

13 November 2023

Price (US\$)	0.84
Shares in issue (m)	496
Mkt Cap (\$m)	434
Net debt (\$m)	0
EV (\$m)	433
BVPS (c)	159.4

Share price performance	
1m	29.4%
3m	-26.7%
12m	-56.5%
12 m high/low	1.9/0.4
Ave daily vol (30D)	3,570,297

Shareholders	
Tencent Holdings	29.3%
Atomico	10.7%
Lgt Global Invest	6.4%
Meiner Matthias	4.6%
Born Sebastian	4.6%
Baillie Gifford & Co	1.2%
B Riley Financial In	0.8%
Millennium	0.7%
683 Capital	0.6%
Allianz Se	0.4%
Total for top 10	59.2%
Free float	56.6%
Source: Bloomberg	10 Nov 23

Next news Q4 Results

Business description

eVTOL developer and regional air mobility operator



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BATTERY DELIVERS PERFORMANCE

Lilium has presented a very comprehensive overview of how its battery technology choice is critical to driving performance of its eVTOL and works together with Lilium's unique design to deliver the power requirements for a working 175km range including reserves. Battery testing is proving cycle life under fast charging and with the high power pulses required for take-off and landing and the company now has dual sourcing on manufacturing, de-risking this critical element of the supply chain. Together with a better approach to certification, we think this puts Lilium in a strong competitive position with a better offering to a better market segment than most of the eVTOL alternatives.

Silicon Anode Battery Delivers Performance

Silicon anode technology has been developing rapidly over the past few years and is capable of delivering more than 30% energy density and five times more power than normal lithium ion batteries and can complete charging in just ten minutes. Silicon anode technology moving rapidly towards commercialisation with many automobile OEMs moving forward with offerings based on this battery technology.

Testing Confirms Battery

Simply adding silicon to the anode of a lithium ion battery can result in significant swelling during charging which degrades the battery, potentially rapidly. Battery partner Ionblox has got round this with a pre-lithiated, silicon dominant design which overcomes these issues. Ionblox has already received UN DOT 38.3 certification which ensures the batteries are suitable for transport. The battery has been independently tested by Idaho National Laboratories and delivered 809 full cycles on 100% depth of discharge with 88% capacity retention. Testing by Lilium using real flight profiles avoiding full discharge shows cycle lives of over 1,450.

Widening the Manufacturing Base

Cell production partner and Customcells is now delivering hundreds of cells every week to Lilium with a capacity to deliver thousands of cells annually with critical pre-lithiation technology supplied by Applied Materials. Lilium has also now announced a second battery partner in Slovakian manufacturer, InoBat, who are backed by battery major Gotion High Tech. The addition of dual sourcing clearly de-risks the supply chain for Lilium and together both companies can deliver further performance and manufacturing improvements to the IonBlox cell including taking range potential well beyond the current 175km mark.

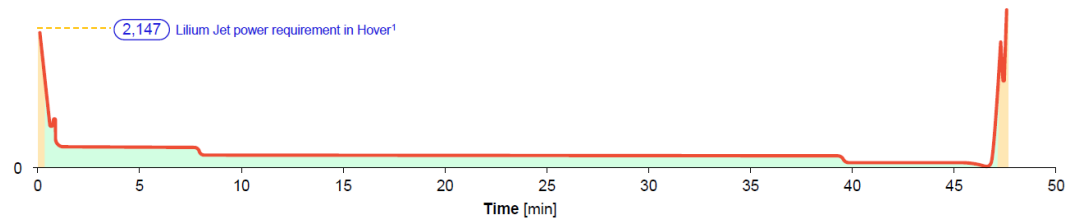
€m, Dec	2021a	2022a	2023e	2024e	2025e	2026e
Sales	0	0	0	0	280	1,268
EBITDA	-284	-273	-288	-315	-305	-80
PBT	-299	-253	-308	-344	-376	-243
EPS	-1.4	-0.9	-0.6	-0.5	-0.2	-0.1
CFPS	-1.9	-0.2	-0.6	-0.4	-0.3	-0.3
DPS	0.0	0.0	0.0	0.0	0.0	0.0
Net Debt (Cash)	-320	-142	-135	31	-69	501
Debt/EBITDA	1.1	0.5	0.5	-0.1	0.2	-6.3
P/E	-0.6	-0.9	-1.2	-1.5	-3.6	-5.6
EV/EBITDA	-0.3	-1.0	-0.9	-1.4	-1.1	-11.4
EV/sales	na	na	na	na	0.3	0.1
FCF yield	-248.3%	-30.6%	-71.1%	-53.6%	-38.7%	-40.4%
Div yield	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

