27 August 2013 | 40 pages

Technology - General (Citi)
Japan

Lithium-ion batteries redux

Market sparking back to life?

- **Lithium-ion batteries** attract a lot of attention from investors because of the high growth potential for the market, the diverse range of associated companies, and the size of the lithium-ion battery impact on a variety of sectors. On July 20, 2012 we issued a primer on the subject (Lithium-ion batteries - A Japanese tech growth story?), and in this report we update on the conditions in the lithium-ion battery market one year on.

- **Our investment stance** is bullish on the automotive market and bearish on the consumer electronics market, although we are bullish on smartphone applications. The prevailing equity market view is that the automotive market is weak due to slack sales, but we think it is likely to resume growth in the coming year or two, as the Tesla Model S and new Nissan Leaf EVs have been hits, lithium-ion batteries are increasingly being used in HVs, and a slew of new PHEV models are slated to debut by 2015. We forecast that the automotive lithium-ion battery market will grow strongly, to $5.1bn in 2015 from $1.9bn in 2012.

- **Fire incidents, most notably with the Boeing 787,** have brought the spotlight on the safety of lithium-ion batteries. We expect fire risk to remain an intrinsic issue, as lithium-ion batteries are vulnerable to catching fire because of their energy density and because rechargeable battery types that could substitute for lithium-ion ones will not be commercialized in the near future. We are interested in technologies that may enhance safety, such as phosphoric acid materials and lithium titanate (LTO) negative electrodes.

- **Our top pick is GS Yuasa**, which we find attractive of growing demand for its lithium-ion batteries for Honda's HVs. Also, the battery earnings of **Panasonic** are improving in both consumer electronics and automotive, on growth in demand for the Tesla Model S and yen weakness. In battery materials, our stock to watch is **Hitachi Chemical**, which is impressively competitive in negative electrode materials in both consumer electronics and automotive markets. It is also pouring efforts into storage batteries and is a big beneficiary of battery market growth.

- **In contrast**, we rate battery pack maker **Simplo Technology** Sell, as it is being hard hit by contraction in notebook PC demand. **Samsung SDI** is appealing for its consumer electronics batteries but we rate it Neutral because expansion in automotive batteries is set to take time and valuation multiples are in our view stretched. **Umicore** is one of the largest players in cathode materials but price competition and cost pressures limit margin and earnings upside. We rate it Neutral.

Tsubasa Sasaki
+81-3-6270-4817
tsubasa.sasaki@citi.com

Kota Ezawa
+81-3-6270-4804
kota.ezawa@citi.com

Takao Kanai
+81-3-6270-4776
takao.kanai@citi.com

Henry H Kim, CFA
+82-2-3705-0720
henry.h.kim@citi.com

Oscar Yee
+852-2501-2473
oscar.yee@citi.com

Wei Chen
+886-2-8726-9085
wei.s.chen@citi.com

Jason Channell
+44-20-7986-8661
jason.channell@citi.com

Phuc Nguyen
+44-20-7986-9852
duy.phuc.nguyen@citi.com

Dominik Frauendienst
+44-20-7986-4299
dominik.frauendienst@citi.com

Contents

Executive summary

What market changes have there been in the past year?

Key changes over the past year

Key changes over the past year have been the maturation of the consumer electronics market, because of the weak notebook demand and the appearance of 8-inch models in tablets. The capacity of smartphone batteries continues to rise but commoditization has become a concern. We are beginning to see signs that the automotive market will expand in the coming year or two, although market expectations are low. Accelerating moves to install storage batteries globally on the spread of renewable energy, especially solar power generation, also merit attention. International competition in battery materials is intensifying, due to the emergence of Chinese firms, but next-generation materials are spreading in high-end areas because of the need to shift to higher battery capacities, especially for smartphones.

Consumer electronics battery market a concern given commoditization of smartphones and tablet PCs

Our take on the consumer electronics battery market is unchanged: demand for use in notebooks is falling, while smartphones and tablets are the growth drivers. However, the continuing commoditization of smartphones and tablets is a source of concern. Smartphone batteries continue to increase in capacity, but we caution on the negative impact commoditization has on unit prices. With the emergence of 8-inch tablets, we have also seen battery capacity falling in some cases. We note that external smartphone batteries (to counter insufficient internal battery capacity) are attracting attention as a new application, and we see demand expansion up ahead.

With yen weakness helping earnings power recover at Japanese firms, the focus is on the rise of Chinese firms

Turning to the competitive environment, South Korean firms had been making gains due to won weakness, but yen weakness from the latter half of 2012 has allowed Japanese firms to recoup earnings power. In addition, Chinese firms have increased their presence in the smartphone market, and Chinese battery makers are an increasing presence as well due to continued adoption by major smartphone firms.

Automotive battery market expectations are low but it remains a growth area

We note that 2012 was a tough year for automotive lithium-ion batteries due to weak sales of EVs. Over the longer term, however, we still see this as a growth market because 1) the number of EV/PHEV/HV models on the market is increasing and their performance is improving and 2) countries around the world are putting in place fuel efficiency standards and charging infrastructure.

Automotive battery market could start to expand again over the next year or two

A number of problems emerged in 2012, like poor sales of the i-MiEV and A123 System's bankruptcy. However, in 2013 there have been some bright spots: sales of the Tesla Model S and the new Nissan Leaf have been strong, while both Toyota and Honda are expected to increase usage of lithium-ion batteries in their HVs. Through 2015, we expect to see an uptick in the launch of PHEVs, particularly by European automakers, suggesting the automotive battery market could start to expand again over the next year or two, although market expectations are low.

Demand for storage batteries used in renewable energy applications is rising

We expect social infrastructure storage batteries to see growth longer term as a third key application. This market is still in its infancy, but with the growing role of renewable energy, there has been increasing usage since late 2012 of storage batteries to stabilize power distribution networks. The Japanese and German governments in particular have provided subsidies and the pace of storage battery installation is accelerating.

Competition heating up in the global battery material market, but next-generation material uptake is rising

Many battery material firms have seen competitiveness and earnings power dwindle due to growing international competition via the rise of Chinese firms and sluggish growth in the auto battery market. But next-generation material uptake is rising at the high-end due to needs for higher battery capacity (particularly in smartphones). In addition, we think the automotive battery market will begin to expand once again.

Estimating the size of the lithium-ion battery market

The lithium-ion battery market was worth $14.2bn in 2011 and $15.9bn in 2012. We forecast it will expand to $17.8bn in 2013, $20.2bn in 2014, $22.6bn in 2015, and $34.3bn in 2020 (Figure 4). We previously thought the market would be worth $23.6bn in 2015, but we revise this down. On one hand, we lower our outlook for consumer electronics demand as tablet PCs and smartphones become increasingly commoditized, but we also raise our forecast for automotive demand (primarily EVs).

Lithium-ion battery investment strategy

Investment stance: Bearish on consumer electronics (but bullish on smartphones), bullish on automotive

Our investment stance over a one-to-two year horizon is bullish on the automotive market and bearish on the consumer electronics market, although we are bullish on smartphone applications. We wish to emphasize that we see a mounting likelihood of renewed growth in the automotive market over the next year or two. Although equity market expectations for the automotive market are depressed, we take a bullish stance. The storage battery market has just begun to ramp up and is not yet large, so it does not lend itself easily to investment actions, but hopes for it are high over a long-term time frame.

GS Yuasa is in an attractive position for an investment in automotive batteries

Among the major battery makers, we note that GS Yuasa, Panasonic, and LG Chem are heavily exposed to the automotive market. Of these, we particularly like **GS Yuasa**, which we think is attractively positioned as an investment target: it has a superior customer base, which includes Honda HVs and MMC's Outlander PHEV, and the earnings impact of automotive batteries is considerable.

At Panasonic, battery earnings are likely to improve, thanks to the Tesla Model S and yen weakness

In addition, battery earnings are improving at **Panasonic** as part of its structural reforms as 1) demand for the batteries used in the Tesla Model S is growing and 2) yen weakness has enabled profitability for consumer electronic batteries. **LG Chem** is highly competitive in both automotive and consumer electronics batteries, and in the latter demand for smartphone products is growing. However, we think it will take time for automotive battery demand to expand. **Samsung SDI** is highly competitive in consumer electronics batteries, and we expect growth in demand for smartphone products, so it is appealing on consumer electronics batteries alone. However, we think it will take time for demand for automotive batteries to increase and the stock's valuations are high, so we rate the shares Neutral.

Simplo a Sell due to concerns about the consumer electronics market

One company with a high exposure to the consumer electronics market is the battery pack maker **Simplo Technology**. Simplo supplies battery packs for notebook PCs, smartphones, and tablet PCs, Given the major hit it is taking from the decline in notebook PC demand, we rate the shares Sell.

Highlighting Hitachi Chemical in electronic materials

Among battery material makers, we believe **Ube Industries**, **Hitachi Chemical**, **Asahi Kasei**, **Mitsubishi Chemical Holdings**, and **Umicore** are likely to maintain their considerable competitiveness thanks to impressive technological capabilities and dominant market shares. We like **Hitachi Chemical** as it is likely to benefit significantly from the battery market due to its competitiveness in anode materials for both consumer electronics and automotive applications and its strategic focus on storage batteries as a growth area. **Umicore** is one of the largest players in cathode materials but price competition and cost pressures limit margin and earnings upside. We rate it Neutral.

Below we list reports on companies related to lithium-ion batteries.

Figure 1. Recent reports on lithium-ion batteries and related names

Analyst name	Region/country	Date	Link
Tsubasa Sasaki	Japan	7/20/2012	Lithium-ion batteries - A Japanese tech growth story?
Dominik Frauendienst	Europe	4/30/2013	Umicore NV/SA (UMI.BR) - Cutting Estimates on Weak Europe; Neutral
Jason Channell	Europe	4/30/2013	Battery storage – the next solar boom? - Germany leads the way with storage subsidies
Henry Kim	South Korea	5/6/2013	Samsung SDI (006400.KS) - Neutral: Still in Long-term Transition Stage
Takao Kanai	Japan	5/30/2013	Ube Industries (4208) - Staying Neutral: Slow earnings recovery likely short term on lactam weakness
Oscar Yee	Hong Kong	7/23/2013	LG Chem (051910.KS) - Healthy 2Q EBIT; But Slow Sales Growth for I&E
Takao Kanai	Japan	7/30/2013	Hitachi Chemical (4217) - Reiterating Buy: Strategy thus far gradually starting to bear fruit
Wei Chen	Taiwan	8/5/2013	Simplo Technology (6121.TWO) - Solid Execution, But Secular Margin Compression Trend Remains a Concern
Kota Ezawa	Japan	8/22/2013	Sony (6758) - Three drivers lined up: governance, restructuring, and growth
Kota Ezawa	Japan	8/22/2013	Panasonic (6752) - Restructuring and weak yen benefits greater than expected
Takao Kanai	Japan	8/23/2013	Asahi Kasei (3407) - Buy: Revising up, mainstay ops strong apart from acrylonitrile
Tsubasa Sasaki	Japan	8/27/2013	GS Yuasa (6674) - Upgrade to Buy: How to play global auto battery growth

Source: Citi Research.

Figure 2. Other thematic reports by Tsubasa Sasaki

Analyst name	Region/country	Date	Links
Tsubasa Sasaki	Japan	1/17/2012	OLEDs - The next generation of displays
Tsubasa Sasaki	Japan	7/20/2012	Lithium-ion batteries - A Japanese tech growth story?
Tsubasa Sasaki	Japan	10/25/2012	Long Term Evolution - Innovation in communication services, devices, and handsets
Tsubasa Sasaki	Japan	1/22/2013	Touchscreen industry - Nitto Denko benefits from film shift for tablet touchscreens
Tsubasa Sasaki	Japan	2/27/2013	Japanese Med Tech in a Global Context - Can Japan's med tech Davids take on the global Goliaths?
Tsubasa Sasaki	Japan	7/17/2013	Home Appliances in a Global Context - The appliance of science: Making money from the mundane

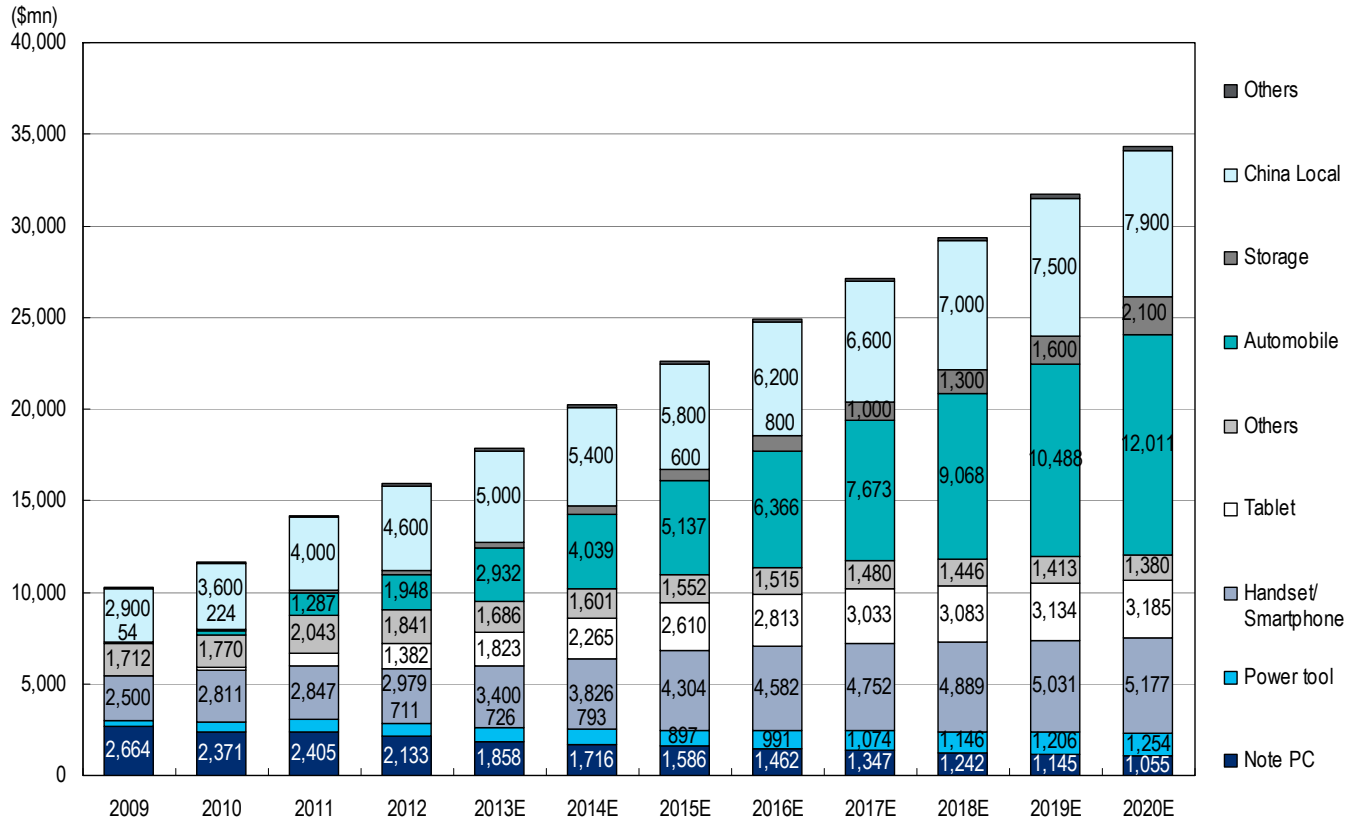
Source: Citi Research.

Figure 3. Battery market overview by application

	Market size (2012)		Desired specs			
Market	($mn)	Growth	Quality	Cost	Safety	Market conditions
Consumer	9,047	○	○	◎	○	High-end fields such as smartphones and tablet PCs are growing but commoditization is ongoing, especially in notebook PCs and feature phones
Notebook PCs	2,133	△	△	◎	○	Commoditization has progressed due to slower growth for notebook PCs and increased competition. With the market shrinking we are seeing some companies specialize in high-end high-capacity batteries
Power tools	711	○	◎	○	○	Demand for high-output cylindrical batteries is growing with the spread of power tools
Handsets/ smartphones	2,979	○	○/◎	◎/○	○	Demand for high-end batteries (thinner, higher capacity) used in smartphones has increased. However, smartphone commoditization is a concern
Tablet	1,382	○	◎	○	○	Demand for high-end laminated batteries is growing with the spread of tablet PCs. However, with the emergency of 8-inch products we have seen battery capacity falling in some cases
Consumer others	1,841	△/○	○/◎	○/◎	○	Growth for batteries used in portably equipment is slowing. Moving forward we look for increasing demand for batteries used in portable storage products, EVs, and wearable devices
Automobiles	1,948	◎	◎	◎	◎	These products need to be extremely safe and highly cost competitive. Their potential is vast, but currently the market scale is small. This is flying below the radar of companies and investors, but we look for growth medium term on an increasing number of HV/PHEV/EV models and improved performance for them
Storage	200	◎	◎	◎	◎	These products need to have long life spans and by extremely safe and cost-competitive. Market potential is vast. Storage batteries are still in the early stages, but the market is off and running due to renewable energy subsidies
Chinese local	4,600	○	X	◎	X	The main users for these batteries are "white box" product makers, low-speed EVs, and unbranded aftermarket battery packs. Cost competitiveness is more important than quality and performance
Total	15,905					The market used to focus on consumer electronics, but going forward we look for expansion in automotive and storage battery applications

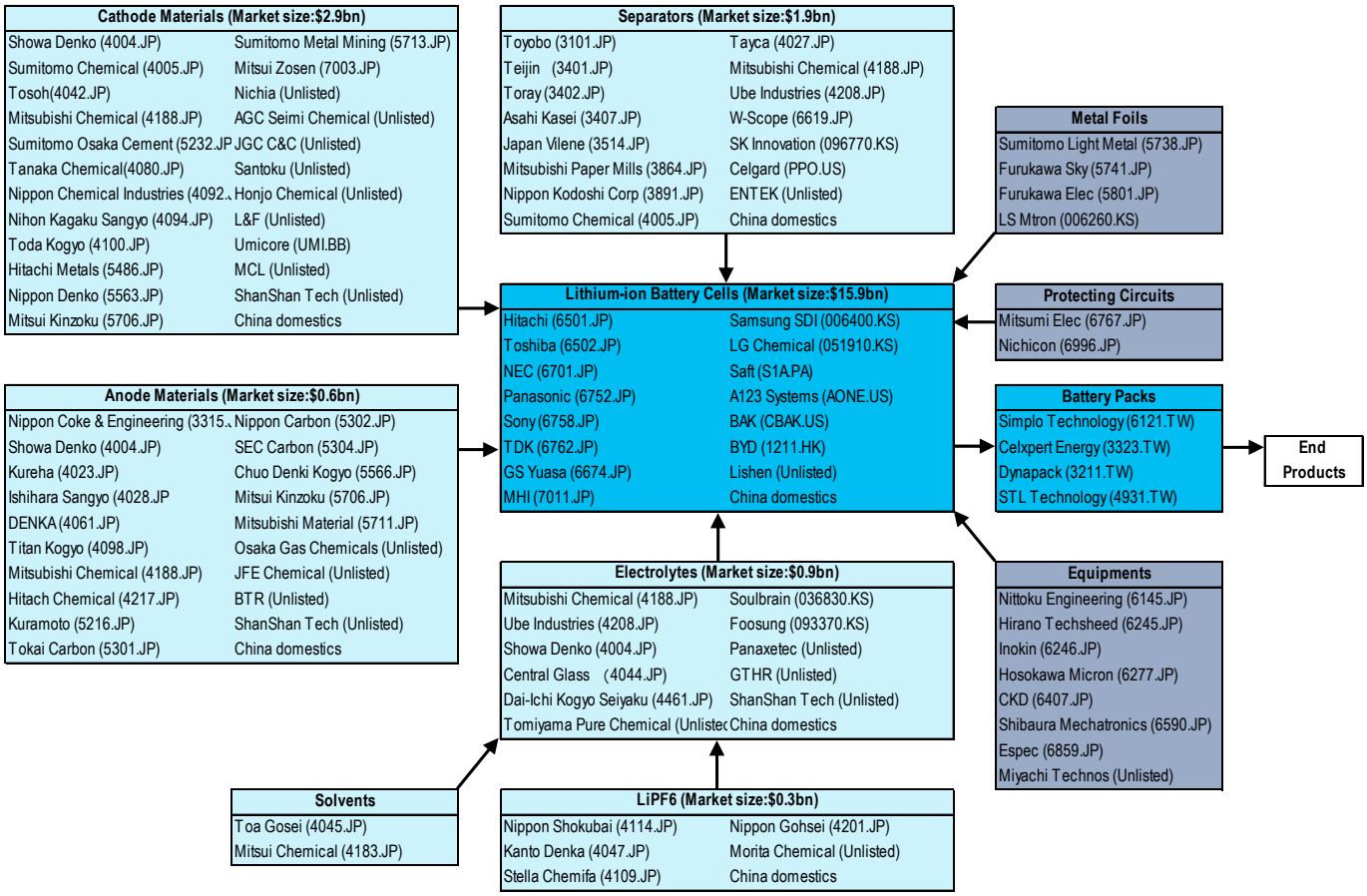
Note: ◎ = excellent, ○ = good, △ = poor, X = very poor.
Source: Citi Research.

