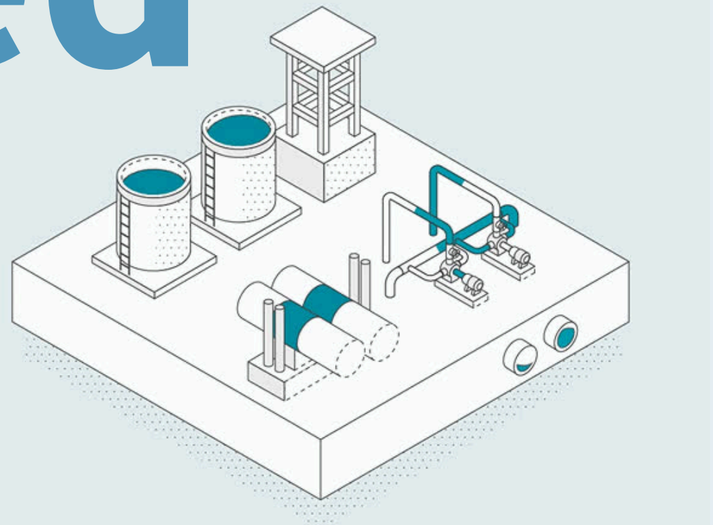
ATLAS 5230 - NASCENT TECHNOLOGY FOR GOOD CASE STUDY

Solar-Powered Desalination



How the MIT Media Labs have developed a solar-powered desalination system that requires no extra batteries

October 31, 2024

Elizabeth Saunders

Agenda

- Online Discourse
- Global Water Crisis
- Desalination
- MIT Media Lab’s Desalination
  - Design Process
  - Implementation
  - Recommendations
- Conclusion
- Discussion Questions

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Real Time with Bill Maher Interview with Elon Musk (April 28, 2023)

Clip by Human Progress | Uploaded on May 2nd, 2023

1.)

2.)

3.)

1.) “There is plenty of water.”

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“Water is at the center of the climate crisis.”

- United Nations

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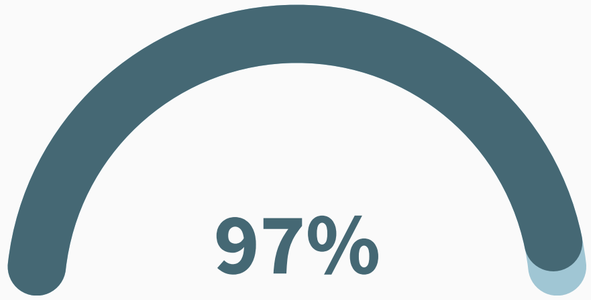

97% of Earth’s water is salt

“Water is at the center of the climate crisis.”

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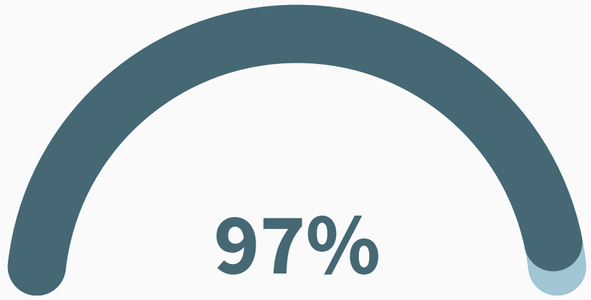

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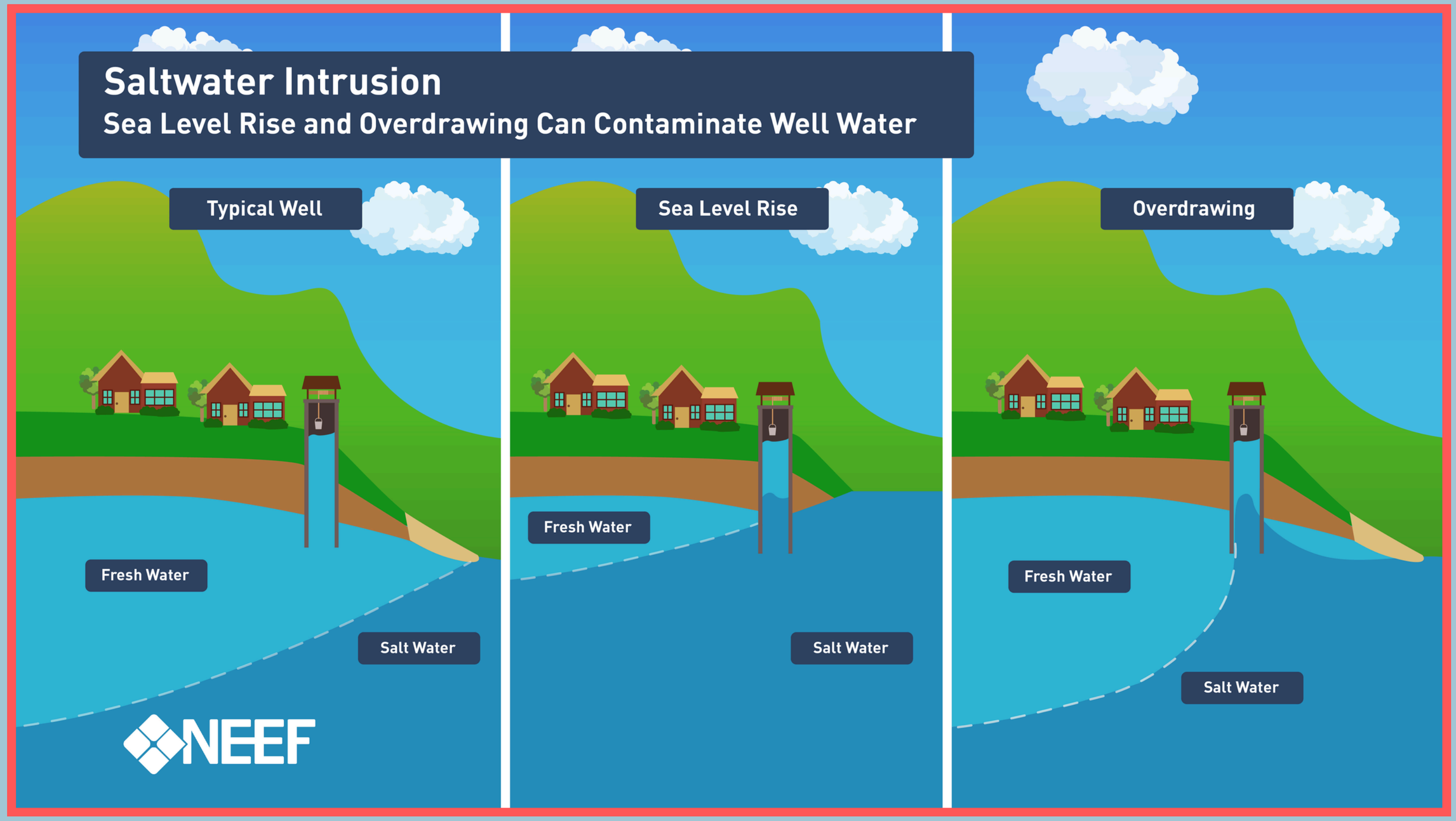
Only **0.5%** of water on Earth is useable and available freshwater


Saltwater Intrusion
Sea Level Rise and Overdrawing Can Contaminate Well Water
Typical Well
Fresh Water
Salt Water
NEEF
Sea Level Rise
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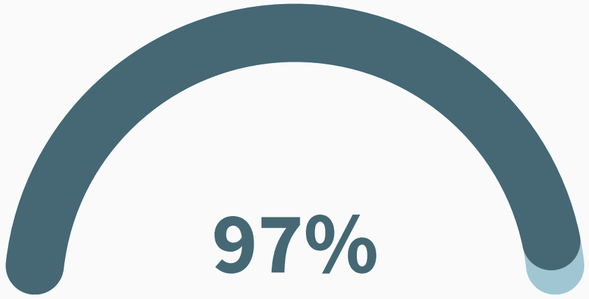

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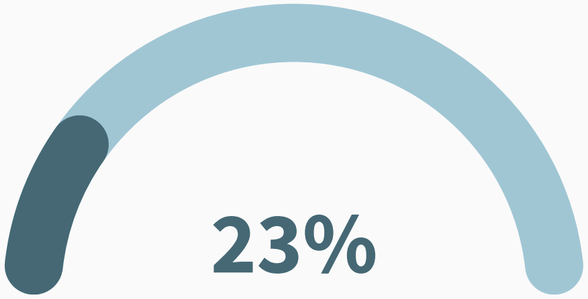

2 billon people in the world do not have access to safe drinking water

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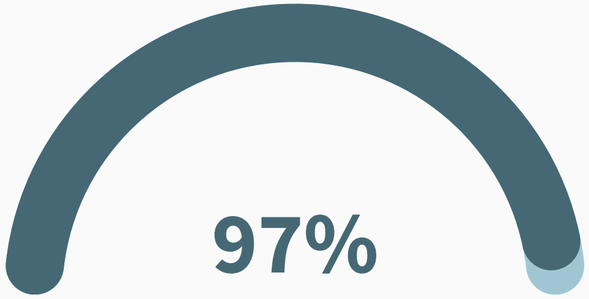

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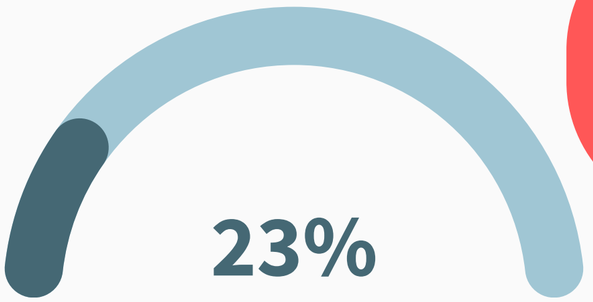

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roughly half of the world’s population experiences severe water scarcity for at least part of the year

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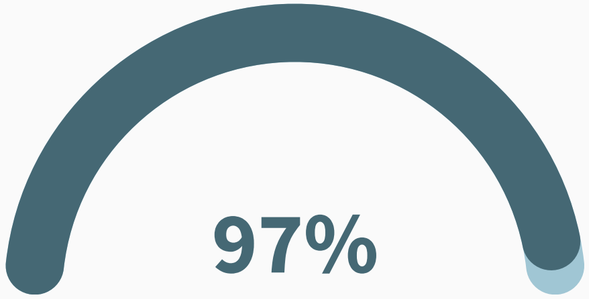

