

Electrical Energy Storage: Technologies, Applications and Markets

A package of reports, backed by individual consultancy time, examining opportunities for long-duration (hour plus) storage technologies, with short-, medium- and long-term market forecasts in stationary and mobile applications, together with technology evaluations and profiles of technology developers

EscoVale's latest multi-client study, backed by dozens of clients from five continents

Electrical energy storage has remarkable diversity. Over 200GW is already installed, just in stationary applications. Some require short bursts of power for milliseconds or minutes; others call for substantial amounts of energy, delivered over a period of hours or even days. *Much* larger opportunities await the development of novel storage technologies, to meet requirements associated with:

- support of renewable and distributed energy resources
- effective production, delivery and management of power
- the provision of secure, high-quality power at end-user sites
- enabling technologies within the transportation sector.

These opportunities are now capturing the imaginations of a wide range of developers, potential users and investors.

Dozens of largely unproven technologies are vying for a stake in a market with tantalizing prospects but many uncertainties. Decision-makers are hampered by a lack of reliable, unbiased information. EscoVale has an unrivalled 30-year track record in meeting this need, gained preparing independent analyses of emerging technologies for many hundreds of clients in six continents.

The study described here is concerned with high-energy storage solutions (typically capable of delivering nominal rated power for an hour or more). Coverage starts at single-digit kW ratings and extends to the largest GW-scale projects. Within this, there is detailed coverage of technologies appropriate for distributed energy applications within the electricity supply industry and for end users (where ratings of 10s of MW will continue to be seen as large projects). Storage for vehicles / transportation is another key area.

Clients will receive:

- Report #5061 (end-2008), quantifying high-energy storage markets, with forecasts to 2025 and a longer-term projection to 2050. Within the overall market analysis, there is focus on the various types of flow / redox battery – seen as serious contenders, capable of achieving a 10% plus share of accessible markets in important stationary applications
- A three-day consultancy allocation, to ensure that each client gets full benefit from the project resources and
- Report #5161 (2009), refining the market analyses, and expanding the technical scope to include a wide range of high energy:power ratio storage technologies

Which is closer to the truth?

“Economic and performance limitations will restrict energy storage to a very minor role in public power and transportation markets”

... or ...

“Advanced batteries and other storage products are about to change the entire framework of the million-dollar-a-minute global power provision business”

Opinions are as varied as the storage sector itself – indeed, many people simply ignore it!

We are all familiar with statements along the lines that, unlike other forms of energy, electricity needs an instantaneous match between supply and demand.

In practice, of course, there is a multi-\$bn business in established storage systems serving grid-connected, remote power and vehicular applications.

The fact that it is commonplace to disregard this, simply underlines the huge opportunities open to emerging technologies with more attractive characteristics

ENERGY STORAGE TECHNOLOGIES

There are numerous candidate technologies for long duration energy storage. **Pumped hydro** has dominated the high power sector, while **conventional batteries** have a near monopoly at low powers. Others are at various states of development: some at the laboratory stage; others with years of operating experience. These include:

- a variety of electrochemical storage systems (**advanced low temperature batteries, high temperature batteries, flow / redox batteries**)
- **compressed air energy storage** (mainly large-scale systems, but also mini-CAES)
- **chemical energy storage** (notably with hydrogen, but this is one of many storage media).

The list goes on, and includes technologies associated mainly with short-duration applications, where some developers are also eyeing hour plus opportunities (e.g. **flywheels** and **ultracapacitors**).

Flow / redox batteries are interesting players within the long-duration storage area. A key feature is that most flow batteries store energy in charged electrolytes, outside the cell. There can be huge benefits in separating the “power” function (determined by the size and number of cells) from the “energy” function (determined by the volume of electrolyte). Flow batteries can be built with a much greater storage capacity than most other battery types. Inert electrodes confer another distinctive flow battery feature – exceptional cycle life. In addition to electrical recharging, flow batteries can be rapidly replenished by electrolyte exchange (and, in one innovation, by converting the chemical energy in a feedstock).

Flow batteries also serve as a useful example with which to explore the wider market. Features include:

- multiple technologies are under development (several vanadium categories, zinc bromine, cerium zinc, iron chromium, polysulphide bromine and others)
- their development status ranges from laboratory based R&D through to field demonstrators on the verge of commercialization
- target areas start at single-digit kW power levels and extend to MWs and ultimately 100s of MW
- most of the effort is going into stationary applications, but various transport/motive power markets are also of interest
- while firmly based in the long-duration sector, redox systems can be very responsive and thus have the potential to generate additional revenue through provision of power quality or other services – at the minute, second or millisecond level.

The study provides a timely analysis of the wider storage market, and of one of its most compelling constituents. There can be no doubt that flow batteries systems would be on the receiving end of a \$bn stampede, if products were available today at the performance and price levels envisaged for mature systems. It has all the hallmarks of a winning technology, characterized by:

- obvious but largely unexploited market opportunities
- great diversity in terms of application areas
- massive potential markets
- powerful market drivers, with decision makers becoming increasingly receptive to storage as a means of tackling some of their most intractable problems
- a proven track-record, demonstrating that at least some variants of the technology actually work
- plausible routes to achieving cost-reduction / performance-improvement targets
- modest technical risk.

