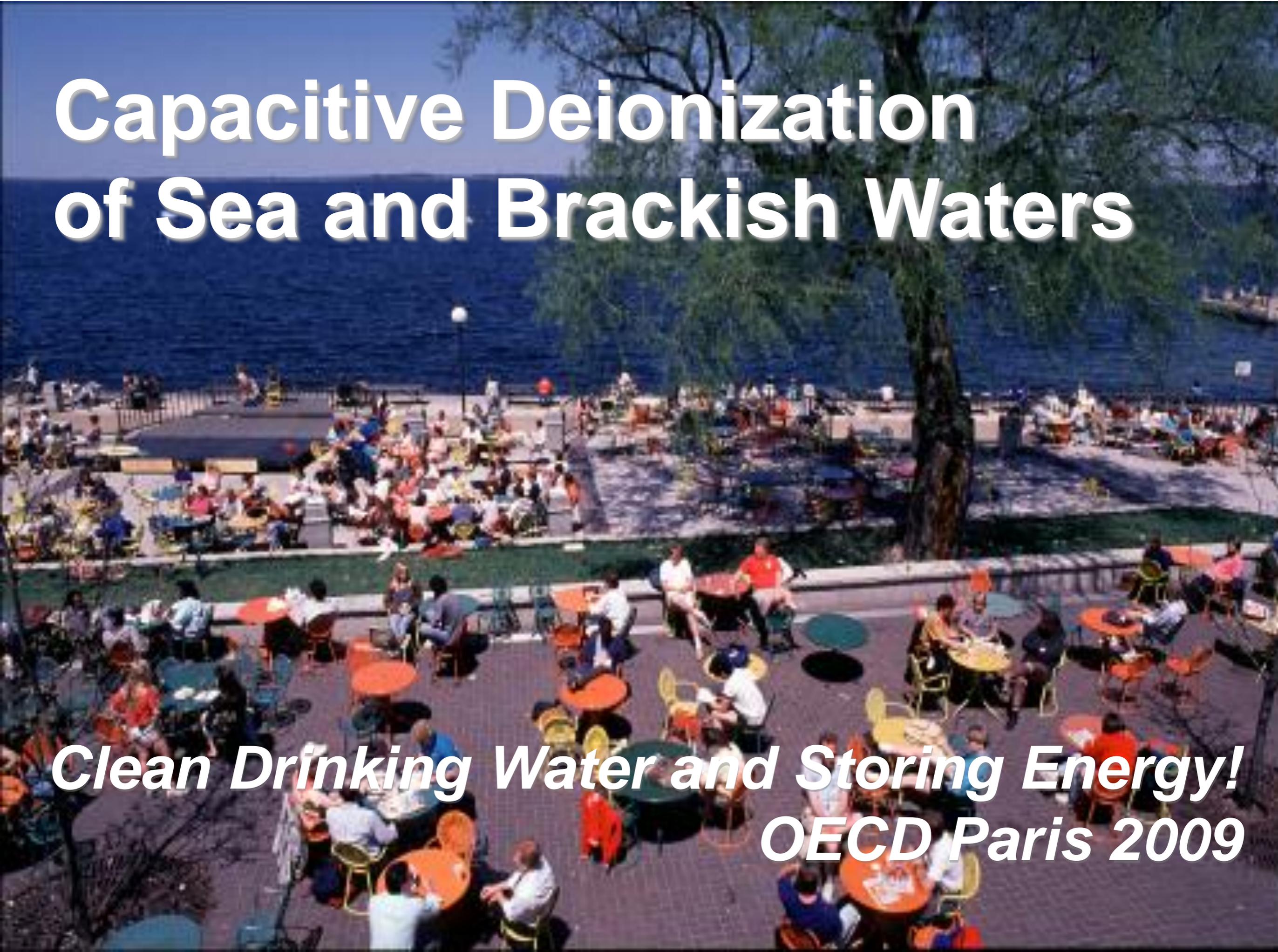
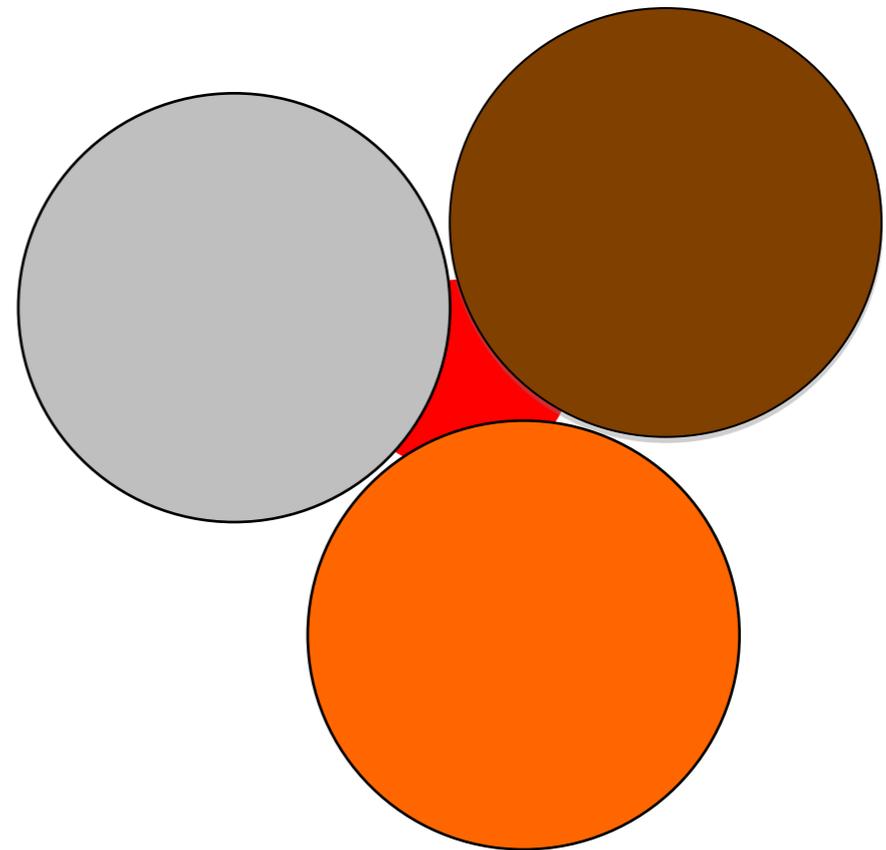


Capacitive Deionization of Sea and Brackish Waters

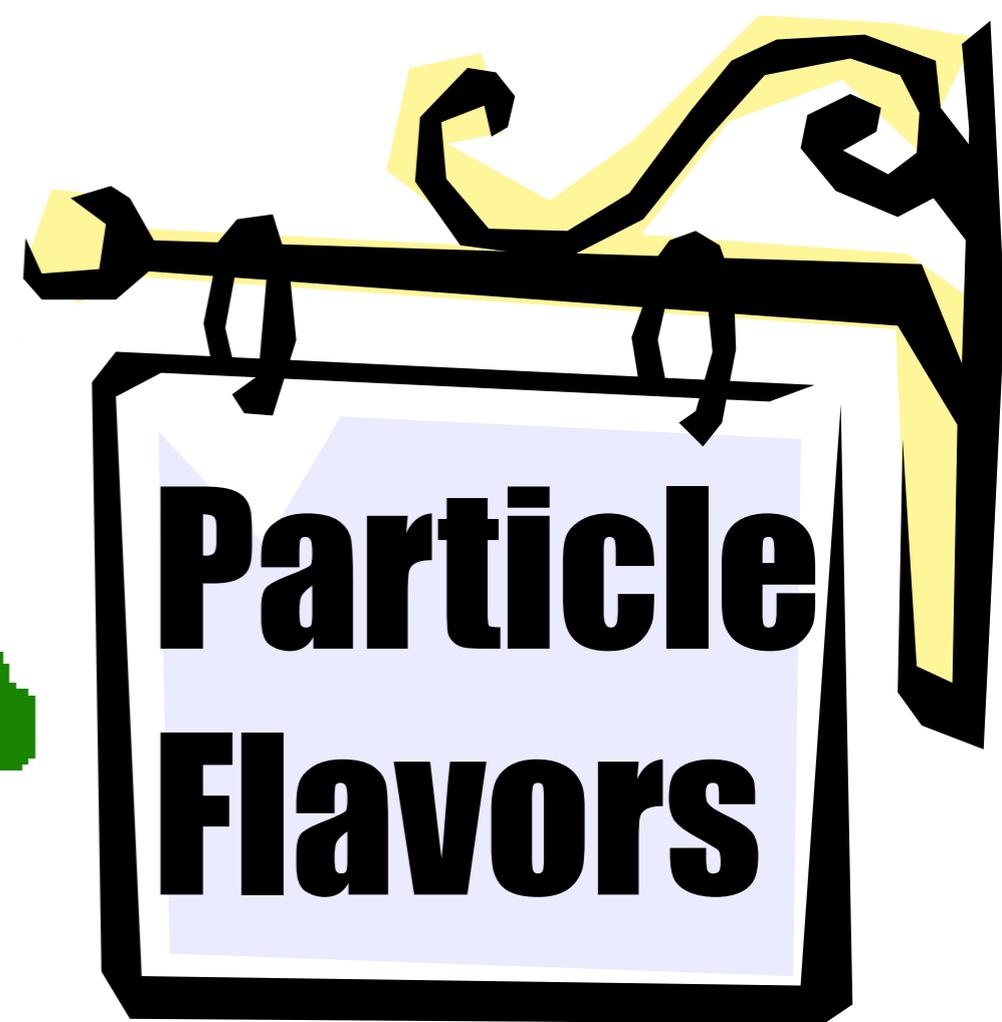
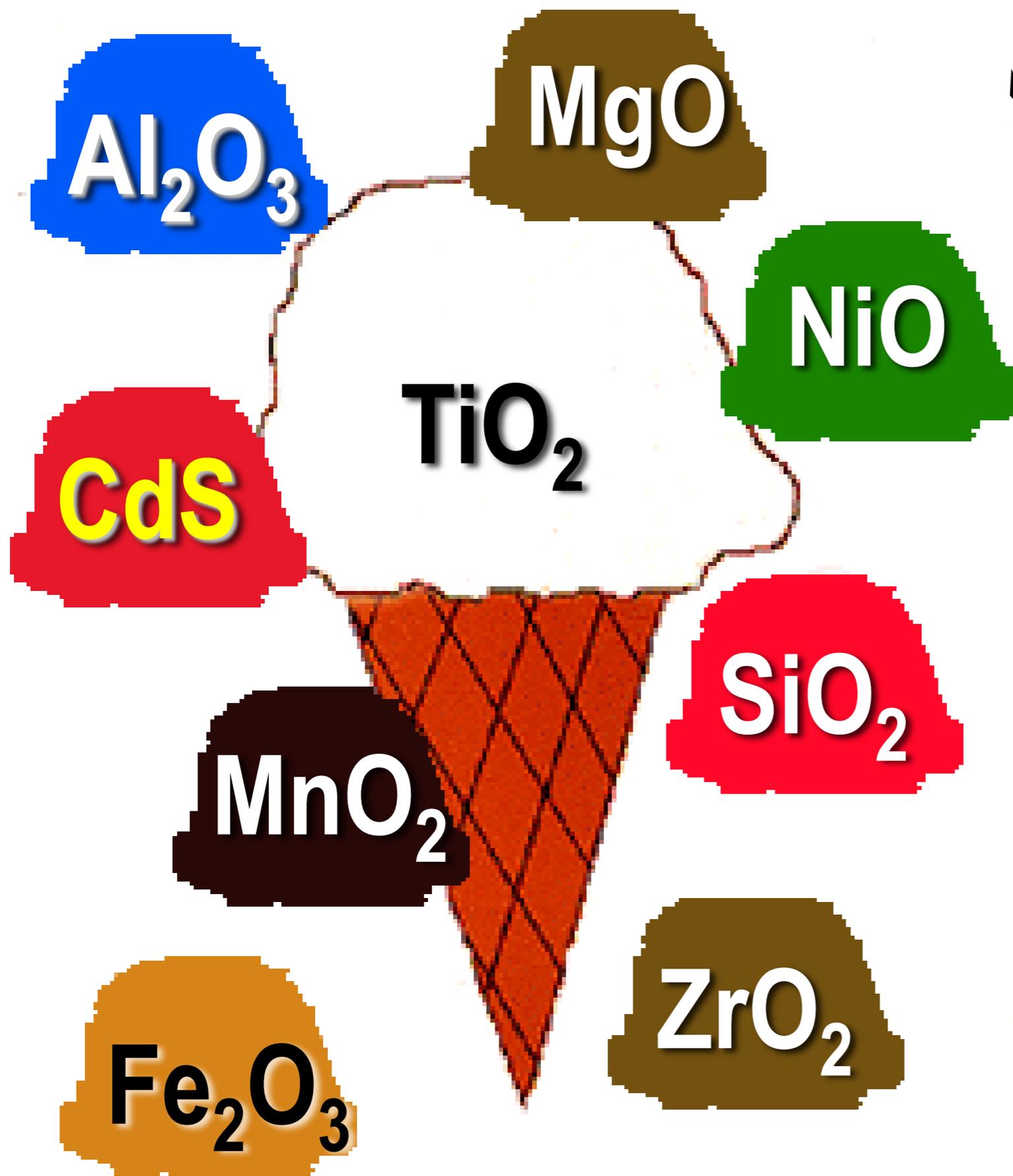
An aerial photograph of a crowded outdoor cafe or terrace. The cafe is filled with many people sitting at small, round tables. The tables are mostly orange and yellow, with some green ones. The chairs are also colorful, in shades of orange, yellow, and green. The cafe is situated on a paved area next to a body of water, which is visible in the background. There are trees and a fence in the distance. The overall scene is bright and lively, suggesting a sunny day.

