Charging Forward:

Explosive Global Growth in the Battery Industry – Opportunities and Challenges Ahead

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Significant technology and system development for the next 10 years in multiple market segments world-wide

Mobility Revolution		Portable Power	 Lithium-ion cell demand growing to \$16Bn by 2018 Requirements: dependable run time, fast charge, safe 				
 Technology Innovations 		Transportation	 EV market for lithium-ion batteries expanding to \$30Bn by 2020; \$175B 2025 Requirements: Extended range, safe, affordable 				
Change in the Economy • Energy Security • Oil Independence		Utility	 Lithium-ion batteries will be one technology with a clear and possibly astronomical growth trajectory estimating \$30B by 2020 to \$400B by 2030 Requirements: Compact & modular, reliable, safe, affordable 				
 Government Support 		Military	 Lithium-ion battery demand driven by growing need for transport, surveillance & communications Requirements: lightweight, safe, long- life, rugged, green 				

Portable Power



Market Forecasts – 3rd party Marking Cadenza TAM assumptions (for auto and for grid)





Sandia Study: Expecting fail safe battery systems at high energy density and low cost to win in grid storage markets.....and that safety will enable the high performance/low cost paradigm

2006 – US CPCS largest recall in history 4.1M Sanyo laptop batteries in Dell computers





2015 – Recalling 500k Hoverboards



2016 – Samsung Galaxy S7... now with follow-on on Note7 ... discontinued product lines



The US national agenda involves energy security at the highest level, with innovation and time to market as levers

US energy policy and programs are diffuse through 50 states and federal government

DOE:

- To reduce U.S dependence on imported oil and increase national energy security
- To save money by cutting fuel costs for American families and businesses
- To protect US health and safety by mitigating the impact of energy production and use on climate change
- To spur innovation to build U.S. industry and jobs
- Battery Goals to be achieved by 2022:
 - \$125/kWh
 - 400Wh/l energy density

DOD/Pentagon:

- Integrating plans for climate change risks across all of its operations, from war games and strategic military planning situations to a rethinking of the movement of supplies
- Predicting increased demand for military disaster responses as extreme weather creates more global humanitarian crises



Cadenza is part of NYSERDA/New York State exploration of lower energy cost and increased electricity reliability





China is moving to energy self-sufficiency with renewables and nuclear while coal remains significant

 2016 "war on pollution" eliminated 335 factories & 400,000+ high-emitting vehicles = 198 "Beijing blue sky days" (12 days in 2015)

- China will spend \$360B by 2020
 - focus on wind and solar
 - creating 13+M new jobs



 In parallel, the electric drive revolution is taking place: 2016: 507,000 xEV vehicles sold 2017 goal: 800,000 xEV by 2025: 5,000,000 xEV will be deployed



Fastest growing GHG emitter, India is looking at multiple solutions with energy storage at the core



ESS ESTIMATED MARKET POTENTIAL (70 GW) THROUGH 2022



70% of Australian solarized homes need energy storage; prediction that ESS outstrips solar by 2025

