Overview of the ATP Premium Power Program: Power for the Digital Information Age

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Abstract

Premium Power is one of six new ATP focused programs that were created in FY1998. The goal of this program is to accelerate progress in the power technologies critical to the paradigm shift taking place in way people communicate and utilize electricity. Technologies within scope for the first competition included: advanced rechargeable batteries and other energy storage devices for portable wireless electronics (laptop computers, cellular telephones); solar PV power arrays and energy storage for new Low Earth Orbit (LEO) satellite based wireless telecommunications; distributed, standalone electric generation based on fuel cells, ultracapacitors and PV, especially intended for new broadband, fiber to the home telecommunications and for power quality applications. A total of 13 projects were selected for funding at over $62 million. With these awards, Premium Power has become the largest government funder of ultracapacitor R&D in the federal government. The Premium Power program also stands out in that it is the first to make significant government R&D funds available for standalone, distributed power technologies, for power quality and for the technologies important to powering broadband and wireless communications technologies.

The Advanced Technology Program

Started in 1990, The Advanced Technology Program(ATP) is a unique partnership between U.S. industry and government to advance the nation's competitiveness -- and economy -- by developing new, high-risk technologies that enable a broad spectrum of potential new applications, commercial products, and services (Fig.1). Through cooperative agreements with individual companies or groups of companies, large and small, the ATP invests in industrial projects to develop technologies with high-payoff potential for the nation (Fig.2). The ATP accelerates technologies that -- because they are risky -- are unlikely to be developed in time to compete in rapidly changing world markets without the stimulus of such a partnership of industry and government. By sharing the cost of such projects, the ATP catalyzes industry to pursue high risk, high payoff technologies.

Until 1994, the ATP used general competitions-- open to proposals in all areas of technology-- as its sole investment mechanism. With the increase in budget (Fig.3), the ATP added a new element to its investment strategy -- focused program competitions(Fig.4). Each type of competition has its unique advantages. General competitions ensure that all good ideas receive consideration, no matter what the technology area. Focused programs have proved to be an effective way of achieving more synergy and building technical momentum in specific areas with high payoff potential. Seventeen focused programs including Premium Power have been created to date. In total, with the General and Focused competitions, ATP has made 431 awards to 1010 participants for $2.783 billion in new advanced

technology development($1.386 billion from ATP and $1.397 billion from industry). Over half (55 percent) of these awards have gone to individual small businesses or to joint ventures led by a small business (Fig.5).

Each focused program within ATP has well-defined research and business goals. Often these involve the parallel development of a suite of interlocking R&D projects. By managing groups of projects which complement and reinforce each other, the ATP can increase its impact on technology and the economy. Since ATP is driven by the needs of U.S. industry, specific focused program areas are selected based on input received from industry- companies, trade associations, professional societies- and academia at open workshops and from numerous white papers.

ATP focused programs are selected based on four major criteria:

- Potential for U.S. economic benefit.
- Window of technological opportunity.
- Strong industry commitment.
- The opportunity for ATP funds to make a significant difference.

ATP Premium Power Focused Program

Premium Power is one of six new ATP focused programs that were created in FY1998. The goal of the program is to accelerate progress in the power technologies critical to the paradigm shift taking place in way people communicate and utilize electricity. While the familiar model of large, centralized electric power generating plants supplying electricity to users through a grided infrastructure is not obsolete, there is burgeoning demand for what can be called Premium Power— small, localized, high-quality, tailored power sources.

This is largely an outgrowth of the global revolution and convergence taking place in information technologies, telecommunications, and electric power industries: portable wireless electronics in notebook computers and cellular telephones; growing networks of commercial Low Earth Orbit (LEO) satellites; high speed, multimedia broadband telecommunications whether wireless (Internet in the Sky) or fiber to the curb based; and a deregulated electric utility environment with growing global niche markets for standalone, blackout-free distributed electricity.(Fig.6)

For the 1998 competition (98-03) premium power technologies included advanced rechargeable batteries, photovoltaic (PV) arrays, integrated fuel cells, ultracapacitors and flywheels(Fig.7). Key applications for these technologies include (Fig.8):

- Portable wireless electronics—notebook computers, cellular telephones, smart cards, microstamp devices, and a host of other small handheld information devices — that require advanced batteries and other energy storage devices. By the year 2001 it is estimated that almost 3 billion recharge- able power batteries will be sold annually, generating over $6 billion in sales. Sixty-five percent of this usage will be for telecommunication and portable computers.

