

## **Appendix 5 – Requirements for documenting California Hydrogen Highway and Senate Bill 1505 Emissions Criteria Have Been Met**

New hydrogen fueling stations that are to be co-funded with funds from Senate Bill 76 (SB 76) must be able to demonstrate the following relative to California reformulated gasoline vehicles. These minimum requirements are outlined in Senate Bill 1505 and will be incorporated into a new regulation being developed for the production of transportation hydrogen.

- 30% reduction in Greenhouse Gases (GHGs) on well to wheel (WTW) basis
- No increase in toxic air contaminants (TACs) on a well to tank (WTT) basis
- 50% reduction in Oxides of Nitrogen (NOx) plus Reactive Organic Gases (ROG) on a WTT basis
- No increase in criteria pollutant emissions relative to current year baseline vehicle

In order for California Air Resources Board (ARB) staff to evaluate if a proposal meets the environmental criteria, bidders must complete Attachment 9 the Hydrogen Production Emissions and Renewable form contained within the RFP. ARB will use the information provided on this form to run a modified version of the “Greenhouse gases, Regulated Emissions, and Energy use in Transportation” (GREET 1.7) model developed by Argonne National Laboratories. The modified model was used to help in the creation of a State Alternative Fuels Plan (AB1007) by Tiax, California Energy Commission (CEC) and ARB. This modified version is publically available on the CEC website under AB1007 at the following web address (<http://www.energy.ca.gov/ab1007/index.html>).

**Early GREET Verification** – As an intermediary, optional step, bidders may choose to submit the Hydrogen Production Emissions and Renewable (attachment 9) form early, along with questions to ARB by the **February 15, 2008** deadline. ARB staff will evaluate the production emissions and renewables, if necessary ARB will contact the bidder to answer any questions regarding the production method or clarify any details of the specific bidder’s process. However the bidder is still responsible for completing and submitting a final Hydrogen and Production Emissions and Renewable (attachment 9) form with the complete bid package.

If bidders choose not to submit a Hydrogen Production and Renewable form early, all information on the form must still be completed and submitted with the final bid package. The information will be used and assumed correct for evaluation of emissions and renewables. Once the final bid package is received

no opportunity will be available for clarification purposes of any hydrogen production processes.

The form contains basic hydrogen production and renewable information questions for bidders to easily specify which type of production pathway is being proposed. All bidders must complete the form in order to be evaluated for emissions and renewable criteria.

**Baseline Emissions**

The proposed station information will be compared to the following for emissions verification. The baseline gasoline vehicle emissions have been determined by using the Modified GREET model.

<b>WTW GHGs</b>					
<b>Item</b>	<b>Feedstock</b>	<b>Fuel</b>	<b>Vehicle Operation</b>	<b>Baseline Total</b>	<b>Bid Requirement</b>
GHGs	7	75	355	<b>438</b>	<b>307</b>
<b>WTW Criteria Pollutants</b>					
<b>Item</b>	<b>Feedstock</b>	<b>Fuel</b>	<b>Vehicle Operation</b>	<b>Baseline Total</b>	<b>Bid Requirement</b>
VOC: g/mile	0.017	0.049	0.180	0.246	N/A
CO: g/mile	0.035	0.058	3.745	3.838	N/A
NOx: g/mile	0.011	0.177	0.141	0.329	N/A
PM10: g/mile	0.001	0.021	0.029	0.051	N/A
SOx: g/mile	0.001	0.081	0.003	0.085	N/A
Weighted Criteria Pollutants				<b>0.122</b>	<b>0.122 or less</b>
<b>WTT NOx and ROG (VOC included as ROG)</b>					
	<b>Baseline</b>		<b>Bid requirement</b>		
VOC: Urban g/mmBtu	14.516		N/A		
NOx: Urban g/mmBtu	65.859		N/A		
Urban total g/mmBtu	<b>80.375</b>		<b>40.1875</b>		

**Table 1.** Baseline vehicle emissions values developed from Modified AB1007 GREET model.

All hydrogen station bids are to be compared to these figures to determine whether the emissions criteria will be met. If the proposed hydrogen station emissions do not meet the criteria, the bid will not be considered. Because the model represents average emissions for most processes likely to be used, the

bidder may provide additional station specific emissions factors, process efficiencies, new renewable inputs, and distribution distances associated with their specific station design and hydrogen production pathway if they are not covered in Attachment 9. However, any changes must be supported and documented as part of the bid package.

