

# EPA Water Disinfection

Solar Pasteurizer with Integrated Heat Exchanger (SPIHX)

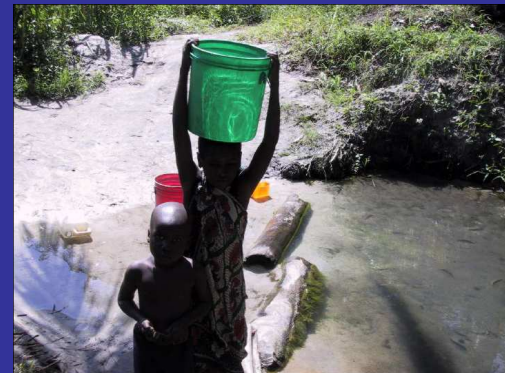
## Project # P07401

Sponsor: Environmental Protection Agency (EPA)

<u>Member</u>		<u>Role</u>	<u>Responsibilities</u>
Sang Lee	(ME)	Project Manager	System Thermal & Fluids Analysis
Elaine Aiken	(ME)	Lead Engineer	Heat Exchanger Analysis
Kellen Bucher	(ME)	Engineer	Heat Exchanger Analysis
Drazen Hadzialic	(ME)	Lead Test Engineer	Solar Collector Analysis
Nate La Croix	(ME)	Test Engineer	Solar Collector Analysis
Alex Kinlock	(ISE)	Support	Materials & Fabrication Analysis
Sulen Gonc	(ISE)	Support	Materials & Life Cycle Analysis

