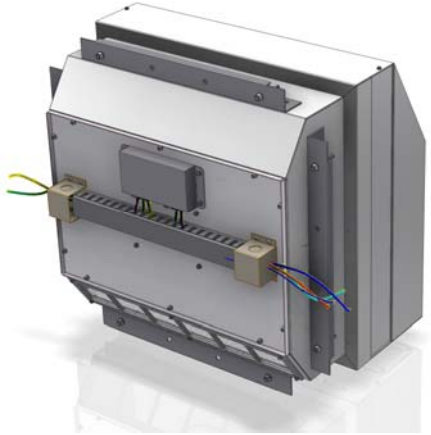
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Keeping Networks Cool

# Energy Efficient Cooling for Communication Networks







GSMA Green Power for Mobile Working Group

August 2013

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# What do the following have in common?

Over-dimensioned Diesel Generators





Automatic Voltage Regulators



Phase Change Materials



High Temperature Batteries




Battery Cooler Cabinet



Free Air Cooling

Outdoor BTS

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# Solving Problems with Air conditioners!

- Too High Inrush Current
  - 5-7x running current
- Narrow AC Voltage Window
  - 198 - 264V, perhaps
- No Backup (DC) Cooling Capability
- Limits alternative powering options
- Too High Power Consumption
  - 30-50% of total site load…







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# Who is Coolsure

- Coolsure is a Hong Kong based company focusing on innovative cooling solutions for Telecom shelter applications
- Founded by ex-director of Emerson Network Power in 2007
- First products, UTS-55W uninterruptible telecom split air conditioner and ECS-2000 fan/filter free cooling system launched in 2010
- Over 2000 Coolsure telecom cooling systems currently deployed, and growing

**Indonesia**
**Malaysia**
**Pakistan**
**India**
**Vietnam**

**Nigeria**
**Tanzania**
**South Africa**
**Sudan**

**Israel**
**Turkey**

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# Coolsure Activities in Pakistan/Afghanistan

- Conducted successful trials with PTCL and Warid Telecom in 2012
- Recently participated in GSMA Mobile Energy Efficiency Benchmarking study/trial at Warid Telecom
- Commercial deployment of first 200 Coolsure UTS-55W systems underway with Warid Telecom
- No activities in Afghanistan to date

# Product Overview – Shelter Cooling

- Coolsure Telecom Air Conditioners and Free Cooling Units can be combined to provide an optimised integrated cooling system for climates with both hot and cool periods (eg hot days/cool nights or hot summers/cool winters)




Telecom Spec Split Type Air Conditioners

Coolbus connection



Free Air Cooling Unit

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# Coolsure Telecom Split Air Conditioners

- Direct one for one replacement for existing “comfort” split airconditioners with field proven >60% energy savings



- Variable capacity “inverter” control and modular N+1 redundant system configuration (up to 5 units) caters for heat loads from 2kW to 20kW

- Optimised for Telecom, with built in Telecom spec controls and features




- Optional 230VAC / 48VDC dual power supply capability – provides uninterrupted active cooling during power failures, or off grid operation

Exceptional efficiency, high availability, modular and intelligent – Coolsure air conditioners provide the performance required to enhance network reliability and deliver big operational cost savings

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# Field Proven > 60% energy savings

| Country | Operator | Site Type | Coolsure Units | Energy Saving |
|---|---|---|---|---|
| Malaysia | Maxis | BTS | 2 x UTS-55W | **62%** |
| Malaysia | Time dotCom | Satellite Earth Station | 4 x UTS-55W | **63%** |
| Malaysia | Telekom Malaysia | Containerised Exchange | 5 x UTS-55W | **60%** |
| Malaysia | Celcom | MSC - NGIN | 12 x ETS-55W | **70%** |
| Nigeria | MTN | Hybrid BTS | 2 x UTS-55W | **65%** |
| Pakistan | PTCL | BTS | 2 x UTS-55W | **77%** |
| Pakistan | Warid | BTS | 2 x UTS-55W | **57%*** |
| Vietnam | VNM | BTS | 1 x UTS-55W | **63%** |
| India | | BTS | 2 x UTS-55W | **75%** |
| Indonesia | Axis | BTS | 2 x UTS-55W | **71%** |

*Frequent Grid Power Interruptions

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# Warid Telecom Coolsure Trial

- A trial was conducted at Warid's BTS Shelter (total equipment load ~3000W) site near Nishtar Colony Stop in Lahore, from 16th of April to 16th of May 2012.

- Goal of the trial was to compare energy consumption and performance of existing split-type units (Brand: Air Supply) to that of Coolsure's UTS-55W.

- Coolsure units demonstrated cooling system energy saving of **57% (1062W)**, while maintaining same room temperature

