Avoiding the IPLV Trap; Using SPLV to Better Predict Performance

This application bulletin provides a procedure to increase the accuracy of comparing part load chiller efficiency between options while maintaining the objectivity and simplicity of the IPLV method.

Building codes in Europe, Australia and potential future building codes in the USA are increasingly focused toward actual building energy consumption as underlined_verified by measurement. When measured performance falls short of predicted values it often leaves consultants searching for explanations. Many contributing causes could have been avoided by leveraging the **data that was available during the design phase**!

With the advent of variable frequency drives, the industry migrated toward the IPLV part load metric recognizing the vast majority of chiller run hours occur at part load or off design conditions. Because the IPLV is well defined by AHRI it ensures consistency among vendors. Additionally, because it is a single value metric it is extremely easy to use to compare energy consumption between manufacturers. But for all its convenience, the use of IPLV can be a common and significant root cause for error in predicted energy performance. **Often chillers with lower kW/Ton IPLV values consume more energy in actual operation, a scenario defined here as the "Low IPLV Trap".**

The IPLV metric was based on a typical single chiller application, based on the weighted average of the most common building types and operations using average weather in 29 U.S. cities, with and without airside economizers, none of which are your buildings. Indeed, AHRI specifically points this out in the AHRI 550/590 standard*. Weather differences, building use, and multiple chiller staging profile differences will all greatly impact the actual chiller operating conditions. Exacerbating this is the reality that chillers are not universal in their response to changes in load or pressure ratios. While the technical explanation is beyond the scope of this bulletin, it is easy to understand that the sweet spots of chillers vary by type and manufacturer. So if a particular chiller is well aligned with a typical single chiller building, can we assume it is also the most efficient solution for your specific multiple chiller plant? Clearly the answer cannot be yes without further analysis that takes into account the differences between those applications.

This further analysis however has proven difficult. No single standard is readily available, and the risk of "paralysis by analysis" becomes very real. This application bulletin will provide a solution that addresses three key differences between actual operating conditions and the IPLV metric, while providing a format that is *as easy to use as the IPLV metric*. This metric is named "SPLV" (System Part Load Value) to reflect that it has taken the IPLV approach and tailored it in three ways to the specific system being evaluated.

* ARI 550/590 Appendix D
1) **Weather -** The owner is interested in the performance of his or her building in its actual location, not typical conditions. Weather can have a significant impact on the performance of water cooled chillers whose compression ratios are highly influenced by the wet bulb temperature. Use of the IPLV metric will not take local weather into account. Ignoring local weather can be a significant source of error in chiller energy evaluations and may result in the purchase of sub-optimal equipment and actual performance well below predicted levels. However, local weather data collected from objective sources (independent of manufacturers) is readily available and can be used to increase the accuracy of the energy evaluation. The SPLV method uses the local weather data rather than typical.

2) **Chiller Staging –** The amount of hours a chiller spends at 100%, 75% 50% and 25% load varies significantly on the number of chillers in the plant room used to meet the building load. As the number of chillers in the system increase, the run hours chillers spend at low load decreases. For example, in a 3 chiller building, the building load would have to be less than 17% before the last chiller on would unload to 50%. IPLV is based on a single chiller plant, and will place 57% of the hours at 50% load or less. Clearly we don't expect a building to operate at 17% load or less 57% of the time! Using IPLV weightings intended for single chiller plants to evaluate chillers applied into multiple chiller plants can be a large source of error in energy evaluations. SPLV address this by assigning weights to the load bins based on chiller staging.

3) **Economizers –** The IPLV formula is not dependent upon whether air or water side economizers are used. However, these devices can significantly reduce the number of low load, cold weather hours water cooled chillers are exposed to. Like chiller staging, this can have a significant impact on the respective weights of each chiller load bin. A chiller may perform very well with 25% load and cold condenser water, but if the system is using a water side economizer, it may never actually run there. If that same chiller was a poor performer at higher loads, an IPLV based evaluation will often result in a purchase of a chiller that draws more energy than other chillers evaluated *even if those other chillers had a less attractive IPLV*!

Like IPLV, SPLV divides operating ton hours into four load bins (100%, 75%, 50% and 25%) at specific entering condenser water temperatures and calculates a single value. But unlike IPLV, SPLV uses a simple program to calculate the weights assigned to each of the four load bins based on the quantity of chillers, load profile, local weather and use of economizers. The SPLV also uses the local weather to assign the average condenser water temperature for each of the four load bins, rather than use the AHRI default condenser temperatures. The result is as if an IPLV were customized to the specific project. Full reports outlining the basis of the weights and condenser temperatures can be provided to the consulting engineer or owner. So how do we create an SPLV?

By utilizing your Hourly Analysis Program (HAP)!

After running a comparison of two (2) different 1,500 ton chiller plants (three (3) 500 ton chillers) you will notice that the Carrier chiller, though lower IPLV, performs better when modeled in a multiple chiller plant compared to the Low IPLV Chiller, even though our IPLV has a higher kW/Ton value.

	IPLV	**SPLV**
Carrier 19XRV	**.361 kW/Ton**	**0.349 kW/Ton**
Low IPLV Chiller	**0.344 kW/Ton**	**0.366 kW/Ton**

While it may be obvious that evaluating chillers at local true operating conditions using objective data makes a great deal of sense, it must also be just as easy to put this evaluation technique into practice. To facilitate this process, we have attached a simplified data collection spreadsheet. This form doubles as a means to collect data from chiller vendors and also as a simplified life cycle evaluation. Because the formulas are clearly visible in the spreadsheet, it is an open, fair and transparent way to evaluate chillers. All vendors can select their best chiller to win the evaluation and this ensures all vendors are aligned and working toward the same goal as the owner/operator … to identify the chillers that perform the best in actual operation at local conditions to lower the real electric bills.

Conclusion

In closing, the goal of this application tip is to provide you guidance on how to avoid getting caught in the "Low IPLV Trap". Instead, you can now provide your customers with actual data based upon their local system requirements.

The consultant can continue to use a simplified data collection form to get chiller data from vendors and continue to enjoy the convenience of the single metric. But there is one big difference … with IPLV, the consulting engineer's recommendation could be stated as … based on a typical single chiller application, based on the weighted average of the most common building types and operations using average weather in 29 U.S. cities, with and without airside economizer, I recommend these chillers for your building. With SPLV, the consulting engineer's recommendation could be stated as … **based on your (3) chiller plant here in town, I recommend these chillers…**

FAQ's

1. IPLV is backed by ASHRAE and SPLV is not, why should I use SPLV?

A: AHRI is actually encouraging the use of evaluations that use local weather, chiller staging and economizers, which is what the SPLV method described here does. According to ARI 550/590…*"The IPLV equations and procedure are intended to provide a consistent method for calculating a single number part-load performance figure of merit for Water-Chilling Packages. The equation was derived to provide a representation of the average part-load efficiency for a* **SINGLE CHILLER ONLY**. **However, it is best to use a comprehensive analysis that reflects the actual weather data, building load characteristics, operational hours, economizer capabilities and energy drawn by auxiliaries such as pumps and cooling towers, when calculating the chiller system and efficiency. This becomes increasingly important with multiple chiller systems because individual chillers operating within multiple chiller systems are more heavily loaded than single chillers within single chiller systems."**