CONCEPT DESIGN PACKAGE

Tiger Mountain Foundation

Container Farm Resilience Concept Design

Passive pilot design, solar feasibility, and build-vs-buy planning for year-round greens and herb production at MAC6

Prepared for	Tiger Mountain Foundation / ASU EPICS Summer Design Program
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Date	June 2026
Status	Concept design for stakeholder review; not construction documents

Recommended first-build posture: passive thermal control, water-path protection, basic instrumentation, and solar-ready electrical planning before expensive active cooling.

Executive Summary

CORE RECOMMENDATION

Run two tracks: build a measured, passive-first pilot now, while treating any full commercial container farm as a separate vendor quote, utility review, and grant-scale procurement decision.

The stakeholder need is best framed as a MAC6 container-farm feasibility problem. Tiger Mountain needs year-round greens and herbs, protected root-zone temperatures, lower water waste, and a system that can survive Arizona heat without pretending that a student pilot and a commercial container farm are the same budget category.

This package recommends a practical first build: shade the water path, add a first-flush bypass, use a shaded buffer reservoir, monitor temperature and pH/EC, and pilot one greens/herbs module. That pilot buys evidence. It does not lock Tiger Mountain into custom-building a full controlled-environment container farm from scratch.

In parallel, Tiger Mountain can evaluate a commercial turnkey option such as a Pure Greens-style container farm as a grant or capital procurement path. That path requires vendor pricing, utility/load review, installation requirements, warranty/service review, and operator training commitments before it should be treated as a final recommendation.

Recommended Design Package

Priority	Subsystem	Design intent
1	Thermal water path	Shade/insulate exposed hose and supply lines, add first-flush bypass, route water through a shaded buffer tank, and monitor root-zone temperature.
2	Hydroponic module	Use leafy-green channels/racks where they fit; use drip-fed buckets or beds for larger vine crops such as squash. Do not force every crop into one hydroponic geometry.
3	Cooling envelope	Use 30-40% shade cloth as the baseline protection layer, then add ventilation or evaporative cooling only where measured temperatures justify it.
4	Solar-ready loads	Meter pump, fan, control, and any lighting loads before sizing panels. Solar should support the measured system, not compensate for vague equipment choices.
5	Procurement decision gate	Compare the pilot path against a quoted commercial turnkey system only after site utilities, operating cost, warranty, and funding source are known.

Basis: UA Cooperative Extension recommends summer shade cloth for low-desert Arizona production; Arizona Solar Center estimates a south-facing 1 kW PV array in Phoenix at 10 degrees tilt produces about 1,600 kWh/year.

What This Delivers

- A credible path from current hose-and-container constraints to a monitored growing system.
- A procurement plan that explains what each purchase proves.

- A decision framework for when active water cooling is justified and when it is overkill.
- A build-vs-buy framing that separates a near-term pilot from a grant-scale commercial container.
- A scalable architecture that can start with one bed zone and expand into additional modules.

Project Context and Problem Framing

The EPICS design prompt identifies three major issues: solar power feasibility for a container-based hydroponic system at MAC6, year-round greens/herb production layout and workflow, and passive/active cooling strategies for container agriculture under extreme heat. Interview notes also flag hot hose water, water waste, plastic exposure in heat, shade needs, summer crop stress, and a desire for durable systems over short-lived cheap fixes.

Problem Statement

DESIGN PROBLEM

How can a container-based hydroponic system at MAC6 be designed for year-round greens and herb production using solar-supported infrastructure while maintaining suitable root-zone and canopy conditions during extreme heat and remain scalable for future expansion?

Known Inputs from Discovery

Community role	Produce supports traditionally low-income communities, farmers markets, and community food access.
Current pain	Hot standing hose water and inefficient watering lead to waste before cooler water reaches plants.
Crop notes	Official scope centers year-round greens and herbs; discovery notes also mention brassicas, arugula, mustard, turnips, radishes, and squashes.
Site condition	Arizona heat requires shade, cooling strategy, and durable materials that can survive UV exposure.
Client preference	Long-term maintainability and durability should be favored over the cheapest possible first purchase.
Open data gaps	Final MAC6 layout, budget cap, electrical loads, water test results, exact greens/herbs crop mix, and operator capacity remain unresolved.