# Warid Coolsure Trial – Site Images









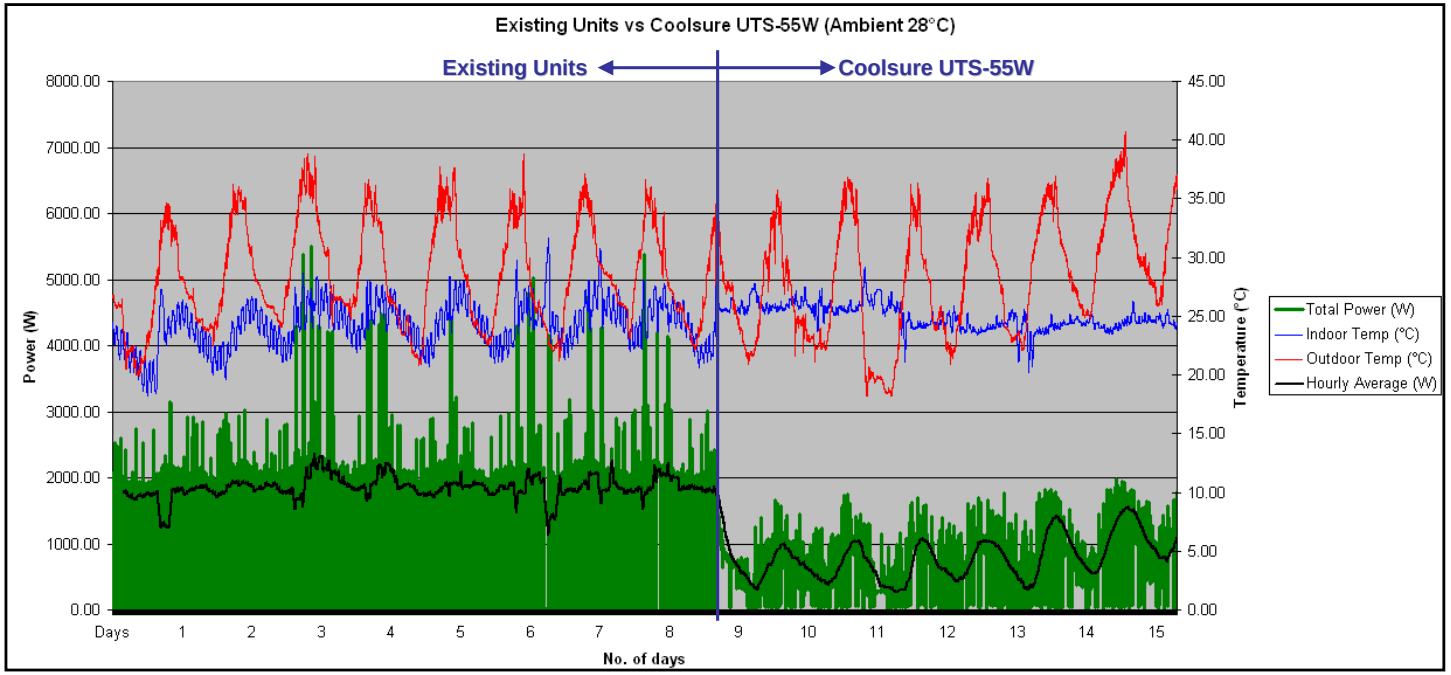






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# Results




| Setpoint Temperature: 24°C | | | | |
|---|---|---|---|---|
| **Parameter** | **Baseline** | **Coolsure** | **Difference** | **%** |
| Av. Ambient Temperature (°C) | 28.3 | 28.2 | -0.1 | |
| Av. Room Temperature (°C) | 24.3 | 24.9 | -0.6 | |
| Av. Room R/H (%) | 37.6 | 44.9 | 7.3 | |
| Av. A/C Power (W) | 1851 | 789 | -1062 | -57% |
| Duration of Trial (Days) | 8.5 | 6.7 | | |

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# Warid Telecom Trial 2 – Higher Ambient

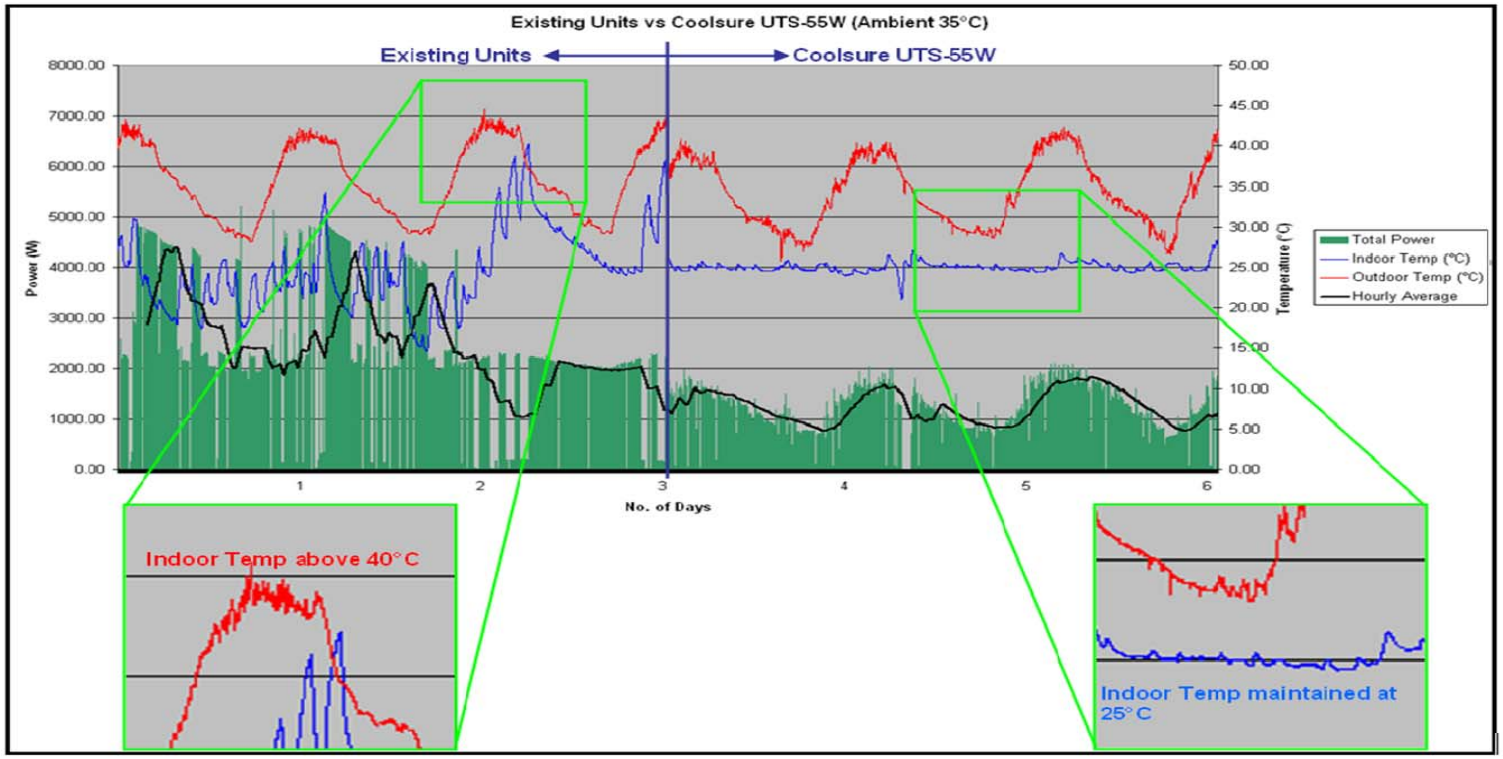
- Keeping in mind the climatic conditions of Pakistan, another trial was conducted under higher ambient temperature (**34°C average, 45°C maximum**).

- Coolsure units demonstrated increase in absolute energy saving to **1117W (49% in relative terms)** at higher ambient temperature, as compared to **1062W (57%)** under lower ambient temperature (**28°C**)

- Coolsure's load share and inverter technology provide greater relative (%) energy savings at lower ambient conditions compared to on/off type units

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# High Ambient Comparative Results




| Setpoint Temperature: 24°C | | | | |
|---|---|---|---|---|
| **Parameter** | **Baseline** | **Coolsure** | **Diff** | **%** |
| Av. Ambient Temperature (°C) | 35.7 | 34.2 | -1.5 | |
| Av. Room Temperature (°C) | 24.7 | 25.0 | 0.3 | |
| Av. Room R/H (%) | 37.7 | 47.4 | 9.7 | |
| Av. A/C Power (W) | 2407 | 1230 | -1117 | -49% |
| Duration of Trial (Days) | 3 | 3 | | |

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# Lower Ambient Reference: BTS site in Pakistan

