STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IN THE MATTER OF

ARIES PINE TREE, LLC SANFORD, YORK COUNTY AIR EMISSION LICENSE APPLICATION (A-1195-71-A-N) AND SOLID WASTE PROCESSING FACILITY LICENSE APPLICATION (S-100033)	**PRE-FILED TESTIMONY OF WILLIAM NORTHROP, PH.D.**

I, William Northrop, Ph.D., declare and state as follows:

1. I am a combustion scientist and tenured professor of mechanical engineering at the University of Minnesota. My curriculum vitae is attached as **Exhibit A**.

2. I have been retained by counsel for the Sanford Clean Air and Water Coalition and Conservation Law Foundation to provide expert testimony in this proceeding concerning the pending applications of Aries Pine Tree, LLC ("Aries") for air emissions and solid waste facility licenses to construct and operate the Aries Pine Tree facility in Sanford, Maine (the "Facility").

3. This testimony addresses (1) the nature of the thermal treatment process for sewage sludge/biosolids proposed at the Facility—specifically, how the Facility will combust sewage sludge/biosolids; (2) how the Facility's expected air emissions compare to the air emissions from solid waste incinerators that do not employ gasification; (3) information that is missing from Aries' permit applications regarding the heat input capacity of the Facility's fuel-burning equipment; (4) Aries' estimates of the Facility's emissions of regulated air pollutants; (5) Aries' proposed operational, compliance testing, monitoring, recordkeeping, and reporting requirements; and (6) Aries' technical ability to operate the Facility in a manner that will consistently achieve Aries' proposed emissions rates.

PROFESSIONAL BACKGROUND AND QUALIFICATIONS

4. I have a B.S. in Mechanical Engineering from Carnegie Mellon University and an M.S. and Ph.D. in Mechanical Engineering from the University of Michigan.

5. I serve as the Leroy M. Fingerson/TSI Incorporated Chair in Mechanical Engineering and Director of the Thomas E. Murphy Engine Laboratory at the University of Minnesota.

6. I have extensive research, teaching, and consulting experience relevant to evaluating the thermal treatment process proposed for the Aries Pine Tree Facility and the Facility's air emissions. My academic and research experience encompasses combustion fundamentals, fuel conversion, synthesis gas ("syngas") formation and combustion, reactor development, and air pollutant emissions from combustion processes. I also have research and professional engineering experience in the design and operation of biomass gasification systems; the utilization of synthesis gas generated by gasification, reforming, and pyrolysis; and the evaluation of air emissions and emissions control strategies for gasification and other combustion systems.

7. I have been teaching the fundamentals of combustion and thermodynamics at the undergraduate and graduate levels for 15 years. I have developed and taught introductory and advanced combustion courses covering thermochemistry, chemical kinetics, reacting flows, premixed and diffusion flames, turbulent combustion, and pollutant formation. I have also taught courses in thermodynamics, power cycles, and energy conversion laboratory. In addition, I have supervised graduate research on gaseous and particulate emissions from combustion processes including engines and burners.

8. My combustion research program combines experimental diagnostics, computational modeling, and thermodynamic analysis investigating combustion performance,

efficiency, and emissions. Topics of my combustion research include ignition chemistry, advanced engine combustion, catalytic fuel reforming, and the formation and characterization of gaseous and particulate pollutants.

9. A major focus of my research is the formation, measurement, characterization, and control of particulate matter from combustion systems. My work characterizing particulate emissions from combustion processes includes characterization of particle mass, number, size, and opacity. I have investigated both solid particles and semi-volatile material associated with combustion exhaust. My research on combustion-generated nanoparticles includes a 2019 Fulbright appointment that involved evaluation of particulate matter emissions from biomass combustion.

10. I have studied how sampling and dilution conditions influence measured particulate emissions. This experience is relevant to interpreting emissions measurements and comparing results across combustion technologies and operating conditions. I have led or participated in sponsored research involving combustion emissions and emissions-control technologies with organizations including General Motors, Aramco, Shell/FCA, Cummins, and Corning.

11. I have also conducted multiple studies characterizing gaseous emissions from combustion devices, including hydrocarbons, carbon monoxide, oxides of nitrogen, and hydrogen.

12. My publications address the influence of combustion strategy, fuel composition, lubricating-oil-derived ash, and operating conditions on particle formation and emissions control performance. Related work has examined nitrogen oxide emissions and strategies for reducing

them through changes in fuel use and combustion operation, including dual-fuel systems and fuel reforming.

13. I have conducted applied research on gasification technologies since 2008. This work includes design of gasification systems and investigation of their emissions and overall environmental impact.

14. I have extensive research experience in syngas production, fuel reforming (converting hydrocarbon fuels into useful products), and syngas utilization. I have led and participated in research on catalytic and non-catalytic partial oxidation, gasification, steam reforming, dry reforming, and oxidative coupling of methane. Relevant to the evaluation of the Aries permit applications, I have participated in and led programs that develop syngas production systems, including biomass gasifiers. My research program has also examined emissions from syngas produced by reforming and gasification systems.

15. My research on gasification systems includes serving as the principal investigator for "Reducing Emissions from Open Burning through Biomass Gasification," a $268,000 project funded by the Legislative-Citizen Commission on Minnesota Resources in 2015. This project investigated small-scale biomass gasifier-generator systems, including their particulate and aromatic hydrocarbon emissions and their environmental performance relative to open burning and larger biomass power generation systems.

16. I coauthored "Particulate and Aromatic Hydrocarbon Emissions from a Small-Scale Biomass Gasifier-Generator System," published in *Energy & Fuels* in 2014.[1] This work

[1] Hamilton, J. E., Adams, J. M., & Northrop, W. F. (2014). Particulate and aromatic hydrocarbon emissions from a small-scale biomass gasifier-generator system. *Energy Fuels, 28*(5), 3255–3261. https://doi.org/10.1021/ef500437z.

directly addressed pollutant emissions from an integrated biomass gasification and power-generation system.

17. I also coauthored "Emissions Factors from Distributed, Small-Scale Biomass Gasification Power Generation: Comparison to Open Burning and Large-Scale Biomass Power Generation," published in 2018 in *Atmospheric Environment*.[2] This research evaluated emissions from distributed gasification power generation in relation to alternative biomass combustion and disposal practices.

18. I have also provided engineering consulting services to Carba, a Minnesota company that produces biochar from biomass via pyrolysis followed by oxidation. My specific role was to help design a burner to combust residual hydrogen-rich gas from the reactor (*i.e.*, pygas) and feed the heat back into the reactor.

19. I worked as a research engineer at Chrysler Corporation (1997–1998) and Nuvera Fuel Cells (1998–2002), developing catalytic fuel-processing systems and systems that combust reforming products. As an example, I am the second inventor on U.S. Patent 7,575,614, a startup burner operating on syngas for rapidly heating a catalyst in a reformer used in fuel cell systems.

20. I conducted research at the University of Michigan from 2003–2005, funded by the U.S. Department of Energy, in which I designed and built a complete natural gas fuel reforming system including a burner that combusted all the syngas from the system. This work was published in a 2011 paper.[3]

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[2] Ahmed, O. Y., Ries, M. J., & Northrop, W. F. (2019). Emission factors from distributed, small-scale biomass gasification power generation: Comparison to open burning and large-scale biomass power generation. *Atmospheric Env't, 200*, 221–227 https://doi.org/10.1016/j.atmosenv.2018.12.024.

[3] Northrop, W. F., Choi, S. O., & Thompson, L. T., Thermally integrated fuel processor design for fuel cell applications, *Int'l J. of Hydrogen Energy, 37*(4), 3447–3458. https://doi.org/10.1016/j.ijhydene.2011.11.034.

21. I have also conducted broader waste-to-energy research, including research addressing energy recovery from wastewater treatment and the use of waste-derived gases. I was corresponding author on a paper that proposed a methodology for selecting energy recovery technology for anaerobic wastewater processing across capacity and chemical oxygen demand levels.[4]

22. Finally, I have held research appointments in General Motors' Propulsion Systems Research Laboratory and served as a co-founder and Senior Technical Advisor at Aza Power Systems. These roles complement my academic research in combustion, alternative fuels, and emissions. My industry-sponsored university projects have included applied investigations of combustion of alternative fuels, particulate emissions, exhaust filtration, catalyst performance, and fuel-reforming technologies.

MATERIALS REVIEWED

23. In preparation for this testimony, I reviewed the Aries applications and relevant documents in the Maine Department of Environmental Protection's ("DEP's") online project folder[5] as well as relevant scientific research.

24. All materials cited below that are not in the DEP permit file are submitted concurrently with this testimony in the **Appendix**.

[4] *See* Lasode, A., Rinn, E., & Northrop, W. F. (2021). Surveying the applicability of energy recovery technologies for waste treatment: Case study for anaerobic wastewater treatment in Minnesota. *J. of the Air & Waste Mgmt. Ass'n, 71*(8), 974–988. https://doi.org/10.1080/10962247.2021.1906353.

[5] *Aries Pine Tree LLC, Sanford*, Me. Dep't of Env't Prot., https://www.maine.gov/dep/projects/aries/index.html (last visited Nov. 9, 2026).

I. THE ARIES PINE TREE FACILITY WILL COMBUST SEWAGE SLUDGE

25. The Aries Pine Tree Facility will use a controlled combustion process to achieve its stated purpose of reducing the volume of sludge/biosolids.

26. Combustion is defined as "rapid oxidation generating heat, or both light and heat; also, slow oxidation accompanied by relatively little heat and no light."[6]

27. Combustion of solid fuels such as sewage sludge involves drying, pyrolysis/devolatilization, and oxidation. All of these processes will occur in the Aries Pine Tree Facility.

28. The Aries Pine Tree Facility's gasifier and integrated thermal oxidizer are designed to jointly perform the main combustion processes in a stepwise manner to achieve the Facility's purpose of reducing the volume of the treated sludge and recovering heat to facilitate that process. Further, combustion will occur within both the gasifier and the thermal oxidizer.

29. Gasification is itself a type of combustion.[7] It dries, pyrolyzes/devolatilizes, and oxidizes fuel. It releases heat (i.e., is exothermic) and produces a small amount of light from oxidation in and around the solid particles and from particle luminescence.

30. Accordingly, gasification is treated as a combustion topic in the scientific literature. By way of illustration, a keyword search in ScienceDirect conducted in October 2026 indicated that the journal *Combustion and Flame* has published 989 research and review articles on gasification and *Proceedings of the Combustion Institute* has published 434 articles. These are leading peer-reviewed journals in the field of combustion science.

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[6] Stephen Turns, *Introduction to Combustion* 6 (1st ed. 1996) (quoting Webster's Dictionary at time of publication).

[7] *See generally The Five Processes of Gasification*, All Power Labs, https://www.allpowerlabs.com/gasification-explained (last visited Nov. 11, 2026) (describing gasification of biomass).

31. Other types of combustion include premixed flames, diffusion flames, catalytic, mild/flameless, and detonation/deflagration, among others.

