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240

Applications received for BNEF Pioneers 2024

23

Pioneers finalists chosen by BNEF in 2024

11

Pioneers winners chosen by BNEF in 2024

Climate-Tech Companies to Watch in 2024: BNEF Pioneers

BloombergNEF has announced the winners of the 2024 Pioneers award, an annual competition that identifies game-changing technologies or innovations with the potential to accelerate global decarbonization and halt climate change. The 11 winners selected this year are helping clean power connect to the grid, rolling out new technologies for decarbonizing buildings, developing next-generation fuels, facilitating biodiversity quantification, and cultivating new techniques for battery and iron production.

- This year’s competition is the 15th edition of BNEF Pioneers. Including this year’s laureates, the contest has now named 152 winners, which have cumulatively raised \$19.8 billion. In 2024, BNEF received applications from 240 companies from 40 countries.
- Each year, the Pioneers competition focuses on three challenges, plus a “wildcard” category.
 - **Challenge 1: Relieving bottlenecks in clean power deployment.** The winners of this challenge are speeding up grid interconnection studies ([Envelio](#)), creating software for planning and designing solar plants ([PVcase](#)) and making advanced conductors for grid lines ([TS Conductor](#)).
 - **Challenge 2: Decarbonizing the construction and operation of buildings.** The winners of this challenge are developing novel ways of sealing buildings ([Aeroseal](#)) and decarbonizing heating in commercial ([Celsius Energy](#)) and residential ([Kelvin](#)) buildings.
 - **Challenge 3: Creating the next generation of net-zero fuels.** The winners of the fuels challenge are developing ways to use cover crops as a feedstock for biofuels ([CoverCress](#)) and creating cost-competitive shipping fuel from waste oils ([XFuel](#)).
 - **Wildcards: Open to any climate-tech innovation outside of the challenges listed above.** This year’s winners are creating simple electrolysis systems for iron production ([Element Zero](#)), lithium metal anodes for batteries ([Li-Metal](#)) and environmental DNA sampling kits for quantifying biodiversity ([NatureMetrics](#)).

Figure 1: BNEF Pioneers 2024 Winners



Source: BloombergNEF

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1. How does BNEF choose its Pioneers?

Each year, BNEF awards the Pioneers prize to innovators addressing three pre-selected challenges. It also recognizes a few ‘wildcard’ winners outside of these categories.

The Pioneers are selected via a four-step process:

1. **Choosing the challenges:** BNEF chooses its challenge areas in collaboration with each of our sector teams, with a particular eye towards identifying topics where an urgent climate challenge still lacks a clear technological solution. BNEF’s long-term outlooks on energy, industry and transport, including the *New Energy Outlook* ([web](#) | [terminal](#)) and the *Electric Vehicle Outlook* ([web](#) | [terminal](#)), help identify these areas.
2. **Finding the applicants:** BNEF searches for potential applicants using its own startup databases and published research, as well as analyst knowledge. We solicit applications from our analysts, network of clients and research contacts. About a third of the 250-300 applications that BNEF receives each year are solicited, while the other two-thirds come from our open application portal. Winners are often chosen from the pool of unsolicited applications.
3. **Choosing the finalists:** Each application is read and scored by a relevant sector analyst based on potential impact, innovation and likelihood of adoption (Figure 2). BNEF balances both quantitative and qualitative scoring data to select finalists that represent a diversity of technological solutions.
4. **Choosing the winners:** BNEF conducts a full day of finalist judging, where BNEF analysts present each finalist to a panel of judges. The judges are the BNEF management committee, which uses a voting and discussion process to determine the winners of the competition.

Figure 2: Scoring dimensions for BNEF Pioneers applicants

Potential impact

- ‘Significant’ potential scale/market size by 2050
- High climate-related or sustainability impact

Innovation

- Uniqueness of technology
- Benefit over incumbent or competing process

Likelihood of adoption

- Cost competitiveness of technology
- Ability to integrate well with the existing market structure

Source: BloombergNEF

2. Challenge 1: Relieving bottlenecks in clean power deployment

According to BNEF’s *New Energy Outlook*, switching power generation from fossil fuels to clean power is the single biggest contributor to global emissions reduction, accounting for half of all emissions abated over 2022-2050. Clean power production also enables decarbonization through electrification, which abates another quarter of emissions during that period. Building out clean power generation as quickly as possible is thus imperative. While renewable deployment reached records levels in 2023, less than 20% of wind and solar that will be necessary in 2050 to reach global climate goals has been installed.

Solar and wind are now the cheapest sources of electricity in most of the world – which means that addressing slow grid buildout, grid connection backlogs, permitting challenges and supply chain constraints is the next step in accelerating deployment.

For more information, see:

- [BNEF New Energy Outlook \(web | terminal\)](#) and [New Energy Outlook: Grids \(web | terminal\)](#)
- [US Power Grid Buildout Dampened by Piecemeal Strategy \(web | terminal\)](#)
- [Grid Connection Queues Threaten Europe’s Net-Zero Goals \(web | terminal\)](#)
- [US Grid Applications Status 2024: Many Projects in Limbo \(web | terminal\)](#)

2.1. Envelio

Table 1: Envelio company details

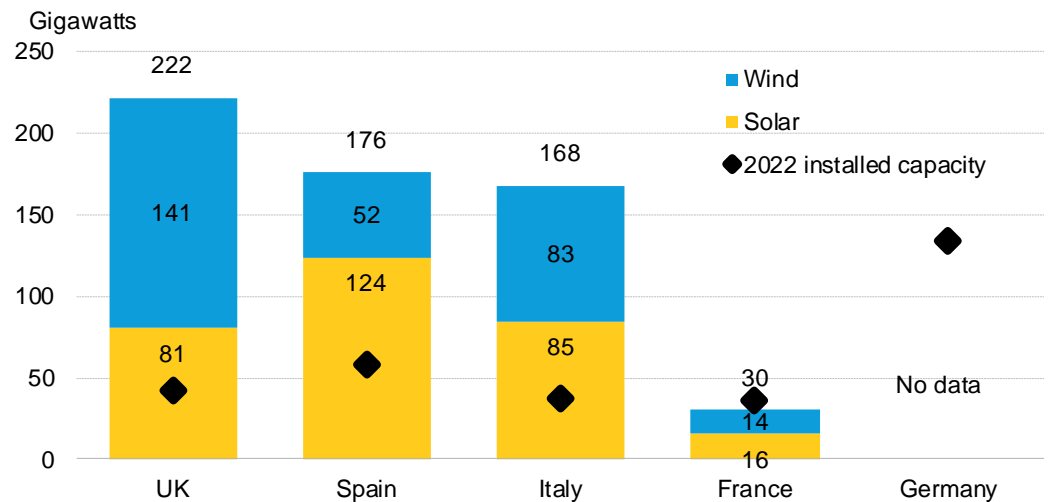
| Name | HQ | Founded | Funding | Technology |
|-------------------------|---------|---------|--------------------------|--------------------------------------|
| Envelio | Germany | 2017 | Acquired by E.on in 2021 | Grid planning and operation software |

Source: BloombergNEF

Why is innovation needed to make interconnection studies faster?

