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HySCapE – Hydrogen Station Capacity Evaluation Overview

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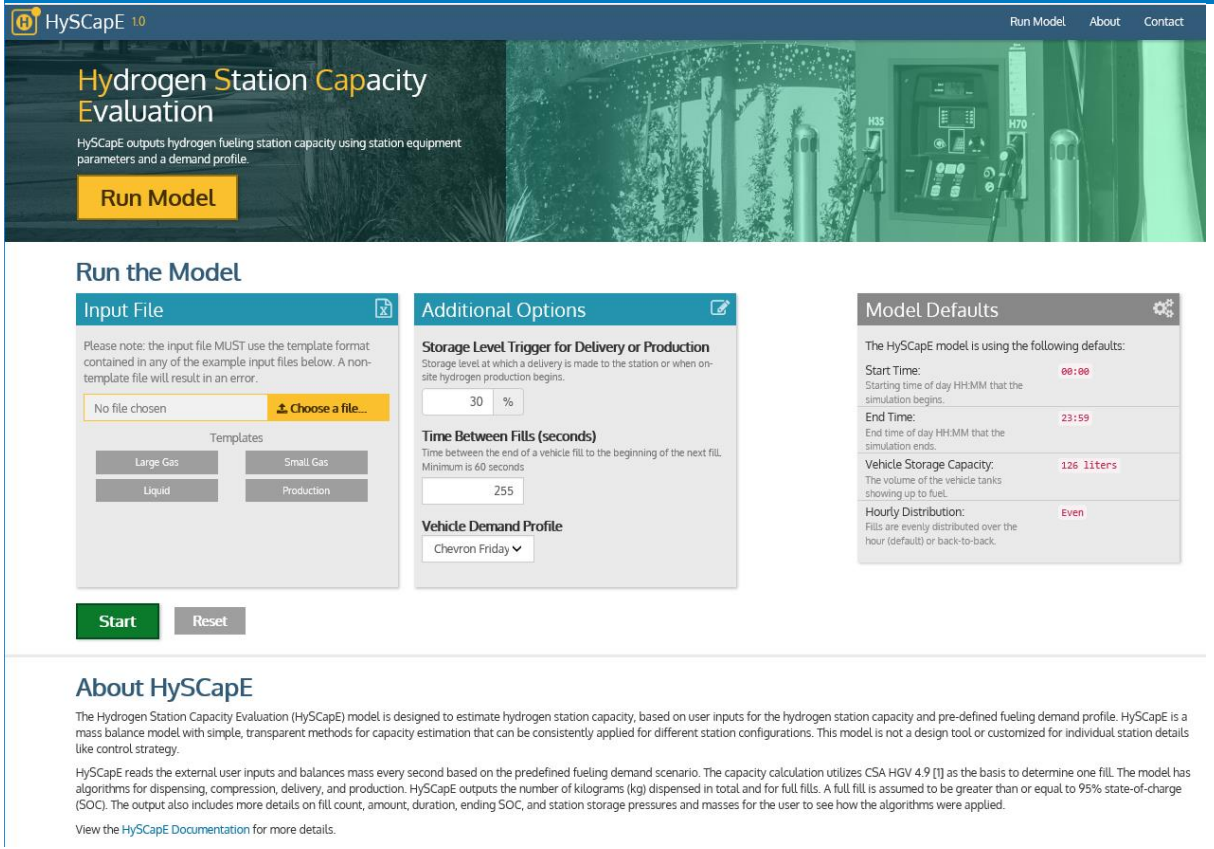
September 27, 2019
CEC Staff Workshop

Agenda

- HySCapE overview
  - Web Interface
  - Inputs, Outputs
- Sample Stations
  - Delivered gas
  - Delivered liquid
- Review of Assumptions
- Questions and Answers

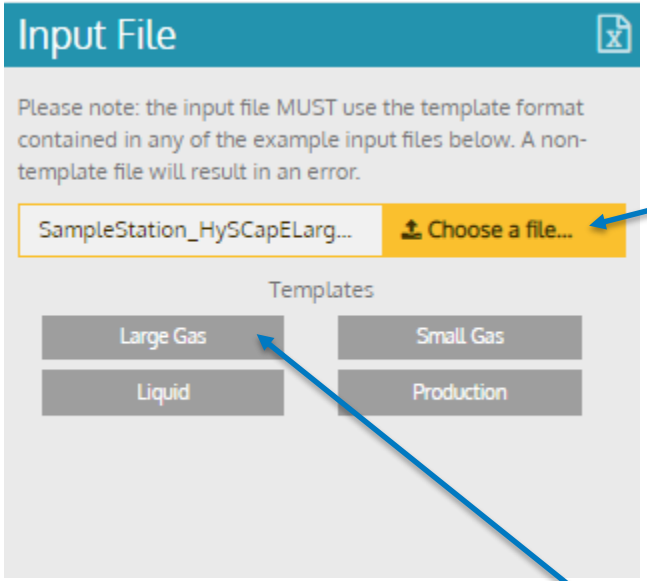
HySCapE 1.0 Web Interface

openei.org/apps/hyscape



- Simple to use physics-based tool
- Publicly available
- Calculates dispensing capacity for multiple configurations of hydrogen stations.
- Runs on server over the internet
- Results are output in images and spreadsheet

Input File Selection



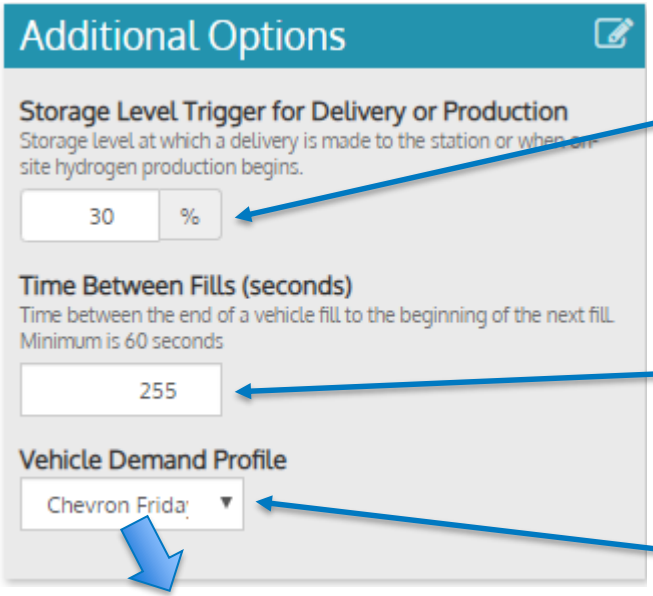
Choose input file. Excel (.xlsx) file with same format as template files

