Refuge Ranch Infrastructure

Gemyndfoundation.org

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Core Physical Layout 1

- the heart of Refuge Ranch should remain recognizable — a place of healing, prayer, and restoration. The structure can be simplified, but not diminished in meaning:
  - **Central Chapel/Prayer Corridor**
    - At the heart, a simple but sacred place — open-air or with minimal materials (bamboo, adobe, local stone).
    - Stations of the Cross or Via Dolorosa imagery could be adapted with local art, making it culturally resonant.

Vision & Core Model

- Vision Statement
- • Refuge Ranch is a global network of self-sustaining sanctuaries integrating faith, agriculture, renewable energy, and education into one living system —where body, soul, and spirit are restored.
- Core Components • Spiritual Heart: Chapel + Stations of the Cross corridor; meeting space for worship, teaching, counseling.
- Sustainable Systems: Solar-top fence + vertical windmills; elevated tanks + irrigation; crops, orchards, spineless cactus; livestock and fish farms.
- Cottages & Villages: 400 sq ft homes, Kinkade-inspired charm, flowers, sidewalks, dignity in simplicity.
- Enterprise & Skills: Workshops (bookbinding, crafts, textiles, woodwork), global internet sales.
- Education & Training: Schools for children; adult training in farming, trades, leadership.
- Global Distinctives • Scalable: Start with 1–2 acres → grow to 10+ acres.
- Culturally Adaptable: Local plants, architecture, and art.
- Affordable: Built where costs are low and needs are high. •
- Connected: All sites linked as a worldwide fellowship of sanctuaries

Executive Summary 1

- Core Components
- Spiritual Heart: Chapel + Stations of the Cross corridor; meeting space for worship, teaching, counseling.
- Sustainable Systems:
- Solar-top fence + vertical windmills for power.
- Elevated tanks + gravity-fed irrigation.
- Crops, orchards, spineless cactus for forage/food.
- Animals: cattle, sheep, chickens, fish farms, hydroponics

Executive Summary 2

- Cottages & Villages: 400 sq ft homes, Kinkade-inspired charm, flowers, sidewalks, dignity in simplicity.
- Enterprise & Skills: Workshops (bookbinding, crafts, textiles, woodwork), internet-based global sales.
- Education & Training: Schools for children; adult training in farming, trades, leadership

Executive Summary 3

- Global Distinctives
  - Scalable: Start with 1–2 acres → grow to 10+ acres.
  - Culturally Adaptable: Local plants, architecture, and art.
  - Affordable: Built where costs are low and needs are high.
  - Connected: All sites spiritually and operationally linked

    a worldwide fellowship of sanctuaries

Core Physical Layout 2

- **Meditation Gardens:** *Note Middle East reclaimation of dessert***)**
  - Shade trees, simple benches, water features if possible.
  - Healing comes from nature, so keep gardens central, even if small.
- **Teaching/Community Pavilion**
  - Multipurpose open structure for Bible teaching, health education, skills training, school for children.
- **Healing Rooms**
  - Simple, quiet spaces — not high-tech, but spiritually rich.
  - Flexible for prayer, counseling, or even medical triage.

Core Physical Layout 2

- **God has revealed Himself through His Creation. Jesus prayed in a Garden for comfort.no**
- **Meditation Gardens:** *Note Middle East reclaimation of dessert***)**
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  - Healing comes from nature, so keep gardens central, even if small.

How Refuge Ranch Differs in Poorer Nations

- **Materials & Construction**
  - Local stone, bamboo, adobe, or earth blocks — sustainable and familiar.
  - Roofing with tin, palm fronds, or local equivalents.
  - Build with community labor, empowering ownership and reducing cost.
- **Scale**
  - Smaller footprint initially, modular growth.
  - Focus on essentials (water, food, chapel, gardens, teaching space) — expansions later.
- **Cultural Integration**
  - Local music, art woven into the design.
  - Use native languages for scripture engravings and murals.
  - Respect rhythms of life (e.g., market days).
- **Practical Supports**
  - Clean water systems (wells, cisterns, rain capture).
  - Food gardens and simple livestock pens — healing is body as well as spirit.
  - Basic medical outreach tied into the healing mission.

Ministry Dimension

- **Local Leadership**: Train indigenous pastors and lay leaders to shepherd the ministry.
- **Worldwide Connection**: Each Refuge Ranch abroad is spiritually connected to the whole network — a “fellowship of sanctuaries.”
- **Symbol of Dignity**: Even the poorest communities deserve beauty. The ranches must embody beauty and sacredness — showing God’s love through form, not just function.

Strategic Rollout & Impact

- **Local Leadership**: Train indigenous pastors and lay leaders to shepherd the ministry.
- **Worldwide Connection**: Each Refuge Ranch abroad is spiritually connected to the whole network — a “fellowship of sanctuaries.”
- **Symbol of Dignity**: Even the poorest communities deserve beauty. The ranches must embody beauty and sacredness — showing God’s love through form, not just function.