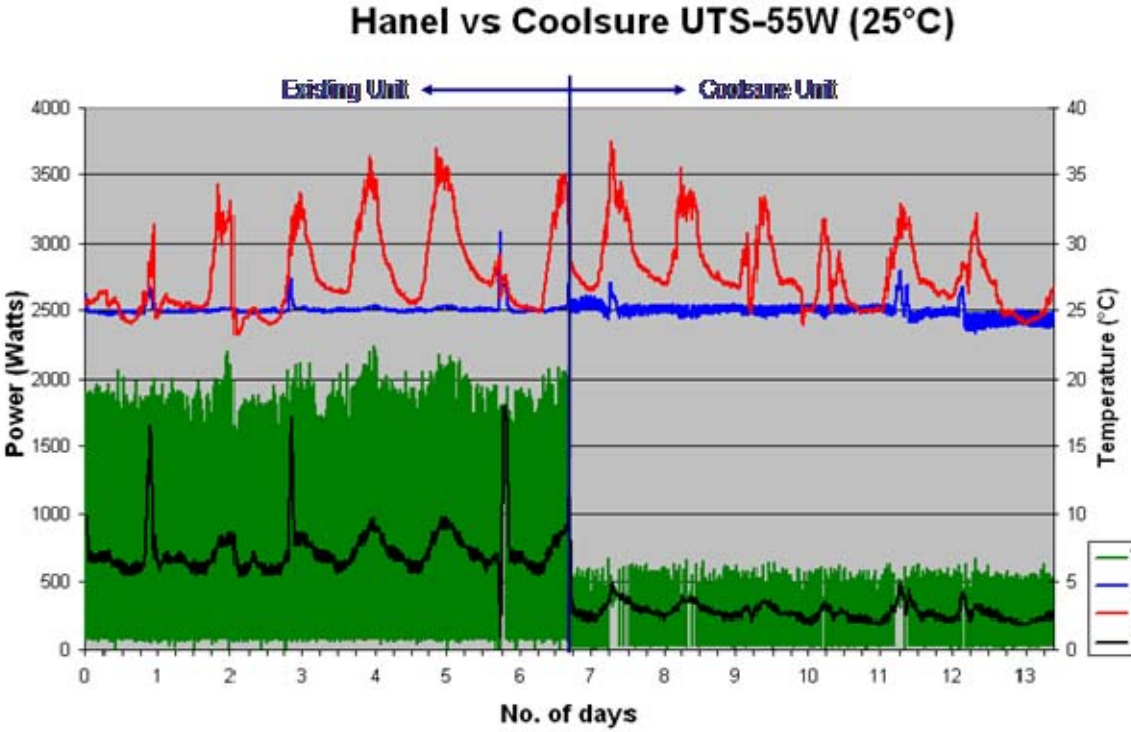
- A trial was conducted at another operators BTS Shelter site (total equipment load ~1200W) in Islamabad in November 2011

- Average ambient temperature during trial period was around **20°C**

- Coolsure units showed energy saving of **77% (522W)**, while maintaining the temperature of the site at **22.7°C** with average power consumption of only **159W.**

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# Vietnam VNM BTS trial – September 2012






Test conducted using 1 x UTS-55W

**63%** energy savings

| Setpoint Temperature: 25.0 ˚C | | | | |
|---|---|---|---|---|
| **Measurements** | **Existing unit** | **Coolsure** | **Difference** | **%** |
| Av. Outdoor Temp (˚C) | 27.64 | 27.83 | 0.19 | |
| Av. Outdoor R/H (%) | 93.91 | 94.86 | 0.95 | |
| Av. Room Temperature (˚C) | 25.06 | 25.00 | -0.06 | |
| Av. Room R/H (%) | 59.7 | 60.86 | 1.16 | |
| Av. A/C Power (W) | **725** | **270** | **-455** | **-63%** |
| Duration of Logging (days) | 6.7 | 6.7 | | |

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# Celcom NGIN room – Scalable Data Centre Deployment

•12 units (3 groups of 4) of ETS-55W deployed in hot aisle/cold aisle configuration for Celcom Malaysia.
•Cooling system energy consumption was reduced from 28kW to 8kW (70% energy saving)
•Coolsure ETS-55W provided better cooling distribution, eliminating problem hot spots





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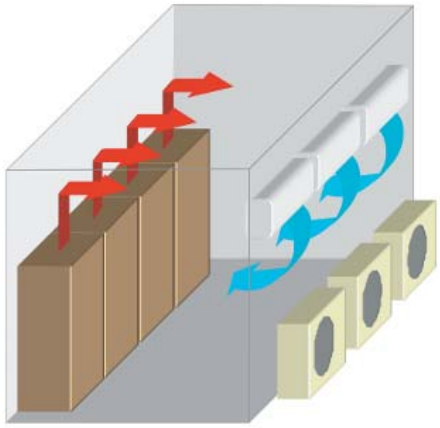
# How Coolsure Telecom A/C differ from “comfort” inverter units

- Intelligent Use of Redundant Capacity
  - Coolsure’s patented load sharing method ensures all units are operated at the highest efficiency (part load) operating point
- Optimised for Electronic cooling, not People cooling
  - Coolsure ETS&UTS air conditioners have a higher Sensible Heat Ratio (SHR) than comfort inverter units, better matching telecom heat load
- High efficiency components
  - Components for standard comfort inverter units are frequently selected on the basis of consumer market cost constraints. Coolsure units use high efficiency components often not included in standard comfort inverter units, such as DC fan motors and Electronic Expansion Valves (EEV) for optimum refrigerant control
- Advanced Controls
  - Coolsure air conditioners incorporate advanced controls and remote monitoring capability to ensure they are always kept in optimum running condition. Standard comfort inverter units may be operated at diminished performance for considerable lengths of time, unknowingly.

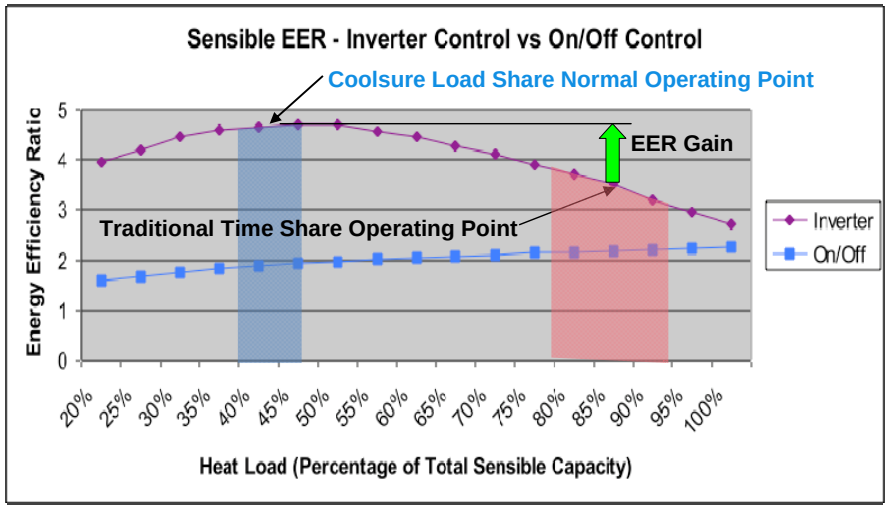
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# Intelligent use of redundant capacity

