

# A breakthrough in inexpensive, clean, fast-charging batteries

## First anode-free sodium solid-state battery

Date:

July 3, 2024

Source:

University of Chicago

UChicago Pritzker Molecular Engineering Prof. Y. Shirley Meng's Laboratory for Energy Storage and Conversion has created the world's first anode-free sodium solid-state battery.

With this research, the LESC -- a collaboration between the UChicago Pritzker School of Molecular Engineering and the University of California San Diego's Aiiso Yufeng Li Family Department of Chemical and Nano Engineering -- has brought the reality of inexpensive, fast-charging, high-capacity batteries for electric vehicles and grid storage closer than ever.

"Although there have been previous sodium, solid-state, and anode-free batteries, no one has been able to successfully combine these three ideas until now," said UC San Diego PhD candidate Grayson Deysher, first author of a new paper outlining the team's work.

The paper, published today in *Nature Energy*, demonstrates a new sodium battery architecture with stable cycling for several hundred cycles. By removing the anode and using inexpensive, abundant sodium instead of lithium, this new form of battery will be more affordable and environmentally friendly to produce. Through its innovative solid-state design, the battery also will be safe and powerful.

This work is both an advance in the science and a necessary step to fill the battery scaling gap needed to transition the world economy off of fossil fuels.

"To keep the United States running for one hour, we must produce one terawatt hour of energy," Meng said. "To accomplish our mission of decarbonizing our economy, we need several hundred terawatt hours of batteries. We need more batteries, and we need them fast."

### Sustainability and sodium

The lithium commonly used for batteries isn't that common. It makes up about 20 parts per million of the Earth's crust, compared to sodium, which makes up 20,000 parts per million.

This scarcity, combined with the surge in demand for the lithium-ion batteries for laptops, phones and EVs, have sent prices skyrocketing, putting the needed batteries further out of reach.

Lithium deposits are also concentrated. The "Lithium Triangle" of Chile, Argentina and Bolivia holds more than 75% of the world's lithium supply, with other deposits in Australia, North Carolina and Nevada. This benefits some nations over others in the decarbonization needed to fight climate change.

"Global action requires working together to access critically important materials," Meng said.

Lithium extraction is also environmentally damaging, whether from the industrial acids used to break down mining ore or the more common brine extraction that pumps massive amounts of water to the surface to dry.

Sodium, common in ocean water and soda ash mining, is an inherently more environmentally friendly battery material. The LESC research has made it a powerful one as well.

### Innovative architecture

To create a sodium battery with the energy density of a lithium battery, the team needed to invent a new sodium battery architecture.

Traditional batteries have an anode to store the ions while a battery is charging. While the battery is in use, the ions flow from the anode through an electrolyte to a current collector (cathode), powering devices and cars along the way.

Anode-free batteries remove the anode and store the ions on an electrochemical deposition of alkali metal directly on the current collector. This approach enables higher cell voltage, lower cell cost, and increased energy density, but brings

its own challenges.

"In any anode-free battery there needs to be good contact between the electrolyte and the current collector," Deysher said. "This is typically very easy when using a liquid electrolyte, as the liquid can flow everywhere and wet every surface. A solid electrolyte cannot do this."

However, those liquid electrolytes create a buildup called solid electrolyte interphase while steadily consuming the active materials, reducing the battery's usefulness over time.

A solid that flows

The team took a novel, innovative approach to this problem. Rather than using an electrolyte that surrounds the current collector, they created a current collector that surrounds the electrolyte.

They created their current collector out of aluminum powder, a solid that can flow like a liquid.

During battery assembly the powder was densified under high pressure to form a solid current collector while maintaining a liquid-like contact with the electrolyte, enabling the low-cost and high-efficiency cycling that can push this game-changing technology forward.

"Sodium solid-state batteries are usually seen as a far-off-in-the-future technology, but we hope that this paper can invigorate more push into the sodium area by demonstrating that it can indeed work well, even better than the lithium version in some cases," Deysher said.

The ultimate goal? Meng envisions an energy future with a variety of clean, inexpensive battery options that store renewable energy, scaled to fit society's needs.

Meng and Deysher have filed a patent application for their work through UC San Diego's Office of Innovation and Commercialization.

