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Chilled-water systems – yesterday and tomorrow

Peter Phillips, F.AIRAH, M.ASHRAE Principal, PCES Consulting

ABSTRACT

When invited to investigate opportunities for rejuvenation of chilled-water systems, how far do we look into yesterday? And, how many opportunities are there for tomorrow?

The paper presents an overview of technical capacity engagement, encountered defects, intuative assessment, engineering validation tools and simple expressions of life-cycle modelling to prepare customers for their commitment to the future of their building's chilled-water system.

There are several options for the engagement of engineering resources. Identifying which delivery methodology best suits a property owner will set the potential for successful engagement.

Employing skill sets able to identify issues potentially affecting perceptions of past system performance, and capable of identifying future responsibilities and opportunities of viable options, should provide a confident basis for adoption of a fulfilling chilled-water system rejuvenation strategy.

INTRODUCTION

When invited to investigate opportunities for the refurbishment of chilled-water systems, how far do we look into yesterday and how many opportunities do we present for tomorrow? As a building owner there are several options for engagement of engineering services to identify potential solutions. Some delivery methodologies pass the immediate test but many fail to realise their full potential to deliver tomorrow's needs.

This paper will present an overview of engagement practices and potential consequences. Issues to be discussed will include identification of yesterday's mistakes, intuative engineering assessment and tomorrow's balance of capital expenditure recurrent costs. An overview of engineering validation tools and simple expressions of life-cycle modelling will be included. Reporting options based on a balance of information should prepare the client for their commitment to the future of their building's chilled-water system.

IS NOW THE RIGHT TIME?

There have been and will continue to be several potential methods of customer engagement with industry to provide a solution for rejuvenation of chilled-water systems. We could simply consider that any of the following could drive a chiller replacement strategy: the chiller is old, inefficient, outdated, becoming unreliable, too costly to repair, has an outdated refrigerant.

Each issue can have relevance, but what should be in our customer's mind is that today's contemplation will have to deliver performance for potentially another 15 to 25 years.

Should it be just as simple as to ring up your local chiller agent and ask them to come out and provide an old-for-new replacement?

If we cast our minds back 25 years, many considerations then were different to modern opportunities. New compressors, refrigerants, methods of heat rejection, energy recovery, capacity control, part-load opportunities, responsibilities to tenants for energy efficiency ratings; these all need to enter into our review process.

As an engineer, in my mind the most important issue is the long-term viability of the advice about to be offered.

TASKING THE BRIEF

The customer can engage expertise in any of the following fashions: ask the current service contractor to provide a quote to replace the chiller; ask the existing chiller manufacturer to provide a quote; contact an installation contractor experienced in this type of work; invite the original designer back; enlist the facility manager; communicate with a professional engineering consultant.

Any of the following could typify a concern for a customer's engagement of expertise:

- Does the current service contractor have sufficient expertise and experience to step into a role to identify solutions needed to remedy a perception of issues hampering the system?
- Does the chiller manufacturer have a cost-effective industry-leading product?

- Would the contractor look far enough into what may be presented?
- Would the original designer admit that there are compromises within the design?
- Does the facility manager have a depth of knowledge for chiller plant design to propose the most advantageous solution?
- Will the professional engineering consultant place somebody with the level of expertise required to sift through aspects of operation to determine all issues needing to be rectified?

We can consider, "How well has the chilled-water system operated to provide conditioning expected for building's purpose?" We should also consider, "Will the expectation of the system or purpose for the building change through the anticipated life of the chilled-water system?" Answers to these questions should lead the customer or the customer's agent toward the level of expertise required and potentially where the expertise may be found.

EXPECTATION OF EXPERTISE

It should not really matter which path the customer takes if we ignore potential consequences of sole sourcing. What is important is the engagement professionalism of the engineer involved. If we consider Engineers Australia's code of ethics (www.engineersaustralia.org.au/resource-centre/resource/code-ethics-199472-a5-brochure-4-pg) there are four core attitudes to exhibit professional conduct: demonstrate integrity, practise competently, exercise leadership, promote sustainability.

AIRAH's code of ethics extends these qualities and includes the obligation to act as faithful agents or trustees. Whether or not you are member of an association governed by a code, when assessing a strategy for a chiller replacement, questions need to be asked about many more issues other than the initial engagement discussion with the customer.

EXPERTISE ENGAGEMENT

There are several options for engagement of engineering intellectual responsibility for the future of chilled-water systems. Identifying which delivery methodology best suits the property owner's needs will set the tone for success potential. Should we rely upon direct engagement practices, or do disconnected delivery methodologies with abstract engineering objectives provide the right solution?

A common theme for causes of defects identified within existing chilled-water systems is a perceived urgency to reduce cost. Whether it to be to win a fee or tender, to maximise contractor of consultant profit, or a lack of expertise of a past customer off-loading responsibility, it behoves our professionalism to investigate, consider, express and counsel our customers to make the correct informed decision.

