

WINTERGREEN RESEARCH, INC.

**World Energy Market Shifts, Forecasts, and Strategies,
2007 to 2013**

World Energy



Picture by Susie Eustis

MOUNTAINS OF OPPORTUNITY

**WinterGreen Research, Inc.
Lexington, Massachusetts**

www.wintergreenresearch.com

CHECK OUT THESE KEY TOPICS

REPORT # SH29821524 509 PAGES 133 TABLES AND FIGURES 2007 \$3,200

DEMAND FOR ELECTRICITY

Grid Energy

Micro Generation Of Energy For Residential Markets

Industrialization Requires Sustainable, Highly Efficient Energy

Transportation

Battery Description

WORLD ENERGY SEGMENTS AND FORECASTS

COMMERCIAL ENERGY SECTOR

DEVELOPED ECONOMY TRANSPORTATION SECTOR

DEVELOPED ECONOMY INDUSTRIAL SECTOR

BATTERY CELL CONSTRUCTION

THIN FILM BATTERIES

NAMING STANDARDS FOR CELL IDENTIFICATION

FUEL CELL OPERATION

FUEL CELL ISSUES

BATTERY FUNCTION

OPPORTUNITY ABOUNDS

WinterGreen Research, Inc.

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World Energy Market Shifts, Description, Market Analysis, Product Description, and Company Profiles

Nanotechnology is providing us next generation systems that rely on micro-generation of energy stored in thin film batteries. Nanotechnology works on both sides of the equation. Solar and wind generators are made more efficient by the use of nanoparticles in the drive and collector mechanisms. Thin film batteries use new materials created using nanotechnology to achieve components that are used to manufacture batteries 40 times more efficient than current batteries.

World energy market shifts are a result of these new renewable energy and storage technologies. Wind and solar energy can be generated and stored as DC current in residential settings. Wind and solar power can be stored by using thin film batteries that in turn are used to power electronics, LED lights, and small appliances in the home. Systems work using a direct current (DC) power system that supplements the power coming off the grid into the home.

Wind and solar generators operating in residential settings store energy in thin film batteries for use in autos. Wind and solar power stored in thin film batteries can be used to power cars by hooking the car battery to the home battery with a wire and a plug at each end of the wire. This assumes that there are lots and lots of solar panels, small windmills like would be used on a boat, and thin film batteries. The billions of units needed create economies of scale and bring prices of these products well below the \$100 per unit price.

Micro-generation of energy is set to bring a worldwide economic revolution brought by the availability of thin film batteries that are more fuel-efficient, charge within minutes, and hold a charge 40 times longer than existing batteries. Thin film batteries can be charged from renewable energy sources and used to power the home and car.

Industrialization requires sustainable, highly efficient energy. Fossil fuel generation is being replaced by clean, renewable energy. Wind and solar energy can be stored in thin film batteries for residential and transportation uses. Renewable energy can be stored in the form of hydrogen for fleet and campus applications.

Increasingly societies are realizing that micro-generation has a role to play in combating global warming, increasing security of energy supplies, alleviating fuel poverty, and generally creating sustainable communities.

Micro generators include wind and solar have not been as efficient as buying electricity from the grid. Micro generation has developed independently of a grid connected house, office, or factory on boats and away from civilization. Now that technology is ready for mainstream use. Once the micro wind turbine has been purchased energy is free, and now it can be stored efficiently, which was never possible before. So there are very good reasons to install micro generation.

For homeowners seeking true electrical grid independence, micro-power generation takes away the dependence and limitations of the electric distribution grid, in a remote standalone package. Other systems provide heat for the home. This lets the homeowner live just about anywhere, in the mountains or deep woods, in the desert or on an island. Now that same technology is ready for the cities and the suburbs.

Fuel cells run on hydrogen that in turn needs to be manufactured. Hydrogen can be manufactured from nuclear, wind, and solar power. It may be more efficient to convert renewable energy directly to electricity because hydrogen evaporates so easily, but in some campus cases, the hydrogen is useful. Nuclear power run at 100% capacity can be used to generate hydrogen with the unused electricity. Stationary fuel cells promise to use that energy stored as hydrogen.

Stationary fuel cells generate grid or campus electric power by combining hydrogen with oxygen. Hydrogen fuels may be methanol, natural gas or petroleum for manufacturing the hydrogen. Natural gas is currently used as an energy source for stationary fuel cells. Landfill gas and wastewater treatment plants provide the most available renewable energy source for hydrogen or to be used directly with the generator. Excess power from nuclear power plants provides a source of energy to manufacture hydrogen over the next 50 years.

2-megawatt fuel cell power plants demonstrate the feasibility of fuel cell research. Monitoring and down time to replace parts are issues. More work still needs to be done to reduce the costs, to develop better catalysts to drive the machines. Research is concentrated on making units smaller and easier to use.

Combined heat and power (CHP) technologies produce electricity, hot water, chilled water, and/or steam from a single fuel at a facility.

Because hydrogen can be manufactured from landfill and wastewater treatment plants, many units are being located close to those energy sources. Giving fuel for stationary campus fuel cell units is a priority. Nuclear energy is also used to generate hydrogen from its excess capacity. The reactors in the world used for nuclear electricity generation in 2006 created 2,756 billion kilowatts of energy.

As the dollars per kilowatt for stationary fuel cell utility units decline to \$4,500 in 2009, markets start to pick up with campus and grid utility power company units shipped.