Before a renewable energy project can connect to the grid, the asset owner must apply for interconnection from the grid operator. For projects above a certain size, the grid operator conducts an interconnection study to assess the project’s impact on the grid. The goal of these studies is to create a dollar estimate for both the grid interconnection and any upgrades required to support the project; if the project moves forward, the developer often bears the cost of the upgrades. In Europe and the US, developers wait one to seven years for permission to connect their projects. These delays have resulted in a significant backlog, with gigawatts of solar and wind capacity waiting in the queue (Figure 3).

Figure 3: Grid connection queue sizes across Europe



Source: BloombergNEF, National Grid, Electricity Northwest, Northern Powergrid, SSE Networks, Scottish Power Energy Networks, UK Power Networks, Terna, Red Electrica, French Ministry of Ecological Transition. Note: Germany does not publish data on project wait times. Interviews by BNEF indicate that connection queues in Germany are shorter than in other countries described in this chart.

What is Envelio’s technology?

Envelio’s Intelligent Grid Platform uses a digital twin of distribution power grids to automate new connection studies. It sells this platform to distribution system operators, who pay a one-time setup fee and an ongoing subscription fee. The platform aggregates and validates data from different systems, such as geographic information systems, distribution management systems and smart-meter data. Envelio says automating this workflow enables grid connection requests to be processed as much as 20 times more quickly.

Why is Envelio a Pioneer?

Grid operators have an ever-growing list of renewables projects that need to be reviewed, but they typically lack the necessary administrative capacity to process these requests in a timely manner. By cutting down on the manpower needed to process interconnection applications, Envelio’s software helps accelerate the connection of clean power projects to the grid.

Envelio’s clients are primarily in Germany, where grid operator studies account for about three months of a 17-month regulated process. Germany is notable within Europe as having relatively short interconnection queues, and a very fragmented market of distribution system operators. The fact that Envelio has generated traction in a fragmented market where its product provides less value than it could in others bodes well for its prospects in the rest of Europe and beyond.

What’s next for Envelio?

Envelio raised \$6.3 million in a Series A round in 2019, and in 2021, E.on acquired a majority stake in the company. The German company already has over 50 distribution system operators in Europe as clients, and it says it manages almost 50% of the distribution grid with its Intelligent Grid Platform. Envelio is targeting international growth and is now launching its products in the US market.

2.2. PVcase

Table 2: PVcase company details

| Name | HQ | Founded | Funding | Technology |
|---------------|-----------|---------|---------------|--|
| <u>PVcase</u> | Lithuania | 2018 | \$124 million | Solar planning, design and siting software |

Source: BloombergNEF

Why is innovation needed to make PV installations easier?

In BNEF’s Net Zero Scenario,¹ solar installations reach 871 gigawatts per year by 2050, a threefold increase over the global solar deployment rate in 2022 (Figure 4). Because solar is already the cheapest form of electricity in many parts of the world, speeding up deployment is now a matter of building faster, not reducing costs. While the solar industry continues to grow rapidly, its scale and mitigation potential mean even marginal improvements in capacity factor and deployment timelines can result in a meaningful impact.

¹ BNEF’s Net Zero Scenario, which is published as part of the *New Energy Outlook*, charts an energy transition pathway consistent with the Paris Agreement goal of keeping global warming well below 2C, while pursuing the more ambitious 1.5C target and achieving net-zero emissions worldwide by 2050.

What is PVcase’s technology?

PVcase is a software company that offers a suite of tools to aid in site selection, design, development and permitting of solar projects. The software is geared toward both utility-scale projects and rooftop installations for commercial and industrial customers (Figure 4). PVcase Ground Mount and PVcase Roof Mount are AutoCAD plug-ins that streamline solar project design processes by automating repetitive tasks such as defining the layout of modules/cables or the mounting structure of the PV system.

Another tool, PVcase Yield, employs ray tracing technology for faster and more accurate yield simulations, and PVcase Prospect (Anderson Optimization by PVcase) is a geographic information system (GIS) and site-selection tool that allows developers to access and visualize data needed to identify optimal sites for project development.

Why is PVcase a Pioneer?

Developers and investors tend to clog permitting queues by requesting to connect in the wrong places – for instance, where there is no node capacity, or in environmentally sensitive areas. With PVcase’s software, project developers can identify suitable sites and design technically viable products early in the development process.

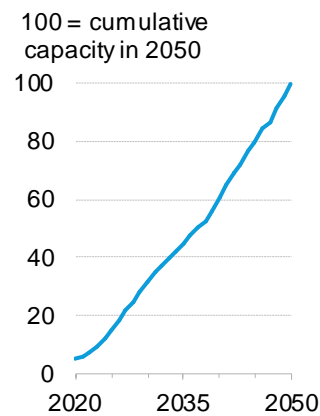
PVcase’s rapid growth indicates that it is meeting a clear need in the market. The company’s revenues have grown at a compound annual growth rate of 88% since 2020, and it is generating gross margins of 80-85%. The company’s software is helping a mature and proven technology scale faster. The planning of solar projects is not a region-specific problem, making it easy for this company to scale across geographies if data is available.

What’s next for PVcase?

PVcase sells to engineering, procurement and construction companies, project developers and consulting and engineering companies. The company raised a \$100 million Series B round in July 2023, which it plans to use to further expand its business. PVcase’s products are already widely used in the US and Europe, and the company has customers in nearly 80 countries. Increased growth in the solar market globally will ultimately translate into increased business opportunities for the company.

2.3. TS Conductor

Figure 4: Deployment of solar, rebased to peak capacity in BNEF’s Net Zero Scenario



Source: BloombergNEF

Table 3: TS Conductor company details

| Name | HQ | Founded | Funding | Technology |
|--------------|----|---------|--------------|--|
| TS Conductor | US | 2018 | \$25 million | Aluminum grid cable with carbon fiber core |

Source: BloombergNEF

Why is innovation needed for the power grid?

