



# Performance and cost analyses of hybrid diesel-PV powered small brackish water RO system in Saudi Arabia

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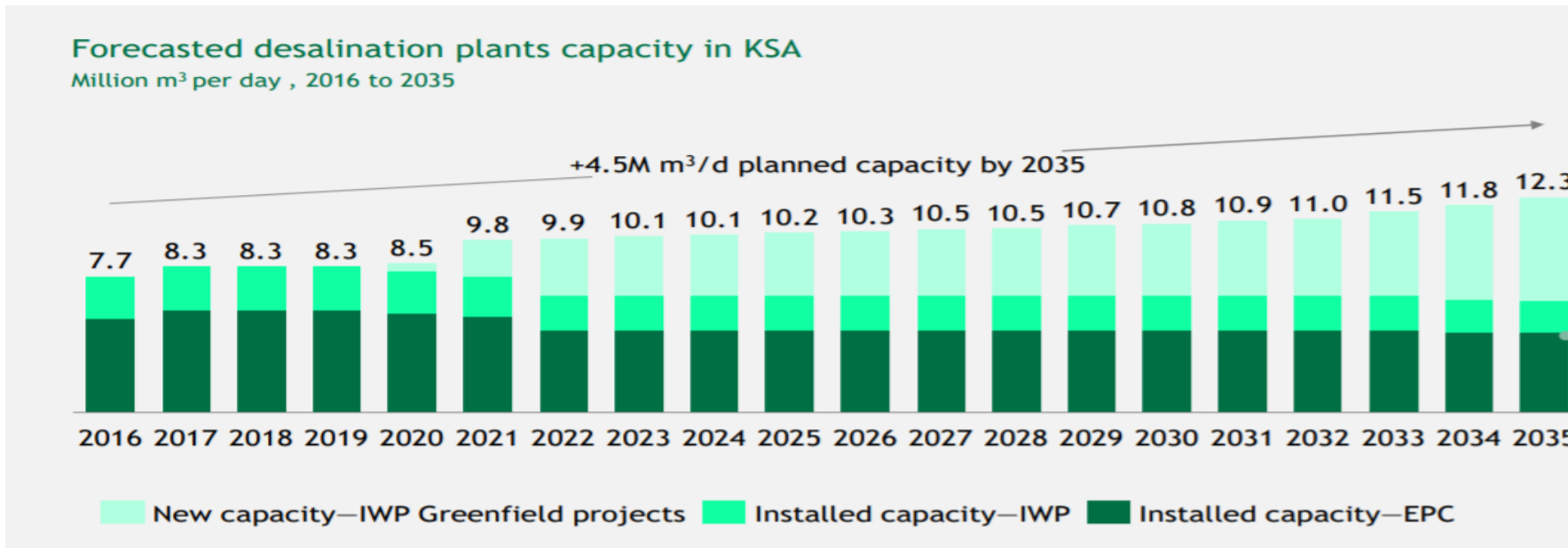
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# Overview

- Introduction
- Overview of Desalination and renewable energy technologies
- Modeling of hybrid diesel-PV powered BWRO
- Performance and cost analysis
- Sensitivity study of variation of RO configuration and fuel cost
- Conclusion

# Introduction

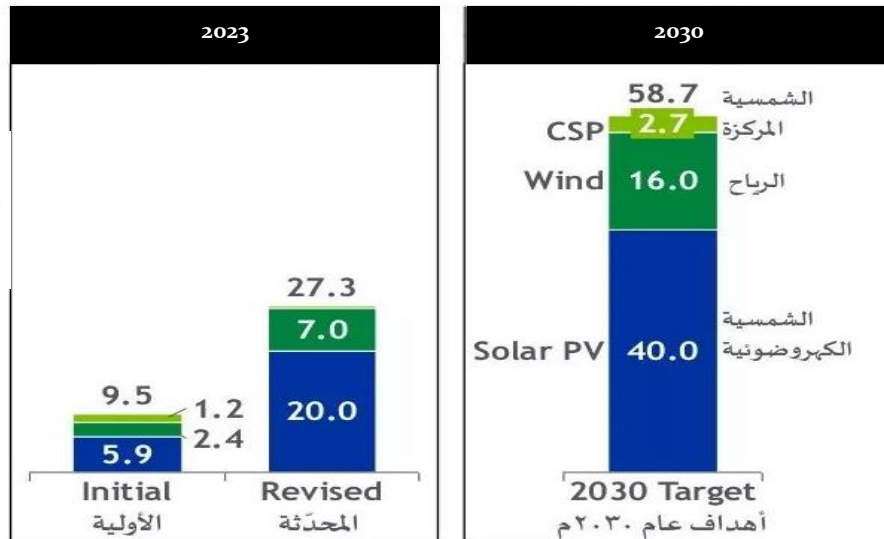
- Rapid increase in population, agriculture, industrialization, and Depletion of groundwater resources lead to an increase in water demand.
- Saudi Arabia leads the desalination market in the world: (~22% world market share and ~7.3 MLD, 2020).
- By 2035, the global water consumption is expected to increase by 85 %
- In KSA, desalination capacity is expected to increase to 12.3 MLD (45%)



