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For a sustainable and desirable future

Solutions

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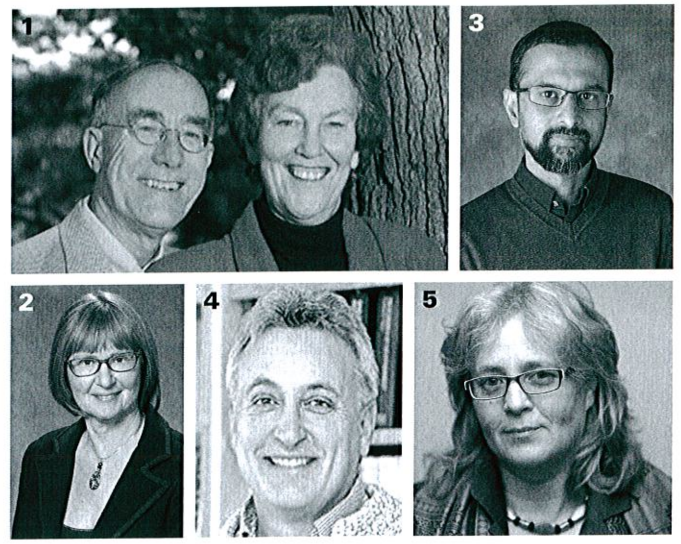
On the Cover

A stained glass window designed and created by Burne Jones depicts angels holding the Earth in the chapel of Harris Manchester College in Oxford, England. Pope Francis' recent encyclical, *Laudati Si*, has declared that environmentalism is an ethical issue. As such, the encyclical has the potential to bring about a tipping point in the global community regarding the climate debate, not merely among Christians, but to all those attending to this moral call to action. Photo by Lawrence OP.

Contributors



1. Mary Evelyn Tucker and John Grim—Tucker and Grim are the Directors of the Forum on Religion and Ecology at Yale University. Over the last 20 years, the Forum on Religion and Ecology has been drawing together the research and insights of scholars, theologians, and laity within the world's religions. They have identified ideas, ethics, and practices regarding ecology and justice from these traditions in books, journals, and films. Now there are environmental statements from the world's religions, educational programs, and grassroots projects on the ground. This work began with 10 conferences and 10 volumes at Harvard from 1996–2004. Since coming to Yale in 2006 the Forum is based at the Yale School of Forestry and Environmentally Studies and Yale Divinity School. Visit the Forum website at http://fore.yale.edu.

2. Nancy Bertaux—Nancy Bertaux (PhD, University of Michigan) is Professor of Economics at Xavier University, Cincinnati, where she co-chairs Xavier's Sustainability Committee and teaches courses in Economics and the Environment. She is Director of two interdisciplinary degree programs, BA in Economics, Sustainability & Society, and BSBA in Sustainability: Economics & Management. She has been a Fulbright Senior Scholar in Germany, and taught in study abroad programs in Ireland and London. She has worked in the private, public, and non-profit sectors, and participates in efforts to increase environmental and social sustainability. She currently represents Xavier on the Greater Cincinnati Green Business Council (GCGBC).

3. H.S. Udaykumar—H. S. Udaykumar is a professor of Mechanical and Industrial Engineering at the University of Iowa. He obtained a BTech degree from the Indian Institute of Technology and MS and PhD degrees from the University of Florida. He has been teaching at Iowa since 1999. His current work is mainly in the area of Energy, Energetics and Computer Simulations. He has done extensive work in tribal villages in Northwest India trying to find solutions to their energy needs. Udaykumar has been working to develop a stored energy solar cooker; in the meantime he and his co-authors have also been exploring other options to cut down on the use of firewood by the villagers.

4. Robert Costanza—Robert Costanza is a Chair of Public Policy at the Crawford School of Public Policy at Australian National University. Costanza is cofounder and former president of the International Society for Ecological Economics. He has authored or coauthored over 350 scientific papers and reports on his work have appeared in *Newsweek*, *U.S. News and World Report*, the *Economist*, *The New York Times*, *Science*, *Nature*, *National Geographic*, and National Public Radio.

5. Nives Dolšak—Nives Dolšak is a professor at the School of Marine and Environmental Affairs, University of Washington, Seattle, and a visiting professor at the Faculty of Economics, University of Ljubljana, Slovenia. She has co-edited two volumes, *The Drama of the Commons* (National Academy of Sciences Press) and *The Commons in the New Millennium: Challenges and Adaptation* (the MIT Press). Her other work examines political and economic factors impacting global climate change mitigation at local, state, and national levels; linkages between commercial interests, voting, and bilateral environmental aid allocation; and the diffusion of market-based environmental policy instruments.

6. Aseem Prakash—Aseem Prakash is Professor of Political Science, the Walker Family Professor for the College of Arts and Sciences, and the Director of the Center for Environmental Politics at University of Washington, Seattle. He is the General Editor of the Cambridge University Press Series in Business and Public Policy, the Co-Editor of *Journal of Policy Analysis and Management*, and the Associate Editor of *Business & Society*. He is the author of *Greening the Firm* (Cambridge, 2000), and co-author of *The Voluntary Environmentalists* (Cambridge, 2006). His co-edited books include *Advocacy Organizations and Collective Action* (Cambridge, 2010) and *Voluntary Programs: A Club Theory Perspective* (MIT Press, 2009).Solange Azor—Solange is an undergraduate student at Harvard College, graduating in 2018. She is currently working as a writer and research assistant for The Fuller Project for International Reporting based in Istanbul. She has a strong interest in global gender equality and hopes to pursue a career with a similar focus after completing her undergraduate degree.

