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What is This?
Undesigned: A Study in Sustainable Design of Apparel Using Post-Consumer Recycled Clothing

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Abstract
This article provides a summary of a study exploring sustainable apparel design methods incorporating the use of post-consumer recycled clothing and materials in the design of new products. The name undesigned was assigned to the garment line that was developed for consumers defined as urban nomads. The key concept for this undertaking is described in the term undesigned and was intended to emphasize the quality of the garments as deconstructed and reconstructed or undesigned and redesigned objects with a prior history, as opposed to conventionally designed and produced clothing. Used clothing, available for purchase by the bale through rag dealers, is an abundant source of raw material. Recent trends show that there is a growing market for post-consumer recycled clothing. The collection designed in 1999 for this study focused on the clothing design needs of urban nomads, a demographic consisting of people living in urban areas who commute using ecologically sensitive public and human-powered modes of transportation. In this study designs that fill the functional clothing needs of this population were created based on sustainable processes. A general audience’s sensitivity to and acceptance of the ecological benefits of a clothing production system defined within sustainability parameters were evaluated in response to these designs.


That which we throw away, we fail to value. When we design and plan things to be discarded, we exercise insufficient care in designing...
Victor Papanek, Design for the Real World (1971, p.74)

Process and Project Organization
The goal of this project was to develop a system of urban nomadic women’s apparel produced from post-consumer recycled (PCR) clothing and PCR textiles. The garment designs were grounded in a framework of sustainable ecological principles and produced using methods developed to accommodate the unique process of working with PCR clothing. The central idea for this undertaking centered around the term undesigned, a word chosen to emphasize the quality of the garments as deconstructed and reconstructed or undesigned and redesigned objects with a prior history, as opposed to conventionally designed and produced clothing. This undesigned line of clothing targeted the needs of urban nomads—young professionals living in urban areas who commute using ecologically sensitive public and human-powered modes of transportation. Multiple sets of an urban nomadic clothing system in a range of sizes with explanatory labels and hangtags were exhibited in an interactive installation. The project was divided into four phases: Design, Production, Exhibition and Evaluation. The designs were evaluated by a general audience via questionnaire and silent bidding. Feedback collected from the exhibition was then used to evaluate the project in terms of personal, environmental, and economic value. Offering the garments for sale in a retail environment further tested the acceptability and viability of the concept.

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Background

This apparel design project is grounded in the broader context of the sustainable design movement that has emerged in the last decade. At the core of the sustainable design movement is the need to completely rethink how we design, what we produce, how we use materials and resources, and what processes we choose to implement in a way that is equally beneficial to the environment and its inhabitants. William McDonough, architect and leader in the sustainable design movement, advocates the closed-loop concept “waste equals food.” This phrase defines a concept in which objects that are ordinarily discarded as useless may instead be recreated into something useful (McDonough & Braungart, 1998). An example of “waste equals food” sustainability of resources found in nature is the closed-loop oxygen-carbon dioxide cycle used by animals and plants. This biological model is offered as a metaphor that can be applied to the problem of human-created waste, such as discarded clothing. According to McDonough “one of the most difficult questions for anyone designing something today is ‘What is an ecologically sound material?’” (McDonough & Braungart, 2001). For the apparel designer, one possible answer is post-consumer recycled (PCR) clothing.

Currently the US is experiencing a clothing glut due to the “planned obsolescence” inherent in the apparel industry and the widespread availability of inexpensive clothing (Kilborn, 1999; Packer, 2002). The production of excess clothing depletes natural resources, contributes to overflowing landfills and often relies on the exploitation of human labor. Export of PCR clothing can also disrupt textile and clothing industries in developing countries by glutting local markets with cheap clothing (Hansen, 1994; Packer, 2002). As an alternative, using PCR clothing as raw material for new garments allows us to redirect excess post-consumer textiles that would otherwise enter the waste stream by harnessing this “waste” as a raw material for the design of environmentally and socially conscious apparel—-a clear application of McDonough’s “waste equals food” model.

