



enable

Your home for today,
and tomorrow

Architecture Narrative D8 Submission

August 10, 2017

HOUSE

by Northwestern

Northwestern University

U.S. Department of Energy
Solar Decathlon 2017



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**architecture
narrative**

INTRODUCTION

Enable by House by Northwestern is Northwestern University's first entry to the Department of Energy Solar Decathlon. Designed for active Baby Boomers living in Chicago's North Shore who are looking to downsize and buy their home for life, *Enable* delivers an **EN**ergized (energy-efficient and active lifestyle) and Adapt**ABLE** (the house meets residents' changing needs) experience for its target users. *Enable* is more than a house. It's a home for today, and tomorrow.

AGING-IN-PLACE & UNMET HOUSING NEEDS FOR BABY BOOMERS

Baby Boomers are important to the U.S. housing industry given their sheer numbers. They were born between 1946-1964 and age between 52-70 years old as of 2016.

According to the Census Bureau, over the next 20 years, the population of individuals over 65 will grow by 30 million¹. In the City of Evanston, home to Northwestern University, 20% of the population is projected to be 65 and older by 2020, up from 15% in 2014.

Recent Boomer homebuyers aged between 52-61 project they will live in their homes for at least 20 years² and 90 percent of those over age 65 report wanting to stay in their homes as long as possible³. This desire to **age in place** means that Boomers' houses will become important places for long-term care as residents deal with disabilities and other aging-related health challenges. However, the Joint Center for Housing Studies of Harvard University estimates that only 1 percent of the current housing stock contains the key features required to support aging in place, such as zero-step entrances, single-floor living, wide hallways and doorways,

wheelchair-accessible light switches and lever-style door handles and faucets⁴.

It is with this housing shortage in mind that the Solar Decathlon team at Northwestern University set about designing a highly energy-efficient, yet fully-accessible home for a rapidly aging Baby Boomer demographic.

ENABLE: A USER-CENTRIC DESIGN APPROACH

The House by Northwestern (HBN) team took a user-centric approach to the design of *Enable*. In other words, community members weighed in at every step of the design process about how *Enable* could best meet their needs. Our research activities included both qualitative interview and observation strategies, as well as a quantitative data-coding methodology.

During Fall 2016, HBN collaborated with the Osher Lifelong Learning Institute (OLLI), which is a continuing education program that serves older adults in the greater Chicago area. Throughout 14 weekly sessions, HBN team members co-led discussions on topics related to our project, which included "What is the Solar Decathlon?," "Sustainable Architecture" and "Interior Design." Not only did the discussions reveal these adults' attitudes towards sustainability, many of them also participated in follow-up user interviews and observations, and even invited their friends to participate as well.

From hundreds of hours of this primary research, HBN learned that when considering housing features, our target customers value **comfort** and **livability, high-performance with functionality**, and **easy home maintenance**. Sustainability and affordability are also important, but relatively less so than the aforementioned features.

The User Research team incorporated these values into a set of design matrices that outlined the requirements for various areas of the home (Appendix A), such as optimal room layouts, furniture type and quality, etc., and allowed us to quantitatively compare potential solutions. These matrices gave us confidence that we were prioritizing the real-life values of our target demographic when designing *Enable*.

In order to test our design decisions, our User Research Team held 5 focus groups and 20+ shopping trips throughout the

winter and spring (Image 1). After construction began we also held 3 on-site reviews to solicit feedback from members as the house took shape.



Image 1. Two OLLI members on a shopping trip with our User Research Team.

In order to package energy-efficient and sustainable features into a comfortable, beautiful, accessible, and easy-to-maintain home, Northwestern University has approached the Solar Decathlon 2017 with the challenge:

How might we design a home for Chicago's North Shore that meets the needs of aging Baby Boomers while consuming very little energy?

Our answer: ***Enable.***

ADAPTABILITY SETS ENABLE APART

The City of Evanston has been recognized as a leader in sustainability at both state and national levels. Since naming "Environmental Sustainability" as one of the three core values in its 2006 Strategic Plan, it has earned several prestigious awards including the U.S. Conference of Mayors 2011 Climate Protection Award and the 2011 Governor's Sustainability Award⁵. Its Climate Action Plan, which was written as a collaborative community process in 2008, recommends nearly 220 strategies to achieve its goal of reduce greenhouse gas emissions. In keeping with these sustainable ideals, *Enable's* carefully-designed envelope and its passive and active systems make it 90% more efficient than the average local home **and** net-positive, contributing its excess green energy back to the grid year after year.



Image 2. *Enable* will exceed the expectations of our target customers by delivering a highly adaptable home with sustainable features that are also healthy, comfortable, high-performing, and easy to maintain over time. Designed with its intended residents' priorities in mind, *Enable* empowers its residents to live their lives to the fullest, despite their changing lifestyle needs.

