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OFF-PLANET SYSTEMS
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A NOVEL METHOD OF HEAT REJECTION AND STORAGE USING LASER VMX PROCESS ON LUNAR REGOLITH

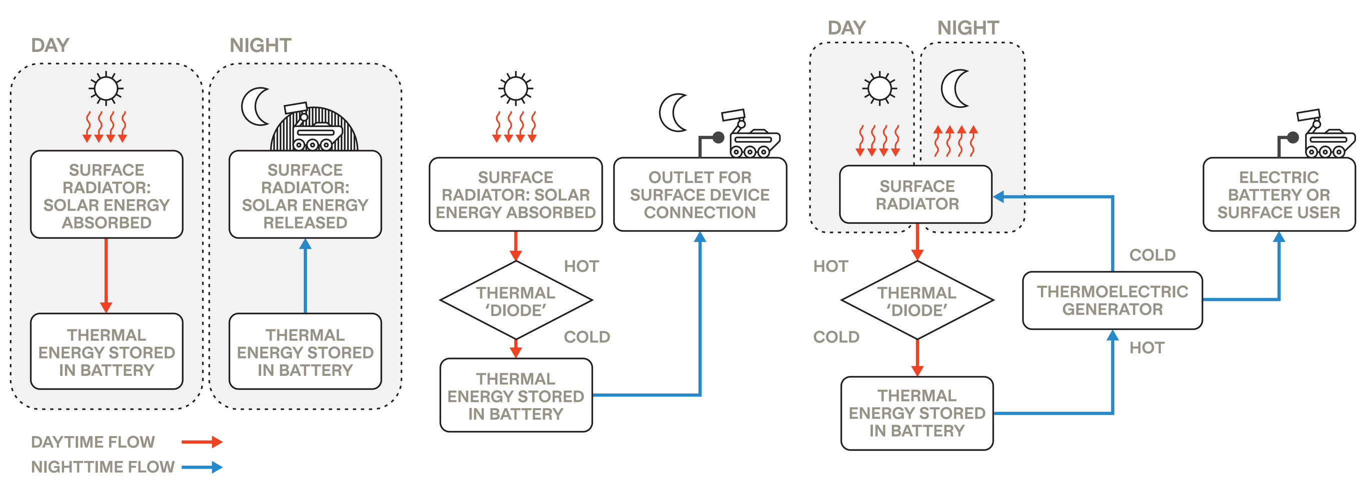
One of the most promising applications of lunar regolith for energy storage is through the creation of regolith-based thermal batteries. These batteries could store energy from intermittent sources like solar power or be directly charged using in-situ resources such as solar panels. By converting regolith into a usable form, such as ICON's laser VMX (Vitreous Multi-Material Transformation), energy could be stored efficiently, providing a reliable power source even during lunar nights when solar power is unavailable. VMX is a lunar regolith product of ICON's process of using a robotic-arm enabled high-powered laser end effector to provide successive heating and controlled cooling to produce a very strong, concrete-like, material that can be used for additive construction.

Using ICON's Laser VMX process to transform the lunar regolith into material that can be used as a thermal battery presents a promising avenue for sustainable energy storage on the Moon. By harnessing the regolith's inherent ability to retain heat, we can effectively store excess thermal energy generated during the lunar day and release it during the frigid lunar night.

This innovative approach to energy storage not only maximizes the utilization of available resources on the Moon but also paves the way for sustainable energy solutions in space and could prove to be an efficient way to maintain a stable source of energy for future lunar habitats and missions.

