

WinterGreen Research, INC.

**Wireless Sensor Networks: Market Shares, Strategies, and Forecasts,
Worldwide, 2013 to 2019**

Mountains of Opportunity



WinterGreen Research, Inc.

Lexington, Massachusetts

www.wintergreenresearch.com

781 853 5078

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

Wireless Sensor Networks: Users Connect Sensors to Achieve the Internet of Things – (IoT)

CHECK OUT THESE KEY TOPICS

Wireless Sensor Network
Wireless Nodes
Microcontroller
Energy Harvesting
Vibration-Based Wireless Energy
Piezoelectric Energy Harvesters
Thermoelectrics
Generating Power From Heat
Smart Computing
Power Community
Wireless Sensor Networks
Smart Cities
Smart Buildings
Military Remote Energy Applications
Off-Grid Special Energy
Energy harvesters
Powering Pipeline Monitoring Stations
Navigational aids energy

Spacecraft energy
Thermoelectric cooling
Automotive Energy
Lighting Community
Manganese dioxide
Nanoparticles
Nanotechnology Graphene
Self-assembly
Nanostructured Thin Films
Microgenerator Transforms
Mechanical Energy
Vibration Electricity
Pressure Of A Finger
Piezoelectricity
Solid State Technology
Microgenerator
Power Source Of Sensor
Sensor node
Vibration Energy Harvesting
Photovoltaics
Piezoelectrics
Thermovoltaics

Energy Scavenging
Power Harvesting
Capture Of Ambient Energy
Algorithmic Control
Energy Harvesters
Sensors Based On Magnetic Materials
Wireless Sensor Network
Economies of Scale
Internet of Things
IoT
Wireless Sensor Network
Standards
System on a Chip (SOC)
Blue Tooth
SimpliciTI
M2M
LXRS® PROTOCOL
ZigBee Alliance
Powering Current Sensors

Wireless Sensor Network: Economies of Scale Provide Growth Strategy

Wireless Sensor Network: Market Shares, Strategies, and Forecasts, Worldwide, 2013-2019

LEXINGTON, Massachusetts (November 21, 2013) – WinterGreen Research announces that it has published a new study Wireless Sensor Network Market Shares, Strategy, and Forecasts, Worldwide, 2013 to 2019. The 2013 study has 640 pages, 266 tables and figures. Worldwide markets are poised to achieve significant growth as the Wireless Sensor Network is used to implement the Internet of things.

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

Advanced technologies for wireless sensor networks are associated with energy harvesting and thin film batteries. Emerging wireless sensor networking is based on leveraging the feasibility of making sensors work independently in groups to accomplish insight not otherwise available. Advanced storage devices are emerging simultaneously with the energy harvesting devices that are economical, making sensor networks feasible. Storage devices can leverage the power captured by energy harvesting when sensors and devices are interconnected as a network.

Energy storage technologies of super-capacitors and thin-film batteries with cost-effective market presence are set to power wireless sensor networking. Energy harvesting devices have attained workable levels of efficiency.

There are significant cost reductions for wireless sensor networking that have been accomplished in the past few years. Many applications are related to smarter computing that depends on sensors capturing change in conditions and making adjustments to the environment based on measured change.

Worldwide wireless sensor network device market driving forces relate to an overall trend toward implementation of the Internet of things addressing disparate initiatives toward adoption of the smarter planet for buildings, roads, transportation, and mobile health initiative for chronic conditions. This smarter planet trend promises to become prevalent as people learn how to use small core processors combined with sensing technology to keep the cities more livable and themselves healthier. Healthy behaviors such as exercise, good diet and stress management have the potential to reverse aging on a molecular level and partly restore the vitality of a person's cells with sensors and communication of the sensor data over wireless sensor networks playing a significant role in management of life.

Healthy lifestyle choices can increase the length of DNA sequences found at the end of a person's chromosomes and reverse aging. This discovery is likely to increase interest in monitoring and testing DNA sequences and looking at the ends of the chromosomes. This discovery is likely to increase a shift toward wellness initiatives. It has stimulated the need for better communication between clinicians and patients. New sensor technology creates the opportunity for monitoring and testing. Wireless sensor network devices can be used to send alerts to at risk people who are exercising.

Wireless sensor networking is set to grow as sensors are freed from the grid and networks implement connectivity that is mesh architecture based. Converting ambient energy to useable electrical energy harvesting (EH) systems creates the opportunity to implement wireless sensor networks. These networks interconnect an inexpensive and compact group of devices and sensors. The networks use wireless capability to power portable electrical devices.

According to Susan Eustis, lead author of the WinterGreen Research team that prepared the wireless sensor network market research study, "Wireless sensor network markets are evolving as smart phone devices and technology find more uses throughout the landscape of the Internet of Things. Sensors can provide monitoring that has not previously been available. Differential diagnostic tools support provide

WinterGreen Research, INC.

differential information that helps manage our daily lives from traffic patterns to crime detections, to medical treatment.”

“The decision process take into account clinical findings from the home monitoring devices and from symptoms verbally communicated in a clinical services setting. Improved economics of healthcare delivery implementation is facilitated by wireless sensor networks. This is true across the spectrum of things that can be monitored by sensors”

These wireless sensor networks in the past have relied heavily on batteries that need to be changed by a human. Energy harvesting technology combined with solid state batteries power an increasing number of consumer and industrial products that are untethered or need to become disconnected from electrical outlets.

The markets for wireless sensor networks at \$552.4 million in 2012 become very big, very fast reaching \$14.6 billion by 2019. Market growth is dependent on emerging technology. As the wireless technology, the solid state battery, the sensor technology, smart phone technology and the energy harvesting technology all become commercialized, these devices will be used to implement wireless sensor networks. The wireless sensor networks markets will be driven by the adoption of 8.5 billion smart phones by 2019, creating demand for apps that depend on sensor networks.

WinterGreen Research is an independent research organization funded by the sale of market research studies all over the world and by the implementation of ROI models that are used to calculate the total cost of ownership of equipment, services, and software. The company has 35 distributors worldwide, including Global Information Info Shop, Market Research.com, Research and Markets, Electronics.CA, Bloomberg, and Thompson Financial.

WinterGreen Research is positioned to help customers face challenges that define the modern enterprises. The increasingly global nature of science, technology and engineering is a reflection of the implementation of the globally integrated enterprise. Customers trust WinterGreen Research to work alongside them to ensure the success of the participation in a particular market segment.

WinterGreen Research supports various market segment programs; provides trusted technical services to the marketing departments. It carries out accurate market share and forecast analysis services for a range of commercial and government customers globally. These are all vital market research support solutions requiring trust and integrity.

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

Companies Profiled

Market Leaders

Northrop Grumman
Boeing
KCF Technologies
Marlow Industries
Cymbet
Micropelt

EnOcean
Silicon Laboratories
Perpetuum
Arveni
Infinite Power Solutions (IPS)

Market Participants

ABB
Adaptive Materials Technology -
Adaptamat Ltd
Alphabet Energy
Arrow Electronics
American Elements, USA
Australian Defence Science &
Technology Organisation (DSTO)
Arveni
Avnet
BAE Systems
Boeing
BYD
CST
Cymbet
Digi International
Dust Networks
EnOcean GmbH
Finmeccanica
Flexible Electronics Concepts
Ferro Solutions
Fraunhofer Institute for
Integrated Circuits IIS
General Electric Company (GE)

GMZ
Honeywell
Infinite Power Solutions
Inventec
IO
ITN Lithium Technology
JonDeTech
KCF Technologies Inc
Kelk
Levant Power
LORD Corporation, MicroStrain®
Sensing Systems
MacSema
Microchip Technology
MicroGen Systems
Micropelt
Millennial Net
Modern Water
National Instruments
Nature Technology
Nextreme
OMRON
Planar Energy Devices –
Perpetua

Phononic Devices
Polatis Photonics
Primus Power
PS
Schneider Electric
Severn Water / Modern Water /
Cymtox Limited
Syngenta Sensors UIC
Teledyne / Rockwell Scientific
Texas Instruments (TXN:NYSE)
Trophos Energy
University of California, Berkeley
University of Michigan
Vishay Precision Group
Zarlink Semiconductor AB
US Department of Energy's
Advanced Research Projects
Agency-Energy (ARPA-E) Seed
Funding
Selected Energy Harvesting
Market Participants

**Wireless Sensor Network: Market Shares, Strategies, and
Forecasts, Worldwide, 2013 to 2019**

Report Methodology

This is the 581st report in a series of primary market research reports that provide forecasts in communications, telecommunications, the Internet, computer, software, telephone equipment, health equipment, and energy. Automated process and significant growth potential are priorities in topic selection. The project leaders take direct responsibility for writing and preparing each report. They have significant experience preparing industry studies. Forecasts are based on primary research and proprietary data bases.

