INNOVATION GRANT PROGRESS REPORT

PROJECT TITLE:	On Farm Generation of Nitrogen Fertilizer
REPORTING PERIOD:	3rd Quarter, 2021
FARMER INNOVATOR:	N/A
COLLABORATING ORGANIZATION/PERSON:	Kennedy Research LLC
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1.) PROJECT ACTIVITIES COMPLETED DURING THE REPORTING PERIOD

Continued design and build work on high volume (100+ L/hr) non-thermal plasma Dielectric Barrier Discharge (DBD) generator for the production of aqueous nitrate, NO_3, fertilizer. A cylindrical DBD design has been chosen. This type of system can also be referred to as a Plasma Activated Water (PAW) system.

2.) IDENTIFY ANY SIGNIFICANT FINDINGS AND RESULTS OF THE PROJECT TO DATE.

Recent fertilizer price increases move this type of system closer to commercial viability

3.) CHALLENGES ENCOUNTERED.

Project schedule has been slowed due to commitments on other University of Minnesota projects by company principles

4.) EDUCATION AND OUTREACH ACTIVITES

No outreach activities 2nd Quarter 2021

5.) HOW CAN WE HELP

No specific ask at this time.

KENNEDY Research

cNTP for Nitrate Theoretical Energy Minimums And Cost Comparison To Common Fertilizers

