Farmers' collective biomethane plant producing sustainable fertilizer and vehicle fuel from cover crops.

Executive Summary:

This project is Part I of a two-part undertaking by a farmers' collective organized as a local governmental entity.

Participating farmers actualize a thriving local market for "cover crops" the growth of which is "fed" by recycled nutrients. These agricultural commodities then support small scale, local production of sustainable nitrogen fertilizer and vehicle fuel at significantly reduced end cost to farmers. This increases local fertilizer supply while also promoting soil health and economic development in a rural community.

In this Part I, a biomethane production facility is established which creates a new local market for grass planted as "cover crop." Grass silage will be co-digested along with cow manure and small amounts of crop residuals, applying commercially available technology widely used in Europe. Raw biogas product (a mixture of methane and CO_2) will be upgraded to "renewable natural gas (RNG)," again applying widely used, commercially available technology.

The new local silage market thus enabled can thrive because of the plant's innovative, sustainable fertilizer product, i.e., N-P-K nutrients recovered from the plant's effluent and re-distributed to participating farmers' fields. Using RNG-fueled vehicles, the collective organizes all harvesting, transport, and ensiling as well as re-distribution of nutrients to farmers who obtain significant revenues without costs for CO_2-intensive fertilizers.

CO_2 output from the plant will be sequestered by injection into a stream of pressurized brine used for enhanced oil recovery in a Class II well situated near the plant site. As a consequence, the RNG output will be "carbon negative" and production of fertilizer product will be associated with significant "greenhouse gas reduction."

In addition to subsidizing conversion of farmers' pickups to RNG dual fuel, revenues from Part I will support expansion of grass throughput capacity of the plant by a factor of about 2.5. As demonstrated for wheat straw in US2021/0246608, by applying steam pretreatment to grass silage, organic loading rate can be increased and retention times decreased. Most of the heat required for steam pretreatment can be recovered and used as process heat. The marginal increased process heat requirement for steam pretreatment as a percentage is about 52% compared with a 150% increased RNG output. The plant's natural gas boiler will have installed capacity to deliver 10 bar steam for eventual use in pretreatment. Some research and development (for which no grant funds are requested) will be required to determine appropriate conditions for steady-state digestion of steam pretreated grass silage using one of the plant's 16 modest-sized digester tanks.

In Part II, the increased RNG output derived from increased throughput of steam pretreated "cover crop" silage will be used for small scale, local production of "carbon

negative" ammonia. Production capacity is expected to approximately correspond with the collective demand of all active farmers in the county.

Replication of this "proto type" can dramatically alter the "competitive landscape" of the fertilizer market in the US. Through collective efforts, farmers can increase supply *and* sustainability by "doing it for themselves."

Applicant information:

Under Kansas law, farmers (landowners) can petition county governments to have their land included within a "rural improvement district." These are political subdivisions of county government legally empowered to issue tax-free revenue bonds to finance revenue-generating projects.

The applicant is a "rural improvement district" named "Kansas Sustainable Agriculture District #001" formally incorporated by Kingman county, Kansas, on February 7, 2022, after submission of a petition by 41 landowners.

The Board of Directors is prepared to approve a bond to finance 75% of the cost of a biomethane plant. N-P-K nutrients will be recovered from effluent and applied to participating farmers' fields as an innovative, sustainable fertilizer product used to support growth of grass silage converted by the plant. Similar fertilizer product is commercially available from biomethane production facilities based on dairy cow manure. Significant "greenhouse gas reduction" will be achieved in production. The District will operate the plant in compliance with all federal, state and local regulations governing production, processing, storage, distribution and waste management.

Grant funds are requested to subsidize costs incurred in (i) plant engineering, construction and commissioning (including initial operating costs incurred in the first year of operation before revenues are received), (ii) certifying the facility for issuance of "renewable identification numbers" (RINs) by the Environmental Protection Agency (EPA), (iii) obtaining EPA approval of a CO_2 sequestration monitoring and verification plan, (iv) adjudicating "emission factor" of the RNG output, (v) final purchase of plant site land, (vi) retro-fit of existing EOR wells for CO_2 sequestration and (vii) requisition of equipment including an RNG-fueled front loader, 6 RNG-fueled semi-trucks fitted with belt unloader trailers, 3 slow-fill RNG fueling stations, a CO_2 compressor, and 3 CO_2 transport trailers.

The District does not currently have any fertilizer market share and does not intend to expand the scope of its market beyond local county scale.

Project information:

Complete land purchase.

Cost: 320,000 USD: Timeframe July 5, 2023.

Design, engineering, construction and commissioning of biomethane plant by WELTEC BIOPOWER working with EPC contractor Montrose Environmental Group.

Cost 110,000,000 USD. Timeframe July 5, 2023 through December 31, 2024.

Requisition 1 front loader from New Holland Agriculture custom fitted with CNG-motor (in which New Holland Specializes), required for operation of the biomethane plant.

Cost 250,000 USD. Timeframe July 5, 2023 through September 1, 2024.

Requisition 6 new CNG-powered semi-trucks and trailers having belt unloaders required for improvement of fertilizer logistics in a cost-efficient and climate smart manner.

Cost:1,800,000 USD. Timeframe July 5, 2023 through September 1, 2024.

Requisition 3 30 GGE/hour slow-fill CNG re-fueling systems required for improvement of fertilizer logistics in a cost-efficient and climate smart manner.

Cost: 249,000. Timeframe July 5, 2023, through September 1, 2024.

Requisition CO2 compressor sufficient to process 794 scfm to 400 psi required for customized reduction of greenhouse gas emissions.

Cost:400,000 USD. Timeframe July 5, 2023 through September 1, 2024.

Requisition 3 CO2 transport trailers required for customized reduction of greenhouse gas emissions.

