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Hydrogen Financial Analysis Scenario Tool (H2FAST): Spreadsheet Tool User's Manual

M. Penev, M. Melaina, B. Bush
National Renewable Energy Laboratory

J. Zuboy
Independent Consultant

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List of Acronyms

DSCR	debt service coverage ratio
EBITD	earnings before interest, taxes, and depreciation
H2	hydrogen
H2FAST	Hydrogen Financial Analysis Scenario Tool
IRR	internal rate of return
IRS	Internal Revenue Service
ITC	investment tax credit
MACRS	Modified Accelerated Cost Recovery System
mmBTU	One million British Thermal Units
NPV	net present value
NREL	National Renewable Energy Laboratory
PP&E	plant, property, and equipment
PTC	production tax credit
SERA	Scenario Evaluation, Regionalization, and Analysis
SMR	steam methane reforming

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1 Introduction

The Hydrogen Financial Analysis Scenario Tool (H2FAST) provides a quick and convenient in-depth financial analysis for hydrogen refueling stations. It is meant to facilitate investments in hydrogen stations and improve policy-design decisions to support early station and fuel cell electric vehicle market development. Intended users include policy and government decision makers, station operators, equity investors, strategic investors, and lenders.

This manual describes how to use the spreadsheet version of H2FAST, which is one of three H2FAST formats developed by the National Renewable Energy Laboratory (NREL). Although all of the formats are based on the same financial computations and conform to generally accepted accounting principles (FASAB 2014, Investopedia 2014), each format provides a different level of complexity and user interactivity.

The web tool is the simplest to use and allows users to quickly vary approximately 20 input values. The results are basic financial performance parameters such as investor cash flow, internal rate of return, and the break-even sale price of hydrogen. The web tool is available at http://www.nrel.gov/hydrogen/h2fast/.

The next most complex format is the interactive Microsoft Excel spreadsheet, which can be downloaded at http://www.nrel.gov/hydrogen/h2fast/. As this manual illustrates, the H2FAST spreadsheet offers basic and advanced user interface modes for modeling individual stations or groups of up to 300 stations. It provides users with detailed annual finance projections in the form of income statements, cash flow statements, and balance sheets; graphical presentation of financial performance parameters for 84 common metrics; life-cycle cost breakdown for each analysis scenario; and common ratio analysis results such as debt/equity position, return on equity, and debt service coverage ratio. It also enables risk analysis based on user-defined distributions of input values.

Finally, the most complex and customizable format is available as part of SERA—NREL's Scenario Evaluation, Regionalization, and Analysis Model—and will be available at http://developer.nrel.gov/. This format is designed for expert users. It accepts user-defined input files and is ideal for examining large numbers of scenarios quickly, for example, to perform sensitivity analyses.

2 Getting Started

To access the spreadsheet version of H2FAST, go to http://www.nrel.gov/hydrogen/h2fast/ and click the "Spreadsheet Version" button. Download the Excel file to your computer (free of charge) and then open it, making sure to enable macros. If after modifying the file you want to revert to the default settings and values, you can simply download the model again. This tool is designed for use with Microsoft Excel 2010 and newer Excel versions; full functionality with older versions is not guaranteed.

The spreadsheet opens on the *Interface* worksheet (Figure 1). This is the primary worksheet you will use to input values and view results. Two other worksheets are accessible by clicking the tabs at the bottom of the screen. The *Description* worksheet provides basic information about the tool. The *Report Tables* worksheet shows detailed technical and financial outputs in tabular form.

Active cells in each worksheet are color coded: yellow for basic user inputs, orange for advanced user inputs, blue for calculated values, and green for key results. Although you can modify the equations in the blue cells, this is not advised unless you are an expert user, because it can cause the model to malfunction or produce inaccurate results. The green cells should never be modified.

For many of the cells, descriptive information pops up when you click in the cell. In addition, you can click the information cells (denoted with an "i" and/or a red triangle in the upper right corner) for more information.

2.1 Inputs

You input information within the *Interface* worksheet. To begin your inputs, click the "Basic" or "Advanced" button above the *Station(s) Information* table to select the interface type. Basic is the default and enables a relatively small number of input fields. Advanced enables additional input fields. Next, proceed to the *Multi-Station Inputs* table, which is immediately to the right of the *Station(s) Information* table. In the first row, enter the number of stations you want to model, from 1 to 300. Then name and define each of your stations. Enter values for capacity, equipment capital cost, non-depreciable fixed asset (such as land) cost, installation cost, proceeds from end-of-project sale of non-depreciable assets, and maintenance cost. The next table accepts inputs for coproduct generation, enabling you to represent conventional configurations without coproducts or non-conventional configurations such as combined heat, hydrogen, and power. The feedstock options in the next table enable you to represent stations with all hydrogen produced onsite from various feedstocks or with some of the hydrogen delivered to the station by truck or pipeline.[1] In the final station-input table, enter information for incentives and incidental revenue (station revenue enhancements derived from the presence of hydrogen). It is important that you replace the default information with your own stations' values. The default values are meant to approximate a feasible station scenario in California, but they do not represent actual or predicted values that would be applicable to a broader set of hydrogen stations or locations.

[1] The customized feedstock fields are also useful for analyzing H2A cases (see https://www.hydrogen.energy.gov/h2a_analysis.html).

H2FAST does not assume a particular station configuration, refueling pressure, or state of technological maturity. The tool is intended to be flexible so that users can input station cost assumptions for whatever system is of interest. H2FAST is not a cost-estimation tool. Guidance on appropriate values for station costs (e.g., capital equipment costs) is available in Melaina and Penev (2013) as well as in Argonne National Laboratory's Hydrogen Refueling Station Analysis Model (HRSAM) (ANL 2015) and the U.S. Department of Energy's Hydrogen Analysis (H2A) forecourt production case studies (DOE 2015). The U.S. Energy Information Administration's *Annual Energy Outlook* is a useful source for forecasts of electricity and natural gas prices (EIA 2015).[2]

After you have defined your stations in this manner, select all the stations by clicking the left blue arrow at the top of the *Multi-Station Inputs* table until you have selected the station 1 column, and then click the left arrow one more time. This selects all of the stations and highlights them in yellow, as shown in Figure 2. Now return to the *Interface* worksheet's left column and accept or overwrite all cells in orange (using the advanced interface) and yellow (using the basic or advanced interface) as you scroll down. Cells are grayed out when you have not entered corresponding values in the station-input tables; you do not need to modify these grayed-out cells.

Among the input fields, those within the *Take or Pay Contract Specification* table are a significant addition since the previous version of H2FAST (Figure 3). Take-or-pay contracts are a way to support the economics of early-stage hydrogen stations (Investopedia 2016). Your stations will receive the value you enter for "Price of unsold hydrogen ($/kg)" for each kilogram of hydrogen they do not sell. The remaining three fields can constrain this support by reducing the unsold hydrogen price annually, limiting the duration of the take-or-pay contract, and setting a station utilization rate above which unsold hydrogen would not be covered under the contract.[3] See Appendix A for descriptions of all inputs and default values.

Once you have entered or accepted the default values for all orange and yellow cells in the left column of the *Interface* worksheet, the results are calculated automatically as described in the following section.

[2] Additional information on hydrogen station network planning can be found within web resources provided by the California Fuel Cell Partnership (www.fuelcellpartnership.org/), the H2USA public-private partnership (http://h2usa.org/), and the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (www.energy.ca.gov/drive/projects). Relevant near-term hydrogen station finance and incentive analyses have been conducted by Energy Independence Now (www.einow.org/reports.html). The Alternative Fuels Data Center's Station Locator (www.afdc.energy.gov/locator/stations/) shows current hydrogen station locations in the United States, and Ludwig Bolkow Systemtechnik GmbH (www.netinform.net/h2/H2Stations/) maintains a map of worldwide hydrogen stations.

[3] Entering a negative number in the price decay field makes the take-or-pay hydrogen price escalate over time.