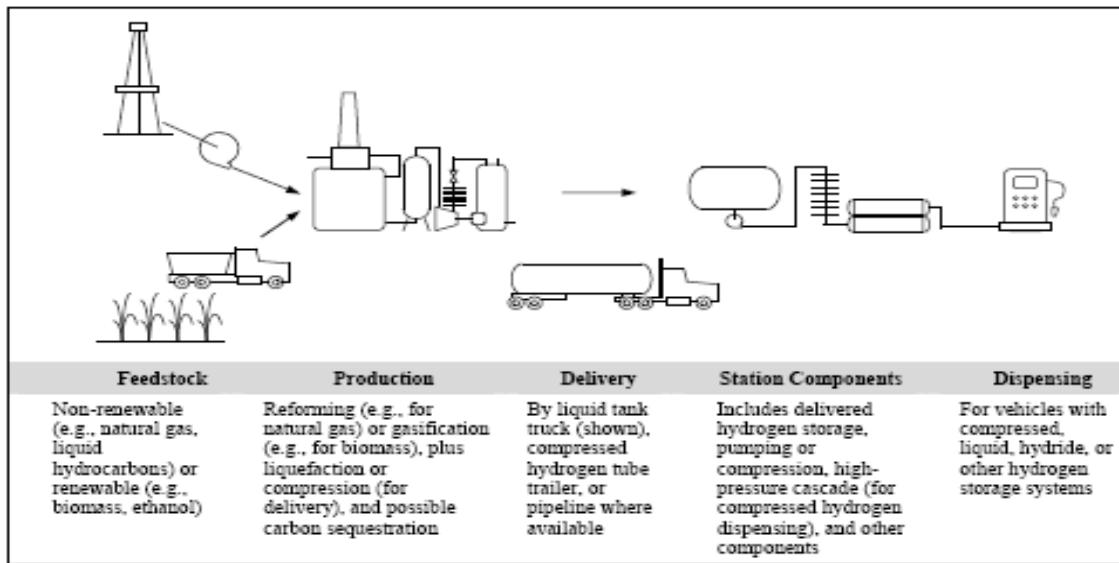
The following are brief summaries of allowable assumptions, which can be made for emissions calculations, consistent with the intent of demonstrating the emission criteria. As well as items which will not be considered:

- All emissions calculations are based on typical values for the first year of operation.
- Natural gas use that is displaced at the station site by waste heat recovery results in emissions reductions from reduced natural gas delivered to the site as well as from reduced emissions (such as from a boiler) resulting from burning less natural gas.
- Buildings, convenience stores and associated energy collocated at a hydrogen station are not part of the energy or emissions calculations. Except where on-site distributed generation at the station site offsets electricity or natural gas use that otherwise would use grid electricity.
- No emissions credits can be claimed for using a specific hydrogen vehicle type at the station. For example, a bidder cannot claim additional emissions reductions for supplying a hydrogen powered bus relative to the emissions of a diesel powered bus. The baseline hydrogen vehicle fleet mix has been predetermined as part of the baseline for consistency in evaluating bid packages.
- A commitment to use lower emission delivery trucks for transporting hydrogen is encouraged and can be stated in the hydrogen production emissions and renewable form. Otherwise emissions factors used will be for the 2006 model year diesel trucks already included in the model.
- If hydrogen is to be supplied from an existing central plant, then the emissions characteristics of the specific plant may be used, including any emissions offsets required in permits for the facility related to its hydrogen production equipment. Documentation to support the emissions factors and permit offsets requirements must be provided with such a bid package.
- Fuel cell and micro-turbine emissions for energy station designs are not part of GREET. The emissions factors for these technologies should be based on the January 1, 2007 emissions factors identified in the ARB Distributed Generation Certification Program (<http://www.arb.ca.gov/energy/dg/dg.htm>) unless data specific to the proposed project is available.

