TRUE NORTH INSTITUTE

Learning From 18 First of a Kind (FOAK) Climate Technology Investment Case Studies

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Executive Summary

It has become a near consensus view in the climate tech investment world that many promising, capital-intensive technologies for reducing global GHG emissions struggle to attract investors willing to take on technical and execution risks at the stage when the first major investments are needed. This is often found when the start-up has proven that the technology works in pilot or demonstration scale plants but has yet to build fully commercial scale production facilities. This stage of financing is often referred to as the "missing middle" or the "valley of death." The investments are often the first production of its kind (FOAK) production facility. However, good companies can hit an early demise due to financing challenges beyond FOAK to include any critically important stage of development where the capital requirements are of such a scale that traditional venture capital sources may be inadequate (small funds), and risks are deemed too high for private equity, infrastructure funds or project finance debt options. Our observation is that the major inflection point in revenue growth and value creation often follows close behind this critical stage of a climate tech startup's development.

This white paper aims to catalog the learning from successfully funded, mostly first of a kind production facility projects which are developing capital intensive technologies that aim to reduce global GHG emissions. Successful technologies studied include electric vehicles and related infrastructure (charging stations), wind turbines, solar panels, heat pumps, batteries and companies serving these sectors as suppliers, developers and distributors.

There is a very strong pattern observable from our selected group of case studies which we have undertaken. Generally, the funding at the commercial scaling stage of a climate technology company comes from a combination of three sources: the original venture capital backers, loans or grants from government agencies (most notably the DoE or China's NDRC) and from corporate customers as investors and/or providers of corporate offtake agreements.

This puts government funding in a highly powerful position, given there are few alternatives (e.g., perhaps just the EPA beyond the DoE in the US). With the Trump administrations cutbacks on the DoE's loan and grant program, this presents a greater challenge to US capital intensive new climate technologies, compounded by the risks to subsidies and other supportive policies. This points to continued Chinese energy transition related technology developments given the ongoing support such young companies receive from China's National Development and Reform Commission and other Chinese government sources. Similarly, this gives an edge to European climate tech startups over US companies, where the Europeans can gain access to the European Investment Bank, the Innovation Fund (EU), Horizon Europe and other programs.

The role of corporate investors and their offtake agreements stand out as critical drivers of successful FOAK financing. Companies like NextEra, Siemens Energy, Maersk, MHI, BP, Shell and Microsoft are notable examples of investors and off-takers supporting some of the recent FOAK success stories.

These findings regarding the historical importance of government grants and loans, combined with the US defunding of such projects, suggests that many of the promising clean technology companies will

have an even greater challenge – a deeper valley of death. Our observation is that perhaps the most viable alternative source of finance for this stage and type of investment will be syndicates of infrastructure, private equity and growth equity investors who bring value added resources to successfully and significantly understand, mitigate and reduce the usual set of risks encountered. This is far from a new concept, but rather such syndicates have been funding many of the most notable capital intensive recent clean tech companies including Form Energy, Fervo, Twelve, Monolith, CFS and others. Repeat investors behind such companies include TPG, NGP, Khosla, Temasek, Generate, Decarb Partners and EIP, most of whom have more than $1B to invest from current funds. Less frequent investors behind FOAK, but investors who are potential well-funded future FOAK investing partners include Brookfield and Blackrock, both of whom have recently raised energy transition infrastructure funds over $10B in aum.

To bridge the “missing middle” in funding first-of-a-kind (FOAK) climate technologies, clean-tech investors could usefully form formal, curated syndicates—coalitions of venture capital, growth equity, private equity, and infrastructure firms—that pool capital, expertise, and credibility to back a small number of high-potential companies through their riskiest scaling phases. By distributing financial and operational risk, leveraging diverse technical and sector know-how, and coordinating due diligence and governance under a lead investor framework, such syndicates can deploy larger capital stacks more quickly and make stronger investment decisions. Recent success stories like Form Energy (iron-air batteries) and Fervo Energy (geothermal) illustrate how aligned, value-added collaborations can overcome FOAK barriers, accelerate commercial deployment, and channel more resources to the most promising climate solutions—transforming execution at scale from the industry’s biggest obstacle into its greatest opportunity.

1. FOAK Definition

In the clean technology industry, a First-Of-A-Kind (FOAK) production facility refers to a commercial-scale installation or plant that implements a new or significantly improved clean technology for the first time. This facility goes beyond pilot or demonstration phases and is designed to operate at or near full commercial capacity, but it still carries higher technical, operational, and financial risks due to the lack of real-world deployment history at that scale.

Key characteristics of FOAK facilities:

1. Novel Technology: The core technology has not yet been deployed at commercial scale, though it may have been validated in labs or pilot plants.
2. Scale-Up Risks: It faces challenges associated with scaling up from smaller prototypes, such as unknown system integration issues or supply chain complexities.
3. High Capital Cost: Costs are often higher due to lack of standardization, unoptimized processes, and custom engineering.
4. Policy Relevance: FOAK status is often important for qualifying for public support programs (e.g., grants, guarantees, or contracts-for-difference), which aim to de-risk early deployments of clean technologies.

Examples:

- The first commercial green hydrogen plant using a novel electrolyzer design.
- A carbon capture and storage (CCS) facility integrated with a power plant using untested capture technology.
- The first large-scale direct air capture (DAC) facility with novel solvent or sorbent systems.

In this research, we use a broad definition of FOAK to include more than the first of a kind installation of technology or first facility being integrated into a given (steel, cement, gas plant, etc.) integration. We have sought to focus simply on the capital-intensive phases of commercial scaling - commercial scale being defined as approaching a scale where the unit economics have achieved much of the scale economies available. So this could in fact be the 5th of a kind if that plant scale achieved far superior unit economics than the 4th of a kind.

2. What do investors and founders mean by the "missing middle" and what creates it?

Some companies get to the commercial scaling stage of their evolution and should not receive funding based on the likely poor long-term return on that investment given the risk of that company or technology. The missing middle is not referring to these companies, but rather to companies that would appear to have attractive long-term return prospects relative to its various risks, but risk capital is constrained by virtue of the structure of the private markets industry. Venture capital finances companies generally up to the pilot stage and infrastructure scales the energy business after it has proven commercial scalability. No segment naturally steps in to fund commercial scaling of capital intensive businesses. So conceptually, good businesses don't get the financing that they may be able to justify on the basis of long-term prospects. Increasingly, we are seeing private risk capital (growth equity, buyout firms and infrastructure funds) being allocated to this stage of energy technology company development which we discuss at the end of this paper.

Beyond capital availability, clean tech FOAK projects face unique challenges relative to other technology scale-up projects, that tend to deter investors. Risk-averse EPC contractors, operating on 1–3% margins, avoid untested technologies and first-time integrations, favoring proven systems, while traditional lump-sum turnkey contracts clash with the dynamic, iterative, nature of climate tech. Building complex infrastructure, like green hydrogen plants, demands detailed engineering and procurement, construction oversight and commissioning, often beyond venture capital's scope. Expertise in cost estimation and stakeholder (strategics, regulators, suppliers) coordination is essential to mitigate execution risks. Finally, policy uncertainties, tied to subsidies and carbon pricing, coupled with limited insurance capacity due to scarce performance data, further undermine investor confidence and project bankability. As The Geneva Association noted in April 2024, the absence of early-stage collaboration between insurers and developers, coupled with few projects and unclear paths to profitability, restricts insurer participation.

3. What have been the funding solutions for the missing middle?

The solution in recent years has been government funding and corporate offtake contracts which serve to derisk the business and lower the blended cost of capital. Our analysis of FOAK case studies below provide illustrations of this common funding solution.

Another solution in syndication. Historically, syndication was the domain of early-stage venture capital as the business model thrived on the few exceptional investments in a 40-50 company fund with over 50% not returning capital. Growth equity is classically a control purchase, with a single large private investor joining the capital structure and board. In the energy transition space, the companies are too risky for classic growth equity investors, unless they syndicate. We saw that for many of the successful FOAK examples below including Form Energy, Fervo, Monolith, CFS, and others.

The investment rounds that are needed are typically in the range $100M-500M so are hard to fund individually but are within the reach of a broad coalition of investors. A more deliberate and consistent coalition investment approach may go a long way toward solving the problem of the missing middle. That coalition should be comprised of not only late-stage venture capital investors, but also other walks of the private equity world including growth equity investors and infrastructure investors. If an

energy transition investment coalition is built as a community, it can be empowered to help propel these companies to true global scale.

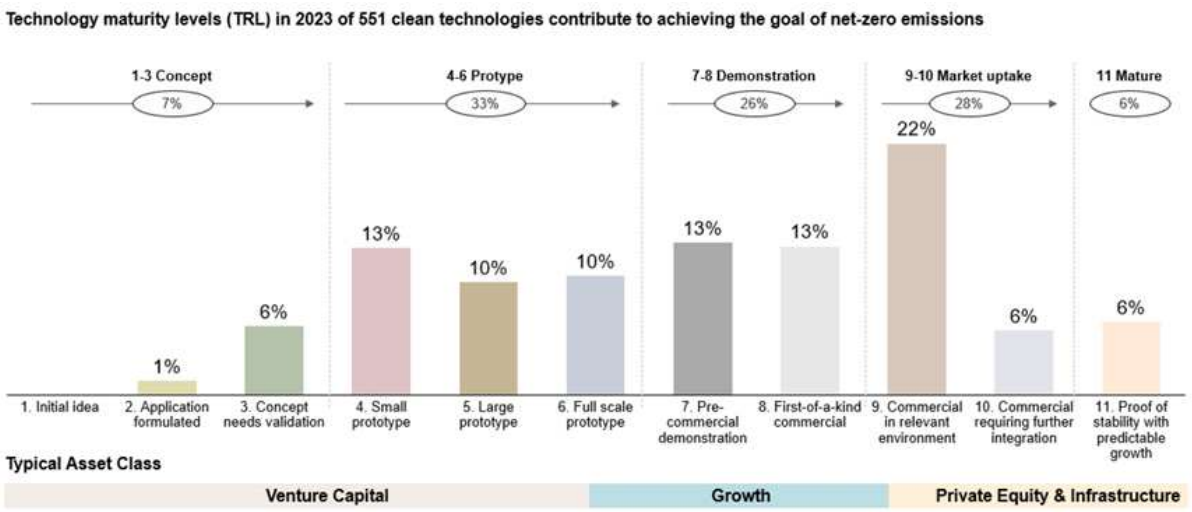
4. What needs funding most for the energy transition?

