



California Bioresource Alliance Symposium

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SLCP & RELATED CA DAIRY ISSUES

AWS is Working to Sustain and Prosper Global Farming by enabling farmers to convert liabilities into valuable assets through nutrient recovery and the sale and reuse of value added co-products:
Carbon negative renewable energy, healthy soils, clean air, and clean water

- SB 1383 mandates 40% methane reductions by 2030, 75% landfill organics diversion by 2025
- ~50% of methane emissions from dairy, ~70% of dairy emissions from anaerobic lagoons (solids)
- Anaerobic Digestion (AD) converts ~ 45% carbon to methane, ~55% of carbon remains in digestate
- Storage, transportation, land application of manure/AD digestate can create further SLCP's
- Composting can create + VOC's; compost option for landfill diversion will create over supply
- Most CV dairies cannot justify AD/RNG pipeline injection due to costs and location
- Most CV dairies facing up to 50% cuts in water rights/allocations
- Nutrient Management Plans require crop uptake/mass balance or removal if no beneficial re-use
- Conversion from flush to dry lot reduces lagoon methane but can create other issues and SLCP's
- Above issues occurring simultaneously with record low milk prices, negative gross margins



AWS Circle of Energy

...that harvest the forage crops grown with biochar for healthy soils and healthy foods...



...that feed the animals...



...that generate the manure to feed the AWS system...



From feed to cow, to manure, to machine, to fuel, biochar, clean water and fertilizer, to tractor/truck, to healthy soil, healthy crops and healthy food, and around again...



...and converts the remaining bio-syngas into renewable, no-sulfur diesel fuel products...



...which removes the solids from the liquids and cleans the water for safe crop irrigation (Stage 1) and for potable water (Stage 2)...



...and conditions the bio-syngas to generate electricity to power the system and the farm...



...and then converts the solids into bio-syngas, biochar and ash...



AWS - SCOTT BROTHERS DAIRY FARMS (SBDF) JV

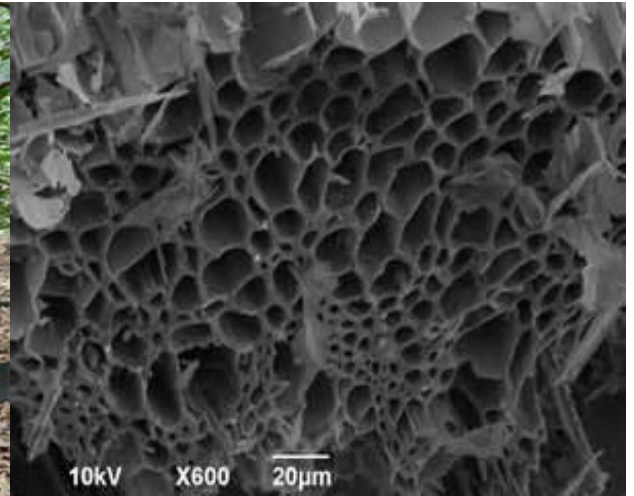
Western Riverside County Agricultural Coalition (WRCAC) consists of 24 dairies, ~38,000 dairy cows in the San Jacinto Watershed. WRCAC must demonstrate by 2018, through Agricultural BMP's and critical reductions in groundwater, surface water, air emissions, nutrients and salts, a regional project to renew the single WRCAC CAFO permit for all 24 dairies

- 2009 - WCRAC needed solution for regulatory changes impacting 2012 permit
- 2010 - Met SBDF (IEUA, Chino dairy) – AWS had first SCAQMD Operating Permit
- 2011 - Awarded CEC ARV-10-043 for small pyrolysis and FT biofuels pilot at SBDF
- 2012 - AWS project commitments (grants + equity) enabled WRCAC 2012 permit
- 2012 - First NRCS EQIP grant for manure pyrolysis, converted from AD EQIP grant
- 2012 - EQIP grant scaled pyrolysis at SBDF to 1 ton/hr. manure feedstock
- 2013 - First SCAQMD Operating Permits for manure pyrolysis + biofuels
- 2014 - AWS project produced fertilizer water + potable water from manure
- 2015 - First ever sulfur-free FT diesel/wax from manure – 1 BPD CEC Stage I grant
- 2016 - Modified pyrolysis from syngas and ash to mostly biochar and some syngas
- 2017 - Greenhouse/field trial AWS Biochar from manure, digestate, ag residuals
- 2018 - Commercial biochar production, WRCAC Project for CAFO permit renewal



