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Publication Date
2015-08-01

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Analysis of the US Power Quality Equipment Market

for

Lawrence Berkeley National Laboratory

August 2015

Funding Acknowledgement

The work described in this report was funded by the Office of Electricity Delivery and Energy Reliability of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123 through a subcontract with Frost and Sullivan, administered by the Lawrence Berkeley National Laboratory.

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Appendix B – Stationary Lead Acid (SLA) Battery

Project Background

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Strategic Imperative

Lawrence Berkeley National Laboratory (LBNL) wanted to estimate the current adoption of reliability-enhancing technologies by US electricity consumers.

As an initial step in this process, LBNL was seeking Frost & Sullivan to provide an independent assessment of reliability-enhancing technologies. LBNL wanted to translate market research that has been conducted on sales trends of reliability-enhancing technologies into a format that will enable more granular assessments of the nation’s current resiliency to power quality events and power interruptions.

LBNL was seeking to add a crucial, yet missing, piece of information that will improve the quality of decisions that are likely to emerge from these discussions.

Project Objectives

The primary aim of this project was to provide LBNL with data and analysis about shipment and sales of power quality and related reliability-enhancing equipment, and analyze potential customers.

Primary objectives are:

- To determine the potential size (sales and unit shipments) of the power quality equipment market in the United States and to use cumulative annual market sales over an estimated lifetime for each equipment type to estimate the total current installed quantities of each equipment
- To analyze the key power quality products (surge protection devices [SPD], voltage regulators, isolation transformers, uninterruptible power supply [UPS], and alternating current [AC] backup generators)
- To analyze end-user groups (residential, commercial, and industrial)
- To identify potential markets by US geographic region

Consulting Approach

Leveraging in-house information and regional expertise	Competitor discussion lead to data collation	Market modeling using Frost & Sullivan's bottom-up approach	Presentation of the final deliverable
• Leverage existing content (past projects and studies) on the power quality equipment market • Assign analysts who have knowledge and understanding of the power quality equipment business	• Conduct interactive discussions with key power quality equipment manufacturers. • Manufacturers include ABB, Eaton, Schneider and Emerson Network Power	• Size power quality equipment market by sales and shipments • Identify demand by each end user group • Identify how power quality equipment is used across US geographic regions	The final deliverable is presented as a Word document

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Project Scope

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Power Quality Equipment Covered

AC Backup Generator: AC backup generator is a backup electrical system that operates automatically and consists of a generator set, an automatic transfer switch, a battery, a charger, and a distribution panel. The system monitors a building's incoming utility power and automatically supplies electrical power when normal power flow is interrupted. When utility power is restored, the system switches the electrical load from the generator to the utility and turns off the generator.

Increased awareness among customers about the features and benefits of the backup power as well as the best-suited equipment combination for their own personal use is driving the growth in the generator sets and UPS markets.

United States has recently had its fair share of natural disasters. Small outages from brownouts to voltage disturbances cause significant losses to businesses that are highly dependent on reliable power. In some cases, end users suffer huge losses due to the lack of preparedness for these unexpected occurrences. This has encouraged users, such as hospitals, data centers, and telecommunication providers, who are highly sensitive to interruptions in power supply, to take proactive measures by investing in backup power.

Due to the critical nature of businesses and the increase need to maintain high-quality power throughout the day a back-up generator is sometimes used in conjunction with a UPS, which provides power during the transition from grid power to back-up generator operation.

Back-up generator is distinct from Cogeneration, which is covered in an abbreviated manner in Appendix A.

Uninterruptable Power Supply: A UPS system is comprised of a battery charger/rectifier, installed batteries, or an energy storage unit and the maintenance bypass switch. A UPS is used to supply electric power to a facility when service from the electric grid is interrupted. When the electric grid power supply cuts out, the UPS senses lack of incoming power and switches to the batteries attached. The response time is almost immediate and provides power from 10 to 30 minutes depending on the capacity of the batteries attached.

The UPS is normally the first source of defense against a number of power interruptions such as blackouts and brownouts. They are used in conjunction with generator sets that serve as the second and final line of defense to ensure that adequate power is supplied to keep the facility functioning.

UPS is closely related to SLA, which is covered in an abbreviated manner in Appendix B.

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Surge Protection Device: Surge Protection Devices (SPD) is comprised of primary component such as metal oxide varistor (MOV), silicon avalanche diode (SAD), gas discharge tubes, selenium cells, spark-gap ignition electronic circuit, hybrid technology, and low pass filters, among others.

SPD protects AC electrical circuits from surges and transients in electrical power created by lightning and power switching devices. Transients and surges can occur anytime and anywhere, with the potential to damage equipment and affect businesses and institutions. SPDs protect electronic appliances against voltage fluctuations—both very low and very high—with the potential to damage or destroy systems. Failure to protect equipment and facilities from power line disturbances can result in production and revenue losses.

Surge suppressors[2] can range from those that protect standalone products to those that protect systems at the service entrance or panel level. For the purposes of this research, the SPD market is analyzed based on the following segments:

Type 1 SPD is a permanently connected device that is UL approved for installation at any location between the secondary of the utility service transformer and the service entrance primary overcurrent disconnect. Type 1 SPDs can also be installed anywhere on the load side of the service entrance and are allowed to be installed anywhere on the low-voltage electrical system without requiring a dedicated fuse or breaker.

Type 2 SPD is a permanently connected device that is UL approved for installation on the load side of the service entrance primary overcurrent disconnect. Type 2 SPDs may or may not require the use of a dedicated fuse or breaker.

Type 3 SPD is a point-of-use device installed at a conductor length of 10 meters (30 feet) or greater from the electrical panel. These devices are typically cord connected, direct plug-in, and receptacle type installed at the load equipment being protected. The distance of 10 meters excludes conductors that are provided with or used to attach the SPD.

Type 4 SPD designation is for SPD components and assemblies that are considered to be incomplete in any aspect that would prevent them from obtaining a UL Listing classification. Examples of Type 4 SPDs range from MOV components to complete SPD system assemblies that are constructed without an outer enclosure.

Type 4 is not included in this research. As per National Electrical Manufacturers Association (NEMA), these are incomplete SPD assemblies, which typically are

[2] Source: UL, GE, Eaton and Schneider Electric; Frost & Sullivan studies A325, F305, N62F: World TVSS Market.

installed in listed end-use products as long as all conditions of acceptability are met. These Type 4 component assemblies are incomplete as an SPD. They require further evaluation and are not permitted to be installed in the field as a standalone SPD. Often, these devices require additional overcurrent protection.

Isolation Transformer: Isolation transformers are a form of power conditioning device. These are available as single and three phases. Isolation transformers come in two varieties that consist of non-shielded and shielded.
These products are designed to isolate equipment from their direct connection to the AC power line. They also provide a step down from higher to lower voltages in standard distribution functions.

Key features consist of isolation of sensitive electronic equipment loads from electrical noise and transient voltage impulses.

Noise includes electromagnetic interference (EMI) and radio frequency interference (RFI)—any condition that disrupts the smooth sine wave, typically caused by lighting, load switching, generators, and industrial equipment.

Voltage Regulator: A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It stabilizes the output voltage according to the equipment's requirement, irrespective of the input voltage. The voltage regulator accepts all ranges of input voltage and ensures that the output voltage is constant, according to the exact specified voltage for the system.

The voltage regulator was used instead of the UPS especially when a lower cost solution tackling only the problem of voltage regulation was required. However, as UPS technology gained in popularity and reduced in price, it was seen as a complete solution that not only deals with voltage stabilization but also backup power.

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Confidence Intervals

Each product category consists of the following variables:

Revenue	Manufacturers earnings from the sale of a given power quality equipment
Study Period: 2005 to 2014	This section of the research relied mostly on input from vendors. Frost & Sullivan's experience in interviews in this market is that respondents (power quality equipment manufacturers and distributors) provide market size estimates that typically fall within 10% to 15% of each other's responses. However, overall accuracy level is closer to 5%. It was observed that vendors had a slight difference in opinion about product definitions or how they track their performance, which is likely to impact the overall accuracy of the numbers. The collected data was cross verified with existing and historic data points regarding vendor and market performance.
Estimated Margin of Error: 5%	
Original Equipment Manufacturer (OEM) Input: 5%	
Secondary Input: 5%	

Unit Shipment	Unit shipments are estimated by dividing total revenues by average selling price. Year-over-year price variable was dictated by input from vendors, change in raw material price, and customer price sensitivity.
Study Period: 2005 to 2014	Responses (power quality equipment manufacturers and distributors) typically fall within about 10% of each other. It was easier to get pricing information than revenue, resulting in a lower margin of error. This was cross verified with existing and historic data points regarding vendor
Estimated Margin of Error: 8%	
OEM Input: 10%	

Secondary Input: 5%	and market performance. Accuracy of pricing was ensured by cross verifying with distributor list prices as well as other published sources.

Installed Capacity	This was determined by units sold during the course of product life/replacement cycle. Historical data used to calculate install base is shared with LBNL.
Study Period: 2005 to 2014	Responses (power quality equipment manufacturer and distributors) generally are within 15% of each other. OEMs do not track this figure or have an agreement on product definitions. To best manage this issue, collected information was cross verified with historical/published data on revenues along with prices to aggregate past unit shipments.
Estimated Margin of Error: 13%	
OEM Input: 15%	
Secondary Input: 11%	

Region	This section of the analysis begins with identifying the type of product and the demand of the product type per customer category. Using the average weighted price per product type along with aggregated revenue split by vendor, unit shipment per customer category was calculated. A top-down approach was used to break out unit shipments by region. This figure was cross verified by secondary sources listed below.
Study Period: 2005 to 2014	Responses (power quality equipment manufacturers and distributors) typically

Estimated Margin of Error: 13%	fall close to 15% of each other. Manufacturers do not have reasonable insight on their regional and end-user market splits or are reluctant to share this information. To best manage this issue, Frost & Sullivan reached out to distributors as well as cross verified splits using the information listed below under secondary sources.
OEM Input: 15%	
Secondary Input: 10%	

Country Focus: United States

Regional Segmentation

Pacific: Washington, Oregon, California, Hawaii, and Alaska

Mountain: Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico

West North Central: North Dakota, South Dakota, Minnesota, Nebraska, Iowa, Kansas, and Missouri

East North Central: Wisconsin, Michigan, Illinois, Indiana, and Ohio

South Central: Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Tennessee, and Kentucky

Mid-Atlantic: New York, Pennsylvania, and New Jersey

South Atlantic: West Virginia, Virginia, District of Columbia, Maryland, Delaware, North Carolina, South Carolina, Georgia, and Florida

New England: Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine

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End-user Focus

Residential	Single-family and multifamily homes
Commercial	Financial institutions, K-12 schools, college campuses, retail stores, warehouses, restaurants, resorts, offices, shopping malls, banks, and office buildings. Data centers, telecom, IT, hospitals, government, and military
Industrial	Factories and manufacturing units, such as machinery and equipment; food and beverage; life sciences; steel and metal; paper and pulp; construction; power; textile; semiconductor; discrete and process manufacturing; oil and gas; marine; chemicals and petrochemicals; rubber; and mining

Project Methodology

Information was gathered by leveraging in-house studies on different power quality equipment markets because data requested was historical. The analyst team did reach out to a few power quality equipment manufacturers to validate the information.

Assumptions were made while calculating the installed capacity. Multiple factors such as equipment life span, type of power quality equipment, installed region, average power range, and the type of end user were considered.

There is no standardized procedure to calculate life expectancy of any power quality equipment. Multiple factors can drive life expectancy; each manufacturer offers its own methodology based on its experience.

For example, to calculate life expectancy of a gas discharge tube (GDT)-based SPD, the following factors are considered: impulse discharge current, waveform duration, number of operations, and number of lightning strikes in a given region.

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Chapter 1

AC Backup Generator Equipment

Product Definition

AC backup generator is a backup electrical system that operates automatically and consists of a generator set, an automatic transfer switch, a battery, a charger, and a distribution panel. The system monitors a building's incoming utility power and automatically supplies electrical power when normal power flow is interrupted. When utility power is restored, the system switches the electrical load from the generator to the utility and turns off the generator.

Increased awareness among customers about the features and benefits of the backup power as well as the best-suited equipment combination for their own personal use is driving the growth in the generator sets and UPS markets.

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Due to the critical nature of businesses and the increase need to maintain high-quality power throughout the day a back-up generator is sometimes used in conjunction with a UPS, which provides power during the transition from grid power to back-up generator operation.

Back-up generator is distinct from Cogeneration, which is covered in an abbreviated manner in Appendix A.

Market Overview

Frost & Sullivan valued the US AC backup generator market at $2,490.8 million in 2014. The market grew an average of 3.2% annually from 2005 to 2014. Factors including increased power demand, unreliable grid infrastructure, and more severe and unpredictable weather-related disasters drive the demand for the AC backup generator market.

With stringent emission regulations and the active Environmental Protection Agency (EPA) enforcement, the demand for natural gas generators is expected to increase. However, continuous investments in infrastructure-related projects are likely to drive the demand for diesel generator sets in the next 5 years.

AC Backup Generator Market: Overview, US, 2014

Market Size (2014)	$2,490.8 Million
Unit Shipment (2014)	134,583
Average Life Cycle	6 Years
Price Range	Diesel Generators <60kW: $5,500–$22,500 60.1–300kW: $16,500–$77,500 300.1kW–1MW: $39,000–$175,000 >1MW – averages $150 per kW Gas Generators <60kW: $2,000–$16,500 60.1–300kW: $12,500–$82,000 300.1kW–1MW: $30,000–$310,000 >1MW – averages $250 per kW
Market Leaders	Caterpillar, Generac Power Systems, Kohler, and Cummins Power Generation Over 10 companies in the market with more than $1 million in revenues Market share of top 4 competitor is 85%

Note: All figures are rounded. The base year is 2014.

Source: Frost & Sullivan

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Gas versus Diesel Generator

The prospects for gas-fired generation have improved in the past years. The availability of natural gas has grown greatly in recent years, not only because of the expanding LNG production and the shale gas boom, but also due to the existent gas infrastructure. Lower input fuel prices and high electricity costs, improve the economics, thereby boosting the small and medium gas generator market.

Consistent power supply has become requisite, as people are more electricity-dependent than in the past. However, many industrial end users are still hesitant to invest in the purchase of a gas generator set due to the high initial cost of installation. Therefore, OEMs are investing in technologies to streamline their operation to minimize cost. Such advancements in technology are likely to further strengthen the position in favor of large gas generators.

On the other hand, diesel generators, with their fast response times and favorable capital costs, remains the technology of choice for medium and high power ranges.

Revenue and Unit Shipment

The total US AC backup generator sets market was worth $1,942.0 million in 2005.

During the last 10 years the market was mainly driven by aging power infrastructure and greater customer awareness.

However, from 2009 to 2011, the market was restrained by the slowdown in industrial activities as a result of the economic recession. Demand declined not only among industrial end users, but commercial and residential as well.

A major challenge for the AC backup generator industry is the impact of the US emissions regulations. Companies are devising a global emission strategy to either meet or exceed EPA Tier 2, 3, and 4 emission standards. Major suppliers of diesel generator sets must upgrade engine designs to comply with regulations. These improvements are likely to increase research and development (R&D) investments and overall manufacturing cost.

Additionally, the maturity of the AC backup generator set market and the sluggish economic growth over the last 4 years is likely to restrict demand for new projects.

To address these challenges, it is imperative that manufacturers introduce products that meet customers' evolving needs. Customers prefer end-to-end solutions to support their power needs, which helps control overall equipment cost and reduces dealings with

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vendors and products. Convergence, therefore, becomes a key area of focus for AC backup generator markets.

Estimating Product Lifetime

The lifetime of the generator sets are highly dependent on the number of hours that operates. However, this is not bound to a fixed rule of expectation. The fuel economy, engine brand and mode of operation play important roles. Further, the degree of importance for the product fuel and power range varies based on the nature of the project and the customer use.

Key Market Trends

Regulations and price competition posed a significant challenge to the industry during 2011–2014. However, average generator prices are expected to remain largely stable at a 0.7% compound annual growth rate (CAGR) from 2014 to 2019. As emissions regulations get tougher and end users start demanding higher levels of compliance, the price is likely to increase to include rising vendor R&D costs.

Average price ranges from $5,500 for the up-to-60kW power range to $175,000 for above-1MW generators.

Key factors influencing generator prices include fuel economy and flexibility. It would add value if the generator is able to operate on dual fuel. For global oil and gas companies, price per kW is not a key criterion in decision making, whereas other end users, such as hospitals, data centers, are likely to place greater importance on price per kW.

Price increases are driven by raw material costs, competition, and the demand for branded products. Lower prices are a key driver for sales growth in the residential segment.

In the last 3 years, gas generators' attractiveness has increased due to stricter environmental regulations on emissions and lower gas prices. Increasing adoption of shale gas has also driven growth.

Some large participants from China and South Korea are offering generator sets at low prices. The threat of low-cost imports is likely to continue as new market entrants are expected to import diesel engines through long-term supply contracts from China. By offering low-cost products, profit margins are likely to be affected, slowing revenue growth. The initial cost of a generator is a key criterion for decision making.

There is no major difference among vendors' generator sets—the majority of the products have the same design, efficiency, and durability. Therefore, price has become a key factor in a customer's decision making process, resulting in vendors offering lower prices to win projects.

Gas turbines are sometimes chosen over diesel and gas engines because they can better suit certain end-user requirements for the above-1MW range. Moreover, micro turbines, hybrid power systems, and renewable offer higher efficiency at competitive prices and have emerged as potential threats to generators.

Increased customer awareness about the features and benefits of backup power as well as the best-suited generators for personal and commercial use is driving US growth.

In 2014, industrial end users were the largest contributor in the US generator sets market with a 40.9% share. Residential demand is expected to increase consistently in the next 5 years.

The 2012–2014 drop in natural gas prices has boosted residential and commercial activities and demand. Residential customers are very price sensitive and use generator sets mainly in the small power range below 60kW.

Installation Cost[3]

Installation cost varies across each power range and end user. The installation cost for a residential generator of up to 60kW is likely to be in the range of $800 to $1,500. A similar commercial installation cost can range from 8% to 10% of the equipment cost. Industrial installation cost depends on the project. In general, large projects use a complete power solution and not just a genset. To identify the installation cost of just the genset is not possible.

[3] Market revenue has been calculated based on the number of units packaged and sold in the United States. Systems manufactured in one country but exported to another are not considered. Information was collected from discussions with industry participants, including generator set OEMs, distributors, and packagers. The bottom-up approach of covering as many stakeholders as possible ensures high accuracy for the quantitative analysis and the ability to cross-check and constantly revalidate market numbers while weeding out misinformation. The primary research is further complemented by secondary research spanning existing in-house Frost & Sullivan data, published deliverables (ND79, ND38, and M9C1) and additional data such as government information (e.g., Energy Information Administration. EPA, Department of Energy, and International Monetary Fund) and trade journals and publications (e.g., PennEnergy, Oil and Gas Journal, Diesel & Gas Turbine Worldwide). A key focus of the primary and secondary research phases is to understand and quantify the impact of key market drivers and restraints for each product segment, geographic region, and vertical. The cumulative effect of the drivers and restraints for each year of the forecast period are a foundation of Frost & Sullivan's proprietary quantitative forecast model and help ensure the best possible forecast, given market uncertainty and dynamics.

AC Backup Generator Market: Revenue, Unit Shipment, and Installed Capacity, US, 2005–2014[4]

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2005	1,942.0	105.2	N/A	N/A
2006	2,050.8	111.1	N/A	N/A
2007	2,152.0	117.1	N/A	N/A
2008	2,279.6	123.1	N/A	N/A
2009	1,819.8	114.2	N/A	N/A
2010	1,834.4	116.0	N/A	N/A
2011	2,039.9	120.9	N/A	N/A
2012	2,174.4	124.8	711.9	197.1
2013	2,335.0	130.1	758.5	210.5
2014	2,490.8	134.6	797.1	221.6

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for

[4] The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for the most common replacement cycle. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

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the longest replacement cycle of 6 years. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

AC Backup Generator Market by Power Range

The up-to-60kW and above-1MW segments hold the largest revenue share in the total US AC backup generator market—almost 60% combined in 2014. In 2014, the up-to-60kW segment had the largest revenue share, and accounted for 78.8% of unit shipments. Growth is likely to continue in the next 3 to 5 years, as these units are predominantly used in the residential and small commercial segments.

AC Backup Generator Market: <60kW Revenue, Unit Shipment, and Average Selling Price, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Average Selling Price	Installed Base in Units (000)	Installed Capacity (GW)
2012	595	10.7%	98.4	$6,048	560.9	17.9
2013	663	11.3%	102.6	$6,460	598.5	19.5
2014	733	10.7%	106.1	$6,911	628.1	20.4

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

AC Backup Generator Market: 60.1–300kW Revenue, Unit Shipment, and Average Selling Price, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Average Selling Price	Installed Base in Units (000)	Installed capacity (GW)
2012	470.8	7.5%	13.5	$34,883	76.9	109.0
2013	509.8	8.3%	14.1	$36,279	81.9	116.7
2014	547.9	7.5%	14.5	$37,704	86.1	122.3

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

AC Backup Generator Market: 300.1–1 MW Revenue, Unit Shipment, and Average Selling Price, US, 2012– 2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Average Selling Price	Installed Base in Units (000)	Installed Capacity (GW)
2012	463.4	4.9%	9.1	$50,804	52.0	31.3
2013	489.3	5.6%	9.5	$51,511	55.4	33.7
2014	512.0	4.6%	9.8	$52,038	58.2	35.2

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

AC Backup Generator Market: Above 1.1 MW Revenue, Unit Shipment, and Average Selling Price, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Average Selling Price	Installed Base in Units (000)	Installed Capacity (GW)
2012	644.8	3.6%	3.8	170,912	22.1	38.9
2013	673.3	4.4%	3.9	170,489	22.8	40.6
2014	697.7	3.6%	4.1	169,740	24.7	43.7

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

AC Backup Generator Market by End User

Residential AC Backup Generator Market: Revenue, Unit Shipment, and Installed Capacity, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Growth Rate	Installed Base in Units ('000)	Installed Capacity (GW)
2012	456.7	16.4%	68.9	3.6%	398.5	23.9
2013	530.7	16.2%	72.0	4.5%	423.4	25.4
2014	598.2	12.7%	74.7	3.7%	444.2	26.7

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

Commercial AC Backup Generator Market: Revenue, Unit Shipment, and Installed Capacity, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Growth Rate	Installed Base in Units ('000)	Installed Capacity (GW)
2012	790.7	6.0%	40	2.9%	225.5	67.7
2013	834.6	5.6%	42	3.8%	241.1	72.3
2014	873.6	4.7%	43	3.1%	254.0	76.2

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

Industrial AC Backup Generator Market: Revenue, Unit Shipment, and Installed Capacity, US, 2012–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment ('000)	Growth Rate	Installed Base in Units ('000)	Installed Capacity (GW)
2012	927.1	2.8%	16	2.8%	87.9	105.5
2013	969.8	4.6%	16	3.9%	93.9	112.7
2014	1,019.0	5.1%	17	3.3%	98.9	118.7

Note: All figures are rounded. The base year is 2014.
Source: Frost & Sullivan

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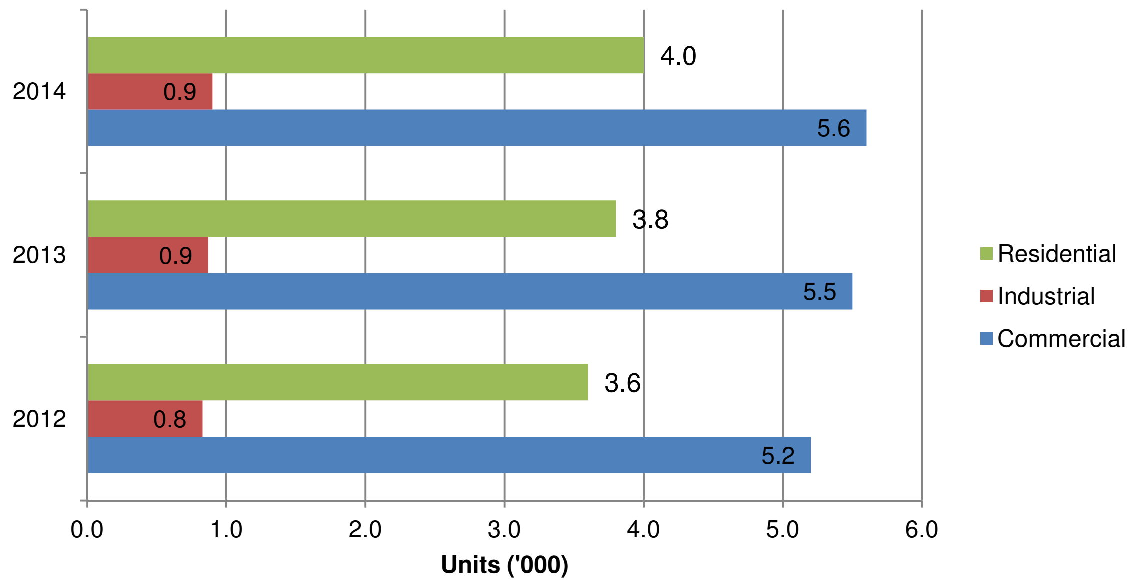
Regional Trends

1.1 Pacific AC Backup Generator Market: Unit Shipment, US, 2012–2014



Note: All figures are rounded. The base year is 2014.

