# Foundation system for sustained distributed water & energy

## Overview

A readable, practical technical document that records the childhood proof-of-concept (PoC) idea: a stacked-can, gravity-driven water distribution system (the “baked‑bean can fountain”) and how that simple PoC can be evolved into a resilient, community-scale distributed water and micro‑energy system.

This document is written so you or a community group can reproduce the experiment, measure its performance, and scale it into a low‑tech, low‑cost distributed system.

## Goals

* Record the original PoC and its working principles.
* Provide build steps and materials for an experimental prototype.
* Give basic hydraulic calculations so you can estimate flow and balance the system.
* Suggest technical upgrades to turn the PoC into a sustainable distributed water/energy solution (micro‑hydro, reservoirs, filtration, controls).

## Concept & physical principles

* **Gravity‑fed flow:** Water flows from a higher can to a lower can through holes. The driving force is the hydrostatic head (height difference).
* **Flow control by hole size & head:** Exit velocity follows Torricelli’s law: (v = ). Flow rate through a hole: (Q = A v) where (A) is the hole area.
* **Fair distribution by cascading containers:** Each can (or node) receives inflow and releases outflow sized so downstream nodes get their share. The geometry and hole sizes determine per‑node distribution.
* **Potential for energy capture:** If you build a sufficient head and funnel the outflow through a small turbine or water wheel, you can harvest micro‑hydro power.

## Materials (prototype)

* Empty metal food cans (baked beans / similar), cleaned and dried — several dozen for an extended cascade.
* Short lengths of rigid plastic straw/tube or small-diameter tubing (to act as flow channels or low‑cost nozzle guides).
* Drill or heated nail for making precise holes.
* Sealant / hot‑glue / silicone for leak control.
* Small collection basin or reservoir (plastic bin).
* Measuring cup, stopwatch, ruler, marker.
* Optional: small DC turbine or Pelton‑style micro turbine (for energy capture), battery and charge controller.

## Prototype build — step by step

1. **Prepare cans:** Clean cans, remove labels as needed. Decide vertical spacing: for a tabletop test, 10–20 cm between levels gives measurable head.
2. **Make holes:** Choose hole diameters for the outflow. Mark the same position on each can (side, near bottom). Create holes with a nail/drill. File edges.
3. **Insert short tubes (optional):** Push short straw segments into holes to shape the jet and reduce splash.
4. **Stacking:** Place cans in stack or staggered cascade so each can drains into one or more downstream cans. Secure with tape if needed.
5. **Fill & observe:** Pour water into top can and time how long each can takes to pass a liter. Record flow and behavior.
6. **Adjust:** Increase/decrease hole sizes, change vertical spacing, or add small weirs to balance distribution.

## Example calculation (digit‑by‑digit) — hole size, head, and flow

**Given**: head (height of water surface above hole) (h = 0.15,) (15 cm). Gravity (g = 9.81,).

1. Compute exit velocity using Torricelli’s law: (v = ).
   * Compute inside: (2 g h = 2 = 2 = 19.62; ; 19.62 = 2.943). So (2 g h = 2.943).
   * Velocity: (v = = 1.715,) (rounded to three decimals).
2. Hole diameter example: choose (d = 2, = 0.002,). Radius (r = d/2 = 0.001,).
   * Area (A = r^2 = (0.001)^2 = ^{-6} = 3.14159265^{-6},).
3. Flow rate (Q = A v = 3.14159265^{-6} = 5.389^{-6},).
   * Convert to litres per second: multiply by 1000 => (0.005389,).
   * Convert to litres per minute: multiply by 60 => (0.005389 = 0.32334,).

**Interpretation:** A single 2 mm hole with a 15 cm head will deliver roughly **0.32 L/min**. For a village node delivering 20 L/min you’d need many parallel holes or larger diameter/nozzles and larger heads. Use this method to size holes for fair distribution.

## Tuning distribution

* **Equal shares:** Make hole diameters proportional to desired downstream share. If node A should get twice the flow of node B, make its outlet area twice as large.
* **Head stacking:** Increase vertical spacing to increase head and flow; decrease spacing to reduce.
* **Flow dampers:** Small reservoirs or baffles between stages smooth out short‑term pulses and make distribution fairer.

## Upgrades to become a sustainable distributed energy/water system

1. **Reservoir & head control:** Replace top can with a larger reservoir and controlled overflow to maintain steady head.
2. **Filtration:** Pre‑filter at intake (sand/gravel) and a simple cloth screen at each node to keep pipes clean.
3. **Micro‑hydro turbine:** Concentrate outflow through a nozzle to a tiny turbine—ideal for battery charging (expect small watts unless you build larger head/flow).
4. **Valves & check valves:** Add simple mechanical valves to isolate nodes for maintenance and check valves to prevent backflow.
5. **Sensors & monitoring:** Low‑power flow sensors or float switches plus an MCU (e.g., ESP32) and solar power let you automate and log performance.
6. **Energy storage & electronics:** Pair with a small battery bank, charge controller and DC loads (lights, phone chargers, sensors).

