

## Technical Appendix

### GHG Reduction Estimate Method:

- **Measure #1:** Replace (30) diesel trucks and buses with H2 trucks and buses and eliminate the associated GHG emissions.
  - Define the type/number/performance of the (30) diesel vehicles to be replaced.
  - Model the annual diesel consumption of the (30) diesel trucks and buses by defining an annual duty cycle and estimating the vehicles fuel efficiency (mi/gal).
  - Calculate the annual CO<sub>2</sub>e that would be produced from diesel consumed using the Emissions Factor provided by EPA
- **Measure #2:** Eliminate the transport diesel from the fuel terminal in Newell, WV to Marion County (240 mi round trip), thereby eliminating the associated GHG emissions from the delivery.
  - Use the estimated annual diesel fuel consumption and an assumed diesel tanker size of 10,000 gal to calculate the number of refueling trips required per year.
  - Use the assumed fuel efficiency (mi/gal) of the fuel tanker to calculate the fuel used in transporting diesel from the fuel terminal to Marion County.
  - Calculate the annual CO<sub>2</sub>e that would be produced from diesel consumed using the Emissions Factor provided by EPA
- **Measure #3:** Sell any surplus H2 produced by the HLH2 Facility to CFS to fuel the H2 vehicles owned by CFS as part of ARCH2 to replace diesel vehicles and eliminate their GHG emissions.
  - Use the estimated annual fuel consumption for the (30) diesel trucks to estimate the equivalent amount of H2 that would be consumed by the replacement H2 vehicles using the assumed H2 vehicle fuel efficiency (mi/kg H2)
  - Compare the estimated annual H2 consumption to the estimated H2 annual production from the HLH2 Facility.
  - If and to the extent the H2 fuel consumption is less than the H2 produced then any surplus would be sold to CFS for use in CFS H2 vehicles.
  - Assume the type of vehicle that would be used by CFS to consume the H2 and calculate the VMT that vehicle would need to travel to consume the equivalent amount of diesel calculated using the diesel fuel efficiency (mi/gal) for that vehicle.
  - Calculate the annual CO<sub>2</sub>e that would be produced from diesel consumed using the Emissions Factor provided by EPA

### Models/Tools Used:

- Marion County used Clean Fuel Services LLC to develop the GHG Reduction proforma submitted as part of this application (GHG Reduction 24-04-01.xlsx)

- The contact details for the developer of this proforma are: Brian Redmond, 713-705-4591, brian@hlaggregates.com.

#### **Measure Implementation Assumptions:**

- A schedule for the HLH2 Facility development and construction is included in this Technical Appendix and are also discussed in Section 2.
- Measure implementation will be completed in 30 months from grant award.
- Measure lifetime will continue until the H2 vehicles are no longer in service and are not replaced with additional H2 vehicles.
- Measure capital cost assumptions are included in this Technical Appendix and are also discussed in Section 3.
- Measure operating cost assumptions are included in this Technical Appendix.

#### **GHG Emission Reduction Assumptions, Scenarios, Calculations, Results:**

- GHG reduction estimate assumptions are provided in this Technical Appendix and are discussed in Section 2.
- Reference case assumptions are provided in this Technical Appendix and are discussed in Section 2.
- Measure-specific activity data used for estimating GHG emission reductions for each measure are provided in this Technical Appendix as discussed in Section 2

**Vehicle Feet Assumptions:** The fuel efficiency and emission values for the fleet of (30) existing diesel vehicles currently used in Marion and Harrison Counties and the fuel efficiency values of the (30) new H<sub>2</sub> vehicles that will replace them are provided in the following table (which is continued on the following page).

FLEET INFO						
Diesel Vehicle Info	Assumption Source/Reference	Heavy Haul Truck	Heavy Haul Truck	Tri Axle Truck	Tri Axle Truck	Service Truck
Vehicle Class		Class 8: On-road	Class 8: On-road	Class 7	Class 7	Class 7
Gross Vehicle Weight Ratings (GVWRs)	Fed. Highway Admin (see table)	26001 - 33,000	26001 - 33,000	19, 501 - 26,000	19, 501 - 26,000	19, 501 - 26,000
Onboard Fuel Storage (gal)	Freight Waves - Internet Search	120	120	75	75	75
Expected fueling profile (#/day)	User assumption	Daily	Daily	Daily	Daily	Daily
Peak fueling case (#/day)	User assumption	2x per day	2x per day	2x per day	2x per day	2x per day
Fill time expectation	User assumption	10 - 15 min	10 - 15 min	15 - 20 min	15 - 20 min	15 - 20 min
Fuel Use - Diesel (mi/gal)	See Vehicle Fuel Use tab	5.0	5.0	4.0	4.0	6.0
CO <sub>2</sub> e Generated (kg/gal)	See Emission Factors tab (EPA)	10.21	10.21	10.21	10.21	10.21
CO <sub>2</sub> e Generated (lbs/gal) @ Convert Fac	2.204	22.5	22.5	22.5	22.5	22.5
Hydrogen Vehicle Info		Heavy Haul Truck	Heavy Haul Truck	Tri Axle Truck	Tri Axle Truck	Service Truck
Vehicle Class		Class 8: On-road	Class 8: On-road	Class 7	Class 7	Class 7
Gross Vehicle Weight Ratings (GVWRs)	Fed. Highway Admin (see table below)	26001 - 33,000	26001 - 33,000	19, 501 - 26,000	19, 501 - 26,000	19, 501 - 26,000
Onboard H2 storage pressure (H70 or H)	Cummins	H70	H70	H70	H70	H70
Onboard H2 tank size (kg)	Cummins	40 kg	40 kg	40 kg	40 kg	40 kg
Tanks size (water volume)	Cummins	800 liters	800 liters	800 liters	800 liters	800 liters
Expected kg per fill	Cummins	35 kg	35 kg	35 kg	35 kg	35 kg
Expected fueling profile (#/day)	User assumption	Daily	Daily	Daily	Daily	Daily
Peak fueling case (#/day)	User assumption	2x per day	2x per day	2x per day	2x per day	2x per day
Fill time expectation	User assumption	10 - 15 min	10 - 15 min	15 - 20 min	15 - 20 min	15 - 20 min
Vehicle Delivery	User assumption	2025	2025	2025	2025	2025
H2 Fuel Use (mi/kg)	See Vehicle Fuel Use tab	6.0	6.0	4.8	4.8	7.2
Hydrogen (mpg) / Diesel (mpg) =>	1.2					

