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Energy Ltd 

# **Battery Growth Opportunities: Meeting the Requirements of Growing Markets and Applications**

**June 2017**

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# Nazareth, Israel – The search for the “Perfect Bite” ...



Basilica of the Annunciation



Fresh hot Humus



Street food Falafel

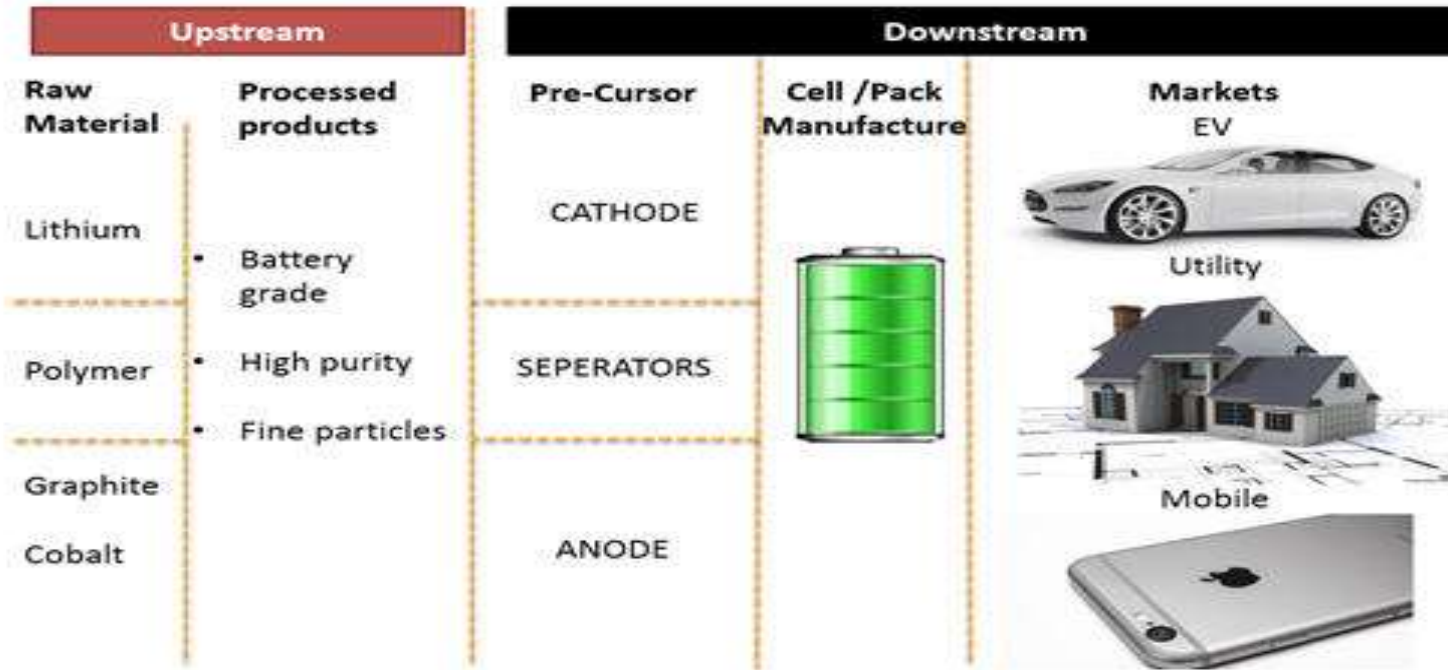


Sweet Baklawa



Street food Shawarma

# Battery Supply Chain

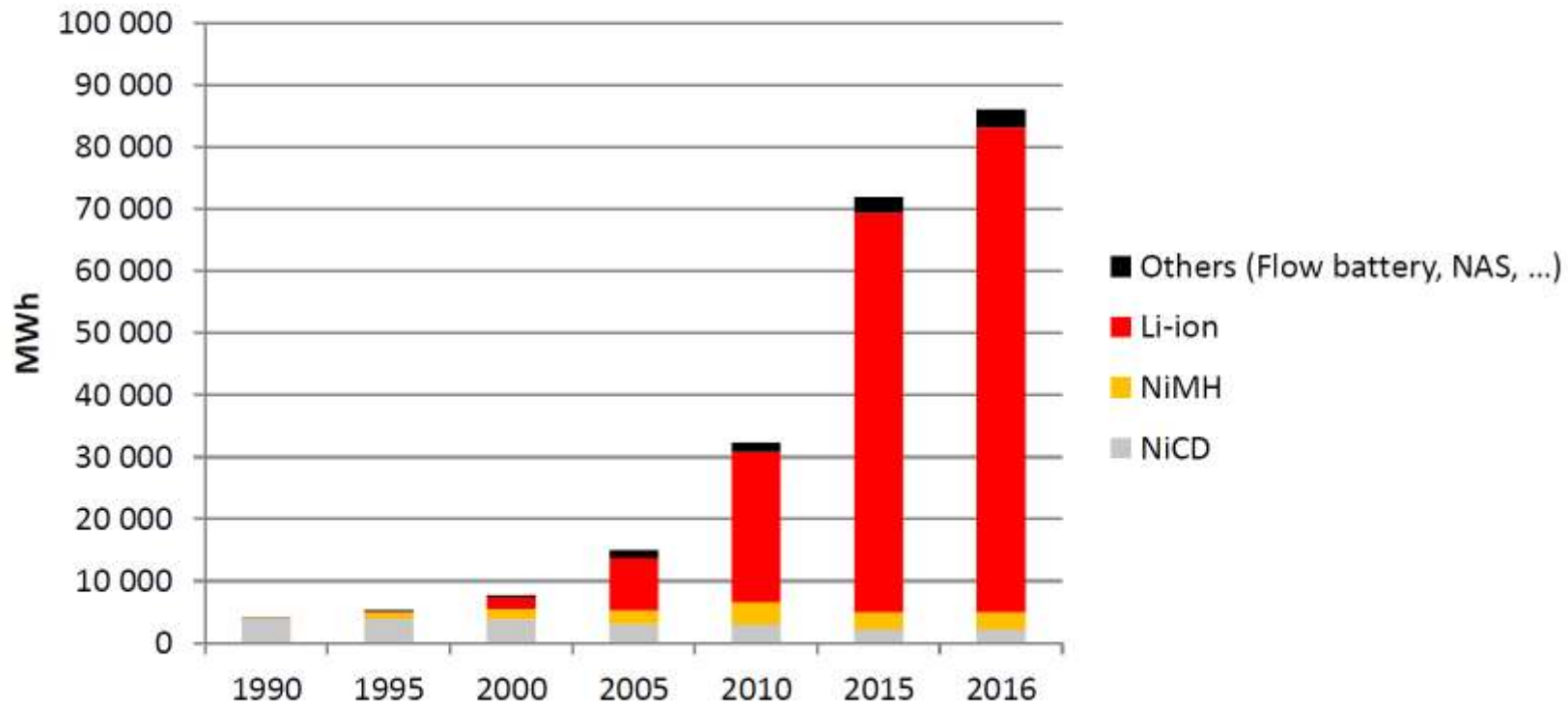


