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# Further Progress of "Mega-ton Water System" Technology for **Green Desalination**

"Mega-ton Water System" technology is developed by the funding of Japanese government "FIRST Program; FY2010-2013" as Innovative Desalination Technology, and supported by New Energy and Industrial Technology Development Organization (NEDO)

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# Vision & Mission of “Mega-ton Water System”

**Vision :** Sustainable SWRO Desalination in the 21st Centuries

**Mission :** “Mega-ton Water System” as **Green Desalination**

**1. Energy saving (20-30%)**

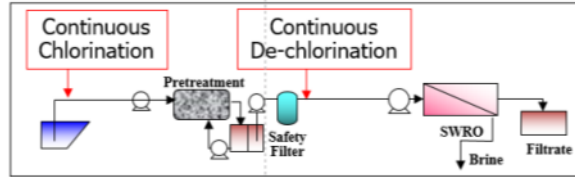
- a. Low pressure SWRO membrane
- b. Low pressure two stage SWRO system with high recovery

**2. Low environmental impact**

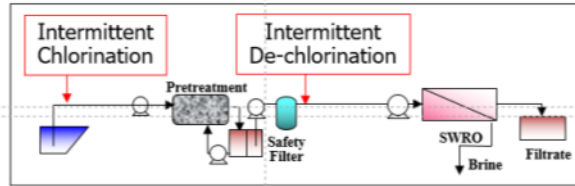
- a. Less chemical for reliable plant operation
- b. Less chemical cleaning
- c. Less chemical and diluted brine discharge

# History of anti-biofouling trials and New System for future SWRO system

Initial stage Conventional SWRO System (1990~)

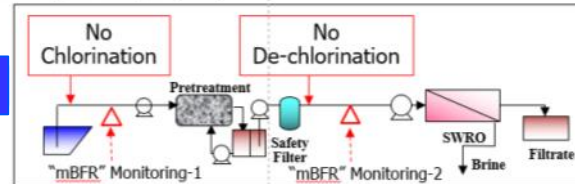


Intermediate stage Current SWRO System (2004~)



Ideal stage Future SWRO System (2017~) proposed by "Mega-ton Water System" project

