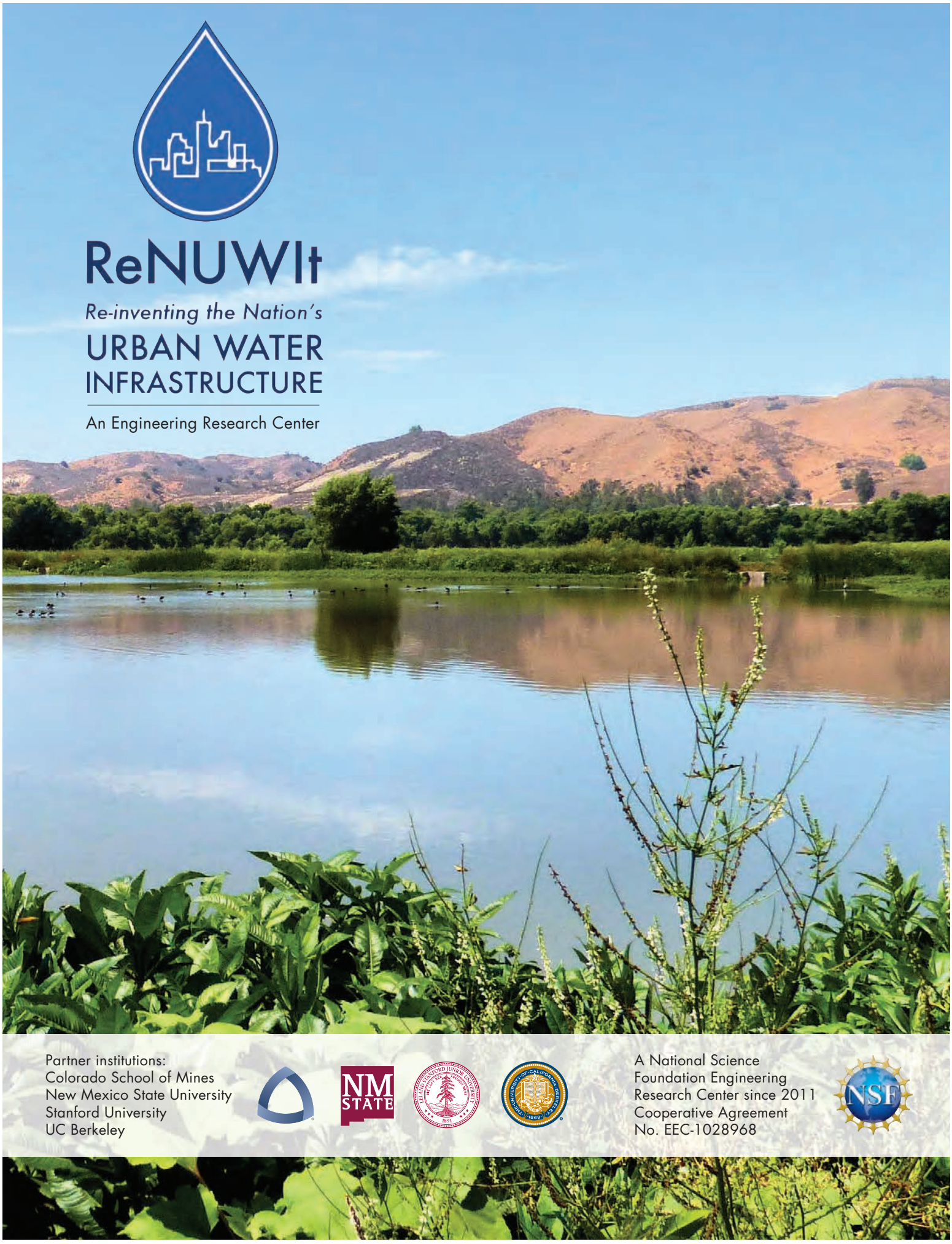

ReNUWIt

Re-inventing the Nation's

URBAN WATER INFRASTRUCTURE

An Engineering Research Center

Partner institutions:
Colorado School of Mines
New Mexico State University
Stanford University
UC Berkeley

A National Science Foundation Engineering Research Center since 2011
Cooperative Agreement No. EEC-1028968

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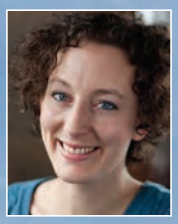

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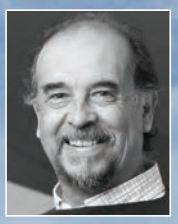

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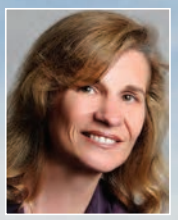

Lisa Alvarez-Cohen
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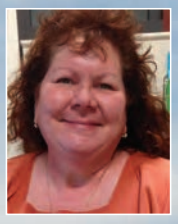

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Administrative Director

WHO WE ARE

OUR STORY

ReNUWIt is a collaborative group of urban water researchers from the Colorado School of Mines, New Mexico State University, Stanford University and University of California, Berkeley.

