

## Additional Documentation of the Learning Model

In addition to the conference paper, two sources of learning model documentation are available, as part of our efforts to follow the guidelines for model documentation (Rahmandad and Sterman, 2012). First, the Learning Model is available for download at <https://github.com/NREL/bsm-learning/releases>. The documentation of variable definitions, sources, and units is embedded within the model. STELLA® unit checking is successful for all but two equations, and these have been verified manually. Second, we conducted a model dependencies analysis. This analysis used a newly-developed STELLA® tool (Chichakly, 2015) with some capabilities analogous to the SDM-Doc tool (Martinez-Moyano, 2012). Results of the dependencies analysis are shown below.

### References

Chichakly, K. (2015). Personal Communication with Steve Peterson.

Martinez-Moyano I.J. 2012. [Documentation for model transparency](#). *System Dynamics Review*, **28**(2):199-208.

Rahmandad and Sterman, 2012. [Reporting guidelines for simulation based-research in social sciences](#). *System Dynamics Review*, **28**(4): 396-411.

### STELLA® Model Dependencies Analysis Results

Total Number of Variables: 390

Total Number of Stocks: 36

Variables:

actual\_fs\_consn: Converter

Used by: Feedstock\_Constraint\_on\_Utilization

actual\_fs\_demand\_at\_nominal\_utilization: Converter

Used by: actual\_fs\_consn, Feedstock\_Constraint\_on\_Utilization, fs\_demand\_incl\_pipeline

Actual\_Output\_gpy\_C: Converter

Used by: C\_industry\_FS\_thruput\_tpy, Output\_gpy\_by\_Technology, UTIL\_by\_tech\_C

Actual\_Output\_gpy\_P: Converter

Used by: Output\_gpy\_by\_Technology, P\_industry\_FS\_thruput\_tpy, UTIL\_by\_tech\_P

Annual\_Loan\_Payment\_C: Converter

Used by: Cume\_Loan\_Payment\_C, PV\_Loan\_Payment\_C

Annual\_Loan\_Payment\_P: Converter

Used by: Cume\_Loan\_Payment\_P, PV\_Loan\_Payment\_P

attractiveness\_C: Converter

Used by: RAT\_C, Total\_Attr\_C

attractiveness\_P: Converter

Used by: RAT\_P, Total\_Attr\_P

attr\_OTHER: Converter

Used by: share\_OTHER, Total\_Attr

Avg\_Plant\_Output\_gal\day\_C: Converter

Used by: Avg\_Plant\_Output\_gal\yr\_C

Avg\_Plant\_Output\_gal\yr\_C: Converter

Used by: Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_C, Output\_Capacity\_C

Avg\_Plant\_Output\_gal\_per\_day\_P: Converter

Used by: Avg\_Plant\_Output\_gal\_per\_yr\_P

Avg\_Plant\_Output\_gal\_per\_yr\_P: Converter

Used by: Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_P, Output\_Capacity\_P

Avg\_Plant\_Output\_gpd\_pipeline\_C: Converter

Used by: Pipeline\_Potential\_Plant\_Output\_gal\_per\_yr\_C

Avg\_Plant\_Output\_gpd\_pipeline\_P: Converter

Used by: Pipeline\_Potential\_Plant\_Output\_gal\yr\_P

Avg\_PY\_C: Converter

Used by: PY\_retirements\_C, Avg\_Plant\_Output\_gal\day\_C, C\_industry\_FS\_thruput\_tpy, Feedstock\_Cost\_\_USD\_per\_gal\_C, Industry\_Process\_Yield\_Gap, Reqd\_Annual\_FS\_Supply\_C

Avg\_PY\_D&C\_C: Converter

Used by: PY\_D&C\_to\_Startup\_C

Avg\_PY\_D&C\_P: Converter

Used by: PY\_D&C\_to\_Startup\_P

Avg\_PY\_P: Converter

Used by: PY\_retirements\_P, Avg\_Plant\_Output\_gal\_per\_day\_P,  
Feedstock\_Cost\_\_USD\_per\_gal\_P, P\_industry\_FS\_thruput\_tpy, Reqd\_Annual\_FS\_Supply\_P

