



Renewable Diesel

Dairy and Livestock Working Group
Dairy Digester Subgroup #2

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AWS MISSION

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

- Enable sustainable profit centers and partnerships from manure and other ag residuals
- Enable farmers to proactively manage the air, water and soil issues associated with ag residuals
- Enable food production to produce the lowest overall “farm to table” Carbon Intensity (CI)
- Enable biofuels + nutrient biochar production to produce the lowest CI and highest value products
- Enable clean water and bio-product production in closed-loop, zero waste environments
- Enable community partnerships to expand AWS Circle of Energy from farm to community
- Enable energy independence through production of profitable, clean, renewable bio-products
- Enable improved animal welfare, food safety and food security practices



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...



...which powers the farm equipment...



...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 gasification and FT biofuels pilot at SBDF
- 2012 - AWS project commitments (grants + equity) enabled WRCAC 2012 permit
- 2012 - First NRCS EQIP grant for manure gasification, converted from AD EQIP grant
- 2012 - EQIP grant scaled gasifier at SBDF to 1 ton/hr. manure feedstock
- 2013 - First SCAQMD Operating Permits for manure gasification + 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 gasifier from mostly syngas and ash to mostly biochar and syngas
- 2017 - Greenhouse/field trial AWS Biochar from manure, digestate, ag residuals
- 2018 - Commercial biochar production, WRCAC Project for CAFO permit renewal



AWS Renewable Diesel + Biochar + Clean Water System

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



Reusable
Flush Water

Growing Barn

Flushed Animal
Waste



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

Separated
Solids

Treated
Water

Fertigation,
Reclaim, Potable
Water Treatment
Module (WTM)

AWS System Carbon Negative Product Options

- FT Biofuels/Wax + Nutrient-Rich Biochar/Ash = Profit Center
- Fertigation Water, Potable Water + parasitic power for farms
- Biochar, water produced on farm; FT produced off farm
- Biochar used on farm, sold or used as feedstock for FT
- FT high-value wax sold off farm; FT liquids used on farm
- Economically viable for farms remote from pipelines, AD digestate, different carbon + nutrient biomass based biochars

Projects: Return On Invested Capital < 3.0 years



Gas Production Module ("GPM")

Biochar and/or ash



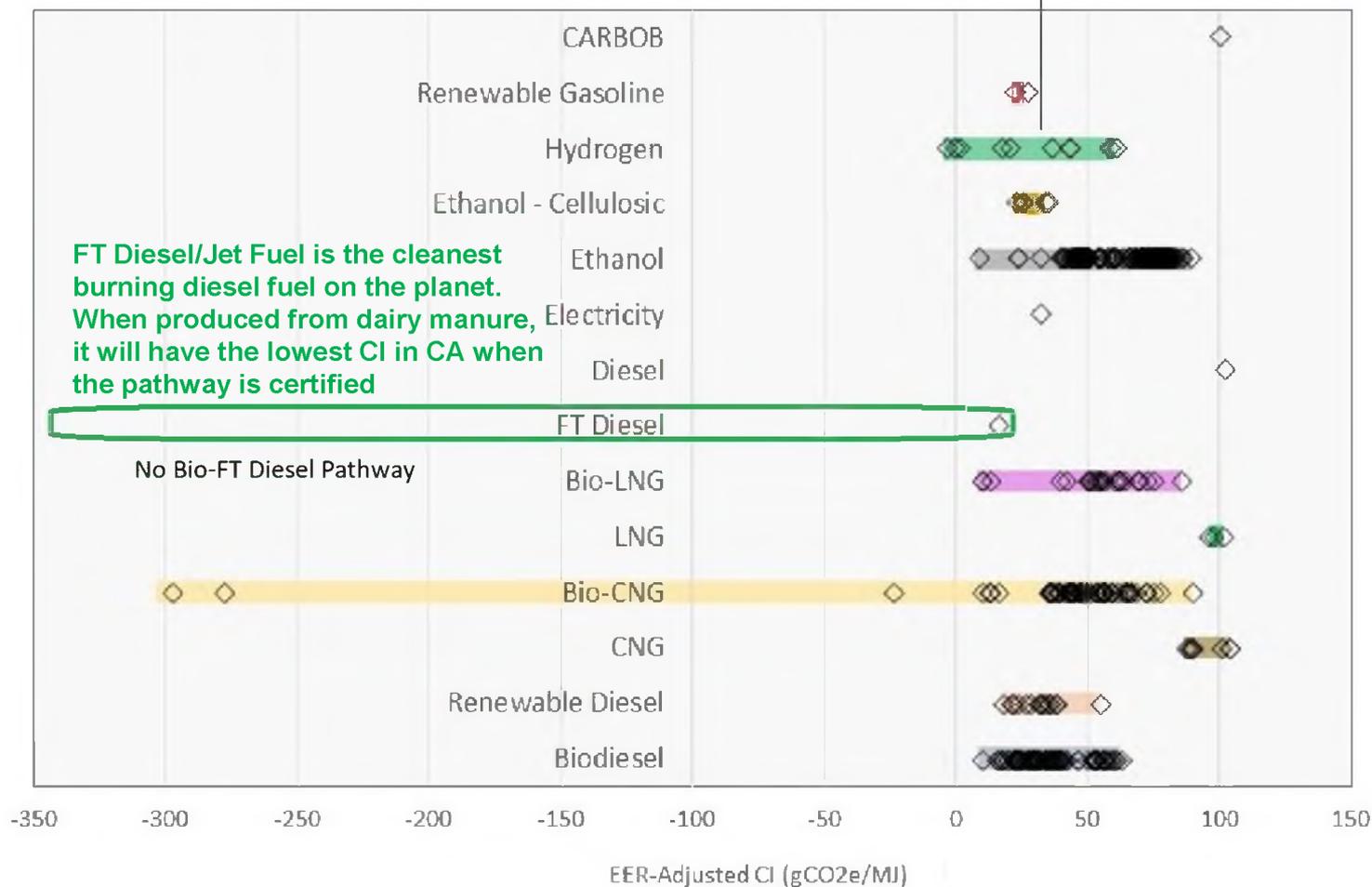
Energy Production Module ("EPM")

