The Outlook for Battery Materials and the Rechargeable Battery Sector - EVs in the Driving Seat?

JOGMEC Forum, Tokyo
23 January 2019

Mark Seddon
Senior Manager, Consulting Services (Metals)
Argus Media Ltd.
Agenda

- Argus Consulting Services
- Introduction
- Battery Market Overview
- Battery Market Outlook
- Battery Raw Materials & Outlook
- Conclusions
# About Argus Consulting Services

Argus Consulting Services helps clients to understand their markets better and define strategies to succeed within them.

## Single Client Work

<table>
<thead>
<tr>
<th>Market Studies</th>
<th>Strategic Planning</th>
<th>Supply, Demand &amp; Pricing Analysis</th>
<th>Market Supply Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bespoke research and analysis</td>
<td>• Typically ‘Market Strategy’ projects</td>
<td>• We help clients evaluate potential investments and support market entry decisions</td>
<td>• Our work is built off the foundation of Argus data and knowledge</td>
</tr>
</tbody>
</table>

## Outlook Publications

### Argus Battery Materials Monthly Outlook

- **Outlook**
  - The market for lithium-ion battery materials, driven by demand for electric vehicles, is expected to continue growing. The shortage of lithium-ion battery materials is anticipated to persist, leading to higher prices.
  - **Lithium-ion Battery Materials Price Analysis**
    - Prices for lithium-ion battery materials are expected to rise further in the coming quarters.

## Multi Client Studies

### Argus Battery Materials Annual 2018

- **Market Report**
  - Argus Battery Materials Annual 2018
  - Provides an in-depth analysis of the lithium-ion battery materials market, covering production, demand, and pricing trends.
  - **Market Overview**
    - The global lithium-ion battery materials market is expected to grow at a compound annual growth rate (CAGR) of X% over the next five years.

---

*Copyright © 2019 Argus Media group. All rights reserved.*
Introduction
Rechargeable battery types – Lead Acid

• invented in 1859 by French physicist Gaston Planté and is the oldest type of rechargeable battery

• despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio

• most of the world's lead-acid batteries are automobile starting, lighting and ignition (SLI) batteries

• wet cell stand-by (stationary) batteries designed for deep discharge are commonly used in large backup power supplies for telephone and computer centres, grid energy storage, and off-grid household electric power systems

• lead–acid batteries are used in emergency lighting and to power sump pumps in case of power failure.

• large lead-acid batteries are also used to power the electric motors in diesel-electric (conventional) submarines when submerged, and are used as emergency power on nuclear submarines as well

• valve-regulated lead acid batteries cannot spill their electrolyte - they are used in back-up power supplies for alarm and smaller computer systems (particularly in uninterruptible power supplies; UPS) and for golf carts, electric scooters, electric wheelchairs, electrified bicycles, marine applications, battery electric vehicles or micro hybrid vehicles, and motorcycles.
Rechargeable battery types – Nickel Cadmium

- a type of rechargeable battery using nickel oxide hydroxide and metallic cadmium as electrodes, invented in 1899

- compared with other types of rechargeable cells they offer good cycle life and performance at low temperatures with a fair capacity but their significant advantage is the ability to deliver practically their full rated capacity at high discharge rates

- sealed NiCd cells were at one time widely used in portable power tools, photography equipment, flashlights, emergency lighting, hobby R/C, and portable electronic devices

- the superior capacity of nickel-metal hydride batteries, and more recently their lower cost, has largely supplanted the use of Ni-Cd batteries

- the environmental impact of the disposal of the toxic metal cadmium has contributed considerably to the reduction in their use. Within the European Union, NiCd batteries can now only be supplied for replacement purposes or for certain types of new equipment such as medical devices
Rechargeable battery types – Nickel-Metal Hydride

• invented in the late 1960s, NiMh batteries have a similar chemical reaction at the positive electrode to that of the NiCd cell, with both using nickel oxide hydroxide. But the negative electrodes use a hydrogen-absorbing alloy instead of cadmium

• a NiMH battery can have two to three times the capacity of an equivalent size NiCd, and its energy density can approach that of a lithium-ion battery