LILIUM'S BATTERY PHILOSOPHY

How the Battery Works with the Lilium Jet Design

The Lilium Jet uses a ducted fan design rather than an open rotor. This is favoured by passengers because it has lower noise and vibration. It is also safer as a contained design and can deliver faster speeds. However, because the enclosed propellers have less swept area, the Lilium Jet uses slightly less than twice the power of its rivals when hovering. This is more than offset by the lower power used for cruising flight. Hovering accounts for 9% of the energy compared to 4% for rivals so the difference is not too great and more than compensated for by the greater range which at 175km puts Lilium well ahead of its rivals.

Power Profile on a 175km Regional Mission



Source: Lilium

This means the Lilium Jet offers more range for its passenger capacity than any other eVTOL in the market allowing it to target the regional aviation market. It can do this because of the battery cell based on its silicon anode technology from Lilium's cell technology partner Ionblox (formerly Zenlabs). Lilium has the exclusive use of this technology for applications in regional eVTOL market.

The inclusion of silicon in the anode of a lithium-ion cell results in greater energy and power density. For Lilium this allows for a battery with sufficient power for take-off and landing yet without much loss of energy for range. It also allows for much faster charging without increased degradation.

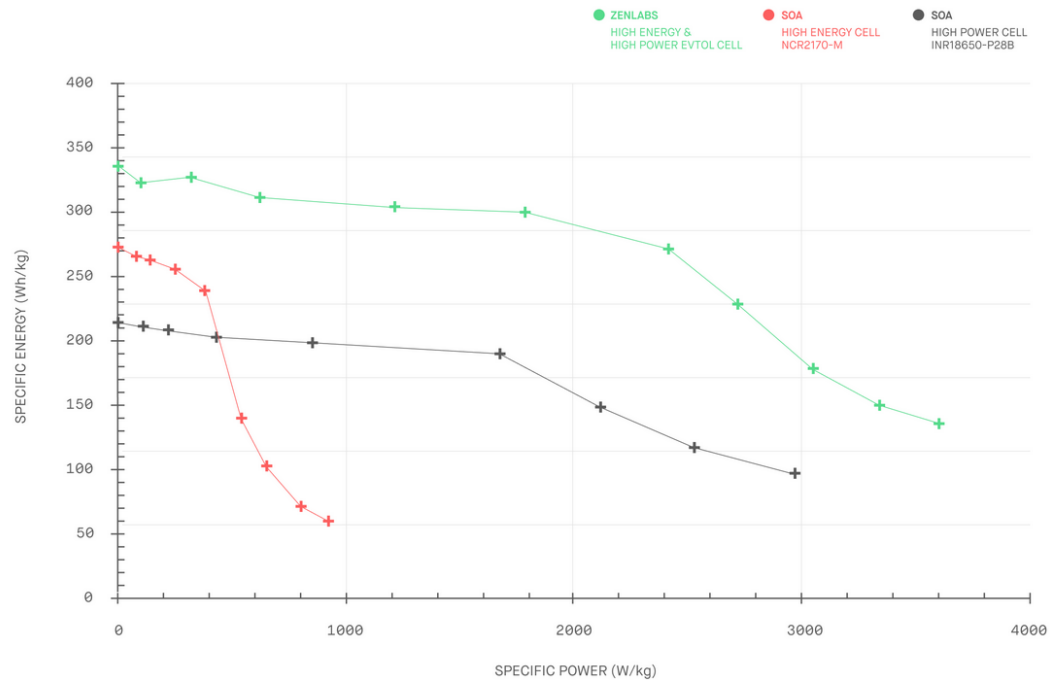
However, swelling issues can be in production during the formation process which is the initial charge and discharge operations of the cell. Swelling is potentially at its greatest during formation. For the Ionblox cell this is not an issue and Customcells has industrialised a proprietary formation process for the high silicon content cells developed by Ionblox and now available to InoBat.

