

Institute of Northern Engineering 2007 Annual Report

College of Engineering & Mines
University of Alaska Fairbanks

Engineering solutions for the world's cold regions and beyond.

Photo Contributors
See page 17.

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INE MISSION STATEMENT

The Institute of Northern Engineering engineers solutions for the world's cold regions and beyond.

INE conducts research in all areas of engineering, including but not limited to: civil, computer, electrical, energy, environmental, geological, materials, mechanical, mining, and petroleum engineering.

INE fosters opportunities for faculty, post-doctoral researchers, and students to tackle these engineering challenges.

INE focuses on basic and applied research and development, as well as research outreach.

INE promotes interdisciplinary and collaborative research and development.

INE supports partnerships with the natural and social sciences, education, business, geography, resource management, and law.

INE seeks to increase student involvement in research and development so that students at the University of Alaska graduate at the cutting edge of engineering and technology.



INE

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Institute of Northern Engineering
Engineering solutions for the world's cold regions and beyond.

It is my pleasure to report on the activities of the Institute of Northern Engineering for 2006-2007. In our third year since joining the College of Engineering & Mines, we have grown, adding 13% to our annual expenditures, principally through increased grant activity. INE continues to be a great place to work. We seek to attract and keep top faculty in engineering and related areas to meet our goal: engineering solutions for the world's cold regions and beyond. We will continue to grow by keeping our research relevant, responsive, and respected.

Relevant: The Arctic Energy Technology Development Laboratory entered its final year of the original design. We focused much of our resources in 2006-2007 toward charting a course for AETDL's future. In doing so, we established the Alaska Center for Energy and Power. ACEP will diversify INE's energy interests by conducting research and testing on rural, sustainable energy solutions; large power opportunities; and planning for the oil field of the future. ACEP will partner with local, regional, and state organizations, agencies, industries, and small businesses. Energy is an issue that Alaskans deal with every day in lighting and heating their homes, getting to work, and powering their lifestyles. In building ACEP, INE will conduct research that matters to every Alaskan, every day. ACEP will launch in 2008 powered by great expectations and anticipation.

INE has continued to develop its relationship with the Cold Climate Housing Research Center. In addition to partnering with CCHRC on concrete research projects, INE invested in two cold rooms to increase site capabilities. Together we refurbished and added to the site two refrigerated buildings. The 8-by-20 foot cold chamber provides a cold environment capable of holding temperatures as low as -20°C. The 8-by-40 footer provides a cold working environment to -50°C. These facilities are available for use by INE as well as CCHRC personnel and contractors. INE looks forward to increased activity in the CCHRC in the areas of water and wastewater management, thermal efficiency testing for new designs of windows and walls, improved concrete mixtures and formulations, and small-scale power generation. These housing research issues stand to improve the lives of all Alaskans.

Responsive: In order to better respond to state needs for research, INE must be agile, adaptable, and committed to our clients. The key to responsiveness is having faculty whose workloads allow them the greatest flexibility to meet our clients'

needs. We've worked hard toward this end, hiring faculty both as pure researchers and in a research/teaching model, and providing joint appointments to traditionally academic faculty.

During the 2006/07 academic year, INE added Mikhail Kanevskiy, Daniel Fortier, Katey Walter, and Sarah Trainor to its research faculty. Kenan Hazirbaba, Daqing Yang, Jenny Liu, Xiong Zhang, and Ming Lee were jointly appointed in INE (4.5 months) and the College of Engineering & Mines (4.5 months).

This new complement of research faculty has already contributed to INE and our growth. The four research faculty hired are 75% dependent on outside funding for their salaries. The 25% funding support they receive is returned to the institute through their high level of grant activity. Research faculty do not normally teach classes and are able to respond quickly to the needs of industry and agencies in the state. It is our hope that by diversifying our talent to include research faculty we improve our ability to respond to industry, agencies, and organizations. The research-faculty model is a win/win/win opportunity for faculty, the institute, and our clients.

We were also able to offer quarter-time joint appointments that released traditionally academic faculty to spend more of their contract period contributing to the research enterprise. INE will continue expanding our research-faculty base as well as pursuing models that allow faculty to conduct research while improving the broad base of skills in the college, improving the breadth of classes that can be offered, and extending research opportunities to undergraduates.

Respected: In order to provide the best research product to our clients, we must have the best faculty. We will continue to attract outstanding and enterprising faculty by providing top opportunities, facilities, and a positive, engaging work environment. As director of INE, I am committed to bringing the top researchers in the world to our institute, offering them comprehensive services, and providing a clear path to success.



