From Soil to Signal:
Home Environmental Intelligence for Decentralized Food and Energy Systems in the Global South.

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Syracuse Architecture

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Syracuse Architecture

Keywords: Environmental intelligence, Food and Energy security, Environmental Justice

Abstract

This research investigates how dependency on global supply chains, and the waste they produce, can be reduced through environmental intelligence and data literacy within the home and garden. It proposes a self-build housing and technology framework that replaces linear, centralized systems with circular resource systems, advancing spatial self-sufficiency while preserving cultural and climatic intelligence.

Grounded in Barbados, these concepts are situated within the island's historical relationship to the transatlantic slave trade, which continues to shape land tenure, housing, food systems, and climate vulnerability. Using a dialectical materialist framework, this research examines the primary contradiction between land as a means of life and land as a means of extraction, revealing how global systems disproportionately impact vulnerable communities.

Positioning land as an active material condition, the methodology studies the chattel house as a vernacular model of inherited environmental intelligence, developed in response to post-emancipation land insecurity and constrained tenure. Through design research, this work reconsiders the typology under contemporary conditions, integrating environmental sensing and self-build strategies to support more autonomous and adaptive forms of dwelling.

GiaNode

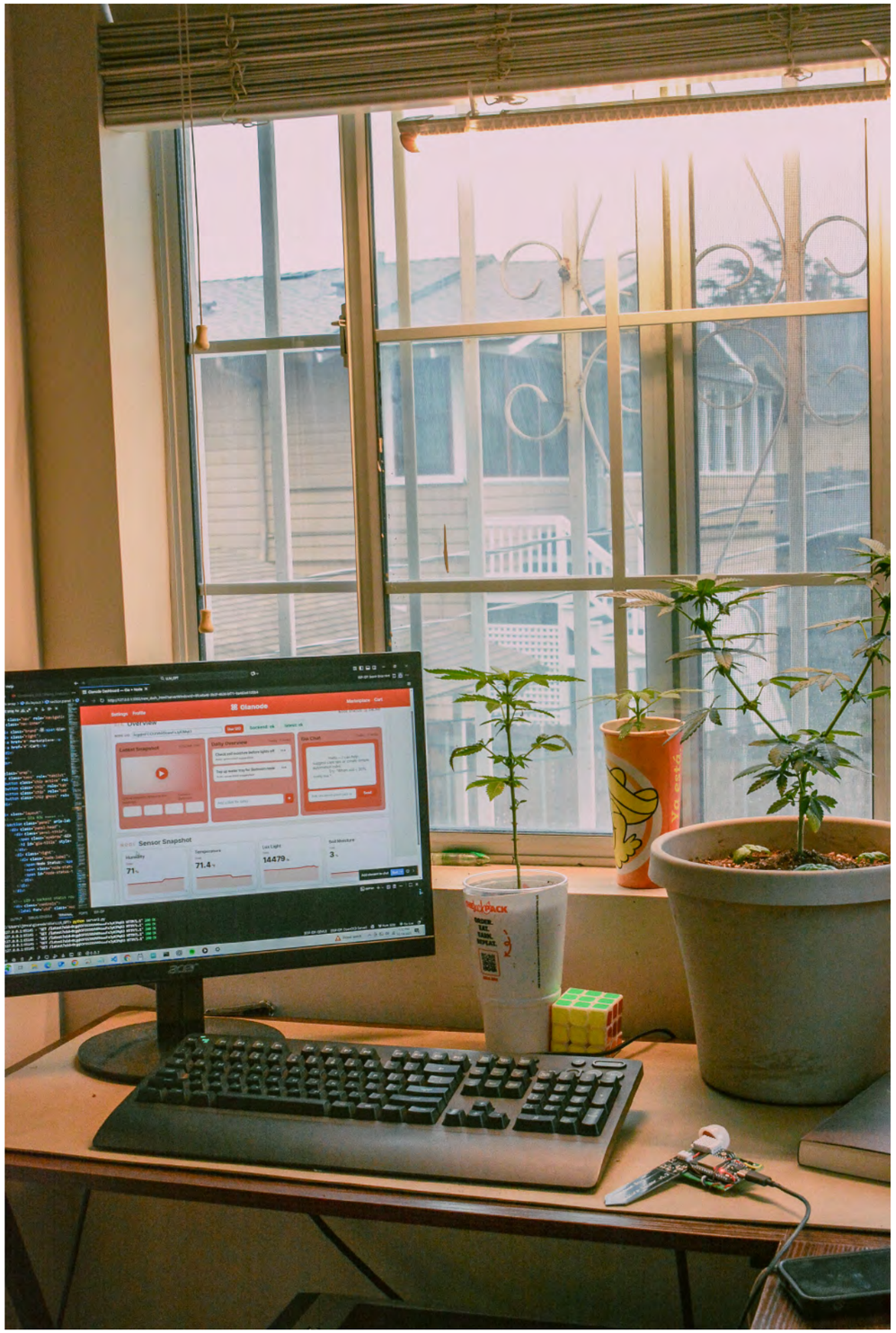
A Guide to : Decentralized Systems

Designing Food, Energy, and Living Systems Beyond the Grid

Jon Carter

Kristian Nunez

GiaNode



A Guide to :
Decentralized Systems

Jon Carter

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This Guidebook proposes a self-build housing and technology framework that replaces linear, centralized systems with circular resource systems, advancing spatial self-sufficiency while preserving cultural and climatic intelligence.

GiaNode

Key Word Glossary

Circular Systems

Systems in which resources are continuously reused, minimizing waste and reducing reliance on external inputs.

Resource Management

The monitoring and control of materials such as water, energy, and food to improve efficiency and reduce waste.

Carbon Sequestration

The process of capturing and storing atmospheric carbon within materials or natural systems.

Food Security

The ability for individuals and communities to reliably access sufficient, nutritious food through local or distributed systems.

Environmental Intelligence

The use of real-time data and observation to understand and respond to environmental conditions.

Self Build

The act of designing and constructing systems or spaces independently, often using accessible materials and techniques.

Agency

The capacity to make informed decisions and take action within a system or environment.

Data Literacy

The ability to read, interpret, and apply data to make informed decisions.

Tenure

The relationship between people and land, including ownership, access, and control over its use.

Sovereignty

Control over resources, systems, and decision-making at an individual or community level.

Supply Chains

The networks through which materials, goods, and resources are produced, processed, and distributed.

Decentralization

The distribution of systems and resources across multiple local nodes rather than a single centralized source.

00 Context
01 Materials
02 Construction
03 Systems
04 Application

Page Number Conventions

03S01

Chapter

Defines the thematic focus of the section.

System

Identifies the system being examined.

Pg Number

Indicates sequence within the set.

Drawing
Naming Conventions

Node:
N/A

Context
Page System

Guide:
Decentralized Systems

Chapter
Context

Date:
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Observations:

GiaNode
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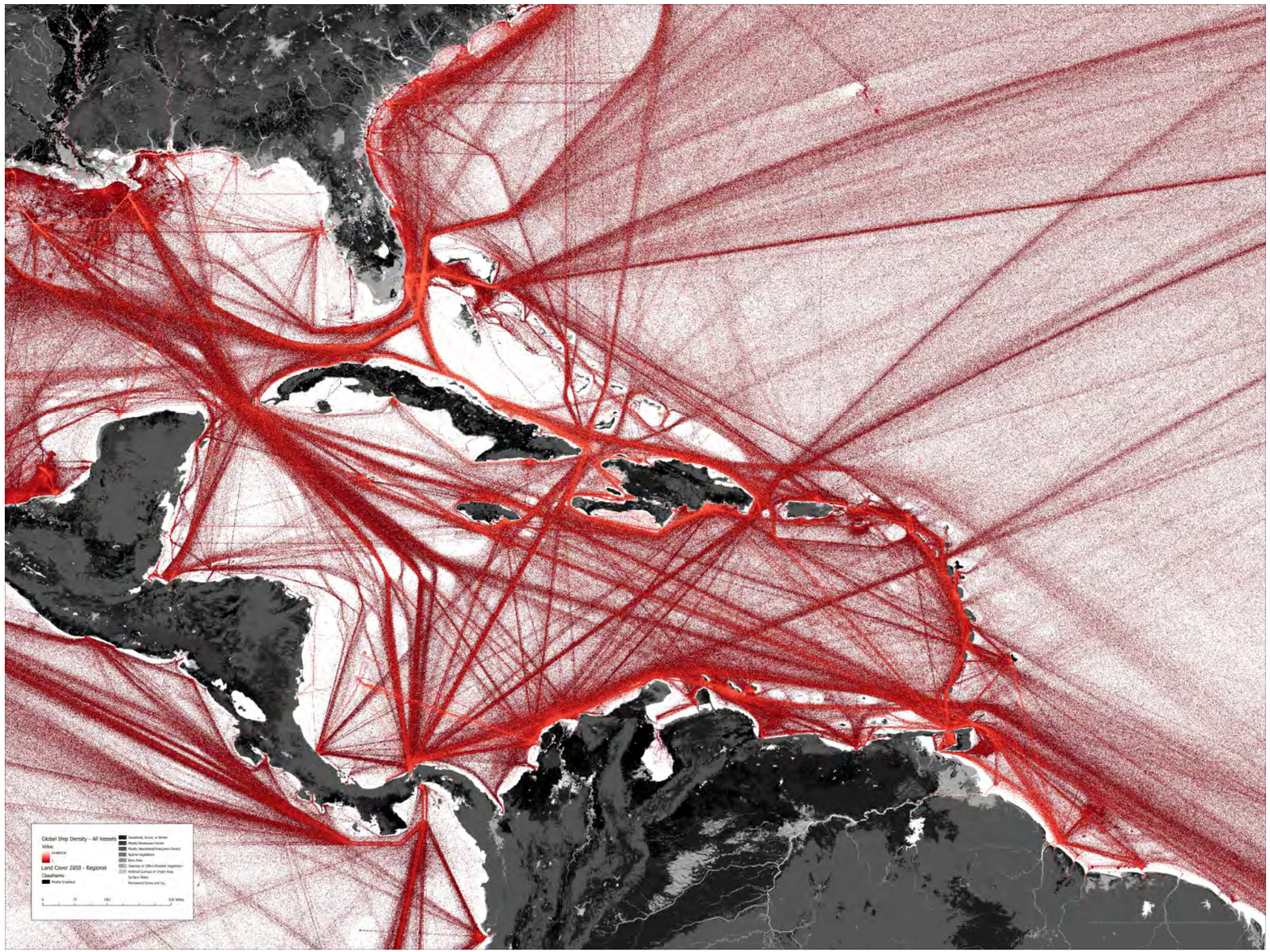
CONTEXT



Introduction

Global Context

This research investigates how dependency on global supply chains, and the waste they produce, can be reduced through environmental intelligence and data literacy within the home and garden.

75%

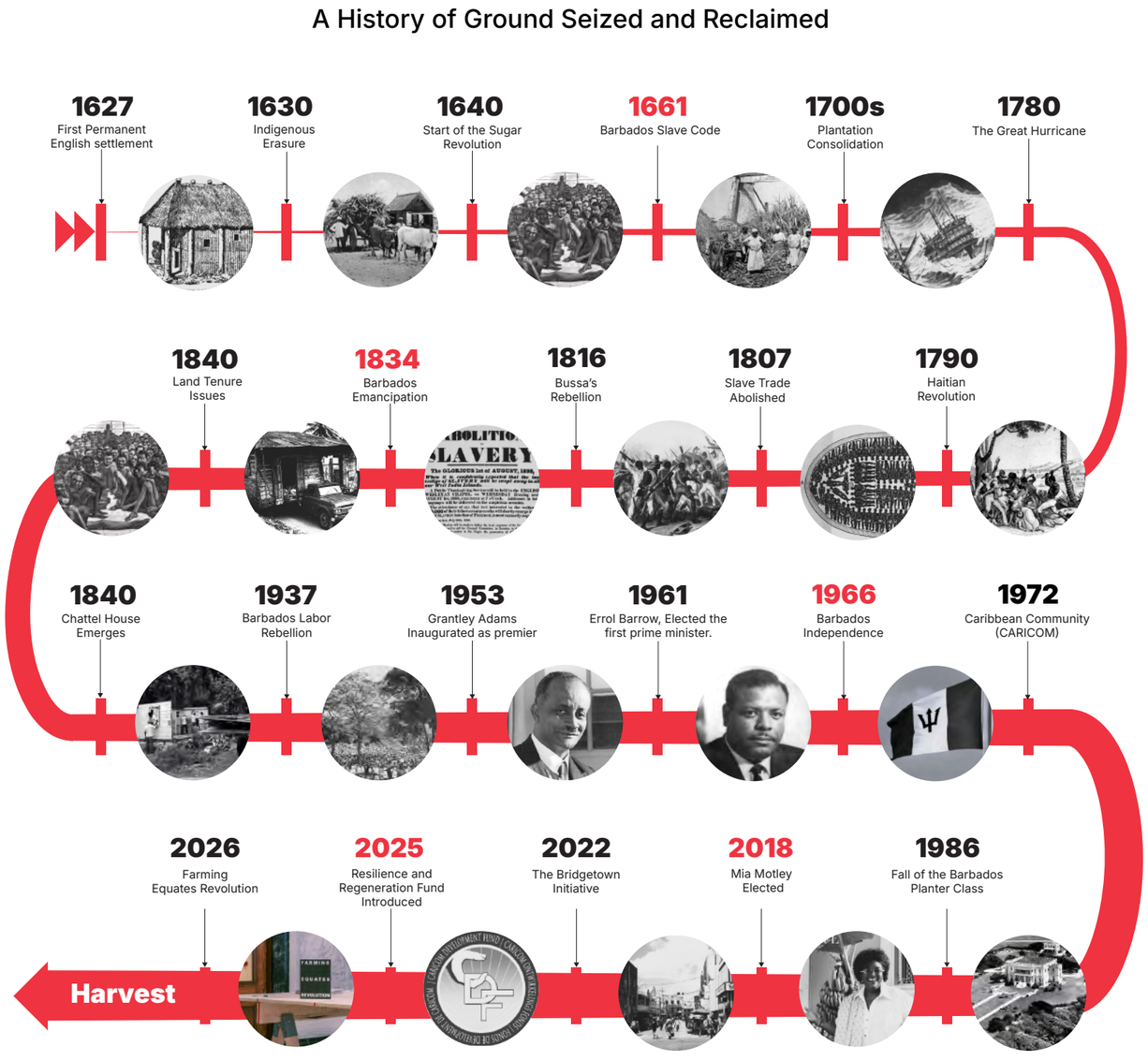
of Food moves through global networks (dependency)

25-35%

Lost across the system

≈1.3 billion tons/year

FAO (Food and Agriculture Organization, UN)



Barbados

Grounded Case Study

Grounded in Barbados, these concepts are situated within the island's historical relationship to the transatlantic slave trade, which continues to shape land tenure, housing, food systems, and climate vulnerability.

