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REVIEW OF DIFFERENT DESALTING TECHNOLOGIES FOR LOW SALINITY WATER IN INDUSTRIAL APPLICATIONS

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OBJECTIVE

1. Focus on different desalting technologies serving industrial applications
2. Discuss the industry needs and provide technical evaluation of available technologies
3. Assess the economic aspects of different technologies

PRESENTATION OUTLINE

- Introduction
- Background and Industry Requirements
- Technical Assessment
- Economic Assessment
- Conclusion

Introduction

This study is focused on **power generation industry** as a model of desalting for producing high purity water. In other industries, same methodology can be implemented with some tolerances to fulfill the specific industry requirements.

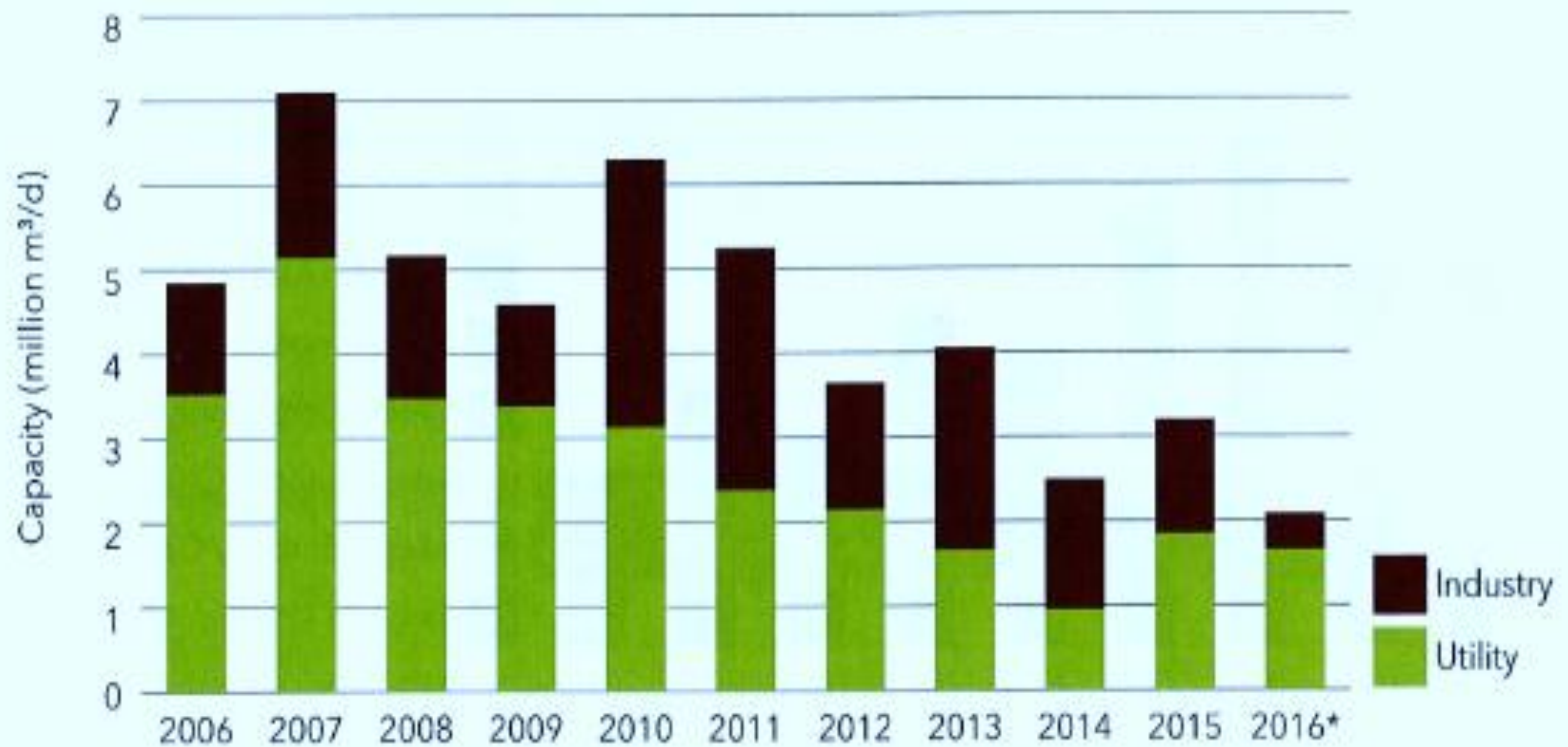
Introduction

Desalting for high purity water production from low salinity includes a removal percentage similar or higher than salt removal percentage of drinking water production from high salinity water.

	Raw water TDS	Product water TDS	Salt removal %
Low salinity	1000 ppm	< 1.0 ppm	99.9 %
High Salinity	35000 ppm	< 500 ppm	98.5%

Introduction

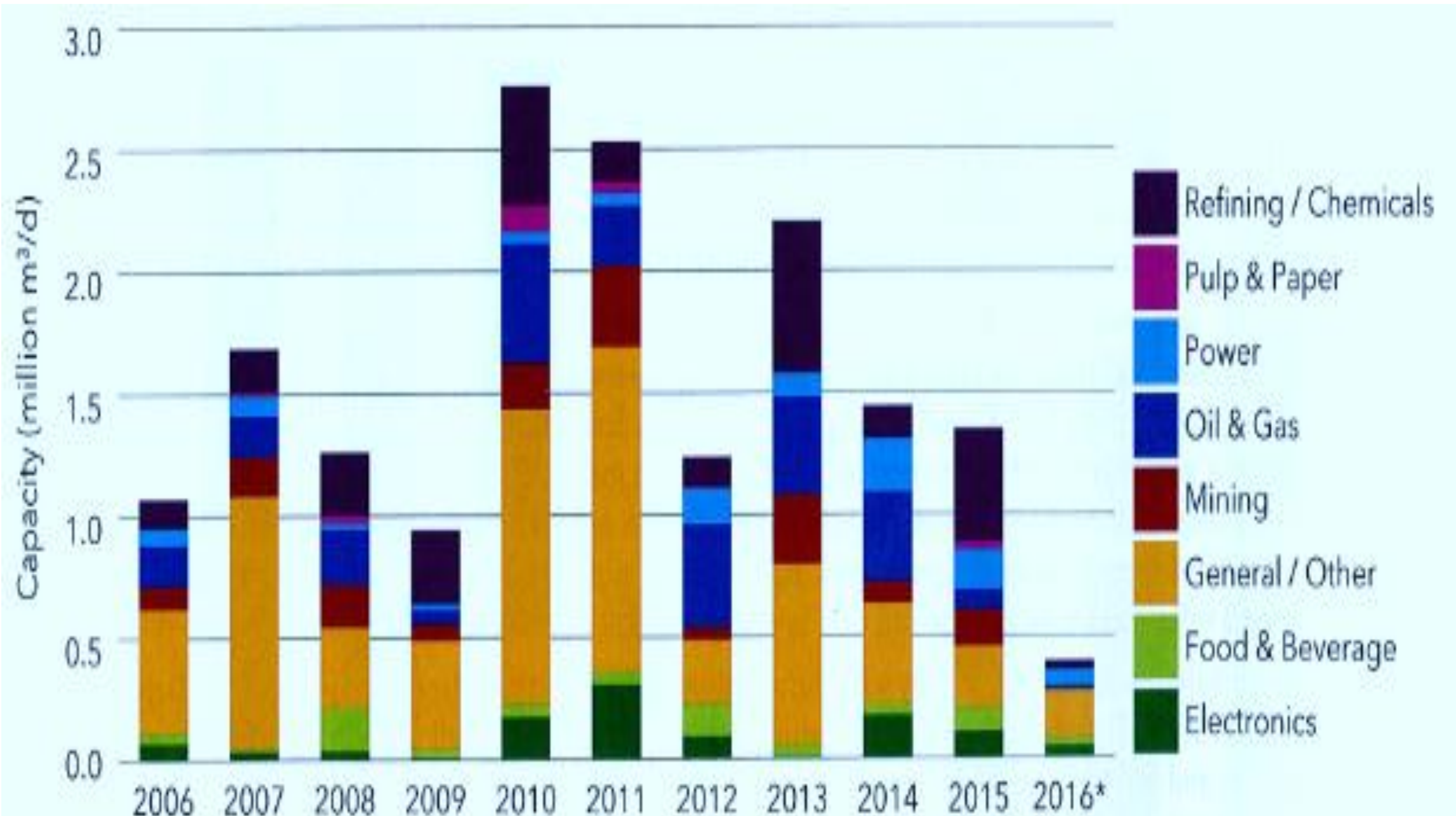
Industrial market represent about 50% of the annual contracted capacity in 2010, 2011, 2013, 2014 desalination market.