Agricultural & Food Sustainability

- Animals
  - *Cows*: milk, cheese, butter.
  - *Sheep/goats*: wool for crafts, milk alternatives, grazing for land management.
  - *Chickens/ducks*: eggs, pest control.
- Crops & Orchards.
  - Region-appropriate staples (rice, maize, cassava, wheat) + vegetables.
  - Fruit trees (mango, papaya, citrus, or apples/pears depending on region).
  - Flower gardens for beauty *and* **pollinator health**.
- Option: Fish Farms & Hydroponics
  - Tilapia or catfish ponds for protein.
  - Hydroponics/vertical growing for greens in places where soil is poor.
- Energy & Water
  - Solar panels and small wind turbines for irrigation pumps and lighting.
  - Subterranean Rain capture, wells, or drip irrigation to maximize water use.

Crafts, Trade & Income

- Craft Workshops
  - Textiles from sheep's wool, dyed with natural plants.
  - Wood carving, pottery, leatherwork.
- Digital Connection
  - Internet hubs for selling crafts, produce, and devotional materials.
  - Global market outreach: "Made at Refuge Ranch" — every purchase supports ministry

Barn for animals and farm machinery

- Sheep sheering.
- Horses.
- Cow milking.

Hydroponic greenhouses 1

- Water efficient
- Fast growing
- Hybrid development building
- Evaporative Air cooler

Hydroponic greenhouses 2

- 🌱 **1. Natural Pollination with Introduced Insects**
- **Bumblebees** are the most common choice in hydroponic greenhouses (especially for tomatoes, peppers, and strawberries). They are purchased and released inside the greenhouse where they work naturally.
- **Honeybees** are sometimes used, but bumblebees perform better in enclosed environments since they tolerate lower light and cooler conditions.
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- 🌬️ **2. Mechanical / Manual Pollination**
- **Air circulation fans** or gentle shaking of the plant support system mimic wind, loosening and spreading pollen.
- **Hand pollination** with a brush, cotton swab, or vibrating tool (similar to an electric toothbrush) is common in smaller-scale hydroponics or for specialty crops.
- Some hydroponic tomato growers use an **electric pollinator wand** to vibrate the flowers, releasing pollen.
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Hydroponic greenhouses 3

- 💡 **3. Environmental Control for Pollen Release**
- Proper **temperature and humidity** in the greenhouse are critical.
  - If humidity is too high → pollen clumps and doesn't release.
  - If too low → pollen dries out and loses viability.
- Ideal conditions: ~70–80°F with relative humidity around 60–70%.
-

- 🌼 **4. Self-Pollinating vs. Cross-Pollinating Crops**
- **Self-pollinating crops** (tomatoes, peppers, beans, peas) need only vibration or airflow to release pollen within the same flower.
- **Cross-pollinating crops** (melons, cucumbers, squash) may require bees or manual transfer of pollen from male to female flowers.

Education & Skills

- Schools for
- Primary & secondary education
  - in literacy, math, science, Bible. Digital Connection.
- Adult Training
  - Children from sheep's wool, dyed with natural plants.
  - Agriculture, crafts, trade skills.
  - Health & hygiene workshops.
- Faith & Formation
  - Bible teaching, worship, pastoral training centers.

Living Spaces

- Cottages Inspired by Thomas Kinkade
  - Simple, charming, human-scaled dwellings.
  - Local materials, pastel paints, flowering vines — dignity in simplicity.
  - Each home a sanctuary of its own, not just a shelter.
- Community Spaces
  - Shared kitchens or dining halls for fellowship.
  - Gardens & shaded paths lined with native trees.

Beauty as Ministry

- Flowers and trees chosen for climate (e.g., jacaranda, hibiscus, bougainvillea, or roses, oaks, maples where suited).
- Paths and courtyards lit by solar lamps.
- Every corner whispers: *God's beauty is here, even in the poorest places*.

The Refuge Ranch Difference (Worldwide)

- Not just a farm, not just a school, not just a chapel. Paths and courtyards lit by solar lamps.
  - It is all three — a *living, breathing parable* of God's Kingdom: food, beauty, worship, and community.
- **Dignity in design.** The cottages, the flowers, the animals — they testify that every soul, in every nation, is beloved.
- **Self-sustaining.** Rather than dependency, each Refuge Ranch becomes a hub of provision and hope.

Luther Burbank's Spineless Cactus: Highlights and Legacy

My Inheritance

- My grandfather owned a **400-acre gentleman's farm in Exton, Pennsylvania**, with an English manor house.
- From his library, I inherited a **complete set of Luther Burbank's works**.
- In those pages, I discovered Burbank's creation of a **spineless cactus** — a crop he believed could help **feed the world**.
- Yet, this remarkable plant **vanished from history**.
- Today, I share the story of its disappearance — and the vision for its **revival as a long-lost promise**.

