



# GREEN ICT WORKING GROUP MALAYSIA

TECHNICAL WHITEPAPER 1

OCTOBER 2013

## ECO<sup>2</sup> DATA CENTRE COOLING SYSTEMS

Supported By:



## Table of Contents

Introduction	3
Fundamentals of Fluid Submersion Technology	4
Eco <sup>2</sup> Proof of Concept Fundamentals	7
Value Propositions of the Eco <sup>2</sup> System	14
Photos of Eco <sup>2</sup> 6U Proof of Concept System	15

## INTRODUCTION

In September of 2013, the Eco<sup>2</sup> project was kick started with the completion of the Proof of Concept model by the Green Computing Initiative and Ecocentus Sdn Bhd. This project was made possible with the support of an industry promotion and development grant from the Malaysian Communications And Multimedia Commission and managed by Malaysian Technical Standards Forum Bhd.

Eco<sup>2</sup> is shorthand for economical and eco-friendly. The Eco<sup>2</sup> System is an end-to-end fluid submersion cooling solution for data centre ICT equipment such as rack based or blade servers, routers, firewalls and switches. It is a full end-to-end cooling system that utilises a non-conductive dielectric liquid coolant derived from an organic, renewable, sustainable, non-toxic and biodegradable source which is re-engineered palm oil.

Compared to a standard air-conditioned rack system, Eco<sup>2</sup> systems are capable of reducing cooling energy consumption of a typical data centre by 90-95%, and reducing total data centre energy consumption by half.

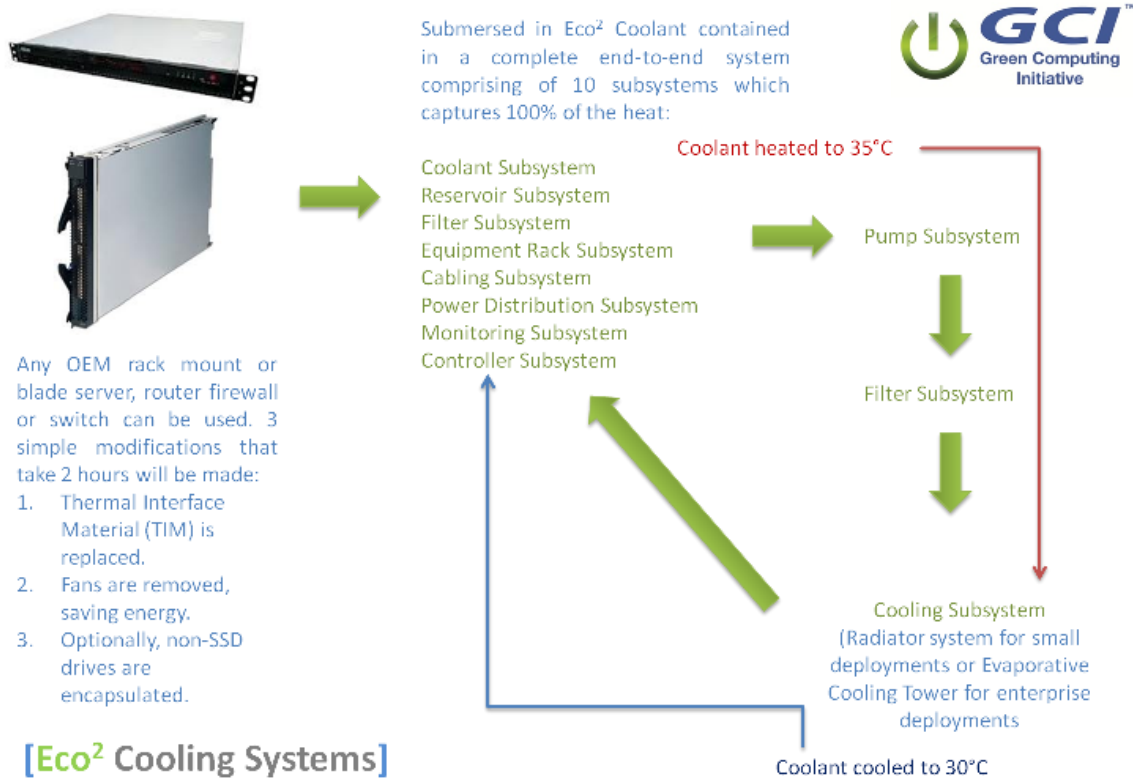
The Eco<sup>2</sup> coolant was invented by Matthew Rajendra the Chief Innovation Officer and Vice President of the Green Computing Initiative Asia after he decided to create a more sustainable and safe alternative to the current fluid submersion coolant which is white mineral oil. After months of research and development, the Eco<sup>2</sup> coolant was conceived and has proven to be 1350 times more effective than air cooling and a more superior alternative to mineral oil which is 1200 times more effective than air.