Every house at the Solar Decathlon is energy efficient; what sets *Enable* apart is our focus on adaptability. Our User Research team quickly discovered that Baby Boomers in our local community seek a home that not only meets their current needs but also ensures their comfort and safety in 20-30 years' time. Luckily, the town of Evanston is also on board with these priorities. Dubbed the "Evanston Livability Plan," the City's sustainability initiatives include a focus on housing for all. Evanston is committed to the nationwide challenge of providing Age Friendly housing, and is one of 45 cities in the U.S. to be designated as a World Health Organization (WHO) Age-Friendly City.

ADAPTABLE SPACES FOR LONG-TERM LIVABILITY

What does this look like? *Enable* is a beautiful, well-appointed home with elegant finishes and seamlessly-integrated efficiency features that are easy to maintain. It is also fully-accessible: every room in the house can be easily utilized by someone with reduced mobility, vision, or dexterity— changes that often occur as part of the aging process.

During our interview process, we learned that Baby Boomers desire a space that can serve as a home office, secondary reading room for when a spouse is watching TV, and guest bedroom (or somewhere to crash for a night if their spouse is snoring). They also voiced concerns about needing a live-in caretaker down the road. Thus, we created what we've called the "convertible room" -- a room that serves all of these functions and, with its ensuite bathroom, can easily serve as a caretaker's quarters (Image A9, Appendix A).

In the kitchen, adaptability manifests in the carefully-designed storage of the essentials: plates, silverware, drinkware and other daily items are located in lower shelves that are well within the guidelines for ADA-compliant design (Image A5, Appendix A).

In addition to the long term adaptability afforded by the features above, *Enable's* spacious sunroom allows it to adapt seasonally, nearly doubling its living space and creating a delightful interplay of indoor and outdoor living (Seen from Image A6, Appendix A)..

We believe *Enable* exceeds the expectations of our target customers by delivering a highly adaptable home with

sustainable features that are also healthy, comfortable, high-performing, and easy to maintain over time. Designed with its users' priorities in mind, *Enable* empowers its residents to live their lives to the fullest, despite their changing lifestyle needs.

DELIVERING A COHERENT, CONTEXT-ORIENTED DESIGN

Enable both reflects Chicago's rich architectural history and responds to Evanston's current sustainability priorities. Over 50% of local residential structures were built before 1939 and without today's regard for efficiency or passive design, giving *Enable* the unique opportunity to make an environmentally-responsible contribution to our local architectural landscape. As Evanston's homes demonstrate a range of influences from Queen Anne, Italianate, Victorian Gothic, Neoclassical and Tudor to Modern⁶, HBN was designed without the constraints of a narrow aesthetic. We began our design process with a study of Frank Lloyd Wright and his Prairie and Usonian-style homes. *Enable* features similar horizontal forms, natural materials, flowing interior spaces and the plentiful natural lighting and ventilation for which Wright's homes are known.

Several key principles guided our design process, including: adaptability, durability, environmental responsibility, and ease of maintenance. This section describes how *Enable's* design reflects these goals, from its massing to its layout.

MASSING

Chicago's cold, windy winters and hot, humid summers represent a high annual temperature differential and poses quite a design challenge. During the cooler months of the year, temperatures can get as low as -16F⁷, while during the warmer months, temperatures can get as high as 103F⁸. As a result, 53% of all residential energy in Illinois used to heat and cool homes⁹. *Enable's* highly adaptable design provides plenty of space for residents to enjoy spending portions of the year both inside and out.

With this knowledge in mind, our team began the Solar Decathlon 2017 with a thorough, iterative process. This creative "form-finding" involved rapidly generating shapes, performing energy modeling analyses and checking our geometries against specific programmatic constraints.

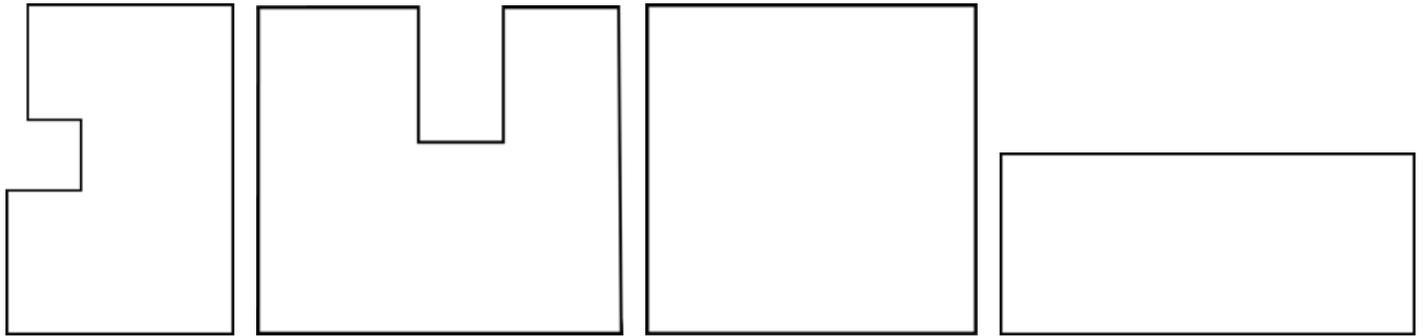


Figure 1. Four early massing iterations: L, U, Square, and Rectangle.

