The Potential for Biochar to Enhance Sustainability in the Dairy Industry
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Polls
This webinar will have polls. Polls will be “launched” by the organizers and will appear in the middle of your screen. Just answer them when they pop up to participate!
IBI Mission
To provide a platform for fostering stakeholder collaboration, good industry practices, and environmental and ethical standards to support biochar systems that are safe and economically viable.

Vision
One billion tons of biochar produced per year within 50 years.
Thank you
New Sustaining, Business & Organizational members

Sustaining
• Norway: Tilapia Group
• USA: Aries Clean Energy, Corigen

Business
• Norway: Scandi Energy
• UK: Carbon Gold, BiocharWorks, Sequest
• USA: Advanced Resilient, City Light Capital

Organizational
• USA: Glanris, SF Biochar
Dr. Shannan Sweet

Shannan Sweet is a postdoctoral researcher in the Lehmann Lab at Cornell University. Her research focuses on climate change mitigation and resiliency. Her recent work includes investigating on-farm pyrolysis of dairy manure to not only address climate change but also make farms more resilient to extreme weather events, while simultaneously protecting the social and environmental wellbeing of local areas.
The Potential for Biochar to Enhance Sustainability in the Dairy Industry

IBI Webinar – January 28, 2021

Shannan Sweet

Kathleen Draper  ithaka institute for carbon intelligence  Johannes Lehmann  Cornell University
AGENDA

Thermo-Chemical Conversion (TCC)
  • What is it TCC
  • How “pyrolysis” and biochar relate to TCC

TCC & Biochar on Dairy Farms
  • Benefits and uses of TCC and biochar on dairy farms
There are various technologies capable of carbonizing organic material using high heat (300°C or higher), but the most common are pyrolysis and gasification.

Gasification can include small amounts of oxygen and will produce some solids, but mostly liquids and gases.

Pyrolysis converts organic matter into solids using no oxygen. This process produces a carbon rich solid that decomposes much more slowly than the original biomass used to make it called biochar.
DAIRY MANURE TO BIOCHAR PILOT PROJECT
AN INNOVATIVE APPROACH TO NUTRIENT MANAGEMENT, FARM WASTE REDUCTION, AND GREENHOUSE GAS MITIGATION

**Benefits of Biochar**
- A valuable soil amendment through improved retention of nutrients and water
- Lowers farm’s manure storage/hauling costs by reducing the mass and volume of manure waste
- Sequesters greenhouse gases by transforming carbon into a stable form
- Integrates with manure solids separation systems, which provide bedding and manure storage/hauling savings to the farm and greenhouse gas reductions by lowering manure storage methane emissions

**Project Partners:**

Native Energy
A Public Benefit Corporation
Burlington, VT

Biomass Controls PBC
Pittsfield, CT

USDA
This work is supported by the Conservation Innovation Grants program of USDA’s Natural Resources Conservation Service
Benefits and Uses of Biochar on Dairy Farms

- Manure Management
- Water Quality
- Cow Health
- Climate Change
- Other Benefits
Manure Management

Reduction of Solids
• Pyrolyzing separated solids on-farm can reduce volume by 75% to 95% and result in a useful by-product (i.e., biochar)

Land Application
• Reduced use of chemical fertilizer
• Improved nutrient holding capacity
• Reduced odors
Manure Management

Photo by Elizabeth Gribkoff/VTDigger
Cow Health

Feed Additive
• Improve health
• Reduce methane emissions
• Binds pathogens (e.g. mycotoxins)

Bedding Amendment
• Reduced odors
• Dryer stalls
• Improved hoof health
Water Quality

Improved Water Quality

- Immobilize toxic metals
- Stabilizes nutrients
- Filters runoff
- Reduced groundwater contamination
- Reduced eutrophication
Climate Change

Mitigation
• Carbon sequestration
• Methane reductions
• Reduced soil emissions
• Reduced GHG emissions
• Renewable energy

Adaptation
• Improved water holding capacity
• Improved soil porosity and water infiltration
Other Benefits

Biochar Compost Additive
• Boosts microbial growth
• Accelerates composting
• Enhances nutrient retention
• Reduces gas losses

Anaerobic Digestion
• Boosts methane quality & quantity
• Reduces $\text{H}_2\text{S}$
Read the full paper...