Life-cycle expectations of our rejeventation strategy may not be realised if latent defects within an existing design continue to affect operation of the chilled-water system and associated air-handling systems.

There have been changes to the methods for engaging expertise. In the past, industry has generally adopted a direct engagement approach. More recently there has been an abbreviated and somewhat disconnected approach to development of outcome.

In the past, customers retained in-house intellectual resources attuned to the whole-of-life needs of assets held. More recently customers have divested their asset responsibility to out-of-reach resources. Too often we are abstract in our responsibility tasking.

How much value do we bring to a system predicament with a design-and-construct engagement model? Can a lowest-cost fee proposal or contractor tender be most advantageous in the pursuit of a satisfying conclusion – with any certainty? Can a contractor with profitability in mind,search far enough to remedy all potential defects and opportunities that may arise?

To achieve any potential for task fulfilment, a customer should provide an informative brief, targeted, to engage with appropriate technical skill sets. Engagement may be staged, but for a satisfying conclusion, engagement should never be abbreviated.

REVIEW OF EXISTING SYSTEMS

A sense of keen observation is required when assessing operational characteristics of an existing chiller system toward developing a rejuvenation strategy.

I have observed many defective concepts and consequences of plant design, construction, commissioning, operation and maintenance that affect how the chilled-water system is operating.

The following and potentially many other considerations, should be part of the initial customer contact:

- Does the chiller have sufficient capacity to offset load?
- Does the chiller selection cope with part-load performance?
- Are there any repeated chiller or supplementary plant failures?
- Is there sufficient heat-rejection potential?
- Are there part-load energy-efficiency strategies associated with the chilled-water system?

Common issues encountered include:

- Small-volume recirculating loops causing unstable capacity delivery
- Capacity gaps within chiller selections
- Unstable field-capacity delivery strategies, causing fluctuating return chilled-water temperature conditions
- Poorly constructed bypass valve control strategies
- Poorly constructed chiller-staging energise and de-energise sequences
- Poor primary and secondary header construction, causing preferential feeding
- Poorly designed COP splitting configurations
- Unstable part-load energy-efficiency strategies
- Disconnected external control, interlock signals and safeties
- Manual-mode automatic control sequences
- Undersized pumps
- Fouled heat exchangers
- Cooling tower airflow recirculation
- Cooling tower fill degradation, and the list goes on.

If issues of a potential defective nature are not exposed during investigation, we are collectively at risk of only committing to a partial rejuvenation of the system.

A discussion with our incumbent stakeholders should be an early tool used by an investigating engineer. Our plant operators, equipment service technicians, BMS service technicians, plant managers and others should be sought out to assist with our investigation. Site documents in the form of operating and maintenance instructions, maintenance log books, breakdown and call out vouchers, BMS event and trend logs and other means of potential issue identification should be reviewed.

We should also discuss the customer's expectations of the system and any anticipated changes of responsibility the system may need to support in the future.

Establishing existing system condition and responsibility for the future, will provide guidance for establishing options for chilled-water system rejuvenation.

POTENTIAL REMEDIES

The following generalisms, presented in brief, represent potential deficiencies and remedies commonly encountered when assessing chilled-water systems.

Small-volume recirculating loops that cause unstable capacity delivery: Too often within large central air-handling systems with local plantrooms, small volume systems exhibit unstable operating characteristics. This is especially true where leaving air temperature control underscores VAV thermal delivery. There has been a tendency to abandon the use of three way AHU chilled-water control valves , this increases reliance on field bypass valves. Short circulation volumes and 'fast' acting control loops and control valves can place the chilled-water circulation system into abbreviated loop mass flow hysteresis. Swinging load returning to the chiller can cycle compressor capacity response placing chilled-water flow temperature into erratic load tracking creating chaos. Compressors can cycle off and the situation results in unreliable performance. Generally the solution is to slow the system down to let it find a response time frame. Replacing existing two way valves with three way valves will expand the effective system volume to increase response volume.

Capacity gaps within chiller selections: Perhaps the system has already had a chiller replaced. A new high load chiller with increased capacity without an improved low load capability, may result in a staging capacity gap. Inadequate overlap of chiller capacity delivery capability will invoke chiller staging cycling, this leads to system instability. This in turn aggravates space thermal control strategies which results in chaotic behaviour within the chilled water system. A solution could be to introduce active thermal inertia. Energy can be stored within an expanded system volume to shift load and capacity. Appropriately sized, active thermal inertia can supplement low load chiller capacity prior to staging up and extend high load chiller capacity utilization prior to staging down.

Chiller water system staging scenarios: Often systems only utilize a single initiator to stage up or down the plant. Many issues can occur within systems that should trigger a requirement for additional capacity. A compressor may be off line through fault or maintenance lock out, this will not invoke an electrical or thermal load, next stage signal. Nor will a chiller operating with head pressure stress, its full load current may not be achieved preventing the next staging signal. Other forms of staging initiation that should be considered include; chilled water flow temperature set point not achieved, reverse flow within a primary/secondary system de-coupler. Each next stage condition initiator will require a complimentary step back initiator. Stability of staging sequence is essential. Staging sequences should incorporate timers to permit establishment of hydraulic and chiller loading stability.

