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Editor
Allan E. Dittmer

Cover Design
Tim Dittmer
Design/Layout
Nick Dawson
University of Louisville
Design & Printing Services

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The Institute provides a forum to conduct interdisciplinary research, applied scholarly analysis, public service and educational outreach on environmental and sustainable development issues at the local, state, national and international levels.

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Send electronic correspondence to r.barnett@louisville.edu

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Cover: 50 killowatt solar photovoltaic array.
More info on page 43.

Energy Efficiency: Achieving the Potential

By Steven Chu
U.S. Secretary of Energy

For the next few decades, energy efficiency is one of the lowest cost options for reducing US carbon emissions.

Many studies have concluded that energy efficiency can save both energy and money. For example, a McKinsey report earlier this year calculated the potential savings assuming a 7% discount rate, no price on carbon and using only "net present value positive" investments. It found the potential to reduce consumer demand by about 23% by 2020 and reduce GHG emissions by 1.1 gigatons each year – at a net savings of $ 680 billion.

Likewise, the National Academies found in 2009 that accelerated deployment of cost-effective technologies in buildings could reduce energy use by 25-30% in 2030. The report stated: "Many building efficiency technologies represent attractive investment opportunities with a payback period of two to three years."

Some economists, however, don't believe these analyses; they say there aren't 20-dollar bills lying around waiting to be picked up. If the savings were real, they argue, why didn't the free market vacuum them up? The skeptics are asking a fair question: why do potential energy efficiency savings often go unrealized?

I asked our team at the Department of Energy to review the literature on savings from home energy retrofits. We are pursuing energy efficiency in many areas – from toughening and expanding appliance standards to investing in smart grid – but improving the efficiency of buildings, which account for 40% of US energy use, is truly low hanging fruit.

In this review, we looked only at studies that compared energy bills before and after improvements and excluded studies that relied on estimates of future savings. We found that retrofit programs that were the most successful in achieving savings targeted the least efficient houses and concentrated on the most fundamental work: air-tight ducts, windows and doors, insulation and caulking. When efficiency improvements were both properly chosen and properly executed, the projected savings of energy and money were indeed achieved. In science, we would call the successful programs an "existence proof" that efficiency investments save money. Too often, however, the savings went unrealized, due to a number of reasons, including poor efficiency investment decisions and shoddy workmanship.

There are other reasons why energy savings aren't fully captured. Market failures include inertia, inconvenience, ignorance, lack of financing and "principal agent" problems (e.g., landlords don't install energy efficient refrigerators because tenants pay the energy bills). To persuade the skeptics and spark the investments in efficiency we need, the

Department of Energy is now focused on overcoming these market failures.

First, the Department is working to develop a strong home retrofit industry. We are creating a state-of-the-art tool that home inspectors can use on a handheld device to assess energy savings potential and identify the most effective investments to drive down energy costs. We're also investing in training programs to upgrade the skills of the current workforce and attract the next generation. The Department is also focused on measuring results – to both provide quality assurance to homeowners and promote improvement. For example, we're pursuing new technologies such as infrared viewers that will show if insulation and caulking were done properly. Post-work inspections are a necessary antidote and deterrent to poor workmanship.

To address inconvenience and to reduce costs, we're launching an innovative effort called "Retrofit Ramp-Up" that will streamline home retrofits by reaching whole neighborhoods at a time. If we can audit and retrofit a significant fraction of the homes on any given residential block, the cost, convenience and confidence of retrofit work will be vastly improved. Another goal of this program is to make energy efficiency a social norm.

The greatest gains can be realized in new construction. By developing building design software with embedded energy analysis and building operating systems that constantly tune up a building for optimal efficiency while maintaining comfort, extremely cost-effective buildings with energy savings of 60-80% are possible.

Regardless of what the skeptics may think, there are indeed 20-dollar bills lying on the ground all around us. We only need the will – and the ways – to pick them up.

-DOE-

Dr. Steven Chu, Secretary of Energy

Dr. Steven Chu, distinguished scientist and co-winner of the Nobel Prize for Physics (1997), was appointed by President Obama as the 12th Secretary of Energy and sworn into office on January 21, 2009.

Dr. Chu has devoted his recent scientific career to the search for new solutions to our energy challenges and stopping global climate change – a mission he continues with even greater urgency as Secretary of Energy. He is charged with helping implement President Obama's ambitious agenda to invest in alternative and renewable energy, end our addiction to foreign oil, address the global climate crisis and create millions of new jobs.

Prior to his appointment, Dr. Chu was director of DOE's Lawrence Berkeley National Lab, and professor of Physics and Molecular and Cell Biology at the University of California. He successfully applied the techniques he developed in atomic physics to molecular biology, and since 2004, motivated by his deep interest in climate change, he has recently led the Lawrence Berkeley National Lab in pursuit of new alternative and renewable energies. Previously, he held positions at Stanford University and AT&T Bell Laboratories.

Professor Chu's research in atomic physics, quantum electronics, polymer and biophysics includes tests of fundamental theories in physics, the development of methods to laser cool and trap atoms, atom interferometry, and the manipulation and study of polymers and biological systems at the single molecule level. While at Stanford, he helped start Bio-X, a multi-disciplinary initiative that brings together the physical and biological sciences with engineering and medicine.

Secretary Chu is a member of the National Academy of Sciences, the American Philosophical Society, the Chinese Academy of Sciences, Academica Sinica, the Korean Academy of Sciences and Technology and numerous other civic and professional organizations. He received an A.B. degree in mathematics, a B.S. degree in physics from the University of Rochester, a Ph.D. in physics from the University of California, Berkeley as well as honorary degrees from 10 universities. Chu was born in Saint Louis, Missouri on February 28, 1948. He is married to Dr. Jean Chu, who holds a D.Phil. in Physics from Oxford and has served as chief of staff to two Stanford University presidents as well as Dean of Admissions. Secretary Chu has two grown sons, Geoffrey and Michael, by a previous marriage.

In announcing Dr. Chu's selection on December 15, 2008, President Obama said, "the future of our economy and national security is inextricably linked to one challenge: energy… Steven has blazed new trails as a scientist, teacher, and administrator, and has recently led the Berkeley National Laboratory in pursuit of new alternative and renewable energies. He is uniquely suited to be our next Secretary of Energy as we make this pursuit a guiding purpose of the Department of Energy, as well as a national mission."

Accelerating Renewable Energy Deployment: Opportunities and Obstacles

Doug Myers
Senior Energy and Environment Policy Analyst
The Council of State Governments

Introduction

Renewable energy—wind, solar, biomass, geothermal, and hydroelectric—has the potential to reduce greenhouse gases that contribute to climate change and balance out our electricity generation portfolio, thereby mitigating price spikes due to the supply constraints of one resource or another, as well as smoothing out generation and positively impacting shortages. States have long recognized the value of renewable energy for these purposes, as well as for others, such as job creation, and have instituted a variety of policy measures to encourage the adoption of renewable energy generation, from the utility scale down to distributed generation at the consumer level. This article provides a brief illustration of four prominent measures available to state policymakers, as well as the four primary challenges needed to be overcome, in further advancing renewable energy, beginning with the renewable portfolio standard.

RPS

The most prevalent of these policies, and the most successful to date, is the adoption of the renewable portfolio standard (RPS). The RPS requires that a portion of the total electricity generated or sold come from renewable energy. To date, 29 states and Washington, DC, have renewable portfolio standards. Seven states have non-mandatory renewable energy goals.[1] Most states typically start out with minimal requirements, on the order of two- three percent RPS, and then gradually ramp up over a period of years to allow utilities time to comply. Hawaii currently has the most aggressive standard at 40 percent, however by 2030 most states typically mandate an end requirement of around 20 percent.[2]

It is important to note that RPSs come in many different colors. Some stipulate that renewable energy be generated in state in order to achieve job creation. Others specify a particular resource mix or count only certain renewables towards qualification. For example, Colorado requires that three percent of retail sales must come from distributed generation, while West Virginia has an alternative energy standard that qualifies certain coal resources not authorized by other states.[3]

One of the challenges RPSs face is that it is often easiest for utilities to comply by using the cheapest resource available (that generally being wind). While this makes economic sense from a compliance standpoint, it doesn't help all technologies equally. Many resources, such as solar, need greater subsidies to help them become cost competitive. Solar is currently estimated to be two to five times too high for large-scale deployment.[4] It is also in our national interest to have as broad a portfolio as possible. Thus some states have devised policies such as carve-outs (or set-asides) that require that a portion of the renewable electricity generated come from a particular source. In Pennsylvania, for example, the solar set-aside is .5 percent photovoltaic (PV) by 2021.[5] Set-asides are expected to play an important role in advancing more technically difficult and costlier renewables.[6]

And while RPSs are relatively new and don't yet have substantial, long-term results to show, they seem to be generating renewable energy at accelerated rates and without increasing the cost of electricity to any significant degree. In fact, 30 percent of the load growth between 2000 and 2025 is expected to come from state RPSs.[7] Expect this trend to continue as more states look to advance renewable energy. Indeed, after seeing years of positive results, several states have already further expanded their renewable portfolio standards. For example, California's original standard was 20 percent by 2010. In December of 2009, the Governor signed an executive order increasing the RPS to 33 percent by 2030.[8]

RPS have also helped spur job growth. The American Wind Energy Association, for example, estimates that 85,000 people worked in the industry in 2008, up from 50,000 a year earlier.[9] These jobs come in the form of manufacturing, engineering, sales, management, and maintenance. And though much of the manufacturing for renewable energy components still takes place offshore, several states have placed an emphasis on in-state manufacturing. In New York, for example, the state crafted a set of incentives to bring a solar manufacturer into the state, which is expected to create several hundred jobs.

FIT

Feed-in tariffs (FIT) are another relatively new means, in the United States, of achieving higher renewable energy penetration. A feed-in tariff works where utilities purchase electricity from renewable energy generators over a fixed period of time, typically 20 years, at a determined price. Though there are a few different payment structures, the FIT essentially creates incentives for potential producers by guaranteeing them a reasonable rate of return. In February 2009, the city of Gainesville, Florida adopted the first feed-in tariff in the United States for solar PV. The FIT pays 32 cents per kilowatt-hour for 20 years.[10]

However, the primary challenge with FIT is that the price has to be set at the right level. If rates are too high, state funds are wasted (and windfall profits potentially created), too low and not enough interest will be generated on the part of potential generators.[11] Another challenge with FIT is that it does not provide the upfront capital costs of building and installing renewable energy generators, though the cost is included in the rate (For most forms of renewable energy, the majority of capital needed is for upfront costs, with only maintenance requirements needed later as the resource is "free"). However, once a payment structure is agreed upon, that will likely ease the burden of securing loans.

FIT can also be designed to focus on technology type, similar to the set-asides or carve-outs of an RPS, by specifically offering higher prices for certain technologies. Research has suggested that feed-in tariffs can accomplish the same goal as an RPS in a quicker (and perhaps less costly) fashion, though they can also be designed to complement the RPS.[12] Generally, as long as money is available for the program and the incentive is appropriate, renewable energy will be produced. Given its success in Europe, where FIT has been the policy mechanism of choice, and its potential to spur renewable energy generation in a relatively low cost method, FIT is likely to continue to grow in the United States.

Net Metering and Interconnection

Net metering is a policy that permits customers to connect small, onsite (also referred to as distributed generation or DG) resources to the grid (such as mini-windmills or solar PV units) and receive favorable rates of return for excess electricity generated. The process works whereby the customer's meter rolls 'backwards' and then goes into the negative. Credits are then transferred to the following month or rolled over indefinitely. In some cases, at the end of the year, the customer is then paid by the utility for the excess electricity generated, often at the retail rate.

Net metering rules vary state-by-state, with some states having exceptional programs, including a majority of the lower western states. IREC, the Interstate Renewable Energy Council, has established a report card that ranks states on the quality of their net metering policies, and includes factors such as the size limit (the larger the acceptable limit of the generating unit the better) on a facility and application fees to determine how well states are doing. IREC has also established model net-metering rules. So although 43 states have net metering rules on the books, the majority of them have room for improvement.[13]

Interconnection rules, on the other hand, govern the actual connection between the unit and the grid. Best practices ensure that the process is equitable, fast, simple, and made aware to consumers (perhaps the most important element in stimulating DG). By simplifying the process, states can ensure projects go forward without delay. In fact, IREC says in its Connecting to the Grid report that poor interconnection procedures have led to many projects being abandoned, thus stymieing state policy goals of advancing renewable energy.[14]

Net metering and interconnection policies serve to encourage the adoption of distributed generation on a commercial and residential scale and help to create a more balanced grid; one that is less susceptible to blackouts and that, if scaled up, could eventually mitigate the need for costly backup generation (which are typically older, less efficient plants that idle until needed or that rely on expensive natural gas). By streamlining the process and making it easier to comprehend and connect, states can further the development of distributed generation.

PACE

Property-assessed clean energy is an innovative way to negate the need for upfront capital to finance distributed generation (PV in particular). Currently, 23 states permit PACE.[15]

Under PACE, the local municipality issues a loan to a property owner (i.e. the home-owner) to purchase a renewable energy system, such as a rooftop PV system. The loan is then repaid through an increase or lien on property taxes. In addition, when the homeowner sells the house, the lien is transferred to the new owner. Loans are typically repaid over a period of twenty years.

The primary advantage of PACE, as mentioned above, is that it resolves perhaps the biggest disincentive to purchasing a renewable energy system: that of securing upfront capital to purchase the system. Another key advantage is that a PACE program is structured so that utility bill savings should outweigh property tax increases, thus creating an additional financial incentive to purchase a system. And when the homeowner goes to sell the house, he or she will be able to show the benefits of the system. The expansion of PACE will allow homeowners to purchase DG systems, and thus expand the spread of distributed generation systems, further driving down the costs associated with those renewable energy systems.

Challenges to Increased Renewable Energy Generation

While states are adopting a myriad of policy measures to accelerate the growth of renewable energy, ranging from mandates to financial incentives, and from utility scale down to residential scale, they continue to face several challenges that impede renewable energy deployment. These challenges—transmission, cost, intermittency and storage, and the current state of the electric grid—will need to be significantly improved upon if renewable energy is to continue its rapid expansion and serve a major role in our nation's electricity profile.

Transmission

Perhaps the most prominent challenge states face has to do with transmission. Siting the transmission lines that connect the generation to the grid (which in the case of renewables such as wind typically run from rural areas to high population centers) has proved quite a challenge for states. Oftentimes, NIMBYism (not in my back yard) gets in the way and prevents added transmission capacity from going forward. For example, the Cape Wind project off the coast of Cape Cod, Massachusetts has faced long delays from groups opposed to siting offshore wind turbines that may impact both property values and the environment. Delays can take years and exponentially increase costs. In order to meet renewable energy mandates and bring this energy to market, states are in need of finding a better way to facilitate, where appropriate, the siting of transmission lines.

One potential solution is an interstate compact. Interstate compacts— in this case, agreements between three of more contiguous states— have the potential to greatly facilitate the siting of transmission lines and forestall intervention from the Federal Energy Regulatory Commission (FERC), which has backstop authority in certain National Interest Electric Transmission Corridors as designated by the Department of Energy (DOE). In addition, Congress granted states consent to form compacts under the Energy Policy Act of 2005, thereby streamlining the process.

Under a compact, states would form regional transmission siting agencies (RTSA) that would have the authority to site lines across state boundaries. The benefit of an RTSA is that states will have the opportunity to explore all options in siting, including whether a line is indeed necessary, and where to most appropriately site that line, taking environmental as well as resource considerations into account. A cooperative approach that includes all stakeholders will help address NIMBYism. In addition to improving interstate relations, a compact has the potential to increase federal-state cooperation, something that has often been lacking on the energy front and that is sorely needed.

Cost

In addition to transmission deadlock, cost is still an issue. Renewable energy as a whole continues to remain expensive, though the cost of generation is coming down. For example, according to the American Wind Energy Association, the cost of utility-scale wind has come down 80 percent in the last 20 years, from 30 cents per kilowatt-hour to 5 cents per kilowatt-hour, making it cost competitive with traditional fossil-fired generation in some areas.[16] As mentioned above, however, solar is still too costly, which is why it requires government subsidies.