32. Gasification produces both products of incomplete combustion (including hydrogen (H_2) and carbon monoxide (CO)) and products of complete combustion (including water (H_2O) and carbon dioxide (CO_2)) because it operates with less than the stoichiometric (chemically perfect) amount of air. Gasification does not completely consume the fuel, but rather converts it into synthesis gas (sometimes referred to as "syngas" or "producer gas") and, in some cases, carbonaceous char. In theory, gasification is a self-sustaining process in which the exothermic oxidation reaction provides the heat required to convert sludge or other solid waste into high-carbon ash and syngas. In contrast, in a pyrolysis facility, no oxygen is intentionally introduced, and heat is supplied externally.

33. Although the gasification process will occur in what Aries characterizes as an "oxygen-starved environment,"[8] the system provides sufficient oxygen to sustain combustion without adding heat. In addition to the oxygen that is present in the sludge feedstock, the gasifier is designed to receive oxygen through air injection at the bottom of the fluidized bed section. Oxygen is supplied from atmospheric air via blowers or from the recycled exhaust of the thermal oxidizer. The air flows through a grate structure and moves upward through the reactor, oxidizing entrained waste particles. This is depicted in Aries' air permit application and in patents assigned to Aries that describe a substantially identical process to the system proposed in the application.[9]

[8] Aries Pine Tree LLC Minor Source Air License Application at 2-10, *In re Aries Pine Tree LLC, Sanford, York County, Air Emission License Application* (A-1195-71-A-N) (Me. Dep't Env't Prot. Jan. 2026) ("Air Permit Application").

[9] Air Permit Application at 2-7 fig. 2-2; Fluidized Bed Biogasifier & Method for Gasifying Biosolids, U.S. Patent No. 9,809,769 B2 (filed Dec. 14, 2015) (issued Nov. 7, 20017); Gasification Reactor with Discrete Reactor Vessel & Grate & Method of Gasification, U.S.

34. Accordingly, Aries' statements that "no combustion occurs" in the gasifier are not accurate.[10]

35. Aries asserts in its air permit application that its sewage-sludge thermal treatment process is not "incineration."[11] Whether or not the process constitutes incineration is not a scientific/technical question, but rather a legal question that turns on the applicable regulatory definition of incineration. "Incineration" is not a commonly used term in the academic combustion literature and is generally defined by the field of application and governing regulations.

36. That said, both the Aries Pine Tree Facility and what is colloquially known as a traditional "solid waste incinerator" treat waste using the same fundamental processes: combustion of a solid fuel followed by emissions control. The primary difference between the design of the Aries Pine Tree Facility and that of a solid waste incinerator that does not include gasification is that the Aries Pine Tree Facility will use staged oxidation in two process steps. First, in the gasifier, the waste reacts with oxygen to produce carbon-rich ash and syngas. This process, as explained above, is a combustion process. Second, the thermal oxidizer combusts the syngas in an excess-oxygen environment (meaning there is more than the stoichiometric amount of air/oxygen), leaving some oxygen in the complete combustion products. In a solid waste incinerator that does not use gasification, there is typically a single oxygen addition rather than

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Patent No. 10,611,973 B2 (filed June 18, 2019) (issued Apr. 7, 2020); Gasification Reactor with Pipe Distributor, U.S. Patent No. 10,696,913 B2 (filed Dec. 20, 2019) (issued June 30, 2020).

[10] *See*, *e.g.*, Aries Clean Techs., *Aries Pine Tree Project – Sanford, ME* 7 (Apr. 2026), https://mrra.net/wp-content/uploads/2026/05/D2_S3_Mark-Lyons_Aries-Sanford-Project-April-2026.pdf.

[11] Air Permit Application at 2-10.

two, combining the gasifier and thermal oxidizer reactions into a single step. Both system designs use combustion processes to reduce waste volume through oxidation.

37. In addition, while Aries is correct that its proposed process does not involve flame combustion, flame is not required for all types of combustion.[12] Further, Aries' proposed process does involve fire. Flame is defined as the rapid, self-sustaining propagation of combustion, typically requiring a reaction front or a well-defined boundary. However, fire is a broader category of combustion that encompasses smoldering, glowing, flames, and combinations of these.[13] The process in the Aries Pine Tree Facility's gasifier involves fire, including smoldering and glowing, emitting light from fuel oxidation.

II. THE ARIES PINE TREE FACILITY'S AIR EMISSIONS WILL BE COMPARABLE TO THOSE OF A SOLID WASTE INCINERATOR THAT DOES NOT USE GASIFICATION

38. The air pollution from the Aries Pine Tree Facility will be substantially the same as the air pollution from a solid waste incinerator that does not use gasification.[14] The gaseous exhaust from the Facility will contain the same primary chemical species as the exhaust from such an incinerator. These include H_2O, CO_2, CO, N_2, O_2, $NO+NO_2$ (NO_x), hydrocarbons (including volatile organic compounds (VOCs)), particulate matter (PM), HCl, and SO_2. The retention of some waste-derived carbon in the ash/char from Aries' proposed gasification process merely lowers the carbon content of the syngas produced in the gasifier but does not alter the chemical species present in the stack exhaust.

[12] *See* Turns, *supra* note 6, at 6.

[13] Douglas Drysdale, *An Introduction to Fire Dynamics* 287–88 (2d ed. 1998).

[14] This discussion does not address air emissions of PFAS, which are discussed in separately filed testimony from Dr. Kyle Doudrick.

39. Aries' application indicates that the overall air-to-fuel ratio, including air injection into the gasifier and the thermal oxidizer, is likely fuel-lean, meaning excess oxygen will be present in the stack exhaust. Aries' application states that the O_2 concentration in the stack exhaust will be 12.1%, which indicates lean operation.[15] Solid waste incineration facilities that do not use gasification also operate fuel lean. Therefore, the profile of uncontrolled pollutants emitted from those facilities and from the Aries Facility will be comparable.

40. The ash produced by the Facility will contain the same non-combustible materials as the ash produced by a solid waste incinerator that does not use gasification, except that it will also include uncombusted carbon, which is referred to as "char" in the applications.

III. ARIES HAS NOT DISCLOSED THE HEAT INPUT CAPACITY OF ITS FUEL-BURNING EQUIPMENT

41. Aries has not provided the heat input capacity of all fuel-burning equipment at the Facility.

42. Regarding the fuel-burning equipment required for normal operations (excluding the emergency generator and building heaters), Aries' air permit application estimates the combined heat input capacity of the gasifier startup burner and the natural gas burner for the thermal oxidizer at 54 MMBtu/hr.[16] Although the application provides sufficient information to estimate the biosolids thermal input capacity of the gasifier, it does not explicitly specify a consistent maximum biosolids heat input based on moisture content and heating value. The application also does not specify the maximum heat input capacity of the thermal oxidizer, which will combust syngas generated in the gasifier in addition to natural gas.

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[15] Emission Calculations at 12, Attachment F to Aries Pine Tree LLC Minor Source Air License Application, *In re Aries Pine Tree LLC, Sanford, York County, Air Emission License Application* (A-1195-71-A-N) (Me. Dep't Env't Prot. Jan. 2026) ("Air Permit Application Attachment F").

[16] Air Permit Application at 2-11.

IV. ARIES' ESTIMATES OF THE FACILITY'S EMISSIONS OF REGULATED POLLUTANTS ARE INADEQUATELY SUBSTANTIATED AND INCOMPLETE

43. Attachment F to Aries' air permit application provides estimates of the Facility's uncontrolled emissions (from the thermal oxidizer) and controlled emissions (after assumed emissions control equipment). However, it is impossible to determine whether these estimates are accurate because insufficient information is provided to validate them.

44. For example, Attachment F at page 4 provides estimated emissions of criteria pollutants with few references. The document asserts without elaboration or documentation that NO_x emissions estimates were generated with an Aspen model and that PM, CO, and SO_2 emissions were "modeled by Aries in Jan-2026."[17] The application cites references for VOC, HCl, HF, metals, ammonia, and dioxin/furan estimates.[18] However, the cited materials are not provided with the application, and there is no justification provided for how the referenced emissions and calculations adequately represent the Facility. As a result, it is not possible to validate the accuracy of any of the estimates presented. The spreadsheet, computer code, and Aspen model used to generate the data for the dryer, gasifier, and thermal oxidizer are all available to Aries and should be disclosed, including mass and energy balances at the inlets and outlets of process equipment.

45. Similarly, Aries assumes that the Aries Pine Tree Facility's uncontrolled ammonia slip (the unreacted ammonia that passes through the Facility's emissions control system) will be 10 parts per million (ppm) on a 15% O_2 basis but provides no reference to support this.[19] Ammonia is injected prior to the selective catalytic reduction system. The quantity of ammonia

[17] Air Permit Application Attachment F at 4.

[18] *See id.* at 4–5.

[19] *Id.* at 5.

injected must match the amount of NO_x in the thermal oxidizer exhaust. If ammonia injection is too low, NO_x will be high in the stack; conversely, if ammonia injection is too high, ammonia slip will increase.

46. Aries also fails to provide references for the gasifier removal efficiencies provided for metals and other compounds in Attachment F at page 5. Moreover, Aries estimates that the removal efficiencies for most compounds will be identical (96.7%), which is atypical because metals have different melting points and physical properties. It is unlikely they will be converted in the gasifier at the same rate, and this assumption requires validation.

47. The same is true for Aries' estimates of the air pollution control equipment removal efficiencies. Here, too, Aries makes the atypical assumption that removal efficiencies will be identical for most compounds, without any references.[20]

48. Additional information about the emissions control system for the Facility is needed to validate Aries' estimated control efficiencies, beyond the presentation slides in Attachment I to the air permit application. If Tri-Mer Corporation is providing the 3-in-1 emissions system to Aries, the manufacturer's sizing and modeling information for the specific plant is required to verify that the conversion efficiencies listed in Attachment F are valid. If other vendors are being used to provide the emissions control equipment, sizing and modeling information from those vendors is also needed.

49. In addition, Aries relies on selected test results from similar facilities operated by Aries or its predecessor companies to support assertions in its application without providing the full results, such as a Florida MaxWest Stack Test Report and Florida MaxWest Stack Test

[20] *See id.* at 5.

Report Acid Gas Correction Letter.[21] The underlying data are essential to validate the assertions made and provide a comprehensive picture of the performance of the same or similar technology at these other facilities.

50. Aries also omits relevant information regarding testing conducted at its Linden, New Jersey facility. Records obtained from the New Jersey Department of Environmental Protection indicate that Aries attempted to conduct a standard stack test, known as an OS7, at the Linden facility in 2024 but was unable to keep the gasifier running long enough to complete the test. According to a memorandum from Aries to the New Jersey agency, the "longest steady-state run" Aries ever achieved at the Linden facility was "slightly over six (6) hours," which is too short to complete standard stack testing.[22] The memorandum further explains that Aries was unable to complete the mandated OS7 testing because of "build-up of material in the heat recovery exchangers, which limited run-time to 8–12 hours followed by approximately 5 days of shutdown, cleanout, and restart."[23] Since the heat recovery exchangers are located after the thermal oxidizer in Aries' design, this suggests there may have been higher-than-expected emissions of tar and other particulate matter from the oxidizer during gasifier operation, which may indicate that the thermal oxidizer was not properly designed to combust all of the tar from the gasifier and/or that the cyclone separator between the gasifier and thermal oxidizer was not sufficient to eliminate ash particulate from the gas, which then made it to the first heat recovery unit. The only stack test Aries was able to complete during that testing campaign was conducted

[21] *See*, *e.g.*, *id.* at 12.