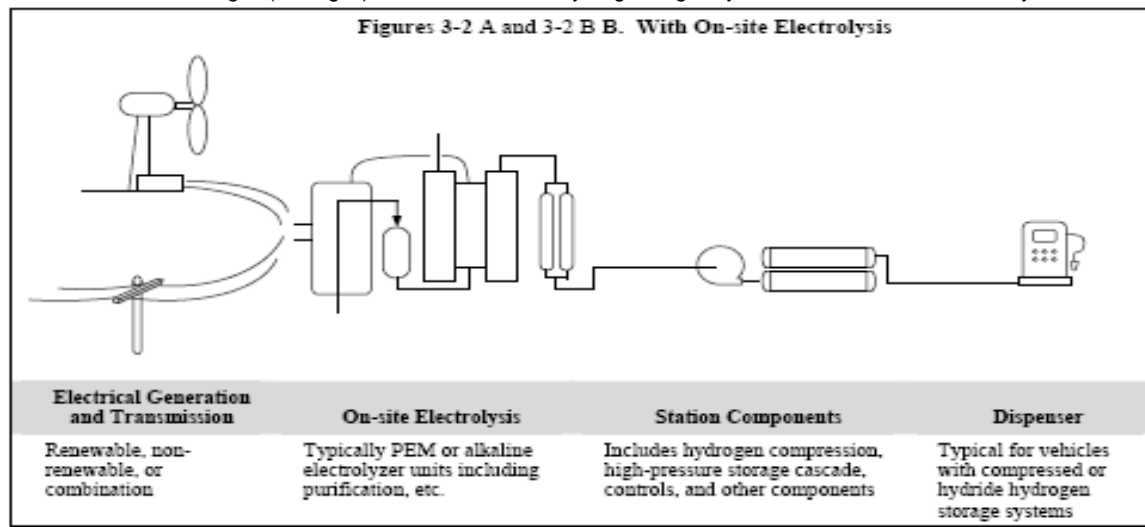
## Methodology

The following is a summary of the methodology employed to determine the emissions from prospective bidders of hydrogen stations.

Hydrogen can be produced from a variety of methods and feedstocks, including natural gas, biogas and electricity. For hydrogen production pathways, the emissions calculations must include all of the fuel cycle emissions associated with collecting and processing the feedstock, producing finished fuel, all transportation and delivery of the feedstock or finished fuel, as well as station storage and dispensing. The following graphics represent examples of steam methane reformation of natural gas (or a biogas) to hydrogen and renewable electric generation for on-site electrolysis.



**Figure 1.** Emissions sources along the hydrogen Production, Transport and delivery pathway for Steam methane reformation and natural gas (or biogas). Source: California Hydrogen Highway Blue Print Plan Volume 2, May 2005.



**Figure 2.** Emissions sources along the hydrogen Production, Transport and delivery pathway for Renewable and non renewable electric generation. Source: California Hydrogen Highway Blue Print Plan Volume 2, May 2005.

The assumptions used in the Modified GREET model will reflect the electricity required to compress hydrogen to 10,000 psi at the station for all hydrogen production pathways. Dispensing compressed hydrogen is the baseline method for comparing stations. The station designs must include the ability to dispense hydrogen at both 10,000 and 5,000 psi. If liquid hydrogen is delivered and dispensed as pressurized H<sub>2</sub>, the liquefaction energy and resulting emissions will be included.

For station bids, only the fuel cycle emissions will be used for comparison to the baseline as shown in figure 4 as the section within the dashed line. The vehicle manufacture (vehicle cycle) and power plant construction (plant cycle) emissions are not part of the comparison.