The stationary fuel cell markets at \$108 million in 2006 have been at stasis for several years, due to the high cost per kilowatt that is not competitive with existing utility technology. As the price of fuel rises, environmental concerns become more compelling, and demand for reliability more intense, the markets become more mature.

This is because the demand picks up for reliable units that can run on hydrogen from excess electricity generated by wind power. Solar power begins to be a factor as well, with nanotechnology breakthroughs giving solar photovoltaic power a cost competitive position in the energy chain. Fuel cells are needed to level out the power distribution.

Wind power is plentiful in the ocean, and can be used to generate electricity there, that can be transmitted to reforming stations where the electricity is stored as hydrogen for use in stationary fuel cells used by utility companies.

2-megawatt fuel cell power plants demonstrate the feasibility of fuel cell research. Monitoring and down time to replace parts are issues. More work needs to be done to reduce the costs and develop a better catalyst to drive machines. Research is concentrated on making units smaller and easier to use.

In the stationary power market, fuel cells could become competitive if they reach an installed cost of \$1,500 or less per kilowatt. Companies aim to decrease costs to \$400 per kilowatt in that time frame. The cost is in the \$4,000+ range per kilowatt in 2007. In the automobile sector, a competitive cost is on the order of \$60 - \$100 per kilowatt, a much more stringent criteria.

Companies Profiled

Market Participants

Acumentrics	Acal Energy
Adaptive Materials	Adelan
Advent International	Agni
Alca Torda Applications	ALLPS Fuel Cell Systems GMGH
Anglo Platinum	Angstrom Power
Ansaldo Fuel Cells SpA-AFC	Apollo Energy Systems
Aperion Energy Systems	Astris Enrgi
Air Liquide	Ball Aerospace & Technologies
Ballard	Baxi Group
BCS Technology	BHP Billiton Olympic Dam Uranium Mine
British Nuclear Group (BNG)	Cameco
Ceramic Fuel Cells Limited (CFCL)	Celex Power
CellTech Power LLC	Cellennium
Cenergie Corporation	Ceramatec
Ceres Power	Clean Fuel Generation
CMR Fuel Cells	Connecticut Clean Energy Fund
Coval H2	CTP Hydrogen
Daimler Chrysler	Delphi
DE NORA s.p.a.	Dias Analytic
Donaldson Company	DTI Energy
Dupont	EBZ Entwicklungs
ESL Electric Auto Science	Electotec
ElectroChem	Element 1 Power Systems
Electric Power Research Institute	Electronic Machining s.r.l.
Emprise	Entegris
Eneco	ENrG
EnergySolutions	Energy Resources of Australia Ltd.
Engelhard	Esoro
Evonyx-eVionyx	Exelon Generation Company LLC
Five Star Technologies	Fuel Cell Components and Integrators
Fuel Cell Control	FuelCell Energy
FuelCells Ltd	Fuel Cells Canada
FuelCell Energy	Fuel Cell Technologies Ltd
Fuel Cell Technologies	Fuji
Franklin Fuel Cells	GE

Market Participants (Continued)

GenCell	General Hydrogen
Gesellschaft fur Angewandte Technik	Global Thermoelectric!
GreenVOLT	GTI-Ga Technology Institute
Hoku	Honda
HyrdoGen	Idaho National Laboratory
IDACORP	Impala Platinum
Ion America	LOGANEnergy
McDermott International	Matsushita Electric Industrial Co. Ltd
Mesoscopic Devices	Millennium Cell
Mitsubishi	NanoDynamics
Navoli Mining and Metallurgical Combine	Nu Element
Nuclear Construction Contractors	Nuvera Fuel Cells
Palcan	Pinnacle
Plug Power	Pacific Telepoint
Parker Hannifin	PEMEAS Polymer Electrolyte Membrane
Power Air Corporation	Praxair
Priargunsky	Prometheus Resources Guyana
Protonetics	Protonex Technology Corporation
Proton Energy Systems	ReliOn
Rolls Royce Group	Rossing
RWW Nukem	Solid State Energy Conversion Alliance
Siemens	Sulzer Group
SXR Uranium One	Takagi Industrial Co, Ltd
Toshiba Polymer Electrolyte Fuel Cells	TOTO
Ultracell	Umicore
Unitec Ceramics	Uranium Information Centre Ltd
United States Enrichment Corporation Inc	United Technologies
Viaspace	WMC
ZAO independent Power Technologies	ZTEK

World Energy Market Shifts, Forecasts, and Strategies 2007-2013

REPORT METHODOLOGY

THIS IS THE 309TH REPORT IN A SERIES OF MARKET RESEARCH REPORTS THAT PROVIDE FORECASTS IN COMMUNICATIONS, TELECOMMUNICATIONS, THE INTERNET, COMPUTER, SOFTWARE, TELEPHONE EQUIPMENT, HEALTH EQUIPMENT, AND ENERGY. 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. 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 PARTICIPATION 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. INTERVIEWING KEY INDUSTRY PARTICIPANTS, EXPERTS AND END-USERS. OUR RESEARCH INCLUDES ACCESS TO LARGE PROPRIETARY DATABASES. LITERATURE SEARCH INCLUDES ANALYSIS OF TRADE PUBLICATIONS, GOVERNMENT REPORTS, AND CORPORATE LITERATURE.

YOU MUST HAVE THIS STUDY

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