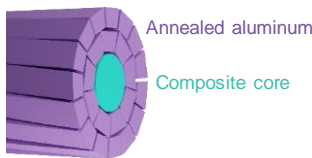
A net-zero world will mean a major increase in electricity demand, which will in turn require a vastly expanded grid. BNEF estimates that \$21.4 trillion of grid investment is needed in its Net Zero Scenario. Yet building new transmission capacity is difficult. The TransWest Express Transmission project in the US, for example, broke ground in June 2023, 18 years after it first started the permitting process. While new transmission lines will be necessary, maximizing the use of existing infrastructure can avoid a number of these bureaucratic bottlenecks.

What is TS Conductor's technology?

TS Conductor has developed a new power cable that has a current-carrying capacity three times higher than – and line losses 50% lower than – traditional cables. TS Conductor's power cable is made of the most conductive forms of annealed aluminum wrapped around a carbon core protected by an encapsulating aluminum sheath (Figure 5). In contrast with the steel core that is traditionally used in power cables, the lightweight yet high-strength carbon core in TS Conductor's cable avoids the weight penalty of steel and virtually eliminates sag while maximizing use of conductive aluminum.

The company sells its aluminum-encapsulated carbon fiber core to conductor companies, and it sells the full power cable to utility customers.

Figure 5: Simplified illustration of composite-core conductor



Source: BloombergNEF

Why is TS Conductor a Pioneer?

While software is useful in addressing the bottlenecks in renewable power deployment, better grid infrastructure will ultimately be needed to accommodate growing demand for electricity. TS Conductor's product allows grid operators to upgrade existing transmission and distribution cables through reconductoring projects that can leverage existing "rights of way" and towers, creating more grid capacity without having to build out new places for wires. Although TS Conductor's power cable is two to three times the cost of a typical power cable of the same diameter, BNEF estimates that for a 100-kilometer line, the payback period would be four years based on opex savings alone. The capex needed for supporting infrastructure is also lowered, primarily through fewer and shorter towers and upgrading existing infrastructure.

What's next for TS Conductor?

TS Conductor was founded in 2018 and made progress towards commercializing its power cable early last year. In January 2023, TS Conductor announced the opening of its first factory in the US. The factory can produce up to 5,000 miles of conductors annually. The firm is currently selecting a new factory site capable of producing 50,000 miles of cable per year.

The company is also exploring a selection of revenue models to encourage the adoption of its product. It has also set up a joint venture with Starwood Energy Group Global (now Lotus Infrastructure Partners) to build transmission lines or reconductor existing lines at no upfront cost, instead financing the lines with savings from using TS Conductor's technology. The company's customers are mainly US-based, but the firm is planning to expand globally.

3. Challenge 2: Decarbonizing the construction and operation of buildings

The CO₂ emissions associated with buildings account for 33% of global emissions. Yet while several pathways for decarbonizing buildings are already available – namely electrification and energy efficiency – few companies have found successful business models for achieving scale. Harder yet is decarbonizing the cement and steel that go into the construction of buildings, as there are no cost-competitive, low-carbon production methods.

For more information, see:

- *Technology Radar June: Software for Commercial Buildings* ([web](#) | [terminal](#))
- *Commercial Building Decarbonization: Digital Innovations* ([web](#) | [terminal](#))
- *Tech Radar: Low-Carbon Cement* ([web](#) | [terminal](#))
- *Circular Strategies for Construction and Demolition Waste* ([web](#) | [terminal](#))

3.1. Aeroseal

Table 4: Aeroseal company details

| Name | HQ | Founded | Funding | Technology |
|----------|----|---------|--------------|---------------------------|
| Aeroseal | US | 1997 | \$89 million | Sealing process for homes |

Source: BloombergNEF

Why is innovation needed to make homes more efficient?

Energy efficiency is an underutilized tool for addressing climate change, and particularly for decarbonizing buildings. Moreover, efficient homes save consumers money on their energy bills. As the world switches away from fossil-fuel heating systems, an increase in energy efficiency will enable the adoption of smaller, cheaper heat pumps. This lowers the upfront cost of electrification, which is a key barrier to widespread adoption.

What is Aeroseal’s technology?

Aeroseal has developed a sealing process that can be applied in new or existing heating, ventilation and air conditioning (HVAC) ducts, or to the building envelope of newly built homes, to boost energy efficiency and thermal comfort. In either application, large openings in the home or building are closed off, and the intended space is pressurized using a large fan and plastic tubing (Figure 6). Upon pressurization, a non-toxic sealant is sprayed into the space through the tubing and into the air. Because the space is pressurized, the sealant particles rush to escape through the leaks, finding any existing small holes and cracks in the ducts or envelope and gradually accumulating to form an air-tight seal. This process effectively seals the leaks without compromising other areas of the ductwork or envelope. The software running the technology measures the reduction of air leakage and completes the process when the necessary tightness levels are achieved.

Figure 6: Sealed duct system connected to an Aeroseal aerosol sprayer and fan



Source: Aeroseal

Aeroseal sells its equipment to residential and commercial and residential contractors, dealers, duct cleaners, and others for their delivery of air sealing in ducts or the building envelope. Additionally, Aeroseal has an in-house team of estimators, engineers, and installers that partner with builders, energy services companies, property owners, and facilities managers to plan and execute sealing projects.

Why is Aeroseal a Pioneer?

Aeroseal’s process reduces energy demand in homes through two means. First, it reduces the energy demand of fans in heating, ventilation and air conditioning systems, since a well-sealed duct mean less pressure is required to force air through the system, and less heat is wasted. Second, its process for homes reduces air infiltration from the outside, reducing heating and cooling demand.

Aeroseal’s process can seal a home up to 0.6 air changes per hour, a level of infiltration that is 80% lower than US Energy Star Standards. One study of Spanish homes estimated that air infiltration is responsible for 2-20 kilowatt-hours (kWh) of additional heating energy consumption per square meter in homes each year. Eliminating this wasted energy for all residential floor space in the US could reduce emissions by up to 90 million metric tons of carbon dioxide equivalent (MtCO_{2e}) annually.

Aeroseal’s process is also four times faster than traditional sealing methods, and far less labor-intensive. HVAC ductwork is largely behind walls and ceilings, but Aeroseal’s technology avoids costly demolition of wall and ceilings. Because the technology provides real-time monitoring of air pressure during the sealing process, technicians track the progress and effectiveness of the sealant applications, and installers and owners can certify that the sealing was successful and that the building will pass inspection. The process does have a higher cost, but BNEF estimates the payback time would be 7.5-10 years, which is in line with typical energy efficiency projects.