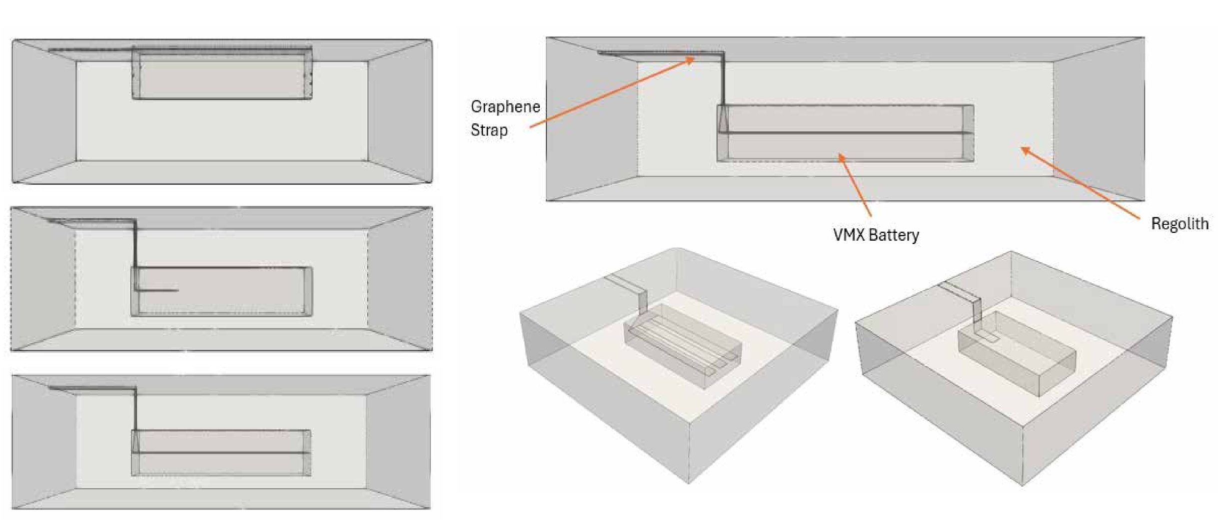
ICON has developed a concept based on real work with Laser VMX and has performed analysis showing the proposed system is a viable solution for storing thermal energy collected during the lunar day for use during the lunar night to protect surface equipment.

