

MIT OpenCourseWare  
<http://ocw.mit.edu>

2.500 Desalination and Water Purification  
Spring 2009

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.



# Water Purification in Haiti

May 13, 2009

2.500: Desalination

# Introduction

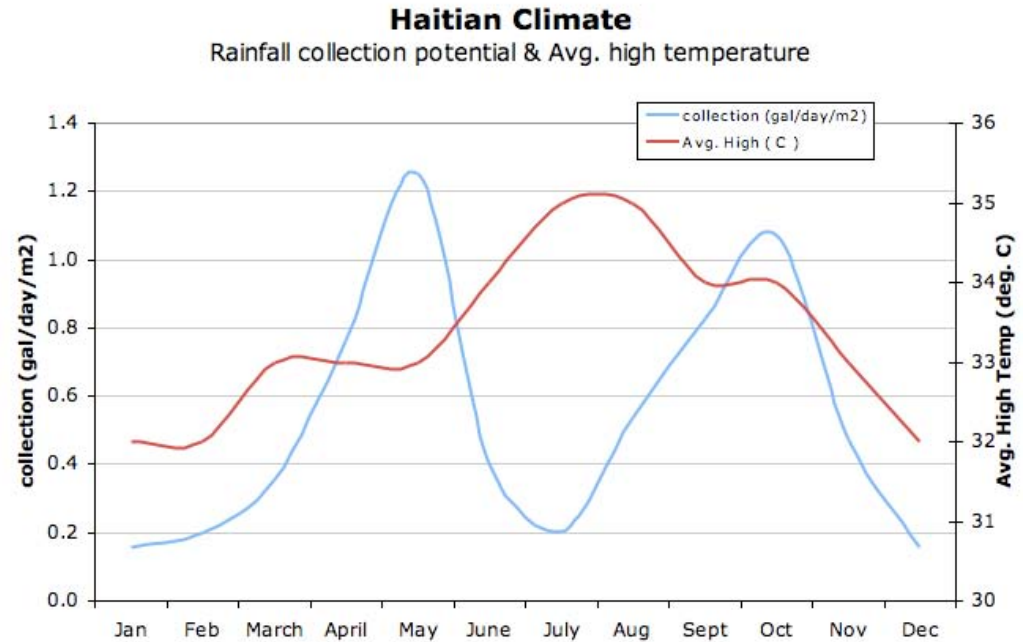
- Phaeton - 2450 people comprising about 500 families
- Paulette - 1750 people, or 350 families.
- Phaeton family well (3860 TDS)
- 30 m<sup>3</sup>/day



Courtesy of the CIA Factbook.

# Haiti: Climate

- Tropical, semi-arid climate
- Little variation in average monthly temperatures
- Distinct wet and dry seasons



# Benchmarking: Spectra

## SSBW 15000

- Recovery ratio: 33%, 15m<sup>3</sup>/day
- Specific power: 2.82 kWh/m<sup>3</sup>
- \$67,770

## SWM 1500

- Recovery ratio: 20%, 1.5m<sup>3</sup>/day
- Specific power: 6.4 kWh/m<sup>3</sup>
- \$16,605

