



## The economic benefits of long cycle life

Long battery cycle life significantly improves user productivity, reduces replacement costs, and delivers lower cost of ownership



### Summary

This white paper describes why it is important to look beyond initial runtime when selecting a battery for notebooks or other portable electronic devices. Conventional lithium-ion batteries fade quickly and usually have to be replaced within twelve to eighteen months. Sonata® is the first and only battery on the market that lasts the lifetime of a typical notebook computer – delivering years of consistently high performance. With Sonata you save money over the long term while enjoying years of convenience and productivity.



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### Introduction

When purchasing a battery, notebook users often focus on runtime—the length of time a notebook can run before its battery has to be recharged. Runtime<sup>1</sup> is governed by capacity—the amount of energy a battery can store. The greater a battery's capacity, the longer a notebook can run before the battery has to be recharged. Battery manufacturers often tout advances in battery capacity when introducing new products to the market.

But it turns out a battery's initial capacity may be a poor indicator of its long-term performance. In reality, there is much more to selecting a rechargeable lithium-ion battery.

Buyers must also consider:

- **Capacity retention** – How will the battery perform over time? Will it maintain enough of its original capacity so mobile users can work productively, even after several months or years of use?
- **Service life** – Will the battery last the entire lifetime of the notebook? When will it have to be replaced?
- **Total cost of ownership (TCO)** – What are the total battery costs over the entire lifetime of the notebook, once replacement costs are factored in?

By evaluating battery performance more fully, consumers and businesses can make more informed purchasing decisions, save money over the long run, and enjoy years of productivity from a single battery.

<sup>1</sup> Many variables influence battery runtime—battery capacity, hard drive settings, display brightness, network connections and functions being performed (videos, spreadsheets, graphics, etc.).



## Understanding battery performance

To fully evaluate battery performance, many characteristics must be taken into account beyond just initial capacity:

- **Fade** – how rapidly battery capacity is lost as it is cycled (charge/discharge cycles). As batteries fade they have to be recharged more frequently. Fade leads to loss of productivity (you can't work for the entire duration of a flight using a single battery), and inconvenience (you have to carry spare batteries or carry power supplies and find access to an electrical outlet).

Over time, all rechargeable batteries eventually lose their ability to hold charge, but conventional lithium-ion batteries have greater fade rates—noticeably after just 100 charges. The higher the initial capacity of the battery, the greater the fade rate.

- **Cycle life** – the total life expectancy of a battery, expressed in the number of charge/discharge cycles. Conventional rechargeable lithium-ion notebook batteries have a useful cycle life of only 200-300 cycles. After 200-300 charges they retain less than 80% of their original capacity and may have to be replaced, depending on the user's level of dissatisfaction.
- **Service life** – the total life expectancy of a battery, expressed in time. Most lithium-ion batteries last only about a year<sup>2</sup>, depending on the user profile. In fact according to a Harris Interactive<sup>®</sup> market study<sup>3</sup>, 40% of consumers who have owned a notebook for three years or longer have replaced the battery as many as five times.
- **Cumulative runtime** – the collective runtime delivered by the battery over its entire service life. Conventional lithium-ion batteries deliver a cumulative runtime of about 800-1200 hours (assuming an average runtime of 4 hours per charge and a cycle life of 200-300 charge cycles).

<sup>2</sup>For active business users who charge their notebooks 200-300 times per year. Typical consumers and less active business users can expect a service life of around 18 months.

<sup>3</sup>September 2008 Harris Interactive<sup>®</sup> Poll.

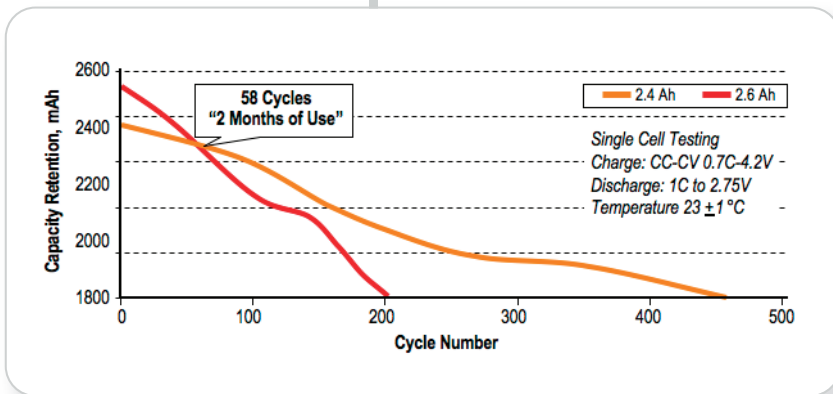


### The myth about battery capacity

While manufacturers often promote advances in battery capacity, the advantages of high capacity batteries are short-lived. As Chart 1 illustrates, greater initial capacity does not translate to improved service life or sustained capacity over the long term.

