Off-Grid 3-Bedroom House Design for Marquette County, Michigan

Design Overview

A 1,280 sq ft single-story house with 320 sq ft attached greenhouse, optimized for Michigan's Upper Peninsula climate, using local materials and simple construction techniques suitable for unskilled labor.

Building Materials (Locally Available)

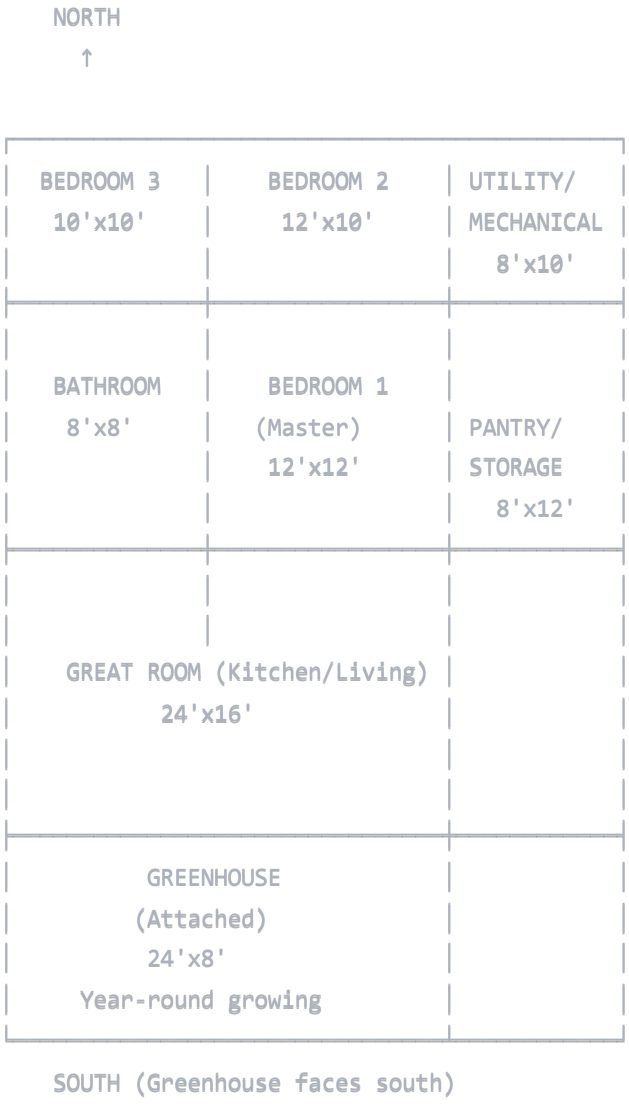
Primary Structure

- **Foundation**: Rubble stone foundation using local fieldstone and concrete
- **Framing**: Local white pine or hemlock 2x6 construction
- **Siding**: Board and batten using local pine, sealed with linseed oil
- **Roofing**: Metal corrugated roofing (excellent for snow load and longevity)
- **Insulation**: Dense-packed cellulose (can be locally sourced/made from newspaper)

Interior Materials

- **Flooring**: Local hardwood (maple/birch) or concrete slab with radiant heating
- **Interior walls**: Pine tongue and groove or drywall
- **Windows**: Double-pane, south-facing emphasis for solar gain

Floor Plan (40' x 32' = 1,280 sq ft + 320 sq ft greenhouse)



Energy Systems

Heating

- **Primary**: High-efficiency wood stove (centrally located)
  - Local hardwood readily available
  - Backup propane heater for extended absences
- **Passive solar**: Large south-facing windows with thermal mass (concrete floor or stone wall)
- **Insulation**: R-30 walls, R-50 ceiling minimum

Electrical

- **Solar array**: 4-6kW system on south-facing roof
- **Battery bank**: 800-1200Ah lithium or AGM batteries
- **Backup generator**: Propane-powered for cloudy periods
- **12V/24V DC circuits for lighting and fans

Water

- **Well**: Hand-dug or driven well with hand pump backup
- **Pressure system**: 12V pump with pressure tank
- **Hot water**: On-demand propane heater or wood-fired coil
- **Greywater**: Simple laundry-to-landscape system

