# Brine disposal and economics of groundwater desalination plant

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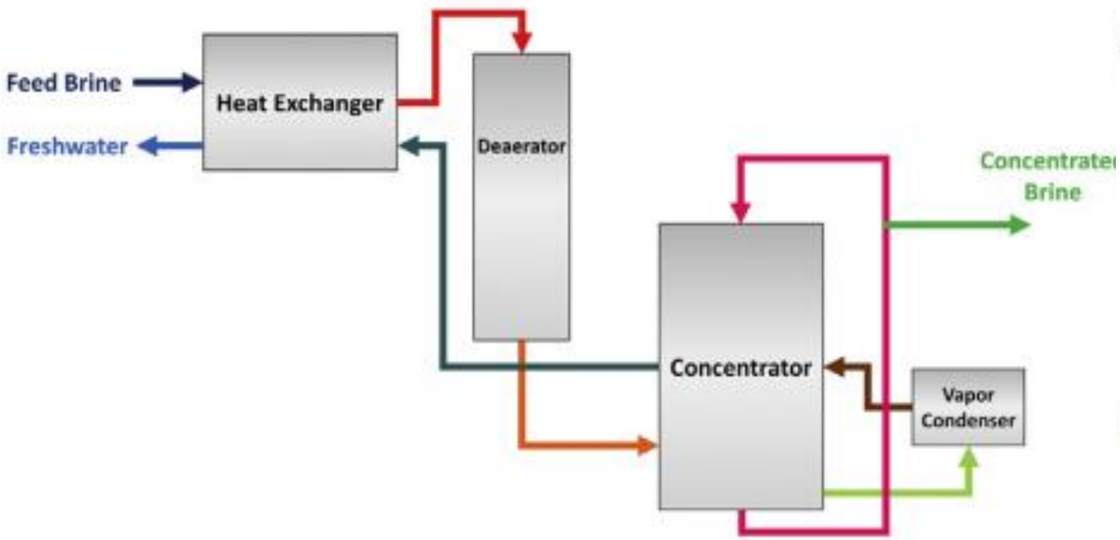
# Brine treatment methods

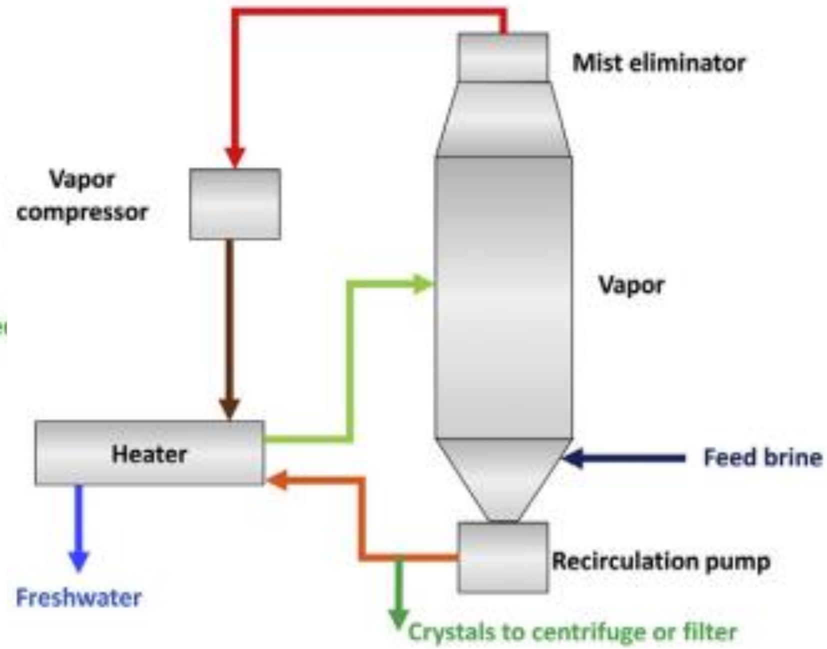
## Zero liquid discharge (ZLD) approach

- As its name indicates, ZLD can be described as a combination of desalination technologies aimed at producing high-quality freshwater with the complete elimination of liquid waste from the plant.
- The freshwater produced from ZLD is highly pure (achieving 95–99% water recovery).
- ZLD system consists of three stages. These stages are (i) pre-concentration, (ii) evaporation and (iii) crystallization.