- New commercial Low Earth Orbit (LEO) satellites for broadband, wireless telecommunications networks—powered by high-performance photovoltaic (PV) power arrays and batteries. Planned LEO communications systems require many more satellites—with much shorter life spans—than geostationary satellites. Cost is a key factor, and the PV and battery arrays needed to power the satellites are a significant part of that cost.

- Distributed, standalone electric power for commercial and residential building uses, especially that intended for broadband terrestrial telecommunications (fiber optic nodes) and for power quality sensitive industries that widely employ digital microprocessors or are involved in continuous manufacture.

Potential for U.S. Economic Benefits

The potential for economic benefit from innovative premium power technologies is significant:

- The U.S. electronics industry is a world leader in communications and information sectors. These technologies are one of the U.S. greatest assets comprising 60% of the growth in GDP and 48% of exports. Many of these products are evolving into the high volume, low cost, consumer products made possible by American leadership in portable electronic devices, software and in the paradigm shift now occurring in satellite and terrestrial broadband communications.

  The National Electronics Manufacturing Initiative(NEMI) made up of the major U.S. electronic manufactures and suppliers has identified advanced batteries and other energy storage systems as one of six core technologies critical to portable, hand held electronic products. A technology roadmap, which served as the basis for the energy storage goals of this program, has been produced with input from large and small battery companies, their customers and universities, that is aimed at establishing strong U.S. leadership in the next decade in rechargeable battery technology and manufacture.

- Today's narrowband communications system will transition to high speed, broadband, multimedia networks that will permit audio, full action video and data text and graphics to be integrated together over the same communication medium. More and more-varied digital network systems and transmission media are being tied together from fiber to the curb and home to new wireless, low earth orbit (LEO)satellite-based networks. And there is growing expectation that all systems should be accessible seamlessly by anyone, anywhere on earth at any time. The network required by this revolution is broadband, digital, and able to serve high density mobile communications and portable electronic devices like cellular telephones, laptop computers and hand held electronic devices. Broadband communications will require an increasingly non-grid connected array of remote antenna sites, fiber-wire node interfaces and extremely reliable microprocessors with a 10-fold increase in power expected per customer 'telephone' line.

- Globally, PV arrays and batteries or small fuel cell systems are ideal for providing electric and wireless telephone service for the more than 2 billion people in the world without access to

electricity or for those who live in countries where the grid is unreliable and subject to outages. China, for example, boasts more pocket beepers than any country outside of the U.S. Sao Paulo, Brazil has more mobile phone users than Paris, France. Thus, developing countries can "leapfrog" generations of intermediate technology in the West.

- The Electric Power Research Institute (EPRI) estimates that 40 percent of all electricity flows through or is controlled by digital electronics—65 percent by 2000. Brief interruptions that would be acceptable in a light bulb can lead to costly and prolonged outages in high-speed digital networks. Power quality problems also beset companies that use microprocessors for process control. It is estimated that $26 billion in losses result annually from power outages and poor power quality in the United States alone.

Industry Commitment

This program was developed based on more than 50 white papers and detailed discussions with most of the major U.S. rechargeable battery companies; photovoltaic manufacturers; technology developers of fuel cells, ultracapacitors, and flywheels; end-users of these technologies in the telecommunications, portable electronics, aerospace and quality power industries; and trade associations, universities, environmental organizations, and other government agencies. It reflects industry concerns expressed in technology roadmaps and policy statements of industry groups such as the National Electronics Manufacturing Initiative (NEMI), EPRI, the Quality Power Alliance, and the Council on Competitiveness.

Window of Technological Opportunity

During the 1990's there have evolved a number of new developments in thin film and solid state ionic power devices which represent radical departures from previous practice and present a window of technological opportunity which can boost U.S. competitiveness. These include:

-novel thin film materials and membranes used in unique multilayer device designs. Examples include: thin film amorphous silicon(a-Si), cadmium telluride(CdTe) and copper indium diselenide(CIS) solar cells; proton exchange and solid oxide ceramic membrane fuel cells; lithium-ion batteries employing solid state organic electrolytes and novel intercalation anodes and cathodes; new carbon and polymer chemistries .

- development new lightweight, high energy battery electrochemistries such as nickel metal hydride and lithium ion "rocking chair" batteries where a single ion is shuttled back and forth between anode and cathode on charge and discharge.

- Potential for new processing enhanced by increased molecular modification that the new polymer, ceramic and thin film technologies offer. The multilayer technologies employed open up the possibility of rapid, high volume, low cost fabrication on an automated continuous, batch or roll-to-roll basis. Large

areas can be covered with good materials utilization in a flexible shape format. Automated monolithic integration of many cells becomes feasible.

