Intellastar®

White Paper

Building Internet of Things

How will it affect our Buildings & Business?

Introduction

We are hearing a lot about the Internet of Things, how there will be huge growth in Connected Devices, how everything with a Processor will be connected over Cellular and Internet to Big Data Systems in the Cloud; about how this will transform how things are operated and managed and create massive amounts of new business value for those involved. We see the people making Chip sets, providing Cellular Services, developing Operating Systems and providing Applications all investing very large sums to grab their part of this Billion Dollar growth bonanza.

We receive predictions from the Market Researchers about where this growth will happen – some say Homes will dominate while others predict Vehicles – Telematics – or Medical will be the leading domain. Almost all commentators see that Buildings and Energy will be two of the major segments to embrace this new Internet of Things Revolution.

All this sounds exciting, heralding innovation and change in our Industry, which is undoubtedly true. However we need to move from the generalities of the Architecture - Cloud, Big Data - to the specifics of the Functions and Applications that will make economic sense for Internet of Things as it is applied to Buildings. In short what are we going to do to create value from Building Internet of Things?

The Solution is not only about the centralized stuff - Connection, Cloud and Big Data - although they certainly have their part to play. It's also about improving what goes on at the local level, the Controls and Diagnostics we can achieve with more capability deployed at the Site level, a combination of Smarter Sites with Cloud based solutions in a distributed Intelligence Architecture. Essentially the way that IoT can create value can be looked at in three basic ways:

1. Reduce Consumption, or Cost of Consumption, particularly Energy
2. Reduce Servicing and Maintenance Costs
3. Improve Performance – typically less down time and shorter time to fix.

Reducing Energy Consumption

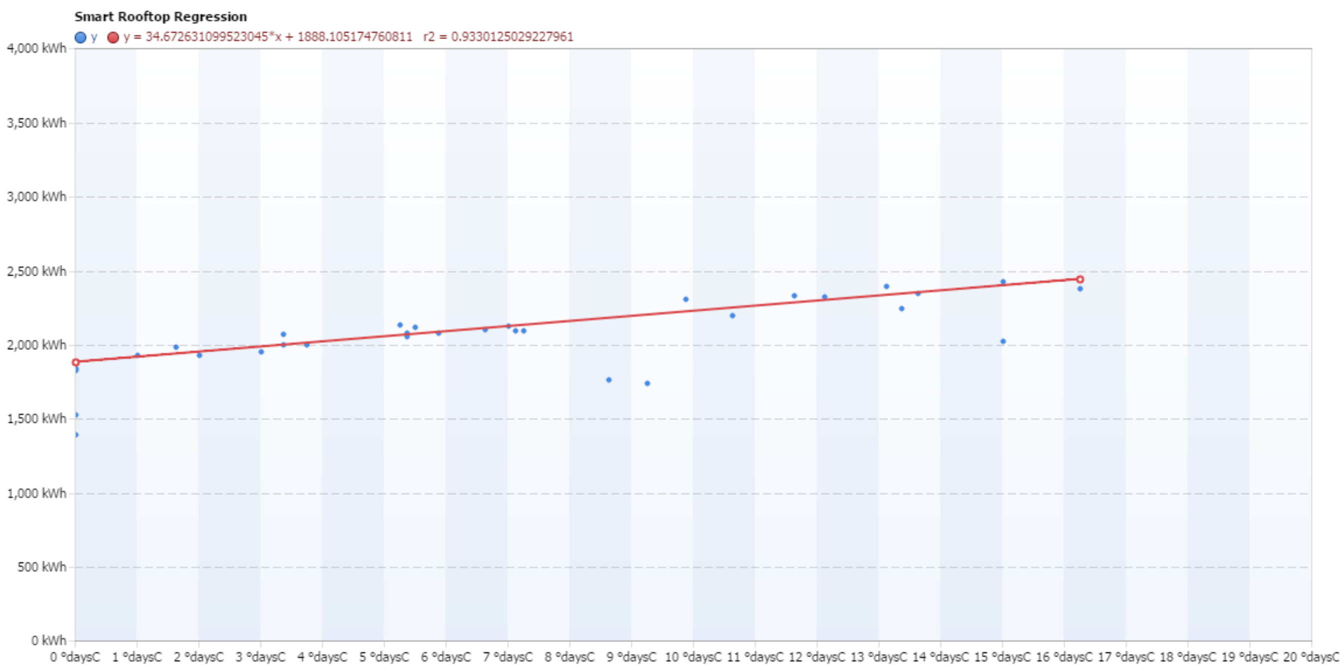
There have been a number of studies that show that buildings typically waste on average 20% of the energy they consume just because the equipment isn't performing as well as it should, and this level of waste is a generally accepted reality. The challenge is finding out what the problems are – getting to what we term actionable data - to fix the issues, because the Control Systems don't detect problems of reduced efficiency, unless the equipment can't maintain the required conditions.