# Introduction

- In KSA about 10-15 % of barrels of oil are consumed daily to power desalination plants
- The major challenges in desalination processes are energy consumption and high cost particularly in arid and rural regions.
- Need to develop alternative and sustainable energy resources
- Solar energy (PV) is the most common and available technology

Planned Capacity (GW)



## NEOM and Red Sea Projects :100 % Renewable energy



# Advantages of PV/RO Systems

## PV

- Modularity,
- Low maintenance,
- Long life: (up to 20 years),
- Well-matched to load,
- Environmentally friendly,
- Possible use of single- or dual-axis trackers

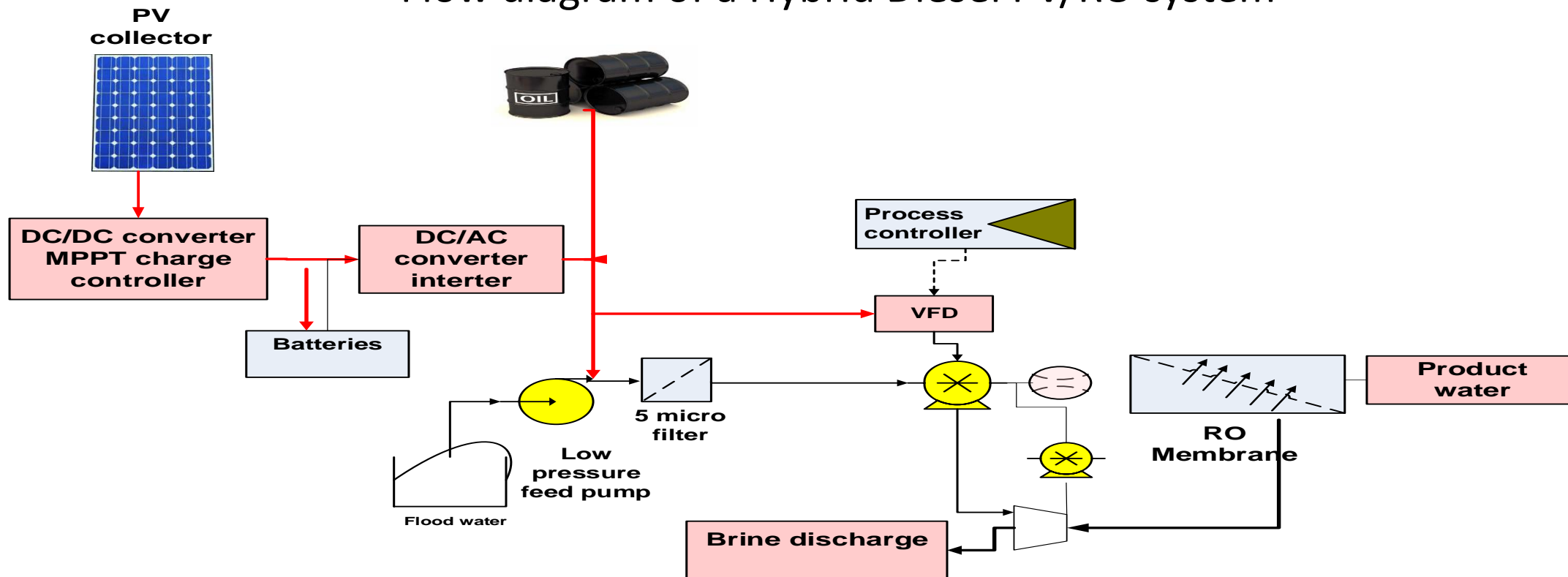
## RO

- The specific energy requirement is significantly.
- The process is electrically driven → adaptable to powering by solar panels.
- The RO plant is normally operated at ambient temperature → reducing scale formation and corrosion problems,
- Low maintenance
- Modularity