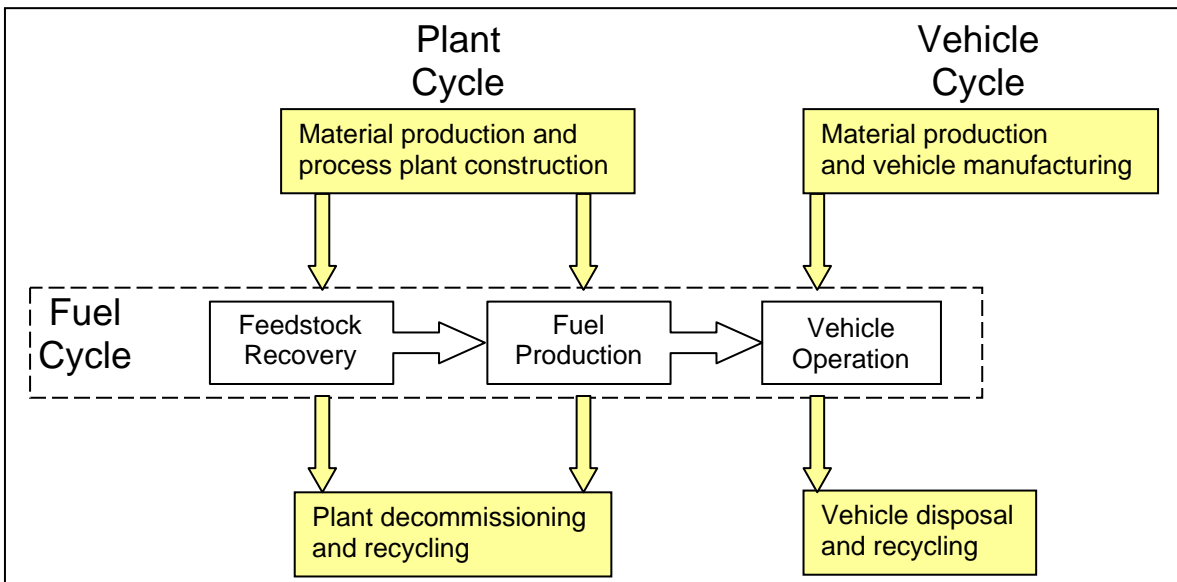


Figure 3. Elements of Fuel Cycle within total life cycle

The modified GREET model enables users to calculate full fuel cycle emissions and it contains all of the process efficiency and emissions factors necessary.

The modified California model outputs include:

- 1) Fuel cycle GHG, criteria pollutant, and toxic air contaminant emissions in grams or milligrams per mile;
- 2) Urban well-to-tank emissions of NO<sub>x</sub> and VOC in grams per gigajoule.

### Modified GREET assumptions

During the State Alternative Fuels Plan process the GREET model was modified to be California specific by Tiax an independent contractor for the state. The following modifications were made to the model in order to better reflect

California specific emissions factors. Both baseline inputs and calculations in the model reflect emission constraints and fuel production scenarios for California.

- Transportation distances reflect the marginal delivery of fuels to California
- Three scenarios reflect fuel production in the U.S., California, and remote locations.
- Emission factors for delivery trucks and off road equipment correspond to CA standards.
- Emission factors for natural gas transmission equipment in CA correspond to BACT requirements
- Marine and Rail emissions reflect in-port and rail switcher activity with an adjustment factor for urban emissions.
- Natural gas transmission and distribution losses reflect data from CA gas utilities.
- Urban emission shares reflect facility and transportation equipment in California.
- A calculation of urban emission shares based on the urban distance and total transport distance was added to the model.
- Emissions from facilities requiring offset emissions are set to zero. These include SO<sub>x</sub> from power plants (acid rain program cap) plus NO<sub>x</sub> and VOC emissions from power plants and large stationary facilities in California (New Source Review, ozone nonattainment areas)
- The heating value and carbon content was adjusted for FTD, reformulated diesel, natural gas, and hydrogen.