

BSE

Biological Systems Engineering Department

2022 ANNUAL REPORT

In remembrance of
Alan Pettibone

Success Stories
from Alumni

Agricultural Engineering
at WSU History Book



WASHINGTON STATE UNIVERSITY

College of Agricultural, Human,
and Natural Resource Sciences

CONTENTS

01 | WHAT IS BIOLOGICAL SYSTEMS ENGINEERING?

02 | LETTER FROM THE CHAIR

06 | IN REMEMBRANCE OF ALAN PETTIBONE

08 | RESEARCH

Juming Tang inducted into the National Academy of Inventors 2021 class of fellows	9
Shulin Chen receives Innovation and Entrepreneurship Award	9
WSU flower thinning robot	10
Lignin-based jet fuel packs more power for less pollution	11
Sustainable jet fuel based on lignin	12
Automated drones could scare birds off agricultural fields	14
Sindhuja Sankaran and Joan Wu honored with CAHNRS 2022 faculty excellence awards	15
WSU's Lav Khot, colleagues receive multi-state award for ag drone research, Extension	16
History book chronicles 130 year evolution of agricultural engineering at WSU.	17

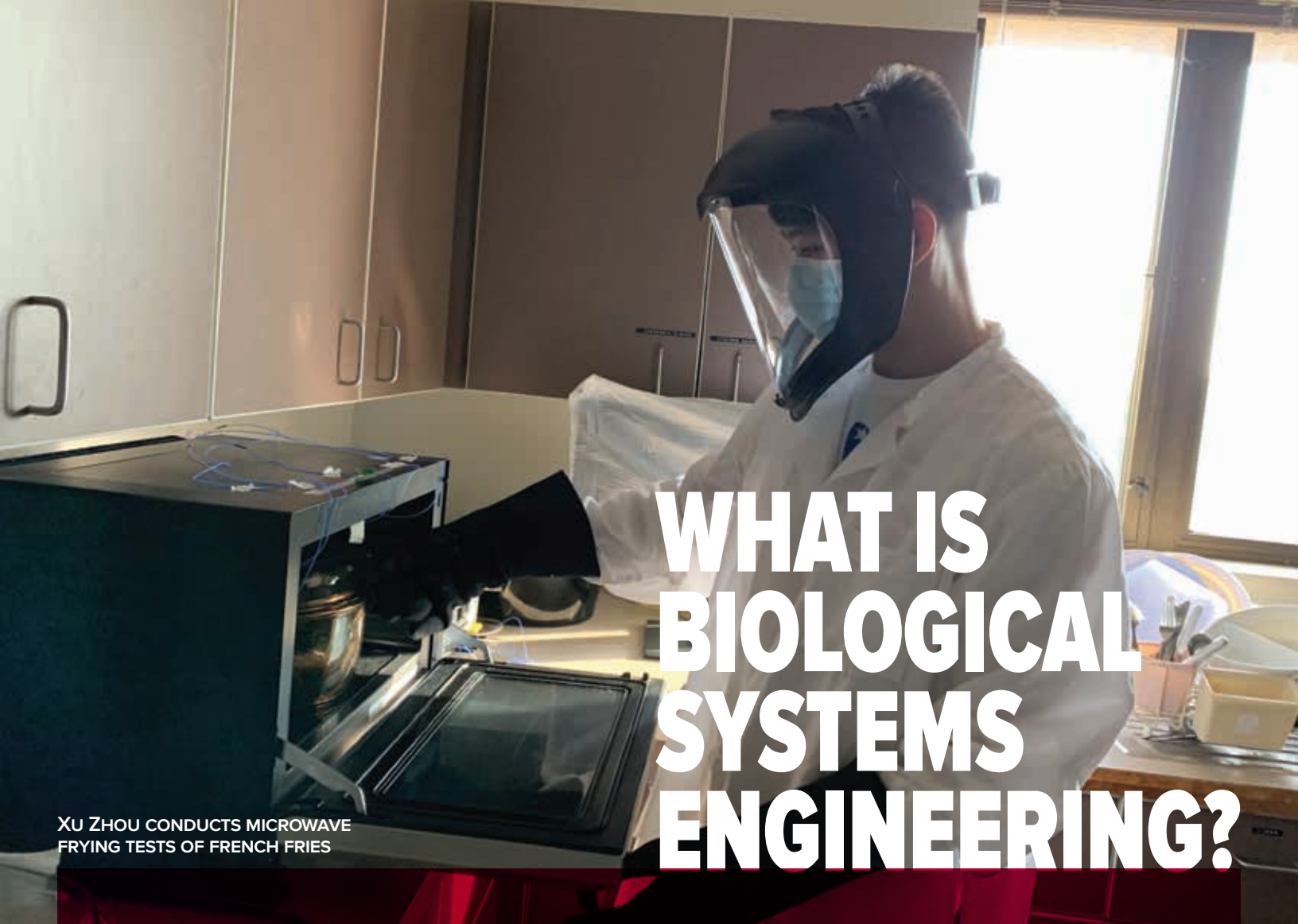
21 | OUTREACH & PARTNERSHIPS

BSE faculty research and outreach make local and global impact	19
Administrative Team	26
Visiting Scholars	27
Our Affiliated Faculty	28
Our Adjunct Faculty	29
Success stories from alumni	30
Cultivating excellence: Empowering the next generation in agriculture	34
Students and faculty participate in 2022 ASABE annual international meeting	35
Partners in University Initiatives	36

37 | ACADEMICS

Students Awards and Recognitions	38
Poster Awards and Best Graduate Seminar Presenters	41
Departmental Awards and Recognition for Students	41
Graduate Student Clubs	42
Welcoming new BSE Students	48
2022 Graduates	49
2022 Peer Reviewed Publications	51
Conference and Symposium Announcements	55
Support Biological Systems Engineering	56
BSE History Celebration, August 2022	57





XU ZHOU CONDUCTS MICROWAVE
FRYING TESTS OF FRENCH FRIES

WHAT IS BIOLOGICAL SYSTEMS ENGINEERING?

Washington State University's Department of Biological Systems Engineering (BSE) trains students and serves society by developing engineering solutions for sustainable agriculture, food, energy, and water. Our internationally prominent programs connect Washington state with the world.

BSE scientists discover and apply engineering principles and methods to the processes of our natural world. We also provide advanced graduate education to engineering professionals. Faculty and students work in one of four primary areas:

- Agricultural Automation Engineering
- Bioenergy and Bioproducts Engineering
- Food Engineering
- Land, Air, Water Resources and Environmental Engineering (LAWREE)

Ranked fifth nationally and eighth globally for

research by EduRank, BSE develops engineering solutions to address some of our most pressing contemporary needs: adaptation and resilience to global warming; robotics and digital agriculture that increase productivity; and new technologies for food quality and safety, improved nutrition, and a healthier environment.

BSE research teams and infrastructure are based at four locations throughout Washington: the WSU Pullman campus, the WSU Tri-Cities campus, and the Research and Extension Centers at Prosser and Puyallup. World-class laboratories in each of these locations address the key issues faced by agriculture in Washington and globally.

This newsletter reports our latest accomplishments and advances to foster involvement and awareness from our partners, stakeholders, and friends.

LETTER FROM THE CHAIR

2022 was the third year of the COVID-19 pandemic and my second year as BSE department chair. As with the previous year, it was a period of intense learning and growth.

I want to start by thanking our faculty, staff, and students for their support and friendship. I especially want to thank Professor Shyam Sablani, who very kindly accepted the role of acting department chair during my sabbatical leave in the second half of the year. During those six months, intensive search and interview activities took place, leading to the hire of two new, outstanding food engineering faculty members (Young-Soo Lee and Kang Huang) who joined our department in fall 2023. This was not the first time Shyam has played administrative and leadership roles in the department. Thank you very much, Shyam, for your great contributions.

This annual newsletter has become one of the best ways I have to communicate our department's great achievements. The work led by former Department Chair Larry James produced the first volume of the departmental history book in 2022 as we celebrated our 100th anniversary. This work was supported by other former and retired department chairs, including Ralph Cavalieri, Denny Davis, and Claudio Stöckle, which truly manifests the department's collegial spirit. My appreciation for their work and contributions to the unit's development multiplied with this experience.

At the recommendation of Larry James, we will continue to celebrate 1918 as the department's founding year. The 1918 catalog included James P. Fairbank as acting head of the Department of

Agricultural Engineering for the first time. Thus, in 2022, our department officially celebrated its 104th anniversary.

The activities in summer 2022 served as a platform to bring together our current and former faculty, students, and staff as we highlighted our achievements during the last century. We also celebrated the retirement and contributions of two of our former department chairs: Professors Ralph Cavalieri and Claudio Stöckle. Professor Larry James took the initiative to start writing the second volume of a history book centered on the accomplishments of our current and past faculty members. It will be released in fall 2023.

In summer 2022, we also received the great news that our distinguished alumnus, Professor Norman Scott, and his family decided to create the department's first endowed professorship. Professor Scott honored us with his presence during our 2022 celebration activities in Pullman, as did several other alumni and their families.

The main takeaway of our 2022 celebration was that the BSE department goes beyond a single life, and that we are building our unit's future on the shoulders of giants. BSE is a huge social enterprise, and generations have invested their lives, their dreams, and their humanity to build what we have today. Each generation brings a new feature to the department, and we must keep adding new dimensions that will propel our unit to continued excellence throughout the next century.

Many of our educational and outreach activities were born and grew during the tenure of Professor L.J. Smith. In 1947, the



Manuel Garcia-Pérez
Department Chair & Professor

department acquired a formal research mandate. In 1950, our BS in agricultural engineering was accredited. In the 1960s and '70s, talented young engineers trained by the generation of June Roberts (John Simpson, Alan Pettibone, Larry King, Gary Hyde, Denny Davis, Larry James) left their Washington homes to conduct their PhD studies at the leading institutions on the East Coast (mainly Cornell University). Upon their return, they built the foundation for a highly productive, research-intensive department.

The hiring of Ralph Cavalieri, Claudio Stöckle, Gustavo Barbosa-Cánovas, Juming Tang, and Shulin Chen in the '80s and '90s further grew our department's research prominence. These faculty members led the creation of centers of excellence such as the Bioproducts Sciences, & Engineering Laboratory (BSEL), the Center for Precision & Automated Agricultural Systems (CPAAS), and the Center of Excellence for Food

Safety. The new generation hired over the last 20 years took advantage of these centers to increase productivity and gain national and international relevance in better conditions than the preceding generation. The department faces financial challenges, but this is not the first time. Despite the challenges, our faculty members and administrators have always had the will to move to the next level. Our department's gradual evolution over the last century was driven by mechanical, irrigational, and electrical revolutions that radically transformed eastern Washington agriculture from a marginal contributor to the state's economy to one of the most productive agricultural regions in the world, with more than 300 different crops. 70% of the apples (\$2.185 billion) sold in the United States come from Washington state. Washington is the country's main producer of blueberries (\$228 million), hops (\$482 million), pears (\$176 million), spearmint oil (\$80 million), and sweet cherries (\$820 million). It is the second most prolific state in the production of apricots, asparagus (\$30 million), grapes (\$301 million), potatoes (\$888 million), and raspberries. It is the third most prolific state in the production of barley, dried peas, dry onions, lentils, and peppermint oil. We are the nation's fifth largest wheat-producing state (\$756.8 million). We are very lucky to work in an institution tasked with growing such a dynamic industry.

I am convinced that our best years still lie ahead. We are on the verge of important revolutions — precision agriculture, artificial intelligence, and automation — and our faculty members are prepared and willing to be leaders in these transformations. We need to grow CPAAS and recruit the best and brightest researchers and Extension specialists to create an industrial ecosystem in Washington state with the capacity to lead these revolutions.

The same is true in the circular economy/clean energy area. The progress in clean electricity, hydrogen production, marine and airplane fuels, biochar production, and the development of new wastewater and animal organic waste treatment methods suggests that technologies are aligning in a critical mass to create viable industrial ecosystems capable of fighting global warming.

Such transformations will propel economic growth and could convert eastern Washington into the industrial engine of the state. Our department, in collaboration with Pacific Northwest National Laboratory (PNNL), is well-positioned to play an important role in these revolutions. As with CPAAS, the WSU-PNNL Institutes (the Bioproducts Institute, the Advanced Grid Institute, and the Nuclear Science and Technology Institute) should attract industrial players and create a critical mass to increase our impact on these transformations. BSE faculty members should be important players in these initiatives. The quest for healthy and nutritious foods and stewardship of our natural resources are also major societal drivers that should propel the growth of our food engineering and LAWREE programs.

We must be aware that growth will be painful. The material resources available will never match our expectations or needs. We will need to drive the unit's growth with our passion and unconditional commitment to do as much good as we can and build a better world with whatever resources we can acquire. As Norm, Larry, Danny, Ralph, Claudio, and Juming did, it is critical to think strategically and focus on recruiting, mentoring, and supporting new faculty members.

This newsletter is also a place to celebrate our unit's achievements in 2022. Our faculty's overall impact and relevance is evident from the 138 peer-reviewed articles published, the 1,347 average citations per faculty, and the average h-index of 54. According to Google Scholar, nine of our faculty members are among the 60 most cited WSU researchers.

BSE's impact is multidimensional and materializes in our work with farmers to improve irrigation, reduce erosion, manage nutrients, develop robots to address labor shortages, fight global warming, and develop a circular economy. Professors Tang and Chen have been recognized for the commercialization of their technologies by their induction into the National Academy of Inventors. Professor Manoj Karkee has been developing flower-thinning robots and using drones to deter birds from agricultural fields, with the potential to solve important agricultural problems in our state. Lav Khot also has a very active drone program that is applicable to agriculture. His achievements were recognized with the 2022 National Excellence in Multistate Research Award from the Experiment Station Section (ESS) unit of the commission's Board on Agriculture Assembly for his research and extension work in unmanned aircraft systems (UAS) applications for U.S. agriculture and natural resources. WSU is a world leader in sustainable aviation fuels (SAF) production, and BSE is making important contributions. Professor Bin Yang's work on converting lignin to SAF and my group's work on the co-hydrotreatment of pyrolysis oils and yellow greases are technologies with great commercialization potential.

Although the department only has three female faculty members (Joan Wu, Kirti Rajagopalan, and Sindhuja Sankaran) I do not have words to express my admiration for their impressive professional and personal achievements. Last year, Joan Wu was recognized for CAHNRS excellence in advising, and Sindhuja Sankaran was honored with the CAHNRS Early Career Excellence Award. Although I take every opportunity to privately express my admiration and appreciation to Joan and Sindhu, I want to convey in this newsletter that they are a source of inspiration and wisdom for the unit. Thank you, Joan and Sindhu, for all your teachings and accomplishments. As part of our commitment to equity and inclusion, our department should work harder to increase the number of female faculty members.

Although 2022 was a challenging year, our department successfully operated thanks to the great job of our administrative staff (Dorota Wilk, Joanna Dreger, Nina Wills, and Marcelo Martinez). The changes in the CAHNRS service center added a lot of extra work for the

unit. I am very thankful that Rich Koenig approved the return of two staff member positions — Nina Willis and Marcelo Martinez — to the department, which were transferred to form the service center few years ago. Thank you to both of them for a great job the first year and thank you to Dorota for her time spent training them.

Last year was very productive for the department. Of the 58 PhD students and nine master's degree students enrolled in our graduate program, 21 graduated. Our overall level of expenditure was \$ 5.8 million (\$342,000 per faculty member), with an output of 138 peer-reviewed publications. According to the 2022 U.S. News & World Report Best Graduate Schools, our program ranks 14th among its peers. Our program is the WSU engineering program best ranked. In terms of research productivity, our department was ranked fifth in the U.S. and eighth in the world by EduRank (<https://edurank.org/engineering/agricultural/>).

The department is seriously studying new

paths for growth. Hanwu Lei continues to evaluate the viability of a new agricultural engineering program at WSU Tri-Cities and WSU Pullman. A committee created in 2020 and led by Shyam Sablani is progressing toward creating online certificates and master's degree programs in each of our four focus areas: food engineering, biomass processing and bioproducts, agricultural automation, and land and water resources. In 2022, the department officially welcomed Liang Yu as a career track assistant professor. Last year, the department appointed Pavlo Bohutskyi from PNNL as a BSE joint professor.

I am humbled and honored by the opportunity to lead our program through a unique period of great challenges and exceptional opportunities. Through its world-class faculty, staff, and students, the department will grow to better serve our students, the region, the state, the nation, and the world.

Thank you for your hard work in 2022!

As always, Go Cougs!



CURRENT AND FORMER DEPARTMENT MEMBERS CELEBRATING 100 YEARS OF AGRICULTURAL ENGINEERING AT WSU, AUGUST 2022.