Transferring supply chain excellence to EV is key



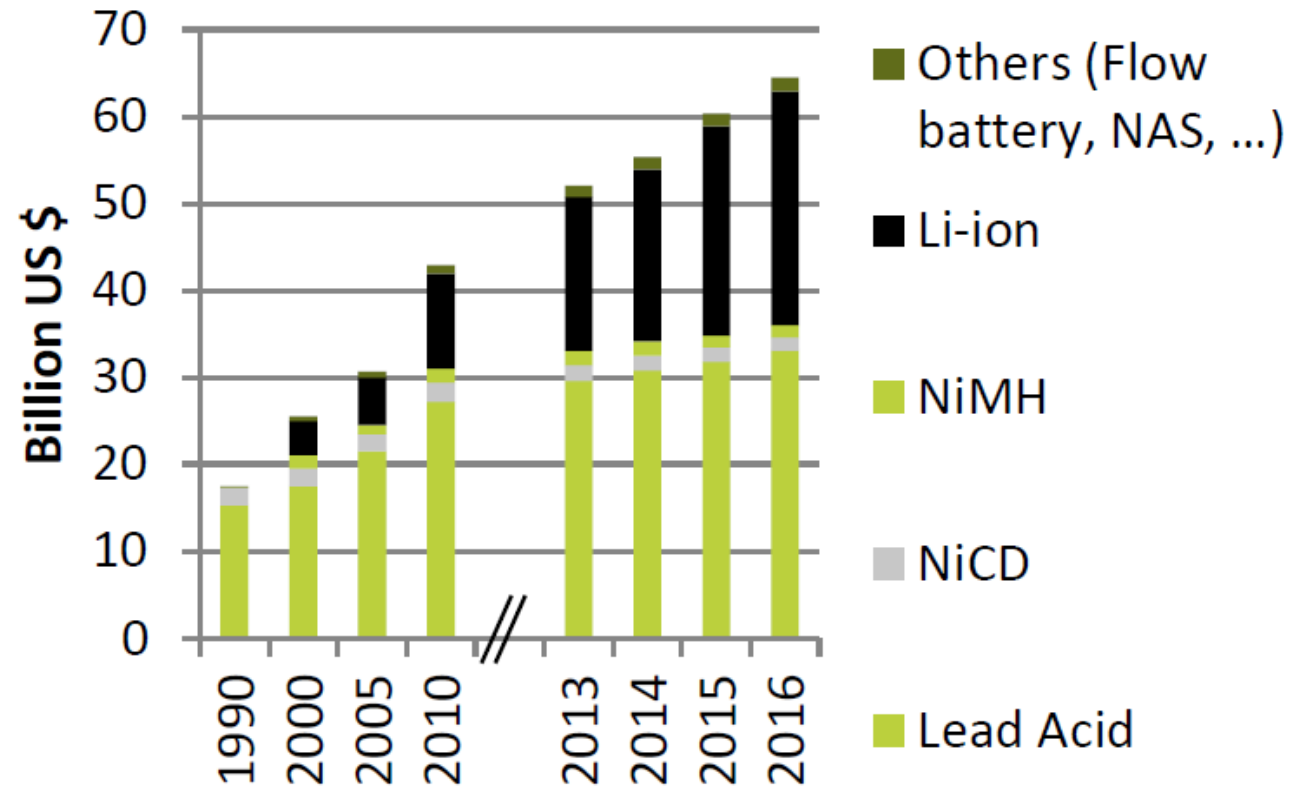
# THE WORLDWIDE BATTERY MARKET 1990-2016

Lithium Ion Battery: Highest growth & major part of industry investments



# Rechargeable Battery Market

- Steady growing market 65B\$ IN 2016
- Market is dominant by Lead Acid batteries
- Li-ion is the fastest growing technology
- NiMh market share is shrinking



# Li-Ion Market trends for 2017

- 2012-2014 The market was under over production
- Cell makers build production capacity for the EV and ESS markets but market demand was low then expected
- 2015-2017 We see a positive change – Market demand grow dramatically mainly because of the EV, E-BUS, E-Bike, ESS, Consumer Electronic and power tool markets
- Cell makers cant supply the current demand –  
We face slow pricing increase and longer delivery time It will not be a surprise if we will see higher pricing till end of 2018 early 2019

