CHAPTER 6

Zero Waste Fashion Design in Fashion Systems

Timo Rissanen

Chapter Objectives

1. Understand the agency that fashion design practice has in determining how much off-cut waste the fashion manufacture creates
2. Understand the sustainability benefits of a fashion system in which design and manufacturing are integrated holistically and non-hierarchically.
3. Identify various approaches to designing and making garments based on material construction, and the implications of each on the amount and type of material waste created.
4. Contextualize contemporary approaches to sustainability in fashion design in various historical and cultural contexts
5. Recognize creativity as a fundamental aspect of fashion and sustainability

With 10 to 20 percent of its fabric swept off the cutting-room floor, the fashion industry is leaving a significant ecological footprint. This waste could be dramatically reduced, however, with some creative design thinking. Zero waste fashion design challenges designers to rethink their relationship with pattern cutters and adopt a process that could result in 100 percent fabric use in the garments that the industry produces. This work requires a systems approach, to ensure that incremental change is contributing towards systems transformation.

Pattern Cutting as Fashion Design

This chapter examines an aspect of clothing production that is often invisible and thus not regarded as a problem: pre-consumer fabric waste. Arguably, the perception of fabric as disposable by many in the fashion industry should be questioned. To produce raw fiber and turn fiber into fabric consumes energy, chemicals, and water: fabric is precious. The wasting of fabric occurs in garment manufacturing, but the ability to eliminate fabric waste resides within fashion design and pattern cutting. To eliminate fabric waste, the garment pieces must use up the entire length of the fabric, interlocking like the pieces of a completed jigsaw puzzle. The combined expertise of the fashion designer and pattern cutter can achieve this. The aim in zero waste fashion design is to

simultaneously design a set of garment pieces that take up a given length of fabric in two dimensions and the garment in three dimensions. No fabric waste is then created exclusive of the garment. Some fabric may be wasted within the garment, but the potential benefits of that will be discussed further in the chapter. A zero waste garment is designed through the making of its pattern, while ensuring that the resulting garment is aesthetically pleasing, fits appropriately, and is within an acceptable range of cost. Fashion design and pattern cutting are not hierarchically or otherwise distinct activities; pattern cutting is part of the design process.

Precious Fabric and Wasted Fabric

Why should we avoid wasting fabric? Fabrics are increasingly inexpensive, and the amount of waste may not seem worth worrying about. A brief look at cotton and polyester, accounting for 76 percent of all fiber use (Niinimaki et al, 2020), reveals some cause for concern. As a natural fiber, cotton is easily mistaken for an environmentally friendly fiber. Cotton, however, is a heavily sprayed crop; cotton occupies less than 3 percent of the world's agricultural land, yet 16 percent of insecticides and 6 percent of total pesticides used globally in agriculture go toward cotton production (Niinimaki et al, 2020). Cotton is also a "thirsty" fiber, both to grow and to treat to achieve a finished cotton fabric from fiber. Nonetheless, by being compostable cotton is compatible with biological systems at the end of its useful life. Furthermore, pending the widespread adoption of regenerative and carbon farming practices, cotton agriculture has the potential to become a carbon sink. The polyesters used in fashion come from a finite source, oil, and consume considerable energy to produce (Allwood et al., 2006, pp. 13–14). Toxic additives accompany polyester, sometimes unnecessarily (McDonough & Braungart, 2002, pp. 37–8). In a landfill, polyester breaks down slowly. Ongoing research is revealing the problematic nature of microplastic pollution in the atmosphere, soils, and the oceans, and polyester in fashion contributes to this escalating problem substantially (Changing Markets Foundation, 2021).

What happens to fabric waste? The dumping of textiles in landfill is problematic. Natural fibers will decompose but may release harmful chemicals and methane in the process; synthetics may take centuries to decompose. A large industry exists trading in scrap fabric (the real "rag trade") and thus keeps the waste from landfill. Fabric recycling, however, is a difficult issue. McDonough and Braungart (2002, pp. 56–9) use the term "downcycling" to describe the degradation in material quality through recycling. The quality of yarn spun from a natural fiber relies on the length of the fiber. Recycled natural fiber tends to be shorter than "virgin" fiber, and thus not suitable for all uses. Nonetheless, recent improvements in systems and technologies have resulted in higher quality fabrics made from off-cut

waste, such as the 100 percent recycled, 100 percent cotton denim by Pure Waste Textiles in Finland.

The production of any fiber and the manufacture of that fiber into fabric consumes energy, raw materials, almost always water, and often chemical additives. Regardless of recyclability, cotton and polyester reveal that fabric arrives at the fashion designer with a significant ecological footprint acquired during its production. Cooklin (1997, p. 9) estimates the average waste to be 15 percent of the total fabric used, while Abernathy et al. (1999, p. 136) place the figure at around 10 percent for pants and jeans, but higher for blouses, jackets, and underwear. Given that global clothing production roughly doubled from 2000 to 2020 (Niinimaki et al 2020), without any significant transformation in the way garments are designed and manufactured from a fabric waste perspective, it is plausible to deduce that the amount of fabric waste by the industry also doubled. In 2020 total global fiber production was estimated at 100 million tons, of which 60 percent was used by fashion. 15 percent wastage translates to 9 million tons of fiber wasted in the offcuts created in fashion in a single year.