Launched in 2011, ReNUWIt is the National Science Foundation's first Engineering Research Center dedicated to civil infrastructure and water systems. ReNUWIt encompasses a diverse team of researchers who collaborate with entrepreneurs and practitioners on innovative solutions for urban water infrastructure challenges. This diverse team specifically addresses the diffusion of new technologies in complex systems.

OUR VISION

ReNUWIt's vision centers around catalyzing the transition of existing water supply systems, urban flood control measures and wastewater treatment systems into a new era in which new technology and management approaches promote security and economic vitality of the nation's cities.

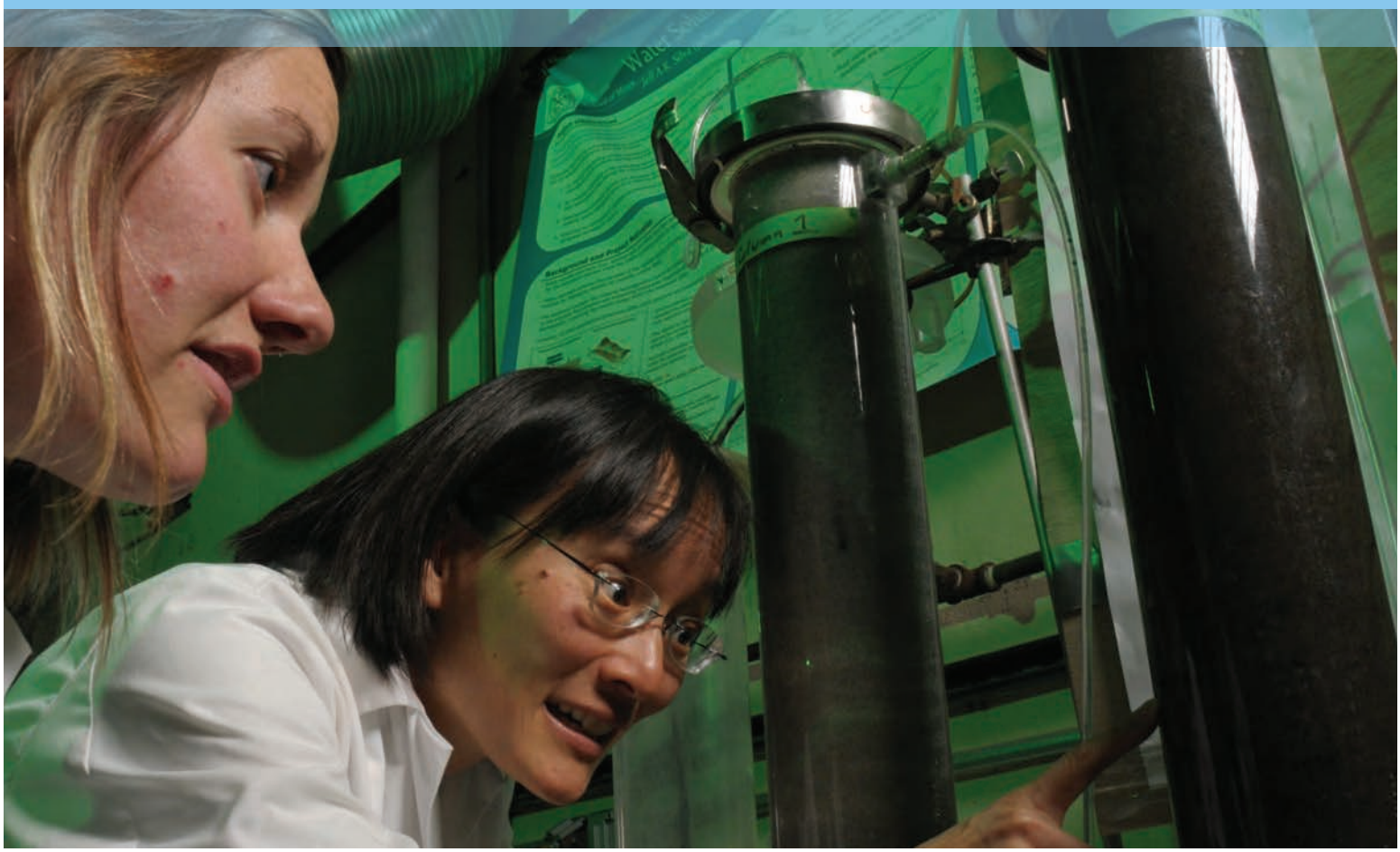
OUR PARTNERS

ReNUWIt is a research center that connects urban water infrastructure researchers to a wide range of ideas, projects, resources and partners.

As researchers and industry members look for innovative solutions and new resources, ReNUWIt provides opportunities for these groups to work collaboratively on current and future infrastructure problems.