College of Engineering & Mines

Institute of Northern Engineering

**Arctic Energy
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(AETDL)**



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**Petroleum
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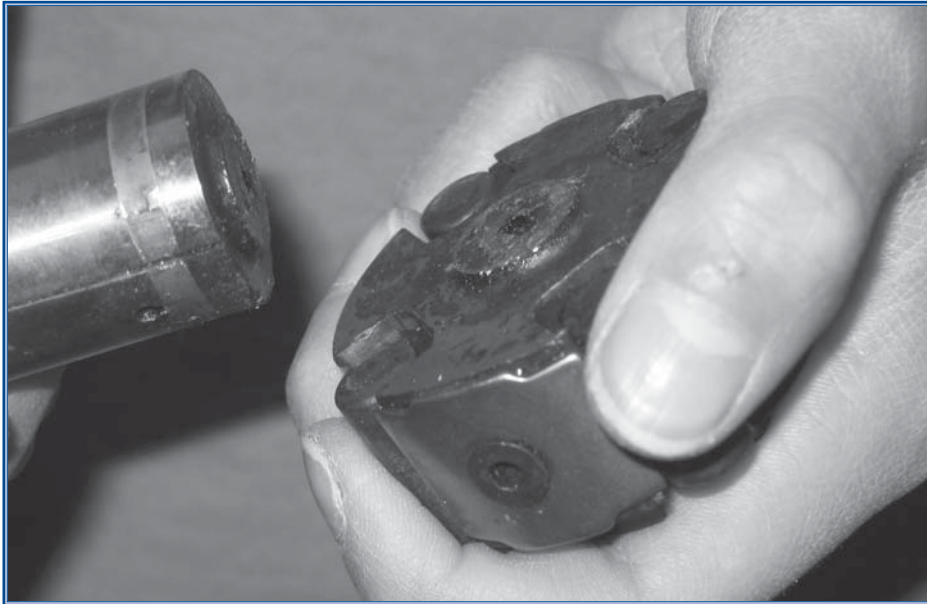
**Water &
Environmental
Research Center
(WERC)**



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**INE General
Research (IGR)**

About 20 faculty conduct research directly through INE in areas such as vehicle development, robotics, sensor networks, materials research, atmospheric studies, & engineering-relevant toxicology issues. To learn more, contact INE Director Dan White, 907-474-5457.



The **Arctic Energy Technology Development Laboratory (AETDL)** mission is to promote research, development, and deployment (RD&D) of energy technologies in arctic regions by bringing together UAF resources and Alaska's energy industry.

Since September 2001, AETDL has identified research needs with strong input from its funding sponsor, the US Department of Energy, then solicited proposals from inside and outside the university to meet these needs. AETDL projects have focused on more efficient use of Alaska's oil, gas, and coal resources and explored ways to bring reliable, affordable power to remote sites across the state.

In 2008 AETDL will lend its resources and expertise to launching the Alaska Center for Energy & Power (ACEP).



The **Alaska Center for Energy & Power (ACEP)** is a new, permanent program designed to expand INE's applied energy research capacity. ACEP will build on the groundwork laid by AETDL, with three focus areas: rural energy solutions, powering the economy, and the oilfield of the future.

ACEP is an interdisciplinary, University of Alaska system-wide organization that can address all aspects of applied energy research.

ACEP is designed from the start to be agile, needs-driven, and responsive in addressing the energy research areas critical to reducing the cost of energy and developing new economic opportunities for Alaska, its residents, and its industries.





The **Alaska University Transportation Center (AUTC)** draws on expertise from throughout the state, building strong partnerships between research, industry, and state agencies. AUTC is uniquely able to address transportation issues common to cold regions. Alaska is both its market and its research laboratory.

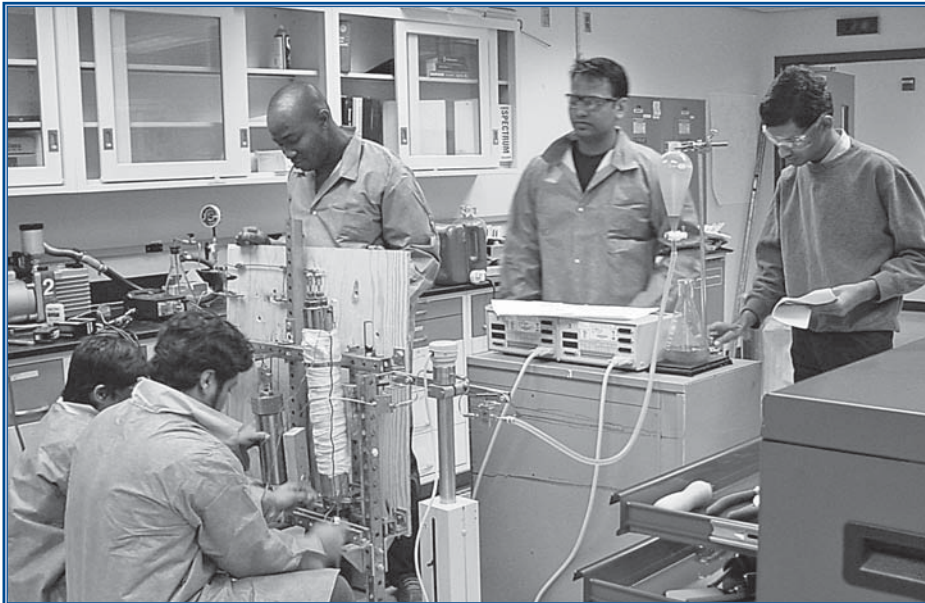
AUTC serves the state by examining and improving the multimodal ways we move people, goods, and energy in Alaska. Research faculty like Daniel Fortier (left, top) focus on the intricate interactions of permafrost and pavements. Jointly appointed faculty such as Jenny Liu (below) conduct research into pavement materials and offer focused classes customized to serve Alaska's professional engineers. Students like Michael Golub (left, bottom) take on research projects such as designing vehicles to run on electricity.



The **Mineral Industry Research Laboratory (MIRL)** engages in basic and applied research supporting exploration, evaluation, development, production, processing, refining, transportation, arctic and subarctic environmental assessment, permitting, and land reclamation related to using the mineral and energy resources of Alaska for the maximum benefit of all its people.