Critical importance of the $/ Watt benchmark. For power applications, technology is driven by performance and cost drivers. New technologies need to achieve a critical $/Watt benchmark for project success and commercial adaptation.

$$\$/W = \$/ m^2 \times (W/m^2)^{-1} = \$/ kg \times (W/ kg)^{-1} = \$/liter \times (W/ liter)^{-1}$$

That is, power technologies are a function of the cost($) to manufacture a m^2 , kg or liter of power generating capacity and of the watts or kilowatts of power that are produced by that unit of capacity.These new technologies will be enabling to a new generation of cheaper, lighter, thinner more powerful electricity sources (Fig.9)

Technologies within scope for the 98-03 competition were limited to advanced rechargeable batteries, photovoltaic (PV) arrays, integrated fuel cells, ultracapacitors and flywheels.The program emphasized portable and distributed standalone power sources (milliwatts to kilowatts) with a premium on high electric quality and reliability that American telecommunications, electronics and power sensitive industries and their customers demand. Special emphasis was placed on long life whether it is expressed in terms of run time, cycle life or useful system life. Laptop computer users, e.g., would like to have a battery that would last for a good part of a day and not a few hours before recharging; a residentialfuel cell has to have a useful 10-20 year life i.e. 5-10X more operating life than an automotive fuel cell if customer expectations are to be met. The program targeted significant innovations in performance, cost effectiveness, and electric quality of portable and distributed power systems through advances in materials, processing, device designs, and systems integration.Within scope were proposals that addressed new high energy density batteries; novel solid state fuel cells and PV power modules suited to residential, commercial or small portable uses; high efficiency, low cost and low weight solar cells for space and terrestrial telecommunication uses; high pulse power flywheels and ultracapacitor devices based on new carbon and metal oxides. Power applications ranged from milliwatts needed in cell phones to < 250 kW distributed power limit. (Fig.10,11)

Premium Power Awards

On October 7,1998, the Advanced Technology Program announced the results of its 1998 Premium Power competition. As detailed in Table 1, thirteen projects were selected for co-funding with industry. Overall industry interest in the Premium Power program was high with the program receiving the most proposals(67) and making the most awards(13) of any of the 1998 ATP focused programs. If carried through to completion, the 13 projects selected will be funded at approximately $62 million with $29 million from private industry, matched by approximately $33 million from the ATP. Awards were made across the five technologies within program scope: fuel cells (4 awards, $25.6 million), PV solar cells (3, $10.3 million), ultracapacitors (3, $7.7 million), advanced batteries(2, $17.2 million) and flywheels (1, $1.6 million).

The Premium Power program is distinct among government programs in that it is the first to make significant government R&D funds available for standalone distributed power technologies and for the technologies important to powering civilian broadband and wireless communications applications. With the announcement of these 98-03 awards, Premium Power has become the largest government funder of ultracapacitor R&D in the federal government.

The majority of the awards,10, went to very small businesses that employ less than 50 employees, including several new startup companies, either for single-company projects or as the lead company in an industry joint venture. Eight universities and non-profit organizations plus three national laboratories are involved in the projects as formal participants or subcontractors. A total of 23 organizations in all are involved as proposers in addition to numerous subcontractors.

For further details on 1998 Premium Power awards check out the ATP website at:
http://www.atp.nist.gov/www/press/g98-74.htm
http://www.atp.nist.gov/www/comps/index98.htm#98-03

In addition, through earlier General competitions (open to all technologies and all applications) ATP has made four awards totaling $29.3 million that involves $13.5 million of ATP money for the development of new solar PV, solid oxide fuel cell and battery (e.g. novel Mg alloys for NiMH batteries) technologies.

ATP 1999 Competition

ATP has typically waited a year before running another solicitation in a focused program so there would not have been a second competition in Premium Power in FY1999. As announced in December 1998, all of ATP's money for new starts in 1999 will be put into **one competition open to all technologies and applications.** This Competition will award $66 million of ATP money for first year project funding in 1999. This effectively means that, as a result of joint industry - ATP investment, something of the order of $350 - $450 million in new R&D will be started in 1999 that will last over the next 3-4 years. Also this new competition, which is aimed at encouraging the broadest participation by industry, will retain one of the most important features of focused program competitions — project proposals will be evaluated and ranked in competition with others in the same technology area by sector boards. Abbreviated preproposals can be submitted to receive feedback on the suitability of a proposed project. Due date for full proposals: April 14,1999.

