TU×2 NARRATIVE & DESIGN GOALS

Setting a higher standard for home construction in Tucson.

Designed to allow privacy and interaction between ADU and principal home residents, **TU×2** [pronounced "two-by-two"] accommodates two households on one lot. **TU×2** fits the constraints of a real 69' x 131' site in the historic Blenman-Elm neighborhood, showcasing the potential of high-performance building design and construction to contribute to historic neighborhoods. Inspired by the climate-responsive architecture of midcentury architect Arthur T. Brown, **TU×2** takes today's most cost-optimal path to net zero energy use: the climate-specific Phius® 2021 targets. This means the building, with the addition of a small PV array, will allow the residents to easily achieve net zero energy use — with minimal effort and *increased* comfort and indoor air quality versus conventional construction. The design also meets the requirements of:

- EPA Indoor Air Plus *for healthy air,*
- EnergyStar *for low operating costs, and*
- EPA WaterSense 2.0 *to conserve the desert's most precious resource,* along with on-site rainwater retention and graywater harvesting.

Affordable and climate-positive.

Because **TU×2** uses familiar construction materials and techniques, such as 2x4 wood studs for walls and wood I-joists for roof joists, the design can be constructed quickly and well by a regular construction crew, or even a skilled DIY'er. Where innovations are made — for example in the use of insulated concrete forms for the stem walls, or the substitution of terracotta brick for a typical concrete slab, the changes simplify construction, reducing skill levels, cost, and specialized labor. Specified materials reduce embodied carbon emissions and increase durability.

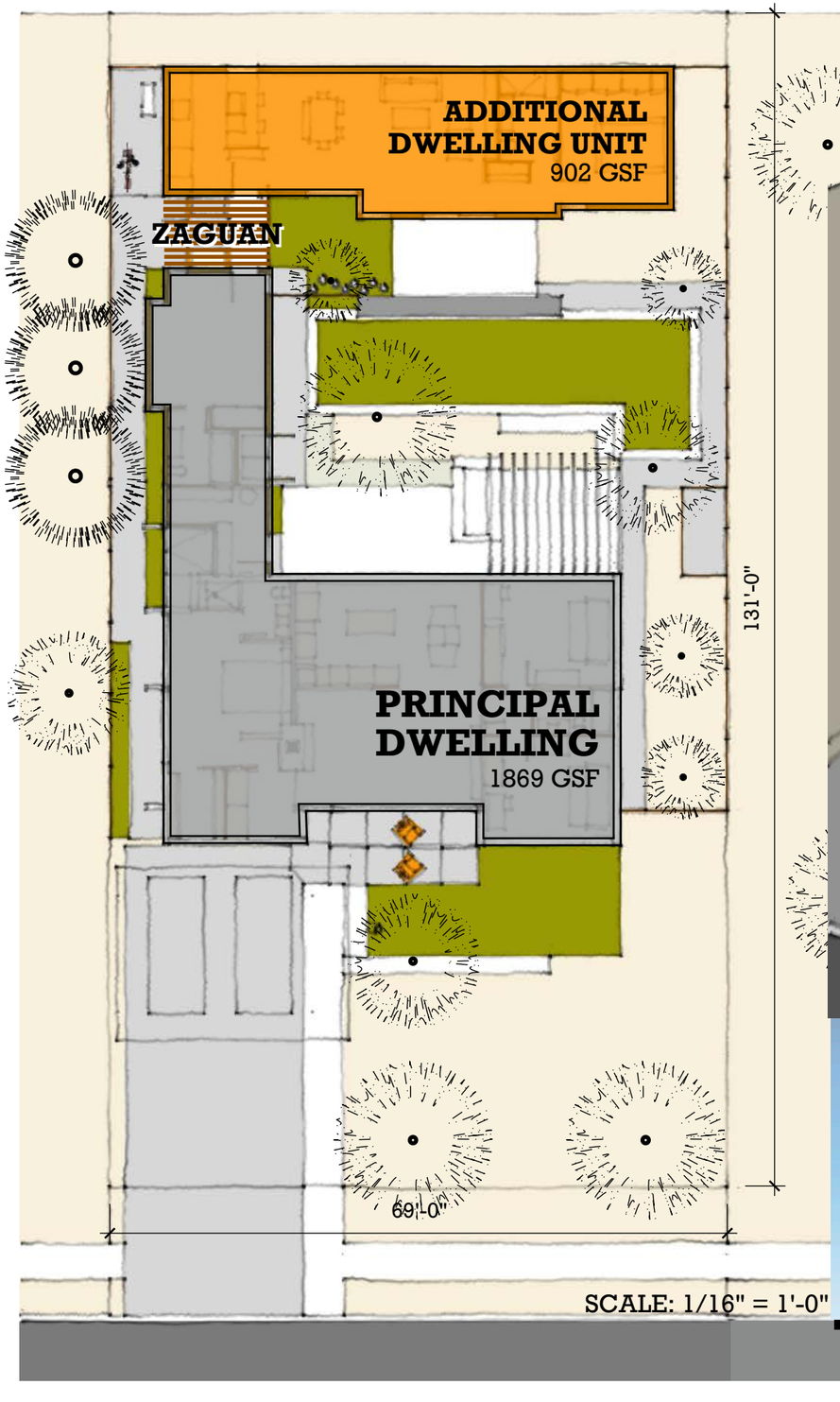
The following package of recognized high-performance design strategies, carefully tuned to climate, enable **TU×2** to deliver both exceptionally low energy use and high levels of comfort, no matter Tucson's extremes:

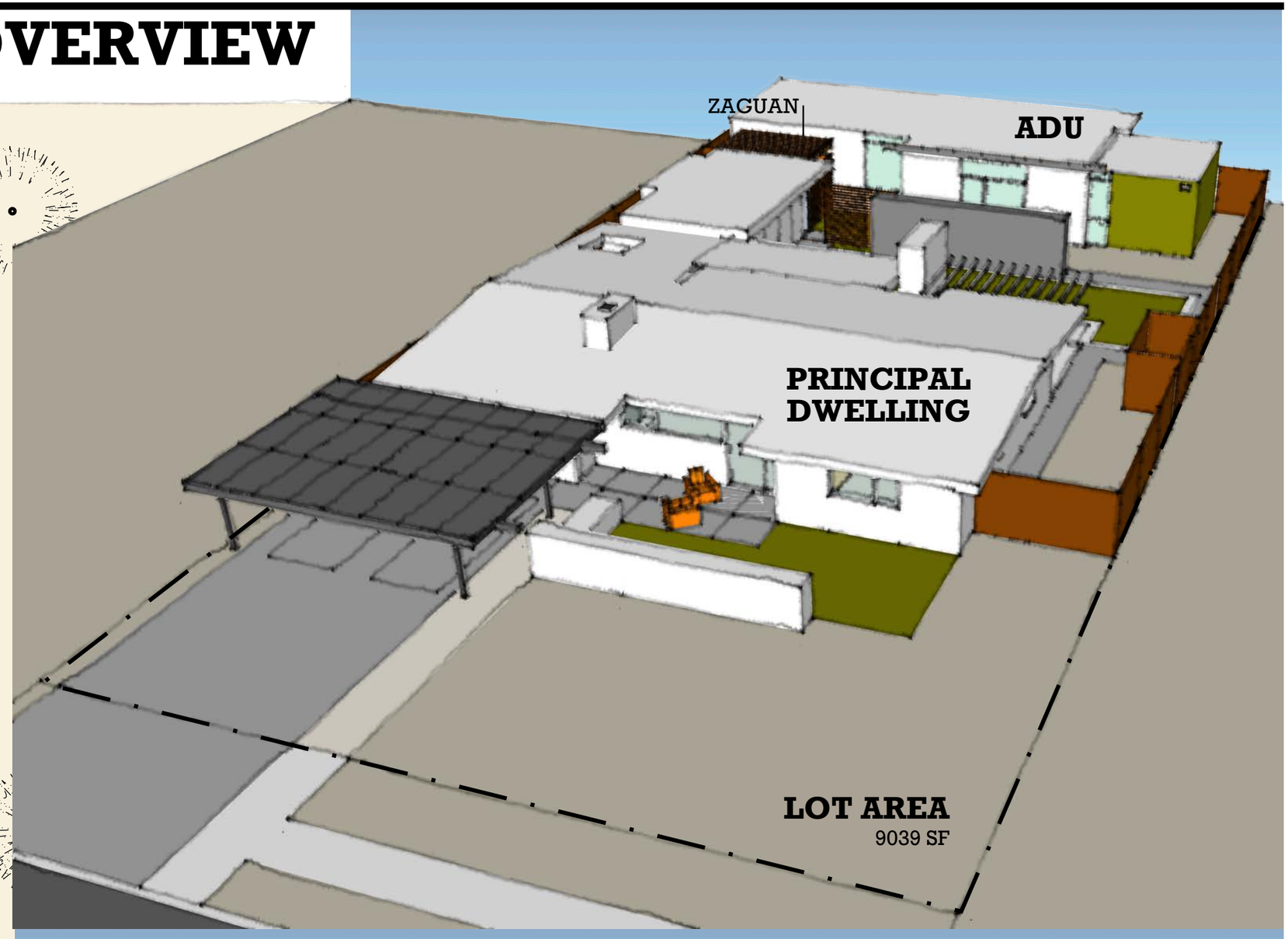
- Careful placement of windows and shading overhang on the south elevation; elimination of windows on impossible to shade east and west elevations; windows exceed code requirements for insulation and protection against solar gain.
- Continuous insulation on all exterior wall and roof surfaces buffers structure and shields occupants from extreme heat and cold.
- All thermal bridging is eliminated (such as steel studs, which can decrease wall performance by 25-50%; exposed uninsulated slab edges, which create discomfort at the perimeter and can account for 10%+ of heating and cooling energy use in a conventional structure).
- Designed for easy, airtight construction to allow the builder to readily meet the Army Corps of Engineers standard of 0.6 CFM per square foot of enclosure area, exceeding the building code's requirement of 5 air changes per hour. When it's too hot or too cold for open windows, a mechanical ventilation system provides filtered fresh air.
- Right-sized mechanical heating and cooling systems — this design can be cooled by a single 1.5 ton minisplit system, 25-50% smaller than a code-compliant design! Smaller systems save money and energy, and less refrigerant reduces global warming potential.

