

Staying Warm Without Power

This is currently three separate fragments across the site: one-room heating gets a single bullet in the Energy & Heat chapter, hypothermia recognition lives in Sanitation & Medical, and carbon monoxide safety lives in Fire-Starting & Generator Safety. This guide is the one place that actually walks through staying warm, start to finish, cross-linking the other two rather than repeating them.

Layer correctly, since it does most of the work for free

Three layers, each doing a different job:

- **Base layer:** moisture-wicking material against the skin. Not cotton; wet cotton actively pulls heat away from the body instead of insulating it.
- **Insulating layer:** wool or synthetic fleece, which traps warm air close to the body.
- **Shell layer:** blocks wind and moisture from getting to the layers underneath.

A hat matters more than it sounds like it should: any uncovered skin loses heat, and once you're otherwise dressed in layers, your head is usually the largest patch of skin still exposed, not because heads are uniquely lossy the way the old "you lose 40-45% of body heat through your head" claim suggests, but simply because it's what's left uncovered. Stay dry; damp clothing or bedding pulls heat away far faster than dry material, even at the same temperature.

Pick one room, and seal it

1. Choose the smallest interior room with as few exterior walls as possible. A room with one exterior wall loses heat far more slowly than a corner room with two or three; an interior bathroom or closet-adjacent bedroom often beats a room that looks more comfortable but bleeds heat through multiple walls.
2. Close the door and hang a blanket over it as a second seal.
3. Cover windows with plastic sheeting or heavy blankets; this is one of the biggest heat-loss points in most homes. A shrink-film window insulation kit, sold at any hardware store, works better than a loose sheet: tape the film to the window frame with the kit's own adhesive tape, leaving about an inch of overlap on all sides, then run a hairdryer on low heat over it to shrink out wrinkles and pull the seal drum-tight. Done well, this alone can cut a room's heat loss by 10-30%.
4. Stuff towels or rolled blankets against the bottom of the door and any obvious drafts.

5. Move the whole household into this one room rather than trying to heat the house. Concentrating people and heat sources in one small space is far more effective than spreading the same heat across a larger area.

WARNING**A sealed room still needs fresh air if you're running a combustion heater in it**

Every sealing step above assumes the room is unoccupied by an open flame or fuel-burning heater; the moment a propane or catalytic heater is running in it, that changes. An oxygen-depletion sensor shuts the heater's gas off once oxygen falls to roughly 18% (normal air is about 21%), which is a safety backstop, not a substitute for ventilation, it doesn't prevent carbon monoxide from building up in an airtight room before that point. Keep a window cracked open at least an inch and the door to the rest of the house open whenever a combustion heater is running, per CPSC's own winter heating guidance; never run one in a fully sealed space, even with an oxygen-depletion sensor and a CO detector both present.

Aim to keep the sealed room at 68°F or above where you can manage it. Below roughly 65°F, sustained indoor cold raises real hypothermia risk for older adults and anyone with reduced mobility; below about 61°F, resistance to respiratory illness drops too. The World Health Organization sets 64°F as a general minimum indoor temperature and recommends 68-70°F for a room with an elderly or sedentary occupant specifically.

TIP**Protect the rest of the house's pipes while you're sealed in one room**

Leave a cold-water faucet in the coldest part of the house, often a kitchen or bathroom on an exterior wall, running at a slow trickle. Moving water is harder to freeze than still water, since a trickle keeps drawing in slightly warmer supply water instead of letting the pipe sit static. It also relieves the pressure that actually bursts a frozen pipe: freezing itself doesn't split the metal or plastic, the pressure trapped between the ice blockage and a closed faucet on the other side does. It costs a little water for real insurance against a repair that costs far more.

Insulate from the floor, not just the air

This is the detail most people miss. A hard floor, tile, wood, laminate, conducts heat directly out of a body in contact with it, regardless of how warm the air in the room is. Put down a layer of clothing, blankets, or a

Safe heat sources, and what's never safe indoors

Source	Safe indoors?
A propane or catalytic heater with an oxygen-depletion sensor and tip-over shutoff, used with a working CO detector	Yes, this is the standard safe choice for indoor emergency heat
Body heat, sleeping close together, or a small tent pitched inside the sealed room	Yes, and free; a tent creates an even smaller air volume to warm than the room itself
A fireplace or wood stove that's properly installed and vented	Yes, if the chimney/flue is already in good condition; see the seasonal chimney-sweep guidance in the Energy & Heat chapter
A gas range or oven	Never. Not designed for space heating; produces dangerous carbon monoxide levels
A generator, propane camp stove, or charcoal grill used indoors, in a garage, or near a window or vent	Never. Same carbon monoxide risk as running it in a closed room

Full detail on CO risk, detector placement, and generator safety is already covered in Fire-Starting & Generator Safety; this guide isn't repeating it, just flagging where it applies here specifically.

Sleeping warm

- A sleeping bag rated for the actual temperature holds heat far better than loose blankets, since it's a sealed shape rather than something that shifts and gaps overnight. Read the tag carefully: most bags print a "Limit" rating, the temperature at which an average sleeper can survive the night curled up without waking from cold, not a "Comfort" rating, which is the temperature an average cold-sensitive sleeper actually sleeps comfortably at. Buy 10-15°F below the coldest temperature you actually expect, and know the printed rating assumes a base layer of clothing and a sleeping pad underneath, not a bare or thinly padded floor.
- Keep a hat on overnight; heat loss doesn't stop when you're asleep.
- Everyone in the sealed room, together, concentrates body heat that would otherwise be lost to separate cold rooms.

Infants need extra care, not bed-sharing for warmth

Infants under one year old lose body heat much faster than adults and should never sleep alone in a cold room, but the right response is room-sharing, not bed-sharing: keep the infant's own crib or bassinet in the same room as an adult, not in the adult's bed, since bed-sharing raises the risk of suffocation and SIDS regardless of the cold. Dress the infant in one more layer than an adult would wear in the same room, and use a wearable sleep sack rather than loose blankets, which are a suffocation hazard in a crib. Check on them more frequently than an older child or adult in the same room.

Recognize the warning signs

Know the early signs of hypothermia, shivering that eventually stops, confusion, slurred speech, before they progress; full recognition and response steps are in First Aid Basics. Confusion or loss of coordination in a cold environment is a medical emergency, not something to wait out.

