

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).

This webinar is being recorded and will be available on the <u>H2IQ webinar archives</u>.

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Questions?

There will be a Q&A session at the end of the presentation.
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



The #H2IQ Hour Q&A

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

All (0)

✓ Q&A

Select a question and then type your answer here, There's a 256-character limit.

Send

Send Privately...

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H2A-Lite & H2FAST Model Summary and Demonstration

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Michael (Misho) Penev NREL November 3, 2022

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 NREL 1 8

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: c
- User-defined

current & future current & future

Model Differences

Dollar basis*:	H2A 2016\$	\rightarrow	H2A-Lite 2020\$
Energy & feedstock basis: Biomass cost: Renewable electricity cost:	AEO Ref. 2017 Billion-ton study N/A	\rightarrow \rightarrow \rightarrow	AEO Ref. 20 AEO bioma NREL Annu
Refurbishments schedule:	Discrete	\rightarrow	Annualized
Production incentive:	Income-basis	\rightarrow	Income or
Capital expenditure:	Scheduled	\rightarrow	Lump sum

- 022
- ass for power generation
- ual technology baseline 2022
- tax credit
 - + construction period
- * Modeling being adapted to allow for user-defined dollar year

Webinar Outline





Model purpose & framework

Layout & walkthrough

Model demonstration

Model purpose & framework Layout & walkthrough Model demonstration

Model Tab Descriptions





Energy & feedstock use	Usage per l	⟨g H₂		Select prices → (AEO 2022)	regional Ref)	US Average		wet.	energy & eedstock mpact on wice	Input Power	Input Energy	Efficiency Switch to LHV
	H2A defaul	t	User override	H2A defaul	t	User override		- U	\$/kg H ₂]	[kW HHV]	[kWh HHV/kg]	[HHV]
Electricity (Commerical)	0.000			0.115	[\$/kWh]		L'PLOT N	W24	\$ -	-		
Electricity (Industrial)	55.500	[kWh]		0.075	[\$/kWh]		L'PLOT N	wat.	\$ 3.59731	130,656	5 55.5000	
Electricity (Solar)	0.000			0.048	[\$/kWh]		VPLOT N	wet.	\$ -	-	(0
Electricity (On-shore wind)	0.000			0.034	[\$/kWh]		CHOT N	4.4		-	(0
Natural Gas (Commercial)	0.000			8.28	[\$/mmBTU]		CPLOT N	4.4	\$ -	-	-	
Natural Gas (Industrial)	0.000			4.11	[\$/mmBTU]		L'PLOT N	404	\$ -	-	-	
Biomass	0.000			52.6	[\$/s.ton]		L'ROT N	W04		-		
Coal	0.000			2.33	[\$/mmBTU]		L'PLOT N	wet	\$ -	-	100 C	
Diesel	0.000			2.94	[\$/gal]		VPLOT N	w*4	\$ -	-		
Water Total	3.780	[gal]		0.0033	[\$/gal]		KHOT N	ar4	\$ 0.03			
							To	tal:	\$ 3.62	130,656	5 55.5	71.2%



3.7%

fvears 25.74%

[\$/kg H

[years

[%/year

Tax credit 10

Real return on equit Debt/equity nterest rate

Depreciation type MACRS depreciation perior

otal income tax rate

er-kilogram incentive

Per-kilogram incentive mechanisr

Per-kilogram annual reduction %

er-kilogram incentive sunset

[Tornado chart spread of parameters ±%	± 10%	of baseline	s: Update to plot ~33
			↑ Please up	date torn
	Electricity (Industrial) cost [\$/kWh] (.068, .076, .083)	4.07	4.45	4
5. equity %	Electricity (Industrial) use [kWh/kg] (50.0, 55.5, 61.1)	4.07		4
=60%, E=40%	Utilization [%] (100%, 97%, 87%)		4.43 4.52	
	Return on equity (7%, 8%, 9%)		4.41 4.50	
	Capacity [kg/d] (62,150, 56,500, 50,850)		4.45 🔜 4.53	
	CapEx [\$] (77,846,161, 86,495,734, 95,145,308)		4.42 🛄 4.48	
	Fixed OpEx [\$/y] (3,874,553, 4,305,059, 4,735,565)		4.43 📗 4.47	
	System life [y] (44, 40, 36)		4.44 📗 4.47	
	Interest rate [%] (3.33%, 3.70%, 4.07%)		4.44 📗 4.46	
	Debt/equity		4.44 4.46	

Middle Atlantic East South Centra East North Centra South Atlantic

est North Centr

New England Mountain

	H2A-Lite: Hydrogen Analysis - Lite	Real levelized cost →	4.45 [2020\$/kg H₂]	IL'PLOT
)	Select H₂ production technology pathway → Lenam Calification Califica			
	Description: The modeled system is a standalone grid powered PEM electrolyzer system with a total hydrogen production capacity of 50,000 kg/day. The production system is b key industry collaborators (KIC) with commercial experience in PEM electrolysis and brief system and subsystem technoeconomic models, the electrolyzer units use process w electricity for electrolysis	ased on a generic s ater, passed throug	ystem using input from h deionizing beds, and	several grid