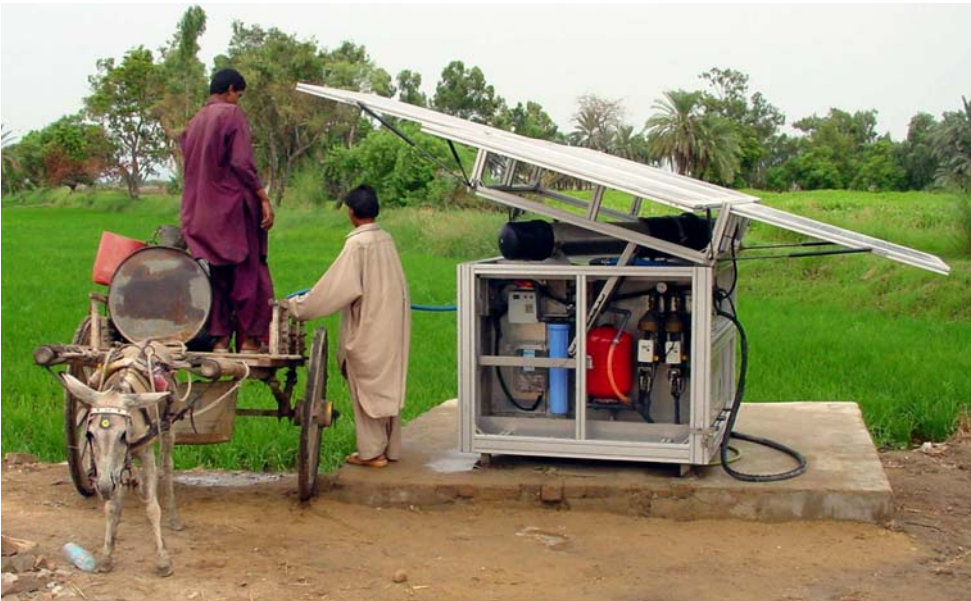
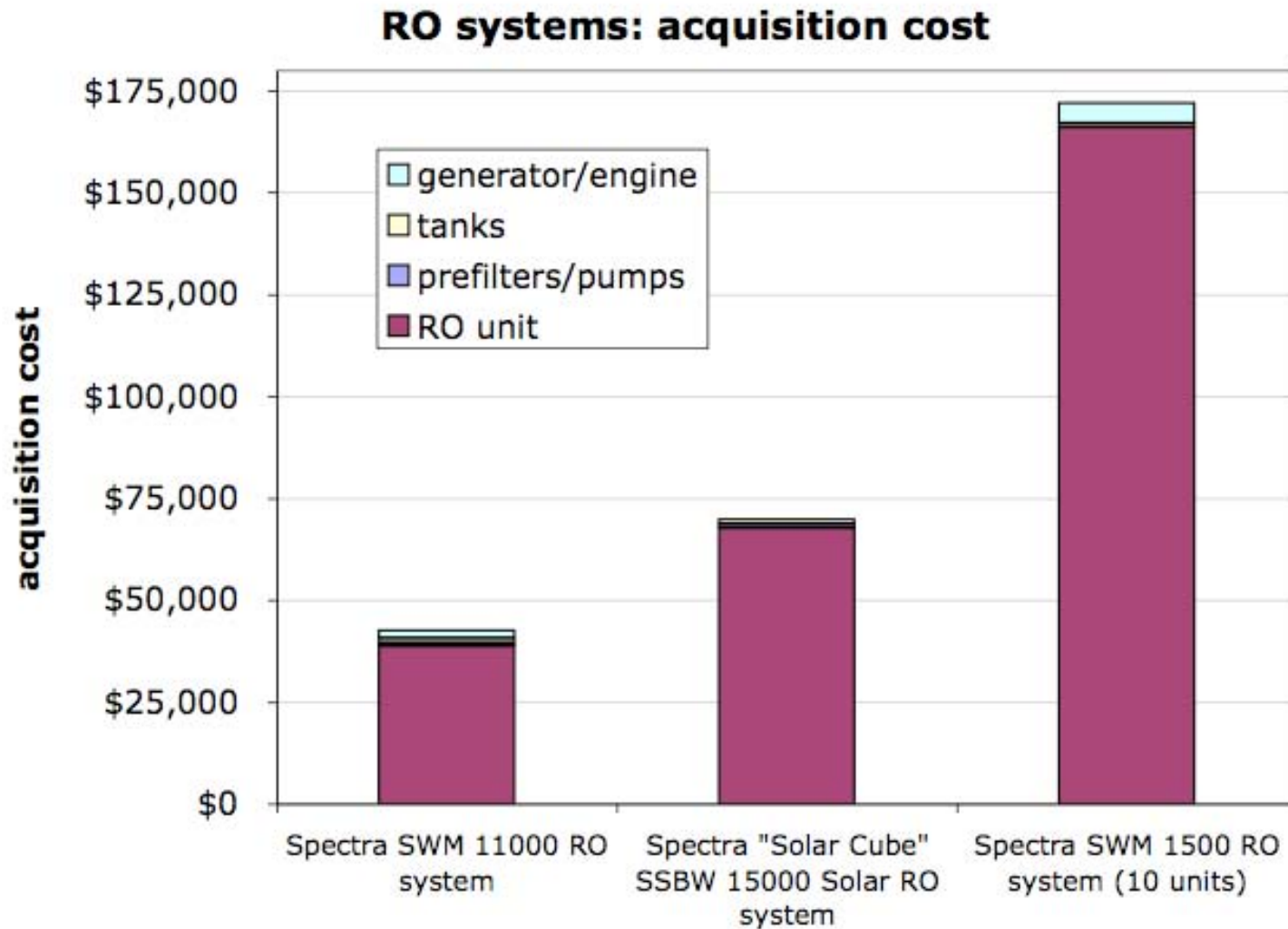