The primary research is conducted by talking to customers, distributors and companies. The survey data is not enough to make accurate assessment of market size, so WinterGreen Research looks at the value of shipments and the average price to achieve market assessments. Our track record in achieving accuracy is unsurpassed in the industry. We are known for being able to develop accurate market shares and projections. This is our specialty.

The analyst process is concentrated on getting good market numbers. This process involves looking at the markets from several different perspectives, including vendor shipments. The interview process is an essential aspect as well. We do have a lot of granular analysis of the different shipments by vendor in the study and addenda prepared after the study was published if that is appropriate.

Forecasts reflect analysis of the market trends in the segment and related segments. Unit and dollar shipments are analyzed through consideration of dollar volume of each market participant in the segment. Installed base analysis and unit analysis is based on interviews and an information search. Market share analysis includes conversations with key customers of products, industry segment leaders, marketing directors, distributors, leading market participants, opinion leaders, and companies seeking to develop measurable market share.

Over 200 in depth interviews are conducted for each report with a broad range of key participants and industry leaders in the market segment. We establish accurate market forecasts based on economic and market conditions as a base. Use input/output ratios, flow charts, and other economic methods to quantify data. Use in-house analysts who meet stringent quality standards.

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Interviewing key industry participants, experts and end-users is a central part of the study. Our research includes access to large proprietary databases. Literature search includes analysis of trade publications, government reports, and corporate literature.

Findings and conclusions of this report are based on information gathered from industry sources, including manufacturers, distributors, partners, opinion leaders, and users. Interview data was combined with information gathered through an extensive review of internet and printed sources such as trade publications, trade associations, company literature, and online databases. The projections contained in this report are checked from top down and bottom up analysis to be sure there is congruence from that perspective.

The base year for analysis and projection is 2010. With 2010 and several years prior to that as a baseline, market projections were developed for 2011 through 2017. These projections are based on a combination of a consensus among the opinion leader contacts interviewed combined with understanding of the key market drivers and their impact from a historical and analytical perspective. The analytical methodologies used to generate the market estimates are based on penetration analyses, similar market analyses, and delta calculations to supplement independent and dependent variable analysis. All analyses are displaying selected descriptions of products and services.

This research includes referencde to an ROI model that is part of a series that provides IT systems financial planners access to information that supports analysis of all the numbers that impact management of a product launch or large and complex data center. The methodology used in the models relates to having a sophisticated analytical technique for understanding the impact of workload on processor consumption and cost.

WinterGreen Research has looked at the metrics and independent research to develop assumptions that reflect the actual anticipated usage and cost of systems. Comparative analyses reflect the input of these values into models.

The variables and assumptions provided in the market research study and the ROI models are based on extensive experience in providing research to large enterprise organizations and data centers. The ROI models have lists of servers from different manufacturers, Systems z models from IBM, and labor costs by category around the world. This information has been developed from WinterGreen research proprietary data bases constructed as a result of preparing market research studies that address the software, energy, healthcare, telecommunications, and hardware businesses.

YOU MUST HAVE THIS STUDY

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

**Wireless Sensor Networks: Market Shares, Strategies, and Forecasts,
Worldwide, 2013-2019**

Table of Contents

Wireless Sensor Network Executive Summary

The study is designed to give a comprehensive overview of the wireless sensor networks market segment. Research represents a selection from the mountains of data available of the most relevant and cogent market materials, with selections made by the most senior analysts. Commentary on every aspect of the market from independent analysts creates an independent perspective in the evaluation of the market. In this manner the study presents a comprehensive overview of what is going on in this market, assisting managers with designing market strategies likely to succeed.

WIRELESS SENSOR NETWORKING EXECUTIVE SUMMARY	37
Wireless Sensor Networking Market	37
Wireless Sensor Networking Minimization of Power Consumption	42
Wireless Sensor Networking Market Shares	43
Wireless Sensor Networking Market Forecasts	45

Wireless Sensor Network Market Description and Market Dynamics

1. WIRELESS SENSOR NETWORKING MARKET DESCRIPTION AND MARKET DYNAMICS	48
1.1 Wireless Network Sensing Objectives	48
1.2 Wireless Sensor Network	51
1.1.1 Wireless Sensor Networks Involve Monitoring, Tracking, Or Controlling	52
1.1.2 Vehicle Tracking and Security	52
1.3 Operating Systems for Wireless Sensor Networks	53
1.4 Zigbee Technology	53
1.5 TinyOS	54
1.6 SOS54	
1.7 Embedded Parallel Operating System (EPOS)	54

Wireless Sensor Network Market Shares and Market Forecasts

REPORT # SH25811715 640 PAGES 266 TABLES AND FIGURES 2013
\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

This section selectively describes market shares, forecasts, segments, and regional revenue. Numbers are the result of primary research in all cases. Selected companies are described from an independent analyst perspective with a thumbnail sketch or analysis of their market numbers or commentary on their strengths and weaknesses. Some of the analysis is focused on looking at the topic segment by segment, including company descriptive analyses by segment and subsegment.

2. WIRELESS SENSOR NETWORKING MARKET SHARES AND

MARKET FORECASTS	55
2.1 Wireless Sensor Networking Market	55
2.1.1 Wireless Sensor Networking Minimization of Power Consumption	60
2.2 Wireless Sensor Networking Market Shares	61
2.2.1 Northrop Grumman	64
2.2.2 EnOcean Equipped Devices	65
2.2.3 Boeing	66
2.2.4 Silicon Laboratories	66
2.2.5 KCF Technologies	67
2.2.6 Perpetuum	68
2.2.7 II-IV / Marlow Industries Inc	72
2.2.8 Arveni	72
2.2.9 Cymbet	73
2.2.10 Infinite Power Solutions –	73
2.2.11 Micropelt Energy Harvesting:	74
2.2.12 Leading Energy Harvesting Market Participants by Technology	75
2.3 Wireless Sensor Networking Market Forecasts	78
2.3.1 Wireless Sensor Networks Worldwide	81
2.3.2 Wireless Sensor Networks Market Unit Forecasts	82
2.3.3 Thermoelectrics Involves Generating Power From Heat	84
2.3.4 Smart City Energy Harvesting Shipments Market Forecasts	85
2.3.5 Transportation Rail and Electric Vehicle Energy Harvesting Market Forecasts	89
2.3.6 Smart Building Energy Harvesting Shipments Market Forecasts	90
2.3.7 Smart Grid Meter and Substation Wireless Sensor Networks Market Forecasts	96
2.3.8 Smart Meter Units Shipped	98
2.3.9 Smart Grid Substation Energy Harvesting Shipments	99
2.3.10 Sensor Nodes	100
2.3.11 Military Use of Wireless Sensor Networks	101
2.3.12 Global Desalination Industry	104
2.3.13 Energy Harvesting Market Industry Segments, Units	108
2.4 Energy Harvesting Pricing	111
2.4.1 Silicon Labs Energy Harvesting Pricing	112
2.4.2 EnOcean products	113
2.4.3 Selected Energy Harvesting Unit Retail Prices	115
2.4.4 Thermal EH solutions	124
2.5 Smarter Computing Depends on Instrumented Devices	127
2.5.1 IBM The Leader In Smart Computing By A Wide Margin	127
2.5.2 Advantages Offered By SOA	130
2.5.3 SOA As An Architecture	132

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

2.5.4	Thin Film Battery Market Driving Forces	132
2.5.5	Smarter Computing Market Driving Forces	133
2.5.6	IBM WebSphere Product Set Leverages Thin Film Batteries	134
2.5.7	Thin Film Batteries Market Shares	140
2.6	Nanotechnology Providing Next Generation Systems	140
2.6.1	Nanotechnology Thin Film Batteries	141
2.6.2	Silver Nanoplates Silicon Strategy Shows Promise For Batteries	144
2.6.3	Argonne Scientists Watch Nanoparticles	145
2.6.4	Thin Film Batteries Use Nanotechnology to Achieve Combining Better Performance With Lower Cost	145
2.7	Wireless Sensor Networks Geographical Region Analysis	146
2.7.1	Geographical Region Analysis	148

Wireless Sensor Network Product Description

This section describes selected companies and selected products. Products for this market segment are described with attention to the most significant aspect of features and functions in this category of product. The juxtaposition of a range of different product descriptions from a single market category provides a really good way to access market directions and achieve market competitive analysis. This section is arranged products. Company products are described in the appropriate sections, meaning a company is mentioned several times in the chapter in different places.