To obtain information about ATP and the kinds of projects we fund, check ATP out at: www.atp.nist.gov. For a proposal kit, call 1-800-ATP FUND. Questions: call Gerald Ceasar at 301-975-5069

Table 1

1998 Premium Power Competition Awards

Modular 2KVA Fuel Cell Power Plant with Live Replaceable, Self-Hydrating, PEM Smart Cartridges
AVISTA Labs, Spokane, WA

Advance the technology of proton exchange membrane (PEM) fuel cells with radical changes in design, materials, and manufacture that will reduce the cost of production an order of magnitude, enabling the manufacture of reliable, cost-effective modular fuel cell power plants for clean, stand-alone, distributed power.
Requested ATP funds: $2,000 K
Est. project budget: $3,225 K

Distributed Premium Power Fuel Cell Systems Incorporating Novel Materials and Assembly Techniques
Plug Power, LLC, Latham, NY
Polyfuels, Melo Park, CA
SRI, Melo Park, CA

Develop new, economically viable fuel cells that tolerate the high levels of carbon monoxide and that can operate with standard hydrocarbon fuels to provide power for residential and commercial service.
Requested ATP funds: $4,738 K
Est. project budget: $9,738 K

Propane-Fueled Fuel Cell Power System for Telecommunications Applications
H Power Corp., Belleville, NJ
Epyx/Arthur D. Little, Inc. (Cambridge, MA)

Develop small fuel cells that operate on propane and can be manufactured economically to replace batteries for telecommunications and ultimately other applications.
Requested ATP funds: $3,159 K
Est. project budget: $6,377 K

Reduced-Temperature, Electrode-Supported, Planar (RTESP) Solid Oxide Fuel Cell (SOFC) System for Premium Power Applications
Materials and Systems Research, Inc., Salt Lake City, UT

Design and demonstrate compact, highly efficient solid oxide fuel cell modules suitable for stand-alone distributed power applications, such as in providing on-site electricity and heat to homes and businesses, particularly those beset by outages or high energy-distribution costs.
Requested ATP funds: $1,991 K
Est. project budget: $3,046 K

Lightweight, Flexible, High-Efficiency CIS-Alloy Tandem Photovoltaic Devices
Global Solar Energy, LLC, Wheat Ridge, CO

Develop new materials and processes for making lightweight, highly efficient photovoltaic (PV) modules that will enable dramatic reductions in the costs of space-based PV arrays for telecommunications and other applications and enhance affordability of terrestrial PV systems.
Requested ATP funds: $2,000 K
Est. project budget: $2,792 K

Novel Process for High-Efficiency Copper-Indium-Gallium-Diselenide (CIGS) Photovoltaic Modules
International Solar Electric Technology, Inc., Inglewood, CA

Develop a low-cost, high-volume process for making high-efficiency solar cells with a unique thin-film fabrication technique that allows precise control of component ratios, enabling economical use of solar cells in a variety of space and terrestrial applications.
Requested ATP funds: $1,295 K
Est. project budget: $1,541 K

Superstrate to Enable Cost-Effective Solar Electric Power Generation
MicroCoating Technologies, Atlanta, GA
PPG Industries, Inc. (Pittsburgh, PA)
Solarex (Frederick, MD)

Develop the new open-atmosphere combustion chemical vapor deposition thin-film process for use in a glass manufacturing line to enable the production of less expensive, better-performing thin-film photovoltaic cells, removing one of the biggest obstacles to widespread commercialization of solar electric power.
Requested ATP funds: $2,958 K
Est. project budget: $5,981 K

Higher Voltage, Lower Impedance Aerogel Ultracapacitor
PowerStor Corporation, Dublin, CA

Radically improve ultracapacitors with new aerogel carbon electrodes to enable development of the next generation of personal computers and portable telecommunication devices.
Requested ATP funds: $2,000 K
Est. project budget: $3,354 K

Asymmetric Supercapacitor Based Upon Nanostructured Active Materials
US Nanocorp, Inc., North Haven, CT
Eveready Battery Co. (Westlake, OH)
JME, Inc. (Shaker Heights, OH)
Florida Atlantic University (Boca Raton, FL)

Create new economical, long-lived supercapacitors with unparalleled energy and power output capabilities—over 20 watt-hours and five kilowatts of power per kilogram—for uses that include wireless communications, computer backup power, and hybrid electric vehicles, outperforming batteries in many applications.
Requested ATP funds: $441 K
Est. project budget: $900 K

Advanced Materials and Processes for Cost-Effective High-Power Ultracapacitor Modules
Maxwell Energy Products, Inc., San Diego, CA

Develop new materials and device designs to improve the performance and reduce the costs of ultracapacitors, which could save U.S. industry billions of dollars in lost productivity, reduce fuel consumption in vehicles, and extend the life of electronic devices.
Requested ATP funds: $2,000 K

Est. project budget: $4,219 K

Preparation and Fundamental Evaluation of Catalytic Materials for Energy Applications
Superior MicroPowders, Albuquerque, NM

