

July 2007 Status Report

Revision of Standard Spectral Weighting Function for Calculation of Solar Optical Properties and Solar Heat Gain

July 23, 2007

Submitted to:

NFRC Project Monitoring Task Group, and
NFRC Research Subcommittee

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Introduction

The intent of this research project is to provide a recommended spectrum to NFRC by assessing the impact of potential changes in reference spectra used to weigh the spectral transmission calculations of glazing systems.

Status Report

Task 1 – Selection of Glazing Systems

The list of 37 glazing systems previously mentioned for analysis in this project has been revised and approved by the PMTG. A plot of the visible transmittance vs. the Solar Heat Gain Coefficient (SHGC) for each glazing system is presented in Figure 1. In addition, Figures 2 and 3 describe the range of spectral selectivity of all the specimens. This is characterized by the Light-to-Solar-heat-Gain ratio, LSG, which is simply the ratio of the Visible Transmittance (VT, or T_{vis}) and SHGC. Figure 2 presents the distribution of LSG for the whole sample, in increasing order of LSG. The frequency distribution of LSG (in number of cases per bin of 0.2 LSG) appears in Figure 3.

The whole dataset (including the original figures) is contained in the attached Excel file.

This Task is now considered complete with the selection of the 37 test specimens covering a large range of optical properties, including a range of LSG ratios from 0.058 to 2.381.