**Google:**
The Potential for Biochar to Enhance Sustainability in the Dairy Industry

Or use the link:

Contact us!
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Johannes Lehmann: cl273@cornell.edu

Or visit:
https://pyrolysis.cals.cornell.edu/
http://www.ithaka-institut.org/en/home
Dr. Greg Campbell

Greg Campbell is the CEO of VGrid Energy Systems, Inc., a renewable energy company in the ag space. He is a successful entrepreneur who has taken two previous companies in the technology space through IPOs and successful acquisition. Greg did his undergraduate degree at Cambridge University in engineering and earned his doctorate in applied plasma physics at UCLA.
VGRID Implements a 3P Climate Change Solution

VGRID’s solution produces clean renewable energy while preventing and removing harmful atmospheric gases and produces a high surface area biocarbon that is valued for its adsorbent properties and uses.

WE PRODUCE
CLEAN RENEWABLE ENERGY & VALUABLE HIGH SURFACE AREA BIOCARBON

WE PREVENT
GREENHOUSE GASES BY REDUCING & REMOVING THEM

WE PROMOTE
BETTER QUALITY OF LIFE USING BIOCARBON SOLUTIONS
## Global Net Zero Carbon Energy Model

<table>
<thead>
<tr>
<th>FOSSIL FUELS</th>
<th>WIND, SOLAR &amp; HYDRO</th>
<th>CARBON CAPTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Dependency</td>
<td>Maintain/Increase</td>
<td>Increase Use</td>
</tr>
<tr>
<td>Carbon Positive +</td>
<td>Carbon Neutral 0</td>
<td>Carbon Negative -</td>
</tr>
</tbody>
</table>

**FOSSIL FUELS**

Carbon in its solid, liquid and gaseous forms are removed from the earth’s soil and converted into various forms of energy which when combusted emits 100% of all its carbon into atmosphere. The accumulative effect over many years has created an imbalance in the natural carbon cycle leading to climate change.

**WIND, SOLAR & HYDRO**

Using the forces of nature to generate renewable energy. These forms of energy generation do not use, emit or capture carbon and so they are considered environmentally safe and neutral.

**CARBON CAPTURE**

The use of carbon negative technology, like V-Grid’s, to transfer carbon from the atmosphere back to soil while making renewable energy and thereby offsetting the current use fossil fuels and reducing and preventing the accumulative atmospheric carbon levels.

**THIS OFFSETS FOSSIL FUELS**
WE PRODUCE CLEAN RENEWABLE ENERGY & VALUABLE HIGH SURFACE AREA BIOCARBON
VGRID Bioservers converts agricultural waste and other biowaste into energy and biocarbon

Input: VGrid BioServers are powered by agricultural biowaste

Output: 100% clean, renewable electricity

POWERING FARM OPERATIONS
- Pumps
- Heating/Air Conditioning
- Dairy Equipment
- Processing Machinery
- Buildings / Polebarns

Output: High Surface Area Biocarbon

BIOCARBON PRODUCTS
- Feed Additive
- Animal Bedding
- Soil Amendment
- Health & Beauty
- Water Filtration
- Air Freshener

VGRID OWN & OPERATES THE BIOSERVERS:
- No Upfront cost to customer
- VGRID paid for electricity consumed
- VGRID controls biocarbon
- Ongoing income stream

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How VGRID’s Bioserver Technology Works

1) Biomass enters the chamber where Pyrolysis occurs to pre-heat the biomass at 500°C

2) Gasification introduces limited oxygen; combustion converts biomass to Carbon and gases with temperatures >1,000°C

3) Hot Carbon drops into the Reduction Zone where syngas is produced

4) Activated Carbon falls to the bottom and is removed for air filtration, water filtration, and agriculture

5) Syngas is cooled, cleaned, and then fed into an internal combustion engine to produce 100% clean, renewable electricity
## GASIFICATION VS PYROLYSIS

