Professor Emeritus Perry McCarty continues his research in South Korea

During Emeritus Professor Perry McCarty’s long career in environmental engineering, his research has been focused on water, biological processes for the control of environmental contaminants and advanced wastewater treatment. More recently, he has been concentrating on the recovery of water, energy, and nutrient resources from domestic wastewater using the anaerobic fluidized membrane bioreactor (AFMBR).

Adequate supplies of water and non-polluting energy are major issues facing the modern world, and attention is now focused on wastewater and the products produced in the treatment process as a rich source of nutrients and energy as well as reusable water. Recycled water is widely used for irrigation, and the methane obtained through anaerobic conversion of wastewater’s organic contents is a useful biofuel, but presently only a limited portion of the potential energy available in the wastewater is captured. Unfortunately for the U.S., advanced wastewater treatment research is mostly being done in other countries, and it was in the Republic of Korea that McCarty found the opportunity to continue his research on wastewater treatment.

A few years ago, Inha University at Incheon, South Korea, initiated a “World Class University” Program through the National Research Foundation of Korea, which aims to bring foreign scholars to conduct cutting edge research there. Jaeho Bae, one of McCarty’s former Ph.D. students, is a professor at Inha University. Together they submitted a proposal to make wastewater treatment energy-self-sufficient using an anaerobic process, while at the same time significantly reducing the production of biosolids that require further treatment and disposal. Their proposal was accepted, and McCarty received a 5-year contract and funding for this research. As research progressed, they realized their initial process was not adequately efficient and turned their attention to combining fluidized-bed and anaerobic membrane bioreactors (AMBR), which proved to be an efficient, economical and reliable treatment system.

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Surprisingly, this system was not as much affected with membrane fouling, a typical problem that usually increases operating and energy costs and thus reduces any advantage over aerobic systems. McCarty now believes “If more of the energy potential in wastewater were captured for use, and even less were used for wastewater treatment, then wastewater treatment might become a net energy producer rather than a consumer”.

McCarty is now focused on three energy-related characteristics of wastewater: energy contained in organics; energy necessary for producing nitrogen and phosphorus for fertilizers; and energy contained in the thermo-content of wastewater itself. He cites as an example of a wasted resource the energy expended in producing the nitrogen contained within the wastewater. Rather than spending more energy for removing nitrogen, it might be used directly with recycled wastewater for crop and landscape irrigation, thus helping to reduce world consumption of fossil fuel.

He and Bae conducted a feasibility study using an anaerobic fluidized membrane bioreactor (AFMBR) for post treatment of effluent from upstream anaerobic bioreactors. Their results not only showed potential energy benefits, but also greatly reduced biosolids production as well as a highly polished effluent. They suggest that the AFMBR may even be a sufficient standalone system, but recommend more research into total energy cost savings and the means by which membrane fouling can be further reduced. With this in mind, a pilot-scale system is now under construction at Inha University to expand their research on AFMBRs at the operational level.

Work on the AFMBR satisfies McCarty’s particular interest both in reducing the amount of energy used for treatment as well as for capturing more fully wastewater’s energy content. Currently aerobic wastewater treatment captures only a small portion of wastewater’s energy potential, while demanding more energy for operation. However, of special concern with anaerobic treatment is the methane produced in the process; it is a particularly harmful greenhouse gas if released to the atmosphere, and must be successfully captured and used.

Retrofitting existing plants to become anaerobic may not be economically feasible, but the anaerobic processes he is researching could be applied in newly built systems. Moreover, existing plants can be modified in many ways to reduce energy consumption:
• energy inefficient equipment can be upgraded
• energy efficient aeration diffusers can be introduced
• reduction of solids retention time would mean more organics could be converted into biosolids for feeding to digesters, thus increasing methane (CH₄) production
• greater use could be made of the CH₄ produced by conventional anaerobic digesters through combined heat and power systems, at the same time preventing its escape into the atmosphere

McCarty is required to spend 2 months of each year of his 5-year contract in Korea, and has one more year remaining of the contract. He has no firm plans for his work after the contract expires, but is busy publishing papers and has many more still pending. Meanwhile he continues to serve on a committee to help select recipients of the Lee Kuan Yew Water Prize, and a Research Peer Review panel, both in Singapore. He also recently received recognition as Honorary Professor at both Harbin Inst. of Technology (China) and National Chiao Tung University (Taiwan), and Distinguished Membership in the the American Society of Civil Engineers.