Cost: 525,000 USD.   Timeframe July 5, 2023 through September 1, 2024.

Retrofit existing EOR wells to be compatible with CO2 (epoxy lined injection tube), requisition and establish monitoring and verification equipment, acquire pump sufficient to process 20,000 barrels per day at 400 psi, rework local piping to re-direct brine to EOR wells, for customized reduction of greenhouse gas emissions.

Cost: 500,000 USD.   Timeframe July 5, 2023 through September 1, 2024.

Apply for and obtain EPA registration of biomethane plant 40 C FR 80.1450, including report from independent engineer.

Cost: 50,000 USD. Timeframe January 1, 2024 through September 1, 2024.

Apply for and obtain approval from EPA of a CO2 monitoring, verification and reporting plan pursuant to 40 C FR 80.1450 supported by modeling and measurements taken at the Tertiary Oil Recovery Program, University of Kansas.

Cost: 75,000 USD: Timeframe July 5, 2023 through September 1, 2024.

Apply for and obtain determination by IRS of the “emissions rate” for the product RNG pursuant to 26 USC 45Z(b)(1)(D), including an independent Life Cycle Analysis of CO_2 costs.

Cost: 75,000 USD: Timeframe January 1, 2024 through September 1, 2024.

Land ownership and access:

The applicant has a conditional deed of sale for the plant site formally executed by the owner and effective upon fulfillment of two conditions: (1) That the District sells all bonds issued for this project or otherwise raises all necessary financing and pays three hundred twenty thousand (320,000) dollars to the owner; (2) That the parcel is re-zoned so as to permit construction and operation of a biomethane production facility and a related small scale sustainable ammonia production facility with such re-zoning to take effect only after fulfillment of condition 1 (Appendix G1). The terms of the conditional sale give the District power to seek re-zoning of the land from agricultural to industrial, which it will proceed to do immediately.

Performance metrics:

In Part I, by the 2025 crop year, sustainable nutrient re-distribution is expected to make available to the 15,000 cultivated acres providing biomass supply approximately 1526 english tons nitrogen (of which about 80% is organic), 597 english tons potassium, and 493 english tons phosphorus.

Fertilizer production in Part I will be achieved with sequestration of approximately 21,976 metric tons CO_2 per year. Where harvest and transport is conducted using RNG-fueled vehicles, and where electrical power is produced on-site from a natural gas generator, net CO_2 emissions after accounting for planting and operating costs will be approximately negative 18,883 metric tons per year. Effective reduction compared with equivalent use of pipeline gas CNG is 49,373 metric tons CO_2. Applying emissions factors in metric tons CO_2 per english ton nutrient (N - 2.33; K - 2.52; P - 5.62), net “greenhouse gas” reduction relative to equivalent amounts of commercial fertilizers corresponds to about 28,821 metric tons CO_2 per year.

In Part II, planned to be operational by the 2031 crop year, sustainable nutrient re-distribution is expected to make available to 37,500 cultivated acres providing biomass supply approximately 2736 english tons nitrogen (of which about 80% is organic), 884 english tons potassium, and 1121 english tons phosphorus. Additionally approximately 26,996 english tons of “carbon negative” ammonia will be made available for Kingman county farmers.

Fertilizer production in Part II will be achieved with sequestration of approximately 71,570 metric tons CO_2 per year. (For this large quantity of CO_2 to be sequestered using the available quantity of petroleum production brine, a new permit will be required permitting direct injection of supercritical CO_2 in a two-phase brine/CO_2 system rather than dissolution at 400 psi as planned and already permitted for Part I). Net CO_2 emissions will be approximately negative 57,592 metric tons per year.

This corresponds to a net “greenhouse gas” reduction relative to equivalent amounts of commercial chemical fertilizers produced from pipeline gas of about 144,641 metric tons CO_2 per year.

Evaluation criteria:

1. Financial Viability, Technical Merit and Readiness.

Through its agent BLUE FLAME BIOPOWER, the District approached WELTEC BIOPOWER, a European technology provider which is experienced in design, construction, commissioning and operation of RNG plants based on grass silage and cow manure. Since 2001, WELTEC has built over 350 plants in more than 25 countries based on a wide range of different feedstocks. The technical performance of WELTEC’s technology is documented by the ongoing performance of plants that it designed, constructed and commissioned (Appendix A).

The District asked WELTEC to draft a plant concept for processing 30,000 dry tons grass silage and 30,000 dry tons feedlot manure per year. They provided a plant capital assessment including an estimate of RNG and CO_2 yields, electrical and thermal power and water consumption (Appendix B) and of nutrient recovery (Appendix C). The City of Kingman, Kansas has granted the District permission to use its wastewater effluent (to be carried 5 miles by water trucks), which should be sufficient (Appendix D). WELTEC’s reported manure yield is based on another of its feedlot projects in North America. It’s grass silage yield is an overall average derived from experience with many different plants. The variability between different grasses is typically within the range +/- 15%.

The primary revenue driver for Part I (this project) is subsidies paid by petroleum refiners under the US Renewable Fuel Standard (RFS). This was implemented by the Energy Policy Act of 2005 and is regulated by EPA under 40 CFR 80.1400-1475. RNG produced from cellulosic feedstocks and manure qualifies for category D3 “renewable identification numbers” (RINs) which are issued by the EPA to the extent that the RNG has been sold “for use as transportation fuel” (40 CFR 80.1426 - pathway Q). One D3 RIN is issued for every 77,000 BTU (lower heating value) of compressed RNG fuel (40 CFR 80.1415 (b)(5)), such that 1 Nm3 RNG earns 0.44212 RINs. The petroleum industry is obliged to buy these RINs according to a “free market” mechanism wherein EPA sets a target amount intended to approximately correspond to the anticipated supply that will be issued in any given year. Approximately 519 million D3 RINs were issued in 2021. The theoretical D3 RIN market cap under the law is 16 billion. Thus, to the extent that farmers’ collectives such as the District create demand for their own RNG “for use as transportation fuel,” the theoretical market cap will only be reached after capacity corresponding to 2810 Part I plants have come online.

