FirstLink

The Department of Defense National Center of Excellence for First Responder Technology Transfer

Battery Charger and Power Reduction System and Method

Market Overview

Naval Surface Warfare Center (NSWC)—Crane Division

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Executive Summary

A general overview of the Battery Charger and Power Reduction System and Method (Battery Charger) and prospective market opportunities is provided by this assessment. Potential markets are defined, quantified, and market drivers and influences are explored. This assessment identifies four primary markets examined within which the Battery Charger may find relevance including, but not limited to the: *military market*, *civilian first responder market*, *portable consumer electronics market*, and *electric vehicles market*. Initial pricing analysis is performed based upon the cost estimates associated with the prototype version of the Battery Charger. Below is a summary of the information relayed within the full assessment.

<u>Technical Synopsis</u>

The Naval Surface Warfare Center (NSWC)—Crane Division has invented a Battery Charger and Power Reduction System and Method (Battery Charger) covered by United States Patent 7,573,235 B2. The Battery Charger is a shunt-type, lithium-ion battery-charging device that is designed to reduce the likelihood of overcharging and the possible deleterious effects (and cooling requirements) that are associated with the generation of heat during the charging process. The limitations of three types of battery chargers, existing as prior art, prompted the invention of this shunt-type charger that is claimed to control the amount of power being used by the battery-charger by monitoring the batteries' level of charge during charging, and by correspondingly reducing the magnitude of the charging current in response to such a monitored level [1]. The Battery Charger may then offer the following prospective advantages:

- Extended battery life
- Decreased likelihood of overcharging
- Increased efficiency of operation
- Decreased generation of heat
- Eliminated need for supplemental cooling components
- Flexibility to charge different types of lithium-ion batteries, as well as ones with differing states of charge
- Precision of charging

The patent provides a brief background on the limitations of existing solutions that prompted the invention of the system. This assessment expands upon that background and provides a brief background on battery chargers so that the prospective advantages of the Battery Charger and the relevance of these advantages can be better understood.

1 Hand, Evan C. United States Patent 7,573,235 B2. 11 Aug 2009. Web July 2010.

Markets and Competitive Landscape

In defining and quantifying markets, focus is placed on the existence of prospective end users, dollars spent on batteries, the number of devices in use that rely on portable power, and industry revenues. Existing battery charger solutions within the military, civilian first responder, portable consumer electronics, and electric vehicle market will serve as competition for the Battery Charger and Power Reduction System and Method (Battery Charger). This assessment found that the marketplace is rather saturated with battery chargers that have significantly lower price points than the Battery Charger at hand. Further, the prospective advantages associated with the Battery Charger may not outweigh the additional cost in most markets. Industry composition analysis found that while a total of 11 out of 1,003 firms classified under North American Industry Classification System (NAICS) code 335999 “All Other Miscellaneous Electrical Equipment and Component Manufacturing” are not considered small businesses, only 21.5% of the value of shipments in 2002 came from the eight largest firms. This may mean that concentration in this industry is low[2].

In addition to broad industry characterizations, *smart chargers* and *other types of chargers* are reviewed as potential substitutes for the Battery Chargers. Products in these categories are examined in comparison to the present invention.

Conclusion

Based upon the functionality and prospective advantages of the Battery Charger and Power Reduction System and Method (Battery Charger), some markets may prove more viable than others. In light of initial pricing and competitive analysis, the military and electric vehicle charging markets may enjoy the most benefit from the Battery Charger’s prospective advantages.

$4,000 per charger could be a considerable upfront investment, however, in high use situations with multiple batteries/cells (ie: military or electric vehicles), a return on this investment could be achieved, especially when precision and reliability are of concern. Additionally, the superior efficiency of the Battery Charger would be an advantage in the case of high use, furthering the cost savings for electricity. First responders could most likely benefit from using the Battery Charger as well, but it is unknown as to whether there would be a willingness and ability to make such a large upfront investment. Further, the portable consumer electronics market is especially saturated with relatively low cost batteries (averaging $27) and chargers (averaging $14.50). The average consumer would be better off simply purchasing a new battery than making a large upfront investment to only extend battery life incrementally. With that said, a recommendation of pursuing one market or another is not given, but the observations within this report may provide substantial data for one to make such a decision.

[2] http://www.census.gov/prod/ec02/ec0231i335999t.pdf

1 Introduction

The Naval Surface Warfare Center (NSWC)—Crane Division has invented a Battery Charger and Power Reduction System and Method (Battery Charger) covered by United States Patent 7,573,235 B2. The Battery Charger is a shunt-type, lithium-ion battery-charging device that is designed to reduce the likelihood of overcharging and the possible deleterious effects (and cooling requirements) that are associated with the generation of heat during the charging process. The limitations of three types of battery chargers, existing as prior art, prompted the invention of this shunt-type charger that is claimed to control the amount of power being used by the battery-charger by monitoring the batteries' level of charge during charging, and by correspondingly reducing the magnitude of the charging current in response to such a monitored level [3]. The Battery Charger may then offer the following prospective advantages:

- Extended battery life
- Decreased likelihood of overcharging
- Increased efficiency of operation
- Decreased generation of heat
- Eliminated need for supplemental cooling components
- Flexibility to charge different types of lithium-ion batteries, as well as ones with differing states of charge
- Precision of charging

The invention of the Battery Charger was prompted by the limitations of battery chargers existing as prior art. The Battery Charger works to overcome those limitations by using a unique algorithm to actively change the charging current. This assessment examines the following potential applications:

- Charging Batteries in Combat Situations
- Charging Batteries in First Responder Situations
- Portable Consumer Electronics Battery Charging
- Electric Vehicle Battery Charging

This assessment also looks at the potential corresponding markets to these applications in which the prospective advantages of the Battery Charger may find relevance. These potential market characterizations include:

- Military
- Civilian First Responder
- Portable Consumer Electronics

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3 Hand, Evan C. United States Patent 7,573,235 B2. 11 Aug 2009. Web July 2010.

- Electric Vehicle

Further, additional factors impacting the technology's technical merit and market viability are explored. The report is broken down into the following main sections:

- Technical Synopsis
- Applications
- Markets
- Competitive Landscape
- Cautions and Considerations

While this report is not undertaken to recommend one action over another, the information contained herein should provide substantial data to make certain decisions.

2 Technical Synopsis

The Naval Surface Warfare Center (NSWC)—Crane Division has invented a Battery Charger and Power Reduction System and Method (Battery Charger) covered by United States Patent 7,573,235 B2. The Battery Charger is a shunt-type, lithium-ion battery-charging device that is designed to reduce the likelihood of overcharging and the possible deleterious effects (and cooling requirements) that are associated with the generation of heat during the charging process. The limitations of three types of battery chargers, existing as prior art, prompted the invention of this shunt-type charger that is claimed to control the amount of power being used by the battery-charger by monitoring the batteries' level of charge during charging, and by correspondingly reducing the magnitude of the charging current in response to such a monitored level [4].

2.1 Prior Art

As mentioned, United States Patent 7,573,235 B2 mentions three battery chargers that are known as prior art. These differing types of battery chargers emerged due to rechargeable batteries being produced in a variety of shapes and sizes. The cost savings realized by using rechargeable batteries is one of the main reasons they have become so popular. Before examining prior art, a brief review of different batteries and battery chemistries is provided.

A primary cell or battery is one that cannot easily be recharged after one use, and is discarded following discharge. Most primary cells are termed dry cells that utilize electrolytes that are contained within absorbent material or a separator (i.e. no free or liquid electrolyte), and are thus termed dry cells[5].

A secondary cell or battery is one that can be electrically recharged after use to their original pre-discharge condition, by passing current through the circuit in the opposite direction to the current during discharge. The following graphic evidences the recharging process. This assessment is concerned with secondary batteries[6]. Charts of primary and secondary battery chemistries and their advantages and disadvantages is provided below[7].

4 Hand, Evan C. United States Patent 7,573,235 B2. 11 Aug 2009. Web July 2010.
[5] http://depts.washington.edu/matseed/batteries/MSE/classification.html
[6] Ibid.
[7] http://www.nexergy.com/media/pdfs/batterychemchart.pdf

Primary (Non-Rechargeable)

Battery	Voltage	Energy Density	Advantages	Disadvantages
Alkaline	1.5v	125Wh/kg 400Wh/L	Long shelf life, low in cost with a reasonable drain rate making these batteries attractive for everyday applications.	Poor low temperature performance batteries with high impedance
Lithium iron disulfide	1.5v	310Wh/kg 560Wh/L	Patented lithium technology from Energizer® used in industrial pplications such as asset tracking due to its excellent rate capability and low temperature discharge capability (down to –40°C). Shelf life to 15 years.	Voltage is half of other lithium primary chemistries resulting in more cells required in series to get desired voltage. Subject to shipping regulations.
Lithium Manganese dioxide	2.9v	240Wh/kg 500Wh/L	Batteries that offer high energy density, extremely long life, a wide operating temperature and excellent durability, offering much higher energy density than alkaline.	Subject to shipping regulations
Lithium Sulfur Dioxide	2.8v	265Wh/kg 400Wh/L	Batteries that share lithium primary advantages, with high rate capabilities performing well at low temperatures.	Subject to shipping regulations.
Lithium Thionyl Chloride	3.6v	520Wh/kg 1050Wh/L	Batteries that share lithium primary advantages. The highest energy density of all Lithium types. Life-span 15 to 20 years.	Subject to shipping regulations.

Secondary (Rechargeable)				
Battery	**Voltage**	**Energy Density**	**Advantages**	**Disadvantages**
Nickel Cadmium	1.2v	90Wh/kg 210Wh/L	Robust and inexpensive, NiCD batteries are used for applications in which long life, high power and extended temperature range are of importance.	Potential threat of voltage depression ("memory effect") and the fact that NiCD batteries contain toxic cadmium (which requires recycling), have made them less popular.
Nickel Metal Hydride (NiMH)	1.2v	125Wh/kg 400Wh/L	Can have capacities as much as 90 percent higher than equivalent size NiCD cells. Less "memory effect" and environmentally safe and lighter in weight.	A slightly lower cycle life needing more sophisticated charge control. In relation to equivalent cell sizes, the cost for NiMH is more than that for NiCD, but the cost per Wh is the same or less.
Lithium Ion (Li-ion)	3.6v	240Wh/kg 550Wh/L	This high energy density battery's chemistry reduces the cell's weight by half and the volume by 20 to 50 percent. The self-discharge rate is less than half that of nickel-based chemistries with no "memory effect."	Rechargeable Li-ion cells are more expensive than both NiCD and NiMH. They also require protection circuitry to keep voltage and current within safe levels. All lithium-based chemistries are subject to shipping regulations.
Lithium Ion Polymer (Li-Polymer)	3.6v	260Wh/kg 540Wh/L	These batteries have greater energy density in terms of weight than Li-ion with more flexibility in cell sizes and shape with a wider margin of safety, superior stability in over-voltage and high temperature conditions.	These batteries command a slight premium price. The cells require protection circuitry. They are also Subject to shipping regulations.

Lithium Ion Iron Phosphate	3.3v	108Wh/kg 220Wh/L	Long life cycle, high rate capability, and best in terms of safety	These batteries are low energy density compared to conventional Li-ion chemistries

This assessment now examines three battery chargers, as well as one shunt-style charger, as prior art to highlight the functionality and prospective advantages of the Battery Charger and Power Reduction System and Method (Battery Charger) examined in the next two sections of this Technical Synopsis.

The first battery charger reviewed as prior art is a low-charge rate charger, which relies on user management of the charge control and termination. As long as the charger is plugged in and the batteries are installed, the charger will charge the batteries. These chargers are usually the least expensive, however charge time can take upwards of 12 hours to complete. Slow charging is usually good for battery life cycle, and low charge rates can limit the effects of overcharging. However, it is important to note that this method is user dependent, so batteries can overcharge if not managed properly by the user[8].

The second type of battery charger mentioned in the patent is a timed charger, which stops the main charge at a predetermined time. Some timed chargers will use a trickle charge (very low charge rate) to top off the batteries or maintain their full charge, following the shut off of the main charge. These chargers are similar to low-charge rate charges in that they are typically inexpensive, use a slow charge which is usually good for battery cycle life, and uses low charge rates which can limit the effects of overcharging. Timed chargers can also require lengthy charge times, usually greater than five hours, since they use low charge rates. However, the timed charger is not dependent upon the user and eliminates the need to monitor charge time due to the timer. There are a few limitations of this type of charger, nevertheless. For example, if power is lost and the timer is reset, overcharging can occur. Also, the timed charging cycle may complete before the batteries are fully charged. Overcharging or undercharging may also occur based on battery capacity vs. charger design. Finally, the timed charger does not include circuitry to monitor the batteries[9].

Rapid chargers are another type of charger that falls within prior art and can also be known as quick chargers. These chargers typically charge batteries within three to six hours and then switch to a trickle charge. Charge time and price point fall in the middle of the continuum of battery charges. This charger uses a higher charge rate and therefore may be more susceptible to overcharging and ruining a battery[10].

[8] http://data.energizer.com/PDFs/charger_appman.pdf
[9] http://data.energizer.com/PDFs/charger_appman.pdf
[10] Hand, Evan C. United States Patent 7,573,235 B2. 11 Aug 2009. Web July 2010.

Based upon the limitations of these chargers, shunt style charging circuits were invented to clamp the charging voltage of each series connected battery to a “precise” predetermined voltage setting. These circuits hold each battery’s voltage constant at the predetermined level by shunting excess current around each series connected battery. In other words, these chargers are able to achieve precise charge voltage levels and are less susceptible to overcharging batteries. They are also rather inexpensive to build. However, the typical shunt circuits are rather inefficient because the power that is dissipated through shunting is wasted. They may also use higher power levels which can shorten the life of the associated electronic circuitry and may add supplemental cooling requirements. It was these limitations that prompted the invention of the Battery Charger explored in the next section. Additional information on other types of chargers is provided in Appendix A. These four forms of prior art are summarized in the chart below.

Prior Art			
Name	**Function**	**Advantages**	**Disadvantages**
Low Charge-Rate Charger	Slow charge	• Least expensive • Good for battery life cycle • Limited effects of overcharging	• Relies on user management for charge control and termination • Can take up to 12 hours to charge
Timed Charger	Slow charge	• Stops the main charge at a predetermined time • Good for battery life • Limited effects of overcharging • Does not rely on user management for charge control and termination	• Can require lengthy charge times, 5+ hours • When power is turned off, timer is reset and overcharging can occur • Charging cycle may complete prior to full charge • Does not include circuitry to monitor the batteries
Rapid Charger	Fast charge	• Charges in 3-6 hours, before switching to trickle charge	• Relies on user management for charge control and termination • Bad for battery life • High effects of overcharging
Shunt Style Charger	Control charge	• Achieves precise charge voltage levels • Limited effects of overcharging • Inexpensive to build	• The power dissipated through shunting is wasted • Can shorten the life of associated electronic circuitry • May add supplemental cooling requirements

2.2 Battery Charger and Power Reduction System and Method (Battery Charger)

The Naval Surface Warfare Center (NSWC)—Crane Division has invented a Battery Charger and Power Reduction System and Method (Battery Charger) covered by United States Patent 7,573,235 B2. The Battery Charger is an improved shunt-type, lithium-ion battery-charging device that is designed to reduce the likelihood of overcharging and the possible deleterious effects (and cooling requirements) that are associated with the generation of heat during the charging process. The limitations of three types of battery chargers, existing as prior art, prompted the invention of this shunt-type charger that is claimed to control the amount of power being used by the battery-charger by monitoring the batteries' level of charge during charging, and by correspondingly reducing the magnitude of the charging current in response to such a monitored level [11].

The Battery Charger at hand presents a more precise and efficient shunt-type battery charging device that is claimed to alleviate some (if not all) of the problems associated with current charging devices. These problems as mentioned in the prior art section of this technical synopsis include, but are not limited to; overcharging, undercharging, inefficiency of operation, lengthy charge time, and the possible deleterious effects (and cooling requirements) associated with the generation of heat during the charging process.

Battery Related Term	Definition
Overcharging	Overcharging a battery occurs when the total capacity removed has been replaced by recharging and the battery remains on charge. In other words, it is the forcing of current through a cell after all of the active material has been converted to the charged state.[12] This overcharging creates excessive heat which can cause the battery plates within the cells to buckle and shed their active material.[13]
Undercharging	Undercharging occurs when an insufficient charge is delivered to the battery.
Inefficiency of Operation	When the battery if overcharged, it results in excessive heat created between the cells of the battery. This will eventually lead to a breakdown of the battery life and efficiency of its operation. Shunt-style chargers often deliver currency that is dissipated, as opposed

11 Hand, Evan C. United States Patent 7,573,235 B2. 11 Aug 2009. Web July 2010.
[12] http://data.energizer.com/PDFs/charger_appman.pdf
[13] http://www.virtualtechnologiesltd.com/FAQs/Battery%20FAQ.htm?PHPSESSID=17f7b8cab5167fc6737d0b2d890c358e#6

	to giving charge to the battery. This dissipation leads to wasted energy while the battery is still connected to the charge.
Lengthy Charge Time	When a slow charge is used in the charging of a battery it often results in a lengthy charge time. This is when the device being charged must be left to charge for extensive periods of time and can often result in overcharging.
Deleterious Effects	Overtime, any of the above issues will lead to the eventual deterioration of the battery. Excessive heat and insufficient charges cumulatively contribute to the breakdown of the life span of the battery.

