



Electrifying Farms, Decarbonizing Agriculture



Tom Whitehouse

CEO: Leif Capital

I believe that some of today's most exciting sustainable investment opportunities are to be found in the electrification of farms and the decarbonization of agriculture. Not only are the costs of renewables declining to the point when they are cheaper than hydrocarbons (meaning that farmers can save money), but the ability to accurately gather greenhouse gas emissions data from across the agricultural supply chain means that corporations and governments can report authoritatively on their action against climate change. And when you combine renewables with the carbon capture capabilities of new soil-based technologies and the incredible efficiencies of electrified precision agriculture, then you have the foundation for a sustainable agricultural revolution. I hope you enjoy the report.

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Introduction

Farms are electrifying. Agriculture is decarbonizing.

Roughly a quarter of the world population is employed in agriculture. The changes afoot affect billions of us.

In this report, we start by taking a look the GHG emissions of the agricultural sector, and recognise that the composition of these emissions should not distract from a simple solution; decarbonisation through sustainable electrification with renewables.

We then consider the broader energy landscape, and the challenges facing the move from centralised power generation to integrated, distributed sources of energy.

The second half of this report focuses on case studies, where we look at some of the leading venture-backed innovators busy electrifying and decarbonizing farms.

An in depth exploration of Eocycle Technologies (disclosure; Eocycle is a client of Leif Capital) is followed by a briefer look at a range of start-ups from around the globe, all focused on electrification and/or decarbonization.



Who we are

Leif Capital is an independent British investment bank. We specialise in energy, transport, materials and manufacturing. Established in 2002, we have extensive experience in the financing of sustainable innovation and draw on a global network of financial and corporate investors.

Our clients are in the vanguard of sustainable technology investment and commercialisation. We have raised over \$300m for early and growth stage sustainable technology businesses. We advise start-ups that need to raise capital and 'grown-ups' that want to invest capital. Independent investment companies, corporate VCs and government innovation agencies seek our support in sourcing investments and co-investors. All are united in seeking out sustainable growth.

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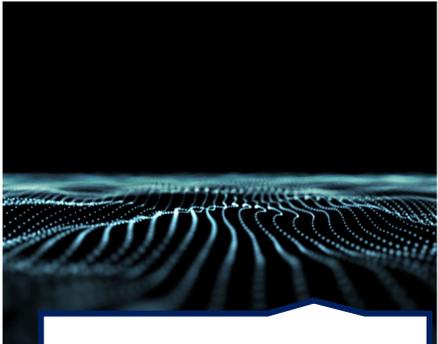
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Executive Summary

Section 1: The Bigger Picture



Energy



Agriculture

Section 2: Case Studies



Investor Perspectives



Billionaire-Backed Fund Invests in Pivot Bio's \$70m Series B to Address 'One of Largest Sources of GHGs on Planet'

"Pivot Bio is addressing one of the largest sources of GHGs on the planet – the potent nitrous oxide and carbon dioxide emissions associated with the use of synthetic fertilizers.....This company has an opportunity to make a meaningful positive difference for our environment while disrupting the \$200 billion fertilizer market."



Carmichael Roberts

Business Lead, Investment Committee at:



Anuvia Plant Nutrients Raises \$103 Million on Strength of New, Proven Carbon-Reduction Technology for Commercial Agriculture

"As consumers and mainstream retailers increase demand for sustainability across the supply chain, Anuvia's technology is helping farms compete in the changing landscape....We are pleased to continue our investment relationship with Anuvia and look forward to being part of its evolution and growth"



Ben Beldegrun

Managing Partner and Co-founder at:



Investor Perspectives



Dendra Systems secures £7.7 million Series A investment led by At One Ventures

“Dendra is by far the world’s most advanced tech for large-scale ecosystem restoration. Their work is an essential to a future where we dramatically reduce the cost to restore ecosystems and enable accountable biological carbon sequestration....These advancements will help governments and large NGOs meet their climate goals, and have already helped heavy industry with mission-critical restoration goals.”



Tom Chi
Founding Partner at:



Soil Scout Raises Significant Late-seed Round Led by Husqvarna Group

“We were particularly impressed with Soil Scout’s track record, with high-profile sports grounds like Wembley Stadium and Citizens Bank Park already utilizing the wireless soil moisture sensor system....This, in addition to a strong team and the truly impressive capabilities of the Soil Scout system, convinced us to invest in Soil Scout”.

Björn Axling

Vice President, Corporate Venture Capital at:



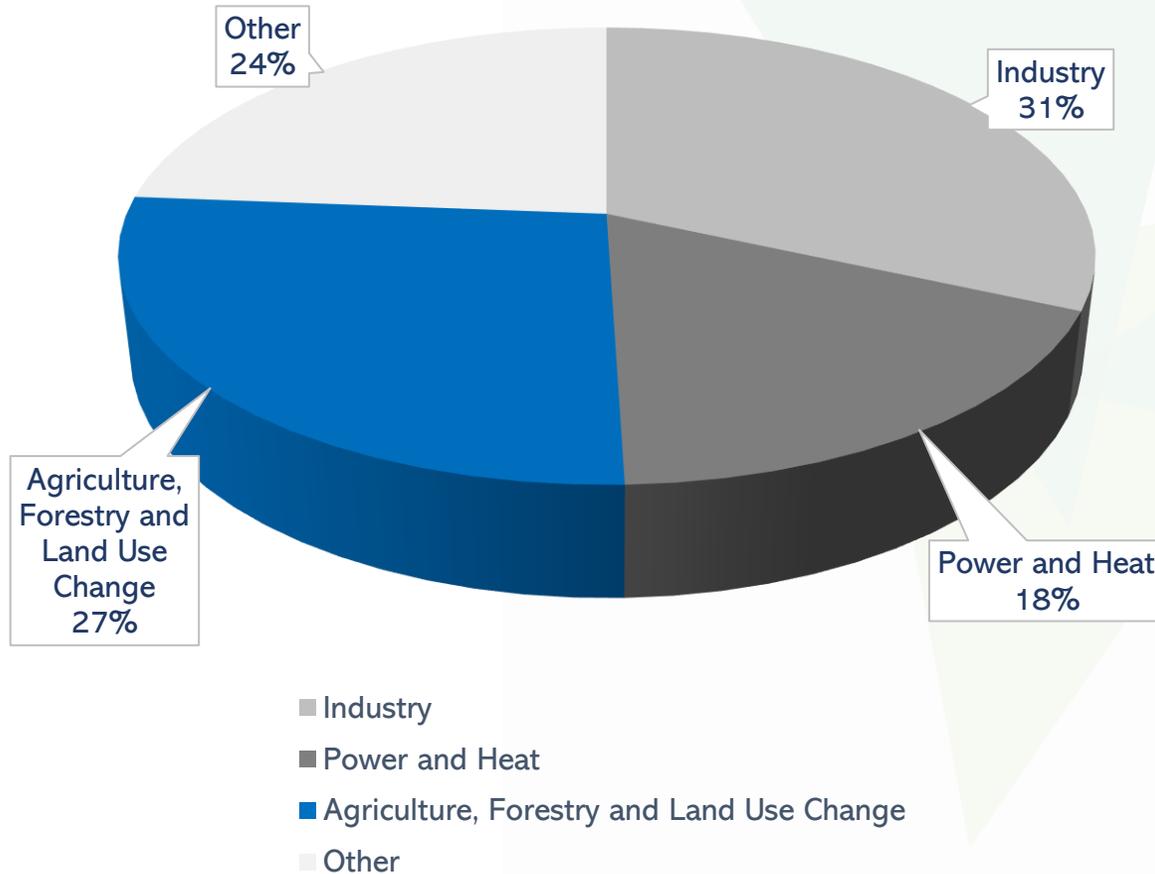
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1. Emissions in Agriculture

