



U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE CALiPER Program The Latest Test Reports and Analysis

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Transformations in Lighting

2008 DOE SOLID-STATE LIGHTING R&D WORKSHOP

January 29-31, 2008

Atlanta, GA



Today's Talk: CALiPER Program

- Purposes of CALiPER
- Testing program scope
- Testing methods & CALiPER process
- Rounds 1-4 results
- Where to go for more info



Photo credit: Luminaire Testing Laboratory



Purposes of CALiPER

- Provide objective, high quality performance information
- Know performance of market available products
 - To support R & D planning
 - To support ENERGY STAR
- Inform industry test procedures and standards development
- Discourage low quality products
- Reduce SSL market risk due to buyer dissatisfaction from products that do not perform as claimed



**YOU MAY NEVER CHANGE
ANOTHER LIGHT BULB**

- ✓ *Long life*
- ✓ *Energy efficient*
- ✓ *Easy to install (standard socket)*
- ✓ *Natural white, superb color rendering*



Testing Program Scope

Commercially-available
SSL products for the
general illumination market

- Luminaires and replacement lamps (white light)
- Indoor and outdoor
- Residential and commercial





SSL Luminaire Testing

SSL energy efficiency is a function of:



LED device efficacy



Thermal management

+



Luminaire design



Driver/power supply efficiency

+

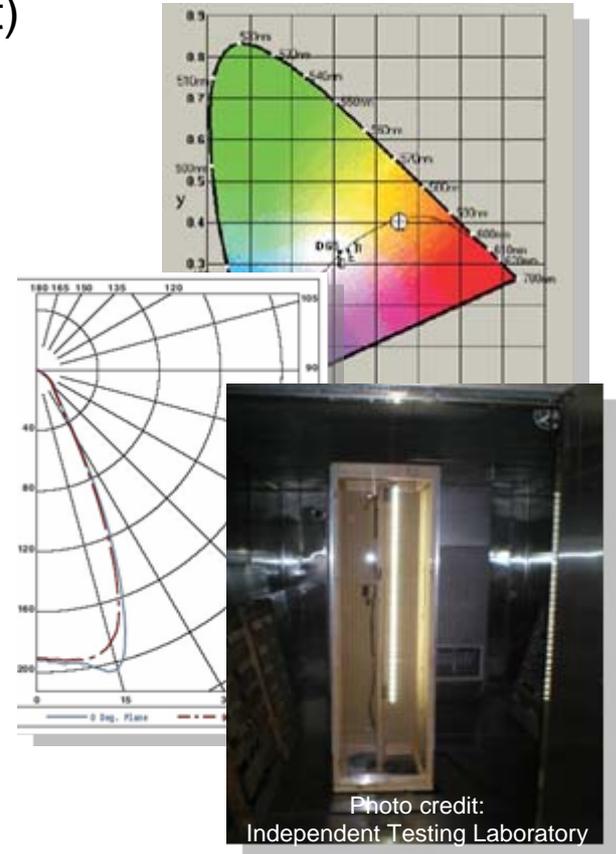
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- Must measure luminaire as a complete system
- Uses 'absolute photometry' rather than 'relative photometry'
- Based on IESNA *draft* standard LM-79
 - Photometric testing methods under development
- Stakeholders are not all familiar with these new testing paradigms



Types of CALiPER Testing

- Basic photometry (following IESNA LM-79 draft)
 - Integrating Sphere and Goniophotometry
 - Luminaire light output, efficacy
 - Color qualities (spectral power distribution, CCT, CRI)
 - Beam characteristics and intensity distributions
 - Electrical measurements, thermal characteristics
 - Benchmarking (other light sources)
- Other, non-standardized testing
 - “In Situ” Testing (relative measurements)
 - Environmental chamber
 - Insulated ceiling, recessed can
 - Lumen depreciation testing
 - Draws from IESNA LM-80 draft
 - Exploratory testing
 - Thermal imaging, dimming...