Image removed due to copyright restrictions.

Please see

<http://www.spectrawatermakers.com/landbased/pics/swm1500.jpg>

# Benchmarking: Economics



# Design selection

- Design selected based on minimal energy and capital requirement

## Least Power Input, kWh

	13 m <sup>3</sup> /day	65 m <sup>3</sup> /day
Theoretical	1.185	5.93
RO	7.8	39
ED	24.2	121
SED	17,184	85,920
MED, N=3	5,928	29,616
MSF, N=10	760,080	3.8*10 <sup>6</sup>

# Simulation: ROSA

**ROSA Control Panel - Haiti Desal\_3**

File Options Element Value Analysis Help

System Permeate Flow: 20.00 m<sup>3</sup>/d    System Feed Flow: 40.00 m<sup>3</sup>/d    System Recovery: 50.01%

No. Passes:  1    Current Pass:  1    Dosing Chemical: None     No Degasification  
Adjusted pH: None     % Carbon Removal: None  
 CO2 Pressure (atm): None

**Configuration for Pass 1**

Stages in Pass: 2    Permeate Flow: 20.00 m<sup>3</sup>/d    Recirculation Loops:  
Fouling Factor: 0.85    Recovery: 50.00%     Blend Permeate: None m<sup>3</sup>/d  
Operating Temp: 35.0 °C    Feed Flow: 40.00 m<sup>3</sup>/d     Pass 1 Conc to Pass 1 Feed: None m<sup>3</sup>/d  
Permeate Flux: 23.00 l/mh     Pass 2 Conc. to Pass 1 Feed: None m<sup>3</sup>/d [Max]

**Configuration for Stage 1 in Pass 1**

Stage in Pass: Stage 1    Pump Efficiency: 80%  
Feed Pressure: None bar  
Boost (2-pass): Calc  
Back Pressure: None bar  
 Same back pressure for all stages  
Pressure vessels in each stage: 1  
Elements in each vessel: 3  
Total elements in stage: 3  
Products: LE-4040 [Specs]  
 Use the same element in the pass

**System Configuration**

The diagram shows a feed stream entering a grey rectangular vessel. From this vessel, a blue stream labeled 'Permeate' exits to the right. A red stream labeled 'Concentrate' exits from the top of a second, teal-colored rectangular vessel. A blue line connects the bottom of the grey vessel to the bottom of the teal vessel, indicating a recirculation loop. A red line connects the top of the grey vessel to the top of the teal vessel, indicating another recirculation loop.