Specifically, ReNUWIt works with an Industry Advisory Board, researchers at participating universities and innovation partners to develop, test and implement new ideas for more sustainable and resilient practices.

Initially focusing on pilot and demonstration-scale prototypes, ReNUWIt is expanding partnerships with industry and innovation partners to enable technology transfer and entrepreneurship.



ReNUWIt 2013-2014 HIGHLIGHTS

Student-Led Team Earns Development Support:

From research to a pilot project, ReNUWIt students are taking the next step in technology development and innovation with a first place finish and a $100,000 award from the Department of Energy's business plan competition for clean energy at the Caltech FLoW meeting in April 2013.

With the award, students are further developing and commercializing the Coupled Aerobic-anoxic Nitrous Decomposition Operation (CANDO) project. As an implemented pilot project, the CANDO process generates energy from wastewater while decreasing nutrient pollution.

ReNUWIt Co-Creates Ingenuity Lab Design Challenge:

Reaching over 2,300 visitors in 2013 and 2014, ReNUWIt graduate students and post-doctoral researchers connected their research to young scientists in the Ingenuity Lab at the Lawrence Hall of Science in Berkeley, CA. The ReNUWIt-Ingenuity Lab team implemented an urban water design challenge on weekends in February.

Based on ReNUWIt research, visitors learned about stormwater, green urban design and engineering through a hands-on activity. Using simple materials, children were able to "see" themselves as engineers as they designed and built a city landscape and tested its ability to retain stormwater.

ReNUWIt and Epicenter-led Innovation Bootcamp:

Adding more tools and a new perspective to their skill set, 17 ReNUWIt undergraduate and graduate students and post-doctoral researchers from the four partner universities engaged in a 2-day innovation bootcamp held at Stanford University in 2013. The bootcamp was a partnership with the NSF-funded Engineering Pathways to Innovation Center (Epicenter).

Students learned and applied an empathy-based design process to "Redesign the Outhouse Experience." Working in multidisciplinary teams, the experience developed skills in brainstorming, need-finding, interviewing, empathy mapping, prototyping, design iteration and final design pitching.

Strengthening International Collaborations:

As an emerging world water research center, ReNUWIt continues to build strong international partnerships, develop greater research collaborations and provide unique student and staff exchanges. Working closely on research opportunities and through exchanges, the Swiss Federal Institute of Aquatic Science and Technology (Eawag) in Switzerland has become one of ReNUWIt's strongest international partners.

As ReNUWIt's reputation as a world leader takes form, that position is reinforced by a partnership with the UK Industrial Doctorate Centre for the Water Sector (STREAM) that encompasses the University of Newcastle, University of Cranfield, University of Sheffield, University of Exeter and Imperial College London, where students and staff interact and exchange ideas, knowledge, skills and research results.

ReNUWIt also is working with the University of New South Wales in Australia and establishing links with the Centre for Water Sensitive Cities based at Monash University in Australia to provide more research and exchange opportunities.

Diversity recruitment:

ReNUWIt is committed to engaging diversity at all levels, from pre-college education all the way up to center leadership, especially encouraging active involvement of groups traditionally underrepresented in engineering, including both minorities and women.

This year, recruitment has increased female and minority participation at ReNUWIt through the work of Director of Diversity Lisa Alvarez-Cohen. ReNUWIt is also drawing on and engaging the partner universities' diverse student bodies and first generation college student populations.

William and Cloy Codiga Resource Recovery Center:

Beginning in 2015, ReNUWIt researchers will have a new facility to test their ideas on the Stanford University campus. The William and Cloy Codiga Resource Recovery Center allows researchers to test promising technologies on a large scale for recovery of clean water and energy from wastewater in decentralized operations.

The center also will support commercial development of new wastewater treatment technologies by providing a platform for researchers to demonstrate that their technology is safe, effective and compatible with centralized treatment plants. The center's first project, developed by ReNUWIt researcher Perry McCarty, will test a newly developed wastewater treatment system that produces methane that can be used to power the water reclamation process.

OUR GOALS

ReNUWIt's four overarching goals unify research, educational activities, outreach and interactions with industry.

1.

Advance Urban Water Reinvention

ReNUWIt excels in innovative urban water infrastructure research. Access to partners that plan, build, operate and maintain urban water infrastructure helps the center make great strides in testing and implementing new technologies in the field. Working with these partners at local and regional levels, researchers demonstrate new approaches under real world conditions with industry partners who can influence change in technology and management approaches industry-wide.

2.

Develop Modular Technologies and Concepts to Support Urban Water Reinvention

Looking at current water systems with an innovative and entrepreneurial eye, ReNUWIt researchers are developing and improving new technologies and concepts for tomorrow's urban water systems. As ideas are developed and piloted, researchers take great care to monitor and collect data and continue to improve systems to ensure reliable performance for wider implementation.