Design Assumptions

- The first implementation should be sized as a pilot that can expand, not as a full commercial container farm on day one.
- A full turnkey container farm should be treated as a separate capital procurement path, not as the expected outcome of the pilot BOM.

- As noted in the client interview, the system should avoid permanent dependence on specialty labor for routine operation.
- Food-contact components should be food-safe and UV-resistant; burlap or fabric cooling should remain exterior/removable, not inside the nutrient stream.
- Any grid-tied solar or permanent electrical work should be handled by qualified installers and follow local code.
- The phrase 'water cooling' should mean root-zone temperature management first, not automatically a refrigerated chiller.

Proposed System Architecture

The proposed architecture separates the system into layers so the team can improve plant survivability without making every decision dependent on one expensive component. Water path, crop loop, cooling envelope, and electrical loads can each be piloted and upgraded independently.

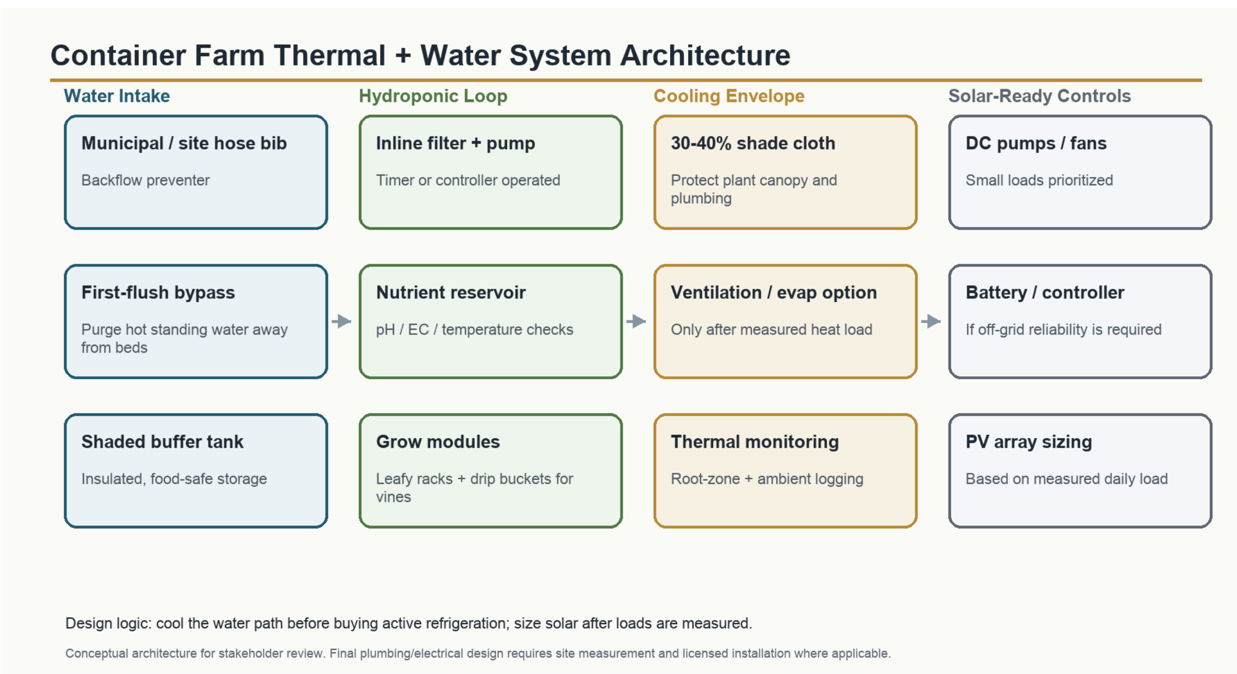

Figure 1. Conceptual system architecture prepared for this design package.

Architecture Rationale

Layer	Why it matters	Primary elements
Water intake	Controls hot standing water before it reaches plants.	First-flush bypass, shaded hose routing, backflow prevention, buffer tank.
Hydroponic loop	Creates a repeatable plant-production system rather than manual ad hoc watering.	Pump, filter, nutrient reservoir, pH/EC/temp checks, crop-specific modules.
Cooling envelope	Reduces heat gain at the source before	Shade cloth, reflective/insulating treatment, ventilation,

Layer	Why it matters	Primary elements
	adding electrical load.	optional evaporative cooling.
Solar-ready controls	Keeps electrical scope honest and expandable.	Measure loads, prioritize DC pumps/fans/controllers, size PV after usage is known.

