

# Operational Costs of Evaporation vs. Rinse Water Recycling

Data compiled by Tim Noble

# Evaporation? Recycling? What is the best choice?



This is a question that will require a little digging and analysis of cost vs performance data. In this presentation I have assembled some data for you, to help assist you in making the right choice given your application.

Each method has its own benefits and its own drawbacks. Switching from one process to the other can often mean a tradeoff. It ultimately will be determined by what is most critical to you, the end user.

I will highlight some positives and negatives first and then show how they tie into the cost performance of your process. This way you know why you are trading one benefit for another and that there is complete understanding of this scenario.

I thank you for letting me share my experience of the equipment involved in this study. Take note, that this study is not a direct endorsement of any specific equipment or brand, it simply uses equipment that I have experience with and represent real life examples of which I may speak.



# Evaporation – Pros and Cons



First off, what is evaporation? Evaporation is the boiling off of water leaving you with solids (aka sludge) to dispose of, while the liquids are vented into the atmosphere.

## Pros:

- Minimal dependence on outside services (No media tank replacement)

## Cons

- Bottleneck of your process as throughput is dependant on machine tank capacity and evaporation rate.
- Eventually restrictions on what is vented out the stack into our atmosphere will become more strict
- Large consumer of energy.



Evaporators use holding tanks and large quantities of energy to evaporate water, even so, they can only evaporate so much in a period of time, that they struggle to stay ahead of your cleaning machine and ultimately limit the throughput of your process.

In this study I have NOT included the solids disposal costs associated with the maintenance of this equipment.

# Rinse Water Recycling – Pros and Cons



What is rinse water recycling? Rinse water recycling is the process of running the discharge back through a recycling system and through DI Resin and Carbon tanks to polish the DI water for reuse. Rinse water recyclers use no drain, or no exhaust, all waste is removed via the media tanks and this is disposed of with a source capable of handling the disposal appropriately.

## Pros:

- No bottleneck – the machine provides DI water virtually on demand
- More environmentally friendly (this needs to be considered as a sales point of your process)

## Cons

- Media exchange costs – DI Tanks replacement costs can be costly.



One aspect to be considered is tank size. Larger tank capacity will give you more cycles, meaning less frequent changeovers and you often get better pricing on higher capacity tanks. This is highlighted, especially when you are evaluating a per board cost of operation.

## Cycle Data

In our study, we are using an Aqueous Technologies Batch Defluxing System, which discharges approximately 3.5 gallons of DI Water per rinse cycle. We were requiring approx. 7-9 rinse cycles per wash, so we used 8 as our average.

We used this data to calculate our data as shown in the chart below. Regarding the Rinse Water Recyclers (RWR), since there is no throughput bottleneck, we calculated based upon how many 40 minute cycles could be ran in an 8 hour work period.

We also calculated how many PCBs the systems where capable of with a batch load of 25 PCBs each load.

	EMC Evaporator	E101 Evaporator	RWR with 1.5 Cu Foot DI Tanks	RWR with 3.0 Cu Foot DI Tanks
	<b>Cycle Data</b>			
<b>Average Board Load per Batch</b>	25	25	25	25
<b>Average Rinse Count per Wash Cycle</b>	8	8	8	8
<b>DischargeVolume per Rinse Cycle</b>	3.5	3.5	3.5	3.5
<b>Total Discharge per Batch (Gallons)</b>	28	28	28	28
<b>Capacity (Gallons)</b>	85	136	-	-
<b>Evaporation Rate (gph)</b>	6	13		
<b>Daily Batch Capacity</b>	3.035714286	4.857142857	11.994003	11.994003
<b>Total Board Cleaning Capacity (Daily)</b>	75.89285714	121.4285714	299.850075	299.850075
<b>Total Board Cleaning Capacity (Monthly)</b>	1979.990434	3167.984694	7822.874277	7822.874277

# Operational Hours

The following data gave us the average operational hours of the equipment given a 6 day workweek. We calculated this data as follows:

$$= 365.25 / 12 \text{ months} = 30.4375 \text{ Average Month Length (Days)}$$

$$= 30.4375 \times (6 / 7) = 26.089 \text{ average days of operation}$$

The operational hours were calculated by the amount of time required to evaporate the 85 or 136 gallons capacity of the two evaporators at their respective rates. The rinse water recyclers are calculated upon the regular 8 hour work period.