Figure 4. Lithium-ion battery market scale estimate by application: We expect market expansion to shift from consumer electronics to auto and storage markets



Source: Company data, Wards, Anfavea, AEB, JAMA, JAPA, CAAM, SIAM,GAIKINDO, TMT, IDC, Gartner, CIPA, TSR, MarkLines, Citi Research estimates.

Figure 5. Overview of the lithium-ion battery supply chain



Source: Company data, Citi Research.

Figure 6. Major lithium-ion battery makers (FY12A): South Korean firms lead the consumer market, Japanese firms lead the automobile market

			($mn)		Local currency (bn)	
Battery company	**Main products**	**Main end-products**	**Sales**	**OP**	**Sales**	**OP**
Consumer						
Panasonic	Cylindrical, prismatic, laminate	Handsets, notebook PCs, digicams, etc.	3,373	-127	266.4	-10.0
Sony	Cylindrical, laminate	Handsets, tablets, notebook PCs, digicams, power tools, etc,	1,376	NA	108.7	Negative
TDK (ATL)	Laminate	Handsets, tablets, etc	1,266	NA	100.0	Positive
Hitachi (Hitachi Maxell)	Prismatic	Handsets, portable games, etc.	NA	NA	NA	NA
Samsung SDI	Cylindrical, prismatic, laminate	Handsets, tablets, notebook PCs, power tools, etc.	2,982	294	3,349	330
LG Chem	Cylindrical, prismatic, laminate	Handsets, tablets, notebook PCs, etc.	1,797	54	2,018	61
BYD	Prismatic	Handsets, etc.	NA	NA	NA	NA
Automotive						
Panasonic	LMN, LMO	Toyota, Honda, Ford, Tesla, Daimler, VW, etc.	633	-63	50.0	-5.0
Hitachi Vehicle Energy	NA	Mitsubishi Fuso, Isuzu, Honda, GM	NA	NA	NA	NA
Toshiba	SCiB (LMO)	Honda, Mitsubishi Motor	NA	NA	NA	NA
NEC	LMO (electrode only)	AESC/Nissan, GS Yuasa (planned)	253	NA	20.0	Positive
GS Yuasa	LMN, LMO	Honda, Mitsubishi Motor, PSA	134	-142	10.6	-11.2
Samsung SDI (SB LiMotive)	NA	BMW, PSA	NA	NA	NA	Negative
LG Chem	LMO	GM, Hyundai, Renault, Volvo, etc.	383	-20	430	-23
BYD	LFP	BYD	NA	NA	NA	NA

Note: Japanese companies' business years end in March. Some figures are our estimates. Panasonic's consumer business includes batteries for Tesla's Model S, and auto-related business includes NiH batteries. Source: Company data, Citi Research.

Figure 7. Companywide earnings at lithium-ion battery stocks covered by Citi Research

		Sales	YoY (%)	OP	YoY (%)	OPM (%)	Pretax Profit	YoY(%)	Net Profit	YoY (%)	EPS
Panasonic	13/03 A	7,303,045	-6.9	160,936	268.1	2.2	-398,386	NM	-754,250	NM	-326.3
	14/03 CE	7,200,000	-1.4	250,000	55.3	3.5	140,000	NM	50,000	NM	21.6
	14/03 E	7,155,000	-2.0	289,700	80.0	4.0	122,500	NM	53,600	NM	23.2
	15/03 E	7,050,000	-1.5	341,000	17.7	4.8	295,000	140.8	127,900	138.6	55.3
	16/03 E	7,124,000	1.0	371,800	9.0	5.2	355,800	20.6	194,600	52.2	84.2
Sony	13/03 A	6,800,851	4.7	230,100	NM	3.4	245,681	NM	43,034	NM	41.5
	14/03 CE	7,500,000	10.3	230,000	0.0	3.1	210,000	-14.5	50,000	16.2	50.0
	14/03 E	7,745,000	13.9	249,700	8.5	3.2	248,800	1.3	64,700	50.3	60.4
	15/03 E	7,899,000	2.0	326,800	30.9	4.1	321,800	29.3	134,900	108.5	126.0
	16/03 E	7,976,000	1.0	366,200	12.1	4.6	363,700	13.0	172,300	27.7	160.9
TDK	13/03 A	851,575	4.6	21,648	15.8	2.5	18,858	54.0	1,195	NM	9.5
	14/03 CE	930,000	9.2	30,000	38.6	3.2	28,000	48.5	13,000	987.9	103.3
	14/03 E	947,700	11.3	30,000	38.6	3.2	27,300	44.8	15,400	1,188.7	122.2
	15/03 E	978,620	3.3	40,000	33.3	4.1	37,300	36.6	22,500	46.1	178.5
	16/03 E	999,832	2.2	44,500	11.3	4.5	41,800	12.1	25,700	14.2	203.9
GS Yuasa	13/03 A	274,509	-3.8	9,775	-39.0	3.6	8,290	-49.2	5,767	-50.9	14.0
	14/03 CE	350,000	27.5	16,000	63.7	4.6			10,000	73.4	24.2
	14/03 E	336,000	22.4	16,500	68.8	4.9	19,100	130.4	11,900	106.4	28.8
	15/03 E	380,000	13.1	24,500	48.5	6.4	26,900	40.8	17,800	49.6	43.1
	16/03 E	406,000	6.8	28,000	14.3	6.9	30,400	13.0	19,700	10.7	47.7
Asahi Kasei	13/03 A	1,666,640	5.9	91,960	-11.8	5.5	82,302	-13.2	53,712	-3.7	38.4
	14/03 CE	1,891,000	13.5	130,000	41.4	6.9			77,000	43.4	55.1
	14/03 E	1,902,000	14.1	137,000	49.0	7.2	124,000	50.7	83,000	54.5	59.4
	15/03 E	1,976,000	3.9	150,000	9.5	7.6	141,000	13.7	93,500	12.7	66.9
	16/03 E	2,035,000	3.0	163,000	8.7	8.0	156,000	10.6	103,000	10.2	73.7
Ube Industries	13/03 A	626,022	-2.0	29,962	-34.9	4.8	15,842	-57.9	8,265	-64.0	8.2
	14/03 CE	675,000	7.8	34,000	13.5	5.0			14,500	75.4	14.4
	14/03 E	671,000	7.2	34,000	13.5	5.1	25,500	61.0	15,000	81.5	14.9
	15/03 E	678,000	1.0	39,000	14.7	5.8	31,500	23.5	18,700	24.7	18.6
	16/03 E	709,000	4.6	45,000	15.4	6.3	37,500	19.0	22,500	20.3	22.4
Hitachi Chemical	13/03 A	464,655	-1.8	23,559	-3.8	5.1	29,077	-3.3	16,869	2.7	81.0
	14/03 CE	500,000	7.6	31,000	31.6	6.2			19,000	12.6	91.2
	14/03 E	500,000	7.6	34,500	46.4	6.9	38,500	32.4	25,000	48.2	120.1
	15/03 E	529,000	5.8	41,000	18.8	7.8	42,000	9.1	26,000	4.0	124.9
	16/03 E	556,000	5.1	47,000	14.6	8.5	48,000	14.3	29,500	13.5	141.7
Samsung SDI	12/12 A	5,771	6.0	187	70.0	3.2	2,029	324.5	1,472	359.8	32,301.0
	13/12 E	5,785	0.2	128	-31.6	2.2	687	-66.1	481	-67.3	10,564.5
	14/12 E	6,281	8.6	259	102.9	4.1	911	32.6	643	33.7	14,119.8
	15/12 E	6,892	9.7	371	42.9	5.4	1,116	22.5	797	23.9	17,492.1
LG Chem	12/12 A	23,263	2.6	1,910	-32.2	8.2	1,880	-32.8	1,464	-30.5	22,084.9
	13/12 E	23,584	1.4	1,973	3.3	8.4	1,962	4.3	1,514	3.4	22,838.7
	14/12 E	24,642	4.5	2,440	23.7	9.9	2,450	24.9	1,898	25.4	28,638.9
	15/12 E	25,341	2.8	2,897	18.7	11.4	2,941	20.0	2,276	19.9	34,348.6
Simplo	12/12 A	58,833	22.3	4,291	6.0	7.3	4,599	5.1	3,303	-10.4	10.7
	13/12 E	53,691	-8.7	3,494	-18.6	6.5	3,949	-14.1	3,118	-5.6	10.1
	14/12 E	56,902	6.0	3,413	-2.3	6.0	3,874	-1.9	2,985	-4.3	9.7
	15/12 E	59,375	4.3	3,470	1.7	5.8	3,983	2.8	3,068	2.8	10.0
Umicore	12/12 A	12,548	-13.3	307	-24.4	2.4	305	-24.1	240	-24.4	2.5
	13/12 E	13,532	7.8	282	-8.0	2.1	280	-8.3	213	-10.9	2.0
	14/12 E	13,862	2.4	327	16.1	2.4	329	17.7	248	16.4	2.3
	15/12 E	14,114	1.8	371	13.2	2.6	377	14.6	281	13.3	2.6

Note: Units are ¥mn for Japanese firms, bn KRW for South Korean firms, mn NTD for Simplo and mn Euro for Umicore. CE denotes company estimates. Earnings estimates are as of August 26. A: Actuals, CE: Company estimates. E: Our estimates, NM: Not meaningful.
Source: Company data, Citi Research

Figure 8. Valuations of lithium-ion battery industry majors

		Rating		Price	Mkt	FY1E=	EPS		PER (x)		PBR (x)	OPM		EV/EBITDA (x)		RoE	
Code	Company				Cap		FY1E	FY2E	FY1E	FY2E	FY1E	FY1E	FY2E	FY1E	FY2E	FY1E	FY2E
Battery					($ bn)												
6752.T	Panasonic	1	JPY	872.00	20.4	3/14	23.2	55.3	37.6	15.8	1.4	4.0%	4.8%	4.3	4.0	4.0%	8.9%
6758.T	Sony	1	JPY	1,981.00	20.3	3/14	60.4	126.0	32.8	15.7	0.9	3.2%	4.1%	3.0	2.5	2.9%	5.7%
6762.T	TDK	3	JPY	3,740.00	4.8	3/14	122.2	178.5	30.6	20.9	0.9	3.2%	4.1%	4.2	4.1	2.7%	3.9%
6674.T	GS Yuasa	1	JPY	452.00	1.9	3/14	28.8	43.1	15.7	10.5	1.5	4.9%	6.4%	7.9	5.9	9.1%	12.3%
6501.T	Hitachi	1	JPY	617.00	30.2	3/14	49.0	60.3	12.6	10.2	1.2	5.6%	6.4%	5.1	4.7	10.8%	12.0%
6502.T	Toshiba	1	JPY	397.00	17.0	3/14	36.4	42.6	10.9	9.3	1.4	5.4%	5.7%	4.6	3.9	13.6%	13.9%
6701.T	NEC	2	JPY	218.00	5.7	3/14	8.7	16.7	25.0	13.1	1.4	3.6%	4.4%	5.3	4.4	4.1%	10.0%
006400.KS	Samsung SDI	2	KRW	176,000.00	7.2	12/13	10,564.5	14,119.8	16.7	12.5	1.0	2.2%	4.1%	3.2	2.4	6.4%	8.0%
051910.KS	LG Chem	1	KRW	284,500.00	16.9	12/13	22,838.7	28,638.9	12.5	9.9	1.6	8.4%	9.9%	6.7	5.5	13.4%	15.0%
JCI.N	Johnson Controls	2	USD	41.63	28.5	9/13	2.7	3.4	15.7	12.3	2.0	5.5%	6.4%	10.0	8.1	13.7%	14.9%
Battery Material																	
3401.T	Teijin	3	JPY	215.00	2.1	3/14	-0.6	1.5	nm	nm	0.8	1.9%	2.2%	5.1	5.1	-0.2%	0.6%
3402.T	Toray	1	JPY	618.00	10.2	3/14	41.8	47.3	14.8	13.1	1.2	6.0%	6.4%	6.3	5.8	8.8%	9.0%
3407.T	Asahi Kasei	1	JPY	724.00	10.2	3/14	59.4	66.9	12.2	10.8	1.2	7.2%	7.6%	3.3	3.0	9.8%	10.3%
4004.T	Showa Denko	2	JPY	127.00	1.9	12/13	9.7	14.0	13.1	9.1	0.7	4.0%	5.1%	5.8	5.1	5.2%	7.2%
4005.T	Sumitomo Chem	1	JPY	361.00	6.0	3/14	19.0	32.4	19.0	11.1	1.1	4.2%	4.5%	5.8	5.2	6.0%	9.4%
4188.T	Mitsubishi Chem	2	JPY	480.00	7.2	3/14	33.6	42.7	14.3	11.2	0.8	4.3%	5.0%	5.6	5.1	5.9%	7.1%
4208.T	Ube	2	JPY	178.00	1.9	3/14	14.9	18.6	11.9	9.6	0.8	5.1%	5.8%	5.4	4.8	6.8%	8.0%
4217.T	Hitachi Chem	1	JPY	1,632.00	3.4	3/14	120.1	124.9	13.6	13.1	1.1	6.9%	7.8%	4.9	4.3	8.0%	7.9%
096770.KS	SK Innovation	1H	KRW	141,500.00	11.7	12/13	13,824.5	14,849.9	10.2	9.5	0.8	3.0%	2.6%	5.5	6.1	8.1%	8.1%
6121.TWO	Simplo Tech	3	TWD	142.50	1.5	12/13	10.1	9.7	14.1	14.7	2.6	6.5%	6.0%	7.9	7.0	18.2%	17.1%
UMI.BR	Umicore	2	EUR	35.95	5.8	12/13	2.0	2.3	18.2	15.7	2.2	2.1%	2.4%	10.0	8.9	11.9%	13.2%

Note: Shares prices and market caps are as of the August 26 close.
Source: Company data, Citi Research.

Consumer electronics lithium-ion batteries

Our market forecasts for lithium-ion batteries used in consumer electronics

We still expect smartphone and tablet PC demand to drive growth as notebook PC demand declines

Lithium-ion batteries are used in a wide range of consumer electronics products including notebook PCs, tablet PCs, mobile phones, and power tools. We estimate the market value was $9bn in 2012 and forecast it will increase to $9.5bn in 2013, $10.2bn in 2014, $10.9bn in 2015, and $12.1bn in 2020 (Figure 9). By application, we forecast smartphone, tablet, and power tool-related demand will continue to expand and notebook PC-related demand will trend downward. By shape, we forecast the market for cylindrical lithium-ion batteries (mainly used in notebook PCs) will decline, and the market for prismatic and laminate lithium-ion batteries (smartphones, tablet PCs) will expand.

We revise down our market forecasts, mainly for notebook PC and smartphone lithium-ion battery demand

We have lowered our consumer electronics lithium-ion battery market value forecasts. Compared with our previous forecasts (please see our July 20, 2012 report Lithium-ion batteries - A Japanese tech growth story?), we 1) lower our notebook PC market assumptions and 2) lower our unit price assumptions to reflect the negative risk of the commoditization of smartphones and tablet PCs. We previously forecast a market value of $13.2bn in 2015, but now estimate a value of around $10.9bn.

Key consumer electronics-use demand points

There is no change to our outlook for smartphones and tablet PCs to drive growth amid declining notebook PC-related demand. However, we believe the following factors will be key to demand: 1) a shift to high capacity smartphone batteries; 2) a decline in the battery capacity of some tablet PCs accompanying the launch of 8-inch models; 3) a continued decline in notebook PC battery demand, but an improvement in product mix as larger capacity batteries are adopted for some models; and 4) the emergence of external batteries, wearable computers, and electric bicycles as potential future demand drivers.

The capacity of smartphone batteries continues to increase but the commoditization becomes a concern

We believe an increase in smartphone battery capacity will continue to drive lithium-ion battery demand. Apart from Apple, almost all smartphone makers are working to increase battery capacity because low capacity is a bottleneck to convenience (Figures 11 and 12). However, the commoditization of smartphones is advancing (please see our July 25 report, Device Exhaustion - The Implications of Smartphone Saturation in Developed Markets). We believe we should pay attention to the negative impact on unit price by the commoditization of smartphones.

