L O A D S H I F T I N G P I L O T

2007

Study on Load Shifting

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1.0 Executive Summary

In January of 2006, Halton Hills Hydro initiated a pilot project to investigate and demonstrate the feasibility of using five sodium-nickel-chloride ZEBRA batteries (100 kWh) for load-shifting. While the ZEBRA battery technology is currently used in the transportation and military equipment industries, this is the first load-shifting application in North America. The key advantages of using this battery technology are:

- 94% battery efficiency
- High energy density and long life
- Rapid charge/discharge capabilities
- Cost-effective commercial availability
- Safe to use with no emissions
- Designed-in safe failure modes
- Contain no hazardous materials
- Maintenance-free
- High reliability
- Established success rate in other applications
- Environmentally friendly and completely recyclable with nothing going to landfill

Applications for this technology are scalable (up or down) with Local Distribution Companies, commercial and residential applications being three key focus areas where this technology could provide benefit. While this project focused on shifting of electrical load from peak hours to off-peak hours to lower peak demand, other potential utility applications include the coupling of electricity storage with renewable generation such as wind to improve its availability.

In August of 2006, the Halton Hills Hydro load-shifting project received final approval from the Electrical Safety Authority, was commissioned and energized and was deemed an unqualified success – installation and operation exactly as planned.

Halton Hills Hydro would like to thank the following partners for their assistance and/or funding in ensuring the Load Shifting Project was a successful start:

- Halton Hills Hydro Conservation Demand Management Program,
- EDA/MEARIE LDC Tomorrow Fund (Vaughan, Ontario),
- Electric Power Research Institute (Palo Alto, California),
- BET Services Inc. (Mississauga, Ontario),
- AGSI-Angus GeoSolutions Inc. (Georgetown, Ontario)

In summary, the Phase One success of the project was a significant step towards the province of Ontario's mandate to investigate economic viable solutions and to develop technologies that reduce the peak requirements or help to shift load requirements to off-peak periods.

2.0 Project Overview

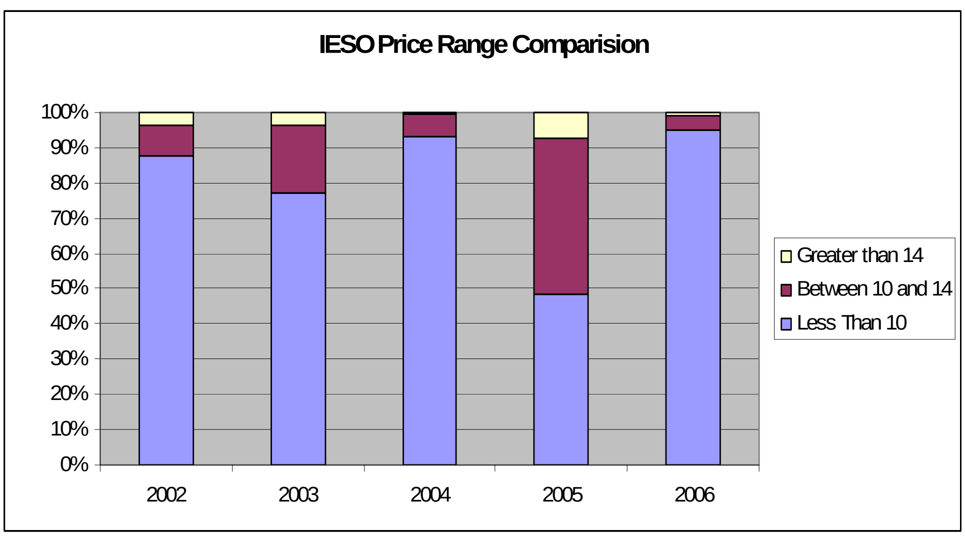
2.1 Challenge Today

Every year the cost and availability of electricity becomes a greater concern and challenge for governments, local distribution companies, businesses and consumers. The price of electricity fluctuates hourly, depending on demand and availability. The difference in the price of electricity within a 24-hour period can be substantial. Furthermore, the differences between one year and the next can also vary considerably. (See following table and chart.) Numerous alternative power generating solutions are either currently available or being investigated to address this challenge. In 2006, Halton Hills Hydro initiated a Load Shifting Project to determine the feasibility of using Direct Electricity battery storage.

The following table compares the IESO price between 2002 and 2006 and the number of hours the price was greater than 10, 12, 14, 16, 18 and 20¢ per kWh.

There is a considerable difference between 2005 and the other years. For example, in 2005 approximately 50% of the hours show the IESO price as greater than 10¢ per kWh.

IESO Price	2002	2003	2004	2005	2006	
>10 ¢/kWh	272	611	292	1539	164	# of Hours
>12 ¢/kWh	183	395	104	915	76	# of Hours
>14 ¢/kWh	129	271	35	529	38	# of Hours
>16 ¢/kWh	100	123	10	273	24	# of Hours
>18 ¢/kWh	72	76	6	140	18	# of Hours
>20 ¢/kWh	61	50	5	75	10	# of Hours

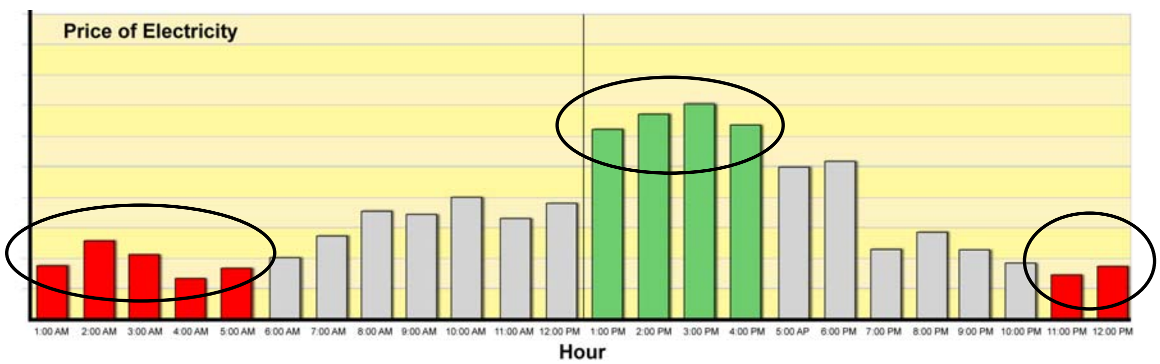


2.2 Load Shifting Project

The prime objective of the Halton Hills Hydro (HHH) Load Shifting Project is to purchase electricity during inexpensive low-demand hours (normally at night), store it in a array of five sodium-nickel-chloride batteries and then use this stored electricity during high-demand hours when the cost of electricity is at its highest. The batteries are marketed under the name ZEBRA (Zero Emission Battery Research Activity).

Below is an example of a typical 24-hour period and the three battery cycles: **Charging**, **Standby** and **Discharging**.

- At night the ZEBRA batteries would enter a charging state (red bars).
- Once fully charged the batteries would be on charged-standby (grey bars).
- When the cost of electricity rises the ZEBRA batteries would enter the discharge cycle and deliver the electricity back into the system, after which they would transition to discharged-standby.



Charging Batteries
Discharging Batteries
Batteries on Standby

The key benefits from this project are as follows:

a) Immediate Cost Savings – buying/storing electricity when the price is low and discharging/delivering energy when the price is high.

b) Environmentally Friendly – end-of-life batteries are completely recycled with nothing going to landfill.

c) Safety – battery/cell failure, if it were to occur, is benign.

d) Low Maintenance – zero maintenance to date.

e) Charging/discharging times can be adjusted in real-time to optimize cost savings and take advantage of fluctuations in the hourly price of electricity.

The short-term goal of this project is to prove the concept, and then make the technology available to other local distribution companies (LDCs), government agencies, and large commercial customers. Larger installations may become viable at a later date. The main long-term goal will be a reduced need for additional electrical power generation and distribution via a cost effective, environmentally friendly, and reliable solution.

2.3 Load Shifting Project Partners

Halton Hills Hydro partnered with BET Services Inc. (Mississauga, Ontario) and Angus GeoSolutions Inc. (AGSI) to provide the battery system hardware, control software, and LSDA software components of the project respectively.

3.0 Project Components

The Halton Hills Hydro Load Shifting Project is comprised of three main parts: Batteries and Auxiliary Equipment, Electrical System, and LSDA software components.

3.1 Batteries and Auxiliary Equipment

The batteries and auxiliary equipment consist of the following elements:

a) Battery System Monitoring and Control Hardware and Software

The battery system monitoring and control addresses the overall status of each battery within the battery network. Using data supplied by each battery's Battery Management Interface (BMI), the system always knows the current state of each battery. For example, batteries may be at slightly different States of Charge (SOC); batteries may be at slightly different temperatures; or batteries may reach different control limits at different times. This system also orders the daily charge and discharge cycles.

