# Sustainability Comparison Study: Assessing Centralized Treatment Upgrades and POU/POE Treatment for Small System Compliance to the SDWA

## Research Brief
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This study examined point-of-use (POU) and point-of-entry (POE) devices in comparison to improvements to existing centralized systems for Safe Drinking Water Act compliance using a triple bottom line analysis. The study was conducted using data from four very small community water systems (serving less than 500 people) from four different EPA regions in the United States to ground the analysis in the community water system (CWS) specific considerations necessary to complete a triple bottom line analysis. An exposure assessment was conducted to evaluate human health impacts of each alternative (POU/POE versus centralized treatment), a life cycle analysis to examine environmental impacts and a life cycle costing analysis to examine economic impacts over a thirty-year study period. The analysis was specifically targeted to examine the considerations necessary to implement POU/POE devices as a compliance solution for either arsenic or nitrate contamination for CWSs. The purpose of the study was to holistically examine the tradeoffs a very small water system may face when choosing an additional treatment solution to remove a specific drinking water contaminant of concern.

The triple bottom line analysis conducted in this study was informed by state-specific and CWS-specific assumptions in order to ensure the analysis was as complete and realistic as possible. As such, the assumptions we documented for each state are presented in the full report to frame the analysis results in detail. In each community water system, we consulted with state administrators, community water system operators and other important water system stakeholders to understand the existing water treatment system and to identify a