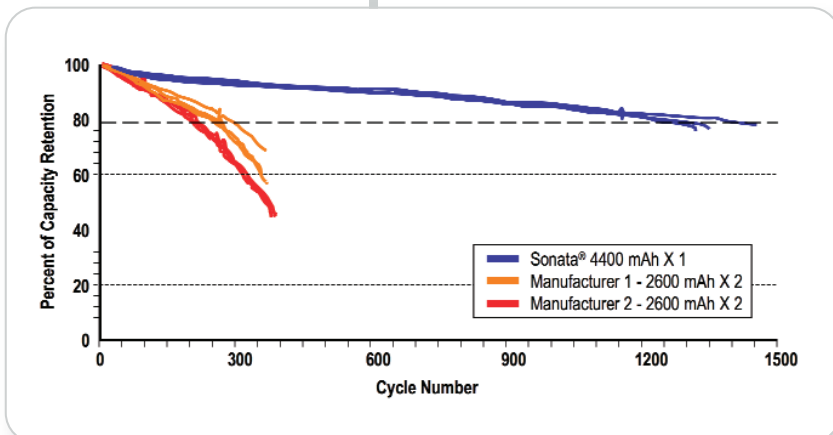
Boston-Power tested Sonata against two industry-standard, high quality, 2.6 Amp-hour cells in order to compare capacity retention. The tests showed that the 2.6 Amp-hour cells faded more rapidly and reached the end of their service life (80% of original capacity) in approximately 200 charge cycles. In stark contrast, Sonata maintained 80% of its original capacity even after over 1000 charge cycles (Chart 2).

**Chart 1: Commercial 18650 Capacity Retention Test**



Higher capacity conventional batteries offer shorter service lives and fade more quickly.

**Chart 2: Sonata Compared to Higher Capacity Batteries**



Sonata outperforms higher capacity batteries and offers longer service life.



### Sonata®—the industry’s highest performing rechargeable lithium-ion battery

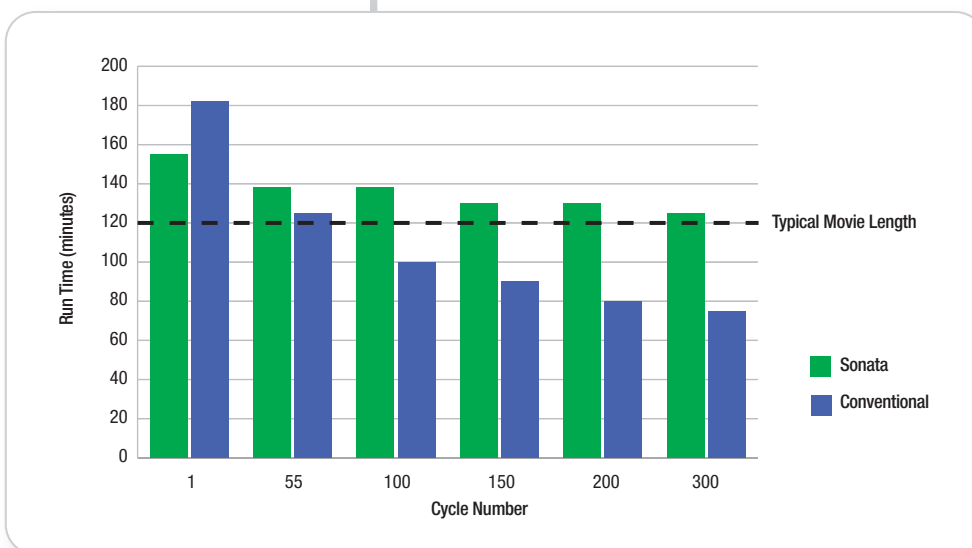
With its patent-pending battery chemistry and innovative design, the Sonata rechargeable lithium-ion battery offers consistently high performance over the lifetime of a typical notebook computer. Sonata users enjoy years of added convenience and productivity with industry-leading total cost of ownership. Sonata offers:

- **Extended capacity retention** – While conventional lithium-ion batteries begin to fade noticeably after only 100 charges, Sonata retains 80% of its capacity after over 1000 charges—enhancing user productivity (work for longer periods of time using a fully-charged battery), and convenience (carry fewer spare batteries or other power sources).

