Designing a System to Empower Consumers to Become More Involved in the End-of-Life of Commodity-Grade Appliances

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Abstract

The United States currently recycles only 34% of the municipal waste that it produces, with some materials such as plastics having only a 7.6% rate of recycling (EPA 2011). Two contributors to low recycling rates are lack of information and confusion among consumers (Earth911 2012). Also, recycling materials from many designed-for-disassembly products may require multiple steps, special procedures, special tools, or special facilities (Boothroyd and Alting 1992).

Current systems available for product labeling, and information barely scratch the surface when it comes to providing adequate information and involving consumers. While simultaneously, commodity-grade appliances—due to the lack of design considerations for their end-of-life—provide ample opportunity for increasing recyclability. Therefore, the purpose of this project is to design a system to empower consumers to become more involved in the end-of-life of their commodity-grade appliances.

The objectives of this project were accomplished through the development of a three-part system. The system is comprised of improved product labeling, an information source in the form of a website, and a redesigned commodity-grade coffee maker aimed at consumer disassembly.
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Introduction
Commodity-Grade Appliances an Opportunity for Increased Recyclability

Current commodity-grade counter top appliances lack many design considerations for their end-of-life. Considering their low intrinsic value when compared to other more popular recycled items, like large appliances or e-waste, that receive more attention when it comes to their end-of-life, their inherent disposability can have a greater environmental impact. Consumers looking to properly dispose of these products are unaware of their options, or that options even exist. In addition, no clear, consistent information exists explaining to consumers how to easily recycle their appliances. (Earth911 2012). These issues prevent the recovery of useful materials and components, increase the demand for new raw materials, and increase the amount of waste diverted to landfills. Opportunity exists for the improvement of current design methods and information systems to promote consumer awareness and increase participation in a product’s end-of-life scenario. This project’s goal is to create a system comprising three parts: improved product labeling, an information source in the form of a website, and a redesigned commodity-grade coffee maker.

Why a Coffee Maker?

Many different products could be considered viable candidates for the use-case of this project, focusing on the commodity-grade automatic-drip coffee maker appliance category is important because of the current lack of end-of-life considerations. Automatic-drip coffee makers tend to have a relatively short product life span, approximately six years (Mudgal 2011), the shortest of all categories of coffee maker. Manufacturers do not provide adequate information regarding appropriate methods of disposal in terms of recycling and material recovery on their websites or in product literature. Current coffee maker design does not provide meaningful consumer involvement in the appliance’s disassembly. In addition, many of the materials either are not identified in a manner familiar to consumers or are not labeled at all. Thus,
increasing the difficulty of recovery. Because coffee makers with 12-cup capacity and a $30 or less price point make up the largest segment of coffee makers sold, with 64% and 49.2% market share respectively (ENERGYSTAR 2011), specific attention will be paid to these coffee makers. Therefore, an improvement in this category could have a significant overall environmental benefit.

**Background**

The United States currently recycles only 34% of the municipal waste that it produces, with some materials such as plastics having only a 7.6% rate of recycling (EPA 2011). Two contributors to low recycling rates are lack of information and confusion among consumers (Earth911 2012). Also, recycling materials from many designed-for-disassembly products may require multiple steps, special procedures, special tools, or special facilities (Boothroyd and Alting 1992). Consumers may not participate because of lack of knowledge or willingness, sending potential resources to landfills instead of back into the manufacturing stream. The philosophies of Design for Disassembly (designing a product to be dismantled for easier maintenance, repair, recovery, and reuse of components and materials) are becoming increasingly popular in the design and manufacturing industries (Reay, McCool et al. 2011). However, these processes can be effective only if the system works as is intended, with all parties doing their respective duties, most importantly the end user.

**Design for Disassembly**

The Design for Disassembly (DfD) philosophy promotes responsible and sustainable development of products. DfD products are designed to be dismantled for easier maintenance, repair, recovery, and reuse of components and materials. This system provides and advocates for a closed-loop product development, manufacturing, and recycling/reuse process.

DfD includes participation from designers, engineers, manufacturers, consumers, and recyclers. This process is mainly concerned with the ease of recovery of materials at the end of a product’s useful life cycle and the efficiency, profitability, and environmental impacts of doing so (Jovane, Alting et al. 1993, Harjula, Rapoza et al. 1996). Product design and manufacturing

**Life Cycle Analysis**

A systematic set of procedures for compiling and examining

- Material and energy input and output
- Associated environmental impact directly attributable to a product/service system throughout its life cycle.
Design for Disassembly

Design for Disassembly (DFD) is a set of principles used to guide designers in designing products that are easy to disassemble for recycling, remanufacturing, or servicing. See appendix for additional information.

Design for Disassembly Principles

When designing products with disassembly in mind, there are three important factors, which must be considered by the designer:

- The selection and use of materials.
- The design of components and product architecture.
- The selection and use of fasteners. In addition to this, the choice of recycling/recovery methods used at the product's end of life can partly determine the recyclability of the product. The resources used in packaging the product can sometimes be factored in.

Active Disassembly Research, Ltd.

Companies have been adopting the practice of using life cycle analysis (LCA) software to implement design for disassembly strategies. This shift of designing products to fulfill only their intended function did not fully consider the products’ end-of-life issues (Tsai C 2005).

Over the last few decades, DFD has become a major factor in many manufacturing sectors, especially in consumer electronics and large appliances. Major reasons for the adoption of design for disassembly methodologies are material and component recovery, competitiveness, and environmental concerns (Bogue 2007). The processes of life cycle thinking have been researched and successfully integrated into the product innovation schemes of many organizations especially in the design, manufacturer, and recycling steps of the process (Sodhi and Knight 1998). Companies that utilize DFD methodologies also often realize the economic benefits of fewer parts, materials, and connectors (Bogue 2007).

Companies like Apple, HP, Xerox, GE, Interface-Flor, Steelcase, and Herman Miller have led the way in the utilization of these methodologies. Apple, through its design implementations and a take-back program, claims to have managed to reach a recycling rate of greater than 70% (as a percentage of weight of products sold) (Apple 2012). HP’s products are claimed to contain a minimum of 65% recyclable content (Smock 2007). Through use of Dfd, component modularization, and a comprehensive program allowing it to disassemble,
Cradle-to-Cradle

- Cradle-to-Cradle design perceives the safe and productive processes of nature’s “biological metabolism” as a model for developing a “technical metabolism” flow of industrial materials.
- Product components can be designed for continuous recovery and reutilization as biological and technical nutrients within these metabolisms.

McDonough Braungart Design Chemistry, LLC (MBDC)

recover, and recycle end-of-life products, Xerox claims to have diverted 46,000 metric tons of waste from landfills in just 2010 (Xerox 2012). GE participates in the EPA’s Responsible Appliance Disposal (RAD) program, through which it claims it disassembles and reclaims roughly 85% of the materials from used refrigerators (GE 2012). GE has also developed a dishwasher that is claimed to be 80% recyclable by weight after disassembly (GE 2012). InterfaceFlor designs its carpet to be 100% recyclable and made from recycled content (InterfaceFLOR 2011). Steelcase produces a line of office furniture, Think, that is claimed to be 98% recyclable by weight and includes disassembly instructions (Steelcase 2004). Herman Miller has adopted the McDonough Braungart Design Chemistry (MBDC) Cradle-to-Cradle design protocol for its products (Solomon 2005, Herman Miller 2011).

One area of product life cycles that has received less attention and research is the role and responsibility of the consumer in the life cycle of a product designed for disassembly (Lebel and Lorek 2008). These programs although successful involve industrial-level processes and facilities to operate which may not be an effective solution for small-scale appliances and would preclude the consumer from taking a more active role. An organization may design a product to be nearly completely recyclable but it is all for naught if the consumer does not recycle the product and instead just throws it away (Darby and Obara 2005).

Labeling

An important and integral part of the disassembly and recovery process is proper materials labeling. The effectiveness of both industrial-scale and consumer-scale recycling is dependent on correct material identification (Earth911 2012).

Currently, several active labeling systems are in use. The first, the resin identification codes (RID), were introduced in 1988 by the Society of the Plastics Industry (SPI 2012). RID codes were designed so that a clear, consistent system could be deployed and utilized by plastics manufacturers nationwide. Originally created to meet the needs of recyclers, these labels are the most common in the marketplace but are potentially misleading. They identify only the type of resin used in the
marked plastic, not the recyclability of the product that contains the plastic, other components of the product may not be recyclable at all, this can cause confusion for consumers (Earth911 2012). Providing information on only a product’s environmental characteristics is much simpler for manufacturers but is much less effective than communicating how a product should be dealt with at the end of its product life-cycle (Lebel and Lorek 2008). Effective labeling can increase consumer awareness and improve literacy of recyclability and proper disposal procedures (Peattie 2010).

Several new labeling systems have recently been introduced: Earth911 on-product messaging, the How2Recycle Label, and the Auto-ID RFID tagging system. The Earth911 and How2Recycle Labels both direct the consumer to their respective websites for more information, while the Auto-ID system is generally geared more towards commercial and industrial uses.

The Earth911 label contains only a web address (Earth911.com) and a phone number (1-800-CLEANUP). Manufacturers typically locate the Earth911 on-product messaging in close proximity to the products UPC label information.

The How2Recycle Label includes information about which materials are recyclable and can be located anywhere on the product packaging. However the How2Recycle Label only applies to the products packaging materials, not the product itself (How2Recycle 2012). Also, the accompanying website, How2Recycle.info, does not provide additional information about the product packaging, it merely explains the label system itself.

The Auto-ID RFID tagging system is part of a larger scale Lifecycle Information System (LIS) that tracks and attaches information to a product throughout its entire product lifecycle. The system makes available critical information about product components, material make-up, and disassembly procedures, as well as various other types of information (Parlikad and McFarlane 2007). Auto-ID’s primary purpose in a products end-of-life scenario is to maximize the product recovery model. While the Auto-ID system carries with it exceptional detail of information and utility it is still aimed at industrial-scale use. The system is not feasible for end-consumer use especially considering it requires the use of RFID reading equipment as well as access to closed corporate lifecycle information systems.

“Insufficient disassembly information leads to inefficient manual disassembly.”

Auto-ID Centre, Cambridge, UK, June 2003
Earth911 and the How2Recycle Label are effective at providing the consumer with a direct conduit to supplementary recycling information regarding the packaging or product they wish to dispose of. Auto-ID RFID tagging is a feature-rich system but is not applicable in the realm of consumer use.

Information Systems

Consumer education is the most effective means to motivate people to participate in recycling programs (Vicente and Reis 2008). Many sources are available, the most prevalent being websites. Many manufacturers, such as Apple, GE, Xerox, Samsung, Panasonic, and HP, to name just a few, provide resources for disposing of their products, mostly in the form of drop-off and take-back programs.

Apple provides the consumer with two options for recycling their old and end-of-life products on its website (www.apple.com/recycling/), an exchange for usable products, and another for products that no longer function.


There are also numerous third-party websites, run by local recyclers and governments, that provide recycling information. The previously mentioned Earth911 website (www.earth911.com) provides consumers with information regarding local recycling facilities and collection points, available for thousands of locations, as well as information about materials and their recyclability.

E-World Recyclers collaborates with many electronics manufacturers and operates E-World online (http://e-worldonline.com). This website provides consumers with information about retailers that accept products for recycling, and about various electronics manufacturers' individual recycling initiatives: mail-back programs, drop-off locations, and recycling events. These resources are specific to e-waste associated with consumer electronics devices.

None of these websites, though they provide consumers with a wealth of information, offer the variety that would enable consumers to take a more active role in disassembling a product.

Given the landscape of currently available solutions, a gap appears to exist in terms of commodity-grade appliances, both in design considerations and information systems. Therefore, the purpose of this project is to design a system to empower consumers to become more involved in the end-of-life of their commodity-grade appliances.
Methodology, Research, Design Criteria
Research
Research Methodology

This project evaluates consumer awareness, participation, and desire to participate in a consumer-focused product end-of-life system consisting of a product and its associated information systems. The project is structured as three phases:

1. consumer surveys, a survey of existing solutions, and a survey of existing products
2. peer/expert review
3. usability testing.

Population

The target population for the project is American consumers over the age of 18.

Phase 1: Survey of Existing Solutions

A survey of existing solutions for product labeling and information systems was performed. Specifically, usage scenarios and efficacy of solutions were evaluated.

Phase 1: Survey of Existing Products

A series of commodity-grade coffee makers were evaluated in terms of the following metrics: availability of recycling information, ease of product disassembly, number of materials used, types of fasteners used, and labeling of materials. These case studies provided insight into the current state of available products. The survey targeted coffee makers that cost $30 or less. This product category was chosen because this price point is the most common among coffee makers and because they are more prone to be discarded when broken and contain fewer parts and materials versus higher-cost units.