The market value of D3 RINs was actively suppressed during the Trump administration, when EPA refused to set an annual “target.” Notwithstanding this “bump in the road,” the price since 2017 (when 227 million were sold) and the present moment has averaged 2.25 USD. During 2022, the price has been above 3.0 USD for all but a few days and has averaged 3.11 (See https://www.epa.gov/

fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information). Especially in light of the enactment of the Inflation Reduction Act (IRA) of 2022 which introduces sweeping new laws favoring renewable fuels, it is assumed that D3 RIN prices will remain at least at 2.50 USD and that all RNG produced can be sold for "use as transportation fuel."

Secondary revenue drivers in order of significance are:
(i) "Clean Fuel" production tax credit: Under the newly enacted 26 USC 45Z the District can receive this credit as a cash payment for credits accrued from Jan. 1, 2025 through Dec. 31, 2027 for RNG sold as "transportation fuel." Provided that wage and apprenticeship standards are followed, the amount of the credit corresponds to 1.0 USD per gallon gasoline equivalent (124800 BTU higher heating value) times an index of ((50 kg CO2/MMBTU minus the "emissions rate" for the fuel") divided by (50 kg CO2/MMBTU)). A credit of 0.5648 USD/Nm3 RNG is assumed for an "emissions rate" of -43.35 kg CO2/MMBTU based on the following assessments: RNG production as described in Appendix B corrected for 30,000 dry english versus metric tons each of grass silage and feedlot manure is associated with a feedstock contribution of -134.04 kg CO2/MMBTU, CO2 sequestration corresponding to -45.38 CO2/MMBTU, methane slip of 2.5% (as described in Appendix B) at a CO2 equivalence of 28X of 36.44 kg CO2/MMBTU, pipeline transmission and fuel distribution as 20.05 kg CO2/MMBTU, physical biogas plant as 11.60 kg CO2/MMBTU, diesel-fueled planting at 1.26 gallons/acre as 0.40 kg CO2/ MMBTU, natural gas-fueled thermal and electrical power (as described in Appendix B) provided by a combined heat and power plant with 78% efficiency of 13.37 kg CO2/MMBTU, compessor for CO2 and pump for EOR brine based on natural-gas fueled generator with 40% efficiency of 2.17 kg CO2/MMBTU, eventual RNG combustion at 52.05 at CO2/MMBTU with no assessment for harvest and transport with RNG-fueled vehicles or for application of re-cycled nutrients as fertilizer. (Note: this estimate is explained in detail in section 3)
(ii) Natural gas sales price: Spot market prices have fluctuated in 2022 with an average of 6.10 USD/MMBTU (0.2077 USD/Nm3). (See the Henry Hub natural gas spot price https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm). It is assumed that natural gas prices will remain at least 3.23 USD/MMBTU (0,110 USD/Nm3).
(iii) CO2 sequestration tax credit: Under the recently amended 26 USC 45Q the District can receive the credit as a cash payment for nine (9) years after termination of the "clean fuel" credit. Provided that wage and apprenticeship standards are followed, the amount of the credit where CO2 is sequestered via an enhanced oil recovery well is 60 USD/metric ton CO2, adjusted for inflation after 2026 (26 USC 45Q (b)(1)(A)(i)(II) and (ii)(II); and 45Q (h)(1)). However, because the District's plant is financed with tax-free bonds, it will only be eligible for 1/2 of this amount, or 30 USD/metric ton CO2 (26 USC 45Q (f)(8)) which corresponds to about 0.0524 USD/ Nm3. It is assumed that the District can sequester all of the CO2 output described in Appendix B. (Note: The sequestration method is explained in detail under criterion 3)
(iv) Other "carbon credits:" Some private carbon credits are available. However, these are unpredictable and are accounted here at only 2.0 USD/metric ton CO2 reduction. Low Carbon Fuel Standard credits for RNG sales in California (and potentially soon in other states) are also theoretically available. Using RNG for agriculture in Kansas is the central aim of the District, which is a governmental entity, not a company. However, LCFS credits could be pursued if necessary. These can

be accounted at 50 USD/ton CO2 (an all time low), where the market appears to have stabilized at about 60 for now after having dropped about 300%. The District would likely have to share any such credit 50/50 with the end user.

The District has biomass supply contracts with area farmers (mostly members) corresponding to 15,000 acres, most of which will be planted with sudan grass as "cover crop," with some native grass. The District will cover harvesting, transport and ensiling costs and also re-distributes recovered N-P-K nutrients to participating farmers' fields. Manure is available in huge quantities from nearby feedlots which do not currently receive any payment for this. One large feedlot nearby confirmed a willingness to permit as much as 30,000 dry english tons per year to be removed for 15 USD/dry ton. Although they were unwilling to sign a contractual committment two years in advance, this remains a good deal for feedlots such that supply disruptions are not likely.

