Youth Corner

International Sustainability Initiatives and Local Applications: An Undergraduate Case Study in East Texas

Angus, G., R. Acevedo, E. Belzle, J. Blackmon, C. Carroll, S. Coffey, E. DeLuca, G. Hinkle, N. Johnson, C. Krnavek, T. Lenert, C. Smith, D. Thompson, J. Weihe, W. Forbes

Correspondence to: William Forbes, Geography and Sustainable Community Development, Box 13047 SFA Station, Nacogdoches, Texas 75962; forbesw@sfasu.edu
Stephen F. Austin State University students researched international models related to renewable energy, energy conservation, alternative transportation, and waste reduction. Next, they looked for programs that could apply locally. Students then worked in partnership with a local citizens group, Renewable Energy Nacogdoches, to help a local health clinic apply for a grant to obtain solar panels. Students also formed an ad hoc "Jacks Go Green" coalition to start a campus green fund, for which they drafted project proposals. This article summarizes this course work and the potential programs for East Texas and its university communities.

Several countries in Europe, such as Denmark, Iceland, Germany, Sweden, and the United Kingdom, are encouraging environmentally friendly alternatives to fossil fuels and motorized transport. Some developing countries can also serve as models of both lower-consumption lifestyles and innovation, namely Brazil, Colombia, Costa Rica, Uruguay, and Rwanda. Some international initiatives include measures of ecological impact.

Ecological Footprints

Matthias Wackernagel and William Rees at the University of British Columbia developed the *ecological footprint* index in 1990. The ecological footprint is the impact of a person, community, or nation on the environment, expressed as the amount of land required to sustain their use of natural resources. Many countries that depend on fossil fuels and have high material consumption rates will have a higher ecological footprint. Lower consumption and greater reliance on renewable energy mean a smaller footprint.

Carbon footprints indicate the amount of carbon emissions, which contribute to climate change in the form of greenhouse gas carbon dioxide. The leading countries in carbon dioxide emissions, as a percentage of global emissions, are China (28%), the US (15%), and India (7%). The top 5 European nations combined emit 6% of the global total. The Union of Concerned Scientists (2020) states:

> The picture that emerges from these figures is one wherein general—developed countries and major emerging economy nations lead in total carbon dioxide

> emissions. However, developed nations typically have high carbon dioxide emissions per capita, while some developing countries lead in the growth rate of carbon dioxide emissions. These uneven contributions to the climate crisis are at the core of the challenges the world community faces in finding effective and equitable solutions to global warming.

Carbon Brief (2016) notes that the amount of emissions will also depend on the efficiency of the country's technology: low production of fossil fuels can be linked to high emissions where there is inefficiency, as is the case in Kazakhstan.

The Global Footprint Network (2020) website allows you to calculate your ecological footprint. The Network also calculates and publicizes Ecological Overshoot Day, the day in the calendar year when, already, "we (all of humanity) have used more from nature than our planet can renew in the entire year. Earth Overshoot Day has moved up from late September in 2000 to August 22 in 2020."

One of the Network's more interesting indices measures *biocapacity* reserve or deficit by nation. The website states:

> An ecological deficit occurs when the Ecological Footprint of a population exceeds the biocapacity of the area available to that population. A national ecological deficit means that the nation is importing biocapacity through trade, liquidating national ecological assets, or emitting carbon dioxide waste into the atmosphere. An ecological reserve exists when the biocapacity of a region exceeds its population's Ecological Footprint.

Nations with the largest deficits are often small city-states such as Singapore, or islands such as Bermuda, with little land and resources to support its citizens without importing. However, some of the larger nations with large deficits include Saudi Arabia, with its emphasis on fossil fuels and an arid land base with fewer basic resources. Their ecological footprint exceeds their biocapacity by a striking 1,390%. Surprising entries include the Netherlands at 487%. Because of its large, productive land base, the US stands at a 122% deficit. Nations with biocapacity reserve include French Guiana (#1) at 3,980%, Uruguay at 419%, and Brazil at 209%.

The Happy Planet Index, created in the United Kingdom by the New Economics Foundation, measures surveyed happiness, life expectancy, and inequality over the ecological footprint, with the latter factor different from other happiness surveys. Western countries that are economically successful do not rank highly on the Happy Planet Index. Instead, "several countries in Latin America and the Asia Pacific region lead the way by achieving high life expectancy and wellbeing with much smaller ecological footprints" (Wahl 2017). Costa Rica, the developing yet most advanced, progressive nation in Central America, ranked number one in the world several times in recent years.

Renewable Energy Examples

Many countries are attempting to reduce their ecological footprint while obtaining energy at a low cost. Once established, energy from the wind can be the most cost-efficient source, providing up to 20% of a country's energy while using only 1% of the

land. Land can often be used for farming or ranching while also producing wind energy. Top ranking nations in wind energy capacity include, in order, China, USA, Germany, India, Spain, UK, France, Brazil, Canada, and Italy. China has more than twice the capacity of the US, while India has the third and fourth largest onshore wind farms in the world. One large German offshore wind farm provides the energy for 400,000 homes (Unwin, 2019).

