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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.

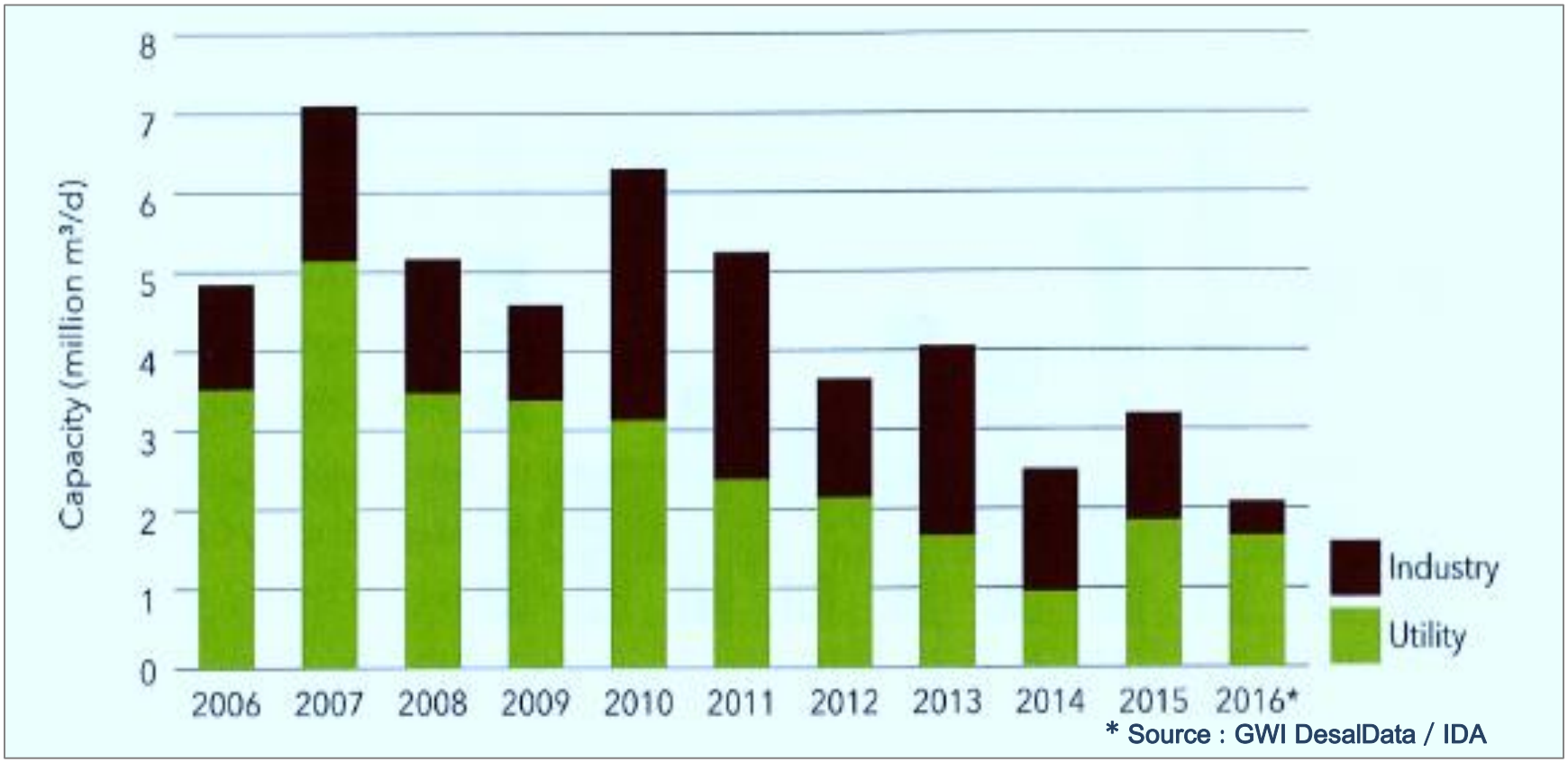
# Introduction

**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% |

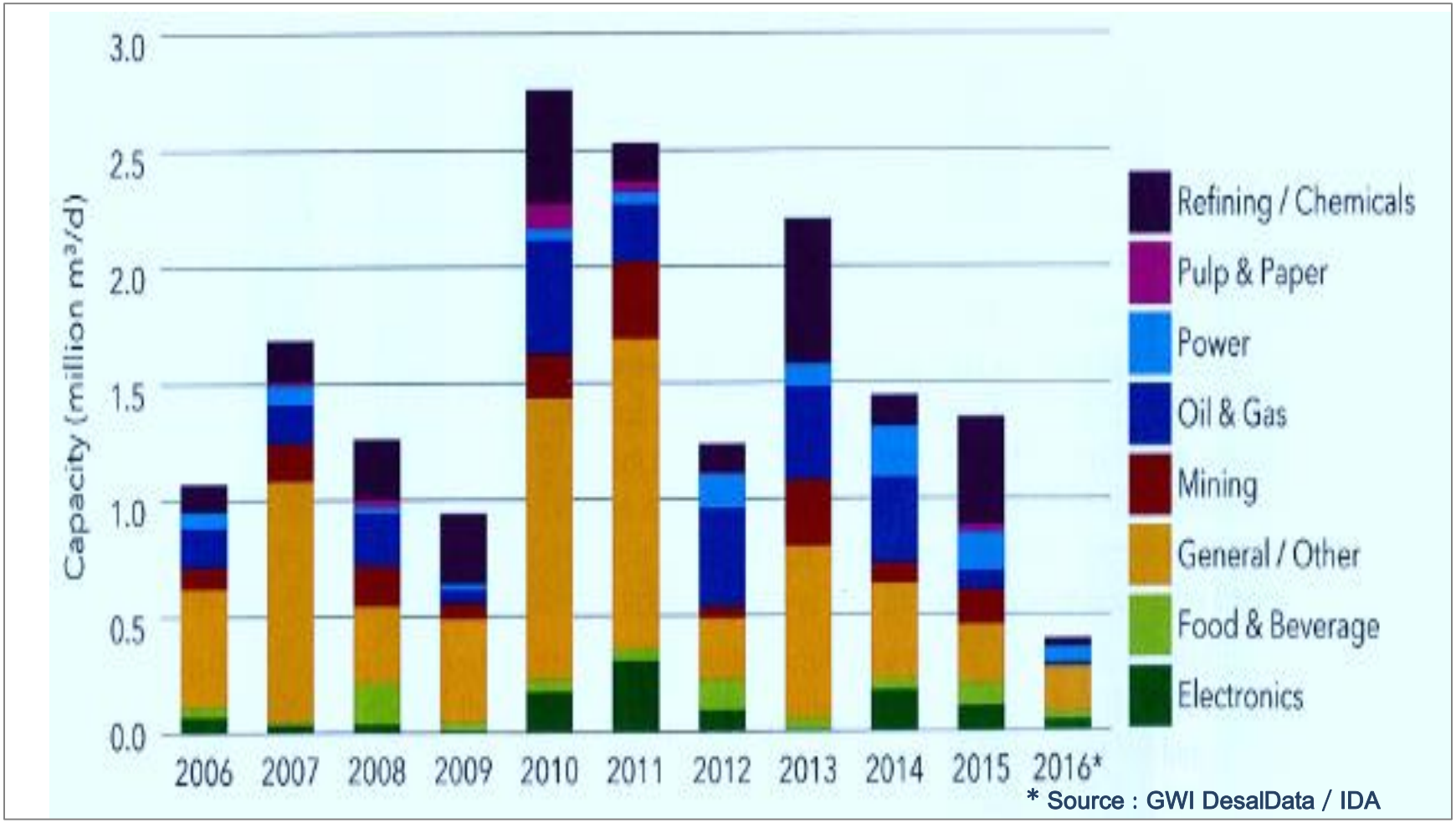
# Introduction

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



# Introduction

## Power Market almost has stable share .



# 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 of organization i.e. EPRI, VGB and IAPWS.
- Total organic carbon is very challenging (< 100 ppb).