It is assumed that all RNG output can be sold as "transportation fuel" within the meaning of 40 CFR 80.1401 and 26 USC 45Z. It is further assumed that an arrangement can be made with a major distributor to store RNG output in an existing gas storage field located in Kingman county and then withdrawn for seasonal demand so as to satisfy the requirements of 40 CFR 1426(f)(11) that, for pipeline transmission, withdrawl be consistent in time with transport between injection and withdrawl points. In the interim period during which District members are creating local demand by applying net revenues to dual-fuel conversion of their own pickups, it is projected that all RNG output can be sold to gas-powered irrigation pumps, which typically have a pipeline tap. Use in irrigation pumps qualifies as "transportation fuel" within the meaning of 40 CFR 1401 which includes "use in motor vehicles, motor vehicle engines, non-road vehicles, *or non-road engines*." There are 23,490 irrigation pumps in Kansas (Kansas Water Plan 2022, p. 19) an estimated 67% of which are gas-powered (Kansas State University Agricultural Experiment Station Report #611, p. 5). The minimum end of the range of annual natural gas consumption by these pumps per acre is 15 MCF (*Ibid.* at tables 2, 3 and 4). Applying this minimum gas consumption estimate and assuming that each pump services 125 acres, we can conclude that the entire annual RNG output of District #001's Part I plant will be consumed by just 354 irrigation pumps. In the case where all of the gas-powered irrigation pumps in Kansas serve as interim end-users, demand would be sufficient to support the *concurrent start-up* of an additional 43 Sustainable Agriculture Districts, along with District #001.

A table of projected operating costs and various revenue scenarios is shown below in Table 1.

Table 1 with Financial details redacted

A detailed explanation of each entry is provided in the Business Plan submitted herewith. Gross revenues and net revenues before bond service are shown for 4 scenarios: A, with RIN price 3.0 USD and gas price 0.207 USD/Nm3, A+ also including 1/2 of the theoretical LCFS credits where all RNG output was sold in California, B, with RIN price 2.50 USD and gas price 0.11 USD/Nm3, and B+ also including 1/2 of theoretical LCFS credits. Service of a 20-year tax-free bond yielding 4% per year is calculated as (1/20+4%) of principal per year. Two different bond service rates are shown - one in which the USDA has indeed supported 75% of the allowable costs in this project, the other where it has not. As shown, without USDA support, the project would be untenable if RIN prices and gas prices drop to Case B levels. In contrast, with USDA support, the District 's estimated average annual net revenue after bond service and after payment of agent fees in years 1-20 would be 2,886,707 USD in case A, 3,784,387 USD in case A+, 1,012,482 USD in case B, and 1,210,846 USD in case B+.

The project will achieve financial viability in Part I by including the first year's operating costs within the bond principal. Going forward, in addition to setting aside annual payments toward principal, the District will endeavor to keep cash on hand corresponding to one year's operating expenses in its account with a local bank that has primarily farmers as clientele (literally and perhaps poetically "The Peoples Bank" of Kingman).

The District commissioned a feasibility report, submitted herewith, about the work required to engineer, construct and commission the plant and the probable cost thereof. The report concluded that the plant can be implemented for 94,329,000

USD not including site work (civil engineering works and driveways) or contingency. Notably, the report estimated higher RNG yields and lower methane slip than those reported in Appendix B which are the basis of all calculations presented here. We conclude that, with 10% contingency and site work, the plant cost will be not more than 110,000,000 USD.

This Part I project is ready to be actualized. Both the Kingman County Commission and the City Commission of Kingman have shown strong support. A bipartisan group of state legislators from the Senate and House Agriculture committees signed a letter of support to the recently re-elected Governor. A contract has been negotiated for an ideal plant site adjacent to an existing industrial facility and accessed by paved roads and a railroad siding. Regulatory permits do not appear to present a significant obstacle.

Risk mitigation strategies applied in Part I include the following:
(i). Working capital: The risk of running short of working capital is mitigated by having included one year's operating expenses as part of the initial bond issue.
(ii) D3 RIN price: The RIN market is unusual in that the demand is defined by the target set by the EPA, which is intended to approximate the supply until the statutory market limit of 16 billion is reached. Provided the EPA acts in good faith in setting the target, there is little risk of a large-scale glut of D3 RINs that will drive the market below the historical average of 2.25. Our Case B revenue figures are based on 2.50 USD/RIN. In the event that the prevailing price fell back to 2.25, the RNG output could be directed towards generation of compensating LCFS revenues. The RNG sales price could also be raised locally. To compensate for a RIN price drop to 2.25, the Case B gas price of 0.11 USD/m3 would have to be raised to 0.23 USD/m3 to compensate. Assuming that this could be passed on exclusively to local consumers and that the projected local consumption of 68% can be achieved, this would correspond to a pump price increase at BLUE FLAME BIOPOWER rural fueling stations of about 0.67 USD/GGE from about 1.36 USD to about 2.03. The risk of a return to bad faith adminstration by the EPA cannot be ruled out. Our mitigation of that risk is the promise that this project (and its replication) offers for rural communities, which should provide some "counter-weight" consideration for politicians who are inclined to such behaviour. In general, financial difficulties occurring in any given year can be ameliorated by use of funds that have been set-aside towards re-payment of bond principal.
(iii) 45Z qualification: Although gas for irrigation pumps unquestionably qualifies as "transportation fuel" within the meaning of EPA regulations governing RINs, the same term as used in 26 USC 45Z is defined differently as: "a fuel which is suitable for use in a highway vehicle or aircraft." The law does not say that the fuel has to be *used* in a highway vehicle or aircraft, only that it is *suitable* for such use. IRS regulations on this point will likely be issued while the plant is under construction. If necessary, an offtake agreement could be pursued with a distributor in California. This should be possible, where the LCFS credit is split with the end user. Another not mutually exclusive alternative would be to separately negotiate supply agreements with existing municipal and private CNG-powered fleets in Kansas. A significantly sub-market gas price could be offered as an enticement.