3.

Provide Global Leadership in Urban Water Reinvention

Connecting ReNUWIt's prominent researchers and research projects with key industry members, the center's success is garnering attention throughout the world. Building on this foundation, ReNUWIt continues to increase the number of global partners, research collaborations and researcher exchanges. As a growing voice in the international conversation, ReNUWIt also is working to influence policy makers, advance technologies and amplify their message to raise awareness.

4.

Prepare Students to Lead Efforts to Reinvent Urban Water Infrastructure

Students are an integral part of ReNUWIt's success. Efforts to educate leaders include project collaboration on ground-breaking research and mentorship opportunities with world-renowned scientists at ReNUWIt and its global partners. Combining this with leadership development within ReNUWIt and through community and K-12 educational outreach, ReNUWIt provides a comprehensive education that develops creative, technically proficient engineers, scientists, social scientists and planners.

ReNUWIt RESEARCH THRUSTS

Harnessing energy and resources, ReNUWIt's research focuses on three key areas, or thrusts: Efficient Engineering Systems (E), Natural Water Infrastructure Systems (N) and Urban Systems and Institutions (U).

Creating an interconnected plan, the thrusts work together to optimize research and resources. Technology developed in the E and N thrusts is analyzed in the U thrust as it is considered for industry adoption.

Led by civil engineering professor Nirmala Khandan, the E thrust concentrates on developing new urban water technologies for more secure and sustainable systems. As new tools are developed, researchers also look at improving technologies that can be integrated into existing systems and identify barriers to new technology adoption to ease the transition. ReNUWIt's efforts are being directed at developing and testing water reuse systems and decentralized technologies for residential and commercial developments; improving energy and resource recovery from wastewater with enhanced technologies in centralized systems; and assessing new processes, approaches and practices with direct potable reuse of municipal wastewater.

Led by civil and environmental engineering professor Alexandria Boehm, the N thrust focuses on integrating natural systems into urban water infrastructure to enhance water quality, improve system resiliency and reduce energy consumption, all while preserving ecosystem integrity and providing aesthetic benefits. Researchers are working to enhance stormwater and surface water quality consistently to enhance urban water supplies. They also are identifying new designs and operations to maximize water quality and flood protection while enhancing ecosystem function and aesthetics, in addition to using sensors and actuators for real-time control to better manage surface and subsurface water systems.

Led by planning and policy researcher William Eisenstein, the U thrust works to identify and overcome implementation and diffusion challenges of ReNUWIt technologies developed in the E and N thrusts, as well as other promising water management technologies. Researchers focus on decision support techniques for utility, municipal and regional planners. They analyze potential legal, institutional, economic, financial and social barriers to implementation and potential solutions to help identify appropriate decision criteria, assess optimal degrees of system decentralization under various conditions, characterize risk and uncertainty, assess economic and financial implications of various technologies, and integrate new technologies into existing water infrastructures and urban landscapes. Examples include regional approaches for integrated water supply management, nutrient control and stormwater use.

CREATING COMPACT WATER RECYCLING SYSTEMS

As water is recognized as an increasingly valuable resource, ReNUWIt researchers are working to increase the resiliency and flexibility of water recycling with small, modular treatment systems that can serve as an alternative to centralized water treatment infrastructure.

To this aim, ReNUWIt researchers developed the tailored water concept, where water can be treated for multiple purposes at one treatment center. These small systems have the potential to be competitive with existing centralized distribution systems, in many situations, because they can be remotely operated and do not require extensive underground pipe networks.

As the name suggests, the water quality provided by these systems is tailored for its intended use, including potable water supply, landscape irrigation and indoor non-potable applications, like laundry and toilet flushing.

With the help of IAB partners, ReNUWIt has taken the projects from an idea to a pilot project at the Colorado School of Mines to demonstrate that the process is reliable, can handle common problems like power outages and varied water volume and quality, and is cost competitive.

The pilot project is housed next to the dormitories at the CSM and uses a membrane bioreactor system that returns reclaimed water for reuse in the dormitories. The tiny treatment plant also produces enough water that is used by researchers at CSM's Mines Park facility for irrigation and streamflow experiments.

Just like the large, conventional treatment plants currently used in most cities, the tailored treatment plant uses microbes to remove organic carbon and nutrients from the wastewater. The technology differs, however, in the final step of the process. Rather than using large settling basins to remove and reuse microbes, the membrane bioreactor system uses different types of thin plastic membranes to remove the microbes, trace organic compounds, and nutrients from the treated water.

Results from the pilot project show that water quality provided by the system can be used for different purposes, from nutrient rich water, used for landscape irrigation, to fully denitrified water that can recharge groundwater and streams, to drinking water.

The system offers many additional benefits, including it is small enough to be placed in basements of office or apartment buildings and trailers, and it uses sensors and a computer for autonomous operation and remote monitoring and control.