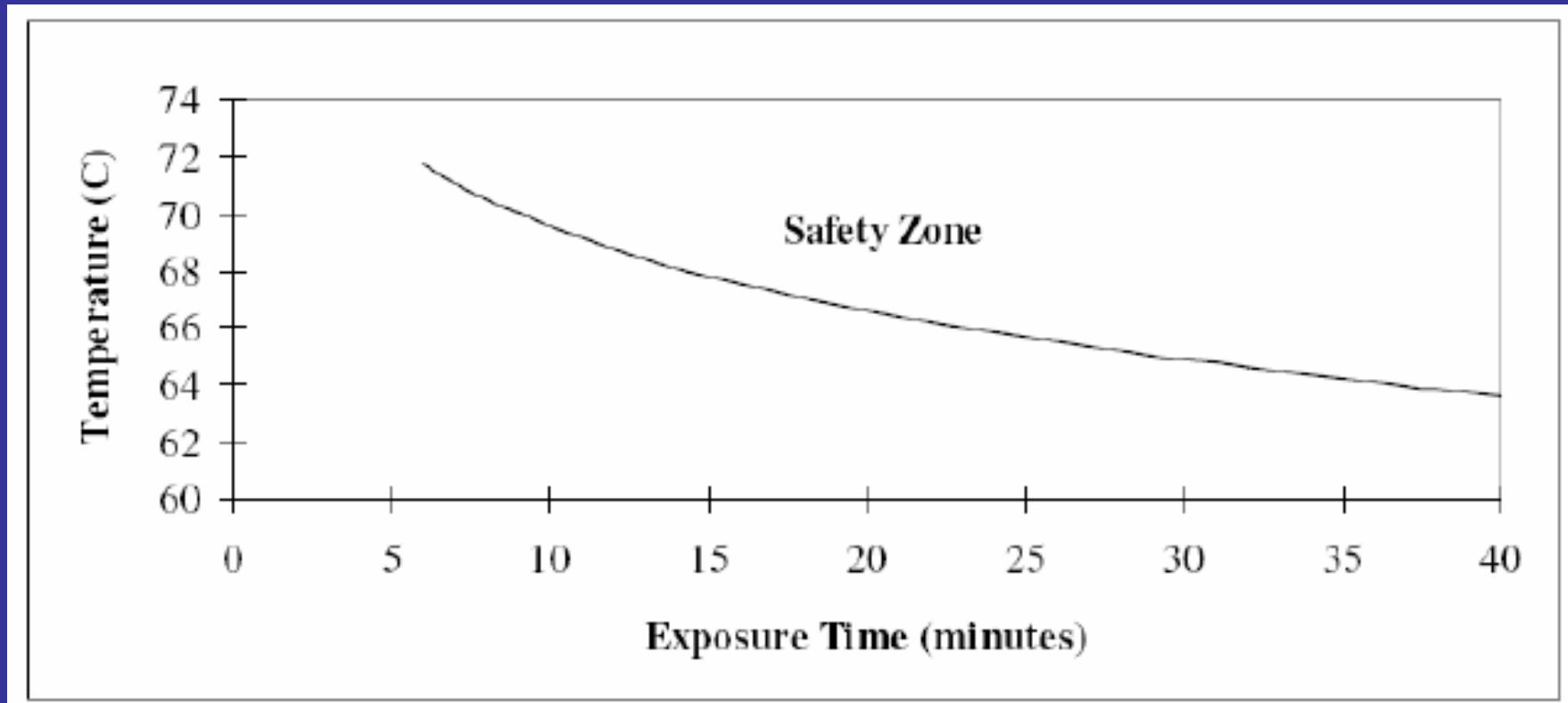
# Project Description / Customer Needs

- World Health Organization (WHO) – Water for Life (2005)
- United Nations (UN) – Millennium Development Goals
- Sustainability & EPA's P3 Competition
  - People
  - Prosperity
  - Planet