A catalyst for sharing savings.

The efficient all-electric design means **TU×2** will be ready for up to $14,000 of tax credits from the DOE-funded High-Efficiency Electric Home Rebate program (to be administered by the State of Arizona energy office). In fact, the **TU×2** design is so energy-efficient that with some mechanical systems, such as an air-to-water heat pump and/or heat pump water heater, it could augment or even replace the mechanical systems in the principal structure — reducing carbon emissions and saving money every month on utility bills and opening the door to additional tax incentives and rebate programs, such as the HOMES program, 179D tax deduction, and 25C tax credit.

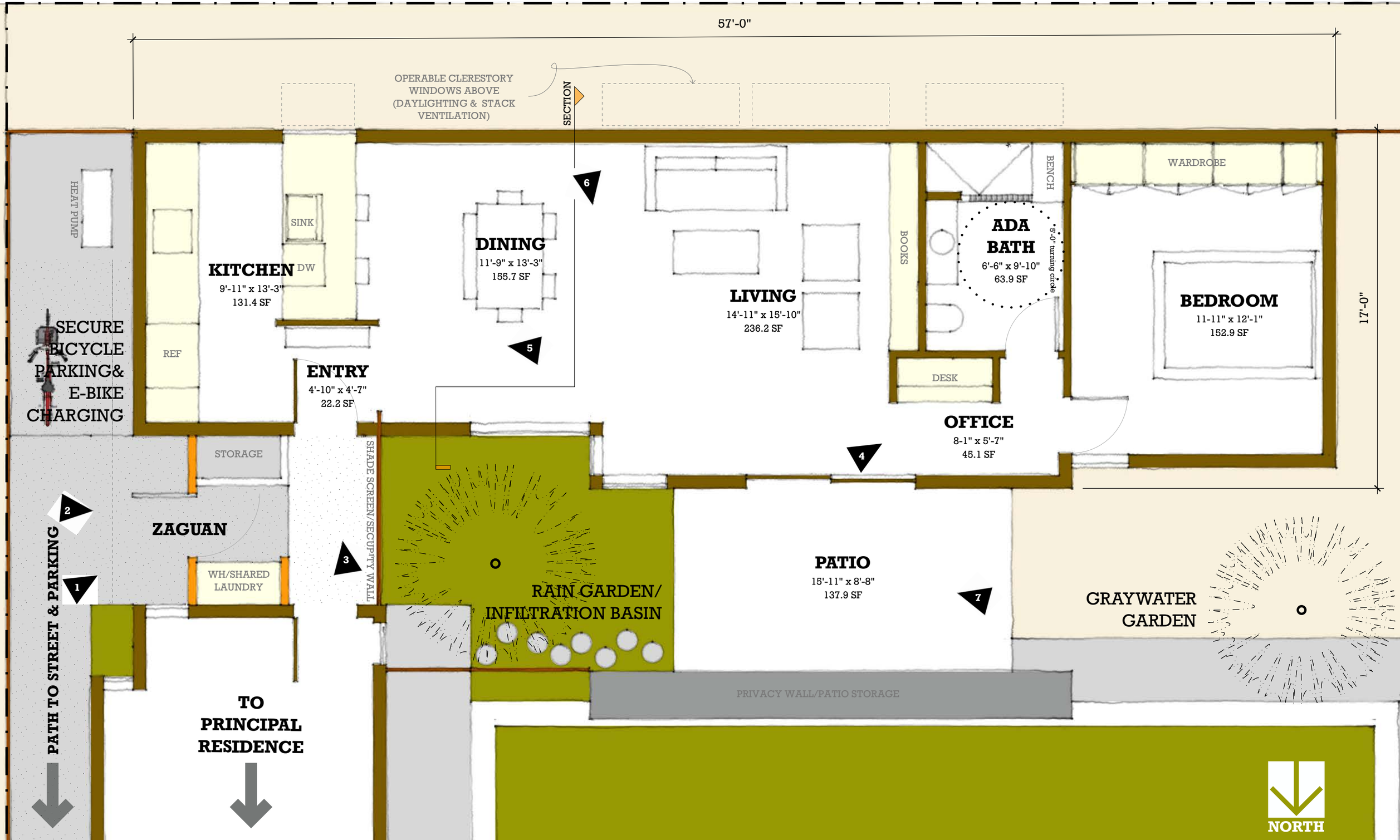
TU×2 SITE PLAN & OVERVIEW





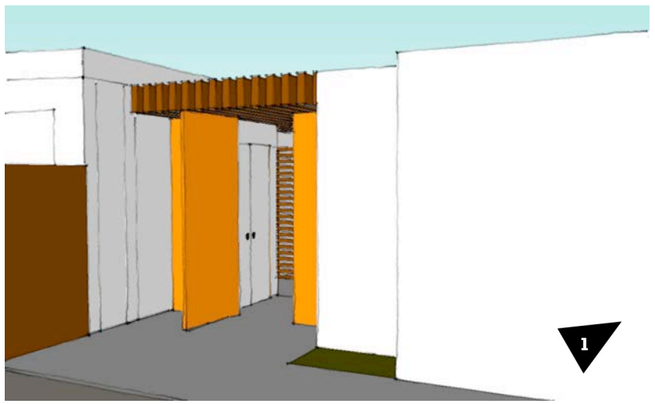
TU×2 PLAN

SCALE: 1/4" = 1'-0"

