The Sanitation Technology Platform

Please Note: This report is a good faith effort by RTI International to accurately represent information available via secondary and primary sources at the time of the information capture.
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The goal of this analysis was to identify viable market segments for the sale of A-OP process water in India.

Background – The Bill & Melinda Gates Foundation is investing in transformative technologies that achieve complete pathogen destruction while generating useful by-products. One such technology is the Ankur-Omni Processor (A-OP), which produces electricity, heat, pathogen-free ash, and water products from fecal sludge and biosolids. The sale of these end products can reduce the cost to society for implementing non-sewer based treatment facilities.

Task Aim – This analysis aims to help A-OP partners and system developers identify industries representing target markets for the sale of A-OP water in India. These sales have the potential to offset costs associated with building and operating an A-OP.

Scope – STeP focused on water that will be generated by Ankur Scientific’s A-OP, which is anticipated to produce approximately 16 to 32 kiloliters per day (KLD) of distilled water as part of the sludge-treatment process.* STeP also only focused on markets for the sale of A-OP water. The production/sale of value-added products, such as coolant, were not considered because of the likely cost/complexity of starting up this type of business on the back-end of a fecal-sludge treatment plant.

Approach – This analysis consisted of two phases.

1. Industry Exploration & Screening: STeP generated a list of industries in India that consume treated/purified water and screened them across key factors likely to impact opportunities for an A-OP operator to sell water. Following evaluation, STeP down-selected to high-priority industry segments for exploration.

2. Characterization of Down-Selected Industry Segments: STeP conducted deep dives into high-priority industry segments. For these segments, STeP considered prices paid for water, volumes consumed, number and locations of buyers, buyer sensitivities to using A-OP water, potential challenges for a new water supplier entering the market, and trends that could impact the market.

*Note that the actual quality/specifications for A-OP water will not be known until operational data is available from the Vadodara demonstration plant. Also note that the original Janicki version of the A-OP (i.e., the J-OP) generates potable water. However, because of potential end-user acceptance issues related to the use of A-OP water for human consumption (revealed during interviews), STeP shifted focus to the potential sale of distilled water generated by Ankur’s system.
Battery and coolant mfg. segments may be relevant segments, but challenges exist for A-OP entry into market.

Approach (Cont.) – Reliable secondary data for these industries was extremely limited (and non-existent in many cases). Thus, STeP relied on primary interviews for the exploration of potential industries relevant for A-OP, as well as for characterization of down-selected industry segments. STeP conducted over 150 interviews with stakeholders across the value chain, including industry observers, water manufacturers/distributors, and industry end users.

Key Findings - Many industries that originally looked promising for A-OP water sales were screened out because of end-user acceptance issues, low volumes procured, low prices paid, and/or startup challenges.* Two markets—battery manufacturing and coolant manufacturing—were identified as possible target markets segments. Water buyers in these markets did not voice acceptance concerns for A-OP water and sometimes buy at prices and volumes that may allow for recoup of some A-OP costs. However, to sell into these markets, an A-OP operator would likely have to identify locations with a high enough concentration of buyers, have to compete with established local water suppliers to win market share, and incur startup costs associated with selling into these markets.

*Although these industries were screened out for the STeP analysis, there may be isolated cases where potential buyers exist in these markets; however, local-level analysis would be required to identify specific opportunities.
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STeP addressed several key questions for the analysis.*

<table>
<thead>
<tr>
<th>Key Questions Addressed During India Water Market Analysis</th>
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<tbody>
<tr>
<td><strong>Industry Exploration &amp; Screening</strong></td>
</tr>
<tr>
<td>• What types of water products are sold in India that could be relevant for A-OP water?</td>
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<tr>
<td>• What industries use water products that could be relevant for A-OP?</td>
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<tr>
<td>• What factors are most likely to impact opportunities for an A-OP operator to sell water into a given industry segment?</td>
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<tr>
<td>• What industry segments represent the best match for the sale of A-OP water in India, given factors most likely to impact overall opportunities?</td>
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<thead>
<tr>
<th><strong>Characterization of Viable Industry Segments</strong></th>
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<tr>
<td>• What is the value chain for relevant water products and where might an A-OP operator fit?</td>
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<tr>
<td>• What is the range of prices buyers pay?</td>
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<tr>
<td>• What factors impact price?</td>
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<tr>
<td>• Would buyers have any acceptability issues associated with using A-OP water?</td>
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<tr>
<td>• How many buyers exist?</td>
</tr>
<tr>
<td>• What volumes do these buyers procure?</td>
</tr>
<tr>
<td>• Where are these buyers located?</td>
</tr>
<tr>
<td>• What market trends could impact the viability of the segment?</td>
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<tr>
<td>• What would be required for “startup” as a new water supplier in the segment?</td>
</tr>
</tbody>
</table>

*During the analysis, STeP considered several other questions including the following: At a high level, what is the range of prices paid for different water products across India, and what factors influence price? What business models might be relevant for the sale of A-OP water and what is the relative cost/complexity for startup associated with those models? (See Appendix for findings.)
STeP reviewed secondary data and interviewed >150 stakeholders across the water value-chain in India.
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Many water products exist; users often need customized qualities even within the same product category.

Water-quality characteristics vary widely across and within product categories. As a result, product-category definitions alone (e.g., distilled, deionized, demineralized) often do not adequately describe required specifications for a given use. Water-quality specifications vary among different organizations and have been subject to ongoing changes. * Many of the standards include qualifiers and defer to requirements needed by a specific end user.

<table>
<thead>
<tr>
<th>Product Category</th>
<th>Definition</th>
<th>International Standards</th>
<th>Indian Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>Raw water is water found in the environment that has not been treated.</td>
<td>• US EPA 822-S-12-001</td>
<td>• BIS 2296:1992 - Different uses of water from natural resources</td>
</tr>
<tr>
<td>Potable</td>
<td>Potable water is safe to drink or to use for food preparation. Drinking water must be free of suspended solids, microorganisms, and toxic chemicals. Mineral concentration guidelines vary from country to country.</td>
<td>• US EPA 816-F-02-013</td>
<td>• Drinking Water (BIS 10500)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• EU 80/778/EEC Directive</td>
<td>• Packaged Natural Mineral (BIS 13428)</td>
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<tr>
<td></td>
<td></td>
<td>• EU Council Directive 98/83/EC</td>
<td>• Packaged Drinking (BIS 14543)</td>
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<tr>
<td></td>
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<td>• WHO Guidelines</td>
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<tr>
<td>Distilled</td>
<td>Electrolytic conductivity and pH values are generally similar to DI water that has equilibrated with the atmosphere (i.e., pH 5.6 and conductivity 1 µS/cm). Distilled water is produced through evaporation and phase separation.</td>
<td>• ASTM D1193-91</td>
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<td></td>
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<td>• ISO 3696</td>
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<td>• USP Standards</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• CLSI-CLRW Guidelines</td>
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</tr>
<tr>
<td>Deionized (DI)</td>
<td>Nearly all mineral ions have been removed (i.e., cations like sodium, calcium, iron, and copper, and anions like chloride and sulfate)–the highest-quality DI water has a conductivity of 0.055 µS/cm. DI water is produced through ion exchange or electro-deionization.</td>
<td>• Water Quality Standards for Industrial Purposes in India is established by BIS. Standards are defined under: “Chemicals” Technical Division Committee Number CHD 13.</td>
<td></td>
</tr>
<tr>
<td>De-Mineralized (DM)</td>
<td>DM water may be produced using a variety of technologies, including membrane filtration (reverse osmosis [RO] or nano-filtration) and/or ion exchange. The term DM is often used synonymously with DI.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra-Pure Water (UPW)</td>
<td>UPW is water that has been purified to very strict specifications. By definition, it contains only H₂, H⁺ ions, and OH⁻ ions in equilibrium. Production typically includes: filtration, micro flocculation, reverse osmosis, degasification, electrodeionization, and ultraviolet radiation. More highly purified distilled, DI, and DM water are sometimes referred to as ultrapure, depending on the level of purification (adding to the confusion around product categories/definitions).</td>
<td>• ASTM D5127</td>
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<td></td>
<td></td>
<td>• ASTM D1193-06</td>
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<td>• ASTM D5196-06</td>
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<td></td>
<td></td>
<td>• US Pharmacopeia (used in India)</td>
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<td>• NCCLS C3-A4</td>
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<td>• SEMI F63</td>
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</tr>
</tbody>
</table>