Source: Frost & Sullivan

1.1.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	103.0	5.2	29.3	8.79
2013	109.3	5.5	31.4	9.42
2014	114.4	5.6	33.1	9.93

Source: Frost & Sullivan

1.1.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	49.2	0.83	4.8	5.75
2013	52.2	0.87	5.1	6.13
2014	54.9	0.90	5.4	6.44

Source: Frost & Sullivan

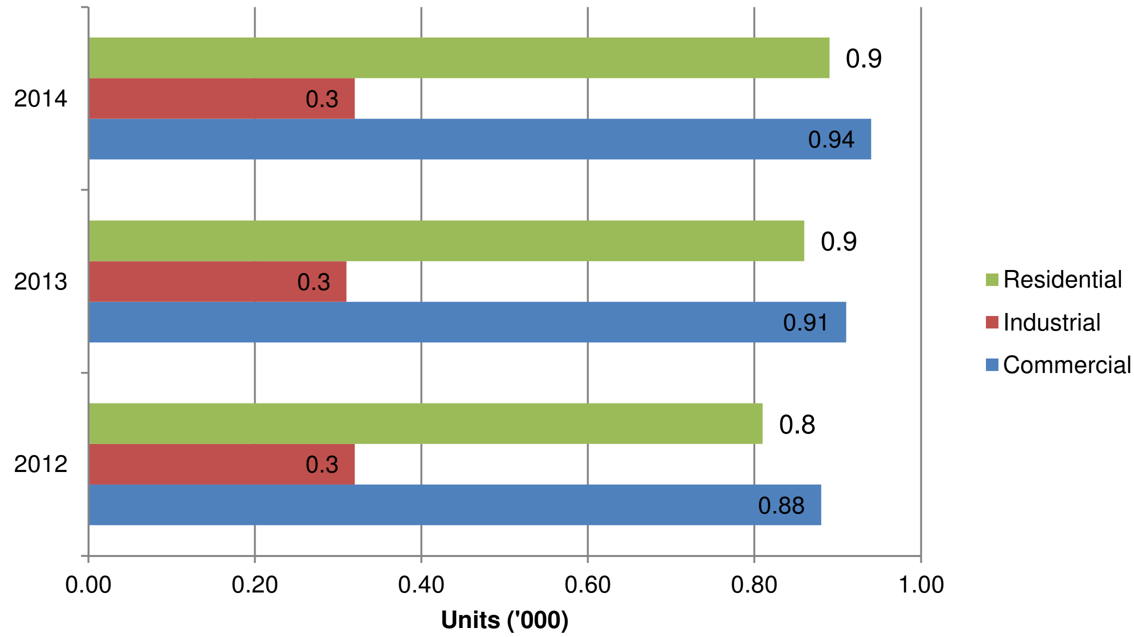
1.1.3 Residential

Residential AC Backup Generator Market: Revenue and Unit Shipments, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	23.8	3.6	20.8	1.25
2013	28.1	3.8	22.2	1.33
2014	31.7	4.0	23.3	1.39

Source: Frost & Sullivan

1.2 Mountain AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.2.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	17.2	0.88	4.9	1.48
2013	18.2	0.91	5.3	1.58
2014	19.1	0.94	5.5	1.66

Source: Frost & Sullivan

1.2.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	18.8	0.32	1.8	2.20
2013	18.5	0.31	1.9	2.32
2014	19.5	0.32	2.0	2.40

Source: Frost & Sullivan

1.2.3 Residential

Residential AC Back-up Generator Set Market: Revenue and Unit Shipments, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	5.4	0.81	5.3	0.32
2013	6.3	0.86	5.5	0.33
2014	7.2	0.89	5.7	0.34

Source: Frost & Sullivan

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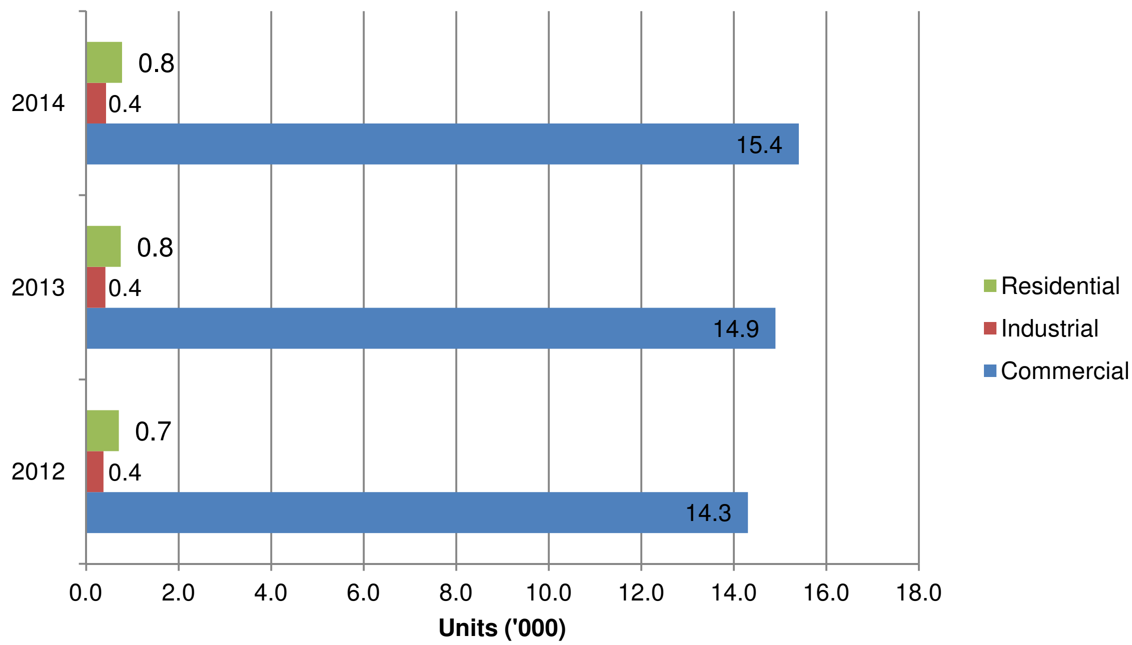
1.3 West North Central AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.3.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	281.5	14.3	80.2	24.1
2013	297.1	14.9	85.8	25.7
2014	311.0	15.4	90.4	27.1

Source: Frost & Sullivan

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1.3.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	22.7	0.38	2.1	2.48
2013	24.9	0.42	2.2	2.69
2014	26.2	0.43	2.4	2.88

Source: Frost & Sullivan

1.3.3 Residential

Residential AC Backup Generator Market: Revenue and Unit Shipments, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	4.7	0.71	3.8	0.23
2013	5.5	0.75	4.1	0.25
2014	6.2	0.78	4.4	0.26

Source: Frost & Sullivan

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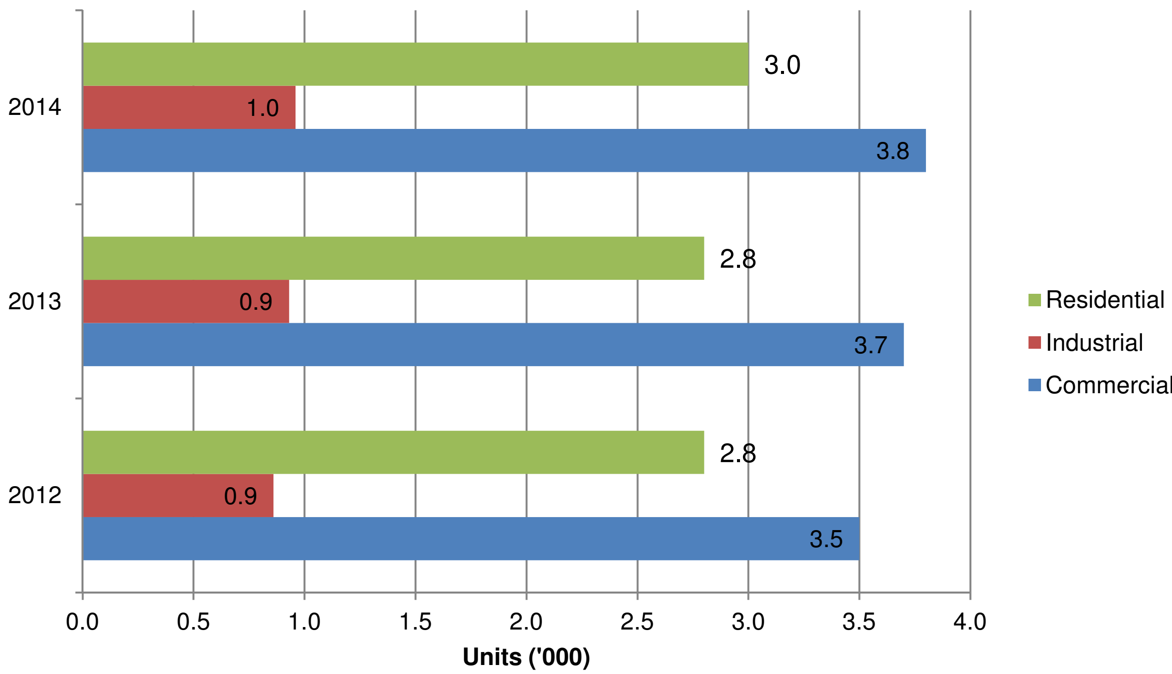
1.4 East North Central AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.4.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	69.2	3.5	20.0	6.0
2013	72.9	3.7	21.3	6.4
2014	76.3	3.8	22.4	6.7

Source: Frost & Sullivan

© Frost & Sullivan

1.4.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	51.3	0.86	4.8	5.77
2013	55.7	0.93	5.2	6.21
2014	58.5	0.96	5.5	6.59

Source: Frost & Sullivan

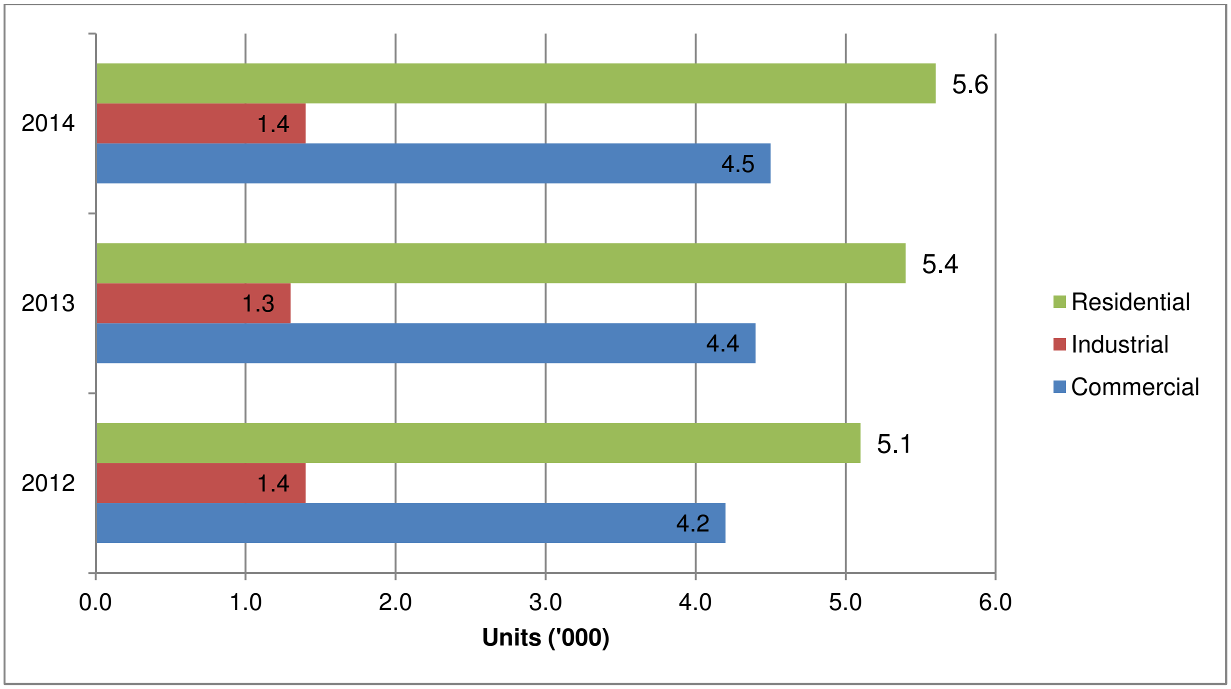
1.4.3 Residential

Residential AC Backup Generator Market: Revenue and Unit Shipments, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	18.5	2.8	16.2	0.97
2013	21.0	2.8	17.1	1.03
2014	23.6	3.0	17.8	1.07

Source: Frost & Sullivan

1.5 South Central AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.5.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	82.1	4.2	22.8	6.84
2013	86.9	4.4	24.5	7.36
2014	91.0	4.5	26.0	7.79

Source: Frost & Sullivan

© Frost & Sullivan

1.5.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	80.2	1.4	7.1	8.5
2013	78.1	1.3	7.6	9.1
2014	82.0	1.4	8.0	9.6

Source: Frost & Sullivan

1.5.3 Residential

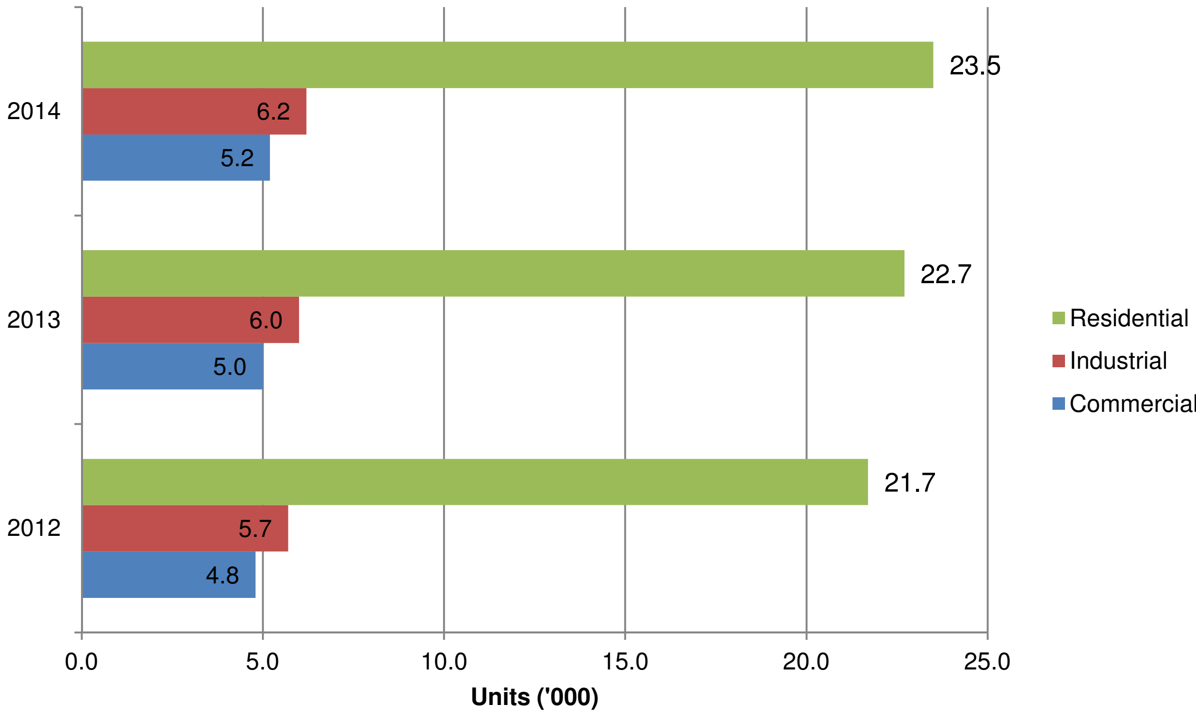
Residential AC Backup Generator Market: Revenue and Unit Shipments, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	33.8	5.1	26.9	1.62
2013	39.6	5.4	29.3	1.76
2014	44.7	5.6	31.3	1.88

Source: Frost & Sullivan

© Frost & Sullivan

1.6 Mid-Atlantic AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.6.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	95.1	4.8	27.1	8.1
2013	99.7	5.0	28.9	8.7
2014	104.4	5.2	30.4	9.1

Source: Frost & Sullivan

1.6.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	339.5	5.7	32.4	38.8
2013	355.7	6.0	34.6	41.5
2014	373.7	6.2	36.4	43.7

Source: Frost & Sullivan

1.6.3 Residential

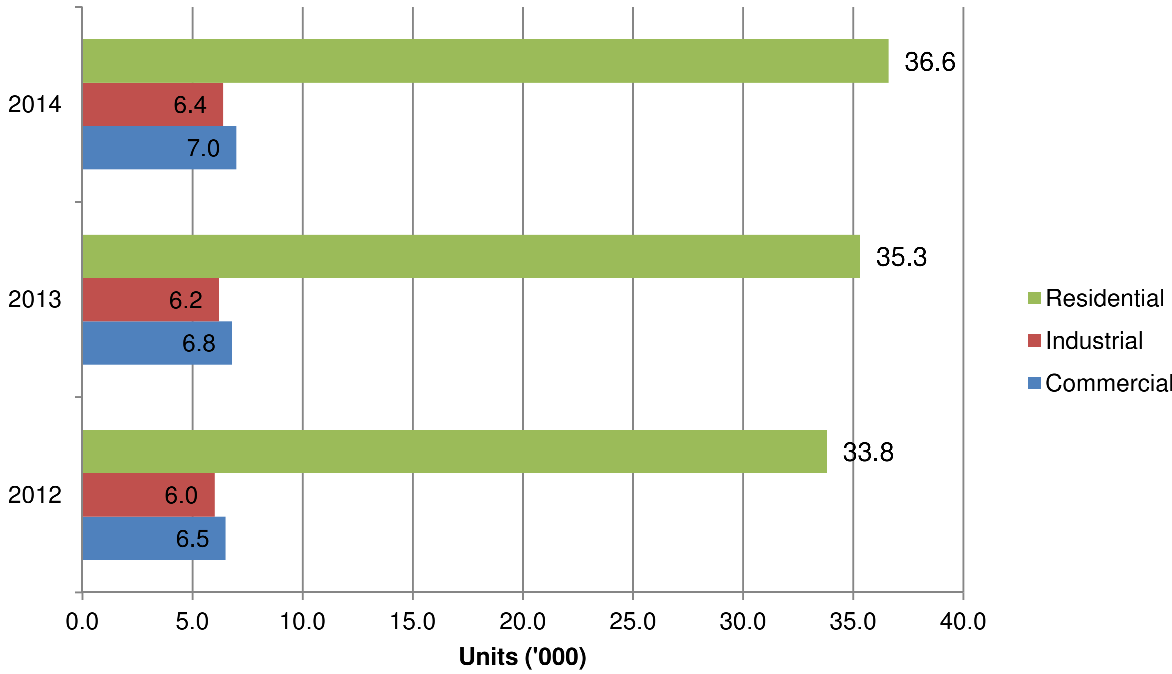
Residential AC Backup Generator Market: Revenue and Unit Shipments, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	144.0	21.7	125.1	7.5
2013	167.1	22.7	133.0	7.9
2014	188.4	23.5	139.7	8.4

Source: Frost & Sullivan

© Frost & Sullivan

1.7 South Atlantic AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.7.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	128.3	6.5	37.1	11.1
2013	135.3	6.8	39.5	11.9
2014	141.6	7.0	41.6	12.5

Source: Frost & Sullivan

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1.7.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, West South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	353.7	6.0	33.7	4.1
2013	371.8	6.2	36.0	4.3
2014	390.6	6.4	37.9	4.6

Source: Frost & Sullivan

1.7.3 Residential

Residential AC Backup Generator Market: Revenue and Unit Shipments, West South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	224.2	33.8	198.4	11.9
2013	260.3	35.3	210.1	12.6
2014	293.4	36.6	219.8	13.2

Source: Frost & Sullivan

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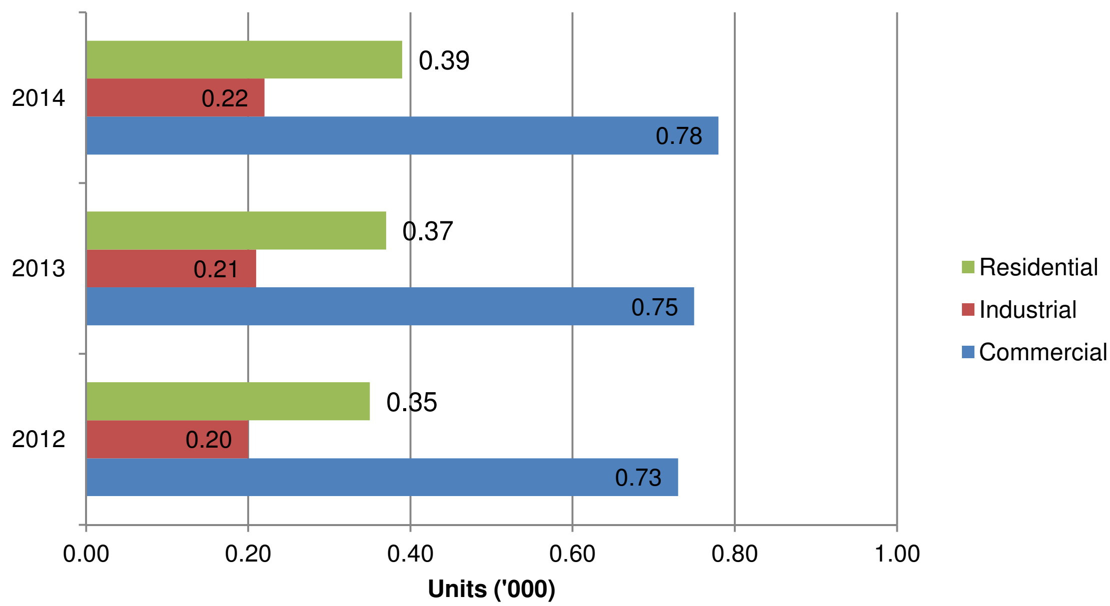
1.8 New England AC Backup Generator Market: Unit Shipment, US, 2012–2014



Source: Frost & Sullivan

1.8.1 Commercial

Commercial AC Backup Generator Market: Revenue and Unit Shipments, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	14.3	0.73	4.1	1.2
2013	15.0	0.75	4.4	1.3
2014	15.8	0.78	4.6	1.4

Source: Frost & Sullivan

1.8.2 Industrial

Industrial AC Backup Generator Market: Revenue and Unit Shipments, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	11.8	0.20	1.2	1.5
2013	12.8	0.21	1.3	1.6
2014	13.5	0.22	1.3	1.6

Source: Frost & Sullivan

1.8.3 Residential

Residential AC Backup Generator Market: Revenue and Unit Shipments, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipment ('000)	Installed Base in Units ('000)	Installed Capacity (GW)
2012	2.3	0.35	2.0	0.12
2013	2.7	0.37	2.1	0.13
2014	3.1	0.39	2.2	0.13

Source: Frost & Sullivan

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Chapter 2

Uninterruptible Power Supplies

Product Definition

A UPS system is comprised of a battery charger/rectifier, installed batteries, or an energy storage unit and the maintenance bypass switch. A UPS is used to supply electric power to a facility when service from the electric grid is interrupted. When the electric grid power supply cuts out, the UPS senses lack of incoming power and switches to the batteries attached. The response time is almost immediate and provides power from 10 to 30 minutes depending on the capacity of the batteries attached.