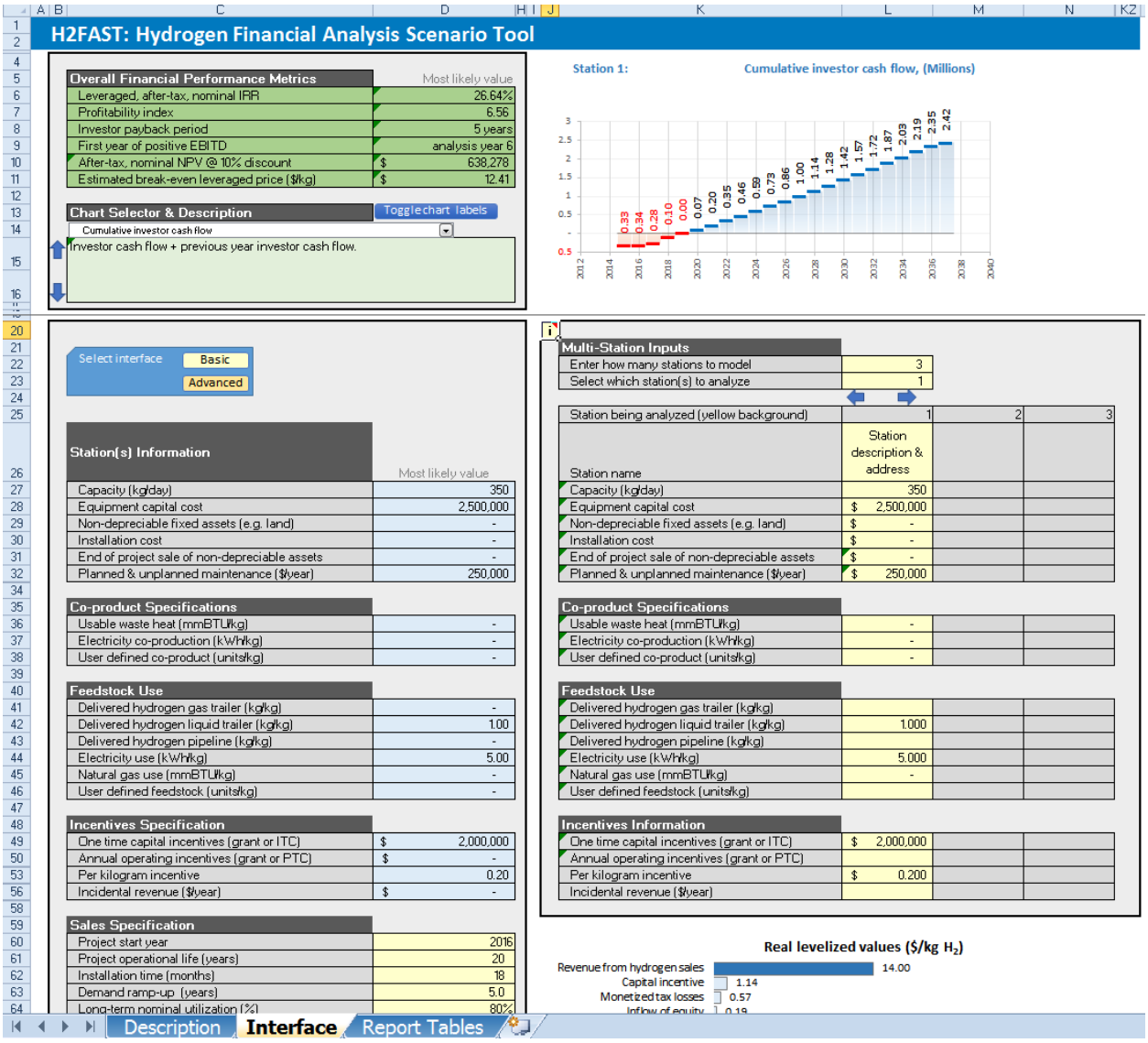


Figure 1. Spreadsheet version of H2FAST, *Interface* worksheet

Multi-Station Inputs			
Enter how many stations to model	3		
Select which station(s) to analyze	All Stations		
Station being analyzed (yellow background)	1	2	3
Station name	42 Hypothetic Rd. Station	Larger Station	Smaller Station
Capacity (kg/day)	200	300	150
Equipment capital cost	$ 2,000,000	$ 3,000,000	$ 1,500,000
Non-depreciable fixed assets (e.g. land)	$ -	$ 200,000	
Installation cost	$ 500,000	$ 650,000	$ 400,000
End of project sale of non-depreciable assets	$ -	$ 250,000	
Planned & unplanned maintenance ($/year)	$ 100,000	$ 150,000	$ 80,000
Coproduct Specifications			
Usable waste heat (mmBTU/kg)	-		
Electricity co-production (kWh/kg)	-		
User defined co-product (units/kg)	-		
Feedstock Use			
Delivered hydrogen gas trailer (kg/kg)	1.000		1.000
Delivered hydrogen liquid trailer (kg/kg)	-	1.000	
Delivered hydrogen pipeline (kg/kg)	-		
Electricity use (kWh/kg)	4.000	4.000	4.000
Natural gas use (mmBTU/kg)	-		
User defined feedstock (units/kg)	-		
Incentives Information			
One time capital incentives (grant or ITC)	$ 1,200,000		
Annual operating incentives (grant or PTC)	$ 100,000	$ 150,000	$ 75,000
Per kilogram incentive	$ -		
Incidental revenue ($/year)	$ -		

Figure 2. *Interface* worksheet, *Multi-Station Inputs* table, showing all stations selected

Take or Pay Contract Specification	
Price of unsold hydrogen ($/kg)	4.00
Price decay (% annually)	0%
Contract sunset (years)	3.00
Utilization supported up to (% of capacity)	60%

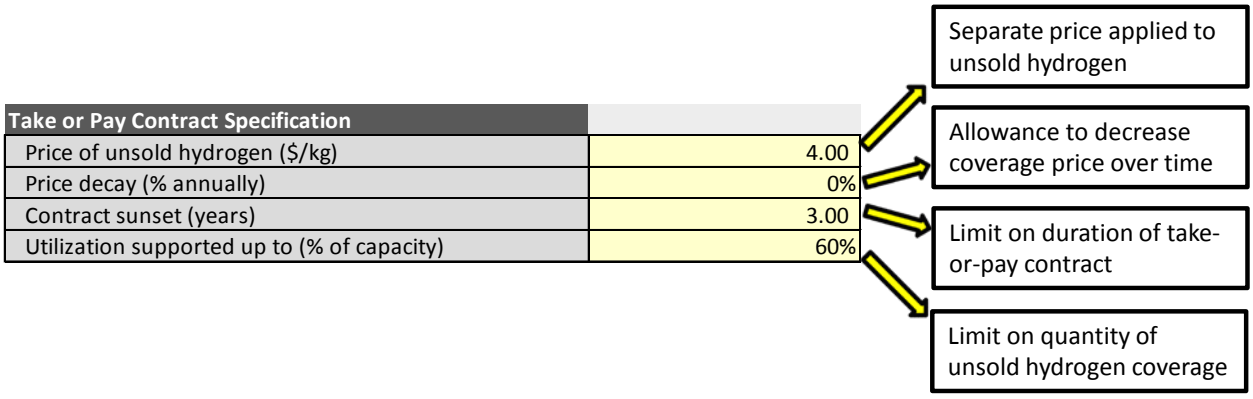
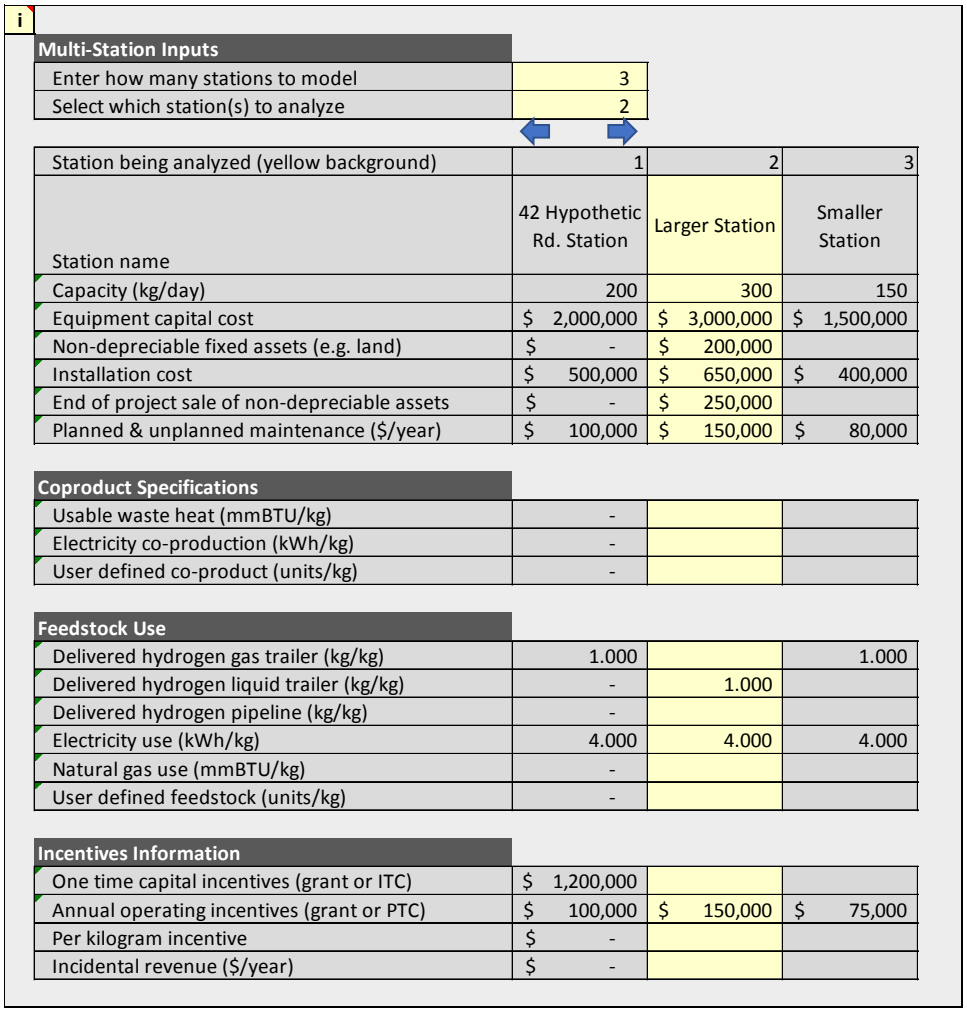


Figure 3. Explanation of fields in *Take or Pay Contract Specification* input table

2.2 Results

You can view results for each of your stations individually or for all of your stations combined. Click the blue arrows at the top of the *Multi-Station Inputs* table to switch between stations. The selected station is highlighted in yellow. Figure 4 shows an example with station 2 selected. As described above and illustrated in Figure 2, to select all stations click the left blue arrow until you have selected the station 1 column, and then click the left arrow one more time.



Multi-Station Inputs	
Enter how many stations to model	3
Select which station(s) to analyze	2

Station being analyzed (yellow background)	1	2	3
Station name	42 Hypothetic Rd. Station	Larger Station	Smaller Station
Capacity (kg/day)	200	300	150
Equipment capital cost	$ 2,000,000	$ 3,000,000	$ 1,500,000
Non-depreciable fixed assets (e.g. land)	$ -	$ 200,000	
Installation cost	$ 500,000	$ 650,000	$ 400,000
End of project sale of non-depreciable assets	$ -	$ 250,000	
Planned & unplanned maintenance ($/year)	$ 100,000	$ 150,000	$ 80,000
Coproduct Specifications			
Usable waste heat (mmBTU/kg)	-		
Electricity co-production (kWh/kg)	-		
User defined co-product (units/kg)	-		
Feedstock Use			
Delivered hydrogen gas trailer (kg/kg)	1.000		1.000
Delivered hydrogen liquid trailer (kg/kg)	-	1.000	
Delivered hydrogen pipeline (kg/kg)	-		
Electricity use (kWh/kg)	4.000	4.000	4.000
Natural gas use (mmBTU/kg)	-		
User defined feedstock (units/kg)	-		
Incentives Information			
One time capital incentives (grant or ITC)	$ 1,200,000		
Annual operating incentives (grant or PTC)	$ 100,000	$ 150,000	$ 75,000
Per kilogram incentive	$ -		
Incidental revenue ($/year)	$ -		

Figure 4. *Interface* worksheet, *Multi-Station Inputs* table, showing station 2 selected

For whichever stations are selected, results are presented in three areas in the *Interface* worksheet. The *Overall Financial Performance Metrics* table at the top left shows values for leveraged, after-tax, nominal IRR (internal rate of return); profitability index; investor payback period; first year of positive EBITD (earnings before interest, taxes, and depreciation); after-tax, nominal NPV (net present value) at your selected discount rate; and estimated break-even leveraged price of hydrogen (Figure 5). Click on each value for a definition of the metric (see Appendix B for descriptions of all outputs).

