TESTING PROTOCOL

ABOUT THE GLOBAL COOLING PRIZE

The Global Cooling Prize (GCP)—initiated by Rocky Mountain Institute (RMI); Department of Science & Technology, Government of India; and Mission Innovation— is rallying a global coalition of leaders to solve the critical climate threat that comes from growing demand for residential air conditioning. By harnessing the power of innovation, we can provide cooling solutions that enhance people's lives without contributing to runaway climate change. This groundbreaking competition led by RMI, Conservation X Labs, Alliance for an Energy Efficient Economy (AEEE), and CEPT University, is designed to incentivize the development of a residential cooling solution that will have at least five times (5X) lower climate impact than today's standard AC units. This technology could prevent up to 100 gigatons (GT) of CO_2-equivalent emissions by 2050,[1] and put the world on a pathway to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries around the globe.

THE NEED

If the global demand for cooling continues to increase on a business-as-usual trajectory, the number of room air-conditioning (RAC) units in service are estimated to increase from 1.2 billion units today to 4.5 billion units by 2050. Developing countries will see a fivefold increase in demand for RACs over this same period. This increase in demand will alone be responsible for over 0.5°C increase in global warming by 2100, making it difficult for us to achieve the Paris climate goals. Therefore, the Global Cooling Prize will act as the necessary catalyst to spur innovation and develop a cooling technology with five times (5X) less climate impact.

THE PRIZE

The competing technologies will be awarded up to US$2 million in intermediate prizes to support design and prototype development. The winning technology will be awarded at least US$1 million to help finance and support its commercialization.

TECHNICAL APPLICATION EVALUATION AND SELECTION OF FINALISTS

After the evaluation of **Detailed Technical Application** of the participants, up to 10 teams will be selected as finalists based on how their submitted design is expected to meet and exceed the minimum qualifying requirements laid out in the **Technical Criteria**. The technical criteria require the participants to deliver a cooling solution that has five times lower climate impact and costs no more than twice the first cost of today's solutions at assessed scale of 100,000 units. In addition, the cooling solution should also operate within predefined limitations on refrigerants, water, full-load power consumption, materials and operation requirements at. These 10 or fewer finalists will then each be awarded up to US$200,000 each to support the development and production of two prototypes and ship (if manufactured outside India) to India, where these prototypes will be tested for performance in accordance with the technical criteria in both lab environments and real-world apartment building in India.

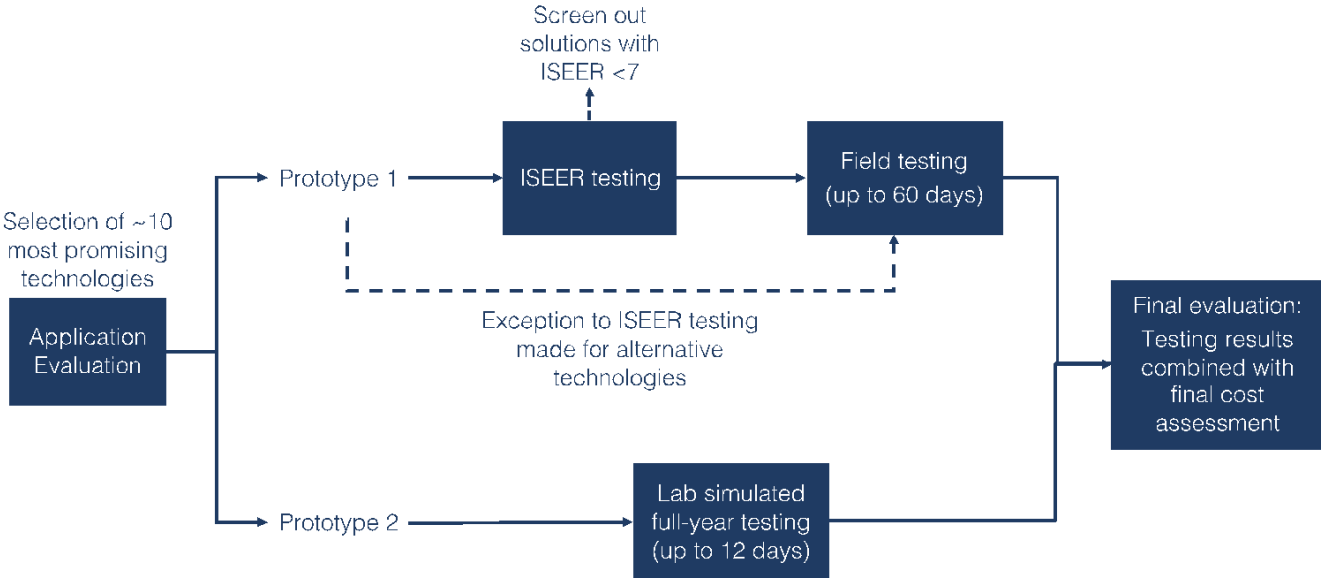
[1] Depending on how fast the grid transitions to cleaner energy sources, and how fast the breakthrough technology can be scaled.