(iv) Labor supply: There is some risk of being unable to find adequate laborers. This is mitigated by an offer of very high salary at a location which is a commutable distance from a large population center.
(v) Zoning: The land for the plant site is transferred by a deed of conditional sale where re-zoning from agricultural to industrial is a condition. The risk of re-zoning denial is mitigated by the choice of plant site immediately adjacent to an existing industrial facility.
(vi) Biomass supply: On average, the excess grass silage achieved in good years should provide a buffer against a drought year. In case of drought emergency, alternative biomass supply would be obtained from urban grass clippings in the city of Wichita (population ca 400,000), the center of which is 51 miles from the plant site, and from organic fraction of municipal waste from the same area.
(vii) HCN toxicity: Especially in the case where sudan grass is harvested after a killing frost, there is some risk of toxicity for the biomethane bacteria and archaea from HCN content to the extent this gets above 5 ppm in the digesters (Gijzen 2000). HCN levels will be monitored and, if necessary, volatile HCN content of silage will be allowed to dissipate before loading in the digester.

The financial viability of Part II should also be briefly mentioned: A high-end estimate for capital cost of a small scale ammonia plant is 2500 USD/metric ton-per-year. (Note that where such small scale plants are standardized and pre-manufactured for other Districts, the price could be considerably lower) For the Part II annual production of 26,996 english tons ammonia, the capital cost would then be 61,354,356 USD. The annual service at 4% on a 15-year tax free bond would be 6,544,465 USD. Operating costs (not including natural gas) of an ammonia plant with CO2 exhaust isolation is reported by a recent industry group study (2022) as averaging 104.6 USD/metric ton in the US. Assuming that on small scale, the figure will be 1.35X, the operating costs per english ton would be ca 128 USD. Not counting CO2 sequestration costs or revenues, and applying the net production cost of delivered RNG of 0.50 USD/Nm3 estimated from Table 1, the annual operating cost would be 9,505,010 USD. After bond service, the breakeven price for sustainable ammonia at the plant would be 595 USD/english ton - about 43% of current prices for farmers and a price not prevailing in the US since 2008. To the extent that market price dropped beneath 595 USD/english ton, the District could re-direct its RNG to RIN revenues and then use pipeline gas, with CO2 sequestration, for its sustainable ammonia product. At current gas prices, the “breakeven” price at the plant would be 463 USD/english ton. Accounting for CO2 costs and revenues (assuming that 70% of CO2 from ammonia production can be captured), the breakeven price for production using RNG and pipeline gas would be 581 and 450 USD/english ton, respectively.

2. Market Impact & Opportunities.

This project demonstrates a new model of sustainable agriculture in which fertilizer consumers (agricultural producers) become, themselves, collectively local-scale fertilizer producers. New opportunities are created for these new producers whereby, in “selling” their sustainable product (re-cycled nutrients in Part I) to themselves, they obtain nutrients with which to raise the agricultural commodity from which the product is derived. This enables a new local market for the agricultural commodity ("cover crops") without reliance on either CO_2-intensive fertilizer products or subsidies from USDA Natural Resources Conservation Service (NRCS).

In this Part I, production of this sustainable fertilizer product, and accordingly its availability, is initiated and thereby expanded on local scale in Kingman county, Kansas. The target operational capacity during the 2025 crop year is sustainable nutrients comprising 1526 english tons nitrogen (of which about 80% is organic), 597 english tons potassium, and 493 english tons phosphorus to be distributed over 15,000 acres.

In Part II, these new producers can offer themselves another fertilizer product in addition to re-cycled nutrients - sustainable ammonia made locally from RNG derived from "cover crops." This will substantially increase competition in the ammonia market in that these new producers can sell to themselves on local scale at significantly lower price. Should market prices drop to their breakeven price, these new producers can apply their RNG to more lucrative RIN revenues and continue to produce sustainable ammonia on local scale at considerably lower cost using pipeline gas with CO_2 sequestration. The target operational capacity during the 2031 crop year is 26,996 english tons of "carbon negative" ammonia.

The District has signed contracts for 5 growing seasons through Dec. 31, 2029, covering 13,640 acres to be planted with sudan grass as cover crop as well as 1,360 acres of native prairie grass. In a year with normal rainfall, this should be sufficient to achieve 30,000 dry english tons per year of grass silage which is sufficient to support the target operational capacity in Part I. Some years might have considerably greater grass yields, which will be ensiled and stored as a "buffer" against poor yield years. The "drought emergency" plan for mitigation of biomass risk is discussed under criterion 1. Maximum operational capacity will only be achieved through use of steam pretreatment which is not within the scope of this project (Part I). After the biomethane plant is operational in Part I, the District anticipates there will be great demand for participation as a "cover crop" supplier and nutrient consumer. Accordingly, no difficulties are anticipated in procurement of supply for Part I target operational levels beyond 2029 and in expansion of supply to 37,500 acres, sufficient to support anticipated maximum operational capacity in Part II. Organization of the harvest using seasonal labor and two (2) new RNG-powered silage choppers is explained in detail in the Business Plan submitted herewith.

The biomethane plant built in Part I produces two products - (i) sustainable fertilizer comprising recycled N-P-K nutrients, and (ii) RNG to be sold for "use as transportation fuel" so as to qualify for D3 RINs. In Part II, an additional ammonia production capacity will be added to the plant such that its product offering can be expanded to include (iii) sustainable ammonia.

Concerning the fertilizer product (i), all of this will be consumed by farmers who provide biomass for the plant. There are initially 15 farmers participating as suppliers and consumers. In Part II, the number of cover crop suppliers/re-cycled nutrient consumers is expected to increase to at least 40. The number of farmers benefitting from locally produced, sustainable, reduced-cost ammonia (iii) in Part II could potentially reach all 740 farms in Kingman County.

Concerning the RNG product (ii), the District intends to use revenues from Part I to convert local vehicles to RNG dual-fuel and to subsidize downpayments on new dual fuel vehicles. This is practicable in Kingman county which is home to one of only three CNG fueling stations in the entire western half of Kansas. The aim is to eventually achieve sufficient local consumption of RNG “for use as transportation fuel” so as to avoid pipeline transmission altogether. In the interim, RNG output will be sold to irrigation pump end users as explained under criterion 1.