## **Researchers develop high-energy, high-efficiency all-solid-state sodium-air battery**

A research team has successfully developed a high-energy, high-efficiency all-solid-state sodium-air battery. This battery can reversibly utilize sodium (Na) and air without requiring special equipment. The team was led by Professor Byoungwoo Kang and Dr. Heetaek Park from the Department of Materials Science and Engineering at Pohang University of Science and Technology (POSTECH).

Secondary batteries find extensive use in green technologies such as electric vehicles and energy storage systems. The next-generation high-capacity secondary batteries, termed "metal-air batteries," draw power from abundant resources like oxygen and metals found on Earth. However, a challenge arises from the formation of carbonate—a byproduct of metal and oxygen reaction involving atmospheric carbon dioxide (CO<sub>2</sub>) and water vapor (H<sub>2</sub>O)—which sacrifices battery efficiency.

To address this, despite the name, metal-air batteries typically require additional equipment such as an oxygen permeation membrane to either purify oxygen or selectively use atmospheric oxygen.

In this research, the team employed Nasicon, which is a Na superionic conductor and a solid electrolyte, to effectively tackle the carbonate issue. Nasicon, comprising elements like Na, silicon (Si), and zirconium (Zr), serves as a solid electrolyte capable of ion movement in the solid state while demonstrating high electrochemical and chemical stability.

Leveraging this solid electrolyte, the team protected sodium metal electrodes from air and facilitated the breakdown of carbonate formed during electrochemical cell operation.

Consequently, the reversible electrochemical reaction involving carbonate led to an increase in the cell's energy density by increasing the working voltage while significantly reducing the voltage gap during charging and discharging, thus enhancing energy efficiency.

Moreover, the team's all-solid-state sodium-air cell exhibited superior kinetic capability through in-situ formed catholyte, which has a fast sodium ion conduction to the inside of the electrode. Remarkably, the cell operated solely on metal and air without additional special equipment for an additional oxygen filtration device.

Professor Kang who led the research remarked, "We've devised a method to harness carbonate, a longstanding challenge in the development of high-energy metal-air batteries. We hope to lead the field of the next generation all-solid-state metal-air batteries, leveraging a solid electrolyte-based cell platform that remains stable in ambient conditions and offers a broad voltage range."

Funding: Funding to support this work was provided by the National Science Foundation through the Partnerships for Innovation (PFI) grant no. 2044465

Researchers unveil fire-inhibiting nonflammable gel polymer electrolyte for lithium-ion batteries

## GMGs Graphene Aluminium-Ion Battery: 1000 mAh Capacity Reached and Next Steps Toward Commercialisation

8:16 AM ET 2/6/24 | Dow Jones

Brisbane, Queensland, Australia--(Newsfile Corp. - February 6, 2024) - Graphene Manufacturing Group Ltd. (TSXV: GMG) ("GMG" or the "Company") is pleased to provide the latest progress update on its Graphene Aluminium-Ion Battery technology ("G+AI Battery") being developed by GMG and the University of Queensland ("UQ").

Notably, this update includes information about GMG's G+AI Battery regarding:

- 1000 mAh Battery Cell Capacity Reached and Next Steps
- Battery Technology Readiness Level
- Next Steps Toward Commercialisation and Market Applications
- Next Generation Battery Performance
- Important Milestones for GMG's Graphene Aluminium-Ion Battery Development

### 1000 mAh Battery Cell Capacity Reached and Next Steps

The Company is pleased to announce it has now produced multiple battery pouch cells with over 1000 mAh (1 Ah) capacity, as seen in Figure 1. In a recent build to confirm repeatability, the Company's development team has built and confirmed multiple cells, all testing greater than 1Ah (1000mAh). This is a major milestone achieved to demonstrate scalability from coin cells to pouch cells, and represents the next milestone in the battery's development, following the announcement of 500 mAh capacity in September 2023: "GMG ACHIEVES INITIAL 500 mAh GRAPHENE ALUMINIUM-ION BATTERY PROTOTYPE IN POUCH CELL FORMAT".

Figure 1: Typical G+AI Pouch Cell Prototype

To view an enhanced version of this graphic, please visit:

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Please see charging and discharging curve typical of the GMG's Graphene Aluminium-Ion Battery 1000 mAh cell in Figure 2 showing a nominal voltage of 1.7 volts.

