FUTURE RESOURCE ENGINEERING

Creating a Data Center Efficiency Plan

Challenges & Steps to Creating an Effective and Impactful Energy Efficiency Plan

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Executive Summary

One of the most widely discussed issues within the data center industry today is how to run the facility more efficiently without impacting uptime and reliability. There is a plethora of industry news about the growing power consumption of data centers which has sparked significant efforts to save energy through the use of better data center management tools and more efficient equipment. Other factors influencing the wave of efficiency efforts include increased awareness of corporate responsibility, "going green", reducing operating costs, and corporate-wide energy reduction goals. These influences have all pressured data center owners/operators to examine new ways to reduce energy consumption in their facilities.

However, every data center is different, and therefore efficiency opportunities, costs, savings, available incentives, equipment strategies, and payback requirements differ widely from one facility to another. Creating a customized efficiency plan for your specific data center will help maximize savings and provide the best payback, equipment strategies, and monitoring and control methods.

This white paper demonstrates how to create a data center energy efficiency plan by outlining the required steps, overcoming common challenges, looking at what information is important and relevant in determining savings, and what factors to consider when calculating a given project's payback period.

The best way to create an energy efficiency plan is to understand and research what opportunities and risks exist, determine which efficiency strategies most closely align with your company's broader goals, and what it will actually take in time, materials, and labor to get a given efficiency project implemented to start reaping its benefits.

Introduction

According to the Center of Expertise for Energy Efficiency in Data Centers, data center efficiency is critical because:

- **Data centers are 10 to 100 times *more* energy intensive than offices.**
- **The demand for computing power and storage is growing faster than efficiency.**
- **Usage is predicted to double in the next five years.**
- **There are significant power and cooling constraints in existing facilities.**

Furthermore, they estimate:

"... benefits of data center energy efficiency include 20-40% typical savings and an extension of the life and capacity of infrastructures. Center of Expertise initiatives have the potential to avoid an estimated 0.6 billion KWh/year in data center electricity consumption, or approximately 1% of the Federal government's annual electricity consumption, representing $60 million savings. If the same best practices are adopted across the country, the estimated benefit would be an avoided 12 billion KWh/year."

Source: https://datacenters.lbl.gov/about

One of the most obvious direct benefits of reducing energy consumption in the data center is a reduction in operating costs. The less energy you consume, the lower your electricity bill becomes.

However, there are additional operational benefits that result from efficiency improvements. These often include:

- **Improved environmental and power monitoring and alerting**
- **Enhanced control and automation of data center infrastructure equipment**
- **Improved cooling and airflow**
- **Better preventative maintenance**
- **Increases in capacity, redundancy, and uptime**

Many large tech companies have dedicated teams of full time on-staff engineers that focus solely on efficiency in existing data centers, and cutting edge design teams that create incredibly efficient new facilities. They also have the huge budgets to support those efforts. The reality, however, is that most data center operators don't have anywhere close to the budgets or resources that these larger companies do. The good news is, there are likely still many things that can be done to increase energy efficiency on a budget.

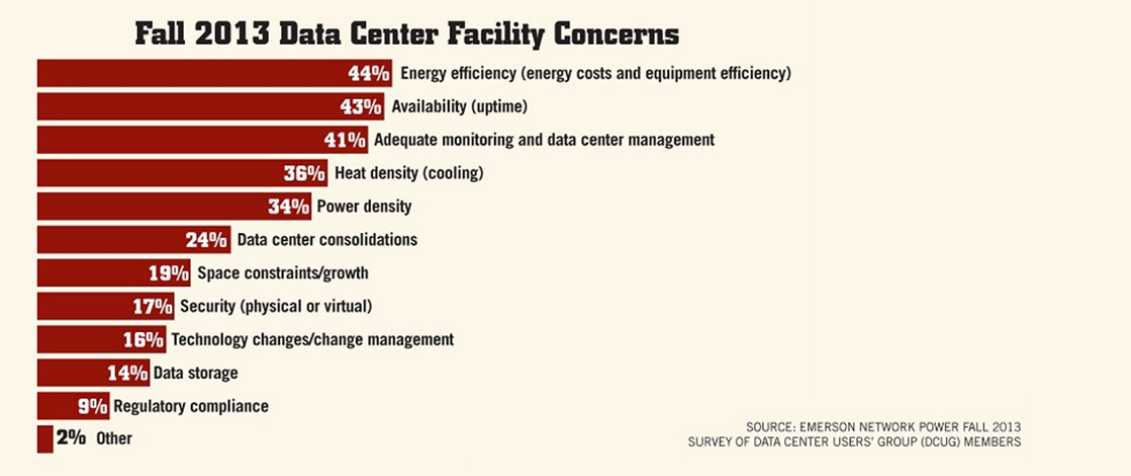
A basic challenge faced by data center managers is time. The main focus for any data center manager is uptime and reliability, but much of their time is spent on capacity planning, responding to customer requests, ensuring security protocols are in place and followed, and handling equipment maintenance issues. That leaves little time to focus on and plan for efficiency improvements.

