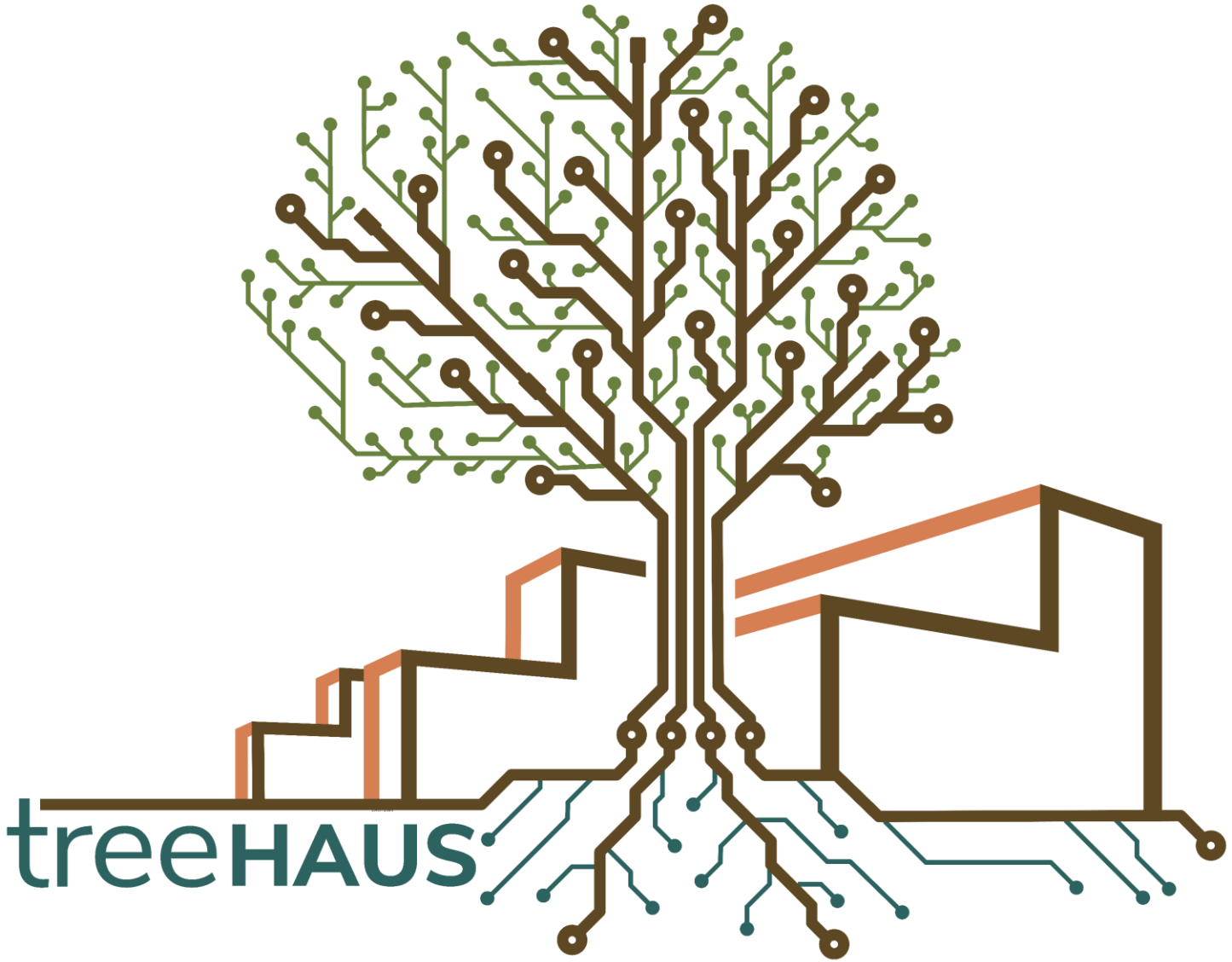

ecologic

Solar Decathlon Design Challenge 2019
Attached Housing (AH) Division

VIRGINIA TECH

ecologic

Combined logic of ecology and technology
Binary intelligence and 10 competitions

Student Leads

Zachary Gould
Engineering

Justin Gravatt
Business

Jackson Reed
Architecture

Alex Arshadi
Landscape

Arjun Choudhry
C.S.

Faculty Advisors

Georg Reichard
Faculty
Technical Lead

Deidre Regan
Faculty
Design Lead

Student Team Lead: Zachary Gould

80% Undergrad | **20% Graduate**

Landscape

Alexander Arshadi
Amanda Hayton
Brooke Pagliarini
Owen Baylosis
Sam Snyder
Tess Reeves

Special thanks to
Delie Wilkens

CS

Arjun Choudhry
Ikechukwu Dimobi

Design

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Jennalee Rowden
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Charlie Crotteau
Nicholas Van de Meulebroecke
Connor Leidner
Ian Edwards
Michael Darby
Thomas Gelb
Victor Zimbardi
Vidusha Sridhar
Nate Bennett
Mustafa Shafique

Business

Justin Gravatt
Alec Fong
Tolulope Adesoji

Engineering

John Hinson
Kewal Agarwalla
Young Kwang Ju
Michelle Baker
Sagar Karki
Racim Badsi
Tori Deibler

Partnerships

Academic

Industry

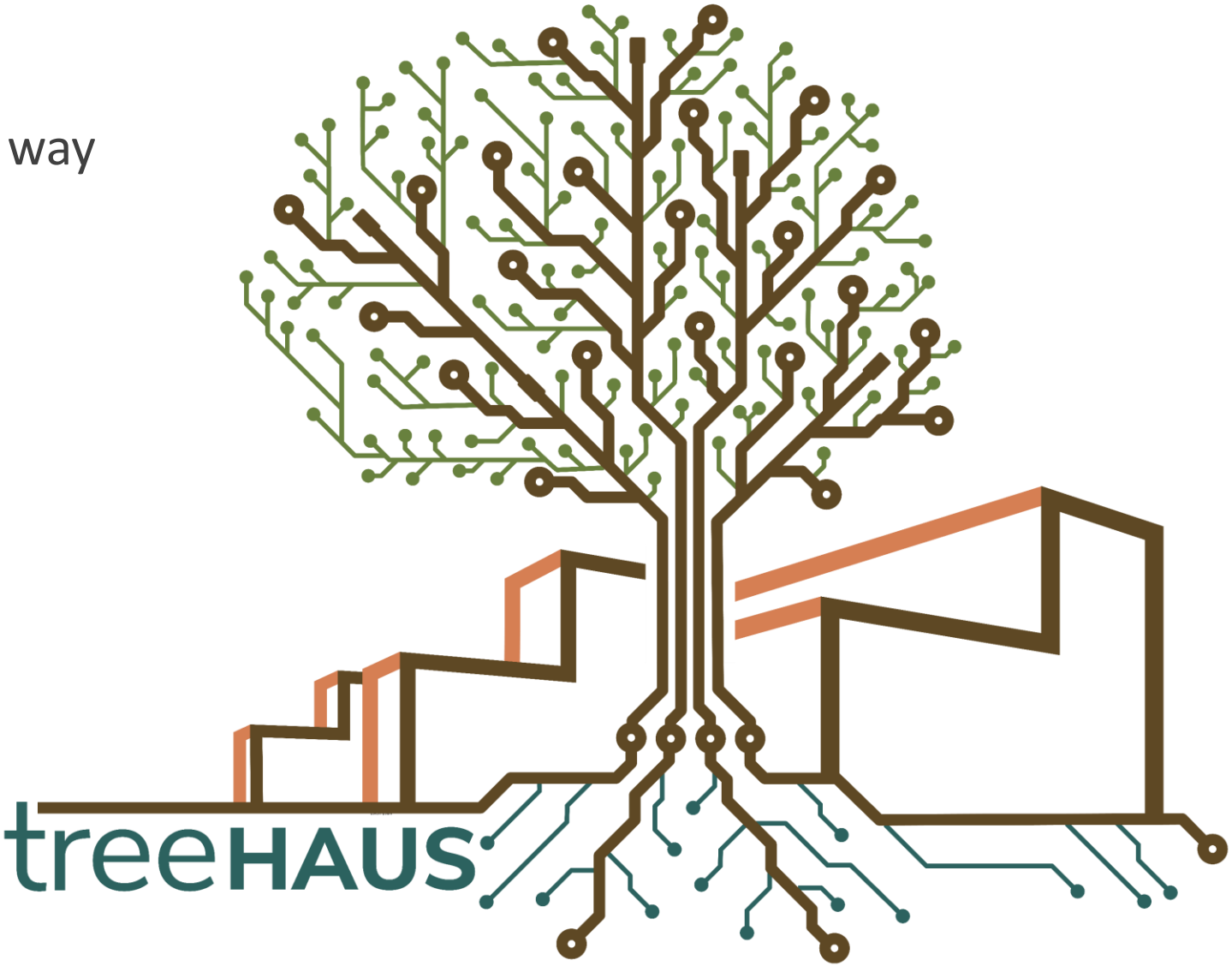
Concept

TreeHAUS is inspired by the way trees collect and distribute resources in the forest:

ENERGY

FOOD

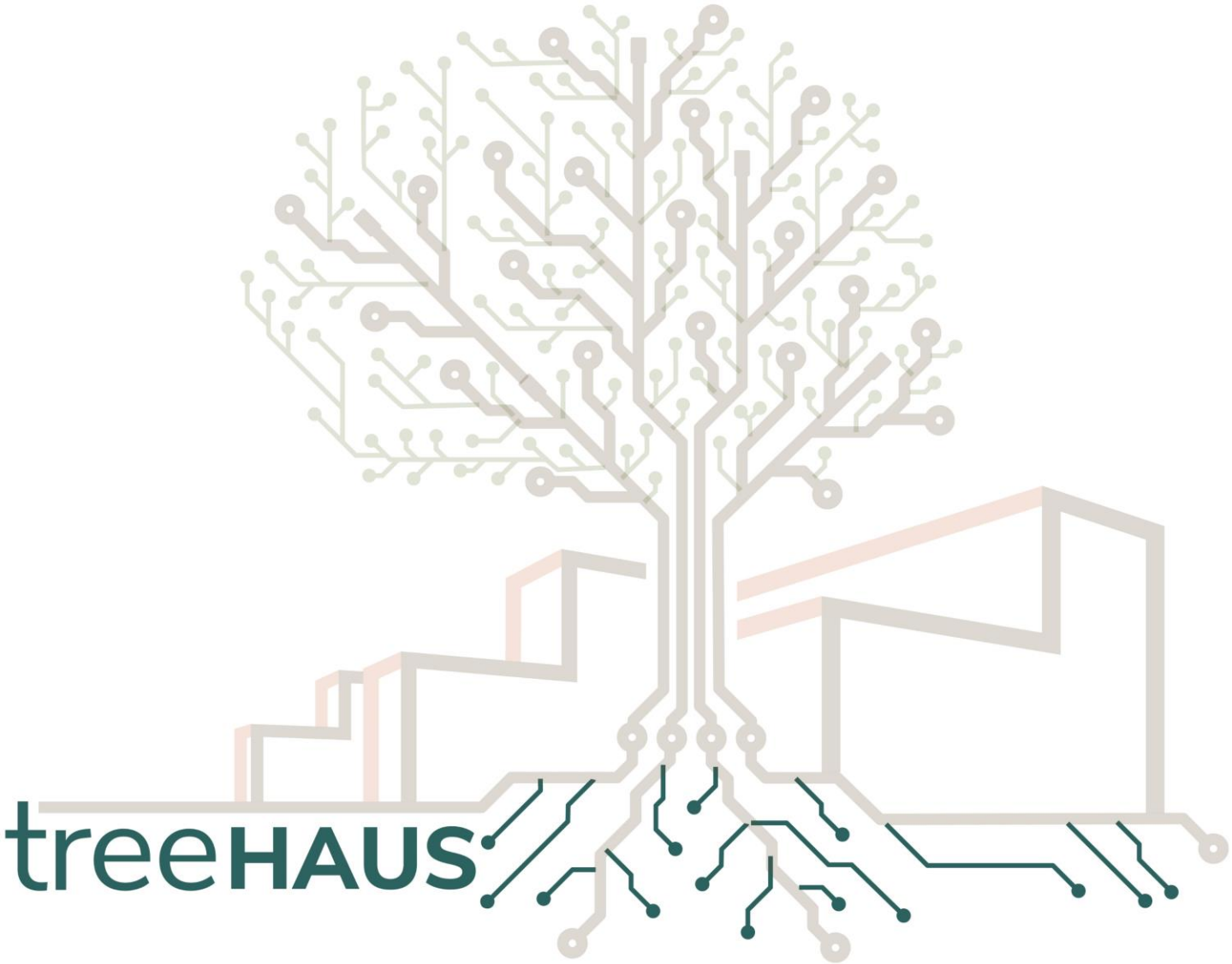
WATER



Roots

Engineering systems:

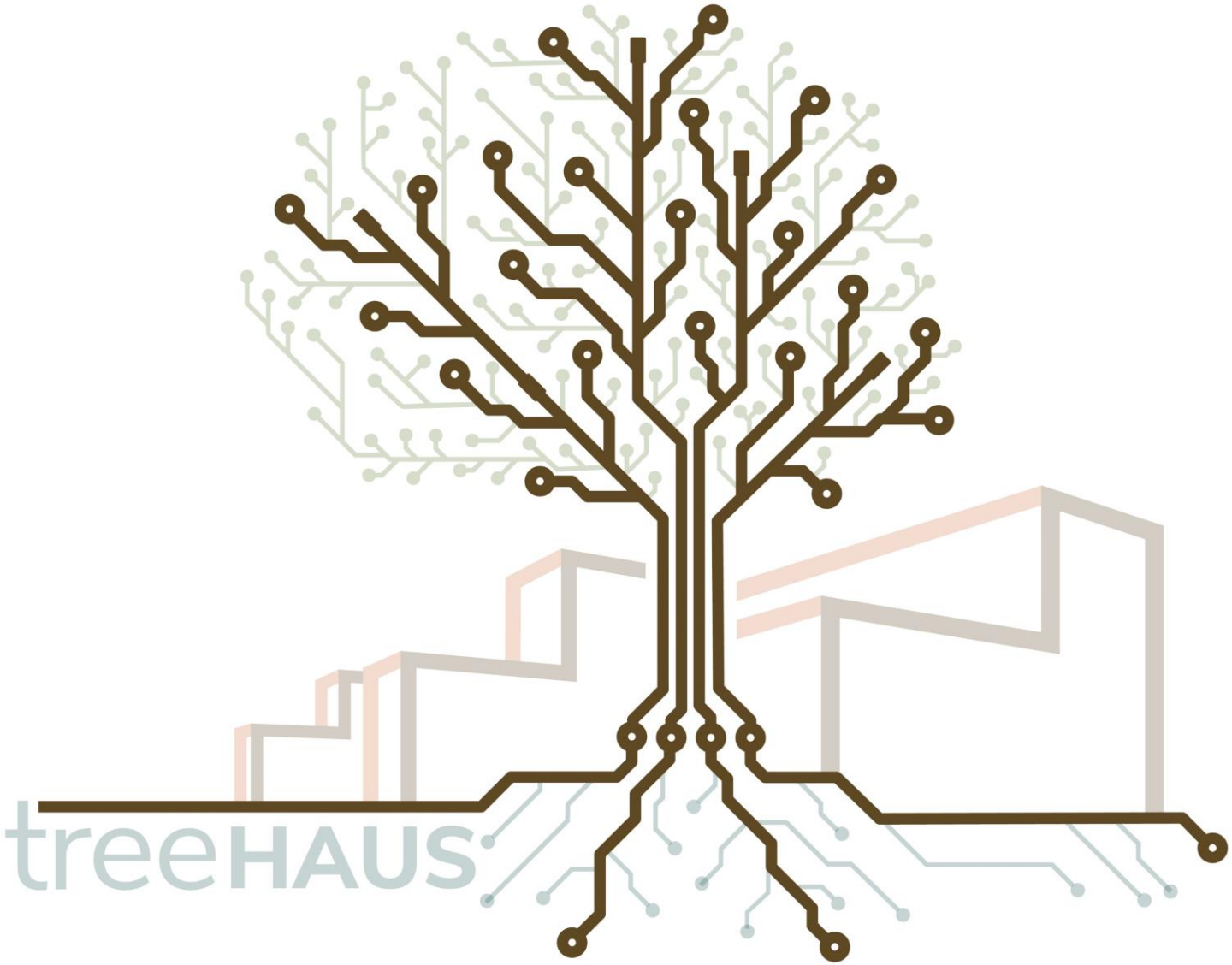
- Blockchain Energy Exchange
- AD / Biogas Back-up Power
- Condensate Irrigation



Branches

Agroforestry landscape:

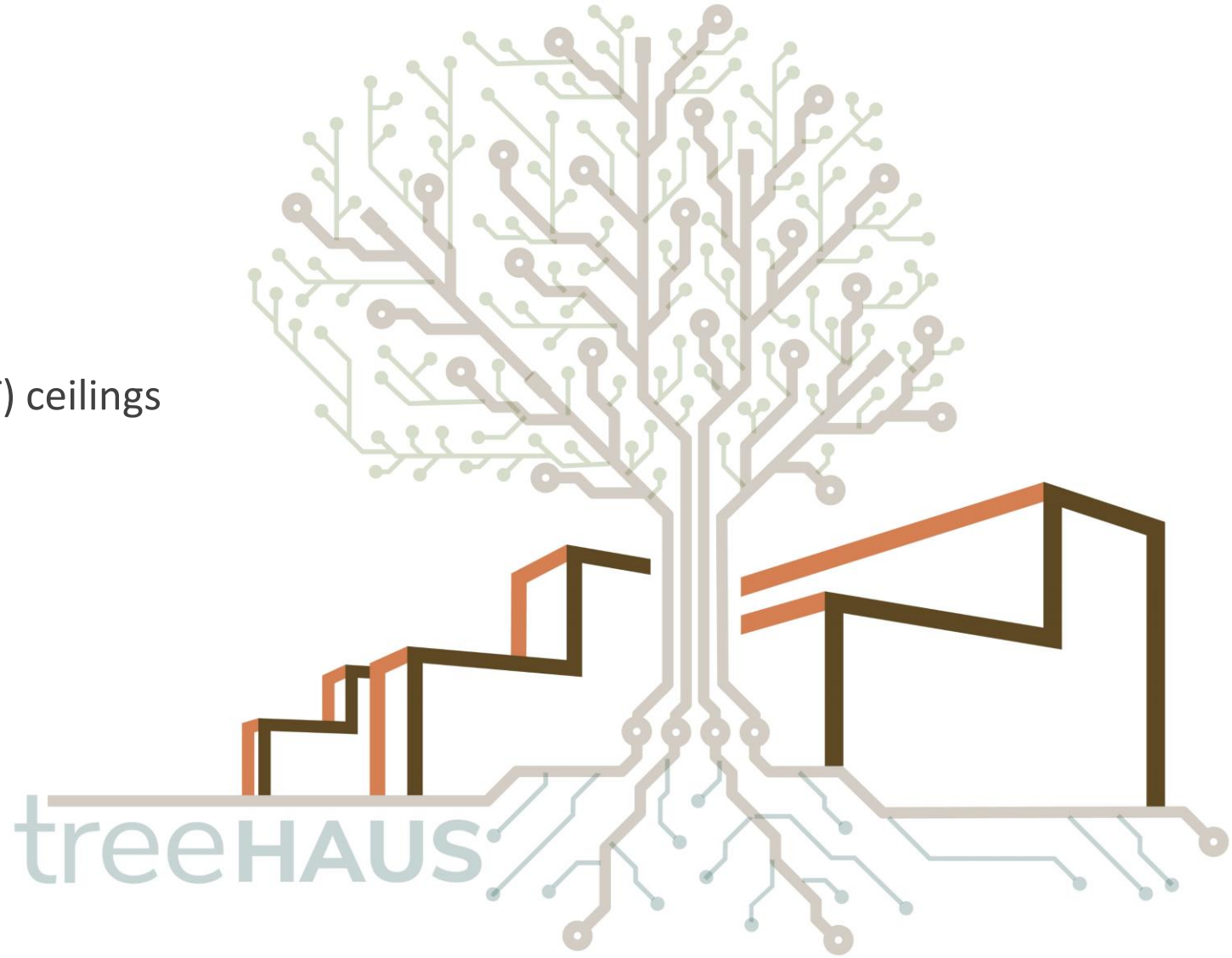
- Food Production
- Ecosystem Services
- Seasonal Energy Savings



Trunk

Architectural design:

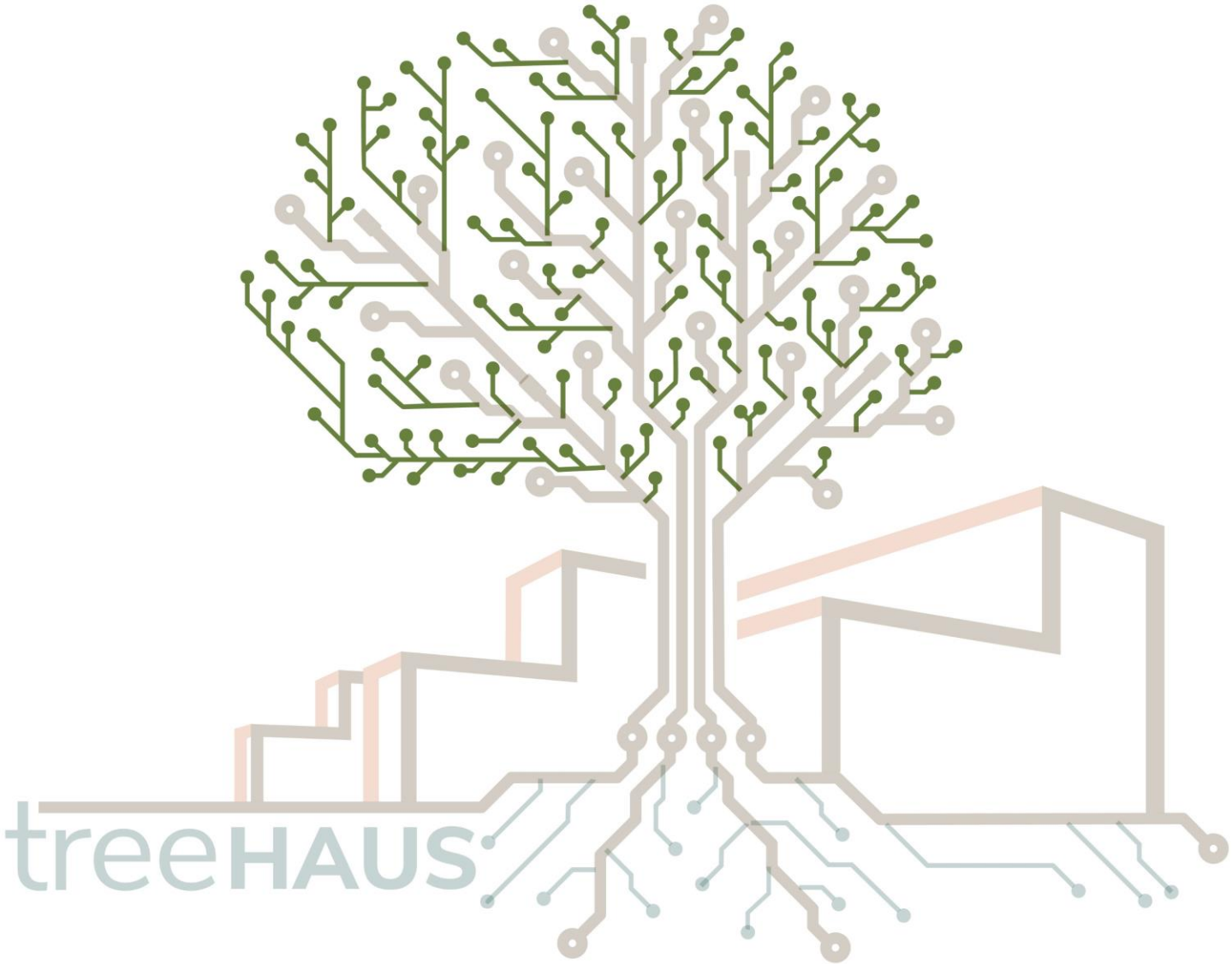
- Dowel Laminated Timber (DLT) ceilings
- All wood exterior wall
- Stomatal window screens

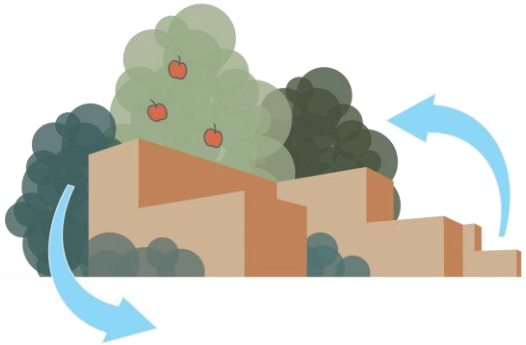


Canopy

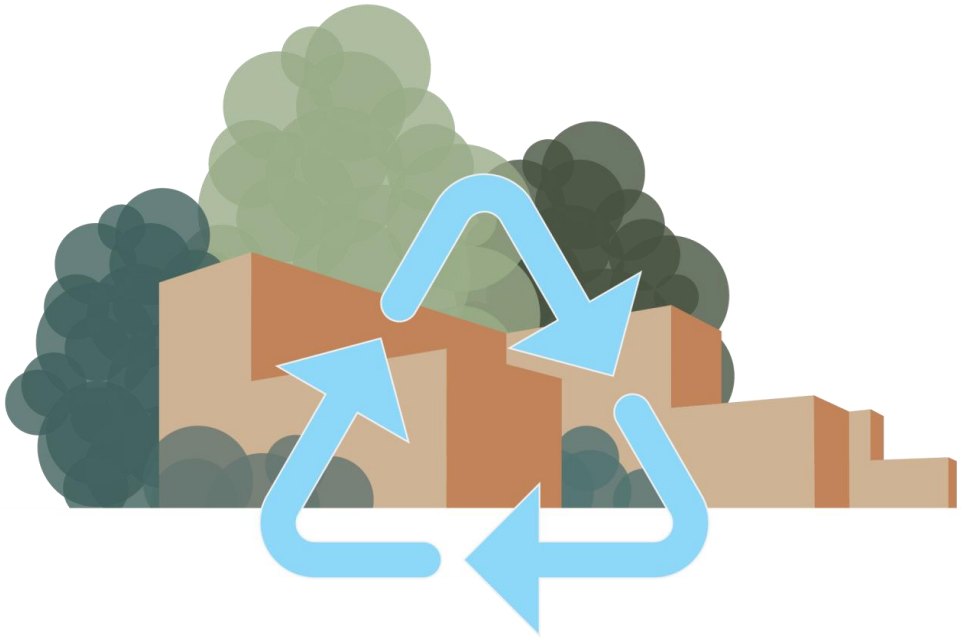
Resource capture:

- Solar PV Conversion
- Rainwater Collection
- Food Waste



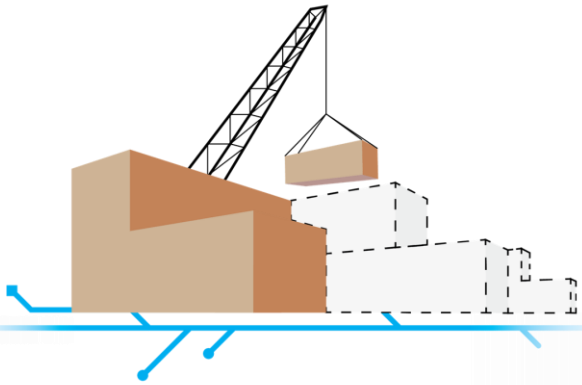


Restorative Landscape

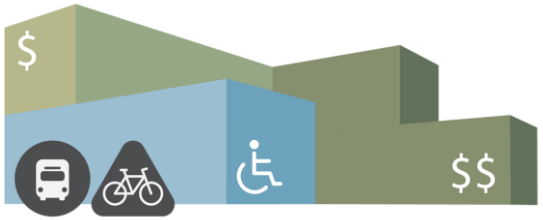


Regenerative Design

Mindful Intelligence



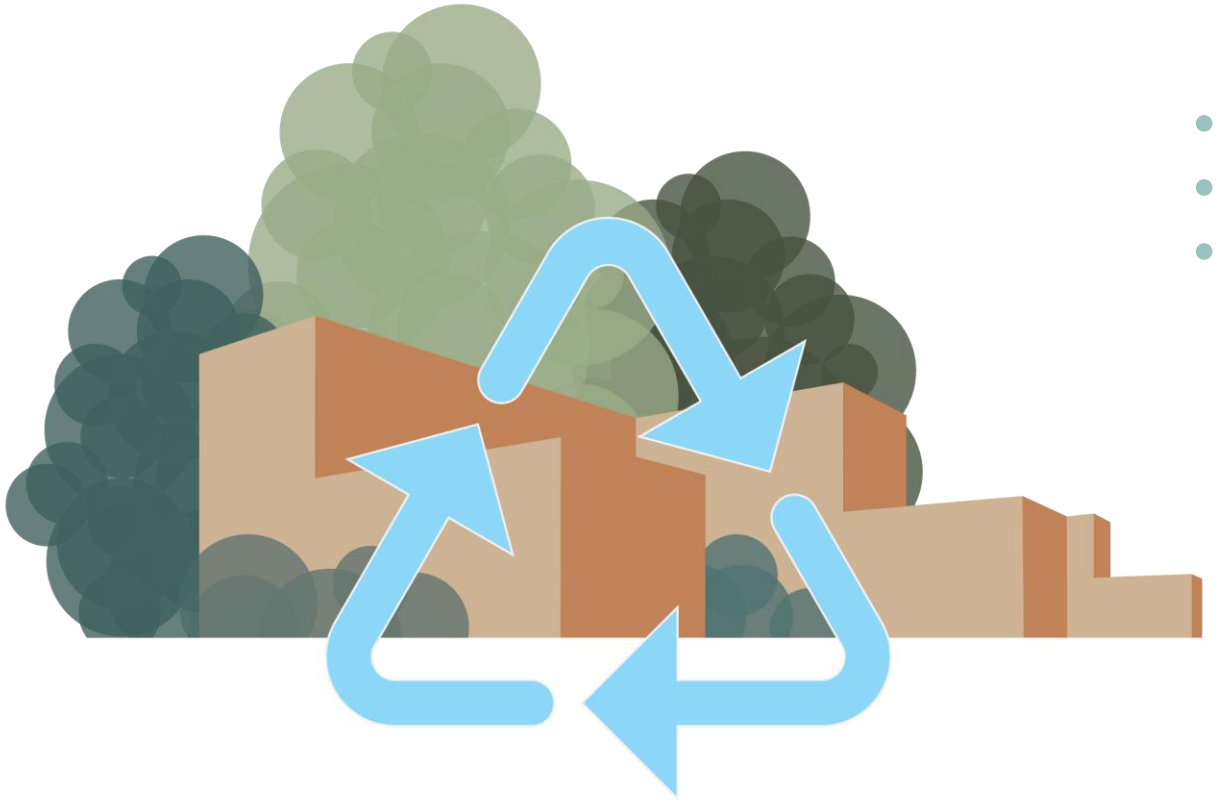
Scalable Modularity



Accessibility

Design Goals

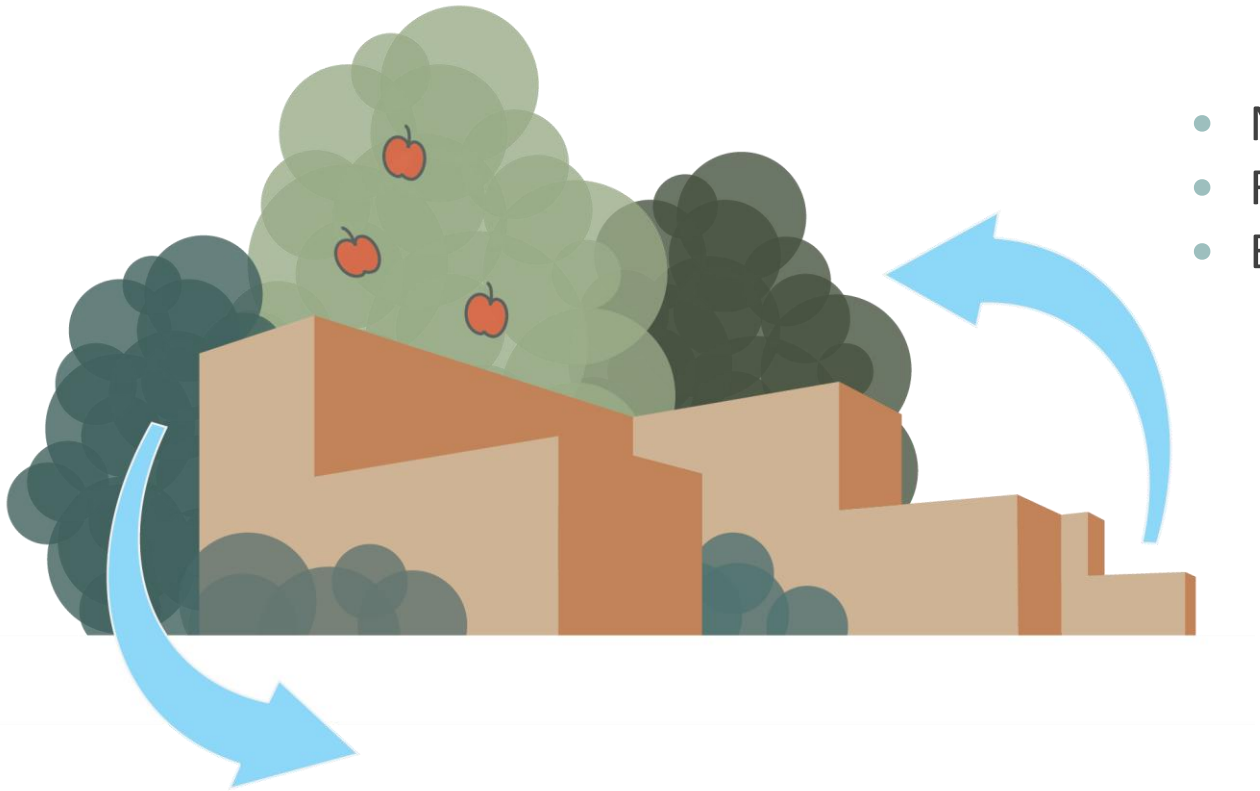
Regenerative Design



- Stronger surrounding ecosystem
- Stronger surrounding population
- Stronger surrounding municipality