Fashion Creation Methods

To put zero waste fashion design into context, a look at all fashion creation methods available to the industry through existing and emerging technologies is necessary (6.1). Examining garments by fabric waste creation, three main categories emerge: *constructed from fabric,* of which zero waste fashion design is a part; *constructed from yarn,* which includes fully-fashioned and whole-garment knitting (also called seamless or 3D knitting); and *constructed from fiber*, which includes garments made by shaping fiber into a felted form. The two most common methods of fashion creation in the industry are cut-and-sew (constructed from fabric) and fully fashioned (constructed from yarn), and these are discussed next. An introduction to fabric construction is also necessary, as different fabric types have implications for the different fashion creation methods. Three broad categories exist for fabric construction: wovens, knits, and non-wovens. Wovens have yarns interlacing in two directions, warp and weft; knits are rows of looped yarns; and non-wovens are made directly from fiber without spinning it into yarn first, or may not consist of fiber at all (e.g., leather).

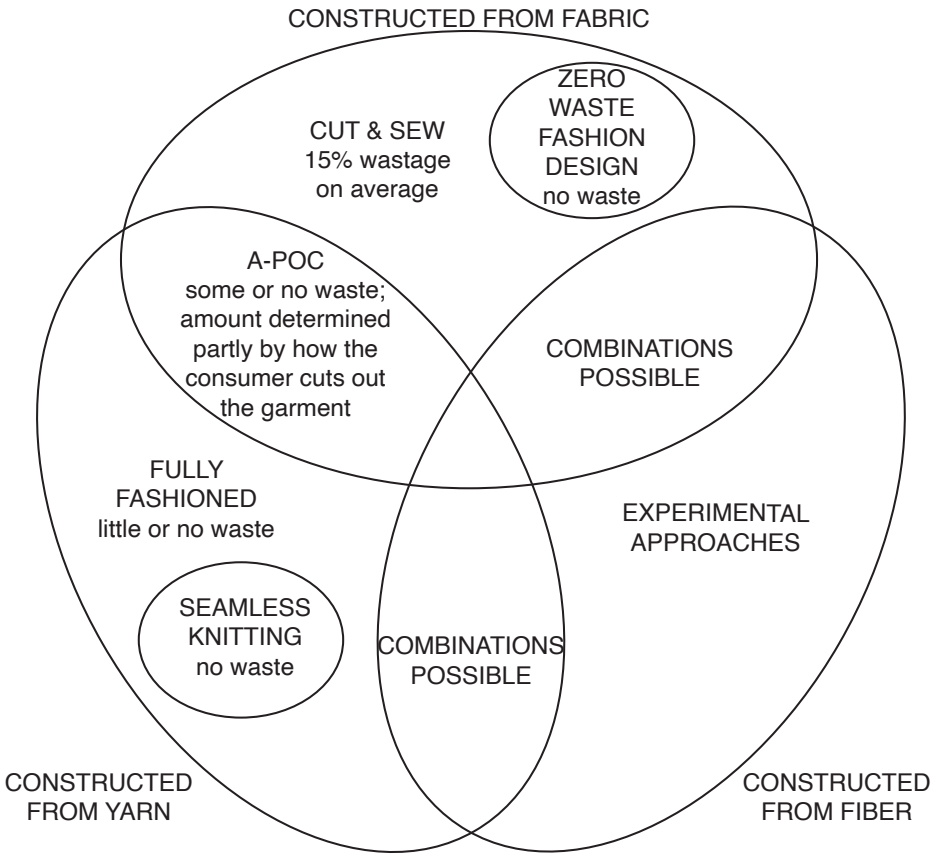

FIGURE 6.1. This illustration depicts fashion creation methods from a fabric waste perspective. Three broad fashion creation approaches exist, but combinations of these are also possible. Zero waste fashion design refers to cut-and-sew that wastes no fabric, in garments constructed from fabric. (Illustration by Timo Rissanen)

Constructed from Fabric

In these approaches garments are constructed from fabric through cutting and sewing; such approaches are the most widely known and used.

Cut-and-Sew (Fabric + Cutting + Sewing = Garment + Fabric Waste) and Zero Waste Fashion Design (Fabric + Cutting + Sewing = Garment)

Cut-and-sew is self-explanatory. Garment pieces are cut from fabric and sewed to make garments. Any type of fabric may be used. Conventional cut-and-sew wastes 10 to 20 percent of the total fabric used, while zero waste fashion design refers to cut-and-sew that wastes none.

Unlike fully fashioned and A-POC (discussed below), cut-and-sew and zero waste fashion design require no reprogramming of machinery to create new garment styles and are suitable for all fabric types. Furthermore, cutting and sewing woven fabrics allows subtleties within a design that may not be

possible through other methods. It is therefore likely that cutting and sewing will remain alongside emerging technologies for the foreseeable future, although the reliance on this approach may be reduced by emerging technologies.

Constructed from Yarn

In these approaches a garment is created from yarn. Fully Fashioned Knitting has a long history, while other approaches are more recent and in some cases, speculative.

Fully Fashioned Knitting (Yarn + Knitting + Sewing = Garment) and Seamless Knitting (Yarn + Knitting = Garment)

Fully fashioned in its true form eliminates yarn or fiber waste, and is commonly used in knits. The garment pieces are knitted individually and then joined together. Seamless or whole-garment knitting eliminates sewing from the process—a machine knits a finished garment (Black, 2002, p. 118).

