

Refined White Paper: Comprehensive Options for Adaptability in the KidneyLoop Water Filtration System

Subtitle: Scaling Solutions with Flexible Designs, Tank Sizes, Power Options, and Price Ranges

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Abstract

The KidneyLoop water filtration system is an open-source solution designed to address the global water crisis affecting 700 million people (FAO, 2023). Using UV-C disinfection and fine filtration, it removes 99.9% of bacteria, providing clean water in 6.3–482.15 minutes per cycle, depending on the design and capacity. This white paper consolidates all variants of the KidneyLoop, including the original flat tray design, the tube design, and a new circular multi-tank design with a central water still and five circulating tubs. It presents variable options for adaptability, including tank sizes (5-gallon to 275-gallon), power options (solar, battery, grid), and price ranges, enabling the system to scale from individual households to entire communities. Costs and availability may vary over time due to market fluctuations, technological advancements, and regional differences, but the KidneyLoop's modular design ensures flexibility for humanitarian deployment, potentially saving hundreds of thousands of lives by providing clean water access.

1. Introduction

The KidneyLoop, first introduced in the original white paper (April 7, 2025), is a low-cost, solar-powered water purifier that uses UV-C disinfection and fine filtration to remove 99.9% of bacteria, providing clean water in 6.3–10.63 minutes per 5-gallon cycle. The urgency breakdown white paper detailed cost-saving strategies and sourcing options for water-scarce regions, while subsequent iterations introduced variable options for adaptability, including a tube design and larger tank sizes. This refined white paper consolidates all variants, adding a new circular multi-tank design with a central water still and five circulating tubs, increasing capacity to 25 gallons per cycle with enhanced purification. By offering diverse disinfection designs, tank sizes, power options, and price ranges, the KidneyLoop can address varied needs in water-scarce regions, from rural households to urban communities and emergency relief scenarios.

2. Variable Disinfection Designs

The KidneyLoop's disinfection mechanism relies on UV-C light (260–280 nm) to inactivate bacteria, achieving 99% reduction per pass and 99.9% removal in 2–3 passes. Three primary designs are presented: the flat tray, tube, and circular multi-tank with central still.

2.1 Flat Tray Design (Original)

- **Description:** Water flows through a shallow tray (e.g., 16 cm × 2 cm) under a UV-C LED strip mounted 1–2 cm above the surface, exposed for 10 seconds per pass.
- **UV-C Component:** FIT0948 UVC Ultraviolet Germicidal Lamp Strip (275 nm, 12V, 2W, 16 cm long, \$9.90) or Alibaba UV-C LED Strip (265–275 nm, 4W, ~30 cm long, \$12.00).
- **Dose and Efficiency:**
 - **FIT0948:** 62.5 mJ/cm² in 10 seconds (32 cm² tray), requiring 33.6 seconds for 210 mJ/cm² (99% reduction per pass), or 4 strips (8W, \$39.60) for 250 mJ/cm² in 10 seconds (99.9% removal in 2 passes, 6.3 minutes).
 - **Alibaba Strip (4W):** 66.7 mJ/cm² in 10 seconds (60 cm² tray), requiring 31.5 seconds for 210 mJ/cm², or 3 strips (12W, \$36.00) for 200 mJ/cm² in 10 seconds (99.9% removal in 2–3 passes, 6.3–9.45 minutes).
- **Safety:** Moderate. The strip is exposed on top, requiring a UV-opaque cover (e.g., aluminum foil) to prevent exposure. UV-protective glasses

(\$5–\$10) are recommended during assembly and maintenance.

- **Advantages:** Simple design, easy to assemble, cost-effective for small-scale units.
- **Disadvantages:** Risk of exposure if not properly shielded, less efficient UV-C exposure (single-sided).