Phase 1: Survey

The goal of this survey was to gauge consumers’ recycling habits, awareness of product end-of-life procedures and programs, and willingness to participate in such programs.

Sampling

Non-probabilistic sampling methods were employed. The samples were voluntary and made up of participants who self-selected their inclusion in the project.

Data Collection Instrument

The data collection methods used in the project were in the form of sample survey. The sample survey used structured, close-ended questions. The responses to the questions were rated in statistical percentages. The percentage of respondents for each survey response was given and analyzed.
Phase 2: Peer/Expert Review

Peer/expert reviews were used to gain feedback on concepts of the proposed design solutions. The proposed design solutions were narrowed to a single design direction to move forward with.

Sampling
The peer/expert review comprised 10 participants. Participants were recruited through convenience sampling and snowball sampling techniques.

Phase 3: Usability Testing

Usability testing was performed on the refined design solution and accompanying system derived from information gained from the peer/expert review session. The usability testing sessions were audio and video recorded for later analysis.

Sampling
The user testing comprised 5 participants. Participants were recruited through convenience sampling and snowball sampling techniques.
Existing Solutions — Labeling Systems

Current product labeling schemes exist to provide product information to manufacturers, consumers, recyclers, or any combination of the three. The success of any given system is providing the right information to the right party at the right time.

The following labeling and tagging systems were evaluated for their appropriateness and efficacy in relation to empowering the consumer and providing actionable information for a product’s end-of-life scenario.

+ Resin Identification Codes
+ How2Recycle.info Label
+ Earth911 On-Package Label
+ Auto-ID RFID Tagging System
Resin Identification Codes

Resin Identification Codes are the familiar symbols printed on labels or imprinted in the plastic of many products. The label is made up of the ubiquitous recycling arrows logo with the numbers 1–7 on the interior of the logo and followed by a series of letters. The numbers and letters identify what type of plastic resin the specific part that it is labeling is made from.

The RIC system was introduced in 1988 by Society of the Plastics Industry (SPI), the plastics industry trade association representing the third largest manufacturing industry in the United States. The codes were created for use by recyclers as a uniform identification for resin content. Used typically for packaging materials, they are now also used on many product parts that use plastic resins.

Contrary to popular belief, the logo itself does not signify the recyclability of the product or part but only the resin it is made of (SPI 2012).

Resin Types Identified

#1 - PET: Polyethylene Terephthalate
#2 - HDPE: High Density Polyethylene
#3 - PVC: Polyvinyl Chloride
#4 - LDPE: Low Density Polyethylene
#5 - PP: Polypropylene
#6 - PS: Polystyrene
#7 - OTHER: Resins not included in 1–6

"The RICs are used solely to identify the plastic resin used in a manufactured article."

SPI: The plastics industry trade association
How2Recycle.info Label

The how2recycle.info label was developed by the non-profit organization GreenBlue to give consumers an easy-to-understand, on-package label for how to recycle product packaging. The label contains information about the packaging materials as well as special instructions for more complicated recycling procedures.

The how2recycle.info label was just recently officially launched (Q1 2013); therefore, adoption in the packaging industry is fairly limited. The program does have the backing of many large corporations. Currently the label is in use by Costco Wholesale, Seventh Generation, Microsoft, REI, Ampac, The Estée Lauder Companies, General Mills, Sealed Air, Clorox, Best Buy, and Minute Maid.

The label is modeled after a program that began in the United Kingdom, the On Pack Recycling Label, created by the British Retail Consortium (How2Recycle.info 2013)
The Earth911 on-package label and the accompanying earth911.com website were created by Infinity Resources Holdings Corporation.

The label’s purpose is to direct consumers to use either the website (earth911.com) or the telephone number (1-800-CLEANUP) to find information on recycling locations in their local area. The label consists of a recycling arrows logo, text that may be unique to the product that it accompanies, the url for the earth911 online directory, and the phone number for the directory. Product barcodes and also QR Codes may also be incorporated into the label.

The label itself does not provide the consumer with any actionable recycling information (Earth911 2012).
Auto-ID RFID Tagging System

The Auto-ID RFID tagging system was originally developed at the MIT Auto-ID Center, which later expanded to a network of university centers now called the Auto-ID Labs network.

The Auto-ID system began with the objective of replacing the UPC or barcodes on products with an electronic product code (EPC) in the form of a radio frequency identification (RFID) tag. The purpose of the system is to act as a Lifecycle Information System (LIS) that attaches information to a product from initial creation to its end-of-life.

The RFID tags work in conjunction with an RFID reader/scanner and a database that stores product information. Information such as a unique product identity, identity information, material composition, design information, product information throughout its lifecycle, performance parameters, process instructions, and disposal information and instructions.

The ability to connect the unique product identity to an external database provides the opportunity to link as much information as desired by the manufacturer. It also allows for the continual updatability of the attached product information and prevents loss of the attached information after the point-of-sale, common with many product labeling/tagging systems. (Auto-ID Labs 2013)
Labeling Systems — Shortcomings

The four evaluated systems all have positive benefits and work well in their respective market spaces. However, none of the systems address making consumers more active participants in the recycling experience and the products’ end-of-life. Therefore, opportunities exist to expand the role of product labeling to include more actionable information for the consumer so that they may more easily become involved.

Resin Identification Codes

Resin Identification codes do just as the name suggests: they identify the plastic resins used to manufacture the part/product/packaging in question. The identification of the resin, while important to recyclers in facilitating proper sorting during recycling, is not aimed at the consumer. The code does not provide the consumer with actionable information. It does not imply the recyclability of the item on which it is located, potentially leading to confusion among consumers. Some resin codes are not easily or readily recycled in many areas, and resin code 7 cannot be recycled. Code 7 is a catch-all code for any resin or mix of resins that do not fall into categories 1–6. The composition of code 7 cannot be determined efficiently, and in some cases the composition cannot be determined at all.

How2Recycle.info Label

The How2Recycle.info label is a well-developed system that provides consumers with actionable information on how to dispose of product packaging that bares the logo. The label identifies the various parts and their recyclability as well as providing instructions for more complex actions. Nonetheless, the system currently targets only product packaging and containers and not the product itself, leaving the consumer wanting for information about proper product disposal procedures.

Earth911 On-Package Label

The Earth911 on-package label system is another well-developed system that provides the user with actionable information. The label directs consumers to either a website or telephone number where they are provided with additional recycling information. The label is clearly defined and easy to understand. On its own it has few shortcomings in terms of functionality.

Auto-ID RFID Tagging System

The Auto-ID system has the ability to attach unlimited amounts of information to a product that remains throughout the product’s lifecycle. However, a specialized RFID scanner is required to retrieve the information, removing it from the reach of consumers, along with the fact that the information is locked away in decentralized proprietary corporate databases.
Existing Solutions — Information Systems

Current product information systems exist to provide product information to consumers. The success of any given system is providing the right information to accomplish the desired outcome. The following information systems were evaluated for their appropriateness and efficacy in relation to empowering the consumer and providing actionable information for a product’s end-of-life scenario.

+ User Manuals
+ Manufacturer Websites
+ Earth911.com Recycler Database
+ E-World Online
User Manuals

The user manuals provided by appliance manufacturers for their coffee makers were evaluated for inclusion of information about disposal/recycling procedures at the end of the products useful life. Of the 16 appliance brands, none of the user manuals provided any information about product disposal, product material compositions, or any sort of recycling procedures.

Disposal/Recycling Information Available in the User Manual

<table>
<thead>
<tr>
<th>Brand</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black &amp; Decker</td>
<td>None</td>
</tr>
<tr>
<td>Bunn</td>
<td>None</td>
</tr>
<tr>
<td>Cuisinart</td>
<td>None</td>
</tr>
<tr>
<td>Delonghi</td>
<td>None</td>
</tr>
<tr>
<td>Hamilton Beach</td>
<td>None</td>
</tr>
<tr>
<td>Kalorik</td>
<td>None</td>
</tr>
<tr>
<td>Keurig</td>
<td>None</td>
</tr>
<tr>
<td>Kitchenaid</td>
<td>None</td>
</tr>
<tr>
<td>Magic Chef</td>
<td>None</td>
</tr>
<tr>
<td>Melitta</td>
<td>None</td>
</tr>
<tr>
<td>Mr. Coffee</td>
<td>None</td>
</tr>
<tr>
<td>Presto</td>
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</tr>
<tr>
<td>Proctor Silex</td>
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</tr>
<tr>
<td>Rival</td>
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</tr>
<tr>
<td>Select Brands</td>
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</tr>
<tr>
<td>Westbend</td>
<td>None</td>
</tr>
</tbody>
</table>
Manufacturer Websites

The websites of manufacturers of coffee makers were evaluated for inclusion of information about disposal/recycling procedures at the end of the products useful life. Of the 16 appliance brands, none of the websites provided any information about product disposal, product material compositions, or any sort of recycling procedures.

In addition, none of the evaluated manufacturer websites included any information about corporate responsibility in regards to the environment.

Disposal/Recycling Information Available on the Website

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<thead>
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<th>Information</th>
<th>Website Link</th>
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<td>Bunn</td>
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<td><a href="http://www.bunnathome.com">www.bunnathome.com</a></td>
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<tr>
<td>Cuisinart</td>
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<tr>
<td>Westbend</td>
<td>None</td>
<td><a href="http://www.westbend.com">www.westbend.com</a></td>
</tr>
</tbody>
</table>
Earth911.com Recycler Database

The Earth911.com website provides consumers with access to a multitude of information and recycling resources. Run by Infinity Resources Holdings Corporation, the website provides articles about sustainability, recycling, and living a more environmentally friendly lifestyle.

The largest and most important feature of the website is the recycler database. Earth911.com compiles, fact checks, and maintains a database of local recycling resources for the entire United States. Earth911.com works with industry and corporate partners to provide accurate, up-to-date recycling information for over 300 different materials.

Users are able to search the database for local recycling centers and drop-off locations. The data can be presented as a list, map, curbside pick-ups, local programs, and mail-in programs (Earth911 2012).
E-World Online

The E-World Online website caters to consumers, manufacturers, and recyclers alike. The system focuses primarily on electronics and e-waste programs.

The manufacturer programs provide manufacturers access to the Manufacturer Interstate Takeback System (MITS) and to E-World’s network of preferred recyclers. E-World Online also provides regulation compliance, access to drop-off locations, and customized mail-back programs. Companies currently using the system include Sony, LG, NEC, Viewsonic, and Onkyo.

E-World’s recycler program allows recyclers to be included in its nationwide preferred provider MITS network; it also can provide recyclers with higher recycling volumes.

The consumer-focused component of the system provides the ability to search for local or nationwide programs for the consumer to participate in. The website also features search functions, mail-back programs, drop-off locations, recycling events, and retailer locations (E-World Online 2010).
### Information Systems — Shortcomings

The four evaluated information systems all provide information about general product categories, but only two provide useful actionable information to the consumer about a product’s end-of-life options. Opportunities exist to create a new system, one that provides the consumer with information specific to individual products that includes detailed steps that they may take to become more involved.

#### User Manuals

The user manuals provided by the product manufacturers for the 16 evaluated coffee makers provide usage instructions, warranty information, and safety instructions. The manuals do not provide any form of information pertaining to the proper disposal or recycling of the coffee makers.

#### Manufacturer Websites

Each of the 16 manufacturers have websites for their products, and each of the evaluated coffee makers can be found on these websites. However, none of these websites provide any information about recyclability or proper disposal procedures. Of all of the manufacturer websites, only Keurig makes any mention of corporate environmental responsibility.

#### Earth911.com Recycler Database

While the Earth911.com recycler database provides a wealth of good recycling information to consumers, it doesn’t provide information for individuals who want to take a more hands-on approach to their recycling habits. It merely lists locations of recyclers requiring consumers to transport their recyclables to the external sites.

#### E-World Online

E-World Online suffers from the same shortcomings as the Earth911.com recycler database in terms of this project. The site lists locations of recyclers for consumers to transport their goods to. It also displays the information in a less aesthetically pleasing and less usable manner. One positive aspect of the site is that it assists users in finding manufacturer mail-back programs.
Existing Solutions — Consumer Involvement

Many systems already exist that enable users to take a more active role. The following systems and information sources were evaluated for their successfulness, especially in terms of educating the consumer and providing useful information for users interested in a more active role in the lives of the products they own.

+ IKEA
+ iFixit.com
+ eHow.com
+ Herman Miller
IKEA

IKEA is a global home furnishings brand and network of warehouse stores. IKEA began in the 1940’s, started by Ingvar Kamprad. In the mid 1950’s, IKEA began to develop its signature flat-pack system of affordable furniture design.

The flat-pack model of furniture design and distribution allows IKEA to cut costs on shipping and assembly. The self-serve warehouses also save money and allow for lower prices.