Waste Management

- **Septic**: Conventional septic system or composting toilet
- **Greywater**: Constructed wetland or simple infiltration

Detailed Construction Methods

Foundation System

Frost-Protected Shallow Foundation (FPSF)

- Excavate 18-24" deep instead of 4 feet below frost line
- Install 2" rigid foam insulation horizontally extending 4 feet from foundation
- Build rubble stone foundation using local fieldstone set in concrete mortar
- **Stone selection**: Choose flat fieldstones 6-12" diameter, avoid round stones
- **Mortar mix**: 1 part Portland cement, 3 parts sand, add lime for workability
- Install French drain with 4" perforated pipe in gravel bed
- **Vapor barrier**: 6-mil plastic sheeting under slab, overlap joints 6"

Concrete Slab Construction

- Pour 4" concrete slab with 6x6 welded wire mesh reinforcement
- **Optional radiant heating**: Install 1/2" PEX tubing 12" on center before pour
- **Thermal mass enhancement**: Add dark aggregate or embed water-filled containers
- Float finish for durability, no need for fancy finishes

Advanced Framing Techniques

2x6 Advanced Framing (Optimum Value Engineering)

- Studs 24" on center instead of 16" (reduces thermal bridging)
- Stack framing: Align floor, wall, and roof framing members
- **Corner construction**: Use three-stud corners with insulation clips
- **Window headers**: Right-size headers, no cripple studs under headers on non-load bearing walls
- **Roof connection**: Use engineered lumber for long spans to reduce framing

Timber Selection and Preparation

- **Green lumber acceptable**: Will dry in place, expect some checking

- **Grade requirements**: Use #2 grade minimum for structural members
- **Moisture content**: Kiln-dried preferred but air-dried acceptable if locally sourced
- **Treatment**: Borate treatment for sill plates and bottom plates only

Roof System Details

Metal Roofing Installation

- **Ice dam prevention**: Install ice and water shield 3 feet up from eaves
- **Ventilation**: Continuous soffit and ridge vents for 1:300 ratio
- **Snow retention**: Install snow guards in zigzag pattern
- **Fastening**: Use pancake-head screws with EPDM washers every 12"
- **Overlap**: Side laps 1.5", end laps 6" minimum

Comprehensive Water Systems

Well Development

Driven Well (Sandpoint)

- Use 1.25" or 2" galvanized steel pipe with drive point
- **Installation**: Drive with fence post driver or hand maul
- **Depth**: Typically 20-40 feet in Marquette County glacial till
- **Casing**: Continue 2-3 feet into water-bearing sand/gravel
- **Hand pump**: Install Bison or similar deep-well hand pump as backup

Drilled Well Alternative

- 6" steel casing to bedrock, then 4" into bedrock
- **Expected depth**: 50-150 feet to reach adequate yield
- **Pump selection**: Submersible pump 1/2 HP typical for household use

Water Storage and Distribution

Pressure System

- **Pump**: 12V Shurflo or Flojet diaphragm pump (3-5 GPM)
- **Pressure tank**: 20-gallon pre-charged tank (40/60 psi settings)
- **Accumulator tank**: Additional 5-gallon tank to reduce pump cycling
- **Pressure switch**: Adjustable 12V DC switch

Storage Tanks

- **Primary storage**: 300-500 gallon polyethylene tank (food grade)
- **Location**: Insulated area of utility room or heated basement space

- **Backup storage**: 50-gallon gravity-fed tank for emergency use
- **Freeze protection**: Heat tape on exposed pipes, insulation wrap

Water Quality

- **Sediment filter**: 20-micron whole-house filter at pressure tank
- **Carbon filter**: For taste and odor improvement
- **Testing**: Annual bacterial testing, initial heavy metals testing
- **Treatment**: UV sterilizer if bacterial contamination present

Hot Water Systems

On-Demand Propane

- **Unit selection**: Rinnai or Takagi 6.6 GPM outdoor unit
- **Venting**: Direct vent through wall, no chimney required
- **Freeze protection**: Built-in freeze protection down to -30°F
- **Propane usage**: 100-200 gallons annually for family of 4