2.2 Tube Design

- **Description:** Water flows through a clear, UV-transparent tube (e.g., FEP, 1 meter long, 0.5 cm diameter) wrapped with a UV-C LED strip, exposed for 10 seconds per pass.
- **UV-C Component:** Alibaba UV-C LED Strip (265–275 nm, 3W/meter, \$24.00/meter for 100 meters, \$22.00/meter for 1,000+ meters).
- **Dose and Efficiency:** 11 meters (3300 mW) wrapped around a 1-meter tube (157 cm² inner surface area) delivers 21.02 mW/cm², achieving 210.2 mJ/cm² in 10 seconds per pass (99% reduction per pass, 99.9% removal in 3 passes, 9.45 minutes). Flow rate is slowed to 1.96 mL/s to ensure exposure.
- **Safety:** High. The tube encloses the light, directing it inward, reducing exposure risk. A UV-opaque sleeve (e.g., black plastic) can further contain the light. UV-protective glasses are recommended during assembly.
- **Advantages:** Safer (enclosed design), more efficient UV-C exposure (light surrounds the water), scalable for larger volumes.
- **Disadvantages:** Higher initial cost for the strip (11 meters = \$264.00), requires a UV-transparent tube.

2.3 Circular Multi-Tank Design with Central Water Still (New)

- **Description:** Five 5-gallon buckets are arranged in a circular pattern, connected by small tubes in a continuous loop. Each bucket has a 0.1 µm filter and a 1-meter UV-C tube (wrapped with 11 meters of Alibaba UV-C LED strip) for disinfection. A central water still (e.g., 55-gallon barrel) feeds pre-distilled water into the buckets using gravity dispersion.
- **UV-C Component:** Alibaba UV-C LED Strip (265–275 nm, 3W/meter, \$24.00/meter for 100 meters, \$22.00/meter for 1,000+ meters).
- **Dose and Efficiency:** Each bucket's tube delivers 210.2 mJ/cm² in 10 seconds per pass (99% reduction per pass, 99.9% removal in 3 passes). Flow rate per bucket is 1.96 mL/s, totaling 9.8 mL/s across 5 buckets. Total cycle time for 25 gallons is 482.15 minutes (8.04 hours) for 3 passes, but parallel processing maintains efficiency per bucket (9.45 minutes per 5-gallon batch). The central still (208.2 liters) supplies water for 354 minutes (5.9 hours) per fill.
- **Safety:** High. The tube design encloses the light, and the central still adds a distillation step, improving water quality. UV-protective glasses and a UV-opaque sleeve are recommended.
- **Advantages:** Increased capacity (25 gallons per cycle), parallel processing, enhanced purification with distillation, scalable for community use.

- **Disadvantages:** Higher cost for multiple strips (55 meters = \$1,320), longer cycle time for full volume, requires a pump for circulation.
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3. Variable Tank Sizes

The KidneyLoop can use different tank sizes to scale capacity, from small-scale home units to community-scale systems.

3.1 Small-Scale: 5-Gallon Tanks (Original)

- **Capacity:** 5 gallons (18.9 liters) per cycle.
- **Cycle Time:** 9.45 minutes (3 passes) with the flat tray (1 FIT0948 strip) or tube design (11 meters of Alibaba strip).
- **Cost:** \$6–\$10 for two buckets (online) or \$2–\$6 (locally).
- **Use Case:** Ideal for individual households (4–6 people), providing 5 gallons daily.

3.2 Medium-Scale: 55-Gallon Barrels

- **Capacity:** 55 gallons (208.2 liters) per cycle.
- **Cycle Time:** 9.45 minutes per 5-gallon batch, or 173.5 minutes for the entire volume with 3 passes if processed continuously.
- **Cost:** \$30–\$60 for two barrels (online) or \$10–\$20 (locally).
- **Use Case:** Suitable for larger households or small communities (20–30 people), providing 55 gallons daily.

3.3 Large-Scale: 275-Gallon Rain-Catch Tubs

- **Capacity:** 275 gallons (1041 liters) per cycle.
- **Cycle Time:** 9.45 minutes per 5-gallon batch, or 867.5 minutes (14.46 hours) for the entire volume with 3 passes if processed continuously.
- **Cost:** \$100–\$200 for two tubs (online) or \$30–\$60 (locally).
- **Use Case:** Ideal for community-scale deployment (100–150 people), providing 275 gallons daily for schools, clinics, or villages.