- Customer Needs
  - Provide potable, pasteurized water
  - Easy to use
  - Low cost
- Goal
  - Design, develop, and test a working prototype of a solar water pasteurizer



# Pasteurization

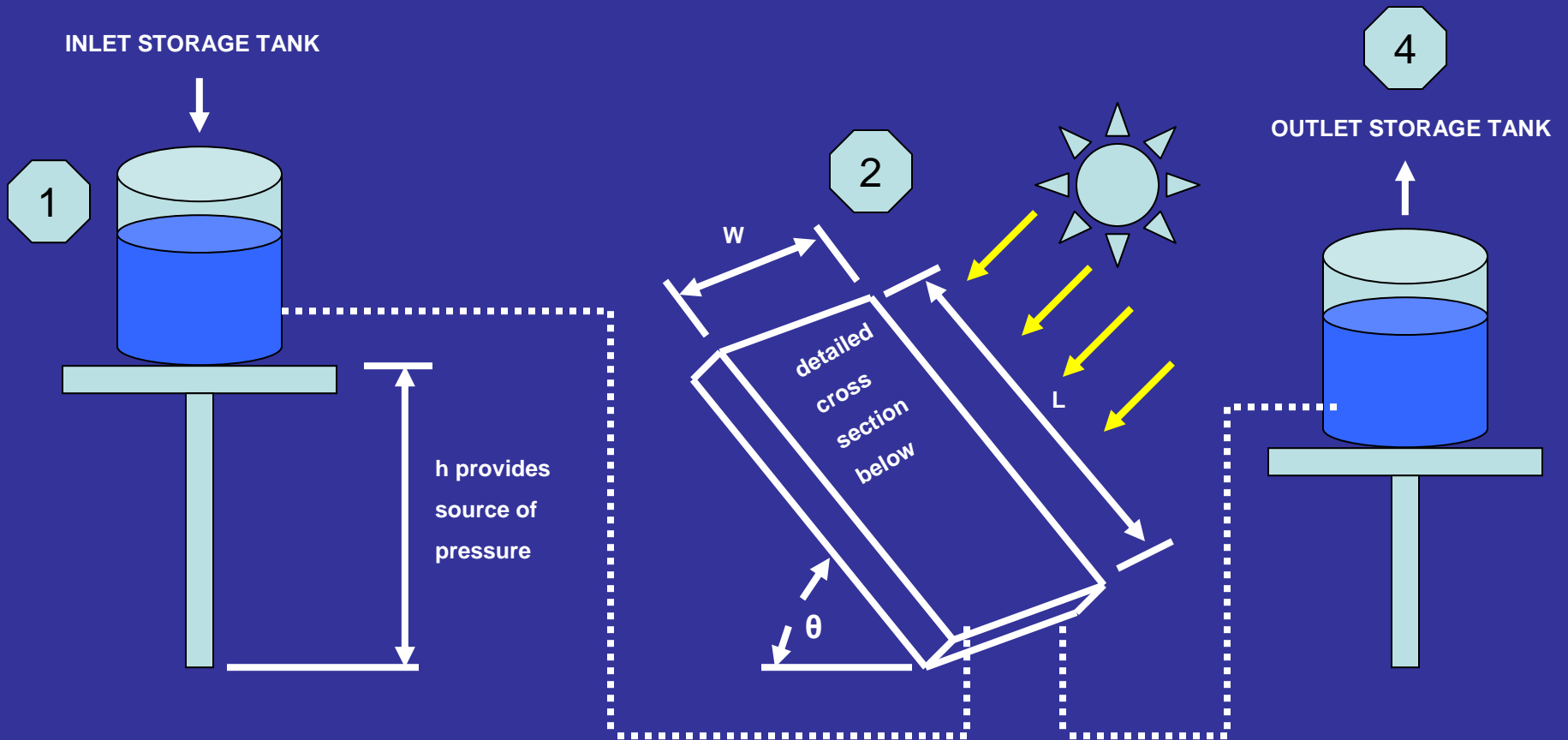
- Pasteurization occurs below the boiling point