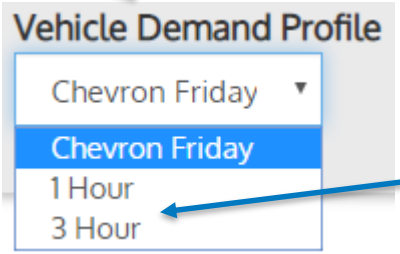
Click to download example templates. Modify these using your station parameters.

	Component	Value	Units	Description
2	Delivery	1	logical [0,1]	Gas delivery to station
3	Delivery	0	logical [0,1]	Liquid delivery to station
4	Production	0	logical [0,1]	On-site production at station
5	Storage	1	logical [0,1]	High pressure storage at station
6	Storage	0	logical [0,1]	Medium pressure storage at station
7	Storage	1	logical [0,1]	Low pressure storage at station
8	Production	0	%	Storage level trigger for production
9	Production	0	kWh/kg	Production unit efficiency
10	Production	0	kg/h	flow/production rate
11	Production	0	MPa	output max pressure
12	Storage	0.42	m3	Volume high pressure (HP) bank %HITRF: 0.342525
13	Storage	0	m3	Volume medium pressure (MP) bank %HITRF: 1.3224;
14	Storage	3	m3	Volume low pressure (LP) bank %Default: 2.6108;
15	Storage	0	m3	Volume of liquid (LQ) bank (22.7125 = 6000 gallons)
16	Storage	4	#	Number of high pressure banks
17	Storage	0	#	Number of medium pressure banks
18	Storage	3	#	Number of low pressure banks
19	Storage	0	#	Number of liquid banks
20	Storage	45	Mpa	Minimum HP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Php is less than or equal to 0)
21	Storage	0	MPa	Minimum MP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Pmp is less than or equal to 0)
22	Storage	0	MPa	Minimum LP bank pressure
23	Storage	90	MPa	Maximum HP bank pressure
24	Storage	0	MPa	Maximum MP bank pressure
25	Storage	50	MPa	Maximum LP bank pressure
26	Storage	0	MPa	Vaporizer output pressure (must be greater than MP compressor minimum) (www.linde-engineering.com.hk/internet.le.le.hkg/zt/images/P_3_4_e_10_150dpi227_5776.pdf?v=.)
27	Storage	1	logical [0,1]	High pressure bank Eligible for fill, 1=eligible, 0=not eligible
28	Storage	0	logical [0,1]	Medium pressure bank Eligible for fill, 1=eligible, 0=not eligible
29	Storage	1	logical [0,1]	Low pressure bank Eligible for fill, 1=eligible, 0=not eligible
30	Compressor	1	logical [0,1]	Allow compressor to fill bank which are used for dispensing?, 1=yes, 0=no.
31	Compressor	1	#	Number of high pressure compressors
32	Compressor	0	#	Number of medium pressure compressors
33	Compressor	5	MPa	Minimum High pressure compressor (HPc) pressure
34	Compressor	0	MPa	Minimum Medium pressure compressor (MPc) pressure
35	Compressor	90	Mpa	Maximum HPc pressure
36	Compressor	0	Mpa	Maximum MPc pressure
37	Compressor	75	kg/h	HPc maximum flowrate

Sheet1

Additional Input Options





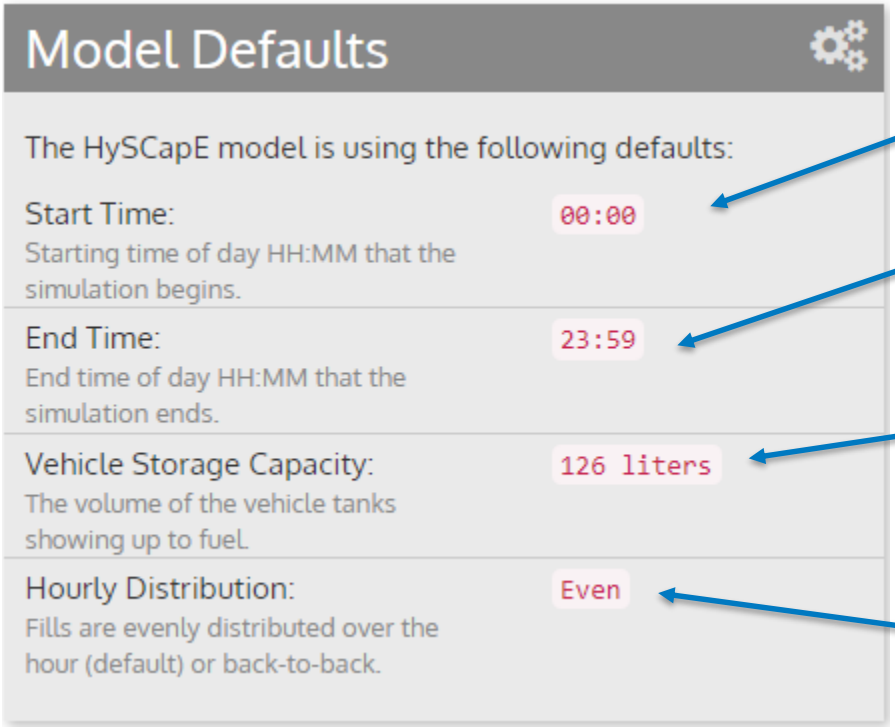
Storage level trigger for delivery or production. Model assumes the station is full at start of run.