What Burbank Achieved

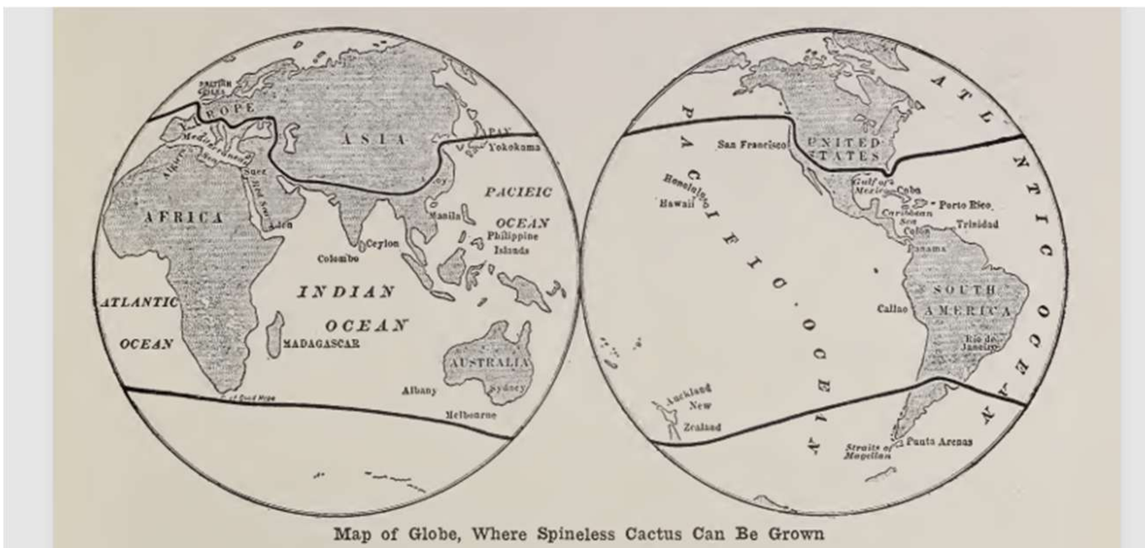
- Between **1907 and 1925**, Luther Burbank developed **over 60 varieties** of spineless cacti, hybridizing Indian fig (*Opuntia ficus-indica*) with Mexican prickly pear (*Opuntia tuna*).
- His goal? A cactus that could yield edible pads and fruit for humans, and serve as high-quality forage for livestock—transforming arid land into productive ground.

What went wrong

- Commercial success eluded the spineless cactus: while it was touted as a miracle feed, it had limitations. It required irrigation, and in harsh desert conditions, plants sometimes reverted to having spines—a natural defense.
- The **LOST MIRACLE.**

We can fix this: solution to world hunger

- Solar and wind irrigation and management, returns this to a fast growing fodder crop in the 21’st century



Map of Globe, Where Spineless Cactus Can Be Grown

Yield per day
0.27 tons per acre per day to
0.55 tons per acre per day

Luther Burbank's spineless cactus

Everlasting Influence: miraculously, there are surviving remnants

- Though Burbank's cactus never became the agricultural revolution he envisioned, some of his varieties—especially for pad production—are still grown today in places like Mexico
- Remarkably, original specimens he introduced remain preserved at Luther Burbank’s Home & Gardens in Santa Rosa. Further, his varieties were even sent to India, notably Meherabad, where a vigorous pad-producer thrives and may be the so-called “Texas Feeder” variant.

Opportunities for Refuge Ranch

- Given plans for sustainable agriculture and livestock feed—particularly in arid or semi-arid regions—Burbank's spineless cactus could be a powerful addition.
  - **Forage Solution**: Low-maintenance pads (thalli) could supplement cattle nutrition, especially where conventional feed is scarce.
  - **Human Food Source**: The pads and fruit are edible—offering both livestock and human consumption benefits.
  - **Resilient Landscaping**: These cacti can serve multipurpose roles—as living fences, erosion control, or artistic hedges.
  - **Heritage Cultivation**: Growing Burbank's spineless varieties could connect your project to a legacy of innovation and give your Ranch a unique story in branding.

Next Steps

- Identify Viable Varieties
  - Explore with botanical gardens or horticultural institutions like the Luther Burbank Home & Gardens or UC ANR for plant material or guidance.
- Field Trials
  - Test growth under your local climate. Assess yield, nutritional value, and livestock acceptance.
- Scale Appropriately.
  - If results are positive, integrate spineless cactus into your forage systems, perhaps near greenhouses or water-efficient irrigation zones.

Refuge Ranch Off-Grid Water System (Solar + Wind)

- How much water do we need?
  - **Crops (drip irrigation)**: 3–6 mm/day → **30–60 m^3 per hectare per day**
    (1 mm over 1 ha = 10 m^3)
    - **Livestock** (per head/day, warm climate):
    - Dairy cow: **40–60 L**
    - Sheep/goat: **5–10 L**
    - hicken: **0.2–0.3 L**
  - **Fish ponds**: replace evaporation + seepage (**2–10 m^3/day** for a modest pond). Remediation: covers to capture evaporation, surface barrier.
  - **Hydroponics**: net make-up is low (mostly recirculated), plan **1–3 m^3/day** per 100 m^2 grow area, water efficient.
  - **People (cottages, school)**: **50–100 L/person/day** (hygiene focused)

Pump power (right-size solar/wind)