In addition, there are new efficiency methods, strategies, software, and equipment hitting the market all of the time. It can be difficult to determine which combination of these new strategies and methods will actually help achieve the efficiency goals and payback criteria for your data center facility. The resulting confusion can lead data center managers to try for a quick fix, like installing variable frequency drives (VFDs) or putting up containment, rather than doing nothing. These examples can be advantageous if installed and used properly, yet this is often done without understanding the true savings and paybacks associated with each measure, and often without taking advantage of available utility incentives.

The data center building envelope may also complicate implementing efficiency strategies. Many data centers were not built in purpose-specific spaces, but rather were "built" in parts of buildings that were never intended to house data centers. This leads to awkward room geometries, shallow floors, a complex array of duct work, constrained access for bringing in new equipment, and limited power and cooling options.

Often, companies obtain existing data center facilities through acquisitions. These companies then find it hard to standardize on efficiency methods across multiple data center sites because the facilities are of varying ages with disparate types of equipment and monitoring systems. This makes it difficult to implement a "one size fits all" efficiency strategy even within the same company. Many data center spaces are also leased, leaving data center managers with limited options for efficiency upgrades since they may not own the infrastructure equipment. The time left on a lease may also add to a non-committal attitude in moving forward with an efficiency project if there is uncertainty about renewing the lease when it is up, or questions surrounding the accuracy of a proposed efficiency project's payback period.

In spite of these challenges, data center managers are still being tasked with improving energy efficiency, and surveys show energy efficiency remains a top concern for data center facilities and managers.



Source: http://www.channelpronetwork.com/article/energy_efficiency_is_a_top_data_center_concernagain1

Step #1

Identifying Energy Efficiency Opportunities

Accurately measuring and monitoring the internal environment and power usage throughout the data center can expose areas of inefficiency and opportunity for savings.

1-A. Assess the Environment:

Continuously monitoring the data center's environmental conditions over a period of time provides an indication of how well air is being managed and humidified. Only monitoring environmental conditions at a single time or limited number of locations does not provide a clear picture of how efficiently the data center is operating. An accurate picture of the data center's environmental condition and efficiency potential is obtained by continuously monitoring relative humidity and temperatures at the following locations: each cooling unit's supply air exit, multiple locations within each cold aisle, and each cooling unit's return air inlet.

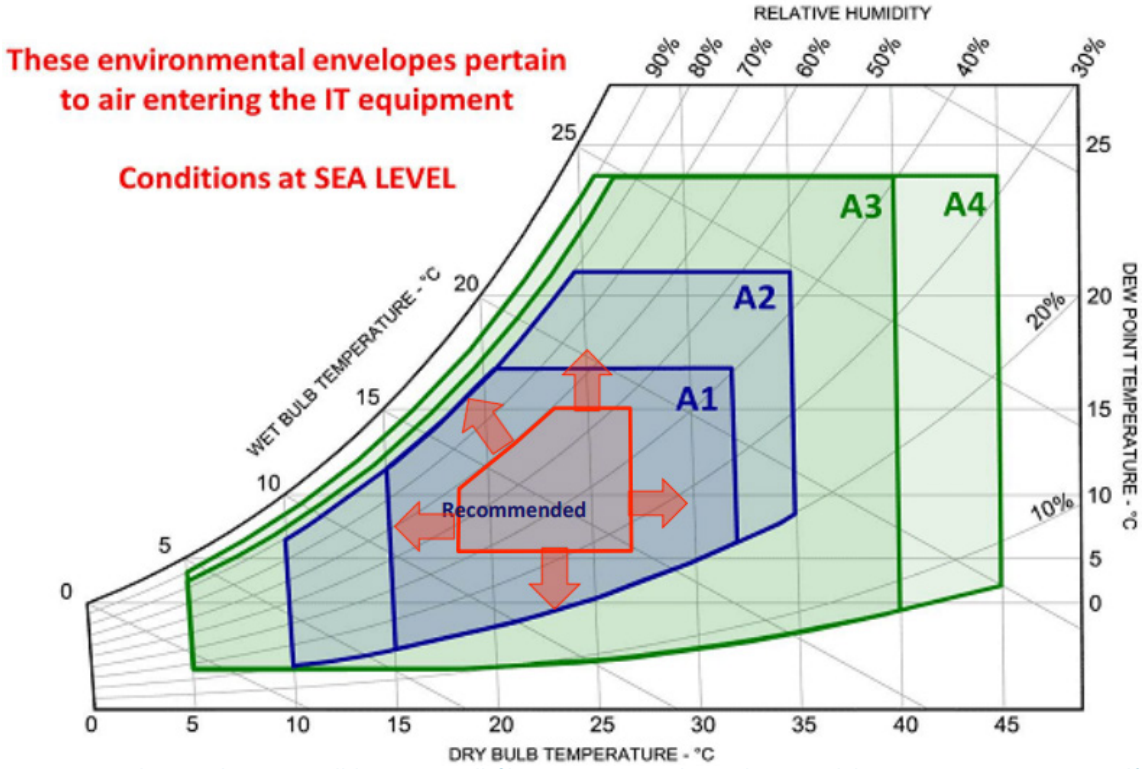
Knowing the temperature and humidity trends at the data center's most important points makes it easy to identify efficiency opportunities:

- Cold aisle temperatures are colder than the ASHRAE TC 9.9 recommendations.
- Humidity is outside the ASHRAE TC 9.9 recommendations.
- The ΔT across the cooling units could be too small.
- Humidification and dehumidification are occurring simultaneously.

Cooling units are more efficient when operating with a higher ΔT, and cooling units with a low ΔT are indicative of cold air bypassing the IT equipment. Ensuring that all return air temperatures are similar among the cooling units can eliminate simultaneously humidifying and dehumidifying, and opening up the allowable humidity range can save huge amounts of energy.

Most data center operators have the capability to monitor temperature and humidity at the cooling unit's supply and return points. These points, however, do not provide an indication of temperatures in the cold aisles, where the IT equipment actually resides. Monitoring each cold aisle can be accomplished by properly locating sensors within the data center and recording and trending the resulting data over time. Thermal imaging can also be used to provide quick feedback and allow data center managers to see where warm air is penetrating into cold aisles, or where cold air is leaking into hot aisles. Any mixing of cold supply air with warm return air indicates an opportunity for efficiency improvements.

Understanding the outside environment of a data center's geographic location can also provide insight into how economization methods can be used to lower the data center's energy consumption. Accurately determining the potential number of hours a given location can take advantage of economization, and what methods would work best and provide the best paybacks can be difficult. However, using ASHRAE or NOAA recommendations for hours of available economization and methods can be helpful.



Source: https://datacenters.lbl.gov/sites/all/files/ASHRAE%20Thermal%20Guidelines_%20SVLG%202015.pdf

1-B Assess Power Consumption:

Monitoring the power consumption of mechanical and electrical equipment can also provide insight to areas of inefficiency and allows for the creation of a power consumption baseline.

Monitoring the power consumed by the individual components within each cooling unit, while simultaneously monitoring the data center's environmental conditions, provides further insight into how effectively the units are being used. Knowing how much power each unit's compressor (if using DX type cooling), fan motor, humidification elements, and reheat elements are using allows the identification of components that are using more power than their nameplate suggests due to deterioration with age or mechanical issues.

Significant losses can occur through underutilized, or old UPS equipment. Understanding current and future IT load demands can help determine if your UPS equipment is right sized and running efficiently.

The data obtained from energy monitoring can be used to determine Power Usage Effectiveness (PUE) and create a baseline for comparing different energy efficiency opportunities. PUE can also be a helpful metric for monitoring a given data center's efficiency over time. PUE is the ratio of total facility energy to the energy used to power the IT equipment:

$$PUE = \frac{\text{total site power}}{\text{IT equipment power}}$$

PUE	Level of Efficiency
3.0	Very Inefficient
2.5	Inefficient
2.0	Average
1.5	Efficient
1.2	Very Efficient

Source: https://www.ukfast.co.uk/power-usage-effectiveness.html

To accurately monitor PUE, however, requires the ability to accurately monitor infrastructure power use over time.

To monitor both power and cooling requires access to specialized equipment and software. It can be difficult to determine if the investment in that equipment is justified if the efficiency opportunity has not yet been identified. Using an engineering firm that has already made the investment in equipment, such as thermal imaging cameras, CT's, data loggers, etc. may make sense, rather than making the investment in the equipment before a savings opportunity has been identified and paybacks calculated.