TESTING METHODOLOGY

The selected finalists will use the interim prize money to support the development and production of two prototypes of their cooling solution and ship it to India (if manufactured outside India) for testing purposes. The testing phase, spanning over a period from May to September 2020, will comprise of three different testing steps and the prototypes will be required to demonstrate the desired performance levels, as stated in the technical criteria, at all the three steps. The three testing methods that will be used to assess the prototypes are:

- Indian Seasonal Energy Efficiency Ratio (ISEER) laboratory test
- Lab simulated year-round performance test
- Field test

The "*field test*" will be conducted in parallel with the "*lab simulated year-round performance test*" to optimize the overall time period required for the testing phase. The below schematic provides an overview of the overall testing protocol that will be adopted for this competition.



During commissioning of the prototype units in the laboratory and real-world test, we encourage representatives from each of the 10 selected finalists to support the Global Cooling Prize testing team in installation of their technology. The role of the representatives is to ensure that their technology is properly installed during the testing phase. Post commissioning, however, any involvement in the operation or maintenance of the prototype will not be allowed for the entire duration of the test period. The selected finalists will use the interim prize money to support the travel of any representative during the testing phase.

The performance of all the prototypes will be compared against the baseline performance of 1.5 TR fixed-speed EER 3.5 W/W mini-split AC unit of brand Voltas. The choice of the baseline unit is based on most commonly sold room AC by the market player with higher share in India.

The specific details for each testing method are detailed below:

I. Indian Seasonal Energy Efficiency Ratio (ISEER) laboratory test

To account for the seasonal variations of temperatures and associated cooling requirement, the Bureau of Energy Efficiency (BEE) in India defined the ISEER rating for air conditioners. The ISEER rating assesses the cooling energy consumption and cooling load met by the air conditioner across a temperature range of 24°C to 43°C for 1,600 annual operating hours.

The first prototype of each selected participant will be sent to a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited lab for ISEER rating. The laboratory will conduct testing in accordance with ISO 16358-1:2013, IS 1391 (Part 1): 2017, and IS 1391 (Part 2): 2018 and will determine the prototype's ability to deliver 1.5 TR cooling capacity under standard test conditions. The IS 1391 standard, as applicable to the testing of prototype design (example: unitary or split type), will be followed accordingly. The prototypes that receive an ISEER rating of less than 7 will be disqualified considering the fact that it is lower than the best available technology in the market in India already.

The prototypes using novel and alternative technologies which cannot be tested in accordance with standard ISEER requirements will be evaluated on a case by case basis at the sole discretion of the Technical Review Committee.

II. Lab simulated year-round performance test

The second prototype of each selected participant will be tested in a state-of-the-art laboratory environment at CEPT University laboratory in Ahmedabad, Gujarat in India. The total duration of this test will be up to 12 days for each individual prototype unit and the baseline unit.

The laboratory has the capability to simulate real world environmental conditions for temperature and humidity. It can also simulate heat gains seen in a typical apartment including heat gains from the occupants, air exchange rates between indoor and outdoor environment, heat gain from the appliances, and heat gains from the envelope. The set-up will include two climate-controlled chambers:

- Internal chamber- where the air conditioning unit will be installed
- External chamber- which simulates the outdoor weather conditions

The prototype units including the baseline unit will be tested in the lab environment to evaluate their performance through a series of conditions simulating the range of a full year.