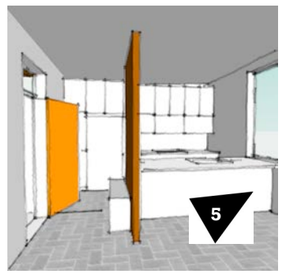


TU×2 DESIGN STRATEGIES REDUCE COST, EXPAND SPACE

BELOW A zaguan — a sheltered entry space that mediates between outdoors and indoors and characteristic to Sonoran architecture, also serves as a point of connection between TU×2 and the principal residence. The zaguan also creates the possibility to share utilities between the new and existing structures — here, a heat pump water heater services both units, which increases efficiency, qualifies for a tax credit, and decreases construction cost.



RIGHT The dining area's inset corner window is a nod to midccentury design providing a visual connection to the lush rainwater garden. Built-in shelving above cabinets in the living area makes the most of limited size; ADUs are limited to 10% of the lot area, capping this ADU at 903 square feet. Because the ADU uses continuous insulation to achieve net zero energy, the exterior walls are 2 1/2" thicker than required to reach code. This seemingly minor additional thickness occupies 30 square feet of floor area — eating up the equivalent of a 2' closet running the entire length of a 15' long room! Thoughtful use of inexpensive IKEA components adds storage throughout. **BELOW** Storage is provided in high cabinets in the office nook and kitchen.



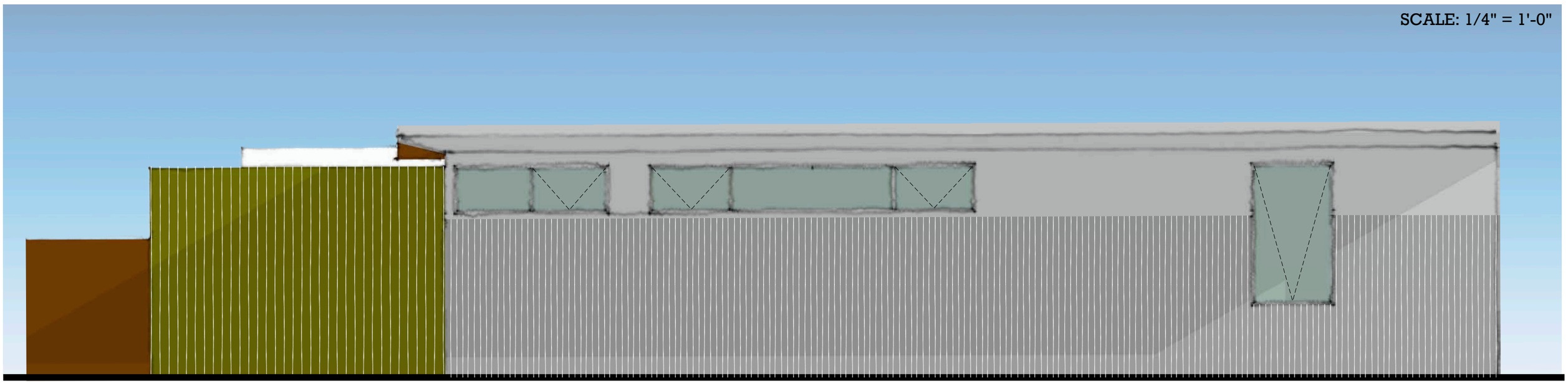
LEFT The patio, readily accessible from the living and dining areas, is level with the interior floor to facilitate an easy flow from inside to outside. Northern exposure and a masonry privacy/shade wall tempers the space, creating a warmer microclimate on cool days and a cooler one when it's hot. A sliding gate (left in rendering) allows the residents of the ADU to connect with the principal residence and provides privacy when desired. Above the sliding glass door, a contemporary take the traditional *canale* funnels water off the roof into the rain garden.