*NH - Division of Technical Resources, Office of Research Facilities
STeP selected 16 industries for preliminary screening that represented potential buyers of A-OP water.*

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Examples of Water Categories Used</th>
<th>Example Application(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Raw water</td>
<td>Irrigation</td>
</tr>
<tr>
<td>Batteries</td>
<td>Distilled, DI, DM</td>
<td>Filling batteries during manufacturing and servicing</td>
</tr>
<tr>
<td>Consumer Packaged Goods (CPG)</td>
<td>Distilled, DI, DM</td>
<td>Product manufacturing, pilot testing facilities</td>
</tr>
<tr>
<td>Domestic Use, Drinking</td>
<td>Raw water, potable, Potable</td>
<td>Washing, toilet flushing, cleaning, Bottled drinking water</td>
</tr>
<tr>
<td>Engine Coolants</td>
<td>Distilled, DI, DM</td>
<td>Mixing with glycol to produce engine coolant</td>
</tr>
<tr>
<td>Food/Beverage</td>
<td>Potable</td>
<td>Food processing, distilling</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Distilled, DI, DM, UPW</td>
<td>Analytical experiments (HPLC, spectroscopy), sterilization/cleaning of glassware</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>DM</td>
<td>Boiler feedwater, cooling water, process water</td>
</tr>
<tr>
<td>Pharmaceuticals/Medical</td>
<td>Distilled, DI, DM, UPW</td>
<td>Injections, consumables, laboratory</td>
</tr>
<tr>
<td>Power Plants</td>
<td>Raw water, DM</td>
<td>Cooling water</td>
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<tr>
<td>Pulp/Paper</td>
<td>Raw water, DM</td>
<td>Cooling water</td>
</tr>
<tr>
<td>Refining/Petrochemical</td>
<td>DM</td>
<td>Boiler feedwater, cooling water, process water</td>
</tr>
<tr>
<td>Semi-Conductors</td>
<td>UPW</td>
<td>Wafer cleaning</td>
</tr>
<tr>
<td>Specialty Chemical</td>
<td>Raw, Distilled, DI, DM</td>
<td>Agrochemicals, dyes/pigments, polymer additives, surfactants, industrial cleaners &amp; coaters, textile chemicals</td>
</tr>
<tr>
<td>Textiles</td>
<td>Raw water, DM</td>
<td>Wet processing (bleaching, dyeing, printing &amp; finishing fabrics)</td>
</tr>
</tbody>
</table>

*With the exception of agriculture, all of these industries use some form of treated/purified water.
STeP evaluated six factors expected to impact overall opportunities for an A-OP operator in a given industry.*

<table>
<thead>
<tr>
<th>Volumes Procured</th>
<th>Pricing</th>
<th>End-User Acceptability</th>
<th>Ease of Startup</th>
<th>Buyer Number/Location</th>
<th>Market Trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volumes of water procured at an industry-wide scale speak to the overall market opportunity for A-OP in a given industry across India. Volumes procured at a local scale (e.g., at an individual end-user facility and/or cluster of facilities in a certain area) speak to the likelihood that industry end-users at a given location buy enough water to have a meaningful impact on system economics at a specific A-OP site.**</td>
<td>Price points in a given industry will need to be high enough for there to be meaningful impact on A-OP economics. Water pricing in India is driven by a variety of factors, most notably treatment/purification requirements, packaging, distance transported, and volume sold.</td>
<td>People in India are very careful about the water they use for drinking, domestic purposes, and industrial applications. Stigmas attached to water originating from fecal sludge can present challenges for the adoption/use of A-OP water in many markets. These stigmas can be associated with real or perceived risks to human health (due to consumption or contact), or with real or perceived risks to end-product quality or functionality.</td>
<td>Ease of startup is a function of the costs/complexities associated with an A-OP operator selling water into a given industry. Costs/complexities may be associated with the following: the establishment of sales/distribution channels for A-OP water; acquisition, maintenance, and operation of equipment for packaging and/or upgrading A-OP water; and potential water-quality testing/certification requirements.</td>
<td>The number and location of water buyers in a given industry can help inform potential market reach of the A-OP. As an example, with a large number of distributed buyers, more potential A-OP sites could benefit from selling into that industry (assuming volumes procured at a given location and pricing are also a good match).</td>
<td>Market trends can provide insights into how stable a market for A-OP water might be over the longer term. A-OP facilities are anticipated to have a lifespan of 20+ years.</td>
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</table>

*The first four factors (Volumes Procured, Pricing, End-User Acceptability, and Ease of Startup) were used during industry screening, and all six factors were used to consider down-selected markets. **For the purpose of this analysis, STeP assumed the generation of approximately 16-32 KLD of distilled A-OP process water per day.
STeP screened out 14 industries based on poor match with first four evaluation factors.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Volumes Procured</th>
<th>Pricing</th>
<th>End-User Accept.</th>
<th>Ease of Startup</th>
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<tbody>
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<td>Iron/Steel</td>
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<td>Power Plants</td>
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<td>CPG***</td>
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- *Volumes Procured:* End users in these industries often require large volumes of water for production. For example, a medium-sized textile factory may use 700KLD–5MLD. Because of the large volumes needed, end users typically treat water to required quality levels on site, rather than buying purified water. Thus, the total volume of water bought in these sectors is likely to be small.*

- *Pricing:* Prices paid for agriculture water appears to be less than INR 0.001/L ($0.000015/L).**

- *Ease of Startup:* For lab applications, costs would be required for additional water purification/upgrading (from distilled to higher grades), packaging, and certification of water quality.

- **Primary factor(s) for screening out industry.

* There may be isolated cases where buyers exist in these industries; however, local-level analysis would be required to identify opportunities. **Estimated from “State of Indian Agriculture 2015-16.” (Government of India, 2016) and “Pricing of Water in Public Systems in India” (Central Water Commission, 2017). ***See Appendix for additional information on these industries obtained by STeP during exploration/screening.
Two sectors, battery and engine-coolant manufacturing, emerged from STeP’s industry-screening process.

Battery Manufacturing

Distilled or demineralized water is used in lead-acid batteries, manufactured for both mobile and stationary uses. Battery manufacturers either produce distilled water on site for production or buy this water from an outside source. When purchased, distilled water is delivered to end users in tankers or large reusable containers. Some batteries also require the addition of distilled water as part of regular maintenance/servicing. This water is typically sold to end users in bottles at retail locations such as gas stations and vehicle repair shops.*

Engine-Coolant Manufacturing

Manufacturers mix distilled or demineralized water with either ethylene glycol or propylene (and sometimes other additives) to produce engine coolant. Coolant manufacturing facilities either generate distilled water on site or buy this water from an outside source. When purchased, distilled water is delivered to these end users in tankers or large reusable containers. Coolant manufacturers often make/sell other products, usually related to engine function (e.g., lubricating greases, oils). Thus, coolant is typically not their only line of business.

