

Shmuel De-Leon
Energy Ltd 

Li-Ion NCA/NMC Cylindrical Hard Case Cells Market 2021

November 2021

Shmuel De-Leon

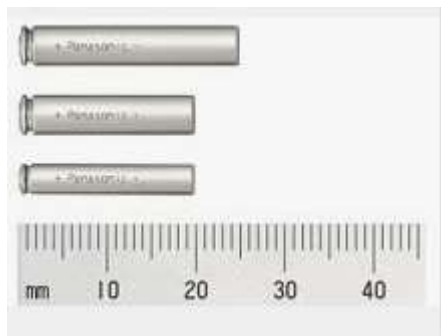
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Li-Ion Cells Different Packaging But the Same Chemistry

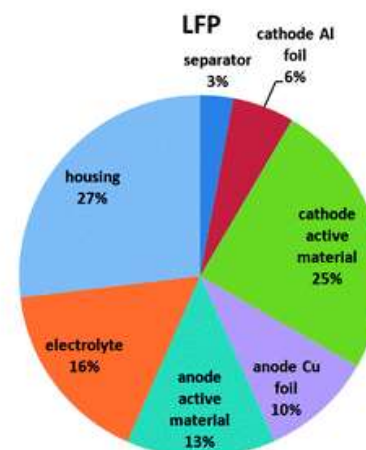
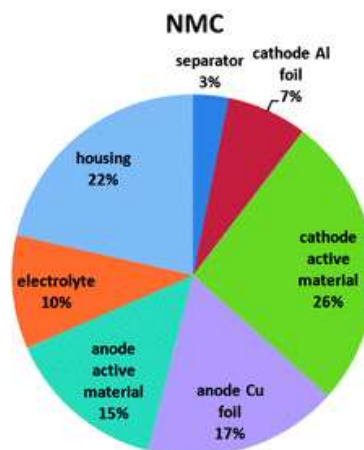
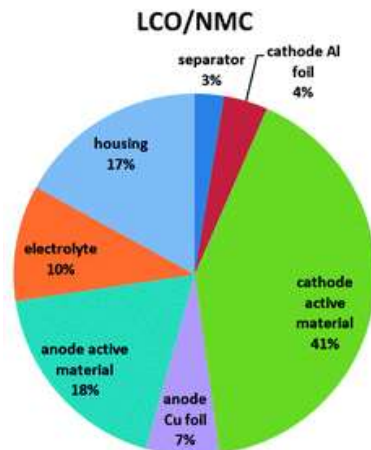
1. Hard Case Cylindrical
2. Hard Case Prismatic
3. Hard Case Button/Coin
4. Hard Case Pin
5. Soft Case prismatic
6. Soft Case Special Shape
7. Soft Case Cylindrical
8. Soft Case Button



Donut Shape

Li-Ion Rechargeable Systems

Technology	Anode	Cathode
Lithium Cobalt Oxide 3.6V	Graphite – Gr/Si	LCO
Lithium Manganese Oxide Spinel 3.8V	Graphite – Gr/Si	LMO
Lithium Nickel Manganese Cobalt 3.7-3.8V	Graphite – Gr/Si	NMC(111, 532, 622, 811)
Lithium Nickel Cobalt Aluminum 3.65V	Graphite – Gr/Si	NCA
Lithium Iron Phosphate 3.2V	Graphite	LFP
Lithium Titanate Oxide 2.3/2.4V	LTO	NMC, LMO, LFP



Cylindrical Cells Advantages

1. High energy density (up to 270Wh/kg, 740Wh/l).
2. Wide operating voltage range 4.35 – 3.0/2.5/2V.
3. Wide power density range (High energy. Medium Power, High Power).
4. Good cycle life ~500-1000 Cycles.
5. Low self-discharge ~ 1% per month.
6. Quick charge is possible ($\leq 2C$).
7. Can Include internal safety devices like vents, shut down separators, PTC, CID etc.
8. Standard sizes: 14500, 18650, 21700, 26650, 46800
9. Automatic mass production lines ensure cost & quality.