1661

The Barbados Slave Code

1966

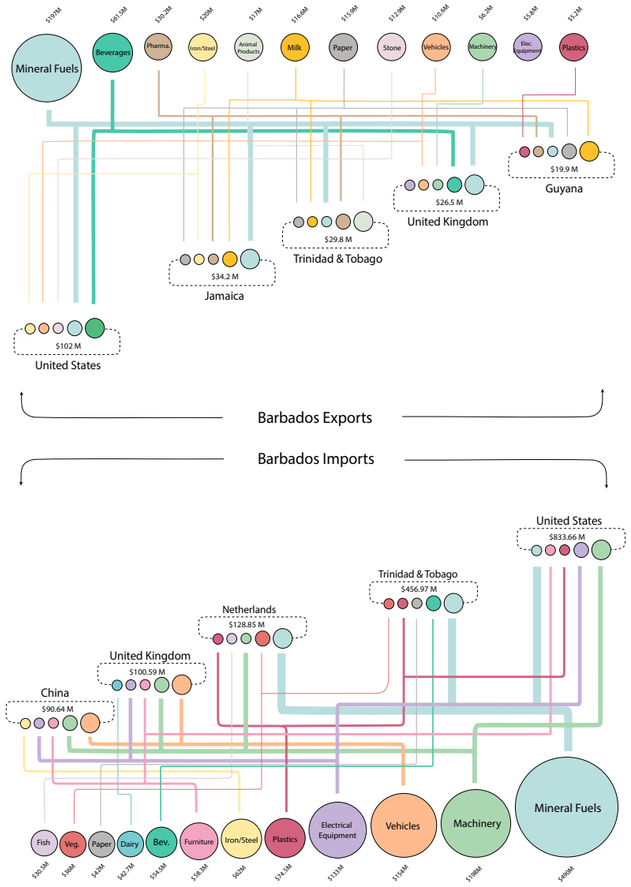
Year of Independence

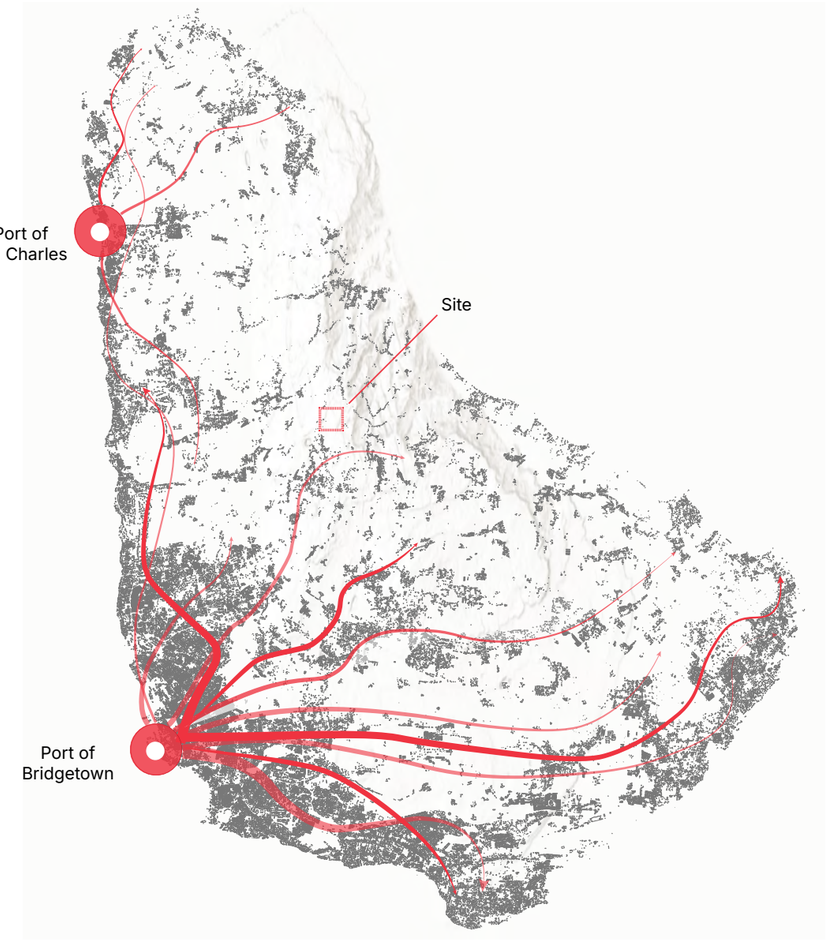
Barbados

Grounded Case Study

The movement of food and materials across Barbados reveals a system built on external dependence, where inflows dominate and local production is suppressed. This imbalance is not incidental, but a continuation of colonial land and economic structures.

Measured Dependency: Inflows + Outflows





75%

of Food moves through global networks (dependency)

80-90%

of Food on the Island imported

FAO (Food and Agriculture Organization, UN)

Chattle House

Grounded Case Study

The chattel house is a vernacular housing typology that emerged from export-driven monoculture and concentrated land ownership that defined Barbados's sugar economy beginning in the seventeenth century, and becomes our case study for Inherited Environmental Intelligence, thought self-built principles.

~80%

Have been Altered or Destroyed Completely

1

MATERIALS

Hemp

Material Study

History

Hemp has been cultivated for thousands of years as a durable, fast-growing material used for rope, textiles, paper, and construction. Its global decline in the 20th century was largely due to regulatory restrictions rather than material limitations. Today, hemp is re-emerging as a critical resource in sustainable building systems due to its low input requirements and high yield per acre.

Social Justice

The legalization of hemp in Barbados reflects a broader shift in how land, labor, and agricultural knowledge are valued. Historically restricted crops are being reconsidered as tools for local empowerment, economic participation, and environmental repair. Hemp's ability to be grown locally and processed into building materials supports more accessible and decentralized production systems, reconnecting communities to both land and resource control.

Limestone

Material Study

History

Limestone is the dominant geological material in Barbados, forming the foundation of the island through centuries of coral deposition and uplift. Historically, it has been quarried and used in construction for its availability, workability, and durability. From early settlements to contemporary infrastructure, limestone has remained a primary building resource, shaping both the material and spatial identity of the island.

25-35%

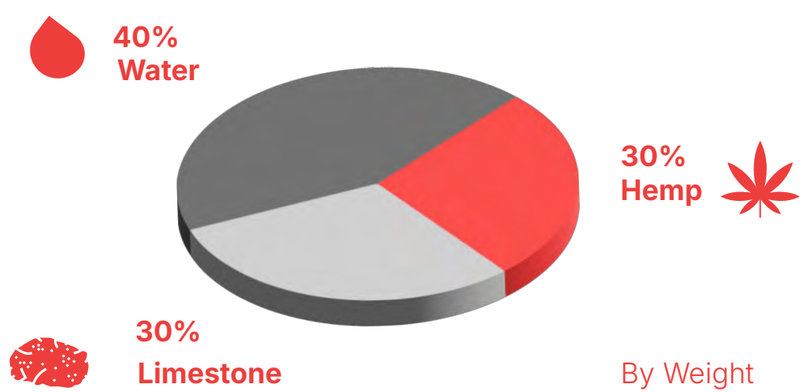
of Barbados’ landmass is exposed limestone, making it one of the island’s most accessible and defining natural resources.

Hempcrete
Material Study

What is Hempcrete?

Hempcrete is a bio-composite made from hemp hurd, lime, and water. It is lightweight, breathable, and non-structural, used primarily for insulation and wall infill.

As it cures, the lime binder absorbs CO_2, making hempcrete a carbon-negative material that supports circular, low-impact building systems.

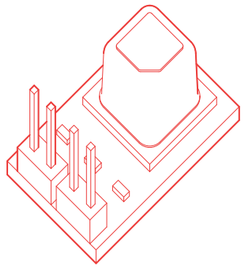


By Weight

Sensors

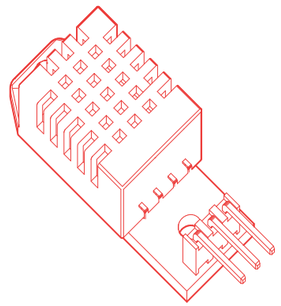
SCD40

Measures CO_2 concentration, temperature, and humidity to track air quality and plant respiration conditions in real time.



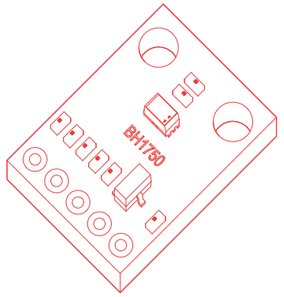
DHT22

Monitors ambient temperature and humidity to help maintain stable environmental conditions for plant growth.



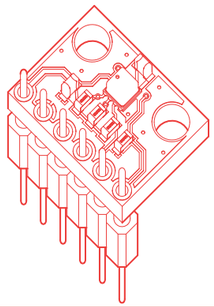
BH1750

Measures light intensity (lux) to track how much usable light plants receive, helping optimize growth and lighting conditions.



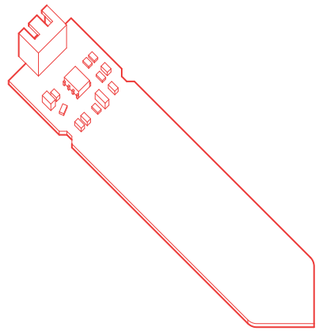
BME280

Captures temperature, humidity, and atmospheric pressure to understand climate patterns and airflow behavior.



Soil Moister Capacity

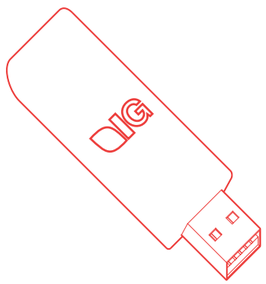
Measures water content in the soil to determine when plants need watering and prevent over- or under-irrigation.



Micro controller

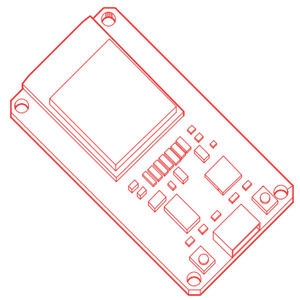
USB Drive

Transfers data to Gia for processing, storage, and insight generation.



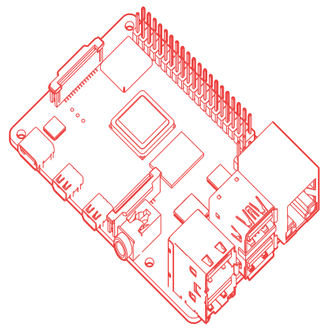
ESP32

Acts as the primary node controller, collecting sensor inputs and sending structured data packets.



Raspberry PI

Serves as the local server and interface hub, storing data, running analysis, and powering the user dashboard.v



Drawing

Sensor List

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Notes:

GiaNode

Processing

Python
Data handling and system orchestration

C++
Low-level sensor control and performance

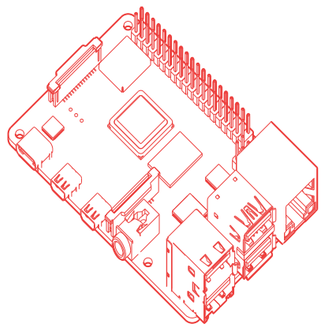
Raspberry Pi
Local computation and system coordination

Intelligence

GiaNode

Interprets environmental data to generate actionable insight, translating sensor inputs into decisions that support growth, efficiency, and self-sufficiency.

Computation



Raspberry PI

Environmental data is contextualized across time and conditions, allowing patterns to emerge and inform responsive actions within the system.

Drawing

Environmental Intelligence Pipeline

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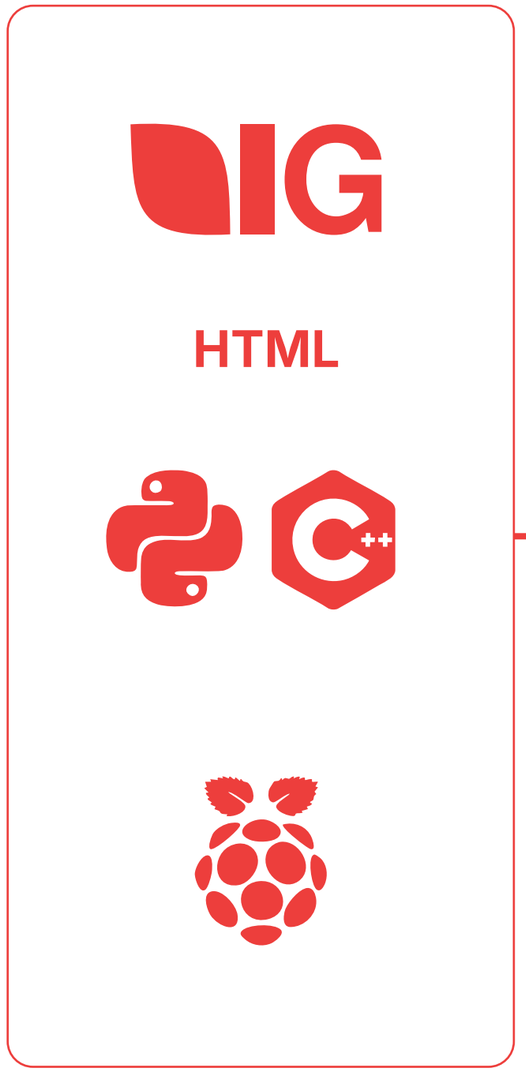
Software



