EOS

ENERGY OPTIMIZATION SYSTEM™

- Internet of Things
- Big Data
- Cloud Computing

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1 | Introduction

A new capability has emerged that lets us operate existing buildings with better comfort, longer equipment life, and less energy. It is called “Intelligent Live Recommissioning”, or ILR. ILR automates a permanent constant commissioning process by writing back to the building. The qualified opportunities that are detected are immediately turned into real benefits in the building. Opportunities are qualified if they maintain or improve equipment life, occupant comfort, and energy performance. ILR became possible because individual building technologies evolved over time to a point where they could be combined to a greater use. More things became possible when the three technologies that make up ILR came together than the value that each technology had on its own.

Intelligent Live Recommissioning evolved from three important technologies:

Cloud-based server infrastructure

Machine-to-machine (M2M) communications

Recommissioning and analytics

These technologies each progressed to a maturity where they could be combined and applied to optimizing building performance. Intelligent Live Recommissioning becomes possible when they are used together.

2 | Recommissioning and Analytics

When a building is initially commissioned, it undergoes a quality assurance process.

This is the first step in ensuring that the building meets the needs of the building owner. Initial commissioning is based on 'Project' requirements. It is possible that those requirements become insufficient at any time after the initial commissioning is done, due to a number of potential reasons including:

1. After that initial project, there may be additional expectations of the building performance in terms of its comfort, equipment life, and energy performance.

2. The use of the building may change from what was captured in the project requirements.

3. The building's actual behaviour may be different than what was initially expected.

As a result, a recommissioning process is often applied to the building. This occurs after the initial commissioning and may be repeated after so many years. The recommissioning process brings the building performance closer to the needs and expectations of the building at the time. The process repairs or replaces defective equipment, and updates the building controls. But this recommissioning is a one-shot process and over time the building performance may not meet expectations or requirements again. As a result, it may be necessary to repeat the recommissioning every 5 to 10 years. Recommissioning may also need to be repeated when issues emerge that were not evident during a previous recommissioning.

A process called Continuous Commissioning, pioneered by Texas A&M, addresses the issue of keeping a living, breathing building at its expected performance. Instead of waiting a lengthy period for another recommissioning, the building is commissioned on a continual basis. This continuous commissioning has opened up many opportunities to reduce the energy performance of buildings. Current continuous commissioning practice uses recommissioning analytics as often as possible to identify opportunities in the building to improve the comfort, equipment life, and energy performance. These analytics may use a number of techniques to identify opportunities, such as trending, alarm logging, live Building Automation System (BAS) review, statistical regressions, deep number crunching, data mining, and more.

> "... that will verify that the heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems achieve the Owner's Project Requirements".
>
> **ASHRAE Guideline 1.1-2007**

Continuous commissioning can find operational improvements and suggest “low or no-cost” measures that do not require the purchase and installation of new equipment or an upgrade of old equipment. Opportunities may include things like reducing equipment runtime, optimizing economizer operation, volume control for HVAC pumps and fans, etc.

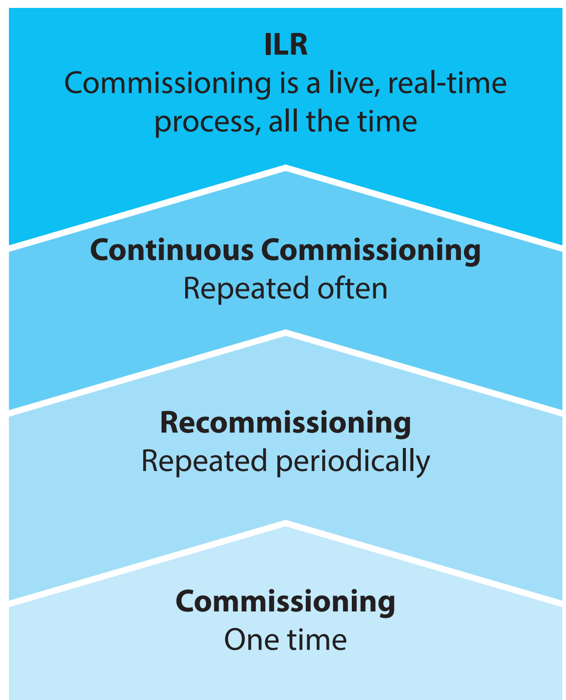
These opportunities are identified to personnel in the building. These personnel then work to make these improvements in the building. This may involve making cost and payback determinations, engaging and coordinating external resources, and scheduling work around timing and other constraints. It can be challenging to execute on all of the opportunities arising in the continuous commissioning process. Some impediments include:

- Personnel do not have the hours available to carry out these mini projects.
- Availability of the required skill sets.
- Hundreds of variables may be involved in responding to opportunities.
- Opportunities may involve 2 BAS systems that do not talk to each other.
- Opportunities may be so small that they do not justify a live person.

Consider the last one, for example. Suppose trimming a setting on an air handler could save $0.10 every minute, if it were updated. One cannot justify placing an operator at a console to make those updates because the value is so small. Yet over the course of a year, those adjustments add up to $52,560 in savings. Depending on its size and complexity, a building may have 10 or 15 or perhaps hundreds of those “impractical” opportunities that when automated by software technology – the cost savings would be huge.

Intelligent Live Recommissioning addresses those impediments by automating the process. No hours are required at all for someone to attend to an energy management system to achieve the savings. The savings opportunities that are found in the analytics are sent directly to the building systems. All of the skill for the analytics is built into the automation. Once the logic has been automated to find the opportunities using the building’s live, real-time data there is no additional manual manipulation to achieve the savings.

The figure below shows the most prominent difference among all four types of commissioning approaches. The more often the commissioning exercise takes place the better, and consistent savings can be derived from the building.



3 | Machine-to-Machine (M2M) Communications

Machine-to-machine (M2M) communications started to evolve when we started to build "systems". When we take a piece of equipment and attach a controller to it – it becomes a system. If we add a controller to a chiller, it becomes a chiller system. We now have many kinds of systems in our buildings: heating systems, cooling systems, ventilation systems, water systems, boiler systems, etc. For a while it was sufficient to have individual stand-alone systems. But the drive for remote interfaces and connecting systems together led the need for these systems to talk.

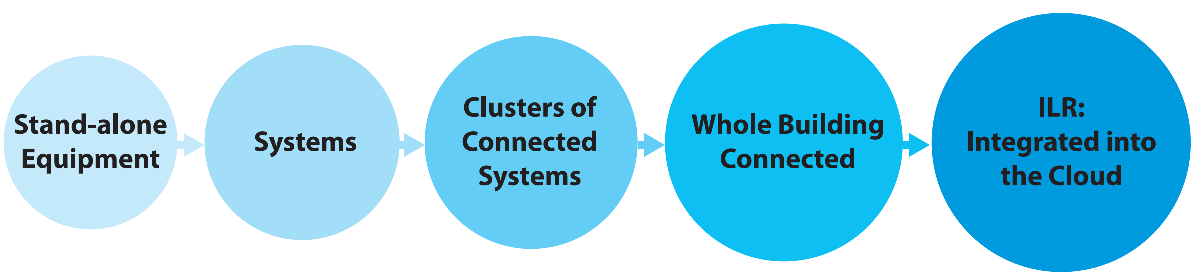
Protocols emerged that allowed the systems to communicate more easily. Protocols such as Modbus, BACNet, LonTalk, Metasys, etc. facilitate communication in our buildings today. Each protocol has many sub-variants to allow systems using the protocol to connect over different types of networks, such as RS485, Ethernet, WiFi, fibre, RS232, and many more. With these protocols in place, the many individual systems in the building become organized in clusters, with a common protocol for each cluster. But still there may be seven or eight clusters in a large building, for example.

These clusters can now be connected via gateways or protocol routers that adapt the communications between protocols. Over the past decade this has begun to expose the data, and has evolved into continuous "Big Data", and lots and lots of it.