Develop and scale up a novel process to make high-purity nano- and micro-structured electrocatalyst materials for higher performance metal/air batteries and proton exchange membrane fuel cells.
Requested ATP funds: $2,000 K
Est. project budget: $3,843 K

Advanced Lithium Solid Polymer Battery Development
Ultralife Batteries, Inc., Newark, NY
Eagle-Picher Industries, Inc. (Joplin, MO)
Lockheed Martin Missiles & Space Company (Sunnyvale, CA)

Develop lithium-ion solid polymer batteries with twice the energy-carrying capacity of present batteries, potentially giving the United States the lead in the market for batteries to power portable electronic products and space vehicles.
Requested ATP funds: $7,263 K
Est. project budget: $15,263 K

Passive Magnetic Bearings for Power Quality Flywheel Systems
Trinity Flywheel Power, San Francisco, CA

Develop passive magnetic bearings to enable the design and manufacture of extremely long-lived, maintenance-free, flywheel systems used to provide backup power for sensitive, high-power applications such as equipment that would be affected severely by momentary power outages and voltage spikes.
Requested ATP funds: $800 K
Est. project budget: $1,618 K

U.S. Department of Commerce
Technology Administration
National Institute of Standards and Technology
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ADVANCED TECHNOLOGY PROGRAM

Overview of the ATP Premium Power Program

Power for the Digital Information Age

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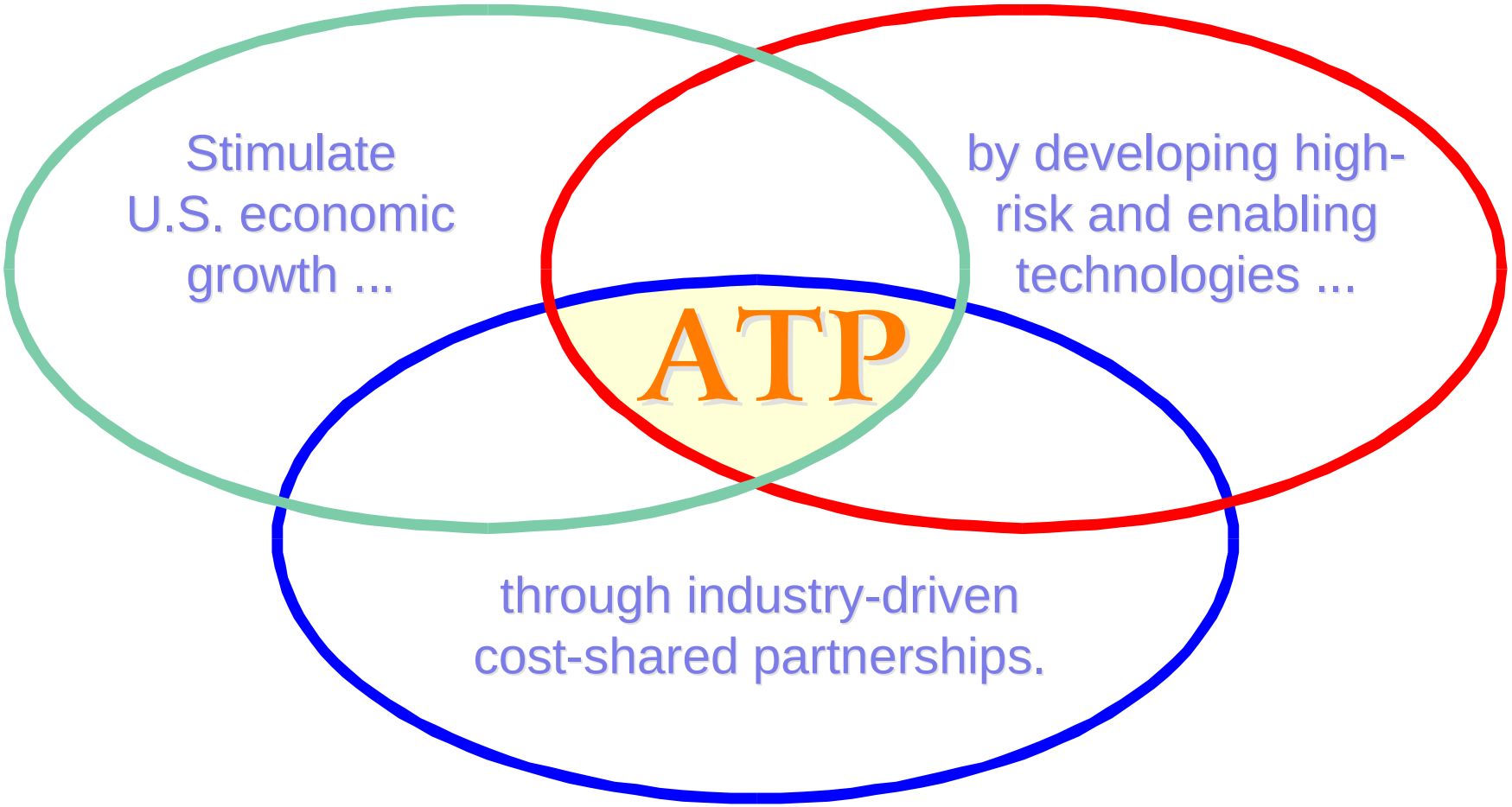
ATP Mission