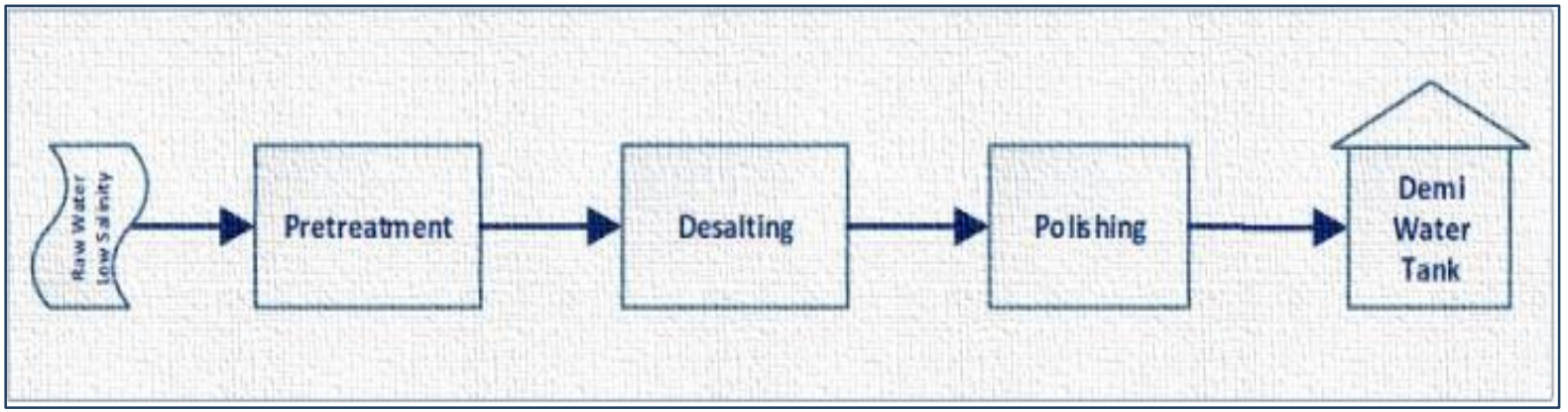
| | |
|---|---|
| Sodium, ppb | < 3 |
| Chloride , ppb | <3 |
| Sulfate, ppb | <3 |
| Silica , ppb | <10 |
| Specific conductivity, µs/cm | <0.1 |
| Cation conductivity , µs/cm | <0.1 |
| Total organic carbon, ppb | <100 |

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.

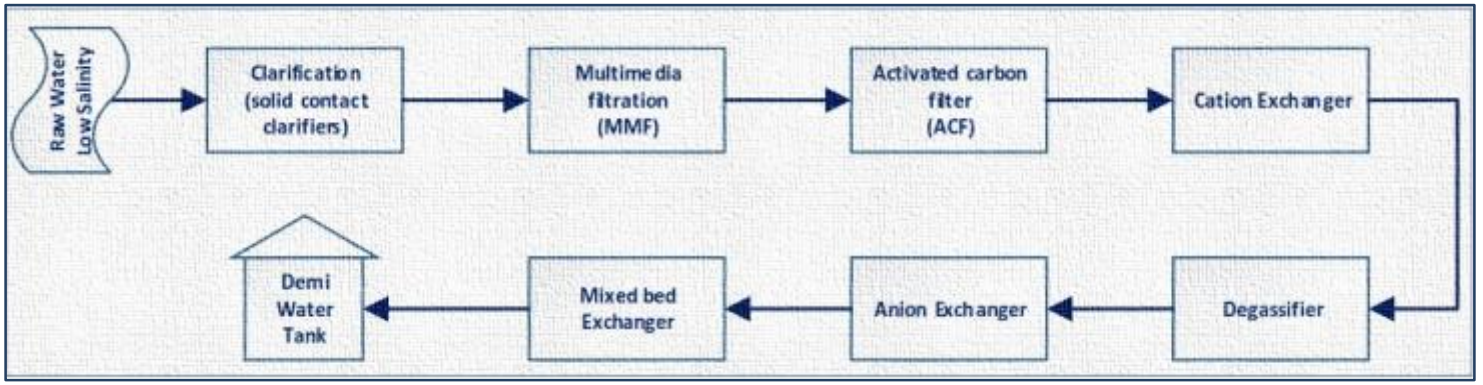
# Background and Industry Requirements

| 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 |

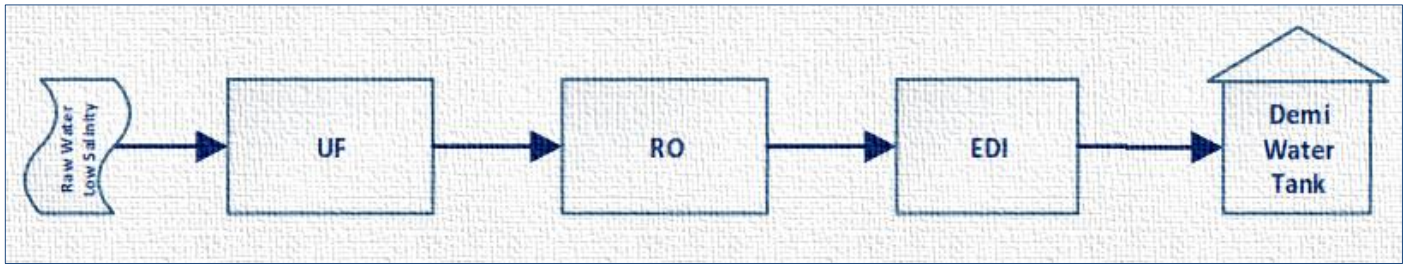
Example of Nile River Water Quality at site South of Cairo governorate