And Note...ES&T recently announced its 2011 Best Papers, included was McCarty, Perry L.; Bae, Jaeho; Kim, Jeonghwan. Domestic Wastewater Treatment as a Net Energy Producer—Can This be Achieved? Environ. Sci. Technol. 2011, 45 (17), 7100–7106
On April 25, Professor Dick Luthy, EES, Director of the NSF Engineering Research Center at Stanford, and Woods Institute Fellow, was the featured speaker at a briefing in Washington, D.C, entitled “Road to the New Energy Economy: Re-Engineering Water for Power”. The event, sponsored by the NSF, IEEE, Society of Mechanical Engineers, and DISCOVER magazine, was one of a series of events held since 2009 focusing on the science and technology required to achieve the nation’s energy goals.

Dr. Luthy’s message emphasized three points:
* current water infrastructure uses a great deal of energy
* new and emerging technologies can save water, energy and dollars
* the right investments and incentives can convert wastewater from a liability to an asset.

He stressed that now is the time to act, to plan for the future and create an efficient and green infrastructure. Demand for energy and competition for water will increase with growing population and the effects of climate change. At the same time, the infrastructure of the state water system is aging, and wastewater treatment plants, in use for the last 40-50 years, are increasingly inefficient and outdated. In fact, the California State Water Project is the state’s biggest user of energy as it moves water from reservoirs to users in southern California.

New technologies can capture the energy within wastewater, and at the same time produce high quality recycled water, at almost no energy cost; we can produce potable water from wastewater, using only one-third the energy required by the desalination process. Conservation and efficient use have the potential of saving large amounts of energy; and constructing decentralized wastewater treatment plants, thus reducing the amount of energy needed to move water long distances, is a very important part of any new infrastructure planning.

The upgrading of our outdated infrastructure will not come cheaply, but research, demonstration projects, and financial incentives will help us move forward. Technological advances require testing and demonstration that they are reliable and safe, but universities cannot do it alone; government, utilities and academia must commit to partnerships; and the private sector needs to invest in our country’s future. Investment support has been flat for the last 40 years and lags by $50B/year according to IEEE and EPA estimates.

Meanwhile, on the Stanford campus, plans are moving ahead with a proposed Wastewater Resources Recovery Test Facility that will give researchers and the Stanford community an excellent opportunity to study wastewater. The Provost and Stanford's Department of Sustainability and Energy Management (SEM) Water Services Group have approved it for more detailed design, and plans are moving ahead.

What is very exciting about this project, is that it will allow Stanford researchers to conduct research at the pilot-scale, a scale that lies between a laboratory (or bench-scale) system that treats gallons per day, and full-scale commercial systems that treat millions of gallons per day. There is no such modern facility anywhere else in the US where new wastewater treatment technologies can be developed and adopted. And the Stanford campus offers a “nearly ideal venue”. It is like a mini city with utilities, a common sewage outlet, a mix of residential, institutional and “commercial” land uses, important ecosystems and habitats, and proximity to green tech entrepreneurs. As proposed, the facility will provide data and technology assessment for academic research purposes, and will provide support for Stanford’s research initiatives on water, including the Water in the West initiative of the Woods Institute for the Environment, and the Center for Re-inventing the Nation’s Urban Water Infrastructure (ReNUWIt), the National Science Foundation (NSF) funded Engineering Research Center, directed by Professor Dick Luthy.
An interview with Professor Emeritus
Bob Street, EFMH

Born in the Territory of Hawaii seven years before the outbreak of WWII, Bob Street and his parents soon moved to the Los Angeles area to avoid the approaching conflict. In 1952, armed with a US Navy scholarship, he entered Stanford as a freshman, and five years later (1957) graduated with an MS in civil engineering. For the next three years he served in San Diego, overseeing Navy construction projects on Coronado Island and living the bachelor life until 1959, when he married his high school sweetheart, Norma.

Moving across the bay to downtown San Diego, Street took on the job of program manager for the many projects being constructed for the Pacific Missile Range along the coast; the Pillar Point Radar Station still to be visited at Half Moon Bay was part of that work. Another of his responsibilities was to instruct naval officers and staff on the handling of classified equipment and documents, an aspect of the work he thoroughly enjoyed, leading him to consider teaching as a career. An NSF fellowship offered him financial support and he returned to Stanford as a Ph.D. student in Civil Engineering in the summer of 1960 to study fluid mechanics and applied mathematics. He successfully defended in May 1962 and his dissertation was approved the following January. In the Autumn of 1962 he was appointed acting assistant professor to succeed his advisor who had left Stanford, handing over to Street two Ph.D. student advisees. In June 1963, the three of them graduated together, and Street was officially appointed Assistant Professor and Assistant Executive Head in the Civil Engineering department.