Sources

- CDC, winter storm safety and power outage guidance (never use a gas range/oven for heat, carbon monoxide risk): CDC; CDC
- CDC, infant susceptibility to cold and carbon monoxide: University of Washington DEOHS (CDC-sourced)
- One-room heating strategy, floor insulation, and catalytic heater safety features: PowerOutage.us; Popular Science
- CPSC, winter heating ventilation requirements and oxygen-depletion sensor mechanism: CPSC
- AAP, infant room-sharing (not bed-sharing) and safe sleep clothing guidance: HealthyChildren.org / AAP
- Window insulation kit technique and heat-loss reduction: ENERGY STAR
- Minimum safe indoor temperature for older adults and general WHO guidance: National Institute on Aging
- Sleeping bag Comfort vs. Limit temperature rating (ISO 23537): Backpacking Light
- Head heat-loss myth correction: Cleveland Clinic
- Dripping-faucet technique for preventing frozen pipes, and pressure buildup (not the ice itself) as the actual cause of a burst pipe: American Red Cross; Consumer Reports

Building a Jean Pain Compost Heat Mound

The Energy & Heat chapter's Tier 3 Biomass Processing item is about squeezing more usable heat out of a finite woodlot. This is a different way to do exactly that: a large mound of chipped wood that generates its own sustained heat through decomposition, with water-filled tubing coiled through it to pull that heat out as hot water. It's also a real option for extending Utah's short growing season, the same goal behind the Water & Food chapter's Greenhouse / Season Extension item; see Building a Walipini for a real passive-only design this mound can add active heat on top of. See Stirling Engines for the honest reality of trying to pull electricity back out of this mound as it cools, rather than just heat.

Where this comes from

The method is named for Jean Pain, a French innovator who built large compost mounds on his land in southern France through the 1970s. His own account, documented in his book *Another Kind of Garden*, describes a mound roughly 18 feet across and 9 feet high, built from around 50-60 tons of chipped brushwood, that produced 140-145°F water at close to a gallon a minute, continuously, for as long as 18 months. He used that hot water for washing, cooking, and heating his home, and separately fed some of the same chipped material into an anaerobic digester to produce methane for a generator, a stove, and his truck.

Treat Jean Pain's own numbers as a ceiling, not a guarantee

Those figures come from his own account, not an independent or peer-reviewed study. The best real-world replication found for this guide, a compost heat mound built at Western Michigan University's Gibbs House to heat a hoop house through winter, used a smaller mound (roughly 13 feet across, 6.5 feet high) and reached soil temperatures of 40-70°F, useful for season extension, but far short of Jean Pain's domestic-hot-water numbers. Other documented backyard-scale builds land in between: a roughly 6-ton test mound produced water around 85°F at a 2-gallon-per-minute draw (up to 112°F when the loop sat stagnant), and froze up partway through winter; a separate backyard builder reported 145°F for the first 4 days, settling down to a sustained 110-115°F after that. Mound size, chip quality, climate, and insulation all matter, and a smaller or less carefully built mound will produce less heat for less time. Plan around this realistic range, not Jean Pain's own best-case historical figure.

How it actually works

Microbes breaking down the carbon in wood chips release heat as a byproduct, the same reaction behind any hot compost pile, just deliberately scaled up and insulated to sustain it for months instead of weeks. A coil of tubing buried in the pile acts as a heat exchanger: water (or an antifreeze loop) circulates through the coil, picks up heat from the surrounding compost, and comes out the other end hot.

Component	What it needs to be
Feedstock	Chipped or shredded brushwood and small branches, not whole logs; a wood chipper is effectively required. A high carbon-to-nitrogen mix (wood chips) generates more sustained heat than a nitrogen-heavy mix (fresh manure or grass alone). It must be freshly chipped, green wood, not dried or seasoned: green wood runs close to 100% moisture content relative to a tree's dry weight, versus roughly 20% for seasoned wood, and that moisture and the still-active cambium underneath the bark are what feeds the microbial reaction. A pile built from seasoned or dried chips largely won't heat up at all.
Moisture	Damp but not soggy, roughly the wrung-out-sponge feel used for any hot compost pile. Too dry and microbial activity stalls; too wet and airflow drops, which also stalls it.
Chip volume needed	Wood chips run roughly 20 lb per cubic foot dry, up to 40-60 lb per cubic foot once saturated with water. Convert a target mound's length x width x height in feet, divided by 27, to get cubic yards of chips to source. A documented real backyard build used a 10x10x15 foot chip pile as its material source, a useful concrete anchor for what a serious build actually requires.
Mound size	Documented builds range from about 6 feet across up to Jean Pain's original 18-foot mound. Bigger mounds hold heat longer, since the pile's own mass insulates the hot core, but need proportionally more chipped material to build, and see the fire-risk sizing note below before building at the larger end of this range.
Heat-exchange tubing	PEX or CPVC, or the black polyethylene tubing commonly used for drip irrigation. Standard PVC is not a good choice here, see below. Plan on roughly 300 feet of 1-inch tubing for a mound with about a 7-foot radius, coiled with about 7 inches between each pass; a smaller or larger mound scales this length roughly with its coil surface area, not its overall volume.

Building it

1. Chip or shred brushwood down to a consistent, small size; this is the single biggest driver of how fast and how hot the pile heats up.
2. Build a rough frame (a cylinder of chicken wire and stakes, or a bamboo/wood form) to hold the pile's shape as you fill it.

3. Fill in layers, wetting each layer as you go, and coil the tubing through the pile as you build, starting near the base and spiraling upward with roughly 7 inches between adjacent coils, rather than trying to thread it through after the fact.
4. Cap and compact the outside of the mound to hold moisture and insulate the core; a finished mound should feel firm, not loose and airy.
5. Connect the tubing ends to your water system (a simple gravity-fed loop to a storage tank, or a pump loop) and give the pile one to two weeks to reach working temperature before expecting useful hot water.

WARNING

Large wood-chip piles have a real, documented fire risk, and it's in real tension with building one big enough to work

Spontaneous combustion in large compost and wood-chip piles is a well-documented hazard, not a theoretical one: internal temperatures above roughly 158°F meaningfully raise the risk, especially in piles that are large, dry on the outside while insulated and hot inside, or unevenly mixed. Standard fire-safety guidance for wood-chip and mulch piles calls for keeping any pile at least 15 feet from structures, fences, or anything else flammable, and for capping individual pile dimensions to roughly 4-6 feet high, 6-10 feet wide, and 10-30 feet long specifically to limit how much heat and flammable material sit in one contiguous mass. That's smaller than several of the mound sizes described above, including Jean Pain's own 18-foot mound, and there's no way around the tension: a mound built at that scale for maximum heat output is also a larger fire risk than standard guidance recommends for a wood-chip pile. If you build at the larger end of the size range above, treat the 15-foot clearance as non-negotiable regardless of pile size, monitor internal temperature if you can (a long compost thermometer is cheap), and keep the pile's moisture consistent rather than letting it dry out and reheat unevenly after rain; if you want to stay inside the standard fire-safety dimension caps, plan around the smaller, hoop-house-scale output described below rather than Jean Pain's own numbers.

