

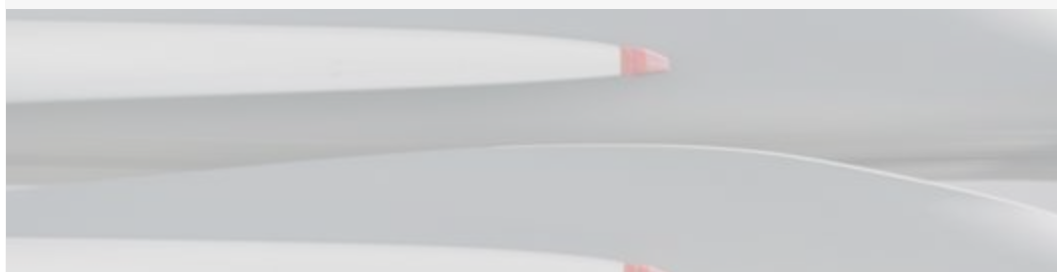


US Utility-Scale Battery Storage Market Surges Forward



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ID# NARP 825-110928



28 September 2011

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US Utility-Scale Battery Storage Market Surges Forward

Summary

Batteries are the most likely technology to capture the grid storage market opportunity, benefiting from flexible siting, performance, and scaling advantages relative to alternatives

- A challenging permitting environment to develop large generation and transmission assets, coupled with a drive to reduce power sector emissions, will accelerate interest in battery technology to optimize efficiency of the power grid and to integrate renewables
- Aside from battery's high cost, the lack of long-term offtake agreements for storage services remains the biggest hurdle to faster deployment
- The long-term trajectory of battery cost reductions, technology lifetime, and performance attributes remain highly uncertain, with the next wave of demonstration projects key to understanding battery's scaling potential for grid applications

Grid-scale battery installations will surge in 2011 and 2012, with 34 individual projects planned for completion, representing more than 230 MW (260 MWh) and US\$500 million in total capital investment

- Driven by utility research and development initiatives, the majority of battery demonstration activity is shifting from substation-level transmission and development (T&D) investment to community energy storage, renewables integration, and ancillary services
- Federal funding awarded by the US American Recovery and Reinvestment Act of 2009 (ARRA) is playing a modest role in spurring project activity: about one-fourth of the total utility-scale project demonstrations planned (on a capacity basis) have received a combined US\$92 million to date

Led by ISO-New England, New York-ISO (NYISO), and PJM, regional markets are advancing rules rewarding battery's storage benefits, unlocking niche, commercial opportunities

- With the greatest value proposition for providing quick-response ancillary services, NYISO and the Eastern PJM region are leading the way. These regional markets are providing incentives for faster-response storage, giving batteries an edge relative to traditional resources
- California's AB2541 policy, coupled with the state's significant renewables requirement, positions California to lead the opportunity for integrating storage with renewables on the mainland
- Hawaii is also a hotbed of demonstration activity, as the state looks to meet lofty renewable policy goals and maintain grid reliability

US Utility-Scale Battery Storage Market Surges Forward

Summary (continued)

The battery market will be driven mainly by regulated utilities in the near term

- Accounting for over half of ongoing battery project activity in the US, utilities are expected to remain the most active, focusing on deferring T&D investments, offsetting peak load, firming renewables, and increasing reliability via community-scale opportunities
- AES Energy Storage (AES ES) has established an early-mover position as an independent storage services provider, tapping its global footprint for scaling a battery-focused storage portfolio
- A handful of developers and independent power producers (IPPs) have sought to integrate storage with renewable projects, but a lack of high-value market opportunities, a low gas price outlook, and surplus capacity in many markets creates significant headwinds to integrated battery-renewable development projects in the US for the next several years

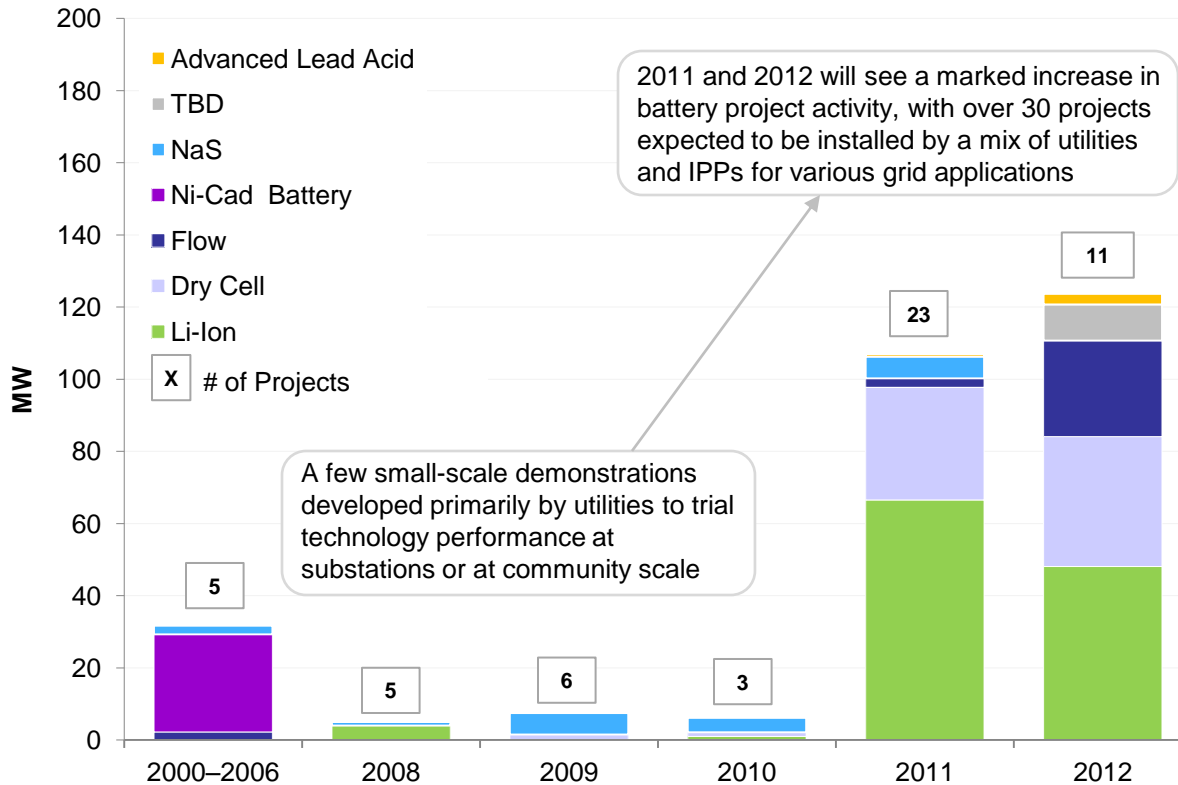
The battle for technology supremacy has not been decided for grid applications, with advanced lead acid and Flow batteries leading on cost, but with optimism that lithium-ion (Li-ion) can catch up

- Li-ion offers potential for low capital costs, but is challenged by limitations on storage duration, creating uncertainty about the competitiveness of large-scale battery technologies
- Advanced lead acid technologies show promise for medium-term storage opportunities, building off of a long track record of technology development and testing for grid applications
- Flow technologies have a cost edge for longer-duration storage applications, but high parasitic energy requirements and lack of manufacturing scale will remain barriers to rapid cost declines

US Utility-Scale Battery Storage Market Surges Forward

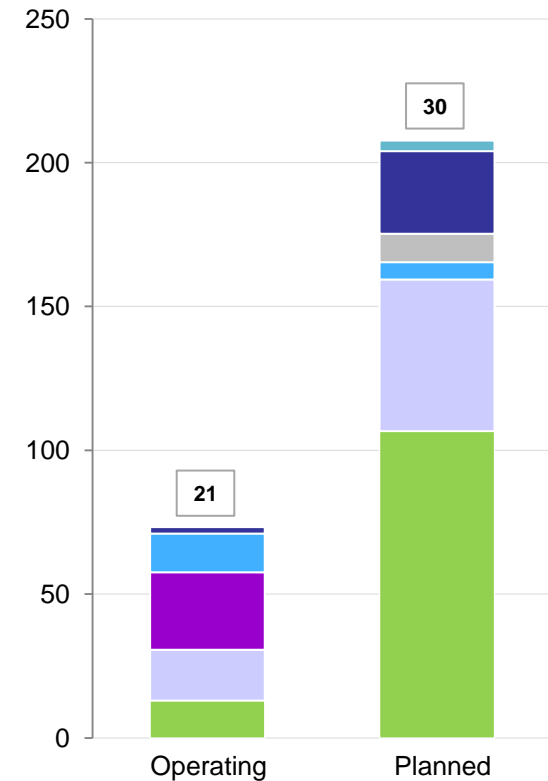
Battery Project Development in the US

Operating Battery Capacity vs. Near-Term Project Pipeline



Source: IHS Emerging Energy Research

Operating vs. Planned



More than 200 MW (230 MWh) of utility-scale battery projects are targeting deployment in the next two years, driven by a combination of US government funding, the evolution of niche commercial opportunities to provide ancillary services, and interest to support renewables integration

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Storage Market Rules in Organized Power Markets