Drawing

Data Transfer System

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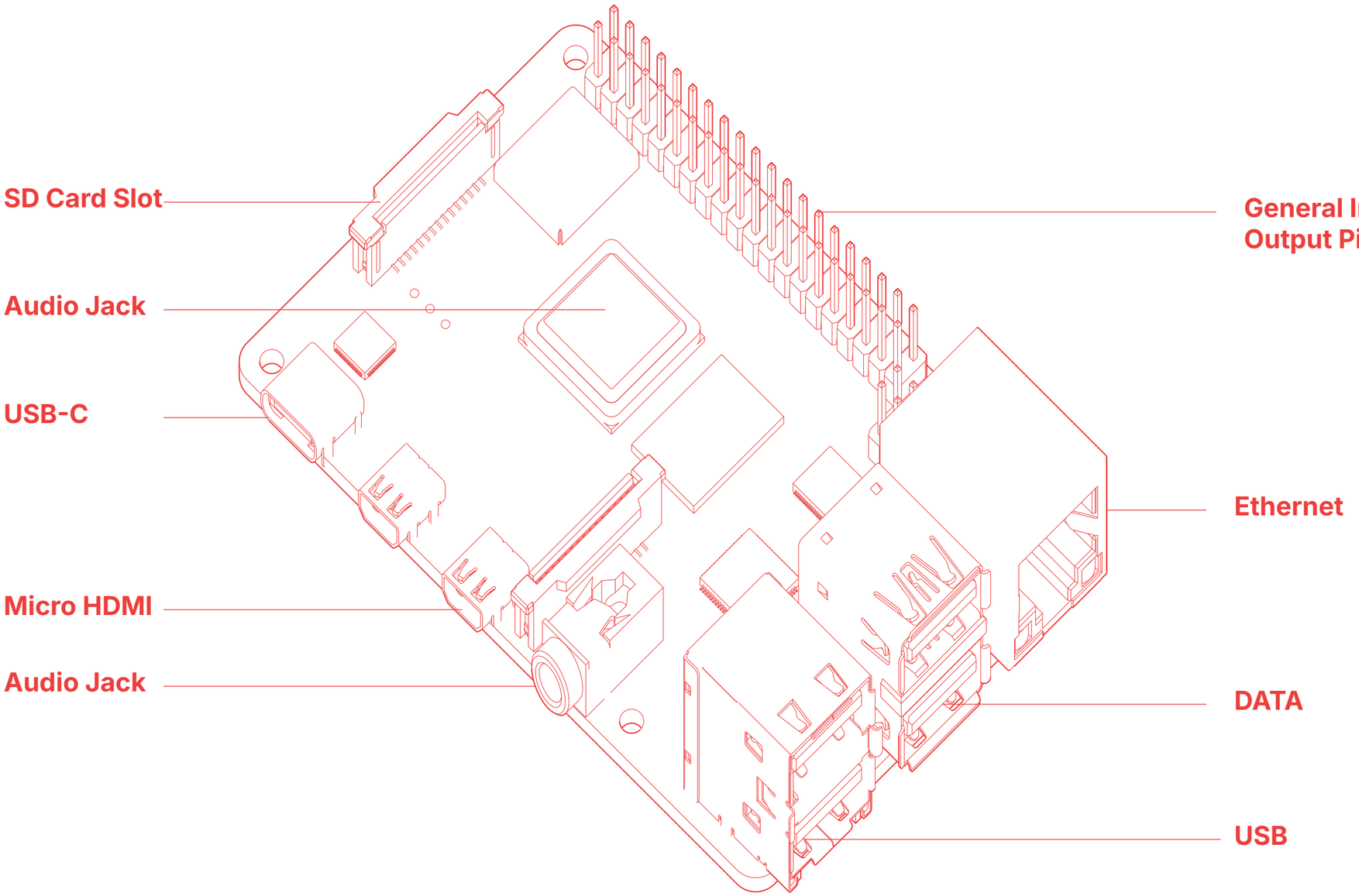
GiaNode



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Raspberry Pi

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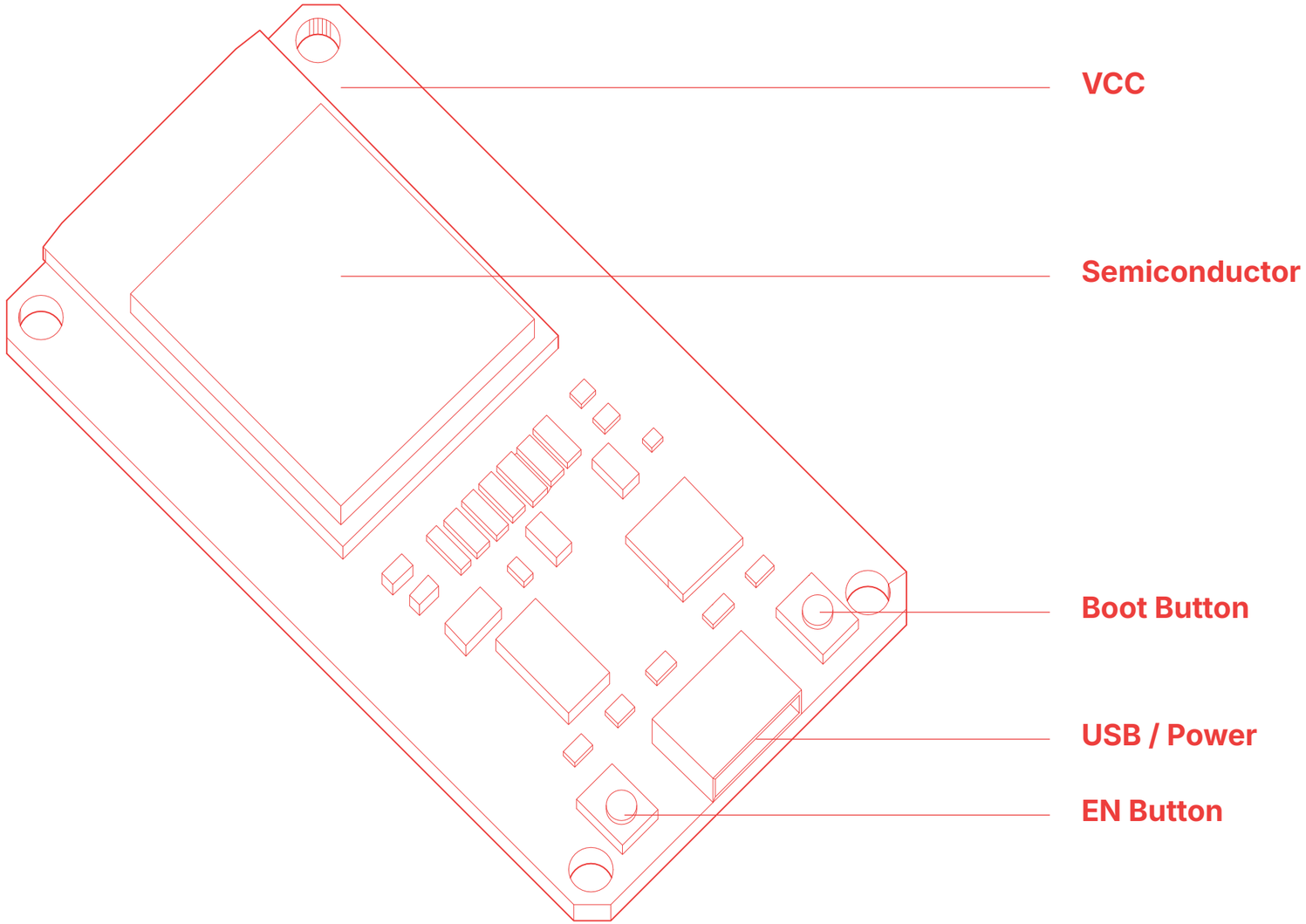

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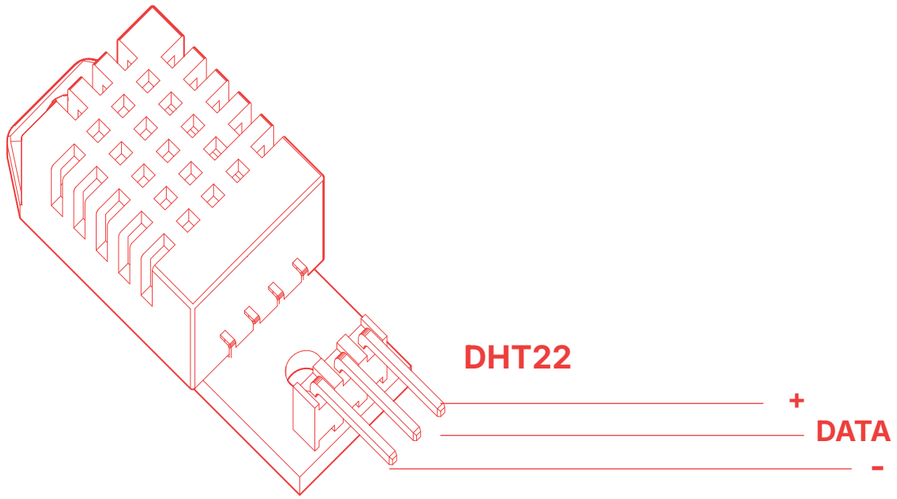

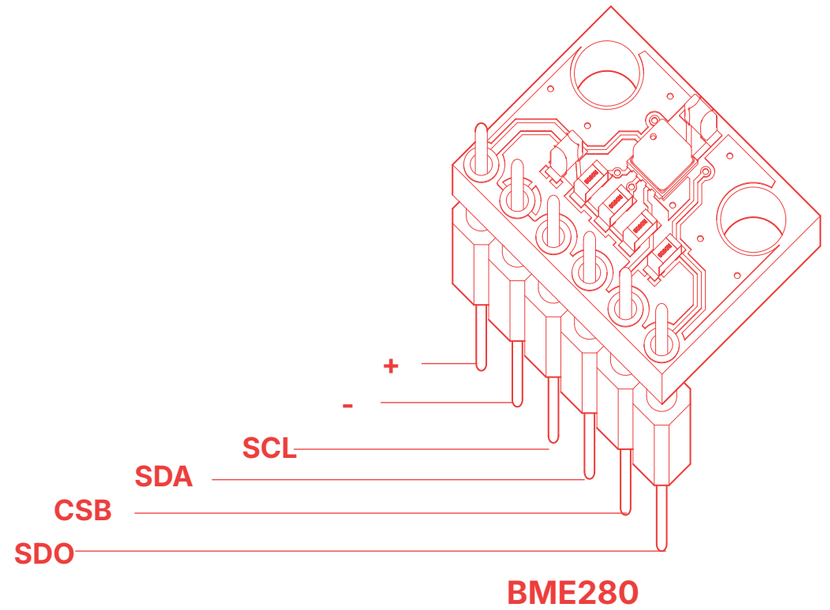

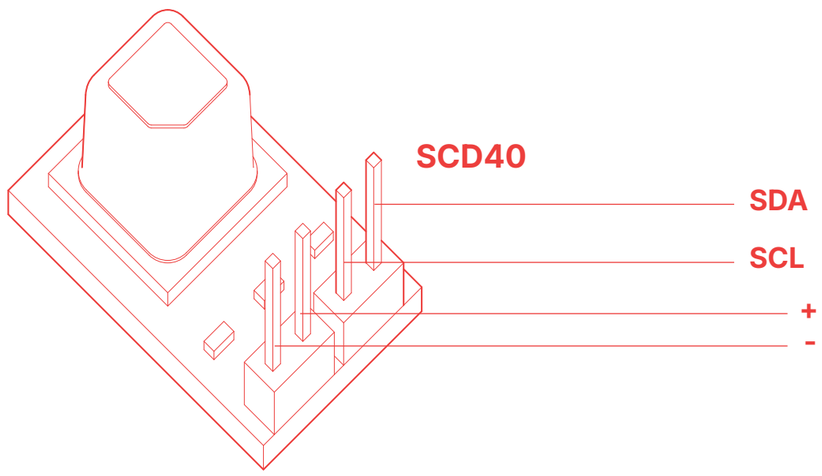

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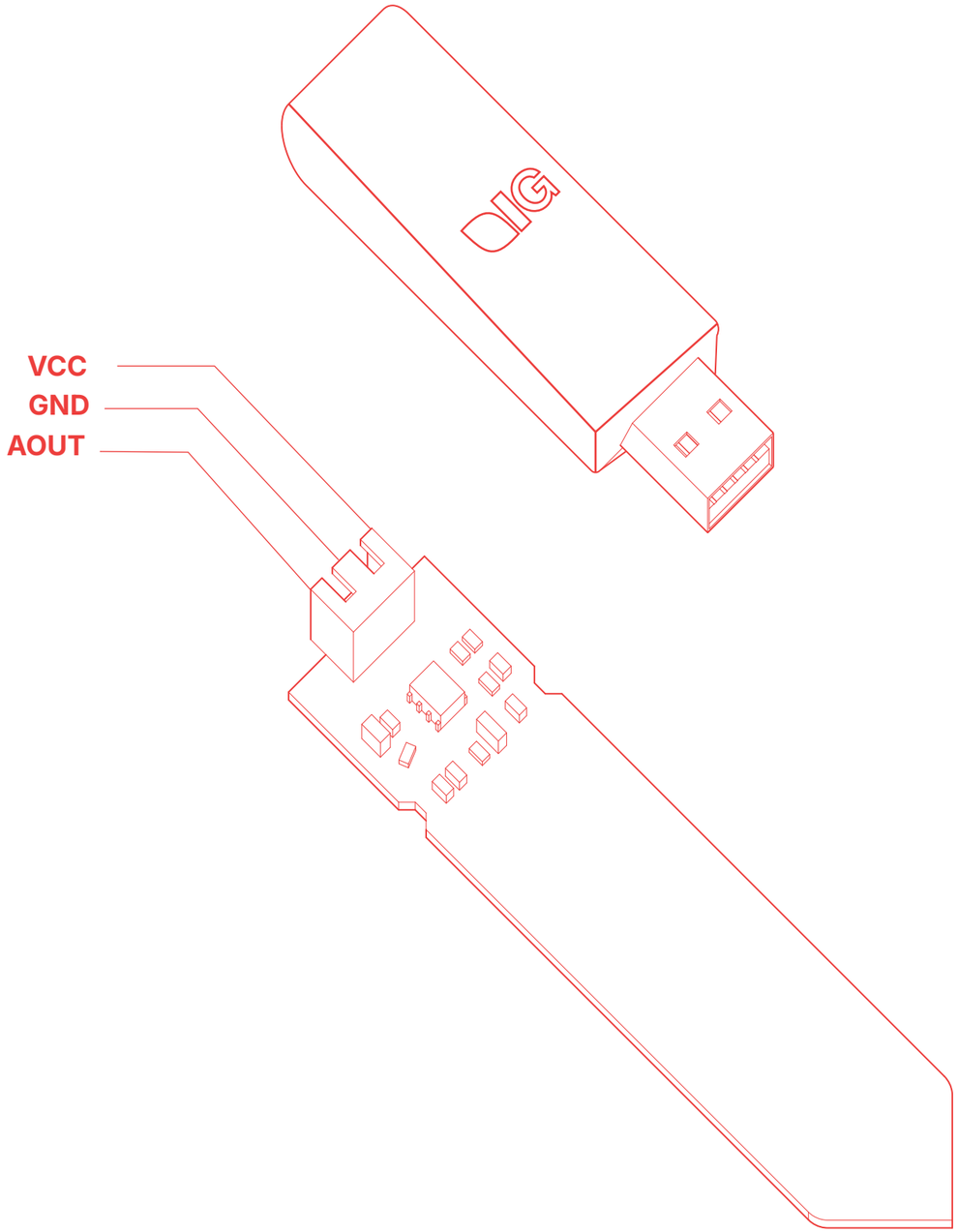

