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The #H2IQ Hour

Today's Topic:

Demonstrations of *H2A-Lite* and *H2FAST* Models

This presentation is part of the monthly H2IQ hour to highlight hydrogen and fuel cell research, development, and demonstration (RD&D) activities including projects funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Housekeeping

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Technical Issues:

- If you experience technical issues, **please check your audio settings under the "Audio" tab.**
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Questions?

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To submit a question, please type it into the **Q&A box on the right-hand side of your screen next to the chat box/Chat**

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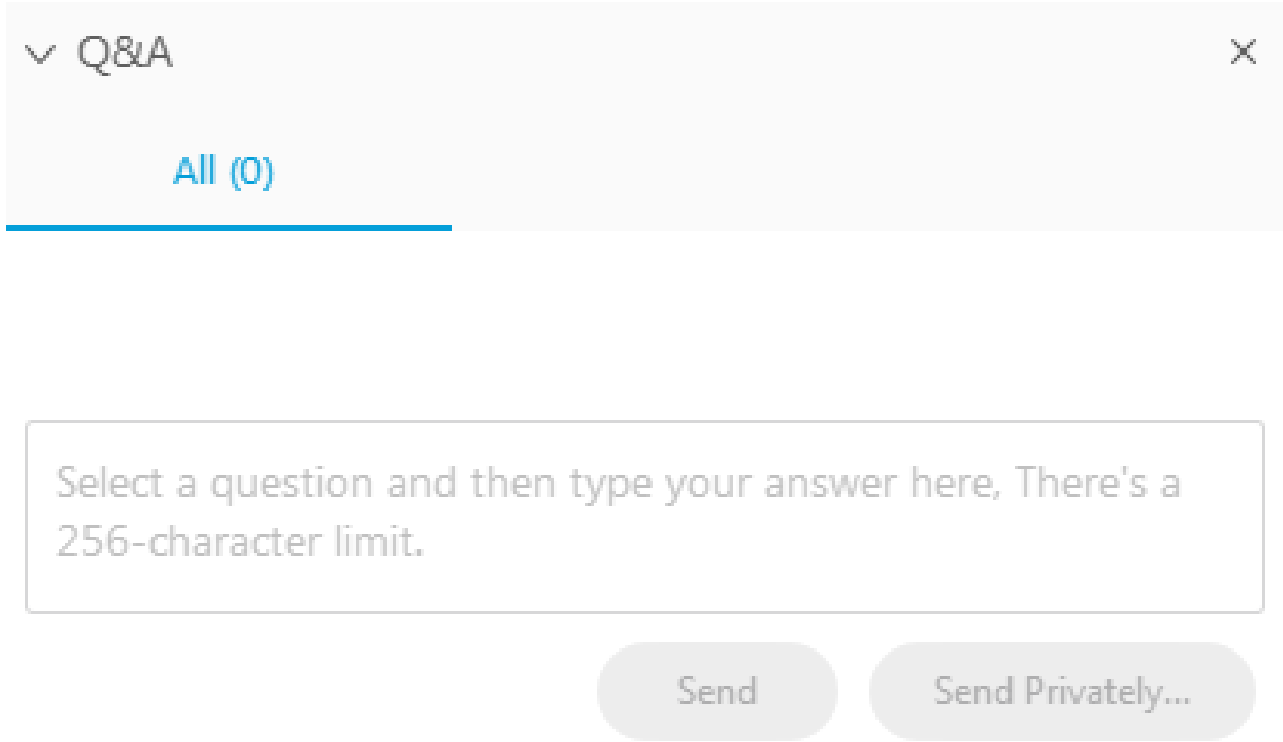
The #H2IQ Hour Q&A

Please type your questions into the **Q&A Box**



H2A-Lite & H2FAST Model Summary and Demonstration

Michael (Misho) Penev
NREL
November 3, 2022

Photo from iStock-627281636

Webinar Outline

Model purpose & framework
Layout & walkthrough
Model demonstration

Model purpose & framework
Layout & walkthrough
Model demonstration

H2A-Lite Model Purpose

Provide high level articulation of hydrogen production technologies with focus on convenience and high impact parameters.

How:

- reduce inputs to key standard parameters
- pre-populated technologies calibrated from H2A
- one-place for multiple technologies
- results rich and visual articulation
- rigorous financial and incentive analysis
- fast model operation
- includes embedded sensitivity and risk analysis
- simple embedded walkthrough + documentation

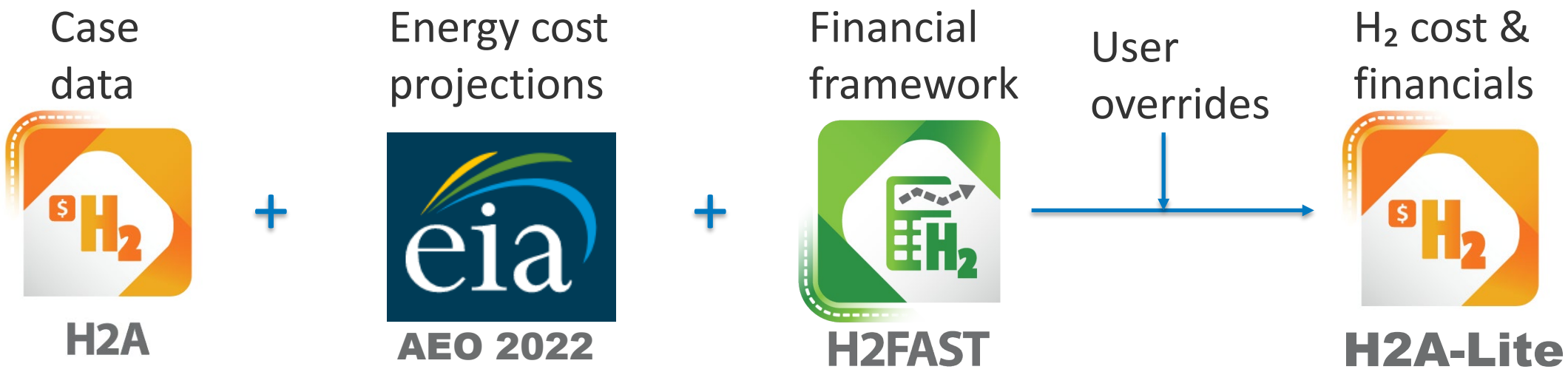
Target audience:

- business professionals / investors
- policy makers
- newer hydrogen analysts
- large scale modelling (e.g. SERA, ReEDS, NEMS)

H2A-Lite Model Framework

Based on Hydrogen Financial Analysis Scenario Tool (H2-FAST)

- Uses Generally Accepted Accounting Principles (GAAP) financial analysis
- Also compatible with International Financial Reporting Standards (IFRS)
- Articulates standard financial reports for duration of analysis
  - Income statements
  - Cash flow statements
  - Balance sheets



Comparison H2A vs. H2A-Lite

Aspect	H2A	H2A-Lite
Model use	Detailed, for R&D and target setting	Technology macro view
User experience requirement	Expert	Novice to Expert
# of input parameters	~100	~30
Number of production files	20	1
Number of tabs	19	5
Risk analysis	Simple	Rigorous
Financial analysis	Disc. cash flow	GAAP*
Documentation	Supplemental PDF	Self documented
Incentives analysis	Basic, income	Rigorous, income, tax credits
Clarity of parameter for other models	Complex	Concise

*GAAP: Generally Accepted Accounting Principles, US-standard accounting and finance methodology

Included Case Studies

- Central PEM: current & future
  - grid, wind, solar
- Central SOEC: current & future
  - natural gas & nuclear heat
- Central biomass: current & future
- Central SMR: current *
- Central ATR+CCS: current *
- Central coal+CCS: current *
- Distributed PEM: current & future
- Distributed SMR: current & future
- User-defined

* Case studies for fossil fuels include assumptions in 2022 NETL Report

Model Differences

	H2A		H2A-Lite
Dollar basis*:	2016$	→	2020$
Energy & feedstock basis:	AEO Ref. 2017	→	AEO Ref. 2022
Biomass cost:	Billion-ton study	→	AEO biomass for power generation
Renewable electricity cost:	N/A	→	NREL Annual technology baseline 2022
Refurbishments schedule:	Discrete	→	Annualized
Production incentive:	Income-basis	→	Income or tax credit
Capital expenditure:	Scheduled	→	Lump sum + construction period

* Modeling being adapted to allow for user-defined dollar year

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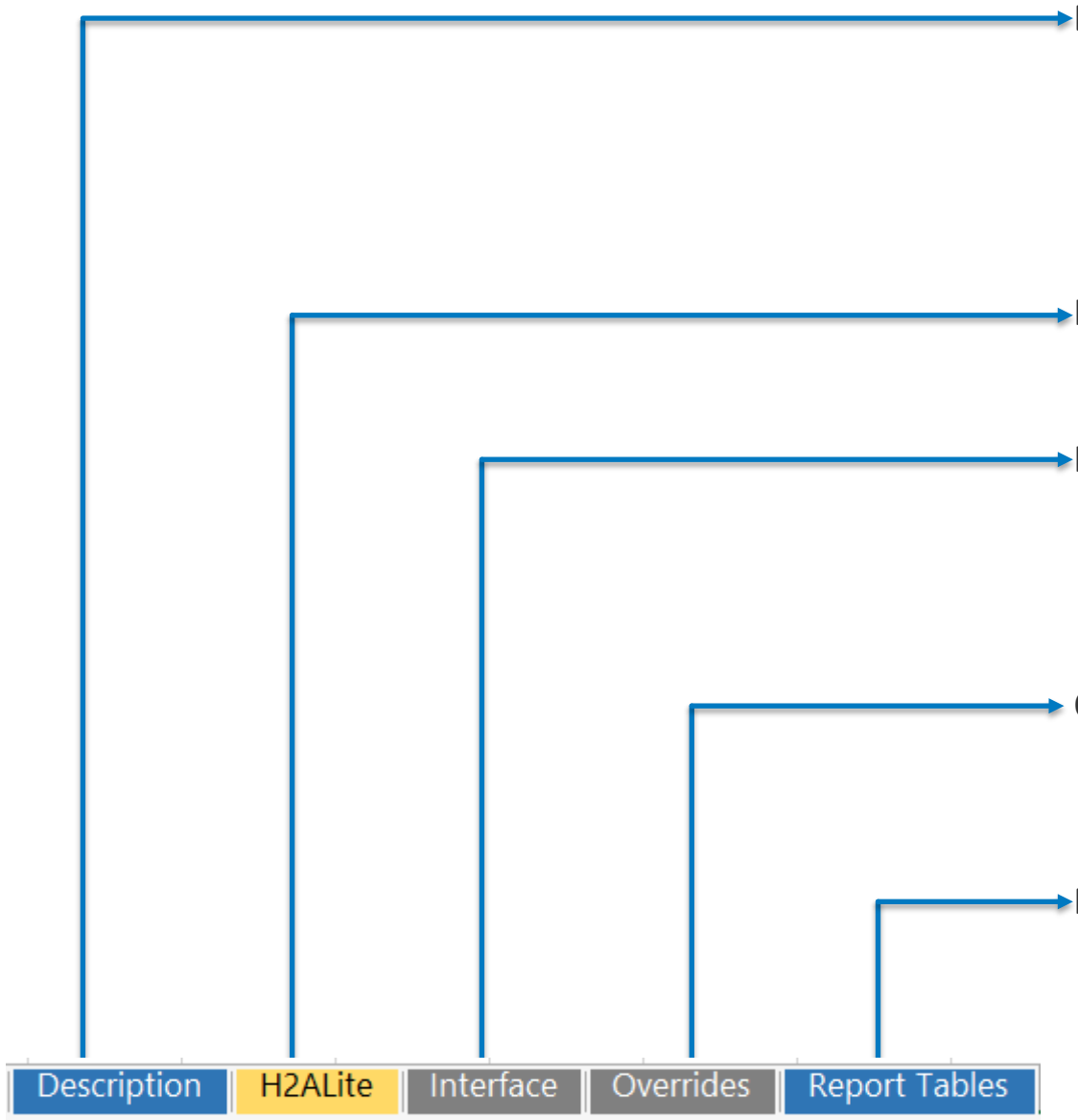
Model Tab Descriptions