More and more of these buildings are manifesting integration of the separate clusters into an aggregate of the thousands of data points in a building. While not a flat network yet by any means, it does allow one to read and write all of the points in a building. The data includes everything from HVAC, lighting, water pressure plants, boiler plants, chiller plants, access control, elevators, etc.

All of this data however is only that: data. Making the best use of all of this data is not the purpose for which all of these systems have been built. It can be difficult and awkward to make more than basic use of the large data set representing the entirety of a building. The individual systems provide some archiving and data history, commonly through features such as trend logs. Adaptions exist for attaching a database to some clusters for archiving and viewing the data. But use of these adaptations is not widespread. So while there is a large volume of data available, its potential to impact building performance is often not realized. It is wasted, or at the very least, underutilized.

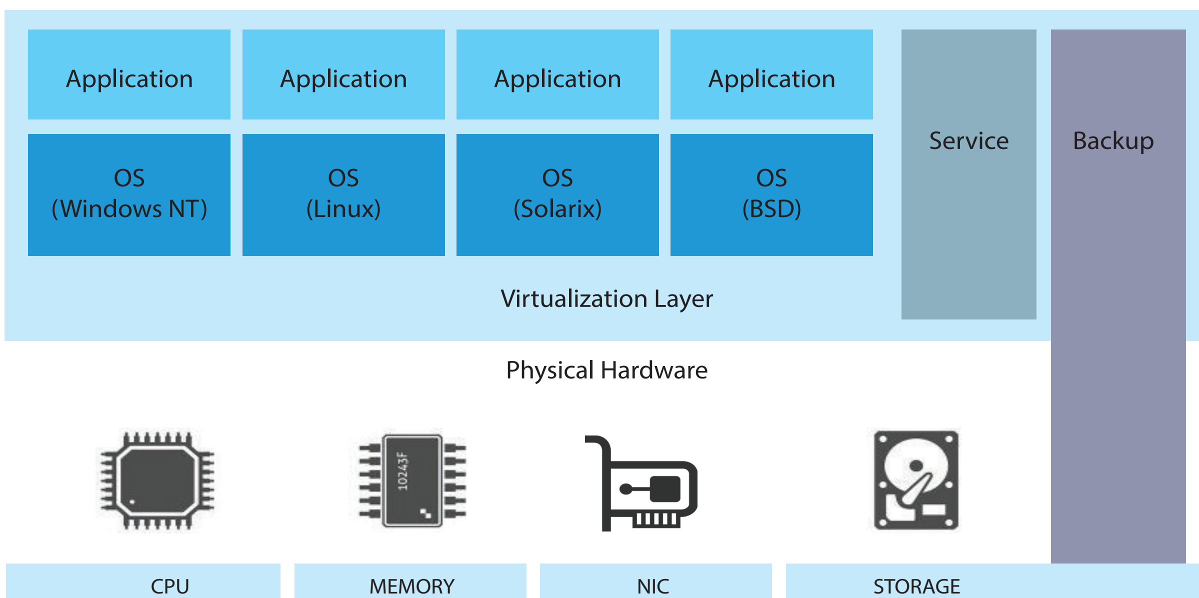
The ILR process exploits the potential of the best M2M we have today and produces value in the building from this data. Every minute of every day, the ILR process uses the data from the whole building to find the opportunities to save energy. The ILR process then returns to the BAS the values that they need to make the energy opportunities happen.



4 | Information Technology in Today's Energy Management

Information Technology (IT) has transformed many businesses over the last 20 years. The transformation is continuing at a rapid pace. Telephones now operate over standard Ethernet networks. TV is streamed over IP networks to a device that fits in your hand. A whole week-long trip can be planned and purchased over the internet. Much of banking is now conducted online.
An important development that has fuelled this progress is the maturity of cloud computing. What was once the avant-garde in IT has become the assumed solution for large-scale projects – and for good reasons. It allows us to use virtually unlimited amounts of storage and processing power in centralized data centres. Gone are the days when every individual application needs to have its own server put up somewhere with someone to do maintenance and backups. The cloud data centres added the advantage of efficiencies-of-scale by grouping together in one place all the smaller bits.