# Brine treatment methods

## Zero liquid discharge (ZLD) approach



# Brine treatment methods

## Brine concentrator (BC)

In the BC, the feed brine is supplied to a heat exchanger that elevates brine's temperature at the boiling point and then proceeds to a deaerator that removes non-condensable gases. Brine is then inserted into the evaporator sump. Thus, the brine slurry is pumped to the top of the concentrator and flows into a bundle of heat transfer tubes. The flowing brine creates a thin film on the inner tube surface where water evaporation occurs. A portion of brine evaporates and moves through mist eliminators before inserting the vapor compressor, at which extra heat is added. Subsequently, vapor from the compressor passes to the outside of the evaporator tubes, where its heat is transferred to the colder brine that falls inside the tubes

# Brine treatment methods

## Brine concentrator (BC)

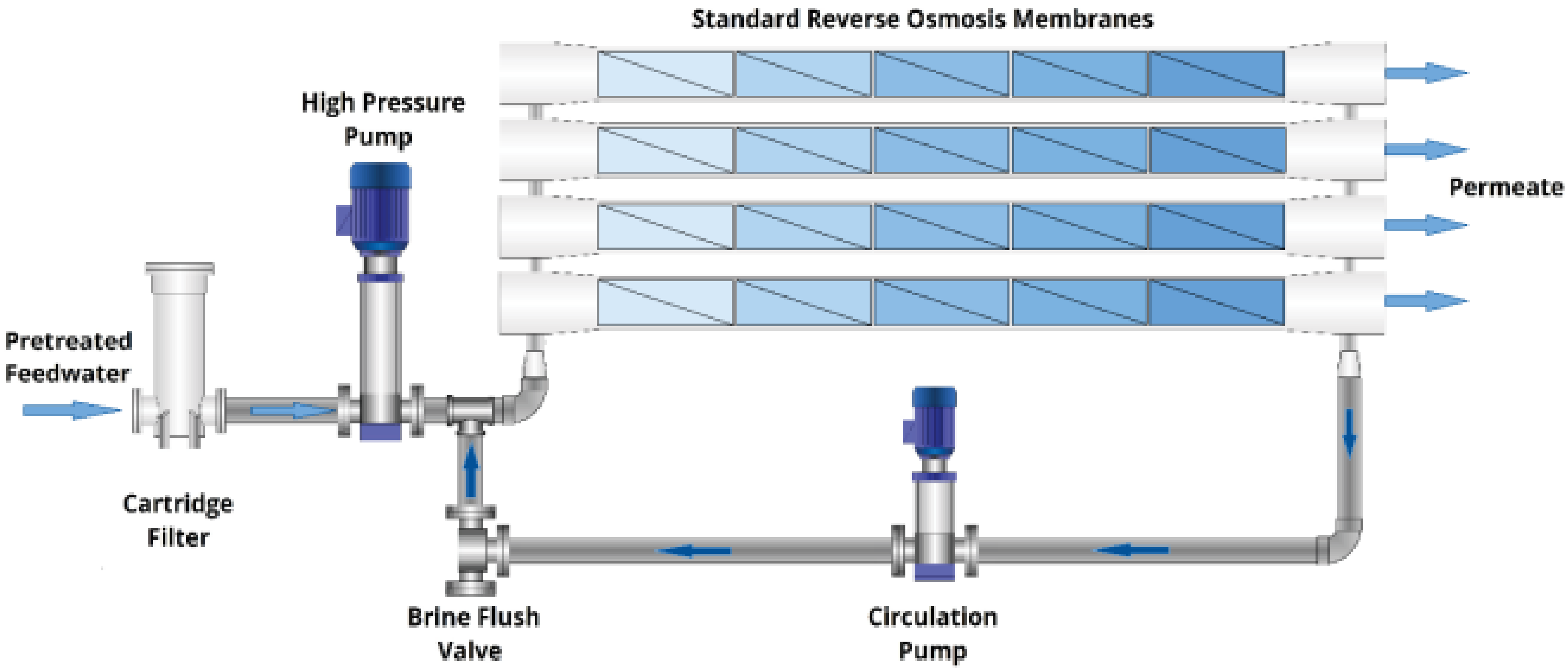
The water recovery of a typical commercial BC system ranges from 90 to 99% and can be used for brine up to 250,000 mg/L TDS. Furthermore, this technology produces high-quality freshwater as its TDS concentration varies from 5 mg/L to 20 mg/L. The SEC of this technology is 15.86–26 kWh/m3

# Brine treatment methods

## Brine CRystallizers (BCr)

- The most common type of crystallizer for brine treatment is the forced circulation crystallizer.
- It can be used for brine up to 300,000 mg/L TDS.
- The SEC of this technology is 52–70 kWh/m3
- .The cost of BC is approximately US$1.11/m3 of freshwater produced, while for BCr it is approximately US$1.22/m3