Testing Program Quarterly Process

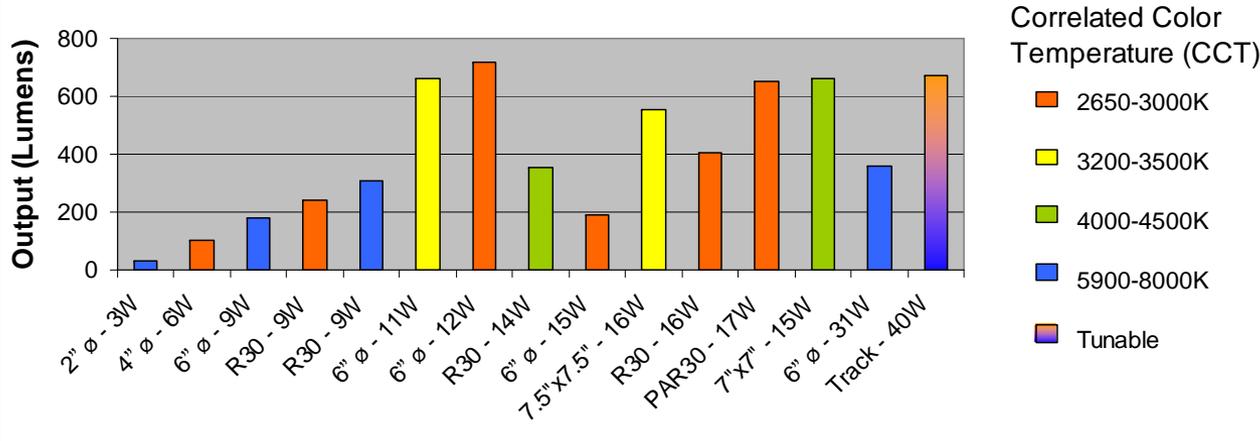
- Product selection & acquisition
- Multiple independent test labs
- Assembly and analysis of results
 - Courtesy sharing of results with manufacturers
 - Retesting options
- Publication of results
 - Summary reports
 - Detailed test reports
 - Analyses and studies
- “No Commercial Use” Policy