	EMC Evaporator	E101 Evaporator	RWR with 1.5 Cu Foot DI Tanks	RWR with 3.0 Cu Foot DI Tanks
	<b>Operational Hours</b>			
<b>Average Daily Operational Hours</b>	14.16666667	10.46153846	8	8
<b>Operational Days per Week</b>	6	6	6	6
<b>Monthly Operational Days</b>	26.08928571	26.08928571	26.08928571	26.08928571
<b>Monthly Operational Hours</b>	369.5982143	272.9340659	208.7142857	208.7142857

# Electrical Costs

Electrical Costs are estimated by the following equation:

$$\text{kilowatts} = (\text{Volts} \times \text{Amps} \times \text{Power Factor} \times 2) / 1,000$$

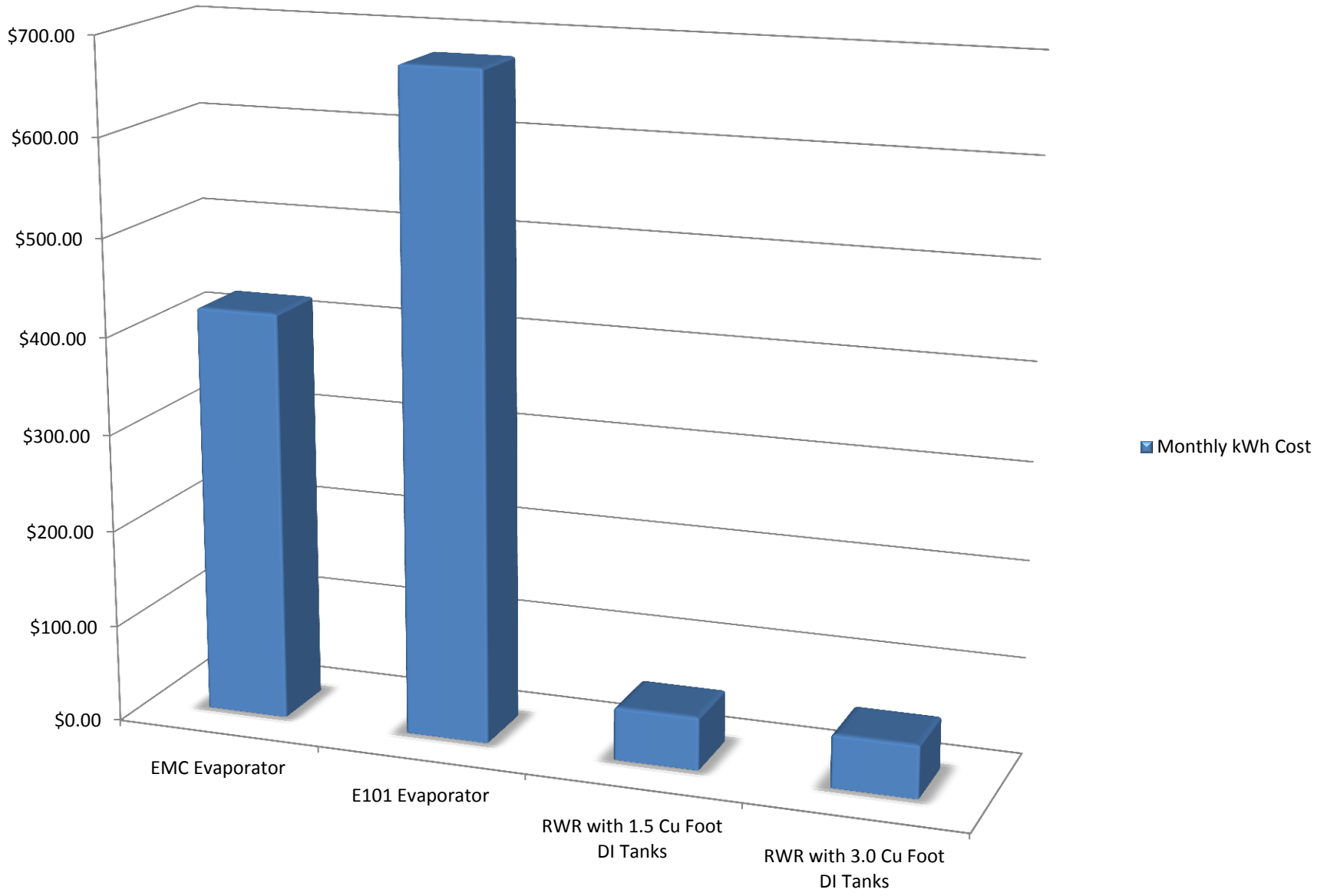
The voltage on both evaporators is the same; however, the Amps on the E101 are significantly higher than the EMC, this contributes to the E101 being able to evaporate over twice as fast (13 gph vs. 6 gph). Essentially the E101 uses more power, but also helps reduce the bottleneck faster, allowing you to divide that cost across more PCBs.

