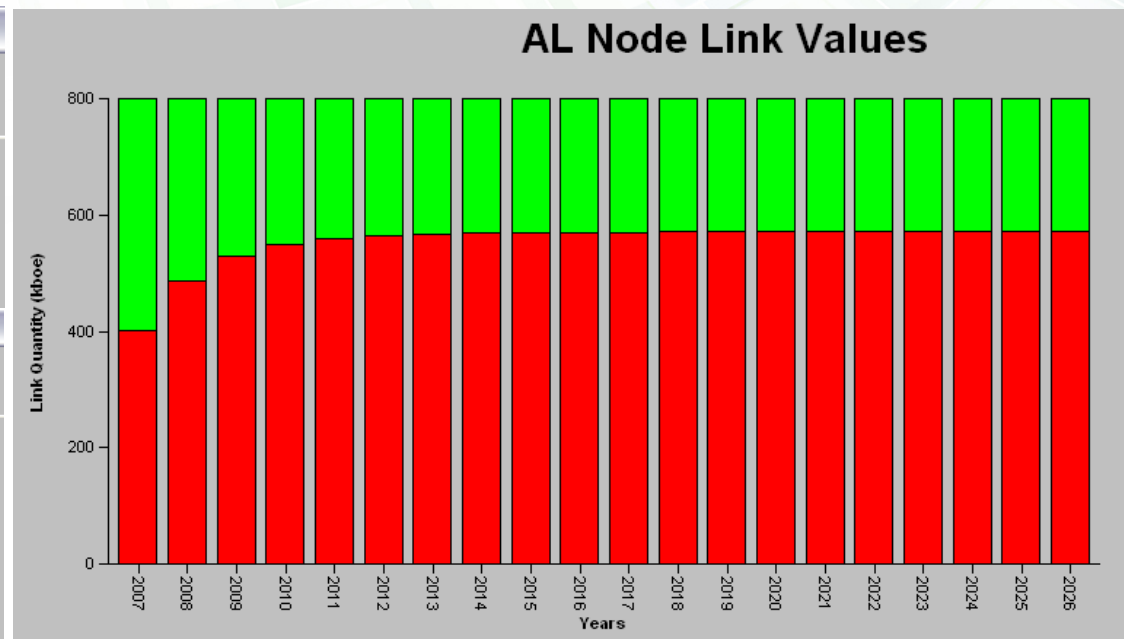
Technical Properties Economic Properties

Year	Price Sensitivity	Lag Parameter (Fraction)
2007	5.000	0.500

AL Allocation Node Properties

Technical Properties Economic Properties

Year	Input Link Abbreviation	Priority	Premium Multiplier
2007	co-st		1.000
	oi-st		0.600
2008	co-st		
	oi-st		



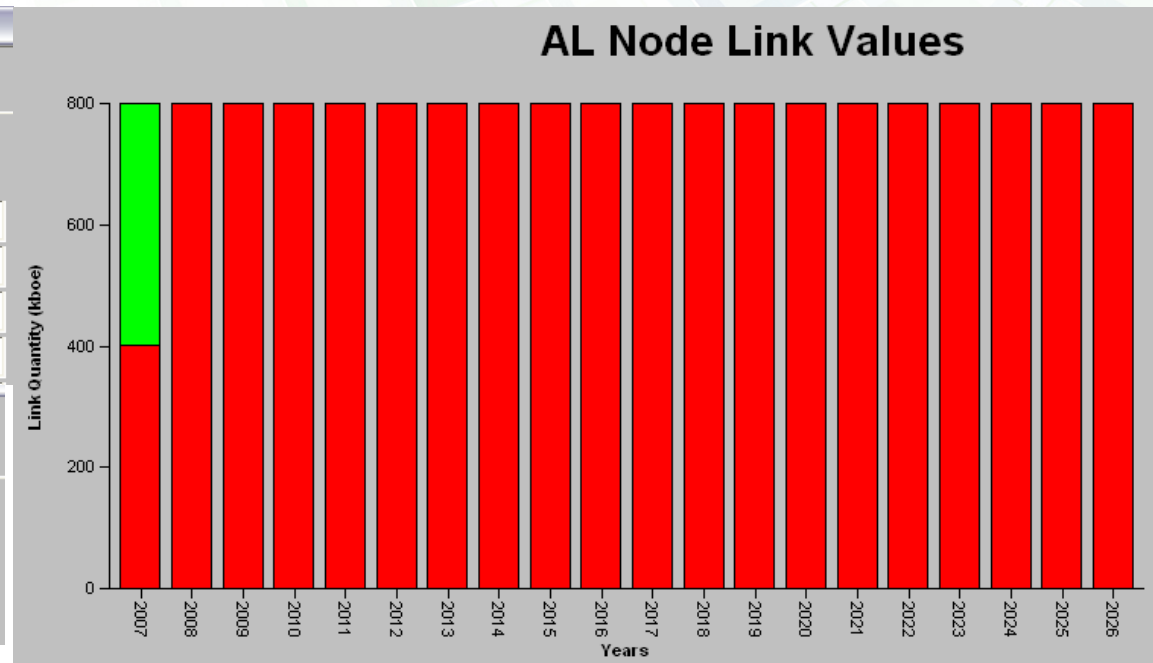
Case 8: Priority Link co-st = 1 (oi-st = 2)

- Except for the base year, for which the quantities are predefined, the decision node will try to take all the supply it can get from priority link 1 first before taking anything from the second priority link
- Only if the priority link (or a node that is connected to it) runs into a capacity limit, will the decision node switch to the other links
- Note: Entering 2 for oi-st is optional

AL Allocation Node Properties

Technical Properties		Economic Properties	
Year	Input Link Abbreviation	Priority	Premium Multiplier
2007	co-st	1	
	oi-st	2	
2008	co-st		
	oi-st		

