OREO
(Overall Room Energy Optimization)

The Cooling Chapter

A Technical Paper prepared for SCTE/ISBE by

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Table of Contents

Title **Page Number**

List of Figures

Title **Page Number**

List of Tables

Title **Page Number**

Introduction

OREO stands for 'Overall Room Energy Optimization'. This document provides an insight into creating and delivering a standard plan for implementing efficiency improvements to cooling systems, and largely based on providing value for money.

OREO is a standardized solution and 'End to End Plan' for improving energy performance for existing TV, Telecommunications and Data Centre facilities. This 'End to End Plan' encompasses consulting, design, delivery and services management. These are all key factors in guaranteeing the performance improvement.

OREO is a partnering project in the UK between Upnorth Engineering Services Ltd and Virgin Media Ltd, a subsidiary of Liberty Global. The Project was formed to investigate methods and strategies for improving energy performance within existing Data Centres.

The fundamental engineering objectives behind an OREO Project are:

- To assess a methodology for rating sites in energy performance
- To specify methodology and technology which would improve energy performance
- To calculate return on investment periods
- To mitigate business risk

This research and engineering feasibility project was carried out in two phases across three Telecommunication sites. Within this document, these three sites are referred to as the 'Trial Sites'. 'Desktop Engineering' was performed initially, and was followed by a practical phase where the scoped work was delivered, monitored and compared to the engineering predictions.

CONTENT

1. Energy Share

Firstly, in order to determine energy saving potential for cooling engineering applications, a study is required to determine the portion of total energy consumption the cooling represents and the impact the cooling improvements will have on the total consumption. This is important if we want to know the impact our improvements have on financials i.e. utility bills. In certain circumstances, this maybe the only data available to quantify the actual benefits i.e. no structured monitoring.

Figure 1 shows energy consumption of a typical technical facility using DX cooling:

- 50% consumed by servers/telco equipment for providing service
- 10% consumed to compensate for general power; for power losses and for charging energy storage
- 40% consumed in cooling processes – this becomes the improvement target area

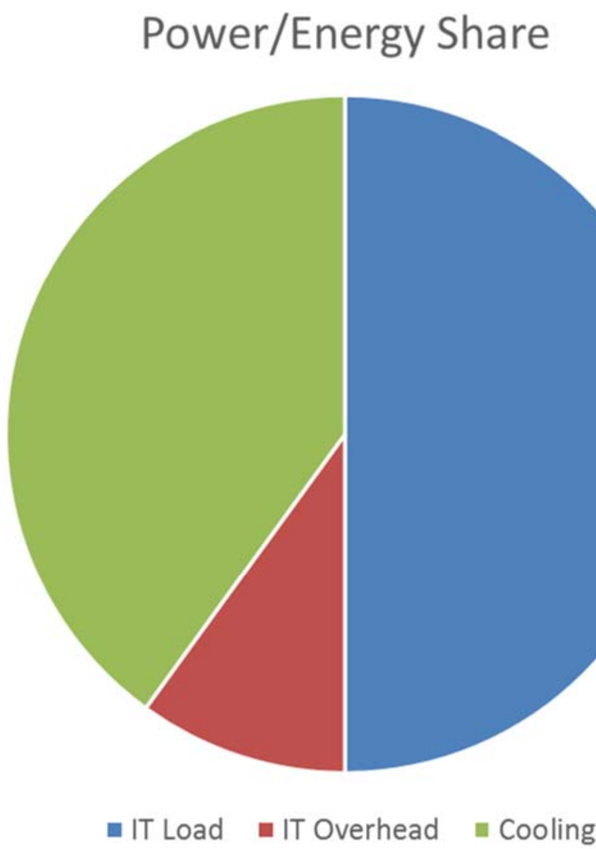

Figure 1 - Energy Share Chart

Reducing the cooling demand by 50% reduces the overall total demand by 20%

2. Why Now?

We have a global responsibility to reduce the unnecessary use of energy to a minimum. For Data Centre, TV and Telecommunication businesses, energy represents one of the major, if not the main the business cost. It is therefore logical, within reason, to reduce the consumption of any unnecessary energy to a minimum and in doing so optimize profitability.