Avg\_PY\_Pipeline\_C: Converter

Used by: Avg\_Plant\_Output\_gpd\_pipeline\_C

Avg\_PY\_Pipeline\_P: Converter

Used by: Avg\_Plant\_Output\_gpd\_pipeline\_P

Background\_Subs: Converter

Used by: Subsidy\_Amt

base\_Gasoline\_POD\_price\_before\_tax\_scenarios: Converter

Used by: Gasoline\_POD\_price\_before\_tax\_scenarios

breakthru\_frac: Converter

Used by: tech\_breakthru\_logic

breakthru\_switch: Converter

Used by: tech\_breakthru\_logic

breakthru\_time: Converter

Used by: tech\_breakthru\_logic

Commercial\_Maturity: Stock

Used by: commercial\_maturity\_gap, State\_of\_the\_Industry\_Multipliers

commercial\_maturity\_gap: Converter

Used by: learning\_logic, tech\_breakthru\_logic

commercial\_plant\_initiation\_logic: Flow

Used by: initiating\_C, yrly\_FCI\_subs\_C, yrly\_Loan\_guarantee\_flux\_C

Commercial\_Progress\_Ratios: Converter

Used by: learning\_logic

commercial\_start: Converter

Used by: c\_plant\_planning\_logic

Completed\_Demo\_Scale\_Ops: Stock

Completed\_Pilot\_Ops: Stock

completing\_D&C\_C: Flow

Used by: PY\_D&C\_to\_Startup\_C

completing\_D&C\_P: Flow

Used by: PY\_D&C\_to\_Startup\_P

completing\_demo\_development: Flow

completing\_demo\_scale\_ops: Flow

completing\_pilot\_development: Flow

completing\_pilot\_ops: Flow

completing\_startup\_C: Flow

completing\_startup\_P: Flow

Cost\_to\_Price\_Ratio\_C: Converter

Used by: Nominal\_Plant\_Utilization\_Factors\_C

Cost\_to\_Price\_Ratio\_P: Converter

Used by: Nominal\_Plant\_Utilization\_Factors\_P

Cume\_FCI\_Sub: Converter

Used by: rollup\_cumulative\_subsidies

Cume\_FCI\_Sub\_C: Stock

Used by: Cume\_FCI\_Sub

Cume\_FCI\_Sub\_P: Stock

Used by: Cume\_FCI\_Sub

Cume\_FS\_Subst: Converter

Used by: rollup\_cumulative\_subsidies

Cume\_FS\_Subst\_C: Stock

Used by: Cume\_FS\_Subst

Cume\_FS\_Subst\_P: Stock

Used by: Cume\_FS\_Subst

Cume\_Interest\_Payment\_C: Converter

Used by: Rough\_Estimate\_Annual\_Interest

Cume\_Interest\_Payment\_P: Converter

Used by: Rough\_Estimate\_Annual\_Interest\_P

Cume\_Loan\_Guarantee\_Exposure: Converter

Used by: Rollup\_Loan\_Exposure

Cume\_Loan\_Guarantee\_Exposure\_C: Stock

Used by: Cume\_Loan\_Guarantee\_Exposure

Cume\_Loan\_Guarantee\_Exposure\_P: Stock

Used by: Cume\_Loan\_Guarantee\_Exposure

Cume\_Loan\_Payment\_C: Converter

Used by: Cume\_Interest\_Payment\_C, per\_plant\_L\_G\_exposure\_C

Cume\_Loan\_Payment\_P: Converter

Used by: Cume\_Interest\_Payment\_P, per\_plant\_L\_G\_exposure\_P

Cume\_Prodn\_Subst: Stock

Used by: rollup\_cumulative\_subsidies

Cumulative\_Module\_Output: Converter

Used by: Use\_Startup\_Subst

Cumulative\_Demo\_Experience: Stock

Used by: frac\_rate\_of\_growth\_demo\_experience

Cumulative\_Industry\_Output: Stock

Used by: Cumulative\_Module\_Output, frac\_rate\_of\_growth\_in\_industry\_output

Cumulative\_Pilot\_Experience: Stock

Used by: frac\_rate\_of\_growth\_pilot\_experience

C\_industry\_FS\_thruput\_tpy: Converter

Used by: yrly\_fs\_subs\_C

c\_plant\_planning\_logic: Flow

Days\_per\_Year\_Online: Converter

Used by: Avg\_Plant\_Output\_gal\yr\_C, Avg\_Plant\_Output\_gal\_per\_yr\_P,  
Expected\_Pioneer\_Plant\_Output, Expected\_Plant\_Output\_C,  
Pipeline\_Potential\_Plant\_Output\_gal\yr\_P, Pipeline\_Potential\_Plant\_Output\_gal\_per\_yr\_C,  
Reqd\_FS\_supply\_Pipeline\_C, Reqd\_FS\_supply\_Pipeline\_P

debt\_interest\_rate\_as\_frac: Converter

Used by: discount\_factor\_Loan\_Payment\_C, discount\_factor\_Loan\_Payment\_P

Debt\_Interest\_Rate\_as\_Pct: Converter

Used by: debt\_interest\_rate\_as\_frac

demo\_dev\_time: Converter

Used by:

demo\_learning\_logic: Flow

Demo\_Maturity: Stock

Used by: demo\_maturity\_gap, Demo\_Multipliers

demo\_maturity\_gap: Converter

Used by: demo\_learning\_logic

Demo\_Multipliers: Converter

Used by: State\_of\_the\_Industry\_Multipliers

demo\_op\_time: Converter

Used by:

Demo\_Progress\_Ratios: Converter

Used by: demo\_learning\_logic

Demo\_Projects\_in\_Development: Stock

Demo\_Scale\_Operations: Stock

Used by: logging\_demo\_experience

demo\_start: Converter

Used by: initiating\_demo\_development

depreciation\_period: Converter

Used by: estimated\_depreciation\_expense\_pioneer, est\_depreciation\_expense\_C, Expected\_\_Taxable\_Income\_2\_C, Expected\_\_Taxable\_Income\_2\_P, length\_of\_period\_1\_C, length\_of\_period\_1\_P, length\_of\_period\_2\_C, length\_of\_period\_2\_P

desired\_c\_starts\_per\_year: Converter

Used by: c\_plant\_planning\_logic

desired\_p\_starts\_per\_yr: Converter

Used by: pioneer\_plant\_planning\_logic

discount\_factor\_1\_C: Converter

Used by: NPV\_Taxes\_1\_C, NPV\_Taxes\_2\_C

discount\_factor\_1\_P: Converter

Used by: NPV\_Taxes\_1\_P, NPV\_Taxes\_2\_P

discount\_factor\_2\_C: Converter

Used by: NPV\_Taxes\_2\_C, NPV\_Taxes\_3\_C

discount\_factor\_2\_P: Converter

Used by: NPV\_Taxes\_2\_P, NPV\_Taxes\_3\_P

discount\_factor\_3\_C: Converter

Used by: NPV\_Revs\_Net\_of\_Op\_Cost\_C, NPV\_Taxes\_3\_C

discount\_factor\_3\_P: Converter

Used by: NPV\_Revs\_Net\_of\_Op\_Cost\_P, NPV\_Taxes\_3\_P

discount\_factor\_DCS\_C: Converter

Used by: NPV\_Revs\_Net\_of\_Op\_Cost\_C, NPV\_Taxes\_1\_C, PV\_Loan\_Payment\_C

discount\_factor\_DCS\_P: Converter

Used by: NPV\_Revs\_Net\_of\_Op\_Cost\_P, NPV\_Taxes\_1\_P, PV\_Loan\_Payment\_P

discount\_factor\_loan\_C: Converter

Used by: PV\_Loan\_Payment\_C

discount\_factor\_loan\_P: Converter

Used by: PV\_Loan\_Payment\_P

discount\_factor\_Loan\_Payment\_C: Converter

Used by: Annual\_Loan\_Payment\_C

discount\_factor\_Loan\_Payment\_P: Converter

Used by: Annual\_Loan\_Payment\_P

Doubling: Converter

Used by: doubling\_factor

doubling\_factor: Converter

Used by: rate\_of\_doubling\_demo\_experience,  
rate\_of\_doubling\_industry\_output\_by\_technology, rate\_of\_doubling\_pilot\_experience