Case: [Slider]

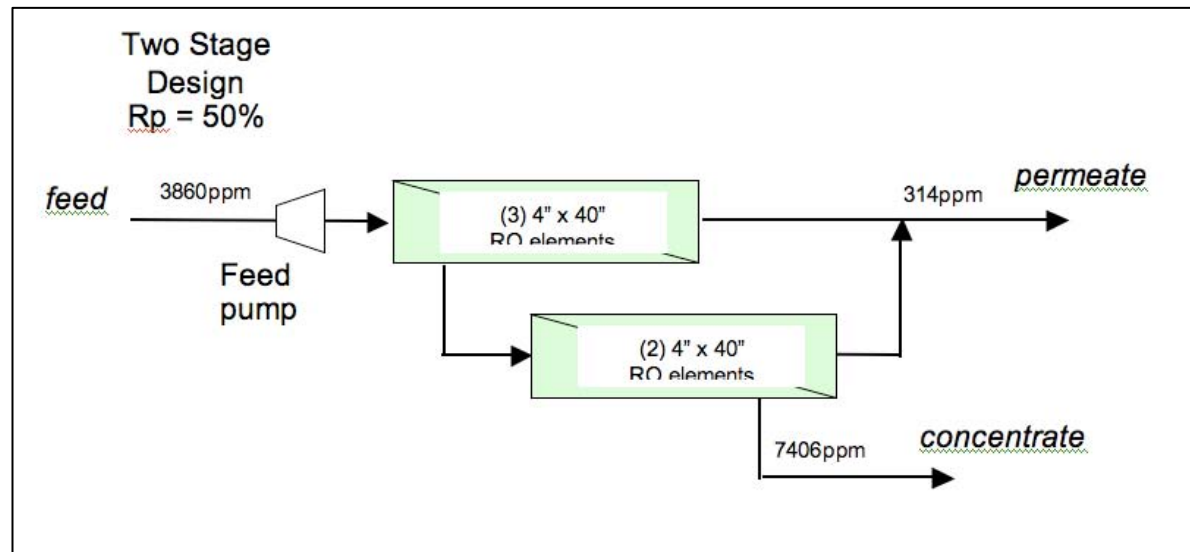
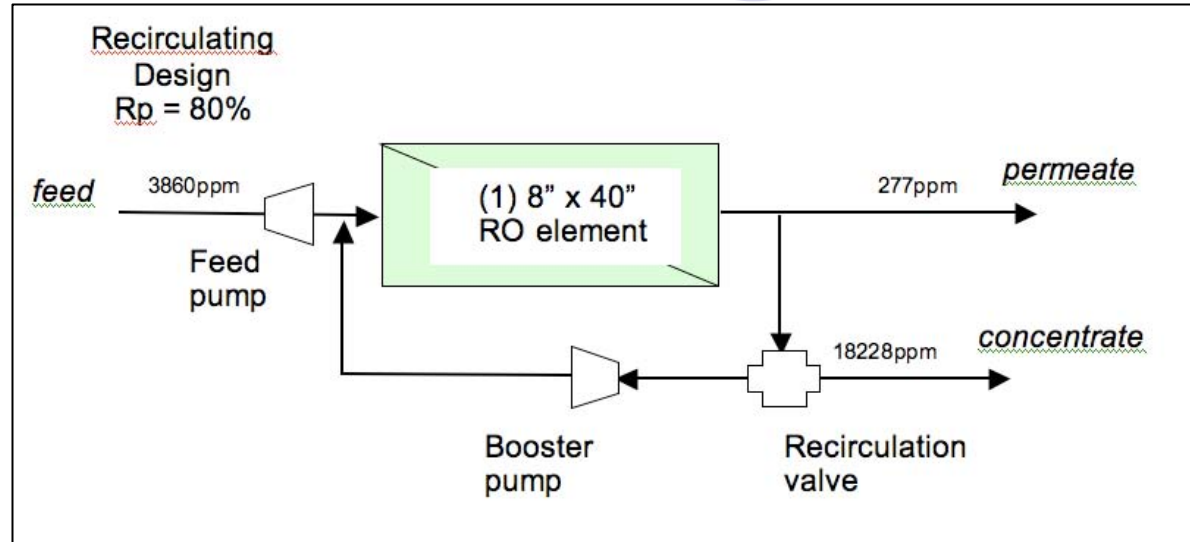
1) Project Information    2) Feed Data    3) Scaling    4) System Configuration    5) Report

