**Reply to Reviewer Comments 2**

Thermal conductivity of molten glass:

Halotechnics will determine the thermal conductivity of the molten glass developed under this program as part of the full thermophysical characterization of leading candidates resulting from screening. We will use our screening workflow to eliminate a large fraction of candidate mixtures, then measure the full properties of a handful of candidates resulting from this process. We will measure the melting point, thermal stability, viscosity, heat of fusion, heat capacity, and density in addition to the thermal conductivity. Plant designers need the full properties of the fluid in order to design an optimal system and calculate the levelized cost of electricity.

Guidance from literature: The thermal conductivity of SiO2-Na2O-CaO glass, a well-studied silica-based glass system, ranges from 0.6 to 0.9 W/m-K over the temperature range of interest (Ref. 1). Other glasses of interest for this proposal are probably within this range given the networked structure common to the molten phase. A mixture of Na2O-P2O5 comparable to E490 described in the Full Proposal and similar to the green glass described in the previous Reply to Reviewer Comments has a thermal conductivity in the solid state (at 120 °C) of approximately 0.4 W/m-K (Ref. 2). These values compare favorably with molten salt, typically 0.4 to 0.5 W/m-K for nitrate mixtures (Ref. 3). Molecular dynamics (MD) calculations can provide good estimates of the thermal conductivity for specific formulations that are identified by the Halotechnics combinatorial approach. The MD method is described by Hayashi (Ref. 4), for example.

1. L. Pilon, et al, “Three-Dimensional Flow and Thermal Structures in Glass Melting Furnaces, Part II: Effect of Batch and Bubbles,” *Glass Science and Technology*, Vol. 75, No.3, pp. 115-124, 2006.
2. O. V. Mazurin, et al, *Properties of Glasses and Glass Forming Compounds* (translated from Russian), Vol. 2, p. 420, 1975.
3. N. P. Siegel, et al, “Thermophysical property measurement of nitrate salt heat transfer fluids,” ES2011-54058, proc. ASME 5th International Conference on Energy Sustainability, Washington, D.C., 2011.
4. M. Hayashi, et al, “Effect of ionicity of nonbridging oxygen ions on thermal conductivity of molten alkali silicates,” *Phys. Chem. Glasses*, Vol. 42, No. 1, pp. 6-11, 2001.

Experimental capabilities: Halotechnics works with specialized analytical laboratories to experimentally measure the thermal conductivity of novel materials. Thermal conductivity is difficult to measure experimentally since radiative effects often affect the measured heat transfer, especially with clear fluids. We will leverage our partner’s capabilities to measure the thermal conductivity of the molten glass developed under this program. We have worked with Linseis Inc., a leading supplier of thermal analytical equipment, to obtain thermal conductivity data of our molten salt materials. The measurement of molten glass will follow similar procedures. Linseis uses its laser flash analyzer to measure the thermal diffusivity of materials from room temperature up to 1600 °C. One can calculate the thermal conductivity by also measuring the density and heat capacity of the material. See Figure 1 for a photo of a laser flash device and the relationship between thermal conductivity and thermal diffusivity.

Effect on heat transfer: In general, a high thermal conductivity improves heat transfer rates. Therefore thermal conductivity is an important parameter for calculating heat flow coefficients. This is especially true for laminar flow of viscous fluids. However at higher flow rates and lower viscosity, turbulence increases and the effect of thermal conductivity on heat transfer is reduced.



**Figure 1: (a) Laser flash analyzer. (b) Thermal conductivity relationship to other physical properties.**