We now get the most out of our resources by sharing them amongst the collective needs. Adding a whole new server to an application with its own dedicated server – when more capacity was needed – used to double, or more, the workload to maintain, backup, etc. these two servers. Now when we add one more server to a centre with a hundred or more, we're adding a small percentage to the effort to maintain the servers. And by the time we get to our hundredth server in the data centre, much of the basic maintenance is automated via scripts and tools.
Redundancy and fail-over is greatly facilitated by the centralized data centre. But all of this scalable storage and processing did nothing for our buildings until we put the actual building data in the data centre. What is now taking place with Intelligent Live Recommissioning is that the full power of data centres is being applied to building science using the Big Data arriving in real time, and an automation of the qualified actions recommended by the analyses.



Virtualization in Cloud Computing

The ability to add, remove, and configure unlimited servers in virtual space has revolutionized computing in today's Cloud era.

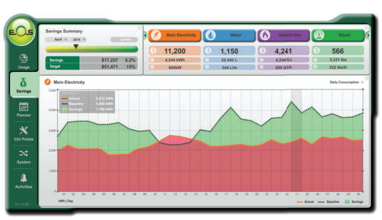
ime, analyzing the performance of a system might have meant printing a report on paper and photocopying it to physically circulate the information to a number of individuals. Eventually it became possible to produce a soft copy of the report and circulate it electronically. Today, that report can be more than a static snapshot of performance. It can be a live report, updating in real-time as new information becomes available. The report can also be interactive, allowing the reader to filter the presentation of the material to that which is of most interest, or changing parameters to get a what-if view of the data. And with the addition of cloud computing, the report can be published online, making it immediately accessible to anyone with the right login to see it anytime, anywhere.

These visualizations have played a part in the management of our buildings' performance. Many dashboards and tools are available to give insight into the opportunities in buildings. Some of these dashboards will feed into and support a process like Continuous Commissioning. Even with these very adept visualizations of the data, i.e. dashboards, it can be overwhelming, or manually impossible, to keep the building at optimal performance using all the information available to the user from the dashboard.

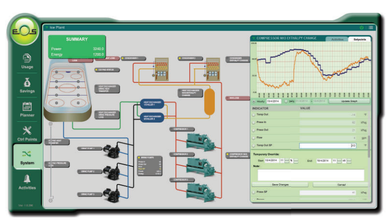
Think of the "automation" leap from a bank teller needed to complete transactions and update to your bankbook in the 1970's to now. Today, payroll deposits, many bill payments, and routine transfers take place automatically without participation of either a user or a bank teller.

These formerly manual processes have been replaced with unattended automated transactions. The user maintains visibility into these automated transactions by means of online, self-serve dashboards and reports via their online banking site. The online site allows the user to make additional transactions and make adjustments to the preprogrammed ones. With ILR, the same transformational change is now possible in improving the energy productivity of a large building.

Today's IT technology also gives us access to outside resources, such as weather forecasts and market energy price information. These outside sources give us more accurate information, or information that would not be accessible with a modern building automation system. For example, it is common to see some of the current weather conditions, such as outdoor temperature and relative humidity, in at least one cluster of a building's automation systems. Such information is usually gathered from local sensors. Local sensors do have issues sometimes, such as a temperature sensor that experiences sun loading at certain times, causing temperatures to be read higher than they actually are, perhaps by as much as 6°C. These errors in local sensors can lead to inefficient or incorrect choices in a modern building automation system. But external weather data can be acquired from high quality sources allowing better choices in building control logic. External weather sources also provide forecasts of what temperatures are going to be, which is rare in the case of local sensors. Increased data sources mean increased intelligence to allow predictive projections and improved occupant comfort.



Finance/Management
Emphasizing cost/savings analysis



Operation
Granular analytics and control

Sustainability/Public
Simple, key indicators

Visualization

Tailoring each view to the needs of its intended audience creates the maximum impact with that audience.