Design Goals

Restorative Landscape



- Native genetics
- Remediation of disturbed land
- Edible agroforestry landscape

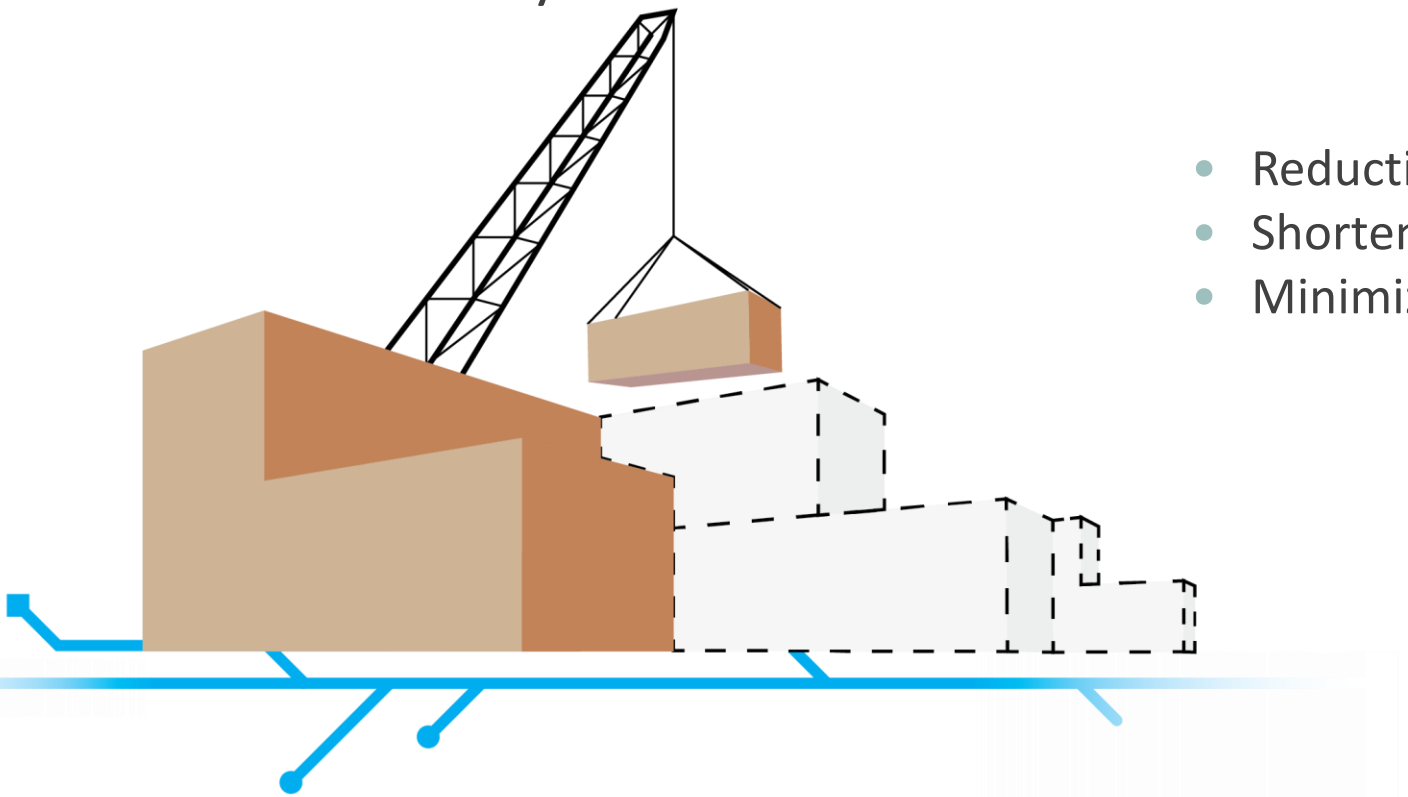
Design Goals

Mindful Intelligence

- Blockchain energy distribution
- Behavioral learning over time
- Seamless biometric integration

Design Goals

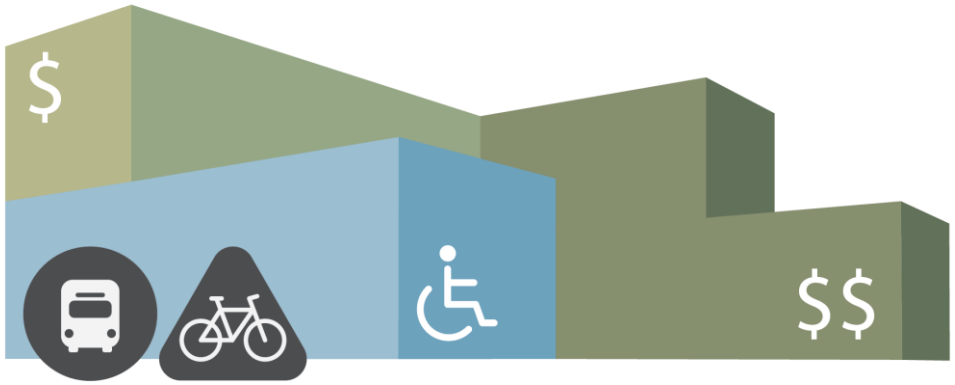
Scalable Modularity



- Reduction of project cost
- Shorten construction timelines
- Minimize waste and site disturbance

Design Goals

Accessibility



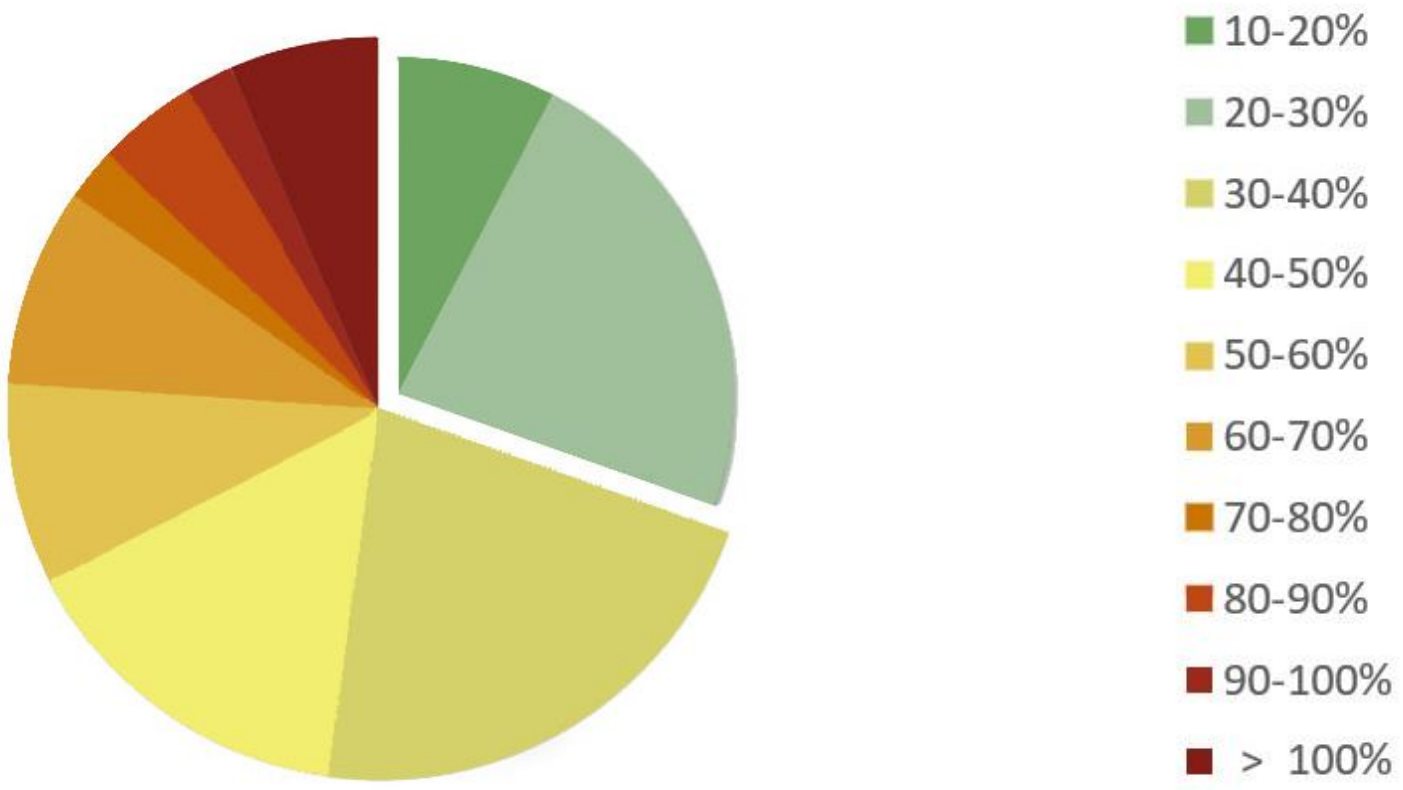
- Multi-tiered affordability
- Promotion of (bio) diversity
- Connection to local transit and trails

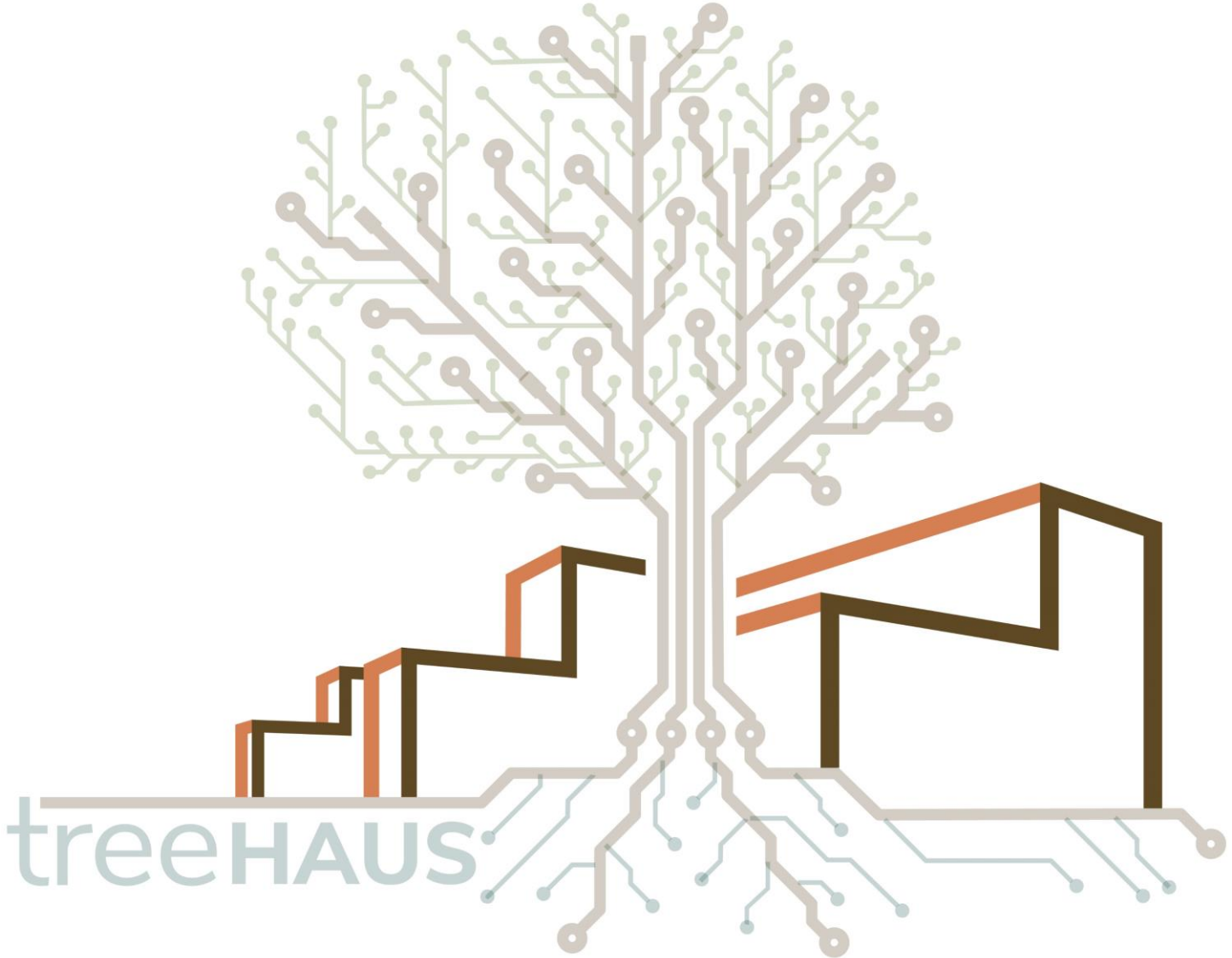

VIRGINIA TECH: 2017
PRICES FORK ROAD
COLLEGE AVENUE
MAIN STREET
OTEY STREET
KENT STREET
WASHINGTON STREET


VIRGINIA TECH: 2047
Proposed Building
Existing Building
PRICES FORK ROAD
MAIN STREET
OTEY STREET
KENT STREET
WASHINGTON STREET

Real Estate Affordability Crisis

70% of VT Grad Students are Housing Insecure




treeHAUS


CRUMPACKER WOODS
VT CAMPUS
VT CRC
10
13
5
12
Learn
Live
Work
11
1. Proposed Site
2. Parking
3. RackSpace
4. Propulsion & Power Lab
5. Power Station
6. Anaerobic Digester
7. Biogas Genset
8. Mycorrho-Grid Storage & Distribution
9. BT Bus Stop
10. Proposed Trail Access
11. Blacksburg Airport
12. Existing Utilities (Gas, Water, Sewer, Lines)
13. Huckleberry Trail
14. Water Purification
Property Line
Blacksburg Transit
Huckleberry Trail
ROAD
BUS
VIRGINIA TECH CAMPUS
BLACKSBURG
SMART VILLAGE
SITE & CORPORATE RESEARCH CENTER
AIRPORT

Unit Layouts

- Shared living arrangements
- Accommodating diversity
- Flex spaces

Level 1

Unit D
4BR

Unit C
3BR

Unit B
2BR

Unit A
1BR

Level 2

Unit D
4BR

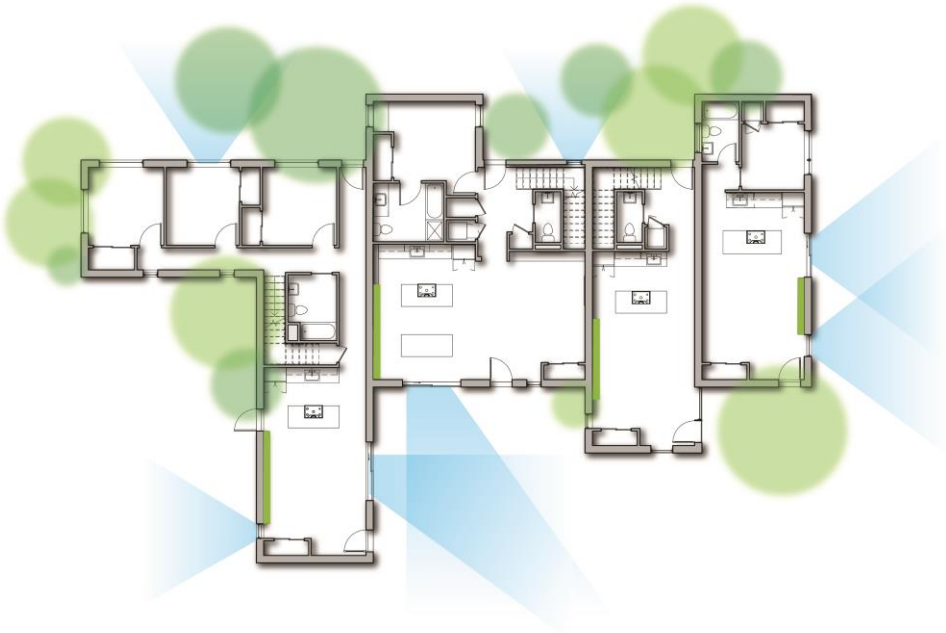
Unit C
3BR

Unit B
2BR

Biophilic Design

Green Spaces

- Exterior courtyards
- Interior green walls
- Strategic viewsheds



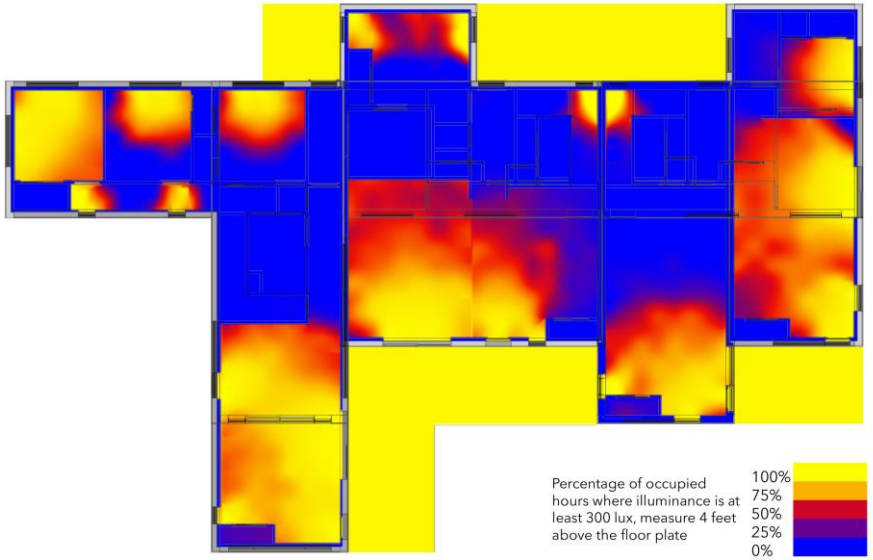
Light & Ventilation

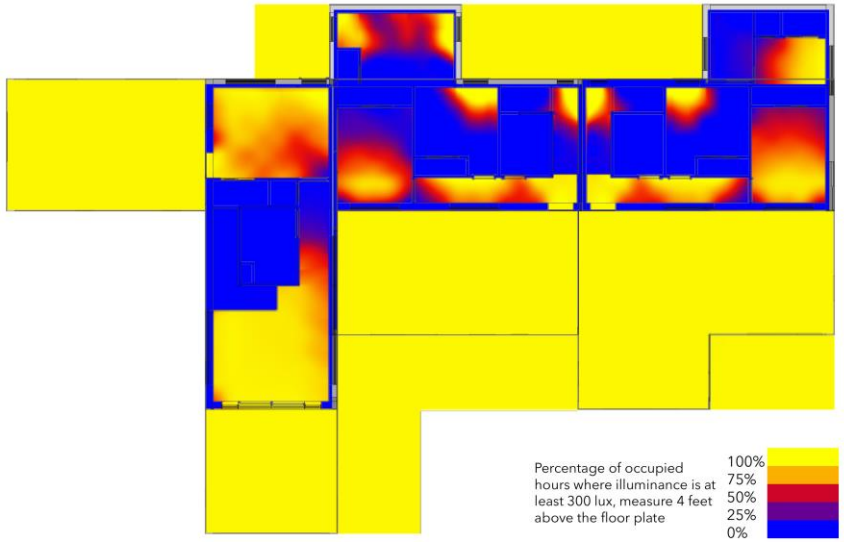
- Cross-ventilation
- Equitable daylight access

Lighting Analysis

Daylighting

- Living spaces at south end
- Bedrooms at north end
- Services and systems at core

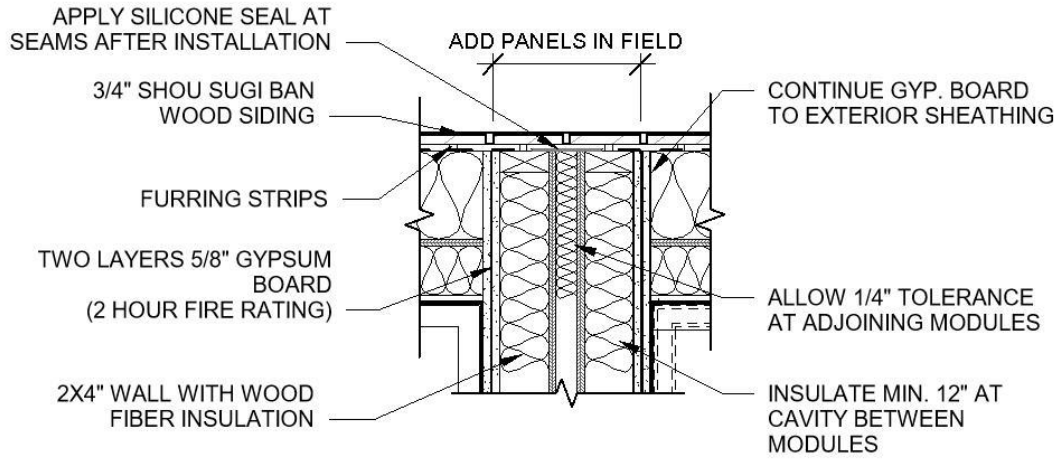


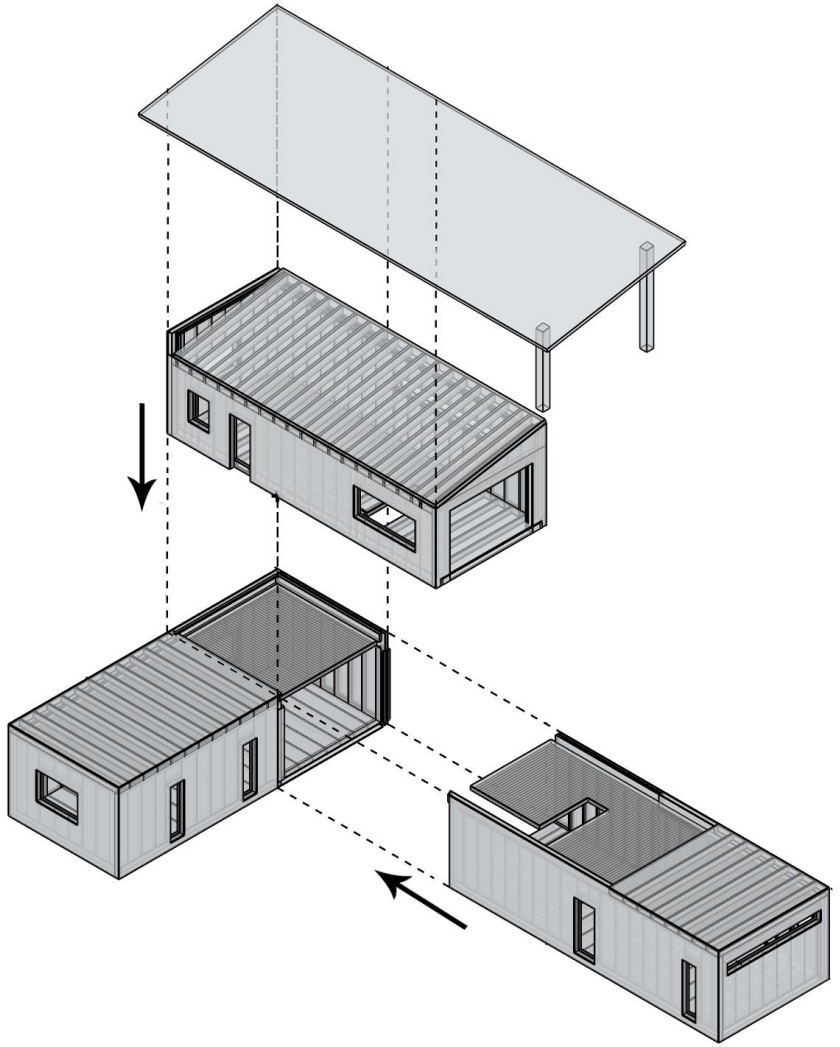


Modularity

Building consists of 16’ modules

- Stud framing with DLT ceilings
- Shared walls provide acoustic/fire separation
- Installed by crane, with joints sealed on-site



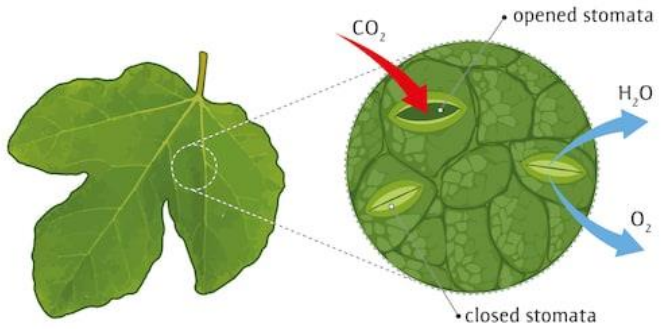


Modular Installation

Stomatal screens

Inspired by the way plant stomata open & close

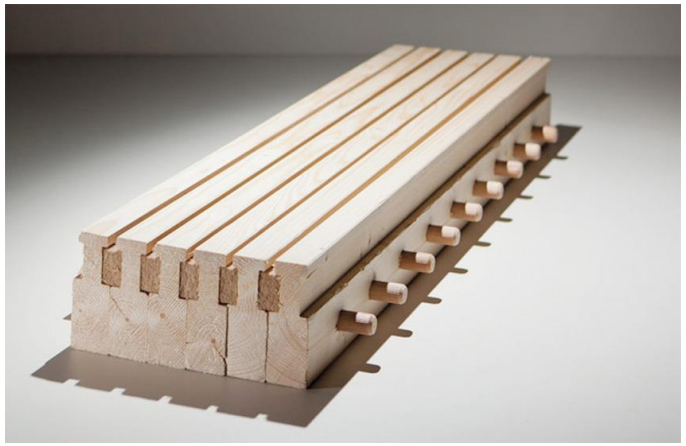
- Insulated panels improve window R-value at night
- Slats operate independently to control daylight