Renewable energy and electric vehicles are well on their way in the substitution of their fossil fuel incumbents with attractive economics only becoming more attractive. With expected developments of lithium-ion batteries, we believe that almost half of all greenhouse gas emissions (measured in CO2 equivalent tonnes) can be eliminated by renewables and electric transportation. The remaining emissions abatement is critically dependent on the successful development and rollout of newer technologies including carbon capture, clean hydrogen, nuclear fission and fusion, geothermal and bioenergy.

The early-stage development of such technologies is taking place at pace in both the arena of large public companies like Mitsubishi Heavy Industries, ArcelorMittal, Heidelberg, Linde, Constellation, Siemens, Air Liquide, Toyota, and ADNOC, and in the arena of venture capital backed private startups.

As you can see in Exhibit 1, IEA tracks over 550 clean technologies that contribute to achieving net zero and believes that 60% are at or beyond the demonstration stage and ready to be scaled commercially. FOAK investments generally commence in the TRL #7-10 range, using the TRL 1-11 scale employed by IEA.

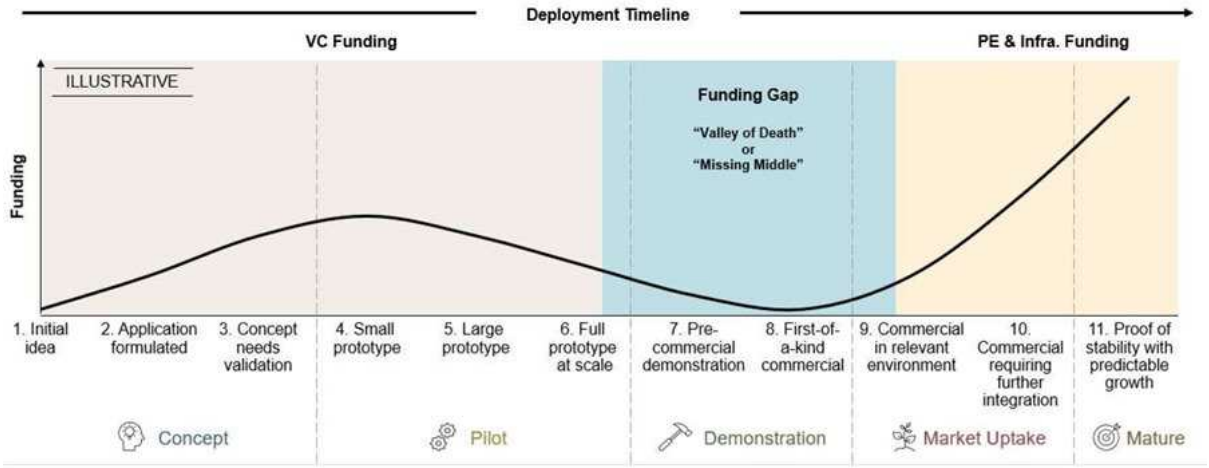
Exhibit 1: 60% of IEA tracked critical clean technologies are ready for commercial scaling



Source: IEA

But there would appear to be limited capital to take this 50% (TRL 7-10) of the energy technologies tracked by the IEA through to the point of becoming mature businesses (TRL 11). Many researchers have written about the “missing middle” or “valley of death” phenomena where there is a relative lack of capital to scale successful growth-stage companies. Exhibit 2 shows the same 11 technology readiness stages and plots a conceptual line for where capital flows.

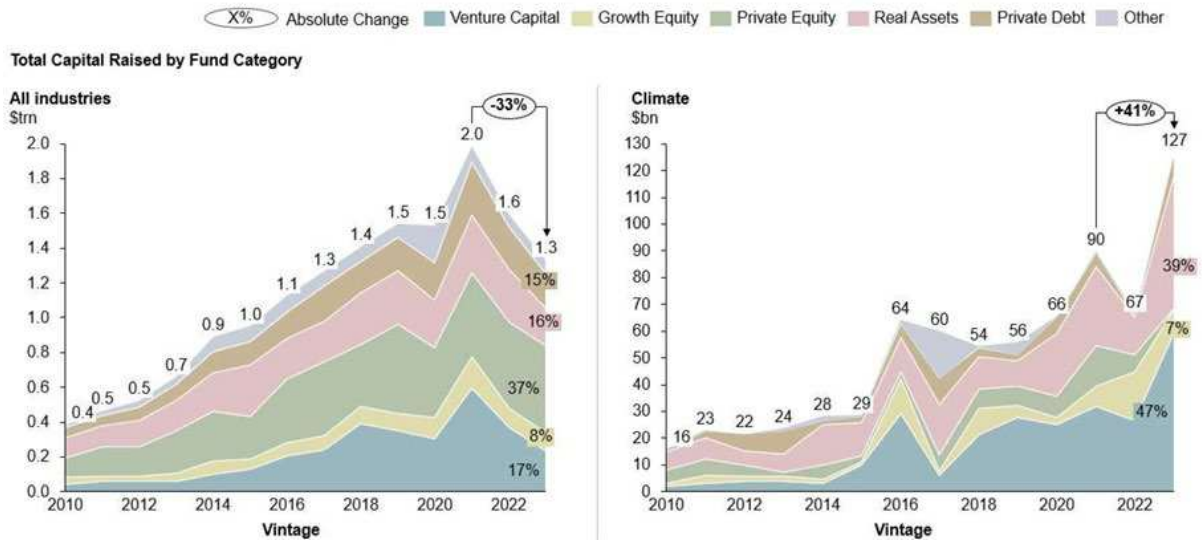
Exhibit 2: But the "missing middle" capital gap limits the scaling of emerging technology



Source: S2G Ventures

The acuteness of this problem is further illustrated in Exhibit 3 below. VC represents only 17% of all private capital raised in 2023, while VC represents 47% of all private capital raised for climate investing; i.e., there is a relative shortage of private equity and infrastructure fund raising to take venture backed companies on into their growth stages.

Exhibit 3: There is a relative shortage of private equity and infrastructure ("real assets") fund raising to take venture backed companies on into their growth stages



Or alternatively, there is a surplus of venture capital for climate investments, which would appear to be evident from the Pitchbook information presented in Exhibit 3. Pitchbook data would appear to support this explanation.

Today, there are over 1600 climate tech venture-backed companies recorded by private equity data provider, Pitchbook, as shown in Exhibit 4. For any given technology, there are anywhere from 30 to 240 companies vying for long-term survival. There is a growing consensus among energy transition VC investors that there will be significant "culling" of this universe of tech companies, as less capital is raised while more capital is needed. For larger private investors in the space, this should be an extraordinary opportunity to help choose and back the long-term winners as their competition leaves the scene and valuations become more reasonable.

Exhibit 4: Number of Energy Transition Startup Companies by Critical Sector and Amount Invested to Date *Ordered by Market Cap, USD $M*

Critical Sector	# of companies	Capital invested ($M)	Capital investment / Company ($M)	Median post Valuation ($M)	Average # investors per company
Next Gen Energy Storage (LDES, Thermal)	122	13,016	107	39	7
Nuclear Fusion	76	8,530	112	67	8
Nuclear Fission / SMRs	54	7,568	140	54	5
Hydrogen	240	7,144	30	31	4
Carbon Capture	113	5,053	45	32	6
Geothermal	76	2,243	30	18	6
Battery Materials & Critical Minerals	33	1,012	31	23	6
Waste to Energy (BioFuels / Electrofuels)	85	858	10	22	3
Other Cleantech	809	16,871	21	11	4
Total (including all sub-sectors)	**1608**	**$ 62,294**	**$ 525**	**$ 297**	**4**

Source: Pitchbook (20.02.25)

Clearly, capital is being spread too thinly across companies in these sectors, and concentrating more capital on fewer companies could see greater success in the critical technologies.

5. What is the universe of successful FOAK examples to be studied?

To identify a shortlist of successful FOAK case studies, we began with a broad set of candidates drawn from HolonIQ's Climate Unicorns database, companies included in the iShares Global Clean Energy ETF, and recipients of U.S. Department of Energy (DOE) funding over the past five years. We refined this list by excluding Chinese firms and "capital-light" businesses, focusing instead on companies developing and deploying hardware-intensive solutions. From there, we selected 17 FOAK examples that have successfully completed a FOAK deployment and remain operational today. From this list shown in Exhibit 5 we studied their histories to glean insight into what it takes to gain funding in the "missing middle".