Description

- Description
- Quick start guide
- Version history
- Use agreement

H2ALite

- Main model interface

Interface

- Underlying H2FAST model
- Populated by H2ALite
- Can be used for higher degree of scenario customizations

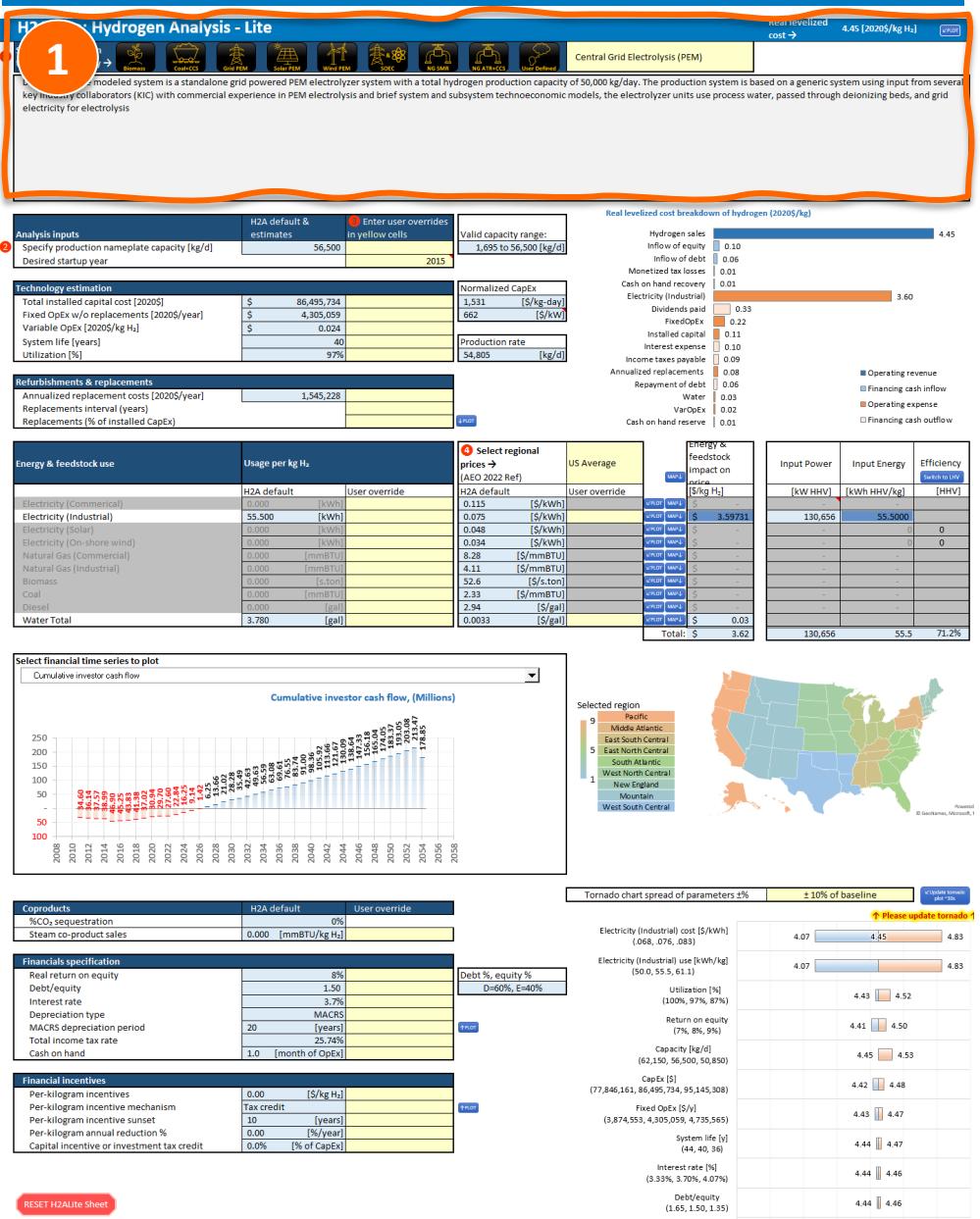
Overrides

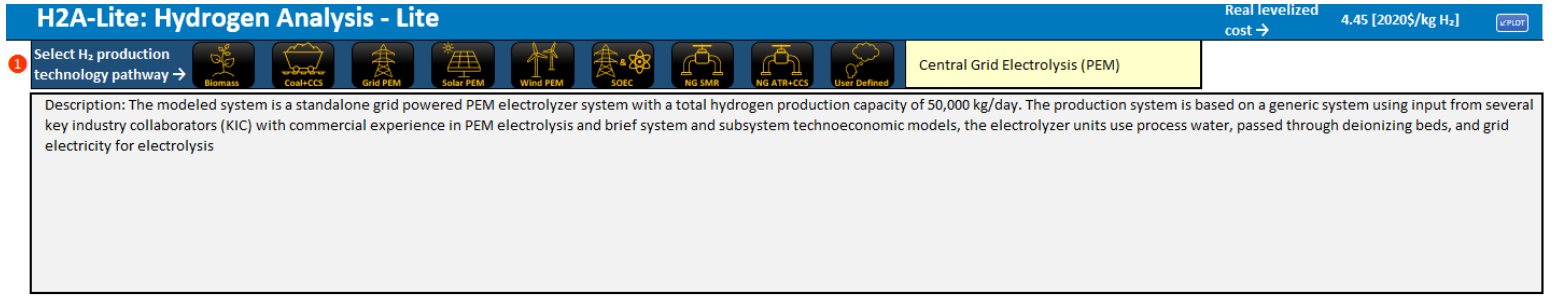
- Custom cost and price profiles vs. calendar years
- Custom performance, sales, refurbishments by analysis year

Report Tables

- Detailed GAAP projected statements

Model Layout: H2ALite tab

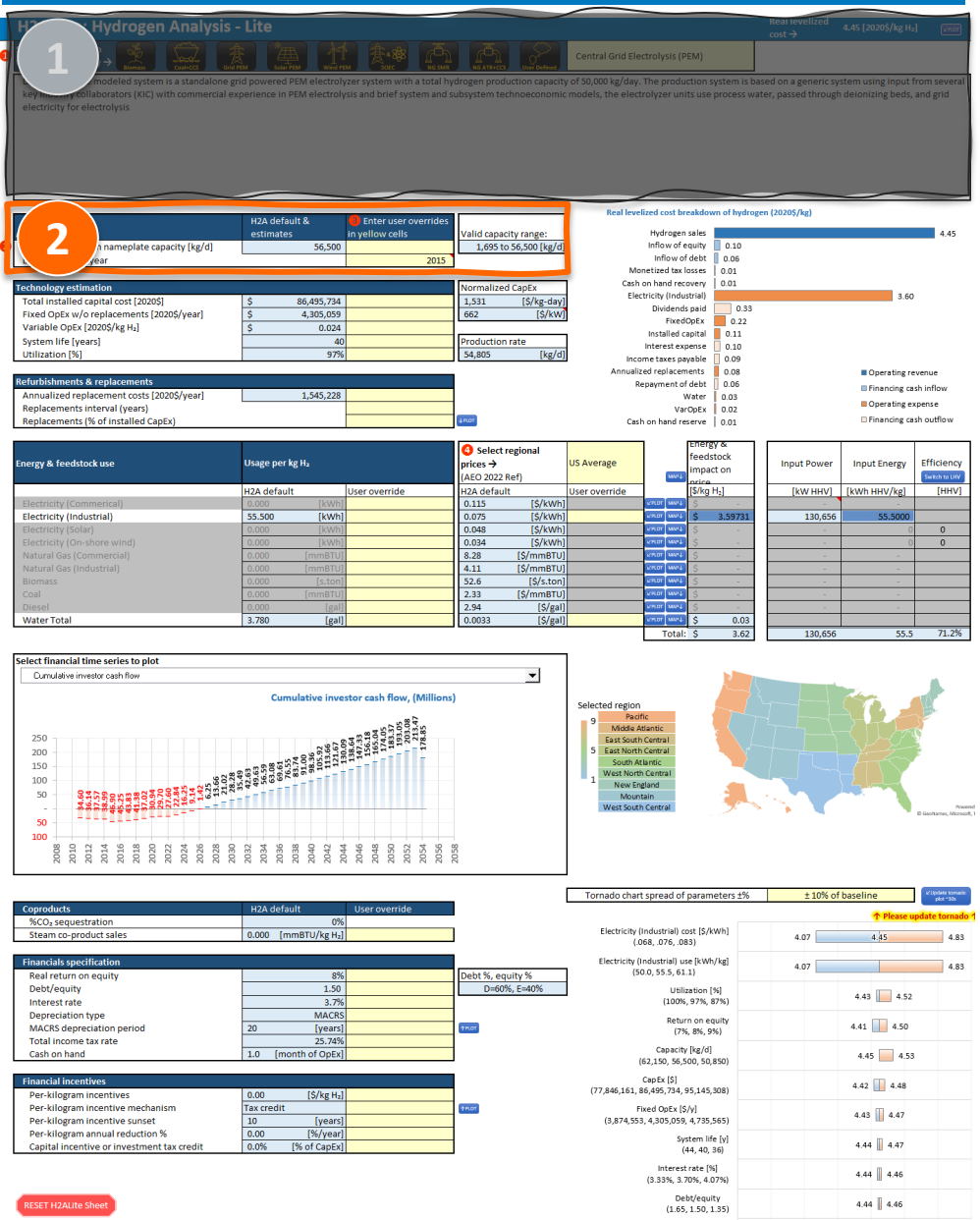




1 **Technology Selection & Description**

1. Click on icon for technology of interest
2. Description of technology will update
3. Technology parameters will populate below
4. Price in upper-right corner will display cost of H_2

Model Layout: H2ALite tab



2 Nameplate Capacity & Tech Year

1. In blue: values from H2A default case.
2. In yellow: user override values.
   - user overrides must be blank for defaults to take precedence
3. Startup year must be populated
   - Select 2015 for startup year to represent "Current" H2A case information
   - Select 2040 for startup year to represent "Future" H2A case information

Model Layout: H2ALite tab

3 Technology CapEx, OpEx, Life, Utilization

1. Parameters in blue will reflect H2A values based on specified nameplate capacity and technology year.
2. Normalized CapEx is available to the right to inform underlying metrics such as $/kW for electrolyzers.
3. Use yellow cells to provide overrides of any of the above parameters.
4. Model results will update as any input values are altered

Model Layout: H2ALite tab

4 Refurbishments & Replacements

1. H2A values for refurbishments are annualized.
2. User can override annualized value or explicit replacement intervals and % of CapEx spent in each refurbishment event.
3. Click "↓Plot" macro to show capital expenditure schedule with any specified refurbishments.

Note: both replacement interval and % of CapEx must be provided for values to take hold.

Model Layout: H2ALite tab

Energy & feedstock use	Usage per kg H_2		
	H2A default		User override
Electricity (Commerical)	0.000	[kWh]	
Electricity (Industrial)	55.500	[kWh]	
Electricity (Solar)	0.000	[kWh]	
Electricity (On-shore wind)	0.000	[kWh]	
Natural Gas (Commercial)	0.000	[mmBTU]	
Natural Gas (Industrial)	0.000	[mmBTU]	
Biomass	0.000	[s.ton]	
Coal	0.000	[mmBTU]	
Diesel	0.000	[gal]	
Water Total	3.780	[gal]	

5 Energy & Water Use Rates

1. In blue: values from H2A default case.
2. In yellow: user override values.

Note: entries with grayed out H2A values can also receive overrides.