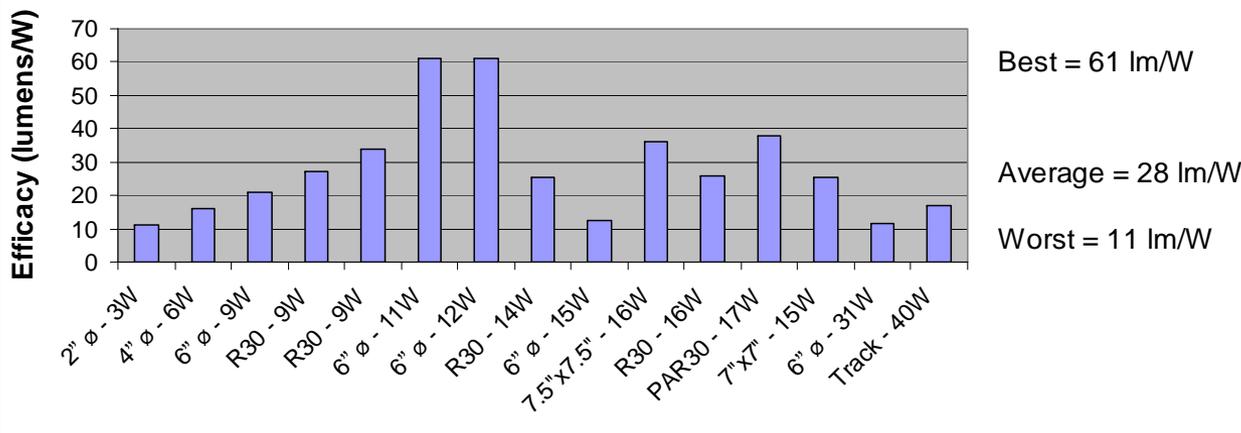
SSL Downlight Performance

Range of Output and CCT of SSL Downlight Products



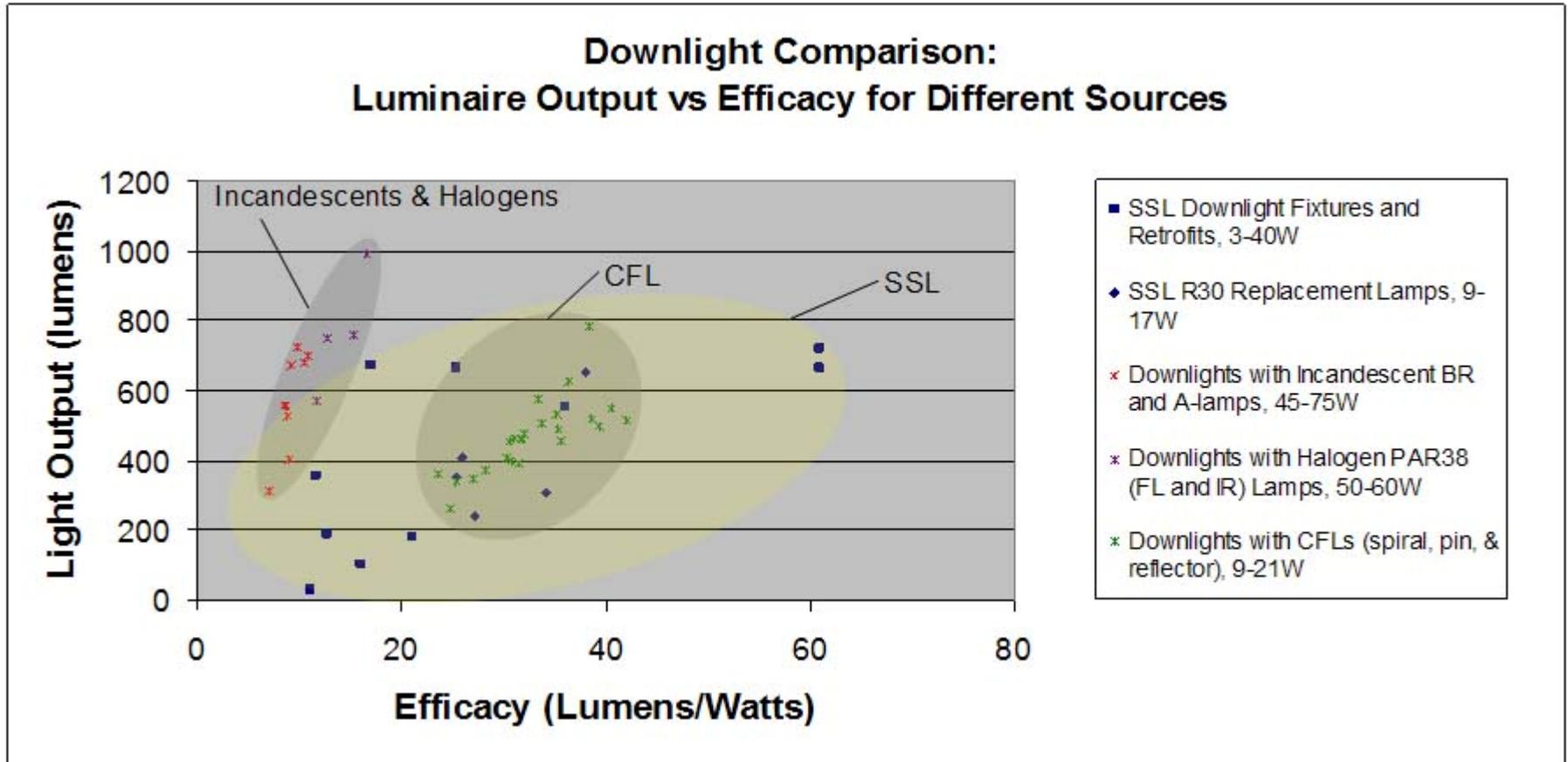
- Different sizes and configurations
- Different color temperatures
- Outputs
 - From 29 to 719 lumens
 - 389 lumens on average
- Efficacies
 - From 11 to 61 lm/W
 - 28 lm/W on average
- CRI
 - Maximum = 95
 - Average = 76
 - 3 RGB products

Range of Efficacy of SSL Downlight Products





Downlight Benchmarking



--Values for SSL downlight products are from CALiPER testing.