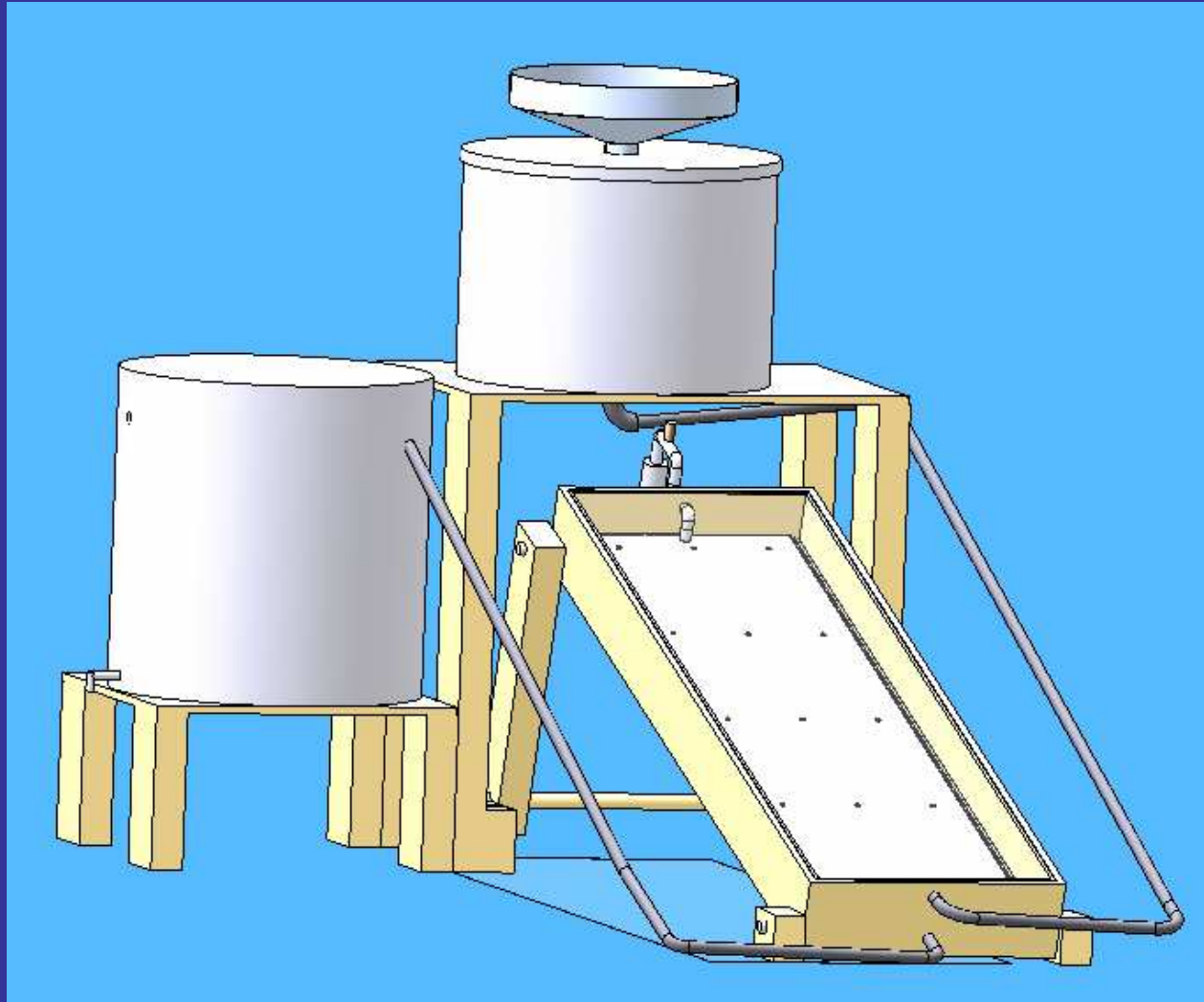
# Concept Selected

— ENERGY

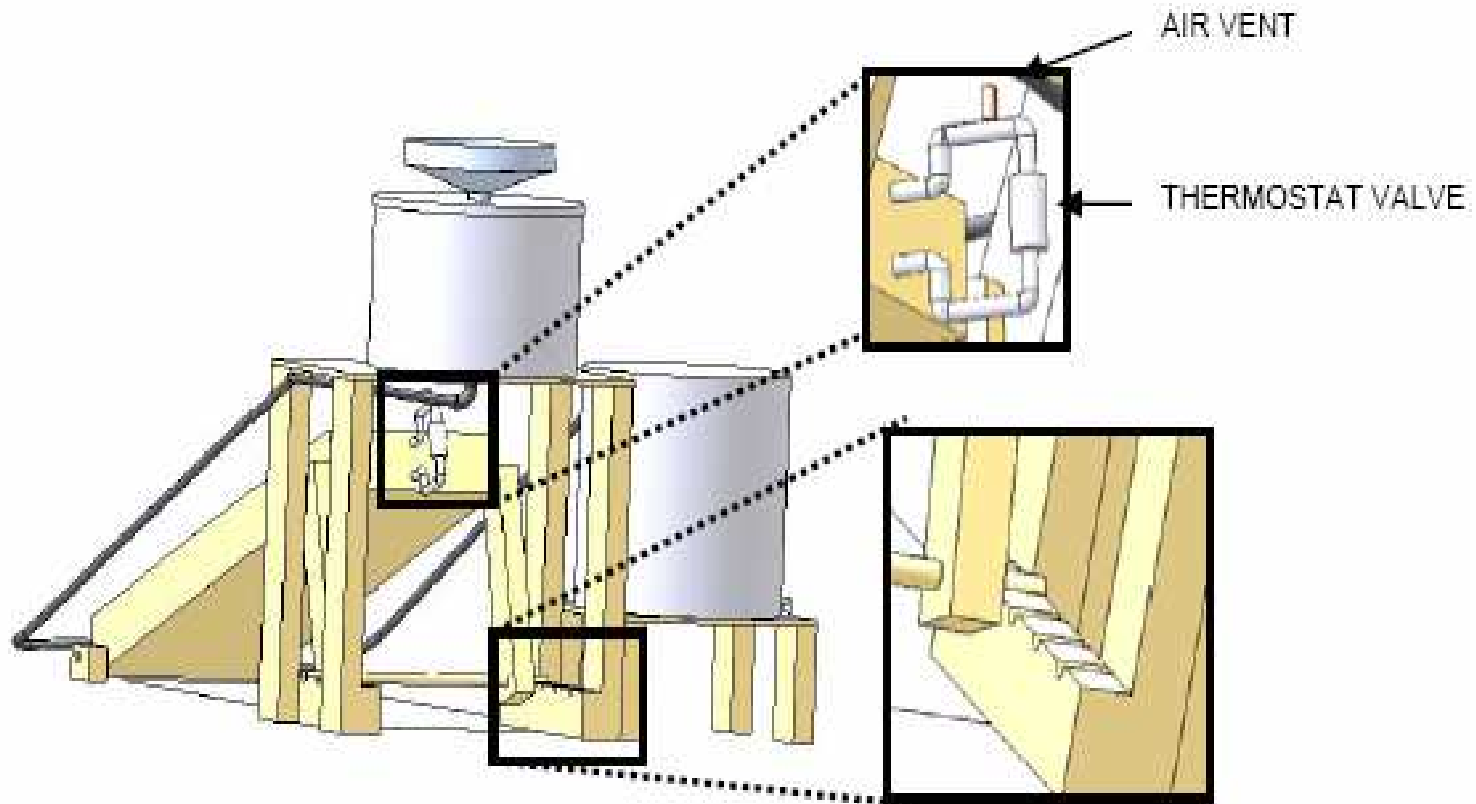
..... PIPING



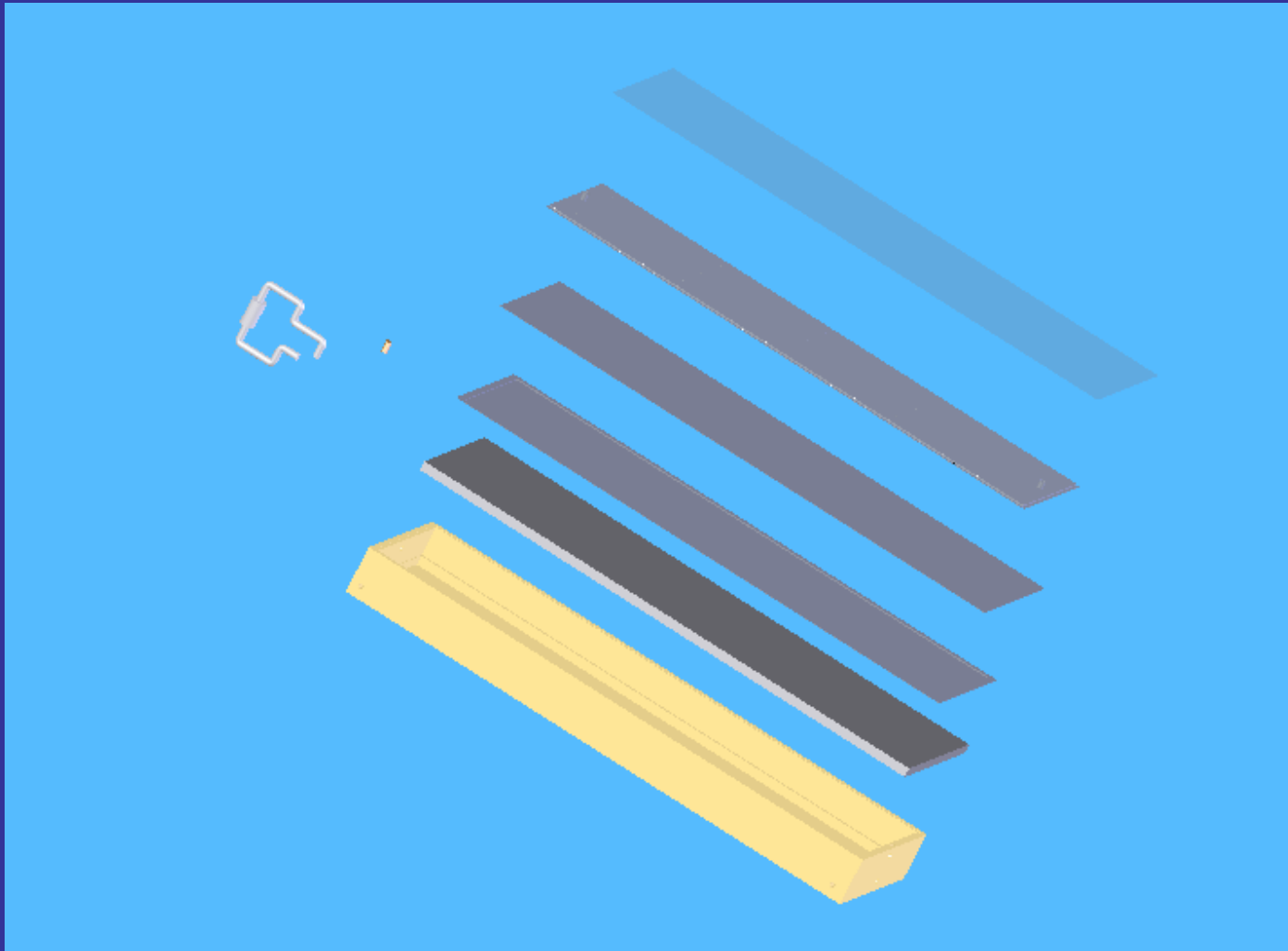
# Prototype Summary



# Prototype Summary



# Prototype Summary



# Product Development Process

1. Completed design phase
2. Currently testing fabrication method
  - Determine the cheapest way to manufacture product while still retaining structural integrity
  - Machine dies to form heat exchanger
3. Create heat exchanger and test stand
4. Assemble pasteurizer
5. Perform tests



# Summary of Design Review

- Noted **Problems/Solutions**:
  - **Modeling After Puerto Rico Solar Data, not Venezuela**
  - **Difficulty Obtaining Hourly Venezuela Data**
  - **Similarity of the Data**
  
  - **Leakage Past Thermostat Valve**
  - **Re-design of Housing, Valve Modification, Incorporate Gasket**
  - **Leak Testing**
  
  - **Welding Issues (JB Weld)**
  - **Aluminum Arc Welding**

# Summary of Design Review

- Durability, Thermal Cycling
- Drop Testing, Environmental Chamber Testing
  