3. WIRELESS SENSOR NETWORKING PRODUCT DESCRIPTION	150
3.1 Wireless Sensor Networking	150
3.2 Northrop Grumman Smart Grid	150
3.3 Boeing Wireless Sensor Applications	151
3.3.1 Boeing Wireless Sensor Network Applications	152
3.4 Silicon Laboratories	156
3.4.1 Silicon Laboratories Energy Harvesting Applications	157
3.4.2 Energy Harvesting Reference Design	158
3.5 KCF Technologies	159
3.5.1 KCF Technologies Energy Harvesting for WMD Detection Systems	160
3.5.2 KCF Technologies Wireless Accelerometer with Ultra-Compact Energy Harvesting for Rotorcraft	162
3.5.3 KCF Technologies Harvester-Powered Wireless Accelerometers for Extreme Temperature Monitoring in Fossil Fuel Power Plants	163
3.5.4 KCF Technologies Wireless Vibration Sensors for Shipboard Environments with Broadband Energy Harvesting	165
3.5.5 KCF Technologies Harvester-Powered Wireless Sensors for Industrial Machine Monitoring and Condition Based Maintenance	166
3.5.6 KCF Technologies Piezoelectric and Smart Material Devices	167
3.5.7 KCF Technologies Compact Narrowband High-Acoustic Sound Source for Particle Agglomeration	168
3.5.8 KCF Technologies Low-Cost Liquid Atomization and Dispensing with a Miniature Piezoelectric Device	170

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

3.5.9	KCF Technologies Extreme Amplitude Piezoelectric Noise Source for HUMVEE Air Filter Cleaning	171
3.5.10	KCF Technologies High-Temperature Piezoelectric Alarm for Personnel Safety Devices	172
3.5.11	KCF Technologies Micro-Robot Swarms for Desktop Manufacturing	173
3.6	II-IV / Marlow Industries Inc	173
3.6.1	Marlow Industries Converting Small Degrees Of Temperature Difference Into Milliwatts Of Electrical Power	175
3.6.2	EverGen™ Plate Exchanger	177
3.7	Micropelt Energy Harvesting:	183
3.7.1	Micropelt Thermogenerator	185
3.7.2	Micropelt Two Micro Thermogenerators In Series	188
3.7.3	Micropelt Thermoharvester	189
3.7.4	Micropelt Products	191
3.7.5	Micropelt Peltier Coolers and Thermogenerators	191
3.7.6	Micropelt Small Micropelt Peltier Cooler	192
3.8	EnOcean	194
3.8.1	EnOcean Link	195
3.8.2	EnOcean Faster Development	196
3.8.3	EnOcean Link Fully Prepared Data	197
3.8.4	EnOcean Encrypted Decoding Gateway	198
3.8.5	EnOcean ECO 200 - Motion Energy Harvesting	199
3.8.6	EnOcean ECT 310 - Thermo Energy Harvesting	202
3.8.7	EnOcean Energy Harvesting Wireless Sensor Solutions	204
3.8.8	EnOcean Energy Harvesting Wireless Sensor Solutions	204
3.8.9	EnOcean Alliance Energy Harvesting Solutions	209
3.8.10	EnOcean-Enabled Wireless Networks	209
3.8.11	EnOcean Alliance	211
3.9	Arveni	215
3.9.1	Arveni's Microgenerator Transforms Mechanical Energy	218
3.10	Ferro Solutions	220
3.10.1	Ferro Solutions Energy Harvesters	221
3.10.2	Ferro Solutions Inductive and PME.	221
3.10.3	Ferro Solutions Piezo-based PME Energy Harvesters	222
3.10.4	Ferro Solutions	222
3.11	Trophos Energy	224
3.12	Millennial Net Wireless Sensor Network:	227
3.13	BYD-Developed Fe Battery	228
3.14	Researchers at MIT	229
3.15	Linear Technology	233
3.15.1	Linear Technology Corporation	235
3.16	Cymbet Energizing Innovation	238
3.16.1	Cymbet EnerChip EP Universal Energy Harvesting Eval Kit	239
3.16.2	Cymbet EnerChip EP Enables New Applications	240
3.16.3	Cymbet Products	242
3.16.4	Cymbet Rechargeable EnerChips and Effective Capacity	243

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

3.16.5	Energy Harvesting Based Products Enabled By Cymbet EnerChip™ EP CB915:	247
3.16.6	Cymbet Development Support	249
3.16.7	Cymbet Solid State Energy Storage for Embedded Energy, Power Back-up and Energy Harvesting	249
3.16.8	Cymbet Energy Harvesting	252
3.16.9	Cymbet Zero Power Devices	255
3.16.10	ComtexCymbet EnerChip™ Thin-Film Batteries	256
3.16.11	Cymbet's EnerChip and Energy Harvesting Solutions	256
3.16.12	Cymbet EnerChip Solid State Battery Energy Harvesting (EH) / TI's LaunchPad Development Kit	257
3.16.13	Cymbet Corporation	257
3.16.14	Cymbet's EnerChip™ EP CBC915,	258
3.16.15	Cymbet Energy Harvesting vs. Nonrechargeable Batteries	259
3.17	Infinite Power Solutions (IPS)—	260
3.17.1	Infinite Power Solutions High-Volume Production Line for TFBs –	262
3.17.2	Infinite Power Solutions Solid-State, Rechargeable Thin-Film Micro-Energy Storage Devices	262
3.17.3	Infinite Power Solutions IPS THINERGY® MEC Products	263
3.17.4	Infinite Power Solutions THINERGY MEC	263
3.17.5	Infinite Power Solutions, Inc. Recharge From A Regulated 4.10 V Source	265
3.17.6	Infinite Power Solutions, Inc. SRAM Backup Guidelines	266
3.17.7	Infinite Power Solutions, Inc. SRAM Backup Power Solution	267
3.17.8	Infinite Power Solutions Recharging THINERGY Micro-Energy Cells	271
3.17.9	Infinite Power Solutions Charging Methods	271
3.17.10	Infinite Power Solutions, Inc. THINERGY MECs	273
3.18	MicroGen Systems and Infinite Power Solutions Wireless Sensor Network (WSN)	274
3.19	Maxim Integrated, Infinite Power Solutions IC to Integrate All Of The Power-Management Functions For Ambient Energy Harvesting	276
3.19.1	Maxim Integrated Products (Nasdaq:MXIM) MAX17710 IC Integrates Power-Management	277
3.19.2	Maxim / Infinite Power Solutions, Inc. (IPS) THINERGY(R) Solid-State, Rechargeable MEC Battery Products	279
3.19.3	Maxim introduces MAX17710 PMIC :: Uniquely enables Energy Harvesting with THINERGY MECs	279
3.20	IPS iTHINERGY ADP	280
3.21	IPS and ITT	281
3.22	Infinite Power Solutions, Inc. (IPS)— Global Leader In Manufacturing Solid-State	282
3.22.1	Infinite Power Solutions (IPS)	282
3.23	JonDeTech AB	283
3.23.1	JonDeTech AB Applications of Infrared Sensing Thermopiles	287
3.23.2	JonDeTech AB Preventive and Predictive Maintenance	287
3.23.3	JonDeTech Thermopile Products	289
3.23.4	JonDeTech Surface Mount Plastic Thermopiles	296
3.23.5	JonDeTech Thermopiles	297
3.23.6	JonDeTech Horizontal Thermocouple	298