Prelithiation

When a cell is used for the first time the lithium forms an interface which results in a high loss of active lithium in the first few cycles. The loss is greater for newer anode materials including silicon anodes which have higher active lithium loss (ALL). Prelithiation looks at pre-setting additional lithium to compensate for this initial loss, therefore significantly increasing the available energy. Customcells has begun the industrialisation of the prelithiation process for the Ionblox cell technology. The manufacturing process is a roll-to-roll solution allowing for mass production with foils provided by technology partner Applied Materials. This means the process is ready for scaling.

The resulting cell can maintain high specific power of 2500 W/kg even at a low State of Charge (SOC).

Ragone Plot of the Ionblox Cell Versus State of the Art (SOA) Cells



Source: Lilium

The advantage of the Lilium cell is then its combination of both superior specific energy and specific power capabilities. This is what allows the high power for take-off and landing to be delivered while maintaining the higher range of the Lilium Jet.

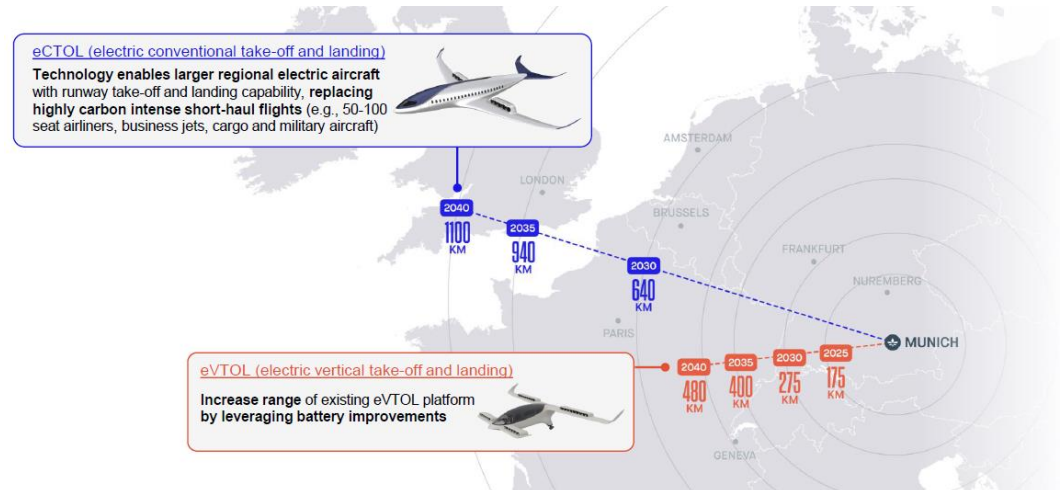
Multi Sourced Manufacturing

Lilium has now moved to multi sourcing for its batteries expanding an existing exploratory relationship with Slovakian battery manufacturer, InoBat. A key feature of the Lilium battery is that it can be produced on standard manufacturing lines with only the pre-lithiation stage requiring an extra step and this makes it relatively straightforward for InoBat to manufacture the cells. Dual source clearly de-risks supply for Lilium but having two partners is also likely to accelerate battery development in our view. InoBat is supported by investor Gotion High-Tech, the world's eighth largest battery producer.

Roadmap to Greater Performance

A roadmap to greater performance is already in development, targeting a rise in energy density from the 320Wh/kg on the current type-conforming battery to 350Wh/kg by 2026 through improvements to the cell overhead weight. Then a 2028 target raises that further to 400Wh/kg by employing a high nickel cathode with less cobalt. These changes could add 100km to the working range putting it at 275km in 2030. With further design options including conventional take off and landing, the option to take ranges to over 1,000km cannot be ruled out.