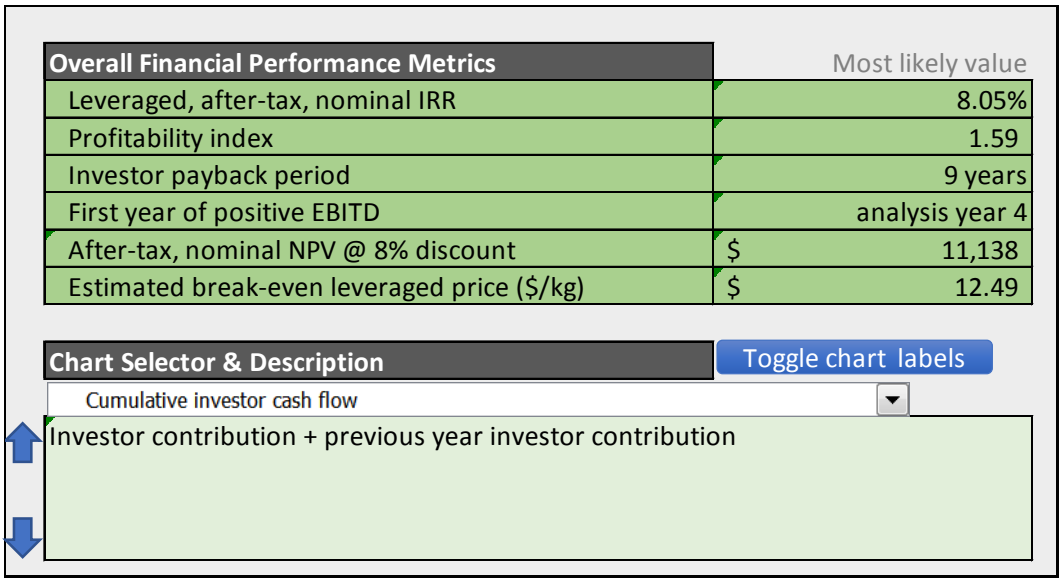


Figure 5. *Interface* worksheet, *Overall Financial Performance Metrics* table

The IRR is the discount rate at which a project's NPV is equal to zero. The IRR calculations can exhibit complex behavior (Miller 2008). In simple cases where investor cash flow is negative in the first year and positive in each subsequent year, the IRR can have only one value. However, if investor cash flow switches between positive and negative more than once during the project period, multiple solutions for the IRR will exist. H2FAST uses Excel's native IRR calculation. In cases with multiple IRR solutions, it typically displays the smallest positive solution. In contrast, the profitability index—the present value of future equity investor cash flows divided by the initial equity investment—is a robust financial performance metric that always returns a single, valid result.

NPV and hydrogen break-even price are linked to the value you entered for "Leveraged after-tax nominal discount rate" in the *Financing Information* table (using the advanced interface). The NPV is calculated using that discount rate. The break-even price is the price at which your station(s) would need to sell hydrogen to receive an IRR equal to the discount rate you specified. If you set your actual hydrogen price ("Price of hydrogen at project onset ($/kg)" in the *Products Value* table) exactly equal to the break-even price, the IRR you receive will equal the discount rate you entered, and the NPV will be zero (Figure 6). You can match the values exactly by using an Excel calculation: type an equal sign in the cell next to "Price of hydrogen at project onset ($/kg)," select the cell next to "Estimated break-even leveraged price ($/kg)," and then press "Enter" on your keyboard.

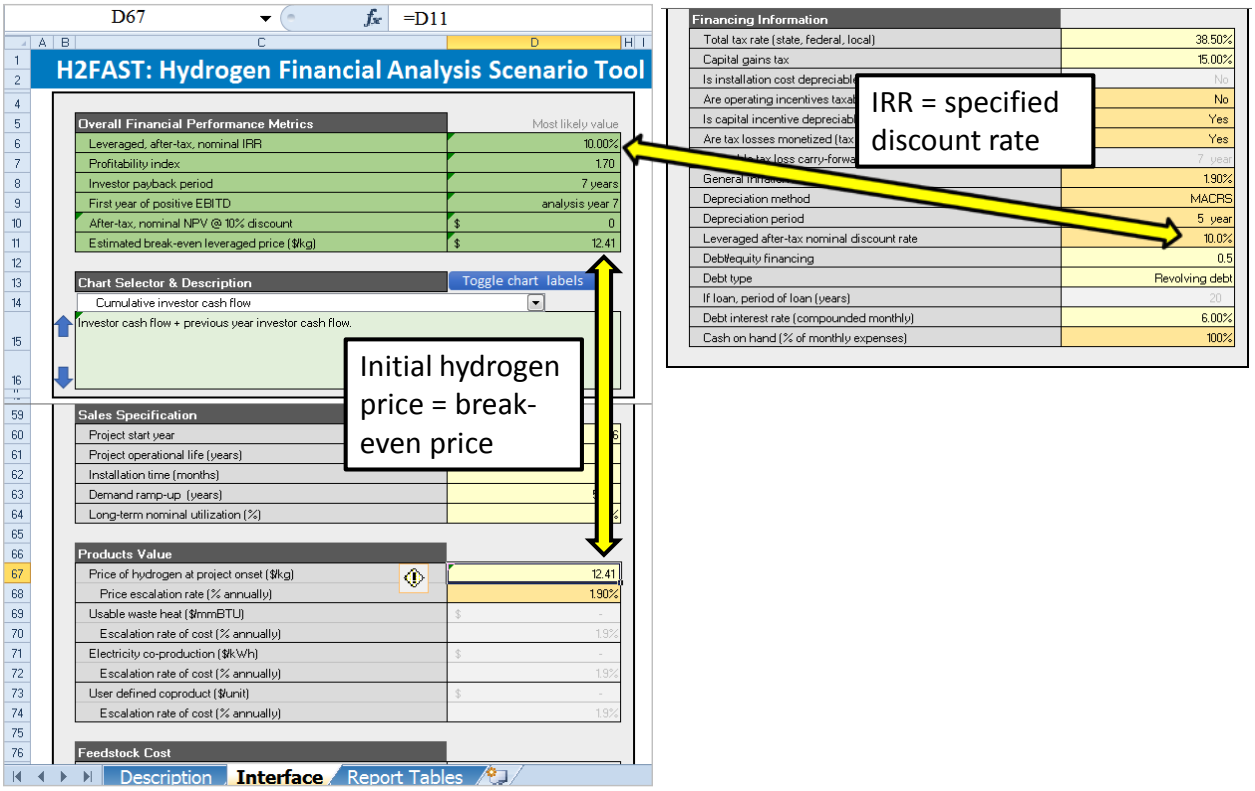


Figure 6. Specifying project IRR by setting the initial hydrogen price equal to the break-even hydrogen price

The break-even leveraged price of hydrogen per kilogram often will be substantially higher than a typical gasoline price per gallon, even though the amount of energy in a kilogram of hydrogen is approximately equal to the energy in a gallon of gasoline. However, because a fuel cell electric vehicle is about twice as efficient as a similar conventional gasoline vehicle, an owner can drive twice as far on a kilogram of hydrogen than on a gallon of gasoline. Therefore, if the hydrogen price is $10 per kilogram, the cost to the owner would be equivalent to a gasoline price of about $5 per gallon on a cost-per-mile-driven basis.

Various results also can be displayed within the *Interface* worksheet's chart field. Selecting a chart from the drop-down menu under *Chart Selector & Description* displays the selected chart (Figure 7). The text field below the menu describes the active chart. You can scroll through the various charts by clicking the blue up and down arrows to the right of the text field. The "Toggle chart labels" button turns the chart labels on and off.

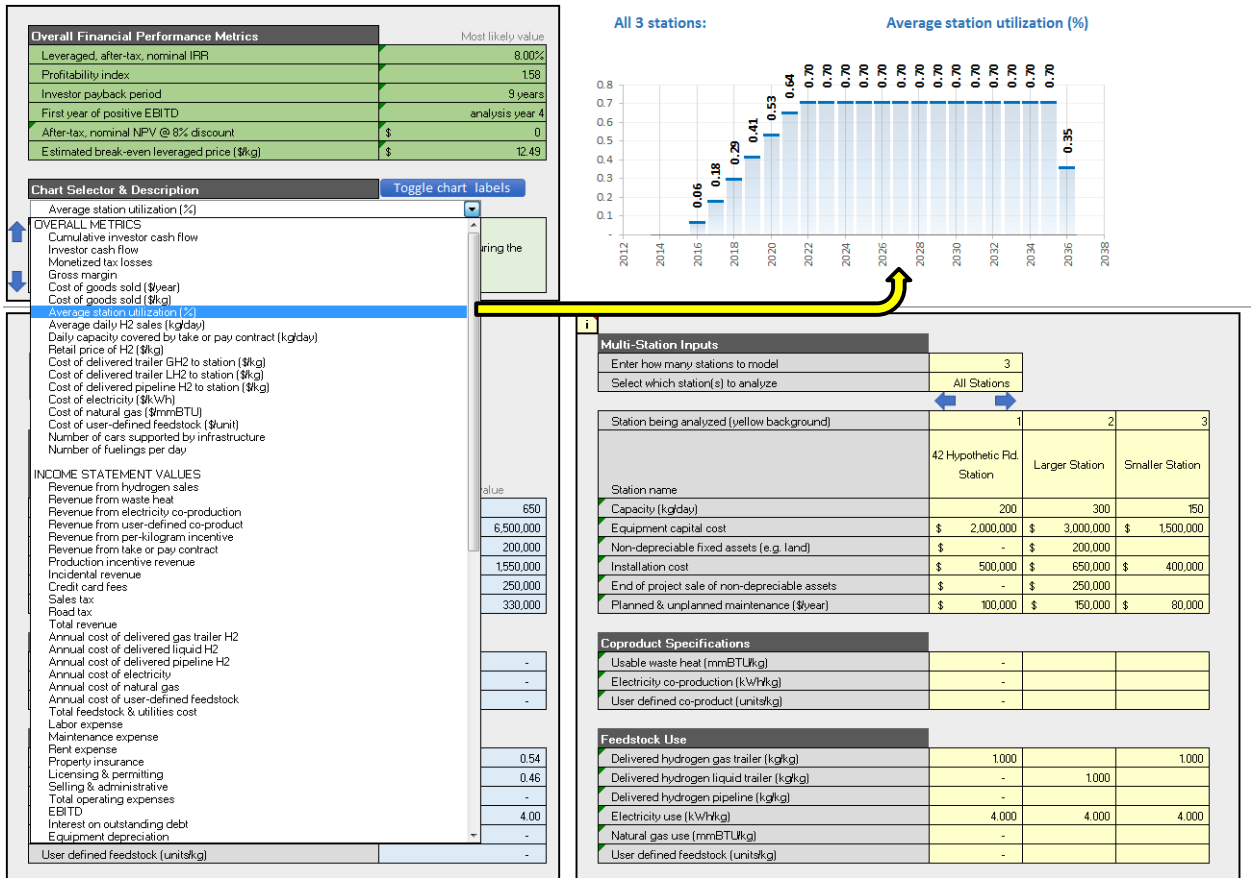


Figure 7. *Interface* worksheet, *Chart Selector & Description*, showing chart options

The final location for results within the *Interface* worksheet is below the *Multi-Station Inputs* table at the bottom right. These bars and values represent levelized (dollars per kilogram of hydrogen produced) cash inflows and outflows (Figure 8).