Cooling and Water-Temperature Strategy

The stakeholder concern about hot hose water is directionally valid, but the solution should be proportional. Standing water in an exposed hose can become hot enough that it should be purged before reaching roots. That does not mean the first purchase should be a refrigerated water chiller.

UC Agriculture and Natural Resources advises checking hose-water temperature before it reaches roots because garden hoses can retain serious heat during heatwaves.

Passive-First Cooling Stack

Tier	Strategy	Design action	Timing
Tier 0	Operating practice	Water early; purge hot standing water through a first-flush bypass; avoid sending the first hot slug into grow beds.	Immediate
Tier 1	Shade and insulation	Install 30-40% shade cloth over exposed plants/plumbing; shade or insulate hose runs and reservoir; avoid black thin plastic where possible.	First build
Tier 2	Ventilation / evaporative assist	Use fans, wet-wall/media, or low-pressure misting only where airflow and humidity make it useful.	After measurements
Tier 3	Active water chiller	Use only if logged reservoir/root-zone temperatures remain outside target range after passive controls.	Conditional

UA Cooperative Extension recommends shade cloth in summer for low-desert Arizona production; UCANR suggests 30-50% shade cloth for container plants during heatwaves.

Why Not Buy the Chiller First?

- A chiller adds capital cost, electrical load, maintenance, and failure points.
- If the main problem is hot standing water in exposed hose, a flush bypass and shaded buffer tank solve the first-order issue cheaper.
- If the container itself overheats, cooling the water alone will not protect canopy temperature, worker comfort, or plastic degradation.
- A chiller may still be justified later, but only after logged temperature data shows passive controls are insufficient.

CONTROL TARGET

Track root-zone/nutrient solution temperature, ambient temperature, and plant response for at least two hot weeks before committing to active refrigeration. The system should be judged by measured root-zone stability, not by whether it looks mechanically impressive.

Hydroponic Growing System

The formal scope centers greens and herbs, which are a good fit for compact hydroponic production. Discovery notes also mention larger or root crops; those should be treated as secondary/future modules rather than forcing every crop into the same container layout.

Recommended Crop-Zone Layout

Crop type	Recommended module	Reason
Greens / herbs	NFT channels, shallow raft/DWC, or vertical rack modules	Best fit for the official scope; efficient space use and repeatable harvest cycles.
Brassicas / arugula / mustard	Leafy channel or raft modules with crop-specific spacing	Works if canopy spacing and heat/bolting risk are managed.
Radishes / turnips	Media beds or deeper grow containers	Root crops need physical media depth and spacing; they are not ideal for thin NFT channels.
Squash / vine crops	Future drip-fed Dutch buckets, grow bags, or beds with trellis support	Secondary only; heavy plants need root volume, structure, and access.
Pilot strategy	Start with one leafy/herb production module plus water-path controls	Demonstrates the core MAC6 scope while keeping the first build maintainable.

Water Quality and Monitoring

Hydroponics succeeds or fails around the root environment. The minimum professional monitoring package should include pH, EC, dissolved oxygen or aeration status, nutrient solution temperature, and source-water testing.

MU Extension identifies pH, EC, dissolved oxygen, temperature, and alkalinity as parameters to monitor/manage in hydroponic nutrient solutions; Oklahoma State Extension lists crop-specific pH/EC ranges.

pH	Target range depends on crop; soilless nutrient solutions are commonly maintained near pH 5-6 before root-zone effects.
EC	Crop-specific nutrient strength; leafy greens generally require lower EC than heavy fruiting crops.
Dissolved oxygen	Maintain aeration, especially in warm water; warm solution holds less oxygen and increases disease risk.
Temperature	Measure at the reservoir and near the root zone; use data to decide whether passive cooling is enough.
Source water	Test alkalinity and mineral profile before final nutrient recipes are selected.

Container Material Guidance

- Use food-grade, UV-stable reservoirs and tubing for the nutrient stream.
- Use shade, insulation, or exterior wraps to reduce heat load; do not place burlap or non-rated materials in direct contact with nutrient water.
- Prefer modular components that can be cleaned or replaced without tearing apart the whole system.
- Label shutoff valves, flush ports, and sensor points so volunteers can operate the system safely.