* Note that STeP focused on the potential sale of bulk A-OP water (tanker or large containers), rather than the sale of bottled battery water—because of the costs/complexities associated with installing/operating a packaging line and warehousing a potentially large numbers of bottles that might be produced.
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Battery mfrs. buy distilled water in tankers or bulk containers from local suppliers who produce the water.

1) Surface Water
2) Groundwater
3) Piped Municipal

Part of value chain most relevant for sale of A-OP water
Battery manufacturers in India provided the per-liter delivered prices they pay for distilled water. Reported values were 0.25, 0.33, 0.35, 0.35, 0.5, and 3 INR/Liter. These manufacturers appear to be reputable businesses. Thus, STeP is assuming they are purchasing water at a quality level acceptable for their specific application. **STeP did not observe any significant geographic differences in prices among the battery manufacturers interviewed for this analysis.

Delivered Prices Reported by Battery Manufacturers*

Key Factors Impacting Price**

- **Delivery costs/distance**—local delivery costs can account for 10%–50% of price, according to experts interviewed.
- **Quality of water**—one manufacturer reported paying INR 3.00/L ($0.045/L). This buyer pays a higher price because his company is manufacturing a more-specialized battery product, which requires higher-quality water than is typical for the segment.
- **Quantity purchased**—lower relative prices were reported for larger-volume purchases. "We have to buy large quantities such as 10,000 liters or higher as [water] manufacturers charge additional money for delivering lower quantities" —Battery Manufacturer, Maharashtra
- **Competition from established suppliers**—“There are many water manufacturers in cities [like Kolkata and Delhi], and it will likely be very competitive to sell water... DI/DM water is sold for very cheap.” —Battery Manufacturer, Telangana

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*Seven battery manufacturers in India provided the per-liter delivered prices they pay for distilled water. Reported values were 0.25, 0.33, 0.35, 0.35, 0.5, and 3 INR/Liter. These manufacturers appear to be reputable businesses. Thus, STeP is assuming they are purchasing water at a quality level acceptable for their specific application. **STeP did not observe any significant geographic differences in prices among the battery manufacturers interviewed for this analysis.
Battery mfrs. did not have concerns about safety of A-OP water. Some buy water at volumes relevant for A-OP.

**End-User Acceptance**

"Willing to buy water derived from treated sewage water if the water meets the required standard and is cheaper than what we currently pay.” – Battery Manufacturer, Tamil Nadu

"Adoption of recycled sewage water will likely not face challenges at least for industrial use.” – Battery Manufacturer, Delhi

**Volume Procured by Individual User**

- 2,857 liters per day, median value
- "Battery manufacturers that consume >5,000–7,000 liters/day prefer installing their own plant.” – Battery Manufacturer, Kolkata
- "A small unit making 20 [lead acid] batteries a day needs DM water of 20-35 liters per day per battery. 16,000 LPD is needed for production of 500-600 batteries a day--this is a sizable production.” – Industry Observer, India

**Number of Buyers:** ~210–840 in India

- More than 2,100 manufacturers in India produce batteries using distilled water.**
- 10%–40% of manufacturers buy distilled water (vs. producing on site***), based on estimates provided by multiple manufacturers.

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*Based on the following values provided by five battery manufacturers during interviews: 286-571; 1,000; 2,857; 5,000; and 5,000. **Based on data from the Annual Battery Directory 2018 (http://www.batterydirectory.co.in)—confirmed during an interview with the editor of directory. ***One manufacturer reported a cost of INR 0.10-0.15/L to produce 500-1,000 L/day onsite. It is unknown if this cost includes both CAPEX and OPEX. Battery manufacturers who make water onsite cited a wide range of costs for water-purification equipment—from INR 12,000-60,000 ($176-$881).
Battery mfrs. are concentrated in cities like Delhi and Bengaluru—potential target areas for A-OP.

Location/Concentration of Potential Buyers*

- Higher concentrations of battery manufacturers were observed in Bengaluru (Karnataka), Delhi, Hyderabad (Telangana), Kolkata (West Bengal), Mumbai (Maharashtra), and Pune (Maharashtra).

- Other observations/comments from experts:
  
  “Target states up north such as Bihar, UP, MP, Rajasthan, Haryana, Delhi, Gurgaon, Uttarakhand. These states usually have water crises and also have poor quality of water... many established battery manufacturers [Amara and Luminous] have facilities there... Do not target Orissa and West Bengal. It is very competitive and you will have to sell the water for free in these states.” —Battery Manufacturer, Kolkata

  “E-rikshaw batteries require a lot of water and they would likely be the right customers to sell this water. Cities like Kolkata, Delhi, have many of these battery manufacturers and would likely be the market to sell water... However, there are many water manufacturers in these cities and it will likely be very competitive to sell water as in my experience DI/DM water is sold for very cheap” —Battery Manufacturer, Telangana

  “Battery industry is fragmented and spread all across India. There is not one specific region/state where battery manufacturers are concentrated. The reason being that raw materials are easily available locally so there are many local players in every state.” —Battery Manufacturer, Gujarat

*Note that this not a complete list of manufacturers. Rather, this subset of ~325 battery manufacturers is meant to illustrate general distribution of manufacturers across India, as well as higher concentrations in some cities. This list does not distinguish between manufacturers who buy water and those who produce onsite. Names and locations (city and state) of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.
The battery mfg. market is expected to grow, but lead-alternative battery options could impact water sales.*

**Market Trends**

- The lead-acid battery industry in India was worth $4.7B in 2016.
- It consists of two general segments: mobile (SLI lead acid, traction) batteries and stationary batteries.
- Two major companies, Exide Industries and Amara Raja Batteries, accounted for ~45% of the lead-acid battery market in 2016.
- “Unorganized,” smaller companies accounted for ~43% of the market in 2016. These companies offer less expensive batteries (up to 25% less expensive than “branded batteries”), but these batteries often have shorter lifetimes because of lower-quality materials used in manufacturing.
- This industry is predicted to experience at a CAGR of 8.36% between 2017 and 2022.
- Key growth drivers
  - for the mobile segment include increasing automobile sales; and
  - for the stationary segment include growing demands for telecommunications infrastructure.
- Factors that could impact future markets include:
  - volatility in lead prices; and
  - potential switch over to other battery types (e.g., lithium ion).
- “Several different batteries such as maintenance, dry, and gel batteries do not require water or require least amount of water. These batteries are catching pace and more and more end users are preferring these over the conventional batteries... Over the next 10 – 20 years, no batteries will use water.” –Battery Manufacturer, Telangana

*As previously noted, distilled or demineralized water is used in lead-acid batteries, manufactured for both mobile and stationary uses. **Source (unless otherwise noted): TechSci Research, 2017. “Indian lead acid battery market: Leading from the front.” (http://www.ipfonline.com/news/detailnews/indian-lead-acid-battery-market-leading-from-the-front/Technical%20Articles/8509/9369)
Coolant mfrs. buy distilled water in tankers or bulk containers from local suppliers who produce the water.

Part of value chain most relevant for sale of A-OP water

1) Surface Water
2) Groundwater
3) Piped Municipal

*One coolant manufacturer said that many of these operations use raw water instead of distilled, to save on costs.
Coolant manufacturers pay INR 0.48-3.00/L for distilled water. An OP operator may have to sell at low end to compete.