As cost becomes more competitive (e.g. solar), it becomes more widely deployed, further lowering its costs. Policies such as renewable portfolio standards and feed-in tariffs, as well as other financial incentives such as PACE, will continue to have a dampening impact on prices by increasing deployment, and renewables will eventually reach parity with traditional fossil-fired generation. And if a carbon cap and trade scheme comes into effect (likely to initially come in the form of caps that limit, and then reduce over time, power plant greenhouse gas emissions), thereby raising the cost of generating electricity from the likes of coal, this will further accelerate the narrowing of the cost gap.

Variability and Storage

Because renewable generation is variable and hard to time (i.e. the sun doesn't always shine and the wind doesn't always blow), there is a need to develop storage capacity so that energy generated when demand is low can be stored until demand rises. Also, storage can serve as backup if a renewable resource (such as wind) suddenly drops. Storage is also essential to ensuring the reliability of supply, a key concern of utilities when it comes to integrating renewable energy. In order to deliver energy consistently, and on demand, utilities need to know that the supply of energy is stable.

Storage currently exists, though not on a scale or quality necessary to support the amount of renewable energy anticipated to be coming online. Future storage is likely to take place in lithium batteries or in deep underground vaults of compressed air, known as compressed air energy storage, which are difficult to find appropriate sites for given geographical constraints. However, computer modeling is improving and utilities are now able to make better forecasts concerning sunshine and wind, which will help minimize the uncertainty of integration. If storage can be adequately addressed, that will considerably ease the worry about ramping up renewable energy generation.

Smart Grid

In order to effectively manage renewable energy, we will need an electric grid in place that can handle the excess, variable generation. That's where the smart grid comes in. A smart grid, which will enable two-way communication between utilities and devices connected to the grid (such as your air conditioning and dishwasher), will allow for such polices as distributed generation and time-of-use pricing, and will more easily handle the fluctuating power of renewable energy (electricity is generally billed at a flat rate, although rates are, in actuality, fluctuating from hour-to-hour, with late afternoon/early evening being the times of peak demand, and thus highest prices, and the late evening being times of least demand and lowest prices). A smart grid will know when the power lines are near capacity and will shut down or idle devices that are less important, such as your dishwasher, in order to curb demand. And though some fear letting utilities control their power, it is important to note that consumers must first grant permission to control these devices.

For instance, in order to prevent brownouts, a smart grid will allow utilities to control AC units during the hottest time of day, when demand rises sharply, by slightly raising temperatures and thereby reducing power output. Such policies will not affect the elderly and poor, and, in fact, will help them by keeping the AC running when it is most needed.

For the smart grid to reach operation though, states and utilities will need to partner together to test such devices and grant utilities permission to recoup costs associated with developing and installing such equipment as smart meters.

Conclusion

Whether the federal government ever devises a national renewable portfolio standard (as it is attempting in current legislation before the Senate and as it has attempted several times in the past) is almost moot at this point; the states are blazing the path forward, and as more reluctant states see that it can be done without pain, and indeed produces some significant benefits as well, the more likely they are going to come on board too.

By keeping an eye towards best practices, implementing a myriad of policy measures that complement one another, and working to overcome the key barriers to increased deployment, states can accelerate that push and our nation can be on its way to a cleaner, more secure, and more stable energy supply.

Doug Myers is a Senior Energy and Environment Policy Analyst with The Council of State Governments where he conducts analyses and prepares briefs for policymakers on a range of energy and environmental issues such as carbon capture and sequestration, electricity transmission and renewable portfolio standards. Doug also facilitates stakeholder interaction on energy and environmental issues of rising importance, working to devise solutions and mutually beneficial outcomes. Stakeholders include state legislators and other public sector officials, including federal officials, as well as private sector and NGO members.

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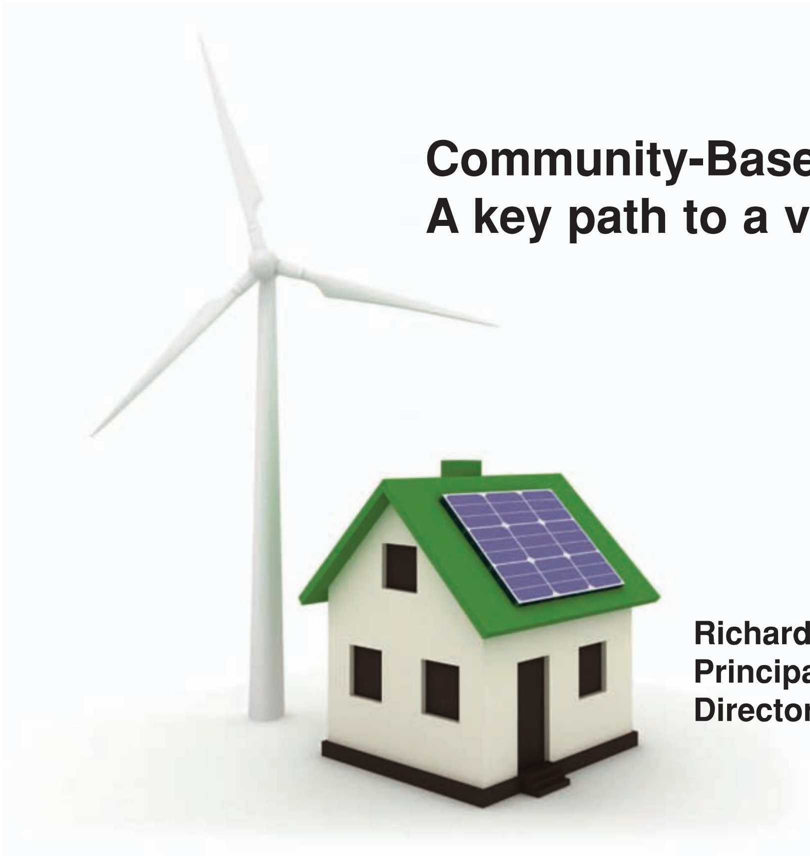


Community-Based Renewable Energy: A key path to a very low carbon economy

Richard Sedano
Principal with Regulatory Assistance Project
Director of U.S. Operations

Many states have taken the initiative over the past decade or more to promote renewable energy. This strategy will displace fossil fuels. States are doing this whether or not Congress acts on national energy security or climate issues since states have their own priorities.

Among their actions are an array of policies which are successfully accelerating renewable energy deployment in communities and across their states. In total, these policies are producing low carbon kiloWatt-hours to be sure, but they are also making clean energy accessible to individuals running households and businesses, and perhaps stimulating a "can do" spirit to support more clean energy development. If the United States is preparing to decarbonize the power sector over the next 40 years, a lot of "can do" spirit will help.

This article will talk about renewable energy and policies that will guide its responsible deployment in the US. In greater detail, it will focus on community scale developments. Why? While there is great potential for large quantities of utility scale wind and other technologies and robust debate about the wholesale markets and transmission systems to support them, these facilities will be largely hidden from most Americans. Renewable systems increasingly designed into our buildings, into our neighborhoods, in our eyesight as we walk our communities, go to work, or go on vacation promise a different kind of revolution that can bring clean energy home, literally. Policymakers in states are beginning to envision a future with policy convergence and public will where buildings or communities fuel their own energy needs.

But first, let's put this crop of community-based renewable supplies in context.

Energy Efficiency, The First Resource

The most powerful resource available for the electric power system today is energy efficiency. Estimates for unmet potential from energy efficiency indicate that the US can at least triple its current rate of investing in energy efficiency programs to produce savings that are cheaper than the supply investments that would be necessary to serve this demand for energy. It is not a stretch to say that natural load growth driven by the economy can be offset completely by savings from energy efficiency programs for decades to come.

This energy efficiency potential comes from building new buildings with better design and selection of products, but the majority of US energy efficiency potential comes from retrofitting existing buildings to address short-comings in initial designs and to change out older and less-efficient appliances and equipment (in developing countries, in which most of the buildings that will stand in 2030 are not built yet, addressing new construction and new appliances and equipment remains the key energy efficiency strategy).

Energy efficiency programs recognize that for a host of reasons, investments that benefit society because the cost of saving energy is less than the cost to produce it do not happen on their own. The more energy efficiency, the less pressure we place on generators to address carbon regulation, clean air requirements, capital formation limits, siting risks, etc. California has coined the term Loading Order for resource planning and energy efficiency, with demand response at the top.[1]

Legacy Fuels Compared with Renewables

Let's assume (a big assumption) that the US has met the challenge of securing all cost effective energy efficiency. Where does that leave us with electricity supply?

Coal, nuclear, natural gas fuel roughly 90% of the power produced in the U.S. The rest comes from a small amount of oil, hydroelectric, and other renewables (biomass, wind, solar, geothermal primarily). Nearly 100% of the power the US produces is in bulk amounts, transmitted at high voltage and sometimes for long distances, before reaching the distribution wires that traverse our streets. A percent of the power is lost along the way to heat, noise and other physical realities of power delivery that can be minimized but not easily eliminated. The grid is built as a one-way ramp from generators to customers.

Is it possible that the small share of the nation's renewable power could be increased to 20%? 50%? 80%? More? And how much of that can be sited in our communities? Given enough time to meet these objectives, and enough latitude to change the way the power sector works, the simple answer to all these numerical questions is yes. As for communities, there is a great and at this point, uncalculated potential for power to be generated in our buildings, right under (or over) our noses. There are no truly simple answers, of course, but work underway is charting some possible paths. What will these paths cost? It is easy to see the current price differential between existing coal, nuclear and natural gas on the one hand, and currently available renewables on the other. A more fair comparison requires forecasting the costs of new generation. With clear risks of new environmental compliance costs weighing down legacy generation, while economies of scale and improved technology are boosting renewables, the notion of grid cost parity is thought to be in hailing distance.[2]

Defining Renewable Energy

Many have a general idea of what renewable energy is. Solar energy and wind to be sure. Land fill gas, yes. It is a surprise to some, then, that the definition of renewable energy can be controversial. The confusion, though not the definition itself, is resolved easily when one accepts that in policy conversations, renewable energy has a legal definition, not a common one. Laws defining renewable energy confer or exclude economic benefit on named resources (and sometimes, in effect, specific companies).

Biomass is renewable, but the Union of Concerned Scientists' Renewable Electricity Standards Toolkit indicates nearly every state that defines it defines it differently. Some require sustainable harvesting, or exclude old growth, for example.[3] Only some states credit biomass used to co-fire with coal.

Geothermal is excluded from the definition in some states, perhaps just because it is not promising there right now.

Many states exclude large hydro-electric generation from their definition of renewable energy, apparently out of a belief that the technology is mature and does not need any government preference (some further question adverse environmental implications of large hydro-electric developments), and some states don't want to encourage any new development of hydro-electric power.

Even solar energy can present a dilemma. Solar thermal systems replace fossil fueled or electrically heated hot water systems with water heated by the sun's radiant energy. Question: should solar thermal get any recognition in the electric system's definition of renewable energy? Most states say yes.

The renewable energy definition in Pennsylvania includes electricity generated from burning accumulated waste coal. Some states want to encourage fuel cells and define as renewable fuel cell output powered by natural gas. Some states include combined heat and power output from on site natural gas systems if the system efficiency is high enough.

Generally, the definition of renewable energy in a state factors in general perception of renewable energy including protecting certain natural resources from development, an interest in favoring renewable and efficient technologies that need a boost to be competitive, and technologies that resonate in importance in that state, perhaps because of local natural resources or manufacturing.

Now that the state has taken pains to define renewable energy, how does it give these resources value or preference in the market?

State Policies that promote renewable energy

If a state wants to see proliferation of renewable energy supplies, how does it do it? The first group of policies influence overall renewable development in a state. These will be described in brief. The second group addresses community development of renewables, and will get a somewhat more detailed treatment.

Renewable Portfolio Standard

Utilities assemble a portfolio of power resources in similar ways to an investor. They combine power resources of different characteristics, attributes, risks. Their aim is to have the lowest cost portfolio consistent with public interest goals. Reliability is one obvious public interest goal.

A minimum percentage of renewables in a utility portfolio is another essential goal in those states with portfolio standards. An RPS is designed to nurture the development of renewable generators in a state. As a result, the minimum standard often appears as a rising series of percentages over time, reflecting a steady infusion of renewables into the system over years [see table for Arizona RPS schedule]. 29 states have a renewable portfolio standard. In some, it applies to all utilities, while in others municipal utilities and/or cooperative utilities are excluded.

Arizona Renewable Portfolio Standard Schedule

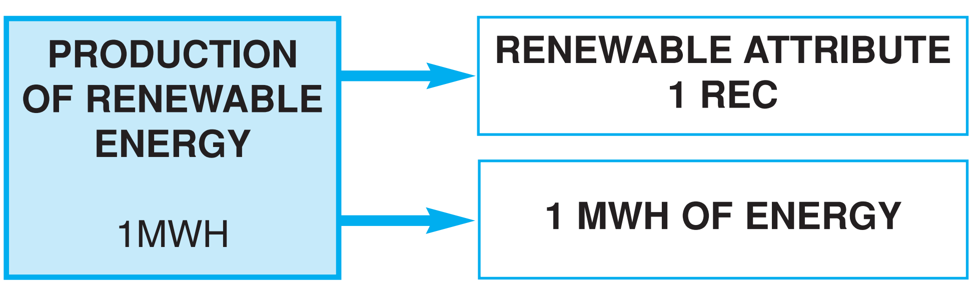
Year	Percent retail sales from renewable sources	Percent of requirment from distributed renewable energy
2007	1.5%	5%
2010	2.5%	20%
2013	4%	30%
2016	6%	30%
2019	9%	30%
2022	12%	30%
2025+	15%	30%

Renewable Energy Credits

Why is renewable energy different from other energy? Regardless of your answer, the consensus is that it is. By agreement among utility regulators and power market participants, the renewable attribute of a renewable kiloWatt-hour can be separated from the energy itself. This attribute, called a renewable energy credit, or a REC, can be sold by a renewable generator to a regulated entity that is subject to an RPS. The remaining energy no longer has any renewable attribute. The ultimate customer of energy stripped of its REC would be committing fraud if it attempts to double count this energy as renewable. Regulators and market participants find RECs a convenient and manageable way to track renewable attributes while allowing power sales to proceed as they always have, though some object that double counting is inevitable.

One REC is generally equal to the attribute output of one MegaWatt-hour of qualifying power. The rules in some states apply multiple or fractional credit for some technologies, generally depending on the importance of the energy form to the state.

An REC is a property right conferred by state law, so attention to REC ownership is important.



A Wires Charge to Pay for Renewable Energy

Instead of deciding how much renewable power to promote through an RPS, government can choose how much it wants to spend. To do this, a charge can be added to everyone's electric bill. The money would be used to buy RECs. New York essentially does this, and its competitive process is designed to buy as many RECs as possible for the money available. As executed in NY, government itself is doing the buying, the utility collects the money and passes it along.

The wires charge can also collect funds to support a small scale renewables incentive program, which might take the form of a rebate of $x per Watt of installed solar photovoltaic, or a production credit (per kWh produced). Some states have a clean energy fund, and most are funded by charges to utility customers. Environmental compliance payments also support renewable projects in some states.

Alternative Compliance Payments

If an entity subject to an RPS does not meet its renewable energy quota, what happens? In most states, a payment is made to the government to support renewable or clean energy development. The state generally establishes the payment and resets it periodically. The typical range of ACP is $20-50 per REC. In several states, a separate solar REC ACP is set between $300-700 per REC.

Green Tariffs

If you want to buy renewable energy from your utility, can you? In some places, you can. Retail sellers of electricity buy power and RECs from renewable providers, or they just buy the RECs. Then, instead of blending it with all the other power they sell, they can allocate it to specific customers who volunteer to buy it. A certifying organization, Green E, reviews the practices of most sellers of green tariffs and confers the Green E on those that meet their standards.[4] Green tariffs have served to prove to, sometimes skeptical executives, that the public wants renewable power.