A



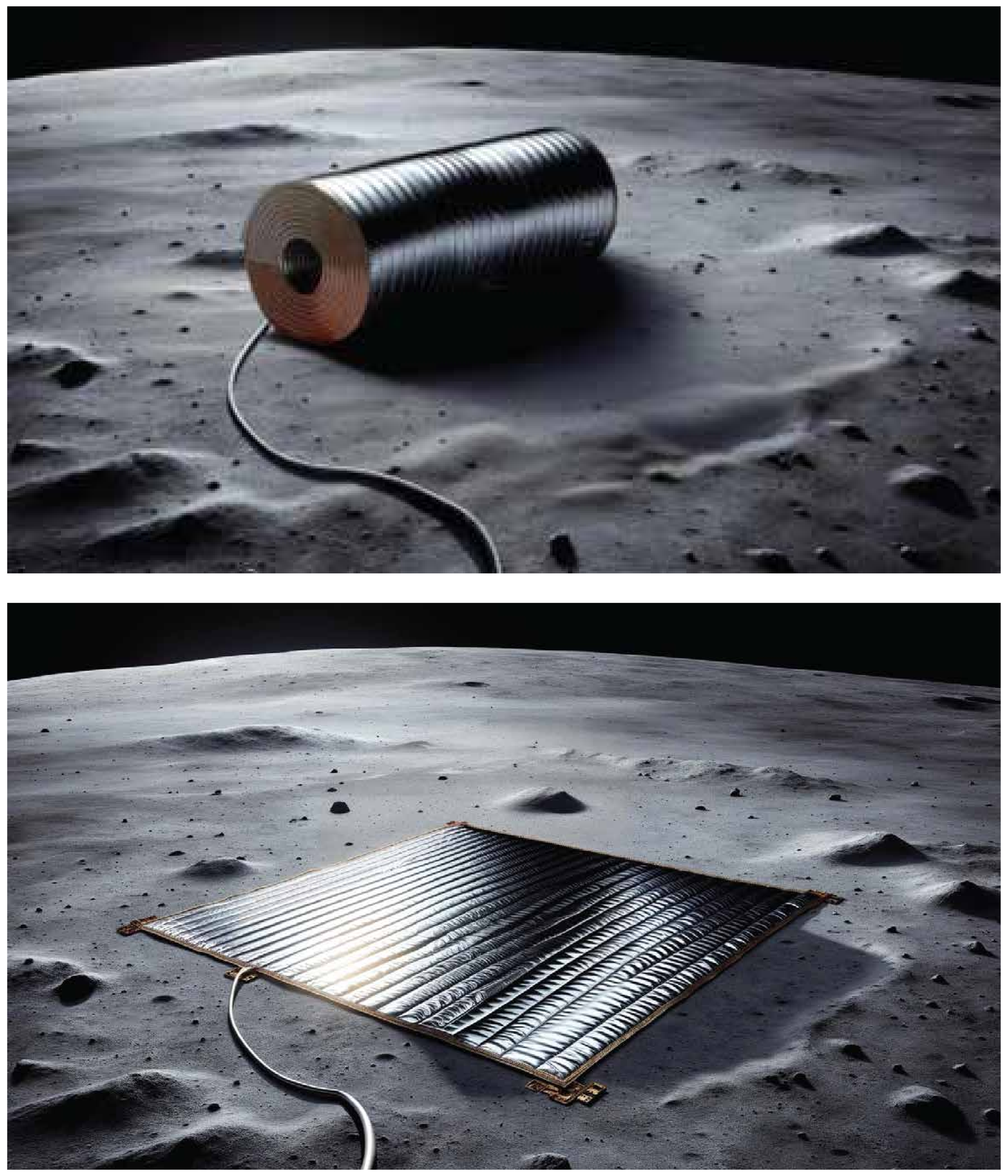
Thermal Battery system diagram illustrating an example configuration that could be used to generate electric power via the use of thermoelectric (Peltier) devices in the path from the battery to a dark sky facing radiator.