During his subsequent, lengthy career at Stanford, he chose to follow two paths making outstanding contributions in both. As an Administrator he has served in a number of senior positions including Chairman of the Department of Civil Engineering (1972-80; 1994-95); Associate Dean of Research, SOE (1972-83); Vice provost for Academic Computing and Information Systems (1983-87); Vice president of Information Resources (1987-90); Vice president for Libraries and Information Resources (1990-92); Vice Provost and Dean of Libraries and Information Resources (1992-94). Street looks back on his time spent as an administrator fondly and believes that two of his key contributions to Stanford were made during that period. Firstly, he is particularly proud of his service as chair of the department, and of Dean Gibbons’ statement in 1994 that “He will bring to his job a wealth of administrative experience that has probably never been equaled in the school”.

Street’s other major contribution sprang from a meeting on computers and computing on the east coast in 1982. He returned to Stanford with deep concern for the lowly state of the campus’ computing systems, and a determination to initiate improvements. His appointment in 1983 as Vice Provost for Academic Computing enabled him to accomplish this, motivating faculty to get involved, establishing a university-wide network, and moving computers “into the forefront of the academic environment”*. His involvement with computing and information systems also fostered meeting and working with the heads of local high tech companies that were creating Silicon Valley; he served on the Academic Advising Committees...
of Apple, Sun, IBM, and NEXT. In 1990 the merging of the University Libraries and Information Resources led to Street’s appointment in 1992 as Vice Provost and Dean of Libraries and Information Resources (LAIR). His vision “…was that you could build a seamless information environment so that it didn’t make any difference whether the information you wanted was in book form or movie form or video form or digital form…”* He remained in this position until 1994, and was succeeded by Michael Keller, whose selection in 1993 as University Librarian Bob views as another of his valuable contributions to Stanford.

Academic research was Street’s parallel path. He had been promoted to full professor in 1970 and was designated Professor of Fluid Mechanics and Applied Mathematics in 1972; in 1985 he cofounded with Professor Jeffrey Koseff the now internationally recognized Environmental Fluid Mechanics Laboratory and served as its Director until 1991; in 1997 he was appointed William Alden and Martha Campbell Professor in Engineering. From his appointment to the faculty in 1963 he had maintained a first class research program, so when, in 1995, he abandoned the administrative path for the academic path, his research program was flourishing. He viewed advising students as a privilege and research as a priority, so the transition from his administrative responsibilities back to the research bench went relatively smoothly.

The overarching theme in Bob’s research is classical applied mathematics, which can involve pure theory, applications, and/or physical experiments. His most cited work was carried out with Jeff Koseff and a student, Yan Zang. It involved an advanced numerical simulation code and a new turbulence model that allowed accurate simulation of some very complex flows. That led to work by Anqing Cui, a doctoral student who implemented the Zang code on parallel processors and produced some very insightful simulations of coastal upwelling. That code, called PCUI (parallel CUI), is at the heart of recent work on internal waves and sediment transport by other students working with Oliver Fringer. Working with Bob and Prof. Margot Gerritsen (SU Department of Energy Resources Engineering), Fringer built a very powerful coastal and ocean modeling tool using what are called unstructured grids, the Stanford Unstructured Nonhydrostatic Terrain-following Adaptive Navier-Stokes Solver or SUNTANS. Bob’s next most cited efforts resulted from collaborations with EES professors Paul Roberts, Perry McCarty and Jim Leckie. During his long career, he has supervised or co-supervised 48 doctoral students (to date!), many of whom have moved into tenured positions at leading academic institutions including Stanford (Jeff Koseff and Oliver Fringer), U. Texas (2 former students there), UC Berkeley, UC Santa Barbara, UC Davis, Univ. of Wisconsin and the Univ. of Illinois, to say nothing of those students who ended up in Canada or Australia. Bob says that these doctoral students are his raison d’être at Stanford.

"Good things will happen if we recognize the opportunities"

At the end of 2004, Street turned 70 and, incentivized by a Stanford retirement program, decided that it was time! He could still participate in research, but he now had ample time to travel with his wife and pursue his hobby of photography. They have traveled on an ice-breaker above the Arctic Circle, covered most of Australia [his mother was Australian] and been on two safaris in Africa, the continent that most appeals to him.

These days Street focuses almost entirely on the creation of turbulence models for atmospheric simulation codes.

At home he reads mystery novels, usually a couple per week (he is a certified Evelyn Wood Speed Reader), but also has made time recently to attend an Artificial Intelligence course being put on by the Stanford’s Computer Science department’s online teaching program.