**Key Factors Impacting Price**

- **Delivery costs/distance**—local delivery costs can account for 10%–50% of the price. Two experts in the coolant value chain said that transport over larger distances (> 50 km) can result in delivery costs of ~INR 2/L ($0.03/L).

- **Quality of water**—some coolant manufacturers pay higher prices for higher-quality water: “We focus a lot on quality, whereas other coolant manufacturers do not. All that they look at is price. You sell it cheaper than the market rate, even if you sell poor quality, people will still buy. This is the harsh truth.” —Coolant Manufacturer, Gujarat

- **Quantity purchased**—this segment is expected to be similar to battery-manufacturing segment, where water manufacturers charge lower per-liter prices for larger volume (e.g., >10,000 L) purchases.

- **Competition from established suppliers**—“Engine coolant is a very competitive market—a lot of companies typically competing on two dimensions—price and quality—usually price.” —Coolant Distributor, Karnataka

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*Nine coolant manufacturers in India provided the per-liter delivered prices they pay for distilled water. Reported values were 0.48, 0.50, 0.50, 0.58, 0.65, 0.70, 1.5, 2.5, and 3.0 INR/Liter. These manufacturers appear to be reputable businesses (e.g., part of the "organized" sector). Thus, STeP is assuming they are purchasing water at a quality level acceptable for their specific application.**STeP did not observe any significant geographic differences in prices among the coolant manufacturers interviewed for this analysis.*
Coolant mfrs. were not concerned about safety of A-OP water, but few buy water at volumes relevant for A-OP.

## Coolant Manufacturing Market

**Number of Buyers:** ~80–250 in India

- 800–1,000 engine coolant manufacturers in India**
- ~10%–25% buy distilled water (vs. producing on site)***
- Above estimate does not include gas stations, automobile part retailers, and auto repair shops who make coolant in small quantities (~200-400 liters/day)—one expert estimated that this segment includes ~4,000 additional end users. It appears that a larger percentage of these end users buy water. However, experts said that many of these operations use raw (or treated municipal) water, instead of distilled, to save on costs.

## End-User Acceptance

“If Bill Gates can drink treated waste water, we can certainly use it. Only the water parameters matter.” –Engine Coolant Manufacturer, Gujarat

“Yes, I would be willing to buy if you can provide the water at a cheaper price [than my current supplier charges]” –Engine Coolant Manufacturer, Rajasthan

## Volume Procured by Individual User*

5,000 liters per day, median value

714–15,000 liters per day per manufacturer

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*Based on the following values five coolant manufacturers provided STeP during interviews: 714; 1,000; 5,000; 5,000; and 15,000. **Based on estimates provided by three experts interviewed by STeP. ***Based on feedback from four experts interviewed by STeP.
Coolant mfrs. are concentrated in cities like Delhi, Mumbai, and Pune—potential targets areas for A-OP.

Location/Concentration of Potential Buyers*

- Higher concentrations of coolant manufacturers were observed in Ahmedabad (Gujarat), Delhi, Jaipur (Rajasthan), Mumbai (Maharashtra), Pune (Maharashtra), and Rajkot (Gujarat).
- Other observations/comments from experts:
  
  “There is some concentration in metros like Delhi and Mumbai... also in Gujarat—base oils come from ports there. [Oils are used in other auto products typically made by companies who make engine coolants].” – Coolant Manufacturer, Rajasthan

  “[Coolant manufacturers are concentrated in] leading auto production states like Maharashtra and Gujarat. –Coolant Wholesaler, Maharashtra

Locations/concentrations of known coolant manufacturers in India.*

(See Appendix for larger map.)

*Note that this not a complete list of manufacturers. Rather, this subset of ~400 coolant manufacturers is meant to illustrate general distribution of manufacturers across India, as well as higher concentrations in some cities. This list does not distinguish between manufacturers who buy water and those who produce on site. Names and locations of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.
The coolant industry is growing. Unorganized mfrs. are entering the market with low cost/quality products.

**Market Trends**

- The engine coolant industry in India is predicted to experience a 6% CAGR between 2014 and 2019.*
- Growth is being driven by
  - an increase in the number of automobiles (end users); and
  - India’s improving capabilities in the production and refining of oil—ethylene glycol, a key component of coolant, is more readily available, which in turn, drives coolant production.*
- The market can be broadly divided into two segments: “first factory fill” (coolant added to engines during production) and replacement (coolant added during engine servicing).*
- New automobiles are typically serviced free of charge at authorized (franchised) auto repair shops—servicing includes the addition of high-quality, branded coolants. When free service expires, owners typically get coolant from local auto-repair shops, which often produce and use lower quality (and lower price) coolant.**
- The coolant replacement market represents a significant portion of the total coolant market in India. Many “unorganized” coolant manufacturers (e.g., gas stations, automobile part retailers, and auto-repair shops making their own coolant) are entering the market and represent a threat to established manufacturers in the replacement market.**
- The “retail channel” has traditionally been the primary sales driver for automobile coolant sales in India. However, demand for “first factory fill” may be increasing, as both auto sales and demand for higher performing coolants grow in India.*

In both battery and coolant segments, A-OP will likely compete with established suppliers for market share.

### Ease of Startup for A-OP Operator

- Established water manufacturers exist in locations where battery and coolant manufacturers currently operate. The A-OP operator would represent a new water manufacturer entering these markets and would likely have to compete based on price.

- Battery and coolant manufacturers were mixed in their willingness to switch to a new water provider like A-OP. Quality, service/reliability, and cost were cited as critical factors driving the decision.

  “A new player would need to build trust to have recurring business from the same end users. It will take some time, but if you provide good quality and service, you will be fine.” —Battery Manufacturer, Tamil Nadu

  “Yes, we can consider buying distilled water from a new manufacturer, but it depends on the price and quality.” —Engine Coolant Manufacturer, Delhi

  “I have been purchasing water from the same manufacturer in the past few years. He provides me with a competitive price, and I have established a good professional relationship with him. He provides quick service and has been providing the correct quality of water so why would I risk a new player. Shifting to a new player involves a number of risks and is a lengthy process, so why would I shift only to save a couple of rupees/paisas.” —Battery Manufacturer, Delhi

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*Note that this is not a complete list. Rather, this subset of ~230 is meant to illustrate general distribution of purified-water manufacturers and the higher concentrations in some cities across India. It excludes companies that appear to be solely manufacturing drinking water, water for pharmaceutical, or water for other human-contact applications. Names and locations of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.*
To sell water into battery and coolant segments, A-OP will likely incur some startup costs.

Ease of Startup for A-OP Operator (cont.)

- A-OP operator may incur costs associated with
  - creating/maintaining business channels with local end users;
  - coordinating delivery/transportation to end users;
  - purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers*; and
  - possibly certifying the facility as a water manufacturing operation—experts indicated that buyers of higher-quality water may desire ISO certification** and/or may require more-frequent/rigorous testing of quality to ensure consistency.
- Little to no anticipated costs for water upgrade, assuming the A-OP can consistently produce water that meets the specifications of these end users***—it is anticipated that A-OP process water will be of a similar quality as water used in coolant and battery manufacturing. If this is the case, little to no costs would be expected for upgrading A-OP water, unlike other industry sectors explored by STeP, such as laboratory. (See Appendix for information on laboratory sector.)
- No costs associated with packaging—A-OP water can be sold in bulk (tankers or large containers) to end users, unlike other parts of the value chain (or other industries) where bottling/packaging operations are required.