In most cases, the customer can decide to buy blocks of green energy, so, for example a residential customer using 800 kWh each month can elect to buy 4 blocks of 100 kWh per month at the green tariff price, and the rest at the normal residential tariff price. Naturally, it is important that the seller be sure that it has all the renewable power it needs to meet its commitments. And it is important that RECs used for these customers are not also used to meet any system-wide RPS to avoid double counting.

States with monopoly utilities have to approve the Green Tariff, states with retail competition need take no special

action if they wish to rely on competitors to supply a Green Tariff option, but they may choose to create a Green Tariff option to the default service that is typically available.

Some utilities choose to emphasize locally sourced power in their Green Tariff. Central Vermont Public Service offers a Cow Power tariff, in which electricity comes from local farm methane systems. Utilities can also emphasize the price stability characteristic of renewables as compared with fossil fuels. Austin Energy in Texas offers a Green Tariff with a fixed price over several years, an assurance they will not make with the base rates, supported by their long term wind supply contracts. Native Energy offers a service to electric retailers nationwide, aggregating RECs from wind and solar power located on Native American lands and selling them to support Green Tariffs. Green tariffs can be unpopular if customers cannot understand the effects of their participation, or if they are just too expensive.

Renewable Tracking Systems

How do you keep score of RECs, measure compliance with RPS and avoid double counting? Several groups of states have collaborated to create databases that track all the relevant information.

On the demand side, all the portfolio standards, green tariffs and other policy preferences in a region are recorded. These define the goals that regulated entities need to meet. On the supply side, all renewable generators that qualify for any RPS or green tariff in the region are recorded. As generators produce energy and RECs, all REC transactions are recorded in the system. Every REC has a unique serial number in the best systems. Auditors can see a path from source to sink, and can demonstrate whether the "no double counting" rule was achieved.

Individual systems of this nature cover the New England states, the PJM system, the upper Midwest, Texas and the entire Western Interconnection. States have endorsed this approach, supporting the allocation of funds to create and maintain it, and they use these systems to verify RPS and Green Tariff compliance.

What follows are policies that states have had to adopt in order to enable renewable generators to be built and put their product in the market, and policies to promote local generation, distributed about the system. An early and still relevant treatment of barriers to distributed generation is Making Connections, published by NREL in 2000.[5]

Interconnection Standards

If you want to generate energy in your building and interconnect with the local utility so that excess power of any amount can be used, how do you start, and are you likely to succeed? For many years, the answers were, who knows? And no.

The challenge facing the customer is to enter into an interconnection agreement with the utility. This contract defines the relationship between the customer generator and the utility. What are the requirements (notice, financial, information) to interconnect? What are the utility obligations to cooperate (system studies, specific site requirements)? Most utilities through the 1990s were not motivated to cooperate and treated each request as if it were the first one. Delays and expense discouraged all but the most determined.

State commissions began to realize, however, that the process of interconnection generally is the same each time. Standard interconnection agreements or guidelines were created and are now in use in all but 8 states, often directed by statute, with the standard agreement issued by the PUC after a hearing. In a few cases, states based their result on the standard adopted by another state.[6]

Customers in states with standard interconnection agreements now have a clear idea of what they need to do, how long it will take and how much it will cost to satisfy the utility. It is reasonable to expect that with experience, current versions will improve. Utilities are increasingly designing distribution systems to accommodate two way energy flows.

Interconnection Standards generally apply unless a generator qualifies for net metering.

Net Metering

Net metering is a policy designed to cover a majority of the on-site power opportunities that are inherently simple and to pass on that simplicity to the customer. Simple systems include most residential rooftop photovoltaic systems, small- scale wind systems or farm methane systems. Qualifying net metering systems are

Annual Photovoltaic Domestic Shipments 1999 - 2008

Year	Photovoltaic Cells and Modules*
1999	21,201
2000	19,838
2001	36,310
2002	45,313
2003	48,664
2004	78,346
2005	134,465
2006	206,511
2007	280,475
2008	524,252
U.S. Total	**1,395,376**

*Total shipments minus export shipments.
Notes: Totals may not equal sum of components due to independent rounding. Total shipments include those made in or shipped to U.S. Territories.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Net Metering in Vermont
Cumulative through 2009

	Installs	MW
Solar	698	3.533
Wind	146	1.245

defined in statutes by technology, and capped at a certain size. There is also generally a limit on the total capacity of net metering systems allowed. Net metering is available to most or all customers in all but 5 states.

The term conveys one important simplification. A net metered customer no longer counts how much power is consumed on site, and does not need to count how much power was produced on site. Instead, all that matters is the net. Simple, and saves the cost of a second meter. Power can flow into the premises or out, depending on the net at any given moment. Payment is based on the net, though in some states, customers cannot make net revenue from the utility – their benefit in these cases is capped by being able to zero out their electric bill for the year.

The customer is essentially paid the retail rate for the power produced, so customers in higher cost states are quickest to embrace net metering.

Photovoltaic system in a home and home business.

Net metering does more than this, however. Utilities are concerned with controlling the power that flows into the grid from all sources to maintain the safety of its workers and to understand the state of its system at all times. They are also concerned about insurance, and other matters. States with net metering have endeavored to simplify these matters so that the requirements are minimized, and clear. States also waive or abbreviate siting requirements that would ordinarily apply to larger generators.

Net metering was originally thought by many to focus on simplifying the "gentleman generator," with a generator that fit into the scale of the premises, and perhaps offset a percentage of the total usage. Even in aggregate, it would take a lot of these to make any noise on the utility system. Typical limits at the beginning exist in Alaska, where the maximum size of a system is 25 kW, and in aggregate, a net metered system cannot exceed 1.5% of total system peak.

The success of net metering has led states and renewable advocates to consider expanding the net metering program's streamlined attributes to apply to generators of larger sizes. New Jersey has no size limit – as long as the generator is sized to offset on-site load, it is OK. It remains to be seen if the simplifications inherent in net metering will scale up well to customer generators of larger sizes. The good news is that even if there is a limit to how large net metered generators can go, interconnection standards are able to minimize hassles for more complex systems.

Another way the program can be expanded is to allow group or aggregated net metering. In this arrangement, a group of customers who may or may not be adjacent to one-another support the new net metering generator, and it offsets the collective load of all participants. One can imagine a housing development, an industrial park, a downtown business association, or farm cooperative developing a project like this. As the reader will note by the space devoted to net metering, this has been a powerful and flexible policy to develop small scale renewables across the US.

Earlier, the abbreviated siting requirements generally associated with net metering were mentioned. Since net metered projects often appear in residential areas, changing the look of houses and surroundings, this has produced some controversies, though only in a small percentage of sites.

Who owns the REC from a net metered system? In some states, the issue is clear in law (usually the customer) while in many other states, the law is silent. In Oregon, the customer must relinquish the REC in order to qualify for state incentives.

An aspect of net metering that has gotten some attention is the tendency for residential participants in these programs to be affluent. These renewable energy systems are expensive (in many cases, you are buying years worth of energy upfront) and often only the higher economic strata are able to make it work, though more may wish to.[7] (See financing, below.)

A Carve Out Within a Portfolio Standard

A state with a renewable portfolio standard can decide to have within it a standard for a particularly favored or important resource. For example, New Jersey decision-makers included within its RPS a carve out for solar PV. Utilities have to acquire REC to meet the RPS, and out of those, a certain number must be REC from solar energy projects, solar RECs, or SRECs. Thus, in New Jersey,

SRECs have their own market and sell at higher prices (recently around $700 per SREC) than other RECs, boosting the value of the solar power. New Jersey's solar electric requirement is 0.01 percent of total retail electric sales in 2004, increasing to 2.12 percent in 2020, and each year thereafter. New Jersey now exceeds 160 MW of grid connected solar, placing second in the US to California and belying the argument that solar energy can only be found in the southern states.[8]

Financing

How can a willing customer with an ability to support a net metered generator with good cash flow afford the big upfront cost of these systems? Most rebate programs don't address the full upfront cost. Or, if the willing owner is not committed to staying for a long time, is the opportunity to add renewable lost? A relatively new financing solution is generating great interest.

Property Assessed Clean Energy finance works like this. The city creates a pool of capital through a bond. The capital is made available to property owners in the community for qualifying renewable energy (and energy efficiency) purposes in a standard process not unlike car loans. The borrower pays back the loan with property tax payments, the loan is secured with the asset, the renewable generator, that stays with the house. An individual moving would pay just while owning the property, and the succeeding owner would pick up the payments, dividing both costs and benefits equitably. The high security of repayment would elicit a low interest rate, and the principal incentive to the customer would be the easy process. Community progress on clean energy is an obvious by-product.

PACE has been implemented in a few communities, notably Berkeley CA. As this is being written, federal mortgage companies are raising strong objections to PACE because these payments joined with property taxes would be senior to the mortgage in the event of default. As a result, progress is stopped.[9] Hopefully, this issue can be resolved to encourage the financial markets to support local renewable energy development for more than just those who can write a check.

There are other financing options. Some states used Petroleum Violation Escrow funds from oil company penalties into a revolving loan fund years ago, and can make a moderate number of loans for renewable energy each year with the proceeds. Some states used American Recovery and Reinvestment Act funds for a similar purpose.

State Fiscal Policy

States can confer tax benefits for renewable power, especially locally developed power. Based on a review of the website, Database for State Incentives for Renewables and Efficiency (Dsire), nearly every state offers a tax benefit for investment in at least one renewable technology. Generally, benefits keyed to production are more valuable to the grid than benefits keyed to investment.

A not-to-minor detail involves including money in state budgets to pay for tax benefits associated with renewable energy. With the increasing popularity of small scale renewable energy, state budget officers should take care to assure adequate funding to avoid disappointment and embarrassment.[10]

Other Issues influencing renewable energy development.

Feed In Tariff

A chronic problem unsolved by any of the policies discussed so far goes to the motivation of the large to medium sized renewable energy developer to pursue a project. This is not an issue of "incidental" on-site energy production, but rather, a renewable energy system designed to produce significant energy for the grid. The project may be on the customer side of the meter, but it probably generates far more than the customer uses. The developer takes on significant debt to fund the project, and while there may be an attractive market for RECs and a good market for the power, for most of the years that debt service is required, there is too much uncertainty about revenue. This is the "long-term contract problem."

The problem is particularly acute in states which have allowed retail electric competition. In these states, the obligation to supply long term power no longer rests with the utility. Shorter term motivations define the power market in these places. Who will buy the ten year output of a project in order to enable financing?

A solution applied in Europe and in a few states is a feed in tariff. The FIT is an obligation for the state regulated utility to buy qualifying power at a rate set to apply for a long time.

For the FIT to be effective, the rate needs to provide cost recovery including a reasonable return for the generator in enough instances to promote development. Thus it can be set at distinct levels for different classes of energy systems. A recent solar FIT price in Vermont was 29 ¢/kWh, but just 12 ¢/kWh for landfill gas.

Unfortunately, until the cost for renewable supplies drop, the FIT rates appear high. An added complication is a recent order by the Federal Energy Regulatory Commission declaring that the California Feed in Tariff rates must reflect avoided cost. This finding asserts federal jurisdiction because the transaction is a wholesale power sale and thus is inherently interstate commerce, and implicitly indicates that rates needed for project development will be out of bounds.

Historic Preservation

A perceived obstacle to the deployment of renewable energy systems in older buildings is historic preservation – the desire to retain the character of our American Heritage as expressed by our buildings. Many presume that the effort to modernize existing buildings and historic preservation imperatives are in conflict. While conflict does exist, there is common ground in the idea of sustainability. Approaching an historic building from this

sustainability perspective can lead to a discussion about how sustainable energy production can best be built into a lasting building.[11]

Integration with Energy Efficiency in Buildings: Zero Net Energy

Perhaps the most important thing in this article is sitting here buried toward the end. The development of thousands of customer-sited generators across the US coupled with more thoughtful building and process design and successful energy efficiency programs have motivated analysts and government officials from around the US to consider a goal of zero net energy.

Zero net energy can be accomplished in a building, or a sub-division, or an entire community. It would be based on building in local generation to supply electricity which is minimized by efficient design and product selection. California is implementing, through its regulatory oversight of utilities, a strategic plan for all new homes to be zero net energy by 2020, and all new commercial building will be zero net energy by 2030.[12] A community or campus-based design might feature a district energy system also producing electricity with solar PV, solar thermal and other renewable systems supporting community needs.

The deployment of the smart grid – including more real time communication and computing power in the grid – will help to automate and control generators, switches and customer loads to support this objective while maintaining reliability.

This objective of zero net energy distills into one coherent idea dozens of policies that are supporting development of small scale renewable energy into US communities. In the American Recovery and Reinvestment Act, $2.73 billion was allocated to Energy Efficiency Community Block Grants. These many hundreds of projects in cities and towns across the US promise progress. Programs that identify and overcome the barriers to making choices that lead to zero net energy will increasingly occupy government over the next decade.

Closing Thought

Some would like to see a national definition of renewable energy as part of a national renewable energy standard, pointing to the hodge podge of state rules and the confusion that ensues. It is certainly true few could master the nuances of renewable policy rules in all the states. However, Dsireusa.org and UCS websites reliably report the facts, which represent real differences about priorities among the states. The state policies are working and parts that don't work well can be fixed. While a national policy may respond to one's sense of order, it may subtract more value than it adds unless it leaves room for states to add their distinct priorities.

Richard Sedano is a prinicpal with the Regulatory Assistance Project, raponline.org, and directs its United States operations.

Sidebar: Two Parallel Universes, Physical Power and Contracts, Help Explain RECs

In order to understand a renewable energy credit, a REC, one has to appreciate that there have always been two distinct ways of looking at power: physical, and contractual.

The physical one is what customers see and results in reliability – at least enough power virtually all the time (adequacy), from whatever fuel sources, operated to run our equipment safely (stability). The physical perspective keeps the lights on.

The contractual perspective determines the way many generators, many transmission owners and many operators of distribution companies sort out financial costs and benefits of operating the system.

So let's look at a single generator, Vermont Yankee Nuclear Power Station in Vernon, Vermont. VY produces electricity equivalent to 70% of Vermont's electricity use. Does that mean it produces 70% of Vermont's electricity? No, this is wrong in two ways, physical and contractual.

Physically, VY is located in the southeast corner of Vermont. Its power supports a part of the New England regional grid that radiates from this location into New Hampshire and Massachusetts supporting customers there. So while it is hard to identify the fraction of power that serves these three states and the rest of New England, it is easy to see that all the power is not dedicated to keep Vermont's lights on.

Contractually, the vision is clearer. One entity owns the generator, Entergy Nuclear. Entergy has a contract with Vermont distribution utilities for a specific fraction, roughly half, of the plant's output. As these utilities create their portfolio of resources to serve Vermont customers, it is their contractual right to this power that matters, and thus VY is seen as serving around 35% of Vermont's electricity use.

Renewable power takes this dual quality one step further to create a REC. First, government needs to confer a special status on generation of renewable sources. Creating a portfolio standard does that.

For qualifying generators, then, we can sever the "renewable attribute" of this energy and create a new valuable commodity, a REC, that can be marketed independent of the power that is created at the same time. If the REC is sold, the remaining energy can no longer be called renewable – that would be double counting and states have consumer protection rules and guidelines that prohibit misleading claims from double counting.

So an entity subject to the renewable portfolio standard, typically a distribution utility, does not have to buy renewable power to meet 100% of its RPS requirement. It can choose from a number of strategies. It can build its own renewables and self-supply RECs, taking REC price uncertainty out of the equation. It can buy renewable power from other generation owners, if the power fits into its physical portfolio. Or it can buy RECs alone, and assemble its physical supplies from other sources.

The key is that the renewable generator gets the financial benefit of producing a preferred resource, either by getting revenue from a utility, or by avoiding having to buy RECs from others.

Previously, Sedano was comissioner o the Vermont Department of public Service and was chairman of the National Association of State Energy Officials. He presently serves on the Vermont Clean Energy Development Board.