Exhibit 5: List of successful FOAK case studies *(ordered by valuation $M. Includes businesses which have built FOAK, raised capital for FOAK and failed to build FOAK)*

Company	Business Description	Industry Sub-Sector	Valuation (May 2025)	Year of FOAK
FOAK successfully completed				
Tesla	Designs and manufactures EVs, battery energy storage systems, solar panels and related software.	Electric Vehicles & Energy Storage	$1,000B	2008
Vestas Wind Systems	Designs, manufactures, installs and services wind turbines.	Onshore & Offshore Wind Turbines	$40B	1980
Ørsted AS	Developed the world's first offshore wind farm. Since led the commercial scaling of offshore wind globally	Offshore Wind	$25B	1991
First Solar Inc	Manufactures cadmium telluride thin-film solar panels.	Thin-Film Solar	$17B	2002
NexTracker	Designs advanced solar trackers for utility-scale projects.	Solar Tracking Systems	$7B	2015

Redwood Materials	Recycles and refines battery materials for electric vehicles	Battery recycling	$5B	2023
Ormat Technologies	Operates geothermal and recovered energy power plants.	Geothermal Energy	$4B	1984
Bloom	Produces solid oxide fuel cells for clean power generation.	Fuel Cells	$4B	2008
Ascend Elements	Recycles lithium-ion batteries into cathode materials.	Battery Recycling	$2B	2023
Climeworks	Develops and operates direct air capture plants	Direct Air Capture	$1B	2017
Electric Hydrogen	Manufactures large-scale electrolyzer systems to produce low-cost, fossil-free green hydrogen	Green Hydrogen Electrolyzers	$1B	2023
Plug Power	Develops hydrogen fuel cell systems and electrolyzers for transportation, stationary power and industrial applications.	Hydrogen Fuel Cells	$1B	2022
Lanzajet	Produces sustainable aviation fuel and renewable diesel from ethanol using proprietary technology	SAF	$0.3B	2022
FOAK in progress				
Commonwealth Fusion	Nuclear Fusion Reactors: employs a high-field tokamak approach, leveraging advanced high-temperature superconducting magnet technology	Nuclear (fusion)	$4B	2030s *target*
Form Energy	Iron-Air batteries with expected discharge life of over 100 hours	LDES	$3B	2028 *target*
Fervo	Develops advanced geothermal energy projects using fracking drilling techniques and fiber-optic sensing technologies.	Geothermal	$2B	2026 *target*
FOAK failure				
Northvolt	Manufactured lithium-ion batteries for electric vehicles and energy storage	Lithium-Ion Batteries	N/A	2021
NuScale	Designed and developed small modular nuclear reactors (SMRs)	Nuclear (Small Modular Reactors)	$3B	2023

Source: Pitchbook, TNI Research

6. Based on past success stories, what is the most proven model for successful commercial scaling of climate tech investments?

In the Appendix to this paper, we have attached a one-page profile of each of FOAK case studies listed in Exhibit 5 describing the FOAK investment and how it was funded.

There is a very strong pattern observable from our selected group of case studies which we have undertaken. Generally, the funding at the commercial scaling stage of a climate technology company comes from a combination of three sources: the original venture capital backers, loans or grants from government agencies (most notably the DoE or China's NDRC) and from corporate customers as investors and/or providers of corporate offtake agreements. This "three-legged stool" for FOAK highlights that this funding model is the standard set of sources for funding clean tech FOAK investments.

Exhibit 6: Almost all FOAK funding has come from three sources: early stage VCs, Corporates and Government agencies like the DoE *(shaded cells indicate this was a feature of the FOAK funding; includes companies which have raised capital for FOAK, built FOAK and failed to build FOAK)*

FOAK Case Study	Blue-chip VCs take to working pilot	Corporate Offtake Agreements and/or Equity stakes	Government loans or grants
Completed FOAK Financing & Construction			
Ascend Elements	■	■	■
Bloom	■	■	■
Climeworks	■	■	■
Electric Hydrogen	■	■	■
First Solar Inc	■	■	■
NEXTracker	■	■	■
Lanzajet	■	■	■
Ormat Technologies		■	■
Ørsted AS		■	■
Plug Power	■	■	■
Tesla	■	■	■
Redwood Materials	■	■	■
Vestas Wind Systems		■	■
FOAK Financing - preconstruction			
Commonwealth Fusion	■	■	■
Fervo	■	■	■
Form Energy	■	■	■
FOAK Failure			
Northvolt	■	■	■
NuScale	■	■	■

Source: Pitchbook, TNI research

Successful funding of climate technology companies building their early or first of a kind commercial facilities hinges on establishing **strategic partnerships with corporates** to leverage their expertise, supply chains, and customer networks for market entry. Securing offtake agreements with corporate, industrial, or utility partners provides the many different stakeholders (employees, EPC firms, suppliers, and sources of finance) with confidence in the firm's future. In many cases today, we are seeing corporate customer support in the form of equity investments in the company, either from the corporate venture arms (CVCs) or directly from strategic investment budgets funded from their balance sheets. The clean hydrogen sector illustrates this, with partnerships like ITM Power and Linde's joint venture, ITM Linde Electrolysis GmbH, which in 2023 secured contracts for 100 MW PEM electrolyzers for RWE's site in Lingen, Germany, marking a milestone in high-volume manufacturing. Similarly, Air Liquide and Siemens Energy's 2023 hydrogen gigafactory in Berlin, with a 1 GW annual capacity and plans to scale to 3 GW by 2025, demonstrates how corporate collaborations drive commercial maturity.

Project finance from government grants, and debt from government or commercial lenders are essential to address the substantial capital requirements of FOAK projects. Government support through robust policy frameworks, subsidies, and risk-sharing initiatives are also important to derisk this stage of the company's growth. Insurers offering tailored risk-transfer products and incentivized

EPC firms participating through performance-based revenue, further contributes to the momentum behind successful commercial scaling.

If there is a standard FOAK funding playbook that energy transition investors should start with, it would be the "three-legged stool" that we see from so many past case studies, where the three legs include:

1) A syndicate of highly respected and often specialist climate tech venture capital firms who take the science to the point of a working pilot with successful customer road-testing,

2) Corporate offtake agreements often combined with direct equity investments from some of the most highly respected of potential long-term customers, and

3) Government grants or loans from agencies including the US DoE and EPA, the European Investment Bank, the World Bank's Climate Investment Funds and China's National Development and Reform Commission.

Most of the successful cleantech FOAK investments are emblematic case studies proving out the 3-legged stool playbook. First Solar, the cadmium telluride solar panels producer, partnered with NREL to refine its technology, adopting an iterative scaling approach with a 25 MW pilot plant before expanding to over 6 GW, backed by government grants and offtake agreements with NextEra and Apple. NEXTracker collaborated with Flex to utilize its supply chain for reliable production and worked with vetted EPC firms for installations, shipping over 100 GW by 2025. Form Energy, with its iron-air batteries for long-duration storage, is proving scalability through a 1.5 MW pilot in Minnesota with Great River Energy in 2024, seeking offtake agreements to de-risk its FOAK plant, Form Factory 1, for 2025 production, and benefiting from government grants. Similarly, Fervo Energy advanced its enhanced geothermal system with a 2021 pilot in Nevada with Google, secured a 320 MW offtake deal with Southern California Edison for its Cape Station project in Utah and is leveraging federal tax incentives for these and other geothermal projects.

None of these three stakeholders in this stage of financing would be willing investors without seeing that they could see a path to risk reduction or mitigation across the major risk categories that all students of FOAK financing generally discuss. The US DoE Loan Program Office uses a tool they call the Adoption Readiness Level (ADL) Assessment Tool, which complements the widely used Technology Readiness Levels (TRLs) stage gates. EQT, S2G and the Clean Air Task Force (Bankability Framework) all point to a common-sense set of "bricks" that need to be in place before corporations will agree to offtake agreements and governments agree to loans or grants. A summary of the risks that the FOAK investment analysis considers include the following:

1) Superior technology that excels in cost efficiency, performance, and scalability
2) Market Acceptance: clear customer demand at a price in excess of long-term cost economics (product-market fit) with a total addressable market of sufficient scale to justify the investment
3) Quality management, project management capability, and workforce adequacy
4) Robust Engineering, Procurement and Construction (EPC) contracts with the right contractors
5) Supply chain development (materials sourcing) to meet the company's needs
   Downstream value chain without structural obstacles (e.g., grid interconnect limitations)
6) Clear line of sight to future funding needs being met at the cost of capital in line with business risk.

It is our conclusion that there will be far less of a missing middle, and appropriately so, where private capital investors fill the gap, but not just any growth equity or infrastructure firm, but those who bring

expertise and resources to help management tackle this set of risks. Where a new company has already benefited from top tier VCs having driven technology's early development up to the point of a proven pilot, later stage private investors may well step in to fund the FOAK investment, but they will need to see committed corporate partners who are willing to provide strategic resources and guaranteed offtake and, ideally, financial support from government grants or loans.

With the recent defunding of the DoE by the Trump administration, US energy transition investments will be more challenged. One solution may well be to see venture capital like syndicates of growth equity and infrastructure investors.

6. FOAK failure case studies

The challenges of scaling FOAK climate technology projects are illustrated by high-profile failures, cases where billions in funding and strong partnerships were not enough to ensure success. High-profile efforts like Northvolt and NuScale Power were derailed by execution failures, revealing that success depends not just on innovation, but on managing volatile markets, fragile supply chains and untested delivery models.