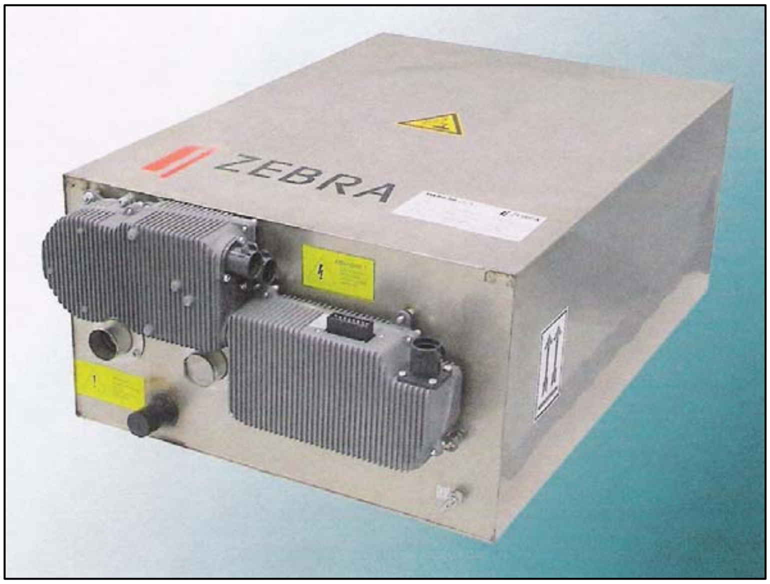
b) Chargers

There are five ZEBRA charging units, one for each ZEBRA battery. The charging technology is not proprietary. Though ZEBRA-specific, these chargers use a commercial design.

The chargers accept 208 VAC, and convert it to 600 VDC (nominal) for the batteries.

c) ZEBRA Battery

The five ZEBRA high-energy batteries are based on the electrochemical couple sodium-nickel-chloride, and are produced in low volume in Switzerland by MES-DEA. Beta Research & Development, located in England, is the leading ZEBRA research and development centre.



Zebra Battery and BMI

d) Battery Management Interface (BMI**)**

Each battery has a BMI which provides battery data back to the battery system monitoring/control.

e) Power Management Cabinet (PMC**):**

Used during the discharging cycle, a battery system software command is sent to the Power Management Cabinet (PMC) to discharge stored power.

The PMC takes the 600 VDC (nominal) electrical energy from the batteries, and inverts it to 600 VAC. The five 600 VDC (nominal) power lines from the batteries enter a splitter box, which consolidates the power and sends it to the PMC. From the PMC, one three-phase 600 VAC power line connects back into the Halton Hills Hydro building's power distribution bus.

Power discharge from the batteries takes place until the battery control software signals the PMC to stop. "Stop" conditions include:

- Power no longer necessary
- Power outage on the grid
- Batteries have reached their maximum discharge point (~ 80% DoD)

After discharge, the system sits idle in discharged-standby mode, until the battery control software instructs the system to start charging again. For Phase One of the project there is one charge cycle and one discharge cycle every business day.

g) Controller Area Network

This network is made up of the bus used to transfer information to and from the batteries, making it available to the control components (PMC and battery system monitoring/control software).

h) System Control / Monitoring Software

Control / monitoring software keeps watch over the current, state of the cells, and state of charge (SOC). This software also orders daily charge and discharge cycles (proprietary software).

3.2 Electrical System

The Electrical Components include:

- Power Distribution 600V Switchboard
- Transformer
- Power Distribution 208V Switchboard
- System protection equipment, including fuses and relays
- Metering equipment

3.3 LSDA Software Components

The following LSDA software components were developed to provide a method for capturing, converting, storing, and analyzing data. This information can be accessed over the Web via the LSDA.

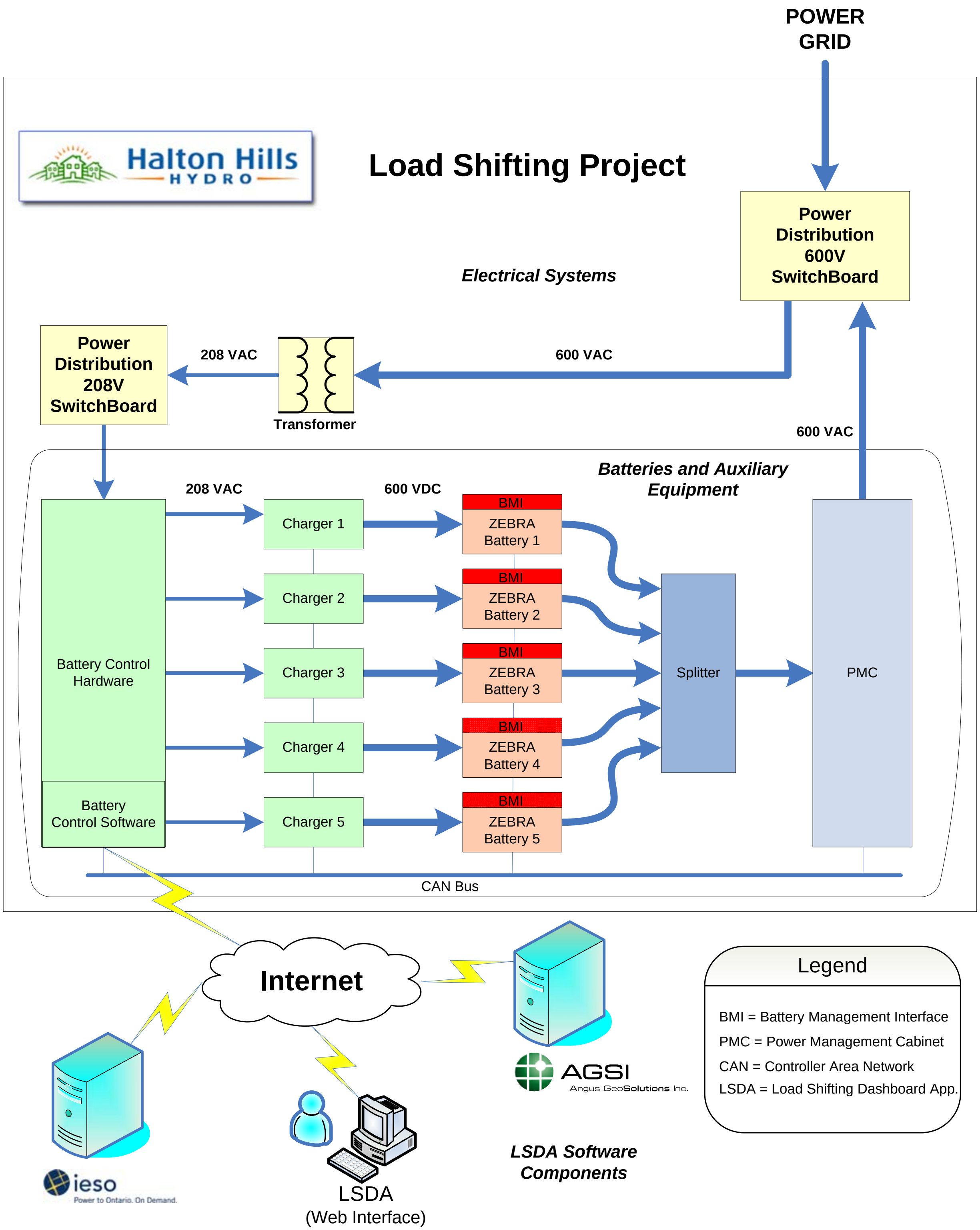
a) Convert the meter data (charging and discharging) received daily from Halton Hills Hydro, and then populate an Oracle database for processing.

b) Access the IESO website hourly, and convert the hourly price data into an Oracle database for processing.

c) Access the database with an interactive user interface to provide Statistical/Reports/Scenario information. This is accomplished via the Load Shifting Dashboard Application (LSDA) that interfaces directly with the Oracle database.

The LSDA was developed in Adobe Flash and provides a simple interface to view and analyze load shifting information from the Oracle database. This information is presented in three forms that allow the user to analyze battery data from a daily, weekly, and monthly perspective. A more detailed description of the LSDA can be found in section 5.0.

The following Diagram illustrates the three main parts of the Load Shifting Project: Batteries and Auxiliary Equipment, Electrical Systems, and LSDA Software Components.



