Pre-Conditioned Expeditionary Assistance Kit (PEAK)

Power Generation, Water Purifier, Shelter and Solar Cooker

Wayne State University

Waleed Al-Taie, Bruce Slykhouse , Era Raizada, Jahirul Chowdhury, Eric Gingrich, and Rosalyn Warner

Design Layout

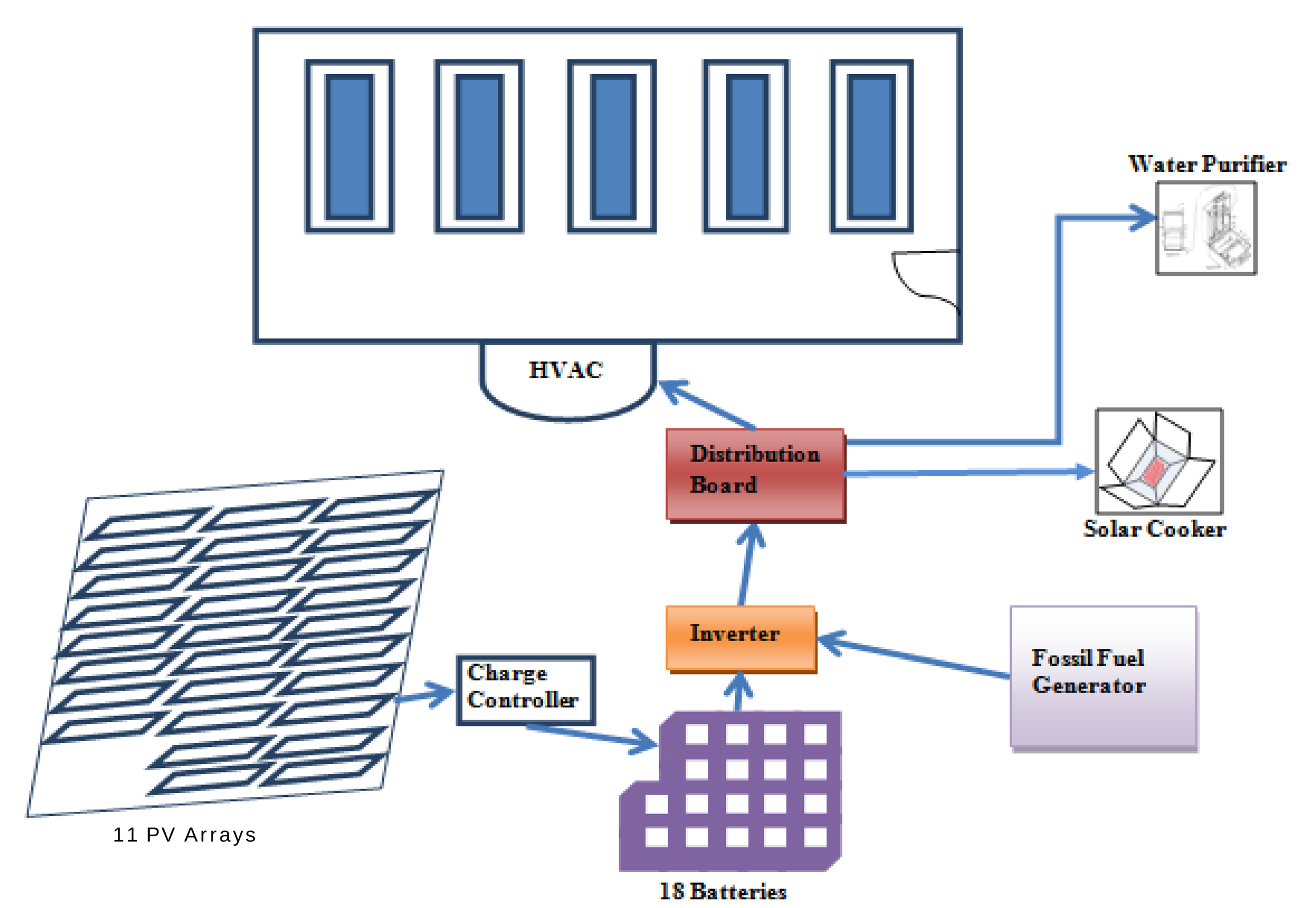

FIGURE A – Design Layout

Warrior Design Innovative (WID) team developed a concept for the PEAK Unit which contains an ultraviolet water purifier, a solar cooker, a conventional refrigerant cycle HVAC system, and a 3.5kW solar power generator. The design uses solar energy for both the cooker and power generation. The HVAC is a conventional unit that both cools and heats the shelter. The solar panels are used as a primary source of power and are backed up by a diesel generator.

Water Purification System

FIGURE B - Aqua Sun International Responder A

The complete water purification system will have two segments Segment-A and Segment-B (see appendix 5.20)

Segment-A: The number/shape/material of sections comprising the column can vary. It will have two polyvinyl chloride (PVC) cylindrical sections. Water is poured through the top section and allowed to move, via gravity, downwardly through the lower section and out an outlet disposed in the lower portion which is connected to an inlet of Segment-B.