OVERALL DEPARTMENT INDICATORS 2022

\$5.8M Overall departmental research expenditures

Average faculty expenditure:
\$342k

138
Number of peer-reviewed publications

Average publications per faculty member **9**

Number of PhD students: **Spring: 59; Fall: 51** (graduated in 2022: 18)

Number of MSc students: **Spring: 10; Fall: 11** (graduated in 2022: 3)

1,347

Average number of citations per faculty member

Average h-index: **54**

According to Google Scholar, **9 BSE FACULTY** are among the **60 most cited researchers** at WSU

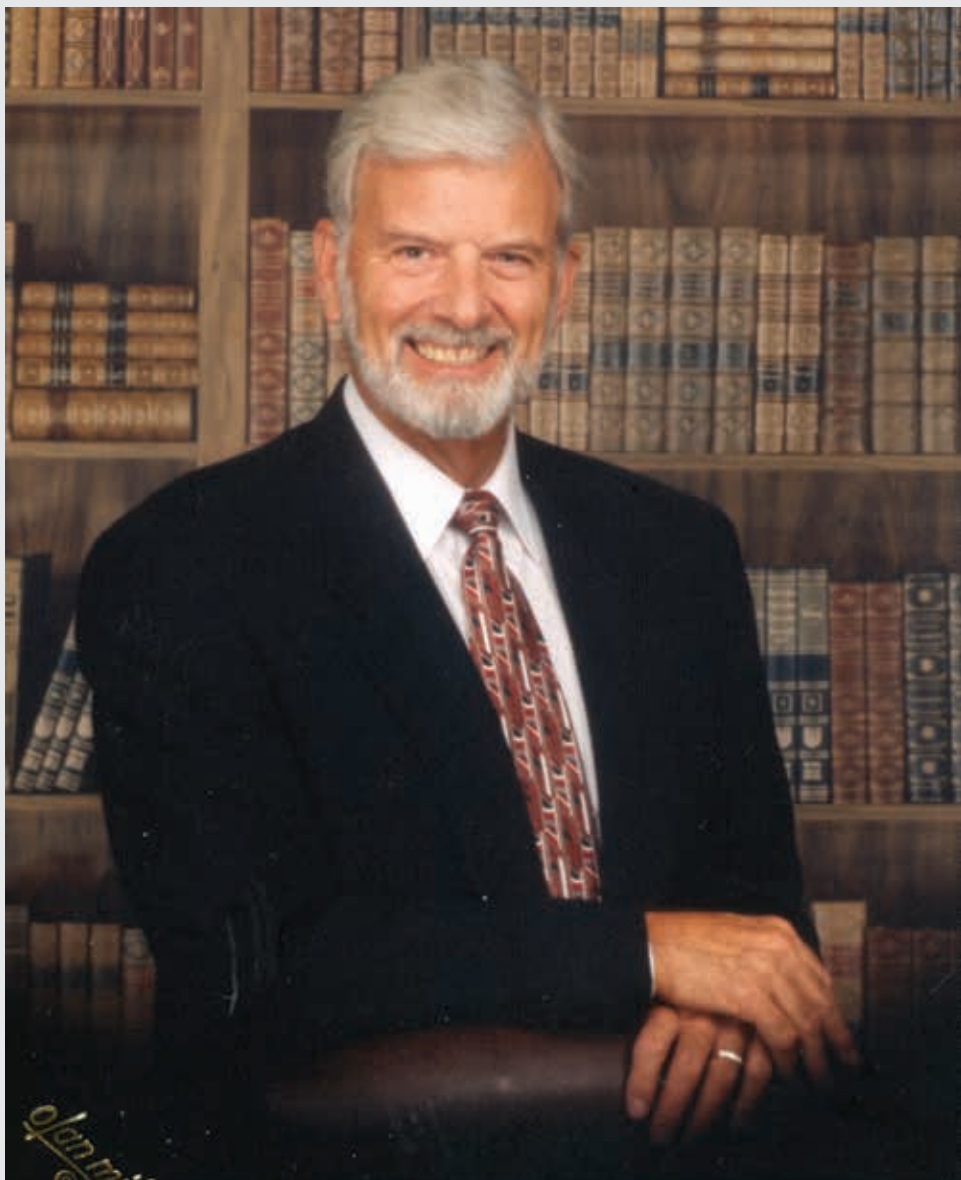


In **EduRank**, BSE is ranked **5TH IN THE U.S.** and **8TH IN THE WORLD** for agricultural engineering (edurank.org/engineering/agricultural)

In a recent **U.S. News & World Report**, WSU **RANKS 14TH** for agricultural engineering

IN REMEMBRANCE OF

ALAN PETTIBONE 1932-2023



Clifford Alan Pettibone had a profound impact on the department, the university and Washington state agriculture.

Pettibone was born March 29, 1932, in Redmond, Ore., and raised on a farm near Steptoe, Wash. He was appointed assistant professor and assistant agricultural engineer at WSU on Sept. 1, 1965. He earned a BS in agriculture with a minor in farm mechanics in 1954,

and BS and MS degrees in agricultural engineering in 1960 and 1965, respectively, all from Washington State College (WSC)/WSU. He joined the WSU faculty after two years as an officer in the Army Corps of Engineers (1955-57), three years as an experimental aide in the WSU Department of Agricultural Engineering (1957-60), and five years with the U.S. Department of Agriculture

(USDA) as a research agricultural engineer (1960-65).

From 1969 to 1970, Pettibone took leave without pay for 15 months to be a National Science Foundation fellow at Cornell University and study for his PhD. He returned to WSU in fall 1970 to resume his faculty assignment while continuing his PhD. In 1972, Pettibone's title was changed to assistant professor of agricultural engineering and food science and technology when he became a joint member of the Department of Agricultural Engineering and the newly formed Department of Food Science and Technology (his salary line remained in the Department of Agricultural Engineering). He received a PhD from Cornell University in 1973, was promoted to associate professor on July 1, 1974, and advanced to professor on July 1, 1978. He was a registered professional engineer in Washington.

Pettibone taught freshman orientation, agricultural processing, and electric power courses in both agricultural engineering and agricultural mechanization, as well as instrumentation and measurement and systems design in agricultural engineering. He was an academic advisor to undergraduate agricultural engineers and served on numerous graduate committees and chaired many others. Students in the department nominated him four times (1967, 1968, 1969, and 1975) for the College of Agriculture's R. M. Wade Award for Excellence in Teaching. He was honored as a "featured teacher" in the College of Agriculture in 1975.

Pettibone's research included heat flow and distribution in soil; soil temperature and plant growth; storage of early harvest potatoes; cooling and storage requirements of sugar beets; electricity on Washington farms; effects of artificial light and other environmental factors on chickens; carbon dioxide control in air-supported greenhouses; and controlled environments for egg storage and transport. He authored more than 50 technical publications and was twice the recipient of the American Society of Agricultural Engineers (ASAE) Outstanding Paper Award (1965 and 1970). He was named engineer of the year in the Inland Empire section of ASAE in 1976 and the Pacific Northwest region of ASAE in 1978.

Pettibone was very active in ASAE, holding several regional and national offices, including Pacific Northwest regional director (1977-78). He served on numerous ASAE committees, chairing many of them, and was elected ASAE fellow in 1984. He was also a member of the American Society for Engineering Education.

Pettibone became chair of the Department of Agricultural Engineering upon Professor June Roberts' retirement on July 1, 1975. His immediate challenge was improving the depth, quality, and productivity of the department's research program while maintaining quality teaching. This was accomplished by increasing college and external grant funding; recruiting new faculty who demonstrated ability and commitment to high quality research and teaching; and implementing faculty performance

reviews and outcome-based resource allocation. These efforts increased the number of grant proposals and grants funded, the amount of outside funding for research, the number of research presentations and referenced journal articles, and undergraduate and graduate student enrollment.

On July 1, 1979, Pettibone was promoted to associate dean and director of resident instruction of the College of Agriculture. He continued as chair of the Department of Agricultural Engineering, serving as both associate dean and department chair, until Nov. 1, 1979, when a national search was completed and a new chair (Larry King) was hired. Pettibone served as acting dean of the College of Agriculture and Home Economics from November 1981 to September 1982, and then continued as associate dean through 1984.

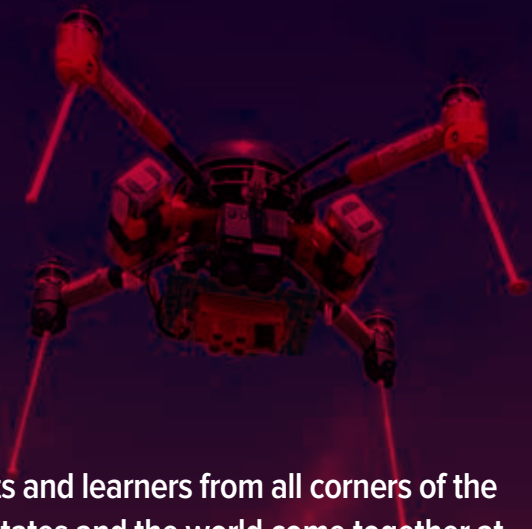
Early in 1985, Gov. Booth Gardner asked Pettibone to be a member of his cabinet and a director of the Washington State Department of Agriculture (WSDA). He was appointed Jan. 16, 1985, after successfully negotiating to remain a tenured WSU employee and to expand WSDA's role in the formulation of environmental policy and the marketing of agricultural commodities and processed food products.

For eight years, Pettibone managed WSDA's eight divisions and its more than 500 employees stationed throughout the state. He negotiated the transfer of the market development program for processed food products from the State Department of Trade and Economic

Development to WSDA. He opened an agricultural trade office in Japan, making Washington the first state to do so. An international marketing program recognized as one of the best and most successful in the nation was developed under his leadership. He also provided essential leadership in formulating a strategic plan for the food and agriculture industry: "Ag 2000: Economic Strategies for Washington Agriculture." This plan was presented to the legislature in 1988 as part of the Washington State Economic Development Board's comprehensive plan, "Washington Works Worldwide."

Pettibone was an active member and president (1988-89) of the Western U.S. Agricultural Trade Association. As a member of the National Association of State Departments of Agriculture, he served on several working committees and was elected president (1990-91), the first from Washington elected in 40 years. In that role, he negotiated the successful merger of two major international food shows. He hosted the International Agriculture and Food Exposition in Seattle, which attracted exhibitors and buyers from around the world. He was also a member of many other boards, councils, and committees.

Pettibone returned to WSU in 1993 to finish his career, serving as interim assistant director of Extension's Agriculture and Natural Resource Program (1993-95) and superintendent of the Puyallup Research and Extension Center (1995-96). Pettibone retired in 1996. He passed away on April 5, 2023.



BIOLOGICAL SYSTEMS ENGINEERING **RESEARCH**

Scientists and learners from all corners of the United States and the world come together at BSE. Research in our department generates knowledge and develops technologies for environmental stewardship, renewable

energy, productive and sustainable agriculture, and safe and nutritious foods. The following section showcases current advances and milestones, alumni success stories and awards, and more.



GAJANAN KOTHAWADE, DR. LAV KHOT, AND DR. ABHILASH CHANDEL.

Shulin Chen receives Innovation and Entrepreneurship Award

WSU Showcase | March 25, 2022

Shulin Chen’s technological innovations have made industrial processes more sustainable. Chen develops bioconversion processes and systems used in the production of biofuels, bioenergy, and bioproducts.

Using anaerobic digestion systems, his research team invented a process to convert manure and other dairy

industry waste to bioenergy. These systems reduce greenhouse gas emissions and recover nutrients from wastewater, alleviating concerns about surface and groundwater pollution. Six anaerobic digestion systems are now functioning throughout Washington.

WSU established the Innovation and Entrepreneurship Award in 2018. Chen is the 2022 recipient.



Shulin Chen
Professor

Juming Tang inducted into the National Academy of Inventors 2021 class of fellows

December 2021 | WSU Research

Juming Tang, Regents Professor in WSU’s Department of Biological Systems Engineering, was inducted into the National Academy of Inventors’ (NAI) 2021 class of fellows.

“Congratulations to Matthew McCluskey and Juming Tang for their induction as NAI members,” said Sita Pappu, assistant vice president for the WSU Office of Commercialization “Through research and discovery, their innovations provide cutting-edge solutions to challenges that will benefit society and influence science,

technology, and innovation worldwide.”

Tang has invented and commercialized electromagnetic spectrum wave-based food processes. He has focused his research on advancing thermal processing technologies and supporting knowledge for control of bacterial and viral pathogens in foods with minimum adverse effects on taste and nutrition.

Tang’s laboratory has developed two commercially viable technologies based on 915 megahertz microwaves for the production of high-quality ready-to-eat meals with extended shelf-lives



Juming Tang
Regents Professor

in different storage conditions. The unique engineering designs, which allow predictable and rapid heating of pre-packaged food while eliminating pathogens, are intended to replace the traditional industrial method of canning.

WSU flower thinning robot

April 26, 2022 | Wake Up Northwest
on NBC Right Now.com

Manoj Karkee reports that the agricultural automation group in WSU's Department of Biological Systems Engineering has begun testing its newest robot.

The robot is designed to produce a more stable and efficient pollination and thinning process. The robotic pollinator includes a camera that can detect flower blossoms and determine which ones need to be pollinated or thinned. Through trial and error,

students are working to find the right stage for fruit flower pollination

Karkee is trying to develop a robotic solution with a camera that works like human eyes to take pictures. The robot would have an artificial intelligence model — similar to a human brain — running on a computer, with the ability to detect flowers and send a signal to the robot's controller. This would signal the robot where to start thinning the flowers. Once the robot learns how to pollinate flowers, Karkee thinks the method could be used to replace honey bees.



Manoj Karkee
Professor

https://www.nbcrightnow.com/wsuflowerthinningrobot/video_e94902d2-c5cb-11ec-9a35-4b3018a54b5f.html

PHD STUDENTS ZIXUAN HE AND ACHYUT PAUDEL
DEMONSTRATE ROBOTIC FLOWER THINNING WITH A NOVEL,
SOFT, GROWING MANIPULATOR AT WSU CENTER FOR
PRECISION AND AUTOMATED AGRICULTURAL SYSTEMS.



Lignin-based jet fuel packs more power for less pollution

By Seth Truscott, College of Agricultural, Human, and Natural Resource Sciences

PULLMAN, Wash. – An experimental plant-based jet fuel could increase engine performance and efficiency while dispensing with aromatics, the pollution-causing compounds found in conventional fuels, according to new research.

In a study published in the journal *Fuel*, researchers analyzed a WSU-developed jet fuel based on lignin, an organic polymer that makes plants tough and woody.

Using a range of tests and predictions, the researchers examined fuel properties critical to jet engine operation, including seal swell, density, efficiency, and emissions. Their results suggest that this sustainable fuel could be mixed with other biofuels to fully replace petroleum-derived fuels.

“When we tested our lignin jet fuel, we saw some interesting results,” said Bin Yang, a professor with WSU’s Department of Biological Systems Engineering and corresponding author on the study. “We found that it not only had increased energy density and content but also could totally replace aromatics, which are a real problem for the aviation industry.”

“Aromatics are associated with increased soot emissions, as well as contrails, which are estimated to contribute more to the climate impact of aviation than carbon dioxide,” said Joshua Heyne, study co-author, a University of Dayton scientist, and the current co-director of the joint WSU-

PNNL Bioproducts Institute. “Aromatics are still used in fuel today because we do not have solutions to some of the problems they solve. They provide jet fuel with a density that sustainable technologies do not. Most unique is their ability to swell the O-rings used to seal metal-to-metal joints, and they do this well.”

“We want to fly safely, sustainably, and with the lowest impact on human health,” Heyne added. “The question is, how do we do all of this as economically as possible?”

Yang developed a patented process that turns lignin from agricultural waste into bio-based lignin jet fuel. Such sustainable fuel could help the aviation industry reduce its dependence on increasingly expensive fossil fuels while meeting higher environmental standards.

The WSU-developed, lignin-based fuel’s properties “offer great opportunities for increasing fuel performance, higher fuel efficiency, reduced emission, and lower costs,” the authors wrote in *Fuel*. “The fact that these molecules show sealant volume swell comparable with aromatics opens the door to develop jet fuels with virtually no aromatics, very low emissions, and very high-performance characteristics.”

“The lignin-based fuel we tested complements other sustainable aviation fuels by increasing the density and, perhaps most importantly, the ring-swelling potential of blends,” Heyne said. “While meeting our material needs, these sustainable blends confer higher



Bin Yang

Professor

energy densities and specific energies without using aromatics.”

“This process creates a cleaner, more energy-dense fuel,” Yang added. “That’s exactly what sustainable aviation fuels need for the future.”

Additional contributors to the study include Zhibin Yang, University of Dayton; Zhangyang Xu and Maoqi Feng, WSU; John Cort, PNNL; and Rafal Gieleciak, Natural Resources Canada.

Yang and his team’s research has been supported by the Defense Advanced Research Projects Agency through the U.S. Department of Defense, the U.S. Department of Energy’s Office of Energy Efficiency & Renewable Energy, the National Science Foundation, the U.S. Department of Transportation’s Sun Grant Initiative, the National Renewable Laboratory, the Joint Center for Aerospace Technology Innovation, and WSU’s Bioproducts, Sciences, and Engineering Laboratory.

The paper, “Lignin-based jet fuel and its blending effect with conventional jet fuel,” published online April 15. It appeared in the Aug. 22 edition of *Fuel*.