Early\_Pilot\_Multipliers: Converter

Used by: Pilot\_Multipliers

Equity\_Fraction\_C: Converter

Used by: Frac\_Plant\_Debt\_Financed\_C, Initial\_Equity\_Investment\_C

Equity\_Fraction\_P: Converter

Used by: Frac\_Plant\_Debt\_Financed\_P, Initial\_Equity\_Investment\_p

estimated\_depreciation\_expense\_pioneer: Converter

Used by: Expected\_Taxable\_Income\_1\_P, Expected\_Taxable\_Income\_2\_P

est\_depreciation\_expense\_C: Converter

Used by: Expected\_Taxable\_Income\_1\_C, Expected\_Taxable\_Income\_2\_C

Expected\_Equity\_Fraction: Converter

Used by: Equity\_Fraction\_C, Equity\_Fraction\_P

Expected\_FCI\_after\_subs\_C: Converter

Used by: est\_depreciation\_expense\_C, Initial\_Equity\_Investment\_C, Loan\_Principal\_C

Expected\_FCI\_after\_subs\_P: Converter

Used by: estimated\_depreciation\_expense\_pioneer, Initial\_Equity\_Investment\_p, Loan\_Principal\_P

Expected\_FCI\_C: Converter

Used by: Expected\_FCI\_after\_subs\_C, FCI\_Sub Logic\_C

Expected\_FCI\_P: Converter

Used by: Expected\_FCI\_after\_subs\_P, FCI\_Sub Logic\_P

Expected\_Fixed\_Op\_Cost\_C: Converter

Used by: Expected\_Fixed\_Op\_Cost\_P, Expected\_Op\_Cost

Expected\_Fixed\_Op\_Cost\_P: Converter

Used by: Expected\_Op\_Cost\_Pioneer

Expected\_FS\_cost\_after\_subs\_C: Converter

Used by: Feedstock\_Cost\_USD\_per\_gal\_C, FS\_Cost\_USD\_per\_gal\_C

Expected\_FS\_cost\_after\_subs\_P: Converter

Used by: Feedstock\_Cost\_USD\_per\_gal\_P, FS\_Cost\_USD\_per\_gal\_Pioneer

Expected\_FS\_Cost\_USD\_per\_ton: Converter

Used by: Expected\_FS\_cost\_after\_subs\_C, Expected\_FS\_cost\_after\_subs\_P

Expected\_Op\_Cost: Converter

Used by: Exp\_Revs\_Net\_of\_Op\_Cost

Expected\_Op\_Cost\_Pioneer: Converter

Used by: Expected\_Revs\_Net\_of\_Op\_Cost\_P

Expected\_Other\_Coproduct\_Sales\_Rev\_P: Converter

Used by: Other\_rev\_net\_of\_vbl\_op\_cost\_P, Total\_Expected\_Revs\_Pioneer

Expected\_Other\_VBL\_Op\_Cost\_C: Converter

Used by: Expected\_Op\_Cost, Expected\_Other\_VBL\_Op\_Cost\_P,  
Other\_rev\_net\_of\_vbl\_op\_cost\_C

Expected\_Other\_VBL\_Op\_Cost\_P: Converter

Used by: Expected\_Op\_Cost\_Pioneer, Other\_rev\_net\_of\_vbl\_op\_cost\_P

Expected\_Pioneer\_Plant\_Output: Converter

Used by: Expected\_Sales\_Rev\_Pioneer, FS\_Cost\_USD\_per\_yr\_Pioneer

Expected\_Pioneer\_Plant\_Output\_Gal\_per\_Day: Converter

Used by: Expected\_Pioneer\_Plant\_Output

Expected\_Plant\_Output\_C: Converter

Used by: Exp\_Sales\_Rev\_C, FS\_Cost\_USD\_per\_yr\_C

Expected\_Plant\_Output\_Gal\_per\_Day\_C: Converter

Used by: Expected\_Plant\_Output\_C

Expected\_Power\_Sales\_Rev\_P: Converter

Used by: Other\_rev\_net\_of\_vbl\_op\_cost\_P, Total\_Expected\_Revs\_Pioneer

Expected\_Price\_after\_Sub: Converter

Used by: Cost\_to\_Price\_Ratio\_C, Cost\_to\_Price\_Ratio\_P, Expected\_Sales\_Rev\_Pioneer,  
Exp\_Sales\_Rev\_C

Expected\_Revs\_Net\_of\_Op\_Cost\_P: Converter

Used by: Expected\_Taxable\_Income\_1\_P, Expected\_Taxable\_Income\_3\_P,  
Expected\_Taxable\_Income\_2\_P, NPV\_Revs\_Net\_of\_Op\_Cost\_P

Expected\_Sales\_Rev\_Pioneer: Converter

Used by: Total\_Expected\_Revs\_Pioneer

Expected\_Taxable\_Income\_1\_C: Converter

Used by: Expected\_Tax\_1\_C

Expected\_Taxable\_Income\_1\_P: Converter

Used by: Expected\_Tax\_1\_P

Expected\_Taxable\_Income\_3\_C: Converter

Used by: Expected\_Tax\_3\_C

Expected\_Taxable\_Income\_3\_P: Converter

Used by: Expected\_Tax\_3\_P

Expected\_Tax\_1\_C: Converter

Used by: NPV\_Taxes\_1\_C

Expected\_Tax\_1\_P: Converter

Used by: NPV\_Taxes\_1\_P

Expected\_Tax\_3\_C: Converter

Used by: NPV\_Taxes\_3\_C

Expected\_Tax\_3\_P: Converter

Used by: NPV\_Taxes\_3\_P

Expected\_Tax\_Rate: Converter

Used by: Expected\_Tax\_1\_C, Expected\_Tax\_1\_P, Expected\_Tax\_3\_C, Expected\_Tax\_3\_P,  
Expected\_\_Tax\_2\_C, Expected\_\_Tax\_2\_P