ReNUWIt researchers also are testing new types of treatment systems to turn wastewater effluent, stormwater runoff or polluted ground water into drinkable water. Researchers are working on a hybrid treatment system with nanofiltration membranes coupled with an advanced oxidation process, as well as an ultrafiltration-forward osmosis system. They also are exploring systems to convert the solids in the wastewater into energy, which will be used to operate the treatment systems.

The ultimate focus with these systems, though, is to create small systems that treat and return resources in localized areas, especially reliable, safe drinking water.

DISTRIBUTED TREATMENT SYSTEM PLANNING

Using creativity and innovation, researchers at ReNUWIt are working to keep treated water close to home with new technology.

As an increasingly recognized valuable resource, researchers are developing planning tools for locating resource recovery facilities and transitioning from massive centralized treatment plants to localized systems.

Traditionally, wastewater can travel tens of miles to reach a large, centralized treatment center. After the wastewater is treated, it is often piped back to the place it was generated, requiring expensive pumps and using a lot of energy. Conversely, using local, or satellite, treatment centers would require less pipe and energy for water delivery.

With that in mind, ReNUWIt researchers set out to determine how to best decentralize the process by considering how to reduce the to pumping distance of the water and to create more usable opportunities for the reclaimed water in the community it originated in.

Partnering with the City of Palo Alto Regional Water Quality Control Plant (PARWQCP) in Santa Clara County, CA, ReNUWIt researchers set the decentralization planning process in motion.

Water resulting from the wastewater treatment process has many valuable applications for local systems. First and foremost is the water itself, whether it is used to recharge aquifers or supply homes and offices with water for irrigation, toilet flushing and even drinkable water — depending on the treatment used.

The wastewater process can also produce heat and electricity from the biodegradable organic matter turned biogas. The nutrients collected in the process can be used as fertilizer.

In Palo Alto, ReNUWIt researchers studied the centralized system that serves six communities, using data from a detailed water audit.

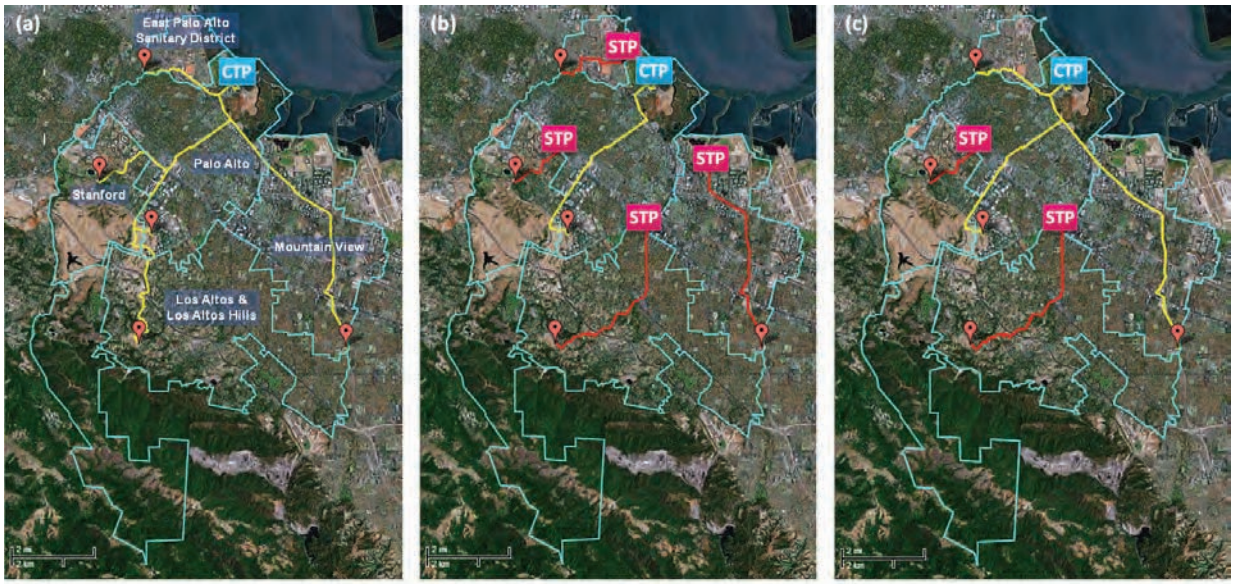
PARWQCP runs on imported energy, which also is used to incinerate biosolids from the treatment process. The plant also pays to haul the ash away to a hazardous waste facility. Most of the treated water is largely sent to the San Francisco Bay, though a minimal amount is used to irrigate a nearby golf course and office park.

Taking this information, ReNUWIt researchers determined that the optimal solution would involve the creation of five clusters using existing political boundaries of East Palo Alto Sanitary District, City of Mountain View, cities of Los Altos and Los Altos Hills, Stanford University and City of Palo Alto. ReNUWIt researchers also outlined three scenarios where the central system delivered reclaimed water for irrigation and two hybrid models that deliver water from satellite systems and the central system. They also analyzed four resource recovery and energy options for the central treatment plant and the satellite hybrid models.