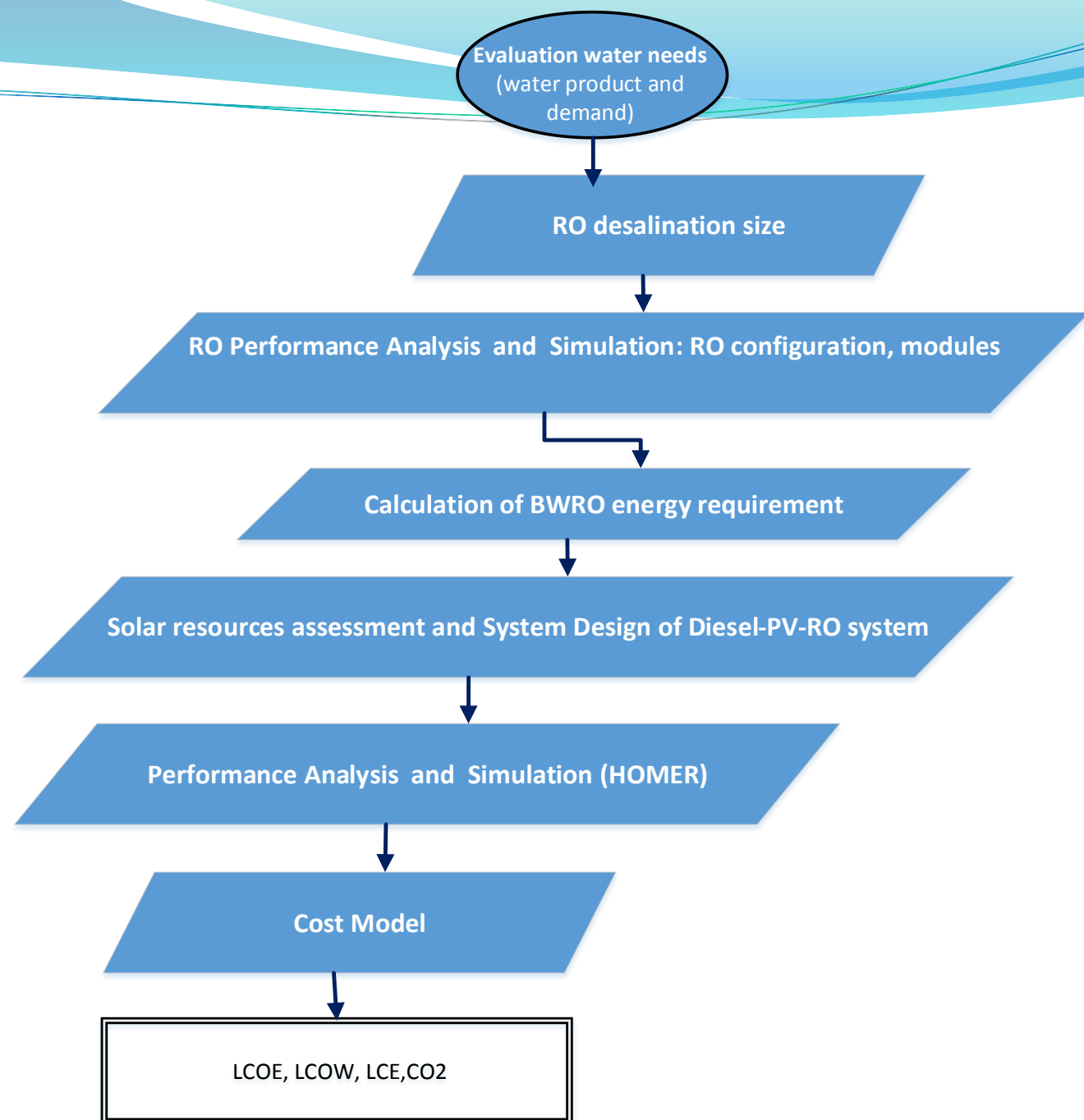
# Description of Diesel- PV/RO system

- HP pump, RO membrane, PV array, Batteries, Tanks are the principal components of PV/RO water desalination unit.