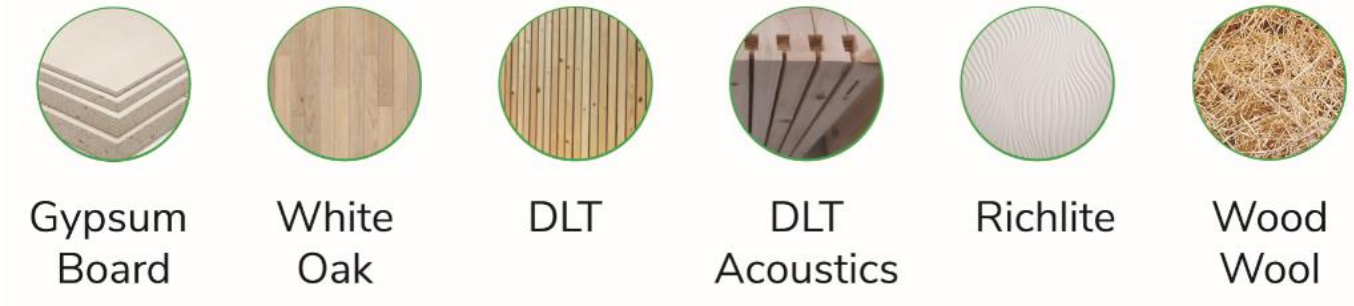


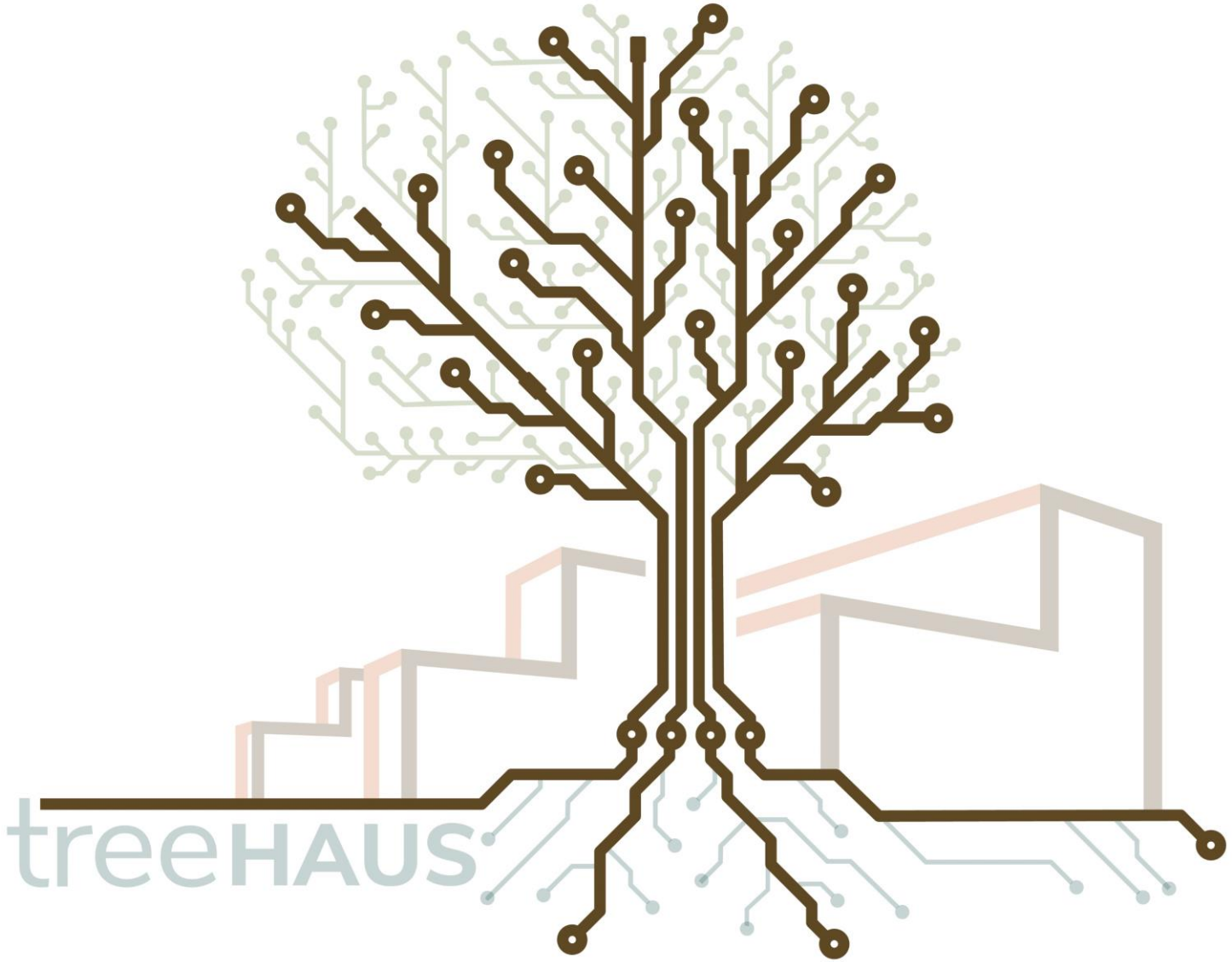
Interior Design

Natural Materials

- Dowel-Laminated Timber
- No glues/VOCs
- Green wall promotes biophilia






treeHAUS

Elements of Resilience

Earth

Water

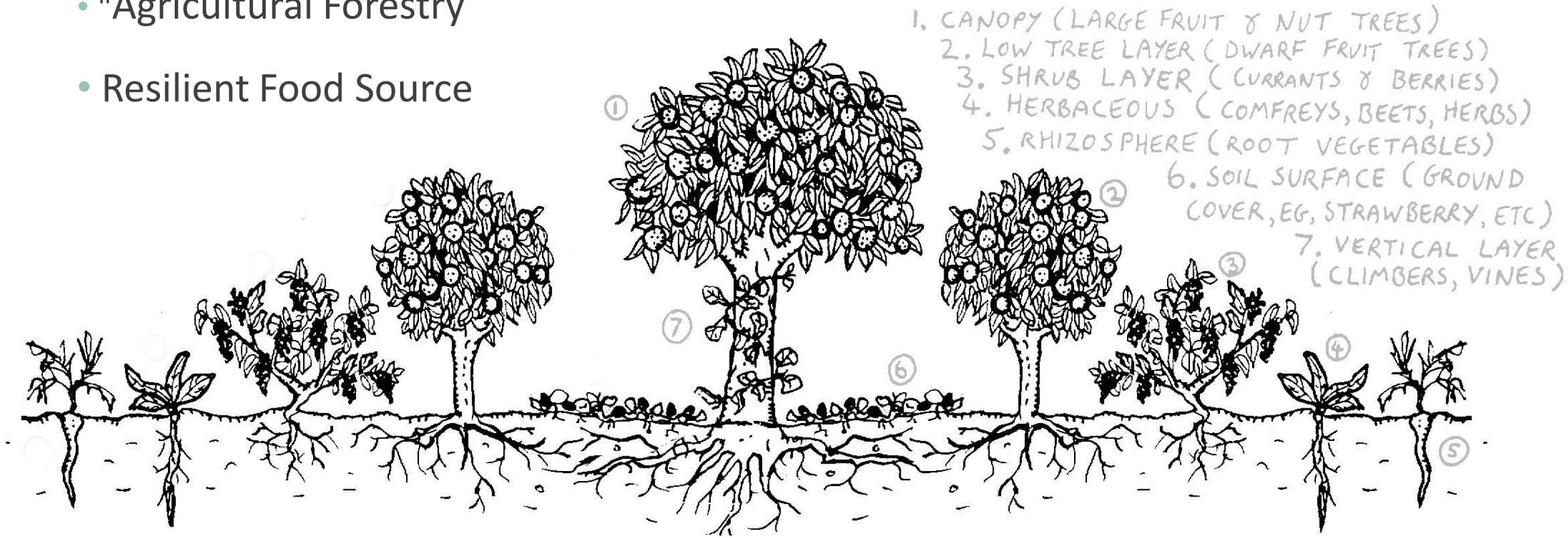
Air

Energy

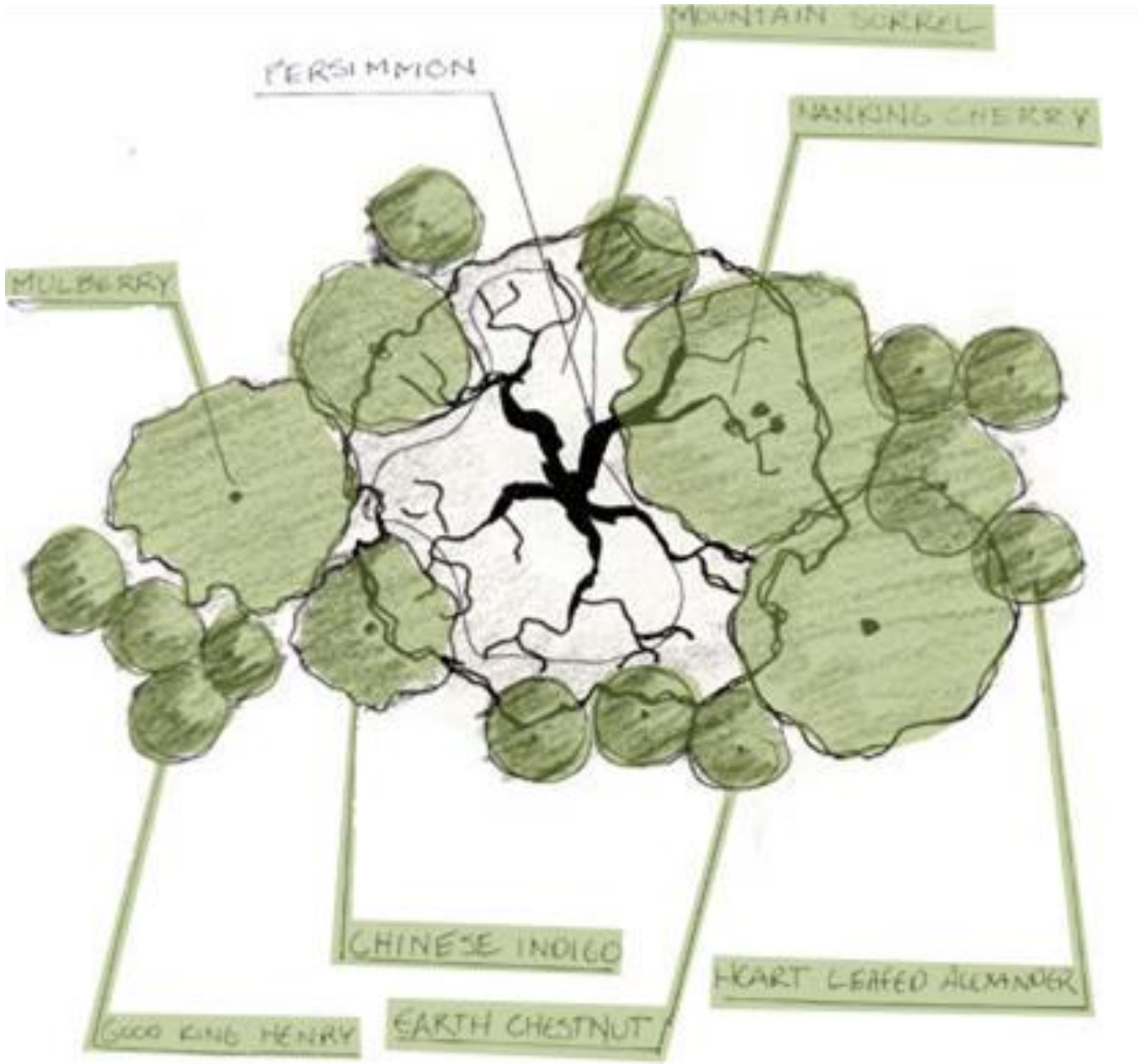
Food

Agroforestry

- "Agricultural Forestry“
- Resilient Food Source

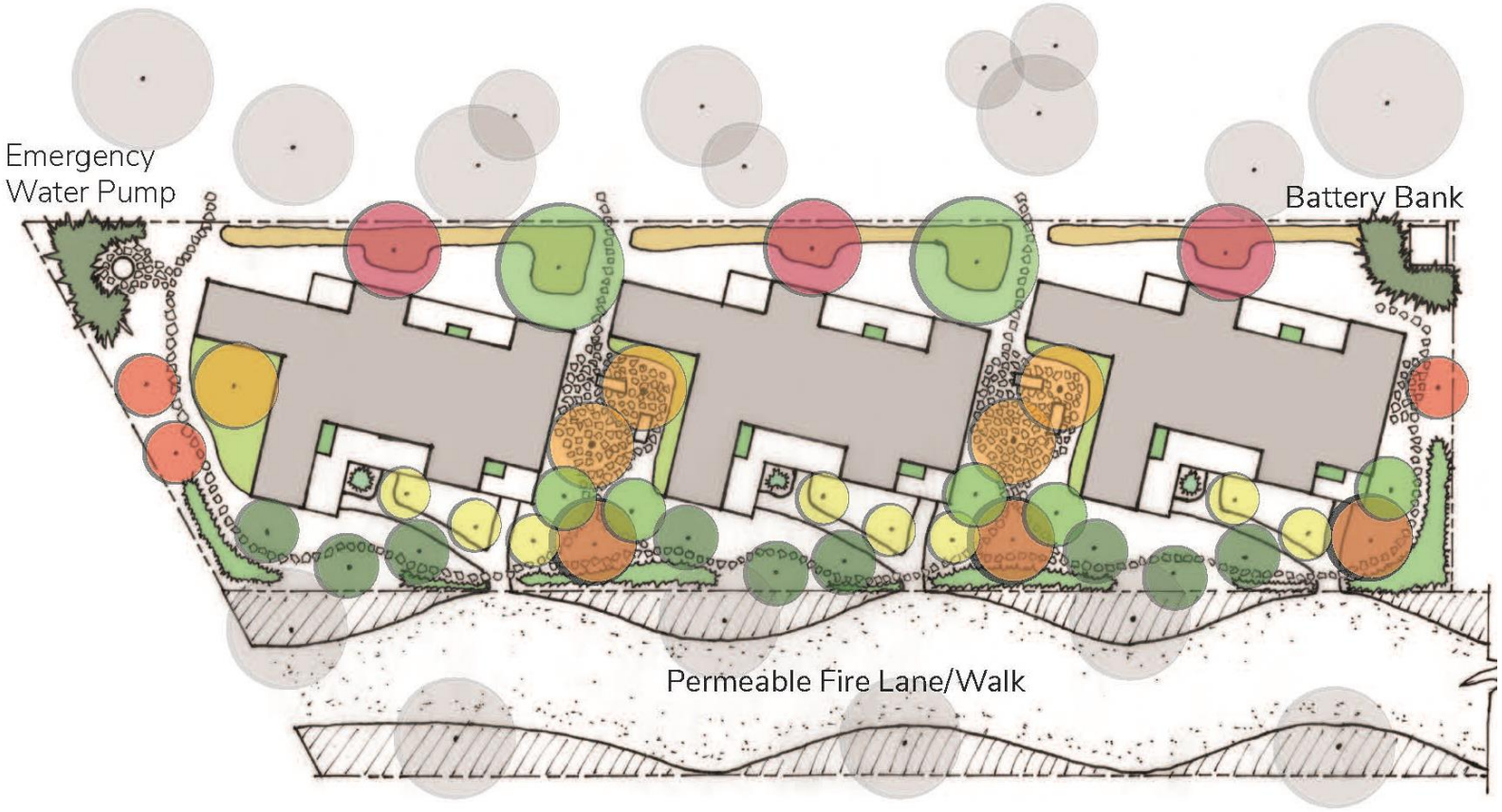


Tree Guilds

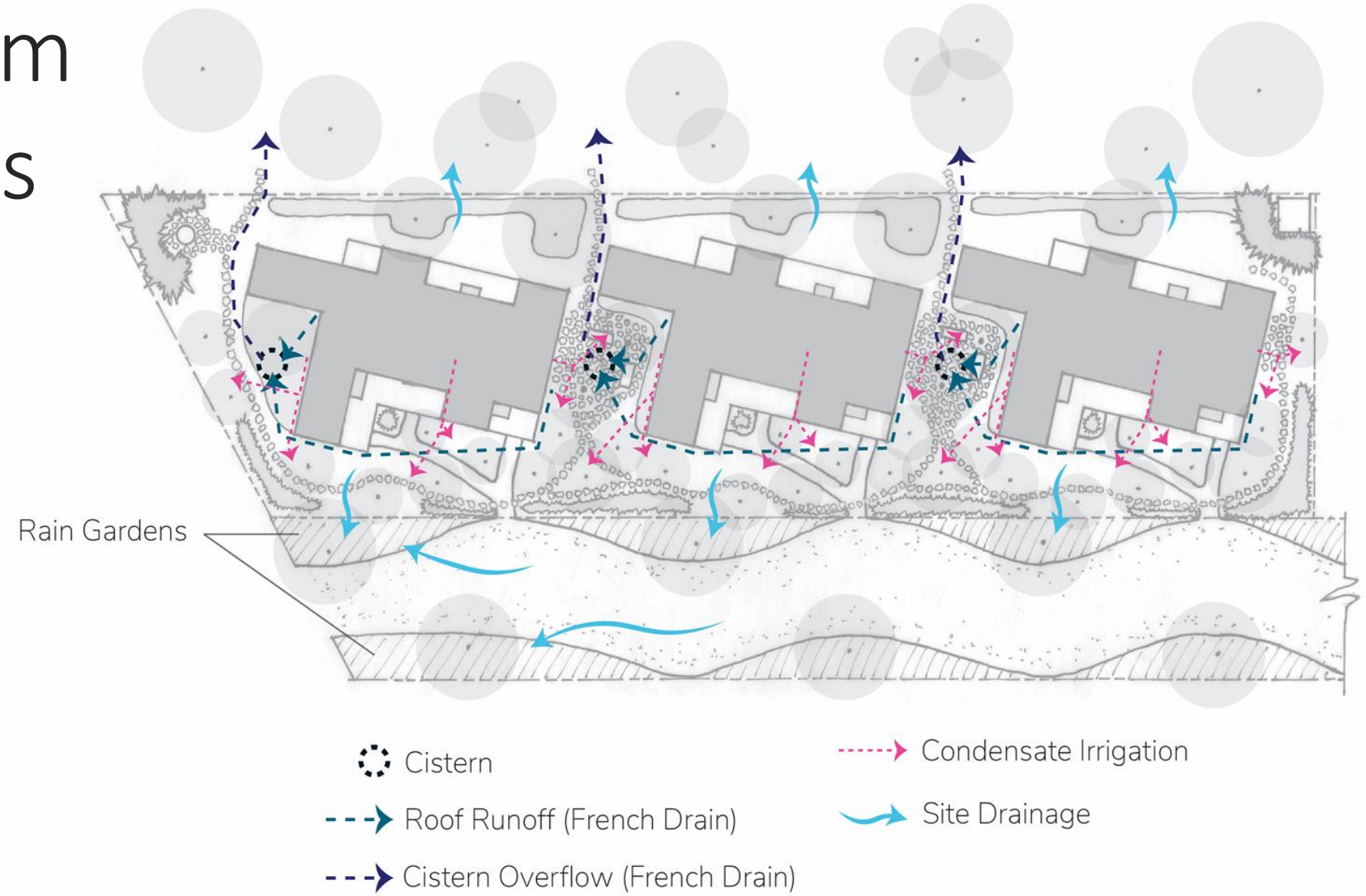

PERSIMMON
MULBERRY
CHINESE INDIGO
EARTH CHESTNUT
HEART LEAFED ALEXANDER

Landscape Design

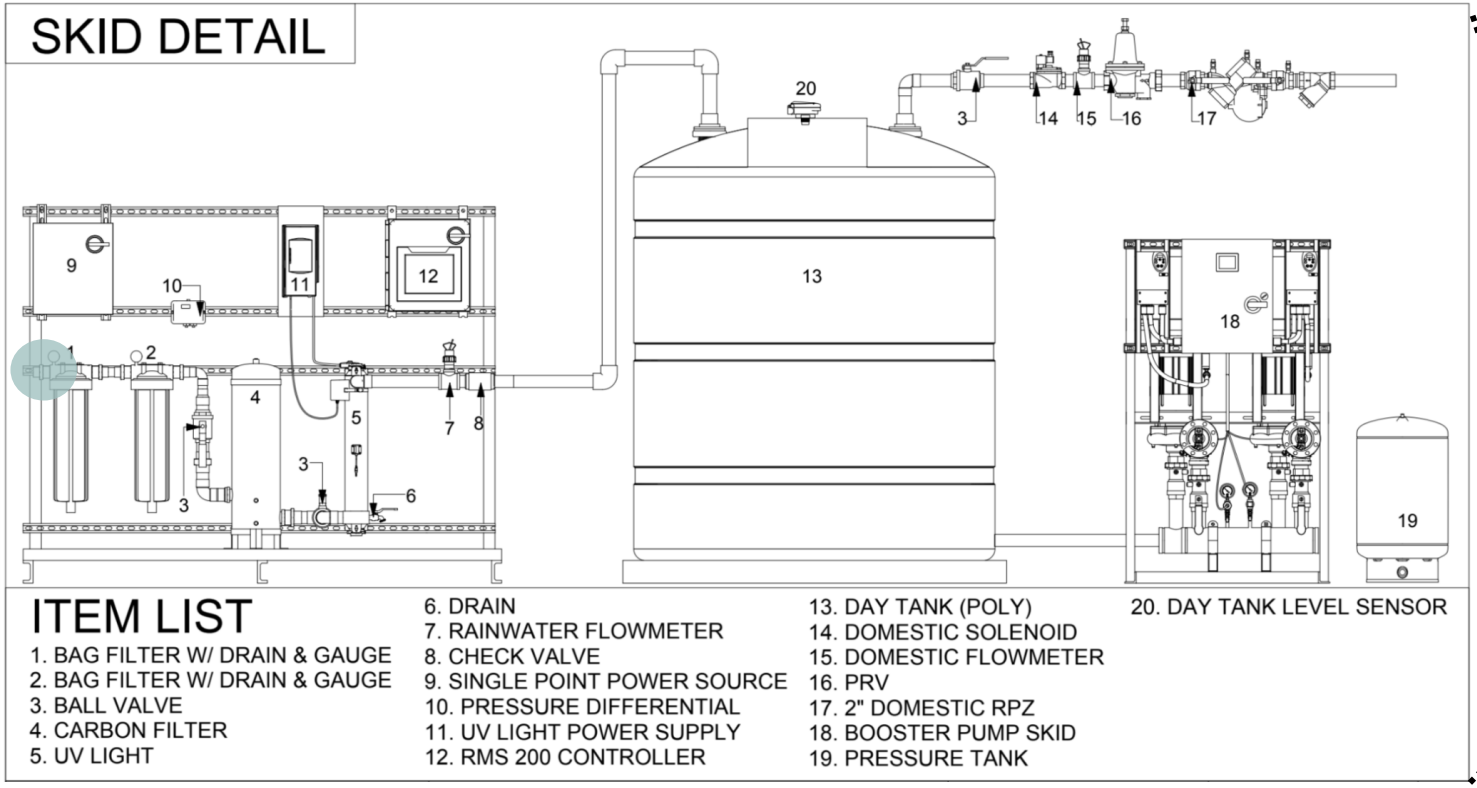
CrumPacker Woods

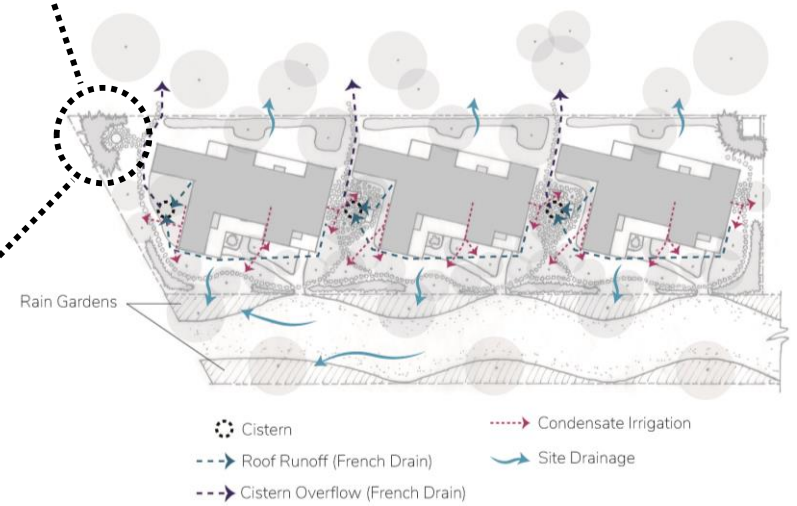


Water System Integrations



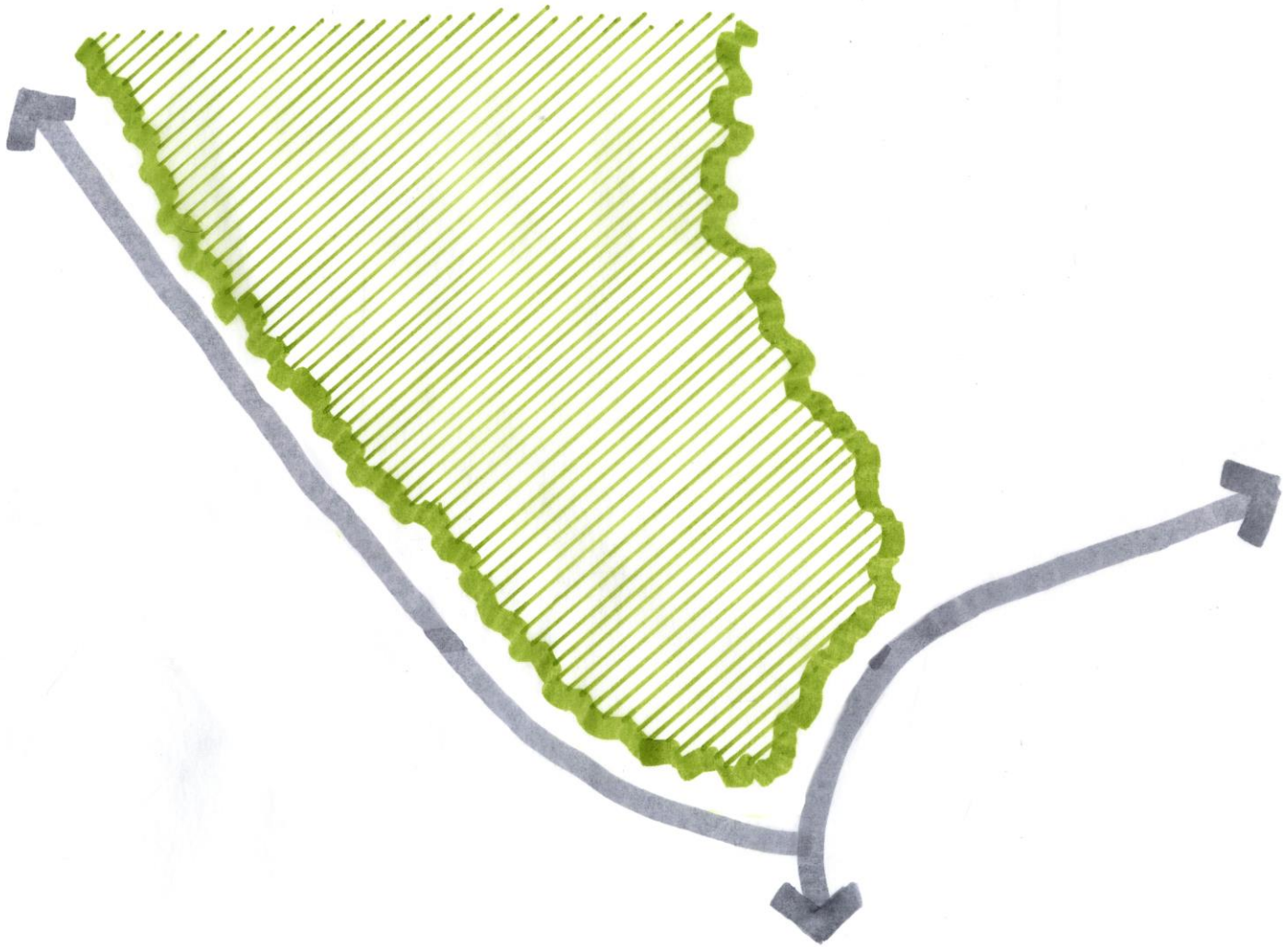
UV Purification Skid





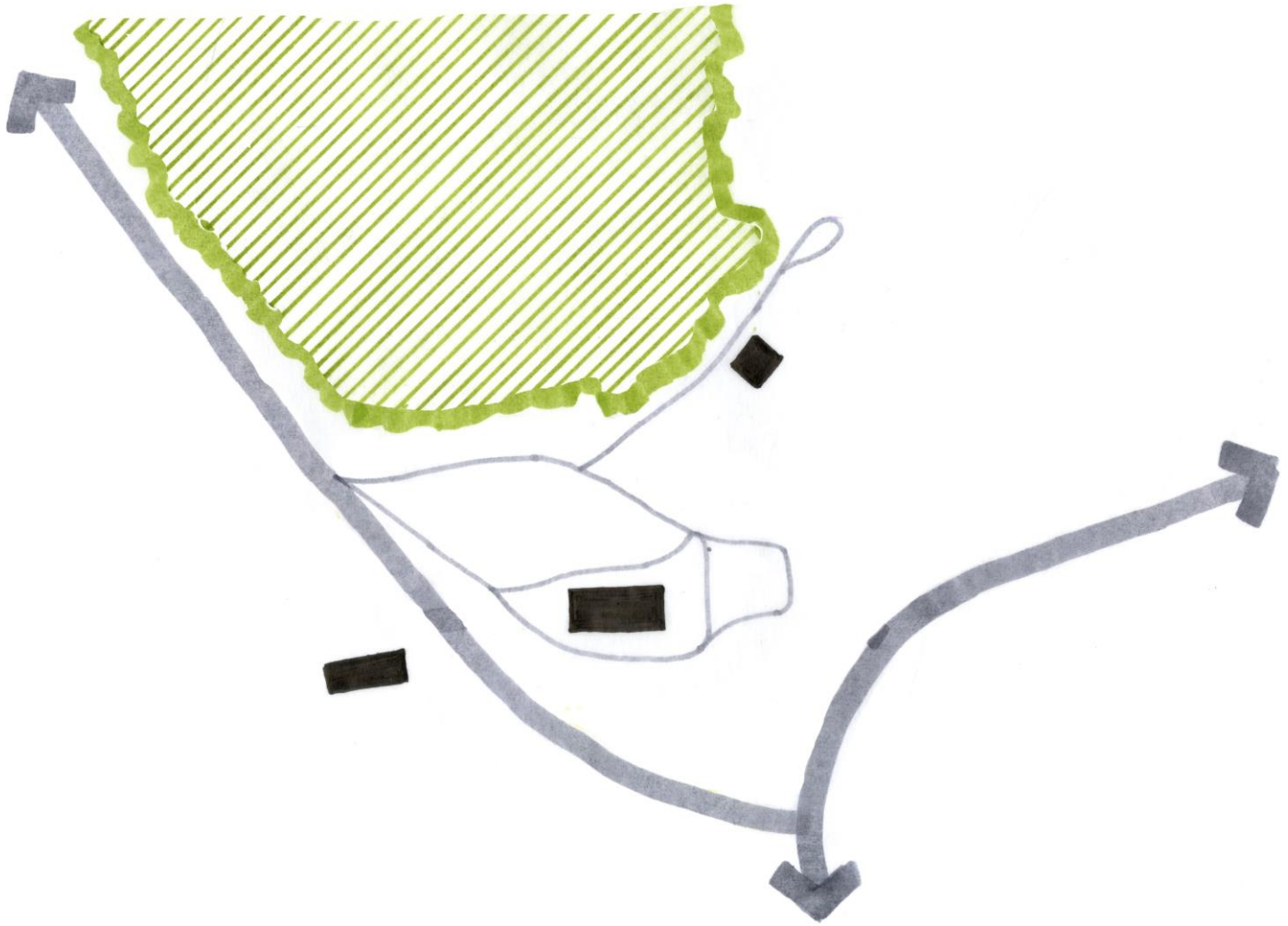
RMS
RAINWATER MANAGEMENT SOLUTIONS™

UV Flow Switch



Site Succession

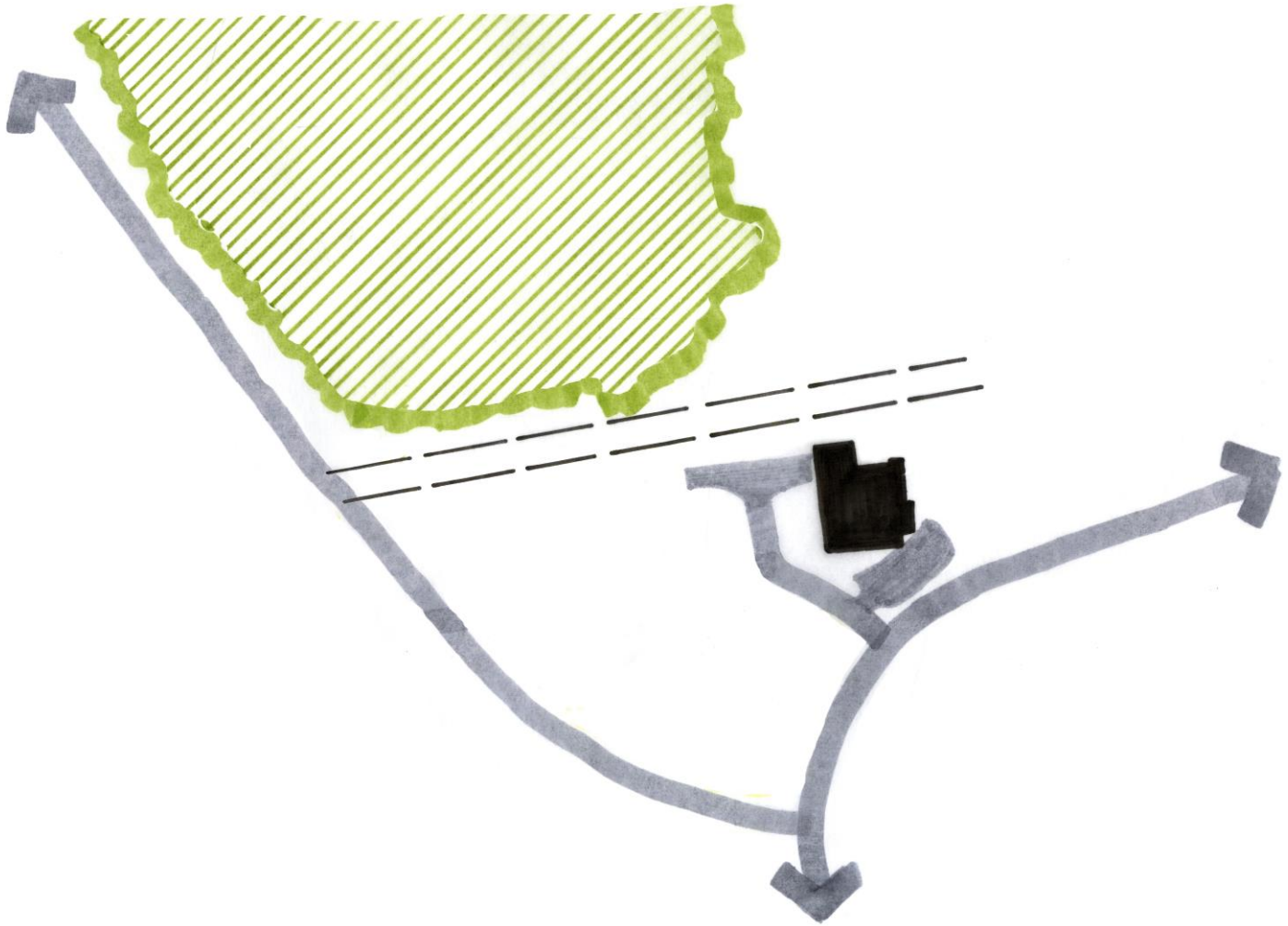
Original Forest



Site Succession

Original Forest

Dairy Barn

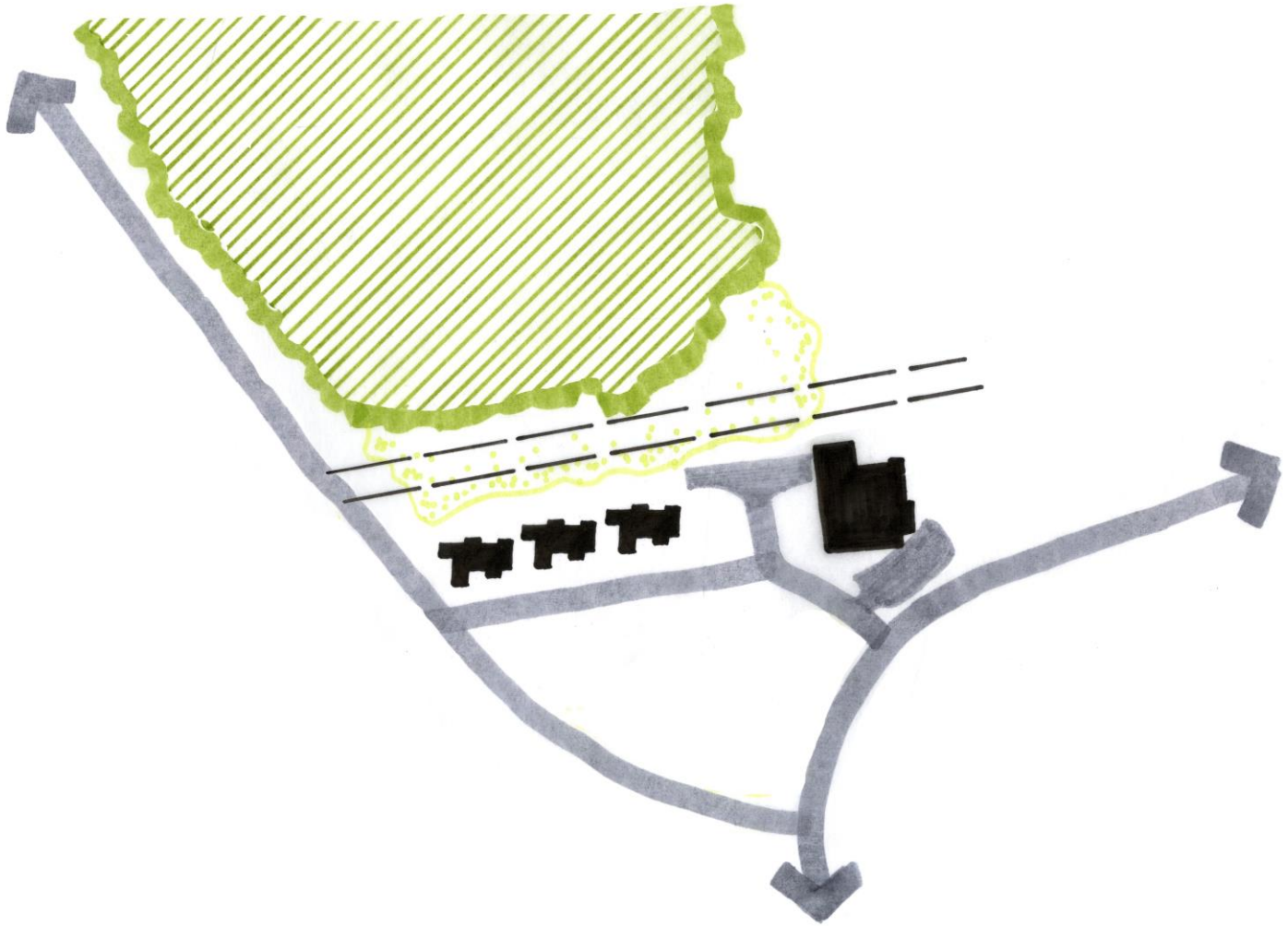


Site Succession

Original Forest

Dairy Barn

Present Day



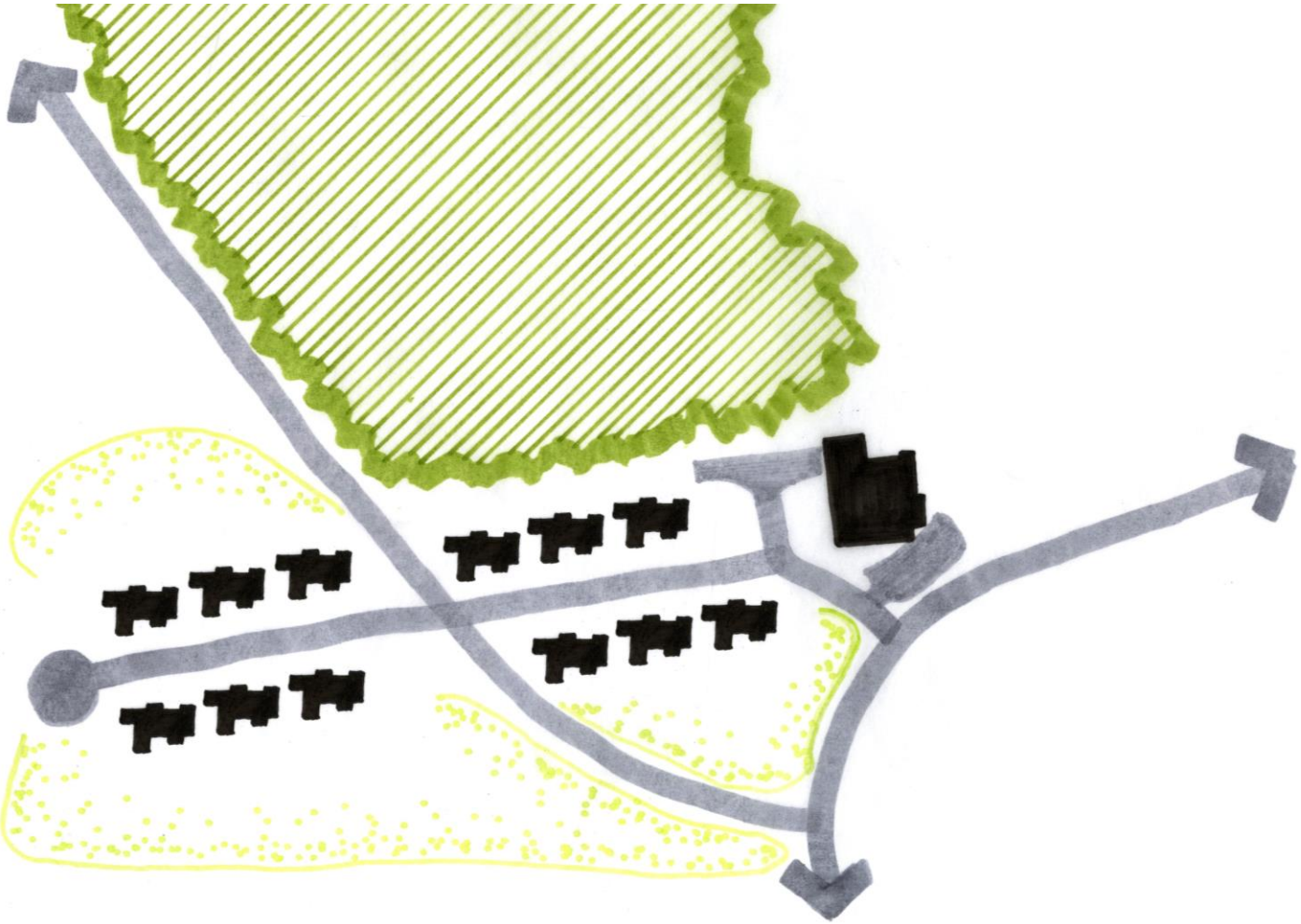
Site Succession