B



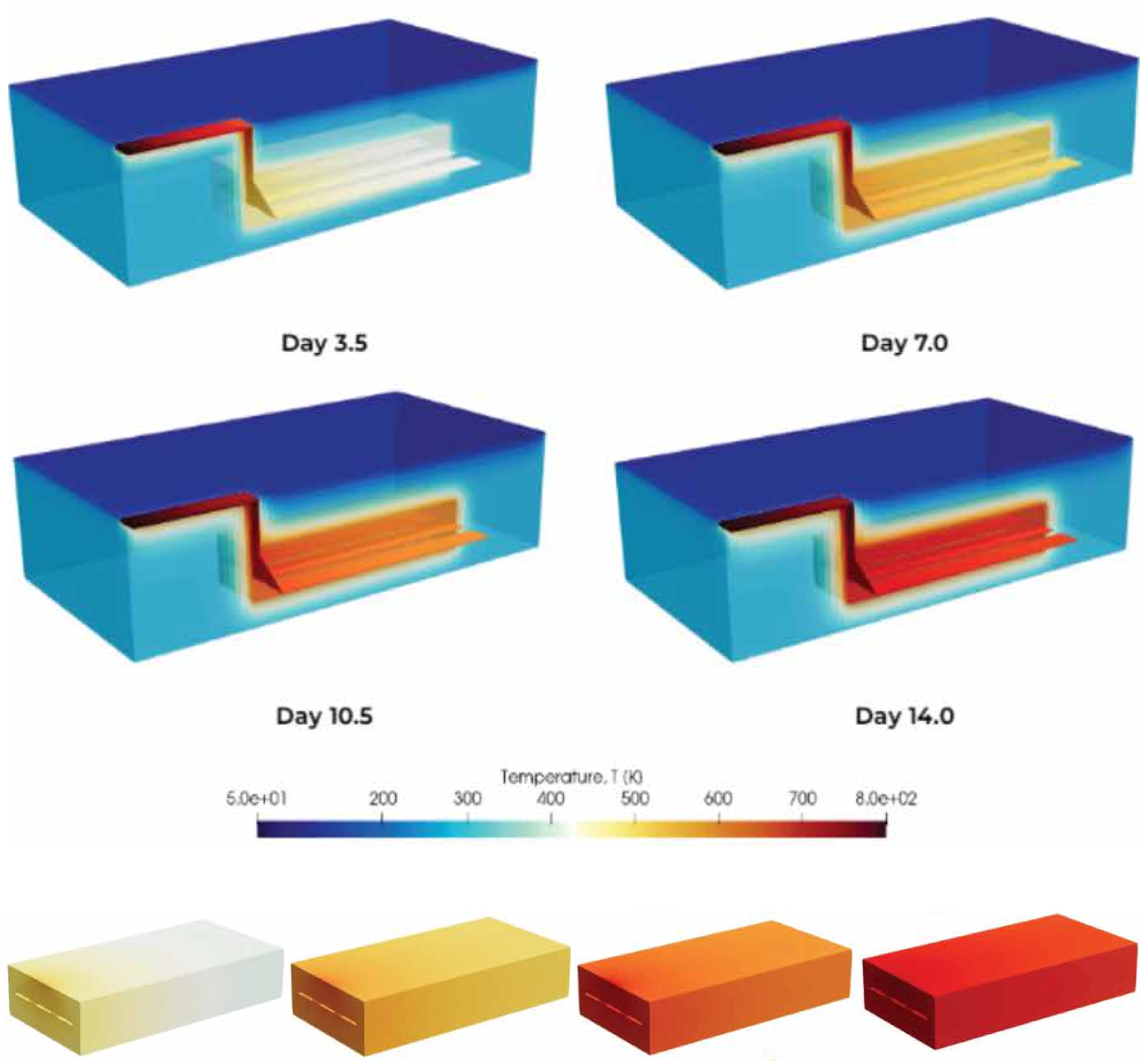
System configuration for proposed conductive battery. Graphene was chosen for this analysis as it has very high thermal conductivity and has been used in space flight applications in the form of thermal straps. The graphene strap to the left in the image above provides a "connector" for any device that needs to dump thermal energy. The thermal straps are placed and incorporated into the VMX melt to form a robust conductive interface. There are two variants shown here, on the bottom left is preferred and uses an array of thermal conductor "tendrils" embedded in the VMX battery to enhance bulk thermal conductivity. Bottom right of the image illustrates the device without the added tendrils.

C



Artistic depiction of deployable thermal blanket in both shipped and deployed configurations.

D



Graphical representation of simulation results for graphene tendrils configuration under constant 800 K input temperature condition. Color contour plot shown of surface temperatures; physical body is section cut.