TU×2 ELEVATION — NORTH

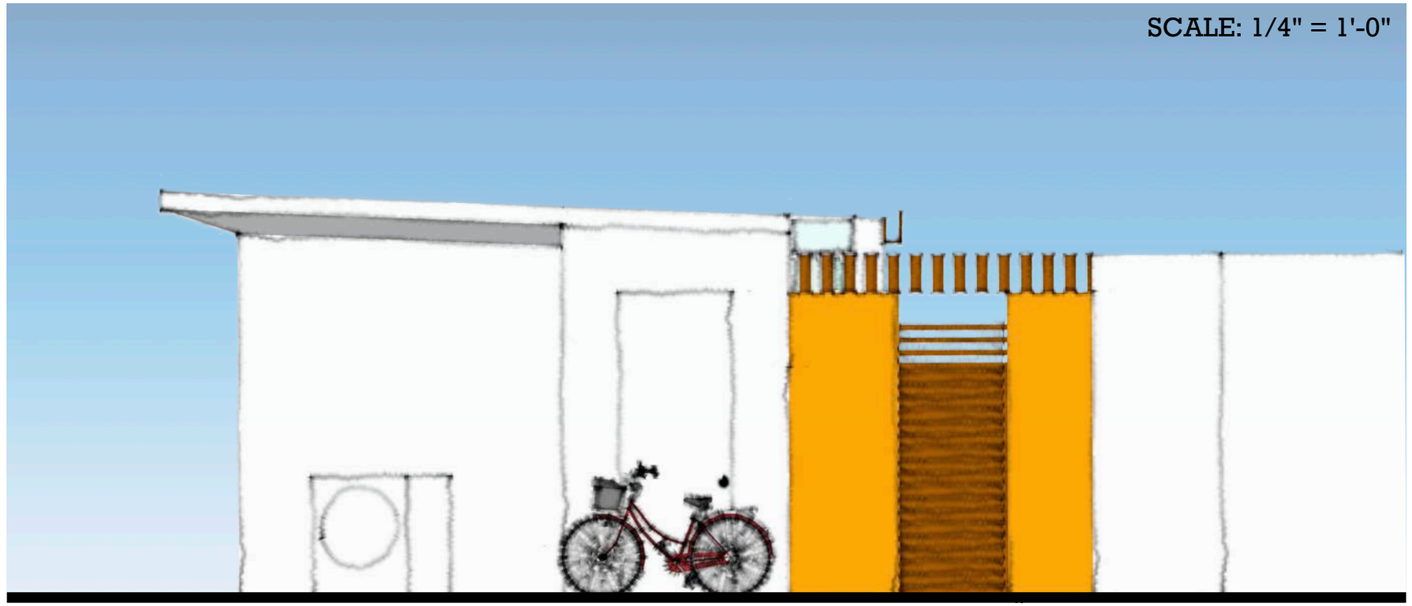
view from principal structure; section shows Zaguan; privacy wall shown dashed