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

of H₂

H ² Hydrogen Analysis -	Lite				R	eat levelized ost →	4.45 [2020\$/kg H ₂]	1 KP107
				Central Grid Electrolysis (PEM)				
modeled system is a standalone gr	id powered PEM electroly	x Sote No swith a total hv	drogen production capacity	of 50,000 kg/day. The production s	ystem is based	on a generic sv	stem using input f	rom several
key manager collaborators (KIC) with commercial ex	perience in PEM electroly	sis and brief system and s	ubsystem technoeconomic	models, the electrolyzer units use	process water,	passed through	deionizing beds,	and grid
	H2A default &	B Enter user overrides		Real levelized cost breakdow	m of hydrogen (3	2020\$/kg)		
(2)	estimates	in yellow cells	Valid capacity range:	Hydrogen sales				4.45
Jear	56,500	2015	1,095 to 50,500 [kg/d]	Inflow of debt	0.06			
Technology estimation			Normalized CapEx	Cash on hand recovery	0.01			
Total installed capital cost [2020\$]	\$ 86,495,734		1,531 [\$/kg-day]	Electricity (Industrial) Dividends paid	0.33		3.60	
Variable OpEx (2020\$/kg H ₂]	\$ 4,305,059 \$ 0.024		002 [\$/kW]	FixedOpEx Installed capital	0.22			
System life [years] Utilization [%]	40		Production rate 54,805 [kø/d]	Interest expense	0.10			
Pofurbichmonte & confacemente				Annualized replacements	0.09		Operating re	venue
Annualized replacement costs [2020\$/year]	1,545,228			Repayment of debt Water	0.06		Financing cas	sh inflow
Replacements interval (years) Replacements (% of installed CapEx)			4 PLOT	VarOpEx Cash on hand reserve	0.02		Operating ex Financing case	sh outflow
				Energy	y∝ ⊏			
Energy & feedstock use	Usage per kg H₂		verect regional prices →	US Average feeds	tock t on	Input Power	Input Energy	Efficiency
	H2A default	User override	(AEO 2022 Ref) H2A default	User override	1,1	[kW HHV]	[kWh HHV/kg]	Switch to LHV [HHV]
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Water Total	3.780 [gal]		0.0033 [\$/gal]	CROT Wet \$	0.03			
				Total: \$	3.62	130,656	55.5	71.2%
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MACRS depreciation period Total income tax rate	20 [years]		1PL07	кеturn on eq (7%, 8%, 99	6)		4.41 4.50	
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Per-kilogram incentive sunset	10 [years]			(3,874,553, 4,305,059, 4,735,5	565)		4.43 📗 4.47	
Capital incentive or investment tax credit	0.0% [% of CapEx]			System life (44, 40, 3	= [y] 36)		4.44 📗 4.47	
				Interest rate [%	1			

(3.33%, 3.70%, 4.07%

(1 65 1 50 1 35

4.44 4.46

	Analysis inputs	H2A default & estimates	Enter user overrides in yellow cells	Valid capacity range:
2	Specify production nameplate capacity [kg/d]	56,500		1,695 to 56,500 [kg/d]
	Desired startup year		2015	