Current media coverage shows that there is a viable market for clothing created from PCR textile materials; designers and fashion lines such as Miguel Adrover, Ggrippo for trash-a-porter, Koi, ynnub, and VICC, are being praised for their innovative reconfigurations of Burberry coats, mattresses, t-shirts, jeans, and suits (Heimstra, 2001; Limnander, 2000; Yabroff, 2001). If these current trends that favor recycling and reuse of post-consumer recycled clothing continue, they will create an even more viable market for deconstructed ready-to-wear (R-T-W) garments. The goal of this project is to explore the design potential of PCR.

Target Market: The urban nomad. An urban nomad can be defined as a person who lives in an urban center, relies on mass transit and human-powered transportation for mobility, is highly mobile on a daily basis, does not return home between work and social activities, and carries items needed for smooth transition from day to night.

High concentrations of people in urban settings with medium to high incomes both generate much clothing “waste” in the form of second hand clothing and also provide a viable market for innovative uses of this material. These populations have particular clothing needs based on their use of mass- and human-powered transportation instead of personal automobiles, a choice determined by both practicality and in some cases sensitivity to ecological benefits of these transportation choices. The phrase urban nomads was chosen for this study to identify this group of people as a unique demographic. Urban nomads who use less polluting modes of transportation need clothing with aesthetic properties suitable for an urban environment paired with the functional properties of active wear. Garments capable of multiple functions and style changes should last longer in the average wardrobe while accommodating the mobile urban lifestyle and providing comfortable clothes for a variety of conditions. The clothing designed for this study was also designed to fill both the functional clothing needs of this specific demographic and to explore its sensitivity and acceptance of the ecological benefits of a clothing production system based on sustainable design.

Some consideration was given to designing a unisex line of clothing, but in the end the decision was made to design this initial clothing system for a female end user.

Design Process

Problem definition. The research and problem identification stage of the design process began with a focus group meeting of six females and four males, ages 19-30, who had lived in an urban setting within the last five years. The participants were recruited using flyers and word of mouth. The focus group participants discussed definitions of urban nomads, their clothing needs and concerns, and their opinions about second-hand clothing. Individual definitions of urban nomad varied among the participants; however, there was general agreement on the definition provided in the section above. The group discussed various situations, climates and environments that urban nomads face on a daily basis. Subway travel was identified as the most problematic, especially during extreme weather conditions. Generally, subways are crowded during rush hour and are often a different temperature from the outside environment. Artificial environments, such as air-conditioned or heated offices, stores and restaurants, also create extreme temperature variations.

Though the conditions faced by a bicycle rider and subway rider, for example, seem on the surface to be very different, all urban modes of travel have much in common; extremes of temperature, necessity of carrying many items, moderate to extreme physical activity and the need to be visible at night. The group made several suggestions for better designs: 1) clothes with many easily accessible pockets, 2) clothes that work from day to night since they seldom go home to change, 3) use of stretch fabrics or designs with built-in movement for increased mobility, 4) less bulkiness and weight in general, 5) lightweight, thin clothing layers that “slide” and have less friction between layers, and 6) jackets that are easy to remove and store.
The second half of the discussion revolved around general attitudes and stigmas associated with used or second-hand clothing. Of the ten participants, two refused to wear or purchase used clothing. Reasons varied from “questionable hygiene” and “aversion to hand-me-downs” to social stigmas due to purely psychological reluctance.

Based on this discussion, project goals were established. General project goals were to develop a viable method to use PCR clothing in new designs, to incorporate functionalities important to the urban nomad, and to preserve and communicate through labels and hangtags the history and meaning of the original garments.

**Ideation: Design approaches.** The design process for the prototype garments began by seeking out which PCR garments were readily available at the Salvation Army in Ithaca, New York. An abundance of jeans, T-shirts, sweatshirts, button-down collar shirts, sweaters and men’s suits were found. Through Internet research it was found that it is feasible to acquire garments of these types by the bale through rag dealers, which would lower the cost of these materials (http://www.cannamm.net, http://www.stuartrags.com).

The inherent qualities of denim jeans are sturdiness, easy care, patina-like aging and soft flexibility. Denim from used jeans will not shrink as they are already well laundered. The twill-weave contributes to wind-resistance and abrasion resistance. Original features such as flat-felled seams, pockets and closures can be retained to take advantage of their existing function as well as add character.