Total GHG Emissions by Sector, %



Agricultural GHG emissions are significant on the global scale

Global greenhouse gas (GHG) emissions from the agricultural sector make up a consequential portion of total global emissions. When looked at over a 20 year time frame, agriculture accounts for approximately 20 percent of global GHG emissions, while forestry and land-use change account for around 7 percent.*

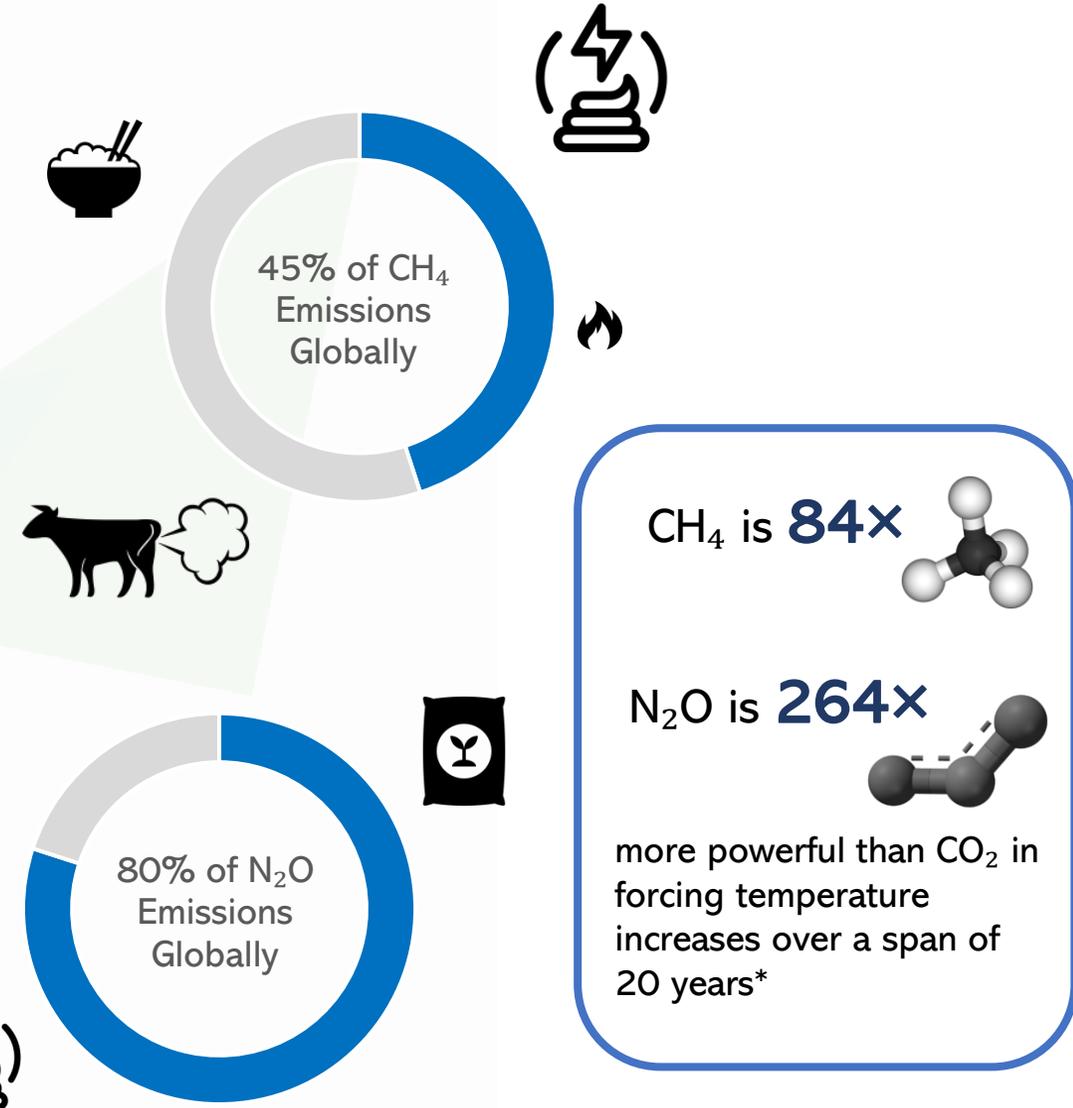
This puts agriculture almost on par with industry in terms of a source of emissions. This is a clear indication that agriculture, and innovators in agriculture, must contribute towards an active effort to limit climate change.

Methane (CH₄) and Nitrous Oxide (N₂O) in the Spotlight

The composition of emissions in the agricultural sector is dominated by Methane (CH₄) and Nitrous Oxide (N₂O). Therefore, it is natural that when efforts are made to reduce the GHG footprint of agriculture, these two potent gases are of primary focus.

Agriculture accounts for an estimated 45 percent of total methane (CH₄) emissions. About 80 percent of agricultural methane emissions are from livestock production, including enteric fermentation and manure management. The second largest contributor of agricultural methane emissions is rice production, with the remaining emissions from the burning of savanna.*

Agriculture accounts for 80 percent of total nitrous oxide (N₂O) emissions, mainly from the application of fertilizers—both synthetic nitrogen and manure added to soils or left on pastures.*