The use of flat-packing also injects a fair amount of “do-it-yourself” into the furniture buying experience. Flat-packing requires the consumer to assemble the furniture themselves. All of the parts required for assembly are retrieved from warehouse shelves by the consumer within the IKEA store and taken home for assembly.

Each piece of furniture includes instructions and simple tools for assembly. The directions are presented in a simplified pictographic manner. This approach allows individuals, regardless of language, to follow along and assemble their own furniture with minimum difficulty (IKEA 2012).
iFixit.com

iFixit.com is an online repair community that caters to do-it-yourselfers, hackers, and tinkerers. Established in 2003, the site focuses mainly on repair guides for consumer electronics. The site also covers upgrading, troubleshooting, and question-and-answer queries. The company has a store selling any tools needed to use the repair guides.

The site allows consumers to repair and/or prolong the life of their products without the need for external assistance free of charge.

The repair guides are laid out in a very usable style, step-by-step, with large images including callouts and text instructions (ifixit 2012).
Another online community with very similar functionality to that of ifixit.com is eHow.com. eHow provides how-to guides, separated into more than thirty categories. The main categories are home, mom, style, food, tech, money, and health. The site contains more than two million how-to articles and videos produced by both professional contributors or community members (ehow 2012).
Herman Miller

Herman Miller is a 100-plus year old furniture manufacturer based in Michigan, USA. Herman Miller integrates sustainability into much of its business model. The company incorporates DfE (Design for the Environment) into its design process. Herman Miller designs furniture for repeated use, repair, maintenance, and reassembly using standard parts, as often as possible. Herman Miller also subscribes to the MBDC Cradle to Cradle Design Protocol, applying it to all new and future product designs.

For example, the Herman Miller Mirra chair pictured below is 97% recyclable. Through the website (www.hermanmiller.com), consumers can download information about the materials and procedures involve with the production of the chair. Also available are the Leadership in Energy and Environmental Design (LEED) ecoScorecard and various environmental certifications. Most importantly, users can download step-by-step recycling instructions on how to dismantle the chair for recycling and disposal. The instructions contain a required tool list and are fully illustrated (Herman Miller 2011).
User Involvement — Successes

IKEA

The IKEA concept of producing furniture of an expected quality, flat-packing, self-service, and self-assembly has proven exceptionally successful. IKEA began as a one-man operation in 1943 and as of 2012 has 338 stores and 154,000 employees.

One phenomenon that has arisen from the success of IKEA is the “IKEA effect.” The IKEA effect essentially is the increased perception of valuation of self-made products. The fact that the individual’s labor, whether enjoyable or not, led to successfully completing the task can induce greater affection for the finished product. This emotion can lead to people believing that their own work is of similar quality to a professional craftsman’s and the expectation that others also do so as well (Norton, Mochon et al. 2012).

The IKEA effect, in this instance, with actual IKEA products can lead to greater satisfaction with the overall experience and end product.

iFixit.com

iFixit.com provides simple, clear, easy-to-understand instructions. Users of the site have the opportunity to maintain and repair thousands of electronic devices. The ability to repair a broken product saves money by prolonging its useful life and can possibly contribute to the above “IKEA Effect.”

Herman Miller

Herman Miller has implemented the ideals of sustainable design throughout its design and manufacture processes. By subscribing to the guidelines of DfE, DfD, and Cradle-to-Cradle, Herman Miller has enabled consumers to take a high level of control over the end-of-life of their furniture. Should they choose to, the owner can completely dismantle many of Herman Miller’s well-made products. This allows for the proper disposal and recycling.

Lessons learned from each of these companies processes, such as simple, clear, step-by-step instruction, and personal ownership of a process factored heavily into the formation of the design criteria for this project.

eHow.com

eHow.com aims to assist the same audiences as both IKEA and iFixit.com, the casual consumer willing to go a little farther in their shopping/consuming experience, the “do-it-yourselfer,” as well as individuals with more advanced skillsets. eHow.com also shares the same successes as both IKEA and iFixit.com. eHow.com, however, affords the user the opportunity to apply the do-it-yourself mentality to many more categories of experience. eHow.com serves up how-to guides that span the breadth of everyday life.
Survey of Existing Products

The commodity-grade coffee maker appliance category is important to focus on because of the current lack of end-of-life considerations. Automatic drip coffee makers tend to have a relatively short product life span, approximately six years (Mudgal 2011), the shortest of all categories of coffee maker. Manufacturers do not provide adequate information regarding appropriate methods of disposal in terms of recycling and material recovery on their websites nor in product literature. Current coffee maker designs do not provide for meaningful consumer involvement in their disassembly. In addition, many of the materials involved are not identified in a manner that is familiar to consumers or are not labeled at all making recovery difficult or impossible. Specific attention will be paid to coffee makers that have a capacity of 12 cups and a price point of $30.00 or less. These coffee makers make up the largest segment of coffee makers sold, with 64% and 49.2% market share respectively (ENERGY STAR 2011).

Automatic-Drip Coffee Maker

73% of Households

12-Cup Capacity

64% Market Share

$30.00 or Less

49.2% Market Share

+ Short product life span, approximately six years
+ No disposal/recycling information provided by manufacturers
To evaluate the difficulty of disassembling current commodity-grade coffee makers, ten were purchased and disassembled. The disassembly procedures were timed and photographed. The number of steps for disassembly, number of parts, and the number of fasteners were all recorded to help inform construction of the proposed redesign. See the following pages for the disassembly procedures for the Black & Decker CM1050B coffee maker and the appendix for complete disassembly procedures for each of the remaining coffee makers.
## Product Disassembly Procedures

### Manufacturer
Black & Decker

### Model
CM1050B

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
<th>Time to Disassemble</th>
<th>Steps : Parts : Fasteners</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Cup</td>
<td>$24.99</td>
<td>07:07</td>
<td>16 21 18 (16 Phillips, 2 spanner)</td>
<td>Requires special tool – spanner security bit</td>
</tr>
</tbody>
</table>

### Steps
- **Step 1**: Disconnect controller circuit board
  - 3 wires - required pliers

- **Step 2**: + Disconnect water tubes
  - 2 pieces - Press fit

- **Step 3**: + Disconnect button controls circuit board
  - Snap connector - Glued in

- **Step 4**: + Remove button controls circuit board
  - 1 piece - 3 screws

- **Step 5**: + Disconnect water tubes
  - 2 pieces - Press fit

- **Step 6**: Cut base or power cord to remove power cord

- **Step 7**: + Remove hotplate assembly
  - 1 subassembly - Snap fit

- **Step 8**: + Remove basket
  - 3 pieces - Loose

- **Step 9**: + Remove reservoir cover
  - 1 piece - Snap fit

- **Step 10**: + Remove water spout
  - 4 pieces - 1 screw - Snap fit

- **Step 11**: Separate base from reservoir
  - 2 pieces - 4 screws

- **Step 12**: + Remove chrome mylar accent piece
  - 1 piece - Snap fit

- **Step 13**: + Remove lid
  - 1 piece - Snap fit

- **Step 14**: + Remove handle
  - 4 pieces - 2 screws
<table>
<thead>
<tr>
<th>Coffee Pot</th>
<th>Coffee Maker</th>
<th>Coffee Maker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td><strong>Step 1</strong></td>
<td><strong>Step 7</strong></td>
</tr>
<tr>
<td>+ Remove lid</td>
<td>+ Remove bottom</td>
<td>+ Disconnect water</td>
</tr>
<tr>
<td>1 piece - snap fit</td>
<td>1 piece - 4 screws</td>
<td>tubes 2 pieces - Press fit</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td><strong>Step 2</strong></td>
<td><strong>Step 8</strong></td>
</tr>
<tr>
<td>+ Remove handle</td>
<td>+ Remove power cord hold down</td>
<td>+ Cut base or power cord to remove power cord</td>
</tr>
<tr>
<td>4 pieces - 2 screws</td>
<td>1 piece - 2 screws</td>
<td>4 pieces - 1 screw - Snap fit</td>
</tr>
<tr>
<td><strong>Steps 3, 4 &amp; 5</strong></td>
<td></td>
<td><strong>Step 9</strong></td>
</tr>
<tr>
<td>+ Disconnect controller circuit board</td>
<td>+ Remove hotplate assembly</td>
<td>+ Separate base from reservoir</td>
</tr>
<tr>
<td>3 wires - required pliers</td>
<td>1 subassembly - Snap fit</td>
<td>2 pieces - 4 screws</td>
</tr>
<tr>
<td>+ Remove controller circuit board</td>
<td></td>
<td><strong>Step 10</strong></td>
</tr>
<tr>
<td>1 subassembly - 2 screws</td>
<td></td>
<td>+ Remove basket</td>
</tr>
<tr>
<td>+ Disconnect button control circuit board Snap connector - Glued in</td>
<td></td>
<td>3 pieces - Loose</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td></td>
<td><strong>Step 11</strong></td>
</tr>
<tr>
<td>+ Remove button control circuit board</td>
<td>+ Remove controller circuit board</td>
<td>+ Remove reservoir cover</td>
</tr>
<tr>
<td>1 piece - 3 screws</td>
<td>1 subassembly - Snap fit</td>
<td>1 piece - Snap fit</td>
</tr>
<tr>
<td><strong>Step 12</strong></td>
<td></td>
<td><strong>Step 13</strong></td>
</tr>
<tr>
<td>+ Remove lid</td>
<td></td>
<td>+ Remove water spout</td>
</tr>
<tr>
<td>1 piece - Snap fit</td>
<td></td>
<td>4 pieces - 1 screw - Snap fit</td>
</tr>
<tr>
<td><strong>Step 14</strong></td>
<td></td>
<td><strong>Step 14</strong></td>
</tr>
<tr>
<td>+ Remove reservoir cover</td>
<td>+ Remove water spout</td>
<td>+ Remove chrome mylar accent piece</td>
</tr>
<tr>
<td>1 piece - Snap fit</td>
<td></td>
<td>1 piece - Snap fit</td>
</tr>
<tr>
<td>Brand</td>
<td>Parts</td>
<td>Screws</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Culinar AC221B</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Hamilton Beach 49316</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Proctor Silex 48521RY</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Brentwood TS-217</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Rival RV-076</td>
<td>19</td>
<td>14</td>
</tr>
</tbody>
</table>

**Disassembly Steps**

1. **Remove bottom**
   - 1 piece, Snap fit
2. **Remove power cord hold down**
   - 1 piece, 1 screw
3. **Disconnect power button**
   - 1 piece, Snap fit
4. **Remove power button and hold down**
   - 2 pieces, Snap fit
5. **Disconnect water tubes**
   - 2 tubes, Press fit
6. **Remove hot plate assembly**
   - 1 subassembly, 2 screws
7. **Remove basket**
   - 3 pieces, Loose
8. **Remove reservoir lid**
   - 1 piece, Snap fit
9. **Remove water spout top**
   - 1 piece, Snap fit
10. **Remove water riser tube**
    - 1 piece, Snap fit
11. **Remove water spout**
    - 1 piece, Captured
12. **Separate reservoir from base**
    - 2 pieces, 5 screws
13. **Separate reservoir from base**
    - 2 pieces, 3 screws
14. **Separate reservoir from base**
    - 2 pieces, 5 screws
15. **Separate reservoir from base**
    - 2 pieces, 4 screws

Time:
- Culinar: 05:31
- Hamilton Beach: 07:23
- Proctor Silex: 06:13
- Brentwood: 06:37
- Rival: 05:41

**Count:**
- Culinar: 17 parts, 14 screws
- Hamilton Beach: 19 parts, 19 screws
- Proctor Silex: 22 parts, 14 screws
- Brentwood: 18 parts, 13 screws
- Rival: 19 parts, 14 screws
Survey of Existing Products

The current landscape of commodity-grade coffee makers does not allow for high levels of consumer involvement in their proper disposal for material recovery. For most, the only option is delivery to a recycling facility. The appliances are not labeled externally with any type of information that would advertise the fact that the whole or any part could potentially be recycled. Furthermore, neither the appliance documentation nor the appliance manufacturer websites include disposal or recycling information of any nature. This lack of information could lead the consumers to think that, once the appliance is inoperable, their only recourse is to throw it away. This belief inevitably contributes to countless products needlessly being sent to landfills at their end-of-life, when in fact a high percentage of the materials could successfully be recovered for re-use. The following identified issues were used to shape the design criteria for the product labels, website, and coffee maker.