What’s next for Aeroseal?

Aeroseal is based on an old technology process that has in recent years started to gain traction. It was founded in 1997 and acquired by HVAC manufacturer Carrier in 2001. The original founder bought back the company in 2010. Since then, Aeroseal has sealed more than 260,000 buildings worldwide. The company’s sealing process qualifies for the US Inflation Reduction Act’s Energy Efficient Home Improvement Credit, which covers 30% of installation costs up to a maximum of \$1,200. Aeroseal raised \$67 million in a Series B round in July 2023.

3.2. Celsius Energy

Table 5: Celsius Energy company details

| Name | HQ | Founded | Funding | Technology |
|----------------|--------|---------|-------------------|--------------------------|
| Celsius Energy | France | 2020 | Subsidiary of SLB | Ground-source heat pumps |

Source: BloombergNEF

Why is innovation needed in heat pumps for commercial buildings?

Heat and electricity demand in commercial buildings accounted for 10% of global CO₂ emissions in 2022, according to the International Energy Agency (IEA). Heating and cooling in commercial buildings can be decarbonized using heat pumps, but the scale of heat demand in these buildings requires big, expensive heat-pump systems.

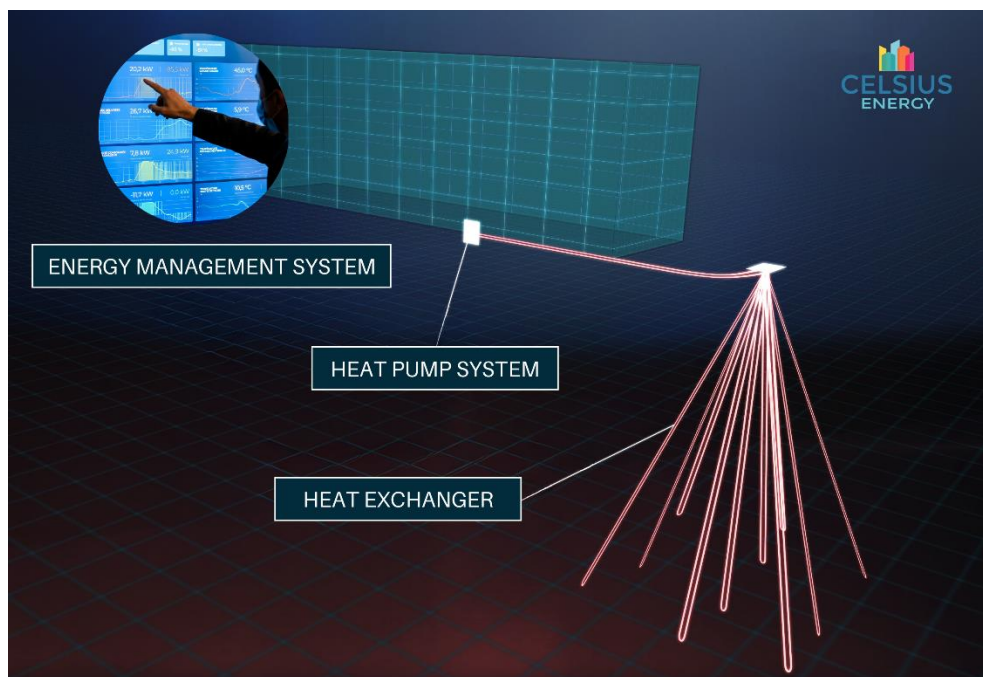
What is Celsius Energy’s technology?

Celsius Energy plans, designs and installs ground-source heat pumps for commercial buildings. Its technology comprises three main components (Figure 7):

- A closed, pyramid-shaped heat exchanger with angled, U-shaped probes, typically 200 meters deep, in which a heat transfer fluid circulates.
- A connected heat pump allows heat to be exchanged with the subsurface. Heat captured and stored underground in the summer can be retrieved efficiently in the winter.
- A digital control platform minimizes electricity consumption by optimizing the operation of the subsurface exchanger and the use of heat pumps coupled to the building in real time.

Celsius Energy’s angled drilling differentiates it from the vertical drilling typical in the industry.

Figure 7: Overview of Celsius Energy ground-source heat pump system



Source: Celsius Energy

Why is Celsius Energy a Pioneer?

Celsius Energy’s tilted-angle drilling reduces the amount of space needed at the surface for installing boreholes. This is an important consideration for commercial buildings in urban spaces where space is at a premium and minimal disruption is beneficial. In conventional vertical drilling, boreholes are spaced six to 10 meters apart to prevent thermal interference between them. For commercial buildings that require dozens to hundreds of boreholes, that surface area may not be available. Celsius Energy uses a surface area equivalent to just two parking spaces to install a standard system with around twenty wells. Additionally, Celsius Energy says it has developed software that improves the design and operation of these ground-source heat pumps, resulting in lower capex and opex, respectively. Digital controls optimize system performance and reduce energy consumption.

What’s next for Celsius Energy?

Celsius Energy is a subsidiary of and financed solely by oilfield services company SLB. The company’s target market is retrofits of urban commercial buildings with a footprint of 5,000 square feet (464 square meters) or larger. It operates in North America and Europe.

3.3. Kelvin

Table 6: Kelvin company details

| Name | HQ | Founded | Funding | Technology |
|---------------|----|---------|--------------|-------------------------------------|
| <u>Kelvin</u> | US | 2012 | \$14 million | Radiator covers and thermal storage |

Source: BloombergNEF

Why is innovation needed for retrofitting multifamily buildings?

Residential buildings were responsible for 17% of global CO₂ emissions in 2022, according to the IEA. Decarbonizing residential buildings requires installing heat pumps and other retrofits, but the high upfront cost remains a barrier to adoption. Replacing heating and cooling systems is particularly hard in occupied multifamily apartment buildings, where traditional retrofits are invasive and disruptive for tenants, and electrification solutions present limited financial returns for building owners.

What is Kelvin's technology?

Kelvin has two products for decarbonizing heating and cooling for apartments:

- Cozy: an enclosure for steam and hydronic radiators
- Hybrid Electrification: a heat pump and thermal battery system

Cozy consists of a thermal enclosure, fan and boiler control system (Figure 8). The insulated enclosure keeps the warmth at the radiator, and fan speed determines how much of that heat is distributed into the room. This prevents rooms from overheating and, with the digital controls on the radiator enclosures connected to the boiler, lowers boiler usage and natural gas consumption.