# Background and Industry Requirements

- Traditional scheme involves numerous step, 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

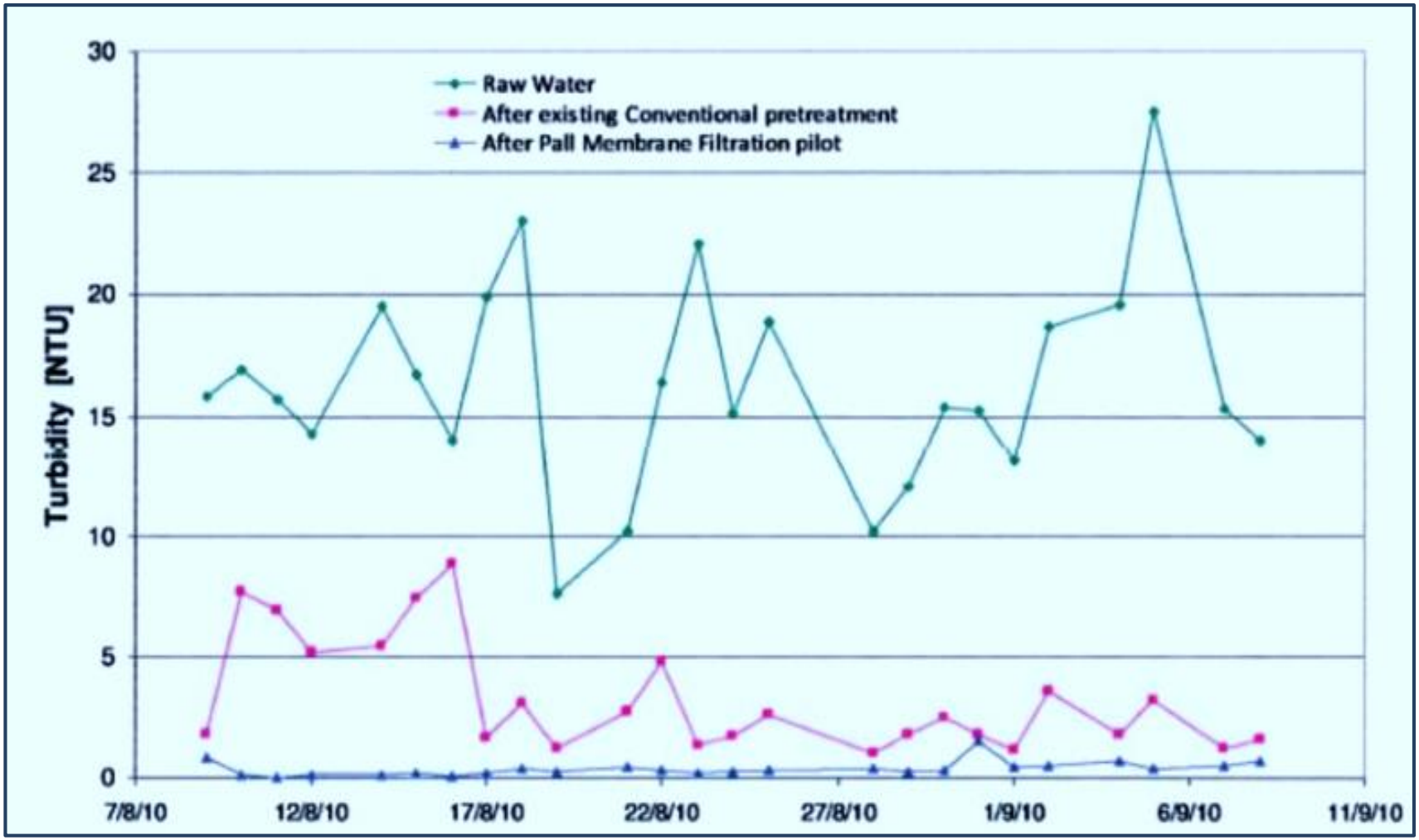
## PRODUCT WATER QUALITY

| | 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

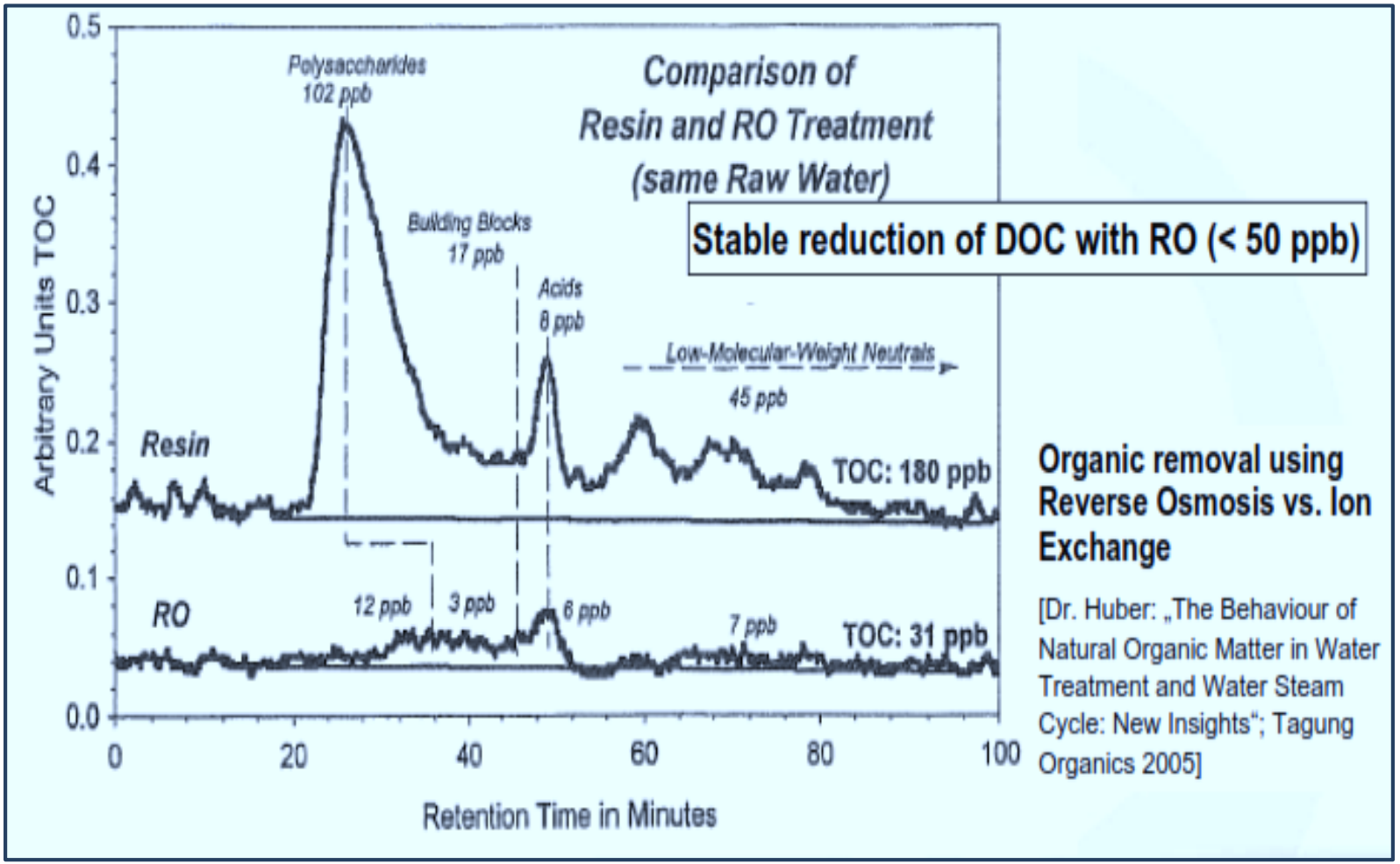
**The performance of Reverse Osmosis compared to Ion exchange systems has benefits in terms of :**

- 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



# Technical Assessment

## 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.