Segment-B: Water flow through Segment-A to Segment-B to provide a purification system capable of decontaminating water making it suitable for human consumption

Solar Cooker

- Maximum Air Temperature: 128^{0}C (263 F)
- 4 steel reflectors
- Fixed orientation through the day
- Window Size: 2.89 ft x 2.89 ft
  - 84% transmissivity
- Size: 2.89 ft x 2.89 ft x 0.82 ft
- 1000 W heating element

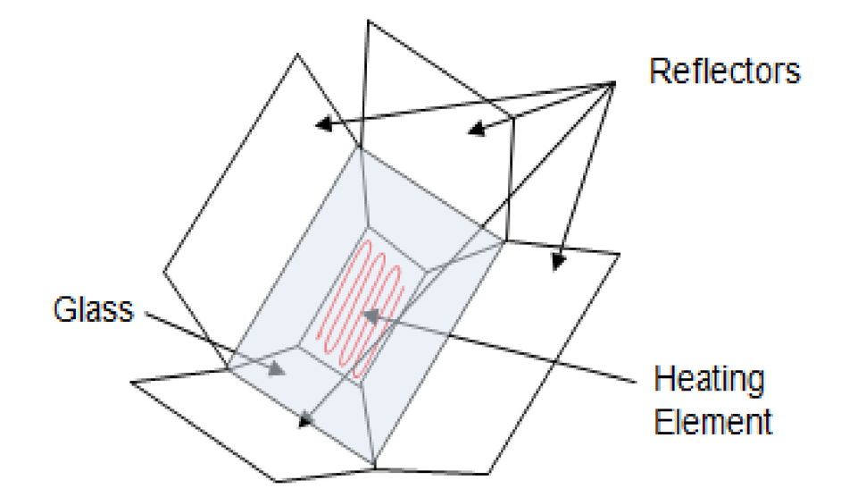

FIGURE C – Solar Cooker

It was assumed that the average solar radiation in the horizontal plane was 450W/m^2. This assumption was based on the solar radiation that regions in Africa receive. Efficiency of solar cooker is defined as energy needed to raise the temperature of water over the energy incident on the cooker

A conservative estimate of 25% efficiency was assumed for the solar cooker. A cook time of four hours was assumed for the cooker. The increased radiation on the cooker from the reflector plates is calculated from a performance factor . A performance factor of one was assumed for the solar cooker.