4.0 Installation

All equipment for the pilot was installed in a storage area of the Halton Hills Hydro service garage. The installation was relatively straightforward, demonstrating that with minimal assistance, any local distribution company can install a similar system. Please note that commercial installations could use their own implementations of the charging/discharging equipment.

4.1 Physical Space

The Battery Components and Halton Hills Hydro meters/switches are located in an area that measures approximately 11 feet wide by 8 feet deep.

The area is simply an industrial cage that was used previously to store electrical equipment such as meters. The ceiling is a heavy industrial mezzanine (metal), and the floor is concrete.

Measurements of the space are:

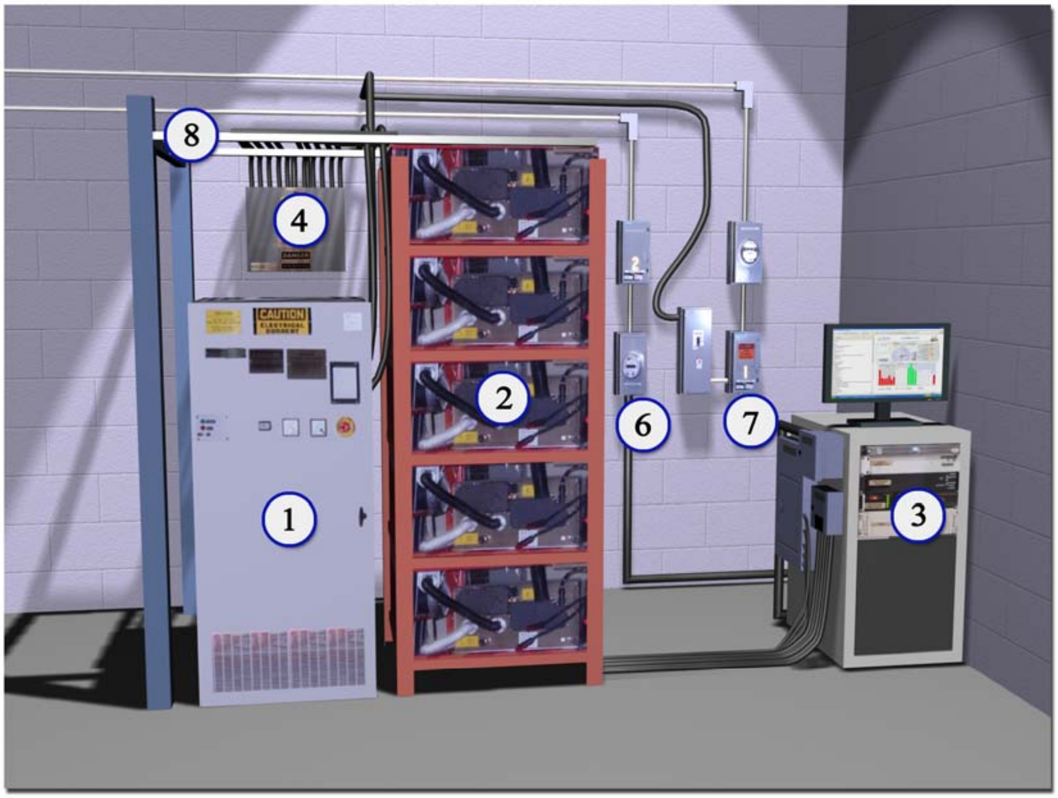
- Front – open, 11' wide
- Left wall – industrial mesh, 8' deep
- Back wall – concrete block, 11' wide
- Right wall – concrete block, 8' deep

Connection to / from Local Grid:

- 600 VAC enters a 600 VAC power distribution switchboard in the Halton Hills Hydro building.
- 600 VAC enters a transformer which steps current down to 208 VAC.
- 208 VAC enters a 208 VAC power distribution switchboard.
- 208 VAC enters the load shifting installation's Battery System Monitoring and Control Hardware and individual chargers.
- Chargers convert the 208 VAC into 600 VDC (nominal) for the ZEBRA batteries.
- Power Management Cabinet (PMC) inverts the 600 VDC from the batteries to 600 VAC, and sends the 600 VAC back into the building's 600 VAC power distribution switchboard.

4.2 Equipment Placement

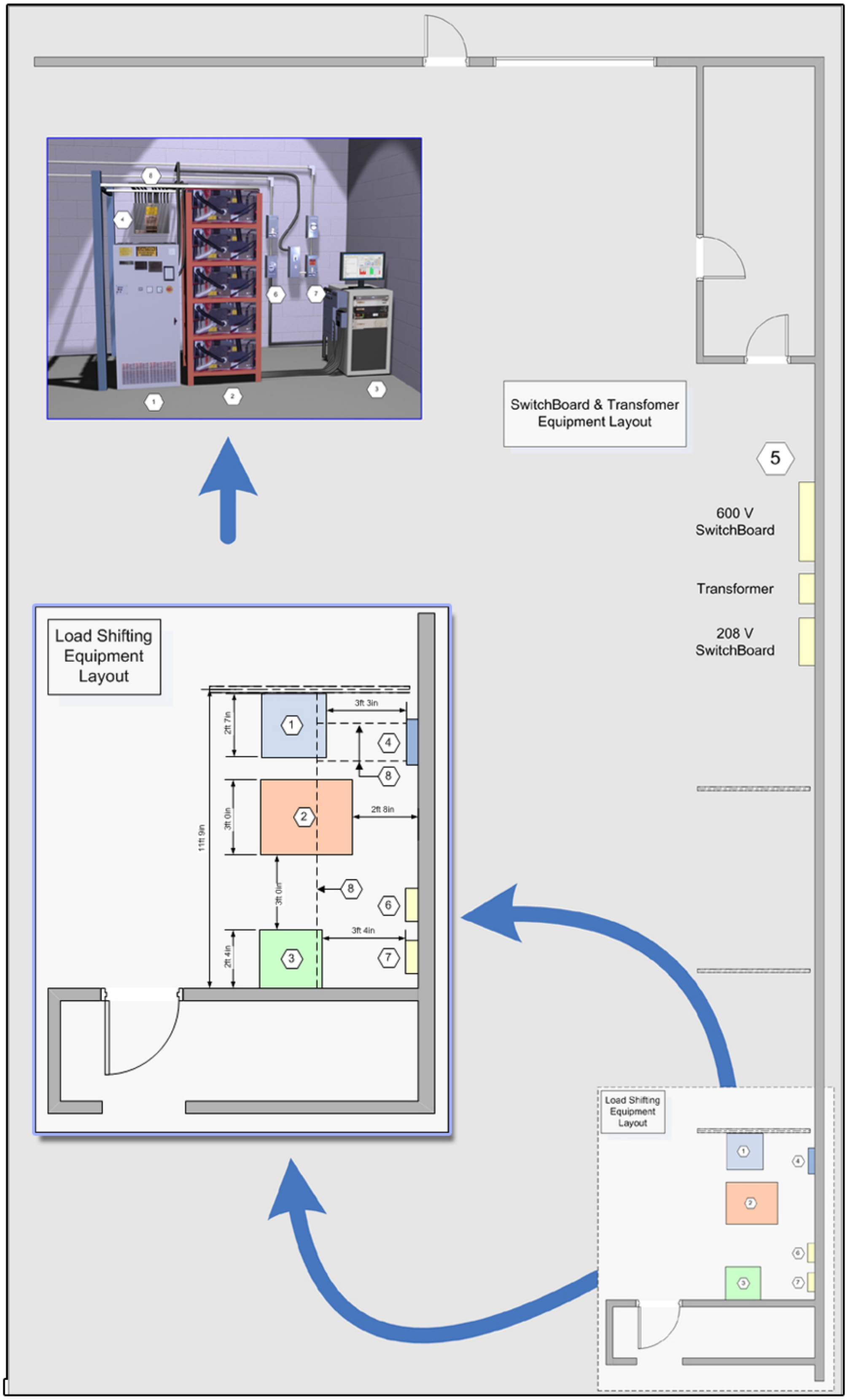
A 3D illustration of Halton Hills Hydro electrical equipment layout appears below:



LEGEND – Electrical Equipment Layout

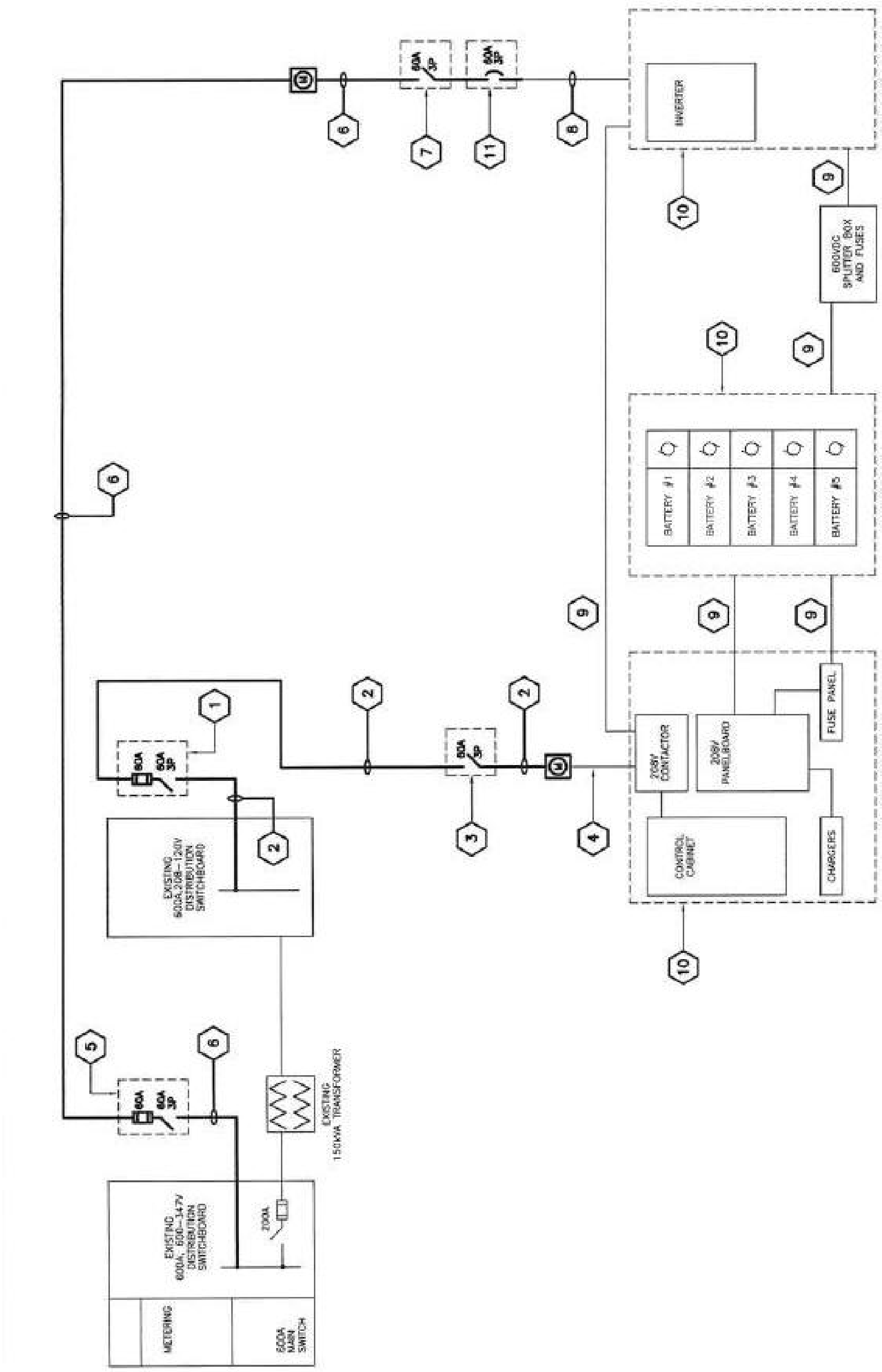
1. Power Management Cabinet (PMC)
2. ZEBRA battery rack
3. Charger cabinet
4. Splitter / Fuse Box
5. 600V and 208V switchboards, and transformer (see next diagram)
6. 600V, 60A unfused disconnect switch.
   600V, 60A, 3-phase breaker and meter
7. 600V, 60A unfused disconnect switch and meter.
   208V, 3-phase, 4W input to battery charger
8. Steel-ventilated Class "C" cable tray – 12" wide, 4" deep

4.3 Halton Hills Hydro Floor Layout



4.4 Equipment Connections

A single-line wiring diagram for the installation appears below, followed by a legend.



SINGLE LINE DIAGRAM

LEGEND – Single Line Diagram

1. Heavy duty single throw fusible disconnect switch, 60A, 600V, 3-phase, 4W, NEMA 1 o/w padlocking provisions and 60A class J fuses.
2. 4-1C #6RW90 + GND in 1" EMT from existing 600A, 208-120V switchboard to new fused switch, and from switch to new meter and new 60A, 3-phase unfused switch.
3. Heavy duty single throw non-fusible disconnect switch, 60A, 600V, 3-phase, 4W, NEMA 1 o/w padlocking provisions.
4. Connection from meter base to BET charger cabinet.
5. Heavy duty single throw fusible disconnect switch, 60A, 600V, 3-phase, 3W, NEMA 1 o/w padlocking provisions and 60A class J fuses.
6. 3-1C #6RW90 + GND in 1" EMT from existing 600A, 600-347V switchboard to new fused switch, and from switch to new meter and new 60A, 3-phase unfused switch.
7. Heavy duty single throw non-fusible disconnect switch, 60A, 600V, 3-phase, 3W, NEMA 1 o/w padlocking provisions.
8. Connection from main breaker to Power Management Cabinet (PMC).
9. Internal wiring.
10. Equipment supplied and installed by BET.
11. 60A, 3-phase 600VAC 18KAIC molded case circuit breaker in NEMA 1 enclosure.

4.5 Safety

The load shift system has an automatic shutoff. In case of disconnection from the grid, the system shuts down within 100 milliseconds. After shutdown, the system requires a manual restart. The project team determined this to be a cautious and safe method of operating the pilot project. Future systems can be automated to return to operation without manual intervention following a power outage.

4.6 ESA Approval

All electrical aspects of the pilot installation (including wiring, over-current protection, disconnecting means, isolating means, grounding, warning notices etc.) have been approved by ESA (Electrical Safety Authority) of Ontario, in accordance with Section 84 of the Ontario Electrical Safety Code.

5.0 LSDA Software Development

The software component includes a user interface Dashboard and the collection/conversion of data from the battery and IESO.

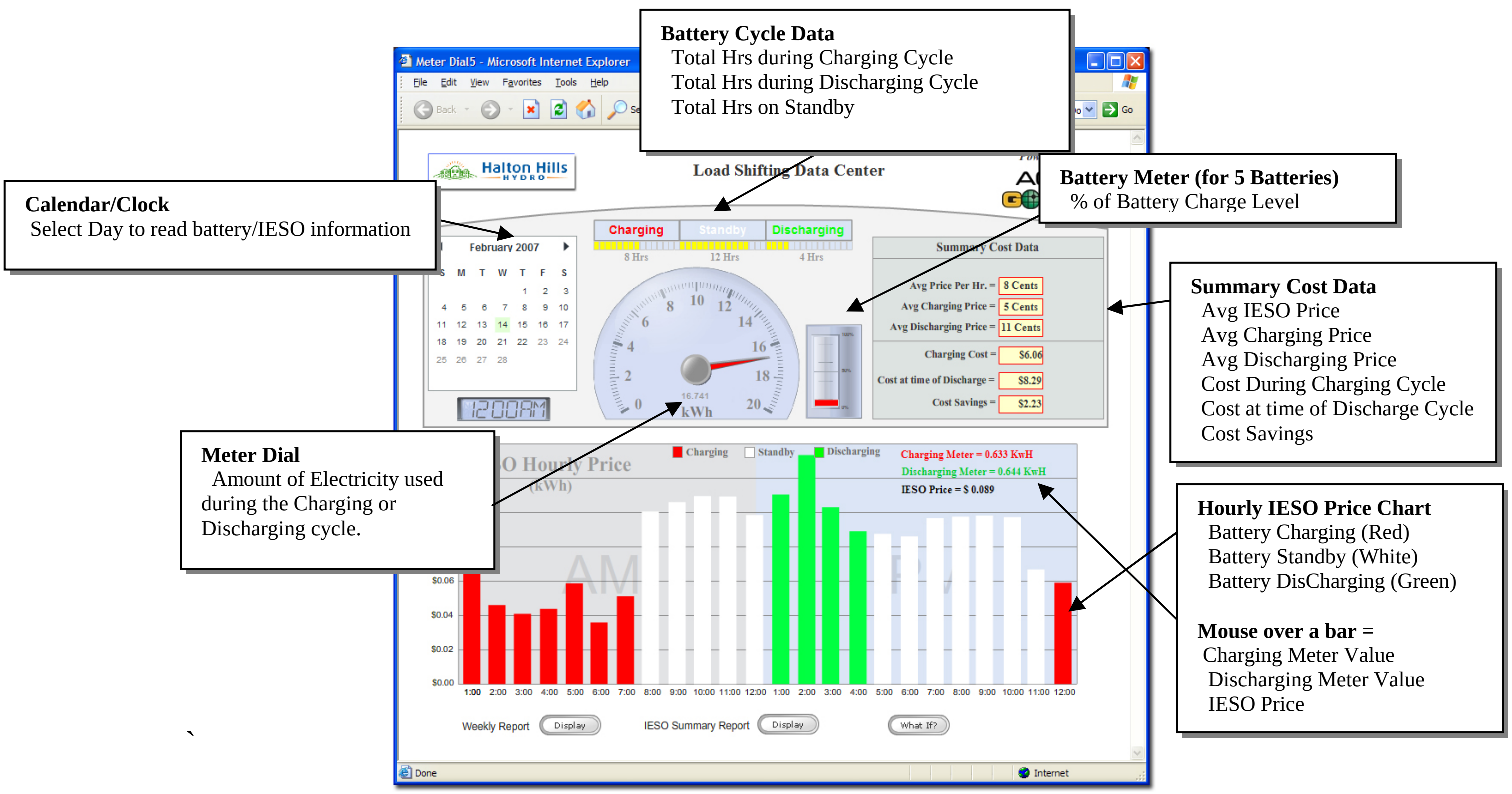
a) Retrieve the hourly price for electricity from the Independent Electricity System Operator (IESO) website, and write this data to the Oracle database.
b) Interface with the Battery software, retrieve battery information, and store this data in the Oracle database.
c) Convert and process statistics on the battery and cost of electricity, then write this information to the Oracle database.