- High Cost
- Mass Production Cost Analysis in Progress
  
- Small Diameter Air Control Tubing
- Increase of Diameter to  $\frac{3}{4}$ "
  
- Low Contact Surface Area of Dimples
- Arc Welding Will Increase Surface Area

# High Risks

- Solar Testing in Rochester
- Short Time for Fabrication and Testing
- Cost
- Design Flexibility

# Customer Needs vs. Specifications

Customer Needs	Target Specifications Addressing the Need	Spec. Met?	Achieved Value	Marginal Value
<b>Category 1:</b> Solar Pasteurizer should be economical				
<b>COST</b>	Inexpensive production, commercial use	No	\$ 190.19	\$ 60.00
	Minimal Imported/specialized Components	Yes	97%	80%
	Use of available Fabrication Techniques	Yes	100%	80%
	Use of only Solar Energy	Yes	Yes	Yes
	Use of no chemical disinfectants	Yes	Yes	No
<b>DURABILITY</b>	# of Moving Parts	Yes	0	2
	Leak Proof	Yes	Yes	No
	Thermal Cycling until Failure	Pending	Pending	1000 cycles
<b>Category 2:</b> Solar Pasteurizer should be safe				
<b>SAFETY</b>	Disinfection from pathogens	Pending	Pending	log5
	Handling sediment in water	Yes	Yes	No
<b>Category 3:</b> Solar Pasteurizer should be versatile				
<b>VERSATILITY</b>	Effective for different water sources	Yes	Yes	No
	Operational in different point of application	Yes	Yes	No
	Applicable to different climates	Yes	Yes	No
	Ease of integration to current system	Yes	Yes	No
	Daily potable output	Yes	20 L/Day	20 L/Day
<b>Category 4:</b> Solar Pasteurizer should be easy to operate				
<b>USABILITY</b>	Scheduled Maintenance	Pending	Pending	2 min
	Operable by population of various characteristics	Pending	Pending	1-10 Rating

# State of design

- **Meeting Specifications**

- Economical
- Safe
- Versatile
- Easy to operate

- **Budget**

- Initial cost was higher than desired
- Reassessing certain areas of BOM to reach budget goal
- Analyzing mass production cost to compare

- **Timeline**

- Paper for project due April 6<sup>th</sup>, Project due April 24<sup>th</sup>
- Plan is to have all materials ordered by the end of week 11 and built the first week of SDII
- Small scale prototype is in progress to see how well our design process works

