



Solaris: A unisex solar-powered jacket for the day hiker

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Keywords: Smart apparel, solar energy, digital printing, aesthetics

Contextual Review and Concept. The power source of portable consumer electronics are typically designed with a limited life-span; however, integration of flexible solar cells into apparel can provide off-grid renewable power for such devices. Solar-powered garments are potentially useful to a range of individuals from the recreational outdoor market to those in the safety industry. Flexible solar panels have been successfully integrated into fashion accessories such as backpacks and hats. However, only a few solar-powered apparel products exist in the marketplace today, due to challenges of apparel manufacturing and sizing (Roston & Bhasin, 2016). Design research is needed not only on the functional integration of flexible solar cells in a garment, but also on how to integrate them into apparel in a manner consistent with consumer's expressive and aesthetic needs (Hwang, Chung, & Sanders, 2016; Sanders et al. 2012). The purpose of this project was to design a mass-producible solar-powered garment that would meet consumers' functional, aesthetic and expressive needs.

Aesthetic Properties, Visual Impact, and Process. A team of apparel designers and engineers used the FEA model and apparel design framework (Lamb & Kallal, 1992), guiding a rigorous design process. The target consumer group, defined as both female and male college-student day hikers, need a continual power source. The solar-powered garment needs of this group were identified through focus group interviews and sample garment analysis. Based on the focus group findings, a list of functional, expressive, and aesthetic design criteria were established to create a gender-neutral jacket. The most important *functional* design criteria for this solar-powered jacket was the minimum energy output requirement to power a cell phone. Another key functional design criteria was the integration of appropriate electronic components (wires, etc.) to transport solar power from the solar panels to the device. Once energy output level was established at 4.6 Watts, the number and size of panels, as well as related electronic equipment needed to achieve this energy output were determined. Additional electronics-related functional design criteria established were: (a) wearer safety (e.g. will not overheat/ electric shocks etc.), (b) electronic components not impeding the movement of user, (c) jacket washability, (d) ease of accessibility of the power source and electronic component for the user and washing of the garment. Other functional user needs included: (a) wearer protection from cold wind (warmth) and (b) storage for the user's items, as interviews indicated most day hikers only bring a few things in their pockets, as opposed to wearing a backpack. The most important *expressive* need identified was visual adaptability. Users wanted to hide the solar panels and have it look like a "normal" jacket, when not harvesting energy. *Aesthetic* needs were: (a) unisex design and (b) colors and style elements reflecting current fashion trends, thus the importance of both expressive and aesthetic properties in adoption.

Techniques and Execution. Flexible solar panels were sourced and tested for durability and user comfort in the form of garment component prototypes. The results of machine-washing the solar panels attached to a jacket resulted in a pleasant aesthetic appearance, as well as no reduction in

ability to collect solar power. From these results, it was determined that the solar panels did not have to be removable. Developing and evaluating these prototypes determined appropriate stitch selections, material handling requirements (e.g. washability), compatibility of shell and interior fabrics, and construction sequencing. A sewing technique was developed for permanently attaching the solar panels without diminishing their energy harvesting capability. Sketches were developed to illustrate solar panel placements that would meet energy harvesting requirements concurrently with users' functional, expressive, and aesthetic needs. A circuit plan was developed to attach the solar panels to other required electrical components inside the garment. Two boxes were 3D printed to house electrical components, which were equally divided in weight and carried in internal pockets between the jacket shell and lining. To meet the functional criteria of warmth, secure closures and adjustable button cuffs were designed to keep the wind out. Multiple pocket types were designed to meet functional storage needs. Side zippers were added to both give the wearer ventilation as well as making the jacket flat so that solar energy can be harvested during breaks. A flap was designed to hide a section of the back solar panels when not in use (e.g. indoor environment).

To meet expressive and aesthetic needs, a custom digital textile print was created to visually integrate the solar panels into the jacket. Solar panels were scanned into Adobe Photoshop and modified by applying filters and adding additional fashion colors to certain areas. Jacket patterns were created in Optitex PDS and imported to Adobe Photoshop for engineering the textile designs onto the pattern pieces. The combined engineered textile prints and garment pattern pieces were then digitally printed on a medium weight 100% cotton twill fabric. The printed pieces were cut and sewn together with the solar panels. Electrical connections were soldered. The lining was sewn to the shell, hiding the wiring. Multiple zippers and snaps were incorporated throughout the design for user access to plug in portable electronic devices, as well as for future access to internal electrical connections, if needed.

Cohesion, Design Contribution, and Innovation. The FEA framework (Lamb & Kallal) was useful in guiding design processes, techniques, and execution to form a cohesive final product integrating the functional electrical component requirements of solar-energy harvesting along with consumers' functional, expressive, and aesthetic needs. In the consumer market, smart apparel must remain visually attractive and enhance the wearer's appearance; to be commercially successful. We successfully integrated flexible solar cells into an aesthetically-pleasing and functional jacket, and generated energy to power electronic devices.

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