The UPS is normally the first source of defense against a number of power interruptions such as blackouts and brownouts. They are used in conjunction with generator sets that serve as the second and final line of defense to ensure that adequate power is supplied to keep the facility functioning.

UPS is closely related to SLA, which is covered in an abbreviated manner in Appendix B.

Market Overview

The UPS[5] market is mature, with mature technology. Its key growth drivers are the increasing need for power reliability and energy efficiency and higher power demand in data centers accompanied by better macroeconomic conditions. Restraints include intense price competition among manufacturers, lack of product differentiation, and delayed projects as a result of end users spending with caution.

About 50% of UPSs may have AC generators connected to them. UPSs typically combine several power quality functions including voltage regulation; hence, most UPS end users have recognized the benefit of using the UPS as a complete power quality solution.

UPS manufacturers have stated that UPS life span is not coupled to battery life. Although UPS vendors offer a wide array of battery options, they take responsibility only for the UPS package excluding batteries. Comparing OEM versus standalone sales, UPSs are mostly sold as standalone devices. A small segment of the market, such as healthcare, may have an OEM-based sale. The OEM market is likely to be less than 15% of the overall market.

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[5] Source: Analysis of the Global Uninterruptible Power Supplies Market, NC62-27, *June 2013.* Frost.com

Life cycle is used is in the calculation of installed capacity. The lowest value on the life cycle range was applied as per the advice of vendors

The product has an average life span of 3 to 5 years in the low power range and 5 to 10 years in the high power ranges. The low power range product is considered a commodity while the higher power ranges offer features that clients are willing to pay a premium to obtain. The low power range is represented by the below 5 kVA range while high power refers to 50 kVA and above.

UPS Market: Overview, US, 2014

Market Size (2014)	$3,253.1 million
Unit Shipment (2014)	2.5 million
Life Cycle Range	Below 5kVA: 3–5 years 5–50kVA: 5–7 years Above 50 kVA: 7–10 years
Selling Price Range	Below 5kVA: $200–$300 5–50 kVA: $3,000–$15,000 Above 50 kVA: above $30,000
Market Leaders	Schneider Electric, Emerson Network Power, Eaton Over 40 manufacturers selling into the US market Top 3 competitors comprise of 52.9% of the market share

Revenue and Unit Shipment Forecast

Revenues have been taken from past studies produced on UPSs combined with some trend analysis.

The market suffered a setback in 2009 due to the lack of spending and several data center projects that were put on hold during the economic downturn. This information was reported by manufacturers themselves. While the UPS market has not returned to pre-downturn growth rates, it is certainly growing better than expected. This growth is mainly driven by the demand from commercial end users.

Estimating Product Lifetime

Product lifetimes in the UPS market vary significantly by power range, type of application and nature of use. If the product is used rigorously, it could shorten its lifetime. Additionally, good maintenance of UPS systems extends lifetime.

Key Market Trends

The lower power ranges are highly commoditized with intense price competition and little product differentiation. Increased awareness of the benefits of UPSs has driven higher market penetration in the low and medium power ranges. Low power sales offer small margins to manufacturers. Several manufacturers have strategically shifted their focus to high power ranges based on their strengths—a good example being Emerson Network Power.

Industrial end users demand rugged UPS systems designed and custom built for a specific environment. In many industrial environments, commercial UPSs are installed on or above the shop floor to back up IT equipment. In many cases, they are off-the-shelf systems ruggedized for a specific environment.

Almost 80% of the total UPS market consists of data centers in the commercial category. Data center growth has driven the UPS market as a whole over the last decade in the United States. Demand from data centers is arising from the need for more power in smaller spaces. For example, trends such as colocation, cloud servers, and shared or hosted spaces for third parties are gaining momentum. Increasing energy efficiency at a data center is a key factor when determining backup power installations. The efficiency of a data center[6] is incumbent on several components, including backup power, cooling, and server. Added efficiency at the level of each device will significantly enhance the functioning of the data center, therefore, UPSs are being tweaked to provide higher efficiency at all loads. The data center market is also witnessing a gradual shift towards the medium power ranges (5kVA to 50 KVA) from higher power ranges. End users have higher bargaining power, and prices can only be lowered using out-of-the-box solutions such as modular and scalable UPSs. Manufacturers are,

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[6] Source: World UPS Markets (N5F1-27), June 2009; Analysis of the Global Uninterruptible Power Supplies Market (NC62-27), June 2013, Frost & Sullivan

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therefore, diversifying product offerings to modular and scalable UPSs. This eases upfront spending for the end user.

Tier I manufacturers such as Schneider Electric have a strong market presence in the below 5VA segment. They also face competition from cheaper, private-label products. Tier 1 manufacturers are manufacturers with the highest revenue contribution to the total market and that together account from 50 to 80% of the total market. There are two tiers of competition. Tier two manufacturers include all other market participants that have a lower market share but still contribute to the overall total market revenue.

Installation Cost

Installation costs: OEMs typically charge anywhere from 10% to 25% of the cost of the UPS for installation. For example, a UPS priced at $100,000 would cost between $10,000 and $25,000 to install. The power ranges below 5kVA typically do not have any installation costs because they are designed to be easy plug-and-play devices. From 5 to 50 kVA, the installation is 10% to 15% of the UPS cost, while above 50 kVA is between 15% and 25%.

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UPS Market: Revenue, Unit Shipments, and Installed Base, US, 2005–2014[7]

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)
2005	2,244.1	1,740.8	N/A
2006	2,544.3	1,997.7	N/A
2007	2,780.7	2,176.8	N/A
2008	2,850.8	2,261.9	N/A
2009	2,573.2	2,059.1	N/A
2010	2,682.9	2,131.3	N/A
2011	2,809.9	2,215.8	N/A
2012	2,945.1	2,312.2	8,998.1
2013	3,092.3	2,418.9	9,352.4
2014	3,253.1	2,523.4	9,738.7

Source: Frost & Sullivan

The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for the longest replacement cycle of 7 years. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

[7] The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for the longest replacement cycle of 7 years. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

UPS Market: Revenue by Power Range, US, (2005-2014)

Year	Below 5kVA ($ Million)	5 to 50 kVA ($Million)	Above 50 kVA ($Million)
2005	989.0	509.6	745.5
2006	1,121.3	577.7	845.3
2007	1,225.5	631.4	923.8
2008	1,256.4	647.3	947.1
2009	1,134.0	584.3	854.8
2010	1,182.4	609.2	891.3
2011	1,238.1	638.4	933.3
2012	1,289.9	676.5	978.6
2013	1,354.4	710.4	1,027.5
2014	1,424.9	747.3	1,081.0

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UPS Market: Revenue by End User, US, (2005-2014)

Year	Residential ($ Million)	Commercial ($Million)	Industrial ($Million)
2005	692.3	1,115.9	435.9
2006	784.9	1,265.2	494.2
2007	857.8	1,382.7	540.1
2008	879.5	1,417.6	553.7
2009	793.8	1,279.5	499.8
2010	827.7	1,334.1	521.1
2011	866.7	1,397.3	545.8
2012	902.9	1,470.9	571.2
2013	948.1	1,544.4	599.8
2014	997.4	1,624.8	631.0

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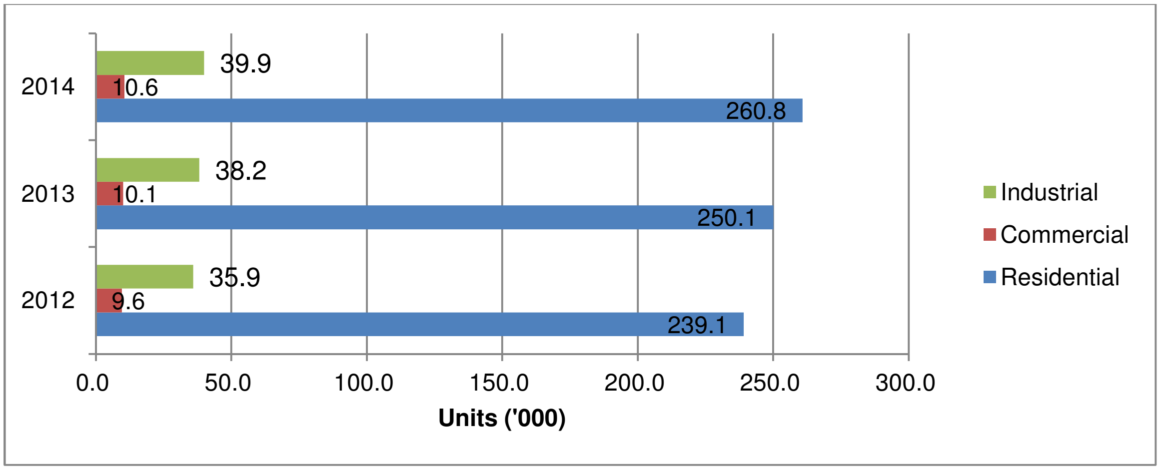
Regional Trends

2.8 Pacific UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.1.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	141.5	239.1	902.1	902.1
2013	148.6	250.1	939.0	939.0
2014	156.3	260.8	979.2	979.2

Source: Frost & Sullivan

2.1.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	129.8	9.6	69.2	6,046.7
2013	137.0	10.1	72.1	6,300.2thank you for the clarification
2014	144.6	10.6	74.5	6,513.3

Source: Frost & Sullivan

2.1.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	30.3	35.9	270.8	2,042.5
2013	32.3	38.2	281.7	2,124.5
2014	34.1	39.9	289.7	2,185.2

Source: Frost & Sullivan

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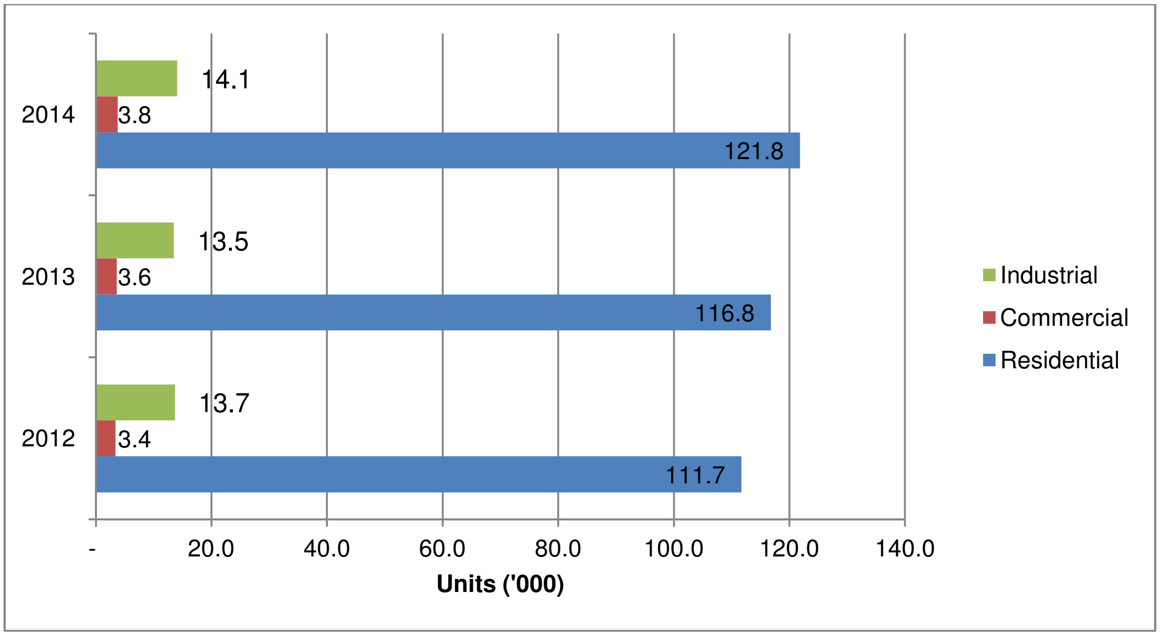
2.2 Mountain UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.2.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	66.1	111.7	421.3	454.9
2013	69.4	116.8	438.5	473.6
2014	73.0	121.8	457.3	493.8

Source: Frost & Sullivan

2.2.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	46.4	3.4	24.9	2,179.5
2013	48.9	3.6	25.9	2,270.8
2014	52.0	3.8	26.8	2,346.4

Source: Frost & Sullivan

2.2.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	11.6	13.7	103.5	780.2
2013	11.4	13.5	106.8	805.2
2014	12.0	14.1	108.6	818.9

Source: Frost & Sullivan

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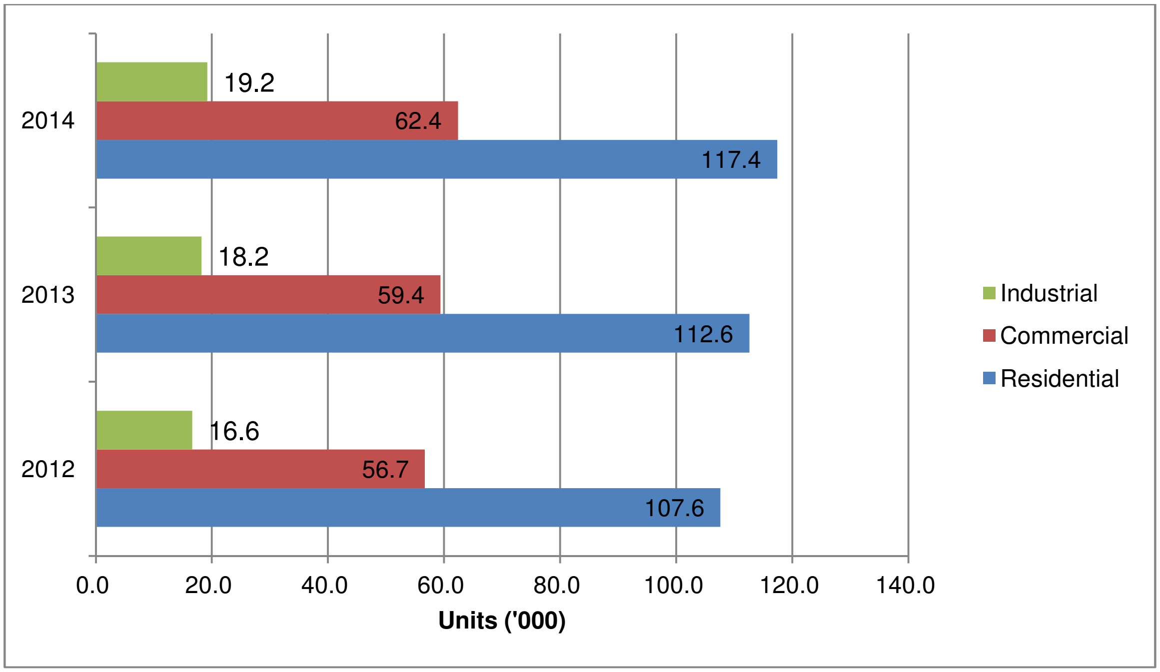
2.3 West North Central UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.3.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	63.7	107.6	406.1	438.6
2013	66.9	112.6	422.7	456.5
2014	70.3	117.4	440.8	476.0

Source: Frost & Sullivan

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2.3.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	768.1	56.7	409.9	35,812.1
2013	806.6	59.4	426.7	37,282.3
2014	848.1	62.4	440.7	38,509.2

Source: Frost & Sullivan

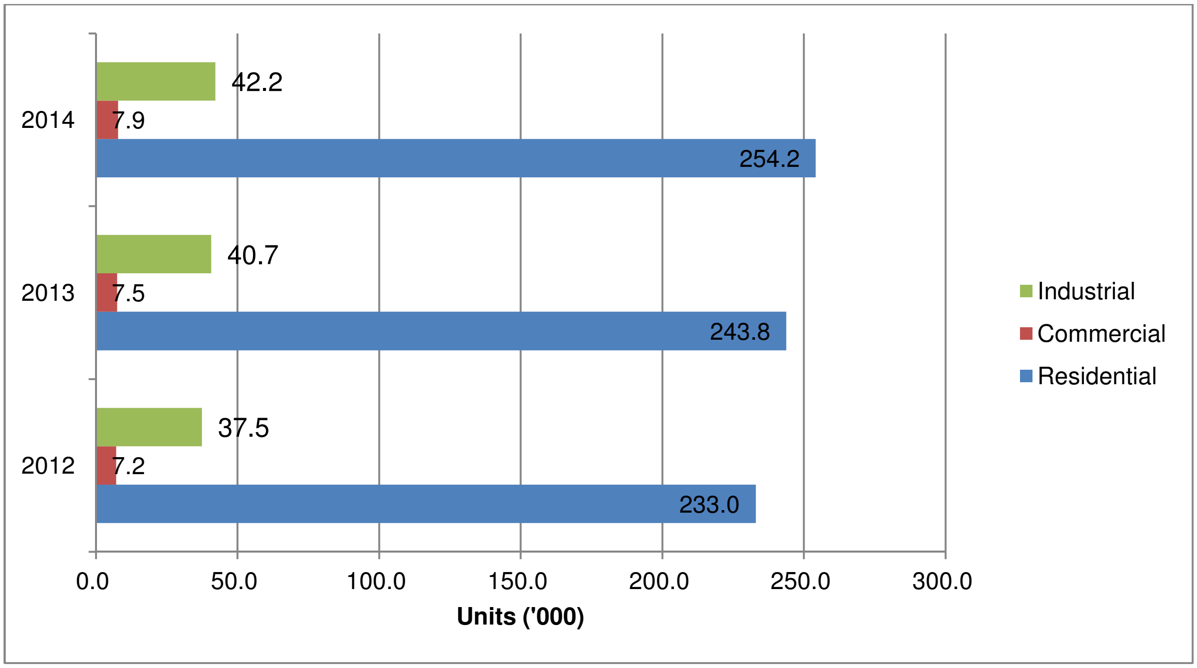
2.3.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	14.0	16.6	115.3	869.4
2013	15.4	18.2	121.9	919.3
2014	16.4	19.2	128.0	965.6

Source: Frost & Sullivan

2.4 East North Central UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.4.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	137.9	233.0	879.2	949.6
2013	144.8	243.8	915.2	988.4
2014	152.3	254.2	954.4	1,030.7

Source: Frost & Sullivan

2.4.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	96.9	7.2	52.7	4,606.8
2013	101.6	7.5	54.5	4,764.4
2014	107.2	7.9	56.0	4,896.0

Source: Frost & Sullivan

2.4.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	31.6	37.5	271.2	2,045.2
2013	34.5	40.7	282.4	2,130.1
2014	36.0	42.2	292.3	2,204.7

Source: Frost & Sullivan

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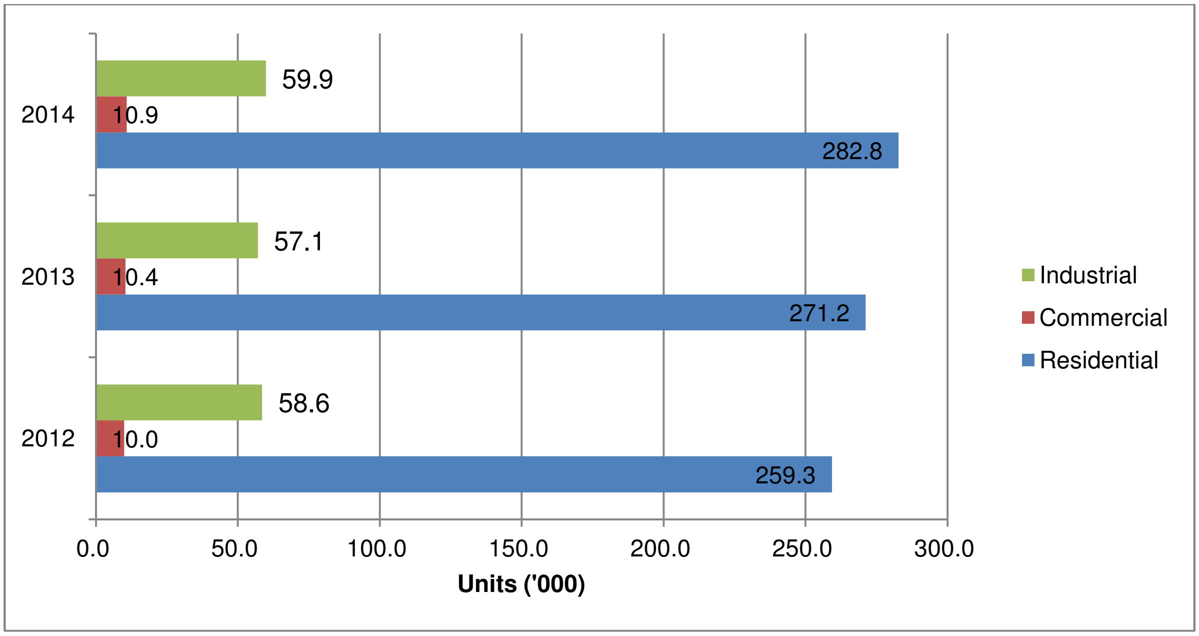
2.5 South Central UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.5.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	153.4	259.3	978.3	1,056.6
2013	161.1	271.2	1,018.3	1,099.8
2014	169.5	282.8	1,061.9	1,146.9