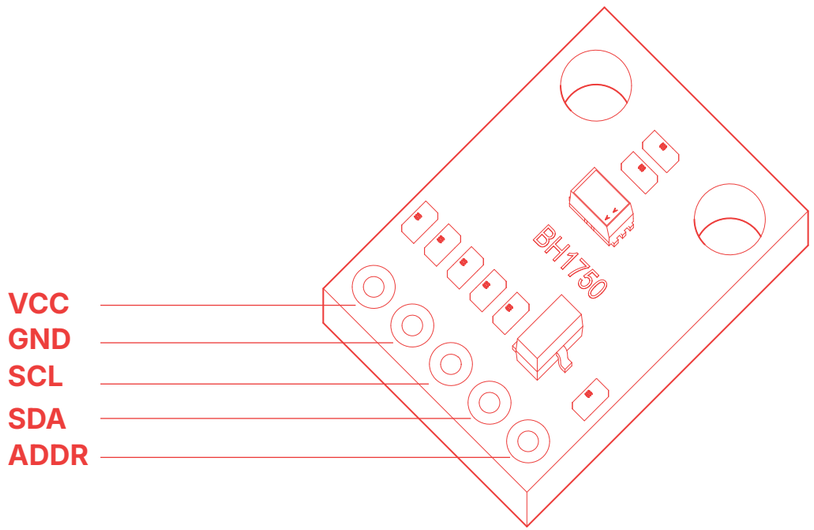

Drawing

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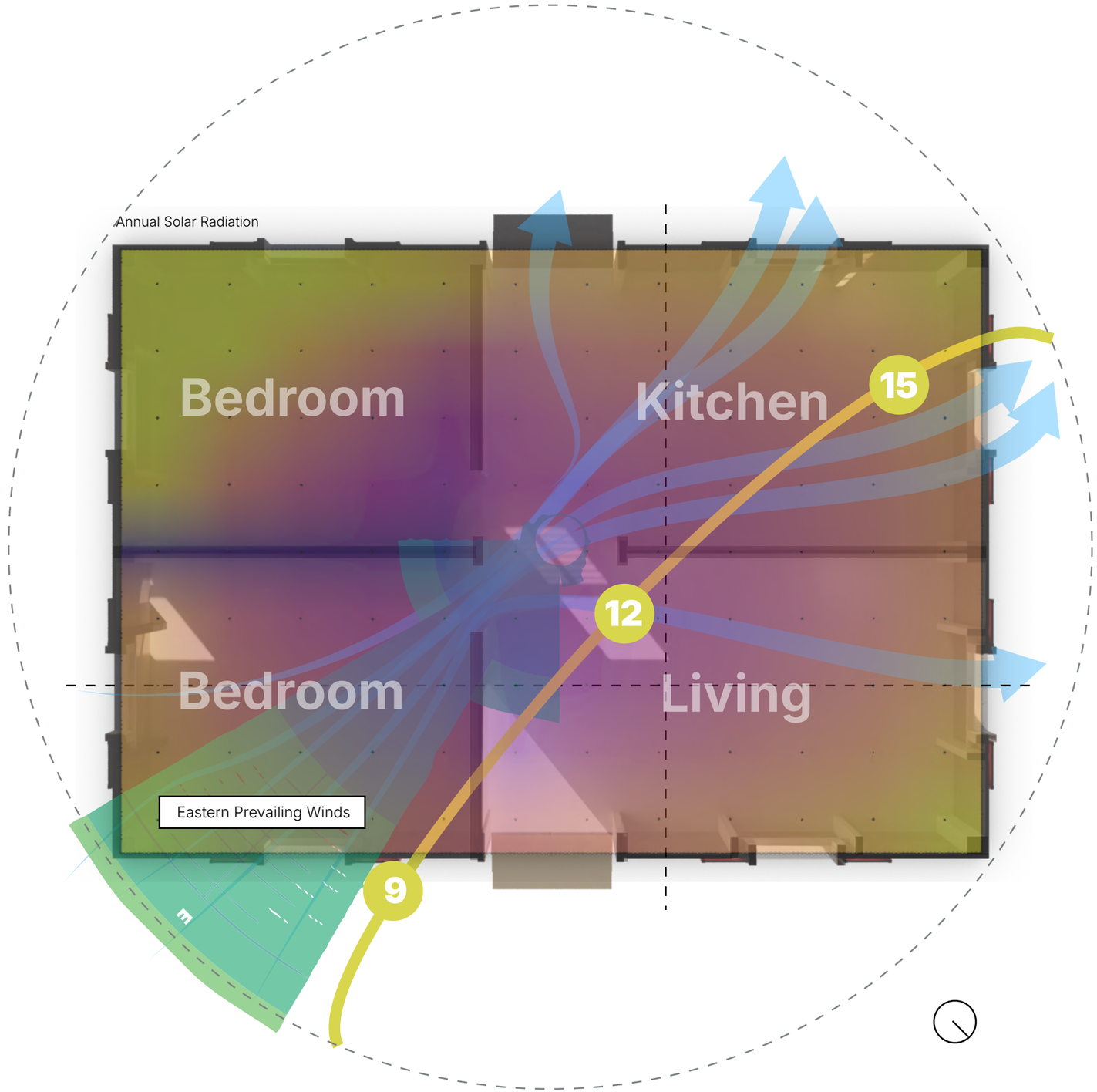
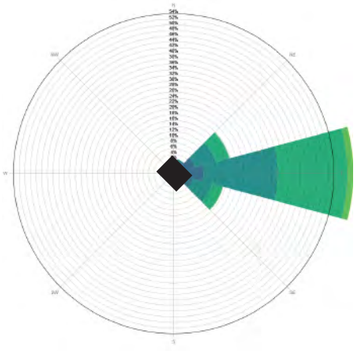
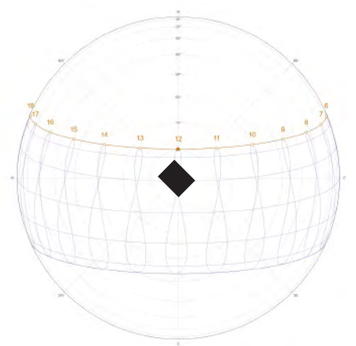
2

CONSTRUCTION





Wind Speed and Direction to Orientation



Solar Radiation to Orientation Path

Drawing
In Home Systems

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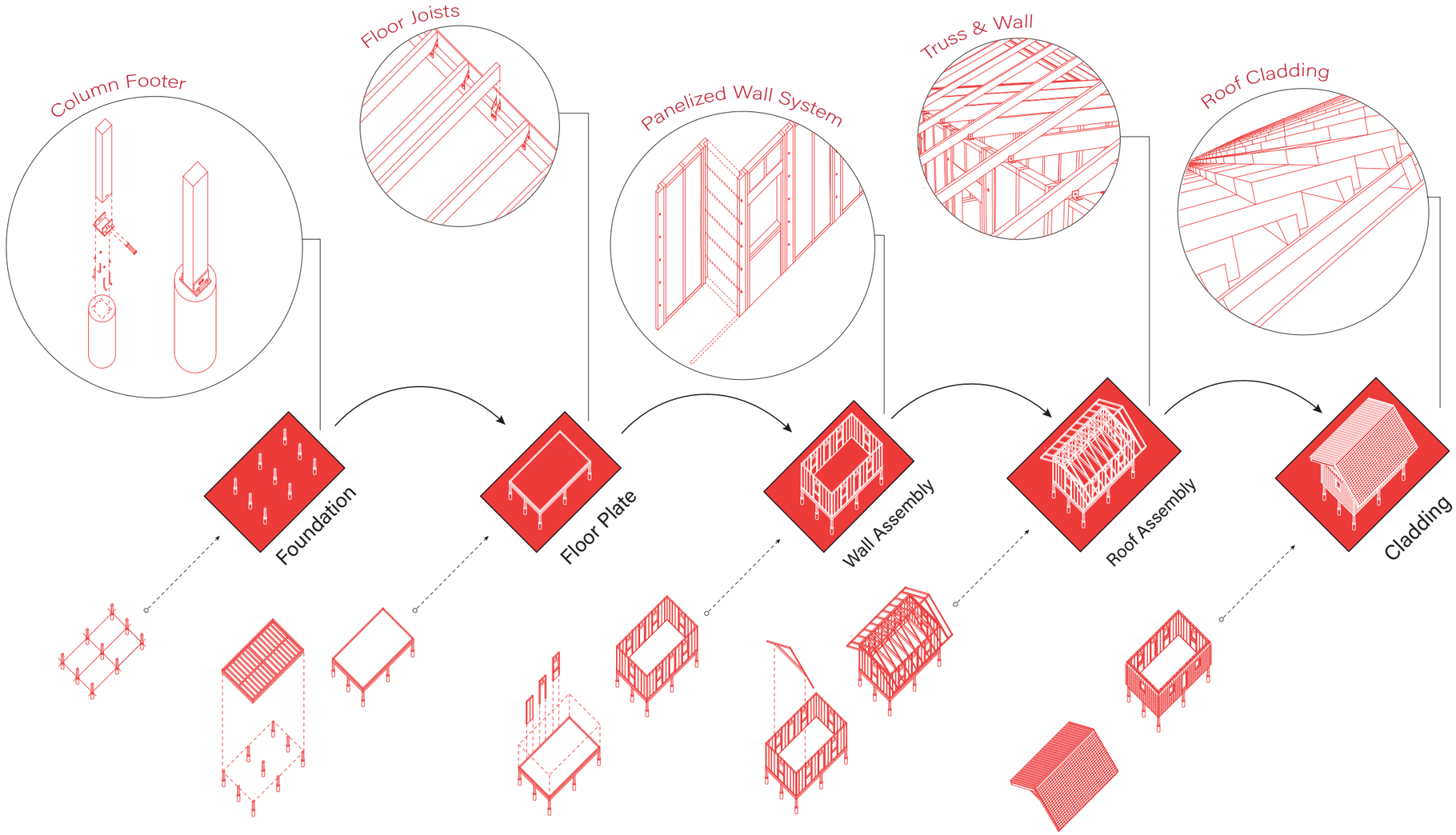
GiaNode

02-03



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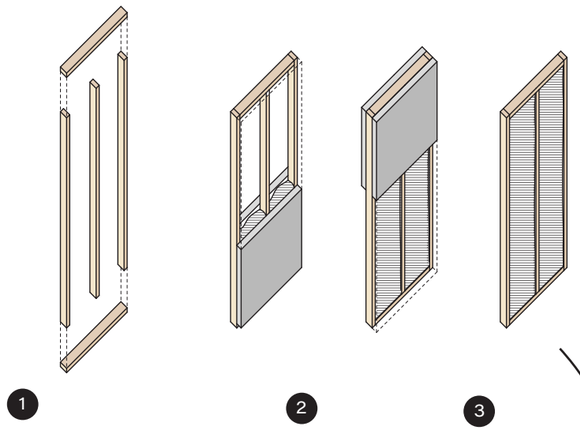
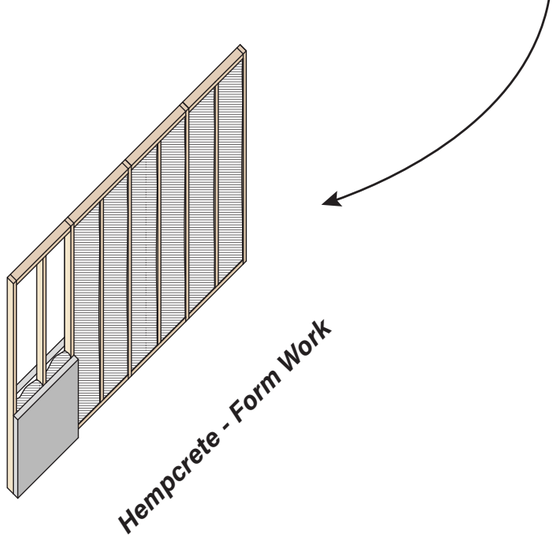
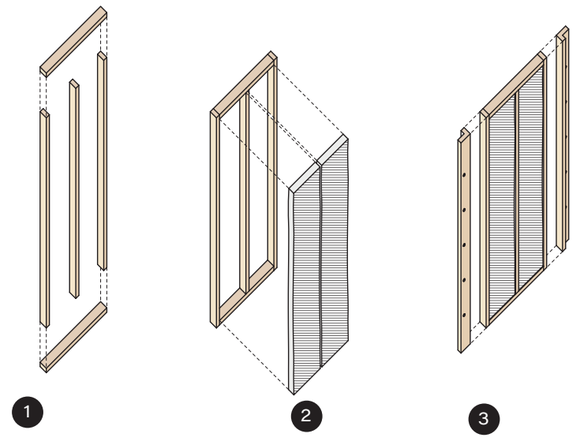
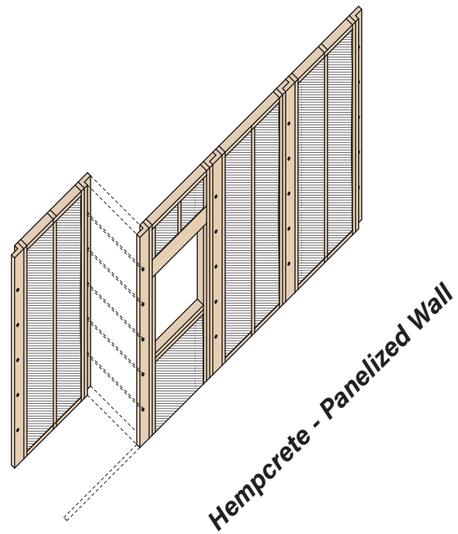
02-03





