Frequently Asked Questions (FAQs)

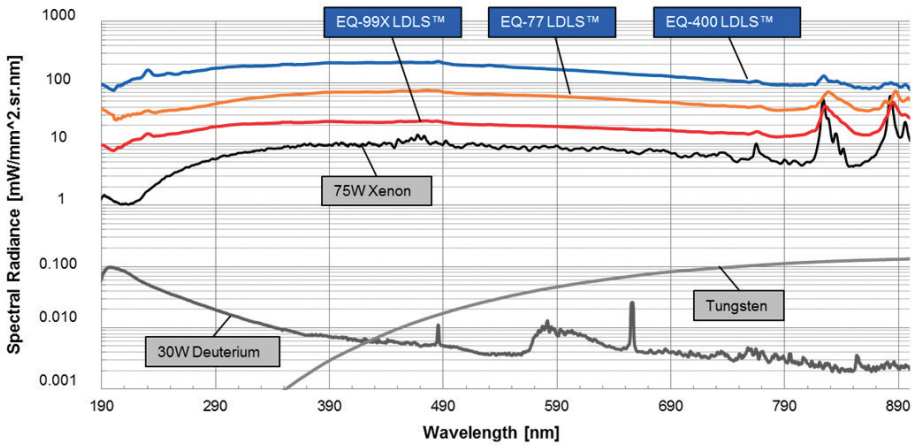
If you have a question about Energetiq's world-renowned Laser-Driven Light Sources that we haven't answered here, feel free to contact us via email at info@energetiq.com.

LDLS™ Performance

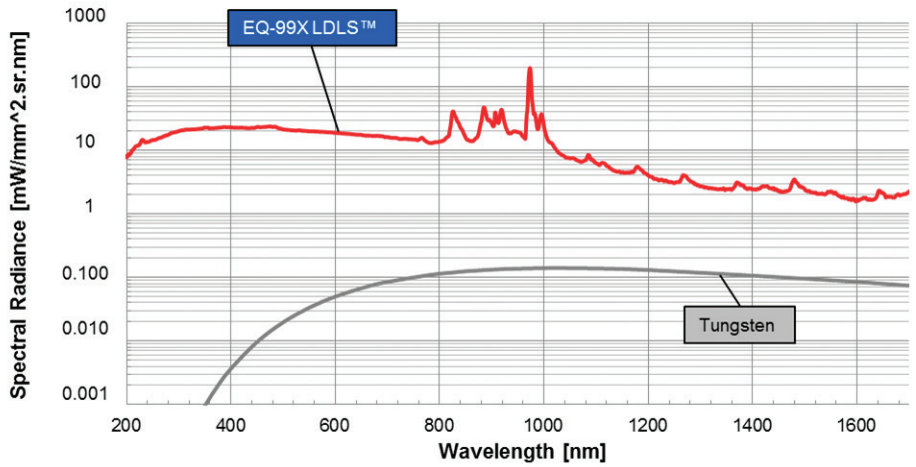
1. What is the spectral range of LDLS?

The EQ-99X, EQ-77 and EQ-400 cover the range from 170nm to 2400nm. The EQ-99XFC covers the range from 190nm to 2400nm. This range is limited by the high purity synthetic quartz of the bulb and output window.

The spectral radiance (brightness) of the LDLS exceeds that of traditional Xe and Deuterium sources across the UV-Vis-NIR spectral range as shown in Figure 1.



The spectral radiance (brightness) of the LDLS exceeds that of traditional Tungsten sources across the UV-Vis-NIR spectral range as shown in Figure 2.