- **Northvol**t aimed to build Europe's first large-scale, homegrown battery gigafactory with its Northvolt Ett facility in Sweden, backed by $5 billion in loans and equity from major investors. But the project ran into serious execution hurdles: constrained access to lithium and nickel, safety incidents during ramp-up, and intense competition from Chinese suppliers who dominate 80% of the global battery market. An overly aggressive push to develop multiple factories in parallel, combined with persistent delays, led to the cancellation of a €2 billion contract with BMW.

- **NuScale Power** aimed to commercialize SMRs through its Carbon Free Power Project in Idaho, supported by $1.4 billion in U.S. Department of Energy funding and Nuclear Regulatory Commission approval. Despite this backing, the project encountered major hurdles. Licensing processes dragged on for years, and cost estimates more than tripled, from $3 billion to over $9 billion. A key contributor to the project's failure was the misalignment with its intended customer, Utah Associated Municipal Power Systems (UAMPS), a consortium of small municipal utilities. UAMPS lacked the technical capacity and financial strength needed to support a complex nuclear project, and many of its members operated in regions where cheaper natural gas made nuclear power economically unattractive. As costs rose and confidence declined, several member utilities withdrew, leaving too few committed buyers to move forward. The project was ultimately cancelled in 2023.

These failures make one thing clear: capital alone does not guarantee the success of FOAK projects. Five key lessons emerge:

1) Supply chain resilience is vital. Northvolt's reliance on scarce lithium and nickel, coupled with global shortages and price volatility, delayed production and eroded customer trust. Diversified sourcing and long-term supplier contracts are essential to shield FOAK projects from market disruptions and maintain execution momentum.

2) Corporate partner alignment is crucial. NuScale's failure highlights the need for customers with the financial capacity and technical expertise to navigate complex FOAK deployments, as its small utility partner faltered under nuclear project demands.

3) Commodity market risk requires proactive management of commodity price volatility, underscoring the need for diversified revenue or hedging strategies.

4) Phased growth plans are essential. Northvolt's simultaneous gigafactory expansions overextended resources, delaying delivery and highlighting the importance of mastering one project before scaling.

5) Execution discipline is paramount. Across all cases, robust project management and integrated EPC planning were critical to avoiding costly setbacks.

7. How can the clean tech private investor industry create a collaborative model that shrinks the missing middle and funds promising companies?

To overcome the market failure in funding FOAK climate technologies, we need more than capital—we need more formal collaborations systems among the private capital investors who have the financial and human resources and energy sector focused expertise to get these companies through their most challenging growth phase. VCs, growth equity investors, energy and power sector private equity investors and infrastructure firms do know each other and do talk. The primary evidence that there is further to go is that different horses are being backed by this group in the same race, when not all can be winners and there may not be a winner if more capital isn't channelled to fewer candidates. The solution may well lie in the formation of a coalition that brings not only funding, but also credibility, expertise, and signalling power (signalling which company is being backed to win by the best investors to do the "anointing"). There are several recent examples where value-added private investor collaboration is behind one or a small number of prospective winners, such as Form Energy in Iron-air batteries and Fervo in geothermal. We need more like this.

Unlike mature markets where control-driven investments dominate, clean tech FOAK projects involve perhaps more unproven technologies, more uncertain demand, more uncertain costs and time to build and generally higher upfront capital costs. These risks make clean tech FOAKs unattractive for single investors accustomed to majority ownership. No one investor wants to shoulder the entire burden and take the risk of a zero in a relatively concentrated private equity or infrastructure fund portfolio.

By bringing together a diverse group of investors—from venture capital to growth equity to infrastructure—the model distributes both financial and operational risks while drawing on collective expertise. Such a diverse group is best able to tailor the scaling strategy to the specific challenges of scaling that particular climate technology (e.g., closed loop geothermal, PEM hydrogen electrolyzers).

While this kind of collaboration can occur organically, it remains the exception rather than the norm. Companies like Form Energy and Fervo Energy have successfully assembled syndicates that blend early-stage conviction with later-stage scaling capabilities, demonstrating the power of coordinated investment to overcome FOAK barriers. But in many cases, this alignment does not materialize on its own.

Syndicates offer a compelling solution for financing FOAK climate projects by allowing investors to limit individual exposure while sharing responsibility. This collaborative model leads to stronger outcomes across several dimensions. First, it enables **risk distribution**: by spreading financial commitments across multiple parties. Smaller individual contributions can still unlock the full capital stack needed to move a project forward.

Second, syndicates benefit from **diverse expertise**. Each participant brings unique strengths—venture investors may excel at evaluating early-stage technologies, while infrastructure funds offer deep experience in scaling and delivering complex projects. This blend of perspectives enhances the collective ability to navigate the technical, commercial, and operational challenges that FOAK projects entail.

Third, the model supports **stronger decision-making**. Shared diligence processes and collective judgement help reduce blind spots and increase the quality of investment decisions. When multiple stakeholders assess a deal from different angles, the result is a more rigorous and well-rounded evaluation.

Finally, syndicates can enhance **market access and influence**. Many investors bring with them strategic relationships, whether with industrial partners, policymakers, or potential customers—that can accelerate deployment, unlock regulatory approvals, and create commercial pull.

The obvious challenge to such a collaboration model is the coordination and governance chaos presented by a dispersed body of equity owners. Governance of companies like Fervo and Form Energy can not be easy. Without a well-structured governance framework to align interests, coordinate activity, and streamline decisions, efforts can become fragmented. But workable best practice governance models from the VC world may be useful frameworks to follow where there is classically a lead equity investor, potentially holding the Chairman role and management tag-teamed to different investors for difference resources and input.

Forming syndicates of investors happen all the time, but not always the best syndicate. A well-designed collaboration or syndicate model begins with a **curated group of top-tier investors** with energy sector expertise, in-house operating value-adding human resources, and a proven track record, committed to co-investing in FOAK opportunities. It also relies on **clear investment criteria**, defining what constitutes an investable project based on technology maturity, market potential, and alignment with climate goals. Finally, it includes **efficient decision making processes**, enabling rapid and predictable capital deployment.

This approach is not just about funding; it is about creating a smarter, faster, and more efficient pathway for climate technologies to reach their full potential. By acknowledging the limitations of traditional, control-driven strategies and embracing shared responsibility, syndicates unlock the resources needed to confront the climate challenge head-on.

Looking ahead, the challenge is no longer invention, it is execution at scale. Hundreds of companies are ready to leap from pilot to commercial production. But without a mechanism to steer and support capital flows, many will fall short of their potential. What’s needed is a smarter, faster, and more efficient way to guide transformative climate technologies toward the scale needed to address the global decarbonization challenge.

Appendix I: Potential Coalition investors

To create a list of potential coalition members, we analyzed the portfolios of generalist VCs, as well as growth and infrastructure investors, identifying those most active in clean tech FOAK projects. We also ranked leading energy transition managers based on their investment track record, appetite, and success with FOAK initiatives. This process has led to a short list of prospective investors we hope to form a coalition of sorts, explicitly supporting attractive FOAK investments, bringing their expertise, resources and capital to derisk such projects, putting companies on their way to groundbreaking clean-tech deployments at commercial scale.

Exhibit 1: Illustrative Example of a possible coalition of clean tech FOAK investors

Generalist Venture Capital Firms' Growth Equity	Energy Transition Focused Growth Equity Funds	Energy Sector Focussed Private Equity Funds	Energy Transition Focused Infrastructure Funds	Sovereign Wealth Funds
Andreesen Horowitz	TPG Rise Climate	Blackstone	Generate	Temasek
General Catalyst	General Atlantic BNZ	KKR	EQT	GIC
Sequoia	Energy Impact Partners	Vision Ridge	Brookfield	CPP
Union Square Ventures	Spring Lane	NGP	Blackrock GIP	
Khosla Ventures	Decarbonization Partners	SCF	Ares	
Lightspeed Venture	S2G	Ara Partners	Arclight	
Activate	Clean Energy Ventures	Oaktree Power		
	Capricorn	Neos		

Source: Pitchbook, TNI Research

Exhibit 2: Most active later stage growth and infrastructure investors in Clean Tech FOAK investing

#	Investor	FOAK Deals Count	FOAK Companies
1	Temasek	22	Ascend, Amogy, Commonwealth Fusion, Electric Hydrogen, Rize, Form, Fortera, Verdagy, TeraWatt Infrastructure, Stegra, Samsara Eco, Caelux, GCL Perovskite, Eavor, Fairmat, Hydrogenious LOHC, Ionblox, Living Carbon, Meva Energy, Our Next Energy, Solugen, Svante
2	Generate	6	Ambient Fuels, Redwood Materials, StormFisher Hydrogen, LanzaJet, xAnuvia Plant Nutrients, GrowUp
3	Closed Loop Partners	5	Phinite, Mycocycle, Capra Biosciences, Dimpora, Full Cycle
4	Decarbonisation Partners	5	Neustark, Ascend Elements, Antora Energy, Monolith Materials, MycoWorks
5	TPG Rise Climate	5	Form Energy, Ohmium, Monolith Materials, Nextracker, Twelve
6	Grok Ventures	5	Goterra, Loam, Rhizocore, Antora Energy, Endolith
7	NGP	5	CarbonFree, LanzaTech, X-Energy, Form Energy, NuScale
8	Wollemi	4	Samsara Eco, Fortera, Pluton Biosciences, Loam
9	Ara Partners	4	CycleØ, Puraglobe, Transform Materials, Utility Global
10	Just Climate	3	Terra CO2, Stegra, Meva Energy