Source: Frost & Sullivan

2.5.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	105.4	10.0	72.1	6,302.2
2013	111.0	10.4	75.1	6,559.1
2014	117.0	10.9	77.5	6,767.4

Source: Frost & Sullivan

2.5.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	49.4	58.6	394.7	2,976.6
2013	48.3	57.1	413.4	3,118.1
2014	51.1	59.9	428.3	3,230.1

Source: Frost & Sullivan

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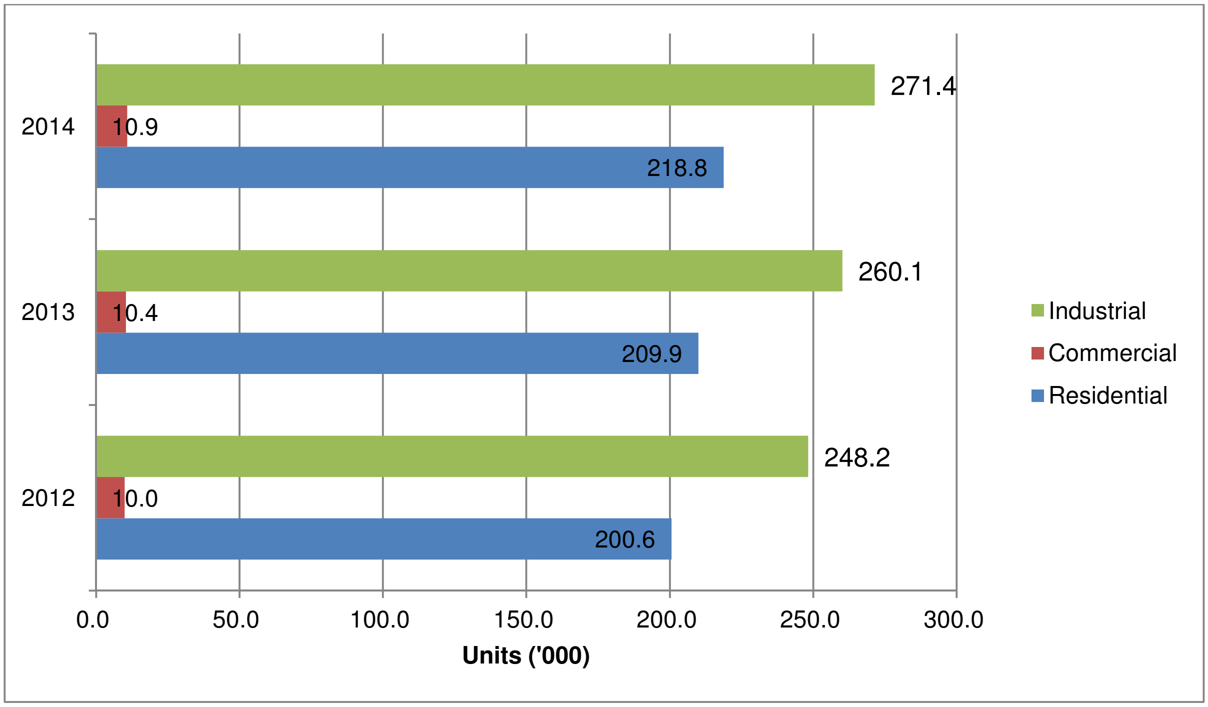
2.6 Mid-Atlantic UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.6.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	118.7	200.6	756.9	817.5
2013	124.7	209.9	787.9	850.9
2014	131.1	218.8	821.6	887.4

Source: Frost & Sullivan

2.6.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	135.5	10.0	72.1	6,302.2
2013	141.3	10.4	75.1	6,559.1
2014	147.9	10.9	77.5	6,767.4

Source: Frost & Sullivan

2.6.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	209.2	248.2	1,825.7	13,769.7
2013	220.0	260.1	1,897.2	14,308.7
2014	231.6	271.4	1,952.4	14,724.7

Source: Frost & Sullivan

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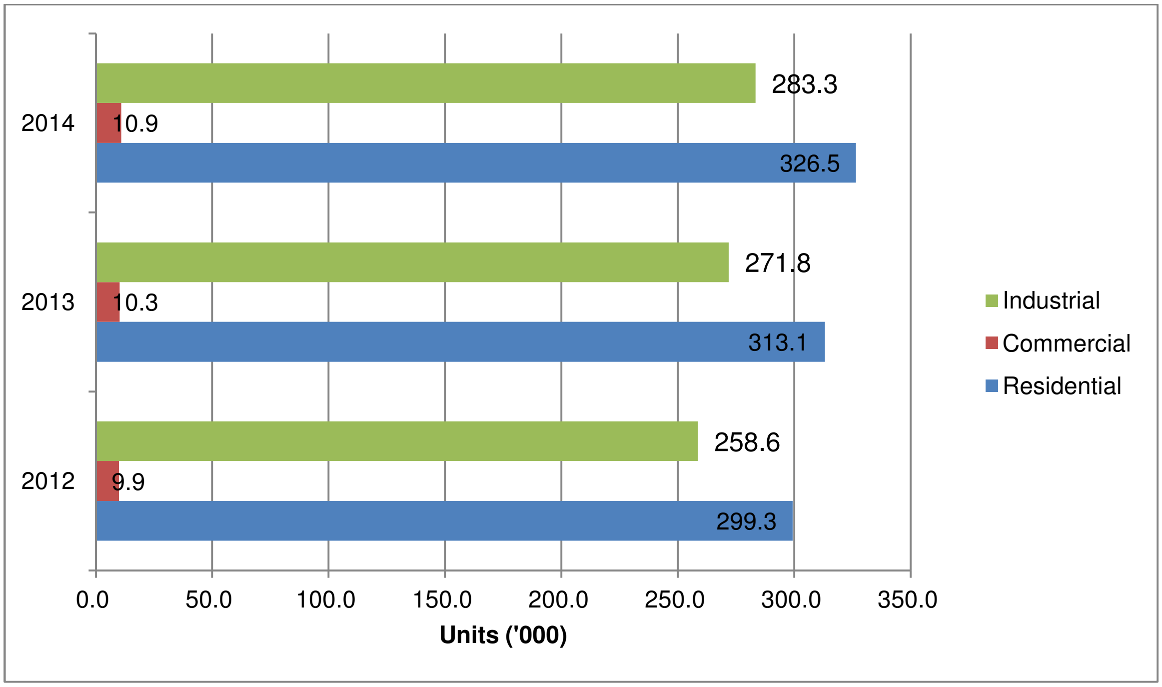
2.7 South Atlantic UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.7.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	177.1	299.3	1,129.3	1,219.6
2013	186.0	313.1	1,175.5	1,269.5
2014	195.6	326.5	1,225.8	1,323.8

Source: Frost & Sullivan

2.7.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	133.5	9.9	72.5	6,330.7
2013	140.1	10.3	75.2	6,569.4
2014	147.9	10.9	77.4	6,764.4

Source: Frost & Sullivan

2.7.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	217.9	258.6	1,902.9	14,352.1
2013	229.9	271.8	1,977.8	14,916.4
2014	241.7	283.3	2,034.9	15,347.4

Source: Frost & Sullivan

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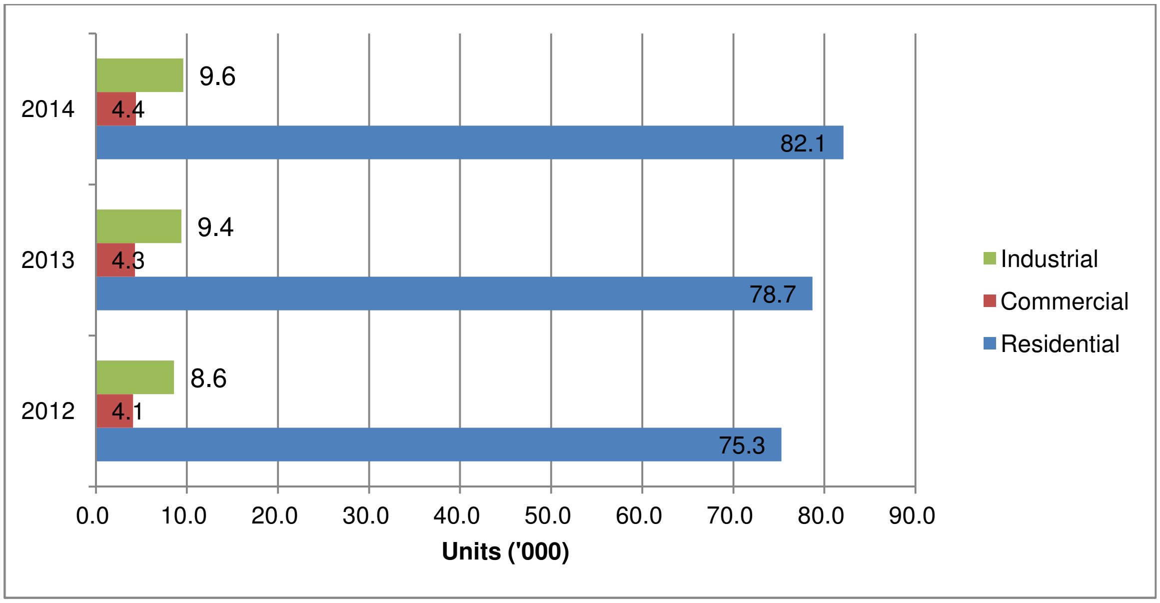
2.1 New England UPS Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

2.8.1 Residential

Residential UPS Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	44.5	75.3	283.9	306.7
2013	46.8	78.7	295.6	319.2
2014	49.2	82.1	308.2	332.9

Source: Frost & Sullivan

2.8.2 Commercial

Commercial UPS Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	55.3	4.1	29.7	2,593.6
2013	58.0	4.3	30.9	2,697.3
2014	60.1	4.4	31.8	2,777.6

Source: Frost & Sullivan

2.8.3 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Capacity (MW)
2012	7.2	8.6	70.1	528.7
2013	7.9	9.4	71.8	541.6
2014	8.2	9.6	72.6	547.2

Source: Frost & Sullivan

Chapter 3

Surge Protection Devices

Product Definition

Surge Protection Devices (SPD) is comprised of primary component such as metal oxide varistor (MOV), silicon avalanche diode (SAD), gas discharge tubes, selenium cells, spark-gap ignition electronic circuit, hybrid technology, and low pass filters, among others.

SPD protects AC electrical circuits from surges and transients in electrical power created by lightning and power switching devices. Transients and surges can occur anytime and anywhere, with the potential to damage equipment and affect businesses and institutions. SPDs protect electronic appliances against voltage fluctuations—both very low and very high—with the potential to damage or destroy systems. Failure to protect equipment and facilities from power line disturbances can result in production and revenue losses.

Surge suppressors[8] can range from those that protect standalone products to those that protect systems at the service entrance or panel level. For the purposes of this research, the SPD market is analyzed based on the following segments:

Type 1 SPD is a permanently connected device that is UL approved for installation at any location between the secondary of the utility service transformer and the service entrance primary overcurrent disconnect. Type 1 SPDs can also be installed anywhere on the load side of the service entrance and are allowed to be installed anywhere on the low-voltage electrical system without requiring a dedicated fuse or breaker.

Type 2 SPD is a permanently connected device that is UL approved for installation on the load side of the service entrance primary overcurrent disconnect. Type 2 SPDs may or may not require the use of a dedicated fuse or breaker.

Type 3 SPD is a point-of-use device installed at a conductor length of 10 meters (30 feet) or greater from the electrical panel. These devices are typically cord connected, direct plug-in, and receptacle type installed at the load equipment being protected. The distance of 10 meters excludes conductors that are provided with or used to attach the SPD.

[8] Source: UL, GE, Eaton and Schneider Electric; Frost & Sullivan studies A325, F305, N62F: World TVSS Market.

Type 4 SPD designation is for SPD components and assemblies that are considered to be incomplete in any aspect that would prevent them from obtaining a UL Listing classification. Examples of Type 4 SPDs range from MOV components to complete SPD system assemblies that are constructed without an outer enclosure.

Type 4 is not included in this research. As per National Electrical Manufacturers Association (NEMA), these are incomplete SPD assemblies, which typically are installed in listed end-use products as long as all conditions of acceptability are met. These Type 4 component assemblies are incomplete as an SPD. They require further evaluation and are not permitted to be installed in the field as a standalone SPD. Often, these devices require additional overcurrent protection.

Hardwired TVSS have been redefined as Type 1 and Type 2 SPD while Plug-in TVSS have been redefined as Type 3 SPD. A segment of hardwired TVSS - receptacle has been grouped under Type 3 SPD. As the data to be generated was historic in nature so we have retained the name hardwired TVSS and Plug-in TVSS for the purpose of this research. All the historic data used to be reported within these two segments. We did calculate the 2012 to 2014 revenues and unit shipments based on the older definitions.

Market Overview

With an increase in the use of microprocessor-based electronic equipment, transients and surges have become a common issue. Microprocessor-based electronics are more susceptible to damage due to greater sophistication and sensitivity of components. As power quality becomes a major issue for businesses and consumers utilizing electrical power, the demand for SPDs is expected to increase. Ideally, utilities should supply stable and consistent AC power. However, entrance level power for entire facility protection and for individual equipment protection is not stable or consistent. As semiconductors continue to shrink in size while increasing power density, the possibility of damage due to surge problems is greater. Such damage can range from minor errors to deterioration and gradual destruction of electronic appliances. This difficulty is expected to continue to exist if surge protection solutions are not implemented.

SPDs are based on the following technologies:

- Metal oxide varistor (MOV): highest energy capability, excellent reliability, consistent performance, better mechanical connectivity for paralleling multiple components, non-linear clamping curve, gradually degrades over repeated use at high surge levels, and moderate capacitance
- Silicon avalanche diode (SAD): flatter clamping curve, excellent reliability, and consistent performance; low energy capability and expensive

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- Gas discharge tubes: high energy capability, very low capacitive (requirement for data line applications), unpredictable and unstable repetitive behavior, "crow-bar" to ground (unsuitable for AC systems), expensive
- Selenium cells: Moderate to high energy capability, high leakage current, high clamping voltage, bulky, expensive, employs obsolete components
- Spark-gap ignition electronic circuit: This technology is based on an ignition current that flows through special ignition elements to produce an initial electrical arc. This is likely to result in a reduced need for further ignition electronics to produce the high-voltage impulse required to ignite the spark gap, thus making a more robust design. The results are powerful lightning arrestors with low-voltage protection levels and limited follow currents.
- Hybrid technology: MOV/filters are the most common hybrid, incorporating the advantages of other components while overcoming the difficulties associated with each individual component. Some of the key features include long life expectancy, faster response, and better clamping performance. Other hybrids used are MOV and SAD or MOV and selenium cells.
- Low pass filters: They have an inductor that acts like a grid, besides 3 different capacitors. When a surge hits the receptacle, it passes through the inductor that filters it so that it becomes smaller and slower. After passing through the inductor, it hits the capacitor where it is filtered further and the remaining surge is handled by the 2 other capacitors. This helps in decreasing the surge and then passing it slowly on to the neutral wire.
- "Phaseback" electromagnetic transient voltage surge suppressor (EMTVSS): This is a solution specifically suited for ungrounded DELTA systems. It uses electromagnetism and not solid-state components, allowing phaseback to react at the speed of the current flow at the beginning of phase-voltage imbalance. Energy is redirected from the phase or phases with higher voltages and fed back to low-voltage phase or phases. This process uses heavy-duty, industrially-rated inductive devices closely coupled for maximum efficiency and continuous duty in wet, dirty environments, and is designed for extreme shock and vibration.

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Surge Protection Devices Market: Overview, US, 2014

Market Size (2014)	$818.0 million
Unit Shipment (2014)	21.9 million
Life Cycle Range	5 to 15 years
Selling Price Range	Type 1: $300–$6,000 Type 2: $150–$2,500 Type 3: $5–$150
Market Leaders	Schneider Electric, Eaton, Smith Industries, Belkin, Monster Cable, Tripp Lite, Power Sentry, Leviton Over 30 manufacturers selling into UPS Top 7 companies have 55.8% market share

Key Market Trends

Higher customer awareness is the result of increased marketing by vendors about the difference between point-of-use (plug-in) and hardwired SPDs.

The market has witnessed consolidation as key vendors increase their presence and enhance their product offerings. This has also given rise to bundling of total power quality solutions. Major vendors including Eaton Electrical, Schneider Electric, ABB, and Smith Industries are bundling their SPD products with panel boards and switchgears.

Consulting engineers and end users are realizing the advantages of facility-wide surge protection rather than focusing on individual equipment.

SPDs must be UL 1449 3rd Edition complaint; they must comply with the recently published 4th Edition by 2016.

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Estimating Product Lifetime

Product lifetimes in the SPD market vary significantly by product type, type of application and nature of use. Product lifetime varies based on location of installation, lightning strikes at that location in a given year, number of operations and an engineering margin of 15% - 20%. These factors determine the product lifetime. It varies between the three different types of SPD.

Installation Cost

Installation cost varies by device and application. Plug-ins are do-it-yourself devices and require no specialized installation.

For Type 1 and Type 2 SPDs, if the device is integrated as part of a circuit board, panel board, or switchgear, there is no specific installation cost because cost is based on the complete unit rather than individual equipment. If it is being connected as a standalone device, the installation cost is 5% to 10% above the equipment cost.

SPD Market: Revenue and Unit Shipment, US, 2005–2014[9]

Year	Revenue ($ Million)	Unit Shipment (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2005	673.9	18.9	N/A	N/A
2006	703.5	19.7	N/A	N/A
2007	737.4	20.3	N/A	N/A
2008	761.6	20.8	N/A	N/A
2009	665.9	18.1	N/A	N/A
2010	687.6	18.6	N/A	N/A
2011	714.4	19.3	N/A	N/A
2012	745.3	20.0	114.7	1.02
2013	779.5	20.9	122.0	1.09
2014	818.0	21.9	128.3	1.20

Source: Frost & Sullivan

The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for the longest replacement cycle of 7.5 years. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

As automation increases on the manufacturing floor, the need for SPDs is expected to rise accordingly. Microprocessor-based devices such as programmable logic

[9] Forecast includes type1, type 2, and type 3 surge protection devices.

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controllers, computer numerical controls, variable frequency drives, process computers, robotics, and other equipment are being used more to increase production capability. As facility managers and engineers become more aware of and knowledgeable about surges and their consequences, industrial and commercial end-users' market shares are expected to increase. The construction of new facilities and the retrofits of older ones will also contribute to the overall growth of the SPD market.

The residential end-user group is expected to increase SPD implementation as consumers and building contractors increase their awareness of the need for surge suppression. The growing use of data communications and other microprocessor-based equipment also contributes to rapid growth, as does home construction as engineers consider the potential of implementing whole-house surge suppression at the service entrance and individual equipment levels.

SPD Market: Revenues by Product Type, US, (2005-2014)

Year	Plug-ins ($ Million)	Hardwired ($Million)
2005	438.8	235.1
2006	456.6	246.9
2007	469.3	268.1
2008	479.4	282.2
2009	416.0	249.9
2010	427.3	260.3
2011	442.6	271.8
2012	459.8	285.5
2013	480.4	299.1
2014	502.4	315.6

Source: Frost & Sullivan

SPD Market: Revenues by End User, US, (2005-2014)

Year	Residential ($ Million)	Commercial ($Million)	Industrial ($Million)
2005	242.3	274.5	158.2
2006	251.7	285.2	165.8
2007	257.0	301.9	178.2
2008	258.6	314.3	188.6
2009	222.0	274.2	169.9
2010	225.1	283.4	178.6
2011	229.8	297.8	186.7
2012	237.5	309.9	197.4
2013	242.8	326.2	210.8
2014	250.2	342.5	224.9

Source: Frost & Sullivan

Regional Analysis

Frost & Sullivan has taken a top-down approach for generating regional information. To determine the end-user split, Frost & Sullivan identified the number of entities for residential, commercial, and industrial in the United States by geographic region[10]. These numbers were sorted by regions and cross-verified by industry participants. Frost & Sullivan used this to separate the figures by geographic region and by end user.