2.3 Components

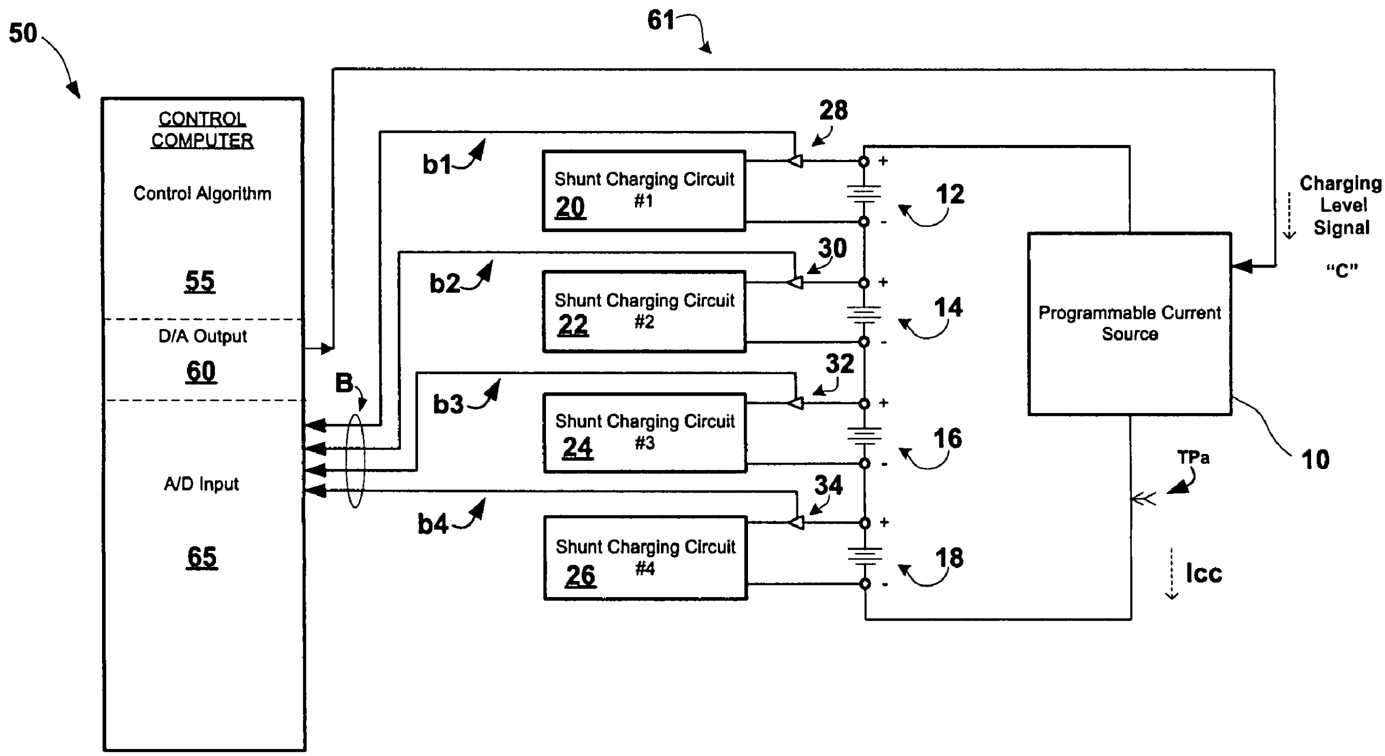
The Battery Charger and Power Reduction System and Method (Battery Charger) claims to eliminate some (if not all) of the issues presented in the previous section of this technical synopsis. This stems from its main functionality of actively changing the charging current. This functionality is further highlighted through a review of the components of the present invention. It is important to note that there are complex workings behind the Battery Charger, but this synopsis focuses on the components that contribute to the prospective advantages of the device.
The schematic block diagram below depicts the components of the Battery Charger. According to the patent, "a Programmable Current Source (10) is electrically connected across, and is representationally used to charge four batteries, which have been removably inserted into the battery charging slots (12, 14, 16, 18)." Each charging slot is part of an associated Shunt Charging Circuit. For example, battery charging slot 12 is associated with Shunt Charging Circuit #1 (20). The patent defines battery charging slots as any appropriate, well-known means for operationally connecting a battery to an electrical and/or electronic circuit. Additionally, each Shunt Charging Circuit is a "shunt style" charging regulator that preferably derives all of its operating power from the battery that it is regulating, and may preferably operate independently of each other. The Battery Charger may use a common charging source and commonly available hardware and/or software solutions including, but not limited to, one or more solar cells or solar arrays.

Each Shunt Charging Circuit will have its own internal voltage comparator and be in electrical communication with the Current Sensors (28, 30, 32, 34), which are preferably precision resistances. The Current Sensors "measure" the individual bypass currents from the shunt charging circuits and transmit the signals of these currents (b1, b2, b3, b4), which serve as the inputs to the key functionality to the Battery Charger and Power Reduction System and Method, as well as the Total Bypass Current signal B, back to the A/D Input Device (65) for further processing.

The operation of the Battery Charger (1) is managed by a Control Computer (50) that includes at least one processor or CPU for implementing the Control Algorithm (55) that monitors and controls the power reduction/battery charging process. The Control Computer (50) uses an analog-to-digital (A/D) Input Device (65) for reading and processing analog signals, a digital-to-analog (D/A) Output Device (60) for provide signals for use in controlling the Programmable Current Source (10), and the Control Algorithm (55).

The components of the Battery Charger and their function have been outlined above. Now we look at how these components function together. Rechargeable batteries are inserted in the battery charging slots (12, 14, 16, 18) (if not all slots are occupied, the unoccupied slots can be “jumpered out”). Each used Shunt Charging Circuit (20, 22, 24, 26) senses the voltage of the associated battery, sets (or have set by the Control Computer (50)) the voltage limiting value (which can also be manually set or preset), and transmits a bypass current signal to the A/D Input Device (65) of the Control Computer (50) via the associated Current Sensor (28, 30, 32, 34). The A/D Input Device reads each bypass signal (b1, b2, b3, b4) and saves the readings for further processing. The Control Algorithm (55) processes these signals and then transmits a Charging Level Signal C via the D/A Output Device (60) to the Programmable Current Source (10) in order to set the initial magnitude of the Charging Current Icc. During charging, the Individual Bypass Currents (b1, b2, b3, b4) will be read, saved, and processed in similar fashion, and then a new Charging Level Signal C is transmitted to the Programmable Current Source (10) in order to ***change the charging current***.

It is the two-way transmission of data that allows the charging current to actively be changed via the signals from the D/A Output Device based upon the bypass current signals received by the A/D Input Device. This allows for the charging current to be actively changed instead of simply dissipating current when a battery is full, as most other shunt-style chargers do. The prospective advantages of the Battery Charger stem from this core functionality which is based upon the unique algorithm. In other words, the algorithm is the main source of competitive advantage for the Battery Charger.



2.4 Prospective Advantages

The prospective advantages of the Battery Charger and Power Reduction System and Method (Battery Charger) claimed by United States Patent 7,573,235 B2 are based upon the unique algorithm employed by the device and its core functionality; actively changing the charging current by two-way transmission of data. The prospective advantages stemming from this functionality are outlined below:

Prospective Advantage	Description
Decreased Likelihood of Overcharging	The D/A Output device is able to transmit a new Charging Level Signal C to the Programmable Current Source (10) in order to change the charging current. Therefore the battery should never overcharge and the issues associated with overcharging as previously discussed should be eliminated.
Increased Efficiency of Operation	As the State of Charge (SOC) increases, more and more excess current must be bypassed when using traditional shunt-style chargers. This excess current is typically wasted as heat. The present invention actively decreases the current instead of dissipating (and wasting) it as heat.

Decreased Generation of Heat	Based upon the previous prospective advantage, the current is decreased instead of wasted as heat, meaning less heat is generated during the charging process. The deleterious effects of heat on batteries as previously discussed should then be decreased or eliminated.
Eliminated need for Supplemental Cooling	With less heat being generated during the charging process, the need for supplemental cooling may be eliminated. This also decreases the complexity of the invention, which may also decrease component and manufacturing cost.
Flexible	The Battery Charger is flexible in that it can effectively and efficiently charge not only different devices, but also batteries with different voltages and capacities without overcharging any of the devices.
Portable	The use of a solar panel or solar array as a source of energy makes charging portable. This is particularly useful in the field where a traditional power source does not exist.
Decreased Cost	The increased efficiency in use of power and eliminated need for supplemental cooling decrease the costs associated with recharging batteries.
Precision	The Battery Charger can precisely charge within 1 milli-volt repeatedly.
Reliable	The device is reliable for field use.

2.6 Additional Considerations

2.6.1 Development

The Battery Charger and Power Reduction System and Method is for the most part fully developed. However, the invention may be modified for specific applications in order to meet the needs of the users. This development does not seem to present a significant hurdle because the algorithms, software, and hardware would either stay the same or be available in the form of Commercial Off the Shelf (COTS) parts. There may be a small integration requirement to reconfigure the Battery Charger for different applications. Ultimately, licensees would need to understand the needs and requirements of targeted end-users and modify the device to satisfy those specifications.

3 Applications

Based upon the functional components and prospective advantages of the Battery Charger and Power Reduction System Method (Battery Charger), the core application of the technology is defined as a charging device with the capability of changer multiple devices at one time while distributing the necessary amount of charge that is required and terminating charge when it is complete. This broad application may be relevant to the following, more specific applications, with their corresponding markets (explored in section *4 Markets*) in parentheses

- Charging Batteries in Combat Situations (Military)
- Charging Batteries in First Responders Situations (Civilian First Responder)
- Portable Consumer Electronics Charging (Portable Consumer Electronics)
- Charging Electric Vehicles(Electric Vehicles)

3.1 Charging Batteries in Combat Situations

The Battery Charger has several aspects that could lead to improvements for the military. One such advantage is the security that would come with a freshly charged battery for the use of the device. Many of the devices used today rely on battery power. When the user is depending on a half drained non-rechargeable battery, they are likely to throw the battery away and opt for a new battery. If the military person has a freshly charged battery for the beginning of each use, they will feel safe going into a combat situation. "Although non-rechargeable batteries offer the highest capacity, the problem is that once a battery is used on a mission, the returning soldier, uncertain of its remaining run time, will replace it with a fresh one rather than take a used battery back out in the field, an understandable action considering the risks associated with running out of battery power. The result is that many of the discarded batteries have sufficient capacity remaining for a second mission, and the loss of this capacity represents a significant cost to the military[14]." Having a newly charged battery, rechargeable or non-rechargeable, is important to mission success. In life and death scenarios the soldiers will always err on the safe side.

There is also a considerable amount of waste involved in using non-rechargeable batteries. When soldiers opt for a new battery and there if still a considerable amount of charge left, money is wasted. "The Army estimates that the batteries are being discarded with 30% to 50% of their energy remaining[15]." There are multi-millions of dollars a year wasted on disregarding of half used batteries. Since many of the items used in combat need charged by battery, it leads to a significant amount of money and resources wasted. "The Army spends over $35 million annually on disposable batteries for equipment such as radios, sensors, and night-vision devices[16]." In effect, almost half of the amount put into the batteries is wasted because of safety.

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[14] http://mobiledevdesign.com/hardware_news/radio_military_takes_aim/
[15] http://mobiledevdesign.com/hardware_news/radio_military_takes_aim/
[16] http://www.almc.army.mil/alog/issues/JulAug02/MS817.htm

There is an incredible amount of savings possible for the use of rechargeable batteries in the military. "One battalion determined that it saved over $600,000 in a 6-month period by using rechargeable batteries and chargers instead of disposable primary batteries[17]." The military could reallocate funds where needed elsewhere if they has an additional $1,000,000 or more per battalion a year.

A list of the different military applications requiring batteries and chargers is given below.

- Aerospace
- Aircraft Instruments
- Missile launching/tracking
- Fire control systems
- Target range equipment
- Gunnery control
- Communications
- GPS
- Thermal imaging
- Night vision
- Surveillance
- Targeting
- Chemical detection
- Search & rescue
- Undersea mines

3.2 Charging Batteries in First Responders Situations

For application in First Responder use, there is need for battery timeliness and efficiency. As with the advantages of military charging, the first responders rely on battery run devices, such as walkie-talkies etc., to be reliable and usable at all times. A list of first responder applications requiring batteries and chargers is given below.

- Bio-sensors
- Blood oximeters
- Cardiac Monitors
- Defibrillators
- Diagnostic equipment
- Dialysis machine

[17] http://www.almc.army.mil/alog/issues/JulAug02/MS817.htm

- Drug dispensers
- Ear thermometers
- GPS
- Infusion pumps
- Inhalators
- Intravenous pumps
- Life support equipment
- Search & Rescue
- Telemetry equipment
- Therapy equipment

3.3 Charging Batteries in the Home

The main purpose and advantage of the Batter y Charger is its ability to reliably distribute power to various devices while saving energy and dispersing the energy where needed. The speed and reliability are qualities that are not necessarily needed for certain items. In the realm of household products, items with lithium ion batteries include, but are not limited to, i-pods, cell phones, rechargeable camera batteries, etc. These items are certainly overcharged fairly often. However, these items don't need the reliable, fast charging that is offered in the Battery Charger. These items are normally packaged with a charger of their own that can charge the battery efficiently, with no cost. The inventor of the Battery Charger suggested that although it could be used to charge household items, it is unnecessary for such devices[18].

3.4 Charging Electric Vehicles

The consumer application with the most possible potential would be for the charging of electric vehicles. In the past, the market has shown great potential: "The EV industry is large and prosperous with $31.1 billion sales globally in 2005 at ex factory prices excluding toys[19]." It is also estimated that by 2015, the industry will grow another 7.3 percent[20]. For every hybrid and electrical vehicle being sold, there is need for an efficient and timely charger in the owner's home. There are currently no commercial options to provide users with in-home charging stations.

As electric vehicles become increasingly more popular and common, so will public charging stations. Europe's first public station was implemented in May of 2010[21]. With the adoption of electric vehicles, similar charging stations will begin to be used throughout the world with a large opportunity for chargers that offer efficiency and the ability to save battery life without overcharging or improper allocation of charge.

[18] Phone interview with inventor
[19] http://www.evworld.com/article.cfm?storyid=860
[20] http://www.evworld.com/article.cfm?storyid=860
[21] http://www.engadget.com/2010/05/26/europe-gets-first-fast-charging-ev-station-hungers-for-more/

4 Markets

This assessment understands the core application of the Battery Charger and Power Reduction System and Method to be charging lithium-ion batteries more precisely and efficiently than existing shunt-style chargers. Prospective markets can then be identified by recognizing potential market relevance and end-user value of said application. Four general market classifications have been identified within which market relevance may be found:

- Military Market
- Civilian First Responder Market
- Portable Consumer Electronics
- Electric Vehicles

Each market is defined and quantified and market drivers and influences are briefly explored.

4.1 Military Market

As previously explored, there are several devices in use by the military that require the power of batteries. While non-rechargeables are still used in many front line operations, rechargeable lithium-ion batteries, which would be compatible with the Battery Charger, are starting to gain acceptance in additional military applications. The precision and reliability of the Battery Charger may be the most important prospective advantages to the military market. This assessment quantifies the military market broadly by enlistment figures and then drills down using expenditures on batteries and number of devices using batteries.

4.1.1 Definition and Quantification

The military market is first defined to include the five branches of the United States military: Air Force, Army, Coast Guard, Marine Corps and Navy. The tables below relay the United States Bureau of Labor Statistics 2009 estimates of current enlistment.[22] It is these enlisted and officer personnel who constitute the military market and may serve as potential end-users of the Battery Charger.

[22] United States Bureau of Labor Statistics. "Occupational Outlook Handbook, 2010-11 Edition ." *Job Opportunities in the Armed Forces*. 17 Dec 2009. United States Department of Labor, Web. Mar 2010. <http://www.bls.gov/oco/ocos249.htm>.

Military Enlisted Personnel by Broad Occupational Category & Branch of Military Service, January 2009						
Occupational Group - Enlisted	**Army**	**Air Force**	**Coast Guard**	**Marine Corps**	**Navy**	**Total, all services**
Administrative occupations	6,727	17,537	1,621	9,219	22,147	57,251
Combat specialty occupations	132,079	480	904	52,445	7,595	193,503
Construction occupations	20,872	4,689	—	6,759	5,521	37,841
Electronic and electrical repair occupations	37,466	34,751	4,663	16,199	47,985	141,064
Engineering, science, and technical occupations	42,770	41,328	1,212	26,940	38,778	151,028
Healthcare occupations	30,945	16,420	772	—	23,960	72,097
Human resource development occupations	20,251	11,321	1	7,134	5,300	44,007
Machine operator and precision work occupations	6,372	6,181	1,816	2,575	8,596	25,540
Media and public affairs occupations	8,233	6,910	152	2,518	3,659	21,472
Protective service occupations	29,076	34,099	2,816	7,156	12,555	85,702
Support services occupations	13,554	6,071	1,263	2,765	9,188	32,841
Transportation and material handling occupations	69,454	31,396	11,748	25,909	45,176	183,683
Vehicle machinery mechanic occupations	54,771	43,409	6,119	22,068	45,209	171,576
Non-occupation coded personnel	1,081	6,681	326	12	755	8,855
Total, by service	**473,651**	**261,273**	**33,413**	**181,699**	**276,424**	**1,226,460**

Military Officer Personnel by Broad Occupational Category & Branch of Military Service, January 2009						
Occupational Group - Officer	**Army**	**Air Force**	**Coast Guard**	**Marine Corps**	**Navy**	**Total, all services**
Combat specialty occupations	20,201	2,611	77	5,315	1,125	29,329
Engineering, science, and technical occupations	21,676	17,800	210	4,006	7,616	51,308
Executive, administrative, and managerial occupations	13,104	7,327	197	2,725	5,442	28,795
Healthcare occupations	10,626	8,661	1	—	7,468	26,756
Human resource development occupations	2,676	2,293	151	279	520	5,919
Media and public affairs occupations	310	305	15	175	290	1,095
Protective service occupations	2,867	1,131	60	353	284	4,695
Support services occupations	1,741	758	3	38	857	3,397
Transportation occupations	12,519	22,828	580	7,345	27,340	70,612
Non-occupation coded personnel	2,597	866	6,769	88	386	10,706
Total, by service	**88,317**	**64,580**	**8,063**	**20,324**	**51,328**	**232,612**

Within the above tabulations, the total military market (as defined via BLS estimates of officer and enlisted personnel) consists of 1,459,072 members. The Battery Charger could potentially have applicability across many if not all of these categories; however, its prospective advantages may make it more relevant in some than in others. In other words, the Battery Charger's precision and reliability for charging multiple cells at once may not provide an improved solution to occupations that do not require that level of precision and reliability. However, for those that do require such specifications, the Battery Charger's prospective advantages may be more relevant. For example, the "combat specialty operations" occupation may have the greatest need for precise and reliable charging of multiple cells in the field because if a battery goes dead, lives could also be at stake. There are a total of 222,832 (or approximately 15%) members across the five branches employed in such positions. It is important to note that these quantification numbers cannot be equated to the number of chargers to be sold, but they do provide an estimate of the number of potential end-users that exist within the military.