# Budget Overview

P07401 Allocated Budget Overview				
<b>Total Allowance</b>	<b>\$4,479.00</b>			
<b>Section: Overview</b>	<b>Allocation %</b>	<b>Allocation \$</b>	<b>Amount Used</b>	<b>Remaining Amt.</b>
Testing	25%	\$1,119.75	\$ 18.47	\$1,101.28
Solar Collector Materials	5%	\$223.95	\$ -	\$223.95
Heat Exchanger Materials	15%	\$671.85	\$ -	\$671.85
Fabrication Materials	6%	\$268.74	\$ -	\$268.74
Insulation Materials	2%	\$89.58	\$ -	\$89.58
Sealing Materials	2%	\$89.58	\$ -	\$89.58
Misc. Materials	5%	\$223.95	\$ -	\$223.95
<b>Total</b>	<b>60%</b>	<b>\$2,687.40</b>	<b>\$ -</b>	<b>\$2,687.40</b>
<b>Remaining</b>	<b>40%</b>	<b>\$1,791.60</b>	<b>\$ -</b>	<b>\$1,791.60</b>
Date of last revision:	2/22/2007			

# Expected Cost/Set of Components

<b>P07401 Allocated Budget Overview for Subcomponent sets</b>		
<b>Total Allowance</b>	<b>\$4,479.00</b>	
<b>Section: Overview</b>	<b>Amt. Anticipated</b>	<b>Remaining Amt.</b>
Testing	\$ 250.00	\$231.51
FeedWater System	\$ 72.95	\$72.95
Heat Exchanger & Solar Collector	\$ 92.15	\$92.15
Fabrication	\$ 130.21	\$130.21
Valve Housing	\$ 68.87	\$68.87
Enclosure	\$ 16.50	\$16.50
Misc. Materials	\$ 200.00	\$200.00
<b>Total</b>	<b>\$ 830.68</b>	<b>\$812.19</b>
<b>Remaining</b>	<b>\$ 3,648.32</b>	
Date of last revision:	2/22/2007	

# Anticipated Costs per Component

Use	Product Name	Product Description	Vendor	Part Number	Cost	Unit	Qty.	Total Cost	Lead Time
Feedwater System	Permanent Filter	Sediment Filter with strainer	Donated	N/A	\$ -	Per filter	1	\$ -	In House
	Bucket	5 Gallon Inlet/Outlet water storage	Amazon.com	50640	\$ 5.69	Per bucket	2	\$ 11.38	1 week
	PVC Tubing	UV Resistant Black PVC Tubing (1/4" ID, 7/16" OD)	McMaster Carr	5187KAC	\$ 0.32	Per ft.	25	\$ 8.00	1 week
	Millstead 4"x 4x 8'	Pressure Teated Lumber	Home Depot	N/A	\$ 6.97	per piece	4	\$ 27.88	In Stock
	Millstead 1/2"x4'x8'	3 ply Sheating	Home Depot	N/A	\$ 11.95	per piece	1	\$ 11.95	In Stock
	5 1/2" long 1/4"-20	SS Bolts	McMaster	N/A	\$ 9.06	10 pack	1	\$ 9.06	In Stock
	Hose Clamps	5/16" Band Width (7/32-5/8" Adjust) Type 301 SS, Zinc Plat Screw	McMaster	5388K14	\$ 4.68	10 pack	1	\$ 4.68	In Stock
Heat Exchanger & Solar Collector	Plate	Aluminium (5052) Plate 18 ga.	Metal Supermarkets	N/A	\$ 0.03	in <sup>2</sup>	2324	\$ 69.72	In Stock
	Glass	Solar Collector surface, 1/16" thick	Ray Sands Glass	N/A	\$ 33.15	per m <sup>2</sup>	0.5	\$ 16.58	In Stock
	Solkote	Selective Solar Coating	Solec	N/A	\$ 0.92	per m <sup>2</sup>	0.5	\$ 0.46	In Stock
	Silicone Sealant	GE Silicone Sealant	Home Depot	N/A	\$ 5.39	Per tube (10.1 FL oz.)	1	\$ 5.39	In Stock
Fabrication	Bearing	Steel Ball Bearing	McMaster-Carr	9292K47	\$ 4.27	Per 20 pack	1 of 20	\$ 0.21	In Stock
	Plate	Steel Plate 1.414m x 0.36cm	Metal Supermarkets	N/A	\$ 65.00	Per plate	2	\$ 130.00	In Stock
	Rod	Steel Rod 15mm Diam., 17mm Length	Found	N/A	\$ -	Per rod	1	\$ -	-
Valve Housing	Al 6061 Rod	For valve housing	McMaster Carr	8974K961	\$ 67.62	12 in.	4	\$ 19.72	1 week
	Al Screw	1/4" x 20 x 1"	McMaster Carr	93306A542	\$ 16.68	50 pack	4 of 50	\$ 1.33	1 week
	Al Hex Hd Nut	1/4" x 20 x 7/16" (7/32" tall)	MSC	67469684	\$ 9.09	100 pack	4 of 50	\$ 0.36	1 week
	Rubber Gasket	Rubber gasket	Donated	N/A	\$ -	N/A	1	\$ -	In house
	Thermo-stat vlv	160 deg. F	Stant Manufact.	13006	\$ 3.97	ea.	1	\$ 3.97	In house
	Al 6061 Tubing	6061 Al Alloy Tubing (.194" ID, 1/4"OD)	McMaster	9924K111	\$ 11.08	3 Feet	1	\$ 11.08	1 week
	Hose Clamp	Stainless steel	Auto Zone	N/A	\$ 1.59	2 pack	1	\$ 1.59	In house
	Al Coupling	1/4" NPT	McMaster Carr	44705K317	\$ 1.44	ea.	2	\$ 2.88	1 week
	Air vent	1/8" NPT	Honeywell	FV180	\$ 11.01	ea.	1	\$ 11.01	In house
	Elbow	90 Degree Elbow ( 1/4"ID)	McMaster	50915K143	\$ 3.20	ea.	2	\$ 6.40	In Stock
	Coupling	Compression Coupling (	McMaster	5220K23	\$ 1.93	ea.	3	\$ 5.79	In Stock
	Tees	Tube (1/4"OD), Male Pipe (1/8"), Tube (1/4"	McMaster	5220K158	\$ 4.74	ea.	1	\$ 4.74	In Stock
Enclosure	Millstead 3/4" x 4ft x 8ft	Plywood panel	Home Depot	166103	\$ 18.99	per sheet	0.3	\$ 5.70	In Stock
	Fiberglass- R-13 Kraft	Insulation material, 15" x 32ft x 35", 40 ft <sup>2</sup>	Home Depot	375004	\$ 10.80	per roll	1	\$ 10.80	In Stock