Model Layout: H2ALite tab

Energy & feedstock use					Energy & feedstock impact on price
4 Select regional prices → (AEO 2022 Ref)		US Average		MAP↓	[$/kg H_2]
H2A default		User override			
Electricity (Commerical)	0.115	[$/kWh]		PLOT MAP↓	$ -
Electricity (Industrial)	0.075	[$/kWh]		PLOT MAP↓	$ 3.59731
Electricity (Solar)	0.048	[$/kWh]		PLOT MAP↓	$ -
Electricity (On-shore wind)	0.034	[$/kWh]		PLOT MAP↓	$ -
Natural Gas (Commercial)	8.28	[$/mmBTU]		PLOT MAP↓	$ -
Natural Gas (Industrial)	4.11	[$/mmBTU]		PLOT MAP↓	$ -
Biomass	52.6	[$/s.ton]		PLOT MAP↓	$ -
Coal	2.33	[$/mmBTU]		PLOT MAP↓	$ -
Diesel	2.94	[$/gal]		PLOT MAP↓	$ -
Water Total	0.0033	[$/gal]		PLOT MAP↓	$ 0.03
				Total:	$ 3.62

6 Energy & Water Costs

1. Select region for price projections.
2. In blue: regional values in startup year
3. Use yellow cells if overriding a price is desired. (Note: model will use override as a constant value on real 2020$ basis)
4. Use "↙Plot" macro to show time series for feed cost.
5. Use "Map↓" macro to display regionalized prices in startup year.
6. Panel on right shows H_2 price contribution

Model Layout: H2ALite tab

Financials specification			
Real return on equity	8%		
Debt/equity	1.50		
Interest rate	3.7%		
Depreciation type	MACRS		
MACRS depreciation period	20	[years]	
Total income tax rate	25.74%		
Cash on hand	1.0	[month of OpEx]	

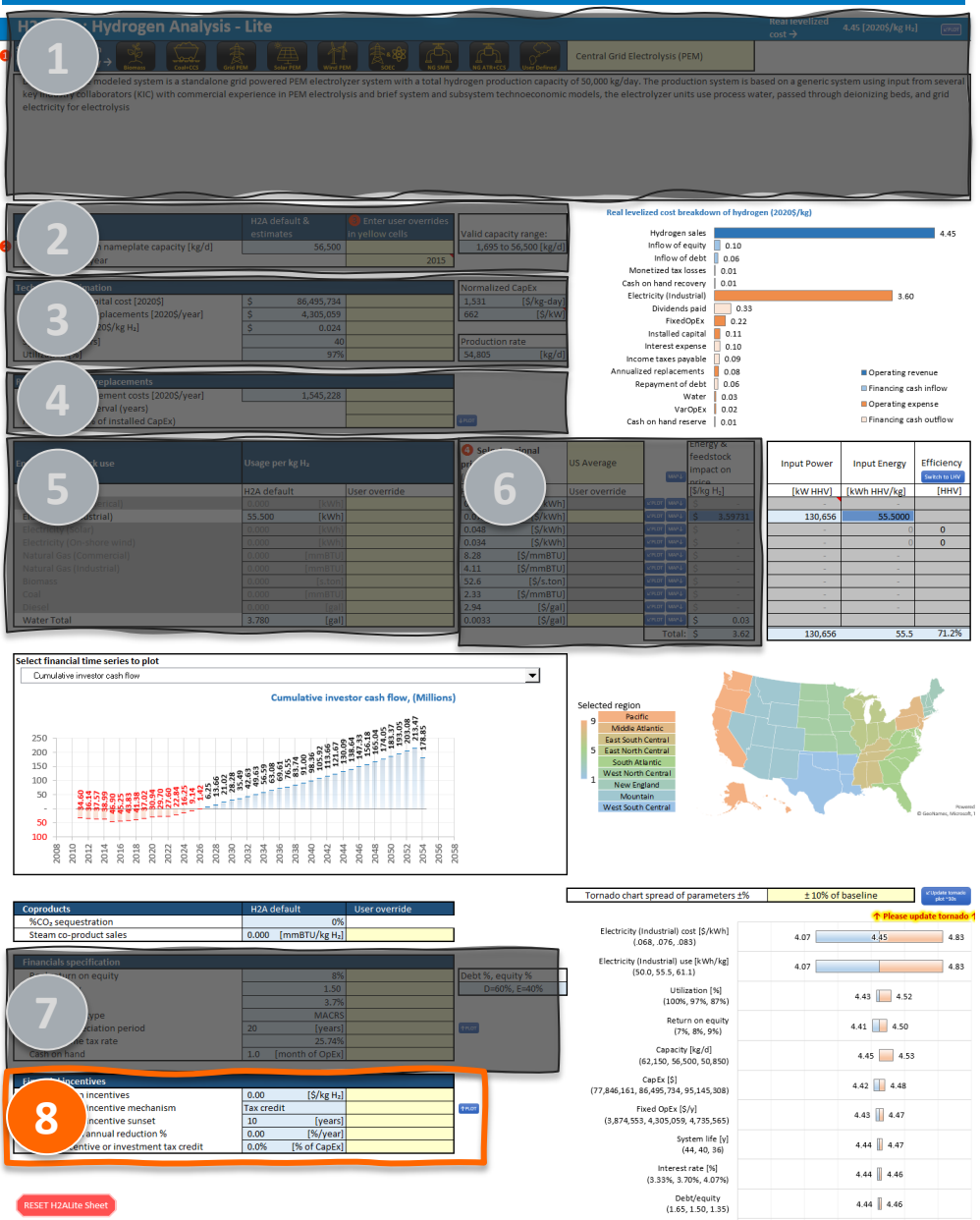
Debt %, equity %
D=60%, E=40%

PLOT

7 Financials Specification

1. H2A default values are provided in blue
2. In yellow are user overrides

Model Layout: H2ALite tab



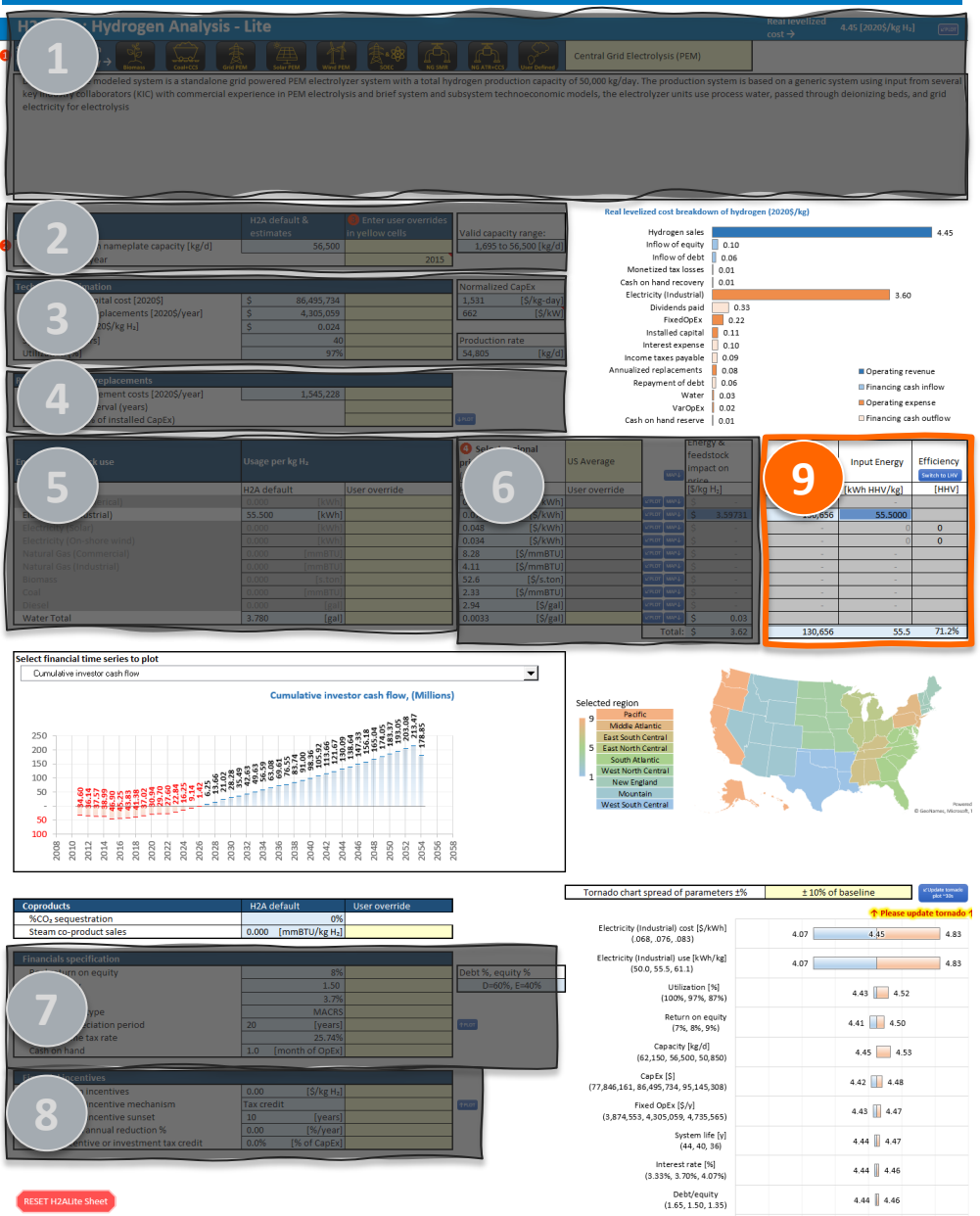
Financial incentives			
Per-kilogram incentives	0.00	[$/kg H_2]	
Per-kilogram incentive mechanism	Tax credit		
Per-kilogram incentive sunset	10	[years]	
Per-kilogram annual reduction %	0.00	[%/year]	
Capital incentive or investment tax credit	0.0%	[% of CapEx]	

PLOT

8 Financial Incentives Specifications

1. By default, incentives are not factored into H2A cases.
2. Per-kg incentives can be modeled as:
   - ordinary income: resulting in ~1:1 reduction in price
   - tax credit: higher price reduction relative to ordinary income mechanics as incentive bypasses taxation

