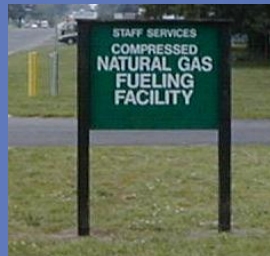


Alternative Fuel Vehicles at Brookhaven National Laboratory

Successes and Challenges



March 16, 2011
Mark Toscano
Manager, Energy Management

BROOKHAVEN
NATIONAL LABORATORY

a passion for discovery

 Office of
Science
U.S. Department of Energy



Brookhaven National Laboratory *A passion for discovery*



5321 acres

350 buildings

~4.2M sq ft

29 miles paved roads

12 miles sidewalks

Housing for ~800

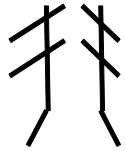
~2800 employees

>4000 guest users per year

FY 08	FY 09	FY 10
\$532M	\$880M	\$700M

Brookhaven National Laboratory Energy Use FY 2009

Electricity



257,601 MWh

879 BBtu

11,645 MWh

40 BBtu

1,684 MWh

6 BBtu

178,011 MWh

607 BBtu

66,261 MWh

226 BBtu

Natural Gas



257,310 MCF

265 BBtu

Oil/LPG



2,855,696 Gal.

395 BBtu

Process



Buildings



Bio-Diesel
4,352 Gal.

No. 2
58,547 Gal.

0.59 BBtu

8.12 BBtu



Note: Vehicle fuels ~ 99,000 Gal/year (includes 25,000 gallons of diesel)

Transportation Vehicle- Overview

- 292 Vehicles of mixed use on site: ~35% are Alternative Fuel
- **Compressed natural gas (CNG) fueling infrastructure installed 2001**
 - 75 CNG vehicles displaced 23,900 GGE (~25% of total) in 2010
 - BNL provides compressed natural gas refueling to local governments that partner with DOE Clean Cities
- **E85 refueling infrastructure operational late 2010**
 - 27 Vehicles
- Biodiesel displacing about 20% of the vehicle diesel consumption
 - Started early 2010
- **Neighborhood electric vehicles to replace some conventional-fuel vehicles**



CNG - Overview

■ CNG Facility - Installed late 2001

- 3000 / 3600 PSI fueling pressure – Fast fill @ ~ 600 SCFM (5 GGE/min)
- 1 Bauer 40 SCFM (30 HP) compressor
- 30,000 SCF storage
- Tulsa fuel dispensers with card readers
- Enclosure for compressor(s), controls, drier
- \$378,000 construction contract. \$575,000 Total Project Cost

■ Second Compressor - Added 2005

- 1 Bauer 40 SCFM compressor
- Controls upgrade/conversion to Allen-Bradley PLC
- \$215,000



CNG – Original Estimate

Natural Gas Vehicles

Updated: 6/14/2000

All Cost Values are 2000\$

End of Year	No. Vehicles	Ave. Miles per year	Ave. Miles per gge	52 wks gge per year	Average: 7 Days, 24 hrs/day						Therms per year	Cubic Feet per year	Nat Gas Cost	Nat. Gas Fuel Savings	Incremental Vehicle Cost	Infrastructure Cost
					gge per week	gge per day	gge/hr 24 hr day	Nat. Gas Ft ³ /Wk	Nat. Gas Ft ³ /day	Nat. Gas CFM						
2000	20	4,000	12	6,667	128	18	0.76	15,385	2,192	1.52	8,333	800,000	\$3,823	\$1,577	\$30,177	
2001	32	4,000	13	9,600	185	26	1.10	22,154	3,156	2.19	12,000	1,152,000	\$5,506	\$2,270	\$24,800	\$580,000
2002	44	4,000	13	13,200	254	36	1.51	30,462	4,340	3.01	16,500	1,584,000	\$7,570	\$3,122	\$24,800	
2003	56	4,000	13	16,800	323	46	1.92	38,769	5,523	3.84	21,000	2,016,000	\$9,635	\$3,973	\$24,800	
2004	68	4,000	13	20,400	392	56	2.33	47,077	6,707	4.66	25,500	2,448,000	\$11,699	\$4,825	\$24,800	
2005	80	4,000	13	24,000	462	66	2.74	55,385	7,890	5.48	30,000	2,880,000	\$13,764	\$5,676	\$24,800	
2006	92	4,000	13	27,600	531	76	3.15	63,692	9,074	6.30	34,500	3,312,000	\$15,829	\$6,527	\$24,800	
2007	104	4,000	13	31,200	600	85	3.56	72,000	10,258	7.12	39,000	3,744,000	\$17,893	\$7,379	\$24,800	
2008	116	4,000	13	34,800	669	95	3.97	80,308	11,441	7.95	43,500	4,176,000	\$19,958	\$8,230	\$24,800	\$375,000
2009	128	4,000	13	38,400	738	105	4.38	88,615	12,625	8.77	48,000	4,608,000	\$22,022	\$9,082	\$24,800	
2010	140	4,000	13	42,000	808	115	4.79	96,923	13,808	9.59	52,500	5,040,000	\$24,087	\$9,933	\$24,800	
2011	152	4,000	13	45,600	877	125	5.21	105,231	14,992	10.41	57,000	5,472,000	\$26,152	\$10,784	\$24,800	
2012	164	4,000	13	49,200	946	135	5.62	113,538	16,175	11.23	61,500	5,904,000	\$28,216	\$11,636	\$24,800	
2013	176	4,000	13	52,800	1,015	145	6.03	121,846	17,359	12.05	66,000	6,336,000	\$30,281	\$12,487	\$24,800	
2014	188	4,000	13	56,400	1,085	155	6.44	130,154	18,542	12.88	70,500	6,768,000	\$32,345	\$13,339	\$24,800	
2015	200	4,000	13	60,000	1,154	164	6.85	138,462	19,726	13.70	75,000	7,200,000	\$34,410	\$14,190	\$24,800	
												Total	\$303,190	\$125,030	\$402,177	