Flow diagram of a Hybrid Diesel PV/RO system

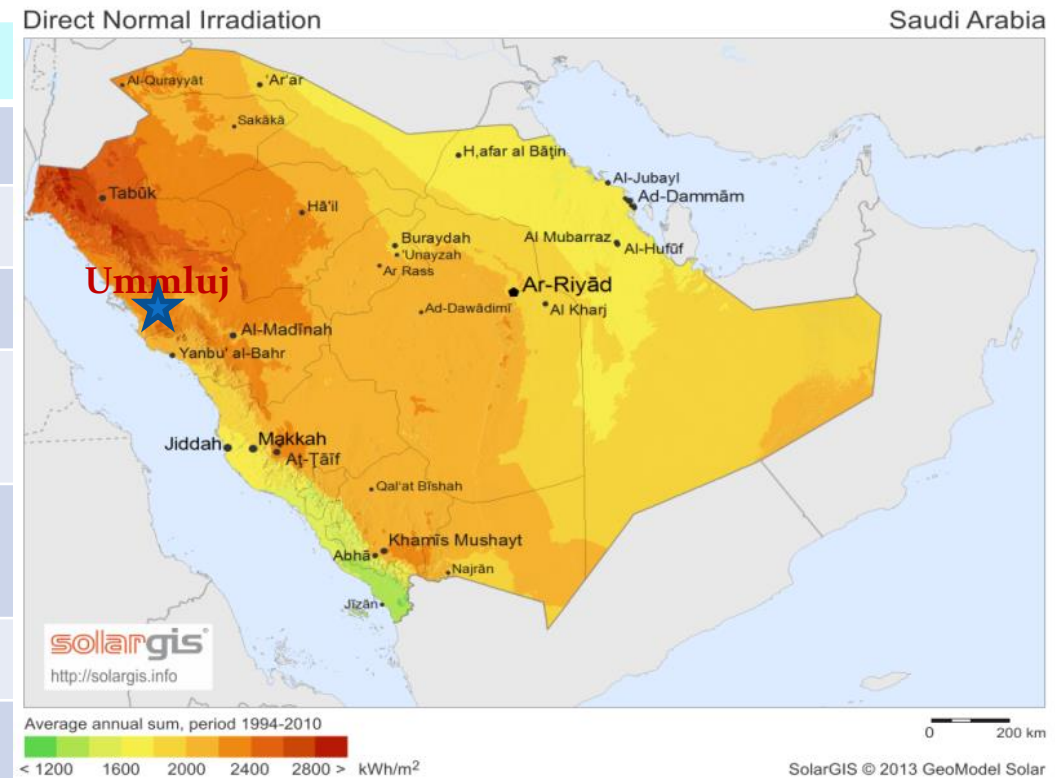


# Flowchart of hybrid diesel-PV system design



# Case Study: Ummluj city in the kingdom

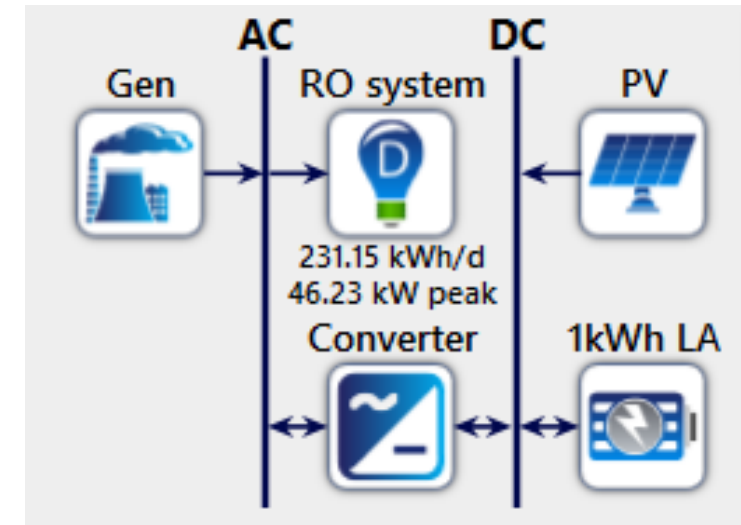
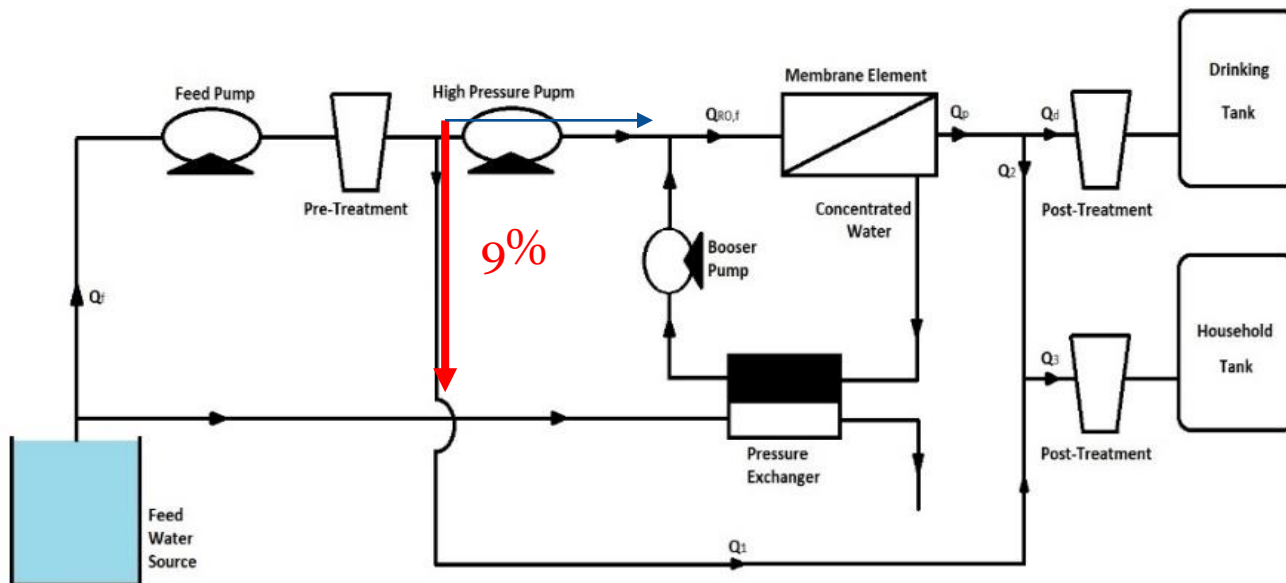
<b>Number of Beneficiaries</b>		<b>1000 Persons</b>
<b>Feed Source</b>		Well Water
<b>Feed Quality</b>		6000 ppm
<b>Well Depth</b>		50 m
<b>Average consumption per capita</b>	Municipal	200 $\frac{\text{Liter}}{\text{day}}$
	Drinking	2 $\frac{\text{Liter}}{\text{day}}$
<b>Product Quality</b>	Municipal	1000 ppm
	Drinking	<500 ppm