Overall, ten system combinations of recovery were looked at regarding initial investment cost, operation and maintenance cost, revenue and avoided cost resulting from resource recovery, net life cycle costs, percent renewable energy and resilience to water stress.

Depending on desired outcomes, ReNUWIt researchers' material will help create wastewater plans that show some of the benefits of using satellite systems compared to only using a central system.

From their results and the created matrix, planners from other communities can look at a variety of conditions and factors as a basis to see what method would be best in their community, or see what factors and methodology could be used for a similar study.



Different configurations for resource recovery for the Palo Alto Treatment Plant Catchment

(a) CTP produces recycled water and delivers it to five clusters (yellow lines).
(b) Hybrid 1: CTP produces recycled water and delivers it to one cluster (yellow line) and 4 STPs produce recycled water and deliver it to four clusters (red lines).
(c) Hybrid 2: CTP produces recycled water and delivers it to three clusters (yellow lines) and two STPs produce recycled water and deliver it to two clusters (red lines). Energy recovery can occur at all scales.

CANDO

Applying creative innovation and research, ReNUWIt is developing a new wastewater treatment to help fuel the future. Researchers are working on a process to remove and recover renewable energy from nitrogen in wastewater, which can then make engines more powerful.

The process, called the Coupled Aerobic Anoxic Nitrous Decomposition Operation (CANDO), works by converting ammonia in wastewater to nitrous oxide gas, then recovering the nitrous oxide and using it as an oxidant in biogas-methane combustion to increase power production.

The idea stems from Stanford researcher Yaniv Scherson's quest for an alternative source for rocket propellant. He discovered a way to convert nitrogen in wastewater to nitrous oxide gas — a gas used in rocket engines. Working with ReNUWIt researchers and partners, they created the process, found a test site and formed a spin-off company.

While the original idea of the project was to provide an alternative strategy for control of nitrogen, the CANDO process also creates a less-expensive, greener solution to nutrient pollution problems. Conventional nitrogen removal creates a major energy demand for aeration and produces large amounts of biosolids, which are the two major operational costs for wastewater treatment facilities. In contrast, CANDO requires roughly 20 percent less energy for aeration and produces 60 percent fewer biosolids. It also increases methane recovery by diverting more organics to anaerobic digestion, and recovers more energy from the use of nitrous oxide in combustion.

Traditionally, wastewater treatment plants use bacteria to break down the ammonia in the waste stream to nitrate, which they can reduce to nitrogen gas. With CANDO, the process uses a different type of bacteria and chemical mix to produce nitrous oxide. That nitrous oxide is then collected and used in the plant's methane-burning cogeneration engines to help the plant consume less power from outside sources.

Ultimately ReNUWIt researchers envision creating large-scale treatment centers that can not only recover energy, but export it to other users outside the wastewater treatment center, as wastewater treatment facilities become more like resource-recovery centers, with the end goal of producing energy and clean water.

Under the ReNUWIt umbrella, CANDO benefited from the numerous partners and Industry Advisory Board members that it was able to connect with more quickly and with greater understanding of the new technology. As a collaborative process, researchers were able to partner with Industry Advisory Board members Veolia Water, Delta Diablo Sanitation District (DDSD), and members of the Bay Area Clean Water Agencies (East Bay Municipal Utility District and the South Bayside System Authority).

The partnerships helped CANDO move their process from the laboratory into a pilot-scale facility at DDSD's wastewater treatment plant in Antioch, CA. The pilot plant treats 300 gallons of wastewater per day using the CANDO process, where sensors collect data to support further research. At 100th of the size of a full-scale plant, the pilot uses three 10-foot tall tanks as bioreactors to produce the usable energy boost.

In addition to partnerships forged through onsite housing and resources, ReNUWIt partnerships helped fund the project, in part, by a $175,000 grant from the TomKat Center for Sustainable Energy at Stanford University, in kind-contributions from DDSD, ReNUWIt, a $50,000 grant from Veolia, and a $150,000 Partnerships for Innovation: Accelerating Innovation Research Technology Translation grant from NSF.

Beyond the innovation of the process itself, the project resulted in the first start-up firm to spin off from the center, NGen Corporation. Sherson formed NGen in 2012, and it was the recipient of a $100,00 prize from the U.S. Department of Energy for its business plan. NGen also is working toward commercialization of the CANDO technology.

With a successful program in place at Delta Diablo, other forward-looking technologies are being worked into the plant and paving the way for innovative processes elsewhere.