Time between fills value sets max possible fills in the peak fueling hour (e.g., 3-4 pm Chevron Friday), which then determines 24-hour capacity.

Demand profile selection

1 Hour and 3 Hour – These are max effort based on time between fills and the average 1kg/min fueling rate.

Model Defaults (Displayed on Web Interface)



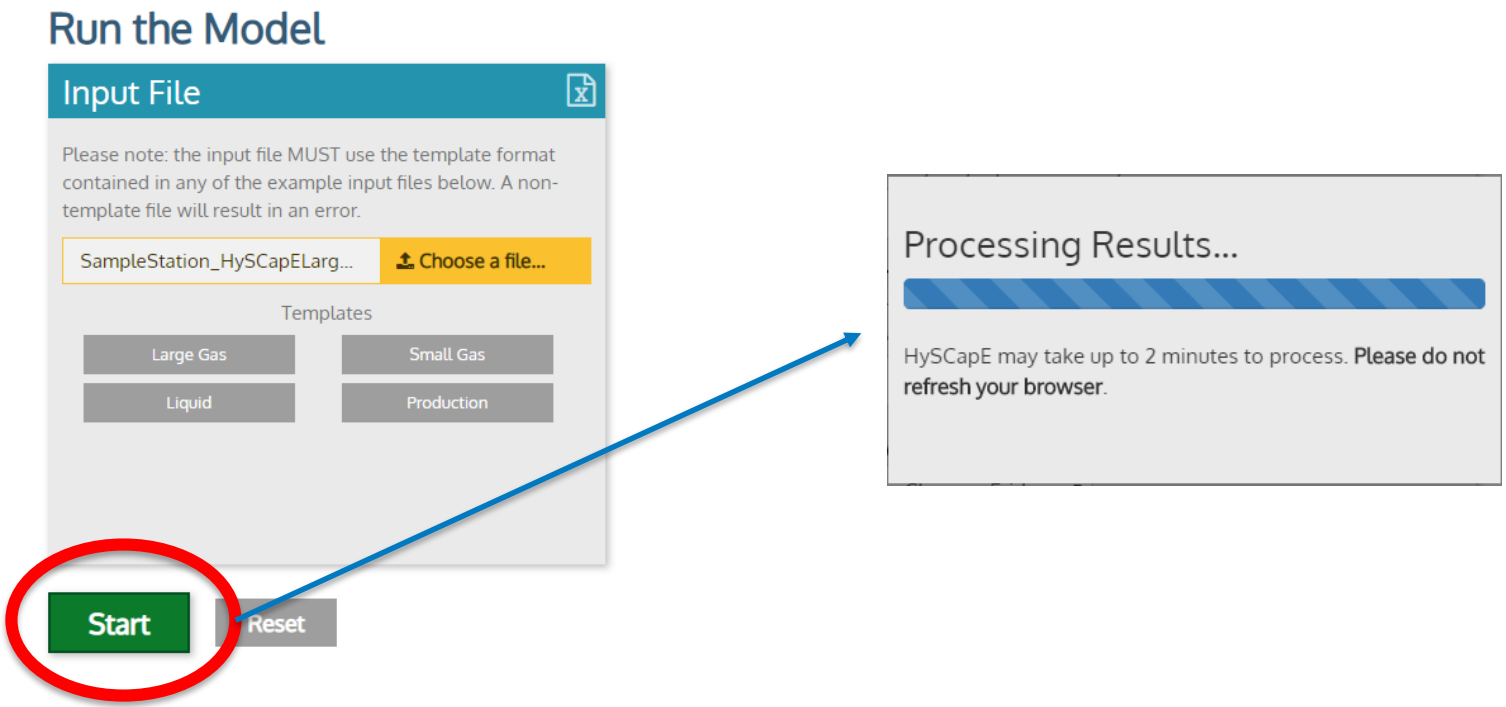
Starts at midnight

Runs for 24 hours.

Vehicle Storage Capacity is fixed at 126 liters (~5 kg at 70MPa)

Even hourly distribution
Fills are spread out over each hour instead of back-to-back from beginning of hour.