# Technical Assessment

## 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

# Technical Assessment

## 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

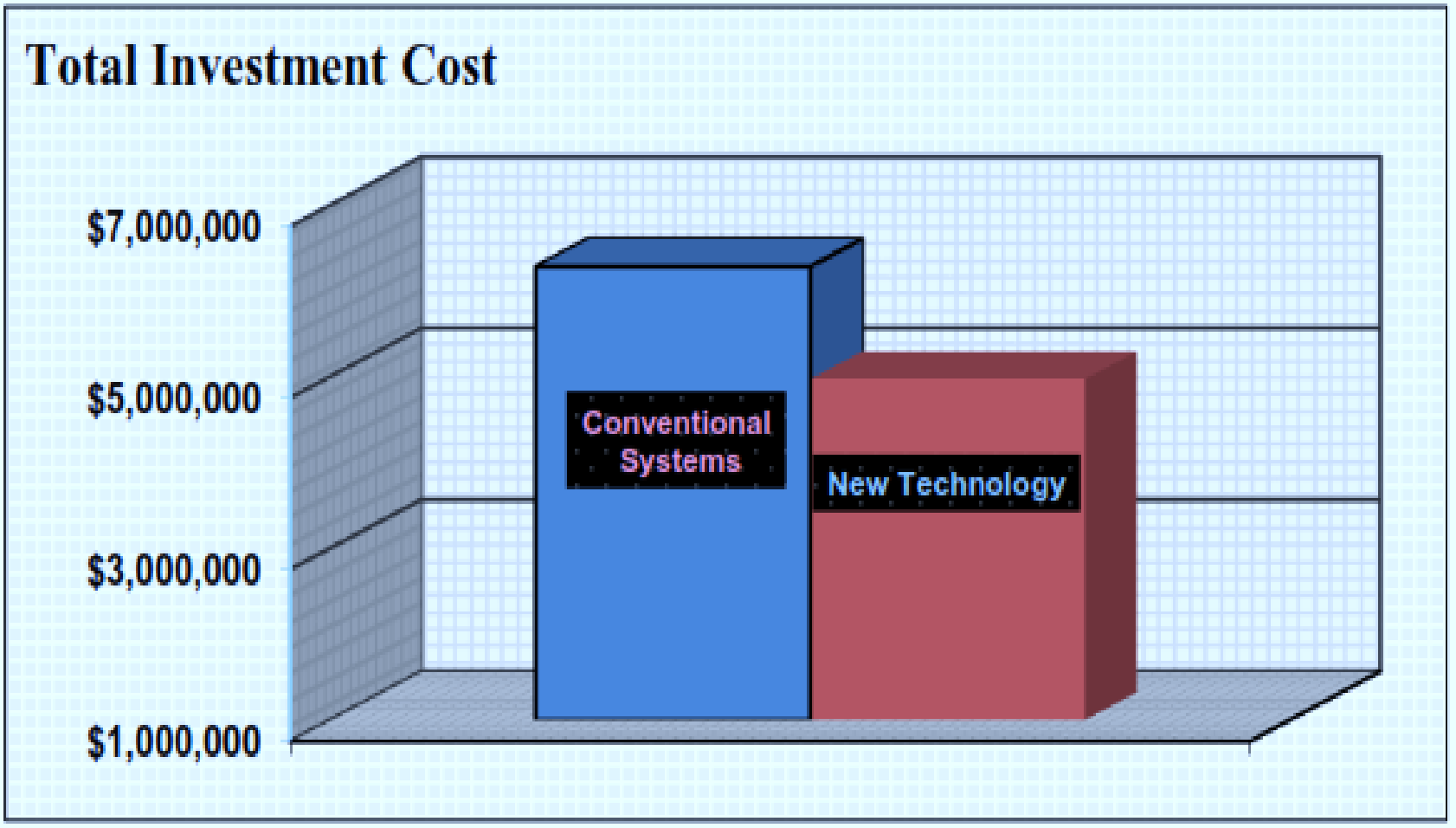
- Provide economic analysis of the alternatives.
- Based on **Annual Worth** calculation in form of **EAUC**.
- The economic analysis includes:
  - Capital expenses (CAPEX)
  - Operating expenses (OPEX)
    - Chemical consumption
    - Power consumption
    - Media replacements
    - Spare parts
- Cost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