Hydraulic design or installation, irregular flow characteristics, inadequate thermal mixing: These issues can have dire consequences on flow paths. Preferential feeding can deprive field connections of temperature-related capacity capability and prevent chillers from realising load balance. Characteristic of errors within the hydraulic construct may be intermittent and not obvious. However, the results of these errors can explain other system defects. Our solutions should include: keep flow within headers in a single direction, keep sufficient length within mixing sections, and add turbulators. We should remember that a header has purpose and is not just a bigger pipe to connect other pipes.

Chiller capacity temperature splitting, COP splitting: This is a beneficial concept; however, care should be taken with series and parallel path designs, particularly with unequal capacity chillers.

Part-load energy-efficiency strategies: There are many part-load efficiency strategies supported by modern chiller manufacturers and advocated by designers. However, cascading safeties, control ranges and control stability need to be atuned to chiller internal strategies.

Too often, focus of instability of operation is directed toward the chiller manufacturer. However, the actual cause of chiller instability, can often be energy-efficiency strategies. I have seen many instances where strategies attempting to exact the last small opportunity for efficiency fall short of achieving stable operation of the system. The chiller is the "big dog" of the system; treat it with respect – slow down those efficiency strategies that should be subservient to chiller internal strategies. This should ensure the chiller tracks actual load and not fluctuating loads that control hysteresis can impose.

Operator or service technician intervention: When a system is failing the operator or service technician, there is a temptation to drive an element of the plant manually. In the worst extreme of this, safeties are removed from their intervention effectiveness. Also, a seemingly innocent manual operation of a plant item can remove the system's most important energy-efficiency strategy. "Tagging off" any potentially defective element of operation without care, identification and approval from the customer can have dire consequences.

Hydraulic capacity: Often a lack of hydraulic capacity finds its way into systems. We have a chilled-water plant that is relatively easy to tap into. We also have set-points that are not always adequately understood. Blaming a lack of chiller capacity should be tempered with a review of potential rogue situations that are driving the inference.

Condensed volume heat exchangers: We have embraced cost-effectiveness of condensed volume/high-surface-area heat exchangers. These space-beneficial items of plant incorporate multiple small-aperture traps for unwanted debris, they can easily become fouled. Heat rejection or refrigeration-effect heat transfer can be impaired, sometimes suddenly, without apparent cause.

Check strainers and water treatment practices to ensure appropriate particulate screening and water quality is being maintained.

Cooling tower effectiveness: Cooling towers are often the least item of importance considered within a chilled-water system evaluation, where in reality, they are potentially the most important. Inadequate sizing, poor water distribution, a lack of airflow, recirculating airflow and deteriorating fill will starve the chiller of its opportunity to perform. Modern chillers combat high head pressure with capacity trimming. The chiller may be in a self-protection mode, still operating, but not fulfilling its strategised responsibility. Halting chiller operation with HP safety intervention generally now requires a more substantial set of circumstances. The solution: keep cooling towers operating effectively; monitor flows and temperature differentials.

CAPITAL OR RECURRENT EXPENDITURE

Understanding a customer's attitudes toward capital and recurrent expenditure is an important part of our engineering responsibility. Often our customer's present tenants are paying the building's recurrent expenses. But what is our responsibility to future tenants? We have energy efficiency rating systems in place to alert tenants to their potential utility costs. However, when our customer places little regard for recurrent expenditure and focuses only on immediate remedial action costs, where do we find ourselves as engineers? How much guidance from AS4183, Value Management, can we determine?

We can identify the project's obvious and potential stakeholders – they are organisations and individuals influencing the situation at hand, and, our potential predicaments for the future life of a chilled-water system.

As engineers we are tasked to provide solutions. We generally evaluate the immediate with relative ease. But what about future needs, reliability, serviceability, manufacturer support, market acceptance and recurrent costs?

How much effort do we place in our abilities to not present the easy solution?

How far will you go to repeatedly and reiteratively recommend or endorse the lowest capital spend?

But what tools can we employ to justify our recommendations?

Energy modelling of chilled-water systems needs to be informative for the designer by way of yesterday's operational characteristics, today's engineering solutions and tomorrow's rewards on financial investment.

Within an engineering depiction of opportunities, presentation of information to clients who often have only a capital-cost view of opportunities is a challenge. The better the tool, the better the presentation, the better the potential to achieve the desired outcome.

The following examples of tools, and many others, can share the justification journey to assist with our self-assessed options and customer-assessed options.

Figure 1 indicates modelling feed-in information from a chiller manufacturer. There are recognised information presentation standards that assist in evaluating how chillers could be expected to perform. Understanding how a chiller will perform at full load and at part load will suggest its potential for incorporation into option development.