LDLS™ Performance (continued)

2. How much total optical power and brightness does the LDLS deliver?

LDLS systems are optimized for high brightness, rather than high power. The LDLS power is radiated from a very small plasma spot, in the range of 100µm in size, and this provides a high brightness (spectral radiance - mwatts/nm/mm²/sr), but modest power (watts). As a guide, the outputs of the LDLS sources are as follows:

- Typically, the EQ-99X delivers spectral radiance (brightness) of about 10 mwatts/nm/mm²/sr (depending on wavelength) and total power of approximately 0.5 watts, broadband measured with a thermopile.
- Typically, the EQ-77 delivers spectral radiance (brightness) of about 40 mwatts/nm/mm²/sr (depending on wavelength) and total power of approximately 2.0 watts, broadband measured with a thermopile.
- Typically, the EQ-400 delivers spectral radiance (brightness) of about 100 mwatts/nm/mm²/sr (depending on wavelength) and total power of approximately 15 watts, broadband measured with a thermopile.

Fiber Coupling

3. What is the fiber connection of the EQ-99XFC?

The EQ-99XFC system has an FC connection. A standard FC connector will interface with the EQ-99XFC lamp house. It is strongly recommended to use the high-performance output fiber assembly provided by Energetiq with the EQ-99XFC. The output fiber assemblies are available in FC to SMA terminations and FC to FC terminations in a variety of fiber core sizes.

4. How much power is delivered by the EQ-99XFC?

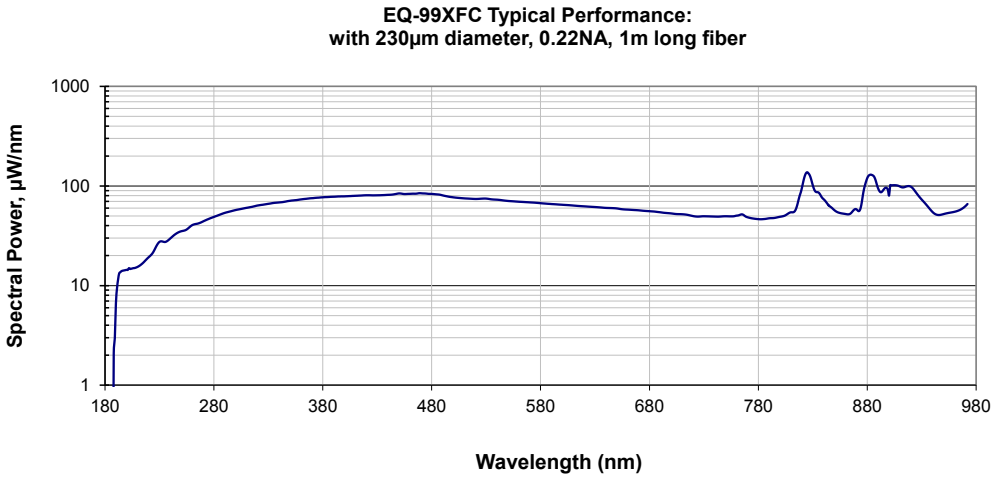
This depends on the chosen optical fiber size, the transmission characteristics of the particular fiber and wavelength of interest. Typical output power is:

- 600µm core fiber, 0.22NA; ~200 mwatts (broadband)
- 455µm core fiber, 0.22NA; ~150 mwatts (broadband)
- 230µm core fiber, 0.22NA; ~70 mwatts (broadband)
- 115µm core fiber, 0.22NA; ~25 mwatts (broadband)
- 50µm core fiber, 0.22NA; ~5 mwatts (broadband)
- 9µm core single mode fiber; ~40 µwatts (broadband)

5. How much spectral power is delivered by the EQ-99XFC?

This depends on the chosen optical fiber, wavelength range and the fiber characteristics. Typical performance with a 230µm diameter, 0.22NA fiber is shown in the chart below;

For larger fiber diameters, the spectral power values from the chart can be multiplied by the following factors: 230µm multiply by 1; 450µm multiply by ~2; 600µm multiply by ~2.25.



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Fiber Coupling (continued)

6. For the EQ-99X and EQ-99XFC, is there a limit on the laser fiber length between the power supply and the lamp house?

The standard fiber length is 1 meter. Currently, a longer fiber is not available.