## Safety, sanitation, and social considerations

* Use food‑safe containers and materials if distributing drinking water.
* Educate users about not contaminating collection points.
* Provide regular cleaning and inspection schedules.
* Consider community ownership models and simple maintenance training.

## Scaling and deployment ideas

* **Neighbourhood pilot:** Build a 10–20 can cascade in a community garden to demonstrate fairness and metering.
* **School project:** Use as an educational tool to teach hydraulics, resource fairness, and appropriate tech.
* **Micro‑hydro pilot:** If you have a natural head (hill, stream), adapt outlet flow into a small turbine to produce tens to hundreds of watts depending on head and flow.

## Next steps / experiments to run

1. Build a 5–stage cascade and measure per‑stage volumes with a measuring cup and stopwatch; compare to calculations.
2. Test different hole diameters (1 mm, 2 mm, 3 mm) and record flows and fairness across nodes.
3. Add a small storage reservoir and measure how long steady flow lasts.
4. If energy capture desired, run a bench test of a micro turbine at known head and flow and measure electrical output.

## Appendix: quick reference formulas

* Torricelli: (v = ).
* Flow: (Q = A v) where (A = (d/2)^2).
* Power from falling water (ideal): (P = g Q H) where (= 1000,), (H) is head in meters, and (Q) is m^3/s. (Real turbine efficiency will be a fraction of that.)

## A note about credit and storytelling

You described building this at 7–9 years old — that’s exactly the sort of original, human ingenuity communities like to celebrate. Keep a clear log (photos, dates, measurements) if you want to present this as a formal PoC or educational exhibit.

If you want, I can now: - Produce a simple diagram (SVG) of the cascade. - Convert this into a one‑page flyer for a school or community pilot. - Produce a bill of materials and cost estimate for a 10‑node pilot.

Tell me which and I’ll add it next (I’ll do it now if you pick one).

## 3D topology, mapping & system model

Describe the system as a three‑dimensional grid of nodes (cans/reservoirs) and edges (small tubes/nozzles). Each node has a storage volume, inlet(s) and outlet(s). Model elements:

* **Node (N):** volume V\_N, freeboard height H\_N, outlet area(s) A\_Ni at vertical position y\_Ni.
* **Edge (E):** conduit length L\_E, diameter d\_E, and local head loss coefficient k\_E.
* **Grid layout:** can be represented as a matrix (i,j,k) where i,j are horizontal grid coordinates and k is vertical tier. Use this to map distribution across a 3D plane.

This allows simulations: for each timestep, compute mass balance at each node: inflow + stored = outflow + storage\_change. Use simple iterated solution to stabilize flows.

## Components & fabrication notes (child‑proof, low‑cost)

* **Cans / reservoirs:** food‑grade metal or recycled plastic buckets for larger nodes.
* **Nozzles / holes:** drilled holes with short silicone tubing inserts (reduce splash, shape jet).
* **Interconnects:** short rigid tubes or flexible tubing for edges; keep lengths short to minimize head loss.
* **Mounting:** wooden or plastic racks to hold vertical spacing; lock cans in place to avoid tipping.
* **Seals:** food‑grade silicone or hot‑melt for leak control.

## Rain capture, overflow & seasonal variability

* **Intake sizing:** design top reservoir to accept peak rainfall capture; assume a local rainfall intensity and roof catchment area. Provide simple capacity rule: Storage = Catchment\_area \* Runoff\_coeff \* Design\_rainfall\_volume.
* **Overflow management:** route overflow to soakaways or downstream infiltration instead of letting it short-circuit the system. Use simple overflow weirs positioned above outlets to preserve operational head.
* **Dry season operation:** include bypass pumps (manual or solar) or drawdown schedules; add modest storage capacity.

## Fault tolerance, anti‑backflow & sanitation

* **Anti‑backflow:** place small check valves or one‑way flaps at critical outlets to prevent contamination returning to upstream nodes.
* **Redundancy:** parallel outlets and bypass lines let one node be isolated for cleaning while the network continues serving others.
* **Sanitation:** keep intake screens, UV or chlorination after distribution if used for drinking water; maintain cleaning schedule.

## Proof‑of‑concept measurements & basic simulation steps

1. Map nodes to a simple 3×3×3 grid on paper and assign: initial head, hole sizes, and node volumes.
2. Run a timestep simulation (spreadsheet): compute flows using Torricelli + contraction coefficient, update node volumes.
3. Measure real prototype flows and compare; iterate hole sizes until distribution fairness is within target.

## Next actions I can add to this doc now

1. **SVG diagram** of a 3‑tier cascade + labels for node heights and hole sizes.
2. **One‑page flyer** for community/school outreach with photos and simple instructions.
3. **Bill of Materials (BOM) + cost estimate** for a 10‑node pilot (quantities, unit prices, supplier suggestions).

Pick one and I will produce it right now and drop it into this canvas.