Fully Fashioned Weaving (Yarn + Weaving = Fabric, Followed by Fabric + Cutting = Garment + Fabric Waste)

With the technology available to fashion design, a fully fashioned approach is possible in woven and non-woven fabrics through craft methods (e.g. hand-weaving and felting). Non-woven sails made of carbon and aramid fiber by North Sails Nevada show that non-wovens can be adapted for an industrial fully fashioned approach. The sails are made into the exact required shape by specialized fiber-laying machinery (Brown, 2005, pp. 53, 55). Recent research projects by Holly McQuillan (2020) and Anna Piper (2019) demonstrate that garments can be woven to shape on a digital jacquard loom, making industrially available fully fashioned weaving plausible.

In the late 1990s, Issey Miyake and Dai Fujiwara launched A-POC (A Piece Of Cloth). In knits, a flat tube of fabric is knitted with the two sides of the tube joined in areas. The wearer buys a tube and, following the lines of the joins, cuts out finished garments (Kries & von Vegesack, 2001). A-POC is similar to whole-garment knitting in that a machine produces a garment that requires no sewing, but the technologies used to produce each are different (Black, 2002, p. 118). How the wearer cuts out the pieces determines partly how much waste is created. Several woven A-POC garments were developed; for example, Caravan and Pain de Mie from 2000. The latter, a dress or skirt and top depending on how it is cut, can be cut out as finished garments like the knits, while the Caravan jacket requires one row of sewing at the back after cutting (Kries & von Vegesack, 2001, p. 63). Considering the non-woven fully fashioned sail technology, it seems possible to extend A-POC to non-

wovens, too. McQuillan's (2020) recent work of weaving garments on a digital jacquard loom builds on A-POC.

Garment Design and Making Process

The following sections describe the processes of garment design and make.

Fashion Design

Most fashion designers use sketching to develop ideas, from initial concept to a design that can be pattern-made and made into a sample garment. The benefits of sketching are many: It is fast, ideas become visible to the designer and others quickly, and various elements of design (e.g., silhouette, balance, and line) can be resolved before the costly pattern cutting and construction processes. Software such as Clo3D allows the fashion designer to view a high-fidelity simulation of a three-dimensional garment while simultaneously showing the two-dimensional pattern. Such software offers zero waste fashion design new workflows, as Holly McQuillan's (2020) research demonstrates.

Pattern Cutting

Pattern cutting, or pattern making, is the making of a pattern for a garment. Usually a pattern maker does this, guided by the designer's sketch. Occasionally the fashion designer makes the pattern, and this chapter proposes, through examples, that pattern cutting can be an effective design tool alongside sketching. Manual pattern cutting using pens, scissors, paper, and card is still common, although computerized approaches using increasingly sophisticated CAD/CAM software, some with the capacity for three-dimensional simulations of garments, now dominate.

Construction: Cutting and Sewing

Using the pattern, a toile is cut and sewed. The toile is a garment prototype in inexpensive fabric, to allow the design team to test fit and examine the design in three-dimensional form. Depending on the design and the amount of required alterations, more than one toile may be necessary before the pattern is made to the design team's satisfaction. A sample cutter then cuts a sample in the actual fabric, which a sample machinist sews.

Production: Grading, Making a Marker, Cutting, and Sewing

Once the designer and pattern maker, and sometimes a buyer or a merchandiser, approve the sample garment, the pattern maker or a grader grades the pattern into the required range of sizes. Grading may be done manually but is increasingly done digitally. A marker maker uses the graded pattern to create a marker. The marker is a cutting layout containing all the pieces of all the sizes to be cut for production. The cutter or an automated cutting system uses the marker as a guide to cut out the garment pieces in fabric. Production machinists, organized for maximum efficiency, make up the garments. Sewing may be segmented; for example, one machinist might only sew side seams while another works on cuffs. Finished garments are pressed, tagged, and shipped to retailers.

Since the early twentieth century, the steps in the process of garment making, from fashion design to production sewing, have been organized somewhat hierarchically. The specialization of each is the result of a search for better efficiencies. The benefits are many; as each role concentrates on fewer tasks, it is likely to result in a higher level of expertise in one area, and garment production also becomes faster. On the other hand, some consequences are problematic. The primary obstacle to fabric waste elimination is the separation of fashion design and pattern cutting on one hand, and fashion design and manufacturing on the other. “Advanced manufacturing”, or approaches to manufacturing that make use of technologies such as 3D printing or seamless

knitting, often necessitates a closer collaboration between design and manufacturing, facilitating simpler workflows. As McQuillan (2020) demonstrates, advanced manufacturing is likely to play an increasing role in fashion design and manufacture.

In current industry practice, the marker maker is responsible for efficient fabric usage. When creating the marker, the marker maker attempts to place all the garment pieces within the fabric as closely as possible. The motivation is economic; the tightest fit of the pattern pieces uses the least fabric per garment, thereby reducing production costs dramatically. Notably, it is economically affordable to waste 10 to 20 percent of the fabric, even if this is not ecologically sound. Even the latest computer software affords only mild increases in this efficiency, because it is bound by what has already been designed and pattern-cut. Conventionally, garments are not designed and pattern-made with the cutting layout (i.e., the marker) in mind. The amount of waste is determined by garment style (e.g., number and shapes of pattern pieces), the number of garment sizes and garments in one marker, and the marker maker's skill. A more efficient marker is usually achieved by mixing the pieces of several sizes in one marker or by cutting more than one of the same size in one marker.