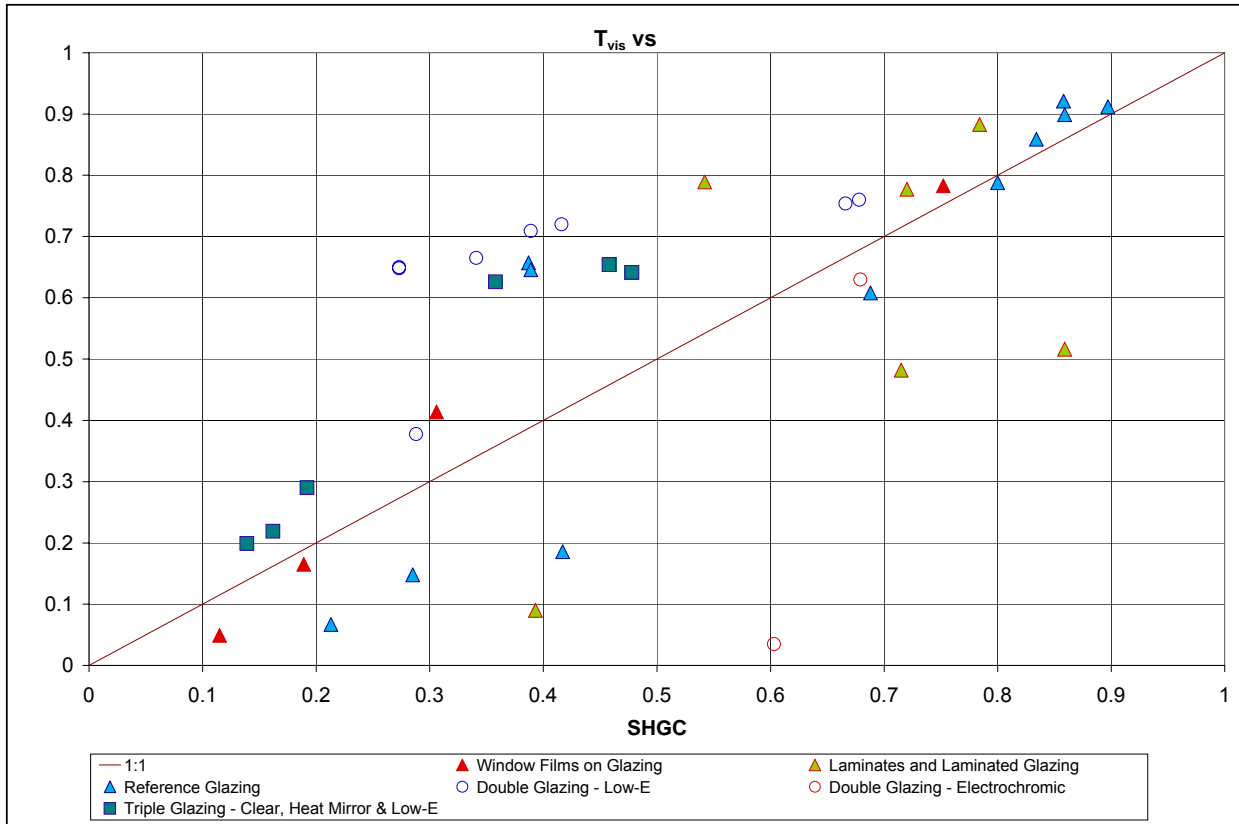


Fig. 1 Visible transmittance (T_{vis}) vs SHGC for the 37 specimens

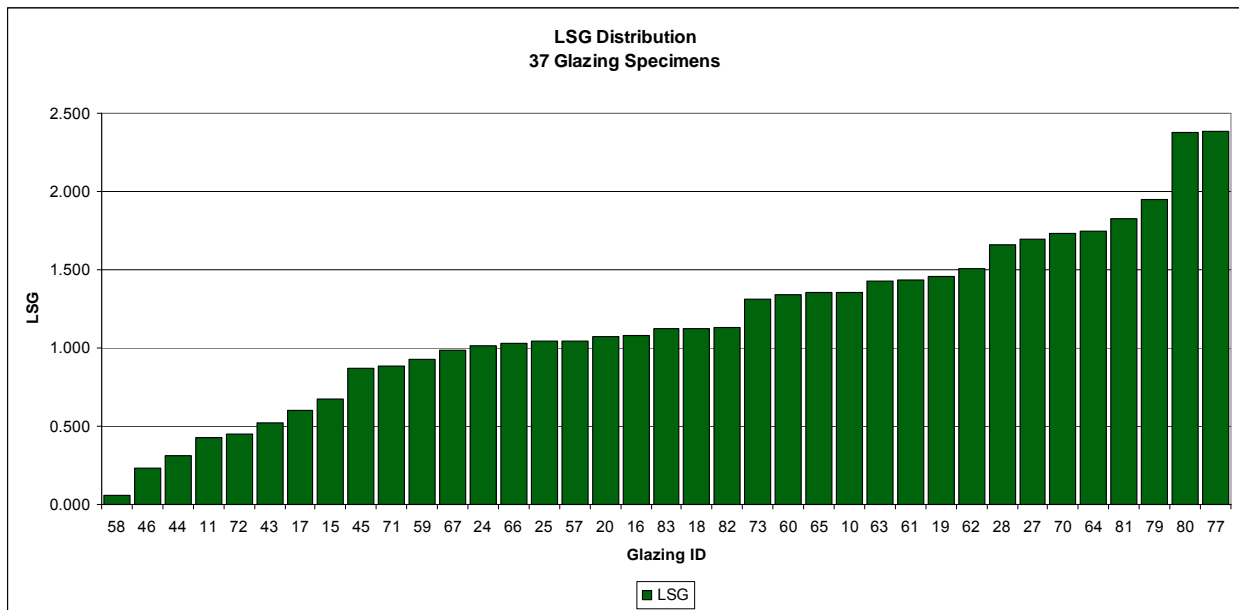


Fig. 2 Distribution of LSG ($=T_{vis}/SHGC$) among the 37 specimens, in increasing order of LSG

