Luzchem Computer-Controlled Solar Simulator
Model CCP-SolSim

November 2015

Luzchem's CCP-SolSim is a fully computer controlled photoreactor providing solar simulating radiation in the UV and Visible regions. Based on a powerful 300W ceramic xenon lamp and enclosed in a standard photoreactor cabinet, the unit illuminates a circle of approximately 6.0" (15.2 cm) in diameter which approximates the spectrum and intensity of the AM1.5 solar spectrum when used in the recommended illumination configuration. The output beam is enclosed within a chamber, which prevents ambient light from influencing experiments as well as operator exposure to UV. A safe exhaust safely removes trace ozone generated by the deep UV of the xenon lamp while cooling the lamp and the filters required for solar simulation are included. The custom software allows computer control of the lamp shutter and timed experiments. The CCP-SunSensor measures power relative to the AM1.5 spectrum and allows total power matching with AM1.5 over 3 different wavelength ranges. Unlike many other solar simulators available, output intensity is computer controlled, correcting for changes to the lamp output power that naturally occur as a lamp ages.

Configuration:

The CCP-SolSim uses a Xenon lamp installed in the tower at the top of the photoreactor chamber, with a custom filter assembly mounted in the chamber ceiling. A proprietary solar simulating filter-diffuser stand with 2" posts is placed on the chamber floor, with samples beneath.

For a more detailed diagram see Appendix 1.

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Unit Specifications:

Dimensions:	*External:* 18” wide, 13.75” deep and 26” high (46 x 35 x 66 cm) *Internal:* 12” wide, 12” deep and 8.5” high (30 x 30 x 22 cm)
Weight:	31 lbs. / 14 kg
Power Rating:	110 or 220 VAC, 50/60 Hz cycle, 6 Amps
Housing Material:	*External:* Stainless Steel *Internal (chamber):* Aluminum alloy (highly reflective)
Ambient Temperature:	Must be between 0°C and 45°C
Chamber Temperature:	Maintained to 3-4 ºC above room temperature
Humidity:	Must be between 0% and 95% (non-condensing)

Lamps: The unit uses a focused 300W Cermax Xenon lamp. The software allow variable power control of the lamp.
A full-UV, focused xenon lamp (supplied) is required for solar simulation. The full- UV lamp irradiates from 200 nm into the near IR region and requires a safe exhaust system.

See manufacturer’s specification sheet for detailed information.

Filters: For solar simulation, Luzchem SolSim proprietary filters are used:

- One 2” circular filter placed at the top of the chamber (in the filter holder)
- One 6” x 6” square filter-diffuser assembly placed on a stand 2” above the chamber floor.

The filter combination simulates the AM1.5 solar spectrum to within 10% total difference between 280-800 nm.

SunSensor: The CCP-SunSensor comprises two photodiodes, one optimized for the visible region and one sensitive only in the UV region. It has been calibrated against a NIST-traceable Luzchem spectroradiometer for AM1.5 power matching and allows the CCP-SolSim software to optimize lamp power output to match AM1.5 intensity over three different spectral regions.

Lenses: The filter adapter accepts lenses 2” in diameter. This be can used to expand or contract the beam with corresponding changes to output intensity. Lenses are a user-supplied option.

Computer: A computer with pre-installed Luzchem CCP-SolSim software is included.

Options Included:

Option	Specifications
Safe exhaust	• Material: galvanized aluminum • Exhaust tube provided: 3" diameter, max length: ~ 8' • Built-in fan: 3100 RPM, Airflow: 110 CFM
UV protecting goggles	• Yellow safety goggles, with 420 nm cut-off
Shutter	• Material: reflective aluminum • Computer-controlled user operation • Computer-controlled timed operation
Timer Mode	• Allows unattended exposure times from a few seconds to min to days • Timer can be set to close the lamp shutter between experiments, or to turn the lamp off after the last experiment.
Variable Power	• User adjusted power in manual mode • User-set target power is automatically achieved by the software in Timer or SolSim modes. • Corrects for changes in lamp power output as the lamp ages.
Gas inlet	• Rear mounted bulkhead gas connector • Only for non-flammable, non-toxic gases • Gas should not dissipate in the chamber, should be used with environmental chamber only.
Accelerated Aging Possible	• With a new lamp, unit will typically exceed 1.5 (times) AM1.5 • Variations between units and lamp aging effects can occur • Power is adjustable to match multiples of AM1.5
Hour Meter	• Built-in to the unit • Keeps track of the number of hours the unit has been in operation

Adjustable Power

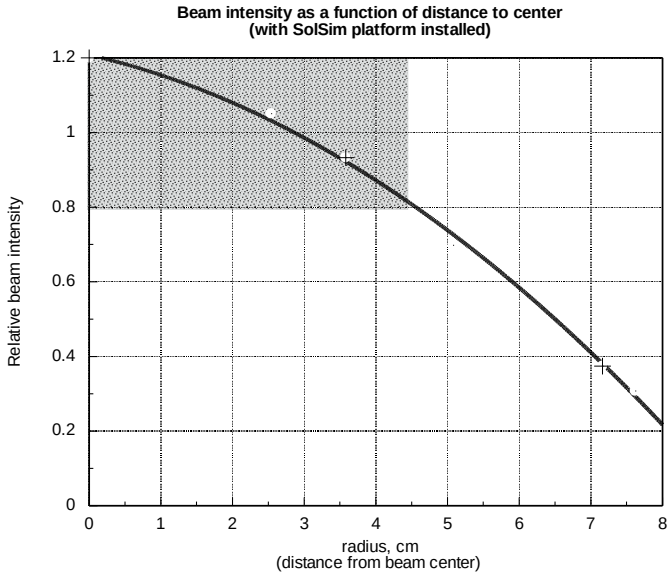
With Luzchem's CCP-SolSim, the lamp power can be easily controlled. This allows users to compensate for lamp aging and achieve AM1.5 simulation as the lamp output decreases with time. To continue to use an aging lamp once maximum power no longer achieves AM1.5, the beam can be concentrated by installing suitable lenses in the 2-inch lens holder at the top of the chamber. For good spectral matching, use lenses made of BK7 glass.