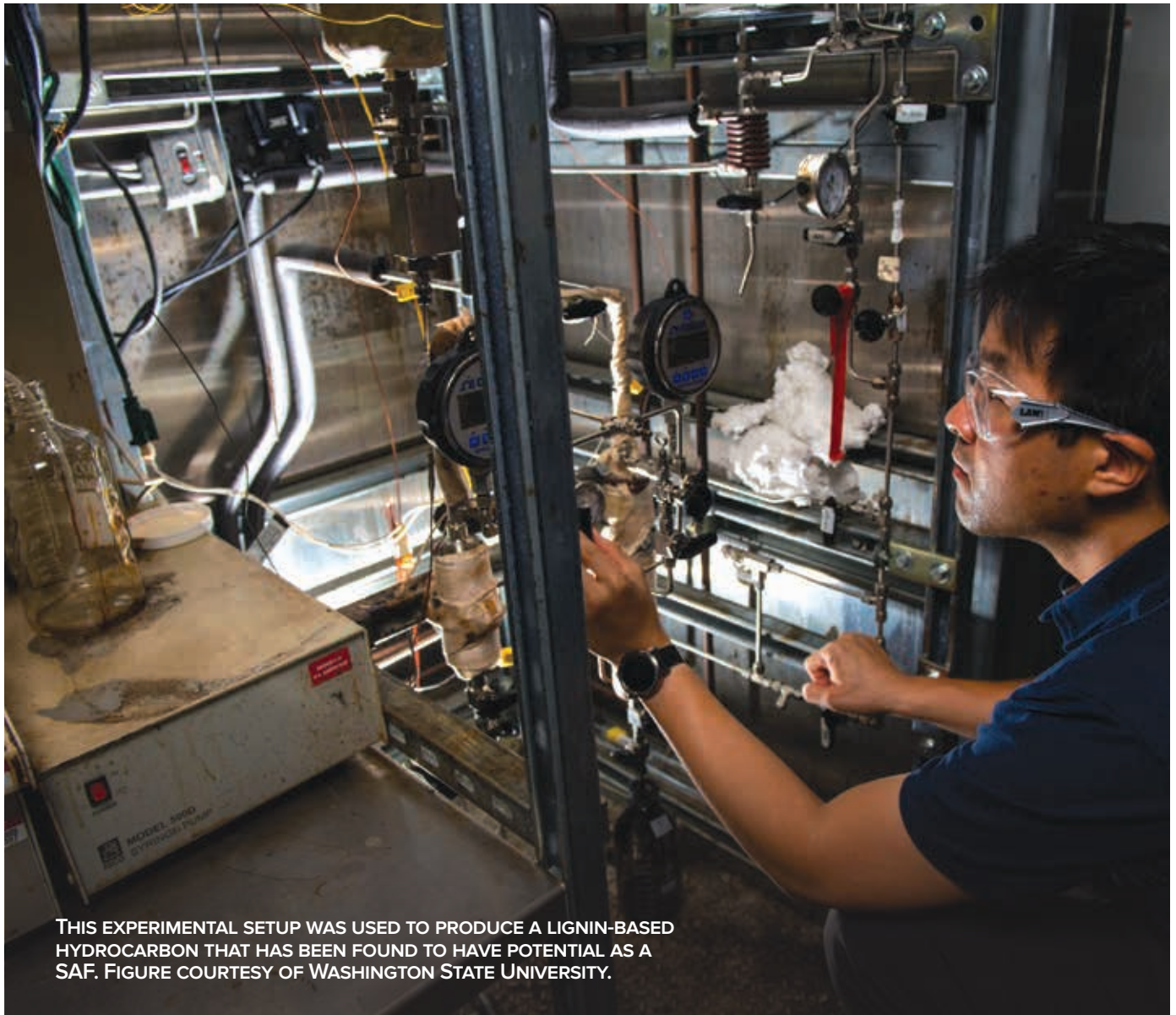
Sustainable jet fuel based on lignin

Jet fuel has a 1%-2% carbon footprint, which does not place a large impact on the environment but is still noteworthy particularly with the growing demands that are now placed on aviation globally. Much of the growth has come from medium and long-haul flights, which represent approximately 73% of total carbon dioxide emissions.

In a previous TLT article,¹ researchers developed a sustainable jet fuel based on the intermediate isophorone that can

be produced from acetone through a pathway that starts with natural sugars. The key step is to convert isophorone, a cyclohex-ene derivative, into a cyclobutane derivative through a (2+2) cycloaddition reaction using ultraviolet light. Testing this cyclobutane derivative versus the main commercial jet fuel in the U.S., Jet-A, showed an energy density improvement of 30% when the naturally derived product was used at a 30% treat rate.

Bin Yang, professor in the Biological Systems Engineering Department at Washington State University (WSU) in Richland, Wash., says, “Besides using jet fuel, other propulsion options such as batteries and fuel cells are not suitable for use in long-distance airplane travel in the near future (less than 30 years). This places the aviation industry in the position of needing to find a sustainable alternative to Jet-A. One big concern with using the incumbent jet fuel is its



THIS EXPERIMENTAL SETUP WAS USED TO PRODUCE A LIGNIN-BASED HYDROCARBON THAT HAS BEEN FOUND TO HAVE POTENTIAL AS A SAF. FIGURE COURTESY OF WASHINGTON STATE UNIVERSITY.

aromatic content, which varies from approximately 8% to 25% by volume, which is key to the density and seal swell characteristics of jet fuel but increases engine soot production. Some approved alternative jet fuels, such as synthetic paraffinic kerosene (SPKs), need the addition of aromatics and others contain aromatics. Ultimately, the aviation industry is seeking a 100% sustainable aviation fuel that produces no emissions.”

One other option that was considered is the use of hydrogen turbine propulsion, but Yang believes this is not an option due to issues with increased NO_x emission and contrail formation, which may be more important to radiative forcing than carbon dioxide.

The other challenge to approving a sustainable jet fuel is the large number of tests required. Yang says, “A long approval process is required that includes up to four tiers of testing, two research reports, each with an OEM review and formal ASTM balloting. This means that any new aviation fuel must be produced in large quantities. ASTM has instituted a Fast Track process, but this still requires at least 380 liters of the candidate and is limited to blends of no more than 10% by volume with Jet-A.”

In seeking a sustainable source for jet fuel, lignin, a series of complex polymers that act as support materials in most plants, is a compelling option. Yang says, “Lignin is an appealing material because it is readily available in biomass in large quantities and exhibits a very cyclic structure that is promising for use in jet fuel. Two reasons that aromatics, another cyclic material, are used in jet fuel are density and o-ring swelling characteristics. Preparation of cycloalkanes derived from lignin may produce similar results.”

Yang and his colleagues developed a process for converting biomass-derived lignin into C12-C18 cyclic hydrocarbons that can be used in jet fuel (see Figure 2). Work is now reported to demonstrate that this lignin-based hydrocarbon can be used in jet fuel.

Tier alpha and Tier beta prescreening procedures

The researchers utilized prescreening procedures known as Tier alpha and Tier beta to evaluate the lignin-derived jet fuel at a 10% treat rate in Jet-A. Yang says, “Tier alpha uses analytical techniques such as nuclear magnetic resonance (NMR) and gas chromatography (GC) to predict critical properties. Tier beta includes techniques that directly measure critical properties. Both protocols are small quantity reduction models developed by the U.S. Navy and are used to predict performance in developmental jet fuels that can be used in future testing when larger quantities become available.”

“ **IN SEEKING A SUSTAINABLE SOURCE FOR JET FUEL, LIGNIN, A SERIES OF COMPLEX POLYMERS THAT ACT AS SUPPORT MATERIALS IN MOST PLANTS, IS A COMPELLING OPTION.** ”

Tier alpha analysis found that lignin-derived jet fuel contains mainly one- and two-ring cycloalkanes that represent 86% of the mixture by weight. The remainder consists of n- and isoalkanes (10.7 wt.%) and almost no aromatics and oxygenates.

Tier beta analysis involved blending 90% Jet-A with 10% of the lignin-derived jet fuel. Key physical properties such as

surface tension, density, viscosity at -40 C and -20 C, derived cetane number and flash point were found to be within the specification limits for Jet-A. Evaluations were done empirically and also predicted due to the low volume available for testing.

Calculation of the heat of combustion shows that the lignin-derived jet fuel displays a superior value than Jet-A due to higher seal swell properties and much lower aromatic content that can lead to lower levels of soot generation.

The one parameter of concern for the current lignin-derived jet fuel is viscosity. Joshua Heyne, the new director of the Bioproducts Science and Engineering Laboratory, co-director of the WSU/Pacific Northwest National Laboratory (PNNL) Bioproducts Institute, a Battelle Distinguished professor and associate professor of mechanical engineering in the school of engineering and applied sciences at WSU, says, “All lignin-derived jet fuel blended operability properties fall within the experience range of conventional jet fuel, with neat o-ring swelling exceeding the typical range of conventional fuels. These results support the potential use of this lignin-derived jet fuel pathway to complement other sustainable aviation fuel (SAF) pathways and achieve 100% drop-in SAF.”

This is the future direction for converting lignin into jet fuel.

Additional information can be found in a recent article or by contacting Wang at bin.yang@wsu.edu and Heyne at heyne@wsu.edu.

Automated drones could scare birds off agricultural fields

By Scott Weybright, College of Agricultural, Human, and Natural Resource Sciences

PROSSER, Wash. – In the future, cameras could spot blackbirds feeding on grapes in a vineyard and launch drones to drive off the avian irritants, then watch for the next invading flock. All without a human nearby.

A Washington State University research team has developed such a system, which they detail in a study published in the journal *Computer and Electronics in Agriculture*. The system is designed to have automated drones available to patrol 24 hours a day to deter pest birds like European starlings or crows which cost growers millions of dollars a year in stolen or ruined fruit.

“Growers don’t really have a good tool they can rely on for deterring pest birds at an affordable price,” said Manoj Karkee, associate professor in WSU’s Department of Biological Systems Engineering and the study’s corresponding author. “With further refinement and industry partnerships, this system could work.”

Over a few years, Karkee’s team developed a camera system and algorithm that would find birds and count them as they flew in and out of fields. The team customized very small drones and deployed them for test flights on small plots with simulated birds.

For the study, the team ran two separate tests: one to detect birds and one to deploy drones automatically.

Technologically, the system resembles those used for drone package delivery.

It will be several years before this particular technology is commercially available for growers because there are still hurdles, including scalability, compliance with federal drone regulations, and the ability to continue deterring birds even if drones are commonly flying around.

“Birds are really clever,” said Karkee, who is also affiliated with WSU CPAAS. “They often find ways around deterrents. We don’t want a system that only lasts for a few months or years before they stop being scared off.”

For now, the birds are scared off just by the motion and whirring noises made by drones. But Karkee said that sounds, like distress calls or predatory bird noises, could be added. Builders could even design special drones for the job.

“We could make drones look like predators, or have reflective propellers that are really shiny,” he said. “All of these working together would likely keep birds away from those vineyards and fields. We need to research that

over multiple years to make sure.”

This automation research is the third of three studies concerning drones and bird pests. The first showed that manually operated drones, doing random flights, successfully drive off or keep birds away from vineyards. They found that drones reduced bird counts fourfold.

The second project showed how driving off the birds can impact crop yield. Karkee’s team followed up on the fields where they manually drove birds off. Those fields had around a 50% reduction in damaged fruits.

Karkee plans to meet with growers, technology companies, and other stakeholders to start next steps on working toward a commercially available automated drone system.

“It takes time,” he said. “But the results so far are exciting. We’re looking forward to doing more work on this project.”



A MANUALLY OPERATED WSU DRONE FLIES OVER A VINEYARD DURING TESTS FOR BIRD DETERRENCE AND FRUIT DAMAGE ASSESSMENT. CREDIT: WSU AGRICULTURAL AUTOMATION AND ROBOTICS LAB.

Sindhuja Sankaran and Joan Wu honored with CAHNRS 2022 faculty excellence awards

Sindhuja Sankaran is an associate professor in WSU's Department of Biological Systems Engineering. Her research program focuses on sensor technologies for crop phenotyping and supports plant breeding, crop plant research, and precision agriculture applications.

Sankaran has secured more than \$2.3 million (\$8.8 million in collaborative research) to support her program, mostly from competitive federal grants. Her research and teaching programs support researchers in other CAHNRS

departments and USDA-Agricultural Research Service labs.

Sankaran has published more than 100 peer-reviewed journal articles, including proceedings papers and book chapters. She is a member of the American Society of Agricultural and Biological Engineers, the National Association of Plant Breeders, the North American Plant Phenotyping Network, the International Society of Precision Agriculture, the International Society of Horticultural Science, and the American Society of Agronomy.



Sindhuja Sankaran
Associate Professor

Joan Wu received her BS in geology and her MS in hydrology from Tongji University, her MS in mathematics from WSU, and her PhD in agricultural engineering from Ohio State University.

From 1995 to 1998, Wu was an assistant professor in the Department of Soil & Environmental Sciences at the University of California, Riverside.

Since 1998, Wu has been an assistant professor, associate professor, and professor in the WSU Department of Biological Systems Engineering. Wu has collaborated extensively with

the USDA and the U.S. Forest Service to develop the Watershed Erosion Prediction Project model, a widely used simulation tool for water erosion in the U.S. and worldwide.

Wu teaches courses in surface and groundwater hydrology and is responsible for a department core course called research and teaching methods. She is a registered civil engineer in Washington state and served as WSU's faculty legislative representative from 2014 to 2018.



Joan Wu
Professor

WSU's Lav Khot, colleagues receive multi-state award for ag drone research, Extension

Nov. 7, 2022 By Seth Truscott

Lav Khot, associate professor in the Department of Biological Systems Engineering, was honored by the Association of Public and Land-grant Universities' (APLU) Commission on Food, Environment, and Renewable Resources for ongoing efforts to enhance the role of drones in agriculture.

Khot and colleagues at more than 20 research institutions received the 2022 National Excellence in Multistate Research Award from the Experiment Station Section (ESS) unit of the commission's Board on Agriculture Assembly for their research and Extension work in applications of unmanned aircraft systems (UAS) for

U.S. agriculture and natural resources.

Launching their project in 2016, participating scientists evaluated and identified reliable, cost-effective, and user-friendly drone platforms and sensors to monitor and manage stressors in agriculture and natural resources. To maximize data accuracy, project members developed hardware, software, and detailed protocols for calibrating and using drones. New drone-based strategies can help address challenges in accuracy, from more sustainably using water and chemical inputs to helping growers make better production decisions.

"Over the last five years, our group, which includes members from many land-grant universities, has worked together to break down barriers and increase adoption of drones for remote sensing and precision management of agriculture and natural resources," Khot said. "This is very much a team award, and I'm happy that we're being recognized by peers for our collaborative efforts."

As the project's technical committee chair, Khot helps support the collaboration with administrative advisor Randy Raper of Oklahoma State University. Other participating institutions include Auburn University, University of Arkansas,



Lav Khot
Associate Professor

Arkansas Cooperative Extension, Clemson University, Cornell University, University of Florida, University of Georgia, University of Illinois, University of Kentucky, Louisiana State University, Mississippi State University, Montana State University, North Carolina State University, North Carolina Cooperative Extension, North Dakota Cooperative Extension, Ohio State University, Purdue University, Rutgers University, Stephen F. Austin State University, University of Tennessee, Texas A&M AgriLife Research, and Virginia Polytechnic Institute and State University.

The award was presented Sunday, Nov. 6, 2022, at the APLU Annual Meeting in Denver, Colo.

APLU is a research, policy, and advocacy organization dedicated to strengthening and advancing the work of public universities in the U.S., Canada, and Mexico. The association works to increase degree completion and academic success, advance scientific research, and expand engagement.



WSU's Lav Khot, center, accepts the National Excellence in Multistate Research Award, Nov. 6, at the APLU Annual Meeting in Denver, Colo., with colleague and team academic advisor Randy Raper, right, and Gary Thompson, executive director of the Southern Association of Agricultural Experiment Station Directors.

History book chronicles 130 year evolution of agricultural engineering at WSU



WSU'S L.J. SMITH HALL, CENTER FOR TEACHING AND RESEARCH IN AGRICULTURAL ENGINEERING, PICTURED IN 1949. THE HALL WAS BUILT IN 1947 AS A PERMANENT HOME FOR A GROWING PROGRAM AT WSU.

Nov. 29, 2022 by Seth Truscott

As Washington agriculture changed over the last century, so too did teaching and research in agricultural engineering at WSU.

That evolution is chronicled in detail in a recently published, 218-page history, "Agricultural and Biological Systems Engineering at Washington State University: More than 100 Years Committed to Building a Better and More Sustainable Agriculture."

Written by current and retired faculty and present staff from the Department of Biological Systems Engineering, the book reaches from the university's 1892 origins to the present, highlighting the forces that shaped the department as well as its growing team and changing faces.

"The department goes beyond a single life," wrote BSE Chair Manuel Garcia-Perez. "It is a huge social enterprise

in which several generations have invested their lives, their dreams, and their humanity. We are a big family with a long and distinguished history well worth documenting."

"The formation and evolution of this department was driven by major national and global trends and events," said retired Chair Larry James. "We were a little ship carried by the currents of a big ocean."

James, who led the department from 1987 to 1991, took on the role of lead researcher and compiler of the book. He spent months assembling the text from recollections and records of past chairs and faculty, catalogs, yearbooks, deans' files, and other materials in WSU Libraries' Manuscripts, Archives, and Special Collections.

James was especially interested in understanding how the department quickly grew mid-century from a tiny,



Retired Chair Larry James holds a copy of the book, "Agricultural and Biological Systems Engineering at Washington State University," at the department's 2022 retreat.

two-person program with dwindling space for teaching and research, to having its own building and a growing staff.

"We went from two faculty to eight in five years," James said.

After World War II, society and the university were changing. Veterans were returning with a need for an education and a career. The Grand

Coulee Dam was completed in 1942, and irrigated agriculture was spreading through the Columbia River Basin. Communities statewide were still rooted in agriculture, and college ag-education graduates needed to be able to teach high school students how to maintain machinery for increasingly mechanized farms and support services.

At the same time, WSC was on its way to becoming a full-fledged university and a center for agriculture and industrial technology.

“There was tremendous interest in mechanization and ag engineering,” James said. “Commodity groups were calling for more research into machinery, farm structures, controlled farm building environments, rural electrification, food processing, and irrigation. All of this came together, and in 1946, WSC’s Agricultural Research Station put the first permanent research funding into ag engineering.”

L.J. Smith Hall, named for the influential early leader of the program and completed in 1947, was the result: the department’s first dedicated building for teaching and research. Space for learning and research doubled with a remodel and addition in 1968.

The program continued to expand, drawing faculty from around the globe. During the 1990s, the mission broadened to encompass biological systems engineering, applying engineering principles and techniques to the field of non-medical biology.

“There was a lot to go through and a lot of thinking about why things happened and who these people were,” James said of his journey through the department’s history. “Learning about

the faculty members was really interesting. The first four professors were young men who had just received an engineering degree and were looking for an adventure out west. They later became prominent ag engineers.”

James enjoyed talking with retired faculty such as Day Bassett, 100, Alan Pettibone (now deceased), and Larry King, 87.

“They were as sharp as ever, that was a joy!” he said. Those conversations, by phone and video conference, helped craft the former chairs’ sections of the book.

Book contributors included Ralph Cavalieri, Claudio Stöckle, Juming Tang, Denny Davis, Birgitte Ahring, James Durfey, Jonathan Lomber, Nina Willis, Dorota Wilk, Valentina Sierra, and Veronica Crow.

University archivist Mark O’English tracked down valuable historic archives, and writer Brian Clark edited, organized, and designed the book. Garcia-Perez wrote the introduction and conceived the project.

Without Garcia-Perez’s vision, “this would merely be stacks of paper in the archive,” James said.

