

Engineering Reverse Innovations:

Using Emerging Markets Constraints to Drive the Creation of High-Performance, Low-Cost, Global Technologies



Prof. Amos G. Winter

Director, Global Engineering and Research (GEAR) Lab

Department of Mechanical Engineering

Massachusetts Institute of Technology



Why think about designing for emerging markets specifically?

Why think about designing for emerging markets specifically?

Unsolved global challenges



United Nations
Millennium
Development Goals



Why think about designing for emerging markets specifically?

Unsolved global challenges

Unique stakeholder dynamics



Why think about designing for emerging markets specifically?

Unsolved global challenges

Unique stakeholder dynamics

Multi-market opportunities



Immelt, "How GE is Disrupting Itself", *HBR*, 2009



Why think about designing for emerging markets specifically?

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Unique stakeholder dynamics

Multi-market opportunities



China and India are projected to have the first and third largest economies, respectively, by 2050¹.

Combined with Brazil and Russia, the BRIC economies are forecasted to grow from 18% of global market capital now to 41% in 2030².

1. J. O'Neill. *BRICs and Beyond*. Goldman Sachs Global Economics Group, 2007.

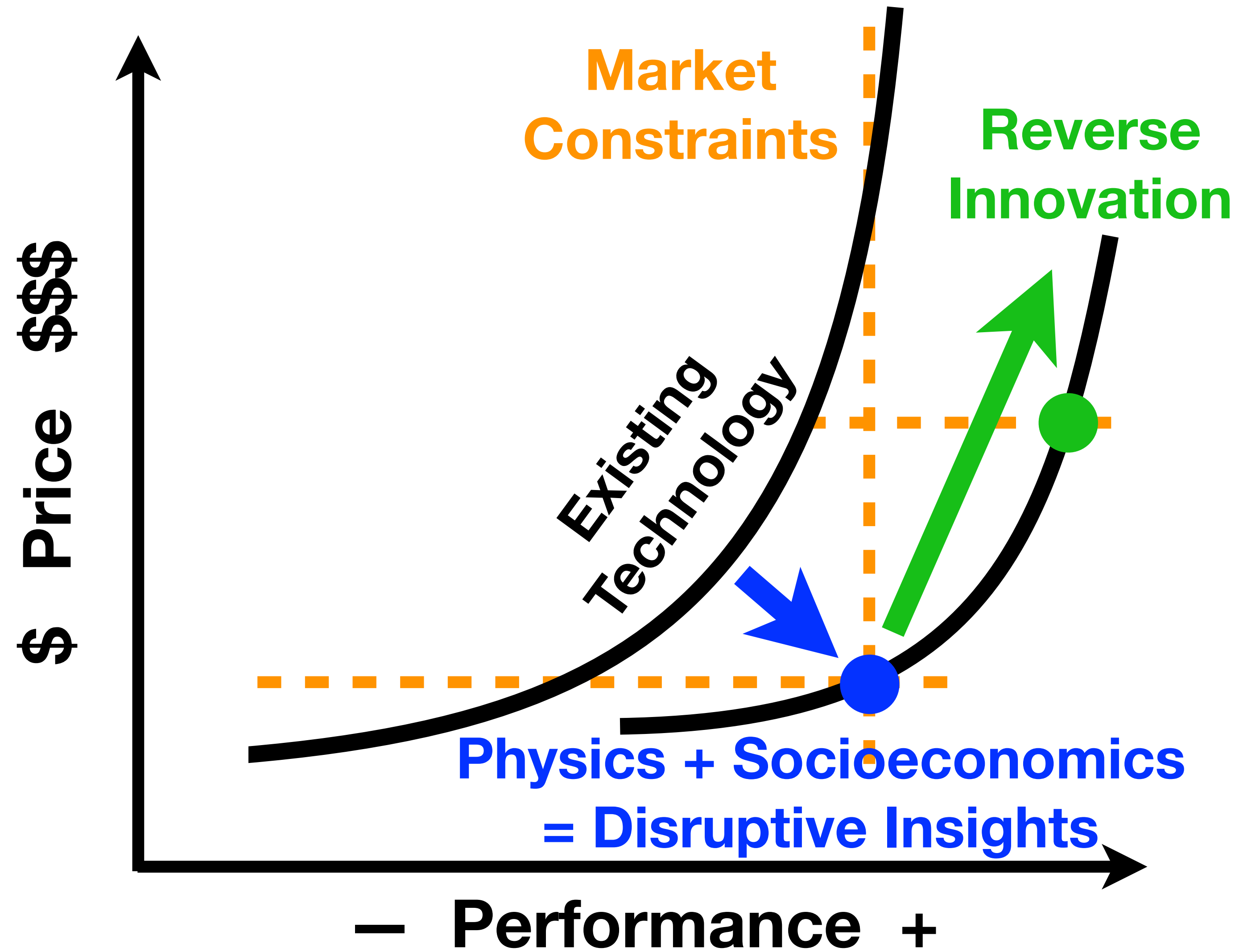
2. T. Moe, C. Maasry, and R. Tang. *Global Economics Paper No. 204, EM Equity in Two Decades: A Changing Landscape*. Technical report, Goldman Sachs, 2010.

Engineering Global Development: characterize the unique technical and socioeconomic constraints of emerging markets, use engineering science and product design to create high-performance, low-cost, globally-relevant technologies.

**Elucidate new markets
by characterizing
socioeconomic and
technical constraints**

**Use engineering science
and product design to
create disruptive insights**

**Reverse innovate to
impact rich and poor
markets alike**



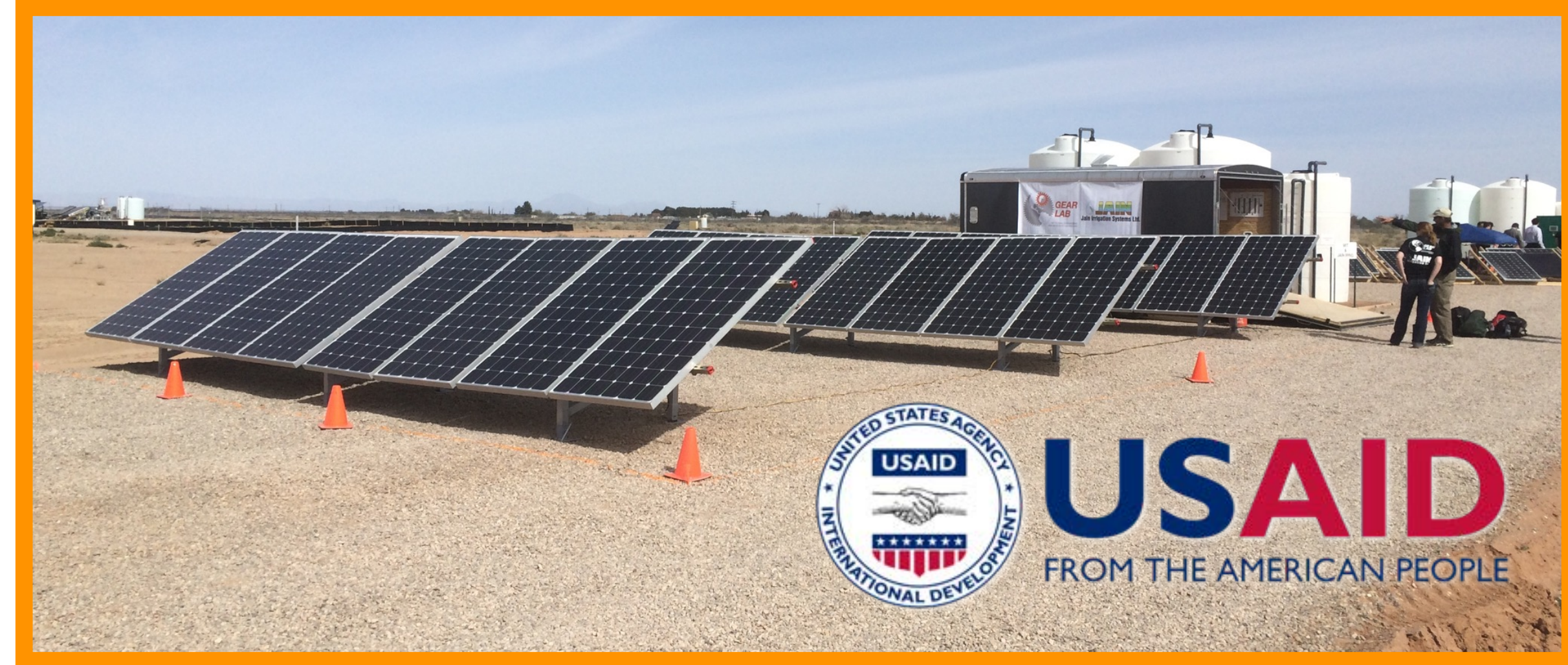
Winter V, A.G. and V. Govindarajan. "Engineering Reverse Innovations". *Harvard Business Review*, July-Aug, 2015
(Winner, 2016 McKinsey Award for best paper of the year in HBR)

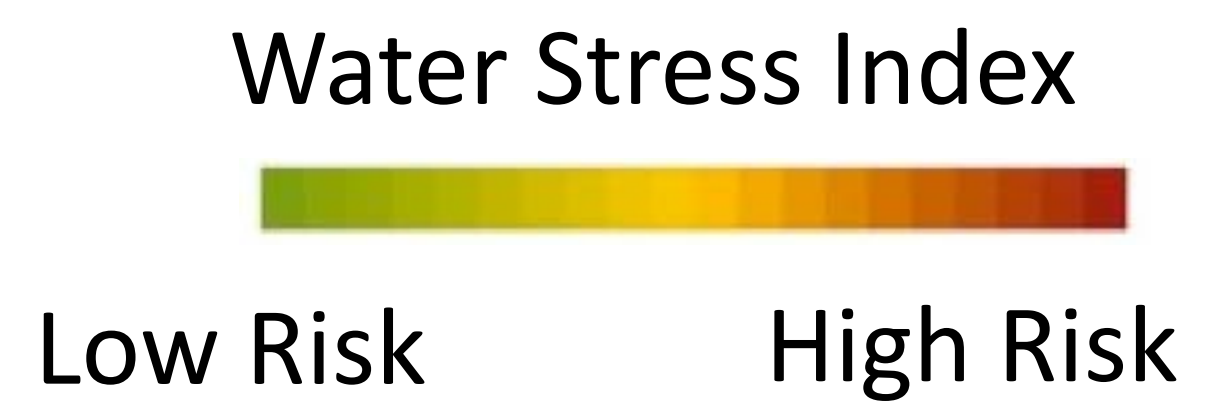
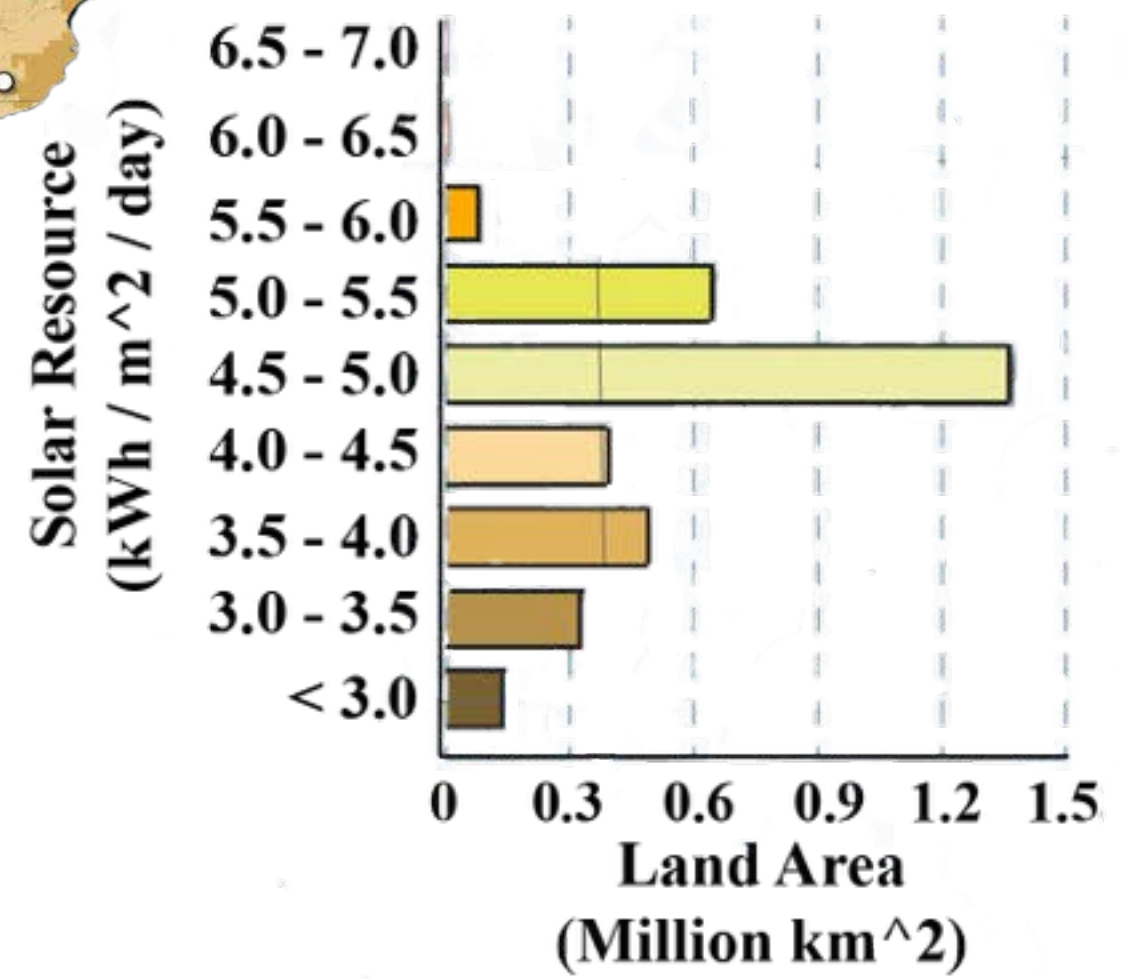
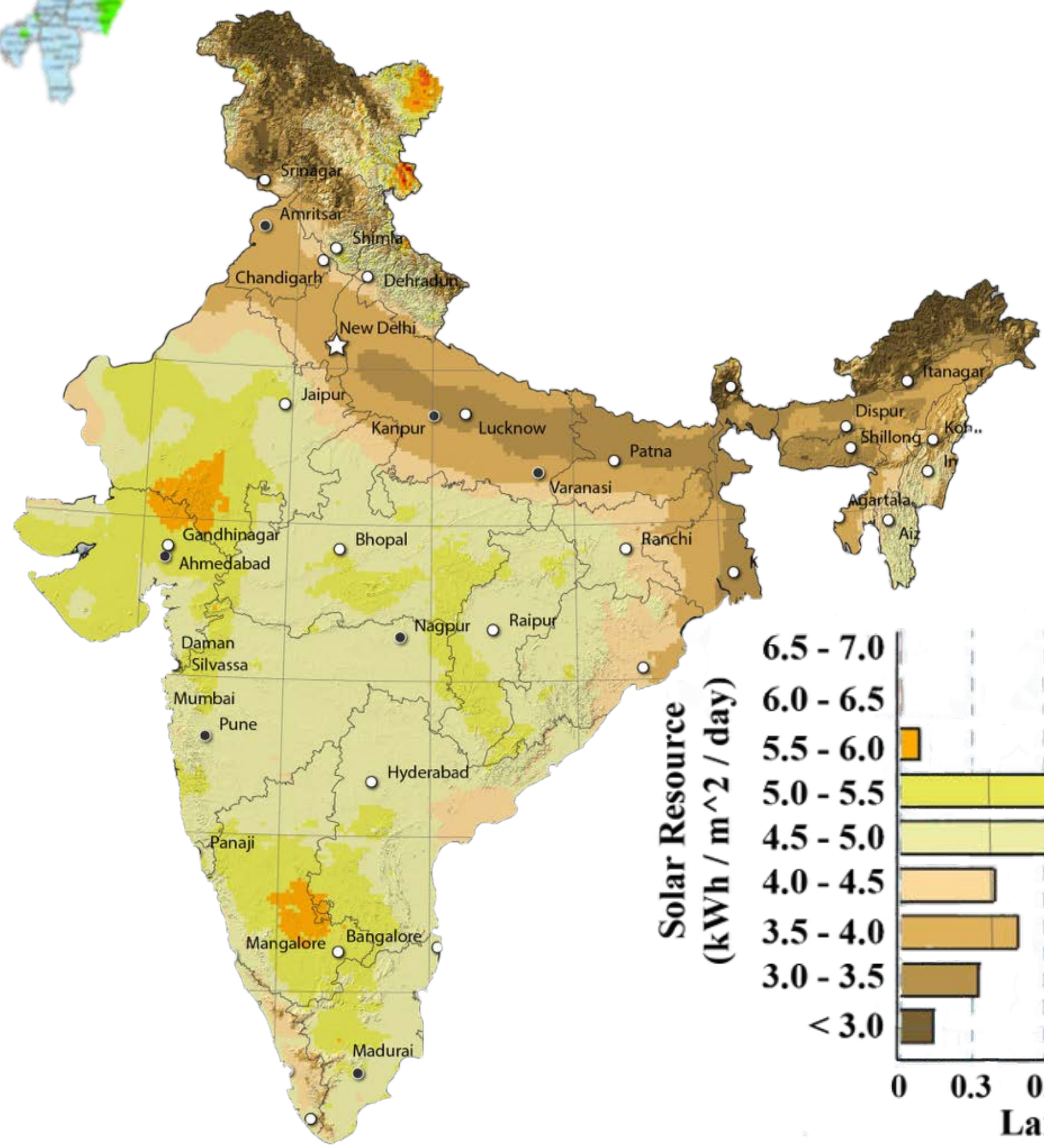
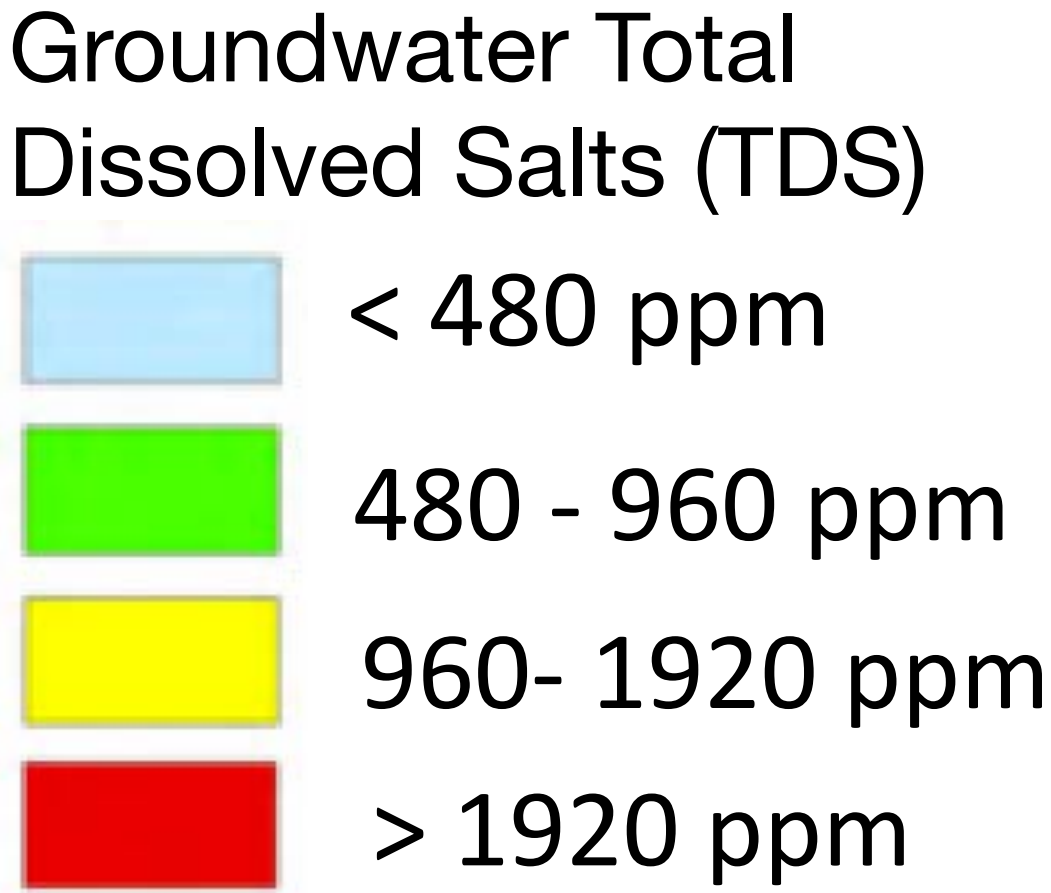
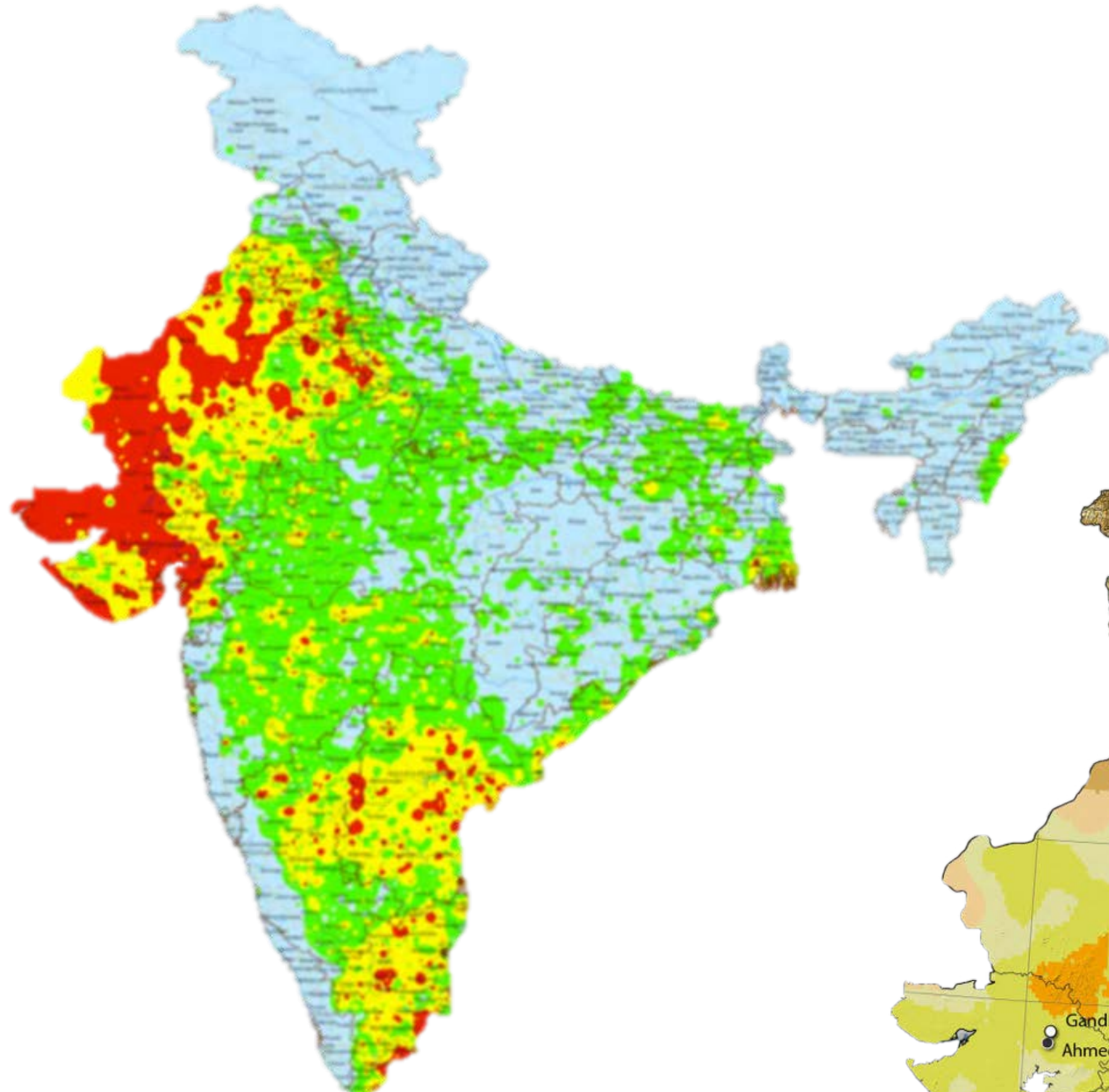
Winter V, A.G. and V. Govindarajan. "What Engineering a Reverse Innovation Looks Like". *Harvard Business Review (online)*, Nov. 2015