d) Provide an interactive user interface (developed in Flash) to access the database information by day, week and month. Provide subtotal, totals, averages, trends, and “what-if” scenarios.

The LSDA utilizes three main forms to analyze Load Shifting data:

1) Main form (see below) reports on the load shifting project during a 24-hour period.
2) The Weekly Report form is a pop-up form that displays statistical information over the selected week.
3) IESO Summary Report form displays statistical information from the beginning of the project to the current month.

LSDA Main Form



The battery system currently performs one *charge* over consecutive hours and one *discharge* over consecutive hours, at the same set times throughout each day. With modifications, the system is able to charge and discharge on demand to meet price and electricity demand fluctuations.

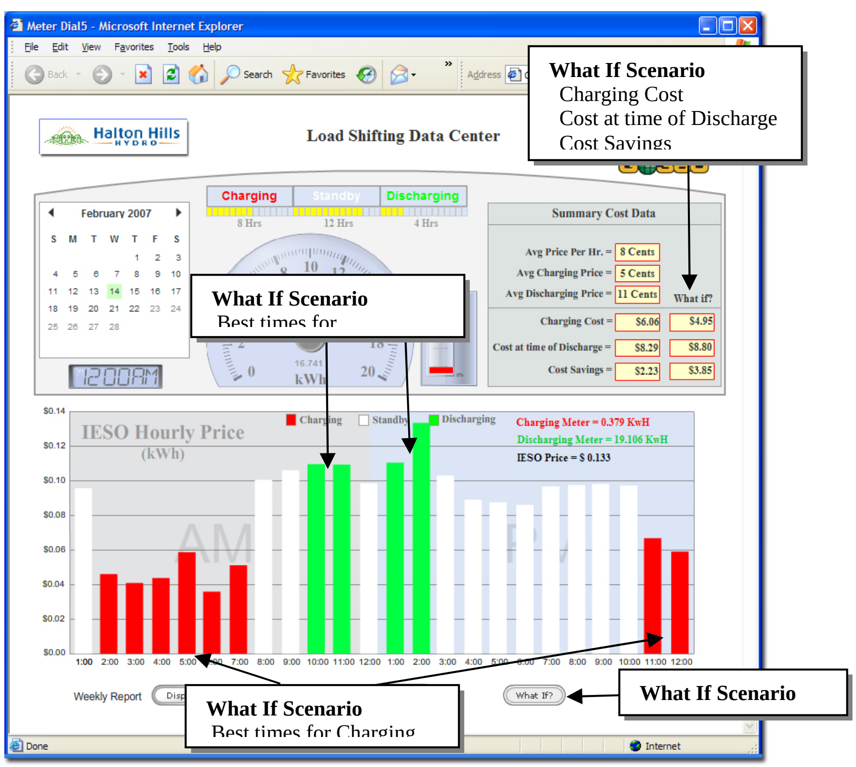
To maximize cost savings (and maximize the reduction in electricity generation at peak hours) it would be best if the battery system could charge at every opportunity throughout the day when the price was below a set point (red bars in the illustrations in this section), and discharge when the price was above a set point (green bars in the illustrations). It would also be best if the very lowest and highest price points were captured.

By examining actual electricity pricing, it becomes evident that it is not generally possible to predict when these lowest and highest price points will occur. Therefore, if the battery system were to react to every low and high price (every red and green bar), it is possible that the battery system may sometimes be at the top of its charge and could not charge any more to capture the very lowest price point if it occurred late in the day. Conversely, it is possible that the battery system may sometimes be at the bottom of its charge and could not discharge any more to capture the very highest price point if it occurred late in the day.

Therefore, it becomes worthwhile to predict in advance when these lowest and highest price points are likely to occur. An initial attempt at these predictions is shown in this section using various "what-if" scenarios.

A daily what-if scenario option is available for the user to select. When selected, the what-if scenario will analyze the current 24 hours of IESO price data and display the best possible hours for charging and discharging the system, with resulting cost savings calculations.

LSDA Main Form (What-If Scenario: Daily)

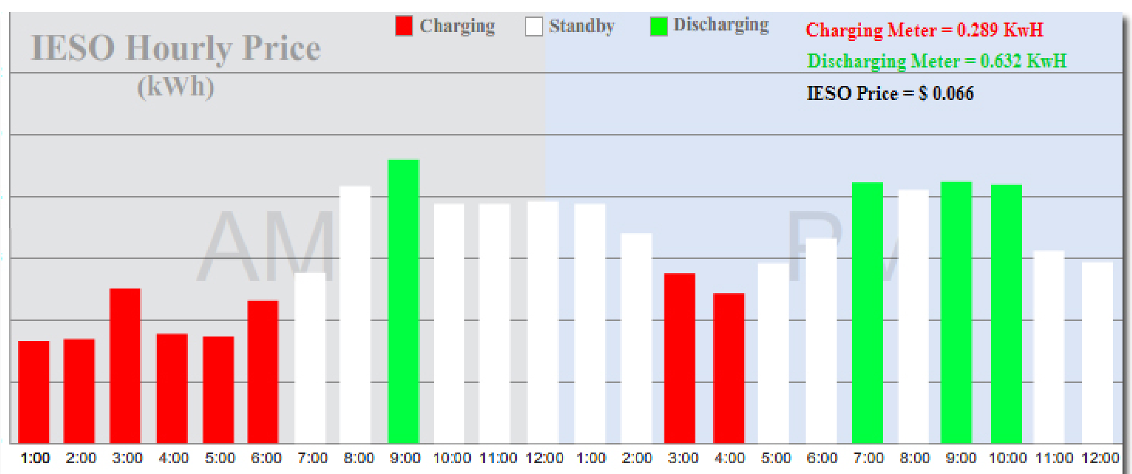


However, it should be noted this is a best-case scenario and is unlikely to be achieved with the existing operational programming for these two reasons:

a) This scenario picks the lowest IESO price for discharging and the highest IESO price for charging using actual posted IESO data.

b) The best charging and discharging cycle times are usually not consecutive. Normal battery charging and discharging cycles are consecutive hours with the existing operational programming.