**New System**



**Sterilization by chlorination was common sense**

*Frequent Bio-fouling!*

**Mild sterilization has been adopted**

*Bio-fouling can not be eliminated*

*There was a doubt as to the effect of chlorine sterilization*

**No chlorination, no de-chlorination**

*Bio-fouling can be controlled*

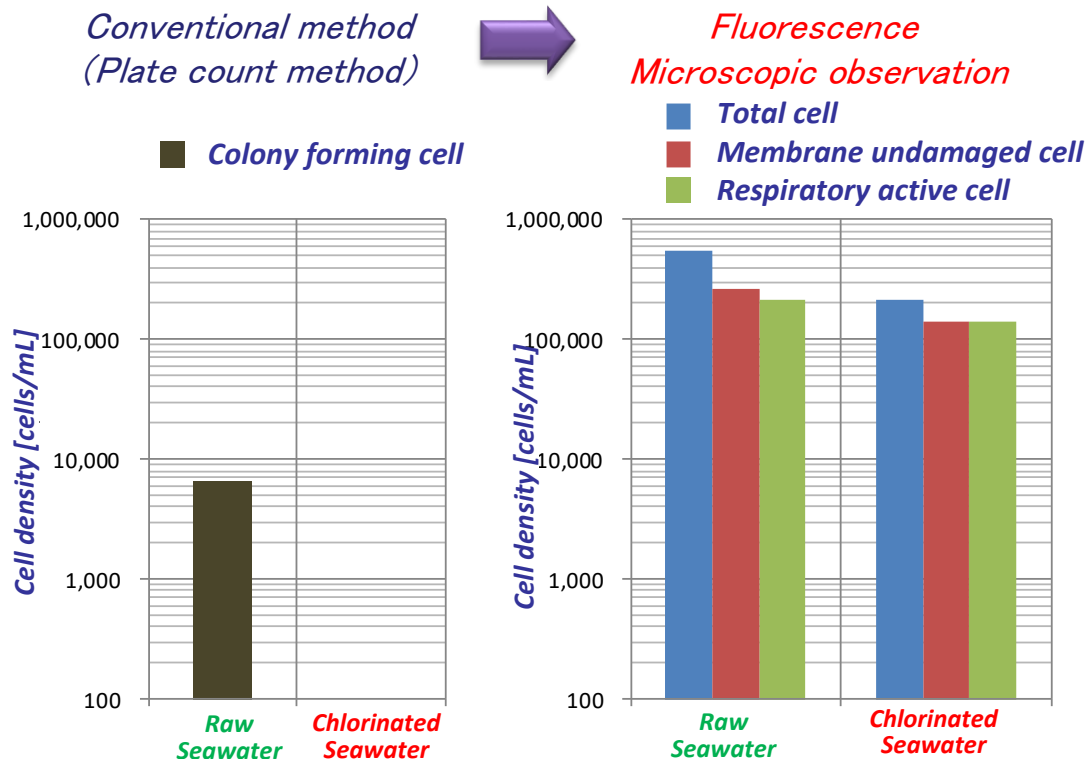
**Recommendation**

*Optimize pretreatment conditions by monitoring "mBFR"*

**"mBFR" : Membrane biofilm formation rate**

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# Chlorine sterilization of sea water has no effect

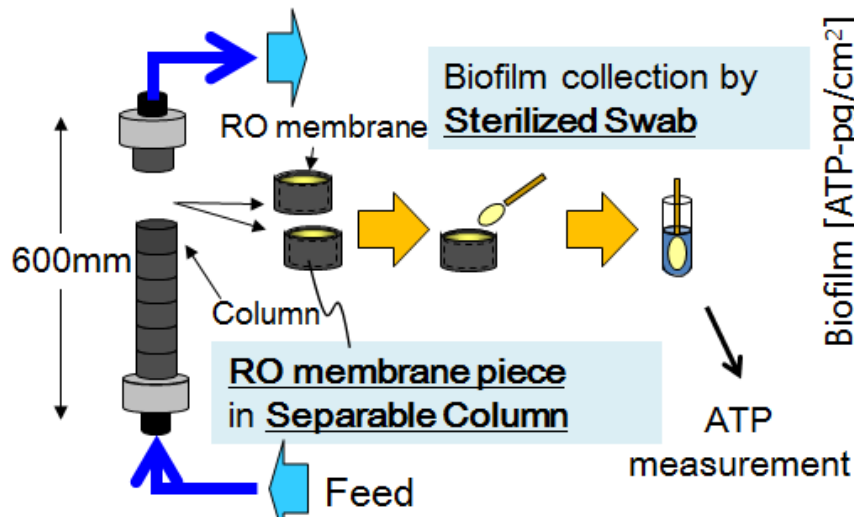


1. Disinfection effect of chlorine by conventional method is overestimated.
2. In the new fluorescence microscope observation, much more marine bacteria survive after chlorine disinfection.
3. Chlorine sterilization of seawater is wrong, not only ineffective, but rather counterproductive.  
>> See later slide.

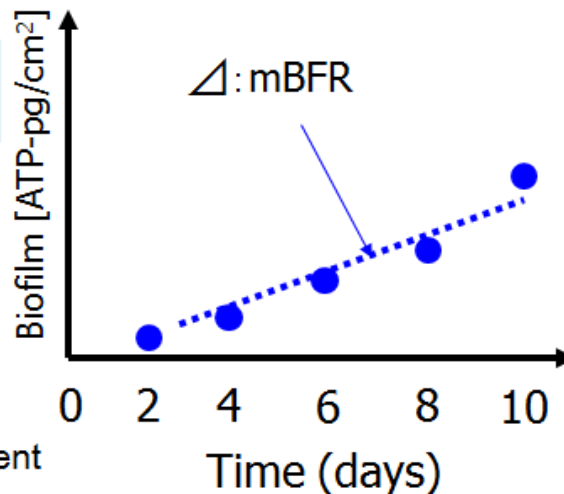
# “mBFR”: Membrane biofilm formation rate

- Biofilm is formed on the carrier while target water being fed inside the column.
  - Biofilm is quantified by measuring ATP amount on the carrier (RO membrane).
- Definition:  $mBFR : \Delta ATP(pg/cm^2) / \text{Time (day)}$  (ATP : Adenosine Triphosphate)