Now that GMG has successfully made multiple 1000 mAh pouch cells - it will continue to focus on making more of these batteries and then seek third party laboratory battery testing data, which GMG expects to complete in H1 2024.

Figure 2: Typical Charging and Discharging Curves

To view an enhanced version of this graphic, please visit:

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At the same time, GMG will review a potential investment for the procurement and installation of an automated pouch cell battery pilot plant in its Richlands Australia Facility. The Pilot Plant will enable the Company to produce pouch cells for potential customers to test in battery packs for different applications. Following the successful start-up of the Pilot Plant and successful customer trials, GMG expects to pursue large scale commercial production, as seen in Figure 3.

Figure 3: Pouch Cell Scale Up Process

To view an enhanced version of this graphic, please visit:

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#### Battery Technology Readiness Level

The battery technology readiness level ("BTRL") of the Graphene Aluminium-Ion technology remains at Level 4 (see Figure 4). GMG is currently optimizing electrochemical behaviour for pouch cells via ongoing laboratory experimentation. If GMG invests, constructs and commissions a Pilot Plant it is anticipated the battery technology progress to BTRL 7 and 8 since the equipment and process to make the Graphene Aluminium-Ion batteries is the same as those employed to make Lithium Ion Batteries.

Figure 4: Battery Technology Readiness Level

Source: "The Battery Component Readiness Level (BC-RL) Framework: A technology-specific development framework", Matthew Greenwood et al

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#### Next Steps Toward Commercialisation & Market Applications

The Company continues to see a broad range of applications for a completed GMG Graphene Aluminium-Ion Battery - utilising its ultra-high power-density and nominal energy density characteristics. Along with Rio Tinto, a range of global companies have confidentially expressed their interest in working with GMG in the following vertical sectors:

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#### Next Generation Battery Performance

GMG's next generation Graphene Aluminium-Ion Battery performance data (as tested and calculated on coin cells), as compared to the most commonly available lithium-ion batteries, is shown below in Figure 5, with a list of its beneficial characteristics.

Performance results for the pouch cells could be significantly different and will be communicated upon successfully producing a repeatable and fully 3<sup>rd</sup> party tested 1000 mAh+ battery pouch cell.

Figure 5: Graphene Aluminium-Ion Battery Comparative Performance Data (for coin cells)

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#### Important Milestones for the Battery's Development:

Important milestones for GMG's Graphene Aluminium-Ion Battery Development:

Month	Important Milestones in the Development of the Graphene Aluminium Ion Battery
May 2020	GMG and UQ wins Australian Research Council grant for Graphene battery development
Apr 2021	The University of Queensland and GMG kick off coin cell battery development project
May 2021	Graphene aluminium-ion battery performance data - Energy Density and Power Density
Jun 2021	Graphene aluminium-ion battery performance data - Cycle Life
Jun 2021	Significant potential battery customer market response to launch of battery
Jul 2021	Investment decision for coin cell battery development centre
Oct 2021	Construction starts for coin cell battery development centre
Oct 2021	Bosch Australia Manufacturing Solutions and GMG sign Letter of Intent
Dec 2021	Commencement coin cell battery development centre
Dec 2021	Initial coin cell batteries sent for customer feedback
Mar 2022	Initial factory acceptance testing of semi-automated prototype battery cell assembly equipment
Mar 2022	Wood Engineering and GMG Sign a Letter of Intent
May 2022	Rio Tinto and GMG sign Letter of Intent
Jun 2022	Commissioning of Pouch Cell Equipment
Jun 2022	Bob Galyen former chief technology officer of CATL joins GMG technical advisory committee.
Aug 2022	Investment decision for Phase 1 modular Graphene Production Plant
Oct 2022	Significant battery performance, cell and graphene production improvements
Dec 2022	Investment of \$600k Battery Development Centre
Feb 2023	Australian Government Approval (AICIS) for production and sale of batteries.
May 2023	Battery Joint Development Agreement with Rio Tinto signed
May 2023	Battery Technology Readiness Level (BRTL) 2-3 reached
May 2023	Decision to switch to develop Pouch Cells (instead of Coin Cells)
Jul 2023	Bob Galyen former chief technology officer of CATL joins GMG board of Directors
Sep 2023	Battery Pouch Cell Prototypes Multilayered Auto-Stacker Demonstration
Sep 2023	Reaching 500 mAh capacity battery
Sep 2023	Battery Technology Readiness Level (BRTL) 4 reached
Nov 2023	Rio Tinto and GMG Partnership Video Launched
Dec 2023	Commissioning of modular Graphene Production Plant
Feb 2024	1000 mAh Capacity Reached

## About GMG

GMG is a clean-technology company which seeks to offer energy saving and energy storage solutions, enabled by graphene, including that manufactured in-house via a proprietary production process.