Hempcrete - Form Work





Hempcrete - Panelized Wall

Drawing
In Home Systems

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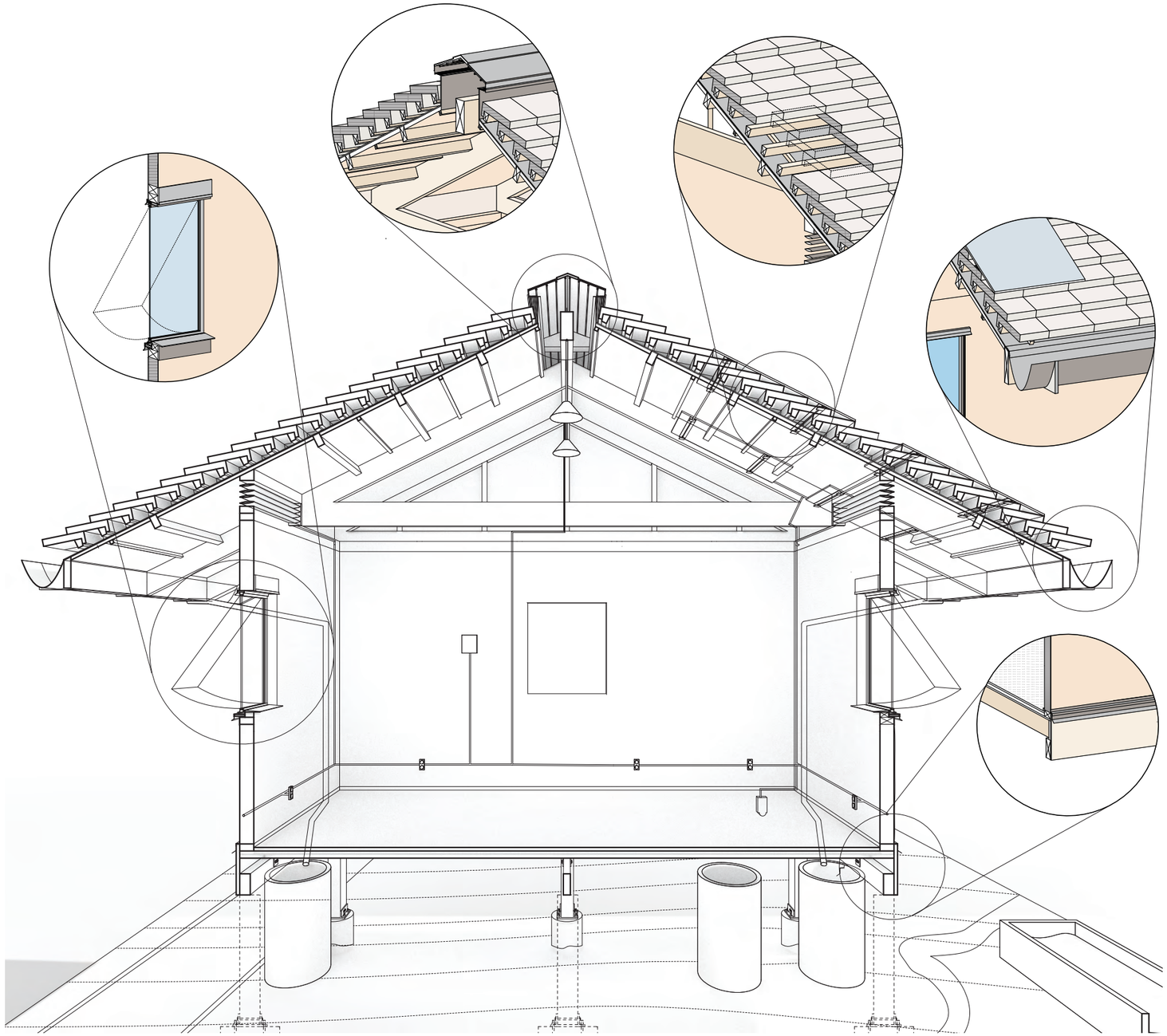
02-03



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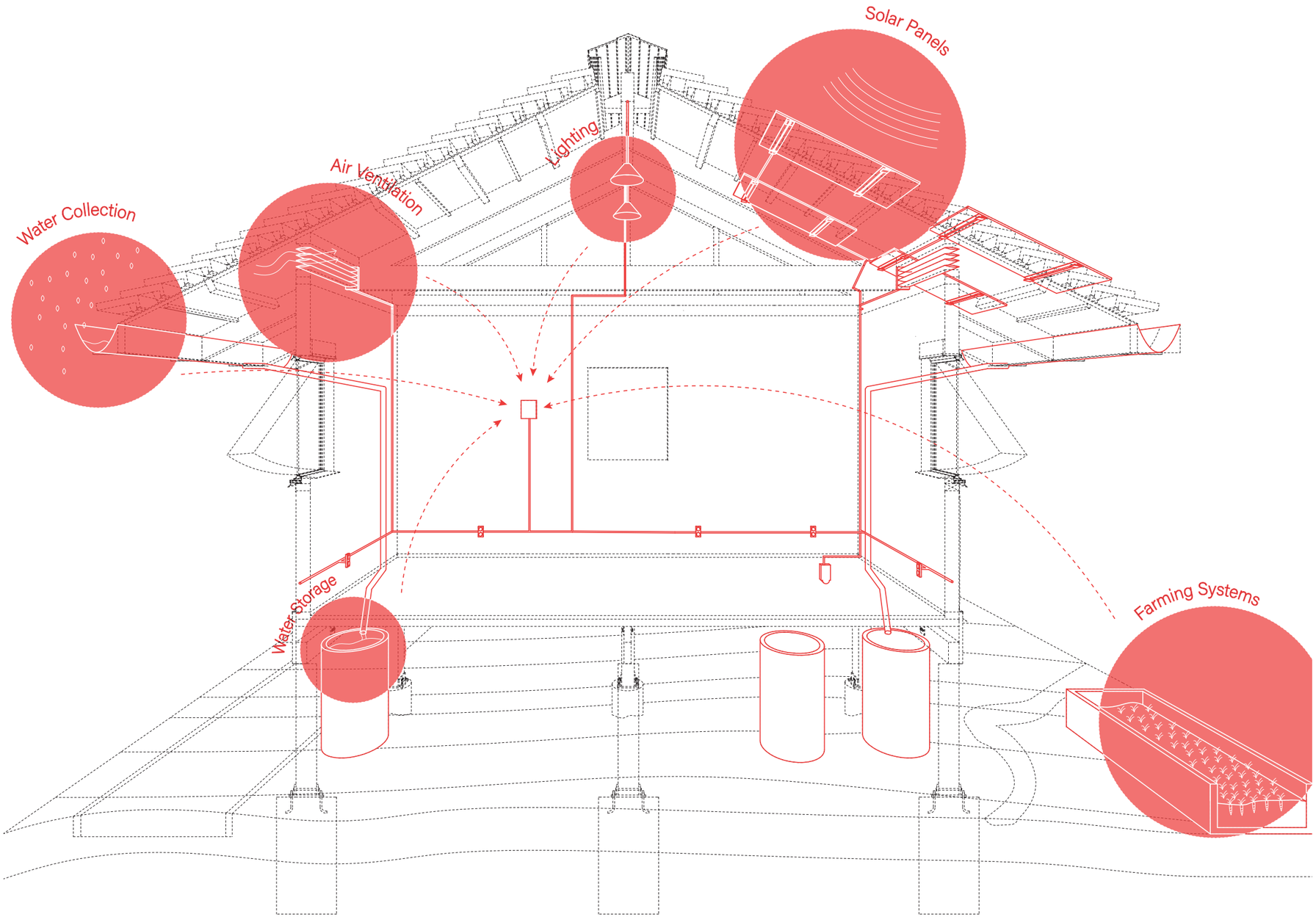
02-04



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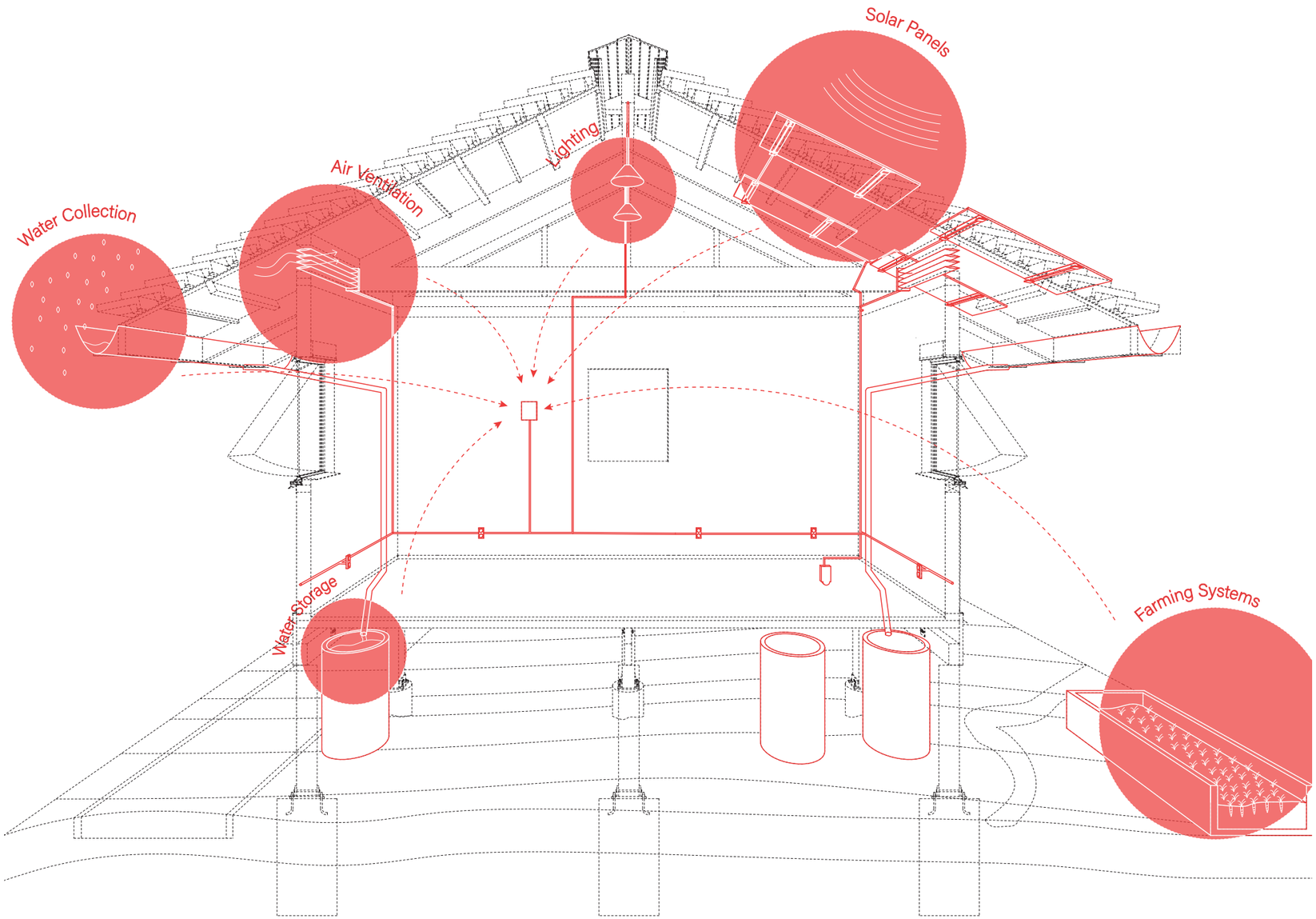
02-05

