Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-376

Proposal Title: High-Efficiency Hybrid Transmissions for Cleaner Agricultural Vehicles

Project Manager Information

Name: James Van de Ven

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: We will develop a highly efficient hybrid transmission for agricultural vehicles, reducing fuel consumption and enabling alternative fuels. We plan on partnering with Minnesota's AGCO to commercialize this eco-friendly technology.

ENRTF Funds Requested: $611,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Region(s): Metro

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota's agricultural sector relies on heavy machinery that burns significant amounts of fossil fuels, contributing to greenhouse gas emissions and impacting local air quality. Significant energy savings and increased productivity is possible through innovation in the transmission for these machines.

Current transmissions for agricultural machines: 1) have discrete gears that prevent the engine from operating at the most efficient condition (reducing efficiency by 15-20%), 2) if the transmission does offer infinite speed variation (hydrostatic), 30-40% of the power is converted into waste heat, and 3) they do not have the ability to store energy (potential for 25% efficiency improvement). The low efficiency of current powertrains requires agricultural equipment manufacturers to use oversized engines to maintain the power needed for tasks like plowing or harvesting.

There is a critical need for a compact, cost-effective, and highly efficient hybrid transmission for agricultural machines. Solving this problem will allow farmers to use smaller, more fuel-efficient engines without sacrificing productivity. Furthermore, creating a highly efficient, energy-storing powertrain is a necessary technological stepping-stone for adopting alternative, cleaner-burning fuels in off-highway vehicles. Overcoming this bottleneck directly addresses a major source of agricultural emissions, supporting Minnesota's long-term environmental, air quality, and natural resource conservation goals.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We propose developing a new, highly efficient hybrid transmission specifically designed for agricultural machinery. Our transmission uses a highly-efficient mechanical power path and an infinite speed varying hydraulic power path. Our innovation lies in two key aspects: 1) The system is hybridized by storing energy in a hydraulic accumulator and 2) The two power paths are combined in a custom hydraulic pump instead of a bulky planetary gearbox (reducing size 4-6X).

These breakthroughs make the powertrain significantly more compact, affordable, and efficient. Crucially, our system incorporates a hydraulic accumulator for energy storage. Unlike expensive batteries that degrade over time, hydraulic accumulators are highly durable, cost-effective, and last indefinitely. This energy storage captures wasted power and allows the engine to run at its most efficient conditions, significantly cutting fuel use and greenhouse gas emissions. It also serves as a necessary bridge to using alternative, cleaner-burning engines in the future.

We will build and test a functional prototype, proving its ability to reduce agricultural fuel consumption and protect Minnesota’s air and natural resources. To ensure this technology reaches Minnesota farmers, we are exploring a partnership with AGCO in Jackson, MN, a global leader in agricultural equipment.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state’s natural resources?

The primary outcome is a tested prototype of a highly efficient, energy-storing hybrid transmission for agricultural vehicles. By proving this technology drastically improves fuel economy, this project directly protects Minnesota’s natural resources by reducing greenhouse gas emissions and air pollution from heavy farming equipment. The design allows manufacturers to use smaller engines and provides a pathway for alternative, cleaner fuels, permanently shrinking the carbon footprint of Minnesota's agriculture. Ultimately, this outcome delivers cleaner air, conserves fuel resources, and advances sustainable, eco-friendly farming practices across the state.

Activities and Milestones

Activity 1: System Modeling and Optimization

Activity Budget: $171,881

Activity Description:
Objective & Tasks: We will build computer models of the transmission to simulate its performance during realistic agricultural tasks. We will use these simulations to optimize component sizes and control system for maximum fuel efficiency.
Impact: Creates a software tool to help manufacturers adapt this green technology to various farm vehicles.

Activity Milestones:

Description	Approximate Completion Date
Complete computer simulation models to maximize transmission fuel efficiency.	July 31, 2028

Activity 2: Prototype Construction

Activity Budget: $176,986

Activity Description:
Objective & Tasks: We will physically build a laboratory-scale prototype of the transmission using customized industrial components.
Impact: Translates theoretical fuel-savings into a tangible, physical system, bridging the gap between academic research and commercial manufacturing in Minnesota.

Activity Milestones:

Description	Approximate Completion Date
2) Finalize mechanical design and purchase materials for the physical prototype.	January 31, 2029
Complete physical assembly of the prototype transmission.	July 31, 2029

Activity 3: Laboratory Testing and Validation

Activity Budget: $262,133

Activity Description:
Objective & Tasks: We will test the physical prototype in a controlled laboratory setting to measure its actual energy efficiency and fuel-saving capabilities against our computer models.
Impact: Provides rigorous proof of the technology's ability to reduce emissions and save fuel, validating the environmental benefits.

Activity Milestones:

Description	Approximate Completion Date
Complete laboratory efficiency testing.	January 31, 2030
Finalize data analysis, publish results and LCCMR report.	June 30, 2030

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
To ensure the results of this research benefit Minnesota's environment and agricultural sector, we will implement a multi-tiered dissemination strategy:

- Direct Industry Transfer: We are exploring a partnership with Agco Corporation (Jackson, MN) to integrate all findings, modeling outputs, and prototype data into their commercial manufacturing pipeline. This ensures the entities capable of producing this technology have immediate access to the results to improve the efficiency of heavy machinery.
- Stakeholder Outreach: We will present our findings at regional agricultural technology expos (e.g., Minnesota Farmfest). We will provide accessible, non-technical demonstrations showing farmers and equipment manufacturers how this technology promotes eco-friendly farming practices by reducing fuel consumption and allowing for alternative fuels.
- Public Accessibility & LCCMR Acknowledgment: A dedicated project webpage hosted by the University of Minnesota will feature plain-language summaries, project milestones, and a video demonstration of the final prototype. All public materials, presentations, and publications will prominently highlight the support and work accomplished with the help of the Environment and Natural Resources Trust Fund.
- Academic Sharing: We will publish the engineering data and efficiency results in open-access engineering journals to ensure the longevity and public availability of the knowledge generated.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
We are working to partner with Minnesota industry partner Agco Corporation for post-project implementation. The prototype can be used to guide the commercial manufacturing of these hybrid transmissions for agricultural equipment. In addition to commercialization, manufacturing scaling, and integration into new tractors and combines internally funded by our partners, future vehicle-level testing may also be supported by federal grants (e.g., DOE, USDA). This ensures the LCCMR's initial investment leverages private industry funding to deliver long-term, statewide environmental benefits to Minnesota farmers.