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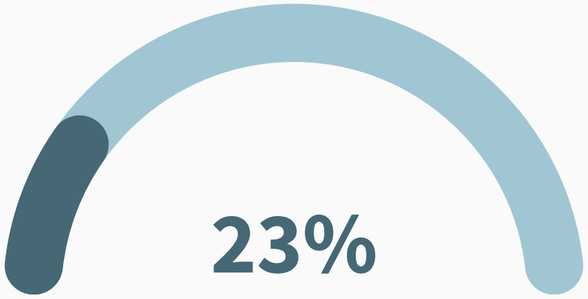

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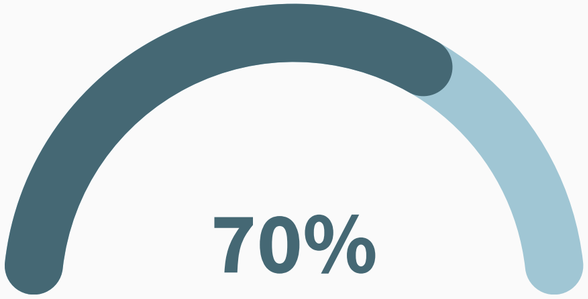

70% of available freshwater is used for agriculture

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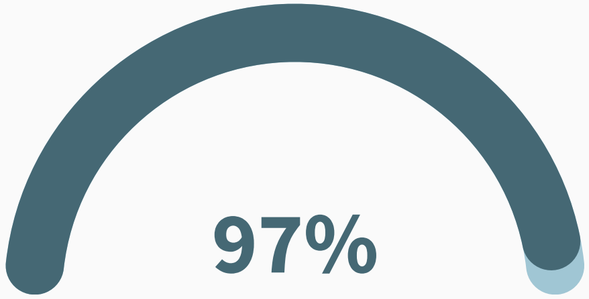

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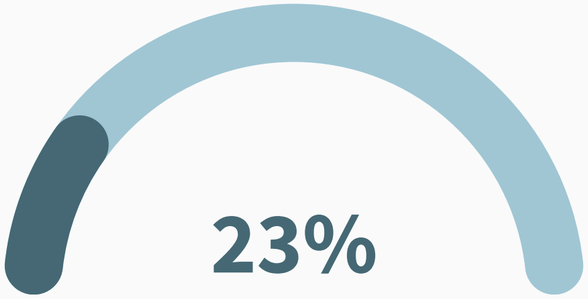

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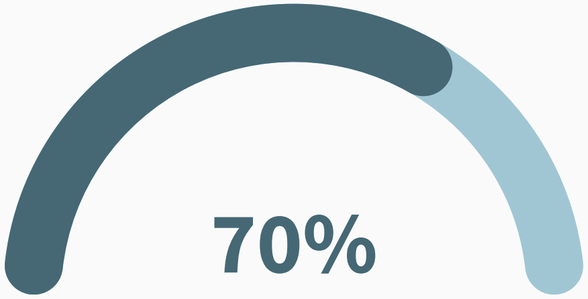
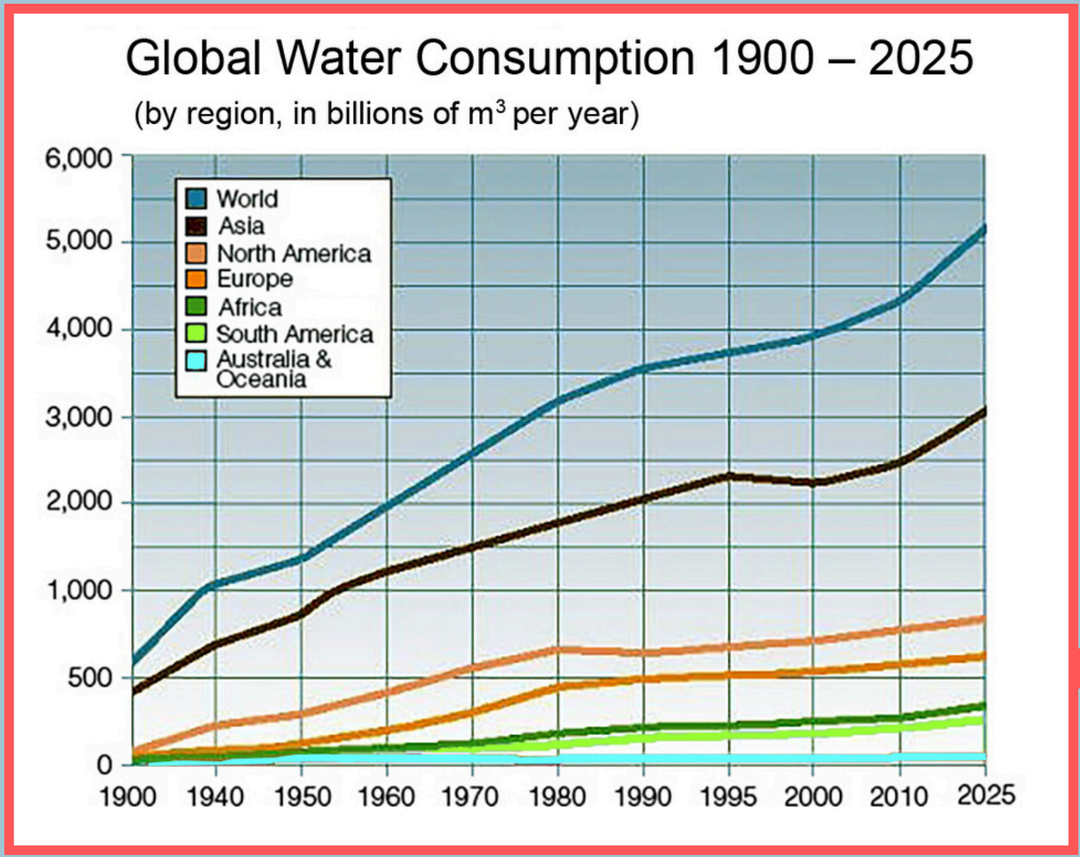
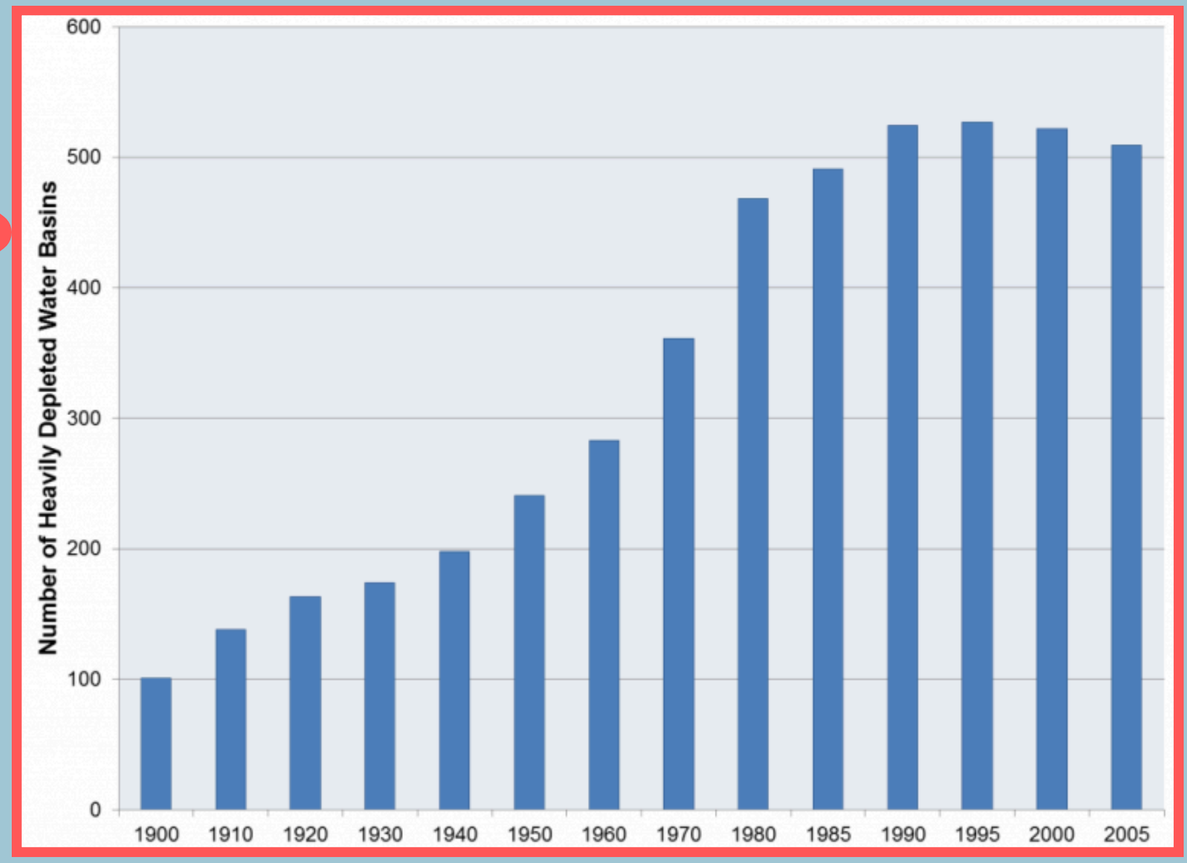


70% of available freshwater is used for agriculture

it takes between 2000 and 5000 liters of water to produce a person’s daily food





Water consumption increasing through:

- Increasing **population**
- Increasing **infrastructure**
- Increasing **economies**
- Increasing **technology**
- Changing **consumption habits**
- Effects of **climate change**

There *is not* plenty of freshwater.

1.) “There is plenty of water.”
2.) “Desalination is absurdly cheap”
3.) “Our resources will be fine… we are not in any danger of resource collapse.”

There *is* plenty of saltwater.