INTRODUCTION TO BIOCHAR

- Soils within the Amazon-basin contain sites where ‘dark earth of the Indians’ *Terra Preta de Indio* exist composed of highly stable organic black carbon waste
 - Modern rediscovery of biochar
 - Scientists believe it is *Terra Preta* that allowed those tropical cities to exist, providing fertile soil to sustain the high population levels in areas that are considered not suitable for long-term farming.
- Produced only through “baking” organic matter under low oxygen (*pyrolysis*)



STANDARD BIOCHAR BENEFITS

- **Highly porous structure with large surface area**
 - Refuge area for beneficial soil micro-organisms and bacteria
 - Positively influences binding of key nutritive cations and anions (NPK)
 - Long soil life (years), resistant to leaching
- **Soil pH adjustment**
- **Higher electrical conductivity (EC) + Cation Exchange Capacity(CEC)**
- **Reduced ammonium leaching, reduced N₂O soil emissions**
- **Increased soil field capacity and water retention (+ 40%)**
- **Increased bioavailability and plant uptake of added/applied key nutrients**
 - Nutrients are available when, where and when the plants need them. **Nutrients DON'T LEACH AWAY** like with raw manure and commercial fertilizers
- **CO₂ sequestration (carbon sink), increased Soil Organic Carbon**
- **Prevents migration of chemicals, pesticides and other pollutants**



WHY IS AWS' NUTRIENT-ENRICHED BIOCHAR BETTER?

- **Best nutrient + carbon source** that farmers KNOW, TRUST AND MISS - **MANURE!**
- **Only manure pyrolysis systems permitted** in the most stringent air district (SCAQMD)
- From a pure, clean, consistent source – **No** municipal/industrial or other **waste contaminants**
- Biologically inert, organic - **benefits of raw manure + 'standard' biochar** but without storage, land application, water contamination, SLCP issues of raw manure and/or AD digestate
- Valuable nutrients, minerals, and carbon from raw manure – **PLUS** up to 40% improved water retention, remediation, controlled nutrient release and other 'standard' biochar benefits
- Lower carbon content **allows for regular re-application** as a nutrient fertilizer + carbon soil amendment, without adding too much carbon that can reduce plant available nutrients
- Produces **faster and higher yield results than "standard' biochar**; AWS controlled greenhouse trials produced up to **27% yield increase** on leafy greens over proven control
- Can also be used as reusable animal bedding, hydroponics mediums, feed additive - nutrient absorption (e.g. lagoons) and other nutrient recovery applications being explored
- **Excellent composting additive** – reduced VOC's and curing times with only 5% volume
- No "shelf life" - can be pelletized/stored indefinitely to be either sold later or used as a **high BTU feedstock** for negative CI (Carbon Index) AWS biofuel production
- Utilize and **mix multiple carbon + nutrient biomass feed stocks** to optimize C:N ratio + microbiology for tailored end use - minimizing transportation costs and Community CI