Figure 8: Kelvin's Cozy



Source: Kelvin

Kelvin's second product is dubbed "Hybrid Electrification." Kelvin installs a window-fixed heat pump (which it does not manufacture) and a thermal storage system (which it does manufacture) in each room, but the existing boiler and radiator system is not replaced. Instead, the heat pump provides heating and cooling for temperatures above freezing, and the boiler and radiator system provides heating when temperatures are below freezing. The thermal storage system, which uses a hydrated salt, phase-change material, allows for the system to provide demand response services to the grid. Kelvin's products do not result in the full electrification of heating and cooling systems, but the company says its products can electrify 80% of a home's heating needs.

Why is Kelvin a Pioneer?

Kelvin's business model provides significant decarbonization benefits at no upfront cost to the customer, overcoming the largest barrier to heat pump adoption. The company instead generates revenue over the lifetime of a 10-year contract. For the Cozy radiator enclosure, Kelvin receives a portion of the natural gas savings the customer sees. For the heat pump and thermal storage system, Kelvin receives most of the demand response revenues generated from its system control. The products are designed specifically for multifamily residential buildings with radiators, a market that has few commercially available decarbonization technologies.

What's next for Kelvin?

Kelvin sells to residential building owners in urban areas, starting with New York City. Most of its business is from multifamily buildings that are rentals, cooperatives, condos or public housing. Kelvin's radiator enclosure is already on the market commercially, with over 30,000 units sold to date. The first deployment of its heat pump and thermal storage system will occur this year, and Kelvin expects to reach full-scale commercialization in 2025.

Kelvin Systems stands to benefit from several favorable market conditions. Its heat pump and thermal storage product would be eligible for the Investment Tax Credit in the US and similar subsidies in the EU. In New York City, the company's first market, Local Law 97 comes into effect this year and limits the greenhouse gas emissions from buildings above a certain size. According to the Urban Green Council, over half of the residential buildings covered by the law are older buildings that use steam systems.

Kelvin Systems most recently raised a \$7 million Series A round in April 2023. Among its investors are 2150, a buildings-focused climate-tech venture capital firm; real-estate company Rudin; and climate-tech investor Third Sphere.

4. Challenge 3: Creating the next generation of net-zero fuels

Shipping and aviation have proven stubbornly difficult to electrify. Ships and planes typically travel long distances, and batteries would need to reach extraordinarily high levels of energy density to provide adequate energy without being unusably heavy. The most practical, near-term pathway toward abating these sectors' emissions is thus to create net-zero fuels.

Demand for these low-carbon fuels is growing as governments and companies set net-zero targets for shipping and aviation. The International Maritime Organization is aiming for net-zero emissions by 2050, and more than 40 air carriers have set some form of sustainable aviation fuel adoption target. The European Union is incorporating shipping emissions into its Emissions Trading System and is mandating that EU aviation fuel suppliers blend sustainable aviation fuel into their jet fuel supply.

Decarbonizing the shipping and aviation industries will require a significant expansion in the supply of net-zero fuels.

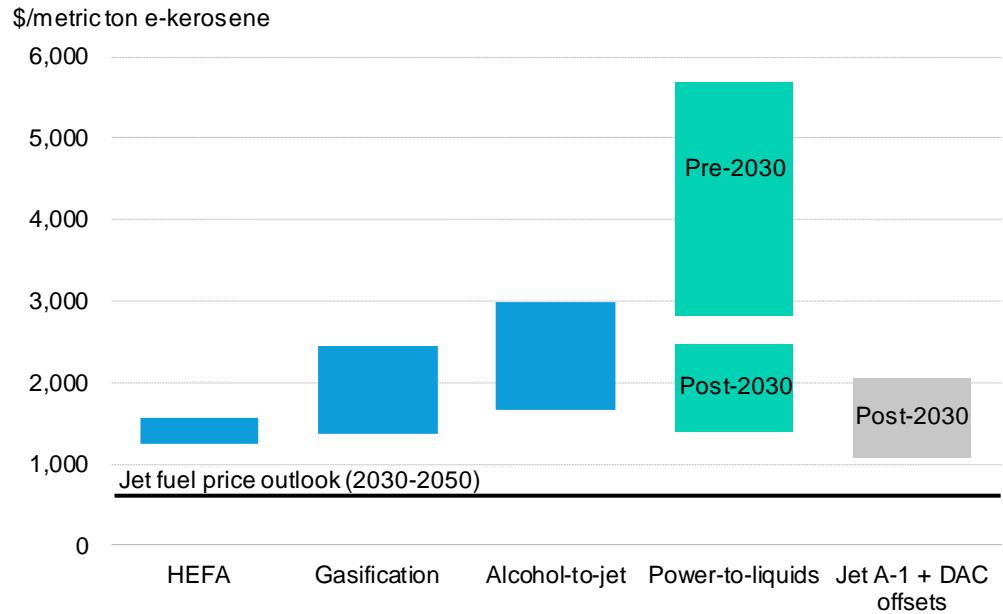
Why is innovation needed in biofuels?

Bio-based feedstocks represent one of the best opportunities to supply low-carbon fuels that will likely be necessary for the aviation and shipping sectors to decarbonize. Many pathways exist for converting these feedstocks into useful fuels, and these conversion processes are more cost-competitive than e-fuels, a synthetic fuel made from hydrogen and carbon.

Unfortunately, all sources of biofuels are supply constrained, and high-quality ones even more so. Hydroprocessing, a mature oil refining process that is currently the cheapest way to produce biofuels, mostly relies on used cooking oil, vegetable oil or tallow as a feedstock. BNEF estimates that waste fats, oil and grease could supply enough sustainable aviation fuel to satisfy only 3-6% of global jet fuel demand.

Additionally, renewable fuels are all more expensive than traditional fossil fuels. Sustainable aviation fuels, for example, cost 2.5 to eight times more than fossil jet fuel (Figure 9). Hydroprocessing is already a mature technology with little potential for production costs to come down, and other methods of producing fuels will also struggle to become cost competitive with fossil fuels.

Figure 9: Production cost of sustainable aviation fuels



Source: BloombergNEF, International Energy Agency, International Civil Aviation Organization, International Council on Clean Transport, de Jong and interview. Note: HEFA stands for hydroprocessed esters and fatty acids. Power-to-liquids assumes a two-step syngas pathway using green hydrogen and direct air capture or biogenic CO₂.