Model Layout: H2ALite tab

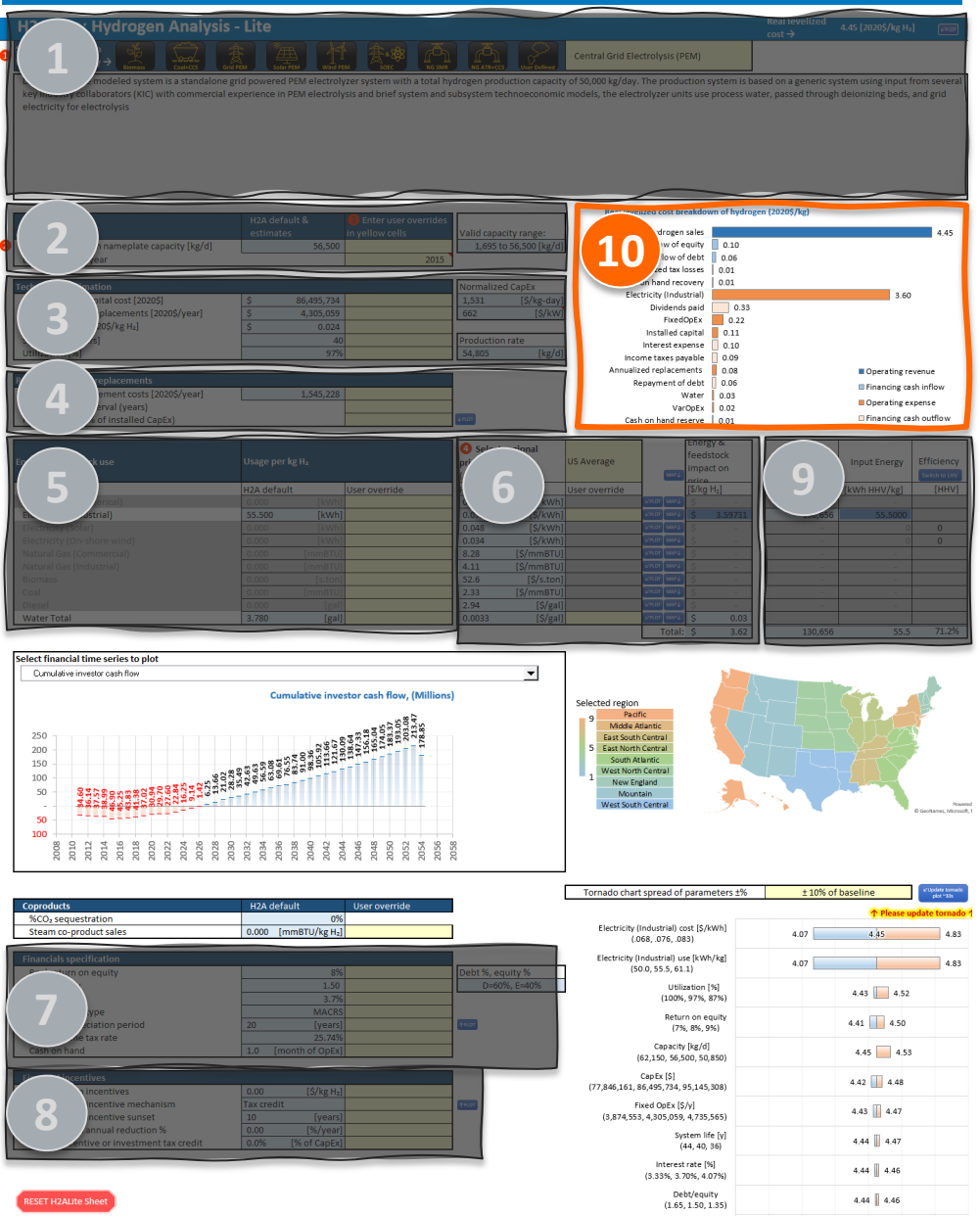


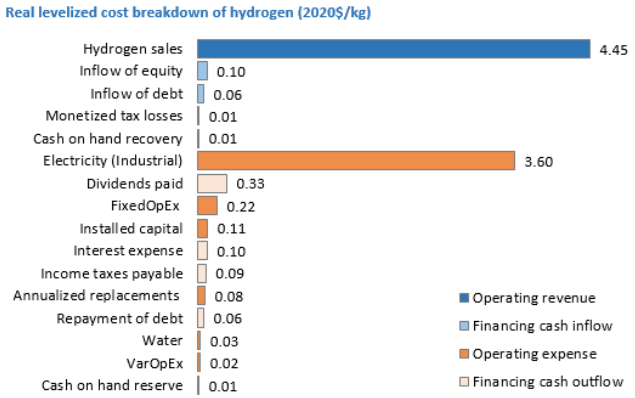
Energy & feedstock use	Input Power	Input Energy	Efficiency (Switch to LHV)
	[kW HHV]	[kWh HHV/kg]	[HHV]
Electricity (Commerical)	-	-	
Electricity (Industrial)	130,656	55.5000	
Electricity (Solar)	-	0	0
Electricity (On-shore wind)	-	0	0
Natural Gas (Commercial)	-	-	
Natural Gas (Industrial)	-	-	
Biomass	-	-	
Coal	-	-	
Diesel	-	-	
Water Total			
	130,656	55.5	71.2%

9 Power & Efficiency Values

1. No user input required in this section
2. Tip: electrolysis power rating result here can be used to set electrolyzer installed CapEx to desired $/kW target. E.g. CapEx in section 3: = $500* 130,565 kW will result in electrolyzer CapEx of $500/kW
3. Clicking "Switch to LHV" macro button will toggle analysis between lower heating value and higher heating value basis.