Tuesday, May 12, 2009    Ready...    Case 2 of 2

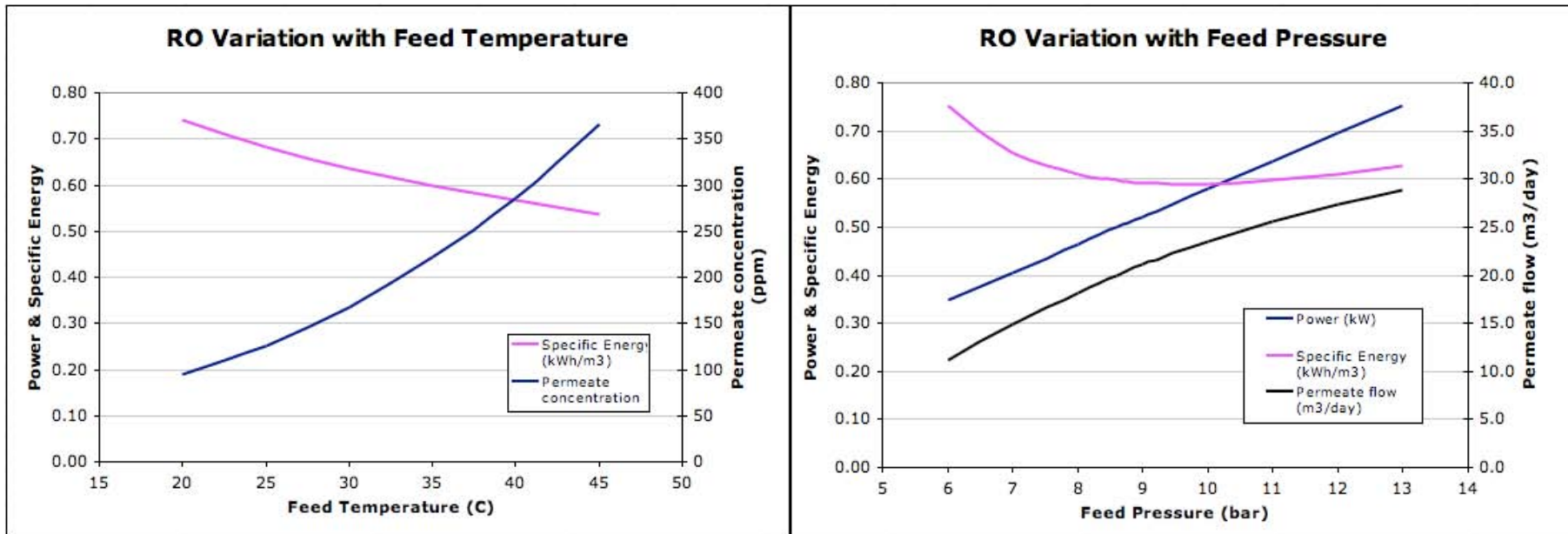


# RO Layout

- Compared single-stage recirculating to two-stage
- Recirculating:
  - more expensive pumps
  - fewer RO parts
  - less maintenance
  - lower capital cost



# Operational optimization



- Specific energy decreases with temperature, limited by membrane upper operating temperature
- Variation with pressure shows a minimum specific energy requirement at optimum pressure

# Final design

- Reverse Osmosis

- Single stage, recirculation:  $R_p = 80\%$
- Solar preheating,  $\Delta T = 5K$
- Waste heat preheating