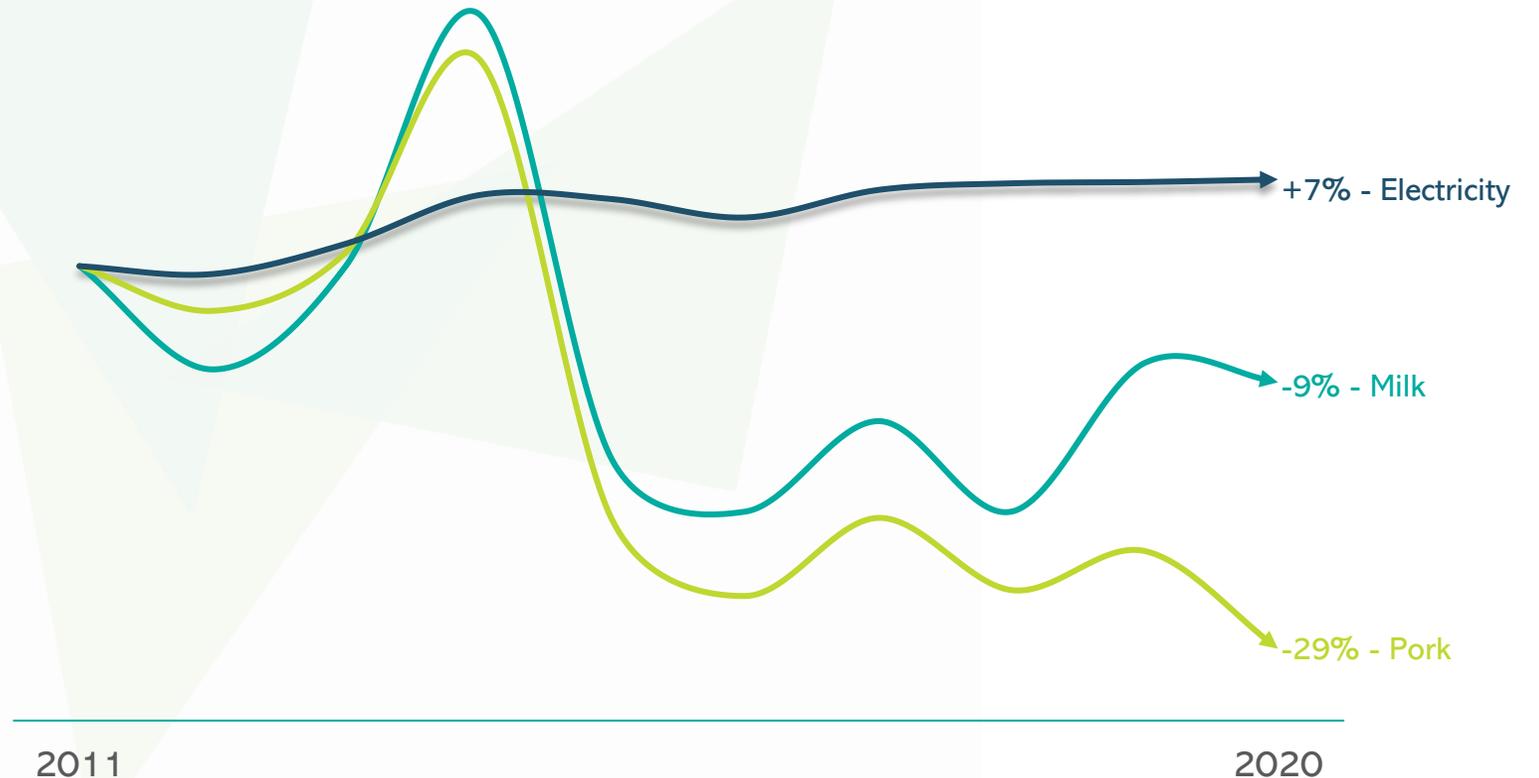


Farmers' Margins Are Under Ever Increasing Pressure

Since 2011, the price of electricity has been consistently rising, with a 7% increase in 9 years. Simultaneously, the prices of essential commodities such as milk and pork have suffered a 9% and 29% decline respectively, squeezing farmers margins even tighter.

Farmers are being pressured to decarbonize and reduce their GHG footprint, but are also struggling to offset the rising electricity costs as the price of their essential commodities is declining.

This puts the agricultural sector in a tight spot.



Change in Prices of Electricity, Pork, Milk in U.S. 2011 – 2020¹

Decarbonizing through sustainably electrifying farms is being overlooked

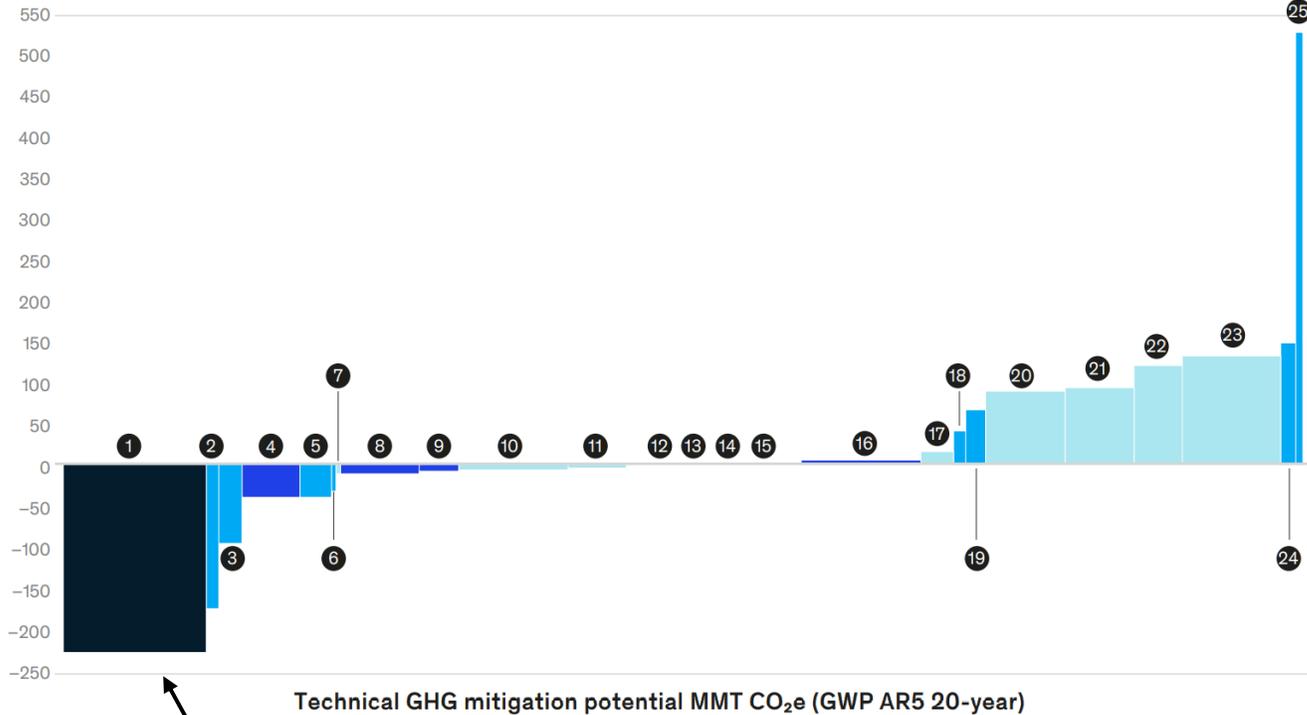
Potent gases such as methane and nitrous oxide dominate the conversation around agricultural emissions, and understandably so. However, this should not distract farmers from simple, efficient and cost-effective solutions that they can implement now.

On-farm energy use accounts for just under 7% of estimated global current emissions from agriculture, forestry, and land use change.* However, this estimation is an average of energy use from all types of farming, both arable and pastoral. When considering dairy and pig farms, who adopt energy intensive practice such as milk cooling, production and general heating, on-farm energy use is considerable higher.