Expected\_\_Taxable\_Income\_2\_C: Converter

Used by: Expected\_\_Tax\_2\_C

Expected\_\_Taxable\_Income\_2\_P: Converter

Used by: Expected\_\_Tax\_2\_P

Expected\_\_Tax\_2\_C: Converter

Used by: NPV\_Taxes\_2\_C

Expected\_\_Tax\_2\_P: Converter

Used by: NPV\_Taxes\_2\_P

Exp\_Other\_Coproduct\_Sales\_Rev\_C: Converter

Used by: Expected\_Other\_Coproduct\_Sales\_Rev\_P, Other\_rev\_net\_of\_vbl\_op\_cost\_C,  
Total\_Exp\_Revs\_C

Exp\_Power\_Sales\_Rev\_C: Converter

Used by: Expected\_Power\_Sales\_Rev\_P, Other\_rev\_net\_of\_vbl\_op\_cost\_C,  
Total\_Exp\_Revs\_C

Exp\_Revs\_Net\_of\_Op\_Cost: Converter

Used by: Expected\_Taxable\_Income\_1\_C, Expected\_Taxable\_Income\_3\_C,  
Expected\_Taxable\_Income\_2\_C, NPV\_Revs\_Net\_of\_Op\_Cost\_C

Exp\_Sales\_Rev\_C: Converter

Used by: Total\_Exp\_Revs\_C

FCI\_Input: Converter

Used by: FCI\_Multiplier

FCI\_Multiplier: Converter

Used by: Expected\_FCI\_C, Expected\_FCI\_P

FCI\_Subst\_Logic\_C: Converter

Used by: yrly\_FCI\_subst\_C, Expected\_FCI\_after\_subst\_C

FCI\_Subst\_Logic\_P: Converter

Used by: yrly\_FCI\_subst\_P, Expected\_FCI\_after\_subst\_P

Feedstock\_Constraint\_on\_Utilization: Converter

Used by: Plant\_Utilization\_Factors\_C, Plant\_Utilization\_Factors\_P

Feedstock\_Cost: Converter

Used by: Expected\_FS\_Cost\_USD\_per\_ton

Feedstock\_Cost\_USD\_per\_gal\_C: Converter

Used by: Cost\_to\_Price\_Ratio\_C

Feedstock\_Cost\_USD\_per\_gal\_P: Converter

Used by: Cost\_to\_Price\_Ratio\_P

fraction\_of\_Commercial\_cost\_growth\_anticipated: Converter

Used by: Expected\_FCI\_C

fraction\_of\_Pioneer\_cost\_growth\_anticipated: Converter

Used by: Expected\_FCI\_P

Frac\_Plant\_Debt\_Financed\_C: Converter

Used by: Loan\_Principal\_C

Frac\_Plant\_Debt\_Financed\_P: Converter

Used by: Loan\_Principal\_P

frac\_rate\_of\_growth\_demo\_experience: Converter

Used by: rate\_of\_doubling\_demo\_experience

frac\_rate\_of\_growth\_in\_industry\_output: Converter

Used by: rate\_of\_doubling\_industry\_output\_by\_technology

frac\_rate\_of\_growth\_pilot\_experience: Converter

Used by: rate\_of\_doubling\_pilot\_experience

FS\_Cost\_USD\_per\_gal\_C: Converter

Used by: FS\_Cost\_USD\_per\_yr\_C

FS\_Cost\_USD\_per\_gal\_Pioneer: Converter

Used by: FS\_Cost\_USD\_per\_yr\_Pioneer

FS\_Cost\_USD\_per\_yr\_C: Converter

Used by: Expected\_Op\_Cost

FS\_Cost\_USD\_per\_yr\_Pioneer: Converter

Used by: Expected\_Op\_Cost\_Pioneer

FS\_Subst\_Logic\_C: Converter

Used by: yrly\_fs\_subs\_C, Expected\_FS\_cost\_after\_subs\_C

FS\_Subst\_Logic\_P: Converter

Used by: yrly\_fs\_subs\_P, Expected\_FS\_cost\_after\_subs\_P

FS\_throughput\_C: Converter

Used by: Avg\_Plant\_Output\_gal/day\_C, Avg\_Plant\_Output\_gpd\_pipeline\_C,  
Expected\_Plant\_Output\_Gal\_per\_Day\_C, Reqd\_FS\_supply\_Pipeline\_C

FS\_throughput\_P: Converter

Used by: Avg\_Plant\_Output\_gal\_per\_day\_P, Avg\_Plant\_Output\_gpd\_pipeline\_P,  
Expected\_Pioneer\_Plant\_Output\_Gal\_per\_Day, Reqd\_FS\_supply\_Pipeline\_P

fs\_\_demand\_incl\_pipeline: Converter

gasoline\_conversion\_technology\_multiplier: Converter  
Used by: PoP\_Unsubsidized\_Price

Gasoline\_POD\_price\_before\_tax: Converter  
Used by: Gasoline\_POP\_Price

Gasoline\_POD\_price\_before\_tax\_scenarios: Converter  
Used by: Gasoline\_POD\_price\_scenario\_array

Gasoline\_POD\_price\_scenario\_array: Converter  
Used by: Gasoline\_POD\_price\_before\_tax

Gasoline\_POD\_price\_scenario\_switch: Converter  
Used by: Gasoline\_POD\_price\_scenario\_array

Gasoline\_POP\_Price: Converter  
Used by: PoP\_Unsubsidized\_Price

Gas\_Price\_Shock\_Scenario: Converter  
Used by: Gasoline\_POD\_price\_before\_tax\_scenarios

increase\_in\_PY\_commercial\_industry: Flow

Industry\_Process\_Yield\_Gap: Converter  
Used by: increase\_in\_PY\_commercial\_industry

initating\_P: Flow  
Used by: PY\_influx\_P

Initial\_Equity\_Investment\_C: Converter  
Used by: NPV\_Investment\_C

Initial\_Equity\_Investment\_p: Converter  
Used by: NPV\_Investment\_P

Initial\_Indices\_of\_Commercial\_Maturity: Converter  
Used by:

Initial\_Indices\_of\_Pilot\_Maturity: Converter  
Used by:

Initial\_Indices\_of\_\_Demo\_Maturity: Converter

Used by:

Initial\_Pilot\_Demo\_Maturity\_Multiplier: Converter

Used by:

initiating\_C: Flow

Used by: PY\_influx\_C

initiating\_demo\_development: Flow

initiating\_pilot\_development: Flow

invest\_attractiveness\_weighting: Converter

Used by: attr\_OTHER, nominal\_attractiveness\_C, nominal\_attractiveness\_P

In\_Design&Cons\_C: Stock

Used by: Avg\_PY\_D&C\_C, Pipeline\_C

In\_Design&Cons\_P: Stock

Used by: Avg\_PY\_D&C\_P, Pipeline\_P

k\_C: Converter

Used by: nominal\_attractiveness\_C

k\_OTHER: Converter

Used by: attr\_OTHER

k\_P: Converter

Used by: nominal\_attractiveness\_P

learning\_logic: Flow

length\_of\_period\_1\_C: Converter

Used by: discount\_factor\_1\_C

length\_of\_period\_1\_P: Converter

Used by: discount\_factor\_1\_P

length\_of\_period\_2\_C: Converter

Used by: discount\_factor\_2\_C

length\_of\_period\_2\_P: Converter

Used by: discount\_factor\_2\_P

Loan\_Guarantee\_Logic\_C: Converter

Used by: Equity\_Fraction\_C, per\_plant\_L\_G\_exposure\_C

Loan\_Guarantee\_Logic\_P: Converter

Used by: Equity\_Fraction\_P, per\_plant\_L\_G\_exposure\_P

Loan\_Principal\_C: Converter

Used by: Annual\_Loan\_Payment\_C, Cume\_Interest\_Payment\_C

Loan\_Principal\_P: Converter

Used by: Annual\_Loan\_Payment\_P, Cume\_Interest\_Payment\_P

logging\_demo\_experience: Flow

Used by: frac\_rate\_of\_growth\_demo\_experience

logging\_pilot\_experience: Flow

Used by: frac\_rate\_of\_growth\_pilot\_experience

Mature\_Commercial\_Multipliers: Converter

Used by: State\_of\_the\_Industry\_Multipliers

Mature\_Demo\_Multipliers: Converter

Used by: Demo\_Multipliers

Mature\_FS\_Thruput\_Capacity\_C: Converter

Used by: FS\_throughput\_C, Mature\_FS\_Thruput\_Capacity\_P

Mature\_FS\_Thruput\_Capacity\_P: Converter

Used by: FS\_throughput\_P

Mature\_Industry\_Equity\_Fraction: Converter

Used by: Expected\_Equity\_Fraction

Mature\_Industry\_FCI: Converter

Used by: Expected\_FCI\_C, Nominal\_Pioneer\_FCI

Mature\_Industry\_Process\_Yield: Converter

Used by: State\_of\_Industry\_Process\_Yield

Mature\_Industry\_P\_Success: Converter

Used by: P\_Success

Mature\_Industry\_Rate\_of\_Return\_as\_%: Converter

Used by: Req'd\_Rate\_of\_Return\_as\_%

Mature\_Pilot\_Multipliers: Converter

Used by: Pilot\_Multipliers

Max\_Plant\_Construction\_Capacity: Converter

Used by: desired\_c\_starts\_per\_year, desired\_p\_starts\_per\_yr

Min\_Cume\_Industry\_Output\_For\_Learning: Converter

Used by: frac\_rate\_of\_growth\_in\_industry\_output

Min\_Demo\_Experience\_for\_Learning: Converter

Used by: frac\_rate\_of\_growth\_demo\_experience

Min\_Pilot\_Experience\_for\_Learning: Converter

Used by: frac\_rate\_of\_growth\_pilot\_experience

nominal\_attractiveness\_C: Converter

Used by: attractiveness\_C

nominal\_attractiveness\_P: Converter

Used by: attractiveness\_P

Nominal\_Pioneer\_FCI: Converter

Used by: Expected\_FCI\_P

Nominal\_Plant\_Utilization\_Factors\_C: Converter

Used by: Plant\_Utilization\_Factors\_C, Req'd\_Annual\_FS\_Supply\_C

Nominal\_Plant\_Utilization\_Factors\_P: Converter

Used by: Plant\_Utilization\_Factors\_P, Req'd\_Annual\_FS\_Supply\_P

NPV\_Investment\_C: Converter  
Used by: NPV\_rel\_to\_a\_million\_C

NPV\_Investment\_P: Converter  
Used by: NPV\_rel\_to\_a\_million\_P

NPV\_rel\_to\_a\_million\_C: Converter  
Used by: nominal\_attractiveness\_C

NPV\_rel\_to\_a\_million\_OTHER: Converter  
Used by: attr\_OTHER

NPV\_rel\_to\_a\_million\_P: Converter  
Used by: nominal\_attractiveness\_P

NPV\_Revs\_Net\_of\_Op\_Cost\_C: Converter  
Used by: NPV\_Investment\_C

NPV\_Revs\_Net\_of\_Op\_Cost\_P: Converter  
Used by: NPV\_Investment\_P

NPV\_Taxes\_1\_C: Converter  
Used by: NPV\_Taxes\_C

NPV\_Taxes\_1\_P: Converter  
Used by: NPV\_Taxes\_P

NPV\_Taxes\_2\_C: Converter  
Used by: NPV\_Taxes\_C

NPV\_Taxes\_2\_P: Converter  
Used by: NPV\_Taxes\_P

NPV\_Taxes\_3\_C: Converter  
Used by: NPV\_Taxes\_C

NPV\_Taxes\_3\_P: Converter  
Used by: NPV\_Taxes\_P

NPV\_Taxes\_C: Converter

Used by: NPV\_Investment\_C

NPV\_Taxes\_P: Converter

Used by: NPV\_Investment\_P

Number\_of\_Doublings\_of\_Cume\_Output: Stock

Number\_of\_Doublings\_of\_Demo\_Experience: Stock

Number\_of\_Doublings\_of\_Pilot\_Experience: Stock

number\_of\_plants\_to\_start: Converter

Used by: commercial\_plant\_initiation\_logic

number\_pioneer\_plants\_to\_start: Converter

Used by: pioneer\_plant\_initiation\_logic

one: Converter

Used by: commercial\_maturity\_gap, demo\_maturity\_gap, pilot\_maturity\_gap

one\_billion: Converter

Used by: output\_bb\_gpy\_by\_tech

one\_dollar\_per\_gal: Converter

Used by: PoP\_Price\_Subs\_Logic

one\_dollar\_per\_ton: Converter

Used by: FS\_Subs\_Logic\_C, FS\_Subs\_Logic\_P

one\_hundred\_%: Converter

Used by: debt\_interest\_rate\_as\_frac, Req'd\_Rate\_of\_Return

one\_million: Converter

Used by: NPV\_rel\_to\_a\_million\_C, NPV\_rel\_to\_a\_million\_P,  
Total\_Annual\_Req'd\_Cellulosic\_FS, Total\_Annual\_Reqd\_FS\_Pipeline

one\_project: Converter

Used by: yrly\_FCI\_subs\_C, yrly\_FCI\_subs\_P, yrly\_Loan\_guarantee\_flux\_C,  
yrly\_Loan\_Guarantee\_Flux\_P, Output\_Capacity\_C, Output\_Capacity\_P,