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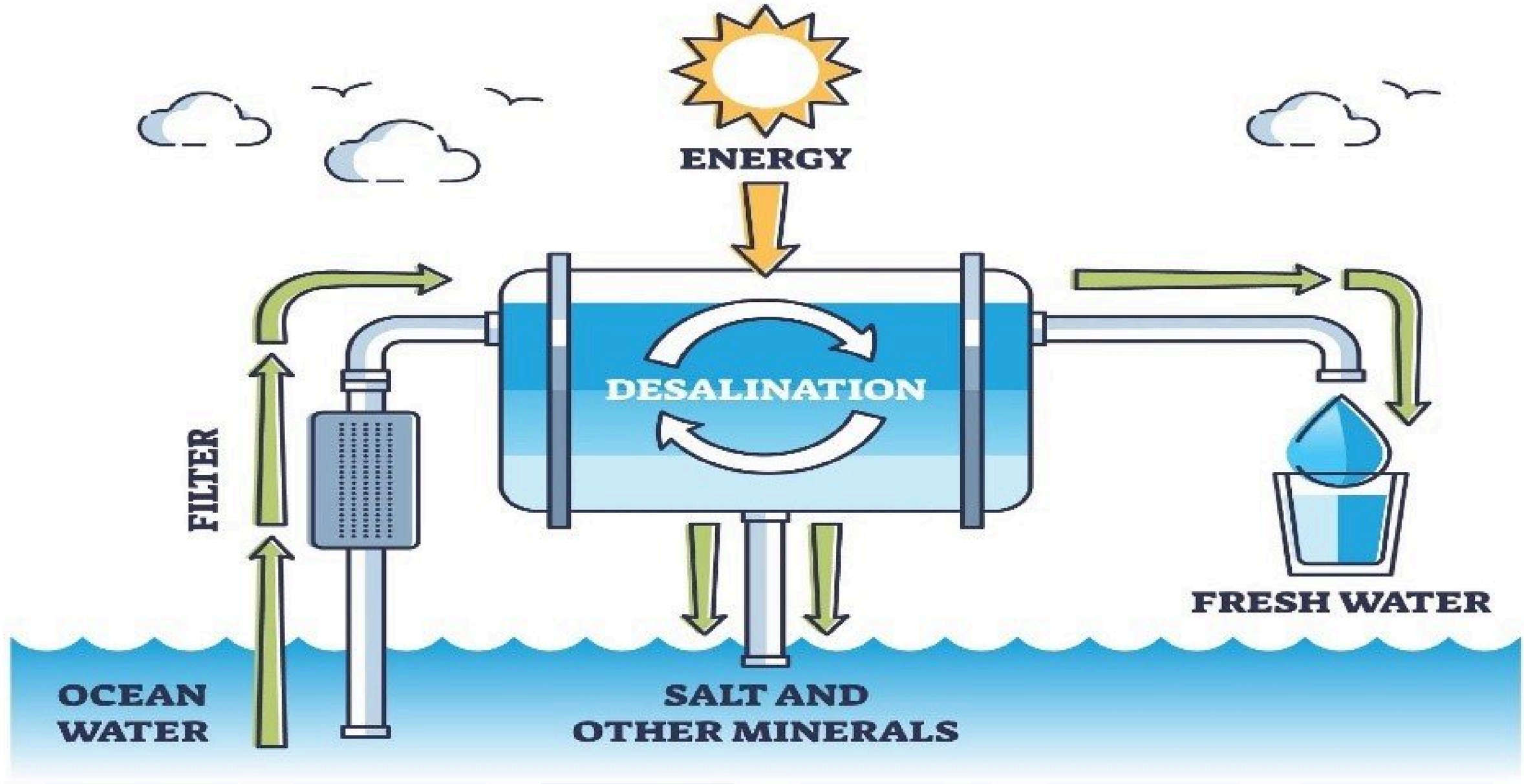
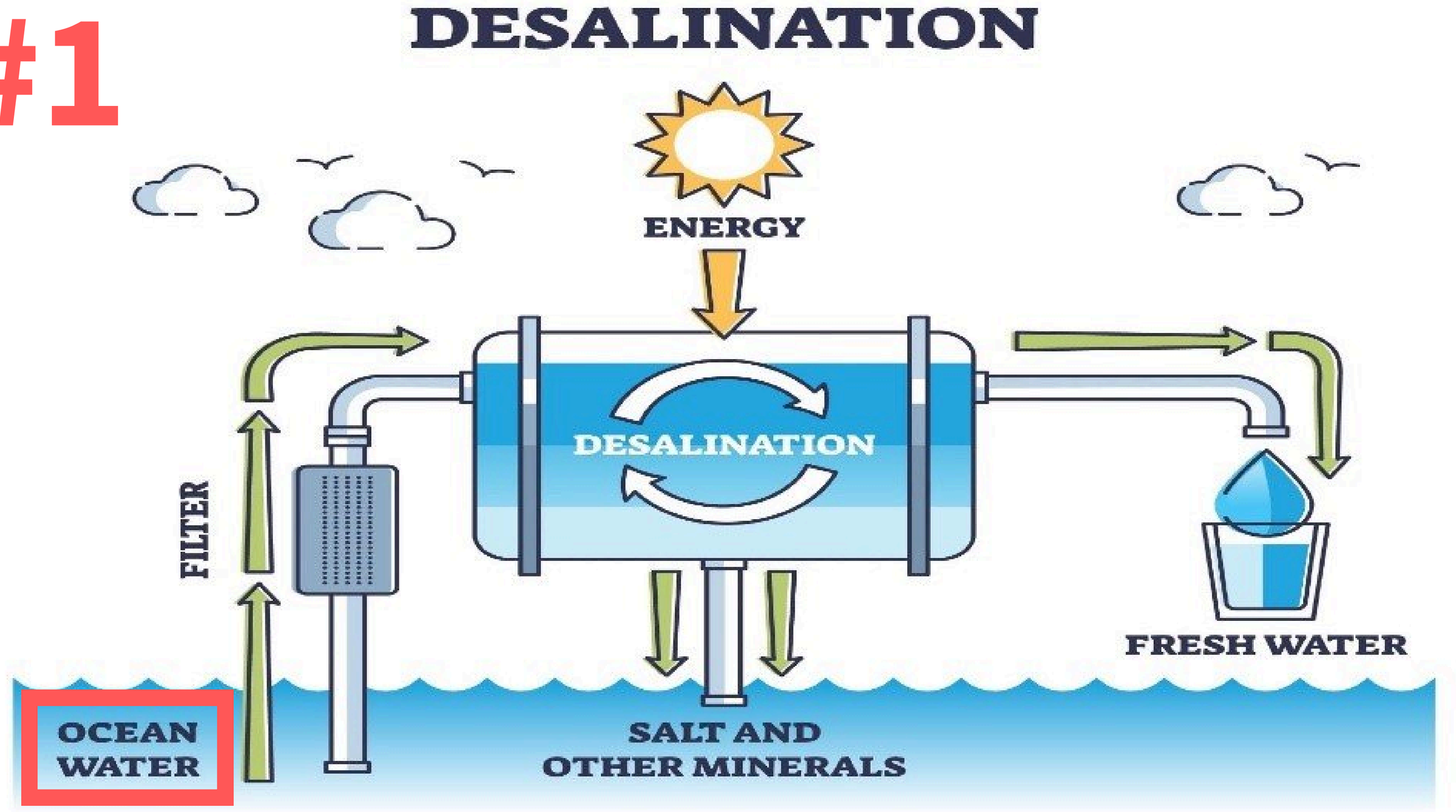
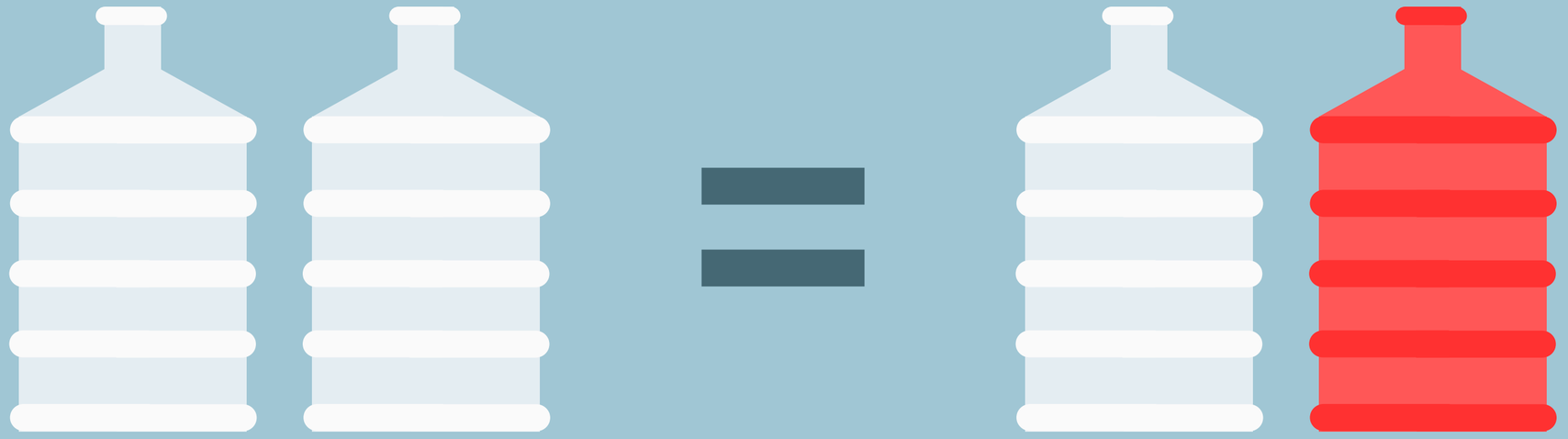
DESALINATION