Fluent Solar Cooker Model

Model Conditions
- Solar ray tracing model
- East Africa location
- June 21 at 12 pm

Boundary Conditions
- Initialized to 22^{o}C

Material Properties
- Transmissivity 84%

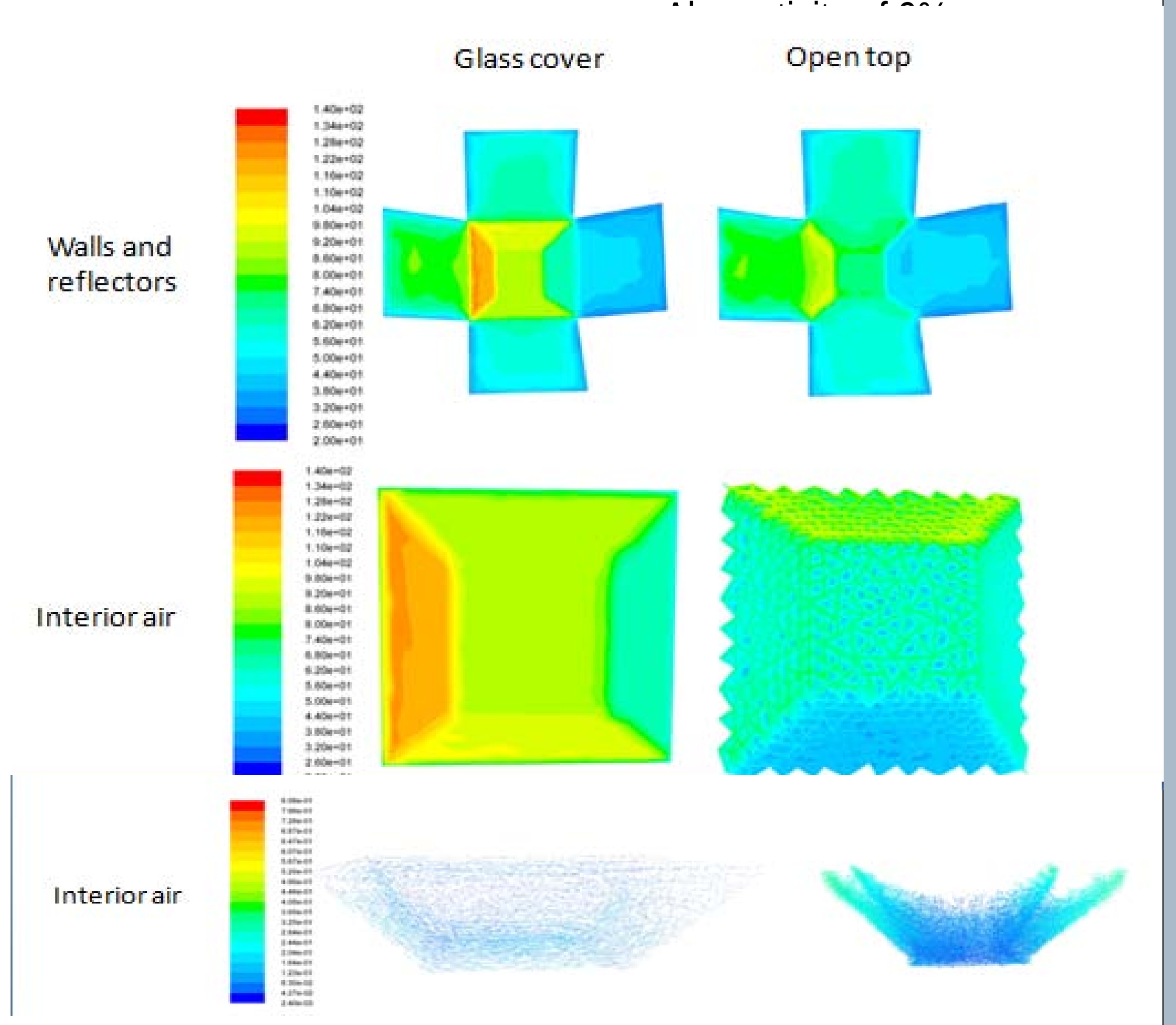

FIGURE D – Contours Temperature (C^o)

From the figures above it can be seen that using a solar cooker with a transparent piece of glass increases the temperature of the oven. With a glass cover the oven less heat is lost due to convection. The figure of velocity show a much smaller velocity field in the glass coved cooker. Both a higher air and surface temperature can be seen in the covered cooker.