Diesel Vehicle Info	Assumption Source/Reference	School Bus	School Bus	Transit Bus	Transit Bus
Vehicle Class		Class 6: School Bus	Class 6: School Bus	Class 7:	Class 7:
Gross Vehicle Weight Ratings (GVWRs)	Fed. Highway Admin (see table)	19,501 - 26,000	19,501 - 26,000	26,001 - 33,000	26,001 - 33,000
Onboard Fuel Storage (gal)	Freight Waves - Internet Search	100	100	100	100
Expected fueling profile (#/day)	User assumption	Daily	Daily	Daily	Daily
Peak fueling case (#/day)	User assumption	2x per day	2x per day	2x per day	2x per day
Fill time expectation	User assumption	10 - 15 min	10 - 15 min	10 - 15 min	10 - 15 min
Fuel Use - Diesel (mi/gal)	See Vehicle Fuel Use tab	7.0	7.0	5.0	5.0
CO <sub>2</sub> e (kg/gal)	See Emission Factors tab (EPA)	10.21	10.21	10.21	10.21
CO <sub>2</sub> e (lbs/gal) @ lbs/kg conversion=>		2.204	22.5	22.5	22.5
Hydrogen Vehicle Info		School Bus	School Bus	Transit Bus	Transit Bus
Vehicle Class		Class 6: School Bus	Class 6: School Bus	Class 7:	Class 7:
Gross Vehicle Weight Ratings (GVWRs)	Fed. Highway Admin (see table)	19,501 - 26,000	19,501 - 26,000	26,001 - 33,000	26,001 - 33,000
Onboard H <sub>2</sub> storage pressure (H70 or H)	Cummins	H35	H35	H35	H35
Onboard H <sub>2</sub> tank size (kg)	Cummins	40 kg	40 kg	40 kg	40 kg
Tanks size (water volume)	Cummins	800 liters	800 liters	800 liters	800 liters
Expected kg per fill	Cummins	35 kg	35 kg	35 kg	35 kg
Expected fueling profile (#/day)	User assumption	Daily	Daily	Daily	Daily
Peak fueling case (#/day)	User assumption	2x per day	2x per day	2x per day	2x per day
Fill time expectation	User assumption	10 - 15 min	10 - 15 min	10 - 15 min	10 - 15 min
Vehicle Delivery	User assumption	2025	2025	2025	2025
H <sub>2</sub> Fuel Use (mi/kg)	See Vehicle Fuel Use tab	8.4	8.4	6.0	6.0
Hydrogen (m/kg) / Diesel (m/gal) =>	1.2				

**Table 1: County Diesel and Hydrogen Vehicle Fleet Assumptions**

**Emissions Factor:** As presented in Section 2, Marion and Harrison counties defined a 30 vehicle fleet mix of the trucks and buses described in the table above that were suitable for H<sub>2</sub> applications and provided the economies of scale to efficiently use the H<sub>2</sub> produced. The EPA emissions factor of 10.21 kg CO<sub>2</sub>e/gal shown in the following table was used to convert gallons of diesel to kg CO<sub>2</sub>e.

Red text indicates an update from the 2020 version of this document.

Emission Factors for Greenhouse Gas Inventories  
Last Modified: 15 September 2021

Table 2	Mobile Combustion CO <sub>2</sub>	
Fuel Type	kg CO <sub>2</sub> per unit	Unit
Aviation Gasoline	8.31	gallon
Biodiesel (100%)	9.45	gallon
Compressed Natural Gas (CNG)	0.05444	scf
Diesel Fuel	10.21	gallon
Ethanol (100%)	5.75	gallon
Kerosene-Type Jet Fuel	9.75	gallon
Liquefied Natural Gas (LNG)	4.50	gallon
Liquefied Petroleum Gases (LPG)	5.68	gallon
Motor Gasoline	8.78	gallon
Residual Fuel Oil	11.27	gallon

**Source:**

Federal Register EPA; 40 CFR Part 98; e-CFR, (see link below). Table C-1 (as amended at 81 FR 89252, Dec. 9, 2016).