- 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

H ² Hydrogen Analysis	- Lite					Real levelized	4.45 [2020\$/kg H ₂]	L'PLOT
						cost 7		
→ Biomass Cost+CC3 Gr	K HEM Solar PEM Wind P			Central Grid Electro				
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key interest collaborators (KIC) with commercial e	experience in PEM electrol	ysis and brief system and s	ubsystem technoeconomi	c models, the electrol	lyzer units use proce	ss water, passed throi	ugh deionizing beds, and	d grid
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				Real Javaliza	d cort braakdown of b	udrogen (2020\$ /kg)		
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feel ination	C 05 405 724		Normalized CapEx	Electric	city (Industrial)		3.60	
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20\$/kg H ₂]	\$ 0.024				FixedOpEx 0.	22		
rs]	40		Production rate	Int	terest expense 0.1	- 0		
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Electricity (Commercial) Electricity (Industrial) Electricity (Solar) Electricity (Solar) Electricity (Onkore wind) Natural Gas (Commercial) Natural Gas (Industrial) Biomass Coal Desel Used Industrial Interesting Solar Select filancial Interesting Solar Comudivis investor cash flow	H2A default 0.000 IXWnij 55.500 IXWnij 0.000 IxWnij	User override	(JEO 2022 Ref) H2A default 0.113 (S/KWh) 0.073 (S/KWh) 0.048	User override	Impact on protection Impact on USAG (Fs) R2 (R4) 5 R4 (R4) 5 <td>(kW HHV 130,6 03 03 130,6</td> <td>Impacting Impacting 1 [kWh HHV/kg] 56 55.5 56 55.5</td> <td>0 0 71.2%</td>	(kW HHV 130,6 03 03 130,6	Impacting Impacting 1 [kWh HHV/kg] 56 55.5 56 55.5	0 0 71.2%
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Electricity (Commercial) Electricity (Commercial) Electricity (Color) Electricity (Col	H2A default 2000 Ekkhol 5.500 Ekkhol 2.000 Ekkhol 2.00	User override	(AEC 3022 Ref) H2A default 0.115 (S/AWh 0.016 (S/AWh 0.034 (S/AWh 0.034 (S/AWh 0.034 (S/AWh 0.034 (S/AWh 0.034 (S/AWh 0.033 (S/AWh 0.033 (S/gal 0.0033 (S/gal 0.0033 (S/gal	Selected region 9 Packic 5 Selected region 9 Packic 5 Selected region 9 Packic 5 Selected region 9 Packic	empation impact on rescal rescal rescal s	21 130.6 32 130.6 33 130.6 34 130.6 35 130.6 36 130.6 36 130.6 37 130.6 38 130	Imposition Imposit	0 0 0 71.2%
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Electricity (Commercial) Electricity (Industrial) Electricity (Industrial) Electricity (Industrial) Electricity (Industrial) Biomass Cond Desel Water Total Select financial time series to plot Consult in the series to plot Series in the series to plot Consult in the series to plot Series in the series to plot	H2A default 0.000 15km/n 0.000 16km/n 6.000 16km/n 0.000 16km/n 6.000 16km/n 0.000 16km/n 0.000 16km/n 0.000 16km/n 1000 15km/n 0.000 [smmB1U] 0.000 [smmB1U] 0.000 [smmB1U] [smmB1U] 0.000 0.000 [smmB1U] [smmB1U] 0.000 0.000 [smmB1U] [smmB1U] 0.000 0.000 [smmB1U] [smmB1U] 0.000 0.000 [smmB1U] [smmB1U] <t< td=""><td>User override</td><td>(AE3 2022 kef) 12.0 default 12.0 default 0.075 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.034 (\$/kmBTU 2.2.6 (\$/k100 2.33 (\$/kmBTU 2.34 (\$/gail 0.0033 (\$/gail 0.0033 (\$/gail 0.0033 (\$/gail</td><td>Selected region 9 9 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9</td><td>mpact on result impact on result non exact (Ling 1/1) impact on result no exact (Ling 1/1) imp</td><td>271 130,6</td><td>6 53.50 6 53.50 7 10 10 10 10 10 10 10 10 10 10 10 10 10</td><td>Content of the second s</td></t<>	User override	(AE3 2022 kef) 12.0 default 12.0 default 0.075 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.034 (\$/kmBTU 2.2.6 (\$/k100 2.33 (\$/kmBTU 2.34 (\$/gail 0.0033 (\$/gail 0.0033 (\$/gail 0.0033 (\$/gail	Selected region 9 9 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	mpact on result impact on result non exact (Ling 1/1) impact on result no exact (Ling 1/1) imp	271 130,6	6 53.50 6 53.50 7 10 10 10 10 10 10 10 10 10 10 10 10 10	Content of the second s
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Electricity (Commercial) Electricity (Commercial) Electricity (Iodustrial) Electricity (Iodustrial) Electricity (Iodustrial) Biomass Coal Desel Water Total Select financial time series to plot Comulative investor cash flow	H2A default 0.000 likknih 0.000 likknih likknih	User override stor cash flow, (Millions stor cash flow, (Millions 1997 - 199	(AE3 2022 Bef) 12.3 default 12.3 default 0.075 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.034 (\$/kmBTU 2.38 (\$/mmBTU 2.34 (\$/stall 0.0033 (\$/gall 0.0033	Selected region Selected region Selected region Selected region Selected region Turnado chart se	mact of parameters:			and the forward of th
Electricity (Commercial) Electricity (Commercial) Electricity (Commercial) Electricity (Commercial) Natural Gas (Commercial) Natural Gas (Commercial) Contential Select financial time series to plot Currulative investor cuth flow	H2A default 0.000 1.84m0 0.000 1.84m0	Uner override	[AE3 2022 Ae7] H23 default 0.075 [S/Av0] 0.078 [S/Av0] 0.038 [S/Av0] 0.038 [S/Av0] 0.034 [S/Av0] 2.38 [S/AmnBTU] 2.34 [S/AmnBTU] 3.34 [S/AmnBTU] 3.3	Selected region	essa impact on response of the second of parameters	(kW HH) 133 5 130 5 1	0 0	The second

Debt %, equity %

fvears

25.749

[\$/kg H

[%/yea

D=60%, E=40%

Real return on equit

Depreciation type

otal income tax rate

MACRS depreciation perio

er-kilogram incentive mechanis

er-kilogram incentive sunset er-kilogram annual reduction %

Debt/equity

nterest rate

(.068..076..083)

Electricity (Industrial) use [kWh/kg (50.0, 55.5, 61.1)

Utilization [9

(100%, 97%, 87%

Peturn on equity

(7%, 8%, 9%

Capacity [kg/d]

(3.33%, 3.70%, 4.07% Debt/equity

(1 65 1 50 1 35

(62,150, 56,500, 50,850

(77 846 161 86 495 734 95 145 308

Fixed OpEx [S/v]

(3,874,553, 4,305,059, 4,735,565)

4.43 📗 4.52

4.41 4.50

4.45 4.53

4.42 🚺 4.48

4.43 📗 4.47

4.44 📗 4.47

4.44 4.46

4.44 4.46

Technology estimation		Normalized Cap	Ex
Total installed capital cost [2020\$]	\$ 86,495,734	1,531 [\$	\$/kg-day
Fixed OpEx w/o replacements [2020\$/year]	\$ 4,305,059	662	[\$/kW
Variable OpEx [2020\$/kg H₂]	\$ 0.024		
System life [years]	40	Production rate	
Utilization [%]	97%	54,805	[kg/d

- Technology CapEx, OpEx, Life, Utilization
 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



(1.65, 1.50, 1.35

efurbishments & replacements		
Annualized replacement costs [2020\$/year]	1,545,228	
Replacements interval (years)		
Replacements (% of installed CapEx)		

Refurbishments & Replacements H2A values for refurbishments are 1 annualized.

