


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

- ^a 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.
- ^b 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
- ^c Heating Value of Hydrogen = 33.3 kWh/kg (LHV)
- ^d “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/> .

^e Units Conversion = 3,413 Btu/kWh (60°F)

^f 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.