[10] http://censtats.census.gov

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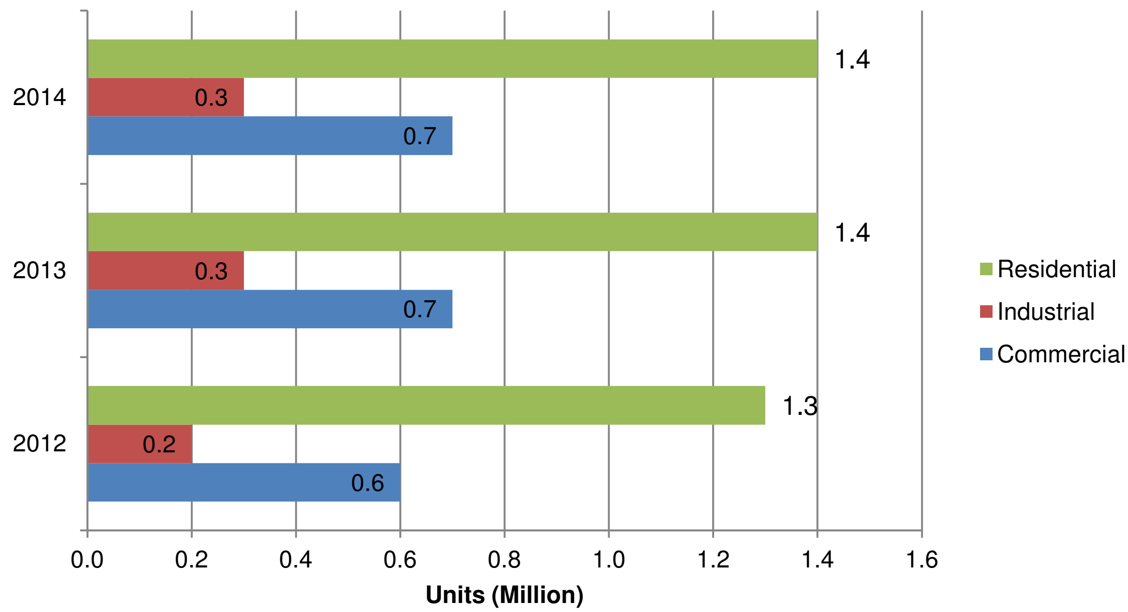
Regional Trends

3.1 Pacific SPD Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

3.1.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	27.2	0.6	3.4	0.051
2013	29.0	0.7	3.7	0.055
2014	30.5	0.7	4.0	0.059

Source: Frost & Sullivan

3.1.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	10.5	0.2	1.4	0.021
2013	11.4	0.3	1.5	0.022
2014	12.1	0.3	1.6	0.023

Source: Frost & Sullivan

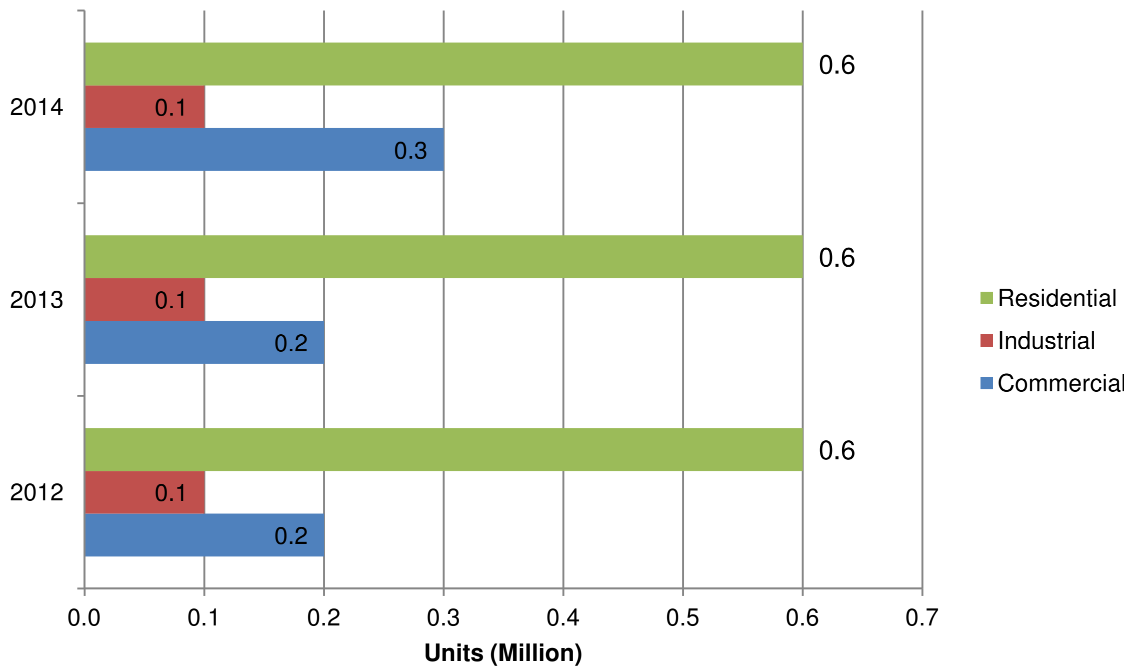
3.1.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	37.3	1.3	7.8	0.009
2013	38.1	1.3	8.2	0.0097
2014	39.3	1.4	8.5	0.010

Source: Frost & Sullivan

3.2 Mountain SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.2.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	9.9	0.2	1.2	0.018
2013	10.4	0.2	1.3	0.019
2014	11.0	0.3	1.4	0.021

Source: Frost & Sullivan

3.2.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	3.9	0.1	0.5	0.0079
2013	4.0	0.1	0.6	0.0083
2014	4.3	0.1	0.6	0.0087

Source: Frost & Sullivan

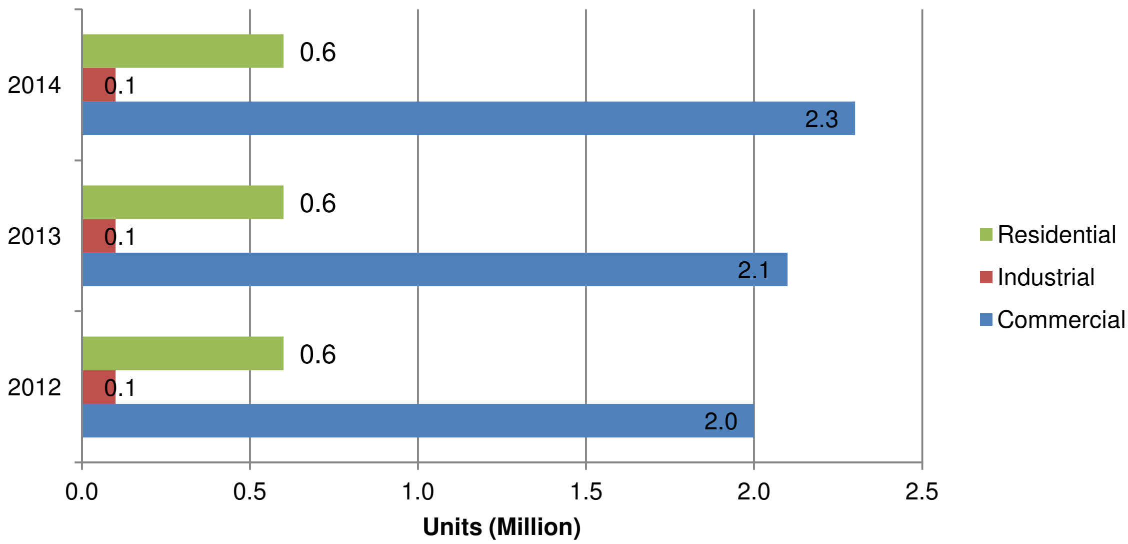
3.2.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	17.4	0.6	3.7	0.0044
2013	17.7	0.6	3.9	0.0045
2014	18.3	0.6	4.0	0.0047

Source: Frost & Sullivan

3.3 West North Central SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.3.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	87.3	2.0	11.0	0.163
2013	91.9	2.1	11.9	0.176
2014	96.6	2.3	12.7	0.188

Source: Frost & Sullivan

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3.3.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	4.7	0.1	0.6	0.0088
2013	5.5	0.1	0.7	0.0097
2014	5.8	0.1	0.7	0.0105

Source: Frost & Sullivan

3.3.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	16.6	0.6	3.5	0.0041
2013	17.2	0.6	3.7	0.0043
2014	17.8	0.6	3.8	0.0045

Source: Frost & Sullivan

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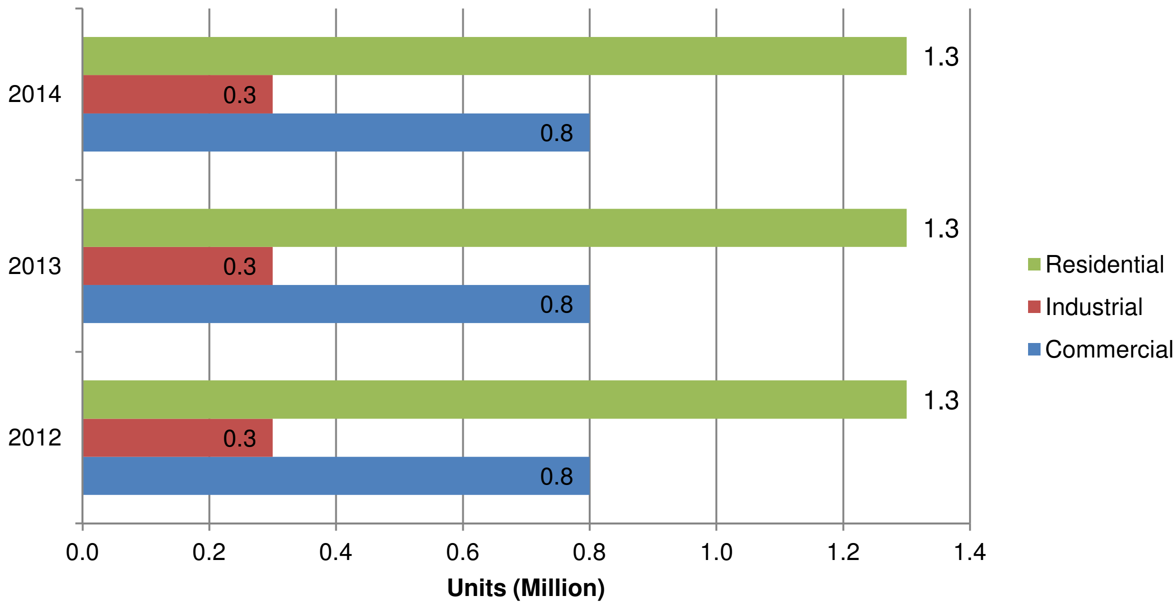
3.4 East North Central SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.4.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	35.9	0.8	4.6	0.0679
2013	37.8	0.9	4.9	0.0731
2014	39.7	0.9	5.2	0.0778

Source: Frost & Sullivan

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3.4.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	10.9	0.3	1,4	0.0205
2013	12.0	0,3	1.5	0.0223
2014	12.9	0.3	1.6	0.0239

Source: Frost & Sullivan

3.4.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	36.4	1.3	7.6	0.0090
2013	37.1	1.3	8.0	0.0094
2014	38.3	1.3	8.3	0.0098

Source: Frost & Sullivan

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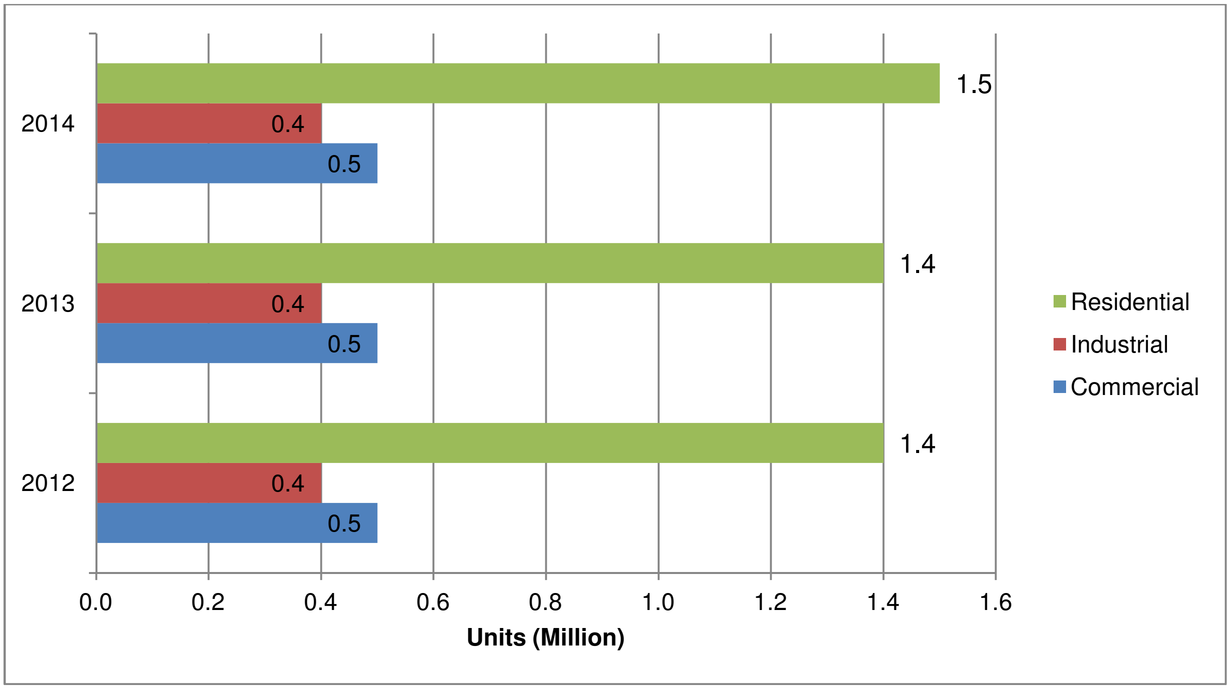
3.5 South Central SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.5.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	22.3	0.5	2.7	0.0405
2013	23.5	0.5	3.0	0.0440
2014	24.7	0.6	3.2	0.0472

Source: Frost & Sullivan

3.5.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	17.2	0.4	2.0	0.0303
2013	17.1	0.4	2.2	0.0327
2014	18.2	0.4	2.4	0.0350

Source: Frost & Sullivan

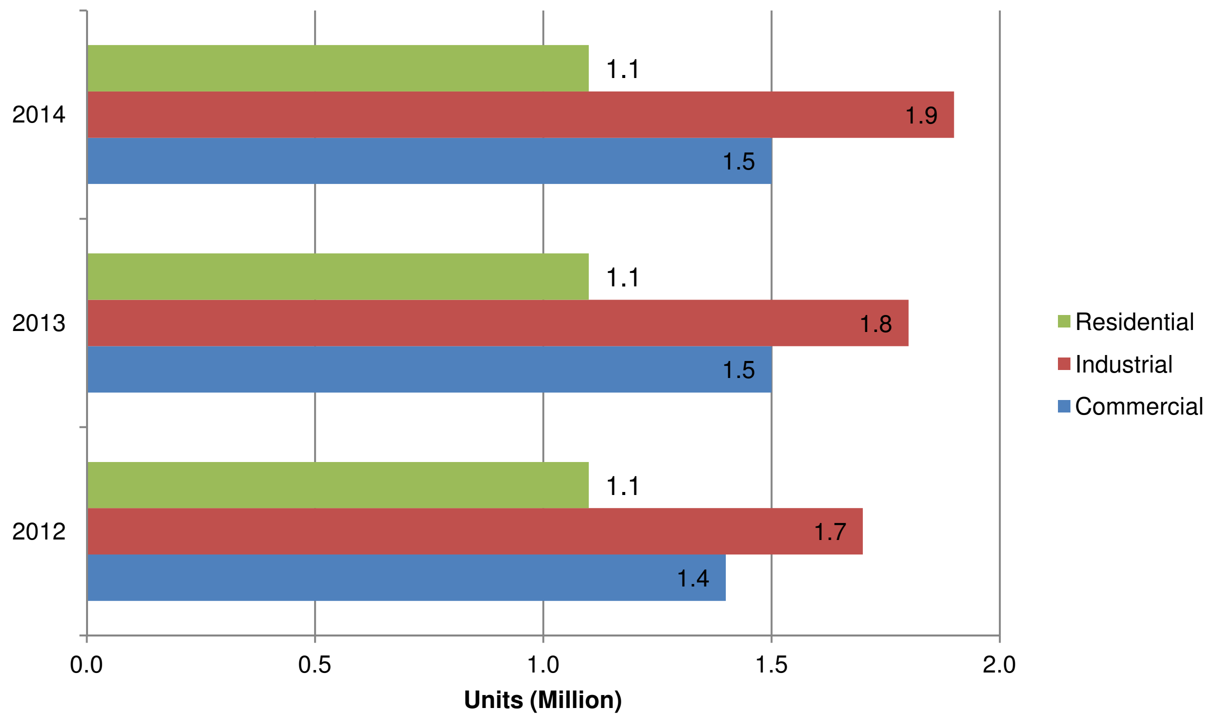
3.5.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	40.4	1.4	8.6	0.0101
2013	41.3	1.4	9.0	0.0106
2014	42.5	1.5	9.3	0.0109

Source: Frost & Sullivan

3.6 Mid-Atlantic SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.6.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	59.4	1.4	7.5	0.1114
2013	62.2	1.5	8.1	0.1200
2014	65.4	1.5	8.6	0.1280

Source: Frost & Sullivan

3.6.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	72.2	1.7	9.3	0.1385
2013	77.3	1.8	10.0	0.1491
2014	82.5	1.9	10.7	0.1588

Source: Frost & Sullivan

3.6.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	31.1	1.1	6.6	0.0078
2013	31.8	1.1	6.9	0.0081
2014	32.8	1.1	7.1	0.0084

Source: Frost & Sullivan

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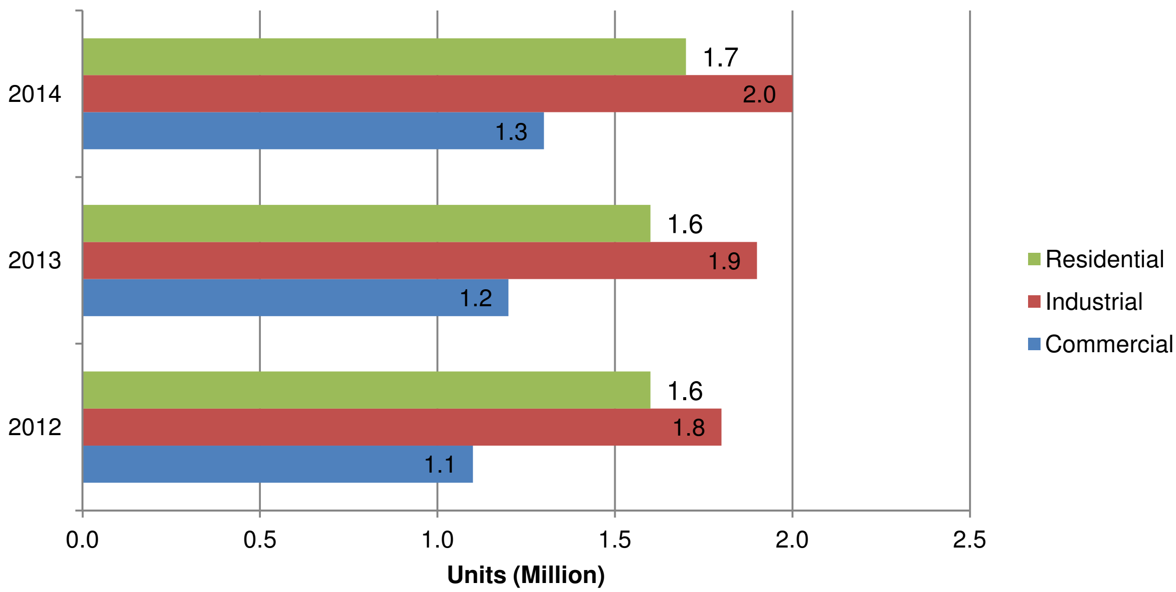
3.7 South Atlantic SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.7.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	49.8	1.1	6.3	0.0941
2013	52.5	1.2	6.8	0.1013
2014	55.1	1.3	7.3	0.1080

Source: Frost & Sullivan

3.7.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, West South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	75.4	1.8	9.7	0.1443
2013	80.7	1.9	10.5	0.1554
2014	86.1	2.0	11.1	0.1656

Source: Frost & Sullivan

3.7.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, West South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments	Installed Base in Units	Installed Capacity (GW)
2012	46.6	1.6	9.9	0.0116
2013	47.6	1.6	10.3	0.0122
2014	49.0	1.7	10.6	0.0126

Source: Frost & Sullivan

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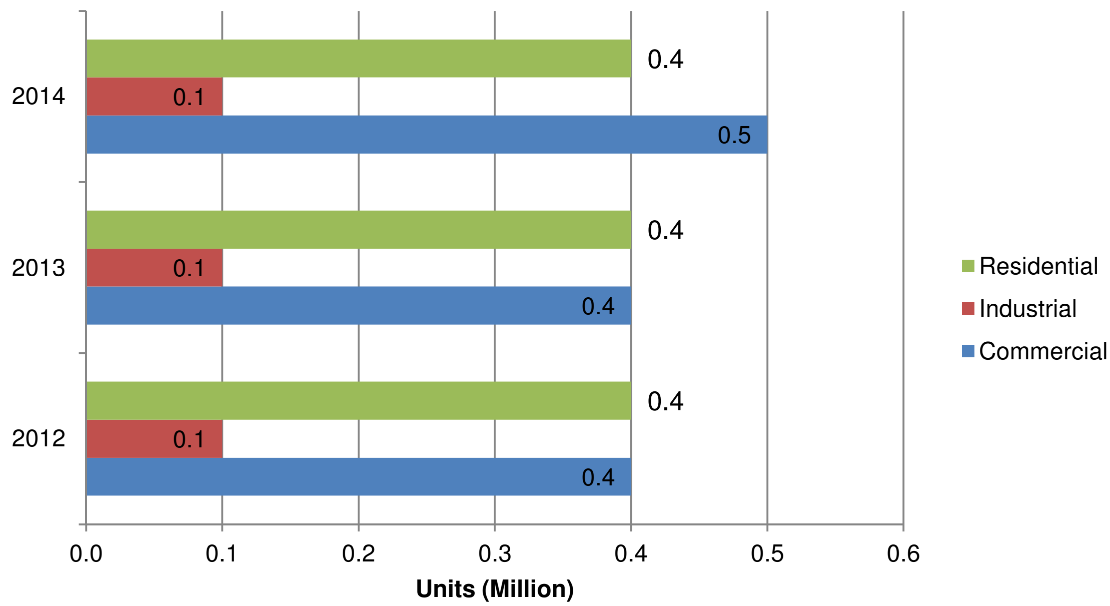
3.1 New England SPD Market: Unit Shipments, US, 2014



Source: Frost & Sullivan

3.8.1 Commercial

Commercial SPD Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	18.0	0.4	2.3	0.0337
2013	18.9	0.4	2.4	0.0363
2014	19.5	0.5	2.6	0.0386

Source: Frost & Sullivan

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3.8.2 Industrial

Industrial SPD Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	2.6	0.1	0.4	0.0052
2013	2.7	0.1	0.4	0.0055
2014	2.9	0.1	0.4	0.0058

Source: Frost & Sullivan

3.8.3 Residential

Residential SPD Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (GW)
2012	11.7	0.4	2.5	0.0029
2013	11.9	0.4	2.6	0.0030
2014	12.3	0.4	2.7	0.0031

Source: Frost & Sullivan

Chapter 4

Isolation Transformers

Product Definition

Isolation transformers are a form of power conditioning device. These are available as single and three phases. Isolation transformers come in two varieties that consist of non-shielded and shielded.

These products are designed to isolate equipment from their direct connection to the AC power line. They also provide a step down from higher to lower voltages in standard distribution functions.

Key features consist of isolation of sensitive electronic equipment loads from electrical noise and transient voltage impulses.

Noise includes electromagnetic interference (EMI) and radio frequency interference (RFI)—any condition that disrupts the smooth sine wave, typically caused by lighting, load switching, generators, and industrial equipment.

Market Overview

Isolation transformers are a form of power conditioning device available as single- and 3-phase. Demand has been declining due to growing competition and a preference for multifunctional power quality equipment such as SPDs, power distribution units, and small UPS units. The product is nonexistent in the residential market, but has found a niche in industrial devices, such as motor drives and medical applications.

The product has a life span of between 10 and 20 years, depending on the application it is supporting. It is considered a commodity; customers are not willing to pay a premium.

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Isolation Transformer Market: Overview, US, 2014

Market Size (2014)	$122.1 million
Unit Shipment (2014)	114,600
Average Life Cycle	Between 10 and 20 years. For instance a medical device, such as MRI, has an average replacement cycle of 10 years.
Average Selling Price	$1,066, based on the weight of single- and 3-phase products
Top Competitors	Square D/Schneider Electric, Eaton, Staco Energy, Tripp Lite, Acme Over 15 manufacturers selling into the U.S. market Top 5 competitors have over 50% market share

Product Function/Type

Isolation transformers are designed to isolate equipment from their direct connection to the AC power line. Other functions include the isolation of sensitive electronic equipment loads from electrical noise and transient voltage impulses. They also provide a step down from higher to lower voltages in standard distribution functions.

Varieties include:

- Nonshielded isolation transformers: The traditional transformer type that provides isolation as well as voltage step down and step up in standard distribution function
- Shielded isolation transformers: Protects from noise and harmonics on the power lines. There is a perception that shielded isolation transformers are capable of improving overall operation and reliability of the protected equipment by preventing noise in the power supply from reaching the equipment. The impedance output level is relatively low, making them suitable for applications that typically have high incoming currents.

Magnetic resonance imaging (MRI) systems are most commonly used in neurological and musculoskeletal medicine for imaging of soft tissues in the spine, brain, and extremities. Frost & Sullivan expects U.S. MRI systems market revenue to grow at a CAGR of 2.8 percent from 2011 to 2016, reaching $1,042.4 million in 2016. With shipments of ranging from 540 to 775 units per year, annual revenue in the U.S. MRI systems market varied from $788.3 to $1,142.2 million during the 2008 to 2011 period. Unit shipments dipped 9.4 percent in 2009 and 23.1 percent in 2010 affecting overall demand for power quality.