While enlistment figures provide data on the number of potential end-users, military expenditures on batteries can be another source of market indication. A figure for overall military spending on batteries could not be obtained by this assessment. With that said, it is important to note that each branch of the military procures their own batteries, independently of one another[23]. According to the U.S. Army Logistics University, the Army spends approximately $35 million a year on non rechargeable batteries[24].

This assessment is focused on rechargeable batteries because it is with such batteries that the Battery Charger would find applicability. However, as will be examined in the market drivers and influences section, there is an overall push toward using rechargeables when possible[25]. If this trend in fact holds true, then the market for the Battery Charger could increase as rechargeables are used more, although primary batteries will most likely always be used in certain applications[26].

Based upon a lack of publically available information detailing the number of rechargeable batteries or battery chargers used in the field currently, this assessment now examines the number of primary batteries used in the field to frame the overall military battery market, keeping in mind that there is a push toward rechargeables replacing primary batteries. According to a 2005 GAO report titled, “Actions Needed to Improve the Availability of Critical Items during Current and Future Operations,” demand for BA 5590 primary Lithium batteries peaked in April 2003 at over 330,000 batteries up from 20,000 batteries per month during peacetime. These batteries power over 60 critical communications and electronics systems. Additionally, batteries are on the “critical few list” of the most critically needed items (about 25 items) worldwide[27].

4.1.2 Market Drivers and Influences

Drivers and influences for the military Battery Charger market have been identified based upon the market relevance of the technology. These factors include, but may not be limited to:

- Cost of primary batteries
- Trend toward use of rechargeable batteries
- Deployment of troops

[23] http://www.acq.osd.mil/ott/natibo/docs/battery_es.html
[24] http://www.almc.army.mil/alog/issues/JulAug02/MS817.htm
[25] Ibid.
[26] Ibid.
[27] http://www.gao.gov/new.items/d05275.pdf

While this assessment was unable to quantify the overall military spending on batteries, it did find that the Army alone spends upwards of $35 million per year on primary batteries. These primary batteries may have higher capacities, but they cannot be recharged and are therefore thrown away after use. In addition, many of these batteries are being disposed of with significant energy remaining because it is difficult to know how much energy remains, which can be particularly important in life or death situations. The article, "Military takes aim at high battery costs," states that, "Although non-rechargeable batteries offer the highest capacity, the problem is that once a battery is used on a mission, the returning soldier, uncertain of its remaining run time, will replace it with a fresh one rather than take a used battery back out in the field, an understandable action considering the risks associated with running out of battery power. The result is that many of the discarded batteries have sufficient capacity remaining for a second mission, and the loss of this capacity represents a significant cost to the military[28]."

The Army estimates that primary batteries are being disposed of with 30% to 50% of their energy remaining, which results in a replacement cost of millions to tens of millions of dollars each year. With this in mind, the Army did switch to using rechargeable batteries for training in 1997. Rechargeable batteries require increased upfront investment. The $9.1 million investment of the Army saved over $30 million in the first five years[29].

In the field, primary and secondary batteries are in use, with more secondary batteries being used when possible. A universal battery charger and rechargeable lithium ion battery systems have been fielded. These batteries are claimed to be able to be charged over 500 times. This may prove to be a hurdle for the Battery Charger in terms of existing competition, which is explored in the Cautions & Considerations section of this analysis.

As the energy densities and capacities of secondary batteries increase and their relative costs decrease, the market for battery chargers may grow. The cost of primary batteries may be a key influence to that occurrence, as well as to the next driver/influence explored, trend toward rechargeables.

As the waste and overall cost associated with primary batteries continues to remain high, the military is moving to replace primary batteries with secondary batteries when possible[30]. Secondary batteries have a higher upfront cost (including cost for the charger), but they are rechargeable. One reason for this move is the cost savings that can be achieved, as previously examined. Additional reasons include but are not limited to safer use and disposal and uninterrupted operations if supply chains are severed or delayed[31].

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[28] http://mobiledevdesign.com/hardware_news/radio_military_takes_aim/
[29] http://www.almc.army.mil/alog/issues/JulAug02/MS817.htm
[30] Ibid.
[31] Ibid.

This change may enhance the need for a device with prospective advantages such as the Battery Charger's and increase the potential military market for such devices. Assuming primary batteries are being replaced by secondary ones, additional Battery Chargers will be needed by the military as well, therefore driving the military Battery Charger market.

Finally, deployment serves as another market driver/influence. As the numbers regarding demand for batteries suggest, more batteries are needed in time of war than in peacetime, due to the large number of devices used in the field that rely on portable power. Therefore, as deployment increases, so too does the need for batteries, and so too may the need for Battery Chargers, depending on the type of battery (primary or secondary). The following deployment figures provide further insight.

Deployment Location	Estimated Number of U.S. Troops Deployed
Afghanistan	22,000
Bosnia & Herzegovina	200
Djibouti	3,000
Egypt	800
Europe	100,000
Iraq	132,000
Japan	35,300
Kosovo	1,500
Philippines	95
South Korea	32,000
Total	**326,895**

4.2 Civilian First Responder Market

Similar to the military, civilian first responders also depend on a number of devices in the field that rely on portable power, including communications devices, GPS devices, and CBRNE detection devices, among others. Assuming that these devices use rechargeable batteries, the Battery Charger and Power Reduction System and Method may then find relevance within this market space. This assessment defines and quantifies this market based upon first responder employment figures and then looks at the market drivers and influences.

4.2.1 Definition and Quantification

The civilian first responder market denotes civilian end-users within a non-military context. Unique to the civilian first responder market, however, is the characterization of civilian personnel *who hold first responder employment*. First responders may then include those grouped within the United States Bureau of Labor Statistics' occupation classifications of "protective services" and "healthcare practitioners and technical occupations." These two categories encompass the traditionally connoted civilian first responders of fire fighters, police officers, and emergency medical technicians (EMTs) and paramedics. The Bureau of Labor Statistics articulates the following employment figures for 2008 and the projected change from 2009 through 2018.[32]

[32] Bureau of Labor Statistics, United States Department of Labor. " Occupational Employment Statistics." Protective Service Occupations. U.S. Bureau of Labor Statistics, 14 May 2010. Web. May 2010. < http://www.bls.gov/oes/current/oes330000.htm>.

First Responder Category	SOC Code	Employment 2008	Projected Employment 2018	Change, 2008-2018	
				Number	**Percent**
Fire Fighters	33-2011	310,400	367,900	57,500	16%
Police Officers	33-3050	665,700	723,300	57,600	8%
EMTS & Paramedics	29-2041	210,700	229,700	19,000	8%
Average		*1,186,800*	*1,320,900*	*134,100*	*10%*

When employment statistics are accepted as a market indicator for the Battery Charger and Power Reduction System and Method (Battery Charger), the civilian first responder market reveals positive indications of growth. Employment projections for each component of the civilian first responder market are positive. It is these first responders who may serve as end-users of the Battery Charger in order to charge secondary batteries in both disaster and normal operations. However, these end-users may not each have their own battery charger, so this should not be taken as a direct quantification of the market.

The United States Fire Administration (USFA) reports the existence of 30,170 fire departments in 2009 with an estimated 52,400 fire stations in the United States.[33] The most recent data provided by the Bureau of Justice Statistics cites 17,876 state and local law enforcement agencies with the equivalent of at least one full-time officer operating in the United States in 2004.[34] The largest fifty law enforcement agencies are outlined below in accordance with the number of full-time sworn personnel. [35]

Agency	Full-time sworn personnel
New York (NY) Police	36,118
Chicago (IL) Police	13,129
Los Angeles (CA) Police	9,099
Los Angeles County (CA) Sheriff	8,239
California Highway Patrol	7,085

[33] United States Fire Administration, U.S. Federal Emergency Management Agency. "Fire Departments." USFA Fire Departments. FEMA, 12 Nov 2009. Web. May 2010. <http://www.usfa.dhs.gov/statistics/departments/index.shtm>.

[34] Bureau of Justice Statistics, Office of Justice Programs. "Census Of State And Local Law Enforcement Agencies, 2004." Bureau of Justice Statistics (BJS) - Publication and Product Details. Bureau of Justice Statistics, 23 Apr 2010. Web. May 2010. <http://bjs.ojp.usdoj.gov/index.cfm?ty=pbdetail&iid=539>.

[35] Ibid.

Philadelphia (PA) Police	6,832
Cook Co. (IL) Sheriff	5,555
Houston (TX) Police	5,092
New York State Police	4,667
Pennsylvania State Police	4,200
Washington (DC) Metropolitan Police	3,800
Detroit (MI) Police	3,512
Texas Department of Public Safety	3,437
Broward County (FL) Sheriff	3,190
Baltimore (MD) Police	3,160
Miami-Dade County (FL) Police	3,094
Dallas (TX) Police	2,935
Phoenix (AZ) Police	2,858
New Jersey State Police	2,768
Suffolk County (NY) Police	2,692
Las Vegas (NV) Metropolitan Police	2,674
Nassau County (NY) Police	2,574
Harris County (TX) Sheriff	2,545
Massachusetts State Police	2,200
San Francisco (CA) Police	2,167
Orange County (CA) Sheriff	2,119
San Diego (CA) Police	2,103
San Antonio (TX) Police	2,054
Memphis (TN) Police	2,017
Illinois State Police	2,008
Boston (MA) Police	1,961
Milwaukee (WI) Police	1,946
Virginia State Police	1,869
Michigan State Police	1,862
Baltimore County (MD) Police	1,798
Honolulu (HI) Police	1,795
Columbus (OH) Police	1,777
Florida Highway Patrol	1,654
New Orleans (LA) Police	1,646
Atlanta (GA) Police	1,643
Jacksonville (FL) Sheriff	1,617
Port Authority of New York-New Jersey Police	1,607
Maryland State Police	1,596
Sacramento County (CA) Sheriff	1,565
Cleveland (OH) Police	1,560

San Bernardino County (CA) Sheriff	1,542
North Carolina State Highway Patrol	1,517
Ohio State HIghway Patrol	1,502
Riverside County (CA) Sheriff	1,490
Charlotte-Mecklenberg (NC) Police	1,483

These larger departments may be more likely to have more devices needed charging and may serve as early adopters of the Battery Charger. The core application of the Battery Charger, charging multiple cells/devices with different capacities and states of charge, may find greater relevance within larger departments, aligning better with their needs.

This assessment tried to drill down to more specific information regarding first responder expenditures on batteries and/or battery chargers, but information was not available. However, the Department of Homeland Security (DHS) 2004 First Responder Grant Program lists battery chargers as one of the qualifying items[36]. While this does not necessarily aid in quantifying the market, it does show the relevance battery chargers have within this market.

4.2.2 Market Drivers and Influences

This assessment has primarily used first responder employment data to quantify the first responder market potentially for the Battery Charger and Power Reduction System and Method due to a lack of other publically available information. Market drivers and influences may include but not be limited to

- Cost of primary batteries
- Trend to use of secondary batteries

4.3 Consumer Market

The prospective advantages of the Battery Charger and Power Reduction System and Method (Battery Charger) may also have relevance in consumer applications. Lithium ion batteries have become the battery chemistry of choice in consumer electronics due to their lightweight, high energy density, no memory effect, and low self-discharge rate, among other factors[37][38]. Lithium ion is also one of the key battery chemistries being implemented in electric car applications[39].

This assessment defines and quantifies the consumer market in two sections; charging of consumer electronics and charging of electric vehicles.

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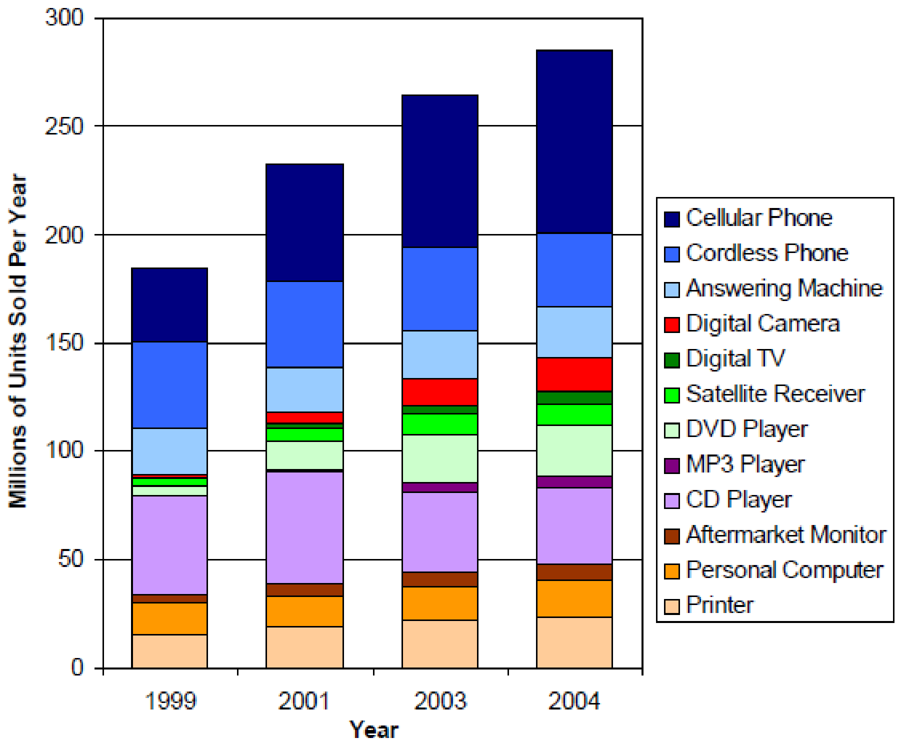
36 http://www.nh.gov/safety/divisions/homeland/2004/documents/2004_firstrespfinal_ael.pdf
37 http://www.batteryuniversity.com/partone-5.htm
38 http://www.fueleconomy.gov/feg/evtech.shtml
39 http://www.pr-inside.com/learn-about-the-world-lithium-batteries-r975859.htm

4.3.1 Consumer Electronics—Definition and Quantification

Consumer electronics are defined as devices with electronic circuit boards that are intended for everyday use[40]. This can include televisions, DVD players, video game consoles, desktop and laptop computers, cell phones, PDAs, digital cameras, calculators, and mp3 players among other devices. It is important to distinguish between stationary and portable consumer electronics because of the Battery Charger and Power Reduction System and Method (Battery Charger)'s core application. The Battery Charger would not be necessary in most stationary consumer electronics because they are typically plugged into a receptacle on the wall instead of relying on battery power. Portable consumer electronics however do rely on battery power and must be charged rather regularly. Therefore, this assessment will focus on portable devices that would require the use of a battery charger.

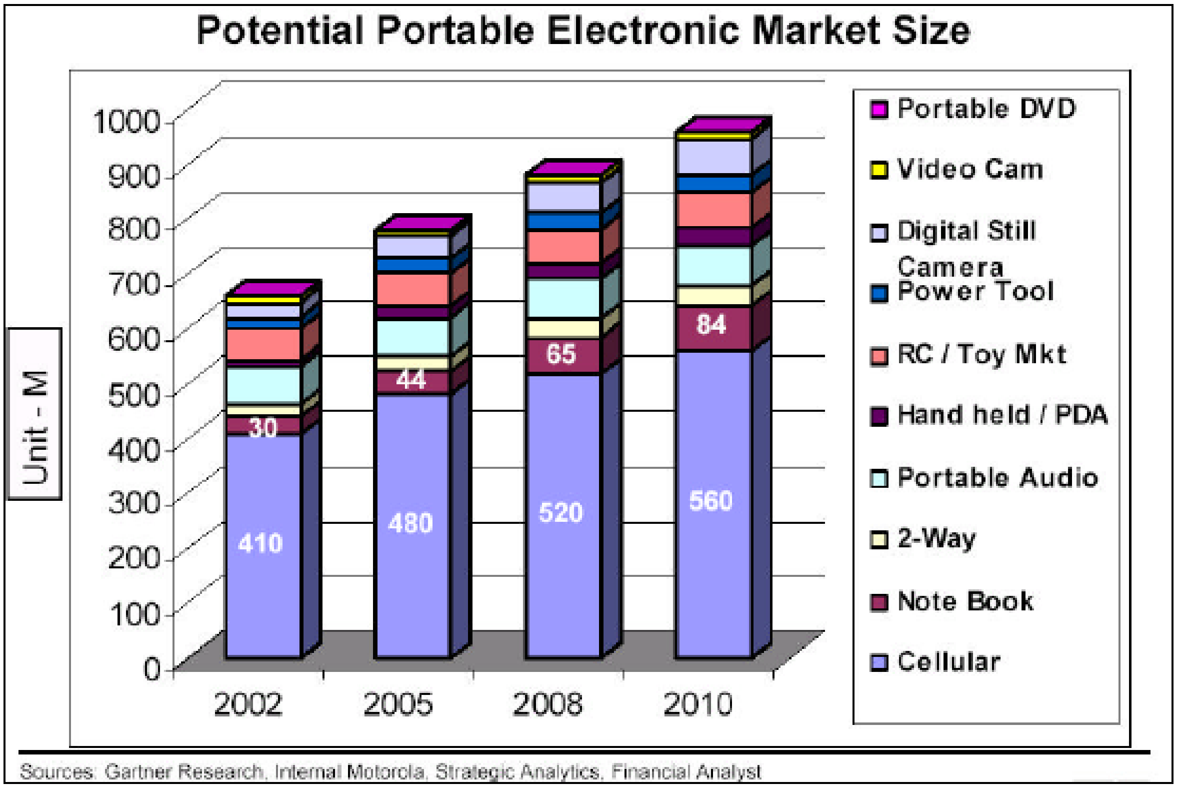
Starting broadly, the consumer electronics market has been touted as potentially a $300 billion a year industry[41]. In 2008, the industry reached upwards of $170 billion in sales[42]. This number represents the consumer electronics market as a whole however, not just portable, so the market for portable consumer electronics may be significantly lower. While this assessment did not find such data, it was found that digital displays made up at least $28 billion of the $170 billion in revenues in 2008, or a little over 16%. Just over 12%, or $21 billion of the $170 billion of revenues came from video gaming wholesale revenues[43]. Further breakdown was unable to be obtained, but the numbers presented here show that data for portable consumer electronics is not necessarily sorted out from in-home/stationary data. The following chart illustrates the increased usage of consumer electronics overall[44].