Figure 2 indicates an expression of manufacturer information as it could be applied to anticipated operating scenarios for the installed chiller. Developing manufacturer information into probable load profiles and operational profiles will add relevance to the potential for incorporation into option consideration.

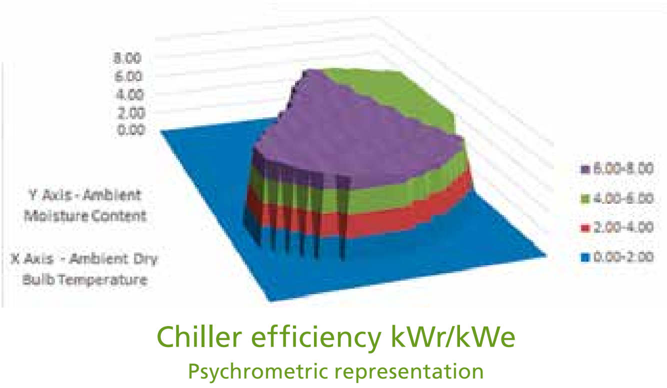

Figure 2: Applied chiller energy efficiency profiles.

Figure 3 indicates how energy-efficiency strategies affect system performance potential. Combining supplementary plant and potential operational characteristics will assist with the determination of whether the option has a balanced approach to energy efficiency through the anticipated ambient profile.

Figure 4 indicates an annualised anticipated plant energy consmption profile. Combining plant efficiency profiles with ambient frequency profiles will indicate whether additional focus could be required to address particular ambient-based efficiency strategies to further effect minimisation of annual energy consumption.

Load %	Gross capacity kW	LWT Evap. °C	EWT Evap. °C	Flow Evap. L/s	WPDA Evap. kPa	Ambient °C	Gross Power kW	Gross Eff. EER (kW/kW)	Net capacity kW	Net power kW	Net Eff. EER (kW/kW)
100	1199.2	7.0	12.1	57.1	45.2	35.0	422.2	2.84	1195.4	426.0	2.81
75	899.4	7.0	10.8	57.1	45.2	30.0	246.4	3.65	895.6	242.6	3.58
50	599.6	7.0	9.5	57.1	45.2	25.0	127.3	4.71	595.8	123.5	4.55
25	299.8	7.0	8.3	57.1	45.2	20.0	46.1	6.51	296.0	42.3	5.94

Figure 1: Chiller manufacturer energy-efficiency profiles.

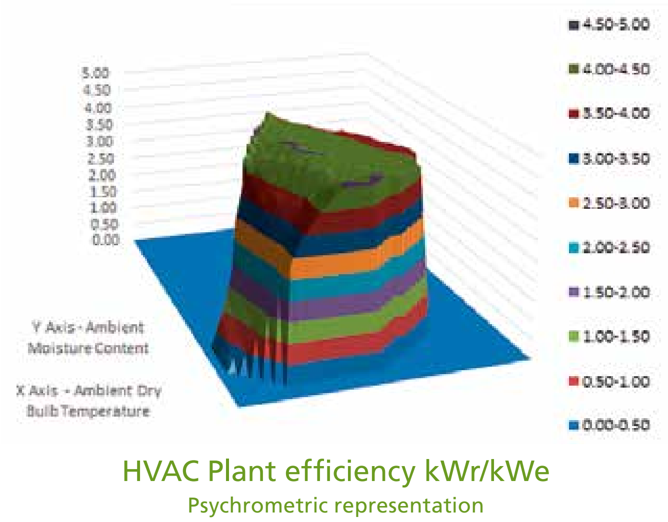

Figure 3: Applied system energy efficiency profiles.

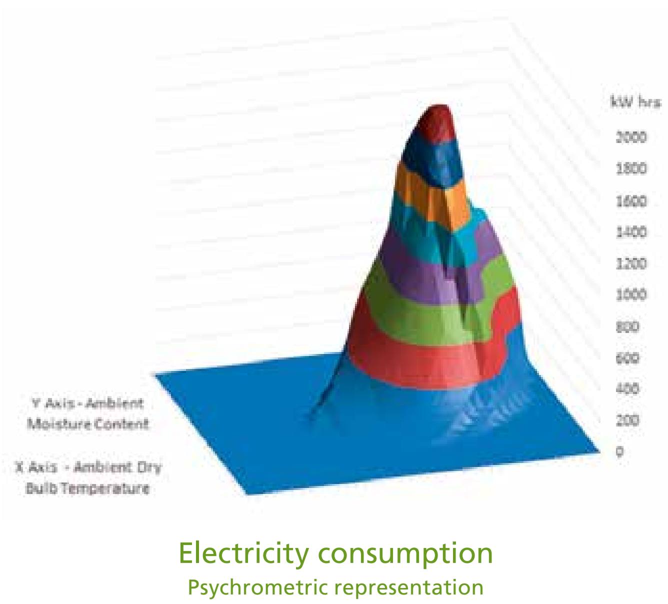

Figure 4: Plant Energy Consumption Profiles.