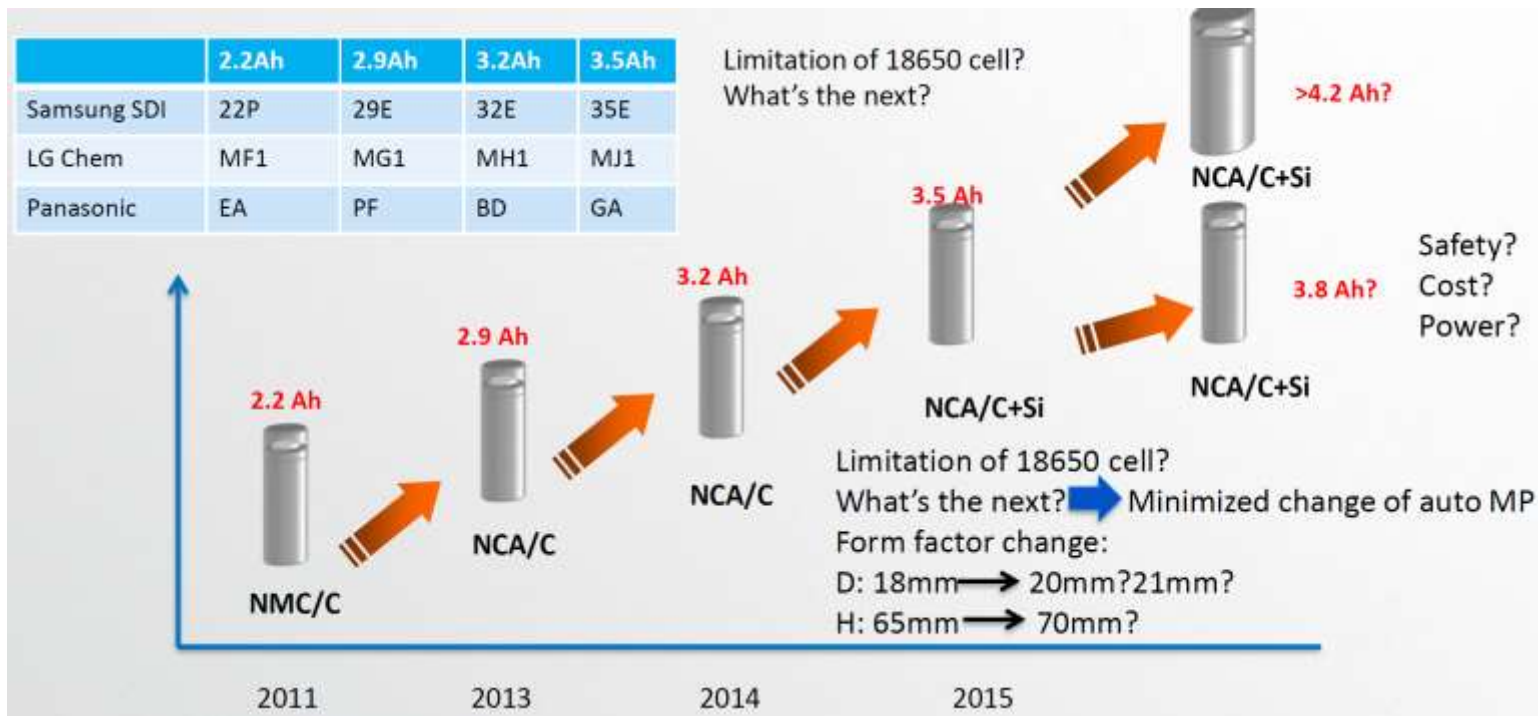


Cylindrical Cells Limitations

1. **Low volumetric energy density pack level.**
3. **Thicker than pouch cells.**
4. **Poor low temperature performance except special cells with electrolyte additives.**
5. **Cylindrical cell's reliability problem in case internal safety component fail (Vent/CID - vibration and shock, Fuse/PTC – Short high current).**
6. **Difficult to custom made special sizes.**
7. **Difficult to thermally cool due to lower external surface area (Pouch are much better).**
8. **Can't be use in cell to pack technology.**



