DECENTRALIZED ENERGY

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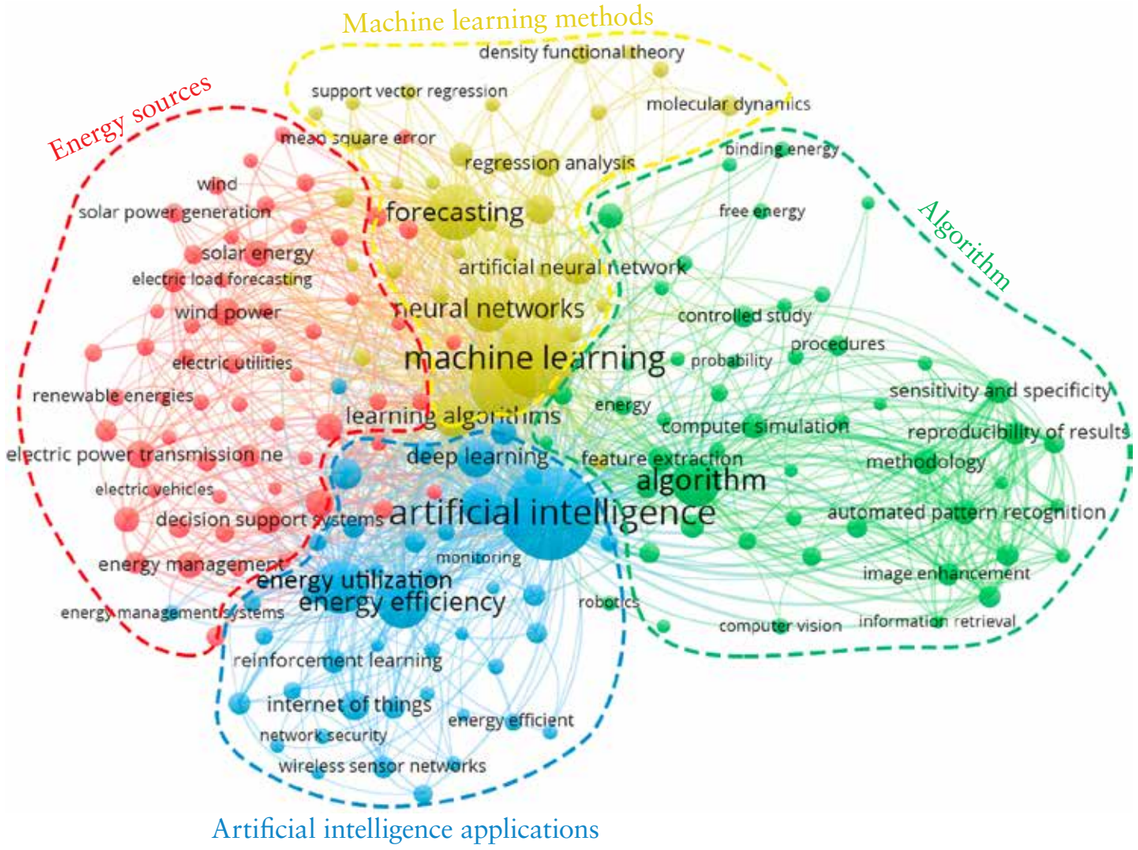
While energy production, storage, and distribution usually guide the energy discussion, the real estate sector—which spans commercial, industrial, and residential—is ultimately the conduit through which molecules move from origin to endpoint.

The global energy network operates as a system of systems, and relationships across this tangled web have become increasingly complicated, interconnected, and in many cases prone to failure. One system's waste can be another's feedstock, so all pieces of the puzzle need to have an energy emission externality value.

Just like our food products are required to label the caloric benefit of what we consume, so should our buildings and infrastructure with respect to energy-emission costs and benefits, The importance of understanding human, commercial, environmental, and technological relationships as a series of networks is the foundation of any meaningful analysis if we are to attempt to apply our learnings towards making more informed decisions that lead to more favorable outcomes for the largest number of people.

In addition, examining energy externalities through the lens of geographic complexity and network sciences can help to better understand the web of relationships which underlie the socioeconomic and technological foundation which is the driver of today's interconnected global economy *(Exhibit 1)*.[1]

EXHIBIT 1: A COMPREHENSIVE NETWORK OF ENERGY, ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING



Source: Energy Strategy Reviews

The figure above depicts the clustered relationships as defined by the connections between artificial intelligence and machine learning in the energy field.