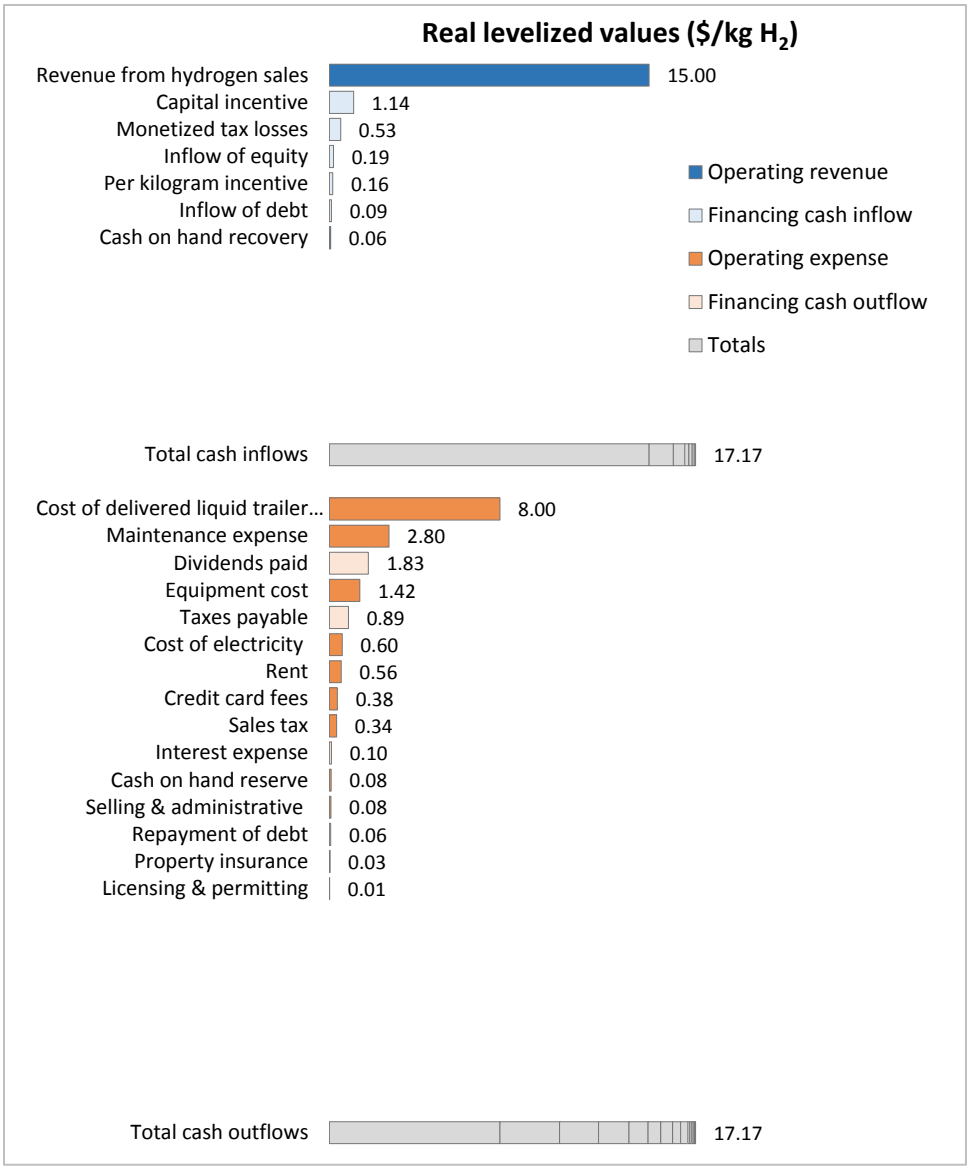
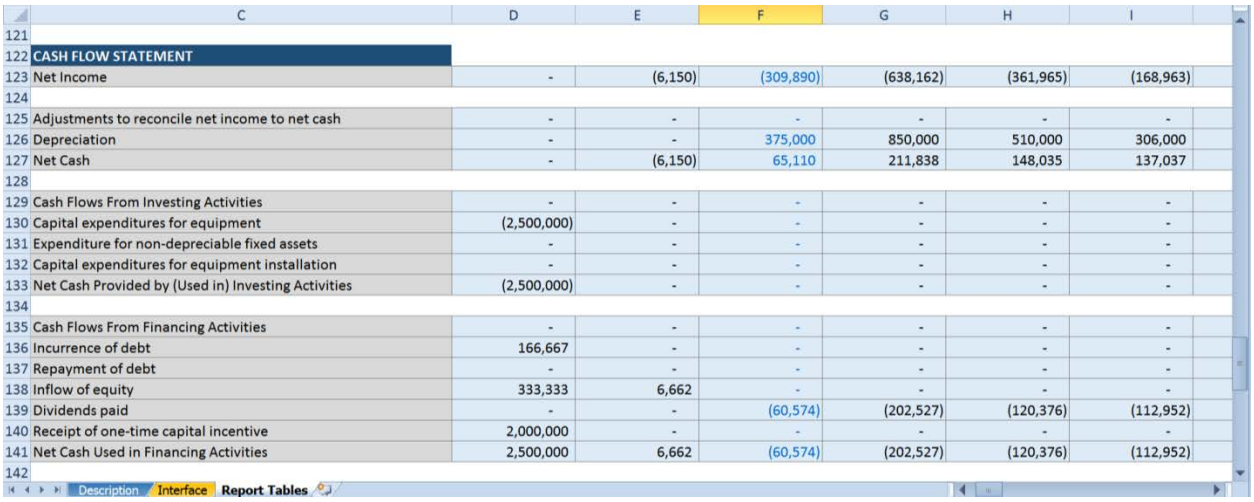


Figure 8. *Interface* worksheet, levelized revenue and expense results

Tabular results for each year of the project's life are available within the *Report Tables* worksheet (Figure 9). In addition to general information and price escalations on an annual basis, these results include income statement, cash flow statement, and balance sheet projections for each year in the analysis period.



	C	D	E	F	G	H	I
121							
122	CASH FLOW STATEMENT						
123	Net Income	-	(6,150)	(309,890)	(638,162)	(361,965)	(168,963)
124							
125	Adjustments to reconcile net income to net cash	-	-	-	-	-	-
126	Depreciation	-	-	375,000	850,000	510,000	306,000
127	Net Cash	-	(6,150)	65,110	211,838	148,035	137,037
128							
129	Cash Flows From Investing Activities	-	-	-	-	-	-
130	Capital expenditures for equipment	(2,500,000)	-	-	-	-	-
131	Expenditure for non-depreciable fixed assets	-	-	-	-	-	-
132	Capital expenditures for equipment installation	-	-	-	-	-	-
133	Net Cash Provided by (Used in) Investing Activities	(2,500,000)	-	-	-	-	-
134							
135	Cash Flows From Financing Activities	-	-	-	-	-	-
136	Incurrence of debt	166,667	-	-	-	-	-
137	Repayment of debt	-	-	-	-	-	-
138	Inflow of equity	333,333	6,662	-	-	-	-
139	Dividends paid	-	-	(60,574)	(202,527)	(120,376)	(112,952)
140	Receipt of one-time capital incentive	2,000,000	-	-	-	-	-
141	Net Cash Used in Financing Activities	2,500,000	6,662	(60,574)	(202,527)	(120,376)	(112,952)
142							

Description | Interface | Report Tables

Figure 9. *Report Tables* worksheet showing tabular results

3 Advanced Functions

Two advanced functions within H2FAST enable you to customize your hydrogen station financial analysis further: risk analysis and goal seek. These are described below.

3.1 Risk Analysis

The risk analysis capability enables you to account for the impacts of uncertain input parameters on the financial performance of your hydrogen stations. To access this capability, activate the advanced user interface and then click the "On/Off" button in the *Risk analysis* field. Clicking this button reveals three fields for most input parameters: a most likely value, a minimum uncertainty value, and a maximum uncertainty value (Figure 10). These three values define a triangular distribution used for Monte Carlo risk analysis. As the default setting, all three values are the same for each parameter, and the uncertainty values are grayed out. When you change an uncertainty value, it turns black and becomes active for subsequent analyses. Note that the minimum uncertainty value must be lower than the most likely value, and the maximum uncertainty value must be higher than the most likely value. Once you have defined the uncertainty distributions for one or more input parameters, click the "Evaluate uncertainty (1,000 runs)" button in the *Risk analysis* field to initiate the analysis. H2FAST takes 1,000 random samples from each of the input distributions you defined to calculate probability distributions for input parameters and financial results. The analysis usually takes a few minutes to run. The elapsed time and percentage of the analysis complete are displayed at the bottom left of the screen.