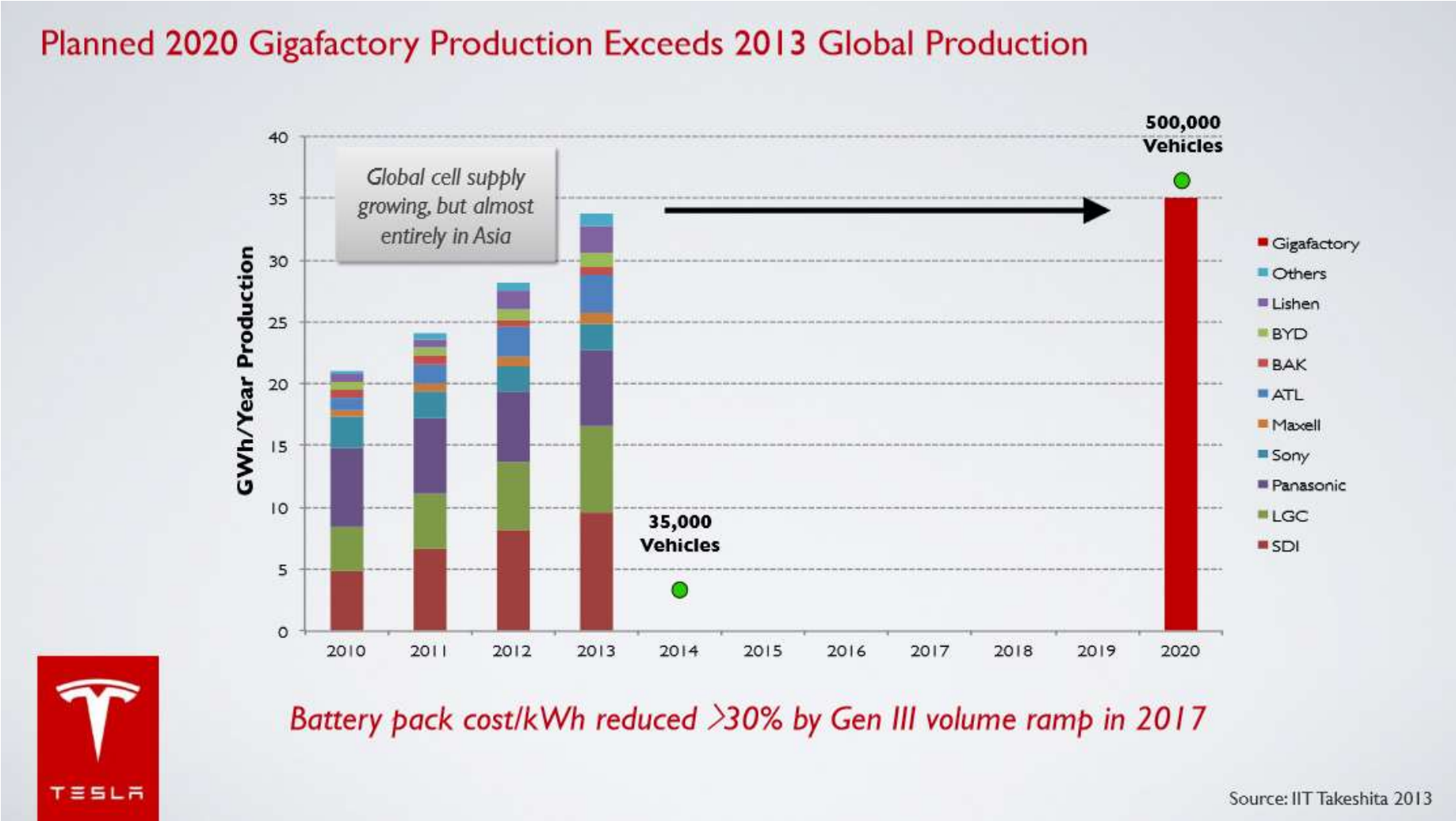


# **Li-Ion Cell Production to Grow 2-3 Times till 2020**

- **Li-Ion battery market size was estimated as 75GWh in 2016 (Source: Avicenne Energy).**
- **Demand from the EV and ESS markets push the cell maker to increase production**
- **Tesla Giga factory will produce 35GWh in 2020**
- **China li-ion battery industry is booming – From 15.7GWh production in 2015 it expected grow to 30-40GWh in 2020 (Source: CCM`s)**
- **LG Chem, MI, USA increase production to meet GM, EV Batteries needs**
- **Samsung invest 600M\$ in their EV cell production facility in China till 2020**
- **A123 invested 200M\$ in increasing production**

The “Giga” factory is necessary for supplying the battery needed for 500k cars – current world production can’t support it.

The “Giga” factory to double word li-ion production capacity...





# Li-Ion Cell Raw Material

- As cell production grow we see a strong demand increase for battery raw materials
- Lithium compound price doubled in time period of several months
- Most of the battery raw material investing on increasing production
- Main issue is the battery raw material prices - Seems that with the grow in demand we can expect cost increase that will not support the planed li-ion battery cost reduction



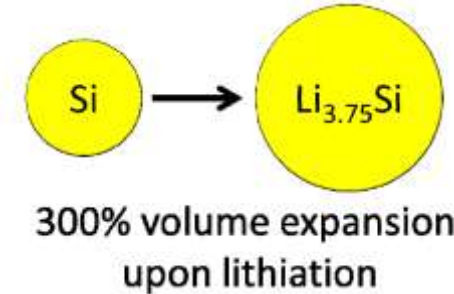
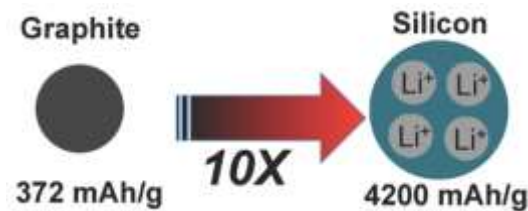
# Short Review of Potential Battery Technologies Break- Through 2020-2050

- Lithium Ion with Silicon based anode
- High Voltage Li-Ion (4.4-4.7V)
- Li-Ion Solid Electrolyte (Li-ion, Li-metal)
- Lithium Sulfur
- Lithium Air



# Li-Ion With Nano-Structure Silicon Anode

- Anodes are carbon based – Si stores 10X more energy than Li carbon (250-300 Wh/Kg).