Output\_Capacity\_Pipeline\_C, Output\_Capacity\_Pipeline\_P, Reqd\_FS\_supply\_Pipeline\_C,  
Reqd\_FS\_supply\_Pipeline\_P

OnLine\_C: Stock

Used by: increase\_in\_PY\_commercial\_industry, retirements\_C, Avg\_PY\_C,  
Plants\_On\_Line\_Equivalent\_C

OnLine\_P: Stock

Used by: retirements\_P, Avg\_PY\_P, Output\_Capacity\_P

OpCost\_Input: Converter

Used by: OpCost\_Multiplier

OpCost\_Multiplier: Converter

Used by: Expected\_Op\_Cost, Expected\_Op\_Cost\_Pioneer

Op\_Experience\_Per\_Year: Converter

Used by: logging\_demo\_experience, logging\_pilot\_experience

Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_C: Converter

Used by: Cost\_to\_Price\_Ratio\_C

Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_P: Converter

Used by: Cost\_to\_Price\_Ratio\_P

Other\_rev\_net\_of\_vbl\_op\_cost\_C: Converter

Used by: Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_C

Other\_rev\_net\_of\_vbl\_op\_cost\_P: Converter

Used by: Other\_rev\_net\_of\_vbl\_cost\_per\_gal\_P

output\_bb\_gpy\_by\_tech: Flow

Used by: frac\_rate\_of\_growth\_in\_industry\_output

Output\_Capacity\_C: Converter

Used by: Actual\_Output\_gpy\_C, Output\_cap\_by\_Tech, Reqd\_Annual\_FS\_Supply\_C,  
Tot\_C\_Cellulosic\_Cap\_by\_Tech\_by\_Region, UTIL\_by\_tech\_C

Output\_Capacity\_P: Converter

Used by: Actual\_Output\_gpy\_P, Output\_cap\_by\_Tech, Reqd\_Annual\_FS\_Supply\_P, Tot\_P\_\_Cap\_by\_Tech\_by\_Region, UTIL\_by\_tech\_P

Output\_Capacity\_Pipeline\_C: Converter

Used by: Tot\_C\_Cellulosic\_Cap\_by\_Tech\_by\_Region

Output\_Capacity\_Pipeline\_P: Converter

Used by: Tot\_P\_\_Cap\_by\_Tech\_by\_Region

Output\_cap\_by\_Tech: Converter

Used by: UTIL\_by\_tech

Output\_gpy\_by\_Technology: Converter

Used by: output\_bb\_gpy\_by\_tech, yrly\_prodn\_subs, UTIL\_by\_tech

per\_plant\_L\_G\_esposure\_P: Converter

Used by: yrly\_Loan\_Guarantee\_Flux\_P

per\_plant\_L\_G\_exposure\_C: Converter

Used by: yrly\_Loan\_guarantee\_flux\_C

pilot\_dev\_time: Converter

Used by:

Pilot\_Efforts\_in\_Development: Stock

pilot\_learning\_logic: Flow

Pilot\_Maturity: Stock

Used by: pilot\_maturity\_gap, Pilot\_Multipliers

pilot\_maturity\_gap: Converter

Used by: pilot\_learning\_logic

Pilot\_Multipliers: Converter

Used by: Demo\_Multipliers

pilot\_op\_time: Converter

Used by:

Pilot\_Progress\_Ratios: Converter

Used by: pilot\_learning\_logic

Pilot\_Scale\_Operations: Stock

Used by: logging\_pilot\_experience

pilot\_start: Converter

Used by: initiating\_pilot\_development

pioneer\_capacity\_scale\_factor: Converter

Used by: Mature\_FS\_Thruput\_Capacity\_P

pioneer\_coproduct\_scale\_factor: Converter

Used by: Expected\_Other\_Coproduct\_Sales\_Rev\_P, Expected\_Power\_Sales\_Rev\_P

pioneer\_cost\_scale\_factor: Converter

Used by: Expected\_Fixed\_Op\_Cost\_P, Expected\_Other\_VBL\_Op\_Cost\_P,  
Nominal\_Pioneer\_FCI

pioneer\_plant\_initiation\_logic: Flow

Used by: initating\_P, yrly\_FCI\_subs\_P, yrly\_Loan\_Guarantee\_Flux\_P

pioneer\_plant\_planning\_logic: Flow

Pioneer\_Plant\_Start\_Batchifier: Stock

Used by: number\_pioneer\_plants\_to\_start

pioneer\_start: Converter

Used by: pioneer\_plant\_planning\_logic

Pipeline\_C: Converter

Used by: Avg\_PY\_Pipeline\_C, Output\_Capacity\_Pipeline\_C, Reqd\_FS\_supply\_Pipeline\_C

Pipeline\_P: Converter

Used by: Avg\_PY\_Pipeline\_P, Output\_Capacity\_Pipeline\_P, Reqd\_FS\_supply\_Pipeline\_P

