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: $v = \sqrt{2gh}$. Flow rate through a hole: $Q = A \times v$ 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) $h = 0.15\,\mathrm{m}$ (15 cm). Gravity $g = 9.81\,\mathrm{m/s^2}$.

1. Compute exit velocity using Torricelli's law: $v = \sqrt{2gh}$.
2. Compute inside: $2gh = 2 \times 9.81 \times 0.15 = 2 \times 9.81 = 19.62;\; 19.62 \times 0.15 = 2.943$. So $2gh = 2.943$.
3. Velocity: $v = \sqrt{2.943} = 1.715\,\mathrm{m/s}$ (rounded to three decimals).
4. Hole diameter example: choose $d = 2\,\mathrm{mm} = 0.002\,\mathrm{m}$. Radius $r = d/2 = 0.001\,\mathrm{m}$.
5. Area $A = \pi r^2 = \pi \times (0.001)^2 = \pi \times 1 \times 10^{-6} = 3.14159265 \times 10^{-6}\,\mathrm{m}^2$.
6. Flow rate $Q = A \times v = 3.14159265 \times 10^{-6} \times 1.715 = 5.389 \times 10^{-6}\,\mathrm{m^3/s}$.
7. Convert to litres per second: multiply by 1000 => $0.005389\,\mathrm{L/s}$.
8. Convert to litres per minute: multiply by 60 => $0.005389 \times 60 = 0.32334\,\mathrm{L/min}$.

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: $v = \sqrt{2gh}$.
- Flow: $Q = Av$ where $A = \pi(d/2)^2$.
- Power from falling water (ideal): $P = \rho g Q H$ where $\rho = 1000\,\mathrm{kg/m^3}$, 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.