Original Forest

Dairy Barn

Present Day

10-Year Plan



Site Succession

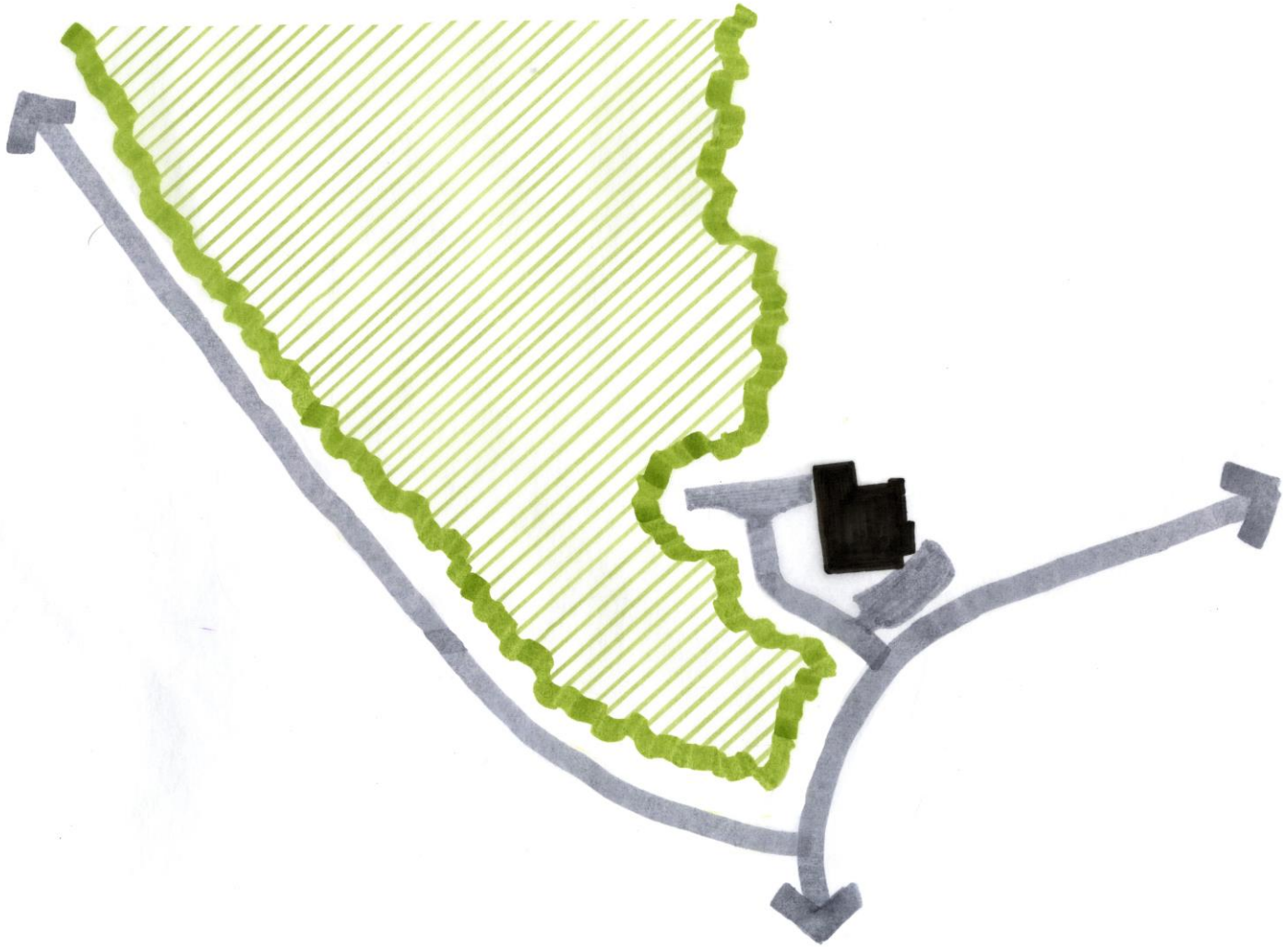
Original Forest

Dairy Barn

Present Day

10-Year Plan

30 Year Plan



Site Succession

Original Forest

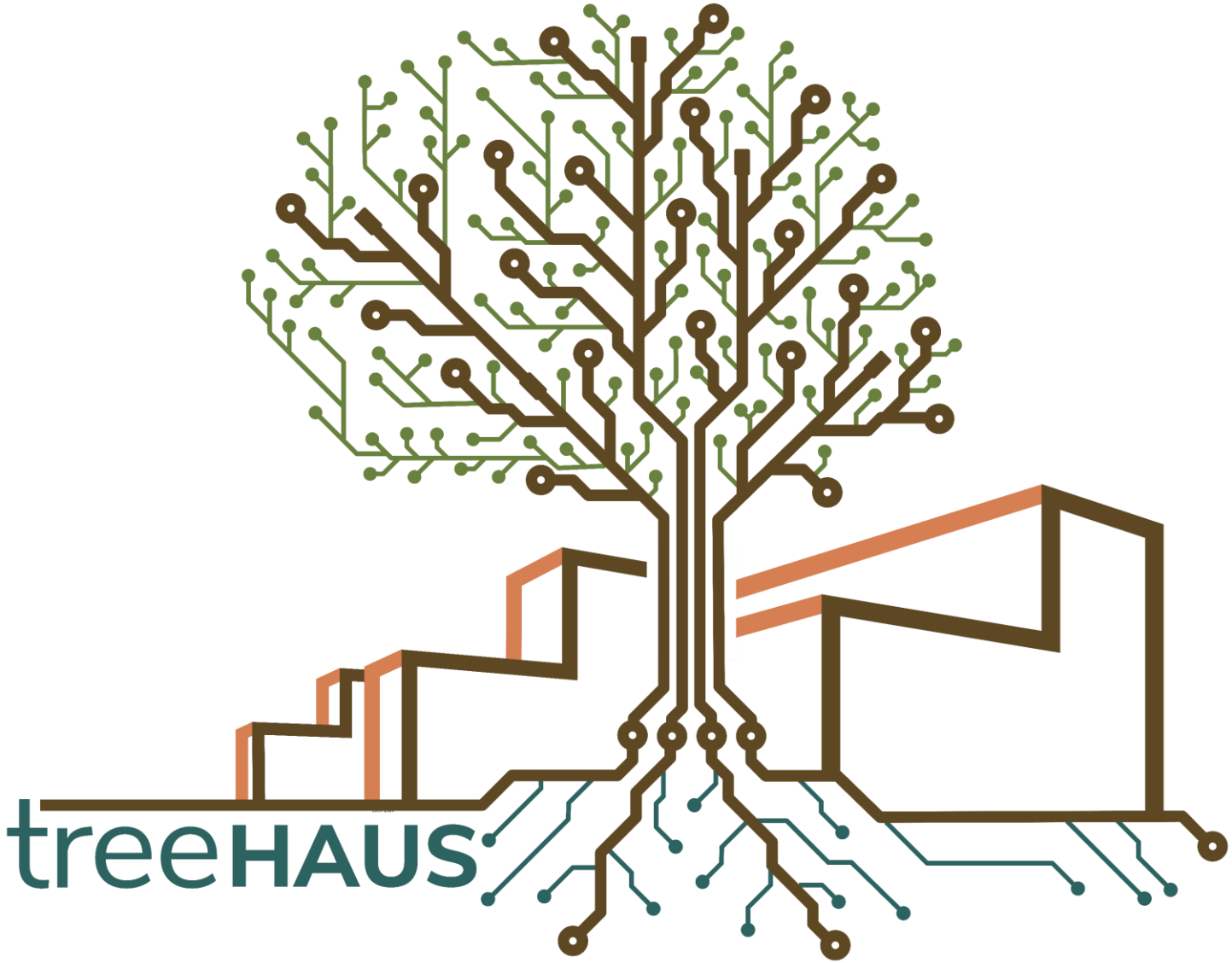
Dairy Barn

Present Day

10-Year Plan

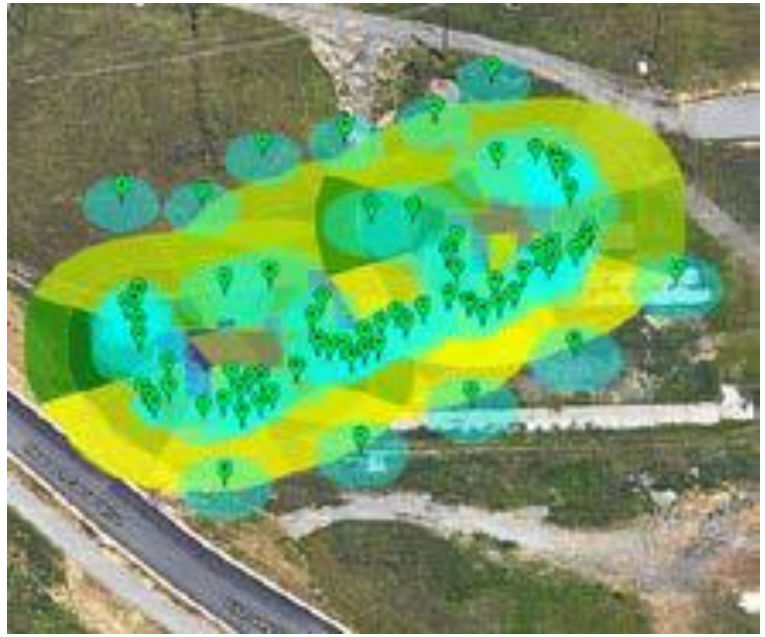
30 Year Plan

Post TreeHAUS

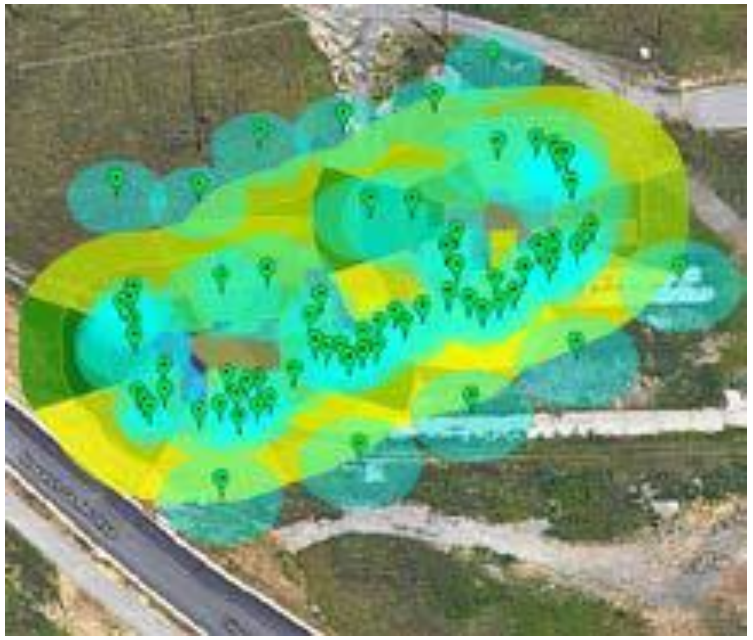

treeHAUS

i-Tree

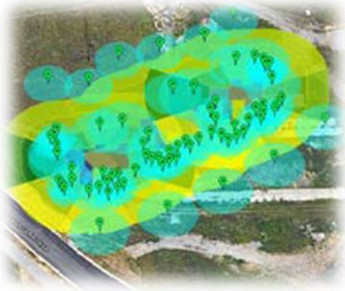
- USDA Software
- Forestry Benefits Analysis



GROWTH



i-Tree Results



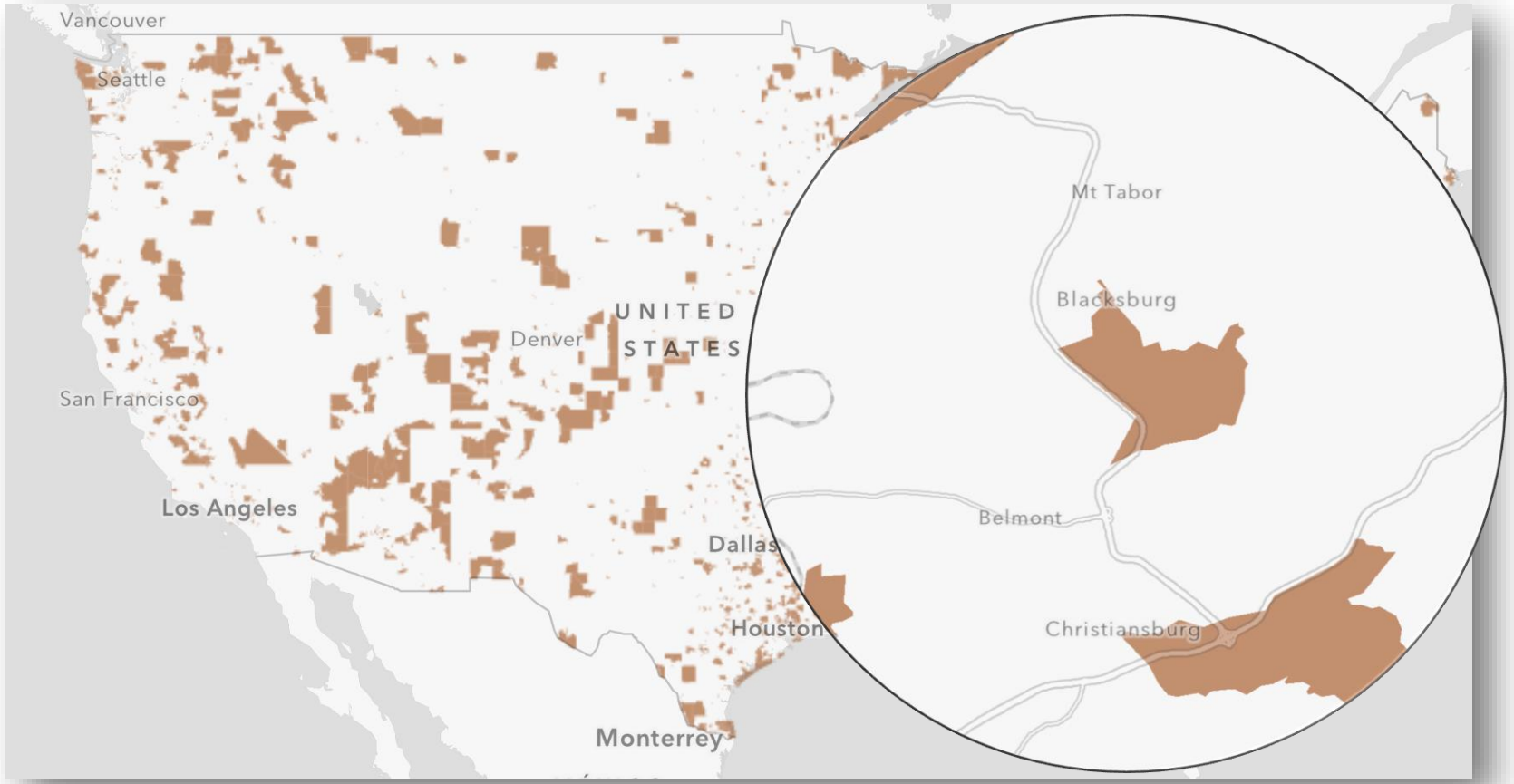
50-Year Cumulative Breakdown

Stormwater	Air Quality	CO2 Capture	Summer Shade	Winter Heat
$238,171	**$3,992**	**$13,558**	**$34,235**	**$4,103**

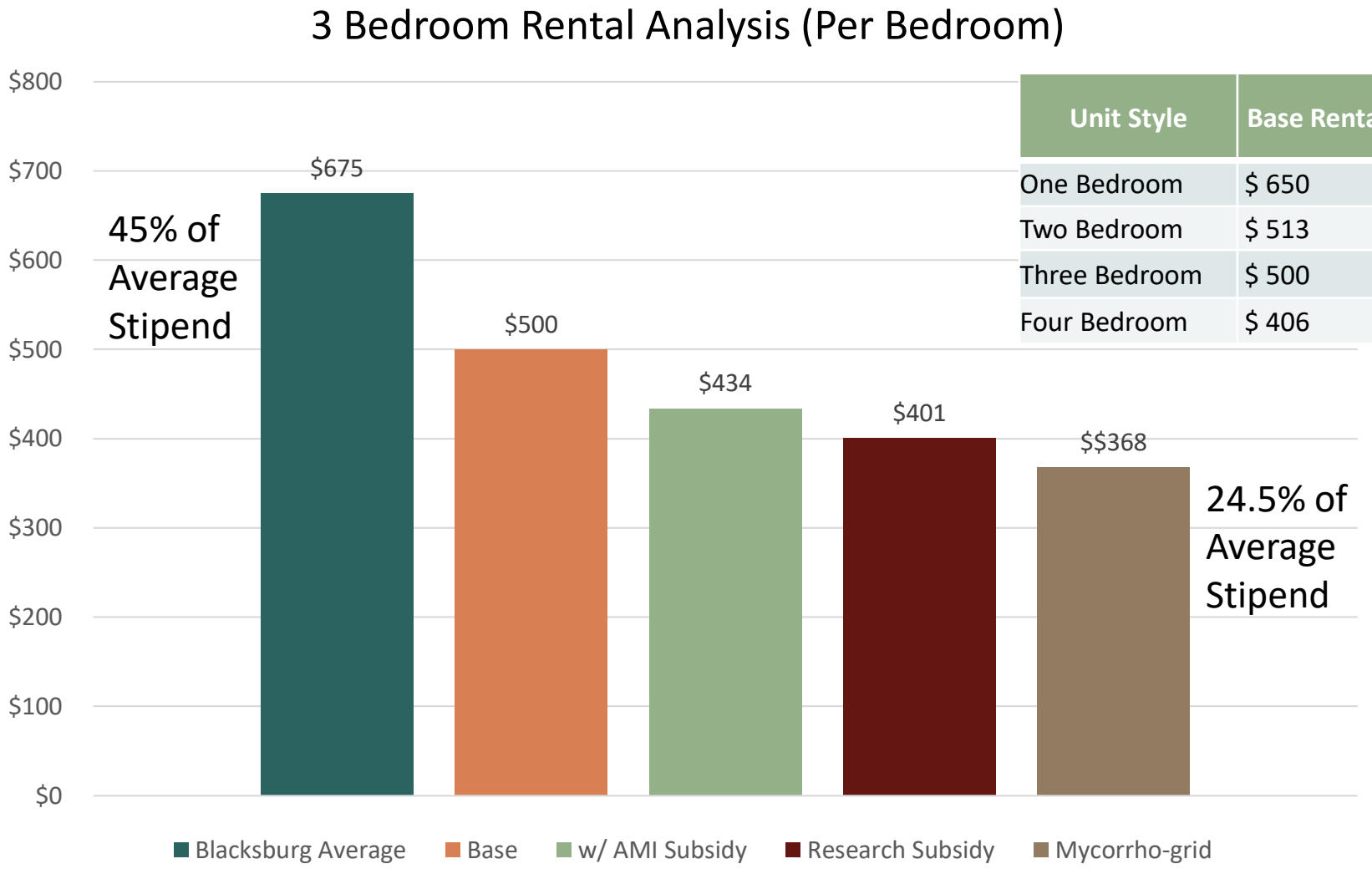
Total Benefits Worth: $294,059

Investor Profile and Opportunity Zones

Dr. John E. Dooley
CEO, VT Foundation

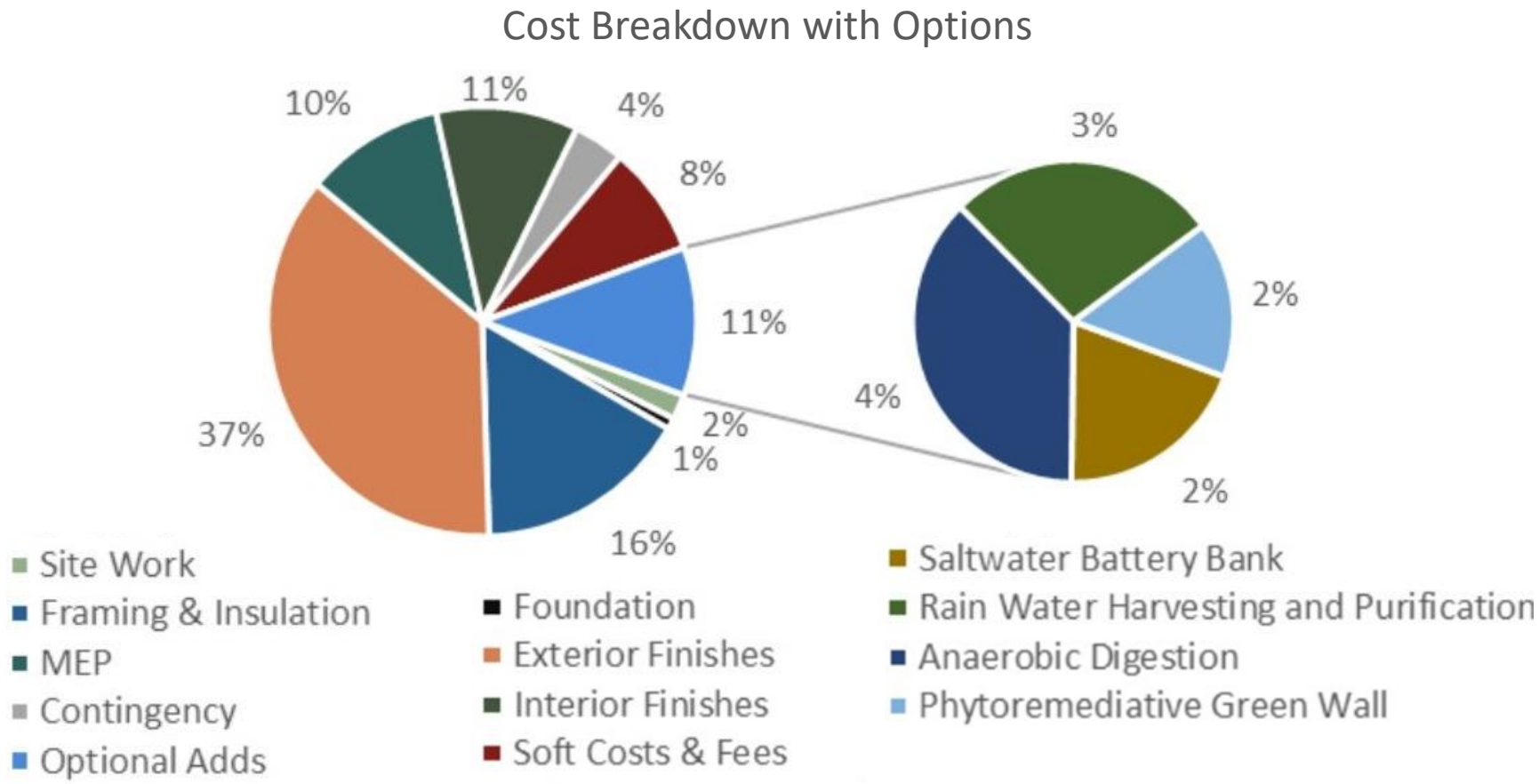


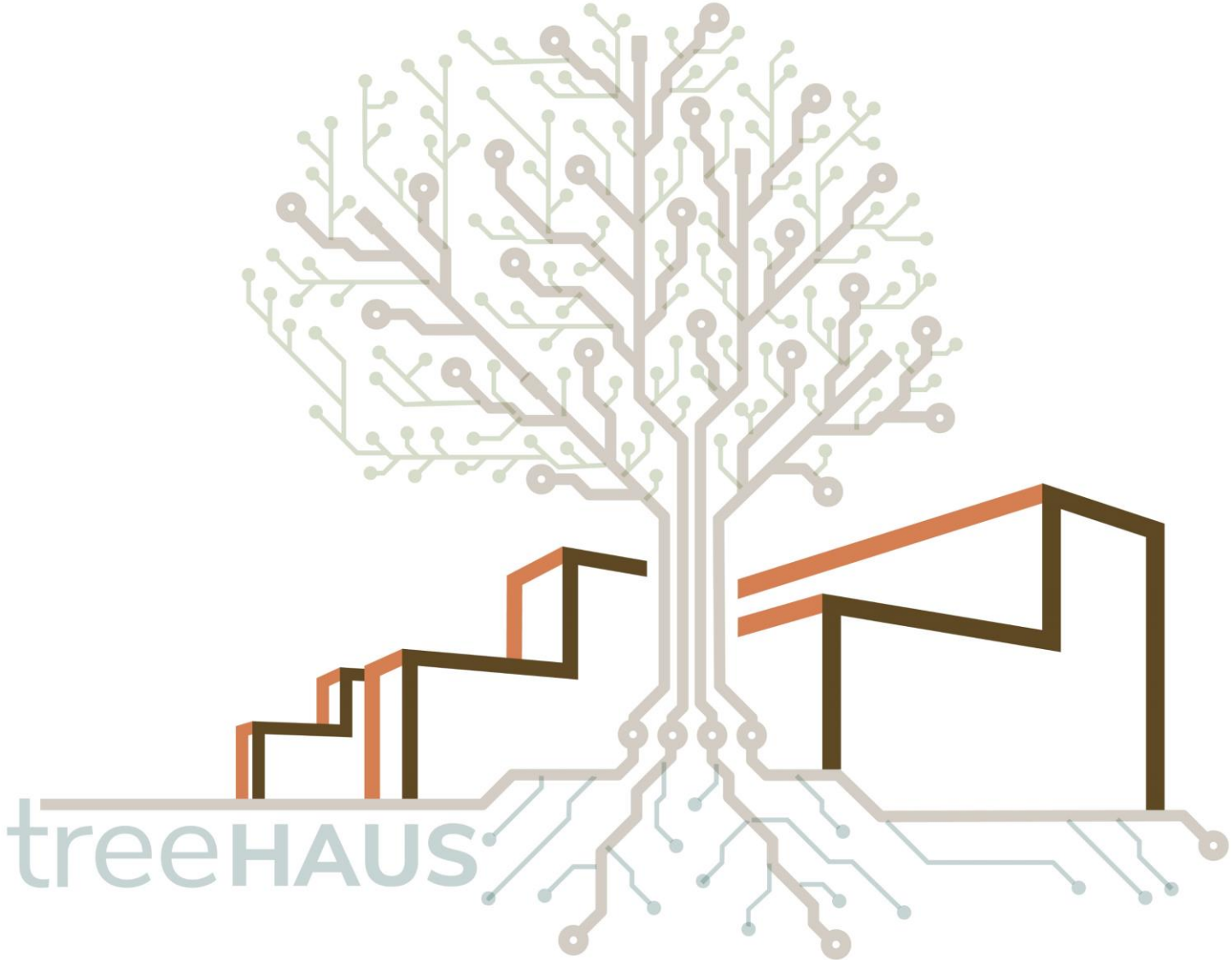
Rental Model Financials



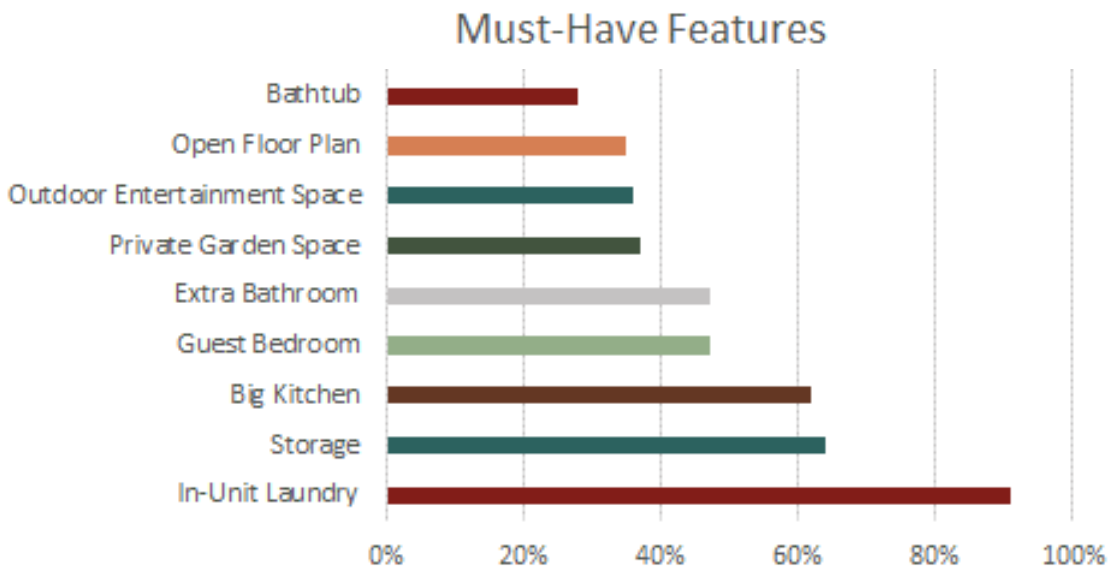
Unit Style	Base Rental Rate	Final Rental Rate
One Bedroom	$ 650	$ 474
Two Bedroom	$ 513	$ 411
Three Bedroom	$ 500	$ 368
Four Bedroom	$ 406	$ 355

