Total Cost of Ownership for Outdoor Enclosures

INTRODUCTION

Total Cost of Ownership (TCO) must be factored into the initial configuration of any outdoor enclosure or cabinet. Although similarly equipped enclosures may have comparable capital costs, the long-term operational costs of the thermal management options vary greatly. If the enclosure design does not properly address the heat load from equipment and the ambient environment, the two major contributors to operational cost could be the power consumption of the thermal management system and the service cost to repair a failed thermal management system.

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Outdoor enclosures require continuous cooling to maintain interior temperatures within recommended operating ranges for the enclosed communication equipment. Communication equipment continues to have higher power density, and this trend increases the amount of power and cooling required per square foot of enclosure space. Thermal management options for an enclosure interior include louvered venting, Direct Air Cooling (DAC), Heat Exchanger (HEX), Air Conditioner (A/C), and Thermoelectric Cooler (TEC). Each of these technologies has unique capital costs, operational costs, strengths, weaknesses, and environmental profiles where they excel.

Service costs, affiliated with the failure of a thermal management system, have two components; the labor affiliated with the service call and the cost of the replacement part. Since enclosures are usually equipped with sensors and a remote alarm capability, a failed thermal management system can be detected immediately upon failure, and a signal can be relayed to a central operations center.

Service interruptions have a large negative impact on the TCO of an outdoor enclosure. As an example, an enclosure could house DSLAM or telephony equipment. If a common piece of switching equipment fails, this impacts numerous customers. Given the crippling impact a service interruption can have on a network, this consideration is not factored into our TCO calculation. But operators must acknowledge that service interruptions facilitate lost revenue and customer dissatisfaction.

Most industrial electronic equipment is specified to operate from – 40 °C as the lower limit, to +45 to + 60 °C range as the upper limit. For electronic components, for every 10 °C rise in temperature, the average reliability is decreased by 50 percent. So maintaining your equipment within the manufacturer's recommended temperature range not only reduces your capital (re)expenditure on equipment, but also improves the reliability of your communication infrastructure. Although this consideration is not factored into our TCO calculation, operators must acknowledge that ignoring thermal management within their enclosures will cost them more in equipment expenditure and downtime with their communication infrastructure.

SAMPLE EQUIPMENT AND ENCLOSURE CONFIGURATIONS

Although selecting the features for an outdoor enclosure may appear to be a simple process of checking the boxes on a data sheet, one must understand the operating characteristics of each piece of equipment installed in the enclosure. Although a simple solution, one should not design the entire enclosure's environment around the worst case or most extreme temperature limits of one piece of equipment. Consider the following operational parameters of specific equipment in our sample configuration, as well as the general environmental parameters.

	Heat Load (w)	Max Operating Temp (˚C)
Power Electronics	600	65
Ancilliary Equipment	50	40
Batteries	200	30
Max Ambient Temp ˚C	38	
Solar Load (W/m2)	754	

Note the different temperatures limits of each group of equipment. Additionally, the batteries should be heated if the ambient temperature drops below -20 °C. When designing and configuring an enclosure, Purcell Systems applies the concept of "Zone Cooling" to enclosure and affiliated equipment. Purcell Systems groups and segregates the equipment into separate zones, and each zone receives a separate thermal

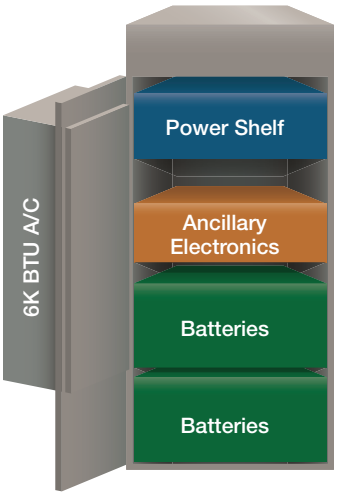
management system. Purcell Systems provides the engineering support to determine which thermal management technology (DAC, HEX, A/C, TEC) can keep the thermal environment under the maximum operating temperature (while dissipating the environmental and equipment heat load) and utilize the least power. By segregating the equipment into different zones, and applying different cooling technologies to each zone, the manufacturer can provide a solution that ensures optimal operating condition for all housed equipment, while minimizing annual power costs.