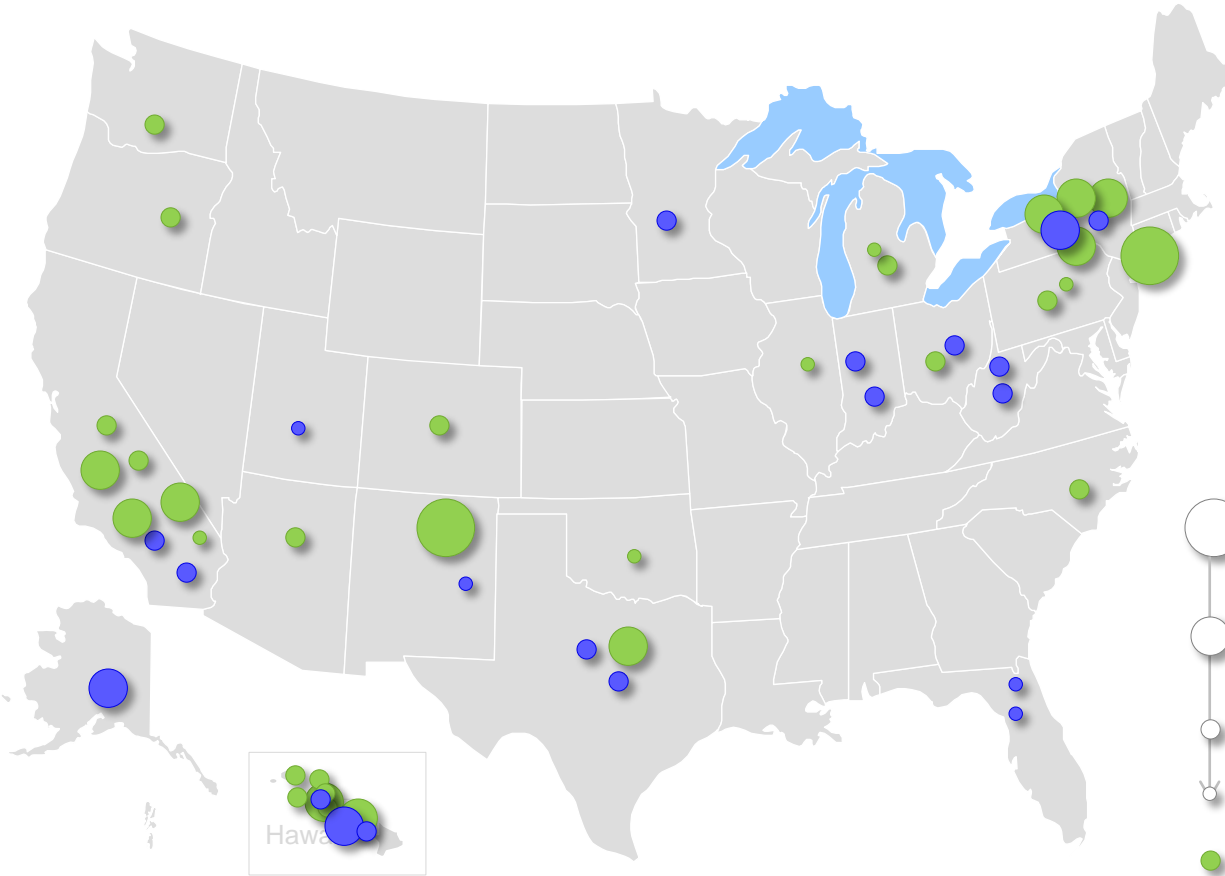
Attractiveness of Market Rules for Battery Storage

	Market Rules for Energy Storage and Key Implications	Outlook
FERC	<ul style="list-style-type: none"> • FERC's 2011 Notice of Proposed Rulemaking (NOPR) on Frequency Regulation proposes that RTOs/ISOs implement "pay for performance" based on accuracy and frequency of storage service • FERC issued a Notice of Inquiry to facilitate competitive markets for ancillary service providers, as well as to assess what barriers exist to storage participation 	<ul style="list-style-type: none"> • No statutory deadlines for FERC action
NE-ISO	<ul style="list-style-type: none"> • First market to establish "pay for performance" for energy storage devices, influencing FERC's NOPR • Storage compensation based on resource capacity, a "mileage payment", and regulation opportunity cost • Presence of pumped-hydro resources, however, depress the near-term need for battery storage 	<ul style="list-style-type: none"> • Current rules in place, no known plans to further advance storage compensation market
NY-ISO	<ul style="list-style-type: none"> • Most advanced regional storage market; high regulation prices attractive for developers • Special rules for "Limited Energy Storage Resources" (LESRs) to participate in the regulation market • Compensation includes an accuracy component, but differs slightly from NEISO's "pay for performance" model 	<ul style="list-style-type: none"> • NYISO considering six-second dispatch from just LESR to all regulation service entities, which would further level the playing field, benefiting battery storage
PJM	<ul style="list-style-type: none"> • PJM is looking to alter market rules to enhance the competitiveness of the distributed storage market • Task force established to implement "pay for performance", for storage devices • PJM looking to lower minimum capacity requirement to participate in the regulation market from 500 kW to 100 kW 	<ul style="list-style-type: none"> • New market rules expected to be passed by year-end 2011 and go to FERC for approval
CAISO	<ul style="list-style-type: none"> • California's AB 2514, passed in June 2011, directs the CPUC to establish binding storage targets for load-serving entities • This is unique, and is the first mandated storage portfolio in the United States 	<ul style="list-style-type: none"> • A final decision on the implementation of CPUC's rule is expected to be issued in the first half of 2012
ERCOT	<ul style="list-style-type: none"> • 2011 proposal to modify energy storage protocol failed to gain approval under stakeholder pressure to also qualify storage facilities as generation assets • Natural gas provides most of the ancillary services in the market, weakening the value of storage • Under current rules, storage costs can be recovered through transmission rates 	<ul style="list-style-type: none"> • The Technical Advisory Committee is expected to address the generation asset concern in its next meeting, creating a more favorable regulatory environment for batteries
MISO	<ul style="list-style-type: none"> • In 2010, MISO classified storage projects as Regulation Qualified Resources, permitting them to submit Regulating Reserve Offers in US\$/MW for use in the Energy and Operating Reserve Markets • MISO supports FERC's "pay-for-performance" NOPR for short-term energy storage; hydro power imported from Canada eyed as key storage resource to firm growing wind penetration 	<ul style="list-style-type: none"> • MISO is evaluating storage market rules and supports FERC's "pay for performance" NOPR, but is unlikely to advance any new market initiatives before 2012
SPP	<ul style="list-style-type: none"> • Early stages of evaluating market rules to support distributed storage market • SPP is keeping an eye on developments in MISO before altering any market rules • Current regional focus is on US\$5 billion for transmission upgrades 	<ul style="list-style-type: none"> • No plans to establish energy storage rules prior to 2014: possible exception is consideration of policies to support pumped hydro to balance wind

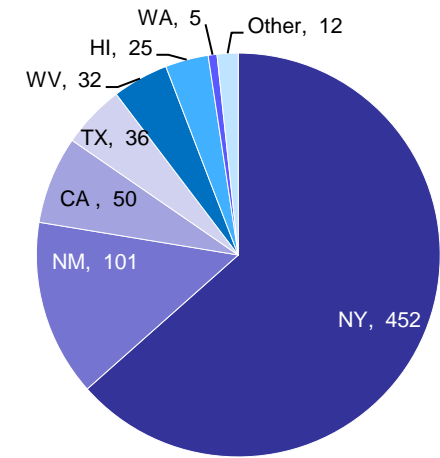
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Regional Utility-Scale Battery Activity

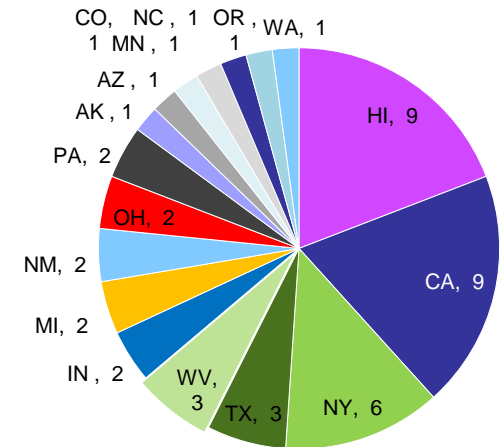
Planned and Operating Battery Projects in the US (>500 kW)



Planned Battery Capacity By State (MW)



Number of Utility-Scale Battery Projects by State



New York, Hawaii, and California are attracting the most battery project activity, driven by a combination of federal government funding, regulatory shifts, renewables growth, and state policy support

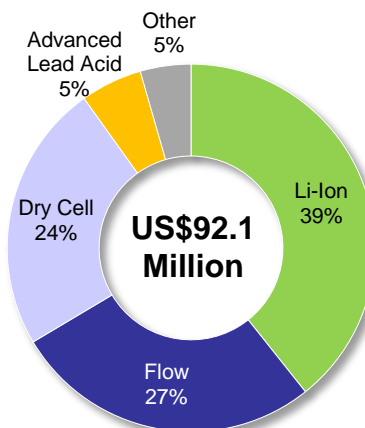
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US Federal Government Funding Awarded to Battery Projects

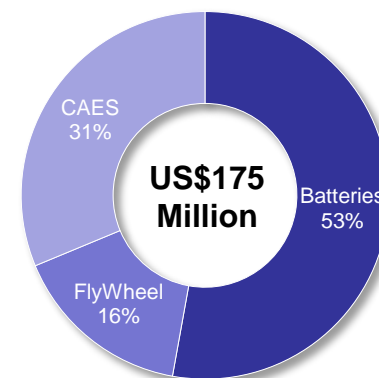
Project, Developer	Technology, Supplier	Funding Amount/ Total Project (US\$ Millions)	Project Size	Year Online	Application
US Government Grants Awarded to Battery Projects					
Southern California Edison (SCE)	Lithium-Ion, A123 Systems	25.0/53.5	8 MW (32 MWh)	2012	Demonstrate longer storage with Li-ion for grid improvement and wind integration
Modesto Irrigation District	Flow, Primus Power	14.0/46.7	25 MW (75 MWh)	2012	Displace investment in a gas peaker to firm wind generation
Duke Energy	Dry Cell, Extreme Power	21.8/43.6	20 MW (24 MWh)	2012	Wind project integration to manage wind intermittency
Premium Power	Flow, Premium Power	7.3/16.1	7 X 500 kW (3 MWh)	2011	Peak demand reduction and reduce power interruptions
Seeo	Lithium-Ion, Seeo	6.2/12.4	25 kWh	2012	Technology development
DTE	Lithium-Ion, A123 Systems	5.0/10.9	20 X 25 kW (50 kWh)	2011	Demonstrate secondary use EV batteries for community-scale applications
Painesville Municipal Power	Flow, V-Fuel	3.7/7.5	1 MW (7 MWh)	2012	Reduce ramping of existing 32 MW coal plant
Xcel Energy	Advanced Lead Acid, Ecoult	1.8/5.9	0.75 MW	2011	Solar integration
East Penn	Advanced Lead Acid, Ecoult	2.3/4.5	3 MW	2012	Frequency, regulation, and ancillary services
44 Tech	AqueousNA-Ion, 44 Tech	5.2/10		2012	Technology development of novel storage technology
Loan Guarantees Provided to Battery Storage Projects					
AES Energy Storage	Lithium-Ion, A123 Systems	17.1	12 MW (5 MWh)	2011	Brought online in 2011 in New York