Insights from the HBN User Research Team¹⁰ told us that in addition to being energy-efficient, *Enable* needed to be fully accessible and contain 2 bedrooms, 2 bathrooms and an indoor/outdoor space.

Our form-finding process yielded four potentially-promising plan shapes: an L, a U, a Square and a Rectangle (Figure 1). In order to choose between them, we performed energy and spatial modeling to create decision matrices. While the L shape offered ample natural light, its long hallway reduced the space available for other programmatic activities. Compressing the L's top gave us a U with a quaint private courtyard, but extensive exterior wall area still detracted from its energy-efficiency. Removing the courtyard gave us a highly-efficient square, but our minimal envelope relinquished a definitive separation of public and private spaces. Stretching our Square balanced our needs for programmatic separation and minimal exterior-wall area;

thus, we decided to move forward with the Rectangle shape. In addition to being energy-efficient, its straightforward space can be replicated efficiently, allowing *Enable* to easily become a model for future sustainable residences.

LAYOUT

With the help of further data from the HBN User Research Team¹¹ about the needs and preferences of our residents, we finessed the configuration of *Enable's* interior (Image 3). In addition to energy-efficiency, space-efficiency and ease of circulation, we prioritized functionality and comfort in the design of our adaptable scheme.

Maximizing Square Footage. With two full bedrooms and bathrooms, as well as a full kitchen, living and dining areas, *Enable* is highly space-efficient. Its 994-sf of fully-accessible conditioned area contain all of its users' desired rooms, and its additional 1,447-sf of unconditioned space enhance

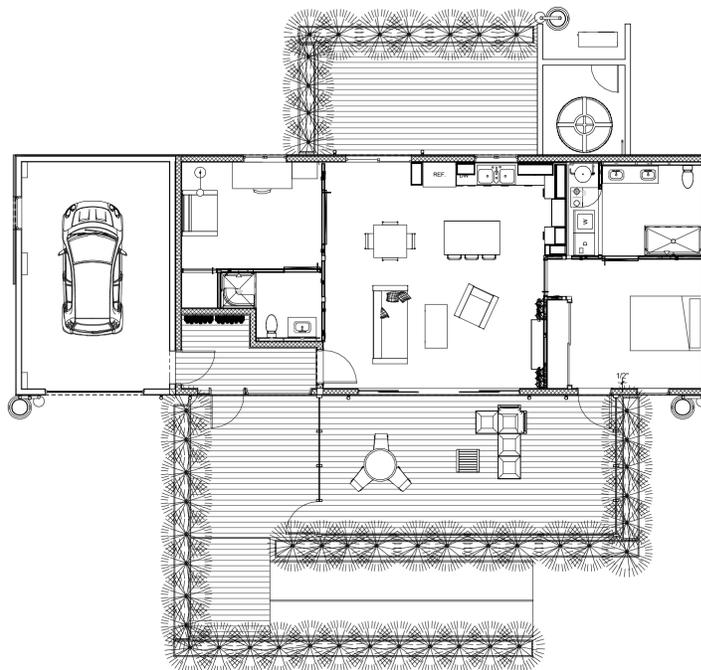


Image 3. Final floor plan for *Enable*.

their storage and outdoor experiences. With large glass sliding doors on either end of its central space, *Enable's* open floorplan expands effortlessly into a three-season sunroom on the south and a relaxed grilling deck on the north. Its unconditioned garage and entryway provide additional shelter and room for their needs.

Separating Public and Private. *Enable's* central public space contains high ceilings to enhance its open atmosphere. Its peripheral private areas have lower ceilings to create a cozy, quieter feel. Together, these physical manifestations of programmatic separation enlarge the social space that users want while maintaining the space for relaxation they need.

Creating Efficient Circulation. *Enable's* central floor plan maximizes ease of mobility for its residents. Every area of the house is wheelchair accessible, and spaces flow nicely into one another. With no carpets, sharp corners or potential tripping hazards, it is safe for both young grandchildren and aging adults.

Multi-Functional Space. The unconditioned passage that connects the garage to the house also functions as its main entrance. It contains ample room for coat and shoe storage, as well as shelves for resting groceries or other heavy bags. *Enable's* convertible room was also designed to fulfill different needs throughout the residents' occupancy, as it can be used as an office, a place for visiting grandchildren to stay or a caretaker suite.