#1

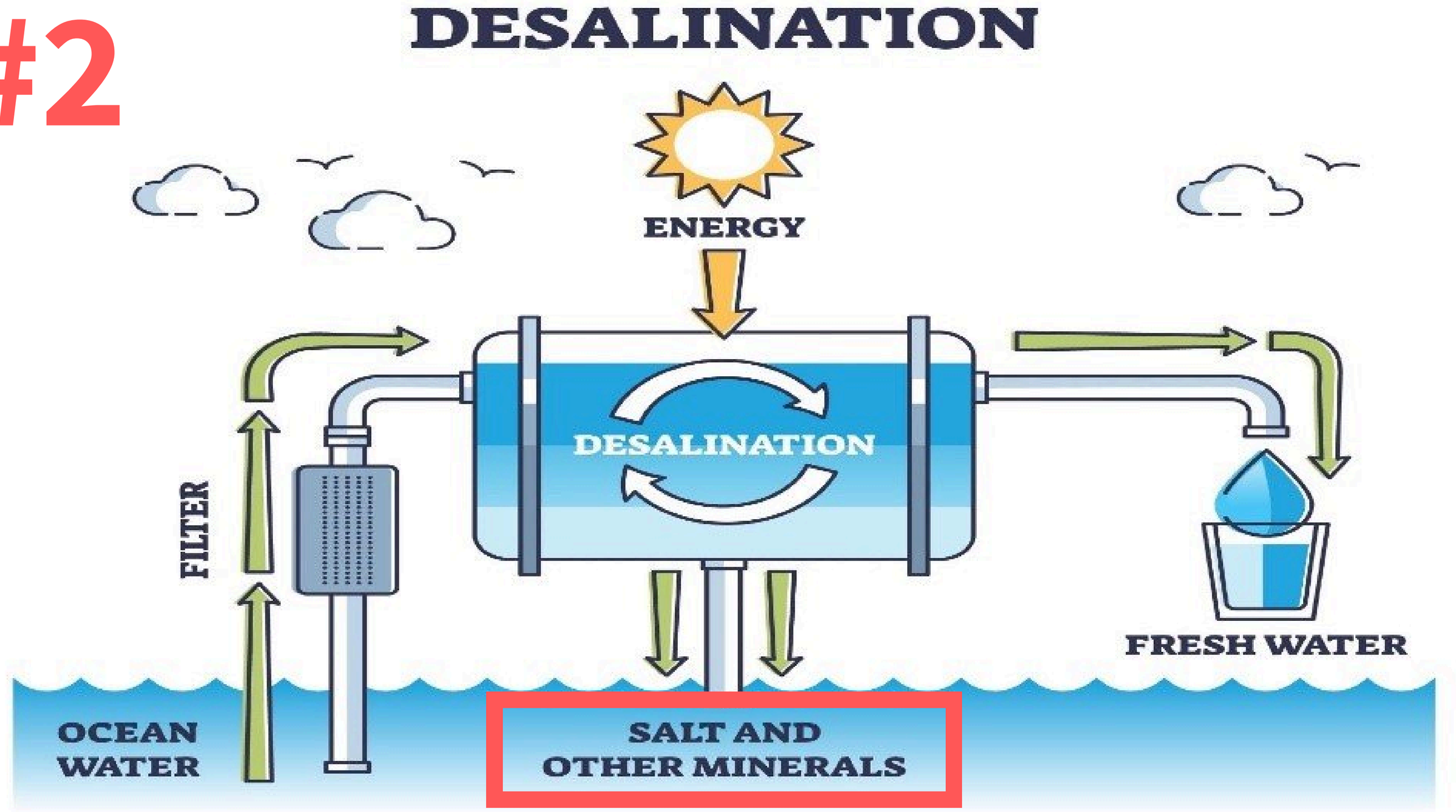

DESALINATION
ENERGY
DESALINATION
FILTER
FRESH WATER
OCEAN WATER
SALT AND OTHER MINERALS

It takes two gallons of seawater to make a gallon of fresh water



which means the gallon left behind is briny.

#2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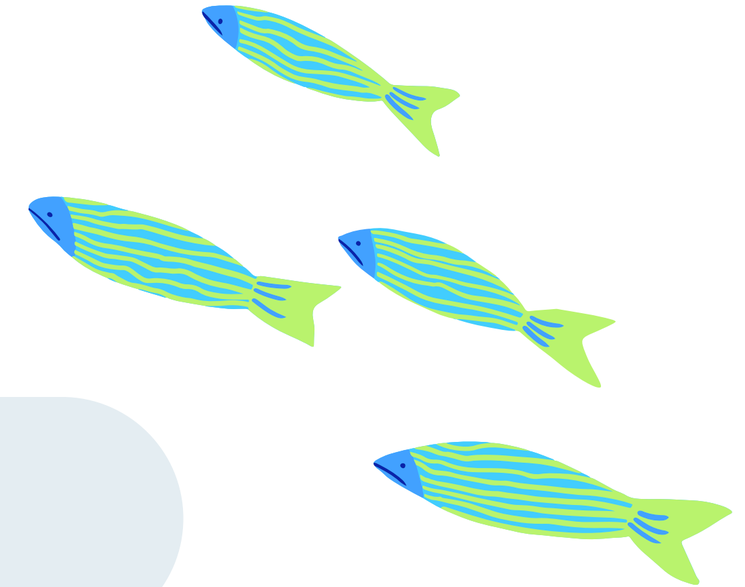
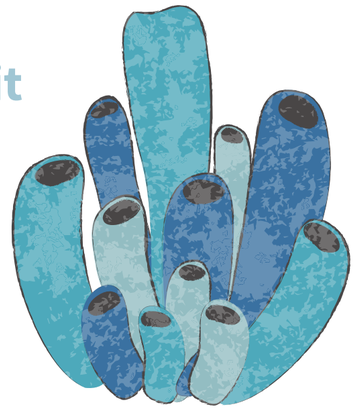
Brine Output of Desalination causes...



waste and toxic chemicals

NaCl rising salt levels

“Brine waste also poses a potential threat to marine life and water quality, as it **contains dangerously high concentration of salts and other minerals**. Because of its high density and salinity, **brine waste can accumulate in and around disposal areas smothering bottom dwelling species** and significantly altering coastal ecosystems.”



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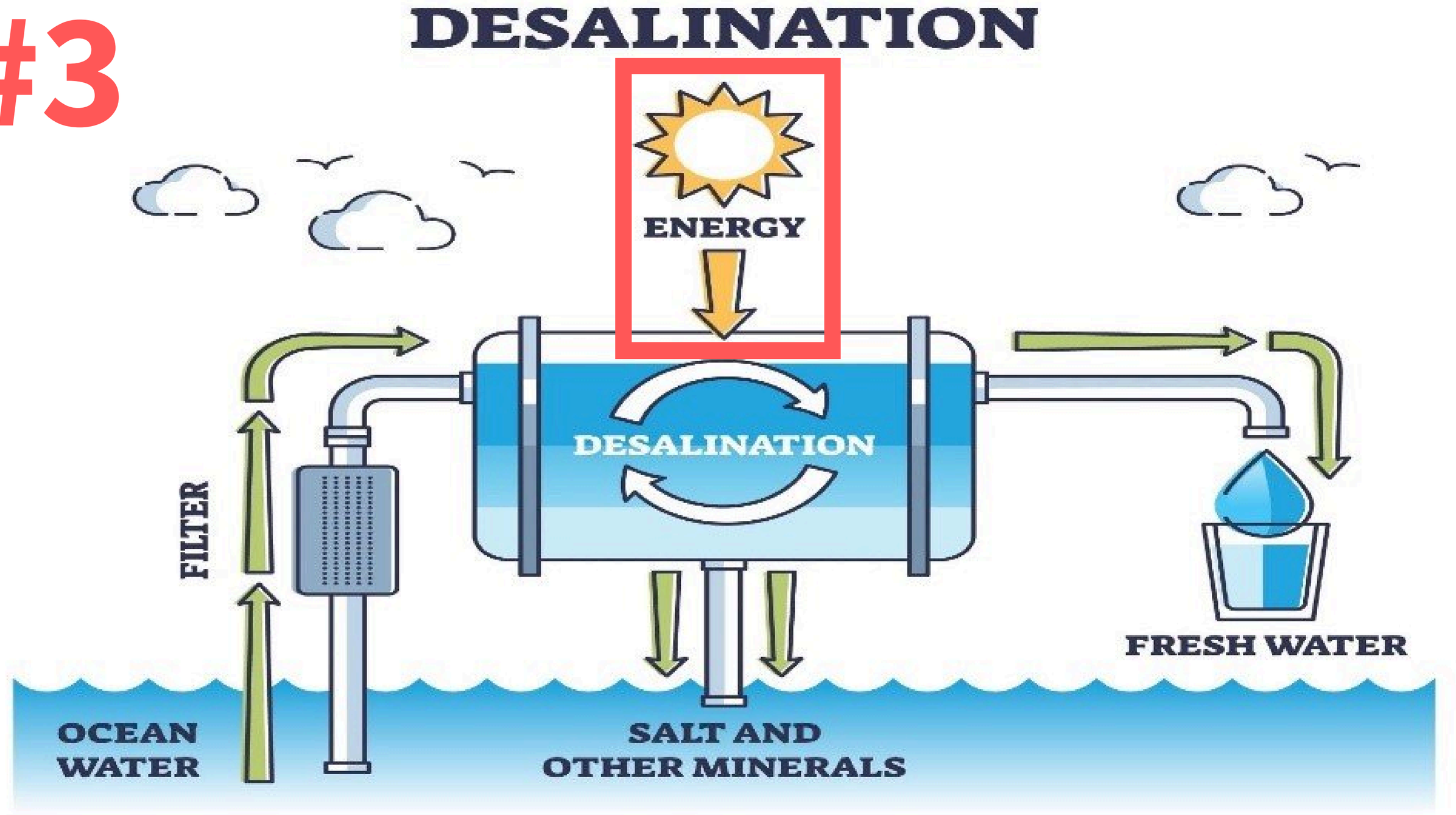
resource collapse.

Desalination is

environmentally expensive

#3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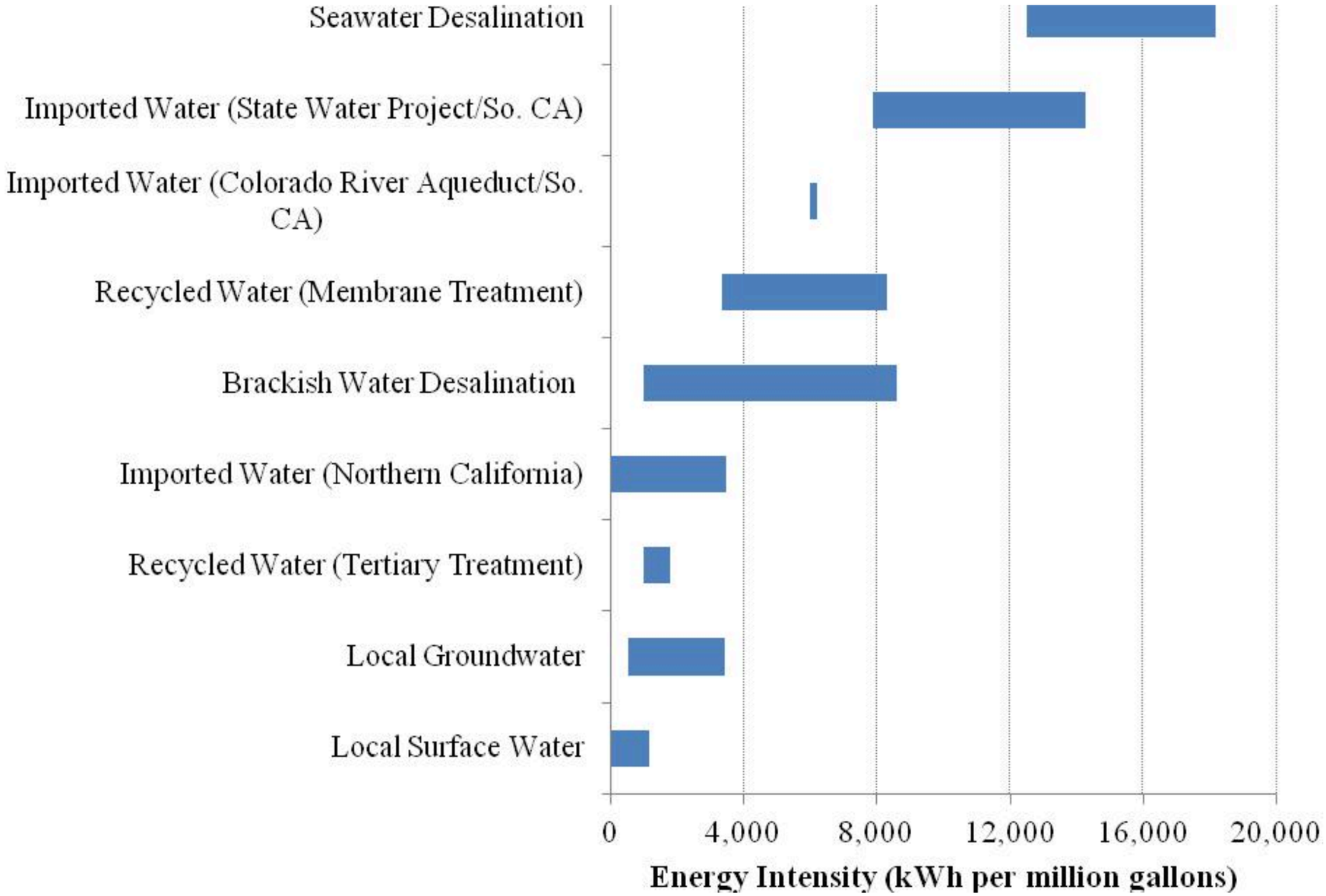
Comparison of the Energy Intensity of California Water Supplies