Step #2

Select the Right Efficiency Opportunities

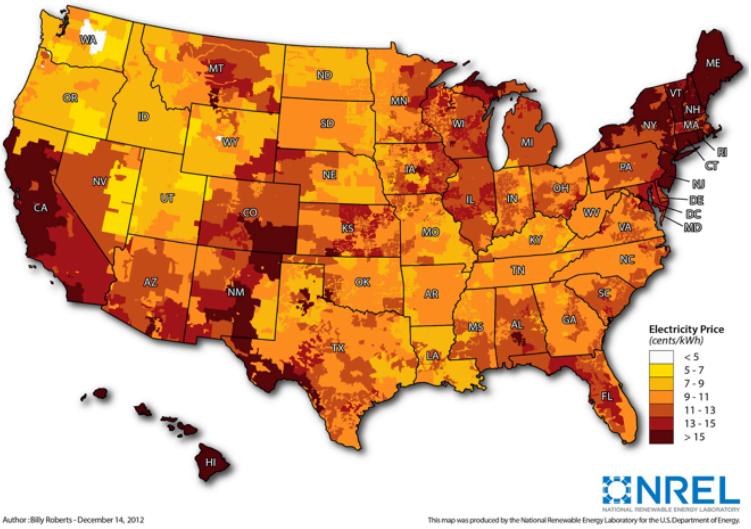
Determining the right efficiency strategy depends in part, on a company's overall efficiency goals, budgets, tolerance for payback periods, and alignment with other strategies, such as planned growth, equipment refreshes, and standardization.

If a determination has been made that efficiency opportunities exist, then the next step is to calculate the savings. These calculations can become complex, and are dependent in part on the size and type of equipment in use, the IT equipment electric load, understanding how to accurately de-rate equipment capacities for various reasons, and often need to take into consideration more subjective observations like how congested the data center under-floor is, or where ducting diffusers are located in relation to IT equipment.

2-A Determine the Cost of Electricity

Determining the true price for power is not as straight forward as it might seem. The best way to understand and calculate what your power cost is for a given facility is to look at 12 months' worth of electric bills. Exclude any credits or other anomalies, and then take each month's total bill and divide by the number of kilowatt hours charged for that month. Once this is done for 12 months, take the 12-month average and use this as your price per kilowatt hour to calculate savings for proposed energy efficiency projects. Looking at only one or two months' worth of electric bills can skew the price much higher

or lower than a 12 month average, causing cost savings calculations to be unreliable. Fully blended rates should also be used, as peak and off-peak rates can vary widely depending on the local utility.



2-B Take Advantage of Available Incentives

In many areas around the country, state and/or utility incentives are available to help offset the cost of an energy efficiency project. Often, these incentives can be as much as 50% or more of the total project cost. This can dramatically reduce the payback period of a given project from one that is outside of approved payback parameters to one that easily falls within those requirements.

Depending on the type of incentive and the size of the efficiency project, the process for qualifying for an incentive can seem bureaucratic and confusing. While this is not intentional on the utility's part, paid incentives must withstand scrutiny to make sure the incentive given for a project actually helps save energy. Incentives are also often subject to future state and regulatory audits. This white paper won't cover all of the intricacies of various incentive programs around the country, but there are some general guidelines to be aware of.

There are two main types of incentives; prescriptive and custom.

Prescriptive incentives pay a set amount for swapping out an existing device with a more efficient device. Lighting incentives are often prescriptive, for example. For every less efficient lightbulb replaced with a more efficient lightbulb, a fixed price incentive is paid.

Custom incentives can often lead to higher incentives amounts, but require more sophisticated and complex pre-approvals and engineering studies. Custom incentives also often require that the facility be pre and post metered. With many custom incentive programs, incentive funds are paid out based on actual measured savings after the project has been implemented.

Funding of incentive programs can also vary widely from one utility to another. Utility programs typically have limited funds available annually that are committed to customers on a first come, first served basis. In many cases, once pre-approval has been given by a utility for an efficiency project the incentive funds are set aside and available to be paid for a defined period of time. These committed incentives can expire if a project is not started or completed within the utility's required timeframe.

Understanding which program is a best fit for a given project can help determine the best incentive amount. For example, many utilities have created data center specific incentive programs, but may pay a higher incentive for a more general non-data center program or vice versa. It is important to investigate which incentives are available in advance to ensure you optimize your potential incentive amount.