Why not standard PVC

Standard PVC pipe is only rated for sustained use up to about 140°F, right at or below the temperatures this method is meant to produce, and heat exposure over time makes PVC brittle and prone to failure. PEX and CPVC both tolerate higher sustained temperatures and are the better choice for tubing that will sit inside a hot compost mound for months at a time.

The methane half: a separate, higher-hazard system

Jean Pain's full method also included feeding material into a sealed anaerobic digester to produce biogas (roughly 60% methane, 40% carbon dioxide, with trace hydrogen sulfide), which he burned for cooking, electricity, and vehicle fuel. That's a materially different and more hazardous project than the compost mound above: biogas is explosive in roughly 10-30% air concentrations, requires gas-tight construction, pressure relief, and monitoring, and needs spark-free equipment and no open flame anywhere nearby. This guide deliberately doesn't walk through building one; treat a home biogas digester as a distinct, advanced project requiring its own dedicated study, not an add-on to a weekend compost-mound build.

Sources

- Jean Pain's original design, output figures, and duration: Wikipedia, Jean Pain; Walden Labs; Jean Pain, *Another Kind of Garden*
- Modern build technique and dimensions: Midwest Permaculture
- Independent replication and real-world output (Gibbs House hoop house study): Western Michigan University, Gibbs House Compost Heat Recovery System report
- Spontaneous combustion risk in compost/wood-chip piles: BioCycle
- Pipe material temperature ratings: The Engineering Toolbox; FlowGuard Gold, PEX vs. CPVC
- Biogas composition and explosion/safety hazards: Farm Energy (eXtension)
- Pipe coil spacing and tubing-length sizing: Walden Labs; Mother Earth News
- Wood chip weight per cubic foot and a documented 10x10x15 foot chip-pile build: Cornell Small Farms Program
- Fire-risk clearance and pile-dimension caps for wood-chip and mulch piles: Safety Insurance
- Documented backyard-scale output figures (6-ton test mound and a second private build): Mother Earth News
- Green vs. seasoned wood moisture content: Wikipedia, Green wood

Building a Rocket Mass Heater

The Energy & Heat chapter's Tier 3 equipment list assumes a standard wood stove, professionally swept and ready for the season. A rocket mass heater is a different, far more fuel-efficient way to burn wood: a purpose-built combustion chamber followed by a thermal-mass bench that keeps radiating heat long after the fire is out. See Stirling Engines for a real way to pull a bonus of electricity out of this same fire while it's burning.

How it actually works

A rocket mass heater burns wood sideways in a J-shaped chamber, then forces the hot gas up through an insulated "heat riser" where it mixes with air and burns a second time, reaching roughly 1,300 to 2,400°F. That near-complete combustion is the whole point: almost nothing is left to condense into creosote further down the line. The hot exhaust then runs through ducting embedded in a large thermal mass, commonly a cob (clay-sand-straw) bench or a barrel-and-bench combination, that soaks up the heat and radiates it slowly for hours after the fire has burned out, rather than losing most of that heat straight up a chimney the way an open fireplace does.

The efficiency claim, and where it comes from

The design traces back to Ianto Evans and the Aprovecho Research Center, and the commonly cited figure, 80-90% less wood than a conventional wood stove for the same heat, comes from that original source lineage rather than an independent lab test of every build. Treat it as the honest claim behind the design's intent, not a guaranteed number for a first-time DIY build; a poorly sealed or undersized heat riser will burn less cleanly and heat less effectively than a well-built one.

What it's built from

Component	What it's typically made from
Burn chamber and heat riser	Fire brick or another refractory (heat-resistant) material able to hold up to sustained temperatures above 1,300°F
Barrel	A steel drum set over the heat riser, both radiating heat directly and acting as part of the ductwork into the mass
Thermal mass	A cob mix (clay, sand, and straw) built up around ducting, commonly shaped into a bench so the stored heat is also a place to sit
Chimney	A standard insulated flue is still required for the small amount of exhaust that exits after the mass has extracted most of the heat

Real dimensions: the ratios that decide whether it burns clean or smolders

The three chambers, feed tube, burn tunnel, and heat riser, aren't sized arbitrarily; a standard J-tube design keeps them in roughly a 1:2:4 ratio of feed tube to burn tunnel to riser height. A 6-inch system, the practical minimum riser diameter and the most common size for a first build, works out to roughly a 12-inch feed tube, a 24-inch burn tunnel, and a 48-inch riser; an 8-inch system scales the same ratio up. Keep the cross-sectional area consistent through all three chambers rather than narrowing or widening partway through, since a mismatched area is one of the most common causes of a smoky, incompletely-burning build.

The riser also needs real insulation, not just refractory mass, to actually reach the temperature that drives clean secondary combustion. Two proven approaches: pack a perlite-and-clay-slip mix (mixed to a milkshake consistency) into the gap between two concentric pipes, or line firebrick with a ceramic fiber insulation blanket at least 1 inch thick, 2 inches performs better. A half-inch layer is a common first-build mistake and isn't enough insulation to reach full combustion temperature reliably.

Sizing the exhaust run and keeping it clear of anything that burns

Match the exhaust ducting's diameter to the riser, 6 or 8 inches for the systems described above. As a rule of thumb, a 6-inch system supports roughly 35 to 40 equivalent feet of horizontal run before draft weakens too much to pull exhaust reliably; an 8-inch system supports up to about 50 feet. Subtract roughly 5 feet of that budget for every 90-degree elbow in the path, and keep the overall horizontal-to-vertical ratio around 1:3, a taller, hotter vertical chimney section buys more horizontal run elsewhere in the layout.

Clearance to anything combustible, framing, furniture, stored goods, isn't optional and isn't a single universal number. An uninspected, non-listed masonry heater generally needs 36 inches of clearance under NFPA 211 unless it qualifies for a reduced-clearance exception (down to 4 inches) by meeting specific masonry-thickness requirements, at least 8 inches of outer wall and 5 inches around the flue channel, verified by whoever inspects the build. Single-wall stovepipe sections of the exhaust run typically need 18 inches of clearance under WETT standards. Don't guess at this figure for your specific build; confirm it against the standard your inspector or building department is actually using.

The test burn: what "small" actually means and what you're checking for

Do a real test burn on the bare core, feed tube, burn tunnel, and riser, before enclosing any of it in the thermal mass. Light a small fire and let it come up to temperature, then watch the exhaust: once the system is properly warmed up, a clean-burning core puts out exhaust that's clear or shows only water vapor, a brief white puff in the first few minutes and again as the fire dies down is normal. Any persistent yellow- or blue-tinged smoke once the system has had time to warm up means something in the riser, insulation, or draft needs fixing before the mass gets built around it and makes that fix far harder to reach.