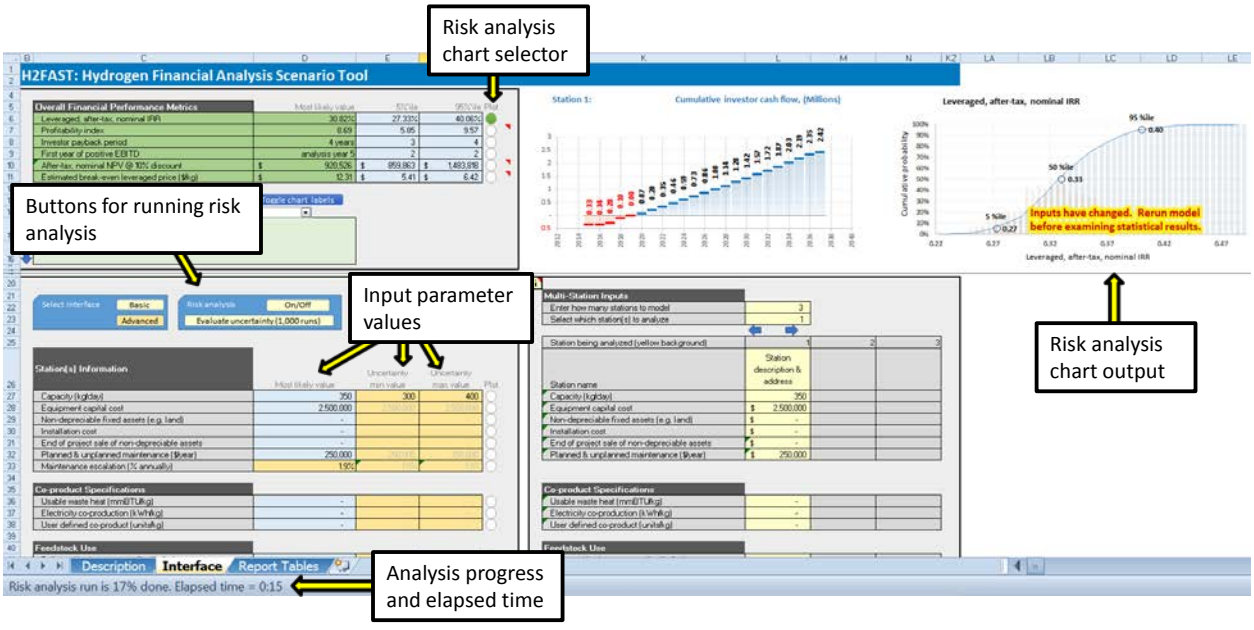


Figure 10. H2FAST risk analysis functions

Once the analysis is 100% complete, the updated results are shown in the *Overall Financial Performance Metrics* table, which provides most likely, 5th percentile, and 95th percentile values for each metric. You can plot the probability distributions for each of these metrics by clicking the adjacent circle under the heading "Plot." The resulting risk analysis chart appears to the right of the financial analysis chart. In a similar fashion, you can plot the probability distributions for

the relevant input parameters. As you are working with the risk analysis, you might see a message on the risk analysis chart stating, "Inputs have changed. Rerun model before examining statistical results." This message appears when you first activate the risk analysis function and when you change input values. If you see the message, you must run the risk analysis again—by clicking the "Evaluate uncertainty (1,000 runs)" button—to receive valid results.

You can view additional analyses for three of the financial performance metrics: profitability index, after-tax nominal NPV, and estimated break-even leveraged price. Click the plot circle adjacent to one of these metrics, and then scroll down below the financial performance and risk analysis charts until you see the tornado and waterfall charts. The tornado chart plots the sensitivity of your selected metric to the variations in input parameters that you defined; if you defined more than 10 input distributions, the tornado chart plots the 10 that have the most impact on the metric. Figure 11 is an example tornado chart, showing the sensitivity of profitability index to initial hydrogen price, cost of delivered liquid hydrogen, and station capacity. At a hydrogen price of $10/kg, the profitability index is -5.70. At $14/kg it is 6.56, and at $16/kg it is 12.69. The sensitivity to the other parameters can be read in a similar manner.

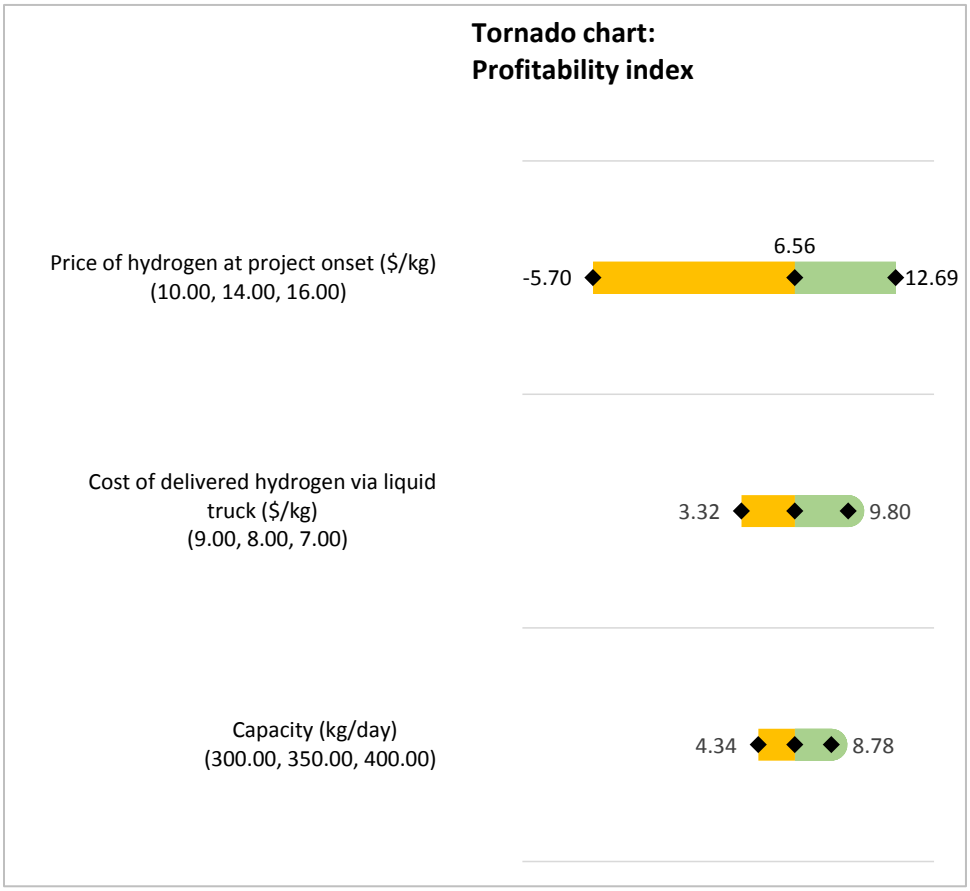


Figure 11. Tornado chart showing sensitivity of profitability index to three input parameters

The waterfall chart plots the cumulative effects on your selected metric of the variations in input parameters that you defined; if you defined more than 10 input distributions, the waterfall chart plots the 10 that have the most impact on the metric. Only variations that improve financial performance are shown. Figure 12 is an example waterfall chart, showing the cumulative effects

on break-even hydrogen price of changes in delivered liquid hydrogen cost and station capacity. Reducing the delivered hydrogen cost from $8/kg to $7/kg reduces the breakeven hydrogen price by $1.06/kg. Increasing station capacity from 350 kg/day to 400 kg/day reduces the breakeven price by an additional $0.43/kg—for a final breakeven price of $10.92/kg.

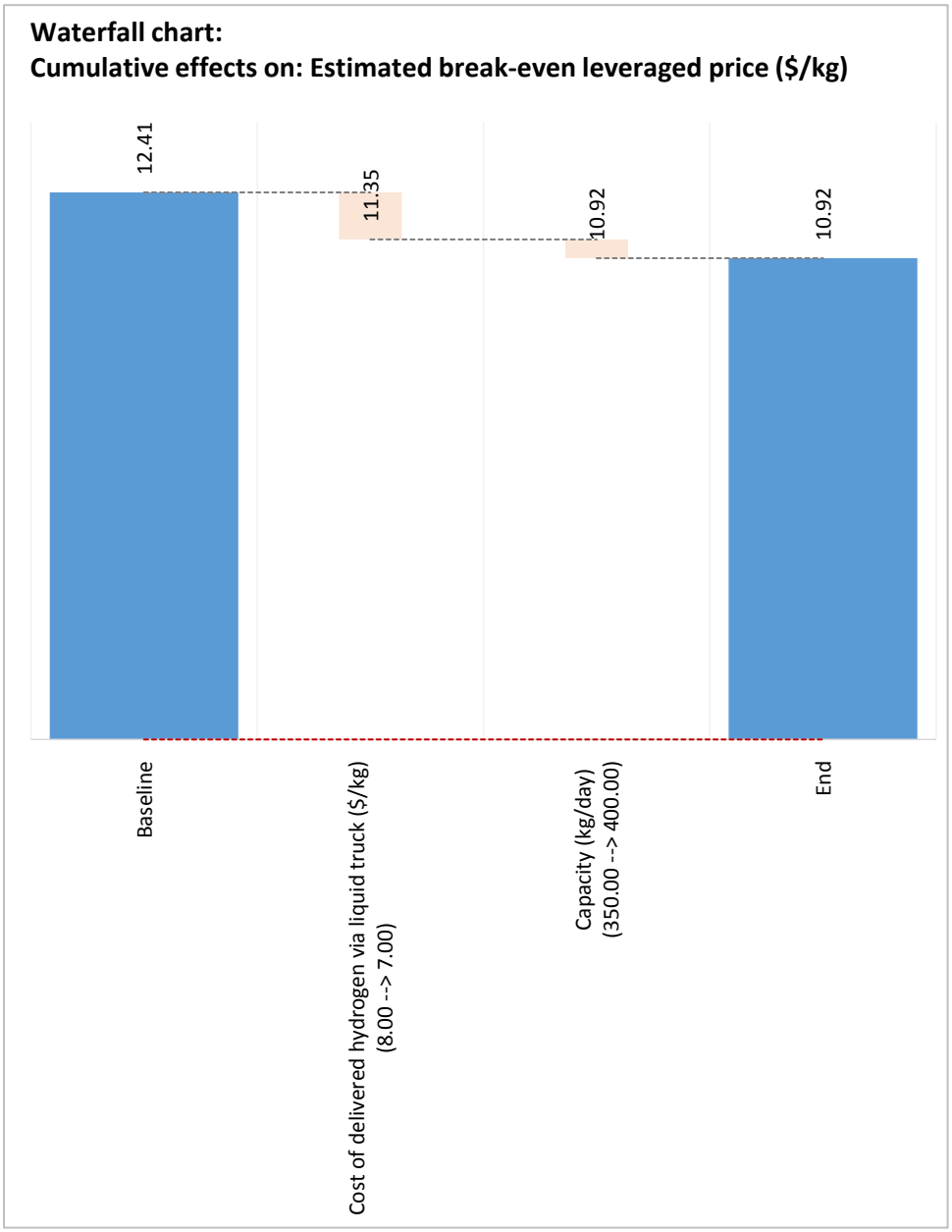


Figure 12. Waterfall chart showing the cumulative effects of input parameter variations on break-even hydrogen price

3.2 Goal Seek

You can use Excel's Goal Seek function to solve for conditional inputs. For example, say you have simulated a station with the financial performance metrics shown in Figure 13, and you want to determine how large of a one-time capital incentive is required to achieve an IRR of 10% and a break-even hydrogen price of $10/kg. First, set the discount rate to 10% in the *Financing Information* table (as Figure 13 shows, the discount rate is already set at 10% in this example). Next, in the *Products Value* table, set the "Price of hydrogen at project onset ($/kg)" to $10. Then complete the following steps.