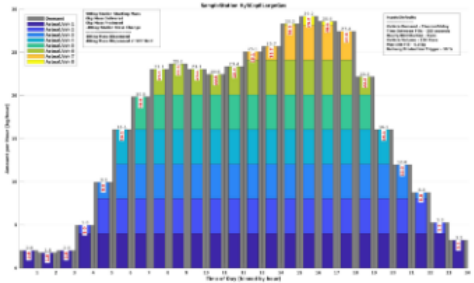
Running HySCapE 1.0



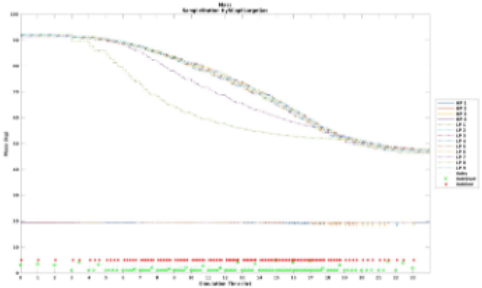
Results Screen

Results

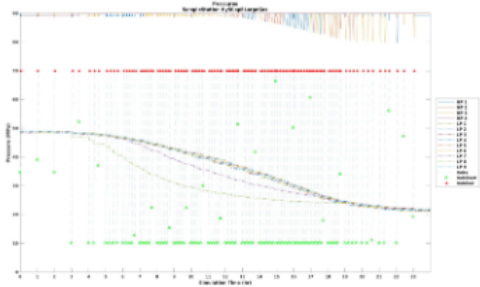
Hourly Dispensed



Mass over 24 hours



Pressures over 24 hours



Output.xlsx

Data Results

Download All

Large delivered gas
Inputs

Component	Value	Units	Description
Production	0	kg/h	flow/production rate
Production	0	MPa	output max pressure
Storage	0.42	m3	Volume high pressure (HP) bank %HITRF: 0.342925
Storage	0	m3	Volume medium pressure (MP) bank %HITRF: 1.3224;
Storage	3	m3	Volume low pressure (LP) bank %Default: 2.6108;
Storage	0	m3	Volume of liquid (LO) bank (22.7125 = 6000 gallons)
Storage	4	#	Number of high prssure banks
Storage	0	#	Number of medium pressure banks
Storage	9	#	Number of low pressure banks
Storage	0	#	Number of liquid banks
Storage	45	Mpa	Minimum HP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Php is less than or equal to 0)
Storage	0	MPa	Minimum MP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Pmp is less than or equal to 0)
Storage	0	MPa	Minimum LP bank pressure
Storage	90	MPa	Maximum HP bank pressure
Storage	0	MPa	Maximum MP bank pressure
Storage	50	MPa	Maximum LP bank pressure
Storage	0	MPa	Vaporizer output pressure (must be greater than MP compressor minimum) (www.linde-engineering.com.hk/internet.le.le.hkg/zt/images/P_3_4_e_10_150dpi227_5776.pdf?v=.)
Storage	1	logical [0,1]	High pressure bank Eligible for fill, 1=eligible, 0=not eligible
Storage	0	logical [0,1]	Medium pressure bank Eligible for fill, 1=eligible, 0=not eligible

Volume of 1 HP bank

# of HP banks

Min Pressure

Max Pressure

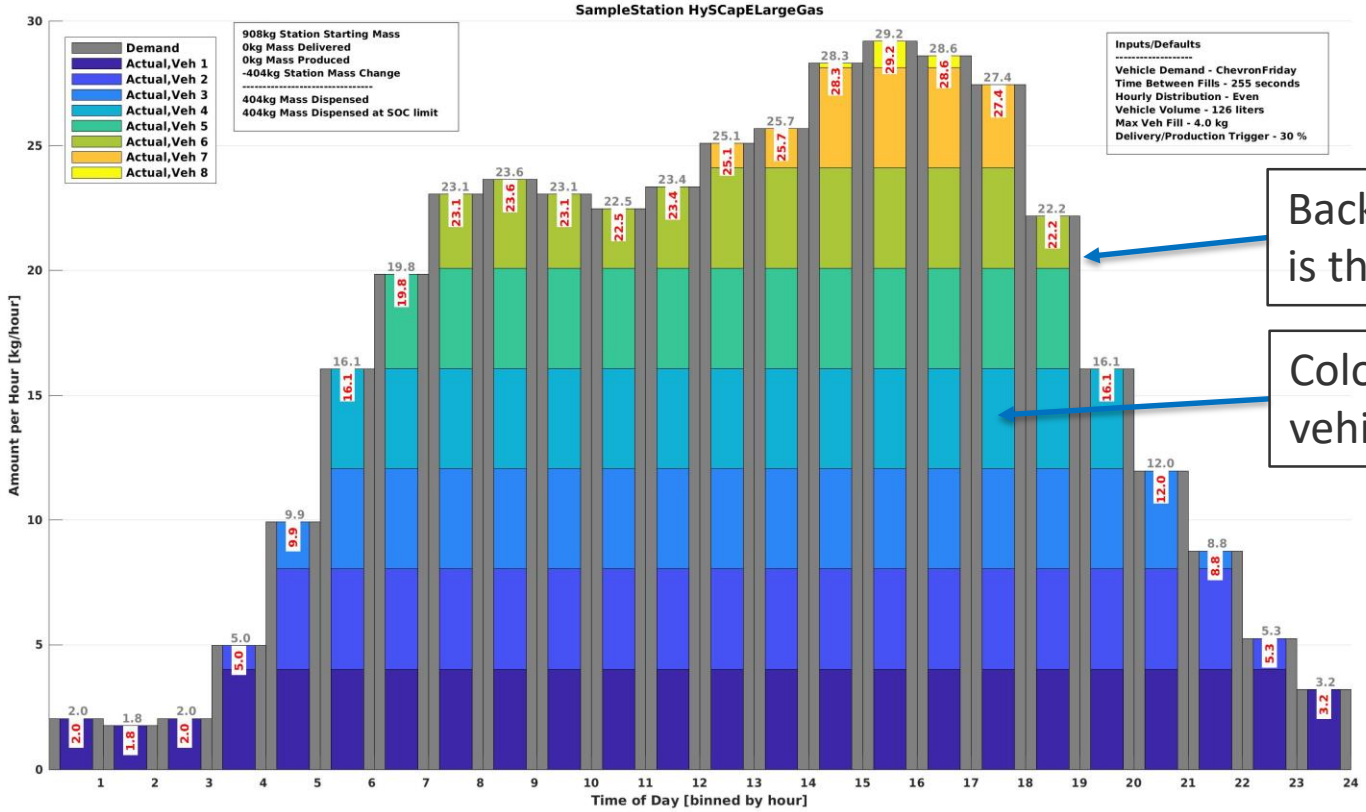
Large delivered gas
Inputs