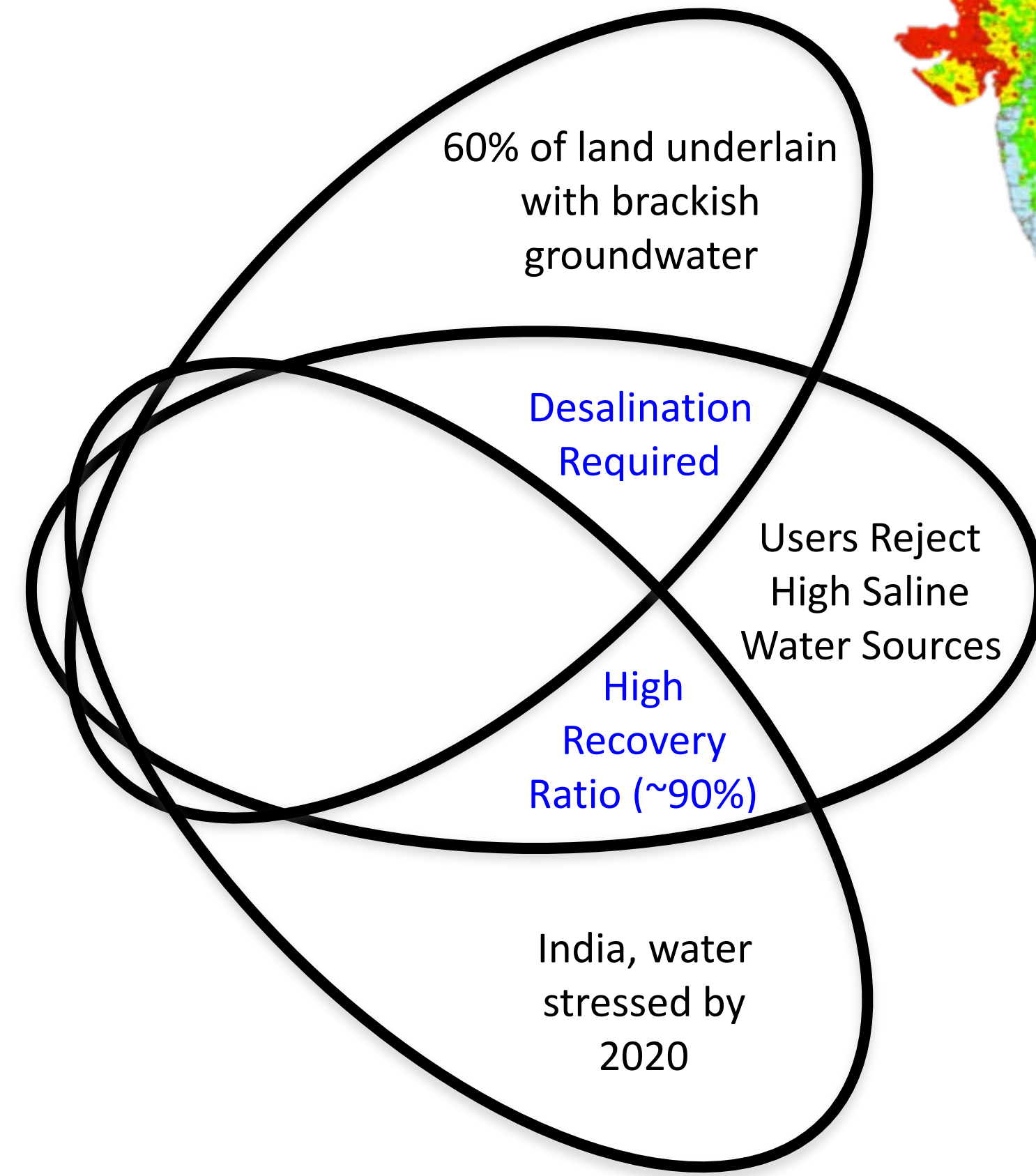
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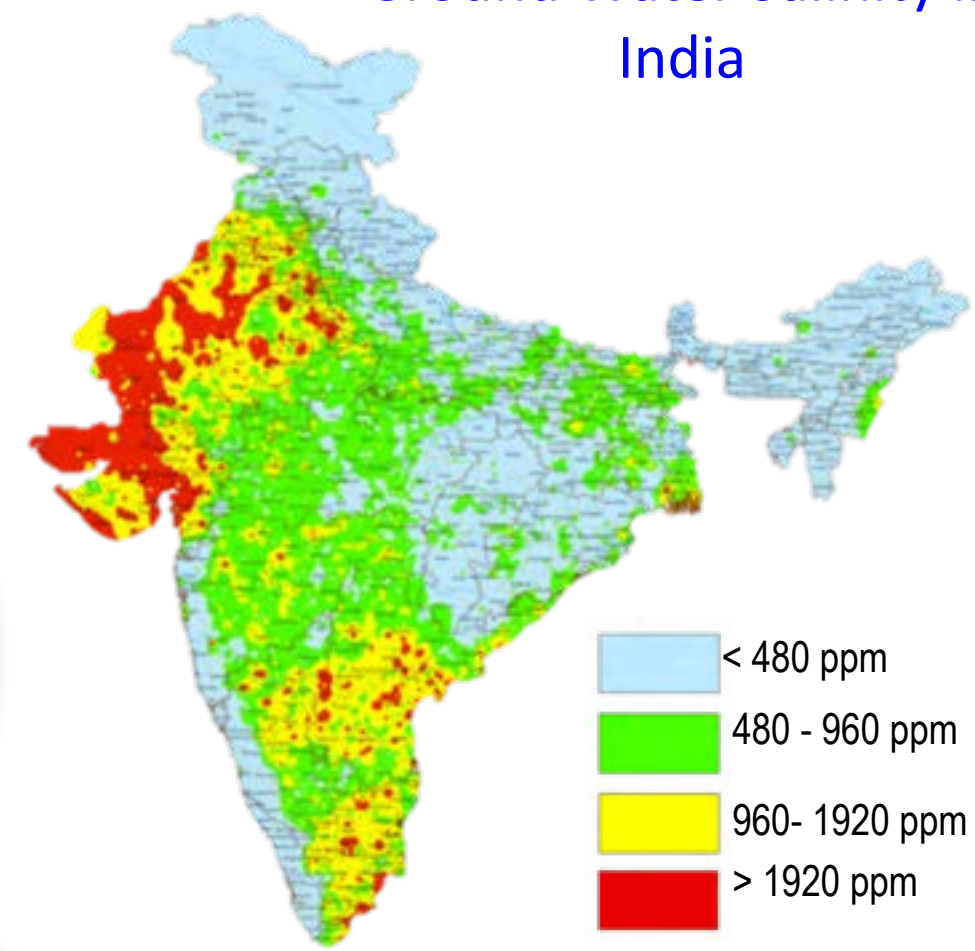
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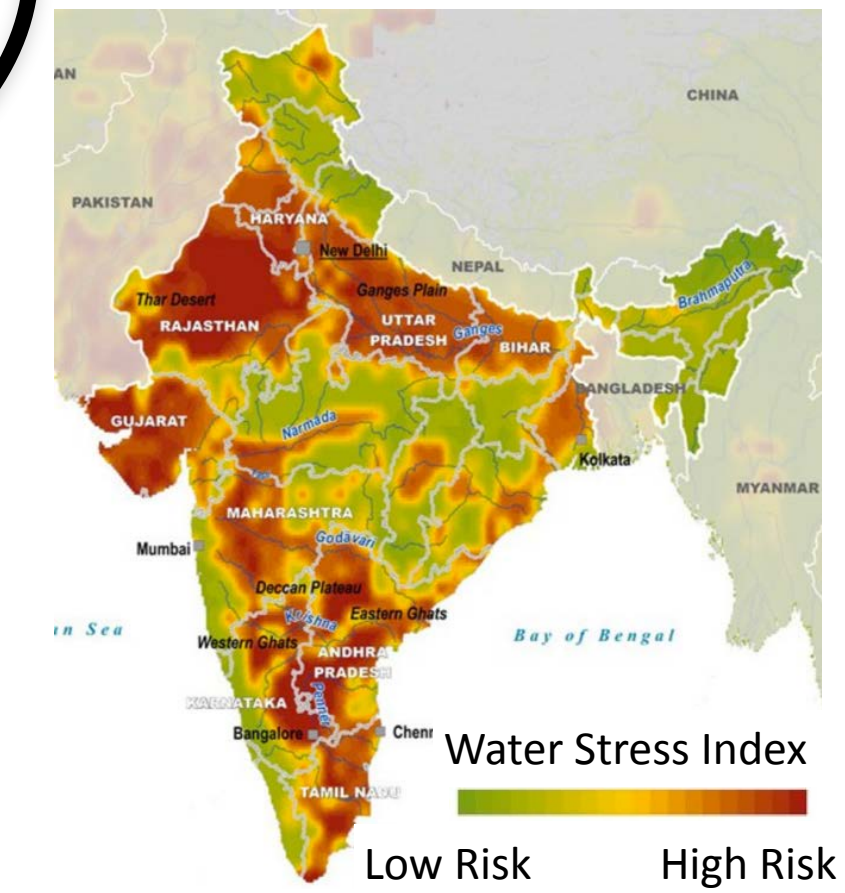




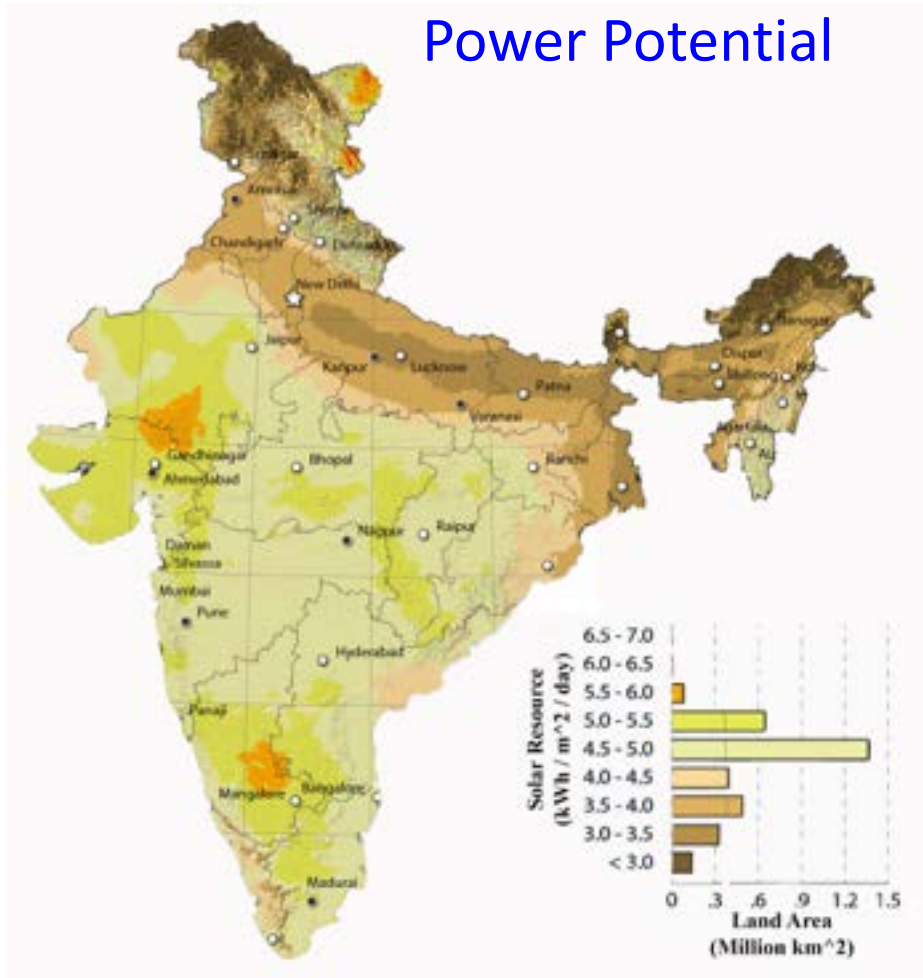
Ground Water Salinity in India



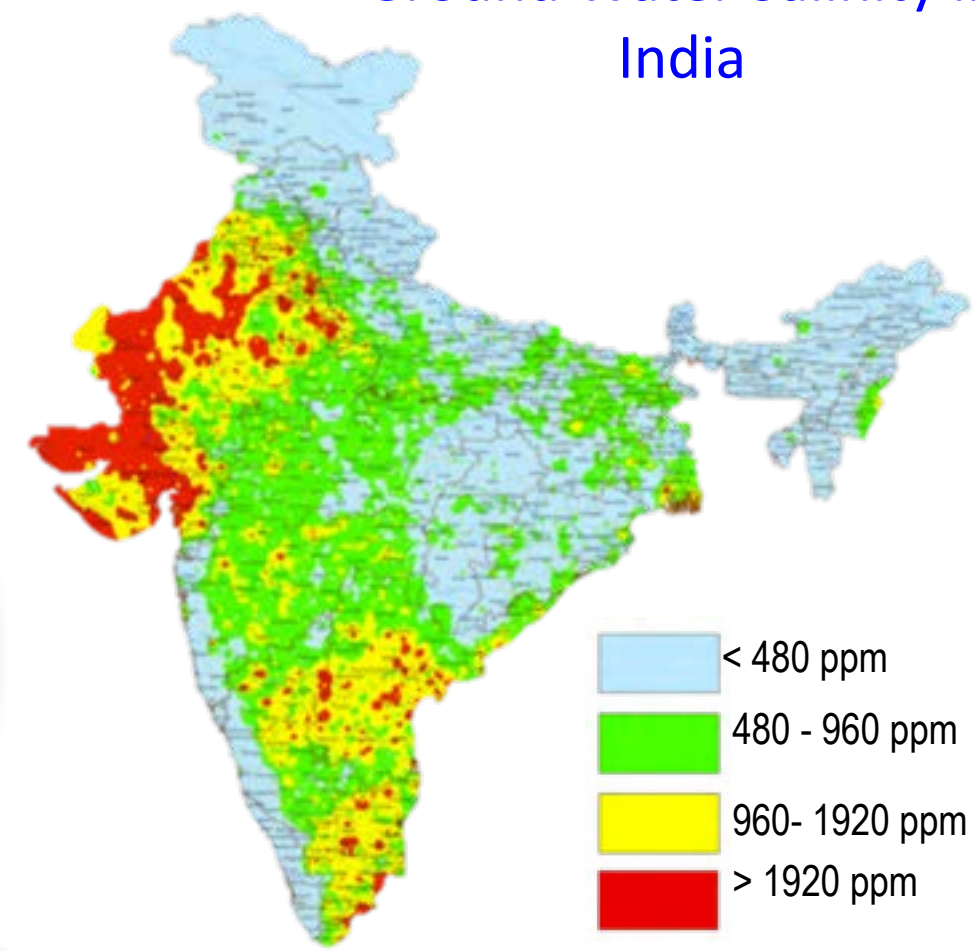
Water Scarce Regions of India



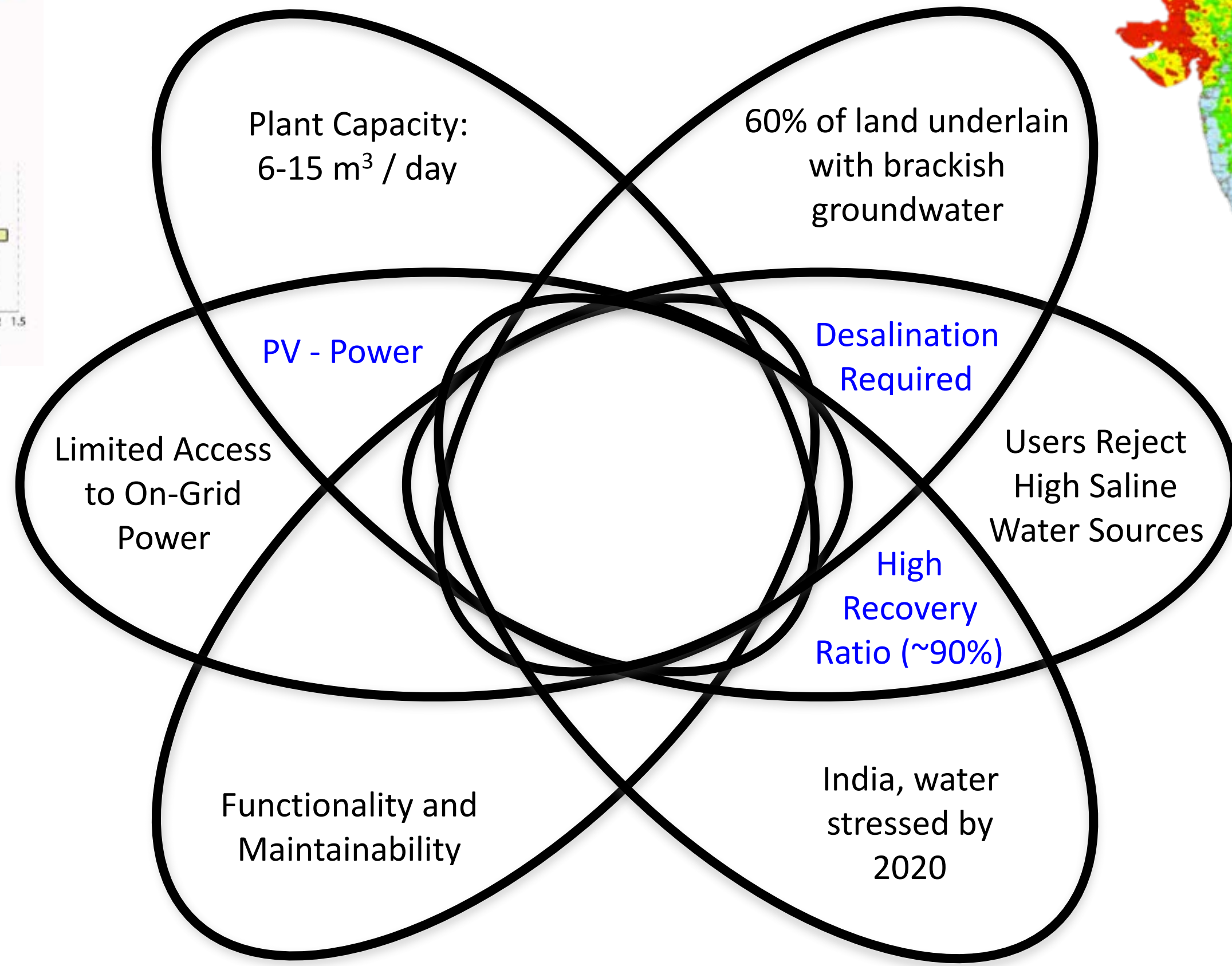
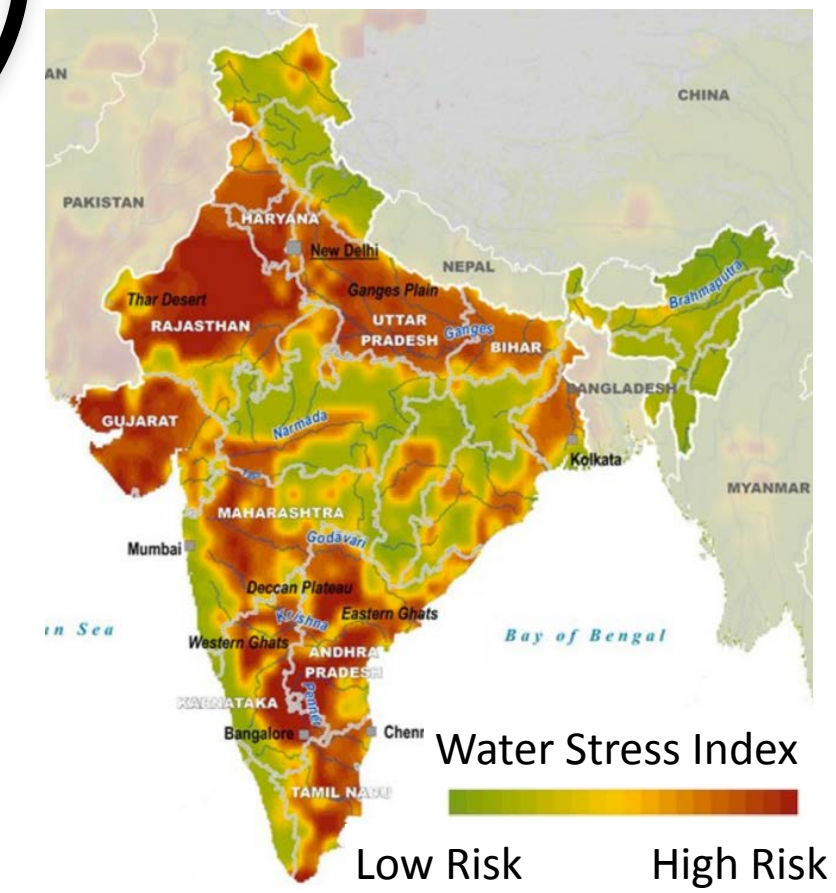
Solar Irradiance in India = PV Power Potential