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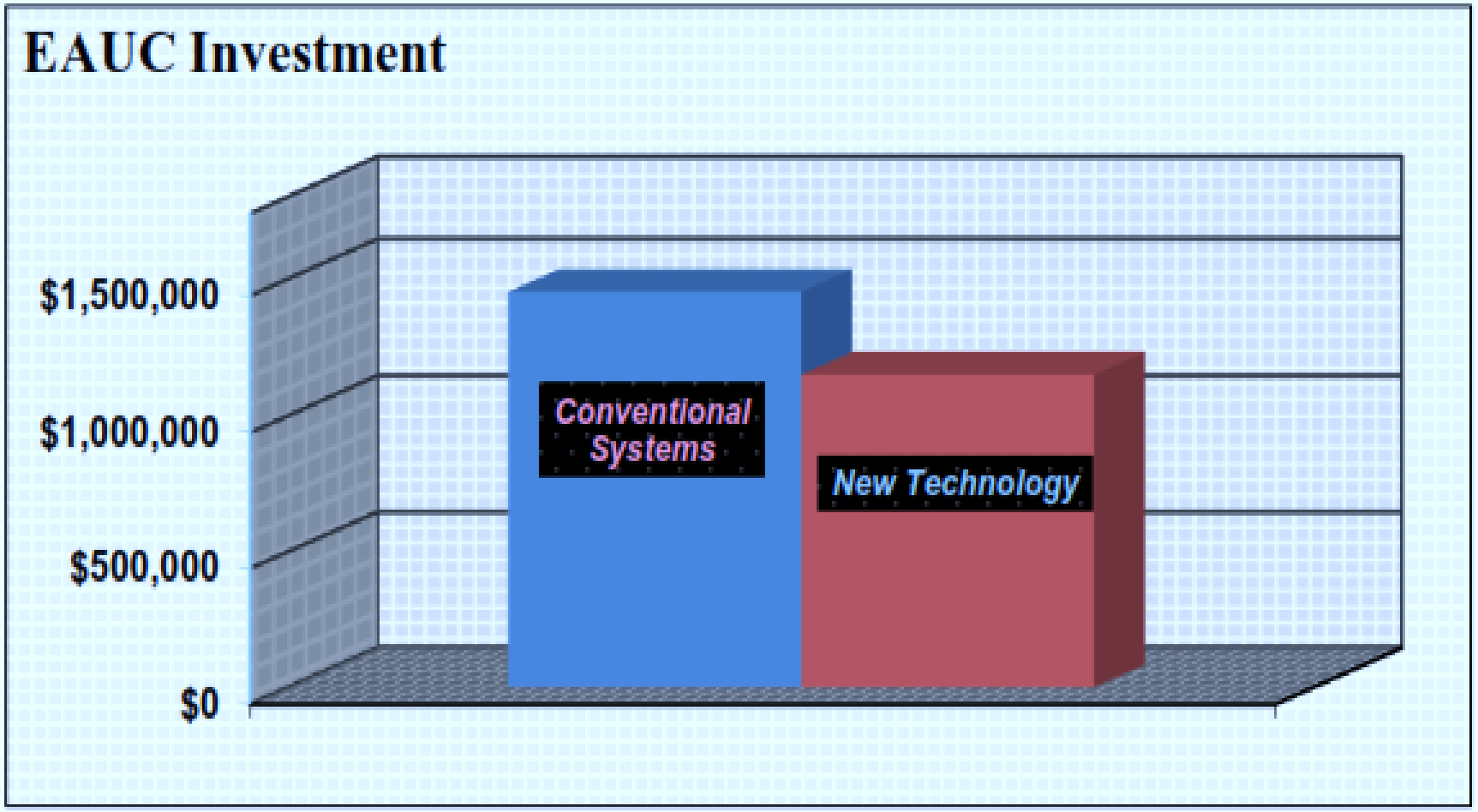
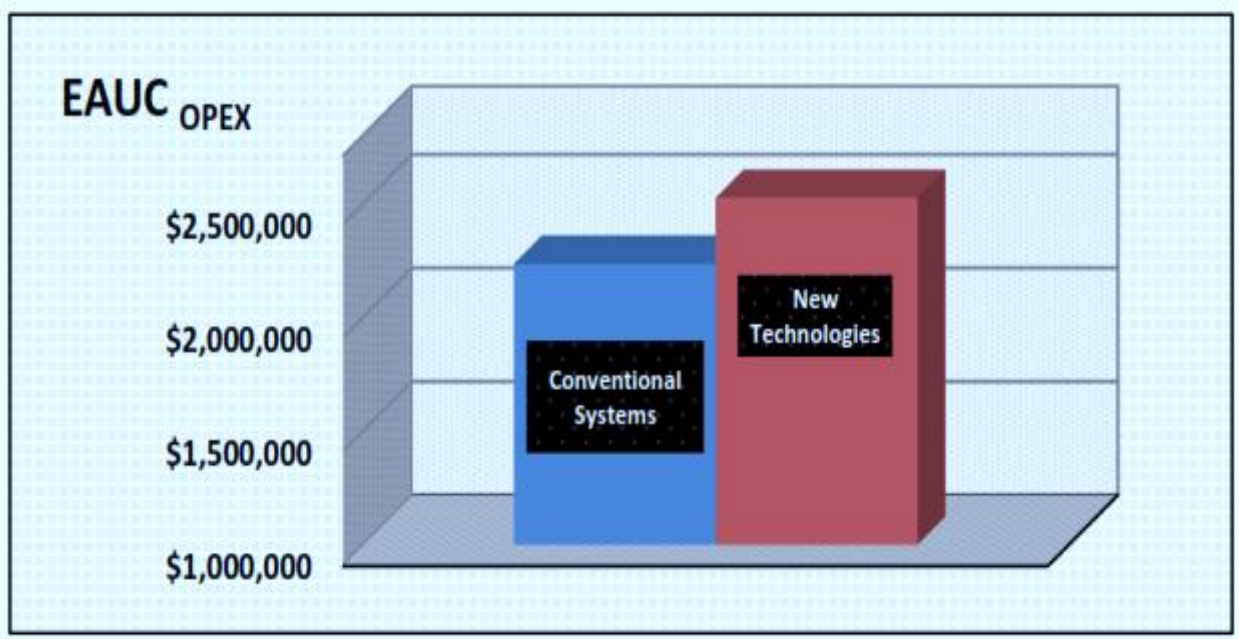