GMG has developed a proprietary production process to decompose natural gas (i.e. methane) into its elements, carbon (as graphene), hydrogen and some residual hydrocarbon gases. This process produces high quality, low cost, scalable, 'tuneable' and low/no contaminant graphene suitable for use in clean-technology and other applications. The Company's present focus is to de-risk and develop commercial scale-up capabilities, and secure market applications.

In the energy savings segment, GMG has focused on graphene enhanced heating, ventilation and air conditioning ("HVAC-R") coating (or energy-saving paint), lubricants and fluids. In the energy storage segment, GMG and the University of Queensland are working collaboratively with financial support from the Australian Government to progress R&D and commercialization of graphene aluminium-ion batteries ("G+Al Batteries").

GMG's 4 critical business objectives are:

1. Produce Graphene and improve/scale cell production processes
2. Build Revenue from Energy Savings Products
3. Develop Next-Generation Battery
4. Develop Supply Chain, Partners & Project Execution Capability

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2024-02-06 13:16:00 GMT **GMG's Graphene Aluminium-Ion Battery: 1000 mAh Capacity Reached and Next Steps Toward Commercialisation -2-**

## **A Chinese battery manufacturer has developed superfast charging cells — and it's not industry leader CATL. 6/05/2024**

Gotion High-Tech, a rival of China's best-known and most successful developer of electric vehicle and other batteries, announced two batteries that can be rapidly charged plus new solid-state technology at its annual conference, Emerging Technology News reported.

One of the batteries, a 5C called G-Current, can be replenished to 80% in 9.8 minutes and 90% in 15 minutes, according to ETN. It can be used in EVs and hybrids and with lithium iron phosphate, lithium manganese iron phosphate, and lithium nickel cobalt manganese chemistries.

The company said the G-Current was "ready for immediate mass production," per ETN.

The other fast charger, named Stellary, is made of second-generation silicon-carbon and a fast-charging electrolyte. It goes from a 10% charge to 70% in nine minutes and enables battery packs to offer a 350-kilometer (217-mile) range after five minutes and a 600-kilometer (372-mile) range after 10 minutes, ETN reported.

A Gotion news release stated Stellary was uniquely designed to dissipate 70% of its heat outside the pack within three seconds, an important safety feature. A wireless battery management system helps ensure its reliability.

Related video: China's leading electric vehicle maker selling cars for \$10,000 (NBC News)

which will allow the Western automakers and the US automakers

China's leading electric vehicle maker selling cars for \$10,000

Indian-origin researcher discovers new tech device that fully charges EVs in 10 minutes

1:36

China Drafts Regulations to Tackle Battery Industry Overproduction

This battery will be made at Gotion's  $\mu\text{m}$ -level Gen7 facility, which will reduce manufacturing costs by 50%.

The other development was the Gemstone battery, which features all-solid-state technology. Its 350-watt-hour per kilogram energy density is 40% more than that of most NCM batteries, which will help EVs increase their ranges and use energy more efficiently.

It is planned for rollout in 2027 and commercial availability in 2030, offering a driving range of 1,000 kilometers, or 621 miles, on a single charge.

Those stats and the charging times of the G-Current and Stellary should help make EVs more enticing to buyers. A \$7,500 federal tax credit plus savings on gas and maintenance are other perks that come with switching from a gas-guzzler, and you can also remove 10,000 pounds of carbon dioxide pollution from entering our atmosphere each year.

The Biden-Harris administration is also working toward widespread EV charger availability by funding the infrastructure as part of the Bipartisan Infrastructure Law. On May 30, \$1.3 billion in grants became available to states, local governments, Indigenous tribes, and more.