Another form of renewable energy is geothermal, which uses the earth's crust: "geothermal technology can only be used in locations with specific geological conditions. For this reason, the major regions of geothermal development are in the most volcanically and tectonically active regions of the world" such as Iceland, Indonesia, New Zealand, Hawaii, California, and Ecuador. For example, Iceland has over 90% of space heating and over 27% of electricity sourced from geothermal energy (Student Energy 2019).

One country that soars high above most others when it comes to the use of renewable energy in Germany. Over three-quarters (77 percent) of Germany's public power supply is generated by renewable energy (Wettengel, 2019). In comparison, renewable energy makes up 11% of total energy use in the United States (EIA 2019). The difference in these numbers is startling. Germany has worked for decades to lower its environmental impact. One source of renewable energy widely used in Germany is wind power, taking advantage of fast winds to power both dispersed and clustered wind turbines to provide electricity. Solar and biomass energy are being used to reduce their carbon footprint.

Other countries ranked high for energy conservation are Iceland, Denmark, and Sweden. Iceland currently gets 100% of its energy from renewable energy sources (Renewable Energy UK 2019). They are the only country in the world to have done this. A large percentage of their energy comes from hydropower. They can produce so much hydropower energy because of glaciers and mountains topped with snow. Denmark plans to be 100% fossil fuel-free by 2050, a goal they have been working towards for years. Sweden has a plan to reach 100% renewable energy production by 2040. Already, over half of their energy comes from renewable resources (Swedish Institute 2019). All of the countries mentioned above set an example for the rest of the world to follow. They are giving hope to the planet and making historical advancements.

However, as shown in the "Happy Planet Index", developing nations can also lead the way in renewables, with Latin America again showing leadership. Uruguay, under its progressive President Mujica, recently moved to renewables to lower energy costs. It now gets 36% of its energy from wind and solar, a figure topped only by Denmark, Lithuania, and Luxembourg. When hydroelectric is included, Uruguay gets 97% of its energy from renewables. Greenhouse gas emissions in 2017 dropped 88% from the 2009-13 average (Bertram 2020).

Alternative Transportation Examples

European nations are also leaders in transportation options, including more environmentally friendly mass transit (bus, rail), cycling, and walking. Six of the top ten most eco-friendly cities are in Europe (Tentree 2017). There are many reasons for this, but

one major factor is the culture of bike riding in many major European cities. Almost every country in Europe today has at least one bike-share system. France alone has 29 bike-share systems, while Lyon was ranked overall as one of the best cities for bicycles. In some parts of Germany, cycling is the easiest transport option. The bike lanes in major cities are prominent and people on bikes are given the right of way. A trend like this not only encourages more individuals to bike but reduces the number of people driving cars. The bike-sharing system in Germany is called "Fahrradverleihsysteme" or, in English, "Bicycle Rental System." There are over 780 bike share stations across Germany, in cities including Berlin, Frankfurt, Munchen, Hamburg, Kassel, Duesseldorf, and Mainz.

In Copenhagen, Denmark, the world's most "bike-friendly city", bicycles outnumber cars more than 5 to 1 (Fleming 2018). It's no surprise the city has this reputation, considering it is more common for people to bike to work than it is for people to drive. Copenhagen is a fairly advanced and modern city, especially when it comes to environmental concerns. Not only are the residents known for being enthusiastic cyclists, but they also practice sustainability. In fact, Copenhagen has already cut its CO_2 emissions by 38 percent since 2005 (Berger 2017). The government has strict laws when it comes to energy usage, promotes wind turbines for power, and has programs to recycle and reuse waste and plastics. Bicycles are an important part of the renewable energy plan - not only bike-sharing systems, but bike paths, bike lanes, and even bicycle/pedestrian bridges. The goal is to make biking the most common form of transportation and to make taking a car the more difficult option.

Another European city making notable progress in biking is Amsterdam. The 17 million-strong population of the Netherlands owns 22.5 million bicycles, more bicycles owned per capita than any country in the world (Bicycle Dutch). Just as in the cities mentioned above, biking has become more than a hobby in Amsterdam, it is a way of life.

It is no secret that many European countries are advanced when it comes to modern transportation alternatives. However, innovative examples also occur in Latin America. A recent mayor of Bogota, Colombia provided leadership in not only improved bus systems for the poor but new bicycle-friendly routes. A Bogota event that closes off selected main roads for bicycles (and pedestrians) on certain days, called "Cyclovia," has been duplicated in Texas cities such as Austin and San Antonio. The city of Buenos Aires, Argentina recently created central lanes designated for buses only on its main street, the multi-lane Avenida Nuevo de Julio. This innovation greatly reduced traffic congestion, decreased bus travel time, and increased bus use.

Curitiba, located in southern Brazil, has also gained recognition. Nicknamed "Cidade modelo" or Model City, Curitiba is widely considered to be Brazil's most sustainable city, as well as the best Brazilian city to live in. This capital of Parana state has many titles such as "green capital", the "greenest city on Earth," and the "most innovative city." Central to its initiatives are pedestrian-friendly streets and low-cost transportation.