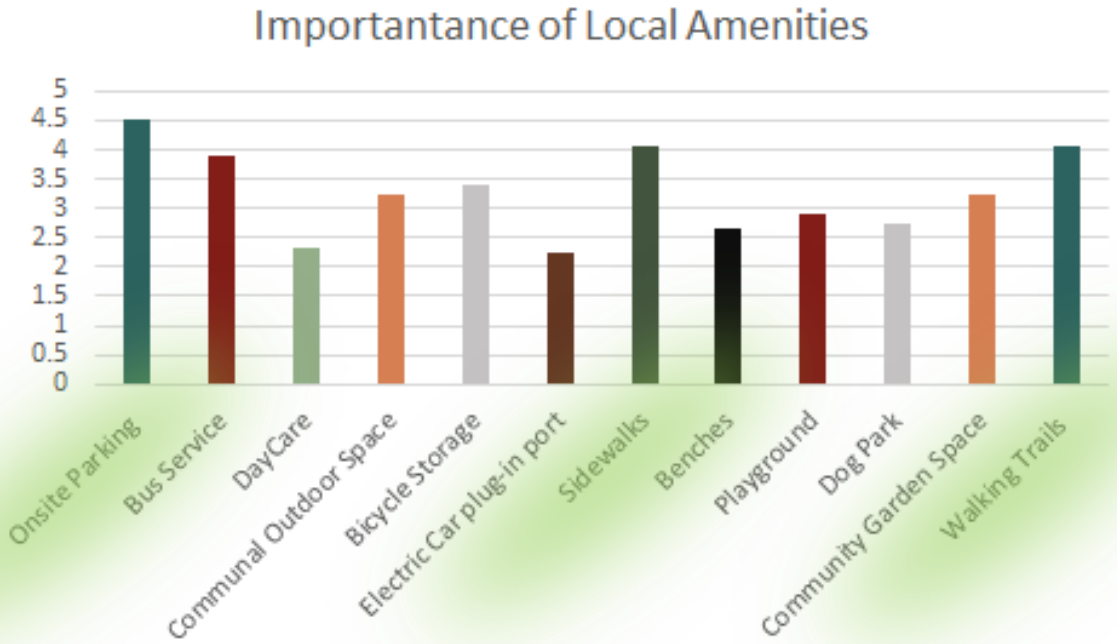
Overview of Construction Costs




treeHAUS

Interviews – Informing the Design



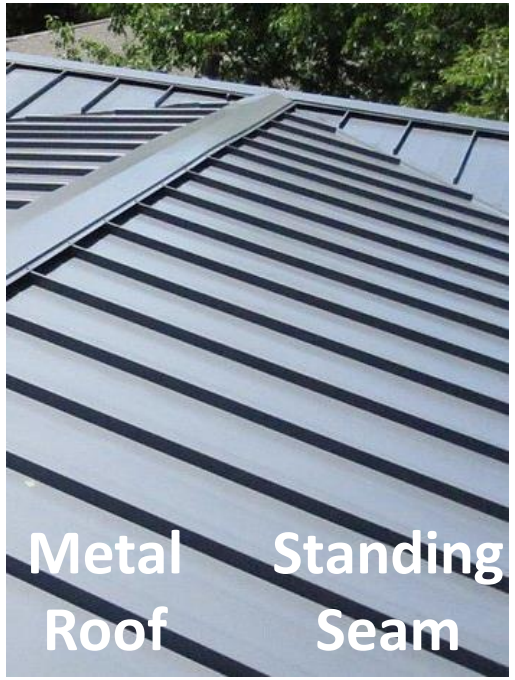


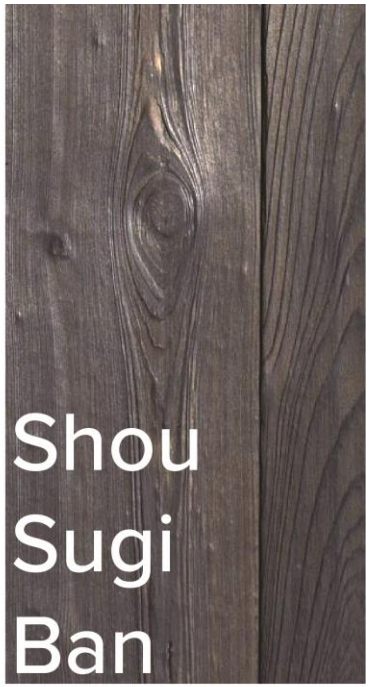
Must Have Features

Operations and Maintenance

Low Maintenance Materials

- Pest-resistant
- Weather-resistant

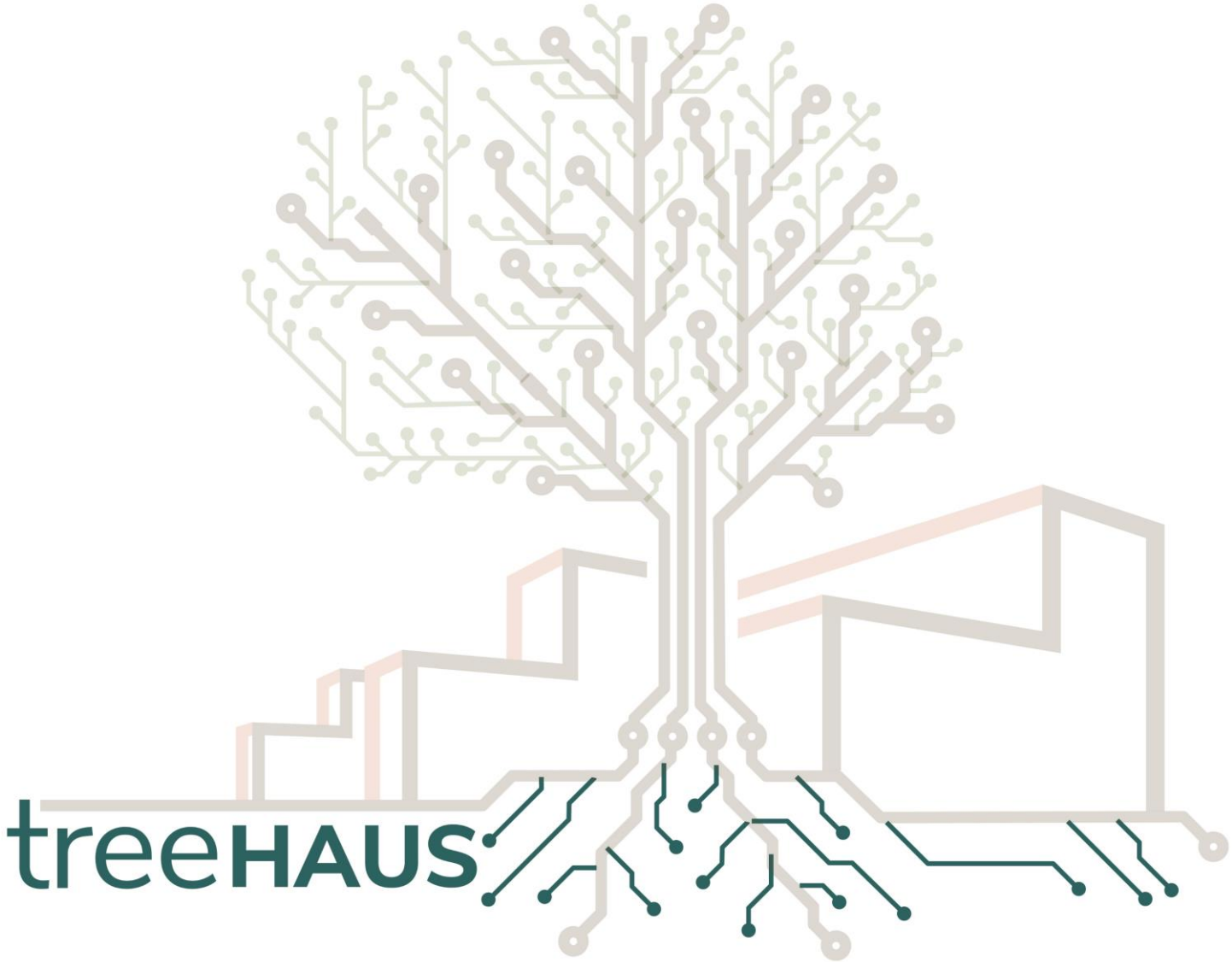




Academic partnerships

- Student Upkeep
- Agroforestry Education
- Research Opportunities

VIRGINIA TECH™


treeHAUS

Free Fuel From Nature

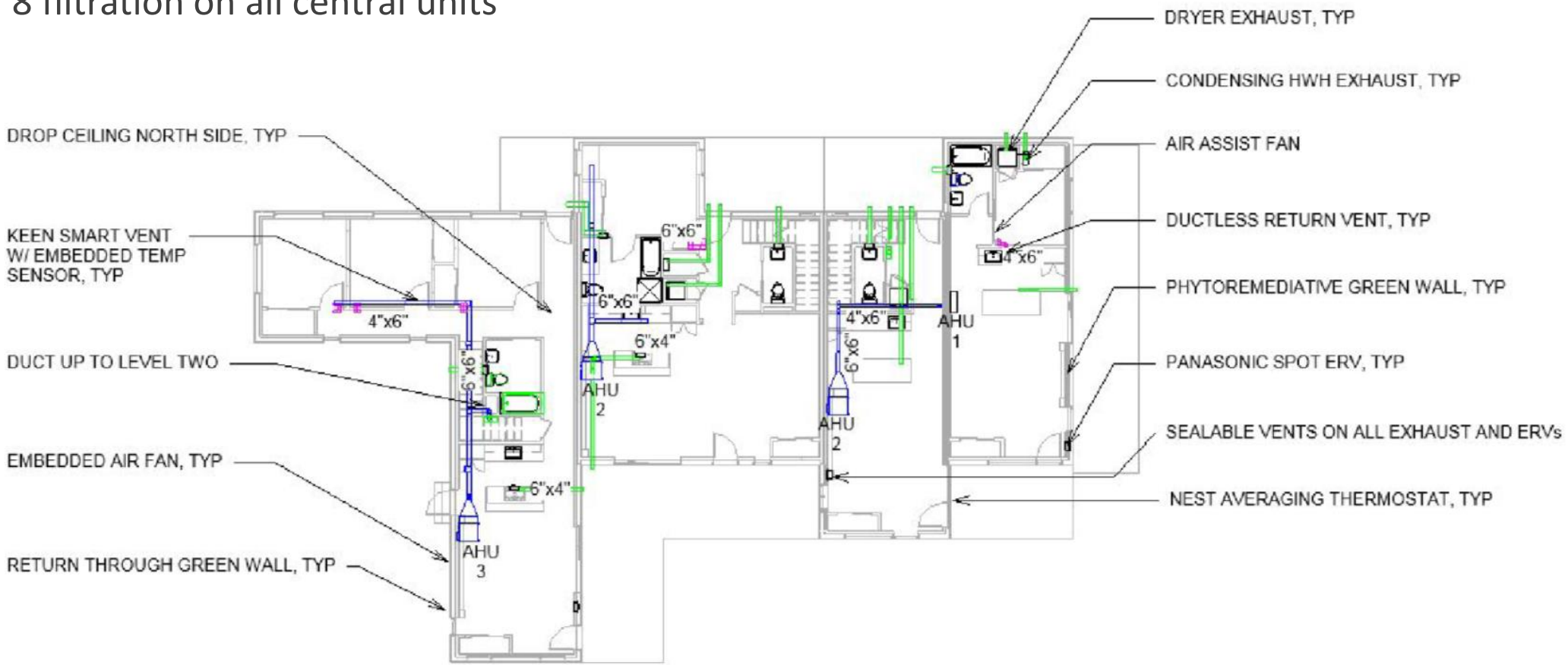
ENERGY
400 MWh/yr

WATER
180K gal/yr

FOOD
558 tons/yr

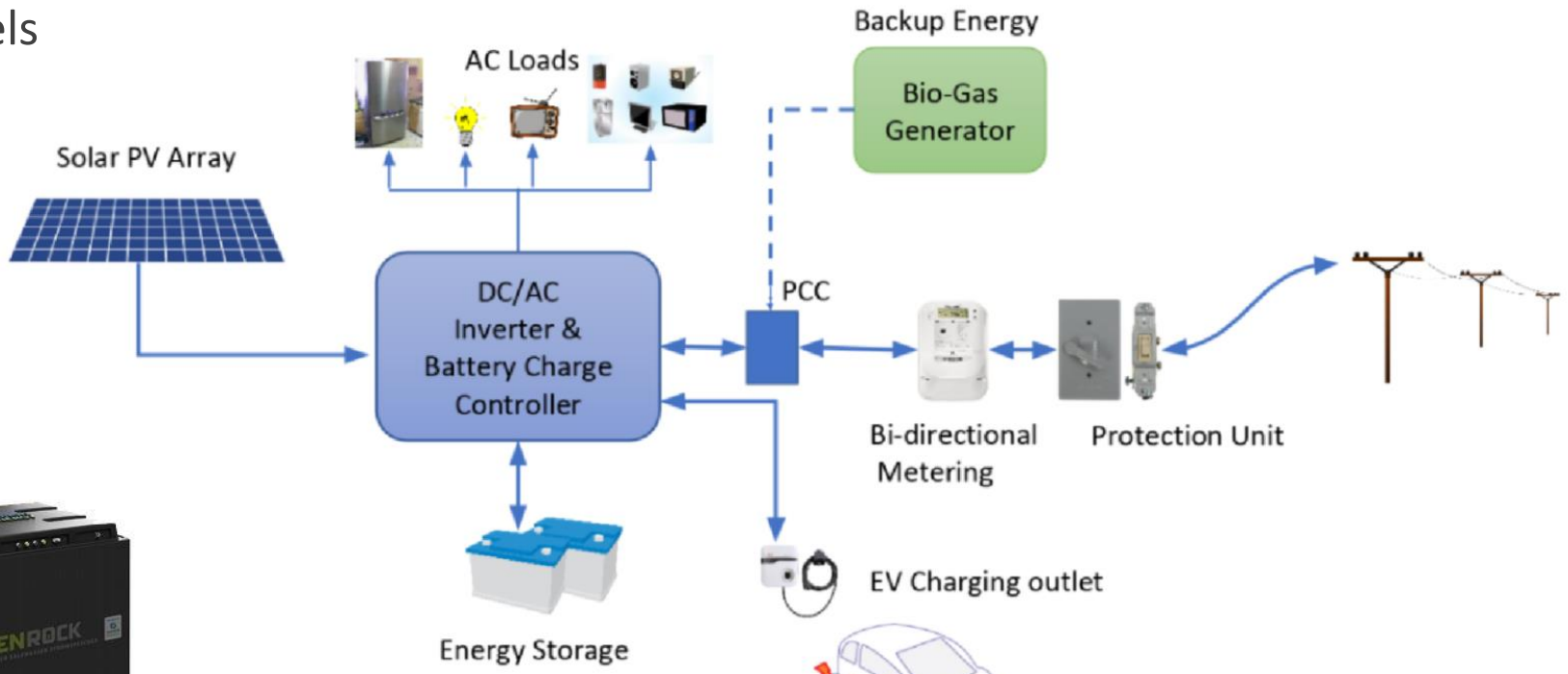
Mechanical Design

- Mitsubishi HyperHeat ASHPs
- Zoning with Keen smart vents and Nest averaging thermostat
- MERV 8 filtration on all central units



Electrical Design

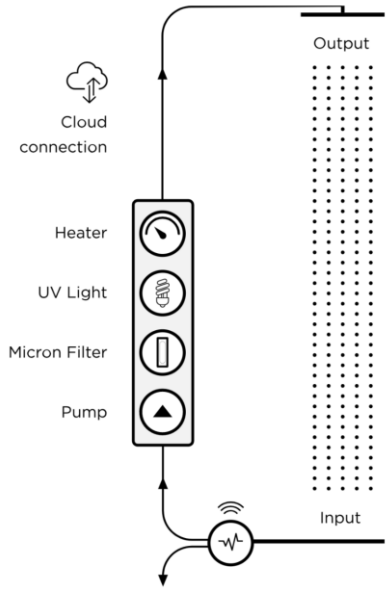
- GreenRock Salt Water Batteries
- Fermata Two-way EV Charging
- 33 West-facing PV Panels

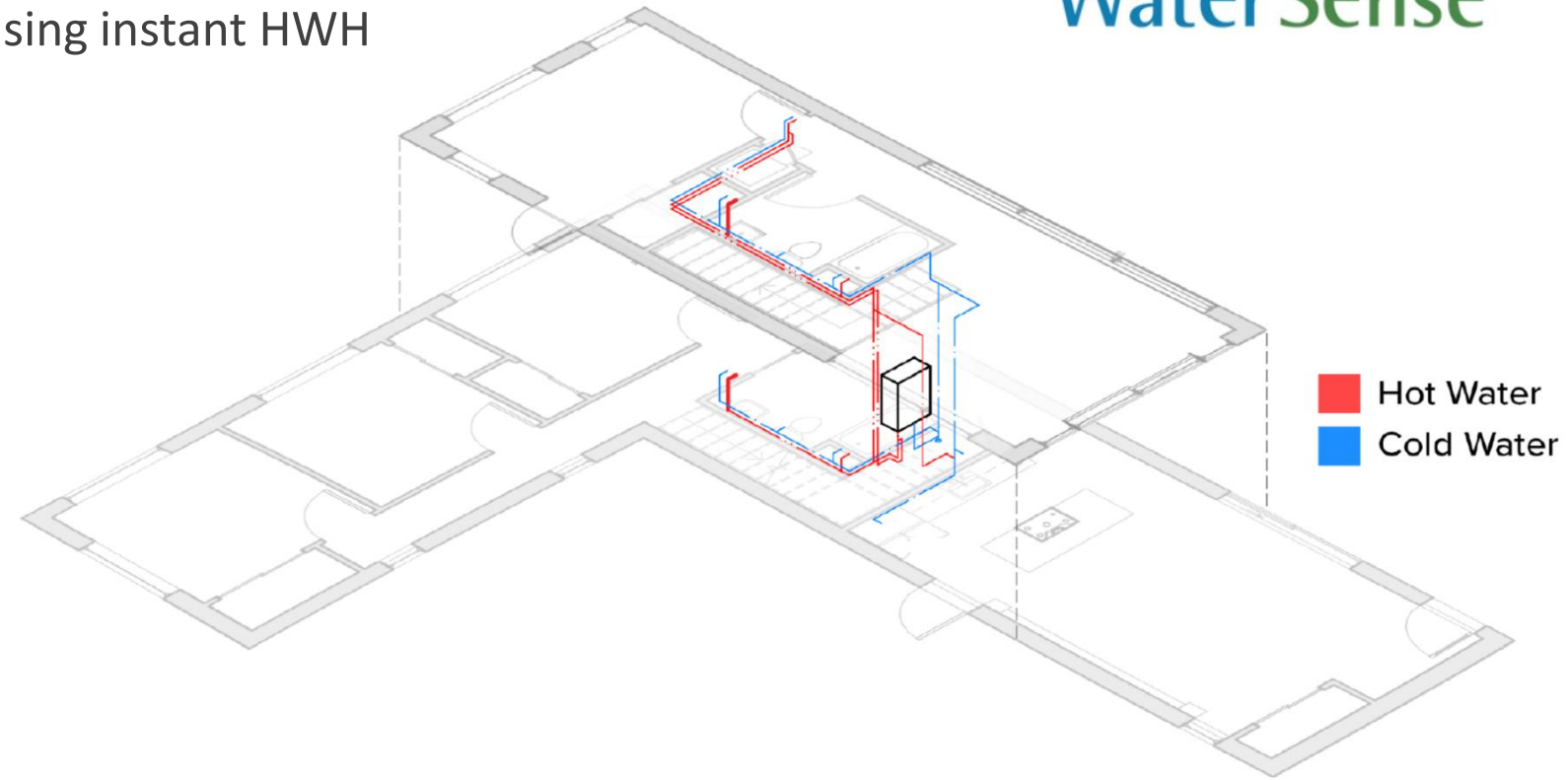


FERMATA ENERGY

Plumbing Design

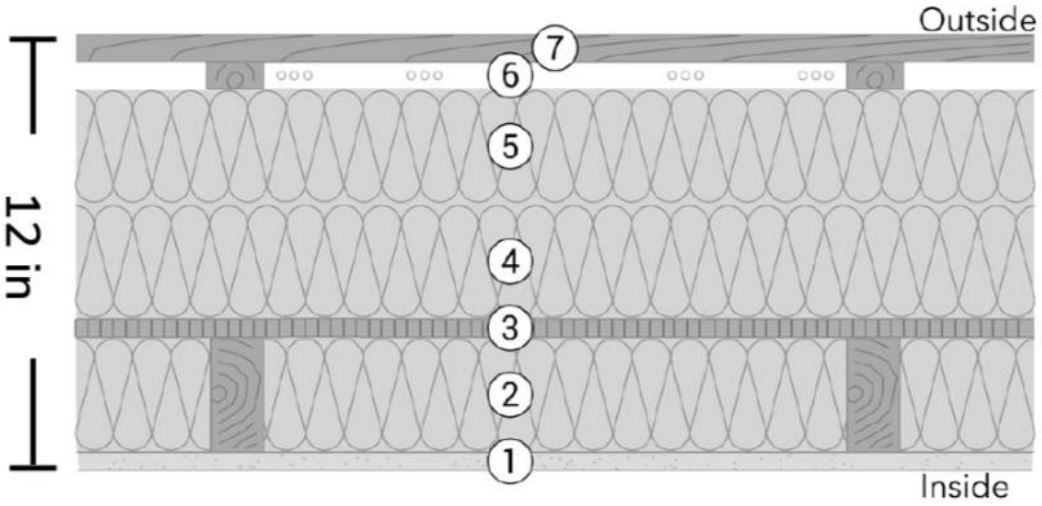
- EPA WaterSense adherence
- Modular interface in pipes
- Orbital Showers and condensing instant HWH



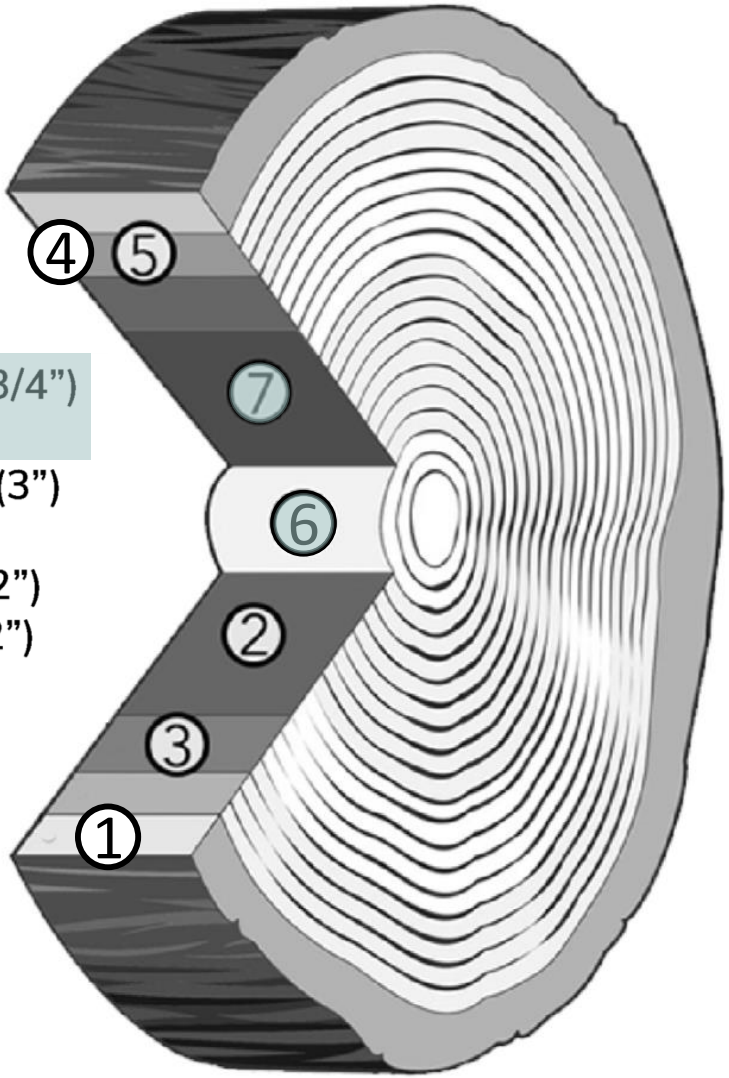


All Wood Exterior Wall

- Production Timber and Post Process Waste
- Gutex Multitherm with integrated weather barrier
- Formaldehyde free and FSC certified



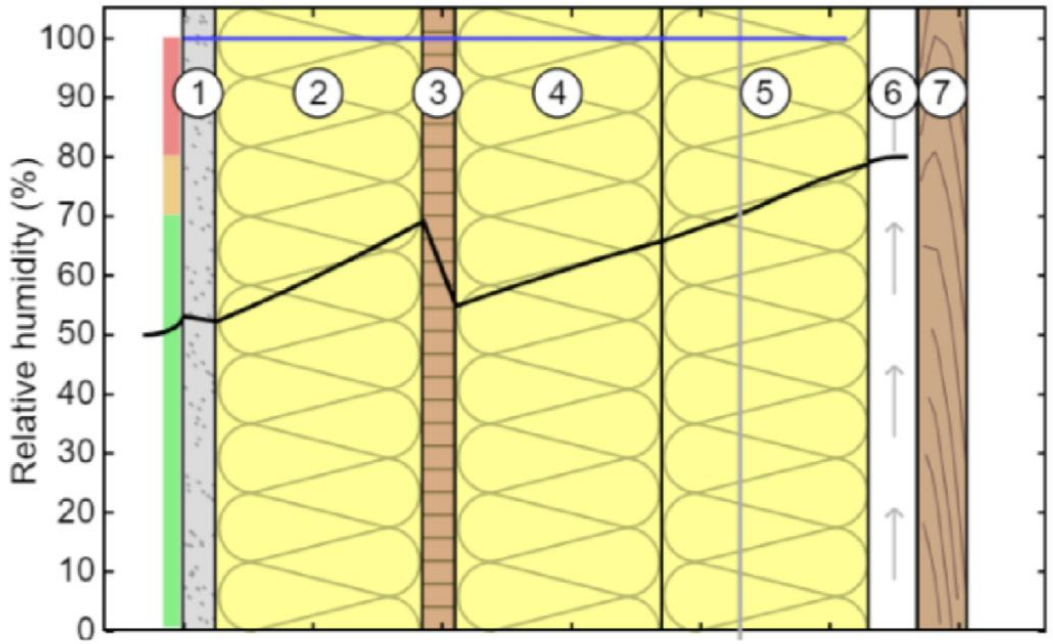
7. Shou Sugi Ban Cladding (3/4”)
6. Pine Furring Strips (3/4”)
5. GUTEX MultiTherm WRB (3”)
4. GUTEX MultiTherm (3”)
3. Blue Ridge Fiberboard (1/2”)
2. GUTEX ThermoSafe (3 1/2”)
1. Richlite Finish (1/2”)

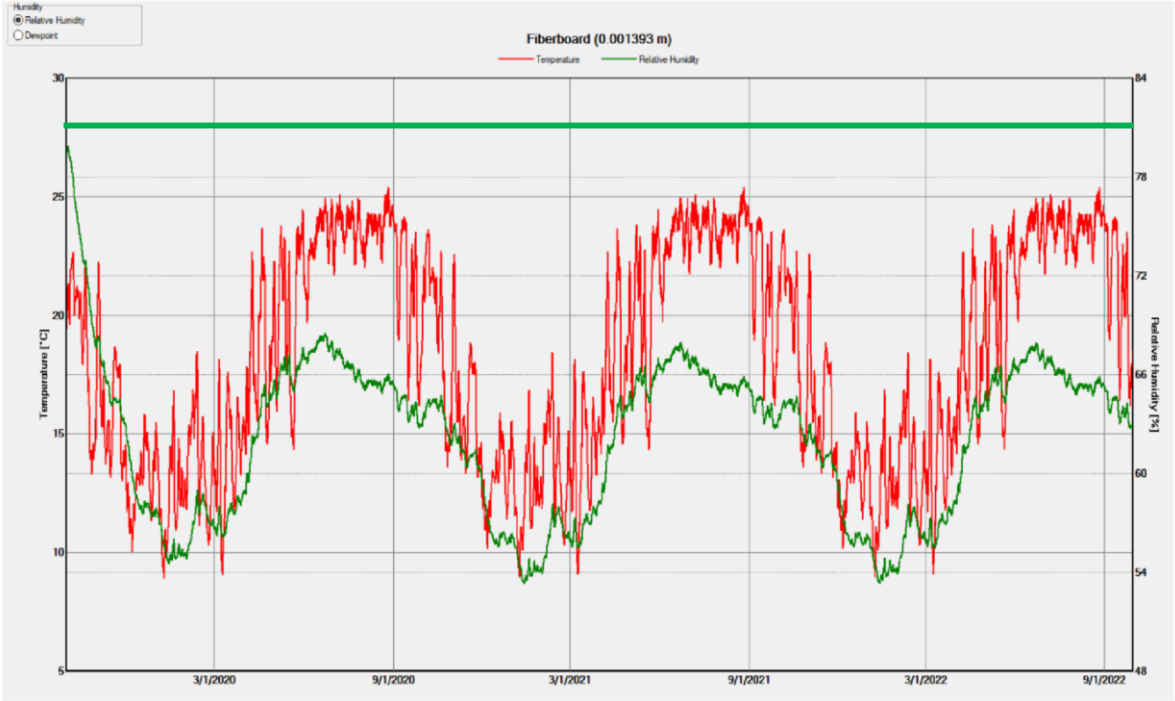


Hygrothermal Check

- Ubakus simulations show low RH
- WUFI confirms breathability year over year
- No risk for condensation in the cavity

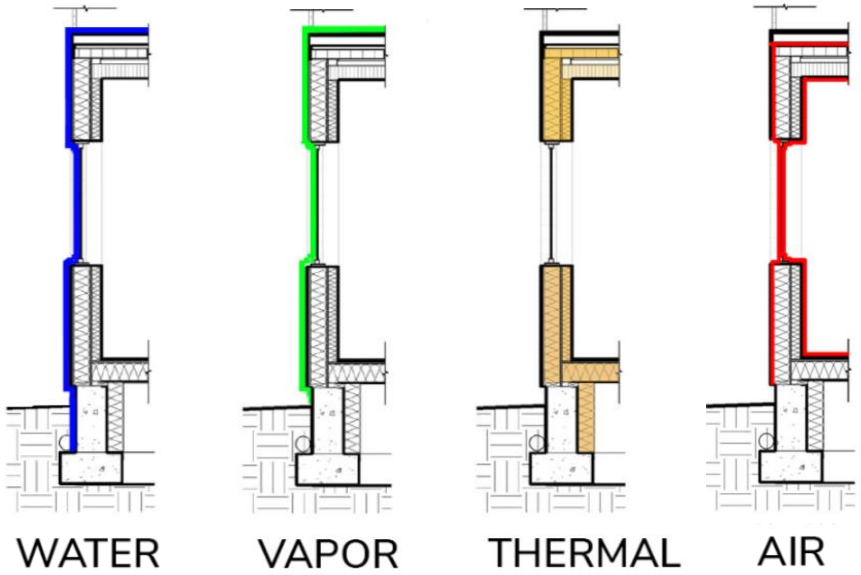
< 80% RH





Hygrothermal Check

Control Layers



Shou Sugi Ban

INTELLOplus®

GUTEX®

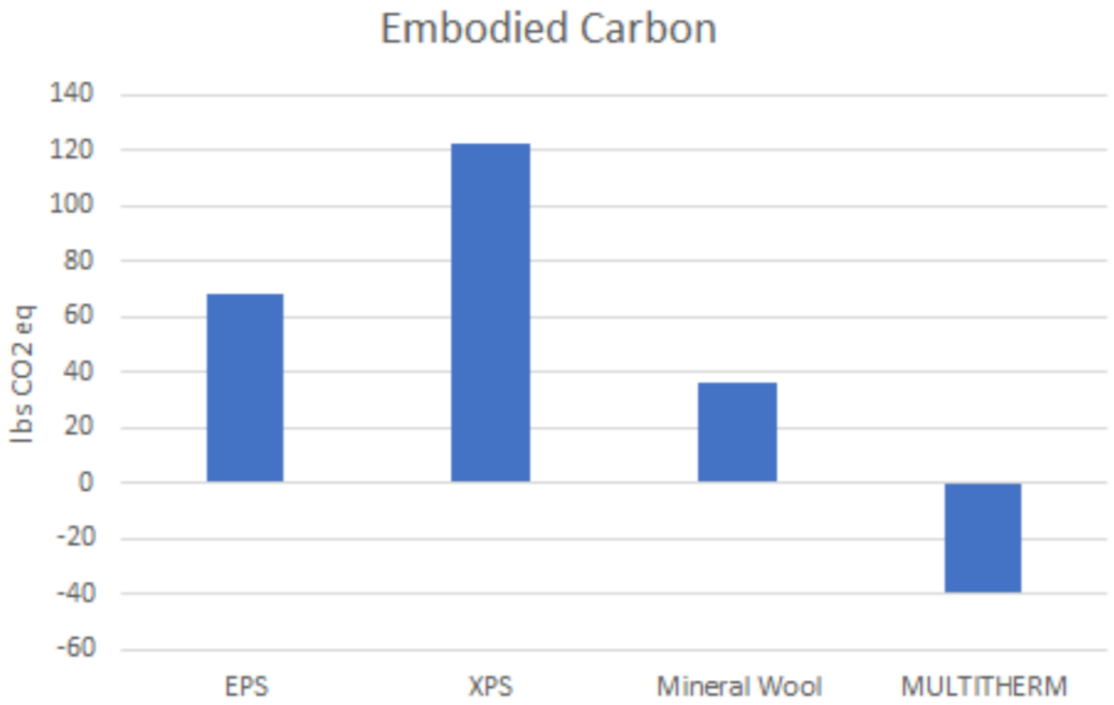
NATURALLY MADE FROM WOOD

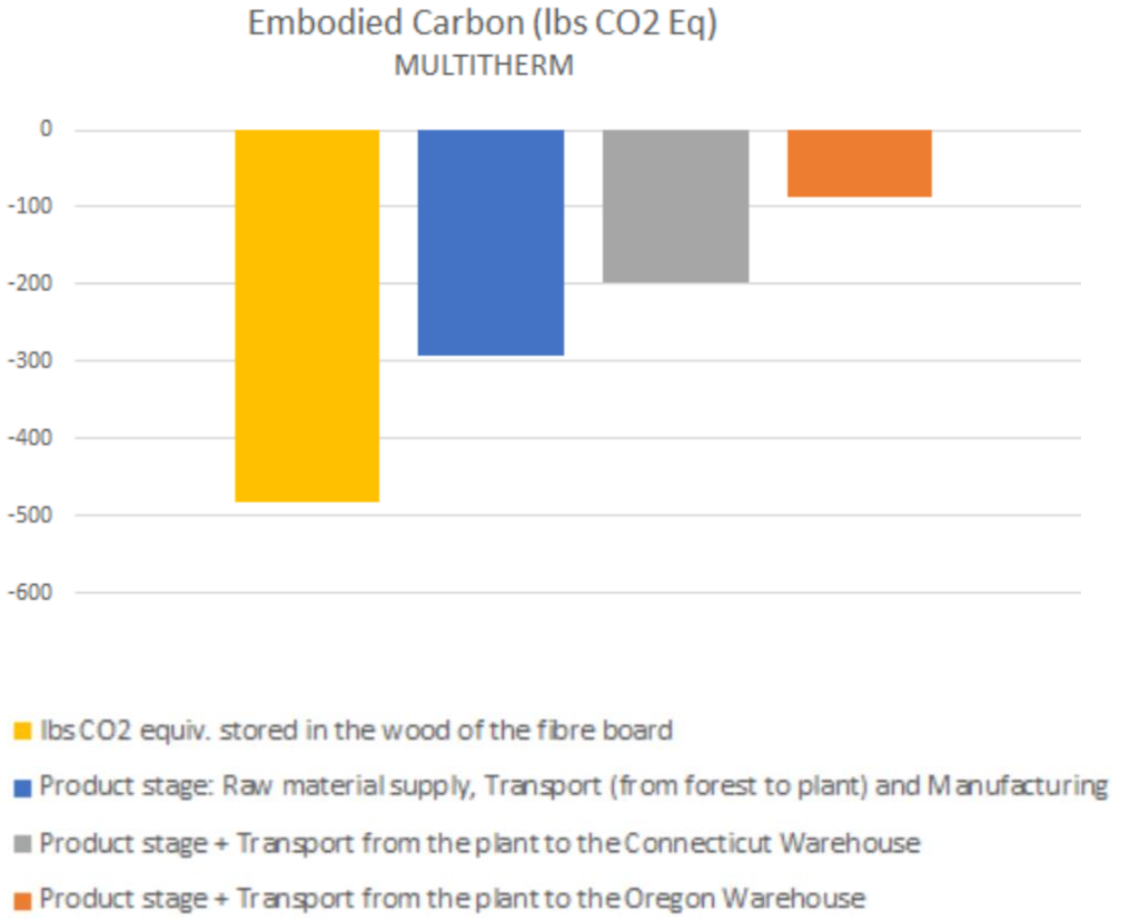
AEROBARRIER™

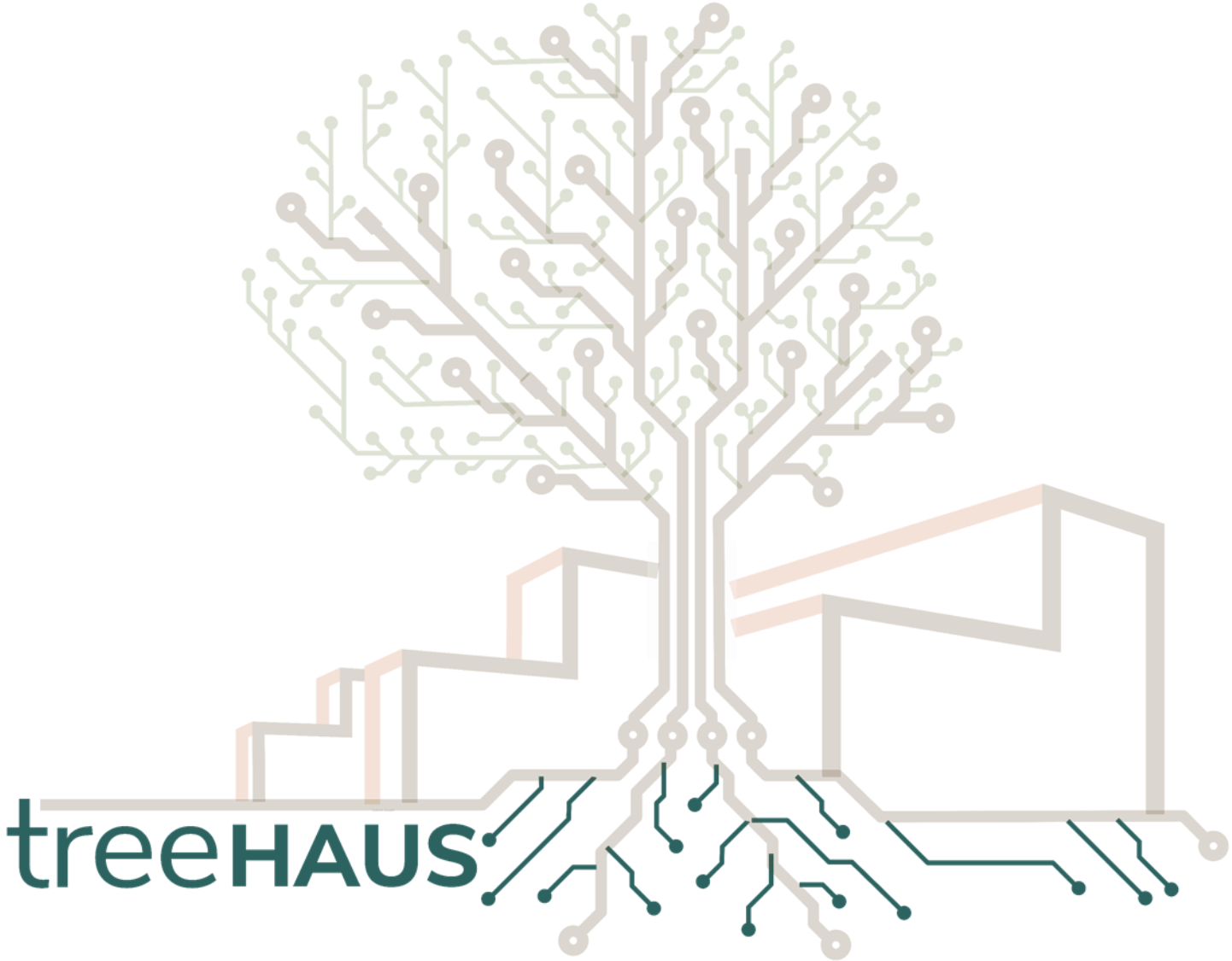
Breakthrough Envelope Sealing Technology