5 | Combining it All

It's now possible to run intelligent software algorithms against the data in the cloud environment and write values back to the controls environment in the building. Opportunities from a continuous analysis can be used immediately and directly in the building with no further delay or cost.

This automation will look at the larger opportunities in the building and make the necessary adjustments. Each piece of equipment in the building gets examined to ensure that it is operating at the optimal conditions for that equipment and that it is meeting the service requirements expected of it. This automation is also very helpful with the smaller opportunities. An algorithm might run and not change anything much of the time, but once in a while it would see an opportunity to make an adjustment that would work in the building and improve conditions, extend the life of equipment, and reduce energy costs.

One such algorithm might only save 0.1% of the building's energy use. But by running hundreds of such algorithms, they tally to 15% savings on average or more. It is simply not feasible for an operator to sit in front of a Building Automation System (BAS) screen and watch for a 0.1% opportunity. But the ILR software can do so without any additional runtime cost.

The result of combining all three modern building technologies together created more opportunities than each possessed separately. For example, instead of running a Continuous Commissioning exercise once a day, once a week, or whenever the staff have the spare time, the analysis can be run every five minutes indefinitely and the benefits are gained immediately.

M2M communications gives us access to the whole data set that represents the building, and access to write back to the controls in the building in real-time, allowing us to execute on the optimized plan in real time.

The scalable cloud environment of servers where we can archive data, process it, and provide live interactive visualizations, and rapid, real-time decisions on the optimized energy plan.

The analytics of a permanent, ongoing, real-time recommissioning running on the whole of the building ecosystem, not just on one of the equipment silos, all the time.

6 | Eco-system

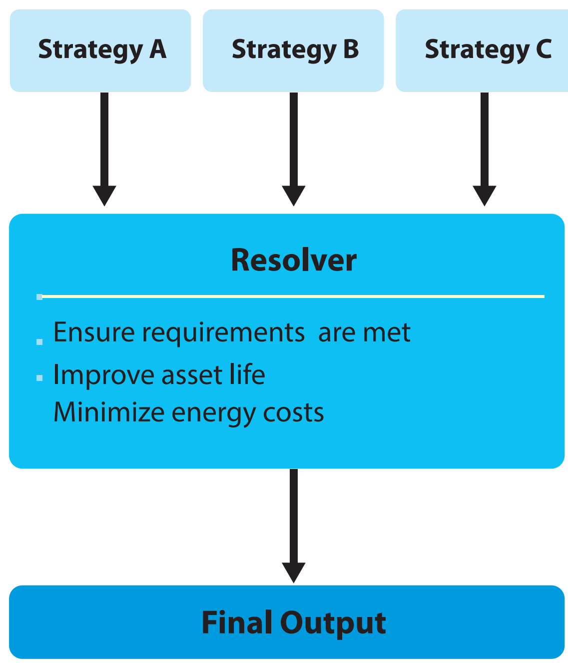
Intelligent Live Recommissioning treats the building as a whole. What happens in one system or cluster affects other systems in the building. This is important because a building behaves like an ecosystem. When something changes in the ecosystem, everything else adjusts to restore a balance. For example, when an air handler discharge air setpoint is reduced, auxiliary heat may come on to maintain the same space temperatures. The analytics of ILR uses the mappings of the connections in the ecosystem to evaluate the overall effect on the building of each component of the building ecosystem. And these mappings can be verified and calibrated in real-time by looking at the actual data coming back from the building.

When the mapping of connections show that a piece of equipment has an effect on one or more components in a building, those connections become very important in aligning the function and service of this equipment with all of the things it is going to affect. For example, an air handler may have an effect on 15 terminal units downstream and their associated spaces. The output and airflow from this Air Handling Unit (AHU) directly affects these other units. Exploiting these connections helps to ensure that the services provided by the equipment are neither oversized, nor undersized – but closely matched to the actual needs.

An important component of the building ecosystem is the occupants. The occupants and their behaviour affect, and are affected by, the rest of the ecosystem. In this sense, the adjustments to the building need to maintain or improve the comfort of the occupants, and not disturb their balance in the ecosystem.