# Economic Assessment

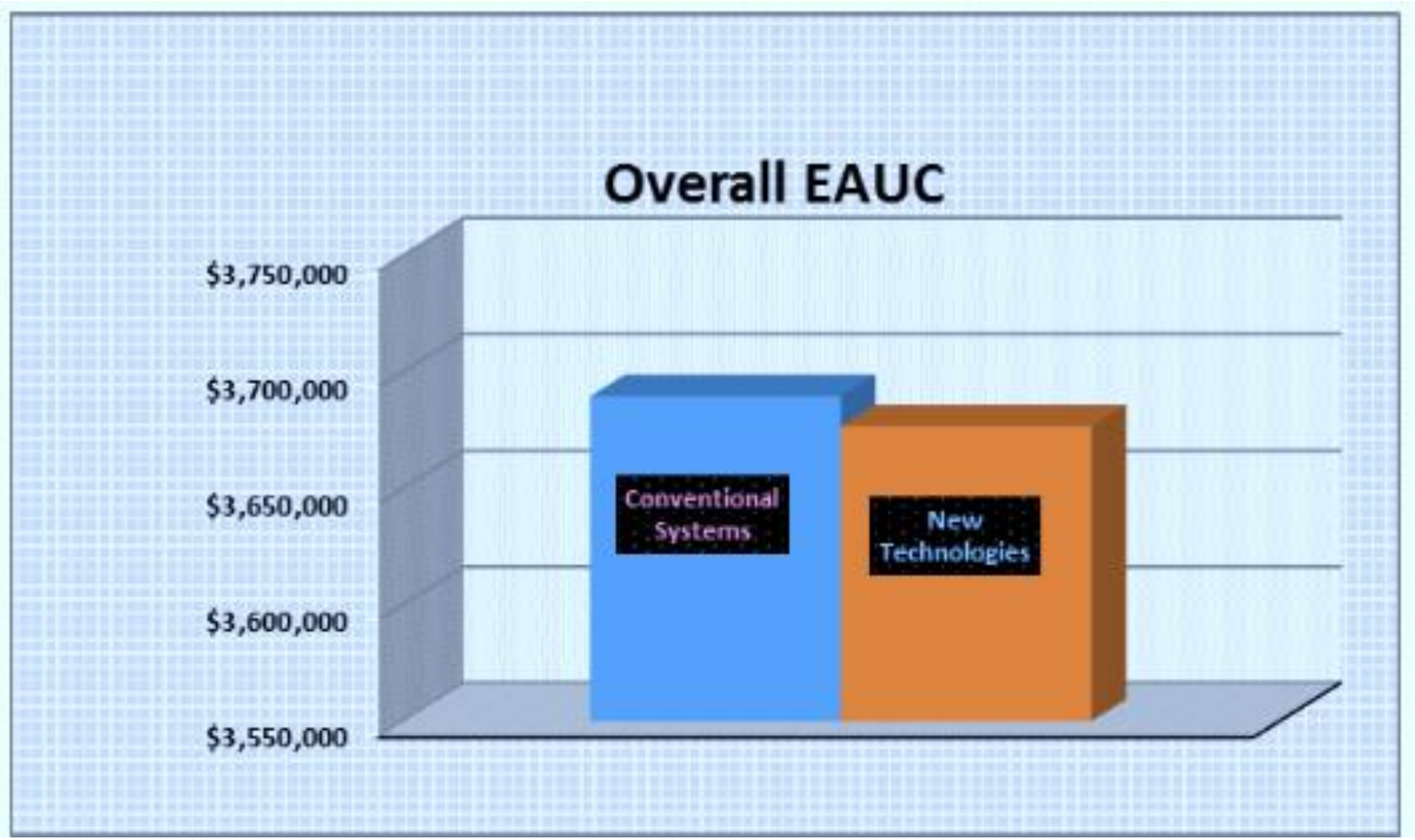
## Operating Expenses




| | 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 |

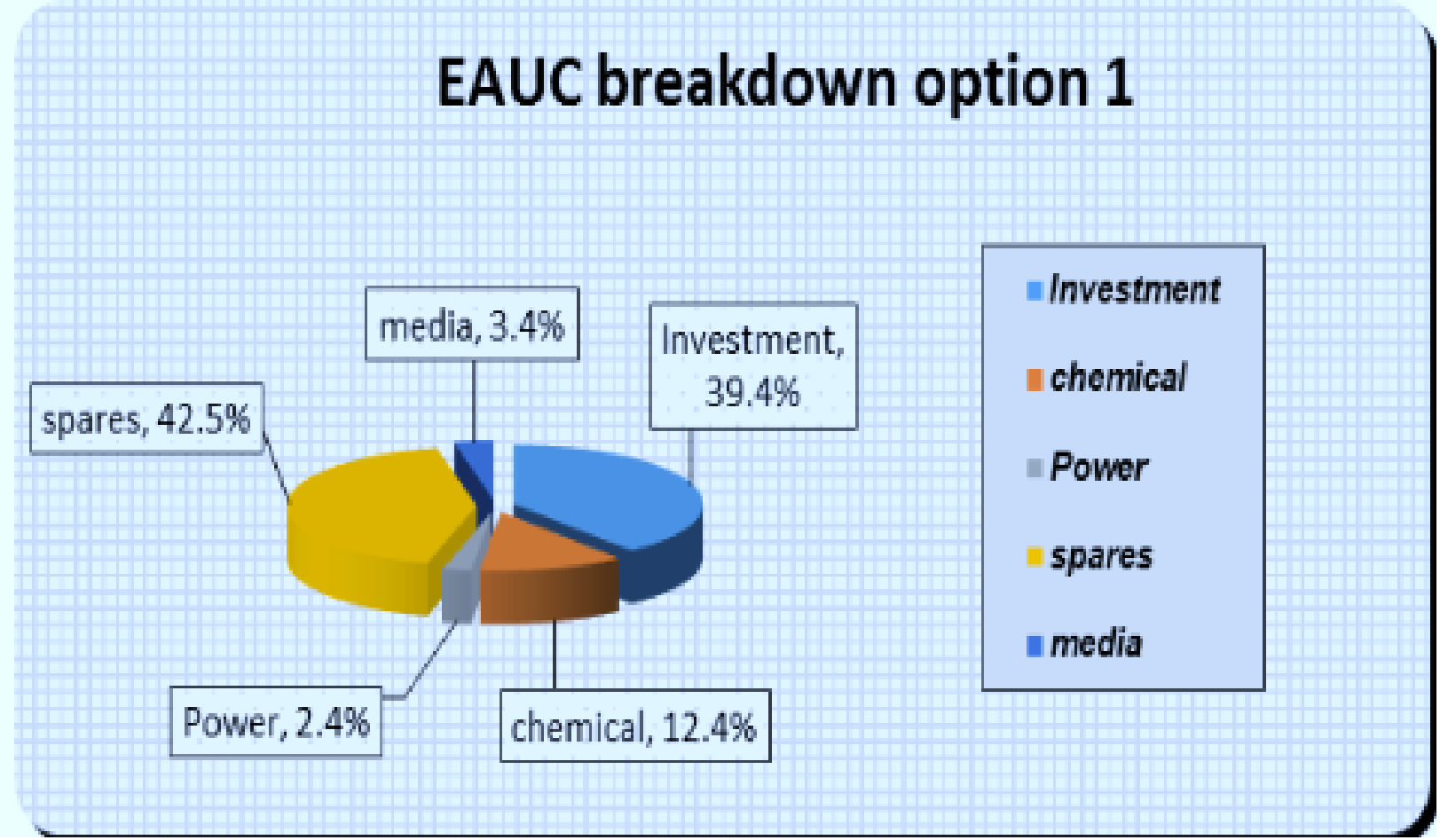