The transition to an energy system capable of supporting a 'Net Zero economy' will require participation from every sector of the global industrial and economic value chain. However, focusing solely on current emissions indicators is an insufficient foundation for effective investment and capital deployment strategies. Now is the time to articulate an attempt at a new spatially and intensity-referenced framework which incorporates decarbonization, emissions, and other sustainability metrics, and translates to signals that serve as precursors to long term environmental and capital appreciation. In the decades ahead, climate and energy considerations will move from being side factors which help capital allocators to a central standard group of data points influencing all investment decisions.

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DECENTRALIZED ENERGY SYSTEMS

Amazon CTO, Dr. Werner Vogels, recently—and indirectly—highlighted the importance of decentralization as a fundamental component of the energy ecosystem of the future. Referencing the ability of Amazon's data centers to remain online during a massive power outage that disrupted much of Portugal and Spain in Spring 2025, Vogels aptly noted that "everything fails, all the time, so plan for failure and nothing fails."

Decentralization is a common methodological foundation associated with data architecture and operating systems. The fundamental building blocks associated with data decentralization are equally important to incorporate when we think about how to provide sustainable energy to the world in the decades ahead.

While the world seems to be at an inflection point with respect to the sustainability of climate and decarbonization themes driving investment and capital expenditure activities, it is clear that AI-driven energy efficiency and scalability will continue to serve as a key catalyst of the thematic discussion for the foreseeable future.

Further, nothing works without a sustainable and reliable energy backbone, and this translates across where people live, work and play. It follows that, whether the emphasis is on residential, commercial or industrial real estate, no capital should be deployed without first understanding the energy challenges and opportunities that are associated with (re) development.

A responsive and smart decentralized energy ecosystem will display characteristics what emphasize localized generation, a portfolio of sources (both renewable and fossil based), and operational flexibility and responsiveness largely driven by advances in artificial intelligence. This end-to-end energy value chain will evolve under the framework of sensible operating parameters. Whether or not climate concerns are at the foundation of capital deployment is secondary; what I believe to be more important is the incorporation of an engineering and distribution architecture that allows for and embraces decentralization.

The degree to which the energy-infrastructure system operates as a decentralized and flexible network will determine its ultimate success as both an investment and as a service. Such a framework yields benefits to both producers and consumers through cost savings, reliability and resilience to disruption, environmental and financial incentives for leveraging cleaner sources where appropriate, and ultimately value appreciation for property owners.

Therefore, the 2025 energy system challenges should be viewed as more evolution than revolution. As this new blueprint includes what, how, and where we build infrastructure, the real estate sector, including both land and the built environment, sits at the epicenter of this important discussion.

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MATERIAL FLOWS TO CAPITAL FLOWS

The transition to decentralization will also reduce the energy externality footprint, which undoubtedly extends to all sectors of the real estate economy. How this unfolds remains to be seen, but given that oil and gas will undoubtedly remain the cornerstone in the new energy systems infrastructure of the future (pretending otherwise is irresponsible), it will likely be more of an evolution than a revolution of the energy system. As such, the ways in which externalities are viewed and accounted for will also need to evolve.

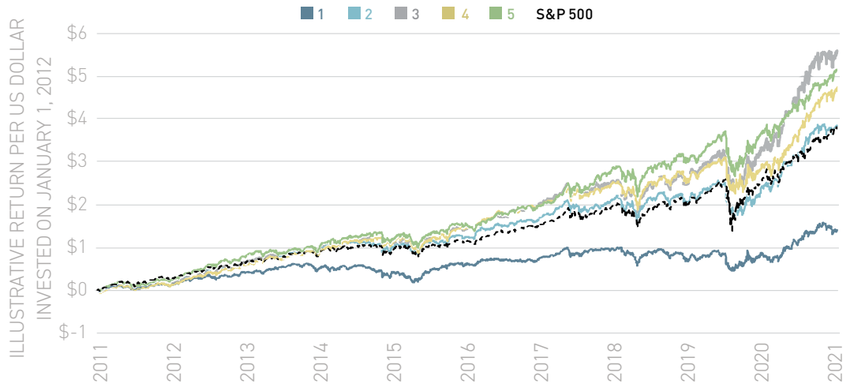
Conventional valuation orthodoxy suggests that assets associated with more favorable sustainability profiles (i.e., lower emissions) should be better performers over a longer duration return profile, as measured by absolute or relative returns through asset price, capital appreciation, or other valuation metric. As shown in *Exhibit 2*, the 'Total Value Framework' investment approach developed by asset management firm Engine No.1 demonstrates this concept as it relates to public market investable assets.[2] This logic can be extended to property and real estate asset valuations with respect to softer characteristics such as location, socioeconomics, and habitability.