Technical Properties		Economic Properties	
Year	Price Sensitivity	Lag Parameter (Fraction)	
2007	2.000	0.900	



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)

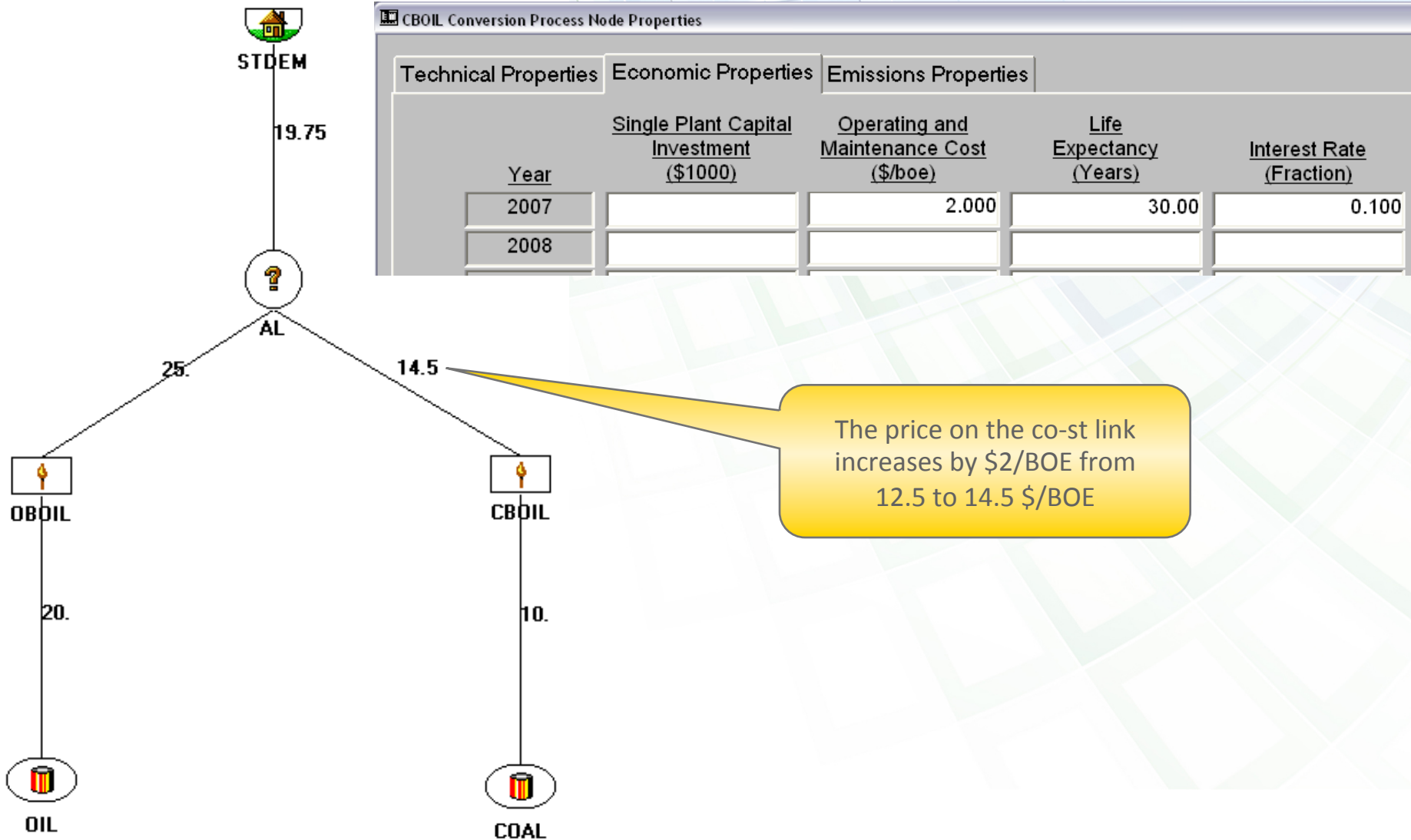


Changes in Input Variables: Case 9 to 17

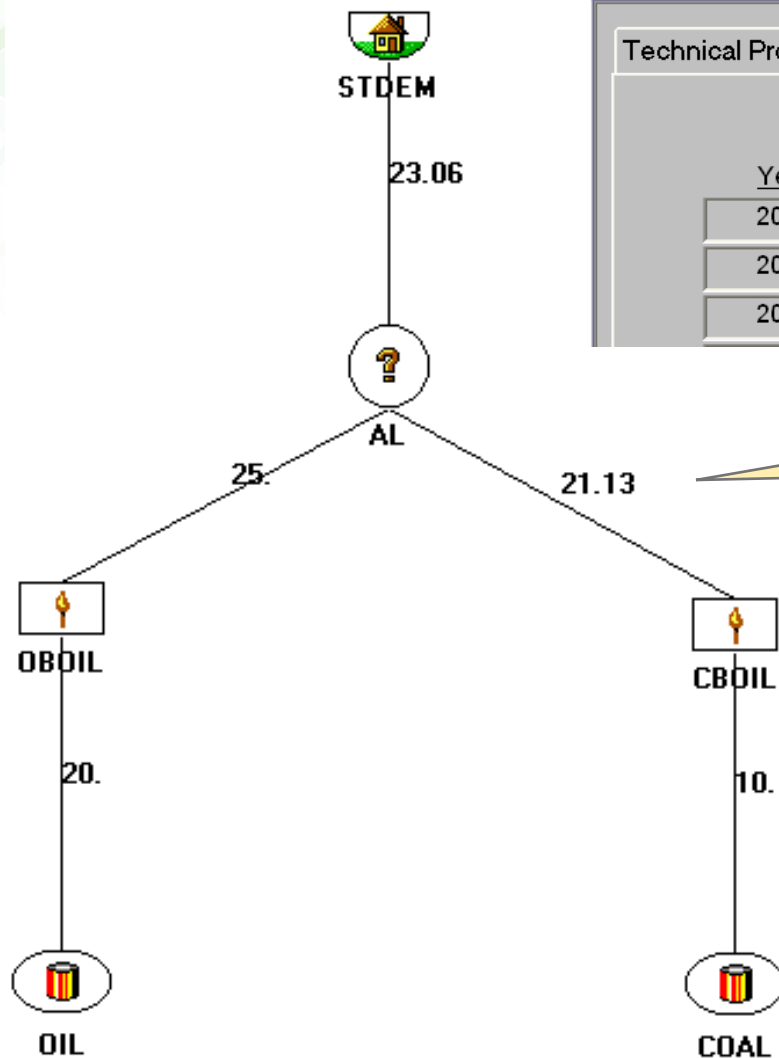
Case	9	10	11	12	13	14	15	16	17
Priority Link	blank	blank	blank	blank	blank	blank	blank	blank	Blank
Premium Multiplier	blank	blank	blank	blank	blank	blank	blank	blank	Blank
Price Sensitivity	5	5	5	5	5	5	5	5	5
Lag factor	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Resource Price Growth (every year)	blank	blank	blank	blank	blank	blank	blank	blank	O: 0.02 C: 0.04
Conversion Process Capacity Factor	O: 0.8 C: 0.8	O: 0.8 C: 0.8	O: 0.8 C: 0.4	O: 0.8 C: 0.4	O: 0.8 C: 0.4	O: 0.8 C: 0.4	O: 0.8 C: 0.4	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	O: 0.8 C: 0.6	O: 0.8 C: 0.6	O: 0.8 C: 0.6	O: 0.8 C: 0.6	O: 0.8 C: 0.8	O: 0.8 C: 0.8
Conversion Process O&M Cost	O: 0 C: 2	O: 0 C: 2	O: 0 C: 2	O: 0 C: 2	O: 0 C: 2	O: 0 C: 2	O: 0 C: 2	O: 0 C: 0	O: 0 C: 0