Project Manager and Organization Qualifications

Project Manager Name: James Van de Ven

Job Title: Professor of Mechanical Engineering

Provide description of the project manager's qualifications to manage the proposed project.
Dr. James D. Van de Ven is a Professor at the University of Minnesota in the Department of Mechanical Engineering where he operates the Mechanical Energy and Power Systems (MEPS) Laboratory. Professor Van de Ven received his Ph.D. in Mechanical Engineering from the University of Minnesota in 2006. From 2007 to 2011, he was an Assistant Professor in the Mechanical Engineering Department at Worcester Polytechnic Institute. Dr. Van de Ven's expertise is in the areas of machine design and dynamics, with specific interest in energy conversion and storage in fluid power systems. Dr. Van de Ven has mentored over 70 graduate and undergraduate research assistants, published over 100 journal and conference papers, given over 70 technical presentations, and holds 12 patents. He is a fellow of the American Society of Mechanical Engineers (ASME), past chair of the ASME Fluid Power Systems Technology Division, and served as general chair for the 2019 and 2025 ASME/Bath Fluid Power and Motion Control Symposium, the premier

international fluid power conference. He is the Deputy Director of the Center for Compact and Efficient Fluid Power (CCEFP), the leading academic fluid power research organization in the United States. Prof. Van de Ven teaches the Fundamentals of Fluid Power Massive Open Online Course on Coursera with over 70,000 students to date. He was awarded the University of Minnesota Graduate and Professional Teaching Award in 2024, Charles E. Bowers Faculty Teaching Award in 2020, George Taylor Career Development Award in 2016, 2014-2016 McKnight Land-Grant Professorship, Russell M. Searle Professorship in 2011, and the Morgan Distinguished Instructor in 2010. He has extensive experience leading large research teams, including serving as PI and co-PI on three Department of Energy grants >$1M.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota (UMN) is the state's premier public land-grant research institution, dedicated to a threefold mission of research and discovery, teaching and learning, and public service.

Within UMN, the College of Science and Engineering (CSE) unites the engineering, physical sciences, and mathematics disciplines. CSE's mission is to advance fundamental knowledge and develop innovative technological solutions that address society's most pressing environmental, energy, and economic challenges.

Housed within CSE, the Department of Mechanical Engineering (ME) is a nationally recognized leader in fluid power, powertrain innovation, and sustainable energy systems. The department is committed to pioneering research that translates complex engineering science into practical, real-world applications. By providing world-class laboratory facilities, advanced computational resources, and top-tier academic expertise, the ME department is uniquely equipped to drive the development of cleaner, high-efficiency technologies. ME houses the Center for Compact and Efficient Fluid Power, the US leader in fluid power research. As the lead organization for this project, UMN brings the technical infrastructure, public-serving dedication, and collaborative industry networks necessary to successfully execute this work and deliver tangible environmental benefits to Minnesota.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Principal Investigator - Van de Ven		Project leader			27.8%	0.24		$75,833
Post-Doctoral Associate		Creating the framework for the simulation tool, developing the drive cycles for simulation, advising the prototype design, assisting with the fabrication and testing of the prototype, and interacting with industry collaborators.			22%	3		$246,404
Graduate Research Assistant		Constructing the powertrain component models, integrating the component models into the vehicle powertrain models, detailed design of the prototype, and fabrication and testing of the prototype.			45.44%	1.5		$203,790
							Sub Total	**$526,027**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Benchtop prototype transmission	A benchtop prototype transmission experimental system will be fabricated to validate the numerical model and demonstrate the technology. The system will include: electric power supply, electric motor, hydraulic pump and motor, control valves, load motor, reservoir, voltage and current sensing, shaft torque and speed sensing, pressure transducers, flow meters, data acquisition system, wiring, custom brackets, and hydraulic conveyance.					$75,000

	Tools and Supplies	Experimental Supplies	Including Miscellaneous consumables such as hydraulic fluid, fasteners, wiring connectors, etc. These expenses are an estimate based on previous supply purchases.					$4,888
							Sub Total	**$79,888**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel for two to Minnesota Farmfest and present at a booth and disseminate the work. Attending each year of the grant. Travel: $200 Hotel: $300 Food: $250 Booth: $945	Present results at a booth and disseminate the work					$5,085
							Sub Total	**$5,085**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$611,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Unrecovered F&A calculated at 54% MTDC	Support of ME facilities where research will be conducted.	Secured	$256,789
			Non State Sub Total	**$256,789**
			Funds Total	**$256,789**

Total Project Cost: $867,789

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 37b60fff-b64.pdf

Alternate Text for Visual Component

Image of hybrid inline hydro-mechanical transmission with the example application to a tractor and bullets describing the primary benefits of the technology....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN Institutional Support Letter	c48ce5f0-b6d.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

sull1129@umn.edu; mitte131@umn.edu

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A