[22] Memorandum from Aries Clean Techs. LLC, to NJDEP, Re: Aries Emission Testing Limitations for Linden Sludge Processing Plant in Linden, New Jersey, at 3 (last accessed Oct. 22, 2026) ("Linden Emission Testing Limits"). This memorandum was obtained from the New Jersey Department of Environmental Protection website.

[23] *Id*.

with the gasifier off, and at a substantially reduced production rate, so it is not a realistic reflection of the system under operational conditions.[24]

51. In addition to raising concerns about the magnitude of the facility's uncontrolled particulate matter emissions and Aries' inability to maintain steady-state operations for more than a few hours, these records suggest there may be no stack test results available from Aries' only commercial-scale sludge gasification facility in Linden, New Jersey (beyond the PFAS stack test results included with the pending air permit application as Attachment H) to validate the emissions estimates in the pending air permit application. This makes it even more critical for Aries to provide the information necessary to validate the modeling results used to estimate emissions from the Aries Pine Tree Facility in its pending application.

52. Furthermore, to the extent that Aries discloses the assumptions incorporated into its emissions estimates, they reflect a mix of best-case, average, and purportedly worst-case assumptions that is inconsistent and lacks justification. For example, to estimate controlled SO_2 emissions, Aries assumes a purported "worst-case" sulfur content of 1.89% in the sludge feedstock.[25] Aries assumes a solids input rate to the gasifier of 8361.1 lb/hr,[26] but the application does not state whether that feed rate is the average, maximum, design value, or something else. Further, to determine the stack emissions rate of SO_2, the application uses a conversion efficiency of 96%.[27] But it is not clear from the application whether this is a best-case conversion scenario or whether the dry sorbent system can consistently achieve this performance. In other

[24] Montrose Air Quality Servs., Compliance Test Report, Sewage Sludge Fluidized Bed Gasifier, Aries Clean Technologies LLC – Aries Linden Sludge Processing Plant (Oct. 30, 2024). This report was obtained from the New Jersey Department of Environmental Protection website.

[25] Air Permit Application at 2-3, 3-3.

[26] Air Permit Application Attachment F at 4.

[27] Air Permit Application at 3-4.

cases, the application does not indicate whether assumptions regarding pollutant formation or destruction reflect average, best-, or worst-case estimates.

53. It is not clear from the application whether estimates of uncontrolled emissions of NO_x, PM, HCl, CO, and VOC used in Attachment F are worst-case emissions. Nor is it clear whether the rates are estimates of average hourly emissions from the plant. Aries does not adequately demonstrate that these five uncontrolled emissions rates represent maximum hourly loadings accounting for the expected feedstock and operating conditions of the Facility.

54. In addition, there are multiple sources of potential emissions at the Facility that are not accounted for in Aries' emissions estimates. For example, Aries' air permit application states that exhaust from the sludge receiving building that exceeds the capacity of the thermal oxidizer will be sent to a carbon adsorption system,[28] and that the full exhaust flow from the receiving building will be sent to a carbon adsorption system "[i]f the thermal oxidizer is down."[29] The receiving building exhaust could be a significant source of sulfur compounds, VOC, and other organic pollutants. However, the application does not include the exhaust flow, operating hours, carbon bed size, or abatement rate for the carbon adsorption system nor an estimate of the resulting emissions under either scenario.

55. Relatedly, the application does not describe where residual syngas from the gasifier will be sent if the thermal oxidizer is down, which is another potential source of emissions not estimated. Moreover, the process flow diagram provided in Attachment M to Aries' air permit application does not show an emergency vent for syngas between the gasifier and the thermal oxidizer. If the thermal oxidizer shuts down and syngas is sent through the

[28] *Id.* at 2-1.

[29] *Id*.

emissions control system, it could cause significant damage to the system. For example, tar is likely to foul the heat recovery unit before the Tri-Mer system, and H_2S would not be converted to SO_2 without the thermal oxidizer working. H_2S is well known to poison selective catalytic reduction ("SCR") catalysts.

56. Aries has also not provided estimates of emissions during start-up, shutdown, maintenance, or malfunction events, except for emissions from the natural gas burners used to start up the gasifier and thermal oxidizer. All unit operations within the Aries Facility are vulnerable to malfunction and emergency shutdown. For example, if the drying system cannot remove sufficient water from the incoming waste, the gasifier will not be able to operate at its design temperature, and the rest of the Facility will be compromised. The emissions control system is also vulnerable to malfunction, especially if adequate monitoring is not in place. Maintenance of Facility components such as air pollution control equipment can also cause emissions spikes, such as during regeneration of the PM filter via pulse cleaning. To ensure the accuracy of Aries' emissions estimates, it is critical for Aries to disclose its standard operating procedures for startup, planned and unplanned shutdowns, and maintenance; estimate the emissions associated with those events; and provide the calculations and data supporting those estimates.

57. Aries also fails to estimate fugitive emissions of regulated pollutants. Leakage from process units and piping can lead to fugitive emissions in any plant. Hydrogen-containing streams, such as those in the cyclone separator and in the plumbing from the gasifier to the thermal oxidizer, are especially susceptible to leakage when at pressures above atmospheric.

V. ARIES HAS NOT PROPOSED SUFFICIENT OPERATIONAL, TESTING, MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS TO ENSURE VERIFIABLE COMPLIANCE WITH ITS PROPOSED EMISSIONS LIMITS

58. The emissions control system that Aries proposes relies on a combination of the thermal oxidizer (to control CO, VOC, PFAS, and other organic compounds) and the Tri-Mer system (to control SO_2, HF, HCl, NO_x, and PM). These emissions control technologies are not passive and require active control and maintenance to achieve and maintain the proposed levels of emissions reduction.

59. To ensure that these systems are operating correctly and that Aries complies with its proposed hourly emissions limits for SO_2, NO_x, PM, HCl, CO, and VOC, Aries proposes biennial stack testing, maintaining a minimum thermal oxidizer temperature of 1800°F for CO and VOC destruction, maintaining certain operational parameters for the Tri-Mer system within the manufacturer's specified ranges, and complying with certain operational requirements for natural gas burning equipment.[30]

60. The proposed measures are not sufficient to ensure continuous, verifiable compliance with the Facility's proposed emissions limits. At the outset, the control logic for Aries' emissions control system, including which measurements will be used as feedback to maintain the emissions at the proposed rates, and the fail-safe/interlock logic for the control equipment (e.g., what happens if the ammonia injection system stops injecting), is not clear from the application.

[30] Air Permit Application at 5-1 to 5-3; Supplemental Best Available Control Technology (BACT) Analysis at 6, 8, *In re Aries Pine Tree LLC, Sanford, York County, Air Emission License Application* (A-1195-71-A-N) (Me. Dep't Env't Prot. Sept. 15, 2026) ("Suppl. BACT Analysis").

61. Further, the proposed combination of biennial stack testing and continuous monitoring of certain operational parameters is insufficient to ensure compliance with the proposed hourly emissions limits. Stack testing can show whether the Facility is capable of meeting its design operating conditions and permitted emissions once every two years; it will not show whether the Facility is continuously operating under design conditions and complying with its permitted emissions limits. Relying on biennial stack testing as the only method of emissions measurement means that lengthy periods of noncompliance and excess emissions could go undetected by Aries and DEP and fail to generate records of their extent and duration. Further, it is possible that these lengthy periods of noncompliance may not result in any equipment failure in the plant and could even save Aries operational costs (e.g., if it does not inject ammonia for a period of time), meaning Aries may lack incentives to take prompt corrective action in the absence of sufficient compliance monitoring.

62. Continuous parametric monitoring is necessary to ensure that the Facility operates safely and promptly alert Aries to operational issues that require correction to avoid damage to Facility components and/or excess emissions. As described below, additional parametric monitoring beyond what Aries proposes is both feasible and necessary to meet these objectives. But parametric monitoring and biennial stack testing alone are not adequate to ensure that the Facility maintains compliance with its proposed emissions limits; as described below, continuous emissions monitoring ("CEMS") is necessary to accomplish that.

63. Having continuous parametric monitoring would inform Aries and DEP that the Facility is operating at the correct flow rate or temperature, for example, but it is not sufficient to verify that the plant is complying with its emission limits, as it remains possible that the emissions control technology is not functioning correctly. For example, in the SCR, ammonia

flow and exit temperature may be within range, but the ammonia-to-incoming-NO_x ratio may be incorrect, which would make NO_x conversion less effective and increase emissions.

64. Furthermore, as described above, the Facility's emissions-generating and emissions-control equipment are vulnerable to malfunctions and unplanned shutdowns that can cause short-term spikes in emissions. For example, if the thermal oxidizer experiences an unplanned shutdown and the gasifier exhaust is vented directly to the atmosphere or sent to an undersized or already-loaded carbon filter, producer gas containing CO, H_2, HCl, sulfur compounds, PFAS, and other pollutants would be released uncontrolled into the environment. However, this may occur on a relatively short time scale, so it would not significantly affect the annual emissions inventory. Emissions spikes also can occur as a result of planned maintenance activities, as noted above.

65. Moreover, Aries' operations will have to be carefully controlled to balance NO_x and PFAS emissions, which are inherently in tension. Maintaining high temperatures in the thermal oxidizer is essential for the destruction of PFAS but will generate higher NO_x emissions.[31] To ensure that Aries does not favor one destruction process over another and maintains compliance with both NO_x and PFAS emissions limits, additional parametric monitoring and CEMS will be required.

66. Accordingly, continuous monitoring (i.e., CEMS) and permit requirements for recording and reporting of CEMS data are necessary for NO_x, SO_2, and HCl in order to demonstrate compliance with the proposed hourly limits for those pollutants. Continuous opacity monitoring also is necessary and feasible to indirectly demonstrate compliance with Aries'

[31] *See* Supp. BACT Analysis at 9 (acknowledging that "[i]ncreasing oxidizer temperature . . . would have . . . environmental impacts (e.g., NOx formation)").

hourly limit for PM. Opacity is an indicator of PM, especially dust and carbonaceous particles, and can be continuously monitored with CEMS.

67. CEMS also are necessary for CO and O_2. Continuous monitoring of CO is necessary to understand the control effectiveness of the thermal oxidizer and is a better metric than temperature alone. Rising CO would indicate reduced destruction of PFAS and VOCs. Continuous monitoring of O_2 is necessary to monitor dilution of the stack exhaust. Most CEMS readouts need to be corrected for dilution (typically to 7% O_2). For example, if the Facility were continuously measuring CO emissions without accounting for dilution, the CO concentration could be made to appear lower through the addition of extra air.

68. If DEP does not require CEMS for SO_2 and HCl, it should at a minimum require Aries to provide better evidence linking lime injection rate and conversion across a range of conditions for the exact configuration and linking reported parametric monitoring variables to SO_2 and HCl compliance.

69. CEMS are required by Aries' permit for its Linden facility,[32] and there is no reason they should not be required for the Aries Pine Tree Facility. CEMS are also required at other facilities that combust sewage sludge, including the Upper Blackstone Clean Water Facility in Millbury, Massachusetts[33]; the Delcora facility in Chester, Pennsylvania[34]; and the Warren Waste Water Treatment Plant in Warren, Michigan.[35]

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[32] N.J. Dep't of Env't Prot., Air Pollution Control Preconstruction Permit and Certificate to Operate, Revision for Aries Linden Sludge Processing Plant, at 26 (Jan. 22, 2018).