Agriculture's electricity consumption has on average been increasing commensurably with industrialization. The US EIA's Annual Energy Outlook predicts there will be more than a 30% increase in electricity demand by 2050, with renewable energy's share to double from 21% to 42%. This increase will only be accelerated by the electrification of farm equipment. Therefore, the decarbonization of energy on farms can have an immediate impact.



Estimated cost of GHG abatement, \$/tCO₂e (20-year AR5 GWP values)



Adopting Zero-Emissions on Farm Machinery and Equipment Abatement Potential, coming with great Cost Savings.

GHG emission abatement potential from farmers adopting zero-emissions equipment is great. The cost-savings are even better.

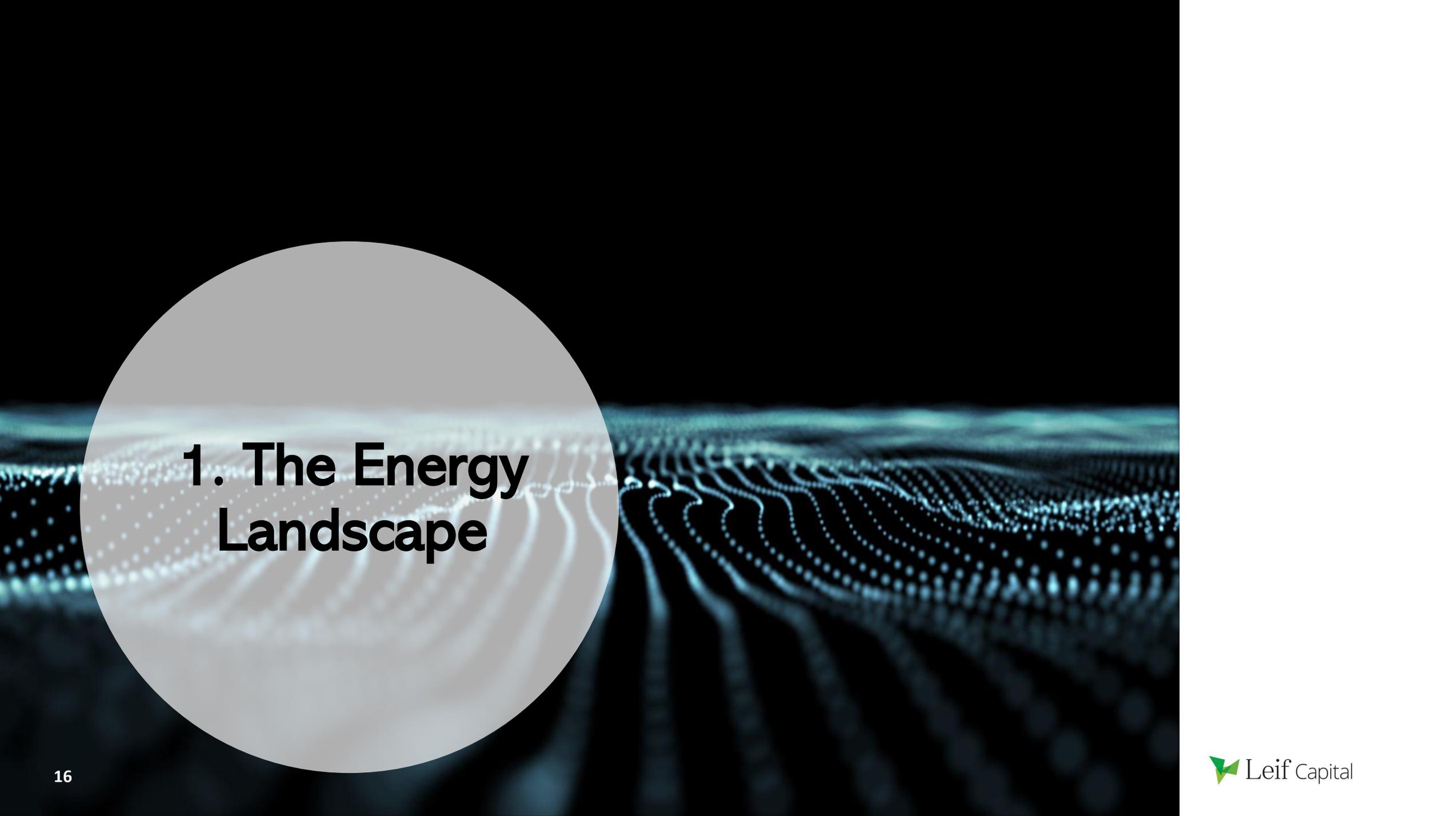
The Mckinsey and Company report '*Agriculture and Climate Change; Reducing emissions through improved farming practices*' published in April 2020 identified the top 15 measures for reducing potential emissions on farms using their own global agriculture marginal abatement cost curve (MACC).

The report stated that adopting zero-emissions on farm machinery and equipment had the largest amount of on-farm emissions abatement potential, with reductions of 537 MtCO₂e, at a huge cost savings of **\$229/tCO₂e**.*

Electricity sales potential from farm beneficial electrification is estimated to be between 55,000 and 67,000 GWh annually**. Taking the top of the range, and the estimated cost savings of \$229/tCO₂e, this could give over **\$6bn** a year in savings for farmers across the US.

*Mckinsey and Company: *Agriculture and Climate Change; Reducing emissions through improved farming practices*, April 2020

**<https://www.cooperative.com/programs-services/bts/Documents/TechSurveillance/Surveillance-Article-Farm-Beneficial-Electrification-October-2018.pdf>



1. The Energy Landscape

The Electrification Of Everything

People want to be in charge of their energy.

The energy landscape is undergoing a period of significant and dramatic change. Society is no longer happy to be reliant on large centralised power generation, sold to the consumer in a price-insensitive market. The demand for a more diverse and flexible energy supply is greater than ever before. How energy is generated, transported and consumed is driven by three main factors:



Decentralization

The traditional model of electricity, which flowed from large, centralized, transmission-connected generators through passive distribution networks to the end consumer, is becoming outdated. Technological advancements in smaller forms of energy generation, particularly **wind and solar**, have transformed the current patterns of supply and demand within the market. The U.S. Energy Information Administration (EIA) suspects U.S. electricity generation from renewables to surpass nuclear and coal within the next three decades.*