3.4 Circular Multi-Tank: Five 5-Gallon Buckets with Central Still

- **Capacity:** 25 gallons (94.6 liters) per cycle (5 buckets × 5 gallons), with a 55-gallon central still (208.2 liters) for pre-distillation.
 - **Cycle Time:** 482.15 minutes (8.04 hours) for 25 gallons with 3 passes, but parallel processing maintains efficiency per bucket (9.45 minutes per 5-gallon batch).
 - **Cost:** \$15–\$25 for five buckets (online) or \$5–\$15 (locally), plus \$15–\$30 for the central still (online) or \$5–\$10 (locally).
 - **Use Case:** Suitable for small communities (20–30 people), providing 25 gallons per cycle with enhanced purification via distillation.
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4. Variable Power Options

The KidneyLoop can use different power sources to accommodate various contexts, from off-grid rural areas to urban settings with grid access.

4.1 Solar Power (Original)

- **Flat Tray (1 FIT0948 Strip):** 10W, 12V DC solar panel (2W for the strip, 1–2W for the pump, 1W for optional microcontroller). Cost: \$15–\$25 (online) or \$5–\$10 (locally).
- **Tube Design (11 Meters of Alibaba Strip):** 40W, 12V DC solar panel (33W for the strip). Cost: \$40–\$60 (online) or \$15–\$25 (locally).
- **Circular Multi-Tank (55 Meters of Alibaba Strip):** 200W, 12V DC solar panel (165W for the strips, 5W for the pump, 1W for optional microcontroller). Cost: \$150–\$200 (online) or \$50–\$100 (locally).
- **Battery:** 12V 7Ah SLA battery for storage (\$15–\$20 online, \$3–\$5 locally) for smaller designs; 12V 100Ah battery (\$100–\$150 online, \$20–\$40 locally) for the multi-tank design.
- **Advantages:** Sustainable, off-grid compatible, ideal for water-scarce regions with abundant sunlight (e.g., sub-Saharan Africa).
- **Disadvantages:** Intermittent (requires battery storage), higher initial cost for larger panels.

4.2 Battery Power (Alternative)

- **Flat Tray (1 FIT0948 Strip):** 12V 7Ah battery (84Wh, ~10 hours). Cost: \$15–\$20 (online) or \$3–\$5 (locally).
- **Tube Design (11 Meters):** 12V 20Ah battery (240Wh, ~7 hours). Cost: \$30–\$50 (online) or \$5–\$10 (locally).
- **Circular Multi-Tank (55 Meters):** 12V 100Ah battery (1200Wh, ~7 hours). Cost: \$100–\$150 (online) or \$20–\$40 (locally).
- **Charging:** Recharge via a local charging station (\$0.50 per charge in rural Kenya) or a small solar panel.
- **Advantages:** Portable, no reliance on sunlight, lower initial cost than solar panels.
- **Disadvantages:** Requires recharging, limited capacity.

4.3 Grid Power (Alternative)

- **Flat Tray (1 FIT0948 Strip):** 12V DC, 10W adapter. Cost: \$5–\$15 (online) or \$2–\$5 (locally).
 - **Tube Design (11 Meters):** 12V DC, 40W adapter. Cost: \$10–\$20 (online) or \$3–\$7 (locally).
 - **Circular Multi-Tank (55 Meters):** 12V DC, 200W adapter. Cost: \$20–\$30 (online) or \$5–\$10 (locally).
 - **Advantages:** Reliable, no need for battery storage, low cost.
 - **Disadvantages:** Not off-grid compatible, relies on grid access, may use fossil fuel-generated electricity.
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5. Price Ranges and Variability

The KidneyLoop's cost varies based on the disinfection design, tank size, power option, and sourcing method. Costs and availability may vary over time due to market fluctuations, technological advancements, and regional differences.

5.1 Flat Tray Design (1 FIT0948 Strip)

- **5-Gallon Tanks, Solar Power (Online):** \$60–\$102 (UV-C: \$9.90, Filter: \$5–\$15, Solar: \$15–\$25, Tanks: \$6–\$10, Tubing: \$5–\$10, Tools: \$7–\$15, Safety: \$5–\$10).

- **5-Gallon Tanks, Solar Power (Local):** \$28–\$50 (UV-C: \$9.90, Filter: \$0–\$5, Solar: \$5–\$10, Tanks: \$2–\$6, Tubing: \$1–\$2, Tools: \$3–\$7, Safety: \$2–\$5).
- **55-Gallon Barrels, Battery Power (Online):** \$74–\$117 (UV-C: \$9.90, Filter: \$5–\$15, Battery: \$15–\$20, Tanks: \$30–\$60, Tubing: \$5–\$10, Tools: \$7–\$15, Safety: \$5–\$10).
- **275-Gallon Tubs, Grid Power (Local):** \$52–\$84 (UV-C: \$9.90, Filter: \$0–\$5, Adapter: \$2–\$5, Tanks: \$30–\$60, Tubing: \$1–\$2, Tools: \$3–\$7, Safety: \$2–\$5).