Clean Drinking Water and Storing Energy!
OECD Paris 2009

In the Land of the Lilliputians...

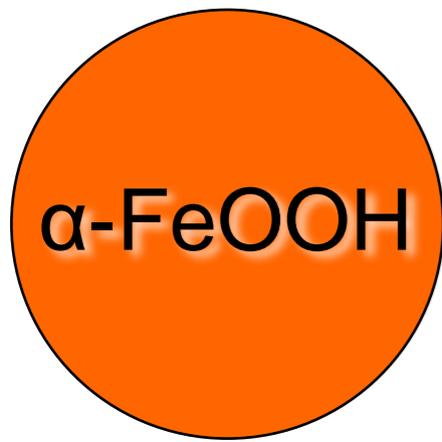


But Not POORLY !



APPLICATIONS





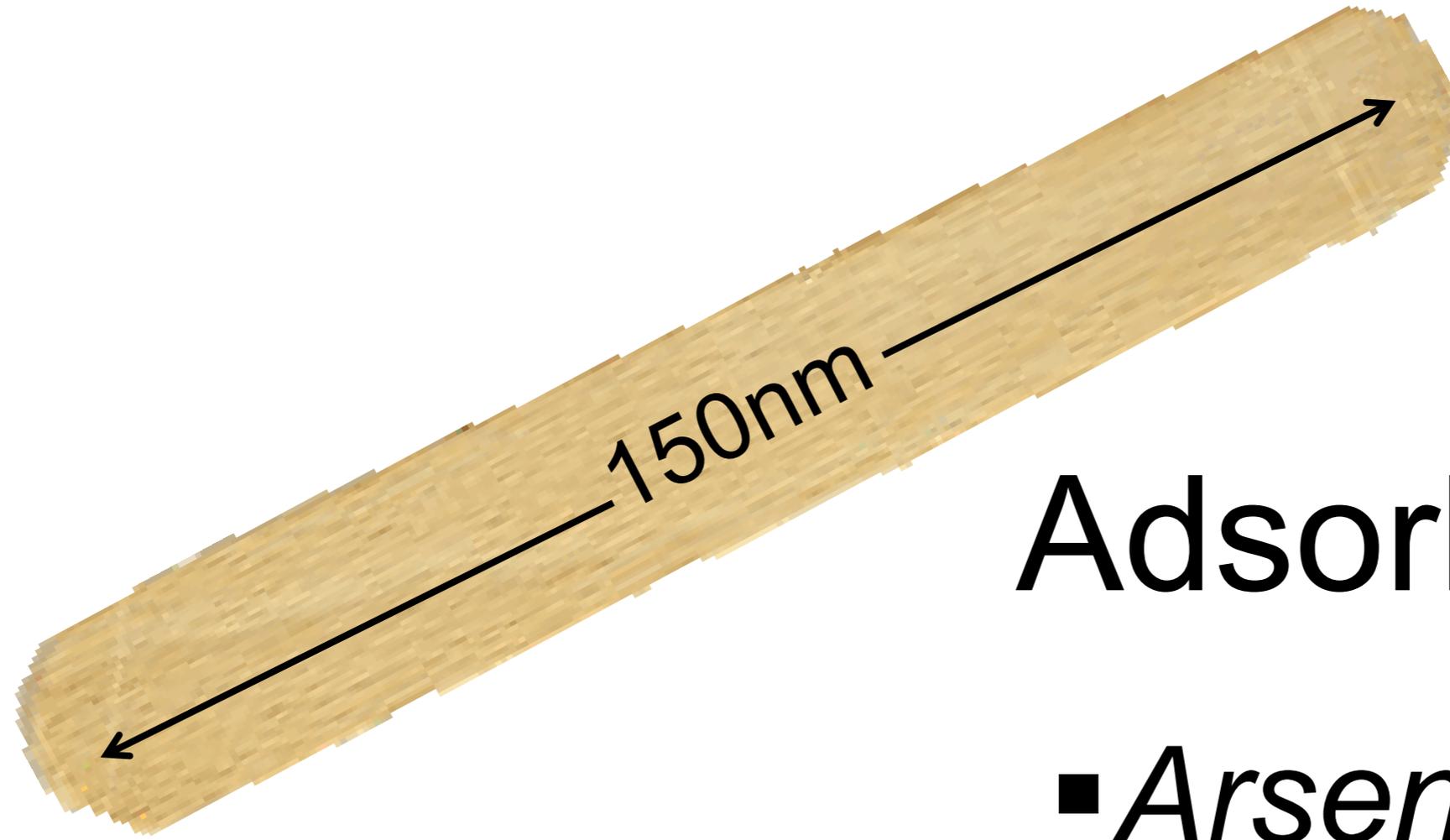
Adsorption 1974- Suspensions

Platelets
!



Natures Nanoparticulate “Tongue Depressors”

α -FeOOH “Goethite”



Adsorbs...