Conversion Process Investment Cost (\$1000)	O: 0 C: 0	O: 0 C: 5000	O: 0 C: 5000	O: 0 C: 5000	O: 0 C: 5000	O: 0 C: 5000	O: 0 C: 5000 (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	O: 30 C: 40	O: 30 C: 40	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	O: 0.1 C: 0.05	O: 0.1 C: 0.05	O: 0.1 C: 0.05	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	O: blank C: blank 200 (2012) 300 (2017)	O: blank C: blank

This entry means investment of \$5 million

Case 9: Coal Boiler O&M Cost Changed from 0 to 2 \$/BOE starting in the Base Year



Case 10: Single Plant Investment Cost Changed from 0 to 5 Million Dollars in the Base Year; O&M = 2\$/BOE



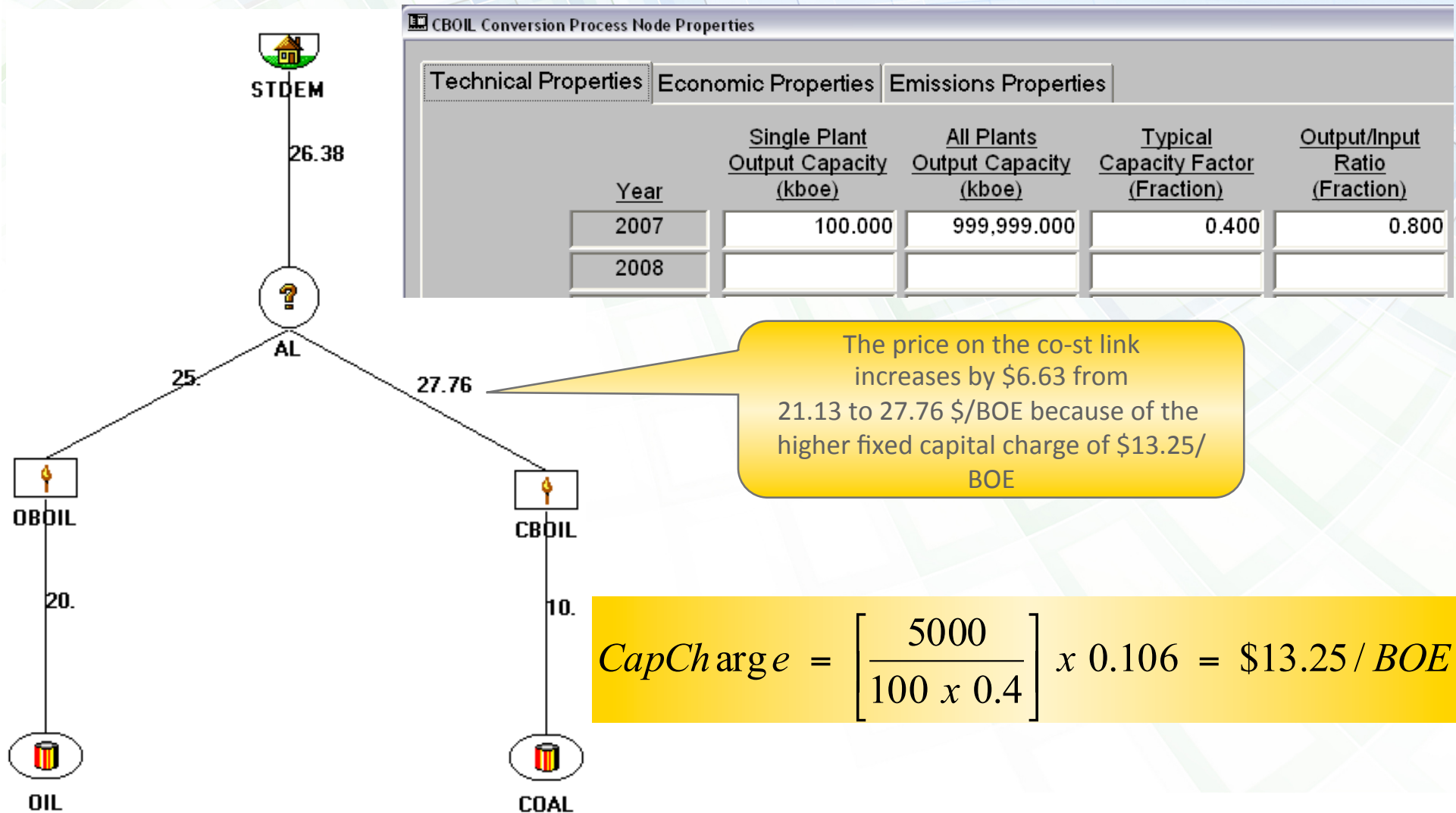
CBOIL Conversion Process Node Properties				
Technical Properties		Economic Properties	Emissions Properties	
Year	Single Plant Capital Investment (\$1000)	Operating and Maintenance Cost (\$/boe)	Life Expectancy (Years)	Interest Rate (Fraction)
2007	5,000.000	2.000	30.00	0.100
2008				
2009				

