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Rice University

House Loops

Upcycling the Single-family House

by

Todd R. Van Varick

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

Master of Architecture

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Abstract

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Todd R. Van Varick

The thesis takes the position that the single-family house will soon move into a consumer cycle of disposability similar to that of products like single-use cameras. This analogy suggests a new house type that uses such material and acquisition cycles to its advantage, creating a service loop within its very production and distribution. The result is an intelligent object that has the ability to recreate itself many times over by cycling its own material components.

While following existing HUD guidelines governing their delivery, construction, and removal, these house units would also be mapped with a second (a third, a fourth....) life cycle for each component material. In addition, the building would be tethered to the original manufacturer and destined for resale, to be de-manufactured and upcycled into new house units or new material products at the end of each life.
Acknowledgments

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Kodak
(closed loops / house loops)
**Closed Loops**

In 1987 Eastman Kodak, a world renown photographic company, introduced to the consumer market a small camera that was deliberately designed to be easy to use, stylish, and disposable. This throw-away product, originally named the FLING, would soon revolutionize the way consumer objects are manufactured in relationship to the environment. Soon after the introduction of the Fling, Kodak re-named the product Funsaver and redesigned how the camera would be marketed and manufactured. Through a simple network of camera retailers and photo finishers, Eastman was able to successfully complete one of the first closed-looped product cycles.

Kodak can now manufacture all new single-use-cameras by simply reusing the materials and parts from old cameras. Returned camera bodies from photo finishers pass through a de-manufacture process where 99% of the original camera parts and materials are retrieved, inspected and sorted. Reusable parts are directly inserted into new camera bodies and recaptured materials are ground and pelletized in order to be blown into new camera parts and bodies.

As a result, Kodak has been able to divert more than 50 million lbs. of waste from land fills. The single-use camera has gone through four major redesigns, all meeting the same three environmental design goals: reduce the material content and energy required in the manufacturing — increase the number of recycled parts — increase the number of parts that are reused in new cameras. The newest single-use-camera, introduced in 1999 has 75% less material content and consumes 67% less energy. In a culture that thrives on disposability, design goals and closed loop product cycles like those of Eastman Kodak’s are concepts that must be applied to the process of architectural design.
**House Loops**

House Loops attempts to take embodied intelligence of Eastman Kodak’s single-use-camera, and apply it to a design for a new type of single-family house. The house is considered, from a marketing and manufacturing standpoint, a consumer product. It attempts to construct a consumer cycle that would satisfy a cultures desire for change, lifestyle and disposability. A cycle scenario looks like this: web ordering and styling, manufacture, sitting, delivery and assembly, addition, subtraction, disassembly, move, sitting, assembly, retrieval, de-manufacture, remanufacture.

The house is flexible and mobile allowing the consumer to customize his or her new home. Choosing from several different models the consumer outfits this model with a type by choosing specific program pieces and appliances. The house arrives to the new home site in sections called hulls. Each hull is placed on a foundation cradle and fastened together. The new house can be easily up-graded by the addition of specific program ordered directly from the manufacturer. House loops provides financial opportunities for new home buyers that include warranty, upgrades and service packages. Regularly scheduled visits from a qualified service technician for routine maintenance are included in each service package and appliance manufactures provide take-back plans on all dated equipment.

The manufacturing of the house is facilitated by an existing housing market governed by a federal building code known as the HUD code. To preserve access to affordable housing for middle and lower income families The United States Congress laid the foundation for the HUD code in the national Manufactured Housing Construction and Safety Standards Act of 1974. It was enacted to resolve discrepancies between local building codes. The HUD code offers to manufactured housing a building standard, that pre-empts many local building code.

In 1999 HUD code homes accounted for nearly 20% of all new home starts. The HUD code plays a critical role in the introduction of a new type house that attempts to close a product loop. The target market for these is estimated to be a rising population of “generation x’ers” becoming first home buyers and an aging population of baby boomers both seeking an affordable opportunity in housing.