- Inverter technology airconditioners are most efficient when partly loaded
- Coolsure's patented load share technology operates both (all) units simultaneously
- Coolsure's modular redundant system architecture ensures partial loading (<50% loading for 1+1 configuration) in normal operation, in addition to Telecom spec N+1 redundancy



**Modularity means that multiple physically separated units become a single logical system (max 5 units per system)**




**Patented load sharing technology allows Coolsure ETS & UTS machines to distribute load evenly, improving efficiency**

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# Advanced Control Features for Telecom applications

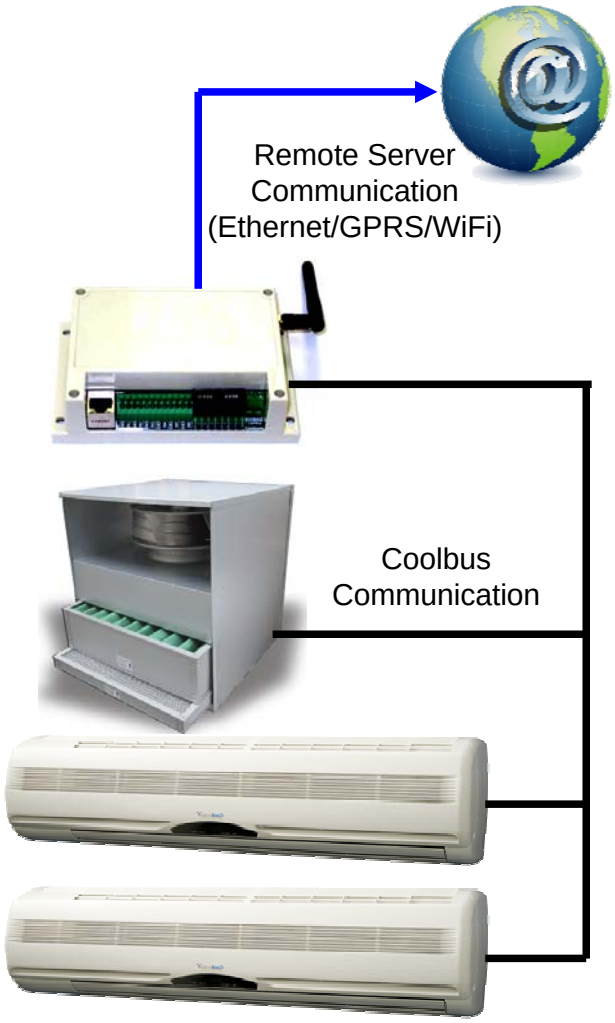
- Built in automatic load-share and modular redundant operation (up to 5 units in parallel) by connecting CoolBus cable between units. No external changeover controls or external controller needed.
- Multiple programmable temperature setpoints (eg backup setpoint, setback setpoint during high electricity cost times, constant difference between outside and inside, etc)
- All setpoints ***password protected*** to prevent un-authorised adjustment/tampering.
- Comprehensive programmable alarms and statistics functions
- Optional Central Control Unit as *Service Tool* or for advanced monitoring and control of all system parameters and alarm log
- Remote alarm monitoring via Central Control Unit, or relay alarm unit. Optional GPRS & Ethernet remote monitoring module




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# Coolsure Remote Monitoring Features

- Remotely monitor live data from your sites through Coolsure *Sentinel* Web Dashboard.
- Record and log parameters like shelter temperature, ambient temperature, Alarms etc.
- Automated alerts feature can be sent email and/or SMS based on client-defined parameters like high shelter temperature, unit faults, etc.
- Report generation (monthly, quarterly or annually) for each site, and consolidated report for a group of sites.
- Sentinel Web Dashboard also allows users to chart historical data, such as temperatures and power (ACU model dependent)




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# Coolsure Sentinel Web Dashboard




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# Sample Site Summary Report

## Monthly Cooling System Performance Report

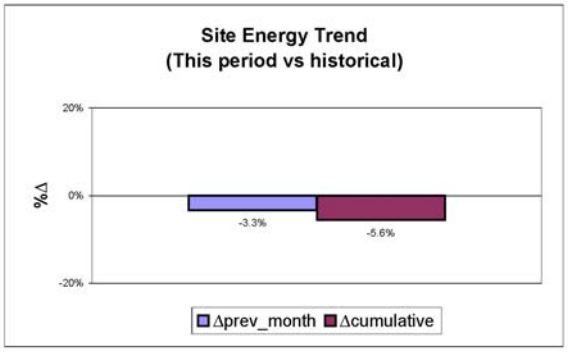
| | | | |
|---|---|---|---|
| **Site:** | Sample Report | **Cumulative Run Time:** | 1,932 Hrs |
| **#Groups:** | 3 | **#Units (4x per Group):** | 12 Units |
| **Period:** | 7/01/2013 to 7/2/2013 (31.1 days) | | |

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### Site Monthly Summary

| Runtime | Energy | Av. Power | Av. Room Temp | Av. Ambient Temp |
|---|---|---|---|---|
| 745 Hrs | 5,481 kWh | 7,353 W | 22.1 °C | 31.9 °C |
| | **Previous Month** | 7,602 W | 22.0 °C | 31.1 °C |

### Site Energy Savings Summary



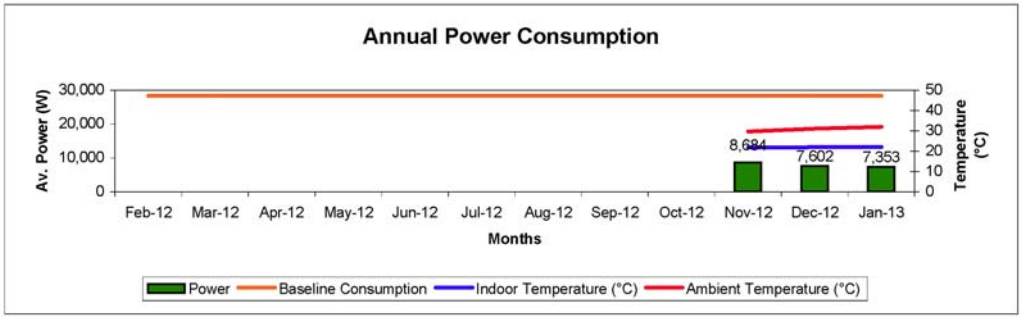

**Savings this period (31.1 days)**
**15,619 kWh** **$2,030**

**Cumulative Savings (80.5 days)**
**39,643 kWh** **$5,154**

**Projected Annual Savings (365 days)**
**179,749 kWh** **$23,367**

**Cumulative Percentage Savings**
**72%**

| Assumptions | |
|---|---|
| **Baseline Power** | 28,306 W |
| **Utility Cost** | $0.13 /kWh |




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# Simple problems can have a high cost