# Performance analyses for Ummluj Well

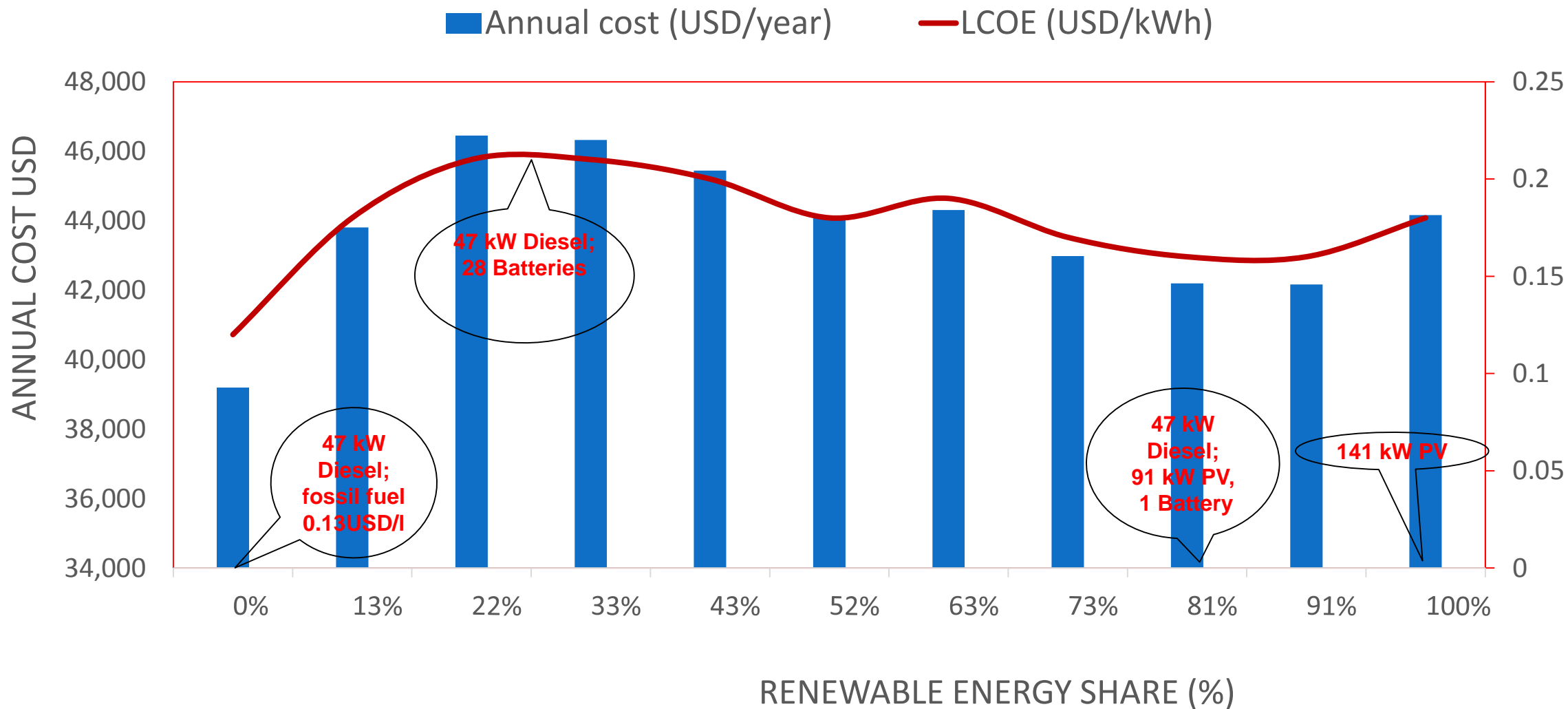
- RO unit: Single stage BWRO with PX , 5 vessels X 6elements, Recovery 50%.
- PV is a flat plate module with 17% efficiency, -0.45 %/°C Temperature Coefficient
- Battery lead acid type, Diesel 47 kW.
- 9% of raw water is not treated and blended with water product