Component	Value	Units	Description
Storage	0	MPa	Minimum LP bank pressure
Storage	90	MPa	Maximum HP bank pressure
Storage	0	MPa	Maximum MP bank pressure
Storage	50	MPa	Maximum LP bank pressure
Storage	0	MPa	Vaporizer output pressure (must be greater than MP compressor minimum) (www.linde-engineering.com.hk/internet.le.le.hkg/zt/images/P_3_4_e_10_150dpi227_5776.pdf?v=.)
Storage	1	logical [0,1]	High pressure bank Eligible for fill, 1=eligible, 0=not eligible
Storage	0	logical [0,1]	Medium pressure bank Eligible for fill, 1=eligible, 0=not eligible
Storage	1	logical [0,1]	Low pressure bank Eligible for fill, 1=eligible, 0=not eligible
Compressor	1	logical [0,1]	Allow compressor to fill bank which are used for dispensing?, 1=yes, 0=no.
Compressor	1	#	Number of high pressure compressors
Compressor	0	#	Number of medium pressure compressors
Compressor	5	MPa	Minimum High pressure compressor (HPc) pressure
Compressor	0	MPa	Minimum Medium pressure compressor (MPc) pressure
Compressor	90	Mpa	Maximum HPc pressure
Compressor	0	Mpa	Maximum MPc pressure
Compressor	75	kg/h	HPc maximum flowrate
Compressor	0	kg/h	MPc maximum flowrate
Compressor	0	kg/h	Liquid pump maximum flowrate
Compressor	0	kg/h	Vaporizer maximum flowrate
Dispenser	20	°C	Ambient temperature
Dispenser	1	#	Maximum number fueling positions capable of simultaneous fill
Delivery	300	kg	Mass per delivery
Delivery	1	#/day	Number of deliveries per day
Delivery	6	#	Number of banks delivering hydrogen
Delivery	35	MPa	Pressure of delivery truck
Delivery	1	kg/s	Delivery flow rate
Delivery	3600	s	Delivery truck dwell time
Delivery	1	selector [1,2]	Fuel delivery type, 1=gaseous, 2=liquid
Liquid	0	kg/s	Liquid truck delivery rate to storage