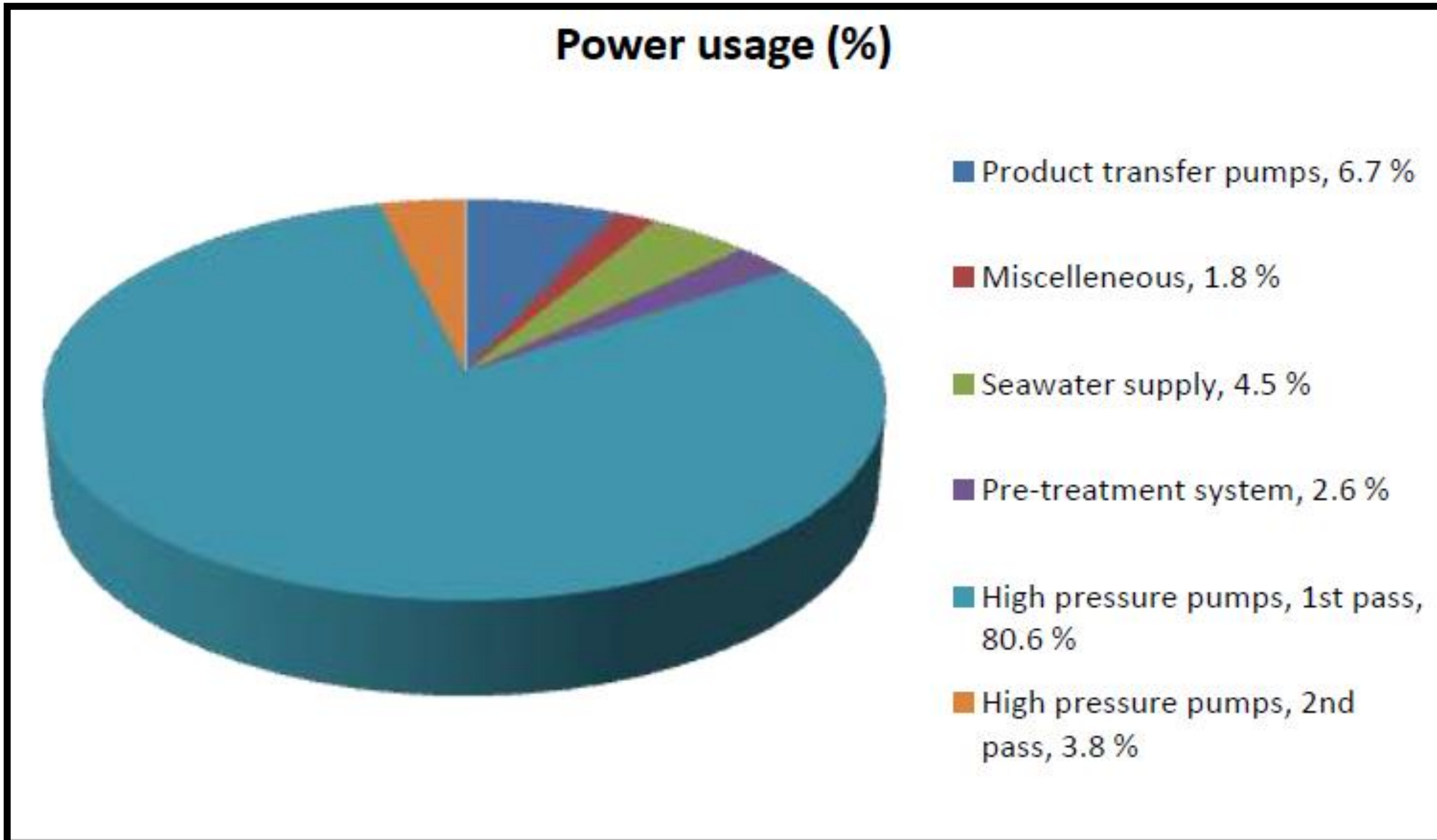
# CLOSED CIRCUIT REVERSE OSMOSIS



# CLOSED CIRCUIT REVERSE OSMOSIS

- The system operates in two modes: closed circuit at 98% recovery.
- A high-pressure pump (HPP) feeds a closed loop comprised of a single-stage of membrane elements and a circulation pump (CP).
- Multiple pressure vessels are operated in parallel with short membrane arrays. Permeate is produced at a rate equal to the flow rate of the HPP.
- When a desired recovery percentage is reached, brine is purged from the system, displaced by feed water from the high-pressure pump in a single plug-flow (PF) sweep.