This whitepaper is the first of two technical whitepapers that will be published on the Eco<sup>2</sup> project. This whitepaper will provide technical information about the technologies behind Eco<sup>2</sup>. The second whitepaper will highlight data and statistics derived from the deployment of Eco<sup>2</sup> at University Putra Malaysia.

For technical information pertaining to Eco<sup>2</sup>, please email Matthew Rajendra at [matt@greenci.org](mailto:matt@greenci.org) and for commercial information please contact Daniel Chang at [daniel@ecocentus.com](mailto:daniel@ecocentus.com).

## FUNDAMENTALS OF FLUID SUBMERSION TECHNOLOGY

Fluid submersion cooling technology places ICT equipment inside nonconductive coolant-filled reservoirs. The coolant dissipates the heat as it circulates through the system. Fluids have superior thermal efficiency, compared with air, and they provide quiet, uniform, secure and effective cooling.



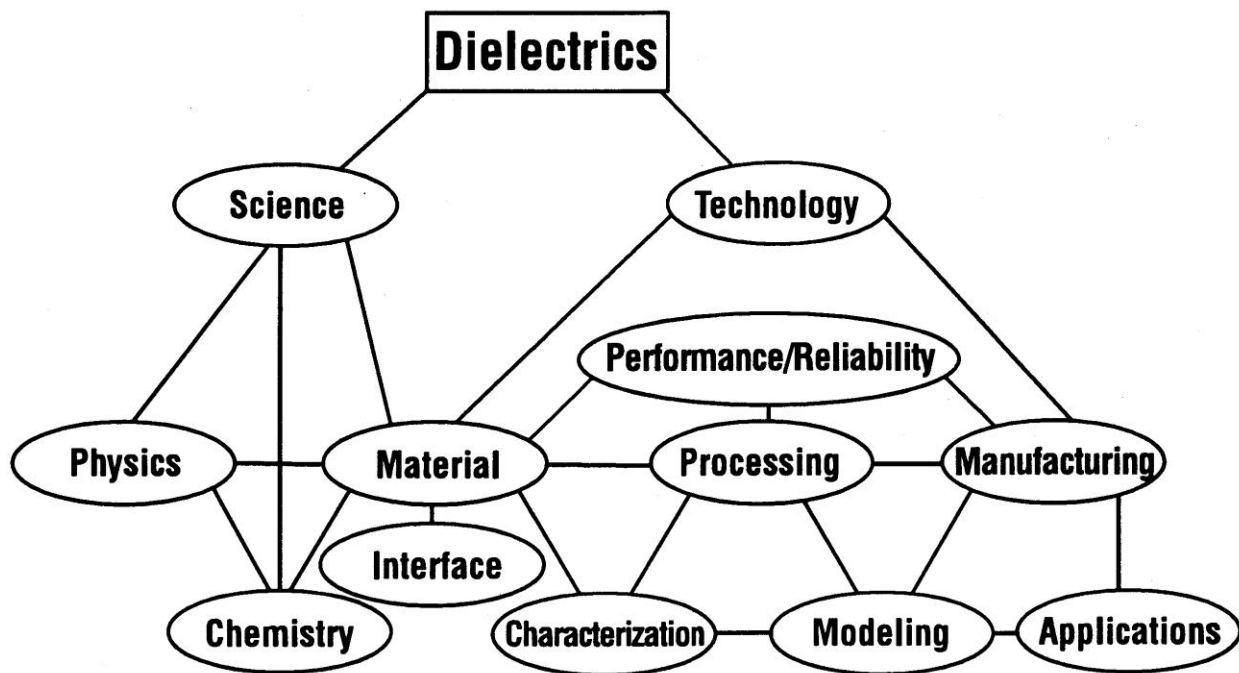
A key characteristic of the Eco<sup>2</sup> coolant is that it possesses high dielectric capabilities. A dielectric material is a substance that is a poor conductor of electricity, but an efficient supporter of electrostatic fields. If the flow of current between opposite electric charge poles is kept to a minimum while the electrostatic lines of flux are not impeded or interrupted, an electrostatic field can store energy.

In practice, most dielectric materials are solid, however Eco<sup>2</sup>'s coolant is a dielectric fluid. An important property of a dielectric is its ability to sustain an electrostatic field while dissipating minimal energy in the form of heat. The lower the *dielectric loss* (the proportion of energy lost as heat), the more effective is a dielectric material. Another consideration is the *dielectric*

*constant*, the extent to which a substance concentrates the electrostatic lines of flux. Substances with a low dielectric constant include a perfect vacuum, dry air, and most pure, dry gases such as helium and nitrogen. Materials with moderate dielectric constants include ceramics, distilled water, paper, mica, polyethylene, and glass. Metal oxides, in general, have high dielectric constants.