Identified Issues

- None of the coffee makers have external labeling that identifies recyclability.
- The majority of materials (i.e. plastics) used are not labeled in a manner that would be familiar or accessible to the average consumer (RID codes).
  - 3 out of 10 reviewed (Rival, Culinair, and Brentwood) contain plastics that are not labeled at all.
  - 3 out of 10 reviewed (Black & Decker, Mr. Coffee, and Delonghi) that are labeled, are done so only with text (>PP<, >ABS< etc.) that is intended for industrial recycling not consumers.
  - Of the products that do include plastic labeling, the labeling is located on the interior, not visible, surfaces of the parts.
- The majority, 7 out of 10, appliances required the use of special security bits or additional tools for disassembly.
  - Two required the use of Torx bits.
  - Five required the use of Spanner security bits, these could not be found locally.
- A specialty security bit set needed to be purchased online.
  - One required the use of a 3/8˝ socket or wrench.
  - One required the housing or wiring to be cut with wire cutters to remove the power cord.
- The need for additional and specialty tools increased the time required to disassemble the appliance.
- The need for additional and specialty tools would most likely prevent the average consumer from attempting or continuing with disassembly.
- None of the product user manuals contained information about recyclability or disposal.
• None of the product manufacturer websites contained information about recyclability or disposal.
• Several designs used additional fasteners to accomplish the same task as others with fewer fasteners, adding to the overall disassembly time.
• Several designs used additional parts to accomplish the same task as others with fewer parts, adding to the overall design complexity, disassembly steps, and disassembly time.
• Locating the controls (i.e. Mr. Coffee) on the top of the appliance above the carafe adds design complexity, additional components, and disassembly steps.

Tools Required for Disassembly

• #1 Phillips screwdriver
• Slotted screwdriver (for prying apart snap-fit parts)
• More specialized tools
  ◦ 4mm Spanner 6 inch extension security bit
  ◦ T15 Torx 6 inch extension bit
  ◦ 3/8 Socket
  ◦ Diagonal wire cutters
Consumer Survey

The goal of this survey was to gauge consumers’ recycling habits, awareness of product end-of-life procedures and programs, and willingness to participate in such programs. The survey is set up in four sections: basic demographic data, general recycling behavior, small appliances, and product information.

40 Questions

159 Total Respondents
+ 139 Complete responses
+ 20 Partial responses

Posted to online forums
+ Appliance discussion
+ Housewares
+ Family
+ Consumer
+ General Interest

20 Forums Total + Facebook + Twitter

Yes – 83.9%
Do You Recycle?

No - 16.1%
Consumer Survey

Demographic Data

**Age**

- 65+ - 3.6%
- 55-64 - 20.1%
- 45-54 - 13.0%
- 35-44 - 17.3%
- 25-34 - 30.2%
- 18-24 - 15.8%
- 5-14 - 1.0%

**What is your age group?**

**Income**

- $100k-$150k - 22.9%
- $75k-$100k - 19.9%
- $50k-$75k - 16.0%
- $25k-$50k - 18.3%
- <$25k - 9.9%
- >$150k - 13.0%

**What is your yearly household income?**

**Education**

- Bachelor's - 45.3%
- Master's - 25.9%
- Associate's - 5.8%
- High School - 16.6%
- Trade/Tech - 3.6%
- Doctoral - 2.9%
- Trade/Tech - 3.6%
- Bachelor's - 45.3%

**What is the highest level of education you have completed?**

**Housing**

- Single-family house - 71.2%
- Townhouse or Duplex - 7.3%
- Rent/Lease - 28.3%
- Rent/Lease - 28.3%
- Own - 71.7%

**What type of home do you live in?**

**Property**

- Rent/Lease - 28.3%
- Own - 71.7%

**Do you own or rent/lease your home?**

**Ethnicity**

- Caucasian/White - 84.1%
- Asian - 7.3%
- African-American - 2.2%
- All Other - 3.6%
- Hispanic - 2.9%

**What is your ethnicity?**

**Sex**

- Male - 43.9%
- Female - 56.1%

**What is your gender?**

**Household**

- 2 - 48.9%
- 5 - 2.2%
- 1 - 9.5%
- 4 - 19.0%
- 3 - 19.0%
- 2 - 48.9%

**How many people live in your household?**
General Recycling Behavior

Do You Recycle?

Yes - 83.9%
No - 16.1%

If no, what are the reasons you do not recycle?

- 4.6% - It won't make any difference
- 9.1% - I don’t think about recycling
- 9.1% - I don’t know how to recycle
- 13.6% - All that stuff is thrown away in the landfill (dump) anyway
- 13.6% - It takes too much time
- 18.2% - I don’t have enough garbage or recyclables to warrant it
- 27.3% - Other
- 36.4% - I don’t have space or the right kind of containers
- 50.0% - It’s difficult and/or a hassle to recycle

Recycle More?

Yes - 87.1%
No - 12.9%

Would you recycle if you were more informed about your options?

Motivation

- Coupons - 40.4%
- More information - 55.6%
- Rebates - 58.6%
- Incentives - 68.7%

What would motivate you to recycle more?

- Not at all important - 8.0%
- Very important - 48.6%
- Fairly important - 43.5%

Personally

How important is recycling to you personally?

- I do not recycle - 13.0%
- I recycle everything that can be recycled - 50.0%
- I recycle a lot but not everything that can be recycled - 37.0%

Home

Which of these statements comes closest to how much you recycle at home?

- Small Appliances - 29.9%
- Large Appliances - 37.2%
- Electronics - 56.2%
- Household waste - 92.4%

Options

Which of the following do you/have you recycled?

- Other - 0.7%
- Don’t know - 0.8%
- Fewer imports - 13.1%
- Job creation - 25.6%
- Lower costs - 27.0%
- Air quality - 4.3%
- Better use of resources - 73.7%
- Saves landfill space - 88.3%
- Better for environment - 99.4%

Benefits

What benefits do you believe recycling brings?

- 88.3% - Religious Organizations
- 41.9% - Thrift Stores
- 49.6% - Salvation Army
- 89.9% - Goodwill

Reuse

Do you donate goods for reuse?

- Yes - 93.5%
- No - 6.5%
Consumer Survey

Small Appliances

Views on small kitchen appliances (i.e. coffee makers, blenders, etc.) and their recycling/disposal options at the end of their useful life.

Do you think manufacturers are doing enough to encourage and promote recycling?

- Yes - 86.2%
- No - 13.8%

Would you be willing to take a more active role in recycling your old appliances?

- Yes - 86.2%
- No - 13.8%

Do you think that consumer products should be made so that they are easier to recycle?

- Yes - 89.2%
- No - 10.8%

If provided simple instructions, would you be willing to perform some minor disassembly in order to fully recycle an old appliance?

- Yes - 85.6%
- No - 14.4%

Would you be more willing to purchase an appliance that was recyclable over one that was not?

- Yes - 76.8%
- No - 23.2%

How much disassembly would you be willing to perform to recycle an appliance?

- Minor – No tools - 45.7%
- Minor – 1 tool - 59.8%
- Moderate – >1 tool - 39.1%
- Major – Specialized tools - 02.9%
- None - 00.8%

How much time would you be willing to spend on disassembly?

- >20 minutes - 10.3%
- 16-20 minutes - 16.2%
- 11-15 minutes - 30.9%
- 6-10 minutes - 39.7%
- 0-5 minutes - 45.6%

Would you be willing to take a more active role in recycling of your appliances/products if you had an incentive?

- Yes - 83.3%
- No - 16.7%
Product Information

Views on product information and its availability.

- **Disposal Info**
  - No: 10.1%
  - Yes: 89.9%

- **Manual**
  - No: 27.3%
  - Yes: 72.7%

- **Delivery**
  - Manual: 46.0%
  - Website: 73.4%

- **Direction**
  - I wouldn't: 03.7%
  - QR code: 30.2%
  - NFC chip: 06.6%
  - A combination of the methods: 30.2%
  - Website address (url): 79.4%

- **Available Info**
  - Materials the appliance contains: 46.7%
  - Incentives to recycle: 67.9%
  - Recall information: 72.3%
  - Recycling information: 83.2%
  - Disposal instructions: 84.7%
  - Repair parts and instructions: 86.9%
  - Maintenance information: 91.3%

- **URL**
  - No: 10.1%
  - Yes: 89.9%

- **Source**
  - Included in the manual: 24.4%
  - Separate manufacturer websites: 21.4%
  - A centralized website for multiple products: 54.2%

- **Information Availability**
  - No: 2.2%
  - Yes: 97.8%

- **Information on product placement**
  - No: 43.9%
  - Yes: 56.1%

- **How much time would you be willing to spend on disassembly?**
  - 0-5 minutes: 45.6%
  - 6-10 minutes: 39.7%
  - 11-15 minutes: 30.9%
  - 16-20 minutes: 16.2%
  - >20 minutes: 10.3%

- **How much disassembly would you be willing to perform to recycle an appliance?**
  - Minor – 1 tool: 55.8%
  - Minor – No tools: 45.7%
  - Moderate – >1 tool: 39.1%
  - None: 05.8%
  - Major – Specialized tools: 02.9%

- **How would you prefer to be directed to a website?**
  - No: 13.8%
  - Yes: 86.2%

- **Would you be more willing to purchase an appliance that was recyclable over one that was not?**
  - No: 23.2%
  - Yes: 76.8%

- **How would you prefer the information be provided?**
  - Included in the manual: 24.4%
  - Source: A centralized website for multiple products: 54.2%

- **Do you think manufacturers are doing enough to encourage and promote recycling?**
  - No: 10.8%
  - Yes: 89.2%

- **Do you think consumer products should be made so that they are easier to recycle?**
  - No: 23.2%
  - Yes: 76.8%

- **Would you be willing to take a more active role in recycling your old appliances?**
  - No: 13.8%
  - Yes: 86.2%

- **If the appliance included a website address (on the product or label) would you use it to access additional information?**
  - No: 86.0%
  - Yes: 14.0%

- **How would you typically save the documentation that comes with your appliances?**
  - No: 86.0%
  - Yes: 14.0%

- **Do you think more information should be included with products in terms of how to properly dispose of them?**
  - No: 10.1%
  - Yes: 89.9%

- **If provided simple instructions, would you be willing to perform some minor disassembly in order to fully recycle an old appliance?**
  - No: 14.4%
  - Yes: 85.6%

- **What information would you like to have available?**
  - No: 10.1%
  - Yes: 89.9%

- **Would you want these types of information available for more of the products you buy?**
  - No: 86.0%
  - Yes: 14.0%

- **Incentives to recycle**
  - No: 86.0%
  - Yes: 14.0%

- **Recall information**
  - No: 86.0%
  - Yes: 14.0%

- **Maintenance information**
  - No: 86.0%
  - Yes: 14.0%

- **Recycling information**
  - No: 86.0%
  - Yes: 14.0%

- **Repair parts and instructions**
  - No: 86.0%
  - Yes: 14.0%

- **Materials the appliance contains**
  - No: 86.0%
  - Yes: 14.0%
87.1% of respondents would recycle more if they were more informed of their options.

Only 29.9% of respondents have recycled small appliances in the past, the lowest percentage of any type of recycling.

69.8% of respondents have curbside pickup of recycling.

86.0% of respondents believe that manufacturers are NOT doing enough to promote recycling.

89.2% of respondents think consumer products should be made easier to recycle.

76.8% of respondents would be willing to buy an appliance that is recyclable over one that is not.

86.2% of respondents would be willing to take a more active role in recycling their appliances.

85.6% of respondents would be willing to perform minor disassembly in order to recycle their old appliances.

55.8% of respondents would perform disassembly requiring one tool.

Most would spend up to 15 minutes on disassembly.
Analysis Highlights

89.9% of respondents think disposal information should be available for the products they purchase.

73.4% of respondents would prefer to get more information from a website.

89.9% of respondents would use a url to located on a product to access additional information.

97.8% of respondents would want information available for more of the products they buy.

54.2% of respondents, a majority, would prefer to the url to direct to a centralized website for multiple products.

Survey respondents showed a fairly consistent level of congruency for most questions across all of the different demographics. Most questions, especially when the response percentages are highly bias toward an extreme, response percentages tended to be within 5-10 percentage points of one another. The survey data corroborates the idea that consumers want more information and believe that recycling, recycling information, and end-of-life options should be important considerations when designing a product.
Design Objectives & Criteria

Based on the performed background research, along with analysis of data collected from the surveys of existing solutions and products, and consumer survey, the following design objectives and criteria were developed for the three part system.

Overall

1. Redesign a commodity-grade coffee maker using DfD methodologies that would allow the consumer to participate in disassembly.
2. Design a labeling system to direct consumers to a website about the end-of-life options for the coffee maker.
3. Design a centralized website to provide the consumer with end-of-life-options for a product.