18650 Cells – General Road Map



Samsung SDI INR18650- 35E

	Value
Nominal Capacity	3.45 Ah
Maximum Capacity	3.35Ah
Nominal voltage	3.6v
Standard Charge	1.5A
Max Charge Voltage	4.2v
STD Discharge	0.69A
Max Continues Discharge Current	8A
Weight	50g
Dimensions	18.5 d, 65.25h mm

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

LG Chem INR18650MJ1

- Nominal Capacity: 3500mAh
- Minimum Capacity: 3400mAh
- Nominal Voltage: 3.6V
- Standard Charge
Constant current: 1700mA
Constant voltage: 4.2V
End condition(Cut off): 50mA
- Max. Charge Voltage: 4.2 ± 0.05V
- Max. Charge Current: 3400mA
- Standard Discharge
Constant current: 680mA(0.2C)
End voltage(Cut off): 2.5V
- Max.Continuous Discharge Current: 10A
- Weight: Max.49.0g
- Dimension: Max.(D)18.5*(H)65.2mm

New 18650 Cells

1. Moli Energy start to manufacture new 18650 3.5Ah cells – INR-18650M35
2. Due to strong shortage with Samsung, LG, Panasonic, Moli 3.5Ah cells we see new Chinese cells arrival.
3. Lishen LR1865HC (R&D – M.P mid 2022).
4. Tenpower 18650-35HE (R&D – M.P mid 2022).
5. EVE 18650-35V (M.P – Q4/2021).
6. DMEGC INR18650-35E - (M.P – Q4/2022)
7. Cham 18650F9L (M.P – Q4/2022)

Model	30HE	35HE	32HE	28HE	26HE	22HE	32ME	48HE
Form Factor	21700	18650	18650	18650	18650	18650	18650	21700
Nominal Voltage (V)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Typical Capacity (mAh)	5,000	3,500	3,200	2,900	2,600	2,200	3,200	4,800
Continuous Discharge Current (A)	10	10	10	10	10	10	15	15
Continuous Charge Current (A)	0.5C	0.5C	0.5C	0.5C	0.5C	0.5C	0.5C	0.5C
Max. Weight (g)	69	47	47	46	47	45	47	69
Datasheet								

Tenpower 18650-35HE

MOLICEL[®] LITHIUM-ION RECHARGEABLE BATTERY

■ CELL CHARACTERISTICS

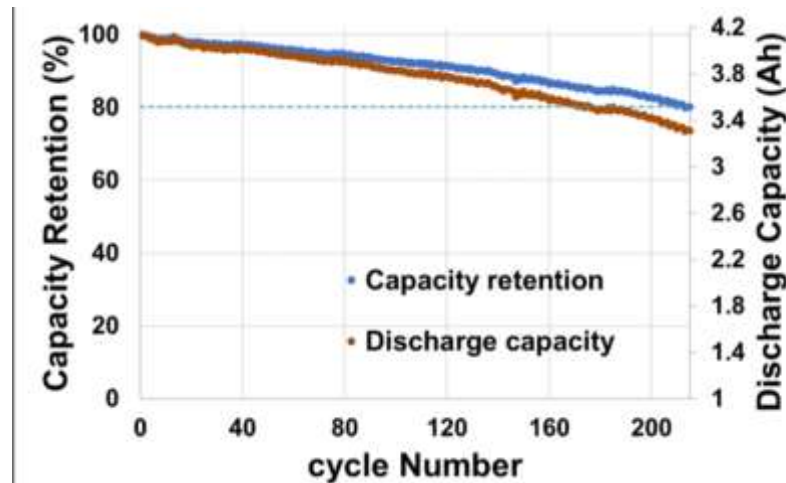
Capacity	Typical	3500 mAh 12.5 Wh
	Minimum	3350 mAh 11.9 Wh
Cell Voltage	Nominal	3.6 V
	Charge	4.2 V
	Discharge	2.5 V
Continuous Charge Current	Standard	1.7 A
	Maximum	1.7 A
Charge Time	Standard	2.5 hr
Continuous Discharge Current	Maximum	10 A
Ambient Temperature	Charge	0°C to 60°C
	Discharge	-40°C to 60°C
Energy Density	Volumetric	700 Wh/l
	Gravimetric	250 Wh/kg