Faculty like Dan Walsh and Steve Lin (below, from left) who conduct research through MIRL offer the latest information to Alaskans involved in mining technology at all levels, from students like Eric Hill and John Hollow (below, from right), to the individual gold prospector, to enterprises such as the Fort Knox Mine.





Faculty in the **Petroleum Development Laboratory (PDL)** conduct fundamental and applied research such as reservoir characterization, modeling, and simulation; enhanced oil recovery; and fluid characterization, drilling, and production. They assist the Alaska petroleum industry and state agencies in efforts to make better use of these resources under stable and healthy environmental conditions. PDL research serves rural communities by exploring ways to keep fuel production and transport as economical and safe as possible. PDL offers extensive graduate research opportunities to students from Alaska and all over the world. PDL focuses on North Slope heavy oil development, North Slope methane hydrate resource assessment and development, and coal bed methane resource development in Alaska.



Faculty of the **Water & Environmental Research Center (WERC)** perform basic and applied research related to water and environmental resources, train graduate students at master and doctoral levels, and serve as an international resource committed to disseminating knowledge to the public. WERC researchers conduct fieldwork all over Alaska, from Kodiak to the North Slope, and throughout the world, from Iceland to the South Pole.

WERC faculty like Mat Wooller (right, top) meet many agency needs, including Alaska's Drug Enforcement Agency. WERC is home to a wide range of skilled postdoctoral researchers. In the photo below (right, clockwise) are Fulbright Research Fellow Muhammed Iqbal, and our three International Polar Year Fellows, Amy Tidwell, Sebastian Mernild, and Amanda Booth.





Many faculty conduct research directly through the Institute of Northern Engineering rather than through a specific research center. Their work is shaped by defined state and national needs in combination with Alaska's unique environments as well as their own considerable talent for innovation.

Faculty like Seta Bogosyan (left, top) develop state-of-the-art robot controls and create opportunities for students like Matt Anttil to explore this technology. Faculty like Dennis Filler (left, bottom) address the structural and climate issues faced by Alaska homeowners. Our faculty involve students at all levels in hands-on research in a way that prepares them to move directly into a competitive and highly technical workforce.



This year INE met state needs by conducting applied engineering research, introducing students to the cutting edge in engineering, and by testing and verifying new technologies for use in Alaska. Highlights include:

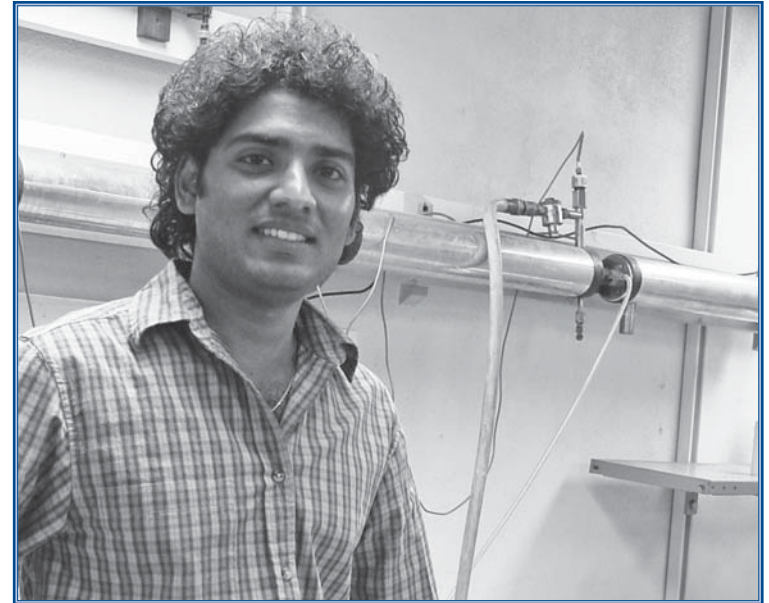
INE attracted approximately \$7.8 million in new proposal-driven research funding, in part by offering joint appointments to our academic faculty (at an investment of roughly \$135,699), allowing them to focus on research growth. INE faculty submitted roughly 103 proposals, with a success rate of approximately 52%.

INE supported 47 graduate students, 10 undergraduate students, and 8 postdoctoral staff on research projects. Our students are entering the job market with highly competitive skills, in part due to the hands-on professional experience they build working on INE projects.

Our students won awards in many national and international forums. One example is John Hollow (2007 graduate, with an interdisciplinary PhD in Mineral Preparation Engineering) and Eric Hill (working on a B.S. in Mining Engineering). They received the Arthur F. Taggart Award for their paper, “Modeling the Influence of Slurry Temperature on Gold Leach and Adsorption Kinetics at the Fort Knox Mine, Fairbanks, Alaska.”

INE supported new research opportunities by making 35 travel awards (at a cost of approximately \$51,423) available to faculty, who used these funds to extend their field work to new sites, build collaborative partnerships with colleagues, and present their latest work to a wider audience.

INE increased its research infrastructure by purchasing new equipment for our own labs (\$40,213) and through shared labs in the Cold Climate Housing Research Center (\$37,414).





INE Goals for the 2007/2008 year reflect our plans for new research in the areas of energy, infrastructure, and the environment.

Specific goals for 2008 include:

Enhancing Alaska's energy resources by investing in mining and minerals research through the Mineral Industry Research Laboratory, the operations of the Petroleum Development Laboratory, and the groundwork for the Alaska Center for Energy & Power.

