Design of a Mobile Shade and Cooling Structure for Grazing Dairy Herds

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Need: Reduce economic losses in dairy operations due to heat stress in cattle.

DAIRY COW TEMPERATURE HUMIDITY INDEX (THI)

Temp °F \ Humidity %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
72	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
74	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73
76	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
78	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
80	68	69	69	70	70	71	72	72	73	74	75	75	76	76	77	78	78	79	79
82	69	69	70	70	71	72	73	73	74	75	75	76	77	77	78	79	79	80	80
84	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83
86	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84
88	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86
90	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88
92	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90
94	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92
96	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94
98	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95
100	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98
102	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100
104	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101
106	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103
108	81	82	83	85	86	88	89	90	92	93	94	96	97	98	100	101	103	104	105
110	81	83	84	86	87	89	90	91	93	95	96	97	99	100	101	103	104	106	107

No Stress

Mild Stress

Moderate Stress

Severe Stress

Background

- Organic dairy produces 2.4 billion pounds of milk yearly.
- Small organic dairy farms use a rotational grazing method.
- Milk production per cow can decrease up to 5 lbs./day due to heat stress.
- This can potentially result in a loss of about $1800 per cow per year.

Objectives

- Reduce heat stress on free-range cows
- Mobile structure for rotational grazing
- Energy-independent
- Act autonomously using onboard logic

Design for 25 cows

Dairy cattle require approximately 40 ft^2/cow of personal space. This necessitates a shade footprint of **1000 ft^2**. Heat stress should be reduced to a **THI of 71**. Weather conditions are monitored to control the cooling system.

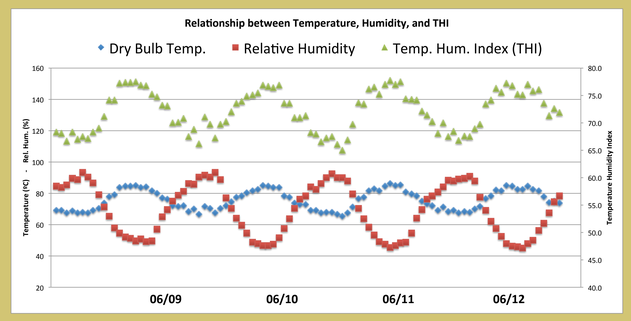
Approach

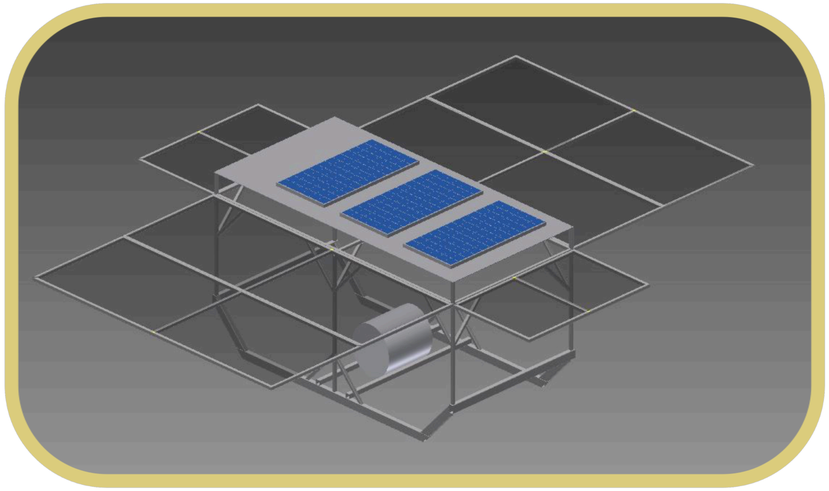
Evaporative Cooling

The temperature-humidity-index is managed by a cooling system combining forced air circulation and water sprinkling to mimic sweating across the cow.

Intelligent Management

Current weather conditions are monitored by sensors and a microcontroller will actuate the fan and the sprinkler pumps accordingly. The electronics package has long-range wireless communication for monitoring.





Design

Stand-Alone System

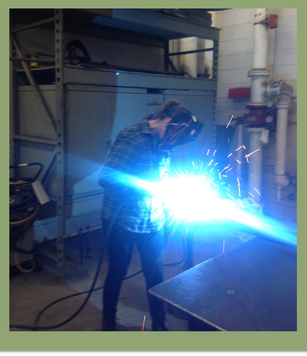
Solar Energy
Three PV panels are monitored and controlled by a MPPT charge controller. Two deep cycle batteries will store excess energy collected.

Water Storage
Water is stored in a 55-gallon drum and dual diaphragm pumps provide flow to irrigation sprinklers.

Structure

Skids
Skids are used for uncomplicated mobility through the pastures. Two D-rings allow for chain towing with a tractor or utility vehicle

Expanding Panels
The structure features folding panels on four sides to vastly expand shaded area for the herd.



Acknowledgements: Dr. John Wilkerson, Dr. Daniel Yoder, Dr. Paul Ayers, Dr. William Hart, David Smith
Thomas Canonico, Elizabeth Fortunato, Mary Nyhus, Phillip Ward