Power Factor is a gray number that isn't really published on many devices, it's dealing with the efficiency of the equipment and could range from 0.60 – 1.0, so using 0.85 as a medium is a conservative estimate.

You'll notice the high costs associated with evaporation, and these numbers are estimating constant use of the equipment for the operational time period.

	<b>EMC Evaporator</b>	<b>E101 Evaporator</b>	<b>RWR with 1.5 Cu Foot DI Tanks</b>	<b>RWR with 3.0 Cu Foot DI Tanks</b>
	<b>Electrical Costs</b>			
<b>Machine Voltage</b>	240	240	110	110
<b>Electrical Phase</b>	3	3	1	1
<b>Amps</b>	40	87	20	20
<b>Power Factor</b>	0.85	0.85	0.85	0.85
<b>Kilowatts</b>	16.32	35.496	3.74	3.74
<b>Monthly kWh usage</b>	6031.842857	9688.067604	780.5914286	780.5914286
<b>kWh Rate</b>	0.07	0.07	0.07	0.07
<b>Monthly kWh Cost</b>	\$422.23	\$678.16	\$54.64	\$54.64

# Monthly kWh Cost



# Media Exchange Costs

Cost of media Exchange can be pricy, finding a reliable local source is key to managing these costs.

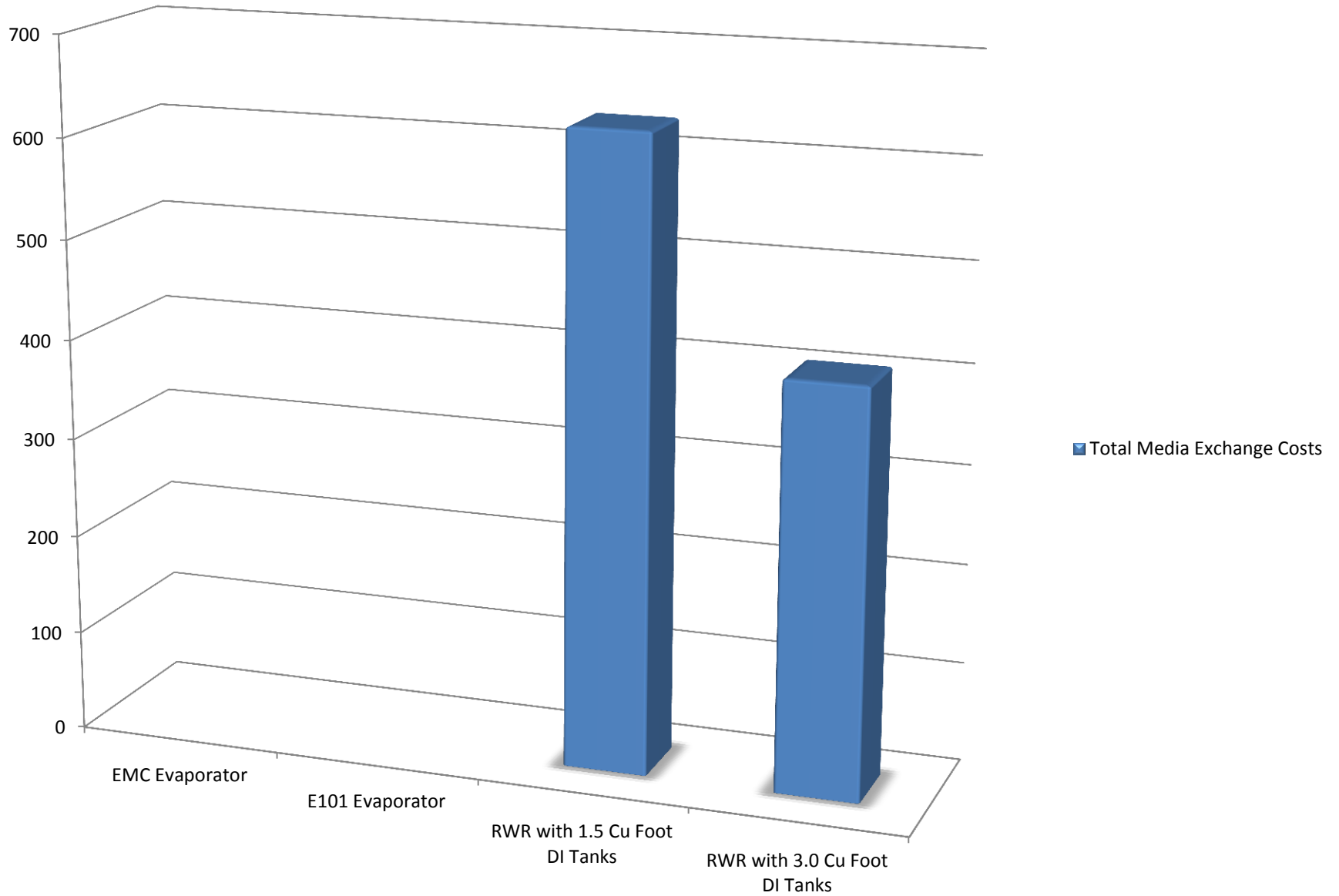
In our study, we estimated the media lasted 24 days using a 1.5 cu. Foot tank, which would equate to media exchange 1.09 times per month based upon the operational days as calculated previously.

At \$290 per tank, with 2 tanks (Resin and Carbon) being changed the total monthly cost is \$630.49.

Switching to 3.0 cu foot tanks would increase the capacity two fold and you would get a better price break per cu foot, which would reduce your monthly cost to about \$407.65

	EMC Evaporator	E101 Evaporator	RWR with 1.5 Cu Foot DI Tanks	RWR with 3.0 Cu Foot DI Tanks
	<b>Media Exchange</b>			
<b>Media Life Batches (Real)</b>			83	166
<b>Media Life (Days)</b>			24	48
<b>Estimated Tank Replacements per month</b>			1.087053571	0.543526786
<b>Tank Replacement Cost</b>			\$290.00	\$375.00
<b>Total Tanks</b>			2	2
<b>Total Media Exchange Costs</b>			\$630.49	\$407.65