Range Potential With Battery Development Pathway



Source: Lilium

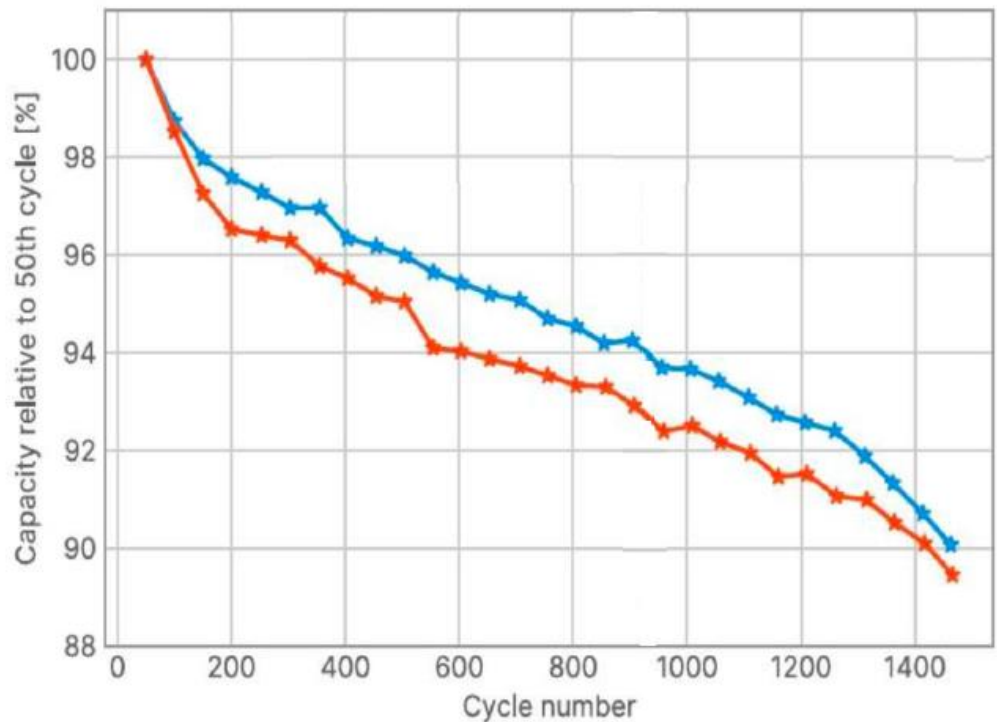
Test Data Confirms Performance

Crucially Lilium is already seeing test data which confirms the performance of its cells. It has successfully flown full sized demonstrators for over four years using off-the-shelf lithium ion batteries showing that the final conforming battery is about delivering range not simply flight. Battery testing on reference flight profiles confirms the 175km range and independent tests by Idaho National Laboratory has shown 88% capacity retention at 809 cycles with 100% depth of discharge.

Using real flight profiles avoids 100% discharge and shows cycle life of over 1450 cycles again to 88% capacity retention. These real flight profile tests were undertaken using fast charging. The design of the Lilium cell also means there are no adverse effects on cycle life from the high power pulses required for take-off and landing. Indeed the design of the battery for these loads also means there is no requirement for on-ground cooling at the landing site. This means charging can be undertaken using normal automotive chargers which we see as an added appeal for certain customer groups.

The tests also show that the batteries can deliver not only the 175km range but do so within the reserve requirement set by the European Air Safety Authority (EASA). EASA has set a reserve requirement based on a performance-based framework which means that the Lilium Jet must have a contingency of 10% of trip energy at touchdown. And it must also have a Final Reserve sufficient for landing to be aborted and diversion to a forward landing achieved. This contrasts with the Federal Aviation Administration (FAA) which has a draft 30 minute energy reserve requirement for visual flight rules flying during daylight and 45 minutes at night. These FAA rules are quite prohibitive for eVTOL operation and the industry is pushing for a move to a performance based approach similar to EASA. However, by pursuing an EASA rating ahead of a FAA rating, Lilium mitigates the risk of regulatory delays on this issue.