[33] Mass. Dep't of Env't Prot., Final Air Quality Operating Permit for Upper Blackstone Water Pollution Abatement District, at 8 (last accessed Oct. 23, 2026).

[34] Pa. Dep't of Env't Prot., Title V/State Operating Permit for Delaware Cnty Reg WA/Delcora Western Reg Trmt Plt, at 53 (Dec. 30, 2025).

[35] Mich. Dep't of Env't, Great Lakes, & Energy, Permit to Install for Warren Waste Water Treatment Plant, at 19 (Oct. 22, 2024).

70. Aries proposes monitoring several operational parameters, including ammonia injection rate, lime injection rate, inlet O_2 at the thermal oxidizer, exhaust temperature at the thermal oxidizer, exhaust temperature at the ceramic filter system, and pressure drop at the ceramic filter system. However, they do not propose recording or reporting these parameters to DEP at any interval. The data generated from emissions testing and continuous emissions or parametric monitoring have value only if Aries is required to record the data at appropriate increments and provide it periodically to DEP. In addition to CEMS, DEP should require parametric monitoring, recording, and reporting of the parameters proposed by Aries, along with other parameters described below, as this is both feasible and essential to ensure the safe and compliant operation of the Facility.

71. For the thermal oxidizer, Aries proposes monitoring the oxygen concentration (using an oxygen sensor) and the thermal oxidizer exit temperature. This is not sufficient to guarantee consistent destruction effectiveness. The thermal oxidizer exit temperature may not be representative of the maximum or average spatial temperature within the combustor. Since Aries does not provide the design for the thermal oxidizer in the application, it is not possible to verify whether exit temperature monitoring is sufficient for this purpose. Combustion temperature and exhaust oxygen concentration are used to control airflow and burner gas flow (beyond the constant 3 MMBtu/hr pilot). Combustion temperature measured inside the thermal oxidizer and airflow should be monitored and recorded. Continuous measurement of total gas or stack flow is also necessary to determine that residence time does not fall below the design value.

72. Further, Aries proposes to record the thermal oxidizer exit temperature continuously in one-hour averages, which will not capture transient conditions within the thermal

oxidizer. It is entirely feasible with modern digital technology for Aries to store and report plant data at a higher sampling rate, and DEP should require that it do so.

73. Aries proposes monitoring the pressure drop across the ceramic filter. DEP should require monitoring, recording, and reporting of the pressure drop across both the ceramic and activated carbon filters to ensure that fouling or breakthrough is not occurring and to indicate whether/when the filters are being overloaded.

74. Aries also proposes that it be required to operate the Tri-Mer system within the manufacturer's specified ranges for ammonia injection rate at the SCR, lime injection rate at the dry sorbent injection system, exhaust temperature at the ceramic filter, and pressure drop at the ceramic filter, but it does not disclose what any of those ranges are.[36] DEP should require Aries to provide this information, which is essential to determine which injection ranges (ammonia and lime) are needed to control NO_x, HCl, SO_2, and HF.

75. As part of the permitting process, DEP should determine an appropriate data sampling rate, record retention period, averaging method, and reporting mechanism to assess Aries' compliance with its permitted emissions limits. DEP should specify in the permit that all continuous monitoring, recording, and reporting of emissions and operational parameters is required during startup, shutdown, maintenance, and malfunction events so excess emissions that may occur during these events are documented.

VI. ARIES HAS NOT DEMONSTRATED THE TECHNICAL ABILITY TO CONSTRUCT AND OPERATE THE FACILITY IN A MANNER THAT WILL CONSISTENTLY ACHIEVE ARIES' PROPOSED EMISSIONS RATES

76. Aries has demonstrated, through its previous projects, that it understands the design and operational parameters necessary to operate the Facility in a manner that meets its

[36] Air Permit Application at 5-1.

proposed emissions rates. However, its operational history, including at its Linden, New Jersey plant, shows that it has yet to consistently and reliably operate a waste gasification system that meets its performance and emissions targets. Indeed, as discussed above, records from the Linden facility indicate that Aries could maintain steady-state operations for only about six hours.[37] Even if previous unit operations, including the dryer, gasifier, thermal oxidizer, emissions control, or heat recovery, functioned during individual tests, Aries has not demonstrated the ability to dry and handle solids, recover heat, and control emissions over a sufficient time to claim that it has the ability to operate the Facility in a manner that consistently meets its proposed emissions rates.

77. Aries should demonstrate that the plant has adequate redundancy in its dryer capacity. It has proposed adding a third dryer compared to its Linden plant, but the three dryers at 150 wet-ton/day capacity can process only the 450 wet-ton/day Facility capacity and do not provide any redundancy should one fail.

78. Aries has not sufficiently demonstrated that it can adequately protect heat recovery equipment from fouling. It has indicated that its Linden plant suffered from heat recovery system fouling caused by solids from the gasifier, a problem it proposes to solve with a cyclone separator and filter. It should provide design specifications and specific locations for this equipment.

79. In addition, Aries omits portions of the Barr PFAS stack test report that are relevant to evaluating Aries' technical ability to operate a biosolids gasification plant. In Attachment H of the application at page 4, the Barr PFAS report states: "A review of the process operating data in Appendix E shows production of a richer syngas from the gasifier with

[37] Linden Emission Testing Limits, *supra* note 22, at 3.

increased concentrations of hydrogen, methane and carbon monoxide during test run 3." This indicates that the Barr report appendices include data on the composition of the syngas, operating parameters for the facility, and potentially emissions of non-PFAS pollutants. However, the application omits the process-data appendix referenced by Barr. Therefore, the detailed operating conditions underlying the reported performance cannot be independently evaluated from the application. The complete Barr report including the operating data should be provided to establish Aries' ability to operate the Facility in a manner that meets its proposed emissions rates.

I affirm that, to the best of my knowledge and belief, the foregoing is true and correct.

Dated: November 12, 2026
Minneapolis, MN



EXHIBIT A

Will Northrop – Curriculum Vitae

L.M. Fingerson/TSI Incorporated Professor
Department of Mechanical Engineering
University of Minnesota
111 Church St. SE
Minneapolis, MN, 55540
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PROFESSIONAL APPOINTMENTS

Department of Mechanical Engineering – University of Minnesota
- Leroy M Fingerson/TSI Incorporated Chair in Mechanical Engineering — 2025-present
- Professor — 2022-present
- Director, Thomas E Murphy Engine Research Laboratory — 2017-present
- Director of Undergraduate Studies in Mechanical Engineering Department — 2020-2022
- Engineering Co-op Program Director — 2021
- Associate Professor — 2017-2022
- Richard and Barbara Nelson Assistant Professor — 2011-2017

Aza Power Systems, LLC
- Co-Founder, Senior Technical Advisor — 2021-present

Exergi Predictive, LLC
- Co-Founder, Chief Executive Officer/Chief Technology Officer — 2020-present

General Motors Research and Development, Warren, MI
- Senior Researcher, Propulsion Systems Research Lab — 2010-2011
- Postdoctoral Visiting Researcher, Propulsion Systems Research Lab — 2009-2010

Department of Mechanical Engineering – University of Michigan - Ann Arbor
- Graduate Research Assistant — 2006-2009

Department of Chemical Engineering – University of Michigan - Ann Arbor
- Graduate Research Assistant — 2003-2005

Nuvera Fuel Cells, Cambridge, MA
- Lead Research Mechanical Engineer — 1998-2003

Chrysler Corporation, Auburn Hills, MI
- Chrysler Institute of Engineering Candidate, Vehicle Platform Engineering — 1997-1998

EDUCATION

Ph.D. Mechanical Engineering, University of Michigan - Ann Arbor — 2009
Dissertation: *Particulate and gas-phase hydrocarbon emissions from partially premixed low temperature compression ignition combustion of biodiesel*

M.S. Mechanical Engineering, University of Michigan - Ann Arbor — 2005
Thesis: *Heat integration strategy for a natural gas fuel processor for PEM fuel cell applications*

B.S. Mechanical Engineering, Carnegie Mellon University — 1997

HONORS AND AWARDS

University of Minnesota

Leroy M Fingerson/TSI Incorporated Endowed Chair	2025
Robert C. Johns Research Partnership Award	2021
McKnight Land Grant Professorship	2015
Center for Transportation Studies Scholar	2013

External Sources

Society of Automotive Engineers Fellow	2025
American Society of Mechanical Engineers Fellow	2024
Fulbright Scholars Award, Spain	2019
SAE Engineering Events Outstanding Oral Presentation Award	2019
Society of Automotive Engineers, Harry L. Horning Award	2018
Society of Automotive Engineers, Ralph Teetor Award	2016
Society of Automotive Engineers, Forest McFarland Award	2016
NSF CAREER Award, Combustion Fire and Plasma Systems	2014
Engineering Graduate Symposium Competition 1st Prize, University of Michigan	2008

Visiting Scholar Positions

Fulbright Scholar, *Centro Universitario de la Defensa, Marin Spain/ Universidad de Vigo, Vigo Spain* — September 2019 – December 2019
Topic: Teaching advanced thermodynamics and research in particulate emissions from biomass combustion.

Visiting Scholar, *Sandia National Laboratory, Combustion Research Facility* — Feb 2015 – April 2015
Topic: Diagnostics of in-cylinder reforming during the negative valve overlap period in low temperature gasoline combustion regimes.