- *Arsenate*
- *Phosphate*
- *Protons!!*

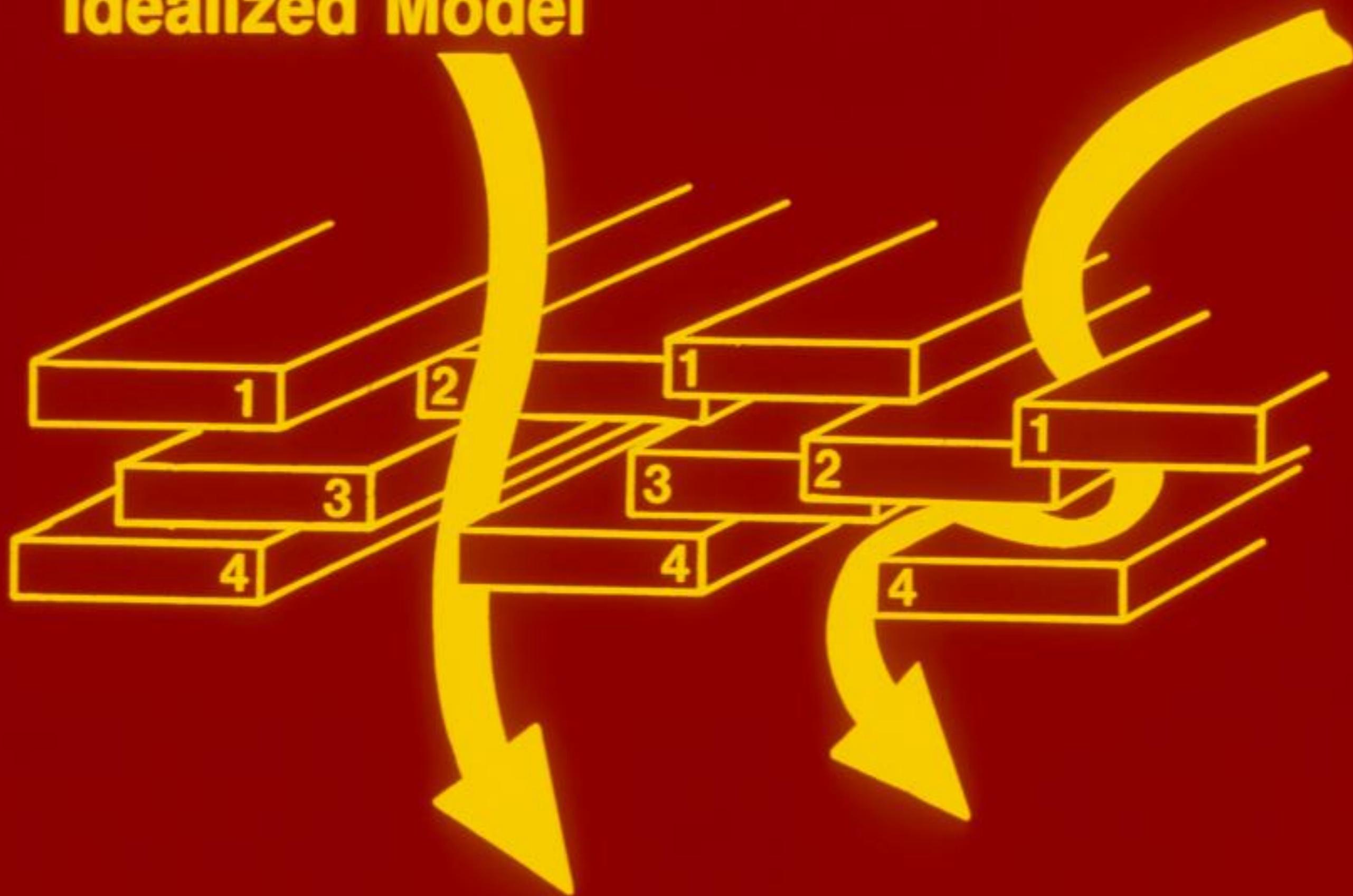
Without PO_4^{-3}





With PO_4^{-3}

Idealized Model



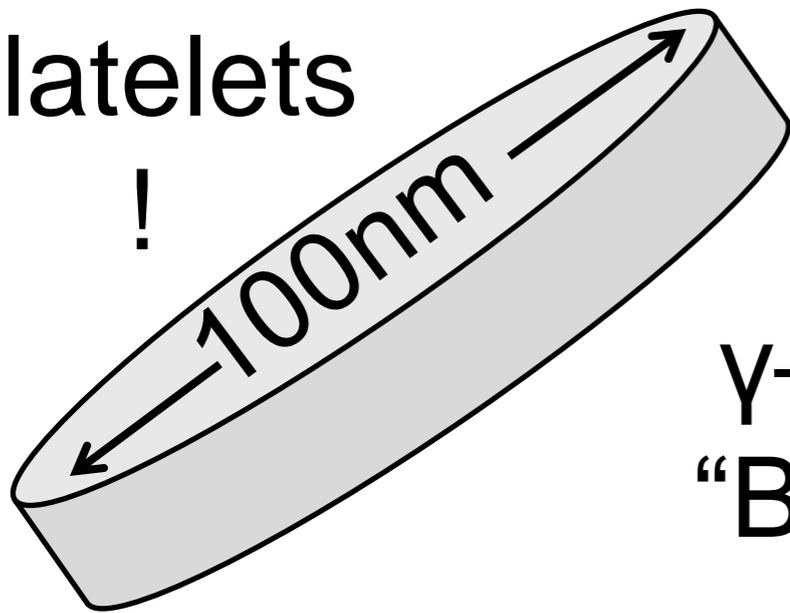
From Suspensions to Thin-Films



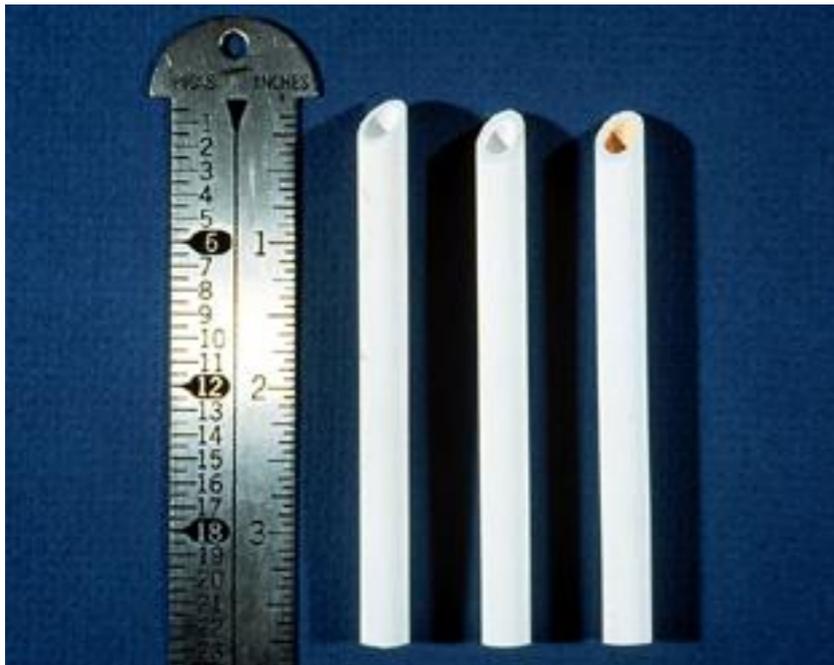
Ceramic Membranes 1983-

Platelets

!



γ -AlOOH
"Boehmite"



*Now – Smaller Particles
Nanofiltration*

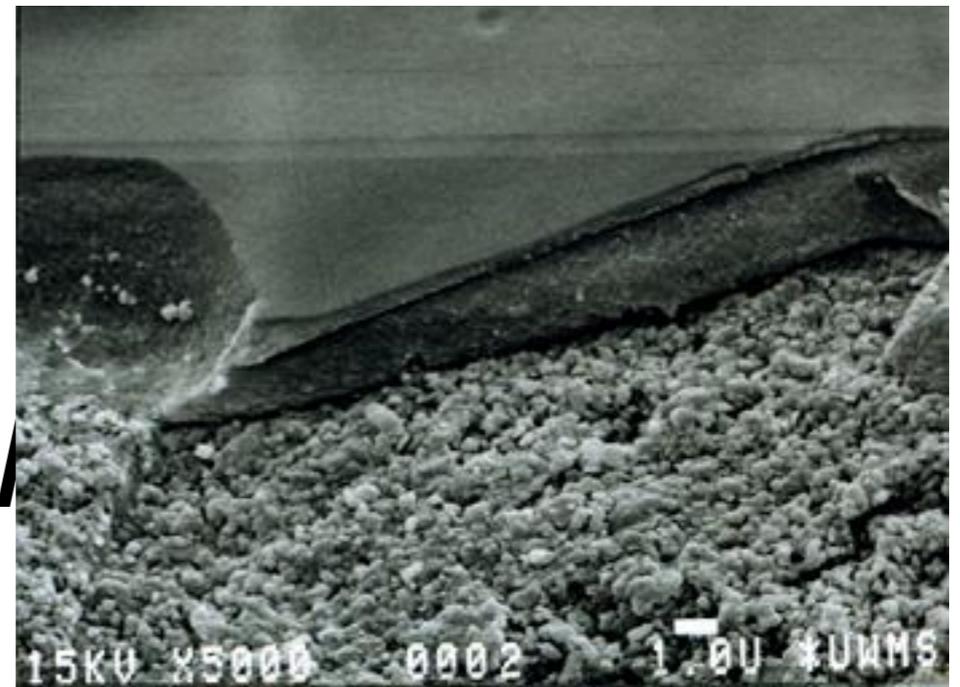
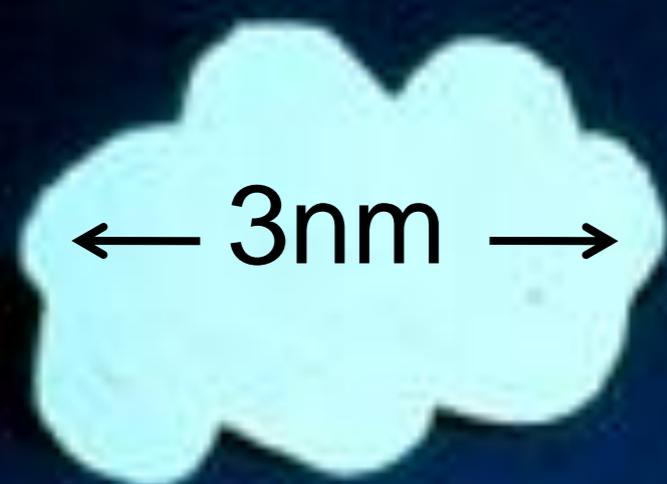


Photo & Photoelectrocatalysis

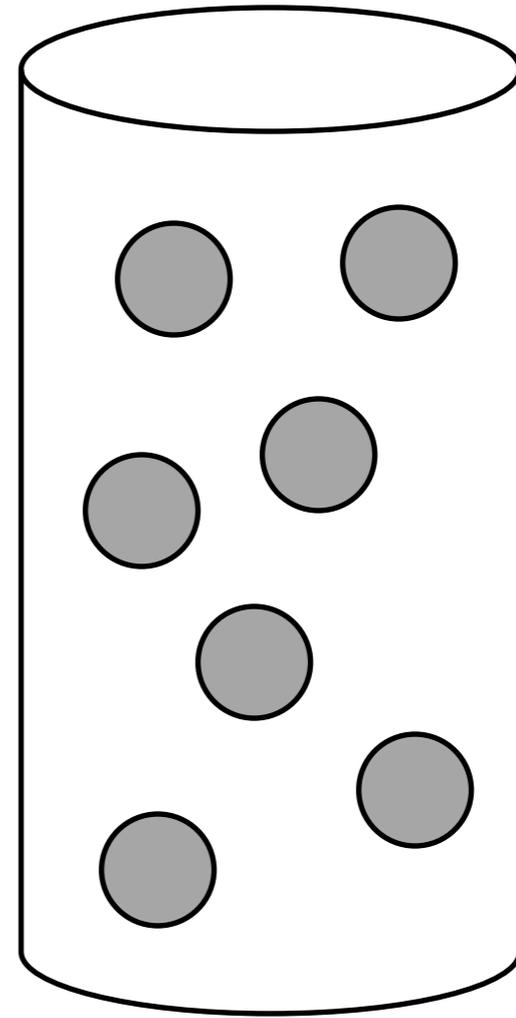
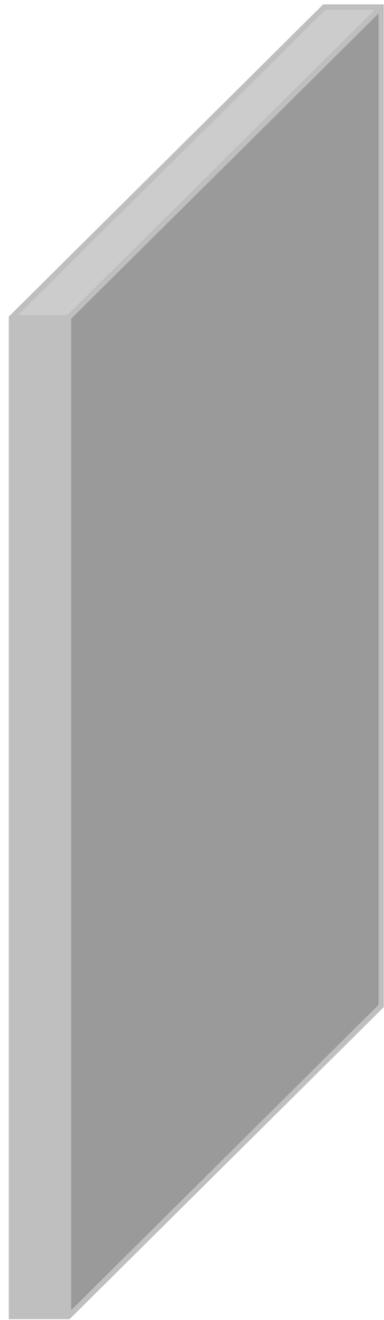
1991-



TiO₂

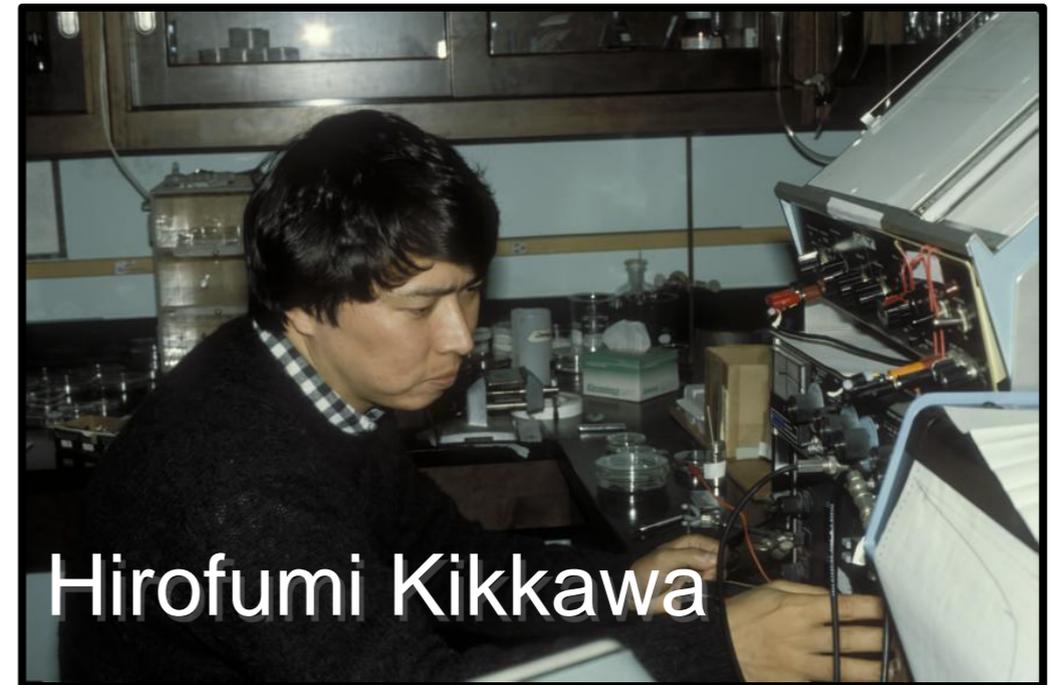
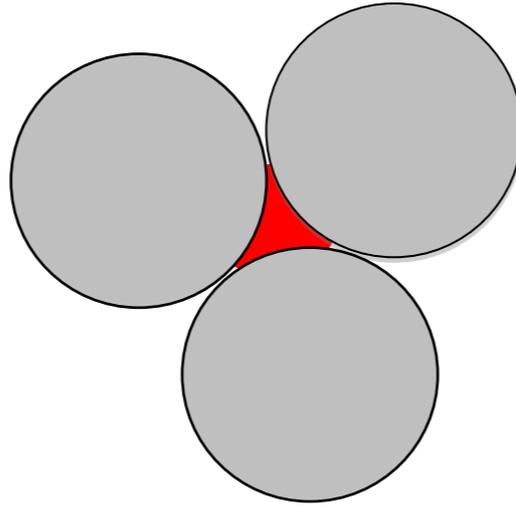