OPEN WATER UNIT PROCESS WETLANDS

ReNUWIt is tackling old problems with new and innovative solutions when it comes to treatment wetlands. Currently, treatment wetland design, maintenance and operation rarely take chemical contaminant or microbe removal into account, and they only provide modest waterborne pathogen removal. Improved designs, however, could allow treatment wetlands to play a more significant role in a multi-barrier pathogen control approach, especially for organisms resistant to common disinfectants, and chemical contaminant removal to protect potable water supplies and sensitive aquatic habitats. ReNUWIt researchers took up the challenge to find new ways to design, operate and maintain more effective wetland treatment systems.

Using sunlight, algae and bacteria to remove more trace organic chemicals, waterborne pathogens and nutrients, researchers created a pilot open water-unit process cell in Discovery Bay, CA. In December of 2013, ReNUWIt and the Orange County Water District expanded the scope of the project and began testing a demonstration-scale system to improve water quality in the Santa Ana River in Southern California in the Prado Wetlands.

From pilot to demonstration-scale, researchers found the open water unit process wetland can greatly improve water quality in areas containing mostly municipal wastewater. After leaving the wetland in the demonstration project, water flowed downstream to an infiltration system where the river water recharged the water supply for an urbanized part of Orange County. The wetland provided a basis for ReNUWIt researchers to assess system performance and evaluate maintenance costs under real-world conditions.

To ensure that their technology will be implemented elsewhere, researchers have to address several barriers to reinvention. For example, consultants and utilities are often hesitant to invest in unproven technologies to treat managed natural systems; the ability of natural systems to remove contaminants often are not considered in discharge regulations; and a lack of consistent and validated guidelines for the design, operation and maintenance of treatment wetlands prevents an accurate assessment of potential benefits of wetlands on urban water system performance.

Keeping these barriers in mind, researchers developed key research objectives to assess contaminant removal rates, connect chemical depletion rates with microbial ecology and relate physical conditions to performance. The result was a robust system for operating, monitoring and maintaining unit-process wetlands that effectively remove a suite of chemical contaminants and microbes.

One of the key aspects of the project is the development of the open-water unit process cell. The first system was built at the ReNUWIt test-bed in Discovery Bay, CA. The 656 foot x 328 foot open-water cell consists of a zone of shallow water about 0.66 feet deep, with a mat of photosynthetic diatoms coating the bottom. Following successful testing at Discovery Bay, ReNUWIt partnered with the Orange County Water District (OCWD) to build a 10-acre open-water unit process wetland in the Prado Wetlands in Southern California. Monitoring of chemical contaminants and pathogen indicator organisms began in winter of 2013/2014.

ReNUWIt researchers also are studying contaminant removal in vegetated unit-process wetlands. To provide new insights into these systems, researchers are employing state-of-the art tools for characterizing the microbial communities in different parts of treatment wetlands.

Further insight into the chemical contaminant removal process is being collected through measuring the rate of chemical contaminant removal in microcosms, pilots and full-scale treatment wetlands.

WORKING TOGETHER

As a collaborative research center, ReNUWIt researchers know the value of creating strong partnerships. With a robust Industry Advisory Board, researchers are working with industry professionals to take their research from concept all the way to the demonstration scale.

Without these partners and their resources, many of ReNUWIt's established projects would be less developed. While researchers benefit by implementing their research, industry partners are able to see the benefits of emerging ideas first hand.

Working with the Elephant Butte Irrigation District (EBID) in New Mexico, the U.S. Bureau of Reclamation, and the City of El Paso and El Paso Water Utilities in Texas, ReNUWIt researchers are studying managed riparian zones and their connection to water conservation, water quality and wildlife habitat.

At the Caballo pilot site, the U.S. Bureau of Reclamation provided two 60 foot x 60 foot plots in a managed saltcedar area. They mowed 158 acres of the high-water consuming, invasive plant to allow native saltgrass to grow at the start of the study.

Based on the Caballo site, ReNUWIt worked with EBID, who brought in heavy machinery to clear a dense stand of saltcedar and prepare the riparian land near the Rio Grande and the Diez Lagos irrigation drainage canal in Sunland, NM for an urban demonstration project to assess new ecologically sound approaches to salt cedar control. The area will include 26 40 foot x 40 foot plots with various native plants to control invasive species, study erosion, reduce runoff and improve water quality. The site is also being studied for operation as a flood regulating reservoir to minimize property damage and enhance the local surface water supply.

Building on the success of the ReNUWIt-created wetland pilot in Discovery Bay, CA, researchers worked with the Orange County Water District (OCWD) to create a new wetland treatment system at the Prado Wetlands.

As a partner in the project, OCWD built a 10-acre open-water unit process wetland, comprising three 656 foot x 328 foot x 0.66 foot open water cells lined with a mat of photosynthetic diatoms coating the bottom. The process uses sunlight, algae and bacteria to remove more trace organic chemicals, waterborne pathogens and nutrients. In addition to constructing the wetland, OCWD staff collects and test the water in their labs for chemical contaminant and pathogen indicator organism levels and share the results with ReNUWIt researchers.