# Total Media Exchange Costs



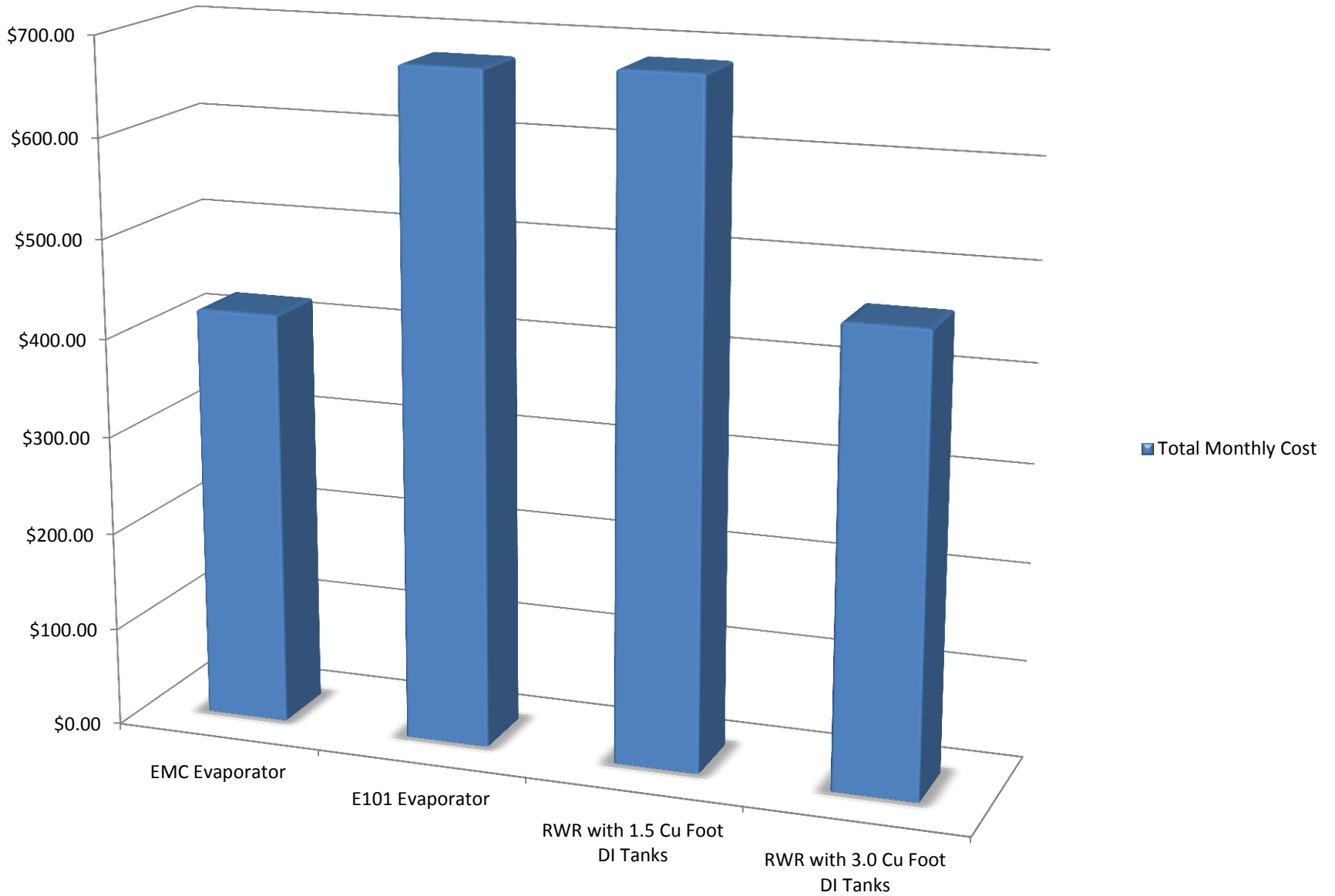
# Total Costs

As you see, the total costs of operation, indicate that the E101 and the RWR with 1.5 cu foot tanks are the least efficient solutions, with the EMC evaporator and the RWR with 3.0 cu foot tanks being the best options.