Pasteurizer Only \$ 190.19

Total \$ 380.68



# Cost per Test Equipment

Item	Test #	Product Name	Product Description	Vendor	Model Number	Cost	Unit	Qty.	Total Cost	Lead Time
1	I - 1,2,4 ; II - 2	Thermocouples	J-Type Temperature Measuring Device	RIT - Wellin	N/A	\$ -	N/A	30	\$ -	In House
2	I - 3,4; III - 2	Pressure Transducer	Temperature compensated pressure measurement	Omega	PX137	\$ 55.00	per transducer	1	\$ 55.00	In Stock
3	II - 1	Incubator	Water Quality test equipment	Dr. Lodge	N/A	\$ -	N/A	1	\$ -	In House
4	II - 1	Lauryl - tryptose	Broth mixture for pathogen testing	Dr. Lodge	N/A	\$ -	20 ml broth/100 ml of water	400 ml	\$ -	On campus
5	II - 1	Test tubes and other equipment	Necessary equipment for testing	Dr. Lodge	N/A	\$ -	N/A	10+	\$ -	On campus
6	All	Pyranometer	Sensor to measure solar flux	LI-COR	LI-200SA BNC connector LI-200SZ bare leads	\$ 195.00	per pyranometer	1	\$ 195.00	In Stock
7	All	DAQ Card	Data Acquisition Card for Test Sensors	LabVIEW		\$ -	per card	1	\$ -	In House
8	All	Air Compressor	Air Compressor (at least 40 psi)	RIT	N/A	N/A	N/A	1	\$ -	In House
									Total	\$ 250.00

# MSD II Schedule

- Week 1 – Fabrication
- Weeks 2 & 3 – Testing / P3 Report
- Week 4 – P3 Report Revision
- Week 5 – EPA Conference Preparation
- Week 6 – Testing / Refine design
- Week 7 – Sustainable Design Expo
- Week 8 – Design Review / Prototype Demo
- Week 9 – Conference paper / poster
- Week 10 – Project Review