WATER CONSUMPTION ANALYSIS AND CONSERVATION THROUGH OPTIMAZATION IN A CONCENTRATE MANUFACTURING PLANT

IE3100M Systems Design Project | Department of Industrial Systems Engineering and Management
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Project Overview

With PepsiCo's focus on water stewardship, its plant in Singapore - Concentrate Manufacturing (Singapore) Pte Ltd has targeted to reduce overall water consumption by at least 10% by the end of year 2020.

Key Objectives

To propose feasible and value for money solutions in order to reduce the overall water consumption of the plant by at least 10% by the end of year 2020.

Key Skillsets Required

- Cost-benefit analysis
- Stakeholder and vendor management
- Critical thinking
- Research skills

Methodology

Lean Six Sigma

Using the DMAIC methodology, concrete checkpoints were set to ensure that the project was progressing in the right direction and in a timely manner.

Life Cycle Costing

Using the parametric estimation method, an estimation of the present total cost which considers all sources of cost during the solution lifetime, was obtained.

Cost Benefit Analysis

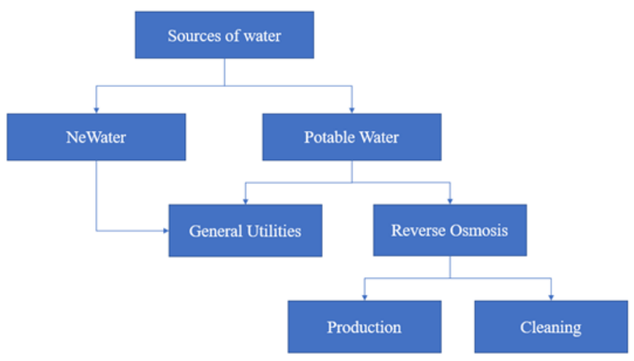
The SMARTER method was used as a decision-making tool. By comparing the aggregate benefit to the life cycle cost of each solution, the optimal decision was determined.

Statistical Analysis

Statistical analysis methods were used to analyze the water data in the plant, model an accurate water usage formula and to verify the findings made.

Current State

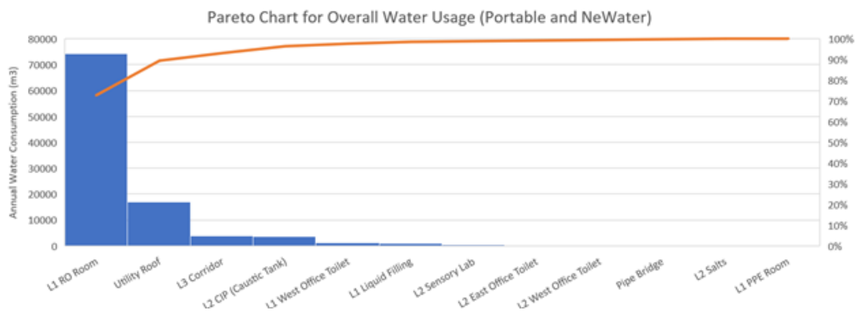
Overview of Water Usage in the Plant



There are **2 types of water** consumed in the plant:
- Potable water: drinking tap water sourced from local water catchment areas, Malaysia and the sea
- NeWater : treated reclaimed water

There are **3 main groups of water usage** in the plant:
- General utilities
- Production
- Cleaning

Under general utilities, potable water is used for normal washing and flushing while NeWater is used for cooling tower and boiler. The rest of the potable water is further purified through a RO system before being used in production and cleaning of the manufacturing machines.



From the pareto chart, about 70% of the plant's water consumption is attributed to the RO system (indicated by L1 RO Room) and the cooling tower (indicated by Utility Roof).
According to the 80/20 rule, the subsequent water conservation solutions proposed should address the RO system and the cooling tower.

Solution Research

Potential Solutions

1. Installation of a more efficient drift eliminator

A drift eliminator that has a lower drift loss will help to reduce the amount of makeup water needed in the cooling tower.

2. Increasing cycles of concentration (CoC) for the cooling tower

Increasing CoC helps to optimise the water usage in the cooling tower and effectively reduce blowdown. A key thing to take note of is the impact this has on the amount of Total Dissolved Solid (TDS) in the water.

3. Reusing RO Reject water

As the RO reject water is of high salinity, only a portion (9.50%) can be effectively used to replace NeWater as the makeup water in the cooling tower.

