Nature Energy Biogas Facility
Roberts, Wisconsin
Digestate and Digestate Products

Nature Energy is a Denmark-based renewable natural gas (RNG) company with significant experience in anaerobic digestion and the design, implementation, and operation of anaerobic digesters. Founded in 1979, Nature Energy (previously, Naturgas Fyn) is a leader in the transition to green energy. Currently, Nature Energy operates 14 innovative biogas facilities located in Denmark, France, and recently purchased an operating plant in the Netherlands. Nature Energy proposes to develop an anaerobic digester and nutrient recovery facility in Roberts, Wisconsin under the name "Nature Energy Roberts" (NE Roberts). Anaerobic digestion would produce biomethane (CH_4) from turkey, dairy, and food processing waste. During operation, the NE Roberts facility would produce an average of 24.5 million normal cubic meters (Nm^3) of biomethane annually. The NE Roberts facility would upgrade the biomethane to RNG, which would be available for commercial sale, while the nutrient-rich byproducts would be provided back to farmers for use in their nutrient management plans (NMPs).

The proposed facility would have the capacity to produce up to 689,500 tons of digestate annually. When the digestate is separated, approximately 85 percent is nutrient water and 15 percent is fiber fraction. Table 1 lists the anticipated nutrients for each output. The values presented are averages determined by Nature Energy's existing operating facilities; the exact nutrient concentrations may vary by up to +/-25% depending on the biomass inputs.

Table 1 Digester Outputs Nutrient Content

	lb N/ton	lb P_2O_5/ton	lb K_2O/ton
Digestate	14.8 +/-25%	9.2 +/-25%	9.9 +/-25%
Nutrient water	14.0 +/-25%	6.4 +/-25%	10.1 +/-25%
Fiber fraction	22.4 +/-25%	33.0 +/-25%	8.9 +/-25%

Notes:
N = nitrogen
P_2O_5 = diphosphorus pentoxide
K_2O = potassium oxide, or potash
The phosphorus and potassium content are provided as P_2O_5 and K_2O equivalents, which are the traditional way of expressing phosphorus and potassium content for their crop nutrient value.
Exact concentrations may vary by +/-25% depending on biomass input composition.

Source: Nature Energy

NE Roberts will transport the digestate and derived products to receiving farms or third-party owned storage locations, where it can then be used. Participating farmers will be responsible for field-applying the nutrients in accordance with their own nutrient management plans. Depending on their specific nutrient needs, farmers may use the digestate as produced or receive the fiber fraction (higher in phosphorus) or nutrient water (nitrogen-rich, but lower in phosphorus) separately. Many nutrient management decisions and factors are involved in determining the amount of nutrients that should be applied to fields. These may include existing soil conditions, crop type and yield expected for the current growing season, crop type from the previous growing season, the use of irrigation and other management practices, the method for nutrient application, and the cost of nutrients. The farmer using the NE Roberts digestate or derived product will be responsible for ensuring that the nutrient management complies with their farm's manure storage requirements, application frequency and amounts, and stipulations for emergency wintertime applications.

Soil fertility specialists in several Midwestern states, including Wisconsin, have agreed upon a uniform approach to developing nitrogen rate guidelines for corn, called the maximum return to nitrogen value (MRTN) method. Although the MRTN method emerged from a regional effort, the Wisconsin MRTN method guidelines in Table 2 are based entirely on experiments conducted on numerous Wisconsin soils. Table 2 shows the recommended application rate for different scenarios using a conservative MRTN value of 0.15, as presented in a guidance document by the University of Wisconsin-Extension, *Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin (A2809)* (University of Wisconsin-Extension 2012). Based on the MRTN guidelines, the annual production of digestate could supplement the nitrogen need for approximately 52,000 – 89,000 acres of corn following corn rotation or 74,000 – 120,000 acres of corn following soy rotation. For sands and loam sands soils, the annual digestate production could supplement the nitrogen need for approximately 42,000 to 55,000 or 65,000 to 85,000 acres of irrigated or non-irrigated crops, respectively.