Contemporary Zero Waste Fashion Design

An investigation into traditional forms of dress as well as fashion history and present fashion reveals many examples where fabric is treated as precious in the making of clothes, and very little or none is wasted. The sheer number of examples and the spread of these over centuries provide us with guidance in moving forward. It helps to examine these examples across broad, overlapping themes. The themes used here are fabric, pattern design, and garment design. With fabric waste elimination as our focus, fabric has some specific implications for design. Similarly, as the making of the garment pattern determines whether the making of the garment wastes fabric or not, pattern design includes issues best addressed during pattern cutting. Garment design refers to aspects that may be addressed prior to commencing making a garment and features that differ from more conventional ways of designing. The themes assist in building a new understanding about zero fabric waste creation and should not be considered exclusionary.

Fabric

In the simplest examples of fabric waste elimination, fabric equals garment: fabric is not cut into and thus none is wasted. The himation, chiton, and peplos of ancient Greece and the sari of India are lengths of fabric with no cutting, worn draped on the body. The sari yields several variations (Lynton, 1995, pp. 14–16), as does ancient Greek dress (Rudofsky, 1947, p. 137). Different fabric lengths and widths allow further diversity.

In zero waste fashion design, fabric width becomes a design consideration, because the width determines how the pattern pieces may be configured on a length of fabric. Fabric width is a major difference between cut-and-sew and zero waste fashion creation: rarely does one need to consider fabric width when designing a cut-and-sew garment, while a zero waste garment is fundamentally informed by the width of its fabric. Perhaps the best-known garment that wastes no fabric is the kimono of Japan. The narrow width of the fabric used in the kimono determines its horizontal dimensions (Tarrant, 1994, p. 36). Rather than make the kimono in a range of sizes, each is adjusted to the wearer by wrapping and tying on a belt (Van Assche, 2005, p. 7).

For Yeohlee Teng, a contemporary designer in New York, economical fabric use has been integral to her work for four decades. In a jacket made in 1998, fabric width determines the length of the sleeves, as these are cut in one and perpendicular to the body of the jacket (Major & Teng, 2003, p. 53). The pattern diagram lacks some pattern pieces such as facings, and the amount of waste is difficult to determine. The purpose of the diagram is probably to be broadly illustrative of garment cut, rather than to accurately reproduce the garment pattern.

Zandra Rhodes is an English designer who often develops a print first, and this informs the garment shape. A blouse from 1979 demonstrates this approach. The print pattern, Chinese Squares, is engineered to the fabric width. The garment is then developed according to the print; it uses the full fabric width (Rhodes, 2005, pp. 34–6). The blouse does create some fabric waste, despite the sleeve and peplum pieces interlocking fully. For complete fabric waste elimination, the fabric selvedges need to be incorporated into the garment somehow. Haute couture sewing, the most expensive level of hand finishing, as demonstrated by Shaeffer (2011, p. 54), provides an example. Selvedge strips can be used internally to stabilize necklines, armholes, and other garment parts, and the technique is easily adapted to ready-to-wear. Selvedge could also be left in the garment as an edge finish, such as a hem or facing edge.

A great variety of fusible interfacings are now available to support parts of a garment (e.g., the jacket front and shirt collar); printed glue bonds the interfacing to the garment fabric. Occasionally the main garment fabric may be used as a sew-in interfacing. For example, in the front neckline of the kimono, surplus fabric in the front neck is pleated inside the collar for support, rather than cut away (Dobson, 2004, p. 54). Often, fusible interfacings are not

used with sheer fabrics; where added body is desired (e.g., the cuffs and collar), three or more layers of the garment fabric may be used. This could also make the eventual recycling of a garment easier, as the fiber content of the garment and its interfacing would be the same.

Pattern Design

While rectangular pattern shapes may seem easier to work with in zero waste fashion design, their design potential warrants inquiry. Bernard Rudofsky was an Austrian-American social historian and an ardent critic of contemporary clothing design and manufacture. Following the 1944–45 exhibition and 1947 book *Are Clothes Modern?* (Rudofsky, 1947), Rudofsky incorporated some of his ideas into a range of clothing in 1950 (Bocco Guarneri, 2003, pp. 294–5). The garments in the collection, Bernardo Separates, were made in one size only from rectangular pieces of fabric. Fit was achieved with drawstrings or belts. The aim was a reduction in price through the minimization of sewing. Fabric was the main source of cost. While the pattern diagrams are too simplified to determine whether fabric was wasted, Rudofsky greatly admired fabric-as-garment in ancient Greek dress. The American fashion designer Claire McCardell was Rudofsky's contemporary, and he included her work in *Are Clothes Modern?* (Rudofsky, 1947). The included garments were geometric in cut, not unlike the garments that Rudofsky created a few years later. I have explored geometric shapes extensively in my work, such as in the pajamas from 2011 (6.2).

Initially, rectangular pattern shapes may seem to only allow basic garment shapes. These shapes can, however, be offset in relation to one another to create three-dimensional rather than flat shapes. Max Tilke was a German ethnographer with an interest in dress from around the world. Whether his depictions of dress are accurate is open to question, but from a fabric waste point of view his work is undeniably interesting. In *Costume Patterns and Designs* (Tilke, 1956, Plate 89: Garments 6 & 7, 9 & 10), a pair of Chinese trousers is made from two rectangles. The offsetting of two rectangles against each other forces the trouser legs to hang "off-grain," on an angle.