- $P \approx \rho \cdot g \cdot Q \cdot H / \eta$
  - ρ (water) ≈ 1000 kg/m^3
  - $g \approx 9.81$ m/s^2
  - Q = flow (m^3/s)
  - H = total dynamic head (m)
  - η = overall efficiency (~0.45–0.60 incl. pump/controller/pipe losses).
- Handy examples (24 h equivalent):
  - **40 m^3/day @ 20 m head** → **~180 W** average
  - **60 m^3/day @ 30 m head** → **~410 W** average
  - **100 m^3/day @ 20 m head** → **~450 W** average

Architecture (simple + resilient)

1. **Source**: borehole/well, spring, or surface intake with coarse screen.
2. **Pump(s)**:
   - **Primary**: solar-direct **DC submersible** (brushless) with MPPT controller.
   - **Backup**: small **AC pump** on a VFD (can run from wind or generator).
3. **Headworks**: sediment cyclone + cartridge filters (and UV if for people).
4. **Storage**: **elevated tank** (steel/poly) sized for **2–5 days** of autonomy.
5. **Distribution**: gravity to fields via **pressure-regulated drip**, to troughs with float valves, to hydroponics/fish via dedicated lines.
6. **Controls**: tank **float switches**, dry-run protection, simple PLC or pump controller logic.
7. **Energy**:
   - **Solar**: roof/ground array near tank or well.
   - **Wind**: either **mechanical windmill (Aermotor-style)** for shallow wells **or** a small electric turbine feeding the DC bus.
   - **Storage strategy**: prefer **water storage** over big battery banks. A **small battery (1–2 kWh)** is plenty for controls/UV/lights.

Pilot layout (1 ha “starter” farm + small animal unit)

4) Pilot layout (1 ha “starter” farm + small animal unit)

Goal: ~**50 m^3/day** total (crops + animals + misc), **20–25 m head.**

- **PV array: 1.5–2.5 kW** (5.5 sun-hr/day typical → 8–14 kWh/day to pumps)
- **Wind (optional)**: 500–1000 W class, cuts cloudy-day risk
- **Pump**: 0.75–1.1 kW **DC submersible** (oversized so it can meet flow in ~4–6 hrs)
- **Storage: 100–150 m^3** (2–3 days at 50 m^3/day) in an **elevated tank** (8–12 m tower)
- **Filtration**: sand/media filter for irrigation, 20–50 µm cartridge; 5 µm + UV for kitchens/school
- **Irrigation**: 16–20 mm mainlines, **pressure-compensated drip** (1.0–2.0 L/h emitters); 2–4 zones
- **Livestock**: float-valve troughs; separate branch with coarse filter
- **Hydroponics/fish**: small dedicated loop with fine filtration and recirculation pumps on the low-voltage side

Result: The numbers above comfortably deliver ~50 m^3/day in sun hours, with stored water bridging nights and cloudy days.

Scaling recipes

5) Scaling recipes

- **Small node (village chapel + gardens):**
  - Water: **10–20 m^3/day**, head 10–20 m
  - PV: **0.6–1.2 kW**, Tank: **30–60 m^3**, Pump: **0.37–0.55 kW**
- **Community node (1–2 ha + animals):**
  - Water: **40–80 m^3/day**, head 20–30 m
  - PV: **1.5–3.5 kW**, Tank: **100–200 m^3**, Pump: **0.75–1.5 kW**
- **Regional hub (5–10 ha + school + processing):**
  - Water: **200–600 m^3/day**, head 20–40 m
  - PV: **7–20 kW** (split arrays), Tanks: **600–1500 m^3** (in multiple cells),
  - Pumps: **2–3× 2–3 kW** in duty/assist/standby, looped mains

Design choices for poorer regions

- **Favor gravity**: bigger tank, fewer pressure pumps.
- **Modular everything**: arrays, pumps, tanks, and drip blocks should add like Lego.
- **Local spare parts**: select emitters/valves/fittings available in-country.
- **Training**: quick visual SOPs for filter backwash, emitter flushing, algae control.
- **Security**: fence the array + well head; lock the pump panel.

Cactus (Burbank spineless) integration

- Plant **windward hedges** of spineless *Opuntia* as living fence + drought feed.
- Use **drip-at-base** (very low flow) for establishment; once mature, minimal irrigation.
- Locate near livestock lanes for easy pad harvest; compost pads for hydroponics nutrient make-up.

Quick Bill of Materials (pilot node)

- 2.0 kW PV (string-wired, MPPT pump controller)
- 1.1 kW DC submersible pump (SS body, sand-tolerant)
- 120 m^3 poly tank on steel stand (≈10 m head) + level switches
- Sand/media filter + 50 µm irrigation screen; 5 µm + UV for potable branch
- 400–600 m of 50–75 mm mains; 2–3 km of 16–20 mm drip laterals (per ha)
- Float-valve troughs; hose bibs; flush ends; air/vac valves on high points
- Small 24 V battery (1–2 kWh) + DC loads (controls, comms, UV)
- Optional 800 W wind turbine or mechanical windmill for shallow wells

Controls & protections (keep it idiot-proof)

- **Float high/low** in tank; pump stops at High, restarts at Low
- **Dry-run sensor** at well; **over-temp** on controller
- **Weekly auto-flush** of drip lines (solenoid manifold)
- **Color-coded valves** and laminated SOPs

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Solar-Top Fence (agrivoltaic perimeter)

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1) Geometry & clearances (beef/dairy cattle)

- **Fence height:** 1.5–1.6 m (5–5.5 ft) wire or rail.
- **Solar canopy height:** underside at **2.4–2.7 m** (8–9 ft) to prevent rubbing/reach.
- **Overhang:** 0.5–0.7 m each side of posts; tilt **10–15°** (south-facing in N. Hemisphere).
- **Bay spacing (posts):** 3.0–3.6 m (10–12 ft). Use **H-frame** braced bays every 5th bay and at corners.

