

# DEVELOPMENTS IN NANOSCALE BATTERIES

## A CHANGE IN THE BATTERY LANDSCAPE

In 1800, Alessandro Volta, an Italian physicist, invented the first battery by exploiting chemical reactions to store and deliver electrical energy. The ability to store electricity in a portable device is a scientific breakthrough that enabled societies to achieve a wide range of technological developments: cars, MP3 players, mobile phones, laptops, and even medical devices such as pacemakers, all require batteries to power them. In turn, societies now more than ever depend on these powered devices and technologies to function.

While battery technology hasn't changed much in the last 200 years, the advancement of nanotechnology is opening up an arena for technological improvements that may lead to similar breakthroughs as the original battery once did. For instance, nanoscale batteries could power new microscopic devices or they may inspire new solutions to extend current battery life and speed up the transition to electric power in the transportation industry. In a world threatened by climate change, nanoscale battery technology can help bring a cleaner and more sustainable world.

Battery technology is relatively straight forward. Electrons flowing from one chemical element (electrode) to the next create an electrical current. This flow of electrons powers a 'load' -i.e., a device, such as a light bulb.

Nanotechnology may drastically change this approach by allowing the tinkering with the molecules of battery materials. For instance, by coating the surface of an electrode with specific nanoscale particles, the resultant material enhances the energy density of a battery because the surface area of the electrode is increased. The size of these batteries is less than a millimeter.

## NANOSCALE BATTERIES OF THE FUTURE

In addition to nanoscale material enhancements, engineers also observe battery processes at a microscopic scale to increase performance. The examination of microscopic processes such as charging and discharging of a single nanowire (i.e., a very small wire) was not possible. Unexpectedly, researchers found that the nanowire rod nearly doubles in length during charging. It was found that it is the length of the rod that affects the length of the battery life, instead of thickness.<sup>1</sup>

Advances in nanoscale battery technology suggest a future wherein batteries will play an even bigger role than they do today. Batteries of the future will be smaller, lighter, cleaner and more durable in terms of energy. As a result, many types of batteries are expected to become cheaper. These developments may have structural impact on the need for batteries, the devices that are powered by batteries, and the energy industries.

## STIMULATING THE SHIFT TO MOBILE AND ELECTRICITY

Developing countries are gradually building up an advanced technological infrastructure. Countries like China, India, Brazil, and South Africa are increasingly developing indigenous R&D and science programs, adopting telecommunication systems, and upgrading their infrastructures with new technologies. This 'horizontal' global technological development throughout societies expands the potential market for batteries as more and more become reliant on energy consuming devices. Experts anticipate the battery business to exceed \$50 billion in revenues by approximately 2014.<sup>2</sup>

While on a global level the need for portable energy is rising, the demand for batteries is further fueled →

## SCANNING EMERGING ISSUES OF THE FUTURE: FOCUS AND METHOD

SCANNING EMERGING ISSUES OF THE FUTURE are a series of briefs produced by the Strategy & Change Program. The briefs in the series identify emerging strategic issues that are relevant for the four themes of S&C: security, technology & innovation, economy & society, and sustainable development (see [strategyandchange.nl/](http://strategyandchange.nl/)).

For each of these issues, we explore policy implications across the four themes. To identify these issues, Strategy & Change employs an innovative approach analyzing a wealth of forward looking resources available the Internet. This process is supported by *Leximancer* text mining software. For a full description of the methodology, please see [strategyandchange.nl](http://strategyandchange.nl).



with a 'vertical' growth in technology adoption. Nanotechnology reduces in size of enabling a host of new applications and devices to adopt portable power. Consumer products such as MP3 players will continue to demand the best and cheapest batteries but also new devices, such as medical or environmental nanobots, or embedded computer chips in intelligent clothing, will require batteries for power. When nanotechnology research matures and nanoscale devices become popular in the commercial industry, new technological devices further drive up battery demand.

Finally, batteries are expected to rise in popularity because they are viewed as a clean alternative to fossil fuels. Already in the transportation industry we witness a gradual shift towards hybrid vehicles –vehicles that use both fossil fuel and electricity for power. However, the current state of battery technology is insufficient to induce a complete shift to electricity. This is likely to change, though, as new batteries are becoming more efficient and durable, a development to which nanobatteries greatly contribute. Future batteries may

allow electric cars to travel longer distances with minimal maintenance. These benefits could turn the tide in favor of electrically powered vehicles. This, in turn, will present new infrastructural challenges. For example, current networks of tank stations would need to be upgraded or replaced with electrical charging points.

Sustainable energy storage is gaining more traction with the ongoing improvement and adoption of renewable energy technology. Cheaper and more efficient wind turbines and solar continue to be installed in both the developed and developing world. Particularly Africa and the Middle-East have enormous potential to produce renewable energy if technical and political hurdles can be overcome.<sup>3</sup>

Despite the hurdles, the renewable energy market is expected to grow in the next 25 years, according to the US Energy Information Administration (EIA). The Organisation for Economic Co-operation and Development (OECD) countries will have an annual renewable energy growth of 1.3%, while the non-OECD countries will grow by 6.9% per annum.<sup>4</sup> This means there will be an increasing demand for batteries to store the clean energy.

---

1 WORLD'S SMALLEST BATTERY: REAL-TIME OBSERVATION OF NANOWIRE ANODE TO HELP IMPROVE LITHIUM BATTERIES, SCIENCE DAILY, 10-12-2010, [HTTP://WWW.SCIENCEDAILY.COM/RELEASES/2010/12/101209152751.HTM](http://www.sciencedaily.com/releases/2010/12/101209152751.htm)

2 THE BATTERY MARKET WILL CHARGE AHEAD, BLOOMBERG BUSINESSWEEK, 02-07-2009, [HTTP://WWW.BUSINESSWEEK.COM/LIFESTYLE/CONTENT/JUL2009/BW2009072\\_953040.HTM](http://www.businessweek.com/lifestyle/content/jul2009/bw2009072_953040.htm)

3 WORLD ENERGY OUTLOOK 2010 FACTSHEET, INTERNATIONAL ENERGY AGENCY, 2010, [HTTP://WWW.WORLDENERGYOUTLOOK.ORG/DOCS/WE02010/FACTSHEETS.PDF](http://www.worldenergyoutlook.org/docs/weo2010/factsheets.pdf)

4 INTERNATIONAL ENERGY OUTLOOK 2010, US ENERGY INFORMATION ADMINISTRATION, JULY 2010, [HTTP://WWW.EIA.DOE.GOV/DIAF/IEO/PDF/0484%282010%29.PDF](http://www.eia.doe.gov/DIAF/IEO/PDF/0484%282010%29.PDF)