realistic improvement that the CWS was interested in exploring. We then identified two POU/POE devices for each community water system that are certified to the relevant NSF/ANSI standards for the removal of either arsenic or nitrate specifically. We consulted state specific guidance on POU/POE devices to determine (1) whether to select a POU or POE solutions and (2) how the state approves and implements POU/POE devices to determine the necessary steps to implement a POU/POE device as a compliance strategy.

### *Selected technology alternatives*

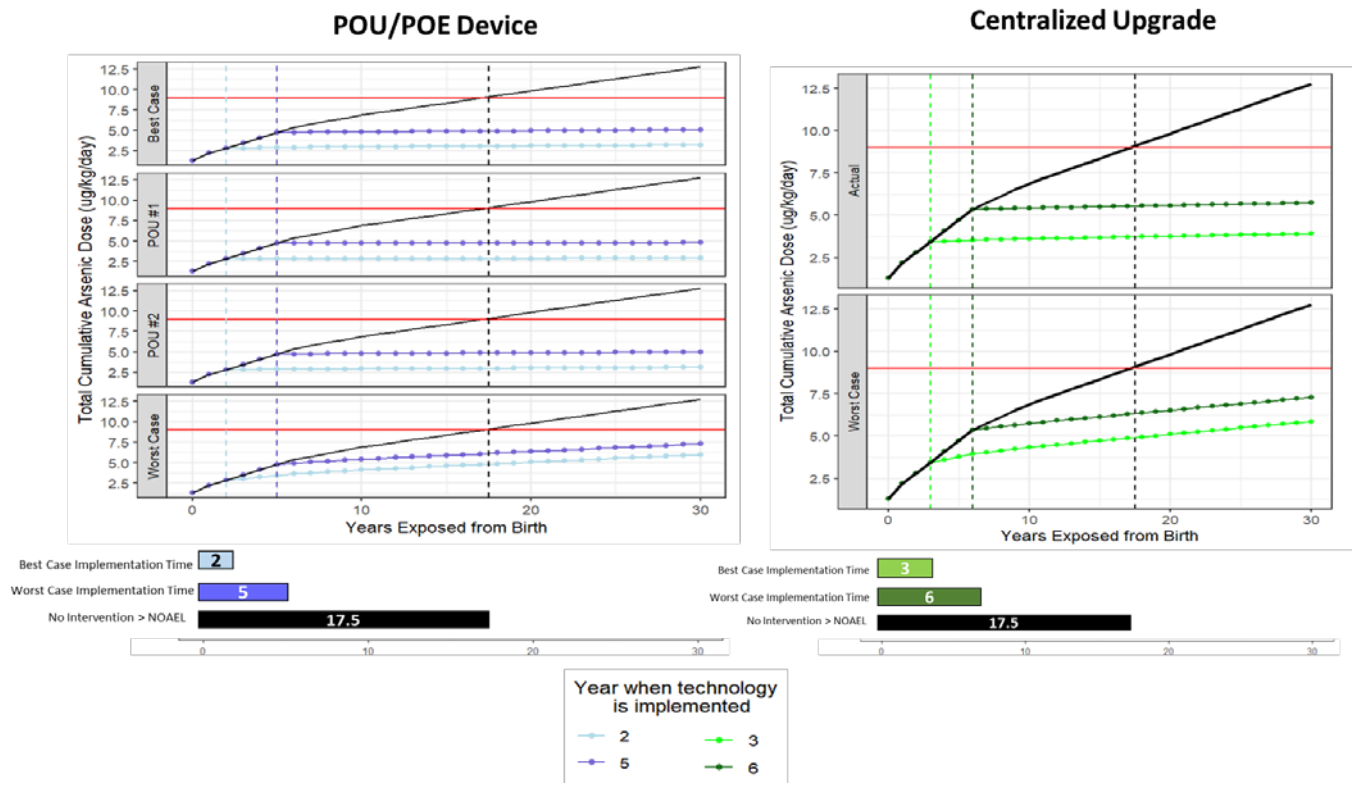
| Region | Current Centralized System | Centralized Upgrade | POU/POE Device #1 | | | POU/POE Device #2 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Company and Model | Type of Device | Certification | Company and Model | Type of Device | Certification |
| 1 | Treatment of 50% of the flow rate from the GW via adsorptive media filtration | Treatment of 100% of the flow rate by adding an additional filtration module | Company B Device B2 | POU carbon adsorptive media | NSF/ ANSI 53 | Company D, Device D1 | POU reverse osmosis | NSF/ ANSI 58 |
| 5 | Aeration and Pressure Sand Filtration for co-precipitation of arsenic with iron | Enhance pre-oxidation by moving pre-chlorination step ahead of aeration | Company K Device K1 | POE GFH* adsorptive media | NSF/ ANSI 53 and CSA B483.1 | Company N, Device N2 | POE GFH* adsorptive media | NSF/ANSI 61 |
| 7 | Wellhead and Distribution System | Centralized anion exchange with a nitrate selective resin | Company G Device G1 | POU reverse osmosis | NSF/ ANSI 58 | Company D, Device D1 | POU reverse osmosis | NSF/ ANSI 58 |
| 9 | Adsorption Media for Arsenic removal + hypochlorite disinfection | Centralized anion exchange with a strong base anion resin | Company B Device B2 | POU carbon adsorptive media | NSF/ ANSI 53 | Company D, Device D1 | POU reverse osmosis | NSF/ ANSI 58 |