The idea for this starts back in the late 1960s, when architect Jaime Lerner became mayor, then eventually the governor of the state of Parana. Brasilia was built as a symbol of triumph over the urban chaos Brazil had faced. In Curitiba, urban planners tried to replicate the model of Brasilia. In the 1940s, the city experienced plenty of growth through

European immigration, with its population increasing by more than 200,000. With the city growing rapidly, it became a typical Brazilian city with favelas (slums or shantytowns) growing around the periphery. In 1964, the mayor of Curitiba, Ivo Arzua presented an idea that would address the city's problems, guiding its growth and expanding its room for automobiles, yet it wasn't until Lerner became mayor later in the 1960s that these ideas became reality (Adler 2016). Lerner's plans focused on transport systems, green areas, social conditions, and recycling initiatives.

A bus rapid transport system went into place, reaching out to the poor peripheral areas with low-cost fares, protected tubular bus stops, and even mini-libraries (Figure 1). City center streets were pedestrianized to reduce traffic congestion (Figure 2). The first street changed in 1972, with a plan to transform the Rua Quinze de Novembro from an automobile thoroughfare into a pedestrian mall. The project was met with backlash from shopkeepers, claiming it would ruin the downtown atmosphere, and that it would take four months to finish. Lerner and his team would finish the project in 72 hours, working nonstop, encompassing his philosophy of "act now, adjust later" (Rojas 2018).