Films vs Suspensions



*No Separation Needed
Better Light Penetration
Photoelectrodes*

Transparent Semiconducting Thin-Films

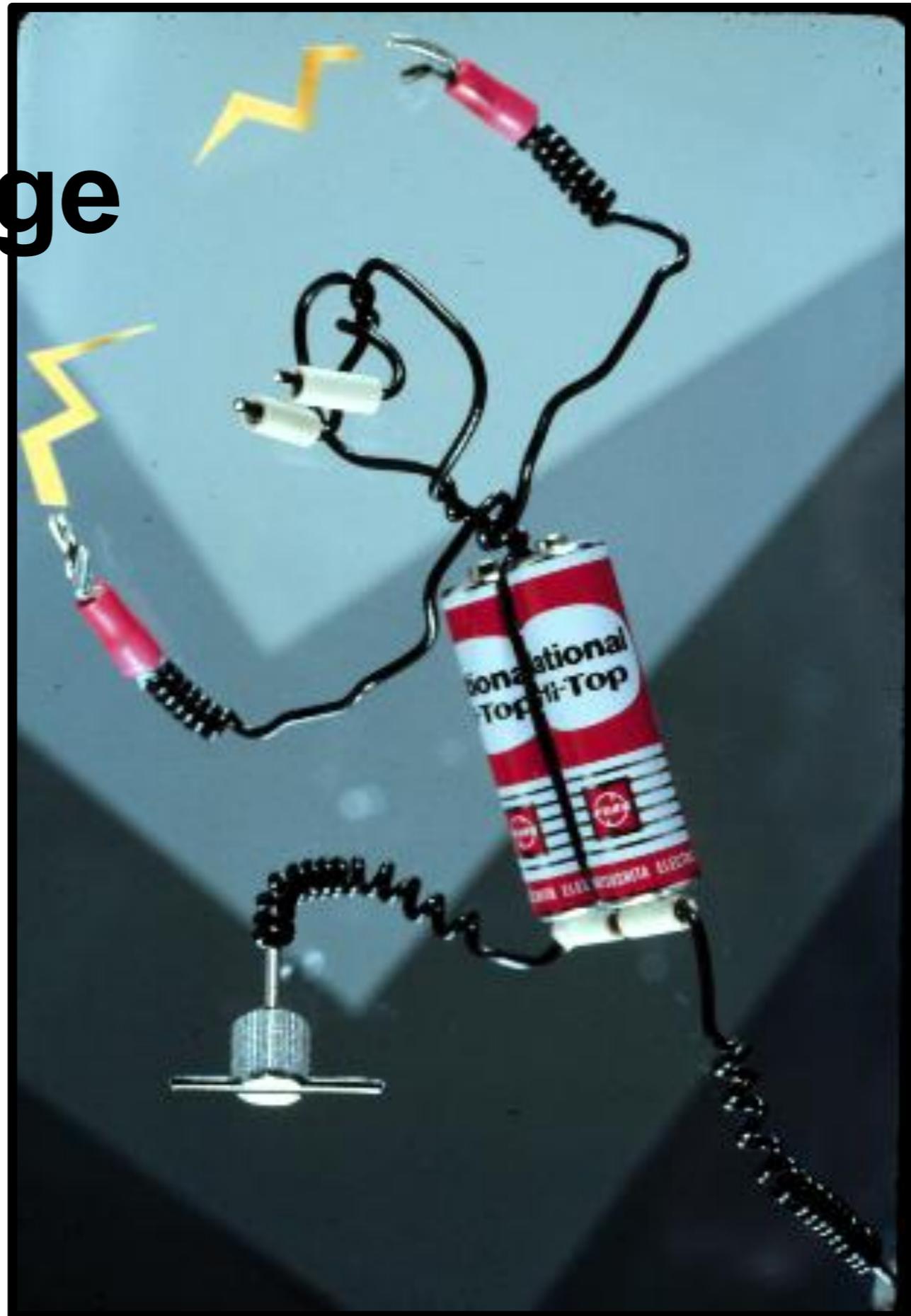


- *Photoelectrochemist*
- *Grätzel Cells*
- *Porous Electrodes !*



Energy Storage

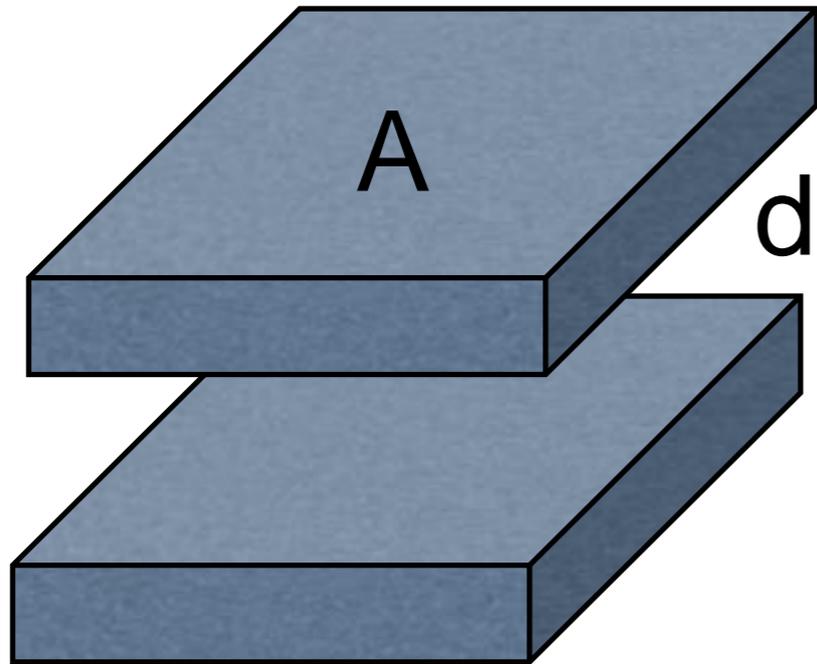
- *Batteries*
- *Capacitors*



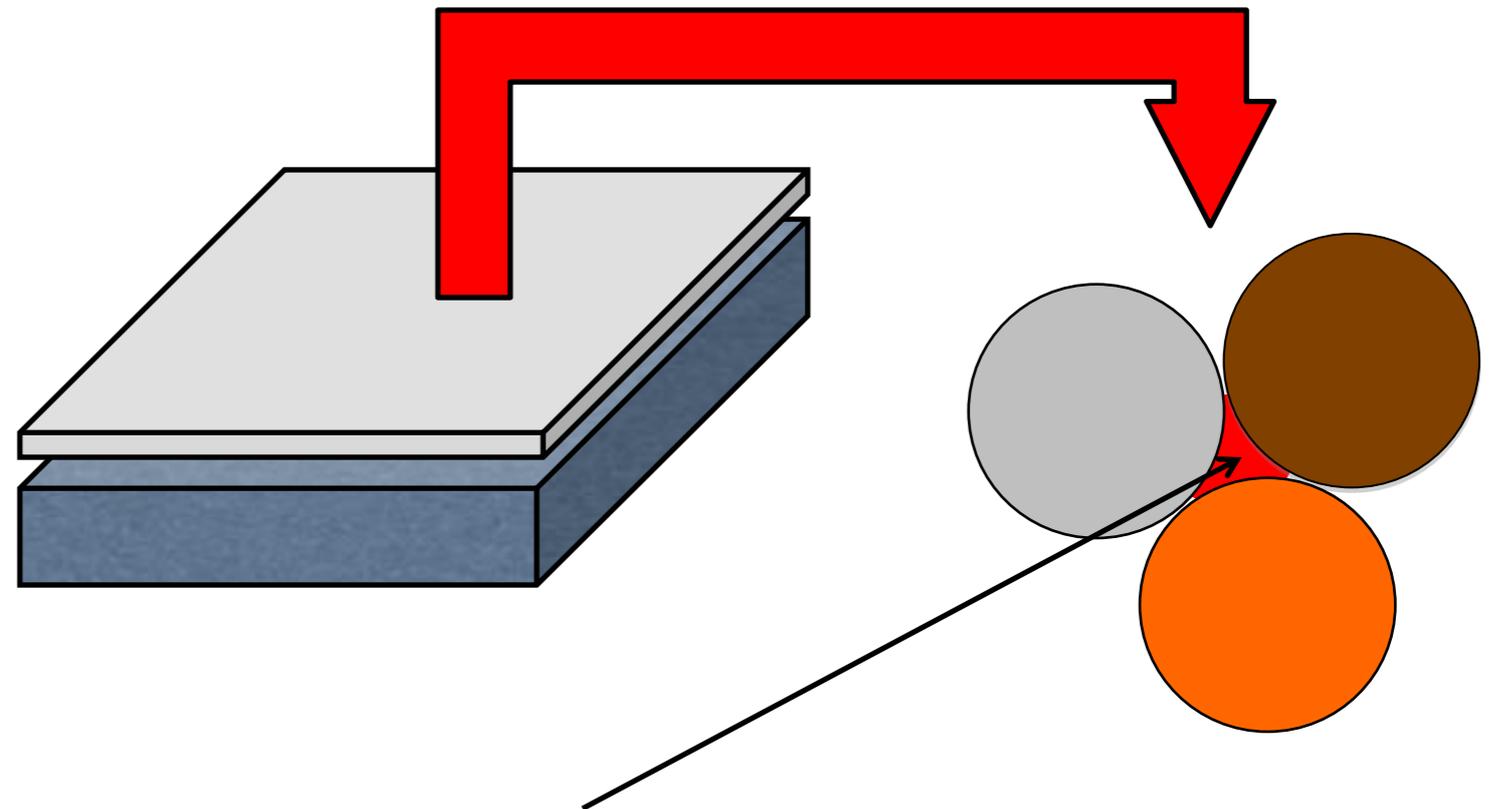
Ultracapacitors

1994-

MnO₂
8nm

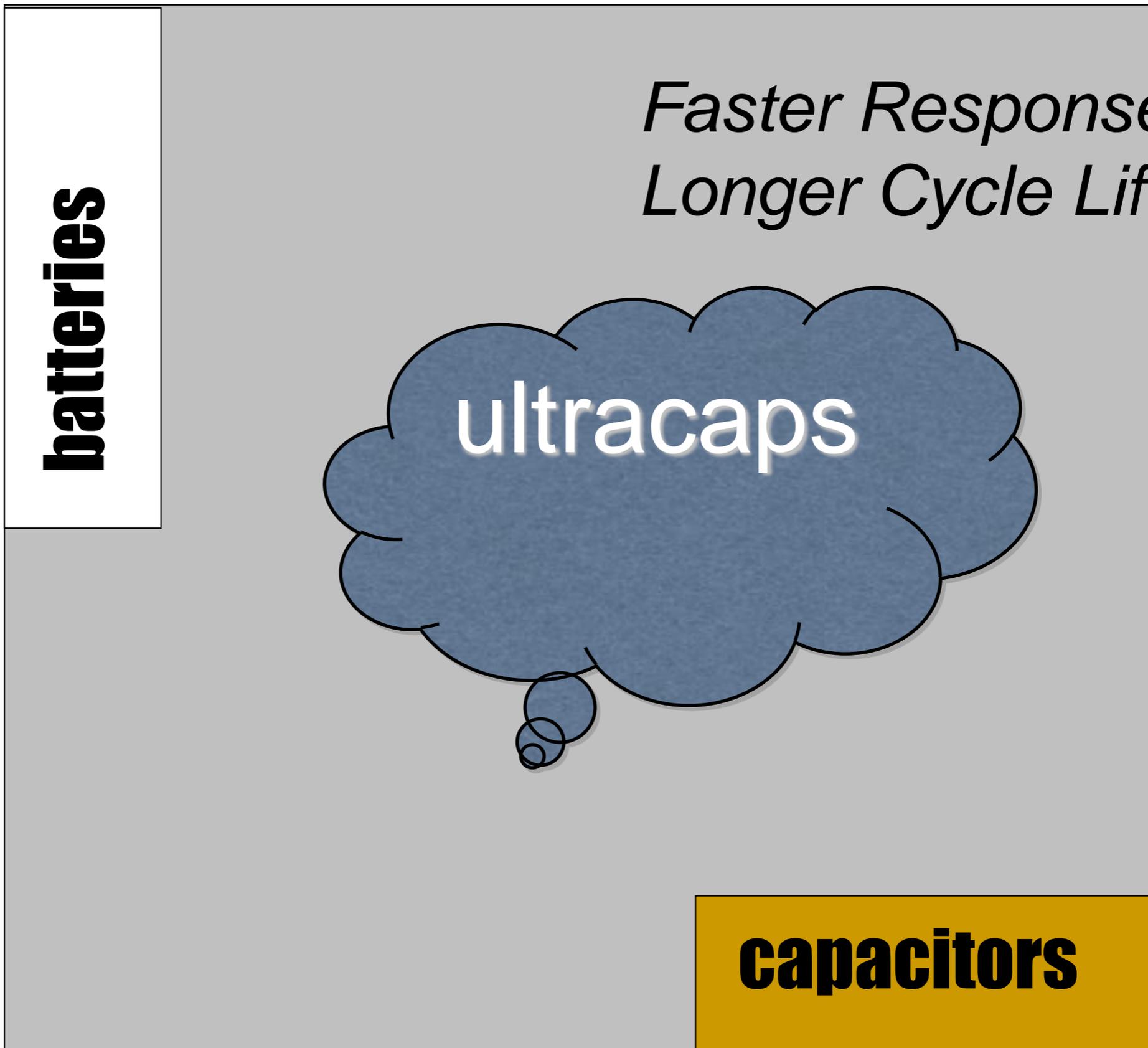


$$C = \epsilon \frac{A}{d}$$