PUBLICATIONS

Summary

Google Scholar – Citations: 2818, h-index: 28

Web of Science – Citations: 1473, h-index: 21

Refereed Journal Publications

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5. Halder, A., Goertemiller, C., Hoxie, A., & Northrop, W. F. (2026). Experimental investigation of a 20 kW atmospheric pressure pure ammonia jet-swirl burner. *Proceedings of the Combustion Institute*, *42*, 106019. https://doi.org/10.1016/j.proci.2026.106019
6. Patil, T. S., Goertemiller, C. F., & Northrop, W. F. (2026). Ammonium nitrate Particle formation from laminar premixed ammonia/hydrogen/air flames. *Proceedings of the Combustion Institute*, *42*, 106147. https://doi.org/10.1016/j.proci.2026.106147
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8. Chen, W., Bock, N., Northrop, W., & Kittelson, D. (2025). Influence of Combustion Strategy and Fuel Ethanol Content on Effective Density, Concentration, and Size of Particles Emitted by a Lean Burn Gasoline Direct Injection Engine. *Emission Control Science and Technology*, 11(2), 29. https://doi.org/10.1007/s40825-025-00276-5
9. Voris, A., Kane, S., Wuthrich, S., Reggeti, S., Okey, N., Herrmann, K., & Northrop, W. F. (2025). Full Operational Map of a Spark-Ignited Medium-Duty Single-Cylinder 100% Ammonia-Fueled Engine. *International Journal of Engine Research*, 14680874251353321. https://doi.org/10.1177/146808742513533
10. Challa, D. R., Eagon, M. J., & Northrop, W. F. (2025). The Influence of Snowfall on Fuel Consumption of Winter Maintenance Vehicles. T*ransportation Research Part D: Transport and Environment*, 139, 104543. https://doi.org/10.1016/j.trd.2024.104543
11. Yang, M., Jayaprakash, B., Ghosh, S., Jung, H. T., Eagon, M., Northrop, W. F., and Shekhar, S. (2025). Climate-smart computing: A perspective. *Pervasive and Mobile Computing*, *108*, 102019. https://doi.org/10.1016/j.pmcj.2025.102019
12. Patil, T. S., Voris, A. R., Kane, S. P., and Northrop, W. F. (2025). Ammonium nitrate nanoparticle emissions from ammonia-fueled internal combustion engines. *Journal of Aerosol Science*, 106614. https://doi.org/10.1016/j.jaerosci.2025.106614
13. Sforza, L., Reggeti, S., Nodi, A., Ramognino, F., Stagni, A., Lucchini, T., and Northrop, W.F. (2025). Impact of hydrogen injection strategies on ammonia internal combustion engines ignited with active pre-chambers. *Fuel*, *388*, 134414. https://doi.org/10.1016/j.fuel.2025.134414
14. Patil, T., Reggeti, S., Kane, S. P., & Northrop, W. F. (2025). Experimental investigation of particulate emissions from an ammonia-fueled internal combustion engine. *Journal of Engineering for Gas Turbines and Power*, *147*(10), 101014. https://doi.org/10.1115/1.4068030
15. Dhotre, A., Voris, A., Okey, N., Kane, S., & Northrop, W. (2025). Comparison of Spark and Turbulent Jet Ignition in a Fully Ammonia-Fueled Engine. *SAE International Journal of Advances and Current Practices in Mobility 361994*, *8*(1), 73-83. doi:10.4271/2025-01-0201.
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18. Northrop, W.F. (2024) Modeling nitrogen species from ammonia reciprocating engine combustion in temperature-equivalence ratio space. *Applications in Energy and Combustion Science*, 100245.
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22. Kane, S.P., and Northrop, W.F. (2023) A Quasi-Dimensional Model of Heat Transfer between Multi-Concentric Monolith Structures. *Thermo,* 3(4): 515-536. https://doi.org/10.3390/thermo3040031.
23. Reggeti, S.A., Kane, S.P., and Northrop W.F. (2023) Hydrogen Production in Ammonia-Fueled Spark Ignition Engines, *Applications in Energy and Combustion Science*, 14, 100136, https://doi.org/10.1016/j.jaecs.2023.100136.
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42. Tripathi, A., Dasrath, D. Sun, Z., Northrop W.F., Kittelson, D., and Stelson, K.A. (2019) Design and Control of a Controlled Trajectory Rapid Compression and Expansion Machine, *IEEE/ASME Transactions on Mechatronics*, 24(4), 1711-1722, https://doi.org/0.1109/TMECH2019.2917820.

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4. "From Fertilizer to Fuel: Can 'Green' Ammonia Be a Climate Fix?" (January, 2022) Yale Environment 360, https://e360.yale.edu/features/from-fertilizer-to-fuel-can-green-ammonia-be-a-climate-fix
5. "Ethanol's Role in Electric Vehicles", (January, 2021) MN Corn Growers Association (https://www.youtube.com/watch?v=VL5LkJccfmQ)
6. "Can Fertilizer Fuel Greener Tractors?", (June, 2019) Dan Gundersen, MPR News Story (https://www.mprnews.org/story/2019/06/19/can-fertilizer-fuel-greener-tractors)
7. "University of Minnesota demonstrates efficient ammonia dual-fuel engine system" (2019) Trevor Brown, Ammonia Energy Association. https://www.ammoniaenergy.org/articles/university-of-minnesota-demonstrates-efficient-ammonia-dual-fuel-engine-system/
8. "UMN researchers look to tune up UPS trucks" (2017) Heidi Wigdahl, Kare 11 News, https://www.kare11.com/article/news/umn-researchers-look-to-tune-up-ups-trucks/89-490699544

INVITED LECTURES/SYMPOSIA/PANELS

Invited Panels, Webinars, and Workshops:

1. Panel: Advancing Powertrains and Electronics for Current/Future Military Ground Vehicles, Military Ground Vehicle Systems Summit, November 14, 2025.
2. Webinar: Experimental Research Activities in Internal Combustion Engines Operating with Ammonia and Hydrogen Fuel Blends, NETL Ammonia Combustion Technology Group Meeting, May 6, 2025.
3. Panel: Future Fuels: Electrification Opportunities in Queensland, *RACQ/QUT/UQ Electric Transport Industry Forum*, Brisbane, Queensland, Australia, March 17, 2023.
4. Panel: Opportunities in Green Ammonia Fueling of Internal Combustion Engines. *SAE 2022 Sustainable Low Impact Combustion Engine Symposium (SLICES), WCX,* Detroit, MI, April 14, 2022.

5. Webinar: Engineering Workforce – Educating for the EV and AV Industry, *ASME Monthly Webinar Series*, May 9, 2022.
6. Webinar: Decarbonizing Engines using Green Ammonia and e-Fuels, *ASME IC Engines Division Webinar Series*, *The Future of the Internal Combustion Engine*, April 13, 2022.
7. Panel: Connectivity and Data-Science for Advancing Electrified Commercial Vehicles, CV502: Electrified Powertrains Panel, *SAE COMVEC Conference*, Virtual, September 15, 2020.
8. Workshop: Funding Collaborative Cross-Atlantic Research Projects in Science and Engineering, *Fulbright Research Seminar*, Madrid, Spain, November 2019.
9. 3rd RCM Workshop, *36th International Symposium on Combustion*, Seoul, South Korea, August 2016.
10. ARPA-E Powertrain Innovations Workshop, *ARPA-E*, Denver, CO, May 14, 2015.
11. Technical Expert Panel Discussion: Current Understanding of Particulate Matter from Low Temperature Combustion Modes, *SAE World Congress*, Detroit, MI, April 21, 2015.
12. Panel: A Voyage through Combustion, *Combustion Institute National Meeting*, Cincinnati, OH, May 19, 2015.
13. Workshop: Grand Challenges in Combustion and Reacting Flows, *NSF*, Palo Alto, CA, July 31, 2014.

Invited Lectures

1. Plenary Talk: Ammonium Nitrate Nanoparticle Emissions from Ammonia Combustion in Engines and Burners, *Symposium on Ammonia Energy*, September 30, 2026.
2. Renewable E-Fuels Including Green Ammonia: Focus on Minnesota, *MN Renewable Energy Roundtable*, St. Cloud, MN, December 6, 2023.
3. State of Research in Ammonia Combustion for Industrial Applications, *Ammonia Safety Management and Utilization Seminar*, Seoul, Korea, November 29, 2023.
4. E-Fuels and Renewable Fuels, *MN Industrial Decarbonization Summit*, Minneapolis, MN, November 1, 2023.
5. Green Ammonia Combustion: Emissions and Advanced Ignition Concepts, *Combustion Webinar Series*, October 6, 2023.
6. Ammonia as a Fuel for Internal Combustion Engines; Advanced Combustion Modes and Emissions Challenges, *ASPACC Workshop*, Virtual, May 16, 2023
7. Opportunities in Green Ammonia Fueling of Internal Combustion Engines, *John Deere Corporation APSE Presentation Series*, Cedar Falls, IA, June 3, 2022.
8. Physics-Guided Machine Learning for Engines and Vehicles, *TPSRG Seminar Series*, Oxford University, Virtual, March 14, 2022.
9. Connected Commercial Electric Vehicle Research, *SAE Twin Cities Section presentation*, November 16, 2021.
10. Post-Pandemic Transportation Trends: Vehicle Technology, *Minnesota State Legislature Transportation Subcommittee*. January 19, 2021.
11. Vehicle Powertrain and Routing Co-Optimization for Energy Management of Electrified Vehicles, *Minnesota Freight Advisory Council (MFAC) Annual Meeting*, Minneapolis, MN, March 27, 2020.
12. Catalytic Fuel Pretreatment Reactors for Improving Thermal Efficiency and Enabling Alternative Fuel Use in Internal Combustion Engines, *Johnson Matthey Research and Development Invited Seminar*, Sonning, United Kingdom, November 12, 2019.

13. Vehicle Powertrain and Routing Co-Optimization for Energy Management of Electrified Vehicles, *UMN Center for Transportation Studies Executive Committee Meeting*, Minneapolis, MN, May 9, 2019.
14. Gasoline Direct Injection Engine Solid Nanoparticle Emissions: Linkage Between Number and Mass Measurements to In-Cylinder Diagnostics, *U.S. Department of Energy ACEC Meeting*, Southfield, MI, March 7, 2019.
15. Vehicle Powertrain and Routing Co-Optimization Research Overview, *ITS Minnesota Annual Meeting*, St. Paul, MN, December 6, 2018.
16. Thermochemical Recuperation for Dual Fuel Off-Highway Engines, *CCEFP Summit*, Minneapolis, MN, October 17, 2018.
17. Vehicle-to-Cloud Connectivity to Enhance Utility of Electrified Fleet Vehicles, *UMN Center for Transportation Studies Joint Councils Meeting*, Minneapolis, MN, May 3, 2018.
18. Engines and Vehicle Research at University of Minnesota: Focus on Connected Vehicles, *SAE Twin Cities Section presentation*, November 19, 2017.
19. Ammonia Dual Fuel Engine, Project Update, *University of Minnesota Ammonia Forum*, Minneapolis, MN, February 22, 2017.
20. The Potential of Dual Fuel Hydrous Ethanol Strategies to Reduce Engine-Out NO_X and Soot Emissions from Diesel Engines, *John Deere Corporation APSE Presentation Series*, Waterloo, IA, April 4, 2016.
21. Semi-Volatile Nanoparticles from Low Temperature Combustion Modes, *MIT Sloan Automotive Lab Seminar Series,* Cambridge, MA, October 8, 2015.
22. Promising Alternative Fuels for Improving Emissions from Future Vehicles, *Center for Transportation Studies Environment and Energy in Transportation Council,* Minneapolis, MN December 17, 2014.
23. Semi-volatile nanoparticle emissions from low temperature combustion and alternative fuel use in compression ignition engines, *Argonne National Laboratory*, Argonne, IL November 18, 2014.
24. Hydrogen as an Emerging Fuel: Alternative Fuel of the Future? *State of Minnesota Legislative Energy Commission*, St. Paul, MN November 13, 2014.
25. Hydrous Ethanol Programs, *Agricultural Utilization Research Institute Renewable Energy Roundtable*. St. Paul, MN. September 30, 2014.
26. Characterizing Nanoparticle Number Emissions from Modern Engine Combustion using Advanced Measurement Techniques *USCAR/USDRIVE Advanced Combustion Emissions Control (ACEC) Meeting*, Southfield, MI, July 17, 2014.
27. Expanding Hydrous Ethanol Use in Diesel Engines. *Minnesota Corn Growers Association Expanded Uses Panel Discussion*. Shakopee, MN. September 26, 2013.
28. Characterization of Hydrocarbon Volatility from Diesel Low Temperature Combustion. *Oak Ridge National Laboratory*, Oak Ridge, TN, August 8, 2013.
29. Diverse uses of corn-based products in internal combustion engines. *Minnesota Corn Growers Association Expanded Uses Panel Discussion*. Shakopee, MN. November 7, 2013.
30. Opportunities for syngas in internal combustion engines. *Cummins Power Generation Lunch Seminar*. Shoreview, MN. October 9, 2012.