* Source : GWI DesalData / IDA

Introduction

Power market almost has stable share .



* Source : GWI DesalData / IDA

Introduction

- Low salinity water sources represent about 60-70 % of the power plants in Egypt.
- Nile River water as well as ground water supplies low salinity raw water to power plants.
- High purity demineralized water is essential in power generation.
- Power industry has a stringent water quality requirements.
- Traditional desalting/demineralization technologies cannot easily fulfill the continuously improved water quality requirements.

Background and Industry Requirements

- Standardized demi water quality is provided by many institutes or organizations i.e. EPRI, VGB and IAPWS.
- Total organic carbon is very challenging (< 100 ppb).

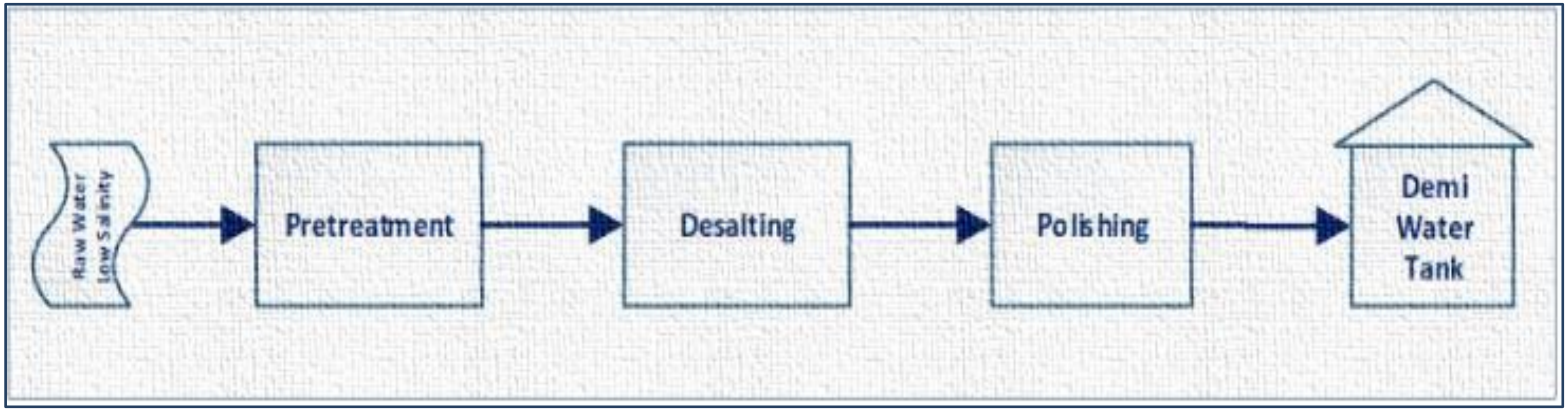
Sodium, ppb	< 3
Chloride , ppb	<3
Sulfate, ppb	<3
Silica , ppb	<10
Specific conductivity, µs/cm	<0.1
Cation conductivity , µs/cm	<0.1
Total organic carbon, ppb	<100

Very challenging

Semiconductor industry : 10-25 ppb

Background and Industry Requirements

- Demineralized water production involves multiple steps.



- Well understanding of raw water analysis and demi water quality requirements associated with evaluation of treatment techniques will result is properly designed system that satisfy industry requirements.

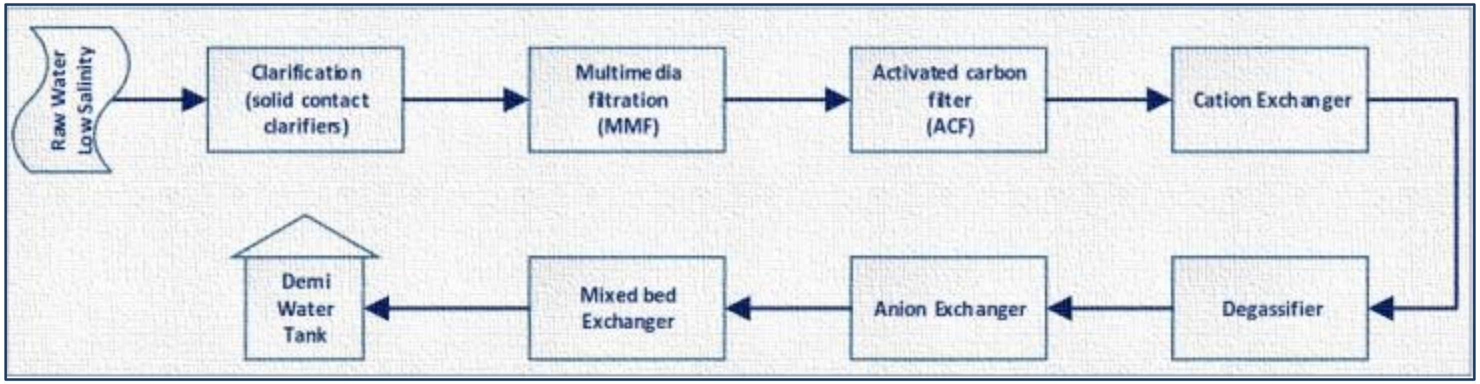
Background and Industry Requirements

Parameters	Units	Conc.
Conductivity	µs/cm	460
Total Hardness, as $CaCo_3$	mg/l	149
Calcium, as Ca	mg/l	40
Magnesium, as Mg	mg/l	14.4
Chloride, as Cl	mg/l	60
Sulfate, as SO_4	mg/l	32
Silica, as SiO_2	mg/l	7.0
Organic Matters, as $KnMO_4$	mg/l	13
Total dissolved solids	mg/l	312
Suspended Solids	mg/l	15
Sodium, as Na	mg/l	40
Turbidity	NTU	9.8