TU×2 ELEVATION — SOUTH

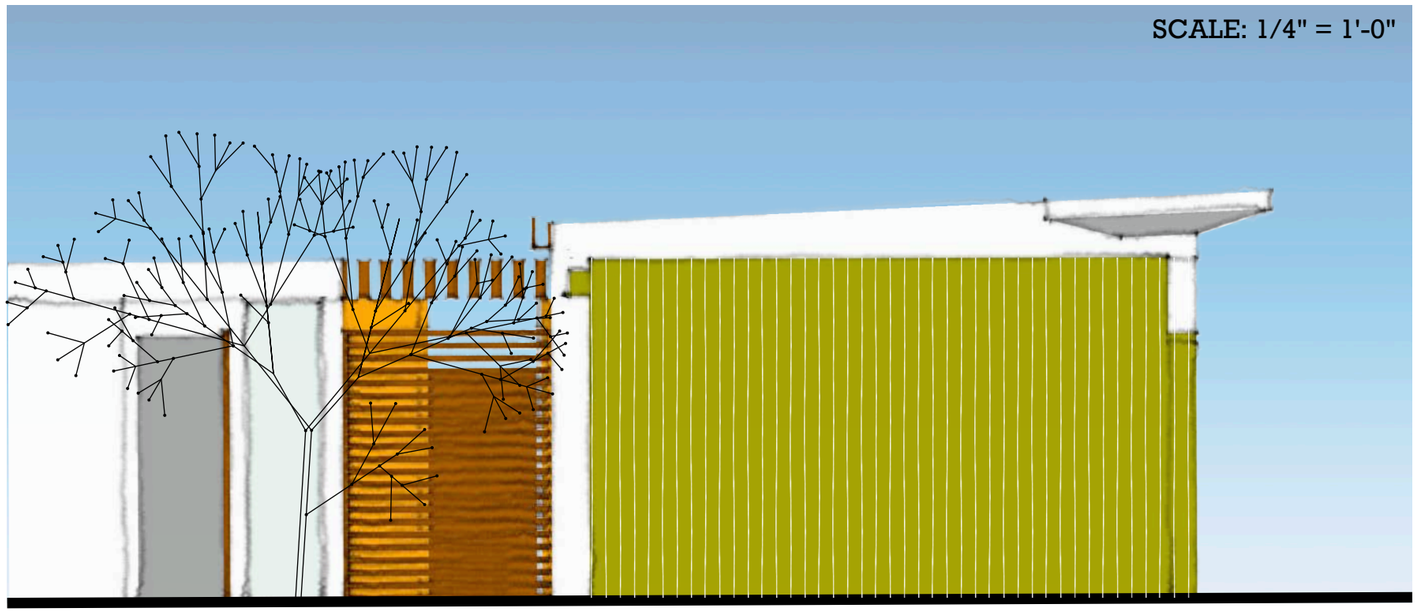
view from rear lot line/utility easement; overhang provides 90% summer shading



TU×2 ELEVATION — EAST *view to Zaguan*



TU×2 ELEVATION — WEST *view from lot line*



MECHANICAL SYSTEMS

TU×2 follows best practices for high-performance home design by providing separate systems for heating, cooling, and dehumidification. Homeowners can choose systems that meet their needs and budget. EnergyStar certified equipment is required for EnergyStar or Phius® certification and tax incentives. Net zero energy use can be achieved by adding a small 4 kW PV array. TU×2 offers enough space for a 10 kW array to offset principal residence energy use.

Space heating and cooling

Fujitsu F2H24W09120000
$3500

Option 1

Air-to-air minisplit heat pump, multizone

pro Highly efficient; wall-mount air handlers conserve space

con Multizone air-to-air systems use large volumes of refrigerant with high greenhouse-warming potential

Mitsubishi PEAD-A24AA7 + SUZ-KA24NA2
$3800

Option 2

Air-to-air minisplit heat pump, ducted

pro Less visible than wall-mounted systems, but not quite as efficient

con Ducts from central air handler require space; cannot separately set temperature in different rooms

Chiltrix CX34 + 2x CXI34
$6800+

Option 3

Air-to-air minisplit heat pump, multizone

pro Most efficient option; also uses very little refrigerant

con Straightforward installation, but may be unfamiliar for some installers

Chiltrix CX34 + 12VMB Air Handler
$8500+

Option 4

Air-to-water minisplit heat pump, ducted

pro Efficient and quiet, depending on air handler selected

con System type typically used in commercial buildings may limit choice of install and repair technicians

Ventilation

Zehnder Q350
$2500+

Option 1

Zehnder energy recovery ventilator

pro Highly efficient, UL-rated plastic ducts for simple plug-and-play insulation

con Costly

Panasonic Intelli-Balance 100
$985

Option 2

Energy recovery ventilator from Panasonic or other manufacturer

pro More affordable

con Efficiency can vary; installation more difficult

Hot Water

Stiebel Eltron Accela 330
$2500

Option 1

Standalone heat pump water heater

pro Highly efficient

con Can be noisy if located indoors

Triangle Tube Smart 30
$1200

Option 2

Storage tank heated by air-to-water minisplit (requires Space heating/ cooling opt. 3 or 4)

pro One system

con Costly additional plumbing, lacks redudancy

TU×2 BUILDING SECTION

SCALE: 1/2" = 1'-0"

NOTE: INSTALL ALL WINDOWS AND DOORS WITH SILL PAN, DRIP EDGE, and BACK DAM TO MAINTAIN AIR CONTROL LAYER.