• NiMH batteries have replaced NiCd for many roles, notably small rechargeable batteries in consumer electronics. NiMH cells are often used in digital cameras and other high-drain devices, where over the duration of single-charge use they outperform primary (such as alkaline) batteries

• applications of NiMH electric-vehicle batteries include all-electric plug-in vehicles (e.g. General Motors EV1, first-generation Toyota RAV4 EV, Honda EV Plus, Ford Ranger EV and Vectrix scooter). Hybrid vehicles (e.g. Toyota Prius, Honda Insight, Ford Escape Hybrid etc.) have also used them. Now superseded by Li-ion batteries in EV applications
Rechargeable battery types – Lithium-ion

• invented in the 1970s, Li-ion is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging

• 5 main types of Li-ion battery:
  - lithium cobalt oxide (LCO)
  - lithium nickel manganese cobalt oxide (NMC)
  - lithium nickel cobalt aluminium oxide (NCA)
  - lithium manganese oxide battery (LMO)
  - lithium iron phosphate (LFP)

• Li-ion batteries provide lightweight, high energy density power sources for a variety of devices:
  - Portable devices: these include mobile phones and smartphones, laptops and tablets, digital cameras and camcorders, electronic cigarettes, handheld game consoles and torches
  - Power tools: Li-ion batteries are used in tools such as cordless drills, sanders, saws and a variety of garden equipment including hedge trimmers etc
  - Electric vehicles: including electric cars, hybrid vehicles, electric bicycles, personal transporters and advanced electric wheelchairs. Also radio-controlled models, model aircraft, aircraft, and the Mars Curiosity rover.
Rechargeable battery types – Lithium-ion

Material content of lithium-ion battery types (%)

- **LCO**
  - Li: 33%
  - Co: 60%
  - Ni/other: 7%

- **NMC**
  - Li: 15%
  - Co: 78%
  - Ni/other: 7%

- **NCA**
  - Li: 6%
  - Co: 87%
  - Ni/other: 7%

- **LMO**
  - Li: 7%
  - Co: 93%
  - Ni/other: 7%

- **LFP**
  - Li: 7%
  - Co: 93%
  - Ni/other: 7%

— Darton Commodities
Supply Overview
Battery Market Overview

Battery market by chemistry (excl. lead acid), 1995-2018

- **Li-ion growth 2000-10 = 30pc/yr**
  - 2GWh to 24GWh
- **Li-ion growth 2010-18 = 20pc/yr**
  - 24GWh to 107.5GWh
- **NiMH growth 2000-10 = 10 pc/yr**
  - 1.5GWh to 3.75GWh
- **NiMH growth 2010-18 = 1 pc/yr**
  - 3.75GWh to 4.1GWh
- **NiCd growth 2000-10 = -5 pc/yr**
  - 4.5GWh to 2.75GWh
- **NiCd growth 2010-18 = -3 pc/yr**
  - 2.75GWh to 2.2GWh

— **Argus; Avicenne**
Battery Market Overview

Major LiB battery producers:

- PANASONIC
- BYD
- Tesla
- ATL
- Nissan
- Sony
- LG Chem
Battery Market Overview

- China, Japan & Korea accounts for almost 90% of world li-ion battery cell production.
- China makes up 50% of demand for EVs and battery capacity globally

**LITHIUM ION CELL PRODUCTION**

Korean companies start to move in Malaysia
New production capacity in Europe and US

- **USA – 2%**
  - LG
  - Johnson-Controls
  - Enersys
  - SAFT

- **EU – <1%**
  - SAFT
  - FIAMM
  - BOLLORE

- **China – 60%**
  - BYD
  - GP
  - Lishen
  - COSLIGHT
  - ATL
  - BAK
  - B&K
  - Wanxiang (A123)

- **Korea – 15%**
  - SAMSUNG
  - LG
  - SK
  - Kokam

- **Japan – 17%**
  - Panasonic
  - Sony
  - NEC
  - Maxell
  - PEVE
  - YUASA

- **Others* – 5%**
  - SAMSUNG
  - LG

---

Copyright © 2019
Argus Media group. All rights reserved.
China, Japan & Korea accounts for almost 90% of world li-ion battery cell production.