Improving INE infrastructure by providing leadership and new facilities. INE will initiate a search for a dynamic and innovative director for the Alaska Center for Energy & Power, as well as investing in improvements to the MIRL Annex and other research facilities.

Extending INE's range of expertise by investing in research faculty positions and assisting academic faculty in pursuing research opportunities.

Mentoring research personnel in strategies for attracting and conducting research, and mentoring students through assistantship support, travel awards, and other opportunities.

Disseminating research findings to the Alaska community through a stronger presence in professional forums such as the Alaska Miners Association Annual Conference, the Research Partnership to Secure Energy for America, the Ninth International Conference on Permafrost, and the 2008 Rural Energy Conference, as well as a wider and more varied presence on the World Wide Web. Visit our extensive research highlights at www.uaf.edu/ine/.

Financial Statements for the Institute of Northern Engineering

show that our faculty continue to be successful in capturing externally funded research. Overall, the institute grew by 13%, from \$15.5 million in FY07 (July 2006 – July 2007) to \$17.5 million in FY08 (July 2007 – July 2008). These numbers include recovered facilities and administrative (F&A) costs spent in the institute.

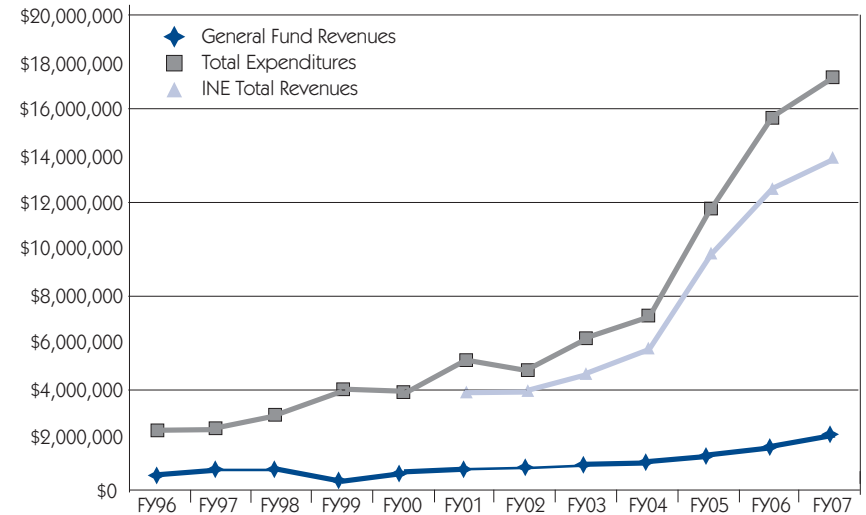
The graph on the lower right indicates the total F&A accrued to the university compared to every dollar of state investment. The result shows that since 1998, for every dollar invested in INE, the university itself has earned more than one dollar in F&A. While this is a great benefit to university operation, it is only a tiny fraction of the benefit such research productivity brings to the communities, industries, agencies, and individuals.

A full 80% of INE’s external funds come from federal sources (see graph on following page), via both initiatives and grants from federal agencies such as the National Science Foundation, the US Departments of Energy, Defense, and Transportation, the National Aeronautics and Space Administration, and the Bureau of Land Management. A portion of this comes from federal initiatives, including funding to support the new Alaska University Transportation Center and the Arctic Energy Technology Development Laboratory, as well as from sources such as the US Department of Interior’s Minerals Management Service.

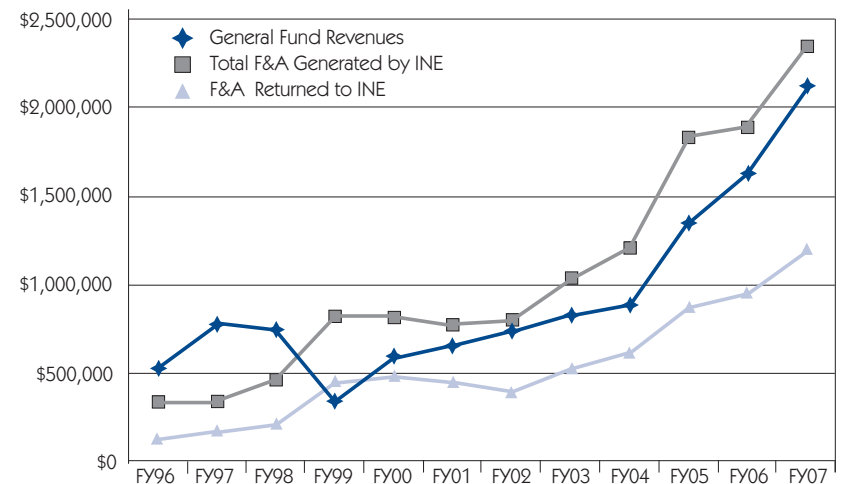
Approximately 9.6% of our external funding comes from Alaska state and local government sources, including the Department of Transportation & Public Facilities, Department of Fish & Game, and the Division of Health & Human Services.

Another 3.9% represents collaborations with other universities. Faculty participate in research consortiums such as the Center for General Aviation Research (lead by Embry Riddle) and the Region Ten Northwest Universities Transportation Consortium, as well as partnerships with organizations such as the University of Washington and the University of New Hampshire.