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4 Green E is managed by the Center for Resource Solutions. http://www.green-e.org/

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10 This is not theoretical. Vermont offered a tax credit for solar energy in 2010. $9.4 million was allocated by the legislature. Applications exceeded $28 million. Fortunately for Vermont taxpayers, the amount available was capped in law, so the result will be that eligible customers will not be satisfied.

11 See National Trust for Historic Preservation Sustainability Program http://www.preservationnation.org/issues/sustainability/

12 California PUC dockets D.07-10-032 and D. 08-09-040

Sidebar: Avoiding an Unintended Consequence – an Environmental Performance Standard for Distributed Generation

Generation in the community is becoming more feasible and more popular. Policymakers want to make sure that the story remains positive. A potential unintended consequence could disrupt distributed generation development. That potential comes from the prospect of proliferating deployment of back up generators using fossil fuel combustion with uncontrolled emissions which they would produce when customers activate demand response programs.

There is potential for customers to be more responsive to utility system conditions, especially system stress and high prices. Technology can make a big difference but is not required for many applications.

Customers who might get used to the idea of managing on site generation because of their renewable energy systems and more suitable rules might want to use highly responsive fossil fueled power to ride through voluntary curtailments from the utility system with no degradation in service.

The problem is the pollution from these back up generators, exacerbated by the timing when they are coincident with hot days typical of system stress and high prices.

A solution is to apply a stick and a carrot. The stick applies environmental standards to these small generators that today are so small that they escape regulatory concern. The carrot is to create a performance standard that would qualify clean back up generators to receive expedited permitting.

"One Man's Waste is..."

Ken Reese, Vice President Sales and Marketing, Parallel Products, Inc.
Gene Kiesel, President and CEO, Parallel Environmetnal Services, Inc.
Eric Berson, Professor of Chemical Engineering, University of Louisville, J.B. Speed School of Engineering

In the past we harvested resources and managed wastes. Now, and in the future, we must manage resources and harvest wastes.

Introduction to Parallel Products

In the days when "Green" was just the name of a color and not a worldwide movement, there was a company in Southern California pioneering technology and processes to create alternative energy from food and beverage wastes. Parallel Products was founded in 1979 and began the unique business of creating alternative fuel (ethanol) from unsaleable and discarded beverage products.

Today, Parallel Products is North America's leader in unsaleable beverage destruction and recycling. Headquartered in Kentucky with regional recycling facilities in Louisville, KY, Bronx, NY, New Bedford, MA and Rancho Cucamonga, CA, services are offered nationally to the leaders of the alcoholic and non-alcoholic beverage, pharmaceutical, health & beauty and industrial alcohol industries.

> *"We are very proud of the technological leaps we have achieved recently. It creates great value for our customers and helps them realize their Corporate Responsibility and Sustainability Goals."*
>
> *-Gene Kiesel*
> *President & CEO, PESC*

The key to success and longevity has been the steady increase in of resource recovery. Recycling processes have been optimized to recover the absolute maximum materials for repurposing. From a bottle of soda, Parallel Products is able to recover and repurpose the primary container, the cap, the label and the liquid.

Each year, over 13 million cases of distressed or out-of-date beverage products are destroyed and recycled by Parallel Products. The company's activities results in the recovery of 4 million pounds of aluminum, 4 million pounds of plastics, 70 million pounds of glass, 7 million pounds of other packaging materials and the production of over 5 million gallons of ethanol.

Over their thirty year history, Parallel Products has evolved and grown from the core business of beverage destruction to now participate in four major business segments. These are: Beverage Destruction and Recycling, Health & Beauty Destruction and Recycling, Ethanol Recovery and Production and Value-Add Plastics Recycling.

Beverage Destruction and Recycling

Beverage destruction and recycling is a business activity that most have not heard or thought of. However, there are in excess of 30 million cases of unsaleable alcoholic and non-alcoholic beverages generated in the U.S. each year. As Parallel Products recycles just over 30% of these products, 70% are disposed of or destroyed by other methods. These methods may include landfill, bovine and swine feed programs, destruction and discharge, illegal marketing or donation programs.

The reason most are not familiar with this business is its value for confidentiality and security. Beverage manufacturing and distribution carry inherent risks. For bottling companies, the potential of tainted, damaged or out-of-date products reaching consumers must be eliminated throughout the entire product lifecycle. The consequences of losing control of off-specification product may severely damage the brand image and resulting sales.

Parallel Products fully understands the importance of brand protection and takes every necessary measure to ensure it. In fact, their two largest facilities, in Kentucky and California, are Distilled Spirits Plants (DSP) and Bonded Wine Cellars (BWC). These facilities fall under the regulatory jurisdiction of the Tax and Trade Bureau (TTB) and the Department of Homeland Security. The stringent requirements of this licensing result in the industry's highest security, auditing and reporting standards.

Fermentation operation in Louisville, Kentucky.

Parallel Products services both the alcoholic and non-alcoholic beverage industries. Due to liquid composition differences, each type of beverage undergoes varying conversion processes. Non-alcoholic beverages require an additional process, fermentation, to be converted to alcohol. Liquids are blended to the selected brix (sugar content) levels and processed via yeast conversion to create an alcohol-containing liquid. Alcoholic beverages do not require fermentation and are blended directly with the sugar converted liquids to achieve the optimum alcohol level for distillation tower feedstock. At this point, the distillation process takes place and waste-derived ethanol is created.

Recoverable materials associated with the packaging, transportation and display of beverage products are also recycled when sent for destruction. Aluminum cans, plastic and glass bottles, aluminum bottles, aseptic pouches, cartons, shrink wrap, stretch film, paperboard, corrugated cardboard and slip sheet or pallets are segregated and processed for recycling in their respective secondary markets.

Alcoholic beverage manufacturers and distributors also benefit from the tax recovery services provided by Parallel Products. Customers who destroy tax-paid unsaleable products are eligible to recover Federal Excise Taxes, State Excise Taxes and Customs Duty Drawbacks where applicable. Parallel Products offers tax recovery administration and assistance via the tax experts in their Tax & Trade Bureau (TTB) department.

Health & Beauty Destruction and Recycling

From the alcoholic beverage recycling business, Parallel Products leveraged their distinctive capabilities to provide recycling services to the Health & Beauty industry.

Due to the elevated alcohol content levels (>24%) of most perfumes, mouthwashes, hand sanitizers cosmo-ceuticals and over-the-counter medicines, these products have historically required disposal as hazardous wastes under the Resource Conservation and Recovery Act (RCRA). Common disposal methods include incineration and fuels blending and are especially costly and administratively burdensome. However, given the registration as a DSP and distillation capabilities to provide reclamation services, Parallel Products is able to receive these products, destroy and recycle the packaging and distill the liquid reclaiming the alcohol for energy uses. This practice enables manufacturers to keep waste products from RCRA classification and claim the ancillary reclamation benefits which include:

1. Reduced Corporate Liability
2. Reduced Regulatory Burden
3. Reduced Consulting and Administrative Costs
4. Reduced Disposal Costs
5. Reduction of Company's Carbon Footprint

These benefits accompanied by the security and brand protection of their services have made Parallel Products an industry preferred option for disposal and recycling. Today, Parallel Products destroys and reclaims over two and a half (2.5) million cases of Health & Beauty products each year.

Ethanol Recovery and Production

Until recently, the core business of creating ethanol from waste consumer goods was simply a "unique business idea". However, as the demand for renewable energy becomes an

Distillation columns in Ontario, Canada.

increasingly prominent part of the National, State and Local agendas, it has become a baseline for the growing industry of waste-derived renewable fuels.

The unique application of fermentation and distillation technologies to waste products creates a complete resource recovery and recycling opportunity for generators and is making a significant contribution for the renewable fuels standards in Kentucky and California. Each year, via fermentation of sugar laden liquids and distillation extraction of alcohol from beverage and industrial waste streams, Parallel Products produces over five million gallons of ethanol.

This ethanol is used to create two distinct products.

1. Fuel Grade Ethanol: Derived from beverage waste products, this is the "E" in the E-10 or E-85 that is burned in automobiles. Parallel Products' fuel ethanol is used by major oil companies as a clean air additive in gasoline blends and is considered an Advanced Biofuel by the RFS2 (Renewable Fuel Standards II).

2. Industrial Ethanol Products: Derived from industrial waste streams, recovered ethanol is blended to make specific SDA (Specially Denatured Alcohol), CDA (Completely Denatured Alcohol) and other TTB regulated formulas. These products are used in a wide array of applications by many industries.

It was Parallel Products' continued mission to fully use resources and reduce waste that created their leadership position in the recovery of ethanol from the beverage, chemical, health/beauty and pharmaceutical industries. This reclamation option provides generators with environmentally sound solutions and alternatives to hazardous waste disposal. Because of this program, materials that would otherwise be unusable wastes now contribute to the production of 51 million gallons of gasoline and industrial alcohol products without the negative effects of food offsets and increased groundwater contamination.

As a renewable resource, ethanol has many significant environmental benefits. For example, when used as a fuel additive in automobiles, ethanol:

- Reduces tail pipe emissions and greenhouse gases by up to 10%
- Reduces emissions of carbon dioxide - a highly toxic gas - by up to 30%
- Results in a net reduction in ground-level ozone, a major component of urban smog and a health hazard to children and adults with respiratory problems
- Helps to reduce our country's dependence on imports of foreign oil

Value-Add Plastics Recycling

With the addition of the Value-Add Plastics Recycling business segment, Parallel Products has rapidly expanded the company and its contribution to the exploding plastics recycling industry.

Through services provided to all tiers of the beverage industry (manufacturing to retail), Parallel Products recycles and value-add processes in excess of 120 million pounds of plastics each year. Though many types of plastics are received and recycled, central focus is in the processing of Polyethylene Terephthalate "PET", the most common resin for use in beverage bottles. The products produced by this process are recycled PET or "rPET".

In 2004, Parallel Products became a major provider of recycling services for beverage bottlers and distributors in the New England States. That year, the third Parallel Products facility was built in Taunton, MA. This plant's activity was anchored by empty beverage container recycling, "Empties". Services for "empties" include collection/transportation, auditing and recycling of bottles generated through the respective state's Bottle Bill Redemption Program. Following, in 2006, the company continued expansion to the Mid-Atlantic States by purchasing an "empties" facility in Bronx, NY to provide similar services for the New York market.

Growth in the recycling culture of the Northeastern states combined with the expansion of the New York State Bottle Bill led to further growth for Parallel Products. In 2009, Parallel Products completed the move from the Taunton, MA facility to a new location in New Bedford, MA. This move was necessary to accommodate significant volume growth and the construction of two new state-of-the-art processing lines. Additionally, by the end of 2010 Parallel Products will complete a major expansion of the Bronx, NY facility.

Optic sorting array in New Bedford, Massachusetts.

These facilities employ the industry's best available technologies for de-bale, optic color-sort and grinding processes. Each process applied to the recycled bottles elevates the value of the recovered plastics in the rPET value chain. Last year in the New Bedford facility, Parallel Products took the challenge to drive value from the lowest value state of PET, mixed-color shred. In all previous scenarios, mixed-color shred was ground to produce mixed-color flake and sold into the market as low-value green product. To increase the value of this material, Parallel Products installed and deployed the nation's largest array of optic sorters. This array is able to separate the rPET flake material into three distinct and higher quality steams.

Continued Improvement

Innovation, improvement and focus on the goal are what keep Parallel Products moving forward. "Drive efficiency and recover and reuse the absolute maximum amount of resources from the products and wastes we receive is what we seek to do. It sustains us." says Gene Kiesel, President and CEO.

Success in the waste-derived energy industry has eluded many new entrants. For Parallel Products, this is its continuing mission - to increase efficiency - that sustains the operation. Producing ethanol from beverage products requires a tremendous amount of energy. The inefficient and suboptimal application of this energy can easily create negative energy consumption to production ratios. This issue compounded by increasing energy costs is the reason many renewable energy (ethanol) plants were taken off-line and new start-ups were delayed in 2008 and 2009.

Contrary to these happenings, during 2008 and 2009, Parallel Products was able to complete a distillation facility project which provided three major benefits: 1. increased energy efficiency 2. increase in the production of renewable energy (ethanol) 3. reduced waste generation

Parallel Products' engineering staff redesigned process flow configurations to better use the energy being consumed (natural gas for steam creation) at the facility. Efficiency was greatly increased and the equivalent volume of energy then became sufficient to power two additional processes. The first was the addition of a second distillation column. This column was added to remove methanol following the initial distillation process. This allows for the receipt and processing/recovery of additional alcohol laden waste streams. Prior to this addition, these streams were rejected from the recovery process. In 2009, the additional column resulted in the production of 559,000 incremental gallons of product ethanol. Secondly, this redirected energy became critical in the efficiency improvement of the facility's evaporation process. This efficiency improvement resulted in a 78.3% reduction in facility waste generation from 2008 to 2009.

What's Next?

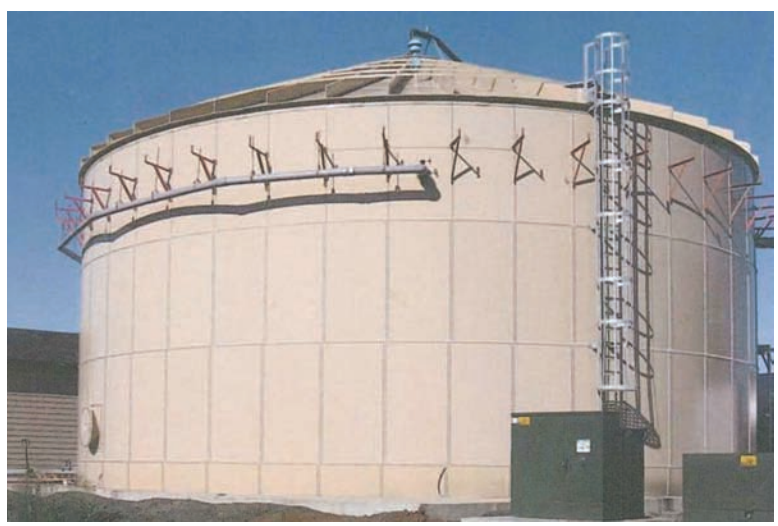
Today, Parallel Products is working to develop new projects that will further their position in the alternative energy sector. As our Nation's agenda is increasingly focused on energy, and specifically, renewable and waste-derived energy sources, the company is finding new ways to make significant contributions.

The ethanol recovery and production process is Parallel Products' signature and key differentiator within the recycling community. Yet, it provides an untapped resource for generating additional and significant amounts of energy.

The distillation facility at Parallel Products-Louisville generates a waste material known as "stillage". This material is the portion of the processed liquids that are not alcohol or water. To date, a viable stillage reclaim/reuse option has not been developed and implemented. A small portion (<1%) is being used as an industrial or agricultural binding agent.

With adherence to the company mission, Parallel Products has devoted years of research and development to identify and create an application to drive value from this waste. Through the use of a current pilot plant, it has been determined that the properties of the stillage lend well to the generation of biogas (methane) in an anaerobic digestion process. Through a cascade of metabolic steps, this process accelerates the degradation of organic materials and increases and concentrates the methane gas production from the waste's decomposition. This methane gas may be captured for use as an alternative fuel resource while reducing reliance on natural gas or other non-renewable energy sources. The application of anaerobic digestion technology will also eliminate the requirement to concentrate the waste through an evaporation process. The methane-derived energy produced versus the energy consumed to create it will be net positive by a ratio of 8 to 1 Btu's.

The project will require the construction and operation of a 1.5 million gallon Biogas Plant using anaerobic digestion technology. This biogas plant will convert 36 tons of organic waste to a volume of methane gas possessing an energy value of 457 MMBtu daily. This is an annual (330 day) equivalent of 150,810 MMBtu . This gas will then be available to offset the use of non-renewable energy sources such as natural gas and coal.



Proposed anaerobic digester unit.