2) Structure

- **Posts:** Galvanized steel pipe (e.g., 3–4" Ø, 11 ga) or schedule 40; set **~1.0–1.2 m** deep in concrete.
- **Rafters/purlins:** Galvanized C-channel or aluminum rails (solar racking).
- **Bracing:** Diagonal knee braces from post to rafter each bay; tensioned cable bracing on long runs.
- **Wind & hail:** Design to **120–140 mph** wind (Texas storms) and tempered glass modules; specify **mechanical test >5400 Pa** snow/wind equivalent.

Solar-Top Fence (agrivoltaic perimeter)

3) Modules & power math (rules of thumb)

- Typical 72/144-cell module: **~2.0 × 1.1 m = 2.2 m²**, **~430–560 W** STC.
- **Per linear meter:** one row of panels gives **~180–260 W/m** (depends on overlaps/gaps).
  - Example: modules mounted long side along the fence, 25–35 mm gaps.
- **Example system size:**
  - **500 m** of fence → **~90–130 kWdc**
  - **Annual energy (Texas): 1400–1750 kWh/kW/yr → 126–228 MWh/yr** (good DNV/TX average)

> Plenty to run pumps, lights, refrigeration, classrooms, and charge tools—plus irrigation.

4) Fencing beneath the canopy

- **Bottom fence:** 5–6 strand hi-tensile wire or woven wire + a **hot offset wire** at 0.6 m to stop leaning.
- **Predator/small stock lanes:** Add **1" x 2" welded wire skirt** to 0.6–0.9 m high if goats/chickens nearby.
- **Gates:** Use **double-swing H-frame gates** every 100–150 m for equipment access; put **flexible PV jumpers** overhead or bury DC conduit to cross the opening.

Solar-Top Fence (agrivoltaic perimeter)

5) Water + shade integration

- **Gutter on module low edge** → downspouts to **cisterns** or **stock troughs** (first-flush diverter on potable branch).
- Troughs with **float valves** placed at intervals (e.g., every 150–200 m).
- Shade line improves **animal heat comfort**; align fence where you want afternoon shade (west and south perimeters are valuable).

6) Electrical & code notes (keep it simple + safe)

- **String sizing:** keep < **600 Vdc** (or < 1000 Vdc if your AHJ/crew comfortable) to simplify O&M.
- **Rapid shutdown:** NEC 690.12 compliant module-level or row-level shutdown.
- **Grounding/bonding:** bonding jumpers across rails/bays; ground ring every ~90–120 m.
- **Conduit:** UV-rated EMT or PVC in **top rail** or **under eave**, drops down posts to buried conduit; **junction boxes** at H-frames only.
- **Lightning protection:** air terminal at corners/high points tied to ground grid.
- **Labeling:** durable placards at every gate/junction.

Solar-Top Fence (agrivoltaic perimeter)

7) Animal behavior / durability

- Keep **module glass ≥ 0.7 m outside** the vertical plane of the fence or above 2.4 m to avoid horn/ear contact.
- **Offset hot wire** stops rubbing.
- Place **mineral blocks** and scratch posts **away** from solar fence line.
- Use **rounded post caps** and eliminate snag points.

8) O&M

- **Walkway** inside fence for inspection.
- Panels at 10–15° mostly self-clean with rain; add **hose bib** every 100 m.
- **Quarterly**: check bolts, wire tension, emitter flushing if drip lines run nearby.
- **After storms**: quick visual pass; spare module stock ~1–2% for replacements.

Solar-Top Fence (agrivoltaic perimeter)

- **Double-row canopy (over lanes):** Place solar over **cattle alleys** or **track lanes**—more kW without shading crops.
- **Solar shade barns:** 3-sided loafing sheds with PV roofs near water points—great for dairy comfort.
- **Bifacial option:** If ground is light-colored gravel or white geotextile, bifacial panels can add **5–12%** yield.

10) Cost & phasing (high level)

- Structure + racking + modules + BOS: typically similar to carport PV on a per-kW basis, but **saves land** and **replaces fence cost**.
- **Phase build** by sides: start with **south and west** perimeters, then expand.
- Design for **module repeatability:** one bay drawing repeated 100×.

11) Add-on: crops & irrigation coordination

- Run **main irrigation header** parallel to the solar fence; tee to fields.
- Put **zone valves** at H-frames (easy to find/maintain).
- Use fence posts to mount **pressure regulators**, **filters**, and **remote nodes** (LoRa) for valve control.