In this sector it's also likely that businesses will face the prospect of redeveloping and/or refurbishing some of their 'older' sites i.e. those sites in which the building services are due to be replaced due to plant and equipment approaching end of life.

3. Cooling Technology, Capacity, Consumption & Engagement

3.1. Cooling: Technology

Our desktop feasibility study concluded that the majority of our savings would come from introducing free cooling (Fresh Air) to sites which currently utilised DX cooling for 100% of the time.

We evaluated the overall performance of three standard 'free cooling' solutions. This was based on energy performance potential, installation cost and ROI (return on investment).

The following table shows those technologies in the order in which they best suited our OREO Plan.

Table 1 - Technologies Best Suited for our OREO Plan

Rank & Technology	Positives	Negatives	Notes
Direct Free Air Cooling Systems (Filtered Direct Fresh Air with DX Backup) **#1 ROI Overall Rating** **#1 Cost Installation** **#2 Potential PUE**	Very good potential o/a PUE's achievable (second best in this assessment) Standard Modular Solution Familiarity for Service and Maintainability	Unsuitable for Coastal i.e. high salinity regions Necessitates at least M5 (UK) filter for suitable internal air quality Air quality i.e. particulate and quality sampling controls recommended for forcing closed fresh air facility avoiding situations which may trigger fire suppression services and/or result in large sways in RH control.	For 'unsuitable' regions revert to Rank #2 or #3 solutions
Direct Free Evaporative Cooling Systems (Filtered Direct Fresh Air with Evaporative and DX Backup HX) **#1 Potential PUE** **#2 ROI Overall Rating** **#3 Cost Installation**	Lowest o/a PUE's achievable when using Direct Fresh Air supplemented with Evaporative. DX for backup only. Few Standard Solutions available from Cooling Manufacturers resulting in solutions generally being bespoke applied most of the time (cost and reliability?)	Evaporative Cooling adds a further layer of service and engineering complexity which demands more space, thought and design investment. Service provider requires expertise in Refrigeration, Air and Evaporative solutions i.e. additional layers of complexity Legionella prevention requires factoring in to maintenance regimes.	For 'unsuitable' applications and/or for accounts where service provisioning doesn't provide the required skills refer to Rank #3

Indirect Free Cooling Systems (Filtered InDirect Fresh Air with DX Backup HX) **#2 Cost Installation** **#3 ROI Overall Rating** **#3 Potential PUE**	Closed environment so less reliant on filtration, G4 generally suitable Configurations can be engineered to provide capacity diversity Reasonable o/a PUE's Standard Modular Solution Familiarity for Service and Maintainability	Plant applications demand more space and are less configurable modularly Service provider requires expertise in Refrigeration, Air and Water Side solutions i.e. additional layer of complexity	

3.2. Cooling: Capacity & Variables

All environments, unless they are perfect, have a reliance to some degree on Overcooling. It is this Overcooling element that we are attempting to mitigate. In order to do so, it is important to learn the relationship between Room Service Efficiency and Overcooling Capacity i.e. the ratio of Room Cooling Capacity to Load.

We assessed a number of our typical environments and discovered the following results:

- Contained rooms required at least 10% overcooling (airflow volume flow rate) to remain resilient in the event of a peak day cooling module failure
- Rooms with common air void (Floor Supply Air) required at least 20% overcooling (airflow volume flow rate) to remain resilient in the event of a peak day cooling module failure
- Void-less rooms, i.e. rooms without a common plenum/duct, required at least 30% overcooling (airflow volume flow rate) to remain resilient in the event of a peak day cooling module failure. Due to limited air distribution paths void-less rooms may also require a zonal (sometimes many in a single room) resilient cooling module application or the installation of ducted air solutions.

We considered the above overcooling margins to be achievable in optimization.

3.3. Cooling: Energy Consumption.

As we consider introducing free cooling technologies (essentially utilizing fresh air) and at the same time we increase room temperatures, our reliance on DX refrigeration technology may, subject to regions and weather conditions, abate considerably.

When assessing consumption of energy and use of power, we can split cooling systems into two separate categories:

- Consumption to **Generate** Cooling (process to remove the heat)
- Consumption to **Distribute** Cooling (process circulating flow rate and cooling medium)

During the engineering feasibility stage, we calculated that converting UK sites, which were cooled using DX refrigeration to systems which could utilize fresh air, would reduce the time spent in DX cooling mode by approximately 80%.