Additional benefits of the anaerobic digestion project include the ability to further diversify recoverable feedstock for energy conversion and create incremental energy efficiencies in the distillation facility. Anaerobic digestion will provide the opportunity for methane conversion of non-distillable products such as dairy based beverages and solid sugar products. Estimated volumes of regionally available dairy and sugar waste materials will generate up to 12,870 MMBtu annually. Currently, many of these products are being disposed of as wastes or are being used to supplement swine and dairy cattle feeding regimens. Additionally, the digester will allow for process modifications in distillation that will reduce on-going natural gas consumption by fifty percent (50%).

In the initial stages of project development, the intended consumer of the produced biogas was the Parallel Products recycling facility. This would take the facility "off the grid" and create a relatively small biogas surplus to be consumed by a third party or to be flared off and destroyed. However, as the project evolved over a two-year period, other opportunities for biogas use became apparent.

As Parallel Products modeled the anaerobic digester, the University of Louisville was concurrently working to develop programs to reduce their dependence on non-renewable energy sources, such as coal. As part of the program development, the University of Louisville signed the American College and University Presidents' Climate Commitment on November 12, 2008 (a copy of the text is available at: http://www.presidentsclimatecommitment.org/about/commitment), which committed the University to work toward achieving a net-zero CO2 emission by 2050.

A significant means to achieving this goal will require the University to reduce its dependence on coal based electrical power. LG&E, the local utility, generates 98% of its electric power from coal-fired boilers (the other 2% from hydroelectric and natural gas). The University's greenhouse gas footprint is estimated to be 92,789 metric tons of CO2e, or 5.4 metric tons of CO2e per enrolled student (CO2e refers to equivalent units of CO2 emitted by other green house gases that contribute to the same degree of warming over a given time period as CO2). Approximately 11,420 metric tons of CO2e of this total is attributable to purchased electricity. The report and emissions data for the University can be found at: http://acupcc.aashe.org/ghg/121/.

Additionally, the University has established a goal to obtain 20% of its energy from renewable resources by the year 2020. Twenty percent of the total campus electricity amounts to: 33,000 MWh/yr (enough to power 3,000 homes) of which 3.77 MW is generated continuously; $1,672,020 in annual electric bills; and 21,679 tons of CO2 emissions. At the same time that this goal was set, the University entered into an Energy Performance Contract that guarantees a reduction of energy consumption of 33%. Currently, over 70% of this contract has been completed and some buildings are already seeing this percent reduction being met. Conversely, the University has also adopted a Master Plan for expansion that calls for almost a doubling of building square footage over the next 25 years. With constantly declining funding from the Commonwealth of Kentucky, it is not known what sources of funding will be available to fully implement this plan. This 20% goal, which is incorporated into the Master Plan, was prompted in part by the Association for the Advancement of Sustainability in Higher Education's Sustainability Tracking Assessment and Rating System (STARS), which the University has adopted as its model for sustainability. A description of the STARS program can be found at: http://www.aashe.org/files/documents/STARS/STARS_1.0.1_Technical_Manual.pdf

The University contracted with Cannon Design(article appears in this issue) to identify options for renewable energy sources. The study concluded that small projects would only be able to produce ~5-10% of the University's energy needs. The study concluded that wind, hydrokinetics, and solar could provide these partial solutions. They estimated that a wind project would generate less than 65kW, and likely closer to 15kW if small turbines were used. A hydrokinetic project might generate up to 100kW. A solar project would produce up to 3,000 MW depending on the size of the solar array. For larger scale projects that have the potential to produce up to 100% of the energy needs of the University, incremental, landfill gas, and biomass are thought to offer the best opportunities. The University has explored Power Purchase agreements with various private entities that are capable of generating electricity from wind, solar, incremental (low impact) hydroelectric, landfill gas, or biomass resources, such as the anaerobic digester planned by Parallel Products.

Because of the aligned agendas, the University of Louisville and Parallel Products are working to develop a Green Energy Partnership that will bring the anaerobic digester program to fruition. This partnership will develop a cutting edge model for sustainability. The processes and technologies developed will become replicable to similar industrial and manufacturing operations throughout the nation. This partnership is focused on a progression of Green Energy Projects that will move the University toward achieving its energy goals. The first and most critical step is the initial anaerobic digestion project. Subsequent projects will expand the applicability of this process to new waste materials such as those created by the University and public school systems. This capability and capacity expansion will exponentially increase energy efficiency and the use of renewable energy sources.

Ken Reese has served as Parallel Products' Vice President of Sales and Marketing since 2006. Since receiving a B.B.A. in Marketing from Texas State University and an M.B.A. from Texas A&M University, Mr. Reese has spent a career in the environmental industry providing recycling and reclamation services to a wide range of industries. For 14 years he provided Hydrocarbon Recycling and Recovery solutions to the Oil & Gas and manufacturing sectors throughout the U.S. These efforts resulted in production of Recycled Fuel Oils and Reclaimed Motor Fuels helping to reduce the consumption of virgin fossil fuels. In recent years, Ken has focused the same principals of the transforming discarded materials into valuable "green" products

in the Beverage, Health & Beauty, Plastics and Industrial Alcohol industries through his work at Parallel Products. In his forth year with the company, his key initiative is to align Parallel Products' service offering with the Corporate Responsibility and Sustainability goals of their existing and prospective clients

Gene Kiesel received a B.S. degree in General Engineering from the University of Illinois specializing in systems control and economics. His previous employer AGA Gas, Inc, enhanced his executive education through the extensive TIO-IFO management program at the Darden School of Business at the University of Virginia. His career spans five companies, Air Products (2 years), AGA Gas (12), Dow Chemical (4), Oil Dri (7) and Parallel Products, Inc (beginning 2006). The primary goal in changing companies was to advance his career by learning new skills, obtaining a diversity of experiences, and taking on increasing responsibility. His functional experiences include Engineering – 3 years, Sales and Sales Management – 7 years, New Product Commercialization – 6 years, and General Management - 12 years.

Dr. R. Eric Berson, University of Louisville Department of Chemical Engineering, has expertise integrating experimental techniques with computational modeling to develop solutions to complex processes with an emphasis on biofuels applications. This experience includes two years of process R&D inindustry followed by seven years of research in academia related to alternative energy production systems. His projects have been funded by the U.S. DOE, NREL, and the Kentucky DEDI. He was also appointed by Governor Steve Beshear to serve on an Executive Task Force on Biomass and Biofuels Development in Kentucky.

The Role of Renewable Energy in the Campus Carbon Neutrality Movement

Moe Tabrizi
Scot Wooley
Dave Newport
University of Colorado at Boulder

Introduction

The era of campus renewable energy growth kicked off ten years ago with students at the University of Colorado-Boulder approving the nation's first student fee to fund renewable energy supplies. The rest is history, and now campuses coast to coast follow an array of connections to renewable energy systems as higher education works to reduce carbon emissions, hedge financial risk, and embrace the leadership society expects from the best and the brightest.

The technical and strategic implications related to the emergence of renewable energy offer higher education opportunities to leverage a technology into a global leadership role. Renewables' impacts on costs, climate, and cultures can be profoundly important for both higher education and the greater global community. These technologies provide a platform for inclusiveness and engagement within and beyond the borders of a college campus. If navigated with a selfless vision, higher education can steer global societies toward a sustainable future while enhancing campus impacts and engaging stakeholders across the board. Hopefully, higher education will seize the moment and evolve these multiple benefits.

> *Campus leaders have also warmed to renewables because of the leadership they show to stakeholders expecting higher education to chart a course to a better future for society and the world we live in. Higher education is increasingly mindful of its ethical responsibility to serve.*

Carbon, Costs and Leadership

Renewables' role in campus climate action is critical. Quite simply, campuses cannot meaningfully reduce carbon emissions without significant supplies of affordable renewable energy for both electrical demands and heating/cooling. Therefore, all renewable energy sources are being sought; solar, wind, hydro, geothermal, and so forth.

Moving forward, renewables offer campuses another significant benefit: cost predictability. Unlike fossil fuel-supplied energy, renewable energy has no fuel cost. A renewable energy project is akin to buying a house; it's all about mortgage and maintenance. Renewables are simply a debt deal and like a fixed-rate home mortgage, you know for thirty years what your monthly costs will be. That flat line energy cost makes campus CFO's happy because it hedges against financial risk.

Campus leaders have also warmed to renewables because of the leadership they show to stakeholders expecting higher education to chart a course to a better future for society and the world we live in. Higher education is increasingly mindful of its ethical responsibility to serve. Community relations and higher education's moral "license to operate" turn on its perceived contribution to the world around us. Renewables are point-to examples of campus leadership that boost that moral platform. This level of commitment contributes to parents sending their children to a particular college, communities supporting various campus needs, and legislatures, foundations, and businesses underwriting their favorite school. In short, renewables are an effective and credible billboard for advertising campus vision and leadership.

Barriers and Bridges to Renewables

While large-scale renewable electricity projects are crucial to carbon emission-reductions, many campuses will be hard pressed to fashion direct connections to large-scale renewable energy projects under existing state and federal electrical transmission regulations. Off-site renewable electricity systems can be located where the renewable resource and land costs are favorable, but the energy generated must be transmitted to the campus. This can be a significant challenge.

As a nation, we built an electrical transmission system around large fossil-fuel power plants located close to their loads such as large urban areas. Transmission capacity—and length—was minimized by this approach. However, in the case of renewable energy resources such as wind and solar, they are generally concentrated in rural areas such as the southwest US deserts and western high prairies—well away from large loads. To connect these rural renewable resources to urban loads will require massive new transmission projects only now being contemplated, designed, funded, and built. It could be decades before we have transmission capacity sufficient to connect rural renewables to urban loads.

In the case of electricity, most of the existing transmission wires are spoken for by the big utilities. Getting "space" on those wires, if capacity is even available, will result in a "wheeling charge" that adds to costs. And generally the utilities don't have to agree to even allow access to their grid if they don't want to. So campuses can be left out.

Over time, electrical transmission limitations may become less of a factor. Major players recognize this market shift and are investing private capital to add new capacity designed to connect renewables to the market[1]. Likewise, campuses have a great political card to play with state regulators when it comes to breaking down barriers to "green electrons for higher education." Indeed, as campuses enter the market for green energy, they bring considerable public support for their mission, campus sustainability, and renewables that can reduce the cost of higher education.

The Hierarchy of Action

With that said, renewables are not the first tool for campus carbon cutters. We cannot power our way to carbon neutrality with renewables if our energy consumption appetite remains ravenous. A more judicious approach to powering the future with renewables will cut costs and speed the transition to a sustainable energy future.

In other words, conservation is job one—turn off unneeded lights. Second, if a light must be used, efficiency is crucial. Only the most energy efficient light, motor or building is appropriate. Finally, only after we have reduced load and enhanced efficiency should we plug into renewable supplies. This approach is similar to the oft cited "reduce, reuse, recycle" maxim; in the case of cutting carbon emissions the batting order is "conservation, efficiency, renewables." Once you have taken actions to address the first two steps of the equation, you can move on to renewable energy. But even then, there are options to consider.

Is Renewable Energy Real—or is it a REC?

Campus renewable energy strategies range from installing small on-site solar or geothermal systems to purchasing Renewable Energy Credits (RECs) from off-site renewable energy generators. While the on-site approach conducts "green energy" directly to campus load, most campuses lack space sufficient for large-scale renewable systems required to energize all facilities 100%.

Instead, with some exceptions, the trend is to connect the campus to large-scale renewable electrical generation through a contract, not a wire. In other words, RECs are a financial connection to renewables, not an electrical connection. RECs pay for off-site renewable energy to be put into the electrical grid with the campus retaining the "environmental attributes" of that energy. That allows the campus to compensate for the direct use of perhaps dirtier energy supplies and claim the carbon reductions from the renewable energy contributing to the grid elsewhere. This process has its critics and advocates as well as its pros and cons. Notwithstanding, the REC market is growing fast and most campus renewable portfolios contain some or all RECs. Of the campuses that are members of the EPA's Green Power Partnership, the majority are off-site renewables "connected" through the purchase of RECs. See Figure 1.

While the use of RECs instead of direct renewable energy supplies is less than optimal, RECs do have a couple of distinct advantages. First, they have helped focus capital into the renewable energy industry sufficient to boost the growth in renewable energy generation capacity nationwide. In wind energy alone, the US is now the fastest growing market in the world. Another advantage of RECs is campuses don't themselves have to capitalize systems and can instead simply pay a la carte for the amount of green energy they wish to purchase. In lean budget times, this is an economical way to keep the inertia of carbon reduction plans going. Even so, RECs are not the only option and sometimes campuses want something to point to and be proud of.

Small Scale Renewable Applications

Small to medium scale renewables are a good fit for higher education campuses. Limited land, financing challenges, and competing campus development master plans are among the issues of concern.

Renewable energy installation starts with an assessment of renewable resources at your location. Small/medium wind turbines are appropriate for campuses as long as wind resources are adequate. Solar PV is an option due to the technology's long expected life, low maintenance cost, and as long as available unused roof space exists and solar resources are plentiful. Many campuses fit the bill and small to medium sized renewable installations are gaining incredible ground in the push for sustainability in higher education.

Small to Medium-Scale Case Study: University of Colorado at Boulder

Given the number of sunny days and availability of solar resources in Colorado, rooftop solar PV is a good fit and a valuable addition to the mix of conservation, energy efficiency, and renewables for CU-Boulder. Several steps were taken to ensure successful outcomes for our rooftop solar PV projects:

Figure 1: Top 20 Campus "EPA Green Power Partners" June 2010[2]

The Top 20 Colege & University list represents the largest purchasers among higher education institutions within the Green Power Partnership. The combined green power purchases of these organizations amounts to more than 1 billion kilowatt-hours of green power annually, which is the equivalent amount of electricity needed to power nearly 90,000 average American homes annually.

	Annual Green Power Usage (kWh)	GP % of Total Electricity Use*	Green Power Resources	Providers
1. **University of Pennsylvania**	200,000,000	48%	Wind	Community Energy
2. **Carnegie Mellon University**	86,840,000	75%	Solar, Wind	Community Energy On-site Generation
3. **Pennsylvania State University**	83,600,000	20%	Biomass, Small-hydro, Wind	3 Degrees, Sterling Planet, Community Energy
4. **University of Utah**	62,879,992	23%	Solar, Wind	Sterling Planet, On-site Generation
5. **University of California, Santa Cruz**	55,000,000	100%	Wind	NextEra Energy Resources
6. American University	54,000,000	100%	Wind	Constellation NewEnergy
7. Oregan State University	51,595,400	56%	Biogas, Biomass, Wind	Bonneville Environmental Foundation
8. Northwestern University	49,007,000	20%	Wind	3Degrees
9. University of Phoenix	47,000,000	30%	Wind	NextEra Energy Resources
10. Texa A&M University System	43,350,000	15%	Wind	TXU Energy
11. **Auraria Higher Education Center**	40,367,932	100%	Wind	Renewable Choice Energy
12. Western Washington University	40,000,000	100%	Wind	NextEra Energy Resources
13. The City University of New York	34,704,000	8%	Biomass, Wind	New York Power Authority
14. Southern Oregon University	33,300,047	287%	Wind	Bonneville Environmental Foundation
15. Harvard University	31,544,600	10%	Small-hydro, Solar, Wind	Essex Hydro Associates, Sterling Planet, On-site Generation
16. University of Central Oklahoma	26,000,000	100%	Wind	Edmond Electric
17. Syracuse University	22,800,000	20%	Small-hydro	Constellation NewEnergy
18. Santa Clara University	22,536,959	74%	Solar, Wind	Silicon Valley Power/ 3Degrees, On-site Generation
19. Adelphia University	20,079,460	100%	Biogass, Biomass, Geothermal, Small-hydro, Wind	Renewable Choice Energy
20. (tie) Dickinson College	18,000,000	100%	Wind	WindCurrent
20. (tie) The Ohio State University	18,000,000	3%	Biomass	Elemnet Markets

- Identify large campus roofs with good sun exposure.
- Review structural integrity and load carrying capacity of campus roofs with a target of 6-8 lbs/ft^2 available load carrying capacity.
- Rank locations by roof age, quality, and condition.
- Seek approval from campus architect while being sensitive to architectural considerations.
- Rank order the list of top-qualified building roofs in favor of programs or departments that have direct educational interest or strong support for onsite solar PV.