Overall Financial Performance Metrics	Most likely value
Leveraged, after-tax, nominal IRR	1.05%
Profitability index	0.92
Investor payback period	17 years
First year of positive EBITD	analysis year 5
After-tax, nominal NPV @ 10% discount	$ (349,987)
Estimated break-even leveraged price ($/kg)	$ 10.77

Figure 13. Initial station financial metrics for Goal Seek example

1) In the Excel menu bar, select the *Data* menu, click "What-if Analysis," and then select "Goal Seek" (Figure 14).

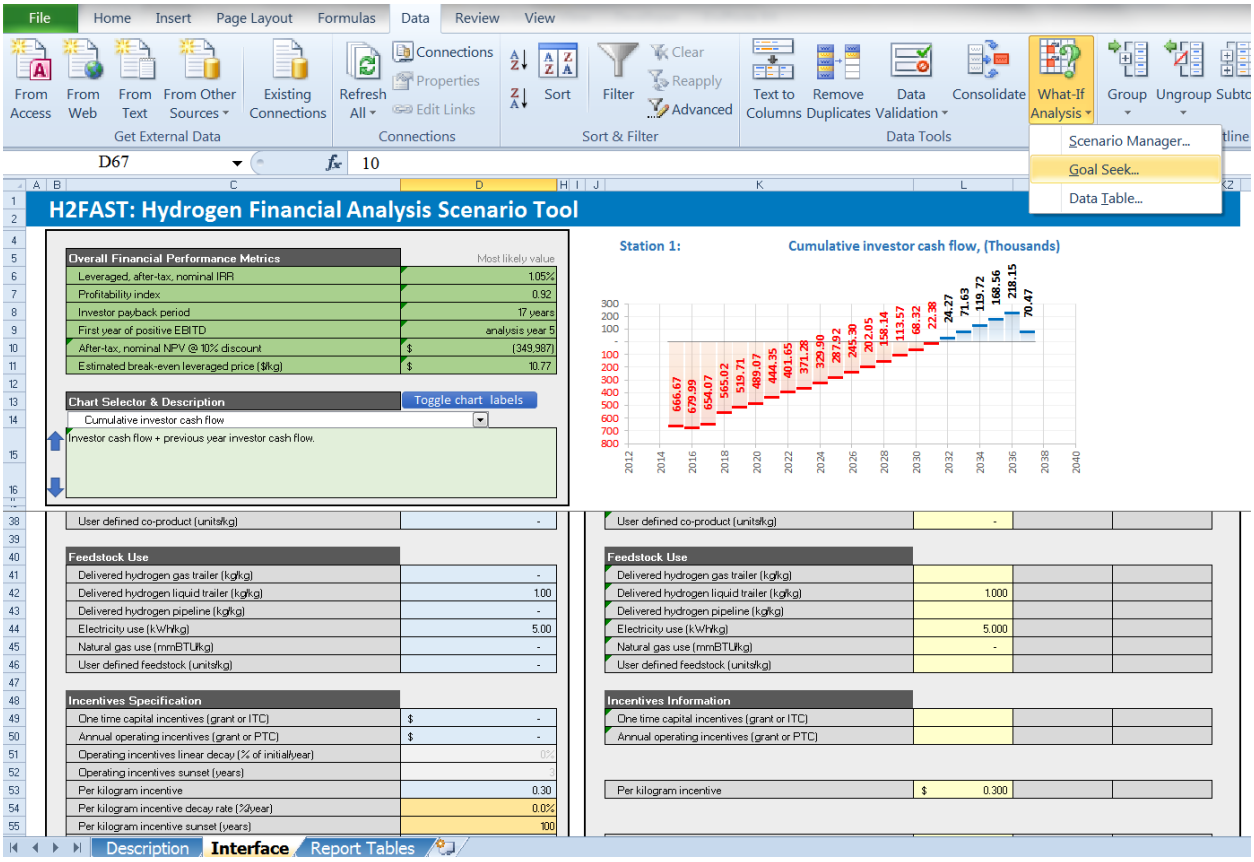


Figure 14. Activating the Goal Seek function in Excel

2) Within the *Goal Seek* window, click the icon next to the "Set cell" field and select the cell next to "Leveraged, after-tax, nominal IRR" within the *Overall Financial Performance Metrics* table, and then click the icon again to return to the *Goal Seek* window.

3) Enter 0.1 in the "To value" field within the *Goal Seek* window.

4) Within the *Goal Seek* window, click the icon next to the "By changing cell" field and select the cell next to "One time capital incentives (grant or ITC)" within the *Incentives Information* table, and then click the icon again to return to the *Goal Seek* window. Figure 15 illustrates steps 2–4.

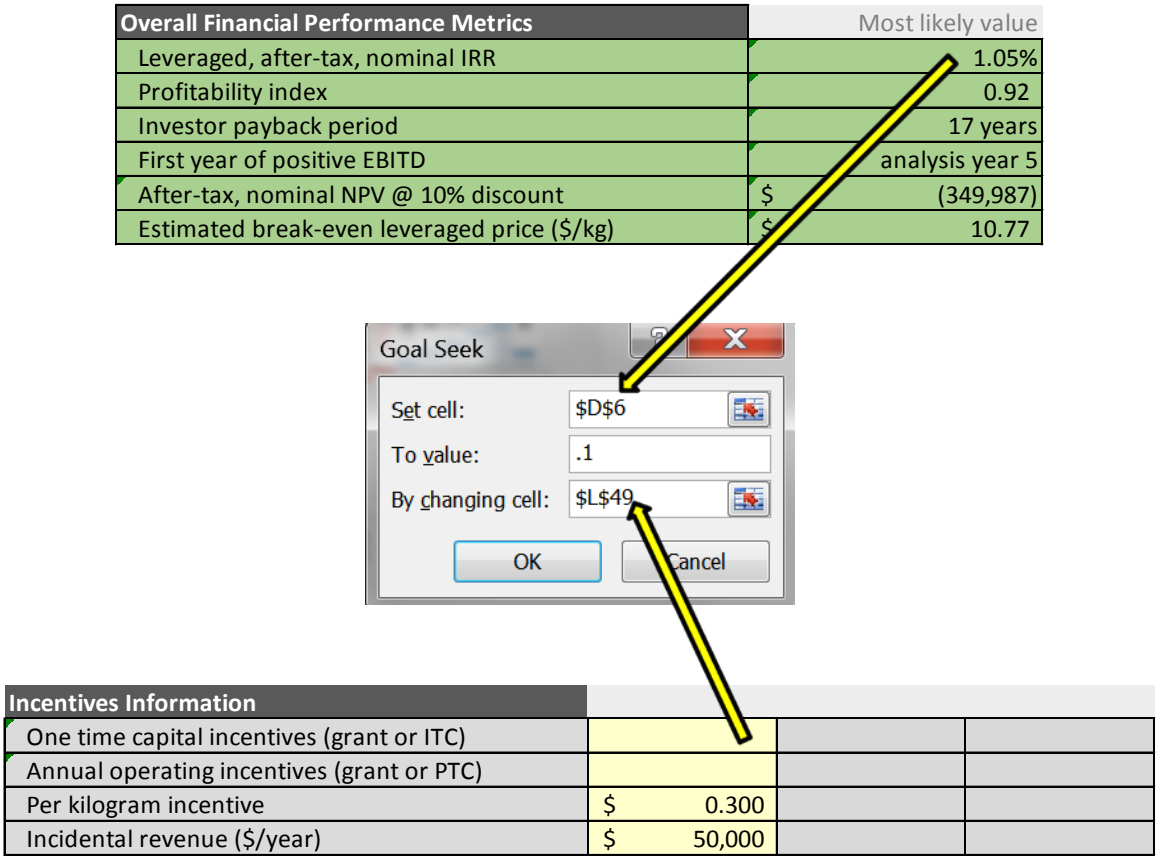


Figure 15. Choosing values for the Goal Seek function

5) Click "OK" within the *Goal Seek* window, which initiates the calculations. When the calculations are complete, each cell will contain the new values resulting in an IRR of 10% and a break-even hydrogen price of $10/kg. In this case, a one-time capital incentive of $429,119 is required, as shown in Figure 16.

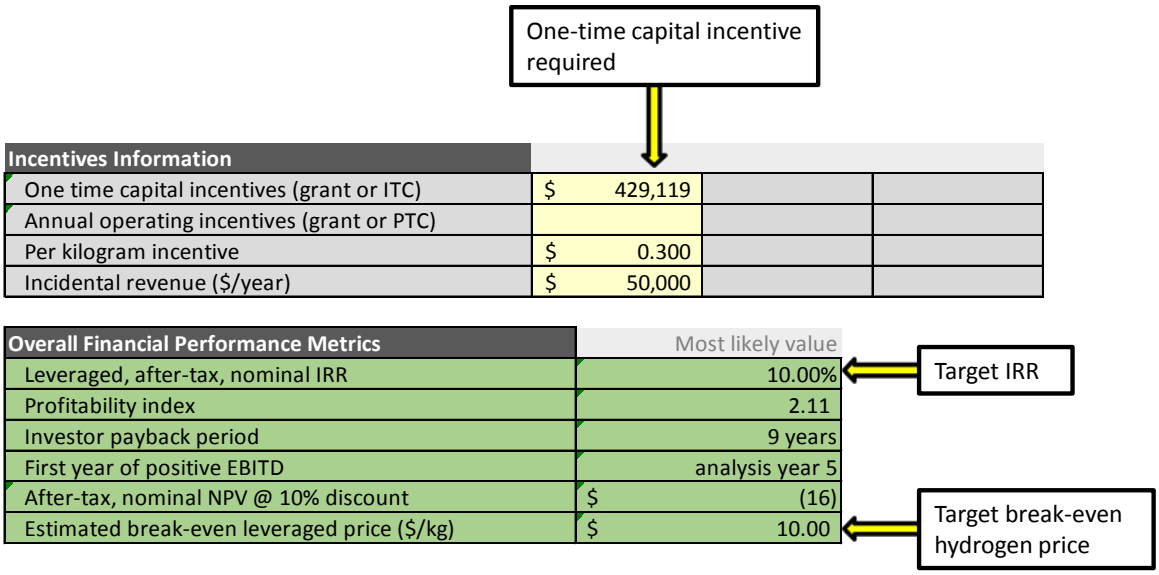


Figure 16. Results of Goal Seek analysis

4 Technical Support

If you have questions or comments about the spreadsheet version of H2FAST, please contact:

Michael Penev
Phone: 303-275-3880
Email: Michael.Penev@nrel.gov

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Appendix A: Model Inputs and Default Values

Station Information[a]		
Input	**Default Value**	**Description**
Select interface	Basic	Advanced mode allows access to detailed model assumptions.
Enter number of stations to model	3	Input information for up to 300 stations. Model can then report financial information on one station at a time or all stations combined.
Capacity (kg/day)	350	This value defines average daily dispensing capacity. The station is still capable of adequately refueling cars during peak demand days.
Equipment capital cost	$2,500,000	Cost of equipment only (not including engineering cost, permitting, and installation). Note: model assumes that salvage value equals decommissioning costs.
Non-depreciable fixed assets (e.g., land)	—	Cost of assets, such as land, that are not subject to depreciation.
Installation cost	—	This cost should include costs associated with installation, such as engineering, permitting, and lot and utility upgrades.
End of project sale of non-depreciable assets	—	Net recovered value at end of life (salvage value – demolition expense), in nominal dollars. This should include non-depreciable fixed assets such as land.
Planned & unplanned maintenance ($/year)	$250,000	Levelized annual maintenance expenses for planned and unplanned equipment servicing and overhauls. Expenses are assumed to be non-depreciable.
Maintenance escalation (% annually)	1.9%	Each year expenses may escalate due to higher cost of technician labor or material expenses.