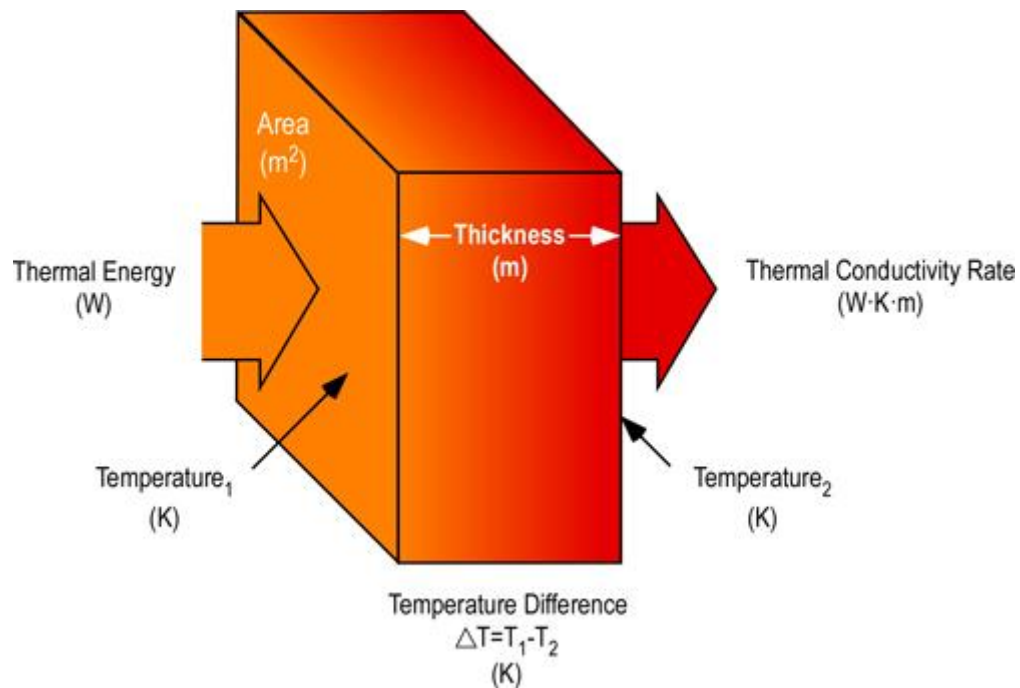
The prime asset of high-dielectric-constant substances is the fact that they make possible the manufacture of high-value capacitors with small physical volume. But these materials are generally not able to withstand electrostatic fields as intense as low-dielectric-constant substances such as air. If the voltage across a dielectric material becomes too great - that is, if the electrostatic field becomes too intense - the material will suddenly begin to conduct current. This phenomenon is called *dielectric breakdown*. In components that use gases or liquids as the dielectric medium, this condition reverses itself if the voltage decreases below the critical point. But in components containing solid dielectrics, dielectric breakdown usually results in permanent damage.

The following diagram depicts the multitude of interactions among the many and diverse core areas of dielectric science and technology that present challenging possibilities for the community of scientists, engineers, and technologists in research, development, and manufacturing.



Another key feature of the Eco<sup>2</sup> coolant is its high thermal conductivity capability. Thermal conductivity (often denoted  $k$ ,  $\lambda$ , or  $\kappa$ ) is the property of a material to conduct heat. It is evaluated primarily in terms of Fourier's Law for heat conduction.

Heat transfer occurs at a higher rate across materials of high thermal conductivity than across materials of low thermal conductivity. Correspondingly materials of high thermal conductivity are widely used in heat sink applications and materials of low thermal conductivity are used as thermal insulation. Thermal conductivity of materials is temperature dependent. The reciprocal of thermal conductivity is called thermal resistivity.



Eco<sup>2</sup>'s other enabling features are its high fire and flash points. Fire point is the lowest temperature where the vapor of a liquid will initiate and sustain a combustion reaction.

Flash point is the lowest temperature at which the vapor of a combustible liquid can be made to ignite momentarily in air. Every liquid has a vapor pressure, which is a function of that liquid's temperature. As the temperature increases, the vapor pressure increases. As the vapor pressure increases, the concentration of vapor of the flammable liquid in the air increases. Hence, temperature determines the concentration of vapor of the flammable liquid in the air.

A certain concentration of vapor in the air is necessary to sustain combustion, and that concentration is different for each flammable liquid. The flash point of a flammable liquid is the lowest temperature at which there will be enough flammable vapor to ignite when an ignition source is applied.

## Eco<sup>2</sup> Proof of Concept Fundamentals

The Eco<sup>2</sup> cooling system is an end-to-end fluid submersion cooling system for rack based OEM servers, routers, firewall and switches that uses a non-conductive dielectric coolant derived from an organic, renewable, sustainable and biodegradable source. ICT equipment are submerged in the reservoir filled with coolant. Circulation of the coolant dissipates equipment heat and returns to the reservoir at a lower temperature, reducing the overall temperature of the reservoir and delivering reliable and consistent cooling to the servers.