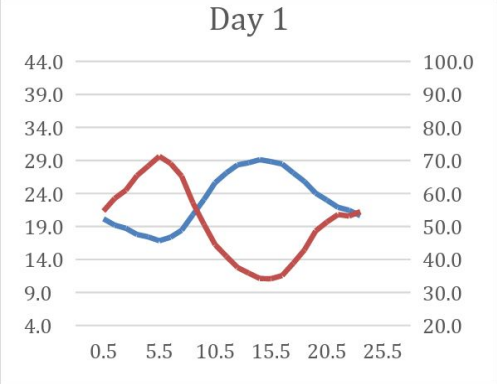
- The internal conditions will be simulated to represent a typical daily sensible and latent load profile observed in a home for internal gains (lighting, infiltration, appliances, occupants etc.) using electric resistance heat, controlled infiltration, and humidifier.

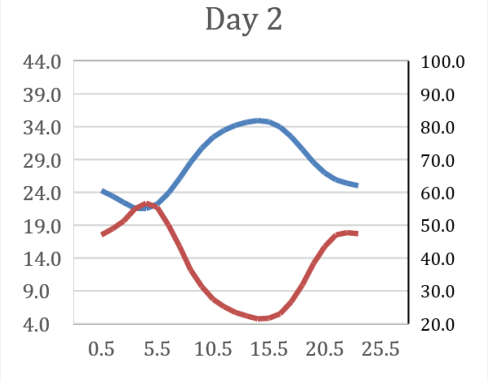
- The external conditions will be simulated to reflect a series of typical daily profiles of warm and dry, warm and humid, hot and dry, hot and humid, and extreme conditions observed across India.

For this test, a set of 10 daily weather profiles have been identified that start from a mild day (with respect to DBT and RH) and end at an extreme day (with respect to DBT and RH) with conditions becoming more challenging each successive day.

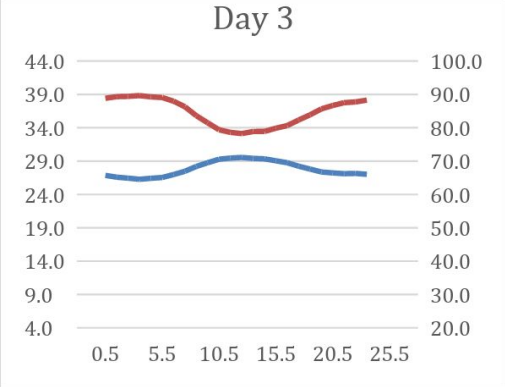
: Dry bulb temperature (left axis) : Relative humidity % (right axis)