Men’s suiting provides a formal, conservative style, quality fabric, classic construction details, and useable fabric amounts due to consistency of garment shapes and generally large sizes. Existing features such as the notched collar, internal and external pockets, and original closures can be reinterpreted in new designs.

T-shirts and sweatshirts are typically constant in form and size and mainly vary only in the location of logo or decoration. Because of this uniformity, they lend themselves to a myriad of transformations. The fabric is comfortable, stretchable, and easy to care for.

Wool sweaters, also commonly uniform in shape, were chosen for their warmth, texture, comfort, and color. At a seminar B. Tatarka (Personal Communication, September 14, 1999) showed samples of wool coats she had made of felted wool PCR sweaters. Wool sweaters are often discarded because of their worn out look due to moth holes, snags and pilling. The felting process Tatarka had applied to the sweaters minimized flaws while adding thickness and texture to the fabric.

In addition to functional qualities and style, the color, material, form, technological compatibility, material opportunism, labor saving convenience, perceived need and simple visual appeal of the designs were important factors in the
prototype design process. To design with PCR garments the material was used as one would use an animal hide or a fabric produced on a narrow loom; the shape and amount of material from the PCR garments influence the shape of the newly designed garment (Burnham, 1973).

**Implementation.** The next step was to decide which recycled garments would lend themselves as raw materials for urban nomadic clothing. Five garment types, 1) denim jeans, 2) men’s suiting, 3) T-shirts, 4) sweatshirts and 5) wool sweaters, were chosen because they possess qualities appropriate to successful deconstruction and reuse.

In addition to PCR clothing, new fabrics made from PCR materials were chosen. Eco Fleece® and Eco Wool® made by Dyersburg Mills with Wellman’s Ecospun® fibers (made from post-consumer recycled plastic containers) were chosen for their lightweight yet insulating quality. Other materials were needed to provide functional qualities that could not be readily acquired from PCR textile materials. Water-resistant lightweight rip-stop nylon, separating zippers, reflective piping, and metal D-rings were sourced. Choices were made based on functional characteristics as well as quality.

The prototype design process began by deconstructing some basic garments and draping them on the dress form to find the best use of existing features and material. Simple garments such as a T-shirt could be cut and used much like a narrow width fabric; more complex garments such as a suit jacket required extensive manipulation on the dress form.

The Reverse Denim Raincoat (Plate XV), the Reverse Denim Raintrench, and the Denim Wave Skirt (Figure 1) are the three styles derived from denim jeans. The Reverse Denim Raincoat and Raintrench were made from leg portions of men’s denim jeans, water-resistant nylon, reflective piping, and metal D-rings. The nylon side of these reversible styles provides water resistance for protection in light rain, a center back pleat for mobility, reflective piping for nighttime visibility, and princess-seam zipper vents for torso ventilation. The Denim Wave Skirt was developed using an entire pair of women’s jeans with the original waist and pocket features.

Men’s suiting was transformed into the Pod Skirt (Figure 2), Backpack Vest (Figure 3), and Reverse Reflect Vest (Figure 4). Suit trousers were used to make the Pod Skirt using the original waistband. An adjustable back bustle allows for style flexibility as well as walking mobility. The Backpack Vest was made from a suit jacket. This style incorporates padding for increased wearer comfort in areas where a backpack rests on the body. The Backpack Vest also has hidden pockets for convenient storage of small items and an adjustable buckle closure. The Reverse Reflect Vest
was also derived from a man’s suit jacket. The original lining with additional reflective materials can be worn to the outside at night for visibility, while the suiting side could be worn for a more formal office look.

T-shirts were cut apart and treated as a narrow width of fabric. Initial designs were developed using a combination of flat patternmaking and draping. The Bubble Elbow Shirt was made out of one T-shirt with the ECO Wool and Fleece® (Plate XVI). The Bubble Elbow Shirt features an action elbow for movement, a thumbhole for warmth and hand protection while cycling, and lightweight for ease of wearing under a jacket or coat.

The felted wool sweaters were also cut apart and used as a narrow width of fabric. The end results were two torso warming hooded garment variations, the Decon Hoodie Cardigan (Figure 5) and Decon Hoodie Pullover. Each style was made from a collage of sweaters, sweatshirts and ECO Wool and Fleece.