--Values for CFL and incandescents are assembled from CALiPER testing, earlier photometric testing and product catalogs.

--Fixture efficiencies are applied to replacement lamp values (factor depends on lamp type).



Round 4 Replacement Lamps

- T8: Look for direct comparisons with fluorescents in troffers in Round 5
 - Respectable performance (42 lm/W), but misleading manufacturer literature
- MR16: not quite competing with 20W Halogen MR16 Flood (40° beam angle)
 - ↑ Efficacy: SSL-MR16 @ 16-27 lm/W > 20W Halogen flood @ 9-19 lm/W
 - ↓ Output: SSL-MR16 @ 75-133 lm < 20W Halogen flood @ 200-450 lm
 - ↓ CBCP: SSL-MR16 @ 59-283 cd << 20W Halogen flood @ ~500 cd
- Candelabra: Low wattage level, advantage or disadvantage?
 - No comparably small wattage incandescent products
 - CFL 5W candelabra rated at 200 lm (40 lm/W), Halogen 25W rated at 280 lm (11 lm/W)

Replacement Lamps		Power	Output	Efficacy	CCT	CRI
SSL T8	07-56	25	1058	42	3494	75
SSL MR16, <i>CBCP=283</i>	07-53	3	82	27	3007	74
SSL MR16, <i>CBCP=220</i>	07-59	9	133	16	3338	89
SSL MR16, <i>CBCP=59</i>	07-64	3	75	26	3458	74
SSL Candelabra	07-57	2.2	28	13	2855	71