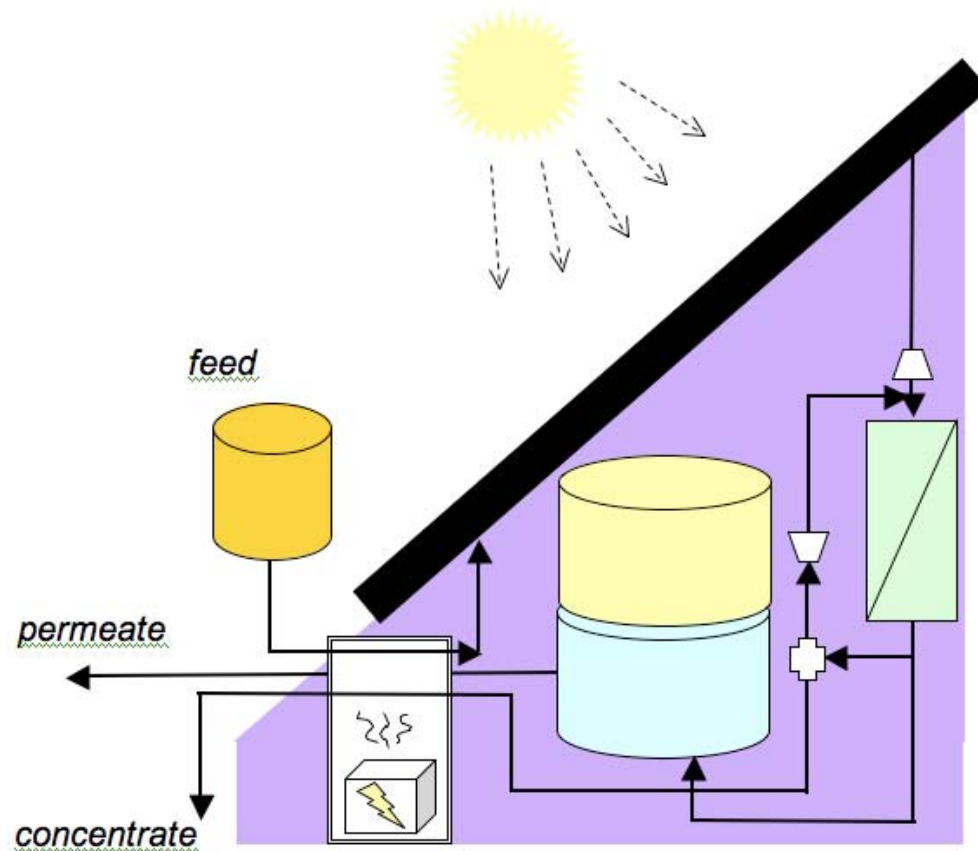
---

	Recirculating	Two stage
Recovery	80%	50%
Specific power	1.02kWh/m <sup>3</sup>	0.6kWh/m <sup>3</sup>
Permeate TDS (35 °C)	277	314