Shelter and HVAC

- Tent
  - Floor Area: 271 ft^2
  - Material: Thinsulate, Prodex & Polyester

FIGURE E – Tent

- Bard CH3s1-B HVAC
  - Cooling Output: 33080 Btu/hr
  - Heating Output: 19802 Btu/hr
  - Power Consumption: 2.2 kW

FIGURE F - HVAC

NOTE: The material that makes up the fabric for the tent is multiple layers. There are three layers, the outer is polyester used for its water resistivity, a layer of foil in the middle which acts as a thermal barrier, and the inner PVC layer is an insulation layer.

Fluent Shelter Model

Model Conditions
- Solar ray tracing model
- East Africa location
- June 21 at 12 pm

Material Properties
- Transmissivity 83%
- Absorptivity of 9

Boundary Conditions
- AC Inlet Conditions
  - Initialized to 18^{o}C
  - Velocity 2.74 m/s
- Wall Condition
  - Initialized to 51^{o}C
  - Wall thickness .011573 m

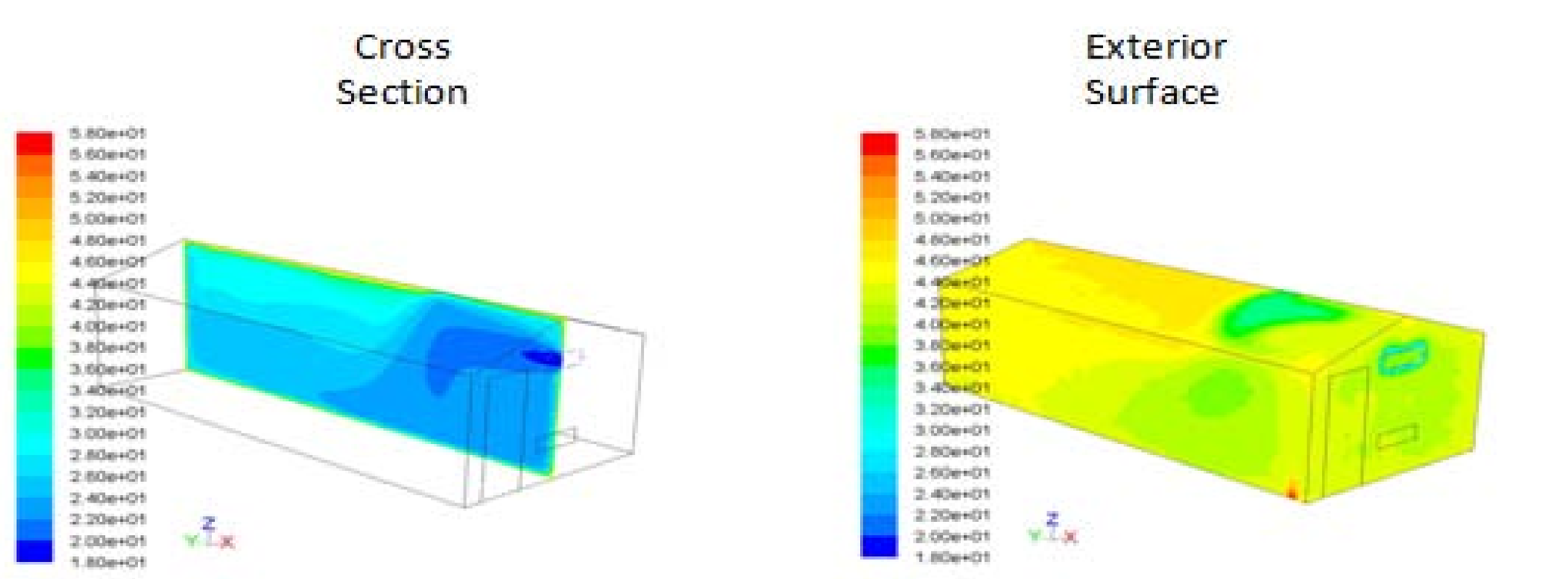

FIGURE G – Contours of Temperature (C^o)