The price on the co-st link increases by \$6.63 from 14.5 to 21.13 \$/BOE because of the fixed capital charges

$$CRF_{(i,n)} = \frac{0.1 \times (1 + 0.1)^{30}}{(1 + 0.1)^{30} - 1} = 0.106$$

$$CapCharge = \left[\frac{5000}{100 \times 0.8} \right] \times 0.106 = \$6.63 / BOE$$

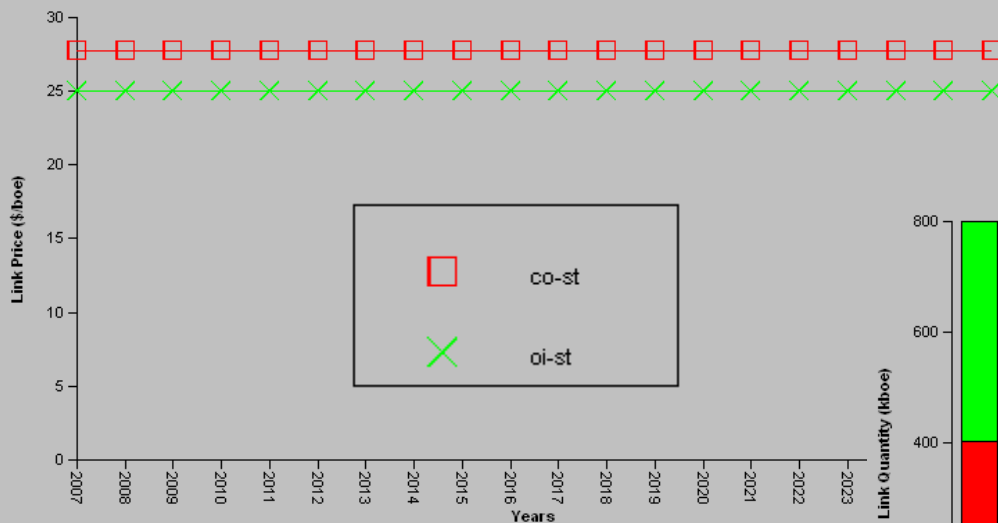
Case 11: CBOIL Capacity Factor Changed from 0.8 to 0.4 in the Base Year



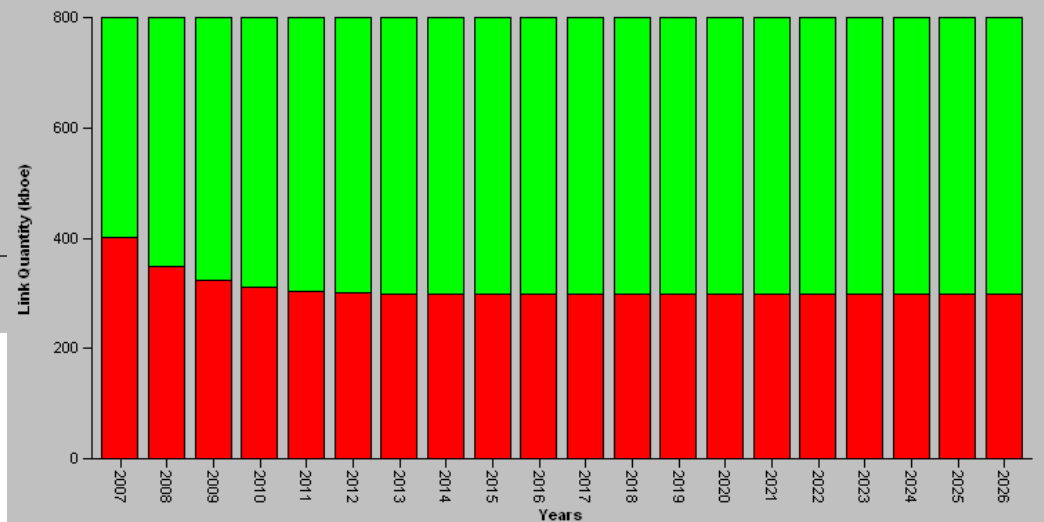
Case 11: CBOIL Capacity Factor Changed from 0.8 to 0.4 in the Base Year (continued)

- The price on link co-st is now higher than the price on link oi-st
- Because of the price sensitivity of 5 and lag parameter of 0.5, the market share of coal steam decreases and oil steam increases