- 18650 3.5-4Ah cells projected by American Lithium Energy, Panasonic, LG, Samsung and Sony (2015-2018).

## Panasonic NCR18650GA



|                           | Value       |
|---------------------------|-------------|
| Maximum Capacity          | 3.45Ah      |
| Nominal Capacity          | 3.35Ah      |
| Nominal Voltage           | 3.6v        |
| Standard Charging Current | 1.67A       |
| Max Charging Voltage      | 4.2V        |
| Std Discharge Current     | 0.2C        |
| Maximum Discharge Current | 8A          |
| Weight                    | 48 g        |
| Dimensions                | 18.5x65.3mm |
| Cut Off Voltage           | 2.5V        |

## Sony US18650VC7



|                            | Value          |
|----------------------------|----------------|
| Maximum Capacity           | 3.53Ah         |
| Nominal Capacity           | 3.4Ah          |
| Nominal Voltage            | 3.6V           |
| Standart Charge Current    | 1.7A           |
| Max Charging Voltage       | 4.2V           |
| Standard discharge current | 0.2C           |
| Maxium discharge current   | 8A             |
| Weight                     | 48 g           |
| Dimensions                 | 18.5 X 65.2 mm |
| Cut off voltage            | 2V             |

# Li-Ion High Voltage Cells

- Li-Ion cell voltages depend on the active materials in use (Cathode/Anodes) and non-active materials like (Separators and Electrolytes)
- A potential solutions for energy storage break through are the high voltage li-ion technologies (>4.35V)
- 4.35-4.45 high charging voltages li-ion cells (with 3.75-3.8V nominal voltage) already available commercially in the market by most of the leading players
- 4.5-5V high charging voltages li-ion cells are under development (Metal, Silicon and graphite materials)



High Power (China) 4.45v  
cells, 3.72Ah,  
772 Wh/l – Mass  
production Q3/2016  
[www.highpowertech.com](http://www.highpowertech.com)



# Envia High Energy Pouch Cell



*High Energy Drone Pouch Cells*  
(ENV35011-CRC)

## **Key Features & Benefits:**

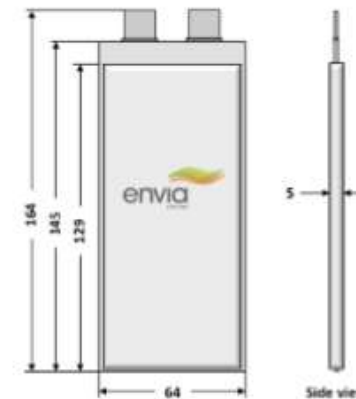
- ✓ 350Wh/Kg usable specific energy at C/10 rate
- ✓ 840Wh/L usable energy density (without terrace) at C/10 rate
- ✓ Excellent high voltage (4.47V) stability
- ✓ Proprietary Si-based anode and Cobalt-rich composite (CRC) cathode
- ✓ Low cost

## **Applications:**

- ✓ Unmanned aerial vehicles (UAVs)
- ✓ Flying automobiles
- ✓ Military applications
- ✓ Grid applications



| Cell characteristics         | Units      | Value        |
|------------------------------|------------|--------------|
| Cell capacity at C/10 rate   | Ah         | 10.6         |
| Specific energy at C/10 rate | Wh/Kg      | 350          |
| Energy density at C/10 rate  | Wh/L       | 840          |
| Cell weight (g)              | g          | 111          |
| Cell dimensions              | mm         | 145 x 64 x 5 |
| Nominal voltage (V)          | V          | 3.65         |
| Operating temperature (°C)   | degrees °C | -10 to 55    |
| Voltage range                | V          | 2.5 to 4.47  |