While the incentive process can be complicated, utility program managers and representatives are willing to help their customers through the process. In addition, there are companies that have special relationships with utilities that can also work with customers to help them qualify efficiency projects for incentives. These are typically engineering firms that have experience working through the utility incentive process, performing pre and post metering, and developing the savings and cost calculations. For companies without their own efficiency engineering teams, using an outside firm with this type of experience often makes sense, and can yield better project economics.

2-C Calculate the Savings Associated with the Identified Efficiency Opportunities

Regardless of what efficiency measures are being considered, accurately calculating the anticipated savings is critical to understanding the payback period of a given measure. The power usage baseline previously mentioned is important to understanding how much money any proposed measures will save. If we take an example of replacing a standard constant speed fan motor in a cooling unit with a variable speed motor, it would be impossible to understand the dollar savings associated with doing that if the candidate cooling unit's

current power consumption has not been examined and measured. In addition, understanding how overcooled the data center is prior to this point is also critical. It is common for a data center to be overcooled from a total available tonnage standpoint, but to be considerably more constrained by available CFM. If these factors are not completely understood beforehand, then installing a new variable speed motor in a cooling unit may not save as much energy as hoped, because the fan speed will need to remain high to provide enough CFM for the removal of heat from the IT load. Continuing with this variable speed motor example, other questions arise. Should all cooling units be retrofitted? Is it less expensive to safely control redundant cooling units off, rather than install variable speed motors on all units? How is a VFD retrofit incentivized compared to a more comprehensive efficiency project (assuming state or utility incentives are available)?

Whatever the proposed efficiency measures are, similar questions need to be addressed, and calculations performed to determine both the energy and dollar savings associated with each measure. It is not uncommon for measures to be implemented, and then savings to be less than anticipated. Returning to the VFD example, countless VFD retrofits have been installed in many data center cooling units, and yet are still running at 90% to 100% of full speed, minimizing any real savings.

Efficiency projects may also result in existing equipment running less, which can translate into lower maintenance costs. Other savings may be associated with an efficiency project that can also be tied into the payback projections. Projects that include enhanced monitoring and controls may free up employees' time for other tasks. Enhanced monitoring and alerting can help avoid sending someone out to a remote site to check on a vague general alarm. Cost savings for these indirect benefits should also be captured and used in savings and payback calculations when appropriate.

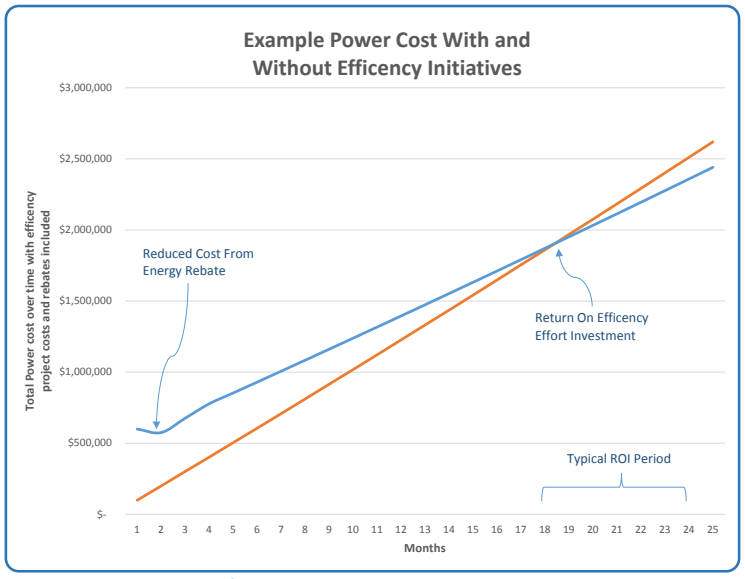
2-D Calculate the Cost to Implement the Identified Energy Efficiency Project

Calculating the true cost of an energy efficiency project is not always as straight forward as it would seem. Many questions are often overlooked beforehand. For example: Will the measures be installed by in-house resources or sub-contracted out? What materials will be used? How easy or difficult are they to install? Is union labor or non-union labor required? Are there continuing software license fees? Does your company require that the project be bid out to multiple vendors? Are those vendors quoting the exact same materials or services? Will those vendors use sub-contractors, and if so, are they approved to do work in your facility? Are the visual aesthetics resulting from any proposed measures important enough to pay a premium for? Will software integration be required? What kind of training is provided?

Some common measures, like installing cold aisle containment, might be more straightforward from a cost perspective, while others, like installing monitoring and control software, might have unforeseen long-term costs and employee training hurdles. Answers to questions such as these need to be examined when determining the true cost associated with any efficiency measure.