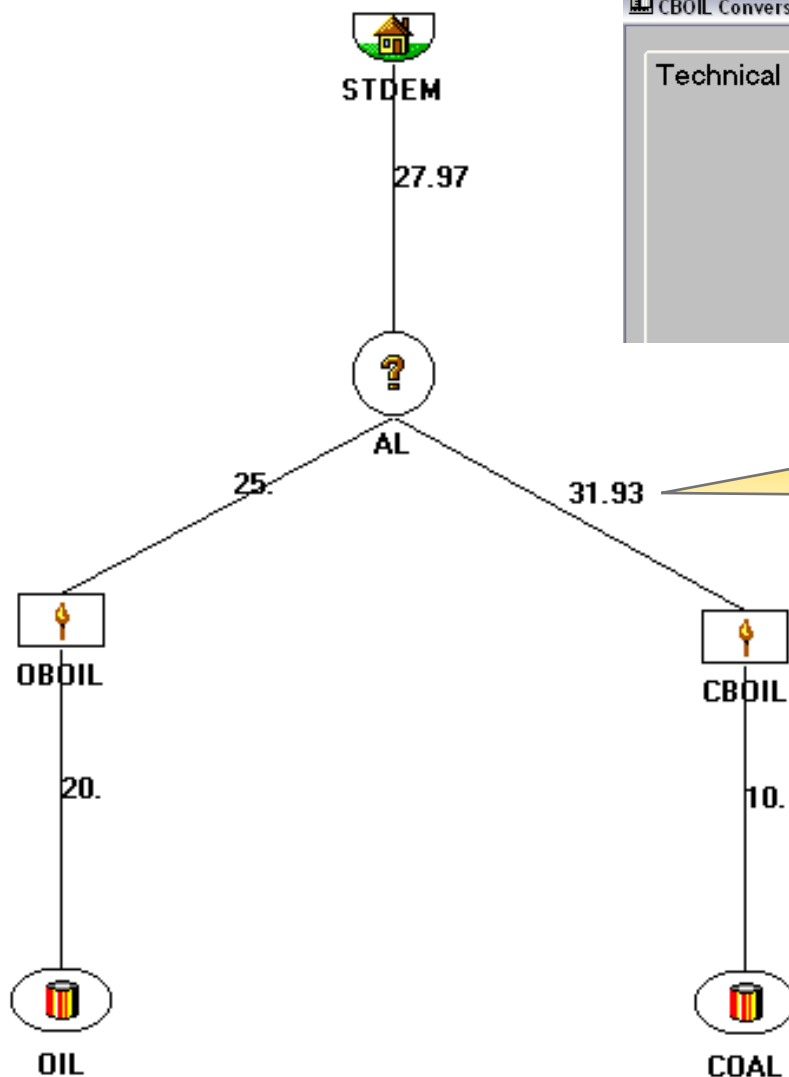
AL Node Link Values



AL Node Link Values



Case 12: CBOIL Efficiency Changed from 0.8 to 0.6 in the Base Year Case 12; Capacity Factor = 0.4



CBOIL Conversion Process Node Properties

Technical Properties		Economic Properties		Emissions Properties	
		Single Plant Output Capacity (kboe)	All Plants Output Capacity (kboe)	Typical Capacity Factor (Fraction)	Output/Input Ratio (Fraction)
Year					
2007		100.000	999,999.000	0.400	0.600
2008					

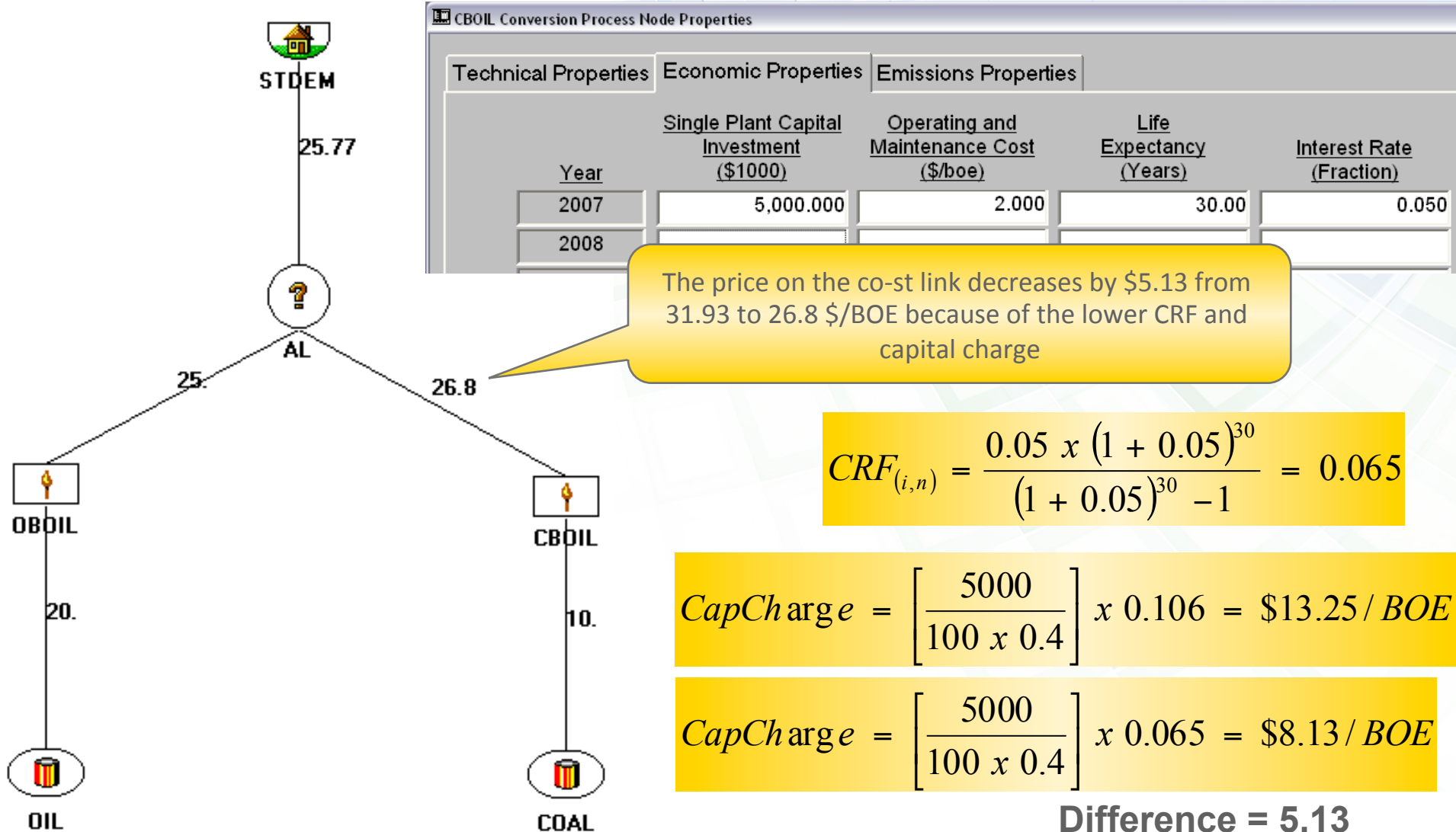
The price on the co-st link increases by \$4.17 from 27.76 to 31.93 \$/BOE because of the higher losses that increase the fuel charge of \$12.50/BOE