Breakthrough Cells for Military Use

- Capacity: 4.0 Ah
- Specific energy: 320 Wh/kg
- 60 °C storage for one week at 100 % SOC
- ~ 95 % capacity retention and > 99 % capacity recovery



- Capacity: 4.0 Ah
- Specific energy: 320 Wh/kg
- > 92 % capacity retention at 1C discharge rate
- > 50 % capacity retention at -40 °C and 0.2 C discharge rate



- Cell Capacity: > 4.0 Ah
- 100 % DOD
- C/3 charge rate
- C/5 discharge rate

Nanograp

NanoGraf Enables Most Energy Dense Battery

3.8 Ah 18650 | 800 Wh/L

NanoGraf Reaches Energy-Density Milestone for its Lithium-Ion Battery Material

Record-setting breakthrough in energy density of silicon anode cells enable longer-lasting, lighter weight, and shortened charge cycles for consumer electronics, electric vehicles, military equipment and more.

CHICAGO - June 10, 2021 (9am CT) - To help us better embrace our electric future, NanoGraf, an advanced battery material company, today announced it has enabled the highest energy density 18650 cylindrical lithium-ion cell in the world - one that provides a 28 percent longer run time than traditional cell chemistries.

Aided by funding from the U.S. Department of Defense and others, NanoGraf's team of scientists, technologists, and engineers today unveiled an 800 watt-hour per liter (Wh/L) silicon-anode based cell that provides compelling benefits for virtually any application - from consumer electronics to electric vehicle batteries to the batteries that power the equipment soldiers use during operations.

"This is a breakthrough for the battery industry," said NanoGraf President, Dr. Kurt (Chip) Breitenkamp. "Energy density has plateaued, only increasing eight percent or so over the last decade. We just achieved a 10 percent increase in a little under a year. This is over a decade's worth of innovation in one technology."

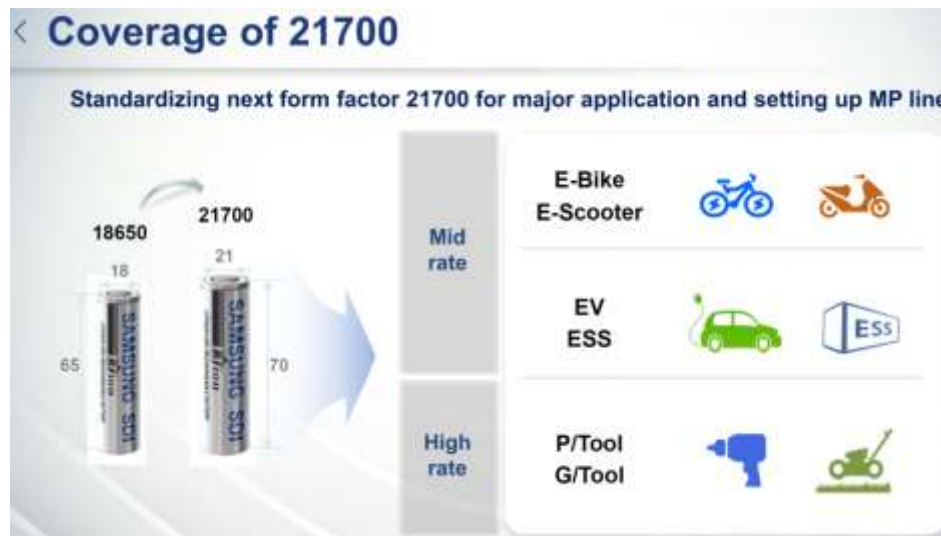
One of the biggest opportunities for more energy-dense batteries lies with electric vehicles, where "range anxiety" is a major impediment to mainstream adoption. NanoGraf's new cell technology could immediately provide a boost to electric vehicles, such as the Tesla Model S, which would last approximately 28 percent longer on a single charge compared to similar vehicles on the road today.