Produit None	Teda Powerwall 2 (DC)	LG Chern Resia 30	LCOres FESU 6.5	Redflow Zord	Simplific PiELE Smarth Tech Ballery	Mexiedei desa Esergy Usiage Hone	Leclarche Apollius Cube	401 P Kelle 1.6	Della Hybrid IS	EUMOPO E-Cells ALE12-136	Abatist newsQuite	Angelus "Liger" Liblum	Printed Salar Ballery	DCLPVLG	BMTESS 0	Pylosiech Exista2000 LPP	Agaian Japan BID-2 3
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EST, unless stated atherwise) Normal Storage	13.3 Mills	1.800	6.5 1925	10 WAY	Lowh	2.5WM	6.345	LAND	6/45	5.5495	1.940	1985	126.00		7040	2.0/05	2.2000
Usable Unitage Capitality	13.5 WA	8.846	5.9 Mb	10 WAA	2.75495	2/85	5.0/20 per module	14446	4.845	4.04%	4 MAND	2.7 Wh	sam			1.82kWh per kallery	2.2358b per dask Greel price per EAN, modular, encironmentally
Pees	Advanced safety features maximum for exit, extremely competitive price, impressive warranty	Can be used in both off-goal and hybrid colups, compact size, modular expansion.	Can be used in both off-grid and hybrid orkays, compart size, modular expansion.	Eafe cherology (has fire danger compared to biburn lord, high depth of vitabarge, can loderate temperatures up to 50 degrees, C, eacily recycloalite, duals star owned & developed	Intentian male, can be used in both off grid an hybrid ortuge, compart care, modular expansion 32 year mananity, very high cycle Me, MMS integrated into each battery	German engineerind, high syste ble, expended to Neve XOL DuD after 10 years	German made, high quality, plag and play with 1988 surray bland, expandable up to 12 modules	Law cost, comet in multiple colours, lightweight	High-spile Me	Can be used in both sift gold and hybrid setups, capable of a high sale of discharge, easy expansion, intelligent BM, developed in Australia using Eastam cells.	German mode, high cycle life and depth of discharge, 10 year warranty	affendig log.	Age system (Area		fill park and play with I samp size and the set of the set of the set of high BBN set of the set of the height power + Gage.	Tafed Library Develop, Isatable, Integrated BMI, goal cost per With	brendy disposed, schemently safe chemistry flow free out compared to Where sait, also available in a 242 section (lagers 20) 403, which enables use of lower and invertex. and chargers.
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ander	100g	75Ag	12hg	210kg	If ig (per individual ballery module)	Ing	tilg per module	47.5kg	28g	6hg	424		1354	84	MAg	2 Tog per ballery	a Vdat
Persett	1889 steady, 769 peak (20 seconds)	SKIV steady, 7kW peak (I seconds)	4.200 clearly, 4.6kW peak (for 3 seconds)	TANK similar, SKAV proci-	11 VM deady, 41kW peak (multiply by number of modules)	ballers in increments of 1.25kW steady per ballery module, to a maximum of 4.6kW steady	3.3kW sleady, 6.5kW peak	This steady	JMW sineady	38W deady, 43kW peak			an every	TAW continuous, 6.44W prob	BW steady, SKW her peak	2VW continuous per module (danks with each additional module)	A Appendi
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Round Scip Efficiency	91.8%	805.	616	806	NEX.	87%	876 Ter with house bland or Terater	95%				WN	-40%	89%			
Off grid Capitale?	Tes	Tes	Tm	Tes	Tes	Tes	inawier/charger	Capable, but designed for on-grid	Capation, Ir			Ini	Ins	76		DEcap Cheerrin	7 16
installation? (Prolong)	electronics, Pill for aving)	Index+(P13)	Indexe (P 11)	installation is ecommended (P EE)	Indeer (P M)	indexer (IP 20)	Indexr (P 22)	Index (P54)				Indexer (P 22)	Industr (P 20)	Index(Dalabase (P 87)			Index (P 22)
Reporting temperature range	-20°C to N°C Amount left up it will be compatible.	-37C to 49C	276 at 275-	LETC in 50 %	-30° to 80°C Yes, when used with any suitable BPV investor	ercie-arc TBD	PC to APC	-27'C 16 10'C			D'C is 40'C	arc to dirc	No. No.	to div		a sire	4°C to 4PC Can be paired with investers that are Reposit
Buch startin and these shares are supported				The state of the s	(such as \$500, hargeoue, Salaw etc.)					(mark)	100		1844.00	geve, talasets.)		Engle place investors currently, I place plane	mady Ter
Waronly	10 years unlimited system. 2016 scipacity of 10 years, Dictor ord's consumptions (include orbit) Other Applications: 10 years or 37.80 MBh.	BZN capacity at 30 years or 33,000 KBh Droughput whishever cares find	02% capacity at 30 years or 20,000 KMh Droughput whichever cames Test	Warranted total energy throughput 38, 304 Minutes a maximum of 32 years, which over correct Proj.	SOyears			7 mm		10 years - if regulared and convexited in the E Cells partiel. If not, warranty is 5 years or 6,000 riples, which ever comes first	a 30 years	15 years's between the second			Japan S	Surfidure	Syran full varianty, I exist years partial warranty