Building the thermal mass without cracking or steaming it

Build the cob mass in layers rather than all at once, a few inches at a time, letting each layer set up before adding the next; a mass built too fast in one wet mass traps moisture that has nowhere to go. Give the finished mass real dry time, commonly one to several weeks depending on thickness and climate, before the first full-intensity fire. A rushed first fire in a still-damp mass can crack the cob or, in a worse case, generate enough trapped steam to spall material off explosively; a slow initial fire with the damper or airflow kept moderate for the first burn or two is the safer way to dry it the rest of the way.

The legal reality: this isn't automatically a permitted heating appliance

A site-built rocket mass heater doesn't carry a UL listing the way a manufactured wood stove does, and it exists in a genuine gray area for a permanent, code-compliant installation. The real path, rather than assuming either "anything goes" or "it's illegal," is that a rocket mass heater can be classified and permitted as a masonry heater under the International Residential Code's R1002 provision, which references ASTM E1602, the standard guide for solid-fuel masonry heater construction. In practice, that means asking your local building department specifically for a masonry-heater permit citing R1002, and expecting the process to involve either an engineer's stamp, a formal inspection against ASTM E1602's mass and clearance

requirements, or sign-off from a licensed masonry-heater mason, not a standard wood-stove permit application. Meeting that standard's mass, clearance, and construction requirements is what gives a local building department something concrete to inspect and approve against; at least one documented case (Washington state, 2018) shows a rocket mass heater passing permit inspection through exactly this path. Skipping this step matters beyond the legal risk too: some insurers are reluctant to cover a home with an uninspected, non-standard heating appliance.

WARNING**Combustion safety still applies in full**

A clean-burning design reduces creosote and chimney-fire risk when built correctly, but it doesn't eliminate carbon monoxide risk from a leaky joint, a botched heat-riser seal, or backdrafting. Install a working carbon monoxide detector in the same room, mounted per the manufacturer's instructions and positioned within 21 feet of any bedroom door on the same floor, matching NFPA 72 and International Residential Code placement rules for any fuel-burning appliance, and have the finished build reviewed by someone experienced with the design, or a certified stove installer, before relying on it as a primary heat source.

Sources

- Design origin, mechanism, and efficiency claims: Wikipedia, Rocket mass heater; Ianto Evans and Leslie Jackson, *Rocket Mass Heaters*; Aprovecho Research Center
- Combustion temperature and clean-burn mechanics: Common Sense Home
- Masonry heater code classification and ASTM E1602: Masonry Heater Association; ASTM E1602
- Documented permit case: The Building Code Forum
- Carbon monoxide and creosote safety practices: permies.com
- J-tube feed/burn-tunnel/riser dimension ratios and minimum riser diameter: permies.com
- Heat riser insulation methods and thickness: permies.com; Green Life Homestead
- Exhaust duct sizing and maximum horizontal run: permies.com; permies.com
- Clearance-to-combustibles requirements and reduced-clearance masonry exception: permies.com; Cornell Legal Information Institute
- Test-burn procedure and what a clean burn looks like: permies.com
- CO alarm placement rules (NFPA 72 / IRC): Merrimack, NH Fire Department

DIY Solar Water Heater

The Energy & Heat chapter's Tier 3 Passive Solar Design item is about capturing the sun's heat without any powered equipment. Applied to water instead of a room, that same principle builds real hot water for washing, dishes, and hygiene, the kind of hot water the Bathroom & Hygiene Without Running Water guide assumes you'll need to heat some other way.

The simplest version: a solar shower bag

Before building anything, know the zero-construction version already exists: a black plastic solar shower bag, filled with water and left in direct sun for a few hours, works on the same principle as everything below and needs no tools at all. It's worth having a couple on hand as a Tier 1 stopgap even if you build a larger system.

A real build: the batch (ICS) heater

A batch heater, also called an ICS (integrated collector-storage) heater, combines the solar collector and the hot water storage into one insulated box. Cold water enters the bottom of a dark-painted tank or coiled tubing inside the box; sunlight passes through a glazed (glass or clear polycarbonate) lid and heats the dark surface; hot water rises to an outlet at the top. Ordinary household water pressure moves the water through the system, no pump, controller, or electricity required.

Component	What it's typically made from	
Collector/storage tank	A dark-painted metal tank (an old water heater tank works well, as long as its lining and any prior contents were potable-safe, never reuse a tank or drum that held fuel, chemicals, or anything non-food-grade) or a long coil of black polyethylene or PEX tubing	
Absorber coating	A high-temperature flat black paint, a silicone-based or selective coating rated for sustained collector heat, not ordinary spray paint	Flat finishes outperform gloss by several degrees since gloss reflects more light away instead of absorbing it
Enclosure	An insulated wooden box sized to the tank, insulated on the back and sides the same way a cooler is	
Insulation	Rigid foam board, extruded polystyrene (roughly R-5 per inch) or foil-faced polyisocyanurate (roughly R-6 per inch), 2 to 4 inches thick on the back and sides	
Glazing	Tempered glass, an old window, or clear polycarbonate sheeting on the sun-facing side	
Plumbing	Standard fittings tying the unit into the household's existing cold-water inlet and hot-water outlet lines, plus a check valve on the cold-supply line and a temperature-and-pressure relief valve on the tank itself	

Size the tank to the household's actual hot-water habit rather than guessing: a single batch heater built from a 40 to 80 gallon reused water-heater tank covers a typical household's daily hot-water draw for washing and dishes in good sun. Tilt the glazing to roughly your latitude, close to 40–41 degrees for most of Utah's Wasatch Front, angled south, for the most direct exposure across the year; a slightly steeper angle trades a little summer output for better results in spring and fall.

A well-built batch heater commonly reaches 110-160°F in good sun and can cover 70-90% of a household's hot water needs during peak summer months.

WARNING

A sealed tank tied into household plumbing needs real pressure and scald protection

This isn't optional hardware. A tank plumbed into a pressurized household water line and heated by the sun can build dangerous pressure with nowhere to go; fit a listed temperature-and-pressure

relief valve rated for the tank's working pressure, positioned to sense the top few inches of water, with its discharge piped safely away per normal plumbing practice, the same device a standard water heater already has. Water at the upper end of this design's range, 160°F, causes a real scald injury in under a second of contact; install a thermostatic mixing valve at the hot outlet to blend it back down to a safe delivery temperature before it reaches a shower or sink, rather than trusting the tank's own output temperature to stay in a safe range on its own.