Date:

October 18, 2023

Source:

Ulsan National Institute of Science and Technology(UNIST)

Summary:

**A research team has succeeded in developing a non-flammable gel polymer electrolyte (GPE) that is set to revolutionize the safety of lithium-ion batteries (LIBs) by mitigating the risks of thermal runaway and fire incidents.**

Share:

FULL STORY

A collaborative research team, led by Professor Hyun-Kon Song in the School of Energy and Chemical Engineering at UNIST, Dr. Seo-Hyun Jung from Research Center for Advanced Specialty Chemicals at Korea Research Institute of Chemical Technology (KRICT), and Dr. Tae-Hee Kim from the Ulsan Advanced Energy Technology R&D Center at Korea Institute of Energy Research (KIER), has achieved a groundbreaking milestone in battery technology. Their remarkable achievement in developing a non-flammable gel polymer electrolyte (GPE) is set to revolutionize the safety of lithium-ion batteries (LIBs) by mitigating the risks of thermal runaway and fire incidents.

In the past, the potential flammability of LIBs has raised significant concerns, especially in electric vehicles, where fire hazards pose a serious threat to underground parking lots. Addressing this critical issue, the research team has successfully developed a groundbreaking non-flammable polymer semi-solid electrolyte, offering a promising solution to mitigate battery fires.

Conventionally, non-flammable electrolytes have heavily relied on the incorporation of flame retardant additives or solvents with exceptionally high boiling points. However, these methods often resulted in a considerable decrease in ion conductivity, compromising the overall performance of the electrolyte.

In their breakthrough research, the research team introduced a trace amount of polymer into the electrolyte, creating a semi-solid electrolyte. This novel approach dramatically increased the lithium ion conductivity by 33% compared to existing liquid electrolytes. Moreover, the pouch-type batteries incorporating this non-flammable semi-solid electrolyte exhibited a remarkable 110% improvement in life characteristics, effectively preventing unnecessary electrolyte reactions during the formation and operation of the solid-electrolyte interphase (SEI) layer.

The key advantage of this innovative electrolyte lies in its exceptional performance and non-combustibility. By suppressing radical chain reactions with fuel compounds during the combustion process, the polymer semi-solid electrolyte effectively inhibits the occurrence of battery fires. The research team demonstrated the excellence of the developed polymer by quantitatively analyzing its ability to stabilize and suppress radicals.

Jihong Jeong (School of Energy and Chemical Engineering, UNIST) emphasized, "The interaction between the polymerized material inside the battery and volatile solvents allows us to effectively suppress radical chain reactions. Through electrochemical quantification, this breakthrough will greatly contribute to understanding the mechanism of non-flammable electrolytes."

Co-first author Mideum Kim, a master student in the School of Energy and Chemical Engineering at UNIST and the Korea Research Institute of Chemical Technology (KRICT), further confirmed the exceptional safety of the battery itself through various experiments. The team's comprehensive approach included applying the non-flammable semi-solid electrolyte to pouch-type batteries, ensuring the evaluation of electrolyte non-combustibility extended to practical battery applications.

"The research team's multidisciplinary composition, involving electrochemistry from UNIST, polymer synthesis from the KRICT Research Center for Advanced Specialty Chemicals, and battery safety testing by the Ulsan Advanced Energy Technology R&D Center at Korea Institute of Energy Research (KIER), has been instrumental in achieving this breakthrough," stated Professor Song. "The use of non-flammable semi-solid electrolytes, which can be directly incorporated into existing battery assembly processes, will accelerate the future commercialization of safer batteries."

The research study has applied for five patents in Korea and two overseas, further highlighting the significance of this achievement. Additionally, it has been selected as a supplementary cover for ACS Energy Letters, with publication online on October 13, 2023. This study has been made possible through the support of the National Research Foundation of Korea (NRF), the Ministry of Science and ICT (MSIT), the Korea Evaluation Institute of Industrial Technology (KEIT), the Korea Research Institute of Chemical Technology, and Samsung SDI Co., Ltd.

## **Fast-charging lithium battery seeks to eliminate 'range anxiety'**

Date:

January 24, 2024

Source:

Cornell University

Summary:

Engineers have created a new lithium battery that can charge in under five minutes -- faster than any such battery on the market -- while maintaining stable performance over extended cycles of charging and discharging.

Share:

### **FULL STORY**

Cornell University engineers have created a new lithium battery that can charge in under five minutes -- faster than any such battery on the market -- while maintaining stable performance over extended cycles of charging and discharging.