Note: Excludes funding for battery manufacturing
 Source: DOE, IHS Emerging Energy Research

Grants by Technology



Overall Storage Funding

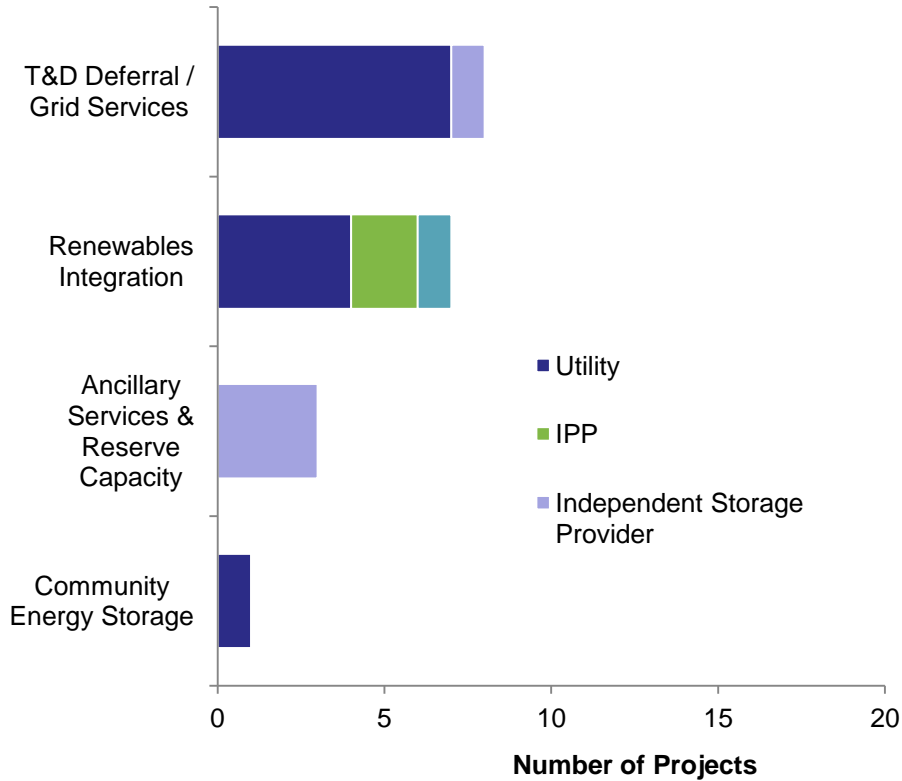


Federal ARRA funding is playing a modest role in spurring project activity: about one-fourth of the total utility-scale project demonstrations planned (on a capacity basis) have received a combined US\$92 million to date

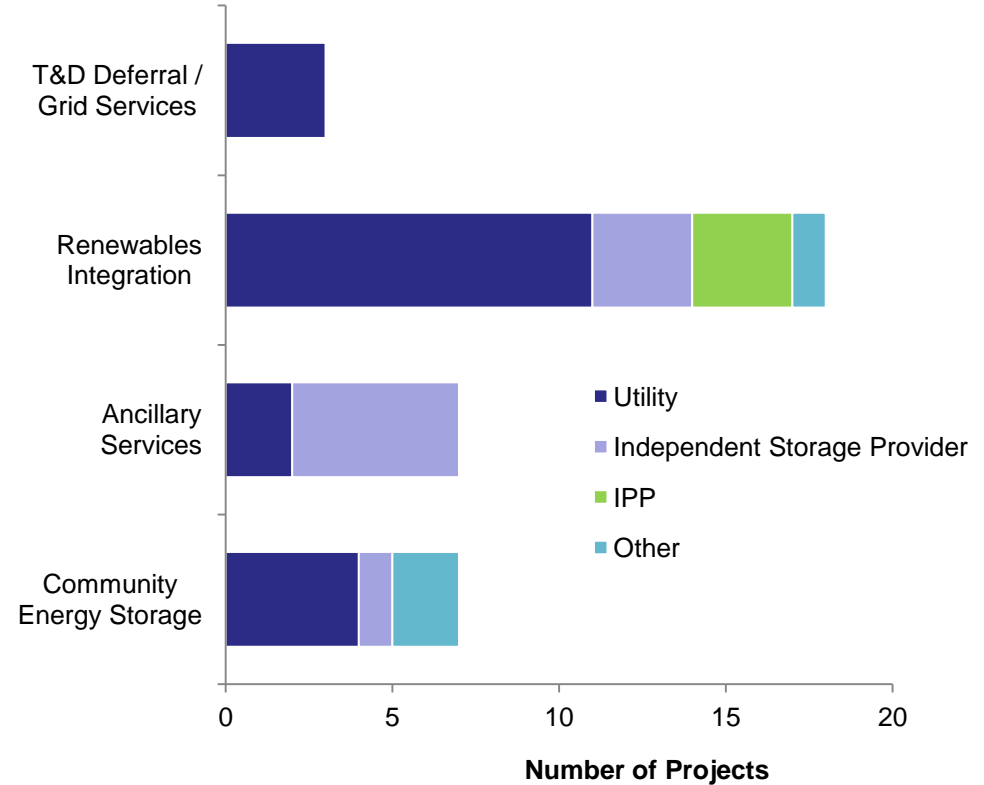
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Project Pipeline by Application

Operating Projects



Proposed Projects



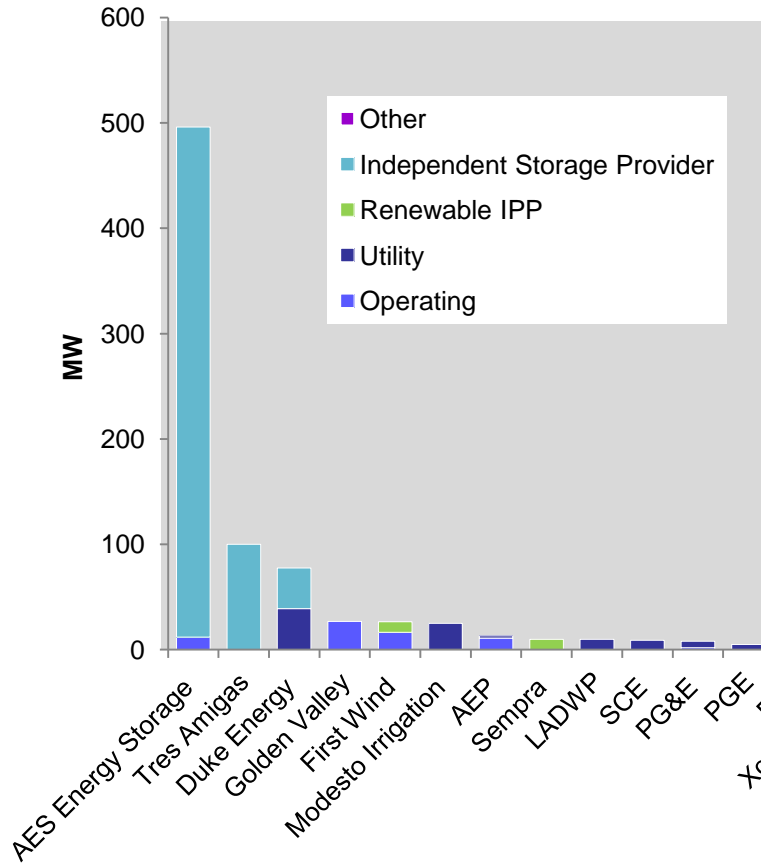
Source: IHS Emerging Energy Research

Led by utility demonstration projects, battery demonstration activity is shifting from substation-level T&D investment to community energy storage, renewables integration, and ancillary services

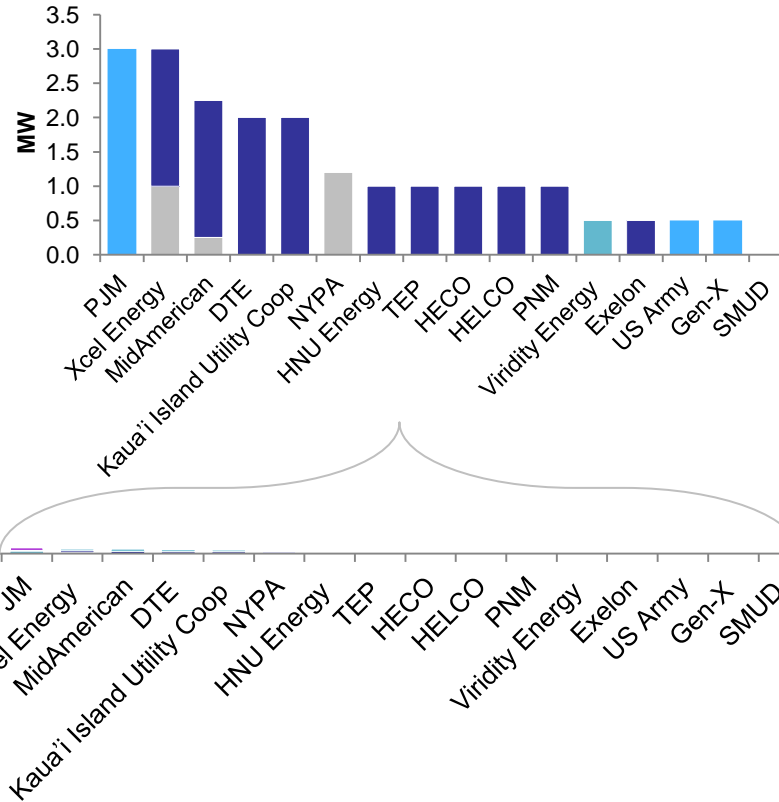
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US Battery Project Pipeline by Developer