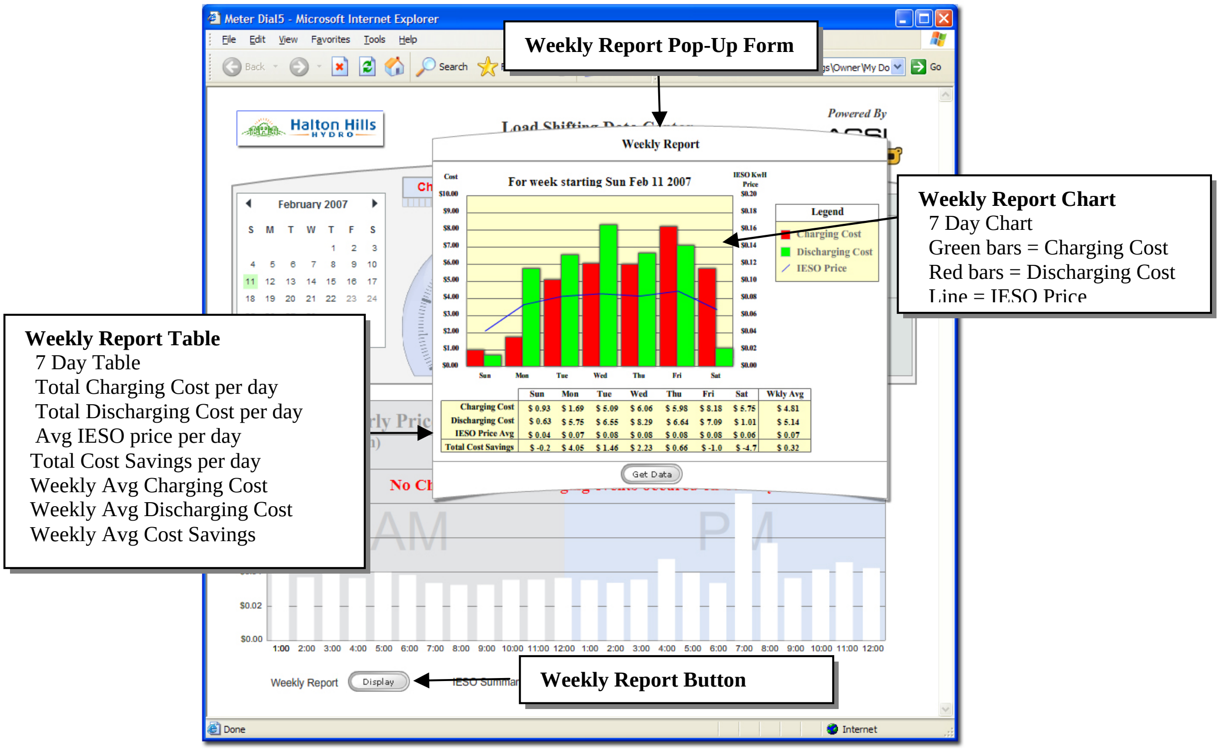
IESO pricing does not have a natural linear trend when rising or dropping, and is almost never concurrent. For example, the next figure shows actual data from February 8, 2007. Notice that the four best times for discharging are in green and the eight best times for charging are in red, but they are not consecutive.



As previously stated, although this what-if daily scenario cannot be achieved with current programming, it does provide a valuable metric for comparing actual cost savings results to a what-if monthly scenario (see IESO summary form). Phase Two will be able to use the IESO forecasting price to automatically change the battery discharging and charging cycles for the day.

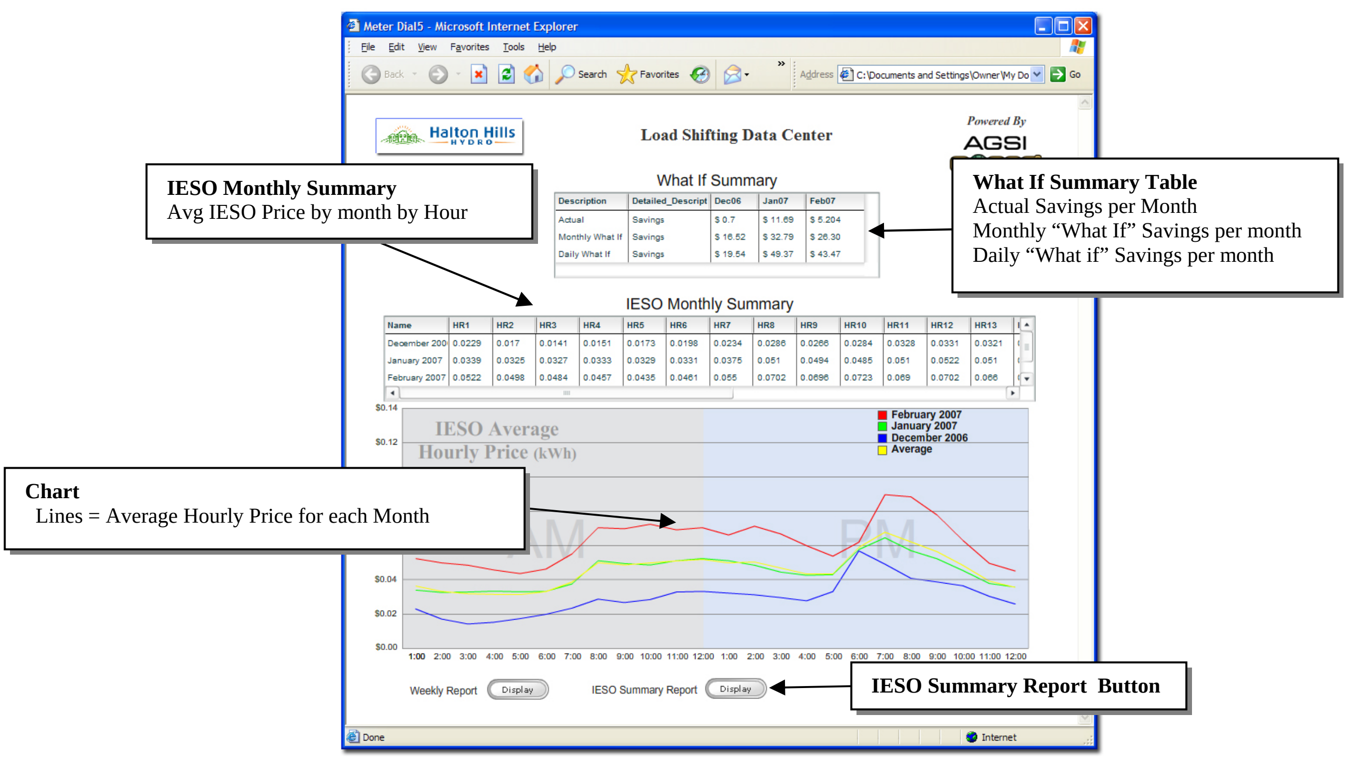
The next form is a pop-up that displays weekly statistics for the load-shifting project. The user selects the start of a week (Sunday) from the calendar to report on.

LSDA Weekly (Pop-Up form)



The last form is the IESO summary report (Monthly Report).

IESO Summary Form



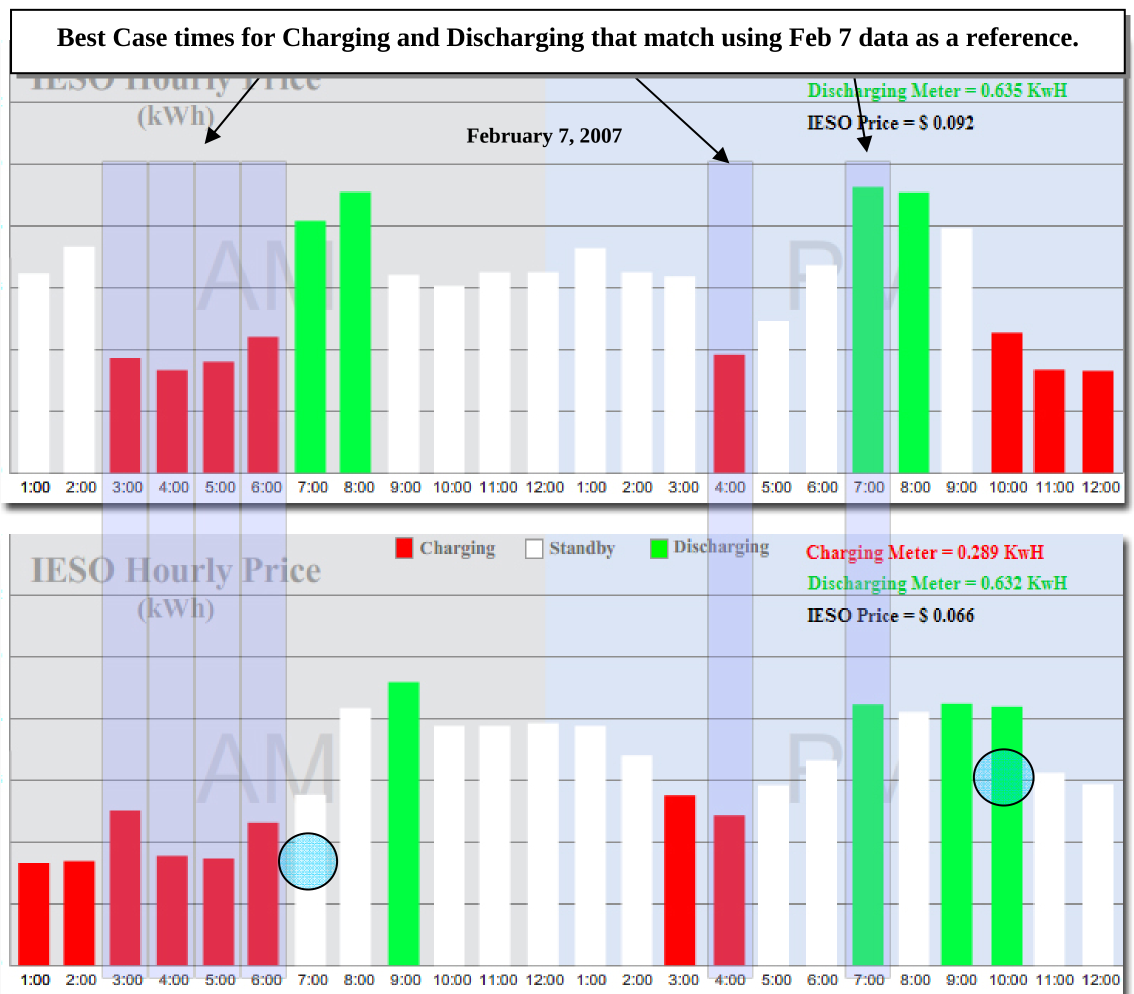
The IESO summary report provides two key statistics for analyzing the load-shifting project data:

a) What-if scenarios table
b) IESO average hourly price chart

The what-if scenario table shows the actual cost savings by month, along with two what-if scenarios: daily and monthly.

Daily What-If Scenario
The daily what-if scenario picks the best times for charging and discharging using actual posted IESO pricing data. It would be impossible to achieve these cost savings by resetting the batteries charging/discharging times using a previous days best times (charging/discharging).

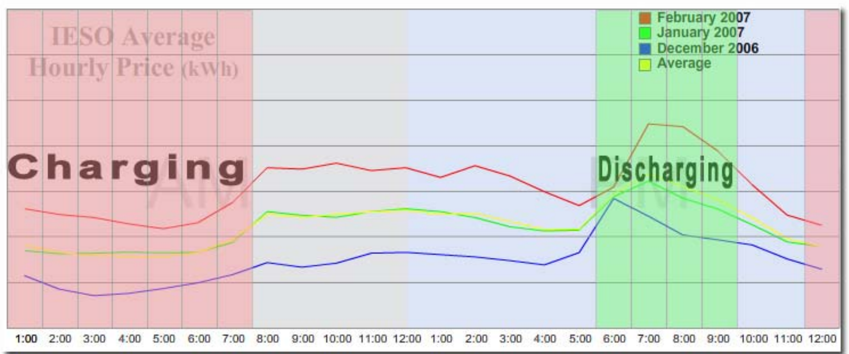
The figure below illustrates an attempt to use the daily best case scenario on February 7 and comparing it the best case scenario on February 8. Out of the total 12 hours used for charging and discharging, only six hours line up from the previous day to the next.



Besides only achieving a 50% prediction rate, for two of the remaining six hours (see circles above) we are discharging at a sub-premium priced hour and charging at one of the four best times to discharge. In summary, the daily what-if scenario is important for setting a reference point when comparing cost savings to other methods, but it cannot be used for predicating the best times for setting charging or discharging cycles.

Monthly What-If Scenario

The monthly what-if scenario also uses actual IESO data to predict the best hours for setting charging/discharging cycles. Since this scenario is based on a month of IESO data (hourly average), it provides a more linear trend line for predicating cost-saving opportunities.



6.0 Environmental Safety and Efficiencies

6.1 Life and Reliability

The ZEBRA batteries used in this initial installation consist of 240 cells connected in series. If cells fail, they fail as a low-resistance fault which allows the battery to continue to operate. Depending on the battery configuration, batteries can operate without a major effect on the battery performance with up to 5% failed cells. This is an important feature: Although the aim is to achieve no cell failures in a battery throughout its required life, *a cell failure does not mean battery failure*. Further, even if one or more batteries in a network fail, the remaining batteries will continue to operate.

Under normal operating conditions, there are no life-limiting factors associated with the positive and negative electrodes and the beta alumina ceramic electrolyte. Individual cells and modules (10 cells in series) have been cycled for many thousands of cycles, equivalent to 15 years use in an electric vehicle, with only a small change in performance, and are still capable of delivering the full nameplate capacity.

The research centre for ZEBRA batteries, BETA R&D in Britain, has conducted tests to determine likely battery life. Previous accelerated testing at elevated temperatures has predicted that cell failure will occur at normal operating temperatures (270° C - 350° C) in 10 to 15 years. This “wear out” failure is due to corrosion of the glass seal, which joins the beta alumina tube to the insulating alpha alumina header. These accelerated testing results are backed up by results of an actual calendar life test battery that has completed over 14 years on test with no failures.

6.2 Immunity to Ambient Temperature

ZEBRA cells operate at an elevated temperature of 270° C to 350° C. Therefore, the cells are packaged in a vacuum-insulated box. The battery is guaranteed to operate at full performance from -40° C to +70° C ambient.

When the battery needs cooling, air is circulated through sealed cooling panels fitted between the cells inside the battery casing. As the battery works at a temperature significantly above even the highest ambient temperature, heat is easily removed. When combined with the large range of operating temperature and the thermal inertia of the battery, this means thermal management of the battery is very straightforward.

6.3 Reliability

The failure mode of the ZEBRA cell is to short-circuit with a similar internal resistance to an operating cell. Therefore if a cell in a string fails, current continues to flow in the string. For long string length, several cells could fail with the only result being a small loss in terminal voltage and rated energy.

6.4 Safety

The ZEBRA cell has certain intrinsic safety features. If a cell is crushed and the ceramic electrolyte is fractured, the sodium metal reacts with the sodium chloro-aluminate to form sodium chloride and aluminum. These products are non-corrosive and do not have high vapour pressures. The cell can tolerate over-charging and over-discharging, however, cells are normally operated within the standard nickel-chloride reaction range, as they will degrade if repeatedly operated well into the over-charge or over-discharge regions.

In extreme fault situations such as a charger malfunction, the over-charge reaction allows cells to over-charge safely. These features, combined with the ability to withstand freeze/thaw cycling, enables cells and batteries to be very resistant to abuse.

Extreme tests were undertaken within the European car manufacturers' EUCAR organization. In these tests, fully operational batteries were subjected to various vehicle crash situations such as 50 km/h impact and penetration tests, complete immersion in water, spike penetration and spraying with water, vibration testing, and a 30-minute gasoline fire test. For example, the photo below on the right shows a battery that was immersed in gasoline and set on fire for 30 minutes .

50 kph impact test on a ZEBRA battery

30-min fire test on a ZEBRA battery

Two of these tests are pictured above. To simulate extreme electrical faults, the batteries were also subjected to an internal overheating test, an external short circuit, and overcharging with a voltage 50% above the normal charger voltage. In these tests the ZEBRA battery did not present any additional hazards, and in many cases survived intact and continued to operate.

6.5 Recycling

As the ZEBRA numbers increase, battery recycling infrastructure will need to be in place to process spent batteries without adverse impact on the environment.

The American company Inmetco (a subsidiary of Inco) has successfully recycled 20-ton loads of ZEBRA cells by adding them to their standard submerged arc smelting furnace. This produces nickel containing re-melt alloy used in the stainless steel industry. The ceramic and salt contained in the cells collects in the slag and is compatible with their process. The slag is sold as a replacement for limestone used in road construction – nothing goes to the landfill. Inmetco has a wealth of experience in battery recycling, and typically processes about 5,000 tons of nickel-based batteries per year. (See also www.inmetco.com)

There is additional capacity for increase as total nickel containing raw material throughput is in excess of 60,000 tons per annum. Thus, there is ample recycling capacity as the ZEBRA battery production is ramped up. The present MES-DEA production facility has been planned with a maximum production capacity of 3,000 batteries per year.

Even at full capacity amounting to 5,400 tons per year, the quantity of spent batteries accumulating annually should be measured in hundreds of tons, which is well within the recycling capability.

High-value nickel powder from a primary source is used to manufacture the ZEBRA battery. At the end of its life, the nickel is converted into a constituent of re-melt alloy used in the manufacture of stainless steel around the world.
One of the weak links in any recycle process is the collection of the spent units at the end of life. In the case of the ZEBRA battery, European customers are required to return old ZEBRA batteries to MES-DEA. After removal of the management electronics, the cells are packaged in their case ready for shipping to Inmetco.