OEMs that incorporate isolation transformers into their own products is a growing market, but is not included in this deliverable. This chapter considers only standalone isolation transformers sold in the US market. They are used for residential applications, and mainly have a niche presence in commercial and industrial applications.

Market Trends

Isolation transformers account for a very small share of power quality equipment. The share is projected to diminish due to the following trends.

- Online UPS with double conversion has been replacing isolation transformers due to its ability to isolate noise generated at the input while at the same time provide backup power and built-in surge protection. The price for online UPS has been declining, making it more competitive.
- Isolation transformers are considered to be large and bulky devices. The product has seen very few refinements over the years.
- Because isolation transformers are not used as a standalone product, growth is dependent on growth in construction investments. Sales suffered during the Great Recession—overall investment for commercial construction declined 37.3% in 2009 and 27.0% in 2010. The market did not fully recover until 2011[11]. Manufacturing construction did not recover until 2012, when it experienced 18.5% year-over-year growth in investments.
- Unit shipments of medical devices experienced a decline of 9.4% in 2009 and 23.1% in 2010[12]. The decline was caused by budget freezes and limited access to capital during the economic crises.
- According to power quality experts, harmonics and noise contamination make up only 10% of all power quality problems; blackouts and sags account for the remaining 90%. This makes isolation transformers a less attractive product.

[11] US Census Bureau, Commercial: US Total
[12] Frost & Sullivan study NC27-54: Analysis of the U.S. Magnetic Resonance Imaging (MRI) Systems Market.

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- Since isolation transformers lack innovation and development, it cannot compete with new products.

Estimating Product Lifetime

Product lifetimes in the SPD market vary significantly by product type, type of application and nature of use. Product lifetime varies based on location of installation, lightning strikes at that location in a given year, number of operations and an engineering margin of 15% - 20%. These factors determine the product lifetime. It varies between the three different types of SPD.

Installation Cost

Installation cost varies by device and application. Overall, the cost of installing Isolation Transformer is very low. If it is being connected as a standalone device, the installation cost is 5% to 10% above the equipment cost. If it is integrated within a device then it is hard to calculate individual cost.

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Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, US, 2005–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base (MW)
2005	256.18	265.85	N/A
2006	264.20	269.47	N/A
2007	271.06	271.73	N/A
2008	259.14	259.89	N/A
2009	160.67	161.32	N/A
2010	118.89	117.37	N/A
2011	118.54	114.99	N/A
2012	119.37	113.77	5.42
2013	120.56	114.00	5.05
2014	122.13	114.56	4.67

Source: Frost & Sullivan

The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for the longest replacement cycle of 7 years. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

Revenues have been taken from past studies produced on isolation transformers[13] combined with trend analysis. Unit shipments were calculated using the basic math formula:

Revenue (R) = Price (P) X Units (U) = > U = R/P

Isolation Transformer Market: Average Selling Price, US, 2012–2014

Year	Average Selling Price ($)
2012	1,049.2
2013	1,057.6
2014	1,085.2

Source: Frost & Sullivan

The average selling price was calculated assuming the following single-phase and 3-phase split by end-user application. The analysis assumed that the split between phases remained constant from 2005 to 2014.

Isolation Transformer Market: Percentage Split by Product Type for End-user Application, US, 2014

End User	Single-Phase	3-Phase
Commercial	69%	31%
Industrial	35%	65%

Source: Frost & Sullivan

[13] Report codes: 7250-27, 5801-27; N22E-27 – World Isolation Transformer market

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Isolation Transformer Market: Average Selling Price by Product Type, US, 2012–2014

Year	Single-Phase ($)	3-Phase ($)
2012	934.6	1,224.5
2013	942.1	1,234.3
2014	949.6	1,244.2

Source: Frost & Sullivan

Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base by End User, U.S., 2012–2014

Commercial

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	87.92	85.71	1512.78	3.92
2013	88.76	85.97	1414.71	3.66
2014	89.92	86.32	1317.06	3.41

Source: Frost & Sullivan

Industrial

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	34.96	28.02	579.62	1.5
2013	35.29	28.07	532.7	1.37
2014	35.76	28.21	485.9	1.26

Source: Frost & Sullivan

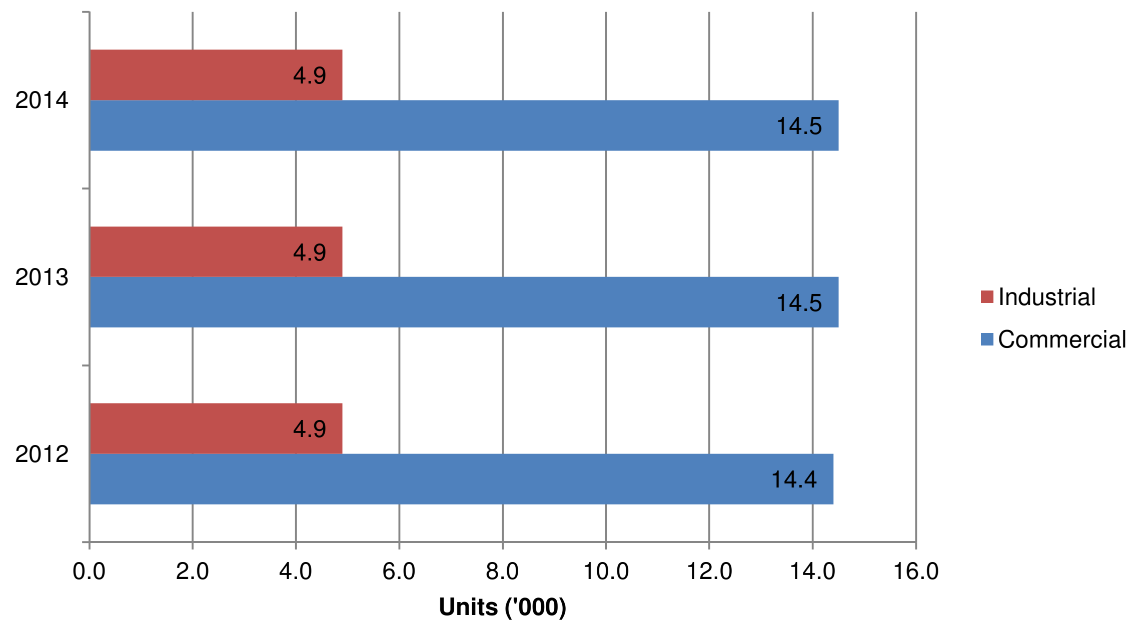
Regional Analysis

Frost & Sullivan has taken a top-down approach for generating regional information. To determine end-user splits, Frost & Sullivan identified the number of commercial and industrial entities in the United States by geographic region[14]. These numbers were sorted by regions and cross-verified by industry participants. Frost & Sullivan used this to separate the figures by geographic region and by end user.

[14] http://censtats.census.gov

Regional Trends

4.1 Pacific Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

4.1.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	14.79	14.43	252.21	0.65
2013	14.94	14.46	236.67	0.61
2014	15.13	14.53	221.20	0.57

Source: Frost & Sullivan

© Frost & Sullivan

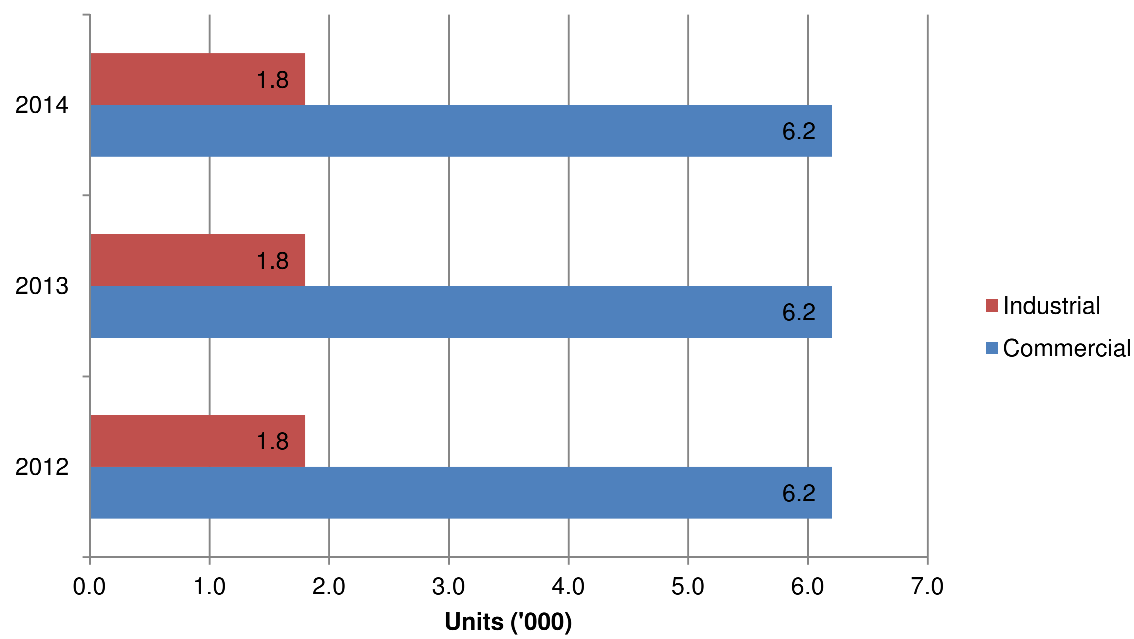
4.1.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	5.47	4.87	101.13	0.26
2013	5.52	4.88	93.01	0.24
2014	5.60	4.90	84.91	0.22

Source: Frost & Sullivan

4.2 Mountain Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

© Frost & Sullivan

4.2.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base MW
2012	6.34	6.19	104.31	0.27
2013	6.41	6.20	98.51	0.26
2014	6.49	6.23	92.74	0.24

Source: Frost & Sullivan

4.2.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base MW)
2012	5.47	1.77	36.61	0.09
2013	5.52	1.77	33.39	0.09
2014	5.60	1.78	30.17	0.08

Source: Frost & Sullivan

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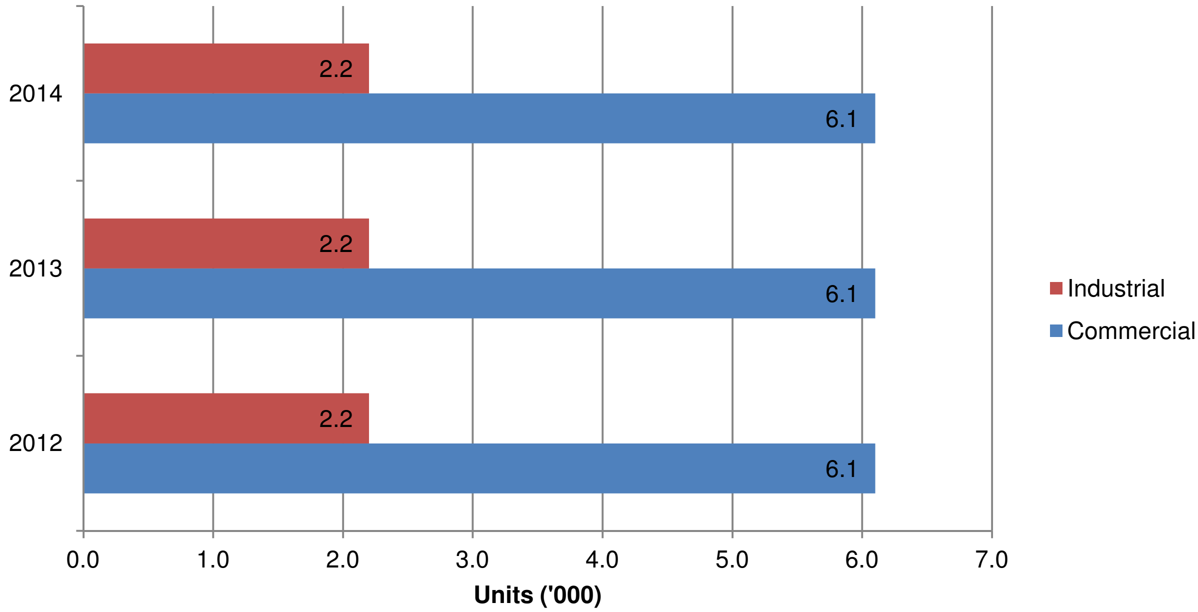
4.3 West North Central Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

4.3.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Install Base (MW)
2012	6.22	6.06	104.87	0.27
2013	6.28	6.08	97.94	0.25
2014	6.36	6.11	91.05	0.24

Source: Frost & Sullivan

© Frost & Sullivan

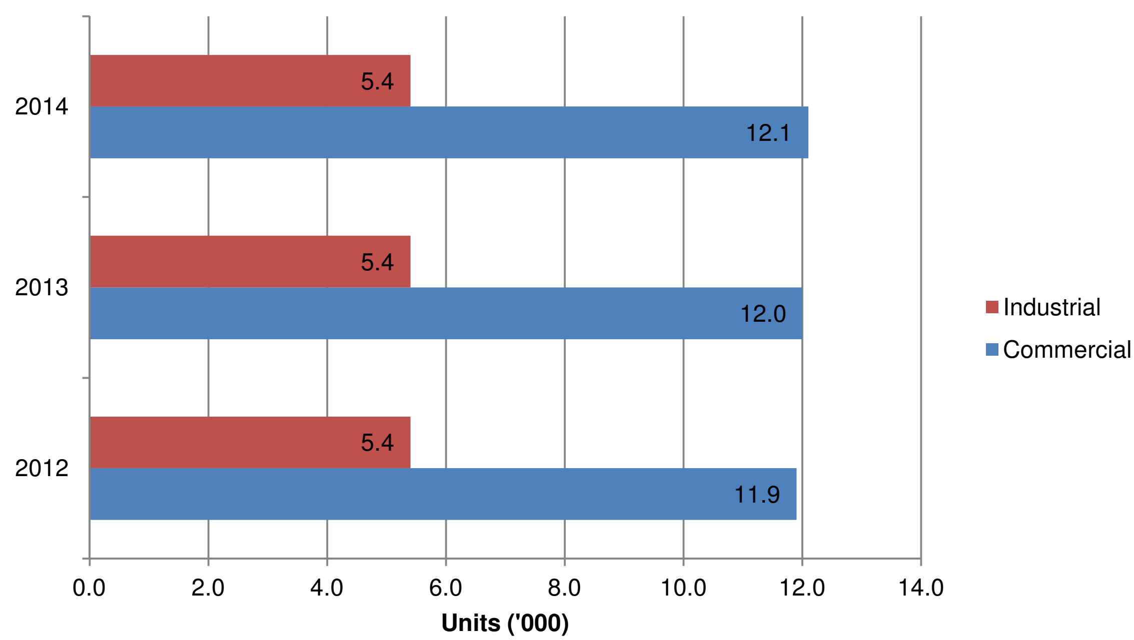
4.3.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	2.46	2.19	42.89	0.11
2013	2.48	2.19	40.08	0.10
2014	2.51	2.20	37.28	0.10

Source: Frost & Sullivan

4.4 East North Central Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

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4.4.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	12.28	11.98	218.19	0.57
2013	12.40	12.00	203.20	0.53
2014	12.56	12.06	188.26	0.49

Source: Frost & Sullivan

4.4.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	6.05	5.39	110.49	0.29
2013	6.11	5.40	101.89	0.26
2014	6.19	5.43	93.31	0.24

Source: Frost & Sullivan

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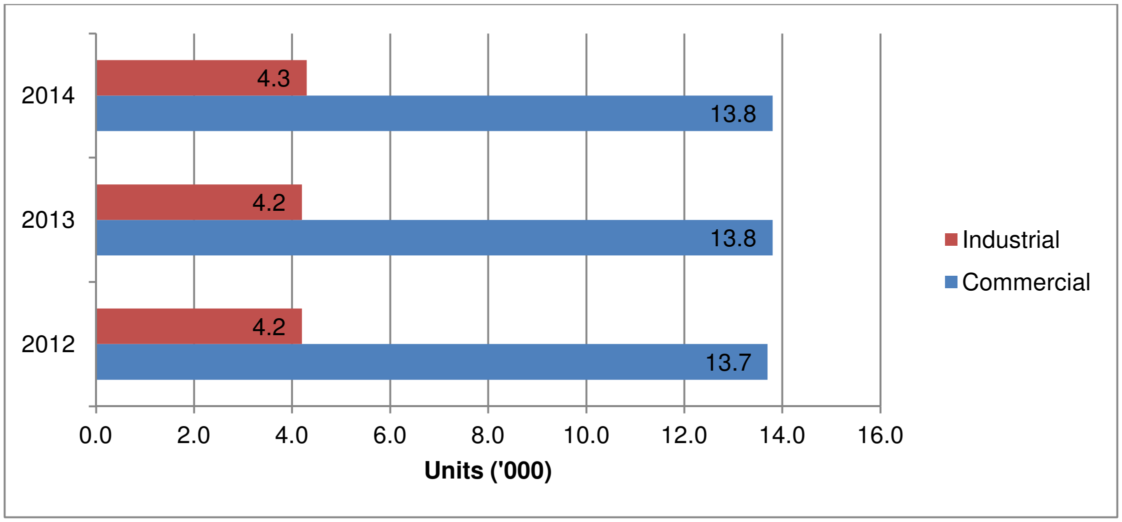
4.5 South Central Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

4.5.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	14.1	13.7	239.47	0.62
2013	14.2	13.8	224.23	0.58
2014	14.4	13.8	209.06	0.54

Source: Frost & Sullivan

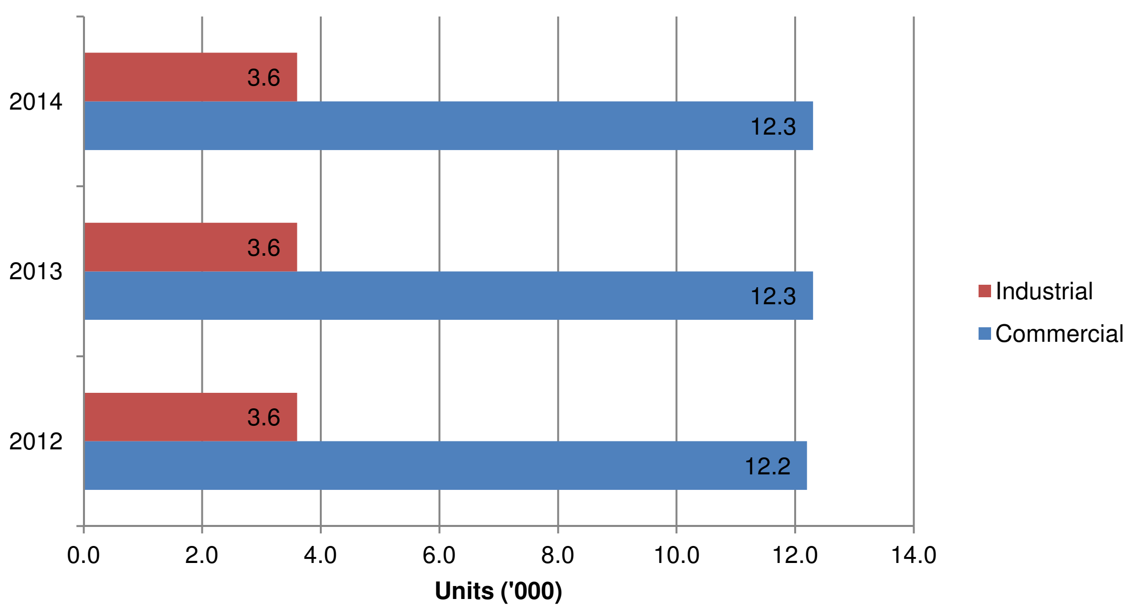
4.5.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	4.75	4.23	85.77	0.22
2013	4.80	4.24	79.01	0.20
2014	4.86	4.26	72.27	0.19

Source: Frost & Sullivan

4.6 Mid-Atlantic Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

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4.6.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	12.55	12.24	220.36	0.57
2013	12.68	12.27	205.63	0.53
2014	12.84	12.33	190.96	0.49

Source: Frost & Sullivan

4.6.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	4.00	3.56	75.51	0.20
2013	4.04	3.57	69.07	0.18
2014	4.09	3.58	62.66	0.16

Source: Frost & Sullivan

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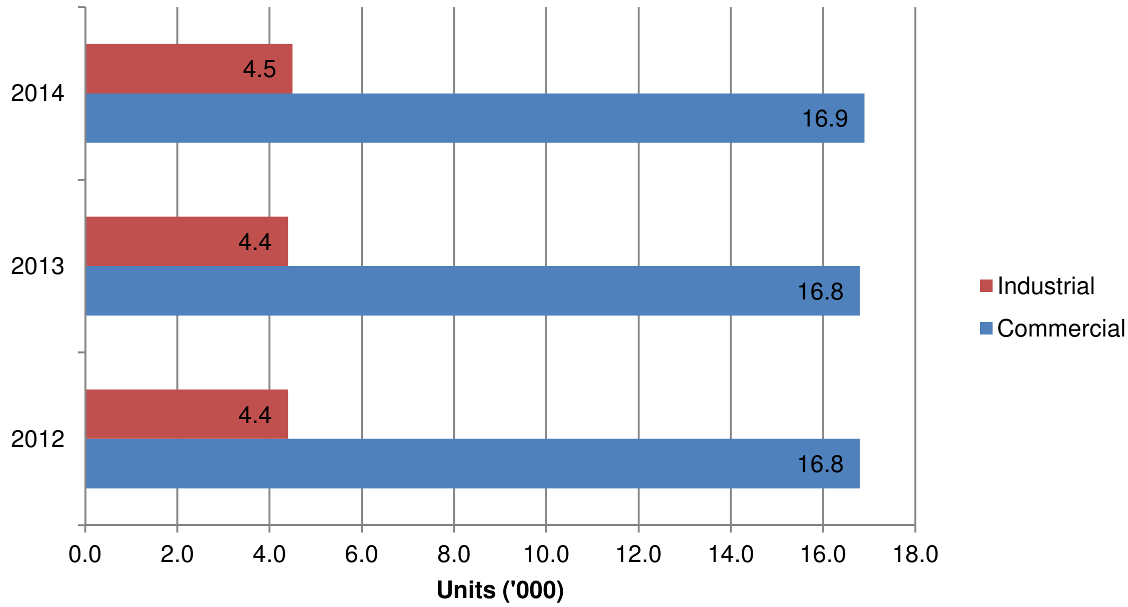
4.7 South Atlantic Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

4.7.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	17.21	16.79	293.65	0.76
2013	17.38	16.83	274.48	0.71
2014	17.61	16.91	255.39	0.66

Source: Frost & Sullivan

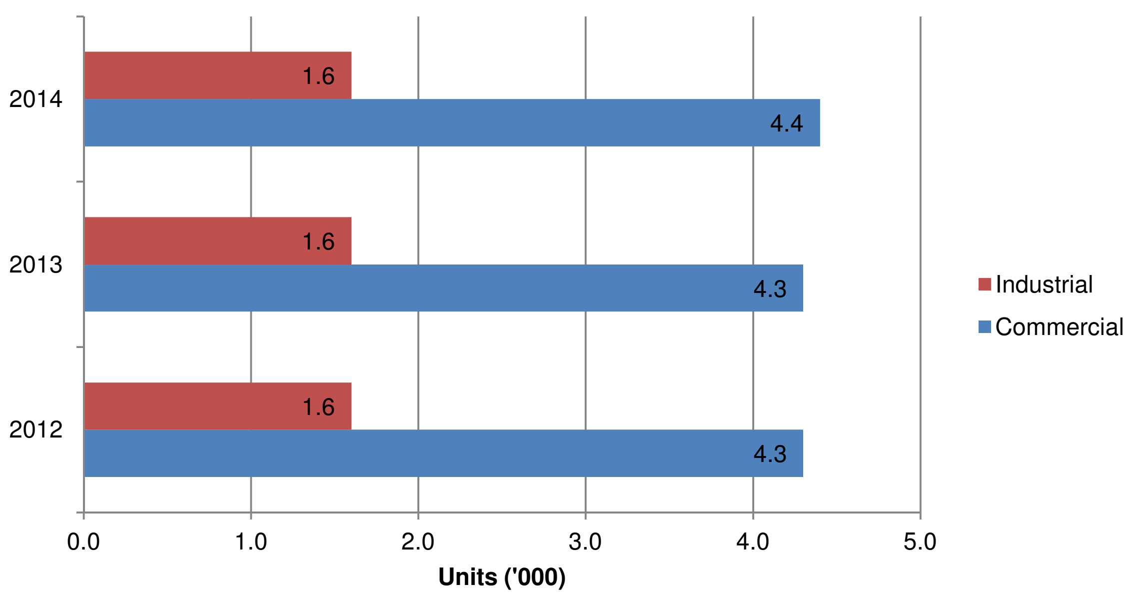
4.7.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, West South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	4.96	4.41	92.36	0.24
2013	5.01	4.42	84.79	0.22
2014	5.07	4.45	77.23	0.20

Source: Frost & Sullivan

4.1 New England Isolation Transformer Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

4.8.1 Commercial

Commercial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	4.43	4.32	79.72	0.21
2013	4.47	4.33	74.05	0.19
2014	4.53	4.35	68.40	0.18

Source: Frost & Sullivan

4.8.2 Industrial

Industrial Isolation Transformer Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments ('000)	Installed Base in Units ('000)	Installed Base (MW)
2012	1.80	1.60	34.86	0.09
2013	1.81	1.60	31.46	0.08
2014	1.84	1.61	28.07	0.07

Source: Frost & Sullivan

Chapter 5

Voltage Regulators

Product Definition

A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. It stabilizes the output voltage according to the equipment's requirement, irrespective of the input voltage. The voltage regulator accepts all ranges of input voltage and ensures that the output voltage is constant, according to the exact specified voltage for the system.