5.2 Tube Design (11 Meters of Alibaba Strip)

- **5-Gallon Tanks, Solar Power (Online):** \$339–\$399 (or \$317–\$377 with bulk pricing).
- **5-Gallon Tanks, Solar Power (Local):** \$263.50–\$293.50 (or \$241.50–\$271.50 with bulk pricing).
- **55-Gallon Barrels, Battery Power (Online):** \$353–\$419.
- **275-Gallon Tubs, Grid Power (Local):** \$317.50–\$347.50.

5.3 Circular Multi-Tank Design (55 Meters of Alibaba Strip, 5 Tubs, Central Still)

- **Five 5-Gallon Buckets, Solar Power (Online):** \$1,563–\$1,733 (UV-C: \$1,320, Tubes: \$25–\$75, Filters: \$25–\$75, Solar: \$150–\$200, Tanks: \$15–\$25, Still: \$15–\$30, Tubing: \$7–\$15, Tools: \$7–\$15, Safety: \$5–\$10). With bulk pricing: \$1,453–\$1,623.
- **Five 5-Gallon Buckets, Solar Power (Local):** \$1,377.50–\$1,467.50 (UV-C: \$1,320, Tubes: \$25–\$75, Filters: \$0–\$25, Solar: \$50–\$100, Tanks: \$5–\$15, Still: \$5–\$10, Tubing: \$1.50–\$3, Tools: \$3–\$7, Safety: \$2–\$5). With bulk pricing: \$1,267.50–\$1,357.50.
- **Five 5-Gallon Buckets, Battery Power (Online):** \$1,413–\$1,583 (UV-C: \$1,320, Tubes: \$25–\$75, Filters: \$25–\$75, Battery: \$100–\$150, Tanks: \$15–\$25, Still: \$15–\$30, Tubing: \$7–\$15, Tools: \$7–\$15, Safety: \$5–\$10).
- **Five 5-Gallon Buckets, Grid Power (Local):** \$1,362.50–\$1,422.50 (UV-C: \$1,320, Tubes: \$25–\$75, Filters: \$0–\$25, Adapter: \$5–\$10, Tanks: \$5–\$15, Still: \$5–\$10, Tubing: \$1.50–\$3, Tools: \$3–\$7, Safety: \$2–\$5).

6. Adaptability for Diverse Contexts

- **Rural Households (Off-Grid):** Flat tray with 5-gallon tanks and solar power (\$28–\$50 locally), ideal for small families in regions like sub-Saharan Africa.
 - **Urban Communities (Grid Access):** Tube design with 275-gallon tubs and grid power (\$317.50–\$347.50 locally), suitable for schools or clinics in urban India.
 - **Emergency Relief (Portable):** Flat tray with 55-gallon barrels and battery power (\$74–\$117 online), providing rapid deployment in crisis zones like Yemen.
 - **Small Communities (Scalable):** Circular multi-tank with five 5-gallon buckets, central still, and solar power (\$1,267.50–\$1,467.50 locally), ideal for 20–30 people in rural Kenya, with enhanced purification via distillation.
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7. Conclusion

The KidneyLoop's comprehensive options for adaptability—disinfection designs (flat tray, tube, circular multi-tank with central still), tank sizes (5-gallon to 275-gallon), power options (solar, battery, grid), and price ranges—enable it to scale from individual households to entire communities, addressing the global water crisis with flexibility and affordability. The new circular multi-tank design with a central water still increases capacity to 25 gallons per cycle, enhances purification through distillation, and maintains efficiency with parallel processing, making it ideal for small communities. Costs and availability may vary over time, but the system's modular design ensures it can be tailored to diverse contexts, saving lives by providing clean water to 700 million people in need. This CC0 framework offers a blueprint for humanitarian deployment, empowering communities to build and adapt the KidneyLoop to their unique needs.