Prior to introducing or replacing layers of technology within our cooling systems, we must first calculate and understand the amount of time each element is in service. Only then can we determine the true value of the investment.

A key question that required answering was "if a certain element of the system is only required for 20% of the time, would applying the most efficient and potentially most expensive £/kWc technology in this area be considered over-investment?"

Fan and pumping power was assessed in great detail. The assessment suggested that replacing the legacy fans and pump with EC fans and pump technology would reduce the power and energy consumption for these components by up to 40%.

3.4. Cooling: Capacity Engagement

This is defined as the time in which the cooling is engaged and active under its control. Once again, we looked to assess the engagement of cooling generators and distributors separately.

Cooling generators are generally thermostatically controlled and this ensures that their activity and energy consumption is proportional to demand.

In distribution platforms (pumps and fans), thermostatic or capacity managed control is not so common, particularly in legacy facilities.

Fans and pumps may be found with no capacity control at all i.e. all active 100% of the time. This results in excessive overcooling and excessive energy consumption. Distribution control, similar to our cooling generators, should be aligned with the demand.

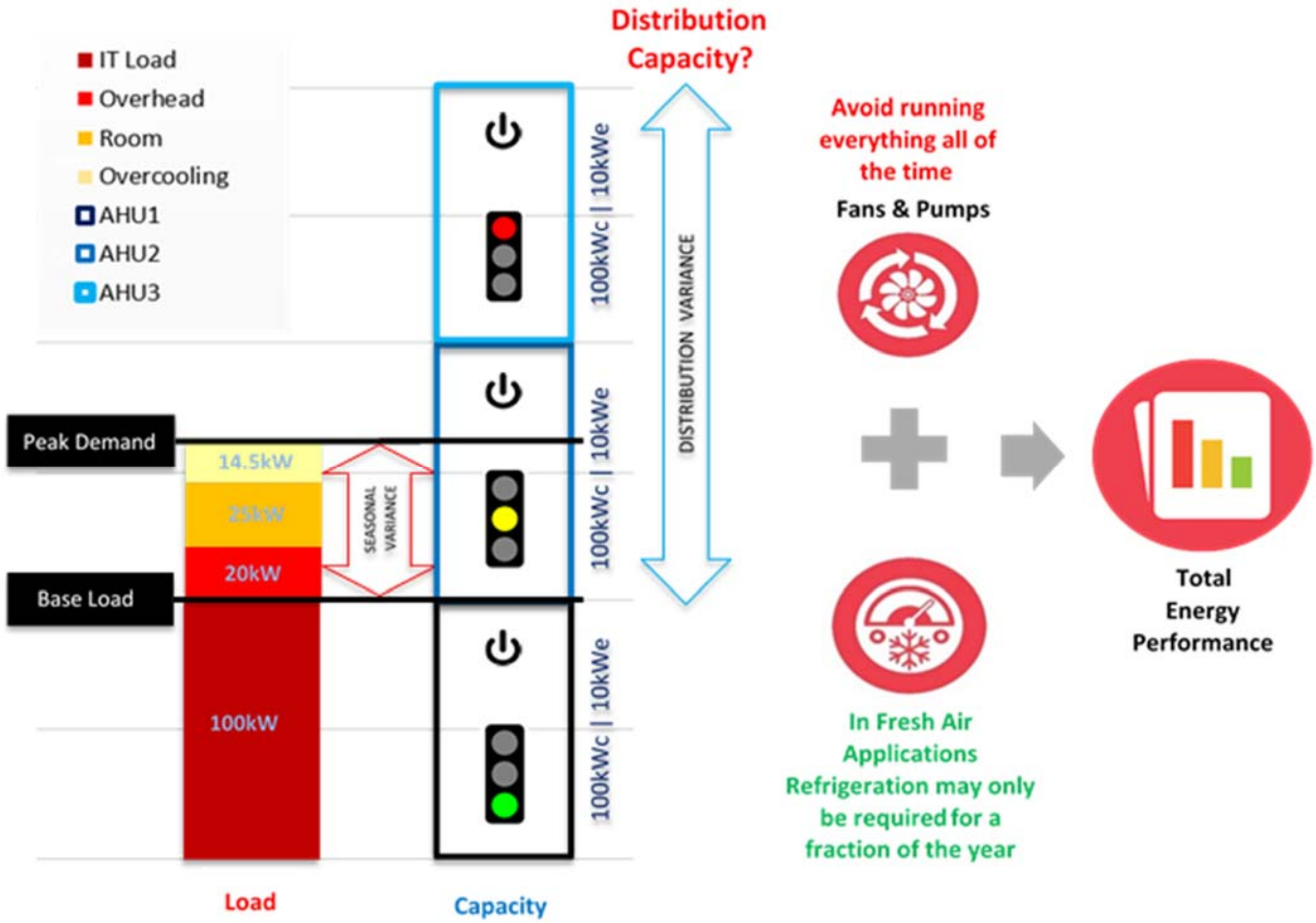

Figure 2 - Cooling Variable Load & Modular Capacity Relationship

Oversized/Overcooled constant volume distribution can be a result of many things. Common causes are:

- Cooling systems may have been initially oversized (or not sized on any particular parameter, such as W/m2)
- Lack of control technology on site
- The facility load has reduced and/or the Client does not monitor actual load
- The room has poor air management effectiveness i.e. significant plenum losses and overcooling is required to prevent zonal overheating

4. Data Source, Information & IMS

Data and information systems are key when undertaking research, design and engineering assessments of this type. Furthermore, the availability of such information is an ongoing requirement to keep management plans on target.

In order to reduce cooling energy consumption, we must provide less overall cooling to the facility. To manage business risk throughout this process we become reliant on asset, record and real time management data. Real time data must be dynamically processed in order to balance risk and energy improvement objectives.

Our recommendations are that businesses consider the following before embarking on any energy investment /restructuring project:

1. Update asset and capacity registers
2. Update record plans and schematics
3. Implementation of site PUE monitoring and room IT load monitoring data systems (all rooms)
4. Implementation of a platform and protocol to host and manage plant and monitoring data
5. An appropriate software to provide 'pre-DCIM' functionality