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The Solar Decathlon Team

The Solar Decathlon is a biennial competition sponsored by the Department of Energy (DOE). Twenty teams (this year 16 from the U.S., and 4 from foreign countries) compete to build a 1000 sq. ft. single-family house with net-zero carbon footprint. Excited about the possibilities and recognizing it as an excellent opportunity for students to experience a project from design through construction, juniors Derek Ouyang (CEE and architectural design) and Taylor Brady (CEE and economics) led the effort to submit Stanford’s proposal to the DOE. This involved preparation of an initial design and also enlisting the required administrative and academic support for the project. To everyone’s delight, the Stanford team was selected to participate in the 2013 competition—a first for Stanford. Ouyang and Brady are co-leads on the project. The team quickly realized the amount of work ahead of them to prepare for the October 2013 competition in Orange County, CA, but are undaunted. They have the enthusiastic backing of faculty advisors also dedicated to the project, including Jim Leckie (EES) who is PI, Martin Fischer (CIFE), Eduardo Miranda (CEE), and John Barton, Director of Architectural Design, and professors Bob Dutton, electrical engineering and Banny Banerjee, mechanical engineering. The team’s task involves building a house that

- Is affordable, attractive, and easy to live in
- Maintains comfortable and healthy indoor environmental conditions
- Supplies energy to household appliances for cooking, cleaning, and entertainment
- Provides adequate hot water
- Produces as much or more energy than it consumes

It will ultimately be moved to Orange County, but during its design and construction stages the house will be placed next to the site where the Terman Building once stood, offering Stanford students, staff and faculty a close view of the process and progress of the project.

The team of undergraduate and graduate students is now deeply involved in planning and design, including visits to local sustainable buildings such as the Jasper Ridge field station, and the photovoltaic panels on the roof of San Francisco airport. Local residents are also getting involved, showing how they have built sustainability into their own houses, and the Solar Decathlon team in return is reaching out to Habitat for Humanity and lending their hands in building local homes. The team estimates costs of the project will range between $800,000 and $1M, so fundraising is an important task. They are seeking any kind of monetary, in-kind, or consulting donations from local companies, organizations, or alumni to support students over these next two years, with the opportunity for publicity and shared success on a national level. More news on project developments will follow…

Stanford enters its first Solar Decathlon

Initial design of house
Infants discover their creativity and find ways to bond with their care providers through crying. An infant learns to cry to get attention. He didn’t go to class to be taught to cry; he or she discovered that crying works to communicate many different things. Unfortunately, education does not take advantage of this inborn creativity, and a valuable resource goes to waste. In the TED2006 video entitled “Ken Robinson Says Schools Kill Creativity,” we hear how schools cannot afford (in terms of time and money) to encourage creative thinking and critical thinking—questioning knowledge. How complete is an education that relies on convergent, logical and deductive thinking? Why is there such a fixation on grades and scores—now even reaching the kindergarten level?

In an effort to influence youth to think more broadly about how their educational development will affect their future, the Center for Sustainable Development & Global Competitiveness (CSDGC) has instituted a Youth Development Program, comprising short workshops held at Stanford from 3 up to 9 days, and designed to promote creative ideation. The title of this program is “Youth Creativity, Innovation and Sustainable Leadership” (YCISL). The workshops are part intervention and part supplementation, including an introduction to the team product development cycle and the theme of sustainability, a global topic that concerns youth as well as adults. The goal is to set innovation paths and provide experience on how to get to the end of the cycle. The expectation is that life lessons about leadership will reveal themselves as a result. The program got a strong start with the first YCISL workshop in June 2011 attended by students from the School of Architecture and Built Environment at Singapore Polytechnic. Special guest speakers included Douglas Osheroff, J.G. Jackson and C.J. Wood Professor of Physics, Emeritus; Glenn Katz, Lecturer, CEE; Jie Wang, Consulting Associate Professor, CEE and Executive director of SDGC; and Mi Feng, Asst. Professor at Beijing University. The group visited SLAC, the Jasper Ridge Biological Field Station, and the Computer History Museum. Enthusiasm was high and gave us opportunities to test many of the lesson modules and help meet objectives. The program continues in start-up mode and will continue to test needs and outcomes. Singapore Polytechnic will send another group of their scholars to a workshop in June 2012. We are also reaching into Korea for a first-time group of visiting students in August 2012. This activity has allowed us to enlist a few undergraduate Stanford students as interns in order to develop new modules and create a mentoring element. We are extremely excited about the direction we are going. We hope to have a positive influence on the minds and actions of today’s youth—who will be tomorrow’s leaders.
Bob Street profile, continued

Street has accumulated many honors over the years including the American Society of Civil Engineers (ASCE) Huber Prize for distinguished research (1972), the ASCE Karl Emil Hilgard Hydraulic Prize (2002) jointly with Dr. Emily Zedler, and the Hunter Rouse Hydraulic Engineering Award (2005); he was elected a distinguished member of ASCE in 2009. He and Jeff Koseff won the R. T. Knapp Award of the American Society of Mechanical Engineers in 1986. Bob was selected in 1993 as a Fellow of the American Association for the Advancement of Science for his work in atmospheric science. In 2004 Bob became a Member of the National Academy of Engineering (NAE), followed in 2005 by induction into the Beverly Hills High School Hall of Fame.