Optimizing Programming. *Enable's* rooms are directionally arranged to make the most of its light and weather conditions. Research from HBN's User Research Team tells us that our users enjoy waking up with morning sun, and thus, the master bedroom is located on the east side of the house. Our users dislike performing activities that require concentration in direct light, which makes the north side of the house a good place for the home office and the kitchen. They also enjoy socializing in spaces with natural light (that also have shading to mitigate harsh afternoon rays), so we placed our living room and sunroom along the house's southern wall. As slipping on ice presents a major hazard for our target demographic, we connected the home with the garage through this unconditioned entryway to mitigate this hazard.

Synthesizing Indoor and Outdoor. Despite its northern latitude and reputation for extreme weather, Chicago's warmer months can be delightful. Many of our users enjoyed yoga, gardening, knitting, painting, people watching and socializing on their porches or patios, so we created ample space within *Enable* for them to do so. The sunroom on the south deck can be opened or closed, making it suitable to use from during the warmer months of the year. It also has shading to block direct summer rays from penetrating *Enable's* living room but let in the softer and more angled morning and winter light. The north deck further enhances residents' space during the summer, when sunshine and long days compel users to spend more time outside. During the colder months, *Enable's* conditioned space feels comfortably cozy, and its ample windows allow for a wide view of the surrounding area. This Seamless integration of indoor and outdoor spaces amounts to 2,441 sf of usable space during the warmer months and comfortable compression into 994 sf of usable space during the winter.

ARCHITECTURAL INNOVATION

From the start, we have closely integrated our team with our target customer demographic and practitioners of construction and energy technologies, as well as architecture and design. This is our framework to rapidly innovate: by taking a user-centric approach to marry the ingenuity and creativity of our student team members with the discipline and know-how of industrial leaders.

Photocatalytic Surfaces that Clean the Air & Themselves.

Enable's exterior surfaces and the interior glazing of its south solarium are treated with a water-based (NSF and NIOSH approved), spray-applied coating that is photocatalytic (provided by PURETi). The invisible active material is titanium dioxide (TiO₂), a benign material used in everyday materials such as toothpaste and powdered sugar, and is activated by UV light from the sun. Titanium dioxide's ultraviolet photocatalytic properties instigate a renewable process by which solar energy naturally breaks down volatile organic compounds (VOCs) and other detrimental organic materials. These types of surface treatment have been traditionally used in hospitals and food preparation facilities, but the HBN team is introducing

it to the residential built environment where we discovered a huge consumer demand for wellness buildings and low maintenance surfaces.

Air Purifying Walls. The drywall (AirRenew Drywall by CertainTeed) actively absorbs airborne formaldehyde and converts it into a safe, inert compound. DIRTT's Breathe™ wall contains air-purifying plants that enhance the air quality throughout *Enable's* interior (Image A5). They also add color and vegetation to its main room, increasing residents' enjoyment of the space. This trio— PURETi, AirRenew, and the Breathe™ wall— ensure high quality indoor air that will promote good health for *Enable's* residents.

Roof-Integrated Solar Panels. HBN's User Research Team found that the unsightly framing often used with residential PV-systems deterred many of our users' from outfitting their homes with solar panels. Thus, *Enable's* roof-integrated PV-cells blend seamlessly into its sloped facade. With such highly-insulated walls, our solar panels cover only half of the roof but still provide more power than *Enable* will use. Together with the battery system, they also serve as a backup power source.

Heating, Ventilation, and Air Conditioning. *Enable's* HVAC system is both seamlessly integrated into the architecture and engineered to exactly match the thermal comfort and indoor air quality needs of its future occupants. A record-setting high-efficiency air-source heat pump (Chiltrix CX34) delivers thermal comfort to the home's conditioned spaces, and a dynamic humidity controller (DHC) ensures that indoor humidity remains at a comfortable level throughout Chicago's humid summer months. This heat pump also provides heat for our domestic hot water tank, which reduces HVAC energy consumption significantly while retaining the efficiency benefits of heat pump water heating. *Enable's* highly-insulated thermal envelope requires efficient ventilation to maintain high indoor air quality standards for its residents. Its ventilation system (the Zehnder ComfoAir 200) accomplishes this by providing exhaust ventilation from both bathrooms and the kitchen while supplying fresh air to the return air duct, which is then distributed to every room in the home.