These costs reflect the total operational costs, both electrical costs and media tank replacement of the selected systems.

	EMC Evaporator	E101 Evaporator	RWR with 1.5 Cu Foot DI Tanks	RWR with 3.0 Cu Foot DI Tanks
	<b>Total Costs</b>			
<b>Total Monthly Cost</b>	\$422.23	\$678.16	\$685.13	\$462.29

# Total Monthly Cost



But wait...is that the whole story?



## Determining Actual Costs per PCB

It is my belief that you also should incorporate the cost of a bottleneck in your process. To do this simply divide the total operational cost of the system(s), by the total throughput capacity of that system to achieve your answer.

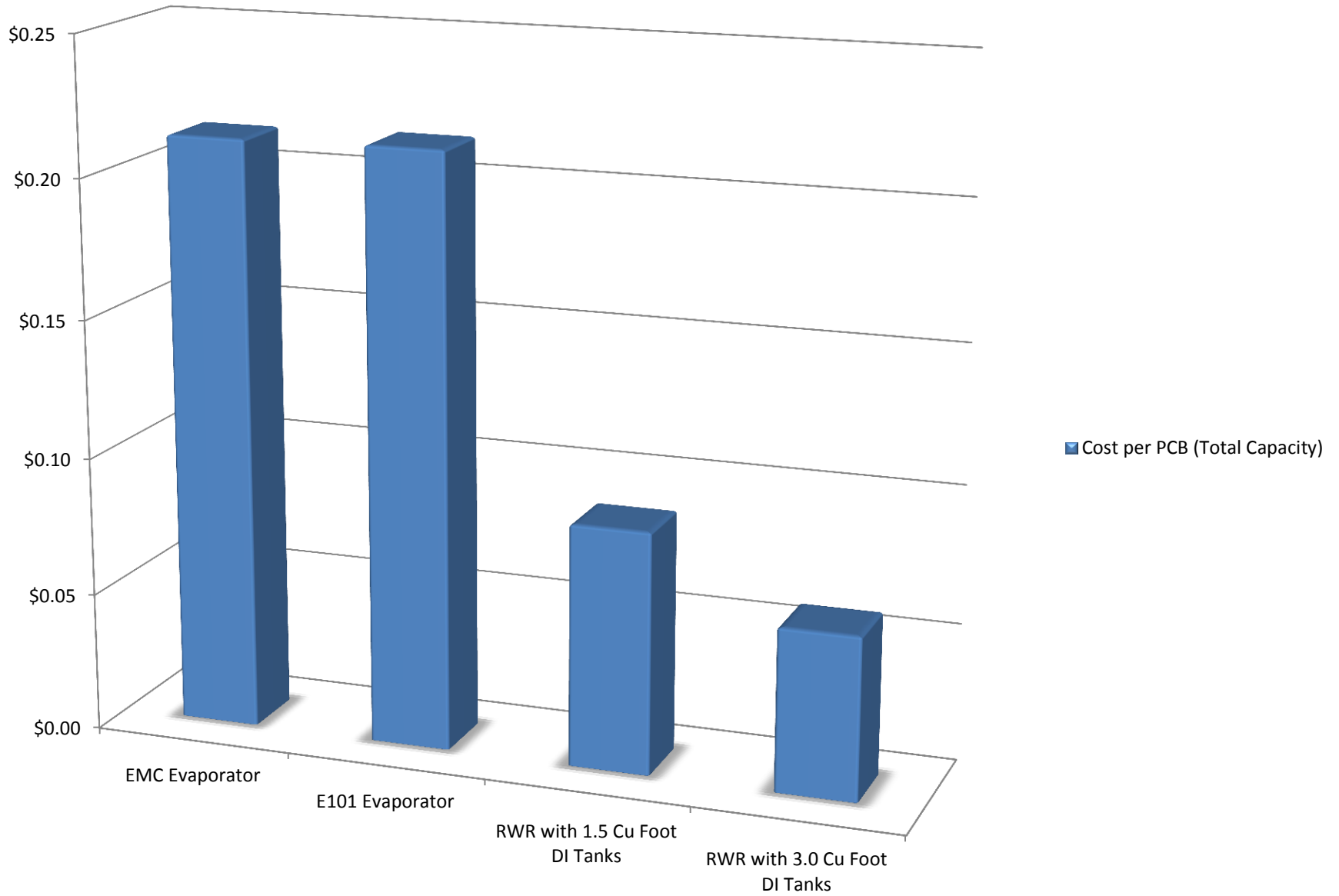
You will notice that I have made two calculations below. One is the cost per PCB using the TOTAL capacity of each respective system and the other is calculated on cleaning a fixed number of 3,000 PCBs per month. This gives us comparative data, as often we don't have the need to run full bore to max out each system.