This is a dangerous time, as developers of every other wunderkind energy technology can testify! As ever, completing the development of acceptable, market-ready products will take longer and cost more than developers can readily afford; and still more time will elapse before these are accepted as mainstream solutions by cautious purchasers – who have got by quite well up to now, without any help from flow batteries. A sizeable casualty list will grow further, but the rewards for those still standing when the market finally lifts off are already attracting new developers, backers and well-wishers.

The objective of this study is to give a thorough understanding of the technical and commercial issues for long-duration storage, providing a solid framework within which potential users, investors and suppliers can make informed decisions. This is accompanied by an objective review of developers and an unbiased assessment of market prospects.

REPORT PREPARATION & CONTENT

REPORT PREPARATION: The report team, led by Frank Escombe, includes experienced EscoVale personnel and others (notably Anthony Price of Swanbarton). EscoVale has supplied around 500 management reports concerned with emerging energy technologies, giving it a leading position in this area. Further details and a partial [list of clients](#) can be found at www.escovale.com

Anthony Price has worked for engineering contractors and consultants in a variety of technical and commercial roles and has considerable experience in developing and commercializing energy storage technologies. He has worked in intellectual property strategy and administration, market research and due diligence work for technology transfer and new business development. He is a member of the US DOE's Peer Review Panel on Energy Storage Systems, and a member of the Electricity Storage Association's advisory committee, having been an elected director for five years.

REPORT CONTENT: Key objectives are to examine the opportunities for long duration storage, and to make sensible market forecasts, taking account of the remarkable changes occurring within the power, transportation and other sectors, and within the energy storage industry itself. The forecasts cover the difficult near-term period; the transition to the next market expansion phase (beginning in earnest in the early 2010s); the subsequent evolution to 2025; and longer term development to 2050. Forecasts are given in MW/year (aggregate rated power), GWh/year (aggregate storage capacity per cycle), and value. The reports include estimates of the changing market distribution, by territory, application and rating.

There are many different storage technologies and one of the main objectives of the study is to make a realistic assessment of market development for particular storage categories. Report #5061 examines flow / redox batteries in this context. It reviews the technical and commercial status of flow battery electrochemistries and their developers, and seeks to make rational projections of future progress, with regard to the technology, costs, performance and commercialization timescales.

Report #5061 will comprise about 15 Chapters and more than 250 pages:

- **Introductory Chapters:** (about 40 pages in all, setting the scene in terms of concepts, types of energy storage and selection criteria, an overview of storage applications, and a forecast of developments within the electric power sector and its position within the wider energy market)
- **Storage Applications & Markets:** (four chapters, 140 pages, examining numerous applications for storage associated with: renewable energy; management of electricity supply systems; use at end-user sites and in off-grid / weak grid situations; vehicular and other mobile markets. Each chapter includes detailed forecasts of storage markets, and their accessibility to flow batteries and similar technologies)
- **Market Opportunities for Flow Batteries:** (this builds on the information in the preceding chapters to provide estimates and forecasts of the global storage market over the period to 2050 in terms of power, energy, units and value. The analysis includes forecasts of the distribution by territory, application and rating, providing a sensible framework within which opportunities for particular storage technologies can be evaluated. This chapter concludes with the flow battery estimates and forecasts, taking account of their attributes and limitations – drawing on the report's technical sections)
- **Technology Chapters:** (50 pages, introducing the concept, history, construction, design features and technical issues, before examining each of the principal flow battery electrochemistries and discussing their characteristics, performance, cost potential and commercial status)
- **Technology Developers:** (notes on about 20 organizations involved in the development of flow battery technology)

Clients also receive **three days of individual consultancy time**, together with **Report #5161**. This continues the examination of commercial opportunities for storage, refining forecasts in the stationary sector, and adding further detail in mobile applications. Scheduled for late 2009, #5161 includes technical coverage, market estimates and forecasts for a wider range of storage technologies and developers. Market analyses will differentiate between some ten storage categories, such as pumped hydro, CAES, "conventional" battery technologies, advanced low temperature batteries, high temperature batteries, flow batteries, high-energy ultracapacitors, flywheels and electrical energy systems based on chemical and thermal storage. Clients will have the opportunity to influence the way in which the research resources are distributed between these areas.

ORDER FORM

“Electrical Energy Storage: Technologies, Applications and Markets” EscoVale Reports #5061 & #5161

Currency	US Dollars	Euro	Yen	GB Pounds
Price	\$9,500	€7,500	¥950,000	£6,000

Deliverables: Copies of each report #5061 & #5161 as described in this leaflet in either printed or pdf format. The price also includes three days of consultancy time, allocated to topics agreed with the client (we reserve the right to decline topics that would involve disclosure of information provided to EscoVale in confidence). The price does not include any travel costs or other expenses incurred in connection with consultancy assignments.
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