- 2. User can override annualized value or explicit replacement intervals and % of CapEx spent in each refurbishment event.
- 3. Click " \checkmark 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.

H ² Hydrogen Analysis	- Lite					Rear revelized cost →	4.45 [2020\$/kg H ₂	:] <u>veor</u>
				Central Grid Electrolysis (PEM)			
modeled system is a standalone gr key meaning collaborators (KIC) with commercial ex-	rid powered PEM electr sperience in PEM electr	olyzer system with a total h olysis and brief system and	ydrogen production capacity subsystem technoeconomic	y of 50,000 kg/day. The produ models, the electrolyzer un	uction system is b ilts use process w	- based on a generic sy vater, passed through	stem using input i deionizing beds,	from several and grid
electricity for electrolysis								
				Real levelized cost b	reakdown of hydro	ogen (2020\$/kg)		
	H2A default & estimates	Enter user overrides in yellow cells	Valid capacity range:	Hydroge	n sales			4.45
ear [kg/d]	56,50	2015	1,695 to 56,500 [kg/d]	Inflow of Inflow of	equity 0.10 of debt 0.06			
				Monetized tax	losses 0.01			
Tech mation	\$ 86.495.73	24	Normalized CapEx	Electricity (Inde	ustrial)		3.60	
placements [2020\$/year]	\$ 4,305,05	59	662 [\$/kW]	Dividenc	is paid 📃 0.33			
20\$/kg H ₂]		24		Installed	capital 0.11			
[LINE S]	0		Production rate	Interest ex	ipense 📋 0.10			
orman and o			(Ng/u)	Income taxes p Annualized replace	ayable 0.09			
P replacements				Repayment o	f debt 0.06		Financing ra	sh inflow
ement costs [2020\$/year]	1,545,22	28	_		Water 0.03		Operating c	roense
erval (years)			4 PLOT	Va Cash on hand r	rOpEx 0.02		Financing ca	sh outflow
	_			1	10.01			
					Energy &			
			Select regional		feedstock			
Ep tk use	Usage per kg H₂		Select regional prices →	US Average	feedstock impact on	Input Power	Input Energy	Efficiency
Er C kuse	Usage per kg H ₂	Liser override	Select regional prices → [AEO 2022 Ref]	US Average	feedstock impact on price	Input Power	Input Energy	Efficiency Switch to LHV
En 5 kuse	Usage per kg H ₂ H2A default 0.000 [kW	User override	Select regional prices → (AEO 2022 Ref) H2A default 0.115 [\$/kWh]	US Average User override	feedstock impact on nrice [\$/kg H ₂] \$	Input Power	Input Energy [kWh HHV/kg]	Efficiency Switch to UV [HHV]
En Stricel	Usage per kg H ₂ H2A default 0.000 [kW 55.500 [kW	User override /h]	③ Select regional prices → [AEO 2022 Ref] 12A default 0.115 [\$/kWh] 0.075 [\$/kWh]	US Average	feedstock impact on srice [\$/kg H ₂] \$ \$ 3.59731	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] - 55.5000	Efficiency Switch to LHV [HHV]
to tuse encal) Electrotry (Solar) Electrotry (Solar)	Usage per kg H ₂ H2A default 0.000 [kW 55.500 [kW 0.000 [kW	User override /h] /h]	 Select regional prices → [AEO 2022 Ref] H2A default 0.115 [\$/kWh] 0.075 [\$/kWh] 0.048 [\$/kWh] 0.048 [\$/kWh] 	US Average	feedstock impact on [\$/kg H ₂] \$ \$ 3.59731 \$	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 55.5000	Efficiency Switch to LHV [HHV] 0
Electricaty (Solar) Electricaty (Solar) Electricaty (Solar) Electricaty (Construction) Natural (Sac Commercial)	Usage per kg H ₂ H2A default 0.000 [kW 55.500 [kW 0.000 [kW 0.000 [kW	User override /h) /h) /h	Select regional prices → (AEO 2022 Ref) H2A default 0.115 [\$/kWh] 0.075 [\$/kWh] 0.048 [\$/kWh] 0.034 [\$/kWh] 8.28 [\$/mmBTU]	US Average User override creat week creat week creat week creat week	feedstock Impact on refere [5/kg H_] \$ \$ 3.59731 \$ \$ \$ \$ \$	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 55.5000 0	Efficiency Switch to UN [HHV] 0 0