In addition to constructing the wetland, OCWD staff collect and test the water in their labs for chemical contaminant and pathogen indicator organism levels and share the results with ReNUWIt researchers.

Working with the Bay Area Integrated Regional Management Plan with the Oro Loma Sanitary District, the Bay Area Clean Water and Environmental Science Associates (ESA) to build a project in Oro Loma, CA, a research team is designing a constructed wetland at the Oro Loma wastewater treatment plant on San Francisco Bay.

In the lab, ReNUWIt researchers are investigating effective nitrogen removal by a wetland subsurface treatment system, which will be incorporated in the demonstration-scale wetland. This project is a solution for rising sea levels, nitrogen pollution and loss of marshland habitat.

The wetland, known as a horizontal levee or ecotone, will provide essential tidal habitat for native animals and buffer the treatment plant from the effects of sea level rise.

ReNUWIt also collaborated with Stanford University to help develop the William and Cloy Codiga Resource Recovery Center on Stanford's campus. At the center, researchers can test promising technologies for recovery of clean water and energy from wastewater.

The $3.5 million facility is funded by Stanford and by a gift from Stanford alumnus William Codiga and his wife, Cloy. Open to all ReNUWIt researchers, the facility's mission is to accelerate commercial development of new wastewater technologies by testing at a scale large enough to demonstrate a process's effectiveness and stimulate investment for full-scale implementation. The center will also test technology that is mobile and can be deployed at remote locations.

STRONG EDUCATION PROGRAMS

ReNUWIt is dedicated to preparing the next generation of urban water infrastructure leaders and to engaging students in quality scholarship. ReNUWIt leaders deliver educational and entrepreneurial opportunities through research experience, seminars, workshops and programs, and encourage interaction between students and industry leaders, international collaborators and researchers at the different campuses.

Drawing students from across the country and world, our researchers are based largely at the four partner universities. Pre-college and community college programs provide opportunities to increase Science Technology Engineering and Math (STEM) education and offer opportunities to learn about urban water infrastructure research as a potential field. As part of the ReNUWIt experience, every student, postdoctoral researcher and faculty member spends a minimum of 40 hours per year on education and outreach activities as a commitment to further educational goals. Undergraduate and graduate students are afforded world-class, innovative and entrepreneurial research opportunities, laboratories and practical field work aligned with top-of-their-field academic leaders and researchers.

Graduate students: ReNUWIt provides graduate students with the tools needed to advance reinventing urban water infrastructure, navigate the entrepreneurial process and address specific challenges associated with innovation in the urban water sector.

Undergraduate students: ReNUWIt undergraduate students gain research experience during the academic year, and benefit from innovative curricula that familiarize them with the latest developments in urban water infrastructure. During the summer, ReNUWIt hosts and mentors non-ReNUWIt students through the Research Experience for Undergraduates (REU) program.

Pre-college students: ReNUWIt focuses on familiarizing pre-college students with the challenges of urban water infrastructure and motivating students from diverse backgrounds to pursue careers in STEM fields. High school students join ReNUWIt research groups in the summer through the Young Scholars Program. ReNUWIt also hosts pre-college teachers in ReNUWIt laboratories through the Research Experience for Teachers (RET) program and participate in outreach activities in the community.

LOOKING FORWARD

After only three short years of operation, ReNUWIt is making great strides as a world-class research center. As milestones are met, ReNUWIt continues its innovative and entrepreneurial research opportunities.

As part of that mission, ReNUWIt has created a new workshop series focusing on identifying potential technology diffusion pathways for ReNUWIt technologies. Researchers are working to understand the path through which ReNUWIt technologies will be assessed, utilized and adopted by decision-makers.

ReNUWIt continues to engage leaders in the water sector. Working with its Industrial Advisory Board members, ReNUWIt is demonstrating tangible benefits of new technologies through pilot- and demonstration-scale research projects.

With several new pilot projects under development and increasing IAB participation, ReNUWIt is working with its partners to build new projects, including modular systems to treat urban stormwater in Sonoma and Los Angeles, CA; a resource recovery facility at Stanford University in Stanford, CA; and a subsurface wetland ecotone in Oro Loma, CA.

Researchers are also working with partners as they seek to understand the role of storm dynamics on stream water chemical variability in a highly polluted urban-fringe watershed at CSM and study how to harvest unique properties of certain algae types that use both organic matter and sunlight to treat wastewater and generate biofuels at NMSU.

As a center, ReNUWIt also is reinventing the university experience through interaction between industry members, researchers and students at seminars, formal meetings and research collaborations. ReNUWIt students also gain experience in entrepreneurship and the analysis of water infrastructure at a systems level through interactions with researchers with experience in law, economics, city planning, and public policy.

With a strong foundation, ReNUWIt's next phase will include increased development of demonstration-scale projects to foster broader adoption of new technologies and tools needed to reinvent urban water infrastructure.

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