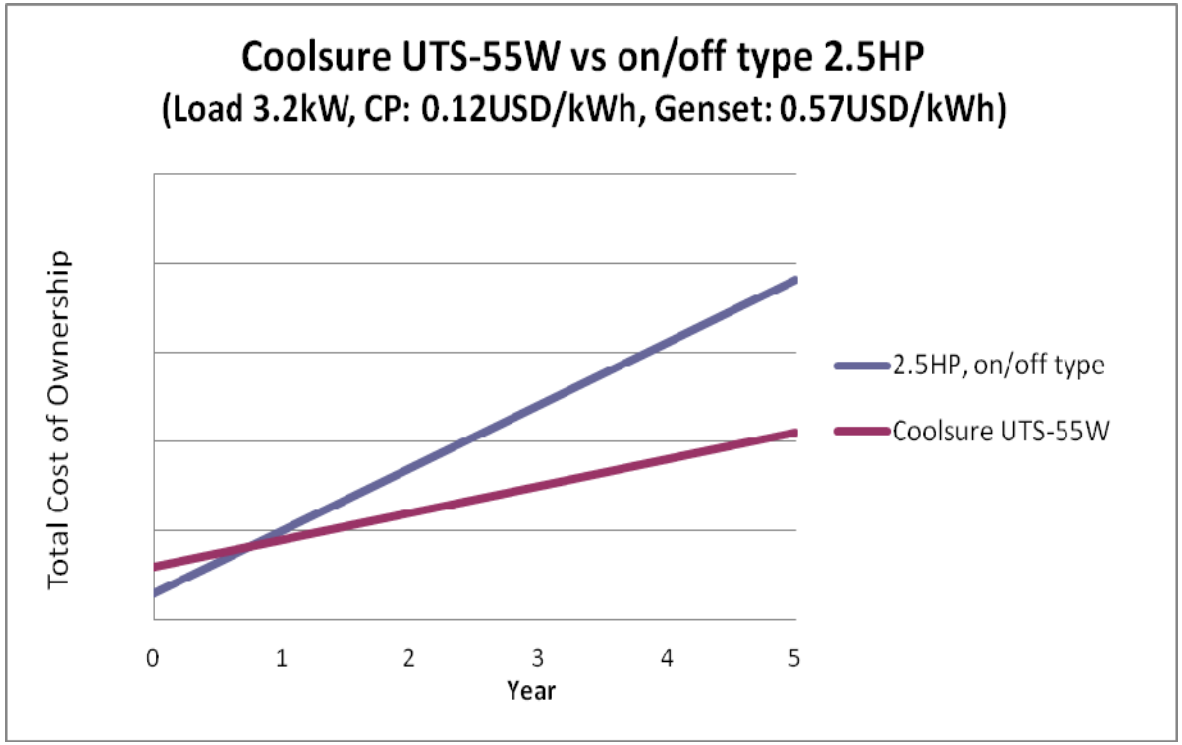
| | Sites | | |
|---|---|---|---|
| | **MDIB3006** | **MDIB3014** | **MDIB3038** |
| Measured Av Outdoor Temp (°C) | 28.19 | 29.14 | 30.42 |
| Measured Av Indoor Temp (°C) | 21.66 | 19.40 | 21.83 |
| Measured Cooling Power (W) | 1,321 | 1,495 | 1,463 |
| Specified Set Point | | 25°C | |
| Estimated Cooling Power (W) @25C | 1,190 | 1,192 | 1,331 |
| Estimated Savings (W) @25C | **131** | **303** | **132** |
| | **10%** | **20%** | **9%** |



- Logging randomly selected sites showed an average temperature up to 6C lower than the instructed set point, causing estimated 10-15% higher cooling system energy usage
- For a network with 2,000 Indoor BTS, this is ~3GWh wasted energy per annum (~0.3MUS$ per year @ 0.12US$/kWh)
- Sometimes no infra-red remote control is a feature!

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# Coolsure UTS-55W TCO – Pakistan Case




| ASSUMPTIONS | |
|---|---|
| Traditional AC Average Power Consumption (W) | 1486 |
| Coolsure UTS-55W Power Saving (%) | 57% |
| Utility Energy Cost (US$ / kWh) | 0.12 |
| Genset average runtime (hours per day) | 8 |
| Genset variable running cost (US$ / kWh) | 0.57 |

| SUMMARY | |
|---|---|
| 5 year Return On Investment (%) | 568% |
| Annual Return on Investment (%) | 46% |
| Payback (years) | 0.75 |

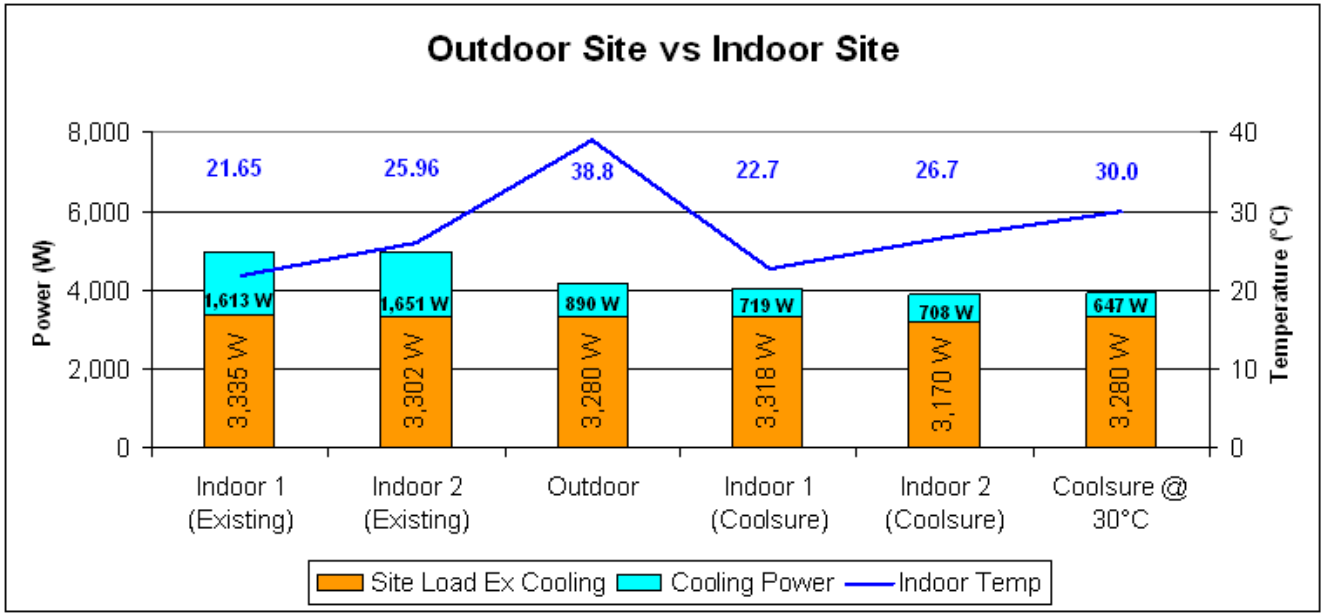
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# Cost Effective alternative to Indoor/Outdoor Conversion