Source: Pitchbook

Exhibit 3: Most active Generalist VCs in FOAK investments

# of Deals across group of VCs across ET, Capital Intensive Energy Transition and FOAK Energy Transition (Last 5 Years)

	Accel	Founders Fund	General Catalyst	Khosla	Sequoia	Andreessen H
Energy Transition	12	11	13	30	18	11
Capital Intensive (within Energy Transition)	7	11	8	24	7	6
FOAK (within Energy Transition)	1	3	4	9	2	2

# of Deals across group of VCs across ET, Capital Intensive Energy Transition and FOAK Energy Transition (All Historic Deals)

	Accel	Founders Fund	General Catalyst	Khosla	Sequoia	Andreessen H
Energy Transition	30	26	36	94	55	29
Capital Intensive (within Energy Transition)	13	20	22	79	28	11
FOAK (within Energy Transition)	1	3	4	15	2	2

Examples of FOAK deals

Revo Zero	Avalanche Energy	Charm Industrial	Aether	General Galactic	Aetherflux
	Fleetzero	Fourier	Caelux	Lithos Carbon	Radiant
	Radiant	Mainspring	Commonwealth		
		Aether	Hyperloop One		
		Pacific Fusion	Koloma		
			LanzaTech (NAS:		
			Limelight Steel		
			Mainspring		
			Pascal		
			Realta Fusion		
			RedoxBlox		
			Spiritus		
			TerraPower		
			Verdagy		
			AltaRock		

Source: Pitchbook

Exhibit 4: Most active corporates in 18 FOAK case study examples below

#	Corporate investors & off-takers	Deals (#)	FOAK Companies
1	Amazon	3	Electric Hydrogen (offtake & equity), Redwood Materials (offtake & equity), Plug Power (offtake & equity)
2	Mitsubishi Heavy Industries	3	Electric Hydrogen (equity), Fervo Energy (equity), Vestas Wind (equity)
3	Microsoft	3	Climeworks (off-take), LanzaJet (equity), Redwood Materials (equity)
4	Google	2	Bloom Energy (off-take), Fervo Energy (off-take)
5	Eni Next	2	Commonwealth Fusion (equity), Form Energy (equity)
6	Equinor Ventures	2	Commonwealth Fusion (equity), Electric Hydrogen (equity)
7	Panasonic	2	Redwood Materials (off-take), Tesla (equity)
8	Sabancı Climate Technologies	2	Commonwealth Fusion (equity), Fervo Energy (equity)
9	Southern California Edison	2	Fervo Energy (off-take), Ormat Technologies (off-take)
10	NextEra Energy	1	NEXTracker (off-take)

Source: Pitchbook

Exhibit 5: Most active VCs in 18 FOAK case study examples below

#	VC investors	Deals (#)	Companies backed
1	Breakthrough Energy Ventures	5	Commonwealth Fusion, Electric Hydrogen, Form Energy, LanzaJet, Redwood Materials
2	Capricorn	4	Form Energy, Tesla, Fervo Energy, Redwood Materials
3	Prelude	3	Electric Hydrogen, Fervo Energy, Form Energy
4	Collaborative Fund	2	Commonwealth Fusion, Redwood Materials
5	Energy Impact Partners	2	Electric Hydrogen, Form Energy
6	Fifth Wall	2	Ascend Elements, Electric Hydrogen
7	Gigascale Capital	2	Commonwealth Fusion, Form Energy
8	Presidio Partners	2	NEXTracker, NuScale
9	Congruent	1	Fervo Energy
10	New Enterprise Associates	1	Bloom Energy

Source: Pitchbook

Appendix II: FOAK Case Study Historical Summaries

FOAK Case Study #1: Ascend Elements (2023)

Company	Ascend Elements
Date Founded	2015
Business Description	Ascend Elements specializes in engineered materials and lithium-ion battery recycling, aiming to create a closed-loop supply chain for EV batteries. Its patented Hydro-to-Cathode process recycles end-of-life batteries into sustainable cathode precursors (pCAM) and cathode active materials (CAM), reducing carbon emissions by up to 93% compared to mined materials. The company's technology supports the domestic EV battery supply chain by producing high-performance materials from recycled feedstock
FOAK Construction Dates	2023 (Covington, GA) – Ascend Elements FOAK Case Study: Commissioned Base 1, North America's first commercial-scale lithium-ion battery recycling facility, capable of processing 30,000 metric tons annually. This FOAK plant commercialized Ascend's Hydro-to-Cathode® technology to recover critical materials from spent EV batteries and produce new cathode materials, marking the company's first large-scale commercial deployment
VCs	**Lead investors:** Orbia VC led Mar 2021 $20M Series B round (total round size) Orbia VC led Oct 2021 $168M Series C1 round (total round size) Fifth Wall led Series C2 $67M round (total round size) **Other investors**: Alumni Ventures, At One Ventures, Axial Partners, Clean Energy Venture Group, Clearvision Ventures, Foothill Ventures, Mass Ventures
Growth/Buy-out/Infra	**Other investors**: Capital Management, Decarbonization Partners, Just Climate, Mirae Asset Global Investments, Oman Investment Authority, Pacific Investment Management Company, Qatar Investment Authority, Shinhan Financial Group, Temasek Holdings, Tenaska, SKS Private Equity
Corp Partners (Equity and/or Offtake)	**Off-takers**: EcoPro Group, offtake agreement for $1B+, with options to expand to $5B+ (2023–2024) **Equity investors**: BHP Group, Doral Group, Hitachi Ventures, InMotion Ventures, Jaguar Land Rover Automotive, Lithium Argentina, TDK Ventures
Govt Funding Support	DOE: Awarded $480M in grants (Oct 2022) under the Bipartisan Infrastructure Law to support the Apex 1 pCAM/CAM facility. Although primarily for Apex, this federal support strengthened the broader commercialization effort, including Base 1
Market Value Today (April 2025)	$2 billion
Funds Raised to date ($M)	Over $1,000M across eight rounds from 29 investors, as reported by Tracxn in March 2025.
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE grants)

FOAK Case Study #2: Bloom Energy (2006-2009 FOAK investment date)

Company	Bloom Energy
Date Founded	2001
Business Description	Solid oxide fuel cell systems that generate on-site electricity from fuels like natural gas, biogas, or hydrogen without combustion for commercial and industrial customers
FOAK Construction Dates	2006 - 2008 (Mountain View, CA) - Bloom Energy FOAK Case Study: Construction of the first commercial fuel cell installation at a Google data center began around 2006-2007, with operations starting in 2008, marking Bloom's FOAK deployment of solid oxide fuel cells for on-site power generation
Lead VCs	**Lead investors:** New Enterprise Associates & Kleiner Perkins co-led May 2002 $4.7M Series A round through to Mar 2014 $150M Series G round (total round sizes) **Other investors**: AdvancedStage Capital, Alpha Venture Capital, Apex Venture Partners, ARTIS Ventures, Bennu Venture Group, Carney Global Ventures, Green Bay Ventures, Israel G-Tek, JC2 Ventures, Leawood Venture Capital, Light Street Investments, Matrix, MicroVentures, R7, Reform Ventures
Growth/Buy-out/Infra	**Lead investors:** Kleiner Perkins co-led May 2002 $4.7M Series A round through to Mar 2014 $150M Series G round (total round sizes) **Other Investors**: Alberta Investment Management, ATEL Capital Group, CPP Investments, Credit Suisse, Crown Capital Partners, GCM Grosvenor Private Markets, Grassmere Partners, Grumman Hill, Kuwait Investment Authority, Madrone Capital Partners, Morgan Stanley Expansion Capital, Northgate Capital, Northport Investments, Goldman Sachs
Corp Partners (Equity and/or Offtake)	**Off-takers**: Google, 2008, 100kW for Mountain View data center eBay, 2010, 5MW for San Jose data center Walmart, 2010, 4MW across multiple stores **Equity investors**: Constellation Technology Ventures, E.ON Strategic Co-Investments, Presidio Ventures
Govt Funding Support	U.S. Department of Energy: California SGIP Subsidies (2010, $218.5M USD)
Market Value Today (April 2025)	$4B
Funds Raised to date ($M)	Public Company since 2018
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (U.S. Department of Energy)

FOAK Case Study #3: Climeworks (2017)

Company	Climeworks
Date Founded	2009
Business Description	Direct Air Carbon Caption (based in Iceland)
FOAK Construction Dates	May 2017 (Capricorn plant, Hinwil, Switzerland): Construction began in 2016, with the plant operational by May 2017. This small-scale commercial DAC plant featured 18 CO_2 collectors, capturing several hundred tons of CO_2 annually, marking Climeworks' first commercial-scale deployment
Lead VCs	**Lead investors:** Zürcher Kantonalbank led Mar 2012 $2.4M Series A round (total round size) Zürcher Kantonalbank led Series B $3.4M round (total round size) **Other investors**: Carbon Removal Partners, Verve Ventures, Global Founders Capital
Growth/Buy-out/Infra	**Lead investors:** Partners Group & GIC co-led Apr 2022 $639M Series F round (total round size) **Other investors**: Baillie Gifford, M&G
Corp Partners (Equity and/or Offtake)	**Off-takers**: Microsoft, 10-year offtake, 10,000 tons CO_2 BCG, 15-year offtake, 80,000 tons CO_2 **Equity investors**: BigPoint Holding AG, Swiss Re
Govt Funding Support	$50M from U.S. DOE for Project Cypress (March 2024); Swiss Federal Office of Energy (SFOE) for Capricorn
Market Value Today (April 2025)	$1B
Funds Raised to date ($M)	$798M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE, SFOE)

FOAK Case Study #4: Commonwealth Fusion Systems (2025)