For more information, see:

- [2024 Sustainable Aviation Fuel Outlook: Getting Airborne \(web | terminal\)](#)
- [What's New in Renewable Fuel Capacity \(web | terminal\)](#)
- [US, Canada Renewable Fuel Ambitions Face Feedstock Crunch \(web | terminal\)](#)
- [E-Fuel Touted as Ticket to Clean Aviation Needs a Tailwind \(web | terminal\)](#)

4.1. CoverCress

Table 7: CoverCress company details

| Name | HQ | Founded | Funding | Technology |
|-----------------|----|---------|--------------|-----------------------------------|
| CoverCress Inc. | US | 2013 | \$48 million | Novel crop for biofuel production |

Source: BloombergNEF

What is CoverCress Inc.'s technology?

CoverCress Inc. (CCI) has developed a winter oilseed crop called CoverCress that can be harvested and used as a feedstock for biofuels such as renewable diesel and sustainable aviation fuels. Using plant breeding to improve yield and maturity plus advanced gene-editing tools to improve the quality and composition of fiber and oil, CCI has converted field pennycress into CoverCress. CoverCress is grown between a corn and soybean crop rotation on land that would otherwise lay fallow.

CCI contracts farmers to grow CoverCress and pays the farmers at harvest, creating a new revenue opportunity for growers. When crushed, CoverCress grain creates two co-products, oil and meal. The oil has a low-carbon intensity that makes it an attractive feedstock for biofuel production. The meal is protein feedstock source for animal feed. CoverCress sells the grain to crushers for fuel production and the resulting meal to producers of chicken feed.

Why is CoverCress Inc. a Pioneer?

CCI’s crop has a very low carbon intensity compared with other biofuel feedstocks used to produce biofuels. This benefit is achieved because CoverCress production does not compete with land for food production, and it does not require clearing new land for growing the crop. CoverCress also confers the ecosystem benefits of a cover crop to the cropland on which it is grown, such as lowering nitrogen runoff and sequestering carbon.

Given that expanding production capacity for biofuels is likely to result in a highly supply-constrained environment for available feedstocks, there will almost certainly be demand for this product. The oil produced from the crushed CoverCress grain is a new feedstock, and it could be converted into biofuels through hydroprocessing, the cheapest form of renewable fuel production available today.

What’s next for CoverCress Inc.?

CCI planted its first commercial crop in the fall of 2023 on 3,000 acres under contract with 24 growers. The grain from this first commercial production, which will be harvested in May 2024, will be sold to a large integrated broiler-chicken producer in its whole grain form for inclusion in feed. As the company continues to scale its acres and further modify the composition of its crop through gene editing, grain from future commercial plantings will be delivered under an offtake agreement for crush volumes with Bunge Chevron Ag Renewables. Bunge Chevron Ag Renewables recently announced the start of construction of a new crush facility where this future CoverCress grain will be delivered.

Bringing a new crop to market has its challenges, with farmer hesitation and policy being the two primary hurdles for CCI to overcome. First, CCI must generate demand from growers to contract with CCI to produce CoverCress. In particular, the timing of when CoverCress is harvested requires farmers to plant their follow-on crop, likely soybeans, later in the year than if the ground lay fallow. Coupled with timing constraints on labor and equipment, this makes the spring planting season an even busier and tighter timeline than it already is. CCI offers incentives in its contracts to share the risks arising from these timing pressures with growers.

Policy is also a challenge for bringing CoverCress to market, from both timing and scaling standpoints. CCI must comply with regulations enforced by the US Department of Agriculture for gene-edited crops, the US Environmental Protection Agency for crop protection products and renewable fuel incentives, and the US Food and Drug Administration for use as animal feed.

4.2. XFuel

Table 8: XFuel company details

| Name | HQ | Founded | Funding | Technology |
|--------------|---------|---------|---------------|---|
| <u>XFuel</u> | Ireland | 2010 | \$9.1 million | Sustainable fuel producer using waste inputs (bio and fossil) |

Source: BloombergNEF

What is XFuel's technology?

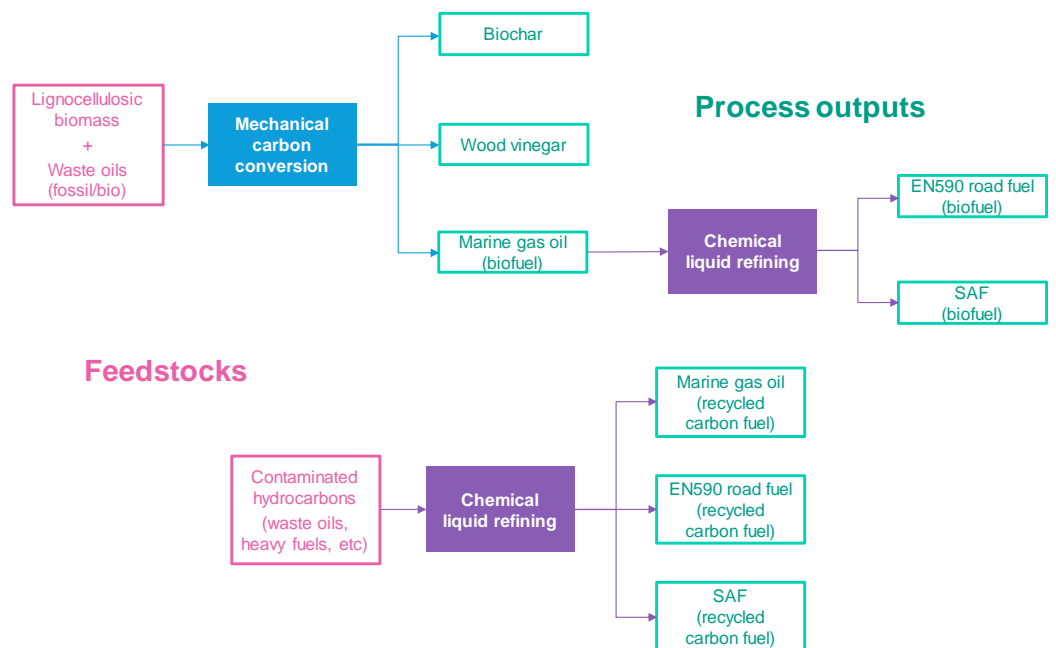
XFuel has developed two technologies that produce sustainable fuels from wastes (Figure 10). The first is "mechanical carbon conversion" (MECC), which it uses to produce drop-in marine fuels and biochar. The feedstocks for this process are:

- lignocellulosic waste such as woody biomass, or manufacturing, agricultural and forestry residues
- waste oils (fossil/bio)

These lignocellulosic waste and waste oils are combined at a 2:3 ratio, respectively. The one-step process is carried out at low temperatures and pressures, keeping costs down. Biochar is also an output of this process, resulting in a carbon-negative fuel if the biochar is sequestered.