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

3.23.7	JonDeTech Advantage Of Nanotechnology Vertical Thermocouple	299
3.24	Schneider Electric Lighting Control Solutions for Comprehensive Facility Energy Management	303
3.24.1	Schneider Electric Lighting Control Systems	303
3.25	Planar	304
3.25.1	Planar Energy Devices –	305
3.25.2	Planar Energy’s Solid State Batteries New Deposition Process	307
3.25.3	Planar Energy Print Guide to Recent Battery Advances	310
3.25.4	Planar Lithium Manganese Dioxide Nanotechnology	311
3.25.5	Planar Energy Devices PowerPlane MXE Module	313
3.26	IBM Energy Scavenging, Power Scavenging –	314
3.27	Cubic Global Wireless Sensor Network Tracking Solutions	315
3.28	Perpetuum	316
3.28.1	Perpetuum PMG Rail: Transportation / Powering Wireless Rail Monitoring Solutions	320
3.28.2	Perpetuum Engineering Evaluation and Development	321
3.28.3	Perpetuum Condition Monitoring	321
3.28.4	Perpetuum Condition Monitoring Technology To Predict Failure	326
3.28.5	Perpetuum Holistic View Of Equipment Condition	326
3.28.6	Perpetuum Need For Greater Accuracy In Condition Assessment Failure Prediction	327
3.28.7	Perpetuum PMG FSH Free Standing Harvester Integrated Perpetual Power Solutions:	328
3.28.8	Perpetuum Powering Wireless Rail Monitoring Solutions	328
3.28.9	Perpetuum Machine Vibration/Motion Energy Harvesting	329
3.28.10	Perpetuum Vibration Energy Harvesting	329
3.28.11	Perpetuum Vibration Source	346
3.28.12	Perpetuum Resonant Frequency: Tuning the Vibration Energy Harvester	346
3.28.13	Perpetuum Vibration Level: Achieving Maximum Power Output	347
3.28.14	Perpetuum Basic Operating Principles Of A Vibration Energy Harvester	349
3.29	Microchip Technology Inc.	360
3.30	MicroGen Systems	362
3.30.1	MicroGen Systems BOLT™ - R MicroPower Generators	365
3.31	LORD Corporation / MicroStrain	367
3.31.1	MicroStrain Wireless Sensor Networks	368
3.31.2	LORD MicroStrain	369
3.32	Nextreme Thermal Solutions	369
3.33	Patria	370
3.34	University of Michigan ISSCC	370
3.34.1	University of Michigan intra-ocular pressure monitor (IOPM) device Ultra-Low Power Management	371
3.34.2	University of Michigan intra-ocular pressure monitor (IOPM) device EH Wireless Sensor Components	372
3.34.3	University of Michigan Intra-Ocular Pressure Monitor (IOPM) Device Building Millimeter Scale EH-Based Computers	374
3.34.4	Permanent Power Using Cymbet Solid State Rechargeable Batteries	374

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

3.35	Australian Defence Science & Technology Organization (DSTO) / VigilX	375
3.36	MacSema	376
3.37	Omron Corp.	376
3.37.1	Omron Photovoltaic Inverter Technology	376
3.38	Silicon Labs Solutions For Energy Harvesting Systems	376
3.38.1	Silicon Labs Energy Harvesting Tipping Point for Wireless Sensor Applications	380
3.38.2	Silicon Laboratories Low-Power Optimization	381
3.38.3	Silicon Labs Solutions For Energy Harvesting Systems	382
3.38.4	Silicon Labs Minimizing The Amount Of Time The Radio Is On	383
3.38.5	Silicon Laboratories Managing Harvested Energy	384
3.38.6	Silicon Labs Ability To Power Wireless Sensor Nodes	387
3.38.7	Silicon Labs Powers Wireless Node with Energy Harvesting	387
3.39	Modern Water plc / Cymtox Limited	388
3.39.1	Modern Water plc / Cymtox Limited	389
3.40	ABB	389
3.40.1	GMZ	390
3.41	Vishay Precision Group / Kelk	391
3.42	Alphabet Energy	391
3.42.1	Alphabet's Technology	392
3.43	Perpetua	393
3.44	Phonomic Devices	398
3.44.1	Phonomic Devices Solid State Cooling, Refrigeration and Air Conditioning	398
3.45	Primus Power	399
3.46	General Motors (GM)	399
3.47	National Instruments	399
3.48	Texas Instruments	401

Wireless Sensor Network Technology

4.	WIRELESS SENSOR NETWORKING TECHNOLOGY	403
4.1	Millennial Net MeshScape™ Wireless Sensor Networking Software Platform	403
4.2	Wireless Sensor Network Architecture	408
4.3	Healthcare Wireless Cardiac Networking	410
4.3.1	Flexible Circuit Board	410
4.3.2	Wireless Heart-Monitoring Devices	412
4.4	Global Spectrum Allocation	413
4.4.1	Bandwidth for Wireless Infrastructure	413
4.4.2	Mobile Subscriptions Worldwide Stress Bandwidth Allocations	416
4.5	Patent Issued to Boeing for "Wireless Aircraft Sensor Network	417
4.5.1	E-Enabled Airplanes	417
4.5.2	Security Of Wireless Sensor Network Enabled Airplane Health	421
4.6	Wireless Standards	422

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

4.6.1	Zigbee Alliance	422
4.6.2	Bluetooth Low Energy	423
4.6.3	SimpliciTI	424
4.6.4	ANT 428	
4.6.5	M2M 432	
4.6.6	LXRS® PROTOCOL	433
4.6.7	Mobile Broadband Standards	434
4.6.8	Qualcomm	435
4.6.9	UMTS Forum	443
4.7	Backhaul Network Architecture	444
4.7.1	Ericsson Standardization Work In The 3rd Generation Partnership Project (3GPP),	445
4.8	Regulatory Solutions	445
4.9	Huawei Pipe Strategy	446
4.10	Small-Cell Architectures	447
4.10.1	Small Cells and LTE	449
4.10.2	Smart Antenna Systems	450

Wireless Sensor Networks Company Profiles

This section selectively describes company strategies, partners, acquisitions, and revenue by segment and regional revenue when available. Companies are described by looking at what is most interesting about that company. The descriptions collectively give a sense of market directions within the industry segment. The alphabetical listing of company thumbnail sketches provides an accessible way to find out what is going on in any particular company.

5. WIRELESS SENSOR NETWORKS COMPANY PROFILES	451
5.1 ABB	451
5.1.1 ABB and IO Deliver Direct Current-Powered Data Center Module	451
5.1.2 ABB / Validus DC Systems DC power infrastructure equipment	452
5.2 Adaptive Materials Technology - Adaptamat Ltd	454
5.3 Alphabet Energy	455
5.3.1 Alphabet Energy Inexpensive Waste Heat Recovery Technology	458
5.3.2 Alphabet Thermoelectrics	460
5.4 Arrow Electronics	460
5.5 American Elements, USA	461
5.6 Australian Defence Science & Technology Organisation (DSTO)	461
5.7 Arveni	461
5.8 Avnet	467
5.9 BAE Systems	467
5.9.1 BAE Key Facts	469
5.9.2 BAE Strategy	469
5.9.3 BAE Operational Framework	470
5.9.4 BAE Key Performance Indicators (KPIs)	471
5.9.5 BAE Systems Ant Size Robot	471
5.9.6 BAE Project Management	472
5.9.7 BAE Engineering	474