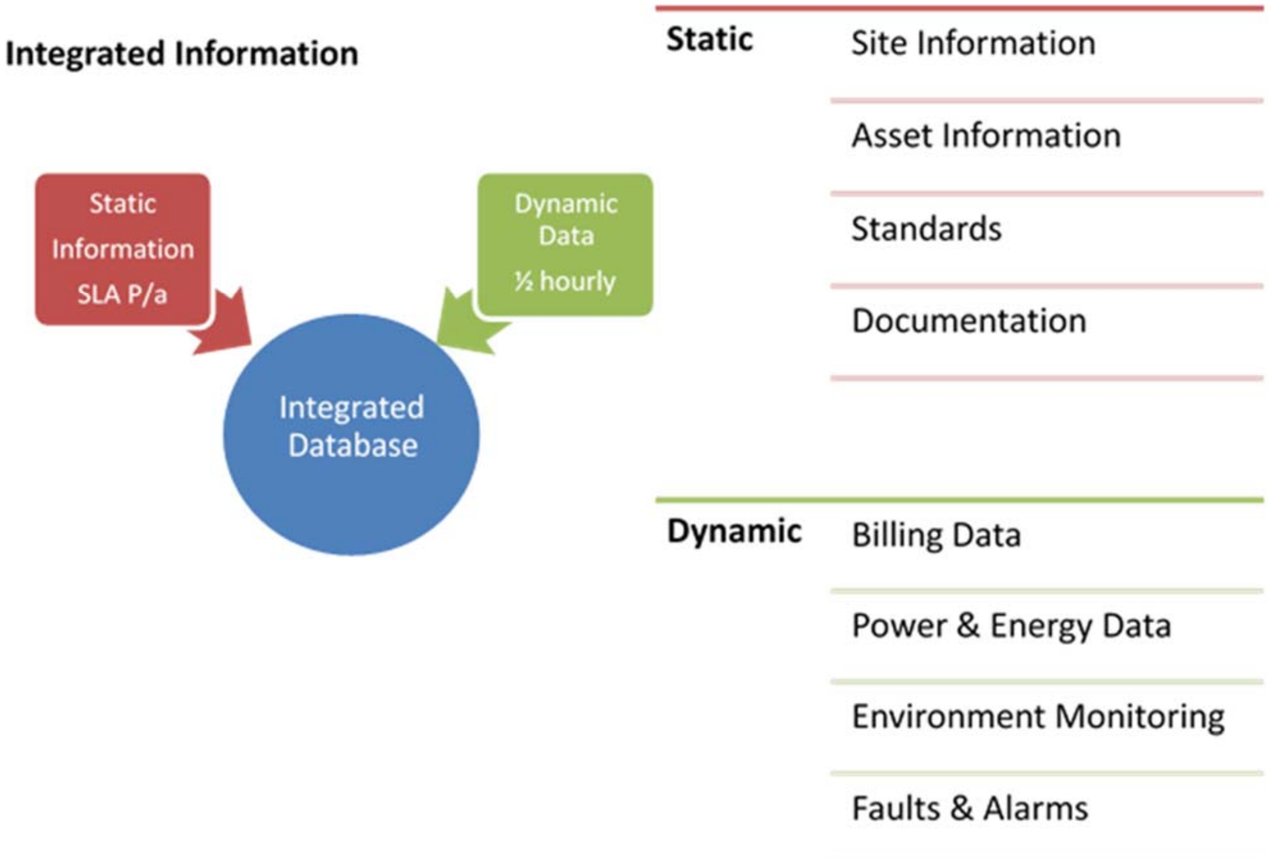

Figure 3 - Example Summary of Information & Data Fields

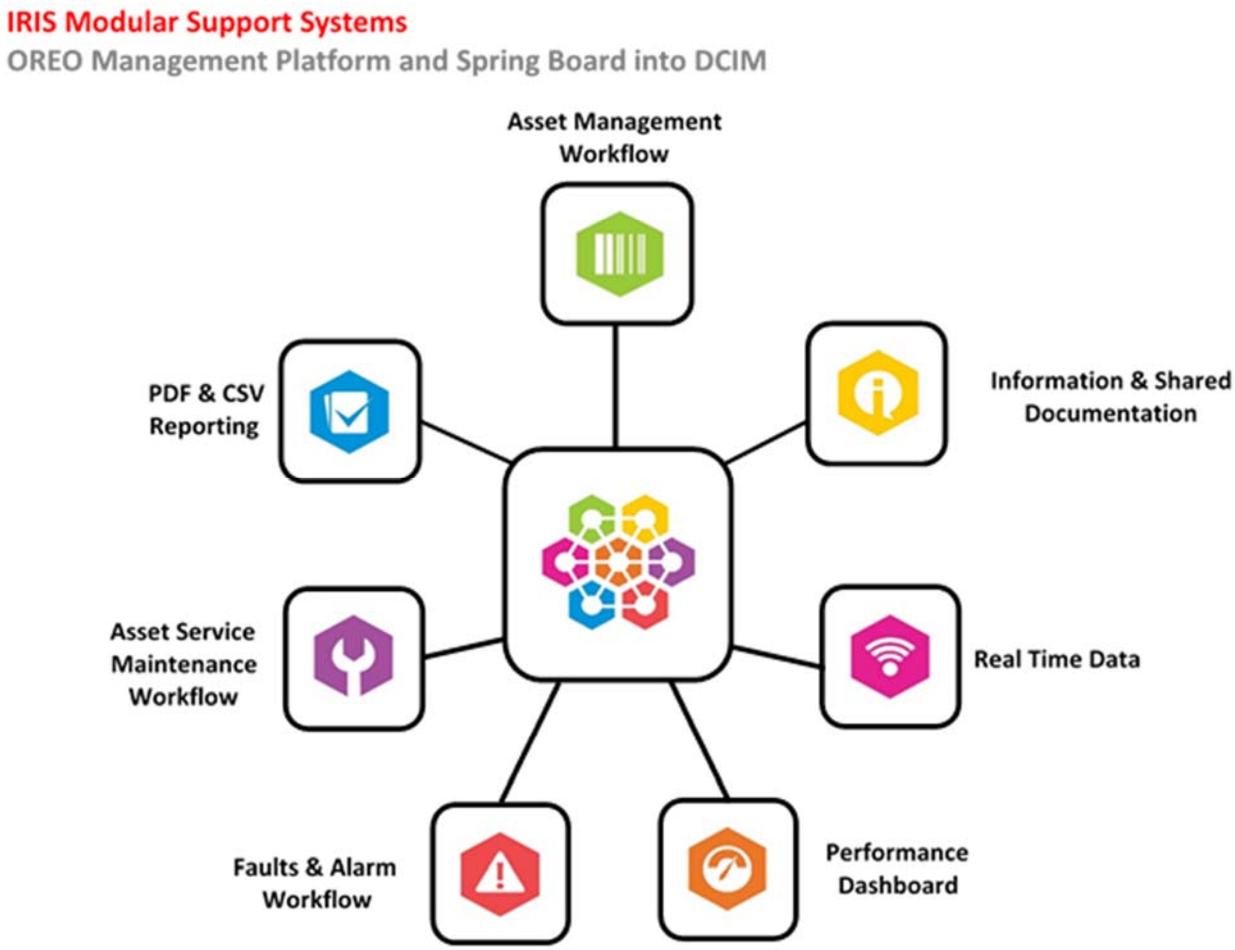

Figure 4 - Example of Integrated Management Software and/or Access Platform

5. Feasibility & Mapping

When designing and specifying solutions we should look to compliment the energy performance potential of the environment with suitable cooling technology.