[40] http://www.webopedia.com/TERM/C/consumer_electronics.html
[41] http://www.brencom.com/data/exec-consumerelectronics.pdf
[42] http://www.docstoc.com/docs/973162/US-Consumer-Electronics-Industry-to-Reach-173-Billion-in-2008-183-Billion-in-2009
[43] http://www.docstoc.com/docs/973162/US-Consumer-Electronics-Industry-to-Reach-173-Billion-in-2008-183-Billion-in-2009
[44] http://www.efficientproducts.org/reports/bchargers/EcosConsulting_BatteryPower2005.pdf



A second note regarding these numbers is that they include both the devices and the chargers if required. This means that battery chargers many only make up a small percentage of the overall number presented here. With that said it is difficult to directly quantify the battery charger market for portable consumer electronics. However, additional data regarding portable electronics gives insight into market size. The following chart[45] illustrates the potential portable electronics market in terms of number of devices. It also breaks the devices down by type of device which is not as relevant for this assessment.

[45] http://www.efficientproducts.org/reports/bchargers/EcosConsulting_BatteryPower2005.pdf



According to Gartner Research, in 2010 the portable electronics market is predicted to reach close to 1 billion devices, all of which require a charger of some sort. Cellular devices make up the majority of these devices. While this information indicates the potential market for battery chargers overall, it does not necessarily represent the potential market for the Battery Charger at hand[46].

The ability of the Battery Charger to gain a share in this market will be dependent upon how the prospective advantages of said charger align with consumer needs. There is not convincing evidence that a charger offering the precision and reliability of the Battery Charger is needed and/or wanted in the consumer electronics market. As seen in the chart below, current battery chargers vary in price for the different types of consumer electronic devices, but overall they are lower than the cost estimates for the present invention (~$4,000). Consumers would most likely opt for the cheaper charger that meets their needs rather than a more complex system with a higher price tag and no higher utility for their purposes. As devices have more expensive battery chargers, such as laptops, the premium may be less for the Battery Charger, but the benefits of use in these applications may still be small to nonexistent. This factor is further examined in the Drivers and Influences section.

[46] Ibid.

Battery Charger Costs		
Charger Type	**Average**	**Range**
Canon Lithium Ion Battery Charger Replacement (Camera)	$11.63	$2.24 - $19.95
Dell Inspiron Lithium Ion Battery Charger Replacement (Computer	$21.45	$10.68 - $29.00
Blackberry Curve Lithium Ion Battery Charger Replacement (Cell Phone)	$10.10	$5.88 - $14.99
iPod Classic Lithium Ion Battery Charger Replacement (MP3 Player)	$14.65	$9.95 - $22.99

*Please see Appendix B for calculations.

4.3.2 Consumer Electronics—Market Drivers and Influences

The successful entry and market penetration of the Battery Charger and Power Reduction System and Method (Battery Charger) will be dependent upon drivers and influences in this market space. Drivers and influences in this market include, but may not be limited to:

- Number of portable consumer electronics sold
- Prices of standard battery chargers and batteries
- Cost-benefit of using the Battery Charger over standard battery chargers

As examined in the previous section, the number of portable consumer electronics sold has been on an increase over the past decade, approaching 1 billion to be sold in 2010[47]. Assuming that each of these devices also needs a charger, the market for battery chargers has also been on the rise. Therefore, as the number of portable electronics sold continues to rise, the number of battery chargers sold may also continue to rise. Remember that this is not indicative of all battery chargers though. Most consumer electronic battery chargers are rather simple devices, as opposed to the Battery Charger and Power Reduction System and Method (Battery Charger).

On that note, chargers for portable consumer electronics are rather inexpensive devices. The following chart details the price of chargers for four portable consumer electronics. As can be seen, these chargers range from $5.88 to $29.00, depending on the type of device they are intended to charge. This may mean that the present invention, estimated to cost $4000 for a 10 cell battery charger, will have a difficult time penetrating this market.

[47] Ibid.

Battery Charger Costs		
Charger Type	**Average**	**Range**
Canon Lithium Ion Battery Charger Replacement (Camera)	$11.63	$2.24 - $19.95
Dell Inspiron Lithium Ion Battery Charger Replacement (Computer	$21.45	$10.68 - $29.00
Blackberry Curve Lithium Ion Battery Charger Replacement (Cell Phone)	$10.10	$5.88 - $14.99
iPod Classic Lithium Ion Battery Charger Replacement (MP3 Player)	$14.65	$9.95 - $22.99

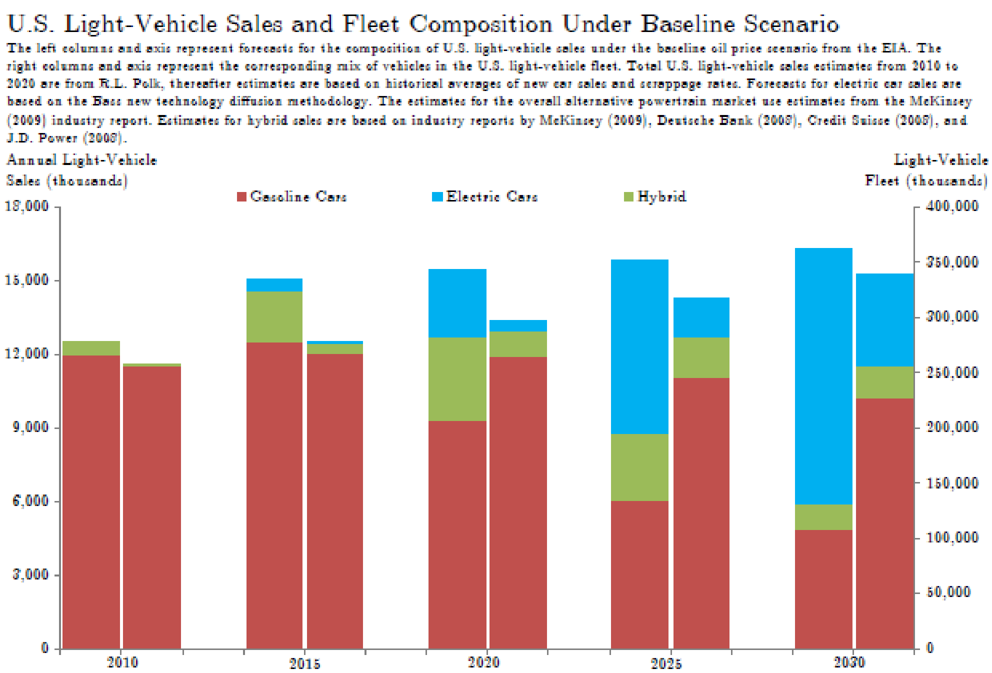
Further, the benefits that stem from the Battery Charger's functionality are not required in the consumer electronics market. The Battery Charger could potentially extend the life of the lithium-ion batteries in portable consumer electronics, however, the price premium for said benefit may still outweigh the cost. The chart below details the prices of batteries for four portable consumer electronics. Much like the price of chargers, the price of batteries is also dependent upon the type of device, ranging from $1.59 to $109.99. In general though, the batteries are relatively inexpensive in comparison to the Battery Charger device. Consumers are most likely to simply dispose of an old lithium ion battery and purchase a new one as opposed to making a significant (~$4000) investment upfront. It would be difficult for consumers to obtain a return on said investment. Detailed information on how these numbers were obtained in contained in Appendix B.

Battery Costs		
Battery Type	**Average**	**Range**
Canon Lithium Ion Battery Replacement (Camera)	$27.37	$20.99 - $36.95
Dell Inspiron Lithium Ion Battery Replacement (Computer)	$53.69	$33.99 - $109.99
Blackberry Curve Lithium Ion Battery Replacement (Cell Phone)	$11.89	$1.59 - $23.38
iPod Classic Lithium Ion Battery Replacement (MP3 Player)	$14.95	$11.55 - $19.99

4.3.3 Electric Vehicles—Definition and Quantification

Electric vehicles (EVs) are vehicles powered by rechargeable battery packs and propelled by electric motors. These types of vehicles are both energy efficient and environmentally friendly[48]. Electric vehicles can be powered by different types of battery chemistries, but lithium ion has been considered the premier battery chemistry for electric vehicles[49]. However, lithium ion has not become the standard battery chemistry quite yet. These vehicles need chargers, and if they are adopted on a large scale, the market opportunity for the Battery Charger could increase.

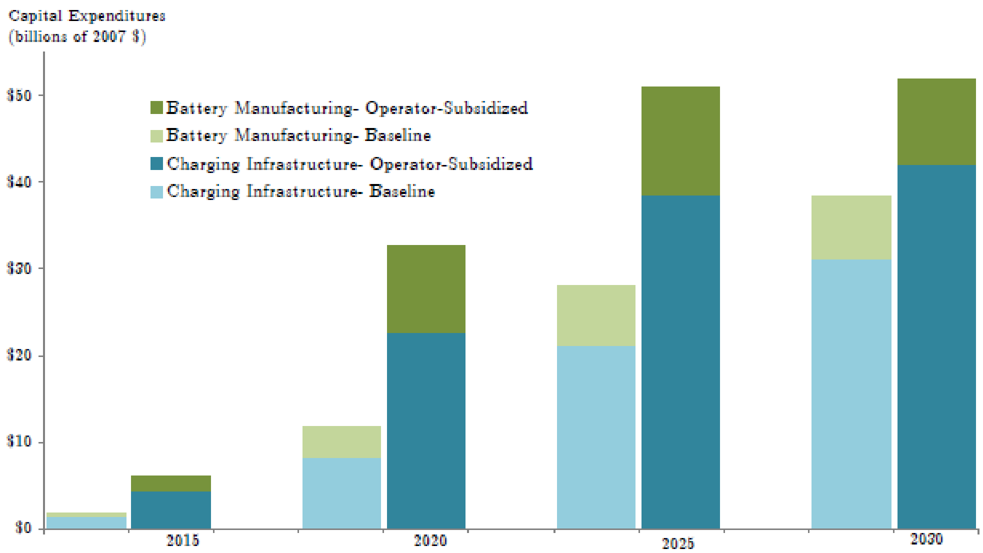
According to the U.S Census Bureau, there were 117,000 gas stations servicing 250 million internal combustion engine light-vehicles in the United States in 2007. Not all of these vehicles would likely be replaced by electric vehicles, especially considering the current limitation of said vehicles and a lack of the proper infrastructure. However, a study done by the Center for Entrepreneurship &Technology at the University of California, Berkeley predicts the adoption of EVs and the capital expenditures on battery manufacturing and charging infrastructure over the next 20 years[50]. This data is illustrated below.



48 http://www.fueleconomy.gov/feg/evtech.shtml
49 http://www.thecarelectric.com/content/what-are-the-different-types-of-electric-car-battery-technologies.php
50 http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf

Capital Expenditures

The left columns represent baseline scenario forecasts and the right columns the operator-subsidized scenario forecasts for the capital expenditures (CapEx) on battery manufacturing and charging infrastructure. The battery manufacturing capital expenditure estimates are based on the estimated sales of automotive Li-ion batteries from domestic producers multiplied by a 30% CapEx-to-Sales ratio. The 30% CapEx-to-Sales ratio is based on discussions with the battery manufacturer A123. The capital expenditures for the charging infrastructure are based on the estimates for a $300 million cell of charge spots and battery switching stations for each 100,000 electric car drivers.



These charts are simply predictive and do not suggest that this will be the course of action, but they do give an idea of the investments in batteries and chargers that may occur if electric vehicles are adopted on a large scale. The first chart shows over 250 million EVs being on the road by 2030. Capital expenditures on charging infrastructure could increase significantly if EVs are adopted at such a rate. The Battery Charger could potentially take a share of the over $40 billion to be spent on charging infrastructure by 2030, but it will have to compete with other technologies, as examined in the Competitive Landscape section of this assessment.

Unlike the portable consumer electronics market, the Battery Charger's prospective advantages could have relevance in the EV charging market. The Department of Energy's price goal for for lithium ion batteries for automotive use is $500 per kWh in 2012 or $12,000 for the price of the battery[51]. These batteries are much more expensive than those used in consumer electronic applications, and therefore the prospective advantage of extending battery life is more relevant.

[51] http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf

If the prospective advantage is in fact relevant, then the Battery Charger may be able to gain market share as this market grows. Further, Research & Markets has predicted that annual US electric vehicle charging sales will reach $200 million by 2015[52].

This assessment has used predications of market revenues and number of EVs to quantify this market. These numbers can and will fluctuate as EVs will face competition while trying to gain adoption. These numbers depend upon EVs becoming the standard alternative to internal combustion engines.

4.3.4 Electric Vehicles—Market Drivers and Influences

While an electric vehicle market is limited to nonexistent currently in the United States, the creation and growth of such a market will be driven and influenced by a number of complex factors. This assessment will look at two of these factors. Further, these factors will affect adoption of the Battery Charger and Power Reduction System and Method (Battery Charger) into this market. Drivers and influences may therefore include, but not be limited to:

- Capabilities and capacity of batteries
- Infrastructure
- Competing technologies

Current capabilities and capacity of batteries is limited due to energy density issues. In other words, there is a tradeoff between weight and battery capacity. On average, EVs currently can go about 100 miles on one charge. This can be an issue without the appropriate charging infrastructure in place to recharge. EVs can be useful in short drives, but are probably not ideal for customers who make long trips often. Until batteries reach a higher energy density, EVs may not be adopted on a large-scale and therefore may limit the market for chargers.

As noted, the energy density is a limiting factor because the appropriate infrastructure for recharging is not yet in place. However, this raises a further issue of who will make the first investment. Government or business may be skeptical to invest in said infrastructure until a certain amount of EVs are on the road. Yet, consumers may be wary to purchase EVs without the infrastructure in place. This may further limit the adoption of EVs.

Finally, a standard for alternative (to internal combustion engines) automotive technologies has not been decided upon. To date, over 1 million total hybrids have been sold in the United States, but other alternative technologies have not seen significant adoption yet. Competing technologies such as hydrogen fuel cells could become the standard over EVs and instead of charging stations

[52] http://www.treehugger.com/files/2009/07/electric-vehicle-charging-market-worth.php

there would be hydrogen stations. It is not the aim of this assessment to perform a competitive analysis of competing alternative automotive technologies.

As can been seen, the market for alternative automotive technologies, specifically EVs, is still unknown. With that said, this assessment works to be as objective as possible and with so much yet to be determined, it is difficult to add additional value with additional analysis.

5 Competitive Landscape

This assessment has worked to establish the prospective advantages, core application, and potential markets of the Battery Charger and Power Reduction System and Method (Battery Charger). Based upon those observations, competition for the Battery Charger system may include chargers that are currently in use in the applications explored by this assessment. Direct competition will stem from other “smart” chargers. Competition is examined based upon the identified prospective advantages of the Battery Charger, namely decreased likelihood of overcharging, precision of charging (including multiple cells), and extended battery life. These prospective advantages may serve as points of product differentiation and competitive advantage. General industry notes are made, and examples of competing technologies and the firms offering them when applicable are explored.

5.1 Industry Composition and Trend

The Battery Charger and Power Reduction System and Method (Battery Charger)’s core application has been defined as precise and reliable charging of multiple cells in order to decrease the likelihood of overcharging and extend battery life. When searching North American Industry Classification System (NAICS) codes, it became apparent that the manufacture of batteries and their power supplies fall into separate categories. The manufacture of batteries falls under the North American Industry Classification System (NAICS) code 33591, otherwise known as “Battery Manufacturing,” but the manufacture of their power supplies or chargers falls under the North American Industry Classification System (NAICS) code 335999, “All Other Miscellaneous Electrical Equipment and Component Manufacturing.” NAICS states that, “This U.S. industry comprises establishments primarily engaged in manufacturing industrial and commercial electric apparatus and other equipment (except lighting equipment, household appliances, transformers, motors, generators, switchgear, relays, industrial controls, batteries, communication and energy wire and cable, wiring devices, and carbon and graphite products). This industry includes power converters (i.e., AC to DC and DC to AC), power supplies, surge suppressors, and similar equipment for industrial-type and consumer-type equipment.”

There are a variety of activities that are included under 335999. In order to understand them, the listing of said activities obtained from NAICS is reproduced below[53].