Quickstart Pilot

Quick starter spec (for a first 200 m run)

- Posts: 3.5" galvanized, 10 ft long, set 4 ft; bays at 10 ft; H-frames every 50 ft + corners
- Rails: galvanized C-channel; knee braces each bay
- Modules: 500–550 W mono PERC, 10–15° tilt, single row continuous
- DC: strings of 10–14 modules (per inverter spec), <600 Vdc; MLPE for RSD
- AC: 208/240 Vac or 480 Vac depending on pump gear; line to pump house and clinic/school
- Water: 6" half-round gutter, 2" downspouts to 5,000–10,000 gal cistern; overflow to swales
- Fence: woven wire + one hot offset, 60–66" total height; predator skirt where needed

Output: ~36–52 kWdc, ~50–85 MWh/yr (Texas), enough to run a serious pump + campus loads.

Solar-Top Fence — Pilot Segment (200 m)

A) Performance at a Glance

- **PV Size (dc): ~40–55 kW** (depends on module choice; see layout)
- **Annual Energy (Texas): ~56–96 MWh/yr** (good sites)
- **Water Delivery: ≥ 50 m³/day** to **25 m head** (sun hours) with a **0.75–1.1 kW DC** pump + storage tank
- **Fence Function:** Full cattle barrier (woven wire + hot offset), shade line, rain catch to cisterns

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B) Geometry & Layout (repeatable bay)

- **Fence height:** 1.55 m (61") woven wire
- **Solar canopy soffit: 2.6 m** above grade (cows can't rub/reach)
- **Tilt: 12°** (south-facing); **overhang:** ~0.6 m each side of posts
- **Bay spacing: 3.05 m (10 ft)** post-to-post
- **Bracing:** H-frame every **5 bays** and at corners/gates; knee brace each bay

Module format (typical): 2.1 m × 1.1 m (500–550 W mono PERC)

- **Mounting:** long side parallel to fence line, one continuous row

Power density rule of thumb: ~200–260 W per linear meter

- For **200 m → 40–52 kWdc**

Solar-Top Fence — Pilot Segment (200 m)

C) Structure (materials)

- **Posts:** 3.5" galvanized pipe, 10 ft length, **set 1.2 m** deep in 250 mm dia. concrete
- **Top rails / purlins:** Galv. C-channel (e.g., 41×41×2.5 mm) or solar racking rails
- **Knee braces:** 1.5" galv. tube, welded/bolted to post & rail each bay
- **H-frames:** dual posts + crossbeam at corners and every ~15 m (5 bays)
- **Wind/Hail rating:** design for **120–140 mph** gusts; specify modules rated ≥**5400 Pa**

Fence fabric under canopy:

- 12.5-ga woven wire to 1.2–1.3 m, plus **offset hot wire** at ~0.6 m (standoff insulators)
- Predator skirt (welded wire 1"×2") to 0.6–0.9 m where needed

Gates: double-swing H-frame gates every **100–150 m**; route PV strings via buried DC conduit (no drooping cables over openings)

Solar-Top Fence — Pilot Segment (200 m)

D) Water Integration

- **Gutter:** half-round steel or formed aluminum along the module low edge
- **Downspouts:** every **12–15 m**, to **first-flush diverters → cisterns / troughs**
- **Main line:** buried 75–90 mm PVC/HDPE parallel to fence; zone valves at H-frames
- **Stock troughs:** float valves at ~150–200 m spacing (shade + water = happy cattle)

E) Electrical — Simple & Safe

- **Strings:** keep <**600 Vdc** for simplicity (e.g., **10–11 modules per string** if using 54–60 Vmp modules)
- **Combiner boxes:** at H-frames only; UV-rated junctions
- **Inverters:**
  - For pumps: **solar pump controller (MPPT) → DC submersible** (0.75–1.1 kW)
  - For AC campus loads: **2–3× 15–20 kW string inverters** (or one 50 kW if convenient)
- **Rapid shutdown:** module/row-level RSD per NEC 690.12
- **Grounding:** bond all rails; ground rods every **90–120 m** with #6 Cu ring; air terminals at corners
- **Conduit:** EMT on top rail or UV PVC under eave; drops at posts to **buried** conduit

Solar-Top Fence — Pilot Segment (200 m)

F) Pump & Storage (to 25 m head; ≥50 m^3/day)

- **Pump:** 0.75–1.1 kW **DC brushless submersible**, sand-tolerant, solar MPPT drive
- **Storage tank: 100–150 m^3** on **10 m stand** (2–3 days autonomy)
- **Filtration:** sand/media + 50 µm screen for irrigation; 5 µm + UV for potable branch
- **Controls:** tank high/low floats, dry-run sensor, auto-flush manifold on drip laterals

Why this works: Pump runs during sun hours (5–6 h), filling tank; gravity feeds fields/troughs all day/night. We store **water, not electrons**—cheaper and far more robust.