Cycle Life for Real Flight Profiles



Source: Liliium

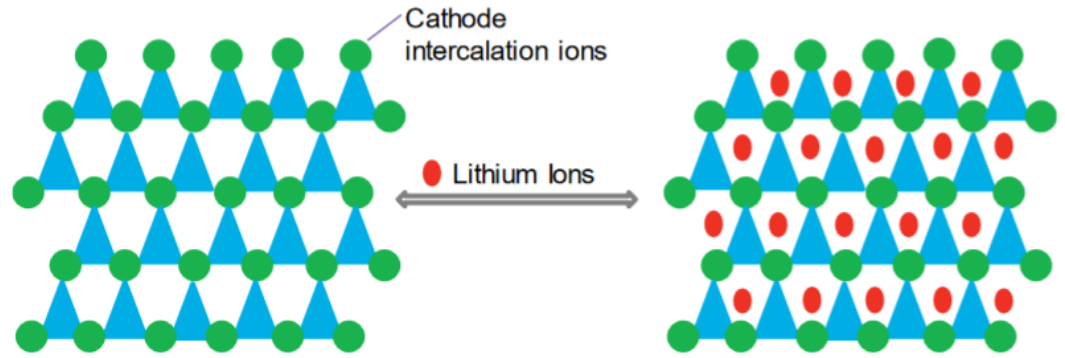
How A Silicon Anode Battery Works

Battery anodes need to receive and store lithium ions in some form, this is how the energy in a battery is stored. In a traditional battery, lithium ions are stored (intercalated) between layers in the anode material. This is normally a stable process with a reasonably high cycling efficiency.

A silicon anode can result in much higher energy density. To achieve this the anode has to use alloying where lithium ions react with the silicon anode material to form an alloy. This allows more lithium ions to be stored which results in a higher energy density. However, the materials see large volume changes during charging and discharging, with silicon anodes expanding to four times their initial volume when fully lithiated. This creates significant damage to the anode structure leading to short cycle lives, with the performance improvements from the silicon lasting only a couple of hundred cycles.

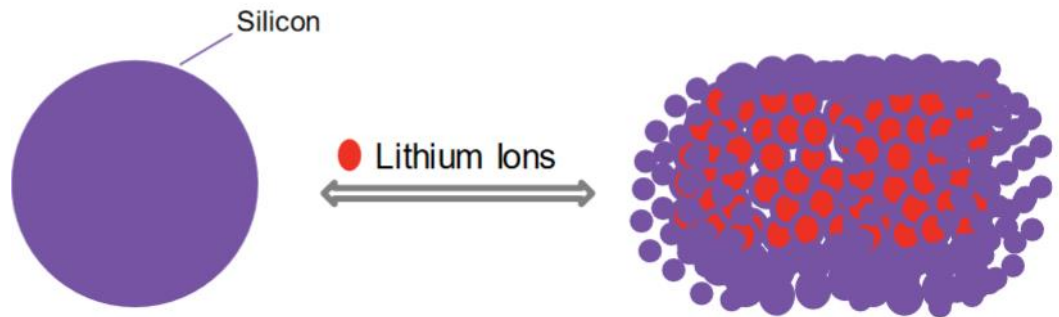
The volume change problem is not trivial and as a result, silicon is being blended with graphite in order to create improvements. The volume expansion problem is so great that blending is currently restricted to c. 3-5% by weight. It is possible to increase this and the ideal is to have a high silicon anode. We have been told that the Ionblox anode contains roughly 50% silicon but in a form that limits swelling of the silicon itself.

Electrode Intercalation Reactions



Source: Bloomberg New Energy Finance

Lithium Alloying With Silicon Showing Volume Expansion



Source: Bloomberg New Energy Finance

Solving The Volume Expansion Problem

- Contain the silicon with graphene or carbon nano structures
- Reduce the particle size of the silicon
- Physically contain the silicon – but would need a new production process writing off existing processes

Ionblox has not disclosed its approach to containing swelling, but we believe it to be based on a matrix design which uses an impure form of silicon less prone to swelling. Additionally there is no graphite in the anode which reduces the impact of any swelling that does occur. In the Ionblox cell this has been shown to be limited to 3% initially rising to no more than 10% over the life of the cell.