Freeze protection: what "drain-down" and "antifreeze loop" actually mean

A drain-down system works by removing the water from the exposed collector entirely rather than trying to keep it from freezing in place: a valve, either a simple manual one you close for the season or an automatic one triggered by temperature or the absence of flow, lets the collector's water drain by gravity into an insulated indoor storage tank whenever the system isn't actively running or the temperature drops toward freezing. An antifreeze loop instead fills the collector permanently with a non-toxic propylene glycol mixture, the same type used in RV plumbing, that never freezes at outdoor temperatures, and transfers its heat to the household's actual drinking water through a separate heat exchanger rather than ever mixing the two. Either approach is a materially bigger build than the simple batch heater described above; for most households, planning to drain and store the unit before the first hard freeze and running it spring through fall is the more realistic option.

WARNING

This is a warm-season tool in most of Utah, not a year-round one, unless you build for winter

A simple batch heater is not freeze-safe. The tank and exposed plumbing sit outside, exposed to the same overnight cold as anything else outdoors, and a hard freeze can split a tank or pipe built for this design. Plan on draining the unit before a hard freeze, or simply treating it as a spring-through-fall supplement to your regular water heater.

Sources

- Batch/ICS heater design and mechanism: Alternative Energy Tutorials; Building America Solution Center (PNNL)
- Real-world output and seasonal coverage: SolarPoweredWaterHeaters.com
- Freeze protection requirements and drain-down/antifreeze-loop design: The Encyclopedia of Alternative Energy; WePowr; drainback mechanism detail: BuildItSolar

- Temperature-and-pressure relief valve requirements: UpCodes; International Code Council
- Scald risk and thermostatic mixing valve use: InterNACHI
- Reused tank potable-safety considerations: BuildItSolar
- High-temperature absorber paint selection: BuildItSolar
- Rigid foam insulation R-value by material: R-Value Associates
- Check-valve and backflow guidance for household plumbing tie-in: Energy Trust

Sizing a Solar Array & Battery System

The Energy & Heat chapter's Solar Generator and Off-Grid Solar Array items both say to size against real load, not marketed capacity. This guide is the actual method: four load tiers, the formulas behind each, and the one Utah-specific number that undersizes most first attempts at this. See Sizing a Fuel-Powered Generator for the same load tiers applied to a generator instead, and an honest comparison between the two.

Four load tiers, not one number

"How much solar do I need" doesn't have one answer, because a household typically wants several different levels of backup, and they don't scale the same way.

Tier	What it covers	What actually scales it
Whole house	Everything: full HVAC, all kitchen appliances, laundry, water heater, every outlet	The house itself: square footage, insulation, climate zone. Headcount matters far less than the building does.
House essentials (critical loads)	Fridge/freezer, a well or sump pump, a furnace blower, key lighting, internet	Also the house: a fridge or a well pump draws the same wattage whether one person lives there or five. A bigger household adds only a smaller secondary load from more hot water, laundry, and cooking.
Non-house essentials	A portable power station running medical equipment, radios, laptops, and charging	Headcount, closely. This is literally each person's own devices and needs.
Bare essentials (recharging only)	Phones, headlamps, handheld radios kept topped off, nothing else	Headcount, almost linearly. A family of five's bare-minimum tier is genuinely close to five times a single person's.

Why this distinction matters for sizing, not just planning

A single formula that scales every tier by household size will oversize your portable power station if you live alone, and undersize your critical-loads panel if you have a big family in a small, efficient house. Size the top two tiers against your actual appliances and square footage; size the bottom two against your actual headcount.

Sizing the panels

Panel wattage = daily Wh needed ÷ (peak sun hours × 0.75) × 1.1–1.2

The 0.75 factor covers real-world losses: wiring resistance, charge controller conversion, panel angle, dust, and heat all take a bite out of a panel's rated output. The 1.1–1.2 is a margin for degradation and bad-weather days.

WARNING

Size against your worst month, not the annual average

Salt Lake City averages 5.1 peak sun hours per day annually, but that swings from roughly 8.3 hours in June down to about 1.8 hours in December, more than a 4x difference. A system sized off the annual average works great in summer and does almost nothing in the exact winter storm outage this manual is built around. Always size the panel array against your local worst-month figure, not the yearly average.

Sizing the charge controller

The charge controller sits between the panels and the battery, regulating how the panels' power actually charges the bank, and it comes in two types worth knowing apart. A **PWM controller** is essentially a fast switch: its output amps equal the array's current regardless of what the panels are rated at in watts, and it only makes sense for small systems under about 300W where the panel voltage closely matches the battery voltage. An **MPPT controller** is a DC-DC converter that trades surplus panel voltage for extra current, harvesting roughly 10-30% more usable energy from the same array; use MPPT for any system over 500W or where the panel voltage runs meaningfully higher than the battery's.

Controller amps (minimum) = (total array watts ÷ battery charging voltage) × 1.25

Use the battery's actual charging voltage, not its nominal voltage, a 12V-nominal battery often charges closer to 14.4V; using 12V in the formula undersizes the controller by roughly 20%. A 1,600W array on a 24V bank, for example, needs $1,600 \div 24 = 66.7\text{A}$, $\times 1.25 = 83.3\text{A}$, so you'd buy a controller rated at least 100A. Also check the controller's maximum input voltage rating against your panels' actual open-circuit voltage in series: cold weather raises a panel's voltage output, sometimes 20% or more above its rated figure on a freezing morning, and exceeding the controller's input rating can damage it.

Sizing the battery

Battery Wh = daily load × days of autonomy ÷ usable depth of discharge

Depth of discharge changes this a lot by battery chemistry: LiFePO4 (lithium iron phosphate) can safely use about 85% of its rated capacity, while lead-acid or AGM batteries should only be drawn down to about 50%, meaning a lead-acid bank needs nearly double the rated capacity for the same usable power. Most home systems target 2-5 days of autonomy; lean toward the higher end in a cloudy winter climate. Cold temperatures also reduce a lithium battery's usable capacity, so an unheated garage or shed installation needs extra margin beyond the autonomy math alone.

Sizing the inverter

Size the inverter's continuous rating to the sum of everything you'd realistically run at once, and its surge rating to your single largest motor-driven load. A fridge compressor or a well pump can spike 3-7x its running wattage for a second or two at startup; an inverter that looks fine on paper for continuous load can still fail to start a well pump if its surge rating is too low.

Calculate your own numbers

Plug in your own figures below to run the two formulas above directly. This doesn't replace understanding the method, it just does the arithmetic; the exact formula used is shown with your numbers filled in.

Daily energy needed (Wh)

e.g. 3600

List each device you'd run, multiply its watts by hours used per day, and add them up. Find watts on the appliance's nameplate/label; if it only lists amps, multiply amps × 120V (or 240V for large appliances) to get watts.