Thirteen alumni from more than 50 years of the department were interviewed and profiled. Staff combed decades of Chinook yearbooks to find pictures and identify former students.



BSE students in 1983; from the WSU Chinook yearbook.



Former BSE Chairs: Larry James, Ralph Cavalieri, Denny Davis, Claudio Stockle, Juming Tang.

More pictures from BSE History Celebration on page 57.

“The alumni stories were the most fun part of doing the book,” James said. “Once they started talking, you’d remember their voices and mannerisms. It was like they were in your office again, but instead of talking about what they might do, they were telling you what they have done. It was fascinating and rewarding to hear about their accomplishments.

“I wish I’d known all of this when I was chair,” he added. “Faculty today can read this book to gain perspective. Alumni can see how they fit in the big picture. It’s 120-plus years of people working together: Everyone had their role and niche in building this department and making this history.”

BIOLOGICAL SYSTEMS ENGINEERING

OUTREACH & PARTNERSHIPS



Scientists in BSE work across the state of Washington and partner with global minds and industries to advance the state of our profession.

We are cross-disciplinary collaborators, editors, ambassadors, and mentors. Through societal involvement and fruitful collaboration with peers at the U.S. Department of Energy's Pacific Northwest National Laboratory, Massachusetts Institute of Technology, the U.S. Army's Natick Soldier Center, and other institutions here in Washington and far afield, we share ideas and spark discovery.

Ahead, learn about some of our department's latest efforts to serve and connect to our colleagues and stakeholders.

MARTIN CHURUVIJA AND DR. EMMANUEL OSAFO AT THE MASTER GARDNER EVENT IN PROSSER, WA.

Birgitte Ahring

Dr. Ahring is a leader in the field of anaerobic processes. Since 2017, she has served on the advisory board for Walla Walla Community College's Energy System Program. In 2021, Ahring co-taught ChE 560. She served as a major advisor for five PhD students (three in BSE, one in engineering science, and one in chemical engineering). Ahring acted as a committee member for five other PhD students. Ahring's research expenditure in 2021 was very high, totaling \$915,754. So far, Ahring has graduated 54 PhD students, 18 of whom have graduated since she joined WSU. She has published 393 peer-reviewed publications, 35 book chapters, and 10 patents. Of the WSU faculty who are

indexed in Google Scholar, Ahring ranks ninth for WSU citations (34,590 total, 1,862 in 2021, h factor-96). Major technical and scientific achievements for 2021: technology to increase the carbon conversion efficiency of sewage sludge by anaerobic digestion; technology to convert CO₂ and H₂ into CH₄; bio-augmentation to reduce CH₄ emission from ruminants; in-situ bio-reductive dechlorination; production of acetic acid from CO₂. In 2021, Ahring was awarded the Chancellor's Distinguished Research Excellence Award, in 2022 she was awarded the Washingtonian of the Day Award by Jay Inslee, in 2023 she was awarded the Anjan Bose Outstanding Researcher Award.



Birgitte Ahring
Professor

Gustavo Barbosa-Cánovas

Dr. Barbosa-Cánovas is a world-renowned leader in food engineering. He is well known for his exceptional leadership in developing nonthermal processing of food. He wrote or edited more than 40 books on food engineering, some of which are bestsellers. Some of the books are used for research purposes and some serve as textbooks. Some have been translated into Spanish, Russian, Chinese, and Arabic. Barbosa-Cánovas is one of the most cited faculty at WSU (38,000-plus citations) thanks to his more than 500 published scientific articles. In 2021, he was appointed as distinguished international professor by the Monterrey Institute of Technology in Mexico. He founded the Journal of Food Engineering Reviews (published by SpringerNature) 14 years ago and continues to serve as editor-in-chief. This journal has the highest impact factor among all journals in food engineering and is 17 out of 250 for food science and technology. For more than 20 years, Barbosa-Cánovas has been the editor-in-chief of the food engineering SpringerNature book

series, which has more than 75 titles and is the largest collection of food engineering books. He is a founder and current executive secretary of the Ibero American Society of Food Engineering, a member of the Latin American and Caribbean Society for Food Science and Technology, and an executive board member of the IFT (Institute of Food Technologists) Food Engineering Division. At the same time, Barbosa-Cánovas is the IFT representative within the International Association for Engineering and Food (IAEF). He helped organize XI INNOVA (September 2023), a conference in Montevideo, Uruguay on food science and engineering topics. He is acting as designated chair of the Conference of Food Engineering (CoFE 2024), to be held in Seattle. Very recently, he became IAEF president and was asked to organize the XV International Conference of Engineering and Food (ICEF) in the US, to be held in 2027. This year, he was honored with the IAEF Distinguished Service Award for his contributions to the organization of ICEF 14 in Nantes, France.



Gustavo Barbosa-Cánovas
Professor

Shulin Chen

Dr. Chen is well known for his contributions to biomass biochemical conversion technologies (algae, anaerobic digestion). Since 2020, he has acted as leader of the biomass conversion and bioproducts research area. During his tenure with the department, Chen has graduated 39 PhD students and 27 MS students. His publications are highly cited, with an h index of 89 and more than 24,000 citations. Chen ranks 21st among the most cited WSU researchers.

His contribution to commercialization was recognized with the WSU 2022 Innovation and Entrepreneurship Award. In 2023, he was named a senior member of the National Academy of Inventors. Chen serves on the editorial boards of the Journal of Energy and the International Journal of Green Technology. He also serves as the technical advisor of the spin-off company, Integrated Lipid Biofuels LLC.



Shulin Chen
Professor

Manuel Garcia-Perez

Dr. Garcia-Perez is the Former director of BSEL. His current research focuses on the fundamentals of biomass thermochemical conversion to maximize bio-oil and carbon yields, bio-oil chemistry, refining and hydrotreatment, biochar chemistry, and the development of engineered biochars for environmental services and sustainable aviation fuel technologies. Has published

nearly 190 peer-reviewed manuscripts and has advised 22 PhD students and 11 MS students. In 2022, he acted as the main advisor of 11 PhD students. He is an associate editor for the Journal of Biomass and Bioenergy, and an editor in charge of review papers for the Journal of Analytical and Applied Pyrolysis.



Manuel Garcia-Perez
Professor and Chair

Manoj Karkee

Dr. Karkee's research program focuses on developing automated and robotic solutions for specialty crop farming operations such as tree fruit pollination, thinning, and harvesting. Once commercially adopted, these technologies are expected to reduce labor use, improve labor safety, reduce production costs, enhance crop yield and quality, and increase long-term sustainability of industries that rely heavily on seasonal labor. Karkee trained 18 PhD students, seven MS students, and seven postdoctoral researchers. He has published more than 100 peer-reviewed research articles. His work has been recognized widely, as reflected through

honors such as the ASABE Rain Bird Engineering Concept of the Year Award (2020) and the Pioneer in AI and IoT Award (2019). Karkee has served WSU as a member of the CAHNRS Tenure and Promotion Committee and the Faculty Research Advisory Committee. He served as chair of the International Federation of Automatic Control's TC8.1 Technical Committee on Control in Agriculture from 2017 to 2023. Currently, Karkee is associate editor of ASABE publications and Computers and Electronics in Agriculture. In 2022, his work was featured 14 times in the national and international media, and he was awarded the Best Conference Paper Award by the ASABE.



Manoj Karkee
Professor

Lav R. Khot

Dr. Khot's research and Extension program focuses on sensing and automation technologies for precision management of production agriculture. Khot's program has several active projects supported by USDA NIFA, FFAR, and state and local commodity commissions. He is lead PI of the newly formed AgAID and co-leads the Farm Operations Intelligence thrust. He is involved in the organization of several Extension events like the Weather School, Drones in Agriculture, Smart Farm field days and related sessions in regional and international conferences. These efforts help ensure optimal use of resources such as chemicals, water, energy, and labor, as well as improved produce quality. Khot is a 2021 recipient of the Fruit + Vegetable 40 Under 40 Award from Fruit Growers News

and the 2018 New Innovator in Food and Agriculture Research Award from the Foundation for Food and Agriculture Research. He has published more than 100 peer-reviewed papers and given or taught more than 350 national and international conference talks, Extension/outreach workshops, and short courses. He currently serves as the associate editor for ASABE Transactions. He also chaired the Mechanization, Digitization, Sensing, and Robotics Workgroup of the International Society of Horticultural Science (2018-2023) and a multi-state group, S1069: Research and Extension for Unmanned Aircraft Systems Applications in U.S. Agriculture and Natural Resources (2021-2022).

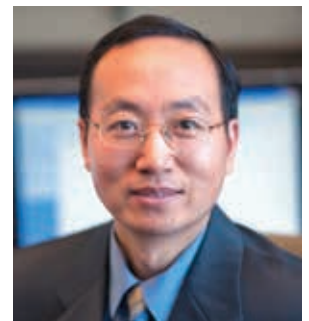


Lav R. Khot
Associate Professor and
Director of AgWeatherNet

Hanwu Lei

Dr. Lei serves as division editor for the International Journal of Agricultural and Biological Engineering. He is also academic editor for the International Journal of Environment and Climate Change as well as the Journal of Global Ecology and Environment. He is a member of the editorial board of the International Journal of Agricultural and Biological Engineering, the Journal of Sustainable Bioenergy Systems, and the Annals of Material Science. Lei has been working with biomass-derived carbon, activated carbon, nanocellulose, nanocarbon, carbon catalyst production, carbon and zeolite catalysis, syngas and hydrogen production, bio-aromatics, and bio-jet fuels. His research investigates the mechanisms responsible for the generation of fuel components and high-value chemicals and bioproducts from biomass and municipal solid wastes, and addresses fundamental and applied questions in conversions. Lei's jet fuel research has made headlines worldwide,

with news releases reaching 230.6 million people globally, according to WSU News. The news was reported through international TV broadcastings and more than 300 major news websites worldwide. The news has also been translated into different languages around the world. Students and postdocs who have graduated from and worked in Lei's lab are now professors at esteemed international universities including Université catholique de Louvain, Central Luzon State University, Tongji University, China Agricultural University, and East China University of Science and Technology. Lei and his group have published more than 170 peer-reviewed journal articles and book chapters. Lei is the invited panel member for the U.S. Department of Energy, the National Science Foundation, and USDA NIFA grant programs. He is the invited grant reviewer for international research programs for the Netherlands, Chile, Canada, the Czech Republic, U.S.-Israel, Hong Kong, and France.



Hanwu Lei
Professor

Pius Ndegwa

Dr. Ndegwa's research, teaching, and Extension long-term goals include evaluation, development, and dissemination of knowledge and technologies to quantify and mitigate odor, particulates, and other gaseous emissions (NH₃, H₂S, CH₄, and NO_x) from livestock production systems; manage and utilize manure and manure nutrients; and reduce the impact of manure and associated waste on water resources. His research projects during 2021 included densification of manure nutrients to enhance the economics of export to distant lands (from production regions), allowing for environmentally friendly utilization. He also worked on developing a novel vermifilter technology to treat dairy wastewater, with

the aim of recovering nutrients in the forms of earthworm meal and vermicasts and reducing wastewater concentration in the liquid stream. The liquid stream from the vermifilter is safely irrigatable in large volumes in nearby crop fields, while recovered nutrients in more concentrated forms can be exported away from regions with a high concentration of dairy productions. Ndegwa is associate editor of three journals supported by ASABE. He serves on the Superior Paper Awards Committee and on two subject-area ASABE committees (Air Quality and Animal Waste Management). Ndegwa is also a faculty advisor for the student chapter of ASABE, the Graduate Student Admission Committee, and the Faculty Research Advisory Committee for CAHNRS.



Pius Ndegwa
Professor

Troy Peters

On average, Troy Peters teaches more than 30 Extension workshops each year to educate growers and other irrigation professionals. He created an irrigation scheduler mobile app that is used in 12 western U.S. states and two Canadian provinces. This application has been used at more than 10,000 fields for irrigation scheduling. Peters also created and maintains an irrigation website (irrigation.wsu.edu), which is widely used for its irrigation calculators. It includes tools to estimate crop water use and irrigation system design capacity based on historical average evapotranspiration (ET) for many different areas and crops. Peters has published more than 100 peer-reviewed journal

papers and Extension publications. He advises graduate students and publishes an average of five peer-reviewed journal publications per year. A major focus of his Extension program is low elevation spray application, a modification to center pivots that increases irrigation application efficiency by 15% to 20% and uses significantly less pumping energy. Thanks to his efforts, these systems are being installed throughout the West. Peters is also working on machine learning to interpret soil moisture sensor signals for irrigation automation, quantifying the suppression of ET from sprinkler water losses, irrigation water quality measures, remote detection of water stress, and ET using satellites and drones.



Troy Peters
Professor and Extension
Irrigation Specialist

Kirti Rajagopalan

Dr. Rajagopalan's program leads cutting-edge research related to climate change's impact on agriculture and water resource management, focusing on understudied dimensions such as pests, pollinators, and extreme weather. She has successful interdisciplinary collaborations with multiple institutions across the country. Rajagopalan is part of the newly formed AgAID

and leads the water intelligence thrust. She is passionate about getting graduate and undergraduate students exposed to and interested in all things digital and interdisciplinary, working with industry and academic partners to coordinate annual agriculture-focused hackathons for students from diverse backgrounds.



Kirti Rajagopalan
Assistant Professor

Shyam Sablani

Dr. Sablani's current research interests include the application of materials science principles to develop high-barrier polymer packaging and understand physical and chemical changes in dehydrated and frozen foods. His research has informed the development of next-generation barrier packaging, which incorporates ethylene vinyl alcohol, metal oxide-coated polyethylene terephthalate, and oxygen scavengers. His research has contributed to an improved understanding of the relationship between

state/phase transitions and physico-chemical stability, which helps with to the design and formulation of dehydrated and frozen foods with a higher nutritional content and a longer shelf life. Sablani is a recipient of the 2021 Frozen Food Foundation Freezing Research Award, the 2018 CAHNRS/WSU Excellence in Advising Award, and the 2016 Institute of Food Technologists Marcel Loncin Research Prize. He is currently scientific editor of the Journal of Food Engineering.



Shyam Sablani
Professor

Sindhuja Sankaran

Dr. Sankaran's work focuses on advanced sensor technologies that detect and measure phenotypes — the physical expression of genes — in crops. Her work supports plant breeding, crop plant research, and precision agriculture. Over the past few years, she has developed new tools to evaluate traits including crop vigor, stress tolerance, and seed size and quality across multiple crop breeding programs. Sankaran has published more than 100 peer-reviewed journal articles, proceeding papers, and book chapters. She has given 100-plus

talks in the U.S. and countries such as Australia, Brazil, Canada, Colombia, India, and Mexico. She is a member of ASABE, the National Association of Plant Breeders, the North American Plant Phenotyping Network, and the International Society of Precision Agriculture. In 2022, she received the International Society for Horticultural Science Medal, the Outstanding Associate Editor Award from ASABE, the ASABE Leadership Citation, and the Early Career Excellence Award from CAHNRS.



Sindhuja Sankaran
Associate Professor

Juming Tang

Dr. Tang has trained more than 50 PhD students, 20 postdoctoral fellows, and 50 visiting students and scholars. He has published more than 400 peer-reviewed scientific papers. His research has resulted in 14 U.S. and internal patents. Tang has led two industrial consortia on advanced thermal processing technologies, with membership representing the U.S. Army Natick Soldier Systems Center and more than 20 companies. His laboratory developed 915 MHz Microwave Assisted Thermal Sterilization (MATS) technology, with acceptance from the U.S. FDA and non-objection from the USDA Food Safety and Inspection Service. He directed a Center

of Excellence for Food Safety, supported by USDA NIFA, on the application of Microwave Assisted Pasteurization Systems (MAPS) for control of bacterial and viral pathogens in ready-to-eat meals. Both MATS and MAPS are licensed for global commercialization. Tang has researched microbial safety in low-moisture foods and advanced drying technologies. He was elected to the Washington State Academy of Sciences in 2019 and the U.S. National Academy of Engineering in 2021. He is a fellow of the International Microwave Power Institute, ASABE, the IFT, and the U.S. National Academy of Inventors.



Juming Tang
Regents Professor, Member of the U.S. Academy of Engineering

Joan Wu

Dr. Wu's research centers on hydrologic modeling for land and water resources conservation. In a recent project supported by USDA NIFA, Wu and her team evaluated long-term trends of water erosion impacted by physical and anthropogenic factors in rain-fed, cereal grain croplands throughout the inland Pacific Northwest. In another study funded by the U.S. Environmental Protection Agency, they adapted a Hydrologic Sensitive Index approach to optimize the placement of Green Stormwater Infrastructure in Puget Sound's rapidly urbanizing watersheds. Wu has collaborated extensively with USDA ARS and U.S. Forest Service

researchers to develop the Watershed Erosion Prediction Project model. She teaches BsysE 512 Research and Teaching Methods, a department core course, and surface and groundwater hydrology. She is the recipient of the WSU CAHNRS Excellence in Teaching Award (2018) and the Excellence in Advising Award (2022). Wu is part of the W-4188 team (Soil, Water, and Environmental Physics to Sustain Agriculture and Natural Resources) recognized for National Excellence in Multi-State Research (2021) by the Western Association of Agricultural Experiment Station Directors.



Joan Wu
Professor

Bin Yang

Dr. Yang is a professor in the BSE department and the Bioproducts, Sciences, and Engineering Laboratory. His major research interests include understanding fundamental mechanisms and advancing cutting-edge biomass processing technologies for advanced biofuels and bioproducts, facilitating the commercialization process as well as improving knowledge of emerging technologies to meet near- and long-term needs worldwide. He has authored more than 135 peer-reviewed papers and book chapters and has six issued patents. He also serves as

an advisory editor board member for leading biorefinery journals. Yang recently pioneered new biomass pretreatment technology and manufacturing technologies to process biomass into jet fuel, bioplastics, carbon fiber, supercapacitor, and other bioproducts. The impacts of his accomplishments have been amply documented in his recent awards, including Fellow of the American Institute of Chemical Engineers, the Fulbright Distinguished Chair in Energy and Sustainable Use of Natural Resources, and the DARPA Young Faculty Award.