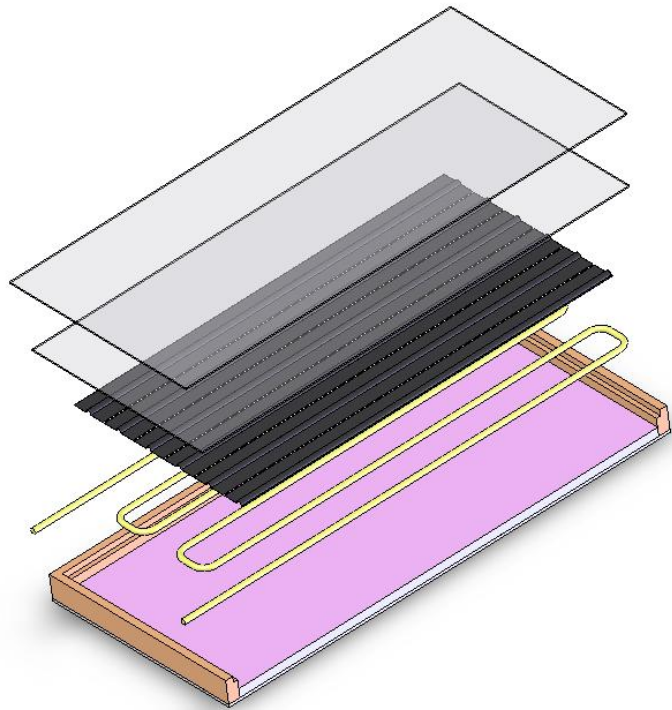
# Design schematic

- 14 m<sup>2</sup> collectors

System Layout



# Design: solar collector



- Locally available materials
- Simple fabrication

# Specific components

Image removed due to copyright restrictions.

Please see <http://www.hyundai-generators.co.uk/graphics/2500Ldualvoltage.jpg>

Image removed due to copyright restrictions.

Please see [http://www.codeline.com/files/Drawing\\_40A30.pdf](http://www.codeline.com/files/Drawing_40A30.pdf)

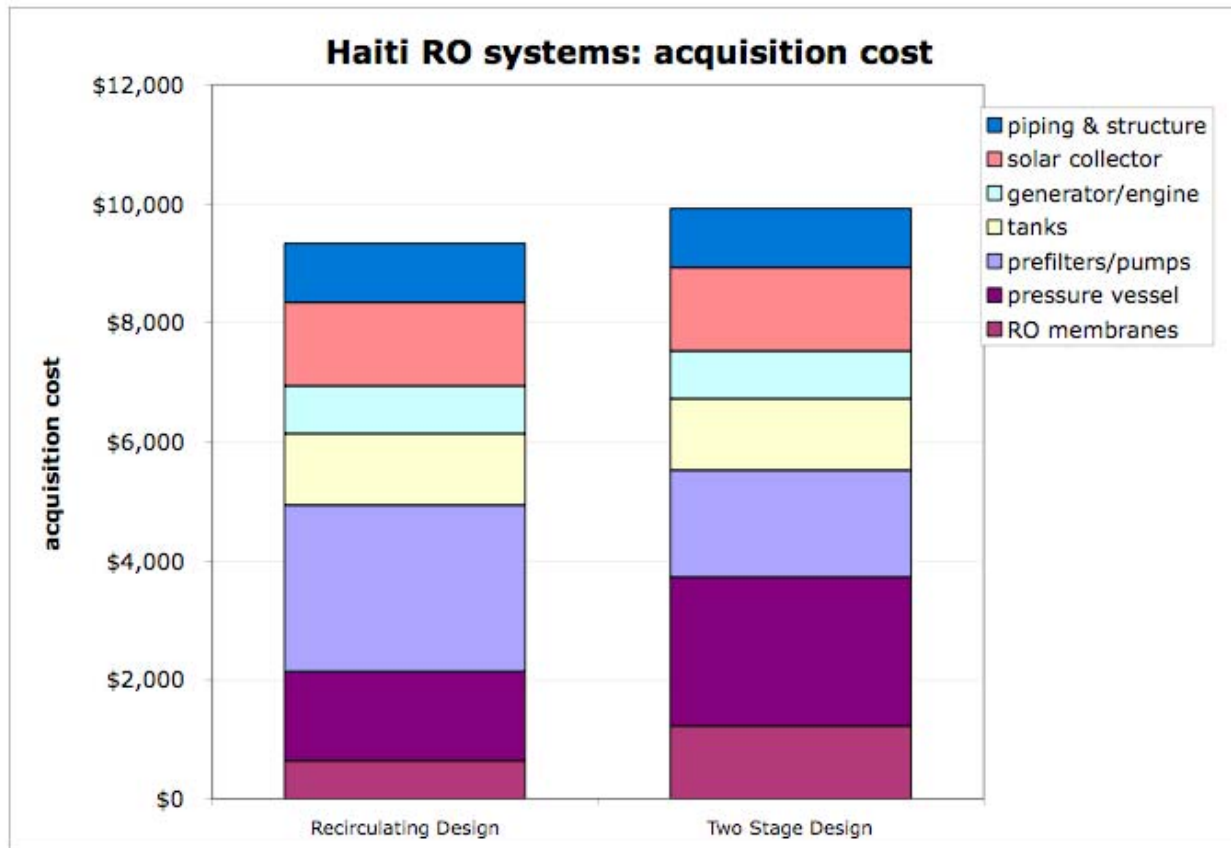
## Cost Estimates (\$)