2-E Determine the ROI of a Proposed Efficiency Opportunity

If there are corporate budget and payback restrictions, any proposed efficiency project will need to fall within those parameters. Accurately calculating the real cost, savings, and payback of a project can be tricky, especially if it involves more than one measure, new equipment efficiency vs. existing equipment, whether or not outside contractors will be used, and if the project can be incentivized.



Source: http://www.futureresource.com/

Step #3

Understanding the Efficiency Project Timeline

Once the savings, cost, incentives, and paybacks have been accurately calculated, putting a project implementation plan together is a good next step.

Obviously, replacing an old inefficient chiller with a new high efficiency chiller with economization capabilities requires a different set of skills and timelines than installing cold aisle containment, which is different again from installing a new monitoring and control system. When several different measures are combined into one project, good planning becomes even more important, as one measure may be highly dependent on the completion of another measure first.

Extensive project management experience, and an understanding and avoidance of associated project risks are key to the smooth implementation of a data center energy efficiency project. Managing material deliveries, subcontractors, and internal resources, all while maintaining a safe data center operating environment can be challenging. Things like getting subcontractors through security, keeping track of project materials that have varying ship dates from multiple suppliers, and understanding key deadlines, along with contingency plans for each, must be factored into the overall timeframe for project completion.

If meeting the payback criteria hinges on a substantial utility incentive, but the project must be finished by the end of the calendar year to receive the incentive, then you must be realistic about the amount of time the project will take and include some buffering to be safe. If post project metering and verification are required by the utility, make sure you understand the timeline required. Some utilities only require a few weeks, while others require months of data before they will pay the incentive.

If subcontractors are involved, make sure they understand the timeline requirements for their piece of the implementation, and get assurances from them that they will easily make the required deadlines. If possible, put financial consequences in place if they do not. Are approvals and/or inspections required? Data center efficiency projects often involve electrical and other modifications that are subject to strict codes. Understanding this before the project implementation starts can save a lot of time and frustration down the road.

If new controls or software packages are involved, determine ahead of time how much training and support is included in the initial price, and who will need to be trained. Add the anticipated learning curve to the timeline projection. If integration between a new system and an existing system are needed, understand what that integration entails and who is responsible for it.

According to Villanova University the Top 10 Project Management Challenges are:

1. Undefined Goals
2. Scope Changes
3. Inadequate Skills for the Project
4. Lack of Accountability
5. Improper Risk Management
6. Ambiguous Contingency Plans
7. Poor Communication
8. Impossible Deadlines
9. Resource Deprivation
10. Lack of Stakeholder Engagement

Source: http://www.villanovau.com/resources/project-management/top-10-challenges/#.Va0ZlnnbK70

Step #4

Presenting for Budget Approval and Securing Funding

Getting the energy efficiency plan that has been developed for the data center approved and funded is the final hurdle. Therefore, it is critical to have the right person leading the effort to secure project funding with fact-based project economics.

According to a survey of over 470 energy professionals published on interiorsandsources.com, several factors can impact a project's approval:

- **Who proposes a project can make a difference.** Energy managers have good completion rates, with 36% securing approval for half or more of their projects and 75% receiving approval for at least one in four projects.
- **Unclear paybacks remain unaddressed.** When projects are proposed, many lack concrete data or assurances regarding ROI. One quarter of the projects are derailed by a "lack of certainty" of their estimated savings, and more than half the time, "not budgeted" is the reason energy projects do not receive internal approval.
- **Third-party financing wasn't considered.** Funding options such as leases or energy savings agreements (ESAs) are often not included in proposals, and 60% of energy managers do not consider financing in their proposals because they aim to fund projects internally. Financing options are available and securing optional funding can influence the approval process. However, the research that is needed to fully vet these financing options can be confusing and time consuming.

Every company is unique, as is every budget approval process. However, just convincing stakeholders and getting buy-in on the energy efficiency plan's economics does not guarantee the project will be funded. Being able to demonstrate how the energy efficiency plan makes more than economic sense and appealing to the social senses can be what it takes to get the energy efficiency plan approved. Showing the stakeholders how the plan fits into the company's culture and overall objectives, and how the plan improves resource utilization within the company can also be key to moving the project through the approval process.

Step #5

Getting Help from a Qualified Outside Source

Product and vendor agnostic companies specializing in helping data centers find and implement energy efficiency projects are not common, but they do exist.