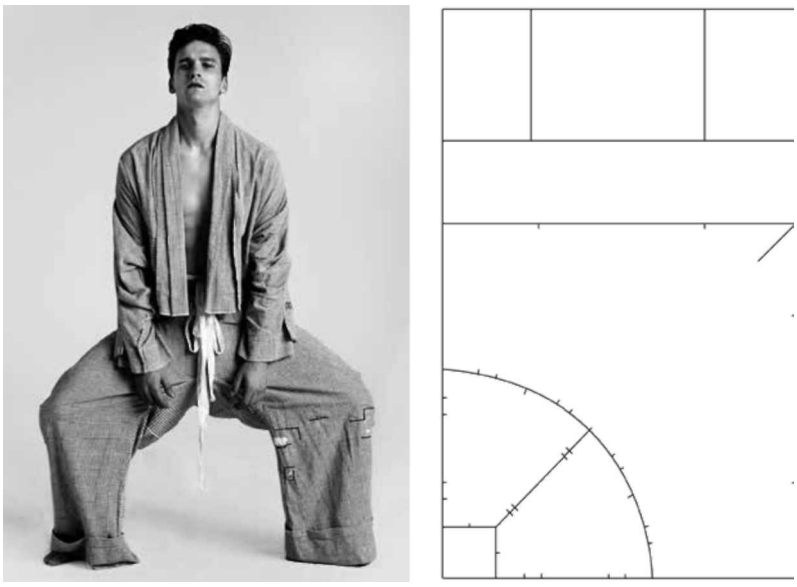

FIGURE 6.2. Pajamas and pattern by Timo Rissanen, 2011. Rissanen designed these using his grandmother's bed sheets from the 1940s, influenced by subtraction cutting by Julian Roberts. (Photograph by Mariano Garcia, patterns by Timo Rissanen)

The Japanese designer Yoshiki Hishinuma has explored similar principles in garments made from equilateral triangles (Hishinuma, 1986, pp. 162–72). For example, he has created a pair of asymmetrical trousers from two triangles. While Hishinuma's garments do not seem to be designed with fabric waste as a consideration, it is possible to engineer the pieces of such a garment to interlock on a fabric width by splitting the equilateral triangle into two right-angle triangles of equal size. These can then be flipped into interlocking rectangles. More recently, the womenwear brand Study NY has made extensive use of offset rectangles by way of garments that through buttoning allow the wearer to modify the garment (6.3).

Similarly, graduated fullness or flare can be achieved through the use of interlocking gores, as demonstrated in European gowns from the fourteenth to the eighteenth centuries (Arnold, 1977 [1966], p. 3; Baumgarten, Watson, & Carr, 1999, pp. 43–6). Rectangular gussets may be inserted into curved or straight slashes as an alternative to shaped seams to create three-dimensional forms. As the kimono demonstrates, folds may replace straight seams. In knits, even curved edges may be folded rather than cut. Rothstein describes a knitted jacket made of rectangles, where the curved neck and armhole are created through folding under rather than cutting fabric (1984, p. 17).

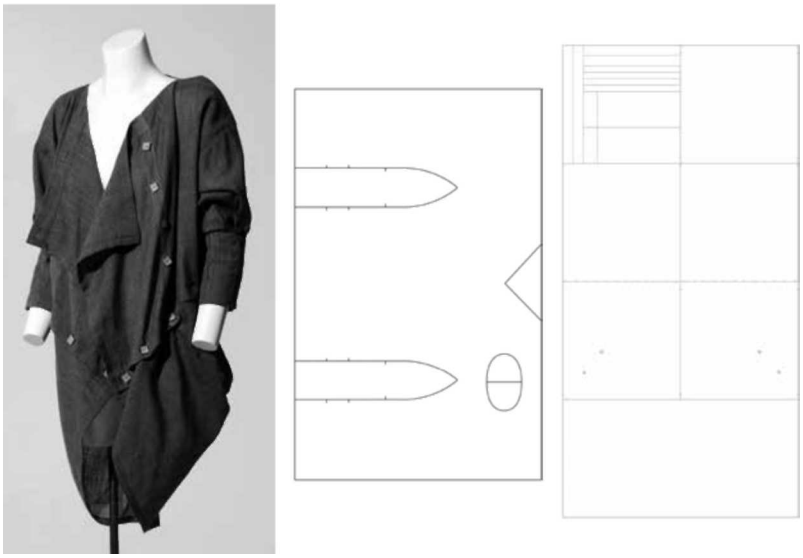

FIGURE 6.3. Dress by Study NY. The company has repeated versions of this dress since its inception in 2009. The dress can be customized by the wearer by altering the buttoning. (Photograph by Thomas McQuillan, pattern by Tara St James)

The 1979 Rhodes bodice and a 1982 hooded cape by Teng (Major & Teng, 2003, pp. 8, 155) show waste occurring from curved pattern edges. Minor modifications to the designs could eliminate most or all of this waste. The sleeve pieces of the Rhodes bodice are squares with a circular cutout in the middle. Straight slashes could replace the circles, and a slash could be offset against another, as described above. In Teng's cape, a more noticeable change would be required to eliminate waste: the cape hem and hood shape could interlock. The text describes the cape as cut "with no waste" (Major & Teng, 2003, p. 18), while the pattern diagram (155) shows some to occur. Achieving interlocking curves within the pattern to eliminate waste may seem difficult, but Holly McQuillan's work demonstrates that it need not be. When designing curved pattern shapes, one needs to simultaneously determine how to use both sides of the curve.