### THE SUBSYSTEMS

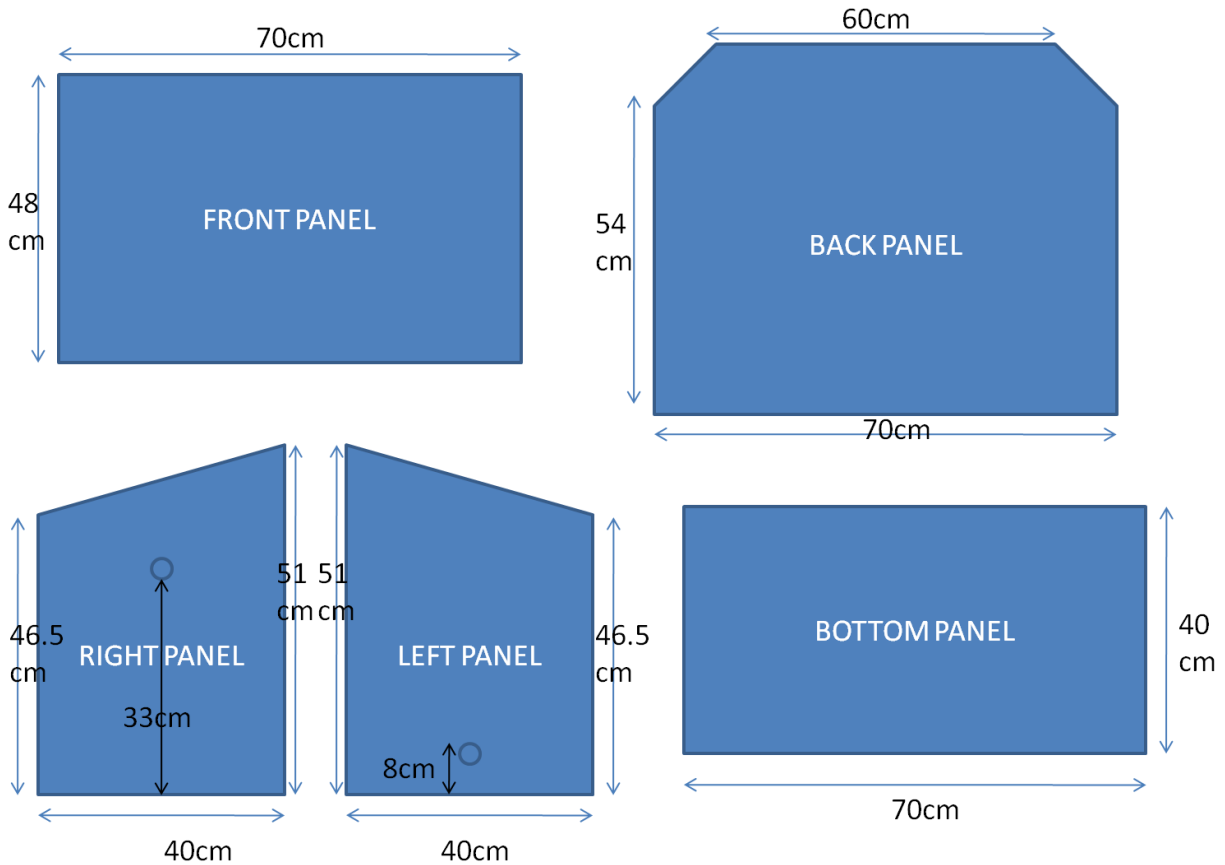
The Eco2 cooling system comprises of 10 sub systems:

1. Reservoir Sub System
2. Coolant Sub System
3. Cooling Sub System
4. Pump Sub System
5. Filter Sub System
6. Equipment Rack Sub System
7. Cabling Sub System
8. Power Distribution Sub System
9. Monitoring Sub System
10. Controller Sub System

#### 1.1 Reservoir Sub System

The 6U Eco2 cooling system has a capacity of up to 6 1U industry standard equipment. This unit is primarily used as an evaluation unit or as a proof of concept demonstration unit. It support up to 150 liters of coolant and has built-in support for attaching all the other sub systems. It features rust proof and non corrosive materials.

Physical dimensions of the reservoir are: Width: 70cm, Length: 40cm and Height: 60cm.