Company	Commonwealth Fusion Systems
Date Founded	2018
Business Description	Nuclear Fusion Reactors: employs a high-field tokamak approach, leveraging advanced high-temperature superconducting (HTS) magnet technology
FOAK Construction Dates	Construction ongoing - 2025 (Devens, MA): Construction of the SPARC fusion energy demonstration machine began in 2021, with expected completion by 2025, targeting first plasma in 2026.
Lead VCs	**Lead investors**: Breakthrough Energy Ventures led Jun 2019 $116M Series A round (total round size) **Other investors**: Brainstorm Ventures, Collaborative Fund, DFJ Growth, Engine Ventures, F-Prime Capital, Future Ventures, Gigascale Capital, Hestia Venture Partners, JS Capital, Khosla Ventures, Lowercase Capital, Quiet Capital, Resilience Reserve, Safar Partners, Something Good Ventures, Starbridge Venture Capital, Starlight Ventures, Strong Atomics, TIME Ventures
Growth/Buy-out/Infra	**Lead investors**: Temasek Holdings led May 2020 $84M Series A2 round (total round size) Tiger Global Management led Dec 2021 $1.80B Series B round (total round size) **Other investors**: Advection Growth Capital, Armada Investment, CAZ Investments, Coatue Management, Devonshire Investors, Emerson Collective, Gray's Creek Capital Partners, Hostplus Superannuation Fund, Schooner Capital, Senator Investment Group, Soros Fund Management, Temasek Holdings, Tisch Family, Vision Capital Group
Corp Partners (Equity and/or Offtake)	**Off-takers**: No off-takers, but corporate support Alphabet provided AI-driven R&D support for reactor design optimization Equinor Ventures expressed interest in future off-take **Equity investors**: Alphabet, Eni Next, Equinor Ventures, FootPrint Coalition, Sabanci Climate Technologies
Govt Funding Support	U.S. Department of Energy ($15M, Jun 2024; multiple INFUSE awards), Arpa-E (grant support)
Market Value Today (April 2025)	$4B (estimated based on $2B raised)
Funds Raised to date ($M)	$2,000M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE, Arpa-E)

FOAK Case Study #5: Electric Hydrogen (2023-2025)

Company	Electric Hydrogen
Date Founded	2020
Business Description	Manufactures high-power Proton Exchange Membrane (PEM) electrolyzers. Their flagship product is a fully integrated 100 MW electrolyzer plant that includes all necessary subsystems such as thermal management, gas processing, water treatment, power distribution, and control systems; suitable for various applications including refineries, e-fuels, ammonia production, and decarbonization of heavy industries
FOAK Construction Dates	2023 - 2025 (Texas): Construction of a 100 MW electrolyzer system for green hydrogen production began in 2023. By Q4 2024, the plant achieved first hydrogen production, with systems commissioning and ramp-up proceeding in stages. The project reached full operational capacity in mid-2025, producing approximately 45 tons of green hydrogen per day
Lead VCs	**Lead investors**: Breakthrough Energy led Jun 2021 $23M Series A round (total round size) Fifth Wall led May 2022 $198M Series B round (total round size) Fortescue, Fifth Wall & Energy Impact Partners co-led Oct 2023 $380M Series C round (total round size) **Other investors**: Energy Impact Partners, Prelude Ventures
Growth/Buy-out/Infra	**Investors**: S2G Investments, Cosan, New Legacy, Oman Investment Authority, Temasek Holdings
Corp Partners (Equity and/or Offtake)	**Off-takers**: BP Ventures, Jul 2023, 50,000 tons/year by 2030 for aviation fuel Amazon, May 2022, for AWS data centers Equinor Ventures provided R&D support for hydrogen integration Mitsubishi Heavy Industries provided R&D support for electrolyzer development **Equity investors**: Amazon, bpVentures, Equinor Ventures, Fatima Group, Fortescue Future Industries, Honeywell Ventures, Kajima, Mitsubishi Heavy Industries, Rio Tinto, SVB Financial Group, United Airlines Ventures
Govt Funding Support	U.S. Department of Energy: Grant (Mar 2024, $47M USD)
Market Value Today (April 2025)	$1.1B (estimated based on $550M raised)
Funds Raised to date ($M)	$550M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #6: Fervo Energy (2023-2026)

Company	Fervo Energy
Date Founded	2017
Business Description	Develops advanced geothermal energy projects using fracking drilling techniques and fiber-optic sensing technologies.
FOAK Construction Dates	September 2023 - 2026 (Cape Station, Utah): Construction began in September 2023, with operations expected by 2026. This 400 MW geothermal plant will use enhanced geothermal systems (EGS), marking Fervo's FOAK commercial-scale deployment.
Lead VCs	**Lead investors**: Congruent Ventures led Jul 2019 $11M Series A round (total round size) Congruent Ventures led Apr 2021 $25M Series B round (total round size) DCVC led Aug 2022 $138M Series C round (total round size) Capricorn Investment Group led Dec 2024 $504M Later Stage VC equity round (total round size) **Other investors**: Echelon Capital, PEAK6 Strategic Capital, Prelude Ventures, RAA Ventures, Activate Global, Galvanize Climate Solutions
Growth/Buy-out/Infra	**Investors:** American Century Investments, California State Teachers' Retirement System, CPP Investments, Liberty Mutual Investments, Marunouchi Innovation Partners, The Grantham Foundation, Macquarie Corporate & Asset Finance
Corp Partners (Equity and/or Offtake)	**Off-takers**: Southern California Edison, Jul 2023, 320 MW from Cape Station Google, Nov 2024, 100 MW from Nevada operations **Equity investors**: BHP Ventures, Devon Energy, Helmerich & Payne, Liberty Energy, Mitsubishi Heavy Industries, Sabanci Climate Technologies
Govt Funding Support	U.S. Department of Energy (Grant, Mar 2021, $0.14M; Grant, Feb 2024, $25M)
Market Value Today (April 2025)	$2B (estimated based on $676M raised)
Funds Raised to date ($M)	$676M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #7: First Solar (2002)

Company	First Solar
Date Founded	2002
Business Description	Cadmium telluride thin-film solar panel assembly and sales
FOAK Construction Dates	First Solar's pilot stage culminated in 2002 with the launch of its first manufacturing facility in Perrysburg, Ohio — a FOAK plant that marked its entry into commercial-scale production of thin-film solar modules
Lead VCs	VCs enabled the construction of the Perrysburg, Ohio plant (FOAK) in 2002. True North Partners, led by the Walton family, acted as a quasi-VC/PE entity by injecting significant capital into First Solar post-1999 to scale manufacturing. Later, institutional VC/PE firms likely participated in pre-IPO rounds, though specific names are less documented
Growth/Buy-out/Infra	None directly in First Solar's cap-table. Scale was funded by operating cash and the equity markets (Energy Capital Partners backed NextLight, which FSLR bought in 2010, but that capital never sat on First Solar's balance-sheet)
Corp Partners (Equity and/or Offtake)	**Off-takers**: Apple committed ~$848 million through a 25-year power-purchase agreement starting in 2015 for the California Flats Solar Project, providing First Solar with a long-term revenue stream and backing for project financing PG&E took offtake for the remaining 150 MW of the California Flats project alongside Apple Dow Inc. 15-yr PPA for 150 MW (Horizon Solar, TX) to power Gulf Coast chemical operations **Equity investors**: General Electric
Govt Funding Support	The U.S. Department of Energy (DOE) provided grants and tax incentives in the early 2000s to support First Solar's R&D and initial manufacturing. Ohio state programs also offered tax credits and grants for the Perrysburg (FOAK) facility. Later, the DOE's Loan Programs Office facilitated project financing for solar deployments.
Market Value Today (April 2025)	$17B
Funds Raised to date ($M)	Public
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #8: Form Energy (2023-2024)

Company	Form Energy
Date Founded	2017
Business Description	Iron-Air batteries with expected discharge life of over 100 hours
FOAK Construction Dates	May 2023: Broke ground on Form Factory 1 (Weirton, WV); Completed construction by May 2024, likely operational in 2025
Lead VCs	**Lead investors**: Breakthrough Energy Ventures led Jun 2018 $9M Series A round (total round size) Eni Next led Aug 2019 $40M Series B round (total round size) **Other investors**: Blindspot Ventures, Cap Table Coalition, Energy Impact Partners, Gigascale Capital, Good Growth Capital, House Of Ventures, Kapor Capital, Prelude Ventures, VamosVentures, Capricorn
Growth/Buy-out/Infra	**Lead investors**: TPG (The Rise Fund) led Oct 2022 $450M Series E round (total round size) T. Rowe Price Group led Oct 2024 $455M Series F round (total round size) **Other investors**: CPP Investments, GIC Private, M&G, Macquarie Asset Management, NGP Energy Capital Management, Perry Creek Capital, Sleeping Bear Capital, Temasek Holdings, Trinity Capital
Corp Partners (Equity and/or Offtake)	**Off-takers**: Xcel Energy, Dec 2024, 10 MW/1000 MWh in Minnesota Great River Energy, Nov 2023, 1.5 MW/150 MWh in North Dakota ArcelorMittal provided R&D support for iron-air battery materials GE Vernova provided R&D support for grid integration studies **Equity investors**: ArcelorMittal, Development Bank of Japan, Eni Next, GE Vernova
Govt Funding Support	National Science Foundation: Grant (Dec 2018, $0.23M USD); Arpa-E: Grant (Sep 2018, $3.7M USD); U.S. Department of Energy: Grant (Dec 2021, $2.8M USD)
Market Value Today (April 2025)	$3B
Funds Raised to date ($M)	$1,390M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE, Arpa-E)