335999	335999	3699	Amplifiers, magnetic, pulse, and maser, manufacturing
335999	335999	3699	Appliance cords made from purchased insulated wire
335999	335999	3699	Atom smashers (i.e., particle accelerators) manufacturing
335999	335999	3629	Battery chargers, solid-state, manufacturing

[53] http://www.naics.com/censusfiles/ND335999.HTM

335999	335999	3699	Bells, electric, manufacturing
335999	335999	3699	Betatrons manufacturing
335999	335999	3629	Capacitors (except electronic), fixed and variable, manufacturing
335999	335999	3629	Cathodic protection equipment manufacturing
335999	335999	3699	Chimes, electric, manufacturing
335999	335999	3699	Cleaning equipment, ultrasonic (except dental, medical), manufacturing
335999	335999	3629	Condensers (except electronic), fixed and variable, manufacturing
335999	335999	3699	Cyclotrons manufacturing
335999	335999	3699	Door opening and closing devices, electrical, manufacturing
335999	335999	3699	Electric bells manufacturing
335999	335999	3699	Electric fence chargers manufacturing
335999	335999	3629	Electrochemical generators (i.e., fuel cells) manufacturing
335999	335999	3699	Electron linear accelerators manufacturing
335999	335999	3699	Electrostatic particle accelerators manufacturing
335999	335999	3699	Extension cords made from purchased insulated wire
335999	335999	3629	Fuel cells, electrochemical generators, manufacturing
335999	335999	3699	Garage door openers manufacturing
335999	335999	3699	Gongs, electric, manufacturing
335999	335999	3629	Inverters, solid-state, manufacturing
335999	335999	3699	Linear accelerators manufacturing
335999	335999	3699	Maser (i.e., microwave amplification by stimulated emission of radiation) amplifi
335999	335999	3629	Mercury arc rectifiers (i.e., electrical apparatus) manufacturing
335999	335999	3699	Particle accelerators, high voltage, manufacturing
335999	335999	3629	Power converter units (i.e., AC to DC), static, manufacturing
335999	335999	3629	Power supplies, regulated and unregulated, manufacturing
335999	335999	3629	Rectifiers (except electronic component type, semiconductor) manufacturing
335999	335999	3629	Semiconductor battery chargers manufacturing
335999	335999	3629	Semiconductor high-voltage power supplies manufacturing
335999	335999	3629	Series capacitors (except electronic) manufacturing
335999	335999	3629	Surge suppressors manufacturing
335999	335999	3629	Thermoelectric generators manufacturing
335999	335999	3699	Ultrasonic cleaning equipment (except dental, medical) manufacturing
335999	335999	3699	Ultrasonic generators sold separately for inclusion in tools and equipment manufa

335999	335999	3629	Uninterruptible power supplies (UPS) manufacturing
335999	335999	3629	UPS (uninterruptible power supplies) manufacturing

As can be seen, NAICS 335999 "All Other Miscellaneous Electrical Equipment and Component Manufacturing," includes the manufacture of Battery Chargers. The root of the NAICS code, 32, indicates "Manufacturing," while the 335 at the beginning of the code indicates, "Electrical equipment, appliance, and component manufacturing.[54]"

Now that the Battery Charger has been identified as part of NAICS 335999 "All Other Miscellaneous Electrical Equipment and Component Manufacturing" industry, information about this industry can provide an understanding of industry composition. Every five years the U.S. Department of Commerce, in conjunction with the Economic and Statistics Administration and the U.S. Census Bureau, publishes the Economic Census. These reports provide information regarding the structure and functioning of the different industry sectors that make up the United States economy. Information in the NAICS 335999 report from 2002 has been used as a starting point for industry analysis. These statistics are summarized in the chart below[55]. This chart does not include all information from the source, but a full chart and other relevant charts can be found in Appendix C.

Industry and year	Companies *	All establish-ments	# of employees	Payroll ($1,000)	Total value of shipments ($1,000)	Total capital expenditure s ($1,000)
2002	957	1003	41,243	1,661,718	7,057,265	276,221**
2001	N	N	47,444	1,742,097	8,285,443	271,482
2000	N	N	47,766	1,830,342	9,394,438	271,692
1999	N	N	45,971	1,663,255	7,982,005	211,796
1998	N	N	47,232	1,625,742	7,683,599	284,274
1997	928	978	45,640	1,542,819	7,039,768	231,419

**For the census, a company is defined as a business organization consisting of one establishment or more under common ownership or control.*
***Statistics presented for years ending in 2 and 7 are census data. Interim census years are derived in a representative sample of manufacturing establishments canvassed in the Annual Survey of Manufacturers (ASM).*

The value of shipments for the All Other Miscellaneous Electrical Equipment and Component Manufacturing market in 2002 exceeded $7 billion. These statistics are broken down further, yet not to the level of identifying chargers specifically. "All other miscellaneous electrical equipment and component manufacturing," is likely where chargers are being classified. This subsection accounted for almost $1.4 billion of the $7 billion total for the industry in 2002.

[54] http://www.census.gov/econ/census02/data/industry/E335.HTM
[55] http://www.census.gov/prod/ec02/ec0231i335999t.pdf

Without knowing further breakdown it is difficult to quantify how large charger shipments were, but these numbers certainly provide a starting point.

As can be seen in the above chart regarding the All Other Miscellaneous Electrical Equipment and Component Manufacturing industry, the data are somewhat inconclusive. However, the 2002 data set shows a decrease in number of employees, payroll, and total value of shipments. Yet, there was an increase in total capital expenditures. Overall the number of companies and establishments was greater in 2002 than five years prior. However, with missing 2003-2006 data, it is hard to get a comprehensive view of what has happened in this industry.

Additional data from the Economic Census is reproduced below for further insight.

Employment Size Class	**All Establishments**	**# of Employees**	**Payroll ($1,000)**
1 to 4 employees	374	781	27,509
5 to 9 employees	137	941	40,431
10 to 19 employees	125	1,757	76,113
20 to 49 employees	169	5,344	217,909
50 to 99 employees	103	7,326	297,563
100 to 249 employees	60	8,876	350,646
250 to 499 employees	23	7,385	282,514
500 to 999 employees	11	i	D
1,000 to 2,499 employees	1	g	D
2,500 employees or more	-	-	-

- Represents zero
g Indicates 1,000 to 2,499 employees
D Indicates data withheld to avoid disclosing data of individual companies; data are included in higher level totals

The United States Small Business Administration (SBA) defines small business in the NAICS code 335999 to be those having less than 500 employees[56].According to the Economic Census, there are 12 firms in this industry had greater than 500 employees. However, there 991 firms remaining that are classified as small businesses. This represents a relatively fragmented sector with several key firms.

The Economic Census also indicates that 12.7% of industry shipments in this industry in 2002 was produced by the four largest companies. The eight largest companies in the industry accounted for 21.5% of industry shipments in 2002[57]. This indicates that industry concentration is low. However, since this sector involves many different activities it is difficult to tell which of this analysis is applicable to battery chargers.

[56] http://www.sba.gov/idc/groups/public/documents/sba_homepage/serv_sstd_tablepdf.pdf
[57] http://www.census.gov/prod/ec02/ec0231i335999t.pdf

According to one source, the leaders in NAICS 335999 include Varian, Emerson Electric, Eaton Corporation, General Electric, and Schneider Electric. However, after reviewing these companies' product offerings, it appears that these companies are involved in manufacturing electrical equipment and components that are not battery chargers. A list of companies involved in battery charger manufacturing is provided in Appendix D.

5.2 Competition

Competition for the Battery Charger and Power Reduction System and Method (Battery Charger) may stem from existing chargers. Other smart chargers will serve as more direct competition or perfect substitutes. As explored in the consumer electronics section of this report, the ability of the Battery Charger to penetrate some markets may be limited by existing, inexpensive solutions. Competition is analyzed in light of the Battery's Chargers core application and prospective advantages.

5.2.1 Smart Chargers

As previously defined, smart or intelligent chargers are battery chargers that are controlled by a microprocessor. These types of chargers are able to charge different batteries or batteries with different states of charge without overcharging. This assessment found a host of smart chargers that could serve as competition to the Battery Charger and reviews eight of them. These eight were selected from PowerStream Technologies[58] to be representative of the wide range of smart chargers that exist on the market. However, it is important to note that from the descriptions it is only confirmed that these chargers use a microprocessor to control the charge. It does not state the advantage of decreased production of heat which is another key prospective advantage of the Battery Charger since heat can have deleterious effects on batteries.

PowerStream One Cell Lithium-Ion Battery Chargers 4.2V 800 mA

This is a battery charger that is a microprocessor controlled unit designed exclusively for charging a 1 cell 3.6 or 3.7 volt Lithium-ion battery pack. The charger has led indicators for indicating the current operating mode. The battery charger complies with the required applicable safety agency standards and the price ranges from $10.25 - $25.25 depending on the specific model type and the number of chargers purchased.

Specifications:

[58] http://www.powerstream.com/rapid.htm

- Input Voltage: 100 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 4.2 Vdc controlled by charger
- Output current: 0.8 A ±0.1 A max., controlled by charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

PowerStream Two Cell Lithium-Ion and lithium-polymer chargers 1200 mA with universal AC input

This battery charger functions as a microprocessor controlled unit designed exclusively for charging 2 cell 7.2 V or 7.4 V. Lithium-ion and lithium polymer (lipo, li-po, li-poly) battery packs. The device has led indicators to indicate the current operating mode of the charger. This battery charger complies with the applicable safety agency standards of UL, cUL and CE. This product is an 8.4V peak battery charger and is priced at $12.75 to $25.75 depending on the volume of the order.

Specifications:

- Input Voltage: 100 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 8.4 Vdc controlled by battery charger
- Output current: up to 1.2 A ±0.1 A max., controlled by battery charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

PowerStream Three Cell 800mA Lithium Ion chargers

This microprocessor controlled battery charger is capable of charging 3 cell 10.8 V or 11.1 V lithium-ion and lithium polymer (LiPo) battery packs. It has Underwriter Laboratory UL1950 approval and UL, cUL and CE marks. The peak voltage for the device is 12.6V which is classified as a highly accurate lithium ion battery charger. The price range of the product is $11.25 - $20.25 depending on the volume of chargers purchased.

PowerStream Three Cell 10.8 Volt Lithium Ion or Lithium Polymer Charger

This current version of the "turtle charger" for lithium ion battery packs uses a microcontroller with an optimized charging algorithm. The updated PST-TL03 charger is CCCV mode (constant current/constant current) and has 1A charging current and safety back up with temperature protection. The difference is an LED indicator with a LED signal if the battery temperature is higher than 50°C. The updated TL03 charger is compatible for a wide range of battery pack capacity. This allows for a charge of 12V 2000mah pack or 12V 8000mAh battery pack using one TL03 charger. The product is user-friendly and convenient for inventory management. On pricing, the device can be bought from $42.00 -$53.40 depending on the volume of product purchased.

Specifications:

- Input Voltage: 100-120 Vac, 50/60 Hz (universal input 90-260 50/60 available).
- Output Voltage: Up to 16.8 Vdc controlled by charger
- Output current: 1.0 A max., controlled by charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating. Don't charge lithium-ion or lithium-polymer cells if their temperature is below 0° or over 45° C.
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

PowerStream Three Cell Lithium Ion Fast charger

This 3-cell li-ion battery charger is a microprocessor controlled device designed specifically for charging three cell 10.8 V or 11.1 V. Lithium-ion and lithium polymer (lipo) battery packs. The charger has indicators to display the systems' operating mode. The unit complies with applicable safety agency standards of UL, cUL and CE. The price of the charger starts at $42.50 for a single unit purchase with discount up to $18.10 for orders over 301 units.

- Specifications:
- Input Voltage: 100 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 12.6 Vdc controlled by lithium battery charger
- Output current: up to 1.8 A ±0.1 A max., controlled by the battery charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

PowerStream Four Cell Lithium Ion chargers

This battery charger is a microprocessor controlled unit. It is exclusively for charging 14.4 V or 14.8 V lithium-ion or lithium-polymer battery packs, with led indicators to display the current operating mode of the charger. The charger complies with applicable safety agency requirements of UL, cUL and CE. There is no minimum order for this product. The price of the product starts at $25.25 - $10.25 for bulk orders over 301 units.

Specifications:

- Input Voltage: 100 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 16.8 Vdc controlled by charger
- Output current: up to 0.6 A ±0.1 A max., controlled by charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating

- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

<u>PowerStream Four Cell 1800 mA Lithium Ion fast chargers</u>

This lithium battery charger is also a microprocessor controlled unit designed specifically for charging 14.4 V or 14.8 V lithium-ion or lithium-polymer battery packs, with led indicators to display the current operating mode of the charger. This battery charger complies with applicable safety agency standards of UL, cUL and CE. The price starts at $42.50 for single units to $18.10 for orders over 301 chargers.

Specifications:

- Input Voltage: 100 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 16.8 Vdc controlled by charger
- Output current: up to 1.8 A ±0.1 A max., controlled by charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-operating
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

<u>PowerStream Lithium-Ion Battery Charger custom design</u>

This battery charger is a microprocessor controlled unit designed specifically for charging a 1.8 A-hr., 14.4 V, Lithium-ion battery pack. It has three led indicators to display the current operating mode of the charger. This charger is capable of providing a full charge in approximately 2.5 hours. This battery charger complies with the applicable safety agency standards. This product’s price is not currently available.

Specifications:

- Input Voltage: 90 - 240 Vac, 50/60 Hz.
- Output Voltage: Up to 16.8 Vdc controlled by charger
- Fuse: 5mm X 20 mm IEC Sheet III (time-lag) fuse, 1.6 A, 250 V.
- Output current: 1.0 A max., controlled by charger
- Temperature: -10 to +45° C, Operating -40 to +70° C, non-Operating
- Humidity: Indoor 90% R.H. @ 35° Celsius, Non-Condensing

As can be seen there are several factors to be taken into account when purchasing a battery charger including, but not limited to the number of cells, the output current, and the output voltage. In terms of comparing these products to the Battery Charger based upon capacity, the four cell comes closest to the present invention that can currently handle up to ten cells. It is unknown as to whether the capacity to handle ten cells is important to end-users, but it could be important in some of the markets, particularly the military.

In terms of functionality, it is known that these products are controlled by microprocessors, but the specific algorithm is obviously unknown. With the prospective advantages of the Battery Charger stemming from the functionality that the algorithm provides, it does not appear that other smart chargers provide the same level of precision and reduced generation of heat which may lead to extended battery life. There are still questions around how long that extended life may be and if there is a real return on investment. Demand for the Battery Charger may likely be dependent on the length of extended life.

When looking at return on investment, the cost of the devices comes into play. The most expensive charger on this list is $53.40, significantly lower than that of the Battery Charger (~$4000). There would have to be a great need for charging multiple cells precisely, reliably and with less generation of heat or the extended life of the battery would need to be an order of magnitude higher for this price to be paid. As mentioned, there may be a military need for such prospective advantages, but other markets may not need (ie: consumer electronics) or be able to afford (ie: first responders) such a heavy upfront investment.

5.2.2 Other Chargers

In addition to other smart chargers, the Battery Charger and Power Reduction System and Method (Battery Charger) may also face competition from other charges that are not controlled by a microprocessor. This may hold especially true in the portable consumer electronics market, as previously mentioned.

On that note, chargers without microprocessors are rather inexpensive devices. The following chart details the price of chargers for four portable consumer electronics. As can be seen, these chargers range from $5.88 to $29.00, depending on the type of device they are intended to charge. This may mean that the present invention, estimated to cost $4000 for a 10 cell battery charger, will have a difficult time penetrating this market.

Battery Charger Costs		
Charger Type	**Average**	**Range**
Canon Lithium Ion Battery Charger Replacement (Camera)	$11.63	$2.24 - $19.95
Dell Inspiron Lithium Ion Battery Charger Replacement (Computer	$21.45	$10.68 - $29.00
Blackberry Curve Lithium Ion Battery Charger Replacement	$10.10	$5.88 - $14.99

(Cell Phone)		
iPod Classic Lithium Ion Battery Charger Replacement (MP3 Player)	$14.65	$9.95 - $22.99

Further, the benefits that stem from the Battery Charger's functionality may not be needed in many markets. The Battery Charger could potentially extend the life of the lithium-ion batteries, however, the price premium for said benefit may still outweigh the cost. The chart below details the prices of batteries for four portable consumer electronics. Much like the price of chargers, the price of batteries is also dependent upon the type of device, ranging from $1.59 to $109.99. In general though, the batteries are relatively inexpensive in comparison to the Battery Charger device. Consumers are most likely to simply dispose of an old lithium ion battery and purchase a new one as opposed to making a significant (~$4000) investment upfront. It would be difficult for consumers to obtain a return on said investment. Detailed information on how these numbers were obtained in contained in Appendix B.

Battery Costs		
Battery Type	**Average**	**Range**
Canon Lithium Ion Battery Replacement (Camera)	$27.37	$20.99 - $36.95
Dell Inspiron Lithium Ion Battery Replacement (Computer)	$53.69	$33.99 - $109.99
Blackberry Curve Lithium Ion Battery Replacement (Cell Phone)	$11.89	$1.59 - $23.38
iPod Classic Lithium Ion Battery Replacement (MP3 Player)	$14.95	$11.55 - $19.99

5.3 Pricing Considerations

Pricing considerations for the Battery Charger and Power Reduction System and Method (Battery Charger) are explored based upon its main prospective advantages of charging multiple cells precisely, and with lower generation of heat, decreasing the risk of overcharging and potentially extending battery life. In addition, the competition information examined in the previous sections reveals a host of competitors, all of which have a lower cost than the Battery Charger.

As mentioned, the one-off version of the Battery Charger cost approximately $4,000 to create, with the circuit boards costing between $650 and $725. With scaled up production these costs could be reduced, but when looking at the competition, they would need to be significantly lower. Regardless of pricing, the prospective advantages of the Battery Charger may not hold a strong value proposition in some markets.

$4,000 could be a considerable upfront investment, however, in high use situations, a return on this investment could be achieved, especially when precision and reliability are of concern. Additionally, the superior efficiency of the Battery Charger would be an advantage in case of high use, furthering the cost savings for electricity.

6 Cautions and Considerations

This assessment has strived to examine the core application, prospective advantages, potential markets, and competitive landscape for the Battery Charger and Power Reduction System and Method (Battery Charger). There are some observations that may warrant caution and/or additional consideration.

The first factor is that of competition. There appears to be a large number of product offerings and companies in this sector that can serve as competition to the Battery Charger. Both smart chargers and regular chargers can be considered competition depending on the application. There may be significant barriers to entry presented by rivalry in this sector. On another note, the concentration in this industry was found to be low making it a more attractive industry to enter.

Another significant hurdle may be pricing structure. As examined, the most expensive charger found by this assessment cost $53.40, significantly lower than that of the Battery Charger (~$4000). There would have to be a great need for charging multiple cells precisely, reliably and with less generation of heat or the extended life of the battery would need to be several orders of magnitude higher for this price to be paid. As mentioned, there may be a military need for such prospective advantages, but end users in other markets may not need (ie: consumer electronics) or be able to afford (ie: first responders) such a heavy upfront investment.

Finally, and related, the need for said prospective advantages may be limited in many markets. The electric vehicle (EV) market however may find value in the prospective advantages of the Battery Charger. Precise charging and extended battery life could be very important when the battery costs $12,000 as opposed to $29 on average in the consumer electronics sector.