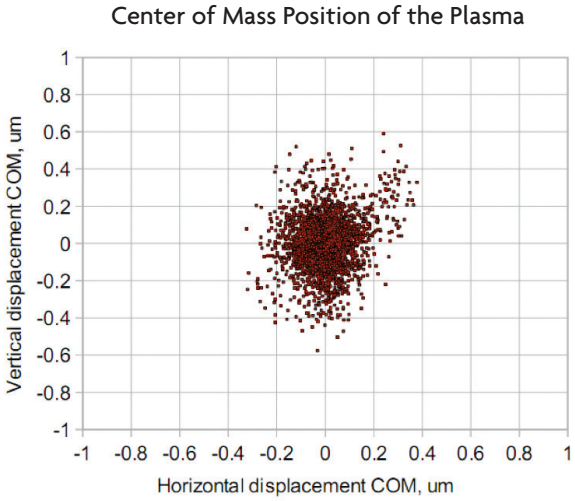
7. Is there a limit on the output fiber length from the lamp house to the application?

Energetiq offers high performance, solarization resistant output fibers in a choice of diameters, and a choice of 1 meter and 2 meter lengths. Since even the best optical fibers absorb light in the deep UV, it is recommended to use the shortest fiber length possible to maximize the potential of the LDLS.

Stability

8. What is the spatial stability of the plasma in the LDLS?

The position of the plasma is very precisely positioned in space by the focal point of the drive laser. The standard deviation of the plasma light intensity 'center of mass' position is less than 0.5µm in the x, y or z position. This is measured capturing 2500 images at 200 frames per second.



9. What is the long term drift of the LDLS?

Long term stability (drift) is dominated by the Lamp House Temperature Coefficient, which is approximately 0.3%/deg C. This temperature coefficient will dominate any other system drift in the timescale of hours.

Energetiq recommends a warm-up time of approximately 30 minutes before making measurements, to ensure that the LDLS system has reached thermal equilibrium. The actual warm-up time for a particular application may be longer or shorter depending on the precision of measurements to be made.

Lifetime

10. How does the output power change as the bulb ages?

The broadband output power reduces over time at approximately 1%-2% per 1000 hours of bulb life.

11. How long is the bulb life?

- The typical bulb life of the EQ-99X Series is greater than 9,000 hours.
- The typical bulb life of the EQ-77 is greater than 9,000 hours.
- The typical bulb life of the EQ-400 is greater than 9,000 hours.

LDLS Technology

12. How much laser power is used to drive the LDLS?

- The EQ-99X and EQ-99XFC use a laser diode module with a total power of about 20 watts.
- The EQ-77 uses a laser diode module with a total power of about 50 watts.
- The EQ-400 uses a laser module with a total power of about 400 watts.

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LDLS Technology (continued)

13. What laser wavelength is used in LDLS products?

- The LDLS products use laser diode modules with wavelength of approximately 1µm

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Optical Considerations

14. What is the plasma size of the LDLS?

• The EQ-99X has a FWHM (Full Width-Half Maximum) plasma size of typically 60µm x 140µm

• The EQ-77 has a FWHM (Full Width-Half Maximum) plasma size of typically 135µm x 320µm

• The EQ-400 has a FWHM (Full Width-Half Maximum) plasma size of typically 302µm x 798µm

15. What is the output beam configuration of the LDLS?

- The EQ-99X is a point source system with a diverging beam with a Numerical Aperture (NA) of 0.47 for coupling of free space-optics.
- The EQ-77 is a point source system with a diverging beam with a Numerical Aperture (NA) of 0.5 for coupling of free-space optics.
- The EQ-400 is a point source system with a diverging beam with a Numerical Aperture (NA) of 0.5 for coupling of free space-optics.
- Both the EQ-99X and EQ-77 are available with coupling optic accessories based on OAPs (Off-Axis Parabolic) Mirrors which can deliver the light into, for example, the slits of a monochromator or spectrometer.
- Choices of focal length are available for these coupling accessories in order to make the most efficient optical coupling from the LDLS to the application.
- The EQ-99XFC has a fiber coupled output with NA of 0.22

16. What OAP configuration is needed for coupling the LDLS into a spectrometer or monochromator?

The EQ-99X and EQ-77 have four different OAP options. Please note that the Numerical Aperture (NA) of the OAP assembly should be slightly less than the entrance NA of the monochromator or spectrometer. Whereas the f/# of the OAP assembly should be slightly larger than the f/# of the entrance to the system, to allow for efficient coupling into the system.