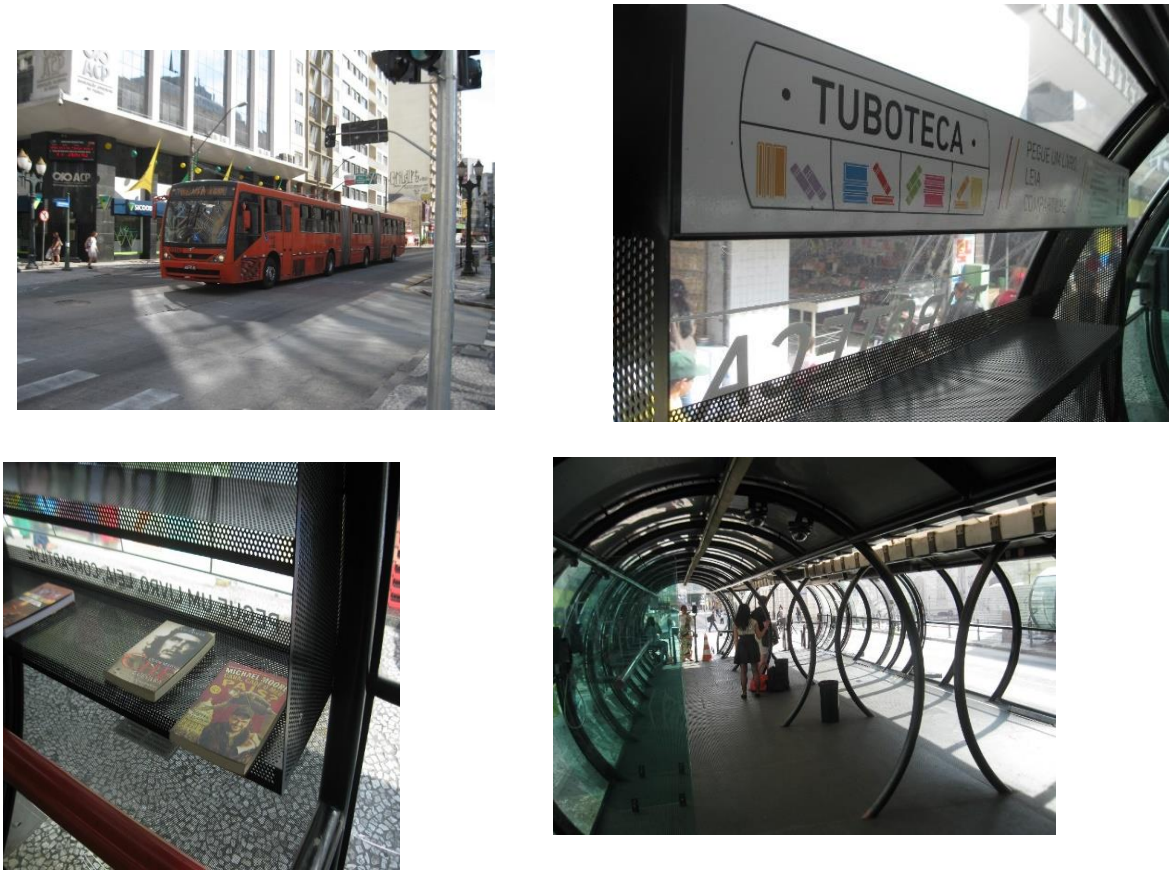

Figure 1. Curitiba tubular bus stop with "tuboteca" free library

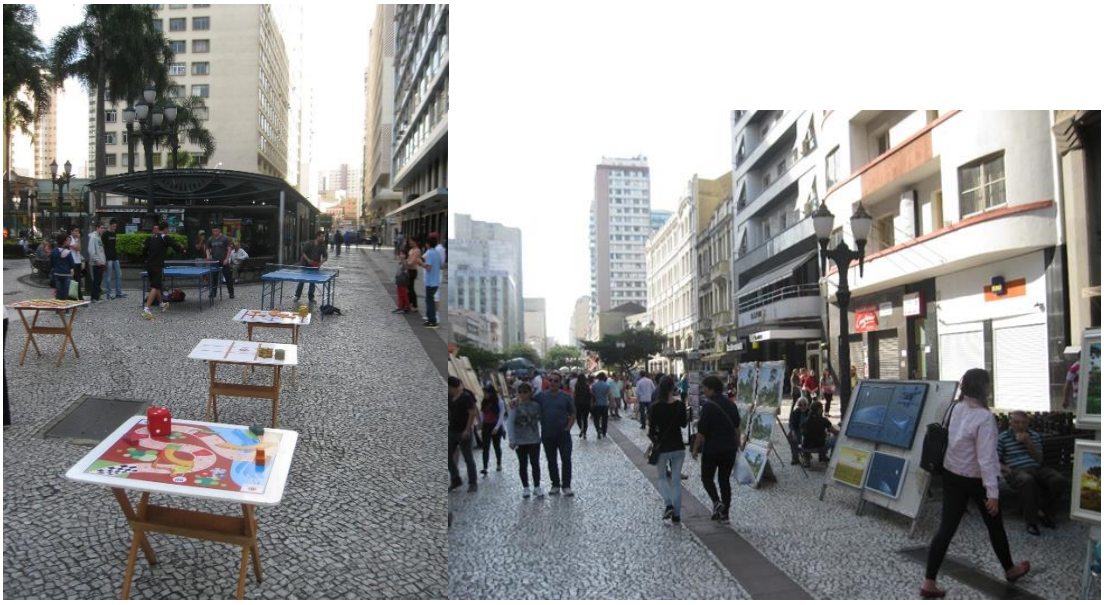

Figure 2. Downtown pedestrian (formerly automobile) streets with art and game boards

Green spaces across Curitiba increased exponentially. New recycling initiatives also were introduced, through which citizens could exchange their trash for bus tokens; today 90% of the city is said to participate in recycling. "Citizenship streets", which offer welfare assistance, processing of employment, housing applications, and cultural activities, were added to the city. Curitiba also experiences the highest literacy rates throughout Brazil, due to its "Lighthouse of Knowledge" in schools, which gives kids access to libraries and public internet use. This has propelled educational programs and job training. These ideas advanced Curitiba and eventually would win the city The Globe Sustainability Award in 2010 (Rojas 2018).

Waste Management Examples

Waste management (recycling, source reduction) offers not only international models of efficiency in Europe but problems with exporting waste to developing nations.

From its 82.5 million people, Germany produces around 50 million tons of waste each year. 87% of the waste is recycled by the separation of household and industrial sources (BMU, 2018). Texas only has a recycling rate of 18.9% (TRDI). Germany's high recycling rates are due to policy passed by the country and proactive initiatives to handle waste management. A one-way deposit scheme for the packaging of refillable drinks was introduced in 2003. All refillable and non-ecologically favorable packaging for mineral water, beer, soft drinks, and alcoholic mixed drinks is subject to a deposit of 25 euro cents. (Oltermann, 2018). According to Zero Waste Europe, this resulted in one of the most successful deposit schemes in the world, with 98.5% of refillable bottles being returned by consumers. Latiff (2019) discusses how other countries neighboring China have started to follow it in how they manage incoming trash:

> Less than two years after China banned most imports of scrap material from abroad, other countries nearby are following the former open borders country in

> terms of waste products. On May 28, 2019, Malaysia's environment minister announced that the country was sending 3,000 metric tons of contaminated plastic wastes back to their countries of origin, including the US, Canada, Australia, and the UK. Along with the Philippines, which is sending 2,400 tons of illegally exported trash back to Canada, Malaysia's stance highlights how controversial the global trade in plastic scrap has become.

Once the recipient of plastic scrap from other countries, China now refuses to import it. Malaysia, Thailand, and Vietnam have followed suit. At a conference in Geneva in May 2019, 186 countries agreed to curb international trade in scrap plastics to prevent dumping of it (O'Neill 2019).

Recycling generates jobs and benefits local US economies by using raw materials produced locally, but this is changing. The Texas Recycling Data Initiative (TRDI) estimates that 12,678 Texas jobs are supported by processing materials recovered from the municipal solid waste (MSW) stream to prepare them for use by recycling manufacturers (Texas Recycling Data Initiative, 2015).

Many Texas cities, including Fort Worth and San Antonio, require apartment buildings to provide people with recycling services. Austin's Universal Recycling Ordinance, which took effect Oct. 1, 2017, requires all commercial properties, including apartments, to offer to recycle (Bunch, 2017). Austin and Dallas both have zero waste initiatives, with plans to divert a certain percentage of a city's landfill waste to recycling. For weekly collection, Dallas' Recycle Now can cost about $5 per unit (Price, 2018). Having on-site bins where residents discard their recyclables is cheaper than valet services. Community waste disposal (CWD), which is a trash pickup company, can service property for as low as $50 for a monthly pickup.

A review of city records by the American-Statesman, written by Asher Price (2018), shows that "Austin lost $1.9 million last fiscal year and a total of $2.7 million in the two previous years as most recyclables have fetched less on the open market than the cost to process them. Still, an Austin Resource Recovery analysis found recycling costs to be $7.35 per customer whereas trash costs $10.70 per customer." That is because the city picks up recyclables less frequently than trash (every other week vs. every week).