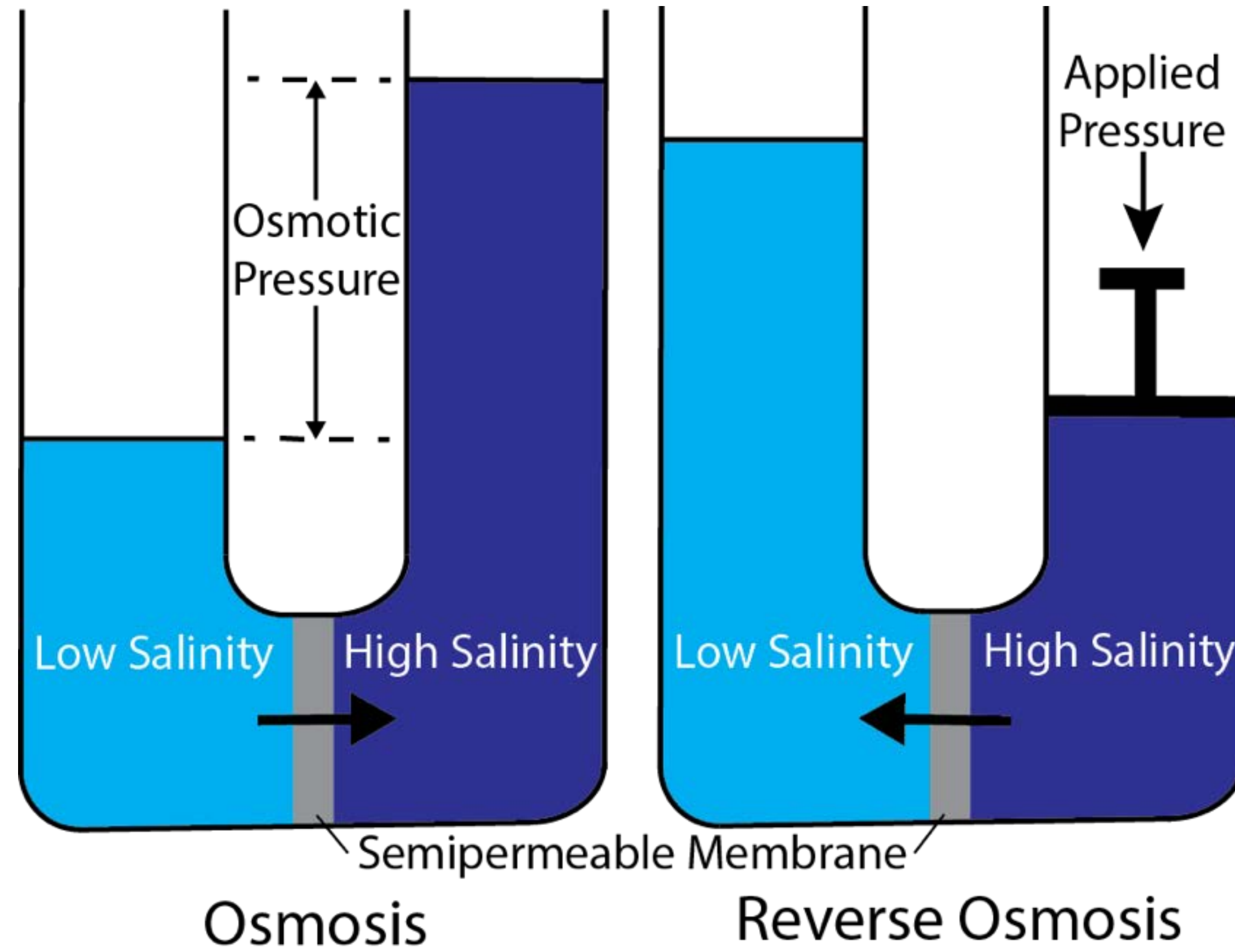
Ground Water Salinity in India



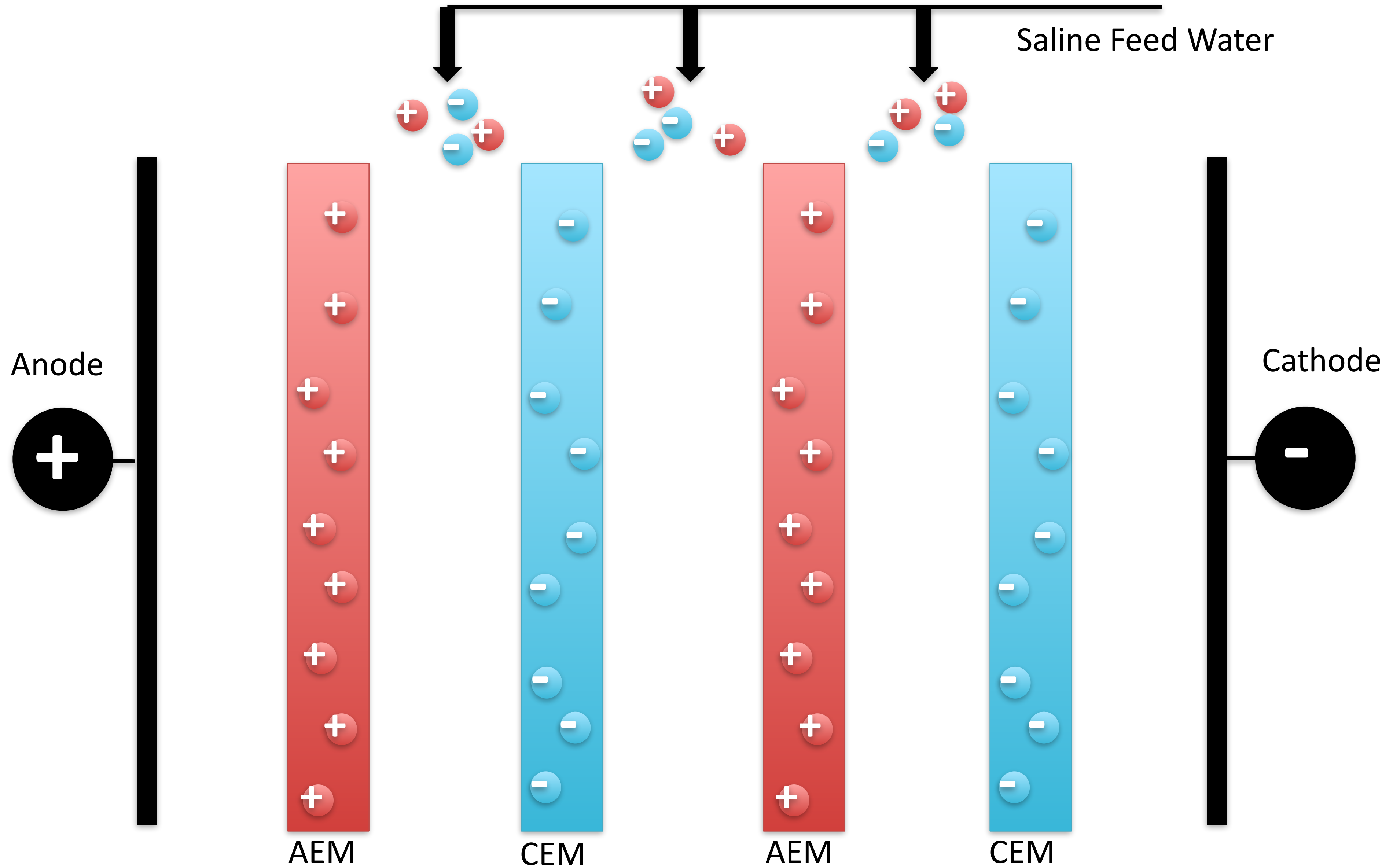
Water Scarce Regions of India



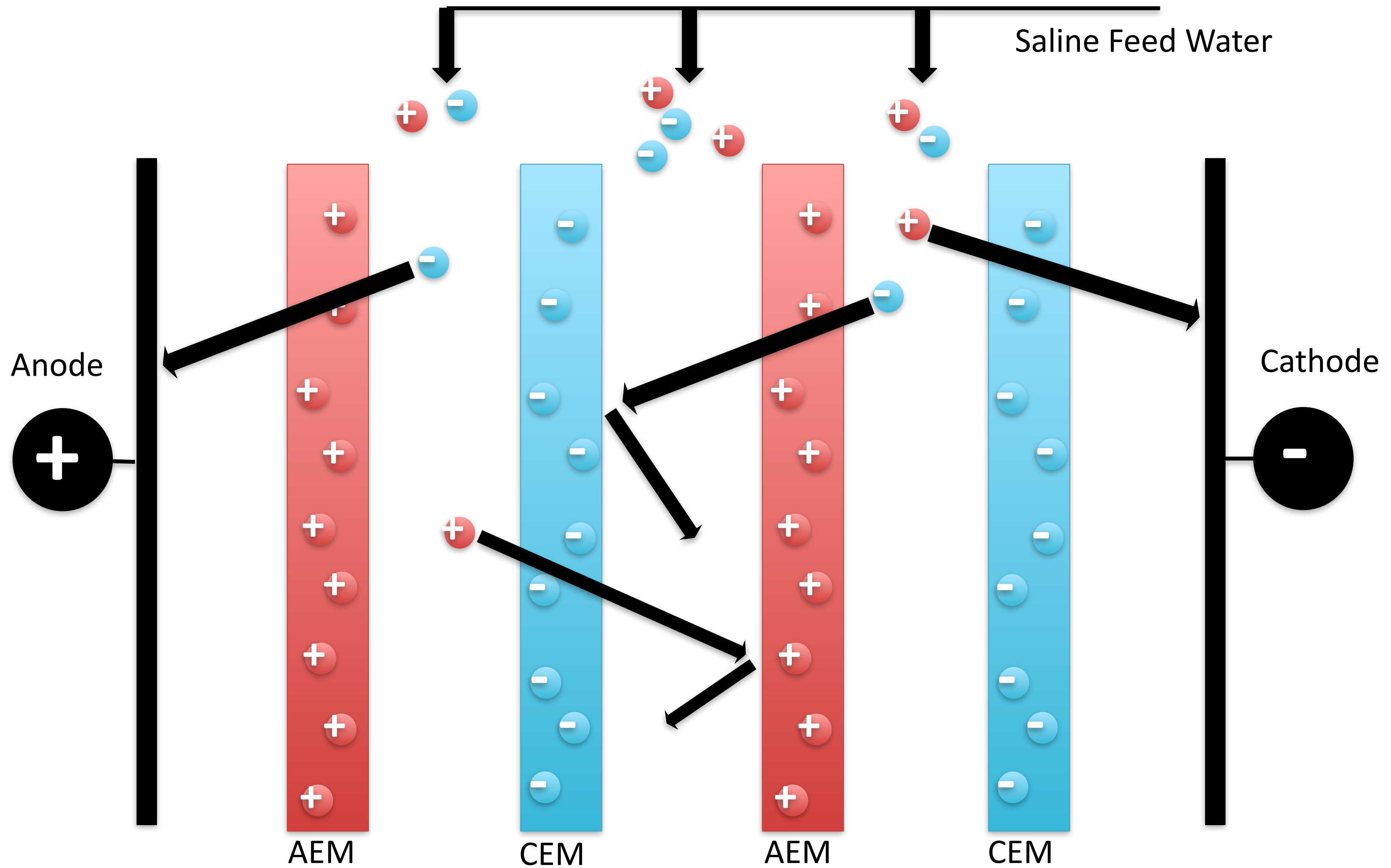
Reverse Osmosis



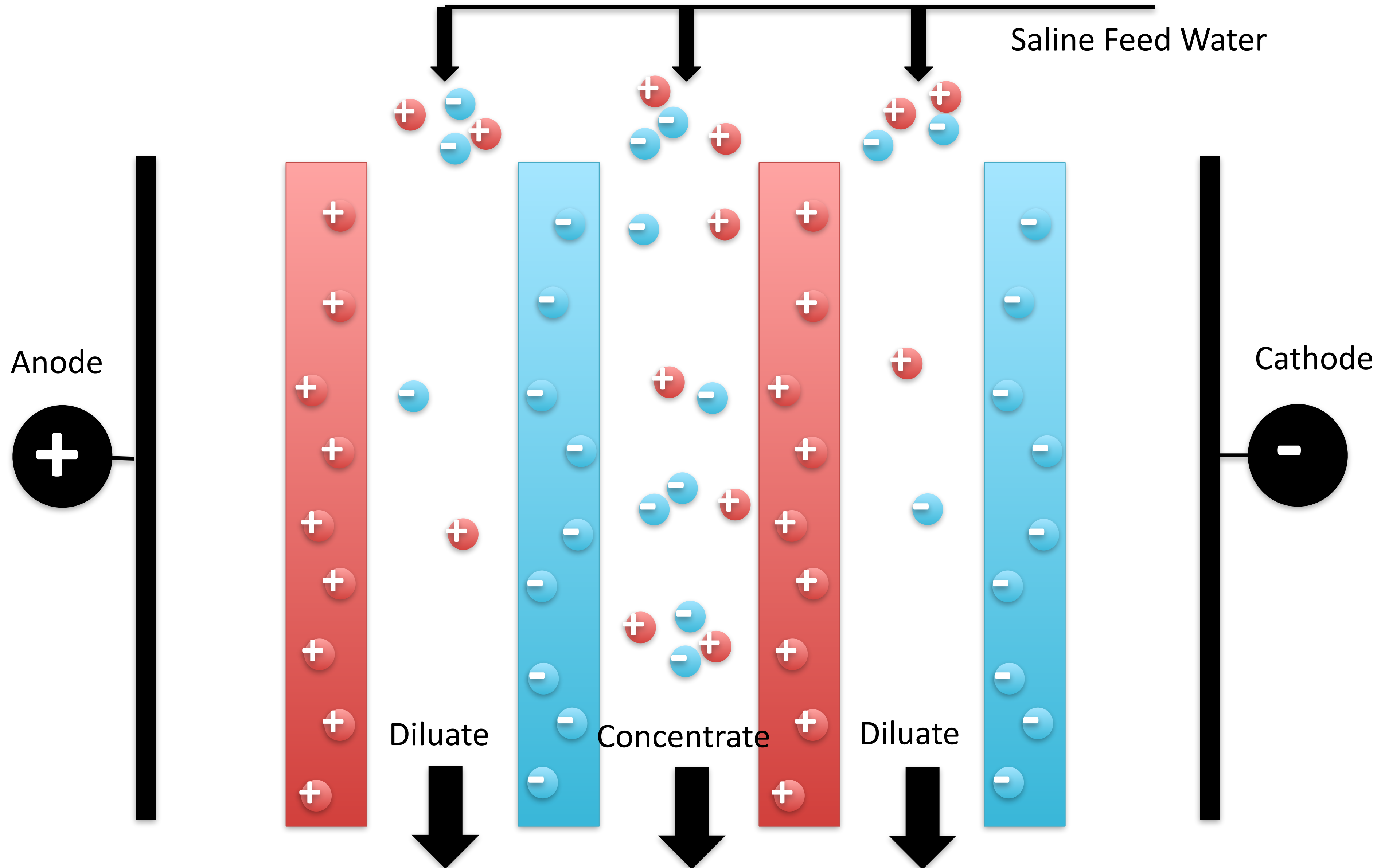
Electrodialysis



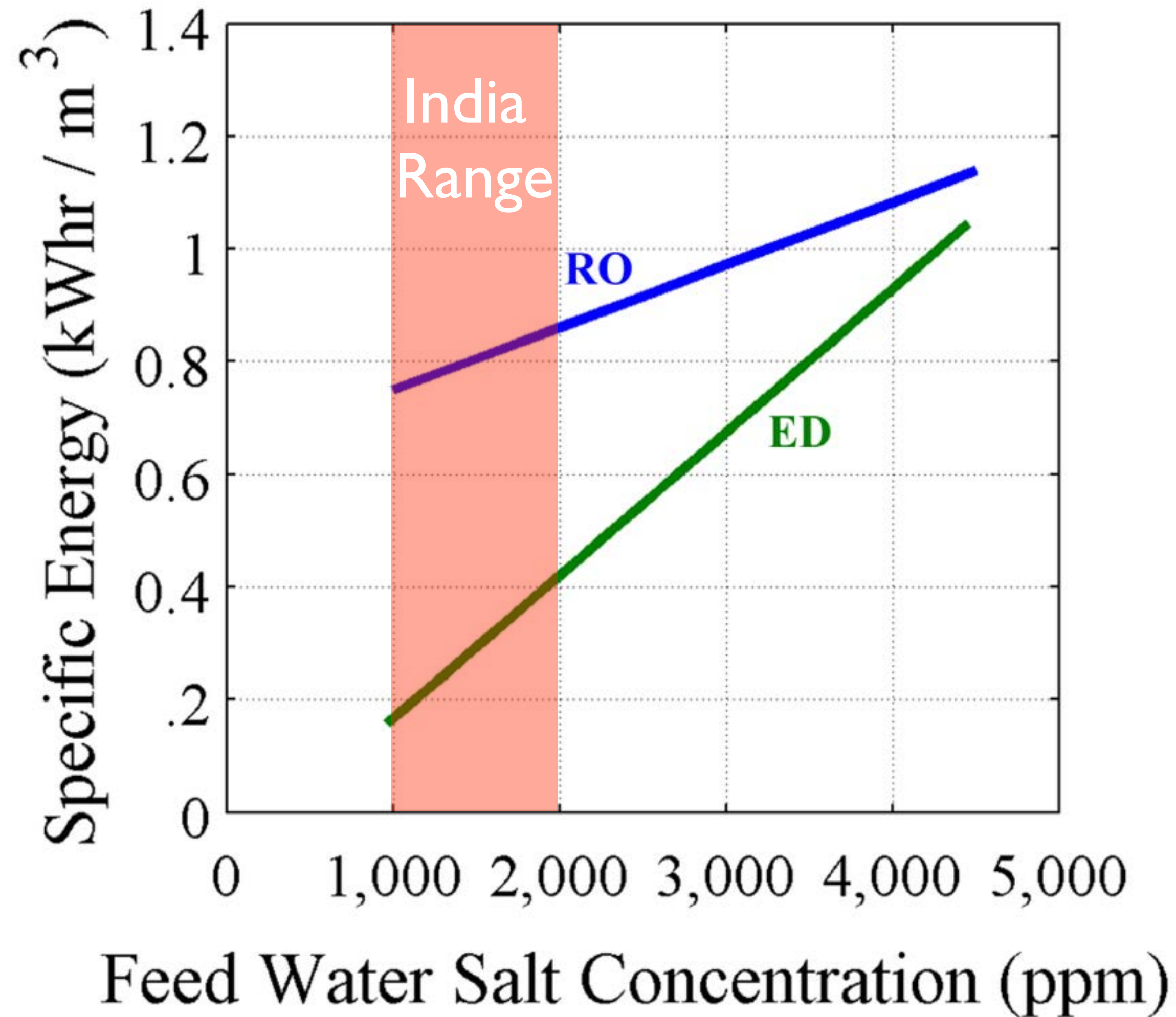
Electrodialysis



Electrodialysis



Dependence of Specific Energy on Feed Water Salinity



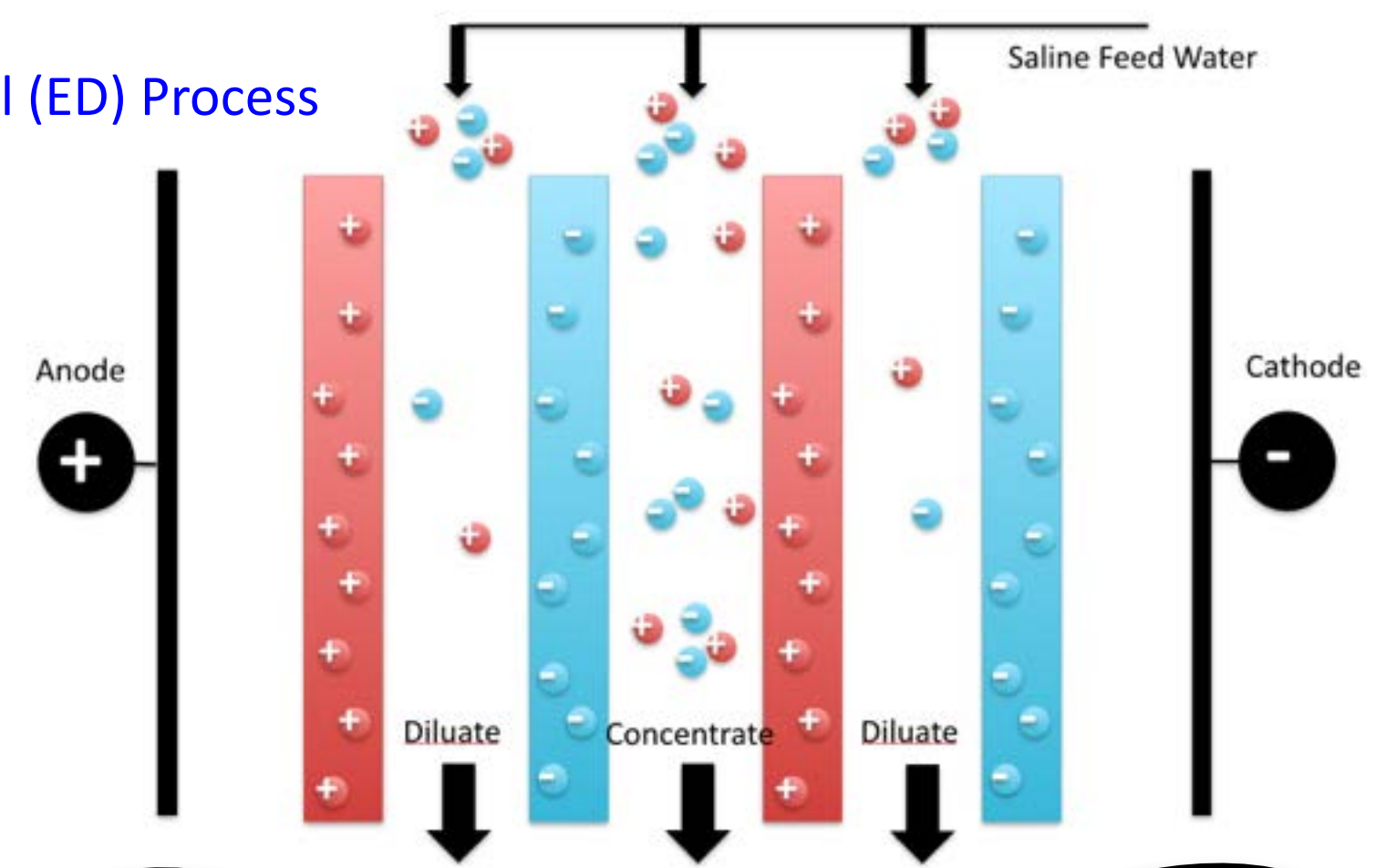
PV-RO systems currently economically unviable

>50% PV-RO cost is in the power system

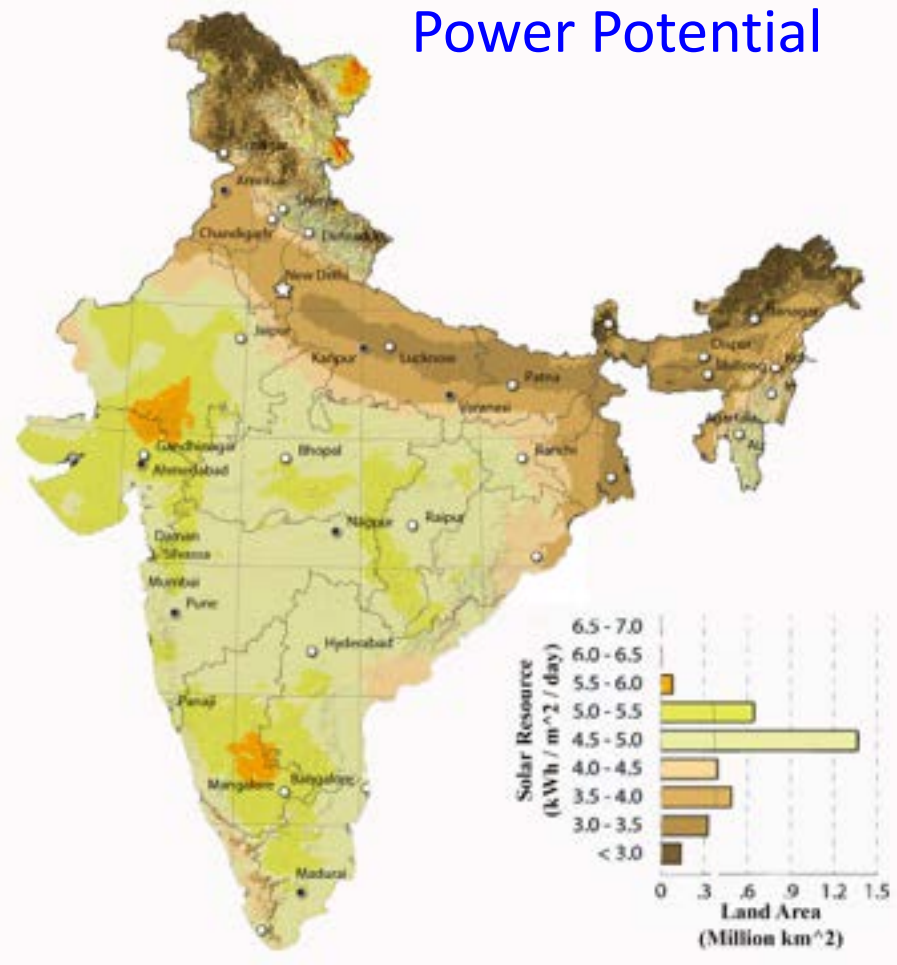
ED can cut the cost of power system by >50% compared to RO, create affordable system