Bin Yang
Professor

Liang Yu

Dr. Yu is a licensed professional engineer in the state of Washington. He is also a guest editor for the Journal of Fermentation entitled Energy Converter-Anaerobic Digestion, a faculty senator for the Non-Tenure Track Faculty, an Anti-Hazing Advisory Committee member, and a review committee member for undergraduate research scholarship applications at WSU. Yu's research involves the development of biorefinery-based industrial symbiosis and the circular economy. He employs multi-scale mathematical modeling techniques, including but not limited to molecular simulation, computational fluid dynamics, bioprocess control, simulation, optimization, integration, techno-economic

analysis, life cycle assessment, and machine learning. Specifically, Yu is working on the development, optimization, integration, and scale-up of an advanced anaerobic digestion-based biorefinery with hydrothermal pretreatment designed to convert animal manure, food waste, biosolids, and other organic waste into renewable natural gas, organic fertilizer, clean water, and other high-value bioproducts. Yu's research has been supported by the DOE and the USDA. He has published more than 60 papers in high-quality peer-reviewed scientific journals such as Applied Energy, Bioresource Technology, Chemical Engineering Science, and AIChE Journal. He holds five patents.



Liang Yu
Assistant Professor

Qin Zhang

Dr. Zhang is a member of the Washington State Academy of Sciences and a fellow of the International Academy of Agricultural and Biological Engineering. He is a trustee on the foundation board of ASABE, a fellow of ASABE, and a full member of the Club of Bologna. He serves as an academic committee member for the Key Laboratory on Integrated Systems for Precision Agriculture, China Agricultural University,

and as a member of the External Advisory Committee, Demonstration Teaching Center for Agricultural Engineering Curriculum, Northwest A&F University, China. Zhang is currently the chair editor of Computer and Electronics in Agriculture, the editor-in-chief for Springer's Encyclopedia of Smart Agriculture Technologies, and a guest editor for the Springer Agricultural Automation book series.



Qin Zhang
Professor and CPAAS Director

Professors Emeriti

Claudio O. Stöckle

Ralph Cavalieri

Larry King

Leslie John Smith

Denny Davis

Larry James

Alan Pettibone

Administrative Team

Our administrative team welcomed two new members.

Nina Willis joined BSE as an administrative assistant on March 16, 2022, after previously working as a work-study clerical assistant in the department. They mainly work on personnel-related processes such as finalizing employee appointments, assisting with visa applications, and inputting costing allocations. Nina graduated from WSU in December 2020 with a bachelor's

degree in animal science. In their free time, Nina enjoys Marvel comic books and hanging out with their two fluffy black cats.

Marcelo Martinez began working as a fiscal specialist on May 1, 2022. He has been working with students and faculty to purchase supplies for their projects, reconcile transactions, and analyze budgets for the department. Marcelo

has been in Pullman for eight years. He received his accounting degree from WSU in 2021. In his spare time, Marcelo performs with the WSU Symphony Orchestra and the Washington-Idaho Symphony Orchestra as a clarinetist. He also enjoys cooking challenges.

**Welcome to our BSE team,
Nina and Marcelo!**



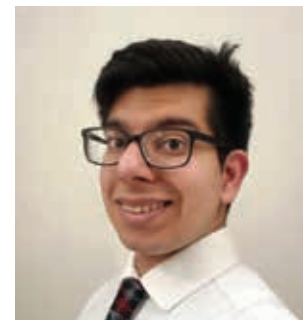
Dorota Wilk
Budget/Finance Manager



Joanna Dreger
Graduate Academic Coordinator



Nina Willis
Administrative Assistant II



Marcelo Martinez
Fiscal Specialist

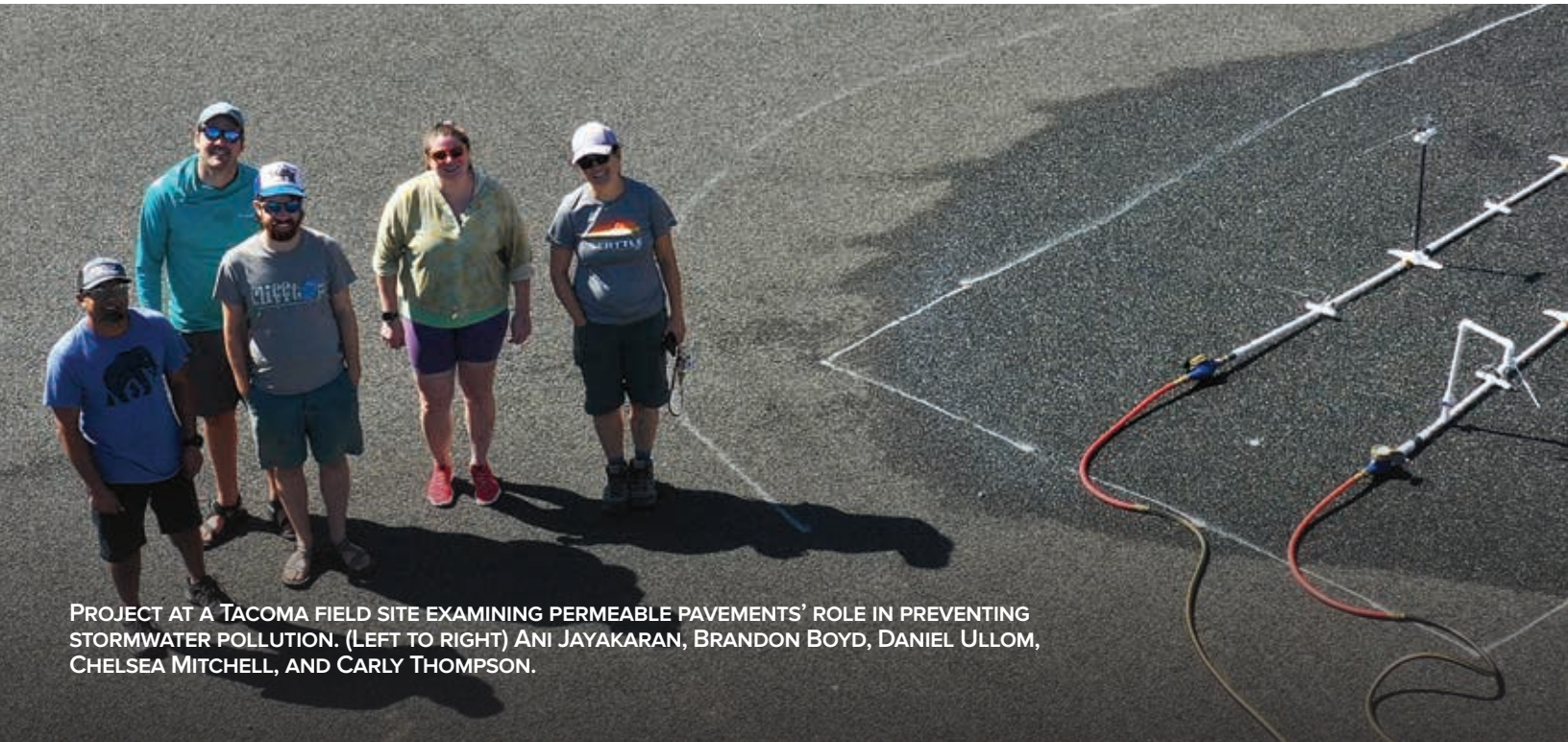
Visiting Scholars

The infrastructure and world-renowned faculty in our department attract students and researchers from all over the world who want to gain research experience in our laboratories. BSE has numerous visiting scholars from different countries who are supported by their universities and governmental agencies. This year, we welcomed and trained the following scholars:

Visitor	Title	Home University	Country	Inviting BSE Faculty
Loredana Dumitrascu	Fulbright Adjunct Faculty	University of Galati	Romania	Gustavo Barbosa-Cánovas
Mohamed Hechmi Aissaoui	Fulbright Adjunct Faculty	Université de Lorraine	France	Manuel Garcia-Perez
Eid Alsbou	Adjunct Faculty	Al-Hussein Bin Talal University	Jordan	Manuel Garcia-Perez
Bikram Borkotoki	Adjunct Faculty	Assam Agricultural University	India	Manuel Garcia-Perez
John Vincent Nate	Visiting Scientist	Central Luzon State University	Philippines	Manuel Garcia-Perez
Carlos David Martinez-Smit	Visiting Scholar	Universidad Nacional de Colombia	Colombia	Manuel Garcia-Perez
Raiza Johanna Manrique Waldo	Visiting Scientist	Universidad Nacional de Colombia	Colombia	Manuel Garcia-Perez
Anthony James C. Bautista	Adjunct Faculty	University of Santo Tomas	Philippines	Manoj Karkee
Salik Khanal	Visiting Scholar	University of Porto	Portugal	Manoj Karkee
Giacomo Tolomelli	Visiting Scholar	University of Bologna	Italy	Lav Khot
Nisit Pukrongta	Visiting Scholar	Rajamangala University of Technology	Thailand	Lav Khot
Tayyaba Alvi	Visiting Scholar	University of Agriculture Faisalabad	Pakistan	Shyam Sablani
Manisha Behera	Visiting Scholar	Institute of Chemical Technology Mumbai	India	Shyam Sablani
Misbah Murid	Visiting Scholar	University of Agriculture Faisalabad	Pakistan	Shyam Sablani
Burcu Tenderis	Adjunct Faculty	Suleyman Demirel University	Turkey	Shyam Sablani
Sweta Rai	Adjunct Faculty	G. B. Pant University of Agriculture and Technology	India	Shyam Sablani
Eduardo F. Carlos	Adjunct Faculty	Agronomic Institute of Parana State	Brazil	Sindhuja Sankaran
Sunil Kadam	Adjunct Faculty	Mahatma Phule Krishi Vidyapeeth, Rahuri	India	Claudio Stöckle
Shuang Zhang	Visiting Scholar	Northwest A&F University	China	Juming Tang
Tesfay Weldelessie	Adjunct Faculty	University of the Free State	South Africa	Joan Wu

Our Affiliated Faculty

Faculty Name	Current Title	Contact Information	Email	Phone Number
Peter Pfromm	Professor	309 Wegner Hall School of Chemical Engineering and Bioengineering VCEA, Pullman, WA	peter.pfromm@wsu.edu	509-335-6579
Jean Sabin McEwen	Assistant Professor	Wegner Hall 257 VCEA, Pullman, WA	js.mcewen@wsu.edu	509-335-8580
Michael Wolcott	Regents Professor and Associate Vice President for Research	PACCAR 250 Office of Clean Technology Pullman, WA	wolcott@wsu.edu	509-335-6392
Vikram Yadama	Professor	PACCAR 154 Composite Materials & Engineering Center Civil and Environmental Engineering, Pullman, WA	vyadama@wsu.edu	509-335-6261
Elizabeth Beers	Professor & Entomologist	1100 N Western Ave. Tree Fruit Research & Extension Center Wenatchee, WA	ebeers@wsu.edu	509-293-8755
Francisco Leal-Yepes	Assistant Professor	1035 CVM Animal Disease Biotechnology Facility, Pullman, WA	f.leal-yepes@wsu.edu	607-216-5536
Hang Liu	Assistant Professor	PACCAR 160 Apparel, Merchandising, Design and Textiles, Pullman, WA	hangliu@wsu.edu	509-335-4726
Hongfei Lin	Associate Professor	Wegner Hall 109 VCEA, Pullman, WA	hongfei.lin@wsu.edu	509-335-1341
Girish Ganjyal	Associate Professor	FSHN 228 School of Food Science Pullman, WA	girish.ganjyal@wsu.edu	509-335-5613
Anand Jayakaran	Associate Professor	Puyallup Research & Extension Center	anand.jayakaran@wsu.edu	253-445-4523
Jenifer McIntyre	Aquatic Toxicologist, WSU School of the Environment	Puyallup Research & Extension Center	jen.mcintyre@wsu.edu	206-369-1832
Markus Flury	Professor	Puyallup Research & Extension Center	flury@wsu.edu	253-445-4522



PROJECT AT A TACOMA FIELD SITE EXAMINING PERMEABLE PAVEMENTS' ROLE IN PREVENTING STORMWATER POLLUTION. (LEFT TO RIGHT) ANI JAYAKARAN, BRANDON BOYD, DANIEL ULLOM, CHELSEA MITCHELL, AND CARLY THOMPSON.

Our Adjunct Faculty

Adjunct Faculty Name	Current Title	Contact Information	Email	Phone Number
Pavlo Bohutskyi	Chemical Engineer	Pacific Northwest National Laboratory Richland, WA	pavlo.bohutskyi@wsu.edu	509-371-7801
Jonathan Male	Director, Office for National Laboratory Partnerships	WSU Office of Research 1815 NE Wilson Rd. Room 02980v Pullman, WA	jonathan.male@wsu.edu	
Mark Wigmosta	Chief Scientist	Energy and Environment Directorate Pacific Northwest National Laboratory Richland, WA	Mark.Wigmosta@pnnl.gov	509-372-6238
Mariefel Olarte	Chemical Engineer IV	Pacific Northwest National Laboratory Richland, WA	mariefel.olarte@pnnl.gov	509-375-2200
Farid Chejne	Professor	National University of Colombia Medellin, Colombia	fchejne@unal.edu.co	+57-44255333
Nigel Pickering	Senior Engineer	Geosyntec Consulting, Minneapolis, MN	npickering@geosyntec.com	612-253-8200
David Brown	Director of Pomology	Meter Group, Inc., Pullman, WA 99163	dave.brown@metergroup.com	509-332-2756
Joaquin Casanova	Public Affiliate – USDA ARS	225 Johnson Hall, Pullman, WA 99164	joaquin.casanova@wsu.edu	352-246-9649
Gerrit Hoogenboom	Professor	University of Florida, Gainesville, FL	gerrit@ufl.edu	352-392-1864
David Gustafson	Independent Scientist	Saint Louis, MO	david.i.gustafson@wsu.edu	314-409-7123
Vivian Wu	Research Leader	Produce Safety and Microbiology USDA-ARS Western Reg. Research Center Albany, CA	Vivian.wu@ars.usda.gov	510-559-5829
Shaojin Wang	Professor	Northwest A&F University Yangling, China	shaojin_wang@wsu.edu	029-87092391
William Elliot	Research Civil Engineer	Rocky Mtn Research Station Moscow, ID	welliot@fs.fed.us	208-883-2338
Peter Robichaud	Research Engineer	Rocky Mtn Research Station Moscow, ID	probi@wsu.edu	208-883-2349
Melvin Tucker	Senior Scientist IV, Retired	National Renewable Energy Laboratory National Bioenergy Center	mtnr@totalspeed.com	303-384-6264
Jian Liu	Senior Research Engineer	Pacific Northwest National Laboratory Richland, WA	jian.liu@pnnl.gov	509-372-4477
Wei-Jun Qian	Senior Staff Scientist, Team Lead for Proteomics	Pacific Northwest National Laboratory Richland, WA	weijun.qian@pnnl.gov	509-371-6572
Vicki Thompson	Department Manager, Bioenergy Feedstock Technologies	Biological & Chemical Sciences & Engineering Department Idaho National Laboratory P.O. Box 1625 Idaho Falls, ID 83415-2203	Vicki.Thompson@inl.gov	208-526-8833

Success stories from alumni

Mohammadali Azadfar

In May 2016, I completed my PhD in biological and agricultural engineering, with a specialization in bioenergy and bioproducts engineering, through the BSE department. In August 2019, I completed my postdoctoral research fellowship with WSU's Composite Materials and Engineering Center's Wood Materials and Engineering Laboratory. I then began my career as an assistant professor of environmental and renewable resources with the State University of New York College of Agriculture and Technology at Morrisville, N.Y. I also started and running the college's Wood Technology Center.

I am highly passionate about relationship-

building and partnerships, resource planning, and sustaining Extension education and applied research programs. My goal is to increase the cost-effective utilization of forest biomaterials.

I have always enjoyed working in a wide variety of creative disciplines, ranging from lignocellulosic materials science and engineering to wood processing and manufacturing. I have been fortunate and honored to be surrounded by a stimulating and nurturing community of faculty and staff who inspired me, supported me, and challenged me to be better. I completed my BS and MS in natural resources engineering in Iran in 2003 and 2009, respectively.



Mohammadali Azadfar
State University of New York
College of Agriculture and
Technology

Abhilash Chandel

I am an alumnus of the BSE class of 2021. I got my PhD in precision agriculture while working in Lav Khot's lab. Currently, I work as an assistant professor and Extension specialist at Virginia Tech. I lead the precision agriculture and data management program, which develops, deploys, and utilizes state-of-the-art tools

and technologies including non-Invasive sensing (ground, aerial, and satellite), artificial intelligence, big data, cybernetics, and Internet of Things to solve problems and enhance the productivity and sustainability of field-agricultural production systems.



Abhilash Chandel

Eric Coppock

How does an old farm kid from Pendleton, Ore., end up working as a software engineer on NASA's James Webb Space Telescope? If it hadn't happened to me, it's probably not a story I could make up. It started with a degree in biological systems engineering from WSU, though it was still called agricultural engineering when I came to Pullman, WA., in 1987.

Ag engineering was a natural fit for me. My dad has a master's degree in agronomy from WSU, and I had a very ag-oriented upbringing, including a year as Oregon Future Farmers of America

state secretary between high school and college.

My first job after graduating in December 1992 was as a ski instructor. I'd been both a racer and a coach with the WSU ski team, and it was a great way to unwind for a few months after graduating. The most interesting story from that winter was when I helped with the overnight rescue of a couple of skiers who had gone out of bounds and gotten lost. Everybody made it home safely!

My first real job was with FaxBack Inc., a small Intel spinoff in Beaverton Ore. I was



Eric Coppock

with the company for seven years, traveled a lot, and got my feet wet in software development.