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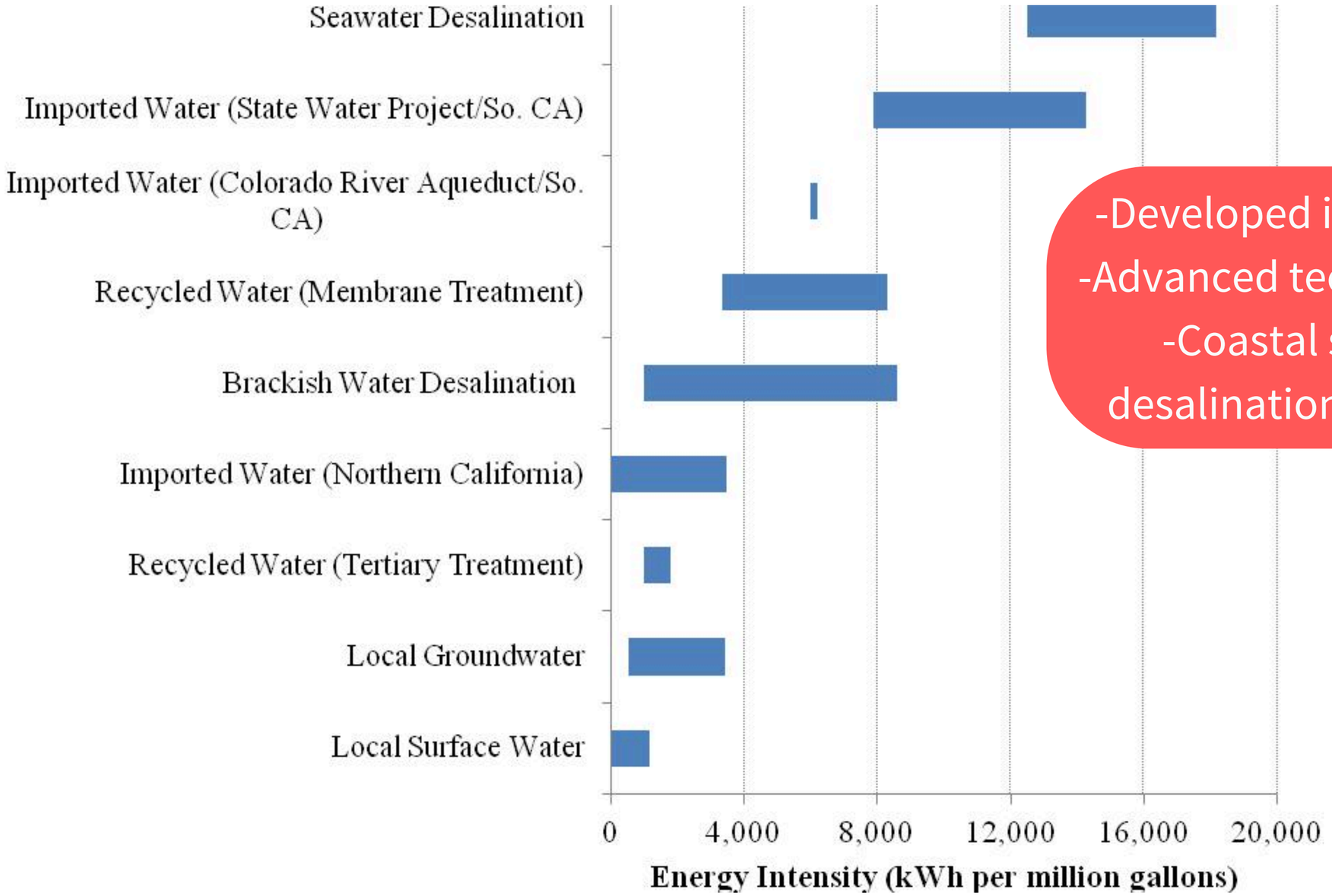

-Developed infrastructure
-Advanced tech capabilities
-Coastal state with desalination capabilities

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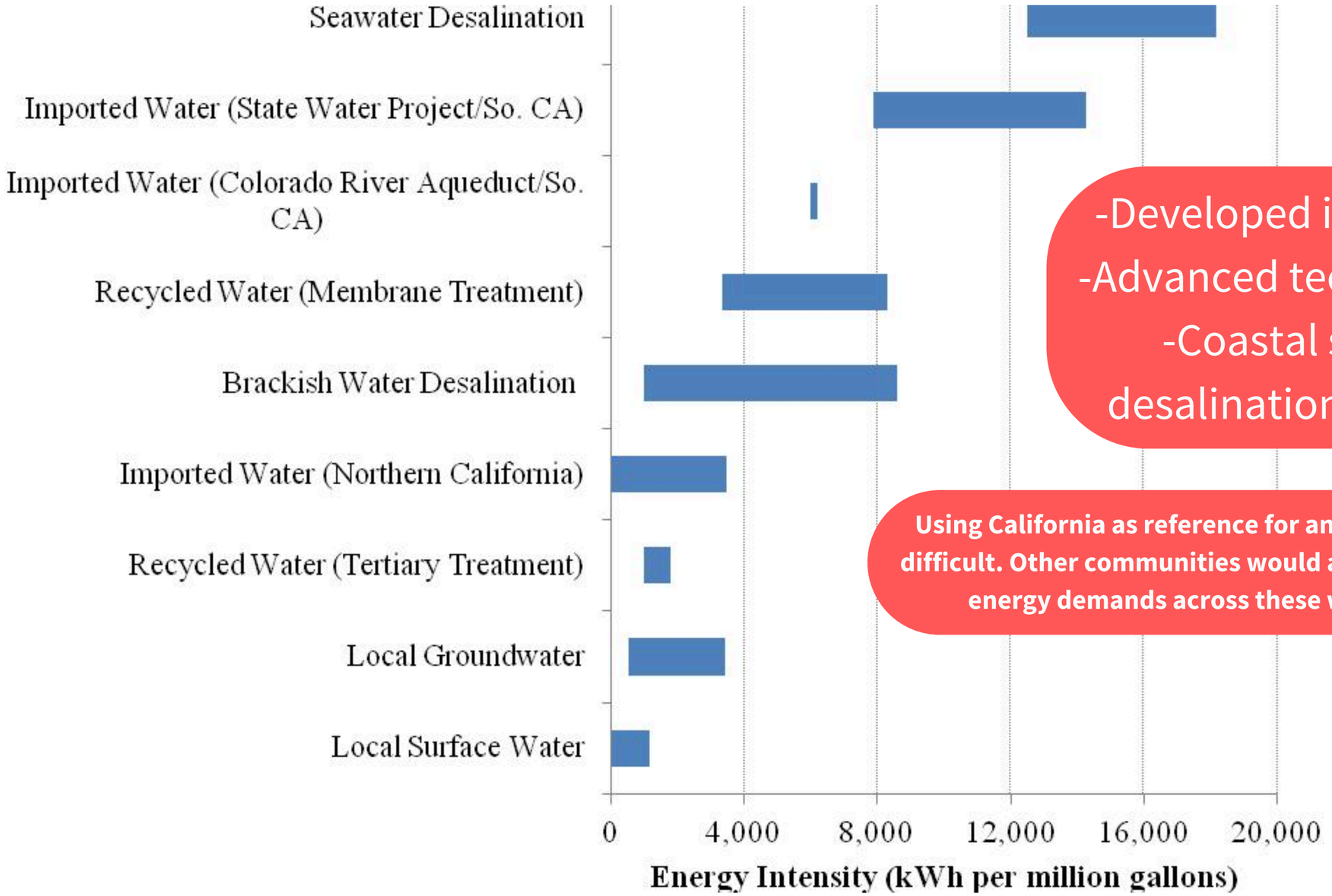

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Using California as reference for another communities is difficult. Other communities would assumably have higher energy demands across these water processes.