7. Solange Azor—Solange is an undergraduate student at Harvard College, graduating in 2018. She is currently working as a writer and research assistant for The Fuller Project for International Reporting based in Istanbul. She has a strong interest in global gender equality and hopes to pursue a career with a similar focus after completing her undergraduate degree.

8. Maisam Alahmed—Maisam Alahmed is currently interning as a freelance journalist with the Fuller Project for International Reporting in Istanbul, Turkey. In the past, Maisam worked as a researcher for the Boston Consortium for Arab Region Studies in Boston, Massachusetts and Amman, Jordan. She has also worked as a Junior Program Officer with the Anti-Personnel Mine Ban Convention Implementation Support Unit in Geneva, Switzerland. Maisam is from Saudi Arabia. She is currently pursuing her Bachelor's degree in International Affairs with a concentration in Middle East Studies at Northeastern University in Boston, Massachusetts. Maisam has also been featured in Mines Action Canada's 30 Under 30 list highlighting the next generation of leaders in humanitarian disarmament.

9. Katherine Dumais—Katherine is a senior studying International Affairs and Economics at Northeastern University. Her research interests include Economic Development, Social Enterprise, and Women's Rights. Previously, she worked as a Fellowship Associate at Ashoka: Innovators for the Public and on various campaigns within her university to create a campus gender resource center and better services for survivors of rape. She currently is completing an internship at RLabs, an organization working to economically empower young people through information technology in Cape Town, South Africa.

10. Naomi Stewart—Naomi is currently a Project Associate at the United Nations University—Institute for Water, Environment and Health, in the Water & Ecosystems program, and previously worked in hydrometric monitoring and water chemistry research for the Government of Canada. Naomi was also Managing Editor for the Water Quality Journal of Canada. She is a long-time freelance editor and writer that is focused on science liaison and communications, with a research background focused primarily on water and agricultural issues and policies. Naomi holds a B.Sc. from the University of Toronto in English, Biology, and Geography, has traveled extensively to learn about global environmental practices, and strives to maintain public interest and fascination in science and nature through her blog and other ventures.

11. Amparo Cerrato—Amparo Cerrato is a Honduran lawyer who worked more than eight years in the Ministry of Forests, Protected Areas and Wildlife of her home country. During her career as a government official, she prosecuted illegal logging and poaching crimes and advised Ministers and Senators in forest policy-making. In the last five years, her work has revolved around solving forest land-tenure conflicts and legalizing land rights for local and indigenous communities living in Honduran public forests and national parks. She is currently finishing her Master's degree in Environmental Management and Development at the Australian National University in Canberra.

12. Teo Grossman—Teo Grossman is Director of Strategic Initiatives at Bioneers. Over his career, Teo has engaged in diverse efforts including federal range management, youth and educator development, state-level assessments of long-range planning, and applied research on topics including climate change adaptation, ecosystem services, biodiversity and ecological networks. A Doris Duke Conservation Fellow during graduate school, Teo holds an MS in Environmental Science & Management from the Bren School at UC-Santa Barbara.

13. Matthew Kelly—Matthew Kelly is Associate Professor of History at the University of Southampton in the UK. He is the author of several books, including *Quartz and Feldspar. Dartmoor: A British Landscape in Modern Times*, published in the UK by Jonathan Cape in 2015.

14. Ryan Coonerty—Ryan Coonerty is a Supervisor for Santa Cruz County in California and a two-time former Mayor of the City of Santa Cruz. He is the cofounder of NextSpace Coworking + Innovation, a lecturer on law and government at UC Santa Cruz, and co-author of *The Rise of the Naked Economy: How to Benefit from the Changing Workplace* (Macmillan, 2013). He also wrote *Etched in Stone: Enduring Words from our National Monuments* (National Geographic, 2007). Ryan was selected by the Aspen Institute to be a Rodel Fellow in Public Leadership as one of "the nation's most promising young elected officials."

15. Peter Schoonmaker—Peter Schoonmaker is founding chair of the MFA in Collaborative Design at Pacific Northwest College of Art, founding president of Illahee, and past board president of Opal Creek Ancient Forest Center. Peter's background is in nonprofit entrepreneurship and ecological research, with field experience throughout North America's west coast as well as New England, the Rocky Mountains, Brazil, and Peru. He has worked with conservation organizations, community groups, government agencies, and natural resource businesses to design local, regional and international initiatives and partnerships. He holds a BA in Biology from Colorado College, and a PhD in Organismic and Evolutionary Biology from Harvard University.

Solutions Skill Sets

Solutions' readers and contributors share some common traits, which I'll call "*Solutions* skill sets and aptitudes," that enable us to detect problems, explore approaches, design solutions, and produce viable real-world policies, practices, and products. The evidence is right here in this issue of *Solutions* (as well as any back issue you might peruse):

- An interdisciplinary water-energy nexus initiative at Xavier University.
- An inexpensive device that radically increases the efficiency of a three-stone hearth.
- Embracing sustainability alliances with new and "unlikely" partners from the Pope to Chinese entrepreneurs.
- Protecting water supplies in Honduras for current and future generations through common asset trusts.
- Betting successfully on sustainable home-building in Texas.

These are just a few of the initiatives and approaches that are attributable to *Solutions* skill sets and aptitudes like the following:

- An adaptive mindset—the ability to pivot quickly in the face of new evidence and opportunities
- Signal to noise recognition—the ability recognize real trends and therefore opportunities
- Scenario foresight—the practice of playing out the consequences of multiple possible futures
- Systems thinking—understanding the world through the flow of energy, materials, and information
- Design doing – finding solutions through problem identification, brainstorming, prototyping, and iteration.