Coffee Maker

1. Design using Design for Disassembly guidelines
   a. Minimize number of parts
   b. Minimize types of fasteners
   c. Minimize permanent fixation
   d. Minimize toxic chemicals and materials
   e. Minimize the use of paint and coatings
   f. Use easy to disassemble fasteners
   g. Identify material types used (using familiar RID codes)
2. Design for high recyclability
   a. Use materials that allow for recycling and full reintroduction to the material stream
   b. Use post-consumer recycled content if possible
   c. Minimize the number of materials used
   d. Identify material types used (using familiar RID codes)
3. Design for consumer disassembly at the product’s end-of-life
   a. Use common fastener types
   b. Do not require the use of special tools
   c. Utilize IML (In Mold Labeling) to demarcate fastening points when necessary
4. Easy to use/Continuity
   a. Maintain common user interface/experience affordances
Labeling

1. Inform users of end-of-life options (recycling logo and or verbiage)
2. Include required appliance information (serial, UL, etc.)
3. Make it easy to read and understand
4. Provide a means to direct the consumer to the website
   a. QR code
   b. URL

Website

1. Present end-of-life options for the given appliance
   a. Step-by-step instructions for disassembly
   b. Instructions for proper disposal
      i. Local recycling resources
   c. Instructions for possible manufacturer take-back programs
2. Provide information about parts and materials for the given appliance
   a. Types of plastic
   b. Hazardous materials
3. Simple UI/UX
4. Design using responsive web design methodologies to facilitate direct usage from smartphones and tablets
5. Possible additional upgrades
   a. Provide information about repair options
   b. Provide information about reuse options for viable appliances (Goodwill, Salvation Army, etc.)
   c. Incentivize the act of recycling
Inspiration, Ideation, Iteration
Design
Design Inspiration — Labeling

The howtorecycle.it label is the first point of contact with the system that the consumer will experience. The presentation of information needs to be clear and concise. Labels that included pertinent manufacturer information, website addresses, QR codes, and appropriate iconography were searched for.
Design Inspiration — Websites

For the website component of the project design, inspiration that was simple, and elegant was sought out. Ideas were drawn from current website designs that possess clean lines and modern style. The design needed to highlight the three main sections of the website: recycle.it, repair.it, and reuse.it. Finding a layout that accommodated the necessary sections was of key importance and a driving factor for the design direction.
Design Inspiration — Coffee Makers

As with the howtorecycle.it label and website, clean modern lines were the goal. Initially, the idea of redesigning a commodity-grade appliance did not elicit feelings or thoughts of great design. An objective of the project then evolved into providing a level of design that while remaining inexpensive to manufacturer would be on par with higher priced units. The design also had to accommodate all of the necessary features of the design for disassemble/recyclability goals of the project and allow for disassembly by the consumer.
The proposed user experience for the developed system using the established coffee maker case study:

1. The coffee maker breaks
2. Using the howtorecycle.it label the consumer is directed, by url or taken by QR code, to the howtorecycle.it website
3. Once at the howtorecycle.it website the user is given step-by-step instructions for how to disassemble and properly dispose of the broken coffee maker
4. The user disassembles the coffee maker per the provided instructions, recycling the recyclable materials and either discarding or returning the non-recyclable parts to the manufacturer.
Somewhere a Coffee Maker Breaks
Consumer Begins Appliance Disassembly
Collect Necessary Tools
Disassemble Appliance Per Instructions
Non-Recyclable Parts
Recyclable Parts
Discard
Return to Manufacturer
Additional Recycling/Reuse/Discard
Send to Landfill
Place into Recycle Bin For Collection
Recyclable Parts
Materials Re-enter Manufacturing Stream

User Enters Website Through Homepage
Homepage
Recycle.it General Information Product Disassembly and Recycling
Repair.it General Information Product Repair Manuals, Parts
Reuse.it General Information Product Donation (Organizations, Maps)
Corporate Information
User Enters Website By QR Code or Direct URL
Product Detail Page
Manuals How-tos Parts
Repair Information
Step-by-step Disassembly Instructions
Recycling Information
Drop-off/Collection Locations
Materials & Manufacturing Information

Website

Disassembly

Label
Ideation — QR Codes

Quick Response (QR) codes are two-dimensional barcodes originally designed for use in the Japanese automotive industry by Denso Wave Corporation. With the increasing ubiquity of smartphones, QR codes have quickly become popular for advertising and product labeling. Their ability to store different types of data that can be read quickly with an app to provide consumers with actionable information can be invaluable. A total of 15 design variations were created. For more technical information about QR codes, see appendix.

These QR codes are encoded with the url (web address): http://www.howtorecycle.it/5Tgy8x. When consumers scan the code with a smartphone or tablet, they will be taken directly to the website.
Ideation — Labels

The redesigned product labels, while incorporating additional information, needed to convey all of the product's required manufacturer and regulatory information. The labels also needed to keep within the constraints of current size limitations given their placement on the product. A total of 25 concept variations were created. See the appendix for all of the label design iterations.

#1 - 3” x 2”

Simple Appliance Co. 12 Cup Coffeemaker Model: AU90377
Read Instructions Before Using Do Not Immerse In Liquid Household Use Only

Made in China 120V - 60hz 1000W

For recycling and disposal information please visit: howtorecycle.it/5Tgy8x

#2 - 1.75” x 3”

Simple Appliance Co. 12 Cup Coffeemaker Model: AU90377
120V-60hz-1000W Household Use Only
Caution: Do Not Immerse In Liquid

Made in China Read Instructions Before Using

For recycling and disposal information please visit: howtorecycle.it/5Tgy8x

#4 - 3” x 1.5”

Simple Appliance Co. 12 Cup Coffeemaker Model: AU90377
Read Instructions Before Using Household Use Only Caution: Do Not Immerse In Liquid
Made in China 120V-60hz-1000W

For recycling and disposal information please visit: howtorecycle.it/5Tgy8x

#7 - 2” x 1.25”

Simple Appliance Co. 12 Cup Coffeemaker Model: AU90377
120V-60hz-1000W Made in China

Read Instructions Before Using Caution: Do Not Immerse In Liquid

For recycling and disposal information please visit: howtorecycle.it
Ideation — Website

The design of the website needed to be easy to understand and simple to use. The goal was to create a simple navigational scheme that drove consumers directly to what they needed. Text as well as graphic icons are used to differentiate each section. The site structure is separated into 3 main sections.

1. recycle.it - information needed to properly dispose of an end-of-life product
2. repair.it - information on how to repair products
3. reuse.it - information on how and where a still working product may be donated

The colors green and blue were chosen because of their inherent connection to recycling and the sustainability movement in general.

Three main concepts were designed with ten total variations. See the appendix for details of all of the concepts.

Concept 1a

Concept 1c
Ideation — Coffee makers

The coffee maker component of the system posed several challenges. The coffee maker needed to retain all of its expected functionality while adding supplementary design considerations to enable more consumer participation in its end-of-life. Adding key disassembly features was the main objective of the design, but overall aesthetics was also essential.

Concept 1
Peer Review

Once the initial ideation for each of the system components, label, website, and coffee maker were completed, the concepts were brought before a group of peers and experts to determine the direction moving forward for each item. Below are the designs chosen for further refinement.

Labels

Concept 14 - 3” x 2.25”

Concept 19 - 2” x 3”
Website

Concept 1c

Concept 2c

Coffee Maker

Concept 2
howtorecycle.it Label

The final label design was derived from 25 concepts and on insights and opinions from the peer/expert review. The label is intended to replace the standard manufacturer label typically placed on the bottom or rear surface of the product.

Manufacturer Voice
Font: Advent Pro
Color: Black

howtorecycle.it Voice
Font: logo: Cherry Swash
text: Helvetica Neue
67 Medium
Color: C50 M0 Y100 K25
C90 M30 Y95 K30
Label Anatomy

Manufacturer Information
Warning/Safety Information
Certification Information
Technical Specifications

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

Read Instructions Before Using
Do Not Immerse In Liquid    Household Use Only

120V - 60hz
1000W
Made in China

For more information
scan code or visit:
www.howtorecycle.it/5Tgy8x

Product Specific Website URL
Product Specific QR Code
Instructions
howtorecycle.it Logo
howtorecycle.it Website

The following website was developed based on a combination of concepts 1c and 2c, and on insight from the peer/expert review session. Layouts were created for the homepage and all necessary internal pages.

The domain names howtorecycle.it, howtorecycleit.com, and howtorecycleit.info were all acquired for use, the latter two forwarding to the main domain howtorecycle.it.

The website is designed to be fully responsive (see appendix) in an effort to accommodate the growing number of users accessing the website from various devices. The website will proactively adapt and serve the site most appropriate for the user. Devices can range from smartphone to tablet to desktop computer. Users will experience a cohesive, smooth, usable experience no matter the method of access.

The website was coded using the following modern web technologies:

- HTML5
- CSS3
- Twitter Bootstrap Framework
- Twitter Bootstrap Responsive Framework
- PHP
- MySQL
Homepage
howtorecycle.it Website

The website is organized in three main sections, plus secondary pages.

**recycle.it**

The recycle.it section of the website provides consumers with all of the necessary information for them to properly dispose of their end-of-life product, including difficulty level, tools needed, and step-by-step instructions on how to disassemble and dispose of their product.

**reuse.it**

The reuse.it section of the website is available for consumers who have a product that has not quite reached the end of its useful life. The section consists of a search function that would provide a local map and information on local service, religious, and charity organizations where the still-working products could be donated. See appendix for more information.

**repair.it**

The repair.it section of the website provides information on available repair mechanisms, whether “DIY” repair guides, information on third-party repair resources, or links to possible service and repair parts for sale. See appendix for more information.

**Site Architecture**

Users can approach the site in two ways: by accessing the website directly in a browser by manually typing in a website address, or by scanning a QR code on a howtorecycle.it label with a smartphone or tablet.
recycle.it section

Simple Appliance: AU90377A: Coffee Maker

Is your coffee maker no longer working? Are you ready to properly dispose of it? Let’s get started!

Disassembly Instructions

Below are all the instructions necessary to properly dispose of the Simple Appliance’s AU90377A Automatic Drip Coffee Maker.

Difficulty Level: Beginner

Required Tools

#1 Phillips Screwdriver

Step 1

- Turn the coffee maker onto its side to find the four screw holes located on the bottom.
Coffee Maker

The following redesign of a commodity-grade coffee maker is intended to be a case study. The redesign employs design and manufacturing techniques to illustrate how a manufacturer might approach a product's design in ways that would allow the consumer to become more involved in its end-of-life. The ultimate outcome of the redesign being to achieve higher levels of recyclability.
Orthographic Views
Filter

Water Reservoir

Carafe

Internal Components
User Testing

User testing was performed to determine the preferred and most efficient disassembly method for a coffee maker.

The user testing consisted of 5 testing participants, recruited by word of mouth.

The test participants were asked to disassemble the internal components of a control coffee maker (Black & Decker CM1050B), as well as three models. The models were constructed from a combination of sign foam and medium-density fiberboard and designed as volumetric placeholders for a coffee maker each with a different method for disassembly.

New disassembly methods tested:

1. 4 Machine screws
2. 4 Thumb screws
3. 2 Thumb screws

After each coffee maker was disassembled, the participants were asked to fill out a NASA-TLX questionnaire. The NASA-TLX questionnaire is a method for gauging a users frustration/difficulty level for a given task.

The evaluation tool was structured as follows:

4. Welcome and introductions
5. Explain the project and goals for the concept evaluation session
6. Explain consent form and collect signatures
7. Request permission for video and audio recording of the session
8. Perform Evaluations
   a. Ask participants to disassemble the control coffee maker
   b. Ask participants to fill out NASA-TLX questionnaire
   c. Ask participants to disassemble coffee maker concept one
   d. Ask participants to fill out NASA-TLX questionnaire
   e. Ask participants to disassemble coffee maker concept two
   f. Ask participants to fill out NASA-TLX questionnaire
   g. Ask participants to disassemble coffee maker concept three
   h. Ask participants to fill out NASA-TLX questionnaire
   i. Ask participants to answer questions about the howtorecycle.it process and system
   j. Collect any final comments, answer any final questions
9. Conclusion/End evaluations
Control Coffee Maker
Black & Decker
CM1050B

Model 1
4 Machine Screws

Model 2
4 Thumb Screws

Model 3
2 Thumb Screws
User Testing Results

Disassembly Times (in minutes)

Black & Decker

Model 1 - 4 Screws

Model 2 - 4 Thumb Screws

Model 3 - 2 Thumb Screws

User 01

User 02

10:36
02:26
01:04
00:55

09:04
01:36
01:20
01:07
Disassembly Times (in minutes)

Black & Decker Model 1 - 4 Screws
Model 2 - 4 Thumb Screws
Model 3 - 2 Thumb Screws

User Testing Results

User 01 User 02 User 03 User 04 User 05

User 01: 10:07 02:39 02:13 01:02
User 02: 08:19 02:08 01:42 01:31
User 03: 10:07 06:11 02:11 01:26 01:08
User 04: 06:11 02:11 01:26 01:08
User 05: 08:19 02:08 01:42 01:31
User Testing Results

NASA Task Load Index Scores

Black & Decker
Model 1 - 4 Screws
Model 2 - 4 Thumb Screws
Model 3 - 2 Thumb Screws
Lower Scores are Better

47.90 85.60
10.00 13.60
5.00 6.60
5.00 6.30

NASA-TLX is a subjective workload assessment tool. NASA-TLX allows users to perform subjective workload assessments on operator(s) working with various human-machine systems. NASA-TLX is a multi-dimensional rating procedure that derives an overall workload score based on a weighted average of ratings on six subscales.

These subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance,
Effort and Frustration. It can be used to assess workload in various human-machine environments such as aircraft cockpits, command, control, and communication (C3) workstations; supervisory and process control environments; simulations and laboratory tests (NASA 2013). See appendix for more information.
### User Testing Results

<table>
<thead>
<tr>
<th>Method Preference</th>
<th>User 01</th>
<th>User 02</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model Preference</strong></td>
<td>Model 2 - 4 Thumb Screws</td>
<td>Model 2 - 4 Thumb Screws</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments/Observations</th>
<th>User 01</th>
<th>User 02</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disassembly</strong></td>
<td>Fairly frustrated with baseline coffee maker</td>
<td>Extremely frustrated with baseline coffee maker</td>
</tr>
<tr>
<td></td>
<td>Would not go through the trouble to recycle the appliance in the future</td>
<td>Would not go through the trouble to recycle the appliance in the future</td>
</tr>
<tr>
<td></td>
<td>Model 1: “Not at all difficult”</td>
<td>Model 1: “Much Easier”</td>
</tr>
<tr>
<td></td>
<td>Model 2: “Easy”</td>
<td>Model 2: “I like it because it doesn’t require tools”, “That one was my favorite”</td>
</tr>
<tr>
<td></td>
<td>Model 3: “Easy”</td>
<td>Model 3: “Easiest of all”</td>
</tr>
<tr>
<td><strong>Label</strong></td>
<td>“The print is large and easy to read”</td>
<td>Does not like the QR code, says it is “silly”</td>
</tr>
<tr>
<td></td>
<td>“Easy to understand”</td>
<td>Likes the large url</td>
</tr>
<tr>
<td><strong>Website</strong></td>
<td>“Extremely easy to understand”</td>
<td>“I like the design of the website, I like the colors”</td>
</tr>
<tr>
<td></td>
<td>“Pictures are always good”</td>
<td>“Simple and easy to navigate”</td>
</tr>
<tr>
<td></td>
<td>“I like the icons”</td>
<td>“I like the icons”</td>
</tr>
</tbody>
</table>

| **Overall System**    | Would use the system if it were available on products | “I would be more likely to recycle an appliance if I knew how to” |
|                       |                                                   | “I would never have thought about recycling an appliance” |

Based on the feedback gained from the user testing it was found that model 2, with the four thumbscrews, was the preferred method for disassembly. Testers generally found the control model to be more frustrating and take significantly more time to disassemble than the test models. Surprisingly the model with the two thumbscrews, while faster and easier to disassemble for most
of the users, was not the preferred method. Most testers commented that model 3, with the two thumbscrews, seemed like it was less securely assembled than the model with the four thumbscrews. While technically untrue, both models were equally secure, tester perception led them to feel otherwise and chose model two.
Design for Disassembly/Recycling

Design for Disassembly best practices were employed when redesigning the new coffee maker. Specifically:

- Minimize the number of parts
- Simplifying structure and form
- Avoid requiring tools for the most common functions
- Use intuitive snap-fits, clips, or sliding connections

As well as the following best practices for Design for Recycling:

- Label parts with recycling codes
- Avoid paints additives and surface treatments
- Avoid combinations of materials that are difficult to separate
- Make it easy to separate components that are hazardous, toxic, or not conventionally recyclable
- Specify the use of recycled materials
- Create an easy take-back program to ensure proper disposal of complicated parts

Upper Body Parts

- All of the parts that combine to create the upper body parts assembly are made of a single type of plastic, polypropylene, and are labeled with the #5 resin id code
- All of the parts are snap-fit or press-fit together and require no tools to disassemble
- As few parts as possible were used
- All of the parts could be manufactured using recycled content polypropylene
- The body shell/reservoir is designed to be made as a single injection molded part

Base Assembly

- The base plate assembly contains all of the internal components for the coffee maker: hot plate assembly, control circuit boards, controls, and water tubing, etc.
- All of the parts are attached using snap-fit connectors or one type of fastener, coarse-thread Phillips head screws
- All of the fasteners are accessed along the same axis
Design for Disassembly/Recycling

All of the internal components are attached to the base plate for efficient removal from the upper body.

Snap-Fit Fasteners

- The power circuit board is attached using four snap-fit connects.
- The control and display circuit board, lcd window, and control buttons are all held in place using two snap-fit connectors and a slot.
- The hotplate assembly is attached using five snap-fit connectors.
- The power cord hold-down tab is attached using two snap-fit connectors.

Postage-Paid Tyvek Mailer

- Included in the base unit is a postage-paid tyvek mailer envelope.
- The mailer is held in place using a living hinge that is molded into the base plate.

Base Plate

- The base plate is a single injection-molded piece of polypropylene.
Design for Disassembly/Recycling

Carafe Assembly

- The handle, band and lid components of the carafe assembly are all made of the same plastic, polypropylene.
- The handle uses two coarse-thread Phillips drive fasteners.
- The lid is snap-fit along its axis of rotation.
Carafe Assembly

Glass Carafe

- The glass carafe is made of borosilicate glass which is not generally recycled.
Thumb Screws

- The base assembly is attached to the body using four thumb screws.
- The thumb screws also have a Phillips drive for occasions where they are too tight to loosen by hand.

howtorecycle.it Label

- The howtorecycle.it label is affixed to the bottom of the coffee maker.
- The label directs consumers to the howtorecycle.it website to get information about how to properly dispose of the coffee maker.
Design for User Disassembly

The new coffee maker was designed, not only with Design for Disassembly in mind, but specifically aimed at consumer disassembly. Once the product is no longer working the consumer can use the howtorecycle.it label on the bottom to assist them in finding the howtorecycle.it website. Once on the website the user will find disassembly instructions unique to their product.

The only disassembly required for this coffee maker is the removal of the four thumb screws and disconnecting the two water tubes from the reservoir. The coffee pot requires the removal of two screws. The handle parts of the coffee pot can be recycled while the glass must be thrown away.

Upper Body Parts

- Once the base assembly is removed from the upper body assembly it can be thrown directly into a curb-side recycling bin.
- All of the parts are polypropylene and are fully recyclable.
- There are no fasteners used, only snap-fit attachments.

Base Assembly

- Once removed the base assembly can be returned to the manufacturer or a third-party recycler using the provided postage-paid tyvek mailer, or discarded in the regular trash.
Design for User Disassembly

Once the consumer has disassembled the coffee maker they can discard the upper body parts, carafe handle, and lid in a recycling bin. The glass carafe, being borosilicate glass and not recyclable with other types of glass, must be disposed of in the trash.

The base assembly once removed provides access to an accompanying postage-paid tyvek mailer. The mailer is stored within a compartment in the base and is secured with a snap-fit living hinge. The user only needs to pop out the mailer, drop the base assembly into the mailer and seal it, and put it into a mailbox. The mailer is already addressed to the appropriate manufacturer take-back program or a third-party recycler. The manufacturer or recycler can then further disassemble the base assembly to recover the remaining components for either additional recycling or remanufacture. This process can divert 75% of the materials, by weight, from ending up in a landfill.

The disassembly methods employed in the design of this coffee maker enable the consumer to properly dispose of it in a minimum of time and provide for the ability of nearly 70% of the those surveyed to fully dispose of it without even leaving their homes.
Included Tyvek Mailer

- Included in the base unit is a postage-paid tyvek mailer envelope.
- The mailer is held in place using a living hinge that is molded into the base plate and snaps closed.
Material Selection

If recycled materials are specified for the manufacture, the available color choices would be limited to black or dark gray if a consistent color is needed given the variation in color of recycled content feedstocks.
Material Selection

The majority of the redesigned coffee maker’s major parts are made of polypropylene, a thermoplastic polymer common to many injection molded parts and products. There are a wide selection of sources for polypropylene feed stocks, from virgin materials to materials containing pre- and post-consumer recycled content. The following are several material types and sources that could be used to manufacture the coffee maker.

Virgin Materials

Virgin polypropylene feedstock is the most pure, reliable, and durable but also the highest impact, least sustainable of the available sources. The production of virgin polypropylene granules consumes more water, oil, coal, natural gas, and electricity than does the production of recycled content polypropylene. It also produces more than twice the amount of greenhouse gases.

Recycled Content Polypropylene

Recycled content polypropylene is typically a mix of both virgin and recycled material, it uses fewer resources and is a more sustainably produced feedstock. There are many sources of recycled material, below are a selection of manufacturers and their recycled content products.

MBA Polymers PP 2172 - A post-consumer recycled polypropylene co-polymer with a very high melt flow rate for injection molding applications. Available in standard black (reference 90/04).


Ravago Manufacturing Americas, LLC

Echo® RPPC 20/6 BK - Polypropylene co-polymer


Recycler Sources

Post consumer reground polypropylene may be purchased from numerous plastics marketplaces and recyclers. The quality can vary greatly, as well as consistency, from batch to batch versus newly manufactured products.
Design Recommendations

Based on the research performed some basic recommendations for future product design were developed.

- Provide easy-to-use instructions on how to properly recycle/dispose of a product at its end-of-life
- Provide direction to an information source providing the instructions
- Adapt Design for Disassembly methods for use by the consumer
  - Use fasteners that do not require tools or require only simple tools
  - Use as few fasteners as possible
- Provide for the easiest possible recycling/disposal experience
  - Require as little time as necessary
  - Require as little effort as necessary
- Take advantage of current recycling infrastructure
  - Allow for as much waste as possible to be recycled using methods such as:
    - Curb-side recycling
    - Recycling drop-off locations
- Institute manufacturer take-back programs for further recycling
- Take advantage of third-party take-back programs
Future Work

The outcomes of this project present a viable future for enhanced consumer involvement in the end-of-life of their appliances. The infrastructure elements necessary to implement the proposed system are all currently available technologies and processes: enhanced product labels, websites, and Design for Disassembly best practices. Only slight changes are needed to position the consumer at the forefront of disassembly.

Based on the research performed consumers are ready and willing to take a greater role in the recycling of their appliances. The consumer survey proved that the majority of people have a desire for additional information and believe that manufacturers are not currently doing enough in terms of informing consumers, or offering avenues to increased recyclability of products. Creating a recognizable brand for the system would be key in spreading and accelerating adoption.

While the website and project as a whole both focused on user-involvement in the end-of-life of appliances, the website also includes the structure to include repair and reuse options for appliances. The inclusion and build-out of these two sections of the website could make it a destination for consumers looking to recycle or extend the life of their appliances.

The user testing proved that the overall system of the howtorecycle.it labels, howtorecycle.it website, and the redesigned coffee maker work well and were well received by the testers. The testing showed the system to be both efficient and effective. Future iterations of the system would need additional user testing regarding the complexity of the disassembly processes involved. The coffee maker case study involved a relatively simple disassembly procedure, further testing would be needed to evaluate acceptance of various levels of disassembly difficulty, complexity, and time commitments.

There are, however, several challenges that would have to be surmounted in order for the system to reach its full potential.

First, the most important factor would be garnering industry support for the system. Manufacturers would need to be willing to use the system in its entirety: the redesigned labels, providing the disassembly instructions, and most difficultly redesigning their products to easily be disassembled.

Secondly, research would need to be performed in regards to government regulations and standards. A product that can be easily disassembled by consumers may face challenges in satisfactorily meeting the safety requirements of certified testing authorities.
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159-164.
AboutPlastics/content.cfm?ItemNumber=823.
Management & Research 26(2): 140-146.
Image References

Appendix
Design for Product Lifetime Quick Reference Guide

Access a product's components to keep it alive longer and enable a responsible end-of-life.

Design for Disassembly
Ensure products are easy to take apart quickly.
- Minimize the number of parts.
- Simplify structure and form.
- Use thermoplastic materials to enable recycling and disassembly.
- Require only a few standard tools.
- Avoid requiring tools for the most common actions.
- Minimize the number and variety of fasteners.
- Use intuitive snap-fit, clips, or sliding connections.
- Design connections that are visually and physically accessible.
- Access fasteners from the same axis.
- Hold multiple parts with one fastener.
- Use coarse threaded screws for speed; use nuts and bolts for strength.
- Use human-scale fasteners.
- Avoid glues, and use only glues that are easily solvable or heat reversible.
- Ensure fasteners are adequate for structural integrity.
- Use fasteners that will hold up over repeated use.
- Embed clear, graphical disassembly instructions into the product.
- Document materials and methods for deconstruction for the user.