Model Layout: H2ALite tab

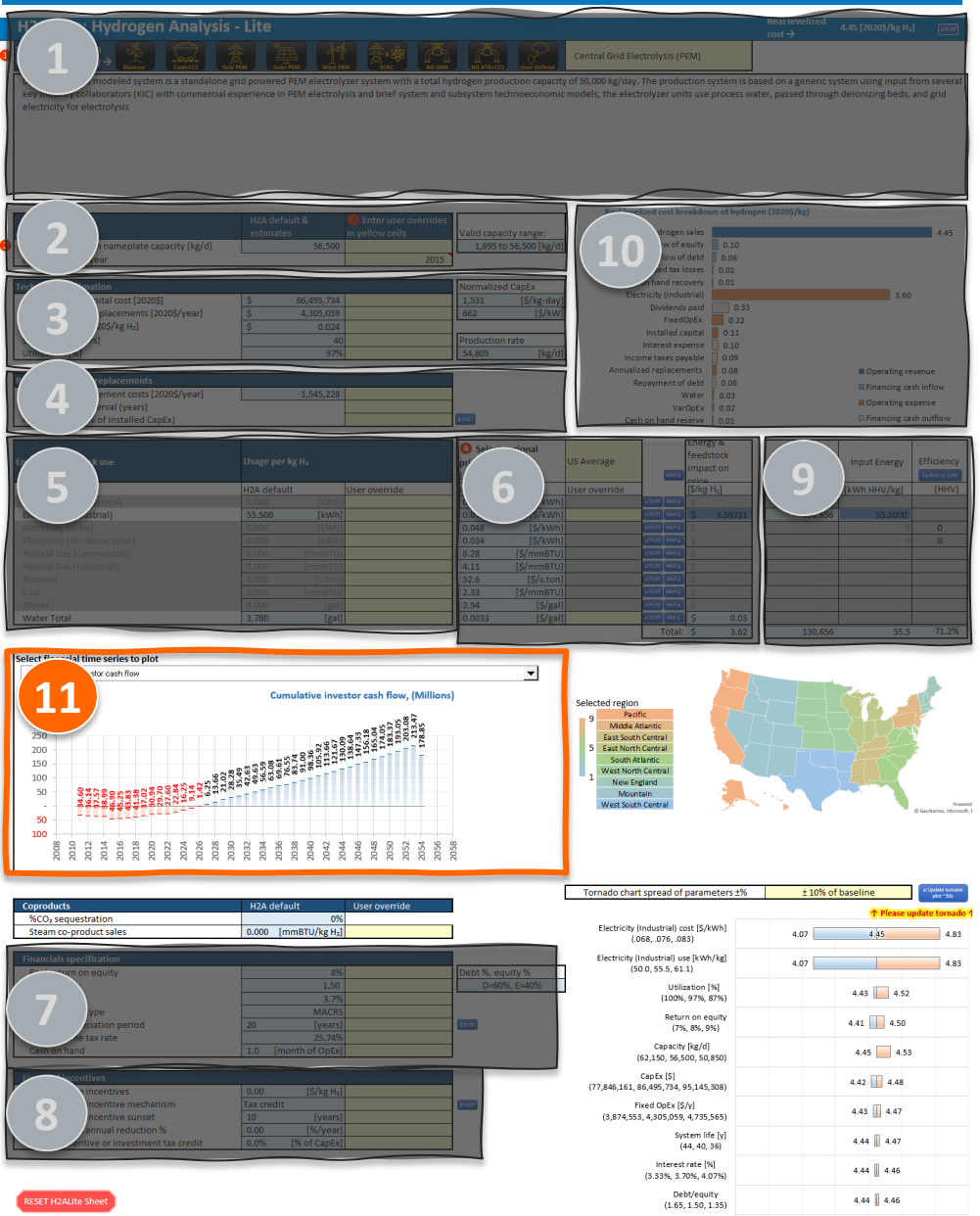


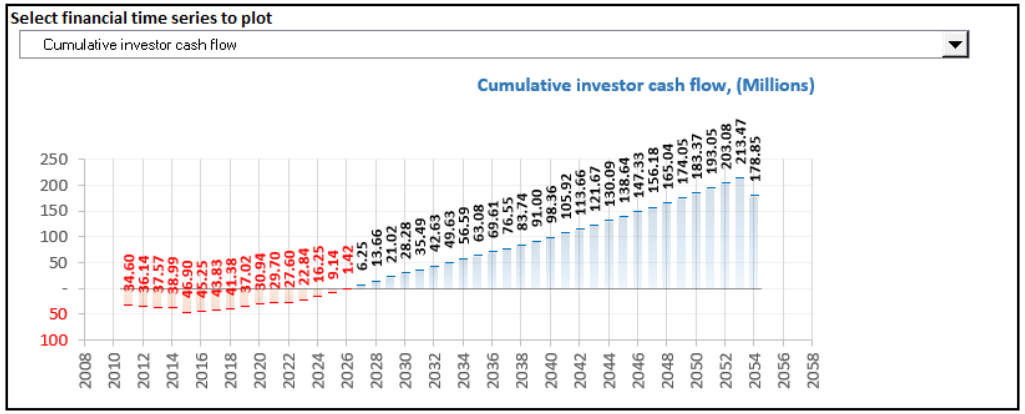


10 Levelized Cost Breakdown

1. Displays levelized cash flows per kg H_2
2. Sorts financing & operating cash flows by total contribution

Model Layout: H2ALite tab

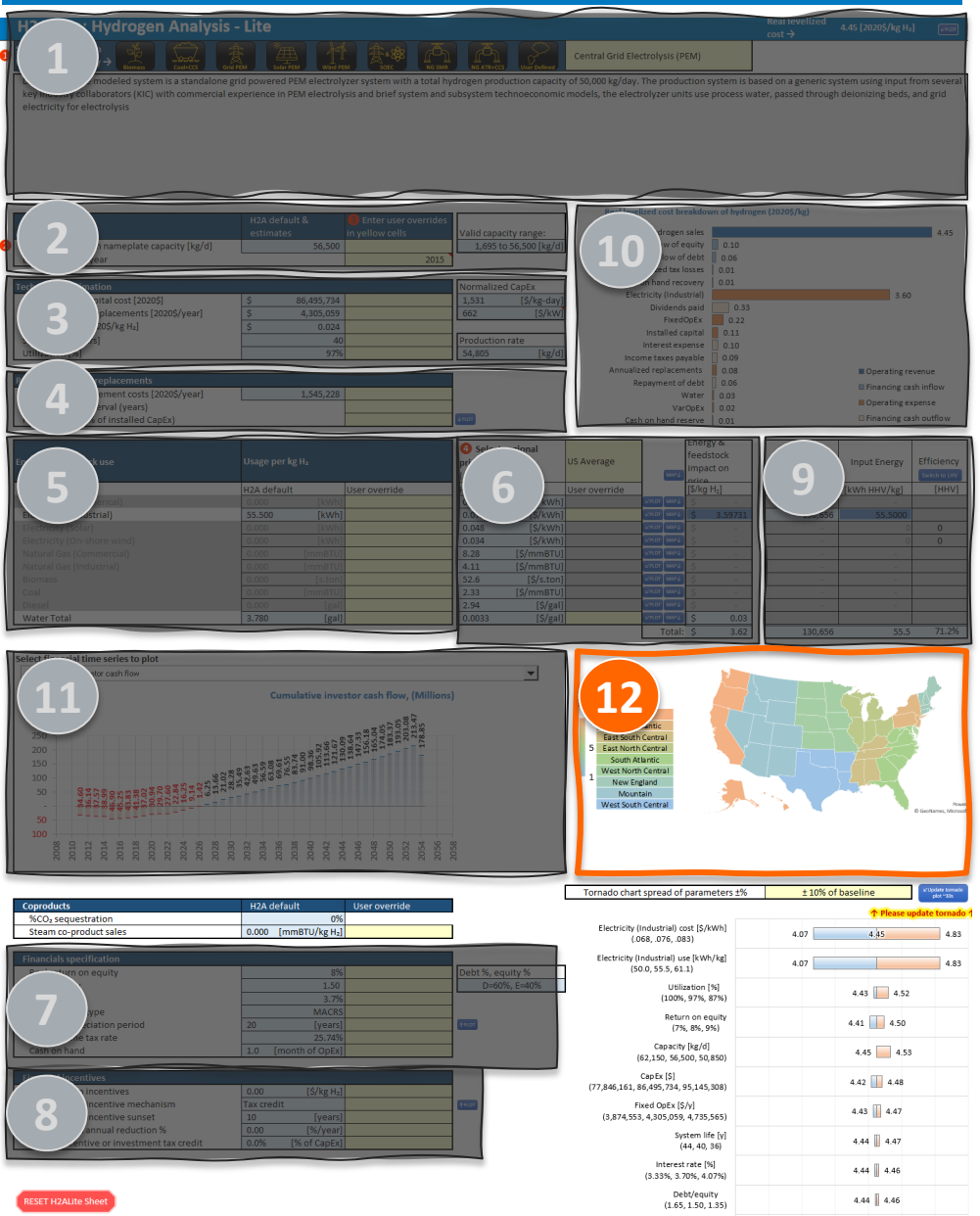


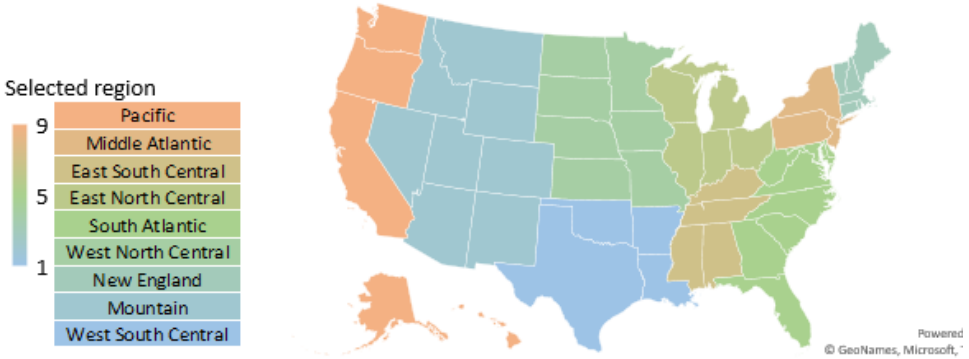


11 Time Series Charts

1. Chart can be updated via drop-down menu on top to any analysis parameter
2. Chart can also be updated by using "Plot" macro buttons in the H2ALite tab

Model Layout: H2ALite tab

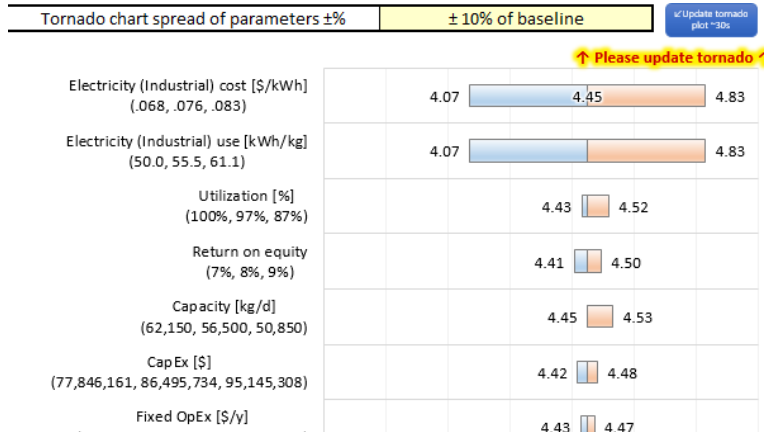




12 Regionalization Map

1. Displays Census Regions used by AEO for informing regional price forecasts
2. Chart can be updated by using "map" macro buttons in the H2ALite tab

Model Layout: H2ALite tab



13 Tornado Chart

1. Provides single-parameter sensitivity for all input variables
2. Spread can be specified (default is 10%)
3. Click “Update tornado plot” macro button to refresh cases

Webinar Outline

H2A-Lite

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Case studies & benchmarking

Model demonstration

H2FAST

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H2FAST

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Model demonstration

Model Purpose

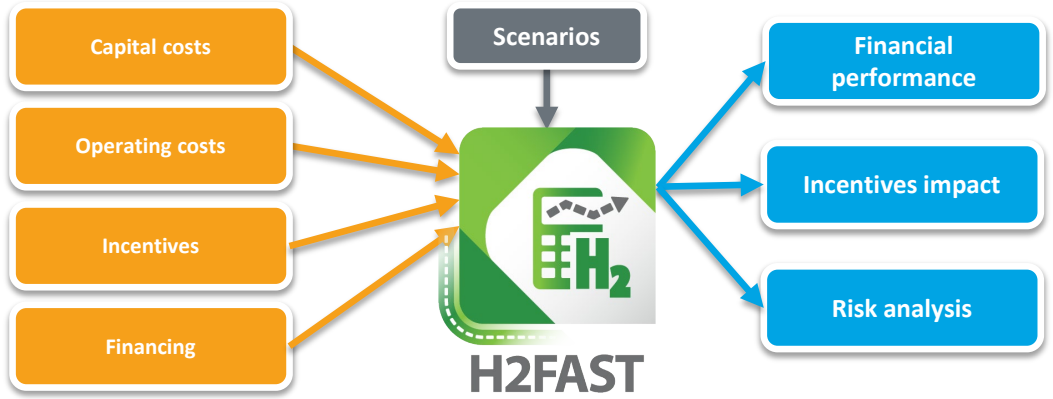
Provide flexible rigorous financial analysis for wide variety of hydrogen and non-hydrogen production and service systems.

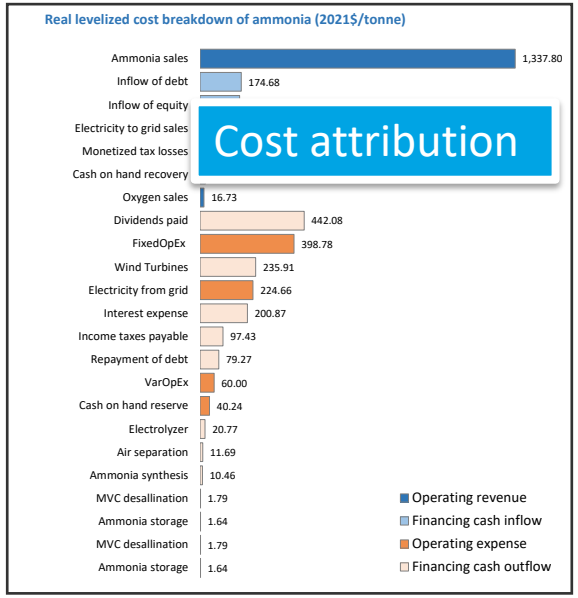
Accommodate diverse systems and services. (example past applications)

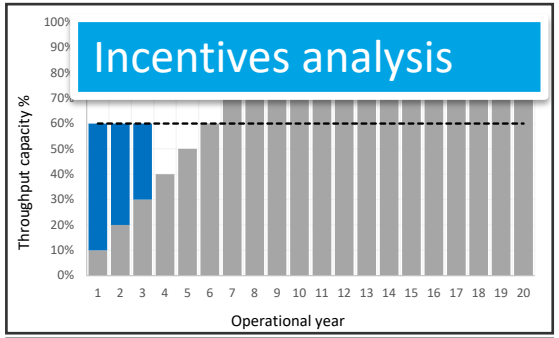
- Retail hydrogen sales
- Hydrogen production (electrolytic, fossil, biomass, others)
- Hydrogen delivery & distribution
- Ammonia production
- Methane pyrolysis
- EV charging
- Seasonal energy storage
- Fleet operations
- Combined heat and power (CHP fuel cells)

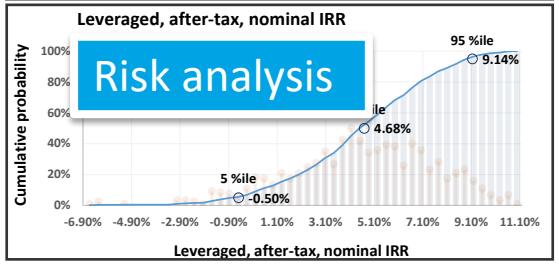
Model users

- System operators
- Government & policy makers
- Equity and debt investors
- Strategic investors (gas suppliers, utilities, car OEMs)
- Equipment manufacturers
- Academic institutions & national laboratories









Model Framework

Model computation framework: Generally Accepted Accounting Principles (GAAP)*

- ✓ **Income statement** projections (revenues, expenses, taxes)
- ✓ **Cash flow statement** projections (cash on hand, capital expenditures, financing transactions)
- ✓ **Balance sheet** projections (assets, liabilities, equity)**

Price taker & price-setting modes

- **Price taker**: user specifies a market price of commodity. Model computes financial performance.

- **Price-setting mode**: user specifies target financial performance. Model computes required price.

* Model can perform analysis compatible with International Financial Reporting Standards (IFRS)

** Model returns all project cash generated in excess of reserve requirements as “dividends” and does not speculate on treatment of any retained earnings. Users can perform their own attribution of retained earnings (e.g. dividends to share holders, reinvestment, reserves for bond repayments)

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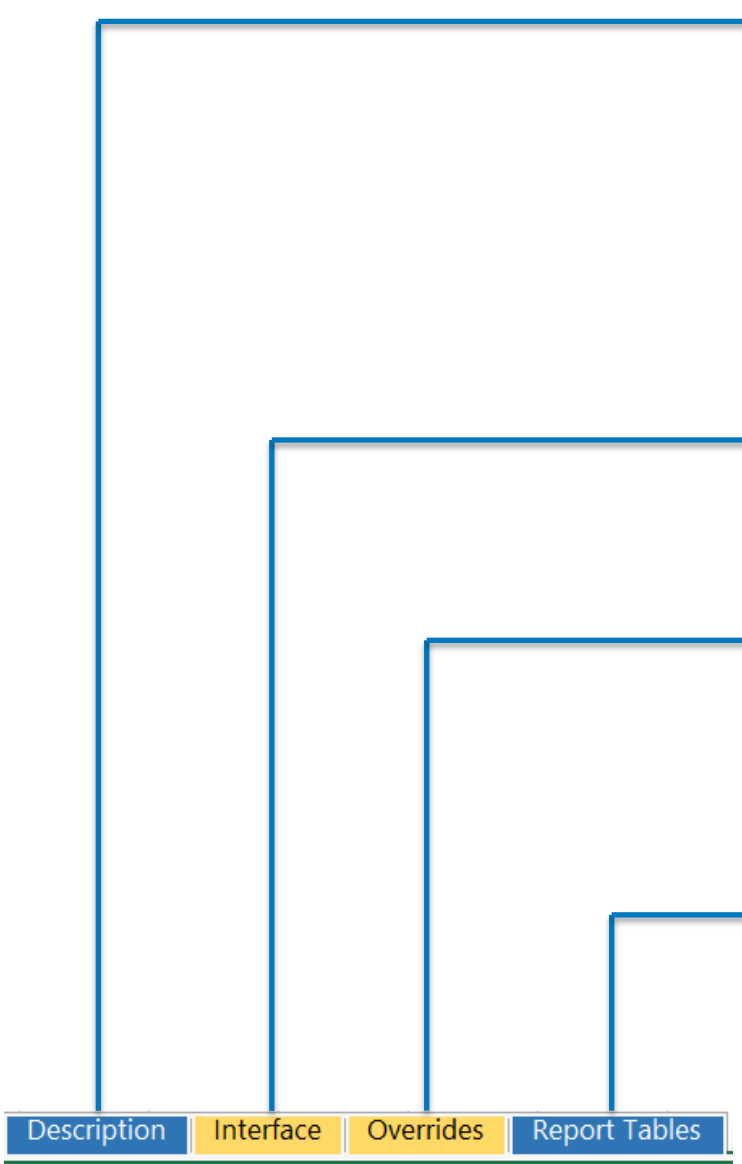
Model Tabs Descriptions