Solar and Electrical Strategy

Solar should be designed around actual loads, not guesses. The first electrical task is to list every powered component, estimate daily runtime, and measure the real draw of pumps, fans, controllers, and any lighting. If grow lights are required because the container is closed, the power problem changes completely; lighting can dominate the entire system.

SIZING RULE

Do not size solar panels until the team knows whether the system is powering only pumps/controls/fans or also grow lights and active cooling. Those are different projects.

Preliminary Load Logic

Load	Typical class	Runtime note	Priority
Circulation pump	40-120 W	Intermittent or continuous depending on hydroponic method	High
Air pump / aeration	10-60 W	Usually continuous for DWC/reservoir aeration	High
Ventilation fans	50-400 W	Triggered by temperature; higher during summer peaks	Medium
Controller + sensors	5-30 W	Continuous low load	High
Evaporative assist	20-200 W	Pump/fan dependent; water use must be managed	Conditional
Grow lights	Hundreds to thousands W	Only if container is mostly indoor/opaque	Avoid unless necessary

Arizona Solar Center estimates that, for Phoenix weather, a south-facing 1 kW PV array at a 10 degree tilt produces about 1,600 kWh/year; use this as a planning anchor, not a substitute for site-specific design.

Electrical Design Recommendations

- Use a plug-load meter during the pilot phase to capture real pump/fan/controller consumption.
- Prioritize low-voltage DC pumps/fans where practical if off-grid solar is a serious requirement.
- Place controls in a weather-rated, shaded enclosure with GFCI protection and clear labeling.

- If grid-tied solar is selected, require an Arizona-qualified installer and treat the student design as concept scope only.
- If off-grid operation is required, include battery capacity for overnight pump/aeration loads before sizing panel wattage.

Feasibility Analysis: Pilot Build vs. Commercial Turnkey Procurement

The project should not force one answer to cover two different realities. A small pilot can be built to prove the water, heat, crop, and maintenance logic. A full controlled-environment container farm is a procurement and utilities decision that belongs in a grant or capital budget.

DECISION FRAMING

Track A is the recommended first action because it is modest enough to learn from and specific enough to reduce risk. Track B is a commercial procurement path that should stay open, but only after Tiger Mountain has vendor quotes and utility requirements in writing.

Two-Track Recommendation

Path	Best use	What it proves / requires
Track A: measured pilot build	Use when Tiger Mountain wants near-term progress, site-specific data, and a maintainable first module for greens/herbs.	Build shade, first-flush bypass, shaded buffer reservoir, monitoring, and one crop module. Result: proof of conditions, operations, and realistic next purchases.
Track B: commercial turnkey procurement	Use when the goal is full container-farm capacity, controlled environment production, and grant/foundation funding.	Request vendor quote, utility requirements, service plan, warranty, crop layout, and installation scope. Result: capital request backed by real operating assumptions.

Commercial Container Reality Check

Pure Greens is useful as a commercial benchmark because it shows what a real turnkey container farm includes: NFT or DFT hydroponic layouts, plumbing and reservoir, automation, HVAC climate control, grow lights, and 20 ft or 40 ft container layouts. That package solves problems the pilot should not pretend to solve.

It also changes the energy conversation. Pure Greens states that school container farms are designed for year-round production using as little as 160 kWh of electricity per day. That is a utility-scale planning input, not something to solve with a small solar starter kit.

Source basis: Pure Greens describes pre-designed container farms with NFT/DFT systems, automation, HVAC climate control, grow lights, and 20 ft / 40 ft layouts; its school container-farm page states that systems can use as little as 160 kWh of electricity per day.

Recommended Position

- Proceed with Track A as the first build because it directly addresses hot water, root-zone temperature, monitoring, and greens/herbs production without overcommitting funds.

- Prepare Track B as a grant/procurement packet only if Tiger Mountain wants full controlled-environment capacity and is ready to confirm water, electrical, installation, and service requirements.
- Do not present a commercial turnkey container as a small solar add-on. The pilot and the commercial system are different scopes, and the document should say that plainly.

Pilot Procurement Matrix

The table below is not a final shopping list for a full container farm. It is the Track A pilot procurement matrix: low-risk purchases that create site data, reduce heat/water failure modes, and clarify whether later solar, active cooling, or commercial procurement is justified. Prices are planning anchors observed from supplier pages on June 11, 2026 and should be rechecked before purchase.