USDA’s selection of this project for funding will greatly empower efforts to *replicate* this model through incorporation of other Kansas Sustainable Agriculture Districts in other counties. The Inflation Reduction Act (IRA) of 2022 amended the Clean Air Act to include a new section 134 establishing a “Greenhouse Gas Reduction Fund” of more than 26 billion USD to be spent before Sep 30, 2024, for grants (primarily) to States for “investment” in greenhouse gas reduction. There are literally thousands of Class II enhanced oil recovery wells in rural Kansas available for small scale CO2 sequestration under regulatory authority of the Kansas Corporation Commission for which *no EPA approval is required* (Appendix G2). The District and its agents seek to persuade the Governor and state legislators to apply for some of these grant funds with which to support Kansas Sustainable Agriculture Districts (e.g., underwrite and/or buy their bonds, provide matching funds, finance legal and technical start-up costs, offer incentives to technology providers, brokers and other agents serving Districts). The extreme high cost of the plant in this project (more than 3X the cost of a comparable plant in Denmark running agricultural residues which was built in 2014) is likely an aberration arising from extreme recent inflation in construction costs. We anticipate that it will ultimately be possible to make a pre-engineered, “cookie cutter” plant that Districts can afford on their own.

3. Climate Impacts & Sustainability.

This project reduces the impact of climate change by the efficient production of a sustainable, innovative fertilizer product (recycled N-P-K nutrients) in such manner as to demonstrate:
(i) that biomethane derived from “cover crops” grown with re-cycled nutrients can provide both vehicle fuel and feedstock for local-scale nitrogen fertilizer production and, in so doing, serve as “primary production” in a sustainable agricultural economic “ecosystem;”
(ii) that CO2 exhaust from biomethane and local-scale ammonia production can be sequestered (at least in Kansas) on small scale via Class II enhanced oil recovery wells without invoking the cumbersome, expensive and often un-accomodating EPA permitting process for Class VI wells (which never contemplated *small scale* sequestration); and
(iii) a new ethos whereby farmers, assisted by technology providers and well educated agents, can collectively improve their own economic condition through sustainable agriculture practices.

While the absolute quantity of sustainable fertilizer produced in Part I is small, the benefit of this project is great. It’s potentially game-changing significance in the nitrogen fertilizer market is its presentation of a new model of local-scale, sustainable production whereby all economic benefits are retained locally. The driving force for this model is the economic benefit derived by farmers from planting “cover crops” grown with an innovative, sustainable fertilizer product (recycled nutrients). The benefits of “cover crops” to soil health are well documented - so much so that NRCS *actively subsidizes* their cultivation. This new model could not have been conceived, let alone advanced, by centralized, large scale fertilizer producers who deliver their product through a chain of pipeline operators, freight haulers and middlemen, each of whom extracts a profit margin from end-consumer farmers. An analogy can be drawn between this project and the recent anouncement by the Department of Energy of successful net power generation from nuclear fusion. The quantity of electrical power produced was small. But the significance of the event was great. This project demonstates how sustainable agriculture can bring the longed-for “rain” of economic development to rural communities that have suffered a long drought.

The project is, itself, a concerted effort at greenhouse gas mitigation through production of RNG from agricultural commodities. The direct benefits of mitigation in Part I include:
(a) **Annual CO2 reduction** of 57,202 metric tons for at least 12 years (duration of sequestration credit) of which 46,159 metric tons will persist for the 30-year life of the plant;
(b) **Annual economic benefit to Kingman county, Kansas**, of 4.62 million USD for 20 years and of 8.80 million USD for 10 years thereafter - 1.4 million in full time jobs, 585,000 in seasonal work with harvest and nutrient spreading using locally produced and distributed RNG for fuel, 1.80 million in biomass payments to farmers, and an average net revenue retained by the District after agent fees in mininimal Case B of 832,343 during years 1-20, and of 4.18 million during years 21-30 with associated local “multiplier effect”;
(c) **Improvement of soil health in Kingman county, Kansas**, for 30 years, of 13,640 acres planted with “cover crops” used for conversion to biomethane. As is well known, and widely publicised by NRCS, in addition to keeping the soil covered so as to buffer soil organisms from heat stress and moisture loss, “cover crops” help ensure support for the entire soil food web throughout the year, increasing nitrogen retention, earthworm population, soil organic matter, aeration, and water retention, and reducing erosion and soil compaction so as to improve soil structure.

The indirect benefits of mitigation in Part I derive from *replication* of this model in other rural, agricultural communities. Especially to the extent that USDA supports it, this project can reasonably be anticipated to inform and inspire incorporation of many more Kansas Sustainable Agriculture Districts - conceivably eventually at least one in every agricultural county (105 in all). The indirect benefits could, thus, plausibly eventually become an annual CO2 reduction enduring for 30 years on the order of 4,800,536 metric tons (104 x 46,159, i.e., not accounting CO2 sequestration) and of an additional 1,148,472 metric tons for 12 years (104 x 11,043 through the end of the 45Q credit for plants initiated by the end of 2032), an economic benefit to rural communities on the order of 393,120,000 USD (104 x 3.78 million) for 20 years and of 915,200,000 USD (104 x 8.8 million) for 10 years thereafter, and improvement of soil health for 30 years in 1,418,560 acres planted with “cover crops” (104 x 13,640) - more than 10% of the “cover crop” acreage currently subsidized by NRCS nationwide.

In Part II, the direct and indirect benefits of mitigation will, of course, be much greater.