However, three recycling centers in Los Angeles County have closed since 2018 as the cost of sending materials overseas rises and profits decline. Many of these recycling centers are operating at a loss as it becomes more expensive to accept materials as the cost to send it overseas continues to increase: "The Burbank Recycle Center was paying almost as much as $40,000 a month to outlets overseas just to get rid of the material" (McDaniel, 2019).

Local initiatives

Global examples can inspire initiatives in the US and Texas, especially when fit to local conditions. Programs described here relate to renewable energy, energy conservation, alternative transportation, and waste management. Student authors have worked on helping local entities implement some of these programs, building skills in community development, policy implementation, grant search, and grant writing.

Renewable Energy and Energy Conservation Initiatives

Stephen F. Austin State University's Sustainable Community Development degree and related outreach program recently switched its focus from broad holistic livability studies to targeted assistance for underserved communities, to help them gain access to financial incentives for renewable energy. Students are learning incentive programs such as 1) Property Assessed Clean Energy (PACE), for commercial, multi-family residential, and non-profit organization buildings; 2) the State Energy Conservation Office (SECO) LoanSTAR program, for public buildings; and 3) Green Mountain Energy's Sun Club, which offers grants to non-profits. Students have worked with a local renewable energy citizens group to help an African-American neighborhood health clinic apply for a Sun Club grant.

The PACE program was first introduced to Texas in 2013 as financial support program that incentivizes property owners to improve their facility's infrastructure in an attempt to reduce environmental impacts and introduce green-friendly appliances. The PACE program enhances these facilities while also supporting local businesses by preserving their capital and credit lines, so these businesses can retain their available capital for revenue-generating components. The PACE program also enables small business owners to lower their operating costs to incentivize using their savings for eligible water conservation, energy efficiency, and distributed generation projects. There are now over fifty cities or counties that have adopted the PACE program in Texas.

The PACE program is not a personal or business loan, PACE is a voluntary land-secured assessment paid off over time. Business owners eligible to apply for the PACE program have commercial, industrial, agricultural, non-profit, or multi-family facilities. Some of the available facility upgrades include and are not limited to heating/cooling systems, lighting, solar panels, water pumps, insulation, roofs, and windows. This program is cash flow positive and structured so that in the end a business owners' energy and water savings exceed the cost of the initial assessment. The assessment connects to the property, not the owner, so if the property sells to a new owner then the next owner is obliged to pay off the remainder of the payment on the upgrades, but still follows the same stipulations.

The city of Corsicana, TX in Navarro became the 14th PACE program to be utilized in Texas when the R.J. Liebe Athletic Lettering Company, also the first manufacturing plant in Texas, completed their PACE program assessment. This company moved from Ohio to Texas because of cheaper real estate, as well as the environmentally friendly programs such as PACE. By using the PACE program, the lettering company was able to reopen a manufacturing facility that had no AC unit after 10-years of being a vacant property. With the help and funding provided by the PACE program, they were able to install a high-efficiency HVAC unit and LED lighting. By installing these upgrades to their manufacturing facility with $324,500 invested, they were able to create 60-80 new manufacturing jobs, save 187,177 kWh in annual electricity savings and reduce 97 tons/year in CO2 emissions.

SFA sustainability students recently presented the PACE program to local officials,

who are now looking at adopting it at the county level. Students are also planning to help rural Palestine, Texas combine the PACE program with other financial incentives for downtown renewal. One student in the degree program completed an internship with PACE in summer 2020, helping numerous Texas cities update their websites with the most recent information.

Other students are planning to link with the East Harris County Empowerment Council to help unincorporated, low-income communities there with cost-saving renewable energy incentives. A new East Houston solar initiative is emerging.

Another program, the State Energy Conservation Office (SECO) LoanSTAR program for public buildings, may be applicable to the local recreation center/public library. A combination of solar panels and green roof materials may be an appropriate fit here (Figure 3).

Figure 3. Students Natasha Johnson, Taryn Lenert, a local solar panel installer, and city staff examining the potential for the roof of the local city library/rec center.

Green roofs involve the installation of vegetation on the top of flat-roofed buildings. They can be utilized in many ways, including for aesthetic purposes, communal farms, leisure areas, and environmental/energy benefits. It is possible to put solar panels in the same area as green roof materials. However, there are certain parameters to meet (Green Roof Technology 2019; Vegetal I.D., Inc. 2019).

One of the most important factors when considering the installation of a green roof is the structural stability of the building. Secondly, green roofs are micro-ecosystems on top of buildings therefore, one will need to ensure that proper levels of subsoil are used. As well as layers of soil, a drainage level is necessary.

The University of Illinois (2015) conducted an experiment on their campus recreation center that showed the two used in conjunction were more beneficial to the

environment. There are numerous positive outcomes when installing a green roof in conjunction with solar panels. For instance: when solar panels are used with green roofs it reduces the maintenance required for solar panels as the vegetation keeps the air around the solar panels clean and free of pollutants and dust. Furthermore, the EPA found that water drainage reduced by 50% when using a green roof, which fits the average fifty inches of annual rainfall in Nacogdoches.