**RO wastes 40-70%;
ED wastes 5-10% input water**

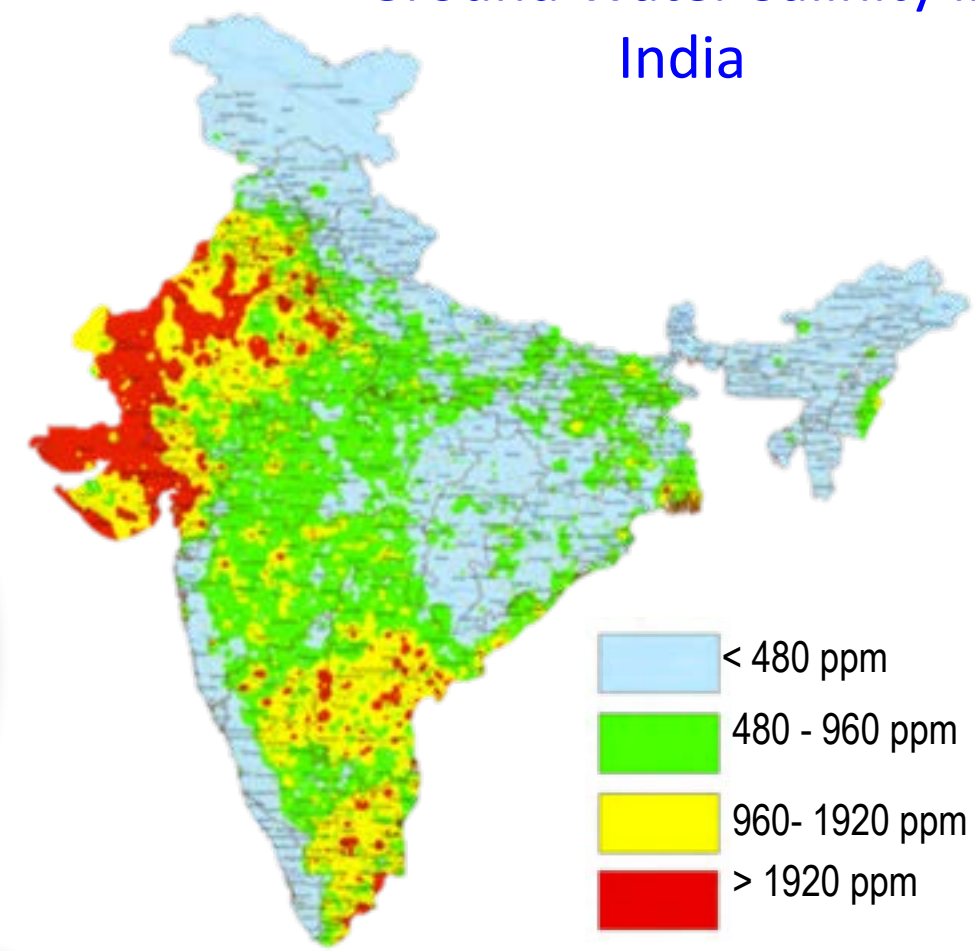
Electrodialysis Reversal (ED) Process



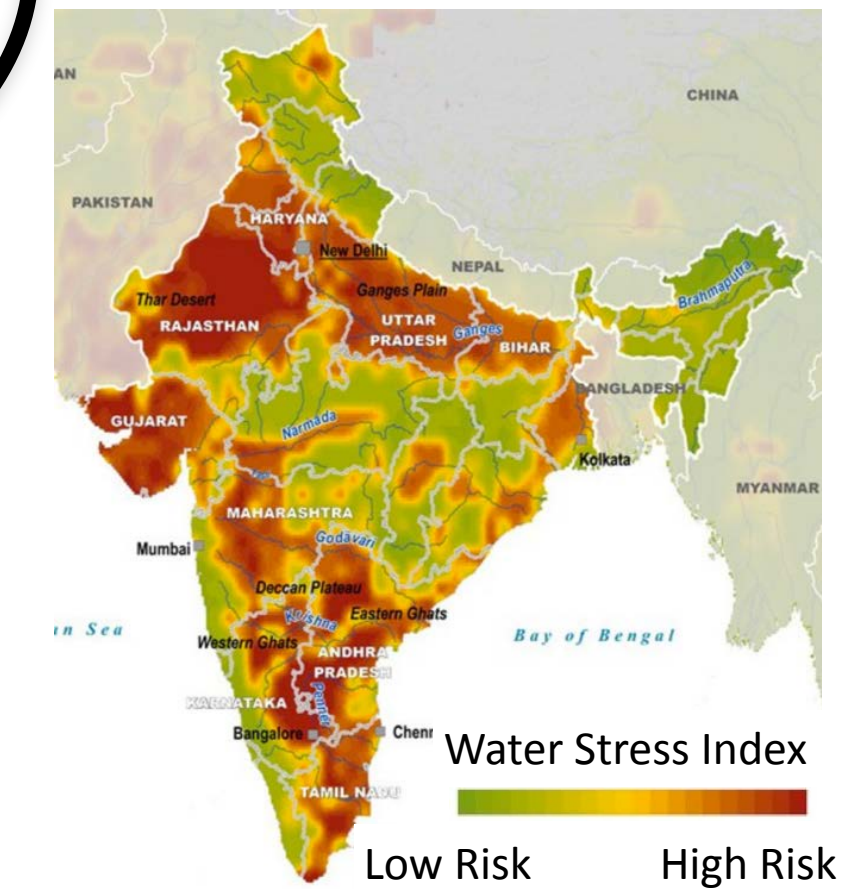
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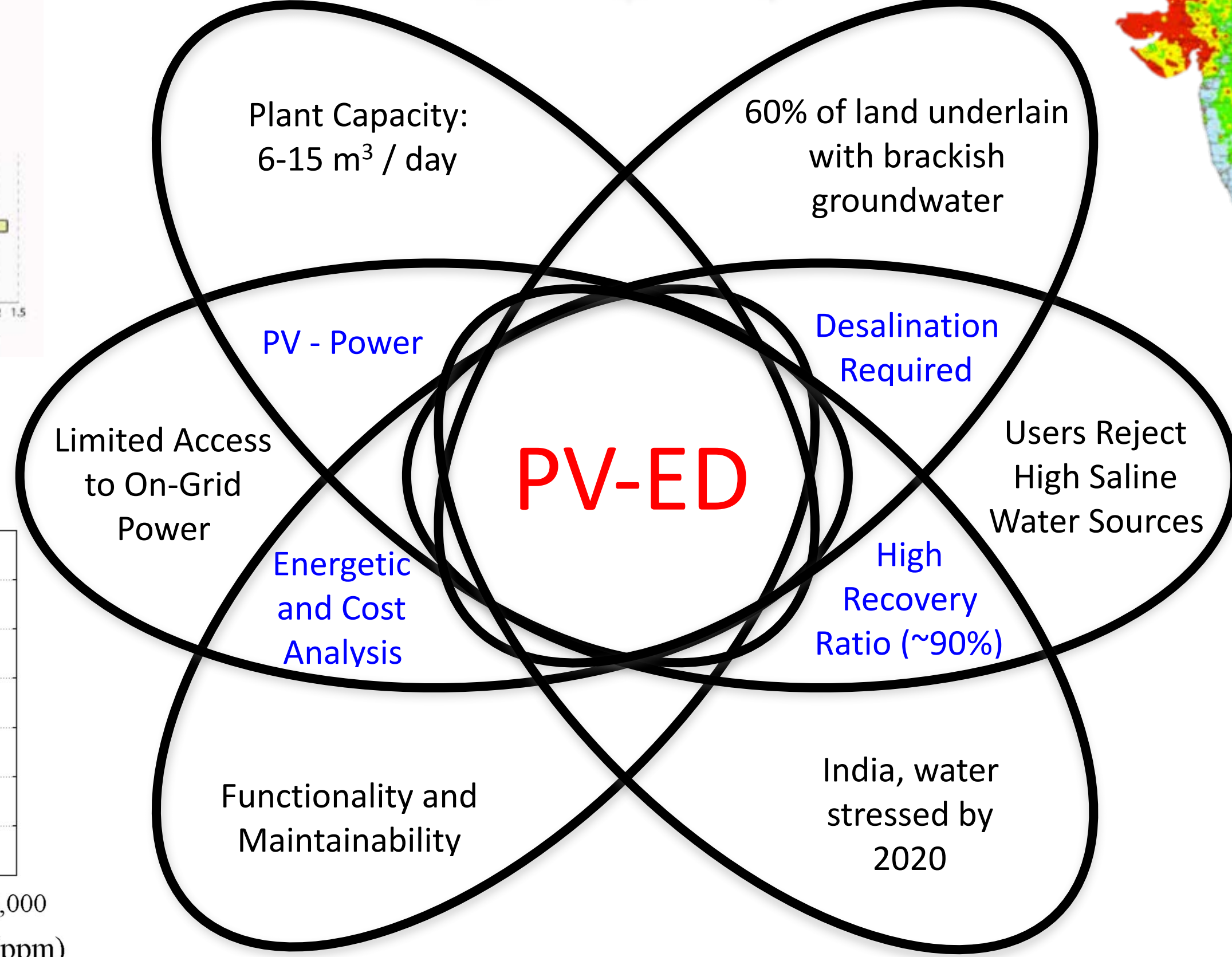
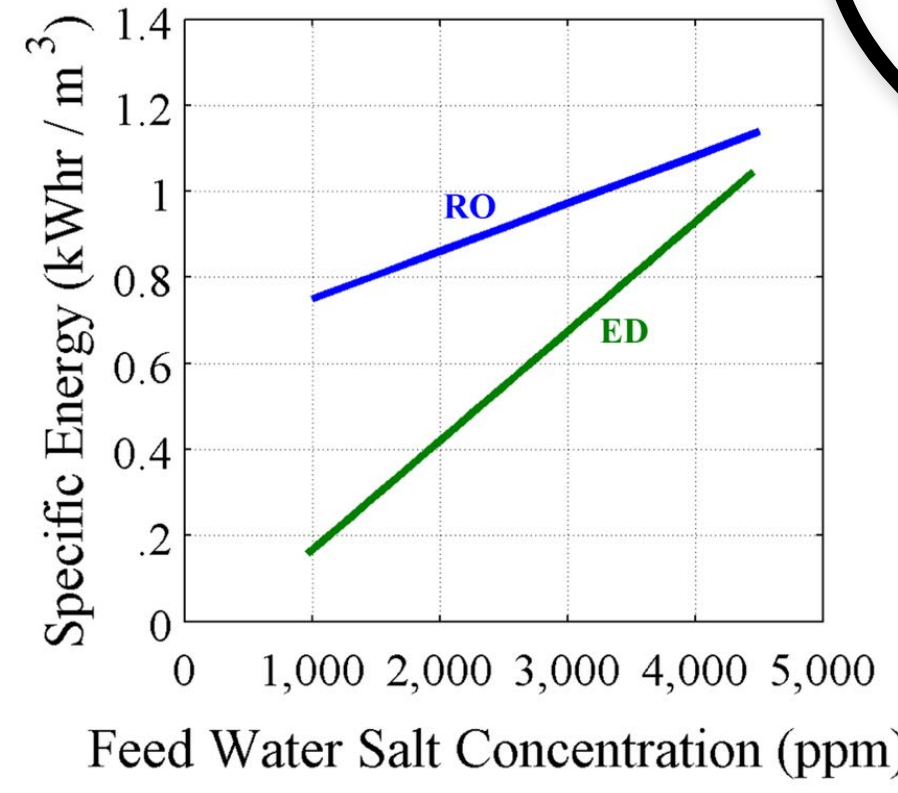
Ground Water Salinity in India



Water Scarce Regions of India



Energetic Advantage of ED over RO



Student



Natasha Wright
MSME 2014
Cont. PhD Student
Forbes 30 under 30 2016

Sponsors



Winner



USAID
FROM THE AMERICAN PEOPLE

Desal Prize



Alamogordo, NM

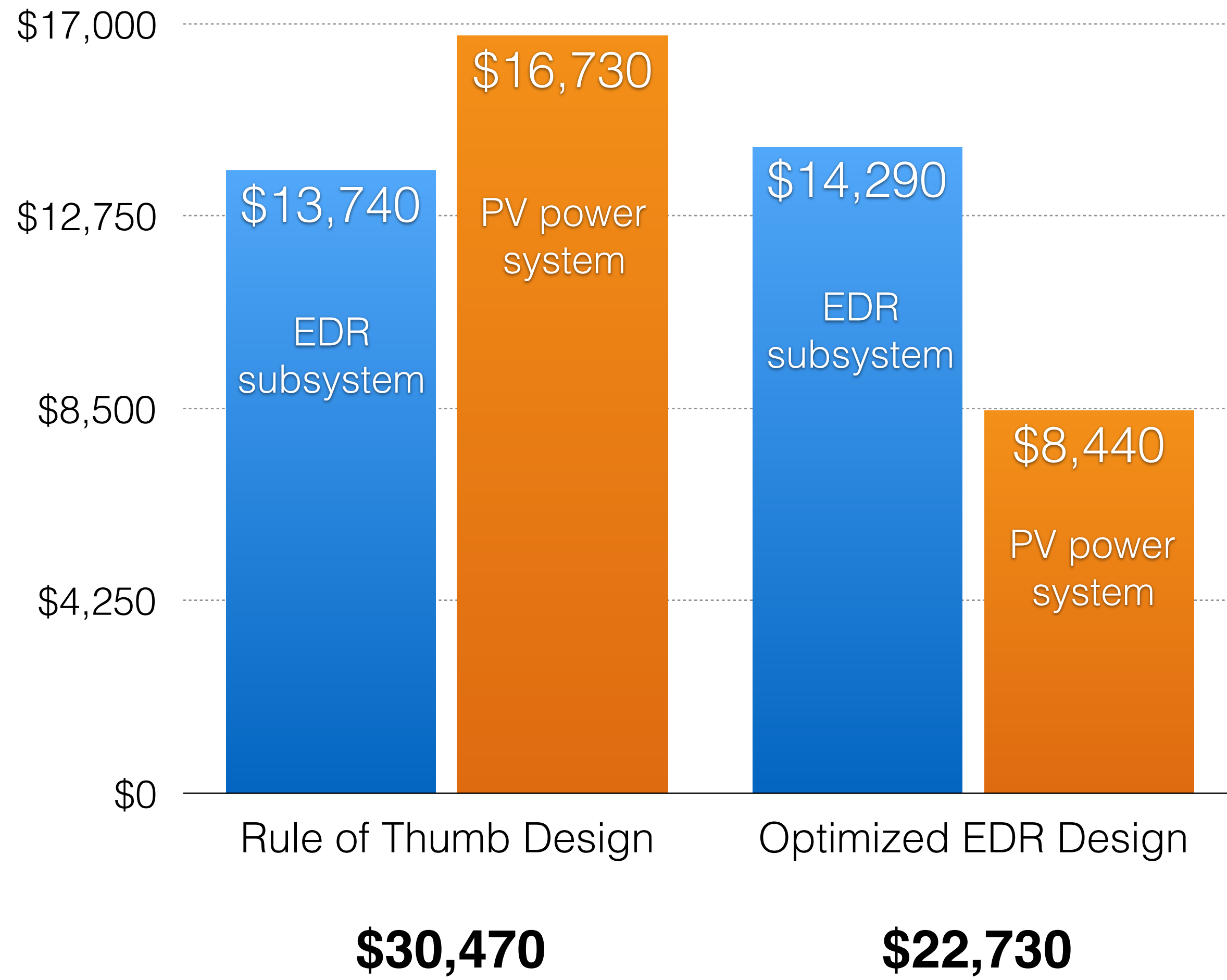


Jalgaon, India



**Two more pilots run
in 2017:
Al Saada, Gaza
and
Chelluru, India**

Comparison of Off-Grid Designs



**Optimized PV-EDR system
in Chelluru, India**



2.5 billion smallholder farmers (< 2 ha)

Water usage > replenishment
in India by 2025

- 70% used for agriculture

Drip irrigation grows 50% more
crops than rain, reduces water
consumption vs. flood by 60%

Student



Pulkit Shamsbery
MSME 2016
Cont. PhD Student

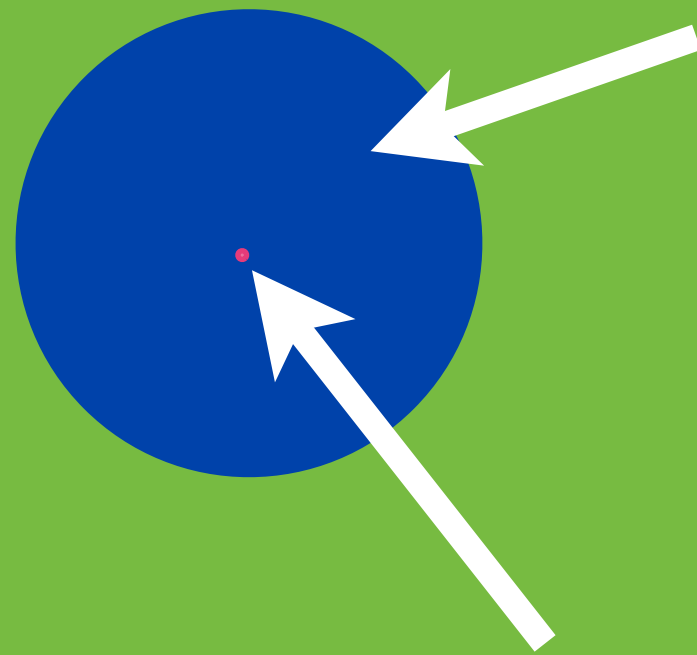
Sponsors



**Total Cropland
(1.43 billion ha)**

**Total Irrigated Land
(257 million ha)**

**Total Land under Drip
(2.57 million ha)**



Student



Pulkit Shamsbery
MSME 2016
Cont. PhD Student

Sponsors



USAID
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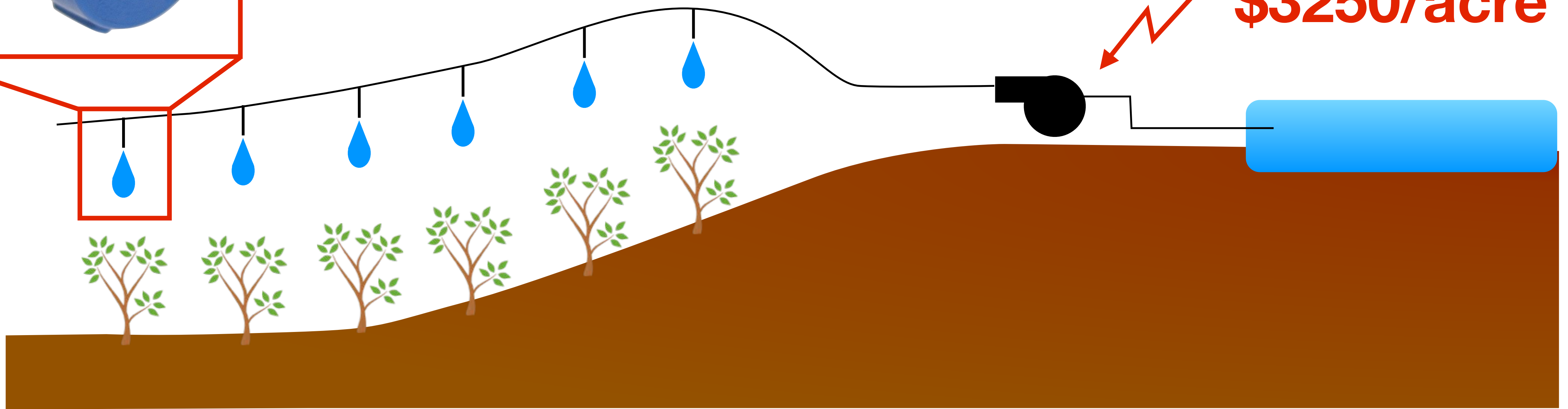
TATA CENTER
TECHNOLOGY + DESIGN

THE
ROCKEFELLER
FOUNDATION



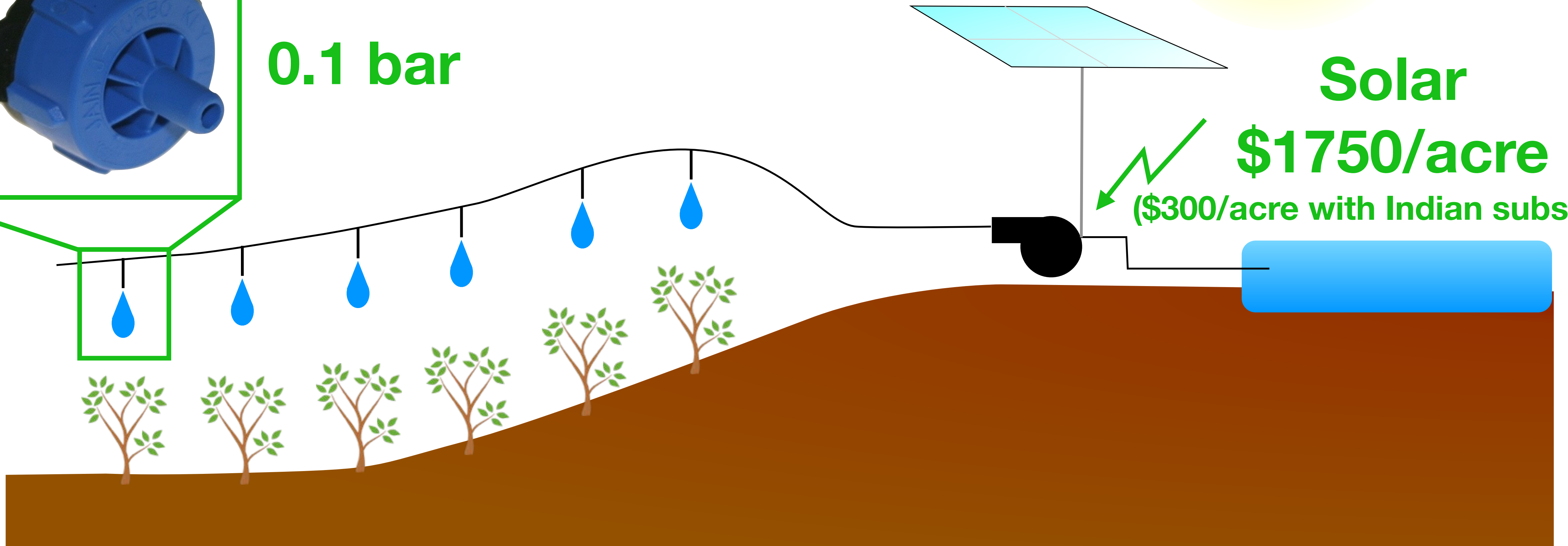
1 bar

**Solar or Diesel
\$3250/acre**





0.1 bar



Solar

\$1750/acre


(\$300/acre with Indian subsidies)

Feb. 1, 1949.