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*Monthly testing may be sufficient for water sale to battery and coolant manufacturers, according to two water manufacturers; however, it depends on the specific buyer (weekly or even daily testing could be required). Two experts indicated that the cost of sending a sample to a certified lab for testing is ~1,500 INR. **One expert noted that ISO 9001:2015 quality management certification would cost ~INR 100,000 (INR 30,000 for consulting services + INR 70,000 for certificate). However cost can vary depending on factors such as plant size, turnover, etc. ***Note that the actual quality/specifications for Ankur A-OP water will not be known until operational data is available from the Vadodara demonstration plant.
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Findings from Industry Exploration & Screening

- Many categories of water products are sold in India, including raw, potable, distilled, deionized, demineralized, and ultrapure. These categories vary in quality, and users often demand customized qualities even within the same product category.
- Prices vary both between and within product categories.
- Water-quality specifications, volume purchased, and delivery cost are three factors that strongly influence price. Supplier competition and branding can also impact price.
- A wide variety of industry sectors in India require some level of treated/purified water that could be relevant to Ankur Scientific’s A-OP. However, many were screened out as priority targets because they
  - treat/purify water on site at the point of use, rather than buying treated/purified water from an outside vendor;
  - pay such low per-liter prices that potential income generated by sales would not likely impact A-OP economics;
  - would not accept A-OP water because of stigmas associated with real/perceived risks to human health (due to consumption or contact), or with real/perceived risks to end-product quality or functionality; and/or
  - would require significant startup costs on the part of an A-OP operator for market capture (e.g., to upgrade water to a higher quality, to bottle/package the water, to certify/validate quality).
- Niche markets for purified water may exist in some of the industries screened out as part of this study. However, local-level analysis would be required to identify individual opportunities.
Findings from Battery & Coolant Mfg. Segments

- Battery-manufacturing and coolant-manufacturing industries may be potential targets for the sale of Ankur Scientific’s A-OP water. Some manufacturers in these segments procure distilled water in tankers or bulk containers from local suppliers who produce the water.*
- During interviews with the battery and coolant industry segments, STeP observed that potential buyers
  - did not have safety concerns about using A-OP water;
  - sometimes procure water at prices and volumes relevant for A-OP, allowing for the potential offset of some costs associated with operating an A-OP; and
  - sometimes expressed a willingness to switch to a new water provider like an A-OP operator—quality, service/reliability, and cost were cited as critical factors driving the decision to switch to a new supplier.
- In the battery and coolant segments characterized by STeP, an A-OP operator would
  - need to identify a location with a high enough concentration of buyers, because of the high costs of transporting bulk quantities of water over large distances;**
  - be viewed as a new water manufacturer entering the market—an A-OP operator would have to compete with established local players to win market share, and the A-OP would likely have to compete based on price; and
  - face startup costs associated with selling into these markets, which could include creating/maintaining business channels with local end users, coordinating delivery/transportation to end users, purchasing equipment for testing water-quality specifications or sending samples to lab for testing (to verify quality and consistency for buyers), and possibly certifying the facility as a water manufacturing operation.

*It is important to note, however, that a significant number of battery and coolant manufacturers treat/purify water onsite, rather than buying it from an outside vendor. **The A-OP produces a significant amount of water (16-36KLD) when operating at capacity. In contrast, the median reported volume of water procured by a battery mfg. was 2.9 KLD, and the median reported value for a coolant mfg. facility was $5KLD. Also note that two experts in the coolant value chain said that transport over distances >50 km can result in delivery costs of ~INR 2/L ($0.03/L).
SUMMARY OF FINDINGS & IMPLICATIONS

Findings from Battery & Coolant Mfg. Segments (cont.)

- In a prior Sanitation Technology Platform (STeP) study, Afri-Dev explored the coolant manufacturing market in Senegal. This study can be found at [http://stepsforsanitation.org/resource-center/omni-processor-technology/](http://stepsforsanitation.org/resource-center/omni-processor-technology/). Findings from the Afri-Dev study and the current analysis indicate that significant differences exist between markets in Senegal and India.
- Key differences that could impact overall near-term opportunities for the sale of OP water in each country include the following:
  - Senegal lacks in-country ISO/international-standard manufacturing capability for coolant, unlike India, which has a more developed and sophisticated coolant manufacturing sector.
  - Senegal does not appear to manufacture glycol, which is used to make coolant. In contrast, India has in-country glycol manufacturing capabilities.
  - The price of distilled water (used to make coolant) appears to be higher in Senegal compared to India, presumably because of a lack of manufacturing capacity in Senegal. Based on cursory market research, the price of distilled water in Senegal was estimated to be $0.12/L or 9 INR/L. In contrast, the highest observed price paid in India by coolant manufacturers was $0.045/L or 3 INR/L (the median observed price was $0.010/L or 0.65 INR/L).
  - Because of the lack of in-country manufacturing capacity in Senegal, ISO-certified coolant from multinational companies such as Shell/Vivo and Total is imported. As a result, prices for quality coolant appear to be relatively higher in Senegal than in India.
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Water prices in India vary widely both within and between product types.

Price ranges observed for select water types/applications during cursory exploration of India market*

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Price Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Water</td>
<td>$0.00000001 – $0.00002/L</td>
</tr>
<tr>
<td>Domestic Water</td>
<td>$0.0001 – $0.02/L</td>
</tr>
<tr>
<td>Industrial Water</td>
<td>$0.001 – $0.2/L</td>
</tr>
<tr>
<td>Bottled Drinking</td>
<td>$0.05 – $1.6/L</td>
</tr>
<tr>
<td>Distilled</td>
<td>$0.03 – $1.4/L</td>
</tr>
<tr>
<td>Deionized</td>
<td>$0.09 – $1.4/L</td>
</tr>
<tr>
<td>Demineralized</td>
<td>$0.06 – $1.6/L</td>
</tr>
<tr>
<td>Ultra Pure</td>
<td>$0.29 – $6.88/L</td>
</tr>
</tbody>
</table>

*This graph consists of a limited number of data points from a mix of primary sources (e.g., vendor quotes, buyer interviews) and secondary sources (e.g., India Mart). Data includes both delivered and nondelivered prices, as well as prices for various volumes sold. Note that the high end of the range for Industrial ($0.20) appears to be an outlier—this private water supplier (who sold to railways and other industries) went out of business.
Water quality and volume purchased are two factors that strongly influence price.

**Example of how price can vary among UPW water products based on quality.**

**Example of how prices for the same water product can vary based on volume purchased.**
FACTORS IMPACTING WATER PRICES

Another example of price differences based on volume purchased.

Water prices for “high-grade pure” distilled water (pre-delivery) from a manufacturer in Karnataka.

Distilled Water Price (USD) Per Liter vs. Container Volume

<table>
<thead>
<tr>
<th>Container Size (Liter)</th>
<th>Distilled Water Price (USD) Per Liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>$0.32</td>
</tr>
<tr>
<td>210</td>
<td>$0.40</td>
</tr>
<tr>
<td>0.5</td>
<td>$1.60</td>
</tr>
</tbody>
</table>

Another example of price differences based on volume purchased.
Delivery cost/distance, supplier competition, and branding can also impact water-product prices.

**Delivery Cost/Distance**
Local delivery costs for bulk quantities (tankers or large containers) can account for 10%–50% of total price paid by a buyer, according to experts. Two experts said that delivery over larger distances (> 50 km) can result in delivery costs of ~INR 2/L ($0.03/L).

**Competition among suppliers**
In many locations, multiple water suppliers exist. Experts indicated that competition between these players drives down prices in many markets.