The controlled environment of the manufactured housing industry, the factory and the manufacture process allows for implementation of new technologies into the house. Responsible materials, used in the manufacture of the house, have known second lives mapped onto them, either as new house parts or new material objects. These materials are molecularly tagged for easy identification and cataloging. The manufactured process also allows for a de-manufacturing process. Homes are tethered to the original manufacture providing opportunities for manufacture take-backs at the end of each homes life. Homes, once returned to the manufacture, are disassembled. All materials used in the home are easily extracted and identified. A new life is determined for that material either in new house parts or another material object.

New material technology and new technologies in the manufacture process make closed loop product cycles possible. House Loops attempts to create a product and material cycle in a specific housing industry. It offers a new house type as a product, that is flexible and relates to new needs and trends. House Loops identifies the importance and the emerging possibilities that closed loop product cycling has on the environment.
Cycle Comparison
(cycles and material loops)
Cycle Comparison

The purpose of the cycle comparison is to gain a stronger understanding of consumer objects manufactured by our industrial society and their impacts on the environment. The comparison aims to extract whole life cycles of consumer objects, mapping them from refinement of raw material to production to use to end-of-life.
production

The original concept was a throwaway product called the Kodak Ring.

Kodak, the company's newest single-use camera introduced in 1980, has 75% less material content and consumes 67% less energy in the manufacturing.

Refined its plastic injection-molding operations. "By adding hot-runner resin delivery systems and using PEA to optimize our mold-filling operations, we're molding 67% quicker than we were back in the 1960s," & saving on energy.

sales

average price of new camera - $8.00
sold in virtually every convenient store to roadside gas station
recycled more than 225 million cameras since programs start in 1980

use

for Kodak single-use cameras, the time from collection to rectification in the store shelf is about 30 days
8 different models are offered ranging in one film speed and lens configuration

disposal

A total of 26 of the 27 parts that make up Kodak's single-use cameras are either recycled or reused in a new camera (some components are reused up to 8 times)
Kodak estimates that it has diverted more than 60 million lbs of waste from landfills (based on unit average of six cameras per pound)
Kodak upholds no landfill policy
Material Production

- Over 15,000 parts in an automobile make-up
- Three generic materials are found in car manufacturing:
  1. Ferrous & non-ferrous metals
  2. Plastic
  3. Glass

The average 1988 car weighed about (2500 lb) and had (267 lb) of plastic, which is expected to grow to about (213 lb) by 2008. Approximately (2.0 million ton) of plastics were used on cars in 1988, and experts predict that amount to increase to about (2.5 million ton) by 2008.

Production

- The energy equivalent of 575,000 barrels of oil a day are required to produce 10 million cars in the U.S.
- Between 98 and 105 gigajoules of energy are needed to produce a motor vehicle, depending on the proportion of recycled materials used. This is equivalent to the energy contained in between 2500 and 3000 lb of gasoline, or the amount of fuel consumed by 18000 to 28000 ton of driving.
- The US DOT reports that in the U.S. in 20 years the number of vehicles has grown six times faster than the number of humans, and increased twice as fast as the number of drivers. There is now one car for every driver.

Sales

- Average sticker price of new car - $20,000
- Number of vehicles sold per month - More than one million
- 50 million new cars are produced each year

Use

- Hours spent in traffic: 8 billion
- Maintaining a car costs you almost $20 a day, $120 a week, $6,000 a year.
- Percent of energy used by fuel vehicles: 35%

Disposal

- 10 million vehicles are retired each year in the U.S. Each year, the total annual quantity is 20 million tons. This is equivalent to about 15 percent as much as municipal solid waste disposed in 1964.
- The automobile is the country’s most highly recycled consumer product - recycling aimed at 11 million cars each year - About 85% of retired cars enter the recycling system - 76% of each car is recycled (Milwaukee, WI).
- Auto recycling is a $4 billion dollar industry.
Manufactured Housing
(facts and statistics)
In 1999, the industry shipped 348,671 homes from 323 manufacturing facilities. Multi section shipments in 1999 outpaced single-section shipments, commanding 64.7 percent of total shipments. In 1998, multi section shipments accounted for 61.3 percent of the total. # 88 percent of manufactured home owners report satisfaction with the manufactured housing lifestyle.