Wood-Fired Coil Alternative

- **Heat exchanger**: Stainless steel coil in firebox of wood stove
- **Thermosiphon system**: Natural circulation, no pumps required
- **Storage tank**: 40-gallon glass-lined tank with temperature relief valve
- **Backup**: Electric element powered by solar for summer use

Advanced Waste Management

Septic System Design

Conventional System

- **Septic tank**: 1,000-gallon concrete or plastic tank (minimum for 3-bedroom)
- **Distribution box**: Concrete or plastic with adjustable outlets
- **Leach field**: 300-400 linear feet of 4" perforated pipe in gravel beds
- **Soil requirements**: Percolation test required, 1-60 minutes per inch acceptable

Construction Details

- **Excavation**: Rent mini-excavator, hand-finish grades
- **Bedding**: 6" clean gravel under pipes, 2" over pipes
- **Fabric**: Filter fabric over gravel to prevent soil infiltration
- **Backfill**: Native soil, no rocks or debris, compact lightly

Alternative Systems for Poor Soil

- **Mound system**: For sites with high water table or poor percolation
- **Sand filter**: Recirculating sand filter followed by soil absorption
- **Constructed wetland**: Legal in Michigan with proper permits

Greywater Management

Laundry-to-Landscape

- **Collection**: Separate washing machine drain from other greywater
- **Distribution**: 1" poly pipe with valve box for zone control
- **Mulch basins**: Wood chip mulch basins around fruit trees/garden beds
- **Soap selection**: Use biodegradable detergents only

Kitchen and Bath Greywater

- **Simple system**: Route to mulch basins through 2" ABS pipe
- **Filtration**: Basic lint trap and grease trap
- **Winter operation**: Route to septic system when ground is frozen

Composting Toilet Option

Self-Contained Units

- **Sun-Mar or Nature's Head**: Self-contained composting units
- **Ventilation**: 12V fan exhausting through roof
- **Maintenance**: Empty finished compost 2-4 times per year
- **Winter operation**: Add heat source to utility room

Detailed Energy Systems

Solar Power Sizing and Installation

System Sizing Calculations

- **Daily load**: 8-12 kWh typical for efficient off-grid home
- **Winter production**: 3-4 hours effective sun in December
- **Array size**: 6-8kW to account for winter conditions and battery losses
- **Panel selection**: 400W monocrystalline panels (15-20 panels)

Installation Details

- **Mounting**: Rail-based system on metal roofing with snow load considerations
- **Orientation**: True south, 45-degree tilt (can adjust seasonally)
- **Spacing**: 3-foot spacing between rows to prevent shading

- **Wiring**: Series strings of 3-4 panels, combine with MC4 combiners

Battery Bank Design

- **Chemistry**: LiFePO4 preferred (10+ year life) or AGM if budget constrained
- **Capacity**: 800-1200Ah at 24V (20-30kWh usable storage)
- **Configuration**: 24V system for efficiency and wire sizing
- **Temperature**: Heated battery enclosure for winter performance

Charge Controller and Inverter

- **MPPT controller**: Victron or Outback 80-100A charge controller
- **Inverter**: Pure sine wave 3000-4000W with transfer switch
- **Monitoring**: Battery monitor with smartphone app for remote monitoring
- **Safety**: DC and AC disconnect switches, proper fusing/breakers

Backup Power Systems

Propane Generator

- **Size**: 5-7kW continuous output to handle peak loads
- **Fuel**: 500-1000 gallon propane tank for 3-5 day autonomy
- **Automatic start**: Generator starts automatically when batteries reach preset voltage
- **Maintenance**: Monthly exercise run, annual service

Micro-Hydro Potential

- **Site assessment**: Look for year-round stream with 10+ foot head
- **Turbine selection**: Pelton wheel for high head, turgo for medium head
- **Output**: 1-5kW possible with good site conditions
- **Integration**: Dump load controller to prevent battery overcharging

Year-Round Food Production

Attached Greenhouse Design

Passive Solar Greenhouse

- **Dimensions**: 24' x 8' attached to south wall of house
- **Foundation**: Stem wall 18" below grade for thermal mass
- **North wall**: Insulated with reflective material to bounce light
- **Glazing**: Double-wall polycarbonate for insulation and durability
- **Thermal mass**: 55-gallon water barrels painted black along north wall