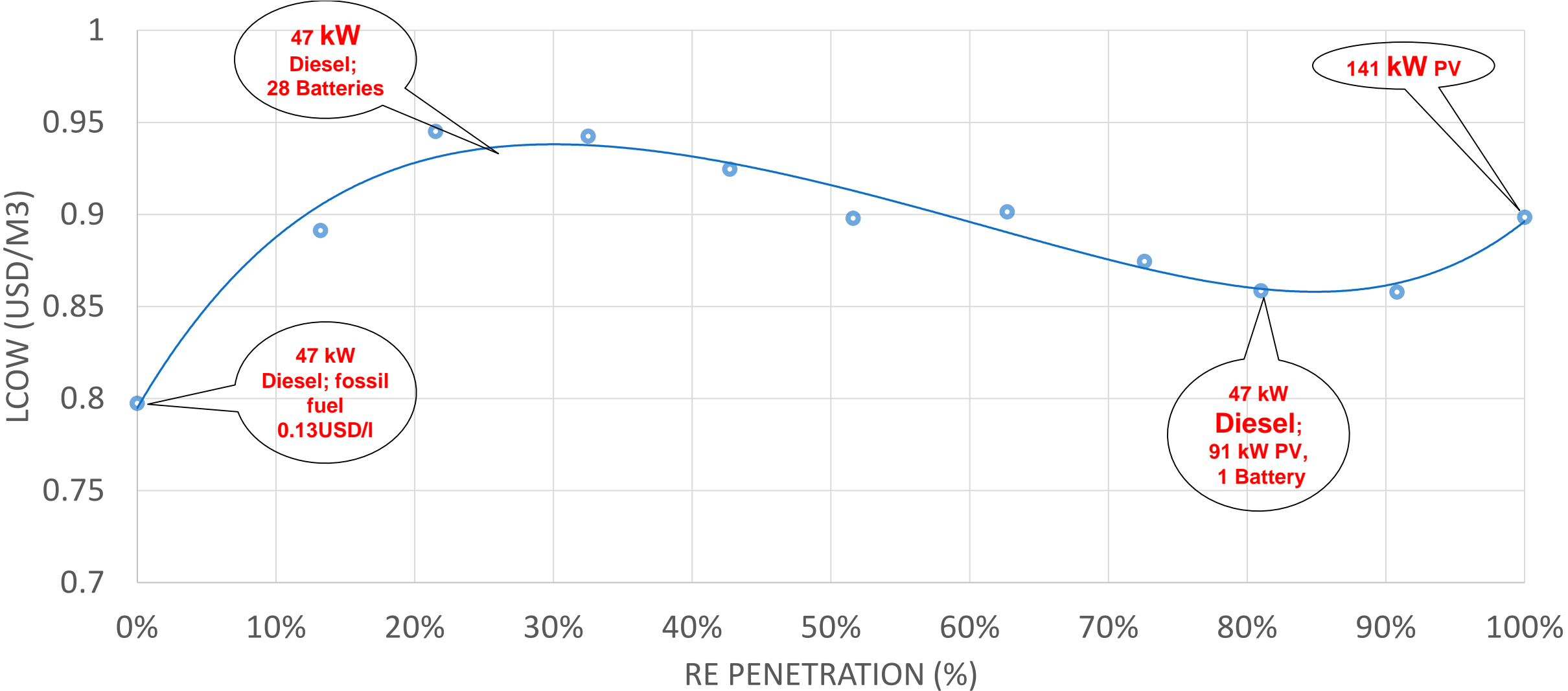
Component	Parameters	Value	
<b>RO system</b>	Recovery ratio (one-stage)	50 %	
	Capital cost of RO	163000 USD	
	Capital cost of PX	72000 USD	
	O&M of RO	10500USD	
	HPP replacement (15 year)	23 700 USD	
	Pumps efficiency[8]	80%	
	ERD efficiency (PX)[16]	96.7 %	
	Pre and psot- treatment power	15 % HPP power	
	<b>PV System</b>	PV cost capacity < 1, 10, 100kW	2500,2000,1500 USD/kW
		Efficiency[17]	17 %
Temperature coefficient		-0.45 % /°C	