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

5.9.8	BAE Personal Robots	476
5.9.9	BAE Systems Large UGV	476
5.9.10	BAE Systems Plc (BAES.L) Hired Advisors To Sell Part Of Its North American Commercial Aerospace Business	477
5.10	Boeing	478
5.10.1	Boeing Automated Identification Technology (AIT)	479
5.10.2	Boeing Structural Health Monitoring	483
5.10.3	Boeing Aircraft Health Monitoring	484
5.10.4	Boeing	485
5.10.5	Boeing 787 Dreamliner	486
5.10.6	Boeing 787 Dreamliner Performance	487
5.10.7	Boeing Advanced Technology	487
5.10.8	Boeing Participation In Commercial Jet Aircraft Market	488
5.10.9	Boeing Participation In Defense Industry Jet Aircraft Market	489
5.10.10	Boeing Defense, Space & Security	489
5.10.11	Boeing Advanced Military Aircraft:	490
5.10.12	Boeing Military Aircraft	491
5.10.13	Boeing-iRobot Team Receives New SUGV Task Order From US Army	496
5.11	BYD	497
5.11.1	BYD Cell Phone Batteries	497
5.11.2	BYD Auto Co	498
5.11.3	BYD Commitment Green Energy	498
5.12	CST	499
5.13	Cymbet	500
5.13.1	Cymbet Team:	500
5.13.2	Cymbet Investors:	500
5.13.3	Cymbet Partners, Sales and Distribution:	502
5.13.4	Cymbet Manufacturing:	502
5.13.5	Cymbet to Open World's Highest Volume Solid-State Battery Manufacturing Facility	502
5.13.6	Cymbet Partnering with X-FAB	503
5.13.7	Cymbet / X-FAB, Inc.	503
5.13.8	Cymbet Expanding in Minnesota	503
5.13.9	Cymbet / LEDA	504
5.13.10	Smart Solid-State Batteries for Embedded Energy, Power Back-up and Energy Harvesting	504
5.13.11	Cymbet EVAL-09 Utilizes Harnessing Ambient Energy	505
5.13.12	Cymbet Secures \$31 Million in Private Financing	506
5.14	Digi International	506
5.14.1	Digi International Business Highlights:	507
5.14.2	Digi International/MaxStream	507
5.14.3	Digi International Revenue	508
5.15	Dust Networks	509
5.15.1	Dust Networks Self-Powered IPV6 Wireless Sensor Network	510
5.16	EnOcean GmbH	511

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

5.16.1	EnOcean Technology	512
5.16.2	EnOcean Alliances	513
5.16.3	EnOcean Self-Powered Wireless Technology	515
5.17	Finmeccanica	516
5.17.1	Finmeccanica / SELEX Galileo	517
5.17.2	SELEX Galileo Inc.	517
5.17.3	SELEX Galileo Technologies	518
5.18	Flexible Electronics Concepts	519
5.19	Ferro Solutions	520
5.19.1	Ferro Solutions	523
5.20	Fraunhofer Institute for Integrated Circuits IIS	528
5.21	General Electric Company	528
5.21.1	GE Energy Wireless Condition Monitoring System / Perpetuum Electromagnetic Vibration Energy Harvesting Device	529
5.21.2	GE HabITEQ Systems and EnOcean Energy-Harvesting Technology Joint Venture	529
5.21.3	General Electric / EnOcean Equipped Devices Sensors Fit In Ultra-Thin Switches On Glass Panels	530
5.21.4	GE Smart Energy Technologies	531
5.22	GMZ	531
5.23	Honeywell	532
5.23.1	Honeywell Energy-Harvesting Sensing and Control	533
5.24	Infinite Power Solutions	534
5.24.1	Infinite Power Solutions Solid-State, Thin-Film Batteries	534
5.24.2	Infinite Power Solutions Micro-Energy Storage Devices	535
5.24.3	Infinite Power Solutions Battery Applications	535
5.24.4	Infinite Power Solutions And Tokyo Electron Device Global Distribution Agreement	535
5.24.5	Infinite Power Solutions Financing	536
5.25	Inventec	538
5.26	IO 538	
5.27	ITN Lithium Technology	539
5.27.1	ITN's Lithium EC sub-Division Focused On Development And Commercialization of EC	540
5.27.2	ITN's SSLB Division Thin-Film Battery Technology	541
5.27.3	ITN Lithium Air Battery	541
5.27.4	ITN Fuel Cell	543
5.27.5	ITN Thin-film Deposition Systems	545
5.27.6	ITN Real Time Process Control	546
5.27.7	ITN Plasmonics	550
5.28	II-VI incorporated / Marlow Industries	551
5.28.1	II-VI Incorporated (NASDAQ: IIVI)	551
5.28.2	II-VI Incorporated / Marlow Infrared And Near-Infrared Laser Optical Elements	553
5.28.3	II-VI incorporated / Marlow Markets	555
5.29	JonDeTech	555
5.30	KCF Technologies Inc	556
5.31	Kelk	557
5.32	Levant Power	561

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

5.33 LORD Corporation, MicroStrain® Sensing Systems	561
5.34 MacSema	563
5.35 Microchip Technology	564
5.36 MicroGen Systems	564
5.37 Micropelt	565
5.37.1 Micropelt Thin Film Thermogenerators	565
5.37.2 Micropelt Systems	566
5.37.3 Micropelt Thermogenerators	567
5.38 Millennial Net	568
5.38.1 Millennial Net Wireless Sensor Network:	569
5.38.2 Millennial Net's MeshScape GO WSN Technology	571
5.39 Modern Water	573
5.40 National Instruments	574
5.41 Nature Technology	577
5.42 Nextreme	577
5.43 Northrop Grumman	579
5.43.1 Northrop Grumman Smart Grid	580
5.43.2 Northrop Grumman	581
5.43.3 Northrop Grumman Corp (NOC.N) Spinning Off Or Selling Its Shipbuilding Business	581
5.43.4 Northrop Grumman Remotec Robots	581
5.43.5 Northrop Grumman Opens New Facilities for Design and Manufacture of Unmanned Ground Vehicles in Coventry	582
5.43.6 Northrop Grumman Business Sectors:	584
5.43.7 Northrop Grumman Aerospace Systems	587
5.44 OMRON	589
5.44.1 Omron Revenue	590
5.45 Planar Energy Devices –	590
5.45.1 Planar Energy Devices Deposition Process	591
5.45.2 DOE Planar Energy for Oak Ridge National Laboratory Collaborative Battery Development	593
5.46 Perpetua	594
5.47 Perpetuum	597
5.47.1 Perpetuum Alliances	598
5.47.2 Perpetuum Venture Capital Investors	598
5.48 Phononic Devices	599
5.49 Polatis Photonics	600
5.49.1 Polatis Technology and Products	601
5.50 Primus Power	601
5.51 PS 601	
5.52 Schneider Electric	602
5.52.1 Schneider Electric	602
5.52.2 Schneider Electric Vision Smart Grid:	602
5.52.3 Schneider Electric Triggers of the Smart Grid	603
5.52.4 Schneider Electric Revenue	605
5.52.5 Smart Grid: Schneider Electric Vision	605
5.52.6 Schneider Electric Triggers of the Smart Grid	607

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

5.53	Severn Water / Modern Water / Cymtox Limited	609
5.54	Silicon Labs	609
5.54.1	Silicon Laboratories Energy Harvesting Applications	610
5.54.2	Silicon Laboratories Products	613
5.55	Syngenta Sensors UIC	616
5.56	Teledyne / Rockwell Scientific	617
5.57	Texas Instruments (TXN:NYSE)	617
5.57.1	Texas Instruments	618
5.58	Trophos Energy	618
5.59	University of California, Berkeley	621
5.60	University of Michigan	621
5.60.1	University of Michigan's Department of Electrical Engineering and Computer Science Nano-Thin Sheets Of Metal	621
5.61	Vishay Precision Group	622
5.61.1	KELK integration	622
5.61.2	Vishay Precision Group Revenue	622
5.61.3	Vishay Precision Group Segments	623
5.62	Zarlink Semiconductor AB	624
5.63	US Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) Seed Funding	625
5.64	Selected Energy Harvesting Market Participants	627
5.64.1	Leading Wireless Sensor Networks Market Participants by Technology	636

List of Tables and Figures

Wireless Sensor Network

Table ES-1	38
Wireless Sensor Networking Technology Uses	38
Table ES-2	39
Energy Harvesting And Energy Storage Market Factors	39
Table ES-3	41
Wireless Sensor Networking Market Driving Forces	41
Figure ES-4	45
Wireless Sensor Networking Market Shares, Dollars, 2012	45
Figure ES-5	47
Wireless Sensor Networking Shipments Market Forecasts, Dollars, Worldwide, 2013-2019	47
Table 1-1	49
Wireless Network Sensing Objectives	49
Table 1-2	50
Wireless Network Sensing Objectives	50
Table 2-1	56
Wireless Sensor Networking Technology Uses	56
Table 2-2	57
Energy Harvesting And Energy Storage Market Factors	57
Table 2-3	58

