CENTER FOR COMPACT AND EFFICIENT FLUID POWER

A National Science Foundation Engineering Research Center



LEAD INNO

INNOVATE

ADVOCATE

EDUCATE

NETWORK

Center for Compact and Efficient Fluid Power University of Minnesota 111 Church Street SE Minneapolis, MN 55455 www.ccefp.org



The Center for Compact and Efficient Fluid Power (CCEFP) was founded in 2006 at the University of Minnesota through an Engineering Research Center award from the National Science Foundation (NSF).

The concept of the CCEFP emerged from the coordinated efforts of the National Fluid Power Association (NFPA) in Milwaukee, Wisconsin. To achieve their strategic priority of a national fluid power research initative, NFPA hosted an academic workshop to discuss opportunities for such an endeavor. One outcome of the workshop was to pursue a prestigious NSF Engineering Research Center (ERC). Despite the significant effort of the first



academic team, the initial proposal was rejected. Four years after the workshop, a second ERC proposal led by Professor Kim Stelson was successful.

After decades of steady decline in U.S. fluid power research, the CCEFP and industry leaders effectively convinced the NSF of the necessity to rebuild the domestic fluid power research capability. Among the 265 proposals submitted, the NSF chose to fund the CCEFP largely due to overwhelming industry support. To this day, the CCEFP's engagement with industry remains the envy of other NSF ERCs.

Since inception, the CCEFP has acquired over \$80,000,000 from the federal government, universities, and industry for fluid power research. More than 70 fluid power companies, 50 academic researchers and 10 universities, have been members or supporters since the CCEFP's beginning.

WHAT IS THE CCEFP?

A network of academic researchers and industry supporters.

OUR MISSION

To change the way fluid power is researched, applied, and taught.

OUR VISION

To make fluid power the technology of choice for power generation, transmission, storage, and motion control.

OUR STRATEGY

To identify and cultivate new sources of government funding; to identify and lead new fluid power directions; to maintain research initiatives, promote progress, and disseminate results; to provide meaningful engagement opportunities; to foster teaching, learning, and talent development programs.



WHAT WE DO

- Lead the nation's fluid power research strategy to improve existing applications and create new markets
- Create, identify, promote, and secure federal funding for fluid power research and education

HOW WE DO IT

- Engage with academic and industry leaders
- Advocate fluid power research opportunities with synergistic federal agencies
- Provide regular venues for networking between students, faculty, and industry supporters

OUR IMPACT

- \$80,000,000 invested in fluid power research, education, engagement, advocacy
- 50 research faculty at 10 partner universities
- 1,000 graduated students directly involved in fluid power research projects
- 66% percent of graduated students work in fluid power
- 20,000 students exposed to fluid power annually through courses or free modules
- 4 federal agencies educated on the potential impact of strategic fluid power research
- 1 fluid power research strategy for the country



WHAT WE DO

Lead U.S. Research Strategy: CCEFP focuses its research in areas that solve industry challenges or create new opportunities in fluid power, improving the way fluid power is utilized, and educating engineers entering the field.

Promote Topic Campaigns: CCEFP organizes campaigns through its extensive academic network to respond to federal solicitations and embed fluid power in U.S. technology priorities.



HOW WE DO IT

Off-Highway Vehicles Initiative: Increase awareness within government agencies and Congress of the substantial energy savings possible through fluid power innovation.

Human Scale Systems Initiative: Partner with existing robotics research communities by persuading thought leaders of the necessity of power dense fluid power actuation.



Fluid Power Manufacturing Initiative: Identify manufacturing technologies that can improve fluid power and identify how fluid power can improve manufacturing.