These skill sets allow *Solutions*' contributors and readers to incorporate new evidence into our thinking, rather than clinging to outdated dogmas. When corn-based ethanol was proposed as a potential energy solution, agricultural ecologists ran the numbers and found that the energy return on investment was barely break-even at best, to say nothing of the effects on food systems. Most of us collectively did a quick pivot and moved on to other solutions (venture capitalists were slower to react—they lost millions).

Solutions skill sets allow us to recognize the broad spatial and temporal challenges of prospective climate change, without for example, dismissing future climate scenarios because of a winter cold snap or a mild summer. This is the same kind of pattern recognition that successful long-term market investors use. (Disturbingly, prescient investors have been buying up coastal areas in the Arctic, recognizing the potential of an ice-free polar region.)

Solutions skill sets allow us to see multiple possible opportunities and try them out in "what-if" models. The history of prognostication is littered with laughable predictions (so far)—flying cars, one world government, nuclear power too cheap to meter—and the power of scenario thinking lies in its ability to test scenarios as the future unfolds before us. We can see which assumptions are playing out, which ones aren't, and incorporate new information iteratively.

Solutions skill sets allow us to see connections between ecological, social, and economic systems. For example, connections between "apparently" unrelated things like educating girls in developing countries, global population, and climate change. They allow us to see negative and positive feedback loops (most disturbingly, cascading effects), and critical leverage and intervention points.

And finally, *Solutions* skill sets help us design solutions more efficiently and effectively. Again, the evidence for that is right here in this issue of *Solutions*. Udaykumar et al. have employed a design doing methodology—problem identification, brainstorming, prototyping, and iteration—to develop multiple potential solar cook stoves to replace wood stoves. But perhaps more importantly, their adaptive mindset allowed them to recognize a more immediate design solution: a simple, low-cost device that can be placed within existing traditional stoves, reducing wood use, smoke, and soot, and to increase thermal efficiency within cultural norms.

This adaptive mindset may be the most important, as we'll certainly face new information and unforeseen setbacks as we collectively pursue a more sustainable future; we'll need to make lemons out of lemonade, or penicillin out of fungus, or microwaves out of magnetron vacuum tubes, or Viagra out of a failed angina drug (okay, maybe that's a solution we could have skipped).

These are just the five *Solutions* skill sets at the top of one list. Perhaps *Solutions* contributors and readers have others. If so, we'd like to hear from you. So here's a two-fold challenge:

- Suggest the top five *Solutions* skill sets and aptitudes (and your rationale of course) that you think are needed to foster a more sustainable future. We'll compile and synthesize your replies and get back to you in a future issue of *Solutions*.
- But wait, we're not done. Tell us how these *Solutions* skill sets might be promoted to less solution-minded global citizens. As the reality of ecological, social, and economic disruption is not enough to convince some of us to pitch in, maybe the intrinsic individual and small-group benefits of a *Solutions* skill sets will bring more people on board.

Water Conservation and the Water-Energy Nexus at Xavier University

by Nancy Bertaux, Ann Dougherty, John Hazlett, and Mark Miller

Elyce Feliz

Xavier University in Cincinnati, Ohio.

In Brief

As Pope Francis' recent encyclical on the environment has reminded us, "*access to safe drinkable water is a basic and universal human right, since it is essential to human survival and, as such, is a condition for the exercise of other human rights.*"[1,2] Even in water-rich regions where water is "cheap," careful attention to water conservation and pollution prevention is a moral necessity, helping us to respect this most essential resource while raising awareness of the lack of access to safe water around the globe. Xavier University in Cincinnati, Ohio is located in an area where water bills are relatively low, yet the area suffers from combined sewer overflow issues with associated water pollution. To tackle this problem, students developed a new model for assessing their water usage that, combined with energy savings, offers a bottom-up approach.

The moral imperative of water sustainability is coming into focus, as witnessed by the work of global water activists and underlined by the recent statement from Pope Francis, "*access to safe drinkable water is a basic and universal human right, since it is essential to human survival and, as such, is a condition for the exercise of other human rights.*"[1,2] The need for water conservation and the interconnections between water and energy (the "water-energy nexus") are also gaining increased attention in the wake of a series of highly visible events, ranging from droughts (across a third of the United States, including long-term drought in California) to storms (impact of loss of power in Hurricane Sandy on water infrastructure). Increasingly, organizations will be seeking to analyze and address issues related to the water-energy nexus. The Department of Energy (DOE) recently formed a special team to issue a major report on the water-energy nexus. Increasingly, organizations will be seeking to analyze and address issues related to the water-energy nexus. As the DOE team states, "It is time for a more integrated approach to address the challenges and opportunities of the water-energy nexus."[3]

Universities as institutions are often major users of both water and energy and also have a unique capacity to inform society and raise awareness; many are working hard to reduce their energy and water footprints, both to reduce their costs and to use their research expertise to provide examples for other institutions.[4] Xavier University's 2010 Campus Sustainability Plan included water sustainability as a key element in overall campus sustainability and led to a number of water conservation measures.[5] Recently, Xavier's experience with their Energy Initiative led campus sustainability leaders to think about achieving similar results with water usage and to seek understanding of the water-energy nexus on campus.