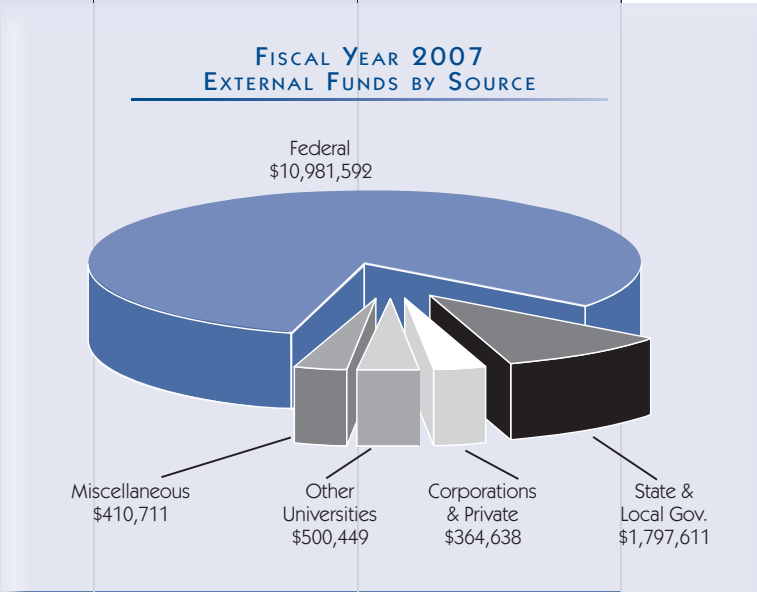
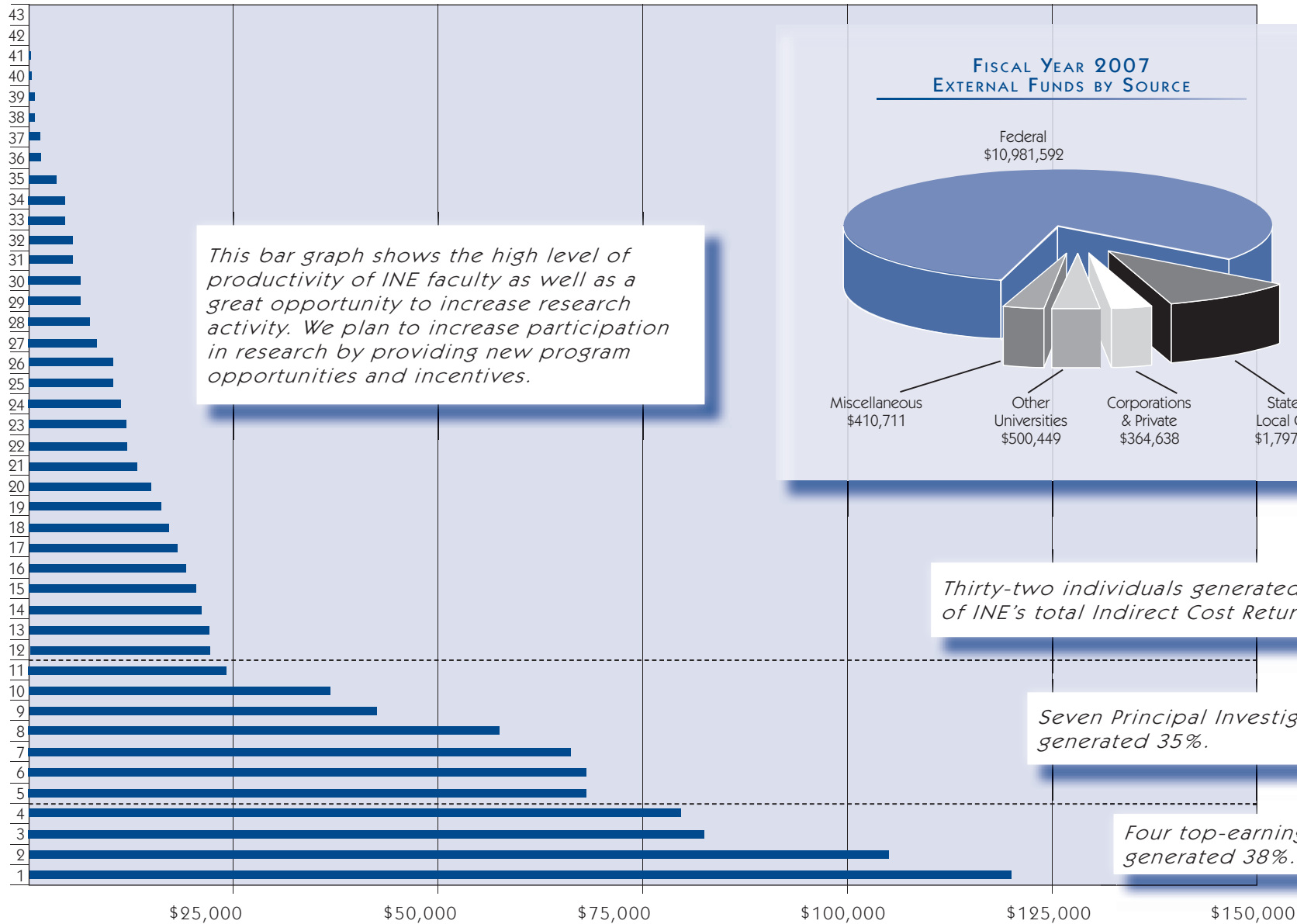
COMPARISON OF INE GENERAL FUND SUPPORT TO TOTAL REVENUE



INE COMPARISON OF F&A TO GENERAL FUND SUPPORT



FISCAL YEAR 2007 DISTRIBUTION OF TOTAL F&A GENERATED BY PRINCIPAL INVESTIGATORS
CONDUCTING RESEARCH THROUGH THE INSTITUTE OF NORTHERN ENGINEERING



Thirty-two individuals generated 27% of INE's total Indirect Cost Return.