True Cost Accounting

- Embodied Carbon comparison
- Raw material extraction, fabrication, and transport



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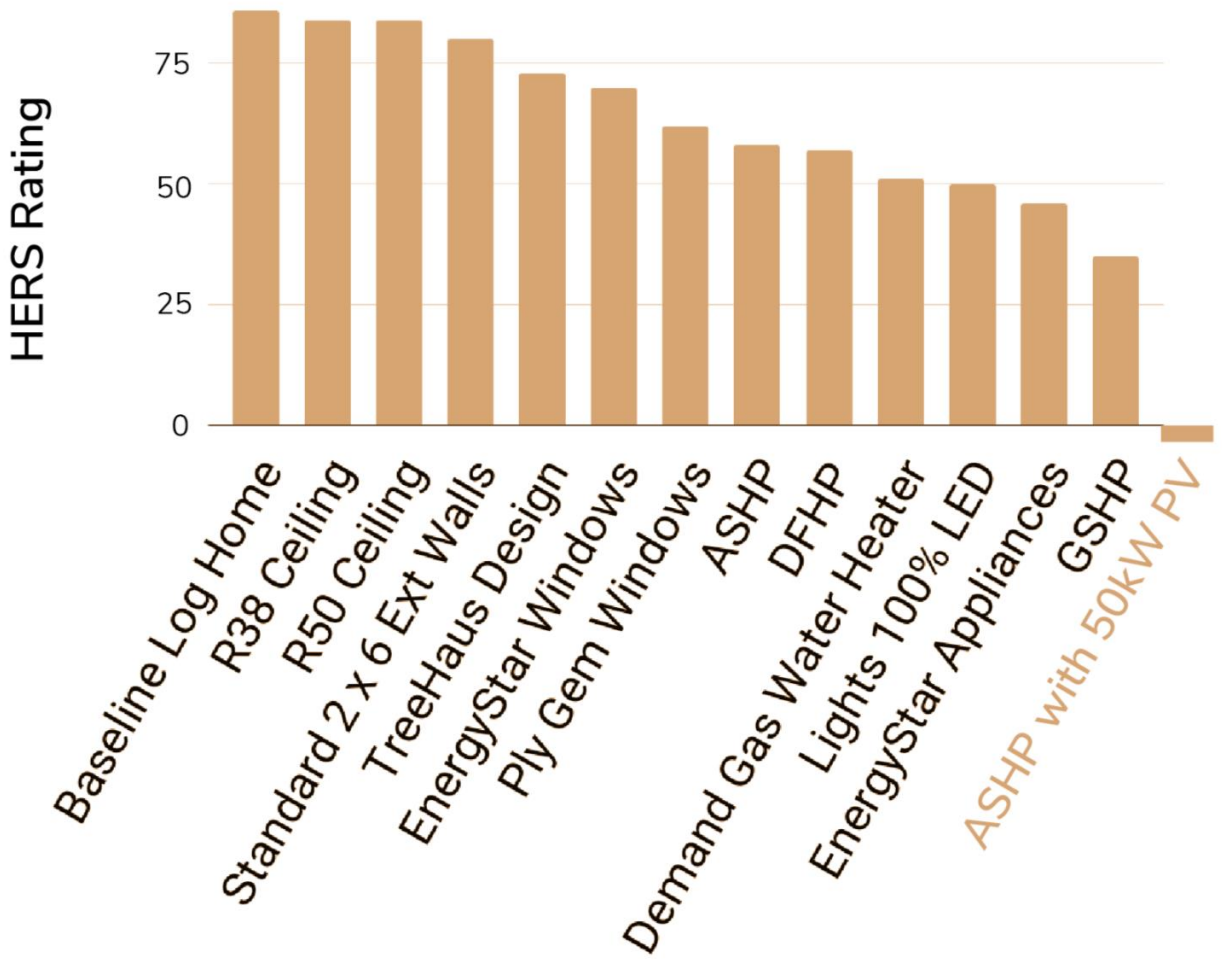
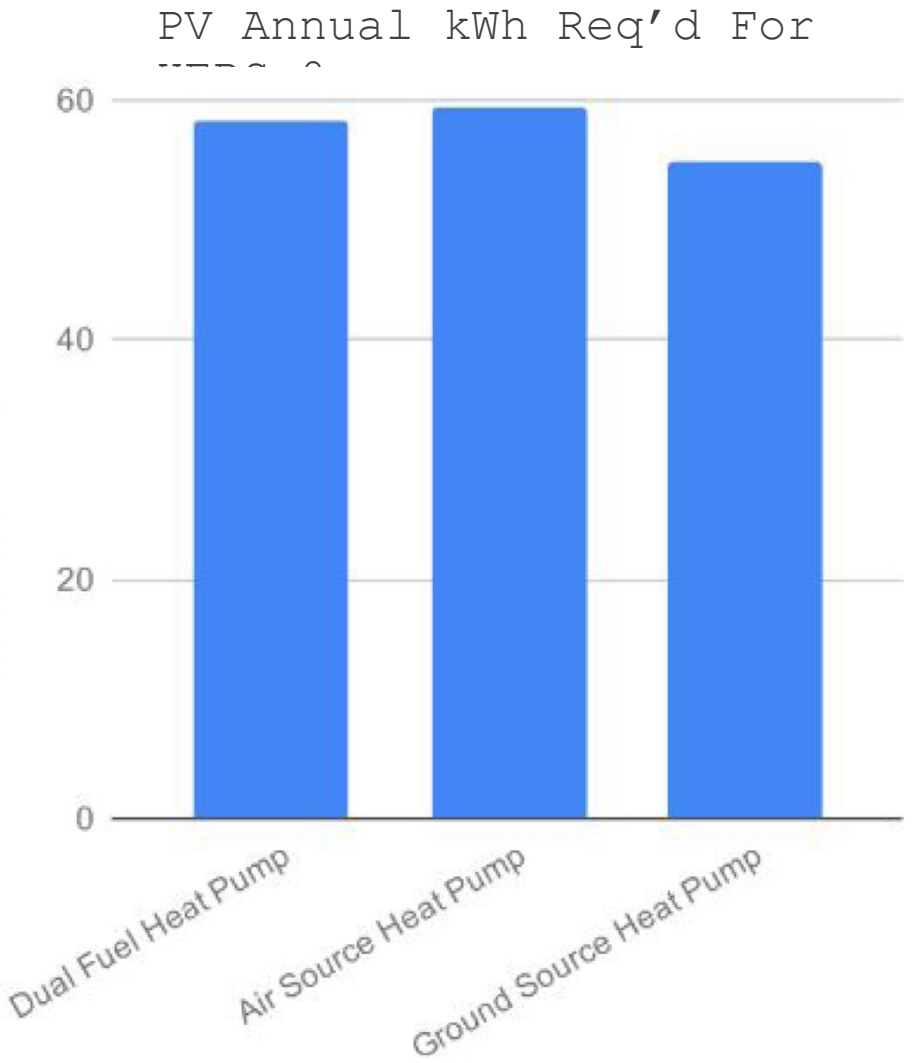
Energy Modelling

- Southland Log Home Baseline
- HERS -1 with 50kW PV Array
- RemRate iterations



HVAC Investigations

- Geothermal roots too expensive!
- 200 year ROI compared to ASHP
- HyperHeat models at -13F



Tree Shading Analysis

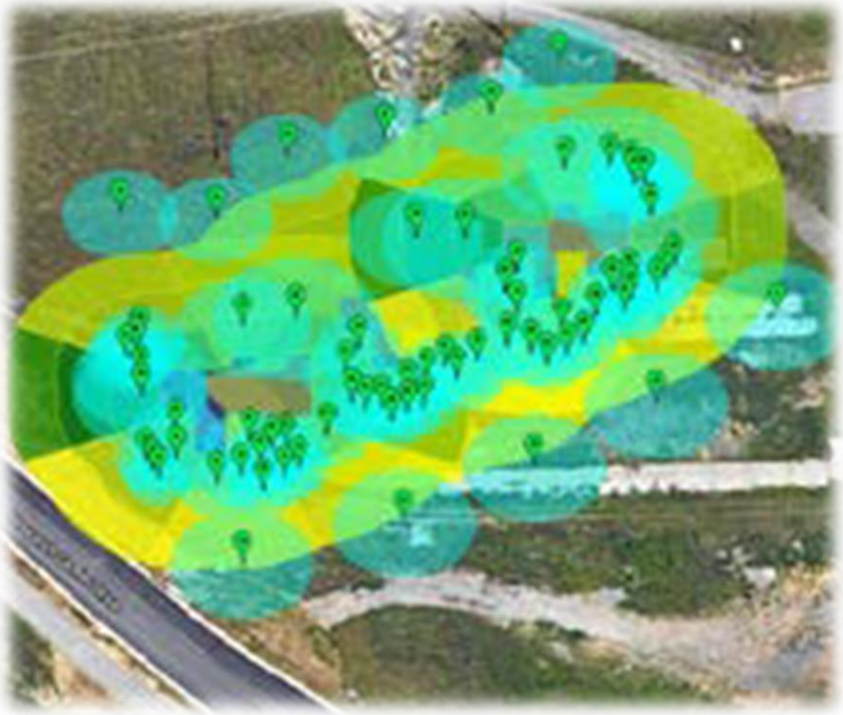
- REM / Rate shading analysis very limited
- i-Tree revealed 4000 kWh average annual savings
- Increases year over year

REM/Rate™

Adjacent Shading

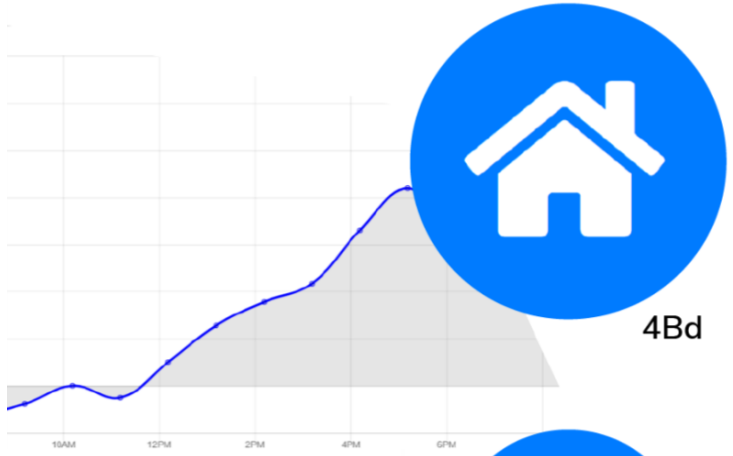
Winter: None

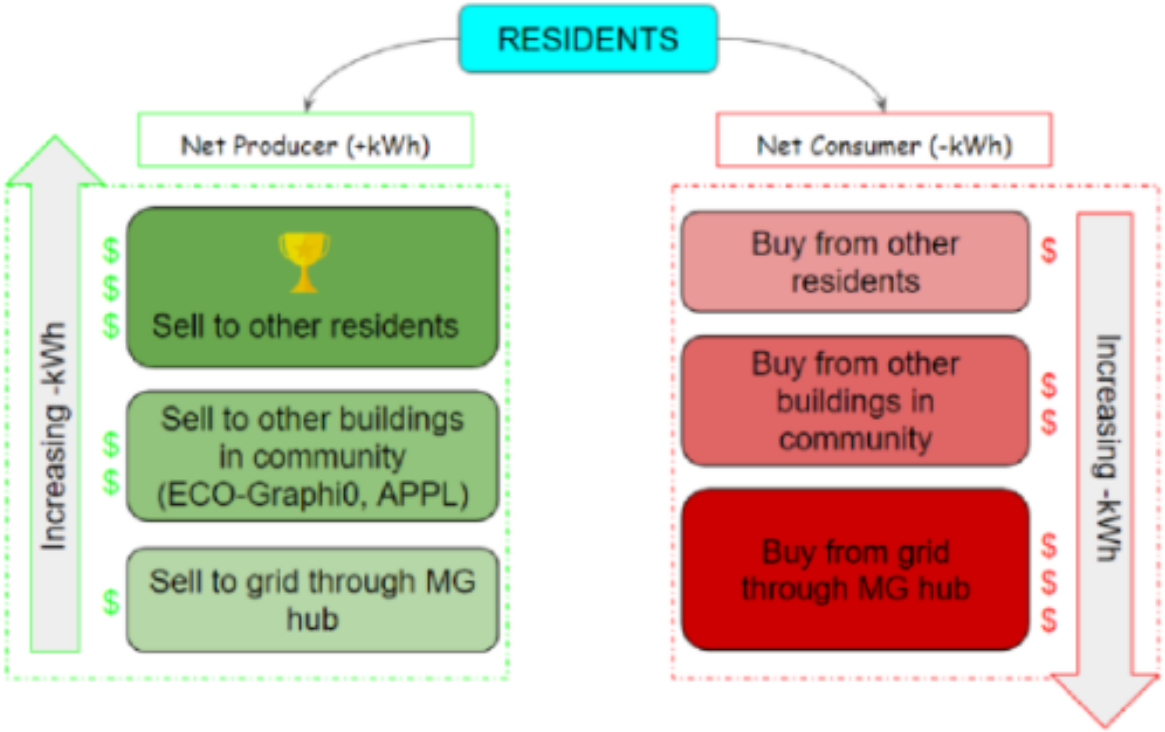
Summer: Most

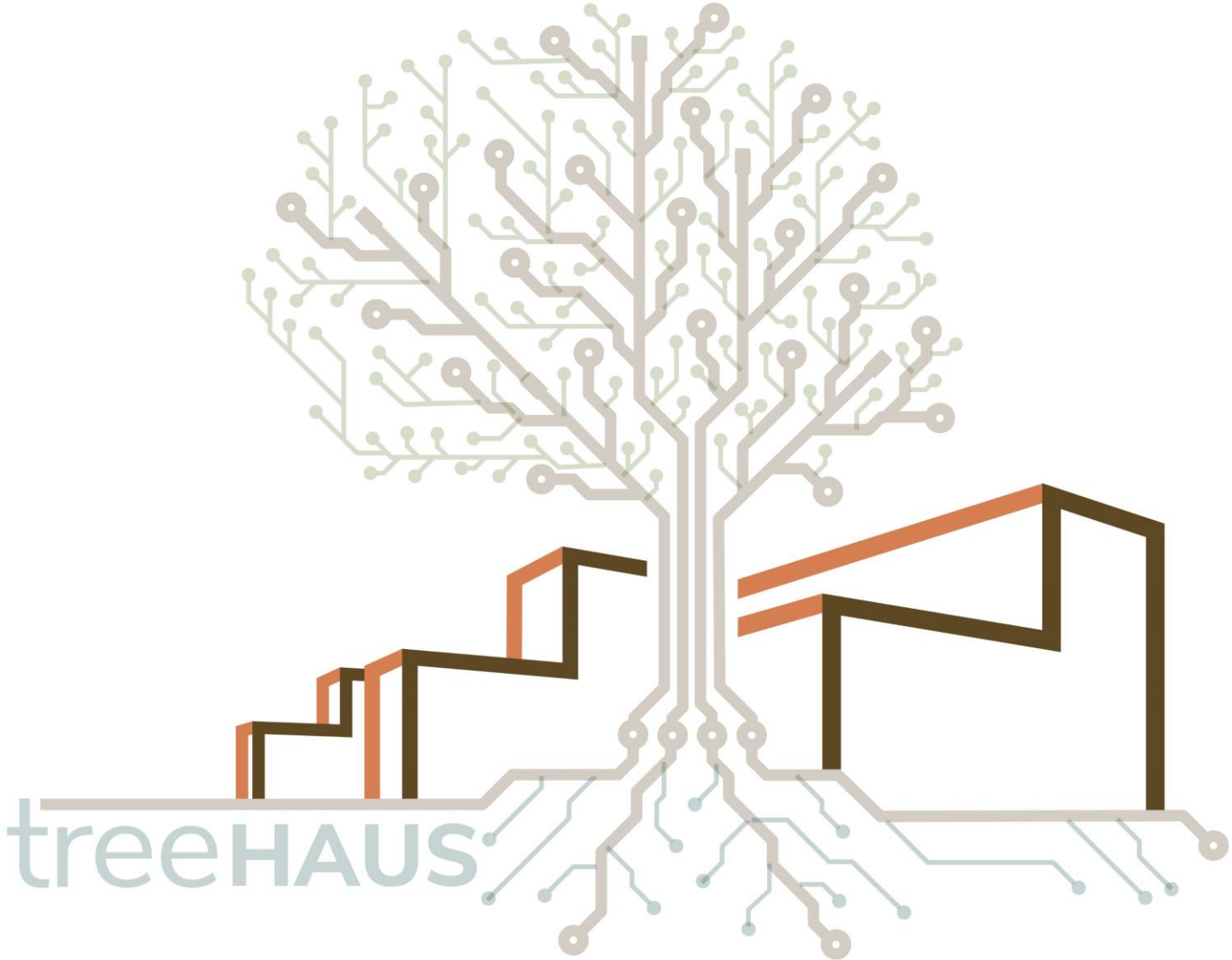


Mycorrho-Grid Simulation

- Weather Station adjacent to our site: TMY-724113
- DOEs Open Energy Information (OpenEI): Base, High, and Low
- Adapted to our unit types
- PVWatts for PV production
- Smart contract logic






treeHAUS

Acoustics – Site Noise

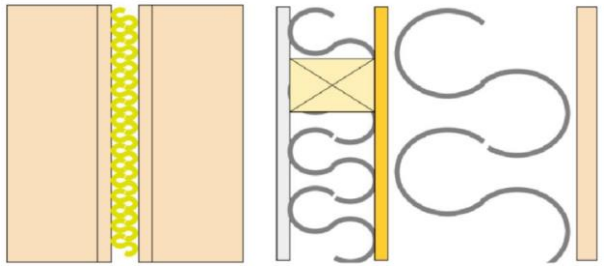
Site proximity to freeway and local airport

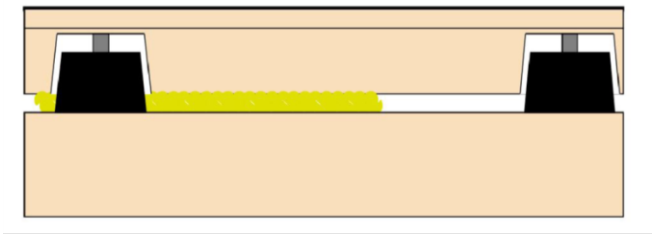
- Recorded baseline octaves
- Envelope will reduce overall site noise by ~40dB
- Only 1/16th of noise will be perceptible

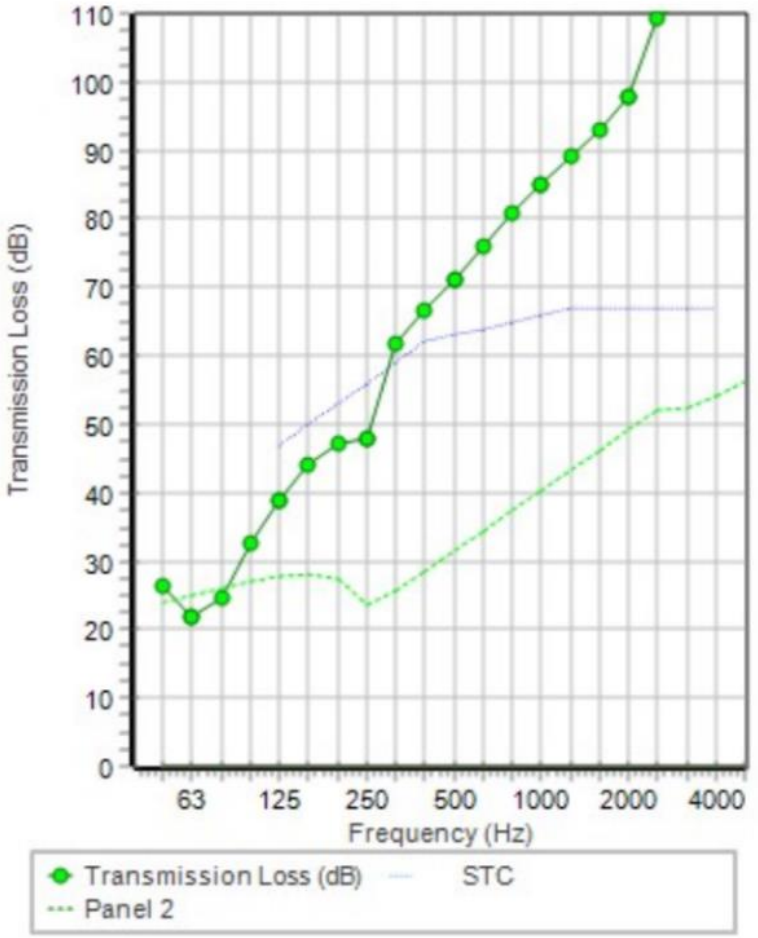
Site consultation with Acentech

Acoustics - Between Units

	Targets:	Actual ratings:
• Shared walls:	STC 50	STC 63
• Exterior walls:	N/A	STC 57
• Floors & Ceilings:	IIC 50	STC 58, IIC 50



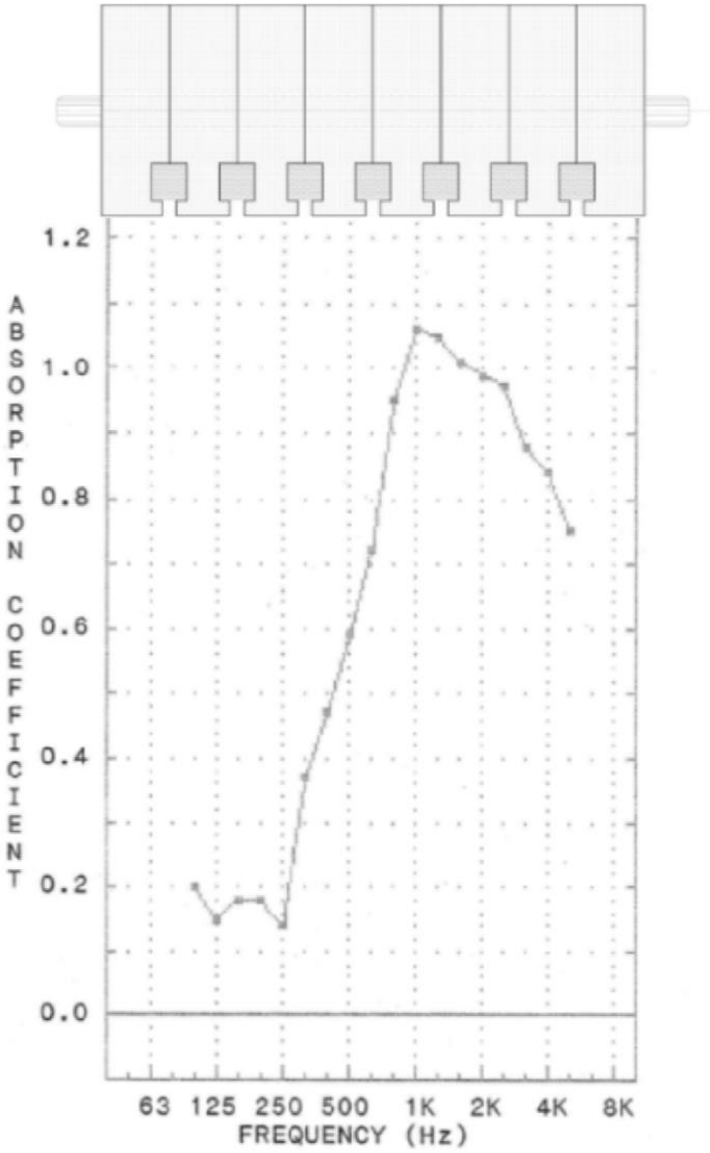




Acoustics - Within Units

Acoustic channels are routed into DLT panel:

- Attenuated to 1000hz for human voice
- Filled with wood-wool fiber
- Fiber also sequesters VOCs



Phyto-remediative Green Wall

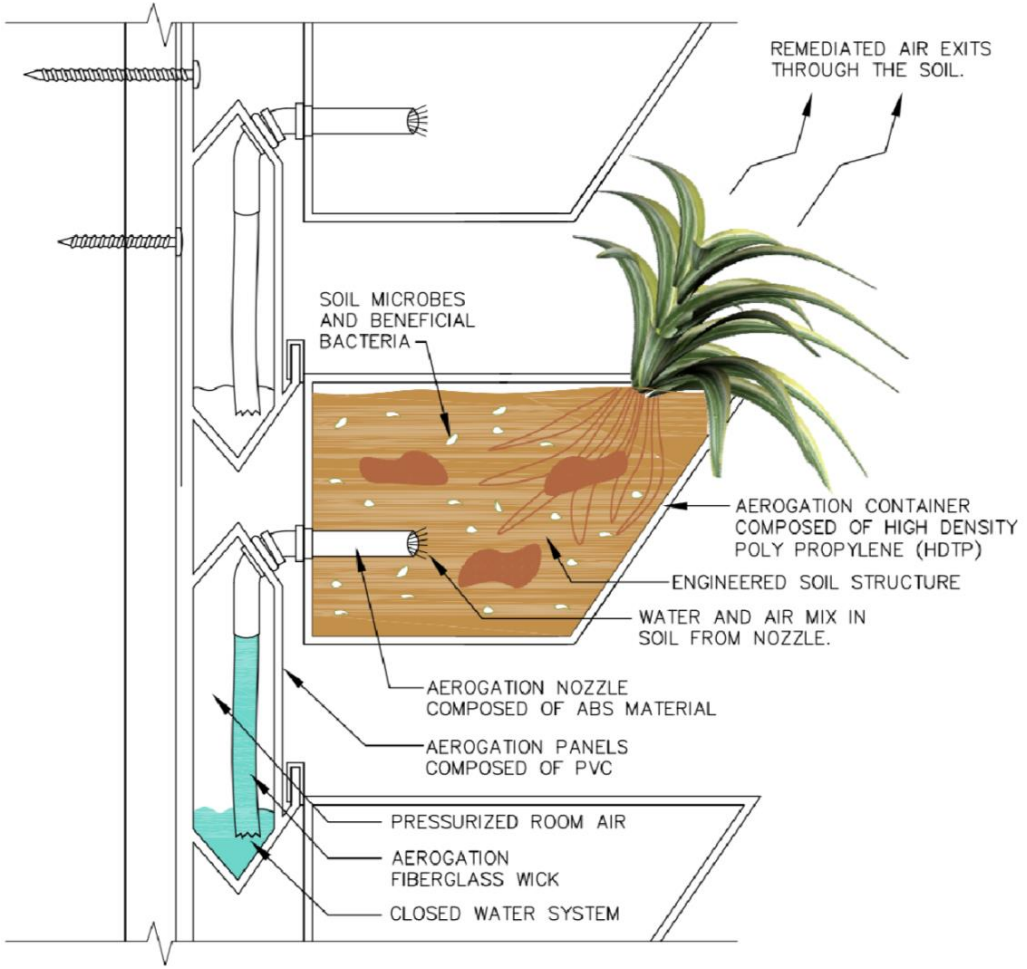
agroSci™

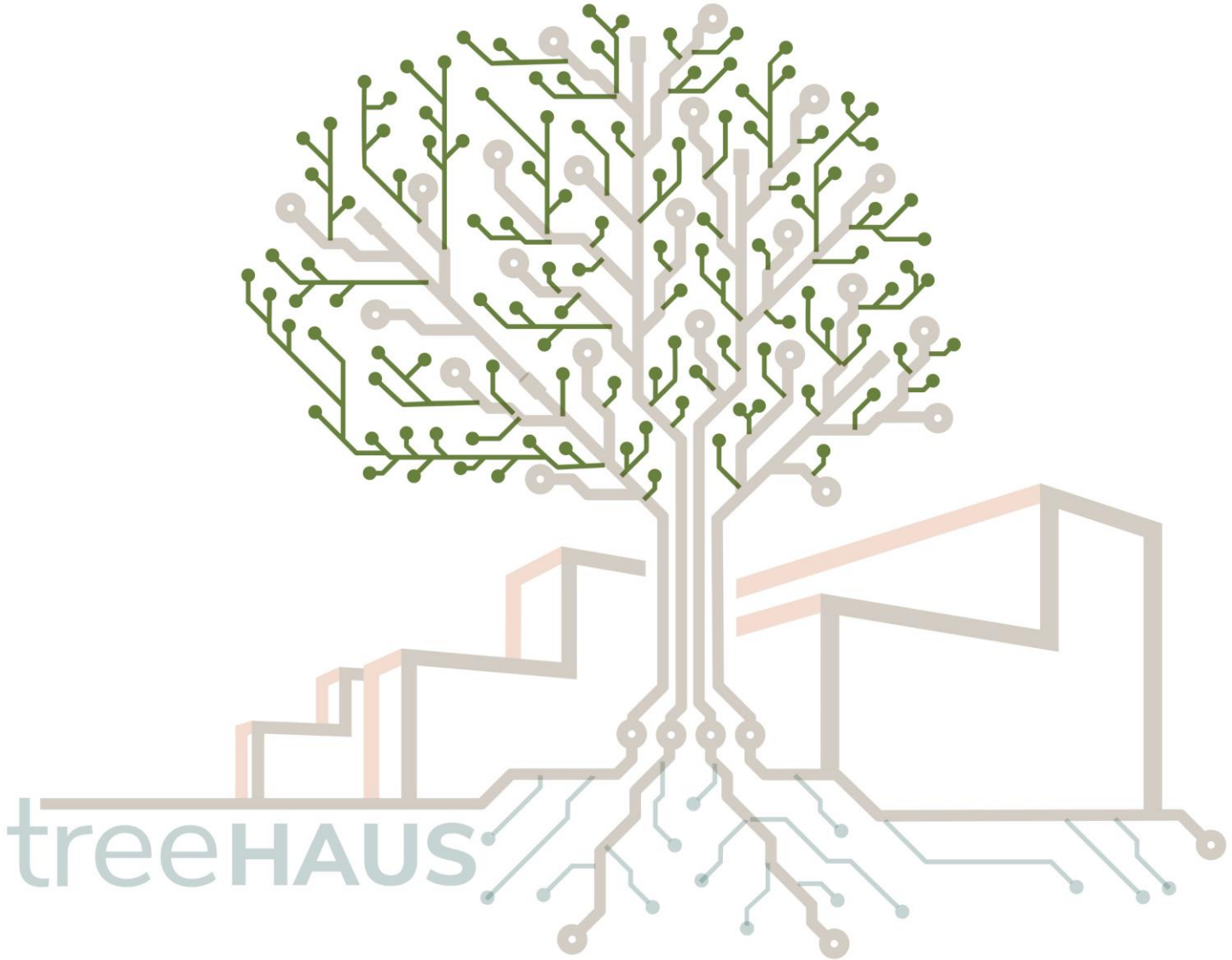
Green wall is integrated into HVAC

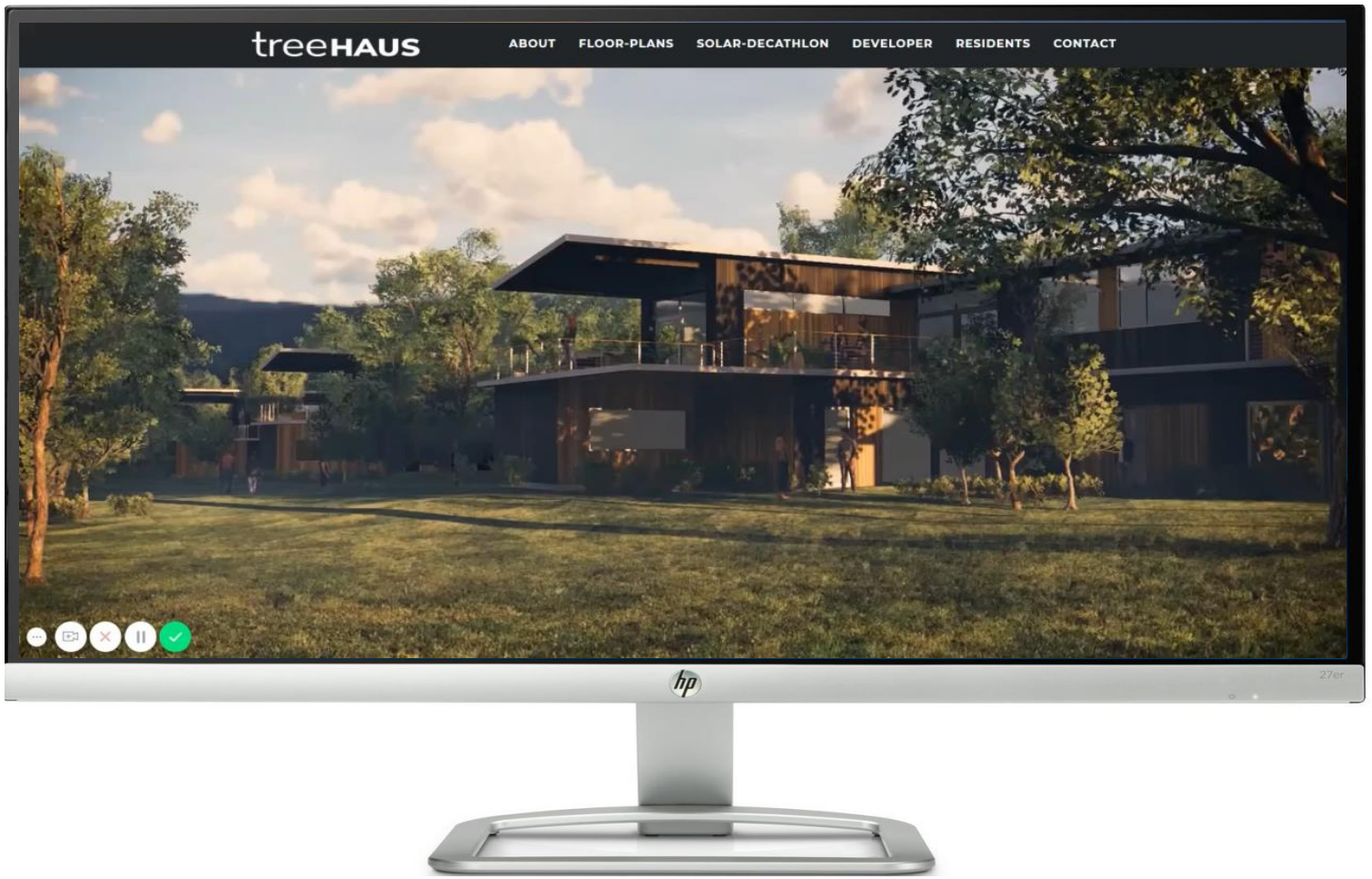
- Air is pulled through the soil
- Meets ASHRAE 62.2 standards
- Also supplemented by ERV