As we've already outlined, managing a data center is a complex and demanding job. Due to time constraints, required engineering expertise, metering and data logging equipment and software, calculating and reviewing the true cost, savings, and payback for a given measure, and project management requirements, it may make sense to outsource part or all of the above to a company that is qualified, experienced, and competent with these types of projects. There is something to be said for having all aspects of a project managed through a single point of contact, and engineering firms that specialize in this can help.

Things to consider when looking for outside help:

- **Is the company "vendor agnostic"? Many companies who provide efficiency studies, or implement efficiency projects on behalf of their customers are also trying to sell a specific set of equipment or products. That doesn't mean that what they are selling is not valid as an efficiency option, but it likely means that their scope and experience for a broad range of possibilities will be narrower, and a fair price comparison with a competing option will be less likely.**

- **Can the company provide turnkey services from start to finish, or do they specialize in only part of the process? Some engineering firms specialize in identifying and calculating economics for certain measures, but do not have the resources or expertise to actually implement the changes. Others may be great at the mechanical and electrical work required, but lack the experience or expertise to conduct an engineering study for utility incentive approval. Some companies are qualified and experienced enough to turnkey the project from start to finish.**

- **Is the company willing to share in the risk of not receiving the full incentive at the end of the project, or guarantee savings for a given project? Some companies will claim a general savings percentage for a given measure, but do not help meter and quantify the actual savings after the project is complete.**

- **Can they provide hard, calculated figures on a proposed project's savings and ROI? If the vendor will provide only vague estimates for project savings they are likely not a good choice.**

- **Can the company help qualify the project for utility incentives? Some companies have a formal relationship with utilities across the country that allow for special incentives or special funding for engineering studies. Navigating incentive programs, putting together an engineering case for savings, and working with utility engineers to gain pre-approval for a potential project can be daunting for someone with limited time or experience.**

Conclusion:

Because data centers collectively account for a large percentage of total power demand in the U.S. and power demand to keep them running is expected to rise, data center efficiency will continue to be a focus for many years to come.

According to the Natural Resource Defense Council:

- **Data centers are one of the largest and fastest growing consumers of electricity in the United States. In 2013, U.S. data centers consumed an estimated 91 billion kilowatt-hours of electricity -- enough electricity to power all the households in New York City twice over -- and are on-track to reach 140 billion kilowatt-hours by 2020.**

- **Some large server farms operated by well-**

known Internet brands provide shining examples of ultra-efficient data centers. Yet small, medium, and corporate data centers are responsible for the vast majority of data center energy consumption and are generally much less efficient.

- **Electricity consumption in U.S. data centers could be cut by as much as 40%. In 2014 this represents a savings of 39 billion kilowatt-hours annually…Such improvement would save U.S. businesses $3.8 billion a year.**

It is not uncommon to find 1 million kWh of energy savings in a single efficiency project in even relatively small to midsize data centers. With utility incentives and careful planning, many of these projects can meet payback criteria of 2 years or less.

The cost of energy is also expected to continue to rise. A recent story in the LA Times quoted energy industry experts confirming this:

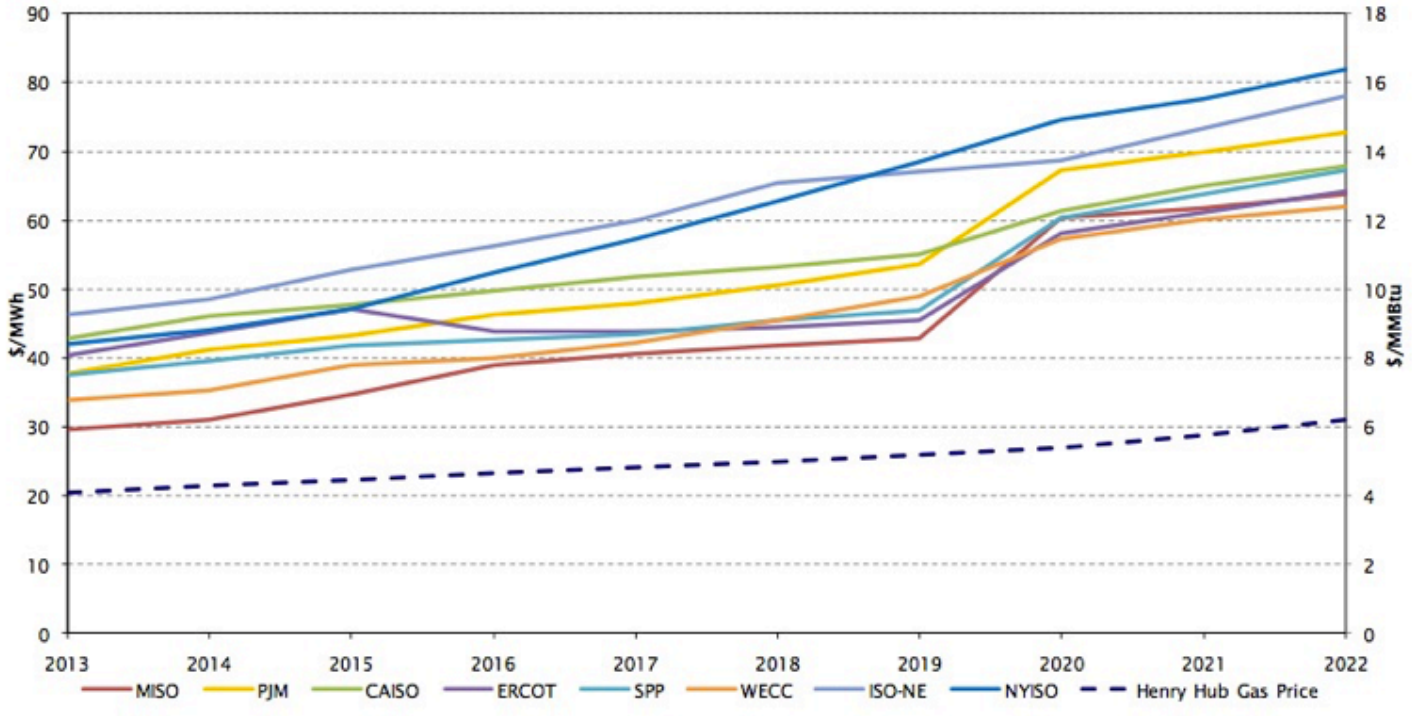
"We are now in an era of rising electricity prices," said Philip Moeller, a member of the Federal Energy Regulatory Commission, who said the steady reduction in generating capacity across the nation means that prices are headed up. "If you take enough supply out of the system, the price is going to increase."

"Everywhere you turn, there are proposals and regulations to make prices go higher," said Daniel Kish, senior vice president at the Institute for Energy Research. "The trend line is up, up, up. We are going into uncharted territory."

Source: http://www.latimes.com/nation/la-na-power-prices-20140426-story.html#page=1

Whether exploring data center energy efficiency opportunities to cut costs, as part of a larger company-wide efficiency plan, or because your business wants to capitalize on the positive environmental and public relations benefits of being "green", following the steps outlined here will help ensure the best outcome, meet savings expectations, and avoid common and sometimes catastrophic mistakes.

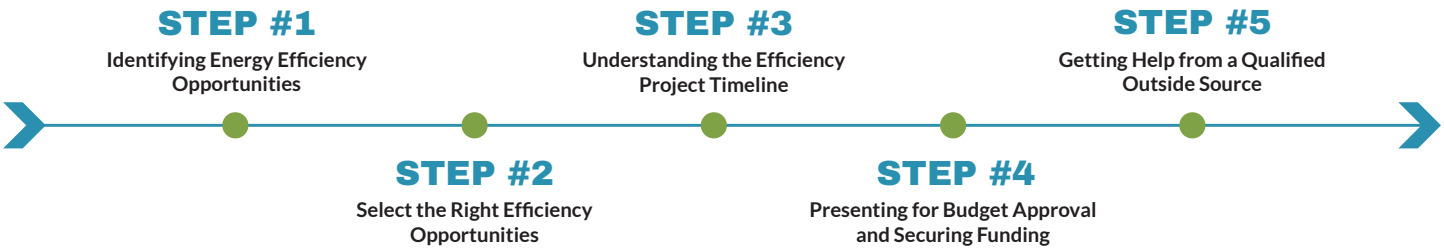
Projected US wholesale electricity prices



(Source: https://askjaenergydotcom.files.wordpress.com/2014/08/us-projected-wholesale-electricity-prices-forecast_2013-2022.jpg)

The Future Resource Engineering Five Step Data Center Efficiency Process

Our professionals at Future Resource Engineering have drawn on their years of experience in data center efficiency space to develop this five step Data Center Efficiency Process. This concise, comprehensive tool is designed to put you on the path to realize savings quickly, with as little impact to your team as possible.



We hope this process helps you both discover and benefit from efficiency opportunities in your data center. If you'd like additional help with a facility evaluation, the rebate process, or implementation of needed upgrades, contact us directly at 844.807.7788.

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