Energy Monitoring

The Starting point for most people is monitoring Energy Consumption. This is an essential first step because that's the only way we are going to be able to understand what we are using and measuring how much the energy consumption has reduced. Energy Information Systems are great at keeping score, so we can understand the energy savings in the same way as an accounting system keeps score of the financial performance of a business and shows the profitability. Using Weather related information such as Degree Days, the Energy Consumption can be normalized for weather variations and the Energy Savings worked out to a reasonably high degree of accuracy. The problem is that Energy Information doesn't tell you if you are using more than you should be, and what is not working properly that requires fixing. If the energy consumption is measured with high enough frequency - typically every 30 minutes or quicker, so called high frequency energy data then we will be able to see if the building is running when it doesn't need to - so at night or over the weekend if it isn't continuously in use. What its not going to tell us is what's wrong with the plant that's causing the energy consumption to be more than it needs to be or should be.

High Frequency Energy Data lets us understand when plant is running when it should be off or set back

Energy Consumption Data is Normalized for Weather using Degree Day analysis. Regression allows Energy Targeting and Savings to be Calculated.



Analytics, Fault Detection & Diagnosis (FDD)

To find out what's wrong with the Plant we need to use Analytics. Control Systems will compensate for many faults rather than recognize them. For example; if the Heating valve is leaking or is stuck partially open, the control system will modulate the Cooling to still achieve the desired Temperature, but will use more energy to do so.

Rule Based analytics can be used to find most of the common problems that occur, such as;

- Simultaneous Heating and Cooling, whether that results from Mechanical Problems with valves or poorly set up Control Systems
- Economizers – Mix Dampers to the Europeans not modulating properly to take advantage of 'free cooling' when ambient condition allows.
- Sensors not reading correctly
- Plant running when it doesn't need to, specially when controls are overridden and Equipment is running continuously
- Control Loops not tuned resulting in poor or unstable control.

Using these and a few other fairly basic Analytic Rules detect the majority of Plant problems and Energy wastage.

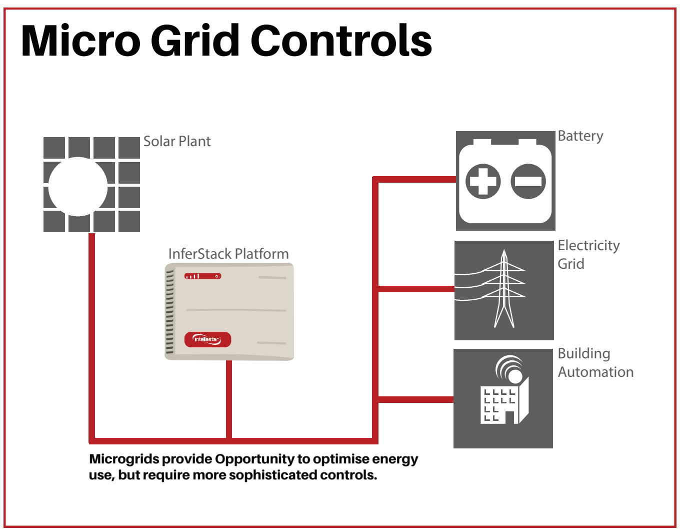
Rule based Analytics can detect when the equipment isn't working as it should. Serving this information locally to the Service Technicians helps them understand the exact nature of the fault.