trop tuse trop trial tereformersial tereformersial Teleformersial Natural Gas (commercial) Natural Gas (commercial)	Usage per kg H ₂ H2A default 0.000 [kW 55.500 [kW 0.000 [kW 0.000 [mmBT 0.000 [mmBT	User override mi mi mi mi mi u U U U	 O Select regional prices → ACO 2022 Ref) H2A default 0.115 (\$/kWh) 0.075 (\$/kWh) 0.048 (\$/kWh) 0.034 (\$/kWh) 0.034 (\$/kWh) 0.034 (\$/kWh) 4.11 (\$/mm8TU) 	US Average User override v.rar (we) v.rar (we) v.rar (we) v.rar (we) v.rar (we) v.rar (we) v.rar (we) v.rar (we)	feedstock impact on nrice [\$/kg H_] \$ - \$ 3.59731 \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ -	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 55.5000 0 -	Efficiency Switch to UVV [HHV] 0 0
trong (Silay) Encina (Silay) Encina (Silay) Encircia (Commercial) Natural Gas (Industrial) Biomass	Usage per kg H ₂ H2A default 0.000 [kW 0.000 [kW 0.000 [kW 0.000 [mmBT 0.000 [mmBT 0.000 [ster	User override (h) (h) (h) (h) (h) (h) (h) (h)	Select regional prices > IAEO 2022 Ref) IAEO 2022 Ref) IAEO 2022 Ref) ISA default 0.115 0.075 [S/kWh] 0.084 [S/kWh] 0.035 [S/kWh] 0.24 [S/kWh] 8.28 [S/mmBTU] 3.11 [S/s.ton] a 20 [S/s.ton]	US Average vor: User override var word var var var var var var var var var var var var var var var	feedstock impact on orice [5/kg H_] S - S - S - S - S - S - S - S - S - S -	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 55.5000 0 0	Efficiency Switch to LW [HHV] 0 0
ture Electricity (Solar) Electricity (Solar) Ele	Usage per kg H ₂ H2A default 0.000 [kW 55.500 [kW 0.000 [kW 0.000 [mmBT 0.000 [mmBT 0.000 [stc 0.000 [mmBT	User override //n /n /n /n /0 /0 /0 /0 /0 /0 /0 /0 /0 /0	O Select regional prices > +2A default 0.115 0.075 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh] 8.28 (\$/mmBTU] 52.6 (\$/stamBTU] 2.33 (\$/mmBTU] 2.94	User override var var var var var var	feedstock impact on ncice [\$Kkg H_] \$ 3.59731 \$ - \$ - \$ - \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$ \$ - \$	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 0 0 - -	Efficiency Switch to LWV [HHV] 0 0
Enconstruction Electrical (construction) Natural Gas (construction) Natural Gas (construction) Natural Gas (construction) Biomass Coal Diesel Water Total	Usage per kg H, H2A default 0.000 [kW, 55.500 [kW, 0.000 [kW, 0.000 [mmBT 0.000 [stc 0.000 [stc 0.000 [stc 0.000 [stc 0.000 [stc	User override (h) (h) (h) (h) (h) (h) (h) (h)	Select regional prices > AEO 2022 Ref) 42A default 0.115 [\$/kwh] 0.075 [\$/kwh] 0.048 [\$/kwh] 0.048 [\$/kwh] 0.34 [\$/kmBTU] 4.11 [\$/mmBTU] 2.3 [\$/mmBTU] 0.0033 [\$/ginmBTU] 0.0033 [\$/ginmBTU]	USer override User override 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02	feedstock impact on ncice [\$/kg H_] \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ -	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Efficiency Switch to UV [HHV] 0 0
Encode de la construit de la c	Usage per kg H ₃ H2A default 0.000 [kW 55.500 [kW 0.000 [kW 0.000 [kW 0.000 [kW 0.000 [kW 0.000 [k] 0.000 [stat 0.000 [stat 0.000 [stat 0.000 [stat 0.000 [stat 0.000 [stat]]	User override 707 707 707 707 707 707 707 70	Select regional prices > AEO 2022 Ref) 72A default 0.115 0.75 15/Xvh) 0.048 15/Xvh) 0.048 15/Xvh) 0.048 15/Xvh) 0.034 15/Xvh) 2.23 12/3 2.34 12/3 0.0033 15/gal	US Average User override Construction Constr	feedstock impact on inica [\$/kg H_] \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ -	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Efficiency Switch to UV [HHV] 0 0 0
Electricity (no.shore wind) Electricity (no.shore wind) Natural Gas (Commercial) Natural Gas (Commercial) Natural Gas (Commercial) Water Total	Usage per kg H, H2A default 0.000 [KW 55.500 [kW 0.000 [kW 0.000 [mmB] 0.000 [mmB] 0.000 [mmB] 0.000 [s.tc 0.000 [s.tc 0.000 [s.tc 0.000 [s] 3.780 [g	User override m m m U U U U U U U U U U U U U	Select regional prices -> AEO 2022 Ref) 242 default 0.115 15 (\$/kvh) 0.075 0.048 0.57 0.404 0.15 15 (\$/kvh) 0.034 52.6 15 (\$/kvh) 0.33 2.34 0.0033 5/gal	US Average User override 000 000 000 000 000 000 000 000 000 00	feedstock impact on inice [\$/kg H_] \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ -	Input Power [kW HHV] 130,656	Input Energy [kWh HHV/kg] 0 0 0 0 0 0 0 0 0 55.5000	Efficiency (see the LMV) [HHV] 0 0 0 71.2%