- Use the chart below to match the entrance f/# or NA of your system with the appropriate OAP Mirror Assembly.

	2" EFL OAP	4" EFL OAP	6" EFL OAP	8" EFL OAP
Effective Focal Length (EFL)	2.0" (50.8mm)	4.0" (101.6mm)	6.0" (152.4mm)	8.0" (203.2mm)
Diameter	1.5"	1.5"	1.5"	1.5"
Magnification*	1x	2x	3x	4x
Numerical Aperature	0.375	0.188	0.125	0.094
f/#	1.33	2.67	4.00	5.33

- Magnification is based on an OAP pair with 2" EFL OAP as the collecting mirror and the second OAP (listed above) as the focusing mirror.

Set-up

17. What is the EQ-99X lamp house temperature?

In normal operation in a typical lab, the EQ-99X and EQ-99XFC lamp houses reach about 55 degrees Celsius. The particular temperature of the lamp house depends on how and where the lamp house is mounted: in a warm lab or in an enclosure the lamp house will be hotter. Mounting the LDLS on an optical table, where the metal table acts to some extent as a heat sink, will cause the lamp house to run at a lower temperature than the equivalent temperature when mounted in free-air.

18. When do I need to purge the LDLS with dry nitrogen?

LDLS products produce significant amounts of deep UV light. Light below 200nm produces ozone in the presence of oxygen, and the ozone produced has an absorption band in the 240-270nm range. To use light from the LDLS in the 170 to 270nm range, the system should be purged with clean dry nitrogen. Purging with dry nitrogen also reduces the possibility of photo-contamination of the bulb from trace organic vapors present in room air.

19. What pressure is needed for the dry nitrogen purge?

For nitrogen purging grade 6 or better gas purity is recommended to maintain cleanliness of the optics, and gas should be filtered to ‹5µm. Supply pressure should be 20psig (0.14 MPa). With a 20 psig inlet pressure, the EQ-99X will consume approximately 1 slm of flow. There is no return fitting for the purge nitrogen. The purge flow normally escapes within the lamp house enclosure, and then to the atmosphere.

20. Can you purge with other gases besides nitrogen?

- No, only clean, dry nitrogen can be used to purge the LDLS systems.

21. Can you put a vacuum on the lamp house instead of purging with nitrogen?

- No. The LDLS systems will not hold vacuum and connecting to a vacuum may cause damage to the optics.

22. What is the LDLS warm-up time?

Energetiq recommends a warm up time of approximately 30 minutes before making measurements, to ensure that the LDLS system has reached thermal equilibrium. The actual warm-up time for a particular application may be longer or shorter depending on the precision of measurements to be made.

23. What is the proper orientation of the EQ-99X or EQ-99XFC lamp house?

- The EQ-99X and EQ-99XFC lamp house should only be mounted so that the label that contains the serial number is facing downward.
- This is particularly important for the EQ-99XFC which must be mounted with the output fiber optic connection on top (serial number on the bottom). The plasma moves slightly depending on gravity and the precision ellipsoidal coupling optic in the EQ-99XFC is adjusted at the factory to optimize output in that particular orientation.
- The EQ-99X and EQ-99XFC exhibit the highest spatial and temporal stability when mounted in the recommended orientation.

24. Can the LDLS lamp houses be mounted in other orientations?

- We strongly recommend that the EQ-99X, EQ-99XFC, EQ-77 and EQ-400 only be mounted in the recommended orientation.
- If for optical reasons it would be desirable to have the optical output in a different orientation, please contact the Energetiq Applications Team to discuss ways that this might be achieved.

Note

Performance measures mentioned in this list of Frequently Asked Questions are typical values for guidance in the selection and use of LDLS products. They are not to be taken as specifications. Please contact Energetiq for further details: info@energetiq.com

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