To help demonstrate capacity retention and user productivity in practical terms, Boston-Power performed DVD runtime tests comparing Sonata to conventional lithium-ion batteries. The test simulated the experience of a notebook user watching a movie on a long flight by measuring how long a fully-charged battery powered a notebook DVD-ROM drive (runtime). For the test, a DVD is played continuously until the notebook battery is fully discharged. The battery is fully recharged and the test is repeated over and over to measure the battery’s ability to retain charge over its cycle life (see Chart 3).

The test illustrates just how quickly some conventional batteries fade. As Chart 3 shows, with a conventional battery, DVD runtime drops from 180 minutes for a new battery, to less than 130 minutes for a battery that has been charged 55 times. And after just 100 charge cycles, the runtime is reduced to just 80 minutes, meaning that midway through the movie the user has to power down the notebook, install a spare battery, and then reboot the notebook to watch the remainder of the movie.

Chart 3: DVD Runtime Test



While some conventional batteries fade quickly, Sonata delivers high performance even after 300 charge cycles—in this test allowing you to watch 300 movies using the same battery.



On the other hand, Sonata continues to deliver 120+ minutes of runtime—the entire duration of a typical feature-length film—even after 300 charge cycles or about a year of typical use. And since Sonata has been found to maintain 80% of capacity after 1000 charge cycles, it would allow you to watch 300 movies using the same battery.

- **Long cycle/service life** – While conventional batteries have to be replaced after about a year, Sonata offers a service life of three years or longer (depending on use) —the entire lifetime of a typical notebook. As a testament to its long service life, notebook PC manufacturers such as HP can offer industry-leading three year warranties on their notebook batteries based on Sonata.
- **Long cumulative runtime** – Cumulative runtime is a direct measure of battery performance. While conventional lithium-ion batteries offer a cumulative runtime of about 800-1200 hours, Sonata delivers a cumulative runtime of over 4000 hours<sup>4</sup>, making it the industry's highest performing rechargeable lithium-ion battery by a significant margin.
- **Low total cost of ownership (TCO)** – With a service life of three times the industry average, Sonata reduces battery replacement costs and delivers a total cost savings of 60%—or greater—over a three year period compared to conventional lithium-ion batteries<sup>5</sup>. As Table 1 illustrates, with Sonata, consumers can save hundreds of dollars in battery replacement costs over a notebook's lifetime. Businesses can also save thousands of dollars a year or more by selecting Sonata for their employee notebooks.

### **Boston-Power—the lithium-ion battery authority**

At Boston-Power, lithium-ion batteries are our sole focus. Our world-class scientists and engineers are recognized industry experts who are fully devoted to battery research, development, and production. With over 60 patents pending, our unique battery chemistry and innovative designs yield the most eco-friendly and highest performing solutions available on the market today. With Sonata, users don't have to choose between battery performance and the environment. With Sonata, users enjoy industry-leading performance while doing their part to protect the environment and preserve resources for future generations.

<sup>4</sup> Assumes average runtime of 4 hours and cycle life of 1000 cycles.

<sup>5</sup> Assumptions: Sonata-based lithium-ion notebook battery sell price = \$150, service life = 3 years, 3 yr TCO = \$150. Conventional lithium-ion notebook battery sell price = \$130, service life = 1 year, 3 yr TCO = \$390. TCO includes the cost of the original battery included with the notebook purchase (Sonata or conventional battery).



**Table 1: Total Cost of Ownership Comparison Costs**

**3 Year Total Cost of Ownership (TCO) for Heavy Users**  
(Assumes 1 year service life for conventional battery)

		# of Notebooks Used by Business				
		1	100	1,000	5,000	10,000
<b>Total # Notebook Batteries</b>	Conventional	3	300	3,000	15,000	30,000
	Sonata	1	100	1,000	5,000	10,000
<b>TCO</b>	Conventional	\$390	\$39,000	\$390,000	\$1,950,000	\$3,900,000
	Sonata	\$150	\$15,000	\$150,000	\$750,000	\$1,500,000
<b>Savings</b>	w/Sonata	\$240	\$24,000	\$240,000	\$1,200,000	\$2,400,000