W. G. MILLER
FLOW CONTROL DEVICE
Filed April 5, 1947

2,460,647



Silicon Membrane


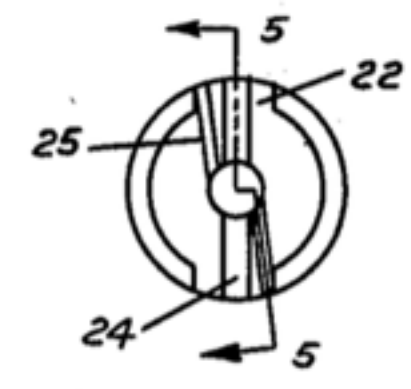


FIG. 6

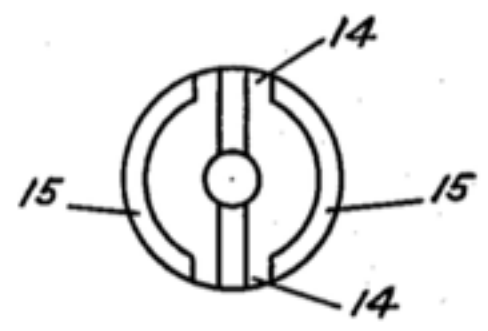


FIG. 3

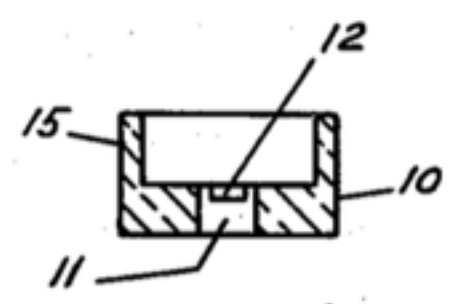


FIG. 4

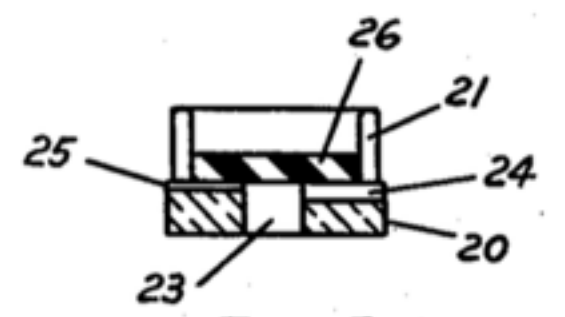


FIG. 5

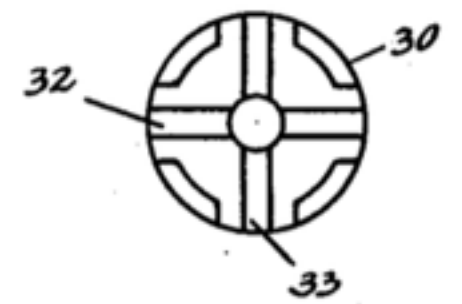


FIG. 8

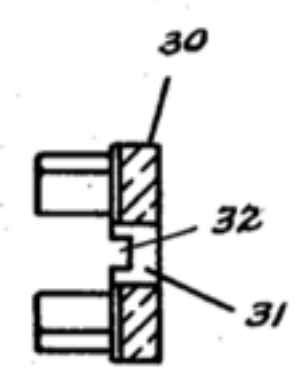


FIG. 9



FIG. 2

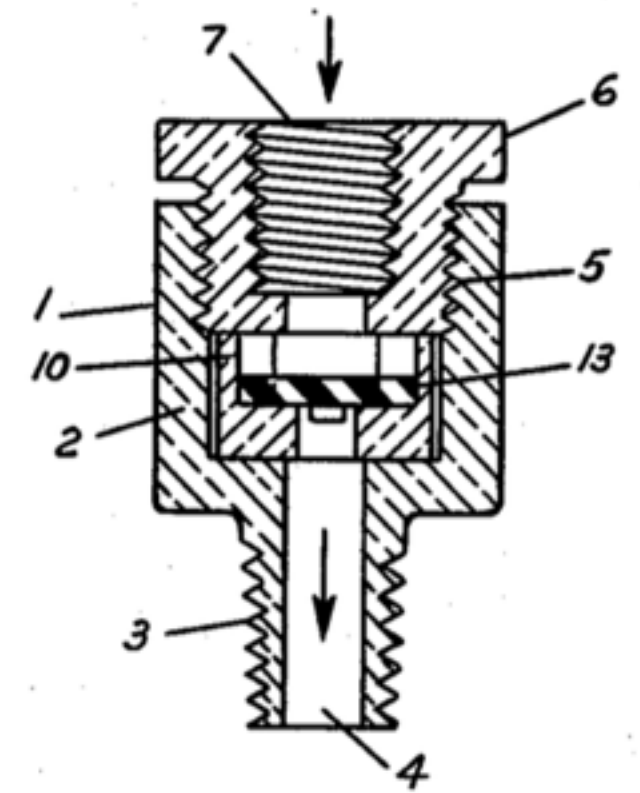


FIG. 1

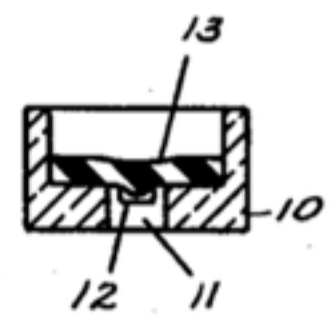


FIG. 7

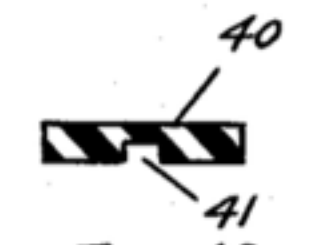
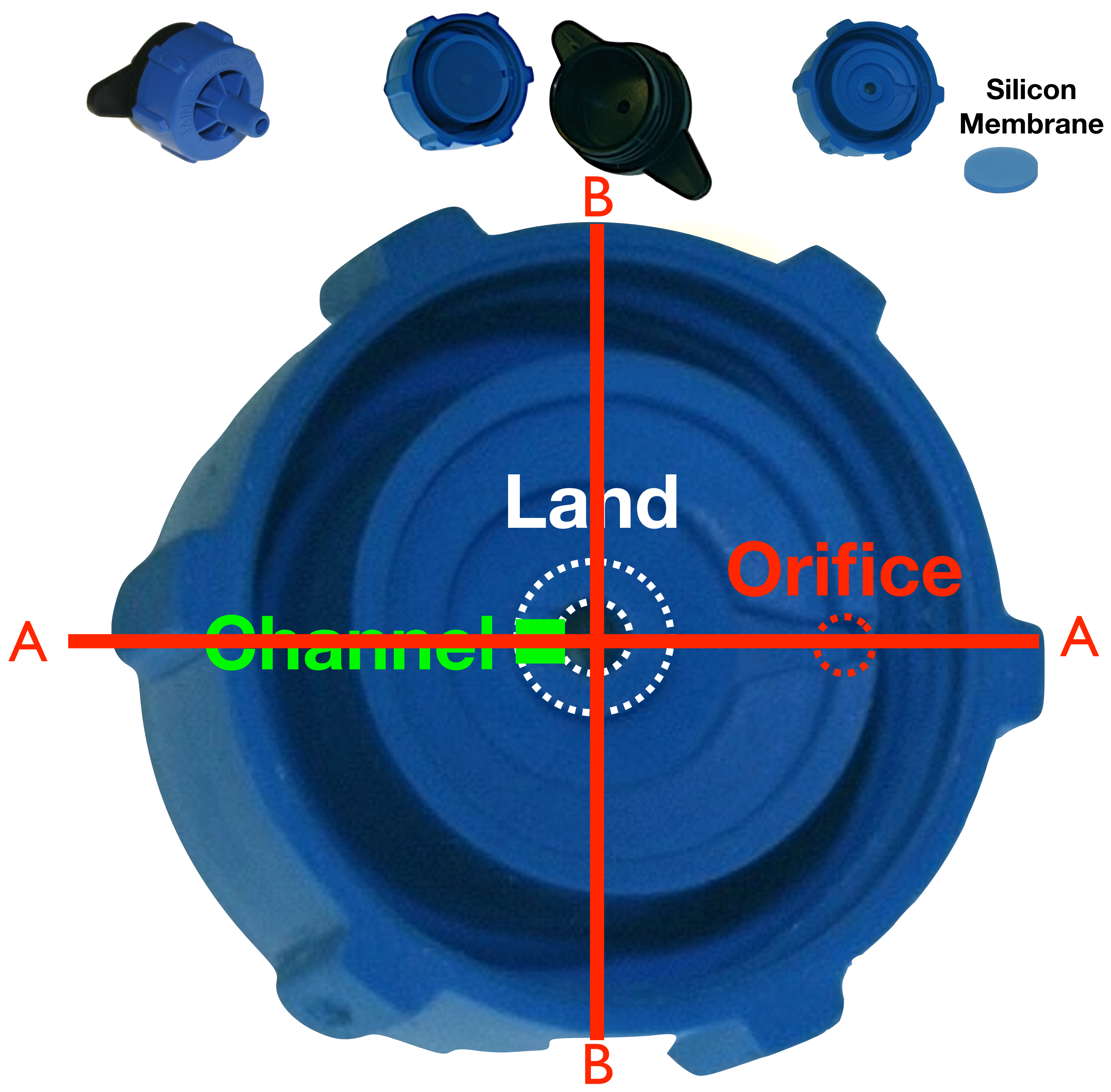
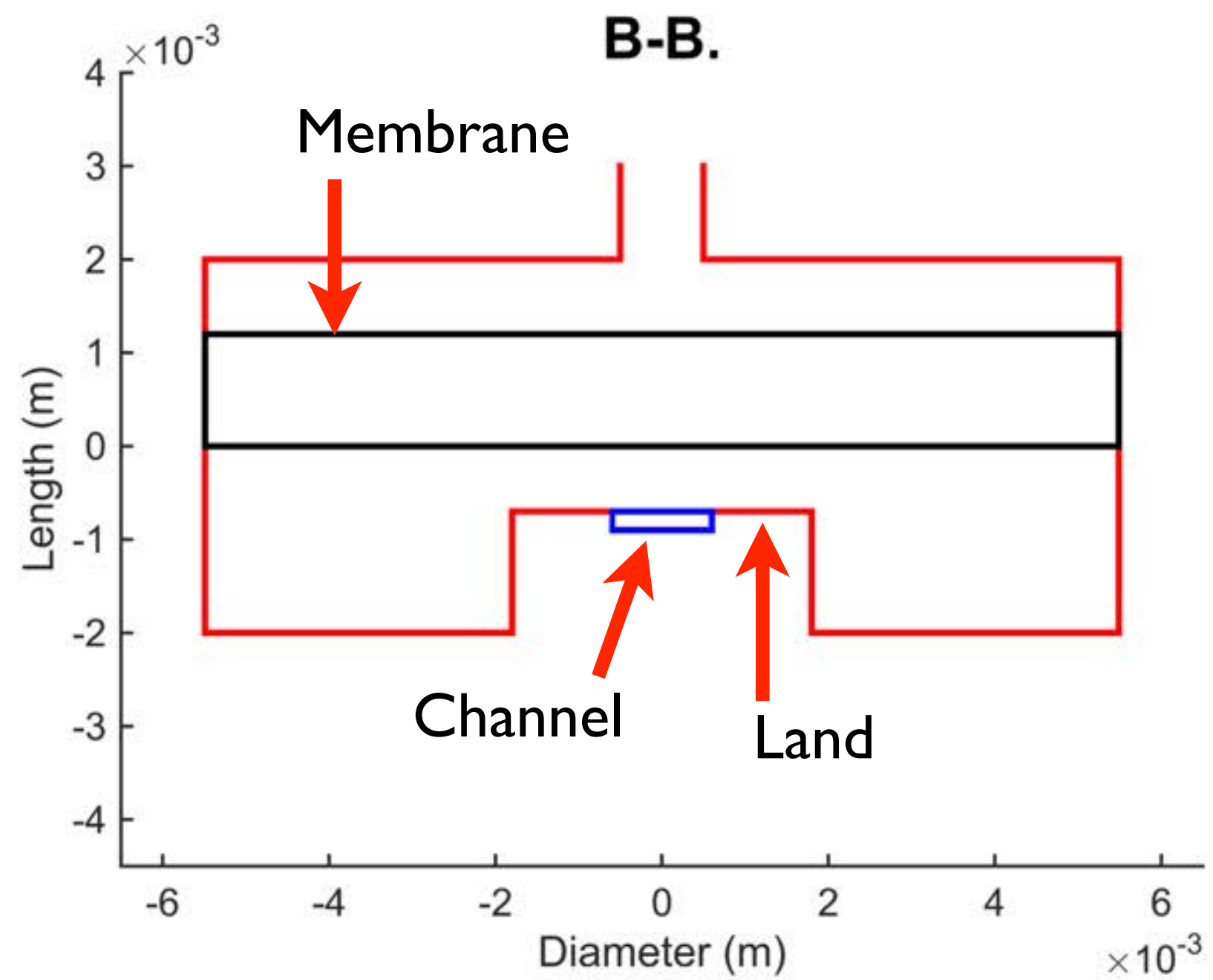
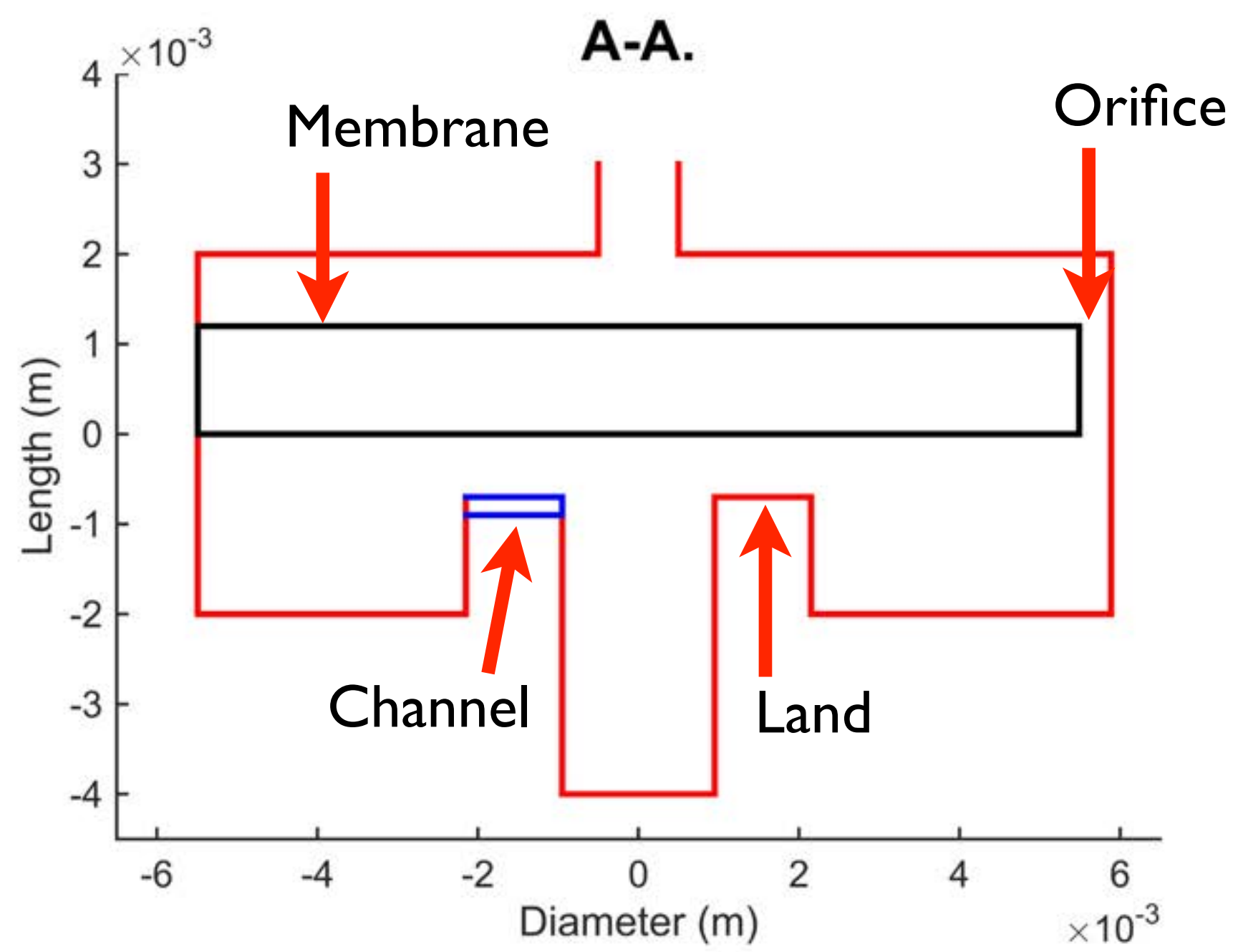


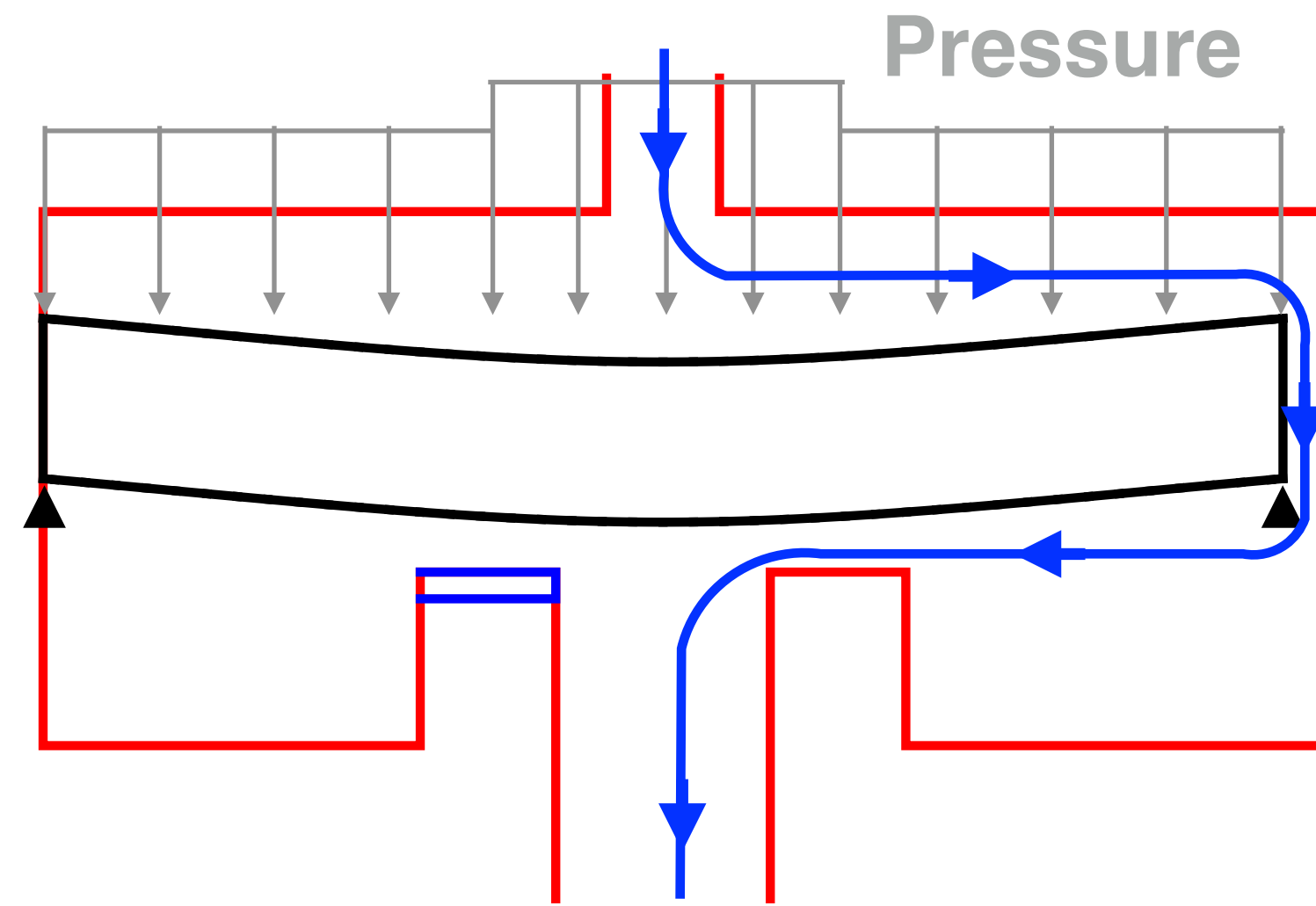
FIG. 10

INVENTOR.
 Wesley G. Miller
 BY
 Florin & Miller
 Atty.