Table 2 Suggested nitrogen (N) application rates for corn for MRTN (lb N/acre) for N price/Crop value ratio of 0.15

Condition	MRTN	Range
Loamy: high yield potential soil		
Previous crop: Corn, forage legumes, legume vegetables, green manures	150	140 – 160
Previous crop: Soybean, small grains	105	95 – 115
Loamy: medium yield potential soil		
Previous crop: Corn, forage legumes, legume vegetables, green manures	115	105 – 125
Previous crop: Soybean, small grains	85	70 – 95
Sands/loam sands		
Irrigated – all crops	185	175 – 195
Non-irrigated – all crops	120	110 – 130

Source: University of Wisconsin-Extension 2012

Previous experience has shown that it is most economical to keep contracts to farms that are within approximately 20 miles of a Nature Energy facility. For the proposed NE Roberts site, there are approximately 155,000 acres of corn and 89,000 acres of soybeans within a 20-mile radius (U.S. Department of Agriculture's [USDA] National Agricultural Statistics Service [NASS] 2021a). NE Roberts would therefore be able to offset N fertilizer needs for approximately 27 percent to 77 percent of local corn production.

The use of digestate also represents an advantage over the use of raw manure, which can over supply phosphorus when applied to meet nitrogen needs. Based on the nutrient requirements, NE Roberts digestate should be well-matched with corn nutrient needs. For example, for corn harvested for grain, the digestate supplies less phosphorus than what is removed by the grain harvested. This deficit can help to reduce soil phosphorus levels. Wisconsin-Extension 2012).

Many farmers use removal-based management for phosphorus and potassium. Table 3 shows nutrient removal rates for corn and soybeans in pounds per bushel harvested (University of Wisconsin-Extension 2012). In 2020, St. Croix County averaged yields of 182.7 and 52.4 bushels per acre for corn and soy, respectively (NASS 2021b; NASS 2021c). Based on the removal rates, yields, and local crop acreage, approximately 14.5 million pounds of phosphorus are removed from local fields annually with the corn grain and soy beans. Similarly, approximately 14.8 million pounds of potassium are removed each year. The digestate from NE Roberts is projected to contain 4.8 – 6.3 million pounds of phosphorus and 5.2 – 6.8 million pounds of potassium annually.

Table 3 Removal-based management of P and K

	Crop Nutrient Removal (lb per bushel)	
Crop	**P_2O_5**	**K_2O**
Corn (grain at 15.5% moisture)	0.38	0.29
Soybean (grain at 13% moisture)	0.8	1.4

Source: University of Wisconsin-Extension 2012

There are additional benefits to digestate beyond application rates. Numerous studies have demonstrated the advantages of applying digestate to crop fields compared to manure. Anaerobic digestion mineralizes the organically bound nitrogen in the manure and other biomass inputs. The resulting mineral form of nitrogen, or inorganic nitrogen, is more available to the crop compared to raw manure (Sørensen et al. 2017). Field application of this substrate results in less organic nitrogen in the soil compared to raw manure, subsequently resulting in less nitrogen leaching (Olesen et al. 2021). A study done by the Danish Center for Food and Agriculture and Aarhus University researchers modeled that anaerobically digested manure reduced leaching by 0.5 lb N/metric ton, compared to raw manure (Olesen et al. 2021). Field experiments by Sørensen & Børgesen (2015) demonstrated a reduction in nitrogen leaching of 22 lb/220 lb biomass (Sørensen & Børgesen 2015).

Similarly, the increase of inorganic nitrogen helps offset the need for additional fertilizer. Field experiments corroborated by laboratory experiments showed that the nitrogen fertilizer replacement value can be increased by 40 percent when using digestate compared to manure (Fontaine et al. 2020). A reduction in additional fertilizer has more than just

economic benefits. Chojnacka et al.)2019) calculated that a reduction of 0.1 lb N/kg treated N results in reduced CO_2 emissions of 12.3 lb CO_2/lb N.

Further, multiple studies have demonstrated the positive impacts of digestate on soil biodiversity (Coelho et al. 2019; Koblenz et al. 2015; Garcia-Sánchez et al. 2015; Barłóg et al. 2020). Digestate has been shown to stimulate an increase in soil microbial biomass (Garcia-Sánchez et al. 2015). This positively impacts soil functionality, diversity, and structure, leading to long-term soil and crop benefits (Garcia-Sánchez et al. 2015).

Finally, the additional manure storage for the NE Roberts digestate would allow farmers to align application timing better to crop needs. Applying digestate at the right time for crop growth reduces the risk of nutrient losses to the environment. The additional storage and ability to better time applications also help farmers to align fall applications with planting cover crops.

In summary, field application of digestate or derived product applications carry lower levels of unused nutrients than raw manure applications. As demonstrated, the nutrients contained in the digestate can be utilized on existing cropland within 20 miles of the proposed facility. The use of anaerobic digestion before manure application helps to reduce the potential for nitrogen leaching into groundwater, phosphorus building up in soils, or nutrient loss to surface water. The characteristics of anaerobically digested biomass offer long-term benefits for soils, crops, and the environment.

References

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