How Energy Led to Water

In academic year 2013–14, a sustainability speaker series theme of "Energy Justice" focused the university's attention on energy and included visits from energy experts such as Rocky Mountain Institute's Amory Lovins and economist Jeremy Rifkin.[6] Green building policies and practices that began in earnest in 2009 (construction of three buildings to LEED silver standards, including a central utility plant for heating and cooling systems) had reduced carbon intensity on campus but not the overall footprint. Inspired by Amory Lovins' visit in the fall of 2013, a year-long Energy Initiative was funded by university President Father Graham, S.J. at a cost of USD$120,000 and directed at uncovering immediate energy savings with a one-year payback, a challenging task on an already efficient campus. Energy consultant Ronald Perkins of Navasota, Texas (who had worked with Lovins in the past) helped Physical Plant staff and students identify problems and holistically analyze and solve them. This included workshops, walk throughs led by Perkins, and students who were appointed to be so-called "energy detectives" using an infrared camera and temperature/humidity pens to search for building leaks. As a result of these measures, Xavier achieved a five percent reduction of campus energy and met the one-year payback guideline from administration.

Key Concepts

- Societies and organizations should analyze water and energy together. The "water-energy nexus" refers to the interconnections between water and energy, such as the energy cost of delivering water, the water cost of producing energy, and the entwined nature of energy and water infrastructures.
- The need for water conservation across the globe is increasingly recognized. All of us should treat water as a precious resource, including those who live in relatively water-rich areas.
- Xavier's water-energy initiative benefited from the perspectives of a diverse group of individuals from multiple divisions and levels. Building a broad-based working group is critical to the success of innovative sustainability projects and can build system interconnections that improve sustainability efforts in the future.
- In areas such as the energy cost of water usage, customizing standardized metrics to reflect local costs allows us to more accurately calculate environmental impacts and therefore make better decisions on related practices and policies.

This successful experience with energy was extended to include a water study. While water bills are relatively low in the region, there is currently a significant combined sewer overflow (CSO) problem in the area (leading to raw sewage flowing into waterways in periods of high rain), resulting in higher sewer bills and indicating an urgent environmental need for storm water management and water conservation.[7] Water consultants assisted staff and sustainability interns as they collected data, developed a water footprint, and made project recommendations. As a follow-up to this analysis, Xavier students in a Natural Resource, Environmental, and Ecological Economics course customized the Environmental Protection Agency's (EPA) Pollution Prevention Calculator to more accurately estimate the embedded energy in water delivered to Xavier's campus.

A Collaborative Approach

This project used a systems thinking approach, so university students worked together with faculty, campus operations staff, and community partners in an integrated and experiential manner.[9] This collaborative approach to tackling environmental and sustainability issues is a model that serves several valuable purposes simultaneously. Students in the Fall 2014 class had studied water as an economic resource and as a crucial element in local and global ecosystems via a general overview and abstract economic analysis.[1,10,11] Studying water usage, storm water runoff, and nonpoint source water pollution issues right on their own campus, where they are personally using water by flushing toilets, using sinks and drinking fountains, and walking through landscaped grounds literally brought the discussion home to students. Students thus gained valuable knowledge and skills by working on real-world problems in an experiential learning methodology, while partners gained from the fresh perspectives and contributions of students. Faculty gained in-depth knowledge of relevant cases that can be communicated to future classes as well as community contacts that can assist them in staying up-to-date on cutting-edge applications.[12]

Further, when campus operations and academic classes work together to improve the efficiency and environmental impact of their common campus, constructive relationships are formed and all parties achieve a better understanding of each other's functions.[13] From a systems thinking viewpoint, this introduced new *interconnections* to the system, which can serve as a basis for further improvements in the campus environment in the future.[9] As a result of the water study, Xavier's Sustainability Committee is now planning to report to the campus community regularly on water sustainability progress, thus solidifying the campus collaboration around water. This expands the foundation for further collaboration on other aspects of sustainability, assisting the University to fulfill and strengthen its sustainability commitments.