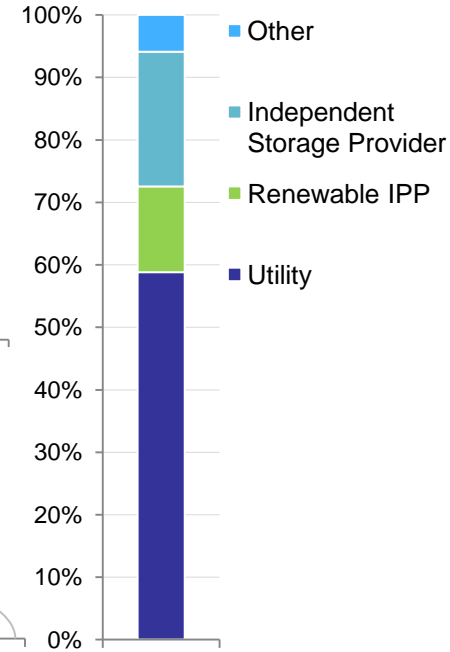
Pursuing Large-Scale Battery Projects (>5 MW)



Looking to Deploy Small-Scale Demonstration Projects (<5 MW)



Market Share by Developer Type (Number of Projects)



Source: IHS Emerging Energy Research

AES ES has been the most aggressive in pioneering a grid-scale battery storage strategy; a combination of other utilities and renewable IPPs including NextEra, Duke Energy, First Wind, AEP, Sempra, SCE, and PG&E are also advancing one or more battery projects >5 MW in size

US Utility-Scale Battery Storage Market Surges Forward

Evolving Battery Project Development Models

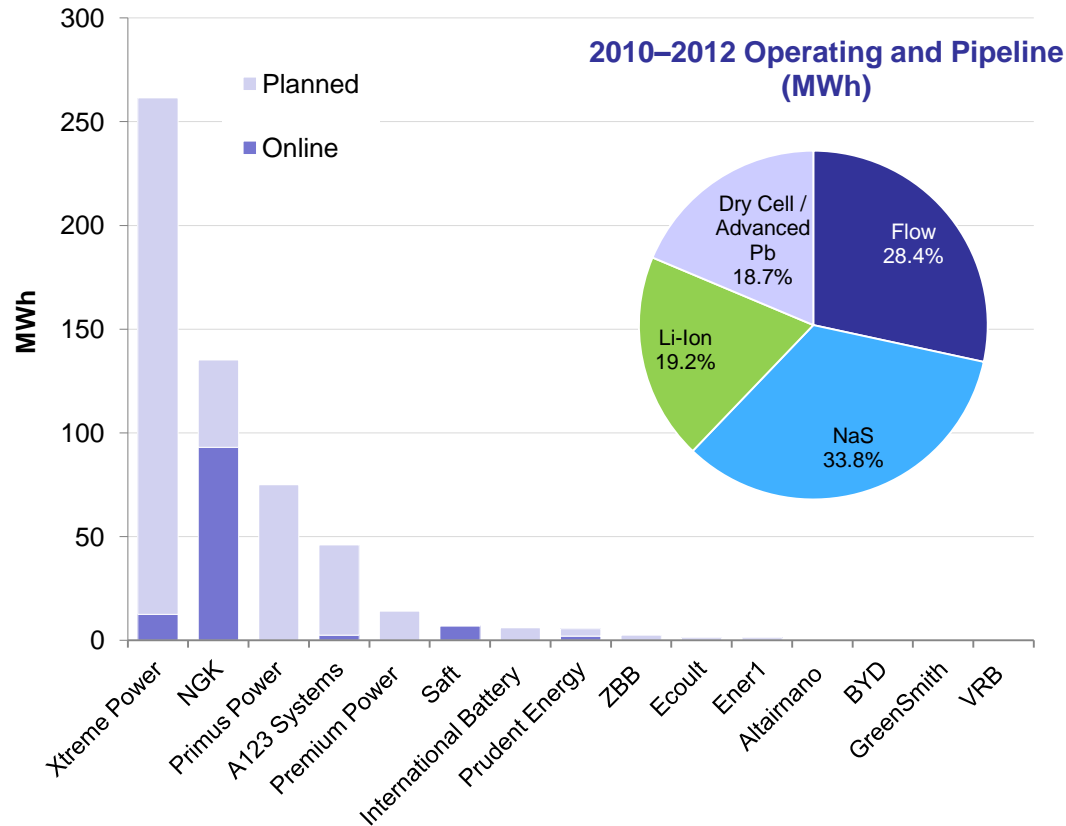
Business Models		Renewable plant owners looking to integrate storage to manage wind and solar intermittency		Independent storage services provider building early competitive advantage in development, ownership, and operation of battery systems			Utilities evaluating storage as a T&D asset to improve reliability, defer T&D investments, manage grid quality, or reduce peak demand		
Developer, Technology	Hours Storage	Ramp/ Voltage Support/ Time Shift	Bulk Storage Arbitrage	Energy	Supplant Spinning Reserve	Frequency Regulation / Ancillary	Peak Shaving / Load Leveling	Transmission / Distribution Deferral	Community Energy Storage
Duke, Dry Cell, Flow, Various	0.66 HR-4HR	Duke Energy					Duke Energy		
FirstWind, Dry Cell, Hawaii,	0.66-2 HR	First Wind					<i>Utilities integrating storage at distributed/ community level for peak-shaving and to increase reliability, while also evaluating ancillary services benefits</i>		
Sempra, TBD, Hawaii	TBD	Sempra							
XCEL, Dry Cell, NAS, MN, CO	1 HR	Xcel Energy							
AES, Li-ion, Various	0.25 to 4 Hrs	AES ES		AES ES					
AEP, Li-ion, NAS, Various	7 HR					AEP			
SCE, Li-ion, Flow, Various	4 HR					SCE			
DTE, Dry Cell, Li-ion, Various	0.25-2.66 HR	<i>Renewable plant owners testing batteries to reduce curtailment and manage intermittency in-house</i>		<i>Pioneer of the independent battery storage services business model</i>			DTE		
MidAmerican, Li-ion, Oregon						MidAmerican			
PG&E, NaS, Flow, Various	7-8 HR					PG&E			
Market Outlook		Growing interest in markets with high renewables penetration; however, outside of high-priced, isolated markets like Hawaii, battery economics are not viable without significant subsidies or battery cost reductions	Weak gas price, lack of long-term contract availability, and limited off-peak/on-peak price spread keep this a much longer-term option. Storage times >8 hours likely needed to fully unlock market potential	Commercial opportunity to enhance value of spinning reserve and to offset new capacity needs in short power markets, or markets with severe transmission congestion (NYISO)	Most commercial near-term opportunity, but market size expected to be limited, with potential mainly confined to New York and parts of Eastern PJM and California	Coupling ancillary services with peak shaving, and in some case T&D investment deferral, is the greatest focus of demonstration projects led by regulated utilities. Most have implemented projects at substations, and look to take advantage of the added benefit of better renewables integration	Opportunity could increase as solar PV integration behind the meter scales, creating much greater demand for localized voltage support		

Source: EPRI, Companies, IHS Emerging Energy Research

US Utility-Scale Battery Storage Market Surges Forward

Battery Manufacturers' Project Pipelines

Project Pipeline by Technology Supplier



Source: IHS Emerging Energy Research

Analysis

Xtreme Power captures most interest for grid applications

- Xtreme Power has attracted strong interest with an advanced technology specifically developed for the power market
- Led by A123, Ener1, and AltairNano, second-tier EV-focused Li-ion players are positioning for US grid applications, which may offer higher margins and bolster manufacturing scaling objectives

Japan-based NGK has the largest grid storage track record, but lack of price declines has detracted utilities

- While a few new projects are planned, the lack of cost declines over the past few years has driven utilities to look to other technologies

A plethora of flow battery players have emerged with venture capital funding for the bulk storage market

- Consolidation is likely among these early-stage players as market growth is expected to be slow
- Reducing costs and high parasitic energy needs will be key to future deployment of flow batteries