Decarbonization

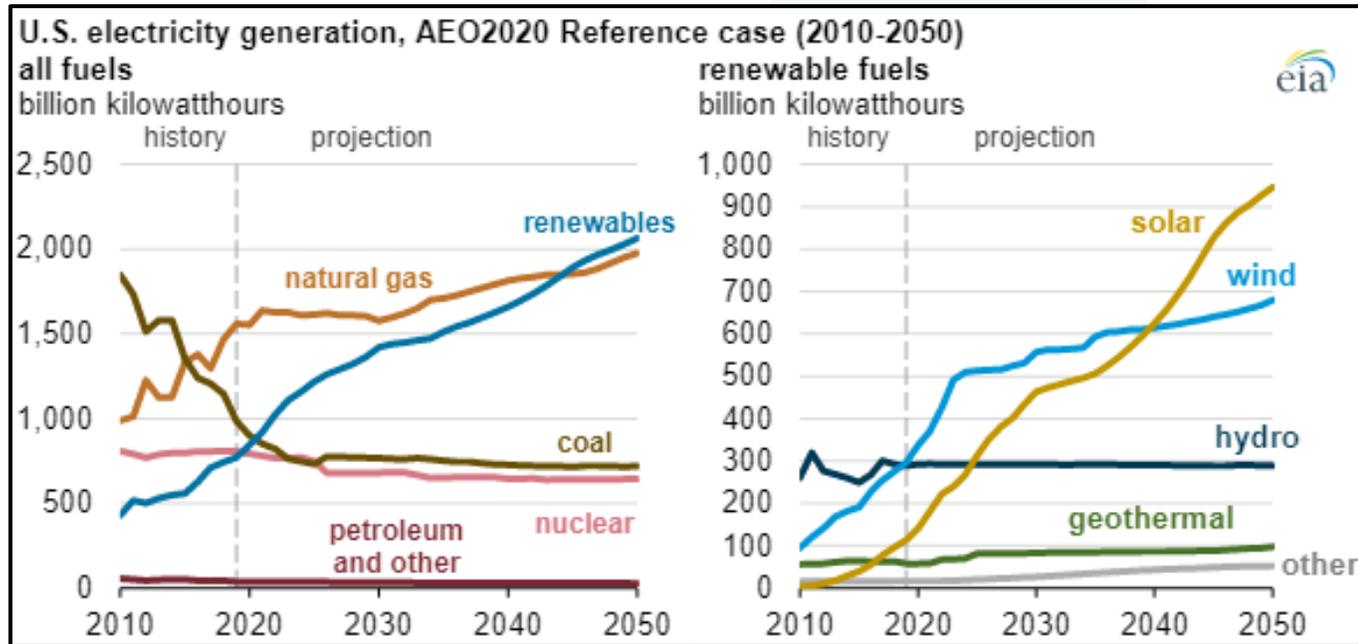
President Biden's recommitment to the Paris Agreement promises decarbonisation of the US economy by 2050. The idea is simple, but it is by no means easy. Biden must attempt to overcome the political polarisation present in climate and energy policy fields, and pave a way for a more bi-partisan approach to renewable energy policy. This will help to trigger technology innovation and therefore subsequent GHG emissions cuts. There is likely to be a considerable role for the electricity system in the deep decarbonization of both transport and potentially heat.



Digitalization

We are living in an increasingly digital world, and our new interconnected reality is sparking fundamental change within the energy sector. New business models are empowering the consumer in an unprecedented manner, through the deployment of smart meters and the exploitation of the 'internet of things (IoT)'; with increases in sensors, data collection and analytics. Digitalization has the potential to transform the way in which we consume electricity.

The U.S Energy Information Administration (EIA) expects U.S. electricity generation from renewables to soon surpass nuclear and coal.*



EIA projected electricity generation from renewables sources such as **wind and solar** to surpass nuclear and coal by 2021 and to surpass natural gas in 2045.

In the *Annual Energy Outlook 2020* (AEO2020) Reference case, the share of renewables in the U.S. electricity generation mix increases from 19% in 2019 to 38% in 2050.

Most of the growth in renewable electricity generation is attributed to **wind and solar**, which account for about half of renewable generation today.*

Accelerating the Transition

This energy transition, bringing about more distributed generation, storage and flexible demand, is being accelerated by a number of factors.

1. Government policy:

President Biden recommitted the U.S. to the Paris Agreement on his first day in office, and his administration plans to invest \$2 trillion in clean energy over four years, aiming for carbon-free electricity by 2035. His policies intend to trigger a nationwide mobilisation to reduce emissions, build infrastructure and advance social justice.

3. Change in end consumer behaviour:

Every significant energy transition has been heavily dependent on end consumer behaviour, and this shift is no different. The rapid adoption of electric vehicles (EVs) as well as the rise of the 'internet of things' (IoT) is significantly changing the patterns and trends of consumer behaviour.

2. Reduction in cost of distributed generation:

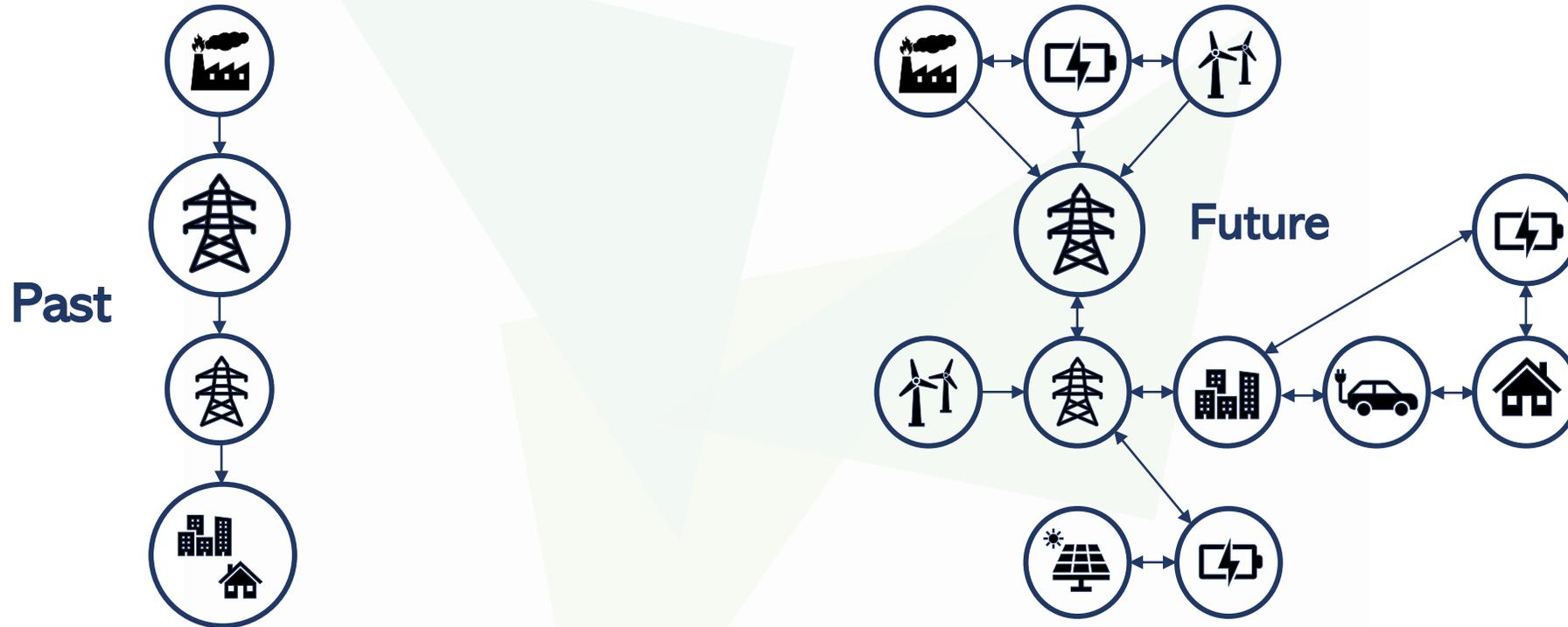
The cost of **wind and solar PV** generation has fallen 66% and 85% respectively over the last 11 years. Energy storage solutions have also undergone a similar reduction in costs over recent years, with these trends expected to continue and accelerate.