Encode Section 2015 Control 201	Usage per kg Ha H2A default 55.560 [kW 6.000 [k] 9.780 [g	User override fin fin fin fin fin fin fin fin	Select regional prices -9 AEO 2022 Ref. 72A default 0.115 152A default 0.075 157K04 0.048 157K04 0.048 157K04 0.034 157K04 0.034 157K04 2.33 157K01 0.0033 157gal	US Average User override Construction Constr	Feedstock impact on <u>value</u> [\$/kg H.] \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ - \$ -	Input Power [kW HHJ] 130,656 130,656	Input Energy (kWh HHV/kg) 55,5000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Efficiency setono.the [HHV] 0 0 0 0 71.2%
to buse busices of the series	Usage per kg H, H2A default 0.000 [KW0 0.000 [KW0 0.000 [KW1 0.000 [KW1 0.000 [KW1 0.000 [FmmBT 0.000 [FmBT 0.000	User override 00 00 00 00 00 00 00 00 00 0	Select regional prices -9 AEO 2022 Ref) H2A default 0.115 (5/kwh) 0.075 (5/kwh) 0.048 (5/kwh) 0.048 (5/kwh) 0.048 (5/kwh) 8.28 (5/km8TU) 2.33 (5/mm8TU) 2.33 (5/gal) 0.0033 (5/gal)	US Average User override User override User override User override User override User override User over over over over over User over over over over over over over ov	Feedstock impact on <u>wice</u> [5/kg H.] S - S - S - S - S - S - S - S - S - S -	Input Power [kW HHV] 130,656 130,656	Input Energy [kWh HHV/kg] 55.5000 0 	Efficiency Serbins UN [HHV] 0 0 0 0 71.2%
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Electricity (Solar) Electricity (Solar) Electricity (Solar) Electricity (Solar) Electricity (Solar) Electricity (Solar) Electricity (Solar) Disease Vater Total	Usage per kg Ha H2A default 53.560 [CW 5.560 [CW 5.000 [CW 0.000 [CW 0.000 [CW 10.000 [C	User override	Select regional prices -9 Acto 2022 Ref) 425 4022 Ref) 424 default 0.115 15/KVM) 0.048 15/KVM) 0.048 15/KVM) 0.048 15/KVM 2.28 15/mm810 2.33 15/mm810 2.34 15/mm81 2.34 2.3	US Average User override Construction Constr	FeedStock impact on islea 5 -	Input Power [kW HHV] 130,656 130,656	Input Energy [kWh HHV/kg] 55.500 0 	Efficiency Serbin UK (HHV) 0 0 0 0 71.2%
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ture ture ture ture ture ture ture ture	Usage per kg H, H2A default 3.000 [kww 3.000 [kww] 3.000 [kww 3.000 [kww] 3.000 [kww] 3.00	User override	Select regional prices -9 AEC 2022 Ref. 72A default 0.115 152A default 0.075 152A default 0.075 157A default 10000 0.034 157/mmBTU 2.34 157/gall 0.0033 157/gall 1	US Average User override User override User override Core	FeedStock impact on 1964 3	Input Power [kW HHV] 330,656 330,656	Input Energy [KWh HHV/kg] 555000 0 0 55.5	Efficiency Tetra to the Efficiency Effi
vue vue strial tindinavvölia identivevölia	Usage per kg H2 H2A default 55.560 [W 5.560 [W 0.000 [cmHB] 0.000 [User override	Select regional prices -9 AEO 2022 Ref) 72A default 0.115 (\$/kwh) 0.075 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kwh) 0.048 (\$/kmBTU) 2.38 (\$/mBTU) 2.34 (\$/mBTU) 2	US Average User override User overide User overide User override User override User override User ov	FeedStock impact on vice 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	Input Power (kw HHV) 130,656	Input Energy [kWh HHV/kg] 55500 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Efficiency Tel: Physical Comparison The second second The second second The second second The second second The second second second The second second second second second The second secon
Control of the series to plot Control of the series	Usage per kg H, H2A default 5.500 [CWW 5.500 [CWW] 5.500 [CWW 5.500 [CWW 5.500 [CWW] 5.500 [CWW 5.500 [CWW] 5.500	User override	Select regional prices -9 AEO 2022 Ref) 42A default 0.115 (\$/kWh) 0.048 (\$/kWh) 0.048 (\$/kWh) 0.044 0.044 (\$/kWh) 0.0	US Average User override Sector Sector Secto	FeedStock impact on trica 5 3-9731 5	Input Power [kWHHV] 130,656 130,656	Input Energy [kWh HHV/kg] 555000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Efficiency Territoria 0 0 0 71.2% Fieldstate Fi