The voltage regulator was used instead of the UPS especially when a lower cost solution tackling only the problem of voltage regulation was required. However, as UPS technology gained in popularity and reduced in price, it was seen as a complete solution that not only deals with voltage stabilization but also backup power.

Market Overview

Voltage regulators are used to maintain a constant voltage for equipment in industrial and mission-critical applications. The market for voltage regulators is mature, with some technologies even witnessing a decline, such as the ferroresonant voltage regulator. The key drivers are the need for voltage stability for the smooth functioning of equipment, the need for tap switching voltage regulators with advanced technology in devices that require voltage stability, and the lack of a reliable power infrastructure. Key restraints include competition from other power quality technologies such as UPS[15] and a lack of technological innovation.

The product has a life span of 7 to 10 years. The voltage regulator revenues is 3.25% of UPS revenues. Life cycle was used in the calculation of installed capacity, and the lower limit was applied as per vendor input.

Voltage regulation is a function that a UPS inherently performs, ensuring that the equipment receives only clean power as the UPS acts as the gatekeeper to prevent voltage sags and surges. Hence, standalone sales of voltage regulators have declined significantly; they are used in the industrial environment for specific needs.

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[15] Source: N22E-27 - World AC Voltage Regulator Markets. *March 2009.* Frost.com

This analysis covers standalone voltage regulator revenue and not OEM-based revenue.

Standalone voltage regulators are sold as individual units in the industrial market; embedded voltage regulators are included in OEM equipment that needs additional safety limits. Typical applications include MRI machines, motor controls and drives, and building controls.

Voltage Regulators Market: Overview, US, 2014

Market Size (2014)	$82.2 million
Unit Shipment (2014)	0.58 million
Life Cycle Range	Ferroresonant: 7–10 years Buck boost: 7–10 years Tap switching: 7–10 years
Selling Price Range	Ferroresonant: $120–$160 Buck boost: $140–$165 Tap switching: $140–$169
Top Competitors	Sola HD (Emerson Industrial Automation), Controlled Power Company, Staco Energy Products Over 20 manufacturers selling into US market Top 3 competitors account for 63.6% of the market share

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Key Market Trends

Voltage regulator[16] demand has declined in the United States due to competition from UPS systems. Ferroresonant and buck boost voltage regulators are considered old and outdated. Tap switching voltage regulators are a newer, more fitting option for more versatile devices in industrial and commercial applications. UPSs, however, have become more affordable with better market penetration and higher volumes. While voltage regulators target a single function, UPSs provide both voltage regulation and backup power protection in the event of a blackout or brownout. Revenue from ferroresonant technology has been declining since 2000 while tap switching has witnessed slow but steady growth.

The magnetic saturation in the ferroresonant core has advantages and disadvantages. Advantages include long life, which in rare instances has exceeded 20 years, according to a voltage regulator manufacturer. It is also highly efficient at full load. However, its lower efficiency at 50% loads or less is an adoption deterrent.

Buck boost technology functions when an electronic switch determines and adjusts the winds in the primary and secondary coils to lower or boost voltage depending on the nature of the fluctuation. Although this technology could have a long life, its design complexity and bulky size deter technology adoption.

Tap switching technology is the most accepted among industrial and commercial end users, primarily due to its ease of use with a wide range of loads. With good voltage regulation and low maintenance needs, the tap switching technology has seen higher adoption over ferroresonant and buck boost voltage regulators.

Estimating Product Lifetime

Product lifetimes in the voltage regulator market vary significantly by power range, type of application and nature of use. If the product is used rigorously, it could shorten its lifetime. Additionally, good maintenance of voltage regulator systems extends lifetime.

Installation Cost

Installation cost varies by product type, end user and application. These equipment are built into the equipment or used as stand-alone device. The installation cost is 5% to 10% above the equipment cost.

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[16] Source: World Voltage Regulators Markets, N4F1-27. March *2009.* Frost.com

Revenue and Unit Shipment

Voltage Regulators[17] Market: Revenue, Unit Shipments, and Installed Base, US, 2005–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)
2005	79.2	0.53	N/A
2006	84.1	0.56	N/A
2007	84.2	0.57	N/A
2008	84.7	0.57	N/A
2009	84.6	0.57	N/A
2010	84.3	0.58	N/A
2011	83.9	0.58	N/A
2012	83.5	0.58	4.01
2013	83.0	0.58	4.02
2014	82.2	0.58	4.03

Source: Frost & Sullivan

The calculation for installed base and capacity was dictated by the number of units sold during the course of the product life to account for the replacement cycle. In order to keep data consistent, installed capacity was calculated from 2011 which accounts for

[17] Source: Primary research includes interviews with top competitors among others. The information was also corroborated with voltage regulator competitors and the Frost & Sullivan database.

the most common replacement cycle of 7 years for voltage regulators. Hence for 2011, installed based from 2005 through 2011 were added and then installed capacity was calculated.

The market has continued to witness a decline since 2009 because of industrial and commercial setbacks related to the economic downturn in 2009 through 2010. Once these end users regained stability, they preferred UPSs to meet the power quality needs.

Revenue Forecast by Type of Voltage Regulator

Year	Buck Boost ($ Million)	Tap Switching ($Million)	Ferro Resonant ($Million)
2005	18.1	48.8	12.3
2006	18.3	54.0	11.8
2007	18.4	54.6	11.2
2008	17.6	56.3	10.7
2009	16.8	57.5	10.3
2010	17.0	57.4	9.9
2011	17.0	57.4	9.5
2012	16.3	58.1	9.2
2013	15.4	58.7	8.9
2014	15.5	58.2	8.5

Source: Frost & Sullivan

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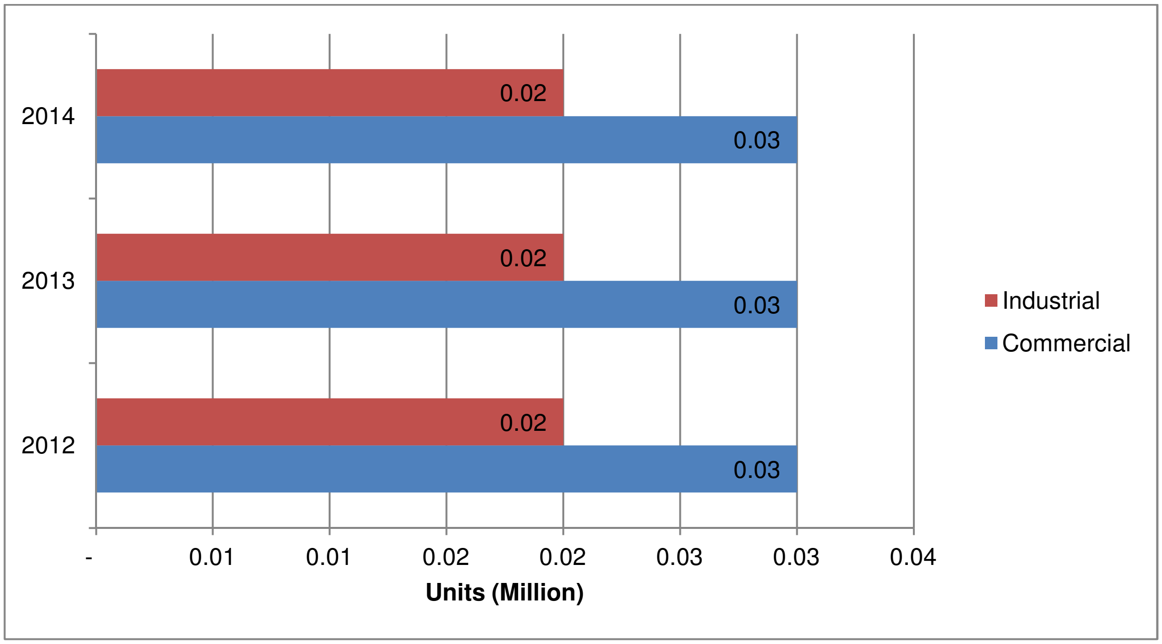
Revenue Forecast by End User

Year	Commercial ($ Million)	Industrial ($Million)
2005	41.3	37.9
2006	44.2	39.9
2007	44.1	40.1
2008	44.4	40.3
2009	44.4	40.2
2010	44.0	40.2
2011	43.7	40.2
2012	43.6	40.0
2013	43.3	39.6
2014	42.6	39.7

Source: Frost & Sullivan

Regional Trends

5.1 Pacific Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.1.1 Commercial

Commercial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	3.8	0.03	0.19	0.037
2013	3.8	0.03	0.19	0.038
2014	3.8	0.03	0.19	0.038

Source: Frost & Sullivan

© Frost & Sullivan

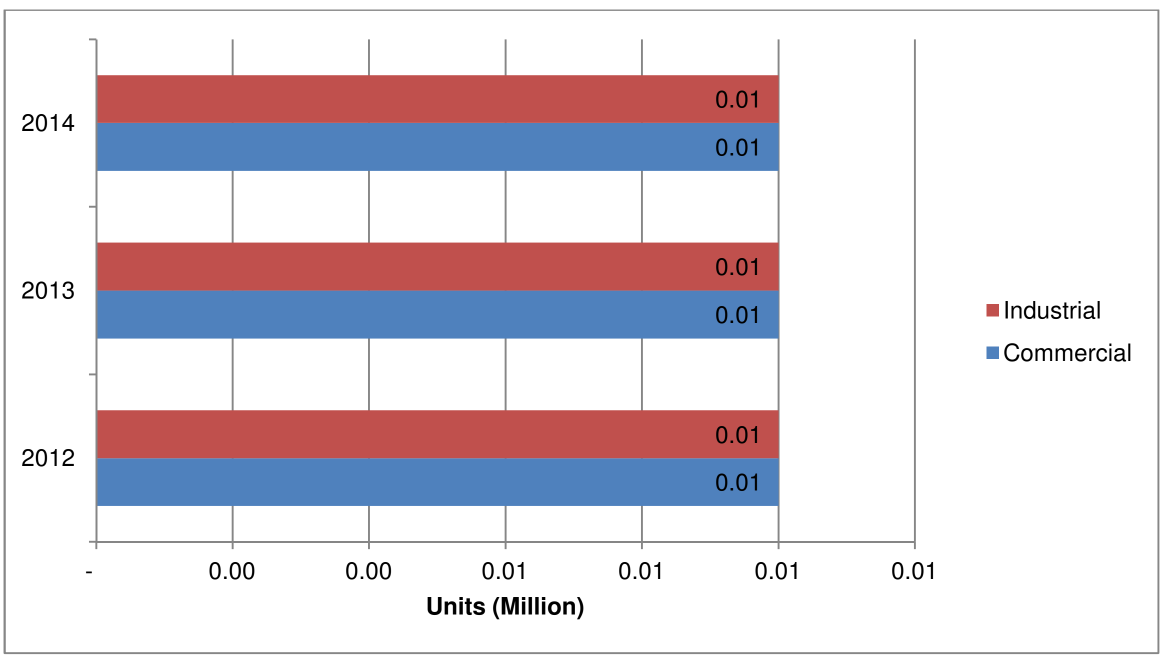
5.1.2 Industrial

Industrial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, Pacific US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	2.1	0.02	0.11	0.0159
2013	2.1	0.02	0.11	0.0159
2014	2.1	0.02	0.11	0.0159

Source: Frost & Sullivan

5.2 Mountain Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.2.1 Commercial

Commercial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	1.4	0.01	0.07	0.0135
2013	1.4	0.01	0.07	0.0135
2014	1.4	0.01	0.07	0.0135

Source: Frost & Sullivan

5.2.2 Industrial

Industrial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, Mountain US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	0.8	0.01	0.04	0.0061
2013	0.8	0.01	0.04	0.0060
2014	0.8	0.01	0.04	0.0059

Source: Frost & Sullivan

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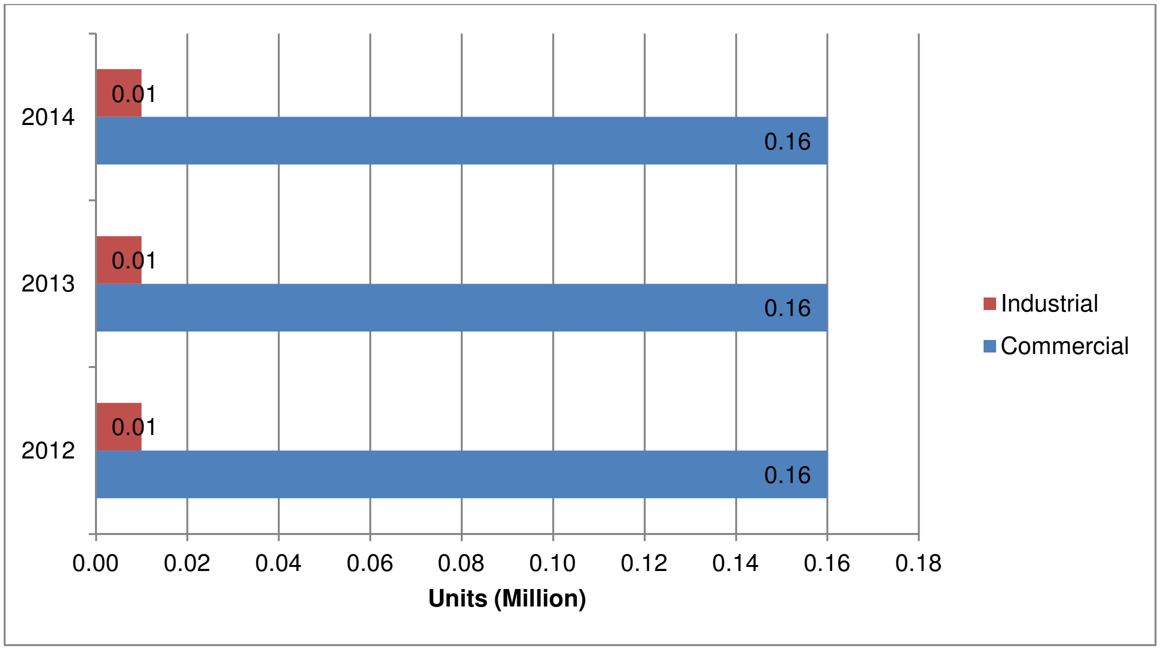
5.3 West North Central Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.3.1 Commercial

Commercial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	22.8	0.16	1.13	0.221
2013	22.6	0.16	1.13	0.222
2014	22.2	0.16	1.14	0.223

Source: Frost & Sullivan

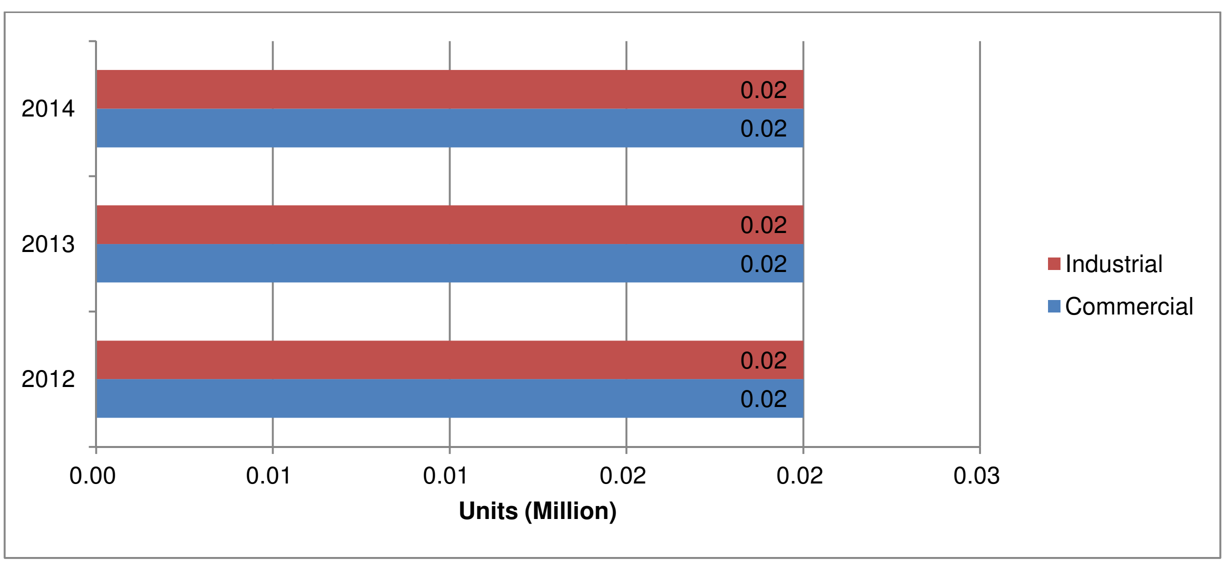
5.3.2 Industrial

Industrial UPS Market: Revenue, Unit Shipments, and Installed Base, West North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	1.0	0.01	0.05	0.0068
2013	1.0	0.01	0.05	0.0069
2014	1.0	0.01	0.05	0.0071

Source: Frost & Sullivan

5.4 East North Central Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.4.1 Commercial

Commercial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	2.9	0.02	0.14	0.0284
2013	2.9	0.02	0.14	0.0283
2014	2.8	0.02	0.14	0.0282

Source: Frost & Sullivan

5.4.2 Industrial

Industrial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, East North Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	2.2	0.02	0.11	0.0158
2013	2.3	0.02	0.11	0.0159
2014	2.3	0.02	0.11	0.0161

Source: Frost & Sullivan

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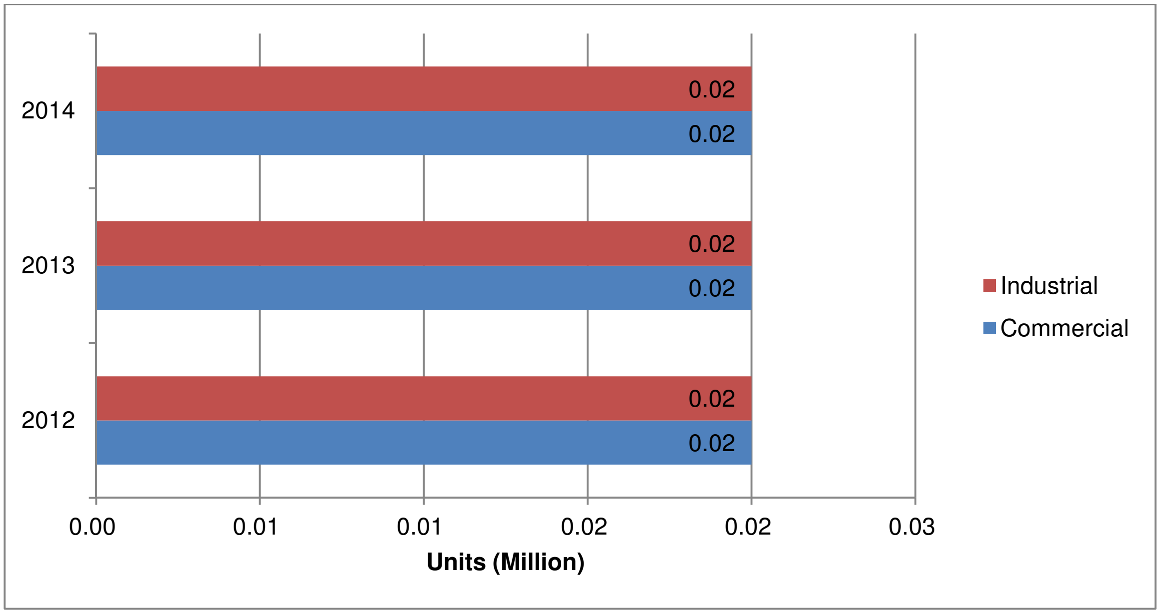
5.5 South Central Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.5.1 Commercial

Commercial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	3.1	0.02	0.15	0.0295
2013	3.1	0.02	0.15	0.0299
2014	3.1	0.02	0.15	0.0302