Our Partners

- Small businesses are thriving
  - > 50% of projects led by small businesses
  - Joint ventures have many small business participants
- Universities play a significant role
  - > 125 different universities involved
  - > 400 instances of participation
- Federal laboratories participate

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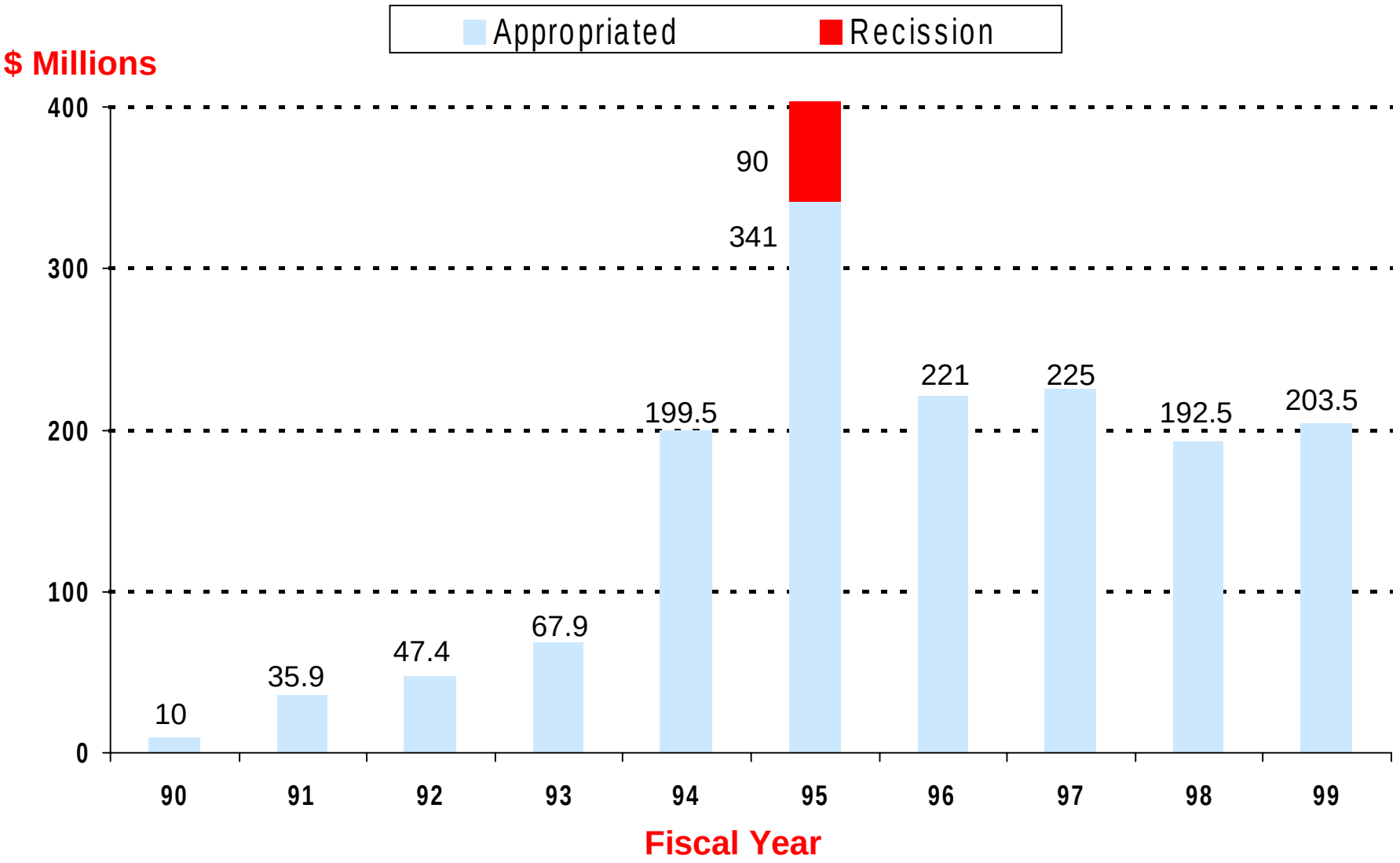
ATP Budget Profile