Departmental Seminars

1. Prechamber Ignition and Aftertreatment for Gaseous-Fueled Internal Combustion Engines, Politecnico di Milano, Milan, Italy, May 29, 2026.
2. Anhydrous Ammonia Combustion in Reciprocating Engines and Atmospheric Pressure Burners, University of Michigan Research Seminar, Ann Arbor, MI, March 20, 2025.
3. Experimental Research Activities in Internal Combustion Engines Operating with Ammonia and Hydrogen Fuel Blends, Politecnico di Milano, Milan, Italy, July 19, 2024.
4. Physics-Guided Machine Learning for Solving Critical Transportation Problems, *Ohio State University CAR Research Seminar Series*, Columbus, OH, September 26, 2023.
5. Ammonia as a Fuel for Internal Combustion Engines: Advanced Combustion Modes and Emissions Challenges, *University of Bologna Seminar Series*, Bologna, IT, June 18, 2023.
6. Physics-Guided Machine Learning for Engines and Vehicles, *University of Minnesota Mechanical Engineering Department Graduate Seminar Series*. Minneapolis, MN. March 23, 2022.
7. Internal Combustion Engines and Data Science to Enhance Electrified Vehicles of the Future. *University of Minnesota College of Science and Engineering Golden Medallion Lecture*. Minneapolis, MN. May 9, 2019.
8. Rule-Based Energy Management Strategy for Improving Fuel Economy of Range Extended Hybrid Electric Vehicles, *University of Michigan Energy Institute Seminar*, Ann Arbor, MI, October 10, 2018.
9. Connected Engines and Vehicles: Data-Oriented Approaches for Improving Emissions and Fuel Economy, *University of Iowa Mechanical Engineering Seminar Series*, Iowa City, IA, October 12, 2017.
10. Minimizing the Environmental Impact of Internal Combustion Engines: Nanoparticles, Fuel Reactivity and Connectivity *University of Minnesota Mechanical Engineering Department Graduate Student Seminar Series*. Minneapolis, MN. September 26, 2016.
11. Semi-Volatile Nanoparticle Emissions from Low Temperature Combustion, *Carnegie Mellon University Center for Atmospheric Particle Studies Seminar Series*, Pittsburgh, PA, April 28, 2016.
12. Improving engine emissions and efficiency with premixed compression ignition combustion. *Stony Brook University Mechanical Engineering Seminar Series*, Stony Brook, NY, November 16, 2012.
13. Activities at Center of Diesel Research, University of Minnesota. *Karlsruhe Institute of Technology, Institute for Reciprocating Engines Seminar*, Karlsruhe, Germany, May 11, 2012.
14. Premixed compression ignition: the future of internal combustion engines. *University of Minnesota College of Science and Engineering Golden Medallion Lecture*. Minneapolis, MN. May 4, 2012.
15. Diesel Passenger Cars in the US: Benefits and Roadblocks. *University of Minnesota Mechanical Engineering Department Staff Lunch Seminar*. Minneapolis, MN. December 15, 2011.
16. Improving engine emissions and efficiency with premixed compression ignition combustion. *University of Minnesota Mechanical Engineering Department Graduate Seminar Series*. Minneapolis, MN. November 30, 2011.
17. Unburned hydrocarbon and particulate emissions from premixed low temperature combustion of biodiesel. *University of Minnesota Mechanical Engineering Department Interview Seminar*, Minneapolis, MN. February 11, 2011.

GRANTS AND RESEARCH FUNDING

Grants and Contracts (All Received at the University of Minnesota)

Total grant funding up to summer of 2025:	**$16,515,223**
Direct sponsored research:	$14,046,915
Indirect to university:	$2,672,249
Non-sponsored funding:	$2,468,308

Current

1. Minnesota Department of Transportation, Quantifying the Influence of Driver Behavior on Greenhouse Gas Emissions and Air Quality, $208,290
2. Centerpoint Energy NGIA (PI), Green Ammonia in Industrial-Scale Burner Applications, $200,212

Completed

1. NSF, III Medium: Investigating Spatial-Temporal Informatics for Transportation Science (Co-PI), $849,893, (Northrop Share)
2. Minnesota Corn Research & Promotion Council (PI), Modeling Production of Sustainable Aircraft Fuel from Corn Ethanol and CO_2, $271,838
3. Stellantis, Electrochemical Marine Carbon Capture and Conversion to Fixed Carbon Materials – Phase 1: Technoeconomic Analysis, $102,385
4. Minnesota Corn Research & Promotion Council (PI), Technoeconomic Analysis of Carbon Dioxide-to-Fuel in Corn Ethanol Plants, $149,951
5. DOE Vehicle Technologies Office (PI), Plasma-Assisted Pre-Chamber Ignition System for Highly Dilute Stoichiometric Heavy-Duty Natural Gas Engines, $1,740,164
6. Aramco Services (PI), Mechanisms Associated with Soot and Other Particulate Matter Removal by Traditional Automotive 3-Way Catalyst, $115,192
7. Minnesota Department of Commerce (Co-PI), Toward a sustainable and resilient energy system enabled by green ammonia, $2,114,545 (Northrop Share)
8. DOE Vehicle Technologies Office (PI), Development of a Heavy-Duty Electric Vehicle Integration and Implementation (HEVII) Tool, $357,580
9. Volvo NA, DOE Vehicle Technologies Office (Co-PI), Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management, $1,001,000
10. ARPA-E (Co-PI), Plasma-Assisted In-Situ Reforming of Flare Gases to Achieve Near-Zero Methane Emissions, $351,546 (Northrop Share)
11. MnDOT (PI), Reducing Winter Maintenance Equipment Fuel Consumption Using Advanced Vehicle Data Analytics, $212,949.
12. Legislative-Citizen Commission on Minnesota Resources (PI), Development of Clean Energy Systems for Farms, $650,000
13. Shell/FCA, Fuel Additive Effects on GDI Engine-Out PM/PN and Catalyzed Gasoline Particulate Filter Loading, $120,000
14. Minnesota Corn Research & Promotion Council, Highly Efficient Range Extender Engine Using E85 and Thermochemical Recuperation, $208,227.
15. Cummins Emissions Solutions, Investigation of Temperature Effects on Size-Dependent Filtration Efficiency in Coalescing Filters, $72,837.

16. DOE Vehicle Technologies Office (PI), On-Demand Reactivity Enhancement to Enable Advanced Low Temperature Natural Gas Internal Combustion Engines, $1,632,572.
17. MnDOT CAVX Office (PI), Helping Automated Vehicles “See” in Minnesota: Ambient Particle Effects on LiDAR Systems, $237,841
18. Exergi Predictive, DOE SBIR (PI) Connected Energy Management System to Enable Battery Electric Last-Mile Delivery Vehicles, 40,680
19. MnDRIVE (Co-PI), Integrated Bioremediation Demonstration for Clean Water and Energy, $486,150.
20. ARPA-E (PI), Connected Hybridization for Improving Delivery Vehicle Fuel Economy using Physics-Aware Spatiotemporal Data Analytics and Real-Time Powertrain Control, $1,399,888.
21. MnDOT LRRB (PI), Techno-Economic Analysis of Implementing Hybrid Electric Utility Vehicles in Municipal Fleets, $100,767.
22. DOE STTR: Plug-In Hybrid Vehicle Optimization Using Vehicle-to-Cloud Connectivity, $49,423.
23. MN Corn Growers Association, Ethanol Reformer for On-Board Octane Control in Spark Ignition Engines, $65,000.
24. Aramco Services (PI), Thermally Integrated Reforming for Gasoline Engines Phase 1: Engine Simulation, $110,000.
25. Fiat Chrysler Automobiles (PI), Real-Time Physics-Based Model for Predicting Spark-Ignition Engine Emissions, $224,248.
26. NSF CAREER (PI), High Equivalence Ratio Partial Oxidation of Liquid Fuels by Reactive Volatilization (2014), $447,950.
27. Legislative-Citizen Commission on Minnesota Resources (PI), Clean Vehicles Fueled by Renewable Hydrogen from Renewable Ammonia, $250,000.
28. Transportation Research Board Transit Idea Program (PI), Development of a Mass-Based Automated Passenger Counter, $133,096.
29. DOE Vehicle Technologies Incubator (PI), Enabling Lean and Stoichiometric Gasoline Direct Injection Engines through Mitigation of Nanoparticle Emissions (2015), $1,090,654
30. Minnesota Corn Growers Association (PI), Hydrous Ethanol Reforming for Reducing NO_X Emissions from Diesel Engines, $99,342.
31. Legislative-Citizen Commission on Minnesota Resources (PI), Reducing Emissions from Open Burning through Biomass Gasification (2015), $268,000.
32. Cummins (PI), In-Use Measurement and Evaluation of NO_X Emissions from a 2015 Certification Diesel Engine in a Transit Bus (2015), $51,248.
33. Minnesota Corn Growers Association (PI), Quantifying Energy Savings Gained through Production of Hydrous Ethanol from Corn (2013), $95,206.
34. General Motors Research Gift (PI), Particulate and Hydrocarbon Emissions from Low Temperature Combustion in Diesel Engines (2012), $150,000.
35. Corning (PI), Pilot Study of Cold Start Emissions from Gasoline Engines and Ambient Nanoparticle Concentrations in Parking Structures (2014), $44,618.
36. University of Minnesota Office of Vice President for Research (PI), Ultrasonic Thermometry for Reciprocating Engines (2013), $36,033.

37. Private Research Gift (PI), Thermodynamic Evaluation of a Dual Expansion Concept for Increasing Internal Combustion Engine Thermal Efficiency (2013), $58,464.
38. Minnesota Corn Growers Association (PI), Development of a Port-Injected Hydrous Ethanol System for Diesel Engines (2012), $127,914.
39. Minnesota Corn Growers Association (PI), High Efficiency Enabled by Hydrous Ethanol use in Dual-Fuel Diesel Engines (2011), $118,504.
40. University of Minnesota Institute for Renewable Energy and the Environment (Co-PI), Performance and Emissions of Second Generation Biofuel DME (2010), $300,000.
41. University of Minnesota Institute for Renewable Energy and the Environment (Co-PI), Enabling the Next Generation of Super Hybrid Transit Bus (2010), $300,000.
42. NSF MRI (Co-PI), Development of a Controlled-Trajectory Rapid Compression and Expansion Machine (2014), $927,605.

Student Grants:

Student: Seamus Kane
Fellowship Program in Renewable Energy Commercialization
50% RA Appointment (July 1, 2020 – June 30, 2021)

Student: Aduramo Lasode
Leadership in Equity, Inclusion and Diversity (LEID) Fellowship
50% RA Appointment (September 1, 2020 – August 31, 2021)

Student: Andrew Kotz
University of Minnesota MnDRIVE Graduate Scholars Program
25% RA Appointment (June 1, 2015 – December 31, 2016)

Startup Companies

Exergi Predictive, LLC – Co-founder and Acting CEO

Army Research Lab, University of St. Thomas
April 1, 2025 – March 31, 2026
$450,000

U.S Army Applications Office, SBIR Phase II
April 1, 2022 – March 31, 2024
$1,500,000

U.S Army Applications Office, SBIR Phase 1
Aug 3, 2021 – December 31, 2021
$250,000

DOE-EERE Vehicle Technologies Program, SBIR Phase I
July 1, 2020 – June 30, 2021
$150,000

ARPA-E SCALEUP Startup Award
September 1, 2020 – January 1, 2021

$50,000

Aza Power Systems LLC – Co-Founder and Senior Technical Advisor

Army Research Laboratory, University of St. Thomas
April 1, 2025 – March 31, 2026
$350,000

TEACHING AND CURRICULUM DEVELOPMENT

Courses Taught

Power Cycles, ME5101, spring 2025
Material Covered: Thermodynamics of power cycles including internal combustion engines, gas turbines, and steam power cycles. New course designed as of 2025.