**Branding**
For some water products (e.g., bottled drinking water, UPW for applications like HPLC), end users may pay higher per-liter prices for branded products. For example, some laboratory end-users purchase more expensive nationally branded HPLC water products (Fisher, Rankem, Millipore, Sigma, etc.) rather than products offered by local producers, because of real or perceived differences in water quality.
Water used for battery/coolant manufacturing in India is often deionized rather than distilled.

**Methods Used to Purify Water**

- In India, purified water used in battery/coolant manufacturing is produced in two ways:
  - Distillation
  - Deionization (ion exchange)
- The term “DM water” in India most often refers to water produced using deionization.
- According to a specialty chemical manufacturer in Gujarat, “Mostly distilled and DM [deionized] water are the same. The reason there is confusion is that originally, distilled was used to mean purified water because it was the only way to make it. As such, it is in all of the text books like this. Now that DM and other technologies have come out that give the same quality water, people are still calling it distilled. Water quality is essentially the same.”
- Overall, deionization appears to be the more common of the two methods for producing water required in battery/coolant manufacturing. Reverse osmosis is also frequently used to treat raw water prior to deionization.

**Examples of Onsite Purification Methods and Costs Reported by Battery/Coolant Manufacturing Facilities in India**

<table>
<thead>
<tr>
<th>Manufacturer Type/Location</th>
<th>Purification Method Used</th>
<th>Volume Purified</th>
<th>Onsite Purification Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Manufacturer, Gujarat**</td>
<td>Deionization</td>
<td>500–1,000 L/day</td>
<td>INR 0.10–0.15/L ($0.0015–0.0023/L)</td>
</tr>
<tr>
<td>Battery Manufacturer, Tamil Nadu***</td>
<td>Deionization</td>
<td>6,000–8,000 L/day</td>
<td>INR 0.10–0.30/L ($0.0015–0.0045/L)</td>
</tr>
<tr>
<td>Battery Manufacturer, Gujarat</td>
<td>Distillation</td>
<td>~800–1,500 L/day</td>
<td>INR 0.10–0.20/L ($0.0015–0.0030/L)</td>
</tr>
<tr>
<td>Coolant Manufacturer, Rajasthan</td>
<td>Deionization</td>
<td>5,000 L/day</td>
<td>INR 0.30–0.40/L ($0.0045–0.0060/L)</td>
</tr>
<tr>
<td>Coolant Manufacturer, Delhi</td>
<td>Deionization</td>
<td>500–700 L/day</td>
<td>INR 0.5–0.6/L ($0.0075–0.0090/L)</td>
</tr>
</tbody>
</table>

*During interviews, it was often unclear what costs (e.g., capital, O&M, raw water) were included in these estimates. Many interviewees struggled to translate costs into per-liter estimates. **This manufacturer indicated that the cost of their purification system was ~INR 50,000–INR 60,000 ($900–$1,000). ***This manufacturer stated that their estimate did not include O&M costs (e.g., labor, electricity, plant maintenance), which is difficult for them to quantify.
Per-liter production costs for deionized water are driven by the volume purified and raw water costs.

STeP obtained cost estimates for two reverse osmosis plus deionization systems. Estimates were provided by an equipment vendor in Maharashtra to illustrate key cost drivers of competing water products.

Examples of Per-Liter Production Costs in India for Deionized Water Using Reverse Osmosis Followed by Deionization*

*The vendor provided capital costs, consumables costs, electricity requirements (12 units of electricity/day), and labor requirements (1 skilled laborer). STeP estimated electricity and labor costs based on vendor-reported requirements (assuming 5 INR/unit of electricity and 1 skilled laborer at INR 15,000/month). Maintenance is assumed to be 1% of capital costs—these costs are too low to be visible on the above figures. The example systems are designed to receive “municipal” water as the raw water source (at <100 ppm Total Dissolved Solids [TDS]). The systems would reject 99.5% TDS. For raw water costs, STeP assumed “low” and “high” cost scenarios. For “low raw water cost,” STeP is assuming INR 0.02/L, which is consistent with 2018 estimates from Rajasthan and Haryana. For “high raw water cost,” STeP is assuming INR 0.06/L, which is consistent with a 2018 estimate from Mumbai. (Source: India Briefing, 2018. “India’s Industrial Water Rates and Supply.”)
STeP considered business models for the sale of A-OP water and relative cost/complexity for startup.*

<table>
<thead>
<tr>
<th>Potential Business Model</th>
<th>Cost/Complexity of Startup for A-OP Operator</th>
<th>Likelihood of Scenario for A-OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-OP operator stores process water onsite until a local buyer picks it up in a tanker or a bulk container</td>
<td><strong>Lowest</strong>—would require installing an onsite storage tank. The local buyer(s) and/or local transportation company would handle/coordinate pickup.</td>
<td><strong>unlikely</strong>—none of the buyers interviewed by STeP expressed a willingness to procure water using this model. All used established (trusted) local water manufacturers, who appear to handle transportation logistics.</td>
</tr>
<tr>
<td>A-OP sells process water in bulk (e.g., in tankers or large reusable containers) to established water manufacturers</td>
<td><strong>Lower</strong>—would require • installing an onsite storage tank; • creating/maintaining business channels with local water manufacturers; • possibly coordinating delivery to local water manufacturer; and • possibly purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers.</td>
<td><strong>unlikely</strong>—most established water manufacturers interviewed by STeP said that the availability of A-OP water would be a threat to their business, and they would not be willing to engage in this model. The only exceptions would be cases where an established water manufacturer is experiencing a temporary/unexpected product shortage. In those cases, the manufacturer may consider purchasing A-OP water.</td>
</tr>
<tr>
<td>A-OP sells process water in bulk (e.g., in tankers or large reusable containers) directly to end users</td>
<td><strong>Medium</strong>—would require • installing an onsite storage tank; • creating/maintaining business channels with local end users; • coordinating delivery to end users; • purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers; and • possibly certifying the facility as a water manufacturing operation—experts indicated that buyers of higher-quality water may desire ISO certification and/or may require more-frequent/rigorous testing of quality to ensure consistency.</td>
<td><strong>likely</strong>—some end users in battery and coolant manufacturing said that they would be willing to switch to a new water manufacturer (like A-OP); however, water quality, service/reliability, and cost were cited as critical factors driving this decision.</td>
</tr>
</tbody>
</table>

* Note that this table does not include all possible business-model scenarios. Rather, it is meant to illustrate potential scenarios, as well as possible tradeoffs between these scenarios.
STeP explored business models for the sale of A-OP water and relative cost/complexity for startup.*  