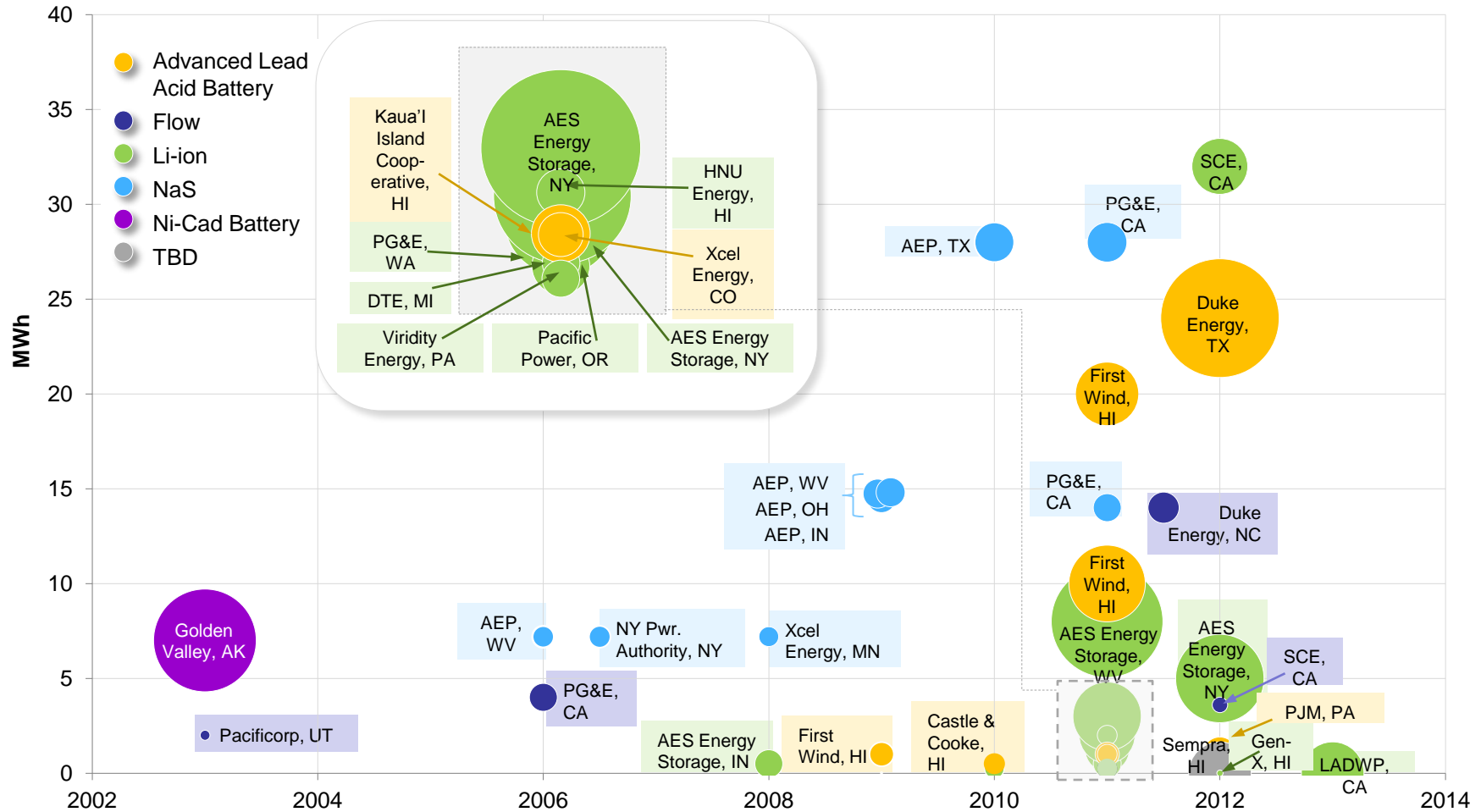
Samsung and EastPenn lead the players crossing over from the electronics and auto battery markets

- Samsung, the world's second-largest battery manufacturer, is eyeing synergies, with a growing focus on wind and solar in North America
- Led by EastPenn via its acquisition of Ecoult, large automotive battery manufacturing players are keeping an eye on grid storage

Xtreme Power and A123 Systems have been selected for the largest capacity projects, but a diverse field of technologies continues to be evaluated by utilities and IPPs seeking the technology with the greatest scaling potential

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Status of Project Development by Technology

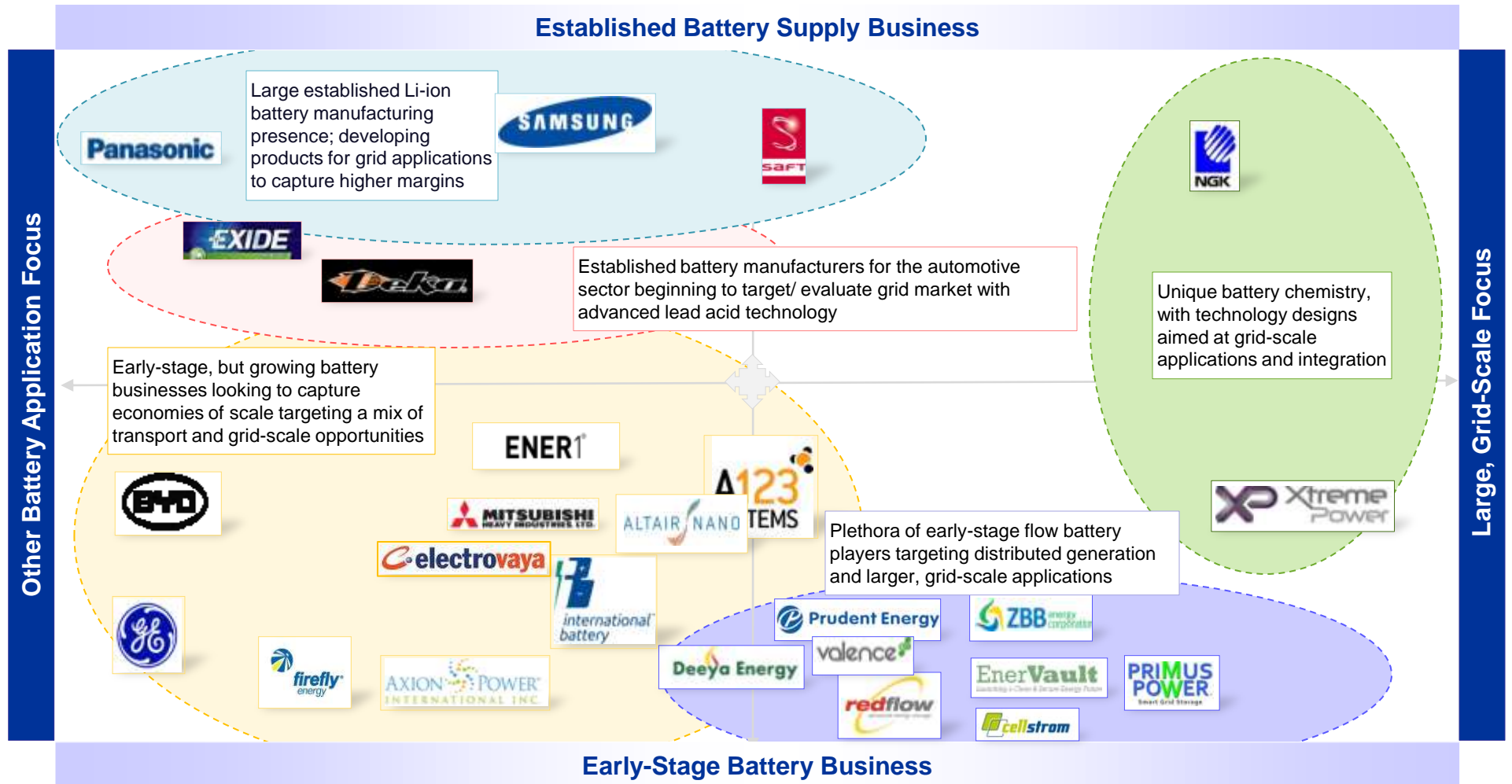


Source: IHS Emerging Energy Research

Demonstration battery projects are scaling up beyond 10 MWh as developers reach for added value market opportunities

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Positioning of Leading Battery Manufacturers Eyeing the Utility Market



Source: IHS Emerging Energy Research

More than 25 battery manufacturers at varying stages of maturity are targeting the utility segment

US Utility-Scale Battery Storage Market Surges Forward Technology Attributes and Manufacturing Maturity

Battery Technology Manufacturers

	Targeting Grid Market	Not Targeting Grid Market
Li-ion	<ul style="list-style-type: none"> • Saft • A123 Systems • Ener1 • BYD • Mitsubishi • International Power • Altairnano • Samsung • Valence • Toshiba • Hitachi 	<ul style="list-style-type: none"> • Blue Energy (Honda) • Panasonic (including Sanyo) • AESC (Nissan) • Dow / Kokam • Hitachi • LG Chem • SK Energy
NAS	<ul style="list-style-type: none"> • NGK 	
Flow (Vanadium Redox, ZnBr)	<ul style="list-style-type: none"> • Prudent Energy • ZBB • Primus Power • Deeya • RedFlow • MES-DEA 	
Dry Cell/ Advanced Lead Acid/ Zebra/ Metal Hydride	<ul style="list-style-type: none"> • Xtreme Power • Exide • EastPenn (Ecoul) • Axion • Firefly 	<ul style="list-style-type: none"> • GE