<https://www.ecfr.gov/cgi-bin/text-idx?SID=ae265d7d6f98ec861cd8640b9793a3f6&mc=true&node=pt40.23.98&rgn=div5#pt40.23.98.19.1>

LNG: The factor was developed based on the CO<sub>2</sub> factor for Natural Gas factor and LNG fuel density from GREET1\_2020.xlsx Model, Argonne National Laboratory.

**Table 2: EPA Emissions Factors**

**Fuel Efficiency:** Marion County estimated the fuel efficiency of each vehicle in the 30 vehicle fleet based on the values provided below by the Federal Highway Administration (FHA) (see Table 3 below). Marion County also consulted with the Marion County Public School Transportation Department, the Fairmont-Marion County Transit Authority, and the White Hall Public Service District to understand the actual fuel efficiencies of these types of vehicles given the VMT and terrain. Based on these discussions, Marion County slightly increased the fuel efficiency for tri axle trucks and slightly decreased the fuel efficiency for Class 8 trucks to reflect actual observed fuel efficiency values.

Though publicly available data as to the fuel efficiency of H<sub>2</sub> trucks is limited, the US DOE has reported that the fuel efficiency of hydrogen trucks (expressed as mi/kg H<sub>2</sub>) is between 15% - 25% higher than the fuel efficiency of equivalent diesel trucks (expressed as mi/gal). For purposes of calculating hydrogen consumption a 20% increase in hydrogen vehicle fuel efficiency was assumed.

	<u>FHA mi/gal</u>	<u>HLH<sub>2</sub> mi/gal</u>	<u>HLH<sub>2</sub> mi/kg H<sub>2</sub></u>
<b>Class 8 Heavy Haul Truck</b>	<b>6.0</b>	<b>5.0</b>	<b>6.0</b>
<b>Class 7 Tri Axle/Refuse Truck</b>	<b>2.8</b>	<b>4.0</b>	<b>4.8</b>
<b>Class 7 Service Truck</b>	<b>6.0</b>	<b>6.0</b>	<b>7.2</b>
<b>School Bus</b>	<b>7.0</b>	<b>7.0</b>	<b>8.4</b>
<b>Transit Bus</b>	<b>3.7</b>	<b>5.0</b>	<b>6.0</b>

Note: DOE studies indicate that H<sub>2</sub> vehicle fuel efficiency (expressed as mi/kg H<sub>2</sub>) is estimated to be 120% of diesel fuel efficiency (expressed as mi/gal)

<b>Average Annual Fuel Use by Vehicle Type</b>					
<b>Vehicle Type</b>	<b>MPG Gasoline</b>	<b>MPG Diesel</b>	<b>VMT</b>	<b>Annual Fuel Use (GGE)</b>	<b>Source</b>
Transit Bus	3.3	3.7	43,647	13,329	A
Class 8 Truck	5.3	6.0	62,751	11,818	B
Refuse Truck	2.5	2.8	25,000	10,089	C
Paratransit Shuttle	7.1	8.0	29,429	4,157	A
Delivery Truck	6.5	7.4	12,435	1,899	B
School Bus	6.2	7.0	12,000	1,937	D
Light Truck/Van	17.5	19.8	11,543	660	B
Car	24.2	27.3	11,467	474	B
Motorcycle	44.0	49.7	2,312	53	B
<b>Data Sources:</b>					
A	Federal Highway Administration. Highway Statistics 2018, Table VM-1. Accessed 02/11/20				
B	Gordon, Deborah, Juliet Burdelski, and James S. Cannon. Greening Garbage Trucks: New Technologies for Cleaner Air. Inform, Inc. 2003. ISBN #0-918780-80-2.				
C	Calculated from statistics found in American Public Transit Association's Public Transportation Fact Book 2019. Accessed 02/11/2020 at: <a href="https://www.apta.com/wp-content/uploads/APTA_Fact-Book-2019_FINAL.pdf">apta.com/wp-content/uploads/APTA_Fact-Book-2019_FINAL.pdf</a>				
D	American School Bus Council. National School Bus Fuel Data. Accessed 11/21/18 at <a href="https://americanschoolbuscouncil.org/insights/environment/">americanschoolbuscouncil.org/insights/environment/</a>				

**Table 3: FHA MPG Diesel Trucks and Buses**

**Measure #1: Elimination of VMT Using Diesel** To calculate the Measure #1 GHG emissions reduction, Marion County assumed a duty cycle for each vehicle in the fleet which included VMT/day and operating days/month as listed in the following Table 4. This assumption was used to calculate VMT/yr and kg/yr of CO<sub>2</sub>e for the entire fleet. Since H<sub>2</sub> FCEVs do not emit GHGs, the entire quantity of CO<sub>2</sub>e would be eliminated. Cumulative GHG Emissions Reduction from Measure #1 is shown in the following table.