Design for Repair
Ensure product repair is simple for everyone.
- Use modular assemblies that enable the replacement of discrete components.
- Ensure easy access to parts likely to need maintenance.
- Use self-locating parts.
- Use robust connectors.
- Label and rank critical parts to enable troubleshooting.
- Standardize parts between product lines and across generations.
- Make technical documentation freely available or open-sourced.
- Include parts list and part numbers.
- Create user interfaces and troubleshooting tools to diagnose problems.
- Make repair and service options clear to customers.
- Consider repair-friendly warranty terms.
- Make replacement parts available and affordable.

Design for Upgrade
Keep products relevant and useful longer.
- Use standard-size modular parts to maintain interchangeability and customization.
- Design easy access to parts likely to become obsolete.
- Use standard, cross-platform connections (for example, USB).
- Build diagnostic tools to help users understand the components that are limiting performance.

Design for Recycling
Make it easy to properly dispose of the product.
- Choose materials that are recycled everywhere.
- Minimize the number of materials used. When possible, use only one.
- Label parts with recycling codes or other permanent ways to identify materials.
- Avoid paints, additives, and surface treatments. Use inherent color.
- Avoid combinations of materials that are difficult to separate.
- Make it easy to separate components that are hazardous, toxic, or not conventionally recyclable.
- Specify the use of recycled materials in your products (this also helps stimulate demand for recycling).
- Create easy take-back programs to ensure proper disposal of complicated products.

Design for Remanufacturing
Enable reuse of old components in new products.
- Create product-as-service business models.
- Design smooth touchpoints between the company and users.
- Design a quality control system for testing returned components.

Autodesk Sustainability Workshop
autodesk.com/sustainabilityworkshop
QR Code (Quick Response Code)

QR Code is a kind of two-dimensional (2D) symbology developed by Denso Wave (a division of Denso Corporation at the time) and released in 1994 with the primary aim of being a symbol that is easily interpreted by scanner equipment.

QR Code (2D Code) contains information in both the vertical and horizontal directions, whereas a bar code contains data in one direction only. QR Code holds a considerably greater volume of information than a bar code.

High-capacity Encoding of Data

QR Code is capable of handling all types of data, such as numeric and alphabetic characters, Kanji, Kana, Hiragana, symbols, binary, and control codes. Up to 7,089 characters can be encoded in one symbol.

Dirt and Damage Resistant

QR Code has error correction capability. Data can be restored even if the symbol is partially dirty or damaged. A maximum 30% of codewords can be restored.

Readability from any Direction

QR Code is capable of 360 degree (omni-directional), high speed reading. QR Code accomplishes this task through position detection patterns located at the three corners of the symbol. These position detection patterns guarantee stable high-speed reading, circumventing the negative effects of background interference.

Symbol Versions

The symbol versions of QR Code range from Version 1 to Version 40. Each version has a different module configuration or number of modules. (The module refers to the black and white dots that make up QR Code.)

"Module configuration" refers to the number of modules contained in a symbol, commencing with Version 1 (21 × 21 modules) up to Version 40 (177 × 177 modules). Each higher version number comprises 4 additional modules per side.
**Product Disassembly Procedures**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Brentwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>TS-217</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>12 Cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$20.15</td>
</tr>
<tr>
<td>Time to Disassemble</td>
<td>06:37</td>
</tr>
</tbody>
</table>

**Steps : Parts : Fasteners**

| Step | 15 | 18 | 13 (Phillips) |

**Notes**

Included a metal accent piece with many bent tabs attaching it to the basket holder, this was difficult to separate.
<table>
<thead>
<tr>
<th>Coffee Pot</th>
<th>Coffee Maker</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3 &amp; 4</th>
<th>Step 5</th>
<th>Step 6</th>
<th>Step 7</th>
<th>Step 8</th>
<th>Step 9</th>
<th>Step 10</th>
<th>Step 11</th>
<th>Step 12</th>
<th>Step 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Remove Lid</td>
<td>+ Remove bottom</td>
<td></td>
<td></td>
<td>+ Disconnect power button</td>
<td></td>
<td></td>
<td>+ Remove hot plate assembly</td>
<td>+ Remove basket</td>
<td>+ Remove water spout cover</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 piece - Snap fit</td>
<td>1 piece - 2 screws</td>
<td></td>
<td></td>
<td>3 wires - Snap fit</td>
<td></td>
<td></td>
<td>1 piece subassembly - 4 screws</td>
<td>1 piece subassembly - Loose</td>
<td>1 piece - Snap fit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ Remove power button</td>
<td></td>
<td></td>
<td>+ Remove basket holder</td>
<td>+ Remove water spout and riser tube</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 piece - Snap fit</td>
<td></td>
<td></td>
<td>2 pieces - Captured</td>
<td>2 piece - Snap fit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ Remove metal accent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ Remove metal accent piece</td>
<td>+ Separate reservoir from base</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 piece - Bent tab and slot</td>
<td>2 pieces - 4 screws</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Included a metal accent piece with many bent tabs attaching it to the basket holder, this was difficult to separate.
# Product Disassembly Procedures

### Manufacturer
- **Continental**

### Model
- **CP43639**

### Capacity
- 10 Cup

### Price
- $21.25

### Time to Disassemble
- 07:45

### Steps : Parts : Fasteners
- 15  23  17 (15 Phillips, 2 torx)

### Notes
- Requires special tool – torx security bit

---

**Product Image**

![Coffee Pot Coffee Maker](image1)

**Disassembled Image**

![Disassembled Coffee Maker](image2)
# Product Disassembly Procedures

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culinair</td>
<td>AC221B</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
<th>Time to Disassemble</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Cup</td>
<td>$19.99</td>
<td>05:31</td>
</tr>
</tbody>
</table>

**Steps : Parts : Fasteners**

| 14 | 17 | 14 (12 Phillips, 2 spanner) |

**Notes**

Requires special tool – spanner security bit
**Coffee Pot**

**Step 1**
- Remove lid
  - 1 piece - Snap fit

**Step 2**
- Remove handle
  - 3 pieces - 1 screw

**Step 3**
- Disconnect power button
  - 3 wires - Snap fit

**Step 4**
- Remove power button
  - 1 piece - Snap fit

**Coffee Maker**

**Step 1**
- Remove bottom
  - 1 piece - 4 screws (2 spanner)

**Step 2**
- Remove power cord hold down
  - 1 piece - 2 screws

**Step 3**
- Disconnect power button
  - 3 wires - Snap fit

**Step 4**
- Remove power button
  - 1 piece - Snap fit

**Step 5**
- Disconnect water tubes
  - 2 tubes - Press fit

**Step 6**
- Remove hot plate assembly
  - 1 subassembly - 2 screws

**Step 7**
- Remove basket
  - 3 pieces - Loose

**Step 8**
- Remove reservoir lid
  - 1 piece - Snap fit

**Step 9**
- Remove water spout top
  - 1 piece - Snap fit

**Step 10**
- Remove water riser tube
  - 1 piece - Snap fit

**Step 11**
- Remove water spout
  - 1 piece - Captured

**Step 12**
- Separate reservoir from base
  - 2 pieces - 5 screws
# Product Disassembly Procedures

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delonghi</td>
<td>DCF212T</td>
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</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>12 Cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$29.98</td>
</tr>
<tr>
<td>Time to Disassemble</td>
<td>13:47</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Steps : Parts : Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 : 33 : 36 (Phillips)</td>
</tr>
</tbody>
</table>

**Notes**

Plastic types labeled with letters (>PP<) not RID codes.
### Coffee Pot

**Steps 1 & 2**

- **Step 1**
  - Pull to remove pot lid
  - 1 piece - Polypropylene
- **Step 2**
  - Remove top screw (1)

**Step 3**

- **Step 3**
  - Pull to remove handle cover
  - 1 piece - ABS Plastic - Snap fit

**Steps 4 & 5**

- **Step 4**
  - Remove metal band retaining screw (1)
  - Remove metal band
  - 1 piece - Steel

**Step 5**

- **Step 5**
  - Pull off plastic handle
  - 1 piece - Polypropylene - Glued on

### Coffee Maker

**Step 1**

- **Step 1**
  - Remove bottom cover
  - 1 piece - Polypropylene - 5 screws

**Step 2**

- **Step 2**
  - Remove button control circuit board
  - 1 piece - 4 screws

**Step 3**

- **Step 3**
  - Remove control buttons assembly
  - 8 pieces - 2 screws

**Step 4**

- **Step 4**
  - Remove controller circuit board
  - 1 piece - snap fit

**Step 5**

- **Step 5**
  - Remove power cable hold down
  - 1 piece - 2 screws

**Step 6**

- **Step 6**
  - Disconnect water tubes [2]

**Step 7**

- **Step 7**
  - Remove hot plate assembly
  - 6 screws

**Step 8**

- **Step 8**
  - Remove base from reservoir
  - 1 piece - Polypropylene - 8 screws

**Step 9**

- **Step 9**
  - Remove top accent piece
  - 1 piece - Snap fit - ABS

**Steps 10 & 11**

- **Steps 10 & 11**
  - Remove top screw covers
  - 4 pieces
  - Remove top
  - 3 pieces - Polypropylene - 3 screws

**Step 12**

- **Step 12**
  - Remove pullout tray
  - 3 pieces - Polypropylene - Captured

**Step 13**

- **Step 13**
  - Remove tray handle
  - 2 pieces - 1 ABS, 1 PP - 2 screws
### Product Disassembly Procedures

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton Beach</td>
<td>49316</td>
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<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
<th>Time to Disassemble</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Cup</td>
<td>$19.99</td>
<td>07:23</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Steps</th>
<th>Parts</th>
<th>Fasteners</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>19</td>
<td>20 (17 Phillips, 2 spanner, 1 hex nut)</td>
</tr>
</tbody>
</table>

**Notes**

Requires special tools – spanner security bit and a wrench/socket set.
The most well marked plastics of all of the reviewed models.
All of the major components had visible RID codes.
The most difficult to disassemble.
Coffee Pot

Step 1
1. Remove lid
   1 piece, Snap fit

Step 2
2. Remove handle
   3 pieces, 1 screw

Step 3
3. Disconnect power button
   3 wires, Pliers required

Step 4
4. Remove power button
   1 subassembly, Snap-fit

Coffee Maker

Step 1
1. Remove bottom
   1 piece, 5 screws (spanner)

Step 2
2. Remove power cable hold down
   1 piece, 2 screws

Step 3
3. Disconnect power button
   1 piece, 3 screws

Step 4
4. Remove power button
   1 subassembly, Snap-fit

Step 5
5. Disconnect water tubes
   2 tubes, Press fit

Step 6
6. Remove hot plate assembly
   1 subassembly, 2 screws, 1 nut

Step 7
7. Remove hot plate retaining ring
   1 piece, 6 screws, 6 metal tabs

Step 8
8. Remove basket
   1 subassembly, Loose

Step 9
9. Remove water spout
   4 pieces, Snap fit

Step 10
10. Remove reservoir lid
    1 piece, Snap fit

Step 11
11. Remove tube bracket & tube
    2 piece, Snap fit

Step 12
12. Separate reservoir from base
    2 pieces, 3 screws
## Product Disassembly Procedures

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxi-Matic</td>
<td>EHC- 2066X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
<th>Time to Disassemble</th>
<th>Steps : Parts : Fasteners</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Cup</td>
<td>$19.98</td>
<td>7:50</td>
<td>16 : 22 : 19 (17 Phillips, 2 torx)</td>
<td>Disassembly required the use of pliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Requires special tool – torx security bit</td>
</tr>
</tbody>
</table>

- **Step 1**: Requires special tool – torx security bit
- **Step 2**: 
- **Step 3**: 
- **Step 4 & 5**: 
- **Step 6**: 
- **Step 7**: 
- **Step 8**: 
- **Step 9**: 
- **Step 10**: 
- **Step 11**: 
- **Step 12**: 
- **Step 13**:

---

![Coffee Pot Coffee Maker](image1.png)