4. Advances in digital technology:

The deployment of smart meters and the introduction of Home Energy Management Systems (HEMS) gather insight for both ends of the supply chain, through providing a secure and flexible platform that is truly customer orientated.



The future of the power system



In the past, electricity flowed from large transmission-connected generation, through passive distribution networks to the end consumer.*

The future power system will be a sophisticated and intelligent infrastructure, integrating key distributed generation sources such as **wind and solar**. It will connect a range of new technologies and more active consumers, while maintaining overall independence, resilience and reliability.*



3. Case Study: In Focus

eocycle 

Distributed renewables is the new asset class: **small** is the new big.

Smaller scale, distributed, behind-the-meter, renewables and storage have some clear advantages over their larger grid-connected cousins. For owners, such energy systems give them more control over their longer-term electricity tariffs, making them more resilient if they lose the grid, and enabling them to electrify their farms without the local network having to be upgraded (or the farmers being 'constrained off').

For investors, the behind-the-meter tariffs could enable a higher return than a conventional windfarm or solar farm. For utilities, the systems can solve the problems of quality of electricity supply at the edge of the network and avoid expensive network upgrade costs. This is a potential win-win-win situation, so why is it only now that the opportunity is arising?



Distributed renewables is an untapped infrastructure opportunity at an inflexion point

The key reasons why we are at an inflection point are firstly that these systems have become more cost effective. This brings us onto our 'in focus' case study, **Eocycle Technologies**, a Canada-based wind turbine manufacturer and systems integrator. Eocycle has reduced the LCOE of smaller wind systems to below the tariffs charged for electricity in the US and Europe. Previously these systems were only cost effective for remote power on islands (displacing expensively shipped diesel) or relied on high feed-in-tariffs. Now, Eocycle is changing things.

Smithfield[®]

Nutrien[™]

ENGIE



Secondly, as farms electrify, they are realizing that they need more capacity than the grid can supply, and **Wind plus Solar plus Storage (WS²)** enables them to avoid exceeding their grid constraints. This effect is magnified as farmers strive for resilience and independence. Finally, farms must decarbonize soon to prevent climate change, and the political will to drive this change is increasing. Therefore, large agricultural corporates are eager to help their supplier farms in their decarbonization efforts. There are cost savings of \$229/tCO₂eq* to be made by farms who electrify (and that's excluding the better electricity tariffs they get from owning their own supply).

So, small scale **WS²** now has the same potential to rapidly scale, as residential solar has done before it.



Wind + Solar + Storage (WS²) reduces costs, land use, emissions and increases resilience.

- Eocycle Technologies Inc is a Canada-based wind turbine manufacturer and systems integrator which electrifies farms and industry sites in the US Mid-West and Europe sustainably.
- Their lowest cost, behind-the-meter, renewable electricity enables farmers to lock in lower electricity prices and decarbonize in a visual, measurable and easy way.
- Their 360° monitoring system enables farmers to measure and reduce their emissions against phased, verifiable milestones.

The Technology:



1. Patented and certified 25kW and 100kW tilt-up turbines with solar and storage



3. Machine learning and regression techniques enable forecasting and continuous learning and benchmarking across regions



4. Basic system covers electricity, add-ons to cover water usage and other inputs



5. Easy integration into supply chain management software for large agricultural corporates

Backed by



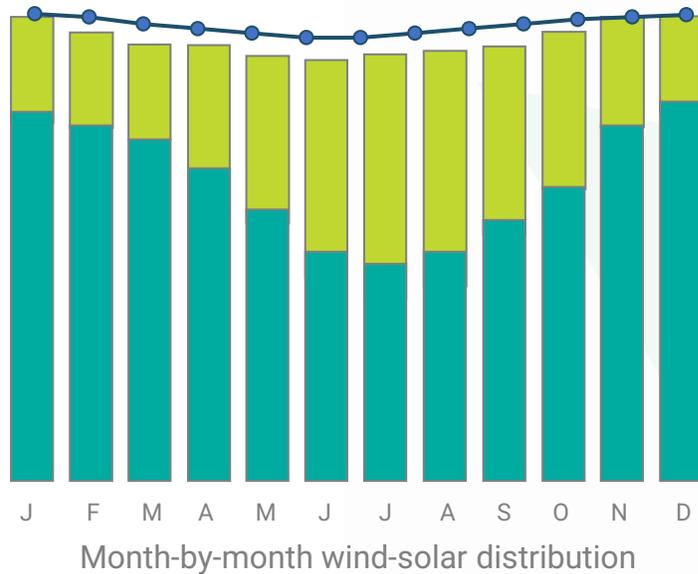
Eocycle provides a seamless solution, which offers savings, emission reductions and energy independence

Their patented and certified wind turbine technology is combined with solar and storage in what they call their WS² solution. This breakthrough in distributed renewable energy services is an essential part of the process of electrifying and decarbonizing agriculture.

Through breaking grid parity, and moving away from outdated, centralised power generation, Eocycle will have the opportunity to dominate WS² solutions in windy areas. Within in 10 years, they aim to have 2,500 sites electrified, 60% in the US, 30% in Europe and the remaining 10% around the rest of the world. This would bring about fleet carbon emissions reductions of more than 200m tCO₂eq.



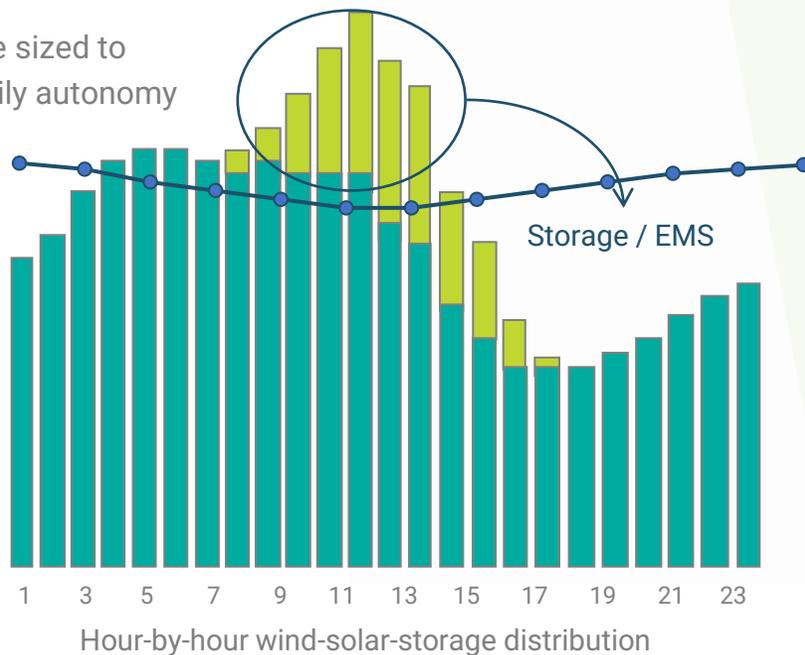
Eocycle also offers a 360° platform which facilitates the electrification journey for customers. Energy Management System (EMS) integration enables grid, renewable energy and storage to be monitored, triggering alerts using Machine Learning. The operations center monitors the fleet and provides insights to farms and corporates. This real-time, centralised data enables electricity, carbon and Renewable Energy Certificates (RECs) reporting for contractual trading.