	Recirculating	Two stage
RO Membrane	638	1,225
Pressure vessel	1,500	2,500
Prefilters/pumps	2,800	1,800
Tanks	1,200	1,200
Solar collector	1,400	1,400
Piping & Structure	1,000	1,000
Generator/engine	800	800
Acquisition price	9,338	9,925
Annual maintenance	600	800
<b>Water price to break even (\$/m<sup>3</sup>)</b>	<b>0.48</b>	<b>0.50</b>

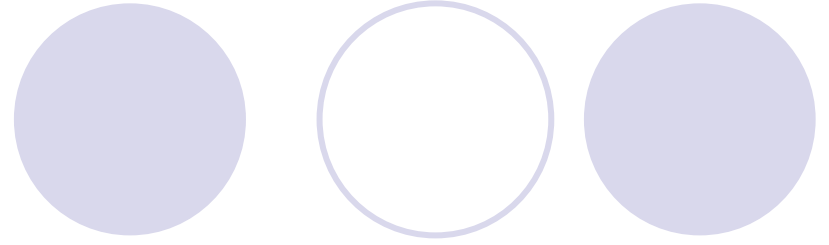
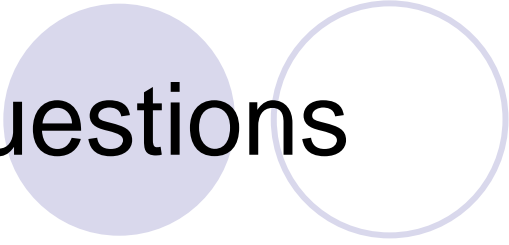
Image removed due to copyright restrictions.

Please see <http://pumpagents.com/store/products/GouldsPumps/images/5GB.jpg>

# Economics: RO system



Questions





# Solarflow

A decorative graphic at the top of the slide consists of two overlapping circles on the left and three separate circles on the right. The circles are light purple, with the first one on the left being solid and the others being hollow outlines.

- Self-contained solar-powered RO system
- 4.5 m<sup>3</sup>/day
- \$130,000

Images removed due to copyright restrictions.

Please see slides 2 and 6 in: Stone, Duncan, and Ali Kanzari. "Solco 'turn key' Solar Water Pumping and Purification System." <http://www.adu-res.org/pdf/Solarflow.pdf>

# Complete Components List

## Components

	Recirculating	Two stage
Recovery	80%	50%
Specific power	1.02kWh/m <sup>3</sup>	0.6kWh/m <sup>3</sup>
Permeate TDS (35 °C)	277	314
Pump flow & power 80% efficiency	Feed: 25m <sup>3</sup> /day 23.4 bar ΔP 850 W Recirculate 120m <sup>3</sup> /day 0.43 bar ΔP 75 W	Feed: 40m <sup>3</sup> /day 8.2 bar ΔP 500 W
Pump	Feed: 10GBS10 Booster: 10GBS10	Feed: 10GBS10
Membrane	1X Filmtec BW30-365FR (34m <sup>2</sup> )	3X Filmtex LP-4040 (8.1m <sup>2</sup> ) 2X Filmtec XLP-4040 (8.1m <sup>2</sup> )
Pressure Vessel (Fiberglass)	1X Codeline 80A-15-1	1X Codeline 40A-30-3 1X Codeline 40A-30-2