<table>
<thead>
<tr>
<th></th>
<th>PYROLYSIS</th>
<th>GASIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENERGY INPUT/OUTPUT</strong></td>
<td>CONSUMES ENERGY</td>
<td>PRODUCES ENERGY</td>
</tr>
<tr>
<td><strong>TECHNOLOGY ADOPTION &amp; USE</strong></td>
<td>Less installations worldwide</td>
<td>Many installations (gasifiers) worldwide</td>
</tr>
<tr>
<td><strong>TECHNOLOGY PROCESS</strong></td>
<td>No oxygen is used</td>
<td>Heating in presence of little oxygen or air</td>
</tr>
<tr>
<td></td>
<td>Thermal decomposition of biomass (300-600°C)</td>
<td>High temperature process (1200°C)</td>
</tr>
<tr>
<td></td>
<td>Constant energy is required to heat the biomass to destruct it</td>
<td>Autothermal or exothermic reactions, requiring significantly less energy once gasification starts</td>
</tr>
<tr>
<td><strong>BIOCARBON OUTPUT</strong></td>
<td>Char is low surface area, low porosity</td>
<td>Char has high surface area high porosity</td>
</tr>
<tr>
<td></td>
<td>Char has high residual organic compounds (&lt;40%)</td>
<td>Char has less residual organic compounds (&lt;10%)</td>
</tr>
<tr>
<td></td>
<td>Char yield is typically around 30%</td>
<td>Char yield is around 20%</td>
</tr>
</tbody>
</table>
WE PROMOTE BETTER QUALITY OF LIFE USING BIOCARBON SOLUTIONS
High surface area biocarbon, with its adsorbent properties can be used in a variety of ways to improve the quality of life for both humans and animals.

✓ Biocarbon can be used in animal feed additives to bind digestive toxins.

✓ It can be used in animal bedding for odor control, improved living conditions while creating nitrogen enriched compost for building healthy soil.

✓ It can be used directly in agriculture as soil amendment to produce more with less water and fertilizers.

✓ It can also be used in air filtration and water filtration

✓ Used to make 100% organic Health and Beauty products

✓ Used in medicine and pharmaceuticals
Manure Management – 200 Cows

- **200 Cows**
- **1,400 Gallons Per Day**
- **2,800 lbs Per Day**
- **Biochar absorbs Ammonia, H2S and Methane**

**Diagram:**
- **MANURE LAGOON**
- **DRYER + PELLETIZER**
- **GASIFIER**
- **ELECTRICITY** 1,500 KWh Per Day
- **BIOCHAR** 600 LBS Per Day

**Other Information:**
- **2,800 lbs Per Day**
- **Heat**
## Manure Processing Using V-Grid BioServer

### INPUT

<table>
<thead>
<tr>
<th>Pellet Moisture (%)</th>
<th>Ash (% dry basis)</th>
<th>Gross Calorific Value (Btu/lb, dry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pistachio Shell Pellets</td>
<td>0.7</td>
<td>8056</td>
</tr>
<tr>
<td>Manure Pellets</td>
<td>7.0</td>
<td>8249</td>
</tr>
</tbody>
</table>

### OUTPUT

<table>
<thead>
<tr>
<th>Electricity Production (kWh/kg)</th>
<th>Char Production (% biomass in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pistachio Shell Pellets</td>
<td>0.53</td>
</tr>
<tr>
<td>Manure Pellets</td>
<td>0.19</td>
</tr>
</tbody>
</table>
Run Comparison Data

GC Syngas Analysis

<table>
<thead>
<tr>
<th>Gas</th>
<th>Pistachio Shells</th>
<th>Biosolids</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>CO</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>CH₄</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>CO₂</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>HCₓ</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

26% less combustion gas than pistachio shells

Manure char Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>0.54</td>
<td>g/cc</td>
</tr>
<tr>
<td>BET</td>
<td>278</td>
<td>m²/g</td>
</tr>
<tr>
<td>Ash</td>
<td>33</td>
<td>%</td>
</tr>
</tbody>
</table>

Biosolids char contains Ca, K, & P nutrients

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Results and Conclusions

We have successfully demonstrated the feasibility of processing manure through the V-Grid Server to generate electricity and biochar.

We generated 0.19 kWh/kg biosolids with approx. 28% char in our first attempt.

Biochar ash obtained from this feedstock shows presence of nutrients which are beneficial for plant growth.

Based on the calorific value of this material, we should be able to improve on our electricity production efficiency by further reduction in moisture content and optimizing our run parameters.
Design Advancement and Reliability Testing

Design Rev 1 – Deployed a single **prototype** Bioserver and genset

Design Rev 2 – Deployed six 2nd generation Bioservers at two different locations: 3 at one dairy and 3 at another.