GHG EMISSIONS REDUCTION FROM MARION & HARRISON COUNTY VEHICLES								
DIESEL USE BY COUNTY VEHICLES	Vehicle Info	# of Vehicles	VMT per day	Diesel Use (mi/gal)	Diesel (gal/day)	(op days per mo)	Diesel (gal/mo)	Diesel (gal/yr)
Clarksburg Public Works Department	Heavy Haul Truck	2	80	5.0	32.0	20	640	7,680
Fairmont City Public Works Department	Heavy Haul Truck	2	80	5.0	32.0	20	640	7,680
White Hall PSD	Tri Axle Truck	2	100	4.0	50.0	20	1,000	12,000
Fairmont City Public Works	Tri Axle Truck	2	100	4.0	50.0	20	1,000	12,000
Tri County Water Association	Service Truck	2	85	6.0	28.3	20	567	6,800
Harrison County Public Schools	School Bus	8	100	7.0	114.3	20	2,286	27,429
Marion County Public Schools	School Bus	8	100	7.0	114.3	20	2,286	27,429
Fairmont-Marion County Transit Auth.	Transit Bus	2	150	5.0	60.0	30	1,800	21,600
Mountain Line Transit Authority	Transit Bus	2	200	5.0	80.0	30	2,400	28,800
<b>TOTAL</b>		<b>30</b>	<b>995</b>		<b>561</b>		<b>12,618</b>	<b>151,417</b>
Note: VMT/day and Operating Days/month are based on discussion with fleet managers in Marion and Harrison Counties								
GHG EMISSIONS GENERATED BY COUNTY VEHICLES	Vehicle Info	# of Vehicles	VMT per day	CO <sub>2</sub> e (kg/gal)	CO <sub>2</sub> e (kg/day)	(op days per mo)	CO <sub>2</sub> e (kg/mo)	CO <sub>2</sub> e (kg/yr)
Clarksburg Public Works Department	Heavy Haul Truck	2	80	10.21	327	20	6,534	78,413
Fairmont City Public Works Department	Heavy Haul Truck	2	80	10.21	327	20	6,534	78,413
White Hall PSD	Tri Axle Truck	2	100	10.21	511	20	10,210	122,520
Fairmont City Public Works	Tri Axle Truck	2	100	10.21	511	20	10,210	122,520
Tri County Water Association	Service Truck	2	85	10.21	289	20	5,786	69,428
Harrison County Public Schools	School Bus	8	100	10.21	1167	20	23,337	280,046
Marion County Public Schools	School Bus	8	100	10.21	1167	20	23,337	280,046
Fairmont-Marion County Transit Auth.	Transit Bus	2	150	10.21	613	30	18,378	220,536
Mountain Line Transit Authority	Transit Bus	2	200	10.21	817	30	24,504	294,048
<b>TOTAL</b>		<b>30</b>	<b>995</b>		<b>5,727</b>		<b>128,831</b>	<b>1,545,969</b>
			(kgs/metric ton)=>	<b>1,000</b>	(mt/day) =>		(mt/yr) =>	<b>1,546</b>
<b>Cummulative GHG Emission Reduction</b>	<b>2025 - 2030</b>	<b>2030 - 2050</b>	<b>2025 - 2050</b>					
GHG Emission Reduction (mtCO <sub>2</sub> e)	9,276	32,465	41,741					

**Table 4: Measure 1 Emissions Reduction**

**Measure #2: Avoided VMT** To calculate the Measure #2 GHG emissions reduction, Marion County calculated the total VMT/yr for a tanker truck delivering diesel from the supply terminal in Newell, WV to the bus/truck depots in Marion and Harrison counties. The quantity of diesel fuel delivered by the tanker truck (gal/year) was used to calculate the number of trips taken/yr and the total VMT/yr assuming a typical tanker size of 10,000 gal and a round trip distance of 240 miles. At an assumed fuel efficiency of 4.9 mi/gal the tanker would have consumed 742 gal/yr of diesel fuel and generated GHG emissions of 7.57 mt/yr of CO<sub>2</sub>e. GHG Emissions Reduction from Measure #2 is shown in the following table.

EMISSIONS FROM DIESEL DELIVERY FOR COUNTY VEHICLES	Fuel Delivered (gal/yr)	Fuel Truck Capacity (gal)	Fuel Deliveries (trips/yr)	Roundtrip Distance (mi/trip)	Diesel Use (mi/gal)	Diesel Use (gal/yr)	CO2 (lbs/yr)	CO2 (mt/yr)
Ergon Fuel Terminal Newell, WV to the CFS H2 Facility	151,417	10,000	15	240	4.9	742	7,572	7.57
	(lbs/metric ton)=>		1,000					
Cummulative GHG Emission Reduction	2025 - 2030	2030 - 2050	2025 - 2050					
GHG Emission Reduction (mtCO <sub>2</sub> e)	45	159	204					

**Table 5: Measure 2 Emissions Reduction**

**Measure #3: VMT Using H<sub>2</sub> Sold to CFS:** Marion County used the following methodology to calculate the Measure #3 GHG emissions reduction provided in Table 6 below:

- Calculate the total expected H<sub>2</sub> production during a given year using the Energy and Mass Balance provided in Table 7 below.
- Calculate the estimated consumption of H<sub>2</sub> from the vehicles in the fleet, assuming the duty cycle for the H<sub>2</sub> vehicles remained the same as the diesel vehicles that were replaced.
- Calculate any surplus H<sub>2</sub> by subtracting the H<sub>2</sub> consumption from the H<sub>2</sub> production to
- Calculate the VMT that a H<sub>2</sub> truck owned by CFS would travel using the surplus H<sub>2</sub>.
- Calculate the equivalent amount of diesel that a truck would consume in traveling the VMT.
- Use the emission factor for diesel to calculate the GHG emissions (CO<sub>2</sub>e) that would have been generated by the diesel truck.
- Use the procedure set for in Measure #2 above to calculate the GHG emissions that will be avoided by not having to transport diesel from the Newell, WV terminal to Marion County.

Diesel Use and GHG Emissions From Operation of CFS Trucks						
HYDROGEN USE BY CFS VEHICLES	Vehicle Info	# of Vehicles	(vehicle-mi) per day	(mi/kg H <sub>2</sub> )	(kg/mo)	Surplus H <sub>2</sub> (kg/yr)
Long Haul Truck 2	Long Haul Truck	1	86	6.0	286	3,427
Heavy Haul Truck 1	Tri Axle Truck	0	0	0.0	0	0
Heavy Haul Truck 2	Tri Axle Truck	0	0	0.0	0	0
Heavy Haul Truck 3	Tri Axle Truck	0	0	0.0	0	0
0	0	0	0	0.0	0	0
<b>TOTAL</b>		<b>1</b>	<b>86</b>		<b>286</b>	<b>3,427</b>
			(kg/metric ton)=>	<b>1,000</b>	(mt/yr) =>	<b>3.43</b>
Diesel Use Reduction from CFS Trucks	Vehicle Info	# of Vehicles	VMT/day	Diesel (gal/day)	Diesel (gal/mo)	Diesel (gal/yr)
Long Haul Truck 1	Long Haul Truck	1	85.68073593	5	17	4,113
Long Haul Truck 2	Long Haul Truck	0	0	5	0	0
Heavy Haul Truck 1	Tri Axle Truck	0	0	5	0	0
Heavy Haul Truck 2	Tri Axle Truck	0	0	5	0	0
Heavy Haul Truck 3	Tri Axle Truck	0	0	5	0	0
<b>TOTAL</b>		<b>1</b>	<b>86</b>	<b>25</b>	<b>17</b>	<b>4,113</b>
Note: VMT = vehicle miles traveled						
GHG Emissions Red. from CFS Trucks	Vehicle Info	# of Vehicles	VMT/day	CO <sub>2</sub> e (kg/day)	CO <sub>2</sub> e (kg/mo)	CO <sub>2</sub> e (kg/yr)
Long Haul Truck 1	Long Haul Truck	1	86	175	3,499	41,990
Long Haul Truck 2	Long Haul Truck	0	0	10	0	0
Heavy Haul Truck 1	Tri Axle Truck	0	0	10	0	0
Heavy Haul Truck 2	Tri Axle Truck	0	0	10	0	0
Heavy Haul Truck 3	Tri Axle Truck	0	0	10	0	0
<b>TOTAL</b>		<b>1</b>	<b>86</b>	<b>216</b>	<b>3,499</b>	<b>41,990</b>
Note: VMT = vehicle miles traveled			CO <sub>2</sub> e (mt/day) =>	<b>0.22</b>	CO <sub>2</sub> e (mt/yr) =>	<b>42.0</b>
Diesel Use and GHG Emissions from Delivering Diesel to CFS Trucks						
Diesel Use Reduction from not Delivering Diesel to CFS Trucks	Fuel Delivered (gal/yr)	Fuel Truck Capacity (gal)	Fuel Deliveries (trips/yr)	Roundtrip Distance (mi/trip)	Diesel Use for Delivery (mi/gal)	Diesel Use for Delivery (gal/yr)
Location of Fuel Sourcing Depot: Ergon Fuel Terminal Newell, WV	4,113	10,000	0	240	5.0	20
GHG Emissions Reduction from not Delivering Diesel to CFS Trucks	Diesel Use for Delivery (gal/yr)	CO <sub>2</sub> e (kg/gal)	CO <sub>2</sub> e (kg/yr)	CO <sub>2</sub> e (mt/yr)		
Ergon Fuel Terminal Newell, WV	20	10.21	206	0.21		

**Table 6: Measure #3 GHG Emissions Reduction**

**Hydrogen Production:** The green H<sub>2</sub> production facility being developed as part of the HLH<sub>2</sub> Facility will generate approximately 130 kg/yr of H<sub>2</sub>. This level of production is sufficient to supply the estimated 126 kg/hr of hydrogen demand from the 30 HD/MD vehicles being used by Marion and Harrison Counties. Any surplus H<sub>2</sub> will be sold through the adjacent CFS Depot to third party customers. The energy and mass balance assumptions for hydrogen production are set forth in Table 1 below:

- Land required for solar development is conservatively estimated to be 8 acres/MW.
- Solar farm capacity factor is estimated to be 15.5% per the National Renewable Energy Laboratory (NREL).
- Solar farm energy losses are assumed to be 25% (per NREL).
- Battery Energy Storage System (BESS) is 4 batteries each sized to produce 979 kw for 4 hours.
- Electrolyzer sized at a 1.25 MW to fully use available solar + battery capacity.
- Water and power from Tri State Water and FirstEnergy are available on site.