*GFH = granular ferric hydroxide

### *Human Health Exposure*

Exposure assessment was used to examine the health impacts associated with the implementation of a drinking water treatment technology. Exposure assessment results revealed the importance of the relationship between the removal efficiency of a treatment solution and the number of years until a solution could feasibly be expected to be implemented in a community water system. While the installation time of POU/POE devices is expected to be quicker than a centralized improvement in many cases, the planning time (including state approvals, device selection, etc.) is expected to contribute a significant amount to how rapidly POU/POE devices can be implemented as a compliance solution.

Below is a figure comparing lifetime exposure to the implementation timeline for the CWS in Region 1. This is presented to show how each intervention changes the exposure experience from birth to 30 years. In this figure, the red line represents the NOAEL value at 30 years, the black trend line represents lifetime exposure if no intervention is implemented, and the remaining curves represent the best case (shortest estimated time to implement) and worst case (longest estimated time to implement) in each CWS. The estimated implementation timeline for the CWS is shown, as well as the number of years before exposure is expected to exceed the NOAEL value if no intervention is implemented (shown in black).



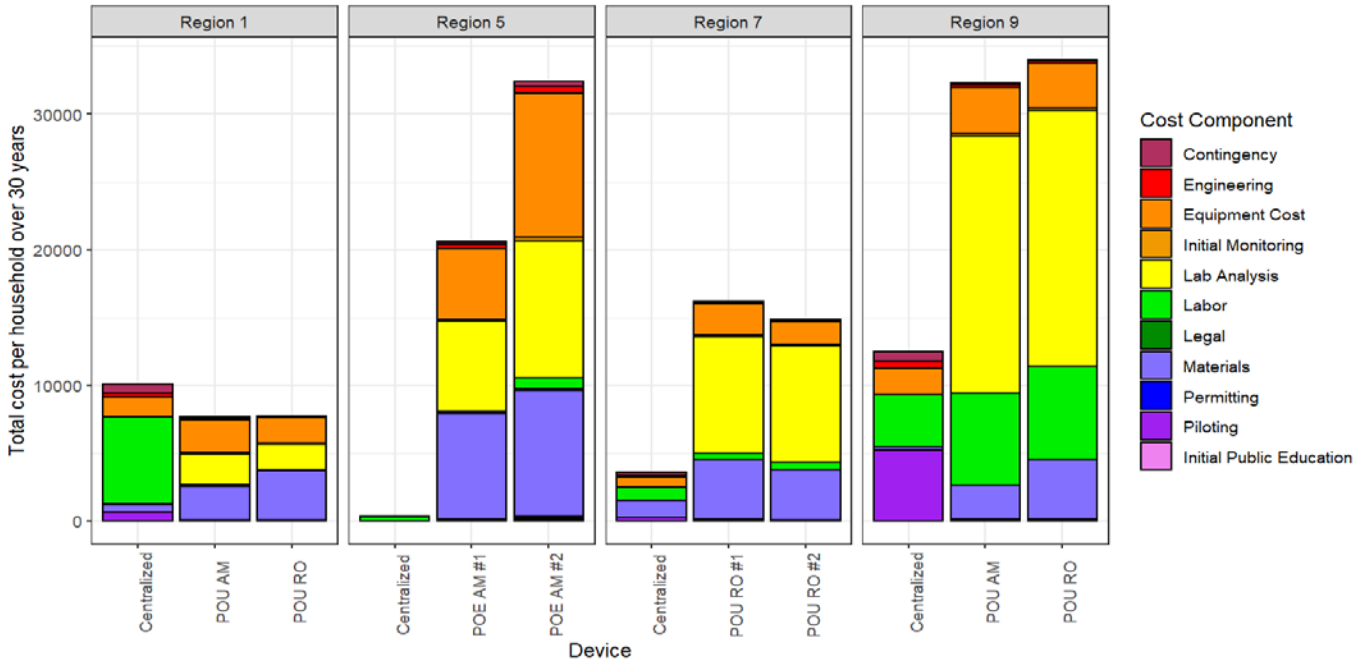

Even though POU/POE device removal efficiencies tend to be higher than centralized technologies, the requirement for 100% participation prior to implementation extends the implementation timeline such that the benefits of removal efficiencies tend to be minimized. Our results show that in systems with high concentrations of contaminants such as arsenic and nitrate, it is critical to implement a technology in a timely manner to reduce lifetime exposure in the most vulnerable populations.