Diesel and/or Electricity and Heat



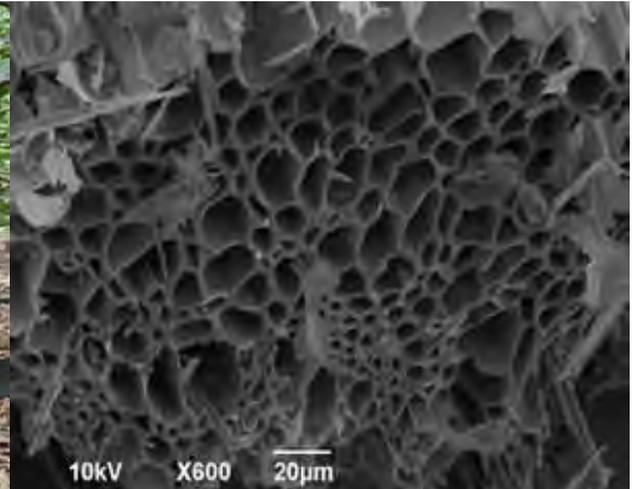
Carbon Intensity Values

Carbon Intensity Values of Current Certified Pathways (2017)



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 EVEN BETTER?

- AWS Biochar is derived from a source that farmers KNOW, TRUST AND MISS - MANURE!
- AWS has the only manure gasifiers permitted in the most stringent air district (SCAQMD)
- AWS Biochar from a pure, consistent source – **No municipal/industrial waste contaminants**
- AWS Biochar is biologically inert and organic, with all of the benefits of manure + carbon-only biochar, but without the storage and application issues of raw manure and/or AD digestate
- AWS Biochar contains **the same valuable nutrients, minerals and blends as raw manure**
- AWS Biochar's lower carbon content allows for regular re-application as a fertilizer + carbon soil amendment, without adding too much carbon that can reduce plant available nutrients
- AWS Biochar produces **faster and higher yield results than carbon-only biochar**
- AWS Biochar can be used as reusable animal bedding, hydroponics mediums, feed additive - nutrient absorption (e.g. lagoons) and other nutrient recovery applications being explored
- AWS Biochar is an **excellent composting additive – reduced VOC's and curing times**
- AWS Biochar has 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**
- AWS Biochar produces lower CI biofuels than does carbon-only biochar from dead wood
- AWS Biochar can utilize multiple carbon + nutrient biomass feed stocks to optimize C:N ratio + microbiology for community application - minimizing transportation costs and CI, maximizing \$\$\$
- AWS Biochar greenhouse trials have produced **up to 27% yield increase on leafy greens**