+ 10% of baseline

4.45

4.43 📗 4.52

4.41 📗 4.50

4.45 📕 4.53

4.42 📗 4.48

4.43 📗 4.47

4.44 📗 4.47

4.44 4.46

4.44 🛛 4.46

Debt/equity

(1.65, 1.50, 1.35

				Tornado chart spread of parameters ±%
Coproducts	H2A default	User override		
%CO ₂ sequestration	0%		-	
Steam co-product sales	0.000 [mmBTU/kg H ₂]			Electricity (Industrial) cost [\$/kWh]
			_	(.008, .070, .083)
Financials specification				Electricity (Industrial) use [kWh/kg]
Real return on equity	8%		Debt %, equity %	(50.0, 55.5, 61.1)
Debt/equity	1.50		D=60%, E=40%	Utilization [%]
Interest rate	3.7%			(100%, 97%, 87%)
Depreciation type	MACRS			Return on equity
MACRS depreciation period	20 [years]		41.07	(7%, 8%, 9%)
Total income tax rate	25.74%			Connection Use (vil)
Cash on hand	1.0 [month of OpEx]			(62 150 56 500 50 850)
				(,,,,,
Financial incentives				Cap Ex [S]
Per-kilogram incentives	0.00 [\$/kg H ₂]			(77,840,101,80,435,734,55,145,508)
Per-kilogram incentive mechanism	Tax credit		(† HLOT	Fixed OpEx [\$/y]
Per-kilogram incentive sunset	10 [years]			(3,874,553, 4,305,059, 4,735,565)
Per-kilogram annual reduction %	0.00 [%/year]			System life [v]
Capital incentive or investment tax credit	0.0% [% of CapEx]			(44, 40, 36)
				Interest rate [%]
				(3 33% 3 70% 4 07%)

Energy & feedstock use	Usage per kg H₂	
	H2A default	User override
Electricity (Commerical)	0.000 [kW	/h]
Electricity (Industrial)	55.500 [kW	/h]
Electricity (Solar)	0.000 [kW	/h]
Electricity (On-shore wind)	0.000 [kW	/h]
Natural Gas (Commercial)	0.000 [mmBT	·U]
Natural Gas (Industrial)	0.000 [mmBT	[U]
Biomass	0.000 [s.to	on]
Coal	0.000 [mmBT	[U]
Diesel	0.000 [g	al]
Water Total	3.780 [g	al]



Energy & Water Use Rates

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

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



(1 65 1 50 1 35

	4 Select report of the sele	gional prices				Ener	gy &
Energy & feedstock use	→		US Average			feed	stock
	(AEO 2022 Re	ef)			MAP↓	impa	ict on price
	H2A default		User override			[\$/kg	H ₂]
Electricity (Commerical)	0.115	[\$/kWh]		∠ PLOT	MAP↓	\$	-
Electricity (Industrial)	0.075	[\$/kWh]		I∠ PLOT	МАР↓	\$	3.59731
Electricity (Solar)	0.048	[\$/kWh]		⊮ PLOT	МАР↓	\$	-
Electricity (On-shore wind)	0.034	[\$/kWh]		L PLOT	MAP↓	\$	-
Natural Gas (Commercial)	8.28	[\$/mmBTU]		I∠ PLOT	MAP↓	\$	-
Natural Gas (Industrial)	4.11	[\$/mmBTU]		⊮ PLOT	МАР↓	\$	-
Biomass	52.6	[\$/s.ton]		L PLOT	MAP↓	\$	-
Coal	2.33	[\$/mmBTU]		I∠ PLOT	МАР↓	\$	-
Diesel	2.94	[\$/gal]		⊮ PLOT	МАР↓	\$	-
Water Total	0.0033	[\$/gal]		⊯ PLOT	MAP↓	\$	0.03
	1			Т	otal:	\$	3.62

Energy & Water Costs

- 1. Select region for price projections.
- In blue: regional values in startup year 2.
- Use yellow cells if overriding a price is 3. 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 $\sqrt{}$ " macro to display regionalized prices in startup year.
- 6. Panel on right shows H₂ price contribution

H Hydrogen Analysis	- Lite			Reat levelized 4.45 [2020\$/kg H₂] cost →
			Central Grid Electrolysis (PEM)	s based on a generic system wing input from
Represented and a space is a summaries a summaries a summaries a summaries a summaries and a summarial e electricity for electrolysis	no powered retried open system with a te	tan nyarogen production capacity	or subuor egrae, the production system models, the electrolyzer units use proces	s under om a gemeint, system roning injut i nom seren i i water, passed through delonizing beds, and grid
	H2A default & Enter user over	rides	Real levelized cost breakdown of hy	drogen (2020\$/kg)
i nameplate capacity [kg/d]	estimates in yenow dens	2015	Inflow of debt 0.00 Monetized tax losses 0.01	54.F
Technological and a second sec	\$ 86,495,734 \$ 4,305,059	Normalized CapEx 1,531 [\$/kg-day] 662 [\$/kW	Electricity (Industrial) Dividends paid	3.60
5 205/kg H2]	\$ 0.024	Production rate	FixedOpEx 0.2 Installed capital 0.11 Interest expense 0.10	2
Venlacements	97%	54,805 [kg/d]	Income taxes payable 0.09 Annualized replacements 0.08	Operating revenue
ement costs [2020\$/year] erval (years)	1,545,228		Water 0.03 VarOpEx 0.02	Financing cash inflow Operating expense
of Installed CapEx)			Cash on hand reserve 0.01	Financing cash outflow
Select financial time series to plot Curulative investor cash flow	Usage per kg HJ	0.044 (SAVA) 0.044	US Average US Average User override Selected region Partice Selected region Selected region Se	Input Power Input Energy Efficiency [LVX HHV] [LVK HHV]/[k] [LHV] 130.656 35.800 0 0 0 0 130.656 55.5 71.26
100 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	- 2602 -	2056	Tornado chart spread of parameters ±	% ± 10% of baseline Construction of the second seco
Steam co-product sales	0.000 [mmBTU/kg H ₂]		Electricity (Industrial) cost [\$/kWh] (.068, .076, .083)	4.07 4.45 4.83
Performance specification Performance and the specification	8%	Debt %, equity % D=60%, E=40%	(50.0, 55.5, 61.1) Utilization [%]	4.07 4.83
Туре	3.7% MACRS		(100%, 97%, 87%) Return on equity	4.43 4.52
Cash on hand	20 [years] 25.74% 1.0 [month of OpEx]		(7%, 8%, 9%) Capacity [kg/d]	4.45 4.53
Financial incentives			(02,150, 50,500, 50,850) CapEx [\$]	4.42 4.48