***Environmental Sustainability***

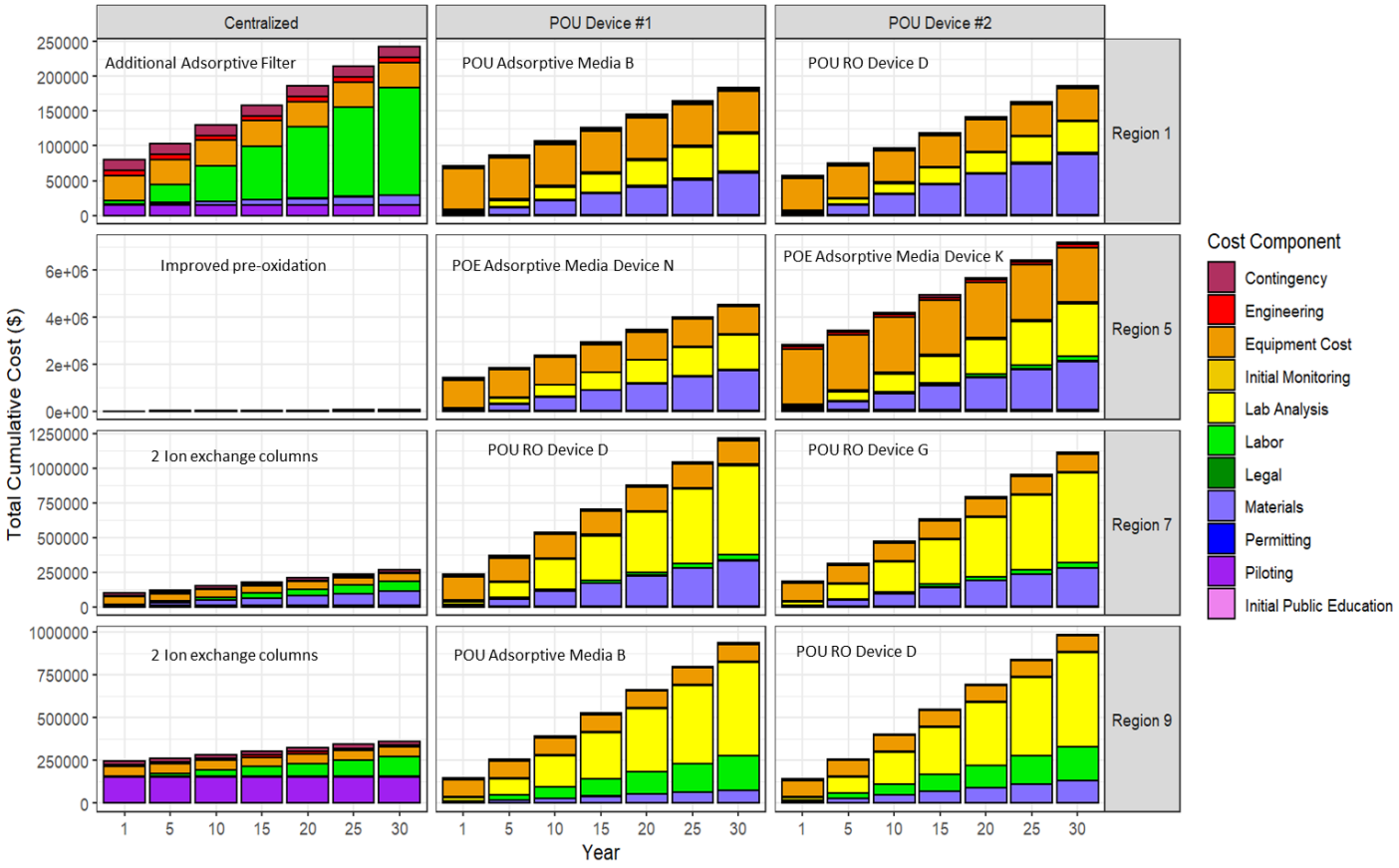
The life cycle analysis (LCA) performed in this study utilized the SimaPro software (version 8.2.1), the ecoinvent inventory database, the TRACI 2.0 method for impact assessment and a functional unit of one household. LCA results indicate that POU/POE devices contribute less per kilogram of material to environmental impacts than improvements to centralized systems in general as a result of a smaller amount of material used in 30 years. Where POU units were compared to centralized adsorptive media and ion exchange technologies, we observed that the cost to process, transport and dispose of these medias contributed the most to the overall impact of these solutions. Similarly, the POE adsorptive media devices examined in Region 5 specifically had larger impacts than the relatively small centralized improvement of optimizing pre-oxidation because of the high environmental impact of the adsorptive media. In Region 1, 7 and 9, POU devices proved to have the lowest overall impacts, with POU reverse osmosis Device D having the lowest total environmental impact overall.

***Economic Cost***

The life cycle cost (LCC) analysis utilized the replacement frequencies from manufacturers, the EPA Cost Models and state specific assumptions to create a detailed inventory of the costs associated with each technological alternative. We extracted unit costs and useful life from the EPA cost models for the centralized cost alternatives and informed these same cost components through conversations with manufacturers and state stakeholders for the POU/POE devices.




Our results indicate that POU devices were a viable alternative from an economic perspective in Region 1, which is the smallest size CWS with 24 connections and a state-enabling environment that removes many of the barriers to POU/POE implementation. The replacement frequency of POU/POE components in each household coupled with the regulatory sampling requirements for POU/POE compliance generate large operation and maintenance (O&M) costs for these devices which exceeded the cost of the centralized upgrade's O&M in Regions 5,7, and 9 over the 30-year study period.




The above figure presents the total cost in the first year and in increments of 5 years to capture how cost increases over time for each alternative during the 30-year period. In the first year of implementation, the total cost per household of a centralized upgrade is within the same order of magnitude as the installation of a POU/POE device. However, over time, the lab analysis costs, material costs and equipment costs of POU/POE devices increase at a faster rate than centralized treatment upgrades. Centralized treatment upgrade components only need to be replaced on average once in the thirty-year time frame, or not at all. However, POU/POE components need to be replaced on average every five years, resulting in a higher equipment and materials cost compared to centralized upgrades. Region 1 and Region 9 have current systems serving approximately the same population and the POU devices considered in the analysis were the same. However, the labor and lab analysis cost model assumptions for Region 9 are such that the cost of ensuring SDWA compliance for the same devices as Region 1 are higher in Region 9, which results in the higher total cost per household over 30 years.