The treatment of the whole ecosystem together is also important for the resolution of conflicts. When multiple optimizations are running in a building independently, sometimes they conflict with, or offset, each other. If one optimization turns down an air temperature, another may offset that by turning up a reheat coil elsewhere.

In another example, both optimizations may want to change the same value of a particular device. If one simply takes priority, then the value of the other is nullified. ILR uses the total ecosystem view and determines what combination of the two has the best economic benefit for the whole building, factoring in all the utilities. When an optimization would have an effect on the ecosystem that would compromise the needs of a space or a system, this is another conflict. Here, clear priority is given to meeting the required needs of the space over a savings opportunity.



Resolution of Conflicts

ILR resolves potential strategy conflicts to ensure all services are met using the minimum possible energy.

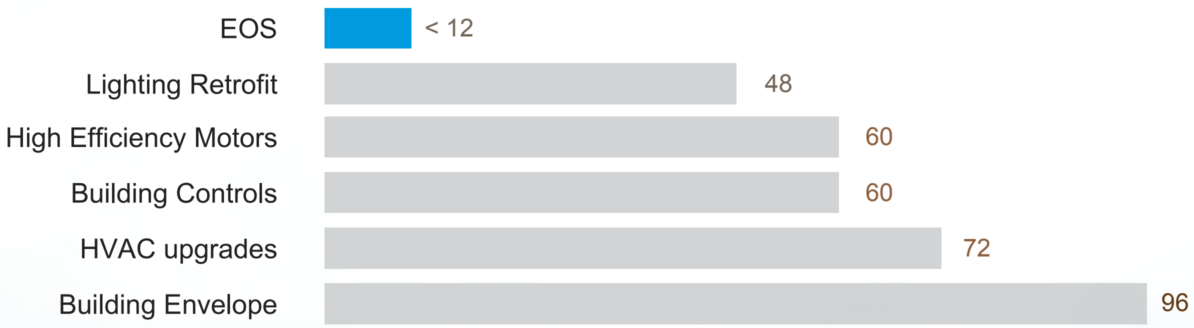
7 | Costs and Payback

As it turns out, the three components of ILR represent the three distinct cost elements in the implementation of an ILR solution. There is a cost for the IT – to own the software and to run it. This is typically software licence and support fees. There is the M2M and hardware and their installation cost. This may be the cost of gateways or protocol adapters to assemble the systems and clusters into a complete data set. And there is a services cost for analysts/ engineers to take all the information from the operators, the building, the BAS's, and documentation – and synthesize it into algorithms and scripts that will make the adjustments in the building. But when these three cost components are put together in a complete ILR package, they are more effective than implementing each individual efficiency activity – resulting in a shorter payback.

Part of what shortens the payback period for ILR is that each of the energy efficiency opportunities requires similar integration efforts. Thus combined into a single integration effort, the total cost to implement is significantly lowered. As an example, a single energy efficiency strategy that is applied to an AHU may require the efforts of a controls contractor. There is a fixed cost to mobilize the controls contractor to make M2M updates to integrate that system or cluster. But there may be multiple strategies applied to the whole ecosystem that use that particular air handler. The integration cost is the same no matter how many opportunities are realized with that machine, whether it is one or ten. By combining all the optimization opportunities into one M2M update more savings can be realized than if they were deployed as standalone opportunities. As a result, the payback improves.

ILR Cost Components

ILR Payback Compared to Other Measures*



* Based on NRCan data.

8 Success

Each of the three technologies of Recommissioning, IT and M2M communications has evolved in its own right. Today, we can combine all three together in a process called Intelligent Live Recommissioning. Combining them means we have more opportunities to save energy in our buildings than we did when we exploited each one of them individually. When we use all three together we achieve better comfort, longer equipment life, and less energy use than we did before.

The key to success in Intelligent Live Recommissioning is bringing together all these three technologies and thus having the greatest impact on the energy performance of a building.

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