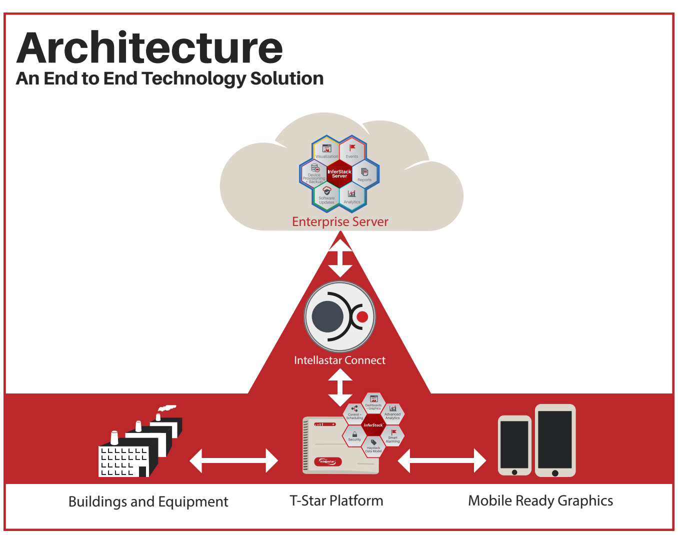
Analytics at the Edge

One of the key issues that determines how effective and successful the Analytics Rules are is the frequency of measurement, that is how often the system takes a measurement and runs the Rule. With Energy Analysis using Energy Information Systems, degree days and Energy Measurements are taken as one measurement per day. If we want to see if the plant is running outside normal hours then a daily measurement won't show that and we need to use the so called High Frequency Measurements which are every 15 or 30 minutes. If we want to run Plant based rules then we need to measure faster, at least as fast as the Control System can make changes. For example if the control system is unstable and the output is oscillating every 3 minutes, then we are not going to detect that using 30 minute measurements. Instead we would have to measure every 1 minute or less to see the effect of the fault we are looking to detect. Energy Information Systems work well transporting daily data points back to the server for long term Trending and Analysis. However bringing back the much higher frequency data needed for Plant Fault Analysis would mean that large volumes of data would need to be transported back to the Server and stored there which can be costly. It is better to perform the Plant Analytics locally – at the Edge of the System – and just transport the results back to the Server as Actionable Data. The High Frequency Data needed for Plant Analytics doesn't need to be stored for long. We are interested to detect specific conditions such as unstable Controls and sticking valves and these analytics don't require long term Data Analysis and Trending. Hence Building Internet of Things need Analytics both at the Server Cloud level and at the Edge - in the Building - to provide the range of Analytics that we need to manage our Buildings effectively.

Renewables & MicroGrid

There is an increasing use and reliance on Renewables – predominantly Solar Electric and Wind Generation – to provide more of our Electricity for understandable Sustainable, Environmental and Economic reasons. These can be large, Grid Scale Plants, or Local Installations co-located with our Buildings, and increasingly include Distributed Generation, Energy Storage, Batteries for Electrical Storage and Thermal Storage for Heat or Cool. Local deployments of Distributed Generation, Renewables and Storage on our Buildings gives rise to Micro Grids where there is interaction between the local Supply, Storage and Consumption of Energy and with the Electricity Grid This movement to Renewables and Micro Grids brings with it more challenges of how we operate and control our Buildings. We need Buildings to be more adaptable and interactive in their consumption to match the currently available energy. Technically the issues are very similar to the ones we face with Demand Management – in both cases we need to be able to measure, predict and adapt the consumption of our Buildings against available Capacity and Cost. To achieve this requires Connected Buildings and more local Control capability to manage the more complex load demands.