Exterior walls. Structural insulated panels (SIPs) are a building material consisting of an insulated foam core sandwiched between two structural sheathing boards forming a modular panel that is used as the wall or roof of the house. SIPs are

very well insulated and airtight, which allows a SIP house to consume less heating and cooling energy and to maintain better control over its indoor environmental conditions. SIPs are made in factories under controlled conditions and can be customized for any design thereby reducing construction waste and improving quality. *Enable's* walls are composed of 6-3/8" SIP panels, with 5-1/2" of R-7 per inch closed-cell rigid polyurethane foam. The entire assembly of the walls provides an effective R-value of 40.5 with nearly no thermal bridges. Our SIP panels also utilize one-piece corners, allowing the continuous insulation barrier to wrap around the corner rather than be stopped by framing members. Our SIP panels utilize strategically located cam-locks for easy disassembly to facilitate efficient modification. The roof is constructed with the same size SIP panels as the walls, with the addition of a 6" metal stud framing cavity with R-24 mineral wool insulation on the interior face. These SIP panels provide our roof with a continuous insulation barrier, which is a feature often not found in conventional roof construction.

Modular Interior Walls. The majority of *Enable's* interior walls are manufactured by the company DIRTT, a technical-construction innovator. DIRTT's connectors are extruded aluminum tracks designed to ensure close fit and strength but slide easily to allow for simple installation and removal. By using pre-engineered, pre-manufactured wall frames and panels, the interior space and rooms of *Enable* can be reconfigured to adjust and used over the owner's different stages of life (including adding medical gases). Any required maintenance behind the walls will only require disassembly and not demolition.

Kitchen Island Accent Panel. Part of our users' need for high-quality finishes manifests in the desire for a gourmet kitchen with stone countertops. To address this consumer demand while maximizing sustainability, *Enable* incorporated a "slab" of back-painted Corning Willow Glass in the kitchen island as a competition demonstration. In this form, the Willow Glass looks and feels exactly like stone but is actually more durable and scratch resistant. The same glass that is used for smartphone touchscreens, it has many advantages including: 1) conformability and ease of application to flat building materials, 2) scratch and stain resistance, 3) ultra-thinness, allowing it to be rolled into long spools like paper, which results in less material scrap and far less energy and water spent on transportation and manufacturing. This demonstration is

an example of the way modern technology has allowed our users to have the look they want without leaving a big carbon footprint.

ARCHITECTURAL IMPLEMENTATION

The HBN team strived to create a holistic and integrated design that was able to deliver on both beauty and performance through architectural implementation of passive strategies, energy production and management, and cutting-edge technologies.

Natural Ventilation. All exterior rooms have operable windows to allow for natural ventilation when desired. Our operable high clerestories on the north coupled with the sliding doors on the south face create passive cross-ventilation through the house's main space by allowing warm air to rise up and out through the clerestories and drawing cool air in through the south doors. Additionally, our entryway has a venting picture window to allow for passive temperature regulation when needed.

Natural Light. *Enable* incorporates natural light into its main living space via Solatube skylight tubes, clerestory windows and large glass doors. The master bedroom, master bathroom and convertible room all contain ample window light, and our second bathroom (the only room in the house without a window) contains a Solatube and daylight harvesting LEDs. The entryway also has Solatubes that contain daylight harvesting LEDs.

Thermal Buffer Spaces. During the colder months, conventional buildings experience significant energy loss through external doors. To mitigate this heat depletion, commercial buildings commonly have either a vestibule or a revolving door. Residential structures rarely feature these airlock spaces, but *Enable* utilizes airlocks in the form of an entryway, sunroom, and garage to enhance residents' comfort, safety and energy-efficiency.

Entryway & Garage. *Enable's* entryway connects its front door, garage and conditioned house space. It serves as a mudroom for dirty shoes, wet coats and bag storage, and

it also provides shelter to residents during Chicago's many months of inclement weather. Though it is unconditioned, large windows allow for high solar gain and an insulated envelope retains this heat. This significant heat source keeps the temperature as high as mid-50s during cold winter days, keeping the entryway a functional space year-round. The garage functions as an insulative barrier to the western side of the house.

Sunroom. *Enable's* three-season sunroom allows for residents to make the most of the Chicago's precious months of warm weather. It can fully close during the spring and fall to retain thermal gains, and it can fully open during the summer to allow for passive ventilation and cooling. When the glass sliding doors on the house's southern facade open, this passive ventilation extends into the main living area of the house, allowing residents to fully relish the fresh air and sounds of the neighborhood on a nice day.

Appliances. All appliances are provided by Beko US, which was named 2017 Energy Star® partner of the year by the Environmental Protection Agency. Beko is a leading appliance manufacturer in Europe and now produces several of the most energy-efficient appliances available in the U.S. market.

Lighting Design & Controls. *Enable* features LED lighting exclusively, which we designed in collaboration with local professionals using photometric modeling design tools (Image 3). This modeling process allowed us to confirm our light levels meet or exceed competition requirements and recommended lighting levels for each space within the home prior to construction.



Image 3. Screenshot from photometric modeling design tool used to develop an effective lighting plan for *Enable*. Source: Paramont-EO & Kelso-Burnett.