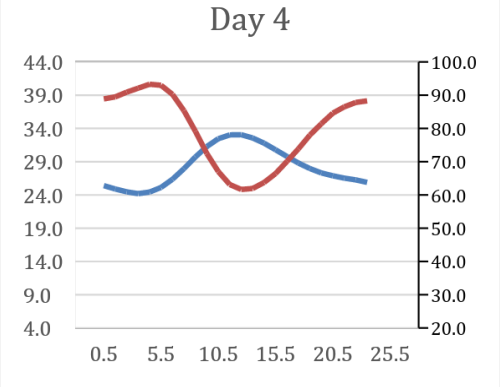
Warm and Dry



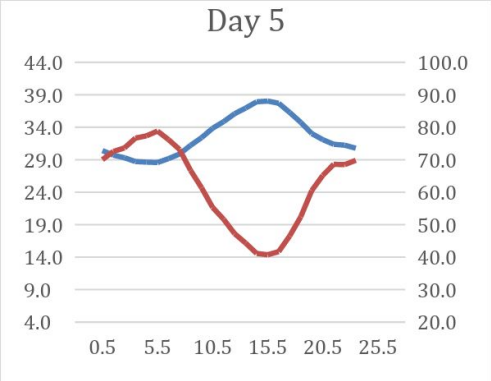


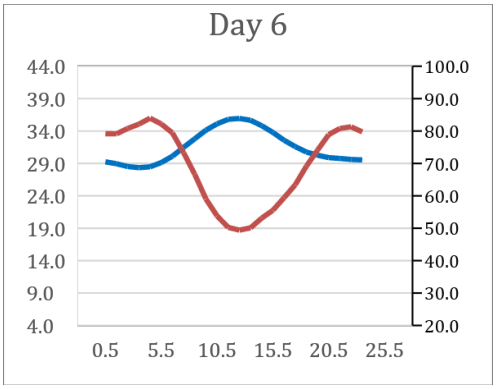
Warm and Humid



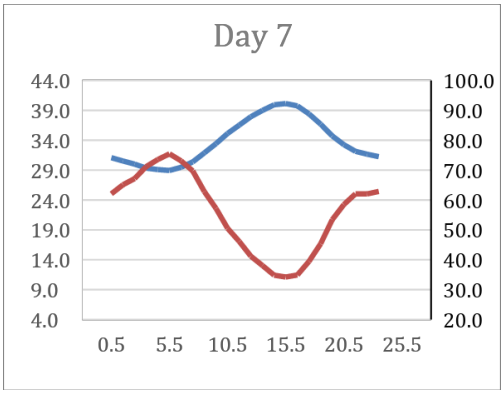


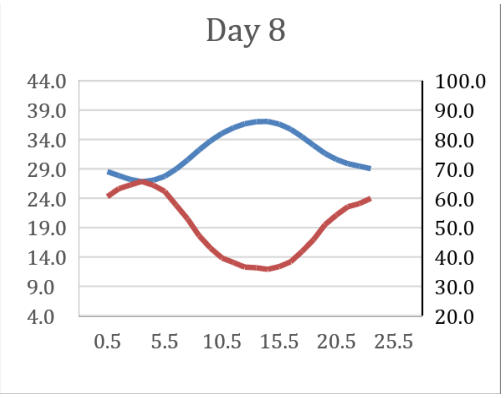
Hot and Humid



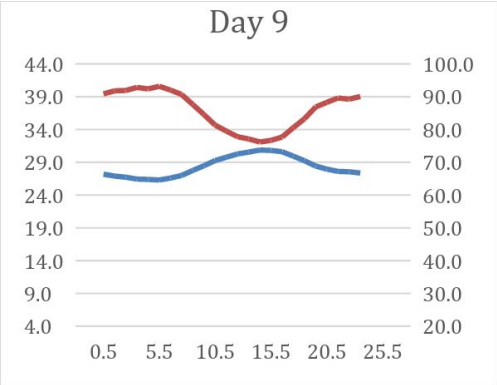


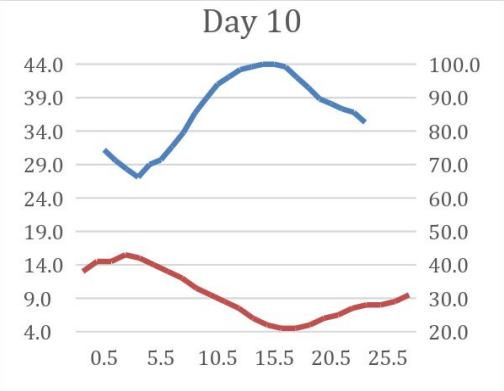
Hot and Dry





Extreme Days





For a complete range of DBT and RH values along with solar GHI data, please refer to the Annexure of this document.

The prototypes and the baseline unit should be able to maintain below 27°C DBT and 60% RH indoor conditions under these varying outdoor conditions for the duration of the test period. All the units will be operated for these 10 typical days in continuous operation mode, excluding day to day transition and stabilization, and the performance will be extrapolated using an assigned weighting for each day to give annual performance. The middle days of the testing period represent the aggregate seasonal variation in DBT and RH and will account for the majority of the weighting for annual days. The weighting for the mild day (starting day), where prototypes will commence operation, is likely to have a weighting of no more than 5% and each extreme day, which represent the most challenging conditions, is likely to have a weighting of no more than 1% when extrapolating to annual performance.

Unmet hours allowance: In addition to the number of hours that the baseline unit does not achieve the desired indoor conditions of below 27°C DBT and 60% RH, an additional allowance of 3.4% hours of the test period will be provided recognizing that the ramp up period and precision of operation of prototypes is likely to be less than that of the established baseline unit. The below formula can be used to estimate the number of additional unmet hours of the technology during the test period.