Source: Frost & Sullivan

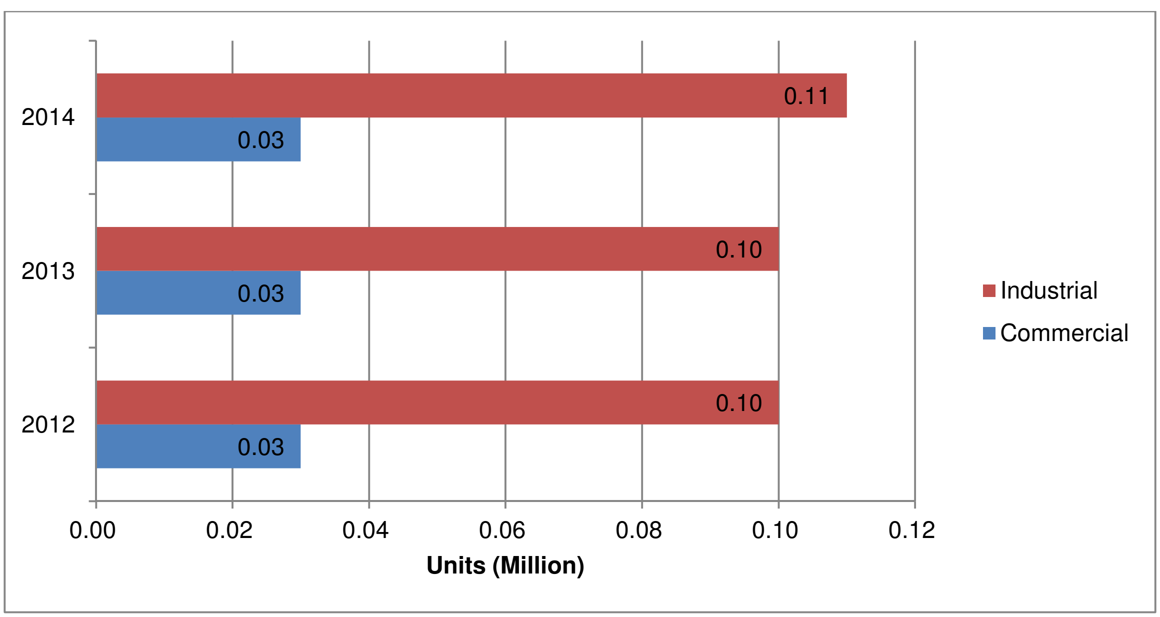
5.5.2 Industrial

Industrial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, South Central US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	3.5	0.02	0.16	0.0232
2013	3.2	0.02	0.16	0.0235
2014	3.2	0.02	0.16	0.0237

Source: Frost & Sullivan

5.6 Mid-Atlantic Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.6.1 Commercial

Commercial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	4.0	0.03	0.20	0.039
2013	4.0	0.03	0.20	0.039
2014	3.9	0.03	0.20	0.039

Source: Frost & Sullivan

5.6.2 Industrial

Industrial Voltage Regulators Market: Revenue, Unit Shipments, and Installed Base, Mid-Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	14.6	0.10	0.73	0.107
2013	14.5	0.10	0.73	0.107
2014	14.6	0.11	0.73	0.108

Source: Frost & Sullivan

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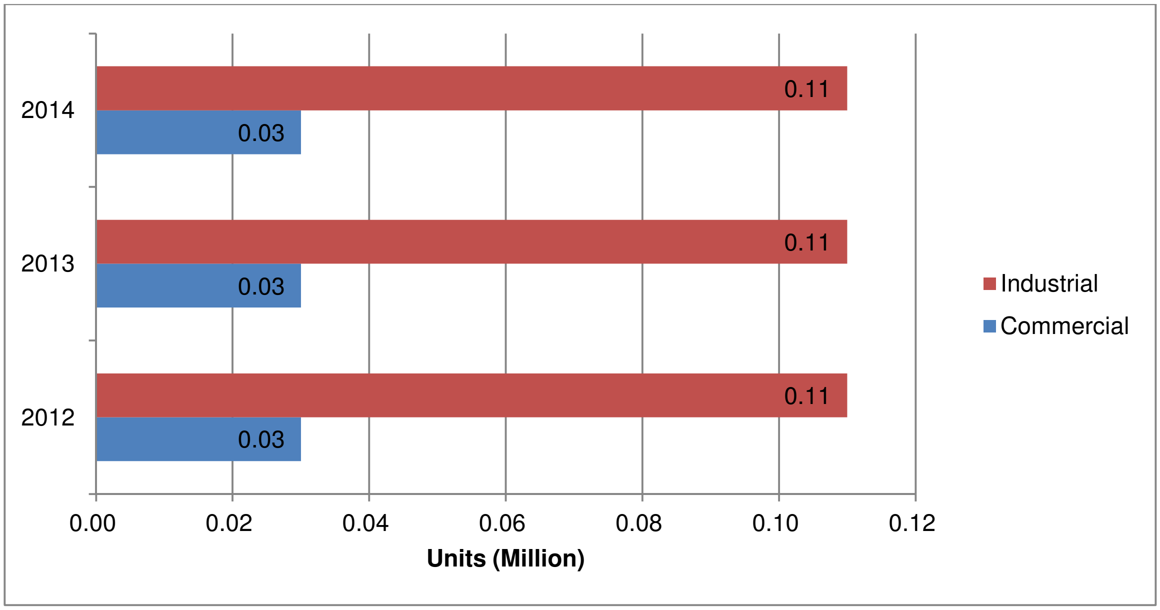
5.7 South Atlantic Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.7.1 Commercial

Commercial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	3.9	0.03	0.20	0.0391
2013	3.9	0.03	0.20	0.0391
2014	3.9	0.03	0.20	0.0390

Source: Frost & Sullivan

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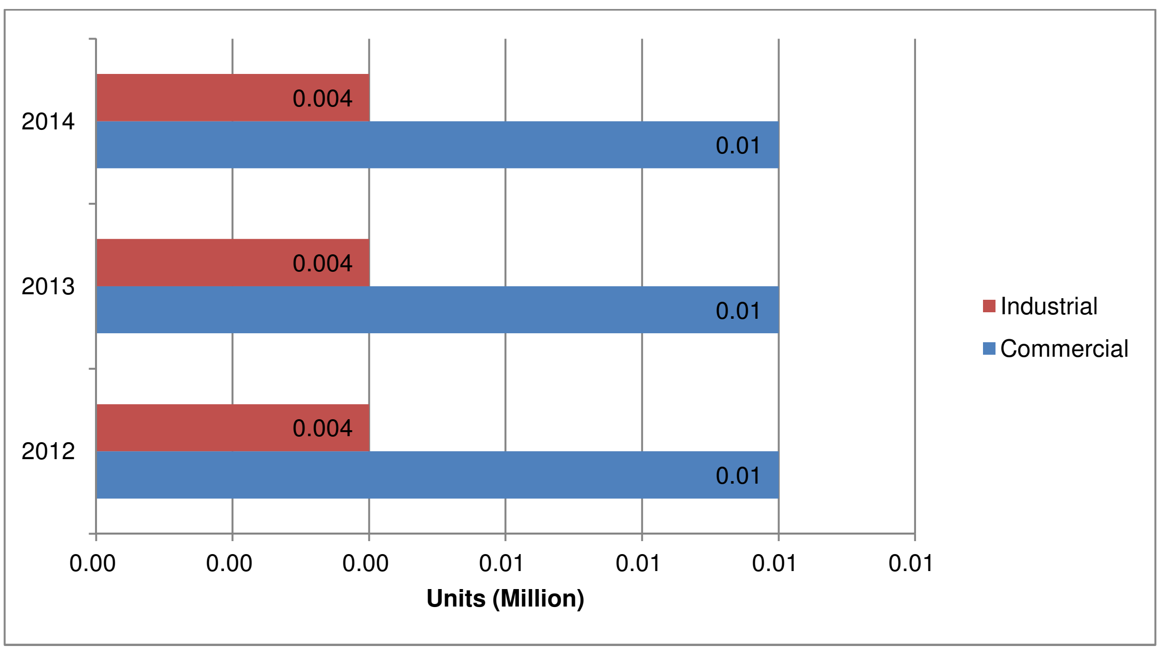
5.7.2 Industrial

Industrial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, South Atlantic US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Million Units	Installed Capacity (kW)
2012	15.2	0.11	0.76	0.111
2013	15.2	0.11	0.76	0.112
2014	15.2	0.11	0.76	0.112

Source: Frost & Sullivan

5.8 New England Voltage Regulator Market: Unit Shipments, US, 2012–2014



Source: Frost & Sullivan

5.8.1 Commercial

Commercial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	1.6	0.01	0.08	0.016
2013	1.6	0.01	0.08	0.016
2014	1.6	0.01	0.08	0.016

Source: Frost & Sullivan

5.8.2 Industrial

Industrial Voltage Regulator Market: Revenue, Unit Shipments, and Installed Base, New England US, 2012–2014

Year	Revenue ($ Million)	Unit Shipments (Million)	Installed Base in Units (Million)	Installed Capacity (MW)
2012	0.5	0.004	0.03	0.0041
2013	0.5	0.004	0.03	0.0040
2014	0.5	0.004	0.03	0.0039

Source: Frost & Sullivan

Appendix A

Cogeneration[18]

Market Overview

In terms of installed capacity, the US market has been growing at a CAGR of 1.3% for the last few years. Industrial states, such as Alabama, California, Louisiana, New York, Oregon, and Texas, have the greatest installed capacity in the US market.

Cogeneration technologies, such as microturbines, biomass, and fuel cells, are likely to register strong growth compared with other prime movers.

Regulations will be the major driver for the cogeneration market. Many states, including Connecticut, New Mexico, and Pennsylvania, have policies that promote cogeneration. Further, federal incentives, including the combined heat and power (CHP) investment tax credit, are driving demand among end users for new cogeneration equipment. Smaller cogeneration equipment, including the microturbine, are expected to register strong growth in the market during the forecast period, mainly because of the increase in average household heating expenditures in the United States. An increase in the price of coal is likely to raise the retail electricity price in the United States. This should increase sales of cogeneration equipment in the United States.

Definition

Cogeneration, also known as CHP, is an efficient, clean, and reliable way to generate electrical power and thermal energy from a single fuel source. CHP is an application of technologies to meet end-user needs for heating and/or cooling energy and mechanical and/or electrical power.

CHP's uniqueness lies in its ability to deliver the most efficient form of thermal and electric energy. This is achieved by recovering the waste heat that usually is not used in conventional energy-generating systems, which makes up 40% to 70% of the heat input into the systems. The recovered energy is used in applications such as process or space heating or cooling that have absorption cooling systems. Therefore, CHP results in lower nitrogen oxide (NOx) and carbon dioxide (CO_2) emissions compared with conventional power generation systems.

[18] Analysis of the Cogeneration Market - NA16, Frost & Sullivan study

Cogeneration systems are classified by the type of prime mover used to drive the electrical generator. The main prime movers currently in use are reciprocating engines, combustion or gas, turbines, steam turbines, microturbines, and fuel cells.

Market Segments

Reciprocating Engine	A reciprocating engine is a heat engine that converts pressure into rotating motion using pistons. In the last 3 decades, the technology has improved constantly due to environmental concerns about emission reductions. Engine sizes ranging from a few kilowatts to more than 5 MW are available for power-generation applications.
Gas Turbine	One of the main advantages of gas turbine systems is that they emit substantially less CO_2 per kilowatt-hour (kWh) generated than any other fossil-fuel technology in general commercial use. This is possible mainly because of their higher efficiency and reliance on natural gas as the primary fuel.
Steam Turbine	As steam turbines are more expensive than other prime movers, these systems are better suited for medium- and large-scale industrial and institutional applications for which inexpensive fuels, such as coal, biomass, various solid wastes and by-products, and residual oil and gases from refineries are available.
Microturbine	Microturbines range in size from 30 to 250 kW, and can operate on a variety of fuels, including natural and sour (high-sulfur, low-British thermal units, or Btus, content) gases and liquid fuels, such as gasoline, kerosene, and diesel/distillate heating oil.
Fuel Cell	Fuel cells can be used in commercial, industrial, and residential CHP systems and backup and portable power systems (0.5 to 5 kW).

Key Market Drivers and Restraints

Drivers include:

- Regulatory policies that promote CHP installations
- End-user demand for higher efficiency that encourages investment in CHP
- Environmental concerns
- An increase in the price of electricity

Restraints include:

- The current regulatory structure
- The local process for permits
- Lack of public awareness

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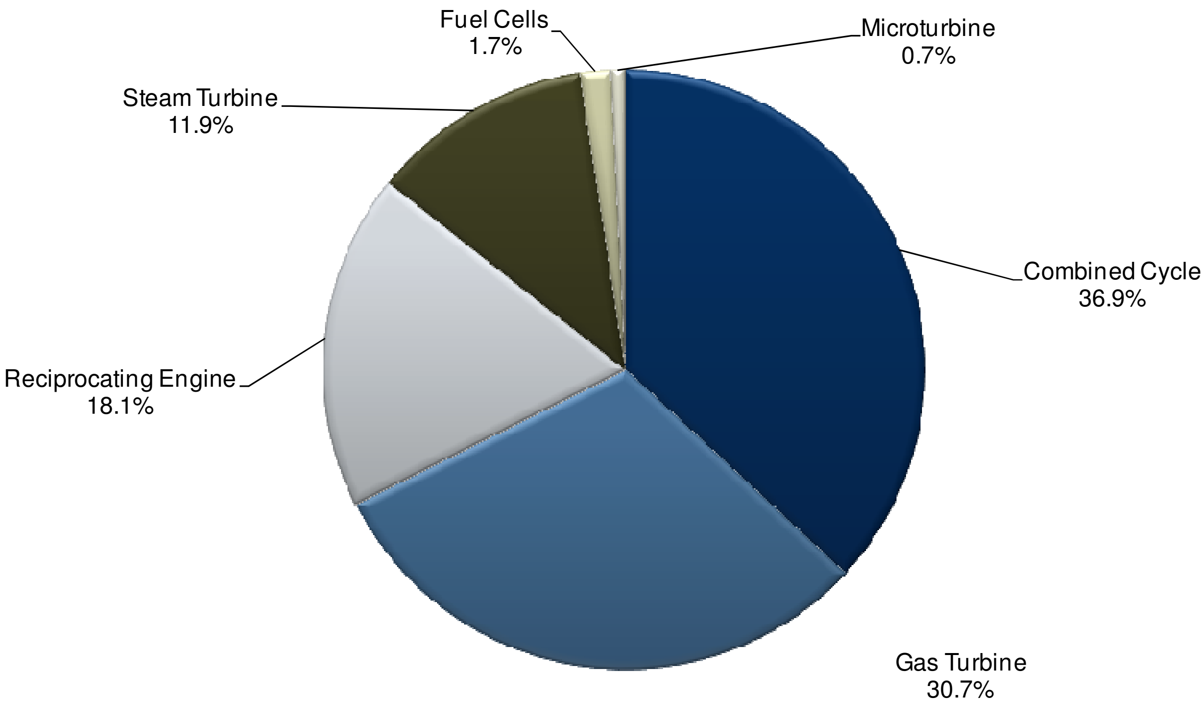
Total Cogeneration Market: Cumulative Installed Capacity and Revenue, US, 2008–2014

Year	Revenue ($ Million)	Installed Capacity (GW)
2008	1,834.9	82.7
2009	753.1	83.7
2010	803.4	84.6
2011	879.6	85.4
2012	1,010.6	86.4
2013	1,339.6	87.6
2014	1,719.4	89.1

Source: Frost & Sullivan

Total Cogeneration Market: Percent Sales Breakdown, US, 2014



Source: Frost & Sullivan

Market Leaders

The US market is highly concentrated because the top 3 participants contributed over 90.0% of total market revenue. The majority of cogeneration installed capacity uses either combined cycle or gas turbines. Therefore, GE Energy has the largest installed base of gas turbines in North America. Also, GE's continuous investment in new technology and systematic acquisitions strengthen its market leadership position for the long term. Mitsubishi is ranked second followed by Siemens AG.

Appendix B

Stationary Lead Acid (SLA) Batteries

Market Overview

SLA batteries are a long-standing, reliable power storage solution and largely remain the battery chemistry of choice in industrial applications. They provide an extremely reliable, robust, and cost-efficient energy storage solution for critical power applications. The initial primary purpose of stationary batteries was to provide backup power to business systems to continue operating during power outages or other interruptions. Power quality remains a high priority. As consumers become increasingly mobile and as applications become increasingly microprocessor based, the need for reliable and consistent power sources is crucial to the infrastructure that supports mobility.

Advanced electronic gadgets and applications are sensitive. Delivering power to these devices is not always a clean, consistent operation. Dips and sags from power-delivery inconsistencies can harm the devices, causing inconvenient and expensive consequences. Stationary batteries are capable of temporarily holding large charge loads as utility power transitions between one generation system to another, such as between off-peak to peak power generation.

Alternative battery chemistries such as lithium ion are showing promise in gaining market share from SLA batteries in the long term for some industrial applications, but they do not pose an immediate threat to SLA batteries. A more established performance history, more extensive distribution channel, and other progress is needed for a large-scale transition of technologies.

SLA batteries[19] are most preferred for powering UPSs. UPS equipment is an integral part of data communication infrastructure to ensure continuous power supply to equipment. Many favorable features such as low maintenance make the SLA battery most suited for UPS equipment. Because the UPS segment is stable, it is a regular contributor to the overall revenue of the SLA battery market. The increasing demand for quality power coupled with increased usage of highly automated electronic equipment results in the dependence on SLA batteries in this segment.

[19] Source: Global Stationary Lead Acid (SLA) Battery Market (N8CA-27), *August 2011; World* Stationary Lead Acid Battery Market, (N4D9-27), *December, 2008, Frost & Sullivan*

SLA Battery Market: Overview[20], US, 2014

Market Size (2014)	~$266.9 million
Unit Shipment (2014)	~18.0 million
Average Life Cycle	3–10 years
Selling Price Range	$14–$65
Market Leaders	Enersys Exide East Penn Manufacturing

[20] Source: Primary research includes interviews with top competitors and bottom-up analysis.

SLA Market: Revenue and Unit Shipment[21] US, 2005–2014

Year	Revenue ($ Million)	Growth Rate	Unit Shipment (Million)	Growth Rate
2005	121.4	--	8.4	--
2006	134.6	10.9%	9.3	10.7%
2007	157.7	17.2%	10.8	16.8%
2008	179.3	13.7%	12.3	13.4%
2009	197.6	10.2%	13.5	9.9%
2010	214.6	8.6%	14.6	8.2%
2011	228.6	6.5%	15.5	6.2%
2012	241.2	5.5%	16.3	5.2%
2013	254.1	5.3%	17.1	5.1%
2014	266.9	5.0%	18.0	4.8%

Source: Frost & Sullivan

UPS is the second-largest end-user segment, contributing 20% to 25% of total revenue of the SLA battery market in 2014—about $266.9 million.

Data communication infrastructure requires uninterrupted high-quality power supply; any downtime—even a fraction of second—or data loss would result in substantial loss of revenue. This makes UPS essential equipment in this application, so UPS must rely on quality batteries.

[21] Source: Primary research included interviews with key competitors in the market. The information was also corroborated with existing Frost & Sullivan research: Global Stationary Lead Acid (SLA) Battery Market (N8CA-27), August 2011; World Stationary Lead Acid Battery Market (N4D9-27), December 2008

UPS has exhibited steady growth and is a stable contributor to the SLA battery market. Demand is likely to be influenced by:

- Increasing dependence on high-quality power supply without voltage fluctuations
- Increasing usage of data communication applications in regions that could not offer high-quality, uninterrupted power
- Increasing technical development to reduce or eliminate downtime of data communication infrastructure

Although UPS offers stable support for the growth of SLA batteries, challenges including newer chemistries and alternative backup energy devices (e.g., flywheel UPS and UPS powered by fuel cells and ultracapacitors) could dampen growth.

Key Market Trends

Applications driving demand for SLA batteries for UPS include data centers. A data center trend is to reduce the use of space and provide more efficiency in a smaller footprint. Data centers are a key focus point for many UPS manufacturers that intend to capitalize on the increase in demand for more reliable power.

The growth of SLA batteries can be mainly attributed to the rising number of data centers and IT build-outs, and steady growth of the healthcare industry and small- and medium-sized businesses.

Despite drastic fluctuations in lead prices, SLA batteries remain the most cost-efficient and performance-proven backup power and power quality solution for many applications, particularly industrial. Alternative solutions, such as fuel cells and flywheels, are more costly. High global production levels of SLA batteries have allowed the industry to overcome cost barriers still confronting other solutions.

SLA batteries have been used successfully for more than a century as a highly reliable standby power solution; therefore, end-user trust in this technology is firmly established. SLA batteries have become the benchmark for rating potential alternative solutions. Until an equally reliable, versatile, and affordable solution is established, SLA batteries will remain the preferred energy storage solution for industrial applications.

Disasters such as the Fukushima Daiichi nuclear power plant accident in Japan and Hurricane Sandy in the United States, have prompted some industry participants to expect additional growth, at least in the short term, due to pressure for redundant backup power solutions.

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Competition among SLA battery manufacturers, intense pricing pressures, production overcapacity in some areas, and overall mature market conditions all contribute to the high competition and lower prices.

Profit margins in a mature industry are already low. Sharp increases of key components further dissolve profits. Engaging in constant inventory-pricing adjustments is impractical for manufacturers. Initially, manufacturers typically absorb costs before passing them along to end users in hopes of a market rebound. Manufacturers that are unable to do so are forced out of business or acquired by a capable manufacturer.

Limited product differentiation is rampant throughout this mature market. Failure to discern product quality allows less-capable units to force prices down. This same failure also presents an illusion that units are identical and void of varying degrees of performance.

Although SLA batteries[22] are the dominant energy storage solution among industrial applications and represent the standard by which other solutions are judged, alternative storage chemistries are nonetheless available. Battery chemistries, such as lithium ion polymer, nickel-cadmium, and nickel metal hydride are being experimented with in various applications. Energy storage solutions such as flywheels, fuel cells, and ultracapacitors also show promise as viable alternatives.

SLA Battery Capacity/Duration

The life of an SLA[23] battery depends on how it is used. It is not advisable to run the battery all the way down to zero during each charge cycle. If the battery is required to last long then it should not be run past 80% of its charge, leaving 20% left in the battery. This not only extends its number of cycles, but lets the battery degrade by 20% before it starts getting less run time than as planned at the design stage. To calculate capacity and duration, cycle life and rate of discharge must be considered.

For example:

Step 1

If the UPS is drawing 20 amps and 20 minutes is the desired run time –

$C = xT$

[22] Source: "Global Stationary Lead Acid (SLA) Battery Market (N8CA-27), August 2011; World Stationary Lead Acid Battery Market (N4D9-27), December 2008.
[23] Source: powerstream.com; batteryuniversity.com; Interviews with SLA battery manufacturers

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Where C is the capacity in amp-hour, x is current drawn in amps, and T is the time in hours

C = 20 amps * 20 minutes = 4.0 amp hours

Step 2

Cycle life consideration – as the battery should not cross 80% of its charge

CL – cycle life

CL = C/0.8 = 4 Ah/0.8 = 5.0 Ah

Step 3

Some battery chemistries give fewer amp hours if they are discharged fast. This is called the Peukert's effect. This is a critical effect in lead acid batteries. For example, a draw at 1C on a lead acid battery will only get half the capacity of a draw at 0.05C. For lead acid batteries, the rated capacity (i.e., the number of AH stamped on the side of the battery) is typically given for a 20-hour discharge rate. Discharging at a slow rate will get the rated number of amp-hours. However, at high discharge rates, the capacity falls steeply. A rule of thumb is that a 1 hour discharge rate will only get half of the rated capacity.

Rate of discharge – RD

RD = 5.0 Ah/0.5 = 10.0 Ah

Thus, a 10.0 Ah SLA battery would have to run UPS for 20 minutes at 20 amps average draw.

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