Solar Powered Evaporator

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Problem

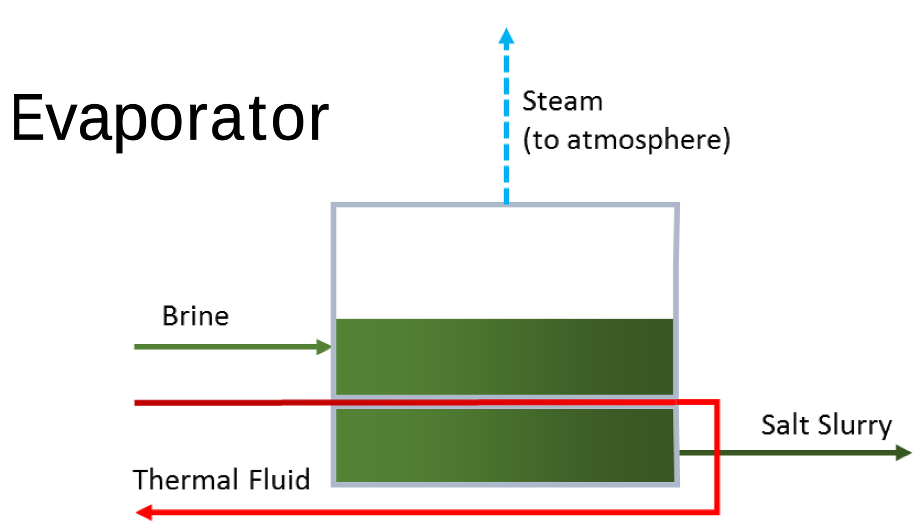
Agribusiness generates a significant portion of the wastewater streams in California. Low salinity wastewater streams are potentially reusable through desalination. High salinity streams often require evaporators to reduce the wastewater volume and disposal costs.

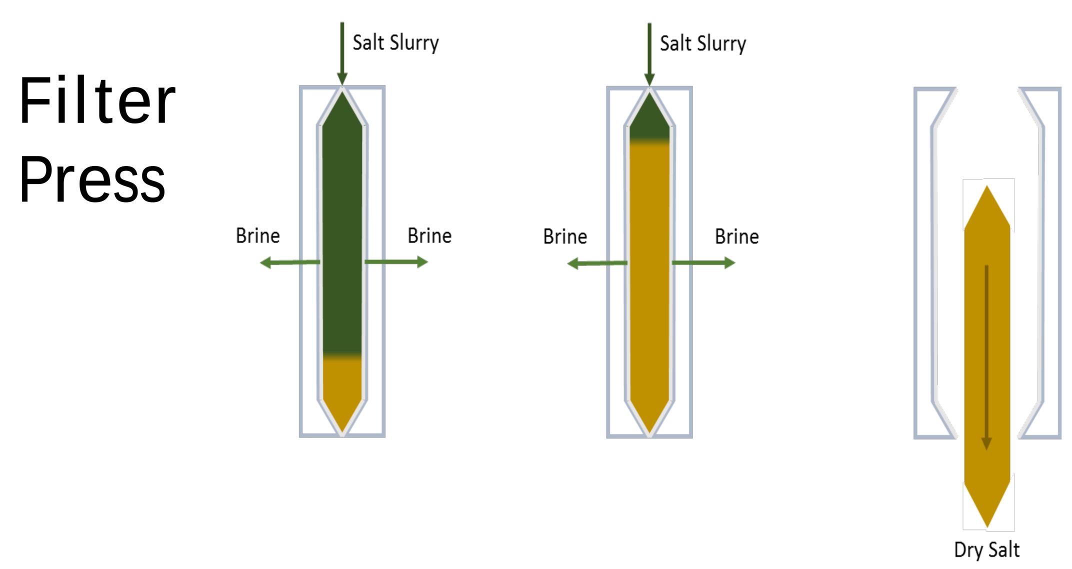
These evaporators require large amounts of thermal energy. This energy has traditionally been supplied by fossil fuels or low grade steam. This makes it problematic to expand the use of evaporators in the large agribusiness industry, as natural gas releases CO_2 and low grade steam is not available in most locations.

To solve this problem, evaporators can instead be powered by solar thermal collector arrays, helping reduce waste streams without exhausting CO_2.

Components

- Small scale solar thermal collector array (~100 kW) with an operating temperature around 150 °C.
- Evaporator configured to run on thermal fluid. Many systems that accept steam can use thermal fluid without modification.
- Optional filter press to convert the salt slurry into salt 'cakes'. Dry salts may be disposed of cheaply or may have a small value.