In addition to commercial applications, the NanoGraf-enabled battery also dramatically improves the performance of soldier-carried military electronics and equipment. U.S. soldiers on patrol carry upwards of twenty pounds of lithium ion batteries, often the second heaviest category of equipment after body armor. NanoGraf's batteries improve run time on U.S. soldiers' equipment and can reduce their battery pack weights by over 15 percent.

<https://www.nanograp.com/18650-press-release>

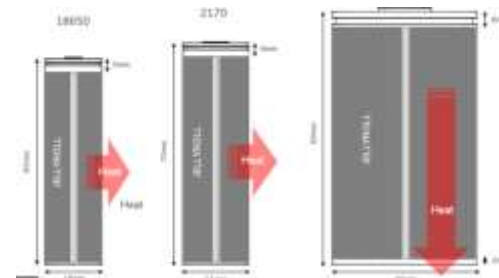
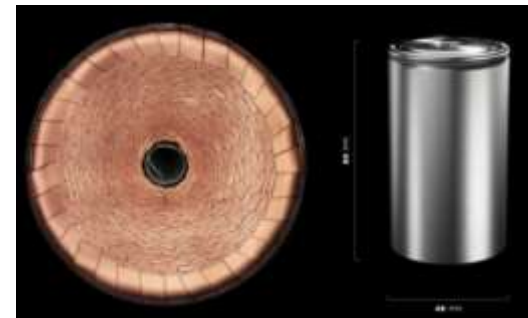
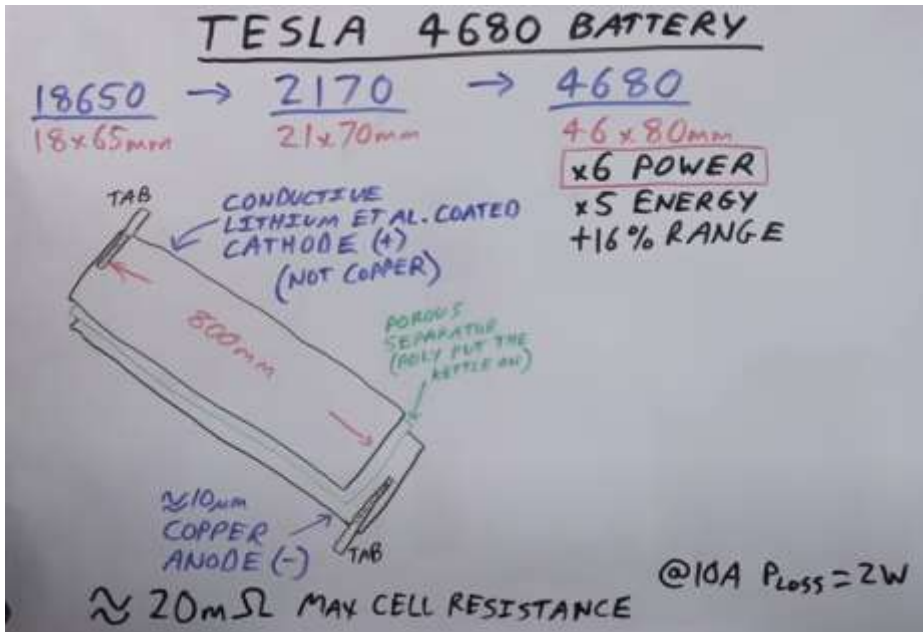
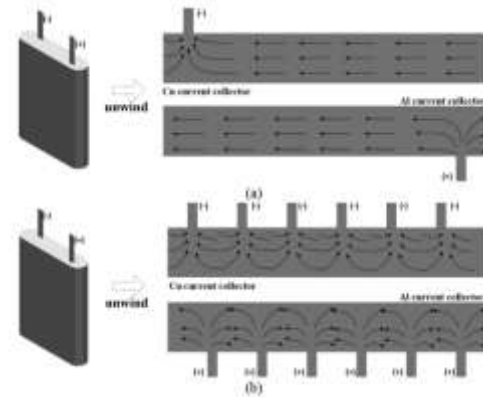
The Need for Larger Li-Ion Cylindrical Cell Sizes

