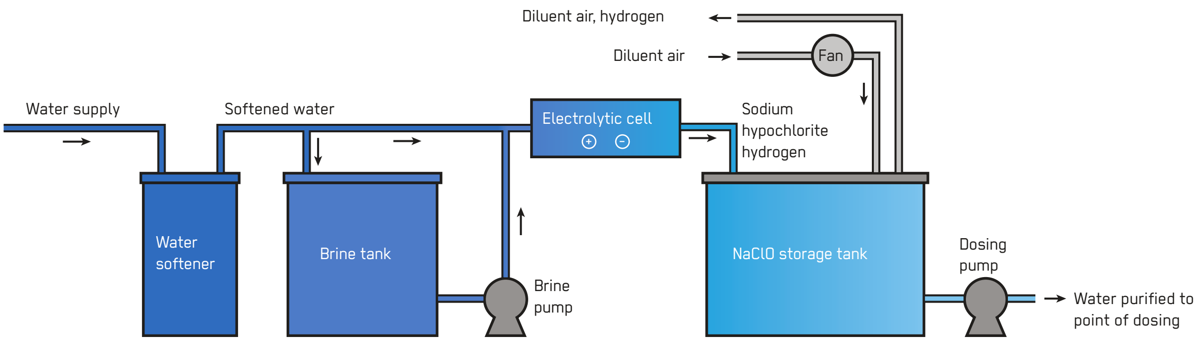
Onsite Electro-Chlorination

Response Phase	Application Level	Management Level	Objectives / Key Features
** Acute Response ** Stabilisation ** Recovery	Household ** Neighbourhood ** City	Household ** Shared ** Public	Disinfection with residual protection
Local Availability	**Technical Complexity**	**Maturity Level**	
** Medium	** Medium	* Low	



Onsite Electro-Chlorination (electrolytic generation of sodium hypochlorite) produces chlorine for disinfection through the electrolysis of aqueous sodium chloride (common salt, or NaCl). It can be produced in batch mode, converting a salt solution into sodium hypochlorite with a concentration of 6–12 g/L either in one buffer tank or in a flow-through system that continuously produces hypochlorite.

Electrolysis uses a direct electric current to drive otherwise non-spontaneous chemical reactions. The reactions occur at two electrodes: the anode and cathode. At the anode, the chloride ion is converted into molecular chlorine (chlorine gas), while the reaction at the cathode produces hydrogen gas and increases the pH. The chlorine gas reacts immediately with hydroxide ions and forms hypochlorite ions. The sodium hypochlorite solution can be used directly for disinfection and/or pre-treatment when operated in a continuous mode or can be stored in a buffer tank for later use when operated in batch mode.

Design Considerations: The quality of the raw water is an important parameter for continuous systems. Generally, the hardness, or the concentrations of manganese, iron, fluoride, free chlorine and cyanides, should be low, or an extensive pre-treatment is needed to protect the electrodes. To account for hard-water, continuous systems are usually designed to have 20–30 % greater capacity to extend the life of equipment. Alternatively, solar salt (i.e. salt produced by the evaporation of brine as opposed to salt that is mined) with a minimum of 99.8 % NaCl is more suitable, as it has lower concentrations of calcium and magnesium (< 0.14 %) as well as other contaminants that foul the electrodes. Batch systems have a greater flexibility in raw water quality, as the electrodes are usually more accessible for cleaning and any salt type can be used. The production cycles can take between 3–12 hours, depending on the scale and manufacturer. The concentration of sodium hypochlorite may vary and must be monitored after every cycle. The produced solution is not stable and needs to be used directly or stabilised by adding caustic soda.

Materials: Small electrolytic cells are available from a few manufacturers as part of a set that includes the testing equipment and solar panel or power adapter. Large continuous systems are available from international companies and occasionally through local distributors as a fully designed system adapted to the local requirements and context.

Applicability: Small batch systems are compact enough to be carried in luggage to produce hypochlorite very quickly in acute emergency contexts when a power supply (or a solar panel) is available. For example, a typical small system on the market can produce 2 L of chlorine with a concentration of 6 g/L in 2.5 hours, enough to treat around 8,000 L of water. Larger systems can produce 30–60 L of chlorine in 4–5 hours and are suited for camps or at drinking water treatment plants when a supply of liquid hypochlorite cannot otherwise be ensured. The systems can be set up using available tanks, and the produced hypochlorite can be dosed through existing dosing systems. When batch systems are set up from scratch, local operators must be trained, which is more realistic during the recovery phase of an emergency or later. Large-scale continuous systems can be considered in protracted urban crises to replace those relying on chlorine gas or liquid hypochlorite, especially when the supply cannot be assured in the long term due to security concerns, embargoes or a limited production capacity in the country.

Operation and Maintenance: Batch systems are relatively simple to operate. They require a power supply as well as equipment to measure salt (brine) concentration, water hardness and final hypochlorite concentration. Most suppliers provide testing equipment as part of the system. Production should be done in well ventilated rooms. Large-scale continuous systems require the support of a trained engineer during the installation and start-up phase, after which the equipment is fully automated. Brine tanks are required to maintain capacity to cover a 15–30-day demand, and the level should be maintained close to the recommended storage capacity to avoid automatic shut-down. Leakage control is essential, as is the careful monitoring of operating voltage, current and the relationship between salt usage versus operating time. Regular inspections should look for signs of electrode fouling and float switches, which may require electrode cleaning. Most systems are supplied with an integrated acid cleaning system, which may be either fully automated or manually operated.

Health and Safety: Onsite Electro-Chlorination reduces the need for the handling, transport, and storage of hazardous materials, thus increasing general site safety. Small batch production should be carried out in well ventilated rooms. For large systems, there is a need for a good ventilation system to remove hydrogen, and hydrogen trapping in pipes should be avoided.

Costs: Small batch systems (producing 0.5–2 L of hypochlorite in up to 3 hours) without solar panels are available starting from 150–300 USD, while large batch systems (producing 30 L of chlorine in 4–5 hours) start from around 1,000 USD. Semi-batch systems require a higher degree of automation and are more expensive. The cost of large-scale continuous systems varies with the context, though they generally have higher initial costs but lower operational costs compared to large-scale chlorine gas systems. When Onsite Electro-Chlorination systems are chosen to replace a conventional chlorine gas system, part of the equipment can be retrofitted to reduce costs.

Social and Environmental Considerations: As for other chlorination techniques, acceptance in areas where it is unknown may prove problematic. It is therefore important to communicate with leaders and the community at the outset to avoid misunderstandings. Taste and odour objections may cause users to reject the water, and this is more likely when the water being treated is turbid or if the chlorine is overdosed. Leakage of concentrated chlorine into the environment is a severe environmental and health hazard.

Strengths and Weaknesses:

(+) Less dependent on chemical supplies, including their availability, transportation and costs
(+) Small batch systems are compact and portable
(+) Continuous systems are automated to a high degree and are less labour intensive
(+) Reduces risk from handling and storage of hazardous materials
(+) Lower operational costs compared to chlorine gas or liquid or solid chlorine systems

(−) Requires skilled operators in O & M for the continuous units or training for batch units
(−) Requires reliable source of electricity
(−) Requires good initial water quality to reduce fouling of electrodes

→ **References and further reading material for this technology can be found on page 218**