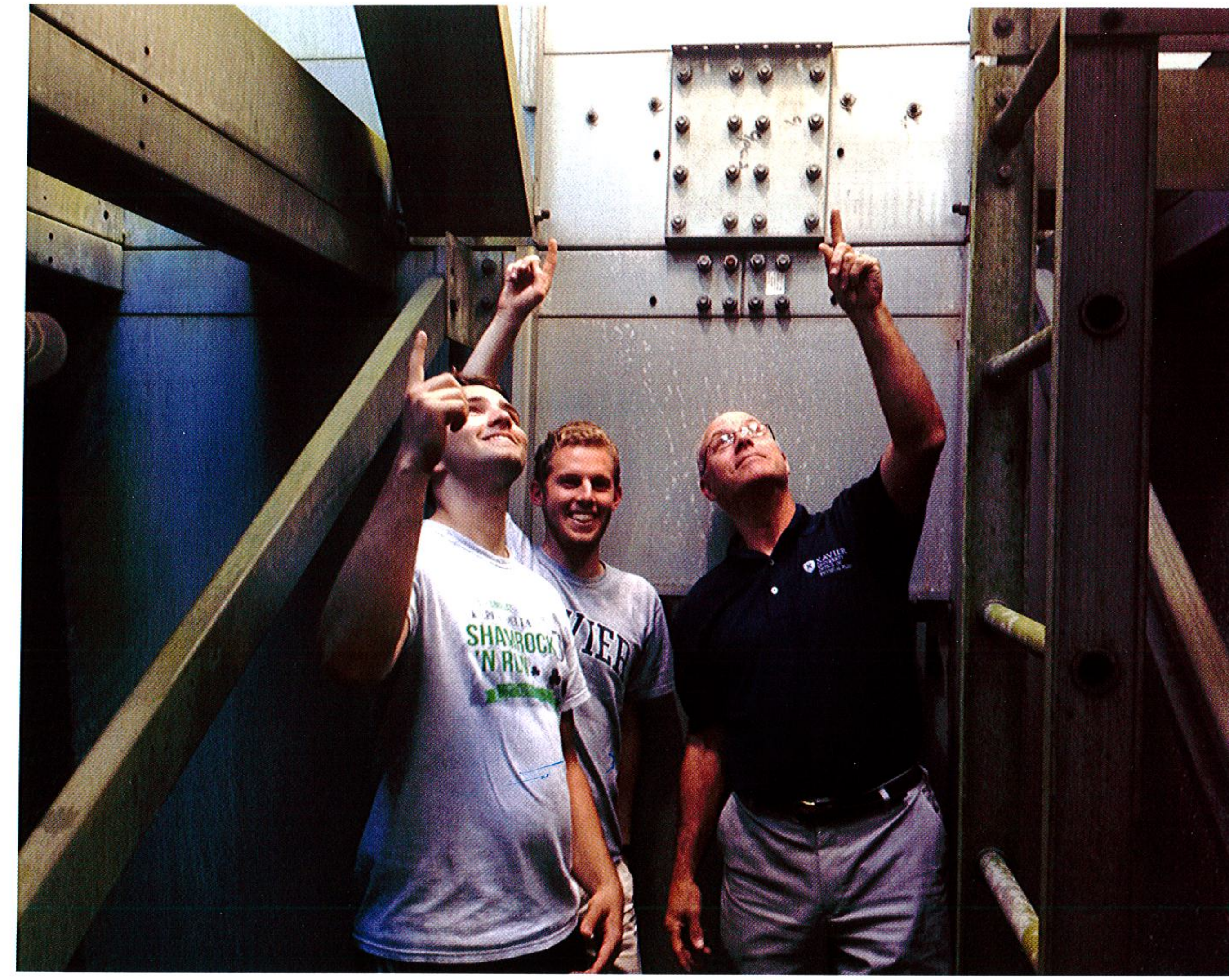
Water Footprint Study

The water study was undertaken in the summer of 2014. Water consultants Williams Creek Consulting worked with staff and sustainability interns to develop a baseline water footprint, that is, the total amount of potable water used and storm water runoff generated on the entire campus. The footprint was used as a basis for project recommendations, with the goal of moving Xavier's campus closer to its long-term goal of Net Zero Water (where water use is minimized and offset by storm water infiltration, using best management practices in green infrastructure). Consultants, staff, and student interns did walk-through assessments of water use and storm-water management practices throughout campus, supplemented by desktop data analysis by consultants. Initial project recommendations were discussed in lively, open-ended workshops with faculty and staff and later refined by input from staff, faculty, students, and administration.

The study documented the fact that more rainwater falls on the campus than is required to meet all of our current water usage. This generated a powerful learning moment for Xavier students, faculty, and administrators as they reflected on these facts: the campus receives all the water it needs from the sky, but instead, this rainwater drains away, contributing to the serious storm water runoff and combined sewer overflow issues in the region, while the campus then has to purchase all their water needs. Specifically, data from the water footprint study estimated Xavier's current annual water use at 79.3 million gallons, with the majority associated with heating and cooling buildings (showing the importance of the water-energy nexus, since we normally focus on the energy aspects of heating and cooling). Additionally, 52 percent of Xavier's 142-acre campus consists of impervious surfaces in the form of rooftops, parking lots, roads, and walkways. Based on the EPA's Storm Water Management Model (SWMM), these impervious surfaces generate 85 million gallons of storm water runoff annually, greater than the usage of 79.3 million gallons. This implies a water surplus if all storm water could be captured, treated, and utilized. Since nonpotable water (water not suitable for drinking) can be used for irrigation for landscaping, the study indicated capturing rainwater for irrigation as a first step. The runoff from Xavier's 930,000 square feet of rooftops alone has an annual rainfall capture potential of over 19 million gallons and would require minimal treatment for sediment prior to use for irrigation.

Sustainability at Xavier University

Xavier's 2010 Campus Sustainability Plan was developed after Xavier President Michael Graham, SJ joined more than 1,000 institutions in signing the American Colleges and University Presidents' Climate Commitment,[8] committing the University to carbon neutrality by 2030. To achieve this goal, a campus-wide Sustainability Committee was formed, a public sustainability speaker series was started, a Sustainability Director was hired, a number of Sustainability Faculty Fellows were funded, and by 2014, several interdisciplinary degrees in sustainability were launched to add to Xavier's BS in Environmental Science: the BA in Economics, Sustainability and Society; BA in Land, Farming and Community; BSBA in Sustainability: Economics and Management; and MA in Urban Sustainability and Resilience.[6] In 2015, a Sustainability Advisory Board for academic programs was formed, with prominent green leaders from private, public, and nonprofit sectors. The University has joined the Association for the Advancement of Sustainability in Higher Education (AASHE) and attends and presents at AASHE conferences. All efforts stress building commitment through involving a broad network of individuals on campus; working with community partners and sharing knowledge; and using campus as a laboratory for student learning and best practices.