The largest pattern pieces need to be resolved first, as they will dominate the marker layout (Rissanen, 2013, p. 91). Thayaht, an Italian futurist, designed the "tuta" overalls in 1919; he later worked for Madeleine Vionnet during the 1920s (Chenoune, 1993, pp. 140–2; Stern, 2004, p. 43). The tuta is composed of relatively few pieces: the entire body (e.g., front, back, and legs) is cut from one piece, with slashes for armholes. The pattern diagram (Stern, 2004) includes measurements, so the wasted fabric amount may be assessed accurately. The tuta does waste some fabric, but minor changes would allow full interlocking. For example, the four patch pockets could be redesigned to use up the waste.

Grading

Grading is the incremental change in pattern size to create a garment pattern in a range of sizes. Zero waste fashion design raises the question: is grading the only way of producing a garment style in a range of sizes? In my PhD research (Rissanen, 2013, pp. 121–31), I identified five pathways to create size ranges of garments:

1. One-size-fits-most
2. Conventional grading
3. Designing each size individually
4. Using a different fabric width for each size
5. A hybrid method

Pathway 1: One-size-fits-most

The need for grading can be eliminated by designing a garment that will fit individuals across a range of sizes. Yeohlee Teng has designed such garments throughout her career, describing them as "the ultimate efficiency" (Luther, in Major & Teng, 2003, p. 18). Teng's skirt in the Yield exhibition (McQuillan & Rissanen, 2011, pp. 12–17) is adjustable to almost any waist size. This pathway is limited to loose, adjustable, or wrapped garments, and occasionally garments made from fabrics with considerable stretch.

Pathway 2: Conventional Grading

Grading in the conventional manner remains an option. The benefit of this pathway is the familiarity and speed of the process to industry practitioners; grading remains within manufacture and digital technologies allow for fast grading. The subsequent sizes are likely to create fabric waste; in conventional grading marker planning is not regarded as design. Not all of the garment components necessarily grade, whilst the ones that do, do so unevenly depending on the garment design. Once each component has been graded, it is unlikely that they will configure on fabric in a way that does not create fabric waste. Is it then truthful to claim a garment to be zero waste, if in fact only the original size is?

Pathway 3: Designing Each Size Individually

Each size can be redesigned using the original size as the starting point and a guide. The visual aspects of the designed garment will be retained as close to

the original as possible across the resulting sizes while ensuring each size is zero waste. Whilst relative to conventional grading this pathway may be time-consuming, research by Glitsch (2020) demonstrates many benefits from improved fit and increased wearer satisfaction across sizes to more pleasing aesthetics. Instead of handing over the patterns of a garment to a grader to produce patterns for a range of sizes, the fashion designer, working with the pattern cutter and/or grader, is responsible for each size; grading becomes a criterion for fashion design rather than manufacture. Changes to the design are inevitable but these would need to be kept to a minimum, in order to satisfy the expectations of retailers and consumers.

In order to design each size, the designer would first need to determine the garment components that need to grade and by how much. These components may need to be given priority in the redesign process, as they may set the limits for the pieces that do not necessarily need to grade (for example, pockets, tabs, epaulettes, etc.) and smaller pieces that grade in one direction only (cuffs, collars, etc.). When it has been determined which components need to grade, two options emerge for the redesign process, depending on the garment design: changing or retaining the configuration of the garment components in the marker. Each will now be examined:

Pathway 3A: Changing the Marker Configuration

Once the garment components have been assessed for their need for grading, they need to be examined on the fabric width to see how similarly they may configure in comparison to the marker of the original size. A number of strategies exist to facilitate the redesign process. For example, pattern pieces that can be added or deleted to affect grading are a possibility.

Changing the marker configuration is likely to result in considerable changes in garment appearance. The marker for Endurance Shirt II (created in 2011) is considerably different from the marker for Endurance Shirt I (created in 2009). Although the two shirts (6.4) are the same size and thus the exercise of adapting a garment from one fabric width to another does not directly relate to grading, it is possible to nevertheless see that changing the marker for each size can significantly impact on garment appearance; the elbow patches from the early shirt were eliminated in the later one. Therefore it would seem that retaining the original marker as much as possible would better facilitate adhering to the criterion of fabric waste in grading.

Pathway 3B: Retaining the Marker Configuration

A number of possibilities exist for retaining the original marker configuration across sizes.

In some garments where fullness (defined as amount of fabric considerably larger than the body it covers) has been designed into the garment, it may be possible to not change the outline of each garment component to produce a range of sizes. What changes is the relative amount of fullness in a component. Pleats, tucks, darts, and gathers can be employed to control fullness across sizes.