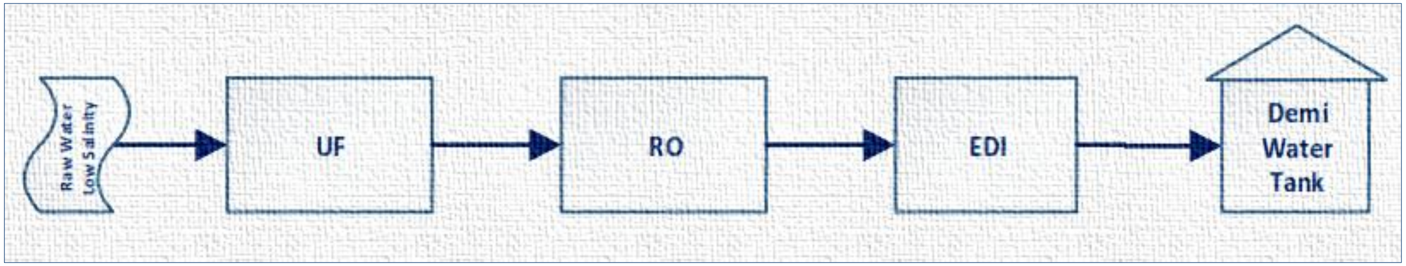
Example of Nile River Water Quality at site South of Cairo governorate

Background and Industry Requirements

- Traditional scheme involves numerous steps, however it can not meets the stringent water quality requirements



- Membrane based scheme can be more effective



Technical Assessment

The technical assessment focuses on evaluating specific technical aspects in both conventional and membrane based schemes, these includes:

- Product Water Quality
- Operation and Maintenance
- Foot print and construction requirements
- Waste disposal

Technical Assessment

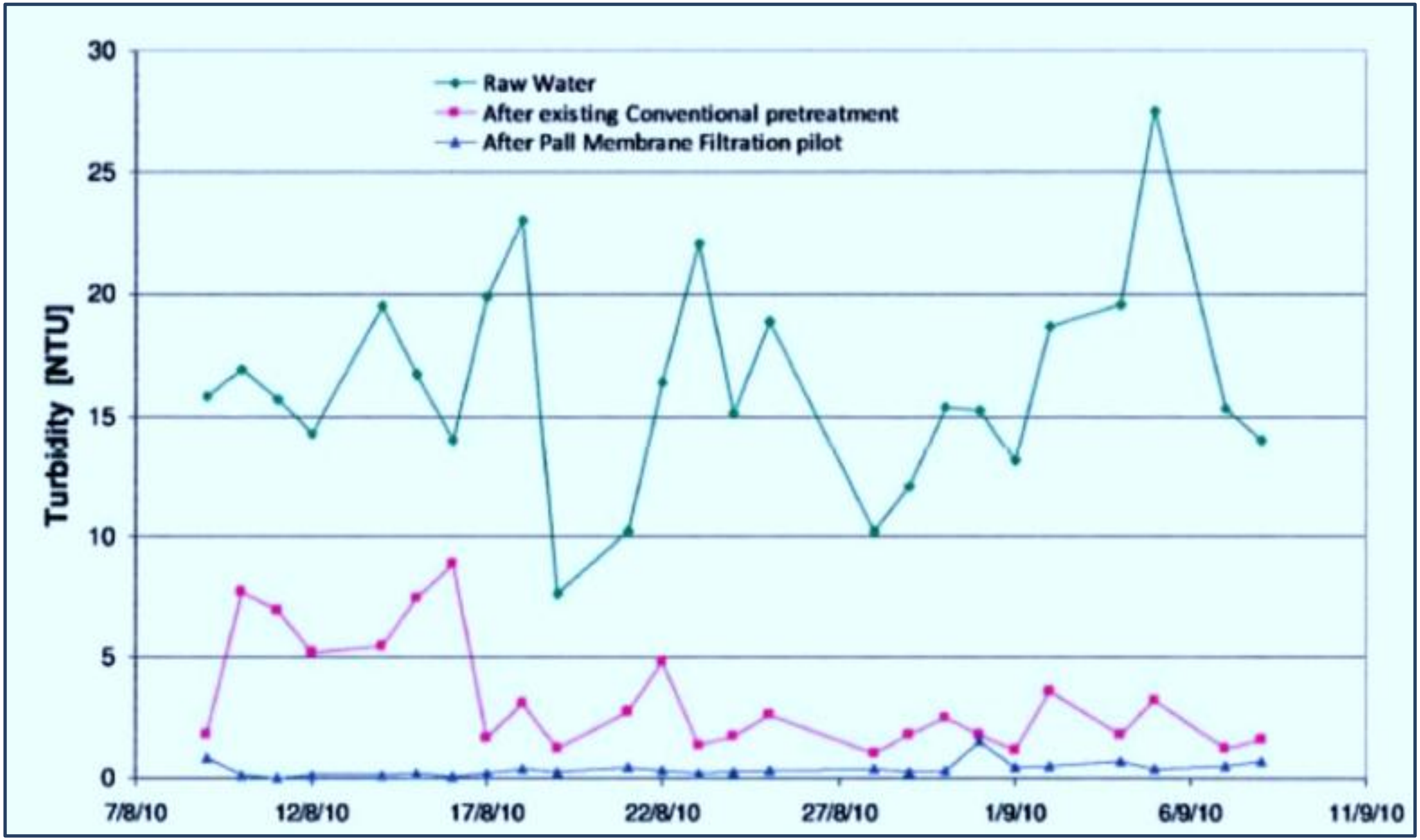
PRODUCT WATER QUALITY

	UF	Conventional
TSS	Non detectable	2.0 - 10.0
Turbidity	< 0.1	2.0 - 8.0
Bacteria removal	Log 6	NA
Virus removal	Log 2.5	NA

- UF is very stable and provide higher quality in terms of turbidity/TSS.
- UF capable of organic removal (bio-polymers) up to 90%.
- This is proved practically : pilot study in AbuQir power plant.