G) Cut List / BOM (pilot 200 m)

Steel & fence

- ~**67 posts** (200 m / 3.05 m + corners), 3.5" galv. pipe, 10 ft
- **Knee braces:** 1 per bay → **~64**
- **H-frames:** ~**14** (every 5 bays + 4 corners)
- Woven wire (60–66"), 200 m + 10% overage; 12.5-ga hi-tensile line & staples
- Offset insulators + hot wire kit (polywire or HT wire) for 200 m

Solar-Top Fence — Pilot Segment (200 m)

Solar

- **Modules:** 500–550 W × **~90–105** pcs (≈45–55 kWdc; pick exact brand, keep 5% spares)
- Rails/clamps: per module specs (end/mid clamps, splice bars)
- **Combiner boxes:** 3–4 (NEMA 4/4X)
- **RSD/MLPE:** row- or module-level per inverter choice
- **Inverters:** 2× 20 kW (or 1× 50 kW) for AC loads + solar pump controller (rated 1.5 kW)
- **Wiring:** PV wire 10/12 AWG, THWN-2 for homeruns, lugs, labels
- **Grounding:** rods, clamps, #6 Cu, exothermic weld kits as needed
- **Lightning:** 4 corner air terminals + down conductors to ground grid

Water

- **Gutter:** 200 m equivalent + brackets; downspouts ~16–18 pcs + first-flush kits
- **Pipe:** 75–90 mm mainline (200–250 m), laterals per field; valves, regulators, air/vac reliefs
- **Filters:** sand/media + screen; 5 µm cartridge + UV (potable)
- **Tank:** 100–150 m^3 poly/steel + 10 m stand, ladder, level switches
- **Pump:** 0.75–1.1 kW DC submersible + MPPT controller; check valve; safety rope

Misc

- Fasteners (hot-dip bolts), anchor concrete, post caps, signage, hose bibs every ~100 m

Solar-Top Fence — Pilot Segment (200 m)

J) Spineless Cactus Field Trial (along fence)

- **Row:** just outside fence shade, **1 m** spacing, **drip button 0.5 L/h** per plant for establishment (3–months), then minimal
- **Data:** monthly pad mass per plant, stock acceptance (palatability), regrowth rate
- **Use:** drought buffer feed + living fence; compost surplus pads for hydroponics nutrients

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K) What to hand your fabricator (now)

- This spec + a request for:
  1. **Shop drawings** of a 10-ft bay (post, knee brace, rail, module clamps, gutter detail)
  2. **H-frame detail** (corner and inline) with conduit/combiner mounting plate
  3. **Foundation schedule** (post hole size/rebar) for 140 mph wind
  4. **Bill of materials with cuts** and **installed cost/kW** & **$/m fence**

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

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Pilot: Solar-Top Fence — Locked Parts (Pump-First)

A) Targets (what this kit delivers)

- **Water**: ≥ **50 m^3/day** to an elevated tank at **~25 m head** (pump runs in sun hours; gravity feeds all day/night).
- **Power**: **Pump-dedicated PV ≈ 3.8 kWdc** now; **AC array** is optional expansion (same fence form factor).

B) Pump System (primary, no batteries)

Controller + Pump (matched kit)

- **Controller**: **LORNTZ PS2-4000** Solar Pump Controller (brushless DC, integrated MPPT)
- **Submersible pump** *(pick at order time based on well static level; both meet the target):*
    - Option 1 (centrifugal, higher flow / clean water): **LORNTZ PS2-4000 C-SJ5-12**
    - Option 2 (helical rotor, handles more head/solids): **LORNTZ PS2-4000 HR-23**
- **Borehole cable**: Submersible pump cable, UV/Water rated, **4-conductor**, sized per run (typically **AWG 10–12**)
- **Check valve** (SS/brass) + **safety rope** (poly/kevlar) + **well cap** w/ cable gland
- **Dry-run protection** sensor (well) + **tank high/low float switches**

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

C) Fence/Racking (for both pump and future AC arrays)

- **Posts**: Galvanized pipe **3.5" Ø**, 10 ft, set ~**1.2 m** deep in concrete
- **Bay spacing: 3.05 m (10 ft)**; **H-frames** every 5 bays and all corners/gates
- **Rails**: Galv. C-channel (e.g., 41×41×2.5 mm) or solar racking rails (IronRidge/Unirac class)
- **Knee braces**: 1.5" galv. tube, each bay
- **Module tilt: 12°** south; **soffit 2.6 m** above grade; **overhang** 0.6 m each side
- **Gutter**: Half-round steel/aluminum on low edge; downspouts every 12–15 m to cisterns/troughs
- **Fence fabric**: 60–66" woven wire + **offset hot wire** at ~0.6 m; predator skirt as needed
- **Wind/Hail spec**: Design **120–140 mph** gust; panels ≥ **5400 Pa** load rating

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

Pump-dedicated PV sub-array (fence-mounted)

- **Modules (exact family): LONGi LR5-72HTH-550M** (550 W mono PERC; 2.28 m²; 49–50 V_oc @ STC)
  (Canadian Solar HiKu7 550W or JA Solar JAM72S30-550 also acceptable equivalents.)
- **Quantity (pump array): 7 modules** (≈ **3.85 kWdc**)
- **Stringing (pump array): 7S1P** (seven in series, one string)
  - **Cold-weather check** (Texas worst case, −10 °C delta ≈ +12% Voc):
    7 × 50 V × 1.12 ≈ **392 Vdc** → within **PS2-4000** input range
  - **Operating Vmp** ≈ 7 × 41 V ≈ **287 Vdc** (ideal for the controller)
- **Disconnect:** 600 Vdc, 2-pole, NEMA 4X, lockable
- **Wiring**: PV wire **10/12 AWG**, MC4-type, home-run in UV EMT/PVC to controller
- **Grounding:** #6 Cu bonding of rails; ground rod near controller & at fence corners