The breakthrough could alleviate "range anxiety" among drivers who worry electric vehicles cannot travel long distances without a time-consuming recharge.

"Range anxiety is a greater barrier to electrification in transportation than any of the other barriers, like cost and capability of batteries, and we have identified a pathway to eliminate it using rational electrode designs," said Lynden Archer, professor of engineering and dean of Cornell's College of Engineering, who oversaw the project.



"If you can charge an EV battery in five minutes, I mean, gosh, you don't need to have a battery that's big enough for a 300-mile range. You can settle for less, which could reduce the cost of EVs, enabling wider adoption."

The team's paper, "Fast-Charge, Long-Duration Storage in Lithium Batteries," published in *Joule*. The lead author is Shuo Jin, a doctoral student in chemical and biomolecular engineering.

Lithium-ion batteries are among the most popular means of powering electric vehicles and smartphones.

The batteries are lightweight, reliable and relatively energy-efficient.

However, they take hours to charge, and lack the capacity to handle large surges of current.

The researchers pinpointed indium as an exceptionally promising material for fast-charging batteries.

Indium is a soft metal, mostly used to make indium tin oxide coatings for touch-screen displays and solar panels.

The new study shows indium has two crucial characteristics as a battery anode: an extremely low migration energy barrier, which sets the rate at which ions diffuse in the solid state; and a modest exchange current density, which is related to the rate at which ions are reduced in the anode.

The combination of those qualities -- rapid diffusion and slow surface reaction kinetics -- is essential for fast charging and long-duration storage.

"The key innovation is we've discovered a design principle that allows metal ions at a battery anode to freely move around, find the right configuration and only then participate in the charge storage reaction," Archer said.

"The end result is that in every charging cycle, the electrode is in a stable morphological state. It is precisely what gives our new fast-charging batteries the ability to repeatedly charge and discharge over thousands of cycles."

That technology, paired with wireless induction charging on roadways, would shrink the size -- and the cost -- of batteries, making electric transportation a more viable option for drivers.

However, that doesn't mean indium anodes are perfect, or even practical.

"While this result is exciting, in that it teaches us how to get to fast-charge batteries, indium is heavy," Archer said.

"Therein lies an opportunity for computational chemistry modeling, perhaps using generative AI tools, to learn what other lightweight materials chemistries might achieve the same intrinsically low Damköhler numbers. For example, are there metal alloys out there that we've never studied, which have the desired characteristics? That is where my satisfaction comes from, that there's a general principle at work that allows anyone to design a better battery anode that achieves faster charge rates than the state-of-the art technology."

The research was supported by the U.S. Department of Energy Basic Energy Sciences Program through the Center for Mesoscale Transport Properties, an Energy Frontiers Research Center. The researchers made use of the Cornell Center for Materials Research, which is supported by the National Science Foundation's Materials Research Science and Engineering Center program.

## **How a simple fix could double the size of the U.S. electricity grid**

There is one big thing holding the United States back from a pollution-free electricity grid running on wind, solar and battery power: not enough power lines.

As developers rush to install wind farms and solar plants to power data centers, artificial intelligence systems and electric vehicles, the nation's sagging, out-of-date power lines are being overwhelmed — slowing the transition to clean energy and the fight against climate change.

But experts say that there is a remarkably simple fix: installing new wires on the high-voltage lines that already carry power hundreds of miles across the United States. Just upgrading those wires, new reports show, could double the amount of power that can flow through America's electricity grid.

"This is something that could be a triple win," said Brian Deese, an innovation fellow at the Massachusetts Institute of Technology who headed the White House National Economic Council under President Biden until early last year. "A win for the electricity system, a win for utilities and a win for consumers."

Since Biden signed the Inflation Reduction Act in August 2022 — pouring hundreds of billions of dollars toward the build-out of clean energy — experts have warned that without a dramatic increase in the size of the electricity grid, most of those new wind and solar farms won't be able to plug in.

Many renewables are stuck in the "interconnection queue," a long line of projects waiting to get connected to the grid. According to Lawrence Berkeley National Laboratory, more than 1,500 gigawatts of power, mostly renewables, are waiting for approval to connect. (That's more than one-third of all the power produced in the United States.)