We took particular care to design the home's lighting around guidelines for aging-in-place. For example, task lights are located next to dedicated reading spots, like the desk and sofa bed in the second bedroom. In the kitchen, under-cabinet and pendant lighting ensure users can fully utilize their counter space. Plentiful accent lighting makes *Enable* feel like a home: with uplighting above the cabinets, the chandelier, floor lamp, and solar-powered string lights in the main room setting an elegant yet comfortable mood.

All light fixtures are controlled by the Lutron Caseta system, which allows occupants to dim all light fixtures, schedule when they are turned on, and create custom lighting scenes and programs. All of this can be done from within the home, or within the Caseta App anywhere with an internet connection. *Enable* includes a host of user-friendly smart home systems, intended to make the operation of the home simpler and more intuitive.

The Caseta system can do more than just lighting controls: in *Enable*, it integrates with the Nest Protect smoke and carbon monoxide detectors, the Nest Learning Thermostat, and Amazon Alexa. Through the smart-bridge, all of these components are linked together through one App, preventing users from needing to switch applications frequently to use different features of the home.

QUALITY DESIGN

MATERIALS

Our design principles—adaptability, durability, environmental responsibility, and ease of maintenance—guided our materials selection indoors and out. We sourced all of our technologies and materials from vendors that are accessible to any consumer, which allows our home to be easily modified and replicated. Thus, *Enable* can be a baseline model for future sustainable houses.

Enable's interior materials were selected with environmental responsibility, durability, healthy living, and aging in place in mind. As a result, many of its fixtures and finishings have been recognized for their durability, use of recycled materials, and low VOC-content.

Environmentally-responsible wood siding. For the north elevation and portions of the east and west, we selected sustainably-forested, thermally-modified timber from ArborWoodCo in Duluth, MN. The thermal modification process makes the wood less prone to rot or decay and much more durable. For the south elevation and remaining portions of the east and west, we chose LP SmartSide, an engineered wood product sourced from forests managed to strict Sustainable Forestry Initiative® (SFI) standards. The binding agents used in this product are low-VOC and safe for pets and children. Durable, low-maintenance, and environmentally-responsible, both of these wood siding products were ideal choices for *Enable*.

Hardwood Floor. *Enable's* responsibly-sourced, engineered hardwood floor consists of quartersawn white oak. Sustainably harvested from a Wisconsin mill (within 500 miles of Northwestern), it contains no added urea formaldehyde (NAUF) and is coated with a VOC-free finish. In addition to being a responsibly-sourced product, it is highly durable, easy to maintain, and will not leach toxic odors.

Bathroom Tile. The tile on *Enable's* master bathroom walls and floor, as well as its guest bedroom floor and entryway floor come from Crossville - a company renowned for its sustainable manufacturing processes (Image A8, Appendix A). By using pre-consumer waste from TOTO toilets, they are able to guarantee at least 4% recycled content in each tile. Additionally, their production facility reuses over 99.8% of the water consumed in its manufacturing process.

Kitchen Countertops. *Enable's* kitchen countertops are made in Chicago by Gilasi, from VOC-free epoxy resin and crushed recycled glass. Sourced from a variety of local businesses, such as oven-door glass manufacturers, hand-blown light fixture and container glass manufacturers, this glass makes Gilasi's countertops 77-85% pre-consumer recycled material.

Furniture. The majority of the high-quality furniture in our house is made from real, FSC-certified wood and is thus highly durable. In addition to giving our users the feeling of earned luxury they so value, this durable furniture will last long enough to be passed down to grandchildren, which reduces consumer-waste.

DESIGNED FOR AGING-IN-PLACE THROUGHOUT

Given our target demographic, we prioritized design guidelines for aging-in-place when it came to decisions large and small. Below are some of the specific ways *Enable* will support its residents in living safely and enjoyably in their home for decades to come.

Clear, Safe Circulation. The flooring throughout *Enable's* interior and deck spaces is all on the same plane. Its circulatory spaces contain no sharp curves, and its furniture and fixtures have no sharp corners. These design decisions make *Enable* both easily accessible by wheelchair and safe for crawling grandchildren to navigate at will. It also allows for clarity of layout, ensuring that *Enable's* spaces are free of nooks and crannies that can be difficult to access.

Lever-style door handles. Keys to aging in place are planning ahead and integrating designs for reduced mobility in older age. Lever-style door handles rather than knobs make opening and closing doors easier for those with arthritis or other conditions that reduce finger dexterity.

Aging-friendly furniture. All furniture items meet user research requirements to ensure stability, ease-of-use, simple maintenance, and the polished look and feel desired by our users.

Counters and Drawers. All of *Enable's* countertops and drawers can be easily reached from wheelchair-level.



CONCLUSION

HBN began the Solar Decathlon 2017 by asking ourselves: How might we design a home for Chicago's North Shore that meets the needs of aging Baby Boomers while consuming very little energy? Our answer: *Enable*.