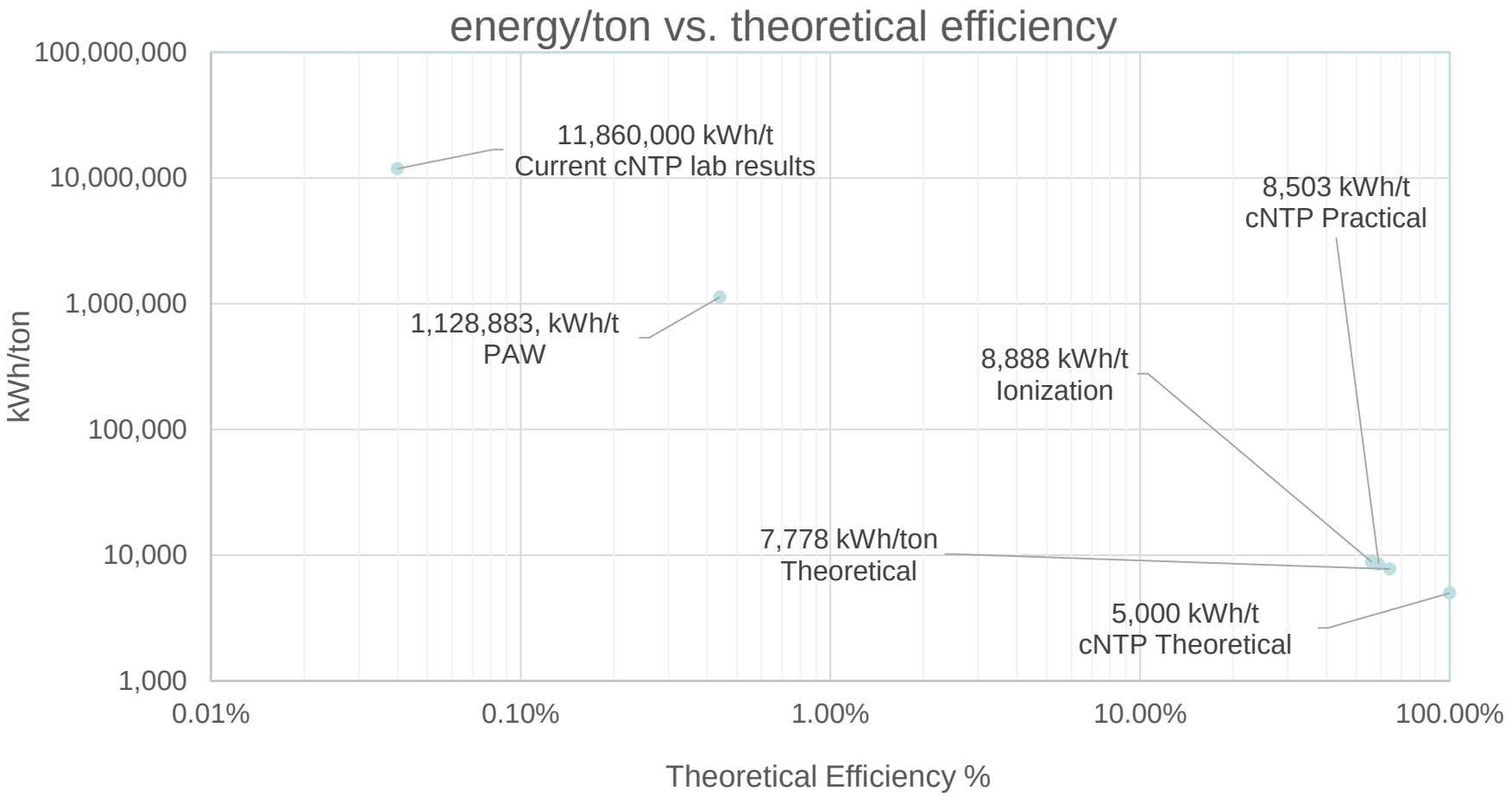
Prepared for MCGA

7 Feb 22

Comments

- Kennedy Research currently working on Plasma Activated Water (PAW) type nitrate production system.
  - Current data from Korean research
- Recent nitrogen fertilizer price increases moves PAW closer to commercial viability.
- Lower electrical rates and/or greater system efficiency will allow commercialization.
  - < $0.01 kWh electrical rates
  - Tenfold increase in system efficiency
- Tenfold increase in system efficiency is focus
  - See next slide

cNTP Lab Results vs. Min Energy by Various Methods
% Improvement to Commercial Viability



Common Nitrogen Fertilizers Cost, Aug 2020 Compared to cNTP Nitrate

Fertilizer	Nominal Physical State	Molecular compound	% N	Price $/ton Product[1] 30 Aug 20	Price, $/ton N	Price, $/lb N
Anhydrous Ammonia	Gas Applied as liquid under pressure	NH_3	82%	$528	$644	$0.32
Urea	Solid	$(NH_2)_2CO$ also expressed as NH_2CONH_2 or CH_4N_2O	46%	$412	$896	$0.45
Urea Ammonium Nitrate (UAN) solutions	Liquid Dry ingredients of varying %s dissolved in water	$(NH_2)_2CO$ Urea NH_4NO_3 Ammonium Nitrate	28%	$256	$914	$0.46
			32%	$290	$906	$0.45
					Theo min cost $/ton/$0.01 kWh	Theo min cost $/lb/$0.01 kWh
FarmGenN® Liquid Nitrogen	Liquid	NO_3 Nitrate Some small concentrations of NH3, ammonia and NO2, nitrite expected	22.6% Max Pure Nitrate	PAW cNTP Practical Ionization HB Baseline cNTP Theo	$11,289 $ 89 $ 85 $ 78 $ 50	$5.640 $0.044 $0.043 $0.039 $0.025

[1]DTN Retail Fertilizer Trends: https://www.dtnpf.com/agriculture/web/ag/crops/article/2019/09/04/nitrogen-fertilizer-prices-decline-3

Common Nitrogen Fertilizers, Dec 2022 Compared to cNTP Nitrate

Fertilizer	Nominal Physical State	Molecular compound	% N	Price $/ton Product[1] 30 Aug 20	Price, $/ton N	Price, $/lb N
Anhydrous Ammonia	Gas Applied as liquid under pressure	NH_3	82%	$1,372	$1,673	$0.84
Urea	Solid	$(NH_2)_2CO$ also expressed as NH_2CONH_2 or CH_4N_2O	46%	$887	$1,928	$0.96
Urea Ammonium Nitrate (UAN) solutions	Liquid Dry ingredients of varying %s dissolved in water	$(NH_2)_2CO$ Urea NH_4NO_3 Ammonium Nitrate	28%	$577	$2,061	$1.03
			32%	$661	$2,066	$1.03
					Theo min cost $/ton/$0.01 kWh	Theo min cost $/lb/$0.01 kWh
FarmGenN® Liquid Nitrogen	Liquid	NO_3 Nitrate Some small concentrations of NH3, ammonia and NO2, nitrite expected	22.6% Max Pure Nitrate	PAW cNTP Practical Ionization HB Baseline cNTP Theo	$11,289 $ 89 $ 85 $ 78 $ 50	$5.640 $0.044 $0.043 $0.039 $0.025

[1]DTN Retail Fertilizer Trends: https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/12/15/nitrogen-fertilizer-prices-continue