My next position was with Carrier Access Corporation in Boulder, Colo., during the telecom boom at the turn of the millennium. Remember Y2K? The telecom boom quickly turned into the telecom bust, but it also turned me into an embedded software engineer.

I've been with Ball Aerospace in Boulder since 2002. I've worked with a wide variety of programs and research and development projects over the years, some classified and some not.

I became the ground software lead for the James Webb Space Telescope sometime in 2013 and worked the program through the end of on-orbit telescope commissioning in mid-2022.

I spent a lot of that time being the only person in the room without a PhD, which made it that much more fun to tell people I'm an agricultural engineer! It would take me a couple of hours to explain what all the software does and how it works.

In addition to lots of development and debugging, I followed the James Webb Space Telescope system all over the country for integration and test activities, working at the NASA Goddard Space Flight Center in Greenbelt, Md., the NASA Johnson Space Center in Houston, and the Northrop Grumman campus in El Segundo, California.

This crescendoed to a trip to the French Guiana launch facility for final pre-launch tests, and four months of 24/7 flight operations shift work at the Space Telescope Science Institute at Johns Hopkins University in Baltimore for on-orbit commissioning.

It's thrilling to see the data that our telescope is now producing, and I'm confident there will be many unexpected discoveries over the next 10-plus years.

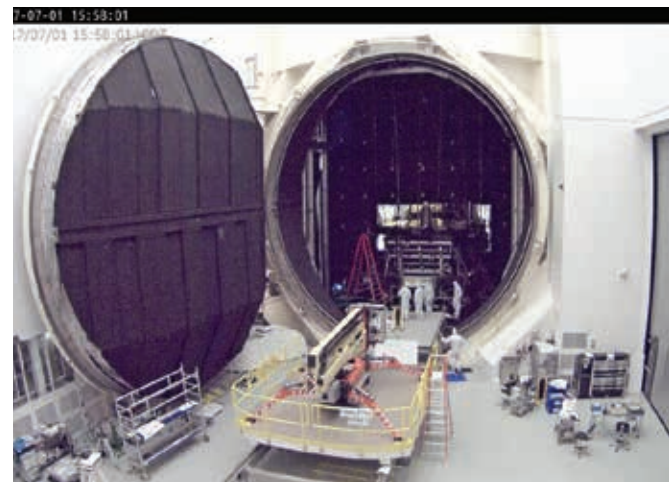
I'm now involved in a new project, developing flight software for the Sierra Space Dreamchaser vehicle. This is my first exposure to systems capable of supporting manned space flight. The adventure continues!



Coppock pictured in front of a replica of our Ariane 5 launch vehicle at the European Space Agency launch site in South America.



"Last Mirror Move Confirmed" – 2:00 a.m. at the flight operations center of the Space Telescope Science Institute at Johns Hopkins University. This was the crew that was on shift when we finally confirmed that the James Webb Space Telescope was fully aligned and ready for science. Left to right: Eric Coppock (Ball Aerospace), Greg Brady and Marshall Perrin (Space Telescope Science Institute), Michael Gordon and Micky Masciarelli (Ball Aerospace).



"A Chamber" – An image from telescope testing in the "A Chamber" thermal-vacuum testing facility at the NASA Johnson Space Center in Houston. Coppock (left) standing in the open door of the chamber with his colleagues. The James Webb Space Telescope is inside the chamber.

Iva Jovanovic Tews

Careers are not predestined by one's PhD dissertation, but rather the sum of experiences a student goes through and their continuous desire to solve challenging problems. That is how Iva Jovanovic Tews ended up at Intel Corp. following the successful defense of her PhD in March 2022.

During her tenure at WSU as an NSF graduate research fellow, Iva specialized in catalytic oxidation of aqueous volatile organics in microscale-based reactor systems. Her dissertation project was based on the research she conducted at PNNL prior to her arrival in Pullman, WA.

At the time, there was little effort being made to understand thermochemical aqueous phase characterization and remediation, allowing for a contribution to fundamental research and process development. At times, this work was exceedingly challenging and isolating, as very few would come to understand both the chemical composition of such aqueous products in

detail and their potential oxidation pathways.

However, it would be the hands-on experience gained in the BSE analytic laboratory as well as designing and developing reactor systems that would give Tews a foundation for working with specialized instrumentation. This proved to be of high value for a specialized manufacturing company such as Intel, specifically for their Logic Technology Development and Research unit.

Today, Tews is responsible for new tool installation and cutting edge process development for future A.I. architecture.

Tews also had the pleasure of mentoring Intel interns while simultaneously growing her career. Although she had the opportunity to work for the DOE upon graduation, her continuous fundamental research and application work at Intel is exactly how she wished to use her skills. She is also very happy to be back in Oregon (her home state), close to her family and enjoying all the blessings of the Pacific Northwest.



Iva Jovanovic Tews
LTD CMP Process Engineer

Ramesh Kumar Sahni

In 2022, I completed my PhD in biological and agricultural engineering, with a focus on precision agriculture.

Currently, I am working as a scientist (Agriculture Research Service) at the Indian Council of Agricultural Research-Central Institute of Agricultural Engineering in Bhopal, Madhya Pradesh, India. My research areas are application of drone technology, high-speed planting, and material properties characterization.

I truly believe that the research and analytical skills I learned as a biosystems engineering

graduate student at WSU made me well positioned for this role.

I will always be thankful for my advisor, Lav Khot, and other faculty members for what they taught me as a professional and for providing me with opportunities to work on many research projects funded by prestigious organizations like the USDA NIFA, the WSU Office of Commercialization, and the USDA ARS research agreement. I enjoyed every moment at WSU. I truly feel that my time there was a golden era of my life, and I will forever cherish it.



Ramesh Kumar Sahni
Scientist (Agriculture Research Service), Indian Council of Agricultural Research-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh, India

Partners in University Initiatives

Biological Systems Engineering faculty members are partners and leaders in collaborative projects and university centers

Bioproducts, Sciences, & Engineering Laboratory (BSEL): This laboratory provides space for critical research in identifying pathways to convert lignocellulosic materials into fuels, chemicals, and materials. BSEL opened in May 2008 as a 57,000-square-foot research and teaching laboratory operated jointly by WSU and PNNL. BSE faculty working at BSEL, including Birgitte Ahring, Bin Yang, and Hanwu Lei, work with biofuels, biochemicals, biomaterials, and bioprocesses. Michael Wolcott is the current interim director.

triticities.wsu.edu/research/bsel

The Aviation Sustainability Center (ASCENT): This cooperative aviation research organization is co-led by WSU and the Massachusetts Institute of Technology. ASCENT works to create science-based solutions to the aviation industry's biggest challenges. The center focuses on meeting the environmental and energy goals of the next-generation air transportation system. BSE contributions include exploring ways to produce sustainable aviation fuels at the commercial scale as an engine for rural economic development and job creation. Michael Wolcott directs the center.

ascent.aero

WSU-PNNL Bio-products Institute: The institute is a joint research collaboration between WSU and PNNL. This institute leverages cutting-edge science, engineering, and analysis to transform engineering plants; turn industrial, agricultural, and municipal waste into valuable materials and chemicals; and develop a pipeline of talent to meet future workforce needs. It also aims to be a leader in education, research, and innovation for the production of high-value engineered materials and chemicals from underutilized waste materials. The institute coordinates all activities in biomass processing and bioproducts with PNNL. Jonathan Male is the PNNL interim director, and Michael Wolcott is the WSU director.

natlab.wsu.edu/bioproducts

Center for Precision and Automated Agricultural Systems (CPAAS): This center offers a framework for precision/smart agriculture and automation efforts at WSU. Its mission is to develop a world preeminent and Washington-relevant research and educational program in agriculture automation and precision farming. The center has three core faculty from BSE who specialize in mechatronics and automation, machine vision and agricultural robotics, and precision/smart agriculture. The center has also recruited affiliated faculty from seven other departments. Qin Zhang directs CPAAS.

cpaas.wsu.edu

WSU Puyallup Research and Extension Center: Located near the Seattle metropolitan area, this center creates opportunities for research, Extension, and teaching for the increasingly urbanized Puget Sound region. Programs focus on watershed science, horticulture, production agriculture, forestry, and community health in the urban-rural interface. The center currently stands at the intersection of rural and urban communities, bridging pristine and developed ecosystems. Todd Murray is the director.

puyallup.wsu.edu

Cultivating excellence: Empowering the next generation in agriculture

At the heart of our department’s mission is a commitment to nurturing emerging talent through mentorship. In addition to graduate student advising and mentoring, our faculty members have been mentoring high school and undergraduate students, helping these emerging talents develop their research and communication skills, offering a glimpse into the rigors and rewards of academic pursuit, and fostering a spirit of curiosity and ambition.

Several students (listed below) engaged in one-on-one collaborations with faculty members and graduate/postgraduate researchers while working on research projects associated with agricultural technology, climate change, and sustainable agriculture.

Manoj Karkee, Kirti Rajagopalan, Lav Khot, and Sindhuja Sankaran are part of the AgAID AI Institute for Agriculture Undergraduate Research

Internship program. Sankaran also leads a USDA National Institute of Food and Agriculture (NIFA) Research and Extension Experiences for Undergraduates program on phenomics big data management. These programs offer graduate students co-mentorship opportunities that develop their leadership skills.

In addition, faculty members work with undergraduate capstone project teams, primarily from computer science and other engineering disciplines, to develop technological or data-driven solutions for agricultural and biological applications.

Our featured 2022 intern is Sienna Alicea, a National Science Foundation environmental engineering REEU intern who worked with Kirti Rajagopalan’s lab in collaboration with Haly Neely.

She performed experiments with a spectrometer to quantify the moisture



Sienna Alicea
Intern

sensitivity of spectral indices that predict crop residue cover fractions and presented her work at the 2023 American Chemical Society conference in Chicago. She is also serving as a co-author in a manuscript to be submitted to the journal Geoderma. She is pursuing graduate school opportunities. We congratulate Alicea and other interns on their accomplishments.

Student Name	School / Institute	Mentor
Ayaka Smart	Emory University	Kirti Rajagopalan
Brandt Geist	Vanderbilt University	Kirti Rajagopalan
Kieran Hampson	Pullman High School	Kirti Rajagopalan
Sienna Alicea	North Central College	Kirti Rajagopalan
Alan Musselman	WSU	Lav Khot
Anthony Edwards	University of Washington	Lav Khot
Bethany Safe	WSU	Lav Khot
Isabella Martinez	Prosser High School	Lav Khot
Joshua Oliver	WSU	Lav Khot
Maxwell Cheeseman	WSU	Lav Khot

Student Name	School / Institute	Mentor
Robert Barragan	Heritage University	Lav Khot
Sayan Banks	WSU	Lav Khot
Shaina Griffiths	Columbia Basin College	Lav Khot
Shannon Whiting	WSU	Lav Khot
Rachel Stehle	Central Washington University	Manoj Karkee
Landon Chase	Ohio State University	Manuel Garcia-Perez
Kevin Hernandez-Ramos	Wenatchee Valley College	Sindhuja Sankaran
Nolan Shepherd	Syracuse University	Sindhuja Sankaran
Will Bieker	Western Washington University	Sindhuja Sankaran



BIOLOGICAL SYSTEMS ENGINEERING FACULTY AND GRADUATE STUDENTS ATTENDING THE 2022 ASABE ANNUAL INTERNATIONAL MEETING IN HOUSTON, TX.

Students and faculty participate in 2022 ASABE annual international meeting

Since 1907, the American Society of Agricultural and Biological Engineers (ASABE), an international educational and professional scientific organization, has been dedicated to offering engineering solutions across agricultural, food, and biological systems.

In 2022, the ASABE Annual International Meeting (AIM) was held in Houston from July 17-20. A total of 29 members from the BSE department participated. Thirteen students received ASABE AIM travel awards from the department: Achyut Paudel, Afef Marzougui, Basavaraj Amogi, Behnaz Molaei, Chenchen

Kang, Do-Gyun Kim, Gajanan Kothawade, Mark Jacob Schrader, Milton Valencia-Ortiz, Rongge Zou, Supriya Savalkar, Uddhav Bhattarai, Worasit Sangjan, Ramesh Sahni.

In addition to active student and faculty participation in several leadership roles (technical committee, technical community, moderation, volunteering, etc.), about 31 technical talks across different technical sessions within diverse communities were presented mainly by students.

Notable accomplishments include the Boyd-Scott Graduate Research Award (PhD category), sponsored

by distinguished alumnus Norm Scott in collaboration with his advisor Landis Boyd and received by Worasit Sangjan (third place); the ITSC Paper Award received by Daniel Borrenpohl and Manoj Karkee; the Outstanding Reviewer Awards received by Uddhav Bhattarai, Rakesh Ranjan (alumnus), and Chongyuan Zhang (alumnus); the Outstanding Associate Editor Awards received by Lav Khot and Sindhuja Sankaran; and the ASABE AIM student oral/poster presentation awards received by Jake Schrader and Behnaz Molaei.

Partners in University Initiatives

WSU Prosser Irrigated Agriculture Research and Extension Center (IAREC): An estimated two-thirds of the state's agriculture production comes from irrigated land. IAREC, the world's largest irrigated agriculture center, focuses its research on agricultural commodities and production systems relevant to the Columbia Basin and the Yakima Valley. This center partners with growers and commodity commissions to turn research-based knowledge into practical applications. IAREC is home to 18 faculty scientists and employs roughly 100 staff. Naidu Rayapati is the director.

larec.wsu.edu

AgWeatherNet (AWN): The WSU AgWeatherNet (AWN) is the first and largest agricultural weather network in the U.S. AWN provides Washington state farmers, gardeners, researchers, and policymakers with weather data and related decision-support tools to improve agriculture/animal production, efficiency, and profitability while minimizing environmental impacts. AWN has more than 400 public and private stations recording air temperature at 1.5 meters, wind speed at 2 meters, relative humidity at 1.5 meters, solar radiation at 1.5 meters, primary and secondary precipitation at 0.6 meters AGL, and soil temperature and water potential at 5, 20 cm.

Additionally, AWN Tier 1 towers monitor wind speed and direction at 10 meters and air temperature at 9 meters. Such data and associated products flow through a network web portal (weather.wsu.edu). AWN has more than 13,000 registered users and the AWN webpage receives an average of 50,000 page views per day. The web portal has free-to-use tools addressing irrigation scheduling, crop phenology, and cold/heat stress indicators for horticultural crops. AWN is currently upgrading its weather sensing infrastructure with a goal of 100-plus 10 meter towers that can map weather at meso-scale. It also hopes to better integrate privately owned weather stations. AWN is also piloting the collection and dissemination of air quality data that is critical for human and animal health systems. Lav Khot is the current director.

Center of Excellence for Food Safety: This WSU center is supported by a USDA AFRI Coordinated Agricultural Projects grant. It is made up of faculty members and scientists from three universities — WSU, University of Tennessee, and North Carolina State University — as well as the U.S. Army Natick Soldier Systems Center. The center bridges knowledge gaps and advances technological solutions for the commercial production of ready-to-eat meals for retail markets and e-commerce. Director Juming Tang leads development and commercialization of advanced industrial thermal processing technologies for control of bacterial and viral pathogens in pre-packaged meals. Shyam Sablani, in collaboration with the Natick Soldier Systems Center, leads the packaging program, which addresses technical issues related to shelf-life extension and food quality in storage. Graduate education is a major element of the center's activities; center members have trained 21 PhD students and four master's degree students. The center collaborates with the Seafood Product Association (Seattle), the NASA Food Center, and many food and food equipment companies.

labs.wsu.edu/coe

BIOLOGICAL SYSTEMS ENGINEERING

ACADEMICS



Students in BSE become scientific leaders addressing agriculture, food safety and security, and the global economy. Our students achieve advanced engineering degrees in food, land, air, water and environment, agricultural automation, bioproducts, and bioenergy. BSE enjoys an excellent track record in placing our graduate students at universities, national laboratories, and global companies.

Ahead, we share national and international awards and recognition, club and society engagement, new students, and our most recent group of graduates.

GRADUATE STUDENTS UDDHAV BHATTARAI
AND MARTIN CHURUVIJA.

Students Awards and Recognitions

Outstanding Graduate Student Spotlight: Behnaz Molaei

Behnaz Molaei joined BSE as a visiting scholar in 2017 and was admitted to our graduate program in 2019. She finished her PhD in 2022. Her research involved using unmanned aerial system (UAS)-based remote sensing techniques to detect the effects of irrigation systems and water management on crop production. She was advised by Dr. Troy Peters. She is currently an assistant professor at Tennessee State University where she is a researcher and teacher. Below are a few awards Molaei received in 2022.



Behnaz Molaei

Behnaz Molaei receives GPSA College Representative of the Year Award

March 23, 2022 Pullman, WA

WSU GPSA President Reanne Cunningham Chilton and GPSA Executive Vice President and Budget Chair **Marwa Aly** announce that **Behnaz Molaei** is the 2022 recipient of the **GPSA College Representative of the Year Award**.

She is being recognized as an exceptional college representative and chair of the awards and scholarships committee.

GPSA is so happy to recognize Molaei's accomplishments by giving her this award. Molaei's advisor is Troy Peters.

Behnaz Molaei receives Graduate Student Leadership Award from CAHNRS Student Success and Academic Programs

CAHNRS Student Success and Academic Programs

April 5, 2022 Pullman, WA

Graduate students are afforded multiple opportunities to be recognized for outstanding academics or scholarship. However, there are few opportunities for them to be recognized for their leadership.

The **CAHNRS Graduate Student Leadership Award** recognizes and celebrates graduate students who have demonstrated leadership that has positively impacted their unit, college, campus, or wider community. The award is not just for longstanding leaders; it is reserved for those who have made significant positive contributions or improvements to the operations and functions of these programs, initiatives, or organizations. The winner receives a \$1,000 award.

CAHNRS Student Success and Academic Programs announces that **Behnaz Molaei** received the **2022 Graduate Student Leadership Award**. Molaei's advisor is Troy Peters.