As an adaptable, energy-efficient home that allows its residents to safely enjoy seasonal indoor and outdoor activities, *Enable* offers a design-solution to the shortage of housing for Baby Boomers who wish to age-in-place on Chicago's North Shore. It is both beautiful and well-appointed, with elegant finishes and seamlessly-integrated energy-efficient features that are easy to maintain. It is also fully-accessible: every room in the house can be easily utilized by those with reduced mobility, vision, or dexterity-- changes that often occur as part of the aging process. Designed with our target market's priorities in mind, *Enable* inspires and delights, empowering its residents to live their lives to the fullest.

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8. Highest temperature in Chicago, IL recorded within the past 10 years (http://www.weather.gov/lot/Chicago_Temperature_Records)
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APPENDICES

APPENDIX A. RENDERINGS



Image A1. Overhead exterior view from the southeast, Summer



Image A2. Exterior view from the southeast, Winter



Image A3. Exterior view from the southeast.



Image A4. Exterior view from the southwest.



Image A5. Interior view from front door, looking into the living room, dining room, and kitchen.



Image A6. Interior view from door to the convertible room, looking into the living room and out to the sunroom.



Image A7. Interior view of the master bedroom; door to the right exits to the sunroom.



Image A8. Interior view of the master bathroom.

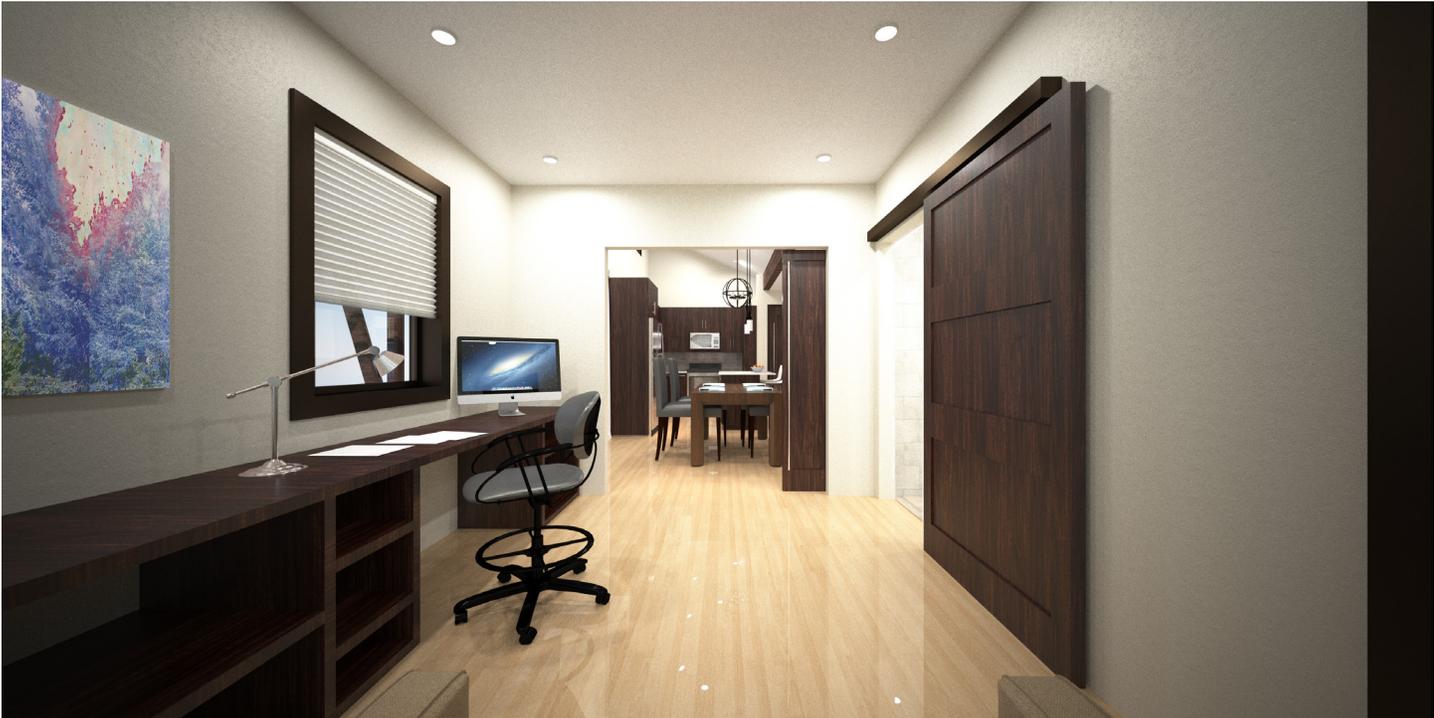


Image A9. Interior view of the convertible room, looking out to the dining room and kitchen.