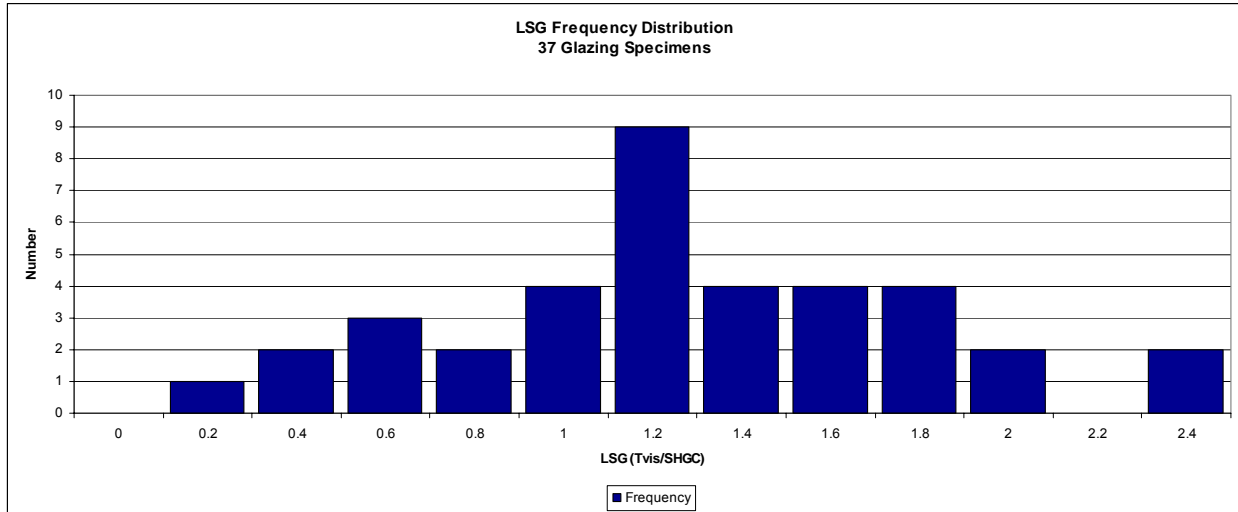


Fig. 3 Frequency distribution of LSG, i.e., number of specimens per bin of 0.2 LSG. The first category, marked “0” on the X-axis, is for LSG < 0. The second category, marked “0.2” is for $0 < \text{LSG} \leq 0.2$, etc.

Task 2 – Evaluation of Rated Optical Properties Using Various Spectral Weighting Functions

This Task is about to get underway once the following issues are resolved:

- a. PMTG needs to approve the seven spectra selected for analysis, as described below. The first three spectra have already been standardized by ASTM. The last four are in the process (see Task 3 below).
 - i. Current ASTM E 891 Spectrum (used in WINDOW 5.2), as prescribed by NFRC 200 & 300. This will be the “base case” or “business as usual.”
 - ii. ASTM G 173 Direct Irradiance at Normal Incidence (2003)
 - iii. ASTM G 173 Global Irradiance for a 37° Tilt (2003)
 - iv. Proposed ASTM Global Irradiance for a Vertical Surface
 - v. Proposed ASTM Global Irradiance for a 20° Tilt
 - vi. Proposed ASTM Direct Irradiance for a Vertical Surface
 - vii. Proposed ASTM Direct Irradiance for a 20° Tilt.

- b. The issue with spectra iii, iv and v is that Global Irradiance is made of a mix of direct and diffuse radiation. The current WINDOW software can only accommodate direct irradiance incident on any type of glazing. This problem can be circumvented in two different ways. The first possibility is to consider that diffuse radiation can be assimilated to direct radiation (owing to the fact that diffuse is usually a relatively small fraction of direct at most wavelengths, see Fig. 4), in which case the global spectrum is simply considered as if it were a direct spectrum. [This is essentially what the Europeans have done so far.] The second possibility is to rely on a (still hypothetical) special version of WINDOW that would explicitly consider the intricacies (e.g., directional dependence) of diffuse radiation incident on glazings.

- c. In case neither of these two processes is agreed upon, we would simply skip these three global spectra and consider only direct spectra i, ii, vi and vii for further analysis.

Notes: Currently, WINDOW 5.2 only calculates the SHGC and VT for direct irradiance, which does not include diffuse radiation. The proposed ASTM Standard (see Task 3 below) includes spectra for both direct and diffuse solar irradiation for both vertical and the 20° tilted orientations. We have been in negotiation with LBNL concerning the implementation of this new capability in WINDOW (i.e., addressing the calculation of SHGC and VT for incident diffuse radiation, in addition to direct radiation), and they have agreed to try to provide this capability. Nevertheless, analysis using the remaining spectra can proceed once they are approved by the PMTG. Just in case, we should confer with the PMTG to establish a deadline at which time the final analysis would be completed with the diffuse irradiation analysis using the special version of WINDOW if that capability becomes finally available in a reasonable timeframe.

Task 3 – Report CIE Activities and Represent NFRC at CIE TC 2-17 Meetings

This Task is well underway. Following the discussions we had at the previous meeting and with the PMTG, and confirmation of very slow progress regarding the activities of this CIE TC, we have changed course and are now considering ASTM in lieu of CIE for adoption of an “NFRC-friendly” spectral standard.

The ASTM G03.09 subcommittee on Radiometry has been approached to develop standard direct normal and diffuse spectra for fenestration at vertical and 20° tilted orientations.