The list of assumptions supporting these estimates is:
1. CO2 sequestration - all of the CO2 produced according to the WELLTEC estimate (Appendix B adjusted to english tons feedstock)(21,976 metric tons) can be sequestered by compression to 400 psi and injection via sparger after the water pump into the brine stream directed to two EOR wells operating under Class II permit numbers E13079.5 and E13079.7, each for 10,000 barrels per day at 400 psi (Appendix E); METHODOLOGY - the Tertiary Oil Recovery Program (TORP) at Kansas University previously measured CO2 solubility in production brine having 118,000 ppm salinity (nearly identical with the brine used in these wells) at 90o Farenheit to be about 8.8 grams/liter at 350 psi and about 28.6 grams/liter at 1000 psi. At 400 psi, with 20,000 barrels per day brine volume, more than 27 metric tons per day will be already dissolved at the surface. CO2 that was initially undissolved at 400 psi would comprise a "void volume" in the brine stream of about 20% and would become fully dissolved by the time the stream reached a depth of 2300 feet (corresponding to a hydrostatic pressure above 1000 psi) - still thousands of feet above the endpoint injection zone. The steady-state downward velocity of the brine stream will easily outpace the maximum upward velocity of any bubbles.
2. CO2 reduction - **(a) RNG offset** - the RNG produced according to the WELLTEC estimate (Appendix B adjusted to english tons feedstock)(12,836,869 Nm3 corresponding to 435,577 MMBTU) will have an "emissions factor" of -43.35 kg CO2/ MMBTU during years 1-12 with CO2 sequestration and of -18.0 kg CO2/MMBTU during years 13-30 without CO2 sequestration but with local consumption sans pipeline transmission corresponding to an absolute annual reduction of 18,883 metric tons CO2 in years 1-12 and of 7840 tons during years 13-30 and to a realized annual reduction relative to equivalent use of pipeline gas for CNG of 49,373 tons in years 1-12 and 38,331 tons in years 16-30; METHODOLOGY - average grasses have about 37% carbon content (average reported by Harper (1933)) whereas feedlot manure has about 28% (average value reported by Larney (2015)); each metric ton of carbon in the feedstock was fixed from 3.67 tons CO2 from the atmosphere (MW44/MW12); total metric tons CO2 inherent in the feedstock was then -64,909; planting with diesel fueled vehicles consumed 1.26 gallons per acre, for 15,000 acres, releasing 192 tons - no penalty for nitrogen fertilizer derived N2O is applied where this was re-cycled nutrients primarily comprising organic N - no penalty is applied for harvest and transport with RNG-fueled vehicles; electrical and thermal power requirements as specified (Appendix B adjusted) are produced by a combined heat and power generator burning pipeline gas with 78% efficiency and thereby releasing 2.75 tons CO2/ton CH4 (MW44/MW16) totalling 6473 tons; CO2 compression to 400 psi requires 198 horsepower corresponding to 1293402 kWh per year - this is generated by a pipeline gas generator with 40% efficiency thereby releasing 484 tons CO2; pumping 20,000 barrels of brine per day at 400 psi requires 169 horsepower corresponding to 1103964 kWh per year produced by natural gas generators operating with 40% efficiency thereby releasing 567 tons CO2; methane slip of 2.5% as specified (Appendix B) will be assessed as 28X CO2 equivalence corresponding to 17,644 tons CO2; RNG combustion will release 25,205 tons CO2; all fermentation CO2 as specified (Appendix B adjusted) is sequestered for -21,976

tons; total RNG production (Appendix B adjusted) in MMBTU is 484287; thus initial kg CO2 per MMBTU is (-64909 + 192 + 6473 + 484 + 567 + 17644 + 25205 - 21976 = -36319)(*1000 kg/ton)/484287 MMBTU = -75.00; without CO2 sequestration, the figure is -29.62 kg CO2/MMBTU; from this pipeline transmission, compression and distribution are accounted at 20.05 and the physical biogas plant at 11.6 kg CO2/ MMBTU applying figures reported by the California Air Resources Board for a net of -43.35; applying this net to the total production in MMBTU the net absolute annual reduction is 18,883 tons CO2; in years 13-30, assuming CO2 sequestration is discontinued, complete local consumption sans pipeline transmission will still make the absolute net - 18.0 kg CO2/MMBTU for annual reduction of 7,840 tons CO2; relative to equivalent quantities of pipeline gas used as CNG, which has a positive emission factor of 70 kg CO2/MMBTU, the realized annual reduction during years 1-12 is 18,883 + 30,490 = 49,373 tons CO2 and during years 13-30, 7,840 + 30,490 = 38,330 tons CO2.

(b) N-P-K nutrients offset - Digestion of 30,000 dry english tons each of feedlot manure and grass silage will lead to recovery in english tons, from plant effluents, of 1526 N, 493 P, and 597 K. This imparts a CO2 reduction relative to use of corresponding amounts of commercial chemical fertilizers of 7829 ton CO2/year; METHODOLOGY - N-P-K content values are given in kg of the pure element per dry metric ton. Feedlot cattle manure is assumed to be the average value reported by Dadrasnia (2021) 24.0 N, 14.0 P, and 10.6 K. P-K content of sudan grass is assumed to be the mid-point of the ranges reported by Li (2011) of 2.45 P and 22.55 K. N content of sudan grass is assumed to be 26.88 based on the protein content reported by Cunningham (1971) of 16.8% dry matter and the assumption that N represents 16% of protein mass. Total recovery of nutrients in digestate is assumed to be as reporeted by WELTEC for digestate processing (Appendix C) of 100% N, 100% P and 60%K. The total inherent annual content for 27,273 metric tons each of sudan grass and feedlot manure dry matter is thus 1388 tons metric N, 449 metric tons P, and 905 metric tons K from which is recovered in english tons 1526 N, 493 P, and 597 K. CO2 emissions factors reported at https://legacy.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_Appendix_H_WSTP_South_End_Plant_Process_ Selection_ Report/Appendix%207.pdf in kg/kg for liquid ammonia, fertilizer phosphate and potash of 2.11, 2.70 and 2.30 were expressed as kg/kg pure elements as N 2.56, P 6.18, and K 2.77. These were divided by 1.1 to yield a factor in metric tons CO2 per english ton element of N 2.33, P 5.62 and K 2.52. The net CO2 reduction relative to commercial fertilizers is thus calculated as N (1526*2.33) + P (493*5.62) + K (597*2.52) = 7829 tons CO2/year.