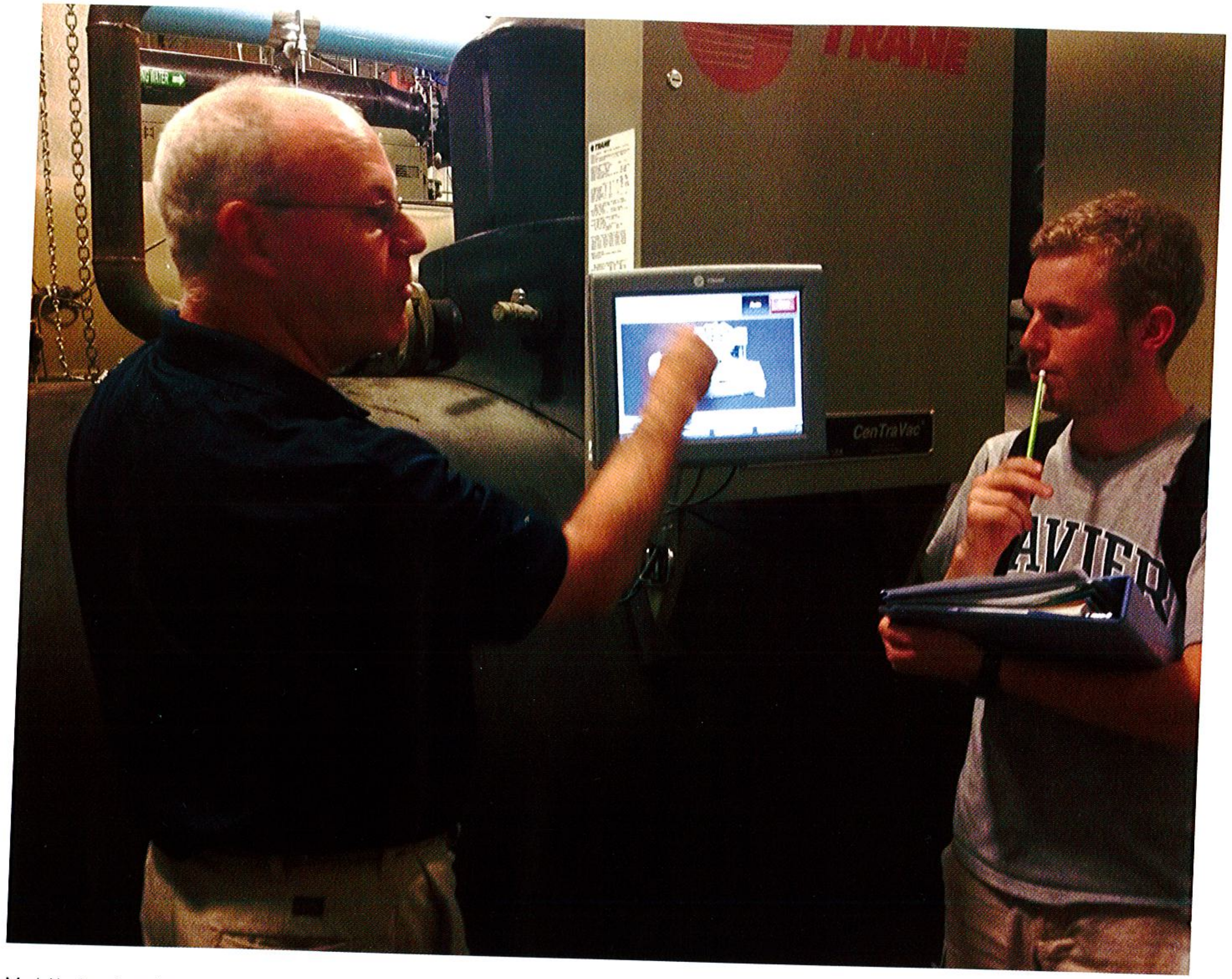
Xavier University

ECOS students, led by Mark Hanlon of Xavier University's Physical Plant, explore the campus' water-related infrastructure, such as the cooling tower depicted above.

Other water footprint reduction opportunities identified by Williams Creek and interns include the following: rain gardens, xeriscaping (landscaping with little or no irrigation), air handler condensate reuse, replacement of domestic fixtures with EPA WaterSense® labeled products, and recommendations for operating pools and fountains with water conservation strategies in mind. For example, the Cintas Center, which holds events with over 10,000 attendees, has two cooling towers and nine air handler units. Air handler condensate represents a significant onsite water resource that is low in sediment, dissolved solids, hardness, and pathogens. Condensate is plentiful at the same time that cooling tower water demands are high, with an estimated 3 to ten gallons of condensate generated for every 1,000 square feet of conditioned space. To utilize this alternative water source, some plumbing alterations are required, and reused water may require disinfection and removal of copper (from contact with the cooling coil). Lastly, opportunities for green infrastructure implementation at Xavier's campus were identified in landscaped areas where storm inlets could be raised to promote infiltration of storm water for shallow aquifer recharge, thus moving Xavier's campus towards a Net Zero Water condition with associated carbon reductions.

Water-Energy Nexus Analysis by Students

In Fall 2014, over 40 Xavier undergraduate students took Professor Nancy Bertaux's course in Natural Resource, Environmental and Ecological Economics. A subgroup of students, led by senior Mark Miller, undertook a class project to follow up on the water footprint study and



Xavier University

Mark Hanlon, Associate Director of Maintenance and Operations at the University's physical plant, explains the control panel of one of the Univeristy's largest chillers to a student.

ultimately reported results to all students in the class, plus attendees from Xavier administration and the Cincinnati water community. Students also participated in the University's sustainability theme of "Water Justice" for the 2014–15 academic year, gaining the bigger picture on water resource issues by attending the speaker series and smaller dialogue sessions with P&G Vice President for Global Sustainability Len Sauers, water journalist Cynthia Barnett, and water activist Maude Barlow.[6]