HLH <sub>2</sub> Facility - Energy and Mass Balance vs. CapEx			
<b>Solar Farm</b> Solar Nameplate Capacity (MW) <b>7.0</b> Acres/MW <b>8.0</b> Solar Farm Cost (\$mm/MW) <b>1.925</b> Nominal Cost (excl. land) (\$mm) \$ 13.5  PV System Losses (%) <b>25.0</b> Capacity Factor % (avg) <b>15.5</b> Energy Production kWh/day @CF 19,530		<b>Water Supply + Treatment + Power</b> Water Use (kg H <sub>2</sub> O / kg H <sub>2</sub> ) <b>9.0</b> Water Density (ft <sup>3</sup> / kg) <b>0.035</b> Water Flow Required (ft <sup>3</sup> /hr) <b>0.522</b> Water Treatment CapEx (\$mm) <b>\$ 0.20</b>  Power Line Upgrade (\$mm) <b>\$ 0.20</b> Transformer + Substation (\$mm) <b>\$ 0.50</b> \$ 0.70	
<b>Battery - Option 1</b> Battery Quantity (# units) <b>4</b> Battery Duration (hr) <b>4</b> Battery Unit Power (kW/unit) <b>979</b> Battery Unit Energy (kWh/unit) <b>3,916</b> Nameplate Energy (kWh) 15,664 Round Trip Efficiency <b>93.7%</b> Nameplate Useable Energy (kWh) 14,677 Nameplate Energy Delivery (kWh/hr) 611.5  Solar Energy Supply (kWh/day) 19,530 Solar Energy Supply (kWh/hr) 814 Interconnection Voltage (V) <b>480</b> Cost (\$/unit) <b>\$ 1,972</b> Cost (\$mm) \$ 7.9		<b>Electrolyzer</b> Type (Alkaline vs. PEM) <b>PEM</b> H <sub>2</sub> Flow @ Pwr Rating (Nm <sup>3</sup> /hr) <b>250</b> H <sub>2</sub> Flow @ Pwr Rating (kg/hr) 22.5 Efficiency (kWh/kg H <sub>2</sub> ) <b>55</b> Equiv. Power Rating (MW) <b>1.25</b> Output Pressure (bar) <b>30</b> Nameplate Battery Energy (kWh/day) 30,000 Nameplate H <sub>2</sub> Production (kg/day) 545.5  Actual Energy Supply (kWh/day) 19,530 Actual H <sub>2</sub> Production (kg/d) 355 Actual H <sub>2</sub> Production (kg/hr) 14.8 Electrolyzer Cost (\$/MW) <b>\$ 2.80</b> Electrolyzer Cost (\$mm) \$ 3.5	
<b>Land Cost</b> Acres Solar Land Required 56 Battery + Electrolyzer <b>0.5</b> Utilities+Dryer+Compressor <b>0.5</b> Total Land Required 57  Land Cost (\$/acre) <b>\$ 35,000</b> Land Cost (\$mm) \$ 1,995 Site Preparation Cost (\$mm) <b>\$ 0.75</b>		<b>Gas Dryer + Compressor</b> (\$mm) Separator CapEx <b>\$ 0.10</b> Dryer CapEx <b>\$ 0.10</b> Compressor CapEx <b>\$ 0.20</b> Total CapEx (\$mm) \$ 0.40	
<b>H<sub>2</sub> Required by County Vehicles</b> H <sub>2</sub> Flow (kg/hr) (during op hours) 19.5 H <sub>2</sub> Flow (kg/day) (during op days) 467 H <sub>2</sub> Flow (kg/yr) (full year) 126,181		<b>Green Hydrogen Production</b> H <sub>2</sub> Flow (kg/hr) (during all hours) 14.8 H <sub>2</sub> Flow (kg/day) (during all days) 355 H <sub>2</sub> Flow (kg/yr) (full year) 129,608	
<b>Conversion Factors</b> Molecular Weight H <sub>2</sub> <b>2</b> kg/kg.mole Volume Flow H <sub>2</sub> <b>250</b> Nm <sup>3</sup> /hr (H <sub>2</sub> ) Density H <sub>2</sub> <b>0.09</b> kg/Nm <sup>3</sup> (H <sub>2</sub> ) Mass Flow (H <sub>2</sub> ) 22.5 kg/hr (H <sub>2</sub> ) Mass Flow (H <sub>2</sub> ) 539 kg/day (H <sub>2</sub> )		<b>Surplus H<sub>2</sub> Sold to Market via CFS</b> H <sub>2</sub> Flow (kg/hr) (during op hours) 6.0 H <sub>2</sub> Flow (kg/day) (during op days) 143 H <sub>2</sub> Flow (kg/yr) (full year) 3,427 H <sub>2</sub> Flow (kg/yr) (used in CFS Depot) 3,427 H <sub>2</sub> Flow (kg/yr) (surplus after CFS use) 0	



**Table 7. Green Hydrogen Production Assumptions**

**Solar Farm + Battery Energy Storage System**

Holt Renewables provided the following cost proposal for the solar farm and Battery Energy Storage System (BESS) that will be used in the HLH<sub>2</sub> Facility.