Allow compression into bank that is simultaneously dispensing

# of simultaneous fueling positions. Entry of 2 doubles the demand at the station

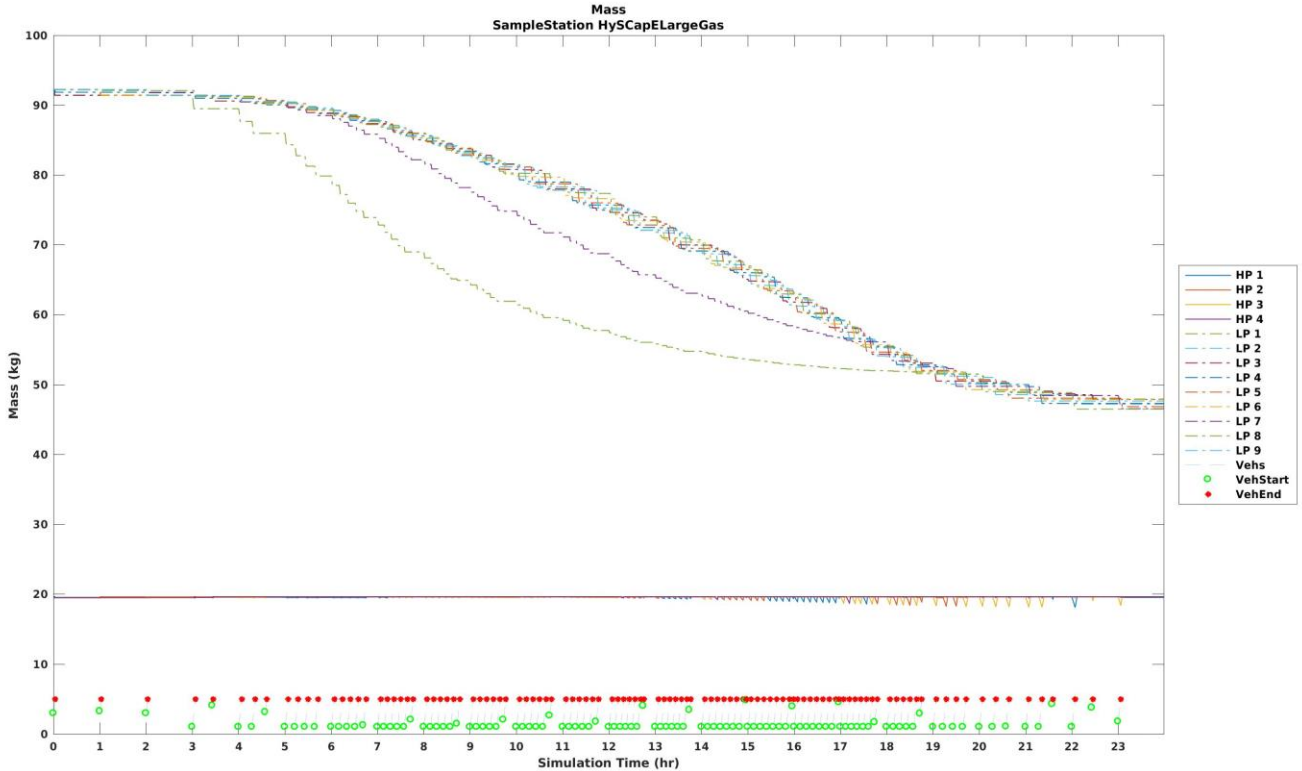
Large delivered gas - *Fill Profile*



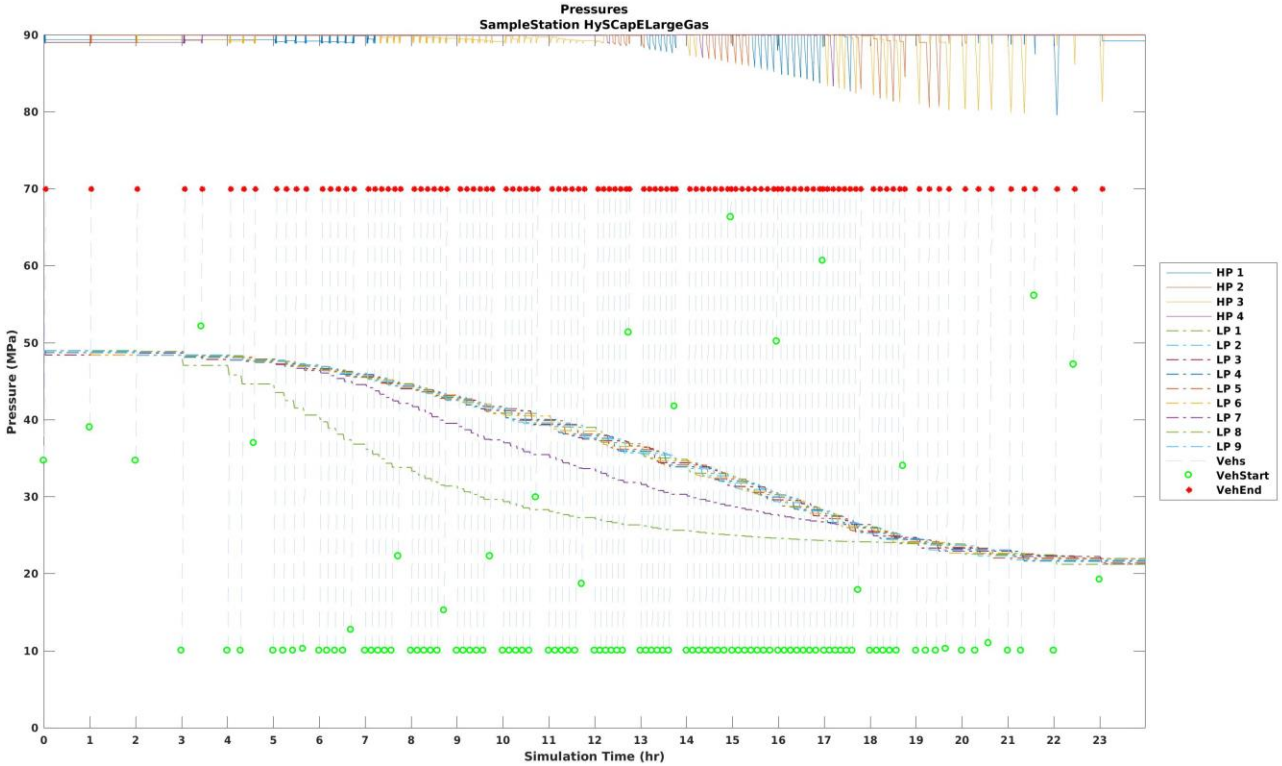
Background gray bar is the demand

Color bars are vehicles

Large delivered gas
Storage/Dispense Mass



Large delivered gas
Storage/Dispense Pressures



Large delivered gas
Output .xlsx file

	A	B	C	D	E
1	C1	C2	C3	C4	C5
2	Input File	SampleStation_HySCapELargeGas_inputs.xlsx			
3	Output File	outfile.xlsx			
4	Vehicle Demand	ChevronFriday			
5	Hourly Distribution	Even			
6	Time Between Fills	255	seconds		
7	Vehicle Volume	126	liters		
8	Delivery Trigger	30	%		
9	Variable	Value	Units	Description	
10	Starting Mass	908.2971318	kg	station starting mass	
11	Ending Mass	504.3135562	kg	station ending mass	
12	Total H2 Dispensed	403.9835756	kg	sum of hydrogen dispensed	
13	H2 Dispensed to SOC Limit	403.9835756	kg	sum of hydrogen dispensed that meets SOC of	0.95
14	H2 Delivered	0	kg	sum of hydrogen delivered to station	
15	H2 Produced	0	kg	sum of hydrogen produced at station	
16	Station Mass Change	-403.9835756	kg	change in mass at station	
17	Duration	23.98333333	hours		
18	StartTime	12:00:00 AM	HH:MM:SS		
19	EndTime	11:59:00 PM	HH:MM:SS		
20	hour 0	2.04326953	kg	amount dispensed this hour	
21	hour 1	1.751373883	kg	amount dispensed this hour	
22	hour 2	2.04326953	kg	amount dispensed this hour	
23	hour 3	4.962226001	kg	amount dispensed this hour	
24	hour 4	9.924452002	kg	amount dispensed this hour	
25	hour 5	16.05426059	kg	amount dispensed this hour	
26	hour 6	19.848904	kg	amount dispensed this hour	
27	hour 7	23.05975612	kg	amount dispensed this hour	
28	hour 8	23.64354742	kg	amount dispensed this hour	
29	hour 9	23.05975612	kg	amount dispensed this hour	
30	hour 10	22.47596483	kg	amount dispensed this hour	