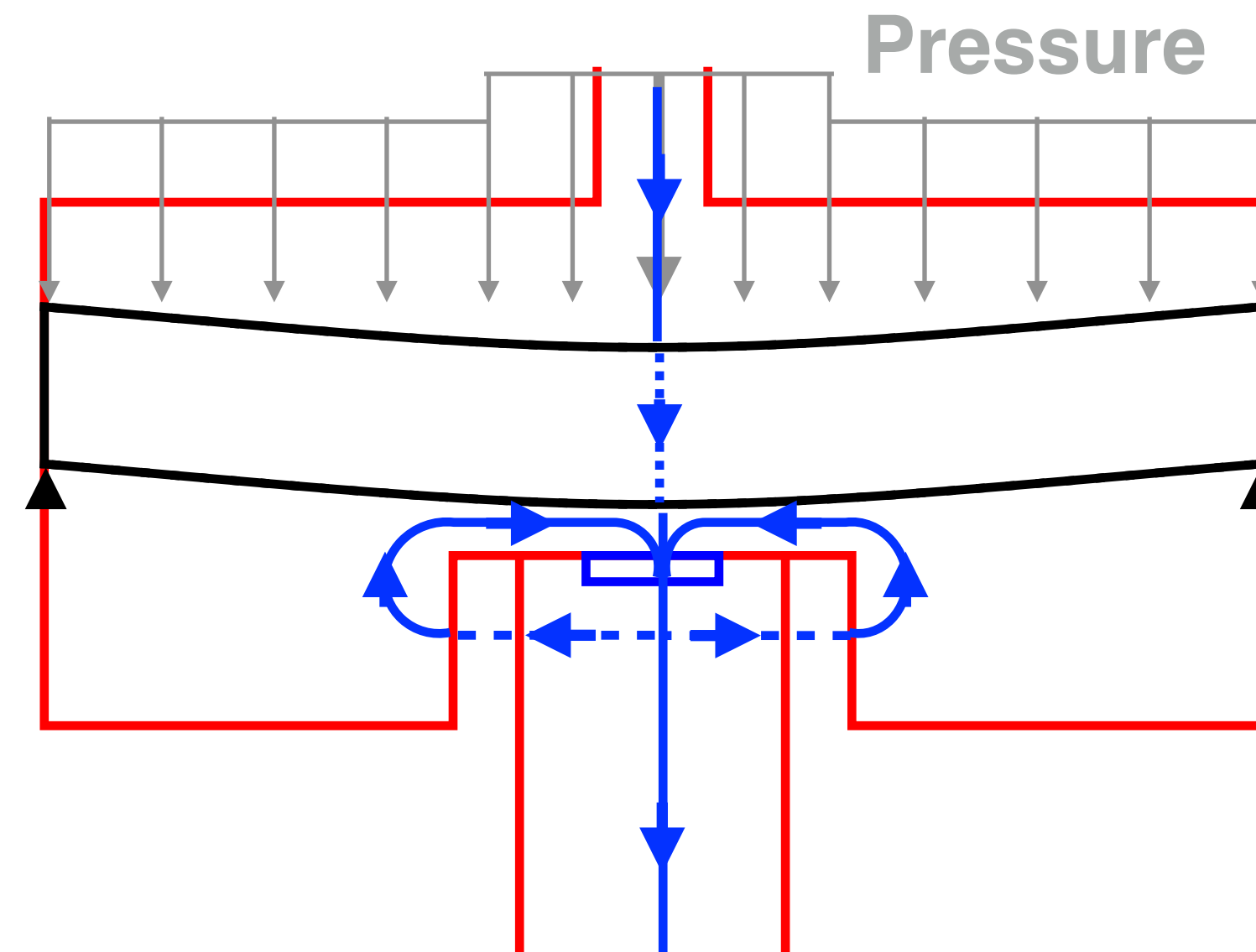


Analytical Model of Membrane Deflection

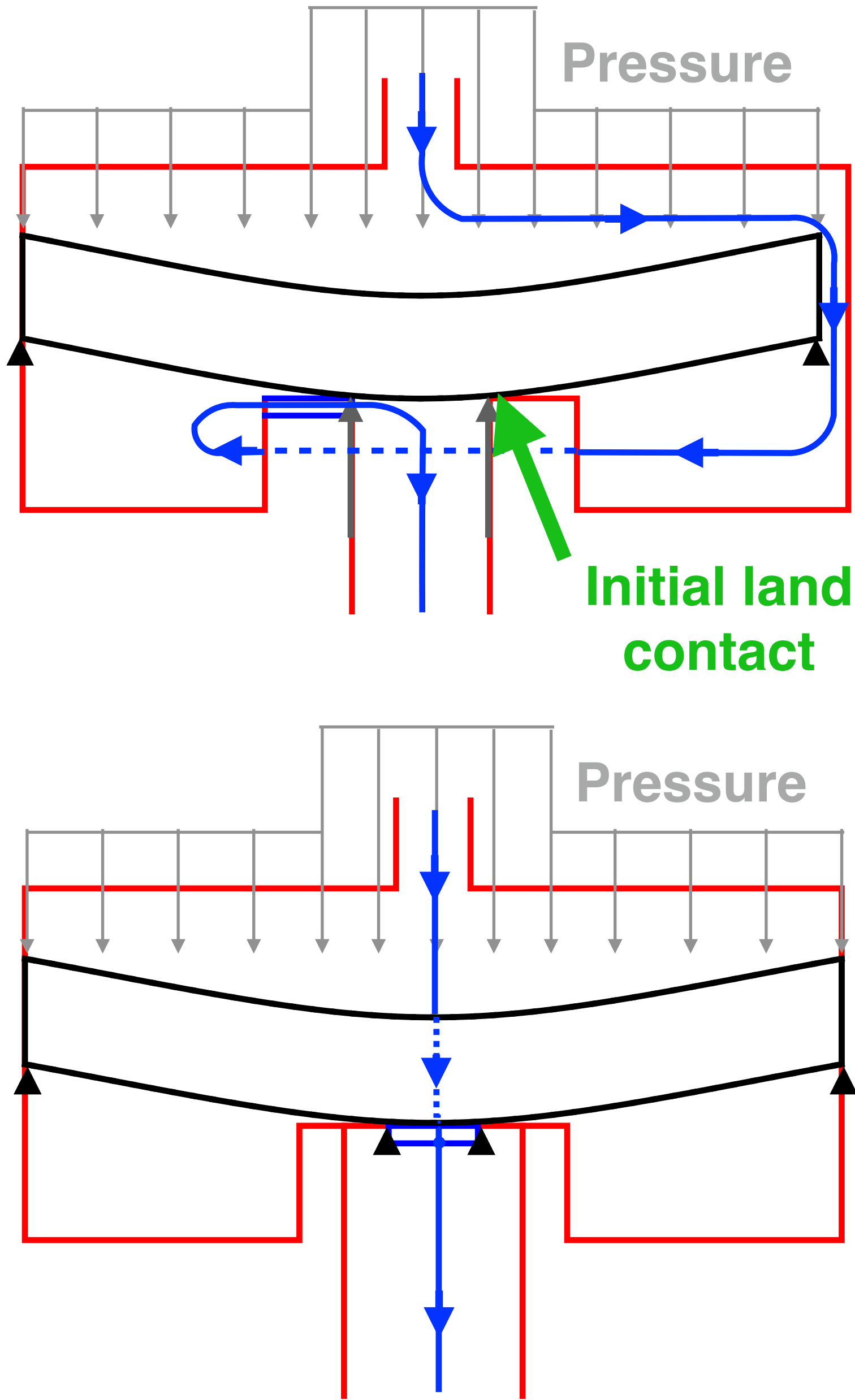


Kirchhoff-Love
plate theory

Small deflection



Analytical Model of Membrane Deflection



Kirchhoff-Love plate theory

Small deflection

Timoshenko correction

Large deflection

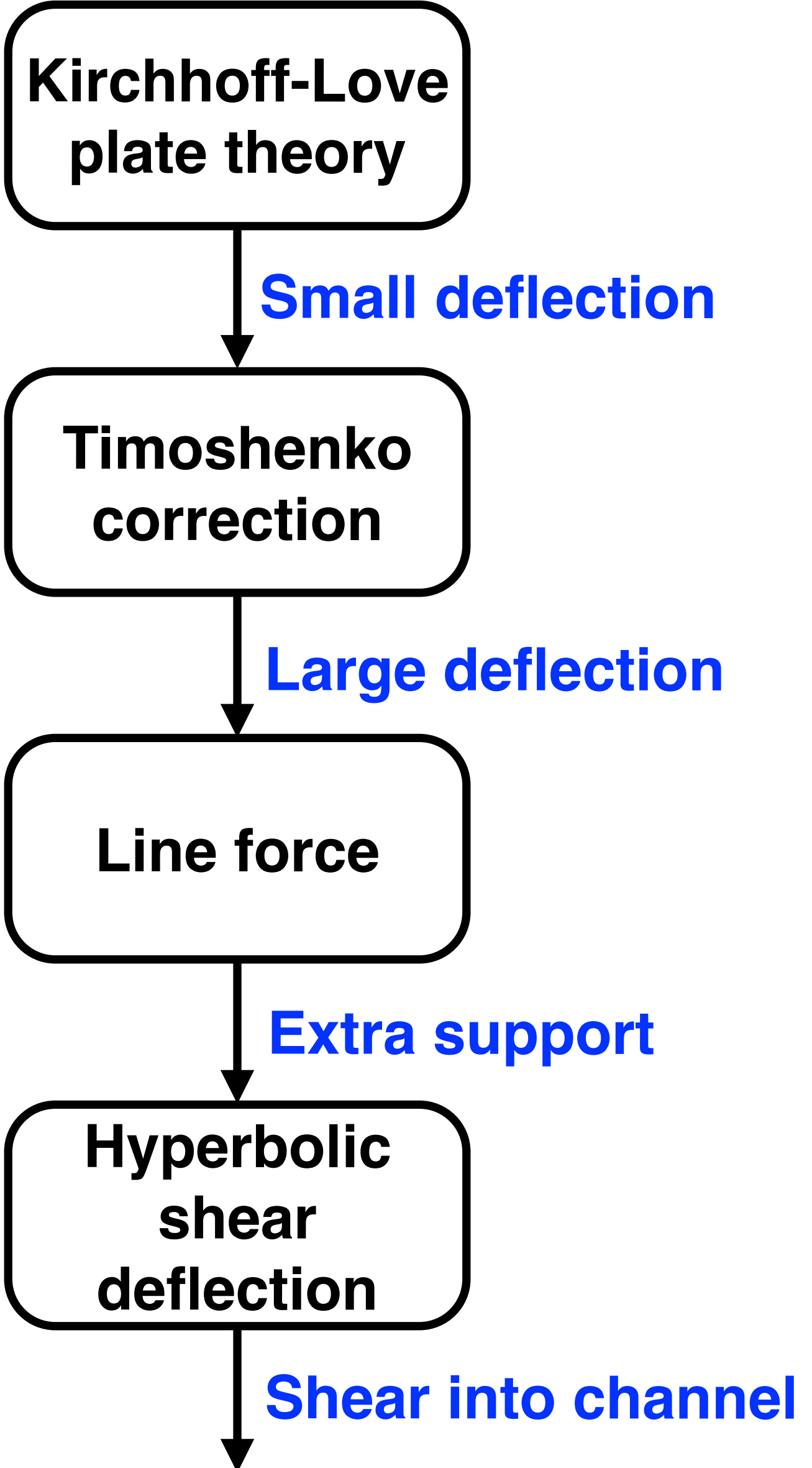
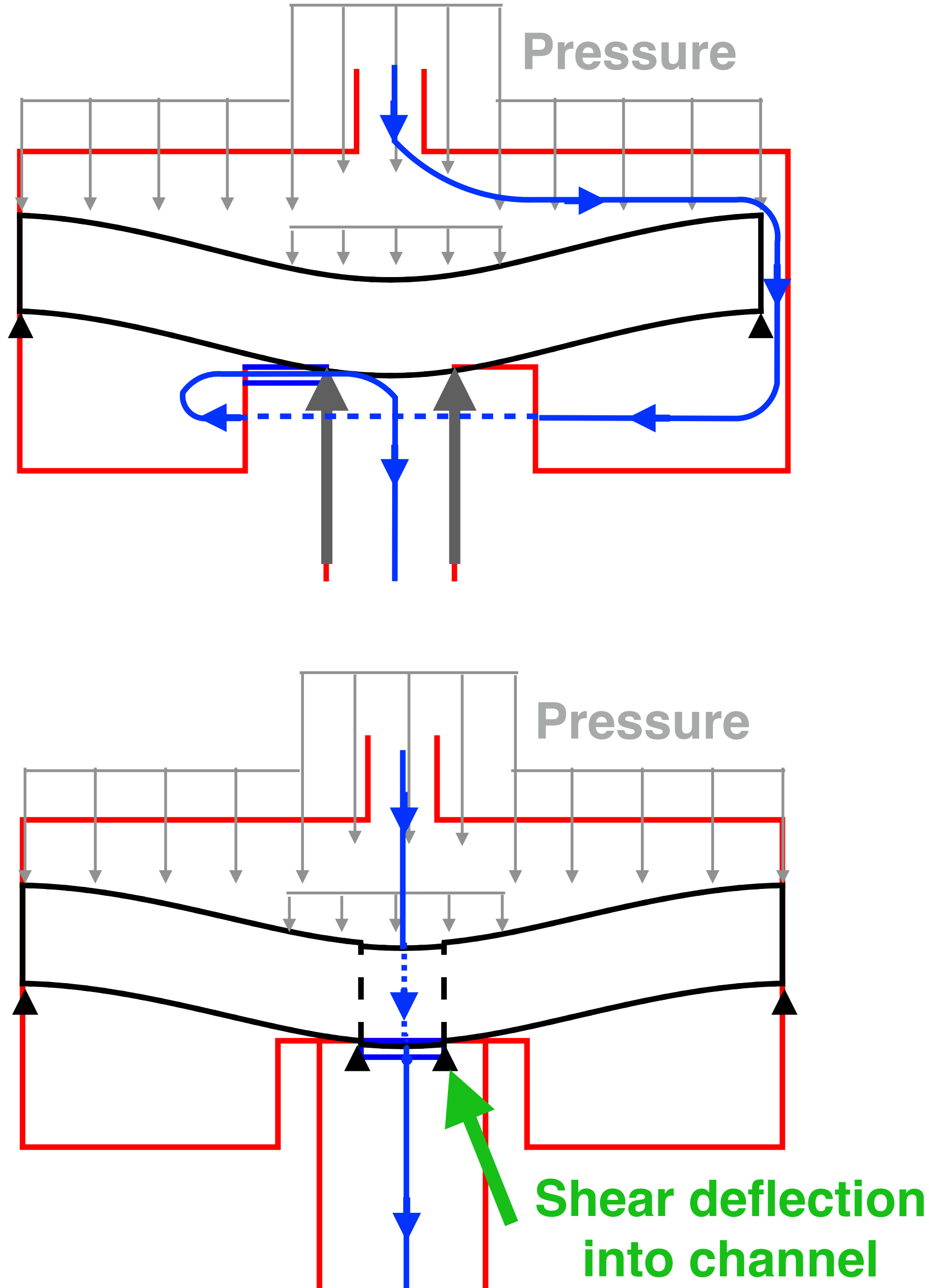
Line force