## 1.2 Coolant Sub System

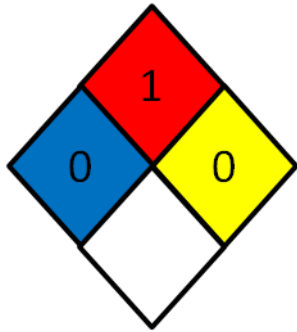
The Eco<sup>2</sup> coolant is a non-conductive dielectric coolant derived from an organic, renewable, sustainable and biodegradable source. It is also non-toxic, non hazardous to human health and environmentally friendly. The coolant is a revolutionary step up from traditional dielectric mineral oil coolants derived from fossil fuels. The coolant has passed the following tests for using dielectric fluids as coolants:

- Turbidity based on ASTM D6181
- Breakdown Voltage based on ASTM D1816/IEC296
- Fire Point rating based on ASTM D92
- Flash Point rating based ASTM D92
- Smoke Point
- Relative Density 15°C based on ASTM D1298
- Viscosity 40°C based on ASTM D88/D445
- Thermal Conductivity based on ASTM D2717
- Moisture Content based on ASTM D3277



The coolant is able to provide similar amounts of cooling at higher temperatures as compared to air cooling. In fact Eco<sup>2</sup> coolant has 1356 times more heat retention capacity than air by volume.

Based on the US National Fire Prevention Association (NFPA) 704 diamond rating, Eco2 coolant is rated as a 0-1-0 substance.



BLUE (Health) - Poses no health hazard, no precautions necessary and would offer no hazard beyond that of ordinary combustible materials.

RED (Flammability) - Materials that require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur. Includes some finely divided suspended solids that do not require heating before ignition can occur. (Flash point at or above 93.4°C.

Yellow (Instability/Reactivity) - Normally stable, even under fire exposure conditions, and is not reactive with water.

WHITE (Special) – No special notice.

### 1.3 Cooling Sub System

The cooling sub system is made up of 100% aluminum construction and utilizes stamped plates sandwiched together to create one of the most efficient cooler devices available. Not only does this unique design provide for maximized cooling through more efficient heat dissipation but it also provides a much sturdier build. An additional feature which protects against low pressure drop is built-in. The coolers assembled with hose bard ends include a unique bypass feature allowing a controlled amount of coolant to bypass the stacked plate core when the fluid s cold.

Controlled by viscosity, coolant is returned directly to the reservoir through bypass openings in the stacked plate core. This highly efficient design combines improved protection against coolant system failure with the required levels of optimal heat transfer.

### 1.4 Pump Sub System

The pump sub system drives the circulation of coolant from the reservoir through the filter sub system and then to the cooling sub system before being returned back to the reservoir. The pump is digitally controlled by the controller sub system which relies on the monitoring sub system for environmental data.

### 1.5 Filter Sub System

The filter sub system is designed to remove contaminants from the coolant. The filter is designed to last the lifetime of the coolant which is more than 10 years. A recommended cleaning period for the filter is once a year. Cleaning the filter should not take more than 5 minutes.

### 1.6 Equipment Rack Sub System

The equipment rack sub system is divided into regions, 1.75 inches (44.45 mm) in height, within which there are three complete hole pairs in a vertically symmetric pattern, the holes being centered 0.25 inches (6.35 mm), 0.875 inches (22.23 mm), and 1.5 inches (38.10 mm) from the top or bottom of the region. Such a region is commonly known as a U, for "unit and heights within racks are measured by this unit.

### 1.7 Cabling Sub System

The cabling sub system ensures that the network and power cables within the Eco<sup>2</sup> system is well organized and routed separately. Power cables are kept on the left side and network cables on the right side.

### 1.8 Power Distribution Sub System

The power distribution sub system is fitted with multiple appliance outlets designed to distribute electric power within the rack, especially to computers and networking equipment.

### 1.9 Monitoring Sub System

The monitoring sub system consists of temperature probes located in various locations within the system and displays the temperature of various hotspots.

### 1.10 Controller Sub System

The controller sub system controls the pump sub system based on the programmed range of permitted working temperature of the coolant.

The following are the results from tests on the 6U proof of concept system:

1. Coolant Properties

<b>Temp</b>	<b>Viscosity</b>	<b>Heat Capacity</b>	<b>Conductivity</b>	<b>Density</b>	<b>Viscosity</b>
<b>deg. C</b>	<b>mPas</b>	<b>KJ/kg-C</b>	<b>W/m-C</b>	<b>kg/m3</b>	<b>cST</b>
25	77.19	1.861	0.1721	887.5	86.97
30	57.85	1.875	0.1717	885.0	65.37
35	44.68	1.888	0.1712	882.5	50.63
40	35.41	1.902	0.1708	880.0	40.24
45	28.68	1.916	0.1704	877.5	32.68
50	23.68	1.930	0.1699	875.1	27.06
55	19.88	1.944	0.1695	872.6	22.78
60	16.93	1.959	0.1691	870.2	19.46
65	14.61	1.973	0.1687	867.8	16.84
70	12.75	1.988	0.1683	865.4	14.73
75	11.23	2.003	0.1679	863.1	13.01
80	9.99	2.018	0.1675	860.7	11.61
85	8.955	2.034	0.1671	858.4	10.43
90	8.087	2.049	0.1668	856.1	9.45
95	7.351	2.065	0.1664	853.8	8.61
100	6.721	2.081	0.1660	851.6	7.89