The above picture is a slice along the centerline of the tent. This image allows the contour of the internal temperature. The figure below displays the temperature of the surface of the tent. These figures are beneficial to the design as the team was able to verify that the internal temperature will remain in the specified range under the worst external conditions.

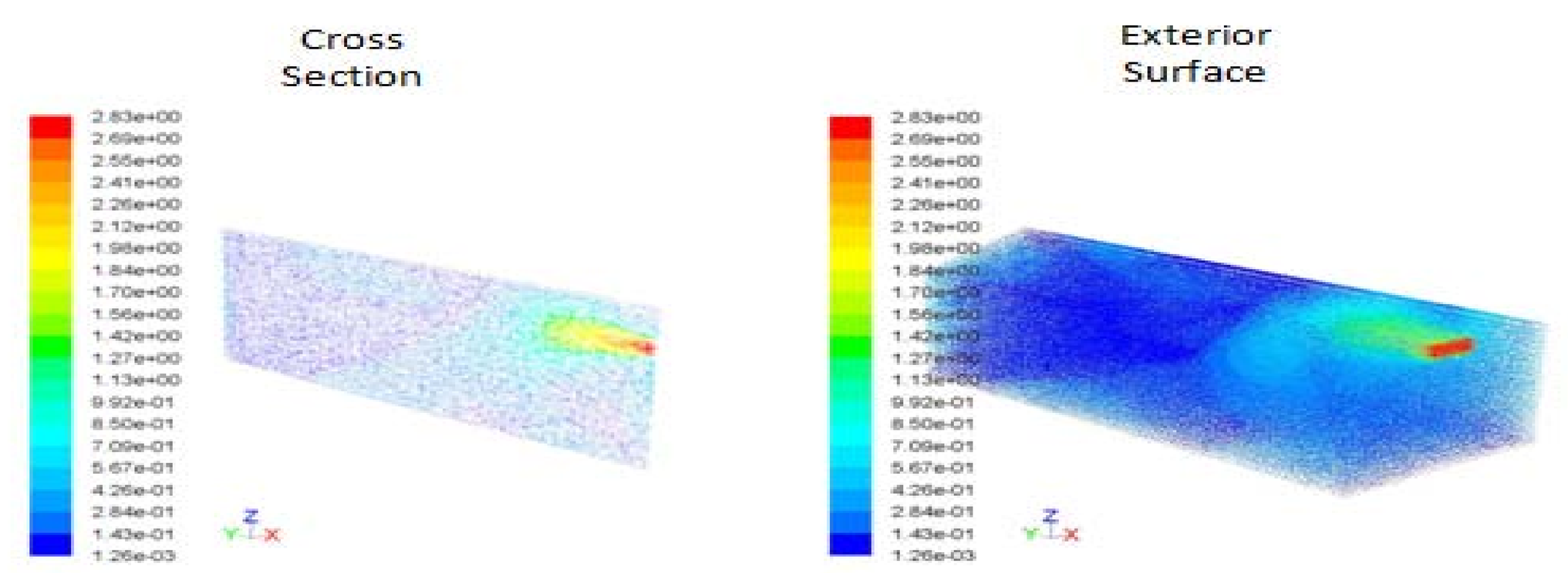

FIGURE H - Vectors Colored by Velocity Magnitude (m/s)