Source: IHS Emerging Energy Research

Battery Technology Comparison

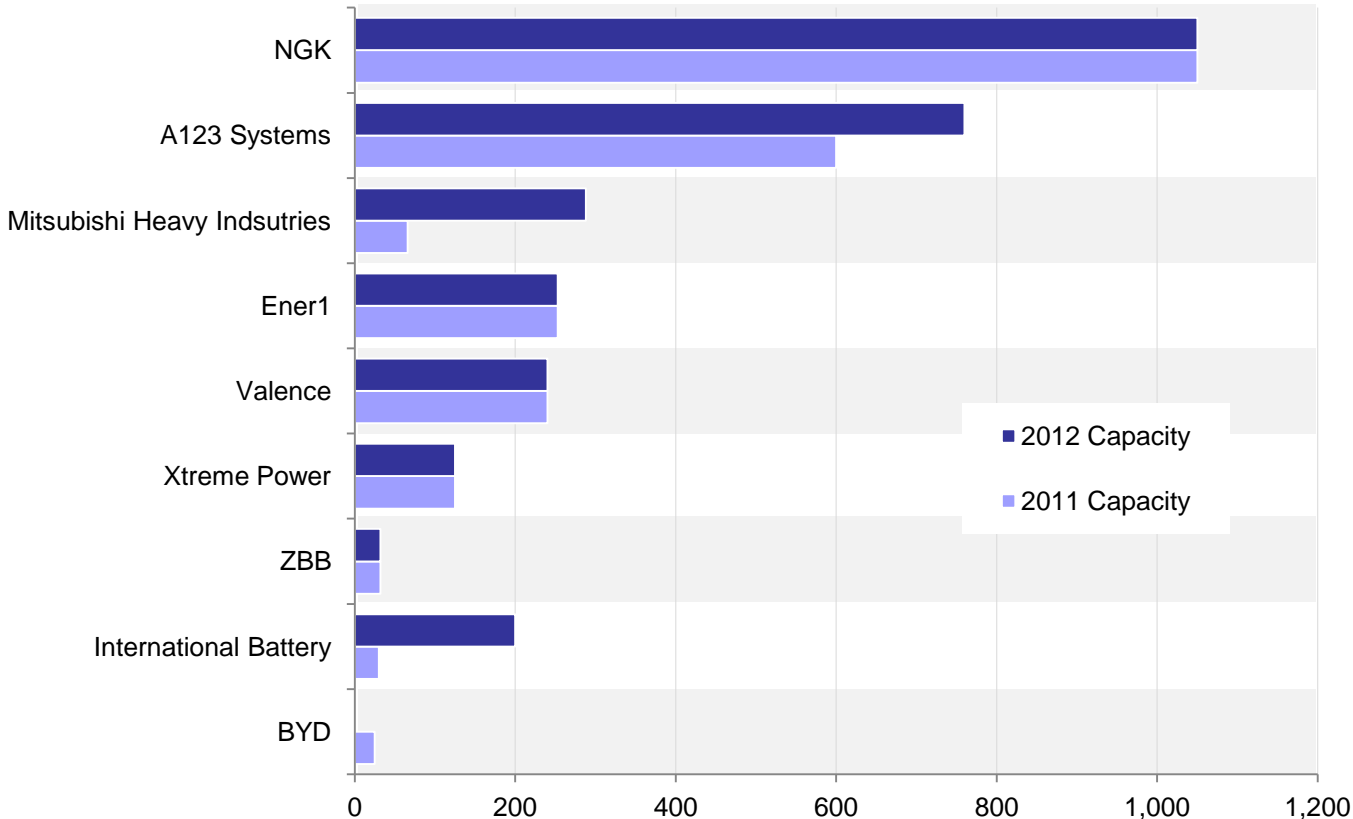
	NaS	ZEBRA	Li-ion	PbC	Flow	Dry
Round Trip Efficiency	85% +	85% +	95% +	90% +	60% to 65%	90%
Energy Density (kWh/m ³)	150–250 (medium)	150–250 (medium)	300–400 (highest)	20–70 (low)	20–30 (low)	80–90 (low)
Discharge Length	Hours	Hours	Minutes	Hours	Hours	Minutes
Calendar Life	15–20 Years	15–20 Years	10 Years	10 Years	7–10 Years	7–10 Years
Primary Applications	Utility, Factory, Telecom	Commercial Vehicles, Locomotives	Utility, Electric Vehicles	Utility	Utility Telecom	Utility
Secondary Applications	Heavy Machinery	Utility	Industrial	Light and Commercial Vehicles		T&D
Utilities/IPPs Involved	Tepco AEP Xcel PG&E NYPA	None	AES PG&E Mid-American SMUD SCE AEP DTE HELCO	None	Duke PG&E Mid-American Progress	MECO Duke Xcel DTE KIUC FirstWind

Competition for a relatively small grid-scale technology market is intensifying, with at least 20 companies positioning for the opportunity as manufacturing oversupply for the EV market materializes

US Utility-Scale Battery Storage Market Surges Forward

Manufacturing Capacity by Application

Estimated Global Manufacturing Capacity (MWh)



Note: Based on IHS EER estimates; Some manufacturers (Altairnano, Premium Power, etc.) did not supply data and so are excluded from analysis
 Source: Companies, IHS Emerging Energy Research

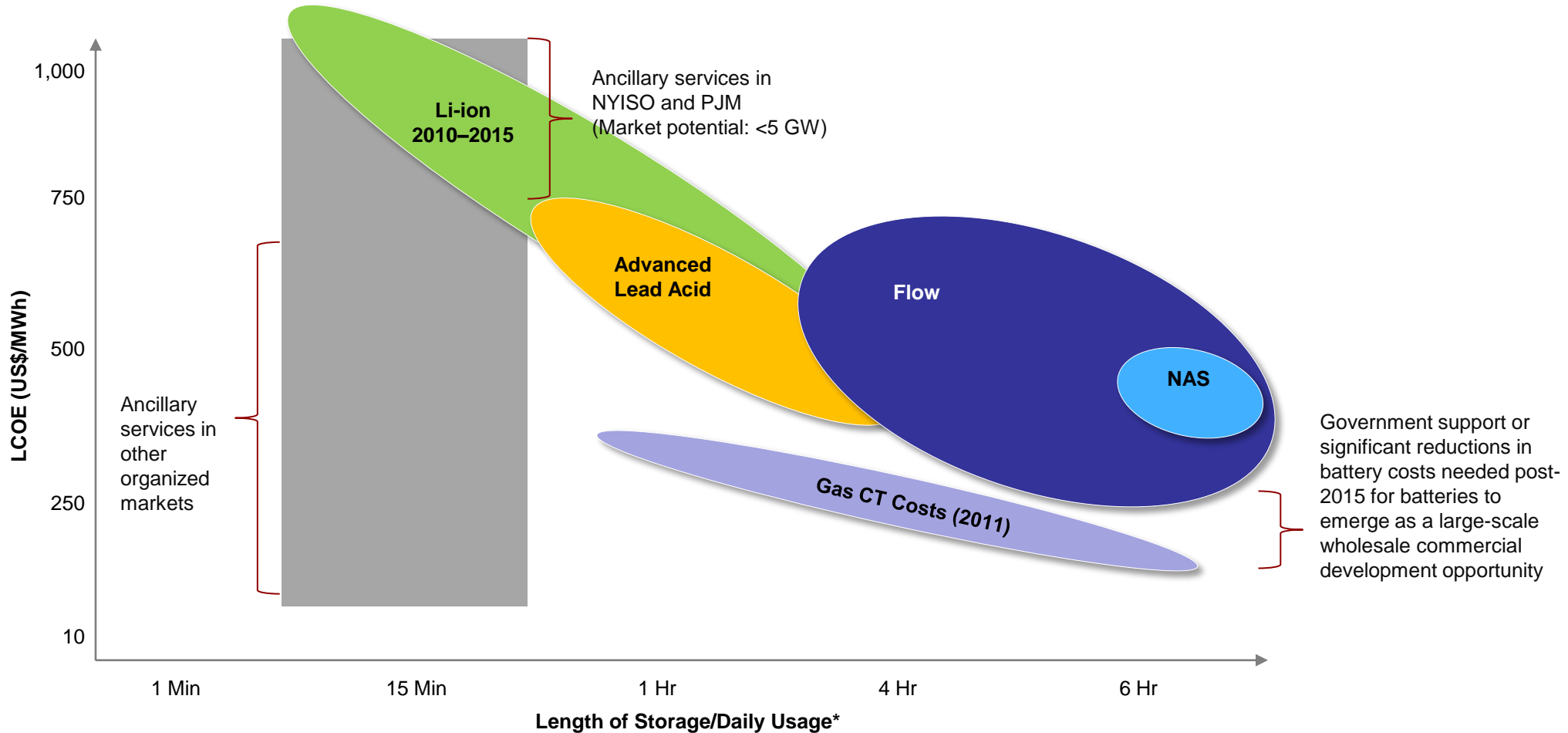
Location of Manufacturing Facilities

NGK: Japan
A123: China, Korea, US (<i>Michigan [2], Massachusetts</i>)
MHI: Japan
Ener1: USA, Korea
Valence: China
Xtreme Power: US (<i>Texas</i>)
ZBB: US (<i>Wisconsin</i>)
International Battery: US (<i>Pennsylvania</i>)
BYD: China

Among the group of battery manufacturers with an active utility-scale focus, NGK and A123 have established the largest manufacturing base. Manufacturing capacity is spread out globally with a strong focus on China, Korea, Japan, and the US

US Utility-Scale Battery Storage Market Surges Forward

Battery Costs Relative to Renewable Integration Benefits







Note: Costs are indicative based on project-level data for grid-scale applications. *Daily usage refers to gas CT costs
 Source: Companies, IHS Emerging Energy Research

Batteries are expected to remain uneconomic for most applications in the absence of funding support, or until costs fall at least an additional 50% beyond projections in 2015





US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Li-ion)