## Outline of measurement

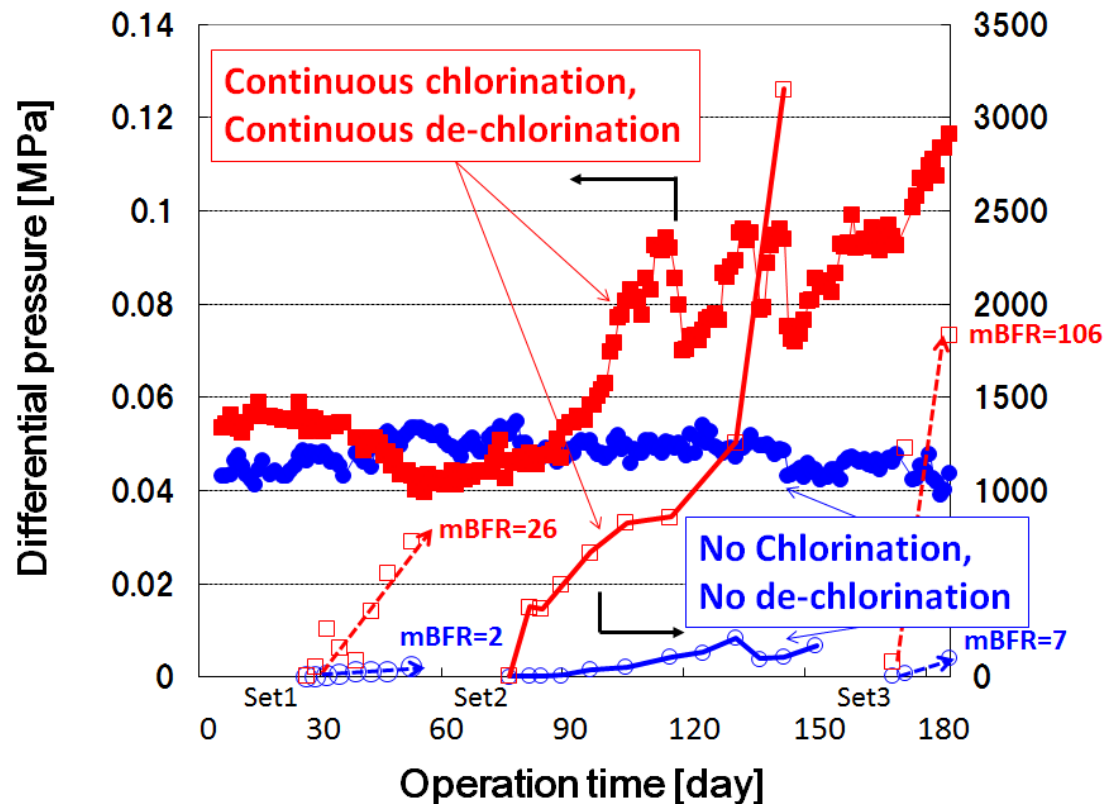


## Result example



*“mBFR” was developed by Toray as an indicator of Seawater RO supply water*

# Chlorine sterilization and SBS dosing triggers biofouling



Initial stage: Continuous chlorination,  
Continuous de-chlorination(SBS)

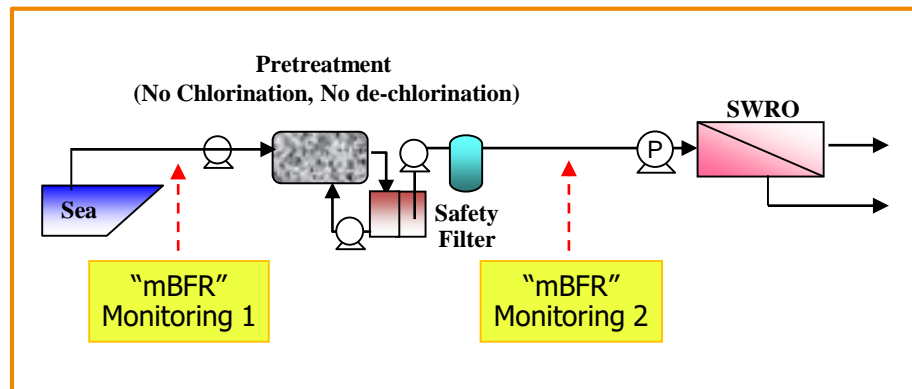
Ideal stage: No chlorination,  
No de-chlorination(SBS)

Filled circle and square:  
RO differential pressure

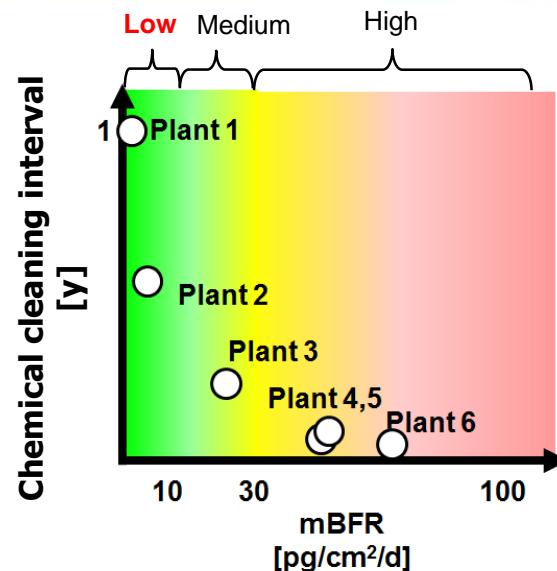
Open circle and square:  
ATP(biofilm) amount on  
RO membrane piece in  
Separable column



# Quantitative RO chemical cleaning interval due to biofouling



Monitoring Points of “mBFR”



Relationship between “mBFR” and Chemical cleaning interval

Low “mBFR” is necessary for reliable operation of SWRO plant with less chemical cleaning.  
Chemical Cleaning interval can be predicted with “mBFR” of RO feed water.