<table>
<thead>
<tr>
<th>Potential Business Model</th>
<th>Cost/Complexity of Startup for A-OP Operator</th>
<th>Likelihood of Scenario for A-OP</th>
</tr>
</thead>
</table>
| A-OP operator packages process water and sells it to buyers (either directly or through a distributor)  
Example of relevant product/buyer: Bottled distilled battery water sold to battery dealers and/or distributors of auto products | High—would require  
• installing an onsite storage tank;  
• creating/maintaining business channels with distributors;  
• coordinating delivery to distributors;  
• purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers;  
• possibly certifying the facility as a water manufacturing operation—experts indicated that buyers of higher-quality water may desire ISO certification and/or may require more-frequent/rigorous testing of quality to ensure consistency; and  
• installing and operating a packaging line and warehousing a potentially large numbers of containers that might be produced. | Unlikely in near-term because of high costs/complexities for startup and uncertainties over returns. This scenario could represent a longer-term opportunity; however, further investigation would be needed to determine whether a strong business case exists.** |
| A-OP operator upgrades process water to higher-quality water product, packages it, and sells it to buyers (either directly or through a distributor)  
Example of relevant product/buyer: Bottled HPLC water (or other grades of UPW) sold to laboratory segment through a distributor | Highest—would require  
• installing an onsite storage tank;  
• creating/maintaining business channels with distributors;  
• coordinating delivery to distributors;  
• purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers;  
• certifying the facility as a water manufacturing operation—experts indicated that buyers of higher-quality water may desire ISO certification and/or may require more-frequent/rigorous testing of quality to ensure consistency;  
• installing and operating a packaging line and warehousing a potentially large numbers of containers that might be produced; and  
• purchasing and operating equipment for upgrading water, which could also include infrastructure to ensure that the product is made in a clean, contaminant-free production environment. | Unlikely in near-term because of high costs/complexities for startup and uncertainties over returns. This scenario could represent a longer-term opportunity; however, further investigation would be needed to determine whether a strong business case exists.** |

* Note that this table does not include all possible business-model scenarios. Rather, it is meant to illustrate potential scenarios, as well as possible tradeoffs between those scenarios. **STeP observed high per-liter price points for higher-quality bottled products; however, overall volumes sold appears to be relatively low and competition exists from established water manufacturers (ability to capture market share is unknown).
STeP considered potential costs involved in bottling and/or upgrading A-OP water.

During industry screening, STeP identified several market segments that would require an A-OP operator to bottle (e.g., to produce bottled battery water) and/or upgrade (e.g., to produce bottled HPLC [ultrapure] water). STeP determined that the costs/complexities of startup, as well as uncertainties over return on investment, make bottling/upgrading unlikely scenarios for an A-OP operator in the near-term. However, some information was collected during industry screening in an attempt to better understand bottling/upgrading costs. This information consisted of price quotes from vendors selling this type of equipment.* Vendor quotes only consider CAPEX and are based on assumptions (e.g., volumes, quality of input/output water) that might not hold true in an operational A-OP environment. As a result, this data appears to be of limited use in understanding the incremental, per-liter costs that might be incurred by an A-OP operator for bottling and/or upgrading.

The following challenges currently exist for accurately calculating incremental, per-liter costs of bottling/upgrading:

**For bottling**

- The exact volume of A-OP water that would require bottling is unknown. Volume will have a significant impact on per-liter cost.

- The type of bottled water product that would be manufactured is unknown. Bottle size, bottle materials, and sterilization requirements can vary between and within industry segments—all of these factors impact per-liter costs. Other factors impacting bottling costs include level of automation required and line speed.

**For upgrade**

- The exact specifications/quality, consistency, and volume of Ankur A-OP water produced in an operational environment is not well understood at this time (due to stage of development). Per-liter upgrade costs will be highly dependent on these parameters (i.e., more details are needed on the input water that will be processed by the upgrade/purification system).

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*Vendor quotes are available, upon request, to OP partners. Also note that STeP attempted to obtain anecdotal cost information during interviews. However, water manufacturers were unwilling to share this information because of business sensitivities. Other value-chain players interviewed by STeP had a poor understanding of these costs and were unable to provide useful information.*
STeP screened out the following industries during interviews with stakeholders.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmaceutical/Medical Mfg.</td>
<td>The pharmaceutical/medical industry requires ultrapure water for injections and consumables. In addition, this industry uses purified water for laboratory uses, such as cleaning and experiments/analysis. (See “Laboratory” below.)</td>
</tr>
<tr>
<td>Specialty Chemical/CPG</td>
<td>Specialty chemicals (SC) and Consumer Packaged Goods (CPG) are both extremely broad industries, consisting of a large number overlapping sub-industries (e.g., SC sells water-based products that are used in CPG home-care products). STeP explored subsectors that experts identified as being sensitive to input water containing high total dissolved solids (TDS)—making these subsectors more likely to require purified water.</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Laboratories consuming purified water include commercial (testing), university, and in-house-industrial labs. Two broad categories of purified water consumed by labs include:</td>
</tr>
<tr>
<td></td>
<td>• Lab-Grade Water—mostly used for cleaning and sanitizing purposes. It is typically produced at a higher quality level than standard distilled water. Large packages (20L+) of lab-grade water is often supplied by local manufacturers.</td>
</tr>
<tr>
<td></td>
<td>• HPLC water (also referred to as distilled – type II)—a highly-purified water primarily used in lab environments for analytical experiments such as HPLC, mass spectrometry, and gas chromatography. End users often purchase branded bottled products from nationally recognized companies. HPLC water is commonly packaged in 1L, 2L, and 5L bottles.*</td>
</tr>
</tbody>
</table>

*Source: Industry interviews conducted by STeP*
Pharma/medical has end-user acceptance issues and most users upgrade water onsite.

<table>
<thead>
<tr>
<th>End User Acceptance</th>
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</thead>
<tbody>
<tr>
<td>“While this will likely not happen, but if anything goes wrong with pharma products, the A-OP water can be an easy target. Additionally, nowadays people’s immunity in India has reduced and such a water can cause more problems or can be perceived to create challenges.” —Water Manufacturer/Distributor, Maharashtra</td>
</tr>
<tr>
<td>“Pharma companies apart from checking the water quality certification, lay emphasis on source of raw water, type of plant, cleanliness of plant, etc.” —Water Manufacturer/Distributor, Gujarat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volumes Procured</th>
</tr>
</thead>
<tbody>
<tr>
<td>“&gt;90% of pharma companies have an in-house plant as they have strict quality requirements.” —Water Manufacturer/Distributor, Gujarat</td>
</tr>
<tr>
<td>“Most pharma companies are purifying the water themselves because of control/quality issues.” —Pharmaceutical Company, Karnataka</td>
</tr>
<tr>
<td>“Another reason pharma companies make it themselves is that production has to be continuous, the pump is on 24 hours a day – it [the water] can’t stagnate.” —Pharmaceutical Company, Karnataka</td>
</tr>
<tr>
<td>“All pharmaceutical companies need to have water purification facilities on site because they are subject to regulatory audits. Without complying to these regulatory audits, pharma companies cannot market their products. Additionally, as purified water specifications in pharma are stringent, all pharma companies have purified water production facilities on site” —Pharmaceutical Company, Gujarat</td>
</tr>
<tr>
<td>“For pharma industry, one cannot outsource water - they have to be careful of the contamination and that’s why pharma companies prefer in-house production” —Pharmaceutical Company, Tamil Nadu</td>
</tr>
</tbody>
</table>
Specialty chem. and CPG subsectors explored by STeP have end-user acceptance issues or buy small volumes.