3

SYSTEMS

01 Air
02 Water
03 Solar
04 Soil



Drawing
In Home Systems

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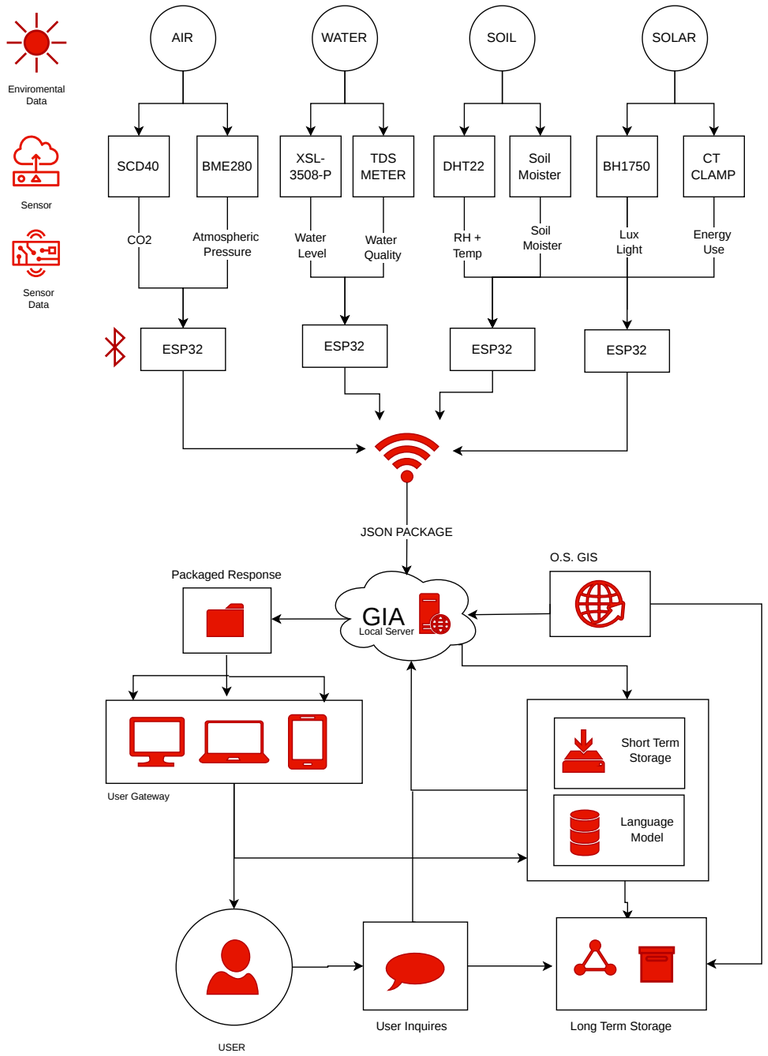
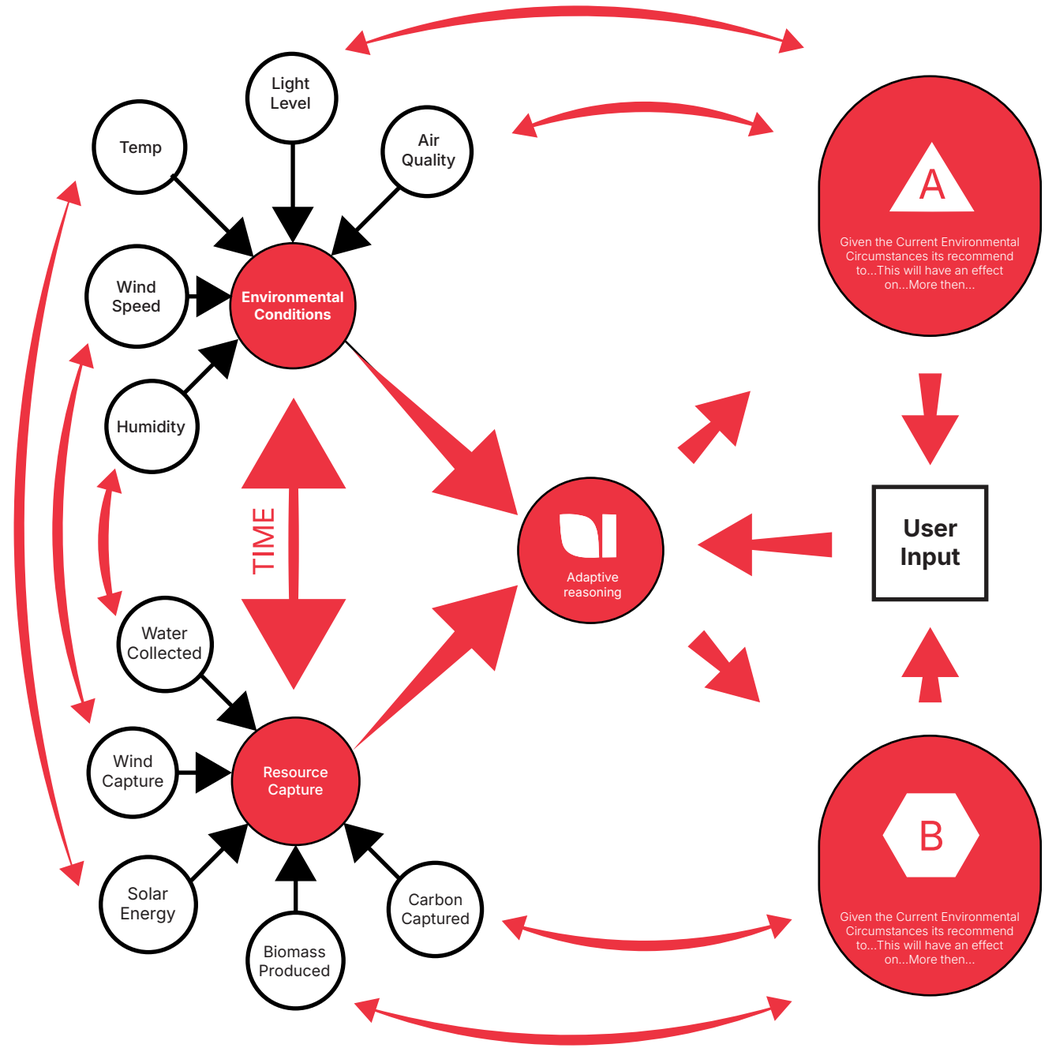
03-01





Drawing
User Gateway Data Tranfer

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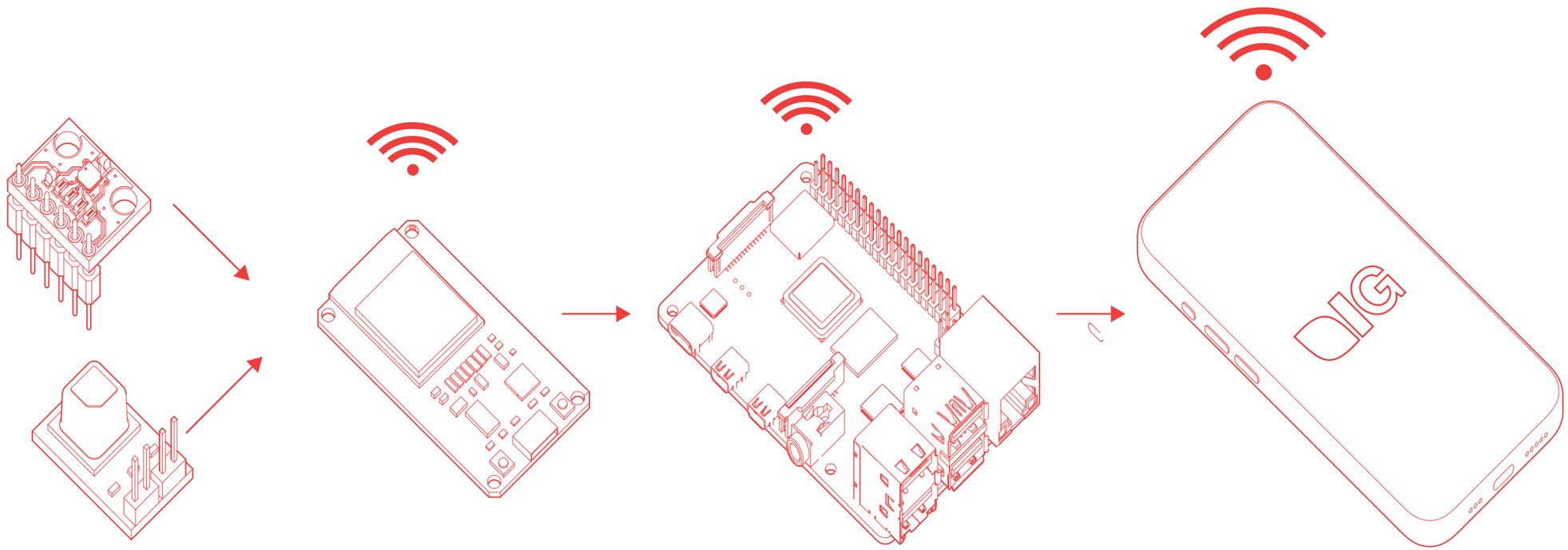
03-02



Sensors

Micro Controller

Server

User Gateway

Drawing
User Gateway
Data Tranfer

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Observations:

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03-03

Effects	PPM
Hazardous Prolonged Exposure	5000
Negative Health Effects	2000
Ventilation Necessary	1200
Ventilation Required	1000
Acceptable Level	800
Healthy Indoor Climate	600
Healthy Outside Air Level	350

Air Quality

Grounded Case Study

Air quality, measured through CO_2 (PPM), reflects how well a space is ventilated. Elevated levels reduce comfort and cognitive performance. Monitoring enables responsive ventilation, improving indoor climate while minimizing energy use.

Drawing
Solar Energy System

Node:
Solar-01

Context
Roof System

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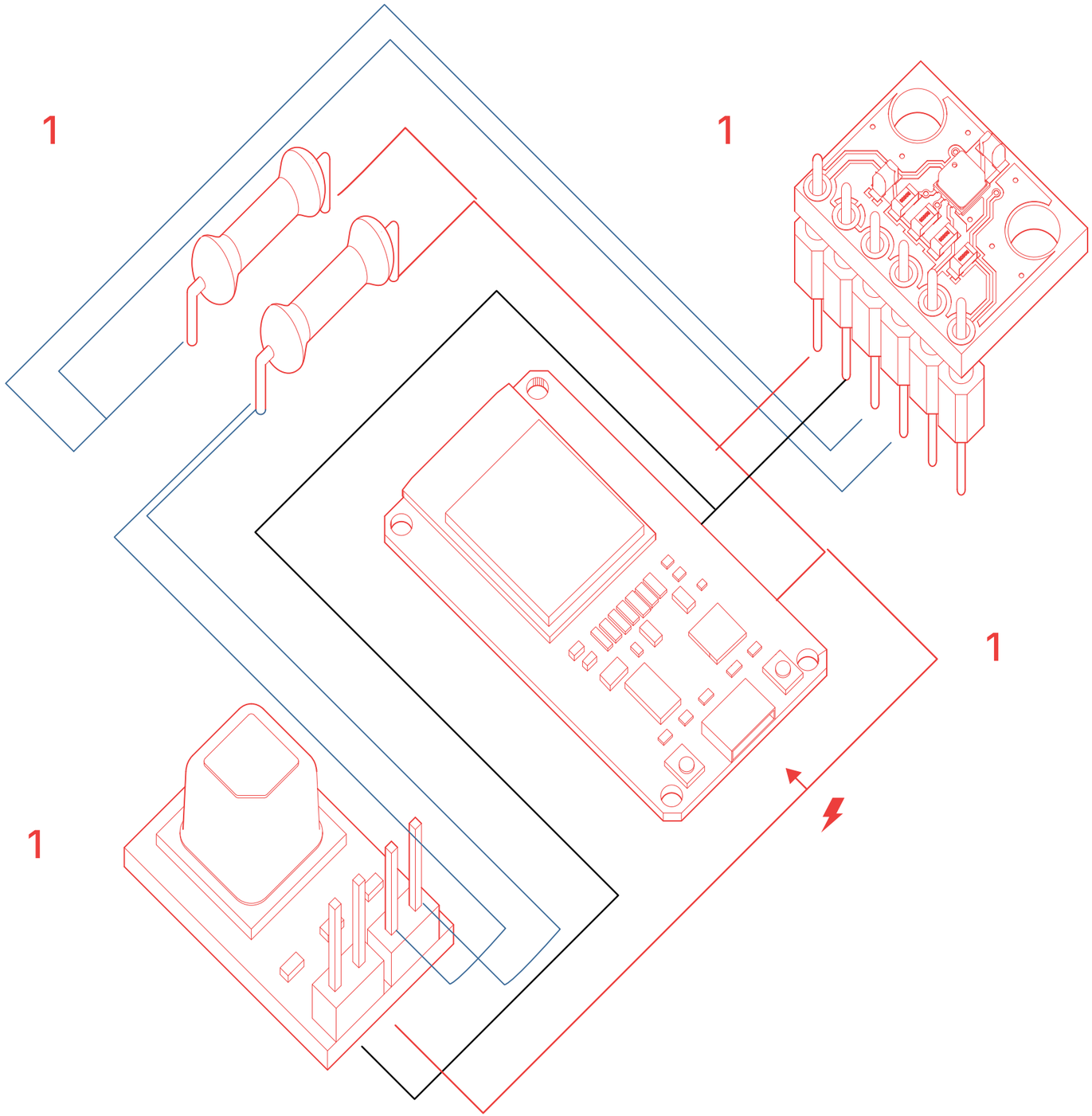

GiaNode
Soil Monitoring

01 Solar Panel
02 Charge Controller
03 Inverter
04 Battery
05 AC Output

Drawing

Section Perspective

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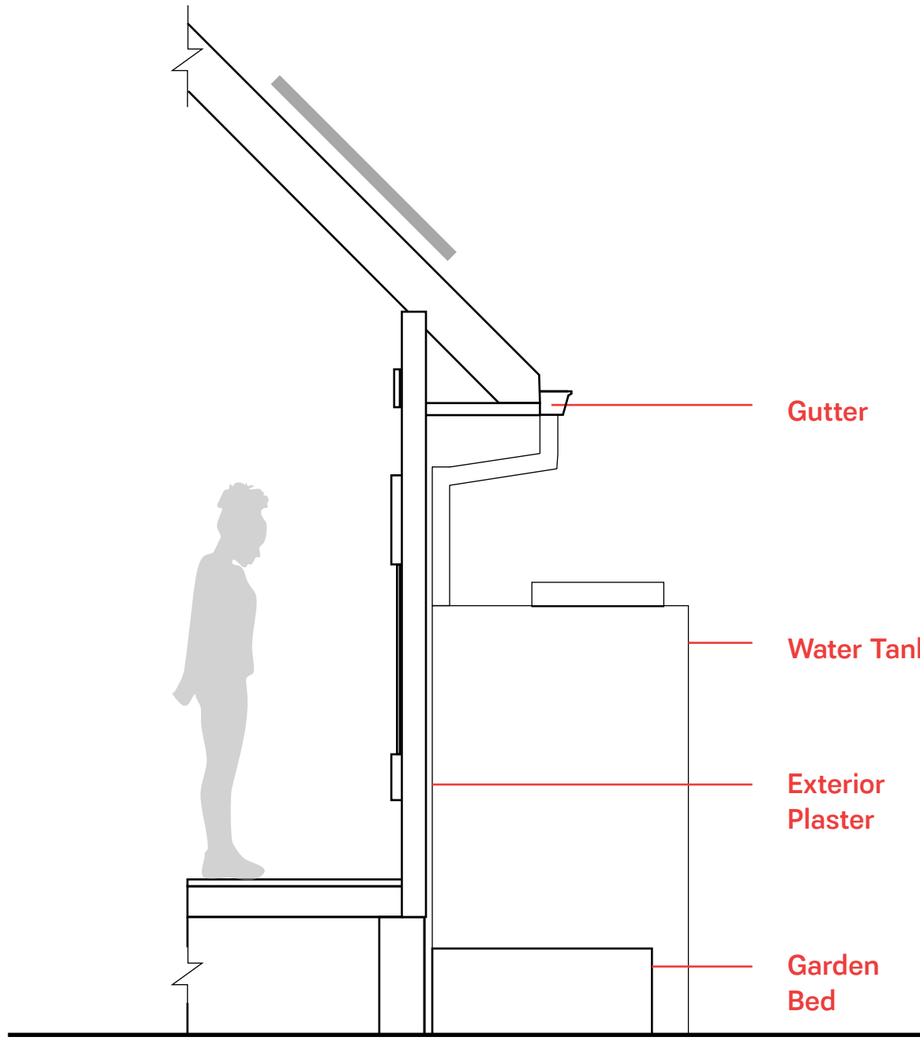
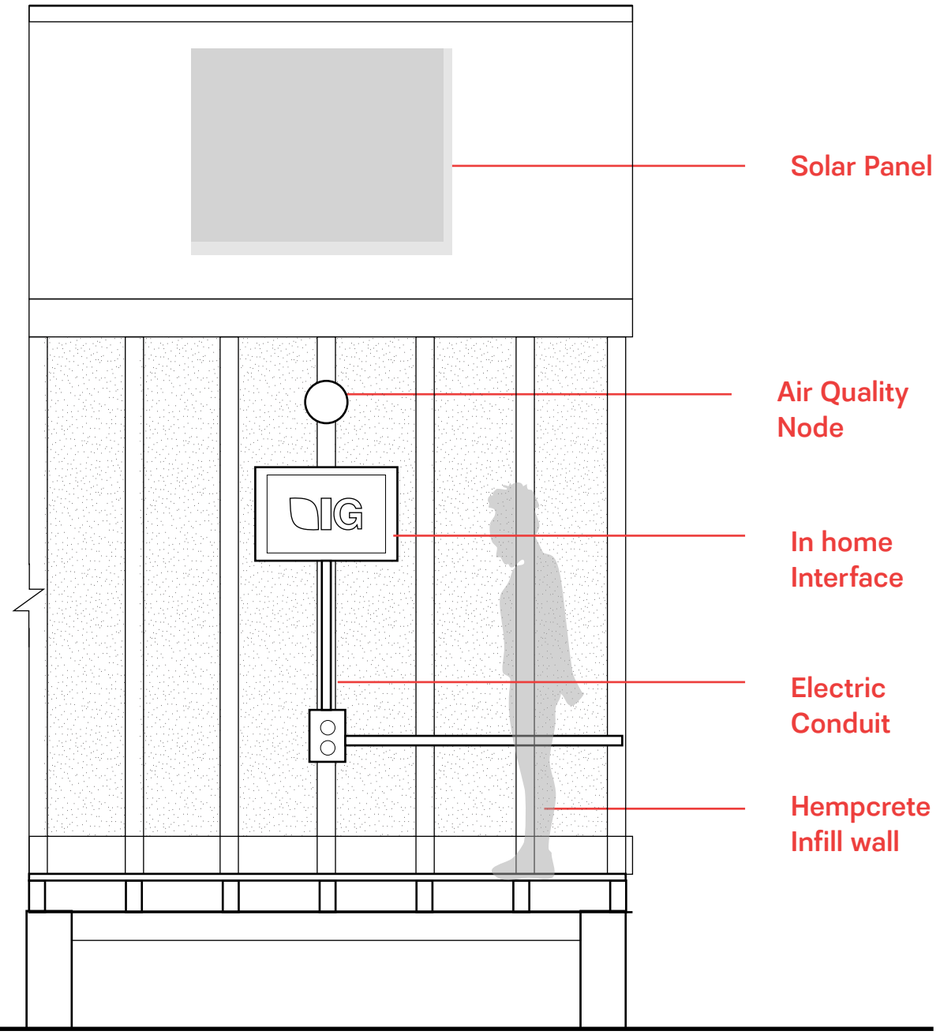
G005