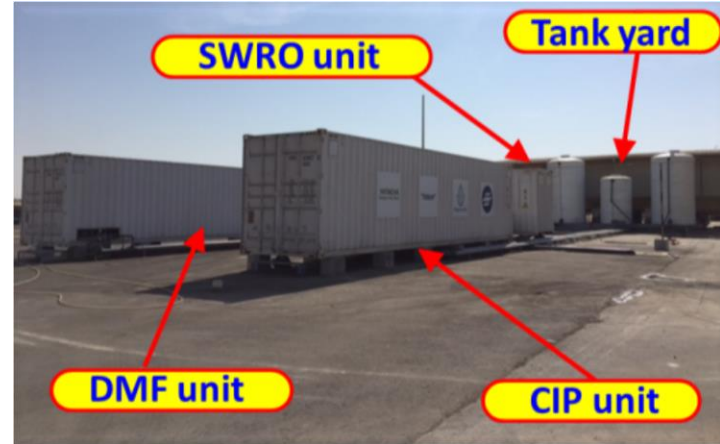
# Preliminary Verification Project /Pilot Plant between SWCC/DTRI and Toray & Hitachi



**Signing ceremony for 500m<sup>3</sup>/day pilot plant, Joint Project  
with SWCC/DTRI, Toray and Hitachi on Feb. 7<sup>th</sup>, 2016**



# Pilot plant Test : 500 m<sup>3</sup>/day

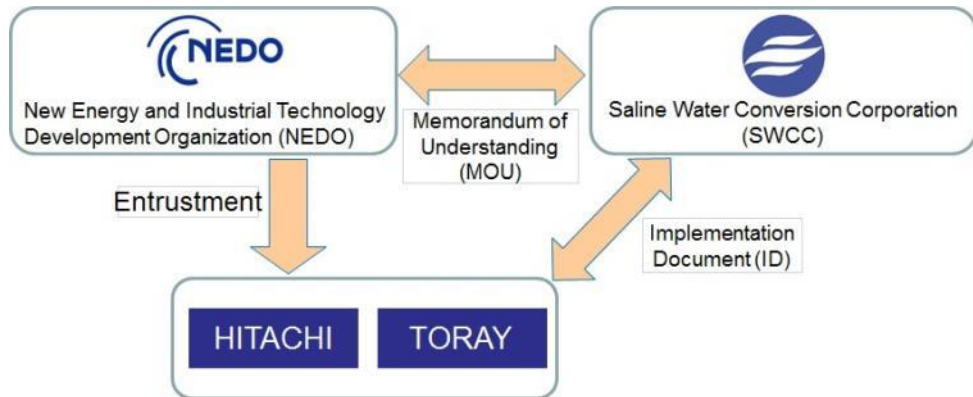


- I. SWCC/DTRI, Toray and Hitachi collaborated to evaluate advanced design system and technologies developed by “Mega-ton Water System” project. (Dec. 2016 - Jan. 2018).
- II. Al-Jubail is located on the Arabian Gulf, subject to high salinity (4.6%) and large temperature variations (14 to 37°C).
- III. New system as ideal stage (No chlorine, No SBS) for biofouling was verified during one year as reliable plant operation.