7 Conclusion

This analysis has worked to provide a general overview of the Battery Charger and Power Reduction System and Method (Battery Charger) and prospective market opportunities. Four applications: *charging batteries in combat situation, charging batteries in first responder situations*, *charging batteries in portable consumer electronics, charging electric vehicles* and their four corresponding markets within which the Battery Charger may find relevance were examined including, but not limited to the: *military market, civilian first responder market, portable consumer electronics battery charger market, and electric vehicle battery charger market*. Each potential market was defined, quantified, and market drivers and influences were explored. Initial pricing analysis based upon the one-off price of the Battery Charger was conducted, and competing technologies were examined.

In defining and quantifying markets, focus wass placed on the existence of prospective end users, dollars spent on batteries, the number of devices in use that rely on portable power, and industry revenues. Existing battery charger solutions within the military, civilian first responder, portable consumer electronics, and electric vehicle market will serve as competition for the Battery Charger and Power Reduction System and Method (Battery Charger). This assessment found that the marketplace is rather saturated with battery chargers that have significantly lower price points than the Battery Charger at hand. Further, the prospective advantages associated with the Battery Charger may not outweigh the additional cost in most markets. Industry composition analysis found that while a total of 11 out of 1,003 firms classified under North American Industry Classification System (NAICS) code 335999 “All Other Miscellaneous Electrical Equipment and Component Manufacturing” are not considered small businesses, only 21.5% of the value of shipments in 2002 came from the eight largest firms. This may mean that concentration in this industry is low[59].

Based upon the functionality and prospective advantages of the Battery Charger and Power Reduction System and Method (Battery Charger), some markets may prove more viable than others. In light of initial pricing and competitive analysis, the military and electric vehicle charging markets may enjoy the most benefit from the Battery Charger’s prospective advantages.

$4,000 per charger could be a considerable upfront investment, however, in high use situations with multiple batteries/cells (ie: military or electric vehicles), a return on this investment could be achieved, especially when precision and reliability are of concern. Additionally, the superior efficiency of the Battery Charger would be an advantage in the case of high use, furthering the cost savings for electricity. First responders could most likely benefit from using the Battery Charger as well, but it is unknown as to whether there would be a willingness and ability to make such a large upfront investment. Further, the portable consumer electronics market is especially saturated with relatively low cost batteries (averaging $27) and chargers (averaging $14.50). The

[59] http://www.census.gov/prod/ec02/ec0231i335999t.pdf

average consumer would be better off simply purchasing a new battery than making a large upfront investment to only extend battery life incrementally. With that said, a recommendation of pursuing one market or another is not given, but the observations within this report may provide substantial data for one to make such a decision.

Appendix A—Types of Battery Chargers

Simple Charger

This type of battery charger is the cheapest format available. The charger works by providing a constant DC power supply into the battery. The charge is constant and does not alter, however it does deliver the power at a slow pace to avoid over charging which can be damaging and on occasions can destroy a battery. This format is cheap and as a result it is lacking in quality.

Trickle Charger

The Trickle charger is a simple technology where the battery is kept topped up whilst being charged by using a ‘trickle’ method by feeding the charge into the battery. The battery is never over-charged using this method.

Timer based Charger

This type of charger functions over a period which is set to a predetermined time. This was a common type of device in the late 1990’s where it was deployed with charging Ni-Cd cells (nickel-cadmium battery).

A step up from the overnight/trickle chargers are timer based chargers which typically feature a higher charge rate than trickle chargers and a timer to assure that batteries are not overcharged.[60]

Intelligent Charger

The intelligent battery charger is a concept that is controlled by a microcontroller. Simple battery chargers do not have the capability to provide intelligence to charge different battery technologies or batteries with the same technology but different voltages and capacities. This may leave the battery improperly charged and it may also be a serious safety hazard. The microcontroller system can provide the intelligence to combat these problems.

Microcontroller Benefits[61]

- Flexibility to handle different technologies, voltages and capacities
- Variable Voltages Generation Control
- Charge/Discharge Multiple Packs
- ‘‘Windowed A/D for High Resolution

[60] http://www.batteryjunction.com/tibach.html
[61] http://ww1.microchip.com/down+loads/en/AppNotes/30451c.pdf

Fast Charger

Fast chargers function by using control circuitry in the batteries which are charged rapidly avoiding damaging the cells' elements. These chargers would mostly have a cooling fan to allow the temperature of the cells to keep under control. The majority of these chargers are also capable of acting as standard overnight chargers if they are used with standard NiMH cells that do not have the special control circuitry. Fast chargers, such as those made by Energizer, can fast-charge NiMH batteries even if they do not have the control circuit.

Pulse

The Pulse chargers work by a pulse which is fed into the battery. This DC pulse has a strictly controlled rise time, pulse width, pulse repetition rate (frequency) and amplitude. This technology is said to work with any size, voltage, capacity or chemistry of batteries, including automotive and valve-regulated batteries. With pulse charging, high instantaneous voltages can be applied without overheating the battery. In a Lead-acid battery, this breaks down lead-sulfate crystals, thus greatly extending the battery service life.

Several kinds of pulse charging are patented. Others are open source hardware.

Some chargers use pulses to check the current battery state when the charger is first connected, then use constant current charging during fast charging, then use pulse charging as a kind of trickle charging to maintain the charge.

Some chargers use "negative pulse charging", also called "reflex charging" or "burp charging". Such chargers use both positive and brief negative current pulses. Such chargers don't work any better than pulse chargers that only use positive pulses.

Inductive

This battery charging system works by using electromagnetic induction. Electromagnetic energy is passed via a charging station into an electrical device which stores the energy in its internal battery system. This concept functions without metal contact between the battery and the charger thus avoiding the likelihood of possible electrocution. A typical example of this type of charger would be in an electric toothbrush or in other bathroom appliances.

USB chargers

A USB (universal serial bus) cable can be used as a power source to recharge batteries in cell phones or portable digital audio players. The USB cable supplies a 5 volt power cable which is used to charge batteries which are compliant to the required specifications.

Solar Chargers

Solar chargers are generally portable, however they also can come in the format of a fixed mount which are known as solar panels. The solar energy which is created by light is converted into DC current. The solar panels are usually connected to the electrical grid. The portable version, which is used ‘off the grid’ would be applied for example in providing a charge for cars, boats and RV’s. This form of energy which is associated with bright sunny environments can also be used in cloudy low light situations; however it depends on the quality of the equipment to deliver a charge effectively. The portable charging system is generally for ‘trickle’ charging although if the wattage is strong enough the battery can be fully charged. Wind power portable charging is also an option. The Kinesis K3 is an example of a unique charging model in that it can deliver both wind and solar power.[62]

[62] http://www.kinesisindustries.com/kinesis/products

Appendix B—Battery Charger and Battery Cost Calculations

Battery Type	Battery Cost
Canon Lithium Ion Battery Replacement (Camera)	$23.99[63]
	$28.99[64]
	$36.95[65]
	$20.95[66]
	$25.95[67]

Battery Charger Type	Battery Charger Cost
Canon Lithium Ion Battery Charger Replacement (Camera)	$2.24[68]
	$14.99[69]
	$14.99[70]
	$6.00[71]
	$19.95[72]

63 http://www.amazon.com/Canon-Battery-SD1000-Digital-Cameras/dp/B00065L5SU
64 http://www.buy.com/prod/canon-nb-4l-nb4l-equivalent-li-ion-battery-2-pk-for-powershot-digital/q/listingid/42884138/loc/111/211111939.html
65 http://www.adorama.com/ICANB4L.html?sid=1283182419240422&utm_source=gbase&utm_medium=Shopping%20Site&utm_campaign=Other&utm_term=Other
66 http://www.newworldvideodirect.com/productdetail.asp?productid=24176&refid=froogle
67 http://www.batterymart.com/p-cam-bli-256.html?utm_source=Google&utm_medium=Base&utm_campaign=ComparisonShopping

68 http://www.buy.com/prod/digital-camera-canon-nb-4l-compact-battery-charger/q/listingid/45426241/loc/111/211241486.html
69 http://www.eforcity.com/270745.html?efprcggbadtf100829=sc+gb+270745
70 http://www.daydeal.com/product.php?productid=12123
71 http://www.amazon.com/Battery-Charger-Digital-Camera-SD-430/dp/B001QWROPK
72 http://www.bhphotovideo.com/c/product/581840-REG/Pearstone_CMNB4L_Mini_AC_DC_Battery_Charger.html

Battery Type	Battery Cost
Dell Inspiron Lithium Ion Battery Replacement (Computer)	$37.00[73]
	$33.99[74]
	$109.99[75]
	$85.99[76]
	$104.99[77]

Battery Charger Type	Battery Charger Cost
Dell Inspiron Lithium Ion Battery Charger Replacement (Computer)	$10.68[78]
	$14.10[79]
	$26.95[80]
	$26.50[81]
	$29.00[82]

73 http://www.amazon.com/Hi-Capacity-Inspiron-Precision-310-6321-310-6322/dp/B001254YOK
74 http://www.buy.com/prod/laptop-battery-for-dell-inspiron-6000-9200-9300-9400-e1705-xps-m170/q/listingid/23055612/loc/101/207985038.html
75 http://www.bestbuy.com/site/Lenmar+-+Battery+for+Dell+Inspiron+6000+Series+Laptops/9049549.p?skuId=9049549&ci_src=14110944&ci_sku=9049549&ref=06&loc=01&id=1218012117115
76 http://www.tigerdirect.com/applications/searchtools/item-details.asp?EdpNo=4396666&SRCCODE=GOOGLEBASE&cm_mmc_o=VRqCjC7BBTkwCjCECjCE
77 http://www.newegg.com/Product/Product.aspx?Item=N82E16834992146&nm_mc=OTC-Froogle&cm_mmc=OTC-Froogle-_-Notebook+Batteries+/+AC+Adapters-_-V7-_-34992146

78 http://www.amazon.com/600M-640M-700M-E1405-E1505/dp/B00277Q0NK
79 http://www.buy.com/prod/dell-inspiron-6000-new-ac-power-adapter-supply/q/listingid/29868370/loc/101/209143270.html
80 http://www.amazon.com/HQRP-Heavy-Duty-Inspiron-Notebook-Mousepad/dp/B001MU49WC
81 http://www.notebookcord.com/g/b/dell-pa-12-65-watt-notebook-cord-gb.html
82 http://www.discountelectronics.com/index.php?l=product_detail&p=1460

Battery Type	Battery Cost
Blackberry Curve Lithium Ion Battery Replacement (Cell Phone)	$18.99[83]
	$1.59[84]
	$2.48[85]
	$23.38[86]
	$12.99[87]

Battery Charger Type	Battery Charger Cost
Blackberry Curve Lithium Ion Battery Charger Replacement (Cell Phone)	$5.88[88]
	$11.99[89]
	$14.99[90]
	$6.97[91]
	$10.67[92]

83 http://www.overstock.com/Electronics/Blackberry-8300-Curve-Original-Battery/3071783/product.html?cid=123620&fp=F&ci_src=14110944&ci_sku=11208161
84 http://www.buy.com/prod/oem-lithium-ion-battery-for-blackberry-curve-7100g-7100i-c-s2/q/listingid/54349278/loc/12435/208296519.html
85 http://www.unbeatablesale.com/pcacc-10477-001.html?utm_source=froogle4&utm_medium=cpc&utm_term=PCACC-10477-001&ci_src=14110944&ci_sku=PCACC-10477-001
86 http://www.unbeatablesale.com/pcacc-10477-001.html?utm_source=froogle4&utm_medium=cpc&utm_term=PCACC-10477-001&ci_src=14110944&ci_sku=PCACC-10477-001
87 http://www.accessorygeeks.com/blackberry-7100-acc-10477-001.html?utm_source=google&utm_medium=comparisonshopping

88 http://www.amazon.com/OEM-Original-Blackberry-Charger-110-240v/dp/B000T4VKBA
89 http://www.handhelditems.com/blackberry-curve-8300-travel-charger-p-12587.html
90 http://www.accessorygeeks.com/blackberry-oem-charger-10600-001.html?utm_source=google&utm_medium=comparisonshopping
91 http://www.thecellguru.com/Products/781
92 http://www.diguniverse.com/CELLULAR-ACCESSORIES/TO-BE-CATEGORIZED/PCSACC-10600-001.html

Battery Type	Battery Cost
iPod Classic Lithium Ion Battery Replacement (MP3 Player)	$11.55[93]
	$13.29[94]
	$14.95[95]
	$14.99[96]
	$19.99[97]

Battery Charger Type	Battery Charger Cost
iPod Classic Lithium Ion Battery Charger Replacement (MP3 Player)	$19.99[98]
	$9.95[99]
	$10.34[100]
	$9.99[101]
	$22.99[102]

93 http://www.buy.com/prod/550mah-battery-fits-apple-ipod-5g-30gb-60gb-80gb-apple-ipod-classic/q/listingid/45426280/loc/111/211241525.html
94 http://www.amazon.com/Lenmar-Replacement-Battery-iPod-classic/dp/B000P9I6B6
95 http://www.ifixit.com/iPod-Parts/iPod-Classic-Thin-Replacement-Battery/IF130-019
96 http://eshop.macsales.com/item/Newer%20Technology/BIPOD900C160/?utm_source=google&utm_medium=shoppingengine&utm_campaign=googlebase
97 http://www.digiexpress.us/Battery-kit-for-80GB-or-120GB-iPod-Classic_p_111.html

98 http://www.buy.com/prod/apple-dock-connector-to-usb-charge-cable/q/listingid/92041889/loc/111/211423513.html
99 http://www.getyourtech.com/servlet/the-86654/Apple-iPhone-fdsh--iPod-USB/Detail
100 http://www.diguniverse.com/CELLULAR-ACCESSORIES/DATA-CABLES-KITS-SOFTWARE-SYNC-SOLUTIONS/PCSMA591GA.html
101 http://www.overstock.com/Electronics/Apple-Dock-Connector-to-USB-Charge-Cable/4714156/product.html?cid=123620&fp=F&ci_src=14110944&ci_sku=12626982
102 http://www.crocwireless.com/apple-iphone-3gs-oem-usb-data-cable-ma591ga.html

Appendix C—Full Charts for NAICS 335999[103]

Table 1. Historical Statistics for the Industry: 2002 and Earlier Years

[Data based on the 2002 Economic Census and the 2002 Annual Survey of Manufactures (ASM). For information on confidentiality protection, sampling error, nonsampling error, and explanation of terms, see note at end of table. For meaning of abbreviations and symbols, see introductory text]

Industry and year[1]	Companies[2]	All establishments[3]	All employees		Production workers			Value added ($1,000)	Total cost of materials ($1,000)	Total value of shipments ($1,000)	Total capital expenditures ($1,000)
			Number[4]	Payroll ($1,000)	Number[4]	Hours (1,000)	Wages ($1,000)				
335999, All other miscellaneous electrical equipment and component manufacturing .... 2002..	957	1 003	41 243	1 661 718	24 424	48 795	683 292	4 031 717	3 012 310	7 057 265	r276 221
2001..	N	N	47 444	1 742 097	28 499	55 503	709 250	4 157 251	4 092 587	8 285 443	271 482
2000..	N	N	47 766	1 830 342	28 941	56 520	743 847	5 029 072	4 492 445	9 394 438	271 692
1999..	N	N	45 971	1 663 255	28 130	55 273	686 660	4 361 077	3 665 898	7 982 005	211 796
1998..	N	N	47 232	1 625 742	29 816	56 706	699 026	4 159 134	3 486 244	7 683 599	284 274
1997..	928	978	45 640	1 542 819	28 578	55 205	675 369	3 786 415	3 276 074	7 039 768	231 419

[1]Statistics presented for years ending in 2 and 7 are census data. Interim census years are derived in a representative sample of manufacturing establishments canvassed in the Annual Survey of Manufactures (ASM).
[2]For the census, a company is defined as a business organization consisting of one establishment or more under common ownership or control.
[3]Includes establishments with payroll at any time during the year.
[4]Number of employees figures represent average number of production workers for pay period that includes the 12th of March, May, August, and November plus other employees for payroll period that includes the 12th of March.

Note: The data in this table are based on the 2002 Economic Census and the 2002 Annual Survey of Manufactures (ASM). To maintain confidentiality, the Census Bureau suppresses data to protect the identity of any business or individual. The census results in this table contain sampling errors and nonsampling errors. Data users who create their own estimates using data from American FactFinder tables should cite the Census Bureau as the source of the original data only. For explanation of terms, see Appendix A. For full technical documentation, see Appendix C.

[103] http://www.census.gov/prod/ec02/ec0231i335999t.pdf

Table 4. **Industry Statistics by Employment Size: 2002**

[Data based on the 2002 Economic Census. For information on confidentiality protection, nonsampling error, and explanation of terms, see note at end of table. For meaning of abbreviations and symbols, see introductory text]

Employment size class	E[1]	All establishments[2]	All employees: Number[3]	All employees: Payroll ($1,000)	Production workers: Number[3]	Production workers: Hours (1,000)	Production workers: Wages ($1,000)	Value added ($1,000)	Total cost of materials ($1,000)	Total value of shipments ($1,000)	Total capital expenditures ($1,000)
335999, All other miscellaneous electrical equipment and component manufacturing											
All establishments	2	1 003	41 243	1 661 718	24 424	48 795	683 292	4 031 717	3 012 310	7 057 265	r276 221
Establishments with—											
1 to 4 employees	9	374	781	27 509	494	823	12 299	53 895	41 959	95 683	r1 697
5 to 9 employees	6	137	941	40 431	585	1 190	16 799	101 142	73 844	178 821	r2 754
10 to 19 employees	5	125	1 757	76 113	1 011	2 056	30 108	176 032	134 359	309 233	r6 210
20 to 49 employees	3	169	5 344	217 909	3 138	6 293	86 487	452 698	386 298	838 093	r24 535
50 to 99 employees	3	103	7 326	297 563	4 105	8 431	116 113	716 624	578 058	1 294 980	r46 203
100 to 249 employees	2	60	8 876	350 646	5 161	10 480	140 281	824 422	673 600	1 496 562	r38 053
250 to 499 employees	1	23	7 385	282 514	4 572	8 923	128 732	809 773	617 035	1 448 091	r37 869
500 to 999 employees	–	11	i	D	D	D	D	D	D	D	D
1,000 to 2,499 employees	–	1	g	D	D	D	D	D	D	D	D
2,500 employees or more	–	–	–	–	–	–	–	–	–	–	–
Administrative records[4]	9	455	1 920	77 294	1 257	2 404	33 750	154 559	127 888	279 551	r5 044

[1]Some payroll and sales data for small single-establishment companies with up to 20 employees (cutoff varied by industry) were obtained from administrative records of other government agencies rather than from census report forms. These data were then used in conjunction with industry averages to estimate statistics for these small establishments. This technique was also used for a small number of other establishments whose reports were not received at the time data were tabulated. The following symbols are shown where estimated data account for 10 percent or more of the figures shown: 1–10 to 19 percent; 2–20 to 29 percent; 3–30 to 39 percent; 4–40 to 49 percent; 5–50 to 59 percent; 6–60 to 69 percent; 7–70 to 79 percent; 8–80 to 89 percent; 9–90 percent or more.