Solar _Diesel Power Generation

- 11 Zytech LCPV array
  - 150 W Max Power
  - PMMA lens cell
  - 23.25 V Max Power Voltage / 6.55A Max Current
- 18 Battery bank (NHE-10-10012V, 100Ah-Features)
  - High power / energy ratio
  - Excellent safety and resistance to abuse
  - Fully recyclable
  - Weight: 18.6 kg
- PRAMAC 5500 Power Generator
  - Voltage: 120/240 VAC
  - Frequency: 60 Hz
  - Fuel Consumption: 0.39 gal/hr
  - Weight: 122kg
  - Size: 2.74ft x 1.92ft x 2.54ft

FIGURE I – Solar Panels

FIGURE J – NHE Battery

FIGURE K – PRAMAC Power Generator

Mass and Energy of Subsystems and Components

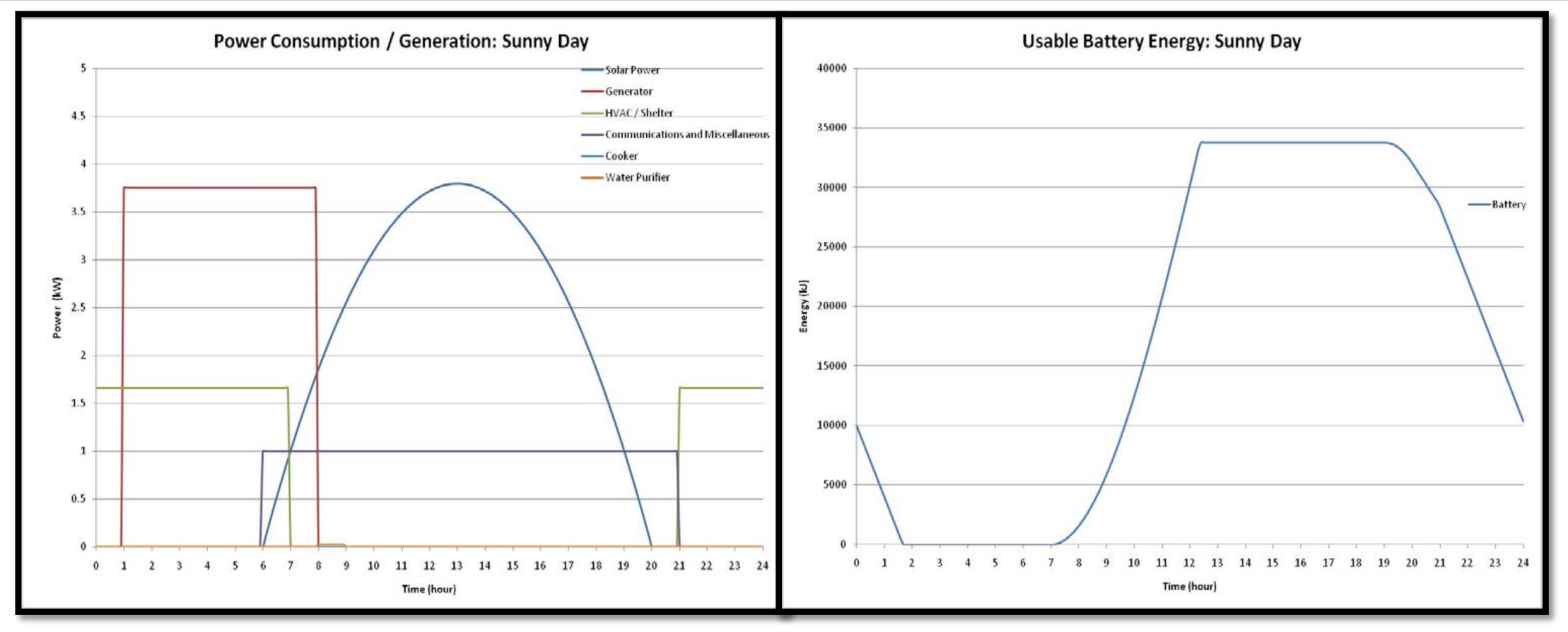

FIGURE L – Power Generation/Consumption and Battery Use on a Sunny Day

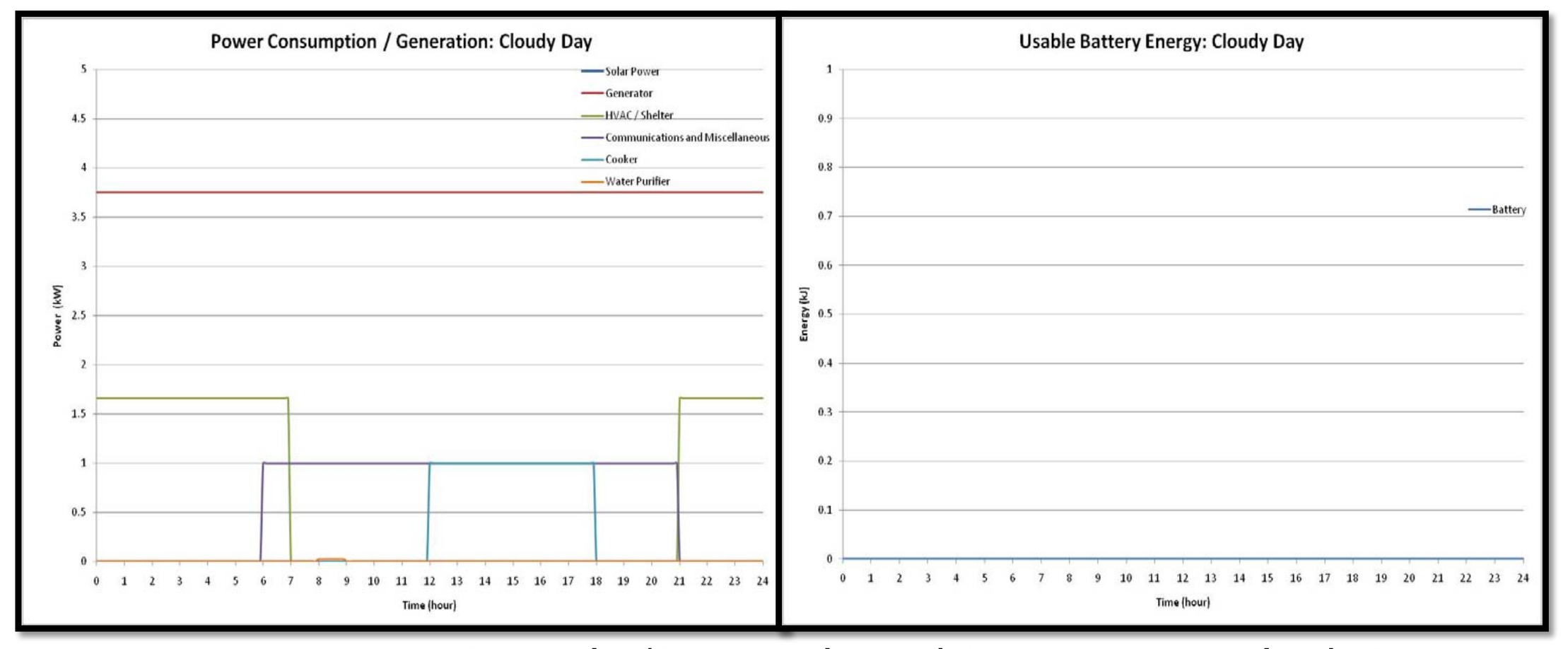

FIGURE M – Power Generation/Consumption and Battery Use on a Cloudy Day

Solar Power System & Back up Generator FMEA

#	Function	Potential Failure Modes	Potential Effects of Failure	SEV	Class	Potential Causes of Failure	OCC	Current Design Controls	DET	RPN	Recommend Actions	Responsible Person & Target Date	Actions Taken	SEV	OCC	DET	RPN
1	Solar Power Generation	Limited Sunlight	Failed to generate the required power	3		Dust storm or cloudy days	4	Clean the panles. Operation & Maintenance instructions	1	12	Clean the panles and Operation and Maintenance instructions	Waleed Al-Taie, Era Raizada		3	4	1	12
2		Panel failed	Failed to generate the required power	8		Piece broke during installation or transporting	2	Operation & Maintenance instructions	3	48	Operation and Maintenance instructions	Waleed Al-Taie, Era Raizada		8	2	3	48
