


<b>DOE Hydrogen Program Record</b>		
<b>Record #:</b> 5003	<b>Date:</b> January 4, 2006	
<b>Title:</b> Carbon Displacement Using Net-Zero Carbon Sources		
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<b>Approved by:</b> JoAnn Milliken	<b>Date:</b> April 4, 2006	

**Item:**

“... if **175 billion kWh of grid electricity** (10% of the growth of the electric generation market in 2025) is replaced by fuel cells operating on hydrogen at **50% LHV efficiency**, about **10.5 million tons of hydrogen** would be needed. If this hydrogen were made from a non-carbon (e.g. nuclear) or net-zero carbon (e.g. biomass, coal with carbon sequestration) source, then it could potentially displace about **27.5 million tons of carbon.**”

**Calculations/References:**

Analysis by TIAX for DOE, August 24, 2005:

- **“10.5 million tons of hydrogen”**  
 Required  $H_2 = 175 \text{ billion kWh}^a / (50\% \text{ kWh/kWh } H_2)^b / (33.3 \text{ kWh } H_2/\text{kg } H_2)^c = 10.5 \text{ billion kg } H_2 (=10.5 \text{ million tons of } H_2)$
- **“27.5 million tons of carbon”**  
 Carbon displaced =  $[175 \text{ billion kWh}^a / (34\% \text{ kWh/kWh fuel})]^d \times 3,413 \text{ Btu/kWh}^e \times 15.7 \text{ kg C/MMBtu fuel}^f = 27.5 \text{ million tons of carbon}$

***Assumptions:***

- <sup>a</sup> Grid electricity replacement of 175 billion kWh:
  1. This amount of electricity is based on ~10% of grid electricity growth from 2003 to 2025 minus power growth contribution from renewables.
  2. The source is Table A8; U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2005, p. 152, DOE/EIA-0383(2005), January 2005.
- <sup>b</sup> Fuel Cell System Efficiency ( $H_2$  to AC Power) = 50% (LHV)
  1. 0.75 V operation
  2. 95% anode utilization
  3. 90% power electronics efficiency
  4. Parasitic loads (e.g. fans, blowers) = 0.016 kWh/kW  $H_2$
- <sup>c</sup> Heating Value of Hydrogen = 33.3 kWh/kg (LHV)
- <sup>d</sup> “Grid Efficiency” (fuel to AC Power) = 34% (LHV)
  1. Based on discussions with industry.
  2. This is really the average utility delivery efficiency (accounting for fuel conversion losses, plant use of electricity, and T&D losses).

3. Consistent with HHV efficiencies of 31.1% for 2002 and 31.3% projected for 2005 from: Table 6.2.4; 2004 Buildings Energy Databook; prepared for the US Department of Energy, Office of Energy Efficiency and Renewable Energy; prepared by Jordan Kelso, D&R International, Ltd., Silver Spring, MD; January 2005 version. Available at:  
<http://buildingsdatabook.eere.energy.gov/> .

<sup>e</sup> Units Conversion = 3,413 Btu/kWh (60°F)

<sup>f</sup> Carbon Emission Factor = 15.7 kg C/MMBtu fuel input

1. OBT: Table E; Guide for the Evaluation of Energy Savings Potential; Office of Building Technology, State and Community Programs (BTS); February 3, 2000. This was an attachment to the solicitation: Energy Efficient Building Technologies; Announcement No. DE-PS26-04NT42114.000; May 5, 2004  
[https://e-center.doe.gov/IIPS2005Archive.nsf/UNID/85256F27004A420B85256E8A0073D9B1/\\$file/Building\\_Technologies\\_Solicitation.doc](https://e-center.doe.gov/IIPS2005Archive.nsf/UNID/85256F27004A420B85256E8A0073D9B1/$file/Building_Technologies_Solicitation.doc)
2. This source does not state whether the factor assumes LHV or HHV. The LHV which yields a grid efficiency of 34% was used in the calculations.