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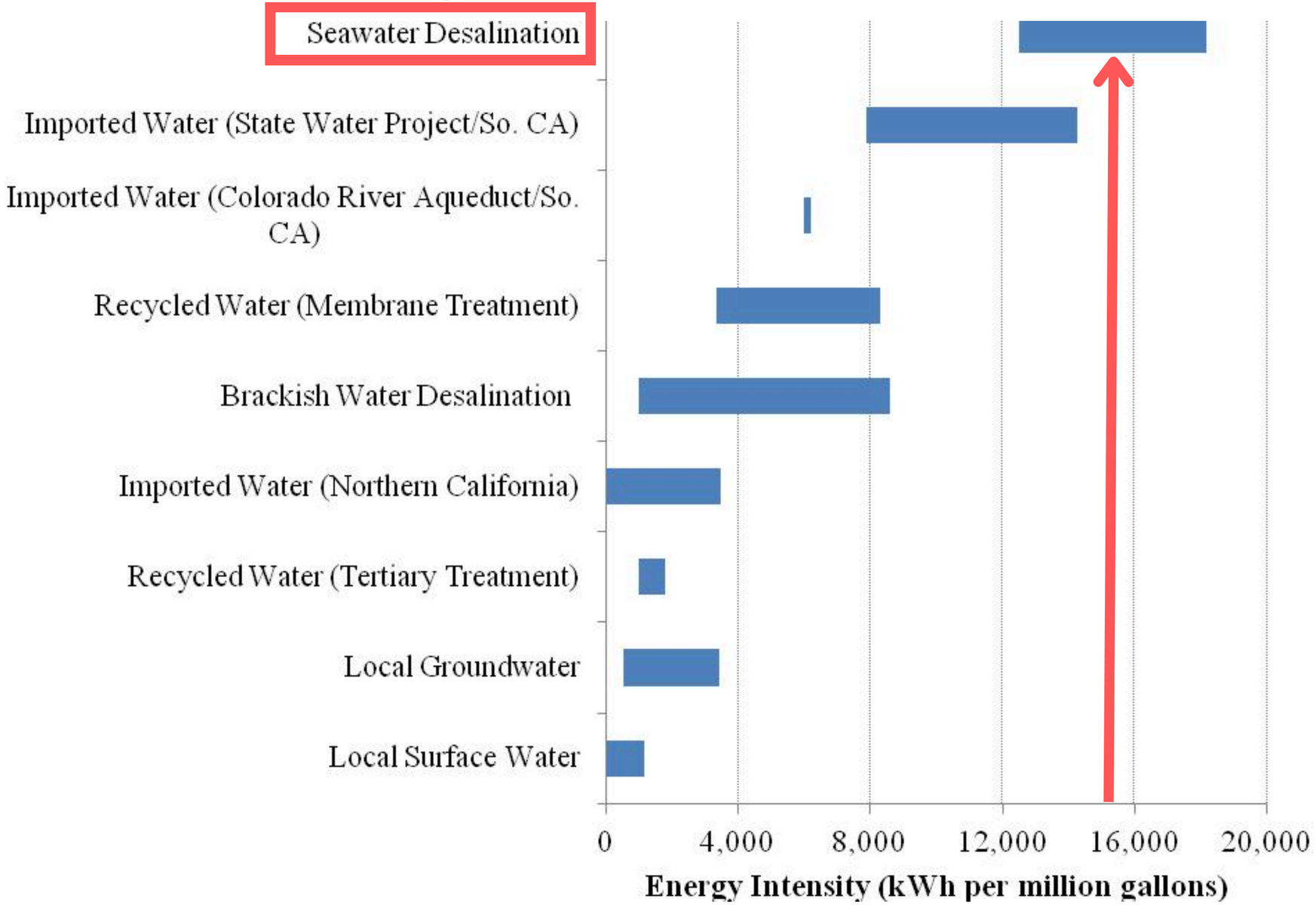
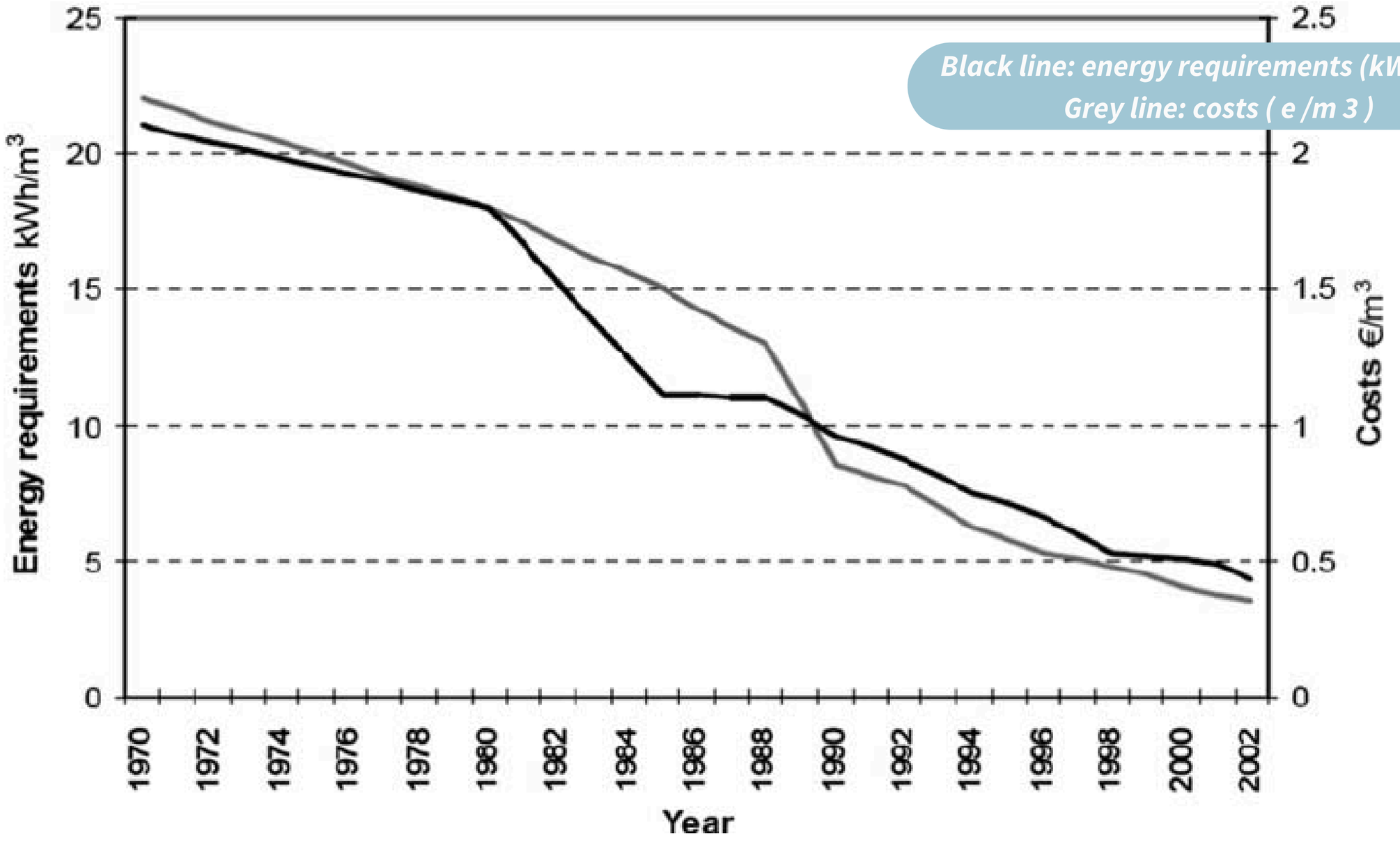


Energy consumption and seawater desalination costs in Spain



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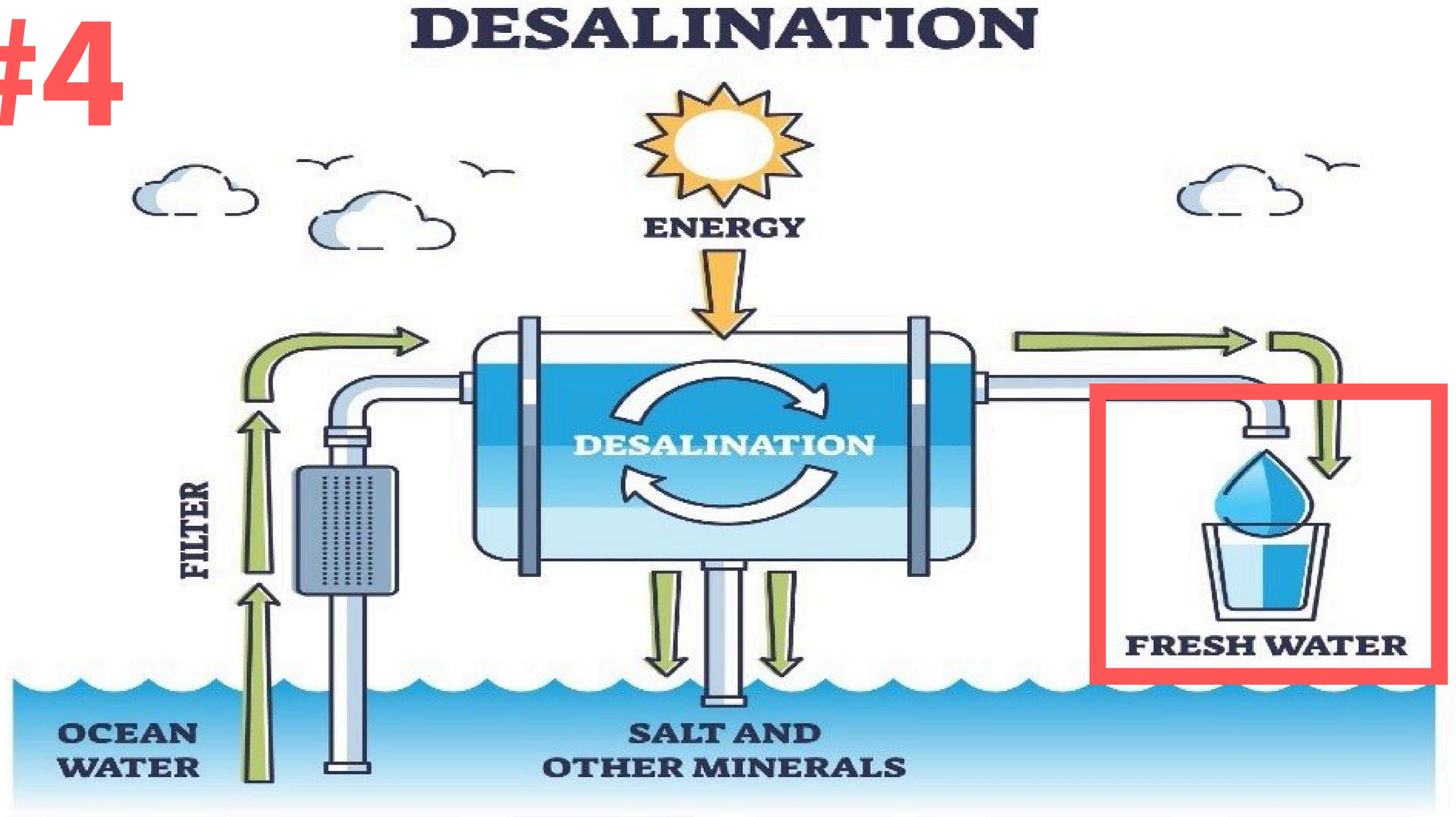
resource collapse.