							' 🧥 🕨 -		-								
Total warranted ER/h (max 2 cycles per day)	17,820 (in cycle more than once per day you'd have to be using it for 'other applications' as per the warranty)	33,000 (hand limit in warranty)	23,000 (kend limit in warranty)	N(5)(2nty-warranted for 1 cycle per step)	20,275 (mples)			(a) v day for 7 years	17,120 (mpled)	13,132 (mples)	H,612 (reptor				27,000 (mplied)	T028(replied)	Read and the second sec
Canil per warranteel WAIh (max 2 systes pe day)	N/L (and init is manashylar high-syde applications)	N/X (hand low) in mananely)	N/S (hard limit in warranty)	N(D. (Only wanteried for 1 spile per day)	SE.27 (* invester card)	Ο┣\	ar said a sai		\$0.09 (* invester coul) @ 2 cycles per day	(0.25 (+ inserier cod) @ 2 cycles pe	5	201 († 12. spinsp	tal (rolling cost) (f. 2 costs perday	(0.21(+ inserier cord) @ 1.4 cycles per day	(0.29 (* inverter and) @ 1.4 opties per day	(32.28) = investion cost) (# 2 system per day	(0.33 (* invester casi) @ 1.6 spiles per day
Table warranted With (5 cpc)e per dag)	37,800 (examing micl people will want to use 'other applications' such as off peak charging and Report)	24,089	17,007	1,00			18,750	11,994	8,760				17,020	2,48	18,753	3,506	6,023 (lanced on 5 or maniped y)
Contiger Total manasted 68% (1 systepe dag) Roudul Norm	(1221 (* invester cost)	(0.33 (+ surveine and)	(6.17 (r swerier card)			\bigcirc	\$3.47 (+ invester coci)	(0.30)* investor cod)				\$0.18 (* insertier coul)	(0.00 (* inverter coal)	(0.32 (+ swerier and)	(0.38 (+ sweter and)	(6.17 (+ swerier coul)	(6.55 (+ investive card)
Pindal Vilage						Ũ	0	rs	E							đ	
EaleryType Alla Dae will	Lead Carloon (Plv-C)	Libium ion	Libium Penile Phosphale Tes (miludes excumenter - requires 1 Enviry)	Lithum Ion (Ehum mananetar coluit oxide)	a let Chierde			n (Liburnina Phesphaia)	Litture tan	Libium Ion	Lithur ton (Lithur Ion Phosphate)	Litture ton (Litture Iron Phosphate)	Libium los (Libium Mangarese Dolle)	Lithurvian Teri	Libium ten (Libium Iran/Nocyhale)	Agenous Hybrid Ian	Libium Iron Phosphele
Price (D.Smoted Relati pricing in 822 and 625, unless stated atherwise)	54,990	(11,000	(2,000 (hily initiality)	120,000			141,000	\$21,700 (fully avoided)	110	\$11,010	51,389	511,005	\$12,000	(28,000 (hully included)	84,05	(23,750	\$8,825 fully installed
Roward Barage	845	8145	1.200h				20049	36 10.9	2005 2005 lase unit exampleir in 2005 months	12 kWh	16.4 KMA	31.0499.	7.2165	11.6649	16.4 WAIN	845	3.7045
Guilde Unrage Capitoly	1045	nove - depades to 4.850h after 32 years	be stat	Lashidar sarrelars			SHAN	14.6185	up to a max of Brith.	ANVAN	11.05485	11.126/06	6.08/05	9.86 W/h	12 Ni Wh	BAN	1445
Pess	High performance with partial charging	Brepher XK. Congoled "socialization, 7 Hear parts & Talasser warrantig, 12 year (32% Socie) butlery performance warrantie	in process of the second secon	Frady, has lankap capels. Autoatlan environment, ca in 28.2 KK		Alloweney, 2005 Dell, high cycle	billede in Germany, 303% DuG, long syste Me, great warranty	Good power output, designed for totally off-grid usage	100% claimed Dath, long cycle Me	Good syste Me	7 Tauliturees + Wi-N, Dual Salar reputs up to BKK, Automatic Machanal protection and free remain manifacing (App & Web)	Good power output, built involtage regulator, patenti pending votor control	Goodvalar if you have an application that discharges up to 3e per day.	extremely high surge paners (K.M.M. Far 32) minutes), very long lifespan. Good 5/hash if cycling lucce per day.	Nigh sycle Me and dryth of discharge, relatively compact size	Environmentally thready stepsoc, interventy rate chemicity (low fire risk compared to lithur loc), high skyth-of-docharge	Compaci, Ifficient, Gold for Inventor agreeding
Cans	Only two year warrandy at 75% Dol3, low cycle Me, heavy	Law power subject comp	and all and all and all all all all all all all all all al	formance and DOD is level	Apersian, Secury	Law power sulpul - 2.5880 min, expensive	continues single phase, 3.35% three phase (38W	Ballery warranty is 32 years but the control system is only warranted for 3 years	Low maximum slorage, low power output	Battery warranty is 12 years had the cardinal system is only warranted for 5 years	Expensive, heavy	Heavy	Expressive for daily cycling	Heavy	Heavy	Yory beauty	Expensive
Weght	Rity	1104		12034	3354	210hg	260g	180	67kg for lase 2618h module, add 37 kg for each	ang	210kg+	120g	190y	800 kg	any	61.6¥	964g