•Total site power consumption was compared for similarly equipped and configured indoor and outdoor sites in Pakistan:

•Indoor: Ericsson RBS2206 / RBS2207, Hub Site
•Outdoor: Ericsson RBS2106 / RBS2107, End Site

•Indoor Site with Coolsure air conditioners had <u>lower total site power</u> consumption with 10 to 15°C lower internal temperature



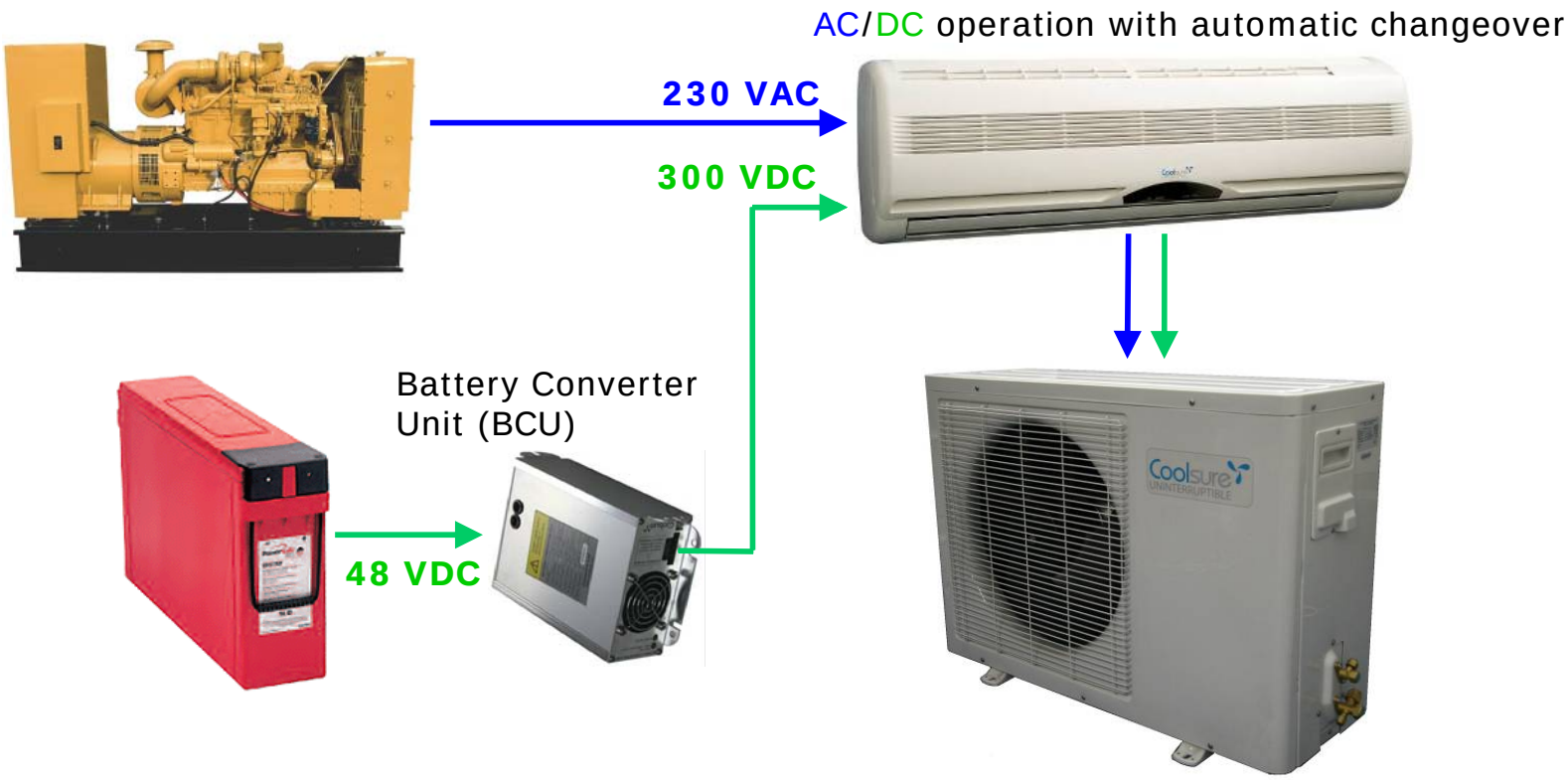

Average Ambient 33°C

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# UTS-55W - Ideal for Hybrid/Alternative Powering Applications

- Dual AC and DC Power sources, with automatic changeover
  - •UTS-55W can be powered from a 230VAC Power Source, or 48VDC Power Source, or both
- Exceptional Energy Efficiency
  - •Reduces cooling system load on genset and batteries, minimising genset fuel consumption and allowing smaller, lower cost, battery to be used with same Depth of Discharge
- Low Inrush Current
  - •Unlike traditional air conditioners which draw inrush current 6-7 times normal running current, required the diesel genset to be oversized in order to run the air conditioner
  - •UTS-55W has a soft start and low inrush current less than normal running current, allowing a substantially smaller, lower cost and more fuel efficient diesel generator to be used
- Adjustable Capacity Limit Function
  - •Coolsure UTS-55W incorporates an adjustable capacity limit function which allows the maximum power consumption of the unit to be limited to a selected value.
  - •Limiting the maximum power consumed by the air conditioning system (eg when the door to the shelter is left open) allows a smaller diesel generator to be deployed to power the BTS site.