Carbon + Nutrients + Microbiology = Healthy Soils, Healthy Foods, Healthy Lives



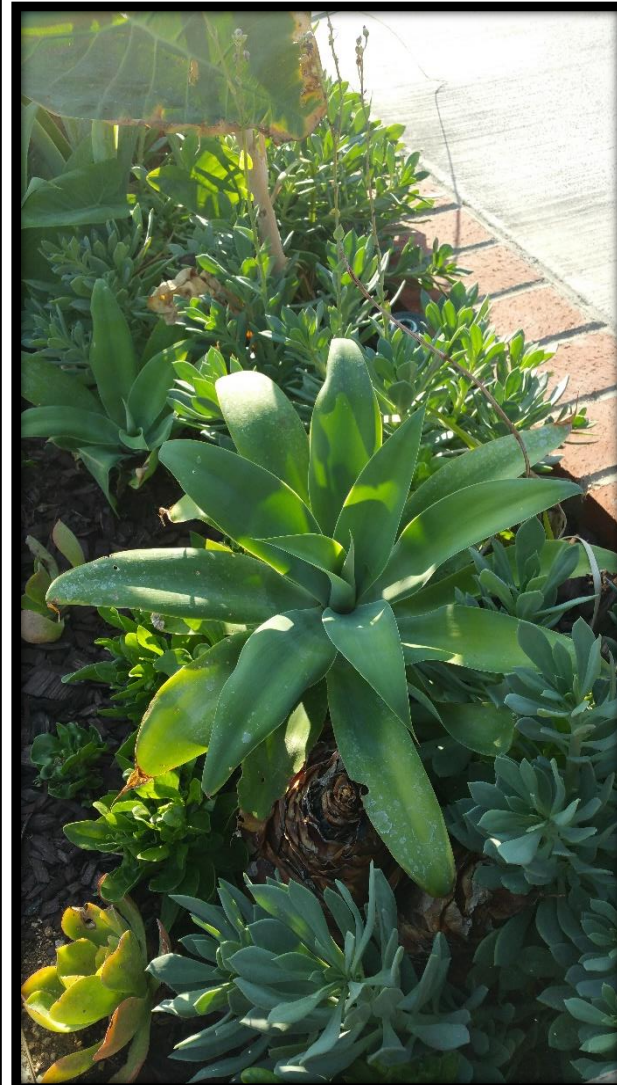
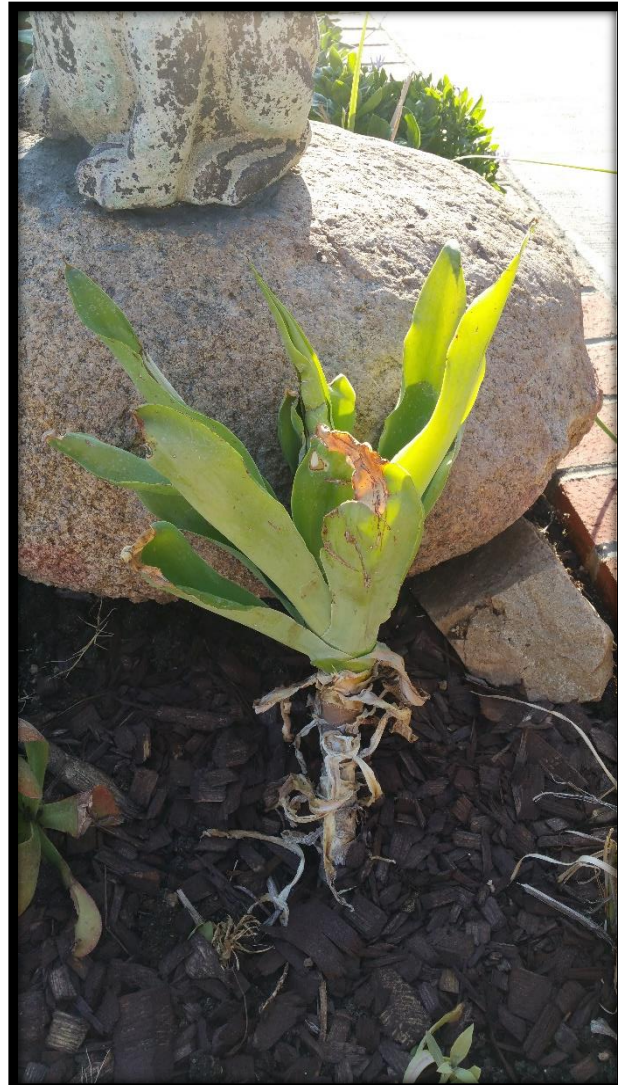
FIRST AWS GROWTH TRIALS - HOME GARDEN PLANTS

STEER MANURE VS. AWS BIOCHAR (DAIRY MANURE), ALL OTHER FACTORS EQUAL

AGAVE

Without AWS Biochar

With AWS Biochar



MIXED PLANT SIDE BY SIDE TRIALS

Without AWS Biochar

With AWS Biochar



AWS BIOCHAR CONTROLLED GREENHOUSE TRIALS

UP TO 27% YIELD INCREASES OVER CONTROL AFTER 6-8 WEEK PHASE I & II TRIALS

Controlled Greenhouse Trials



AWS Biochar Next Steps

- Greenhouse biochar trials to full fruiting: AD digestate, microbiology, tea water, other ag residuals
- Biochar field trials using mixed feedstocks to confirm optimum C:N ratios + microbiology for end applications
- Accredited university field trials @ UCR
- Commercial production and off-take agreements