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Status of ATP

Our Status to Date

- 3,585 proposals submitted by industry
- 431 projects cofunded with 1,010 participants
- $2.783 billion of advanced technology development funded
  - ✓ ATP Share = $1.386 billion
  - ✓ Industry Share = $1.397 billion

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Two Ways to Participate in ATP

- **General Competitions**

  (Open to all technologies/industries)

- **Focused Program Competitions**

  (Clusters of related projects)

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Premium Power

* Targets the enabling, value-added power technologies critical to the sweeping changes taking place in information systems, telecommunications, and the electric power industries

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Waves of Change

INDUSTRY	LAST 20 YEARS	NEXT DECADE OR BEYOND
Information Systems	Central Mainframes giving way to PC/LANs	PC/LANs with high speed Internet Connected laptops, PDAs
Telecommunications	Analog, Narrowband copper wire	Digital high speed multimedia broadband Fiber to the home or wireless Digital cellular
Aerospace Satellite Telecom	Single, powerful GEO satellites, long delay	Multi Leo satellite networks Internet in the Sky
Electric Utilities	Grid connected Central Generation	Deregulated environment Important niches in distributed high quality "green" power

***Bottomline*: Growing convergence, interdependence between these industries with systems architectures that are more dispersed and targeted at global markets. Value added, high quality electric power emerging that meets customer needs.**

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Premium Power Technologies

- Advanced Rechargeable Batteries
- Photovoltaic Solar Modules
- Fuel Cells
- Ultracapacitors
- Flywheels

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Commercial Applications

- Targets the power technologies for the digital information age:

  - ✓ *Advanced batteries and ultracapacitors for portable wireless electronics*
  - ✓ *Photovoltaic(PV) power arrays and energy storage for new Low Earth Orbit satellite (LEOS)*
  - ✓ *Distributed standalone electric power for commercial/residential buildings, for broadband telecommunications and power quality uses.*

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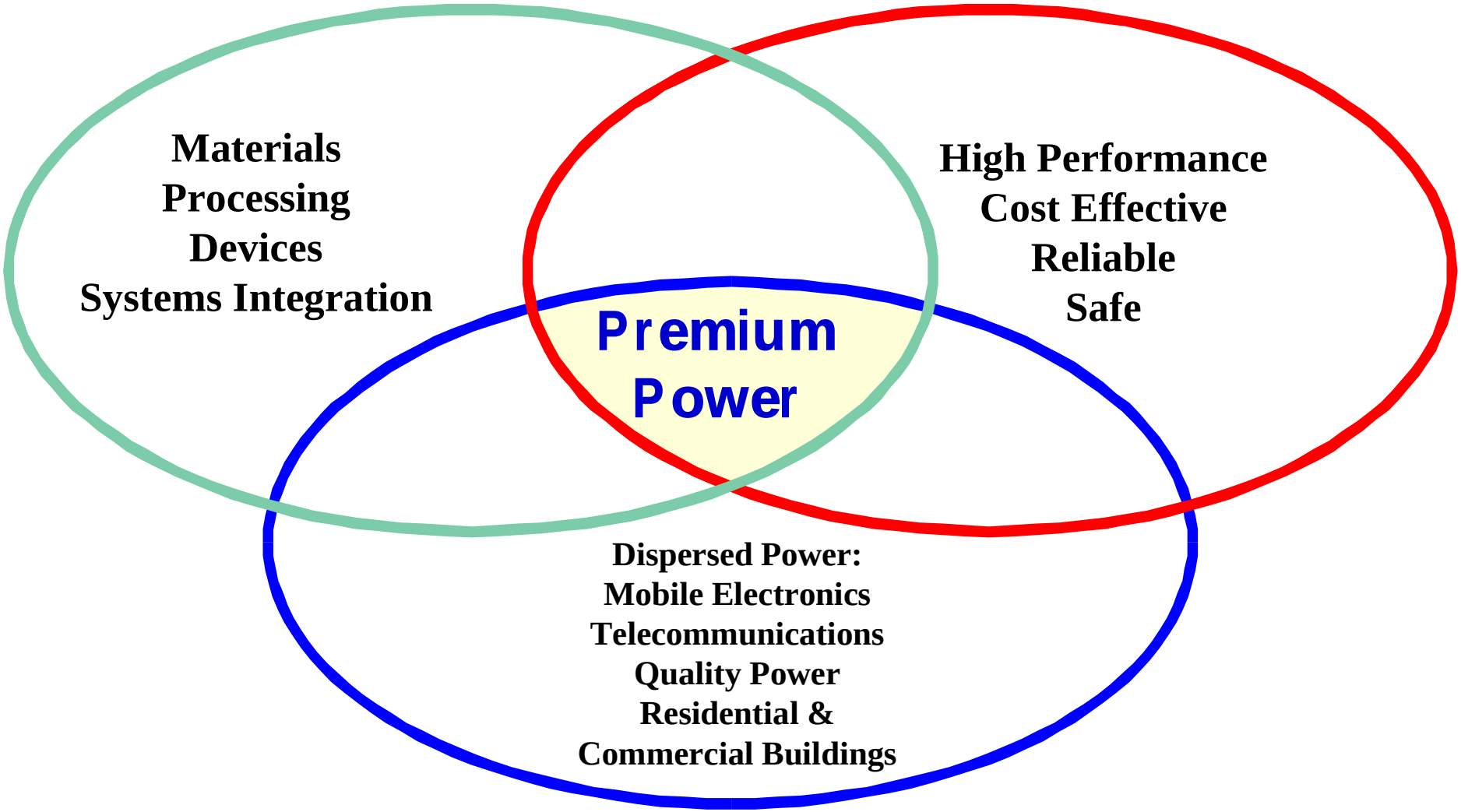
Technical Scope