The WS² solution provides a stronger value proposition, with the combination of wind and solar to reach energy independence with less storage.

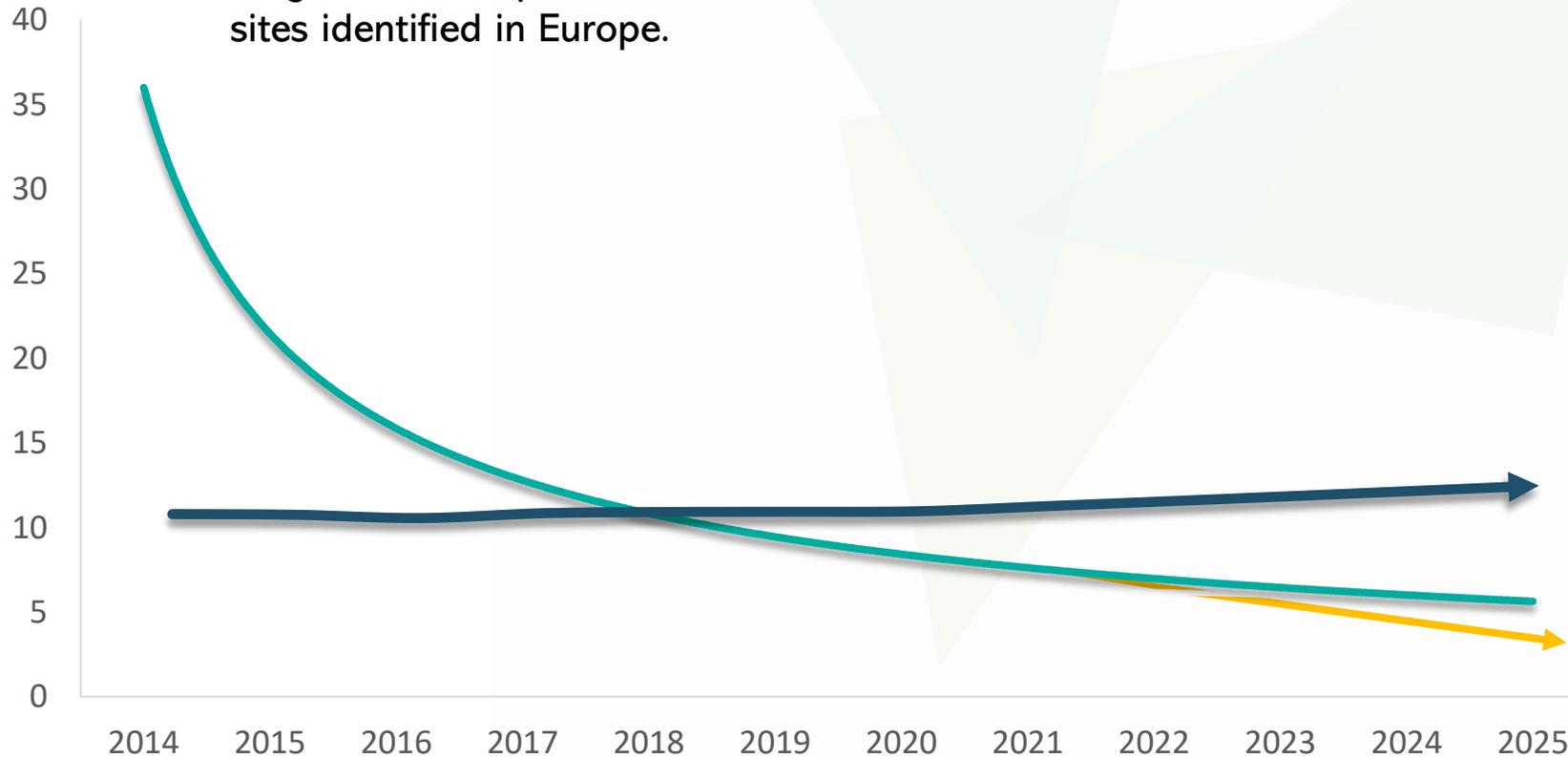
The combination of wind and solar is the clear way forward. Eocycle has had 12 patents granted. Its 25kW and 100kW tilt-up turbines are solar and storage ready. Their IP-driven traction has been building for some time, as they have more than 500,000 operating hours under their belt. Eocycle has strong partnerships with both the National Renewable Energy Laboratory (NREL) and the US Department of Energy (US DOE), and their turbines are certified Investment Tax Credit (ITC) eligible. Eocycle are on track for a Levelised Cost of Energy (LCOE) of 4c/kWh.

Storage sized to achieve daily autonomy

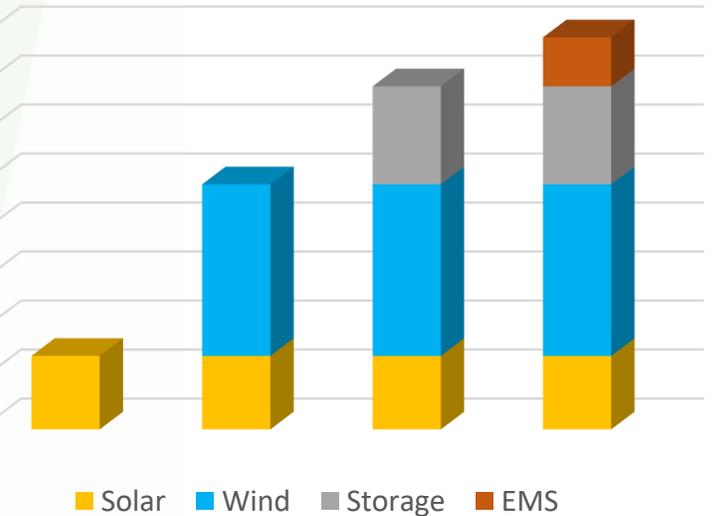


Eocycle's price already beats the grid, at 4¢/kWh, more than 85% of cost reduction

The U.S National Renewable Energy Laboratory estimates 1 million farms (of the 2.1 million total in the USA) could save money with wind alone by 2030. The cost-savings brought about by Eocycle's WS² solution would be greater, with potential outside of the US, such as 300,000 near time sites identified in Europe.