Filtration & Storage (to match the pump)

- **Tank: 100–150 m³** (poly or corrugated steel) on **~10 m** stand; ladder + level gauge
- **Irrigation filter set:** media/sand filter + **50 µm** screen; **5 µm** + **UV** on potable branch
- **Main:** 75–90 mm HDPE/PVC from tank; zone valves at H-frames

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

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Pilot: Solar-Top Fence — Locked Parts (Pump-First)

D) Optional Expansion: AC Array for Campus Loads (same fence form factor)

(Add when you want clinic/school power, refrigeration, tools, etc.)

- **Inverters (choose one path):**
  - **SMA Sunny Tripower CORE1 50-US** (50 kW, 1000 Vdc) **or**
  - **Fronius Symo 24.0-3-480** (24 kW, 1000 Vdc); add units as you grow
- **Strings (1000 Vdc class): 18 modules per string** typical with 550 W modules
  - Voc cold check: 18 × 50 V × 1.12 ≈ **1008 V** → OK for 1000 Vdc gear (confirm exact module Voc)
  - Vmp ≈ 18 × 41 V ≈ **738 V** (in MPPT window)
- **Rapid shutdown**: Module- or row-level RSD (NEC 690.12), e.g., Tigo TS4-A-F or equivalent
- **AC**: 480 Vac 3-phase preferred for pumps/long runs; otherwise 208/240 Vac as site dictates
- **Grounding/Lightning**: Bond rails; ground rods every 90–120 m; air terminals at corners

Tip: If you want to stay <**600 Vdc** everywhere, use more/shorter strings (e.g., **10 modules/string**) and inverters rated for 600 Vdc DC inputs; it reduces string length at the cost of more homeruns/combiners.

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

E) "First 200 m" Population Plan

- **Immediately install:**
  - Pump sub-array **(7 modules)** on the fence near the pump house
  - PS2-4000 controller, pump, tank, filters, mains, troughs
- **Pre-wire for growth:**
  - Rails and wire clips along the 200 m line
  - Empty combiners at H-frames (labeled)
  - Conduits stubbed for future AC inverters at the equipment pad
- **Later**: add **strings of 18** along the fence until you reach desired AC kW

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

F) Locked Module/Balance SKUs (examples)

- **Modules**: LONGi **LR5-72HTH-550M** (or Canadian Solar **CS7N-550MS**, JA Solar **JAM72S30-550**)
- **Racking**: Unirac/IronRidge rail + mid clamps (30–40 mm frame) + end clamps, splice bars
- **DC switches**: IMO or Littelfuse 600/1000 Vdc PV disconnects (NEMA 4X)
- **Combiner**: NEMA 4/4X 6–12-in input with touch-safe fusing (Mersen/Littelfuse)
- **RSD** (AC array only): Tigo **TS4-A-F** (one per module) + CCA/TAP, or equivalent

(Brands are interchangeable in class; pick what your distributor stocks fastest.)

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

G) Stringing Tables (ready to drop into drawings)

Pump Array (now)

- **Array:** 7 × 550 W = **3.85 kWdc**
- **Layout: 7S1P** (one string of seven) → **DC disconnect → PS2-4000**
- **Voc (cold)** ≈ 392 V; **Vmp (oper.)** ≈ 287 V

Future AC Array (example)

- **Per string: 18S1P** (18 modules in series)
- **Per 20 kW block: 3 strings** (≈ 18 × 0.55 kW × 3 ≈ **29.7 kWdc** DC-to-AC ratio ~1.5 is fine)
- **Homeruns** from H-frames to inverters in buried conduit; label each bay

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

H) Commissioning Checklist (pump system)

1. Megger test pump cable; verify polarity/insulation.
2. Set **dry-run** threshold; confirm well recovery rate > pump draw.
3. Verify **float switch** logic (Low = start; High = stop).
4. Record **open-circuit PV voltage** and **operating current** at noon; log to O&M sheet.
5. Fill tank; confirm gravity pressure at farthest trough/zone.
6. Flush filters/lines; set irrigation **pressure regulators**.
7. Train caretaker: weekly emitter flush; monthly filter backwash; storm inspection SOP.

Pilot: Solar-Top Fence — Locked Parts (Pump-First)

I) Minimal Cut Sheet (for fabricator)

- **Bay**: 3.05 m post spacing; 12° rafter angle; soffit 2.6 m; 0.6 m overhang both sides
- **Post**: 3.5" Ø × 10 ft; embed 1.2 m in 250 mm dia. concrete
- **Bracing**: knee each bay; H-frame every 5 bays & corners (with combiner/inverter plates)
- **Gutter**: low edge of modules; downspouts every 12–15 m to cisterns/troughs