Climate Control

- **Ventilation**: Automatically opening roof vents and side louvers
- **Heat distribution**: Fan to circulate warm air to house in winter
- **Cooling**: Evaporative cooling pad system for summer
- **Backup heat**: Small propane heater for extreme cold nights

Growing Systems

- **Soil beds**: Raised beds 30" wide with 18" deep soil mix
- **Hydroponic option**: NFT or deep water culture for leafy greens
- **Vertical growing**: Trellises for tomatoes, cucumbers, beans
- **Seed starting**: Heated propagation area with grow lights

Outdoor Growing Areas

Season Extension

- **Cold frames**: Simple hinged-lid boxes for early/late season crops
- **Row covers**: Floating row covers and low tunnels
- **High tunnel**: 12'x30' unheated hoop house for cool season crops

Permaculture Elements

- **Food forest**: Fruit trees (hardy apples, plums) with understory shrubs
- **Berry production**: Blueberries, raspberries, elderberries
- **Perennial vegetables**: Asparagus, rhubarb, perennial onions
- **Medicinal herbs**: Echinacea, ginseng, goldenseal (native to region)

Food Preservation

Root Cellar

- **Location**: North side of house, partially underground
- **Construction**: Concrete block walls, earth berms
- **Ventilation**: Natural ventilation to maintain 32-40°F, 85-90% humidity
- **Storage**: Wooden bins and shelves for potatoes, carrots, apples

Solar Dehydrator

- **Design**: Slanted glazing with dark absorber plate
- **Ventilation**: Natural convection through screened vents
- **Capacity**: Multiple removable trays for herbs, vegetables, fruits

Cost Updates with Food Production

- **Greenhouse addition**: $8,000-12,000
- **Growing systems**: $2,000-3,000
- **Food preservation**: $1,000-2,000
- **Updated total**: $76,000-117,000

This expanded design provides true food security and energy independence suitable for Michigan's challenging climate while remaining buildable by motivated novices with basic instruction.

Climate Considerations

Winter Design Features

- **Steep roof**: 6/12 pitch for snow shedding
- **Deep overhangs**: Protect walls from weather
- **Thermal mass**: Concrete floor or interior stone wall stores solar heat
- **Vestibule entry**: Prevents heat loss when entering
- **Storm windows**: Additional protection for harsh weather

Summer Comfort

- **Cross ventilation**: Windows on north and south walls
- **Roof ventilation**: Ridge and soffit vents
- **Shading**: Overhangs sized for summer sun angle

Cost Breakdown (Estimated)

Materials

- Lumber and framing: $15,000-20,000
- Foundation materials: $3,000-5,000
- Roofing and siding: $8,000-12,000
- Windows and doors: $6,000-10,000
- Insulation: $2,000-3,000
- **Total Materials**: $34,000-50,000

Systems

- Solar power system: $15,000-25,000
- Well and water systems: $5,000-8,000
- Septic system: $8,000-12,000
- Wood stove and chimney: $3,000-5,000
- **Total Systems**: $31,000-50,000

Grand Total: $76,000-117,000

Construction Timeline

- **Planning and permits**: 2-4 weeks
- **Site preparation**: 1 week
- **Foundation**: 2 weeks
- **Framing and roof**: 3 weeks
- **Exterior completion**: 4 weeks
- **Interior and systems**: 6-8 weeks
- **Total**: 4-6 months with weekend/evening work

Local Resource Connections

Materials

- Sawmills in Marquette County for lumber
- Local quarries for stone
- Building supply stores in Marquette for manufactured items

Labor Assistance

- Consider organizing barn-raising style work parties
- Partner with local technical college building programs
- Hire skilled trades for electrical and plumbing connections only

Maintenance Schedule

- **Annual**: Clean solar panels, check roof, service generator
- **Semi-annual**: Clean chimney, check battery system
- **Monthly**: Test backup systems, inspect foundation
- **Weekly**: Monitor water and power usage

This design balances cost, efficiency, and buildability while using materials that perform well in Michigan's climate. The simple rectangular shape minimizes heat loss while the centralized wood stove and passive solar design reduce heating costs significantly.