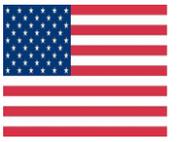


Levels of savings/autonomy, /resilience



A white autonomous agricultural robot is shown in a cornfield. The robot has a camera and a sensor array on its front. It is positioned in the center of the frame, surrounded by rows of corn plants. The background is a bright, sunny day with green leaves and a clear sky.

4. Other Case Studies



Products



nitrogen-producing microbe that is changing the way nitrogen is applied to corn.



biological nitrogen solution for sorghum growers

- Pivot Bio is a California based company making game-changing advances in crop nutrition.
- Their technology harnesses the power of naturally occurring microbes to provide more nutrients to crops.
- It's a smart, sustainable way for farmers to improve yield as they work to help feed the world's growing population

Process



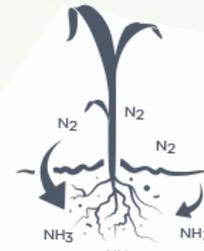
STEP 1: IDENTIFY

Collect diverse soils to isolate and identify millions of microbes. In the process, we create a sophisticated map of the soil microbiome.



STEP 2: CHARACTERIZE

Determine if key microbes have the genetic potential to fix atmospheric nitrogen and live in a symbiotic relationship with cereal crop.



STEP 3: FINE-TUNE

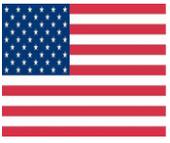
Precisely fine-tune these microbes so they release nitrogen through the roots to meet the growing crop's nutritional needs.

Backed by



Breakthrough Energy





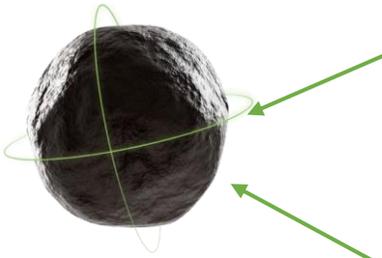
High-efficiency, sustainable bio-based fertilizers for the agriculture, turf, and lawncare industries

Technology:

Organic MaTRX™

Combined electrostatically charged organic particles act as docking sites for desired nutrients.

(NH₄⁺), (K⁺), (SO₄⁻), (PO₄³⁻), (Fe²⁺), all easily taken up by plants and are less susceptible to loss via leaching or volatilization.



- Anuvia Plant Nutrients, headquartered in Winter Garden, Florida, is a company focused on an innovative and patented way of manufacturing an enhanced efficiency fertilizer (EEF) for the turf and agricultural industries.
- Anuvia addresses the three pillars of sustainability – social, environmental and economic – simultaneously by providing an avenue for organic materials to be used in a resource efficient and environmentally friendly manner that helps people, plants and the environment thrive.
- Anuvia’s process reclaims organic materials in the last step of their lifecycle and repurposes them with no waste stream.

SYMTRX™ Agricultural Fertiliser

GREENTRX™ Professional Turf Fertiliser

ANUGREEN™ Residential Fertiliser



Renewable+ Sustainable



Bio-based



Homogenous



Dual Release



Fixes Carbon and brings Economic Benefits

Backed by





Creating the tools needed to power scalable ecosystem restoration and restore the balance of our natural world.

Services:



Custom drones perform extremely high resolution data collection to show you vegetation, species, condition, and erosion characteristics of every square metre. See what's happening down to every single blade of grass.



AI software trained by ecologists and grounded in real research identifies trouble spots and changes in the land that could derail rehabilitation efforts, providing precise guidance on where to direct work efforts



Specialised seed mixes, packaging, and aerial delivery algorithms based on years of on the ground work enabling not only scale seeding, but ensure that it actually works to transform the land as desired quickly.

- Dendra Systems is an Oxford based environmental services business, who are building powerful tools for ecosystem restoration.
- Dendra uses advanced data science, artificial intelligence, and drone automation to rehabilitate land and restore biodiverse ecosystems at scale.

Backed by





Leading the digital transformation of farming

- Monarch is an autonomous tractor manufacturer based in California.
- Using state of the art hardware and machine learning, the Monarch Tractor is able to autonomously use implements, identify and eliminate plant ailments, and estimate yields.
- Monarch’s tractor platform acts as a full data collection and analysis suite, enhancing existing growing operations and providing superior precision to farmers globally.
- Despite it’s cutting edge tech, the Monarch still has best in class plow, till, and hauling capabilities

FULLY ELECTRIC

DATA ENHANCED



**POWERFUL
+
EFFICIENT**

Backed by



**ECONOMICALLY
SUPERIOR**

DRIVER OPTIONAL

UNPARELLED SAFETY



SOIL SCOUT

The Most Advanced Wireless Soil Moisture Sensor For Agriculture, Golf Courses and Sports Stadiums



- Soil Scout is environmental services company based in Helsinki, Finland. It provides the most advanced fully buried underground wireless soil sensor and monitoring solution for professionals in Agriculture, Golf and Sports turf maintenance.
- Several golf courses and sports fields worldwide, including such iconic venues as the Wembley Stadium and Philadelphia Phillies, use Soil Scout to maintain their turf in tip-top shape while reducing maintenance costs and water consumption.
- Farmers and agriculture professionals around the world use Soil Scout to understand their fields, optimize soil conditions for better growth and improve crop production, also reducing operational costs and water consumption.

Applications:



Agriculture



Golf Courses



Sports Fields



Soil
Monitoring

Backed by



Husqvarna®



**AUTONOMOUS
MODULAR
MULTI-TASKING**

Services:

- 1. **Light Treatment:** Leads to 80-95% proven reduction of mildew in strawberries
- 2. **Harvester:** Autonomous harvester activated in the presence of ripe strawberries
- 3. **Other:** Precision weeding, plant data collection, grass cutting and soil sampling

Autonomous Modular Robot delivering Agricultural Services

- Saga Robotics is Norwegian company whose aim is to develop robotic solutions that address the growing labour shortages in agriculture, as well as making agriculture more sustainable and energy efficient.
- Saga Robotics have developed an autonomous and completely self-propelled robot, Thorvald, that uses advanced algorithms to navigate in challenging conditions found on farms.
- Thorvald is a new module-based robot design that allows for different robots to be built using the same basic modules. These modules enable high quality robots that can be quickly customised for a given application in a given environment (e.g. greenhouse, tunnel or orchard)

Backed by:

ADM CAPITAL



Nysnø





5. Conclusion



Conclusion

The path towards an electrified and decarbonized agricultural future is becoming clearer. A diverse range of measures must be taken, from improving fertilization practices to optimizing animal feed mix. Decarbonization through renewable electrification is one of the quickest and easiest wins that farmers can make, allowing them to produce the world's food while protecting our planet.

Companies like Eocycle and the other innovators mentioned in this report are giving farmers the tools to capitalize on this opportunity. Significant economic and environmental rewards are within their grasp.

Sources

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- Soil Scout Raises Significant Late-seed Round Led by Husqvarna Group
- Mckinsey and Company: *Agriculture and Climate Change; Reducing emissions through improved farming practices*, April 2020
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