The appearance of 8-inch models has meant lower battery capacity for some tablet PCs

Tablet PC-use battery capacity has also increased, but the appearance of 8-inch models in 2012 H2 and out has led to a decline in battery capacity for some models. The 8-inch iPad mini battery has capacity of 17Wh, about 60% lower than the 43Wh capacity of the 10-inch i-Pad battery. Samsung's 8-inch tablet battery has capacity of 19Wh, about 27% lower than the 26Wh capacity of the 10-inch model battery. This is mainly because smaller displays consume less power and also reduce the amount of space for the battery. Unlike smartphones, most tablet PCs can be kept on for a long time, which reduces the pressure to increase battery capacity.

Notebook PC-related demand continues to decline but there are some signs of product mix improvement

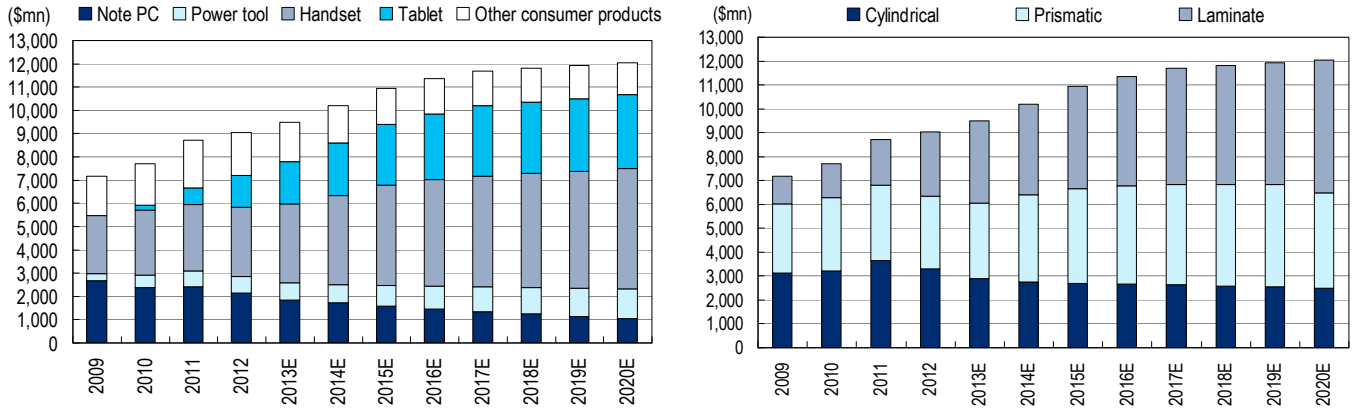
Notebook PCs account for about 40% of the lithium-ion battery market. Notebook PC demand is sluggish and we believe related lithium-ion battery demand will continue to decline (see our April 11 report, Global Technology Hardware - Device Destruction: The Worst Is Imminent for PCs for an analysis of the PC market). Also, the replacements of Note PCs by smartphones and tablets are negative to the overall battery demand. This is because smartphones and tablets use only one battery cell per product although Note PCs use six battery cells per product. But while the notebook PC market may be contracting, product mix is improving with the introduction of high-end models that are differentiated by the use of laminate

batteries or high-capacity cylindrical batteries. In this regard the interests of end-product makers and battery makers are aligned.

Expectations of external batteries as a new application rising

We highlight external batteries, wearable computers, and electric bicycles as potential future demand drivers for lithium-ion batteries. Interest in external batteries is particularly high; demand for use with smartphones is expanding because of insufficient internal battery energy density. To date, most external batteries have been supplied by Chinese companies, but we believe this could be a business opportunity for major battery makers. Wearable computers, the most high-profile of which are Apple's iWatch and Google Glass, are generating "add-on" demand for electronic devices and we expect this spur the development of a new market for lithium-ion batteries. Electric bicycles are another product that are gradually adopting lithium-ion batteries and could contribute to longer-term demand expectations.

Figure 9. Lithium-ion battery market scale by application (Left) and type (Right)



Source: Company data, IDC, Gartner, CIPA, TSR, Citi Research.

Figure 10. Lithium-ion battery market scale by type and application

Shipment value by type ($mn)	2009	2010	2011	2012	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E
Cylindrical	3,132	3,208	3,645	3,302	2,886	2,750	2,699	2,653	2,622	2,578	2,543	2,504
Prismatic	2,882	3,084	3,154	3,031	3,174	3,653	3,973	4,132	4,202	4,246	4,289	3,971
Laminate	1,161	1,398	1,909	2,714	3,432	3,798	4,276	4,579	4,861	4,983	5,096	5,576
Total	**7,176**	**7,690**	**8,708**	**9,047**	**9,492**	**10,201**	**10,949**	**11,364**	**11,686**	**11,806**	**11,928**	**12,052**
Shipment units (mn units)												
Cylindrical	1,261.2	1,564.4	1,762.0	1,650.5	1,481.1	1,455.0	1,469.2	1,485.2	1,511.7	1,528.5	1,553.9	1,577.4
Prismatic	1,512.3	1,697.3	1,744.6	1,664.5	1,620.7	1,879.2	2,052.7	2,178.7	2,260.7	2,329.9	2,401.6	2,264.6
Laminate	559.3	663.8	802.2	1,065.2	1,300.5	1,391.4	1,566.5	1,712.3	1,846.2	1,971.6	2,095.4	2,438.6
Total	**3,332.8**	**3,925.5**	**4,308.8**	**4,380.1**	**4,402.4**	**4,725.6**	**5,088.4**	**5,376.2**	**5,618.5**	**5,830.1**	**6,050.8**	**6,280.6**
ASP ($)												
Cylindrical	2.48	2.05	2.07	2.00	1.95	1.89	1.84	1.79	1.73	1.69	1.64	1.59
Prismatic	1.91	1.82	1.81	1.82	1.96	1.94	1.94	1.90	1.86	1.82	1.79	1.75
Laminate	2.08	2.11	2.38	2.55	2.64	2.73	2.73	2.67	2.63	2.53	2.43	2.29
Total	**2.15**	**1.96**	**2.02**	**2.07**	**2.16**	**2.16**	**2.15**	**2.11**	**2.08**	**2.03**	**1.97**	**1.92**
Shipment value by application ($mn)												
Note PCs	2,664	2,371	2,405	2,133	1,858	1,716	1,586	1,462	1,347	1,242	1,145	1,055
Power tools	300	542	696	711	726	793	897	991	1,074	1,146	1,206	1,254
Handsets	2,500	2,811	2,847	2,979	3,400	3,826	4,304	4,582	4,752	4,889	5,031	5,177
Tablets	0	196	717	1,382	1,823	2,265	2,610	2,813	3,033	3,083	3,134	3,185
Other consumer products	1,712	1,770	2,043	1,841	1,686	1,601	1,552	1,515	1,480	1,446	1,413	1,380
Total	**7,176**	**7,690**	**8,708**	**9,047**	**9,492**	**10,201**	**10,949**	**11,364**	**11,686**	**11,806**	**11,928**	**12,052**
Shipment units (mn units)												
Note PC	1,065.7	1,247.8	1,265.6	1,181.4	1,083.3	1,053.5	1,024.5	994.1	964.6	935.9	908.2	881.2
Power tools	109.1	208.5	290.0	308.8	328.2	373.3	440.2	506.6	571.8	635.3	696.4	754.3
Handsets	1,388.7	1,653.5	1,683.4	1,727.1	1,789.4	2,013.9	2,265.3	2,460.7	2,604.0	2,734.2	2,870.9	3,014.4
Tablets	0.0	53.0	194.0	366.7	474.0	589.0	678.7	746.6	821.2	878.7	940.2	1,006.1
Other consumer products	769.3	762.7	875.8	796.1	727.6	695.9	679.6	668.2	656.9	645.9	635.2	624.6
Total	**3,332.8**	**3,925.5**	**4,308.8**	**4,380.1**	**4,402.4**	**4,725.6**	**5,088.4**	**5,376.2**	**5,618.5**	**5,830.1**	**6,050.8**	**6,280.6**
ASP ($)												
Note PCs	2.50	1.90	1.90	1.81	1.72	1.63	1.55	1.47	1.40	1.33	1.26	1.20
Power tools	2.75	2.60	2.40	2.30	2.21	2.12	2.04	1.96	1.88	1.80	1.73	1.66
Handsets	1.80	1.70	1.69	1.73	1.90	1.90	1.90	1.86	1.82	1.79	1.75	1.72
Tablets		3.70	3.70	3.77	3.85	3.85	3.85	3.77	3.69	3.51	3.33	3.17
Other consumer products	2.23	2.32	2.33	2.31	2.32	2.30	2.28	2.27	2.25	2.24	2.22	2.21
Total	**2.15**	**1.96**	**2.02**	**2.07**	**2.16**	**2.16**	**2.15**	**2.11**	**2.08**	**2.03**	**1.97**	**1.92**

Source: TSR, Citi Research.

Figure 11. Capacities for lithium-ion batteries used in key electronic devices (1)

Company	Product	Category	Launch date	Battery type	Battery size (Wh)
Apple	iPhone4/4S/5	Smartphone	2010, 2011	Laminate	5.3
	iPhone3GS	Smartphone	2009	Laminate	4.5
	iPhone3G	Smartphone	2008	Laminate	4.3
	iPhone	Smartphone	2007	Laminate	5.2
	iPad mini	Tablet	2012	Laminate	16.5
	iPad retina	Tablet	2012	Laminate	42.5
	New iPad	Tablet	2012	Laminate	42.5
	iPad/iPad2	Tablet	2010, 2011	Laminate	24.8
	MacBook Pro	Notebook PC	Present model	Laminate	74.0, 95.0
	MacBook Air	Notebook PC	Present model	Laminate	38.0, 54.0
Samsung Electronics	Galaxy S4	Smartphone	2013	Prismatic	9.6
	Galaxy Note II	Smartphone	2012	Prismatic	11.8
	Galaxy S III	Smartphone	2012	Prismatic	7.8
	Galaxy Note	Smartphone	2011	Prismatic	9.3
	Galaxy S II	Smartphone	2011	Prismatic	6.1
	Galaxy S	Smartphone	2010	Prismatic	5.6
	Galaxy Tab 7.7 plus	Tablet	2012	Prismatic	18.9
	Galaxy Tab 10.1	Tablet	2011	Prismatic	25.9
	Galaxy Tab	Tablet	2010	Prismatic	14.8
Amazon	Kindle Fire HD 8.9	Tablet	2012	Laminate	22.3
	Kindle Fire HD	Tablet	2012	Laminate	16.3
	Kindle Fire	Tablet	2011	Laminate	16.3
Microsoft	Surface Pro	Tablet	2012	Laminate	42.0
	Surface	Tablet	2012	Laminate	31.5
Nokia	Lumia 925	Smartphone	2013	Prismatic	7.4
	Lumia 900	Smartphone	2012	Prismatic	6.8
	Lumia 800	Smartphone	2011	Prismatic	5.4
	Lumia 710	Smartphone	2011	Prismatic	4.8
	Nokia N8	Smartphone	2010	Prismatic	4.4
HTC	One	Smartphone	2013	Laminate	8.5
	One X	Smartphone	2012	Prismatic	6.7
	Sensation	Smartphone	2011	Prismatic	5.6
	Desire	Smartphone	2010	Prismatic	5.2
	Droid Incredible	Smartphone	2010	Prismatic	4.8
Sony	Xperia Tablet Z	Tablet	2013	Laminate	22.2
	Xperia Z	Smartphone	2013	Laminate	8.6
	Xperia S	Smartphone	2012	Prismatic	6.5
	PS Vita	Handheld game	2011	Prismatic	8.2
	PSP	Handheld game	2004	Prismatic	6.7
	Cyber Shot series	DSC	Present model	Prismatic	2.3-3.4
	Vaio series	Notebook PC	Present model	Cylindrical	30.0-60.0

Source: Company data, Citi Research.

Figure 12. Capacities for lithium-ion batteries used in key electronic devices (2)

Company	Product	Category	Launch date	Battery type	Battery size (Wh)
Nintendo	3DS	Handheld game	2011	Prismatic	4.8
	DS i	Handheld game	2008	Prismatic	3.1
	DS Lite	Handheld game	2006	Prismatic	3.7
	Nintendo DS	Handheld game	2004	Prismatic	3.1
Dell	XPS 12	Notebook PC	2012	Laminate	47.0
	XPS 13	Notebook PC	2012	Laminate	47.0
	Alienware M11X	Notebook PC	2011	Cylindrical	63.0
	Vostro 3550	Notebook PC	2011	Cylindrical	48.0
	Inspiron Mini1012	Notebook PC	2010	Cylindrical	56.0
	Inspiron Duo	Notebook PC	Present model	Cylindrical	29.0
Acer	Aspire R7-571-N58G	Notebook PC	2013	Laminate	52.7
	Aspire V3 Series	Notebook PC	2013	Cylindrical	48.8
	Aspire Timeline Ultra M3	Notebook PC	2012	Laminate	53.8
	Aspire S Series	Notebook PC	2012	Laminate	36.2
	Aspire Series	Notebook PC	2012	Prismatic	48.8
	Aspire Ethos Series	Notebook PC	2012	Prismatic	65.1
Makita	TD134DX2	Power tool	2012	Cylindrical	43.2
	TD136RFXB	Power tool	2012	Cylindrical	43.2
	TD136RFX	Power tool	2011	Cylindrical	43.2
	TD132DRFXB	Power tool	2008	Cylindrical	43.2
Hitachi Koki	WH14DDL	Power tool	2013	Cylindrical	43.2, 54.0
	WH18DDL	Power tool	2013	Cylindrical	47.6, 72.0
	WH18DBAL2	Power tool	2012	Cylindrical	54.0
	WH14DBAL2	Power tool	2011	Cylindrical	43.2
	WH18DBDL	Power tool	2011	Cylindrical	54.0
Bosch	GSB 10.8-2-LI	Power tool	Present model	Cylindrical	14.0
	GDR 18V-LIS	Power tool	Present model	Cylindrical	23.4, 46.8
	GSB 18V-LIN	Power tool	Present model	Cylindrical	23.4, 46.8

Source: Company data, Citi Research.

Competition in consumer electronics apps: Changes since 2012 H2 having an impact

South Korean companies have expanded rapidly in the consumer electronics lithium-ion battery market since 2009

South Korean companies have rapidly strengthened their presence in the consumer electronics lithium-ion battery market since 2009. By volume, in 2008 Japanese companies had a market share of 53%, South Korean companies 22%, and Chinese companies 18%. By 2012, South Korean companies had overtaken Japanese companies, with a market share of 41% versus 37%. And in terms of profit margins, Panasonic remains in the red while Samsung SDI and LG Chem remain profitable.

A weak won, aggressive capex, technology improvement, and the use of low-cost materials contributed to the rise of South Korean companies

We believe the success of South Korean companies was underpinned by 1) the merits of a weak won throughout the supply chain; 2) aggressive facility investment and superior management in sales and other areas; 3) improvements in quality, technology, and product development; and 4) strengthening cost competitiveness by the bringing in of South Korean and Chinese-made inputs and manufacturing equipment. In the battery space, too, we believe South Korean firms have leapt ahead for the same reasons as they have in semiconductor memory and LCD panels.

Yen weakening since 2012 H2 and the rise of Chinese companies increased potential industry realignment

The competitive environment for consumer electronics lithium-ion batteries began changing in 2012 H2

We believe the competitive environment for lithium-ion batteries used in consumer electronics began to change from 2012 H2 for the following reasons: 1) yen weakening against the won driven by Abenomics; 2) the strengthening presence of Chinese companies in the electronics industry; and 3) potential for industry realignment centered on Sony.

Key point 1): Yen weakening leads to a recovery in earnings power at Japanese firms

The first change we cite is the way that yen weakening on Abenomics has brought about changes in cost competitiveness between Japanese firms and South Korean firms. As we said earlier, we believe one reason for the rapid advance of South Korean firms was the weakness of the won and that the biggest reason Japanese firms lost market share and saw margins fall was the rise in supply chain costs, including materials and equipment, caused by yen strength. Moving forward, we expect Japanese firms' margins to improve as their relative costs fall thanks to yen strength.

Panasonic's battery business returned to the black in April–June in yen weakness

In the April–June quarter, Panasonic's consumer electronics battery operations posted sales of ¥70.6bn and OP of ¥4.1bn (operating margin of 6%), a big improvement over January–March sales of ¥65.1bn and an operating loss of ¥2.0bn (-3% operating margin). Even if we set aside the strong performance of automobile batteries for Tesla, which are booked as consumer electronics batteries, we believe the consumer electronics battery margin improved to around 3%. Panasonic is expressing confidence in margin improvement and we think that the impact of yen weakness did indeed appear in the numbers in Q1.

Japanese companies will find it difficult to recover market share

Amid increasingly intense competition with South Korean and Chinese companies in international markets, Japanese companies have abandoned the quest for market share and instead focused on high end-product fields. Because of an increased strategic emphasis on profitability, we think it is unlikely that Japanese companies will increase market share.

(2) The rise of Chinese companies

The rise of Chinese companies in the market for lithium-ion batteries used in consumer electronics is the second point we highlight. BYD, China BAK, and Tianjin Lishen have entered the market, but product quality and technology remain

problems and they are suffering amid fierce competition from South Korean companies.

Structural change in the smartphone market a tailwind for Chinese lithium-ion battery makers

However, in 2012 H2 1) Apple and Samsung began using batteries made by Tianjin Lishen in their smartphones and 2) Chinese smartphone makers, which primarily procure batteries from Chinese companies, began to strengthen their market presence. This has been a strong tailwind for Chinese battery makers. Even the largest Chinese battery makers only have single digit market shares (Figure 14). Over the longer term, we believe some Chinese companies are likely to increase their market share, most notably ATL (a TDK subsidiary) and Tianjin Lishen.

(3) Potential for industry realignment centered on Sony

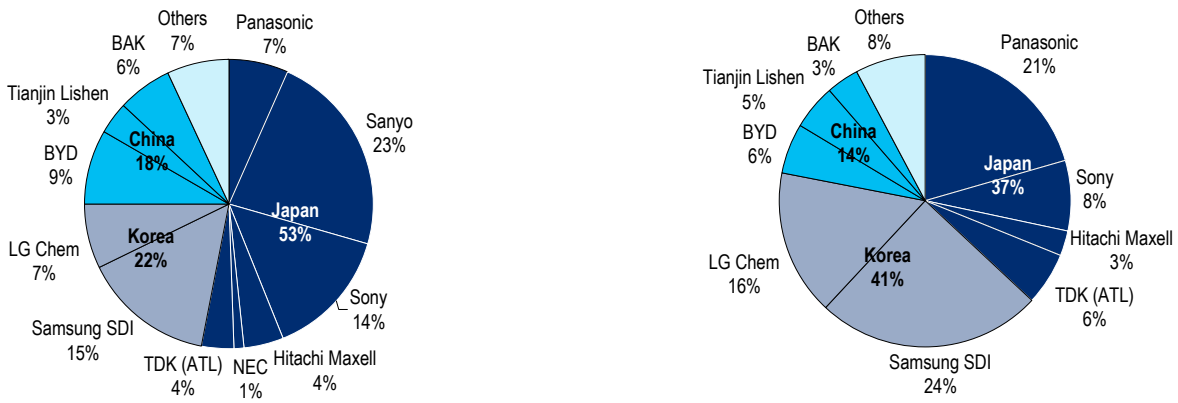
Our third key point is the potential for industry restructuring centered on Sony. Since reports in January that Sony and Automotive Energy Supply Corporation (AESC) had entered negotiations to merge their battery operations (please see our January 25 Sony note, Sony (6758) - Reports Sony in negotiations to integrate lithium-ion battery ops with NEC/Nissan, there have been no media reports about Sony selling its battery business. However, Sony needs to restructure its non-core businesses and we believe the battery business, which continues to make losses, is one of the candidates for sale. If the battery business is sold, we believe the acquirer would need to strengthen cost competitiveness and improve profit margins by procuring battery materials from overseas or making them in house.