Pager	Address and the state in both or some	201 (214)	- see	With strate	Allow Grade, Well and	2 MW strady	This (angle phase) or 3.30W (bree phase) (NW)	140	additional weakly	Bill strade, 6 Mill and	LDW gid comedied / LDW peak in backup	THE Grade day and		Weinstein Linterer	Witten	LWAstrate	Wenet/200 all end
Denensions (MHC)	112 cm + Hon + Mon	Nona 13km x 23m		70cm + 182 cm + 65cm	Now a 121cm a 16 cm	those likes	prob) 64cm x284cm x 22cm	She a Mona Mon	08am + 76am + 22am	71cm + 90cm + 21cm	made dition = 12 on = 51 on	72 cm a 132 cm a 53 cm	28cm a 120cm a 11dam	Bows 180cm + 30cm	60m x 136 cm x 80 cm	Elons Lillion a Xion	this stars Zon
Cycle Life	2000 cycles at 70% DeD	SEID cycles @ 1005 Depth of Durhard Col and a 025 State of Health (Said) warranted for	A MIX DeD	4,000 cycles at 90% Data	1,000 cycles at 80% DeD	12,000-cycles at 100% DeD	10,000 vijeles at 100% DwD	6,000 cycles at 90% DoD	4,000 cycles at 100% DuO	6,000 cycles at 80% DeD	6,000 systes to XIX. Ded (KIX capacity	4,400 cyclins at 80% DeD	6,000 cyclins at 90% DwD	8,000 cycles at 85% DarD	6,000 system at 90% DarD	8000 cycles at 300% capacity, 5000 additional cycles at 80% capacity, 1000 additional cycles a	RODE-cycles at RON DuD
Revel Trip Efficiency	83-90%	12 prais. BBL		175	93%	95%	NEX single phase, NEX three phase	180	925	THD	876	175	91N	MN	105	70% capacity (local 5000 cycles) 50%	85
Off-grid Capable?	Tes - Wilh 2 AC andpuls (Drid/Bashup)	No.		No.	Tes	No - Inchapterly	No - energency backup available Q2 2017	Tes - designed specifically for it	180	Tes	Yes - With 2.6C autputs (Snie)Backup)	16	les.	No	Tes	140	Backout protection available for excertal loads
Designed for industrial address	Industr (1# 22)	Culdear (P 14)	indexr (P 22)	Indian (Database (IP34)	Indexe (Database under cover (IP 42)	indexr (P21)	indust (# 22)	110	Indust (# 23)	Industr (IP Z2)	indust (IP 20)	Indexr (P-62)	Industry/Childney (JP 54)	Industry/Database (IP 34)	Index+(IP21)	Indexe/Database (IP NI)	indexe (P.12)
Operating lemperature singe	-30°C to 50°C	010 10 1010	-30%C tie 45%C	6%C - 45%C	-20% to 92%	2108 41210	7.06 40.77	180	870 W 4870	0°C 1+ 40°C	-12°C to 50°C	758 or 85	-90°C to 48°C	-30°C to 10°C	0.0 19.0 2.0	-17C too 507C	0°C to 40°C
Report Ready?	Capitale - working with Reposit to Tradise	No	Tes	76	No	Rannel	na - ony new over can safeware that campeles with feyosit	160	180	Planned for the future	Capable - working with Report to finalise	110	Ne	na - survey raise date a un callmare that comprise density with Report	Natiourently - planning to add in Nature	No	Currently not available
Both single and three phase compatible !	single chase, can initial multiple units for 1 phase siles if required	unger prove sociaul, can indeal multiple units for Tiphase sites if required	les.	Drily-single phase	Cirily single phase	785	Tes	110	180	Chily single phase	unger Aase, can indial multiple units for 3 phase sites if required	16	Ins	Tes	Single phase only	160	Tes
	2 years	20 yean (performance) Types (product)	20 years	S year investor warranty, 12 year ballery warranty	5 years	10 years or 11,000 cycles, whichever cores first	10 years ar 30,000 systes, whistewer sames first	Syear invester washing, 32 year ballery washing	780	5 year product mananity, 32 year balleny mantanity	Syran.	5 years	5 years	10 years.	5 years product warranty, 20 years lattery performance warranty (indexidable to 20 years)	8 years and al system including enclosure, inverter, charge cantrafter and balleries	32 years hallery. S years halance of spinons
Warsanly Document Supplied?	No	Tes	Ne	No	No	No	No	No	No	No	No	No	Tes (sages 10-62)	Tes	Ne	Ne	No
Total warranted \$20% (max 2 cycles per day)	9,300 (mysled)	N/X (not wantanted for >1 syste per day)	8,332 (replied)	42,008 (replect	24,882 (mples)	73,000 (mplied)	226,822 (replied)	12,182 (mpled)	TRD	31,043 (implied)	42(548 (mpled)	42,548 (english)	21,812 (inglied)	71,878 (mpled)	47,824 (mpled)	27,000(implied)	10,952 (mpled)
ConJ per warranted WAIN (max 2 system per day)	SLITE (F. L.K. spiles per day	N(D, (wit wananted for >1 cycle per day)	\$0.31.07.2 system per day	\$0.81 (\$ 2 system per day	\$2.75 @ 1.8 cycles per sky	(0.21) (0.2 cycles per day	Sti 28 (E 2 cycles per day	\$2.41 @ 2 spiles perday	10	\$0.37 @ 2 cpclms.per day	\$2.35.07 2 system per day	\$0.27 @ 2 cycles per day	(0.31 @ 2 cycles per day	\$2.35 @ 2 system per day	(3.31.02 system per day	\$3.11 @ 1.71 spiles per day	\$0.77 @ 2 vycles.per day
Total warranted WAN (2 cycle per day)	4,627	20,440	4,941	21,024	14,034	34,500	18,400	34,280	180	17,130	25,634	31,004	11,626	2,989	21,612	21,802	5,475
		10.14	10.48	10.10	5.48	\$0.17	93.52	10.83	180	90.N	92.47	93.54	95.05	pa.72	98.52	10.10	5.0
daj)	51.0																