OUR IMPACT

- Department of Energy Mobile Fluid Power Research Program: CCEFP led an academic/industry session to promote idea generation and proposals for commercial off-road vehicles to improve performance, emissions, noise, user interface, and other factors will reduce the barriers of acceptance of efficient fluid power systems in a competitive marketplace
- **Department of Defense Advanced Robotics for Manufacturing (ARM) Institute**: CCEFP pursuaded ARM to incorporate fluid power into their research strategy for robotic actuation
- National Science Foundation (NSF) Emerging Frontiers in Research & Innovation (EFRI): CCEFP campaigned NSF to include "soft robotics" in its current solicitation
- National Institute of Standards and Technology (NIST): CCEFP authored the first fluid power manufacturing technology roadmap



WHAT WE DO

Government Relations: CCEFP champions fluid power government grant program creation. The fluid power industry, as a whole, benefits from the direct and indirect accomplishments of the CCEFP.

HOW WE DO IT

Influence Agent: Propose and initiate discussions with key government legislators and agency leaders. Engage lobbyists to identify ideal strategic alignment with appropriate decision makers. Develop strategies that resonate and address areas of concern. Advocate for fluid power funding and future investment.

Professional Connections: CCEFP researchers are recognized leaders in their field. They have deep relationships with agency leaders, who are sometimes former colleagues or students. These connections open doors that would otherwise be closed to get conversations started.

OUR IMPACT

- Creation of a *new* \$5,000,000 Department of Energy Mobile Fluid Power Research Program with the potential to increase to \$10,000,000 annually in the future
- Inclusion of fluid power actuation as a key enabling technology in the \$178,000,000 Advanced Robotics for Manufacturing Institute
- Incorporation of \$15,000,000 for soft robotics research in the recent NSF Emerging Frontiers for Research Innovation (EFRI) program



WHAT WE DO

Research: Research is not only the creation of new knowledge; it is the most vital form of education. Research projects create a pathway for highly educated engineers entering the fluid power workforce as the next generation of leaders. The best way to train fluid power experts is through hands-on fluid power research projects.



Education: Engaged research faculty incorporate fluid power into core engineering curriculum to expose a broad audience of undergraduate students to fluid power.

HOW WE DO IT

The CCEFP has a robust research and education program. Through hands-on fluid power experiences, the Center drives workforce development and innovation for the fluid power industry. Examples include:

- A free piston engine hydraulic pump promises to revolutionize future powertrains for both on and off highway vehicles
- The displacement controlled hybrid excavator doubles fuel efficiency
- A hydromechanical powertrain transmission introduces novel propel and work circuit architecture on various off highway vehicles
- The variable-linkage pump achieves unparalleled efficiency through a novel mechanism
- Advanced engineered fluids research demonstrates the important role of fluid in hydraulic systems
- The **sealing and tribological studies** explore the interaction between sliding surfaces and thin film lubrication
- The **hydraulic ankle-foot orthosis** demonstrates the extraordinary ability of fluid power to achieve high forces in an exceptionally lightweight package, making fluid power a perfect solution for next-generation wearable robots
- The **lightweight pneumatic actuators for robotics and rehabilitation** enables cutting edge human scale applications
- The **Fluid Power in Engineering** initiative embeds fluid power content into core undergraduate curriculum at partner universities
- *Fundamentals of Fluid Power*, a massive open online course, is available on a regular basis at no cost to students and industry practitioners. Thousands of enrollees are introduced annually to the fundamental principles and analytical modeling of fluid power components, circuits, and systems
- The **Research Experiences for Undergraduates (REU) Program**, a 10-week summer program, to recruit motivated engineers to pursue graduate degrees in fluid power

OUR IMPACT

- 50 faculty trained in fluid power research and teaching
- 121 PhD, 150 Masters, and 948 Bachelor's graduates with hands-on experience
- 599 technical journal papers, conference proceedings, awards
- 586 disclosures, 44 patent applications, 7 patents awarded
- 24 new courses and 177 offerings of modified courses with fluid power content
- 20,000+ people impacted through courses, curriculum, and free modules
- 66% of graduates working in fluid power; 26% of graduates remain in academia



WHAT WE DO

Industry Relations: The CCEFP connects the various stakeholders in the fluid power supply chain --OEMs, manufacturers, suppliers, distributors-- with academic researchers through networking activities and events. Engaged industry representatives network with academic faculty and students.

Academic Relations: CCEFP cultivates relationships with academic researchers through sponsored research, networking activities, dissemination opportunities, campaigns to answer federal research solicitations, and government advocacy.