Section



Interior Elevation

Drawing

Section Perspective

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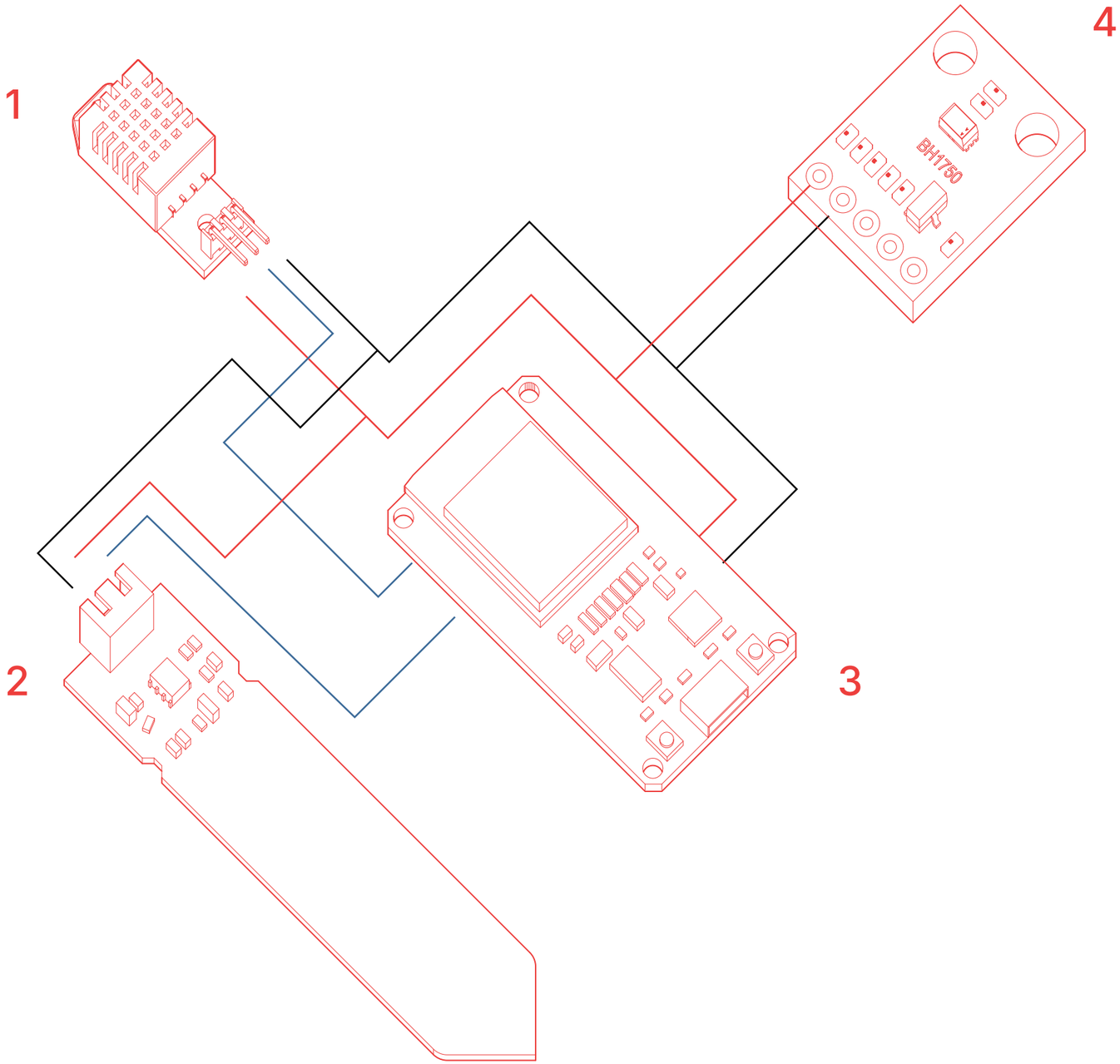
G005

Quality	TDS
Hazardous / Not Potable	2000+
Poor Quality	1000
Hard / High Mineral	500-900
Acceptable (General Use)	300-500
Good (Drinking Range)	100-300
Very Pure	50-100
Ultra Pure / Distilled	0-50

Water Quality

Grounded Case Study

Water quality, measured through TDS, reflects the concentration of dissolved minerals and impurities. Monitoring these levels informs filtration, reuse, and conservation, enabling more efficient and circular water systems.



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Air Quality Node

01 DHT20
02 Soil Meter
03 ESP32
04 BH1250

Drawing
Solar Energy System

Node:
Solar-01

Context
Roof System

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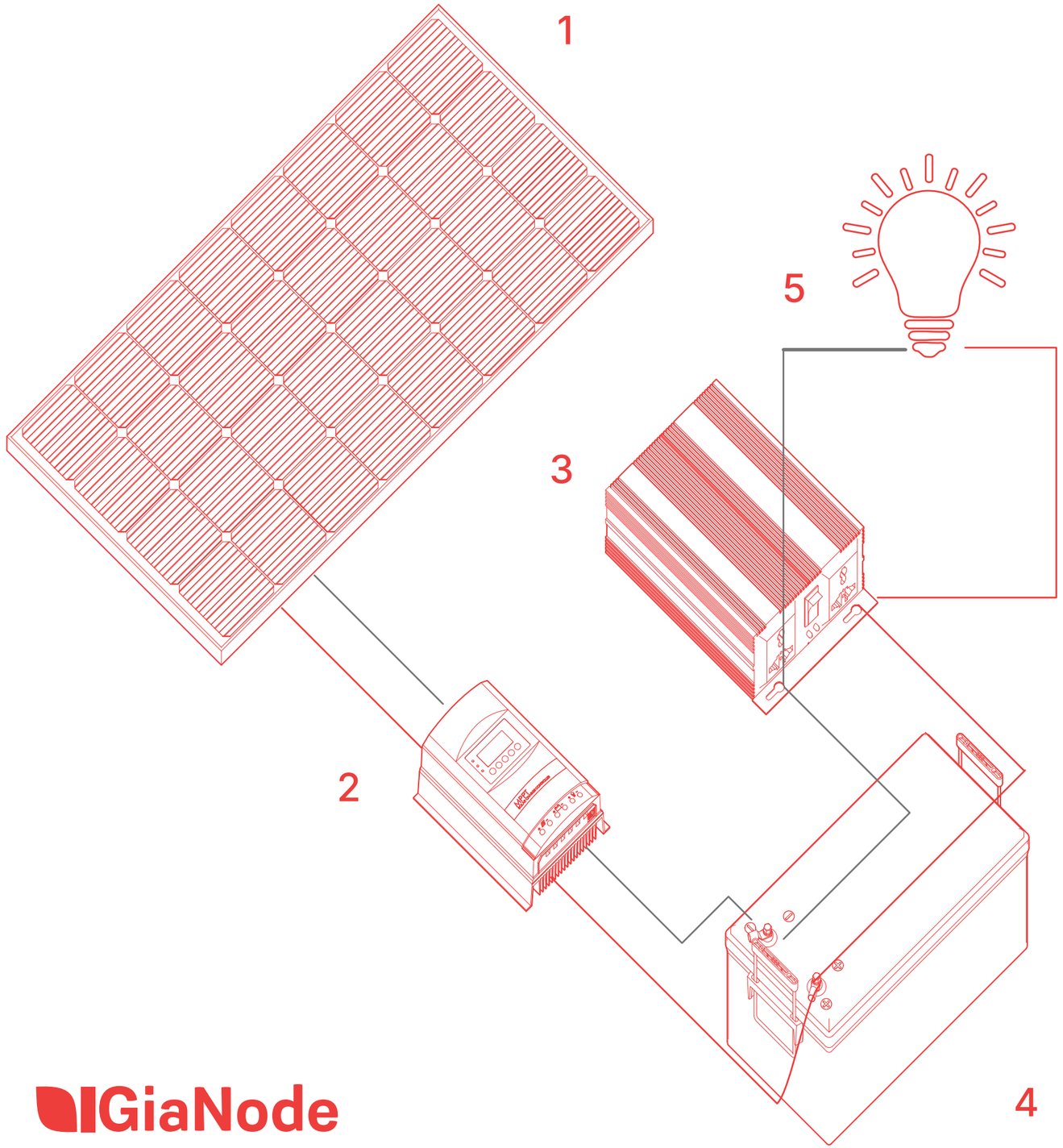
03A01



Solar Energy Systems

When sunlight hits the panels, it creates direct current (DC) electricity by moving tiny particles called electrons. However, most homes use alternating current (AC) electricity. So, the power from the panels is sent to a device called an inverter, which changes DC into AC. This allows the electricity to be used in your home, stored in batteries, or sent back to the power grid.

01 Solar Panel
02 Charge Controller
03 Inverter
04 Battery
05 AC Output

IGiaNode

Drawing
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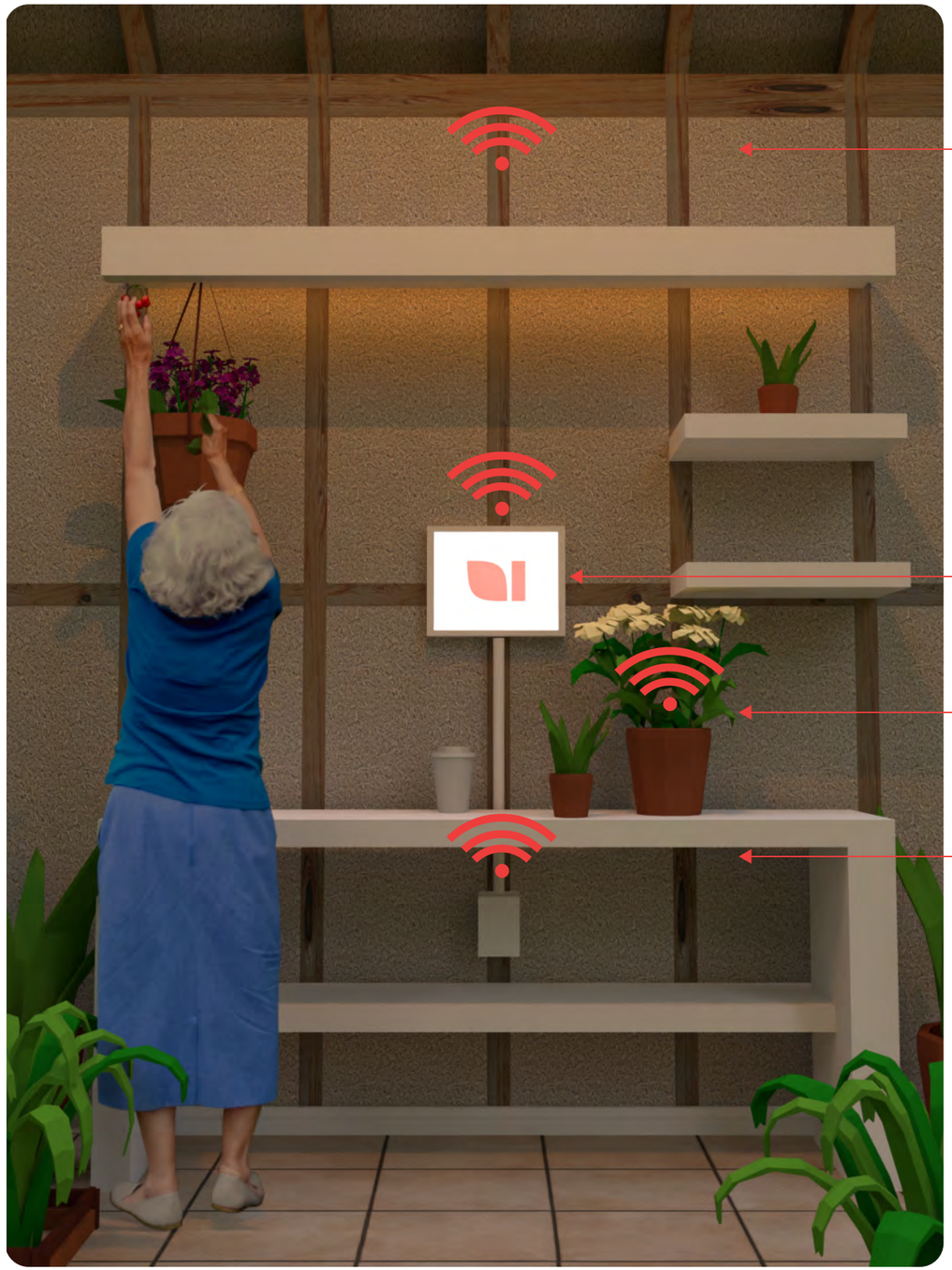
4

APPLICATION



Air Node

Home Interface

Soil Node

Solar Energy Node

Interior Perspective

A network of sensors embeds intelligence into the home, monitoring air, soil, and energy in real time. Data is translated into simple guidance, enabling inhabitants to respond directly to their environment.