- i. Chris Gueymard attended the ASTM G03-09 subcommittee meeting in Cleveland, Ohio on June 19, chaired by Gene Zerlaut. About 20 members of this subcommittee attended the meeting. Chris introduced the proposed “ASTM-NFRC” standard, and distributed draft hard copies of it. His presentation was well received and no difficult questions were asked. A green light for balloting was given, and only minor editorial changes were suggested.
- ii. A revised Draft for this proposed ASTM standard addressing these editorial changes has been sent to Gene Zerlaut on 6/26. He is to submit this draft for ballot soon. This Draft is attached to this document. If NFRC or PMTG Members want to make any revision to the ballot draft, please submit your comments directly to us ASAP. We encourage you to join ASTM G-03.09 so that you can directly participate in the process. The next meeting will be in Fort Lauderdale on January 22, 2008.
- iii. The comparison between the existing NFRC 200/300 spectrum (i.e., ASTM E 891) and the proposed direct and global spectra for vertical and 20° tilts are presented in Figs. 5–7. The good news to NFRC members is that the proposed spectra are less different from the current NFRC weighting function than the existing ASTM G 173 standard spectra.
- iv. The proposed spectra separate direct and diffuse irradiance because it is anticipated that the WINDOW and other fenestration software will eventually calculate the transmission of diffuse radiation. This would be particularly important for diffusing fenestration systems (i.e., frits, frosted glass, etc.). The total diffuse irradiance can even be easily separated into *sky diffuse* and *ground-reflected diffuse*, because spectral *and* angular distributions are both different. This might come into play in a future version of WINDOW, per our discussions with LBNL.

- v. A provision is made in the proposed standard that the tabulated *diffuse* spectral irradiance can be used solely to represent cases when a surface is shaded from the sun, and therefore no direct radiation impinges on fenestration.
- vi. The proposed standard also mentions explicitly that it can be used to rate building-integrated devices, such as photovoltaics applied directly on fenestration systems, which are already popular in Europe and Japan, and now being introduced in North America. It is anticipated that manufacturers of such devices will have to rate their products using ad-hoc NFRC procedures (to be determined) in the near future.

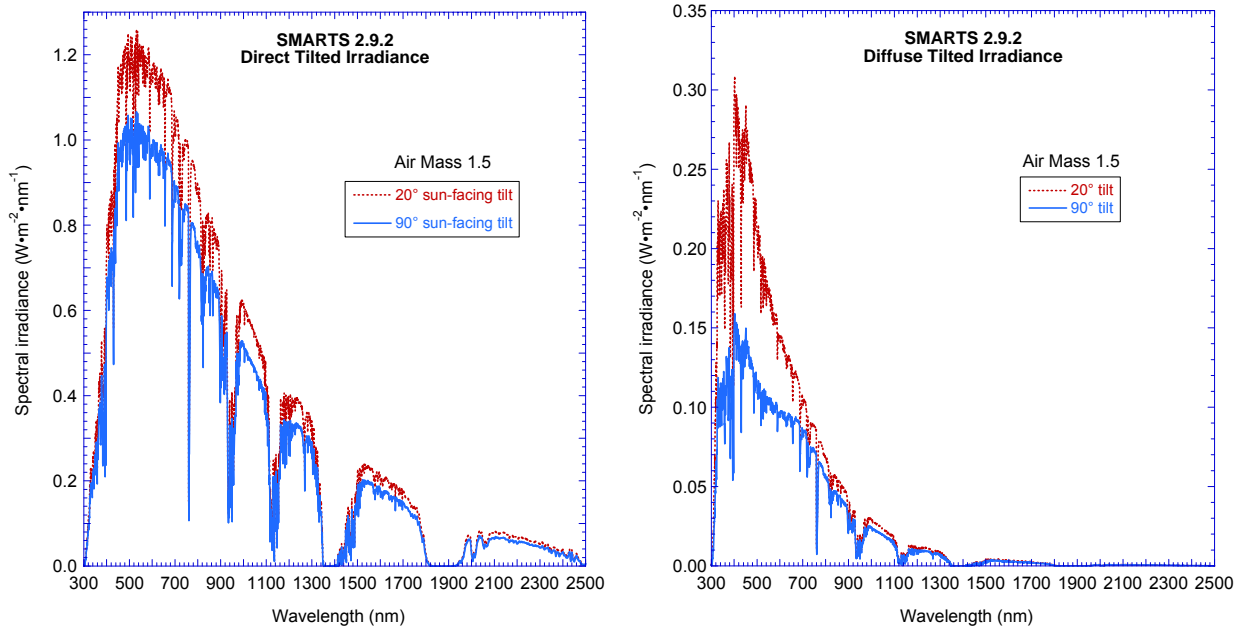


Fig. 4 Direct and diffuse reference spectral irradiance distributions as proposed to ASTM