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Wireless Sensor Networking Market Driving Forces	58
Figure 2-4	62
Wireless Sensor Networking Market Shares, Dollars, 2012	62
Table 2-5	63
Wireless Sensor Networking Market Shares, Vibration, Piezoelectric, Thermoelectric, Magnetic, Dollars, Worldwide, 2012	63
Figure 2-6	69
Perpetuum Markets Served By Industry	69
Figure 2-7	70
Perpetuum ROI Addresses The Hidden Costs Of Under Monitored Assets	70
Figure 2-8	71
Perpetuum Estimates Number of BOP Machine Assets Under Monitored Exceeds 70%	71
Table 2-9	75
Leading Energy Harvesting Market Participants by Technology	75
Figure 2-10	80
Wireless Sensor Networking Shipments Market Forecasts, Dollars, Worldwide, 2013-2019	80
Table 2-11	81
Wireless Sensor Networks Market Forecasts, Worldwide, 2013-2019	81
Figure 2-12	83
Wireless Sensor Network Units, Worldwide, Forecasts, 2013-2019	83
Figure 2-13	87
Wireless Sensor Networks Smarter City Shipments Market Forecasts, Dollars, Worldwide, 2013-2019	87
Figure 2-14	88
Smarter Computing Depends on Instrumented Devices	88
Figure 2-15	89
Transportation Rail and Electric Vehicle Wireless Sensor Networks Market Forecasts Dollars, Worldwide, 2013-2019	89
Figure 2-16	92
Number and Floor Space of US Commercial Buildings	92
Figure 2-17	93
Energy Use Intensity for LEED Certified Buildings (kBtu per Square Foot)	93
Figure 2-18	94
Smart Building Wireless Sensor Networks Shipments Market Forecasts, Worldwide, Dollars, 2013-2019	94
Figure 2-19	95
Contractors And Construction Wireless Sensor Networks Shipments Market Forecasts, Worldwide, Dollars, 2013-2019	95
Figure 2-20	97
Smart Grid Meter Wireless Sensor Networks Market Forecasts Dollars, Worldwide, 2013-2019	97

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Figure 2-21	99
Smart Grid Substation Wireless Sensor Networks Shipments, Market Forecasts, Worldwide, 2013-2019	99
Figure 2-22	102
Airline / Space / Defense Industry Wireless Sensor Networks Market Forecasts, Dollars, Worldwide, 2013-2019	102
Figure 2-23	103
Border and Perimeter Security Energy Harvesting Shipments Market Forecasts, Dollars, Worldwide, 2013-2019	103
Table 2-24	106
Wireless Sensor Networks Market Industry Segments, Dollars, Worldwide, 2013 -2019	106
Table 2-25	107
Wireless Sensor Networks Market Industry Segments, Percent, Worldwide, 2013 -2019	107
Figure 2-26	109
Energy Harvesting Market Industry Segments, Units, Worldwide, 2013-2019	109
Table 2-27	109
Energy Harvesting Market Industry Segments, Units, Worldwide, 2013-2019	109
Figure 2-28	123
Marlow Energy Harvesting Device Price	123
Figure 2-29	124
Nextreme Energy Harvesting Modules WPG-1 WRLES PWR GEN 1mW 3.3, 4.1 OR 5V	124



	124
Figure 2-30	125
MicroPelt Energy Harvester	125
Figure 2-31	128
Smarter Computing Depends on Instrumented Devices	128
Figure 2-32	129
Smarter Planet Impact on IT	129
Table 2-33	131
Advantages Offered by SOA	131
Table 2-34	133
Thin Film Battery Market Driving Forces	133
Table 2-35	136
Smarter Computing Market Driving Forces	136
Table 2-36	137
Thin Film Battery Benefits	137

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Table 2-37	138
Comparison Of Battery Performance	138
Figure 2-38	139
Thin Film Battery Energy Density	139
Figure 2-39	144
Silver Nanoplates	144
Table 2-40	147
Wireless Sensor Networking Regional Market Segments, Dollars, 2012	147
Table 2-41	148
Wireless Sensor Networking Regional Market Segments, 2012	148
Table 3-1	152
Boeing Energy Harvesting Development Programs Functions	152
Figure 3-2	153
Boeing Wireless Sensor Aircraft Applications	153
Figure 3-3	155
Broadband Energy Harvester (Boeing)	155
Figure 3-4	156
Broadband Wireless Sensor Network (Boeing)	156
Figure 3-5	157
Silicon Laboratories Energy Harvesting Components	157
Figure 3-6	158
Silicon Laboratories	158
Table 3-7	159
KCF Technologies Energy Harvesting Wireless Sensors Offered	159
Figure 3-8	160
KCF Technologies Smart Rod End for Wireless Monitoring of Helicopter Rotor Components	160
Figure 3-9	162
KCF Technologies Rotor Energy Harvesting Devices	162
Figure 3-10	164
KCF Technologies Harvester-Powered Wireless Accelerometers	164
Table 3-11	165
KCF Technologies Wireless Vibration Sensors for Shipboard Environments	165
Figure 3-12	166
KCF Technologies Harvester-Powered Wireless Sensors for Industrial Machine Monitoring	166
Table 3-13	167
KCF Technologies Energy Harvesting Devices	167
Table 3-14	168
KCF Technologies Piezoelectric Devices	168
Figure 3-15	169
KCF Technologies Compact Narrowband High-Acoustic Sound Source	169
Figure 3-16	170
KCF Technologies Liquid Atomization and Dispensing	170

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Figure 3-17	171
KCF Technologies Extreme Amplitude Piezoelectric Noise Source for HUMVEE Air Filter Cleaning	171
Figure 3-18	174
Marlow Industries Evergen	174
Figure 3-19	176
Marlow Industries Evergen	176
Figure 3-19	177
Marlow Industries Product Specifications	177
Table 3-20	178
Marlow Industries EverGen™ Plate Exchanger Advantages:	178
Table 3-21	179
Marlow Industries EverGen™ Plate Exchanger Target Markets:	179
Figure 3-22	180
Marlow Industries Evergen Plate Exchanger	180
Table 3-23	181
Marlow Industries Evergen Energy Harvesting Solutions	181
Figure 3-24	184
Micropelt Energy Harvester	184
Figure 3-25	186
Micropelt Energy Thermogenerator	186
Figure 3-26	187
Micropelt Energy Thermogenerator	187
Figure 3-27	190
Micropelt Thermoharvester	190
Figure 3-28	191
Micropelt Peltier Coolers and Thermogenerators	191
Figure 3-29	192
Small Micropelt Peltier Cooler	192
Figure 3-30	193
Micropelt Peltier Cooler	193
Figure 3-31	194
Micropelt Small Peltier Cooler Specifications	194
Figure 3-32	196
EnOcean Middleware For Energy Harvesting	196
Figure 3-33	199
EnOcean ECO 200 - Motion Energy Harvesting	199
Table 3-34	200
EnOcean ECO 200 - Motion Energy Harvesting	200
Figure 3-35	201
EnOcean ECO 100 - Motion Energy Harvesting	201
Table 3-36	202
EnOcean Energy Harvesting Motion Converter	202
Table 3-37	202

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

EnOcean ECT 310 Perpetuum	202
Table 3-38	203
EnOcean Thermo Converter	203
Table 3-39	203
EnOcean Energy Converters For Energy Harvesting Wireless Applications	203
Figure 3-40	205
EnOcean-Enabled Wireless Sensor Networks	205
Table 3-41	210
EnOcean Alliance Energy Harvesting Solutions Advantages	210
Table 3-42	212
EnOcean Energy Harvesting Sources	212
Figure 3-43	213
EnOcean Energy Harvesting Wireless Sensor Technology	213
Figure 3-44	214
EnOcean Energy Harvesting Wireless Sensor Devices	214
Figure 3-45	215
Arveni Core Business In Energy Harvesting Using Piezo Electricity	215
Figure 3-46	216
Arveni Wireless Network Sensor	216
Table 3-47	217
Arveni Wireless Network Sensors Used	217
Table 3-48	217
Arveni Wireless Network Sensors Range & Link Budget	217
Table 3-49	219
Arveni Micro Generator Features	219
Figure 3-50	222
Ferro Solutions Wireless Sensor Network	222
Table 3-51	225
Trophos Energy Marine Applications	225
Table 3-52	225
Trophos Energy Land Applications	225
Figure 3-53	226
Trophos Energy innovative Marine, Land, and Electrocics Power Generation Products	226
Figure 3-54	230
MIT Energy Harvesting Device Converts Low-Frequency Vibrations Into Electricity	230
Table 3-55	234
Linear Technology Micropower Voltage Devices	234
Table 3-56	236
Linear Technology Comprehensive Line Of High Performance Battery	236
Figure 3-57	239
Cymbet Energy Harvesting Transducers	239
Figure 3-58	240
Cymbet EnerChip Energy Processor CBC915-ACA and Universal Energy Harvesting Eval Kit	240