Having a solid list of buildings with large and good quality roofs allows us to focus our attention on locations and projects that have promising potential to reach fruition. The siting process is a vital component to any renewable installation on a college campus as adequate details and approvals will allow stakeholders to feel comfortable, knowing the proper processes and liabilities are being considered. This, however, is only the first step. Project financing can be a major hurdle to overcome, however there are many options for making a project more economically feasible.

Currently there is an upfront cost premium for renewables. High initial investment is especially true for solar PV. The first task for successful renewable energy financing is to educate oneself regarding all available renewable energy incentives. This includes rebates and tax credits on municipal, state and federal

levels. Researching and understanding these financial tools is a highly important step in project financing because project size must correlate to the appropriate local utility program and size as well as state and federal tax incentives.

Several years ago, citizens of Colorado voted in support of Amendment 37. Amendment 37 mandates that the local utility company collect a small fee from rate payers and design an incentive program to promote renewable energy and achieve a 20% mix of green power within its portfolio. In March of 2010, Colorado Governor Bill Ritter increased the State's Renewable Portfolio Standard to 30% by 2020, demanding that major utilities expand their mix of renewable energy sources. The largest utility, Xcel Energy, therefore created a three-tier program:

- Less than 10kW (intended for Residential customer)
- Midsize (10 kW – 100 kW) (intended for industrial/commercial customer)
- Large solar installation (Typically large ground-mounted systems, several MW of solar PV covering several acres of land)

At CU-Boulder, we have focused on midsize programs as a best fit for our campus. These rebate programs offer up to $2.00 per Watt of solar energy ($200,000 for 100kW project), which is quite a significant upfront support. The program is also offering a premium price for generated electricity although this premium has been declining in response to very strong demand during the past few years. To finance the project successfully one must also focus on renewable tax credits.

For a tax-exempt institution, this presents a problem. Although tax exemption provides a number of benefits to the institution, our campus is not qualified for any of the tax benefits. To overcome this problem, we have formed business relationships with venture capital firms or renewable energy financing companies that also have a direct relationship with solar design and installation companies. The venture capital firm finances the entire project by counting on upfront local utility incentives and premiums for green power in addition to accelerated asset depreciation and federal renewable energy tax credits. As such, the projects typically require very little or no upfront funds from our campus.

One of the benefits of this sort of third-party contract is that it allows the University to purchase and own the asset after a fixed term and at a fraction of the upfront cost. The financing company owns the asset for the initial 7 years and sells generated power to the campus while maintaining the equipment. Once the campus purchases the asset, this business relationship is terminated and the green power belongs to the University. We have successfully completed seven solar projects so far with an installed capacity of 240 kW or about 340,000 kWh/year of electrical production capabilities. Our goal is to continue with this strategy up to the limitations of our local utility's program.

Large scale renewables on college campuses

Of the 4300+ US institutions of higher education, about 175 campuses have directly installed some solar PV systems[3] and about 60 campuses have on-site wind energy generation,[4] however, only a few of these systems generate a significant fraction of the total energy consumed by the campus.

Total installed wind energy capacity of all campus wind systems is about 259MW, the total US campus solar PV capacity is even less at about 37MW, based on data developed by the campus sustainability organization AASHE.[5] According to wind energy proponents, a 5-MW wind turbine can produce more than 15 million kWh in a year—enough to power more than 1,400 households.[6] By that math, the 259 MW of total installed campus wind capacity will power 72,520 homes. However, even one medium sized campus can consume upwards of 100 million kWh per year meaning a 5MW wind turbine might only provide enough electricity to power 10-30% of the electricity needed for one college campus.

Large-Scale Case study: The University of Oklahoma

OU has a better idea: power the entire campus by wind. They have begun purchasing as much wind energy as they can and plan to be 100 percent wind powered by 2013. "We intend to be a role model and a leader in energy independence for this country. We're ready to do it," said OU's president David L Boren. A new $260 million wind farm built in partnership with Oklahoma Gas & Electric will power Oklahoma's sprawling campus. "It is our patriotic duty as Americans to help our country achieve energy independence and to be sound stewards of the environment," Boren said. "All of us as Americans should unite in this effort." Oklahoma is not alone. Other campuses are seeking large-scale renewable energy supplies and finding them.

Large-Scale Case Study: The University System of Maryland

This east-coast school system is funding four renewable energy projects that will produce more than 20 percent of the annual electric needs for USM institutions and state agencies.[7] The contracts will also advance the state's commitment to reducing its carbon footprint by 25 percent by 2020 and the USM's commitment to carbon neutrality under the American College and University Presidents Climate Commitment.

Large-Scale Case Study: Butte Community College

In May of 2011, Butte Community College will take the lead in renewable energy installations and become the first grid positive campus in the nation. By adding 15,000 solar PV panels – or 2.7 MW – to the existing 1.85 MW of solar PV, they will be producing more electricity than they consume – adding clean electrons to the grid and reaping the financial benefits. When the project is complete and all 25,000 solar panels are online, Butte College will see an annual reduction of 3450 tons of CO_2.

The funding needed for the project totaled $17 million, but Butte College only paid $4.35 million after capitalizing on available incentives and low interest loans. According to Mike Miller, Butte College Director of Facilities, Planning and Management, "the funding to pay for all of the solar projects, is the funding budgeted annually to purchase electricity from the grid, and for Phase III, almost $1 million in rebates from PG&E, the California Solar Initiative, and benefits from the American Recovery and Reinvestment Act/CREBS allocation".[8] These financial tools help make the projects more economically feasible, but the real benefits come over the long term. The Phase III addition to Butte College's already impressive solar installations is expected to save the college over $150 million net over the next 30 years. Those kinds of figures can make any renewable project very enticing.

Diana Van Der Ploeg, Butte College President, is proud of the inspiring leadership Butte has shown, saying, "sustainability is at the heart of everything we do. Being the first grid positive community college in the country demonstrates our commitment to the sustainable practices we're modeling for our students and our community."[9]

Heating and Cooling with Renewables

Wind and solar PV are the darlings of renewable energy advocates, but little known geothermal offers help with the thorny problem of heating and cooling buildings—an enormous energy load that electricity is poorly suited to address. Indeed, for many campuses, heating and cooling buildings ranks second to electricity in terms of carbon emissions and cost.

Geothermal in the form of ground-source heat exchange uses the relatively constant temperature of the Earth to provide a heat sink—or source—for fluids circulated through buildings to keep them warm or cool. Generally, a large array of wells is located close to buildings through which fluids are circulated to either remove building heat or provide it.

While an exact estimate of installed geothermal on campuses is difficult to secure, there is no doubt that this is an increasingly desirable option. Once thought to have much higher up front costs than traditional heating and cooling systems and longer paybacks, geothermal has surprised many and is rapidly becoming a favorite of K-12 and higher education facilities nationwide.

Heating and Cooling Case Study: Lipscomb University

One pioneer of geothermal is Lipscomb University in Nashville, Tennessee. This Christian-based college spent $1.2 million in 2005 to install a geothermal heating and cooling system, expecting to save $70,000 a year in energy costs. They were wrong; they saved about double that amount.

Yet Lipscomb's facilities director Dodd Galbreath said that Lipscomb isn't going green just to save money. He also views sustainability as consistent with its Christian mission. "Why create more mess for God to purify?" said Galbreath.[10]

Lipscomb's "going green for God" attitude bucks another trend too—the prevalence of geothermal in western US states. While the U.S. is currently the world's top geothermal market, with approximately 3 GW of installed capacity, developers of large scale systems are focused largely on California and Nevada. And with more than 4.4 GW of confirmed projects teed up, the US may more than double existing capacity over the next five years.[11]

Unlike large scale renewable electricity projects, large scale geothermal projects may be better suited to on-campus installations as the "power plants" (arrays of wells) can be buried below active spaces like softball fields, parking lots, quads, even under buildings. In short, geothermal does not need the exclusive use of precious campus real estate in order to provide significant energy needs.

Inclusion: The Linkage Between Research, Education and Engagement

As these campuses strive to balance their budgets, drive enrollment and improve the sustainability of their institutions, renewable energy is becoming increasingly popular. The potential to lower campus carbon emissions while hedging against financial risk and taking a lead in the push for sustainability is enticing to college administrators at all levels, but where and when does the internal campus community get involved? What is the value of renewable energy to faculty, staff and students and, further, how do these disparate stakeholders engage with the project and provide support?

If a truly sustainable future is the goal, inclusiveness needs to be at the center of any effort. By including stakeholders from across campus in a renewable energy project, an institution can sustain higher visibility, greater community support and more purposeful student engagement. The campus can feel involved in the effort and aligned with the university's vision while maintaining a sense of shared ownership over the project. With that said, ongoing and extensive campus engagement needs to be central to renewable energy projects at the level of higher education.

Organizations around the world are, and have for decades been, realizing the seriousness of the current global context. Economic, social and environmental risks stemming from climate change are bringing carbon to the forefront of public dialogue and lower-carbon energy sources are a crucial component of this conversation. Capital investment helps bolster the renewable energy industry, increasing the efficiency of renewable energy technologies and improving their return on investment, but continued research is vital as we push forward towards a carbon neutral future. In this capacity, research labs in institutions of higher education have and will play a central role in promoting, improving and delivering a viable energy future to the world.

The great minds of our institutions, our best and brightest, will be the pioneers of the rapidly developing renewable energy industry. These academic leaders can play a significant role in pushing the limits of the existing technology and engaging students – inspiring them to become leaders themselves. By tapping this intellectual resource and broadening the conversation around renewables, an institution can build a stronger campus community, increase its visibility to potential applicants and attract greater funding for research and tech transfer. There are, however, benefits that go beyond the material acquisition of funds and technology, especially when it comes to on-site installations.

Renewable energy installations are, at their root, germane to ongoing student engagement, education and service learning. Highly visible campus projects gain the attention of students and the greater community, but all projects present an opportunity for involvement and curriculum integration. Students are increasingly interested in and aware of energy-related issues, and renewable energy installations provide a hands-on occasion for students and community members to learn more.

Faculty members from across campus can integrate renewables into their class schedule. Curriculum development can range anywhere from the social and aesthetic impacts of a project to the specifics of carbon mitigation and the economic benefits delivered. Departments from myriad academic silos can come together around a single idea, driving innovation and understanding while adding value to the student's academic career. Students can work to install, monitor and even analyze installed energy systems and this knowledge and experience will put them ahead of the curve and encourage them to become leaders in the renewable energy space. In this regard, renewables can be a source of inspiration to students and a driver for innovation and awareness on a college campus. They can bridge the gap between disparate internal stakeholders and help engage them with an institutions' goals and values.

The Climate of Campus Commitment

Jim Hansen, the head of the NASA Goddard Institute for Space Studies, has posited that to maintain the ecological balance on earth and to avoid catastrophic irreversibilities stemming from climate feedback loops, humanity needs to maintain a concentration of 350ppm CO2 in the atmosphere.[12] Likewise, leading economic and military experts warn that global climate change could cost us trillions of dollars annually, while stretching our resources dangerously thin.[13,14] These concerns are being echoed by university leaders around the nation as over 650 campus administrators have signed on to the American College ACUPCC Presidents' Climate Commitment. "These colleges and universities will be providing students with the knowledge and skills needed to address the critical, systemic challenges faced by the world in this new century and enable them to benefit from the economic opportunities that will arise as a result of solutions they develop."[15]

As we learn more and more about the context we find ourselves in and struggle to limit our impacts on the world, institutions of higher education need to be a beacon of light — guiding the leaders of tomorrow in the right direction. On-site renewable energy installations as well as the purchase of RECs are both effective ways to communicate a commitment to this end. Renewable energy installations provide a platform for further research, education, engagement and inclusion. Even RECs show a campus community that the administration is willing to put money where its mouth is.

Getting Renewables Right

There are clearly lots of good reasons to significantly increase the use of renewable energy across higher education. Leadership, engagement, cost control, carbon abatement, and risk mitigation all factor favorably for the academy. Likewise, campuses have the political leverage and resources to make renewables a central part of their strategic vision and campus infrastructure. Over time, the trend towards renewables is clear and probably immutable. Costs will continue to decline. Carbon emissions will continue to grow as a liability. New technologies will continue to emerge and dazzle us with their potential.

What's Missing from this Benefits Matrix?

Well, people. Specifically, renewables are most needed and most appropriate for people who can't afford them; low income people in the US; subsistence farmers in developing nations; rural villages everywhere from our own Native American reservations to Bangladesh, Nairobi, South America, etc. In many of these circumstances renewables answer a crucial binary question: electricity or no electricity. Developing nations simply need energy to grow, to power schools, computers, and communications; to keep medicines chilled, to process food crops, to pump water for life sustaining irrigation, to live a higher quality life.

We would propose that US higher education pair its development of renewables with a focus on the under-resourced peoples of the planet. It's not enough for our comparatively rich nation to enjoy the benefits of renewables if we don't also mature as a civilization. **The US is already infamous for commanding and consuming over 25 percent of the planet's fossil fuel resources to power just four percent of the planet's people. Will we make the same selfish mistake with renewables too just because we can?** Higher education needs to be mindful of its global leadership responsibilities if we as a society are truly the world leaders we aspire to be.

The model for this response already exists. Engineers Without Borders has an approach the breadth of higher education could adopt.[16] Working in developing nations, engineering faculty and students use renewables, clever design, and their own sweat to improve the water systems, cooking technologies, refrigeration, and so forth in rural villages to give people a chance to improve their own lives. Besides helping others in need, these

volunteers are among the most inspiring people on a college campus. Their altruism is infectious, joyful, and adds a dimension to renewables that isn't in the instruction manual; they inspire hope. Anyone lucky enough to get a class with EWB principles like its founder Professor Bernard Amadei at the University of Colorado-Boulder comes away from that semester a changed person. Professor Amadei would be the first one to state that there is a long list of other faculty, students and organizations engaged in this great work.

In short, renewables offer higher education a means to enhance its "moral license to operate" while at the same time providing an array of tangible benefits. In a globalized world, we simply cannot look only at on-campus benefits. To provide the hope the world is so hungry for, higher education must advance its role by transforming its approach—and an old environmental maxim— to the level of leadership we desperately need now: "Think globally, and act…globally."

With that perspective, renewables can not only transform campus energy systems, but renew our spirit as well. We need both.

Moe Tabrizi is Campus Resource Conservation Officer and Head of Campus Engineering.

Scot Woolley is a senior majoring in Environmental Policy/Mandarin Chinese and the Interim Energy and Climate Program Manager at the CU Environmental Center.

Dave Newport is the Director of the CU Environmental Center.

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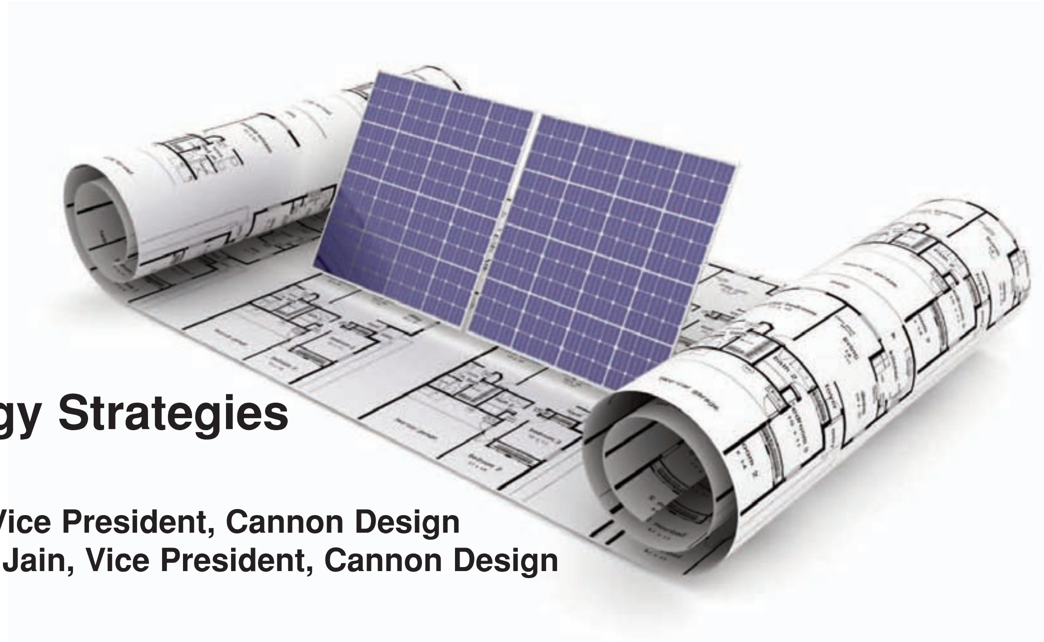


Renewable Energy Strategies

Gerald G. Williams, Vice President, Cannon Design
Punit Jain, Vice President, Cannon Design

Why Renewable Energy Now?