Green roofs also reduce the number of nitrogen oxides in the air and the ecological footprint of the building. Lastly, in summer roofs are known to heat up to 158 degrees Fahrenheit; however, with that useful layer of vegetation on top, the amount of heat caused by the albedo is reduced to just 77 degrees Fahrenheit, reducing the need for air conditioning up to 75%.

Taylor (2015) quotes the EPA in stating that the start-up cost for a green roof ranges anywhere from 10 dollars a square foot to 25 dollars a square foot. Meanwhile, solar panels range widely, depending on the brand and company. The time required for payback on the solar panels alone was 13 years, while the green roof required 73 years. Combining them can significantly reduce the time for recouping the lower green roof installation costs.

While there are many positive results from using green roofs, there are a few downsides. Increased maintenance, heavier load on the ceiling, and start-up cost are the main concerns voiced. Several programs can assist in installing a green roof in conjunction with solar panels in Texas: PACE, Sun Club, LoanSTAR, and more. According to Power House Growers (2017), there are over 90 incentive programs throughout the United States and Canada.

Alternative Transport Initiatives

Bike-sharing systems are being implemented in cities all around the world as an initiative to reduce air pollution and limit the number of cars on the road. The bikes are kept at a "dock" in major cities and unlocked through an app and credit card. People can rent a bike, ride it for thirty minutes, and then return it to any one of these docks. Such programs can connect communities with universities and other important sites in town, such as entertainment, health services, schools, and shopping.

One study in Milwaukee and Madison, Wisconsin found that if 20% of people used bikes instead of cars for short trips, 57,405 fewer tons of carbon dioxide would be emitted (Zickle 2008). Bike share programs are just one way to make a change.

A few small cities in Texas, such as Seguin, have had success at creating bicycle route infrastructure. A professionally prepared bicycle route plan is often the first step. The large border city of Brownsville financed a professional bike plan using fees collected for supplying plastic bags to grocery store customers. Students can help promote such a plan to the city. They also plan to highlight League of American Bicyclist standards required to qualify as a "bicycle-friendly" city or community.

Waste Reduction Initiatives

Recycling challenges for larger US cities, related to the shrinking global market for

materials, are covered at the end of the first section on international examples. Financing large-scale recycling is an even bigger challenge for small cities. Long-distance transport costs for large loads of material other than cardboard can be prohibitive. Palestine has canceled their recycling program. One business in Nacogdoches now offers transport of individual household materials to a recycling facility an hour north in Kilgore, at minimal cost (~$25 per month).

Other solutions, such as source reduction, can be controversial. The state has banned citizen environmental referendums after oil and gas drilling was prohibited by some cities. Thus, banning single-use plastic containers may be a challenge at the city level, but the topic should be discussed.

Campus initiatives

Various sustainability initiatives can occur on university campuses, ranging from creating a student fee-based green fund to improvements in dining, recycling, and energy conservation. Stephen F. Austin State University (SFA) offers examples. The largest energy conservation initiative also saved the university millions of dollars. The Siemens Corporation, which guaranteed overall long-term savings up-front in their contract, helped retrofit campus buildings in stages, installing more efficient heating, cooling, and lighting. After an initial outlay, energy bills have gone from approximately $11 million to $7 million per year. Interestingly, similar savings occurred by retrofitting the famous Empire State Building in New York City!

Renewable Energy and Energy Conservation Initiatives

Potential for more energy conservation initiatives exists. There are many benefits to installing solar panels in parking garages. Despite its predominant tree cover, solar panels are a viable option for obtaining a constant and reliable source of renewable solar energy in sunny East Texas. Solar panels produce less pollution than fossil fuel-sourced electricity. The panels would also provide cars shade and protection from the sun in summer, which is a major "perk" considering summer temperatures within cars have been hot enough to bake food!

Stephen F. Austin State University has four parking garages on campus and a commuter parking lot that are all possible electricity-producing spaces. The upper floors of the four parking garages have a total area of 93,234 square feet and the commuter parking lot has a total area of 433,800 square feet. A larger solar panel system takes up about 1000 square feet; thus, SFA has room to add 527 solar panel arrays.

With a population of 13,000 students, SFA consumes a lot of electricity in the everyday running of the school. Being located in East Texas, local electrical lines run off the energy produced by burning coal. Coal is infamous for being one of the dirtiest burning fossil fuels and is a major contributor to air pollution and the buildup of greenhouse gases. Coal is also nonrenewable, meaning once it has all been used and burned, we will never be able to use it again. By switching some of our universities power usages to a more sustainable source, such as solar power, the effects created by the demand for coal-based power will lessen and SFA will be better off financially

Michigan State University has installed solar carports on its campus to help meet sustainability goals. They determined that "based on projected electricity costs, this 25-year (project) will save money for the university, and therefore the state, throughout the contract" (Rackstraw 2017). The average solar panel pays for itself in eight years; some take more or less time depending on the location. Another benefit not as obvious is that solar panels on the top of parking garages would make parking there more appealing, reducing competition for spaces on lower levels. Rackstraw (2017) states: "We ensured the space would continue to be functional – no parking spaces will be eliminated as a result of the solar installation."