**Evaluation.** Constant evaluation of style and function are an essential part of the design process. After the initial designs were created they were wear-tested by nomadic student subjects to assess style, fit, and function. Garments were tested daily for a period of one week and worn while walking through campus, travelling by bus, and riding bicycles. Wear-test subjects maintained a “garment diary” that included sections on environmental conditions, comfort, function, and general acceptability. Subjects were also interviewed about the fit and style of the garments. Wear testers’ comments and responses were incorporated in the redesign of several of the garments. This redesign process continued throughout the production phase as interactions among the graded ready-to-wear pattern shapes, the limitations of the PCR garments, and the desired style and functional features of the designs were resolved.

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**Production Processes and Issues**

The next step in the process was to resolve the production issues inherent in creating this line of garments using sustainable design methods. Issues related to patternmaking, material preparation, and garment construction were addressed. Labels and hangtags were also designed to communicate issues related to the intrinsic value of the collection.

**Computer-aided pattern making and grading.** Patterns from the prototype designs were digitized into the computer using Lectra Modaris software and graded into a range of sizes from 28 to 42 (bust measurement) and 34 to 44 (hip measurement) using standard X-Y grading methods. Difficulties arose from the irregular pattern shapes due to shapes of the fabric pieces from the used clothing (Figure 6). Pattern changes needed to be made to allow the full range of sizes to be cut. The changes allowed for the use of key elements from existing features of the PCR clothing, such as pockets for the Backpack Vests and the jean fly for the Denim Wave Skirts. This resulted in slight variations in the design.

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**Textile preparation.** Preparing PCR clothing as raw material requires disassembly and cleaning prior to use by the end users. Jeans, T-shirts and sweatshirts were the easiest garments to process. They were simply washed with detergent in hot water and tumble-dried at a high heat. Cleaning the suiting was more difficult. Rather than wash before production, suiting was first deconstructed, then reconstructed into the new garment and finally dry-cleaned. Finished reconstructed garments could be either dry-cleaned or...
carefully hand washed in cold water. The felting of PCR sweaters was the most time-consuming textile preparation process. Felting the wool sweaters required a minimum of two hot water machine washes with detergent (Synthrapol) and tumble drying with high heat. Felting occurred best when 1) the washing machine was packed 2) a pair of jeans was added to the wash and 3) felted sweaters were ironed on high heat with steady pressure and steam. When color purity is desired it is necessary to wash contrasting colors separately since the different colored fibers intermingle if washed together.

**Garment construction.** A hybrid method of cutting and assembling the garments was developed. Each garment was individually cut by hand and then all garment pieces were bundled to be sewn in an assembly line fashion. This hybrid method of production, hand cutting with assembly line sewing, combined individual treatment when necessary with partial industrial application.

**Labels and hangtags.** Labels were designed to provide information about wash and care, and also to communicate the garment’s reconstruction history (Figure 7). Each label showed a prototypical image of an original PCR garment. For example, pictures were chosen of a pair of used jeans for denim items, wool sweaters for felted wool items, and a suit jacket for garments made from suiting. The original item dictated the care instructions, but the labels advised hanging to dry when possible to conserve energy.

**Figure 7.**

Hangtags were designed as fabric bookmarks to live on past their life as opposed to disposable hangtags (Plate XIV). These bookmarks had images of the appropriate reconstructed garment with the style name (i.e. Pod Skirt) and style code -size numbers (i.e. “This is SK2-36”). Material information was presented in the form of prior garment history (i.e. “In her former life she was...”) that would clue the purchaser in to the past history in the garment’s life.

**Exhibition and Project Evaluation**

**Exhibition.** The clothing collection was displayed in a gallery space on campus; however, a retail store format was used to encourage people to interact with the clothing as if they were shopping for clothing instead of just viewing the garments. The concept for the exhibit was a prototypical Undesigned store; the store name was chosen to emphasize the quality of the garments as re-made urban nomadic objects with a prior history instead of typically designed and produced clothing. Customer interaction with the clothing and communication of the design concepts were crucial elements that drove the “store” layout. Posters were designed to describe the ecological concept and the ‘history’ of the PCR clothing. “Customers” were able to try on garments, to make silent bids and respond to the designs by filling out questionnaires over the course of a two-week period. A total of 34 questionnaire responses and 31 silent bids were collected for evaluation. The questionnaire’s topics covered garment appeal, function and market value, response to the overall ecological concepts, and social acceptance of second-hand clothing.