APPENDIX B. USER RESEARCH DATA

View the video we made about our user research process here: https://www.facebook.com/pg/HouseByNorthwestern/videos/?ref=page_internal

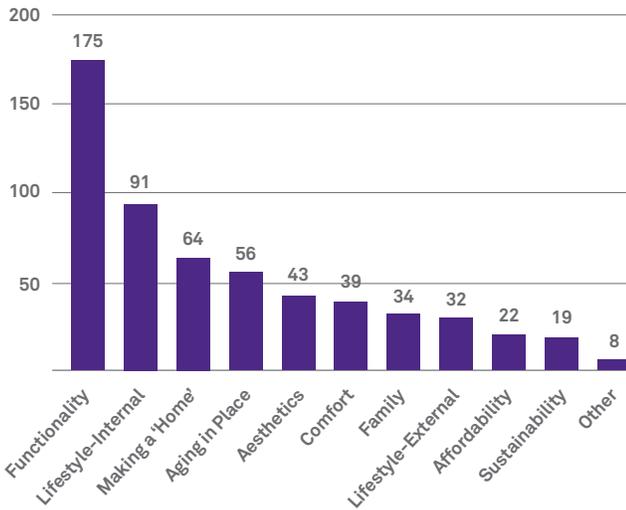


Figure B1. Target demographic housing priorities (ranked in order of importance). Source: House by Northwestern User Research Team (bit.ly/2hgkw1k)

Requirements (Counter Stool)	Folio Top-Grain	Lowe Smoke Cc	Rouka Grey Up	Phoenix Ivory 2	Curran Crema Counter Stool
	\$499	\$279	\$349	\$149	\$369
Has a back for support, can grab on when getting in and out	1	1	1	1	1
Footrest to step on and off stool	1	1	1	1	1
No armrests so users can slide in and out	1	1	0	1	1
Feels sturdy, wide footprint by feet	1	1	1	1	1
Skinny enough to fit two in center island	1	1	1	1	1
User appeal (material, quality, design)	1	1	1	1	1
Comfortable to sit in (curve, upholstered)	1	1	1	2	1
Does not swivel	1	1	1	1	1
Design matches our aesthetic (grey=0.5, not grey = 1)	0.5	0.5	0.5	1	0.5
Price (ranked)	-1	2	1	3	0
TOTAL:	8.5	8.5	7.5	10	8.5

Requirements (Dining Chair)	Lowe Smoke Le	Curran Quilted	Sava Dining Ch	Monterey Charcoal Dining Chair
	\$199	\$349	\$249	\$199
Comfort	1	1	1	2
Customer reviews (durability, ease of cleaning)	-1	1	1	1
Aesthetic	1	1	1	2
Price	2	0	1	2
Lead time				
Seat depth no deeper than 17"	1	1		1
Width no larger than 19"	1	0		1
Seat height (29"-12") = 17"	0	0.5		1
TOTAL:	5	4.5	4	10

Figure B2. User Research Team design matrix used to determine most suitable counter stools and dining chairs. Requirements gathered from interviews, home observations, and focus groups with target demographic.

Requirements	Loveseat + swivel	2-seat sofa + armchair	Armless loveseat + swivel	L-shape	Right-arm + swivel
Can see 55" TV	2	-1	2	2	2
Looks out sunroom	-1	1	-1	1	-1
Comfortable armrests for lying down	1	1	-1	1	1
Easy to get in and out of	1	1	-1	-1	0
Correct firmness	1	1	1	1	1
Correct height	1	1	1	1	1
Sturdy	1	1	1	1	1
User appeal	1	1	0	1	0
ADA compliance + tour route	1	1	1	-1	1
Total:	8	7	3	6	6
Armchair Requirements:					
	Elyse Swivel	Elyse Swivel Glider			
Arms match sofa	1	1			
Swivels to face conversation or outside	1	1			
Does not rock to allow users to get up	1	0			
Proper seat dimensions	1	1			
Fits in space	1	1			
Total:	5	4			
Fabric Requirements:					
	Duet - Natural	Diamond - Flax			
Interesting read	1	1			
Nice hand	1	1			
Matches color scheme	1	1			
Easy to clean	1	1			
Wrinkle resistant	0	1			
Total:	4	5			

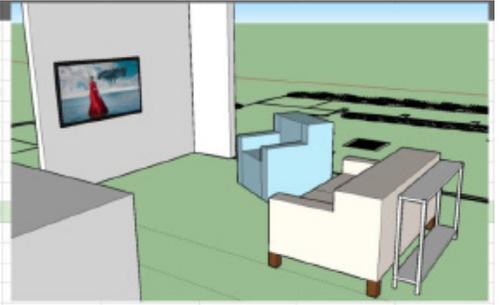


Figure B3. User Research Team design matrix used to determine most suitable living room layout. Requirements gathered from interviews, home observations, and focus groups with target demographic.