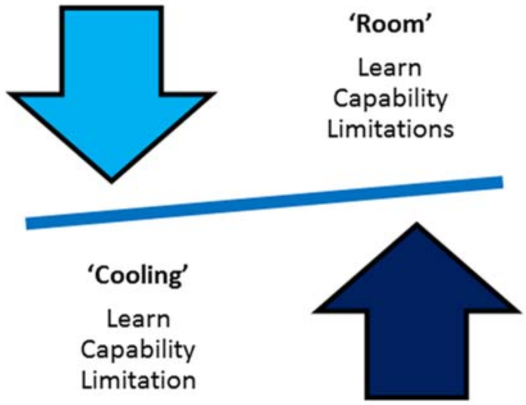

Figure 5 - Room and Cooling Performance Relationship Chart

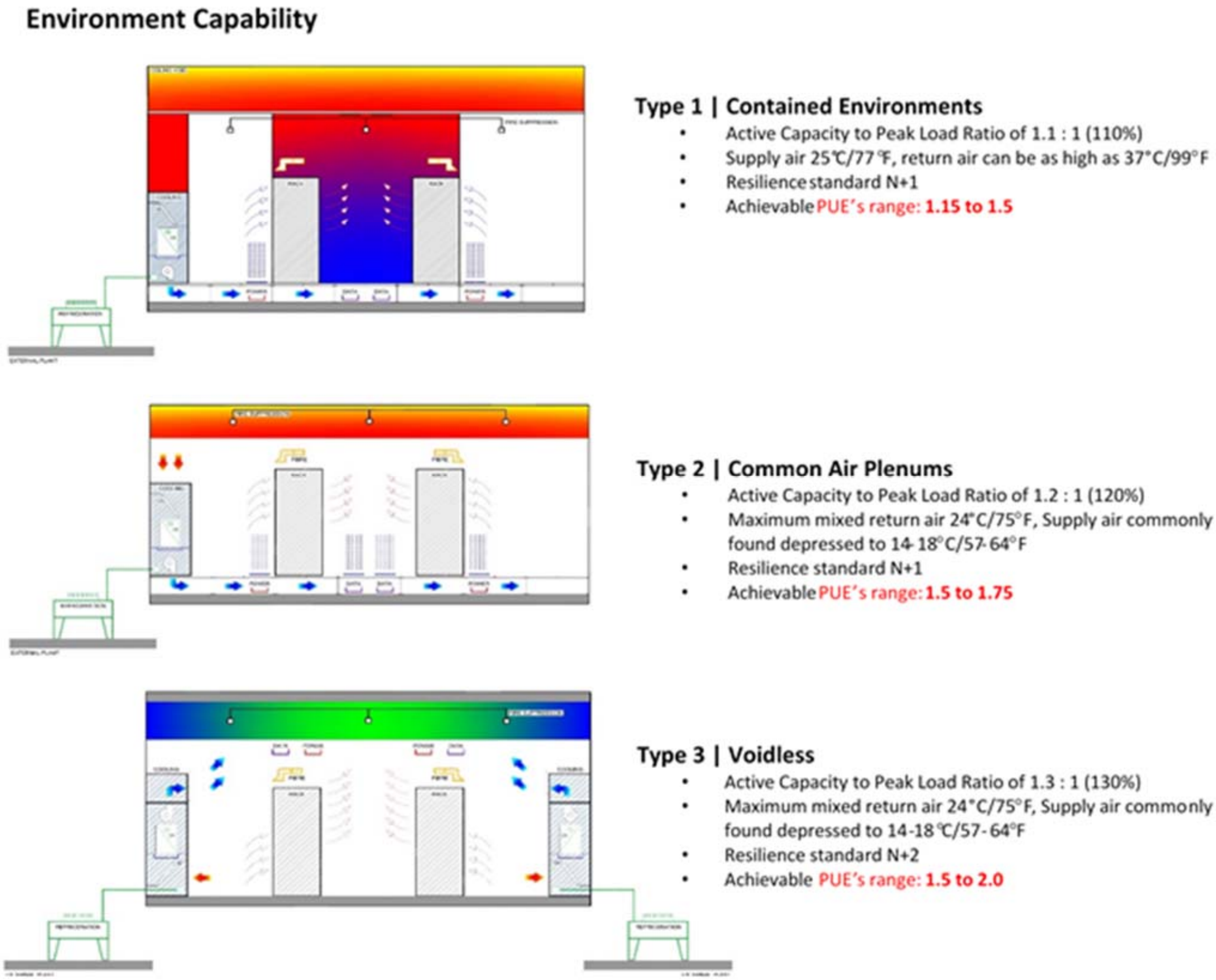

Figure 6 - Summary of Environmental Potential & Minimum Overcooling Ratios

6. Outlined Solution

Our OREO Plan comprised the following Key Stages:

- Agree the following project parameters with the client:
  - Budget
  - Programme
  - ROI
  - Accommodation parameters
- Implementation of real time data gathering capability and acquisition of necessary technical information e.g. asset & capacity register, bill data etc.
- Improvement Design, resulting in delivery of:
  - Room & rack air management optimisation

- Room temperature re-engineering (lifting server inlet temperatures)
- Replacement of cooling systems and/or supplementing with free cooling platforms
- EC motor replacement on any existing services which are to be retained
- Implementation of room capacity control logic

Developing an OREO Plan is about tailoring a solution to meet the Energy Performance, Business Risk Management and Client budgetary requirements. Therefore, your plan may be different but ours looked like this:

Figure 7 - Example Development Strategic & Standardised Plan

7. Methodology & Summary

The following figure outlines the key stages of an OREO Plan and the expected cooling energy savings for these stages.

OREO | Key Stage Plan	
IRIS Information System Implementation of Monitoring & Capacity Control Intelligence for Benchmarking the facility and to provide the PUE monthly reporting data going forward	**Benchmark** Created billing data 'Import' function. Project PUE reporting can be configured at 'Room' or 'Site' level?
Optimisation Room and Rack airflow optimisation, blanking of air losses etc to balance the environment and allow environment temperatures to be increased without creating hot spots	**Savings** Estimated to provide up to: ✓ **10%** Cooling Energy Savings
Fan Power EC fan replacement program and/or the intelligent thermostatic capacity control/isolation of fan power	**Savings** Estimated to provide up to: ✓ **10%** Cooling Energy Savings
Free Cooling The introduction of Direct and/or Indirect fresh air cooling stages	**Savings** Estimated to provide up to: ✓ **50%** Cooling Energy Savings
✓ **Savings are based on 100% of the Site/Facility Cooling load being affected by the works**	

Figure 8 - Methodology Summary

8. Trial Project Data

The following data outlines the performance of our three OREO Trial Projects.

The RAG colour bands represent order in % of energy saved. However, it should be noted that when we factor in the actual portion of the technical facility developed, the improvement initiative results become more linear.