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Table 3-59	241
Cymbet Solid State Energy Storage Energizing Innovation Target Markets	241
Table 3-60	242
Cymbet Solid State Energy Storage products	242
Table 3-61	244
Cymbet EnerChip™ Solid-State Product Line	244
Table 3-62	246
Cymbet's EnerChip Benefits	246
Table 3-63	248
Cymbet Energy Harvesting (EH) Features	248
Figure 3-64	250
Cymbet EnerChip CBC3105-BDC:	250
Table 3-65	251
Cymbet EnerChip CBC001-BDC: Target Markets	251
Table 3-66	253
Cymbet Energy Harvesting Applications	253
Figure 3-67	261
Infinite Power Solutions Thinergy Component	261
Table 3-68	264
Infinite Power Solutions THINERGY® Product Family	264
Table 3-69	269
Infinite Power Solutions, Inc. Maxim Energy Management Chips	269
Table 3-70	270
Infinite Power Solutions, Inc. Applications For Energy Harvester	270
Table 3-71	272
Infinite Power Solutions Charging Methods	272
Table 3-72	278
Wireless Sensor Network Applications	278
Figure 3-73	284
JonDeTech Thermopile SMDs	284
Table 3-74	285
JonDeTech AB Thermopile Features	285
Figure 3-75	286
JonDeTech AB Low-Cost, Surface Mount Thermopiles	286
Table 3-76	288
JonDeTech AB Consumer Electronics Mid IR Sensors	288
Table 3-77	289
JonDeTech AB Residential Control Systems Mid IR Sensors	289
Table 3-78	290
JonDeTech's Technology Competitive Advantages	290
Figure 3-79	291
JonDeTech AB JIRS3 Sensor	291
Table 3-80	292
JonDeTech AB Key Features of the Thermopile	292

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Figure 3-81	293
JonDeTech AB JIRS5 Sensor	293
Figure 3-82	294
JonDeTech AB Close-up of JIRS5 Sensor	294
Figure 3-83	295
JonDeTech AB Nanowire Sensors	295
Figure 3-84	296
JonDeTech AB Linear Array of IR Sensorson Polyimide Foil	296
Table 3-85	298
JonDeTech Thermopile Applications	298
Figure 3-86	300
JonDeTech AB Vertical Heat Flow Model Of Jondetech Thermopiles	300
Figure 3-87	301
JonDeTech AB Vertical Heat Flow Model	301
Figure 3-88	302
Jondetech Thermopile Infrared Radiation Tectors Generation Flex	302
Figure 3-89	304
Schneider Electric Energy Harvesting	304
Figure 3-90	308
Planar Energy's Solid State Batteries Spraying Materials Onto A Metal Substrate	308
Figure 3-91	318
Perpetuum Rail Based Vibration Energy-Harvesting	318
Figure 3-92	319
Perpetuum Industrial Based Vibration Energy-Harvesting	319
Table 3-93	320
Applications Powered By PMG Rail	320
Table 3-94	322
Perpetuum Condition Monitoring Technologies	322
Table 3-95	323
Perpetuum Business Benefit To Dominate The Industrial Maintenance Scene	323
Figure 3-96	324
Perpetuum Vibration Energy-Harvesting Wireless Sensor Node Components And Structure	324
Figure 3-97	325
Perpetuum Switch Mode Efficiency	325
Figure 3-98	330
Perpetuum Condition Assessment Need	330
Figure 3-99	331
Perpetuum Condition Assessment Principle of Operation	331
Figure 3-100	332
Perpetuum Vibration Energy Harvesting for Rail Cars	332
Figure 3-101	333
Perpetuum Vibration Energy Harvesting for Rail Wheels and Bearings	333
Figure 3-102	334

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Perpetuum Temperature Variation Energy Harvesting for Rail Wheels and Bearings	334
Figure 3-103	335
Perpetuum Temperature Variation and Vibration Energy Harvesting Wireless Network Solution	335
Figure 3-104	336
Perpetuum Vibration Energy Harvesting Solution Benefits	336
Figure 3-105	337
Perpetuum Energy Harvesting ROI for Ten Years	337
Figure 3-106	338
Perpetuum Energy Harvesting Current Produced	338
Figure 3-107	339
Perpetuum Energy Harvesting Power Measurement	339
Figure 3-108	340
Perpetuum Energy Harvesting Wireless Monitoring	340
Figure 3-109	341
Perpetuum Energy Harvesting Installation	341
Figure 3-110	342
Perpetuum Energy Harvesting Innovation Solutions	342
Figure 3-111	343
Perpetuum Energy Free Standing Harvesting Development Kit	343
Figure 3-112	344
Perpetuum Energy Harvesting Wireless Monitoring and Automation	344
Figure 3-113	345
Perpetuum Energy Harvesting of Under Monitored BOP Assets	345
Figure 3-114	348
Perpetuum Power Output Spectrum	348
Figure 3-115	350
Perpetuum Vibration Energy Harvester powering the Wireless Sensor Node	350
Figure 3-116	351
Perpetuum Vibration Energy Harvesters	351
Figure 3-117	352
Perpetuum Power Solutions for Wireless Monitoring and Automation	352
Table 3-118	353
Perpetuum Vibration Energy Harvester (VEH) Functions	353
Figure 3-119	354
Perpetuum Vibration Energy Harvester	354
Table 3-120	355
Perpetuum Industrial Markets Served	355
Figure 3-121	356
Perpetuum Markets Served By Industry	356
Figure 3-122	357
Perpetuum ROI Addresses The Hidden Costs Of Under Monitored Assets	357
Figure 3-123	358

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Perpetuum Estimates Number of BOP Machine Assets Under Monitored Exceeds 70%	358
Figure 3-124	359
Perpetuum Assessment of Machine Assets Under Monitored	359
Figure 3-125	361
Microchip Technology Energy Harvesting Kit	361
Figure 3-126	362
Microchip Technology Energy Harvesting Kit Features	362
Table 3-127	363
MicroGen Systems Leveraging of Factors Converging To Open Up Opportunity In Energy Harvesting	363
Table 3-128	364
MicroGen Systems Energy Harvesting For Battlefield	364
Table 3-129	366
MicroGen Systems BOLTTM family of Micro Power Generator Features	366
Table 3-130	367
MicroGen Systems BOLT Industrial Product	367
Figure 3-131	373
University of Michigan Intra-Ocular Pressure Monitor (IOPM) Device Wireless Sensor Basic Elements	373
Table 3-132	377
Silicon Labs Solutions For Energy Harvesting Applications	377
Table 3-133	378
Silicon Labs Solutions For Energy Harvesting Solutions	378
Table 3-134	379
Silicon Labs Solutions For Energy Harvesting Systems	379
Figure 3-135	381
Silicon Laboratories Wireless Sensor Node Power Cycle	381
Figure 3-136	384
Silicon Labs Solutions For Energy Harvesting Systems	384
Figure 3-137	394
Perpetua Renewable Energy Source for Wireless Sensors	394
Figure 3-138	394
Perpetua Renewable Energy Source Applications	394
Figure 3-139	395
Perpetua Energy Harvesting Device	395
Table 3-140	396
Perpetua Thermoelectric Technology Key Differentiating Features	396
Figure 3-141	397
Perpetua Technology	397
Table 4-1	403
Wireless Sensor Networking Technology Benefits	403
Table 4-2	405
Millennial Net Wireless Sensor Networking Protocol Responsive Functions	405
Table 4-3	406