# Full Plant Verification Project between SWCC and NEDO



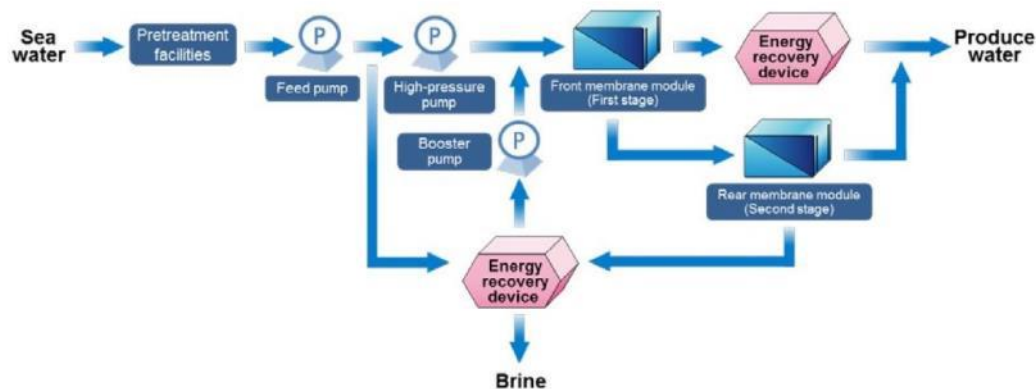
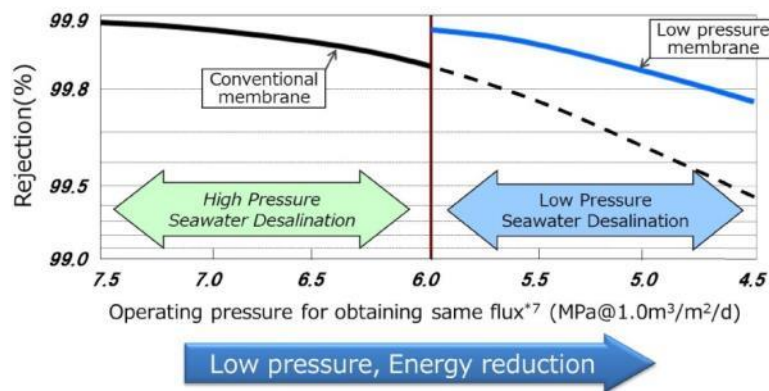
**MOU exchange ceremony for 10,000 m<sup>3</sup>/day full plant verification project between SWCC and NEDO on Dec. 11, 2017**



# Verification project for energy saving & low environment impact seawater desalination system in Saudi Arabia

## Advanced Core Technology

- I. New Advanced Low pressure SWRO membrane
- II. Low pressure two-stage high recovery SWRO system
- III. Biofouling Monitoring “mBFR” technology