The identification and quantification of energy and decentralization pathways and related exposures at the asset level using a more comprehensive library of data is one way that allows for early signal detection towards long term asset appreciation and alpha generation. Companies that operate in the energy and manufacturing sectors have physical and financial exposures to a unique set of risks and opportunities; early identification of mispriced assets and deeper attribution and understanding of the emissions drivers can allow us to take advantage of the catalysts that impact future performance, many of which are not captured by traditional research and engineering accounting methodologies.

Material environmental risk and raw material/commodity costs are both the starting and ending points of the attribution exercise. Think "Life Cycle Analysis" rather than upstream/downstream accounting estimates.

We then move from material flows to capital flows, which have already served as a catalyst for this transition. There is no need to look any further than the earmarked and deployed capital following the passage of the Inflation Reduction Act for support. In addition to the environmental and security benefits, real money is already being made as a precursor to the decades-long transition in front of us.

EXHIBIT 2: ILLUSTRATIVE RETURN BASED ON TOTAL VALUE PROFILE (FROM 1 TO 5) VS. S&P 500



Note: Engine No. 1's Total Value Framework analyzed the performance of 700 S&P 500 firms between December 2, 2011 and August 9, 2021, separating the firms into quintiles; '1' represents firms with the lowest Total Value Profile (or largest negative impacts) which substantially underperformed the benchmark, and '5' represents the highest Total Value Profile (or smallest negative impacts) which outperformed the benchmark.

Source: Engine No. 1

REFRAMING THE ENERGY DISCUSSION

So how can investors and operators with physical and financial property exposures begin to evaluate the benefits of energy management and emissions abatement potential through a thematic story that is still being written? There are surely as many approaches as there are analysts one way is to start with externalities.

Every atom of material which contributes to the products, goods, and services that we consume, transform and interact with—including property and—carries an energy and emissions burden.

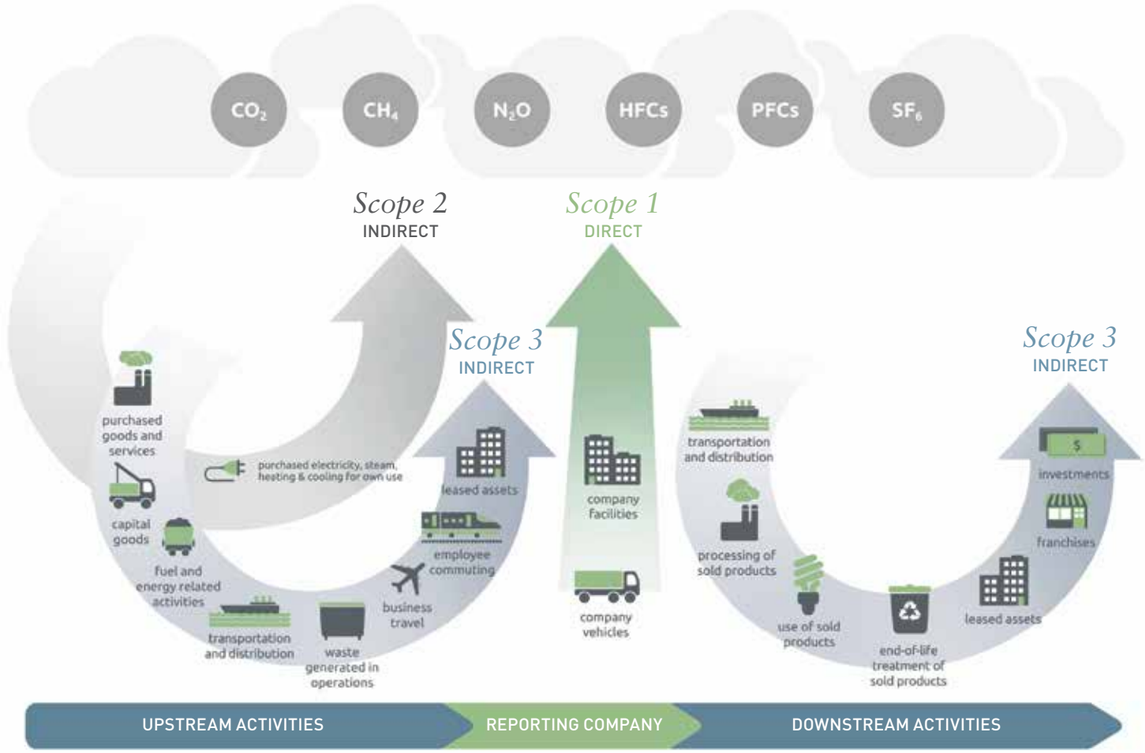
As shown in Exhibit 3, the current Scope 1 through 3 (and Scope 4 for avoided emissions) accounting methodologies and standards are a start, but there is a long way to go before we can accurately and defensibly estimate the material flows, consumption, transfer and attribution quantities in a defensible manner—all associated with greenhouse gas emissions.