Extra support

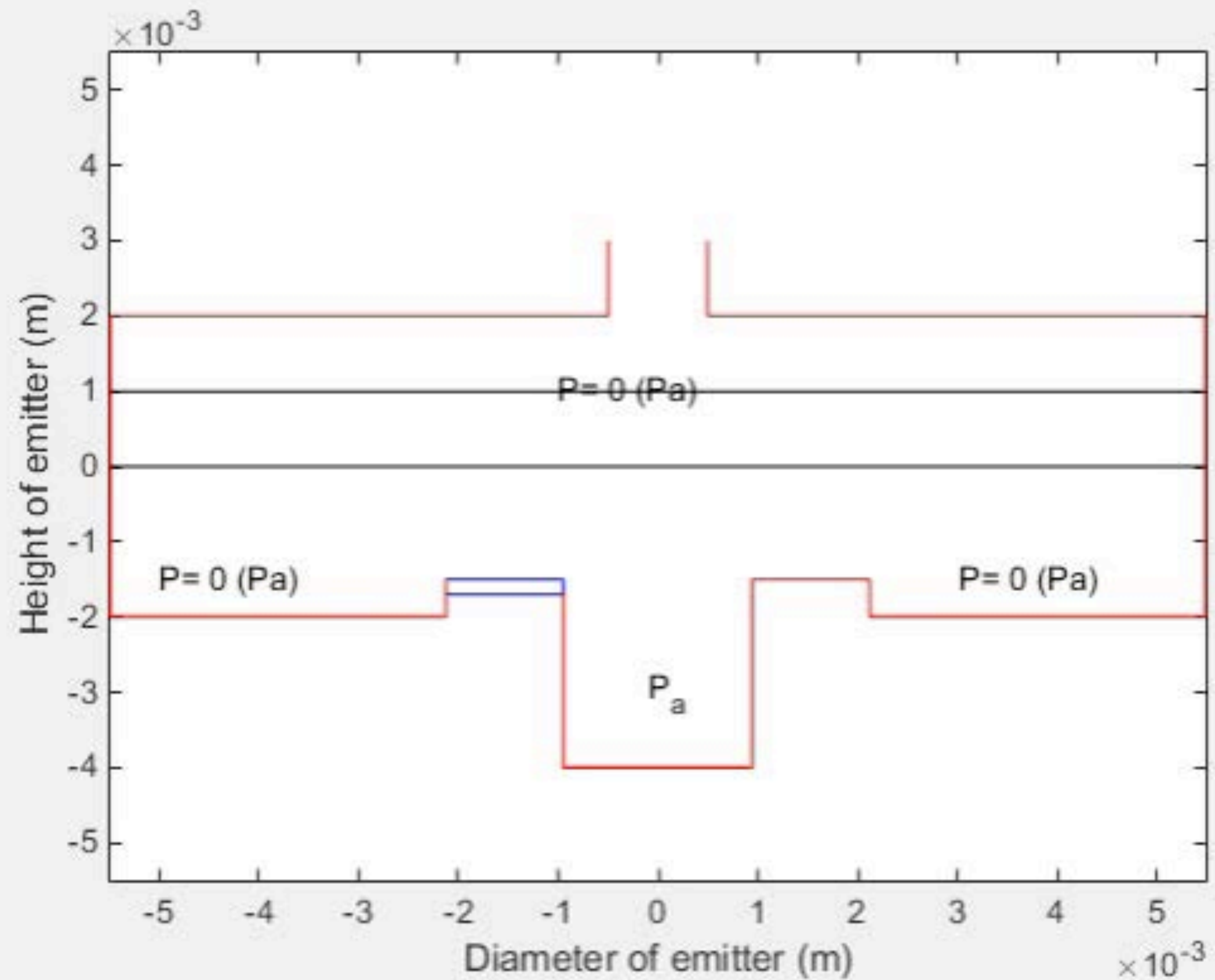
Increasing pressure



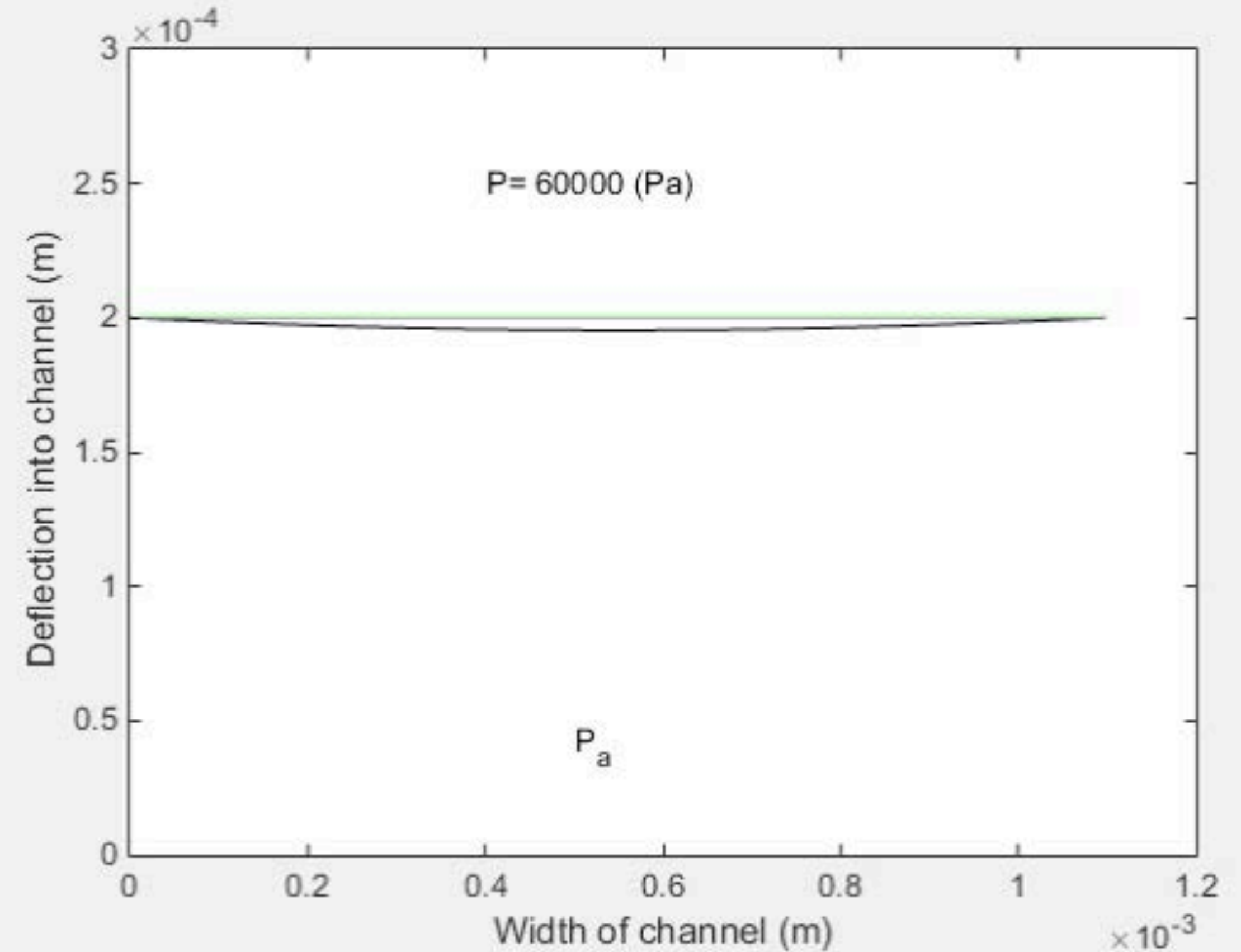
Analytical Model of Membrane Deflection



Analytical Model of Membrane Deflection

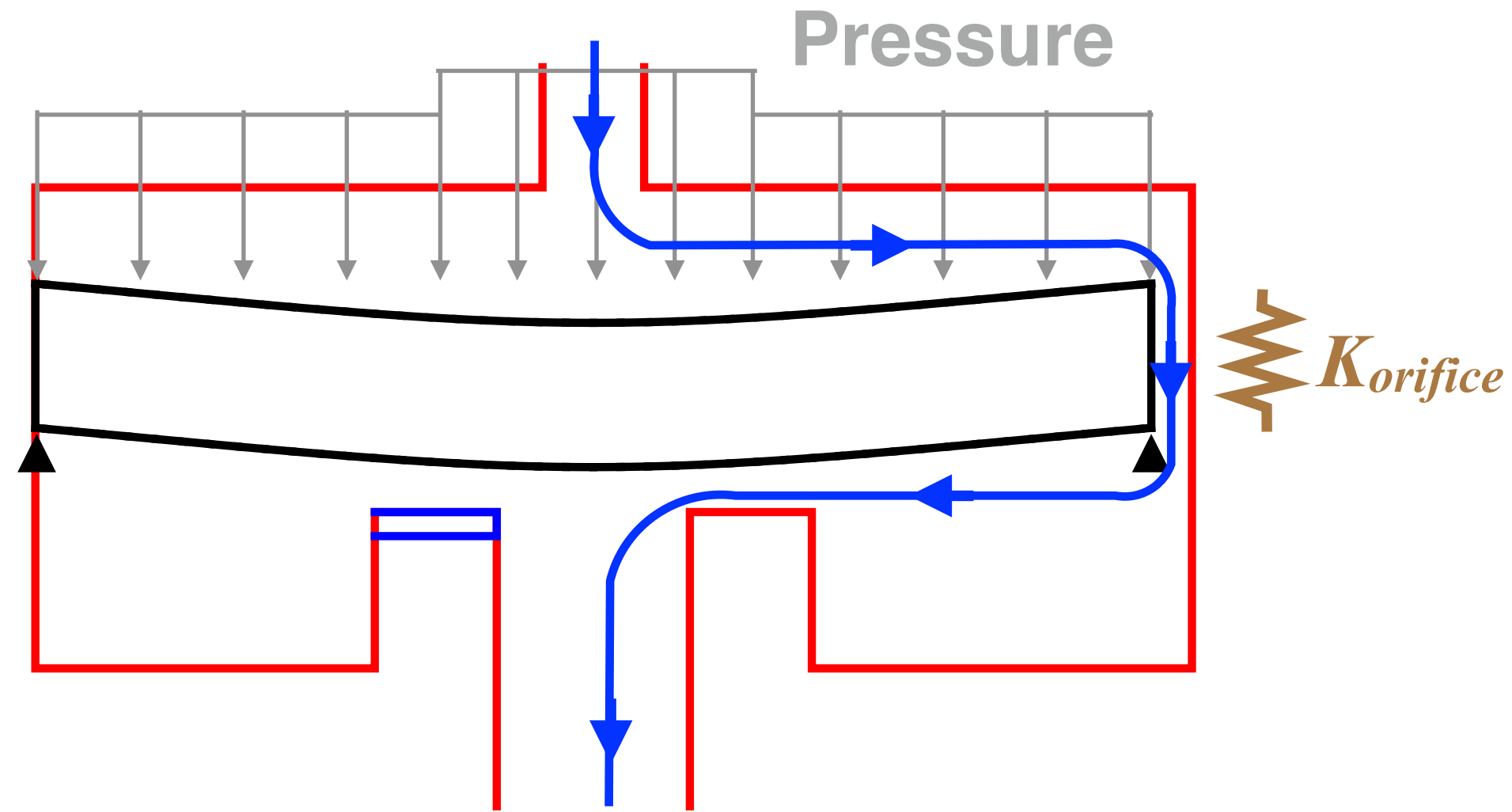


Membrane deflection to land

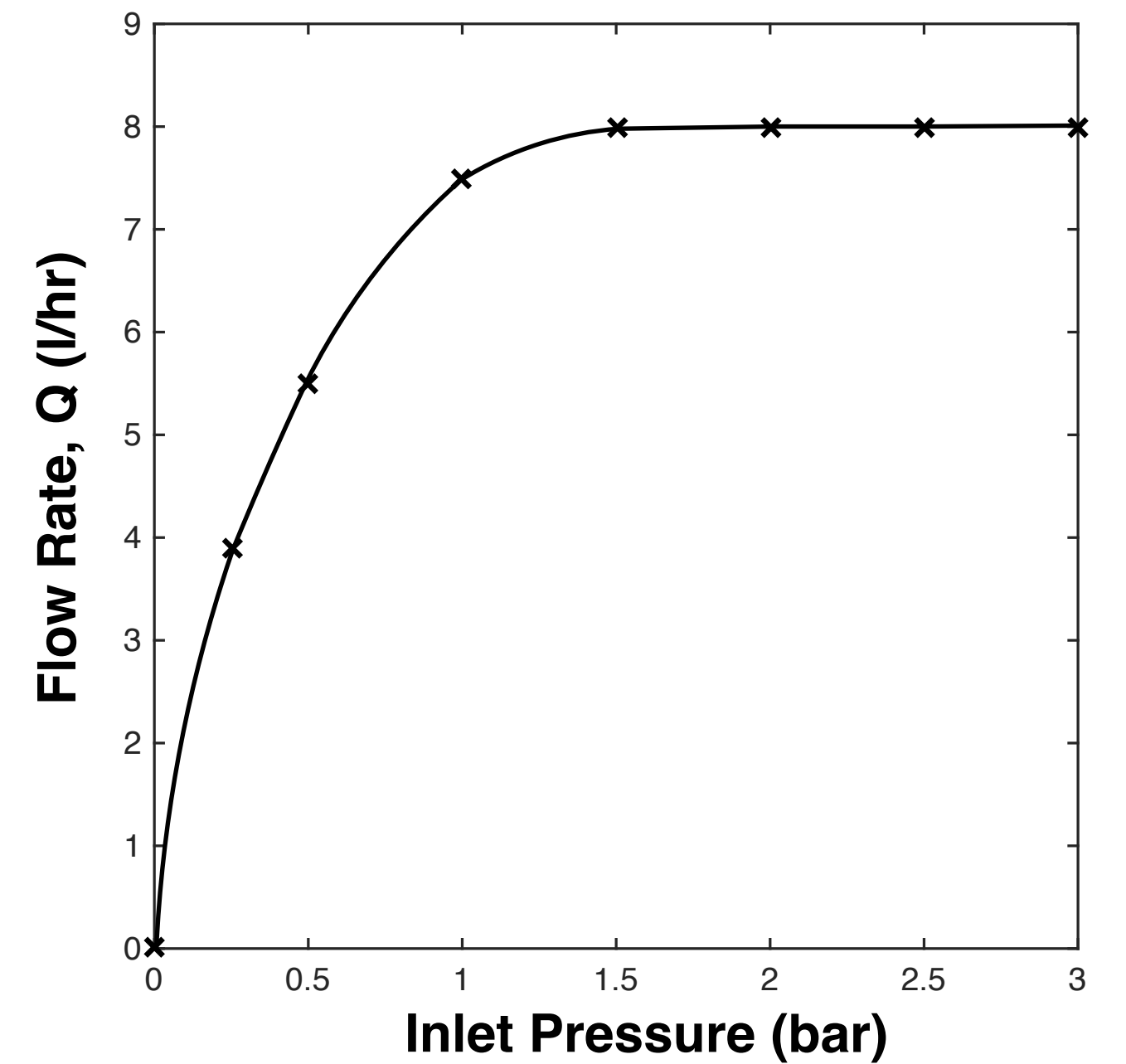
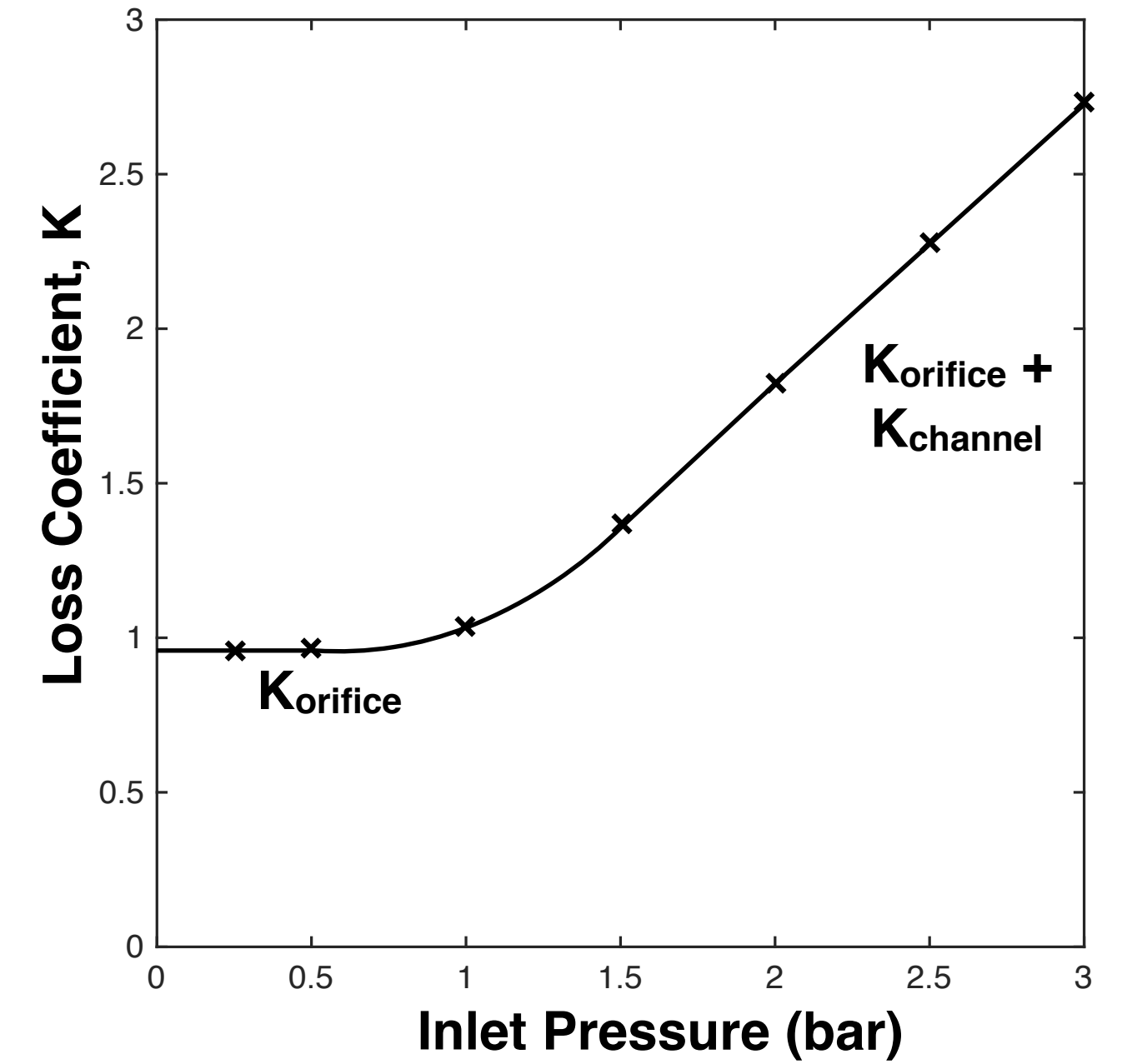
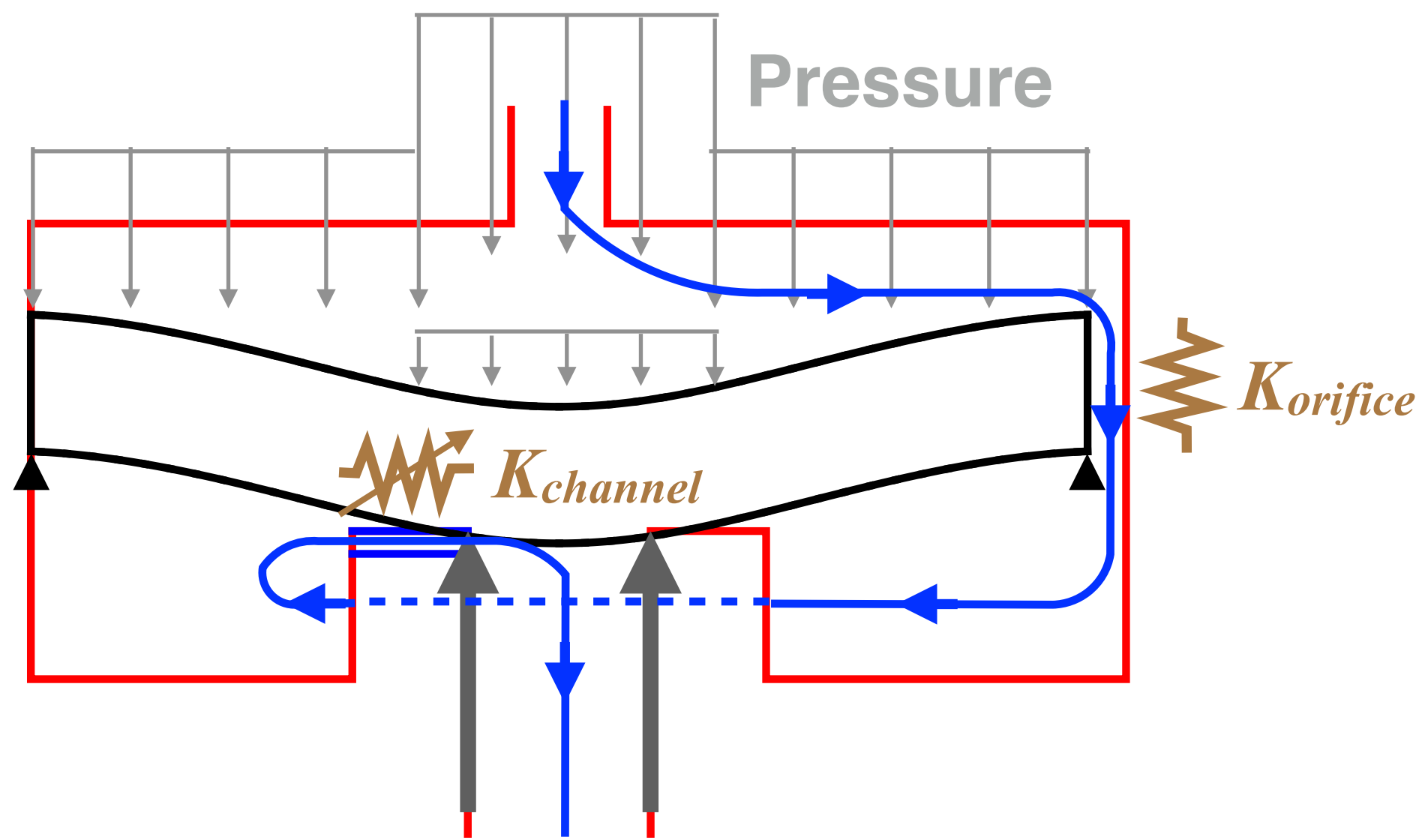


Membrane deflection into channel

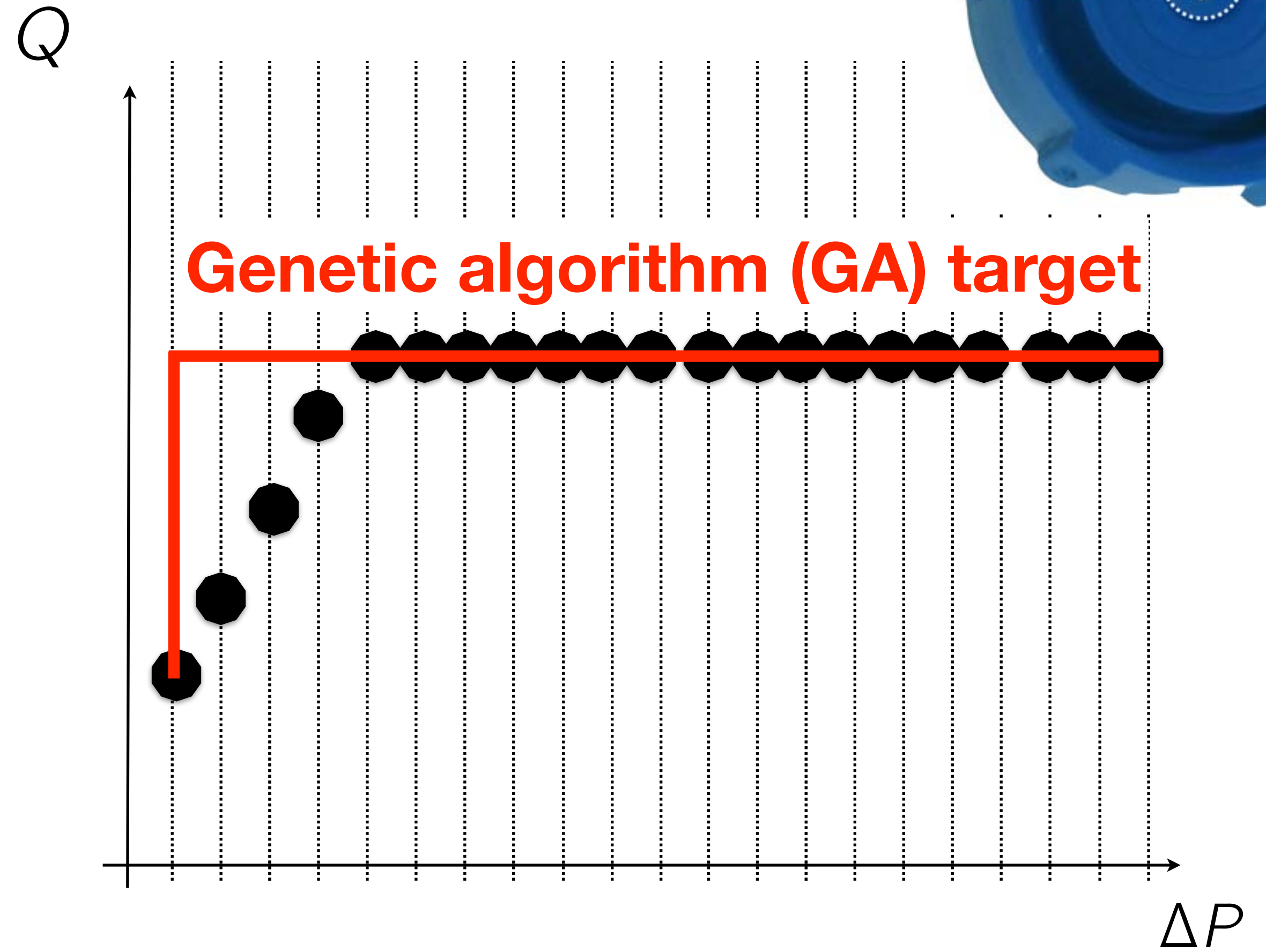
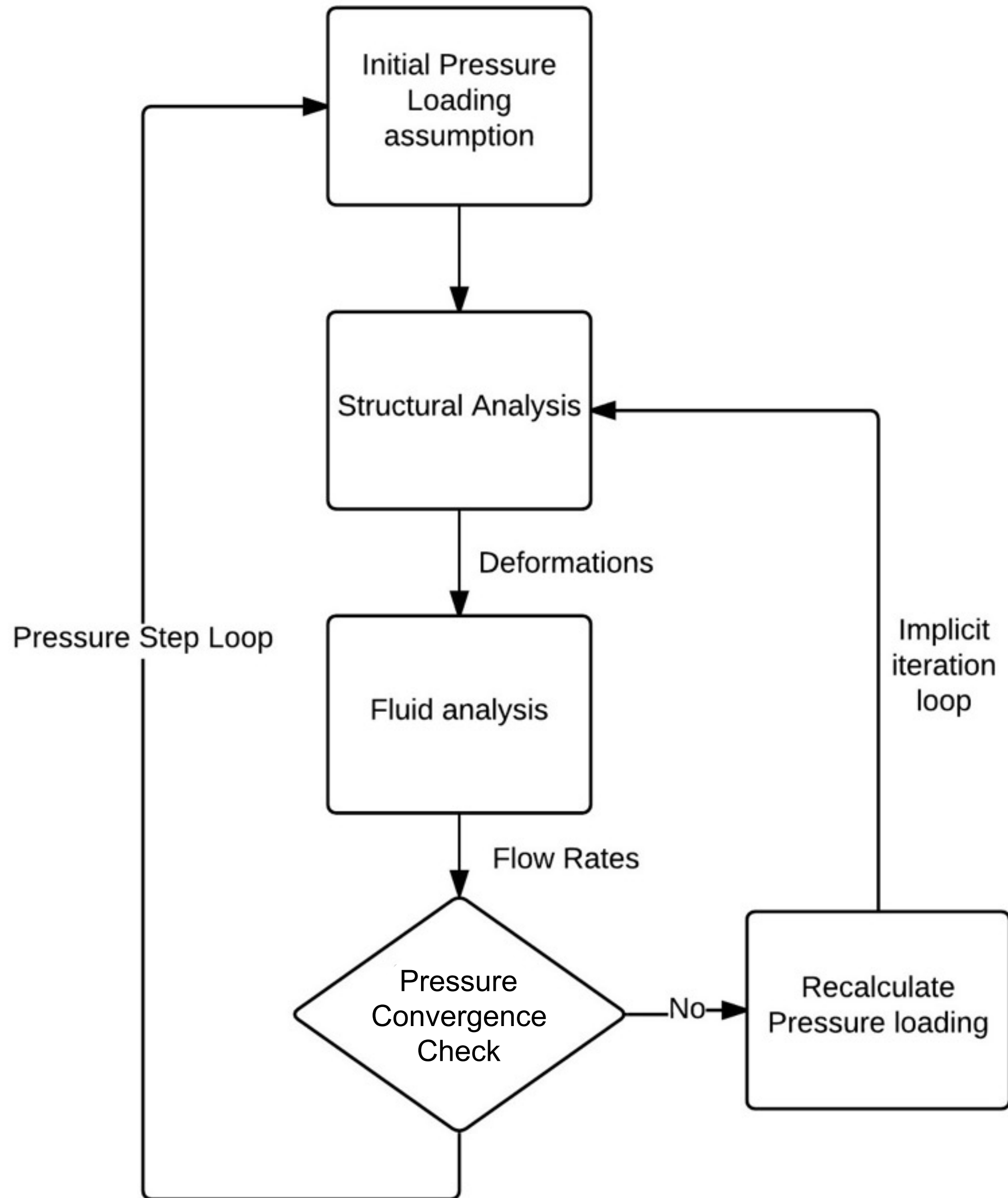
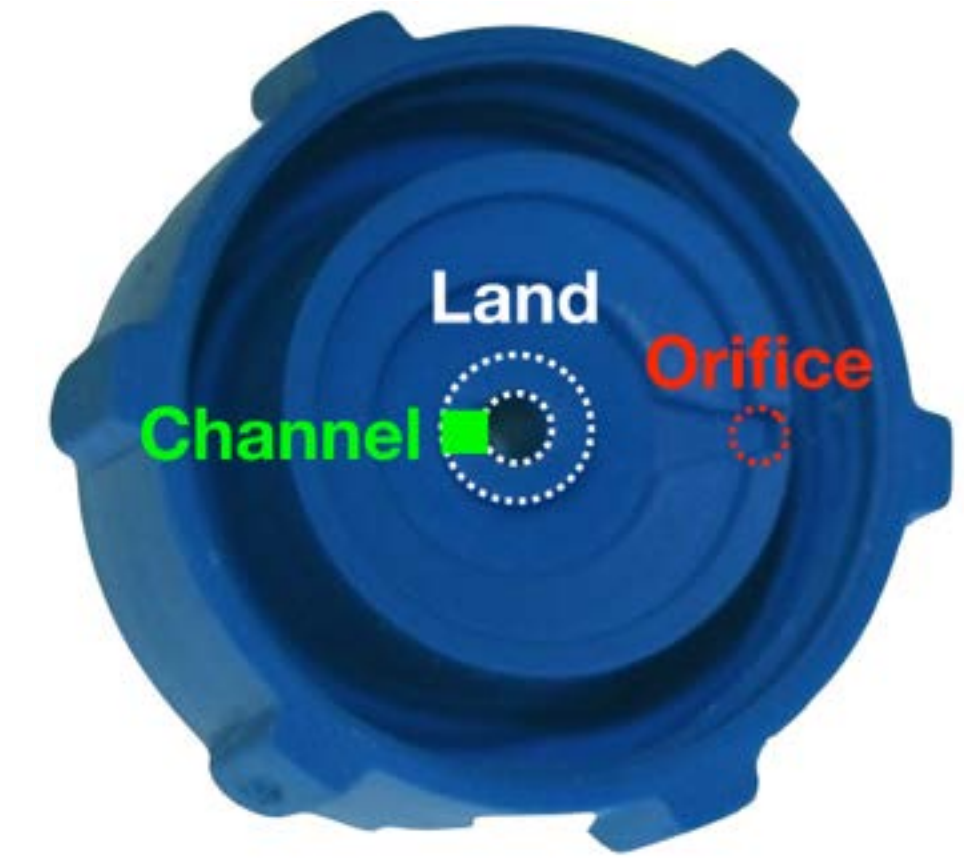
Analytical Model of Fluid Flow

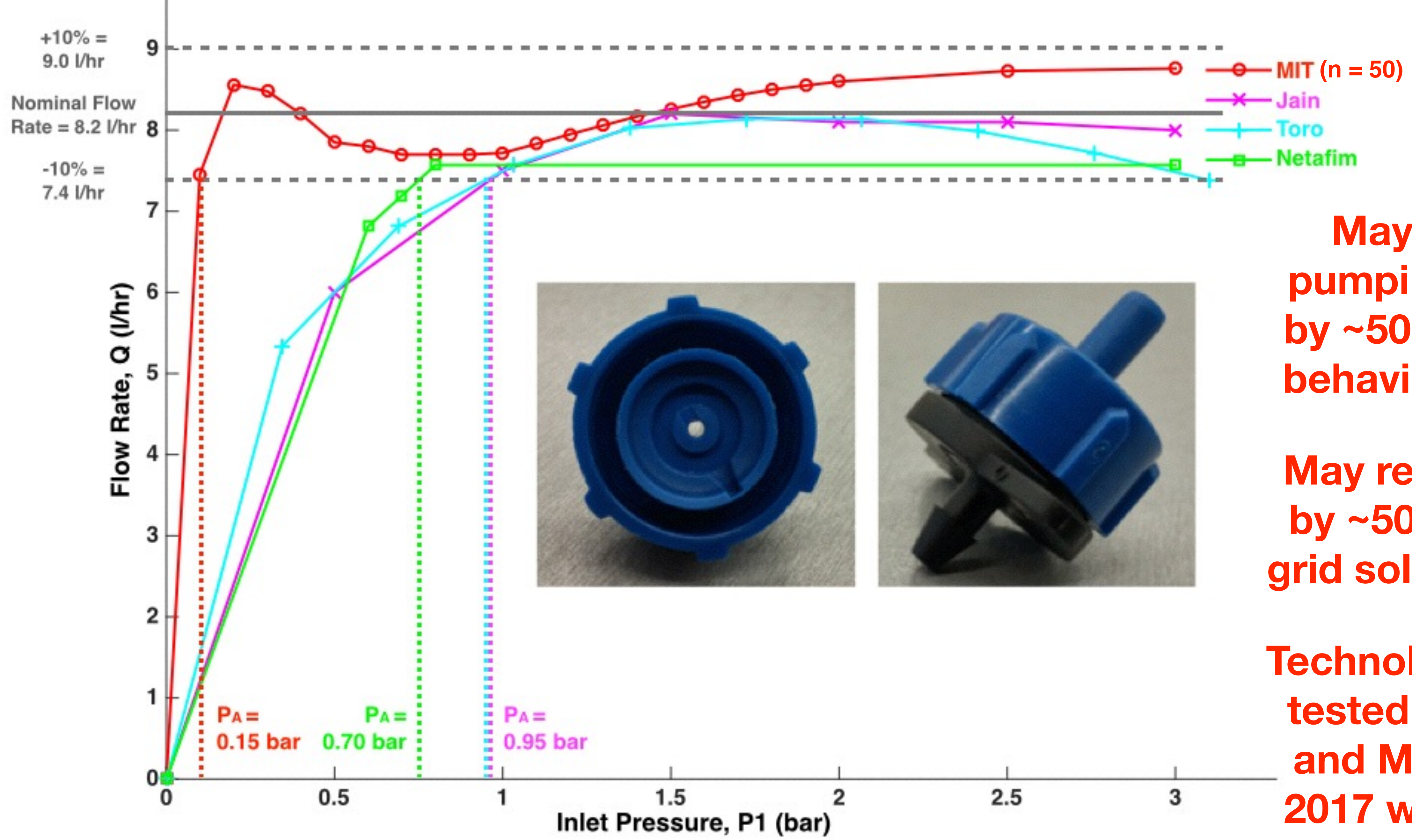


$$\Delta P_{total} = \frac{1}{2} \rho Q^2 \left[\frac{K_{orifice}}{A_{orifice}^2} + \frac{K_{channel}}{A_{channel}^2} \right]$$