Large facilities and campuses are coming under increased pressure to become more sustainable. National, state and local mandates are changing the way facilities consider their power generation methods and renewable power is becoming a much more important part of a sustainable campus portfolio. The AIA 2030 challenge for all new buildings to be net carbon-neutral by the year 2030 is driving more building owners to take seriously the prospect of on-site power generation and even be willing to pay a premium for it. The concept of being grid independent or partially independent also has benefits from a reliability and survivability perspective for critical facilities.

Although the notion of generating power on site using free energy from the sun or the wind sounds tempting, many building owners are unclear as to what it means to generate a significant portion of a facilities power needs on site.

Sustainability In The Context Of Renewable Power

For an institution seeking true sustainability in generating its own power, it is not enough merely to use renewable resources. Sustainable power generation requires that the institution select a renewable energy system that maximizes the useful contributions of renewable resources and maximizes environmental benefits.

To determine the most sustainable and holistic approach, objectives such as reducing the carbon footprint, educating the community, and using locally available resources must all be considered alongside economic feasibility. Each technology investigation should include a regional and site analysis that explores which energy sources are locally abundant and should consider technologies that have already been successfully incorporated in the area. Available real estate and facilities that can be retrofitted must also be considered.

Ultimately, a sustainable energy solution makes use of local resources and opportunities, forming a region-specific, and not institution-specific, energy portfolio that provides for the institution's needs while reducing environmental impact.

Case Study: University of Louisville

Motivated in part by its membership in the Association for Advancement of Sustainability in Higher Education (AASHE), which set a goal of 15% electricity generation from renewable sources as part of its climate control commitment, the University of Louisville recently commissioned a study to assess how it could generate a significant amount of power on or near campus from renewable sources.

The University currently uses two main sources of fossil fuel (coal and natural gas) to generate power, for heating and cooling its campuses. The local utility uses coal and natural gas to generate electricity for the University, and coal is also used on campus to generate steam.

Liquid fossil fuels are also used to power the University's 75 vehicle fleet. This includes gasoline, ethanol, and diesel totaling approximately 90,000 gallons per year, but this is a relatively small amount compared to the energy used by campus buildings.

Fifteen percent of the University's electricity consumption would amount to approximately 22,500,000 kilowatt hours annually, or approximately $300,000 per year. However, the University has gone beyond this figure, setting its goal to provide 20% of total campus electricity via on-site renewable generation. The study therefore analyzed potential power generation sources that could be installed to meet this 20% goal.

The Study

Seven renewable energy technologies were studied for application at the University of Louisville:

- Incremental Hydropower
- Hydrokinetics
- Wind
- Enhanced Geothermal Systems
- Biomass
- Landfill Gas
- Solar

These technologies were studied with respect to their suitability for the Kentucky location, suitability for the University campus environment, and potential for implementation on campus or, in some cases, in the areas surrounding the University.

Findings

Hydropower

Hydropower is currently the most widely used source of renewable energy, but traditional large-scale hydro projects have received considerable criticism due to their negative environmental impact. Hydrokinetics responds to this concern by producing electricity from flowing water on a smaller, less intrusive scale. Whereas typical hydro projects require a dam to build pressure due to elevation differences, hydrokinetic turbines are designed to work in free-flowing streams. Similar to wind turbines, these devices generate power from the velocity of the flowing stream. Figure 1 is a generated image of an installation of hydrokinetic turbines on an underwater mast.

Figure 1 -Hydrokinetic Turbine

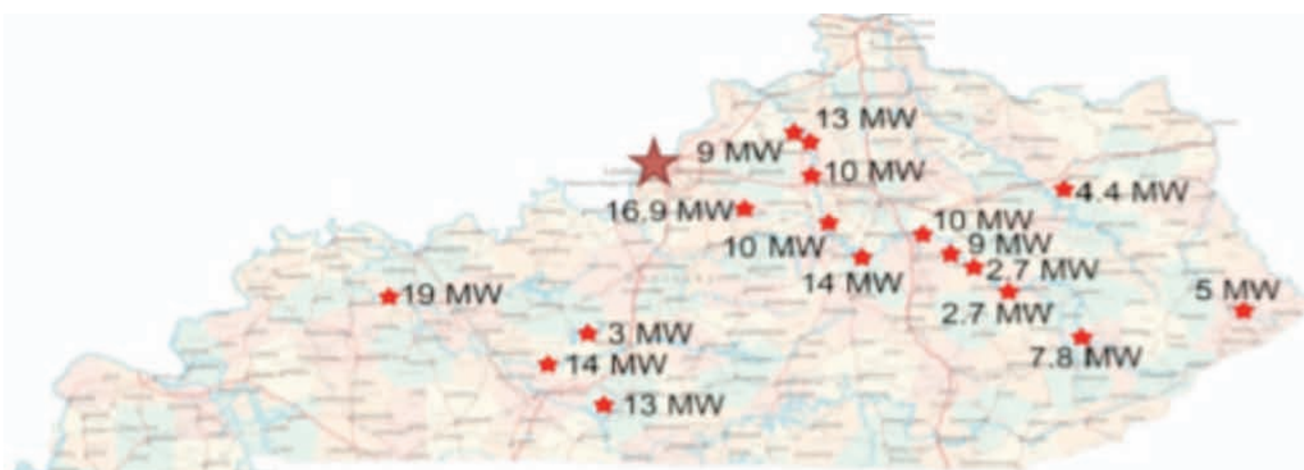
The power production of a turbine is roughly related to the square of flow velocity, putting particular emphasis on the velocity characteristics of the water source. Turbines can be affixed to bridge towers, piers, and even barges to place them in the ideal flow. Hydrokinetic projects, although a new technology, are being rolled out in pilot programs on the Missouri, Mississippi, and Ohio rivers by a number of companies.

For the University of Louisville, there were two main options for generating power from flowing water:

- Incremental Hydro: Retrofitting existing dams for power generation
- Hydrokinetic Turbines: Locating turbines in the free-flowing stream

Building a new dam was not considered an option for a number of reasons. Not only is it not practical to dam the Ohio River, or the Kentucky River (which is navigable up to Frankfort), but dams also have a clear history of damaging upstream and downstream ecology. The modern consensus is that large hydro projects (dams) compromise the environment, offsetting the positive outcomes of sustainable power generation.

Currently at least five groups are seeking to obtain permits to develop over 160 Megawatts (MW) of hydropower in Kentucky. This map shows the locations of new permits for hydro (mostly incremental) projects around the state. The scale of these projects was ideal for the University's purposes. However, these projects are far away and would limit exposure and research potential, and the University would likely be partnering only to purchase electricity or renewable energy credits.



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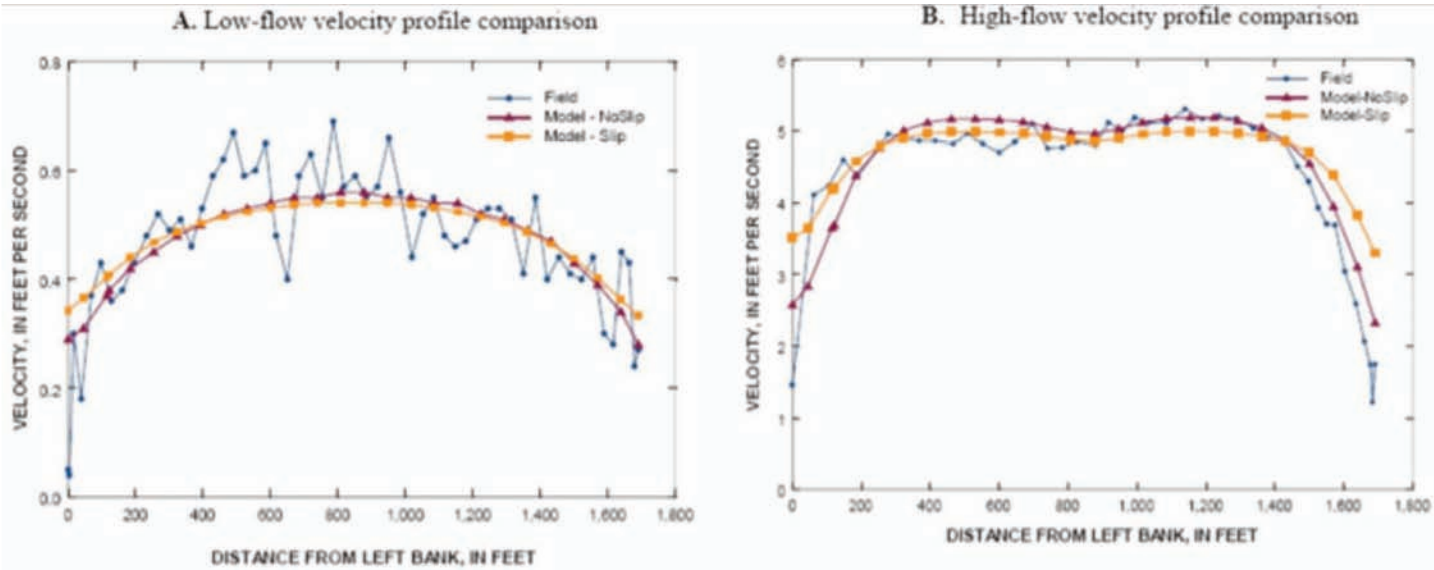


Figure 2 – Ohio River Velocity Profile Charts

Hydrokinetics

The Ohio River is the closest major hydropower resource to the University of Louisville campus. An analysis begins with a study of the river's flow profile. Figure 2 shows two velocity profiles from the U.S. Geological Survey of the Ohio River, taken 13 miles upstream of the McAlpine Lock and Dam at Louisville. On the left is a profile for a low-flow period and on the right, a high-flow period.

These charts indicate the maximum velocity in the high-flow profile is only 4.9 ft/sec. Table 1 shows recent performance figures from a Free Flow hydrokinetic turbine for comparison.

Flow Velocity	Available Power
4.9 ft/s	3kW
7.4 ft/s	10kW
12.8 ft/s	40kW

Table 1 – Hydrokinetic Velocity/Power Chart[1]

At this velocity, the turbine would be operating at the bottom end of its performance envelope, producing less than a tenth of its capacity in faster water. It is notable that 4.9 ft/s is observed during a high-flow period on the river and average flow velocities are likely to be slower.

While the cost might prohibit the development of a large-scale hydrokinetics project, a small pilot project could provide real value to the University as a research opportunity, as the technology is still new and in the demonstration stage. Hydro turbines are much less visible than other on-site options and would require considerable cooperation with waterside landowners and facilities managers to allow for regular access.

Incremental Hydropower

Hydropower is the most prominent renewable energy source in the United States and by far the most widely applied in Kentucky. Growth of conventional hydro projects has slowed, due in part to the concern over the ecological side effects of damming rivers. However, more ecologically friendly efforts to tap hydropower have led to projects that add hydroelectric capacity to existing dams, a process called *incremental hydropower*.

The recent push toward projects on existing dams has been supported by the Army Corps of Engineers, which has begun upgrading hydropower capabilities. The Federal Energy Regulatory Commission (FERC), the body responsible for permitting developments on public waterways, is also considering these projects.

Incremental hydro projects can be installed on dams that were originally intended for other purposes, such as flow control. These projects can range anywhere from below 1 MW up to 200 MW in size, depending on the selected dam. Another approach involves adding generators to existing hydroelectric dams.

In 1998, the Idaho National Laboratory completed a study of Kentucky's hydroelectric resources and concluded the state had nearly 500 MW of power potential at existing dams. At the time, only one of those dams was generating electricity.[2]

Development has since increased. The Kentucky River's Mother Ann Lee hydroelectric plant is one such project and has earned recognition from the Low Impact Hydropower Institute (LIHI). It is one of only 40 dams in the country with this certification and was renovated to produce 2 MW of electricity.

Figure 3 shows the structure housing the Mother Ann Lee hydroelectric plant on Lock and Dam Number 7 near Harrodsburg, KY. This project may allow for additional generators.

Figure 3 – Mother Ann Lee Hydro Plant

The McAlpine Lock and Dam is located not far from the University and the Cannelton Lock and Dam is just over 70 miles away. Few major universities have dams of this size located nearby. These two dams offer the potential for hundreds of MW of electricity generation. The McAlpine lock hydroelectric plant is undergoing a renovation that will increase its power generation up to 100 MW.[3] Another project at the Cannelton Lock and Dam will produce 82 MW of power.[4]

The upper tainter gates at the McAlpine dam, shown in Figure 4, provide one possible location to increase generation capacity. These gates provide flow control to the downstream hydro dam, and currently have no power generating equipment installed. The University could perform a smaller hydroelectric retrofit without overwhelming the infrastructure.

Wind Power

Wind power harnesses the energy in the movement of wind currents to produce electricity. In a wind turbine, blades capture the wind's energy and connect directly to a generator. The turbines are a modular technology and can be installed on masts or on rooftops of buildings. Horizontal axis turbines, shown in a wind farm in Figure 5, require more space and come in capacities between 10kW and 3.5 MW. Vertical axis helical turbines, shown at the top of Figure 5, come in capacities as low as two Kilowatts (kW) and require less space. These are often found on rooftops of buildings.

Figure 4 -McAlpine Lock and Dam upper gates[5]

Figure 5 -Wind Turbines[6]

The Kentucky area, along with much of the Eastern U.S., has little in the way of wind resources. Figure 6 shows maps depicting wind resources across the U.S. and Kentucky.

More detailed numbers for Kentucky wind speeds are shown in Table 2. For reference, wind speeds in Kansas and South Dakota reach 8 m/s at elevations around 50m.

Small urban turbines vary widely in cost due to the varying levels of efforts required to make them aesthetically pleasing. Many of the models have a cut-in speed (minimum speed to start the turbine turning) of 4.5 – 5 m/s. Average ground wind speeds in Louisville are around 3.5 m/s. A medium-sized turbine installed at a 37-meter hub height (21m rotor) will see 3.7 m/s wind speed. Large GE turbines, with hub heights between 77 and 82.5 m, would see about 4.7 m/s windspeed at the University of Louisville.