Desalination is

energy expensive

#4


DESALINATION
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SALT AND OTHER MINERALS

The actual price of desalinated water entering distribution systems varies widely globally based on the above factors

ranging from $0.50 up to $2.50 per cubic meter

Middle East: $0.50/m3

Due to cheap solar power and government fossil fuel subsidies

United States: $1.00–$2.00/m3

Large inland brackish desalination plants in California and Texas supply water to cities like El Paso

Asia-Pacific: $1.75/m3

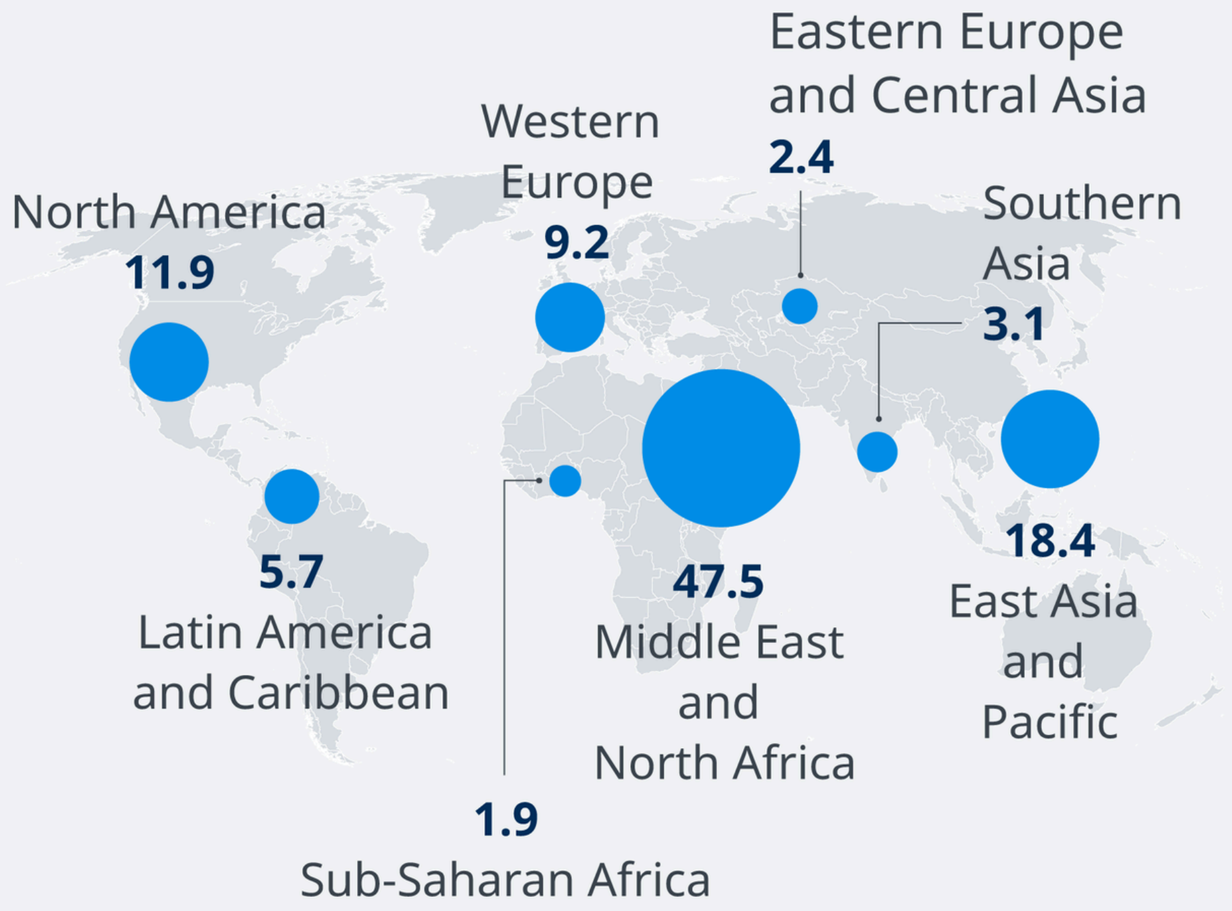
Singapore sells desalinated water to citizens at US$0.49/m3. Australian plants supply water to cities like Perth for around

Europe: $1.75-$2.50/m3

Prices in Spain range from exposure to oil prices and economic cycles add volatility

Desalination capacity by region

in percent



The countries leading the charge have largely been arid Middle Eastern nations like ***Saudi Arabia, United Arab Emirates, Kuwait, and Israel*** that lack renewable freshwater and have the financial resources and energy supply to rapidly expand desalination infrastructure.

Source: researchgate.net

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ranging from $0.50 up to $2.50 per cubic meter

Rivers / Lakes	$0.10 — $0.50 /m3
Groundwater / Wells	$0.30 — $1.00 /m3
Rainwater Harvesting	$0.15 — $1.50 /m3
Wastewater Recycling	$0.30 — $1.15 /m3
Seawater Desalination	$0.50 — $2.50 /m3
Brackish Desalination	$0.60 — $2.00 /m3

*these costs are the price for the consumer, not the economic cost of installing these plants

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Other alternative Water Production Options

Fog Harvesting ---------- $0.10 — $0.50 /m3

Atmospheric Water Generation ----------$0.50 — $2.00 /m3

Cloud Seeding ---------- $0.10 — $5.00 /m3

Imported Icebergs ----------$0.60 — $3.50 /m3

*these

st of installing these plants

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Desalination ***could be*** the cheapest option for communities.

1.) “There is plenty of water.”

2.) “Desalination is absurdly cheap”

3.) “Our resources will be fine… we

resource collapse.

Desalination is

financially expensive

“We are going to run out of water!”

“Deslaination sucks!”

“This is not super empowering!”

“Climate change is gonna end us all!”

Why are you attracted to this project?

Professor Mark Giordano

Dr. Giordano and I fishing on Easter Sunday

STIA 381 - Water

Why are you attracted to this project?

Professor Mark Giordano

Water issues are complex.
But there are many people, organizations, and projects that are working towards sustainability!

STIA 381 - Water

1.) “There is plenty of water.”
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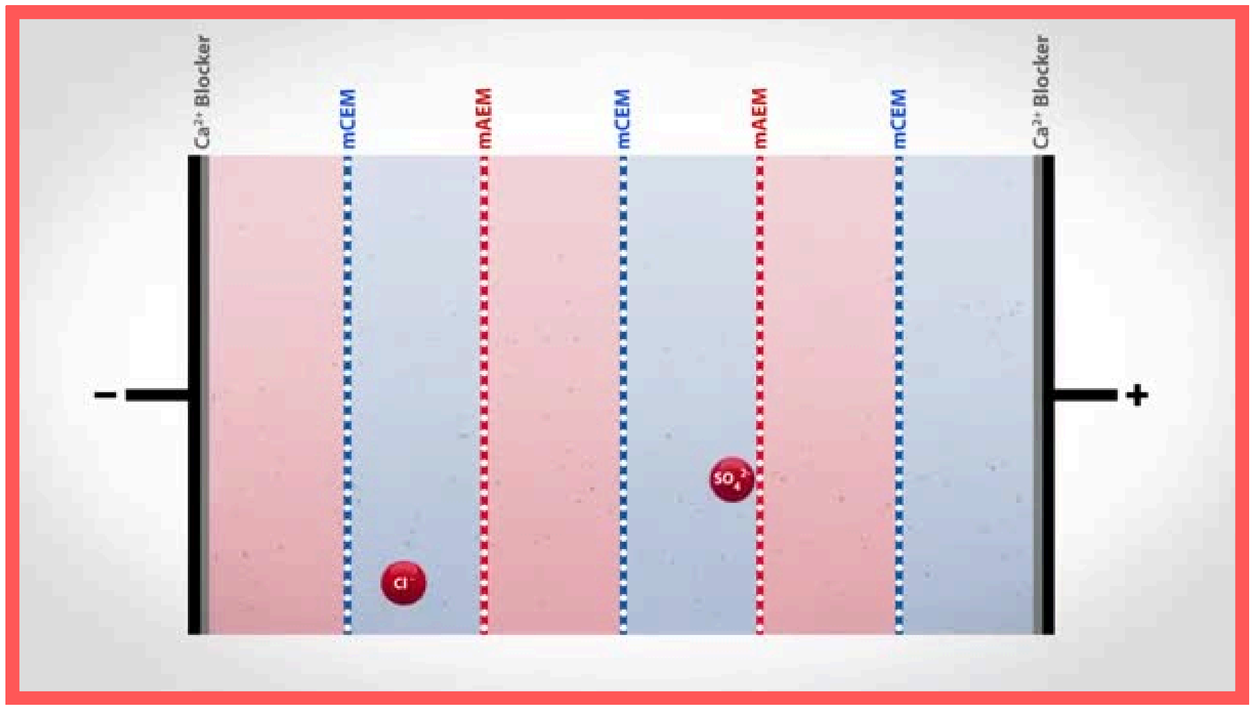
mit
media
lab

Jon Bessette sits atop a trailer housing the electrodialysis desalination system at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico. The system is connected to real groundwater, water tanks, and solar panels.

Shock Electrodialysis

Shock electrodialysis (SED) is a water purification technique that uses an electric current to separate ions from water



Clip by Saltworks Technologies: Industrial Water + Lithium

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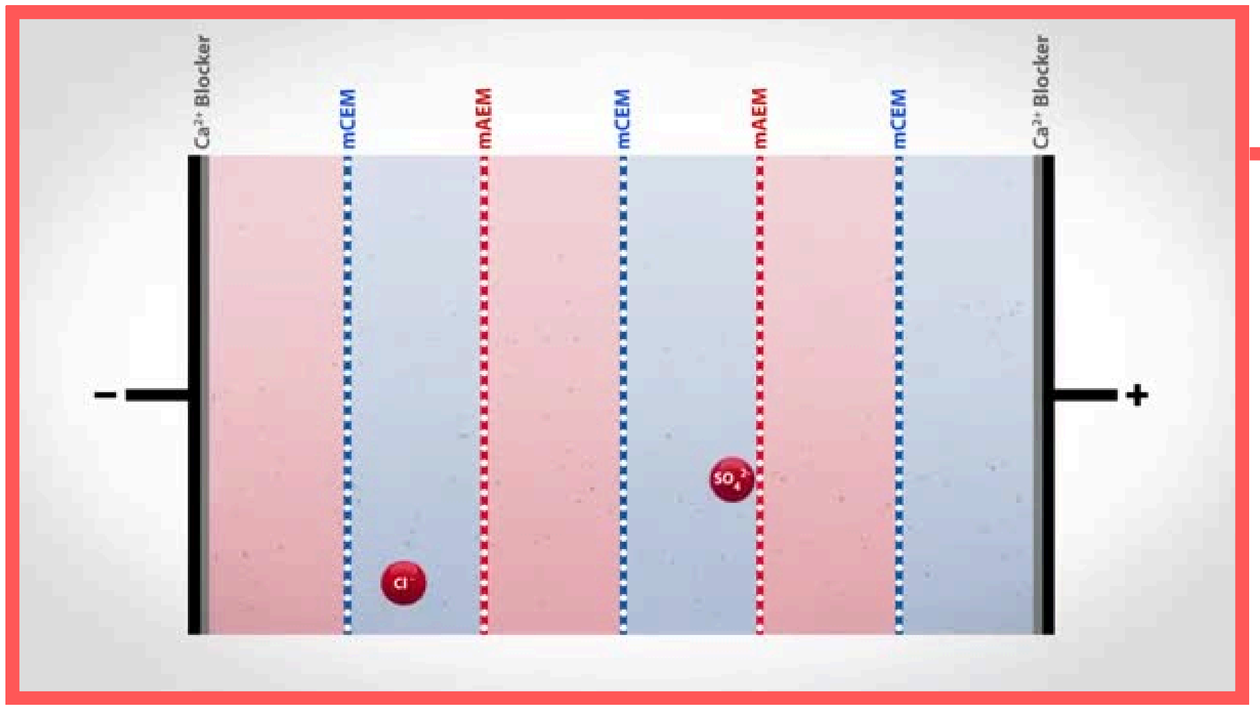

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SED uses a deionization shock wave to separate streams of water on either side of a charged porous medium. The shock wave is created by passing an overlimiting current between electrodes.