Although the gallery presentation did not take place in an urban environment many of the residents of Ithaca and the members of the College where it took place are originally from urban areas or have participated in internships or study abroad in urban areas. Because of highly restricted parking on campus most students do not use cars for transportation.

**Evaluation.** Focus group responses, garment diaries and exhibit questionnaire data were evaluated for personal, environmental, and economic value. The data from the urban nomad focus group and the garment diaries were analyzed using content analysis, and the exhibit questionnaires using descriptive statistics. The results were as follows:

**Personal value.** An understanding of the personal values of the respondents was sought throughout the project. Questions were asked about the: 1) acceptance of second-hand clothing for use in creating new clothing, 2) response to the functional value of the designs for urban nomadic wear, and 3) reactions to the value of the clothing’s built-in histories expressed through the informational hangtags and labels. In addition, the concept of added value through history was explored further by asking for responses to the concept of clothing made from the second-hand clothing of people known to the wearer, for example their grandfather’s suit, or a set of sweaters from close friends.

Respondents found the garments appealing, valued the design, uniqueness, environmental principles and functionality of each garment. They found the labels and hangtags informative and valued the added information about garments’ histories. In addition, it was found that the deconstruction and reconstruction of second-hand clothing into new garments made the wear of second-hand clothing more socially acceptable; eleven of the thirty-four exhibit respondents claimed they do not wear second-hand clothing yet found the study garments wearable and appealing. Twenty-four of the exhibit respondents said they would value the garments more if they were made from clothing of friends and family, suggesting a potential market for custom as well as mass production. However, it was clear from reactions to the garments that good design is a crucial first step for the environmental principles to be understood and accepted. Once the design is accepted by the wearer/consumer/audience, then the value through personal identification with the concepts may take place; the concepts cannot stand alone without good design. Good design is seamlessly incorporated in modern life, and addresses all of its intrinsic and extrinsic needs. Ultimately, the power of the environmental concepts is that they can strengthen the value of the accepted design.
Environmental value. The project was evaluated for environmental value to determine whether the use of post-consumer clothing as raw material is a viable option that has the potential to reduce the amount of post-consumer textile products entering the waste stream and the amount of new resources needed to make new apparel.

The use of PCR clothing as a base material was successful on some levels and problematic on others. During the deconstruction of the second-hand garments about 20% of the material became scrap not used for the selected designs. Other methods of fiber recycling implemented in a commercial setting could make some of this “waste” useful. Garments designed from the PCR clothing took advantage of original garment details, such as pockets and closures, reusing these features and saving construction time and energy. According to Ecospun’s informational hang tag, “via recycling, Wellman is able to keep 2.4 billion plastic containers out of landfills annually... Recycling has the potential to save 650,000 barrels of oil and eliminate 375,000 tons of harmful air emissions.” The use of these PCR materials satisfied functional garment needs and contributed to the overall ecological concept of “waste equals food” as applied to an industrial product.

Satisfying the needs of urban nomads such as durability, protection, and thermal comfort required compromises in material choice. New materials, such as the rip-stop water resistant nylon, were chosen for their functional rather than environmental characteristics. Choices for new closures, such as invisible zippers and plastic buckles, were made to maintain quality control and to address specific functional design and aesthetic purposes. The reflective piping for the jackets was used for its visibility function. Collaboration and compromise are necessary steps in the process of developing sustainable clothing design. Although the method is not yet perfected and waste is still generated, the choice of materials addresses some of the issues of post-consumer waste while satisfying functional and aesthetic apparel needs.