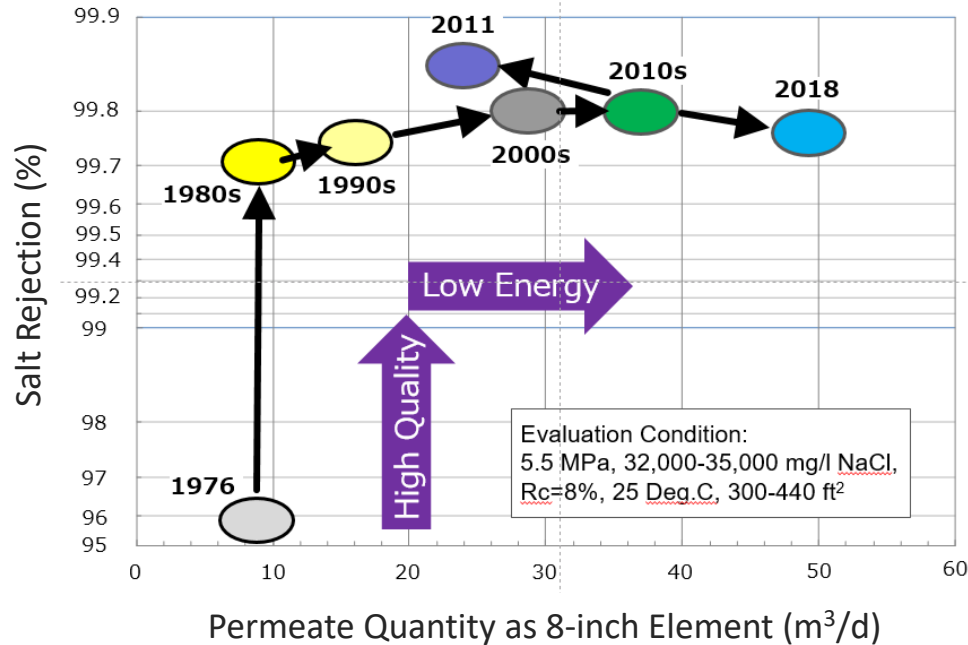


**New advanced low pressure  
SWRO membrane**

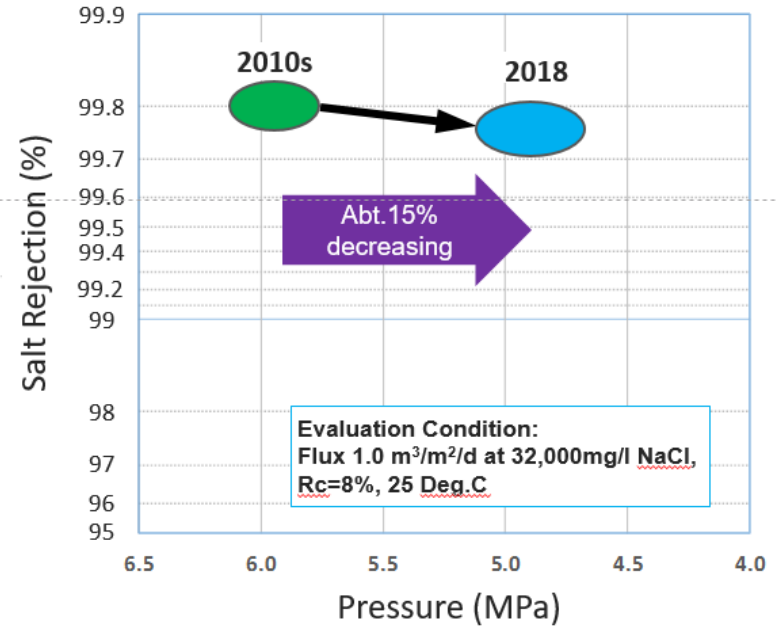
**Low pressure two-stage high recovery  
SWRO system**

# History of High performance SWRO Membrane and New Innovative SWRO membrane

## History of Toray "ROMEMBRA" SWRO Membrane Element Performance



## Same Flux base Latest SWRO Membrane Element Performance





# SEC Rate (%) comparison of Conventional SWRO and “Mega-ton Water System” SWRO

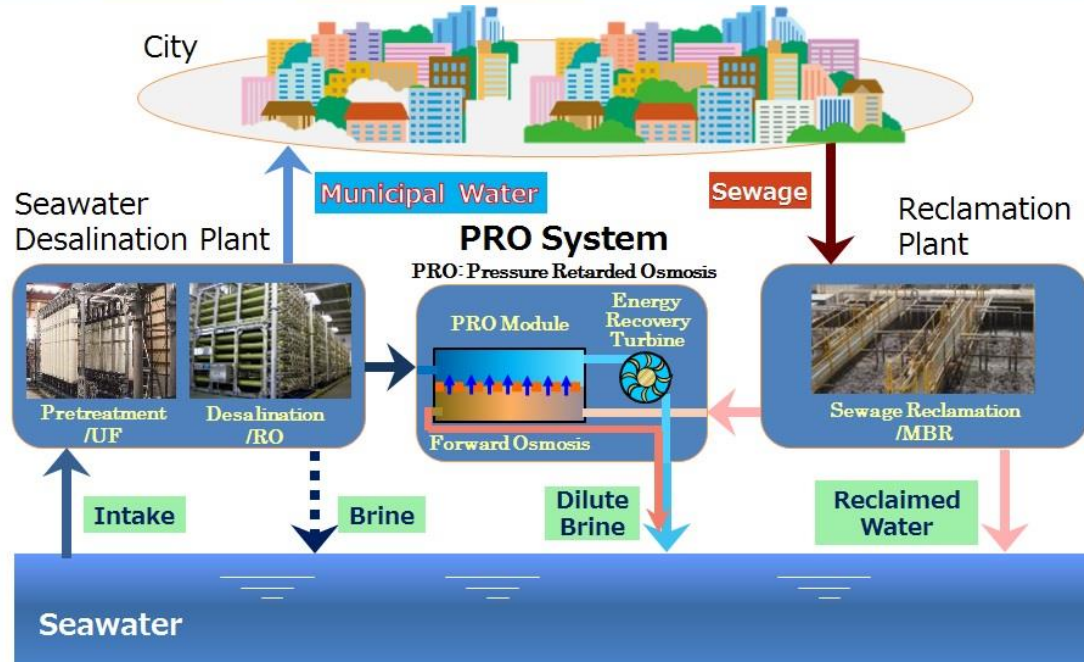


System <Seawater Conc. = 3.5%>	Membrane	ERD	Pump Efficiency	SEC Rate (%)
Conventional (R=45%)	Conventional	Turbo	70-85%	100
Megaton (R=60%)	Megaton Technology	New ERD	90%	80

\* Benchmark is Conventional Technologies in 2010.

<Note> The figure described above presents an example of FS cost estimation result for a 1,000,000 m<sup>3</sup>/day seawater RO desalination project under normal seawater and typical design conditions.