[a] These values are entered in the *Station(s) Information* and *Multi-Station Inputs* tables.

Co-Product Specifications and Feedstock Use[a]		
Input	**Default Value**	**Description**
Usable waste heat (mmBTU/kg)	—	Yearly average amount of usable waste heat per kilogram of hydrogen sold.
Electricity co-production (kWh/kg)	—	Yearly average amount of co-produced electricity per kilogram of hydrogen sold.
User defined co-product (units/kg)	—	Yearly average amount of user-defined co-product per kilogram of hydrogen sold.
Delivered hydrogen gas trailer (kg/kg)	—	Yearly average amount of delivered hydrogen in gas tube trailer per kilogram of hydrogen sold.
Delivered hydrogen liquid trailer (kg/kg)	1.000	Yearly average amount of delivered hydrogen as liquid per kilogram of hydrogen sold.
Delivered hydrogen pipeline (kg/kg)	—	Yearly average amount of delivered hydrogen in gas pipeline per kilogram of hydrogen sold.
Electricity use (kWh/kg)	5.000	Yearly average amount of electricity used per kilogram of hydrogen sold.
Natural gas use (mmBTU/kg)	—	Yearly average amount of natural gas used per kilogram of hydrogen sold.
User defined feedstock (units/kg)	—	Yearly average amount of user-defined feedstock used per kilogram of hydrogen sold.

[a] These values are entered in the *Co-product Specifications* and *Feedstock Use* tables.

Incentives Information[a]		
Input	**Default Value**	**Description**
One time capital incentives (grant or ITC)	$2,000,000	Incentive is provided at the beginning of the project (accounted on Dec. 31, the year before construction begins). The credit can be a grant or an investment tax credit (ITC).
Annual operating incentives (grant or PTC)	—	Production-based incentives commence the month of station commissioning. This can be a grant or a production tax credit (PTC). If PTC, specify as non-taxable (row 115).
Operating incentives linear decay (% of initial/year)	0%	Annual operating incentives may be reduced each year. This input allows this revenue stream to be ramped down to zero by a fixed annual percentage.
Operating incentives sunset (years)	3	Number of years in which operating incentives are available. This input can simulate early termination of incentives before an annual ramp-down is complete.
Per kilogram incentive	$0.20	Incentive issued on per-kilogram basis. Example: low-carbon fuel standard (LCFS) credit.
Per kilogram incentive decay rate (%/year)	0%	Annual incentive decay rate per year as % of the initial quantity. Note: escalation can be specified by entering a negative number.
Per kilogram incentive sunset (years)	100	Number of years in which incentives are available. This input can simulate early termination of incentives before an annual ramp-down is complete.
Incidental revenue	—	Station revenue enhancements derived from hydrogen. Value should be expressed as (marginal revenue − marginal expenses).
Incidental revenue escalation rate (%/year)	1.9%	Rate of annual escalation for incidental revenue.

[a] These values are entered in the *Incentives Information* and *Incentives Specifications* tables.

Sales Specification		
Input	**Default Value**	**Description**
Project start year	2016	Year in which the project starts (Jan. 1). Note: financial reporting occurs Dec. 31, and investments into the project will be reported as of Dec. 31 of the prior year.
Project operational life (years)	20	Operating life of the project. Enter a value between 5 and 60. Note: project operational life plus installation time must be less than 100 years.
Installation time (months)	18	Months between investment in a station and its first sale.
Demand ramp-up (years)	5.0	Number of years to achieve long-term average utilization. This value imposes a straight-line ramp-up in station utilization.
Long-term nominal utilization (%)	80%	Infrastructure requires reserve capacity for network robustness to nearby station outage and abnormal traffic events. 70% is advised.

Products Value		
Input	**Default Value**	**Description**
Price of hydrogen at project onset ($/kg)	14.00	This is the total cost to the end customer and includes all transaction costs such as credit card fees and sales taxes. Specified price is for the beginning of the project.
Price escalation rate (% annually)	1.9%	Rate of annual escalation.
Usable waste heat ($/mmBTU)	—	Revenue per mmBTU of usable waste heat.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Electricity co-production ($/kWh)	—	Revenue per kWh of usable electricity.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
User defined coproduct ($/unit)	—	Revenue per unit of usable user-defined co-product.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.

Feedstock Cost		
Input	**Default Value**	**Description**
Cost of delivered hydrogen via gas truck ($/kg)	—	Stations using delivered hydrogen are charged for delivered gas. Price is defined at the start of the project (not at start of operation).
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Cost of delivered hydrogen via liquid truck ($/kg)	$8.00	Stations using delivered hydrogen are charged for delivered liquid. Price is defined at the start of the project (not at start of operation).
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Cost of delivered hydrogen via pipeline ($/kg)	—	Stations using delivered hydrogen are charged for delivered gas. Price is defined at the start of the project (not at start of operation).
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Cost of electricity ($/kWh)	$0.120	Blended electricity price.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Cost of natural gas ($/mmBTU)	—	Blended natural gas price.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.
Cost of user defined feedstock ($/unit)	—	Blended user-defined feedstock price.
Escalation rate of cost (% annually)	1.9%	Rate of annual escalation.

Take or Pay Contract Specification		
Input	**Default Value**	**Description**
Price of unsold hydrogen ($/kg)	—	Price paid for unused capacity up to supported level. Price point at the year of start of sales. Note: price is in nominal dollars.
Price decay (% annually)	0%	Price support may be reduced each year by a fixed annual percentage. Note: escalation can be specified by entering a negative number.
Contract sunset (years)	—	Years of consideration for take-or-pay contract.
Utilization supported up to (% of capacity)	80%	Ceiling of equipment utilization covered under take-or-pay contract.

Other Operating Expenses		
Input	**Default Value**	**Description**
Credit card fees (% of sales)	2.50%	This is a flow-through expense for credit card fees.
Sales tax (% of sales)	2.25%	This is a flow-through expense for sales taxes.
Road tax ($/kg)	—	This is a flow-through expense for road taxes.
Road tax escalation rate (%/year)	1.90%	Rate of annual escalation.
Staffing labor hours (h/year-station)	—	This value allows allocation for any on-site labor attributed to dispensing. As stations are typically fully automatic, this value is usually zero.
Labor rate ($/h)	$40	Fully burdened rate of labor. Note that this is for on-site labor, if any, and should not factor in labor rates for maintenance and station hydrogen restocking.
Labor escalation rate (% annually)	1.9%	Rate of annual escalation.
Licensing & permitting ($/year-station)	$1,000	All licensing and permitting expenses. Do not include licensing and permitting during station installation (those are accounted for in the installation expense).
Licensing & permitting escalation rate (%/year)	1.9%	Rate of annual escalation.
Rent of land ($/station-year)	$50,000	Rent is paid annually for the footprint of any hydrogen equipment. Rent expenses prior to operation should be rolled into installation cost.
Rent escalation (% annually)	1.9%	Rate of annual escalation.
Property insurance (% of dep capital)	1.5%	Annual expense as percentage of the depreciated equipment value. Insurance covering installation should be rolled into installation costs.
Selling & administrative expense (% of sales)	0.5%	Use this value to assign any overhead expenses, such as administrative and management costs, as a percentage of the sales revenue stream.

Financing Information		
Input	**Default Value**	**Description**
Total tax rate (state, federal, local)	38.50%	Specify the total tax rate, which may include federal, state, county, and city taxes.
Capital gains tax	15%	Specify the total tax rate, which may include federal, state, county, and city taxes.
Is installation cost depreciable?	No	Specify whether costs associated with construction and permitting are depreciable.
Are operating incentives taxable?	No	Specify whether operating incentives are treated as income (taxable) or whether they are tax exempt.
Is capital incentive depreciable?	Yes	Specify whether incentives received for capital are taxable or tax exempt.
Are tax losses monetized (tax equity application)	Yes	Can tax losses be monetized by offsetting coupled business tax liabilities?
Allowable tax loss carry-forward	7 years	IRS allows carry-forward of tax losses usually for 7 years. Note: this is not used if tax losses are monetized (tax equity application).
General inflation rate	1.90%	This value specifies a general inflation rate and is used in calculation of levelized costs.
Depreciation method	MACRS	Specify depreciation method: Modified Accelerated Cost Recovery System (MACRS) or linear.
Depreciation period	5 years	Value should be less than or equal to the project life. If MACRS is used, it should also be one of the allowed schedules (use drop down).
Leveraged after-tax nominal discount rate	10.0%	Specify a discount rate for reporting of net present value. Note that this rate should include consideration of inflation.
Debt/equity financing	0.5	This factor guides the initial financing capital structure (ratio of debt financing to equity financing).
Debt type	Revolving debt	Specify the type of debt financing (loan or revolving debt). In case of revolving debt, a fixed amount of debt is issued.
If loan, period of loan (years)	20	Enter repayment period for loan (if loan debt is used). This value should not exceed the equipment life.
Debt interest rate (compounded monthly)	6.00%	Enter interest rate on debt—used for both loan and revolving debt calculations.
Cash on hand (% of monthly expenses)	100%	This is cash retained by the business for purposes of liquidity and includes operating expenses, taxes, and interest.