*Weighted unmet hours of a test day = Actual no. of unmet hours on a test day * test day weighting * no. of test days*

The ability of the baseline unit and the prototypes to maintain the desired indoor conditions and their performance against the technical criteria, will be compared at the end of the test period to determine the relative performance.

The Global Cooling Prize evaluation team will monitor the following data points (at minimum 15-minute interval) to evaluate and compare the performance of the baseline unit and the prototypes:

- Electricity consumption (kWh) of the AC unit, lighting and plug loads

- Electricity consumption (kWh) of the whole chamber
- Demand (W) i.e. at maximum cooling output, of the AC unit
- Water consumption, if any, for operation (liters)
- Dry bulb temperature (°C) and relative humidity (%) maintained in the inside chamber
- Dry bulb temperature (°C) and relative humidity (%) maintained in the outside chamber
- Airflow between indoor test chamber and environmental chamber
- Indoor air velocity at a central location
- Globe temperature at a central location
- Refrigerant charge (measured only at the time of installation))
- The methods specified in ISO/IEC Guide 98-1 to 4 will be used to evaluate the uncertainty of measurements during the lab simulated year-round performance test.

III. Field Test

To demonstrate the performance and scalability of the climate friendly and radically efficient solution, the prototypes will also undergo a field test in an actual residential apartment. The apartments will be selected in a mid to high rise building and will be representative of the apartments that are south-facing with proportionately equivalent exterior wall surface area and have a typical cooling load that can be met by a 1.5 TR air conditioner. The testing of all the prototypes will be carried out in parallel with the baseline unit.

In the field test, the prototype's ability to maintain the indoor conditions below 27 °C dry bulb temperature (DBT) and relative humidity 60% relative humidity for the duration of test period in a hot and humid / hot and dry climate in India while demonstrating performance against the technical criteria will be assessed. This performance of the prototype will be compared to the baseline unit installed in an identical apartment and subject to the same external and internal loads in order to determine its relative performance.

Unmet hours allowance: In addition to the number of hours that the baseline unit does not achieve the desired indoor conditions of below 27°C DBT and 60% RH, an additional allowance of 3.4% hours of the test period will be provided recognizing that the ramp up period and precision of operation of prototypes is likely to be less than that of the established baseline unit during the field test.

The Global Cooling Prize evaluation team will monitor the following data points (at minimum 15-minute interval) to evaluate and compare the performance of the baseline unit and the prototypes:

- Electricity consumption (kWh) of the AC unit, lighting
- Electricity consumption (kWh) of the whole test site
- Demand (W) i.e. at maximum cooling output, of the AC unit
- Water consumption, if any, for operation (liters)
- Indoor and Outdoor Dry bulb temperature (°C) and relative humidity (%)
- Site wind speed

- Solar radiation (global)
- Indoor and outdoor air pressure
- Refrigerant charge (measured only at the time of installation)
- The methods specified in ISO/IEC Guide 98-1 to 4 will be used to evaluate the uncertainty of measurements during the field test.

It is extremely important that the apartments selected for the field test are materially equivalent in all aspects. Therefore, prior to installation and testing of the prototype units in the apartment, the testing team will ensure the following:

- The apartments will remain unoccupied to limit variation in loads due to human behavior.
- The apartments are identical in size and materially equivalent in every other aspect including the solar gain, shading conditions, envelope characteristics etc. Thermal imaging to be done to ensure similar envelope characteristics between test units.
- A blower door test is conducted in each apartment unit to ensure an equivalent air tightness. Wherever necessary, envelope will be properly sealed or leaked to ensure that air tightness characteristics are equivalent across all the apartments.
- Airflow measurements are taken for kitchen and exhaust fans, and adjustments are made to ensure even flow rates between units.
- Any modification that may be required to fit the prototype unit will be noted.

After conducting the checks, the testing team will install and test the performance of prototypes and the baseline unit in these apartment units as noted above. The team will ensure that all the metering systems and data loggers are in place and calibrated and an in-person visit is conducted at least weekly.

SCORING AND EVALUATION OF THE PROTOTYPES

After the testing phase, the top 10 finalists will once again be reviewed for their performance against the prize criteria - primary and supplementary criteria. The achievement of the supplementary criteria is an expectation of all prototypes while the final ranking will depend on the technology's performance based on the 5X climate impact and affordability criteria. In case one or more supplementary criteria are not met by the competing technologies during the testing phase, the technical review committee will take a decision on whether or not the participant is qualified to compete in the final round.