Pipeline\_Potential\_Plant\_Output\_gal\yr\_P: Converter

Used by: Output\_Capacity\_Pipeline\_P

Pipeline\_Potential\_Plant\_Output\_gal\_per\_yr\_C: Converter

Used by: Output\_Capacity\_Pipeline\_C

Plants\_On\_Line\_Equivalent\_C: Converter

Used by: Output\_Capacity\_C

Plant\_Economic\_Lifetime: Converter

Used by: total\_project\_length\_C, total\_project\_length\_P

Plant\_Start\_Accumulator: Stock

Used by: number\_of\_plants\_to\_start

Plant\_Utilization\_Factors\_C: Converter

Used by: Actual\_Output\_gpy\_C

Plant\_Utilization\_Factors\_P: Converter

Used by: Actual\_Output\_gpy\_P

PoD\_PoP\_gasoline\_Offset: Converter

Used by: Gasoline\_POP\_Price

Policy\_End: Converter

Used by: Policy\_time\_constraints

Policy\_Start: Converter

Used by: Policy\_time\_constraints

Policy\_Switch: Converter

Used by: FCI\_Subst\_Logic\_C, FCI\_Subst\_Logic\_P, FS\_Subst\_Logic\_C, FS\_Subst\_Logic\_P, Loan\_Guarantee\_Logic\_C, Loan\_Guarantee\_Logic\_P, PoP\_Price\_Subst\_Logic

Policy\_time\_constraints: Converter

Used by: FCI\_Subst\_Logic\_C, FCI\_Subst\_Logic\_P, FS\_Subst\_Logic\_C, FS\_Subst\_Logic\_P, Loan\_Guarantee\_Logic\_C, Loan\_Guarantee\_Logic\_P, PoP\_Price\_Subst\_Logic

PoP\_Price\_Subst\_Logic: Converter

Used by: yrly\_prodn\_subs, Expected\_Price\_after\_Subst

PoP\_Unsubsidized\_Price: Converter

Used by: Expected\_Price\_after\_Subst

PreCom\_Invest\_Multiplier: Converter

Used by: initiating\_demo\_development, initiating\_pilot\_development

PreCom\_Inv\_Input: Converter

Used by: PreCom\_Invest\_Multiplier

PreCom\_Maturity\_Input: Converter

Used by: Initial\_Pilot\_Demo\_Maturity\_Multiplier

ProgRatio\_Input: Converter

Used by: ProgRatio\_Multiplier

ProgRatio\_Multiplier: Converter

Used by: demo\_learning\_logic, learning\_logic, pilot\_learning\_logic

PV\_Loan\_Payment\_C: Converter

Used by: NPV\_Investment\_C

PV\_Loan\_Payment\_P: Converter

Used by: NPV\_Investment\_P

PY\_D&C\_to\_Startup\_C: Flow

PY\_D&C\_to\_Startup\_P: Flow

PY\_influx\_C: Flow

PY\_influx\_P: Flow

PY\_in\_Design&Cons\_P: Stock

Used by: Avg\_PY\_D&C\_P, PY\_Pipeline\_P

PY\_in\_In\_Design&Cons\_C: Stock

Used by: Avg\_PY\_D&C\_C, PY\_Pipeline\_C

PY\_in\_Startup\_C: Stock

Used by: PY\_Pipeline\_C

PY\_in\_Startup\_P: Stock

Used by: PY\_Pipeline\_P

PY\_OnLine\_C: Stock  
Used by: Avg\_PY\_C

PY\_OnLine\_P: Stock  
Used by: Avg\_PY\_P

PY\_Pipeline\_C: Converter  
Used by: Avg\_PY\_Pipeline\_C

PY\_Pipeline\_P: Converter  
Used by: Avg\_PY\_Pipeline\_P

PY\_retirements\_C: Flow

PY\_retirements\_P: Flow

PY\_startup\_to\_OnLine\_C: Flow

PY\_startup\_to\_OnLine\_P: Flow

P\_industry\_FS\_thruput\_tpy: Converter  
Used by: yrly\_fs\_subs\_P

P\_Success: Converter

rate\_of\_doubling\_demo\_experience: Flow  
Used by: demo\_learning\_logic

rate\_of\_doubling\_industry\_output\_by\_technology: Flow  
Used by: learning\_logic

rate\_of\_doubling\_pilot\_experience: Flow  
Used by: pilot\_learning\_logic

rate\_of\_industry\_process\_yield\_adjustment: Converter  
Used by: increase\_in\_PY\_commercial\_industry

RAT\_C: Converter  
Used by: share\_to\_C

RAT\_P: Converter

Used by: share\_to\_P

Req'd\_Annual\_FS\_Supply\_by\_Tech\_by\_Region: Converter

Used by: Total\_Annual\_Req'd\_Cellulosic\_FS

Req'd\_Rate\_of\_Return: Converter

Used by: discount\_factor\_1\_C, discount\_factor\_1\_P, discount\_factor\_2\_C,  
discount\_factor\_2\_P, discount\_factor\_3\_C, discount\_factor\_3\_P, discount\_factor\_DCS\_C,  
discount\_factor\_DCS\_P, discount\_factor\_loan\_C, discount\_factor\_loan\_P