Ion Distance to Surface = Angstroms

Energy Density ⇌



Power Density ⇌



Load-Leveling



***USA
Alkaline
Battery***



WATER

ENERGY

Rhone River Plant- France



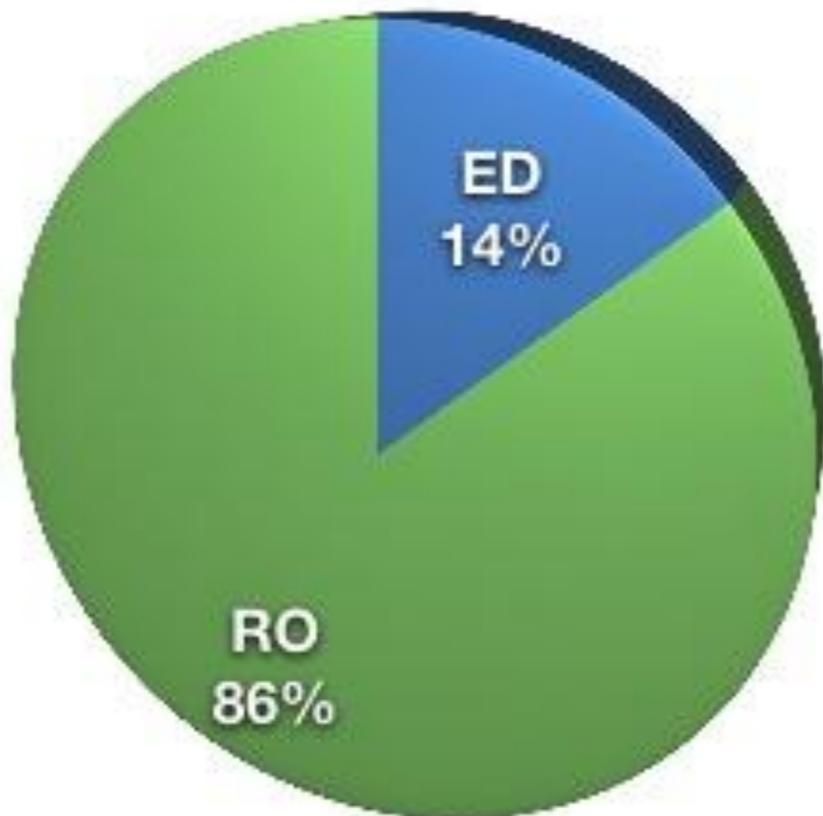
POWER PLANTS NEED WATER!

WATER PLANTS NEED ENERGY!

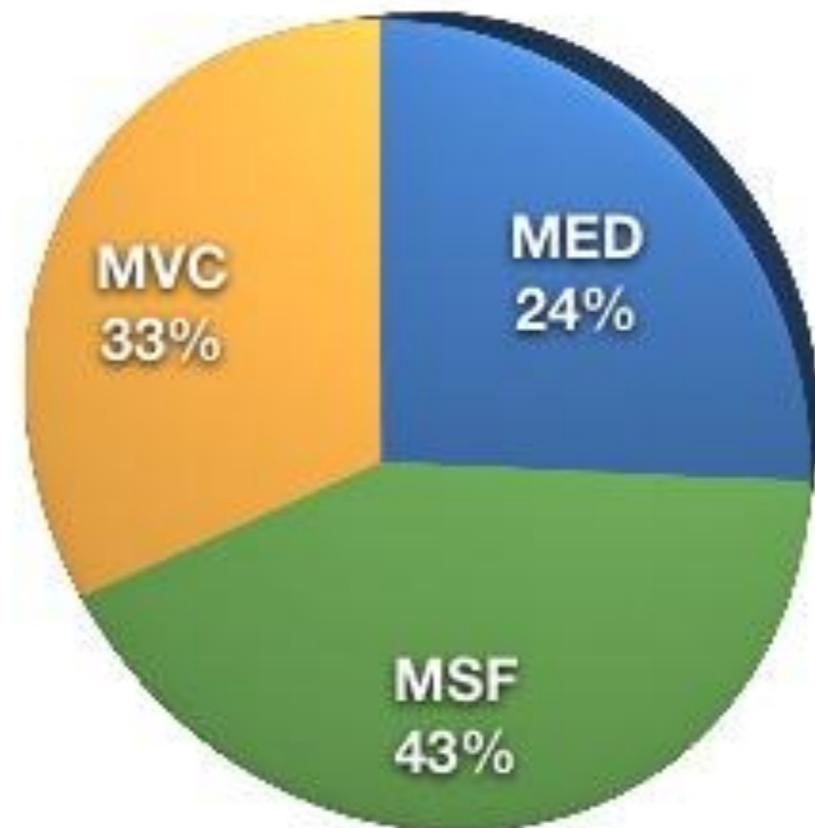


Adelaide Australia

DESALINATION PLANTS USING GIVEN TECHNOLOGIES



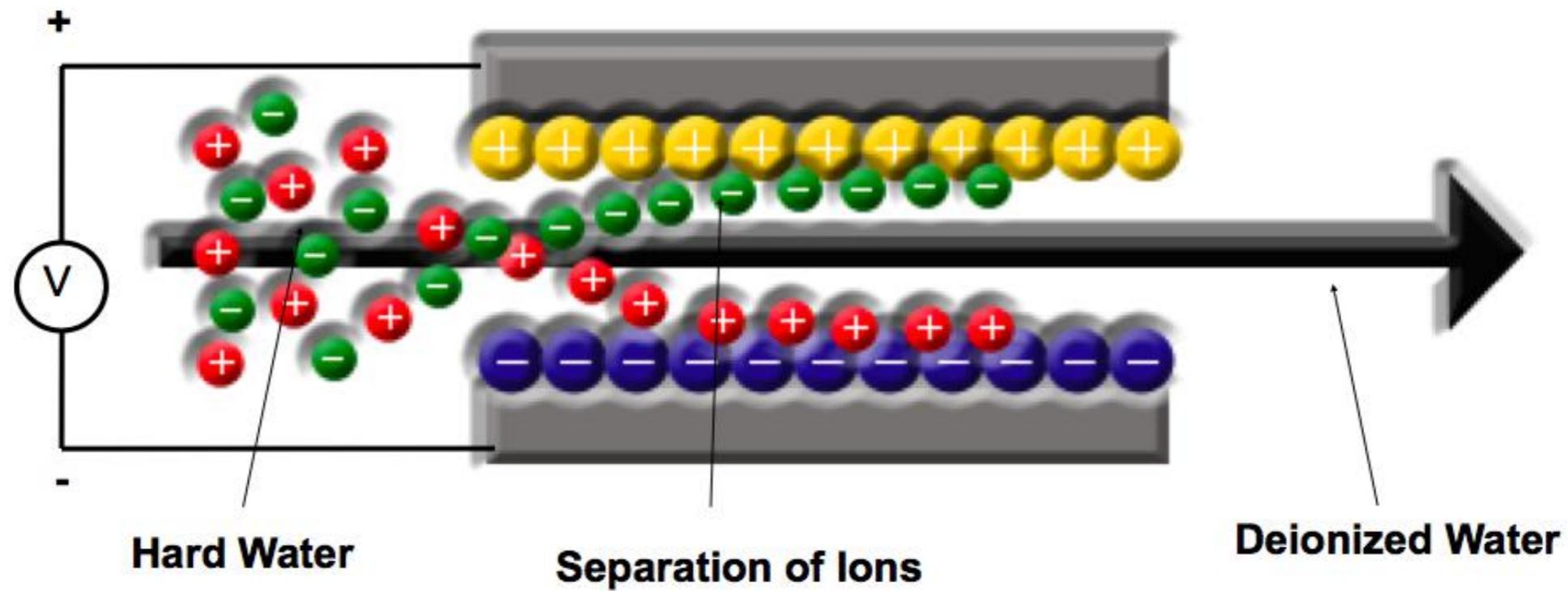
MEMBRANE PROCESSES



THERMAL SYSTEMS

**DELIVER WATER
&
STORE ENERGY?**

CAPACITIVE DEIONIZATION!