3. Economic benefits - The revenue and cost figures reported in Table 1 are assumed to apply under conditions where USDA finances 25% of allowable costs in this project, reducing bond debt service by a corresponding amount. For extrapolation of benefits to other Districts, the Table 1 figures are assumed to apply without USDA support but with an assumption that the exorbitant cost of the plant in this project will be reduced by at least 25% through standardization; METHODOLOGY - the details of Table 1 are explained under criterion 1 and in the Business Plan.

4. Regional Impact & Support.

The District was initially incorporated by the Kingman County commission after submission of a petition which stated: “The district is necessary to provide a means whereby farmers can reap economic benefits from the national conversion to renewable energy and sustainable agriculture practices. Benefits will accrue to current and future inhabitants in eventual provision of renewable and low-cost vehicle fuel and nitrogen fertilizer.”

Thus, the County commission not only supports this project but quite literally *enabled* it. The County Economic Development office has facilitated dissemination on its website of information about the project, including the District’s biomass conversion service agreement form.

The city of Kingman commission has also formally and officially indicated support for the project in authorizing the District to utilize, as water source for the plant, city wastewater effluents which are currently released into a local river (Appendix D).

The District’s commercial partner in organizing and operating the biomethane plant in Part I is its agent BLUE FLAME BIOPOWER whose business plan is based on providing similar services to many other Districts. The District’s strategy for generating regional support is to rely on Blue Flame’s efforts to initiate other Districts in other Kansas counties.

A bi-partisan group of legislators representing two extremes of political viewpoint in Kansas including members of both the state House and Senate Agriculture Committees signed a letter of support for the District and Blue Flame addressed to the recently re-elected Governor: “We believe that conversion to renewable energy will be vastly more palatable to farmers to the extent that they, themselves, benefit from this conversion…The Kingman county proto type could become a model for rural economic development that is replicable in many other Kansas counties.”

Local state representatives have already introduced proposed legislation having the short title “The Kansas Sustainable Agriculture Act” (Appendix F) for the legislative session beginning January 9, 2023. This would direct the Kansas Department of Agriculture to create a new “Division of Sustainable Agriculture” having the express purpose of providing financial assistance to Kansas Sustainable Agriculture Districts in the form of grants, loans, bond guarantees and other assistance using funds obtained through federal grants from the newly established Greenhouse Gas Reduction Fund. To inform their deliberations about this legislation, BLUE FLAMER BIOPOWER will present this grant application to the Governor and to the state legislative Agriculture Committees. If the legislation passes, BLUE FLAME BIOPOWER will endeavor to initiate additional Districts in each of the 14 Kansas counties identified by USDA as economically “at risk.”

5. Personnel.

The project team includes Bernard B. Sheff, P.E., Chairman of the American Biogas Council (ABC) and Vice-President of Montrose Environmental Group Inc., which is the engineering, procurement and construction (EPC) contractor that will build the plant; Robert C. Casad, Jr., Ph.D., J.D., Director of Blue Flame Biopower L.L.C., which acts as the District's RNG distributor and agent; and the District's Directors - Shasta Wewe, M.S., B.A. Treasurer and effectively manager, William R. Tetrick, A.A., President, and Andy Warner, Secretary.

Bernard Sheff's leadership of the engineering team brings a very high profile to this project, which can be expected to attract considerable attention in the biogas community. Until now, most investment in biogas plants in the US has focused on "low hanging fruit" such as dairy manure and landfills. This project advances and demonstrates a bold new concept whereby biomethane becomes a "primary producer" in a sustainable rural economic ecosystem rather than simply a "green" investment opportunity. There is no one in the country better suited than Sheff to advance this narrative.

Robert Casad originally developed the Kansas Sustainble Agriculture District model as a vehicle for exportation of Danish biomethane technology. He returned to his native Kansas from Denmark, where he lived and worked in the biofuels industry for the past 17 years, to initiate District #001. He maintains a rural residence near Kingman and meets regularly with the Directors. The operations plan explained in the Business Plan was arrived at through "group process." Casad is well situated to be able to communicate the District's needs to Montrose.

The Directors, each of whom is a farmer, play a critical role in organizing grass harvest, manure hauling and nutrient spreading using local farm labor.

6. Administrator points.

This project demonstrates how a technology that inherently reduces climate pollution (RNG vehicle fuel production from agricultural commodities) can provide access to an innovative, sustainable fertilizer product (re-cycled N-P-K nutrients) and, in so doing, be a primary driver of rural economic development by enabling a new local market opportunity for "cover crops." The livelihood of farmers (rural residents) is improved by this project through annual payments of 1,800,000 USD for "cover crops" grown with re-cycled nutrients re-distributed to their fields, with no requirement for investment in harvest or transport costs, through 1,400,000 USD per year in full time employment in their community, and through 585,000 USD annual payments in their community for seasonal farm labor. The annual CO2 reduction of 57,202 metric tons achieved by this project contributes to climate-impact goals through implementation of climate-smart agricultural practices including cultivation of "cover crops" and their conversion to RNG (with CO2 exhaust sequestration), avoidance of CO2-intensive chemical fertilizers, and conducting harvest and transport with RNG-fueled farm vehicles.

The applicant's certifications can be found in Appendix G3.