Appendix B: Model Outputs

Global Scenario Outputs

Overall Financial Performance Metrics	
Output	**Description**
Leveraged, after-tax, nominal IRR	Rate of return based on investor cash flow (investments and withdrawals).
Profitability index	(Present value of future equity investor cash flows)/(initial equity investment)
Investor payback period	Number of years before cumulative investor cash flow first becomes greater than zero.
First year of positive EBITD	First year in which earnings before interest, tax, and depreciation are greater than zero.
After-tax, nominal NPV	Net present value of investor net cash flow (investments and withdrawals).
Estimated break-even leveraged price ($/kg)	Price of hydrogen that would yield specified leveraged, after-tax, nominal IRR.

User-Selectable Graphs

Overall Metrics	
Output	**Description**
Cumulative investor cash flow	Investor cash flow + previous year investor cash flow.
Investor cash flow	Investor withdrawals − investor contributions.
Monetized tax losses	Tax loss credits could be applied when majority equity holder has tax liabilities in excess of any credits.
Gross margin	(Total revenue − cost of goods sold) / total revenue.
Cost of goods sold ($/year)	Total operating expenses + depreciation + interest − selling and administrative.
Cost of goods sold ($/kg)	Cost of goods sold / annual hydrogen sales (kg).
Average station utilization (%)	Annual dispensed hydrogen / design annual capability. Note: design capacity hinges on no excessive customer wait times during peak demand during the year.
Average daily H2 sales (kg/day)	Total annual sales / 365.
Daily capacity covered by take or pay contract (kg/day)	Daily average hydrogen capacity qualifying for take-or-pay contract payments.
Retail price of H2 ($/kg)	Price of hydrogen to the end customers (nominal $).
Cost of delivered trailer GH2 to station ($/kg)	Amount paid to a gas supplier for delivering hydrogen to a fueling station via gas tube trailer, on per-unit basis (nominal $/kg).
Cost of delivered trailer LH2 to station ($/kg)	Amount paid to a gas supplier for delivering hydrogen to a fueling station via liquid tube trailer, on per-unit basis (nominal $/kg).
Cost of delivered pipeline H2 to station ($/kg)	Amount paid to a gas supplier for delivering hydrogen to a fueling station via pipeline, on per-unit basis (nominal $/kg).

Cost of electricity ($/kWh)	Total annual expense for electricity / total electric energy used (kWh). Note: this “blended” price should include all utility expenses such as time-of-day use charges and utility administrative fees.
Cost of natural gas ($/mmBtu)	Total annual expense for natural gas / total natural gas used (mmBtu). Note: this “blended” price should include all expenses such as administrative fees.
Cost of user-defined feedstock ($/unit)	Cost of user-defined feedstock as annual average $/unit.
Number of cars supported by infrastructure	Number of cars supported by stated demand assuming average vehicle use of 12,000 miles/year and fuel economy of 60 miles/kg.
Number of fuelings per day	Average number of light-duty car fuelings per day assuming 4.0 kg average dispensing per vehicle.

Income Statement Values	
Output	**Description**
Revenue from hydrogen sales ($/year)	Annual revenue derived from sales of hydrogen. Does not include revenue from incentives.
Revenue from waste heat ($/year)	Revenue from co-production of waste heat.
Revenue from electricity co-production ($/year)	Revenue from co-production of electricity.
Revenue from user-defined co-product ($/year)	Revenue from user-defined co-product.
Revenue from per-kilogram incentive ($/year)	Revenue from per-kilogram incentives.
Revenue from take or pay contract ($/year)	Revenue from take or pay contract
Production incentive revenue	Annual revenue derived from production incentives (nominal $).
Incidental revenue ($/year)	Other station revenue enhancements from presence of hydrogen. This value should be expressed as (marginal revenue − marginal expenses).
Credit card fees ($/year)	Reduction in total revenue based on credit card fees (flow-through expense).
Sales tax ($/year)	Reduction in total revenue based on sales tax expense (flow-through expense).
Road tax ($/year)	Reduction in total revenue based on road tax expense (flow-through expense).
Total revenue	Sales revenue + incentive revenue − credit card fees − sales tax − road tax (annual basis).
Annual cost of delivered gas trailer H2 ($/year)	Annual expense for hydrogen delivered to the station via gas tube trailer.
Annual cost of delivered liquid H2 ($/year)	Annual expense for hydrogen delivered to the station via liquid trailer.
Annual cost of delivered pipeline H2 ($/year)	Annual expense for hydrogen delivered to the station via pipeline.
Annual cost of electricity ($/year)	Annual expense for electricity use.
Annual cost of natural gas ($/year)	Annual expense for natural gas use.
Annual cost of user-defined feedstock ($/year)	Annual expense for use of user-defined feedstock.

Total feedstock & utilities cost ($/year)	Expense for delivered hydrogen + electricity + natural gas + user-defined feedstock.
Labor expense ($/year)	Annual labor expense.
Maintenance expense ($/year)	Annual expenses for maintenance.
Rent expense ($/year)	Annual expense attribution for equipment footprint on the retail location.
Property insurance ($/year)	Annual insurance expense associated with value of equipment. Note: insurance is proportional to the depreciated equipment value.
Licensing & permitting ($/year)	Annual expenses associated with licensing and permitting.
Selling & administrative ($/year)	Annual expenses associated with selling and administrative activities (management overhead).
Total operating expenses ($/year)	Annual total operating expenses. Does not include depreciation, taxes, and interest.
EBITD ($/year)	Total annual revenue − total operating expenses. Earnings before interest, taxes, and depreciation (EBITD).
Interest on outstanding debt ($/year)	Annual interest on outstanding debt. Note: in case of loan debt, interest is accrued monthly.
Equipment depreciation ($/year)	Depreciation expense for equipment, calculated based on quarter of equipment commissioning. Note: this is a tax-accounting metric and not a cash expenditure.
Taxable income ($/year)	Income subject to taxation, before consideration of tax loss carry-forward.
Available deferred tax losses ($/year)	Tax loss carry-forward remaining after annual taxes payable calculations.
Ordinary income taxes payable ($/year)	Taxes payable for the year.
Income before extraordinary items ($/year)	Income after interest, ordinary income taxes.
Sale of non-depreciable assets ($/year)	Sale of non-depreciable fixed assets such as land.
Capital gains ($/year)	Sale of non-depreciable fixed assets less cost basis.
Capital gains taxes payable ($/year)	Capital gains taxes payable on sale of non-depreciable assets gains.
Net income ($/year)	Revenues − operating expenses − interest expense − taxes payable − depreciation expense.

Cash Flow Statement Values	
Output	**Description**
Net annual operating cash flow	Net income + dividends.
Capital expenditures for equipment	Cash flow for initial equipment purchases.
Expenditure for non-depreciable fixed assets	Expenditure for the purchase of non-depreciable fixed assets such as land.
Equipment installation cost	Cash flow for initial installation, permitting, and commissioning expenses.
Total capital expenditure	Total cash flow for initial equipment and installation expenses.
Incurrence of debt	Cash flow associated with acquisition of debt financing.
Repayment of debt	Cash flow associated with repayment of debt. Note: in the case of revolving debt, repayment is done in full at the end of the analysis period.
Inflow of equity	Cash flow associated with equity investment.
Dividends paid	Cash flow to equity investors (dividends or owner withdrawals).

One-time capital incentive	Cash flow from receipt of capital incentive and/or grants.
Net cash for financing activities	Incurrence of debt − repayment of debt + inflow of equity − dividends paid + receipt of capital incentives.
Net change of cash	Annual change in cash position.

Balance Sheet Values	
Output	**Description**
Cumulative cash	Previous year cash position + current year net cash.
Cumulative PP&E	Total undepreciated plant, property, and equipment (PP&E).
Cumulative depreciation	Accumulated depreciation: previous year depreciation expense + current year depreciation expense.
Net PP&E	Depreciated value of plant, property, and equipment (PP&E): cumulative PP&E − cumulative depreciation.
Cumulative deferred tax losses	Tax loss carry-forward usable to offset future year tax liabilities.
Total assets	Accumulated cash + accumulated PP&E − accumulated depreciation + accumulated tax loss carry-forward.
Cumulative debt	Outstanding debt.
Total liabilities	Outstanding debt. Note: accounting is performed on annual basis (assumes accounts payable = accounts receivable, and maintains cash on hand for liquidity).
Cumulative capital incentives equity	Accumulated equity from one-time receipt of capital incentives.
Cumulative investor equity	Accumulated equity from investor contributions.
Retained earnings	Previous year retained earnings + current year net income − current year paid dividends.
Total equity	Accumulated equity from capital incentives + accumulated equity from investor contributions + retained earnings + accumulated tax loss carry-forward. Note: value can be negative in highly leveraged scenarios.
Investor equity less capital incentive	Total equity − capital incentive.

Ratio Analysis	
Output	**Description**
Returns on investor equity	Net income / investor equity. Note: investor equity = total equity − capital incentive.
Debt/equity ratio	Total debt / total equity.
Returns on total equity	Net income / total equity. Note: total equity = investor equity + capital incentive.
Debt service coverage ratio (DSCR)	EBITD / interest. EBITD: earnings before interest, taxes, and depreciation.

Appendix C: Quick Facts about Hydrogen Refueling

Photo by Chris Ainscough, NREL 19512

Hydrogen	
Sources of hydrogen	Conversion of natural gas via steam methane reforming is the primary means of producing hydrogen today. Onsite production by electrolysis is also used for smaller demands. Future systems may include gasification of biomass, large-scale electrolysis using wind, or direct conversion using solar, coal, or nuclear resources.
Energy equivalence	The energy in 1 kilogram of hydrogen is approximately equivalent to the energy in 1 gallon of gasoline.
Cost per kilogram of hydrogen	Because a fuel cell electric vehicle is about twice as efficient as a similar conventional gasoline vehicle, an owner can drive twice as far on a kilogram of hydrogen than on a gallon of gasoline. Therefore, if the hydrogen price is $10/kg, the cost to the owner would be equivalent to about $5/gal gasoline on a cost-per-mile-driven basis.
Fuel Cell Vehicles	
Onboard hydrogen storage methods	Compressed hydrogen at 5,000–10,000 psi (near term); other options include liquid hydrogen and hydrogen stored on or in other materials
Projected range per full fuel tank	300+ miles
Hydrogen required for 300-mile range	~ 5–6 kilograms
Hydrogen Stations	
Public stations open	29
Private stations open	25
States with most stations	California (35), Hawaii (4), Connecticut (2), Massachusetts (2)

Data sources: Alternative Fuels Data Center (www.afdc.energy.gov/fuels/hydrogen.html), FuelEconomy.gov (www.fueleconomy.gov). Station statistics are as of September 15, 2016.