CNG - Performance

Fuel							Electric			Total Energy		
FY	Therms	GGE	Cost	\$/GGE	\$/Th	CCF	kWh	kWh /GGE	Cost	Total Cost	Net \$/Th	Net \$/GGE
FY04	33,500	26,800	\$ 26,329	\$0.98	0.7859	32,375	29,350	1.10	\$ 1,656	\$27,985	\$0.84	\$1.04
FY05	42,107	33,686	\$ 47,717	\$1.42	1.1332	41,788	42,802	1.27	\$ 2,782	\$50,499	\$1.20	\$1.50
FY06	42,558	34,046	\$ 60,274	\$1.77	1.4163	42,444	48,000	1.41	\$ 3,231	\$63,506	\$1.49	\$1.87
FY07	40,820	32,656	\$ 54,877	\$1.68	1.3444	40,646	47,099	1.44	\$ 2,964	\$57,841	\$1.42	\$1.77
FY08	41,921	33,536	\$ 84,536	\$2.52	2.0166	41,945	44,706	1.33	\$ 3,087	\$87,623	\$2.09	\$2.61
FY09	41,795	33,436	\$ 50,602	\$1.51	1.2107	41,358	44,518	1.33	\$ 2,872	\$53,474	\$1.28	\$1.60
FY10	42,810	34,248	\$ 60,643	\$1.77	1.4166	42,358	52,735	1.54	\$ 3,400	\$64,042	\$1.50	\$1.87
Total	285,510	228,408	\$384,978	\$1.69	1.3484	282,914	309,211	1.35	19,992	\$404,970	\$1.42	\$1.77

Note: BNL GGE for 2010 was 23,913. The balance was consumed by others.

CNG Fueling Facility Highlights

Original Investment for CNG Station (2001)	\$575,000
Second Compressor (2005)	\$190,000
Control System Upgrade (2005)	\$25,000
Total Station Infrastructure	\$790,000
Annual Maintenance Contract	\$4,800
Total GGE produced to-date (2001-2010)	256,824
Current annual production/usage (GGE)*	34,000
Number of CNG vehicles in operation	75
<u>Production Costs</u>	
Current fuel cost/GGE	\$1.77
Current electric cost/GGE	\$0.09
Maintenance/GGE	\$0.14
Total Cost/GGE	\$2.01



WARNING
"STOP MOTOR"
"NO SMOKING"
"NO OPEN FLAMES
PERMITTED"
"FLAMMABLE GAS"

Door
A B

CAUTION
IF METHANE LEAK
ALARM OCCURS
Strobe Light & Horn
LEAVE AREA

WARNING
"STOP MOTOR"
"NO SMOKING"
"NO OPEN FLAMES
PERMITTED"
"FLAMMABLE GAS"





CNG – Lessons Learned

- **OEM Manufacturers extremely limited**
 - Most have left the market
 - Mainly pick-up trucks and vans
- **Retrofits for new vehicles are very expensive**
 - Conversions ~\$18,000/vehicle in addition to vehicle cost
 - May/will void manufacturers warranty
- **CNG Vehicles**
 - Require annual inspections of fuel systems
 - Storage tanks lasting ~5 years - Many fail inspection process
 - Parts have become expensive, with some increasing by 3x in 5 years
 - Less range than conventional fuel vehicles

CNG Summary

- **CNG vehicles are a practical, albeit expensive alternative to gasoline versions**
 - Try to take advantage of grants and other incentives
 - Clean cities, NYSERA, etc.
- **CNG better suited for:**
 - **Fleet operations and high usage per vehicle**
 - Large infrastructure investment softened on a unit cost basis
 - Areas where low emissions are particularly important
 - Populated areas, long idling time, etc.
- **Must budget for additional maintenance and capital investments**
 - Compressor rebuild/replacements
 - Tank certification and replacements
 - Higher vehicle first cost