Summary Section

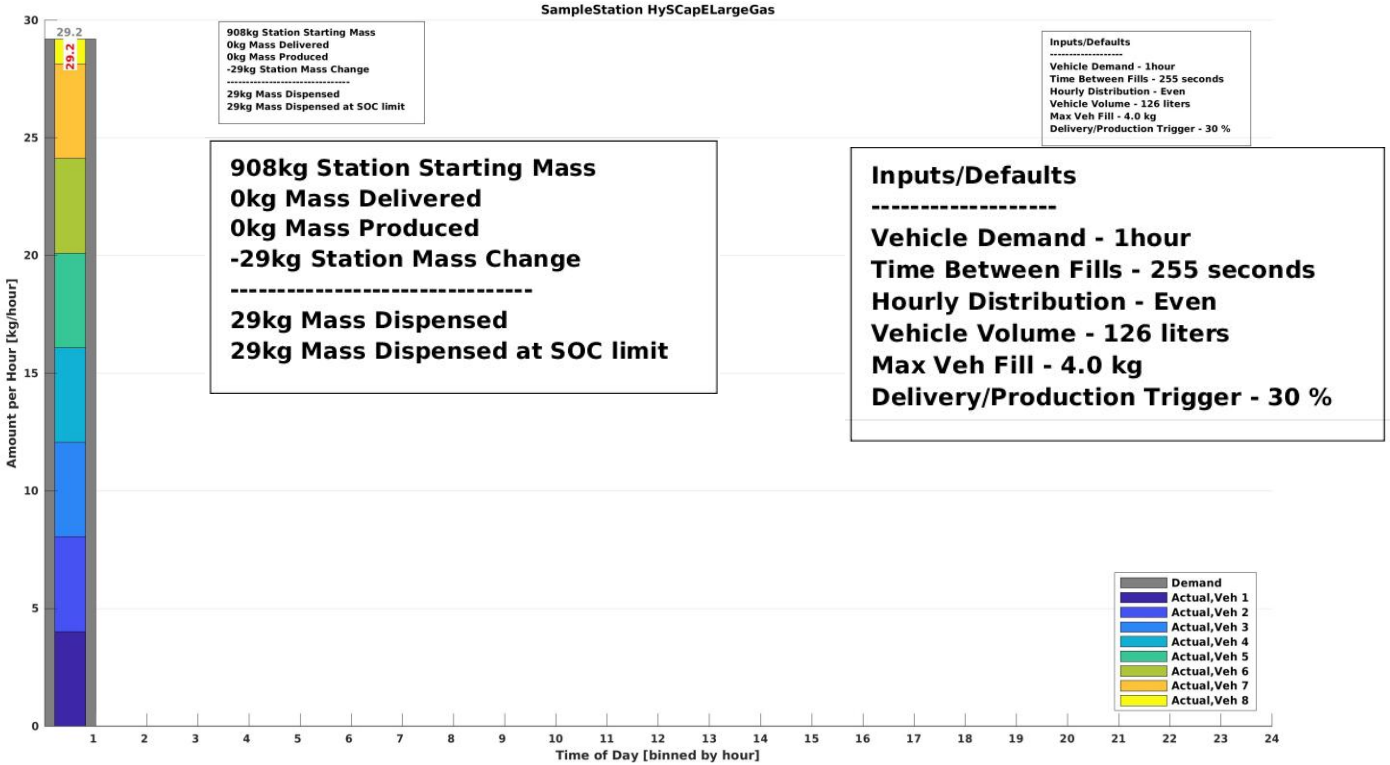
Hourly Amounts

Large delivered gas
Output .xlsx file

	A	B	C	D	E	F	G	H
40	hour 20	11.96772153	kg	amount dispensed this hour				
41	hour 21	8.756869413	kg	amount dispensed this hour				
42	hour 22	5.254121648	kg	amount dispensed this hour				
43	hour 23	3.210852118	kg	amount dispensed this hour				
44	Dispensed by Vehicle							
45	Time (start of fill)	Time (end of fill	Duration	Car Number	Init kg	Final kg	Added kg	Final SOC
46	00:00:01	00:02:05	00:02:04	1	2.957905453	5.001174983	2.04326953	1
47	01:00:00	01:01:45	00:01:45	2	3.249801101	5.001174983	1.751373882	1
48	02:00:01	02:02:07	00:02:06	3	2.957905453	5.001174983	2.04326953	1
49	03:00:00	03:04:05	00:04:05	4	0.982357913	5.001174983	4.01881707	1
50	03:25:53	03:26:50	00:00:57	5	4.057766052	5.001174983	0.943408931	1
51	04:00:00	04:04:05	00:04:05	6	0.982357913	5.001174983	4.01881707	1
52	04:17:15	04:21:20	00:04:05	7	0.982357913	5.001174983	4.01881707	1
53	04:34:30	04:36:23	00:01:53	8	3.114357122	5.001174983	1.886817862	1
54	05:00:01	05:04:07	00:04:06	9	0.982357913	5.001174983	4.01881707	1
55	05:12:57	05:17:03	00:04:06	10	0.982357913	5.001174983	4.01881707	1
56	05:25:53	05:30:00	00:04:07	11	0.982357913	5.001174983	4.01881707	1
57	05:38:49	05:42:54	00:04:05	12	1.003365602	5.001174983	3.997809381	1
58	06:00:00	06:04:07	00:04:07	13	0.982357913	5.001174983	4.01881707	1
59	06:10:21	06:14:28	00:04:07	14	0.982357913	5.001174983	4.01881707	1
60	06:20:42	06:24:48	00:04:06	15	0.982357913	5.001174983	4.01881707	1
61	06:31:03	06:35:10	00:04:07	16	0.982357913	5.001174983	4.01881707	1
62	06:41:24	06:45:15	00:03:51	17	1.22753926	5.001174983	3.773635723	1
63	07:00:00	07:04:06	00:04:06	18	0.982357913	5.001174983	4.01881707	1
64	07:08:38	07:12:45	00:04:07	19	0.982357913	5.001174983	4.01881707	1
65	07:17:15	07:21:21	00:04:06	20	0.982357913	5.001174983	4.01881707	1
66	07:25:53	07:30:00	00:04:07	21	0.982357913	5.001174983	4.01881707	1
67	07:34:30	07:38:37	00:04:07	22	0.982357913	5.001174983	4.01881707	1
68	07:43:07	07:46:10	00:03:03	23	2.035504212	5.001174983	2.965670772	1
69	08:00:01	08:04:08	00:04:07	24	0.982357913	5.001174983	4.01881707	1
70	08:08:38	08:12:45	00:04:07	25	0.982357913	5.001174983	4.01881707	1
71	08:17:15	08:21:22	00:04:07	26	0.982357913	5.001174983	4.01881707	1

Individual Vehicle Fill

1 hour back-to-back fueling



Liquid delivered
Inputs

Component	Value	Units	Description
Production	0	MPa	output max pressure
Storage	0.33	m3	Volume high pressure (HP) bank %HITRF: 0.342925
Storage	0	m3	Volume medium pressure (MP) bank %HITRF: 1.3224:
Storage	0	m3	Volume low pressure (LP) bank %Default: 2.6108;
Storage	20	m3	Volume of liquid (LQ) bank (22.7125 = 6000 gallons)
Storage	4	#	Number of high prssure banks
Storage	0	#	Number of medium pressure banks
Storage	0	#	Number of low pressure banks
Storage	1	#	Number of liquid banks
Storage	45	Mpa	Minimum HP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Php is less than or equal to 0)
Storage	0	MPa	Minimum MP bank pressure (Must use whole numbers or adjust pressure lookup function, Must adjust dispensing algorithm if min Pmp is less than or equal to 0)
Storage	0	MPa	Minimum LP bank pressure
Storage	90	MPa	Maximum HP bank pressure
Storage	0	MPa	Maximum MP bank pressure
Storage	0	MPa	Maximum LP bank pressure
Storage	0.92	MPa	Vaporizer output pressure (must be greater than HP compressor minimum) (www.linde-engineering.com.hk/internet.le.le.hkg/zt/images/P_3_4_e_10_150dpi227_5776.pdf?v=.)
Storage	1	logical [0,1]	High pressure bank Eligible for fill, 1=eligible, 0=not eligible
Storage	0	logical [0,1]	Medium pressure bank Eligible for fill, 1=eligible,