# Graphical System Representation

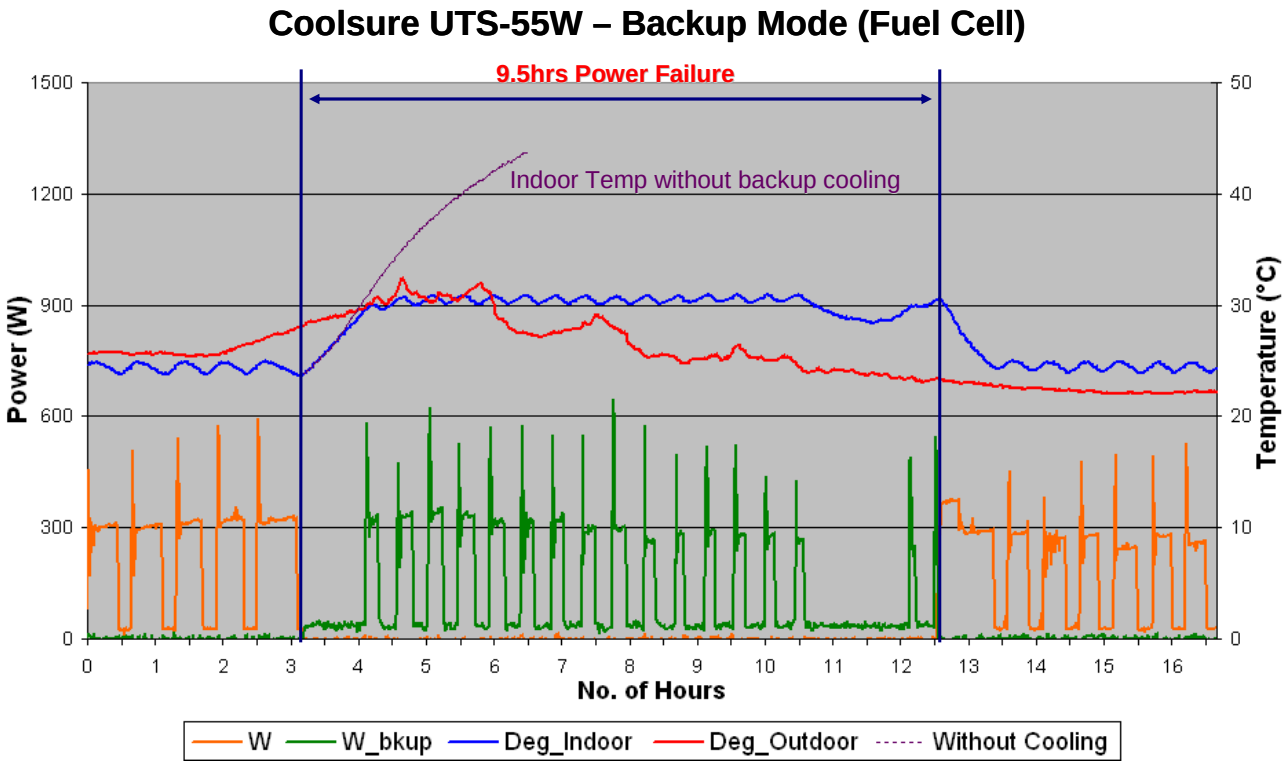



- UTS-55W can be permanently powered from AC Supply, or from DC Supply, or can automatically switch between AC and DC
  - •Automatic changeover to AC when genset is running can free rectifier capacity for fast charging the batteries, further reducing genset runtime and increasing fuel savings

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# Vietnam BTS site: Fuel cell Backup for 9.5 hour power failure

- IdaTech 2.5kW fuel cell was installed at the site to provide backup power for extended AC power outages
- Coolsure UTS-55W set points were 25C from AC power, 30C from DC, to minimise power draw from fuel cell
- BTS telecom load was around 1200W (1 x BTS cabinet)
- Average UTS-55W power consumption was **126W** during the power outage, maintaining shelter temperature at 30C




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# Free Cooling + Active Cooling Integration

- Coolsure Telecom Air Conditioners and Free Cooling Units can be combined to provide an optimised integrated cooling system for climates with both hot and cool periods (eg hot days/cool nights or hot summers/cool winters)




Telecom Spec Split Type Air Conditioners

Coolbus connection



Free Air Cooling Unit

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# UTS-55W / Free Cooling in Hot/Humid climates

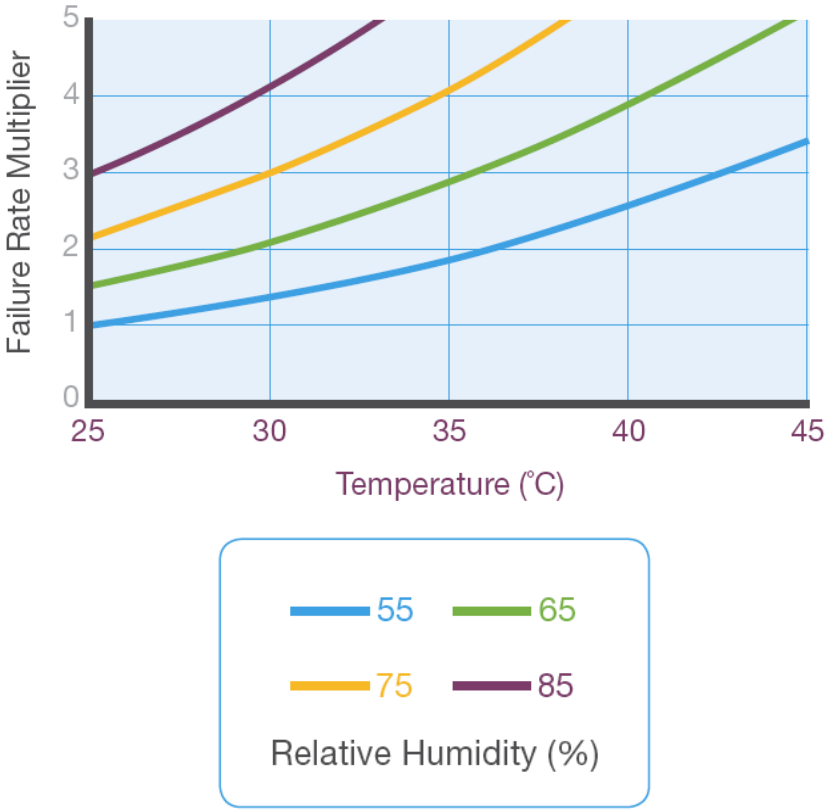
| UTS-55W | Free Cooling |
|---|---|
| Excellent energy savings (>60%) while maintaining same safe low temperature in BTS site (eg 25C) as today – low risk cooling solution | Highest energy savings (>70%), but only if operator can accept risky high temperature and high humidity in BTS (eg 35C / 75% RH) |
| No negative impact on Telecom equipment and batteries reliability and life | Telecom equipment and batteries reliability and life reduced (replacement cost/downtime needs to be considered) |
| No increase in service/maintenance costs vs current air conditioning solution | Need to consider additional service cost for filter replacement/service |
| Uninterrupted cooling for all outside ambient conditions | Uninterrupted cooling only if outside ambient temperature is low enough |
| Lower capital cost for new sites (compared to 1 x FCU + 2 regular air conditioners) | Lower capital cost for existing sites if existing air conditioners are in good condition and can be re-used |