EPA Indoor airPLUS QUALIFIED HOME

WhisperComfort™ VENTILATION FAN SpotERV
Energy Recovery Ventilator




treeHAUS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SOLAR-DECATHLON
DEVELOPER
RESIDENTS
CONTACT


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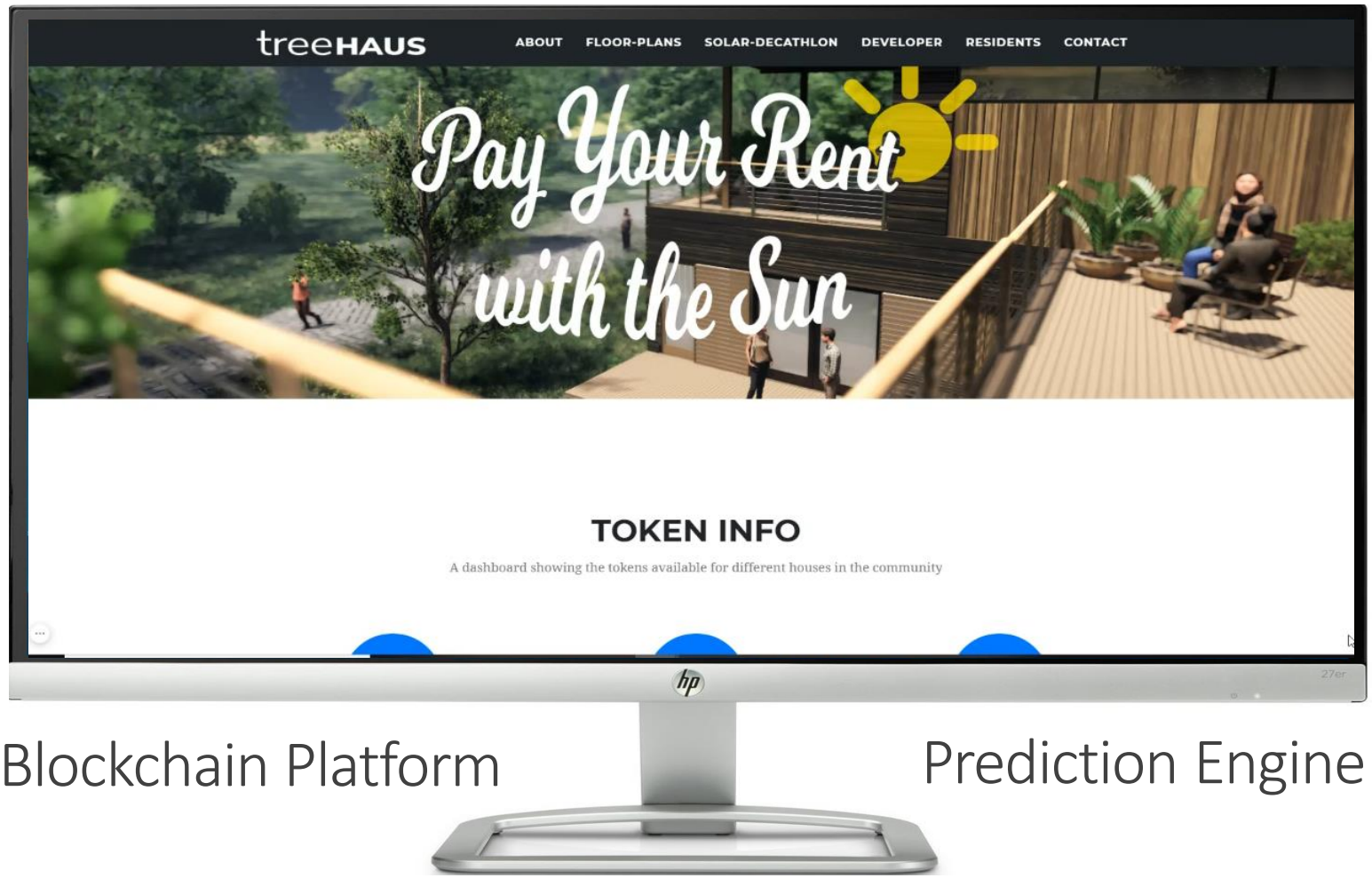
INSPIRATION
CONCEPT

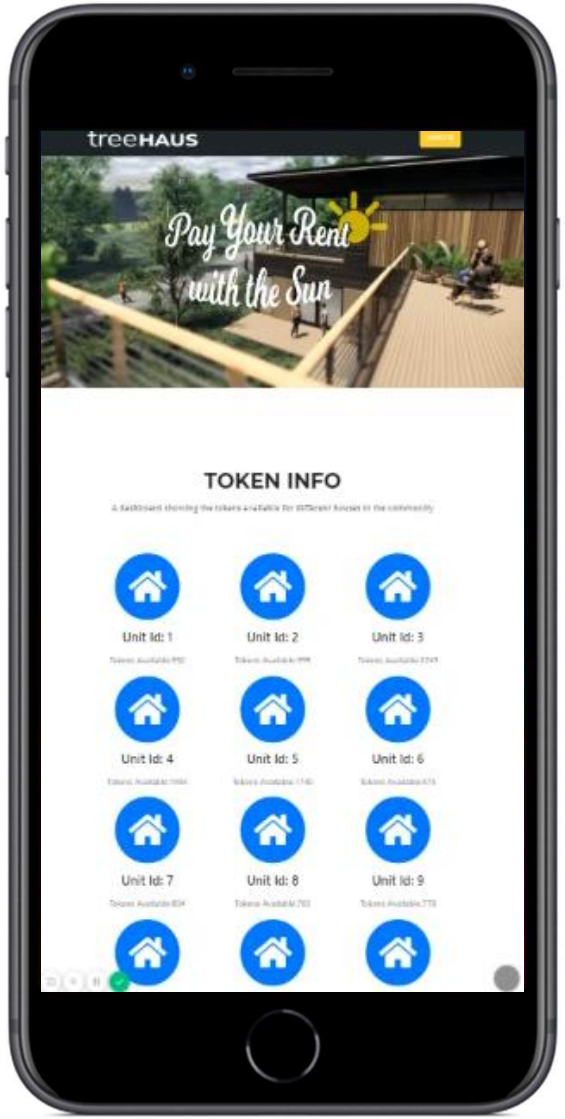
www.treeha.us

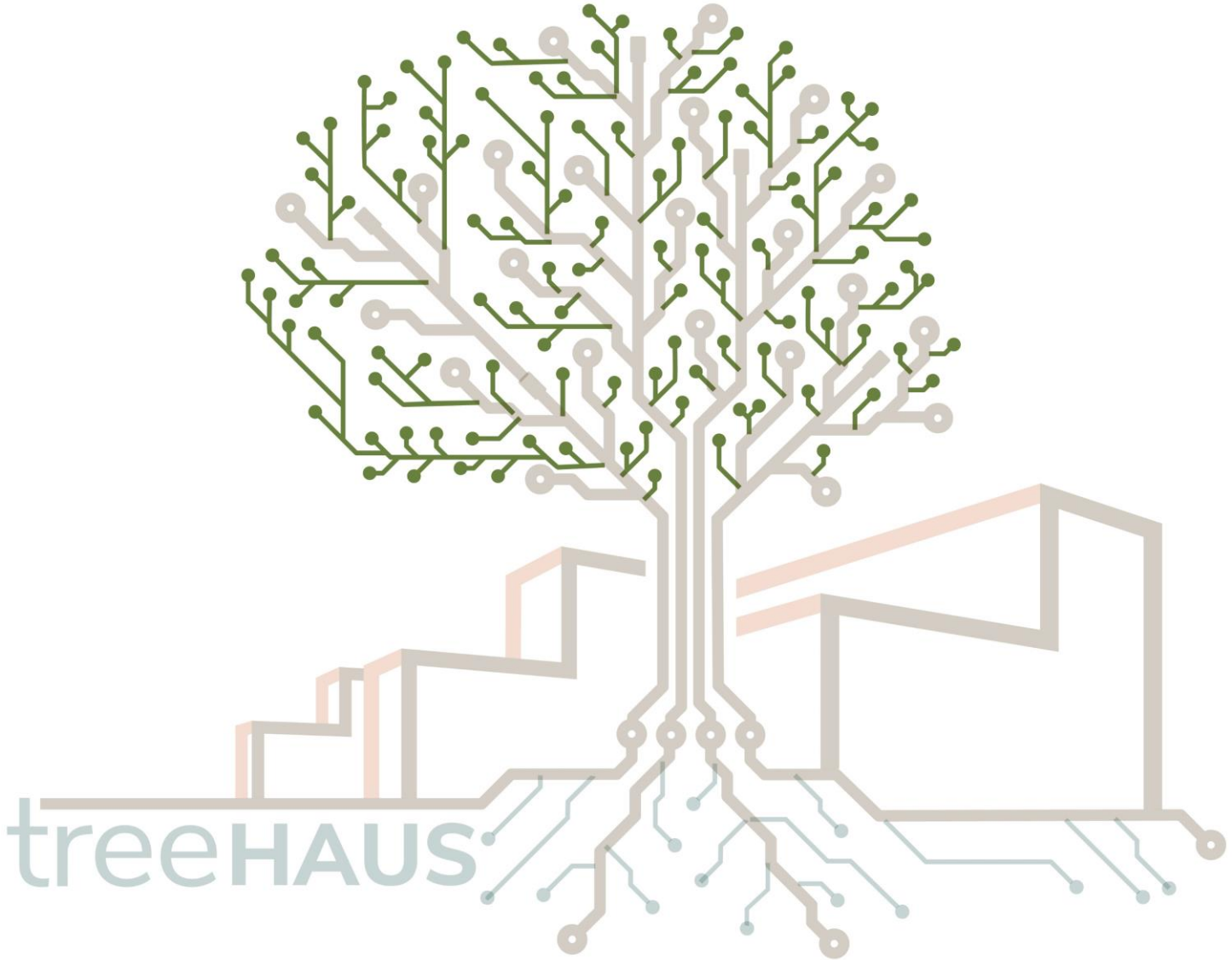


Blockchain Platform

Prediction Engine

One Integrated Dapp

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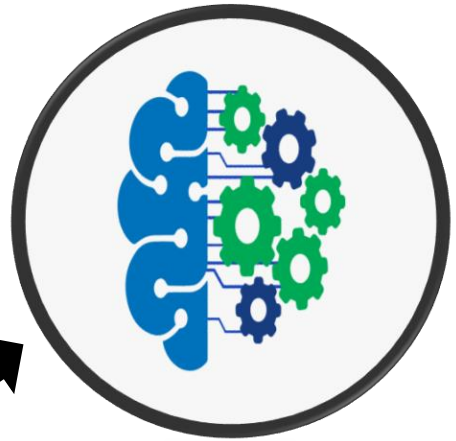
Prediction Engine

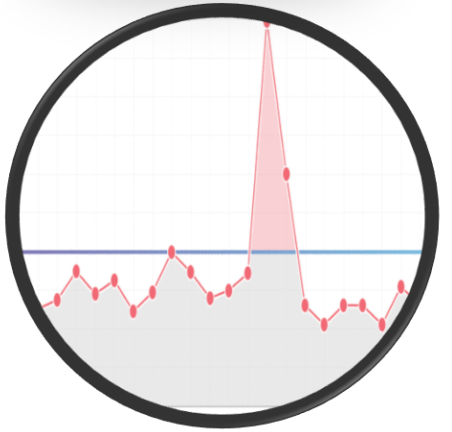
User Consumption

Behavioral Learning

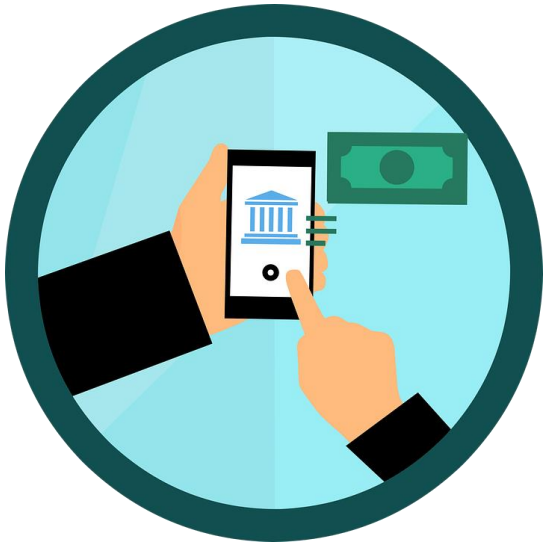


Forecasting

Estimating Peak Load Demands



Blockchain Applications

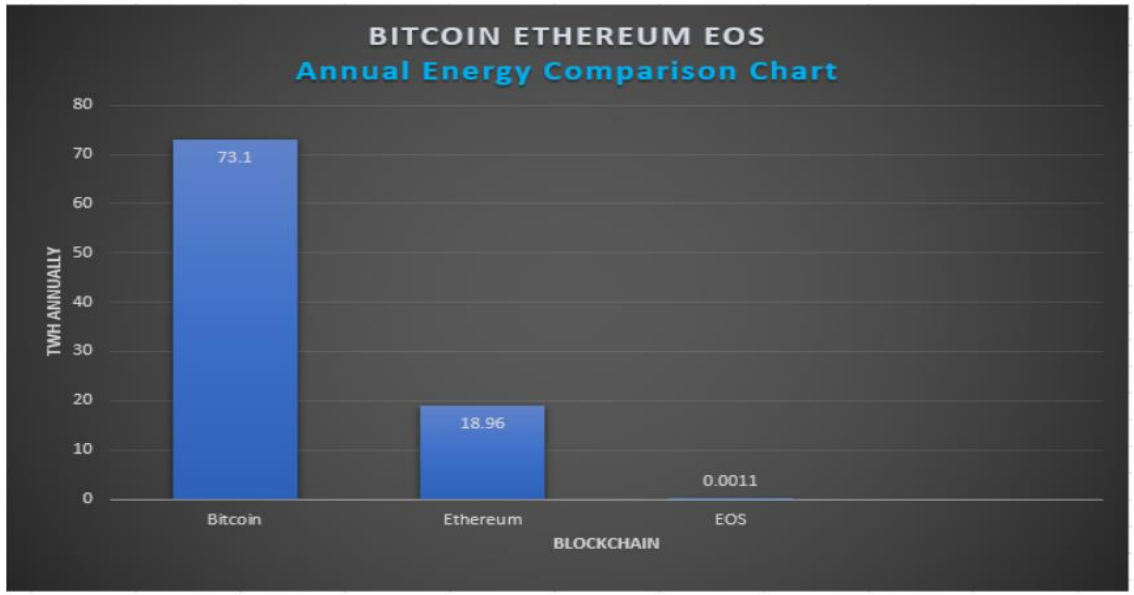


Transparent Energy Transactions

Immutable Maintenance Log

Geofencing Security control

Powered by eosio



Our blockchain platform is powered by EOSIO

It is the privilege of the Department of Computer Science, Virginia Tech

to recognize

Arjun Choudhry, Zachary Gould, Ikechukwu Dimobi -

Eco10gic Team

recipients of the

Blockchain Challenge, Phase I

Top Graduate Team: $1,000

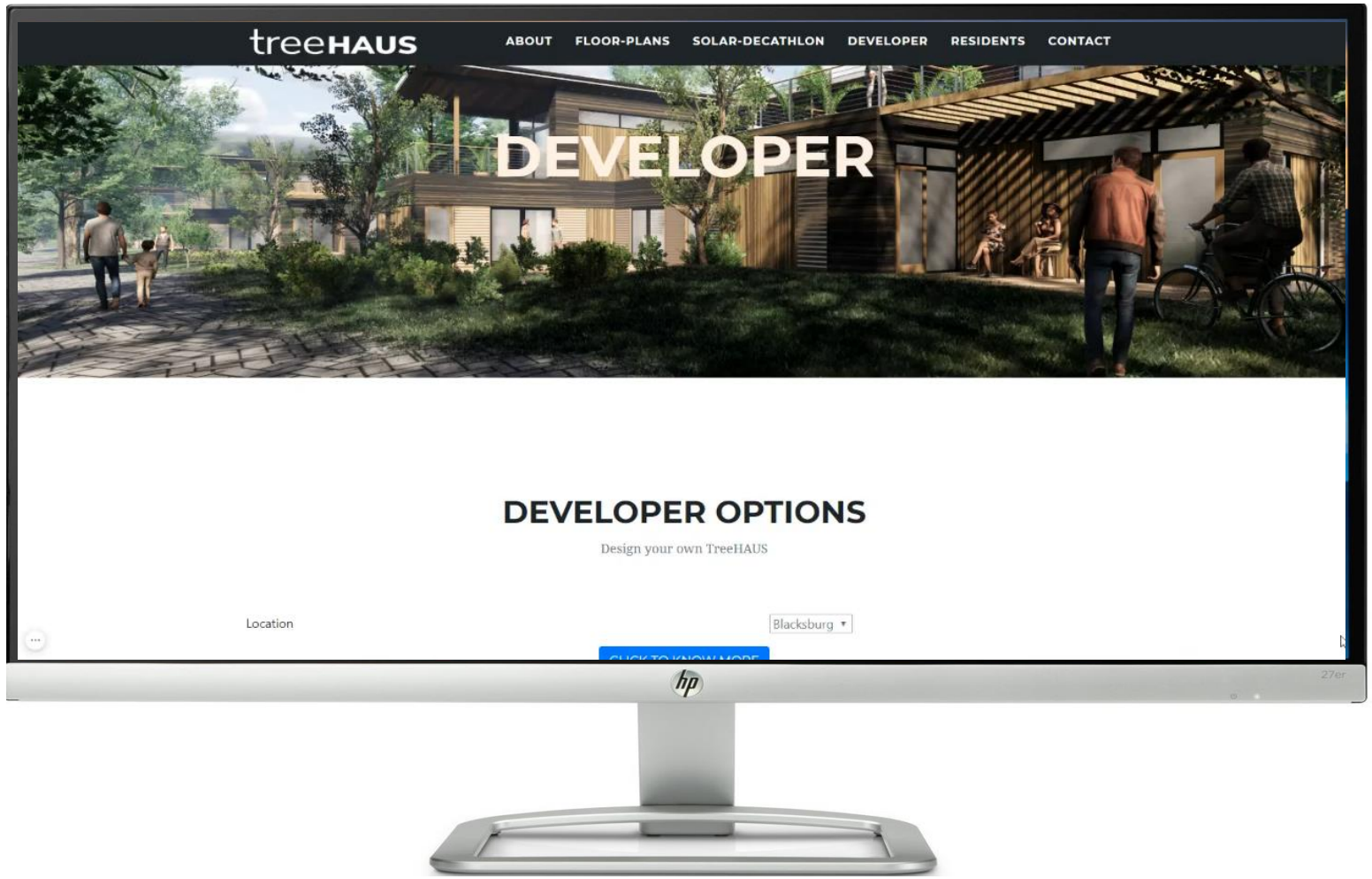
awarded by the Department of Computer Science, Virginia Tech for excellence in computing on this 1st day of March 2019, at Blacksburg, Virginia.

COLLEGE OF ENGINEERING COMPUTER SCIENCE VIRGINIA TECH.

Kirk W. Cameron

Professor, Associate Department Head for Research and Engagement

EOSIO VT Challenge Winners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DEVELOPER OPTIONS
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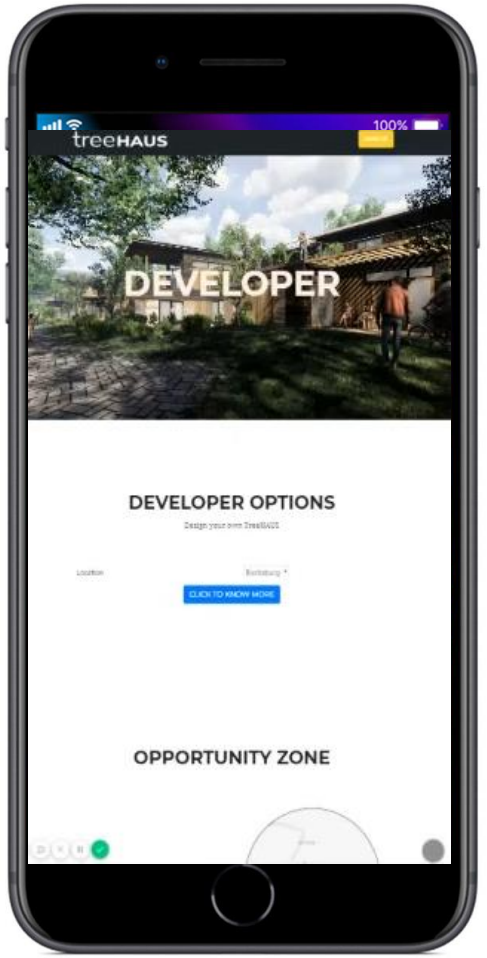
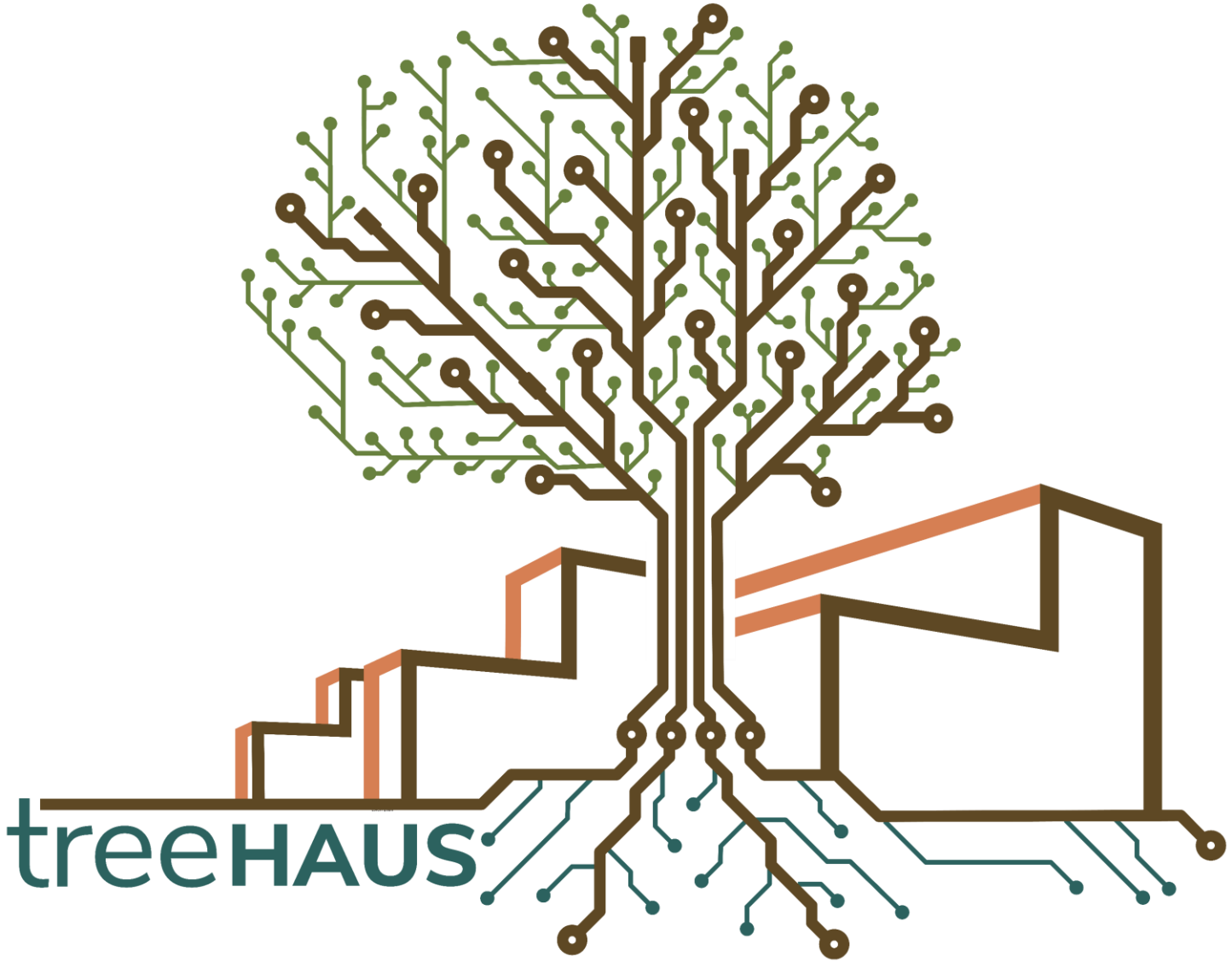
Location
Blacksburg


treeHAUS
100%
DEVELOPER
DEVELOPER OPTIONS
OPPORTUNITY ZONE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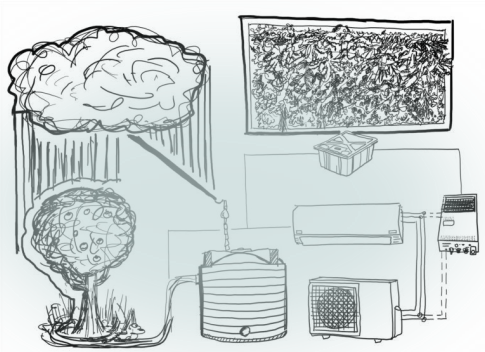
Back to our Roots