Pri.	Component	Purpose / planning anchor	Timing
P0	Water temperature logger / IR thermometer	Confirms whether hot standing water is actually creating root-zone risk.	Buy first
P0	pH/EC meter + calibration solution	Minimum viable hydroponic monitoring. Bluelab starter pack observed around $209; combo meter around $356.	Buy first
P0	30-40% UV-rated shade cloth + frame hardware	Reduces canopy and plumbing heat load. 20 ft x 20 ft 30% cloth observed around $53; 20 ft x 48 ft UV cloth around $88.	Buy first
P0	First-flush bypass valve + drain route	Purges hot standing hose water before irrigation reaches plants.	Build first
P0	Food-safe shaded buffer reservoir	Stabilizes incoming water temperature and supports nutrient mixing. 55 gal potable tanks observed around $188-$240.	Build first
P0	UV-rated tubing, fittings, inline filter	Reduces leaks, clogging, heat exposure, and volunteer maintenance confusion.	Build first
P1	400 GPH pump, timer/controller, labeled shutoffs	Enables a repeatable irrigation loop. 400 GPH hydroponic pump observed around $33-$41 and about 24 W.	Pilot
P1	Leafy-channel / raft module for greens and herbs	Tests the official crop scope. NFT channels observed from about $6.20/channel; larger commercial kits run into thousands.	Pilot
P1	Ventilation fan with thermostat/speed control	Adds active heat relief only where logged temperatures show shade and buffer storage are not enough. 12 in shutter fans observed around $79-$93.	Data-gated
P2	Solar kit + inverter + battery	Deferred until real loads exist. Example anchors: 400 W kit around $433, 1000 W inverter around $176, 12V 100Ah LiFePO4 battery from around $308.	After load logging
P2	Dedicated 1/10 HP water chiller	Deferred unless logged water temperatures exceed targets after passive controls. Active Aqua 1/10 HP observed roughly $358-$596 depending supplier.	Conditional

Planning anchors are examples only. Confirm live pricing, shipping, availability, warranties, food-contact suitability, and code requirements before purchasing.

Procurement Guardrails

- Do not buy active cooling until the passive system has been temperature-logged.
- Do not buy solar hardware until the electrical load schedule is measured or credibly estimated.
- Do not use pilot parts pricing to imply that a commercial turnkey container farm is cheap.
- Do not buy hydroponic channels before crop zoning is locked; greens/herbs are the core scope, while squash/root crops need different physical systems.
- Prefer fewer higher-quality food-safe parts over a large pile of disposable plastic fittings.

Phased Implementation Plan

#	Name	Major work	Planning horizon
0	Site verification	Confirm MAC6 container/bed dimensions, water source, sun path, existing power, budget ceiling, operator/maintenance owner.	1 week
1	Passive heat control	Install shade, route/shade hose, build flush bypass, place shaded buffer tank, begin temperature logging.	1-2 weeks
2	Hydroponic pilot	Build one greens/herbs module; establish pH/EC/temp check routine; add secondary crop module only after the core system works.	2-4 weeks
3	Electrical/load validation	Measure pump/fan/controller consumption; build daily load schedule; decide grid-tied vs off-grid solar.	1-2 weeks
4	Build-vs-buy decision	Compare pilot data against commercial turnkey quotes, utility requirements, service terms, and grant/funding options.	After pilot + quotes
5	Solar + active cooling decision	Size PV and battery/inverter if needed; add ventilation/evap or chiller only if data supports it.	Design after pilot data
6	Scale-out	Repeat successful module geometry or pursue commercial procurement with a defined operating owner.	Future phase

Operating Rhythm

Daily	Check reservoir temperature, pump function, water level, visible plant stress, and leaks.
2-3x weekly	Record pH/EC, inspect shade/plumbing, flush filters as needed, and note crop condition.
Weekly	Review temperature log, clean accessible surfaces, inspect algae growth, check trellis/supports.
Monthly	Calibrate meters, inspect fittings, review energy consumption, update procurement/maintenance log.
Seasonal	Reassess shade percentage, crop mix, irrigation timing, and whether active cooling is justified.