There often will be down time while you assemble and load the next batch, or while PCBs are being built/reflowed, etc.

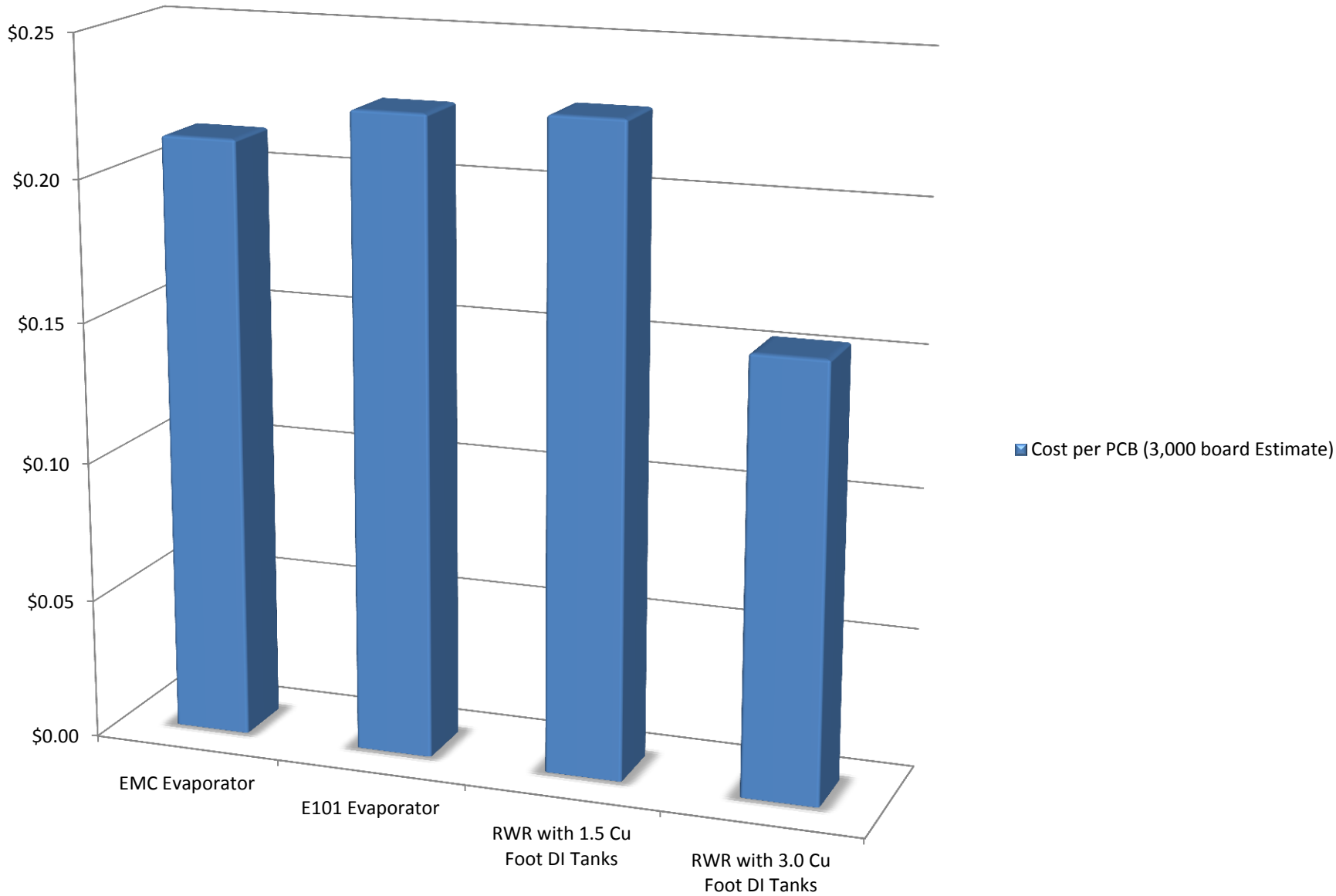
Plus another topic of conversation is overtime labor costs. If a bottle neck slows you down, you will need to operate the system beyond the normal 8 hour shift to bring the evaporator back up to speed. This may put you at risk to higher labor costs due to hours logged.