VGrid Bioserver 100 – Released **product** 5 Bioservers installed and in operation at South Corner Dairy. 3 more Bioservers to be installed in next 3 months
  - 2yr+ Field proven reliability
  - Full Automation Implemented

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Summary

- V-Grid has developed field proven mobile gasification technology that produces low-cost on demand renewable electricity.
- V-Grid has developed valuable biocarbon products that have been tested and accepted in the market.
- V-Grid has verified the use of manure as a feedstock, producing biochar with good surface area and with important soil nutrients.
- V-Grid’s technology is environmentally friendly in producing renewable clean energy while reducing/removing harmful greenhouse gases which cause climate change.
Steve McCorkle

Steve McCorkle is founder and CEO of Ag Waste Solutions (AWS) and is the developer of AWS’ unique carbon regeneration solution and business model. Steve has over 35 years of successful international leadership experience, with a large part of that experience earned while managing energy and technology businesses for Schlumberger Limited – the world’s leading service and technology supplier to the oil and gas industry. Steve’s interest in regenerating waste carbon into clean burning transportation fuels developed while exploring for oil and gas in remote deserts in the Middle East. He served as Board Chair of the Animal & Poultry Waste Management Center (APWMC) at North Carolina State University as he developed the AWS technology solution for distributed micro biorefineries on animal farms. Steve decided to implement the AWS solution in Southern California first because the region represents the most stringent regulatory environment in the world.

Mr. McCorkle holds a Bachelor of Science in Electrical Engineering from North Carolina State University and an Executive MBA from the University of Houston.
Carbon Negative Jet Fuel & Biochar from Dairy Manure

Steve McCorkle, Founder & CEO
Ag Waste Solutions (AWS)
January 28, 2021
AWS MILESTONE HISTORY

Pre-2009: Filed patents, NCSU trials (Smithfield Project), IEUA pilot (utilities agency)

2009 - 1st ever SCAQMD air district full Operating Permit for biomass pyrolysis
2010 - Operated manure pyrolysis/water treatment pilot on Chino dairy farm
2011 - CEC grant to produce FT (Fischer-Tropsch) sulfur-free diesel fuel from manure
2012 - 1st USDA EQIP grant for manure pyrolysis, converted from AD EQIP grant
2013 - 1st SCAQMD permits for manure pyrolysis + biofuels production
2013 - AWS project enabled 26 dairy WRCAC co-op to renew CAFO operating permit
2014 - Produced fertigation + potable water from flushed manure
2015 - 1st ever sulfur-free FT (Fischer-Tropsch) diesel/jet fuel produced from manure
2016 - Accepted “EPA Nutrient Recycling Challenge” Award at White House
2016 - Modified pyrolysis process to produce nutrient-rich biochar from manure
2017 - Controlled greenhouse growth trials of manure biochar - up to + 27% yields
2018 - Contract with largest landfill diversion digester in U.S.
2020 - Create Carbon Regeneration Center (CRC) model for micro biorefinery scale up
2021 - Commercialize CRC micro biorefinery with jet fuel and biochar production
ISSUES & OPPORTUNITIES

The Problems: Aviation and Agriculture together contribute ~ 13% of Global GHGE; Biochar production is expensive when producing low $ value co-products

- Aviation travel creates the highest GHGE per passenger mile of any form of transportation
- Ozone damage increases at higher altitudes (sulfur in jet fuel, aerosol formation )
- Aviation industry has no viable solutions (e.g. electric, H2) to achieve carbon neutrality
- Desulfurizing petroleum jet fuel is expensive, increases lifecycle CO2 emissions by 2%
- FAA certified jet fuel refineries cannot meet CA emissions standards, need carbon offsets
- Soil carbon levels declined from an average of 5% pre-industrial revolution to ~1% today

The Solution: Regenerate carbon emissions from manure/ag into Carbon Negative Jet Fuel and Biochar to achieve carbon neutrality for Aviation and Agriculture

- Micro biorefineries on farms to produce sulfur free, carbon negative jet fuel and biochar
- Next generation nano materials to cost effectively produce jet fuel from biochar syngas
- Produce lowest Carbon Intensity (CI) and highest Low Carbon Fuel Standard (LCFS) credits
- Automate jet fuel production from syngas to minimize operational costs, maximize profits
- Biochar added to soils to increase arable land, reduce water, add nutrients & carbon credits
1) Cows feed on food crops

2) Cows excrete manure

3) Solids separated from liquids

4) Solids into pyrolysis process to produce Biochar and Bio-syngas

5) Bio-syngas conditioned to produce Jet/Diesel Fuel and power

6) Bio-syngas converted into Jet/Diesel Fuel

7) Biochar and fertigation water to Healthy Soils; Diesel fuel to farm equipment; Jet Fuel to Aviation industry

8) And the closed loop, Zero Waste Carbon Regeneration Cycle cycles again and again...