Students explored the water-energy nexus on their own campus by researching embedded energy in the water delivered to Xavier's campus. EPA's Pollution Prevention Calculator's water conservation tool was utilized to estimate the greenhouse gas impact of Xavier's water usage.[11] The calculator tool was then customized by incorporation of more granular data pertaining to Xavier's campus. Working with expert guidance from John Hazlett of Williams Creek Consulting, and in partnership with Xavier University's Physical Plant and Sustainability Director Ann Dougherty, students gathered data from local utilities serving the Xavier campus, customized the calculator, and compared results obtained by using the EPA's Pollution Prevention Calculator versus results from the customized calculator (described in the Appendix).[14]

Students learned that water footprinting is a rapidly developing field in need of (and approaching) standardized measurement and improved data collection. The water conservation tool contained in the standard EPA calculator includes parameters based on averages, reflecting the principle of diminishing feasibility (for every step of complexity in data collection, the data becomes disproportionately more complex to attain). For a single institution such as Xavier, modifications to the data collection tool can add accuracy without adding much complexity, given the institution's easy access to its own data (e.g., organizational databases and water bills). The Appendix outlines the specific procedures for customizing the EPA calculator's water tool, which will allow other institutions to more accurately calculate the carbon impact of their water-energy nexus. Note that the EPA's calculator converts data relevant to water conservation into greenhouse gas (GHG) emissions equivalents. It takes into account pumping, treatment, and distribution but *not* heating. There are three main parameters in the calculator: water conserved, conversion factor, and set energy expenditure per million gallons pumped, treated, and distributed. These are described in the Appendix, including procedures to customize the calculator where applicable, and calculations performed for Xavier University are presented. Accounting for all adjustments, Xavier University's emissions footprint was 37 percent lower than the estimate from the standard EPA calculator (23 percent coming from the conversion factor alone).

By customizing the calculator, institutions benefit from more accurate estimates. For example, if the institution is located closer to their water source than suggested by the generalized model, as was Xavier, they will enjoy a more accurate, lower water footprint, a welcome and nearly costless improvement in their green profile. Conversely, if local parameters are adverse compared to the generalized calculator, the institution could find their energy use is being significantly underestimated, causing them to enhance their carbon footprint mitigation strategies. Either way, the higher quality information will be helpful to institutions committed to reductions in their GHG emissions.

While the water-energy nexus analysis allowed Xavier to report lower GHG emissions due to a more accurate calculation, Xavier remains committed to pursuing water conservation with its associated energy conservation. Water is an abundant resource in the Cincinnati area, averaging 42 inches of rainfall annually, but as noted above, the region is challenged by serious storm water runoff and combined sewer overflow problems.[7] Xavier also wants students to be aware that around the world and in parts of the US, water shortages are serious and chronic, with significant pricing and access problems that relate to issues of just distribution, as we teach our students to be "Men and Women For and With Others."[1,2,10]

Students thus gained valuable knowledge and skills by working on real-world problems in an experiential learning methodology, while partners gained from the fresh perspectives and contributions of students.

Future Ideas on the Water-Energy Nexus: Use Local Geography

The water study showed the benefits of Xavier's previous water conservation efforts that included careful, drip irrigation and automatic moisture monitoring methods, installation of low-flow toilets and aerated sink faucets and showerheads in all new and renovated buildings, and tanks for slow discharge of storm water. The water study has spurred action plans that will further increase water conservation and recharging of aquifers, while reducing storm water runoff. These include the reuse of condensation from HVAC systems and systematic increase in green infrastructure on campus, such as rain gardens and xeriscaping. With the water-energy nexus as inspiration, the University is now planning two further pilot projects that capitalize on the physical geography of the campus and could expand water-energy knowledge and awareness in the community:

1. Work with a local mechanical engineering company to design a turbine to use the high volume of rainfall and steep hillsides on campus to create energy. Two campus locations have been identified that have large parking lots that are adjacent to hillsides and drops of 20 feet or more, with minimum slope of 75 percent. In addition, rainfall to roofs on newer buildings flows to underground tanks for slow, gravity discharge to the region's combined sewer system. Engineering and physics students will work with professors, the campus chief plumber, and mechanical engineers to implement their best design, exploring the following:
    - Can in-pipe or in-tank turbines take advantage of this flow during high rainfall events?
    - At what resistance would the turbine be set to not block but rather slow flow under different incoming flow rates?
    - What topographical "drops" and pipe geometries are necessary for such technologies to be used effectively?
2. Recycle rainwater on campus through use of rainwater barrels and solar panels for pumps. Locations with buildings that have downspouts in the right

AgriLife Today

One method of water conservation now employed by Xavier University is xeriscaping, or landscaping with little or no irrigation, as pictured.

areas to connect to a rainwater barrel have been identified in three areas, and estimated costs for a project with 10 barrels, solar panels, pumps, drip irrigation, and engineering are USD $50,000. Rainwater from barrels would irrigate lawns around these areas, and solar panels for the pumps would conserve energy and reduce the campus carbon footprint. The barrels will need to be maintained over time—for example, emptying barrels prior to freezing temperatures in winter to avoid cracking. Total annual water yield, based on an estimated 20 gallons of harvested storm water per square foot of rooftop, would be 786,000 gallons for the three rooftops combined. Professors from Environmental Science, Physics and Economics would involve students with this project, including measuring pH, turbidity, and other aspects of water in the barrels; building a system to indicate water levels in the barrels; testing the most efficient way to move water from the barrels to the irrigation system; and tracking water, energy, and cost savings.