Figure 5 indicates anticipated recurrent costs over the course of an anticipated plant life. Establising relevance of projected utility costs and routine and overhaul costs, will assist in option evaluation.

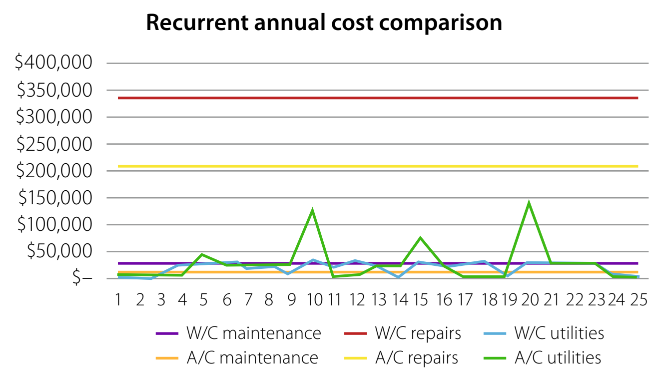

Figure 5: Recurrent Cost Comparisons.

Figure 6 indicates a cumulative cost comparison of two options explored. In this example, additional capital cost expenditure of the reduced recurrent cost option, is anticipated to be returned within the third to fourth year of operation. This provides the customer with an indication how whole-of-life expenditure may effect an alterate approach to capital expenditure.

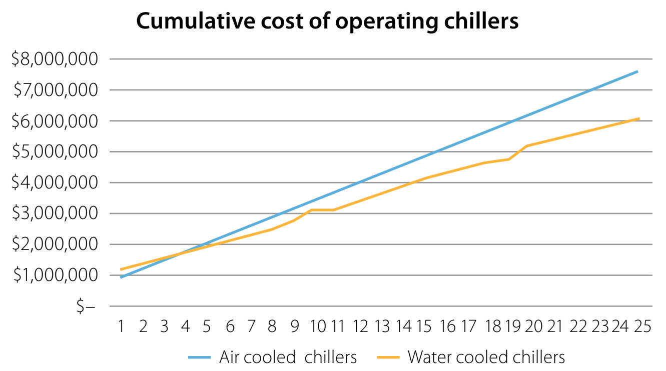

Figure 6: Cumulative Cost Comparisons.

Figure 7 indicates a tabulated representation of potential life costs for options explored. Summarising potential options should provide a susinct review of information to aid in the assessment of options.

System	System COP	Potential Life Cycle Cost
MEPS air-cooled	2.8	$11.3M
Air-cooled chillers	2.5	$12.1M
Water-cooled chillers	3.9	$8.5M
Water-cooled chillers with energy-efficiency strategies	4.1	$6.9M

Figure 7: Tabulated options data.

Potentially, defective self-assessed options should not be incorporated into submissions to our customer. Only opportunities that can be both justified and endorsed by "you, the engineer" with a stamp of confidence and a signature of responsibility should be presented to your customer.

ENGINEERING RECOMMENDATION

How broad should the options for presentation be? How narrow do we confine our options to satisfy our individual preference? How far should our report position the customer to make the right choice?

These are all questions for your relationship with the customer.

Each option should have purpose, presenting the best option toward the purpose identified will provide confidence toward an informed customer decision.

What is certain, if engagement is ineffective with the situation opportunity, potentially a naïve unilateral presentation of assumed facts may result in somebody else fixing up an abbreviated assessment.

CHARACTERISTICS OF CHILLER AND SYSTEM OPERATION

If we now ask ourselves, "What is the existing chiller performance scenario?' Simplistically we consider it as a coolth generation machine with a thermal capacity rating. But what other factors have been contemplated through the life of the machine?

Many hands have had an influence over the design and installation. The designer may have considered its cycle-off capability and the design peak heat load. The sales team may have considered its name-plate selection. The commissioning technicians, BMS programmers and service technicians may have limited the chilled-water system's performance potential. And then we have a chiller's present operating capability. We can then generally ask the facility manager, "Does the chiller do what you need it to do?"

Figure 8 indicates potential chiller selection and operating characteristics. Where a chiller sits with its performance characteristics is a consideration for its potential replacement.