2x6 RAFTER EXTENSIONS
2' projection for summer shade at south wall

ROOFING
COOL ROOF/REFLECTIVE LOW SLOPE ASPHALT OR METAL ROOFING w/ UNDERLAYMENT/STRAPPING PER MANUFACTURER
owner's choice

HEADER
ENGINEERED LUMBER

CONTINUOUS INSULATION + SHEATHING
1" CONTINUOUS
POLYISO INSULATION R-6 min.
over WRB OSB [ZipS System or equiv.]

JOIST
11 7/8 WOOD I-JOIST
@ 24" O.C.
[TJI or equiv.]

CAVITY INSULATION
DENSE-PACK
CEULLOSE
R 3.6/in

1x4 STRAPPING
@ 16" O.C. w/
GYPSUM WALL
BOARD [typ.]

10 kW PV system (max)
16,131 kWh/yr production equivalent to $2245 of electricity @ TEP retail rate (13.92¢/kWh)

ROOF TERMINATION BAR with DRIP EDGE

GUTTER/CANALE

CLADDING *owner's choice*

WINDOW [typ.]
DOUBLE GLAZED [typ.]
U ≤ 0.25
SHGC ≤ 0.25

CLERESTORY WINDOW
DOUBLE GLAZED [typ.]
U ≤ 0.25
SHGC ≤ 0.25

FINISH
GYPSUM WALL BOARD [typ.]

ADVANCED FRAMING
2x4 @ 24" O.C.

CAVITY INSULATION
DENSE-PACK CELLULOSE R 3.6/in

SHEATHING
AIR CONTROL LAYER
+ WEATHER-RESISTIVE BARRIER
[Zip System or equiv.]
Tape or seal all seams

CONTINUOUS INSULATION
w/ INT. DRAINAGE & RAINSCREEN
R 4.0/in
[2.5" INSOFAST or equiv.]

CLADDING
owner's choice

SEAL TERMITE BARRIER @ SHEATHING
[PANGO® TAPE or equiv.]

SILL SEAL

TERMITE FLASHING

ICF w/ COVER BOARD

BEDROOM DOOR
beyond

11'-7"

10'-2"

Where's the concrete?

Concrete is responsible for 10% of global carbon emissions. This detail, which eliminates concrete in favor of low-carbon terracotta brick is inspired by floors in historic Tucson homes. It provides a code-compliant, stable, termite-free, and lifelong floor for the ADU. There's still concrete in the footings — plenty to provide stability for the entire building. *This assembly is adapted from a concrete-free slab assembly Birdsmouth Design Build of Portland, Ore., installs as standard in their new projects. For more, see Inside the Concrete-Free Slab, Fine Homebuilding February/March 2022.*

Why build tighter than code requires?

It's expensive to use energy to heat or cool air! Why let it leak out of a building when you've paid for it? Meeting the higher standard used by the Army Corps of Engineers standard (0.6 CFM/sq. ft. of enclosure area) instead of the code requirement, which allows 5 air changes per hour, means TU×2 will use less energy and stay cooler for longer in a power outage. It also means a smaller, less expensive cooling system can be installed. A well-sealed house also means air quality measures like filtration can work better to keep people healthy and indoors free of wildfire smoke and vehicle pollution.

INSULATED CONCRETE FORM
[ICF]

LAYER 1
COMPACTED SOIL

LAYER 2
COMPACTED 3/4"
CRUSHED STONE
NO FINES

LAYER 3
1" EPS FOAM

LAYER 4
POLYOLEFIN
TERMITE BARRIER
(PANGO® WRAP or equiv.]

LAYER 5
PAVER BASE

LAYER 6
TERRACOTTA
BRICK WITH
NATURAL WAX
FINISH