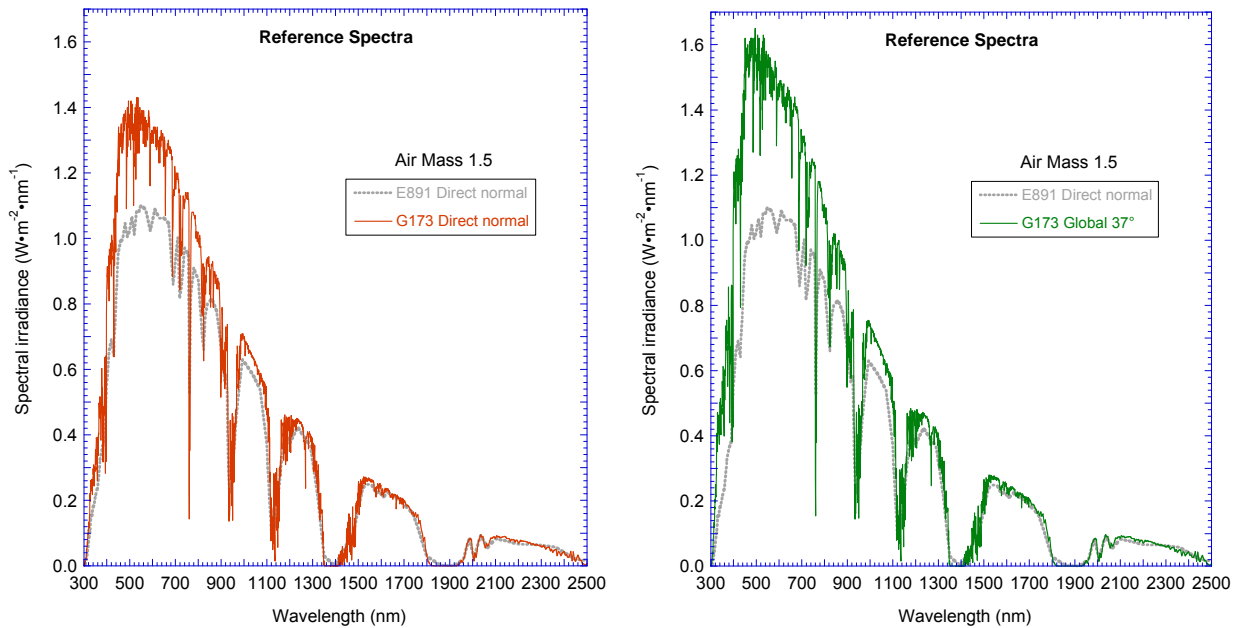


Fig. 5 Direct and global reference spectral irradiance distributions from ASTM G173 compared to the current NFRC distribution, per ASTM E891

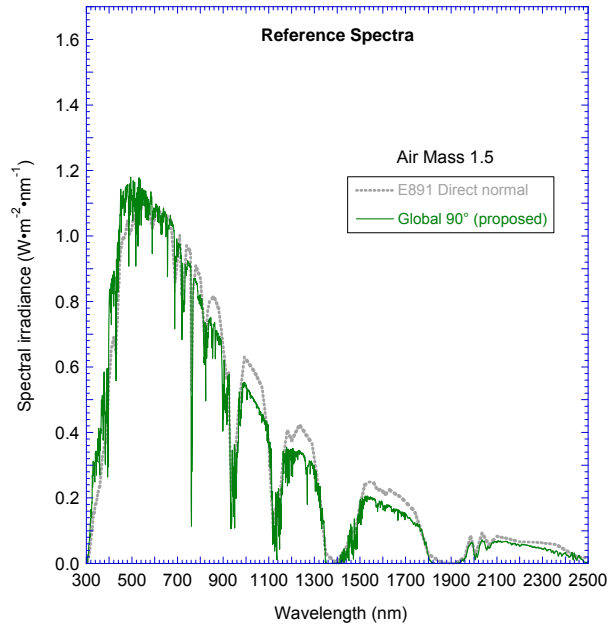
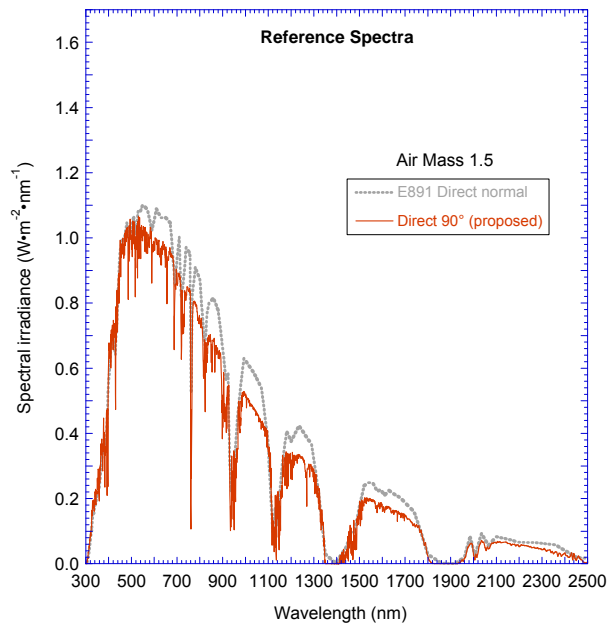