The following values are given for reference only, since every SolSim system shows variations of as much as 10%. Users should also anticipate variations in this range when they replace the xenon lamp. These values correspond to the AM1.5 units achievable within the power adjustment range provided:

- Power at minimum: ≈ 50% of AM1.5
- To achieve AM1.5 power setting ≈ 30%
- Maximum achievable (new lamp, center) ≈ 1.5 times AM1.5

Beam Homogeneity

The following graph shows the variation of the beam intensity as a function of distance from the beam center. The gray area shows the region with $\leq \pm$ 20% variation from the normalization value and corresponds to a circle of 8.8 cm diameter with a surface area of 61 cm^2. Similarly variations of only $\pm$ 10% can be obtained in a region of 3.0 cm diameter, corresponding to a surface area of 28 cm^2. Points identified with a + marker correspond to distances in a diagonal line that crosses the center of the stage.



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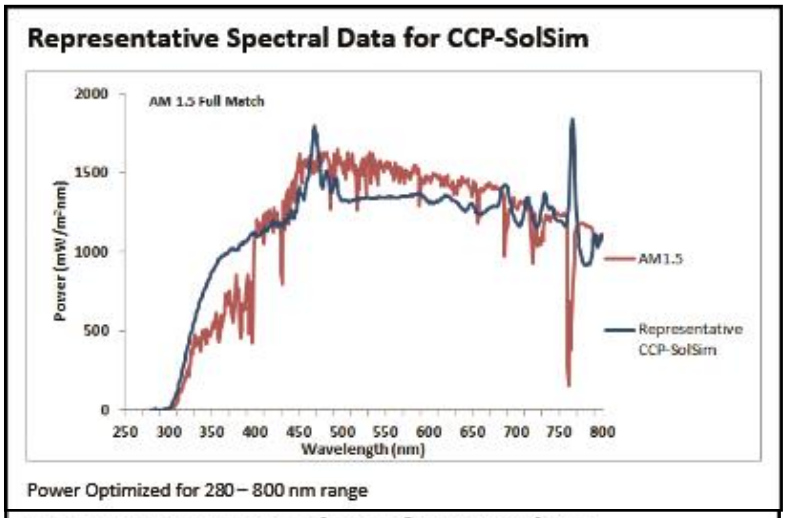
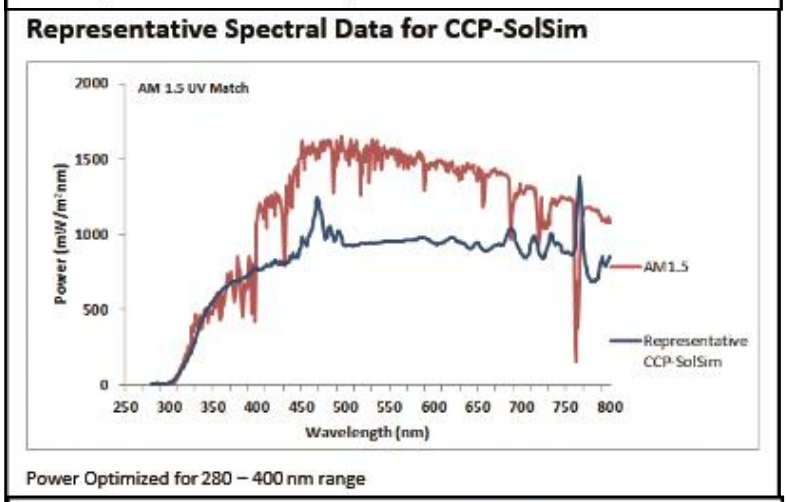
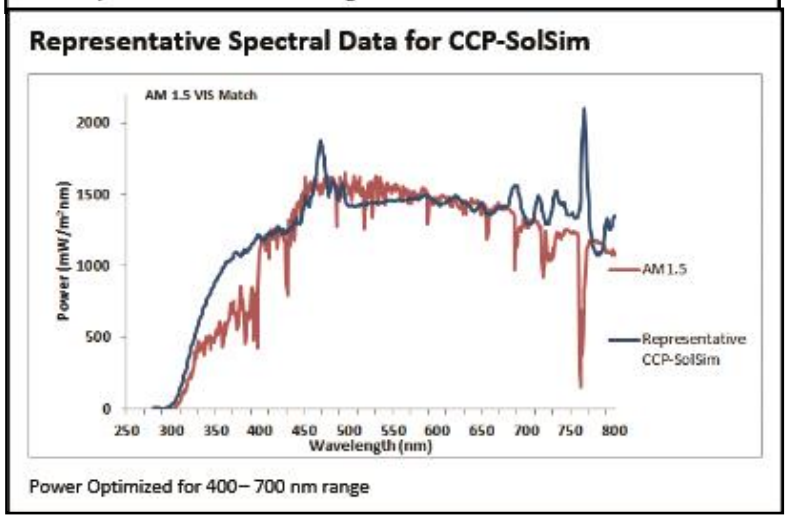
Typical Spectral Graph:



Solar Match: Full
Optimized Region: 280-800 nm
Total power over optimized region: 589 W/m^2



Solar Match: UV
Optimized Region: 280-400 nm
Total power over optimized region: 46 W/m^2



Solar Match: Visible
Optimized Region: 400-700 nm
Total power over optimized region: 430 W/m^2

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Appendix 1: System diagram