# Different component and their power usage



# Specific energy consumption (SEC)

SEC is the amount of electrical energy required to produce one $m^3$ of permeate, can be used to evaluate the energy costs of an RO plant. Ideally, assuming 100 % pump efficiency, work done by the pump is assumed to be equal to the electrical energy required.

$$SEC = \frac{W_{pump}}{Q_p}$$

Where:
$Q_p$ – Permeate flow rate,
$W_{pump}$ – Rate of work done by the pump

$$W_{pump} = \Delta P * Q_f$$

$$\Delta P = P_f - P_o$$

$P_f$ – Feed pressure at the entrance of the membrane module,
$P_o$ – Pressure of the raw water,
$Q_f$ – Volumetric Feed Flow rate

# The total energy requirement for the running RO desalination plant

$$E_T = E_{in} + E_{pt} + E_{hp} + E_A$$

$E_T$ – Total energy requirement,

$E_{in}$ – Energy required to draw the feed water from the source,

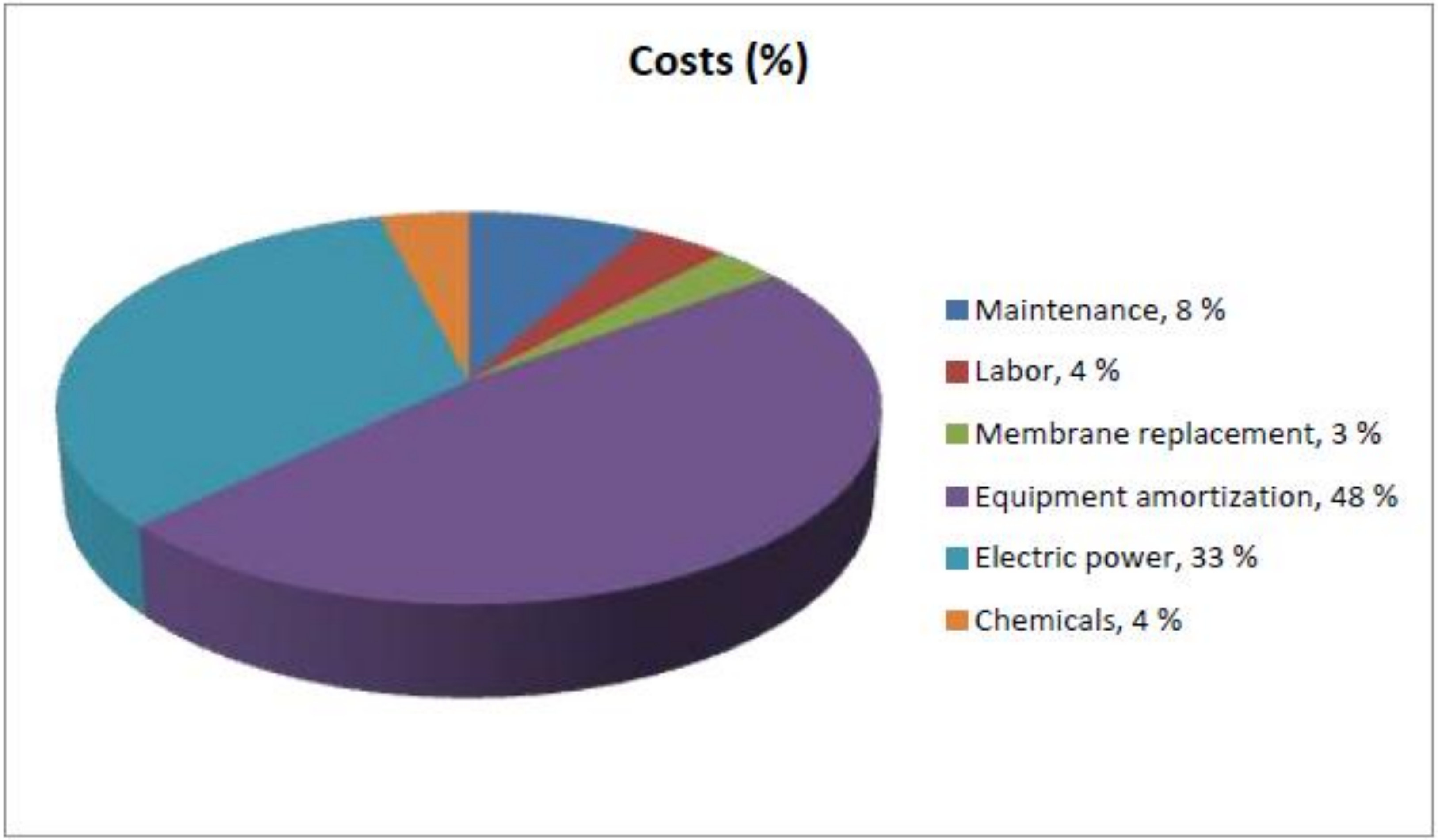
$E_{pt}$ – Energy required for pre-treatment and post-treatment (micro filtration and pumping)