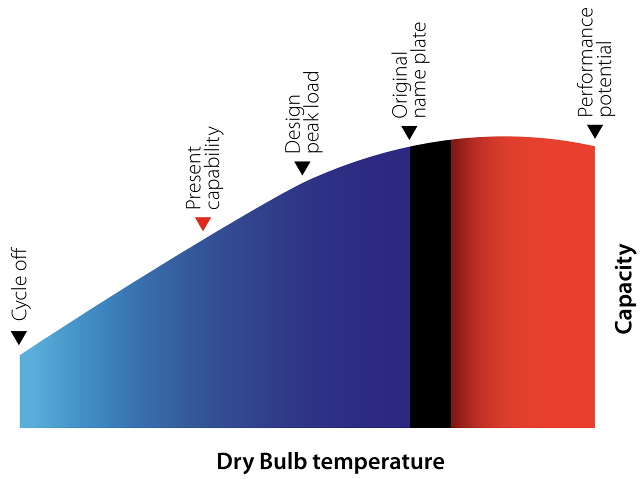

Figure 8: Chiller selection and operating considerations.

This simplistic representation of capacity delivery potential indicates a stable operation cycle-off capacity at one extreme, and a limited performance potential at the other extreme, relative to ambient dry-bulb temperature. The colour bar suggests ease of operation in the blue zone graduating to a machine at stress in the red zone.

Dry-bulb temperature is not the only operating criteria, particularly for water-cooled machines. Ambient wet bulb affects cooling tower heat-rejection potential, and moisture content affects AHU thermal load presented to the chiller.

Figure 9 indicates how ambient and conditioned space moisture content may affect a chiller plant's potential performance. The green to red scale indicates a progression of potential additional latent cooling demand from air-handling units on chiller capacity, and wet-bulb stress on the heat rejection capability of cooling towers.

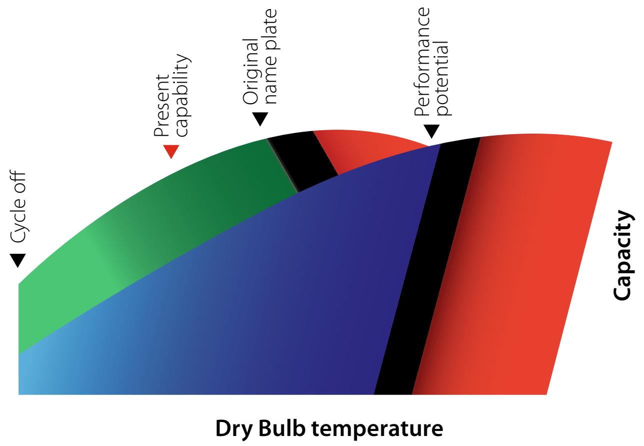

Figure 9: Potential moisture content effect on chiller preformance.

Ambient loads and space loads on air handling units, chillers and cooling towers are dynamic. Control systems put into practice what is difficult to depict graphically. System performance does have limitations.

We do expect the chiller and its supportive plant to establish an equilibrium relationship of load to capacity. This is often a challenge for the commissioning and service technicians, potentially in association with guidance from an experienced plant engineer. However, it is not uncommon to witness instability within chilled-water mass-flow control valves and chilled-water reset strategies that results in load/capacity hysteresis. The extreme manifestation of this is chillers cycling on internal compressor shut-down and restart routines, which in turn exaggerates control hysteresis.

If we consider load presentation, air-handling unit heat exchangers utilise chilled-water mass flow, and approach differential to absorb heat load. Cold cooling is common practice; we deliver a chilled-water temperature below the desired condition space dew-point and latent cooling is afforded to the space, generally through a space dry-bulb temperature control strategy.

Figure 10 attempts to depict AHU heat exchanger performance. The purple graduation indicates an increasing sensible capacity performance of the heat exchanger relative to increasing dry bulb temperature stress. The orange graduation depicts a potential latent cooling responsibility the space may require as a result of ambient related moisture content stress. The red curve indicates the potential heat exchanger operational characteristic to achieve both sensible and latent cooling. Ambient-related moisture content stress above the red curve suggests that occupants may experience discomfort.

Generally discomfort associated with a lack of performance from our air-handling unit heat exchangers results in a service technician's most common remedy, to "lower the set-point".

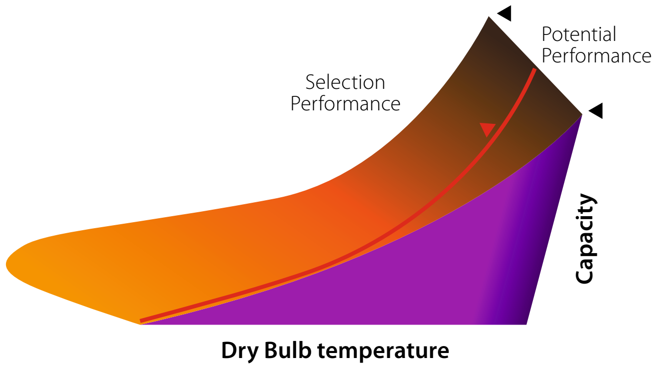

Figure 10: AHU heat exchanger performance.

This consequentially employs additional energy to simulate an alternate comfort scenario. This will generally continue until the next discomfort complaint or system review.