9

Three unmet market needs for lithium-ion battery technology:

Costs need to beat current solutions

- prices at \$350/kWh provides access to limited segments today
- but reaching \$125/kWh delivers profitability across all markets



Three unmet market needs for lithium-ion battery technology:

Safety means no fires propagating upon failure – new standards require non-cascading structures (UL1973)





Three unmet market needs for lithium-ion battery technology:

Devices and systems are currently limited by energy density

- how much battery power can fit into a given space and how far does that get me
- 300 Wh/L being competitive in large cells and

- 500Wh/L changes the paradigm





Current technology stage: completed platform entering into product demos and early commercialization 2017-18







2017 Cadenza Innovation EV Demo

Fiat 500e, 35kWh, 96 Cadenza Cells





2017-18: NYSERDA is betting on a technology solution: Cadenza cells optimized into grid modules for peak-shaving







Battery Storage Rack Manufacturer	Large	OEM1	Large	OEM2	Cadenza DEMO		
Region	USA '17	Canada '17	USA '17	Canada '17	USA '17	USA '18	
Rack Capacity	137kWh	166kWh	56kWh	56kWh	190kWh	220kWh	









2020 forecasts indicate that China will expand 6x to manufacture more than 60% of global Li-ion batteries



Source: Deutsche Bank: BMI



Significant recent examples of capital deployment in energy storage indicate we are hitting the tipping point

Electric Vehicle Players

- Volkswagen will invest \$3.7-billion in e-mobility and digitalization
- Ford is investing \$4.5 billion to add 13 electrified vehicles
- Mercedes-Benz to electrify all model series through \$7.8 billion R&D investment
- Apple offers \$1.8 billion for McLaren Technology Group (EV knowledge)

Grid/Home Storage Initiatives

- Total purchased battery maker Saft for \$1.1 billion
- GE invests "double-digit million-Euro sum" in storage firm Sonnen

Supply Chain Growth

- Albemarle, FMC, Sociedad Química y Minera and Tianqi Lithium (Lithium)
- Katanga, Lundin Mining, First Qvantum and Vale Inco (Cobalt)
- Syrah Resources opening world's largest Graphite mine (Carbon)





100+M tons



Already increasing technology adoption rates are projected to grow even faster driven by the large millennial generation





Solar PV boom underestimated by nearly all



source: International Energy Agency and IMF



Low cost, well defined safety, high energy density designed for end market in acceleration phase – lots of opportunity!



Lowest cost platform for EV, PHEV and grid storage

- Taking cost out of the traditional system in a simplified design
- Inventing and enabling low cost components and systems (with partners)
- Use of readily available and known components
- Launch new materials into known massproduction platforms

World-leading safe high energy density in large cell

- For Grid: smaller footprint, ease of operation
- For Auto: smaller, flatter, cells inside crash zone