Efficiency 0.8
$$\text{Fuel Price Cost} = \frac{10}{0.8} = \$12.50 / \text{BOE}$$

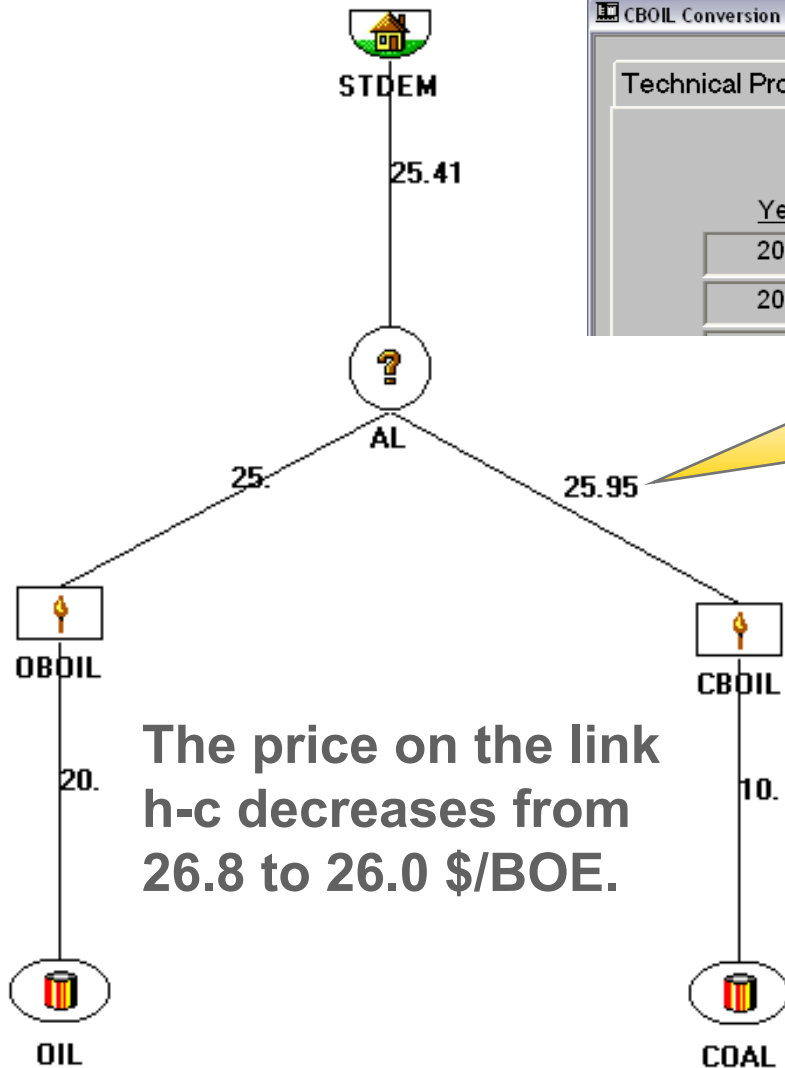
Efficiency 0.6
$$\text{Fuel Price Cost} = \frac{10}{0.6} = \$16.67 / \text{BOE}$$

Difference = 4.17

Case 13: CBOIL Interest Rate Changed from 10% to 5% in the Base Year



Case 14: CBOIL Economic Lifetime Changed from 30 to 40 Years in the Base Year



The price on the link h-c decreases from 26.8 to 26.0 \$/BOE.

CBOIL Conversion Process Node Properties				
Technical Properties		Economic Properties	Emissions Properties	
Year	Single Plant Capital Investment (\$1000)	Operating and Maintenance Cost (\$/boe)	Life Expectancy (Years)	Interest Rate (Fraction)
2007	5,000.000	2.000	40.00	0.050
2008				

The price on the co-st link decreases by \$0.85 from 26.8 to 25.95 \$/BOE because of the lower CRF and capital charge

$$CRF_{(i,n)} = \frac{0.05 \times (1 + 0.05)^{40}}{(1 + 0.05)^{40} - 1} = 0.058$$

$$CapCharge = \left[\frac{5000}{100 \times 0.4} \right] \times 0.065 = \$8.13 / BOE$$

$$CapCharge = \left[\frac{5000}{100 \times 0.4} \right] \times 0.058 = \$7.28 / BOE$$

Difference = 0.85

Case 15: CBOIL Investment Cost Changed from 5 to 10 Million Dollars in 2012 (e.g., Retrofit)