ENERGY

FOOD

WATER



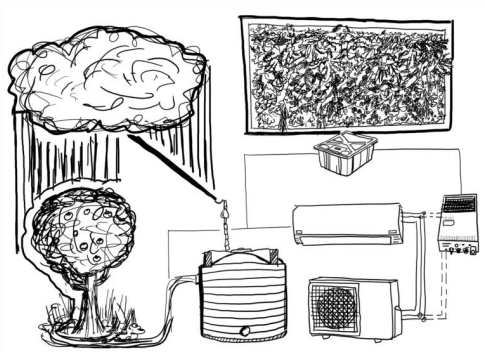
WATER

ENERGY

FOOD

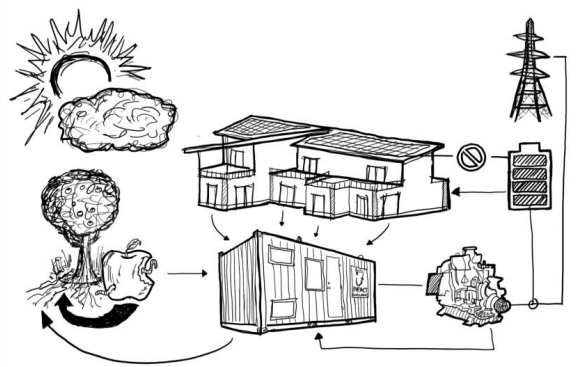
Back to our Roots

ENERGY: Mycorrho-GRID



WATER

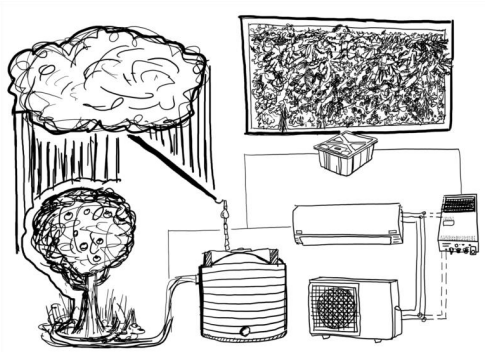
ENERGY



FOOD

Back to our Roots

FOOD: Anaerobic Digestion



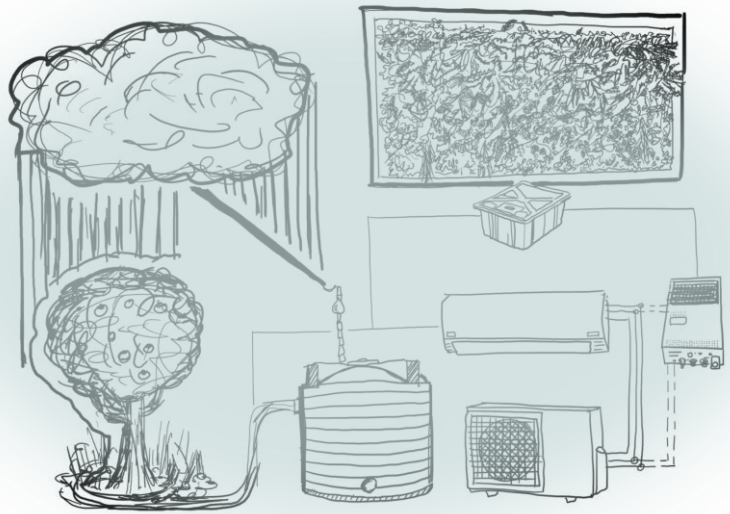
WATER

ENERGY

FOOD

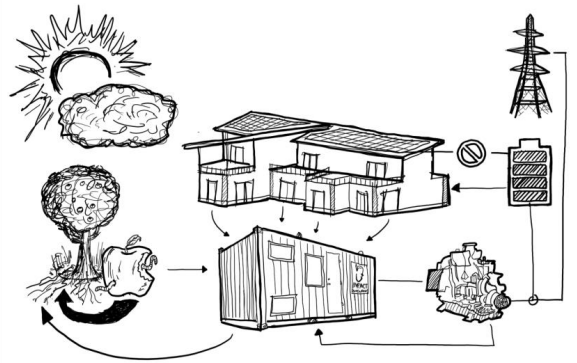
Back to our Roots

WATER: Condensate Raingardens



WATER

ENERGY

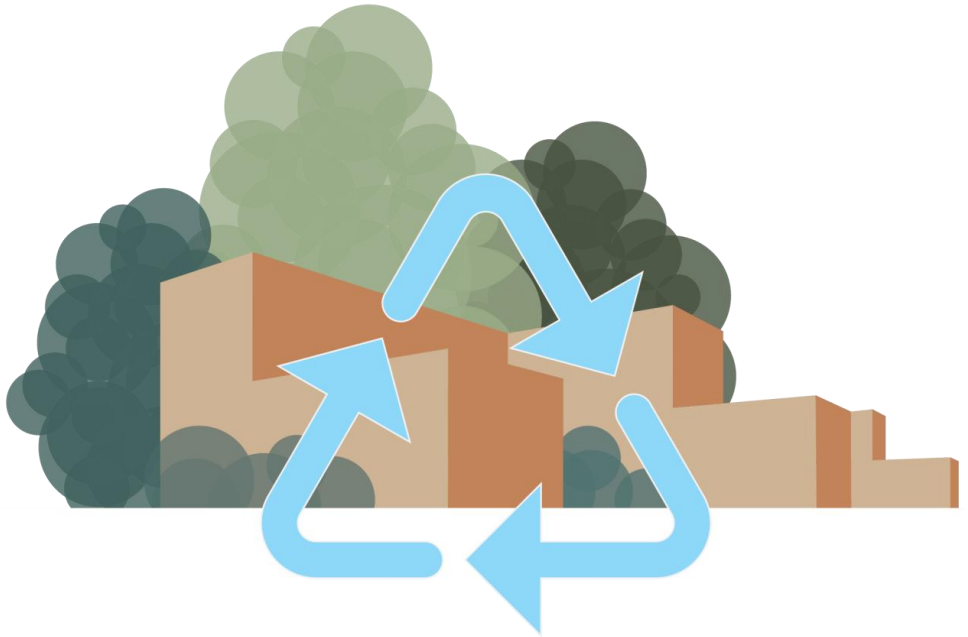


FOOD

Back to the Earth: Succession

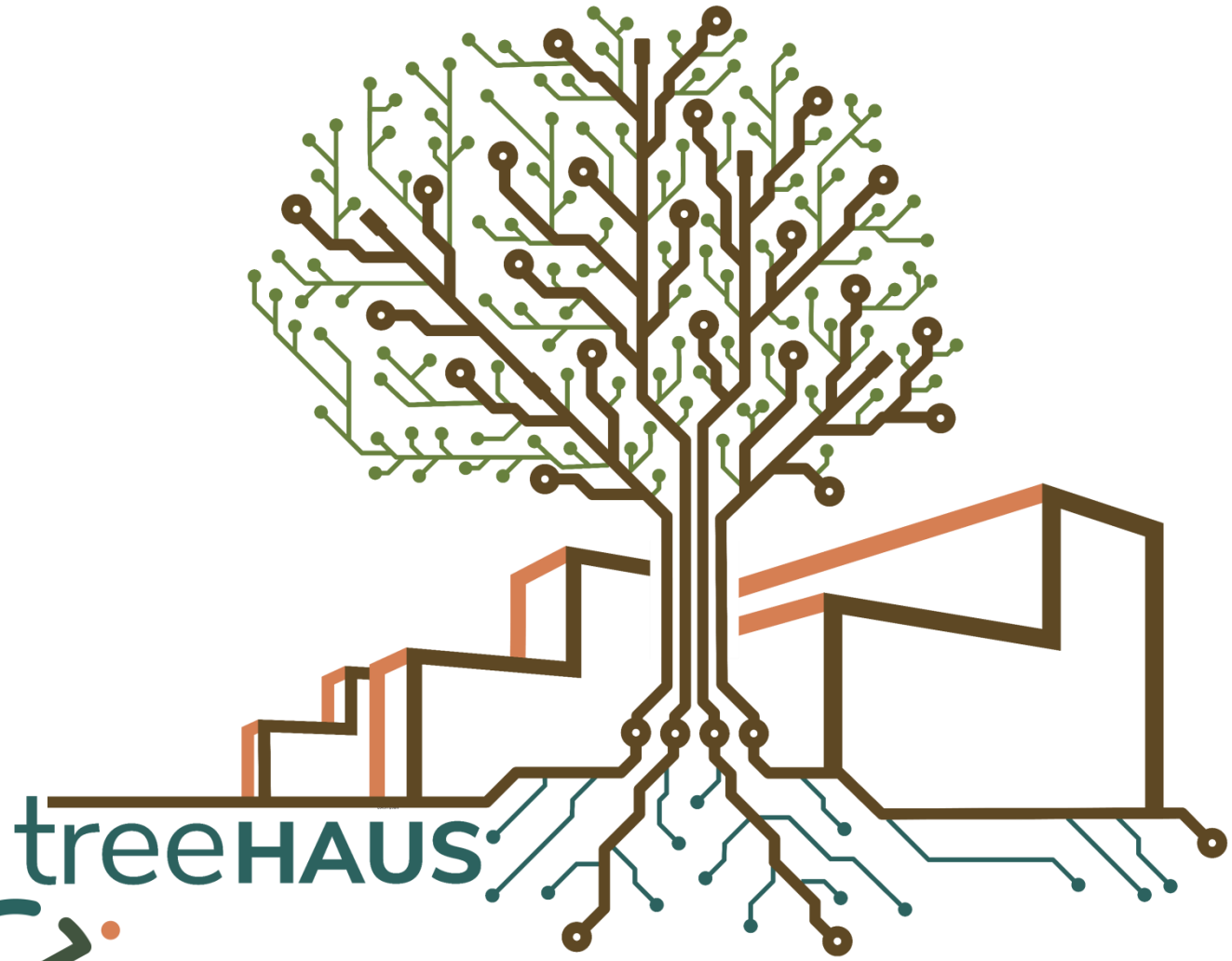
Although TreeHAUS is Built to Last we have designed for a truly regenerative future.

- Design for deconstruction
- Design for recyclability
- Design for biodegradability




“Far into the future, once our structures disappear, the remedial grasslands will be overtaken by trees. Through natural succession, the entire site will regrow into an extension of Crumpacker woods.”
- Delie Wilkens

Thank You!



And a special thanks to our crowd-funding sponsors:

Gold:

Juan Del Alamo, Charlie Regan, Lisa and Bruce Gould, in Memory of John T. Regan, Samuel Piper, Jeff and Isa Warner, Saeid and Stacy Arshadi, Gretchen Gruenhut, Chris Fong

Silver:

Rachel Peacock, Elaine and Steven Strongwater, John Nuckols of JRN Environmental Health Service, Lorann Stallones, Kimberley Homer, Brad Tilley, Taryn Gould, Sharon Jaffe Dan

Bronze:

Halley Futterman, Don Janus

JUMP CROWDFUNDING AT VIRGINIA TECH

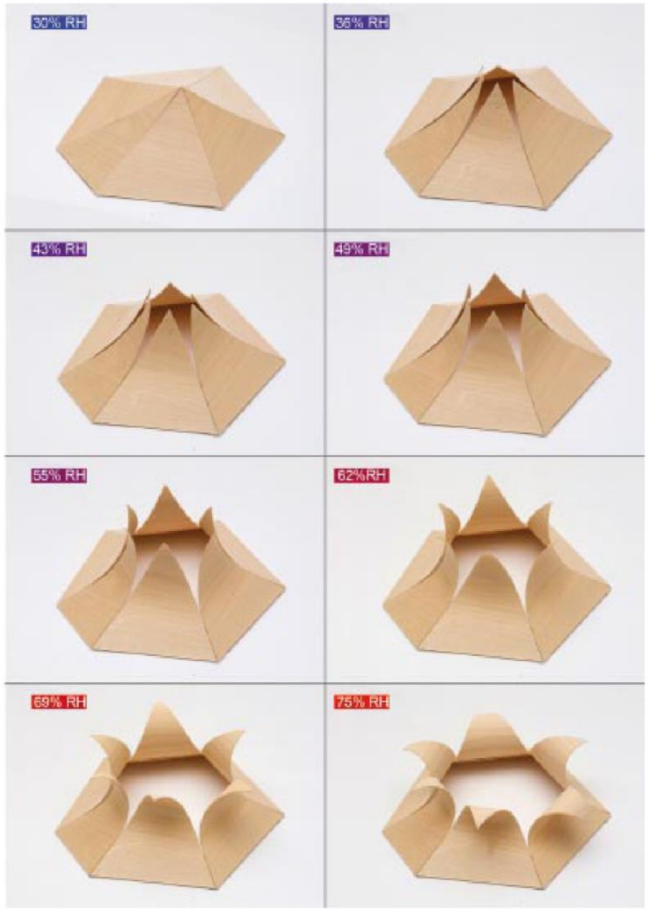
Appendices

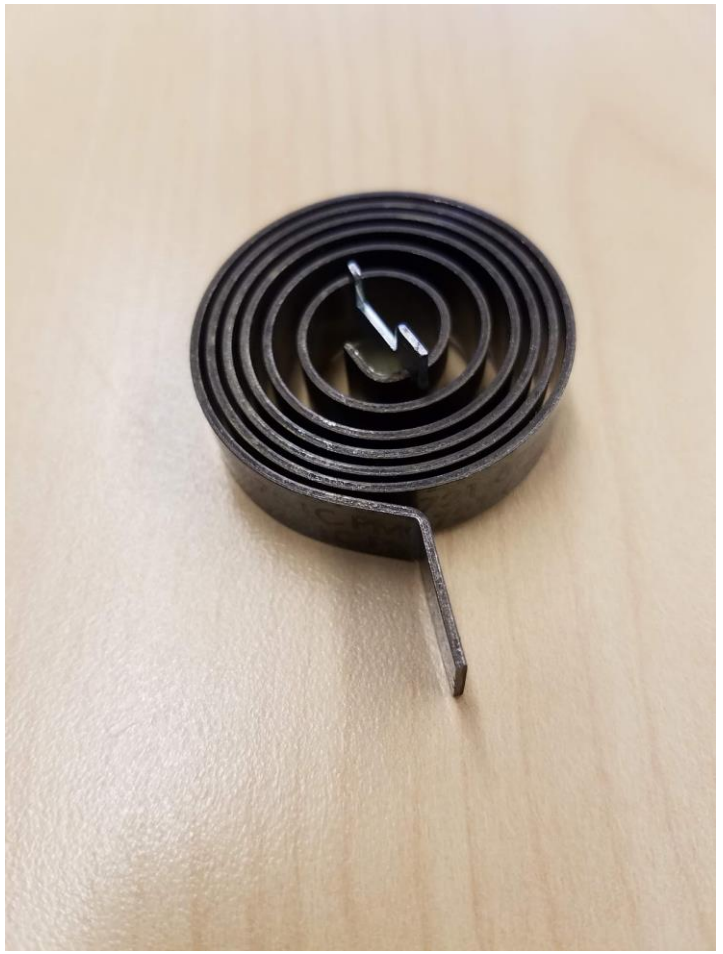
Loads

UNIT TYPE	HOT WATER LOAD	INITIAL TOTAL WATER LOAD	TOTAL WATER LOAD W SAVINGS	HEATING LOAD	COOLING LOAD	VENTILATION LOAD
1Bd (1Ba)	3.5 GPM	5 GPM	4.5 GPM	3.4 kBTU/hr	3.7 kBTU/hr	42.2 CFM
2Bd (1.5Ba)	5.5 GPM	8.5 GPM	7.5 GPM	5.3 kBTU/hr	6.0 kBTU/hr	70.5 CFM
3Bd (2.5Ba)	7.5 GPM	12 GPM	10.5 GPM	7.7 kBTU/hr	8 kBTU/hr	98.7 CFM
4Bd (2Ba)	7.5 GPM	12 GPM	11 GPM	12.8 kBTU/hr	13.8 kBTU/hr	117.5 CFM

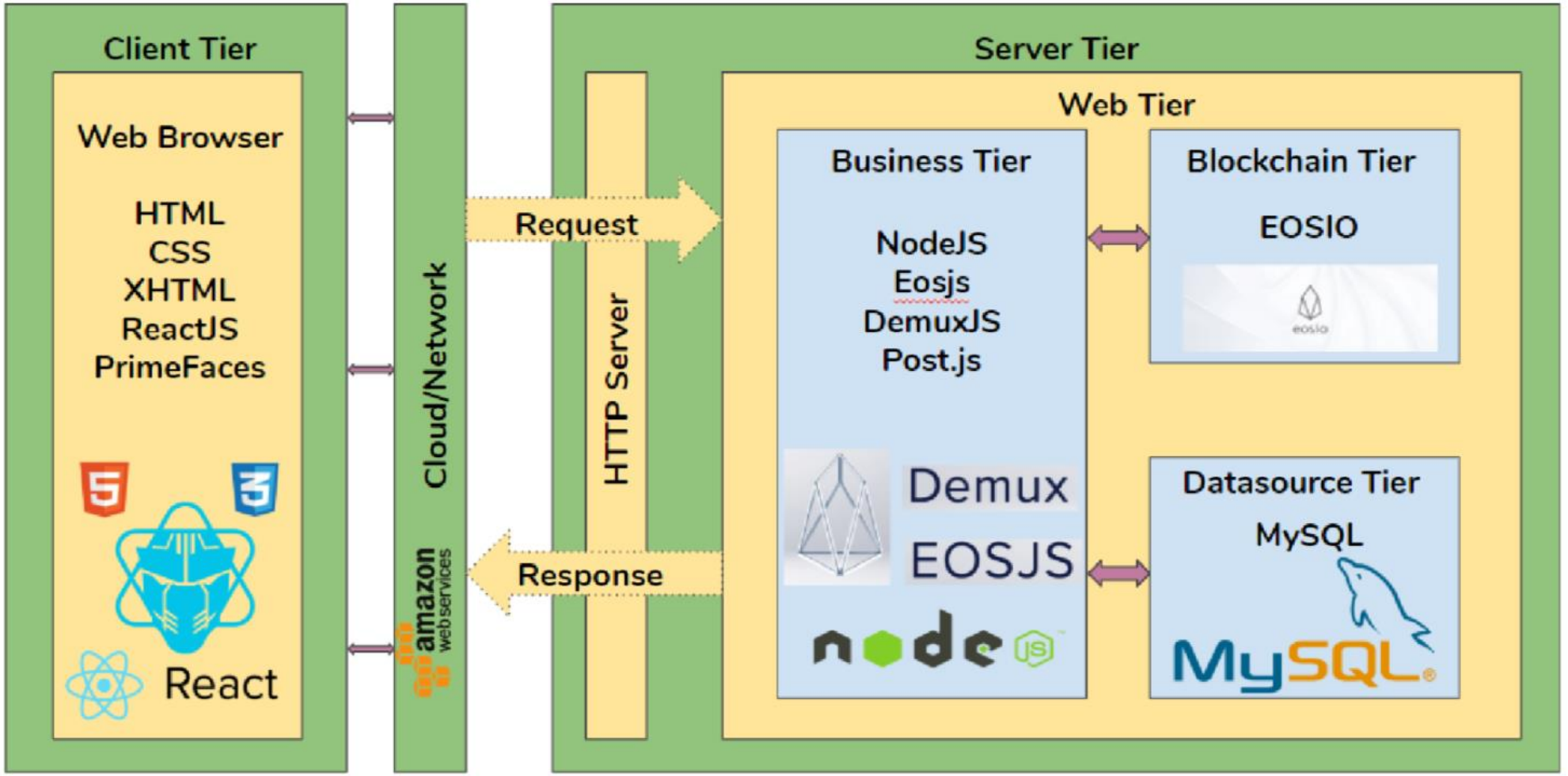
	HEATING	FRIDGE	30% LIGHTS & APPLIANCES	H20 PURIFICATION PUMPS	TOTAL
DAILY PER CLUSTER	15 kWh	4 kWh	14 kWh	16 kWh	49kWh
DAILY PER DEVELOPMENT	45 kWh	12 kWh	42 kWh	48 kWh	147 kWh

Passive Sensors





Hybrid Back-end Architecture



CFM Calculations

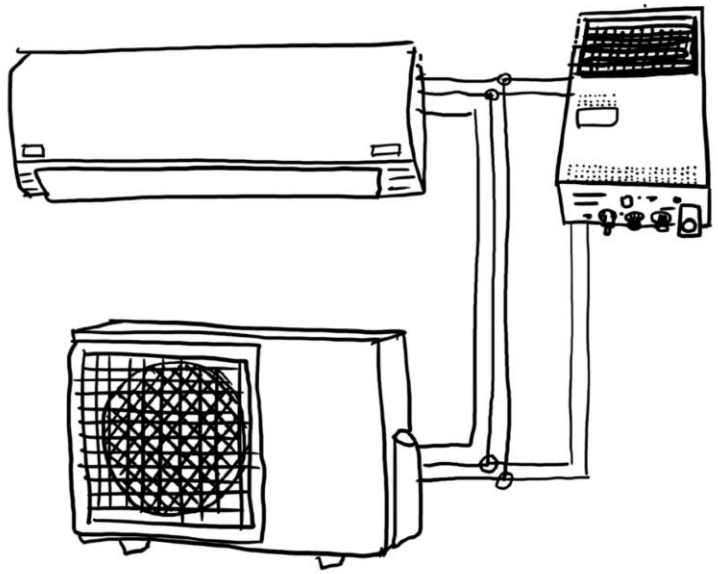
	Area (sf)	A/C CFM Calc.	CFM Ashrae 62.2 (Air Flow)	Green Wall Area for 62.2 Compliance (sf)
Unit A	640	-	34.2	42.3
Bedroom	77.25	111.1	-	
Living Room	383.5	379.6	-	
Unit B	1152	-	57.06	70.5
Living Room	405	385	-	
Bedroom (Single)	96	126	-	
Bedroom (Double)	104	133	-	
Unit C	1664	-	79.92	98.7
Bedroom (Level 1)	138	162	-	
Living Room	536	494	-	
Bedroom (Level 2 single)	96	127	-	
Bedroom (Level 2 Double)	104	133		
Unit D	1920	-	95.1	117.5
Bedroom (1)	112	139	-	
Bedroom (2)	107	123	-	
Bedroom (3)	110	126	-	
Living Room plus hallways	524	497	-	
Bedroom (level 2)	150.5	172	-	

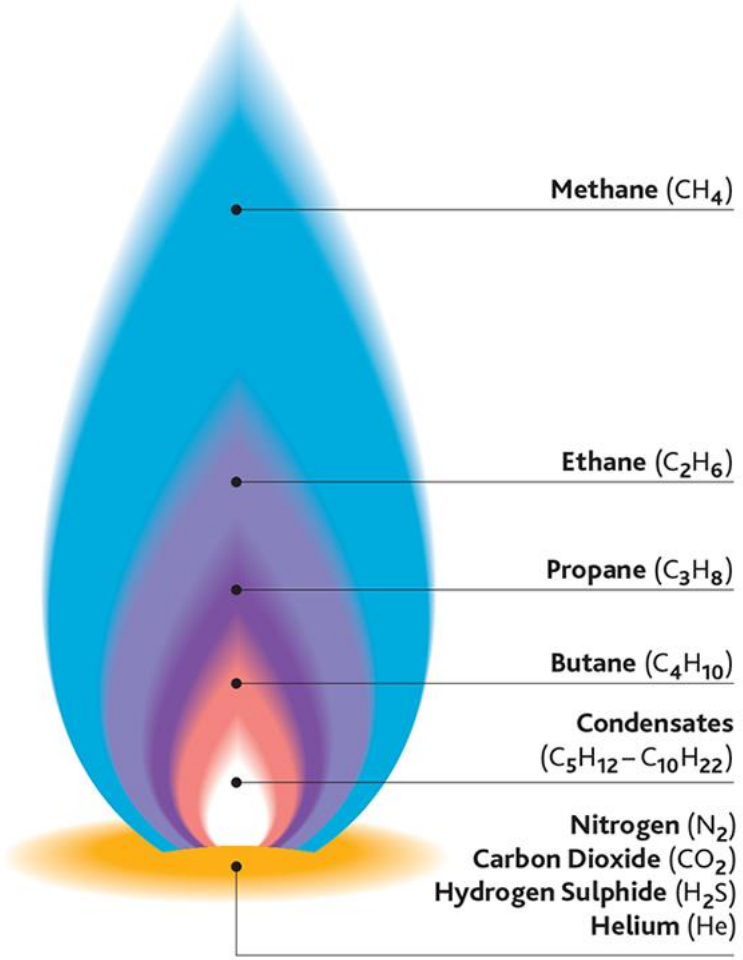
Mechanical Schedule

SPLIT SYSTEM HEAT PUMP (INDOOR SECTION)								
TAG	TON/BTU	EFFICIENCY DATA		V	Φ	Hz	BASIS OF DESIGN	HEAT CAPACITY (BTU/hr)
		SEE	HSPF					
AHU1	.5/6000	24.6	12.8	20	1	6	MITSUBISHI MSZ-GL06NA	7,200
AHU2	.675/8100	15	10	20	1	6	MITSUBISHI SEZ-KD09NA4R1.TH	10,900
AHU3	.96/11500	16	10	20	1	6	MITSUBISHI SEZ-KD12NA4R1.TH	13,600

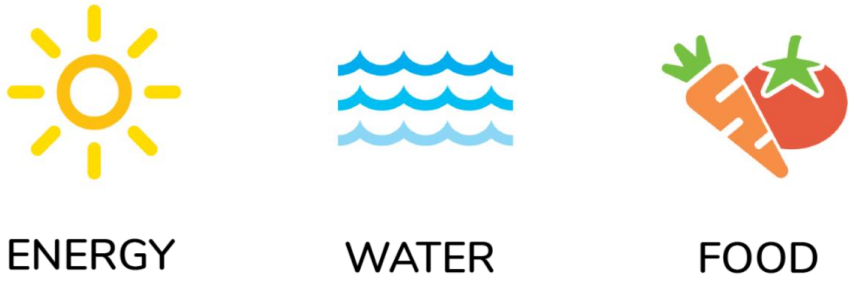
Dual Fuel / Flex Fuel

Hot Water Heater Back-up heat considered
ASHPs efficient and better for modularity
Natural gas / Bio-gas interchangeability





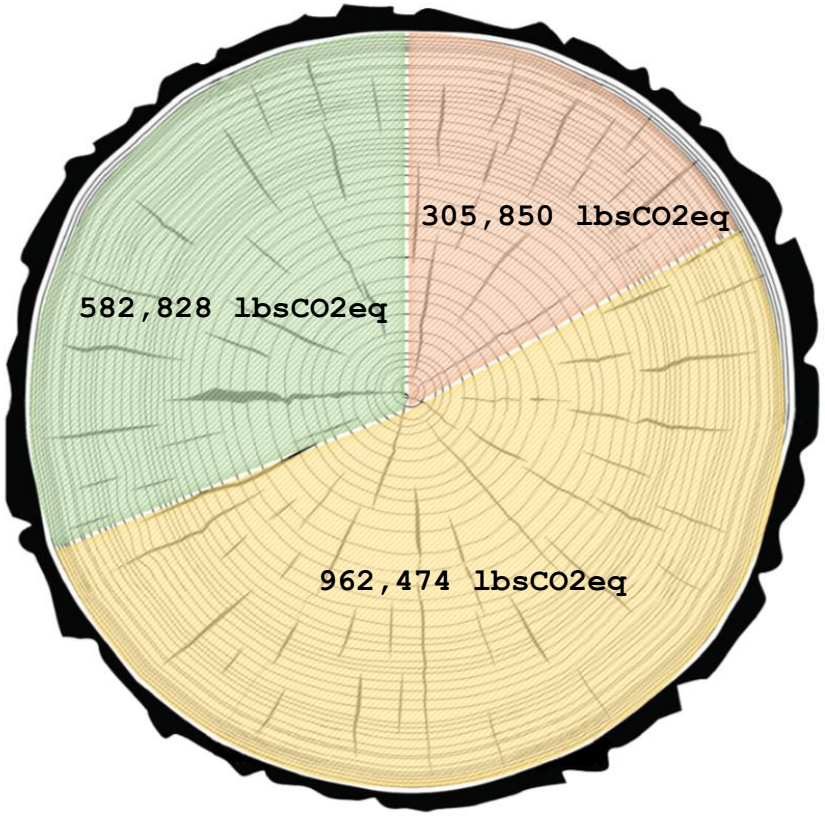
Free Fuel From Nature



	SOLAR: ROOF RESOURCE	RAIN: ROOF RESOURCE	FOOD WASTE from TreeHAUS	FOOD WASTE from VT	ENERGY from FOOD	HEAT from FOOD
TOTAL	400 MWh/yr	180,000 Gal/yr	8 Tons/yr	550 Tons/yr	89,000 kWh/yr	89,000 kWh/yr
HARNESSED	60 MWh/yr	153,000 Gal/yr	8 Tons/yr	17 Tons/yr	28,480 kWh/yr	52,510 kWh/yr
EFFICIENCY	15%	85%	100%	3%	32%	59%

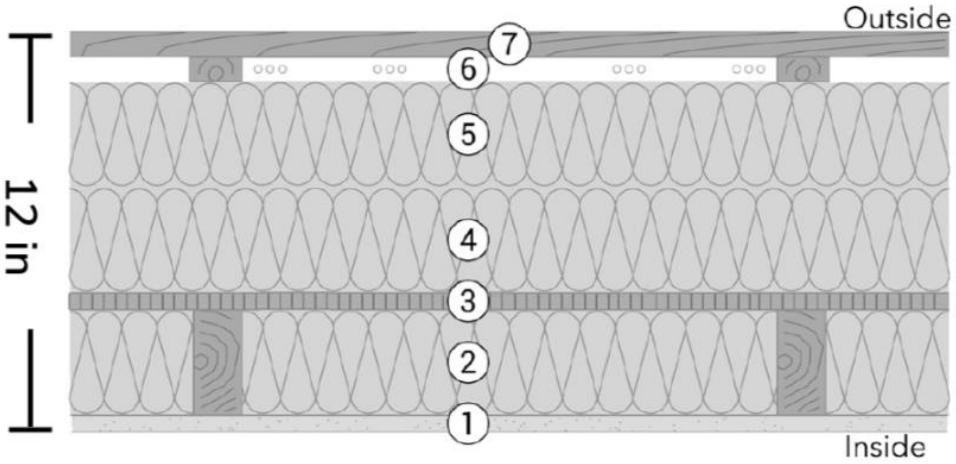
Net Carbon Sink

- DLT mass timber has the largest net negative impact
- Landscape impact over full lifetime doubles
- Gutex travels the furthest but still performs

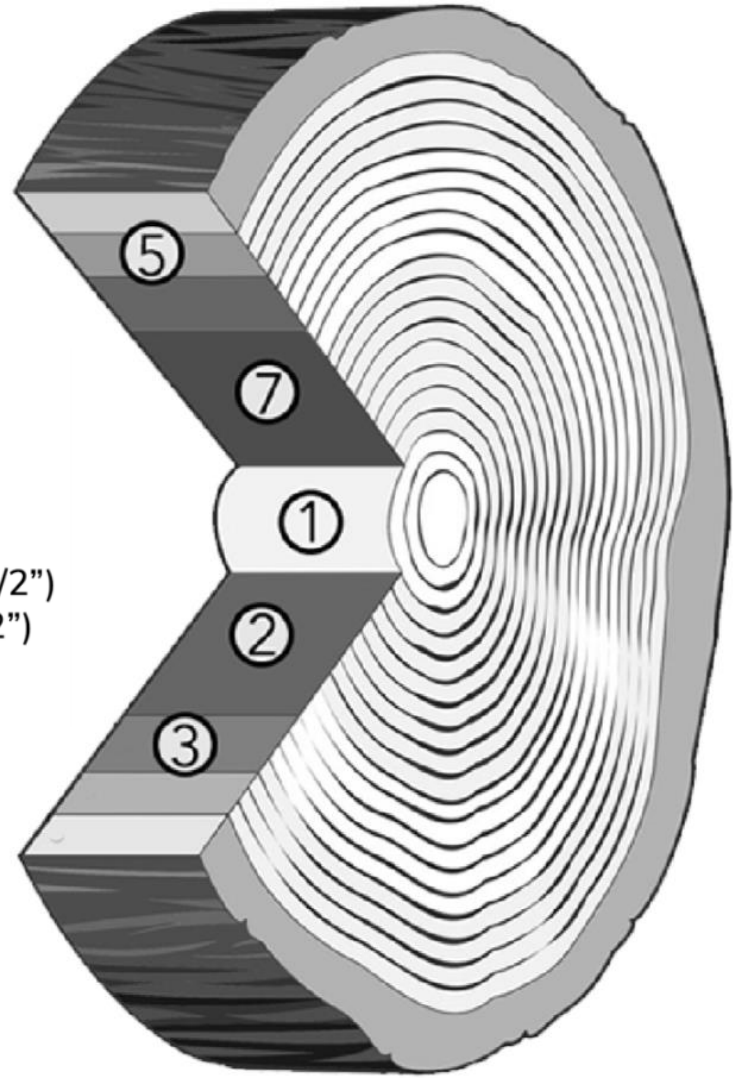


Carbon

All Wood Wall Section



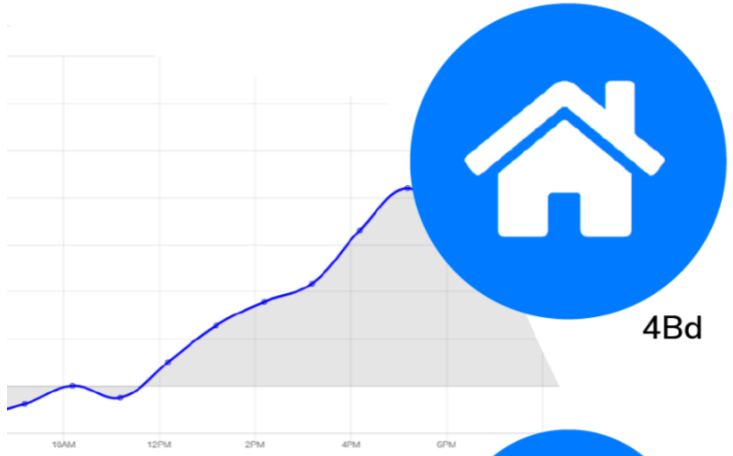
7. White Oak Cladding (3/4”)
6. Pine Furring Strips (3/4”)
5. GUTEX MultiTherm*, ** (3”)
4. GUTEX MultiTherm** (3”)
3. Blue Ridge Fiberboard*** (1/2”)
2. GUTEX ThermoSafe** (3 1/2”)
1. Richlite Finish**, **** (1/2”)

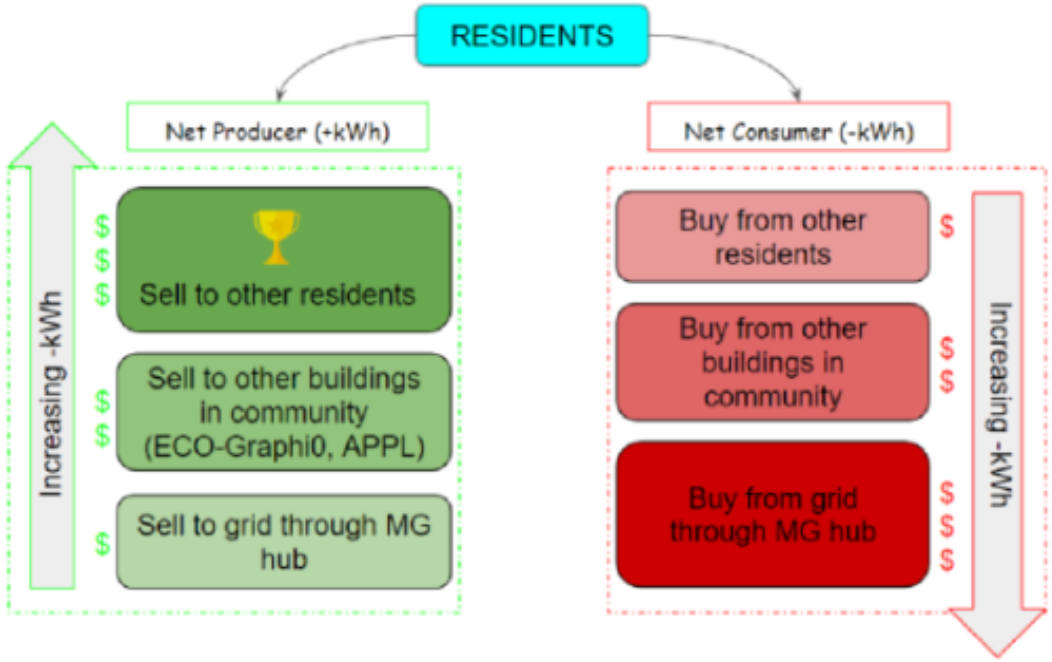


* Integrated Parafin-based weather barrier
** Post Production Waste (pulp, dust) -> Formaldehyde free binding
*** with optional Intello Plus variable moisture barrier, OSB corners
**** Recycled Paper product from VA, alternated with gypsum board

Mycorrho-Grid Simulation.

- Weather Station on our site! TMY-724113
- DOEs Open Energy Information (OpenEI) Base, High, and Low Profiles
  Building America House Simulation Protocols
  Residential Energy Consumption Survey (RECS)
- Adapted to our unit types
- Run through smart contract logic
- PVWatts CSV used for PV production





Acoustics – Site Noise

ACENTECH
ACOUSTICS AV/IT/SECURITY VIBRATION

Our site's relative proximity to a freeway and occasional air traffic brings acoustic challenges, which we consulted with Acentech to solve:

- We recorded baseline octaves with Acentech overnight
- Our envelope was analyzed, and predicted to reduce overall site noise by ~40dB
- This results in 1/16th as much noise perceived

Environmental Noise									
		63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	Overall A wt
		69 dB	67 dB	63 dB	62 dB	68 dB	70 dB	62 dB	74 dB
	Awt	-26	-16	-9	-3	0	1	1	

Interior Noise Level Estimates								
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	Overall A wt
Only Glazing	51 dB	43 dB	42 dB	30 dB	30 dB	33 dB	13 dB	39 dB
Only Doors	51 dB	43 dB	42 dB	30 dB	30 dB	33 dB	13 dB	39 dB
Only Exterior Wall	54 dB	39 dB	15 dB	02 dB	-03 dB	-20 dB	-36 dB	29 dB
All Façade Elements	53 dB	41 dB	37 dB	25 dB	26 dB	29 dB	08 dB	35 dB