1. High demand for more energy lead to larger battery packs.
2. Larger number of 18650 cells in the battery packs lead to more complicated BMS and higher pack cost production.
3. 21700 cells increase pack energy density, reduce number of cells in battery packs and increase pack efficiency.
4. 21700 is the default choice, 46800 under design.



Tesla 4680 New Cell Size

1. Tab`s less technology.
2. Lower internal impedance.
3. Better thermal heat flow.
4. 16% better energy density.
5. Less cells in battery pack – Saving assembly cost.



Leading 13 Li-Ion Cylindrical Cells Manufacturers by Production Capacity

Companies	18650	21700	Web Site	UL Certification File
Panasonic - (Japan)	✓	✓	https://industrial.panasonic.com/	MH12210
Samsung SDI - (Korea)	✓	✓	https://www.samsungodi.com/	MH21015
LG Energy Solution - (Korea)	✓	✓	https://www.lgensol.com/	MH19896
Murata Manufacturing - (Japan)	✓	✓	https://www.murata.com/en-global/products/batteries/cylindrical	MH12566
E-One Moli - (Taiwan)	✓	✓	http://www.molicel.com/	MH27672
Tianjin Lishen Battery Joint-Stock - (China)	✓	✓	http://en.lishen.com.cn/	MH27663
EVE Energy - (China)	✓	✓	https://en.evebattery.com/	MH28717
Dalian CBAK Power Battery - (China)	✓		http://www.cbak.com.cn/	MH61126
Guangzhou Great Power - (China)	✓	✓	http://www.greatpower.net/	MH27311
Jiangsu Highstar Battery Manufacturing - (China)	✓	✓	http://www.highstar.com/	MH46739
Dong Guan K-Tech New Energy - (China)	✓	✓	https://www.greenway-battery.com/	MH49877
Jiangsu Tenpower Lithium - (China)	✓	✓	https://www.tenpowercell.com/	MH46259
DLG (Shanghai) Electronic Technology - (China)	✓		https://www.dlg-battery.com/	MH29824

65 Li-Ion Cylindrical Hard Case Cells Manufacturers covered by our battery market report, Li-Ion Cylindrical Cells Market Review 2021, <https://www.sdle.co.il/products/market-research-reports/>

New Giga Cylindrical Cells Factories in Europe/USA

Company Name	Web-Site
AMTE (Turso, Scotland)	https://amtepower.com/
Blackstone Resources (Switzerland)	http://www.blackstoneresources.ch/
British Volt (UK)	https://britishvolt.com/
Evercharge Energy (UK)	https://everchargeenergy.com/
FAAM/Lithops (Italy)	https://www.faam.com/eng/
Freyr (Norway)	www.freyrbattery.com
HE3DA (Czech Republic)	https://www.he3da.com/
InoBat Auto (Hungary)	https://inobatauto.eu/
Italvolt (Italy)	https://www.italvolt.com/
Morrow Battery (Norway)	https://www.morrowbatteries.com/
Northvolt (Sweden, Germany)	https://northvolt.com/
Phi 4 Technology S.L. (Spain)	https://www.phi4tech.com/
Saft, PSA & Opel (France, Germany)	https://www.acc-emotion.com/
Tesla (Germany)	https://www.tesla.com/
Varta (Ellwangen, Germany)	http://varta.com/
Verkor (France)	http://verkor.com/

Company Name	Web-Site
Tesla	https://www.tesla.com/
iMperium3	http://chargecccv.com/
Moli Energy	http://www.molicel.com/

These companies may produce cylindrical cells but their effect on the market will be not before 2024.