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



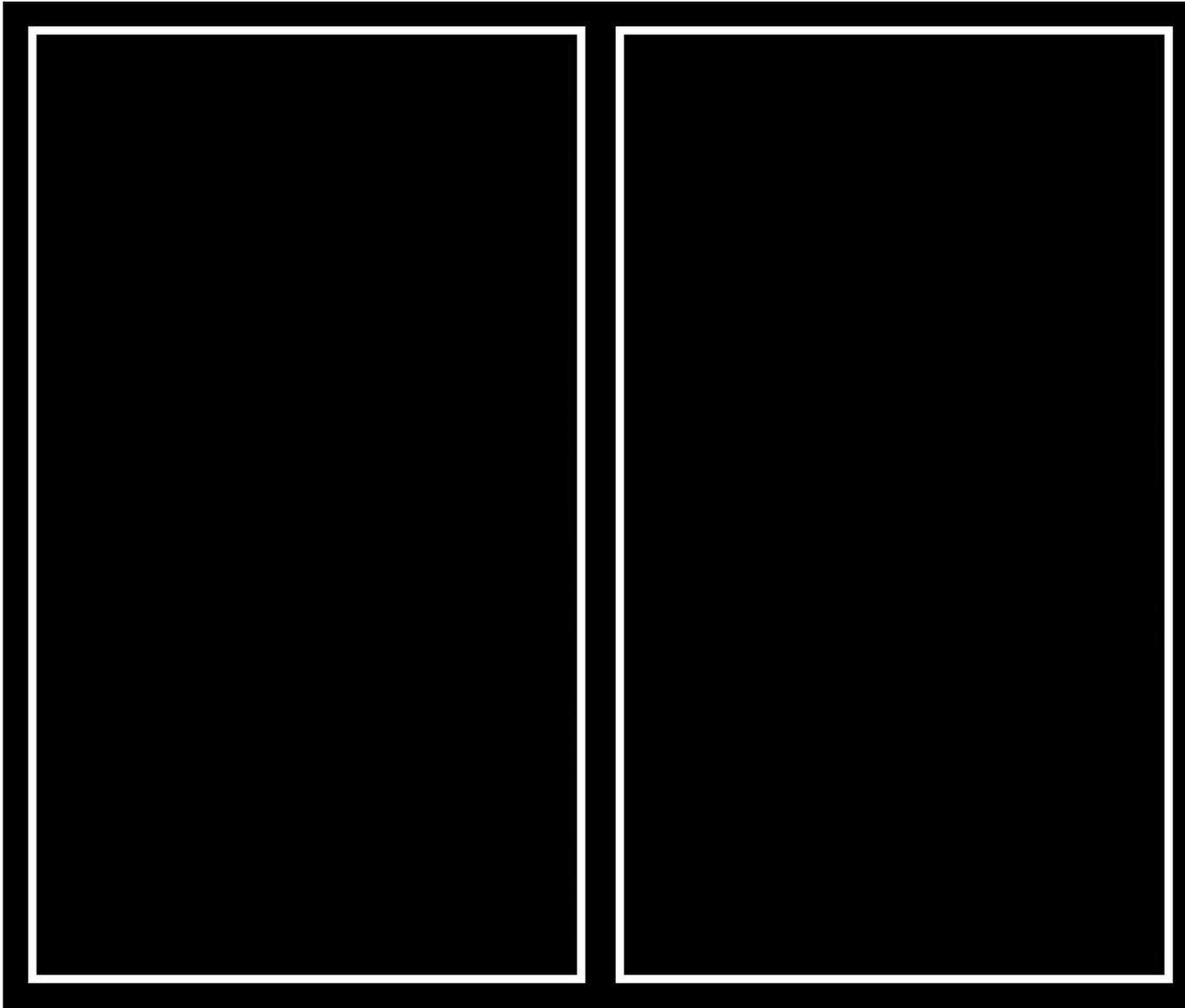
FIRST AWS GROWTH TRIALS - HOME GARDEN PLANTS

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

AGAVE

Without AWS Biochar

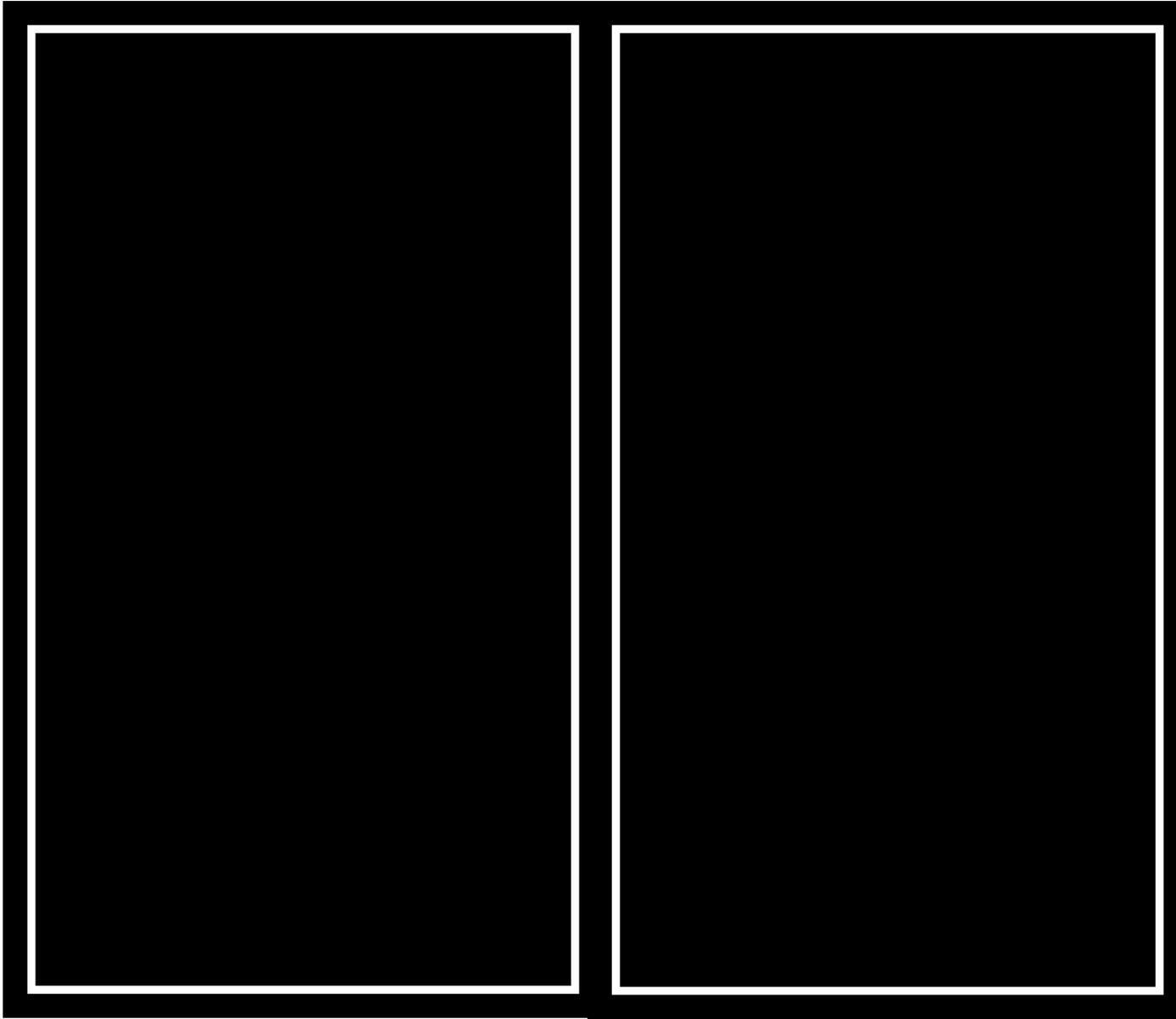
With AWS Biochar



DAISY

Without AWS Biochar

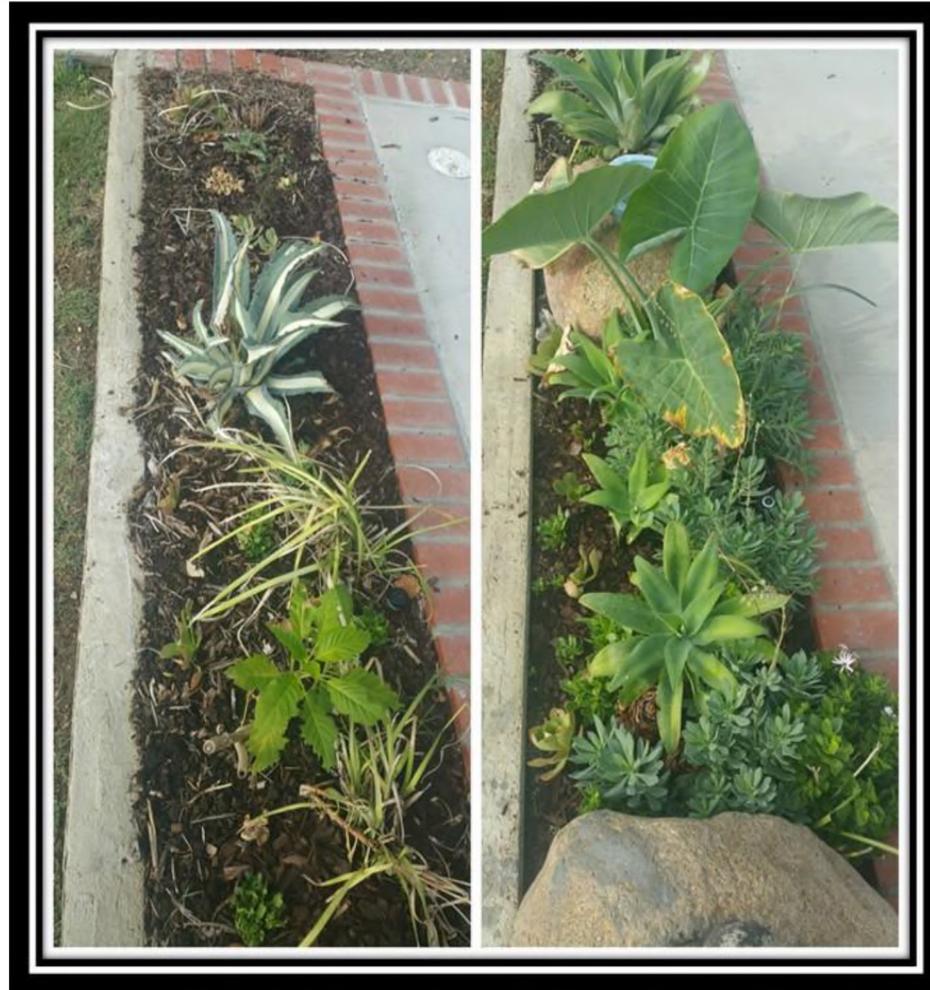
With AWS Biochar



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



AD Digestate Pyrolysis to produce up to 2X Bio-CNG

AWS' modular on-farm RNG system is prefabricated, skid-mounted, closed-loop, scalable

Growing/Milking Barns, Feed Lanes



Flush and/or
Fertigation Water

Flushed/Scraped
Manure

Digestate

\$Carbon Negative Bio-CNG



Anaerobic Digester Bioreactor ("ADBR")

98% TSS Removed Water