However, Chris O'Brien of Customer First Renewables indicates that many campuses enter into contracts with private energy providers, who own the solar arrays and sell the energy to the university on twenty-year agreements. Universities can also contract with power companies that source from other solar and wind sources to get 100% renewable energy, sometimes at less cost than traditional energy providers. His firm does an office analysis first using remote sensing of the campus, then does a site visit and is compensated by the energy provider if the university enters into a long-term contract.

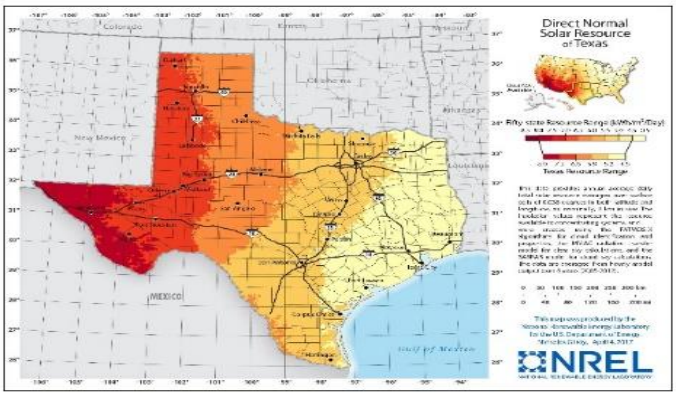

Figure 4. Solar resource yield in Texas; Source: National

Among the three main types of renewable energy (solar, hydroelectric, and wind) Nacogdoches and the University campus are most suited for solar (Figure 4) and hydroelectric power. Hydroelectric power could be generated from Lanana Creek on the eastern side of campus. The creek could serve as a perfect testing ground for engineering majors and provide sufficient energy to the campus itself. Due to the slow movement of Lanana creek, hydroelectric power could only be viable if using impulse turbines such as Peltons or Cross-Flows. Certain reaction turbines could work as well as whirlpool-assisted propeller turbines. According to SFA's *Energy and Water Management Plan,* the campus used 63.1 MWh of energy in FY2017, accounting for a cost of $3.3 M. Long term this cost could be lowered by systems such as hydroelectric turbines and solar arrays.

The benefit of having a running creek on campus is significant. The easiest and most cost-effective use of hydroelectric would come from impulse turbines. The University could either pursue quotes from companies such as Waterotor, likely around

ten to twenty thousand dollars or offer experience and learning opportunities to engineering students. Electrical yields with this method would be low but would be creatively beneficial to students and extremely low cost if classroom oriented.

The higher-yielding method would be to create whirlpool turbines (Figure 5) by building a series of drops in the creek (Figure 6). The drops would be necessary for Lanana Creek to assist in the flow rates of the creek. During wet periods, these drops would not obstruct wildlife in the creek. According to companies such as Turbulent Hydro, when done correctly these turbines are not hazardous to fish as they can safely pass through the turbine itself. A highly efficient one of these whirlpool turbines has the potential to produce 87.6 MWh of energy in a year. For reference, the University again used 63.1 MWh in FY2017.

Given the low energy summer season and inefficiencies of drier seasons, it is feasible that at least 50% of the University's yearly usage could be managed by a series of these turbines. Costs for turbines like this from reputable companies like Turbulent Hydro reach prices upwards of $90,000. A return on investment for a system from them in optimal conditions is around five years. The STEM program on campus could attempt their designs and diminish that cost down to the cost of labor and materials. The design and implementation process from a student-led program like this could also serve as a priceless experience for the disciplines involved. A return on monetary investment could be much quicker in a method like this, and an educational return could be realized immediately.

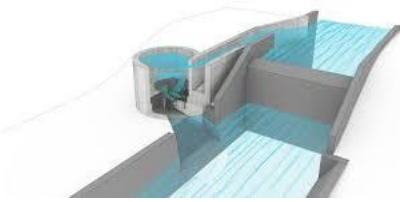

Figure 5

Turbulent Hydro design example for the whirlpool assisted turbine method of hydroelectric power

Figure 6

Turbulent Hydro's example of a multistage turbine system. This figure gives a visualization of the dropping method used to increase flow rates while not

Campus Green Fund Initiatives

Stephen F. Austin State University passed their first-ever Green Fund initiative. This was accomplished by the university's Student Government Association voting unanimously to call for a referendum. This vote let students decide whether they want to introduce a $5 per semester Green Fund, to bring environmentally friendly projects to campus. The online ballot passed with 77.2% approval. These green fund referendums have been passed by five other Texas universities, as well as by other universities around the United States. This initiative expands public knowledge of sustainability by providing various educational and research opportunities to not only students, but the university's faculty, staff, and administrators. This fee will finance student-led propositions to

stimulate renewable energy sources, overall efficiency, waste reduction, and educational experiences. These experiences gained will be able to teach important life skills through understanding and leading meetings, training, and internships.

The University of Texas at Austin, The University of Texas at El Paso, the University of North Texas, and Texas A&M University have implemented their versions of the Green Fund. Students voted to pay anywhere from $3-$5 per semester. Some of the more popular expenditures have been water bottle filling stations, solar power, transportation, agriculture, recycling, and student employment. The counters on water bottle filling stations at Texas A&M indicate that, since 2011, they have diverted over *two million* plastic water bottles from the landfill.