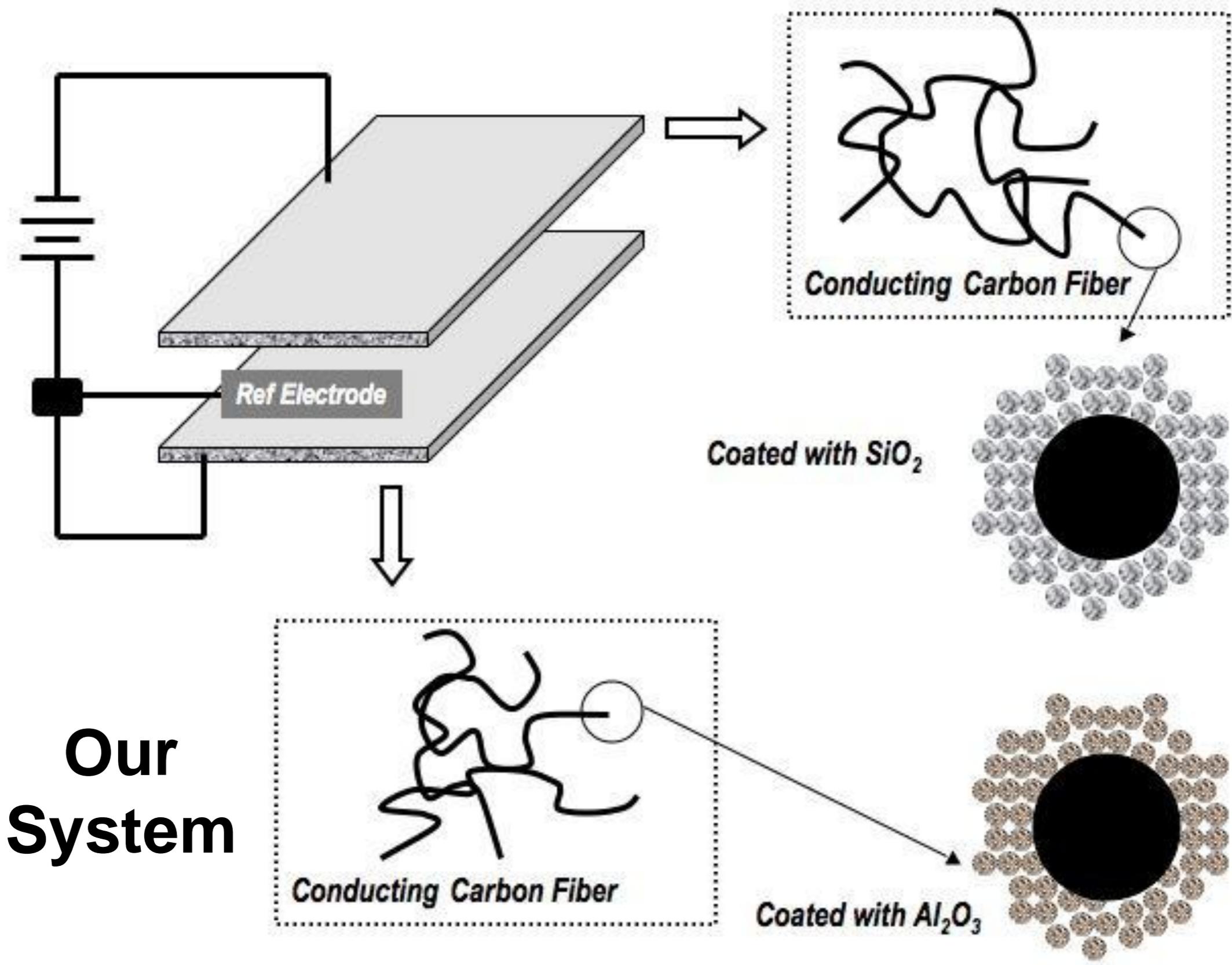
History of CDI

Caudle et al 1960's

Oren et al 1970-1980's

Farmer et al 1990's

FIFTY YEARS BUT NO COMMERCIAL SUCCESS ?



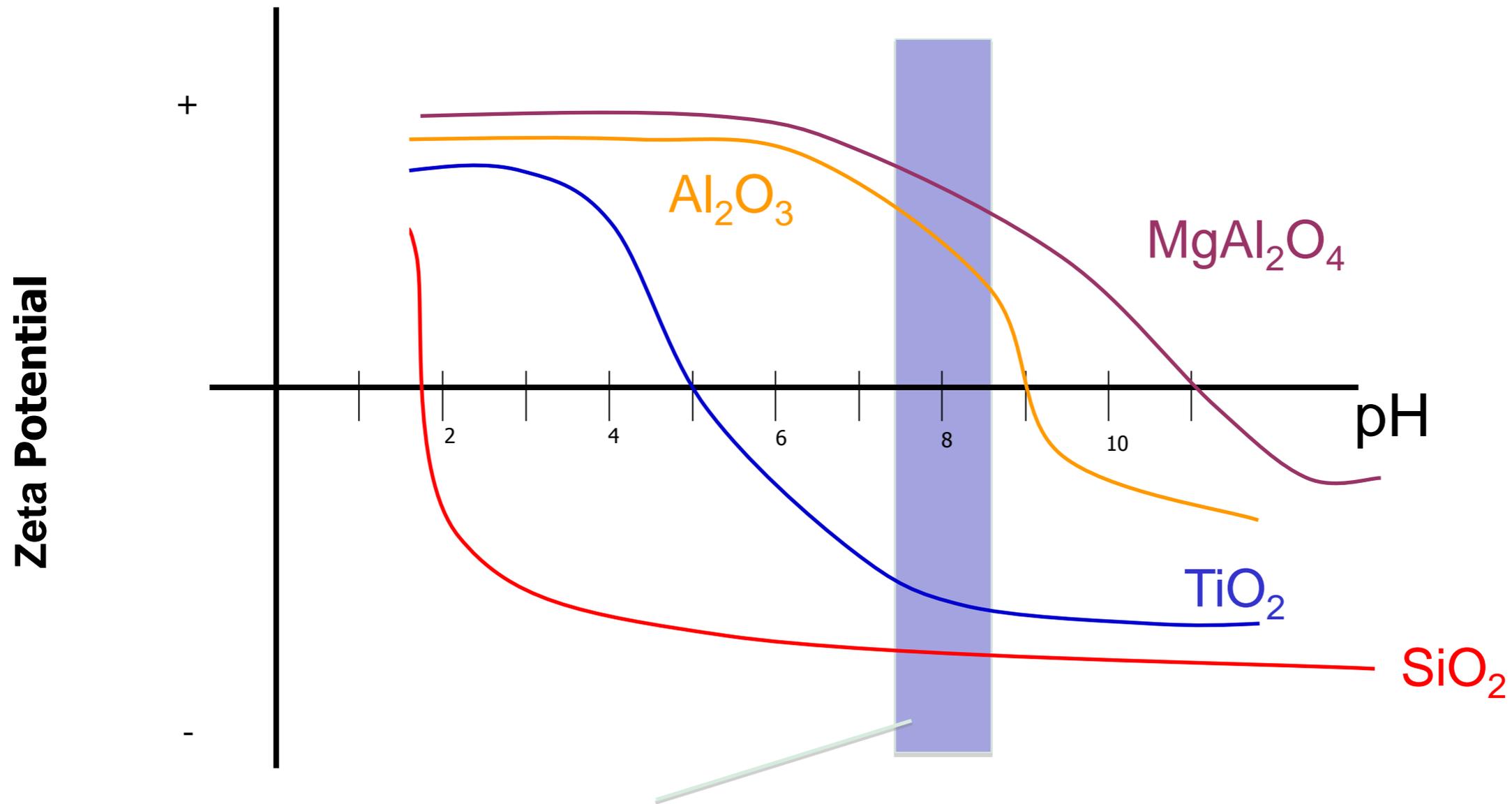
Our System

Proton is a Potential Determining Ion



THE PROTON HAS RETURNED!