Figure 13. Comparison of Japanese, South Korean, and Chinese makers in the consumer electronics lithium-ion battery market: Can the Japanese bolster cost competitiveness by yen depreciation

	Technology	Quality	Cost	Material Purchase	Track record	Recent Situation
Japanese makers	◎	◎	Δ(→◎?)	Δ(→◎?)	◎	Strong presence thanks to considerable technological and development capabilities. Forex had been a problem for international competitiveness, but yen weakness is helping profitability recover. Over the longer term, Japanese firms intend to improve their global competitive standing by 1) shifting production to and procuring materials in China, 2) focusing on high-end products.
Korean makers	Δ→○	Δ→○	○→◎	○→◎	○→◎	They became international winners by strengthening their cost competitiveness by introducing South Korean and Chinese materials and South Korean devices, building out marketing and support networks, and improving quality and R&D prowess. That said, a maturing market has caused earnings growth to slow.
Chinese makers	Δ	Δ	◎	◎	Δ→○	They are cost competitive but have issues with quality and technology. Many firms continue to struggle due to rising labor costs and competition internationally with South Korean makers. However, some companies continue to grow on the back of expansion of Chinese boxmakers, particularly in smartphones.

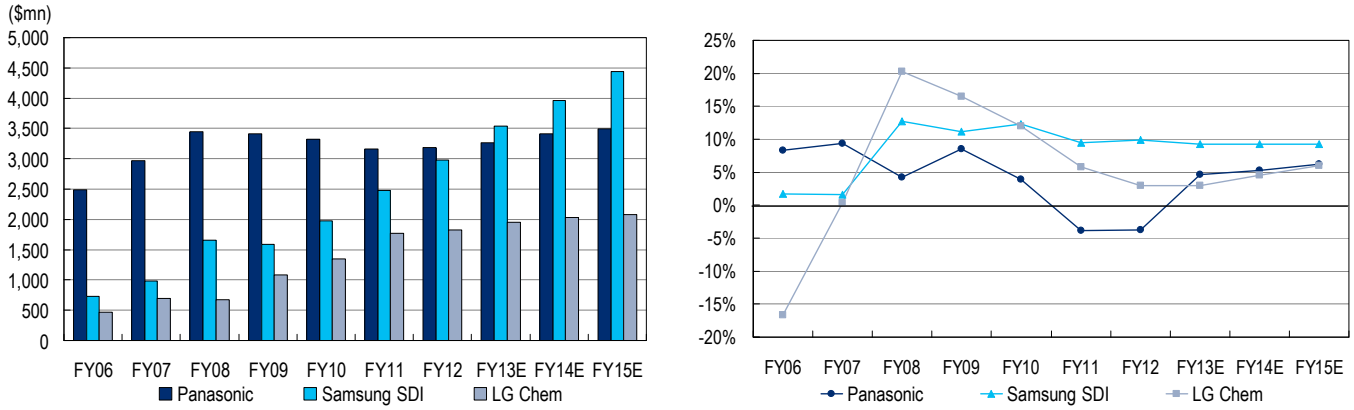
Note: ◎ = excellent, ○ = good, Δ = poor, X = very poor
Source: Citi Research.

Figure 14. Market share by volume in consumer electronics lithium-ion batteries (LHS 2008, RHS 2012)



Source: TSR, Citi Research.

Figure 15. Sales (Left) and margins (Right) in lithium-ion batteries at Panasonic, Samsung SDI, and LG Chem



Note: Panasonic earnings forecasts area for its small Li-ion battery business. This business includes the batteries for Tesla Motors' Model S. Panasonic has changed their business segment breakdown since FY2012.
Source: Company data, Citi Research.

Automotive lithium-ion batteries

HV/PHEV/EV introduction trends

HV/PHEV/EV release trends

Figure 16 shows the status of hybrid vehicle (HV), plug-in hybrid vehicle (PHEV), and electric vehicle (EV) releases by automakers. There were only a limited number of EV/PHEV models on the market before 2012, including the Leaf (Nissan) and the i-MiEV (MMC) EVs, and the Prius PHV (Toyota) and Chevrolet Volt (GM) PHEVs. However, in 2012 H2, PHEV/EV releases by Japanese, European, and US automakers began to accelerate.

EV/PHEV moves out of the shadows

The main EV models introduced since 2012 H2 are the iQ EV and RAV4 EV (Toyota), Fit EV (Honda), Model S (Tesla), Smart fortwo EV (Daimler), and Zoe (Renault). The main PHEV releases include the Accord PHV (Honda), Outlander PHEV (MMC), C-Max Energi (Ford), and V60 Plug-in-Hybrid (Volvo). With this influx of models, we believe the EV/PHEV can be said to have truly arrived.

VW starting to roll out PHEV/EV in earnest

Automakers that were not actively introducing HV/PHEV/EV before are doing so now. Volkswagen, a leader in TSI (Twincharger Stratification Injection, a technology that couples direct fuel injection with a turbocharger to achieve low gasoline consumption) and in diesel technologies, has not been active in terms of PHEV/EV introductions. But it has announced that it will start to roll out PHEVs in 2013 and aims to have 10 models on the market by 2015. BMW will release the i3 in November 2013 and is expected to release more PHEV/EVs moving forward. As we discuss in more detail later, we believe expectations of fuel efficiency regulation tightening around the world from 2015 from the backdrop to this pickup in activity.

Adoption of lithium-ion batteries for HVs has started in earnest

Adoption of lithium-ion batteries in HVs underway

One major change for HVs occurred in 2012 H2, when HV technology frontrunners Toyota and Honda forecast that lithium-ion batteries would become the batteries of choice for HVs. Previously, nickel-metal hydride batteries had been used in the majority of HVs made by Toyota and Honda, but as a result of cost reductions, there is now a real shift from nickel-metal hydride batteries to smaller and lighter lithium-ion batteries.

We expect the number of Toyota and Honda HVs sporting lithium-ion batteries to increase

The North American version of the Civic Hybrid had been the only Honda model that used a lithium-ion battery, but in September 2012 Honda began putting a lithium-ion battery in the CR-Z. From 2013 there are plans to increase the production capacity of Blue Energy, a joint venture between Honda and GS Yuasa six-fold, with the number of Honda HVs sporting lithium-ion batteries also expected to increase.

The only Toyota to use a lithium-ion battery is the Prius α, but the *Nikkei* and other media sources reported that there are plans to increase the production capacity of Prime Earth EV Energy (PEVE), a joint venture with Panasonic, from 36,000 units/year to 200,000 units/year, and that the number of Toyota HVs that have a lithium-ion battery will increase notably from around 2015.

Nissan has plans to introduce HEV/PHEVs

Nissan is a frontrunner in EV development, but as EV demand is not growing as fast as it had expected, it plans to expand its HV/PHEV lineup, with 15 HVs (including PHEVs) due out by 2016. To some extent it seems Nissan was forced to make a change in its strategic direction.

Figure 16. HEVs, PHEVs and EVs by major automobile makers

Auto companies	Model	Category	Date	Battery supplier	Shape	Battery size (kWh)	Cathode
Toyota	Prius αHEV	HEV	05/2011	PEVE	Prismatic	1.0	NCA
	Prius PHV	PHEV	01/2012	Panasonic	Prismatic	4.4	Ternary
	RAV 4 EV	EV	09/2012	Panasonic	Cylindrical	41.8	NCA
	iQ EV	EV	12/2012	Panasonic	Prismatic	NA	Ternary
	Prius Series (LIB)	HEV	2015	PEVE	NA	NA	NA
Honda	Civic HEV	HEV	04/2011	Blue Energy	Prismatic	0.7	Ternary
	Fit EV	EV	08/2012	Toshiba	Prismatic	20.0	LMO
	CR-Z (minor change)	HEV	09/2012	Blue Energy	Prismatic	0.7	NA
	Accord PHV	PHEV	06/2013	Blue Energy	Prismatic	6.0	NA
	Accord HEV	HEV	06/2013	Blue Energy	Prismatic	1.3	NA
	Unknown (New Fit, NSX, etc)	HEV	2013-	Blue Energy	NA	NA	NA
Nissan	Fuga HEV	HEV	11/2010	AESC	Laminate	1.4	LMO
	Leaf EV	EV	12/2010	AESC	Laminate	24.0	LMO
	Serena HV	HEV	08/2012	AESC	Prismatic	4-5	LMO
	14HEV model and 1PHEV model by 2016	HEV/PHEV	2013-	NA	NA	NA	NA
Mitsubishi Motor	i-MiEV G	EV	08/2011	Lithium Energy Japan	Prismatic	16.0	LMO
	i-MiEV M	EV	07/2011	Toshiba	Prismatic	10.5	LMO
	Outlander PHV	PHEV	12/2012	Lithium Energy Japan	NA	NA	NA
GM	Chevrolet Volt	PHEV	12/2010	LG Chem	Laminate	16.0	LMO
	Chevrolet Volt 2nd Gen	PHEV	2013	LG Chem	Laminate	16.5	LMO
	Buick LaCrosse HEV	HEV	2011	Hitachi VE	Cylindrical	NA	NA
	Spark EV	EV	2013 Summer	LG Chem	Laminate	20.0	NA
Ford	Focus Electric	EV	05/2012	LG Chem	Laminate	23.0	Ternary
	C-MAX HEV	HEV	09/2012	Panasonic	Prismatic	1.4	Ternary
	Fusion HEV (2nd Gen)	HEV	09/2012	Panasonic	Prismatic	NA	Ternary
	C-MAX Energi	PHEV	2012	Panasonic	Prismatic	NA	Ternary
	Fusion Energi	PHEV	2013	Panasonic	Prismatic	NA	Ternary
Tesla	Model S	EV	2012/08	Panasonic	Cylindrical	40.0, 60.0, 85.0	NCA
	Model X	EV	2014	Panasonic	Cylindrical	60.0, 85.0	NCA
	BlueStar	EV	After 2015	Panasonic	Cylindrical	50.0?	NCA
VW	Audi Q5 HEV	HEV	2011	Panasonic	Prismatic	1.3	Ternary
	Jetta HEV	HEV	11/2012	Panasonic	Prismatic	1.1	Ternary
	Golf EV	EV	2013	NA	NA	26.5	NA
	e-up!	EV	2013	NA	NA	18.7	NA
	Golf PHEV	PHEV	2014	NA	NA	NA	NA
	More than 10 HEV/PHEV models by 2015	HEV/PHEV	2015	Panasonic?	NA	NA	NA
Daimler	S400 HEV	HEV	06/2009	JCI	Cylindrical	0.8	Ternary
	Smart Fortwo EV	EV	08/2012	LI-TEC	Prismatic	17.6	Ternary
	E400 HEV	HEV	10/2012	LI-TEC	Cylindrical	0.8	Ternary
BMW	Active Hybrid 7	HEV	07/2010	JCI	Cylindrical	0.4	Ternary
	Active Hybrid 5	HEV	04/2012	A123	Cylindrical	1.4	LFP
	Active Hybrid 3	HEV	09/2012	A123	Cylindrical	1.4	LFP
	i3	PHEV/EV	11/2013	Samsung SDI	Prismatic	22.0	Ternary
	i8	PHEV	2014	Samsung SDI	Prismatic	7.2	Ternary
Renault	Fluence Z.E.	EV	07/2011	AESC	Laminate	22.0	LMO
	Kangoo Z.E.	EV	10/2011	AESC	Laminate	22.0	LMO
	Zoe	EV	08/2012	LG Chem	Laminate	22.0	LMO
PSA	iOn/C-ZERO	EV	09/2011	Lithium Energy Japan	Prismatic	16.0	LMO
	Peugeot Partner	EV	After 2013	Lithium Energy Japan	NA	22.5	NA
	Citroën Berlingo	EV	After 2013	Lithium Energy Japan	NA	22.5	NA
Volvo	V60 Plug-in Hybrid	PHEV	11/2012	LG Chem	Laminate	11.2	LMO
Hyundai	Sonata HEV	HEV	05/2011	LG Chem	NA	NA	NA
	Sonata PHEV	PHEV	After 2013	LG Chem	NA	NA	NA
BYD	F3DM	PHEV	03/2010	BYD	NA	16.0	LFP
	e6	EV	10/2011	BYD	NA	48.0	LFP

Source: Company data, Various media reports, Citi Research.

Comparison of major automakers' PHEV/EV models

The number of PHEV/EV models is rising and consumer choices are widening

Figures 17 and 18 show an overview of the main PHEV/EV models of major automakers. As the number of models has increased, big differences in the design, performance, and price of the available models have emerged. As a result, we think consumers will have more options in the PHEV/EV space moving forward.

Sales of Nissan's Leaf are improving with the launch of the new model

In EVs, the hot-selling models are the new Nissan Leaf and the Tesla Model S. A new Nissan Leaf model debuted in 2013 and sales have been improving. According to various sources and media reports, the Leaf sold 27,000 units in 2012 and we believe it sold close to 20,000 units in the first half of 2013. Above all, the North American market is strong, and since the new model began to make a real contribution in March 2013, sales of c2,000 units/month have been continuing. We think the cost and distance that the new Leaf can travel has led to strong sales.

What should we make of the Model S hit? Success in opening up a niche market catering to the wealthy

The strong sales of the Tesla Model S, a sedan car EV, has become a hot topic in the EV market. Model S H1 2013 shipments amounted to 10,000 units and we think they will come in at over 20,000 for the full year. We think sales have been strong because Tesla has succeeded in opening up a niche market in "eco" sports cars for the wealthy in the US.

The Model S has solved the problem of "range anxiety", albeit at a high cost, by carrying a large volume of batteries

The Model S, by carrying a large volume of small cylindrical cells of the sort used in notebook PCs, boasts more than twice the battery capacity of traditional models, with 60/85kWh. This gives it a range—range issues have been one of the bottlenecks to the spread of EVs—of 370/480km, comparable to that of a gasoline vehicle, and as a sports car, it is pleasurable to drive. However, the Model S costs around $95,000 (This figure includes option etc) in 2013 H1, so it is a high input-cost, high-price product.

The implications of the Model S: the EV market can be opened up if batteries are given higher capacities and produced at a lower cost

We attribute the strong sales of the Model S to Tesla's success in opening up a niche market in a high price bracket and we do not think it augurs the explosive spread of EVs. However, we feel that it proves that if automakers can increase the capacity of batteries and resolve the issue of "range anxiety", they will generate a certain amount of demand. Moving forward, we think that the success of the Tesla S shows that if progress is made with giving batteries larger capacities and producing them at a lower cost, EVs will spread.

PHEV battery capacity polarization

PHEVs can be split into two groups according to battery capacity

Figure 18 shows the PHEVs that have been launched by major automakers. We see the key PHEV point as being the way they can be sorted into two categories according to differences in their battery capacity: ones with batteries of around 5kWh that can run around 30km as EVs and ones with batteries of around 10kWh-15kWh that can run around 60km as EVs.

Toyota and Honda have been developing PHEVs as extensions of their HV technology

The PHEVs that have been launched by Toyota and Honda fall into the former category. We regard the PHEVs of both companies as having been developed as extensions of their HV technologies: they share many of their components with HVs and deliver impressive fuel economy of around 30km/l with HV performance. However, they can only travel around 30km as EVs. In a sense, they are a type of HVs that can also travel short distances as EVs. We think that Toyota and Honda developed these kind of PHEVs to leverage their impressive technical prowess in HVs, where they have been frontrunners. Ford's C-Max Energi also falls into the former category.

The PHEVs from MMC and GM can travel long distances as EVs

MMC's Outlander PHEV and GM's Chevrolet Volt fall into the latter category. Both models are characterized by their design, which could be said to be those of EVs that resolve the range issue by adding a gasoline engine. Costs are higher but they can run for over 60km as EVs thanks to their being fitted with batteries of 10kWh or more. These types of PHEVs are also known as range-extended electric vehicles (REEVs).

What kind of models will sell well? Demand is relatively robust for models with large-capacity batteries

Among PHEVs, sales tend to be strong of models with large battery capacity. According to various sources and media reports, the GM Chevrolet Volt sold around 8,300 units in 2011 (7,671 in the US) and around 30,000 in 2012 (23,461), with cumulative sales in 2013 through June of 9,855 units (up 12% YoY) in the US. Shipments of MMC's Outlander PHEV have been halted due to fire incidents but in Japan between December 2012 and March 2013 it racked up orders of around 8,000 units, twice the target, and overseas, too, it has been doing well, with some 2,000 orders in the Netherlands.

In contrast the Toyota Prius PHV sold around 20,000 units in 2012 (just over 7,000 in Japan and just under 13,000 in the US), while cumulative sales in the US in 2013 through June were only 4,214 units, falling below the Chevrolet Volt. (Japan cumulative sales through April were 1,945 units). Honda's Accord PHV is only available to corporates on leases and is not being sold to consumers.

Models with large battery capacity can win EV demand substitution

We think the reason that demand is relatively strong for vehicles with large capacity batteries is that they win EV demand substitution from consumers who would like to buy EVs but worry about the bottlenecks caused by their short ranges and lack of a battery-charging infrastructure. Short ranges, battery-charging infrastructure, and price brackets are impeding the spread of EVs but range does not become such an issue with gasoline engines and neither does battery-charging infrastructure with household power supply. In many countries, the average distance driven by 70%-80% of consumers is 80km/day or less, so PHEVs can be adequate substitutes for EVs with batteries of 10kWh or more and EV ranges of 60km.

Models with low-capacity batteries fall between two stools

We think demand has been relatively weak for PHEV models with low-capacity batteries because their ranges are short when they are used as EVs and their prices are high for HVs. METI estimates that the average daily distance traveled by consumers in Japan is around 25km; with battery capacity of around 5kWh PHEVs have only around 30km of range as an EV and with this it would frequently become hard to complete one day's driving in EV mode. This is even more true of the US, where we believe the average daily distance traveled is further than in Japan. Moreover, when these models are used as HVs, we think consumers feel they are expensive when set up against regular hybrids, due to their bigger battery capacity, which impedes their spread. Indeed, there is a big price difference between a regular Prius at ¥2.17mn and the Prius PHV at ¥3.05mn.