Risk Register and Open Decisions

Risk	Impact	Mitigation
Unmeasured loads	Solar system is over/under-sized.	Meter loads during pilot; separate grow-light scenario from pump/fan scenario.
Wrong crop geometry	System works for greens but fails for squash/root crops.	Split crop zones; pilot one leafy and one drip/media module.
Hot root zone	Heat stress, bolting, disease pressure, crop loss.	Shade, buffer tank, monitor nutrient temp, escalate cooling only with data.
Poor water chemistry	Nutrient lockout or unstable pH/EC.	Test source water; use pH/EC monitoring and crop-specific ranges.
Maintenance burden	System degrades after handoff.	Use simple checklists, labeled valves, standard fittings, and low-specialty components.
Material degradation	Leaks, brittle plastics, contamination concern.	Use UV-rated, food-safe parts and keep non-food-contact cooling wraps external.
Turnkey procurement mismatch	Commercial unit is over-scoped, under-funded, or unsupported after delivery.	Require vendor quote, utility review, warranty/service terms, training plan, and operating owner before grant submission.

Decisions Needed from Tiger Mountain

1. Confirm the final MAC6 site and whether the design is for a shipping container, open grow beds, or both.
2. Define the first-year greens/herbs crop mix and decide whether root/vine crops are in scope or future-only.
3. Set a budget ceiling for Phase 1 and a separate ceiling for future solar/active cooling.
4. Decide whether a commercial turnkey quote should be pursued in parallel for grant or foundation funding.
5. Clarify whether the system needs off-grid operation or only solar offset/support.
6. Assign the person or role responsible for weekly maintenance and meter calibration.
7. Approve whether the first build should be a pilot module or a full container retrofit.

References and Source Basis

This concept package uses stakeholder discovery notes from the EPICS project document and the public sources below. Final engineering design should verify site-specific measurements, current prices, code requirements, and crop-specific production targets.

Travis Manion Foundation: MLK Day of Service 2026 at Wee Wee Belcher Garden of Tomorrow. Public event page identifying Tiger Mountain Foundation garden context and service tasks. https://www.travismanion.org/events/operation-legacy/mlk-day-of-service-2026-at-wee-wee-belcher-garden-of-tomorrow

University of Arizona Cooperative Extension: Specialty Crop Production Practices for Beginning Farmers in Arizona and the Southwest. Notes that low-desert Arizona hoop houses should use shade cloth in summer to mitigate high temperatures and radiation. https://extension.arizona.edu/sites/default/files/2024-08/az1774-2018.pdf

UC Agriculture and Natural Resources: Caring for Container Plants During Heatwaves. Advises checking hose-water temperature and letting hot hose water cool before watering roots; suggests 30-50% shade cloth for container plants. https://ucanr.edu/blog/under-solano-sun/article/caring-container-plants-during-heatwaves

University of Missouri Extension: Hydroponic Nutrient Solutions. Identifies pH, EC, dissolved oxygen, temperature, and alkalinity as key nutrient solution management parameters. https://extension.missouri.edu/publications/g6984

Oklahoma State University Extension: Electrical Conductivity and pH Guide for Hydroponics. Provides crop-specific EC/pH ranges and explains pH management in soilless culture. https://extension.okstate.edu/fact-sheets/electrical-conductivity-and-ph-guide-for-hydroponics

University of Kentucky CCD: Hydroponic Lettuce Production in Controlled Environments. Discusses monitoring equipment, root-zone stability, and heat-stress mitigation for hydroponic lettuce. https://ccd.uky.edu/sites/default/files/2026-02/ccd-cp-63_hydrolettuce_accessible-2.pdf

Arizona Solar Center: Considerations in Sizing a PV System in Arizona. Estimates that a south-facing 1 kW PV array in Phoenix at 10 degrees tilt produces about 1,600 kWh/year. https://azsolarcenter.org/considerations-in-sizing-a-pv-system-in-arizona

Pure Greens: Pre-Designed Container Farms. Describes NFT/DFT grow systems, automation, HVAC climate control, grow lights, 20 ft / 40 ft layouts, delivery assembled, and water/electric connection requirements. https://puregreensaz.com/container-farms/

Pure Greens: Container Farms for Schools. States that school container farms can be designed for year-round production using as little as 160 kWh of electricity per day. https://puregreensaz.com/school-container-farms/

Supplier research snapshot: Planning-grade examples reviewed June 11, 2026: Home Depot shade cloth/tanks/fans/Renogy solar components; Hydrobuilder/Hydrofarm/Agriculture Solutions Active Aqua chillers; Bluelab pH/EC meters; CropKing pumps and NFT channels. Use for budget framing only, not final procurement approval.