**Hog Lick Aggregates – Electrolyzer Hub**

**7.11 MWdc / 5.5 MWac Ground Mounted Solar Array + (4) 979kW / 3,916 kWh BESS**

*April 1, 2024*

**Bid Clarifications**

**HOLT Renewables, LLC** (the “Contractor”) offers the following clarifications to the bids stated below for **Hog Lick Aggregates** (“Customer”), for the bid for work on the captioned project. Notwithstanding any language in the contract documents to the contrary, the provisions of these Clarifications shall be controlling in the event of any discrepancies, inconsistencies or ambiguities between these Clarifications and any other contract document. References in these Clarifications to specific sections in the Subcontractor Agreement are by way of illustration and not intended to limit the applicability of provisions contained herein.

**Solar Array: 7.11 MWdc / 5.5 MWac Fixed Tilt Ground Mount Array**  
**Budget: \$13,686,400**

**BESS: (4) 979kW / 3,916 kWh (Tesla)**  
**Budget: \$7,820,000**

**Hydrolyzer**

Accelera, a US based subsidiary of Cummins provided the following cost proposal for the hydrolyzer described in the Energy and Mass Balance table above.



[accelerazero.com](https://accelerazero.com)

Date: 18/03/2024

Quotation : 485737 REV00

**9 Commercial Proposal**

**9.1 PRICING**

Scope of Supply:	
1 x HyLYZER®-250-30 PEM Electrolyzer, as described in this proposal with – <b>540 kg of Hydrogen per day</b>	
<b>Each unit includes:</b>	
<ul style="list-style-type: none"><li>• 1 x 40ft Electrolyzer Process Container per unit, each unit includes:<ul style="list-style-type: none"><li>○ PEM cell stack (1 stack will be producing 540 kg/day total)</li><li>○ Hydrogen Purification System - HPS (99.998%)</li><li>○ Analyzer Panel</li><li>○ Water Treatment</li><li>○ Chiller</li><li>○ Dry Cooler</li><li>○ Instrument Air Compressor</li></ul></li><li>• HyLYZER® Power Container (Transformer/Rectifier)</li></ul>	
<b>Site Services</b>	
<ul style="list-style-type: none"><li>• Technical assistance during project execution or installation (one trip, 5 days total including travel time and expenses) – Adder option fee maybe required for additional technical reviews outside of standard Cummins standard technical assistance offering</li><li>• Startup, Site Acceptance Testing and Training (one trip, 10 days on site including travel time and expenses)</li></ul>	
<b>Total Price (USD):</b>	<b>\$3,500,000.00</b>