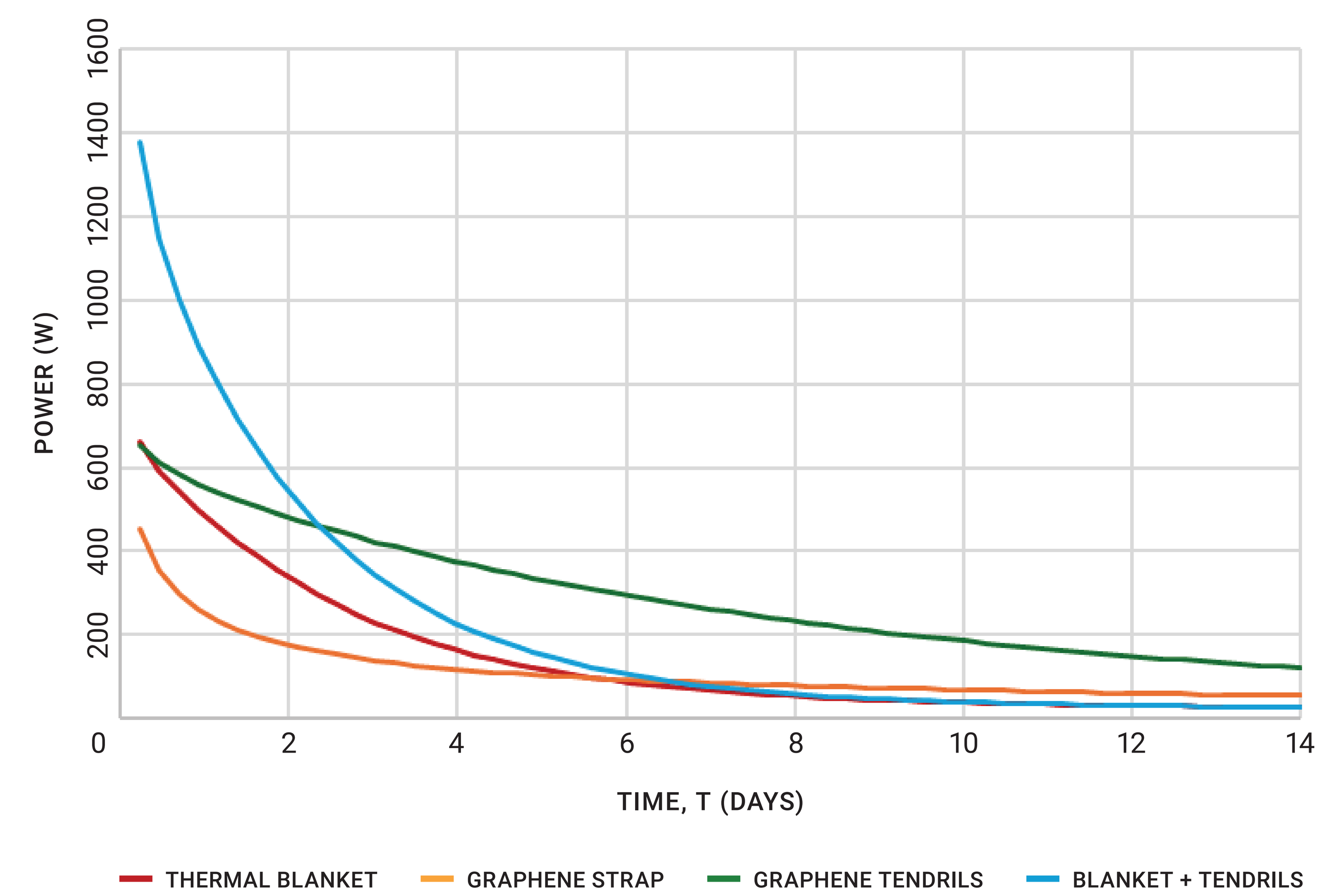
E

TABLE 1: SIMULATION RESULTS COMPARISONS FOR BATTERY CONFIGURATIONS WITH 800 K INPUT				
	Thermal Blanket	Graphene Strap	Blanket + Tendril	Graphene Tendril
Input Energy [kWt-hr]	48.0	38.0	74.4	99.1
Energy Stored [kWt-hr]	36.7	27.0	37.2	30.6

TABLE 2: SIMULATION RESULTS COMPARISONS FOR BATTERY CONFIGURATIONS WITH 200 W INPUT				
	Thermal Blanket	Graphene Strap	Blanket + Tendril	Graphene Tendril
Input Energy [kWt-hr]	67.2	67.6	67.2	67.2
Energy Stored [kWt-hr]	50.7	47.9	31.6	20.0