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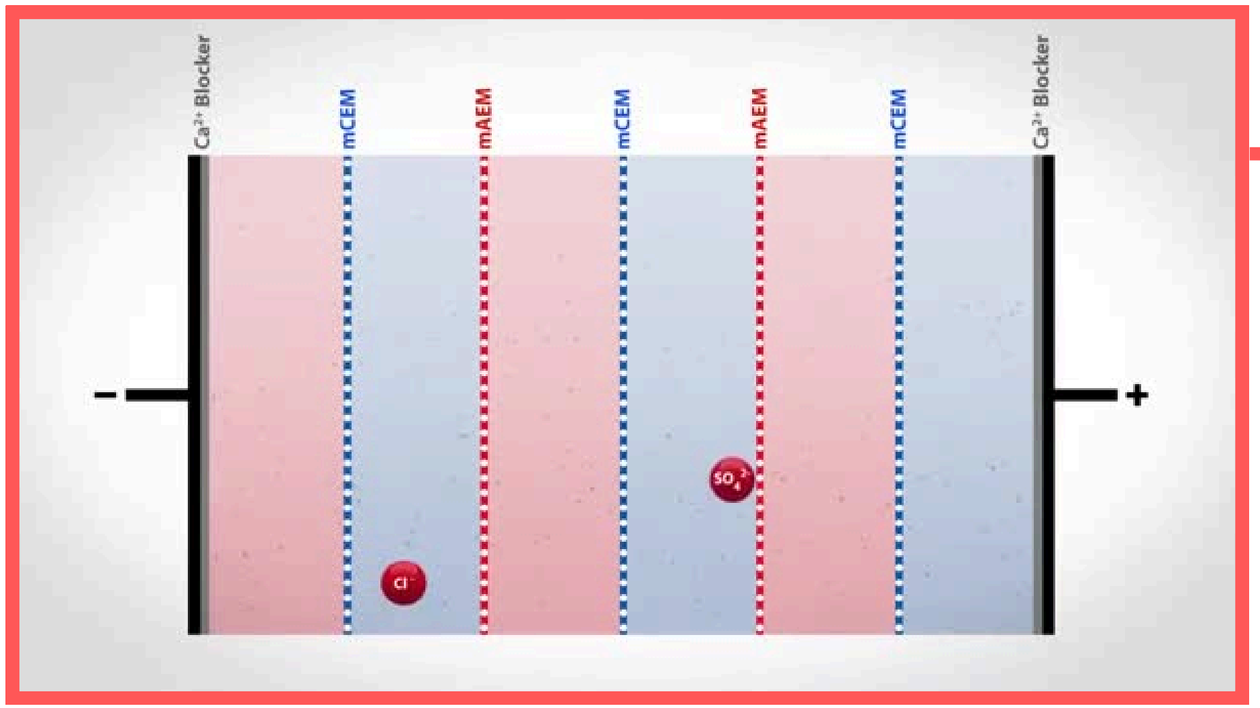

Clip by Saltworks Technologies: Industrial Water + Lithium

SED uses a deionization shock wave to separate streams of water on either side of a charged porous medium. The shock wave is created by passing an overlimiting current between electrodes.

- SED **can remove over 99% of salt** from electrolytes
- Can be used to **deionize water with over 99% efficiency**
- SED can also be used to **selectively remove multivalent ions**
- The strong electric fields created by SED may also **reduce the viability of bacteria**

Shock Electrodialysis

For the past decade, MIT’s Martin Z. Bazant and his coworkers developed the theory of SED

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MIT has continued to lead the way for SED discoveries:

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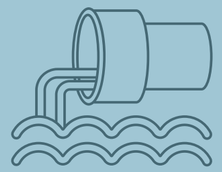

2019

MIT uses Shock Electrodialysis to remove contaminants from nuclear wastewater

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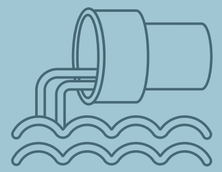

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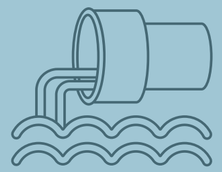

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MIT builds a portable desalination unit using solar panels and ion concentration polarization (ICP) after a decade of research

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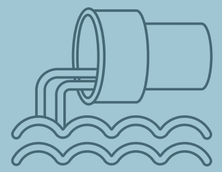

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MIT builds a portable desalination unit using solar panels and ion concentration polarization (ICP) after a decade of research

2023

MIT announces using Shock Electrodialysis to remove salt from water as a form of desalination

Shock Electrodialysis

For the past decade, MIT's Martin Z. Bazant and his coworkers developed the theory of SED

MIT has continued to lead the way for SED discoveries:

2019

MIT uses Shock Electrodialysis to remove contaminants from nuclear wastewater

2021

MIT uses Shock Electrodialysis to remove lead from water

2022

MIT builds a portable desalination unit using solar panels and ion concentration polarization (ICP) after a decade of research

2023

NaCl

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Oct. 8th, 2024

MIT announces the success of its Media Lab project. Led by Jonathan Bessette and Akash Ball

“The engineers incorporated the new control strategy into **a fully automated system** that they sized to desalinate brackish groundwater at a daily volume that **would be enough to supply a small community of about 3,000 people**.”

They operated the system for six months on several wells at the Brackish Groundwater National Desalination Research Facility in Alamogordo, New Mexico.

MIT’s system is a HUGE advancement for sustainable development for three main reasons.

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The system is **a universal design** because it can be seamlessly integrated into any energy infrastructure without the need for additional batteries or grid power, making it **adaptable and efficient across diverse environments and energy needs**.

#2 Desalination extends beyond coastal communities

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"**The majority of the population actually lives far enough from the coast, that seawater desalination could never reach them.** They consequently rely heavily on groundwater, especially in remote, low-income regions. And unfortunately, this groundwater is becoming more and more saline due to climate change. This technology could bring sustainable, affordable clean water to underreached places around the world."

-Jonathan Bessette

MIT PhD student in mechanical engineering

#3 Solar panel advancements in the team's design

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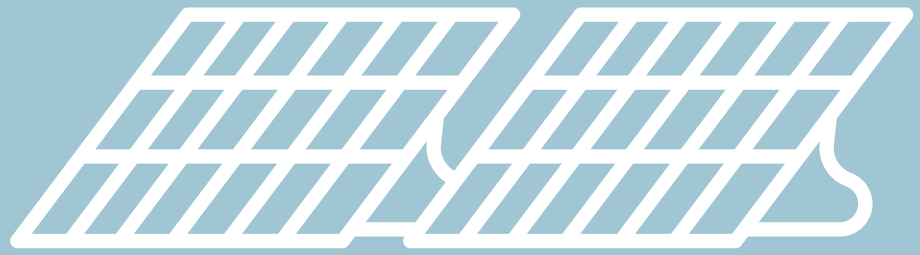
Improvements in solar cell materials and designs are leading to **longer-lasting and more efficient solar panels**, further contributing to the overall effectiveness and adoption of solar energy solutions in diverse applications



“Conventional desalination technologies require steady power and need battery storage to smooth out a variable power source like solar. By continually varying power consumption in sync with the sun, our technology directly and efficiently uses solar power to make water. Being able to make drinking water with renewables, without requiring battery storage, is a massive grand challenge. **And we’ve done it.**”

-Amos Winter

the Germeshausen Professor of Mechanical Engineering and
director of the K. Lisa Yang Global Engineering and Research (GEAR) Center at MIT

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How should they deploy this technology?

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Rural communities in developing countries, particularly in Africa and South Asia.

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MIT Media Lab, local NGOs, community leaders, and the target communities.

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Increase community training programs on maintenance and operation to enhance local ownership and sustainability.

1.) “There is plenty of water.”
2.) “Desalination is absurdly cheap”
3.) “Our resources will be fine… we are not in any danger of resource collapse.”

1.) “There is plenty of water.”

“While this is a major step forward, we’re still working diligently to continue developing lower cost, more sustainable desalination methods.”

- Bessette

resource collapse.”

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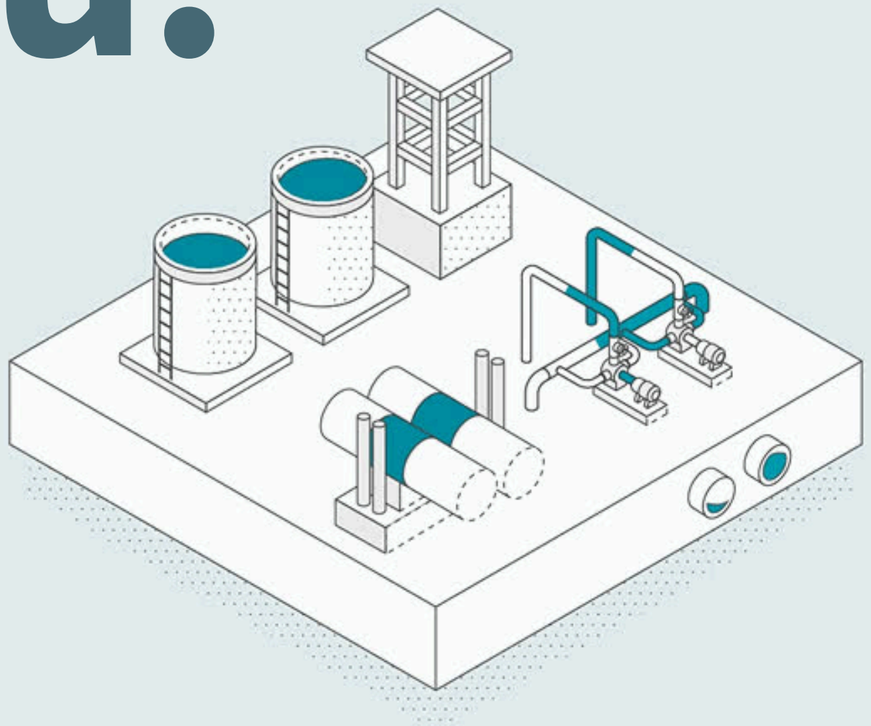
Thank you!

Any questions?



Opening up to discussion:

Thoughts on Musk?

1.) “There is plenty of water.”
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Thoughts on MIT’s Implementing this tech?

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