[2]Includes establishments with payroll at any time during the year.

[3]Number of employees figures represent average number of production workers for pay period that includes the 12th of March, May, August, and November plus other employees for payroll period that includes the 12th of March.

[4]Some payroll and sales data for small single-establishment companies with up to 20 employees (cutoff varied by industry) were obtained from administrative records of other government agencies rather than from census report forms. These data were then used in conjunction with industry averages to estimate statistics for these small establishments. Data are also included in respective size classes shown.

Note: The data in this table are based on the 2002 Economic Census. To maintain confidentiality, the Census Bureau suppresses data to protect the identity of any business or individual. The census results in this table contain nonsampling errors. Data users who create their own estimates using data from American FactFinder tables should cite the Census Bureau as the source of the original data only. For explanation of terms, see Appendix A. For full technical documentation, see Appendix C.

Table 5. **Industry Statistics by Primary Product Class Specialization: 2002**

[Data based on the 2002 Economic Census. For information on confidentiality protection, nonsampling error, and explanation of terms, see note at end of table. For meaning of abbreviations and symbols, see introductory text]

Industry or product class code	Industry or primary product class	All establishments[1]	All employees: Number[2]	All employees: Payroll ($1,000)	Production workers: Number[2]	Production workers: Hours (1,000)	Production workers: Wages ($1,000)	Value added ($1,000)	Total cost of materials ($1,000)	Total value of shipments ($1,000)	Total capital expenditures ($1,000)
335999	All other miscellaneous electrical equipment and component manufacturing	1 003	41 243	1 661 718	24 424	48 795	683 292	4 031 717	3 012 310	7 057 265	r276 221
3359991	Capacitors for industrial use (except for electronic circuitry)	11	932	31 309	638	1 277	19 185	86 276	70 553	156 748	r3 307
3359993	Rectifying apparatus	102	13 143	488 435	8 124	16 178	217 249	1 119 806	1 165 128	2 295 496	r82 937
3359996	Other electrical equipment for industrial use (except for electronic circuitry)	40	2 579	110 633	1 501	3 130	45 836	269 830	181 402	456 917	r15 680
3359997	Laser generator power supplies and components	18	4 468	232 628	2 333	4 945	86 956	619 683	333 163	939 530	r108 125
3359999	All other laser systems and equipment	25	1 134	53 979	548	1 139	17 428	126 993	74 739	201 949	r2 939
335999A	Ultrasonic equipment (except medical and dental)	15	1 735	76 705	825	1 638	24 787	149 252	107 262	261 875	r3 466
335999B	Apparatus wire and cord and flexible cord sets (except wiring harnesses and fiber optic), made from purchased insulated wire	16	953	24 576	742	1 457	14 578	52 764	49 584	103 086	r1 791
335999E	All other miscellaneous electrical equipment and components (except for industrial use)	15	1 172	47 389	646	1 356	19 697	78 116	70 627	148 393	r3 115
335999F	All other miscellaneous electronic systems and equipment (including automatic garage door openers, and amplifiers)	43	4 553	177 579	2 539	4 895	65 410	703 653	291 542	1 002 440	r17 535

[1]Includes establishments with payroll at any time during the year.

[2]Number of employees figures represent average number of production workers for pay period that includes the 12th of March, May, August, and November plus other employees for payroll period that includes the 12th of March.

Note: The data in this table are based on the 2002 Economic Census. To maintain confidentiality, the Census Bureau suppresses data to protect the identity of any business or individual. The census results in this table contain nonsampling errors. Data users who create their own estimates using data from American FactFinder tables should cite the Census Bureau as the source of the original data only. For explanation of terms, see Appendix A. For full technical documentation, see Appendix C.

Appendix D—List of Battery and Battery Charger Companies[104]

A.G. Engineering Inc. (DD)* ** **

Rancho Cucamonga, CA

A.T.I. (DD) * ** *

Lancaster, OH

Adcour (MR) * ** **

Woburn, MA

Advanced Power Services LLC (DD) * ** *

Plainville, CT

Advanced Power Technology Inc. (MR) * ** **

Setauket, NY

Alaska Prime Power (DD) ** ** *

Palmer, AK

Allpower Generator Sales & Service (DD) * ** *

Boothwyn, PA

A1taStream Power Systems (MF) * ** *

Canada, Delta, BC

Alternative Power Sources Inc. (DD) ** ** *

Gibsonia, PA

AMICI Electric & Generators LLC (DD) ** ** *

Norwalk, CT

Antilles Power Depot (DD) * ** *

Carolina, PR

ARCCO Power Systems (DD) * ** *

[104] http://www.highbeam.com/doc/1G1-193140543.html

Baton Rouge, LA

Arizona Generator Technology Inc. (DD)* ** *

Glendale, AZ

Arthur N. Ulrich Co. (MR) * **

Pataskala, OH

Atlantic Detroit Diesel--Allison LLC (DD) * ** **

Pine Brook, NJ

Atlantic Power Solutions Inc. (DD)* ** *

Siler City, NC

Authorized Services of New England (DD) * ** **

Marlborough, MA

Bay City Electric Works Inc. (DD) * ** *

Lakeside, CA

Bay Diesel Corp. (DD) * ** *

Richmond, VA

BAY-SAN Co. Inc. (MR) * ** **

Waukesha, WI

Benchmark Power Solutions (MR)* ** **

Douglasville, GA

Benroth-Nolty Co. (MR)* ** **

Bluffton, OH

Boulden Co. (MR) * ** **

Conshohocken, PA

Broadcrown Inc. (MF) * ** **

Medley, FL

Buckeye Power Sales Co. Inc. (DD) * ** *

Blacklick, OH

Butler Machinery Co. (DD) * ** *

Fargo, ND

C.B.G. Inc. d.b.a. Gory Electric Motors * ** *

& Generators (DD) Los Angeles, CA

Caribbean Powergen Solutions Corp. (DD) * ** **

Bayamon, PR

Cashman Equipment (DD)* ** *

Henderson, NV

Caterpillar Inc. (MF) * ** **

Mossville, IL

Central Machinery & Electric Ltd. (DD)* ** *

Bahamas, New Providence

RW Chapman Co. Inc. (MR) * ** **

Charlotte, NC

Circle Generator Service Inc. (AE)* ** *

Ft. Lauderdale, FL

CJ's Sales & Service (DD) * ** *

Ocala, FL

Clarke Power Services (DD)* ** *

Cincinnati, OH

Coffman Electrical Equipment Co. Inc. (DD)* ** **

Grand Rapids, MI

Continental Engines Inc. (DD) * ** *

Greenville, SC

Control Equipment & Sales Inc. (MR)   * ** **

Maylene, AL

Cummins Bridgeway LLC (DD)* ** **

New Hudson, MI

Cummins Power Generation (MF) * **

Minneapolis, MN

Cummins Power South (DD) * **   *

Atlanta, GA

Cummins Southern Plains Ltd. (DD) * ** **

Arlington, TX

D-Square Energy Systems (DD) * ** **

North Bend, WA

Data Power Source Inc. (CI)   * ** **

Covington, GA

Davidson Sales Co. (MR)   * ** **

Daytona Beach, FL See Ad, Page 85

Deep Sea Electronics Inc. (MF)* ** **

Rockford, IL

Dennis Don & Associates Inc. (MR) * ** **

Costa Mesa, CA

Diesel Engine Technician Inc. (AE)* ** **

San Juan, PR

DOD Project Mgr-Mobile Electric Power (AC)* **   *

Ft. Belvoir, VA

Duthie Power Services (DD)* ** *

Long Beach, CA

DynaTech Industries Ltd. (DD) * ** **

Lebanon, PA

EC Power Systems (DD) * ** *

Portland, OR

Echo Group Inc. (DD) * ** **

Beatrice, NE

Elecon Services Inc. d.b.a. Esposito's* ** *

Electric (CI) Denville, NJ

Electric & Power Generator Services (AE) ** ** *

Guanica, PR

Electro-Mechanical Services Inc. (DD) * ** **

Cocoa, FL

Electro-Motion Inc. (DD) * ** **

Menlo Park, CA

Emergency Power Services (DD) * ** *

Hialeah, FL

Emergency Power Systems Inc. (DD) * ** *

Tulsa, OK

Emergency Systems Service Co. (DD)* ** *

Quakertown, PA

Empire Power Systems (DD) * **

Phoenix, AZ

Energy Systems (DD) * ** **

Stockton, CA

ENTEC Services Inc. (AE) * ** **

Peoria, IL

EPAC, Sales & Service Co. Inc. (MR) * ** **

Hurst, TX

Ewing & Associates (MR) * ** **

Chester, MD

Ewing Two Inc. (MR) * ** **

Linwood, NJ

Fabick Power Systems Inc. (DD)* ** **

Fenton, MO

Flint Power Systems (DD) * ** **

Albany, GA

Foley Power Systems (DD) ** ** *

Piscataway, NJ

Francisco Equipment (DD) * ** **

Ravena, NY

Frontier Diesel (AE) ** ** *

Canada, Timmins, ON

Gabel Equipment Corp. (CI)* ** *

Port Chester, NY

GAL Power Systems (DD)* ** *

Canada, Nepean, ON

Gen Power Products Inc. (DD) * ** *

Wixom, MI

Gen Tech of Nevada (DD)   * **   *

North Las Vegas, NV

Gen-Power Specialists LLC (DD)* ** **

Cotati, CA

Gen-Set Specialties (MR) * **   *

Levittown, PR

General Power Ltd. (DD)   * ** **

Doral, FL

Generator Service Co. Inc. (DD)   * **   *

Hueytown, AL

Generator Services Co. Inc. (DD) * ** **

Rancho Cucamonga, CA

Generator Services Inc. (DD) * ** **

West Columbia, SC

Generator Works (DD) * **   *

Norwalk, CA

Generatrice Drummond (DD) * ** **

Canada, St. Nicephore, PQ

GenPro Power Systems (DD) * **   *

Rapid City, SD

Genserve Inc. (DD)* **   *

Bay Shore, NY

Genset Services Inc. (DD) * **   *

Pompano Beach, FL

GenTune LLC (AE) ** **   *

Spotsylvania, VA

Goodall Industrial Equipment Co. (MR) * ** **

Natick, MA

GPR Industries (1994) Ltd. (DD) * ** **

Canada, Grande Prairie, AB

Gregory Poole Power Systems (DD) * ** **

Raleigh, NC

H.O. Penn Machinery Co. Inc. (DD) * ** **

Newington, CT; Bloomingburg, Bronx,

Holtsville, Poughkeepsie, NY

Halton Co. (DD) * ** *

Portland, OR

Harold Wells Associates Inc. (MR) * ** **

San Ramon, CA

Harper Power Products Inc. (DD) * ** *

Canada, Toronto, ON

Hatton Marine (AE)* ** *

Seattle, WA

Hewitt Equipment Ltd. (DD)* ** **

Canada, Pointe-Claire, PQ

Huston Electric Inc. (CI) * ** *

Lafayette, IN

Illini Power Products Co. (DD)* ** *

Carol Stream, IL

Innovative Electrical Technology (MR) * ** **

Swisher, IA

Integrated Power Systems Intl Inc. (DD) * ** **

Rochester, NY

Interstate PowerSystems Inc. (DD) * ** **

Minneapolis, MN

James Houlihan Inc. (DD) * ** *

Brookline, MA

JD Power Systems (DD) * ** *

London, OH

Johnson & Towers Inc. (DD)* ** *

Baltimore, MD

Johnson Power Systems (DD)* ** *

Riverside, CA

Jpex Engine Service Inc. (AE) ** ** *

Dade City, FL

Kelly Generator & Equipment Inc. (DD) ** ** *

Owings, MD

Kim Schneider Electrical Contracting (CI) ** ** *

Chalfont, PA

Kinsley Power Systems (DD)* ** *

East Granby, CT

Kossen Equipment Inc. (DD)* **

Bessemer, Theodore, AL; Bossier City, LA;

Jackson, MS

KPB Services Co. (DD) * ** **

Ft. Lauderdale, FL

Laeverco Products (MR)* ** **

Alta Loma, CA

LaMarche Mfg. Co. (MF)* ** *

Des Plaines, IL

Lechmotoren US Inc. (MF) * ** *

El Paso, TX

Leedy Electric Corp. (CI) * ** **

Mulberry, FL

Linn State Technical College (AG) ** ** *

Linn, MO

LionHeart Engineering (AE)** ** *

Woodstock, IL

Lucho's Garage Services (AE) ** ** *

Miami, FL

LYNX Power Systems (MF) * ** *

Kennesaw, GA

Magnus Inc. (DD) * ** *

Milaca, MN

Markair Power Solutions * ** **

a Division of Markair Inc. (DD)

Jacksonville, FL

McBride Inc. (CI) * ** **

Round Rock, TX

McDonald Equipment Co. (DD) * ** *

Willoughby, OH

Meco-Marine Electrical Co. (DD) * **

Port Lavaca, TX

Mel Clark Electric Inc. d.b.a. Clark * ** *

Electric Service (CI) Mesquite, TX

Michigan Cat Power Systems (DD) * ** **

Novi, MI

Mid America Power Systems (DD)* ** *

Riverside, MO

Midnight Sun Energy Ltd. (MF) * ** **

Canada, Yellowknife, NT

Morris Electric & Repair (DD) * ** *

Great Bend, KS

MTU Onsite Energy (MF)* ** **

Mankato, MN

Murphy Ltd., FW (MF) * ** **

United Kingdom, Salisbury

Murphy, FW (MF) * ** **

Tulsa, OK; Rosenberg, TX

National Power Corp. (DD) * ** **

Raleigh, NC

Nixon Power Services Co. (DD) * ** *

Brentwood, TN

Nolen Sales Agency (MR) * ** **

Memphis, TN

North Shore Generator Systems Inc. (DD)   * **   *

Ronkonkoma, NY

O-K Generators & Diesel Service (DD) ** **   *

Deerfield Beach, FL

Ohio CAT (DD) * ** **

Cleveland, OH

On-Site Power Inc. (AE)   * ** **

Ocala, FL

Onsite Power Inc. (MR)* ** **

Aurora, CO

Pacific Power Products (DD)   * **   *

Kent, WA

Panel Components & Systems Inc. (MF) * ** **

Stanhope, NJ

PEG Power Equipment Group Inc. (MR)   * ** **

Houston, TX

Penn Power Systems (DD)   * **   *

Buffalo, Rochester, Syracuse, NY;

Cranberry Twp., Lebanon, Philadelphia, PA

Peregrine Power LLC (AE) * ** **

Wilsonville, OR

Peterson Power Systems Inc. (DD) * **

San Leandro, CA

PJ Power Inc. (MR)* ** **

Ocala, FL

PM Technologies (DD) * **   *

Wixom, MI

Pothering Generators (DD) * **   *

Llewellyn, PA

Power Depot Inc. (DD) * ** **

Miami, FL

Power Plus! (DD) * **   *

Orange, CA

Power Station Generators (DD) * ** **

Canada, Mississauga, ON

Power Systems Electric Inc. (MF) * **   *

Myerstown, PA

Power-Gen Electrics Ltd. (AE) ** **   *

United Kingdom, Nottingham

PowerManageMent (AE) * ** **

Long Beach, MS

PowerPro Service Co. Inc. (AE)* **   *

Bohemia, NY

Powers Generator Service LLC (DD) * ** **

Swanzey, NH

Professional Engine Systems (DD) * **   *

Canfield, OH

Progen Inc. (AE) * **   *

Jacksonville, FL

Quick Cable Corp. (MF)* **   *

Franksville, WI

R.A. Mitchell Co. Inc. (DD) * ** **

New Bedford, MA

R.B. Grove Inc. (DD) * ** **

Doral, FL

R.B. U'Ren Equipment Inc. (DD)* ** *

Niagara Falls, NY

R.F. Partridge & Associates Inc. (MR) * ** **

Cerritos, CA

Reading Electric (DD) * ** *

Reading, PA

Rudox Engine and Equipment Co. (DD) * ** **

Carlstadt, NJ

Saft America Inc. (MF)* ** **

North Haven, CT

SAVCO (AE)* ** **

Trinidad West Indies, Petit Valley

Scherbon Consolidated Inc.* ** *

(DD) Amesbury, MA

Schnurr Power Corp. (MF) * ** **

Canada, Kamloops, BC

Scott's Emergency Lighting & * ** *

Power Generation Inc. (DD)

Bensalem, PA

SEIGUA, S.A. (DD) * ** *

Guatemala, Guatemala

Sheldon Andrews Inc. (AE) * ** *

Canada, Moncton, NB

Simson-Maxwell (DD) * ** **

Canada, Edmonton, AB

South Shore Generator Service Inc. (DD) * ** *

East Wareham, MA

Southworth-Milton Power Systems (DD) ** ** *

Milford, MA

Standby Power Enterprises LLC (DD)* ** **

Higganum, CT

Steiner Electric Co. (DD) * ** **

Elk Grove Village, IL

Stewart & Stevenson LLC (MF) ** ** *

Houston, TX

Stored Energy Systems (MF)* ** **

Longmont, CO

Sure-Gen Inc. (DD)* ** *

Winnabow, NC

Swartz Sales Co. Inc. (MR)* ** **

Charlotte, NC

TAW Power Systems (DD)* ** *

Riverview, FL See Ad, Page 49

Technology Research Corp. (MF)* ** **

Clearwater, FL

Tecun, S.A. (DD) * ** *

Guatemala, C.A.