Component	Parameters	Value
<b>Lead acid battery</b>	Nominal capacity	1kWh
	Capital cost [17]	300 USD
	Life time[17]	5 year
	Discount rate	5 %
<b>Diesel generator</b>	Lower heating value [17]	43.2 MJ/kg
	Carbon content (%)[17]	88 %
	Capital cost [17]	500 USD/kW
	Life time[17]	15000 USD
	O&M [17]	0.03 USD/hour
	Initial fuel price	0.13 USD
	Fuel transportation	325 USD/truck

# Cost analysis of hybrid diesel-PV RO

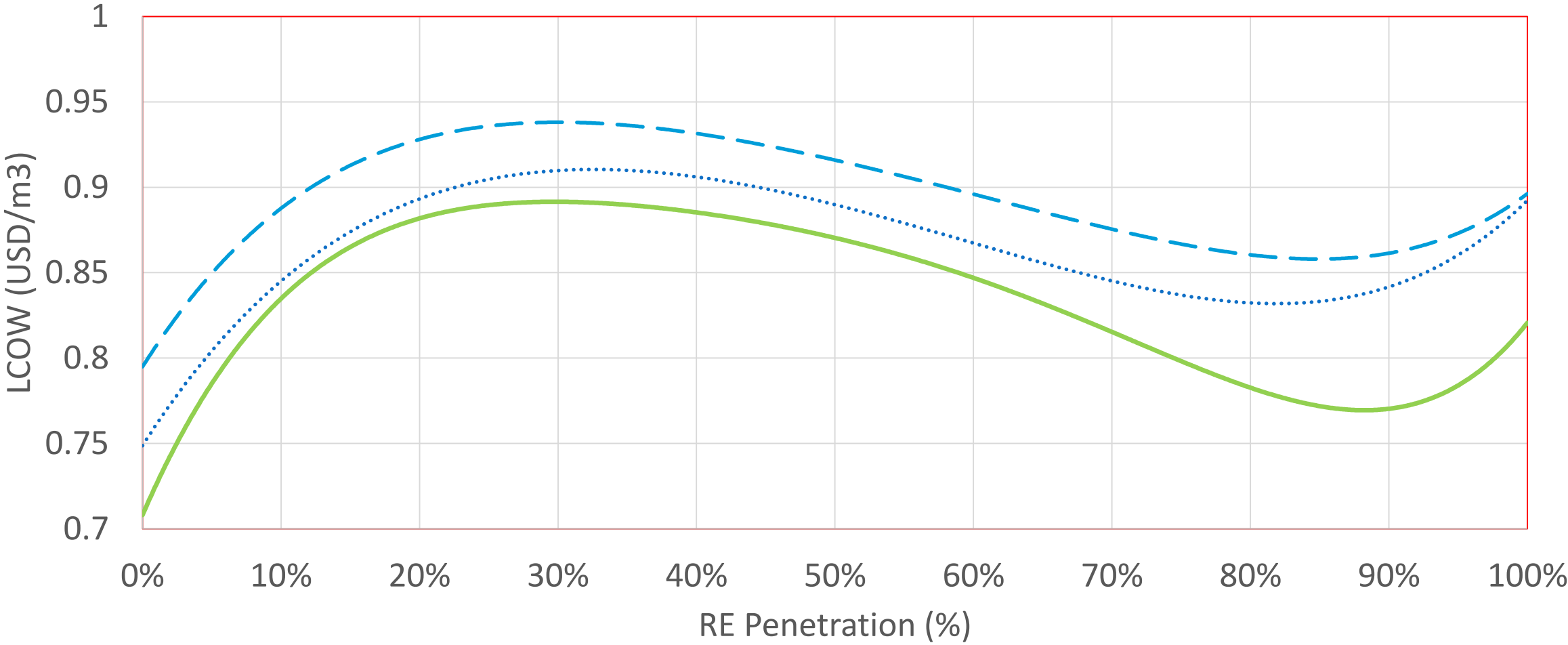


# Levelized Cost of Water (\$/m3)

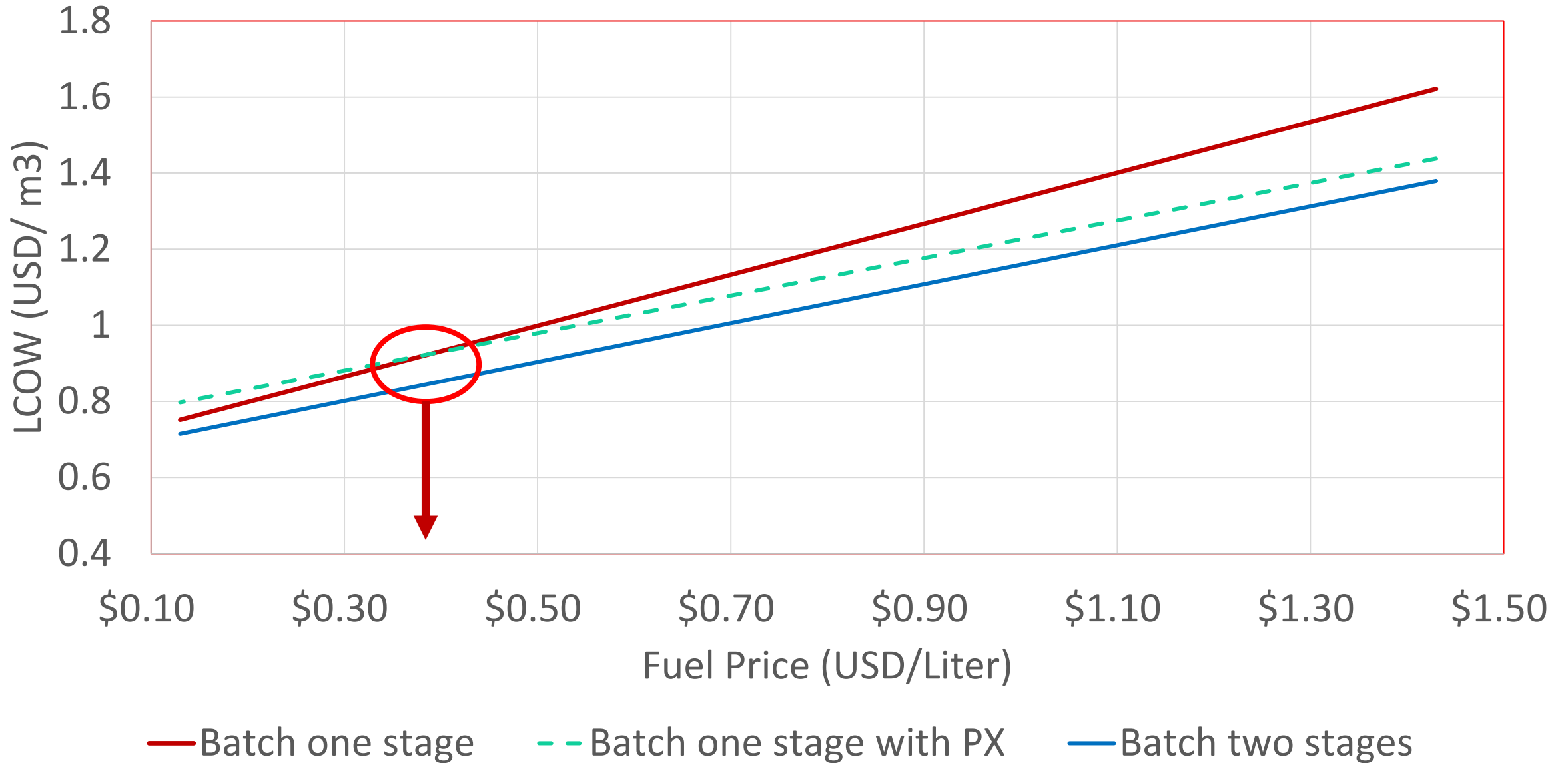


# Effect of number of stage and ERD on water Cost

..... One Stage Without PX    - - - One Stage With PX    — Two Stages



# Effect of fuel price on water Cost



## Conclusion and Recommendations

- Suppling fresh water to a small rural community in KSA was studied.
- Power cost has a high share contribution to the total cost of water production with about 65 %.
- LCoE and LCoW for different combinations range between 0.12 to 0.18 USD/kWh and 0.8 to 0.9 USD/m<sup>3</sup>.
- Two-stage RO configuration positively affects the recovery ratio leading to 22% reduction in the specific energy consumption
- For the integration of pressure exchanger (PX), it is demonstrated that it is cost effective solution for the diesel prices higher than 40 USD/l.

# Credits and Acknowledgements

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**THANK YOU**