Seven Principal Investigators generated 35%.

Four top-earning PIs generated 38%.

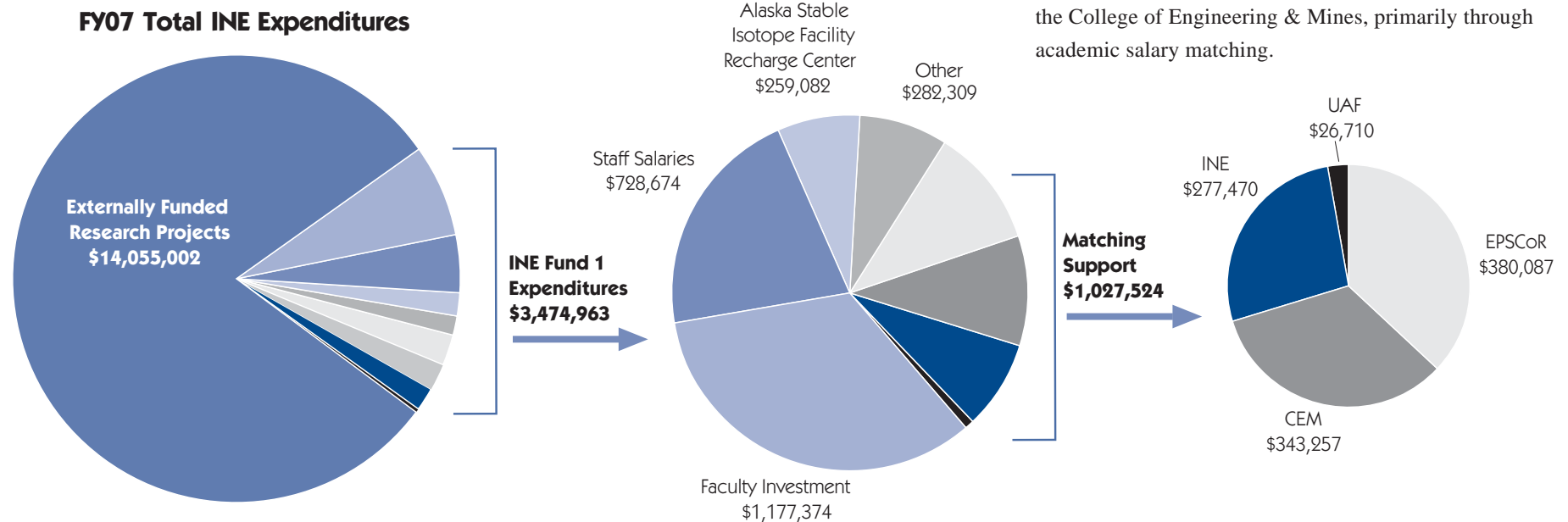
Corporations and private businesses provide roughly 2.8% of INE’s external funding. This includes research and analytical support performed for oil companies and local businesses such as Chena Hot Springs Resort. The balance of funds (about 3.2%) comes from other sources, such as foundation grants.

Unrestricted funds (sometimes called “Fund 1”) represent support not committed to specific research projects. Out of the approximately \$3.5 million in unrestricted funds available in FY07, INE invested 34% in faculty as salary support, student travel, research equipment purchase and maintenance, project supplies, and most importantly, new faculty start-up funds.

About 21% of FY07 unrestricted funds supported INE staff, ranging from partial support of director salaries to research staff, as well as those who staff the INE Business Office and the Proposals & Publications Office.

Activity in the Alaska Stable Isotope Facility, which is housed in the Water & Environmental Research Center, accounts for about 7.5% of FY07 unrestricted expenditures. ASIF is a self-supporting recharge center that provides analytical services to both internal (to UAF) and external researchers. Another 8.1% of these funds cover administrative and miscellaneous expenditures.

A key category in unrestricted expenditures is matching funds, or funds that are devoted to mandatory cost-sharing on research projects. About \$1,027,524 (31%) of Fund 1 expenditures fall into this category. Of this amount, 37% is provided by the University of Alaska as a 1:1 match for the federally funded Alaska Experimental Program to Stimulate Competitive Research (Alaska EPSCoR). Another 26% is provided by UAF, primarily through funds the provost has targeted for infrastructure growth; these funds are used as cost-share on successful proposals to organizations such as the Murdock Foundation and the National Science Foundation Major Research Instrumentation program. About 27% is cost-share provided directly through INE. Finally, about 33% of cost share funding comes from the College of Engineering & Mines, primarily through academic salary matching.





INE seeks to build partnerships with local, regional, and state organizations; our research partnership with the Cold Climate Housing Research Center is a good example. CCHRC provides an outstanding, hands-on, applied research facility fully equipped for studies designed to meet the state's housing needs. We all benefit from this partnership and the forward-thinking leadership of the CCHRC.