One of the main reasons for that long wait is that the nation builds transmission lines — those giant, high-voltage wires that carry power across large distances — extremely slowly. The average transmission line takes about 10 years to complete, and the country has been building even fewer lines recently than it did a decade ago.

Without enough power lines, there is nowhere for new solar, wind and battery power to go.

"We have to be able to integrate all this low-cost, renewable energy fast," said Amol Phadke, a scientist at the University of California at Berkeley and Lawrence Berkeley National Laboratory.

Most of America's lines are wired with a technology that has been around since the early 1900s — a core steel wire surrounded by strands of aluminum. When those old wires heat up — whether from power passing through them or warm outdoor temperatures — they sag. Too much sag in a transmission line can be dangerous, causing fires or outages. As a result, grid operators have to be careful not to allow too much power through the lines.

But a couple of decades ago, engineers designed a new type of wire: a core made of carbon fiber, surrounded by trapezoidal pieces of aluminum. Those new, carbon-fiber wires don't sag as much in the heat. That means that they can take up to double the amount of power as the old lines.

According to the recent study from researchers at UC-Berkeley and GridLab, replacing these older steel wires could provide up to 80 percent of the new transmission needed on the electricity grid — without building anything new. It could also cost half as much as building an entirely new line and avoid the headaches of trying to get every state, city and even landowner along the route to agree to a new project.

"You're not acquiring a new right of way; you're not building new towers," Phadke said. "So it can be done much faster."

If stringing new lines is so easy — and cheap — why hasn't it been done already? Part of the problem, experts say, is that utilities profit more from big infrastructure projects. Routine maintenance or larger-scale upgrades of the electricity grid don't help utilities make a lot of cash compared with building new transmission lines.

Deese compares it to having leaky pipes in a building — building managers don't get rewarded for fixing all of a building's problems, but rather for just keeping things running as long as possible on a limited budget. "You patch and plug rather than thinking systematically," Deese said.

Duncan Callaway, a professor of energy and resources at UC-Berkeley and one of the authors of the recent study, said that many transmission engineers are not used to thinking of rewiring as one of their tools. "But it's a much faster way," he said.

Some changes are already underway to encourage this approach. For a long time, utilities had to undergo lengthy environmental reviews if they were rewiring a line longer than 20 miles. Earlier this month, the Federal Energy Regulatory Commission announced that those would no longer be necessary if utilities are simply replacing wires.

And last month, the Biden administration announced a goal to upgrade 100,000 miles of transmission line over the next five years — which could include rewiring the lines.

"We actually need stuff that can cook right now, right away," Ali Zaidi, the White House national climate adviser, said Tuesday at a White House summit on grid modernization. "And the way to do that is by deploying grid-enhancing technologies, by reconductoring the lines that we have already strung up or buried across the country."

This doesn't mean that new lines don't need to be built. "In the longer run, newer lines will play an important role," Phadke said. But as new demand surges onto the grid in the short term, upgrading the nation's wires could help keep clean energy flowing until those new lines can be built.

"We have the potential to achieve all of these things with just taking new technology and running it through old lines," Deese said. "It's pretty cool."

## **DJ Tech Trader: ASML Saved Moores Law. Then It Wrecked The Market.**

-- Barrons

9:30 PM ET 10/18/24 | Dow Jones

This past week, ASML's third-quarter earnings leaked a day early. The market was caught off guard in more ways than one. ASML's outlook was weak, and the worries sparked an industrywide panic.

Why did ASML's update sour everyone on the whole chip industry? How did ASML, a company not known to many investors, become so central to the sector? The answer stems from Moore's Law.

Moore's Law isn't really a law, but rather a prediction in 1975 by semiconductor pioneer Gordon Moore. He said that the number of transistors that could be etched into silicon would double every two years. As Moore's Law is generally understood, you get twice the chip, for the same price or less, every two years.

This prediction had held up pretty well until recently, when tinier and tinier transistors ran up against the limits of ultraviolet light wavelengths used to etch them into silicon.

Enter Dutch-based ASML, a manufacturer of semiconductor lithography machines. Over two decades ago, ASML saw where things were headed and began working on extreme ultraviolet (EUV) lithography machines with even smaller wavelengths, allowing for the creation of ever-smaller transistors. ASML says it invested more than six billion euros (\$6.49 billion) in EUV research and development over 17 years.