Colorado State University (CSU) is located in Fort Collins, Colorado, at the base of the Rocky Mountains. CSU was recently recognized as the greenest higher learning institution in the nation by the Association for the Advancement of Sustainability in Higher Education (AASHE). CSU is home to the first solar heating and cooling air-conditioners for campus buildings. They have also worked with NASA to develop a cloud profiling radar system, CloudStat, to monitor climate change and allow CSU students to research their energy usage.

SFA's own Green Fund can be accredited to a newly formed "Jacks Go Green" organization that tabled at the Student Center Plaza four days a week during the vote. Nature has painted the best setting for the university, the "Pineywoods." Now it is up to the students to give back to the environment they call home.

Alternative Transportation

The process to start a bike-share program on a university campus is relatively simple but requires permission from the university and the community. SFA could bring in a third-party company like VeoRide and they would handle the rest with no cost to the community. The company makes money through bike rentals, membership fees, and selling customer data. Referring to the SFA Master Plan, new crosswalks, bike lanes, and city routes could emerge. Campus initiatives often lead to city-wide changes as well.

VeoRide also offers stations with less bike share, which is less expensive and easier to implement. Logical cluster sites for bikes could be located in different locations on campus, including the Village residence hall, the commuter lot, campus Recreation Center, Steen Library, and Baker Pattillo Student Center. Low-traffic streets such as Raguet could serve as a north-south artery for bike lane traffic.

Not only would a bike share system provide transportation for students at a low cost, but it might also reduce car traffic on campus, reduce the emissions of cars to the environment, and reduce SFA and Nacogdoches' carbon footprint. Some drawbacks of the dockless bike systems are the tendency for disorderly clustering of bikes while not in use. Companies will suggest large numbers of bikes, which have caused excessive concentrations of bicycles in higher use areas such as scenic parks.

Another critical partnership could be using green funds to help the city finance a master plan for bicycles and pedestrians, such as done in Brownsville, Texas in 2013. Halff Associates and City of Brownsville Planning created a network not only mapping out

potential bike lanes and separate bike pathways but also providing specific recommendations for each street and district based on safety needs, road width, etc. This specific expertise is rare and provides support to ask for later infrastructure funds.

The model campus for bicycles in the US is the University of California at Davis. BestColleges.com (2019) states, "In the 1960s and 1970s, when the rest of America was building only for cars, Davis built for bicycles." The university even restricted the use of cars on campus, with 98% of its roads having some sort of bicycle provision. Approximately 20% of the city population cycles every day, thanks to the infrastructure.

Campus Food Service Waste Reduction Initiatives

Aramark offers another example. The company provides industrial levels of food and dining services to institutions around the nation, such as universities and correctional facilities. One such institution is Stephen F. Austin State University (SFA Dining), where one can see the company's efforts towards sustainability.

College students are often very busy, on the go between classes, work, and extra-curricular activities. Aramark recognizes this and offers students at SFA the ability to get their food to go. However, this can produce a lot of waste, ranging from styrofoam take-out containers to plastic forks, spoons, and knives. In recent years, Aramark has taken steps to minimize this waste. The company has promised to reduce single-use plastics and instead focus on reusable systems, better-designed materials, and public education on related environmental issues.

Perhaps the best example of this is the Eco To-Go container, which allows patrons to check out reusable, dishwasher-safe plastic boxes to take their food with them. The system is well managed, as students who check one out are required to return it before they can take another. Rather than constantly receiving shipments of styrofoam that fill university dumpsters with the trash that does not biodegrade, they can reuse containers for a long period without sacrificing any conveniences.

They have also recently transitioned to paper cups, which are much more sustainable than the plastic-coated cups they replaced. They have also eliminated straws (except for special cases) by introducing lids that do not require them and replacing plastic stirrers with wooden ones. There are only a few remaining single-use plastics in SFA's cafeterias, such as cutlery and cup lids.

To help generate new ideas on how to improve their sustainability efforts, as well as their service overall, Aramark hosts biweekly food service meetings at the university. This forum allows the company's regular patrons, most of whom are college students and professors, to propose new ideas. The paper cups were put into use after a suggestion from one of these meetings. Aramark continues to host them and is always open to new suggestions for future improvements.

Despite a recent petition to get Aramark to offer more climate-friendly dietary options (less meat, etc.) nationwide, they (SFA Dining) won second place recently in a national competition for healthy food options. They also host a sustainability intern, who has contributed to another article for this journal.

Conclusion

Campuses and cities in Texas can adopt some of these programs to move towards international leadership illustrated in the article's first section. Artistic "place-making" can enter into the equation to create more user-friendly downtowns, even in smaller East Texas cities such as Palestine, where locals are cleaning up alleyways and older walls with murals and other artistic pieces. "Pop-up" events can bring residents together with temporary street closures and food vendors, before (and hopefully after) the 2020 pandemic. These sometimes lead to longer-term pedestrian walkways and more business activity downtown. This can combine with renewable energy initiatives to help both the environment, economics, and livability of Texas cities small and large. The overlap of creativity with different disciplines gives hope for innovation by Texas students and community leaders, into the rest of this decade and beyond.

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