- Site-A, (1 of 1 Data Centre developed representing 100% of the IT load)
- Site-B, (1 of 2 Switch Rooms developed representing 85% of the IT load)
- Site-C, (1 of 2 Switch Rooms developed representing 50% of the IT load)

For the purpose of this, SCTE Submission the energy savings have been monetised in American Dollars are based on a unit rate of $0.12/kWh

Proof of Concept Builds								
Site	Environment Category	Size of Data Centre (m²)	IT Load Annual Average (kW)	Average PUE Before	Average PUE After	Energy Saving kWh 1 Year	% Site Energy Saving1 Year	Money Saved ($/Pa over Benchmark) $0.12/kWh
Site-A	Type 2	818	337	1.74	1.21	1,561,350	30%	$187,362
Site-B	Type 3	481	127	2.08	1.65	483,272	20%	$57,992
Site-C	Type 2	295	124	1.9	1.6	323,704	15%	$38,844
Totals & Averages				1.91	1.49	2,368,326	25%	$284,198

Figure 9 - Trial Project Offical Reference Data

9. Performance Summary

OREO Plans, such as the one described in this document, have the potential to yield the energy savings outlined in Figure 10. Trial data suggests that if the OREO Plan addresses 100% of the network load, energy savings of up to 28% are achievable.

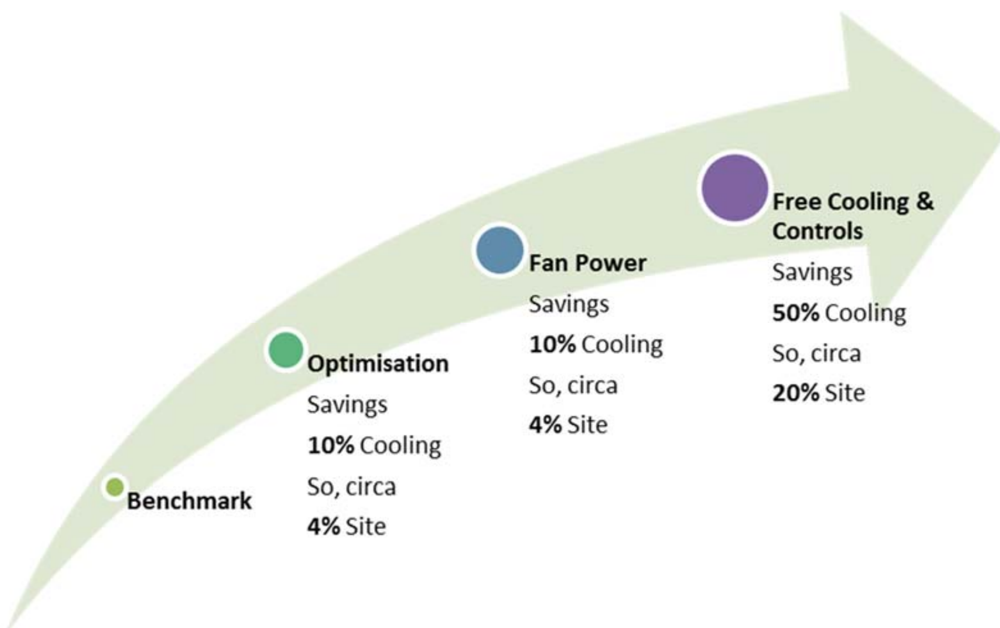

Figure 10 - OREO Project Performance Trajectory

Conclusion

Energy Improvement Strategies for existing and legacy environments may differ considerably to strategic solutions that have been designed against standards for new build facilities. This is largely due to the fact that we often have to accommodate existing obstacles and limitations, both of which may compromise performance potential and ideology.

A standard OREO Plan (or something similar) will provide a structured outline for the operator and/or service provider to move forward and address energy improvement confidently. The process, like most engineering feasibility is heavily reliant on good, current information and data being available. The availability of this current information/data should be a number one priority if the OREO Plan is to be a success.

The OREO Plan and results detailed in this document indicate that in typical legacy telecommunication facilities between there is potential to save 10-28% of total site energy.

Abbreviations

BRAG	Black, Red, Amber, Green
COBRA	Continuity of Business Risk Assessment
CSP	Current Service Provider
DX	Direct Expansion (Refrigeration)
HX	Heat Exchanger
ISBE	International Society of Broadband Experts
kWc	Kilowatt of Cooling
kWe	Kilowatt of Electricity
NHS	National Health Service
OREO	Overall Room Energy Optimization
PUE	Power Usage Effectiveness
RAG	Red, Amber, Green
SCTE	Society of Cable Telecommunications Engineers