Scope 1 and 2 emissions calculations are both relatively straightforward: Mass balance approaches allow operators to measure and manage emissions associated with their own products and the energy used to create them. Scope 3, the largest emissions exposure for most companies which focuses on downstream emissions, is where it gets messy. Due to the intent of why Scope 3 emissions need to be tracked, and the uncertainty of the estimate's attribution methods for downstream users, Scope 3 in many cases does not have any true meaning. Until there is literally a recording instrument on every single discharge point (i.e., never), we will need to rely on estimates to determine attribution. And until there is a standard that can accurately and defensibly account for downstream emissions (also, never), quantification techniques leveraging artificial intelligence are the next best alternative. The image below illustrates some of the measurement and management complexities with respect to emissions tracking, accountability, and attribution.

As downstream attribution methods evolve with the help of AI, the framework through which we view and assess economic and environmental opportunities which should start to proactively dictate investment over the coming decades— the remit of what an 'energy investment' is, will also need to expand. Essentially, economic growth and environmental stewardship start with energy, and every company therefore should then be viewed through the lens of spatially referenced energy systems science and engineering. But rather than focusing explicitly on emission reduction for the sake of permitting or public relations, the driving force behind quantifying, controlling, and reducing emissions—moving from Scope 3 to Scope 4 territory—should be to view energy derived emissions as externalities.

By definition, an externality is a cost or a side effect. A balance sheet item that carries a cost. However, if we place a value on emissions, and in the process flip the conversation from side effect to opportunity, real estate operators can start to see ways that reducing emissions can create value, as opposed to simply minimizing line-item costs that impact margins. Reducing emissions has been demonstrated to improve worker productivity, raise property values and reduce the disease burden which in turn decreases health care expenditures while raising GDP per capita. As we shift the energy emissions discussion from being a climate issue to one focused on economic and societal well-being, return on investment with respect to place takes on a different meaning.

EXHIBIT 3: OVERVIEW OF GHG PROTOCOL SCOPES AND EMISSIONS ACROSS THE VALUE CHAIN



Source: The World Resources Institute and World Business Council for Sustainable Development, Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard, 2011

THE PATH FORWARD

When we expand the definition of what constitutes an energy real estate investment, the aperture needs to be broadened so that upstream and downstream opportunities rise to the surface and become part of the capital discussion. Decentralization provides the lens through which such investments start to make sense. Sustainable energy is the lifeblood of the planet.

Where people live, work, and socialize all have one common denominator—the energy required to do so. Let's use this inflection point to steer the discussion in the direction that is responsible to all partners, accretive in value, and beneficial for the participants. It is time to embrace decentralization.

ABOUT THE AUTHOR

Dr. Michael Ferrari is Chief Scientific and Investment Officer at AlphaGeo.

NOTES

[1] Entezari, Ashkan; Alireza Aslani; Rahim Zahedi; Younes Noorollahi, "Artificial Intelligence and Machine Learning in Energy Systems: A Bibliographic Perspective." Energy Strategy Reviews 45 (January 2023): https://doi.org/10.1016/j.esr.2022.101017