Description

- Description
- Version history
- Use agreement
- Contact info

Interface

- User inputs, scenarios, risk analysis, graphical outputs

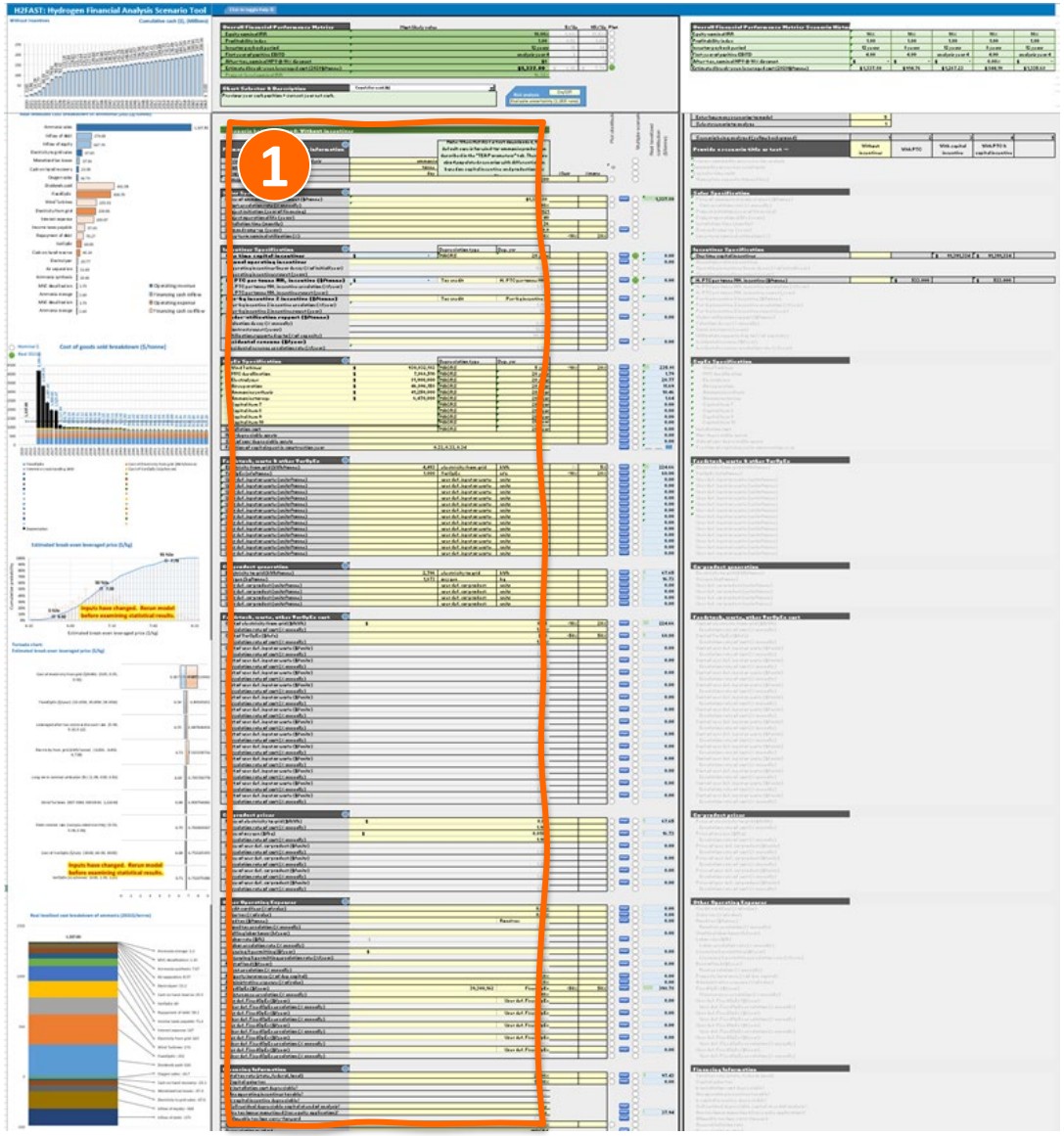
Overrides

- Custom cost and price profiles vs. calendar years
- Custom performance, sales, refurbishments by analysis year

Report Tables

- Detailed GAAP projected statements

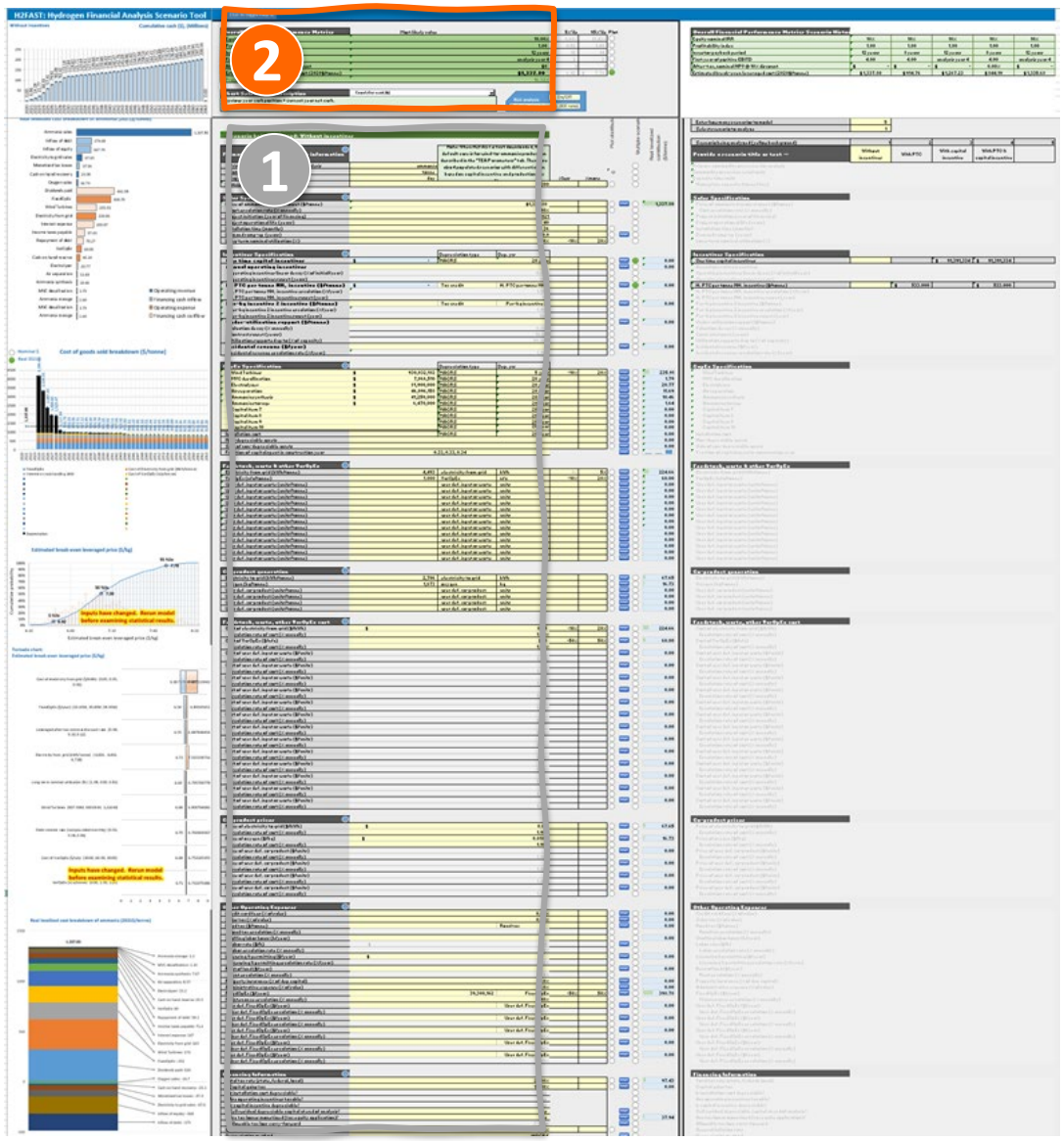
Interface Tab Organization



1 Inputs for currently analyzed scenario

1. Specify primary commodity
2. Sales specifications (price, system life, utilization)
3. Incentives specifications
4. CapEx specifications
5. Feedstock, waste streams, other VarOpEx **quantities**
6. Co-products generation **quantities**
7. Feedstock, waste streams, VarOpEx **cost** profiles
8. Co-products **price** profiles
9. Other operating expenses
10. Financing information (capital structure, taxation, liquidity)

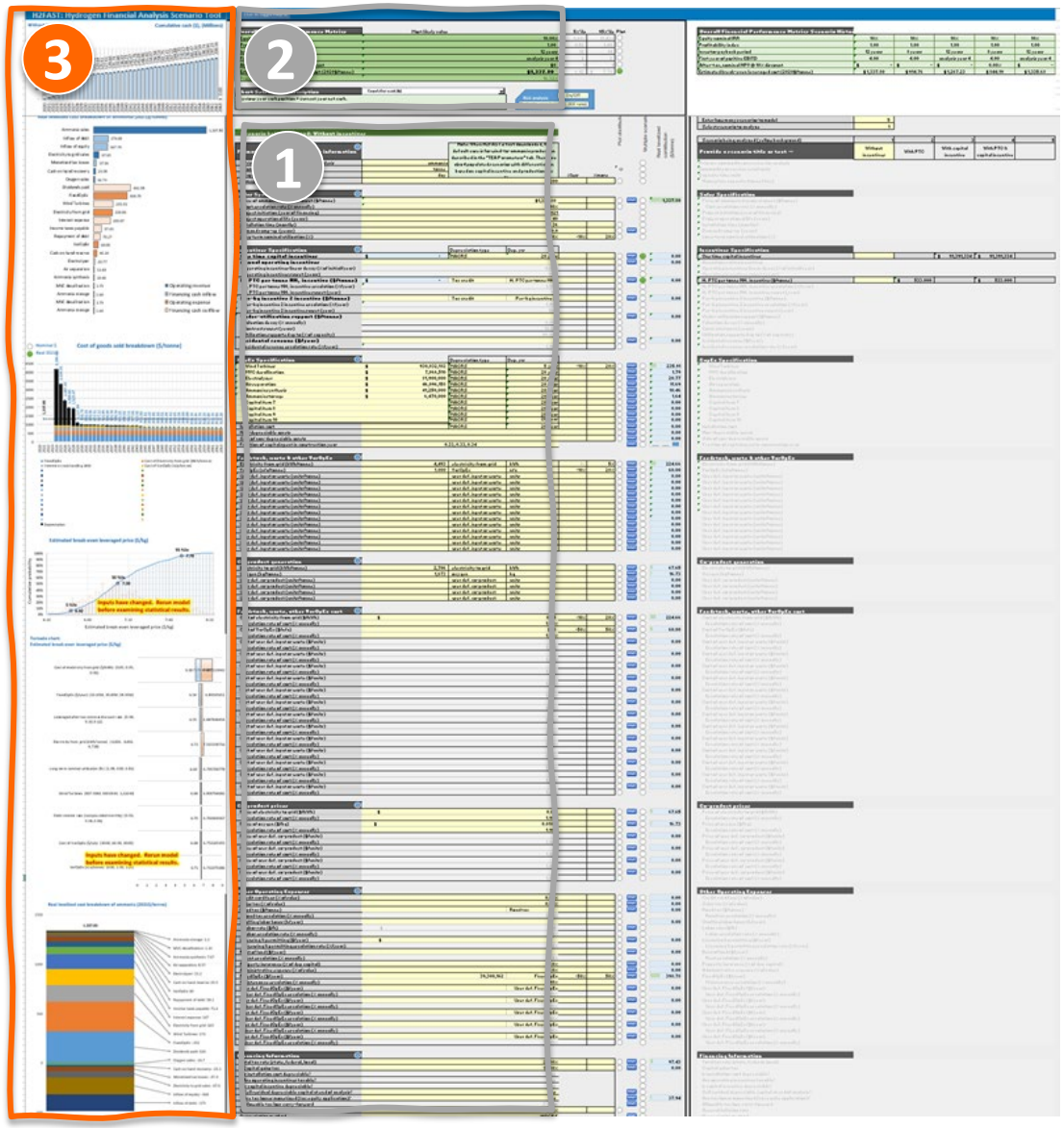
Interface Tab Organization



2 Overall financial metrics for currently analyzed scenario

1. Equity nominal IRR
    1. Note: IRR functions can have multiple results if equity cash flow is complex.
2. Profitability index
3. Investor payback
4. First year of positive earnings before interest taxes and depreciation (EBITD)
5. After-tax nominal NPV
6. Price to achieve targeted IRR
7. Project nominal level-IRR