**3 Year Total Cost of Ownership (TCO) for Occasional Users**  
(Assumes 18 month service life for conventional battery)

		# of Notebooks Used by Business				
		1	100	1,000	5,000	10,000
<b>Total # Notebook Batteries</b>	Conventional	2	200	2,000	10,000	20,000
	Sonata	1	100	1,000	5,000	10,000
<b>TCO</b>	Conventional	\$260	\$26,000	\$260,000	\$1,300,000	\$2,600,000
	Sonata	\$150	\$15,000	\$150,000	\$750,000	\$1,500,000
<b>Savings</b>	w/Sonata	\$110	\$11,000	\$110,000	\$550,000	\$1,100,000





### Sonata—the clear choice in battery performance

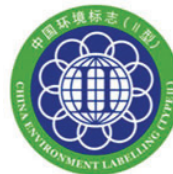
When all aspects of battery performance are considered, Sonata far exceeds conventional lithium-ion solutions on the market today. Compared to conventional batteries, Sonata maintains capacity longer and does not have to be replaced after a year of use. Only Sonata offers:

- **Extended capacity retention** – Sonata maintains 80% of capacity for 1000 or more charge cycles for unparalleled convenience and productivity.
- **Long service life** – Sonata lasts the lifetime of a typical notebook computer – boasting a service life that is at least triple the industry average.
- **Market-leading cumulative runtime** – Sonata outperforms every other lithium-ion battery on the market – delivering a cumulative runtime of over 4000 hours over its 3+ year service life.
- **Industry-leading total cost of ownership** – Sonata reduces battery replacement costs and delivers a total savings of 60% or greater over a three year period compared to conventional lithium-ion batteries.

Sonata is the clear choice for consumers and businesses who want to save money over the long run while enjoying years of convenience and productivity from a single high-performance battery.

### Extended service life minimizes environmental impact

Sonata's extended service life reduces waste plus conserves natural resources and non-renewable materials (lithium, copper, nickel, etc.) consumed in the manufacturing process. Sonata is the only rechargeable lithium-ion battery to receive the coveted Nordic Ecolabel and China Environmental United Certification Center (CEC) Ecolabel certifications for environmental sustainability. These accreditations ensure products meet strict environmental guidelines and let consumers know they are purchasing environmentally-sound products.





## Glossary

**Battery** – a collection of lithium-ion cells governed by electronics packaged together to power portable electronic devices, such as notebook PCs. Also referred to as a battery pack.

**Capacity** – a measure of the amount of energy that a battery can deliver in a single discharge, normally listed in amp-hours or watt-hours. Over time, all rechargeable batteries eventually lose their ability to retain their original capacity. Sonata batteries are designed and built to retain 80% of their original capacity over three years (assuming 300 cycles per year)—the typical useful life of a notebook computer. Most conventional lithium-ion batteries can only retain 80% capacity for 200-300 cycles.

**Cell** – an electrochemical device capable of storing electrical energy. Notebook batteries contain cells and other components.

**Cumulative Runtime** – the collective runtime delivered by the battery over its entire service life. Conventional lithium-ion batteries deliver a cumulative runtime of about 800-1200 hours. Sonata delivers a cumulative runtime of over 4000 hours.

**Cycle Life** – the total life expectancy of a battery, expressed in charge/discharge cycles. A conventional lithium-ion battery has a typical cycle life of 200-300 charge/discharge cycles. Sonata has a typical cycle life of at least 1000 charge/discharge cycles.

**Fade** – to lose the ability to maintain battery charge. Over time all batteries eventually lose their ability to hold charge. Conventional batteries begin to fade after just a hundred or so charges. Sonata retains its ability to maintain charge longer than conventional batteries, allowing users to enjoy several years of long battery runtime.

**Lithium-ion Battery** – a rechargeable battery commonly used in portable computers and other consumer electronics.

**Retention** – a battery's ability to maintain charge. Over time all rechargeable batteries eventually lose their ability to retain charge. Conventional batteries retain less than 80% of their original capacity after 200-300 charge cycles. Sonata retains 80% of original capacity even after 1000 charge cycles.

**Runtime** – the amount of time a notebook can run before its battery needs to be recharged— usually about four hours for a new battery depending on individual notebook settings.

**Service Life** – the total life expectancy of a battery, expressed in time. A conventional lithium-ion battery has a typical service life of about a year. Sonata has a typical service life of at least three years.



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BOSTON-POWER WHITE PAPER: THE ECONOMIC BENEFITS OF LONG CYCLE LIFE

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