Mechanical Engineering Modeling, ME4053, fall 2023
Material Covered: Synthesis of engineering curriculum in solving relevant problems in mechanical engineering. Focus on thermal systems, co-taught with another faculty member.

Advanced Thermodynamics, Centro Universitario de la Defensa, Marin; Spain, fall 2019
Material Covered: Psychometrics, Thermochemistry of Combustion, Advanced Power and Refrigeration Cycles

Introduction to Thermal Sciences I, ME3331, fall 2012, spring 2020, fall 2022
Material Covered: Introductory thermodynamics; properties, state relations, 1st law, 2nd law and cycles

Introduction to Combustion, ME5446, fall 2011, spring 2013, fall 2014, fall 2015, fall 2016, fall 2017, fall 2018
Material Covered: thermochemistry, mass transfer, chemical kinetics, laminar premixed flames, computer applications in combustion, introduction to engine combustion and pollutant formation

Advanced Combustion, ME8446, fall 2013, spring 2016, spring 2018, spring 2022
Material Covered: Conservation for reacting flows, laminar premixed and diffusion flames, turbulent combustion

Energy Conversion Laboratory, ME4431, spring 2017, spring 2019, fall 2020, fall 2024
Material Covered: Pumps, compressors, diesel engines, spark ignition engines, gas turbines, combined heat and power systems

Undergraduate Student Advising, fall 2014, fall/spring 2017/18, fall 2020-present

Mechanical Engineering Senior Design Project Advisor
1. Variable Compression Ratio Teaching Engine, fall 2014
2. Fuel Metering and Conditioning System, fall 2013

Advanced projects ME4090

Guest Lectures
1. *Spatial Database Research,* ME8715 – spring 2016
2. *Molecular Gas Dynamics*, ME8361 – (2 lectures) fall 2015
3. *Introduction to Thermal Sciences I*, ME3331 – spring 2013, spring 2015

Curriculum Development

1. *Power Cycles*, ME5101 – Combined three elective courses into one, more frequent course on power cycle thermodynamics of gas turbines, vapor power cycles, and internal combustion engines in spring 2025.
2. Revised technical elective program for mechanical engineering department
3. Advanced Thermodynamics, CUD 4th year ME course – Translated from Spanish and created new course in advanced combustion for Spanish military students – Fall 2019
4. *Introduction to Combustion*, ME5446 – Developed new curriculum in fall 2011
5. *Advanced Combustion*, ME8446 – Developed new curriculum in fall 2013
6. *Introduction to Thermal Sciences I*, ME3331 – Developed course materials in fall 2012
7. *Energy Conversion Laboratory,* ME4431 – Developed new laboratory manuals and curriculum in fall 2017, Converted lab to all online using video labs in fall 2020

Collaborative Efforts and Activities

1. Revised technical elective program for mechanical engineering department for fall 2022
2. Developed curriculum for new Co-op program in ME department
3. Planning curriculum for ME4431 Senior Energy Conversions Laboratory course with Prof. David Kittelson – summer/fall 2016

Faculty Teaching Development Activities

Early Career Teaching Program – UMN Center for Teaching and Learning, 2012 academic year

ADVISING AND MENTORING

Undergraduate Student Activities

Undergraduate Mentoring

ME advisor as Director of Undergraduate Studies, fall 2020-fall 2021

ME Department undergraduate student advising, fall 2014, fall/spring 2017-2018, fall/spring 2022-2023

Undergraduate Research Projects

ME4090/4094 Students:
Kyle Anderson (Spring 2026)
Nathan Oakey (Fall 2025)
Vincente Marin (Spring 2023)
Faruk Aydin (Spring 2019)
Po-Tin Mak (Fall 2018)
UROP Students:
Omar Ahmed (Summer 2016)
Abigail Hempy (Summer 2015)
Peter Irvine (Spring 2015)
Laurel Hunt (Spring 2014)
John Adams (Spring 2011, Spring 2012)
Dalen Miller (Spring 2012)
Undergraduate Research Assistants:
Kyle Anderson (Fall 2025-present)
Nathan Oakey (Fall 2024-present)
Antonio Gaeta (Spring 2025-Fall 2025)

Ham Farmer (Summer 2023-Spring 2025)
Tucker Blezak (Fall 2022-Spring 2023)
Everett Kroll (Fall 2022-Spring 2023)
Gus Krough (Fall 2022-Spring 2023)
Adam Pernsteiner (Fall 2021-Spring 2023)
Omar Al Busaidi (Spring 2021-Fall 2022)
Joseph Francis (Spring 2021- Fall 2021)
Min Kim (Fall 2019-Summer 2020)
Myles Hicks (Summer 2019-Fall 2020)
Ka Ho Lai (Fall 2019)
Nicholas Jantschek (Summer 2019, Spring 2021)
Mazen Alarmri (Spring 2018)
Cole Ramsey (Spring 2018-Fall 2018)
Clay McCarthy (Spring 2017-Summer 2018)
Omar Ahmed (Fall 2016-Spring 2019)
Rachael Adams (Fall 2018)
Abby Hempy (Spring 2017-Fall 2018)
Frank Siracusa (Summer 2016)
Elizabeth Vertina (Summer 2016)
Brian Amundson (Spring 2016)
John Sandell (Spring 2015, Spring 2016)
Laurel Hunt (Fall 2014 – Fall 2016)
Frank Spicuzza (Fall 2015)
John Adams (Summer 2011-Summer 2014)
Kieran McCabe (Summer 2013-Spring 2015)
Kali Johnson (Spring 2014)
Alex Chaddock (Spring 2014)
Juan Nakagawa (Spring 2013)
Sam Homan (Fall 2011-Spring 2012)
Ted Sanborn (Fall 2012)

Undergraduate honors projects directed

Adam Pernsteiner (ME Spring 2023)
Omar Ahmed (ME Spring 2019)
Elizabeth Vertina (ME Fall 2017)
Laurel Hunt (ME Fall 2017)
Kieran McCabe (AEM Spring 2015)
Alex Beane (ME Spring 2015)

REU Students

Christian Ramos (Summer 2020)

Student Groups

Faculty Advisor for Formula SAE and Minnesota Electric Racing, 2021-present

Faculty Advisor for SAE Clean Snowmobile Team, 2018-2021

Faculty Advisor of ME Department Student Council 2021-2022

Graduate Student Activities

Master's Plan A Theses Directed

1. Evan Swift, *Investigation into the Performance and Emissions of Ammonia / Hydrogen Blends in a Spark Ignition Engine and Demonstration of Improved Engine Thermal Efficiency using Oxidative Coupling of Methane Pretreatment*, Summer 2022
2. Harish Panneer Selvam, *Physics-Aware Artificial Intelligence Models for Vehicle Emissions Prediction*, Summer 2021
3. Matthew Ries, *Environmental and Economic Impacts of Small-Scale Biomass Gasification*, Summer 2017
4. Kali Johnson, *Investigation on the Influence of Organic Polymer Additives on n-Heptane Autoignition*, Fall 2016
5. Chad Weigelt, *A Method for Measuring Time-Resolved Path-Integrated Temperature in a Reciprocating Internal Combustion Engine Cylinder using Ultrasonic Thermometry*, Summer 2016
6. Alex Nord, *Efficacy of Heated Hydrous Ethanol Injection for Improving Emissions from Dual Fuel Diesel Engines*, Spring 2017
7. Alex Melin, *Parametric 1-D Modeling Study of a 5-Stroke Spark-Ignition Engine Concept for Increasing Engine Thermal Efficiency*, Spring 2016
8. Huzeifa Badshah (Co-advised with David Kittelson), *Particle Emissions from Light Duty Vehicles during Cold-Cold Start and Identified from Ambient Measurements*, Spring 2016
9. Aaron Avenido, *Measurement and Fractionation of Diesel Exhaust Hydrocarbons through Variable Temperature Controlled-Condensation and Flame Ionization Detection*, Spring 2014
10. Kathleen Vignali (Co-advised with David Kittelson), *Performance and Emissions of a Single-Cylinder Engine Fueled with Dimethyl Ether,* Spring 2014
11. Jamie Hamilton, *Characterization of Emissions from Small Scale Biomass Gasifier*, Fall 2013

Master's Plan B/Capstone Projects Directed

1. Dinesh Reddy Challa, *Influence of Snowfall on the Fuel Consumption of Winter Maintenance Vehicles*, Computer Science and Engineering, Data Science, Spring 2024
2. Jeromy Trujilo, *Mass Detection for Heavy-Duty Vehicles by Gaussian Belief Propagation & Deep Neural Network*, Spring 2022
3. Setayesh Fakhimi, *Model-Based Simulation & Geospatial Analysis for Charger Placement Optimization*, Spring 2022
4. Roopana Chenchu, *Correlation Between Rolling Resistance and Presence of Snow Traps*, Spring 2021
5. Kodie Olshefsky, *Early Injection Modeling of a Physics-Based Model for Predicting Spark-Ignition Engine Emissions*, Spring 2020
6. Abhey Sandhu, *Gasoline Knock Intensity Study Using a CFR Engine*, Spring 2018
7. Aditya Salapaka, *Development of a Mass-based Automated Passenger Counter*, Fall 2018
8. Joseph Viavattine, *Investigation and Allocation of the Main Reactions in a Self-sustaining Catalytic Diesel Fuel Evaporation Process to Determine Reaction Zones*, Fall 2016
9. Vivek Kongot, *Two Piece Piston Design for a Variable Compression Ratio Laboratory Engine*, Spring 2016

Master's Student Advisees (Current)

1. Mike Marsden, Spring 2026

Master's Students Plan C and Other Departments (Current)

Doctoral Dissertations Directed

1. Dhotre, Akash, *Experimental Studies on Enhanced Ignition for Improved Pre-Chamber Combustion in Gas Engines*, Fall 2025