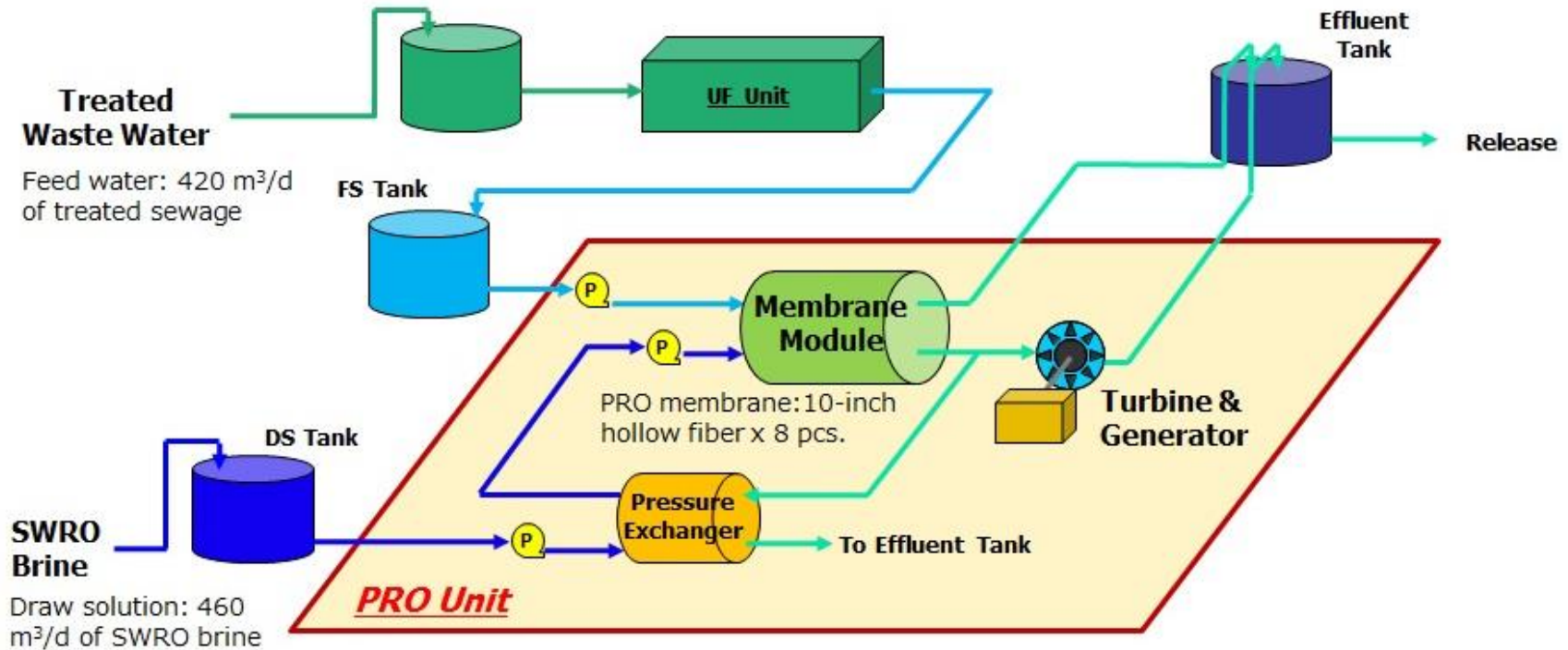
# SWRO with PRO System of "Mega-ton Water System"



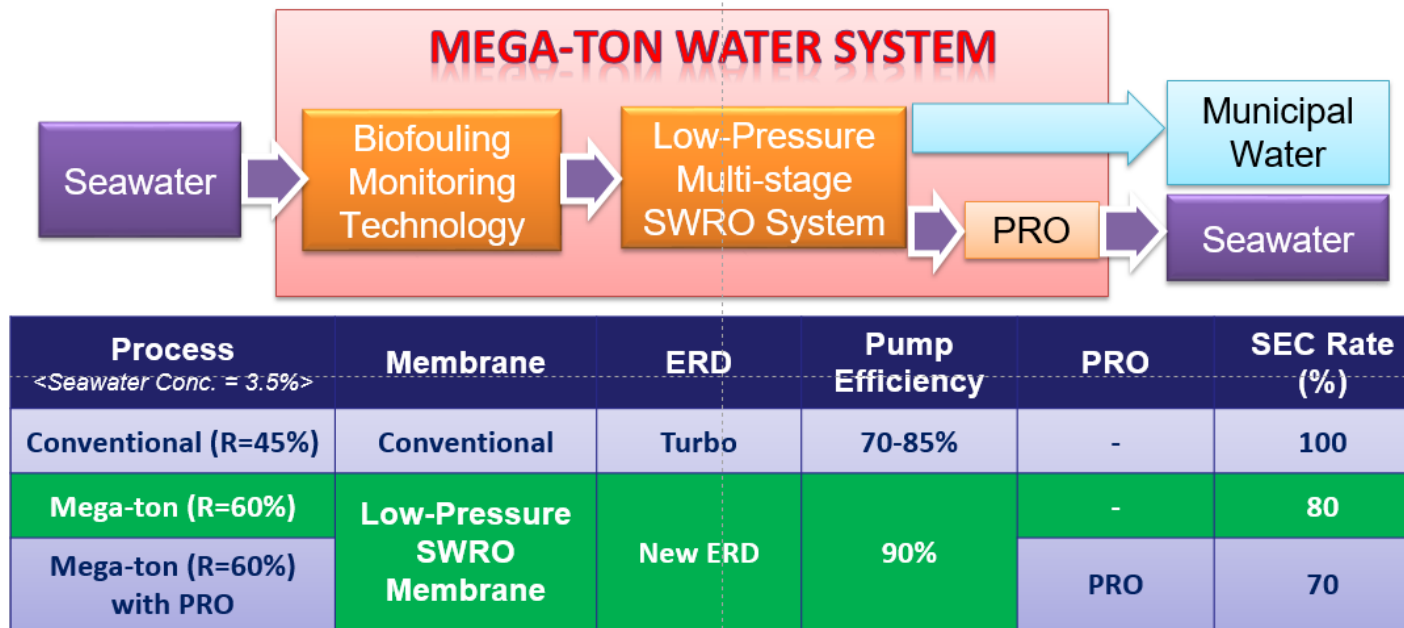
**Target : Energy recovery from the concentrated brine and Discharge of less chemical and diluted brine for Low environmental impact.**