## 2. Energy Usage with values normalized to server power usage

	<b>Before</b>	<b>Eco<sup>2</sup></b>
Servers	1.00	0.85
UPS*	0.08	0.07
Cooling	0.9	0.03
Total Power	1.98	0.95
PUE	1.98	1.12
<b>Power Savings</b>		<b>-52%</b>

## 3. Engineering Results

90% less cooling energy: Our coolant is controlled to 40° C. It requires very little energy to maintain Eco<sup>2</sup> at 40° C because heat naturally flows from hot (inside) to cold (outside). By comparison, air conditioners typically chill water to 7° C and then use that water to cool the air in the data center to around 23° C. Chilling water requires a much more energy-intensive process of pumping heat outside. As a result, Eco<sup>2</sup> can save a significant amount of energy by not requiring water chilling. Additionally, moving large quantities of air is much less energy efficient than moving small quantities of fluid.

Server Failure Rates: Our solution offers the potential to lower failures significantly in three ways:

- Removal of all server fans
- Low temperature gradient
- Better electrical connector reliability

Server fans are one of the largest reasons for server failures.

External to the server, data centers do not evenly cool all the servers in a rack: the temperature at the top of a rack may be 10 °C hotter than the bottom of the rack, while our servers enjoy ± 1 °C temperature variation from one end of the rack to the other.

Inside the server, local hot spots can occur due to the accumulation of dust, an excellent thermal insulator, and uneven air flow. Dust and other contaminants are removed in the Eco2 Cooling system down to a few microns in particulate size. Due to the large heat capacity of the fluid, 1,350x higher than air by volume, temperature differences around power dense components should be significantly reduced. As an example the CPU's are measured to be as much as 20 °C cooler than in an air cooled system with comparable load.

Our coolant enhances electrical connections because the dielectric strength is 6x that of air (12MV/meter vs. 2 MV/meter) which allows less micro-arcing. The micro-arcing causes intense localized heating, which then creates corrosion and oxidation. Micro-arcing in air is why many connections are gold plated. The use of dielectric compounds to increase connector reliability is well documented and common in other industries such as industrial automation, automotive, and the military.

### Other Observations

**Disaster Recovery:** Unlike air-cooled servers that overheat within minutes of an air-conditioning outage, Eco2 systems can run for 1-4 hours before overheating. Because Eco2 coolant holds much more heat by volume than air, there is significantly more time to problem-solve before the servers overheat.

**Server Reliability:** Servers don't collect dust and there are no fans to break. Excellent circulation of coolant means uniform temperatures without hot spots.

**Lower Priced Hard Drives/Less Vibration:** Normal server vibrations are cited as causing up to 50% of read/write failures in hard drives. Because all server fans are removed and the hard drives are surrounded by dampening fluid, most vibration is eliminated. Enterprise-class hard drives have vibration dampening, unlike consumer-grade, but this vastly increases the cost of hard drives.

**Easy Access:** Servers are easily removed from rack for quick access. Below, a technician removes a server and prepares to place it on the rails (background) for inspection.

**Heat Recapture:** Using solid-state or disk-less boot, our coolant can run at 60° C exit temperature to allow easy heat recapture. The coolant temperature is dictated by type of storage since platter-style hard drives are typically significantly less heat tolerant component than other components.

**Cleanliness:** Dust is a thermal insulator that raises server temperatures and reduces reliability. The coolant also keeps servers clean as it circulates in the rack and the pump module. Below, a server being removed from the rack shows no signs of gathering dust or other particles that typically accumulate in air-cooled systems. One recent study showed that dust accumulation increased power draw by 2% due to server temperature increases.

## Value Propositions of the Eco<sup>2</sup> System

The value experienced by Eco2 customers is all-encompassing by nature. Customers experience a positive outcome from the onset by enjoying reduced capital expenditure and simplified infrastructure efforts. After deployment, customers enjoy substantial reduction in operating costs in the form of lower electricity bills. Customers also enjoy a lower cost of ownership as costs related to the upkeep and repairs of conventional cooling systems are eliminated. Customers also enjoy the publicity benefits of sustainable efforts. Finally in the medium term, customers enjoy a fast payback period.

### Why The Industry Is Excited

#### Substantial Cost Savings:

- For greenfield installations, the CAPEX savings are up to 60%.
- For retrofits or greenfield installations, the OPEX on electricity costs are reduced by up to 90%.
- For greenfield installations, the TCO is reduced by up to 35%.

#### Attractive Return on Investment:

- Average payback period of between 1 to 3 years.

#### Ease of Implementation:

- No complicated engineering required for space, just cement rendered flooring and comfort cooling for staff.
- All new and existing OEM servers, routers, firewalls and switches are compatible with Eco2 after minor modifications.