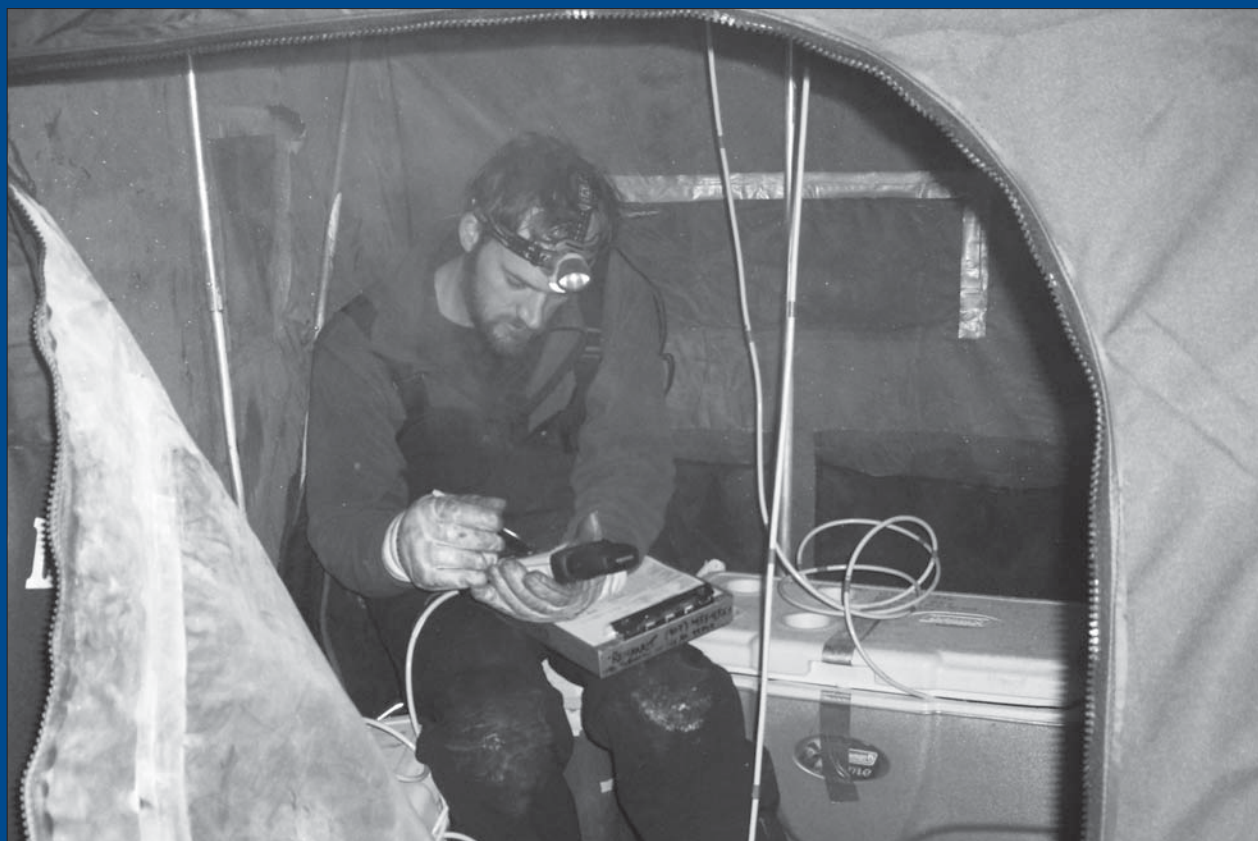
INE faculty and staff also take advantage of opportunities provided by the Fairbanks Economic Development Corporation to become more involved in local issues. FEDC has led regional efforts in energy, economic, and climate change planning. This partnership allows INE faculty to engage with the community and understand community needs. FEDC has welcomed INE into this partnership, which helps ensure the relevance of our applied research.

INE welcomes these and other partnerships. We participate in professional societies as well as state and federal engineering planning efforts. INE is grateful for the private (Usibelli Coal Mine, British Petroleum, Arctic Slope Regional Corporation, ConocoPhillips Alaska, and others), state (Alaska Departments of Transportation & Public Facilities, Natural Resources, Environmental Conservation and others), and federal (Bureau of Land Management, Department of Energy, National Science Foundation and others) partnerships that have allowed our research to continue to grow.

For these efforts, we owe a great deal. Thank you!