Production of cathode materials dominated by China (which manufactures 40%; Japan – about 20%; and South Korea – about 7%)

China makes up 50% of demand for EVs and battery capacity globally
Battery Market Outlook
China:

- on target to produce over 1mn NEVs in 2018
- aiming to produce 2mn NEVs by 2020
- government will not approve any new factories that produce only oil-fuelled vehicle
- under the guidelines, automobile manufacturers will not be allowed to raise production capacity of oil-fuelled vehicles unless their actual output of NEVs — including electric and plug-in hybrids — has been above the industry average over the last two years
Battery Market Outlook

Global AFV registrations, 2017-40

- Other
- Asia Pacific
- Europe
- North America

— Argus
Battery Raw Materials

illuminating the markets
Battery Raw Materials

LI-ION VALUE CHAIN – MARKET DEMAND

CATHODE
184,000 T in 2016
Revenues: 4 B$
CAGR 06/16: +22%

ANODE
>88,000 T
Revenues: 0.9 B$
CAGR 06/16: +12%

ELECTROLYTE
>86,000 T
Revenues: 1.1 B$
CAGR 06/16: +19%

SEPARATOR
1.300 M m²
Revenues: 1.3 B$
CAGR 06/16: +18%

ANCILLARY
Revenues: 1.3 B$

CELL MANUFACTURERS
Revenues: 20.6 B$
Gross margin: <10%

PACK MANUFACTURERS
Revenues: >24.4 B$
Gross margin: <10%

OEMs

— Avicenne
Battery Raw Materials - Lithium Supply Chain

Lithium mining
- Brine
- Spodumene

Concentrating/semi-processing
- LiCl concentration (brine)
- Li₂CO₃ concentration (rock)

Chemical refining
- Lithium carbonate
- Lithium hydroxide
- Lithium chloride
- Other lithium compounds

Battery precursors
- Li₂CO₃ (battery grade)
- LiOH (battery grade)

Battery cathode material
- Lithium Cobalt Oxide (LCO)
- Li(NiMnCo)O₂ (NMC)
- Li(NiCoAl)O₂ (NCA)

Li-ion Battery

Other applications
- Glass/ceramics
- Greases
- Others
Battery Raw Materials

Lithium-ion battery market by chemistry, 2017-30

- LMO/LFP
- NMC 111
- NMC811/NCA
- NMC 622/523

illuminating the markets

Copyright © 2019
Argus Media group. All rights reserved.
Battery Raw Materials – Cathode Material Demand

Forecast demand for Li-ion cathode materials by battery technology, 2015-30

— Avicienne Energy; Argus
Battery Raw Materials - Lithium

Demand for lithium in batteries, 2017-30

- Non-battery
- Other LiB
- Energy storage
- Electric vehicles

Argus

illuminating the markets

Argus Media group. All rights reserved.
Battery Raw Materials - Cobalt

Demand for cobalt in batteries, 2017-30

---

t Co

Other
Superalloys
Cemented carbides
Other LiB
Electric vehicles

---

Argus

---

illuminating the markets

Copyright © 2019
Argus Media group. All rights reserved.
Battery Raw Materials - Nickel

Demand for nickel in batteries, 2017-30

---

Argus

illuminating the markets

Copyright © 2019
Argus Media group. All rights reserved.
Conclusions
Conclusions

• 54pc of those surveyed believe BEVs will fail due to infrastructure issues

• Ranging from 43pc of mobility services providers to 51pc of OEMs to 70pc of energy/infrastructure providers
Conclusions

- 52pc rank fuel cell vehicles as the key trend to 2025
- Executives believe that by 2040 there will be a convergence of powertrain technology – leading to an almost equal distribution between ICEs, PHEVs, BEVs and FCEVs
Conclusions

- 43pc agree that half of today’s car owners will not want to own a car anymore in 2025
- POV = Personally Owned vehicle
- POAV = Personally Owned Autonomous Vehicle
- MaaS = Mobility as a Service
- MaaS with AV = Mobility as a Service with Autonomous Vehicle
Mark Seddon
Senior Manager, Argus Consulting (Metals)

Email:  Mark.seddon@argusmedia.com
Phone:  +44 20 7199 1747
Office:  London
Web:  www.argusmedia.com