**AWS Carbon Regeneration Cycle**
From Farm to Sustainable Planet
AWS Biochar + Jet Fuel + Clean Water System

AWS’ patented, proven modular system is prefabricated, skid-mounted, closed-loop, scalable

Any and All Organic Feedstocks

- Dairy Bio-Fiber Production
- Solids Recovery Module (“SRM”) - Removes 98% Suspended Solids > 5 microns (1/10 hair)
- DBF for Bedding, Peat Replacement
- Fertigation and/or Potable Water

Solids

- Solids
- Liquids

Gas Production Module (“GPM”)
- Nutrient-Rich + Carbon Biochar
- AD Biogas
- Landfill Gas
- Oilfield Flare Gas
- Any Stranded /Flare Gas
- Treated Water

Energy Production Module (“EPM”)
- Jet Fuel & Wax
- Site Power

Multiple Carbon-Negative Product & Profit Options
- Nutrient-Rich Dairy Manure Biochar + Jet Fuel = + Profit Flexibility
- Fertigation Water, Potable Water, Power = - Carbon Footprint & Cost
- AD Biogas, Landfill Gas, Flare Gas to Jet Fuel = + Profits
- AD digestate to Biochar + Jet Fuel = + Profits (>50% feedstock carbon)
- Dairies remote from utility network backbones = + Profits
- Scale up by adding portable, standard modules = + Profits & Flexibility

Project Financial Goal: EBIT Return on Capital Employed (ROCE) > 28%

Mission: Create Profitable Carbon Regeneration Centers by Converting Potentially High GHGE into Carbon Negative Jet fuel and Biochar

Nutrient-Rich + Carbon Biochar Site Power

Removes 98% Suspended Solids > 5 microns (1/10 hair)
Declining Carbon Intensity Curve

Program continues with a 20% CI target post 2030
CARBON INTENSITY AND LCFS CREDITS

Businesses that sell fuel with carbon intensity ABOVE the cap must buy credits

Businesses that sell fuel with carbon intensity BELOW the cap can sell excess credits
FT (Fischer Tropsch) Jet Fuel is the cleanest burning Jet Fuel on the planet. When produced from dairy manure, it will have the lowest CI of any transportation fuel, even without biochar CO2e credits.
AWS process avoids high GHGE emissions from biomass (manure) decomposition.
- Manure derived jet fuel burns cleaner than petroleum or renewable jet fuel - sulfur free
- Manure derived jet fuel has dramatically lower "well to wings" Carbon Intensity
- Burning manure derived Jet Fuel removes > 4X the GHGE that petroleum jet fuel adds

Net carbon drawdown using AWS Biochar and Jet Fuel in lieu of Petro Jet Fuel > 500%
Carbon Intensity of Petroleum Jet Fuel = 100  Carbon Intensity of AWS Manure Jet Fuel = - 400
WHY IS AWS’ SERVICE SOLUTION UNIQUE?

• Economically viable Build, Own and Operate solutions for each animal species, farm type/size
• Profit sharing program for host sites to help drive common project profitability goals
• Most profitable and carbon negative dual revenue solution from biochar production
• Micro biorefineries placed directly at feedstock source, eliminating the highest cost of biofuels production - the cost of harvesting/securing feedstock & transporting to the central plant
• AWS’ carbon neutral/negative biochar, jet fuel, sulfur-free wax offtake products are energy dense/volume reduced, reducing offtake transportation costs & increasing market reach
• Permitted in the most stringent regulatory environment - can be permitted anywhere
• Closed loop, zero waste, AWS micro biorefineries are completely independent of utility grids
• Next generation, graphene-based GTL (Gas to Liquids) technology with high conversion of gas to liquids/wax BTU (> 70%), high selectivity of FT wax to liquids ratio (70/30), high value sulfur free FT wax has a high selectivity to FAA certified jet fuel (> 85%)
• Fully integrated GTL components with singular, automated, remote control – no reliance on multiple vendors. 1 engineer can monitor several systems in a region, reducing opex
• Dairy model project will work beside current AD systems to process > 50% carbon left behind
• Distributed micro biorefinery model works for both large and small dairy clusters
Thank you! Questions?
QUESTIONS?
Upcoming Events

WEBINARS
• Viticulture
• Storm water management
• Feed Char

2021 STUDY TOURS?

ROUNDTABLES – for Sustaining & Business members

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This offer is only good through the end of January, 2021
Please contact Brian Schorr at:  
BSchorr@ttcorp.com