$E_{hp}$ – Energy required by the high-pressure pump,

$E_A$ – Energy required by other accessories (chemical dosing, filter backwashing/cleaning and pumping the product water)

# The total energy requirement for the running RO desalination plant

# Costs associated with RO desalination plants



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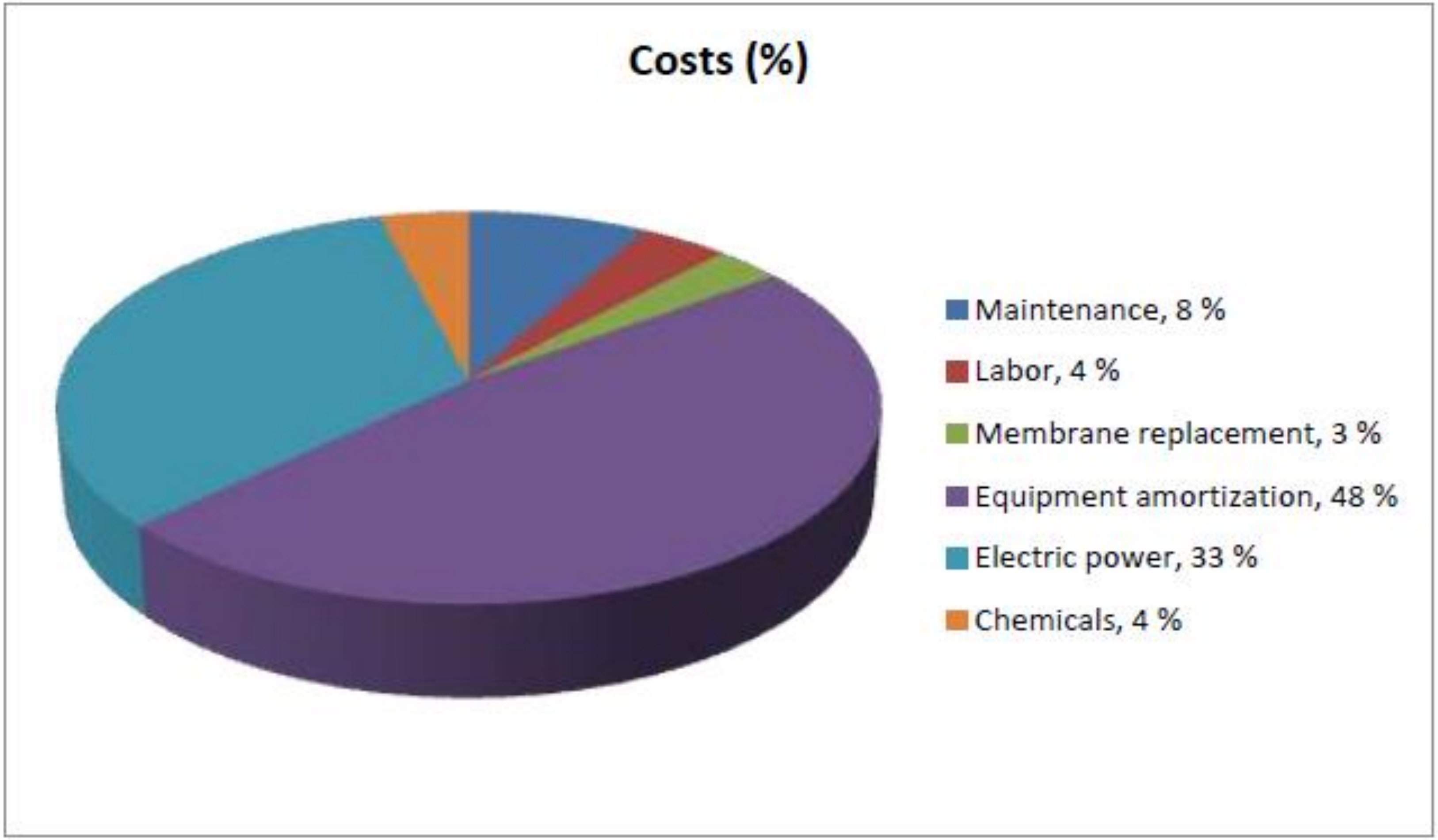


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