Favorable Manufactured Housing Industry Trends:

- Increased service-sector job creation in southeast and south-west regions (traditionally strong areas for manufactured housing)
- Aging baby boomer population
- Generation "X" population moving into first time home buying market
- Substantial cost savings (20-50%) versus site built housing
- Greater availability of financing including longer loan terms
- Improved construction quality and appearance
- Population shift towards suburban and rural areas (traditionally strong areas for manufactured housing)
- Housing, in general, losing it's investment appeal (consumers satisfied with more modest housing)
- Growing share of the single-family housing market (32% in 1999)
A majority of manufactured homes are never moved after they have been installed.

Manufactured housing retail sales were estimated at $16.3 billion in 1998. In 1999, 20.7 percent of all new single-family housing starts were manufactured homes.

The average sales price of a manufactured home was $43,800 in 1998. Single-section homes average $30,300, while multi-section homes average $52,300.

In 1998, the estimated economic impact from manufactured housing was $36.9 billion. The economic impact Many housing industry observers believe manufactured home growth will outpace stick-built housing growth in the next 10 years.

According to the U.S. Census, over 65 percent of manufactured homes were placed on private property, while the remaining 35 percent were sited in residential land-lease.

A senior vice president at Moody’s Investors Service, Inc., thinks the manufactured home “product really does have a place in society. Manufactured homes represent a good value, especially for first-time buyers, and demand is there.”

Over the past decade, the rate of growth of the manufactured housing industry has been dramatic. According to the U.S. Census Bureau, by 1998 manufactured homes accounted for nearly a quarter of all new single-family housing starts.

At an average cost of $43,800 as of 1998, it is clear that a manufactured home is much more affordable than a site-built home at an average cost of $136,425 (excluding land price).
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>New home construction, 1,000s</td>
<td>1,000s</td>
<td>1,000s</td>
<td>1,000s</td>
<td>1,000s</td>
<td>1,000s</td>
<td>1,000s</td>
</tr>
<tr>
<td>Total</td>
<td>1,256,000</td>
<td>1,266,000</td>
<td>1,276,000</td>
<td>1,286,000</td>
<td>1,296,000</td>
<td>1,306,000</td>
</tr>
<tr>
<td>Single-family, 1,000s</td>
<td>863,800</td>
<td>873,800</td>
<td>883,800</td>
<td>893,800</td>
<td>903,800</td>
<td>913,800</td>
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<td>Multi-family, 1,000s</td>
<td>392,200</td>
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<td>Single-family, new single-family, 1,000s</td>
<td>417,200</td>
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<td>417,200</td>
<td>417,200</td>
<td>417,200</td>
<td>417,200</td>
</tr>
<tr>
<td>Multi-family, new single-family, 1,000s</td>
<td>246,200</td>
<td>246,200</td>
<td>246,200</td>
<td>246,200</td>
<td>246,200</td>
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</table>

**Exhibit 19.**
Distribution of Population Growth Across U.S. Metropolitan Areas

<table>
<thead>
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<tr>
<td>Large MSAs</td>
<td>111,744</td>
<td>252,250</td>
<td>506,686</td>
<td>11.4</td>
<td>10.6</td>
</tr>
<tr>
<td>Center City</td>
<td>37,116</td>
<td>38,706</td>
<td>36,765</td>
<td>4.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Suburbs</td>
<td>74,629</td>
<td>98,550</td>
<td>91,801</td>
<td>14.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Other MSAs</td>
<td>80,768</td>
<td>87,279</td>
<td>71,040</td>
<td>10.2</td>
<td>13.6</td>
</tr>
<tr>
<td>Non-Metro</td>
<td>54,068</td>
<td>58,171</td>
<td>58,615</td>
<td>3.9</td>
<td>10.6</td>
</tr>
<tr>
<td>Adjacent</td>
<td>32,668</td>
<td>34,882</td>
<td>36,623</td>
<td>5.7</td>
<td>11.6</td>
</tr>
<tr>
<td>Non-Adjacent</td>
<td>21,100</td>
<td>21,308</td>
<td>22,062</td>
<td>1.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Total</td>
<td>226,549</td>
<td>248,709</td>
<td>280,341</td>
<td>9.3</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Notes: Large MSAs (Metropolitan Statistical Areas) defined as those with population over one million in 1980. Adjacent counties have a common border with a core area.