***Considerations for POU/POE as a compliance strategy***

Through our analysis, we identified several critical factors that influence whether a POU/POE device may be used as a compliance solution in very small community water systems. We separated these factors into three categories: systemic barriers to timely and effective POU/POE implementation, technical barriers to long-term sustainability and viability of POU/POE devices and model specific assumptions that need to be considered when applying the triple bottom line analysis to other community water systems. Systemic barriers included whether a state allowed POU or POE devices for compliance purposes, the requirement of 100% community participation prior to piloting and implementation, difficulties identifying certified POU/POE options suitable to a specific CWS and SDWA monitoring compliance requirements. While POU/POE devices are independently certified and tested to ensure contaminant removal, similar to a centralized system, monitoring for SDWA compliance is required in systems using POU/POE devices. While a centralized facility may only need to monitor for contaminant compliance at 1-3 locations, monitoring for compliance with POU/POE devices requires sampling at each individual household to ensure no one CWS customer receives inadequate water quality.

Technical barriers included the high replacement frequency of POU/POE components over the 30-year study period, the number of households where POU/POE units needed to be installed and maintained, and the piloting requirements specific to state guidance on POU/POE devices. Finally, assumptions that need to be changed based on the specific community water system include disposal options for specific technology types and contaminants of concern, long-term sampling frequencies for compliance, the number of O&M activities (labor and frequency of maintenance) and the source water characteristics of the community water supply.

Based on the three different factors above, we present recommendations both to state compliance agencies and POU/POE device manufacturers to aide in the implementation and viability of POU/POE devices in very small water systems.

For CWS stakeholders including managers, operators and homeowners interested in implementing POU/POEs for compliance, we recommend:

- Initiating the community household consultation process early when considering POU/POE devices as a compliance strategy to ensure 100% participation in a timely manner. Provide structure and support when creating legal agreements to facilitate 100% participation.
- Understanding the CWS financing situation to best forecast upfront capital costs and examine long-term O&M costs of using POU/POE devices as a compliance strategy.
- Understanding changes in operator certification requirements, legal administrative costs, etc. that would occur when implementing a centralized or POU/POE device. Consider hiring an engineering firm to establish these costs prior to making a commitment to either a centralized improvement or a POU/POE device.
- Streamlining and coordinating maintenance and sampling activities to limit the burden on households during O&M activities.

For POU/POE device manufacturers and distributors, we recommend:

- Aligning the information available to CWSs across the certifier, manufacturer, and distributors websites and media platforms to ensure that CWSs have easy access to device cost and performance information.
- Collaborating with state agencies and administrators to pilot and test device performance with CWS specific water quality to decrease the time required to pilot and implement POU/POE devices.
- Increasing the durability and useful life of POU/POE components to decrease the frequency of replacing components to ultimately decrease the total overall O&M costs of POU/POE devices over the long-term.
- Include clear information on manufacturer or trade association websites that can be used not only by homeowners, but also by CWS managers to understand the appropriateness of POU/POE devices as a CWS SDWA compliance solution.

For state administrators and agencies, we recommend:

- Establishing clear guidance for both POU and POE devices within the state to allow small CWSs greater flexibility to meet SDWA compliance regulations.
- Continually review the sampling requirements for POU/POE device compliance over time to verify whether the sampling program is both cost effective for the community and whether the POU/POE device is adequately removing the contaminant of concern at a representative number of households within the CWS.
- Helping CWS stakeholders to adequately characterize the water quality in both the source and treated water to enable informed decisions about appropriate technologies. For example, speciating arsenic to understand whether additional pre-oxidation is needed for the removal of As(III) in addition to As (V).
- Establishing clear procedures to permit and approve POU/POE devices to minimize a case-by-case approach. The state should document the steps taken to approve the POU/POE solution to aide future CWSs interested in using POU/POE devices as a solution and promote knowledge sharing.
- Providing support and structure for constructing legal agreements in CWSs that facilitate 100% household participation in a timely manner.