Technical Assessment

Product Water Quality



Technical Assessment

Product Water Quality

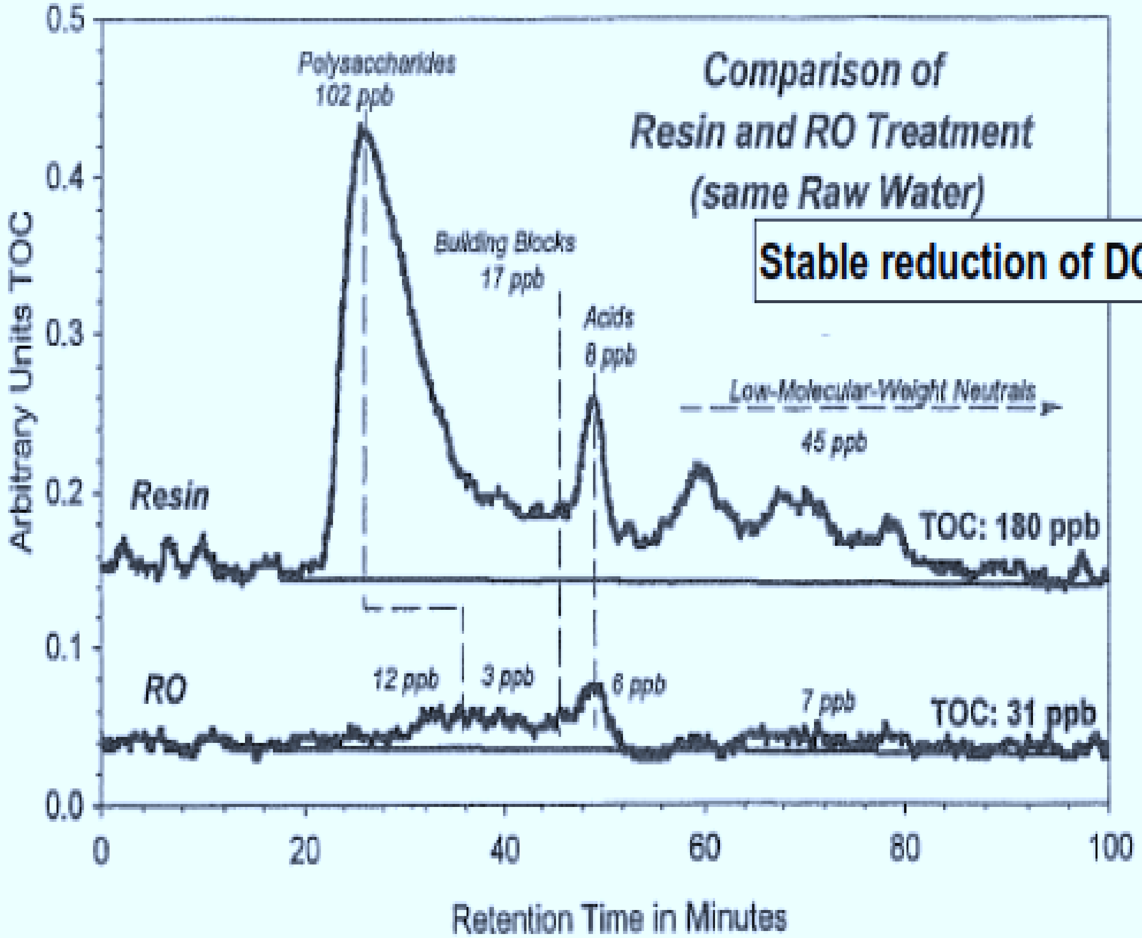
The performance of Reverse Osmosis compared to Ion exchange systems has benefits in terms of :

- Sensitivity to raw water fluctuation.
- Organic removal capability (up to 99%)

With RO system the total organic carbon target level of 100 ppb is achievable while in IX systems is debatable.

Technical Assessment

Product Water Quality



Stable reduction of DOC with RO (< 50 ppb)

Organic removal using Reverse Osmosis vs. Ion Exchange

[Dr. Huber: „The Behaviour of Natural Organic Matter in Water Treatment and Water Steam Cycle: New Insights“; Tagung Organics 2005]

Operation and Maintenance

- Operation of clarifiers in PT systems takes longer time to reach stability and requires continuous operation while UF is very flexible.
- Conventional PT required dosing many chemicals to enhance performance and need frequent Laboratory testing (jar testing).
- UF requires media replacement (7-10 years).
- Power consumption is limited in both options.

Operation and Maintenance

- IX systems requires continuous regeneration using acid/caustic (consume chemicals) while it is not required in RO systems.
- Both IX and RO requires media replacement with almost the same frequency (5 years).
- RO needs chemical injection for anti-scaling and de-chlorination.
- Both options has also limited power consumption.

Foot Print

- The foot print required for membrane based systems is reduced by at least 50%.

	Membrane based	Conventional
Pretreatment *	200 m^2	1500 m^2
Desalting **	300-500 m^2	1500 -1800 m^2

* based on 500 m^3/h capacity
** based on 300 m^3/h capacity

Waste Disposal

- The IX system generates elevated TDS waste in range of 6,000 - 12,000 ppm that is challenging when dealing with regulatory discharge limits

Nile River	Nile River branches	Drain channels
1200 ppm	800 ppm	2000 ppm

- RO systems generates lower TDS that can be fulfill regulations requirements (depend on raw water TDS)

Economic Assessment

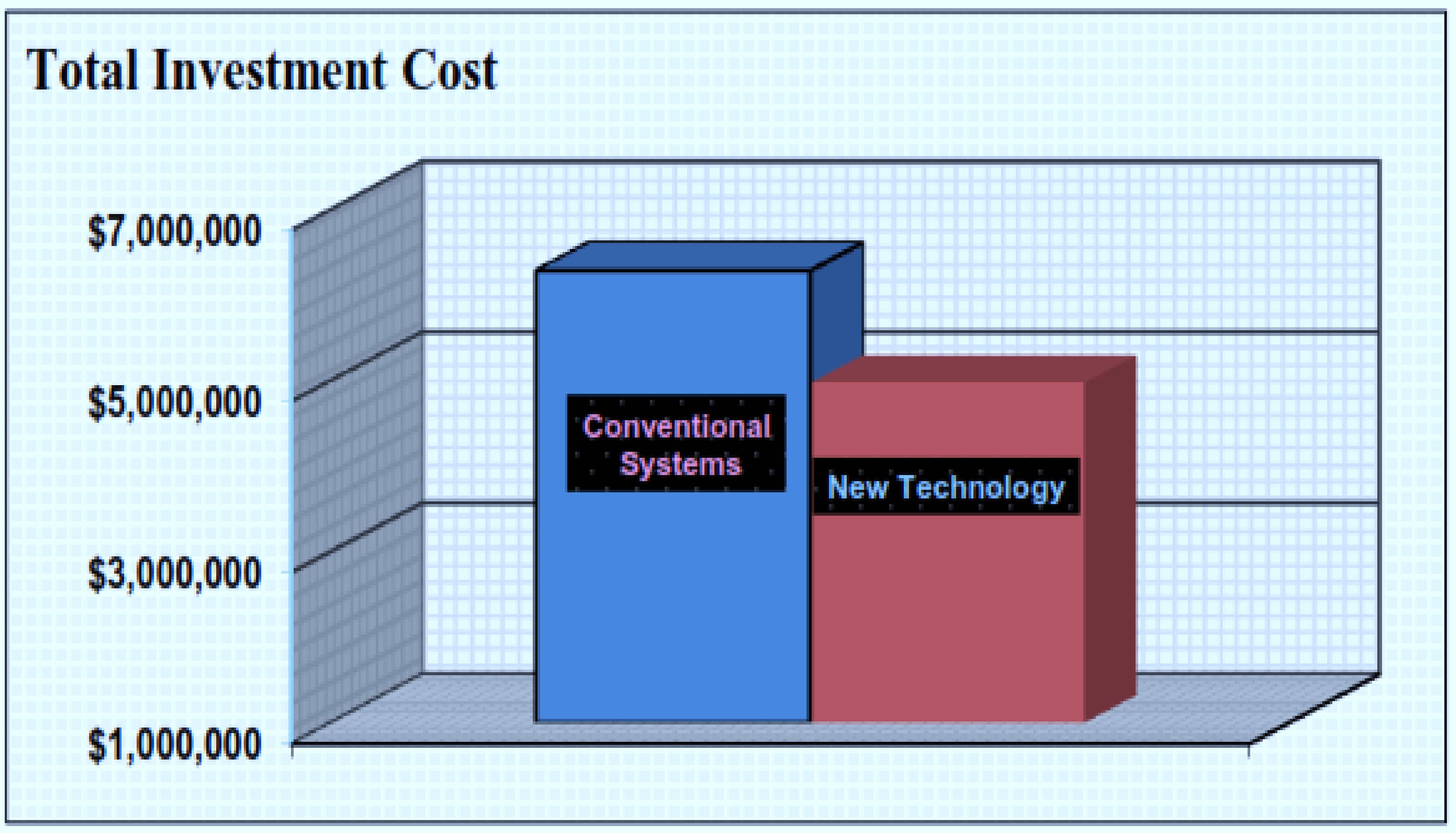
- Provide economic analysis of the alternatives.
- Based on **Annual Worth** calculation in form of **EAUC**.
- The economic analysis includes:
  - Capital expenses (CAPEX)
  - Operating expenses (OPEX)
    - Chemical consumption
    - Power consumption
    - Media replacements
    - Spare parts
- Cost estimates are based on actual contract prices executed in Egypt.