Cylindrical Cells Manufacturing Capacity Forecast

- 1. Cylindrical li-ion cell manufacturing capacity is around 850 Million per month during 2021 and will reach 3.2 Billion during 2025 and 6.7 Billion during 2030 (Carin Energy).**
- 2. Majority of cells manufactured will be used by Tesla.**
- 3. Cylindrical cells market are dominant by Panasonic, Samsung SDI, LG ES, Murata from Korea, Japan and tier one Lishen, BAK, EVE from China.**
- 4. Northvolt cylindrical cells production capacity will an important part of the future production capacity.**
- 5. 46800 new Tesla cell format – When Tesla will move to 46800 cell format it will free some 21700 cells demand and my effect the market – However Tesla 46800 cells production are in delay, and it is not clear when BAK, EVE will start production.**

2021 Cylindrical Cells Market Shortage Root Causes

1. **Tesla!!!!** - with 5000-7000 cylindrical cells on each EV battery pack and increasing EV sales.
2. **Panasonic** is fully committed to Tesla – small deliveries to other customers.
3. **Other Customers** for EV and ESS batteries made from Cylindrical cells increasing sales (Volvo trucks, .
4. **LG** begin supply cylindrical cells to Tesla and prioritize it over other customers (Models 3 and Y).
5. **Covid effect** – Periodically Production capacity reduction at LG, Samsung, Murata, Moli Energy during 2020-2021.



6. **Limited investment on expending cylindrical production lines (2020).**
7. **The large cell manufacturers prioritize expending production resources on EV cells (Hard case and pouch prismatic) over cylindrical cells production capacity (Higher profits).**
8. **Long time for production capacity expansion – 2-3 years for existing cell makers, 3-4 years for newcomers.**
9. **Shortage on battery raw materials since all li-ion cells production capacity expansion use the same materials.**



**For how long that shortage will exist?
What the cell customers should do for securing the cells supply?**

What to Expect?

1. **Strong shortage in cylindrical cells with cell pricing increase for at least 2-3 years until new production capacity will be release.**
2. **More severe shortage on cylindrical cells then other cell packaging (Prismatic pouch and hard case).**
3. **Stronger shortage on 18650 cells since most cell manufacturers moving to 21700 as their main cell size.**
4. **Production expansion mainly lead by Chinese manufacturers that can fast increasing production capacity (Strength market position of Chinese manufacturers).**
5. **Some expansion expected also by Korean and Japanese leading companies.**
6. **When Tesla will move to 46800 that may free some pressure over 21700 cells production capacity.**

- 7. Customers push to secure cell supply and buy any cells they can find even in higher cost (Supply-Demand).**
- 8. Power tool makers like Bosch, Makita, Stanley, Dyson, Electrolux and similar companies will suffer from shortage since cell manufacturer prefer to sell the cells in higher cost to other customers.**
- 9. Customer move to purchase cylindrical cells from Chinese suppliers and Moli Energy from Taiwan when Samsung, LG, Panasonic, Murata can't deliver.**
- 10. Customers move to Chinese pouch cells where there is better availability.**

More detailed information in our battery market report:

Li-Ion Cylindrical Cells Market Review 2021

<https://www.sdle.co.il/products/market-research-reports/>



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Information in this report was obtained by:

- 1. Public web sources.**
- 2. Shmuel De-Leon Battery/Energy Sources DataBase[®] (Includes 15,000 cell PDF data sheets).**