The Edward D. Newell Co. (MR) * ** **

Bristol, WI

Thomson Technology (MF) * ** *

Canada, Langley, BC

Toromont CAT (DD) * ** *

Canada, Concord, ON

Total Power Ltd. (DD) * ** **

Canada, Mississauga, ON

Tower Generator Systems & Service * ** *

LLC (DD) Canton, CT

Tower One International (DD) * ** **

Houston, TX

Traycana Inc. (MR)* ** **

Canada, Vaudreuil-Dorion, PQ

TRIENERGY S.D. (DD) * ** *

Columbia, Bucaramanga

Triton Power Corp. (MF) * ** **

Miami, FL

Troy Belting & Supply Co. (DD)* ** **

Watervliet, NY

Universal Engine Services LP (AE) * ** **

Houston, TX

Vermette Consulting Inc. (AC) * ** *

Barrigada, GU

Viking Power Products Co. (MR)* ** **

Louisville, PA

VoltAmpere Electrical & Mechanical** ** *

Engineering (Pty) Ltd. (MR)

South Africa, Pretoria

W.W. Williams (DD)* ** **

Brunswick, OH

W.W. Williams Co. (DD)* ** *

Atlanta, GA

Wagner Equipment Co. (DD) * ** *

Aurora, CO

Waterous Power Systems (DD) * ** **

Canada, Edmonton, AB

Waukesha-Pearce Industries* ** *

Inc. (DD) Houston, TX

Weisler & Associates Inc. (MR)* ** **

Houston, TX

Western Power Group Inc. (DD) * ** **

Walsenburg, CO

Western States Equipment (DD) * ** *

Meridian, ID

Whayne Power Systems (DD) * ** *

Louisville, KY

Wheeler Power Systems, Div. * ** *

Wheeler Mach. (DD) Salt Lake City, UT

William Lane Enterprises Inc. d.b.a. * ** **

Fritz & Co. (DD) Sacramento, CA

Winter Engine-Generator Service Inc. (DD) * ** *

York, PA

Wolter Power Systems (DD) * ** **

Brookfield, WI

Wolverine Power Systems (DD) * ** *

Zeeland, MI

Yancey Power Systems (DD) * ** **

Austell, GA

Zabatt Inc. (DD) * ** **

Jacksonville, FL

Ziegler Power Systems (DD)* ** *

Shakopee, MN

Appendix E—Battery Charger Products for Original Equipment Manufacturers (OEMs)

Product	Features	Price
48Volt PV System Charge Controllers	Compact, low power solar charge controller for remote 48 volt communications equipment	$39-$59 depending on model type
Charging board for NiMH/NiCad 8 cell to 10 cell packs	Wide DC input which is also designed for solar applications and other alternative energy applications.	$61-$80 depending on volume of order
Solar Charge Controller for Li-Ion, NiMH, NiCad, etc.	A charger for alternative chemistry batteries which uses solar power or other energy-harvesting sources.	$61-$80 depending on volume of order
PV System Charge Controllers	A 12 volt solar charge controllers for charging lead acid batteries using solar panels	$46-$72 depending on model & volume of order
K3 Wind & Solar charger	3-in-1 tribrid charging ability for collecting and storing power from wind, sun, or AC wall plug	$99.95
Lead Acid Battery Charger Index	Lead acid battery chargers ranging from 6V to 48V in a variety of amperages	Price unavailable
NiMH and NiCad Charger Index	A variety of chargers for packs and single cells.	Price unavailable
Lithium-Ion Battery Charger Index	A variety of chargers for lithium ion cells and packs	$7.90 - $15.00
18 Volt lead acid charger	Minimoto style 18 volt sealed lead acid charger	Price not available
6 Volt Pb-Acid Chargers	1200 mA 3-stage chargers and maintenance chargers for 6 volt lead acid batteries	$9.80 - $18.00
Battery Back Up for Cars--10Amp	A charger for an external battery at 1.5 amps which acts like a 120 watt DC UPS to keep equipment running in a vehicle even when the vehicle power fails.	$19.60 - $50.00
Battery Back Up for Cars--3Amp	A module that charges an external battery at 400 mA and acts like a 36 watt DC UPS to keep equipment	$19.50 - $50.00

	running in a vehicle even when the vehicle power fails.	
DC Input Lead Acid Battery Chargers	These charge sealed lead acid, SLA, gel cell, and VRLA, or even flooded lead acid batteries from 12 volt or 24 volt cars, batteries, forklifts, etc.	Price unavailable
Medical use Sealed Lead acid Chargers	IEC60601 chargers designed for 24 volt batteries 4, 6, and 8 amps output.	$150.00 - $212.50
High Power Lead Acid Chargers	12V, 24V, 36V and 48V chargers for lead acid, sealed lead acid, and valve regulated lead acid batteries, where high currents are required.	Price unavailable
Wheel Chair in-Car Chargers	A high powered 4-stage intelligent charger system for charging wheelchairs and scooters in your van or car.	Price unavailable
Multibay Chargers	Multibay chargers for Lead Acid, NiMH, NiCad, and Lithium Ion batteries.	Price unavailable
Lithium Ion Coin Cell chargers	Off-the-shelf wall mount charger that will charge the complete line of PowerStream lithium-ion coin cells	$7.00 - $15.00 depending on volume of order
Custom Chargers	Chargers for NiCad, NiMH, Lithium Ion, Nickel Zinc and Lead Acid batteries.	Price unavailable
Remote Charging Boards	Microprocessor controlled board charger for a 12 volt lead acid battery from a low voltage DC input. Range from 18 to 28 volts. Allowing the charger be positioned at a remote battery while being powered with low voltage DC up to 1000 feet away.	$98.30 - $141.52
Smart Battery Charging and Safety Boards	Boards that can communicate battery status to the system with protection against overcharging, over discharging, over current, and over or under temperature. The charger includes NiMH,	$75.00

	NiCad and Lithium Ion protection and safety boards.	
Ferroresonant Chargers	A charger for industries that need the cheapest high current charger available for lead acid. A quality ferroresonant charger in a metal screen frame package. This product is designed strictly for incorporation into original equipment.	$27.50 - $37.50 depending on model & volume of order
Complete Removable Battery Pack and Charger Solution for OEMs and Designers, NiMH and NiCad	A system for a design engineer which can include a removable battery pack without paying for tooling.	$106.00 - $160.00 depending on model & volume of order
Stand-Alone Charger for Camcorder Batteries	A Smart Charger that charges NiCad and NiMH battery packs compatible with Sony NP Series battery packs. AC and Automobile power sources included.	$34.92 - $57.00
Universal battery charger for research and hobby use	A charger designed for laboratory, engineering, research or hobby use. Charges 6/12V lead acid, NiMH or NiCad 3-12 cell packs and Li-Ion 1-4 cell packs	Price unavailable

Appendix F—Other Battery Chargers

Full Time Intelli Universal Charger (Lithium & AA/AAA) made by LuminAir[105]

- Charges all lithium batteries (3.6/3.7V &7.2/7.4V) for **All** hand-held equipments from **All brands** : Cameras, Cell phones, PDAs, iPod, GPS, Translators, Games Machines, MP3, 2-way Radios, DVD Players and Recorders, etc.
- Charge AA/AAA NiMH batteries.
- 110 - 240V Universal current.
- Intelligent polarity detection by adjustable probe pins.
- Fast / Trickle charge to maximum capacity.
- Average charging time: 1.5~2.5 hours (dependent on capacity of batteries).
- Max. Charging current: 800 mA.
- Built-in USB socket for additional charging capability.
- Power transfer from lithium battery or AA/AAA in the Charger to other devices.
- 12V car cigarette adaptor included.
- Easy to carry (merely 3 .8 oz; palm size 5.0" x 2.65" x 1.65"), ideal for traveling.
- Price $49.95

Full Time Lithium Charger made by LuminAir[106]

- Charges all lithium batteries (3.6/3.7V) for **All** hand-held equipments from **All brands** : Cameras, Cell phones, PDAs, iPod, GPS, Translators, Games Machines, MP3, 2-way Radios, DVD Players and Recorders, etc.
- 110 - 240V Universal current.
- Intelligent polarity detection by adjustable probe pins.
- Fast / Trickle charge to maximum capacity.
- Average charging time: 1.5~2.5 hours (dependent on capacity of batteries).
- Max. Charging current: 500 mA.
- Built-in USB socket for additional charging capability.
- Power transfer from lithium battery in the Charger to other devices.
- 12V car cigarette adaptor sold separately.

[105] http://www.logicbattery.com/l_charger.htm
[106] Ibid.

- Easy to carry (merely 3 .8 oz; palm size 5.0" x 2.65" x 1.65”), ideal for traveling.
- Price $39.95

15-watt solar charger[107]

- Plugs into your vehicle's 12-volt lighter socket
- Works with automobile, all terrain vehicle (ATV), personal water craft (PWC), and boat batteries
- Made of durable ABS plastic and amorphous solar cells
- Manufacturer recommends using a charge controller (not included) in tandem with this charger for optimal results
- Measures 15.5 x 2.5 x 41.5 inches (WxHxD)
- Price $69.99

Solar powered on-the-go battery charger[108]

Easily charges electronic devices while on the go, including iPhone/iPod, mobile phones, PDAs, portable game systems, MP3 players and more. High-quality rechargeable Lithium-ion battery recharges easily via solar power or computer systems USB port (with included USB charging cable). Extends talk time up to 2 hours, up to 4 hours of video, or up to 20 hours of music. Includes adapter tips for use with various Motorola, Samsung, LG, BlackBerry, Palm, Nokia, HTC, and more.

Key Features:

- Compatible with any USB powered portable device
- Charging Time: Solar, 10-12 hours; USB, 3-4 hours
- Extends talk time up to 2 hours, up to 4 hours of video, or up to 20 hours of music
- Battery Capacity: 800mAh

Specifications:

[107] http://www.goldengadgets.com/solar-power/15-watt-12v-solar-panel.html
[108] http://www.walmart.com/ip/SIIG-Solar-Portable-Battery-Charger/14236019?sourceid=1500000000000003142050&ci_src=14110944&ci_sku=14236019#ProductDetail

Type: Solar Battery Charger

Charger Usage: 5.5V

Model Number: CE-CH0112-S1
Shipping weight (in pounds): 0.1
Product in inches (LxWxH): 4.4x3.9.1.5
Assembled in country of origin: USA and/or imported
Origin of components: USA and/or imported

Appendix G—Medical Equipment Battery Companies[109]

3M
Abatel
ABB
Abbott Laboratories
Accu Chek
Accustat
Accutub Corporation
ACME Medical
Acoma
Advanced Medical Syst
Advanced Technology L
Aequitron
Aerogen
Agilent Technologies
Air Shields Medical
Airborne Life Support
Alaris Medical
Alaron
Albury Instruments
Alcon
Allied Medical Produc
Alphasource
Alton-Tol
Amerex
American Bentley
American Hospital Sup
American Optical
Amsco
Antek Instruments Inc
Keeler
Keithley Instrument I
Keller Medical Specia
Kendall-Mcgaw
Kinetic Concepts
Knight Medical
Kontron
Krown Research
Ladd Steritak
Laerdal
Life Care Products
Life Mobile
Life Science
Linear Instruments
Lionville Systems Inc
Litton-Data
LSE Inc.
MADA
Magnetic Resounants
Mansfield Smec
Marcal
Marquest
Marquette Electronics
Masimo
Matrx Medical
Maytag
McGaw
MDT Biologic
MDT Corporation

[109] http://www.interstatebatteries.com/cs_eStore/Results.aspx/Medical%20Equipment?dsNavigation=N~36

Anybattery
Applied Power
Armor
Armstrong Medical
Arp
Arrow International
Artromick Internation
Arvee Medical
Aspect Medical System
Aspen Labs
Astro-Med Inc
AVCO
Avea
AVI
Avox Systems
Axon Systems
BAO Tong
Bard Medical
Bardstead Thermolyne
Basic Measuring Co
Batteries Plus
Baxter Healthcare
BCI International
Bear Medical Systems
Belmont Instrument Co
BFW
Bio-Med Devices
Bio-Medicus
Biomedical Design Ins
Biomedical Systems
Bioness
Biosearch Medical
Biotek Instruments
Bird Products Corpora
Med Rad
Medasonics Inc
Medela Baar
Medex Inc.
Medfusion Systems
Mediana
Medic Alert
Medical Data
Medical Engineering C
Medical Systems
Medical Technology Pr
Medimex
Medivix Inc. (Diatron
Medtronic
Melco
Mennen Medical
Mentor Corporation
MESA
Micro Medical Labs
Microcor Inc
Miles
Military
Minolta Konica
Mla Medical Lab Autom
Mobilizer
Moltech
Monaghan Medical
Monitrex
Mortara Instrument In
Motorola
MRL
Narco
National Power Corpor
Nellcor

Birtcher Medical Syst
Boehringer-Mannheim
Boston Scientific Cor
Bourns Medical System
Braun
Brentwood Instruments
Brookline
BSI
Burdick
Burron Medical Inc.
Cache Controller
Cambridge Instruments
Camino Labs
Cardiac Pacemakers
Cardiac Resuscitator
Cardiac Science
Cardiac Telecom
Cardinal Medical
Cardio Dynamics
Cardioline
CAS Medical
Centrimed
CGH Medical
Chattanooga Group
Chloride
Ciba - Corning Diagno
Clarion
Clinical Dynamics
Codman & Shurleff
Colin Medical
Concept Inc.
Continental Scale
Copeland
Cordis
Newport Medical Instr
Nihon Kohden
Nivec
Nonin Medical
Norand
North American Drager
Novametrix
O'Donnell
Oec Medical Systems I
Ohio Medical Products
Ohmeda
Olympic Medical
One Touch
Optical Micro Systems
Orange Medical Instru
OSI Batteries
Otto Bock
Oxford Medical Inc.
PACE
Pacific Rim Medical S
Palco
Panasonic
Pancretec Inc (Abbott
Parks Medical
Penlon (Ferraris Medi
Pharmacia
Philips Medical Syste
Physio Control Medtro
Picker International
Plainview Batteries
Portable Power System
Power Pak
Powersonic
Powertron

Corometrics Medical S
Corpak
Criticare Systems
Critikon
Cutter Labs
Cybex
Dallans
Dalphin Medical
Dantona
Data Medical
Datascope
Datex Medical
Davol Inc
Defibtech
Del Mar Medical
Depuy
Detecto Scale
Devilbiss
Digitrace Care Servic
Digitron Scales
Diversified Medical N
Dog Guard
Draeger
Drummond Scientific C
Dual Lite
Dukane
Dyna Feed
Dyna Tech
Dyonics
EAC
Eclipse
Eclipse Plus
Edentech
EDP Engineering

Ppg Biomedical System
Priebe Electronics
Progressive Medical
Propper Manufacturing
Protocol Systems
Psion Teklogix
Pulmonetic Systems
Puritan-Bennett
Quest Medical
Quinton
R&D
Radiometer America
Radionics
Rauland-Borg
Rehabilicare Inc
Replacement Battery for Welch Allyn
Respirodyne
Respironics (Aka Heal
Richards
Rigel
Robert Bosch Corporat
Romex
Ross Laboratories (Ab
RS Medical
Rubbermaid
Rustronics
Sabratek
Sandoz Nutrition
Sanyo
SBC
Scale Tronix
Schiller America
Schuco Inc
Seca Scale

Elan Pharmaceuticals	Sechrist Industries I
Electromedics	SensorMedics
Electronic Waveform L	Sentinel
Elekta Instrument	Seratron
Elmed Inc	Servomex
Emergent	Servox
Emmerich	Sherwood Medical
Empire	Siemens
Epic Systems	Sigma
Ericsson	Simed
Expo	Simonsen-Weel
Fairfield Medical	Site Microsurgical Sy
Fcs Tricor	Smart
Fenwal	Smith-Kline
Ferno (Mdt Corporatio	Sonicaid
First Medical Devices	Sonnenschein
Flexo	Spacelabs Medical
Flo Healthcare	Spectromed
Fluke	Spirometrics Medical
Forma Scientific	Squibb Vitatek
Franz Medical	SR Instruments
Fukuda Denshi	Sscor
Gambro Engstrom	Staidymics Inc.
GE	Stereo Optical
General Scanning	Sterling Medical
Gould	Stimtech Products
Graco	Strato Medical
Grason	Stryker
Grieshaber & Company	Sunrise
Guinta Associates	Superior Health Care
Haliburton	Surgidyne
Hamilton Industries	Surgitek (Medical Eng
Harvard Apparatus	Survival Technologies
Hawker/Gates Energy P	Sylvan

Health-O-Meter
Healthdyne
Heine
Hemochron
Henley International
Hewlett Packard
Hillrom
Hoffman Laroche
Hospira
Hoyer
Hudson Respiratory Ca
IMED
IMEX Medical Systems
Impactinstrumentati
Infrasonics
Inspired Energy
Intellikey
International Biomedi
International Technid
Interro
Interstate Batteries
Inton
Invivo Research Inc
ISL
IVAC Medical Systems
Ivion Inc
Ivy Biomedical System
Jedcom
Jewett Refrigeration
Tamtha Medical
Tate Western
Tektronix
Tenzcare
Thermolyne
Timeter
Toshiba
Tri-Med
Unipower
Universal Battery
Universal Power Group
Us Surgical
Valley Labs
Varidyne
Viasys Healthcare
Vickers
Vinil
Vital Technology
Vitalcom
Vivitar
Voice Box
Ware Medical Diagnost
Wavetek
Wehmer Company
Wellkeeper
Wemed Fusion
Wr Medical Electronic
Zenith
Zoll Medical

Appendix H—First Responder Specific Batteries

First Responder Batteries	Price per battery
CAM0300 Cardiac Science 9001 FIRST RESPONDER replacement battery	$44.99
CAM0260 Cardiac Science 9001 FIRST RESPONDER replacement battery	$42.99
MED1600 Cardiac Science 9001 FIRST RESPONDER replacement battery	$97.97
Amstron Medical Monitor Replacement Battery for Cardiac Science First Responder 9004 Battery	$26.99