Economic Assessment

- Some parameters is not considered in the economic analysis to make pessimistic analysis toward membrane based technologies, these includes:
  - Land (footprint) : **depend on project circumstances**
  - Labor : **country specific labor rates to be applied**
  - Construction requirements (i.e. civil works, steel)
- The economic analysis is carried out for a model includes:
  - 250 m^3/h (6000 m^3/d) : pretreatment
  - 200 m^3/h (4800 m^3/d) : desalting/demineralization

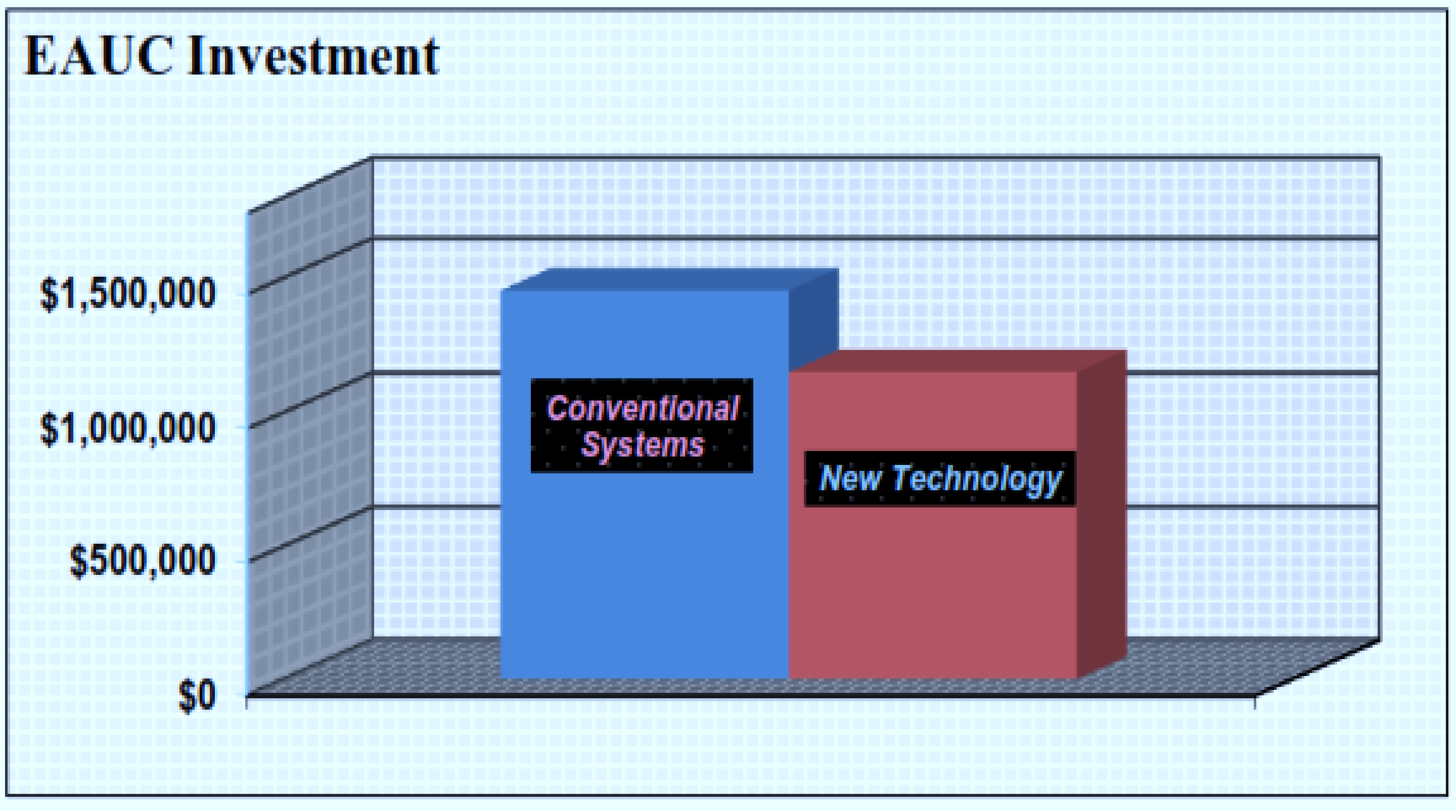
Economic Assessment

CAPITAL EXPENSES



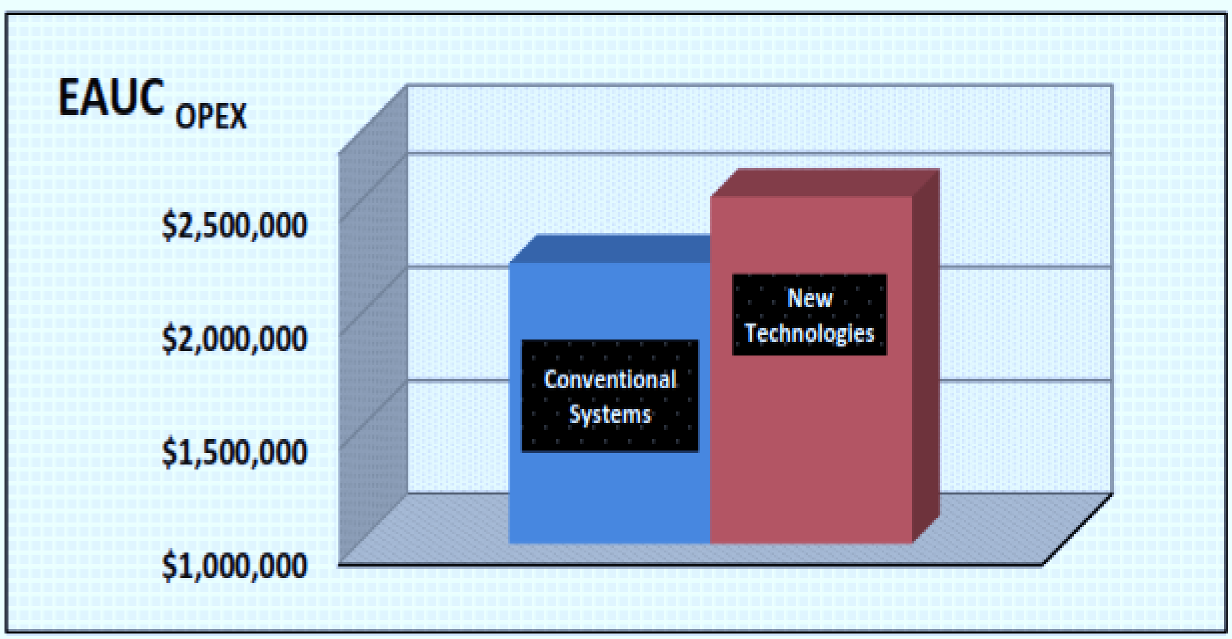
Economic Assessment

CAPITAL EXPENSES



Economic Assessment

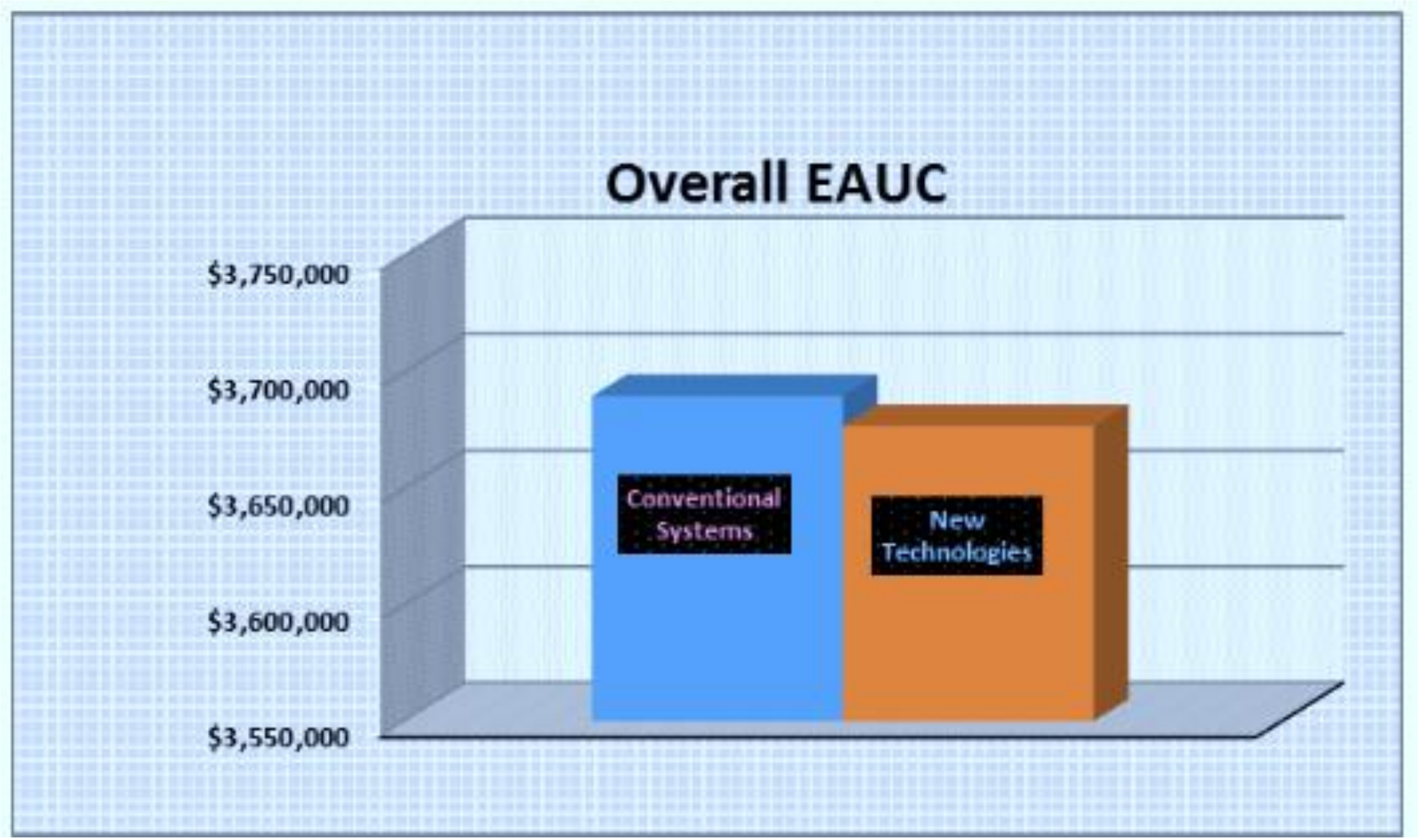
Operating Expenses



	Option 1	Option 2
$EAUC_{OPEX}$	**$ 3,689,747**	**$ 4,676,839**
$EAUC_{chemical}$	$457,099	$252,938
$EAUC_{power}$	$89,624	$163,306
$EAUC_{media}$	$124,155	$872,618
$EAUC_{spares}$	$1,566,744	$1,239,321