Approximate dimensions in mm

# Solid Electrolyte Pouch Cells

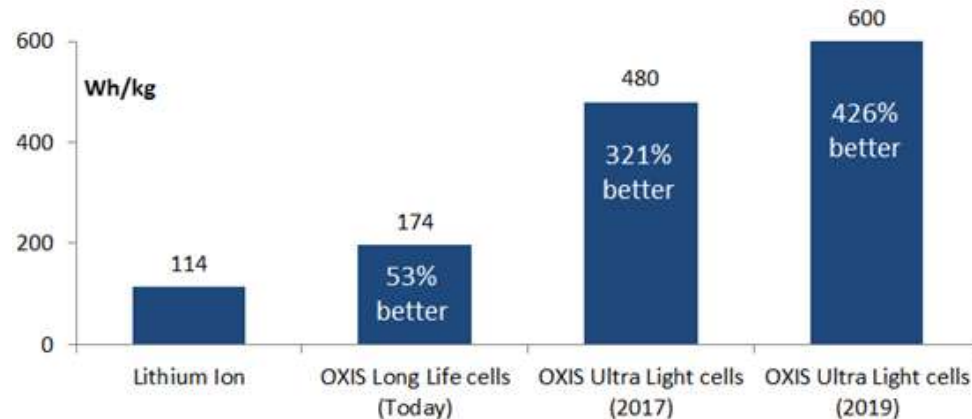
**Developers:**  
Toyota  
Apple  
Samsung  
Imprint  
Prologium  
And 20 more...



- Higher energy density than Li-Ion (When use Li-Metal anode)
- Safety – no flammable electrolyte, No leaks (Ceramic, Dry Polymer)
- less Lithium dendrite formation
- Can fit any casing shape (soft packaging)
- Cells can be made as thin as 0.1 mm or about one-tenth the thickness of the thinnest prismatic liquid Li-ion cells
- Low potentially manufacturing cost
- Excellent cycling stability
- Excellent shelf life

# Lithium Sulfur

- High theoretical capacity, energy and power density – Expected for practical 300 to 600 Wh/kg
- Sulfur cost is cheap and environmentally safe
- Li-S can provide the break through we are waiting for – but farther development needed
- **Developers:** Sion power (U.S.A.), Eagle-Picher (USA), PulyPlus (U.S.A.), Oxis Energy (U.K.) - Oxis is leading with a 310 Wh/kg pre-production

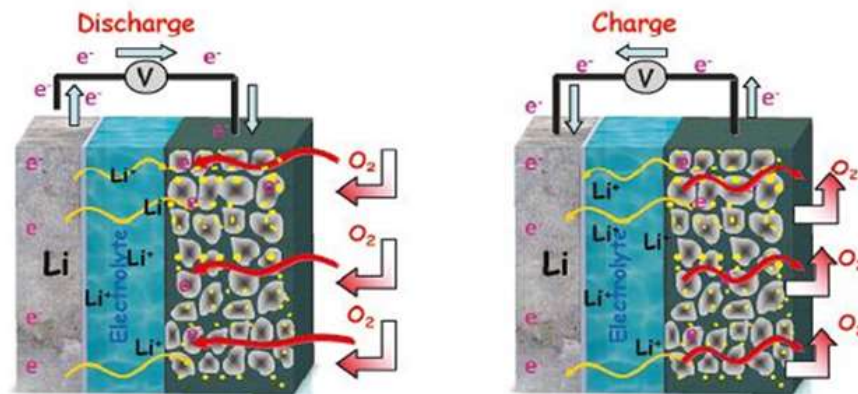


|       | Li-S | Li-Ion |
|-------|------|--------|
| Wh/Kg | 2500 | 580    |
| Wh/L  | 2660 | 1810   |



# Li-Air Rechargeable - Background

- **Metal Air batteries provide higher energy densities**
  - Aluminum Air
  - Zinc Air
  - Silicon Air
  - Lithium Air
- **But these metal air batteries up till now have been primary batteries (non rechargeable or only mechanically rechargeable)**
- **Academics and Industry alike are working on making the lithium air battery rechargeable.**







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**Information for presentation obtained by:**

- 1. Public web sources.**
- 2. Shmuel De-Leon Battery/Energy Sources DataBase ® (Includes 29000 cell PDF data sheets ) <http://www.sdle.co.il/Default.asp?sType=0&PagelId=45580>**