Consider the typical equipment configuration. The non-engineered solution would utilize a 6000 BTU A/C unit, and attempt to keep the interior chamber temperature below 30 °C to accommodate the batteries. However, this is a wasteful design, as the ancillary equipment needs to be kept below 40 °C and the power equipment needs to be kept below 60 °C. The A/C would run excessively to keep the entire chamber at 30 °C. And to exacerbate the situation, a high heat load may jeopardize the A/C from even maintaining the batteries at 30 °C, which will shorten their cycle life. Additionally, excessive operation of the A/C could potentially accelerate failure of the A/C system.

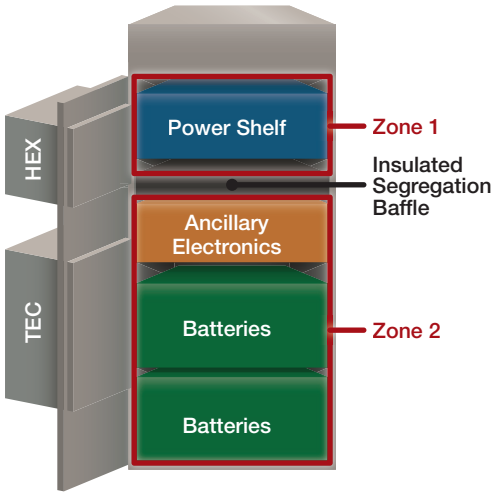
Purcell Systems will design an enclosure and thermal management system around the equipment housed in the enclosure. The three groups of equipment can be segregated into two zones, and Zone Cooling can be implemented. The batteries and ancillary equipment can be grouped into one zone, and they can be maintained below 30 °C using a TEC system. The TEC system complements the battery compartment, as it also heats the chamber when needed. The power equipment, which has a high temperature limit and dissipates much heat during operation, is segregated into its own zone and maintained below 60 °C using a HEX system.

TOTAL COST OVER A THREE YEAR PERIOD

Presented below is the combined capital and operational cost of both solutions. Although the initial capital cost of each solution is comparable, the power consumption for the HEX/TEC system is substantially less on an annual basis. Additionally, the average MTBF for an A/C system is two years, so a service call is added to the operational cost of the A/C system in Year 2.



Typical Equipment Configuration



Purcell designed enclosure with thermal management zones.

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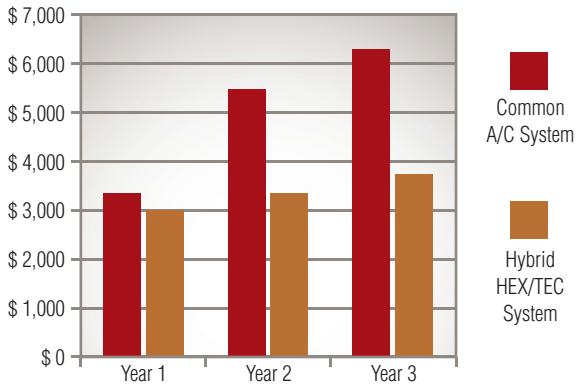
	Year 1	Year 2	Year 3	Total
Common A/C System	$ 3,334	$ 5,469	$ 6,303	$ 15,106
Hybrid HEX/TEC System	$ 2,975	$ 3,351	$ 3,726	$ 10,053

Although the initial difference in the capital cost of the two solutions was only $ 600, the difference in the TCO for each enclosure over a three year period was over $ 5,000. If an operator has 120 nodes (and enclosures) in their network, a small number for any carrier or utility, their annual savings would exceed $ 200,000. Again, this calculation ignores the costs affiliated with service interruptions or premature equipment failure.