# Economic Assessment

## Overall Cost



# Economic Assessment

## CAPITAL EXPENSES



# Economic Assessment

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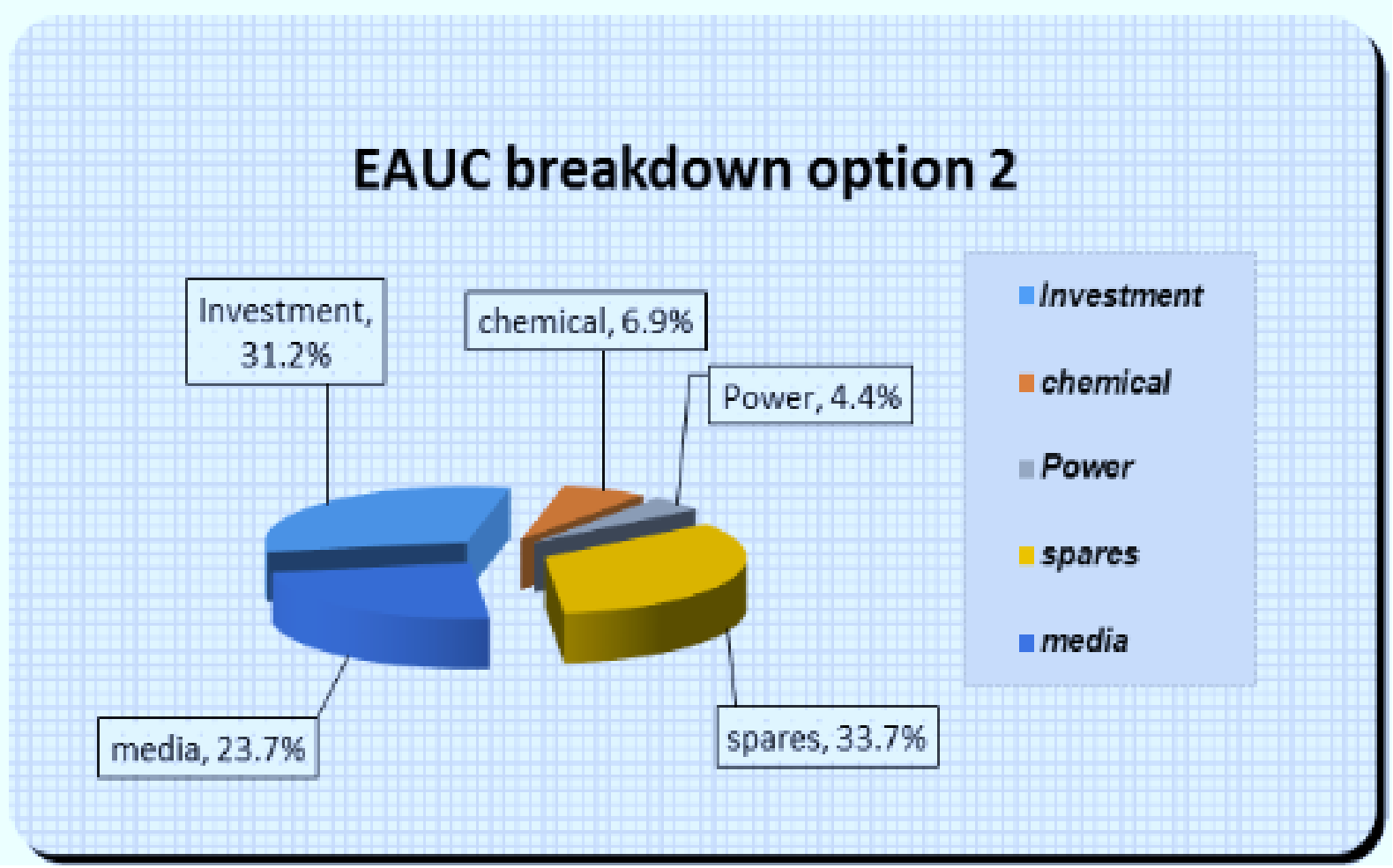
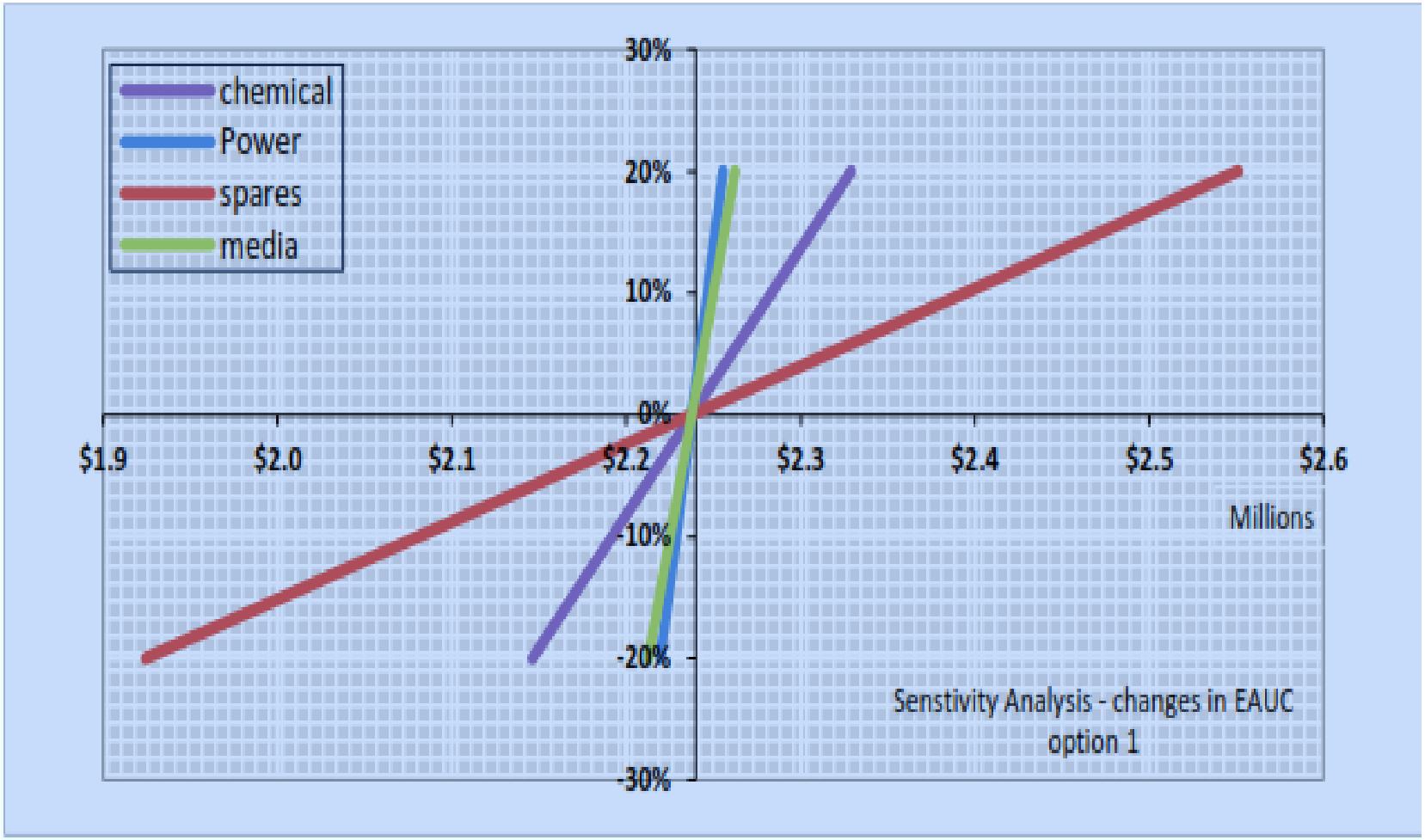