3		Conroller Failed	Failed to regulates the voltage & current coming from panels to the battery	9		Device malfunction	3	Light detector. Operation & Maintenance instructions	1	27	Light detector and Operation and Maintenance instructions	Waleed Al-Taie, Era Raizada		9	3	1	27
4		Inverter Failed	Failed to changes DC voltage to AC from batteries or panels	9		Device malfunction	3	Light detector. Operation & Maintenance instructions	1	27	Light detector and Operation and Maintenance instructions	Waleed Al-Taie, Era Raizada		9	3	1	27
5		Battrey Failure	Failed to obtain the required power	9		Cells disqualification	3	Light detector. Operation & Maintenance instructions	1	27	Light detector and Operation and Maintenance instructions	Waleed Al-Taie, Era Raizada		9	3	1	27
6		Wiring Failure	Failed to run the system	9		Corrosion	3	Check periodically the electrical connections for loose connections and corrosion. Operation & Maintenance instructions	1	27	Check periodically the electrical connections for loose connections and corrosion.	Waleed Al-Taie, Era Raizada		9	3	1	27

Table A - Solar Power System FMEA

#	Function	Potential Failure Modes	Potential Effects of Failure	SEV	Class	Potential Causes of Failure	OCC	Current Design Controls	DET	RPN	Recommend Actions	Responsible Person & Target Date	Actions Taken	SEV	OCC	DET	RPN
1	JP 8/Diesel Power Generator (back up)	Engine Failure	Failed to generate the required power. No back up power for the project	9		Fuel valve break . Piston arm crack . Piston rings expand.....etc	4	Light detector . Operation & Maintenance instructions	1	36	Light detector. Operation & Maintenance instructions	Waleed Al-Taie, Era Raizada		9	4	1	36