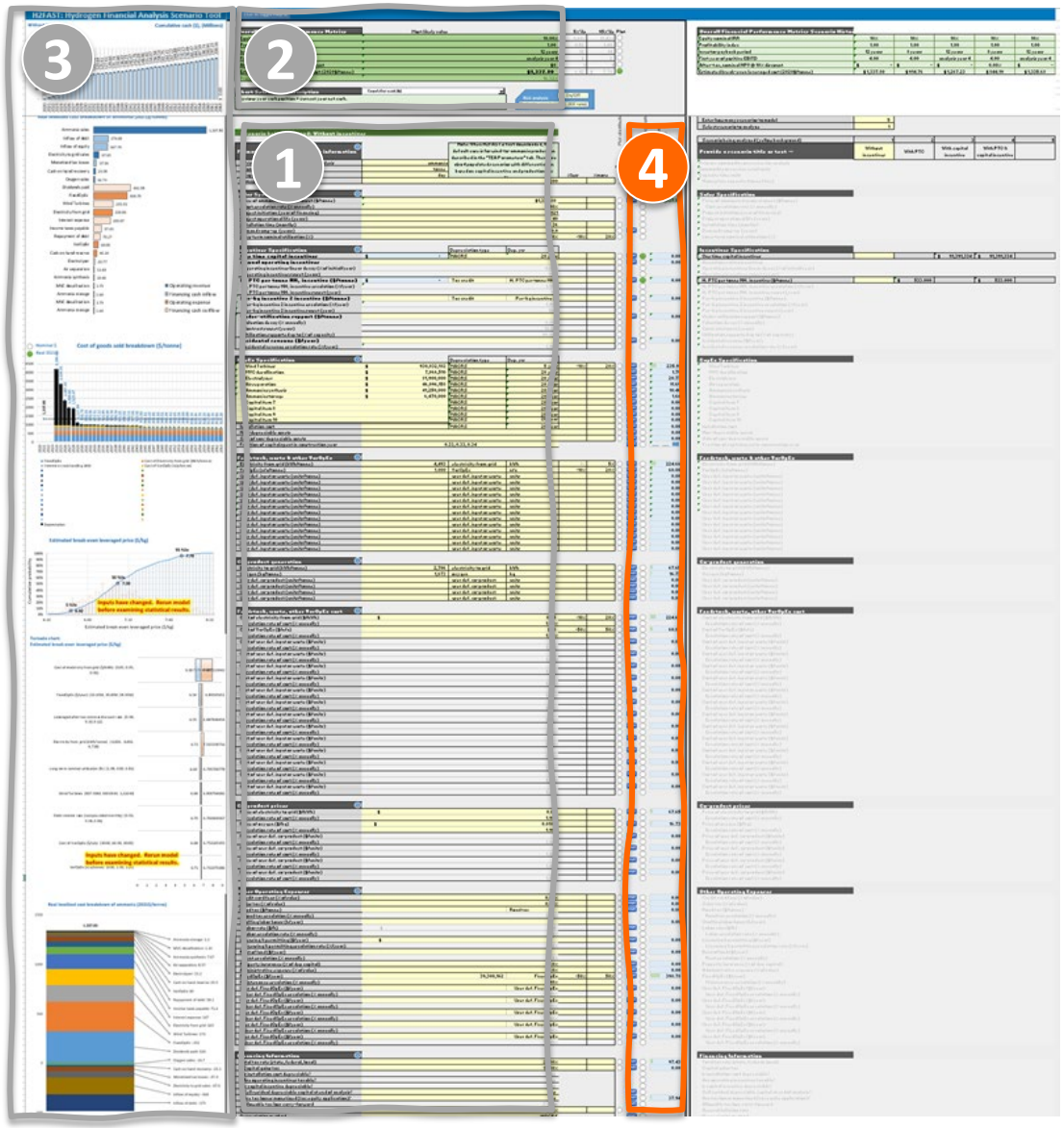
Interface Tab Organization



3 Visualizations

1. Time series of all financial parameters. User can switch among parameters to plot via drop down menu or by clicking “Plot” buttons next to input parameters.
2. Cash flows normalized to primary commodity (operating and financing cash flows)
3. Cost of goods sold (operating costs & depreciation vs. time)
4. Statistical distribution of specified input or output parameter
5. Sensitivity to single-parameter uncertainty spread (tornado chart)
6. Normalized costs to primary commodity. (cost stack-chart)

Interface Tab Organization



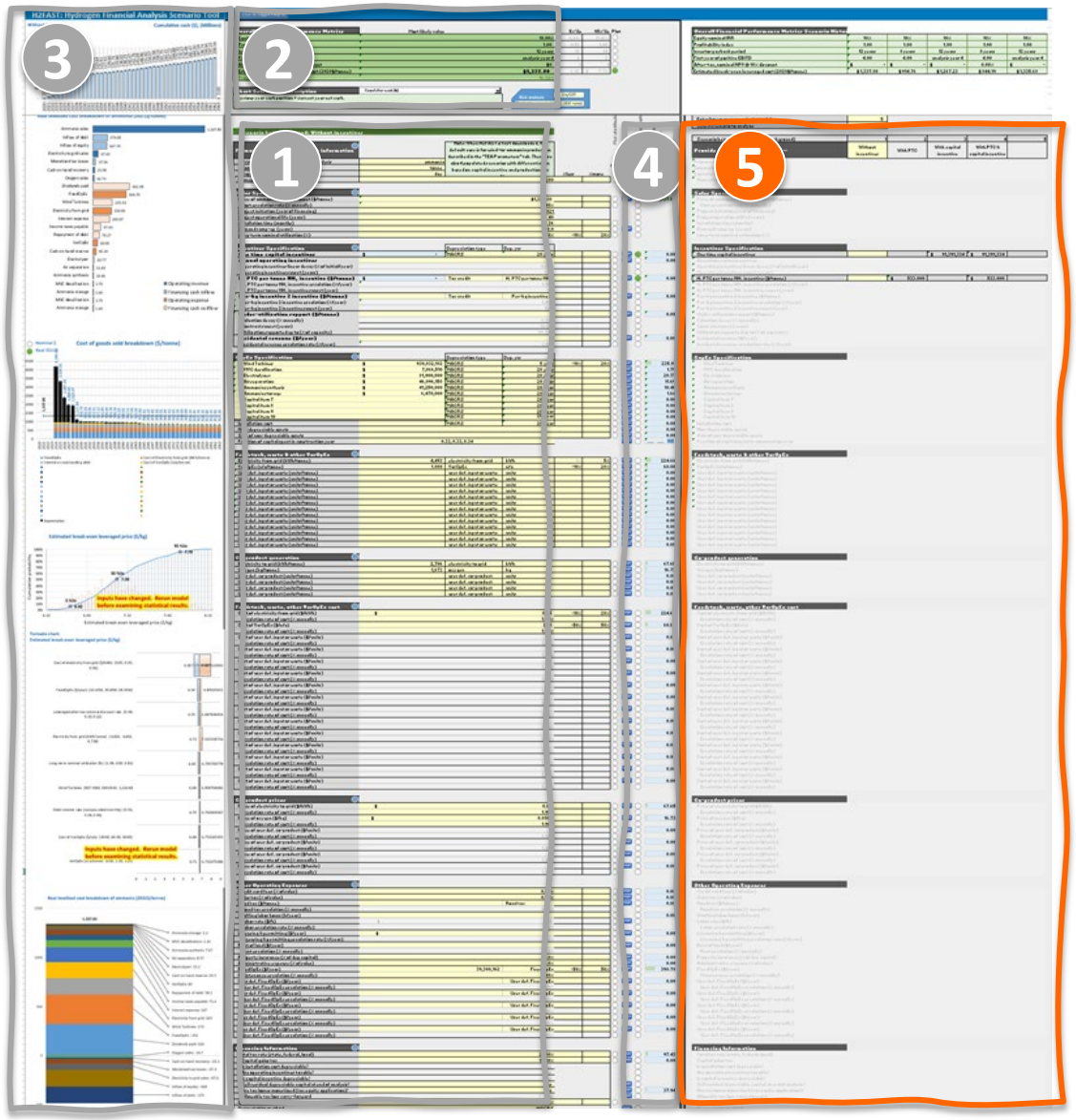
4 Scenario differentiation selectors

Specify which parameters will be different among modeled scenarios. E.g.

To model fueling stations of different nameplate capacities:

1. select nameplate capacity as a scenario differentiator (click button to highlight it as)
2. similarly, select capital cost and any other items that would change with nameplate capacity.

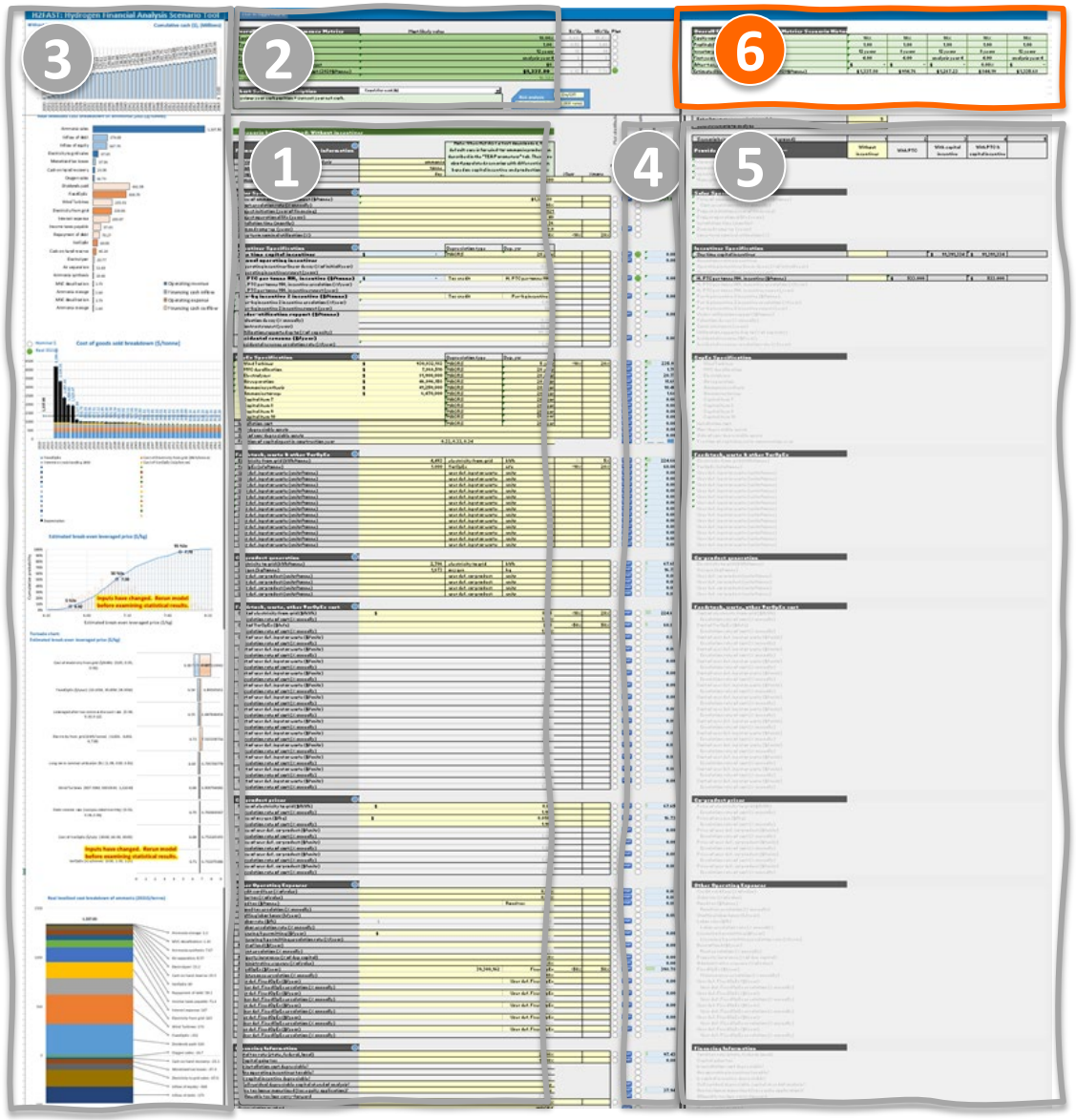
Interface Tab Organization



5 Scenario differentiation parameters

1. Select how many scenarios you would like to model
2. Arrows (⬅ ➡) let user chose scenario to analyze. Highlights scenarios in yellow.
3. Name each scenario (e.g. large station, small station)
4. Enter values for parameters that will be differentiators. (lines with selected differentiators will be highlighted)