Round 4 Direct Comparisons

Same Recessed Wall Fixture, Different Sources

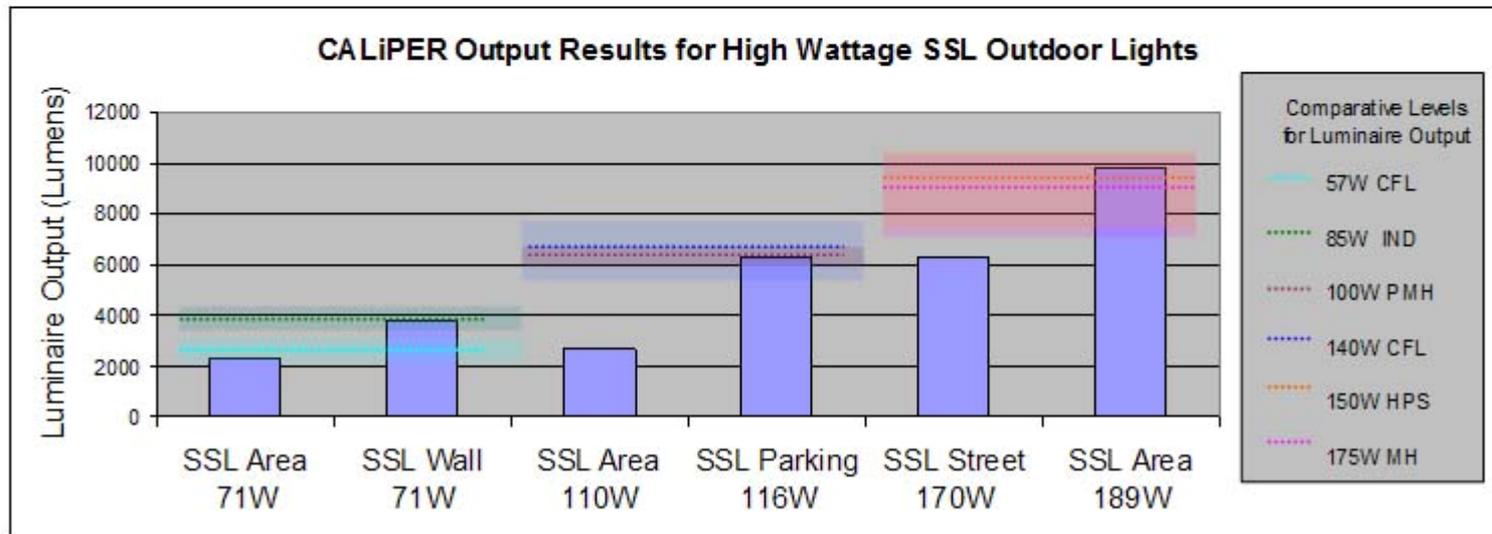
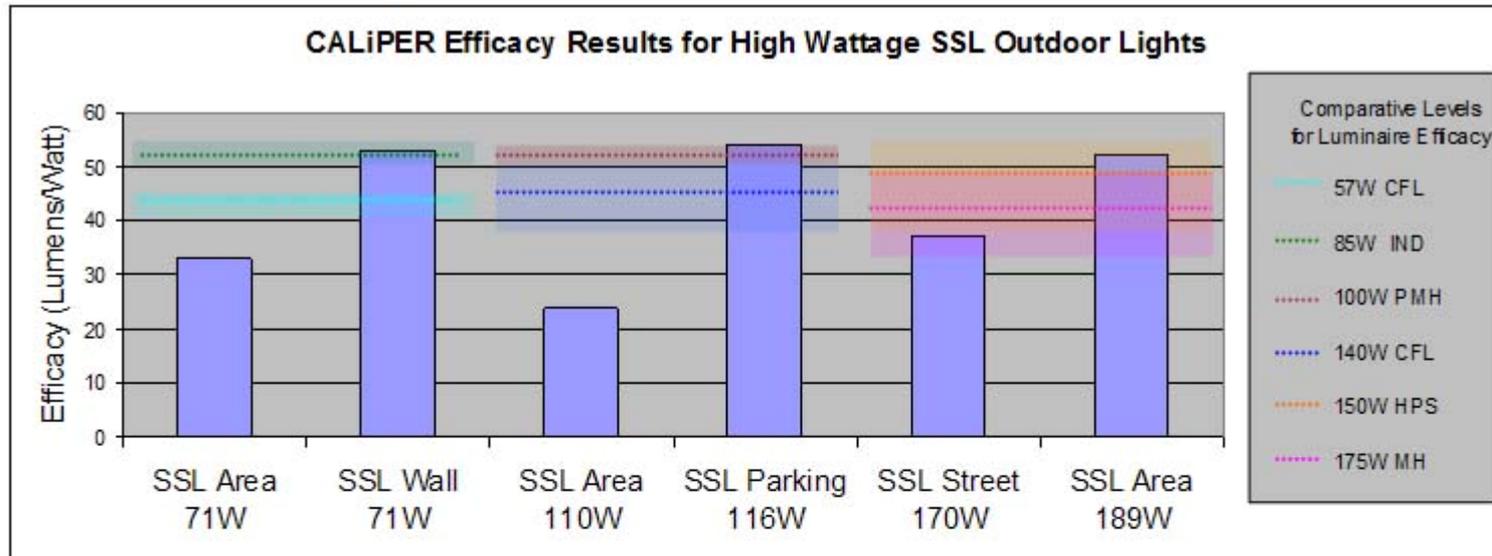
	Halogen (20W)	CFL (13W)	LED (12W)
Luminaire Output (lm)	174	199	154
Luminaire Efficacy (lm/W)	8	16	10
CCT	3085	3956	5166
CRI	98	77	73
Power Factor	0.99	0.97	0.97

Manufacturer Published Values

Recessed Wall Fixture	Manufacturer Brochure Output "Lumens"	Efficacy Calculated from Manufacturer IES files (lumens/W)	CALiPER Measured Luminaire Efficacy (lumens/W)
Halogen (20W)	350	8	8
CFL (13W)	900	19	16
LED (12W)	195	5	10



Outdoor Luminaires





Rounds 1-4 Key Conclusions

- Results include a wide range of products with a wide range of performance.
 - Be careful not to generalize.
- Product literature not always consistent, not always reliable
 - Be informed. Request luminaire testing results.