#### Green Efforts

- Reduce carbon footprint by up to 90%.
- Embark on CSR efforts to obtaining positive publicity and to increase customer, investor and stakeholder buy-in for sustainability efforts.
- Prepare for eventual regulations including carbon taxes and regulatory reporting requirements.
- Earn carbon credits.

#### Product Offerings

6U, 14U, 28U and 42U capacity rack systems are available. Smaller deployments utilise radiator cooling whilst enterprise deployments use evaporative cooling towers. Complete systems are available for lease or for outright purchase.

# Photos of Eco<sup>2</sup> 6U Proof of Concept System











# GREEN ICT WORKING GROUP MALAYSIA

## TECHNICAL WHITEPAPER 2

### DECEMBER 2013

# ECO<sup>2</sup> DATA CENTRE COOLING SYSTEMS

Supported By:



## Table of Contents

Introduction	3
PUE Analysis	4
Testing of Alternative Source of Coolant	6
Value Propositions of the Eco <sup>2</sup> System	7
Photos of Eco <sup>2</sup> 6U Proof of Concept System	10

## INTRODUCTION

In September of 2013, the Eco<sup>2</sup> project was kick started with the completion of the Proof of Concept model by the Green Computing Initiative and Ecocentus Sdn Bhd. This project was made possible with the support of an industry promotion and development grant from the Malaysian Communications And Multimedia Commission and managed by Malaysian Technical Standards Forum Bhd.

Eco<sup>2</sup> is shorthand for economical and eco-friendly. The Eco<sup>2</sup> System is an end-to-end fluid submersion cooling solution for data centre ICT equipment such as rack based or blade servers, routers, firewalls and switches. It is a full end-to-end cooling system that utilises a non-conductive dielectric liquid coolant derived from an organic, renewable, sustainable, non-toxic and biodegradable source which is re-engineered palm oil.

Compared to a standard air-conditioned rack system, Eco<sup>2</sup> systems are capable of reducing cooling energy consumption of a typical data centre by 90-95%, and reducing total data centre energy consumption by half.

The Eco<sup>2</sup> coolant was invented by Matthew Rajendra the Chief Innovation Officer and Vice President of the Green Computing Initiative Asia after he decided to create a more sustainable and safe alternative to the current fluid submersion coolant which is white mineral oil. After months of research and development, the Eco<sup>2</sup> coolant was conceived and has proven to be 1350 times more effective than air cooling and a more superior alternative to mineral oil which is 1200 times more effective than air.

This whitepaper is the second of two technical whitepapers that will be published on the Eco<sup>2</sup> project. This whitepaper will provide additional information on further testing of the Eco<sup>2</sup> system which was conducted between 13 November to 6 December 2013. For technical information pertaining to Eco<sup>2</sup>, please email Matthew Rajendra at [matt@greenci.org](mailto:matt@greenci.org) and for commercial information please contact Daniel Chang at [daniel@ecocentus.com](mailto:daniel@ecocentus.com).

## POWER USAGE EFFECTIVENESS (PUE) ANALYSIS

The Eco<sup>2</sup> system was subjected to a comprehensive test that encompassed measuring the ICT equipment energy consumption load and the total facility energy consumption load to derive the Power Usage Effectiveness (PUE) reading for the system.

PUE has become the industry preferred metric for measuring infrastructure energy efficiency for data centers. The PUE metric is an end-user tool that helps boost energy efficiency in data center operations. It was developed by The Green Grid Association, a nonprofit, open industry consortium of end users, policy makers, technology providers, facility architects, and utility companies working to improve the resource efficiency of information technology and data centers throughout the world. Since its original publication in 2007, PUE has been globally adopted by the industry.

PUE is the ratio of total amount of energy used by a computer data center facility to the energy delivered to computing equipment.

PUE is the inverse of data center infrastructure efficiency (DCIE). An ideal PUE is 1.0. Anything that isn't considered a computing device in a data center (i.e. lighting, cooling, etc.) falls into the category of facility energy consumption.

$$\text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

### How to Determine PUE

1. Take a measurement of energy use at or near the facility's utility meter. If the data center is in a mixed-use facility or office building, take a measurement only at the meter that is powering the data center. If it is not on a separate utility meter, estimate the amount of power being consumed by the non-data center portion of the building and remove it from the equation.
2. Measure the IT equipment load after power conversion, switching, and conditioning is completed. According to The Green Grid, the most useful measurement point is at the output of the computer room power distribution units (PDUs). This measurement should represent the total power delivered to the server racks in the data center.

According to the Uptime Institute, the typical data center has an average PUE of 2.5. This means that for every 2.5 watts in at the utility meter, only one watt is delivered out to the IT load. Uptime estimates most facilities could achieve 1.6 PUE using the most efficient equipment and best practices.