Figure 17. Comparison of major EV models

Company	Nissan	Mitsubishi Motor	Tesla Motors	Ford	Renault
Model	**LEAF (S model)**	**i-MiEV (G model)**	**Model S**	**Focus Electric**	**ZOE**
Battery supplier	AESC	Lithium Energy Japan	Panasonic	LG Chem	LG Chem
Battery voltage (V)	360.0	330.0	NA	240.0	NA
Battery amount (kWh)	24.0	16.0	60.0, 85.0	23.0	22.0
Battery technology	LMO	LMO	NCA	LMO	LMO
EV driving range (km)	228	180	370, 480	122	210
Weight (kg)	1,430	1,110	2,108	1,644	1,468
Motor power (kW)	80	47	225, 270, 310	107	65
Motor Torque (N·m)	254	180	430, 440, 600	250	220
Launch date	2010/12	2009/06	2012/06	2012/05	2012/08
Price ($)	22,094 and up	29,500 and up	62,400, 72,400, 87,400 and up	35,200 and up	21,272 and up

Note: The Price of EVs is as of mid-August and are subject to change.
Source: Company data, Citi Research.

Figure 18. Comparison of major PHEV models

Company	Toyota	Honda	Mitsubishi Motor	GM	Ford
Model	**Prius PHV**	**Accord PHV**	**Outlander PHEV**	**Chevrolet Volt**	**C-Max Energi**
Battery supplier	Panasonic	Blue Energy	Lithium Energy Japan	LG Chem	Panasonic
Battery voltage (V)	207.2	320.0	300.0	360.0	361.0
Battery amount (kWh)	4.4	6.7	12.0	16.5	7.6
Battery technology	Ternary	NA	NA	LMO	Ternary
EV driving range (km)	26.4	37.6	60.2	61.0	33.8
PHEV fuel cost (km/L)	61.0	70.4	67.0	NA	NA
HEV fuel cost (km/L)	31.6	29.0	18.6	15.7	18.3
Weight (kg)	1,400	1,740	1,770	1,715	1,769
Motor power (kW)	60	124	60	111	88
Motor torque (N·m)	207	307	137, 195	370	240
Engine	1.8l, four-cylinder	2.0l, four-cylinder	2.0l, four-cylinder	1.4l, four-cylinder	2.0l, four-cylinder
Power (kW)	73	105	87	63	104
Torque (N·m)	142	165	186	NA	175
Launch date	2012/01	2013/06	2012/12	2010/12	2012/10
Price ($)	32,000 and up	39,780 and up	¥,3,324,000 and up (Equivalent to $33,240)	34,185 and up	33,745 and up

Note: Japanese makers use JC08 standard and US makers us EPA standard for fuel efficiency. PHEV prices are as of mid-August and are subject to change.
Source: Company data, SAE International, Citi Research.

Auto lithium-ion battery market scale forecasts

Forecast the size of the automotive lithium-ion battery market

We split the automotive lithium-ion battery market into HVs, PHEVs, and EVs and estimate the scale of the markets using assumptions for battery volume, battery capacity and average watt hour prices. We forecast that the market will grow to $2.9bn in 2013, $4.0bn in 2014, $5.1bn in 2015, and $12.0bn in 2020 from $1.3bn in 2011 and $1.9bn in 2012 (Figures 19 and 20).

Fuel economy regulations and charging infrastructure will lead to the spread of HVs, PHEVs, and EVs

With sales of EVs weak, 2012 was a tough year for the automotive application market, but we continue to see it as a growth market over the long run, on 1) expansion in the number of EV/PHEV/HV models and improvement in their performance and 2) fuel economy regulations and progress with charging infrastructure in countries around the world. Figure 21 shows fuel economy regulations in the key geographies of Japan, Europe, the US, and China, with high fuel efficiency expected to be sought in 2015 and out even in China and the US.

In Japan the government has given ¥100bn in subsidies for the charging infrastructure build-out and Toyota, Nissan, Honda, and MMC have announced they will cooperate on the build-out. In the US, automakers, heavy electrical equipment makers, Google and others are working on the charging infrastructure build-out both in the US and overseas, aiming to increase the number of charging stands tenfold in five years.

Revising up our outlook for the EV market in particular

Previously we estimated the size of the market in 2015 at $4.4bn (for more details, see our July 20, 2012, report, Lithium-ion batteries - A Japanese tech growth story?). We now put the market in 2015 at around $5.1bn. We revise up our outlook for the market for HVs, PHEVs, and EVs but interestingly the biggest factor behind the upward marketwide revision is that we raise our outlook for the EV market.

Model S and Nissan/Renault EVs to make big contributions to EV market size

We raise our outlook for the EV market on strong demand for Tesla's Model S and for EVs from Nissan and Renault. First, there is a significant impact from the success of the Model S, which is equipped with ample battery cells (assuming annual sales for the Model S of 20,000 units, a battery unit price of $400/kWh, and battery capacity per vehicle of 60kW, then the battery market is worth $480 mn). Also, in July 2013, Nissan and Renault announced they had broken through the 100,000 unit mark for cumulative EV sales, with the Leaf at around 71,000. Although we think it will be hard for them to reach their cumulative EV sales target of 1.5mn by 2016, we think it is worth monitoring growth in sales of the firms' EVs, most notably the new Leaf.

We expect real expansion in the HV/PHEV market from around 2015

We forecast that growth will continue in the HV and PHEV markets, on growth in HVs with lithium-ion batteries and contributions from the Chevrolet Volt from GM and the Outlander PHEV from MMC. Further out, we think the market is likely to enter a real expansion phase from around 2015, on 1) the introduction of tougher auto fuel regulations in key geographies around 2015, 2) the launch of many models by automakers such as VW that have not been proactive on HVs and PHEVs around 2015, and 3) an increase in the number of models equipped with lithium-ion batteries by Toyota and Honda, the top 2 HV player, by 2015.

Caution needed over the long-run emergence of fuel-cell vehicles as substitute tech

The shale gas boom raises the possibility that fuel-cell vehicles will emerge as a substitute technology

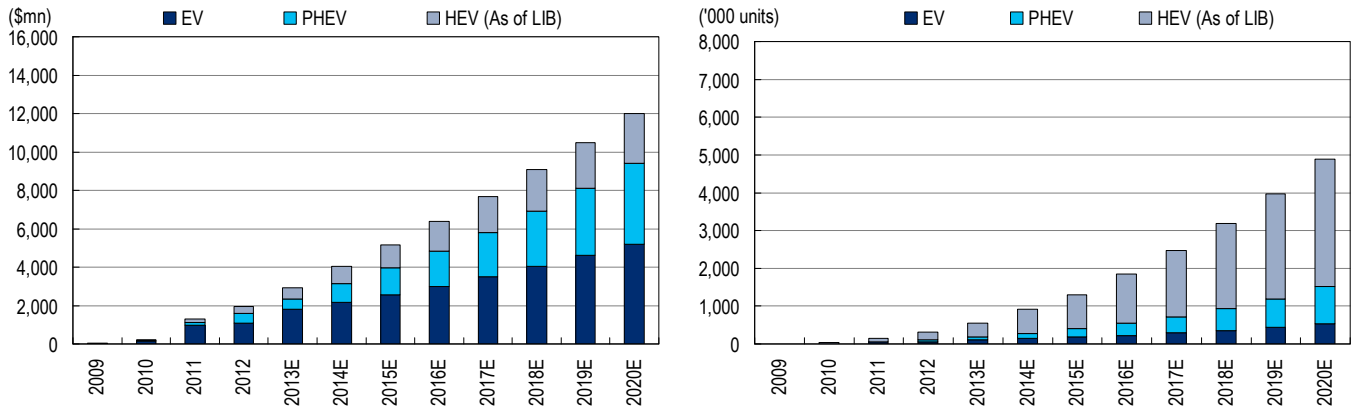
One big change that has emerged since 2012 is the possibility that fuel-cell vehicles will emerge in the long run as a substitute technology for PHEVs and EVs thanks to the shale gas boom. Fuel-cell vehicles are a species of electric vehicle that use electricity generated from hydrogen via a special catalyst as their motive power.

They do not generate carbon dioxide and can travel as far as a conventional gasoline-engined vehicle but high costs and the supply infrastructure of hydrogen are issues. However, expectations are that thanks to the shale gas boom, it will be possible to supply hydrogen in large volumes, so fuel-cell vehicles have rapidly become a focus of attention.

We expect fuel-cell vehicles to have little impact near term

We expect fuel-cell vehicles to have little impact near term, as 1) Toyota and Honda will only debut mass-market models in 2015 and out, 2) production costs are around ¥5mn per vehicle, and 3) an infrastructure build-out for hydrogen stations (the equivalent of EV charging infrastructure). However, many automakers are focusing efforts on the development of fuel-cell vehicles, so we advise caution on them as a long-term risk scenario.

Figure 19. Market size of lithium-ion batteries (LHS) and market units of HEV, PHEV and EV (RHS)



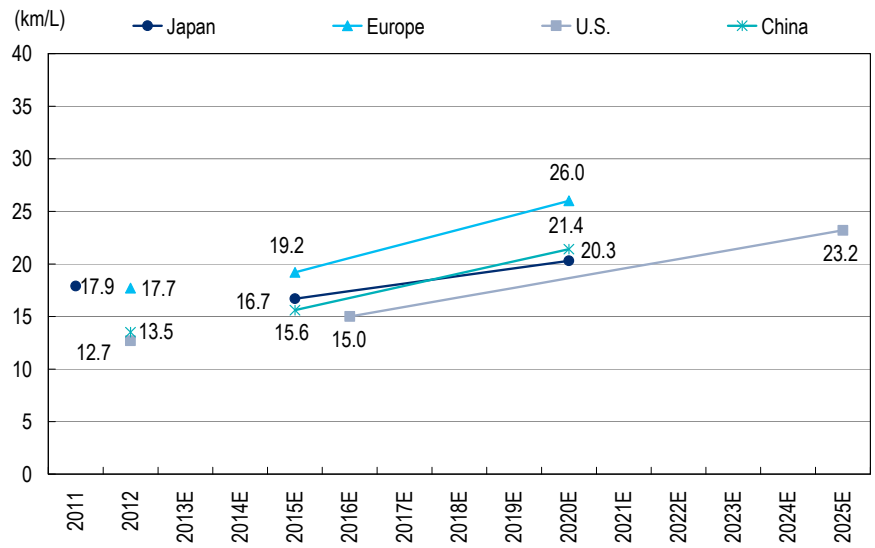
Source: Company data, Wards, Anfavea, AEB, JAMA, JAPA, CAAM, SIAM, GAIKINDO, TMT, TSR, MarkLines, Citi Research estimates.

Figure 20. Estimated market scale for lithium-ion batteries used in HEV, PHEV and EV

Shipment value ($mn)	**2009**	**2010**	**2011**	**2012**	**2013E**	**2014E**	**2015E**	**2016E**	**2017E**	**2018E**	**2019E**	**2020E**
EV	38	160	979	1,094	1,792	2,179	2,572	3,004	3,507	4,045	4,602	5,178
PHEV	0	13	142	509	540	942	1,381	1,823	2,304	2,866	3,500	4,218
HEV (As of LIB)	16	51	165	344	601	918	1,184	1,539	1,862	2,158	2,386	2,616
Total	**54**	**224**	**1,287**	**1,948**	**2,932**	**4,039**	**5,137**	**6,366**	**7,673**	**9,068**	**10,488**	**12,011**
Shipment units ('000 units)												
EV	2	8	46	60	102	139	180	227	285	354	432	524
PHEV	0	1	9	55	73	140	226	321	436	583	765	993
HEV (As of LIB)	6	23	83	191	371	630	903	1,304	1,751	2,256	2,772	3,376
Total	**8**	**32**	**138**	**306**	**546**	**909**	**1,308**	**1,851**	**2,473**	**3,193**	**3,969**	**4,894**
ASP ($)												
EV	24,000	19,281	21,098	18,331	17,530	15,629	14,255	13,231	12,296	11,438	10,647	9,883
PHEV		19,200	16,000	9,341	7,395	6,729	6,125	5,685	5,283	4,914	4,574	4,246
HEV (As of LIB)	2,500	2,200	2,000	1,800	1,620	1,458	1,312	1,181	1,063	957	861	775
Average battery capacity (kWh)												
EV	16.0	16.1	21.1	23.3	30.0	30.4	30.7	31.3	32.0	32.6	33.3	33.9
PHEV	16.0	16.0	16.0	11.3	11.9	12.0	12.0	12.3	12.5	12.7	13.0	13.3
HEV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Price per kWh ($.kWh)												
EV	1,500	1,200	1,000	786	585	515	464	422	385	351	320	291
PHEV	1,500	1,200	1,000	830	620	561	510	464	423	386	352	320
HEV	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Source: Company data, Wards, Anfavea, AEB, JAMA, JAPA, CAAM, SIAM, Gaikindo, TMT, TSR, Marklines, Citi Research Estimate

Figure 21. Fuel economy regulations in Japan, Europe, the US, and China



Note: JC08 standard for Japan, and CAFÉ standard for Europe, China and US
Source: ICCT, Citi Research.

Competitive environment in the automotive market: Focus on industry realignment

No major changes in trading relationships but industry realignment progressing since 2012

Figure 22 shows alliances among the major battery makers and the trading relationship between them and the automakers. In the last year, there have been no major changes in the trading relationships between the battery makers and the automakers. However, several companies have realigned in the industry, a change that has been occurring since late 2012.

Industry realignments (1): Bosch and Samsung SDI dissolve JV

The first industry realignment we turn to is the dissolution of the SB LiMotive JV between Bosch and Samsung SDI. Samsung SDI has little experience in the automotive field and was a laggard versus peers in entering the arena. So it partnered with Bosch from 2008 to learn the auto area ropes but the JV was dissolved in September 2012. (Samsung's tie-ups with other firms, such as S-LCD and Renault-Samsung, have generally been successes, although the partnership with Corning is an exception). Moving forward, Samsung SDI will run the automotive market operations alone, taking over clients such as BMW.

Industry realignments (2): A123 bankruptcy and acquisition by Wanxiang

The second industry realignment we note is the bankruptcy of A123 Systems and its acquisition by Wanxiang Group. In October 2012, A123 filed for Chapter 11 amid weak demand for electric vehicles. We understand A123 had expected its assets to be acquired by auto parts maker Johnson Controls, but Wanxiang Group of China ended up buying the company for $257mn. Wanxiang is an auto parts maker that has grown through acquisitions, and we think it purchased A123 to acquire technology for automotive batteries.

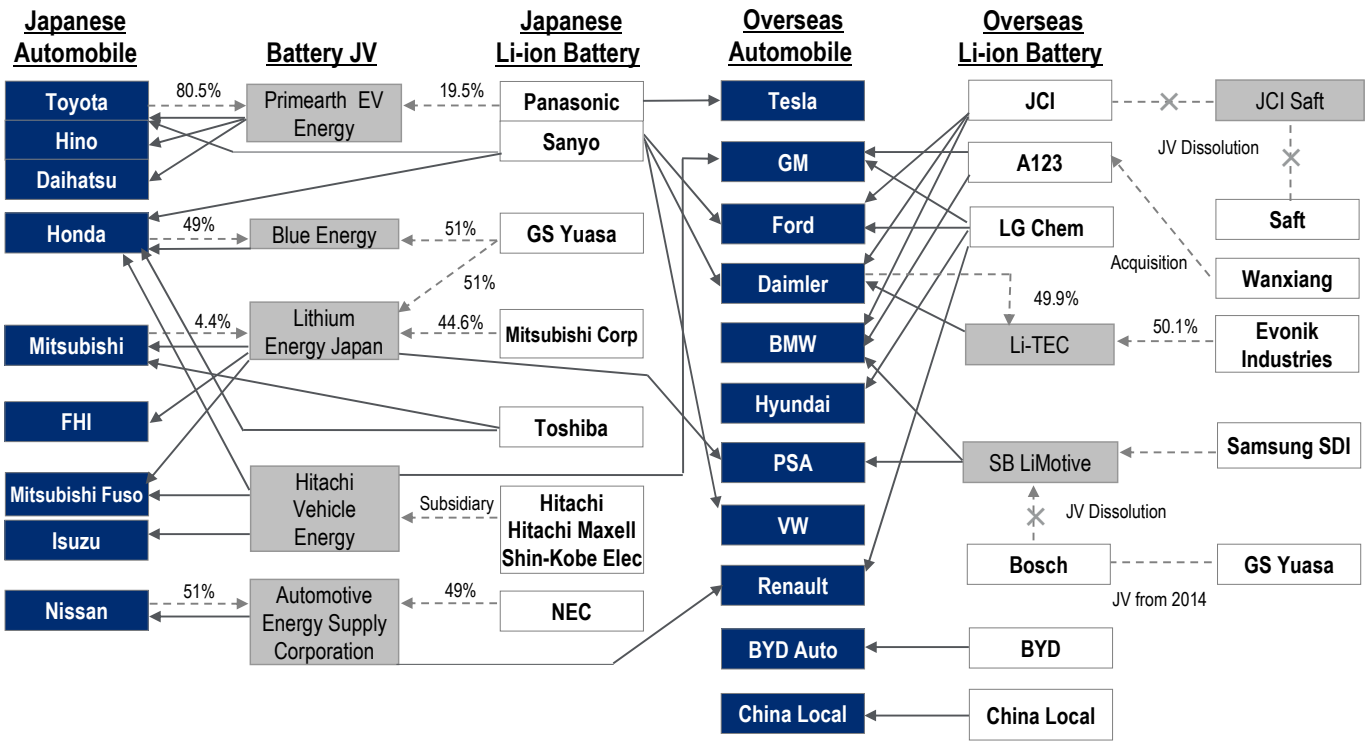
Industry realignments (3): GS Yuasa and Bosch form JV

As the third industry realignment, we cite the establishment of a JV between GS Yuasa and Bosch to develop next-generation batteries (for details, see our June 20 report, GS Yuasa (6674) - Agrees to develop next-generation batteries with Bosch, Mitsubishi Corp.). We surmise GS Yuasa is seeking to expand its customer base while Bosch needs access to battery technologies after dissolving its tie-up with Samsung SDI. We note, however, that the venture will be established in 2014 and it will take time to develop technologies and win new customers, so the impact of this alliance will be minor over the near term for both GS Yuasa's earnings and the battery industry as a whole.

Outlook for future realignment: focus on independence and new entrants

Going forward, we see the key points to consider for industry realignment to be independence and new entrants. In the vehicle battery market, independents like Panasonic and LG Chem are finding easier to win customers, while the opposite is true for JVs between automakers and battery companies due to questions of independence. We think joint ventures can expand their customer bases if they are able to increase their independence, and so we target independence as a theme for industry realignment. We will also be monitoring new entrants seeking to acquire vehicle battery technologies through M&A of battery makers, such as with the A123 acquisition.