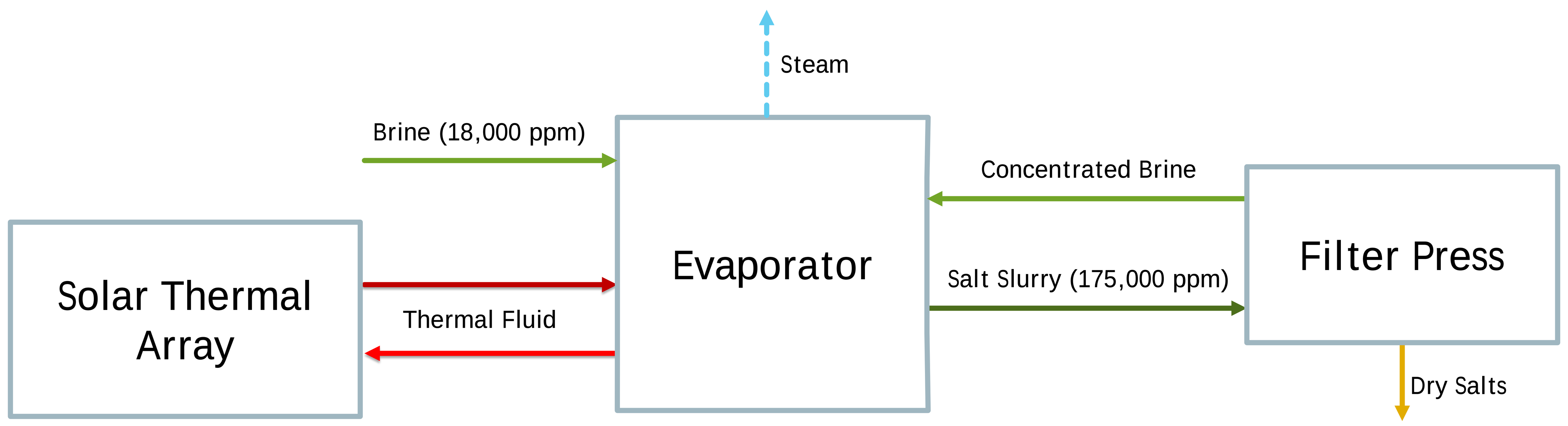
Solar Thermal vs. Natural Gas

In order for solar thermal arrays to have widespread use in agribusiness, they need to be economical enough to compete with natural gas. Natural gas has seen historically low prices in the past few years. The current cost is around 2.7 cents per kWh, with lower costs available for industries.

To directly compete with natural gas, a solar thermal array would therefore have to be installed and operated for around $325 per kW over 10 years of operation, equivalent to 2.7 cents per kWh (estimating 1200 working hours a year).

Current tracking small scale solar thermal installations, capable of reaching 150 °C, cost closer to $2,000 per kW for installation alone. However, non-tracking collectors can be installed for less than $1,000 per kW and still easily achieve the desired working temperature. If these non-tracking collectors were mass produced, the installation price could reduce drastically. In addition, the State of California has monetary incentives making solar thermal systems economical if installed and operated for less than $1,000 per kW. These incentives help offset the price gap between solar thermal and natural gas in the short term.

Example Application



Actual numbers will vary by installation and salt content.

- Incoming brine with Total Dissolved Solids (TDS) around 18,000 ppm enters the evaporator.
- The solar thermal array provides 150 °C thermal fluid to power the evaporator.
- The evaporator* removes 90% of the water, leaving the salt slurry with a TDS around 175,000 ppm.
- The filter press removes the salt solids, returning some concentrated brine to the evaporator.
- Dry salts are collected and cheaply disposed or sold for a small profit.

* Water normally needs 2.4 kWh/gal of energy to phase change into steam. Large evaporators have multiple effects, which lowers the energy required to evaporate water. This reduction in energy is defined as the Coefficient of Performance (COP). $\left(\mathrm{COP} = \frac{2.4\ \mathrm{kWh/gal}}{\mathrm{Energy\ Required}}\right)$.

Conclusion

- 90% reduction in wastewater volume is achievable with evaporators.
- Evaporators lower the cost of wastewater disposal (because disposal costs are on a per gallon basis).
- Evaporators can be powered by clean and economical solar thermal collectors.
- A filter press can optionally be added to generate salt solids from the wastewater stream.

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