Days of battery autonomy

3

Worst-month peak sun hours

e.g. 1.8

Look up your own address at NREL's PVWatts Calculator (a free, real government tool), then use the lowest "Solar Radiation" value shown across all 12 months, not the annual average, same reasoning as the Salt Lake City example above.

Battery chemistry

Lithium (LiFePO4), 85% usable



Calculate

Want an exact reading instead of an estimate?

A plug-in power meter (a "Kill A Watt" or equivalent, roughly \$20-30) gives you a real number for anything that plugs into a standard outlet: plug the meter into the wall, the appliance into the meter, and leave it connected a full 24 hours to read the accumulated kilowatt-hours, this captures a cycling load like a fridge far better than a nameplate figure or a guess at hours-used. Most of these meters cap out around 1875W, check that against the appliance first. For a hardwired 240V load that can't plug into anything, a well pump, electric dryer, or central AC, a clamp meter at the breaker (a one-time reading, or worth having an electrician do if you're not comfortable near an open panel) or a whole-home monitor like Emporia Vue or Sense, installed at the panel, gives the same kind of real, continuous number per circuit.

Real anchor numbers by tier

Tier	Typical figure
Bare essentials	Roughly 150-300Wh/day per person for phone charging, a headlamp, and a handheld radio; a household's absolute floor is often cited around 500-1,000Wh/day total
Non-house essentials	Roughly 2-5kWh/day for a household's first 72 hours running a power station for medical equipment, communication, and charging; higher if a CPAP or oxygen concentrator is in that mix
House essentials (critical loads)	Roughly 1-2kW continuous for a typical critical-loads panel, spiking to 3-4kW when a well or sump pump cycles
Whole house	Roughly 10-20kWh/day for an energy-conscious off-grid household, versus about 29kWh/day for a typical grid-connected U.S. household; a 5kWh/day site needs roughly 1.5kW of panels, a 20kWh/day site roughly 6kW

Sources

- Panel and battery sizing formulas, depth of discharge by chemistry: How to Go Solar; AltE Store
- Salt Lake City peak sun hours by month: TurbineGenerator.org
- Critical-loads panel tiers and typical draw: Palmetto; SunWatts
- Emergency/portable power station daily targets: Entropy Survival
- Whole-house off-grid daily energy figures: The Act of Thriving, Physical Foundation chapter (this site)

- Plug-in power meter accuracy and use: Wikipedia, Kill A Watt; P3 International
- Clamp meters and whole-home circuit-level monitoring: Energy Vanguard
- Charge controller sizing formula, MPPT vs. PWM, and cold-weather voltage rise: Renogy; PowMr Academy

Sizing a Fuel-Powered Generator

The Fire-Starting & Generator Safety guide covers not killing yourself or a lineworker with one; it doesn't cover choosing the right size. This guide is that sizing math: running watts vs. starting watts, real fuel consumption by type, and the honest tradeoff between a generator and the solar and battery alternative.

Start from the same load tiers

The four load tiers in the solar sizing guide, whole house, house essentials, non-house essentials, and bare essentials, apply here too; a generator gets sized against the same real numbers, not a different framework. What's different about a generator is the sizing math itself and the fuel behind it.

Running watts vs. starting watts

Add up the running watts of everything you'd realistically run at the same time, then add just your single largest starting (surge) watts on top, not every device's surge added together.

WARNING

Starting watts is where undersizing actually happens

A fridge or well pump's motor can spike 2-6x its running wattage for a second or two at startup. A generator sized only against running watts will stall or trip the moment that motor kicks on, even though it looked adequate on paper. Check the appliance's starting watts, not just its running watts, before sizing against it.

Target running the generator at roughly 50-80% of its rated capacity with 20-25% headroom above your calculated load, not near its maximum. As a rough real-world anchor: most households cover their house-essentials tier with a 5,000-7,500 watt portable unit; a true whole-house standby unit (central AC included) typically runs 12,000-22,000 watts.

A generator's rated wattage assumes sea level, and much of Utah isn't

Most portable generators lose roughly 3% of their rated output for every 1,000 feet of elevation above sea level, thinner air means less oxygen for combustion. At 6,500 feet, common in Utah's mountain valleys and higher canyons, that's close to a 20% real-world derating from the number printed on the box. Build that margin into your sizing if you live or plan to run a generator at elevation, rather than discovering the shortfall during an actual outage.

Calculate your own numbers

Plug in your own numbers to size against your actual load. This doesn't replace understanding the method, it just does the arithmetic; the formula is shown with your numbers filled in. If you can't find a real number for an appliance, the typical-wattage table below the calculator is a reasonable stand-in.

Total running watts (everything at once)

e.g. 1800

Add up the running watts of everything you'd have on at the same time. Check each appliance's nameplate/label; if it lists amps instead of watts, multiply amps × 120V (or 240V for a large appliance like a well pump or electric range).

Largest single device's starting watts

e.g. 2200

Check the manual for "starting watts," "surge watts," or LRA (locked rotor amps × volts). If it's not listed, estimate 2-3x that device's own running watts, a real, commonly-cited range for motor-driven appliances.

Target load percentage

65

Calculate

Want an exact reading instead of an estimate?

A plug-in power meter (a "Kill A Watt" or equivalent, roughly \$20-30) gives you a real running-watts number for anything that plugs into a standard outlet, and leaving it connected 24 hours reads real accumulated energy use too. Most cap out around 1875W, check that against the appliance first. For a hardwired 240V load, a well pump, electric dryer, or central AC, a clamp meter at the breaker (or an electrician, if you're not comfortable near an open panel) or a whole-home monitor like Emporia Vue or Sense gives the same real number per circuit. One caveat either way: these tools read average current, not a motor's true instantaneous starting surge, so for starting watts specifically, the manufacturer's spec sheet ("LRA," locked rotor amps, times voltage) is still the more authoritative number.

Typical figures for common appliances, use the real nameplate value when you can find one; these are reasonable stand-ins when you can't.

Appliance	Running watts	Starting watts
Refrigerator	~700W	~2,200W
Well pump	~1,000W	~2,000-3,000W
Sump pump	~800W	~1,300-2,400W (2-3x running)
Furnace blower	~800W	~1,600-2,400W (2-3x running)
Window AC, 5,000 BTU	~500W	~1,500W
Window AC, 10,000 BTU	~900W	~2,700W

Fuel type: a real tradeoff, not a clear winner

Fuel	Consumption (typical mid-size unit)	Shelf life	Tradeoff
Gasoline	~0.25-0.8 gal/hr depending on load and generator size	Starts degrading in as little as 30 days untreated; stabilizer extends this to roughly 12-18 months	Cheapest and most available fuel, but needs active rotation and stabilizer to stay usable in storage
Propane	~2-3 gal/hr at full load; burns about 20-25% more by volume than gasoline for the same output	Effectively indefinite if the tank and valves aren't damaged	The best fuel for long-term storage without maintenance, at the cost of needing more volume and a propane-rated unit
Diesel	~0.6-3.0 gal/hr depending on load and size	Degrades slower than gasoline but still benefits from a biocide/stabilizer in long-term storage	Most fuel-efficient and durable option, but generally the highest upfront equipment cost

A dual-fuel unit (gasoline and propane) trades a small amount of efficiency for real flexibility, useful if you're not sure which fuel you'll actually be able to resupply.