FINANCIAL MODEL

Profit and Loss Account

€m, Dec	2021a	2022a	2023e	2024e	2025e	2026e
Turnover						
eVTOL	0	0	0	0	279	1,262
CO2	0	0	0	0	1	6
Other	0	0	0	0	0	0
Other	0	0	0	0	0	0
Total	0	0	0	0	280	1,268
Operating profit						
eVTOL	-289	-279	-307	-343	-371	-227
CO2	0	0	0	0	1	6
Other	0	0	0	0	0	0
Other	0	0	0	0	0	0
Operating profit	-289	-279	-307	-343	-370	-221
P&L Account						
Turnover	0	0	0	0	280	1,268
Operating Profit	-289	-279	-307	-343	-370	-221
Investment income	-1	-3	0	0	0	0
Net Interest	-9	28	-1	2	-4	-22
Pre Tax Profit (UKSIP)	-299	-253	-308	-341	-373	-243
Goodwill amortisation	0	0	0	0	0	0
Exceptional Items	-111	0	0	0	0	0
Pre Tax Profit (FRS3)	-410	-253	-308	-341	-373	-243
Tax	-1	0	0	0	0	0
Post tax exceptionals	0	0	0	0	0	0
Minorities	0	0	0	0	0	0
Net Profit	-411	-253	-308	-341	-373	-243
Dividend	0	0	0	0	0	0
Retained	-411	-253	-308	-341	-373	-243
EBITDA	-284	-273	-288	-315	-305	-80
EPS (c) (UKSIP)	-1.40	-0.90	-0.64	-0.51	-0.22	-0.14
EPS (c) (FRS3)	-1.91	-0.90	-0.64	-0.51	-0.22	-0.14
FCFPS (c)	-1.94	-0.24	-0.56	-0.42	-0.30	-0.32
Dividend (c)	0.00	0.00	0.00	0.00	0.00	0.00

Source: Company data, Longspur Research estimates

KEY POINTS

- Company pre-revenue while it develops until 2025 when we assume first revenue begins
- C. €200m cost outflow rising ahead of launch in 2025

Balance Sheet

€m, Dec	2021a	2022a	2023e	2024e	2025e	2026e
Fixed Asset Cost	42	55	120	181	416	909
Fixed Asset Depreciation	-11	-18	-37	-65	-130	-271
Net Fixed Assets	31	37	83	116	286	638
Goodwill	0	0	0	0	0	0
Other intangibles	1	1	1	1	1	1
Investments	15	39	39	39	39	39
Stock	0	0	0	0	92	417
Trade Debtors	0	0	0	0	46	208
Other Debtors	31	32	32	32	32	32
Trade Creditors	-35	-34	-59	-88	-180	-625
Other Creditors <1yr	-15	-10	-10	-10	-10	-10
Creditors >1yr	-3	-4	-4	-4	-4	-4
Provisions	-3	-1	0	2	4	5
Pension	0	0	0	0	0	0
Capital Employed	22	61	84	89	307	703
Cash etc	353	180	172	5	212	12
Borrowing <1yr	23	29	29	29	29	29
Borrowing >1yr	10	8	8	8	115	484
Net Borrowing	-320	-142	-135	31	-69	501
Share Capital	40	53	55	55	59	59
Share Premium	779	843	1,102	1,222	1,848	1,848
Retained Earnings	-717	-970	-1,278	-1,622	-1,998	-2,241
Other	240	278	340	403	467	536
Minority interest	0	0	0	0	0	0
Capital Employed	22	61	84	89	307	703
Net Assets	343	204	219	58	376	202
Total Equity	343	204	219	58	376	202

Source: Company data, Longspur Research estimates

KEY POINTS

- Fixed assets grow with capex accelerating from 2024 with assumed network capex
- Cash is adequate but tight in 2024

Cashflow

€m, Dec	2021a	2022a	2023e	2024e	2025e	2026e
Operating profit	-289	-279	-307	-343	-370	-221
Depreciation	6	8	19	28	65	141
Provisions	2	-2	-2	-2	-2	-2
Other	61	23	62	63	64	69
Working capital	4	-8	25	29	-46	-42
Operating cash flow	-215	-257	-203	-224	-289	-55
Tax paid	0	0	0	0	0	0
Capex (less disposals)	-17	-9	-65	-61	-235	-493
Investments	-185	200	0	0	0	0
Net interest	-2	0	-1	2	-4	-22
Net dividends	0	0	0	0	0	0
Residual cash flow	-419	-67	-268	-283	-527	-570
Equity issued	0	120	1,000	0	0	0
Change in net borrowing	189	178	-732	283	527	570
Adjustments	-36	-231	0	0	0	0
Total financing	153	67	268	283	527	570

Source: Company data, Longspur Research estimates

KEY POINTS

- Operating cash outflow and capex dominate ahead of launch
- Capex for network from 2025 assumed in our forecasts but could be external
- Working capital impact with first revenue in 2025

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