Figure 22. Alliances and trading relationships for auto-use lithium-ion batteries



Note: Black lines denote battery supply relationships, dotted lines denote capital relationships.
Source: Company data, Citi Research.

Storage battery market

Moves to introduce storage batteries in social infrastructure (power distribution networks, etc.) accelerating

The storage battery market is the third major market for lithium-ion batteries after consumer electronics and automobiles. We anticipate growth over the long term as a key part of the social infrastructure. We see the main applications for storage batteries as 1) stabilizing power supply, 2) easing peak power demand, and 3) assisting with the introduction of renewable energy sources. Right now, the storage battery market is in its infancy and remains small in scale, but from the latter half of 2012 the installation of storage batteries accelerated, particularly for social infrastructure like power distribution systems.

The installation of storage batteries as part of solar generating systems is accelerating globally

Germany has introduced subsidies for storage batteries used in solar power generation

The stabilization of power supply necessary when shifting to renewables is attracting attention as one driver of demand for storage batteries. In Germany, a global leader in shifting to renewables, power supply instability stemming from the increased usage of solar and wind power generation has become a social problem. With this in mind, in May 2013 the German government set up a subsidy system under which a company can 1) apply for a grant worth 30% of the cost of installation when it builds in a solar power generating system with battery storage and 2) also benefit from favorable loan conditions. For more, see our April 30 report, Battery storage – the next solar boom? - Germany leads the way with storage subsidies.

Japan is also subsidizing storage battery installation as megasolar projects become more common

In Japan, a number of megasolar facilities are scheduled to be set up on the northern island of Hokkaido, and a subsidy scheme is expected for storage batteries used to stabilize power supply there. We understand METI plans a ¥20bn subsidy with which Hokkaido Electric will install large storage batteries at substations. The *Nikkei* has reported that SHI's redox flow batteries are likely to be installed. We see other leading candidates to be storage battery suppliers as Toshiba, which makes the lithium-ion battery SCiB (appealing for its long life and safety) and operates a rechargeable battery business, GS Yuasa, which makes power conditioners for power generation and operates a lithium-ion battery business, and Hitachi Chemical, which operates a storage battery business in Shin-Kobe Elec.

With more usage of solar cells worldwide, we think storage battery installation will increase

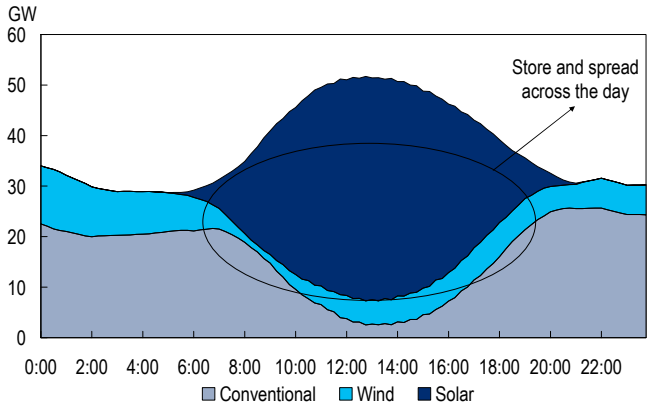
With solar cell usage becoming more common not just in Germany and Japan but worldwide, over the longer term we think storage battery installation could become a major trend. There are three reasons for this: 1) as prices for solar cells fall, solar generation facility installation is increasing, 2) as solar generation facility installation increases, it will become difficult to avoid instability in the power distribution system, and 3) power distribution system instability could result in large-scale blackouts, which would have serious social costs (Figure 23). In addition to Japan and Germany, we will be interested to see what happens in the US and China, where solar power facility volume is similar.

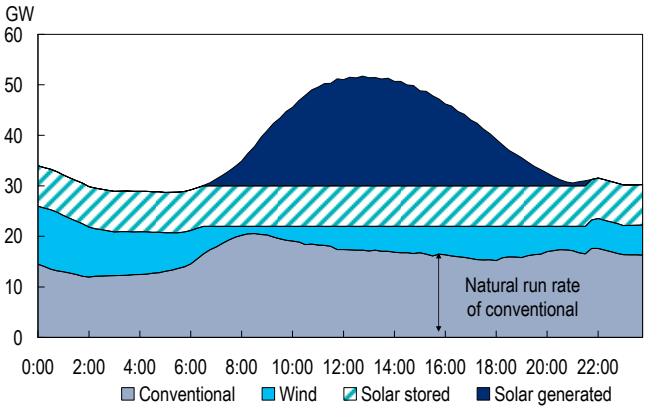
Price of household storage batteries still high

Price of household storage batteries still high

At the same time, the cost of household storage batteries remains high, and demand has not yet begun to expand in earnest. In Figure 24 we list the main household storage battery systems on the market, and for most the unit price is more than ¥200,000/kWh. For it to make economic sense to use a storage battery to lower power costs via peak shifting we estimate the cost would have to be in the several tens of thousands of yen per kWh (assuming a gap between daytime and nighttime rates of ¥30/kWh and reduction of 1kwH per day in peak current over ten years, we put power cost savings at ¥110,000; the actual number would likely be lower due to utilization issues). Right now we can only say that the price of household storage batteries is too high.

Figure 23. When a large volume of renewable power generating facilities are installed, storage batteries are necessary (RHS) to avoid power distribution instability (LHS)





Source: European Energy Exchange, Citi Research.

Figure 24. Comparing specs for the main storage systems

Company	Product	Release date	Application	Life span	Battery output (W)	Battery density (kWh)	Price ('000 JPY)	Price per kWh
Panasonic	Souchiku System	Mar 2011	Home	NA	NA	4.65	122	26
	VBBA210PB	Dec 2011	Home	NA	120	0.96	46	48
	LJ-SA32A5K/6K	Nov 2011	Home	NA	700	3.20	160	50
	LJ-SA16A5K/6K	Nov 2011	Home	NA	700	1.60	132	83
	XLJ-ME15A	Oct 2011	Public / Industry	NA	10,000	15.00	770	51
	VBBA216LB	Nov 2012	Home	NA	120	1.60	71	44
	VBBA210PB	Nov 2012	Home	NA	120	0.96	46	48
Sony	CP-S300W/E	Oct 2011	Home	over 10 years	300	0.30	15	49
	ESSP-2000/2000L	Aug 2011	Office	over 10 years	1,000	2.40	200	83
	ESSP-3001/10	Aug 2012	Home	over 10 years	1,000	1.20	170	142
	ESSP-3002/10	Aug 2012	Home	over 10 years	1,000	2.40	200	83
Hitachi	ESK-I03B08-A	Oct 2011	Home / Office	NA	3,000	7.80	210	27
Toshiba	SBE1P-U10010SC	Jul 2011	Office	4,000 times	700	1.60	120	75
	Enegoon	Nov 2012	Home	6,000 times	NA	6.60	150	23
NEC	ESS-H-002006B	Jul 2012	Home	NA	2,000	5.53	158	28
	ESS-H-002006A	Jul 2011	Home / Office	NA	2,000	6.00	250	42
Kyocera	EGS-LM72A	Aug 2012	House	NA	2,500	7.20	240	33
	EGS-LM144A	Aug 2012	House	NA	2,500	14.40	445	31
GS Yuasa	Acrostar LPSi1000-180	Jul 2011	UPS	NA	600	2.46	188	76
	Acrostar LPSi1000-180-8	Jul 2011	UPS	NA	800	2.46	NA	NA
BYD	MEPS-1000I	Jul 2011	Home	NA	1,000	2.40	80	33
Edison Power	EP-1000	Apr 2011	Home	NA	500	1.00	87	87
	EP-2500	Apr 2011	Home	NA	1,000	2.50	189	76
Eliiy Power	PPS-11	Oct 2011	Home / Office	NA	1,000	2.50	183	73
	PPS-20	Oct 2011	Home / Office	NA	1,000	2.50	183	73
ENAX	PBAC400	Apr 2012	Home / Office	NA	200	0.40	NA	NA
	PBAC2800	Jun 2012	Home / Office	NA	1,000	2.80	NA	NA
	PBAC5600	Jun 2012	Home / Office	NA	1,000	5.60	NA	NA
	PBAC8400	Jun 2012	Home / Office	NA	1,500	8.40	NA	NA
	PBAC11200	Jun 2012	Home / Office	NA	1,500	11.20	NA	NA

NA: Not available.
Source: Company data, Citi Research.

Lithium-ion battery materials

Global competition to advance the spread of next-generation materials

Japanese firms had been highly competitive

Lithium-ion battery materials were previously seen as an area where Japanese companies enjoyed a dominant market share and high profitability. We think the reason for this is that Japanese firms possess considerable technological capabilities cultivated via years of R&D. As with LCD materials, many thought that even if Japanese firms were to become less competitive in batteries themselves they could remain competitive in battery materials.

The rise of Chinese firms has meant greater competition

From around the beginning of 2011, however, global competition intensified as overseas firms (particularly from China) began to enter the market. In battery materials, many Japanese firms began to suffer from waning competitiveness and profitability. This was because in addition to a strong yen, rival battery makers in China and South Korea were making increased use of low-priced materials from China, while the quality of these materials was also improving. Moreover, the supply chain disruption that followed the earthquake and tsunami in March 2011 resulted in the spread of Chinese materials.

Lack of expansion in the automotive lithium-ion battery market also negative

One negative was weaker-than-expected expansion in the automotive market, which many thought would take over from the consumer electronics market as the major driver of demand. Automotive lithium-ion battery materials have difficult technological requirements due to safety and capacity issues, and expectations for Japan's material makers were high due to their strong competitiveness. However, this is actually a high-risk market, given the need for capital pending and cost cuts, as well as the significant role sales of "eco cars" plays in demand. Against this backdrop, sluggish demand from the auto market weighed down battery material maker profits.

Competition intensifying globally

We discussed this industry structure problem in our previous report Lithium-ion batteries - A Japanese tech growth story? published July 20, 2012, but global competition has intensified over the past year as Chinese makers increased their market presence (Figure 25).

Cathode material makers having a tougher go

Among battery material makers, companies that make cathode materials have seen a particularly sharp decline in competitiveness. In addition to a loss in market share for Japanese firms, margins are also on a downward trend not least at Tanaka Chemical, which is incurring losses, but also at companies like Toda Kogyo, and Nippon Denko. We believe this is because 1) China's sizable output of metals used in the manufacture of cathode materials makes it easy for Chinese companies to do business; 2) makers of cathode materials are likely to be pressed by battery makers to cut prices as they account for a sizable proportion of total raw material costs; and 3) the large number of available materials technologies facilitates frequent materials switching.

The Japan Big 3—Asahi Kasei, Ube, and Hitachi Chemical—are putting up a relatively good fight

Meanwhile separator specialist Asahi Kasei, electrolytic solution and separator specialist Ube, negative electrode specialist Hitachi Chemical, and electrolytic solution and other material specialist Mitsubishi Chemical are putting up relatively good fights for battery material makers. Earnings have been sluggish, due to intensifying competition and the lackluster automotive market, but this trio have been maintaining market share and profitability to a degree. We think this is because they have impressive technology in the high-end consumer electronics and in the automotive market and that it is hard for customers to substitute their products, due to safety and capacity issues, and 2) they have supply capacity and cost advantages because they have large-scale production capacity. Chinese

materials are used a lot in low-end areas by Chinese and South Korean firms and in a sense we feel they are indirect competitors of Japan's Big 3.

Umciore

Umicore has over 15 years of experience in lithium-ion technology and is the market leader in cathode materials closely followed by Nichia and L&F. It offers the broadest product portfolio with lithium cobaltite (LCO), nickel manganese cobalt (NMC) and lithium ferrophosphate (LFP) and has a strong IP position in these materials. It has four production sites (one each in Korea and Japan and two in China through JVs) and offers a "closed loop" given its strong position in metals and battery recycling which ensures competitive access to raw materials.

We estimate annual battery materials sales are about €200m ($260m) and the business grows by about 8%-10% p.a. However, EBIT margins are only about 4%-6%, according to our estimates. Strong competitive pressures, customer requirements to reduce costs/selling prices and ongoing investments keep margins depressed for the time being.

In 2013 H1, the company reported solid growth in the battery materials business (we estimate +8%-10% YoY) but noted very competitive market conditions (see our July 30, 2013 note Umicore NV/SA (UMI.BR) - 1H13 Results in line; Guidance reiterated). The main growth drivers were high end portable electronics, such as tablets and smartphones. Demand for NMC materials was down due to declining sales of notebook PCs. Sales of hybrid and electric cars are gradually increasing and Umicore remains optimistic regarding the outlook for EVs.

Next-generation material uptake on the rise

Focus on moves to increase capacity and safety

Many companies are attempting to focus on the high end of the market as a way around the intensified global competition. This is because of the increasing usage of next-generation materials that can guarantee higher capacity and improved safety. Please see our July 20, 2012 report for details of the core materials technology.

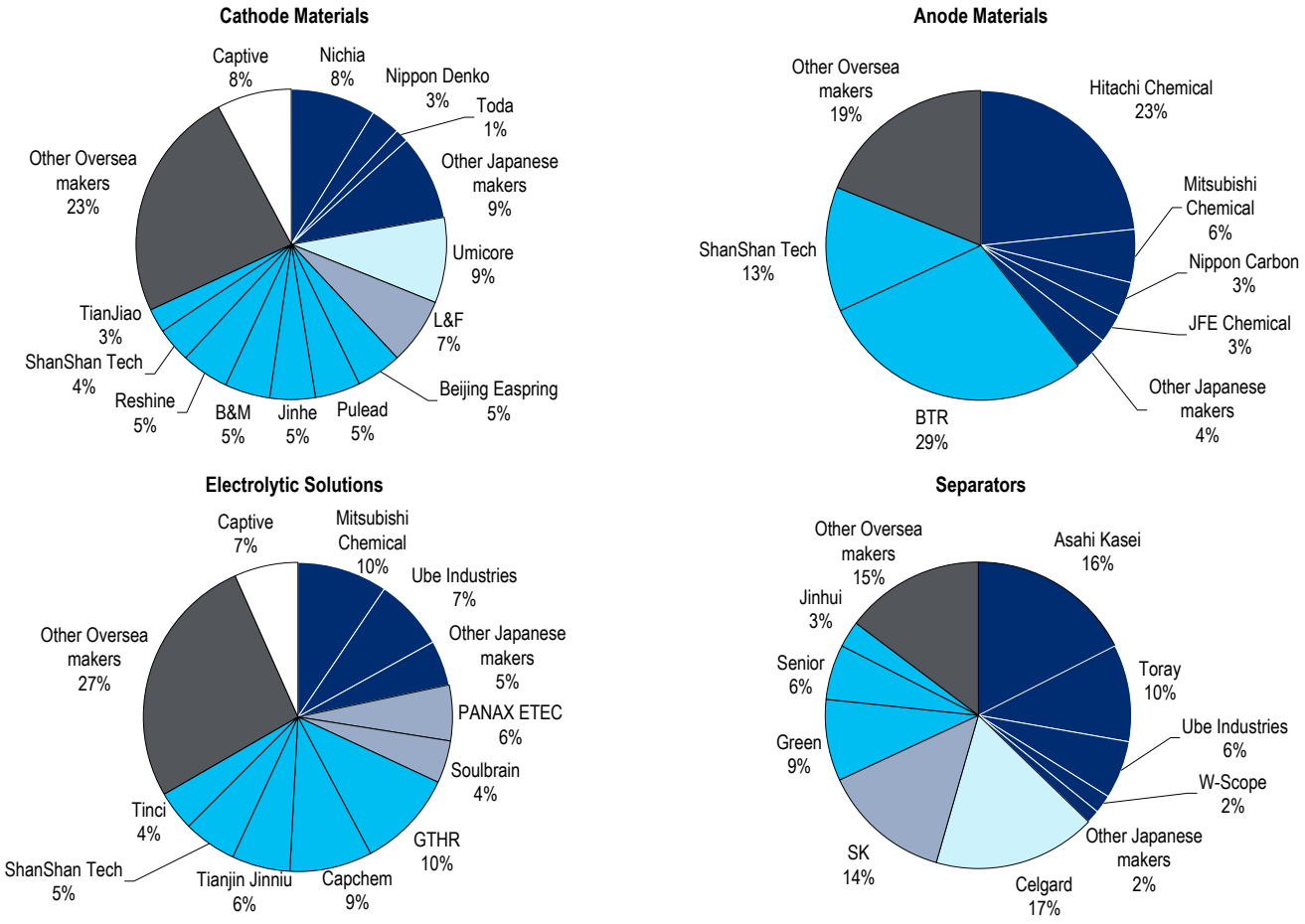
Materials technology that can support higher capacity increasingly used in consumer electronics

Demand for materials technology that can support higher capacity is increasing because of insufficient smartphone battery capacity. These technologies include silicon-based anode materials (see our August 1, 2013 report Shin-Etsu Chemical (4063) - Nikkei: Progress in development of silicon LiB material) and high-voltage materials (technology that increases battery capacity through the use of higher voltages, like high-voltage LCO, coating separators etc).

High capacity and safety are focal points for the automotive market

The automotive market is focused on high-capacity technologies like lithium excess cathode materials and high-voltage materials, and in addition the impact of B787 battery packs catching fire is raising interest in safety. Safety-related technologies include phosphoric acid fuel cells (see our August 1, 2012 report Sumitomo Osaka Cement (5232) - LiB positive electrode material business briefing), coating separators (where separators are coated with aluminum or other substances to preserve safety), and anode materials (for instance the LTO-based negative electrode materials used in Toshiba's SCiB super-charge ion batteries). Going forward, we expect demand for automotive battery materials to expand in line with growth in the automotive market.

Figure 25. Market share for major battery materials (2012; clockwise from left: cathode materials, anode materials, separators, electrolytic solutions)



Source: TSR, Citi Research.

Figure 26. Comparison of materials makers

	Technology	Quality	Cost	Material Purchase	Track record	Latest Situation
Japanese makers	◎	Δ	◎	◎	Δ	Japanese materials makers remain competitive in high-end consumer electronics batteries because of superior technologies, but need to become more cost competitive as battery prices fall. Many are aggressively expanding overseas operations amid intensifying competition with Korean and Chinese companies. They are developing materials for auto and industrial batteries, which are viewed as future growth markets.
Overseas makers	X→Δ	◎	X→Δ	Δ→○	◎	Korean materials makers are leveraging their cost competitiveness to gain market share with Korean battery makers, and their technical capabilities are improving as they gain experience. Some European and US materials makers have production bases in China
Chinese makers	Δ→○	○	○	○→◎	Δ	Customers are mainly local Chinese battery makers, although some Chinese materials makers are leveraging their cost competiveness to gain market share with Japanese and Korean battery makers who are suffering amid steep price declines. Chinese materials makers are overcoming technology and quality issues as they gain experience and are now able to supply materials suitable for low-end consumer electronics batteries.
New entry makers						European and US materials makers aim to draw on technical experience in other fields and strong financial positions to enter markets for auto and industrial battery materials. But they need to establish results and entry barriers are high.