Req'd\_Rate\_of\_Return\_as\_%: Converter

Used by: Req'd\_Rate\_of\_Return

Reqd\_Annual\_FS\_Supply\_C: Converter

Used by: Req'd\_Annual\_FS\_Supply\_by\_Tech\_by\_Region

Reqd\_Annual\_FS\_Supply\_P: Converter

Used by: Req'd\_Annual\_FS\_Supply\_by\_Tech\_by\_Region

Reqd\_FS\_supply\_Pipeline: Converter

Used by: Total\_Annual\_Reqd\_FS\_Pipeline

Reqd\_FS\_supply\_Pipeline\_C: Converter

Used by: Reqd\_FS\_supply\_Pipeline

Reqd\_FS\_supply\_Pipeline\_P: Converter

Used by: Reqd\_FS\_supply\_Pipeline

retirements\_C: Flow

Used by: PY\_retirements\_C

retirements\_P: Flow

Used by: PY\_retirements\_P

Retirement\_Fraction\_C: Converter

Used by: retirements\_C, Retirement\_Fraction\_P

Retirement\_Fraction\_P: Converter

Used by: retirements\_P

rollup\_annual\_subsidies: Converter

rollup\_cumulative\_subsidies: Converter

Rollup\_Loan\_Expsure: Converter

Rough\_Estimate\_Annual\_Interest: Converter

Used by: Expected\_Taxable\_Income\_1\_C, Expected\_\_Taxable\_Income\_2\_C

Rough\_Estimate\_Annual\_Interest\_P: Converter

Used by: Expected\_Taxable\_Income\_1\_P, Expected\_\_Taxable\_Income\_2\_P

share\_OTHER: Converter

Used by: share\_to\_A\_B\_and\_C

share\_to\_A\_B\_and\_C: Converter

share\_to\_C: Converter

Used by: desired\_c\_starts\_per\_year

share\_to\_P: Converter

Used by: desired\_p\_starts\_per\_yr

Starting\_Up\_C: Stock

Used by: Pipeline\_C, Plants\_On\_Line\_Equivalent\_C

Starting\_Up\_P: Stock

Used by: Pipeline\_P

Startup\_Sub: Converter

Used by: Subsidy\_Amt

Startup\_Sub\_Vol\_Thresh: Converter

Used by: Use\_Startup\_Sub

State\_of\_Industry\_Process\_Yield: Converter

Used by: PY\_influx\_C, PY\_influx\_P, Expected\_Pioneer\_Plant\_Output\_Gal\_per\_Day, Expected\_Plant\_Output\_Gal\_per\_Day\_C, FS\_Cost\_USD\_per\_gal\_C, FS\_Cost\_USD\_per\_gal\_Pioneer, Industry\_Process\_Yield\_Gap

State\_of\_the\_Industry\_Multipliers: Converter

Used by: Expected\_Equity\_Fraction, Expected\_FCI\_C, Expected\_FCI\_P, FS\_throughput\_C, FS\_throughput\_P, P\_Success, Req'd\_Rate\_of\_Return\_as\_%, State\_of\_Industry\_Process\_Yield

Subsidy\_Amt: Converter

Used by: FCI\_Subst\_Logic\_C, FCI\_Subst\_Logic\_P, FS\_Subst\_Logic\_C, FS\_Subst\_Logic\_P, Loan\_Guarantee\_Logic\_C, Loan\_Guarantee\_Logic\_P, PoP\_Price\_Subst\_Logic

technology\_switches: Converter

Used by: initiating\_demo\_development, initiating\_pilot\_development

tech\_breakthru\_logic: Converter

Used by: learning\_logic

term\_of\_loan: Converter

Used by: Cume\_Loan\_Payment\_C, Cume\_Loan\_Payment\_P, discount\_factor\_loan\_C, discount\_factor\_loan\_P, discount\_factor\_Loan\_Payment\_C, discount\_factor\_Loan\_Payment\_P, Expected\_\_Taxable\_Income\_2\_C, Expected\_\_Taxable\_Income\_2\_P, length\_of\_period\_1\_C, length\_of\_period\_1\_P, length\_of\_period\_2\_C, length\_of\_period\_2\_P, Rough\_Estimate\_Annual\_Interest, Rough\_Estimate\_Annual\_Interest\_P

Total\_Annual\_Req'd\_Cellulosic\_FS: Converter

Used by: actual\_fs\_demand\_at\_nominal\_utilization

Total\_Annual\_Reqd\_FS\_Pipeline: Converter

Used by: fs\_\_demand\_incl\_pipeline

Total\_Attr: Converter

Used by: RAT\_C, RAT\_P, share\_OTHER

Total\_Attr\_C: Converter

Used by: Total\_Attr

Total\_Attr\_P: Converter

Used by: Total\_Attr

Total\_Expected\_Revs\_Pioneer: Converter  
Used by: Expected\_Revs\_Net\_of\_Op\_Cost\_P

Total\_Exp\_Revs\_C: Converter  
Used by: Exp\_Revs\_Net\_of\_Op\_Cost

total\_project\_length\_C: Converter  
Used by: discount\_factor\_3\_C

total\_project\_length\_P: Converter  
Used by: discount\_factor\_3\_P

Tot\_C\_Cellulosic\_Cap\_by\_Tech\_by\_Region: Converter

Tot\_P\_\_Cap\_by\_Tech\_by\_Region: Converter

use\_endogenous\_commercial\_logic: Converter  
Used by: c\_plant\_planning\_logic, pioneer\_plant\_planning\_logic

use\_exogenous\_commercial\_scenario: Converter  
Used by: c\_plant\_planning\_logic, pioneer\_plant\_planning\_logic

Use\_Startup\_Subs: Converter  
Used by: Subsidy\_Amt

UTIL\_by\_tech: Converter

UTIL\_by\_tech\_C: Converter

UTIL\_by\_tech\_P: Converter

Util\_rate\_for\_starting\_up: Converter  
Used by: Plants\_On\_Line\_Equivalent\_C

Years\_in\_D&C\_C: Converter  
Used by: Years\_in\_D&C\_P, years\_in\_D\_C\_S\_C

Years\_in\_D&C\_P: Converter  
Used by: years\_in\_D\_C\_S\_P

years\_in\_D\_C\_S\_C: Converter

Used by: discount\_factor\_DCS\_C, discount\_factor\_loan\_C, length\_of\_period\_1\_C, length\_of\_period\_2\_C, total\_project\_length\_C

years\_in\_D\_C\_S\_P: Converter

Used by: discount\_factor\_DCS\_P, discount\_factor\_loan\_P, length\_of\_period\_1\_P, length\_of\_period\_2\_P, total\_project\_length\_P

Years\_in\_Startup\_C: Converter

Used by: years\_in\_D\_C\_S\_C, Years\_in\_Startup\_P

Years\_in\_Startup\_P: Converter

Used by: years\_in\_D\_C\_S\_P

Yield\_Input: Converter

Used by: Yield\_Multiplier

Yield\_Multiplier: Converter

Used by: State\_of\_Industry\_Process\_Yield

yrly\_FCI\_subs\_C: Flow

Used by: rollup\_annual\_subsidies

yrly\_FCI\_subs\_P: Flow

Used by: rollup\_annual\_subsidies

yrly\_fs\_subs\_C: Flow

Used by: rollup\_annual\_subsidies

yrly\_fs\_subs\_P: Flow

Used by: rollup\_annual\_subsidies

yrly\_Loan\_guarantee\_flux\_C: Flow

yrly\_Loan\_Guarantee\_Flux\_P: Flow

yrly\_prodn\_subs: Flow

Used by: rollup\_annual\_subsidies