	<b>EMC Evaporator</b>	<b>E101 Evaporator</b>	<b>RWR with 1.5 Cu Foot DI Tanks</b>	<b>RWR with 3.0 Cu Foot DI Tanks</b>
<b>Cost per PCB (Total Capacity)</b>	\$0.21	\$0.21	\$0.09	\$0.06
<b>Cost per PCB (3,000 board Estimate)</b>	\$0.21	\$0.23	\$0.23	\$0.15

# Cost per PCB (Total Capacity)



# Cost per PCB (3,000 board Estimate)



## Conclusion

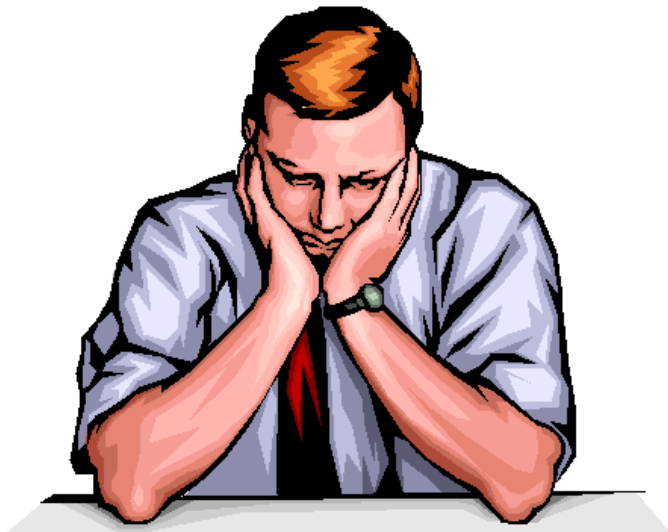
It is our conclusion that even though there is no one size fits all answer, that ultimately there will be better fits than others, but rarely ever a solution that doesn't include a tradeoff at some point. The best solution available in our study was the RWR with the 3.0 Cu Foot.

- Increased media tank capacity, gave us better pricing per PCB
- No bottleneck on our process meaning we have room to expand our operation
- Provides a "Greener" solution that adds benefit to our process

Even through all of this, there are still other factors to be considered which weren't calculated. For example, the cost of sludge removal from the evaporator, labor costs required to operate beyond the 8 hour standard business hours to fully evaporate the evaporator.

All in all, the RWR is the best solution where throughput is any type of factor.

Thank you for your time and if there are any questions on this material, please contact us at:



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