CBOIL Conversion Process Node Properties

Technical Properties			Economic Properties			Emissions Properties		
			Single Plant Capital Investment (\$1000)			Operating and Maintenance Cost (\$/boe)		
Year								
2007			5,000.000			2.000		
2008								
2009								
2010								
2011								
2012			10,000.000					
2013								

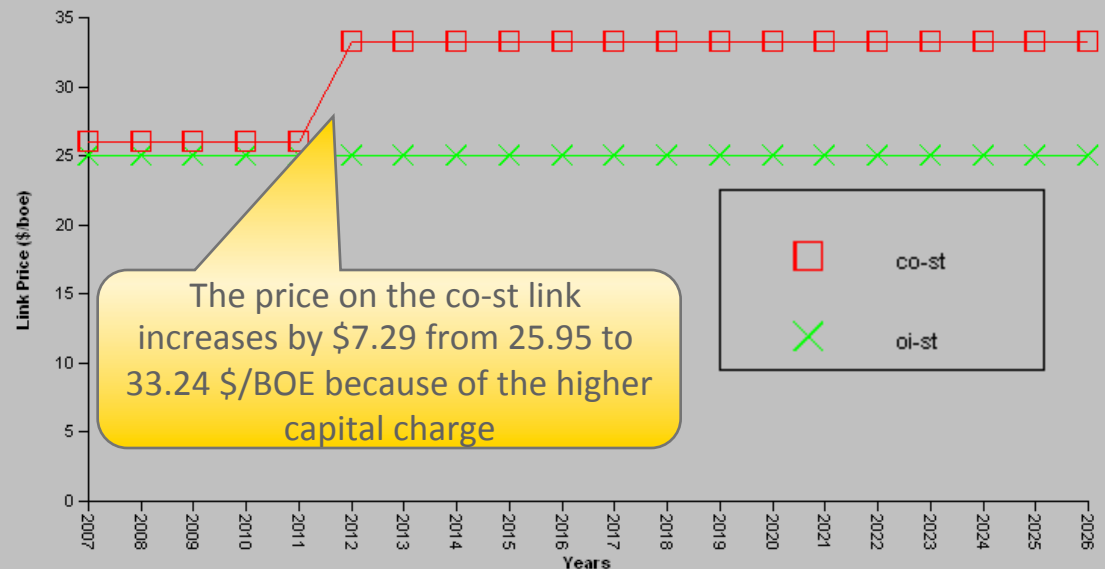
$$CapCharge = \left[\frac{5000}{100 \times 0.4} \right] \times 0.058 = \$7.28 / BOE$$

$$CapCharge = \left[\frac{10000}{100 \times 0.4} \right] \times 0.058 = \$14.57 / BOE$$