0.00 Tax credit 10

0.00

Per-kilogram incentive mechanism

Per-kilogram incentive sunset Per-kilogram annual reduction % [\$/kg H₂]

[%/year

[% of Cap

[years]

(77,846,161, 86,495,734, 95,145,308)

Fixed OpEx [S/v]

(3,874,553, 4,305,059, 4,735,565)

System life [y] (44, 40, 36)

Interest rate [%]

(3.33%, 3.70%, 4.07%) Debt/equity (1.65, 1.50, 1.35) 4.43 📗 4.47

4.44 📗 4.47

4.44 4.46

4.44 🛛 4.46

Financials encelfication		
Financials specification		
Real return on equity	8%	Debt %, equity %
Debt/equity	1.50	D=60%, E=40%
Interest rate	3.7%	
Depreciation type	MACRS	
MACRS depreciation period	20 [years]	↑ PLOT
Total income tax rate	25.74%	
Cash on hand	1.0 [month of OpEx]	

Financials Specification

7

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



inancial 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]

- Financial Incentives Specifications
- 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



4.44 4.46

4.44 4.46

(3.33%, 3.70%, 4.07% Debt/equity

(1.65, 1.50, 1.35

nergy & feedstock use		Input Power	Input Energy	Efficiency Switch to LHV
	\\ F	[kW HHV]	[kWh HHV/kg]	[HHV]
lectricity (Commerical)		-	-	
lectricity (Industrial)		130,656	55.5000	
ectricity (Solar)		-	0	0
tricity (On-shore wind)))[-	0	0
al Gas (Commercial)	// [-	-	
ural Gas (Industrial)		-	-	
mass))[-	-	
al		-	-	
sel		-	-	
ter Total				
	\ \	130.656	55.5	71.2%

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.



Electricity (Industrial) use [kWh/kg]

(50.0, 55.5, 61.1) Utilization [%

(100%, 97%, 87%) Return on equity

(7%, 8%, 9%) Capacity [kg/d]

(62,150, 56,500, 50,850) Cap Ex [\$]

Interest rate [%

(3.33%, 3.70%, 4.07%) Debt/equity (1.65, 1.50, 1.35)

(77,846,161, 86,495,734, 95,145,308) Fixed OpEx [S/v]

(3,874,553, 4,305,059, 4,735,565) System life [y] (44, 40, 36) 4 07

4.85

4.43 📗 4.52

4.41 📗 4.50

4.45 📕 4.53

4.42 📗 4.48

4.43 📗 4.47

4.44 📗 4.47

4.44 4.46

4.44 4.46

Real	levelized	cost	breakdown	of	hydrogen	(2020\$/	/kg



10 Levelized Cost Breakdown

- 1. Displays levelized cash flows per kg H₂
- 2. Sorts financing & operating cash flows by total contribution





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





Regionalization Map

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



Tornado chart spread of parameters ±%	± 10% of baseline	plot "30s
	↑ Please updat	te tornado
Electricity (Industrial) cost [\$/kWh] (.068, .076, .083)	4.07 4.45	4.83
Electricity (Industrial) use [kWh/kg] (50.0, 55.5, 61.1)	4.07	4.83
Utilization [%] (100%, 97%, 87%)	4.43 4.52	
Return on equity (7%, 8%, 9%)	4.41 4.50	
Capacity [kg/d] (62,150, 56,500, 50,850)	4.45 4.53	
Cap Ex [\$] (77,846,161, 86,495,734, 95,145,308)	4.42 4.48	
Fixed OpEx [\$/y]	4.43 4.47	



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





Model purpose & framework Case studies & benchmarking

Model demonstration

Model purpose & framework Layout & walkthrough Model demonstration

Webinar Outline





Model purpose & framework Layout & walkthrough Model demonstration Model purpose & framework

Layout & walkthrough 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)

Webinar Outline





Model purpose & framework Layout & walkthrough Model demonstration

Model purpose & framework

Layout & walkthrough

Model demonstration

Model Tabs Descriptions

Description	
Description	
Version history	
Use agreement	
Contact info	
Interface	
 User inputs, scenarios, risk analysis, graphica 	loutputs
Overrides	
Custom cost and price profiles vs. calendar ye	ears
Custom performance, sales, refurbishments b	by analysis year
Report Tables	
Detailed GAAP projected statements	
Description Interface Overrides Report Tables	NREL 31



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)



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



Visualizations

- 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.
- 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 stackchart)



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 hi) light it as)
- 2. similarly, select capital cost and any other items that would change with nameplate capacity.



Scenario differentiation parameters

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

6



Recorded overall financial metric per scenario

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



Risk parameter analysis

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

Model purpose & framework Layout & walkthrough

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)

www.nrel.gov



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

H2A-Lite



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

Transforming ENERGY

Please direct any additional questions to h2fast@nrel.gov