After several false starts, the company was able to harness the very tiny wavelengths needed to manufacture high-performance chips used in smartphones, PCs, and data centers. Ultimately, ASML's EUV machines saved Moore's Law.

ASML once described how EUV works like this: "To generate extreme ultraviolet (EUV) light, a CO(2) laser fires two separate laser pulses at a fast-moving drop of tin. This vaporizes the tin and creates EUV light. It does this up to 50,000 times per second."

It could be straight out of a science-fiction novel.

EUV machines are unique to ASML. They have competition in their less advanced lithography machines from the likes of Canon, but no one else makes the EUV variety.

There are currently five major customers for EUV machines: Intel, Taiwan Semiconductor Manufacturing, Samsung Electronics, Micron Technology, and SK Hynix. The cost of a single ASML machine can top EUR350 million.

ASML's customers use the machines for a variety of applications.

Without EUV, the chips in smartphones, PCs, and Nvidia GPUs would be less efficient and much slower. That means chip designers like Apple, Advanced Micro Devices, and Nvidia are dependent on ASML, and so are companies manufacturing their chips, including Taiwan Semiconductor and Samsung. Even in China, where ASML is restricted to selling their less advanced machines, manufacturers cannot get enough of ASML lithography. In the just-reported third quarter, China accounted for 47% of ASML revenue.

ASML may have just five EUV customers, but the entire semiconductor sector is downwind of its technology. And that brings us back to this past week's selloff.

For a while now, Wall Street had been focused on ASML's outlook for 2025, when multiple trends were seen to be converging:

- More advanced manufacturing processes from Intel, TSMC, and Samsung are set to get going next year. That presumably creates high demand for ASML's highest-end EUV machine, the one that costs EUR350 million or more.
- A wave of newly opened, government-subsidized semiconductor factories are beginning to open. There are manufacturing subsidies in the U.S. European Union, China, South Korea, India, and elsewhere. These economies all want to achieve some level of semiconductor independence, and new factories will require the purchase of more machines from ASML.

For several years now, ASML has been guiding to a revenue range of EUR30 billion to EUR40 billion for 2025. As recently as three months ago, the company suggested that 2025 would be closer to the top of that range than the bottom.

"As it relates to 2025, we're very consistent, I think, in our messaging and that's what we say," Chief Financial Officer Roger Dassen told investors on July 17. "We confirm what we said in November of 2022, which is we expect 2025 to be between EUR30 billion to EUR40 billion. We've also said it's not the low point of that guidance."

Wall Street analysts had settled on an estimate of EUR35.8 billion for ASML's 2025 sales.

But in reporting its third quarter this week, ASML forecast those 2025 sales at EUR30 billion to EUR35 billion, at the bottom half of the previous range. Cue the selloff.

The change in outlook reflects lower demand from one or more of ASML's EUV customers. But it also means that demand for manufacturing services from the chip designers may be faltering, which would imply weak demand for traditional semiconductors in smartphones, PCs, and servers.

ASML emphasized that the problem wasn't related to demand for artificial-intelligence chips. That means Nvidia GPUs could be immune to the concerns. Strong earnings from Taiwan Semiconductor on Thursday also suggested the news wasn't quite so gloomy for the broader chip sector.

But ASML's warning still stands out because of the company's vital role across the supply chain. ASML's problem is everyone's problem.

Corrections & Amplifications: Micron Technology and SK Hynix have bought EUV machines from ASML. An earlier version of this article incorrectly said that ASML's only EUV customers were Intel, Taiwan Semiconductor Manufacturing, and Samsung.

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**On 12/01/2024 Artificial Intelligence Copilot was asked:**

**Question:** As of 12/01/2024, has there recently been a public announcement, of any primary specific effort to build a long distance travel-capable, rechargeable lithium, or graphene, or sodium battery powered railroad locomotive?

**Copilot Answer:** Yes, there has been a recent announcement! **Norfolk Southern Corporation** has partnered with **Alstom** to launch a cutting-edge hybrid locomotive project. This project aims to convert two engines to hybrid technology, significantly reducing carbon emissions by 90% and increasing pulling power by 30%. The hybrid locomotives will use batteries for primary propulsion, with a smaller diesel engine to charge the batteries when needed.

Does this align with what you were looking for, or were you thinking of a different type of battery-powered locomotive?