Round 1-4 products designed from 2005-2007, showing some now clearly rival traditional sources

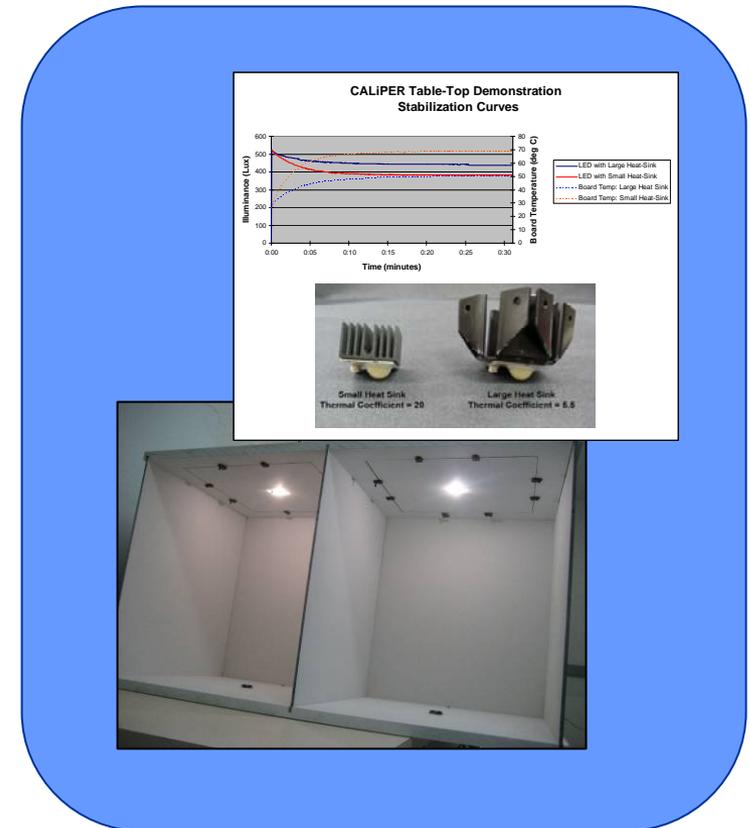


Great promise for upcoming generation of SSL luminaires



CALiPER Positive Influences

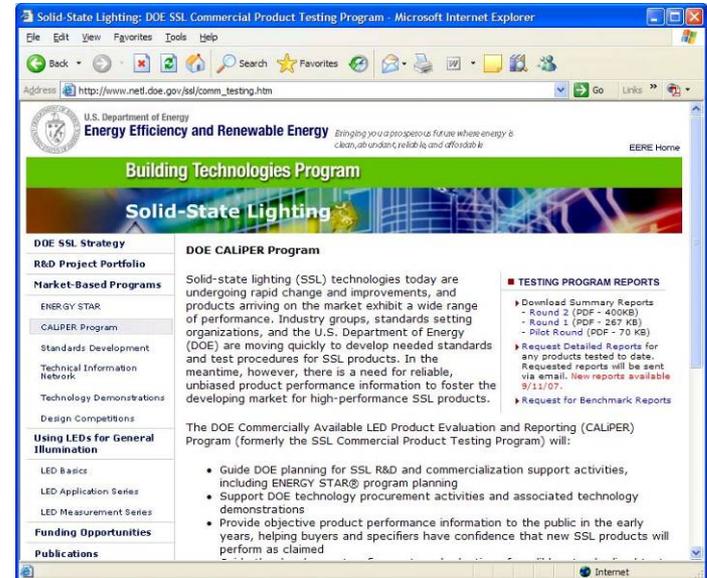
- Testing standards validation & refinement
 - CALiPER Roundtable interactive meeting of experts (proceedings on-line)
- Market/industry awareness & involvement
 - Articles and discussions
 - Improvements in SSL product literature
 - CALiPER Booth





More Info on CALiPER

- Via website
 - Summary reports
 - Detailed reports
 - Must be requested via web form
 - Requestor's contact information must be provided
 - Must agree to adhere to 'No Commercial Use Policy'



http://www.netl.doe.gov/ssl/comm_testing.htm