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Millennial Net Wireless Sensor Networking Protocol Reliability Functions	406
Table 4-4	407
Millennial Net Wireless Sensor Networking Protocol Power Efficient Functions	407
Table 4-5	408
Millennial Net Wireless Sensor Networking Protocol Functions	408
Figure 4-6	409
Wireless Sensor Network Architecture	409
Figure 4-7	411
Wireless Autonomous Transducer electrocardiogram Solution	411
Figure 4-8	413
Global Spectrum Allocation	413
Figure 4-9	414
Bandwidth for Wireless Infrastructure	414
Table 4-10	416
Network Traffic Units	416
Table 4-11	418
Wireless Sensor Networking Technology Uses	418
Table 4-12	419
Wireless Sensor Networking E-Enabled Airplane Benefits	419
Table 4-13	420
Wireless Sensor Networking E-Enabled Airplane Functions	420
Figure 4-14	421
Security Of Wireless Sensor Network Enabled Airplane Health Monitoring	421
Table 4-15	425
Texas Instruments Simpliciti Key Features:	425
Table 4-16	426
Texas Instruments Simpliciti Key Applications:	426
Table 4-17	426
Texas Instruments Simpliciti Key Low-Power RF Devices And Tools Supported	426
Figure 4-18	429
ANT Extended Messaging	429
Figure 4-19	431
ANT Layers in Standard Host and System on A Chip (SOC)	431
Figure 4-20	433
LXRS® Wireless Protocol	433
Figure 4-21	436
Smart Phone CDMA, LTE, and WiFi Roadmap Evolution Path	436
Figure 4-22	437
LTE Interoperability Positioning	437
Figure 4-23	438
LTE Frequency Band Assignments	438
Figure 4-24	439
Projected LTE Global Spectrum Usage	439
Figure 4-25	440

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Challenge to Support 3GPP and 3GPP2 Frequency Assignments	440
Figure 4-26	441
Bandwidth Spectrum Economies of Scale	441
Figure 4-27	442
LTE Device Availability by Frequency	442
Figure 4-28	444
Backhaul Network Architecture, Flow Delay, Jitter, Packet Loss, Continuity, Availability, Throughput, and Traffic Stats	444
Figure 4-29	446
Wireless Infrastructure Traffic Model	446
Table 5-1	454
ABB Product Launches	454
Figure 5-2	455
Alphabet Energy Heat To Electricity Examples	455
Figure 5-3	462
Arveni Harvesting Energy Target Markets	462
Figure 5-4	463
Arveni Wireless Sensor Block Diagram	463
Table 5-5	464
ARVENI's Microgenerators Systems Functions	464
Table 5-6	465
ARVENI Growth Positioning	465
Figure 5-7	466
Arveni Strategic Focus	466
Figure 5-8	476
BAE Military Robot in Development	476
Figure 5-9	481
Boeing Vulture technology	481
Table 5-10	491
Boeing Military Aircraft Key programs	491
Table 5-11	494
Boeing Unmanned Airborne Systems:	494
Table 5-12	495
Boeing Weapons:	495
Table 5-13	499
CST Target Markets	499
Table 5-14	515
Selected Enocan Shareholders:	515
Figure 5-15	521
Ferro Solutions Energy Harvesters And Sensors	521
Figure 5-16	522
Ferro Solutions Energy Harvesters And Sensors Target Markets	522
Table 5-17	522
Ferro Solutions Selected Clients	522

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Table 5-18	524
Ferro Solutions Energy Harvester Uses	524
Table 5-19	526
Ferro Solutions FS Energy Harvester Industrial & Process Automation and Utilities	526
Table 5-20	534
Honeywell Energy-Harvesting Sensing and Control	534
Table 5-21	542
ITN Technologies	542
Figure 5-22	543
ITN Thin Film Battery Technology	543
Figure 5-23	544
ITN Battery	544
Figure 5-24	545
ITN Thin-Film Deposition Systems	545
Figure 5-25	546
ITN's Thin-Film Deposition Systems	546
Table 5-26	548
ITN Thin-Film Deposition Systems Products and Services Offered	548
Table 5-27	549
ITN Thin-Film Deposition Systems	549
Figure 5-28	550
ITNIYN Fuel Cells	550
Table 5-29	557
KCF Technologies Core Technical Focus Areas	557
Table 5-30	558
Kelk Recent Orders	558
Table 5-31	566
Micropelt Thin Film Thermogenerator Functions	566
Table 5-32	568
Micropelt Product Functions	568
Table 5-33	572
Millennial Net's MeshScape System Functions	572
Table 5-34	573
MeshScape GO Deployment Components:	573
Figure 5-35	575
National Instruments Accelerating Innovation and Discovery	575
Omron Revenue	590
Figure 5-36	595
Perpetua Renewable Energy Solutions For Wireless Sensors	595
Figure 5-37	595
Perpetua Energy Harvesting Product Set	595
Table 5-38	596
Perpetua's Thermoelectric Technology Features	596
Figure 5-39	603

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

WinterGreen Research, INC.

Schneider Energy Value Chain:	603
Table 5-40	604
Schneider Electric Triggers Innovation For the Smart Grid	604
Figure 5-41	605
Schneider Electric Revenue	605
Figure 5-42	606
Schneider Energy Value Chain	606
Table 5-43	608
Schneider Electric Triggers of the Smart Grid	608
Figure 5-44	611
Silicon Laboratories Revenue	611
Table 5-45	614
Silicon Laboratories Product Functions	614
Table 5-46	615
Silicon Laboratories Product Areas and Description	615
Table 5-47	620
Trophos Energy Harvesting Power Solutions Applications	620
Table 5-48	636
Leading Wireless Sensor Networks Market Participants by Technology	636

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING

ABOUT THE COMPANY

WinterGreen Research, research strategy relates to identifying market trends through reading and interviewing opinion leaders. By using analysis of published materials, interview material, private research, detailed research, social network materials, blogs, and electronic analytics, the market size, shares, and trends are identified. Analysis of the published materials and interviews permits WinterGreen Research senior analysts to learn a lot more about markets. Discovering, tracking, and thinking about market trends is a high priority at WinterGreen Research. As with all research, the value proposition for competitive analysis comes from intellectual input.

WinterGreen Research, founded in 1985, provides strategic market assessments in telecommunications, communications equipment, health care, Software, Internet, Energy Generation, Energy Storage, Renewable energy, and advanced computer technology.

Industry reports focus on opportunities that expand existing markets or develop major new markets. The reports access new product and service positioning strategies, new and evolving technologies, and technological impact on products, services, and markets. Innovation that drives markets is explored. Market shares are provided. Leading market participants are profiled, and their marketing strategies, acquisitions, and strategic alliances are discussed. The principals of WinterGreen Research have been involved in analysis and forecasting of international business opportunities in telecommunications and advanced computer technology markets for over 30 years.

The studies provide primary analytical insight about the market participants. By publishing material relevant to the positioning of each company, readers can look at the basis for analysis. By providing descriptions of each major participant in the market, the reader is not dependent on analyst assumptions, the information backing the assumptions is provided, permitting readers to examine the basis for the conclusions.

About The Principal Authors

Ellen T. Curtiss, Technical Director, co-founder of WinterGreen Research, conducts strategic and market assessments in technology-based industries. Previously she was a member of the staff of Arthur D. Little, Inc., for 23 years, most recently as Vice President of Arthur D. Little Decision Resources, specializing in strategic planning and market development services. She is a graduate of Boston University and the Program for Management Development at Harvard Graduate School of Business Administration. She is the author of recent studies on worldwide telecommunications markets, the top ten internet equipment companies, the top ten contract manufacturing companies, and the Top Ten Telecommunications market analysis and forecasts.

Susan Eustis, President, co-founder of WinterGreen Research is a senior analyst. She has done research in communications and computer markets and applications. She holds several patents in microcomputing and parallel processing. She has the original patents in electronic voting machines where she was featured in People Magazine in 1976. She has new patent applications in format varying, multiprocessing, and electronic voting. She is the author of recent studies of the Solar Renewable Energy, Wind Energy, Thin Film Batteries, Business Process Management marketing strategies, Internet equipment, biometrics, a study of Internet Equipment, Worldwide Telecommunications Equipment, Top Ten Telecommunications, Digital Loop Carrier, Web Hosting, Web Services, and Application Integration markets. Ms. Eustis is a graduate of Barnard College. Susan Eustis was named as top female executive of the year by Who's Who Worldwide in 2012. She was named page one of the top 100 Industry leaders in Who's Who in 2013.

REPORT # SH25811715

640 PAGES

266 TABLES AND FIGURES

2013

\$3,800 SINGLE COPY -- \$7,600 WEB SITE POSTING