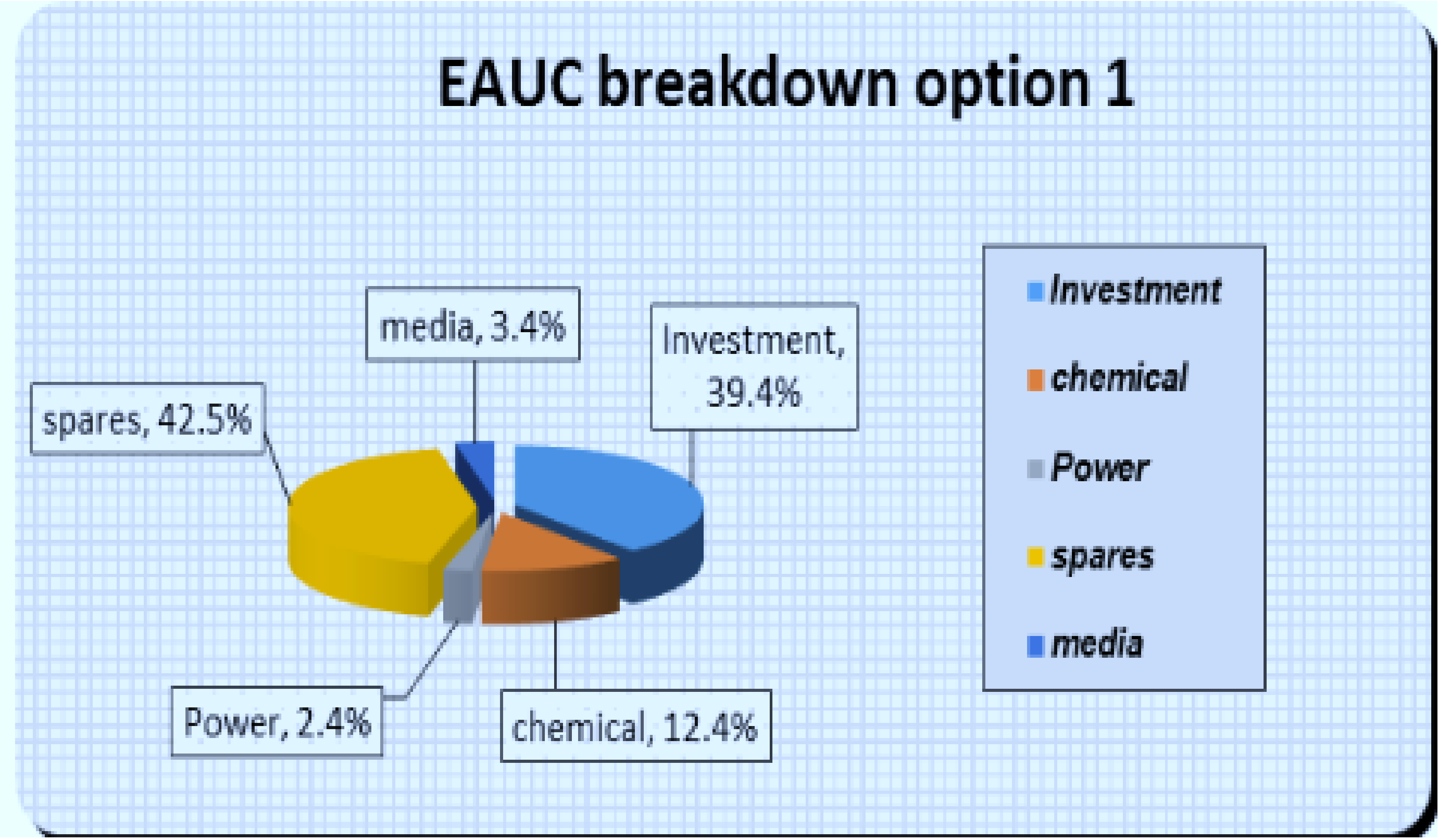
Economic Assessment

Overall Cost



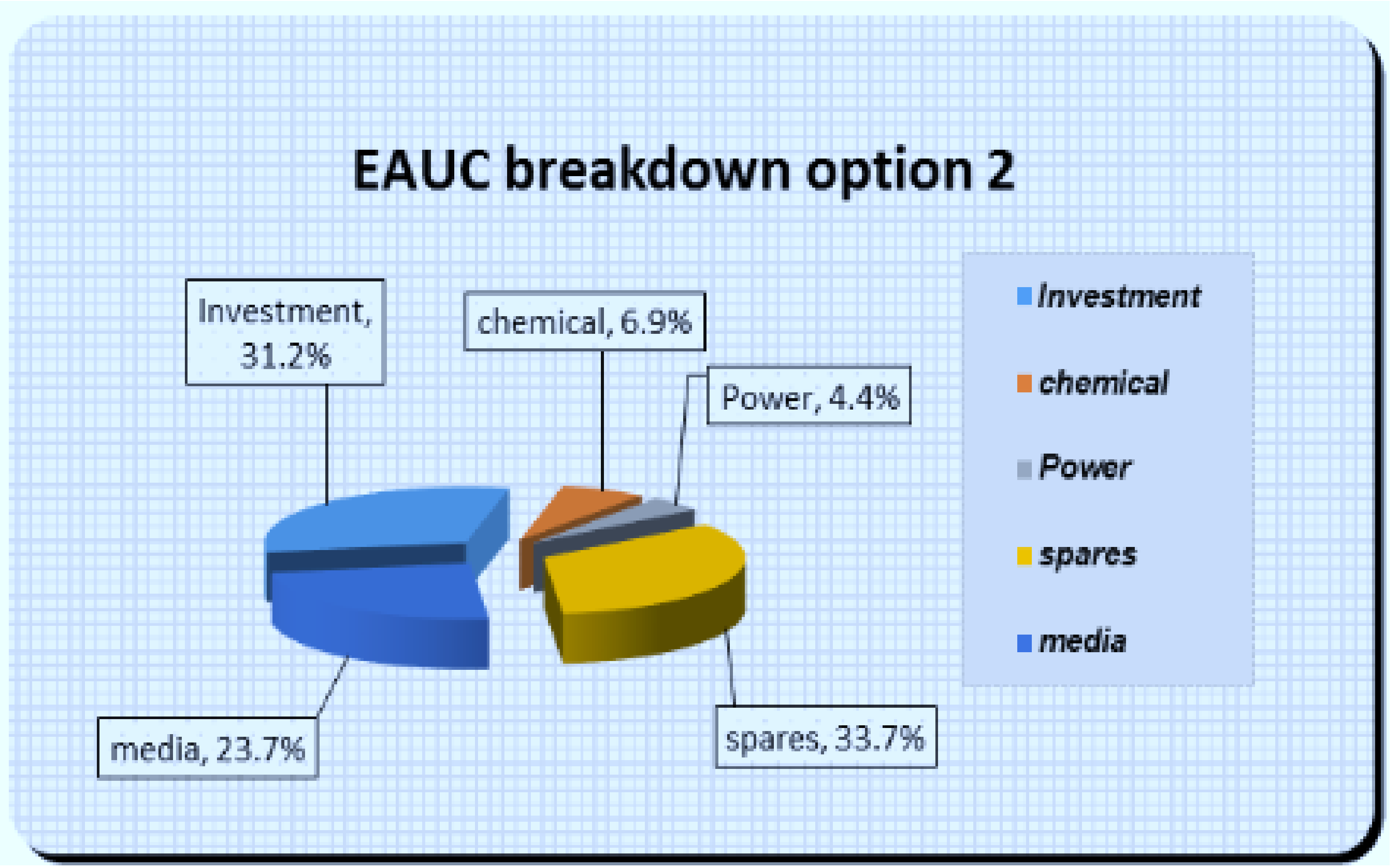
Economic Assessment

CAPITAL EXPENSES



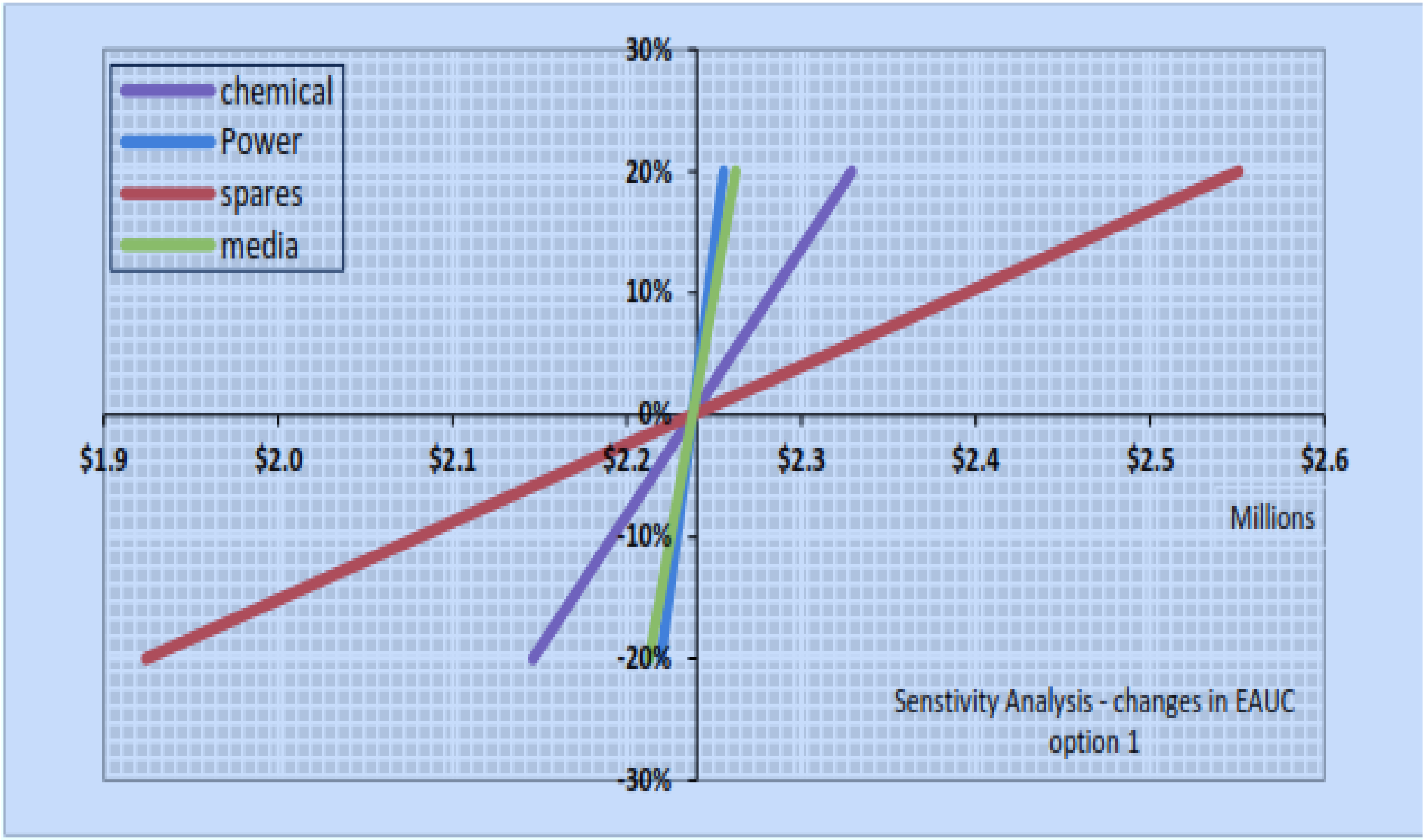
Economic Assessment

CAPITAL EXPENSES



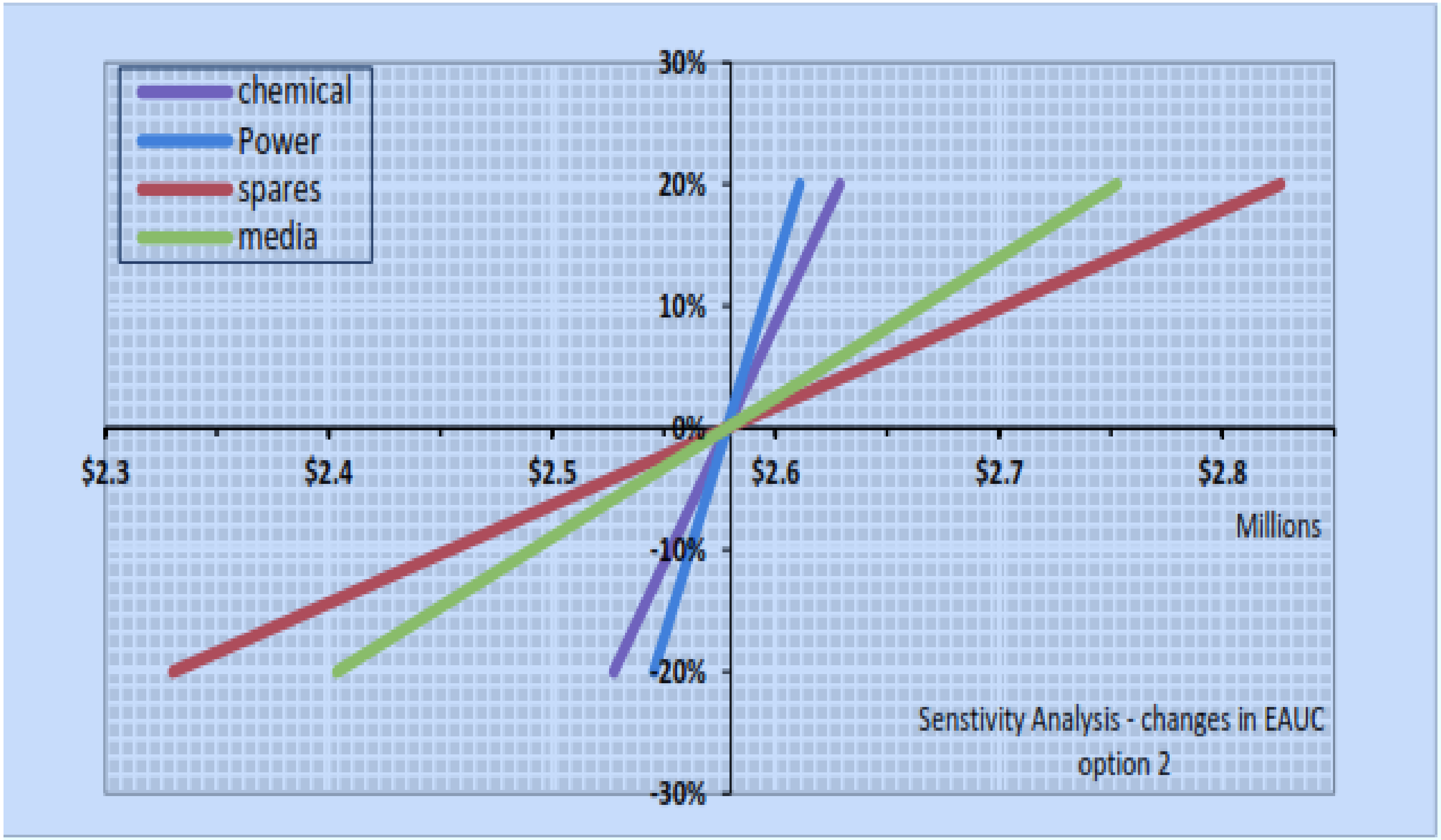
Economic Assessment

Sensitivity Analysis – option 1



Economic Assessment

Sensitivity Analysis – option 2



Conclusion

- UF and RO has a better performance that meets the industry challenging water quality requirements.
- UF and RO has more benefits in waste disposal, foot print, and operation flexibility.
- RO is sensitive to the pretreatment system.
- The overall costs of membrane based technologies can be considered very competitive to conventional technologies or may be better.
- Power industry and similar industries should employ membrane based technologies in their desalting applications to get benefits of its better performance.

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