XFuel's second technology is "chemical liquid refining" (CLR), a one-step cleaning and cracking process to convert any contaminated hydrocarbon liquid into low-carbon marine (distillate marine fuel), road (EN590 diesel) and aviation fuels. CLR is similar to hydrotreating and hydrocracking but uses a chemical reactant instead of hydrogen to desulphurize and upgrade waste streams into fuels. CLR can also upgrade the drop-in fuel produced by MECC, reducing its level of sulfur to meet road and aviation fuel specifications.

Figure 10: XFuel inputs and outputs for their fuel production processes



Source: BloombergNEF. Note: SAF stands for sustainable aviation fuel.

While the company can produce several fuels, its first product is a marine gas oil distillate that it intends to sell to shipping companies, marine fuel traders and sustainable fuel distributors. This marine gas oil is produced through the CLR process using Marpol Annex I "sludge" as a feedstock.

Why is XFuel a Pioneer?

XFuel is creating sustainable fuels for shipping, a hard-to-abate sector that has been stunted by the lack of economically viable alternatives to fossil fuels. XFuel says its drop-in fuels will be sold

at fossil-fuel pricing with the option to attain sustainability premiums under schemes like the EU's FuelEU Maritime and EU Emissions Trading System. The wide range of feedstocks, namely waste lignocellulosic biomass and waste oils, mitigate concerns about the availability of feedstock in the medium term.

XFuel's products result in significant reductions in greenhouse gas emissions if used. The company's first commercial product, marine gas oil produced through CLR results in an 85% reduction in greenhouse gas emissions compared with traditional fossil fuels. Due to the cost efficiency of the CLR process, the fuel can be sold at fossil fuel pricing and still be very profitable, according to the company. In MECC, lignocellulosic biomass and waste lubricate oils are used to produce fuel and biochar, resulting in a carbon-negative fuel with 145% greenhouse gas savings once the biochar is sequestered. The go-to-market strategy of the company is to penetrate the market with its CLR products, gain market share and transition customers to the more sustainable MECC biofuel.

What's next for XFuel?

XFuel has two operational demonstration plants, one for each of its technologies. The MECC demo plant produces 1,000 tons of marine gas oil annually. The CLR demo plant runs in batches and produces 100 liters of marine gas oil per run.

The company wants to build, own and operate its plants with strategic partners. It plans to build the first CLR plant, capable of producing 14,000 tons per year of marine gas oil, in Europe in 2024 or 2025. It also plans a MECC plant for 2025 with a capacity of 4,000 tons of marine gas oil per year. XFuel raised \$9.1 million in a seed round in April 2022. Investors include climate-tech and generalist investors Union Square Ventures, HAX/SOSV and AENU.

5. Wildcards

Each year BNEF Pioneers accepts applications for our wildcard category. These companies are developing technologies to address other challenges in the transition to a net-zero future. This year's BNEF Pioneers wildcard winners are innovators across steel, lithium-ion batteries and biodiversity.

5.1. Element Zero

Table 9: Element Zero company details

| Name | HQ | Founded | Funding | Technology |
|--------------|-----------|---------|----------------|--|
| Element Zero | Australia | 2023 | \$10.5 million | Iron production for steel through electrolysis |

Source: BloombergNEF

Why is innovation needed for producing low-carbon steel?

Steel is the most widely used metal in the world and essential in buildings, infrastructure, vehicles, tools and packaging. The sector accounts for 8% of total global emissions and almost 30% of industrial emissions. Moreover, global steel production is rising to meet demand from growing economies in India and Southeast Asia.

Several methods of decarbonizing steel are available, including green fuels, recycled scrap, new production pathways and carbon capture, but implementing these technologies will require additional capital expenditures of around \$278 billion by 2050. Innovation is needed to lower costs and create technologies that can be easily adopted in the industry.

For more information, see *Decarbonizing Steel: Technologies and Costs* ([web](#) | [terminal](#)).

What is Element Zero’s technology?

Element Zero has developed an electrolysis process, which uses neither membranes nor carbon electrodes, to produce metals (and cement as a minor byproduct) with intermittent renewable power. It can produce high-quality (98%) iron with low-quality iron ore fines.

Element Zero’s process dissolves iron ore in a large tank of molten alkaline electrolyte. The electrowinning tank has multiple cathodes (stainless steel) and anodes (nickel) where oxygen and iron are produced when an electrical current is applied. The process takes place at ~250C and can be without power for four to 12 hours as the solvent only loses a few degrees of heat per hour. There is no membrane, and iron ore grades as low as 30% can be used (58% is the average for Australia; 62% is typical globally). The iron produced is 96-98% pure, which is higher than the 92% purity produced from blast furnaces.

Why is Element Zero a Pioneer?

Iron is the biggest component of steel and its greatest source of carbon emissions, but Element Zero’s ironmaking process is net zero if powered by clean electricity. Moreover, the equipment used is simple. The process does not contain any membranes, and the electrodes are not made from carbon, avoiding any direct emissions. Despite operating at a higher temperature than other processes, the high heat capacity of the solvent used means the process can maintain its temperature without power for hours, making it compatible with intermittent renewable power.

Currently, iron ore is processed at high temperatures to remove impurities and oxygen. The leading steel decarbonization routes (hydrogen and carbon capture and storage) have issues with inefficiencies, ore grade, cost and a lack of large-scale infrastructure. Directly electrifying steel production can help avoid these challenges, and the simplicity of Element Zero’s system could make scaling easier.

What’s next for Element Zero?

Element Zero is an early-stage company, and its technology has been tested at small scale. The company is currently building a demonstration plant capable of processing one metric ton of iron per day in Perth, Australia, with a target date of 2025. The company expects commercial-scale deployments will happen in the late 2020s. It is working with major European, Japanese and Korean iron and steel companies to test its product, and it has signed exploration agreements, including one for initial iron supply from major iron ore miners.

5.2. Li-Metal

Table 10: Li-Metal company details

| Name | HQ | Founded | Funding | Technology |
|--------------------------|--------|---------|------------------------|------------------------------|
| Li-Metal | Canada | 2018 | Reverse merger in 2021 | Lithium-metal battery anodes |

Source: BloombergNEF

Why is innovation needed to improve the energy density of lithium-ion batteries?