<table>
<thead>
<tr>
<th>Evaluation Factor</th>
<th>Subsector</th>
<th>Interview Quotes/Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-User Accept.</td>
<td>Catalysts (SC)—used to increase the rate of chemical reactions in many products</td>
<td>• “For most customers, conversation would stop at “sewage”, they won’t want to take that risk because they are supplying high-value products” – Industry Observer, Karnataka</td>
</tr>
<tr>
<td>End-User Accept.</td>
<td>Enzymes (SC)—used in CPGs such as home-care products</td>
<td>• “For every enzyme, detailed study would have to be done to ensure that there was no interference with their microbial activities” – Industry Observer, Karnataka</td>
</tr>
<tr>
<td>End-User Accept.</td>
<td>General Water-Based Chemicals (SC)—used to add specific properties to products (e.g., biocidal properties)</td>
<td>• “Would be similar to enzymes - fundamental systems that deal with microbes. It would be important to ensure there are no adverse effects.” – Industry Observer, Karnataka</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Acids—sulfuric acid (SC), as an example, is used in battery manufacturing</td>
<td>• “Most acid manufacturers have their own plant as it is very cheap to produce it onsite. If one is using 5-10 KLD, they are bound to have an onsite plant”—Specialty Chemical Manufacturer, Gujarat</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Acids—sulfuric acid (SC), as an example, is used in battery manufacturing</td>
<td>• “I don’t think anyone [acid manufacturers] will want water as they all produce on site. If they are producing acid, how difficult would it be to produce water? Many acid manufacturers are also in the water business.”—Specialty Chemical Manufacturer, Maharashtra</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Agrochemical (SC)</td>
<td>• “Very few agrochemical companies use distilled water. Most of them use raw water.” – Specialty Chemical Manufacturer, Gujarat</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Agrochemical (SC)</td>
<td>• “Membrane technology used in water purification procedures (RO) have become much more affordable in recent years.” – Specialty Chemical Manufacturer, Maharashtra</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Agrochemical (SC)</td>
<td>• “Almost 100% of small- and medium-size agrochemical companies use raw water to save on cost.”—Specialty Chemical Manufacturer, Maharashtra</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Inks and Pigments (SC)</td>
<td>• Of 8 companies interviewed by STeP, 4 are using treated/purified water. All companies using treated water had their own systems.</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Home Care Products (CPG/SC)</td>
<td>• “We bought water initially, but it was not cost-effective and was labor intensive so we installed RO. Ideal situation would be DM water, but not a high priority. [As long as cost of DM] is more, we will stay with RO”–Home Care Product Manufacturer, Karnataka</td>
</tr>
<tr>
<td>Volumes Procured</td>
<td>Home Care Products (CPG/SC)</td>
<td>• “We mix DM with RO water in some products for cost-saving” – Home Care Product Mfr., Gujarat</td>
</tr>
</tbody>
</table>

SC = Specialty Chemicals, CPG = Consumer Packaged Goods
Laboratory water buyers may have acceptance issues, and startup costs to serve these buyers could be high.

### End-User Acceptance
- Many lab buyers are in the pharma/medical industry, where social acceptance issues exist—*“Selling recycled wastewater/sewage water to pharma will be very difficult and not a good option.”* – Water Manufacturer/Distributor, Maharashtra
- However, lab end-users outside of pharma/medical that were interviewed by STeP said they would consider buying A-OP water if it meets technical requirements and has the required certifications.

### Ease of Startup
- End users appear to be highly fragmented—as a result, it could be difficult to find locations where enough local buyers exist that consume large enough volumes to be relevant for A-OP.
- A-OP operator may incur costs associated with
  - creating/maintaining business channels with local end users
  - coordinating delivery/transportation to end users
  - purchasing equipment for testing water-quality specifications or sending samples to lab for testing—to verify quality and consistency for buyers
  - possibly certifying the facility as a water manufacturing operation—experts indicated that buyers of higher-quality water may desire ISO certification and/or may require more-frequent/rigorous testing of quality to ensure consistency.
  - upgrading water from distilled to either lab-grade or HPLC—*“Manufacturing UPW is very complicated. It requires high-tech machines, which are expensive and require proper maintenance.”* – Water Manufacturer/ Distributor, Maharashtra
  - installing and operating a packaging line and warehousing the large numbers of containers that would be produced.
Laboratory end-users pay relatively high per-liter prices for purified water products.

### Delivered Prices*

- **Lab-Grade:**
  - INR 27.50/L ($0.41/L), Median
  - INR 33.88/L ($0.51/L), Average
  - INR 15 – 90/L ($0.23 – $1.35/L), Range
- **HPLC Water—Nationally Branded Products:**
  - INR 277/L ($4.16/L), Median
  - INR 271 ($4.07/L), Average
  - INR 100 – 430/L ($1.50 – $6.45/L), Range
- **HPLC Water—Locally Manufactured Products:**
  - INR 135/L ($2.03/L), Median
  - INR 133/L ($2.00/L), Average
  - INR 50 – 200/L ($0.75 – $3.00/L), Range

### Key Factors Impacting Price**

- **Brand** (for HPLC, which is associated with real or perceived differences in water quality)—some end users purchase more expensive nationally branded products (Fisher, Rankem, Millipore, Sigma, etc.) from local and/or regional authorized/independent distributors. Others buy products that are manufactured and sold locally.
- **Quality of water**—including parameters such as organic content, pH, and total dissolved solids.
- **Quantity and frequency of purchase**—discounts may be given to regular/larger purchasers.
- **Delivery costs/distance**
- **Competition from established suppliers**

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* Based on estimates provided by a small number of laboratories and established water suppliers interviewed by STeP.

** STeP did not observe any significant geographic differences in prices.
Lab buyers at both national and local levels seem to purchase relatively small quantities of purified water.

**Number of Buyers: 1,000s in India**

- ~2,000 NABL* certified chemical and biological testing labs were identified in India; most labs were concentrated in Maharashtra, Gujarat, Karnataka, and Tamil Nadu. Interviewees indicated that the majority of these labs are located in metro cities such as Mumbai, Delhi, Pune, and Bangalore.
- When considering university and in-house industrial labs, the total number across India is much larger than 2,000.
- However, not all labs buy water (larger-volume end-users tend to produce purified water onsite).

**Volume Procured by Individual User**

<table>
<thead>
<tr>
<th>Lab-Grade</th>
<th>HPLC Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 of 7 labs interviewed buy lab-grade water, rather than produce it on site.</td>
<td>4 of 7 labs interviewed buy water, rather than produce it on site.</td>
</tr>
<tr>
<td>“In India, testing laboratories might be buying around 400,000 L/year of lab-grade water, as labs just use around 25-30 L/day for cleaning of glassware.” – Water Distributor, Gujarat</td>
<td>“In India, HPLC water sold will likely be around 1M L/year” – Water Manufacturer/Distributor, Maharashtra</td>
</tr>
<tr>
<td>“Not a lot [sold in India overall], probably around 600,000 L/year.” – Water Distributor, Gujarat</td>
<td></td>
</tr>
</tbody>
</table>

Lab-Grade: ~40 – 55 L/day per laboratory

HPLC Water: ~20 L/day per laboratory

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*National Accreditation Board for Testing and Calibration Laboratories

**Based on estimates provided by a small number of laboratories interviewed by STeP
Location/concentration of battery mfrs. in India*

*Note that this not a complete list of manufacturers. Rather, this subset of ~325 battery manufacturers is meant to illustrate general distribution of manufacturers across India, as well as higher concentrations in some cities. This list does not distinguish between manufacturers who buy water and those who produce on site. Names and locations of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.
Location/concentration of coolant mfrs. in India*

*Note that this not a complete list of manufacturers. Rather, this subset of ~400 coolant manufacturers is meant to illustrate general distribution of manufacturers across India, as well as higher concentrations in some cities. This list does not distinguish between manufacturers who buy water and those who produce on site. Names and locations of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.
Location/concentration of purified water mfrs. in India*

*Note that this not a complete list. Rather, this subset of ~230 is meant to illustrate general distribution of purified-water manufacturers and the higher concentrations in some cities across India. It excludes companies that appear to be solely manufacturing drinking water, water for pharmaceutical, or other human-contact applications. Names and locations of these manufacturers are available to OP partners in spreadsheet format upon request from STeP.