# SWRO with PRO System Flow of “Mega-ton Water System”



# SEC Rate (%) comparison of 1) Conventional SWRO, 2) Mega-ton SWRO and 3) Mega-ton SWRO with PRO



\* Benchmark is Conventional Technologies in 2010.

<Note> The figure described above presents an example of FS cost estimation result for a 1,000,000 m<sup>3</sup>/day seawater RO desalination project under normal seawater and typical design conditions.

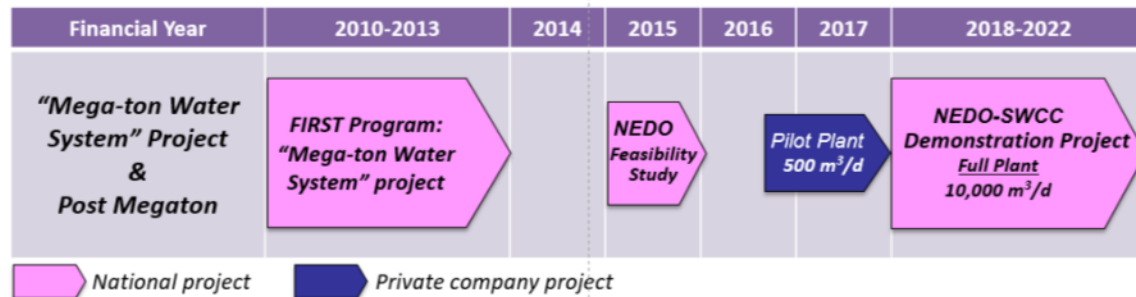
# Conclusion

## **“Mega-ton Water System” for Green Desalination afford the following conclusion**

1. Chemical Addition of chlorine and SBS dosing triggers biofouling, thus no chlorine and no SBS dosing SWRO system is proposed as new system for ideal stage.
2. Biofouling monitoring technology “mBFR” is good indicator for reliable seawater desalination system design and operation.
3. “mBFR” technology was verified in pilot test, located Al-Jubail, SWCC/DTRT in Saudi Arabia
4. Full plant verification project between SWCC and NEDO started at Ummluji , Saudi Arabia to confirm followings.
  - (1) New advanced low pressure SWRO membrane
  - (2) Low pressure two-stage high recovery SWRO system
  - (3) Biofouling monitoring “mBFR” technology
5. As a next step, by incorporating PRO of "Mega-ton Water System", it can contribute to reducing environmental impact as it can achieve energy saving of 30% and dilution of high concentration discharge at the same time as compared with the conventional system it can.

# Acknowledgements and Remarks

## Time schedule of “Mega-ton Water System” project



### FIRST Program:

Funding Program for World-Leading Innovative R&D on Science and Technology

### NEDO:

New Energy and Industrial Technology Development Organization

## Acknowledgement

Part of the “Mega-ton Water System” research in this presentation was funded by a grant from the Japanese Society for the Promotion of Science (JSPS) through the Funding Program for World-Leading Innovative Research & Development on Science and Technology (FIRST Program; FY2010-2013) initiated by the council for Science and Technology Policy (CSTP).

We deeply appreciate the New Energy and Industrial Technology Development Organization (NEDO) and their support of the “Mega-ton Water System” project.