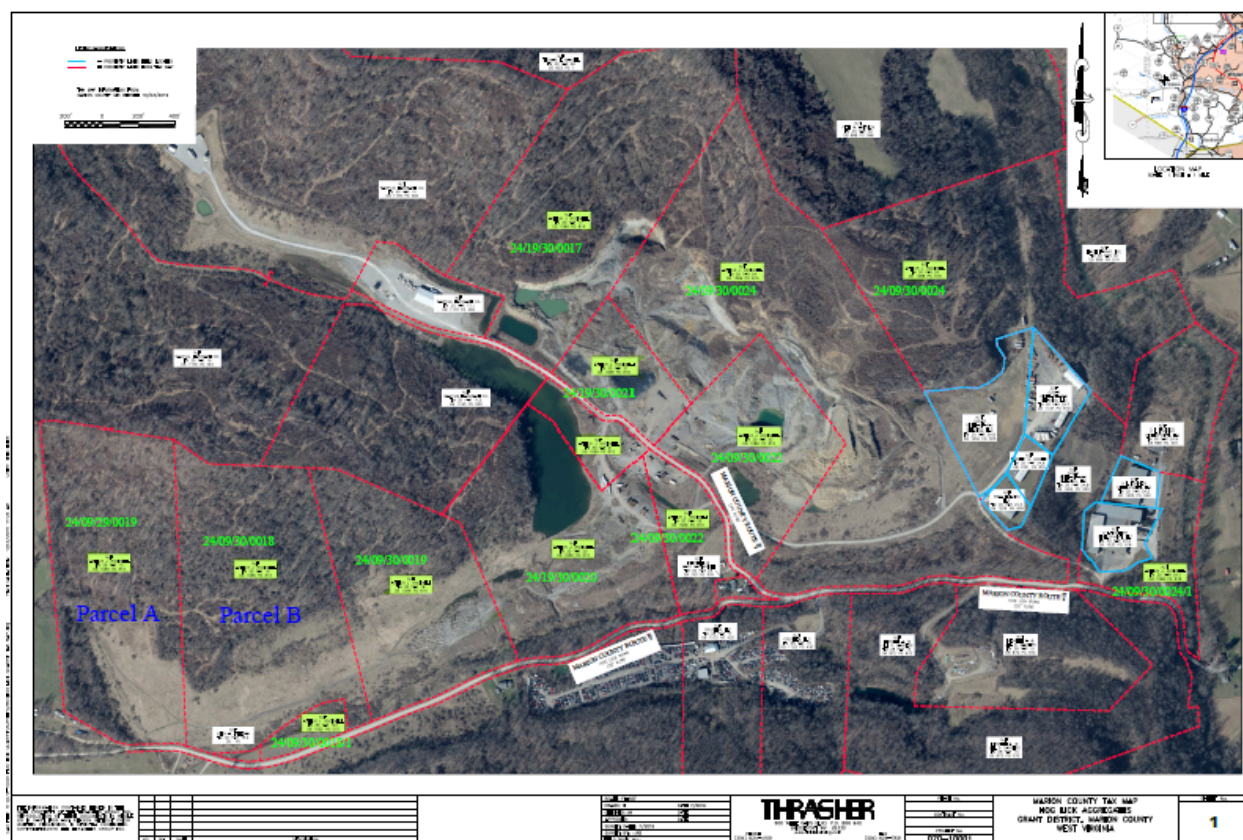


### **Balance of Plant**

The pricing listed above for the balance of plant, including: water supply connection, water treatment, upgrade to existing power line, H<sub>2</sub> gas dryer + separator, and compressor were based on vendor discussions and market due diligence.

### **Land Cost**

Marion County has secured the commitment of the owner of the target site to sell the site to Marion County for the purpose of the HLH<sub>2</sub> Facility if the CPRG implementation funds are awarded. The site is industrial land adjacent to the CFS Depot and has no prior environmental issues. Marion County has assumed a budget cost of \$35,000 per acre which is comparable to land sales in the area. See the following map which references Parcel A and Parcel B as the proposed location of the HLH<sub>2</sub> Facility located adjacent to the CFS Dept and the Hog Lick Aggregates Quarry in White Hall, WV.



**Vehicle Fleet Cost:** As discussed in Section 2 GHG emissions reduction measures #1, #2, and #3 will be achieved by replacing 30 diesel fueled trucks and buses currently used in Marion and Harrison Counties with H<sub>2</sub> fueled vehicles. Table 7 below lists the assumed capital cost for each of the H<sub>2</sub> vehicles that will replace their diesel equivalent. The H<sub>2</sub> vehicle cost estimates were based on market research and conversations with Cummins and Hyzon - two of the leading US based companies developing HD/MD H<sub>2</sub> vehicles. Hyzon is currently producing and selling H<sub>2</sub> FCEVs and Cummins is developing both H<sub>2</sub> FCEVs and H<sub>2</sub> ICEs with expected commercial availability in 2025. These prices are also supported by a 2022

paper by the International Council on Clean Transportation entitled “A Meta-Study of the Purchase Costs for Zero Emission Trucks”.

Fleet Customers	Vehicle Info	# of Vehicles	Cost per Vehicle	Cost per Customer	Note
Clarksburg Public Works Department	Heavy Haul Truck	2	\$ 600,000	\$ 1,200,000	
Fairmont City Public Works Department	Heavy Haul Truck	2	\$ 600,000	\$ 1,200,000	
White Hall PSD	Tri Axle Truck	2	\$ 325,000	\$ 650,000	
Fairmont City Public Works	Tri Axle Truck	2	\$ 350,000	\$ 700,000	
Tri County Water Association	Service Truck	2	\$ 325,000	\$ 650,000	
Harrison County Public Schools	School Bus	8	\$ 325,000	\$ 2,600,000	
Marion County Public Schools	School Bus	8	\$ 325,000	\$ 2,600,000	
Fairmont-Marion County Transit Auth.	Transit Bus	2	\$ 500,000	\$ 1,000,000	
Mountain Line Transit Authority	Transit Bus	2	\$ 500,000	\$ 1,000,000	
<b>TOTAL</b>		<b>30</b>		<b>\$ 11,600,000</b>	

**Table 7: Fleet Vehicle Capital Costs**

**Operation and Maintenance Cost Assumptions:** Fuel cost is by far the largest cost incurred in operating a vehicle. The HLH2 Facility produces H2 fuel on-site using the solar farm, BESS and electrolyzer and does incur the cost of purchasing hydrogen from a third party. The associated operating costs for these systems include the following:

- Costs to monitor and clean the solar panels
- Costs to monitor the BESS and electrolyzer
- Costs for periodic maintenance of the various components.

Maintenance costs are the second highest cost in operating a vehicle. The HLH2 Facility intends to enter into performance based vehicle purchase agreements with vehicle manufacturers that will require specific performance factors (e.g., fuel efficiency, uptime, etc.). In addition, the HLH2 Facility will use the H2 maintenance and service capabilities of the CFS Depot which will operate and maintain HD/MD at the CFS Depot which is part of the DOE funded ARCH2. The ability to share H2 vehicle maintenance equipment and personnel with the CFS Depot will provide a significant savings for the HLH2 Facility.