![Coffee Pot Coffee Maker Disassembled](image2.png)
<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Steps 4 &amp; 5</th>
<th>Step 6</th>
<th>Step 7</th>
<th>Step 8</th>
<th>Step 9</th>
<th>Step 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Remove lid 1 piece - Snap fit</td>
<td>+ Remove feet/screw covers 2 pieces - Press fit</td>
<td>+ Remove bottom 1 piece - 4 screws (2 ph, 2 torx)</td>
<td>+ Disconnect power button wires 3 wires - Required pliers  + Remove power switch 1 piece - Snap fit</td>
<td>+ Disconnect water tubes 2 tubes - Press fit</td>
<td>+ Remove hot plate assembly 2 pieces - 6 screws - 4 plastic tabs</td>
<td>+ Remove reservoir lid 1 piece - Snap fit</td>
<td>+ Remove basket 2 pieces - Loose</td>
<td>+ Remove basket holder 1 piece - Snap fit</td>
</tr>
<tr>
<td>16</td>
<td>19</td>
<td>22</td>
<td>+ Remove handle 3 pieces - 1 screw</td>
<td>+ Remove screw cover 1 piece - Press fit</td>
<td>+ Remove bottom 1 piece - 4 screws (2 ph, 2 torx)</td>
<td>+ Remove power cord hold down 1 piece - 2 screws</td>
<td>+ Remove reservoir lid 1 piece - Snap fit</td>
<td>+ Remove basket cover 1 piece - Snap fit</td>
</tr>
<tr>
<td>Step 1</td>
<td>Step 2</td>
<td>Step 3</td>
<td>Steps 4 &amp; 5</td>
<td>Step 6</td>
<td>Step 7</td>
<td>Step 8</td>
<td>Step 9</td>
<td>Step 10</td>
</tr>
<tr>
<td>+ Remove lid 1 piece - Snap fit</td>
<td>+ Remove feet/screw covers 2 pieces - Press fit</td>
<td>+ Remove bottom 1 piece - 4 screws (2 ph, 2 torx)</td>
<td>+ Disconnect power button wires 3 wires - Required pliers  + Remove power switch 1 piece - Snap fit</td>
<td>+ Disconnect water tubes 2 tubes - Press fit</td>
<td>+ Remove hot plate assembly 2 pieces - 6 screws - 4 plastic tabs</td>
<td>+ Remove reservoir lid 1 piece - Snap fit</td>
<td>+ Remove basket 2 pieces - Loose</td>
<td>+ Remove basket holder 1 piece - Snap fit</td>
</tr>
<tr>
<td>16</td>
<td>19</td>
<td>22</td>
<td>+ Remove handle 3 pieces - 1 screw</td>
<td>+ Remove screw cover 1 piece - Press fit</td>
<td>+ Remove bottom 1 piece - 4 screws (2 ph, 2 torx)</td>
<td>+ Remove power cord hold down 1 piece - 2 screws</td>
<td>+ Remove reservoir lid 1 piece - Snap fit</td>
<td>+ Remove basket cover 1 piece - Snap fit</td>
</tr>
</tbody>
</table>
Product Disassembly Procedures

Manufacturer
Mr. Coffee (Sunbeam)

Model
BVMC-SJX36GTWM

Capacity
12 Cup

Price
$29.92

Time to Disassemble
14:09

Steps : Parts : Fasteners
17  27  44 (Phillips)

Notes
Some plastic types labeled with letters (>PP<) not RID codes.
### Coffee Pot

**Step 1**
- Remove lid
  - 1 piece - polypropylene - snap fit

**Step 2**
- Remove handle assembly
  - 3 pieces - steel, polypropylene
  - 1 screw

**Steps 3 & 4**
- Remove controller circuit board
  - 2 pieces - 2 screws
- Disconnect control button circuit board
  - 1 plug

**Step 5**
- Disconnect small sensor
  - 1 piece - 1 screw

**Step 9, 10 & 11**
- Remove top screw covers
  - 6 pieces
- Remove water spout
  - 2 pieces - 1 screw
- Remove top
  - 2 pieces - polypropylene - 6 screws

---

### Coffee Maker

**Step 1**
- Remove bottom cover
  - 1 piece - polypropylene - 7 screws

**Step 2**
- Remove power cord hold down
  - 1 piece - 2 screws

**Steps 3 & 4**
- Remove controller circuit board
  - 2 pieces - 2 screws
- Disconnect control button circuit board
  - 1 plug

**Step 5**
- Disconnect small sensor
  - 1 piece - 1 screw

**Step 6**
- Disconnect water hoses (2)

**Step 7**
- Remove hot plate assembly
  - 1 subassembly - 5 screws

**Step 8**
- Remove cable housing
  - 1 piece - polypropylene - 4 screws

**Step 9, 10 & 11**
- Remove top screw covers
  - 6 pieces
- Remove water spout
  - 2 pieces - 1 screw
- Remove top
  - 2 pieces - polypropylene - 6 screws

**Step 12**
- Remove water reservoir and back
  - 1 piece - polypropylene - snap fit

**Step 13**
- Remove control button assembly
  - 1 subassembly - 4 screws

**Step 14**
- Remove faceplate
  - 1 piece - coated ABS - 11 screws
# Product Disassembly Procedures

**Manufacturer**
Proctor Silex

**Model**
48521RY

<table>
<thead>
<tr>
<th>Capacity</th>
<th>12 Cup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td>$24.99</td>
</tr>
<tr>
<td><strong>Time to Disassemble</strong></td>
<td>06:13</td>
</tr>
</tbody>
</table>

## Notes
Requires special tool – spanner security bit
### Coffee Pot Disassembly Procedure

**Step 1**
- Remove lid
  - 1 piece, - Snap fit

**Step 2**
- Remove handle
  - 3 pieces - 1 screw

**Step 3**
- Remove power cord hold down
  - 1 piece - 2 screws

**Step 4**
- Remove power button and hold down
  - Captured between the base and bottom

---

### Coffee Maker Disassembly Procedure

**Step 1**
- Remove bottom screw covers
  - 2 pieces - Press fit

**Step 2**
- Remove bottom
  - 1 piece - Snap fit - 2 screws (spanner)

**Step 3**
- Disconnect water tubes
  - 2 tubes - Press fit

**Step 4**
- Remove hot plate assembly
  - 1 subassembly - 4 screws - 4 plastic tabs

**Step 5**
- Remove basket
  - 1 subassembly - Loose

**Step 6**
- Remove water spout
  - 5 pieces - Snap fit

**Step 7**
- Remove reservoir lid
  - 3 pieces - Snap fit

**Step 8**
- Remove inner retaining ring
  - 1 piece - Snap fit

**Step 9**
- Remove reservoir lid
  - 3 pieces - Snap fit

---

**Model:** Proctor Silex 48521RY

**Manufacturer:**
- Requires special tool – spanner security bit

**Capacity:** 12 Cup

**Price:** $24.99
# Product Disassembly Procedures

**Manufacturer**
Rival

**Model**
RV-076

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Price</th>
<th>Time to Disassemble</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Cup</td>
<td>$9.50</td>
<td>05:41</td>
</tr>
</tbody>
</table>

**Steps : Parts : Fasteners**
15 : 19 : 14 (12 phillips, 2 spanner)

**Notes**
Requires special tool – spanner security bit
**Coffee Pot**

**Steps 1, 2 & 3**

- + Remove lid
  1 piece - Snap Fit
- + Remove handle
  2 pieces - 2 screws
- + Disassemble handle
  2 pieces - 2 screws

**Coffee Maker**

**Step 1**

- + Remove rubber feet
  2 pieces - Snap fit

**Step 2**

- + Remove bottom
  1 piece - 4 screws (2 spanner)

**Step 3**

- + Remove power cord hold down
  1 piece - 2 screws

**Steps 4 & 5**

- + Remove power switch
  1 piece subassembly - Snap fit
- + Unplug power switch
  3 connectors

**Step 6**

- + Disconnect water tubes
  2 pieces - Press fit

**Step 7**

- + Remove hot plate assembly
  1 piece subassembly - Snap fit

**Step 8**

- + Remove basket
  1 piece

**Step 9**

- + Remove reservoir cover
  1 piece - Snap fit

**Step 12**

- + Disassemble reservoir
  2 piece - 4 screws

**Steps 10 & 11**

- + Remove top
  3 piece - Snap fit
- + Remove water spout and riser tube
  1 piece - Snap fit

---

**Model**  
**Manufacturer**  
**Steps**  
**Parts**  
**Fasteners**  
**Capacity**  
**Price**  
**Time to Disassemble**  
**Notes**
Ideation — Labels

#1 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

120V - 60hz
1000W

For recycling and disposal information please visit:
howtorecycle.it/5Tgy8x

Made in China

#3 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

120V - 60hz
1000W

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

Made in China

#4 - 3” x 1.5”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

Read Instructions Before Using
Household Use Only
Caution: Do Not Immerse In Liquid

120V-60hz-1000W

For recycling and disposal information please visit:
howtorecycle.it/5Tgy8x

Made in China
Ideation — Labels

#8 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

#9 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

#10 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
Read Instructions Before Using
Do Not Immerse In Liquid - Household Use Only

For recycling and disposal information please scan the QR code at left with a smartphone or tablet or visit the website below
www.howtorecycle.it/5Tgy8x

#11 - 3” x 2”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
Read Instructions Before Using
Do Not Immerse In Liquid - Household Use Only

For recycling and disposal information please scan the QR code at left with a smartphone or tablet or visit the website below
www.howtorecycle.it/5Tgy8x
# Ideation — Labels

136 - 2” x 3”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
120V - 60Hz - 1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

17 - 2” x 3”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
120V - 60Hz - 1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

18 - 2” x 2.125”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
120V - 60Hz - 1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please scan the QR code at left with a smartphone or tablet or visit this website:
www.howtorecycle.it/5Tgy8x

19 - 2” x 3”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
120V - 60Hz - 1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

21 - 3” x 2.125”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377
120V - 60Hz - 1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

For recycling and disposal info scan or visit this website:
www.howtorecycle.it/5Tgy8x

23 - 3” x 2.5”

For recycling and disposal information please visit:
www.howtorecycle.it/5Tgy8x

For Recycling and Disposal Information Scan or Visit this Website:
www.howtorecycle.it/5Tgy8x

Do Not Immerse In Liquid - Household Use Only

Read Instructions Before Using

www.howtorecycle.it/5Tgy8x
Ideation — Labels

#24 - 3” x 2.5”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

120V - 60hz
1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

howtorecycle.it

For more information
scan code or visit:

www.howtorecycle.it/5Tgy8x

#25 - 2” x 3.6”

Simple Appliance Co.
12 Cup Coffeemaker
Model: AU90377

120V - 60hz
1000W
Made in China

Read Instructions Before Using
Do Not Immerse In Liquid
Household Use Only

howtorecycle.it

For recycling and disposal info visit
www.howtorecycle.it/5Tgy8x
Ideation — Websites

Concept 1a

Concept 1b
Ideation — Websites

Concept 1c

Concept 2a
Ideation — Websites

Concept 1

Concept 2
Final Concept — Website

repair.it
Final Concept — Website

reuse.it

Does your item still work? Are you looking for a place to donate it? Let's get started!

Reuse.it

Search for your address and we'll find local donation centers where you can drop off your item.

Enter your address here  Find Donation Centers
Responsive Web Design

Responsive web design (RWD) is a web design approach aimed at crafting sites to provide an optimal viewing experience—easy reading and navigation with a minimum of resizing, panning, and scrolling—across a wide range of devices (from desktop computer monitors to mobile phones).

Elements of responsive web design

A site designed with RWD uses CSS3 media queries, an extension of the @media rule, to adapt the layout to the viewing environment—along with fluid proportion-based grids and flexible images.

Media queries allow the page to use different CSS style rules based on characteristics of the device the site is being displayed on, most commonly the width of the browser.

The fluid grid concept calls for page element sizing to be in relative units like percentages or ems, rather than absolute units like pixels or points.

Flexible images are also sized in relative units (up to 100%), so as to prevent them from displaying outside their containing element.

Ethan Marcotte coined the term responsive web design (RWD) in a May 2010 article in A List Apart. He described the theory and practice of responsive web design in his brief 2011 book titled Responsive Web Design.
NASA-TLX Questionnaire

Questionnaire Part 1

Click on each scale at the point that best indicates your experience of the task.

**Mental Demand**

- Low
- High

**Physical Demand**

- Low
- High

**Temporal Demand**

- Low
- High

**Performance**

- Good
- Poor

**Effort**

- Low
- High

**Frustration**

- Low
- High

How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?

How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slick or strenuous, restful or laborious?

How much time pressure did you feel due to the rate of pace at which the task or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

How hard did you have to work (mentally and physically) to accomplish your level of performance?

How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

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Questionnaire Part 2

Mental or Physical
Performance or Mental Demand
Performance or Temporal Demand
Performance or Frustration
Physical Demand or Temporal Demand
Frustration or Mental Demand
Temporal Demand or Mental Demand
Effort or Performance
Physical Demand or Performance
Effort or Physical Demand
Mental Demand or Effort
Temporal Demand or Frustration
Frustration or Effort
Physical Demand or Frustration
Temporal Demand or Effort

Results

<table>
<thead>
<tr>
<th>Rating</th>
<th>Tally</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Demand</td>
<td>85</td>
<td>2</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>85</td>
<td>1</td>
</tr>
<tr>
<td>Temporal Demand</td>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>Performance</td>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>Effort</td>
<td>85</td>
<td>3</td>
</tr>
<tr>
<td>Frustration</td>
<td>85</td>
<td>3</td>
</tr>
</tbody>
</table>

Overall = 85