Chilled-water reset is an energy-efficiency strategy commonly used to create chiller energy efficiency. However, the consequence of this, particularly if there is no relevance in the strategy to potential ambient latent load, is a diminishment of heat exchanger latent cooling performance, particularly during instances of low sensible load. Chilled-water reset typically pulls the red heat exchanger performance curve in Figure 10 closer to the purple sensible cooling capacity profile.

What becomes evident within this mode of performance representation, is the depiction of latent cooling demand continuing to exist while the dry-bulb-temperature-driven cooling strategy is satisfying only deviation of dry bulb. This under-satisfied cooling demand is one cause for discomfort within our conventional dry-bulb-only simulation of presumed occupant comfort.

We now turn our thoughts to how this overlays onto our more traditional representation: our psychrometric plot. Figure 11 attempts to indicate AHU chilled-water-coil performance relative to its potential approach to saturation.

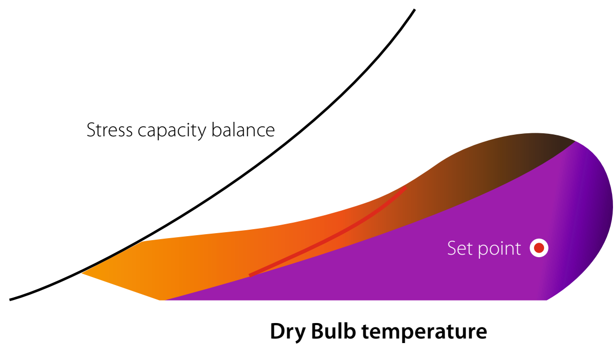

Figure 11: AHU chilled-water coil performance – Air on, stress capacity balance.

Higher air-on coil conditions to the right and above set-point depict an increase in ambient-related sensible and latent loads. As ambient dry-bulb temperature load reduces, our chilled-water coil's ability to satisfy latent loads reduces, resulting in moisture content stress for occupants.

Our AHU chilled-water coils generally experience impairment through their operational life. Over time, if there is ineffective maintenance, heat exchangers become fouled. Too often, a lack of particulate filtration efficiency and cleaning and replacement rigour fouls the coil, thereby progressively diminishing heat-transfer potential. Our under-maintained cooling coils will fall short of their peak-load performance expectation.

Often, as designers we have not fully appreciated the design life of our plant selection. As an industry we select plant to a "limitation of performance". There are many systems that are experiencing not only lack of maintenance performance degradation, but also a lack of vision of the designer.

Through economic imperative and engineering expertise, we also "abbreviate our opportunity" for one of the most critical aspects of design: the heat exchanger potential of our chilled-water coils. We have a practice of under-sizing and incorrectly evaluating performance expectations of our heat exchangers, particularly our cold-cooling chilled-water coils.

We pay for copper and aluminium within heat exchangers only once in their substantial life role within the system; however, poorly selected heat exchangers drive our through-life coolth generation energy efficiency.

Figure 12 indicates a looming expectation that our heat exchangers should preform beyond their anticipated responsibility.

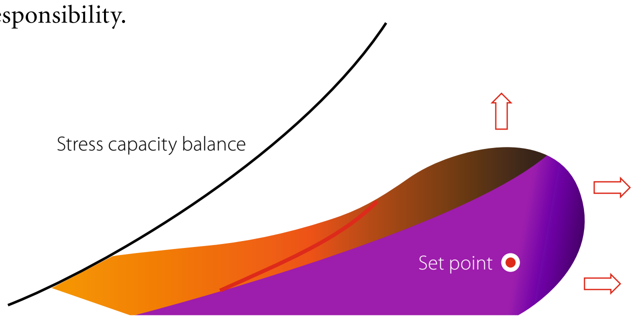

Figure 12: Increasing expectation on chilled-water coil performance.

Increasing ambient dry-bulb and moisture-content loads are becoming more relevant within our assessment of load stress upon chilled-water systems.

The potential for climate change to exaggerate the frequency and duration of load stress on our systems is a topical issue. Increasing heat loads and reducing heat rejection potential exacerbate anxiety of our occupants, maintenance crews, facility managers and corporate executives to varying degrees.

While reviewing an opportunity to renew a plant, we must ask ourselves, "What pressure does the system endure", and, "Do I have the responsibility to simply replace like for like or to drive a future-based solution?'

Figure 13 indicates the potential future performance expectations on chilled-water coils. An expansion of operating durations with higher energy content (enthalpy) air-on-coil conditions will exacerbate load stress.When assessing a replacement strategy, there is potentially marginal value in just "throwing additional chiller capacity at it'. Although potentially easing stresses on the new chiller, additional capacity, unable to be effectively delivered through air handling units, may not achieve the advocated need for additional capital investment.

Figure 13: Potential future performance expectations on chilled-water coils.

Replacing all the AHU chilled-water coils to deliver additional capacity may not be cost effective and may not effect a substantial improvement. Our design supply airflows may become our limiting factor. Often our supply air flows are based on a psychrometric solution limitation and not an air change effectiveness scenario. There is a potential solution to offset additional fabric load through lowering chilled water temperature and "pulling" the supply air temperature down with it to satisfy space condition set points. This however reduces energy efficiency potential of the chiller plant.