FOAK Case Study #9: Lanzajet (2021-2023)

Company	Lanzajet
Date Founded	2020
Business Description	Produces sustainable aviation fuel and renewable diesel from ethanol using proprietary technology
FOAK Construction Dates	2021 - 2023 (Soperton, GA): Construction of the Freedom Pines Fuels biorefinery began in early 2021, with operations starting in January 2023
Lead VCs	**Lead investors:** Breakthrough Energy Ventures & Microsoft Climate Innovation Fund investment co-led Jan 2022 $100M round (total round size)
Growth/Buy-out/Infra	N/A
Corp Partners (Equity and/or Offtake)	**Off-takers**: British Airways, Apr 2021, 70,000 tons/year SAF by 2025 Shell, Apr 2021, for SAF supply chain decarbonization Southwest Airlines, Feb 2024, 20M gallons/year SAF starting 2025 LanzaTech Provided extensive R&D support for SAF production technology Mitsui & Company Provided R&D support for SAF process optimization **Equity Investors**: Aéroports de Paris, Airbus Group, ANA Holdings, British Airways, LanzaTech, Microsoft, Shell, Suncor Energy, IAGi
Govt Funding Support	U.S. Department of Energy: Grant (Date not specified, $14M USD)
Market Value Today (April 2025)	$0.3 billion
Funds Raised to date ($M)	$150m
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #10: NEXTracker (2015)

Company	NEXTracker
Date Founded	2013
Business Description	Provides smart solar tracking systems that optimize the performance of large-scale solar power plants.
FOAK Construction Dates	2015 (Fremont pilot facility): Construction of the Fremont, California facility began in late 2014, with the plant operational by 2015. This FOAK site produced the NX Tracker, a single-axis solar tracking system, targeting utility-scale solar farms with capacities in the tens of megawatts, marking Nextracker's shift to commercial manufacturing.
Lead VCs	**Lead investors**: DBL Partners & Sigma Partners co-led Feb 2014 $7M Series A round (total round size) SJF Ventures led Feb 2015 $25M Series B (total round size) **Other investors**: Forseo, Presidio Partners, Sigma Partners, SJF Ventures
Growth/Buy-out/Infra	**Investors**: ClearSky, Tennenbaum Capital Partners
Corp Partners (Equity and/or Offtake)	**Off-takers:** SunEdison, NextEra Energy and Engie **Equity investors**: Flex (acquired for $330M, 2015), Solaria
Govt Funding Support	U.S. federal ITC (indirect support via solar demand, 2015). The ITC, a federal tax incentive for solar energy projects, increased demand for solar installations, indirectly supporting Nextracker's market growth during its FOAK phase in 2015. In 2018, Nextracker participated in a DOE-funded research project led by DNV GL to evaluate the performance of bifacial PV modules
Market Value Today (April 2025)	$7B
Funds Raised to date ($M)	Public
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (support via ITC)

FOAK Case Study #11: NorthVolt (2018-2021) - failed

Company	**NorthVolt**
Date Founded	2016
Business Description	Manufactures lithium-ion batteries for electric vehicles and energy storage.
FOAK Construction Dates	2018 - 2021 (Northvolt Ett gigafactory, Skellefteå, Sweden): Construction began in 2018, with the facility commissioned in 2021. This gigafactory marked Northvolt's FOAK commercial-scale deployment of sustainable lithium-ion battery production
Lead VCs	**Lead investors**: Vargas Holding led Jan 2017 $14M Seed round (total round size) **Other investors**: AE Ventures, Boundary Holding, East Innovate
Growth/Buy-out/Infra	**Lead investors**: Goldman Sachs Growth Equity led Jan 2019 $13M early-stage round (total round size) Goldman Sachs Growth Equity & Baillie Gifford co-led Sept 2020 $600M Series B1 round (total round size) Goldman Sachs Growth Equity led Jun 2021 $2.75B Series E round (total round size) **Other investors**: Ava Investors, Baillie Gifford, Baron Capital, BlackRock, Caisse de dépôt et placement du Québec, Chow Tai Fook Enterprises, CIC Capital Corporation, Dragoneer Investment Group, Fjärde AP-fonden, Hedonova, IMAS Foundation, InnoEnergy, Norrsken VC, Ontario Municipal Employees Retirement System, OMERS Capital Markets, Susanna Campbell, Swedbank Robur, TM Capital, Swedish AP Pension Funds
Corp Partners (Equity and/or Offtake)	**Off-takers**: Volkswagen Group offtake agreements for battery supply BMW had agreement, cancelled in early 2025, part of past $55B contracts Volvo offtake contracts, supporting EV battery supply, confirmed in 2024 **Equity investors:** ABB Ventures, BMW Group, Folksam, Olympia Group, PCS Holding, Scania CV, Siemens, Skelleftea Kraft, Stena, Tioex Technologies Nordic, Vattenfall, Vestas Ventures, Volkswagen Group Services
Govt Funding Support	Energimyndigheten: Grant (Sep 2017, $15.02M USD); Grant (Feb 2018, $18.4M USD) EU Funding: Support from the European Investment Bank and other EU initiatives
Market Value Today (April 2025)	N/A (company in bankruptcy as of March 2025)
Funds Raised to date ($M)	$9,000M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (EU Funding)

FOAK Case Study #12: NuScale (2023) - failed

Company	**NuScale**
Date Founded	2007
Business Description	NuScale Power designs and markets small modular reactors (SMRs), specifically the NuScale Power Module™ (NPM), a pressurized water reactor generating 77 megawatts of electricity (MWe). Its scalable VOYGR™ plants, ranging from 4 to 12 modules, support applications like electrical generation, district heating, and hydrogen production
FOAK Construction Dates	NuScale's planned FOAK facility was the Carbon Free Power Project (CFPP) in Idaho, intended to deploy a 462 MWe SMR plant using six 77-MWe modules. Announced in 2015, the project aimed for operations by 2030, with construction planned to start in 2023. However, escalating costs—from $3.6 billion to $9.3 billion—led to its cancellation in November 2023 before construction began
Lead VCs	**Lead investors:** Presidio Partners led Feb 2008 $3M Series A round (total round size) **Other VC investors:** SB Partners, The Michael Kenwood Group, Doosan Enerbility (led later stage funding)
Growth/Buy-out/Infra	**Lead investors**: NGP Energy Capital Management led Jun 2022 $235M PIPE (Private Investment in Public Equity) **Other Investors:** Credian Partners, DS Private Equity, Enercon Services, Pearl Energy Investments, Pulsar Capital Management, Segra Capital Management, Ultra Electronics
Corp Partners (Equity and/or Offtake)	**Off-takers:** UAMPS planned to deploy the CFPP, with offtake agreements, but withdrew due to cost issues ENTRA1 Energy exclusive global partner for commercialization, distribution, and deployment, supported projects like the Ohio and Pennsylvania data centers Orano collaborated on fuel cycle services and nuclear waste management **Equity investors**: Chubu Electric Power, Doosan Enerbility, GS Energy, IHI, Japan Bank for International Cooperation
Govt Funding Support	U.S. Department of Energy (DOE): Provided $1.35 billion over 10 years for the CFPP, subject to congressional appropriations, and $600 million since 2014 for SMR commercialization
Market Value Today (April 2025)	$3B
Funds Raised to date ($M)	NuScale raised $198 million in private funding, supplemented by $1.35 billion in DOE commitments, totaling approximately $1.55 billion in direct funding, with additional market capital post-IPO in 2022
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE Funding)

FOAK Case Study #13: Ormat Technologies (1984)

Company	Ormat Technologies
Date Founded	1984
Business Description	Ormat Technologies engages in the geothermal and recovered energy power business, operating through Electricity and Product segments. It develops, builds, owns, and operates geothermal and recovered energy-based power plants and manufactures equipment for geothermal energy generation, serving markets in over 30 countries
FOAK Construction Dates	1986, Ormesa I, a 30 MW geothermal power plant in the USA, marking Ormat's first owned and operated commercial geothermal facility (Ormat History)
Lead VCs	Founded in 1965, Ormat predates the modern VC era. Early funding came from founders Lucien and Yehudit Bronicki, private investors, and government support, with the company listing on the Tel Aviv Stock Exchange in 1991
Growth/Buy-out/Infra	**Investors**: FIMI Opportunity Funds, Israel's largest PE house, bought 22.5 % for $150M (2012) and installed new board/strategy; ORIX Corporation (Japan) acquired stake (22.1 %) for $627M and signed a long-term strategic partnership (Jul 2017).
Corp Partners (Equity and/or Offtake)	**Off-takers**: NV Energy off-take agreements (signed 2021–2022) for up to 160 MW across two 25-year PPAs, deliveries from 2024–2028 Clean Power Alliance 15-year PPA for 14 MW from Heber South (signed 2021) Calpine Energy Solutions 10-year PPA for up to 15 MW from Mammoth-2 (effective Jan 2025) Southern California Edison legacy PPAs from Ormesa and Heber projects, partially still in place
Govt Funding Support	Ormat received financial assistance from the Israeli government for early projects, including research and development in the 1960s and 1970s, which likely supported the development leading to Ormesa
Market Value Today (April 2025)	$4 billion
Funds Raised to date ($M)	At least $340 million from a 2020 public offering, with additional funds from earlier private investments and stock offerings
Funding solution for FOAK	Combination of all three pillars: Venture Capital (limited, with funding support from founders), Corporate Investment/Offtake & Government Financing (Israeli government)