The result is a self-regulating interior that supports localized food growth and resource management, reducing dependence on external systems while strengthening everyday agency.

Drawing

Data Transfer System

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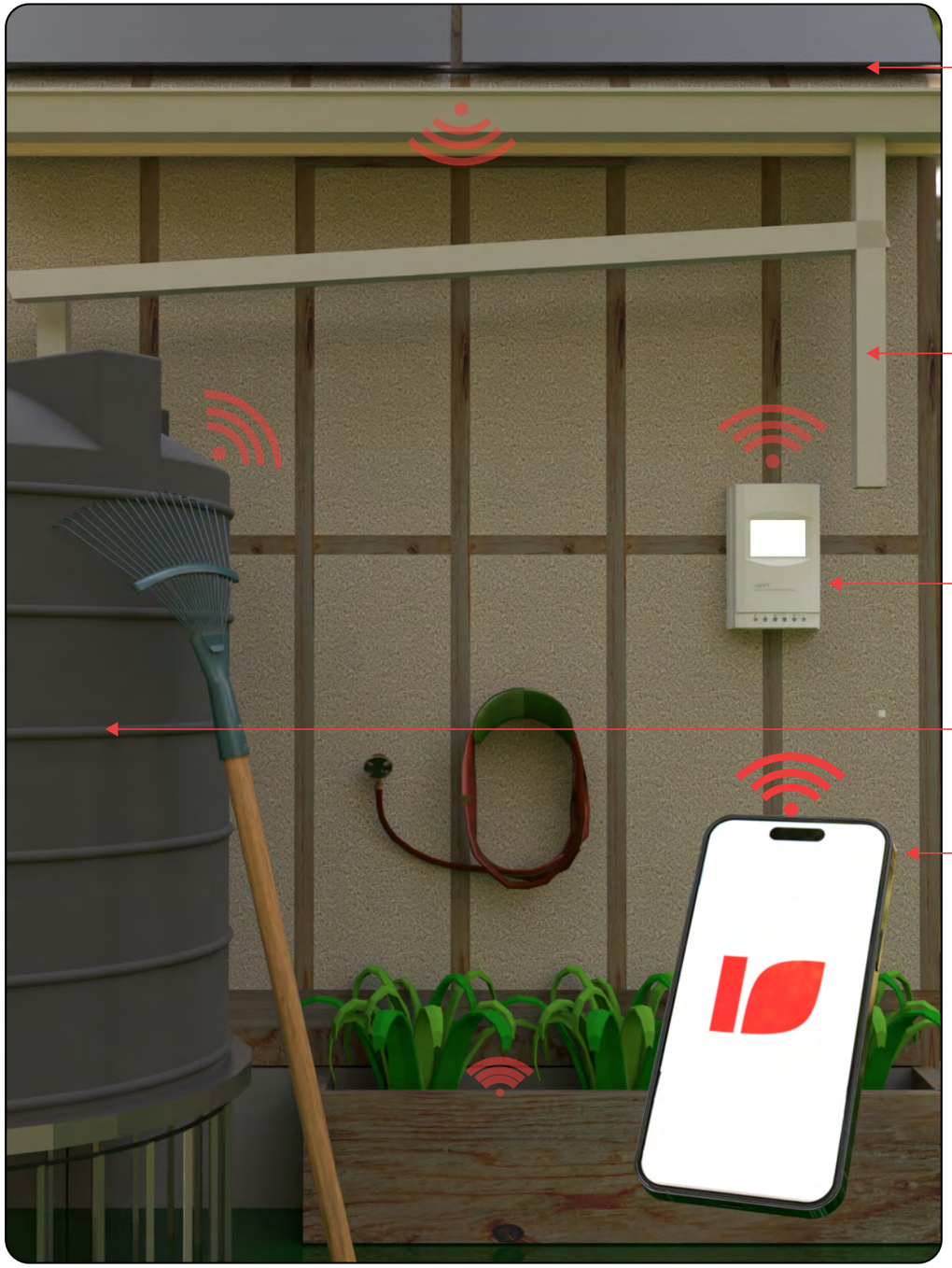

Solar Panel

First Flush Divert er

Solar Charge Controller

Water Tank / Node

User Gateway

Exterior Perspective

Water and energy systems extend this intelligence outward, capturing rainwater and generating solar power within a responsive network. These flows are measured and communicated through the user gateway, providing real-time awareness of resource availability.

The exterior operates as active infrastructure, supporting localized resource management and reinforcing a self-sustaining relationship between inhabitant and environment.

Drawing

Data Transfer System

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1.

Environmental Data

Environmental Data is Captured with the Node aspect of The Device

2.

Growing Guidance

GIA this data and generates best case Care plan for specified Plant + Environment its in.

3.

The Grower

User Gets the Customized Plant Care Routine and is able to converse with GIA to better understand the Data

Drawing
Solar Energy System

Node:
Solar-01

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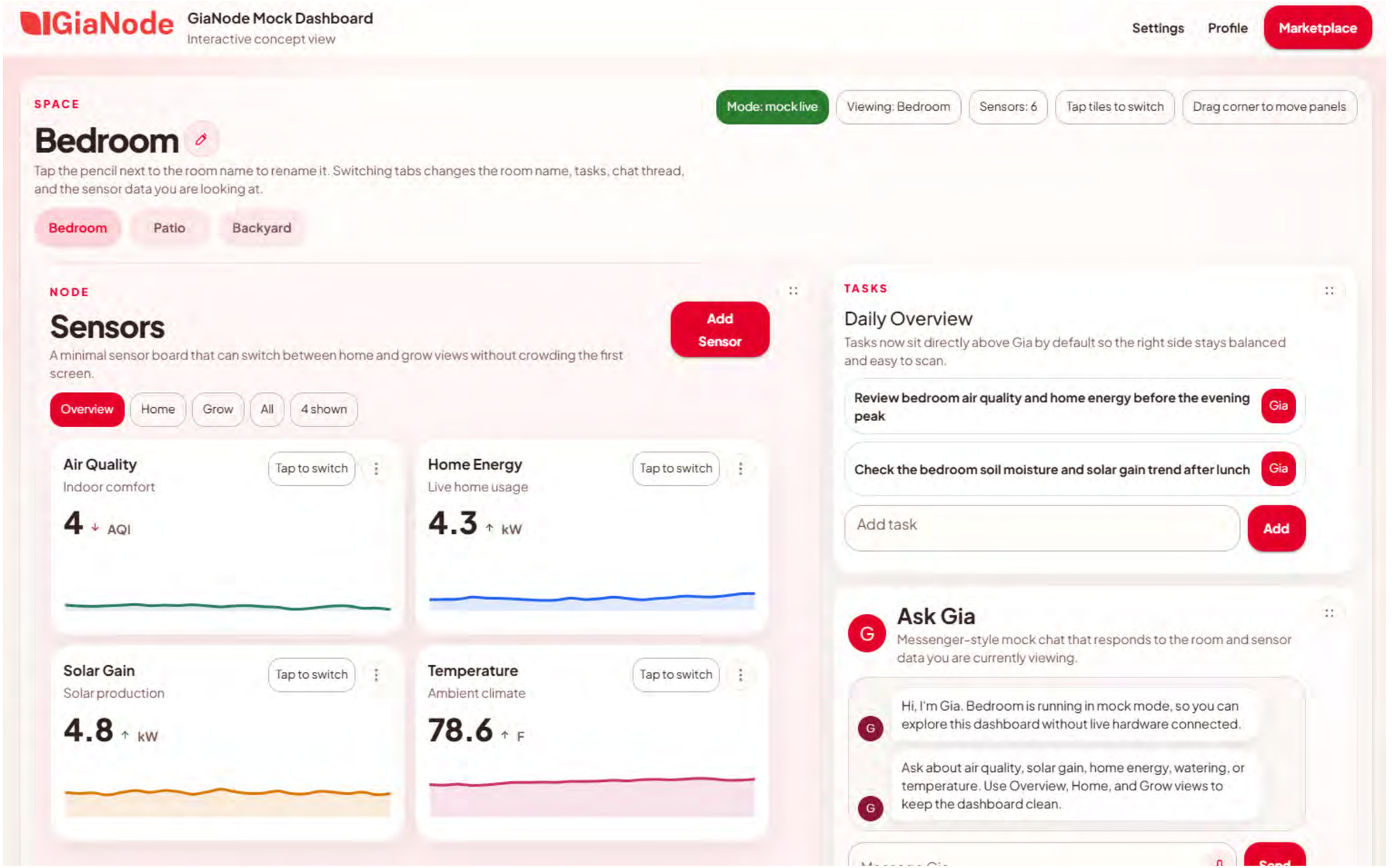

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CanFarm

Use real-time soil data to optimize plant health and growth cycles

Deliver nutrient recommendations based on live environmental conditions

Reduce input waste while improving yield and consistency

BuffaloGoGreen

Deploy Gianode in K–12 learning environments and community gardens

Use live data to teach food systems, climate, and resource awareness

Co-develop curriculum connecting sustainability, technology, and local impact

nationalgrid

Integrate energy education with food and environmental systems

Visualize real-time energy and resource use through Gianode

Build early awareness of efficiency through interactive, data-driven learning

IG

Drawing

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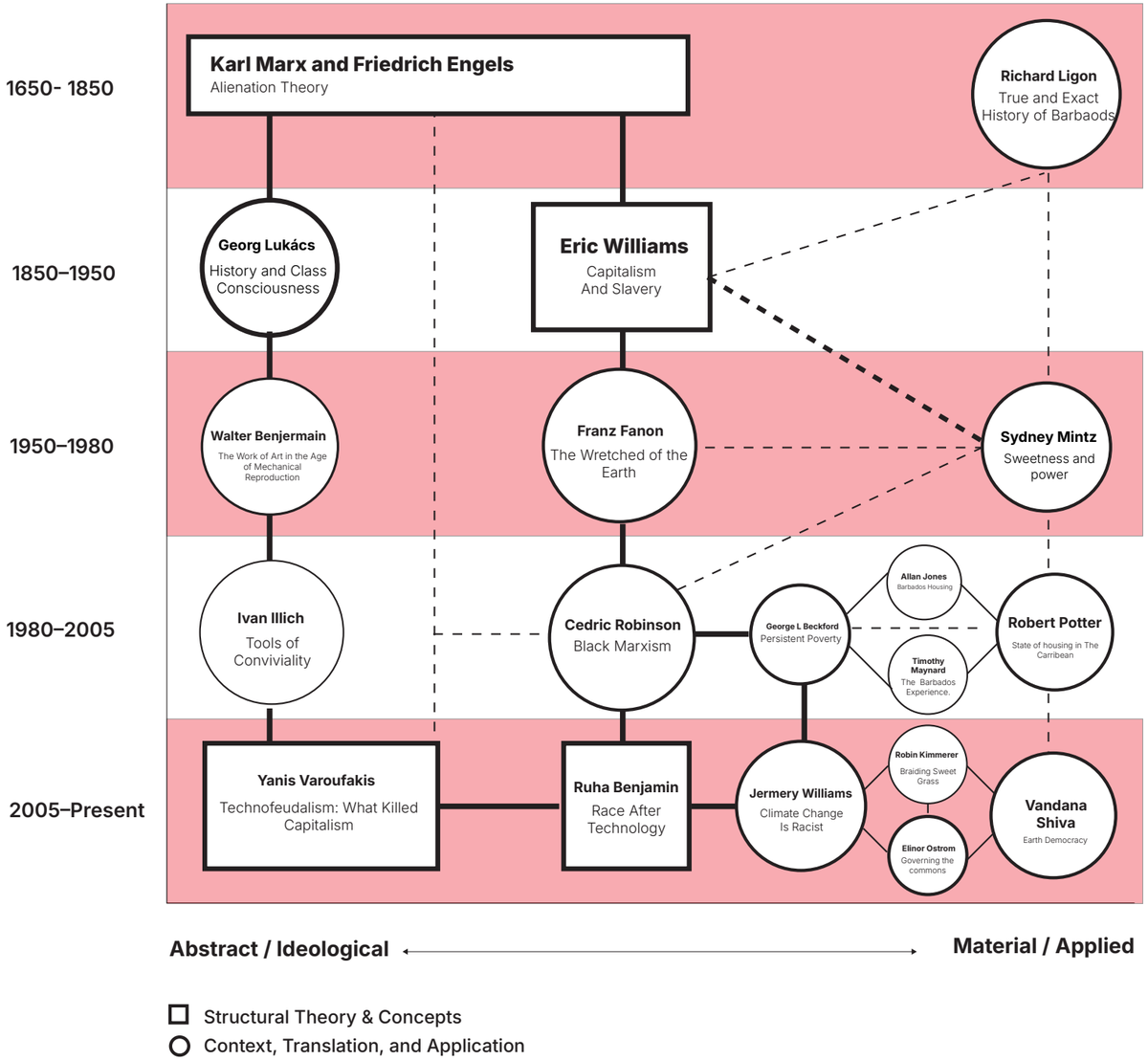
04-01

The Intellectual Ground: Seeds of the Argument

Visual Literary Review



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