A 20 kWh ZEBRA battery weighs about 200 kg. In future, complete battery packs could be shipped for recycling. One weakness in any recycling scheme is the cost of collection, transport and processing. For ZEBRA batteries, there is sufficient value to cover the transport costs to Inmetco and the cost of their processing.

The net worth of the nickel ensures that the entire recycle process is cost-neutral. So with the ZEBRA battery, there is no additional recycling cost in addition to the purchase price.

7.0 Project Synopsis

7.1 Software Lessons Learned

During the LSDA software development phase it became apparent that designing an interface to pull data from the battery computer system was going to be problematic due to the proprietary nature of software design. While not impossible, the option to make changes to the battery software program was considered costly and providing only a short term fix.

This was an important concern, since with any pilot project there has to be a cost/time balance when making changes and enhancements to ensure the overall project success. It was decided that making changes to a proprietary software system was too costly in terms of price/time and was going to severely limit the project's success. Two other options were explored:

a) Redesign the battery software component from the ground up to a non-proprietary software solution

   Advantages:
   - Future interface changes/enhancements can be developed quickly and cost effectively.
   - Not tied to one vendor for future changes/enhancements.

Disadvantage:

- Delay to the start of the Pilot Project due to the redevelopment of battery software.
- Cost to redesign battery software was not planned or budgeted for.

b) Use the existing two electronic meters that could provide the basic battery information (via a modem hook-up).

Advantage:

- No additional cost.
- No delays in the start of the pilot project.

Disadvantage:

- The electronic meters provide only the basic information of hour and electricity used, while the battery software system had very detailed stats/information for the entire battery system.
- Meter information is provided via an FTP site, so no direct interface provided.

Option (b) provided the best cost solution and flexibility for the pilot project, and has resulted in no significant project delays.

7.2 Battery Lessons Learned

Success: in the opinion of Halton Hills Hydro, the system works as it should and rates as an unqualified success. While load-shifting installations have been built before, this is the first time such a project has been implemented with such an environmentally friendly and low-cost battery.

Scalability: while this project involved five ZEBRA batteries, the installation is easily scalable both up (for manufacturing plants, utilities) and down (for residential use). While the installations vary in scale, the control system remains the same; only the battery footprint could change as the number of batteries changes.

Battery Weight: installations that stack a number of batteries on top of each other should ensure that the supporting floor can take the weight.

7.3 Electrical System Lessons learned

Installation: project installation was straightforward, and went as planned. There were no significant problems, and minor issues were easily resolved. Total elapsed time for the installation was approximately five days.

Power Outages: the main system problem was local power outages such as fluctuations and sags. Since the pilot system was designed to shut down in response to any type of outage, each shutdown required a manual startup.

While inconvenient, this problem is fixable, and various options are under consideration.

Governmental Approval: the installation required the approval of Ontario's Electrical Safety Authority (ESA), which is responsible for public electrical safety in Ontario. ESA was brought in after the installation was fully operational.

Since this was a unique installation of highly-customized equipment, there was no precedent for approval. ESA classified the installation as a "non-utility generator" (NUG), an electricity generation facility not owned by a public utility.

The main issue was how the installation connected to the local grid, given that the installation both charges and discharges electricity. ESA required safeguards to prevent the discharge of power when the local grid was out.

The ESA Notice of Alterations included items that specified the use of particular equipment (such as circuit breakers and fuseholders) to satisfy the Ontario Electrical Safety Code. Each alteration was completed to the satisfaction of ESA inspectors.

Since each installation is a custom job, we recommend that the local electrical approval body be brought in once the installation is up and running. As more jurisdictions become familiar with NUG installations, approval will likely become easier over time. In cases where customized components are being manufactured for an installation, it would probably save time to involve the local electrical approval body at the manufacturing stage.

7.4 Summary

The success of using the existing electronic meters to provide the basic information for the load shifting project has resulted in the planned redesign of the proprietary battery system control software can be moved to Phase Three of the project.

ESA approval did interrupt the project schedule due to the number of changes that were requested and not planned for. However, this was mainly due the uniqueness of the installation. It is also clear that having ESA's involvement earlier on in the installation would have be advantageous and facilitated the approval process.

8.0 Load Shifting Next Step (Phase Two Plan)

8.1 Software/User Interface Enhancements

8.1.1 Web Enabled (Version 4)

Port/Publish//Host the Dashboard application website that requires a valid username/password for user access.

The Load Shifting Dashboard Application (LSDA) is Flash-based and can currently run standalone in a web browser. However, one of the project's short-term goals is to prove the concept, and then make the technology available to other local distribution companies (LDCs), government agencies, and large commercial customers. In order to achieve this goal ***secure access*** must be made available to interested parties for the purpose of research and investigating the progress on the project, and act as a central repository for information gathering.

8.1.2 Dashboard CR1 (V5)

While the dashboard software component provides a wealth of information, statistics, and reports on the Load Shifting project, it would be beneficial to also include an interactive Learning Center Page (LCP).

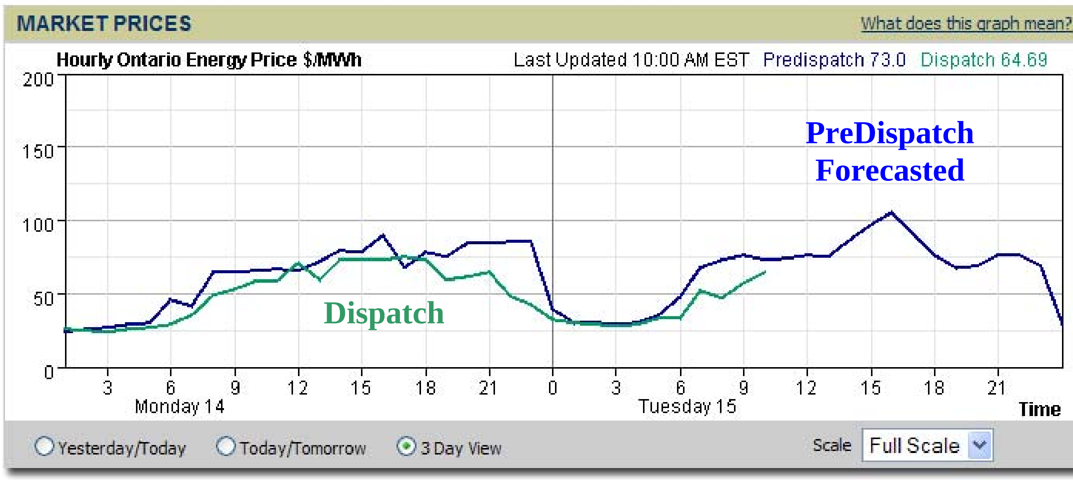
An additional learning section on the Flash dashboard application will allow users to learn more on the project by providing information on the equipment used, physical layout/placement, major component diagram, and general theory. This information would be provided by adding interactive 2D/3D illustrations, diagrams, images, and mouse-over events to pop up details describing the selected component. The LCP could also include links to download project white papers and presentations.

8.1.3 Auto IESO Settings (V6)

Incorporate additional software functionality to analyze the latest IESO data in real-time to predict the best times for charging and discharging. This information will then automatically adjust the charging and discharging cycles to increase load shifting efficiencies.

IESO's web site http://www.theimo.com/ provides detailed reports on demand and hourly price (actual and forecast). Currently, in Phase One of the load-shifting project, the charging and discharging times are fixed. However, it would be advantageous to adjust the charging/discharging times based on IESO's pre-dispatch data estimates during a 24-hour period.

The figure below is an example of dispatch and pre-dispatch Hourly Ontario Energy Prices (HOEP). This data can be accessed hourly via the Load-Shifting Dashboard Application (LSDA), and then compared to the current times set for charging/discharging. The LSDA would analysis the current times/prices to forecasted times/prices and then automatically set the optimal times for both the charging and discharging cycles.



■ (blue)	Pre Dispatch (Forecasted)
■ (green)	Dispatch

Above Snapshot taken on May 15 @ 10:00am

The weekly and monthly reports will also reflect the cost savings comparisons to:

- Default Settings
- PreDispatch Settings
- What-If Monthly Scenario

The capturing, storing, and reporting on this data will provide valuable historic information analysis to illustrate the different cost savings methodologies that can be employed and their overall success rate.

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BMI. = Battery Management Interface
ESA. = Electrical Safety Code
EUCAR. = European Car Manufacturers
HHH. = Halton Hills Hydro
HOEP. = Hourly Ontario Energy Prices
IESO. = Independent Electricity System Operator
LCP. = Learning Center Page
LDCs. = Local Distribution Companies
LSDA. = Load Shifting Dashboard Application
PMC. = Power Management Cabinet
SOC. = State of Charge