Increasing energy density is a constant quest for battery makers. Higher energy density translates to improved range for electric vehicles, and once the average range of electric vehicles better

matches consumer expectations, energy density improvements should begin to reduce the average battery pack size. This will be critical to speeding up electrification of the passenger car fleet. More energy-dense batteries will also expand the potential of battery-powered drive trains into harder-to-abate segments such as trucks and small aircraft.

What is Li-Metal's technology?

Li-Metal produces lithium-metal anodes from lithium carbonate. Typically, lithium metal production involves an intermediate and costly step where lithium carbonate is converted into lithium chloride; Li-Metal's process eliminates this step. The pure lithium metal is used to produce lithium-metal anodes for batteries, which have a higher density than the graphite anodes used today but are unstable with conventional liquid electrolytes. Once solid-state batteries are commercialized, demand for lithium-metal anodes will rise. Li-Metal aims to sell lithium metal and lithium-metal anodes to automakers and battery developers.

Why is Li-Metal a Pioneer?

BNEF expects solid-state batteries will become commercial towards the end of the decade, and their growth will open the way for lithium-metal anodes. The combination of solid-state batteries and lithium-metal anodes will provide a substantial boost to battery performance and capacity. BNEF expects that lithium-metal anodes will make up 22% of the anode chemistry mix in 2035. For more information, see *Technology Radar: Next-Generation Battery Anodes* ([web](#) | [terminal](#)).

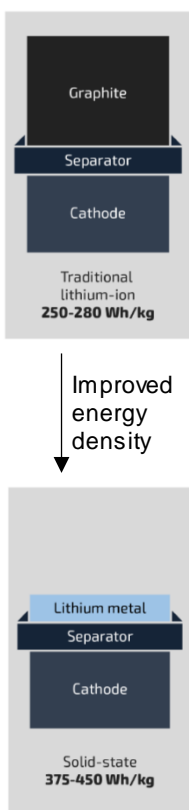
Lithium-metal anodes are difficult to produce, but Li-Metal is a leading manufacturer. Unlike the graphite anodes produced today, lithium-metal anodes require extremely dry conditions, as lithium metal is reactive with moisture in the air. Battery makers are increasingly looking to secure supplies of lithium metal for testing but are finding this difficult. Li-Metal has developed a lithium-metal manufacturing process that works and requires 40% less energy than conventional production. Additionally, Li-Metal's anode production process is designed to use less lithium per square meter of anode material, a more efficient use of the material (Figure 11), though adoption of lithium-metal anodes would increase overall lithium demand by 45-130%.

What's next for Li-Metal?

Li-Metal is currently operating two pilot plants in anticipation of scaling in the second half of the decade. In 2023, Li-Metal produced its first lithium-metal product as its pilot facility in Markham, Ontario. It also has an anode pilot plant in Rochester, New York that produced more than 8,200 meters of sample lithium-metal anode material in 2023. Li-Metal has a joint development agreement with Blue Solutions for developing solid-state, lithium-metal batteries and with Mustang Vacuum System for equipment. Li-Metal aims to commission a 125-megawatt-hour (MWh) commercial-scale line for lithium-metal production and a 500MWh commercial line for anode production, both to be completed by the end of 2024.

Li-Metal went public via reverse merger in October 2021. The company raised more than \$25 million through private placements and warrants in connection with the reverse merger.

Figure 11: Traditional lithium-ion and solid-state battery comparison



Source: Li-Metal. Note: Wh/kg is watt-hours per kilogram.

5.3. NatureMetrics

Table 11: NatureMetrics company details

| Name | HQ | Founded | Funding | Technology |
|-------------------------------|----|---------|--------------|--|
| NatureMetrics | UK | 2014 | \$37 million | Biodiversity monitoring with environmental DNA |

Source: BloombergNEF

Why is innovation needed for monitoring biodiversity?

Over half of the global economy is dependent on the ecosystem services provided by nature, according to the [World Economic Forum](#), and nature and biodiversity impacts are increasingly seen as material concerns for large corporates and financial institutions. Biodiversity is shrinking faster than at any point in human history, according to the International Science-Policy Platform on Biodiversity and Ecosystem Services. Reducing biodiversity loss is important as a climate mitigation strategy, but it also addresses a grand environmental challenge in its own right.

Quantifying the biodiversity impact of human activity will be essential in combatting biodiversity loss. However, the issue cannot be simplified into a single global metric, like CO₂ equivalent now is for climate change. Measurement often involves costly and invasive manual measurements of ecosystem factors.

For more information, see:

- [Biodiversity Finance Factbook: COP28 Edition](#) ([web](#) | [terminal](#))
- [TNFD Release Puts Nature at Heart of Financial Disclosure](#) ([web](#) | [terminal](#))

What is NatureMetric’s technology?

NatureMetrics has devised a standardized way to use environmental DNA (eDNA) analysis to measure biodiversity health at scale. The company’s key technology is a portable kit that allows for the collection of small samples of water, soil or sediment. Samples are then pushed through a filter and sent to a lab, where DNA is extracted to reveal the presence (or absence) of thousands of species. The data is analyzed and converted into simple insights and ecosystem condition metrics to enable stakeholders to calculate and monitor the biodiversity impacts of their activities.

NatureMetrics sells kits to conservation organizations, but most of its revenue generation is from advisory services and larger-scale offerings to corporate clients through a subscription service. Samples are typically collected by environmental consultancy firms on behalf of the customer.

Why is NatureMetrics a Pioneer?

Biodiversity monitoring is in its infancy, and NatureMetrics is a first mover in the space. The company is the only one to have scaled and standardized eDNA to the point it can be offered as a subscription service. The technology has been demonstrated to be effective in hundreds of academic papers from its team of over 40 PhD researchers.

What’s next for NatureMetrics?

NatureMetrics has raised \$37 million to date and has [500 customers across 100 countries](#). Since the launch of its Nature Intelligence platform in 2023, it is now incorporating other data sets, such as geospatial assessment and advanced AI modeling to provide a comprehensive solution for its corporate clients. The key to the rapid adoption of its technology is the enactment of regulation requiring land developments and company operations to report and disclose their impacts on

biodiversity. The most promising markets for uptake of the technology are the EU, the UK, the US and Japan, where nature-related reporting and disclosure is either beginning or under discussion. Approving or recommending the use of eDNA for reporting would be a significant boost to the company. A recent [report](#) by the Taskforce on Nature-related Financial Disclosures outlines the benefits of eDNA in measuring ecosystem condition metrics.

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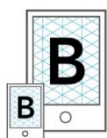
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