2. Bhakta, Sagardeep, *Investigation of Fuel Reforming and Catalytic Strategies for High Efficiency And Low Emissions Gasoline Direct Injection Engines*, Spring 2025
3. Matthew Eagon, *Data-Driven Approaches to Intelligent Energy Management for Electric Vehicles and Supporting Infrastructure*, Spring 2024
4. Lee, Hyewon, *Catalytic Oxidative Coupling of Methane and Ammonia Decomposition for Production of Valuable Chemicals in Energy Applications*, Spring 2024
5. Daniel Thomas, *Ammonia-Hydrogen Diffusion Flames: Toward clean-burning green ammonia*, Summer 2022
6. Seamus Kane, *Thermochemical Recuperation and Catalytic Strategies for Anhydrous Ammonia in Combustion Systems*, Summer 2021
7. Noah Bock, *Investigation of Particulate Matter Emissions from Gasoline Direct Injection Engines: Effects of Lean Combustion Strategies, Fuel Properties, And Lube Oil Additives*, Fall 2020
8. Ying Lin, *Catalytic Partial Oxidation in Novel Non-Premixed Counter-Flow Reactor Configurations*, Fall 2020
9. Pengyue Wang, *Data-Driven Framework for Energy Management in Extended Range Electric Vehicles Used in Package Delivery Applications*, Summer 2020
10. Dereck Dasrath, *Investigation of Piston Geometry in Rapid Compression Machines and Sampling Methods for Internal Combustion Engine*s, Summer 2019
11. Jeffery Hwang, *Investigation of Novel Hydrous Ethanol Dual-Fuel Strategies for Reducing Emissions from Fixed-Calibration Diesel Engines*, Spring 2018
12. Andrew Kotz, *Data Driven Approach to Vehicle Emissions Reduction*, Fall 2016
13. Glenn Lucachick, *Volatility Characterization of Particle Emissions from Premixed Low Temperature Compression Ignition Combustion*, Spring 2016
14. Wei Fang (Co-advised with David Kittelson), *An Experimental Investigation of Reactivity-Controlled Compression Ignition Combustion in Diesel Engines using Hydrous Ethanol*, Spring 2016

Doctoral Students Advised (Current)
1. Mahdi Barenji (Spring 2027)
2. Aritri Halder (Spring 2027)
3. Aylar Aghaalizadeh (Fall 2026)
4. Tejashri Patil (Spring 2027)
5. Clifford Goertemiller (Fall 2026)
6. Bharat Jayaprakash (Fall 2026)
7. Brady Wilmer (Spring 2026)
8. Aduramo Lasode (Fall 2026)

Post-Doctoral Fellows Supervised
1. Alex Voris, August 2024 - Present
2. Shawn Regetti, July 2022 – August 2024, Current Affiliation: Postdoctoral Researcher, Argonne National Laboratory
3. Seamus Kane, June 2021 – July 2022, Current Affiliation: Research Staff, University of Minnesota
4. Lu Zhan, March 2020 – January 2022, Current Affiliation: Postdoctoral Researcher, Argonne National Laboratory
5. Chaitanya Wadkar, May 2021 – October 2022, Current Affiliation: Research Engineer, Amogy, Inc
6. Seokwon Cho, August 2019 – June 2020, Current Affiliation: Research Scientist, Southwest Research Institute
7. Joonho Jeon, March 2017- January 2019, Current Affiliation: Assistant Professor, Pukyong National University, Korea
8. Xuesong Li, January 2015- August 2017, Current Affiliation: Associate Professor, Shanghai Jiaotong University, China

Other Mentoring Activities

High School Student Research Interns

1. Jackson Mayeron (Summer 2025)
2. George Lyu (Summer 2020)
3. Audrey Yang (Summer 2020)
4. Brian Lin (Summer 2020)
5. Gabrielle Bobgon (Fall 2016-Spring 2017)
6. Cooper Meinhart (Summer 2016)
7. Brian Boehm (Summer 2015)
8. Philip Cerles, Post-Secondary Enrollment Options Student Research Mentee (Spring 2012)

Student Projects

1. Formula SAE and Minnesota Electric Racing Advisor, 2021-Present
2. SAE Clean Snowmobile Team, engine mentor, 2014-2016
3. Liquid Propellant Rocket Development, combustion mentor, 2015-2018
4. Formula SAE, engine mentor, 2012-2021

Visiting Graduate Students

1. Alessandro Nodi, Ph.D. Student, Politecnico Di Milano, Italy, Spring-Summer 2025
2. Wüthrich, Silas, Ph.D. Student, University of Applied Sciences, Switzerland, Summer 2024
3. Natalia Cid, Ph.D. Student, University of Vigo, Spain, Spring 2022
4. Xiaolu Chen, CSC Visiting Scholar Program, Fall 2017-Fall 2018

Research Scientists

1. Seamus Kane, 2022-present
2. Joseph Sweeney, 2021
3. Darrick Zarling, 2014-2021

Research Program Manager

1. Shawn Haag, 2016-2021

Hourly and Volunteer Researchers

1. John Earl, Hourly Laboratory Assistant, Spring 2019-Fall 2019
2. James Radomski, Volunteer Research Associate, Fall 2018-Summer 2019
3. Charles Lo, Volunteer Research Associate, Fall 2014-present

K-12 Volunteering

Combustion and engines demonstration for Minneapolis Public Schools Washburn High School students, Spring 2014

Presentation about turbine blades and demonstration project at Minneapolis Public Schools Burroughs Elementary 3rd-grade class, 2018-2019

Destination Imagination coach at Minneapolis Public Schools, Burroughs Elementary, 2017/2018 and 2018/2019 academic years

FIRST Lego League coach, 2021, 2022, 2024, and 2025 (state finalists)

SERVICE AND PUBLIC OUTREACH

Editorships/Journal Reviewer Experience

Associate Editor, *Proceedings of the Combustion Institute*, Fall 2023 – present

Associate Editor, *Journal of Ammonia Energy*, Fall 2023-present

Associate Editor, *Journal of Engineering for Gas Turbines and Power*, Summer 2018-Summer 2022

Associate Editor, *Results in Engineering*, Fall 2018-Summer 2018

Guest Editor, *International Journal of Powertrains*, Special Issue: Internal Combustion Engine Powertrain Technologies for Future Connected Vehicles, May 30, 2016-December 31, 2016.

Guest Editor, *Applications in Energy and Combustion Science*, Special Issue: Piston Engines as Chemical Reactors, 2022

Journal Papers Reviewed (2011 – present)
Applied Energy – 7
Aerosol Science and Technology – 5
Atmospheric Environment - 5
AIMS Environmental Science – 1
Engineering Applications of Artificial Intelligence - 2
Journal of Aerosol Science – 3
Emissions Control Science and Technology - 2
ASME Journal of Energy Resources and Technology – 2
ASME Journal of Engineering for Gas Turbines and Power - 2
Proceedings of the Combustion Institute – >40
PLOS One – 1
Energy – 4
IEEE Transactions on Instrumentation and Measurement - 1
Energy and Fuels – 14
Environmental Science and Technology – 11
Fuel – 3
Fuel Processing Technology – 1
International Journal of Engine Research – 10
International Journal of Hydrogen Energy – 5
Plasma Chemistry and Plasma Processing – 3
SAE International Journal of Engines – 3
Transportation Research Part D: Transport and Environment – 2

Conference Paper Reviews (2011 – present)
SAE Technical Papers, World Congress or Fuels and Lubricants Meeting – >40
ASME Technical Papers, Fall/Spring Technical Meeting – >40

Committee memberships

American Society of Mechanical Engineers, Internal Combustion Engines Division
Ammonia Energy Research Institute
- Division Awards Nominations Chair, 2023-present
- Division Strategic Planning Chair, 2022-2023
- Division Past Chair, 2022-2023

Division Chair, 2021
Division Co-Chair, 2020
Executive Committee Member, 2016-2021
Clean Energy Technology Group Member, 2022-2025

Central States Section of the Combustion Institute
Advisory Board Member, 2016-present

Society of Automotive Engineers
Powertrain Fuels and Lubricants Committee, Fall 2017-present
2020 COMVEC Planning: Powertrain Committee, Fall 2019-present
Horning Award Review Committee, Spring 2019-present
Fuel Cell Vehicle Standards Committee, 1999-2002

Ammonia Energy Research Institute
Internal Combustion Engine Session Chair, 2022-present

Review panels for external funding agencies, foundations, etc.

NSF Combustion and Fire Systems – 2013, 2014
NSF SBIR – 2015
DOE BES – 2019, 2021
DOE Vehicle Technologies – 2014, 2015
DOE EERE – 2012
ARPA-E – 2015, 2018
Davidson Institute for Talent Development – 2012
Health Effects Institute – 2015

Organization of conferences, workshops, panels, symposia

American Society of Mechanical Engineers, Internal Combustion Engines Division

Chair, Fall Technical Conference, Chicago, IL, 2019
Co-Chair, Technical Expert Panel, Engines for Electrification at Fall Technical Conference, San Diego, CA, 2018
Co-Chair, Fall Technical Conference, San Diego, CA, 2018
Chair, Undergraduate Student Presentation Competition, Fall Technical Conference, 2011- 2016
Co-Chair, Advanced Combustion Technical Track, Fall Technical Conference, 2014-2016
Session Co-Organizer, Advanced Combustion, Fall Technical Conference, 2011-2013
Panel Co-Organizer, Engines for Electrification, Fall Technical Conference, 2018

Society of Automotive Engineers
Session Co-Organizer, PFL 260-Dual Fuel Combustion, SAE World Congress 2013-2019
Organizer, Technical Expert Panel Discussion: Current Understanding of Particulate Matter from Low Temperature Combustion Modes, SAE World Congress, Detroit, MI, April 21, 2015.

Central States Section of the Combustion Institute
Hosted Spring Technical Meeting, Minneapolis MN, May 20-22, 2018

International Energy Agency – Clean Combustion TCP
Soot Task Chair 2019-present

Ammonia Energy Research Institute
Internal Combustion Engine Session Chair 2021-present

Service to the Department of Mechanical Engineering

Chair, Faculty Search Committee, 2024-present
Organized committee reviews and coordinated review discussions
Coordinated virtual and on-campus reviews
Resulted in hiring two new assistant professors in the ME Department

Member, Post-Tenure Review Committee, 2024-present
Reviewed tenured faculty performance reviews and compared to departmental requirements

Director of Engineering Co-Op Program, May 2021-August 2021
Wrote curriculum for two new co-op courses
Worked to transfer student hiring and placement to college
Instructor of record on co-op courses and CPT courses in summer 2021

Director of Undergraduate Studies, Department of Mechanical Engineering, July 2020-July 2021
Formed a new undergraduate student council
Re-established the undergraduate curriculum committee
Led town hall events on remote teaching
Conducted surveys on remote learning

ME Department Strategic Planning Committee
Member of Teaching Sub-Committee fall 2019-present
Co-Chair of Administration and Processes Sub-Committee, fall 2019-present

Member of Graduate Student Curriculum Innovation Committee, Fall 2018-Spring 2019

Chair, Undergraduate Student Experience Committee, Spring 2018-Spring 2020

Member of Departmental Head Evaluation Committee, 2018

Member of Mechanical Engineering Faculty Search Committee, 2016/2017, 2017/2018, 2019/2020

Department representative for TE Murphy Engine Research Laboratory, Fall 2012-Fall 2014
Primary departmental contact responsible for fundraising, design, construction, and commissioning for a new $5M engine research laboratory at the University of Minnesota to replace the aging facility in the Mechanical Engineering building.

Member of ME/AE Department Enet Mission and Staffing Committee, Spring 2014
Participated in bi-weekly meetings to discuss potential reorganization of the mechanical engineering and aerospace engineering departments IT support staff.

Service to the College/University

Marine Initiative Task Force Member, Research and Innovation Office, Spring 2026

Grant in Aid Review Committee Member, Research and Innovation Office, Fall 2025, Spring 2026

Member of Faculty Search Committee, Bioengineering and Bioproducts Department, AY2024-2025