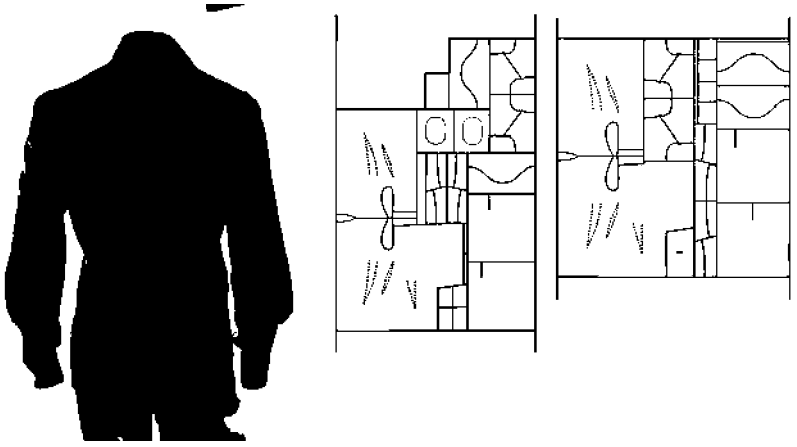

FIGURE 6.4. Patterns for Endurance Shirts I and II (2009 and 2011, respectively). (Photograph by Silversalt, patterns by Timo Rissanen)

The Rhodes bodice discussed earlier breaks some rules about grading in order to maintain the interlocking across a range of sizes. The square sleeve pieces with circular center cutouts do not grade, except for the two cutouts that attach to armholes. The vertical length of the largest-size bodice is the same as one size smaller, so that the pattern fits on the fabric width. The body and peplums are cut on the weft grain, perpendicular rather than parallel to selvedge, to allow conventional horizontal grading. Baumgarten, Watson, and Carr (1999, p. 108) note that in the eighteenth century, shirt size was determined by fabric width, with different sizes cut according to the same pattern configuration. Using a wider fabric made a larger shirt. Weaving a range of fabric widths may be too expensive, but T-shirts without side seams, cut from knitted tubes of various widths, are common.

Pathway 4: Using a Different Fabric Width for Each Size

Using a different fabric width may be feasible with some tubular knit fabrics like jersey or rib, knitted in a range of diameters. Whether each size is zero waste and exactly replicates the design of the original size are issues for design to resolve.

Pathway 5: A Hybrid Method

Combinations of the previous four pathways are likely to provide many solutions to grading. Multiple solutions exist, given the variability of garments, varying size range requirements, and variations in grade rules. Garment type and style, the size range that is required, and fabric type and width determine the most appropriate solution. Grading is a consideration for zero waste fashion design as well as for manufacture.

Garment Design

Designing more than one style of garment simultaneously and cutting these from one length of fabric together can reduce the amount of fabric waste, although it does not necessarily do so. The mixing of jacket, trouser, and sometimes vest pieces on one length of fabric instead of cutting each separately is common tailors' practice (Cabrera & Flaherty Meyers, 1983, p. 57). Yeohlee Teng maximized fabric use on a 7-meter length by designing and cutting three different dresses from it simultaneously (Major & Teng, 2003, pp. 80–3). McQuillan similarly designs multiple garments simultaneously. For Yield, McQuillan partnered with textile designer Genevieve Packer to design an outfit of three garments that were seemingly made from dozens of fabrics. The three garments are cut together from one fabric (6.5). An engineered digital print developed by Packer creates the illusion of multiple fabrics.

To eliminate waste, the technical and visual elements of a garment need to be considered simultaneously; whether they should ever be treated separately is open to question. While considering the appearance or visual aesthetics of a garment, the designer also needs to understand how its pattern pieces may interlock. The garment needs to be considered in two and three dimensions simultaneously. Using design practice as a research methodology, Katherine Townsend (2004) explored the relationship between a two-dimensional textile print and three-dimensional garment form. Like the McQuillan/Packer collaboration above, Townsend's research involved engineering the textile print to work within the flat shapes of the garment patterns as well as the three-dimensional garment. Along similar lines, the English designer Julian Roberts sometimes develops a garment pattern without an exact prediction of the garment itself. The garment form reveals itself once made (McQuillan 2011, p. 85). If designers were open to some degree of trust in such unpredictability, even risk, the adoption of zero waste fashion design could become easier. Zero waste fashion design could not only eliminate waste but perhaps also offer new ways of practicing fashion design.

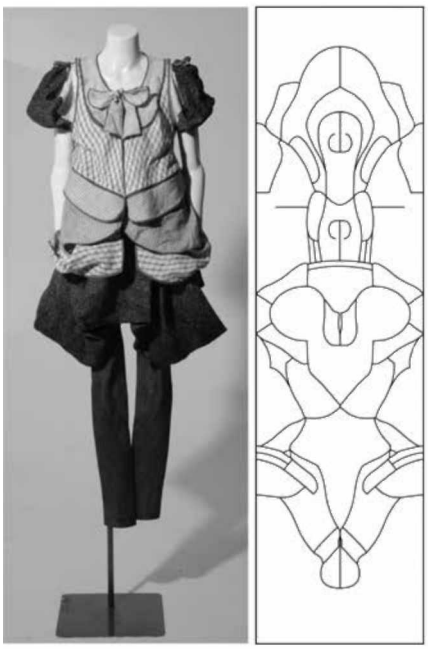

FIGURE 6.5. Vest, dress, and trousers, and their patterns, by Holly McQuillan, with textile design by Genevieve Packer (2011). McQuillan developed the garments and textiles collaboratively with Packer for the Yield exhibition. (Photograph by Thomas McQuillan, pattern by Holly McQuillan)