Company	Background	Manufacturing Capacity	Target Applications	Announced Supply To Date	Products
	<p>A123 Systems</p> <ul style="list-style-type: none"> Based in Waltham, Massachusetts, US Founded in 2001 Technology provider to project developers <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>As of 31 December 2010, annual manufacturing capacity was 350 MWh, with plans to expand manufacturing capabilities to more than 760 MWh by the end of 2011. Approximately half of total manufacturing capacity will be located in the US by year-end 2011 at the two facilities in Michigan and one in Massachusetts</p>	<ul style="list-style-type: none"> Automotive and transportation (electric vehicles) Commercial products (power tools, wheel chairs, etc.) Large-scale storage for grid applications <ul style="list-style-type: none"> Ancillary services (frequency regulation) Spinning reserves Transmission and distribution deferral Renewables integration 	<p>Operational</p> <ul style="list-style-type: none"> AES ES, 2 MW, 2008 AES ES, 8 MW, 2011 <p>Pipeline</p> <ul style="list-style-type: none"> AES ES, 12 MW, 2011 AES ES, 32 MW, 2011 DTE, 1 MW, 2011 SCE, 8 MW, 2012 	<ul style="list-style-type: none"> Smart Grid Stabilization System (SGSS™)—module units at 500 kWh scales to anywhere between 2 MW and 200 MW
	<p>Greensmith</p> <ul style="list-style-type: none"> Based in Bethesda, Maryland, US Founded in 2007 Technology supplier to utilities, consumers <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Greensmith has a third-party manufacturing contract in China</p>	<ul style="list-style-type: none"> Large-scale storage for grid applications <ul style="list-style-type: none"> Renewables integration Ancillary services market Load shifting and peak flattening Small-scale storage for distributed generation 	<p>Operating:</p> <ul style="list-style-type: none"> Progress I, 0.005 MW, 2009 Progress II, 0.005 MW, 2009 	<ul style="list-style-type: none"> Distributed Energy Storage System (DESS) Nominal availability of 15 kWh to 20 kWh
	<p>Altairnano</p> <ul style="list-style-type: none"> Based in Reno, Nevada, US Founded in 1998 Technology provider to utilities, project developers <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Altairnano has 80,000 square feet of production space at its headquarters in Nevada and expanded its prototype and production facility in Anderson, Indiana to 70,000 square feet in late 2010</p>	<ul style="list-style-type: none"> Automotive and transportation (electric cars and buses) Large-scale storage for grid applications <ul style="list-style-type: none"> Frequency regulation Renewables integration—PV smoothing and wind ramp rate <p>Remote applications and uninterruptible power supply</p>	<p>Operational</p> <ul style="list-style-type: none"> AES ES, 2 MW, 2008 <p>Pipeline</p> <ul style="list-style-type: none"> Gen-X, 0.1 MW, 2012 Hawi Wind Farm, 1 MW, 2011 Waiawa PV, 1 MW, 2011 	<ul style="list-style-type: none"> ALTI-Power Module—1 MW (250 kWh) module house in 53' shipping container—targeted at large-scale power applications
	<p>Prudent Energy</p> <ul style="list-style-type: none"> Based in Seoul, South Korea Founded in 1938 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Through its joint venture with Bosch, SB LiMotive, Samsung SDI operates two commercial-scale manufacturing plants—one for Li-ion battery cells in Ulsan, South Korea (34,000 square feet), and one in Springboro, Ohio, US for metal hydride cells and packs</p>	<ul style="list-style-type: none"> Large-scale power systems <ul style="list-style-type: none"> Peak shifting Frequency regulation Load leveling Renewables integration Distributed generation—residential and commercial sector Transportation 	<p>None announced to date</p>	<ul style="list-style-type: none"> Energy Storage System (ESS)—available for power generation applications in 500 kWh to 1 MWh modules—Samsung also offers RES and CES systems for residential and commercial energy storage with modules 7 kWh to 25 kWh





US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Li-ion)

Company	Background	Manufacturing Capacity	Target Applications	Announced Supply To Date	Products
	<p>SAFT</p> <ul style="list-style-type: none"> Based in Bagnolet, France Founded in 1918 Technology provider to industrial and military entities <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Saft has six production facilities in the US and 15 globally producing batteries. The company is expecting a new, US\$200 million Jacksonville, Florida, US facility to begin production in Q3 2011 and reach full production by Q4 2012. The facility has capacity for US\$300 million in annual sales</p>	<ul style="list-style-type: none"> Transportation—railway power back-up, civil and military transportation applications Large-scale <ul style="list-style-type: none"> Power back-up T&D support Renewables integration 	<p>Operational</p> <ul style="list-style-type: none"> Golden Valley, 27 MW, 2003 <p>Pipeline</p> <ul style="list-style-type: none"> TEP, 1 MW, 2011 SEPTA, 0.5 MW, 2011 Anatolia III, 0.005 MW, 2011 	<p>Saft offers a large-scale containerized energy storage system with storage capacity of 560 kWh scalable to 3 MWh to 5 MWh, typically and geared toward renewable energy integration</p>
	<p>Valence</p> <ul style="list-style-type: none"> Based in Austin, Texas, US Founded in 1989 <p>Technology:</p> <ul style="list-style-type: none"> Phosphate Li-ion battery 	<p>100,000 square-foot production facility in Suzhou, China. Dedicated in 2004, primarily produces U-Charge product. Current capacity is 240 MWh per year</p>	<ul style="list-style-type: none"> Automotive and transportation sectors (military, private, and public) Industrial and off grid 	<p>None announced to date</p>	<p>U-Charge XP and RT products come in varying voltages with scalability to over 700 kWh</p>
	<p>International Battery</p> <ul style="list-style-type: none"> Based in Allentown, Pennsylvania, US Founded in 2004 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Pennsylvania facility currently at 30,000 kWh/year, with plans to grow to 200,000 kWh/year in the near term</p>	<ul style="list-style-type: none"> Stationary (distributed ES, bulk ES, renewables integration) Military/ defense Transportation/ propulsion/ mobile (electric vehicles, utility and specialty platforms) 	<p>Pipeline</p> <ul style="list-style-type: none"> AEP Ohio, 2 MW, YE 2011 HNU Energy, 1 MW, 2011 	<p>International Battery offers a line of Battery Management Systems (BMS) with transportation and power applications</p>
	<p>International Battery</p> <ul style="list-style-type: none"> Based in Ontario, Canada Founded in 1996 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Electrovaya has production facilities in the US and Ontario , Canada</p>	<ul style="list-style-type: none"> Large-scale power storage <ul style="list-style-type: none"> Off grid and uninterruptible power services (UPS) Renewables integration Peak shaving, load shifting Transportation Consumer electronics and specialty applications 	<p>Pipeline</p> <ul style="list-style-type: none"> HydroOne, 1.2 MWh, 2012 US utility, 1.5 MWh 	<p>Li-ion Battery Energy Storage System (LIBESS) is scalable from 1 MWh to 100 MWh and incorporates Electrovaya's Li-ion Super Polymer cell technology</p>





US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Li-ion)

Company	Background	Manufacturing Capacity	Target Applications	Announced Projects	Products
	<p>BYD</p> <ul style="list-style-type: none"> Based in Hong Kong Founded in 1995 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Current capacity is estimated at 100 MW annually, with production based in China</p>	<ul style="list-style-type: none"> Automotive Large-scale energy storage <ul style="list-style-type: none"> Frequency regulation Renewable integration Substation support Commercial power back-up 	<p>Planned</p> <ul style="list-style-type: none"> Pacific Power, 0.25 MW, 2011 LADWP, 10 MW, 2013 	<ul style="list-style-type: none"> BYD Transportable/ Removable Energy Storage System (TESS) 800 kWh of storage capacity (200kW at four hours)
	<p>Mitsubishi Heavy Industries, LTD</p> <ul style="list-style-type: none"> Based in Tokyo, Japan Founded in 1964 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>MHI launched a Li-ion plant at the company's Nagasaki Shipyard & Machinery Works in late 2010, which has a production capacity of 66 MWh. MHI, through its joint venture with GS Yuasa—Lithium Energy Japan—expects to reach production capacity of 288 MWh by year-end 2011</p>	<ul style="list-style-type: none"> Large-scale energy storage <ul style="list-style-type: none"> Renewables integration Frequency regulation Transportation <ul style="list-style-type: none"> Rail and automotive applications 	<p>None announced to date</p>	<p>Medium-size cells for transportation formatted for 165 Wh, stationary batteries formatted starting at 350 Wh, up to 1 MW power and 450 kWh storage capacity</p>
	<p>Ener1</p> <ul style="list-style-type: none"> Based in New York, New York, US Founded in 2002 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Ener1 has assembly and manufacturing facilities in the US through its subsidiary EnerDel and in South Korea through Ener1 Korea. The company recently expanded its US facility and now has an annual production capacity of 253 MWh</p>	<ul style="list-style-type: none"> Automotive Large-scale energy storage <ul style="list-style-type: none"> Renewables integration Peak shaving Load shifting Back-up power and UPS <ul style="list-style-type: none"> Medical, military, and industrial applications 	<p>Planned</p> <ul style="list-style-type: none"> PGE, 5 MW, 2011 	<p>Company is developing a 0.25 MWh pack for deployment in Russia and the US</p>
	<p>Prudent Energy</p> <ul style="list-style-type: none"> Based in Osaka, Japan Founded in 1918 <p>Technology:</p> <ul style="list-style-type: none"> Li-ion battery 	<p>Operates manufacturing facility through joint venture with Toyota. 2010 production capacity is estimated at 9,400 units</p>	<ul style="list-style-type: none"> Transportation Distributed renewables integration <ul style="list-style-type: none"> Residential solar 	<p>None announced to date</p>	<p>Offers a wide array of Li-ion and nickel hydride battery technologies for industrial and residential applications</p>





US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Lead Acid)

Company	Background	Manufacturing Capacity	Target Applications	Announced Projects	Products
	Firefly Energy <ul style="list-style-type: none"> Based in Peoria, Illinois, US Founded in 2003 Technology: <ul style="list-style-type: none"> Advanced lead acid 	Manufacturing location at Peoria, Illinois, US headquarters	<ul style="list-style-type: none"> Transportation <ul style="list-style-type: none"> Automotive Marine Military Back-up power and UPS 	No projects announced to date	<ul style="list-style-type: none"> Oasis—5.4 kWh capacity pack geared toward transport applications
	Prudent Energy <ul style="list-style-type: none"> Based in Lyon Station, Pennsylvania, US Technology: <ul style="list-style-type: none"> Gel tech lead acid 	Deka's primary production facility is a 2,000,000-square-foot production facility in Lyon Station, Pennsylvania, US	<ul style="list-style-type: none"> Large-scale power systems <ul style="list-style-type: none"> Solar PV Renewables integration Communications and other off-grid applications Transportation Water pumping 	None announced to date	<ul style="list-style-type: none"> Deka Solar—a specific line of battery geared toward small-scale solar PV storage and support
	Exide Technologies <ul style="list-style-type: none"> Based in Baltimore, Maryland, US Founded in 1888 Technology: <ul style="list-style-type: none"> Lead acid 	Multiple production sites in the US and Europe. Current global production is 1,500 units per year for AGM and MFH products	<ul style="list-style-type: none"> Transportation applications Large-scale power systems <ul style="list-style-type: none"> Renewables integration Back-up power for off-grid and telecommunications options UPS 	None announced to date	<ul style="list-style-type: none"> Various product offerings ranging from small-scale residential and transportation to industrial
	Axion Power <ul style="list-style-type: none"> Based in Newcastle, Pennsylvania, US Founded in 2003 Technology: <ul style="list-style-type: none"> Lead acid 	The company's main manufacturing plant is located in Newcastle, Pennsylvania, US	<ul style="list-style-type: none"> Large-scale energy storage Standby and back-up power, UPS 	Planned: <ul style="list-style-type: none"> Niagara Falls State Park, 0.125 MW, 2011 	<ul style="list-style-type: none"> Power Cube—1 MW of capacity for 30 minutes or 100 kW for 10 hours. Directed toward utility-scale power applications