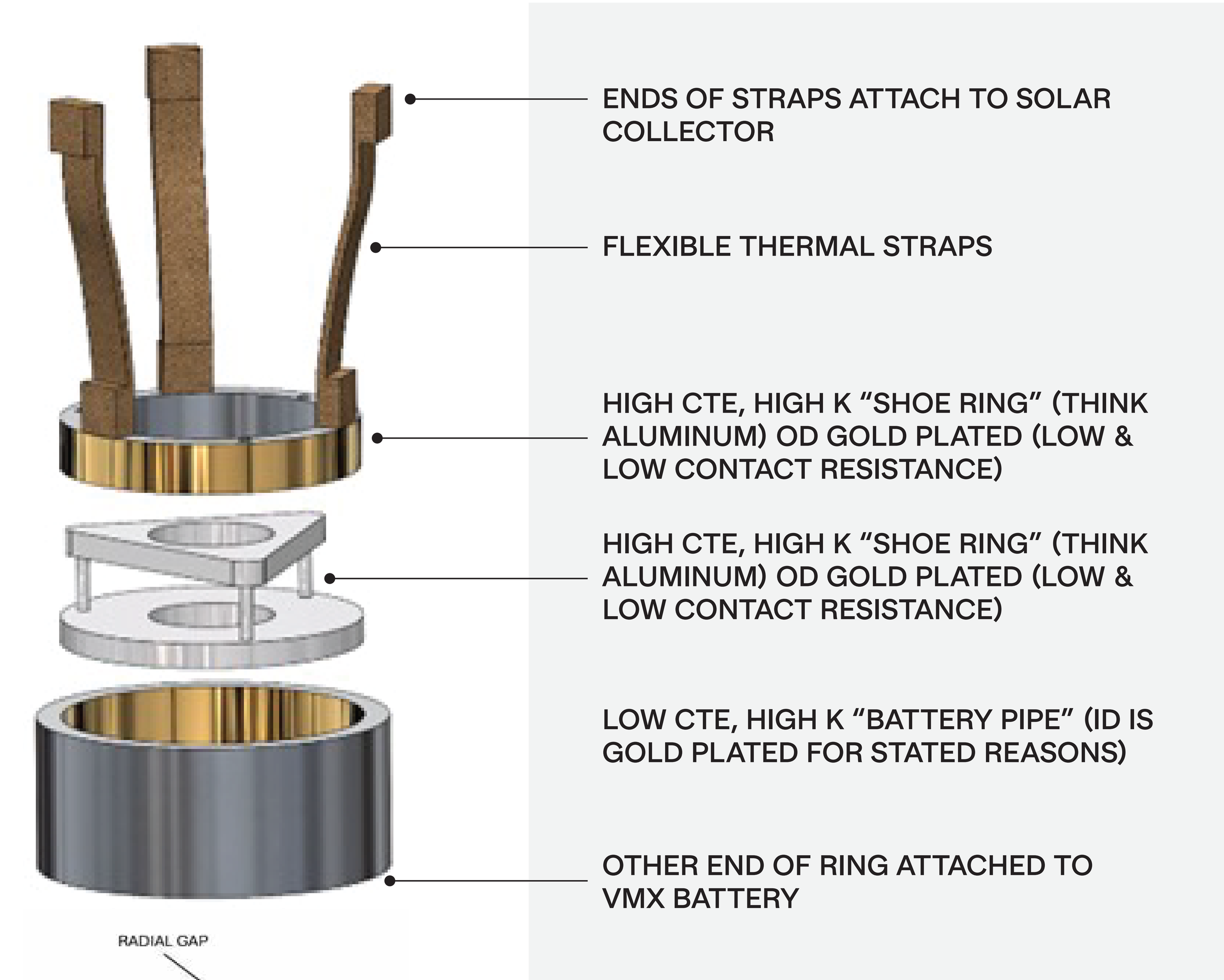
Simulation results comparisons for battery configurations with 800 K input

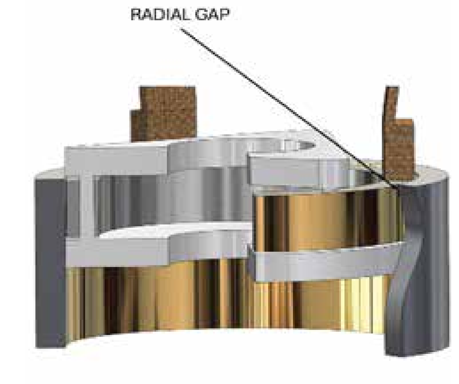
F



Plot of power input versus time for constant temperature cases as measured/calculated at probed locations along thermal conduit leading to blanket/strap/tendrils. Power is Watts-thermal, Wt.

G





Graphic representation of design for thermal diode concept.

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