Note: ◎ = excellent, ○ = good, Δ = poor, X = very poor
Source: Citi Research.

Thoughts on fire risk

Fire incidents an intrinsic risk for lithium-ion batteries

Given high-performance nature lithium-ion batteries are susceptible to overheating and fire

Lithium-ion battery safety has come under the spotlight following recent incidents where B787 battery packs caught fire, but we regard fire as an intrinsic risk factor for lithium-ion batteries. The highly flammable nature of lithium-ion battery electrolyte solutions (water solutions are used in NiH and NiCD batteries) along with the high energy densities of lithium-ion batteries explain why they are prone to catching fire.

High levels of quality control required to ensure safety

A range of measures have been taken to prevent lithium-ion batteries from catching fire, such as avoiding contamination during the manufacturing process, the adoption of safer materials, and controlling external circuit-induced over-charging. However, the reality is that many battery makers have had problems with fire and overheating because of battery handling or manufacturing-related issues. The risk of fire is particularly great for high-capacity lithium-ion batteries used in consumer electronics or automotive applications. Accordingly, to maintain safety a high level of quality control is required.

Many firms impacted by overheating and fire incidents

Many companies have been dogged by issues with battery fires or overheating (Figure 27). The outbreak of a fire in an electric vehicle equipped with a phosphoric acid lithium-ion battery manufactured by BYD suggests that the use of materials that are considered highly safe may not completely eliminate fire risk. Toyota and Honda opted to fit their hybrid cars with NiMH batteries, which are inferior in terms of energy density and capacity. We think this decision was made after careful consideration of the fire risk of lithium-ion batteries, as well as of costs.

Cause of Boeing 787 fires still unclear

It is still not clear what caused fire to break out in B787 battery compartments. We think it will be difficult to determine the cause as in addition to cell, external circuit, and incorrect wiring problems, there is also the problem unique to aircraft of cosmic radiation-induced semiconductor malfunction. While the exact cause remains unclear, Boeing has introduced a wide range of measures to address possible causes and also reviewed the overall design of the aircraft to prevent fire from spreading to other compartments even if fire were to break out again. As a result, the B787 was cleared for take off once again.

Safety is likely to remain a key issue going forward

Considering the lack of any alternative to lithium-ion batteries in terms of energy density, and also that lithium-ion batteries are being used increasingly in a broad range of applications, we think fire will remain a key risk for lithium-ion batteries.

Figure 27. Major fire incidents involving batteries

Year	Battery makers	Fire incidents	Impact
2006	Sony	Notebook PC battery catches fire	One-off charge of ¥51.2bn booked for recall and replacement
2006	Sanyo Electric	Mobile phone battery catches fire	NA
2012	BYD	Electric vehicle battery catches fire during traffic accident	NA
2012	LG Chem	GM's Chevrolet Volt battery catches fire during testing	NA
2013	GS Yuasa	Boeing 787 fire incident	NA
2013	GS Yuasa	Overheating case in MMC's Outlander PHEV	Booked extraordinary loss of ¥3bn on recall

Source: Company data, Citi Research.

LG Chem

Valuation

Our W350,000 target price is based on a mid-cycle 1.7x FY14E P/BV, reflecting the bottoming of the chemical cycle in 2012 and improving ROE (15-16% in 2014-15E vs. 13% in 2013E). We value chemical stocks using P/BV methodology due to the asset-heavy nature of the business.

Risks

Key downside risks to our target price include: 1) Weaker-than-expected China chemical demand and/or globally; 2) Further ASP pressure on polarizer/battery on industry oversupply and softer demand; 3) Unscheduled plant shutdown for rechargeable battery; and 4) Uncertainty of various assumptions in DCF valuation of new business, which is highly subjective. Key upside risks to our target price include: 1) Stronger-than-expected electronics recovery; 2) Delays for new Middle East capacity startups; and 3) Sharp weakening of the Won:US$ exchange rate.

Samsung SDI

Valuation

Our target price of W140,000 is based on 0.8x P/B, the low end of the stock's historical trading band of 0.8-1.2x. Given the depressed core OP profile due to the cost burden from start-ups and limited visibility of the new businesses even in the medium-term, we use the historical low end of its trading band.

Risks

Upside risks to our target price include: 1) more earnings visibility into the new businesses and 2) monetization of the underlying investment assets. Downside risks to our target price include: 1) unexpected margin deterioration in mobile battery from competition or slow demand, 2) prolonged losses in new business development without any visibility, 3) faster KRW appreciation and 4) limited possibility of liquidating investment assets.

Appendix A-1

Analyst Certification

The research analyst(s) primarily responsible for the preparation and content of this research report are named in bold text in the author block at the front of the product except for those sections where an analyst's name appears in bold alongside content which is attributable to that analyst. Each of these analyst(s) certify, with respect to the section(s) of the report for which they are responsible, that the views expressed therein accurately reflect their personal views about each issuer and security referenced and were prepared in an independent manner, including with respect to Citigroup Global Markets Inc and its affiliates. No part of the research analyst's compensation was, is, or will be, directly or indirectly, related to the specific recommendation(s) or view(s) expressed by that research analyst in this report.

IMPORTANT DISCLOSURES

LG Chem (051910.KS)

Ratings and Target Price History
Fundamental Research

Analyst: Oscar Yee

	Date	Rating	Target Price	Closing Price
1	16-Sep-10	*2L	*350,000.00	322,000.00
2	30-Jan-11	2L	*435,000.00	408,000.03
3	20-Apr-11	2L	*550,000.00	549,000.00
4	25-Sep-11	*1L	*440,000.00	316,500.00
5	7-Oct-11	Stock rating system changed		
6	7-Oct-11	*1	440,000.00	322,000.00
7	23-May-12	1	*390,000.00	275,000.00
8	29-Jan-13	1	*360,000.00	313,000.00
9	20-May-13	1	*350,000.00	278,000.00

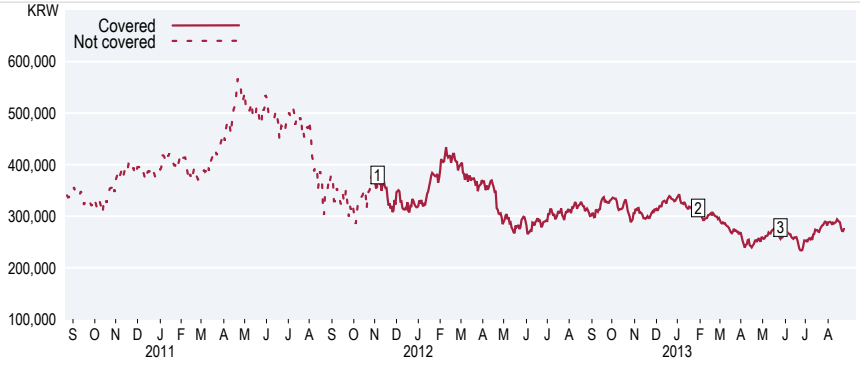
* Indicates change

Rating/target price changes above reflect Eastern Standard Time

LG Chem (051910.KS)

Ratings and Target Price History
Best Ideas Research
Relative Call (3 Month)

Analyst: Oscar Yee



	Date	Rating	Target Price	Closing Price
1	4-Nov-11	*ADD MP	-	372,500.00
2	30-Jan-13	*REM MP	-	302,000.00
3	27-May-13	*ADD MP	-	256,000.00

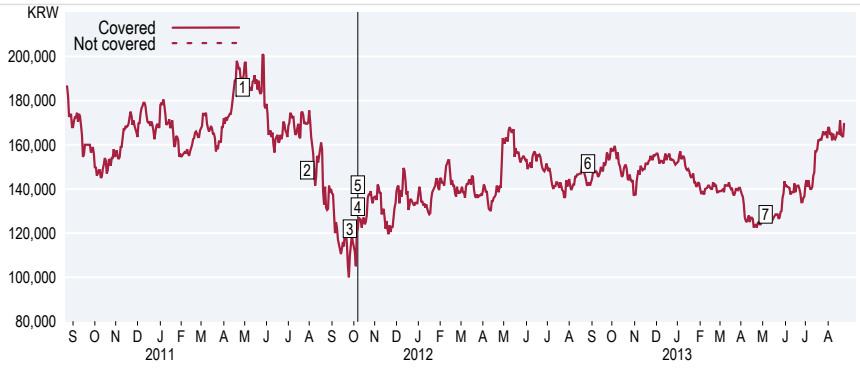
* Indicates change

Rating/target price changes above reflect Eastern Standard Time

Samsung SDI (006400.KS)

Ratings and Target Price History
Fundamental Research

Analyst: Henry H Kim, CFA
Covered since August 29 2012



	Date	Rating	Target Price	Closing Price
1	28-Apr-11	3M	*165,000.00	189,000.00
2	28-Jul-11	3M	*173,000.00	169,500.00
3	27-Sep-11	3M	*100,000.00	110,000.00

	Date	Rating	Target Price	Closing Price
4	7-Oct-11	Stock rating system changed		
5	7-Oct-11	*3	100,000.00	122,000.00
6	28-Aug-12	*2	*155,000.00	142,000.00

	Date	Rating	Target Price	Closing Price
7	6-May-13	2	*140,000.00	128,000.00

* Indicates change

Rating/target price changes above reflect Eastern Standard Time

Samsung SDI (006400.KS)

Ratings and Target Price History
Best Ideas Research
Relative Call (3 Month)

Analyst: Henry H Kim, CFA
Covered since August 29 2012

	Date	Rating	Target Price	Closing Price
1	11-Feb-11	*ADD LP	-	155,000.00

	Date	Rating	Target Price	Closing Price
2	29-Aug-12	*REM LP	-	143,000.00

* Indicates change

Rating/target price changes above reflect Eastern Standard Time

Citigroup Global Markets Inc. owns a position of 1 million USD or more in the debt securities of Johnson Controls Inc

Within the past 12 months, Citigroup Global Markets Inc. or its affiliates has acted as manager or co-manager of an offering of securities of Sony, SK Innovation.

Citigroup Global Markets Inc. or its affiliates has received compensation for investment banking services provided within the past 12 months from Sony, Mitsubishi Chemical Holdings, Hitachi Chemical, Hitachi, Toshiba, SK Innovation, Johnson Controls Inc, Sumitomo Chemical, Panasonic.

Citigroup Global Markets Inc. or its affiliates expects to receive or intends to seek, within the next three months, compensation for investment banking services from SK Innovation.

Citigroup Global Markets Inc. or an affiliate received compensation for products and services other than investment banking services from Sony, NEC, Mitsubishi Chemical Holdings, Hitachi Chemical, Hitachi, Toshiba, Ube Industries, Simplo Technology, LG Chem, Asahi Kasei, Umicore NV/SA, SK Innovation, Johnson Controls Inc, Sumitomo Chemical, Toray Industries, TDK, Panasonic, Samsung SDI, Teijin in the past 12 months.

Citigroup Global Markets Inc. currently has, or had within the past 12 months, the following as investment banking client(s): Sony, Mitsubishi Chemical Holdings, Hitachi Chemical, Hitachi, Toshiba, SK Innovation, Johnson Controls Inc, Sumitomo Chemical, Panasonic.

Citigroup Global Markets Inc. currently has, or had within the past 12 months, the following as clients, and the services provided were non-investment-banking, securities-related: Sony, NEC, Mitsubishi Chemical Holdings, Hitachi Chemical, Hitachi, Toshiba, Ube Industries, LG Chem, Asahi Kasei, Umicore NV/SA, SK Innovation, Johnson Controls Inc, Sumitomo Chemical, Toray Industries, TDK, Panasonic, Samsung SDI, Teijin.

Citigroup Global Markets Inc. currently has, or had within the past 12 months, the following as clients, and the services provided were non-investment-banking, non-securities-related: Sony, NEC, Mitsubishi Chemical Holdings, Hitachi Chemical, Hitachi, Toshiba, Ube Industries, Simplo Technology, LG Chem, Asahi Kasei, Umicore NV/SA, SK Innovation, Johnson Controls Inc, Sumitomo Chemical, Toray Industries, TDK, Panasonic, Samsung SDI, Teijin.

Analysts' compensation is determined based upon activities and services intended to benefit the investor clients of Citigroup Global Markets Inc. and its affiliates ("the Firm"). Like all Firm employees, analysts receive compensation that is impacted by overall firm profitability which includes investment banking revenues.

The Firm is a market maker in the publicly traded equity securities of Asahi Kasei, Toray Industries, TDK, Teijin.

For important disclosures (including copies of historical disclosures) regarding the companies that are the subject of this Citi Research product ("the Product"), please contact Citi Research, 388 Greenwich Street, 28th Floor, New York, NY, 10013, Attention: Legal/Compliance [E6WYB6412478]. In

addition, the same important disclosures, with the exception of the Valuation and Risk assessments and historical disclosures, are contained on the Firm's disclosure website at https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures. Valuation and Risk assessments can be found in the text of the most recent research note/report regarding the subject company. Historical disclosures (for up to the past three years) will be provided upon request.

Citi Research Equity Ratings Distribution

	12 Month Rating			*Relative Rating*		
Data current as of 30 Jun 2013	**Buy**	**Hold**	**Sell**	**Buy**	**Hold**	**Sell**
Citi Research Global Fundamental Coverage	48%	40%	12%	6%	88%	6%
% of companies in each rating category that are investment banking clients	53%	50%	45%	58%	51%	49%

Guide to Citi Research Fundamental Research Investment Ratings:

Citi Research stock recommendations include an investment rating and an optional risk rating to highlight high risk stocks.

Risk rating takes into account both price volatility and fundamental criteria. Stocks will either have no risk rating or a High risk rating assigned.

Investment Ratings: Citi Research investment ratings are Buy, Neutral and Sell. Our ratings are a function of analyst expectations of expected total return ("ETR") and risk. ETR is the sum of the forecast price appreciation (or depreciation) plus the dividend yield for a stock within the next 12 months. The Investment rating definitions are: Buy (1) ETR of 15% or more or 25% or more for High risk stocks; and Sell (3) for negative ETR. Any covered stock not assigned a Buy or a Sell is a Neutral (2). For stocks rated Neutral (2), if an analyst believes that there are insufficient valuation drivers and/or investment catalysts to derive a positive or negative investment view, they may elect with the approval of Citi Research management not to assign a target price and, thus, not derive an ETR. Analysts may place covered stocks "Under Review" in response to exceptional circumstances (e.g. lack of information critical to the analyst's thesis) affecting the company and / or trading in the company's securities (e.g. trading suspension). As soon as practically possible, the analyst will publish a note re-establishing a rating and investment thesis. To satisfy regulatory requirements, we correspond Under Review and Neutral to Hold in our ratings distribution table for our 12-month fundamental rating system. However, we reiterate that we do not consider Under Review to be a recommendation.

Relative three-month ratings: Citi Research may also assign a three-month relative call (or rating) to a stock to highlight expected out-performance (most preferred) or under-performance (least preferred) versus the geographic and industry sector over a 3 month period. The relative call may highlight a specific near-term catalyst or event impacting the company or the market that is anticipated to have a short-term price impact on the equity securities of the company. Absent any specific catalyst the analyst(s) will indicate the most and least preferred stocks in the universe of stocks under consideration, explaining the basis for this short-term view. This three-month view may be different from and does not affect a stock's fundamental equity rating, which reflects a longer-term total absolute return expectation. For purposes of NASD/NYSE ratings-distribution-disclosure rules, most preferred calls correspond to a buy recommendation and least preferred calls correspond to a sell recommendation. Any stock not assigned to a most preferred or least preferred call is considered non-relative-rated (NRR). For purposes of NASD/NYSE ratings-distribution-disclosure rules we correspond NRR to Hold in our ratings distribution table for our 3-month relative rating system. However, we reiterate that we do not consider NRR to be a recommendation.

Prior to October 8, 2011, the firm's stock recommendation system included a risk rating and an investment rating. **Risk ratings,** which took into account both price volatility and fundamental criteria, were: Low (L), Medium (M), High (H), and Speculative (S). **Investment Ratings** of Buy, Hold and Sell were a function of the Citi Research expectation of total return (forecast price appreciation and dividend yield within the next 12 months) and risk rating. Additionally, analysts could have placed covered stocks "Under Review" in response to exceptional circumstances (e.g. lack of information critical to the analyst's thesis) affecting the company and/or trading in the company's securities (e.g. trading suspension). Stocks placed "Under Review" were monitored daily by management and as practically possible, the analyst published a note re-establishing a rating and investment thesis. For securities in developed markets (US, UK, Europe, Japan, and Australia/New Zealand), investment ratings were:Buy (1) (expected total return of 10% or more for Low-Risk stocks, 15% or more for Medium-Risk stocks, 20% or more for High-Risk stocks, and 35% or more for Speculative stocks); Hold (2) (0%-10% for Low-Risk stocks, 0%-15% for Medium-Risk stocks, 0%-20% for High-Risk stocks, and 0%-35% for Speculative stocks); and Sell (3) (negative total return). For securities in emerging markets (Asia Pacific, Emerging Europe/Middle East/Africa, and Latin America), investment ratings were:Buy (1) (expected total return of 15% or more for Low-Risk stocks, 20% or more for Medium-Risk stocks, 30% or more for High-Risk stocks, and 40% or more for Speculative stocks); Hold (2) (5%-15% for Low-Risk stocks, 10%-20% for Medium-Risk stocks, 15%-30% for High-Risk stocks, and 20%-40% for Speculative stocks); and Sell (3) (5% or less for Low-Risk stocks, 10% or less for Medium-Risk stocks, 15% or less for High-Risk stocks, and 20% or less for Speculative stocks).

Investment ratings are determined by the ranges described above at the time of initiation of coverage, a change in investment and/or risk rating, or a change in target price (subject to limited management discretion). At other times, the expected total returns may fall outside of these ranges because of market price movements and/or other short-term volatility or trading patterns. Such interim deviations from specified ranges will be permitted but will become subject to review by Research Management. Your decision to buy or sell a security should be based upon your personal investment objectives and should be made only after evaluating the stock's expected performance and risk.