- Inside cover: Left: INE/WERC project staff and graduate student Chad Cormack drilling holes in the ice for a lake-water management project on Alaska's North Slope. Photo courtesy of WERC staff. Right: Rajive Ganguli, faculty in Mining Engineering, collects a pulverized coal sample from an air-coal pipe at Healy Unit #1 Power Plant. This research into the relationship between particle size distribution and power generation has made Alaska coal more marketable internationally. Photo by Sukumar Bandopadhyay.
- Page 2: INE Director Daniel White. Photo by Larry Hinzman.
- Page 3: Left to right: Dennis Witmer, photo by Charles Mason; Gwen Holdmann, photo by Jack Schmid; Billy Connor, photo by K. Hansen; Paul Metz, photo by K. Hansen; Shirish Patil, photo by Todd Paris, UAF Marketing & Communications; Douglas Kane, Photo © Patrick Endres / Alaskaphotographics.com.
- Page 4: Top: Fuel pump shaft failure caused by oxidized fish oil bio-diesel fuel. Photo by Dennis Witmer. Bottom (left): Mining equipment at the Usibelli Coal Mine. Photo courtesy of INE staff. Bottom (right): Brent Sheets, of the US DOE Arctic Energy Office, examines a vintage diesel generator at the Nome power plant. Photo by Dennis Witmer.
- Page 5: Top: Douglas Goering, CEM faculty and Interim Dean, during a visit to the Usibelli Mine. He stands in a 16-yard drag-line bucket used in coal mining. Photo by Dan White. Bottom (left): Jack Schmid and PhD student Winston Burbank examine the control center of a vanadium redox battery (VRB); this flow battery stores electricity. AETDL has been measuring this battery's performance since summer 2006. The battery has potential as an element of a wind/diesel hybrid independent energy system. Bottom (right): This steam pipe is part of the geothermal energy system at Chena Hot Springs Resort. The valve served as a sampling port for gathering information on the capacity of the underground reservoir. Photo by Dennis Witmer.
- Page 6: Top: INE faculty researcher Daniel Fortier uses soil coring technology to collect data for the "Preservation of the Alaska Highway" project. Photo by graduate student research assistant Eva Stephani. Bottom (left): Student Michael Golub shows off his latest project, a truck converted to run on electricity. Photo by Dennis Witmer. Bottom (right): AUTC researcher and professor Jenny Liu in her Asphalt Testing Laboratory. Photo by K. Hansen.
- Page 7: Top: Rinu Samuel, a student majoring in geological engineering and assisting on INE research projects, prepares samples in a Duckering Building lab. Bottom (right): Professor Gang Chen of Mining Engineering (right) explains the finer points of rock bolts to student Joe Filla at the Delta Mine Training Center. Both photos by Todd Paris, UAF Marketing & Communications. Bottom (left): MRL faculty Dan Walsh and Steve Lin, and John Hollow (2007 graduate, interdisciplinary PhD in Mineral Preparation Engineering) and Eric Hill (undergraduate in Mining Engineering) receive the Arthur F. Taggart Award for their paper, "Modeling the Influence of Slurry Temperature on Gold Leach and Adsorption Kinetics at the Fort Knox Mine, Fairbanks, Alaska." Photo by Bill Cronin of Englewood, Colorado courtesy of the Society for Mining, Metallurgy and Exploration.
- Page 8: Top: Graduate students work in a PDL lab. From left to right are Chirag Raisharma, Okechukwu Anyanwu, Viniit Tathed, and Shivkumar Patil. Photo by K. Hansen. Bottom (left): Erik Lehman, who will graduate with a degree in Petroleum Engineering in 2008. Photo by Todd Paris, UAF Marketing & Communications. Bottom (right): Melanie Hess (right) points out minerals to Karen Peters (left) during a field trip to Fort Knox Mine. Photo by S. Chanar.
- Page 9: Top: Alaska Stable Isotope Director Mathew Wooller works in an ASIF lab. Photo by K. Hansen. Bottom (left): WERC staff member Peter Prokein works on the prototype water filtration system at the Toolik Field Station, located in the northern foothills of the Brooks Range in northern Alaska on the southeast shore of Toolik Lake (68°38'N, 149°36'W, elevation 720 m, 254 km north of the Arctic Circle). Photo courtesy of WERC staff. Bottom (right): INE postdoctoral fellows (l to r) Muhammed Iqbal, Amy Tidwell, Sebastian Mernild, and Amanda Booth. Iqbal visited INE/WERC as a Fulbright researcher; Tidwell, Mernild, and Booth are all International Polar Year Fellows conducting research through WERC. Photo by K. Hansen.
- Page 10: Top: Electrical engineer Seta Bogosyan discusses robotics and control systems with student Matthew Ancil. Photo by K. Hansen. Bottom (left): Civil engineer Dennis Filler stands in the center of a massive icing site, the result of an uncontrolled artesian well near Fairbanks, Alaska. Note the house in the background. Photo by Charles Jones of C&S Construction. Bottom (right): Graduate students work under the direction of faculty member Margaret Darrow, initiating a firing sequence for a seismic survey. Visible from left to right are Chloe Peterson, Margaret Darrow, Celso Reyes, Eva Stephani (background), and Tshering Penjore. Photo by Will Robinson.
- Page 11: Top: INE postdoctoral researcher Namburu Praveen Krishna in the Mechanical Engineering Heat Transfer Lab. Photo by K. Hansen. Bottom: AETDL staff engineer Tom Johnson examines the computer screen showing data acquisition (DAQ) from a fuel cell experiment at the Schatz Energy Research Center at Humboldt State University, California. One of AETDL's strongest contributions has been encouraging partnerships among diverse research centers. Photo by Dennis Witmer.
- Page 12: Top: Tim Howe, research staff in the Alaska Stable Isotope Facility, examines a combustion reactor for use in the ASIF mass spectrometer. Photo by K. Hansen. Bottom: WERC graduate student researcher Shawna Laderach measures the dielectric constant of frozen materials inside the CRREL Permafrost Tunnel at Fox, Alaska. Photo by Kenji Yoshikawa.
- Page 16: Left: The Cold Climate Housing Research Center. The solar panels in the right foreground are one component of a system (HMPEP) that uses combined renewable power sources to demonstrate how different forms of alternative energy can be used in combination in cold climates to potentially provide year-round heat and power on a small scale to homes or villages. To learn more about this project, visit <http://www.cchrc.org/>. Photo courtesy of CCHRC. Right: CCHRC facilities from the back. In the foreground are the cold chambers developed by CCHRC and the Institute of Northern Engineering for completing controlled tests on different products and materials to observe how they perform in cold climates. Photo by S. Boatwright.
- Back cover: WERC graduate student researcher Dan Reichardt records data during field research on Alaska's North Slope. Photo by WERC project staff.

INE



UAF
UNIVERSITY OF
ALASKA
FAIRBANKS

America's Arctic University