Iterative Fluid-Structure Solver and Optimizer





May reduce pumping energy by ~50% with no behavior change

May reduce cost by ~50% for off-grid solar systems

Technology will be tested in Jordan and Morocco in 2017 with USAID

P. Shamschery, A.G. Winter V. "Topology optimization of online pressure compensating drip emitters to achieve lower activation pressure". (In preparation)



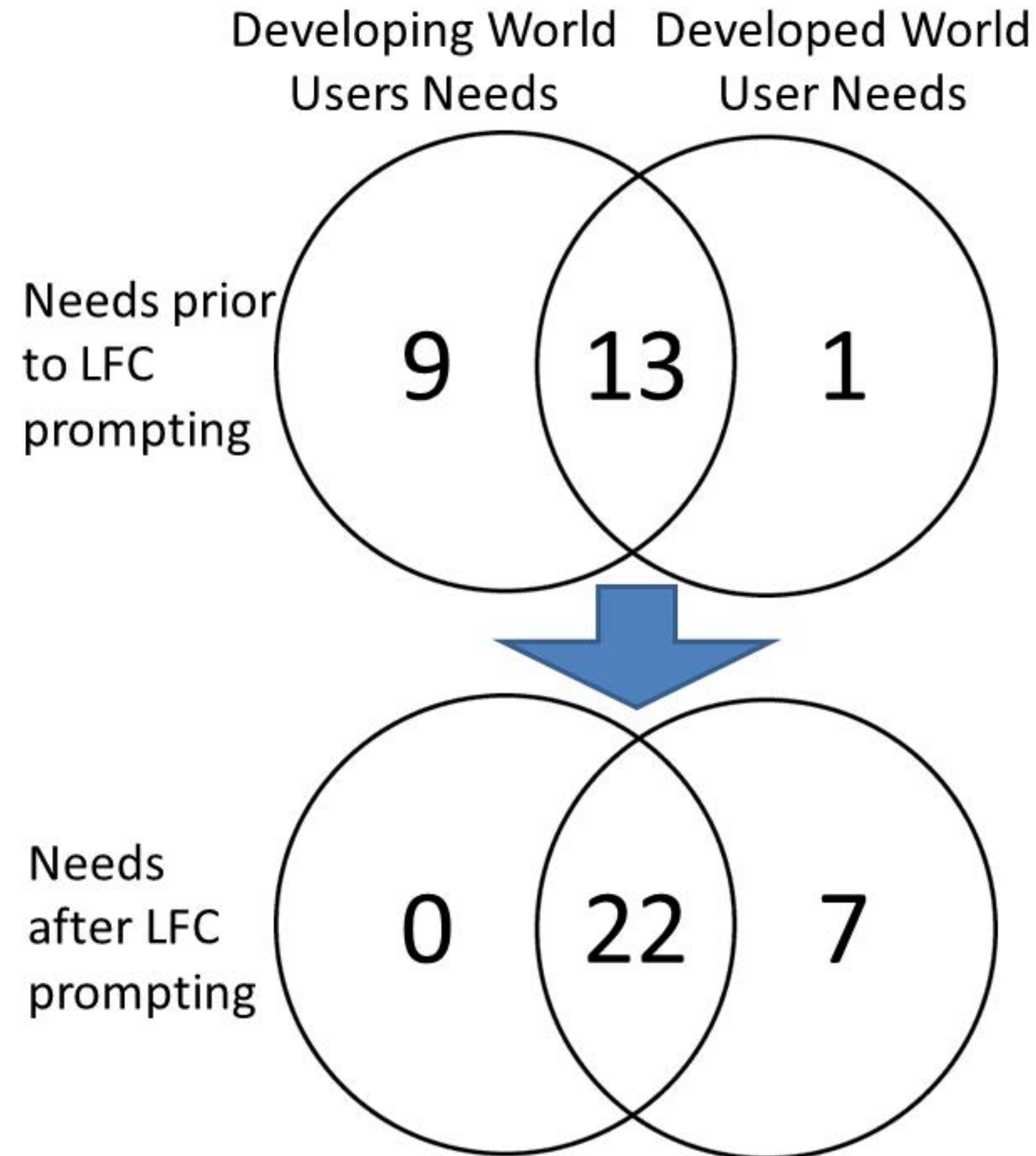
A.G. Winter, V., "Helping the Disabled Get Off-Road and On with Their Lives," DEMAND: ASME Global Development Review. 1 (Fall): 18-23 (2013).



A.G. Winter, V. "Stakeholder and Constraint-Driven Innovation of a Novel, Lever-Propelled, All-Terrain Wheelchair."
25th International Conference on Design Theory and Methodology, ASME IDETC/CIE 2013. Paper# DETC2013-12588.

Engineering Reverse Innovation for the LFC

Developing world users were lead users for the developed world



Student



Ben Judge
MIT-SUTD Dual Masters 2014

Sponsor



SINGAPORE UNIVERSITY OF
TECHNOLOGY AND DESIGN

Established in collaboration with MIT

Sold ~2000 units in 2014-16
TED talk has >930,000 views



Kickstarter goal met in 5 days
Sold ~200 chairs in 2016

A screenshot of a Kickstarter campaign page for the Freedom Chair. The page features a video player with a "PLAY" button and a "KICK STARTER STAFF PICK" badge. The video title is "move beyond the pavement". The campaign statistics show 208 backers, \$61,137 pledged of a \$50,000 goal, and 47 days to go. A blue button says "Manage Your Pledge". The project is by GRIT, Cambridge, MA, and was first created with 0 backers. The creator is Tish Scolnik, with 932 friends. The website gogrit.us is listed at the bottom.

Home Updates 1 Backers 208 Comments 4 Cambridge, MA Product Design

208 Backers
\$61,137 pledged of \$50,000 goal
47 days to go

Manage Your Pledge

This project will be funded on Tue, Dec 30 2014 3:00 PM EST.

Project by GRIT Cambridge, MA

First created · 0 backed

Tish Scolnik 932 friends

gogrit.us

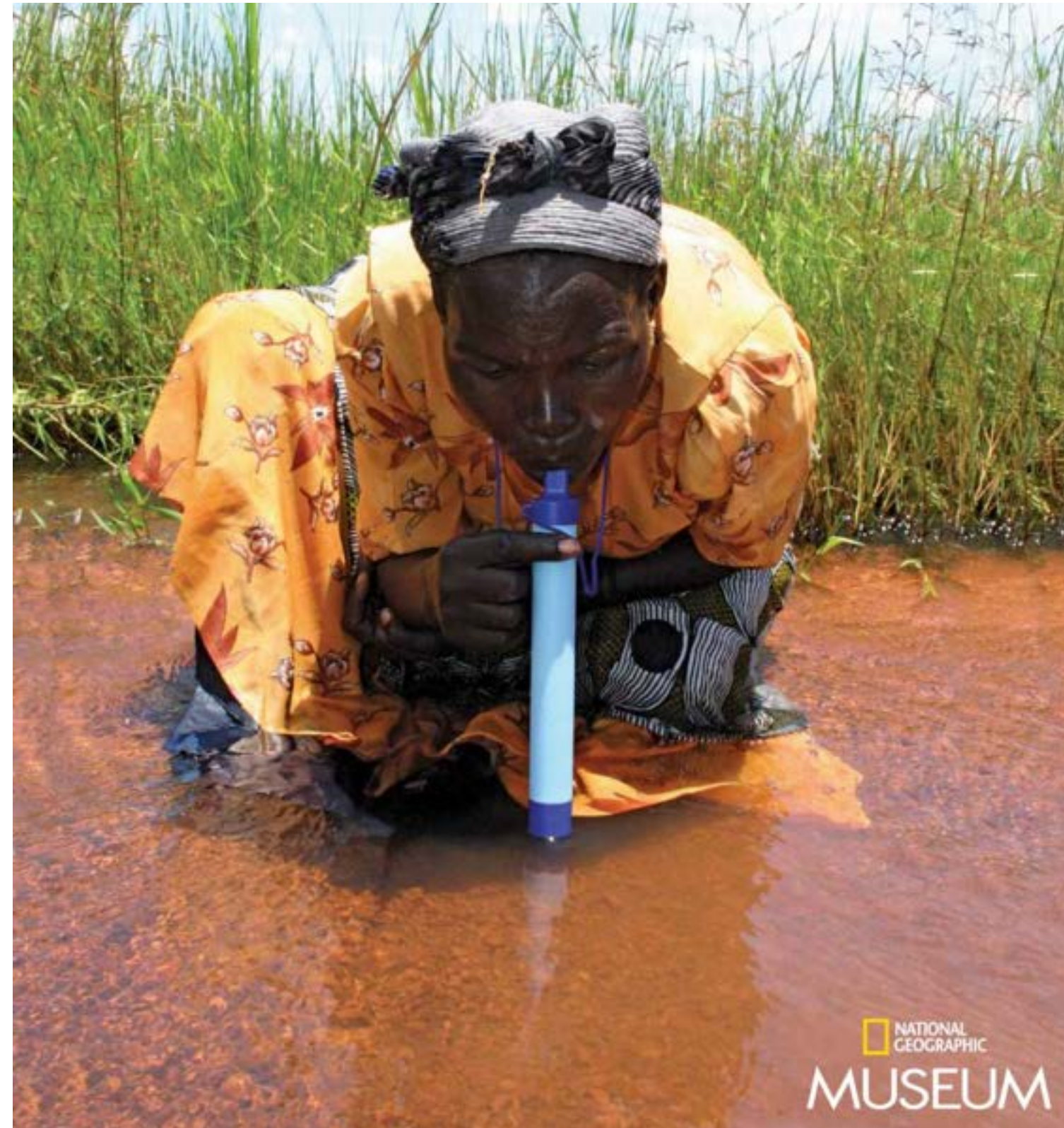
Share 1,360 Tweet Embed Remind me

The Freedom Chair empowers people with disabilities to move beyond the pavement. Join us in redefining mobility around the world.

What skills are needed for developing/emerging market design?

What skills are needed for developing/emerging market design?

**Define design
reqs accurately**



What skills are needed for developing/emerging market design?

**Define design
reqs accurately**

**Understand
consumers and
market dynamics**

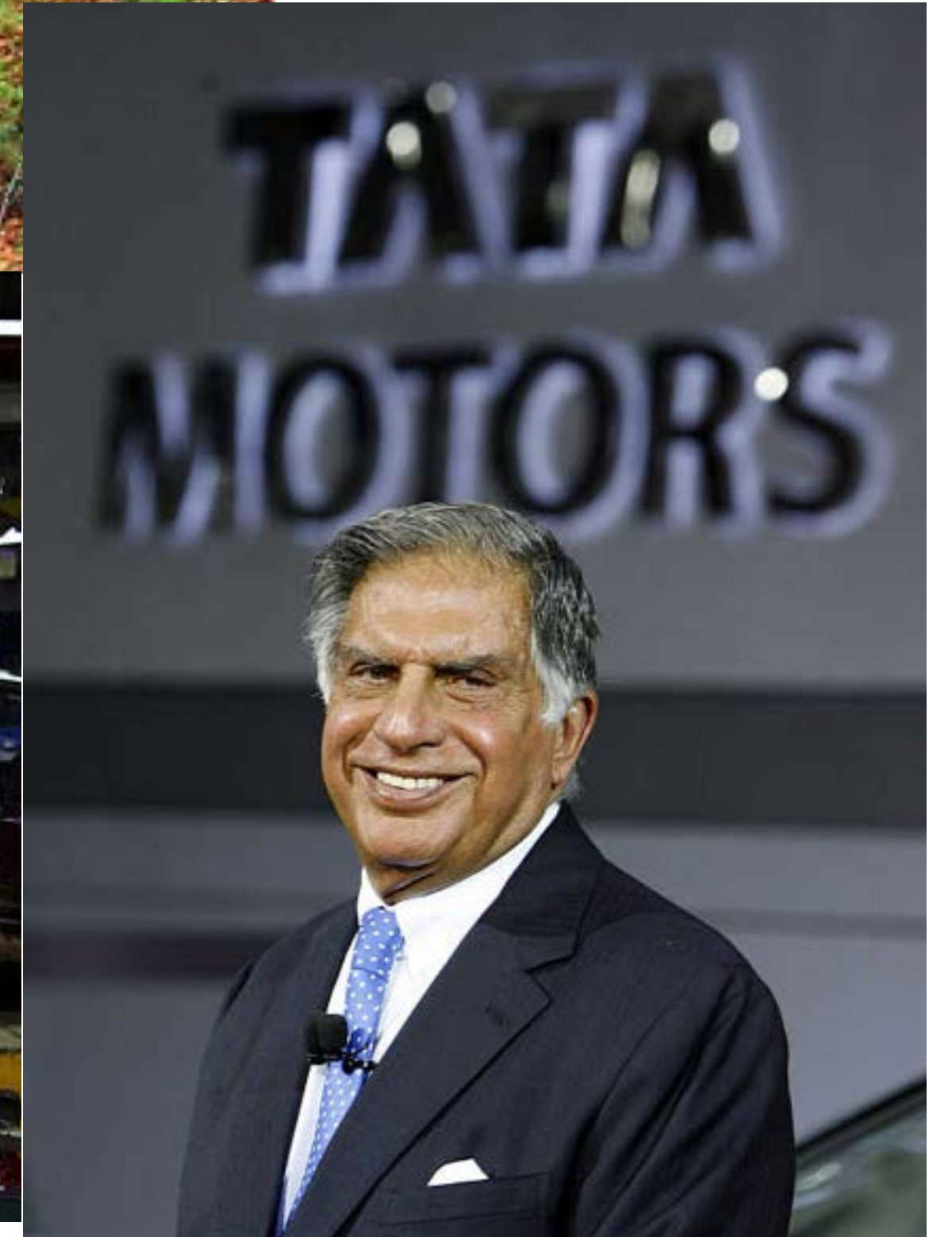


What skills are needed for developing/emerging market design?

Define design reqs accurately

Understand consumers and market dynamics

Engage stakeholder hierarchy



What skills are needed for developing/emerging market design?

Define design reqs accurately

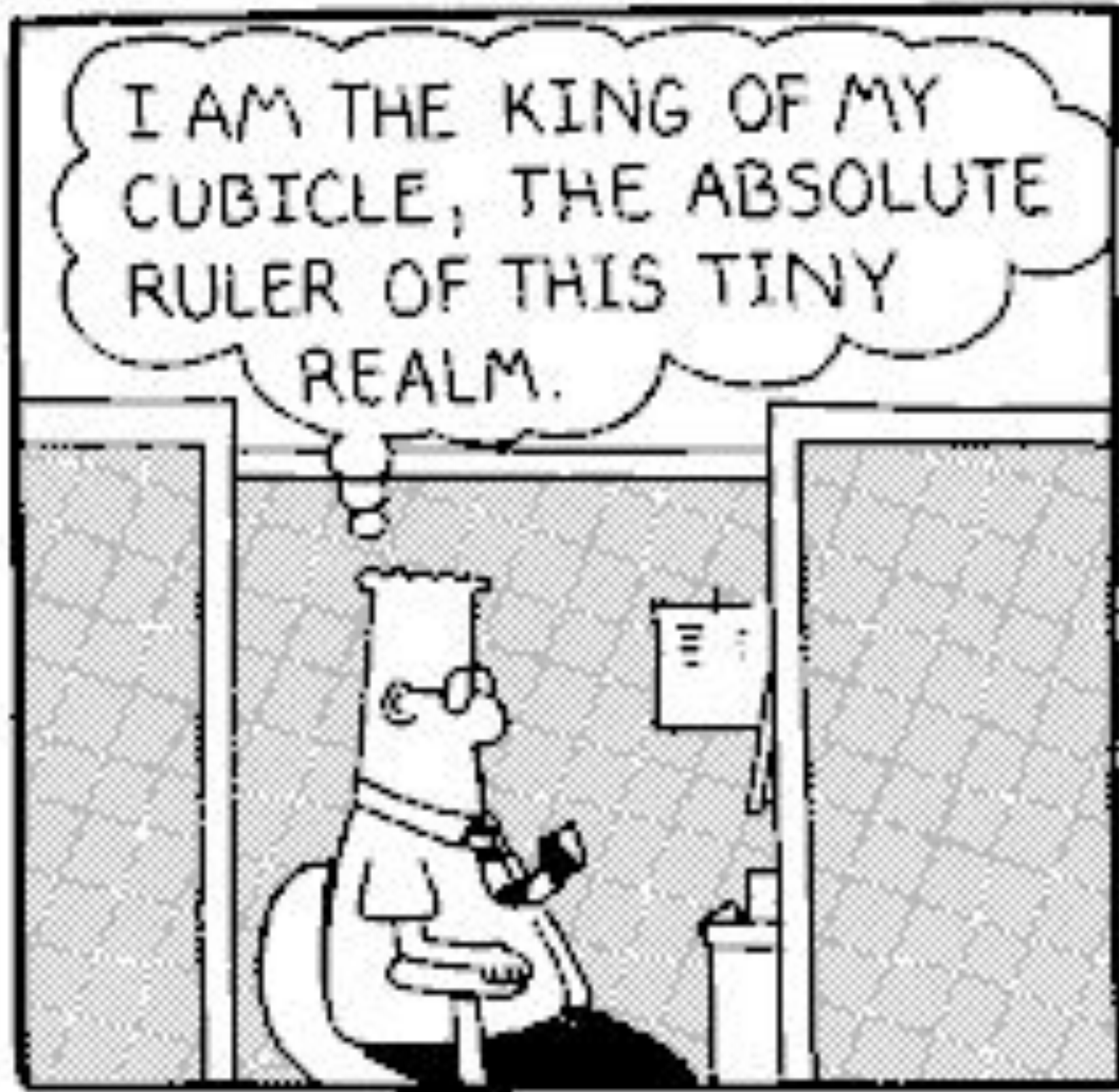
Understand consumers and market dynamics

Engage stakeholder hierarchy

Engineer reverse innovations



What type of engineer/manager are you going to be?



What is your value added?

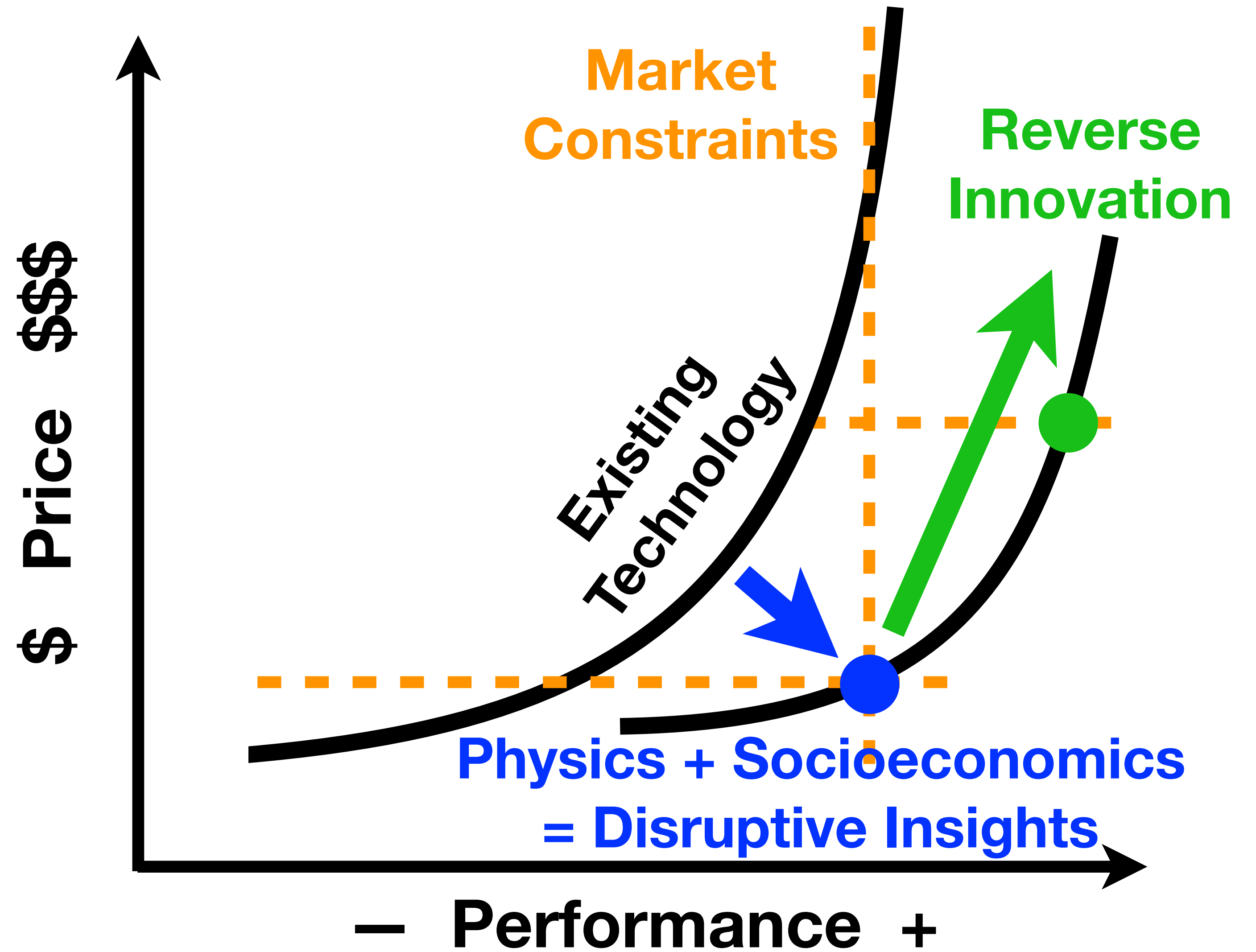


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(Winner, 2016 McKinsey Award for best paper of the year in HBR)

Winter V, A.G. and V. Govindarajan. "What Engineering a Reverse Innovation Looks Like". *Harvard Business Review (online)*, Nov. 2015

Thank You!



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awinter@mit.edu