Convert AD Digestate Carbon into Bio-CNG and/or Biochar/Ash

- Portable ADBR + SRM + GPM = 2X RNG \$\$\$, nutrients, clean water
 - 55% carbon in AD digestate converted into RNG and/or \$ bio-products
 - Economically viable option for new RNG Pipeline Injection projects AND for converting existing AD systems' digestate into \$ bio-products
 - Small, economically viable, on-farm systems can be readily permitted; each farm measures its bio-product contribution to central project sales
 - Compliments AWS Renewable Diesel + Biochar + Clean Water model
- Return On Invested Capital < 3.0 years for each on-farm project*



Solids Recovery Module ("SRM")

Separated
Solids



Gas Production Module ("GPM")

Inject Syngas from Digestate into ADBR

\$Biochar or ash

Optional Water Treatment
Module (WTM):
Potable Water, Nutrient
Recovery



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, high VOC compost (in over supply)
- Farmers need profitable, portable systems - readily permitted and measured for individual results

2. AWS biofuels (FT or RNG) + biochar + clean water systems can address all of the above issues with a carbon negative solution that creates 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 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**
- 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: **Potentially < 300 CI**
- No CARB protocol exists for Pyrolysis/Gasification (e.g. Livestock Protocol) for CA Carbon Credits
- 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 needed for all grants

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



QUESTIONS?