Behnaz Molaei receives AFW Karen P. DePauw Leadership Award

AFW's 2022 Karen P. DePauw Leadership Award given to Behnaz Molaei
April 11, 2022 Pullman, Wash.

Behnaz Molaei received the Karen P. DePauw Leadership Award from the Association for Faculty Women (AFW) and the WSU Graduate School. The award was given during a special ceremony on April 7.

The Karen P. DePauw Leadership Award (for doctoral candidates) was created in 2003 to honor DePauw's service to WSU and recognize doctoral candidates who demonstrate evidence of leadership skills and/or university involvement.

Congratulations to Molaei and her proud advisor/mentor, Troy Peters!

This story has been shared by DePauw, Provost Elizabeth Chilton, and President Kirk Schulz.



twitter.com/kpdepauw/status/1512067877947334658?s=20&t=ax-hPsZrhfByUuL_PdNV8A

Behnaz Molaei – one of the finalists in 2022 ASABE Oral/Poster Competition

Behnaz Molaei (former PhD student of Troy Peters, LAWREE) is shown presenting at the ASABE Oral/Poster Competition during the ASABE Annual International Meeting in Houston, 2022.

Molaei was one of the finalists in the ASABE Oral/Poster Competition within the machinery systems technical community for her work entitled, "Investigating Practical Artificial Hot and Cold Reference Surfaces for Improved ET Estimation using the UAS-METRIC Energy Balance Model."

She will receive a \$250 prize check for her presentation.



Students Awards and Recognitions

CAHNRS Three Minute Thesis – Uddhav Bhattarai wins PhD level competition

Uddhav Bhattarai won the PhD level of the CAHNRS Three Minute Thesis competition and later competed at the WSU-wide competition.



Uddhav Bhattarai

CAHNRS 2022 – Three Minute Thesis results

PhD

1. Uddhav Bhattarai – BSE – \$1,000 (Presentation Title: Robot Laborers for Apple Crop Management) – won tiebreaker and will advance to the university-level competition.
2. Ramesh Sahni – BSE – \$1,000 (Presentation Title: Fixed spray system: Every drop to the drop)
3. Sudha Upadhaya – Plant Pathology – \$500 (Presentation Title: Can a picture save thousands of plants?)

Master's

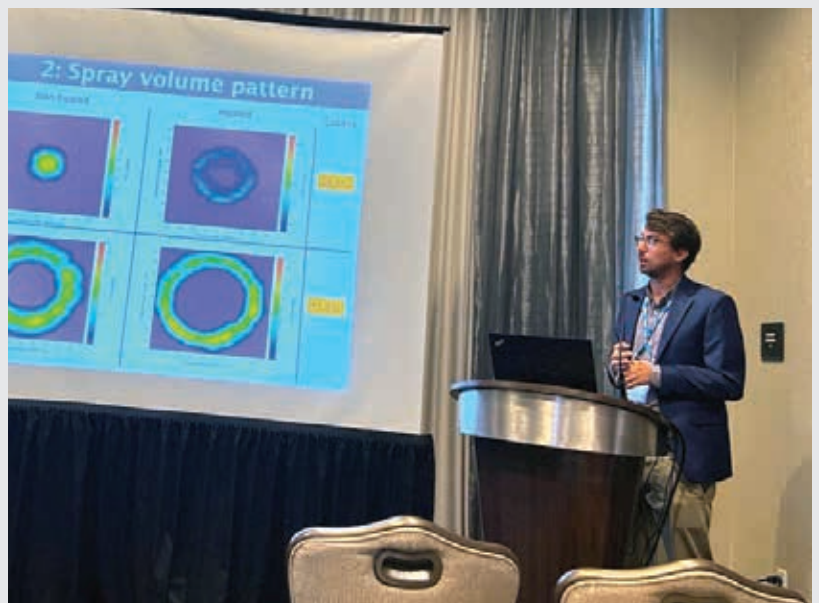
1. Em Rendleman – Entomology – \$1,000 (Presentation Title: Experimental Varroa Mite Treatment in the European Honey Bee *Apis Mellifera*)
2. Srijana Shrestha – Horticulture – \$500 (Presentation Title: Professional Development Training for Soil-Biodegradable Plastic Mulch (BDM))
3. Noah Willsea – Horticulture – \$250 (Presentation Title: Retractable Netting Reduces Sunburn Risk While Maintaining Red Color in Apples)
4. Jasmine Richman – Animal Sciences – \$250 (Presentation Title: Investigating the Activin Receptor Signaling Pathway as a Key Regulator of Muscle Growth Following Whole Genome Duplication Events)

Jake Schrader – one of the finalists in 2022 ASABE Oral/Poster Competition

Jake was one of the finalists in the ASABE Oral/Poster Competition within the machinery systems technical community for his work entitled, “Thermal analysis of heated spray and implications for agricultural spray technologies.”

He received a \$250 prize check for his presentation.

Photo: Jake Schrader (PhD student of Lav Khot, agricultural automation engineering), presenting at the ASABE Oral/Poster Competition during the ASABE Annual International Meeting in Houston, 2022.



Poster Awards and Best Graduate Seminar Presenters

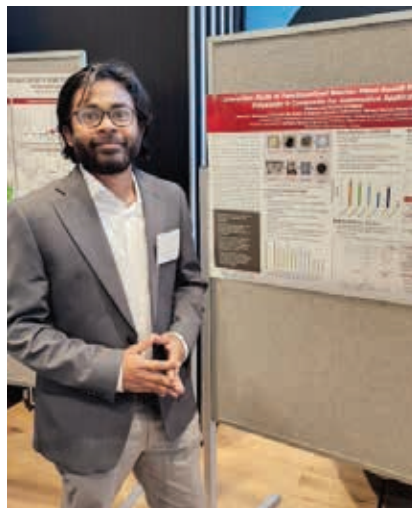
Event	Award	Advisor
BSYSE 512 Spring 2022 Poster Award	First Place: Bhupinderjeet Singh Second Place: S. M. Hasan Shahriar Rahat Third Place: Mugilan Govindasamy Third Place: Supriya Savalkar	Kirti Rajagopalan Shulin Chen Sindhuja Sankaran
BSYSE 598 Fall 2022 Graduate Seminar Best Presenter	First Place: Claire Castillo Second Place: Kalidas Mainali Third Place: Do-Gyun Kim	Kirti Rajagopalan Troy Peters Manuel Garcia-Perez Shulin Chen

Poster Awards and Best Graduate Seminar Presenters

BSE Outstanding Graduate Students Awards		Advisor
Automation	Basavaraj Amogi - Partial award from: Walter and Vinnie Hinz Scholarship & Alfred and Genevieve Gallucci Scholarship Milton Valencia Ortiz - Walter and Vinnie Hinz Scholarship	Lav Khot
	Milton Valencia Ortiz - Walter and Vinnie Hinz Scholarship	Sindhuja Sankaran
	Priyanka Upadhyaya - Arnie & Marta Kegel Endowed Fellowship	Manoj Karkee
	Chenchen Kang - Arnie & Marta Kegel Endowed Fellowship	Qin Zhang /Manoj Karkee
	Zixuan He - Arnie & Marta Kegel Endowed Fellowship	Manoj Karkee
	Achyut Paudel - Arnie & Marta Kegel Endowed Fellowship	Manoj Karkee
Bioenergy	Rongge Zou - Arnie & Marta Kegel Endowed Fellowship	Hanwu Lei
	Austin Gluth - Arnie & Marta Kegel Endowed Fellowship	Bin Yang
Food Engineering	Xu Zhou - Arnie & Marta Kegel Endowed Fellowship	Juming Tang



Supriya Savalkar and Meghana Mendon at the BSE Celebration, August 2022.



Mohammad Hoque at the BSE Celebration, August 2022



Gajanan Kothawade at the BSE Celebration, August 2022

Graduate Student Clubs

Our engineering clubs provide opportunities for students and faculty to explore their interests while making friends. The clubs encourage students to learn more about leadership, communication, and how to present their research and projects.

Club members are actively engaged in professional societies and paper competitions. They also have the chance to earn travel grants and acquire prestigious industrial internships.

- Agricultural Automation and Engineering Club
- American Society of Agricultural and Biological Engineers – WSU Student Branch
- Biomass Engineering Club
- Food Engineering Club



FOOD ENGINEERING STUDENTS AT THE CAHNRS FALL FESTIVAL.

Agricultural Automation and Engineering Club

The Agricultural Automation and Engineering Club aims to foster a global exchange of knowledge and expertise, provide students with industrial exposure, and develop engineering solutions to growers' problems. The club focused on coordinating the AgTalk series, industrial trips, workshops, and panel discussions with growers.

The club's activities commenced in March with a study tour to Meter Group Inc., in Pullman, Wash., where students from various departments were introduced to diverse environmental sensors and the processes involved in their manufacturing.

Following that, the AgTalk series was introduced in June to bring together experienced professionals and graduate students from various countries to share their expertise and insights on agricultural advancements in their respective nations. The first AgTalk featured Eric Mozzanini, a visiting scholar at WSU, who presented his research on crop protection technologies in Europe. In August, a second talk was given by Alan Campbell, an experienced plant physiologist and the owner of Smart Vineyards and Northwest Vineyards Consulting. The students learned how his company used wireless monitoring of soil moisture and tension to help growers manage irrigation and produce quality wine grapes in the Pacific Northwest.

The club also co-hosted a guest seminar with the Prosser Graduate Student Association at IAREC. Sarang Nerkar, an

electrical and computer engineer from the University of Toronto, gave a talk on "Humanistic Intelligence and its use in Climate Smart Agriculture." Nerkar discussed human and robot interaction and how it could help manage vineyards.

The club plans to organize a two-day workshop to provide students with hands-on experience integrating microcontrollers and various sensors for managing different agricultural activities.

Finally, the club intends to facilitate discussions with growers and industrial leaders to bridge the gap between academia, industry, and growers.



FACILITATION OF ERIC MOZZANINI, VISITING SCIENTIST FROM DEPT. OF AGRICULTURAL FOREST AND FOOD SCIENCES, UNIVERSITÀ DEGLI STUDI DI TORINO, ITALY FOR HIS INVITED TALK (ORGANIZED BY BSE AG AUTOMATION CLUB).



INDUSTRIAL VISIT TO METER GROUP INC., PULLMAN (MANUFACTURER OF ENVIRONMENTAL SENSORS) ON MARCH 11, 2023.

American Society of Agricultural and Biological Engineers (ASABE) – WSU Student Branch

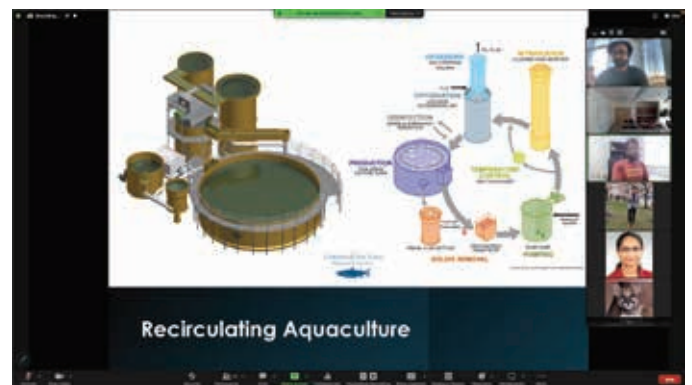
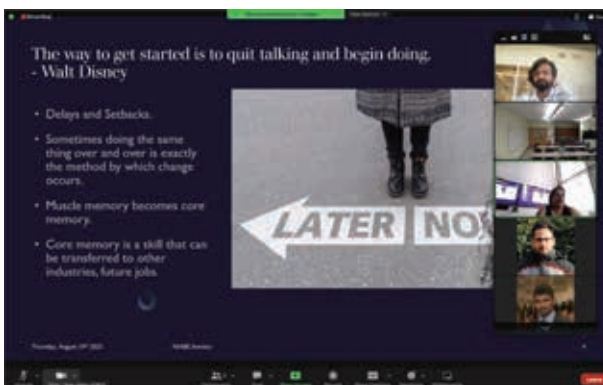
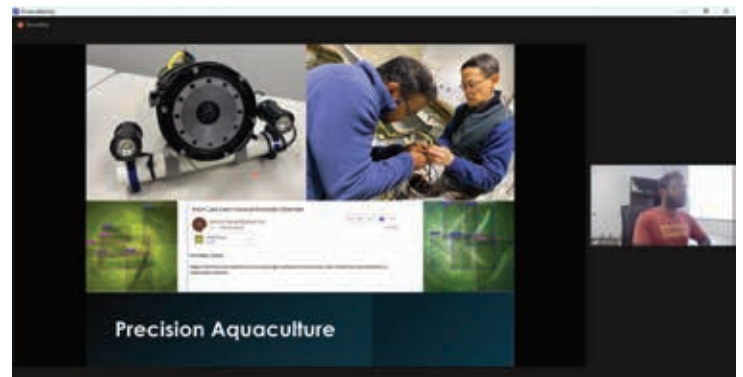
The American Society of Agricultural and Biological Engineers – WSU Student Branch (WSU ASABE-SB) is a thriving Registered Student Organization (RSO), established on Sept. 21, 2012.

The primary purpose of WSU ASABE-SB is to promote and support the mission of ASABE. This esteemed society aims to gather, organize, and disseminate ideas and information for the advancement of agricultural, biological, food, environmental, and ecological engineering. By participating in WSU ASABE-SB, students have the opportunity to engage with professionals in the biological and agricultural engineering fields and contribute to those fields' continued growth and innovation.

Our student branch also serves as a platform for enhancing communication and collaboration among

students and faculty within and across departments. Through various events, workshops, and networking opportunities, we aim to foster meaningful connections, friendships, and professional relationships. WSU ASABE-SB provides a supportive community where students can gain valuable insights, knowledge, and career opportunities from experienced professionals and fellow enthusiasts in the field.

We invite you to join us on this exciting journey of exploration, innovation, and growth in agricultural and biological engineering. WSU ASABE-SB is here to support and empower those interested in expanding their knowledge, forging connections, or making a positive impact on the world. Together, let's make a difference in the future of agriculture, food systems, and environmental sustainability.



WORKSHOPS/SEMINARS ORGANIZED BY THE ASABE CHAPTER.

Academic Seminars

Seminars/events

We are pleased to announce that an enlightening academic seminar titled, “Transition Into the Next Phase After Graduate Life,” was organized on May 12, 2023. The seminar was delivered by Rakesh Ranjan, a distinguished research scientist affiliated with The Conservation Fund Freshwater Institute.

Continuing our commitment to providing valuable learning opportunities, we hosted our second seminar on Aug. 10, 2023. This seminar featured Iva Jovanovic, a process development engineer at Intel, Corp., and a prominent member of the chemical and mechanical planarization team.

The seminars served as a platform for graduate students, postdoctoral researchers, and early-career professionals to engage in thoughtful discussions and gain valuable perspectives. The seminars also enabled them to prepare for their own transitions into the next phase of their professional careers.

Upcoming seminars/events

We are also planning BSE department poster competition in collaboration with other RSOs and other academic seminars. These competitions can be especially valuable for students and early-career professionals, helping them build relationships with potential employers or collaborators.

2023-2024 Executive Branch Officers



Pius Ndegwa
Faculty Advisor



Md. Redwan Khan
President



Prabesh Khanal
Vice President



Meghana Mendon
Treasurer



Kesawa Dadallage
Secretary



Join Us!

Biomass Engineering Club

The WSU Biomass Engineering Club (BEC) is dedicated to advancing the science and technologies that transform biomass such as crop waste into valuable products, fuels, and compounds. BEC strives to foster a sense of community and create a strong bond between biomass engineering students, faculty, and other interested individuals. The club encourages leadership, enhances presentation and communication skills, and introduces students to various facets of their field, stimulating greater interest in the profession.

1. CAHNRS Fall Festival: At the CAHNRS Fall Festival, BEC set up an interactive game called PyroMaze. This engaging activity drew students and guests' attention to primary research lab processes: pyrolysis, fractionation, and purification of valuable compounds. In addition to creating value-added products in the biofuel industry, these compounds exhibit various biological activities, including anti-bacterial, anti-fungal, anti-termite, and anti-cancer properties. Winners of the game were given the opportunity to spin a wheel and receive valuable prizes.

2. BSE Food Drive: BEC organized the BSE Food Drive, inviting the department's students and staff to contribute nonperishable food items. The collected items, totaling around 40 pounds, were donated to a Pullman food bank, making a positive impact on the local community.

3. BSE Ramadan Night: BEC celebrated a Ramadan Night to promote diversity, equity, and inclusion within the BSE department. This event honored Ramadan, the Muslim fasting month, and contributed to enhancing cultural understanding. Raed Alsawaier, our esteemed guest speaker, delivered a presentation, followed by a brief discussion. The event concluded with the delightful serving of authentic Arabian cuisine and desserts.

4. Women's self-empowerment in STEM discussion table: BEC is currently organizing a discussion table focused on women's self-empowerment in STEM fields. The event will feature two speakers who will share their success stories and experiences, highlighting challenges and opportunities for women in STEM around the world. This initiative aims to inspire and support women pursuing careers in STEM.



VALENTINA JIMENEZ (RIGHT) AND MELBA DENSON, BOTH CLUB OFFICIALS, WELCOME THE PYROMAZE CHALLENGERS.



OUR DEPARTMENT'S STAFF AND STUDENTS GENEROUSLY DONATED 40 POUNDS OF FOOD.



BSE RAMADAN NIGHT FEATURED A MIX OF ENJOYABLE AND EDUCATIONAL ACTIVITIES.



WOMEN'S SELF-EMPOWERMENT IN STEM ANNOUNCEMENT.

Through these diverse activities, **Biomass Engineering Club** successfully achieved its mission of connecting students, enhancing their skills, and promoting the field of biomass engineering. The club's commitment to innovation, community engagement, and inclusivity has contributed to a thriving and dynamic environment for students and faculty alike.

Faculty advisor for BEC: Manuel Garcia-Pérez.