The following is the average measured readings of the 6U Eco<sup>2</sup> system which consists of the following ICT equipment and cooling equipment:

ICT Equipment:

- 1 Unit 1U Cisco 24 Port Catalyst Switch
- 1 Unit 1U Cisco Router
- 1 Unit Cisco PIX Firewall Appliance
- 2 Units 2U Enterprise Servers

Cooling Equipment:

- 1 Unit 12V Pump Module
- 1 Unit 12V Fan Module
- 1 Unit Monitoring Module

The PUE was calculated as follows:

Total 6U Eco<sup>2</sup> (ICT and Cooling) Power Usage: 223 Watts

Total ICT Equipment Power Usage: 189 Watts

$$\text{PUE} = 223/189 = 1.17$$

Based on industry PUE benchmarking, a PUE of between 1.8 – 2.0 is industry standard. The Ministry of Energy, Green Technology and Water (KeTTHA) green data centre was recently recertified with a PUE of 1.48.

The Eco<sup>2</sup> Proof of Concept system has performed beyond expectations with a PUE of 1.17 making it a very energy efficient system for cooling ICT equipment.

## Testing of Alternative Source of Coolant

Upon the request of the Green ICT Working Group committee, we embarked on a study of how used cooking palm oil can be potentially used as an Eco<sup>2</sup> coolant. We created a test reservoir and filled it with 60 liters of used cooking oil sourced from 13 restaurants in Petaling Jaya. Prior to filling, we filtered the oil and heated it to 60 degrees Celsius in order to eliminate excessive moisture. We then added 40 liters of additive to create an Eco<sup>2</sup> coolant.

A 1U server and 1U Cisco router was then submersed in the derived coolant for a period of 8 hours. The following observations were made:

Time	Temperature of Coolant	Thermal Conductivity Test	Dielectric Test	Comments
<b>10:30am</b>	28.9 deg C	Pass	Pass	All Normal
<b>11:30am</b>	29.1 deg C	Pass	Pass	All Normal
<b>12:30pm</b>	29.4 deg C	Pass	Pass	All Normal
<b>1:30pm</b>	30.3 deg C	Pass	Pass	Odor of French Fries
<b>2:30pm</b>	31.4 deg C	Pass	Pass	Odor Stronger
<b>3:30pm</b>	31.8 deg C	Fair	Pass	Odor Stronger
<b>4:30pm</b>	32 deg C	Fair	Pass	Odor Stronger
<b>5:30pm</b>	32.3 deg C	Fair	Pass	Odor Stronger
<b>6:30pm</b>	32.5 deg C	Fair	Pass	Odor Stronger
<b>7:30pm</b>	32.9 deg C	Fair	Pass	Odor Strongest

Based on preliminary testing, we find that the reused cooking oil will not be able to withstand the high thermal conductivity requirements of ICT equipment. The dielectric strength of the coolant is also suspect based on the high amounts of microscopic contaminants in the coolant. A strong odor of cooked food was also obvious. As such the recommendation is not to reuse cooking oil as a base for the Eco<sup>2</sup> coolant.

## Value Propositions of the Eco<sup>2</sup> System

The value experienced by Eco2 customers is all-encompassing by nature. Customers experience a positive outcome from the onset by enjoying reduced capital expenditure and simplified infrastructure efforts. After deployment, customers enjoy substantial reduction in operating costs in the form of lower electricity bills. Customers also enjoy a lower cost of ownership as costs related to the upkeep and repairs of conventional cooling systems are eliminated. Customers also enjoy the publicity benefits of sustainable efforts. Finally in the medium term, customers enjoy a fast payback period.

### Why The Industry Is Excited

#### Substantial Cost Savings:

- For greenfield installations, the CAPEX savings are up to 60%.
- For retrofits or greenfield installations, the OPEX on electricity costs are reduced by up to 90%.
- For greenfield installations, the TCO is reduced by up to 35%.

#### Attractive Return on Investment:

- Average payback period of between 1 to 3 years.

#### Ease of Implementation:

- No complicated engineering required for space, just cement rendered flooring and comfort cooling for staff.
- All new and existing OEM servers, routers, firewalls and switches are compatible with Eco2 after minor modifications.

#### Green Efforts

- Reduce carbon footprint by up to 90%.
- Embark on CSR efforts to obtaining positive publicity and to increase customer, investor and stakeholder buy-in for sustainability efforts.
- Prepare for eventual regulations including carbon taxes and regulatory reporting requirements.
- Earn carbon credits.

#### Product Offerings

6U, 14U, 28U and 42U capacity rack systems are available. Smaller deployments utilise radiator cooling whilst enterprise deployments use evaporative cooling towers. Complete systems are available for lease or for outright purchase.



# Photos of Eco<sup>2</sup> 6U Proof of Concept System