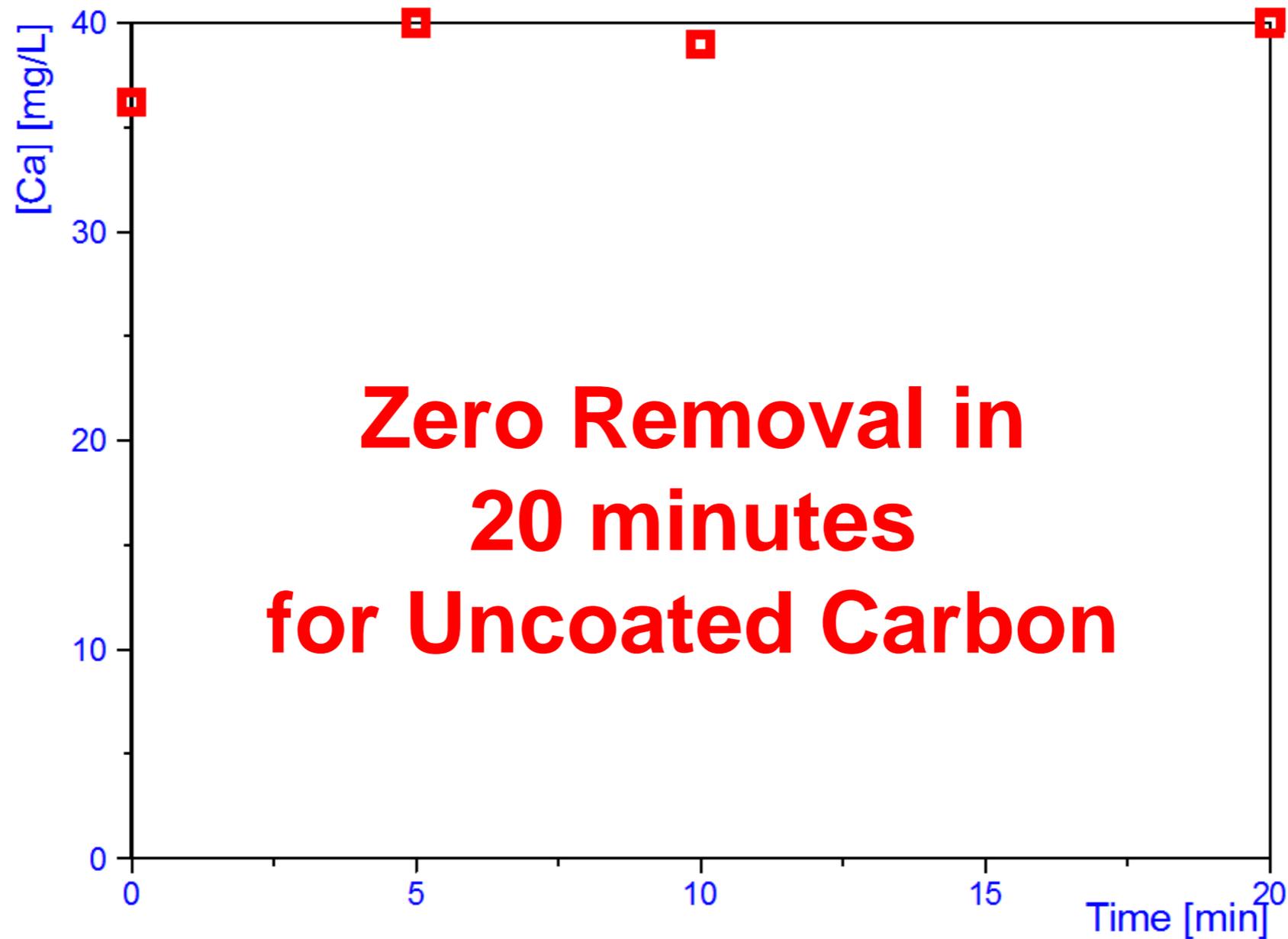
Choosing Capacitor Materials



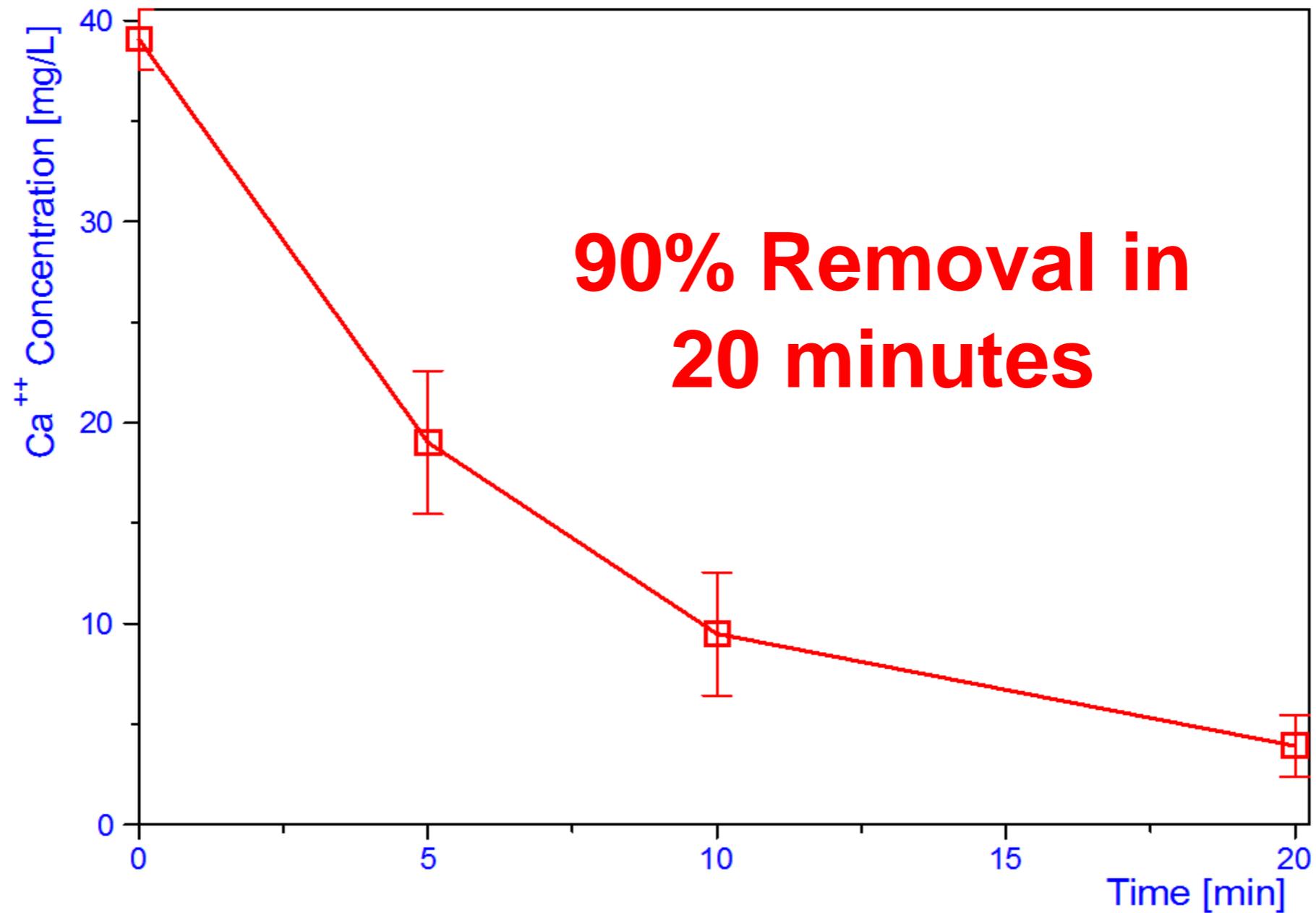
The pH range of Normal Waters.

CaCl₂ Removal

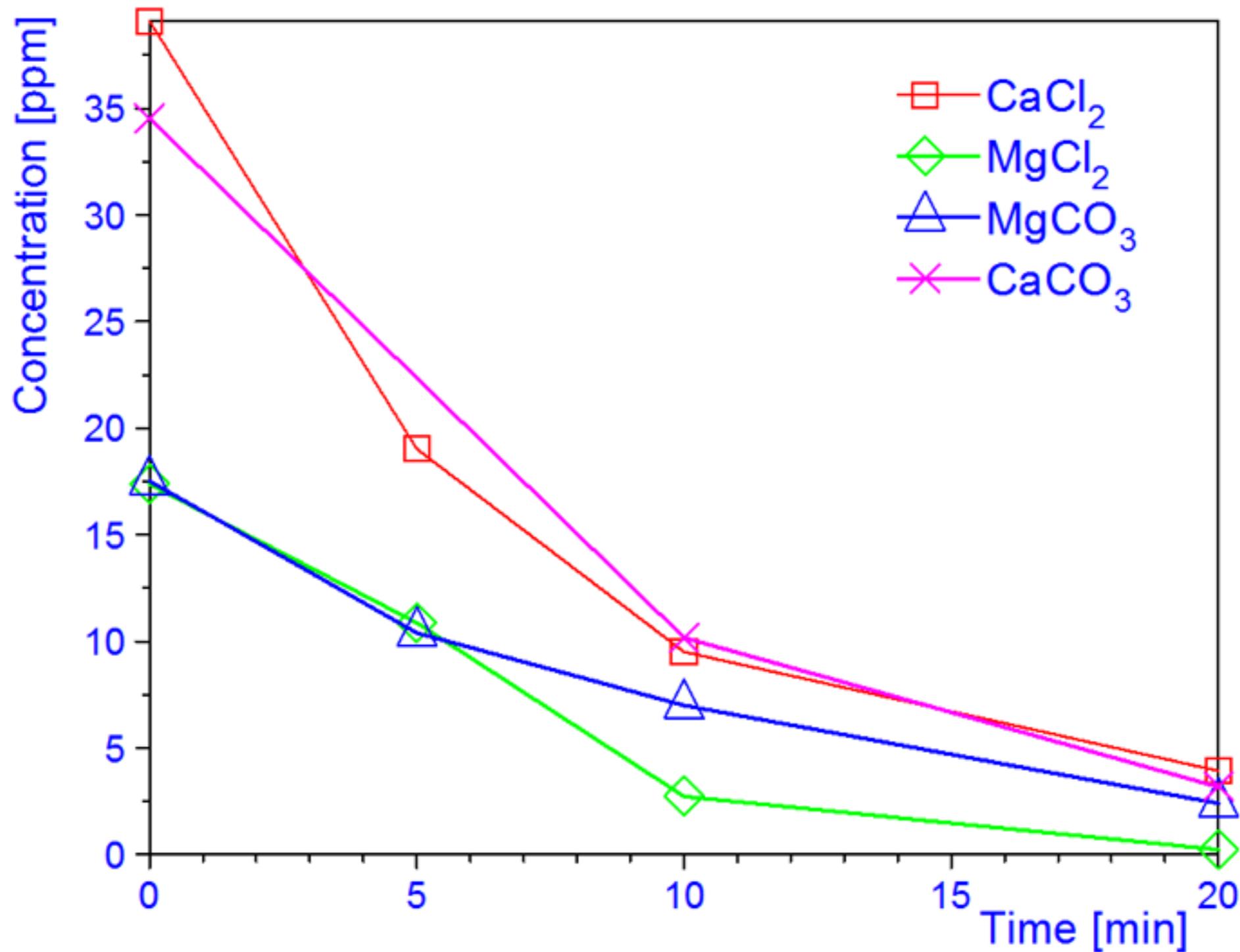
How Effective is Coating?



CaCl₂ Removal with Coatings

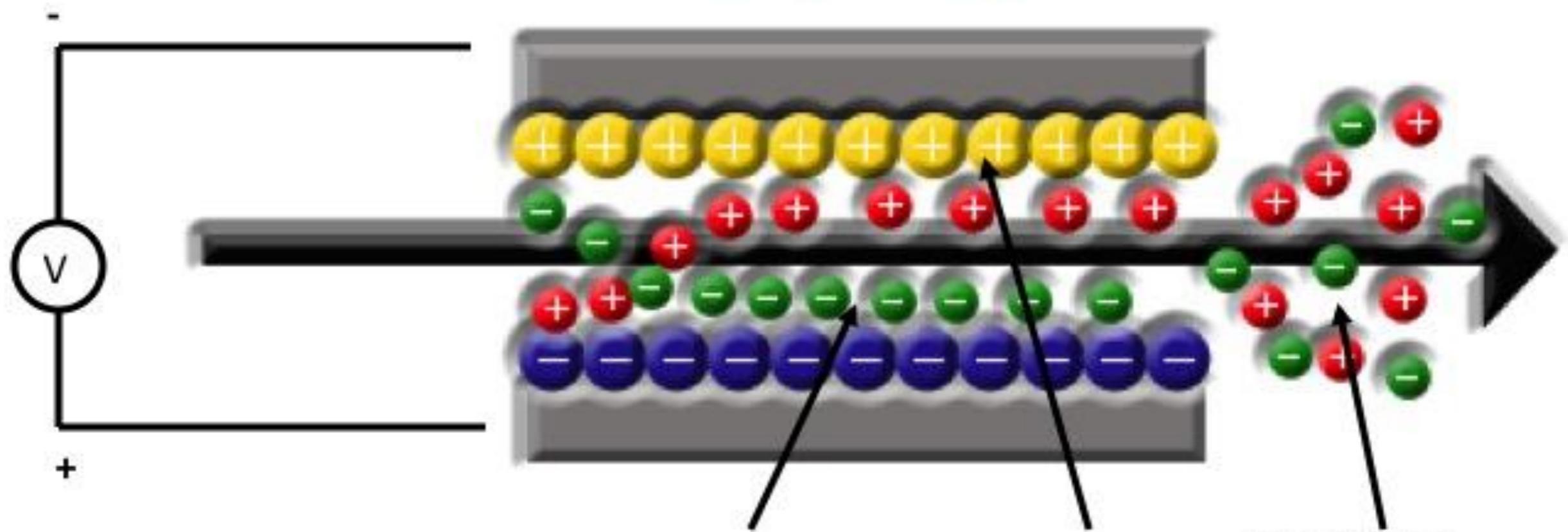


Other Ion Removal



Note: Calcium is Difficult if Not Impossible to Remove with Carbon Aerogels Capacitive Systems!

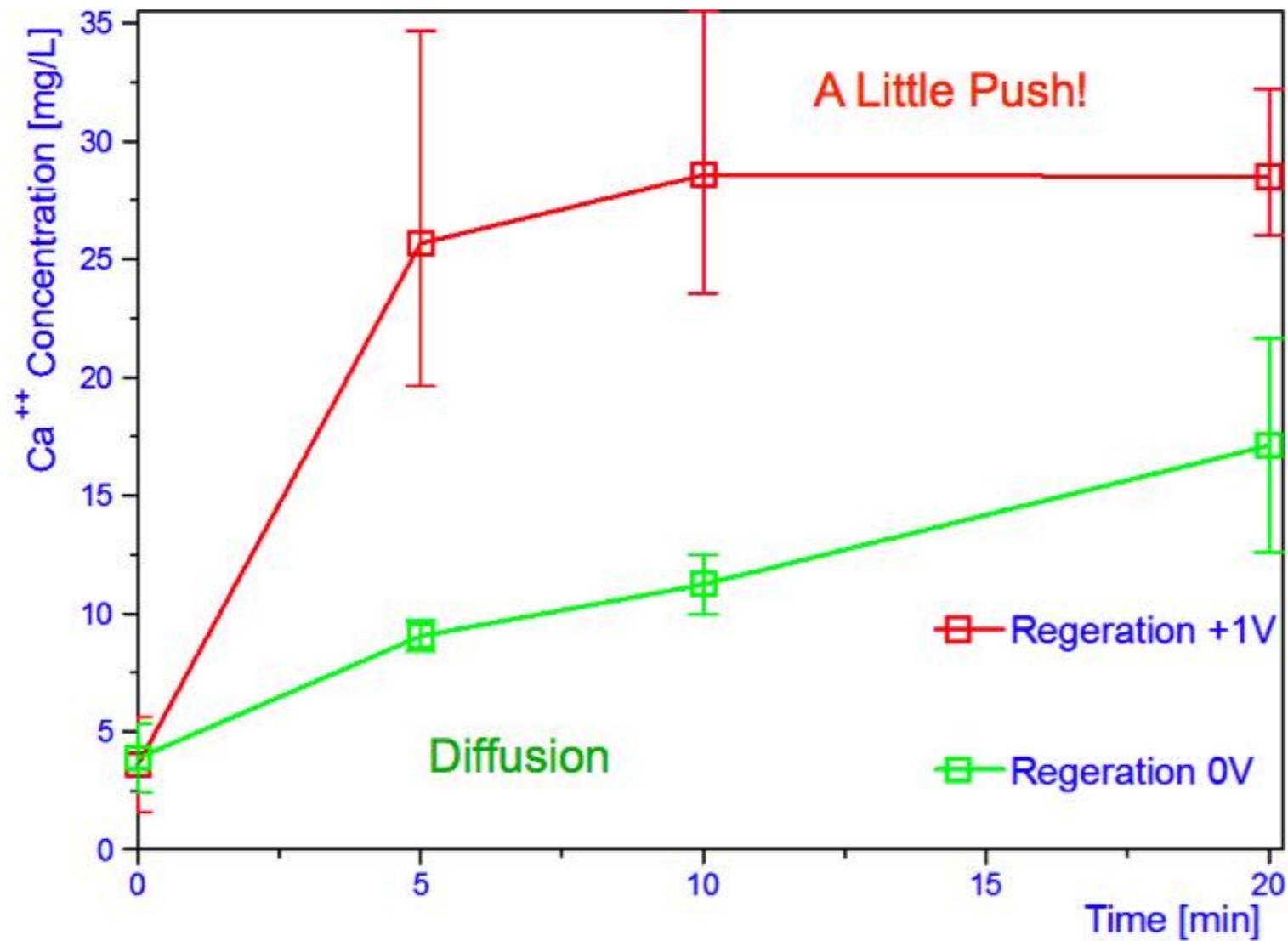
Regeneration buy
Reversing the Voltage!!