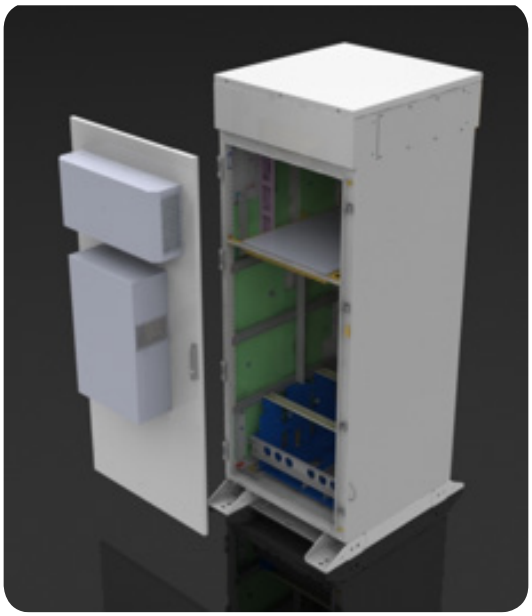


ENCLOSURES DESIGNED TO DELIVER SUPERIOR TCO

Many external factors affect the thermal performance of an outdoor enclosure – primarily the range of seasonal temperatures and humidity, the thermal load produced by the sun, and the thermal load produced by the equipment. As presented, the thermal management system has the largest impact on the operational expenses. Purcell Systems offers a myriad of features that will optimize the thermal management and TCO through the life of the enclosure. Listed below are some of the most critical features that uniquely enable Purcell Systems to deliver optimal TCO for operators.

Zone Cooling – Purcell Systems will engineer the enclosure, and all its affiliated accessories, to accommodate multiple temperature zones. This design method enables the enclosure to keep one zone at a different temperature than another. By understanding the operating ranges of the groups of equipment in the enclosure, Purcell Systems can design the enclosure to keep each group of equipment within its specific operating temperature range. As demonstrated, this capability is especially useful for enclosures that house both batteries and electronics.

FlexAir™ Door - The FlexAir™ Door supports up to three different thermal systems, thus creating three different cooling zones. Purcell Systems analyzes and models the thermal environment of each zone, and can recommend the optimal thermal management system that complies with the equipment specifications while minimizing operational cost. Multiple intelligent controllers can be supported to manage up to three zones as well.



Zone cooling is supported with the FlexAir™ door.

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Intelligent Controllers - A critical consideration when selecting a cooling system is the intelligent controller. Based on multiple temperature sensors, the controller has the ability to operate the fan at variable speeds and regulate airflow. Variable speed fan control reduces energy consumption and acoustic emissions to the surroundings.

Solar Shielding - The temperature rise inside an enclosure above outdoor ambient is caused by energy absorption. Solar shields are beneficial in shading the enclosure's surface by shielding the direct and reflective radiation from the sun. As an example, an enclosure with a top shield provides about a 3° C temperature reduction to the interior temperature, while a top and side shielded enclosure provides a 6° C temperature reduction.

Custom Thermal Systems - Purcell Systems offers a wide range of thermal system technologies and capacities that allow us to match virtually any thermal management requirement with the best combination of technology, performance, reliability and cost rather than simply putting the highest capacity A/C unit that will physically fit each cabinet. This range of thermal solutions also enables adaptability to changing equipment configurations that result in completely different thermal requirements. It is not necessary to equip the cabinet with the largest thermal management system that will fit only to try and "future-proof" the deployment. Enclosures with incorrectly sized thermal systems lead to high failure rates, high energy and maintenance costs, and the potential for reduced equipment reliability and service life.

Purcell Systems will engineer a thermal management configuration that optimizes the environment for the equipment groups within the enclosure, which will minimize the total cost of ownership over the lifetime of the enclosure.

SOURCES OF DATA

- U.S. Bureau of Labor Statistics reported that 2012 average cost of KiloWatt-Hour (KWH) was $0.127.
- 6000 BTU A/C consumes 1000 Watts power.
- TEC consumes 350 Watts power.
- HEX consumes 100 watts power.
- Solar shielding data sourced at http://www.newark.com/pdfs/techarticles/hoffman/Solar_Shielding_to_Lessen_Heat_Load_Protect_Enclosure_Components.pdf

About Purcell Systems Inc.

Purcell Systems Inc. is a leading global company based in the US, with an International counterpart based in Stockholm, Sweden, and has been servicing the telecom market since 2000. The company designs and manufactures innovative, industry-leading, thermally managed, modular outdoor electronic equipment enclosure solutions, and provides system level solutions to a variety of global customers in Telecom, Cable/MSO, Energy/Utility, Land Mobile Radio, Transportation, and U.S. Government/Military.

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