Inverter vs. conventional: a real difference for medical electronics

An inverter generator produces meaningfully cleaner power, generally under 3% total harmonic distortion (THD), compared to 5-10% or higher from a conventional generator. That's not a marketing spec; a CPAP, an oxygen concentrator, or anything else with a circuit board and a precision power supply is more vulnerable to that dirtier power than a simple resistive heater or incandescent bulb is. If the Access & Functional Needs chapter's medical equipment applies to your household, an inverter generator is the safer default, not just the quieter and more fuel-efficient one.

Getting power from the generator to what you're running

Without a transfer switch or interlock kit (see Fire-Starting & Generator Safety for why backfeeding a wall outlet is never the answer), you're running extension cords from the generator to individual appliances, and cord gauge matters more than it looks like it should. A standard 12-gauge cord is fine for a 20A circuit at distances under 50 feet, but push past 50 feet, or run anything close to 30A, and you need to step up to 10-gauge; a cord that's too thin for its load and length drops voltage and heats up, both real fire and

equipment-damage risks, not just an efficiency loss. As a working rule: 10-gauge for generator use in general, and mandatory at 30A regardless of length.

Portable vs. standby

A portable generator needs a person to deploy, fuel, and run it every time, and needs a transfer switch or interlock kit (see the Fire-Starting & Generator Safety guide) to power your house's circuits legally and safely. A standby generator auto-starts on its own transfer switch within seconds of an outage and needs no manual intervention, at a real cost: several times the price of a comparable portable, plus professional installation. Neither is the objectively right answer; it's a genuine budget-versus-convenience tradeoff.

Generator or solar and battery: an honest comparison

A generator gets you back to near-full power immediately and doesn't care about cloud cover or the time of year the way solar does. Its real limit is fuel: a finite, resupply-dependent resource in exactly the kind of prolonged disruption this manual plans around, and the same disruption that makes fuel harder to buy is often the reason you need the generator in the first place. Solar's limit is different: capacity and weather, not a supply chain, once it's installed, it keeps working for free as long as the sun does. Many households reasonably want both: a generator for fast, high-wattage recovery in the first days, and solar plus battery for the indefinite stretch after fuel runs out or becomes hard to resupply.

Sources

- Running vs. starting watts and generator sizing method: BigRentz; Batteries Plus
- Fuel consumption by type: GRETECH; Generator Source
- Gasoline vs. propane shelf life: Ferrellgas; TruePrepper
- Inverter generator power quality and THD: Anker SOLIX; Erayak Power
- Typical appliance running/starting watts: SizeMyHome; HVAC Base
- Plug-in power meter accuracy and use: Wikipedia, Kill A Watt; P3 International
- Clamp meters and whole-home circuit-level monitoring: Energy Vanguard
- Generator altitude derating (roughly 3% per 1,000 ft): Genesal Energy; Generator Bible
- Extension cord gauge selection for generator use: Vantecable

Pedal Power: Bicycle Generators

The Energy & Heat chapter's Bicycle Generator item names this as a way to charge small batteries when solar input is low. This guide is the real detail behind that: honest output numbers, a real commercial option, the DIY design that actually works, and a viral claim about this exact technology that's worth knowing is false.

Realistic output, mechanical and electrical

A person's own sustained mechanical output varies a lot by fitness and duration: roughly 75W or less for casual pedaling with no real effort, about 100W sustained for an hour from an untrained adult, 150-200W from a fit recreational cyclist, and up to 250W from a trained athlete over extended periods.

WARNING

Electrical output is meaningfully lower than mechanical output

Generator conversion losses mean 100W of pedaling might only yield 31-74W of actual electricity, depending on the system's efficiency. Any pedal-power plan built around the mechanical number rather than the electrical one will disappoint.

A real commercial option

The K-Tor Power Box (roughly \$200) delivers 20-50W of continuous, smooth DC output at a pedaling cadence of about 90rpm, consistent with the real-world losses above rather than the higher mechanical figures. Its intended use is charging small and medium gadgets: phones, tablets, cameras, radios, walkie-talkies, flashlights. K-Tor's own guidance is refreshingly honest: nobody sustains an hour of pedaling, they recommend 10 minutes several times a day instead.

Building your own: what actually works

A DIY build has three real parts: a stand to hold the bike stationary, a generator to spin, and a way to get that generator's output safely into a battery. Mount the bike on a bicycle trainer stand (the kind sold for indoor winter training) rather than improvising a frame, it's built to hold a bike rigid under real pedaling force. A car

alternator, salvaged or bought used, is the generator most DIY builds actually use, since it's cheap, durable, and already built to charge a 12V battery.

If building a DIY pedal generator, drivetrain choice matters more than most builders expect. A direct chain-and-sprocket drive from the pedals to the generator runs up to 98% efficient. A friction drive (a roller pressed against the tire) runs only 80-90% efficient, wears the tire quickly, and its efficiency varies with tire pressure, making it inconsistent as well as lossy. Build a direct chain/sprocket drive if you're building one at all: connect a chain from the bike's own rear sprocket (with the bike in its lowest gear) to a second sprocket welded or clamped onto the alternator's shaft, sized so a comfortable 60-90rpm pedaling cadence spins the alternator up into its efficient range, typically 1,000-3,000+ rpm depending on the specific alternator.

An alternator's own internal voltage regulator and diode trio already rectify its output to a clean 13.5-14.5V DC suitable for charging a 12V battery, which is a real reason to use one instead of a bare DC motor. Still wire a blocking diode and a fuse in series between the alternator and the battery: without the diode, the battery can drain backward through the alternator's windings whenever you stop pedaling, and the fuse protects the wiring if something shorts.

Does adding a flywheel increase output?

No, and it's worth being precise about why not: a flywheel cannot create energy, only conservation of energy applies here, the same physics problem behind the debunked claim below. What a flywheel actually does is smooth pedaling's naturally uneven, pulsed torque (much harder on the downstroke than the upstroke) into steadier rotational speed. That steadiness keeps the generator running in its efficient RPM range instead of constantly moving in and out of it; a real documented example uses sprocket sizing to turn a 60-100rpm pedaling cadence into 2,000-5,000rpm at the alternator shaft, right in a small alternator's efficient band. Net effect: less of your effort is wasted as heat and vibration, not more electricity from the same effort than physics allows. It also reduces peak stress on your legs and the drivetrain.