The organizations represented on the Operating Council will provide the Technical Review Committee with 2-3 staff members to assist. The Technical Review Committee will assign these staff members tasks as needed (example: summarizing and compiling applications) but the Technical Review Committee will review the documented performance of all prototypes in the context of the prize criteria and develop a recommendation of final award to be sent to the Supervisory Board for ratification. Finally, the Supervisory Board ratifies the recommendations after ensuring the recommended selections meet the detailed prize technical criteria and intent and are able to be disclosed with full and appropriate transparency.

FINAL PRESENTATIONS, AWARD CEREMONY AND MARKET SCALING

Come October 2020, participants will share their technology, prototype performance, proposed business model, and route to market with the Supervisory Board, Technical Review Committee, Investment and Scaling Committee, Innovation Advisors, and Operating Council in the form of a presentation. The final winner will be announced at a day-long international award ceremony with Mission Innovation, as well as ministerial and funder presence in November 2020. Following the final prize announcement, the global coalition of partners will continue providing assistance to scale the winning solution in India and across the rest of the developing world.

CONTACT US AND APPLY AT: www.globalcoolingprize.org

ANNEXURE

The table below provides the hourly data of DBT, RH and solar GHI for each of the select 10 days that will be simulated during the lab simulated year-round performance test.

LEGEND	DBT	RH %	GHI Wh/m2

Day / Hours	Day 1			Day 2			Day 3			Day 4			Day 5		
	Warm and Dry			Warm and Dry			Warm and Humid			Warm and Humid			Hot and Dry		
0.5	20.2	54.6	0	24.3	47.0	0	26.9	88.8	0	25.4	88.9	0	31.1	62.1	0
1.5	19.2	58.5	0	23.4	48.9	0	26.6	89.3	0	24.9	89.5	0	30.5	65.1	0
2.5	18.7	61.0	0	22.5	51.3	0	26.4	89.4	0	24.5	90.9	0	30.0	67.2	0
3.5	17.8	65.4	0	21.6	55.0	0	26.3	89.6	0	24.2	92.1	0	29.3	71.2	0
4.5	17.4	68.3	0	21.5	56.7	0	26.4	89.3	0	24.4	93.3	0	29.1	73.5	0
5.5	16.8	71.3	0	22.2	55.4	0	26.5	89.1	0	25.1	93.0	0	28.9	75.5	0
6.5	17.4	69.1	0	23.9	50.1	3	27.0	88.0	0	26.4	90.2	0	29.5	73.1	0
7.5	18.4	65.3	0	26.1	43.5	166	27.5	86.3	50	27.9	85.3	69	30.4	69.7	100
8.5	20.8	57.2	91	28.6	36.3	430	28.2	83.6	215	29.7	79.1	287	31.9	62.8	300
9.5	23.1	50.6	331	30.7	31.3	672	28.8	81.5	374	31.3	72.5	499	33.4	57.2	524
10.5	25.6	44.5	582	32.4	27.4	833	29.3	79.4	512	32.5	67.0	647	35.1	50.5	726
11.5	27.1	41.0	724	33.5	25.1	925	29.5	78.6	575	33.0	63.1	743	36.5	46.1	877
12.5	28.3	37.6	779	34.2	23.4	932	29.5	78.3	589	33.1	61.6	711	37.9	41.2	941
13.5	28.6	35.9	724	34.7	22.4	887	29.4	78.9	617	32.6	61.9	646	39.0	38.1	942
14.5	29.1	34.2	674	34.9	21.5	817	29.3	78.9	552	31.8	63.7	483	39.9	34.8	890
15.5	28.8	34.1	521	34.7	21.7	604	29.0	79.9	438	30.8	66.4	357	40.1	34.2	735
16.5	28.5	35.1	372	34.0	23.0	425	28.8	80.6	344	29.8	70.1	244	39.8	34.9	543
17.5	27.1	38.9	179	32.5	26.6	226	28.2	82.3	220	28.8	73.9	101	38.4	39.5	308
18.5	25.8	42.9	26	30.6	31.8	40	27.8	83.9	92	28.0	78.0	0	36.7	45.4	112
19.5	24.0	48.6	0	28.6	38.3	0	27.4	85.6	0	27.3	81.4	0	34.7	53.4	0
20.5	23.0	51.3	0	27.0	43.5	0	27.2	86.7	0	26.9	84.6	0	33.3	58.5	0
21.5	21.9	53.6	0	25.9	47.0	0	27.1	87.5	0	26.5	86.5	0	32.1	62.1	0
22.5	21.5	53.1	0	25.4	47.7	0	27.2	87.7	0	26.3	87.8	0	31.7	62.0	0
23.5	20.6	54.5	0	25.0	47.4	0	27.0	88.3	0	25.9	88.3	0	31.3	62.9	0