An alternate solution could be to install additional heat exchangers to precondition the now 'hotter than expected" outdoor-air stream. Dedicated outdoor-air systems are becoming commonplace in recent new construction projects. The benefits of dew-point control is discussed within industry journals and design guides with increasing urgency.

Rejuvenating chilled-water systems with supportive outdoor-air preconditioning heat exchangers will deliver needed capacity, satisfy cooling loads and potentially relieve load stress for occupants.

Figure 14 indicates the potential benefit of installation of an outdoor-air preconditioner selected and operated to satisfy latent load stress. The orange graduated zone indicates potential control of moisture content through installation of an outdoor-air pre-conditioner responding to a dew-point-motivated capacity-control strategy.

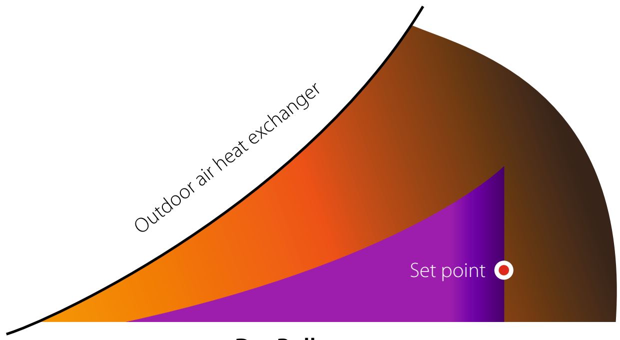

Figure 14: Potential outdoor-air preconditioning.

This method of capacity support will not only provide additional cooling capacity in response to exaggerated and prolonged high ambient exposure, but will also improve part load energy efficiency strategies, and improve occupant comfort through the range of AHU heat chilled-water coil.

SUMMARY

When invited to investigate opportunities for rejuvenation of chilled-water systems, we should adopt a responsibility commensurate with potential difficulties existing within the system encountered. We should also engage with a stated and implied responsibility to the system's future role.

Our customers can engage with industry expertise through a variety of means, from chiller manufacturers, to installing contractors, to consulting engineers. But what is important for our customer is to engage with a competent person who is committed to execute obligations acting as faithful agents for customer and as intellectual trustees of the plant.

Existing chilled-water systems and chillers may be operating in a defective manner. A common theme for defective work is a perceived urgency to reduce cost. Cost reductions have short-and long-term effects on system performance.

It behoves our professional imperatives to investigate, consider, express and counsel our customers to make the correct, informed decision. Our customers share in this responsibility, and should provide an informative brief, targeted to engage engineering skill sets appropriate to task complexity.

Our engaged engineers should have observational and communication skills commensurate with the perceived complexity of issues potentially affecting system operation. Active communication with stakeholders including technicians, facility managers and decision makers should lead our engineers to issues for consideration and solution recommendation.

There are common issues to be encountered with recent system design. Many issues stem from our previous collective "cost-effective" attitude to decision making and engagement with appropriate expertise.

If issues of potential defect are not exposed, our system investigation may result in a continuance of operating difficulties, thereby rendering an opportunity for a fulfilling system rejuvenation potentially impotent.

We should express options that identify purpose to permit confident endorsement. We can offer options for effectiveness with capital, or recurrent bias, or a mix thereof. Identifying capital-expenditure-efficient options may satisfy immediate customer needs; identifying recurrent expenditure options may satisfy tenant needs. What is important is identifying options that can be justified, incorporating needs of reliability, serviceability, manufacturer support and downstream acceptance. Identifying criteria for a "value" assessment of design opportunities should lead us to construct viable options. Use of evaluation tools – including engineering and economic modelling and charting – aid option development, evaluation and determination.

System and chiller evaluation needs an appreciation of other factors, potentially more intuitive than obvious. How chilled-water systems deliver capacity to variable-load scenarios may lead us to resolving understated system perceptions. The effects of prolonged ambient extremes on air-handling systems and chiller capacity, and potential part-load comfort shortcomings, may lead us to recommend supplementing air-handling systems to achieve desirable system enhancements.

CONCLUSION

When embarking upon a path toward a chilled-water system rejuvenation, there are several options for the engagement of engineering resources. Identifying which delivery methodology best suits a property owner will set the potential for successful engagement.

Employing skill-sets able to identify issues potentially affecting perceptions of past system performance, and capable of identifying future responsibilities and opportunities of viable options, should provide a confident basis for adoption of a fulfilling chilled-water system rejuvenation strategy. ▮

ABOUT THE AUTHOR

Peter Phillips has over 40 years' experience consulting and contracting in the HVAC industry. He works as an engineering consultant, providing investigative master-planning documents for an array of clients and situations. Email: peter.pces@gmail.com