Difference = 7.29

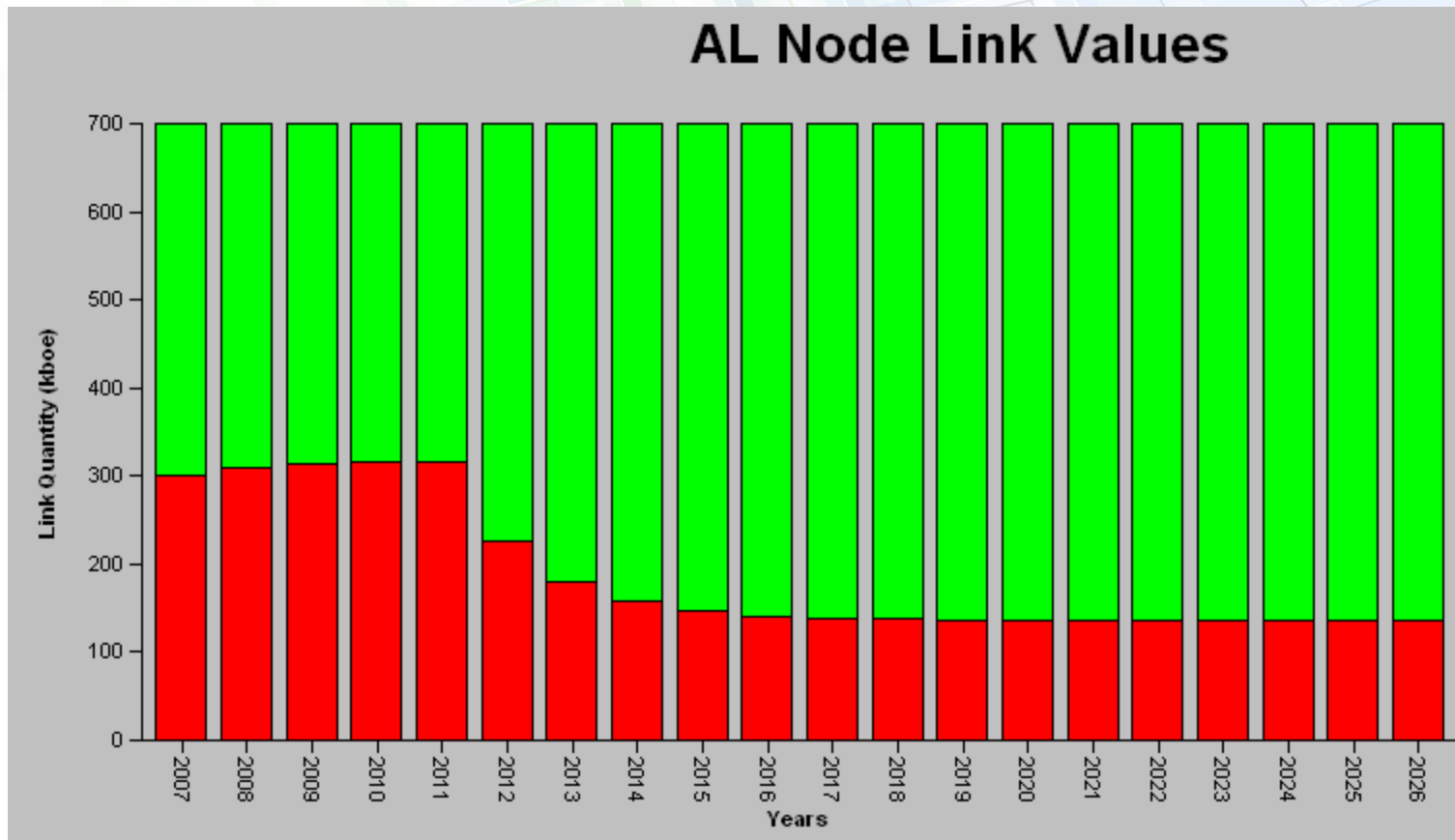
Energy Report Energy Graph

AL Node Link Values

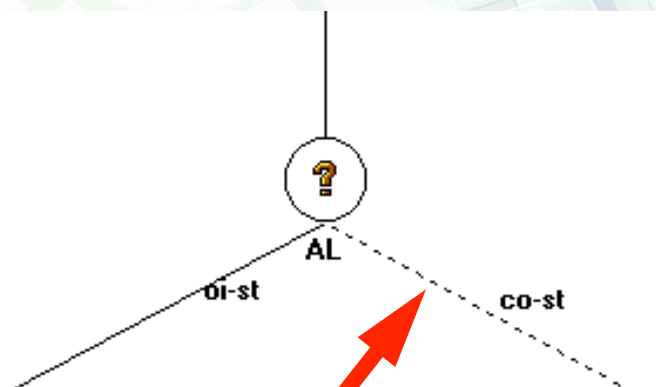


Case 15: CBOIL Investment Cost Changed from 5 to 10 Million Dollars in 2012 (e.g., Retrofit)

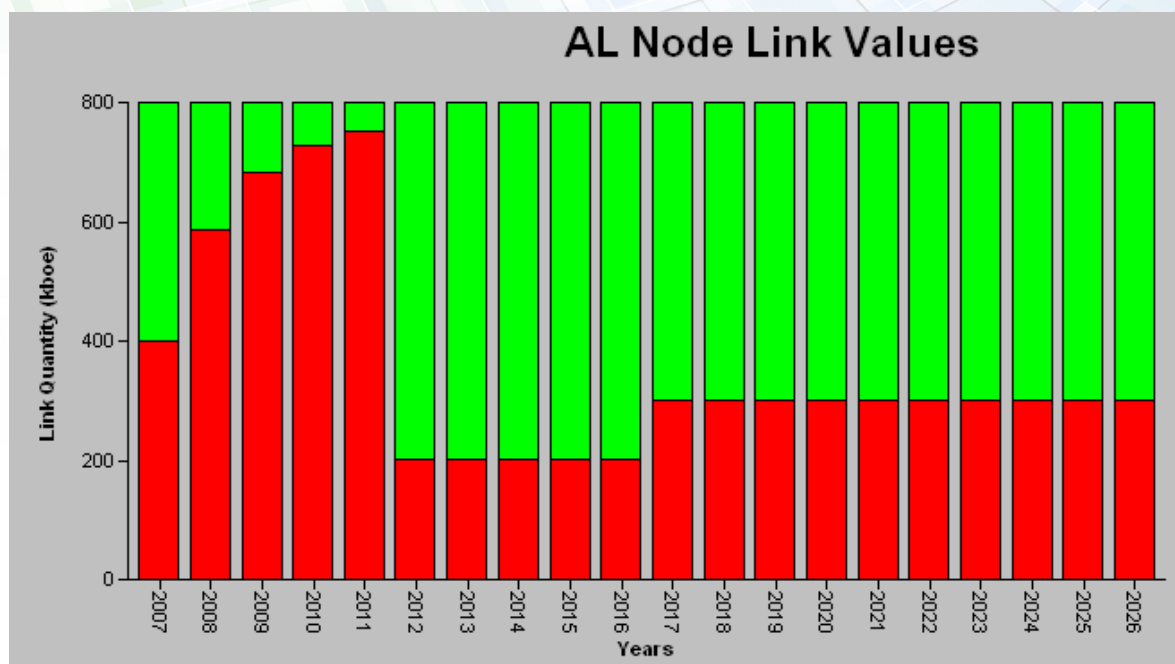
- Because the price on the co-st link increases in 2012, its market share begins to decline



Case 16: Link co-st Capacity Changed from Unlimited in Base Year to 200 kBOE in 2012 and to 300 kBOE in 2017



Year	Link Capacity (kboe)
2007	
2008	
2009	
2010	
2011	
2012	200.000
2013	
2014	
2015	
2016	
2017	300.000
2018	
2019	



Case 17: Change of Price Growth Rate of Resources in all Years from Blank (0) to 2%/yr for Oil and 4%/yr for Coal

OIL Depletable Resource Node Properties		
Technical Properties	Economic Properties	Emissions Properties
Year	Price Growth Rate (Fraction)	Curve Intercept (\$/boe)
2007	0.020	20.000
2008	0.020	
2009	0.020	
2010	0.020	
2011	0.020	
2012	0.020	
2013	0.020	
2014	0.020	
2015	0.020	
2016	0.020	
2017	0.020	
2018	0.020	
2019	0.02	

COAL Depletable Resource Node Properties		
Technical Properties	Economic Properties	Emissions Properties
Year	Price Growth Rate (Fraction)	Curve Intercept (\$/boe)
2007	0.040	10.000
2008	0.040	
2009	0.040	
2010	0.040	
2011	0.040	
2012	0.040	
2013	0.040	
2014	0.040	
2015	0.040	
2016	0.040	
2017	0.040	
2018	0.040	
2019	0.04	