2		Lack of fuel	.Failed to generate the required power.	8		No Diesel/ JP-8 available to run the generator	2	Store a sufficient amount of fuel	1	16	Store a sufficient amount of fuel	Waleed Al-Taie, Era Raizada		8	2	1	16
3		Lack of engine oil	Failed to run the generator.	8		No engine oil available to run and maintain the generator	2	Store a sufficient amount of engine oil	1	16	Store a sufficient amount of engine oil	Waleed Al-Taie, Era Raizada		8	2	1	16
4		Engine oil Leakage	Failed to run the generator.	9		Leaks from the engine case or washers.	5	Light detector . Operation & Maintenance instructions	1	45	Light detector. Operation & Maintenance instructions	Waleed Al-Taie, Era Raizada		9	5	1	45
5		Fuel leakage	Failed to run the generator. Safety hazard .	9		Leaks from the fuel tank , washers or hoses.	5	Light detector . Operation & Maintenance instructions	1	45	Light detector. Operation & Maintenance instructions	Waleed Al-Taie, Era Raizada		9	5	1	45
6		Wiring Failure	Failed to run the generator. Safety hazard of fuel and electricity contact	9		Corrosion	4	Check periodically the electrical connections for loose connections and corrosion.	1	36	Check periodically the electrical connections for loose connections and corrosion.	Waleed Al-Taie, Era Raizada		9	4	1	36

Table B – JP8/Diesel Back up Gen.FMEA

www.PosterPresentations.com