Source: Joint Center for Housing Studies, *The State of the Nation’s Housing, 1996.*

- Manufactured housing accounts for nearly half of all new housing in Montana, Alabama, Mississippi and West Virginia - and for more than one-third of new homes in South Carolina, Louisiana, Oklahoma and Arkansas.

- According to the U.S. Census, over 65 percent of manufactured homes were placed on private property, while the remaining 35 percent were sited in residential land-lease

- Over 19 million people (about 8 percent of the U.S. population) live full-time in over 8 million manufactured homes.

- Over the past decade, the rate of growth of the manufactured housing industry has been dramatic. According to the U.S. Census Bureau, by 1998 manufactured homes accounted for nearly a quarter of all new single-family housing starts.

- At an average cost of $43,800 as of 1998, it is clear that a manufactured home is much more affordable than a site-built home at an average cost of $136,425 (excluding land price).

- The manufactured home can be financed as personal property, on leased land, in a manufactured home community or on a private site.
Model-A Type-2
(manufactured homes)
1. Exterior Skin (A1-01580-SK) Exterior Skin is composed of recycled plastic and wood product and is manufactured on site. Skin is stripped from Hulls at end of life, chipped into composite pellets and re-blown into new skin.

2. Insulation (A1-01580-SK) Vacuum insulated panels are extracted from shell and inspected for punctures. Panels are re-vacuum sealed and reinstalled into new shells.

3. Interior Skin (A1-01800-ISO) Interior skin is composed of compressed straw board. Panels are extracted from shell interiors and stripped of there painted surfaces. Straw board is then degraded into compost.

4. Shell Beams (A1-01274-MQ) Shell Beams are disassembled and inspected for structural integrity. Profiles are reused in new Hulls of the same model. Profiles can be truncated and used in other models. At profiles end of life cycle material is hulled and sold on a recycled steel market.

5. Light Gage Steel (A1-01924-5T) Light gage stud framing members are disassembled and hulled. They are then fed into a recycling process that reforms the hulled material into new framing studs and similar products.

6. Hull Beams (A1-01730-HB) Hull Beams at end of life are inspected for structural integrity, refurbished and reused in new Hulls. Any surplus of beams are marketed back into the truck trailer manufacturing industry.

7. Window and Frame (A-83370-W) Window and Frames are disassembled cataloged and re-fit into new Hulls.

8. Service Lines (A-85100-SV) All service lines enter the Seed Hull through central foundation cradle. At Hull’s end of life all service lines are stripped and inspected for structural integrity. Lines that pass inspection are cleaned and re-fitted for use in future Hulls. Lines that fail inspection are stripped of their raw material (copper form electric wires), separated and delivered to second life user (fresh water plumbing hose sold to garden hose manufacture.)

Seed Hull

Primary to the building system, the seed hull provides the essential program and special qualities of the house. It offers open space program and entrance. All mechanical systems and appliances are stored in the belly of the seed hull. A network of chases, housing loc in, electric, network and plumbing lines link the systems to adjoining hulls.
Exterior Skin (A-01580-SK) Exterior skin is composed of recycled plastic and wood product and is manufactured on-site. Skin is stripped from hulls at end of life, palletized and re-blown into new skin.

Shell Beam (A-01274-MG) Shell beams are disassembled and re-used for structural integrity. Profiles are re-used in new hulls of the same model. Profiles can be truncated and used in other models. At profiles end of life cycle material is hulded and sold on a recycled steel market.

Window and Frame (A-01370-W) Window and Frames are disassembled cataloged and re-fit into new hulls

Insulation (A-01580-SH) Vacuum insulated panels are extracted from shell and inspected for punctures. Panels are re-vacuumed sealed and re-installed into new shells.

Interior Skin (A-01880-SK) Interior skin is composed of compressed straw board. Panels are extracted from shell interiors and stripped of there painted surfaces. Raw straw board is then degraded into compost.