FOAK Case Study #14: Orsted (1991)

Company	Orsted AS
Date Founded	1972 (as Dansk Naturgas A/S, later DONG Energy, renamed Orsted A/S in 2017)
Business Description	Orsted is a Danish multinational energy company specializing in renewable energy, particularly offshore and onshore wind farms, solar farms, energy storage, renewable hydrogen facilities, and bioenergy plants. It is the world's largest developer of offshore wind power
FOAK Construction Dates	1991, Vindeby Offshore Wind Farm, located off the coast of Lolland, Denmark. This was the world's first offshore wind farm, consisting of 11 turbines with a total capacity of 5 MW, costing an estimated €10 million (Vindeby Offshore Wind Farm)
Lead VCs	Not applicable. Orsted was a state-owned entity during the Vindeby project, and venture capital was not a significant funding source for early offshore wind projects
Growth/Buy-out/Infra	Post-IPO, Ørsted is >50% state-owned and otherwise free float. The only strategic shareholdings are the legacy Goldman Sachs/ATP/PFA block (gradually sold down, now <3 %) and the Danish state
Corp Partners (Equity and/or Offtake)	The Vindeby project was built by SEAS and Elkraft, predecessors of DONG Energy (now Orsted), indicating utility-based corporate involvement. Specific offtake agreements are not detailed, but utilities likely purchased the generated electricity
Govt Funding Support	The Danish government provided financial assistance and concessions for early offshore wind projects, including Vindeby, as part of its renewable energy promotion in the 1980s and 1990s. The project was considered a pilot, with a 25-year government concession from 1991 to 2016 (Vindeby Offshore Wind Farm)
Market Value Today (April 2025)	Approximately $20-25 billion, based on stock price data from May 2025
Funds Raised to date ($M)	Not specified. As a publicly traded company listed on the Copenhagen Stock Exchange since 2016, Orsted has raised funds through initial public offerings (IPOs) and subsequent offerings
Funding solution for FOAK	Government financing was primarily from the Danish government, supplemented by corporate investment from utilities like SEAS and Elkraft. **Venture capital was not used**, as the project predated modern VC involvement in renewables

FOAK Case Study #15: Plug Power (2022-2024)

Company	Plug Power
Date Founded	1997
Business Description	Develops hydrogen fuel cell systems and electrolyzers for transportation and stationary power
FOAK Construction Dates	2022-2024 (Georgia green hydrogen plant): Construction began in early 2022, with the plant becoming operational by mid-2024 (specific date not provided but noted as "mid-2024"). Located in Woodbine, Georgia, the plant produces 15 tons of liquid green hydrogen daily using PEM electrolyzers, marking Plug Power's FOAK commercial-scale hydrogen production
Lead VCs	**Lead investors**: In 2000, Plug Power raised $94 million in a private placement round, a significant pre-IPO investment (it went public in 1999 but continued private raises). Lead Investor: DQE Enterprises, the venture arm of Duquesne Light, led this round, investing alongside GE Capital **Other investors:** FA Technology Ventures
Growth/Buy-out/Infra	**Investors:** Generate Capital, senior project debt facility to fund GenKey deployments (Apr 2019); Brookfield Renewable 50-50 JV; 15 t/day green-H_2 plant at Holtwood, PA (Mar 2021)
Corp Partners (Equity and/or Offtake)	**Off-takers:** Toyota Material Handling Europe, Amazon and Walmart **Equity investor**: SK Group, Amazon
Govt Funding Support	$1.7B DOE loan guarantee (2025) for six green hydrogen plants, with the initial plant located in Graham, Texas
Market Value Today (April 2025)	$1.2B
Funds Raised to date ($M)	Public
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #16: Redwood Materials (2022-2025)

Company	Redwood Materials
Date Founded	2017
Business Description	Recycles and refines battery materials for electric vehicles
FOAK Construction Dates	2022 - 2025 (McCarran, NV): Construction of the first major battery recycling facility began in 2022, with operations starting in 2023 and scaling planned through 2025
Lead VCs	**Lead investors:** Breakthrough Energy Ventures & Capricorn co-led Jul 2020 $41M Series B round (total round size) **Other investors:** Bossa Invest, Collaborative Fund, Franklin Venture Partners, Good Capital, Inflection Ventures, Leitmotif, OMERS Ventures, Woori Venture Partners
Growth/Buy-out/Infra	**Lead investors**: Goldman Sachs Asset Management & T. Rowe Price Group co-led Aug 2021 $719M Series C round (total round size) Goldman Sachs Asset Management & T. Rowe Price Group co-led Aug 2023 $1B Series D round (total round size) **Other investors:** Baillie Gifford, CPP Investments, Deepwater Asset Management, Emerson Collective, Ericsenz Capital, Fidelity Investments, Franklin Templeton, Lurra Capital, Meyer Global Management, Microsoft Climate Fund, Redefine Ventures, T. Rowe Price Group, Valor Equity Partners
Corp Partners (Equity and/or Offtake)	**Off-takers**: Amazon off-take agreement (Aug 2021, for logistics fleet batteries) Ford off-take agreement (Aug 2021, for EV battery materials) & provided R&D support for battery recycling optimization Panasonic off-take agreement (Jul 2022, for recycled cathode materials) Tesla provided early R&D support for battery recycling processes **Equity investors:** Amazon, Caterpillar Venture Capital, Ford, Tesla
Govt Funding Support	U.S. Department of Energy: Conditional Loan Commitment (Feb 2023, value unsure)
Market Value Today (April 2025)	$5.0B
Funds Raised to date ($M)	$1,800M
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #17: Tesla (2008)

Company	Tesla
Date Founded	2003
Business Description	Designs and manufactures EVs, battery energy storage systems, solar panels and related software
FOAK Construction Dates	2010 (Fremont factory retooling): Tesla acquired the NUMMI factory in Fremont, California, in May 2010 for $42M from Toyota. Retooling began immediately, with production of the Model S starting in June 2012. The factory's initial capacity targeted a few thousand vehicles annually, marking Tesla's transition to commercial-scale EV production
Lead VCs	**Lead investors**: Valor Equity Partners led Feb 2005 $12M Series B round (total round size) Valor Equity Partners led May 2006 $40M Series C round (total round size) Technology Partners led May 2007 $45M Series D round (total round size) **Other investors**: Capricorn, Compass Technology Partners, Draper Associates, Invest Nova Scotia, SDL Ventures, SeedFord Partners, Technology Partners, The Vertical Group, The Westly Group
Growth/Buy-out/Infra	**Investors:** Aabar Investments, Capital Q Ventures, CCMP Capital Advisors, Fjord Capital Partners, J.P. Morgan, Redefine Ventures, Riverwood Capital, Saudi Arabia's Public Investment Fund, Silver Lake, T. Rowe Price Group, Trift Capital, Fidelity Investments, Vantage Point Capital
Corp Partners (Equity and/or Offtake)	**Off-takers**: Hertz (100,000 vehicle order, 2021) Panasonic (co-invested in Tesla's Gigafactory Nevada, providing critical support for battery production scaling) **Equity investors**: Daimler, Toyota, Samsung
Govt Funding Support	$465M DOE loan (2010, repaid 2013); state incentives (e.g., $1.3B tax credits for Gigafactory Nevada). California and Nevada provided tax breaks and incentives (e.g., $1.3 billion in tax credits for Gigafactory Nevada), while China offered land and tax benefits for Gigafactory Shanghai
Market Value Today (April 2025)	$1,000B
Funds Raised to date ($M)	$581B
Funding solution for FOAK	Combination of all three pillars: Venture Capital, Corporate Investment/Offtake & Government Financing (DOE)

FOAK Case Study #18: Vestas Wind (1980s)

Company	Vestas Wind Systems
Date Founded	1945
Business Description	Designs, manufactures, installs and services wind turbines for electricity generation
FOAK Construction Dates	Early 1980s (Lem facility expansion): Following the 1979 launch of its first three-blade turbine, Vestas expanded its Lem, Denmark facility starting in 1980. The expansion was completed by 1983, with the plant producing turbines at a capacity of dozens of units annually (55-100 kW each), marking its FOAK commercial production phase.
Lead VCs	None. Primarily private company funding. No significant venture capital (VC) or external investments are noted. Additional support came from Danish subsidies/tax incentives (1970s-80s), U.S. tax breaks for exports, and EU Horizon Europe (R&D support)
Growth/Buy-out/Infra	**Investors**: ECM Equity Capital Management led Jan 1994 Buyout/LBO Egeria led Jun 1997 Buyout/LBO
Corp Partners (Equity and/or Offtake)	**Off-takers**: Zond Systems purchased ~1,100 V15-65 kW turbines in the 1990s, anchoring Vestas' first U.S. export push Enron Wind (ex-Zond) continued multi-hundred-MW V47 and V66 turbine orders (1997–2001) for U.S. merchant wind projects **Equity investors**: Mitsubishi Heavy Industries formed 50/50 JV (Apr 2014) with Vestas to commercialize the V164-8 MW turbine; MHI contributed capital, tooling, and market access. Vestas bought out MHI's stake in Oct 2020 for €709M in shares (2.5% equity and board seat)
Govt Funding Support	Danish subsidies/tax incentives (1970s-80s); U.S. tax breaks for exports; EU Horizon Europe (R&D support)
Market Value Today (April 2025)	$40B
Funds Raised to date ($M)	Public
Funding solution for FOAK	Vestas did not use all three pillars, relying on government financing and corporate partnerships without venture capital