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Technical Scope (con't)

	In Scope	Out of Scope
Advanced Rechargeable Batteries	High energy density chemistries	Low risk modifications of rechargeables already in the marketplace. Pb-acid, NiCd; primary batteries
Fuel Cells	All solid state fuel cells suited to distributed power use e.g. polymer and ceramic electrolyte membrane fuel cells (PEM & SOFC)	Technologies for central utility use. Liquid electrolyte fuel cells (phosphoric acid and molten carbonate)
Electrochemical, Ultracapacitors	High pulse power, double layer devices such as those based on new carbon and metal oxides	Traditional bulk electrolytic capacitors

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Technical Scope (con't)

	In Scope	Out of Scope
Photovoltaic Solar Cells (Solar Batteries)	High efficiency, cost effective, low weight solar cells that can meet demands of LEO space or terrestrial telecom and distributed power uses.	Crystalline silicon Modifications of present expensive GEO PV cells
Flywheels	New materials and reliable, safe designs that significantly overcome present limitations	Modules that are in a phase of advanced product development

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1998 Premium Power Competition

- Excellent response - largest number of proposals received in 8 focused competitions.

- $62 million awarded to 13 projects
  Batteries(2) Fuel Cells (4) Ultracapacitors(3)
  PV(3) Flywheels(1)

- Very small businesses did very well.

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98-03 Awards

- AVISTA Labs
- Plug Power, W.L. Gore
- H Power, Epyx/Arthur D. Little
- Materials and Systems Research
- Maxwell Energy Products
- PowerStor
- US Nanocorp, Eveready, JME, Florida Atlantic U
- Ultralife Batteries, Eagle Picher, Lockheed Martin
- Superior MicroPowders
- Global Solar Energy
- International Solar Electric Technology
- MicroCoatingTechnologies PPG, Solarex
- Trinity Flywheel Power

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FY 1999 Competition Changes

What's New in FY 1999 . . .

- $66 Million in first-year funding leverages $350-$450 Million in R&D investment
- Technology-Specific Source Evaluation Boards
- Two Selection Criteria Weighted Equally
  - ✓Scientific and Technological Merit
  - ✓Broad-Based Economic Benefits
- Continuous Pre-proposal Evaluation (optional)
- Large Company Defined by Revenue of $2.721 Billion per Year

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Contact Information

http://www.atp.nist.gov

To Get on the ATP Mailing List:

Call toll-free:	800-ATP-FUND (800-287-3863)
Fax your name and address to:	(301) 926-9524
Send an e-mail message to:	atp@nist.gov

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ATP Focused Programs

- Tools for DNA Diagnostics
- Information Infrastructure for Healthcare
- Manufacturing Composite Structures
- Component-Based Software
- Technologies for the Integration of Manufacturing Applications (TIMA)
- Tissue Engineering
- Photonics Manufacturing
- Premium Power
- Selective-Membrane Platforms
- Catalysis and Biocatalysis Technologies
- Motor Vehicle Manufacturing Technology
- Digital Data Storage
- Digital Video in Information Networks
- Vapor Compression Refrigeration Technology
- Materials Processing for Heavy Manufacturing
- Microelectronics Manufacturing Infrastructure
- Adaptive Learning Systems