Kitchen Components (A-011180-KTC) Interior kitchen appliances are extracted from house unit and quality inspected. Units are re-furbished and redistributed into new hulls. Appliances that fail quality inspection are disassembled, toxins are reclaimed and usable parts are stocked for future repair or sold on used parts market.

Light Gauge Stud (A-01834-ST) Light gauge stud framing members are disassembled and hulded. They are then fed into a recycling process that reforms the hulded material into new framing studs and similar products.

Shell Beam (A-01730-HB) Hull beams at end of life are inspected for structural integrity, re-furbished and re-used in new hulls. Any surplus of beams are marketed back into the truck trailer manufacturing industry.

Program Hull

The program hull provides specific programmatic functions to the house. Each program hull is joined to the seed hull and has the opportunity to be added to or replaced with new program hulls.

 Appliances (kitchens and bathrooms) specific to program hulls can be easily changed in and out of the hull.
Model-A Type-1

Model-A Type-1 is a one bedroom one bath single family house that is delivered to your new home site in four separate hulls. Type-1 is composed of two seed hulls and two program hulls. Hulls are unloaded from their delivery trucks onto your new home site and are attached, seammed and sealed together. Future expansion of your home is possible by the delivery and attachment of other hull sections.
Model-A Type-3

Model-A Type-3 is a two bedroom two bath single family house that is delivered to your new site in six separate hull sections. Type-3 is in the Model-A family and can be created by expanding Type-1 with additional program and seed hull or can be delivered solely to your new home site. Hulls are unloaded onto your new home site and are attached, seamed and sealed together. Future expansion of your home is possible by the delivery and attachment of other hull section.
Model - A Type - 2

Model - A Type - 2 is a two bedroom one bath single family house that is delivered to your new site in five separate hulls. Type - 2 is composed of two seed hulls and three program hulls. Type - 2 can be created by attaching an additional program hull to Type - 1 or can be order solely to your site. The Hulls are unloaded onto your new home site and are attached, seamed and sealed together. Future expansion of your home is possible by the delivery and attachment of other hull sections.
wiring & plumbing

Plumbing and communication services enter the building through the Seed Hull's concrete cradle. In the belly of the Seed Hull HVAC appliances and plumbing manifolds are stored. Lines are distributed from the belly of the Seed Hull to adjoining Hulls.
Assembly & Siting

Model A is assembled from a catalog of several different seed and program hulls. New home buyers can choose different configurations of seed and program hulls according to special and program needs. Once the type has been established the home is ordered and shipped from the manufacturer to the new home site. Each hull is placed onto a foundation cradle which is prepared on site. Hulls are unloaded onto your new home site and are attached, sealed and sealed together. Future expansion of your home is possible by the delivery and attachment of other hull sections.
1. Model - A Type - 2 (primary seed hull)

The primary seed hull contains the in-set and out-set of services to the building through its foundation cradle. It is equipped with HVAC and plumbing manifold in the belly of the hull and an exterior fuel cell power unit. It provides appliance service to other building components through a network of service lines woven through each building hull.

2. Model - A Type - 2 (secondary seed hull)

The secondary seed cell provides the entrance to the building and serves as open space. Plumbing and HVAC services are linked together with adjoining hulls at key locations in each hull.

3. Model - A Type - 2 (program hull)

Program hulls are woven with plumbing and HVAC lines to facilitate specific programs. Each hull can be divided with partition wall and inserted with specific program pieces (kitchen, bath, bedroom).

4. Model - A Type - 2 (program hull / kitchen)

Program hulls are woven with plumbing and HVAC lines to facilitate specific programs. Each hull can be divided with partition wall and inserted with specific program pieces (kitchen, bath, bedroom).

5. Model - A Type - 2 (program hull / bath)

Program hulls are woven with plumbing and HVAC lines to facilitate specific programs. Each hull can be divided with partition wall and inserted with specific program pieces (kitchen, bath, bedroom).
Delivery and Installation

Model-A Type-1 is delivered by standard trucking practices that follow federal and state highway maximum height and width restrictions. Following these restrictions, hulls can be inserted into existing complex delivery systems.
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