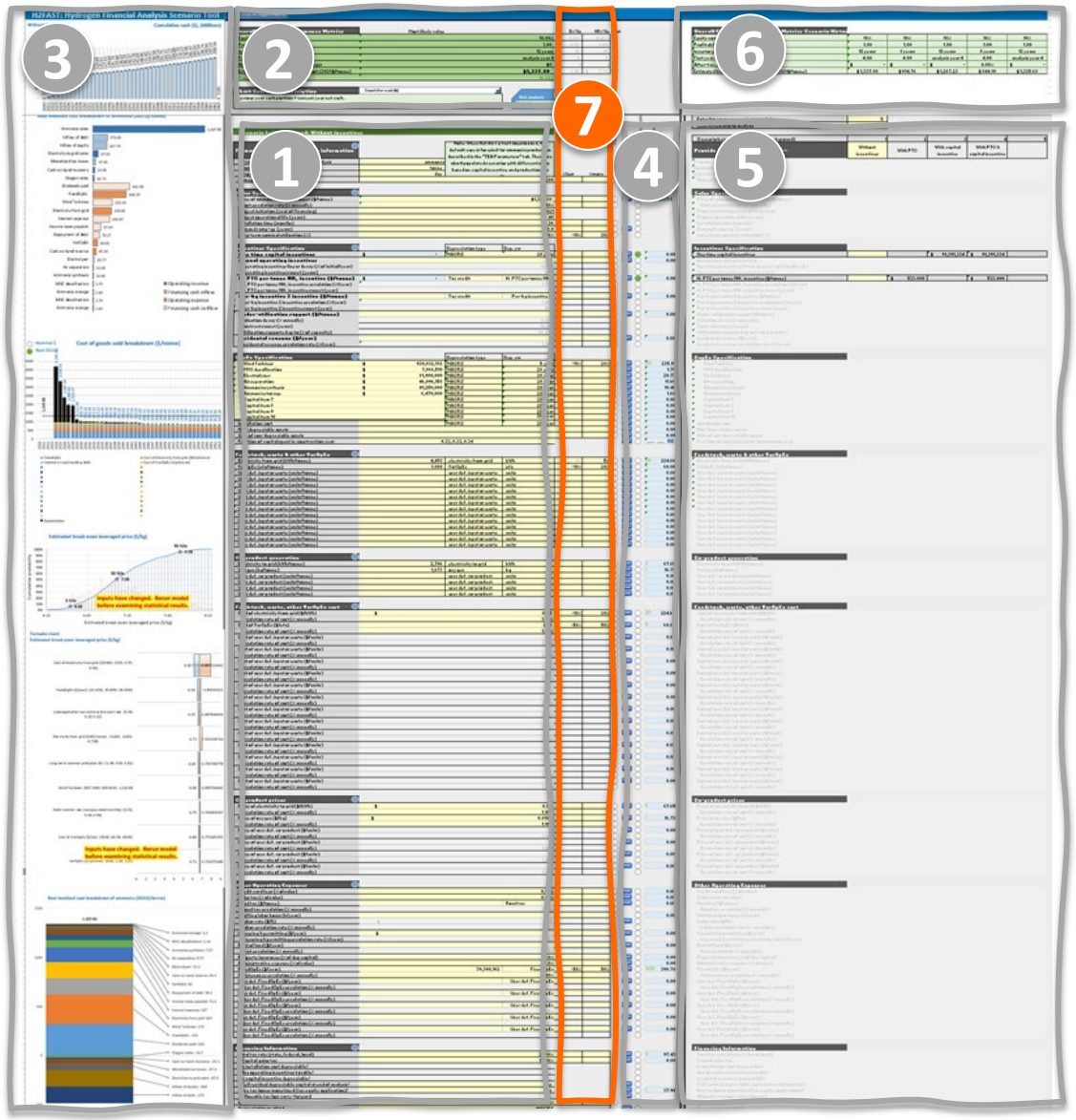
Interface Tab Organization



6 Recorded overall financial metric per scenario

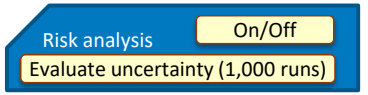
1. Financial metrics will be stored here for each scenario.
2. Recording occurs when scenario selector is moved from one scenario to another using the selector arrows (⬅ ➡).
3. Remember to refresh scenarios as needed by selecting each scenario.

Interface Tab Organization



7 Risk parameter analysis

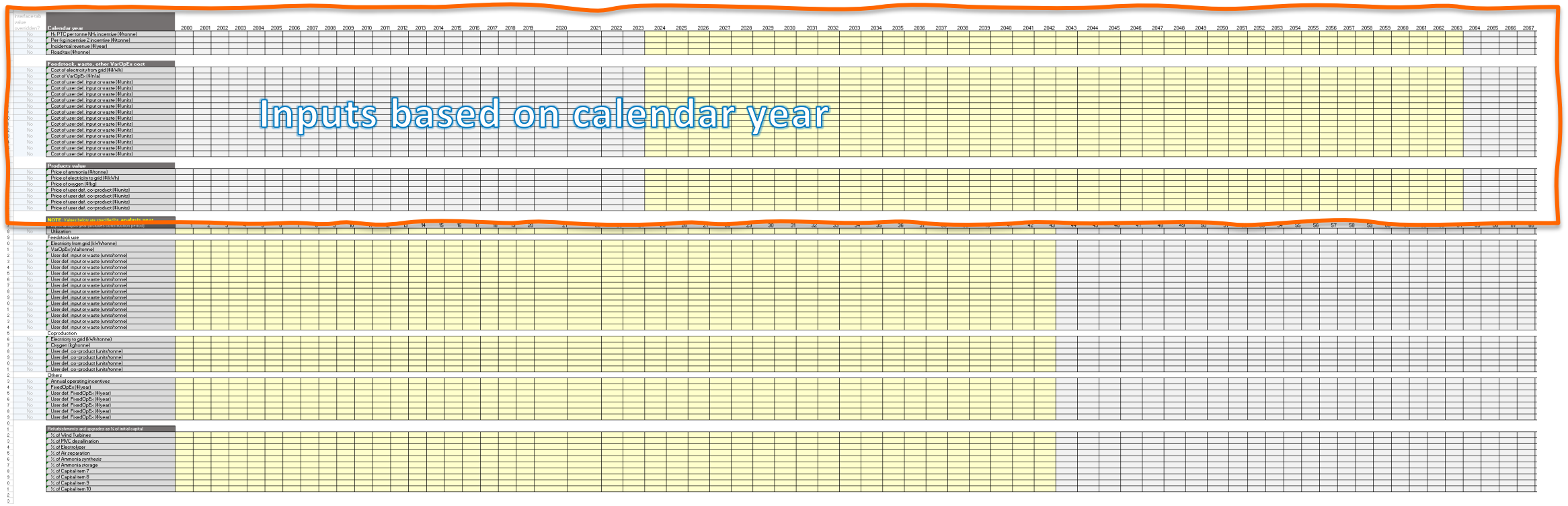
1. Activate this section by clicking the “Risk analysis On/Off” macro button.



2. Enter ranges for all parameters that are significantly uncertain. E.g. -20%, +50% CapEx. This will result in a triangular distribution with most likely value of specified CapEx.
3. Clicking “Evaluate uncertainty (1,000 runs)” macro will perform a Monte Carlo analysis. Progress of run is displayed on Excel’s status bar (lower left corner of window)
4. After completion of runs
    1. User can select plot of any input or result distribution
    2. Tornado chart will be updated for any items selected in the results (section 2)

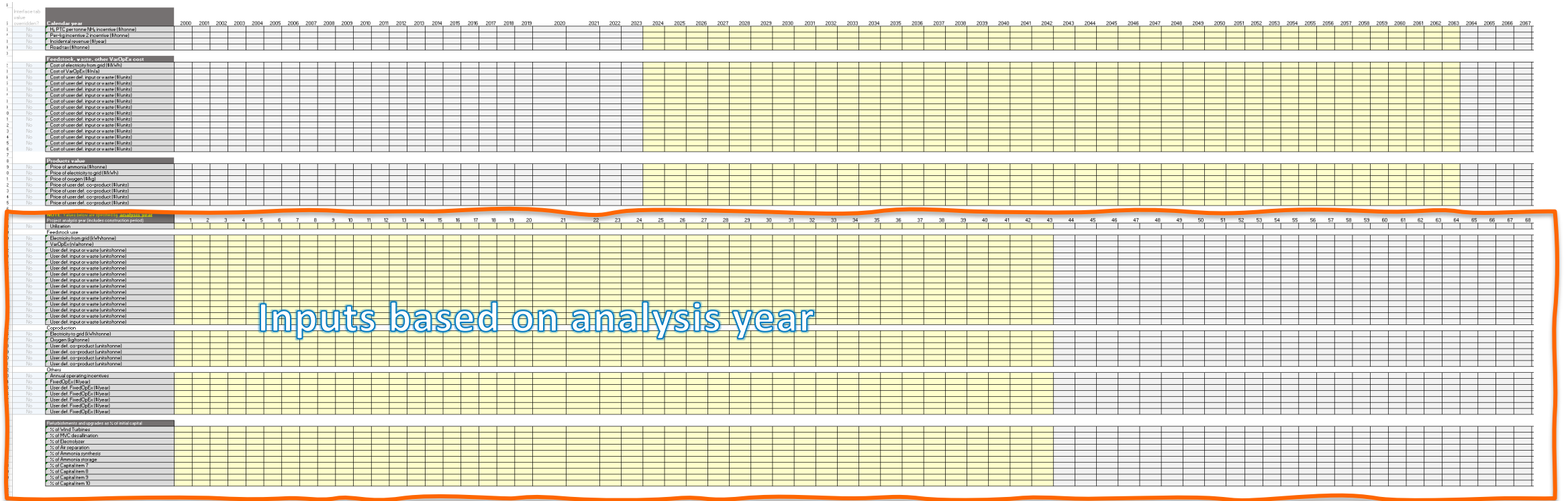
Overrides Tab Organization

- Use this section to provide calendar-year based parameters. E.g. AEO energy cost projections.
- Use nominal $
- Sections highlighted in yellow span specified analysis period
- Any inputs in this section will override corresponding inputs from the Interface tab



Overrides Tab Organization

- Use this section to provide analysis-year overrides. E.g.:
  - Capacity factor vs. year of operation
  - Feedstock consumption rate (e.g. to simulate efficiency degradation if desired)
  - CapEx expenditure for refurbishments (% of up-front capital investments)



Webinar Outline

Model purpose & framework
Layout & walkthrough
Model demonstration

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Model demonstration

Funding for H2A-Lite and H2FAST is provided by the U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO)

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H2A-Lite

https://www.nrel.gov/hydrogen/h2a-lite.html

H2FAST

https://www.nrel.gov/hydrogen/h2fast.html

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