HOW WE DO IT

Industry Engagement Committee (IEC): The IEC serves as the advisory board of the CCEFP. The committee helps to define key strategies and initiatives for the CCEFP.



Webinars: Faculty, students, and guests present monthly webinars on fluid power research initiatives and special topics for CCEFP industry members and academic partners.

Summits: Industry supporters, university faculty, and student researchers network to learn of progress and discuss the results of fluid power research and innovation. Summits are held twice a year at partner universities.

Workshops: Focused workshops to discuss fluid power research and technology needs of its industry members. Outcomes include industry-directed research topics, formation of research teams, and campaigns to answer broad federal requests.

Engagement Programs: At CCEFP events, structured engagement programs for industry and students are provided such as speed meetings, poster sessions, and commercialization pitches.

OUR IMPACT

- 38 CCEFP events with over 2,500 attendees --NSF-CCEFP Site Visits, Fluid Power Innovation & Research Conferences, Summits, special topic workshops, and fluid power bootcamps
- Host institutions or organizations of CCEFP events include: Argonne National Laboratory, Iowa State University, Georgia Institute of Technology, Milwaukee School of Engineering, National Renewable Energy Laboratory, North Carolina A&T State University, Oak Ridge National Laboratory, Purdue



University, Texas A&M University, University of Illinois Urbana-Champaign, University of Kentucky (future), University of Minnesota, and Vanderbilt University

- More than 120 IEC conference calls
- 12 IEC Chairs and Vice-chairs
- 190 research, State of the Center, and guest industry presentation webinars
- Over 70 company sponsors that represent the entire fluid power industry spectrum
- Over \$7,000,000 of industry sponsorship



The CCEFP is dedicated to meeting the technology and workforce development needs of the U.S. fluid power industry. By combining the financial and volunteer contributions of many companies and individuals in a concerted effort, the Center creates the resources, partners, and opportunities needed to tackle industry's greatest challenges.

WHAT YOU GET

Through support and engagement, companies can:

- Stay abreast of new developments in fluid power technology
- Access leading researchers and research facilities
- Interact with and recruit fluid power knowledgeable students with systems engineering experience
- Gain competitive insights by networking with customers, suppliers, and competitors
- Focus Center-funded research on industry needs
- Ensure fluid power visibility at a national level
- Participate in government-funded initiatives

HOW WE DO IT

- Provide access to research progress and results
- Invite sponsors to networking events attended by researchers and students
- Allow sponsors to designate funds toward research topic areas
- Invite sponsors to appoint one representative to serve on the Industry Engagement Committee (IEC)
- Solicit IEC research topic recommendations for CCEFP call for proposals
- Encourage IEC participation in the Center's proposal review process, research progress, and mentorship
- Notify, explain, and provide collaboration opportunities on government fluid power initiatives
- Designate funds for research, events, education programs, and operating costs (to be capped annually)
- Publish an annual report of funds raised and activities supported

CCEFP Sponsorship Structure

Company size	Annual global fluid power sales	CCEFP Sponsorship
Very Large	Over \$1.5 billion	\$60,000
Large	Between \$500 million and \$1.5 billion	\$40,000
Medium	Between \$50 and \$500 million	\$20,000
Small	Between \$10 and \$50 million	\$10,000
Start-Up	Below \$10 million	\$1,000
Sponsorship Responsibilities & Oppo	rtunities	
Recommend the selection of pre-competitive CCEFP-funded fluid power research projects		1
Invitation to CCEFP Summits, Fluid Power Innovation & Research Conference, and other special events		1
Participation in Industry Engagement Committee monthly teleconferences, research, and special topic webinars		1
Early access to research progress and results		1
Networking opportunities with students, faculty, and other industry supporters		1
Notification of government funding programs and industry/academic partnerships		1
Leverage government relations initiatives creating fluid power research programs		1
Optional tax-deductible donation		1
Sponsorship Supports		
CCEFP research projects, events, fluid power government relations programs, webinars, supplemental research grants, travel, and operations		1

CCEFP