Food Engineering Club

The Food Engineering Club had a productive year in 2022-2023, despite facing challenges related to a decreased number of students. We remained dedicated to organizing impactful events and providing valuable experiences for our members. This report highlights two significant events that took place during this period.

CAHNRS Fall Festival - September 2022:

As an active participant in the CAHNRS Fall Festival, the Food Engineering Club organized an engaging booth to showcase the field of food engineering. Our booth featured interactive displays, demonstrations, and informative materials that aimed to educate attendees about the role of engineering in food production, processing, safety, and packaging. The festival provided an excellent platform for us to engage with a diverse audience and promote awareness of food engineering to students and the public.



FOOD ENGINEERING STUDENTS AT THE CAHNRS FALL FESTIVAL.

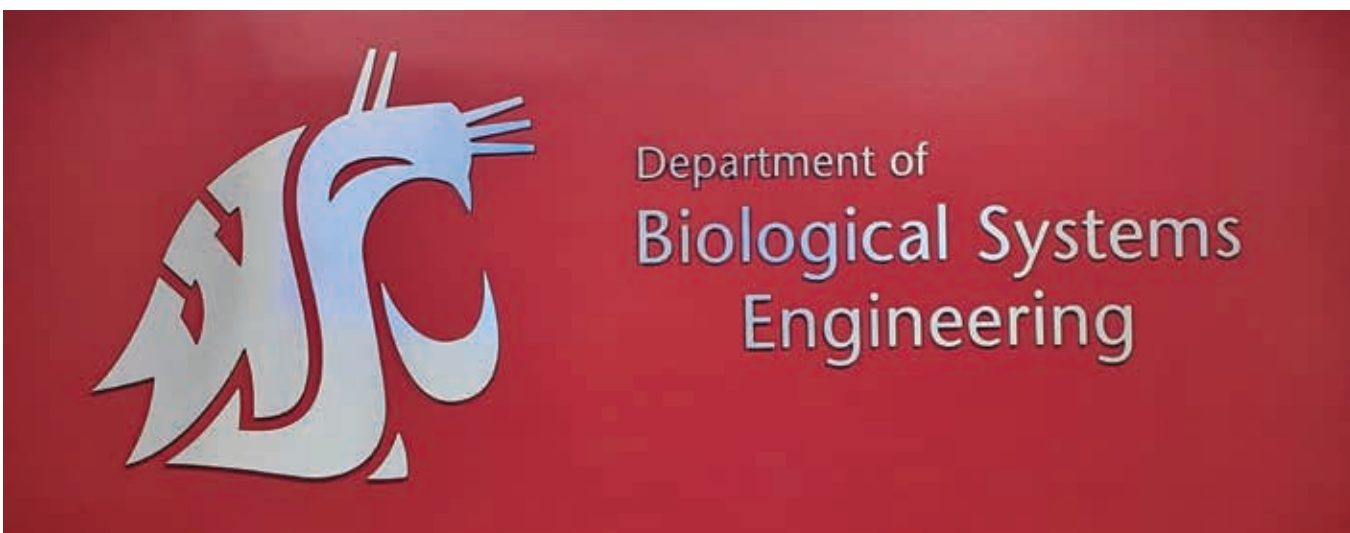
Seminar presented by Jie Xu - November 2022:

In November 2022, we had the privilege of hosting Jie Xu, an esteemed alumna of our club who recently completed her postdoctoral research at Harvard University. Xu shared her groundbreaking research study, which was published in *Nature Food*. Her seminar provided valuable insights into the latest advancements in biodegradable antimicrobial packaging and her *Nature Food* submission experience. Xu's industry experience and career advice also inspired our members, offering a glimpse into potential career pathways within food engineering.

Looking Ahead:

As we reflect on the past year, we acknowledge the decrease in membership and participation in the Food Engineering Club. However, we remain optimistic about the future and are committed to revitalizing our club and fostering a vibrant community. We have outlined the following strategies for the coming year:

- (1) Collaborations with other clubs: We plan to explore collaborations with other clubs within the BSE department.
- (2) Engaging activities and events: We will organize engaging activities and events that cater to the interests and needs of our smaller group of members. These activities may include guest lectures and workshops that provide valuable experiences and foster connections within the food engineering community.



Welcoming New BSE Students

In 2022, we welcomed 17 new graduate students from around the world.

Name	Degree	Last School Attended	Research Area	Advisor
Dawood Ahmed	PhD	National University of Sciences & Technology – Islamabad	Automation	Manoj Karkee
Elda Yitbarek Bezuayene	MS	Technion-Israel Institute – Haifa, Israel	Automation	Lav Khot & Troy Peters
Dattatray Bhalekar	PhD	Indian Agricultural Research Institute – New Delhi	Automation	Lav Khot
Veronica Crow	PhD	Scripps College – Claremont, Calif.	Bioenergy	Manuel Garcia-Perez
Oluwatumise Dada	PhD	University of Ibadan – Nigeria	Bioenergy	Shulin Chen
Rachel Emerson	PhD	Idaho State University – Pocatello, Idaho	Bioenergy	Bin Yang
Jonah W. Hart	MS	Washington State University – Pullman, Wash.	Bioenergy	Birgitte Ahring
Mohammad Hoque	MS	Bangladesh University of Engineering & Technology – Dhaka, Bangladesh	Bioenergy	Manuel Garcia-Perez & Vikram Yadama
Zachary D. Johnson	PhD	San Diego State University – San Diego	Bioenergy	Bin Yang
Sarah Kemmerer	MS	Washington State University – Pullman, Wash.	Bioenergy	Shulin Chen
Shafik Kiraga	PhD	Chungnam National University – Daejeon, Republic of Korea	Bioenergy	Troy Peters
Valentina Sierra Jimenez	PhD	Universidad Nacional de Colombia – Medellin, Colombia	Bioenergy	Manuel Garcia-Perez
Kingsley Umani	PhD	University of Uyo – Nigeria	Automation	Sindhuja Sankaran
Ranjan Sapkota	PhD	North Dakota State University – Fargo, N.D.	Bioenergy	Manoj Karkee
S.M. Hasan Shahriar	PhD	Shahjalal University of Science and Technology – Sylhet, Bangladesh	Bioenergy	Shulin Chen & Liang Yu
Srikanth Venkata Gorthi	PhD	Indian Institute of Technology – Kharagpur, India	Automation	Lav Khot
Karisma Yumnam	PhD	Indian Institute of Technology – Roorkee, India	Automation	Lav Khot

2022 Graduates

Our heartfelt congratulations to the 18 PhD students and 3 master's students who graduated in 2022. Our graduates will follow their chosen paths, discovering new ways to shape the future in national laboratories, institutions of higher learning, and the agricultural industry at large.



2022 GRADUATES.



COMMENCEMENT DECEMBER 2022.

2022 Graduates

Name	Degree	Area	Title Of Dissertation	Advisor
Zhangyang Xu	PhD	Bioenergy	FUNDAMENTALS OF BIOLOGICAL PRODUCTION OF POLYHYDROXYALKANOATE FROM BIOMASS-DERIVED CARBON SOURCES IN PSEUDOMONAS PUTIDA	Bin Yang
Yucen Xie	PhD	Food Engineering	CONTROL OF SALMONELLA IN SPICES: THERMAL RESISTANCE, STABILITY DURING STORAGE AND SURROGATE	Juming Tang
Michelle Hendrickson	PhD	LAWREE	GROUT DEVELOPMENT AND HYDROLOGIC MODELING OF A LANDFILL COVER SUPPORTING CLOSURE FOR HANFORD'S FIRST SINGLE-SHELL TANK FARM AND ASSOCIATED WASTE MANAGEMENT AREA C	Joan Wu
Lina Pilar Martinez Valencia	PhD	Bioenergy	A SYSTEM DYNAMICS MODEL APPROACH FOR POLICY ANALYSIS OF SUSTAINABLE AVIATION FUEL	Manuel Garcia-Perez
Anamaria Paiva Pinheiro Pires	PhD	Bioenergy	CONTRIBUTIONS TO THE DEVELOPMENT OF PYROLYSIS OIL BIOREFINERIES	Manuel Garcia-Perez
Iva Jovanovic Tews	PhD	Bioenergy	CATALYTIC WET OXIDATION OF ORGANIC RICH AQUEOUS FRACTION DERIVED FROM BIOMASS THERMOCHEMICAL PROCESSING WITH NOVEL CHAR CATALYSTS IN ICROSCALE BASED REACTORS	Manuel Garcia-Perez
Yaojing Qiu	PhD	Bioenergy	SYSTEMATIC EVALUATIONS ON HYPERTHERMOPHILIC ANAEROBIC DIGESTION (HTAD) OF LIGNOCELLULOSIC BIOMASS (DAIRY MANURE AND CORN STOVER) WITH THE EMPHASES ON HYDROLYSIS, ACIDIFICATION, AND METHANE PRODUCTION	Shulin Chen
Sivapratha Sivabalan	PhD	Food Engineering	DESIGN OF ENCAPSULATION SYSTEM FOR TEMPERATURE, LIGHT AND STORAGE STABILITY OF B-CAROTENE	Shyam Sablani
Afef Marzougui	PhD	Automation	PHENOMICS-DATA DRIVEN TOOLS FOR MACHINE LEARNING-ASSISTED DECISION SUPPORT IN AGRICULTURE	Sindhuja Sankaran
Daniel Borrenpohl	MS	Automation	AUTOMATED PRUNING DECISIONS IN DORMANT CANOPIES USING INSTANCE SEGMENTATION	Manoj Karkee
Jiewen Guan	PhD	Food Engineering	SCALE-UP TREATMENT OF GASEOUS CHLORINE DIOXIDE IN REDUCING FOODBORNE PATHOGENS ON FRESH PRODUCE	Juming Tang
Ramesh Sahni	PhD	Automation	AN OPTIMIZED PNEUMATIC SPRAY BASED SOLID SET CANOPY DELIVERY SYSTEM FOR EFFICIENT AGROCHEMICAL APPLICATIONS IN MODERN APPLE ORCHARD	Lav Khot
Bhargavi Rane	PhD	Food Engineering	INDUSTRIAL SCALE GASEOUS CHLORINE DIOXIDE FUMIGATION TREATMENT ON LOW MOISTURE FOODS	Shyam Sablani
Zhangyang Xu	PhD	Bioenergy	FUNDAMENTALS OF BIOLOGICAL PRODUCTION OF POLYHYDROXYALKANOATE FROM BIOMASS-DERIVED CARBON SOURCES IN PSEUDOMONAS PUTIDA	Bin Yang
Anish Mahat	MS	LAWREE	OPTIMIZING PLACEMENT OF BIORETENTION SYSTEMS IN THE US PUGET SOUND REGION	Joan Wu
Mugilan Govindasamy	MS	Automation	SENSOR-BASED EVALUATION OF ARCHITECTURAL TRAITS IN TREE FRUITS	Sindhuja Sankaran
Yonas Gezahegn	PhD	Food Engineering	PROCESSING CONDITIONS OPTIMIZATION USING ANALYTICAL MODELS AND COMPUTER SIMULATION OF MICROWAVE ASSISTED THERMAL STERILIZATION AND PASTEURIZATION SYSTEMS	Juming Tang
Sohrab Haghighi Mood	PhD	Bioenergy	CONTRIBUTION TO NUTRIENT RECOVERY FROM ANAEROBICALLY DIGESTED LIQUID EFFLUENT USING ENGINEERED BIOCHAR	Manuel Garcia-Perez
Kalidas Mainali	PhD	Bioenergy	SELECTIVE CARBONIZATION OF N CONTAINING COMPOUNDS TO PRODUCE N DOPED CHARs AND DENSIFIED INTERMEDIATES	Manuel Garcia-Perez
Behnaz Molaei	PhD	LAWREE	UAS-BASED REMOTE SENSING TECHNIQUES FOR DETECTING THE EFFECTS OF IRRIGATION SYSTEMS AND WATER MANAGEMENT ON CROP PRODUCTION	Troy Peters
John Paulo Saccalan	PhD	LAWREE	INTERPRETING UNCALIBRATED SOIL WATER CONTENT SENSORS DYNAMICS FOR IRRIGATION MANAGEMENT	Troy Peters

2022 Peer-Reviewed Publications

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- Bhattarai, U., Karkee, M. 2022. A Weakly Supervised Approach for Flower/Fruit Counting in Apple Orchards. *Computers in Industry*, 138, 103635.
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Books and Book Chapters:

Books:

1. Li, M., Yang, C., Zhang, Q. 2022. *Soil and Crop Sensing for Precision Crop Production*. Springer, ISBN: 978-3-030-70432-2, (324 pp).

Book chapters:

1. Barbosa-Cánovas, G.V., Bermúdez-Aguirre, D., Gonçalves Franco, B., Candoğan, K., Shin, G.Y. 2022. Chapter 12 - Novel food processing technologies and regulatory hurdles, Editor(s): A. Martinović, S. Oh, H. Lelieveld, *Ensuring Global Food Safety (Second Edition)*, Academic Press, 221-228.
2. Li, H., Li, M., Sygrimis, N., Zhang, Q. 2022. *Soil and Crop Sensing for Precision Crop Production: An introduction*. In soil and crop sensing for precision crop production, pp. 1-17, Springer Nature.
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4. Karkee, M., Bhattarai, U. 2022. Applied Machine vision technologies in specialty crop production. In sensing, data managing, and control technology for agricultural systems (Editors: Shaochun Ma and Kuan-Chong (KC) Ting), Springer Nature Switzerland AG.
5. Karkee, M., Zhang, Q., Silwal, A. 2022. Agricultural Robots for Precision Agricultural Tasks in Tree Fruit Orchards. In *Innovation in Agricultural Robotics for Precision Agriculture* (Editor: Avital Bechar), Springer Nature Switzerland, AG.
6. Sablani, S.S., Sonar, C., Tang, J. 2022. Thermal Pasteurization. In *Encyclopedia of Food Safety*, 2nd edition, Jackson L, Ed. Elsevier.
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CONFERENCE & SYMPOSIUM ANNOUNCEMENTS

2024 Conference of Food Engineering (CoFE'24) —Seattle, WA, 2024

Three food engineering professors from our department, Juming Tang, Shyam Sablani, and Gustavo Barbosa-Cánovas, together with Yanyun Zhao of Oregon State University, are organizing an international Conference on Food Engineering (CoFE'24), which will take place at the Seattle Convention Center during fall 2024.

All CoFEs are organized by the U.S. Society of Food Engineering every two to three years; the first conference was held in 1989. Colleagues from around the world are actively involved with the events, which include plenary and invited lectures, oral and poster presentations, and great participation by graduate students.

ASABE Conferences

2024 Agricultural Equipment Technology Conference, Feb. 11-14, 2024, Hyatt Regency, Louisville, Ky.

2024 Annual International Meeting, Marriot, Anaheim, Calif., July 28-31, 2024



DR. SINDHUJA SANKARAN REPRESENTING BSE AT CAHNRS REUNION EVENT FOR ALUMNI FROM THE 1950-1983 GRADUATING CLASSES.

OUTREACH AND PARTNERSHIPS

2024 Conference on Food Engineering (CoFE'24)

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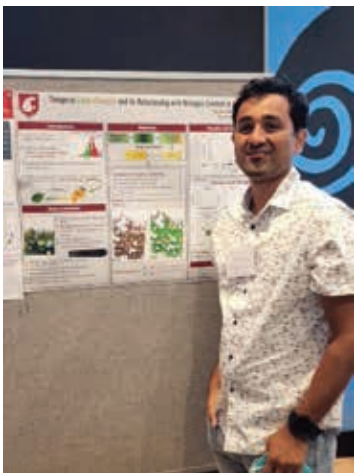
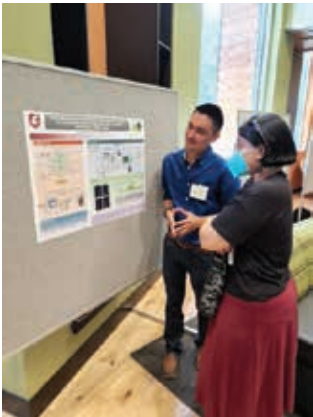
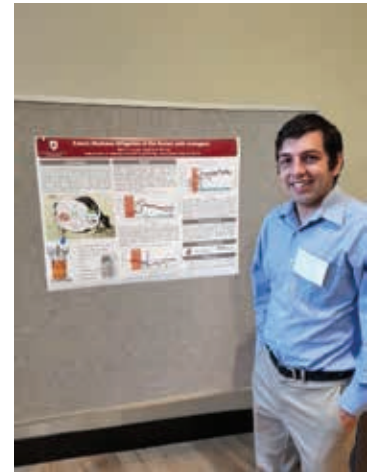
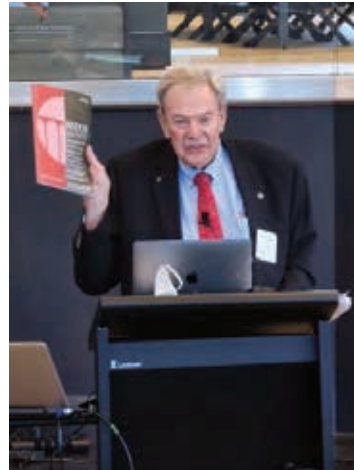
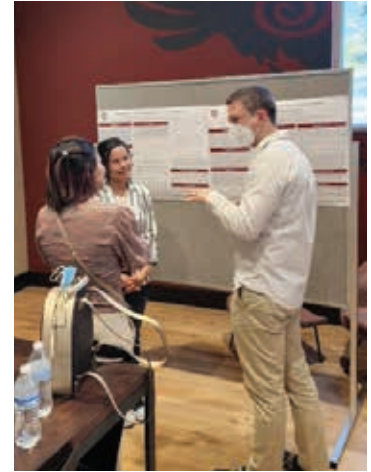
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- Scholarships to support graduate students.
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- The equipment in our central analytical lab is more than 15 years old. We seek donor support to maintain and replace these very important tools for our research mission.
- An endowed chair position for our areas of expertise: food engineering; biomass conversion and bioproducts; land, air, water resources & environmental engineering; and agricultural automation.



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