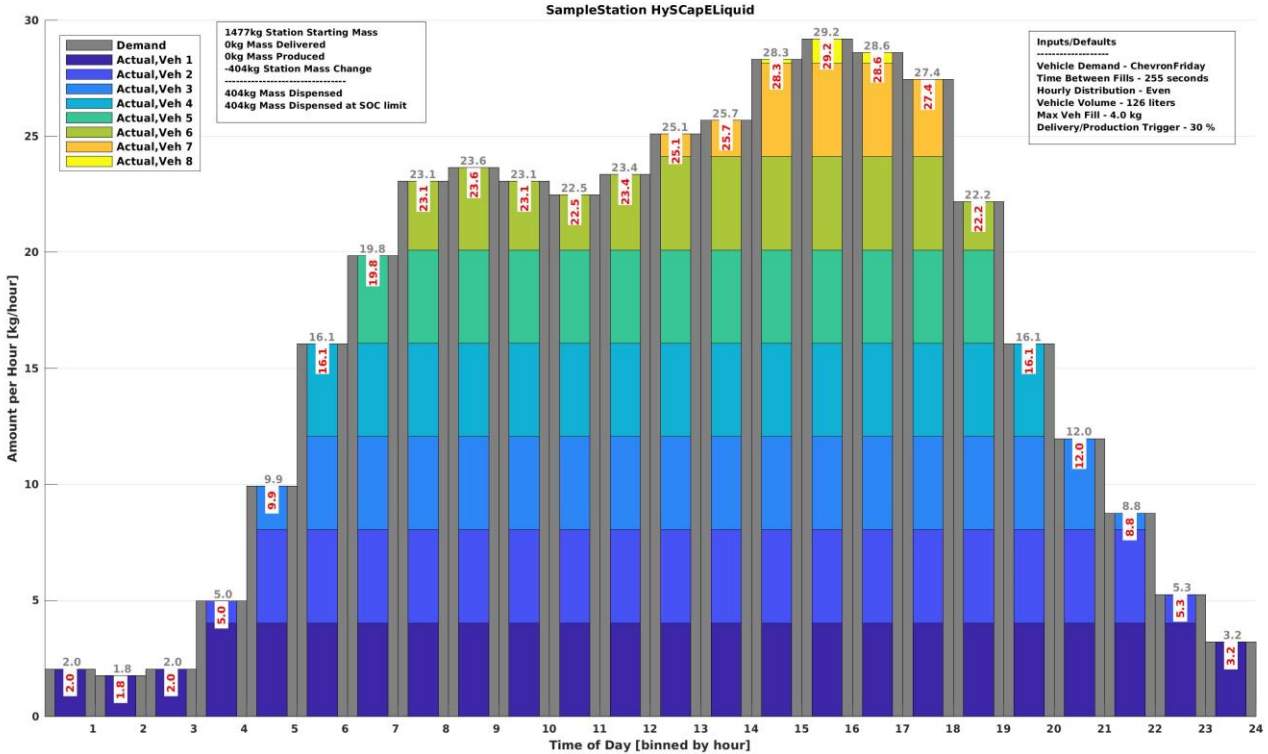
Liquid storage

Liquid delivered
Inputs

Component	Value	Units	Description
Storage	0	logical [0,1]	Low pressure bank Eligible for fill, 1=eligible, 0=not eligible
Compressor	1	logical [0,1]	Allow compressor to fill bank which are used for dispensing?, 1=yes, 0=no.
Compressor	1	#	Number of high pressure compressors
Compressor	0	#	Number of medium pressure compressors
Compressor	20	MPa	Minimum High pressure compressor (HPc) pressure
Compressor	0	MPa	Minimum Medium pressure compressor (MPc) pressure
Compressor	93	Mpa	Maximum HPc pressure
Compressor	0	Mpa	Maximum MPc pressure
Compressor	25	kg/h	HPc maximum flowrate
Compressor	0	kg/h	MPc maximum flowrate
Compressor	0	kg/h	Liquid pump maximum flowrate
Compressor	100	kg/h	Vaporizer maximum flowrate
Dispenser	20	degC	Ambient temperature
Dispenser	1	#	Maximum number fueling positions capable of simultaneous fill
Delivery	0	kg	Mass per delivery
Delivery	0	#/day	Number of deliveries per day
Delivery	0	#	Number of banks delivering hydrogen
Delivery	0	MPa	Pressure of delivery truck
Delivery	0	kg/s	Delivery flow rate
Delivery	3600	s	Delivery truck dwell time
Delivery	1	selector [1,2]	Fuel delivery type, 1=gaseous, 2=liquid
Liquid	0.4464	kg/s	Liquid truck delivery rate to storage

If using Liquid pump
Vaporizer flow rate must be at least the liquid pump flow rate

Liquid delivered
Fill Profile



HySCapE 1.0 Assumptions

- Not a design tool. Does not verify equipment.
  - Example: assumes the hydrogen chiller is sized appropriately
  - Example 2: assumes the flow rates specified are achievable
- Average dispensing rate of 1 kg/min
- CSA HGV 4.9 the basis for defining a fill
- Station will not see more demand than the “Chevron gasoline profile”.
- Vehicles are full at 5 kg, with a starting pressure of 10 Mpa
- Ambient temperature used to calculate pressures
- Station storage is 100% at start
- Compression is scaled based on suction pressure
- 2 dispensers double the demand

Questions and Answers

Question: How is the demand profile used in the model?

Along with the time between fills, it is used to determine how many and when vehicles show up each hour for fueling.

Question: What is HITRF and associated example values in input files?

Hydrogen **I**nfrastructure **T**esting and **R**esearch **F**acility at NREL. Example values from our station were used in testing and developing the software.

Question: Where can I find more details on how the model works?

- July 20, 2018 workshop ww2.energy.ca.gov/altfuels/notices/2018-07-20_workshop/2018-07-20_ARFVTP_Workshop.mp4

Thank you

www.nrel.gov

Publication Number

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