Putting the Water and Energy Conversations Together

Increasing attention is now being directed both at water sustainability, and at the connection or "nexus" between water and energy. A leading water journalist has observed:

> The nation's energy and water problems are remarkably similar. So are the solutions: focusing on the demand side rather than constantly growing the supply side will help save the nation's water resources and billions of dollars. At the very least, we should put the water and energy conversations together.[15]

For Xavier, 'putting the conversations together' meant analyzing energy and water usage holistically. Sustainability initiatives of all kinds will increasingly incorporate more attention to issues related to water, and Xavier University's experience in progressing from an energy focus to a water-and-energy focus will and should be replicated in other institutions who want to be a positive force for change on water. When water justice advocate Maude Barlow was asked how change will happen on water sustainability, she answered, "It's going to come from the bottom up," and to the question of who will do this, she said, "go home and look in the mirror."[16] S

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Appendix

There are three main parameters in the calculator: water conserved, conversion factor, and set energy expenditure per million gallons pumped, treated, and distributed.[14] (Institutions are advised to monitor the conversion factor periodically, as these can vary significantly as energy providers change sources of energy, for example from coal vs. natural gas.[17])

1. **Water Conservation.** The institutional user's monthly water bills provide all required data for this parameter.
2. **Conversion Factor.** The calculator includes an index of conversion factors collected by region. Users can contact their specific energy provider (in our case, Duke Energy) to determine the metric for a customized calculator. In our case, this metric proved to be critical. The regional default conversion factor in the standard calculator was 0.0008909, but our research for Xavier University yielded a value of 0.00068199388. This factor alone suggested a 23 percent decrease in estimated emissions compared to the standard calculator.
3. **Set Energy Expenditure Factor.** This is perhaps the most important parameter to customize. This value quantifies the kWh needed to pump, treat, and distribute a million gallons of water, and is set at 3,300 kWh per million gallons.

Since Xavier University is closely situated to the Miller water treatment plant on the Ohio River, this estimate was high. Data from our water provider, Greater Cincinnati Water Works, yielded a value of 2714.117 kWh per million gallons. For users seeking to make the same adjustments, the following two-step process can be followed:

a. Contact local water pumping/treatment/distribution facilities and request the gallons and kWh associated with each process. In the case of Cincinnati, this is a single, municipally managed unit, but some institutions may need to contact several facilities, not necessarily municipally-owned.

b. Use data to calculate customized set energy expenditure per million gallons pumped, treated, and distributed, as follows:

The total energy expended per million gallons is:

$$kWh_{Total} / gal_{Total} = kWh_{Raw} / gal_{Raw} + kWh_{Treatment} / gal_{Treatment} + kWh_{Distribution} / gal_{Distribution}$$

For institutions that receive water through more than water distribution pipeline (even if the water comes from the same treatment plant), this will only affect the distribution term in the equation above, which should be calculated using a weighted average in order to give appropriate representation to pipelines with asymmetric contributions. In this case, the distribution term will appear as the following equation with an index of $i = a...n$:

$$(kWh^{i}_{Distribution} / gal^{i}_{Distribution})^{2} / (kWh^{a}_{Distributed} / gal^{a}_{Distributed} + ... + kWh^{n}_{Distributed} / gal^{n}_{Distributed})$$

Accounting for both the conversion factor adjustment and the adjustment to set energy expenditures, Xavier University's emissions footprint was 37 percent lower than the estimate from the generalized EPA calculator (recall it was 23 percent lower due to the conversion factor alone).

References

1. Barlow, M. *Blue Future: Protecting Water for People and the Planet Forever* (New Press, New York, 2014).
2. Pope Francis. *Laudato si'.* The Holy See [online] (2015) http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html.
3. Department of Energy. The water-energy nexus: challenges and opportunities [online] (2014) http://energy.gov/downloads/water-energy-nexus-challenges-and-opportunities.
4. NC State Energy Management. Strategic energy and water annual report [online] (2014) http://sustainability.ncsu.edu/campus/energy-water/.
5. Xavier University Sustainability Committee. Campus sustainability plan [online] (2010) http://www.xavier.edu/green/The-Plan.cfm.
6. Xavier University. Academic programs [online] (2015) http://www.xavier.edu/green/Academic.cfm.
7. Environmental Protection Agency. EPA approves plan to control sewer overflows in Cincinnati area [online] (2010) http://yosemite.epa.gov/opa/admpress.nsf/docf6618525a9efb85257359003fb69d/12e8a727953bad4f85257b7f00548201!OpenDocument.
8. American College and University Presidents' Climate Commitment (ACUPCC) [online] http://www.presidentsclimatecommitment.org/about/mission-history.
9. Meadows, D. *Thinking in Systems* (Chelsea Green, White River VT, 2008).
10. Daly, H & Farley, J. *Ecological Economics* 2nd edn (Washington DC, Island Press, 2010).
11. Tietenberg, T & Lewis, L. *Environmental Economics and Policy* 6th edn (New York, Prentice Hall, 2009).
12. Wurdinger, S & Carlson, J. *Teaching for Experiential Learning: Five Approaches that Work* (Lanham MD, R&L Education, 2009).
13. Dougherty, A, Sheeran, R & Bertaux, N. Sustainability integrated with buildings and books: who does what? Presentation to the Society of College and University Planning (SCUP) (Pittsburgh, July 16, 2014).
14. Environmental Protection Agency. Pollution prevention program [online] (2014) http://www.epa.gov/p2/pubs/resources/measurement.html.
15. Barnett, C. *Blue Revolution: Unmaking America's Water Crisis* 79 (Boston, Beacon Press, 2011).
16. Maude Barlow interview. *The Progressive* [online] (2008) http://www.progressive.org/mag/intv1208.html.
17. Duke Energy. *Lighting the Way* (n.p., 2013).

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The water study revealed that more rainwater falls on campus than is needed to meet all of the university's water usage needs. Future projects such will aim to capture and recycle that rainwater to make Xavier University more sustainable.