Fig. 6 Direct and global reference spectral irradiance distributions for vertical surfaces from the proposed ASTM standard compared to the current NFRC distribution, per ASTM E891

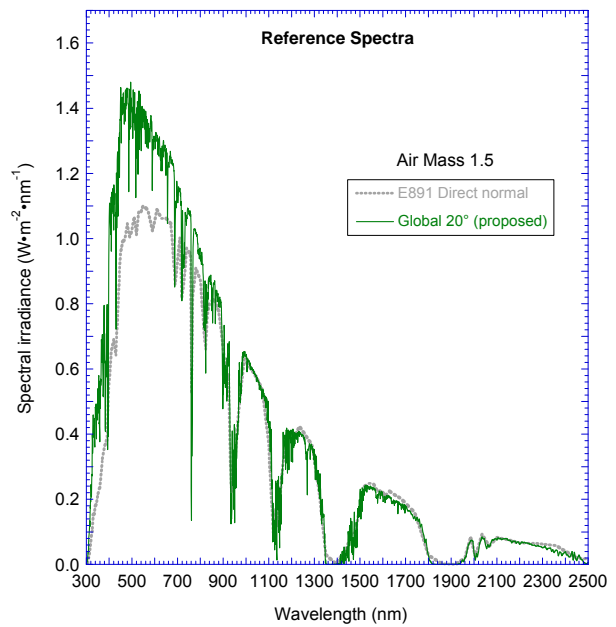
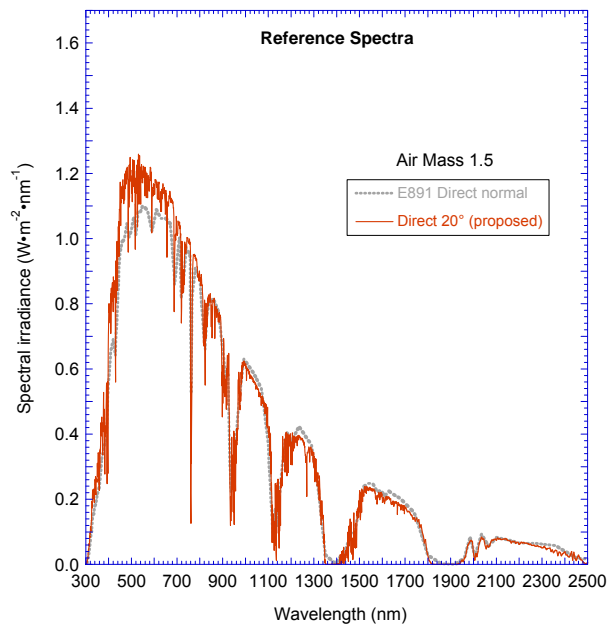


Fig. 7 Direct and global reference spectral irradiance distributions for 20°-tilted surfaces from the proposed ASTM standard compared to the current NFRC distribution, per ASTM E891

Immediately following the ASTM G03.09 meeting, there was also a CIE TC 2-17 meeting. The North American representation to CIE TC 2.17 is modest compared to the European one, but the latter does not attend the North American meetings such as this one, thus creating a difficult situation. Gene Zerlaut tries to convey a CIE TC 2.17 meeting in Europe, but the location and dates are still in a state of flux, due to many timetable conflicts and therefore difficulties in reaching quorum. This state of affair appears to us as a confirmation that the projected “NFRC-friendly spectrum” can be standardized by ASTM much faster than by CIE. Gene hopes to have Chris invited to serve as technical expert in future CIE meetings, but no specifics are known at this point.

Future Work

Tasks 1 and 2 should be completed in time for the next NFRC Meeting on November 5-8, 2007 in Tempe, Arizona. We may ask for an extension for Task 3 to attend the next ASTM G03.09 meeting (January 22, 2008) to finalize the proposed ASTM Standard, assuming that the forthcoming ballot is globally positive and translates into minor revisions only and rapid adoption.