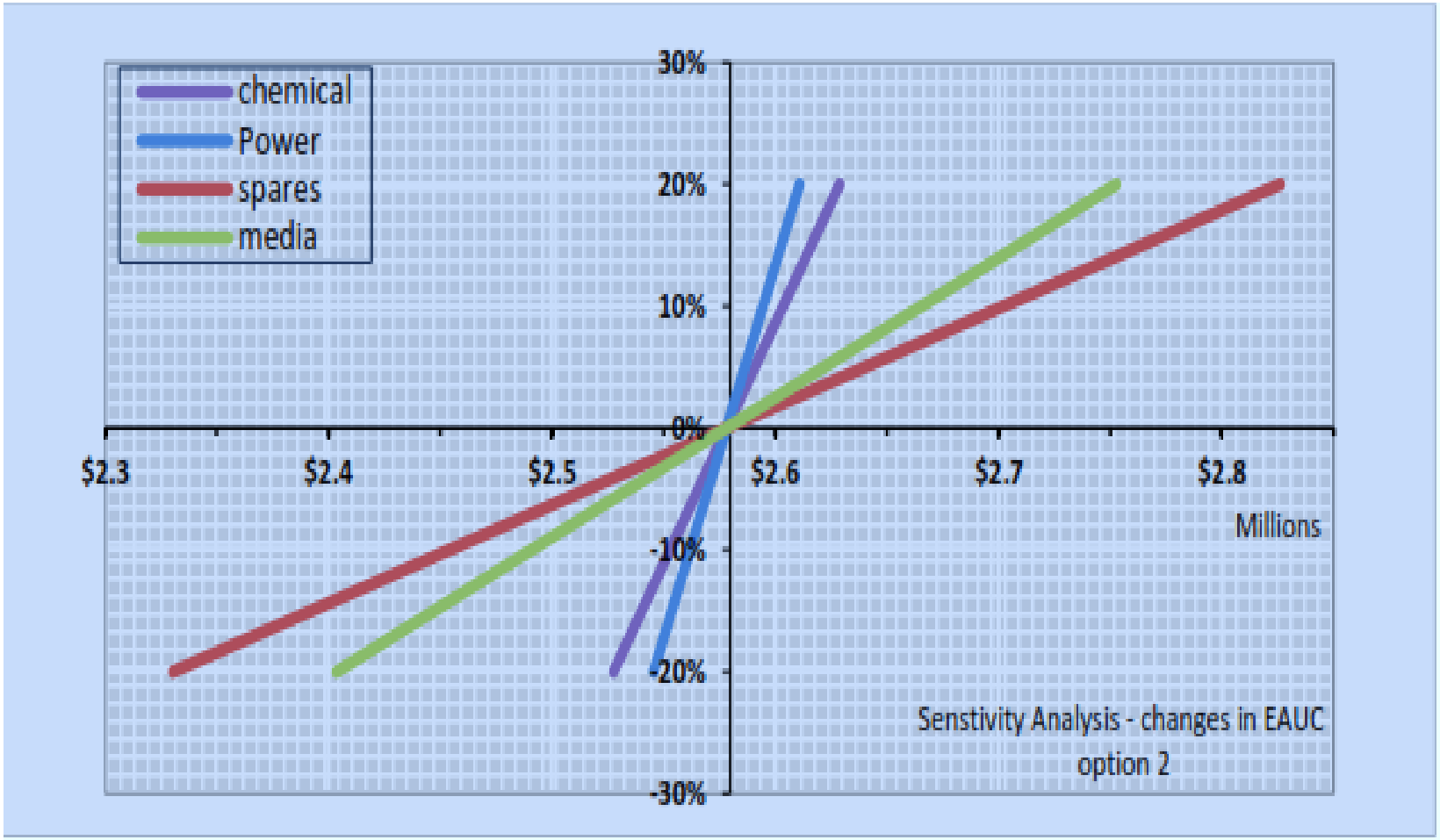
# Economic Assessment

## 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.


# Thanks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