Day / Hours	Day 6			Day 7			Day 8			Day 9			Day 10		
	Hot and Dry			Hot and Humid			Hot and Humid			Warm and Extreme Humid			Extreme Hot and Dry		
0.5	28.5	60.5	0	30.4	70.0	0	29.2	79.2	0	27.2	90.9	0	31.2	38.0	0
1.5	27.8	63.3	0	29.7	72.6	0	29.0	79.1	0	26.9	91.8	0	29.6	41.0	0
2.5	27.2	64.5	0	29.3	73.6	0	28.5	80.8	0	26.7	91.9	0	28.3	41.0	0
3.5	26.8	65.7	0	28.7	76.7	0	28.3	82.1	0	26.4	92.8	0	27.1	43.0	0
4.5	27.1	64.5	0	28.6	77.4	0	28.5	84.0	0	26.4	92.4	0	29.0	42.0	0
5.5	27.7	62.4	0	28.6	78.8	0	29.1	82.2	0	26.3	93.2	0	29.7	40.0	0
6.5	29.0	57.6	20	29.2	76.2	0	30.1	79.4	6	26.6	92.0	0	31.7	38.0	66
7.5	30.5	53.0	207	29.9	73.2	104	31.5	73.4	182	27.0	90.7	30	33.8	36.0	300
8.5	32.2	47.3	441	31.2	66.7	290	32.8	66.6	397	27.8	87.6	185	36.7	33.0	593
9.5	33.8	43.0	625	32.4	61.4	494	34.1	59.0	606	28.5	84.5	352	38.9	31.0	789
10.5	35.0	39.7	793	33.8	55.3	683	35.1	53.8	756	29.3	81.3	505	41.0	29.0	765
11.5	36.0	38.1	865	34.9	51.7	787	35.8	50.3	826	29.8	79.5	575	42.1	27.0	1098
12.5	36.7	36.5	861	36.1	47.2	893	35.9	49.4	809	30.3	77.8	611	43.2	24.0	1085
13.5	37.0	36.3	846	37.0	44.3	868	35.7	50.1	715	30.6	77.1	635	43.6	22.0	1082
14.5	37.1	35.8	727	37.9	41.1	855	34.8	53.1	583	30.9	76.2	588	44.3	21.0	990
15.5	36.6	36.7	567	38.0	40.7	718	33.8	55.5	410	30.8	76.7	472	44.1	21.0	813
16.5	35.8	38.4	381	37.7	41.7	548	32.6	59.4	259	30.6	77.7	349	43.6	22.0	530
17.5	34.5	41.9	209	36.3	46.5	313	31.6	63.4	126	29.9	80.6	219	42.0	24.0	307
18.5	33.0	45.9	65	34.8	52.4	138	30.8	69.2	3	29.2	83.3	73	40.5	25.0	143
19.5	31.6	51.0	0	33.0	60.5	1	30.3	74.1	0	28.4	86.9	0	38.8	27.0	0
20.5	30.6	54.3	0	32.1	65.2	0	29.9	78.9	0	28.0	88.3	0	38.1	28.0	0
21.5	29.9	57.1	0	31.4	68.6	0	29.8	80.8	0	27.6	89.6	0	37.3	28.0	0
22.5	29.5	58.2	0	31.2	68.5	0	29.6	81.3	0	27.6	89.3	0	36.8	29.0	0
23.5	29.0	60.0	0	30.8	69.8	0	29.5	79.7	0	27.4	90.1	0	35.3	31.0	0