Optimization

In Building Systems, Optimization is about dynamically changing the working point of the plant to reflect the current actual load conditions rather than the system design point. For example varying the Chilled Water Temperature to reflect current conditions rather than a fixed 5 DegC (40 DegF) that was the design condition for the highest Ambient Conditions. If the system can manage with 10 DegC (49 DegF) Chilled Water then the Chiller efficiency will increase by 7 to 10% and heat losses will reduce too. Hot water systems get a similar efficiency gain when Hot Water temperature is reduced from the 80 DegC (176 DegF) design point. Weather Compensation Systems, where there is a fixed, linear relationship between Ambient Temperature and Hot and Cold Water Temperatures help but only go so far, dynamic optimization where true load conditions are measured and the temperatures adapted accordingly provide bigger benefits. VAV Systems can have their duct Static Pressure optimized to reduce their typical Energy Consumption. Pump Systems with Variable Speed Drives can control on pressure rather than on a fixed Flow rate. Of course, a well designed and implemented System will already have some or all of these System Optimization routines in built, but many if not most systems, especially older Systems, don't include full Optimization so there is often a significant opportunity to improve efficiency using these techniques. Optimization Control Algorithms work well in a Supervisory System and can be part of the same equipment that handles the Energy, Demand Management and Analytics for Fault Detection and Diagnosis.

Reducing Services & Maintenance Costs

All the techniques we have discussed above have the effect of reducing cost of Energy by either reducing KWHr consumption or by reducing the cost of that consumption. Most organizations also experience reduction in the costs of Operating and Maintaining their Buildings Systems and the amount of those cost benefits can be comparable with the Energy Cost Savings. The biggest benefit comes from drastically reducing the number of visits to site. The information that comes back from the building in many cases allows diagnosis of the problem before anyone has gone to the site. That means we can send the appropriate person with the right skills and hopefully even the relevant components to the site and get a first time fix. So many initial visits have been to diagnose the problem with the fix requiring a follow up visit. Sometimes there is no actual problem or it is one that can be resolved remotely, using the Connected Building capabilities and so avoiding any site visits. Problems that are detected can be ranked how important they are to get fixed – by criticality and cost of wastage, and less severe issues can wait to be grouped together rather than needing an immediate fix. The other way that better information helps us is through Condition Based Maintenance. That way equipment is serviced when needed either through hours run or because performance has deteriorated. This also improves service costs by reducing visits.

The flip side of the improved Service is that Customers experience better quality of service with reduced downtime and shorter time to fix. In some Critical Applications this improved uptime creates the greatest value for these smart services.

Better Information Display

We need to make sure that when the Technician does get to the site, he has all the information and tools available to understand the issue and effect the fix. By providing the Edge device with excellent Visualization tools, and local Analytics, the Maintenance Technician can view all the relevant information on a Laptop or Tablet, which he connects to the device through WiFi. The Edge Device stores the Histories of the Data Points and Analytics Rules so the data can be searched back in time to find the cause and effect of the problems.

In Conclusion

The Internet of Things is bringing great opportunity to operate 'Things' more efficiently and effectively by bringing the Infrastructure of Connectivity with Big Data, Cloud and Analytics. With the Building Internet of Things there are some very specific Applications that we can use that bring particular value to the Building Environment. Specifically we can;

- Measure Energy use and analyze energy savings
- Use Analytics for Fault Detection and Diagnosis to find the things that are set up or operating inefficiently
- Link Buildings to the Smart Grid and achieve cost savings through Automatic Demand Response and Dynamic Pricing.
- Work with Renewables and be part of a Micro Grid.
- Improve and Optimize the Control Systems.
- Reduce Operation and Maintenance costs reducing Site visits through better understanding of what's happening in the building.

These improvements, Applications and benefits can provide significant improvements in Building Efficiency and provide short payback and large returns. Implementation does require a change in the way the Buildings are Operated and Maintained. Problems and faults detected need to be fixed, not ignored. Maintenance procedures and processes need to change to make use of the information available to reduce site visits. Companies performing Building Operations and Maintenance will need to adapt and change to this new way of working. What today is a great opportunity for those who embrace these new ways, will equally become a threat to those who believe that business will continue as before.