US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Flow)

Company	Background	Manufacturing Capacity	Target Applications	Announced Projects	Products
	<p>Primus Power</p> <ul style="list-style-type: none"> Based in Hayward, California, US Founded in 2009 <p>Technology:</p> <ul style="list-style-type: none"> Redox Flow Battery (Zn Br) 	<p>Primus plans to use contract manufacturing to supply its projects in the near term</p>	<ul style="list-style-type: none"> Large-scale storage for grid applications <ul style="list-style-type: none"> Renewables Integration Load shifting Ancillary services 	<p>Pipeline:</p> <ul style="list-style-type: none"> Modesto Irrigation, 25 MW, 2012 	<p>EnergyCell, EnergyPod™ and EnergyFarm architectures provide residential, commercial, industrial, and grid-scale solutions</p>
	<p>ZBB Energy Corporation</p> <ul style="list-style-type: none"> Based in Menomonee Falls, Wisconsin, US Founded in 1986 <p>Technology:</p> <ul style="list-style-type: none"> Zinc-bromide flow batteries 	<p>75,000-square-foot production facility in Wisconsin, US. Estimated 2011 capacity is 300 MWh (PECC) and 15 MWh (ZESS)</p>	<ul style="list-style-type: none"> Large-scale storage for grid applications <ul style="list-style-type: none"> Time shifting of renewable energy Back up power Grid voltage support Transportable storage to relieve bottlenecks 	<p>Operating:</p> <ul style="list-style-type: none"> PG&E, 0.5 MW, 2006 <p>Pipeline:</p> <ul style="list-style-type: none"> San Nicolas Island Naval Facility, 0.5 MW, N/A Fort Sill, 0.25, 2012 City Cottage, 0.25 MW, 2012 Target, 0.25 MW, 2012 	<ul style="list-style-type: none"> Power and Energy Control Center (PECC) Modular design, 125 kW AC rating <p>ZESS 50v3</p> <ul style="list-style-type: none"> 50kWh storage capacity, 25 kW discharge rate—scalable to 500 kWh
	<p>EnerVault</p> <ul style="list-style-type: none"> Based in Sunnyvale, California, US Founded in 2008 <p>Technology:</p> <ul style="list-style-type: none"> Redox flow battery (iron chromium) 	<p>EnerVault is currently in the pilot production phase, with the company targeting megawatt-scale annual production via a new plant slated for 2013</p>	<ul style="list-style-type: none"> Distributed generation Commercial and industrial peak shifting Large-scale power <ul style="list-style-type: none"> Renewables integration T&D deferral 	<p>Pipeline:</p> <ul style="list-style-type: none"> Almond Farm, 0.25 MW, 2011 	<p>Engineered Cascade</p> <ul style="list-style-type: none"> Modules enable application-specific configurations; 500 kW/1 MW-hr or 125 kW/1.5 MW-hr, for example
	<p>Cell Strom</p> <ul style="list-style-type: none"> Based in Austria Founded in 2002 <p>Technology:</p> <ul style="list-style-type: none"> Vanadium Redox flow battery 	<p>Cell Strom released the FB10/100 in 2008 for commercial-scale series production</p>	<ul style="list-style-type: none"> Residential-scale electricity supply Transportation—electric vehicle filling stations Telecommunications applications Large-scale power <ul style="list-style-type: none"> Local stabilization Load shifting and peak shaving 	<p>No announced projects in the US to date</p>	<p>Cellcube No FB10-100</p> <ul style="list-style-type: none"> Provides up to 15 kW continuous power and 100 kWh energy storage




US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Flow)

Company	Background	Manufacturing Capacity	Target Applications	Announced Projects	Products
 Prudent Energy	Prudent Energy <ul style="list-style-type: none"> Based in Bethesda, Maryland, US Founded in 2006 Technology: <ul style="list-style-type: none"> Vanadium Redox flow battery 	Maintains assembly facilities in Canada, the US, and Asia	<ul style="list-style-type: none"> Large-scale energy storage <ul style="list-style-type: none"> Renewables integration Grid stabilization Telecommunications base stations and remote area power supply needs 	Operating <ul style="list-style-type: none"> Pacifcorp, 0.25 MW, 2003 Pipeline <ul style="list-style-type: none"> Gills Onions, 0.6 MW, 2012 SunPower, 0.3 MW, 2011 	Vanadium Redox Battery Energy Storage System (VRG-ESS) <ul style="list-style-type: none"> 200 kW modular system scalable to 10 MW of capacity and 60 MWhs of storage Kilowatt-class product for telecommunications markets
 NGK	NGK <ul style="list-style-type: none"> Based in Aichi Pref, Japan Founded in 1919 Technology: <ul style="list-style-type: none"> NAS flow battery 	NGK has rapidly scaled its manufacturing capacity, increasing threefold from 48 MW per year in 2005 (906 modules) to 150 MW per year in 2010	<ul style="list-style-type: none"> Large-scale energy storage <ul style="list-style-type: none"> Load leveling Peak shaving Renewables integration Substation stabilization Emergency power supply, off-grid 	Operating: <ul style="list-style-type: none"> Texas AEP, 4 MW, 2010 WV AEP 2 MW, 2009 OH AEP, 2 MW, 2009 IN AEP, 2 MW, 2009 WV II AEP, 1.2 MW, 2006 MN Xcel Energy, 1 MW, 2008 NY NYPA, 1.2 MW, 2006 Pipeline: <ul style="list-style-type: none"> Vaca Dixon, 2 MW, 2011 PG&E Office Development, 4 MW, 2011 	50 kW module, with 300 kWh storage capacity—typical unit is 1 MW to 2 MW
 Deeya Energy	Deeya Energy <ul style="list-style-type: none"> Based in Fremont, California, US Founded in 2004 Technology: <ul style="list-style-type: none"> Redox flow battery (Fe-Cr) 	Manufacturing facility in Haryana, India	<ul style="list-style-type: none"> Large-scale energy storage <ul style="list-style-type: none"> Off-grid and critical infrastructure support to low-availability areas Eventually moving toward renewables integration and bulk storage 	None announced to date	GEN 1.5 ESP <ul style="list-style-type: none"> 3-hour charge and typically at 0.5 kW—3 kW capacity geared toward telecommunications applications Developing MegaModule ESP, geared toward large-scale power applications

US Utility-Scale Battery Storage Market Surges Forward

Battery Technology Profiles (Flow and Others)

Company	Background	Manufacturing Capacity	Target Applications	Announced Projects	Products
	<p>RedFlow</p> <ul style="list-style-type: none"> Based in Brisbane, Australia Founded in 2004 <p>Technology:</p> <ul style="list-style-type: none"> Zinc bromide flow battery 	<p>RedFlow signed a contract manufacturing agreement with Jabil Circuit on 7 June 2011 with operations expected in Q3 2011</p>	<ul style="list-style-type: none"> Large-scale energy storage <ul style="list-style-type: none"> Load shifting Renewables Integration Peak shaving Deferred T&D Distributed generation and smart grid Emergency power and off-grid, particularly telecommunications applications 	<p>None announced to date</p>	<p>Redflow ZMB</p> <ul style="list-style-type: none"> Zinc Bromide battery technology—5 kW/ 10 kWh modules <p>Electricity Storage Systems (ESS)</p> <ul style="list-style-type: none"> Scaled up ZMB product from 10 kWh to 200 kWh capacity
	<p>Xtreme Power</p> <ul style="list-style-type: none"> Based in Kyle, Texas, US Founded in 2004 Turnkey system provider <p>Technology:</p> <p>Dry cell battery</p>	<p>Xtreme Power has manufacturing capacity at its home base in Kyle, Texas, US. The company plans to raise US\$425 million in capital to expand its capacity to 2 GW in the near future</p>	<ul style="list-style-type: none"> Large-scale storage for grid applications <ul style="list-style-type: none"> Renewables integration Ancillary services market T&D Harnessing multiple value streams 	<p>Operational</p> <ul style="list-style-type: none"> First Wind, 1.5 MW, 2009 Castle & Cooke, 1.125 MW, 2010 First Wind, 15 MW, 2011 <p>Pipeline</p> <ul style="list-style-type: none"> First Wind, 15 MW, 2011 Xcel, 1. MW, 2011 DTE, 0.75 MW, 2011 KIUC, 1.5 MW, 2011 Fosters, 3 MW, 2011 Duke, 36 MW, 2012 Tres Amigas, 100 MW, 2013 	<p>Dynamic Power Resource (DPR) is Xtreme's standard utility-scale product. The containerized system offers 1 MWh of storage capacity</p>
	<p>General Electric</p> <ul style="list-style-type: none"> Based in Schenectady, New York, US Founded in 1892 <p>Technology:</p> <p>Sodium halide battery</p>	<p>GE opened a US\$100 million battery manufacturing facility this year geared toward producing batteries for the railroad market. At full capacity, the plant will be able to produce 900 MWh per year</p>	<ul style="list-style-type: none"> Transportation <ul style="list-style-type: none"> Rail Automotive Heavy industrial uses Telecommunications 	<p>None announced to date</p>	<p>Durathon—sodium-metal-halide battery geared toward multiple end markets. Basic module has 15 kWh of storage capacity</p>

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