NON-US RESEARCH ANALYST DISCLOSURES

Non-US research analysts who have prepared this report (i.e., all research analysts listed below other than those identified as employed by Citigroup Global Markets Inc.) are not registered/qualified as research analysts with FINRA. Such research analysts may not be associated persons of the member organization and therefore may not be subject to the NYSE Rule 472 and NASD Rule 2711 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account. The legal entities employing the authors of this report are listed below:

Citigroup Global Markets Japan Inc.	Tsubasa Sasaki; Kota Ezawa; Takao Kanai; Yuta Fukasawa; Atsushi Ikeda
Citigroup Global Markets Korea Securities Ltd	Henry H Kim, CFA
Citigroup Global Markets Asia	Oscar Yee
Citigroup Global Markets Taiwan Securities Co. Limited	Wei Chen
Citigroup Global Markets Ltd	Jason Channell; Phuc Nguyen; Dominik Frauendienst
Citigroup Global Markets Inc	Itay Michaeli

OTHER DISCLOSURES

Citigroup Global Markets Inc. and/or its affiliates has a significant financial interest in relation to Sony, Mitsubishi Chemical Holdings, Toshiba, Johnson Controls Inc, Sumitomo Chemical. (For an explanation of the determination of significant financial interest, please refer to the policy for managing conflicts of interest which can be found at www.citiVelocity.com.)

This Product has been modified by the author following a discussion with one or more of the named issuers/issuers of the named securities.

For securities recommended in the Product in which the Firm is not a market maker, the Firm is a liquidity provider in the issuers' financial instruments and may act as principal in connection with such transactions. The Firm is a regular issuer of traded financial instruments linked to securities that may have been recommended in the Product. The Firm regularly trades in the securities of the issuer(s) discussed in the Product. The Firm may engage in securities transactions in a manner inconsistent with the Product and, with respect to securities covered by the Product, will buy or sell from customers on a principal basis.

Securities recommended, offered, or sold by the Firm: (i) are not insured by the Federal Deposit Insurance Corporation; (ii) are not deposits or other obligations of any insured depository institution (including Citibank); and (iii) are subject to investment risks, including the possible loss of the principal amount invested. Although information has been obtained from and is based upon sources that the Firm believes to be reliable, we do not guarantee its accuracy and it may be incomplete and condensed. Note, however, that the Firm has taken all reasonable steps to determine the accuracy and completeness of the disclosures made in the Important Disclosures section of the Product. The Firm's research department has received assistance from the subject company(ies) referred to in this Product including, but not limited to, discussions with management of the subject company(ies). Firm policy prohibits research analysts from sending draft research to subject companies. However, it should be presumed that the author of the Product has had discussions with the subject company to ensure factual accuracy prior to publication. All opinions, projections and estimates constitute the judgment of the author as of the date of the Product and these, plus any other information contained in the Product, are subject to change without notice. Prices and availability of financial instruments also are subject to change without notice. Notwithstanding other departments within the Firm advising the companies discussed in this Product, information obtained in such role is not used in the preparation of the Product. Although Citi Research does not set a predetermined frequency for publication, if the Product is a fundamental research report, it is the intention of Citi Research to provide research coverage of the/those issuer(s) mentioned therein, including in response to news affecting this issuer, subject to applicable quiet periods and capacity constraints. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security. Any decision to purchase securities mentioned in the Product must take into account existing public information on such security or any registered prospectus.

Investing in non-U.S. securities, including ADRs, may entail certain risks. The securities of non-U.S. issuers may not be registered with, nor be subject to the reporting requirements of the U.S. Securities and Exchange Commission. There may be limited information available on foreign securities. Foreign companies are generally not subject to uniform audit and reporting standards, practices and requirements comparable to those in the U.S. Securities of some foreign companies may be less liquid and their prices more volatile than securities of comparable U.S. companies. In addition, exchange rate movements may have an adverse effect on the value of an investment in a foreign stock and its corresponding dividend payment for U.S. investors. Net dividends to ADR investors are estimated, using withholding tax rates conventions, deemed accurate, but investors are urged to consult their tax advisor for exact dividend computations. Investors who have received the Product from the Firm may be prohibited in certain states or other jurisdictions from purchasing securities mentioned in the Product from the Firm. Please ask your Financial Consultant for additional details. Citigroup Global Markets Inc. takes responsibility for the Product in the United States. Any orders by US investors resulting from the information contained in the Product may be placed only through Citigroup Global Markets Inc.

The Citigroup legal entity that takes responsibility for the production of the Product is the legal entity which the first named author is employed by. The Product is made available in **Australia** through Citi Global Markets Australia Pty Ltd. (ABN 64 003 114 832 and AFSL No. 240992), participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000. The Product is made available in Australia to Private Banking wholesale clients through Citigroup Pty Limited (ABN 88 004 325 080 and AFSL 238098). Citigroup Pty Limited provides all financial product advice to Australian Private Banking wholesale clients through bankers and relationship managers. If there is any doubt about the suitability of investments held in Citigroup Private Bank accounts, investors should contact the Citigroup Private Bank in Australia. Citigroup companies may compensate affiliates and their representatives for providing products and services to clients. The Product is made available in **Brazil** by Citigroup Global Markets Brasil - CCTVM SA, which is regulated by CVM - Comissão de Valores Mobiliários, BACEN - Brazilian Central Bank, APIMEC - Associação dos Analistas e Profissionais de Investimento do Mercado de Capitais and ANBID - Associação Nacional dos Bancos de Investimento. Av. Paulista, 1111 - 11º andar - CEP. 01311920 - São Paulo - SP. If the Product is being made available in certain provinces of **Canada** by Citigroup Global Markets (Canada) Inc. ("CGM Canada"), CGM Canada has approved the Product. Citigroup Place, 123 Front Street West, Suite 1100, Toronto, Ontario M5J 2M3. This product is available in **Chile** through Banchile Corredores de Bolsa S.A., an indirect subsidiary of Citigroup Inc., which is regulated by the Superintendencia de Valores y Seguros. Agustinas 975, piso 2, Santiago, Chile. The Product is made available in **France** by Citigroup Global Markets Limited, which is authorised and regulated by Financial Services Authority. 1-5 Rue Paul Cézanne, 8ème, Paris, France. The Product is distributed in **Germany** by Citigroup Global Markets Deutschland AG ("CGMD"), which is regulated by Bundesanstalt fuer Finanzdienstleistungsaufsicht (BaFin). CGMD, Reuterweg 16, 60323 Frankfurt am Main. Research which relates to "securities" (as defined in the Securities and Futures Ordinance (Cap. 571 of the Laws of Hong Kong)) is issued in **Hong Kong** by, or on behalf of, Citigroup Global Markets Asia Limited which takes full responsibility for its content. Citigroup Global Markets Asia Ltd. is regulated by Hong Kong Securities and Futures Commission. If the Research is made available through Citibank, N.A., Hong Kong Branch, for its clients in Citi Private Bank, it is made available by Citibank N.A., Citibank Tower, Citibank Plaza, 3 Garden Road, Hong Kong. Citibank N.A. is regulated by the Hong Kong Monetary Authority. Please contact your Private Banker in Citibank N.A., Hong Kong, Branch if you have any queries on or any matters arising from or in connection with this document. The Product is made available in **India** by Citigroup Global Markets India Private Limited, which is regulated by Securities and Exchange Board of India. Bakhtawar, Nariman Point, Mumbai 400-021. The Product is made available in **Indonesia** through PT Citigroup Securities Indonesia. 5/F, Citibank Tower, Bapindo Plaza, Jl. Jend. Sudirman Kav. 54-55, Jakarta 12190. Neither this Product nor any copy hereof may be distributed in Indonesia or to any Indonesian citizens wherever they are domiciled or to Indonesian residents except in compliance with applicable capital market laws and regulations. This Product is not an offer of securities in Indonesia. The securities referred to in this Product have not been registered with the Capital Market and Financial Institutions Supervisory Agency (BAPEPAM-LK) pursuant to relevant capital market laws and regulations,

and may not be offered or sold within the territory of the Republic of Indonesia or to Indonesian citizens through a public offering or in circumstances which constitute an offer within the meaning of the Indonesian capital market laws and regulations. The Product is made available in **Israel** through Citibank NA, regulated by the Bank of Israel and the Israeli Securities Authority. Citibank, N.A, Platinum Building, 21 Ha'arba'ah St, Tel Aviv, Israel. The Product is made available in **Italy** by Citigroup Global Markets Limited, which is authorised and regulated by Financial Services Authority. Via dei Mercanti, 12, Milan, 20121, Italy. The Product is made available in **Japan** by Citigroup Global Markets Japan Inc. ("CGMJ"), which is regulated by Financial Services Agency, Securities and Exchange Surveillance Commission, Japan Securities Dealers Association, Tokyo Stock Exchange and Osaka Securities Exchange. Shin-Marunouchi Building, 1-5-1 Marunouchi, Chiyoda-ku, Tokyo 100-6520 Japan. If the Product was distributed by SMBC Nikko Securities Inc. it is being so distributed under license. In the event that an error is found in an CGMJ research report, a revised version will be posted on the Firm's Citi Velocity website. If you have questions regarding Citi Velocity, please call (81 3) 6270-3019 for help. The Product is made available in **Korea** by Citigroup Global Markets Korea Securities Ltd., which is regulated by the Financial Services Commission, the Financial Supervisory Service and the Korea Financial Investment Association (KOFIA). Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. KOFIA makes available registration information of research analysts on its website. Please visit the following website if you wish to find KOFIA registration information on research analysts of Citigroup Global Markets Korea Securities Ltd. http://dis.kofia.or.kr/fs/dis2/fundMgr/DISFundMgrAnalystPop.jsp?companyCd2=A03030&pageDiv=02. The Product is made available in Korea by Citibank Korea Inc., which is regulated by the Financial Services Commission and the Financial Supervisory Service. Address is Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. The Product is made available in **Malaysia** by Citigroup Global Markets Malaysia Sdn Bhd (Company No. 460819-D) ("CGMM") to its clients and CGMM takes responsibility for its contents. CGMM is regulated by the Securities Commission of Malaysia. Please contact CGMM at Level 43 Menara Citibank, 165 Jalan Ampang, 50450 Kuala Lumpur, Malaysia in respect of any matters arising from, or in connection with, the Product. The Product is made available in **Mexico** by Acciones y Valores Banamex, S.A. De C. V., Casa de Bolsa, Integrante del Grupo Financiero Banamex ("Accival") which is a wholly owned subsidiary of Citigroup Inc. and is regulated by Comision Nacional Bancaria y de Valores. Reforma 398, Col. Juarez, 06600 Mexico, D.F. In **New Zealand** the Product is made available to 'wholesale clients' only as defined by s5C(1) of the Financial Advisers Act 2008 ('FAA') through Citigroup Global Markets Australia Pty Ltd (ABN 64 003 114 832 and AFSL No. 240992), an overseas financial adviser as defined by the FAA, participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000. The Product is made available in **Pakistan** by Citibank N.A. Pakistan branch, which is regulated by the State Bank of Pakistan and Securities Exchange Commission, Pakistan. AWT Plaza, 1.1. Chundrigar Road, P.O. Box 4889, Karachi-74200. The Product is made available in the **Philippines** through Citicorp Financial Services and Insurance Brokerage Philippines, Inc., which is regulated by the Philippines Securities and Exchange Commission. 20th Floor Citibank Square Bldg. The Product is made available in the Philippines through Citibank NA Philippines branch, Citibank Tower, 8741 Paseo De Roxas, Makati City, Manila. Citibank NA Philippines NA is regulated by The Bangko Sentral ng Pilipinas. The Product is made available in **Poland** by Dom Maklerski Banku Handlowego SA an indirect subsidiary of Citigroup Inc., which is regulated by Komisja Nadzoru Finansowego. Dom Maklerski Banku Handlowego S.A. ul.Senatorska 16, 00-923 Warszawa. The Product is made available in the **Russian Federation** through ZAO Citibank, which is licensed to carry out banking activities in the Russian Federation in accordance with the general banking license issued by the Central Bank of the Russian Federation and brokerage activities in accordance with the license issued by the Federal Service for Financial Markets. Neither the Product nor any information contained in the Product shall be considered as advertising the securities mentioned in this report within the territory of the Russian Federation or outside the Russian Federation. The Product does not constitute an appraisal within the meaning of the Federal Law of the Russian Federation of 29 July 1998 No. 135-FZ (as amended) On Appraisal Activities in the Russian Federation. 8-10 Gasheka Street, 125047 Moscow. The Product is made available in **Singapore** through Citigroup Global Markets Singapore Pte. Ltd. ("CGMSPL"), a capital markets services license holder, and regulated by Monetary Authority of Singapore. Please contact CGMSPL at 8 Marina View, 21st Floor Asia Square Tower 1, Singapore 018960, in respect of any matters arising from, or in connection with, the analysis of this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). The Product is made available by The Citigroup Private Bank in Singapore through Citibank, N.A., Singapore Branch, a licensed bank in Singapore that is regulated by Monetary Authority of Singapore. Please contact your Private Banker in Citibank N.A., Singapore Branch if you have any queries on or any matters arising from or in connection with this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). This report is distributed in Singapore by Citibank Singapore Ltd ("CSL") to selected Citigold/Citigold Private Clients. CSL provides no independent research or analysis of the substance or in preparation of this report. Please contact your Citigold//Citigold Private Client Relationship Manager in CSL if you have any queries on or any matters arising from or in connection with this report. This report is intended for recipients who are accredited investors as defined under the Securities and Futures Act (Cap. 289). Citigroup Global Markets (Pty) Ltd. is incorporated in the **Republic of South Africa** (company registration number 2000/025866/07) and its registered office is at 145 West Street, Sandton, 2196, Saxonwold. Citigroup Global Markets (Pty) Ltd. is regulated by JSE Securities Exchange South Africa, South African Reserve Bank and the Financial Services Board. The investments and services contained herein are not available to private customers in South Africa. The Product is made available in **Spain** by Citigroup Global Markets Limited, which is authorised and regulated by Financial Services Authority. 29 Jose Ortega Y Gasset, 4th Floor, Madrid, 28006, Spain. The Product is made available in the **Republic of China** through Citigroup Global Markets Taiwan Securities Company Ltd. ("CGMTS"), 14 and 15F, No. 1, Songzhi Road, Taipei 110, Taiwan and/or through Citibank Securities (Taiwan) Company Limited ("CSTL"), 14 and 15F, No. 1, Songzhi Road, Taipei 110, Taiwan, subject to the respective license scope of each entity and the applicable laws and regulations in the Republic of China. CGMTS and CSTL are both regulated by the Securities and Futures Bureau of the Financial Supervisory Commission of Taiwan, the Republic of China. No portion of the Product may be reproduced or quoted in the Republic of China by the press or any third parties [without the written authorization of CGMTS and CSTL]. If the Product covers securities which are not allowed to be offered or traded in the Republic of China, neither the Product nor any information contained in the Product shall be considered as advertising the securities or making recommendation of the securities in the Republic of China. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security or financial products. Any decision to purchase securities or financial products mentioned in the Product must take into account existing public information on such security or the financial products or any registered prospectus. The Product is made available in **Thailand** through Citicorp Securities (Thailand) Ltd., which is regulated by the Securities and Exchange Commission of Thailand. 18/F, 22/F and 29/F, 82 North Sathorn Road, Silom, Bangrak, Bangkok 10500, Thailand. The Product is made available in **Turkey** through Citibank AS which is regulated by Capital Markets Board. Tekfen Tower, Eski Buyukdere Caddesi # 209 Kat 2B, 23294 Levent, Istanbul, Turkey. In the **U.A.E**, these materials (the "Materials") are communicated by Citigroup Global Markets Limited, DIFC branch ("CGML"), an entity registered in the Dubai International Financial Center ("DIFC") and licensed and regulated by the Dubai Financial Services Authority ("DFSA") to Professional Clients and Market Counterparties only and should not be relied upon or distributed to Retail Clients. A distribution of the different Citi Research ratings distribution, in percentage terms for Investments in each sector covered is made available on

request. Financial products and/or services to which the Materials relate will only be made available to Professional Clients and Market Counterparties. The Product is made available in **United Kingdom** by Citigroup Global Markets Limited, which is authorised and regulated by Financial Services Authority. This material may relate to investments or services of a person outside of the UK or to other matters which are not regulated by the FSA and further details as to where this may be the case are available upon request in respect of this material. Citigroup Centre, Canada Square, Canary Wharf, London, E14 5LB. The Product is made available in **United States** by Citigroup Global Markets Inc, which is a member of FINRA and registered with the US Securities and Exchange Commission. 388 Greenwich Street, New York, NY 10013. Unless specified to the contrary, within EU Member States, the Product is made available by Citigroup Global Markets Limited, which is regulated by Financial Services Authority.
Pursuant to Comissão de Valores Mobiliários Rule 483, Citi is required to disclose whether a Citi related company or business has a commercial relationship with the subject company. Considering that Citi operates multiple businesses in more than 100 countries around the world, it is likely that Citi has a commercial relationship with the subject company.
Many European regulators require that a firm must establish, implement and make available a policy for managing conflicts of interest arising as a result of publication or distribution of investment research. The policy applicable to Citi Research's Products can be found at https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures.
Compensation of equity research analysts is determined by equity research management and Citigroup's senior management and is not linked to specific transactions or recommendations.
The Product may have been distributed simultaneously, in multiple formats, to the Firm's worldwide institutional and retail customers. The Product is not to be construed as providing investment services in any jurisdiction where the provision of such services would not be permitted.
Subject to the nature and contents of the Product, the investments described therein are subject to fluctuations in price and/or value and investors may get back less than originally invested. Certain high-volatility investments can be subject to sudden and large falls in value that could equal or exceed the amount invested. Certain investments contained in the Product may have tax implications for private customers whereby levels and basis of taxation may be subject to change. If in doubt, investors should seek advice from a tax adviser. The Product does not purport to identify the nature of the specific market or other risks associated with a particular transaction. Advice in the Product is general and should not be construed as personal advice given it has been prepared without taking account of the objectives, financial situation or needs of any particular investor. Accordingly, investors should, before acting on the advice, consider the appropriateness of the advice, having regard to their objectives, financial situation and needs. Prior to acquiring any financial product, it is the client's responsibility to obtain the relevant offer document for the product and consider it before making a decision as to whether to purchase the product.
With the exception of our product that is made available only to Qualified Institutional Buyers (QIBs) and other product that is made available through other distribution channels only to certain categories of clients to satisfy legal or regulatory requirements, Citi Research concurrently disseminates its research via proprietary and non-proprietary electronic distribution platforms. Periodically, individual Citi Research analysts may also opt to circulate research posted on such platforms to one or more clients by email. Such email distribution is discretionary and is done only after the research has been disseminated via the aforementioned distribution channels. Citi Research simultaneously distributes product that is limited to QIBs only through email distribution.
The level and types of services provided by Citi Research analysts to clients may vary depending on various factors such as the client's individual preferences as to the frequency and manner of receiving communications from analysts, the client's risk profile and investment focus and perspective (e.g. market-wide, sector specific, long term, short-term etc.), the size and scope of the overall client relationship with Citi and legal and regulatory constraints.
Citi Research product may source data from dataCentral. dataCentral is a Citi Research proprietary database, which includes Citi estimates, data from company reports and feeds from Reuters and Datastream.

ADDITIONAL INFORMATION IS AVAILABLE UPON REQUEST