The claim that gets oversold

A viral pitch for a bicycle-generator product claimed "pedal for one hour and you have electricity for 24 hours." The real, documented output: about 120Wh from an hour of pedaling, averaging out to roughly 5W over a full day, enough for some phone charging and a few small lights, not a house. The hour of pedaling that produces it also burns roughly 550 kcal, a real cost nobody selling these mentions. Treat any bicycle-generator claim that doesn't specify actual watt-hours with real skepticism.

Pedal power or a small solar panel

For the same 20-50W of charging capacity, a small solar panel costs less than a \$200 purpose-built pedal generator and needs zero ongoing physical effort once installed. Pedal power's genuine advantage is working when solar can't: at night, during heavy overcast, or in deep winter when panel output drops, exactly the niche the manual's own equipment list already names.

Charging a thermal battery instead of an electrical one

Running pedal-generated electricity straight into a resistive heating element, rather than a battery, skips a real loss: converting electricity to heat through a resistor is close to 100% efficient, while charging a battery loses another 10-20% to round-trip inefficiency on top of the generator loss already at play. For heat specifically, resistor-to-thermal-mass is the more efficient path of the two. Skipping the generator and resistor entirely, using a direct mechanical friction heater instead, is more efficient still, since virtually all mechanical work against a resistive load becomes heat directly, though this means building a genuinely unusual DIY device rather than buying one.

WARNING

This is a trickle charge, not a fast one

Even at a generous 50W electrical output, an hour of pedaling delivers only 50Wh, enough to raise about 10kg of sand by roughly 20°F. This is a real, legitimate supplement to a thermal-mass system like a Jean Pain mound or a rocket mass heater's bench, not a fast or primary way to heat one.

Sources

- Sustained human mechanical power output by fitness level: Mapawatt; PedalPC
- K-Tor Power Box specifications and use guidance: K-Tor; Walden Labs
- Direct chain drive vs. friction drive efficiency: Low-Tech Magazine
- Flywheel smoothing and alternator RPM matching: Hackaday; Early Retirement Extreme Forum
- "Free Electric" bike claim, debunked with real output figures: Metabunk; Science for Sustainability
- Resistive heating efficiency and thermal-battery charging: Polar Night Energy, Sand Battery technical documentation
- DIY alternator-based bicycle generator build (trainer stand, sprocket ratio, diode trio, blocking diode): Appropedia; Practical Survivalist

Stirling Engines: Turning Stored Heat Back Into Power

Everything else on this site about wood stoves, the Jean Pain mound, and the rocket mass heater is about generating and storing heat. A Stirling engine runs the other direction: it turns a heat source, live or stored, back into mechanical or electrical power. Here's how it actually works, what it really produces, and why it behaves differently on a cooling thermal battery than on a fire you're actively feeding.

How it works, and its real advantage

A Stirling engine runs on external combustion: a sealed working gas is cyclically heated and cooled between a hot side and a cold side, and that temperature difference drives a piston. Because the heat source is external and never touches the working gas directly, a Stirling engine is genuinely fuel-agnostic, wood, propane, solar-thermal concentration, or waste heat from something else entirely all work, unlike a fuel generator locked to one specific fuel type.

Real efficiency, stated honestly

Small Stirling engines are commonly cited at 5-15% real-world efficiency, well below their theoretical Carnot-limit ceiling. Documented small builds have come in as low as 1-6% at modest input power. A better research example recovered heat from a source as cool as 70°C and produced 30-40W at about 14% efficiency. Know the temperature threshold before planning around one: most small hobby and DIY Stirling engines need a hot-side temperature difference of at least 150-300°C to run at any meaningful output, well above what a lukewarm surface or gentle heat source provides. A specialized "low-temperature-difference" design can start moving on as little as 15°C, but those are a different, more specialized engine, not what a typical kit or garage build uses.

WARNING

Precision machining is the real bottleneck

Seal friction, dead volume, and internal gas leaks kill a Stirling engine's efficiency faster than anything else. A well-made kit or commercial unit will meaningfully outperform a garage-built one for exactly this reason; this is a harder DIY build to get right than a pedal generator.

The realistic use case: combined heat and power

The practical application isn't a standalone power source, it's a bolt-on to heat you're already generating. If a wood stove is running 10 hours a day for actual heating anyway, adding a Stirling generator can realistically produce 50-100Wh of bonus electricity over that period: a genuine, worthwhile extra, not a primary power plan on its own.

Where to find it: ready-made commercial CHP-oriented Stirling units are genuinely rare, most manufacturers target natural gas or wood pellets rather than a standard wood stove. The RIGID RS1000 is one real example built for exactly this pairing, starting to generate once its hot chamber reaches roughly 180°C and producing up to 1kW electrical alongside usable hot water. Outside a purpose-built unit like that, this remains a genuinely harder DIY build than most others on this site, plan on a kit or a real machining background, not an afternoon project.

A more available comparison: thermoelectric generators

A thermoelectric generator (TEG), the Seebeck-effect technology behind BioLite-style camp stoves, does a similar job with no moving parts at all: typically 3-10W, commercially available today, simpler and more durable than a Stirling engine, at a lower practical ceiling. A Stirling engine has a higher theoretical output and can scale further, at the cost of real mechanical complexity a TEG doesn't have. For a simple, buy-it-today option, a TEG stove is the more practical starting point; a Stirling setup is the higher-effort, higher-ceiling path.

The thermal-battery caveat

A Stirling engine needs a sustained temperature difference to keep running, and a live, fed fire holds that difference steadily. A discharging thermal battery, a cooling Jean Pain mound, a cooling rocket-mass-heater bench, doesn't: output would decline as the stored heat runs down, the same way a candle dims as it burns rather than holding a constant brightness. Don't expect a Stirling engine paired with stored thermal mass to behave like a battery with steady voltage; it behaves like a fire dying down, because that's genuinely what's happening to the heat source underneath it.

Sources

- Stirling engine mechanism and fuel-agnostic external combustion: Physics Forums
- Real-world small Stirling engine efficiency figures: Solar Powered Project; DIY Solar Power Forum

- Combined heat and power use case and realistic daily output: off-grid cabin/RV Stirling CHP documentation
- Thermoelectric generator (TEG) output and BioLite-style stove comparison: Wikipedia, BioLite; Resilience.org
- RIGID RS1000 commercial CHP Stirling unit and startup temperature: RIGID
- Minimum hot-side/cold-side temperature difference for small and low-temperature-difference Stirling engines:
Real World Physics Problems