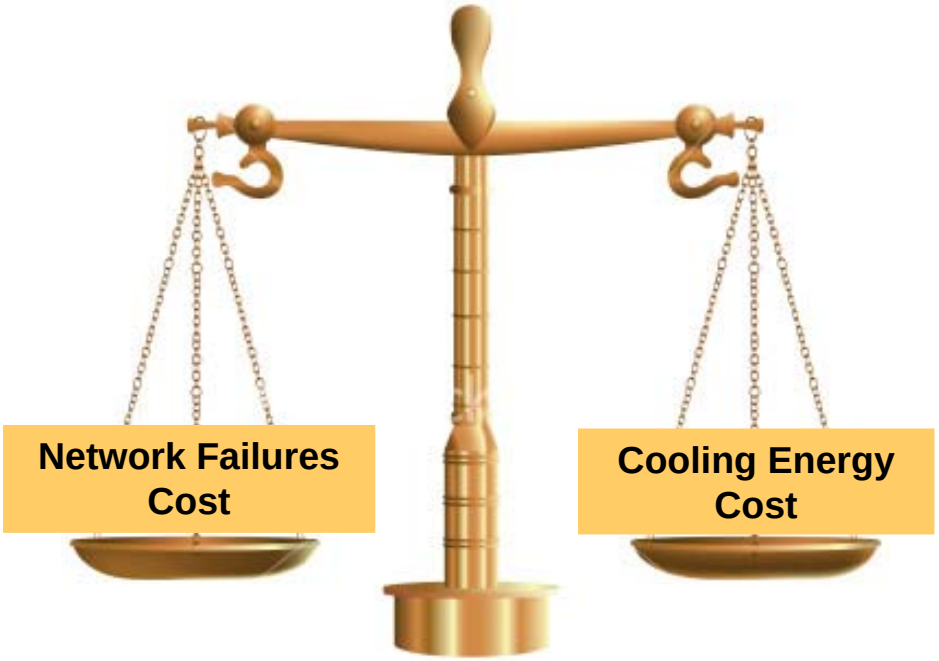
•Use of passive fan/filter solutions in hot, humid climates generally requires the compromising of temperature and humidity setpoints within the BTS shelter, in order to allow the fan to operate for a significant portion of the time

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# Why temperature and humidity regulation matters

- Telecom equipment and batteries are specified to function over a range of operating conditions - but reliability and life is reduced at elevated temperatures and humidities
- Arrhenius and Peck models are widely used to accurately predict the impact of elevated temperature and humidity on the MTBF of electronics and batteries




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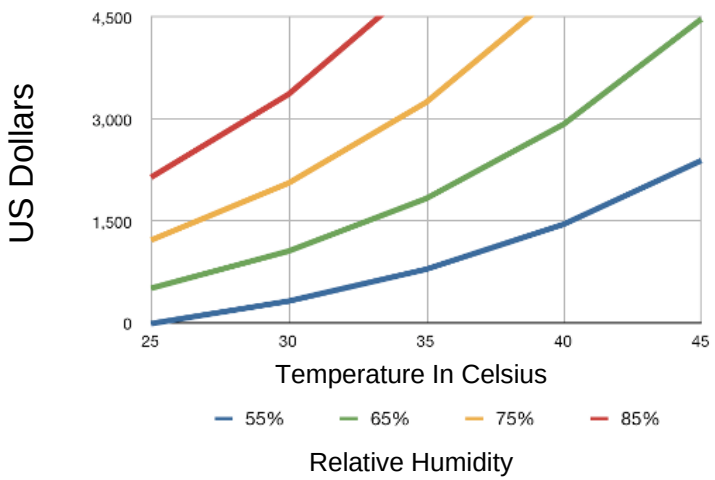
# Why temperature and humidity regulation matters

- Equipment cooling strategies that accept elevated temperatures and / or humidities are a trade off between energy savings and equipment attrition rates

- By plotting MTBF changes against an estimated value for total BTS site equipment the increase in hardware failure costs is expressed as a function of increase in temperature and humidity

  - **Total costs of increased equipment attrition will also include time to replace hardware and down time effects**

***Implied Annual Hardware Replacement Costs***




| | | |
|---|---|---|
| **Rated Temperature** | 25 | Celsius |
| **Rated RH** | 55% | |
| **Rated MTBF** | 25 | Years |
| **Hardware Value** | 20,000 | USD |

***During recent product trials in Kuala Lumpur, the ambient temperature was below 25 C only 6% of the time - The average ambient RH was 90% in these cases with the minimum being 72 %.***

***Malaysia has a typical tropical climate. Preventing exposure of electronics to these harsh conditions is a priority.***

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# Technical Specifications

| | ECS-2800 | ECS-4000 |
|---|---|---|
| Max airflow | 2750 $m^3$ | 4020 $m^3/h$ |
| Cooling capacity (ΔT = 5 K) | 4.6 kW | 6.6 kW |
| Cooling capacity (ΔT = 7 K) | 6.4 kW | 9.3 kW |
| Cooling capacity (ΔT= 10 K) | 9.2 kW | 13.3 kW |
| Supply voltage range | 36-57 VDC [Option: 230 VAC] | |
| Nominal power consumption | 250 W | 524 W |
| Nominal current draw | 4.6 A @ 54 V | 9.7 A @ 54 V |
| Fan type | EC backward curved impeller | |
| Fan control | Variable speed | |
| Main filter class | F5 [Option: H11] | |
| Main filter type | Washable Synthetic (F5), PTFE membrane (H11) | |
| Main filter surface area | 2.15 $m^2$ (F5), 11 $m^2$ (H11) | |
| Pre-filter class [Optional] | G2 | |
| Pre-filter type | Washable Aluminium mesh | |
| Pre-filter surface area | 2.10 $m^2$ | |
| Mounting position | Wall / Floor / Door | |
| Height | 607 mm | |
| Width | 568 mm | |
| Depth | 560 mm | |
| Weight | 29.4 kg | 30.1 kg |
| Construction material | Aluzinc AZ 150 [Options: Aluminium, Stainless steel] | |

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# ECS-2800 Key Selling Points

- Variable fan speed control – saves energy, reduces noise and extends filter life
- Incorporates enthalpy (humidity) control to prevent excessive damaging humidity from being introduced to BTS shelter
- Optional waterproof membrane filter for best possible elimination of contaminants such as salt spray, acid mist, etc for problem areas
- Optional metallic pre-filter to extend service interval
- Can directly connect to Coolsure ETS&UTS air conditioners via CoolBus to provide optimised integrated hybrid cooling system
- Can control up to 2 external third party air conditioners via “failsafe” relay units – automatic changeover function and activation of standby air conditioner
- Analogue filter pressure monitor provides adjustable filter service, filter clogged and filter missing alarms.
- 3 Programmable relay alarm outputs
- No access needed to shelter for filter replacement/service

# Free Cooling Unit – Retrofit Controls

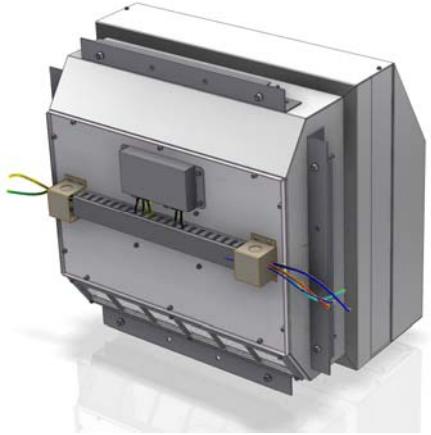


- Coolsure Free Cooling Controls can also be retrofitted to existing third party free cooling units, to facilitate seamless system operation when installing Coolsure air conditioners
- Retrofitting kits can also be provided in cases where existing free cooling controls or vendor support is deficient

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# Energy Efficient Cooling for Communication Networks







GSMA Green Power for Mobile Working Group

August 2013

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