Repulsion Between Surface
Charge and Ions

Flush Water

CaCl₂ Regeneration



CDI vs RO

Reduced Energy (>30%)

Reduced Fouling (>60%)

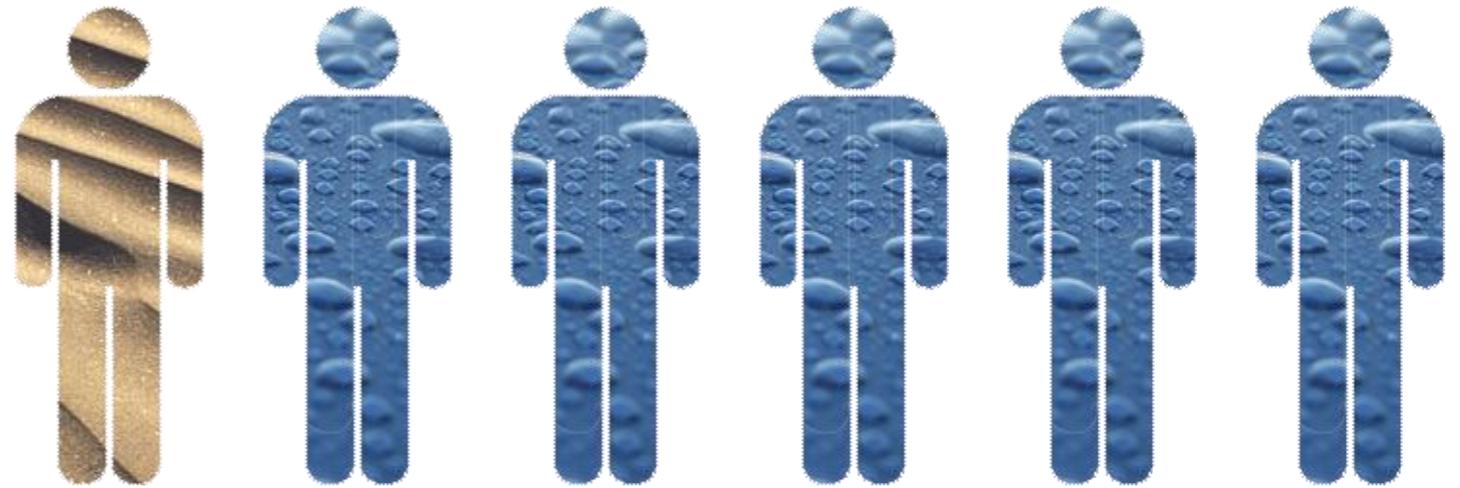
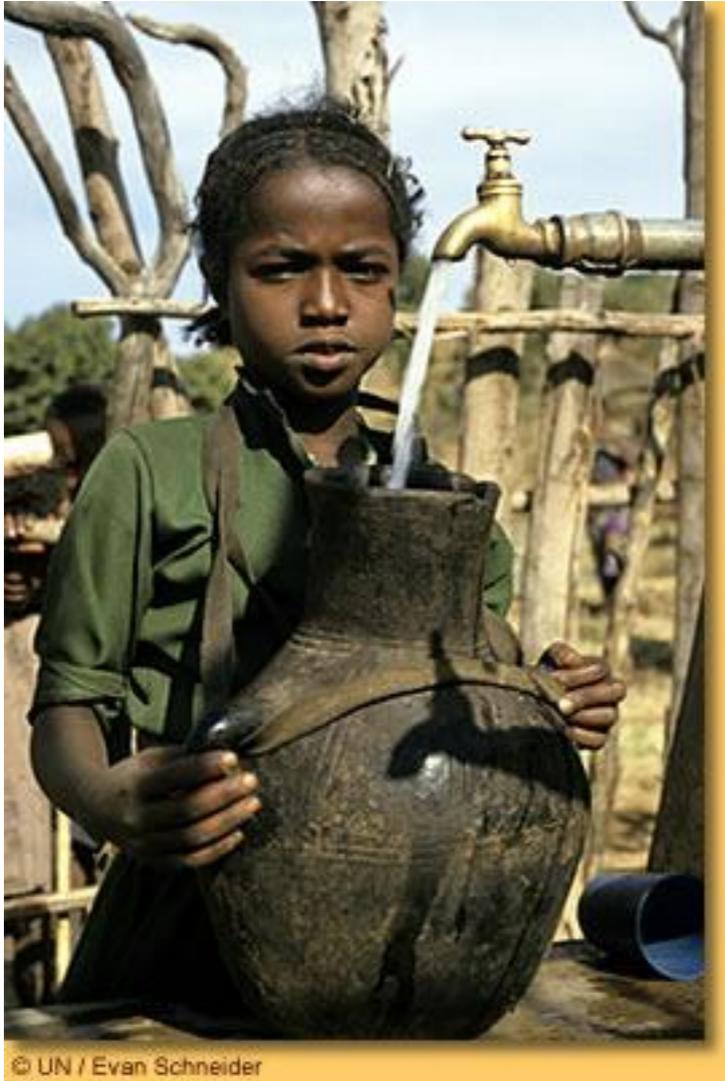
Less Brine (>40%)

Low Maintenance Cost (>50%)

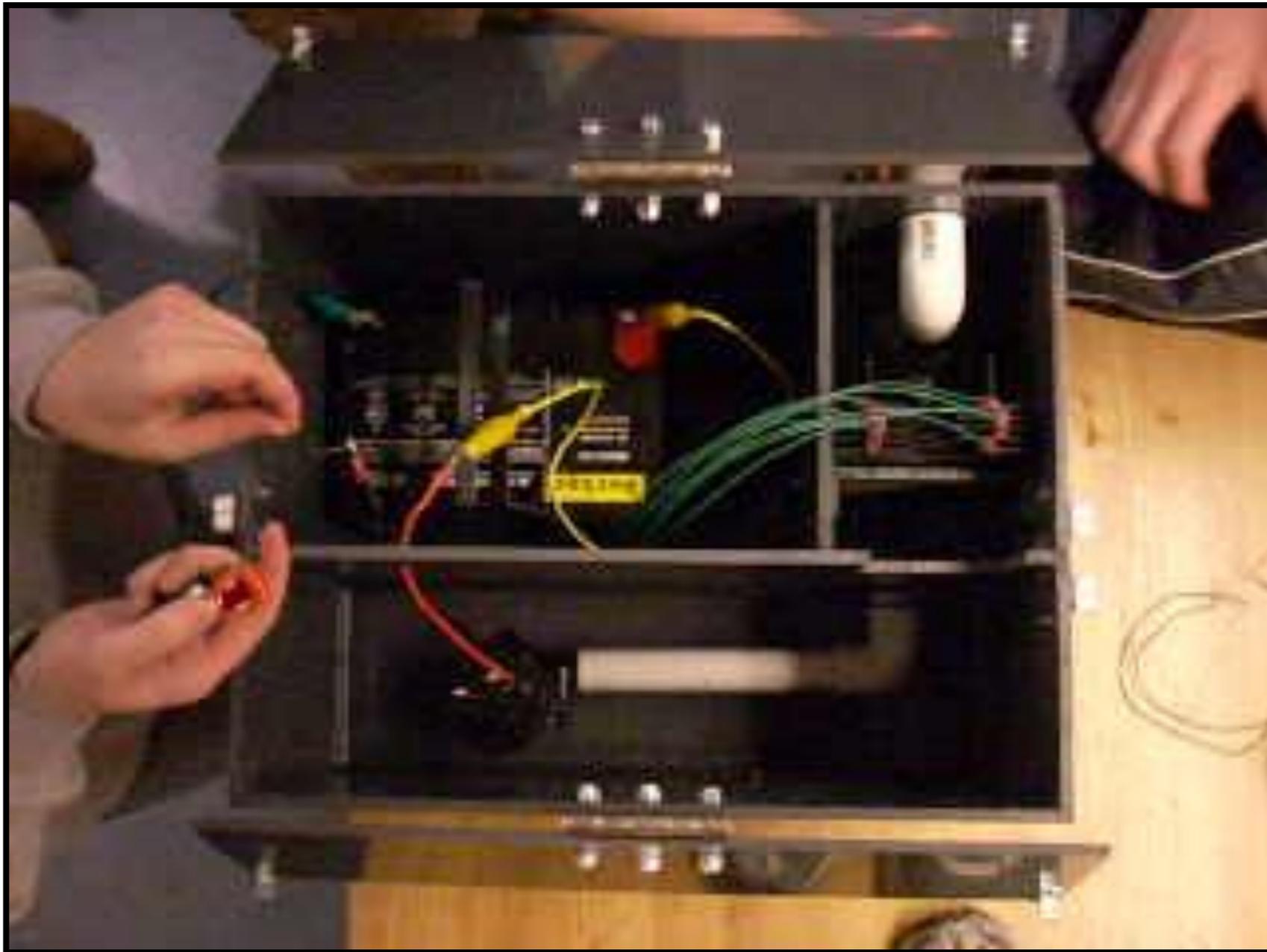
Higher Throughput (>70%)

Lower Capital Costs (>40%)

Third World Water



Solar Powered CDI For A Family of Four

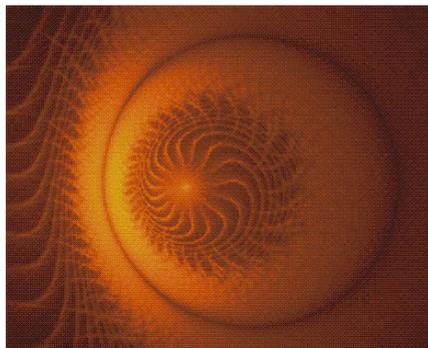


Where Do We Go From Here?





THE UNIVERSITY
of
WISCONSIN
MADISON



imdea
energía

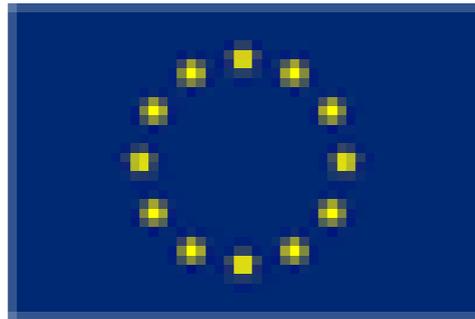


PROINGESA
PROYECTOS, INGENIERÍA Y GESTIÓN S.A.





Senior 5-Year Proposal



To Be Continued . . .



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