Economic value. According to McDonough, “commerce is the engine for change (McDonough & Braungart, 1998).” Economically feasible design and production methods for harnessing discarded clothing as a raw material were explored since economic sustainability is crucial for implementing social and environmental changes. The concept of custom production was explored, as well as mass production. In terms of economic viability, design for production efficiency is necessary to make the use of PCR clothing economically feasible. The design, patternmaking, and production processes developed for this project used some mass production techniques, but required additional labor as compared to the average mass-market item. Therefore it is doubtful that the average consumer would place a high enough value on the environmental concepts to purchase these reconstructed items that had to be higher priced than the average garment. Additional application of mass production methods would reduce price, however. Nonetheless, garments with higher price points would have to be marketed to consumers with higher incomes. The appeal of these garments depends on social and aesthetic views of the consumer, as well as the purchasing criteria required by the consumer (product quality, content, aesthetics, individuality and function). The garments produced in this project therefore target a niche market with a higher-priced product (Kotler, 1997, p.396). The complete inversion of devalued “second-hand clothing” to revalued and highly valued new garment must occur in order for the product to be successful.

Implications of the Study

To take full advantage of the potential for PCR design, a three-tier system that would have three different price-points is proposed — 1) mass-produced sustainable apparel, 2) deconstructed ready-to-wear (R-T-W), and 3) commissioned reconstructions.

Tier I: Mass-produced sustainable apparel. The first tier would utilize new materials with less environmental impact, such as organic cotton and recycled fleece. Designs could be variations of the second tier’s deconstructed R-T-W but would use new materials and be manufactured using mass production, thus yielding a lower price. The affordable price would allow a wider range of consumers the choice of environmentally sensitive clothing.

Tier II: Deconstructed R-T-W. The second tier would utilize PCR clothing as the base material and the production methods developed in this study. Because of the more complex design and production methods, these garments would be priced higher than the mass-produced versions. The garments would be completely unique, limited edition personal items with a built-in history; they would include documentation of the deconstructed garment similar to the study’s labels and “bookmark” hang tags. Garments from this tier would fall into a niche market catering to customers who are willing to spend more for a more individual product. Subsequent to the formal completion of this project, seven of the collection garments were placed at the ACCI artists’ cooperative gallery in Berkeley and displayed in the gallery gift shop in order to test the viability of this concept. Although the garments were priced to cover complete production costs plus a profit for both producer and retailer, five of the seven garments sold within the first week, and generated much customer interest. The gallery manager reported that customers were delighted by the hangtag portraits of each garment and valued each garment’s uniqueness and their environmental qualities.

Commissioned reconstructions. The third tier would fall in the premium or couture price range with customers bringing in personal items to be reconstructed into completely new garments. The level of customization would range from deconstructing/reconstructing the customers’ clothing using pre-developed designs (i.e. patterns already developed for the deconstructed R-T-W tier) to custom designing garments for customers from “family heirloom” pieces. One wear tester from this study said she would value a garment such as her grandfather’s suit “morphed into something to fit me that I could have a memento of him,” thus crossing generations and genders. Study participants met this concept with enthusiasm. The creation of one-of-a-kind garments that are meaningful, symbolic and cherished is a viable option that would have value for the customer, strengthening social connections while making use of old clothing.
The first step towards changing our society starts with educating the consumer about social and environmental issues. Clothing is a universal object that everyone in the world uses and understands; it is a ubiquitous part of our society. When in use it is a mobile visual object open for interpretation and discussion; it is not tied down to any one location, but may travel far and wide with its wearer. Successful design will be well worn and loved by its owner, and possibly passed down to a new generation for another rotation in the clothing lifecycle. In essence, it is an ideal object with which to communicate and experiment. This study explored the creation of meaningful, functional, re-valued clothing from the discarded clothing of our current disposable society. The garments act as vehicles for encouraging recycling and reuse. By inverting what we once considered “waste” into “food” for thought and continued use we are able to reassess our relationship with what our current society undervalues.

References

Plate XIV. Hangtags as Fabric Bookmarks

Plate XV. Reverse Denim Raincoat Derived from Denim Jeans
Plate XVI. Bubble Elbow Shirt with Functional Design Features.

Plate XVII. “Silk Bridge”.

Plate XVIII. “Cathedral”.

Plate XIX. [Image of a design or clothing item, possibly labeled or annotated with text or symbols.]