It may take longer to create a zero waste garment than to create one through more conventional methods, particularly if a designer has not previously worked in such a way. Whether experience over time turns a designer into a zero waste expert is subject to further research. For the time being, evidence shows that at the garment sampling stage more styles are created than are eventually taken to production. According to Waddell (2004, p. 40), "most design houses estimate at least 20 percent wastage at this stage"; the cull is due to limitations in technical or financial feasibility, or because of artistic reasons. The deleted sample garments represent a considerable amount of work by the design team, a cost to the company, and a significant waste of physical resources. Would closer consultation with sales and merchandising, combined with more effective market research and range planning, eliminate some of this waste? If design were subject to more effective research and planning, would more time become available for design? Three-dimensional simulation of garments with software such as Clo3D can potentially limit or even eliminate this type of waste. The Swedish brand Atacac takes pre-orders on garments that are only “sampled” digitally; if a particular style does not receive sufficient interest, it is not produced at all.

take Take Action 1: Study NY

Tara St James is the founder of Study NY, a design studio with a concern for the environmental and human aspects of the fashion industry. St James

founded Study NY in 2009, after having worked as the creative director for Covet. St James is the winner of the 2011 Ecco Domani Fashion Foundation Award for Sustainable Design.

Her considered approach to zero waste fashion design and sustained collaborations with artists and textile designers are the key components of her success. St James aims to build upon her brand's sustainability and evaluate the chain of production to see where possibilities exist for further transparency. A believer in open sourcing and information sharing, over the years St James has shared her sources and contacts on her blog. By doing so she supports her suppliers, often smaller, fair-trade textile mills and fashion manufacturers.

St James started Study NY with an entirely zero waste collection for spring 2009 and she has continued zero waste fashion design in subsequent seasons. For example, for spring 2011, St James created a zero waste skirt from a hand-woven silk ikat from Uzbekistan. Zero waste is one of many aspects of sustainability that St James built into the company's core mission. Several times a year Study NY (the company no longer subscribes to the traditional fashion calendar, adopting a slower pace of evolution) repeats a version of a square-cut zero waste dress, which can be worn in a number of ways. This is an efficient example of zero waste fashion design, as a square of fabric with intricately placed buttons and buttonholes allows the wearer to play with the garment and find her ideal way of wearing it. This is a deep engagement with waste elimination; fabric as well as the experience it creates as a garment are equally valued.

Conclusion: The End of Fabric Waste

Zero waste fashion design is not good in and of itself; it needs to be examined in a systemic context. Furthermore, entirely new ways of thinking about how the industry could exist and function within planetary boundaries and with an earth logic (Fletcher & Tham, 2019) while allowing humanity to flourish are required. This points toward a new, expanded vision for fashion design: as well as designing and making garments, fashion design needs to design the consumption, wearing, and using of garments, and design collaboratively with other fields the systems in which the wearing and using occurs. A goal may now be set: the fashion industry should aim for 100 percent of the fabric it uses to stay in the garments it produces. To eliminate fabric waste, the often hierarchically distinct areas of pattern cutting and fashion design need to interact more closely. Sketching tends to dominate as the primary design tool, but to eliminate fabric waste, pattern cutting needs to be integral to the design process, not a step following it. Sketching does have its unique advantages as a design tool, but sketching and pattern cutting can and should work in tandem. If fashion designers were to address fabric waste, and evidence

suggests they should, sketch-based designing could combine with pattern-based designing. Many fashion schools such as Parsons School of Design and California College of the Arts in the United States, Massey University in New Zealand, and LAMK in Finland have experimented with zero waste fashion design in their curricula. Some of the initial difficulties of two-dimensional garment pattern design may be overcome by working through draping with fabric; the relationship between flat fabric pieces and three-dimensional form may then become easier to understand. This is further facilitated with the increasing availability of software that allows simultaneous two- and three-dimensional design. Reflecting on the passion that the contemporary designers covered in this chapter have for textiles in fashion, perhaps fabric- or textile-based designing is more apt a term than pattern-based designing. Fabric is the backbone of fashion and fashion should respect it as such; fabric could positively inform and inspire fashion design in more ways than most current practice suggests.

Fabric waste elimination could foster more carefully considered design and making processes. To adopt more ecologically sustainable fashion creation practices, the industry needs to critically examine its present practices. Currently some of these practices may be taken for granted, such as fabric waste, grading, and the nature of fashion design itself. In light of multiple escalating crises, with climate change and biodiversity loss and their myriad impacts on humanity, profound systems change in fashion is urgent. This change is possible.

When you next design or make a garment, examine the fabric. Try to see how the garment you want to create could use all of it. What is the relationship between the width of the fabric and the garment? If you have the pattern, see where the largest gaps or waste occur between the pieces. How can you adjust the design by incorporating these gaps into the garment? How might you reconfigure the placement of the existing pieces to create a new, more useful pattern shape? Remember, your imagination and openness to possibility are your greatest assets. Remember also that these can be your greatest limitations. Try to identify what learned rules guide your practice. One useful advantage of rules is that they can help us make sense of things. Once we have learned a rule, breaking it may take us forward. Be brave.

Discussion Questions

1. What factors have contributed to creating the condition where the fabric industry perceives fabric as disposable?

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2. If the goal is to eliminate fabric waste, what are the processes that create obstacles to this goal?

3. What opportunities exist for designers for reducing or eliminating fabric waste?

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