4. Reusing RO Backflush water

The backflush water used to clean the RO membranes is rather clean and can be easily reused as makeup water in the cooling tower.

5. Using Electrodialysis Reversal (EDR) to recycle RO reject water

EDR uses advanced technology to purify the RO reject water so that a greater volume can be recovered and reused as makeup water in the cooling tower.

The combination of some solutions can yield greater amount of water savings. As such, after analysis and calculations, the table below summarizes the possible solution combinations.

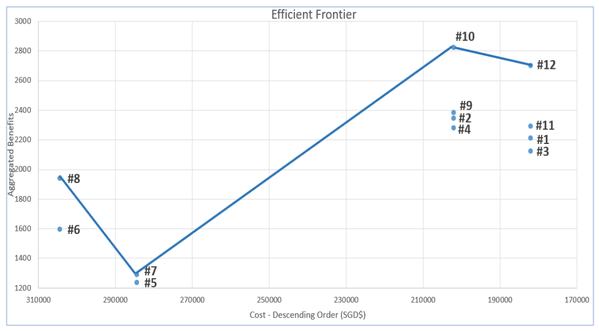
Combination	Combination Details
Combination #1	RO reject (reuse) + RO backflush
Combination #2	RO Reject (reuse) + RO backflush + Drift eliminator
Combination #3	RO Reject (reuse) + RO backflush + Increase CoC
Combination #4	RO Reject (reuse) + RO backflush + Drift eliminator + Increase CoC
Combination #5	RO Reject (EDR) + RO backflush
Combination #6	RO Reject (EDR) + RO backflush+ Drift eliminator
Combination #7	RO Reject (EDR) + RO backflush + Increase CoC
Combination #8	RO Reject (EDR)+ RO backflush + Drift eliminator + Increase CoC
Combination #9	RO backflush + Drift Eliminator + Increase CoC
Combination #10	RO backflush + Drift eliminator
Combination #11	RO backflush + Increase CoC
Combination #12	RO backflush

In order to evaluate and rank the effectiveness of the solution combinations, some criteria were set. The criteria chosen are:

- **Volume of water that can be saved per year (m^3/year)**
- **TDS of water discharged (mg/L)**
- **Physical space**
- **Ease of maintenance**

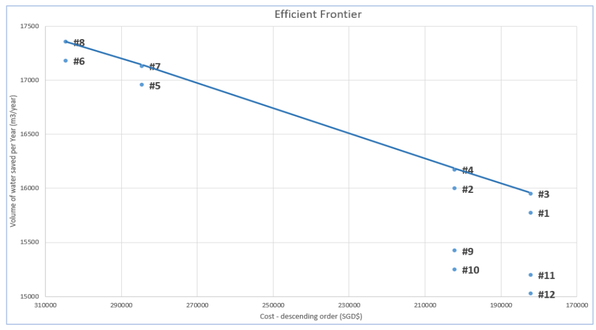
Results Discussion

1. Using SMARTER



Aggregated benefits based on the criteria were calculated for all combinations. Considering combinations on the efficient frontier, combinations #7 and #8 with RO Reject (EDR) included were considered uneconomical since they were more expensive and brought about less benefits compared to combinations #10 and #12.

2. Volume of water saved/year vs lifecycle cost



Combinations #8 and #7 with RO Reject (EDR) included outperform combinations #4 and #3 on the efficient frontier. Therefore, by just focusing on the volume of water saved, combinations #8,#7,#4,#3 can all be considered and the choice will be determined by the budget.

Recommendations

In the short run where the focus is on reducing water consumption for utilities, PepsiCo should consider implementing either Combinations #10 or #12 depending on the budget available. These combinations can help the plant achieve its goal of reducing the overall water consumption by at least 10% by year 2020. (Combination #10: 14.1%; Combination #12: 13.9%)

In the long run, PepsiCo can consider using recycled water from the RO Reject (EDR) into the production, as the water has comparable water quality to the potable water currently used. This can help them achieve an additional 5.85% reduction in overall volume of water consumed.

Conclusion

Through the usage of skills learnt in school, such as Lean Six Sigma, Project Management, Statistical Analysis and Life-cycle Costing, the team managed to develop and execute this water saving project for PepsiCo. After months of research and analysis, the team was able to propose solutions that were not only cost effective but also exceeds the targeted 10% reduction set by the management. The team also went one step further to look into other long-term solutions that PepsiCo can implement to further aid in their quest for water sustainability.