Orange County Fair Centennial Farm Exhibit



AWS Renewable Diesel + Biochar + Clean Water System

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



Multiple Carbon-Negative Product Options

- Biofuels + Nutrient-Rich Biochar/Ash Sales = Profit Center
- Fertigation Water, Potable Water + Parasitic Power
- Biochar, clean water produced on farm; water left on farm
- Biofuels can be produced either on farm or off farm
- Biochar can be used on farm and/or sold off farm
- Economically viable for farms remote from pipelines, AD digestate conversion to biochar and/or biofuels

Project Goal: EBITDA Return On Invested Capital < 3.0 years

Reusable
Flush Water

Growing Barn

Flushed Animal
Waste



Solids Recovery Module ("SRM")
98% TSS Removed Water

Separated
Solids



Gas Production Module ("GPM")



Energy Production Module ("EPM")

Treated
Water

Fertigation,
Reclaim, Potable
Water Treatment
Module (WTM)

Biochar and/or ash

Diesel and/or Electricity and Heat



CA DAIRY ISSUES & OPPORTUNITIES

1. Dairy AD systems alone may not meet 40% methane reduction mandates and local water/air quality regs when ~ 70% of methane is from dairy lagoons

- Profitability issues for electricity sales due to declining PPA pricing as RPS quotas are met
- Inability/cost to permit electrical generators, grid interconnects, pipeline injection
- Pipeline injection expensive, most farms too remote, low bio-methane production from lagoon AD's
- Difficult to permit multi-farm AD, land application of digestate, + VOC compost (over supply)
- Farmers need profitable, portable systems - readily permitted and measured for individual results

2. AWS biofuels + biochar + clean water systems can address all of the above issues with a carbon negative solution that creates new profit centers

- AWS' closed loop, portable systems readily permitted, produce only carbon negative bio-products
- 98% of the solids are kept out the lagoon and processed while fresh, before anaerobic decay from transportation, storage, composting and land application can occur – dramatically reducing GHGE
- Land application of CO2 sequestration biochar lowers GHGE further while retaining/reducing water
- FT Wax, Biochar are dramatically volume reduced, dramatically increased in energy value and \$/kg
- High-value bio-product combinations increase off-take \$, reduce single source revenue reliance
- AWS systems can work in concert with existing AD systems to lower GHGE and improve profitability
- Large volume of CA carbon feedstocks for biochar production to supplement dairy nutrients/ash
- Biochar is biologically inert (no shelf life) - excellent feedstock for AWS biofuel production and/or for sales as a carbon + nutrients + microbiology Healthy Soils amendment for California



CA DAIRY ISSUES & AWS OPPORTUNITIES (CONT.)

3. Project Grant Funding and Financial Incentives

- Pyrolysis/Gasification now listed as an accepted Alternative Manure Management Practice (AMMP); however, CA GREET 2.0 modified does not currently contain a GHGE model for Pyrolysis/Gasification or for carbon negative co-products (e.g. biochar). As a result, **Pyrolysis is not accepted for current AMMP grants**
- No certified pathway exists for Bio-FT Diesel/Jet Fuel from Dairy: Potentially **< 300 CI**
- No CARB protocol exists for Pyrolysis (e.g. Livestock Protocol) for CA Carbon Credit generation
- Clean, low emissions, closed loop Pyrolysis systems need to qualify for the same grant, loan guarantee, and carbon incentive programs as AD systems. Renewable transportation fuel goals (US Biogas Roadmap, RPS, RINS, CDFA DDRDP, CA LCFS), and dairy methane reduction mandates (SB 32, SB 1383, AB 2313, SB 840, SB350) need to **include bio-syngas as a 'renewable biogas' in all applications**

4. The AWS solution enables the long-term dairy feedstock and off-take agreements required to address the huge carbon negative biofuels and biochar markets - creating new profit centers from ag residuals that enable dairy CAFO's to meet and exceed environmental regulations, mandates, and sustainability objectives

- Interest growing for complimentary technologies that lower Community CI - landfill diversion of organics, bio-methane pipeline injection, AD digestate to bio-methane and biochar, mixing food, green, manure & other ag residual feedstocks. CalRecycle needs to adjust regulations accordingly; Nutrient Recovery, Negative Carbon Intensity (CI), Community CI reduction emphasis should be included in all grants



QUESTIONS?