Elevation(m)	WindSpeed(m/s)
40	3.7
60	4.26
80	4.6
100	4.9

Table 2 -Wind Speeds by Elevation[8]

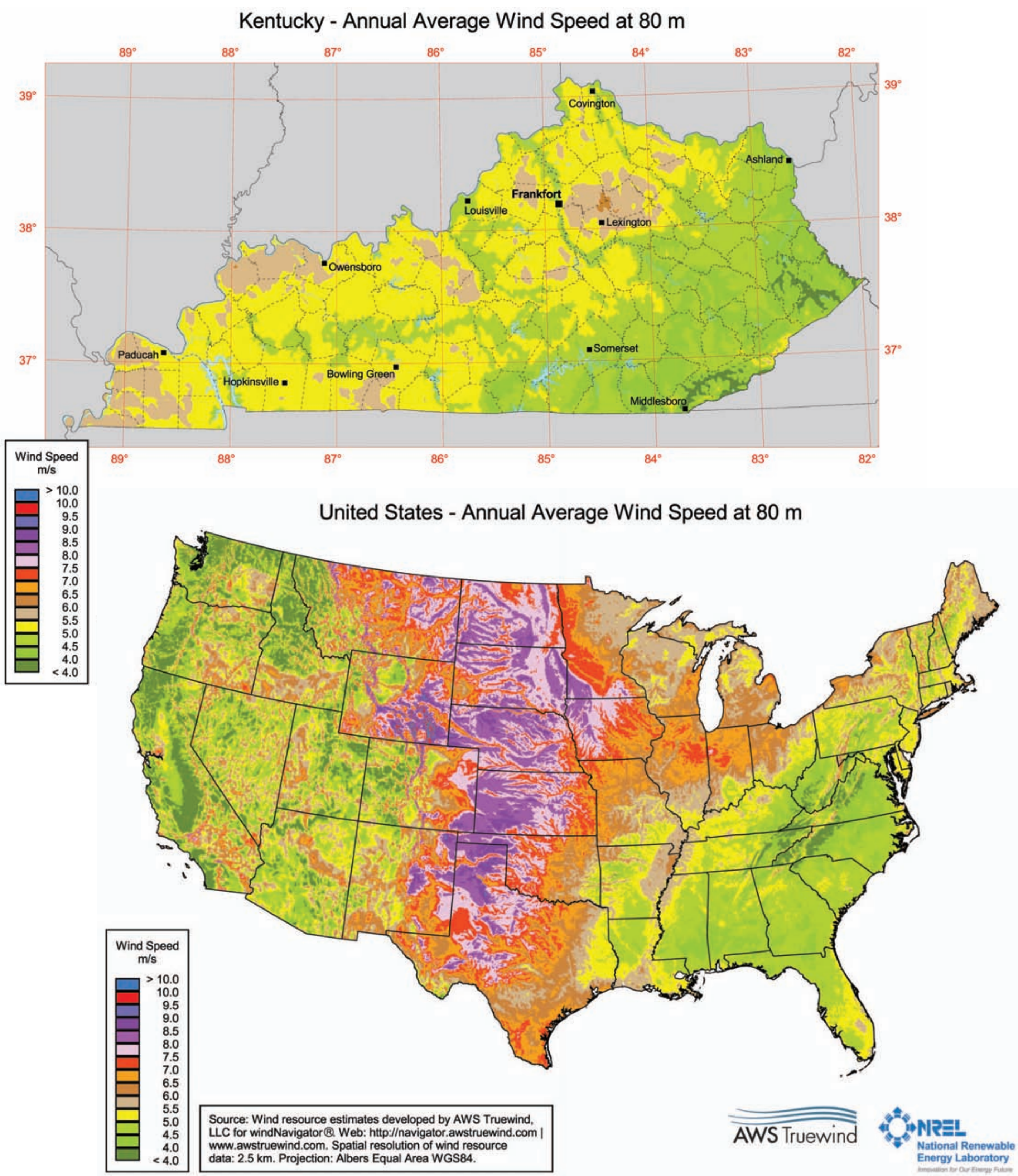


Figure 6 -Wind Resource Maps[7] *The maps show the predicted mean annual wind speeds at 80-m height (at a spatial resolution of 2.5 km that is interpolated to a finer scale). Areas with annual average wind speeds around 6.5 m/s and greater at 80-m height are generally considered to have suitable wind resource for wind development.*

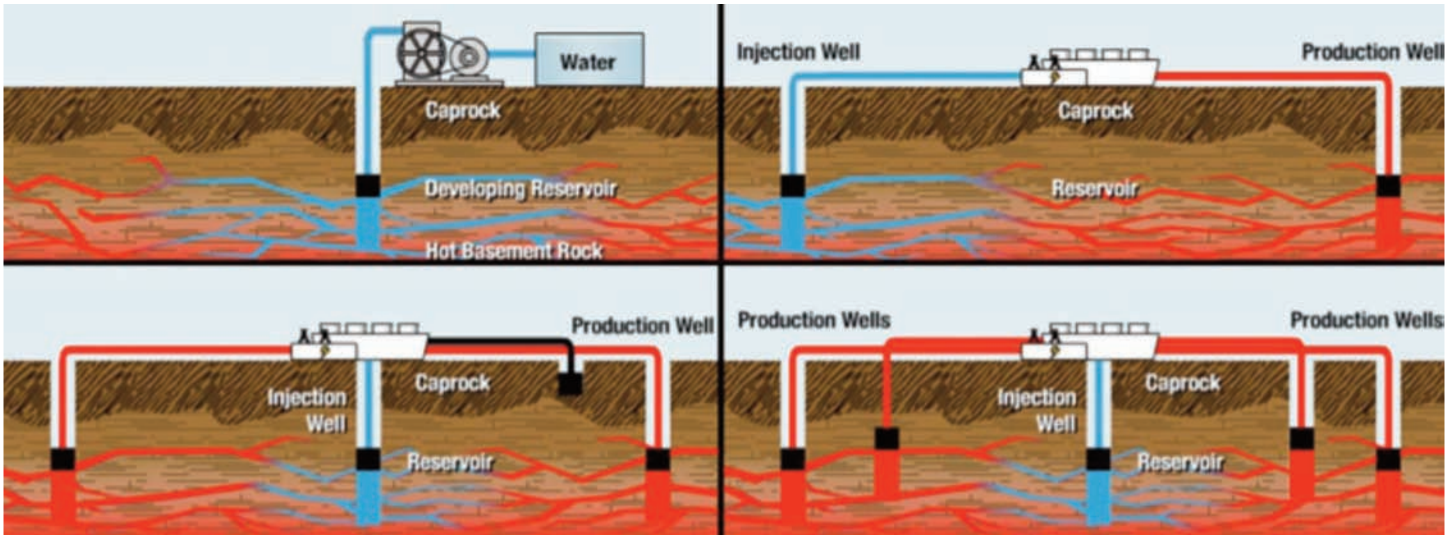
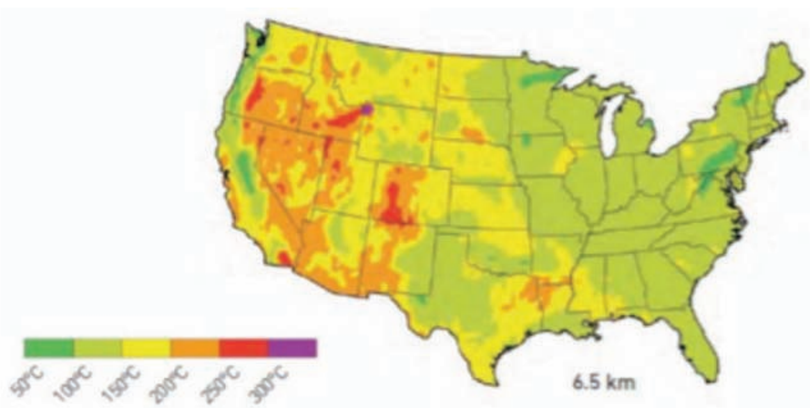
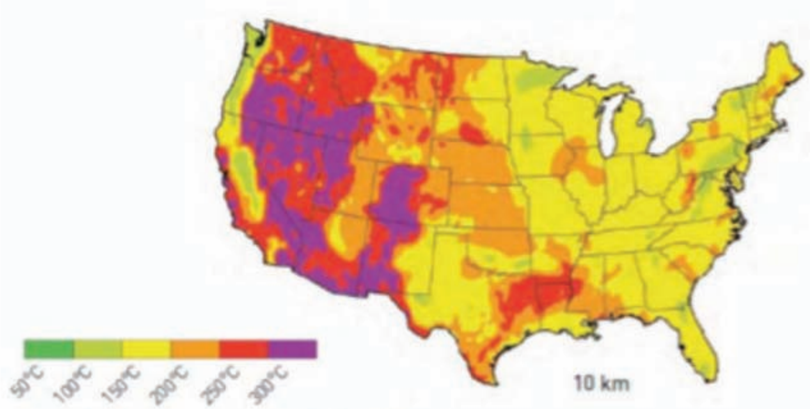


Figure 7 -Geothermal Well Construction[9]



Temperatures at a depth of 6.5 km.



Temperatures at a depth of 10 km.

Geothermal

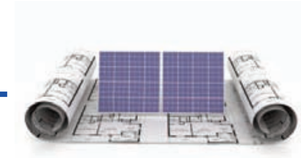
This is the thermal energy stored in the porous rock that makes up the earth's crust. Rock deep in the crust is much hotter than the surface ambient temperature because of the heat flow from the earth's mantle and the decay of radioactive elements.

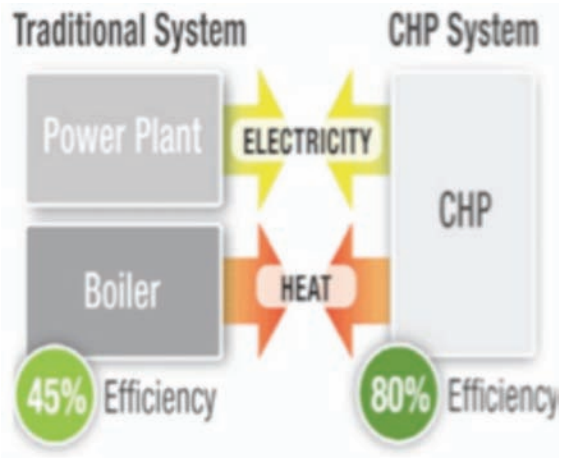
Traditional geothermal plants use existing underground water located close to underground hot spots, taking advantage of natural steam reservoirs. These geothermal plants are mostly located in the American West, close to tectonic faults. New developments have recently emerged that are beginning to expand geothermal applications to a much wider range of geographic locations.

Much of today's research focus is on Enhanced Geothermal Systems (EGS). EGS involves drilling multiple injection and production wells deep into the earth's crust (3-10 kilometers) and pumping pressurized water into the earth to fracture the rock. The resulting network of cracks produces a reservoir that simulates the ideal natural locations discussed above. The images in Figure 7 show the drilling stages in the construction of an EGS plant, starting with the initial injection well and hydraulic fracturing and progressing through the drilling of multiple production wells.

Depending on the depth of the well, temperatures can reach 250°C or higher. Water passed into the injection well is recovered through the production well at high temperatures as hot water or steam. The hot water or steam is used to produce electricity through a stream turbine.[10]

In the western half of the country, these temperatures are reached at a depth of 4.5 km (2.8 mi). To achieve this temperature in Kentucky, as well as much of the eastern half of the country, would require wells about 10 km (6.2 mi) deep. EGS must be developed further in order to expand geothermal technologies to the eastern half of the United States. This technology stands in need of significant research. Simulation and prediction models, high temperature tooling and sensors, and hydraulic fracturing detection are some current barriers to commercialization. The Department of Energy has formulated a Geothermal Technology Research plan with the goal of





CHP Process Flow Diagram

demonstrating EGS technology ready for commercialization by 2015, and capable of producing at least a sustained 5 MW of electricity by 2020.[11]

Lack of test results in the Kentucky area prevented a detailed prediction of geothermal performance, power output, and well requirements. Available data suggested that wells would need to be approximately 10 km deep.

Another important point is that the production of any geothermal well cannot be guaranteed at this time. Wells are found on an experimental basis after drilling and fracturing are performed. Developments in modeling technology in the next few years could shed more light on performance prediction, but currently it is hard to predict how many wells would be required to meet U of L's renewable electricity goal.

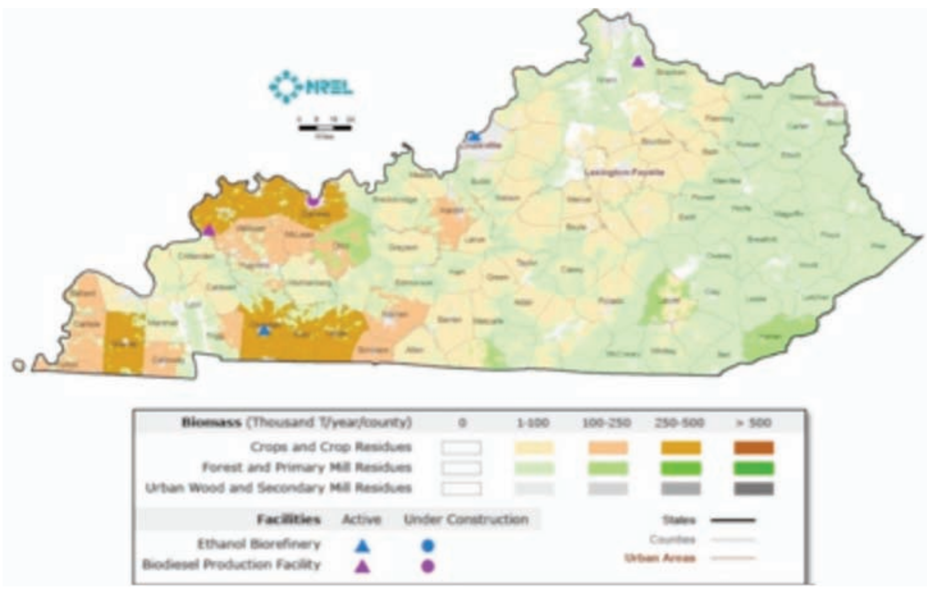


Figure 9 - Biomass density map of Kentucky[13]

Biomass Gasification

Biomass is a broad term that refers to combustible organic material, including agricultural waste, forestry residues, mill and clean urban wood waste, dedicated biofuel crops such as switch grass or willow, and animal waste. Biomass has traditionally been burned like fossil fuels to create steam or mechanical power, but a newer technology, biomass gasification, provides a cleaner, more efficient method to convert biomass to energy. Biomass gasification systems treat the organic material in a low-oxygen combustion reactor, converting the fuel into a gas mixture called syngas. Syngas primarily consists of hydrogen, carbon monoxide, carbon dioxide, and methane. Further treatment can produce a fuel much like natural gas.

Burning the syngas in a combined heat and power (CHP) system produces efficiencies up to 80 percent or higher, as opposed to the sub-30% performance typical of direct-fired applications. Gasifiers also allow a high turn-down ratio with the capability of idling during low load periods, whereas direct-fire biomass or non-biomass fuels can become unstable operating at lower loads.[12]

Figure 10 - Biofuel suppliers within 60 minutes of Louisville[14]

Combined Heat and Power

Combined heat and power (CHP), also known as cogeneration, is the concurrent production of electricity and useful thermal energy (heating and/or cooling) from a single source of energy. CHP involves a suite of technologies that can use a variety of fuels to generate electricity or power at the point of use, allowing the heat that would normally be lost in the power generation process to be recovered to provide needed heating and/or cooling. Cooling can be provided by using steam reduction chillers.

CHP technology can be deployed quickly, cost-effectively, and with few geographic limitations. CHP can use a variety of fuels, both fossil- and renewable-based. It has been employed for many years, mostly in industrial, large commercial and institutional applications.

Because biomass has a lower energy density than fossil fuels, transportation costs limit operations to local fuel supplies to keep costs competitive. Figure 9 is a Department of Energy map showing the biomass density of Kentucky. There are significant urban wood and secondary mill residues in the Louisville area with plentiful crop and forest residues in the surrounding counties. Five ethanol and biodiesel facilities have already responded to these favorable resources. Figure 10, a more detailed analysis from Ecostrat, shows a number of biomass suppliers within a one-hour drive of Louisville.

A self-contained university campus provides an ideal setting for the kind of distributed heat and power that biomass gasification provides. A biomass cogeneration plant could provide some or all of the campus's electricity and heating needs while dramatically reducing fuel consumption.

With a biomass cogeneration plant on campus, the University of Louisville could tap a unique opportunity to produce renewable power while hosting simultaneously an important research and education tool. With biofuel, energy and combustion technologies taking center stage in research, the University would have unlimited access to a valuable R&D platform.

Other schools with more traditional biomass plants have capitalized on their new investments. The University of Minnesota at Morris (UMM) has partnered with the West Central Research and Outreach Center and the USDA, making UMM a hub for renewable energy research and drawing students, faculty, and interested businesses to the school. At the University of South Carolina, a classroom was constructed inside the university's biomass plant to house engineering classes focused on alternative energy.[15]

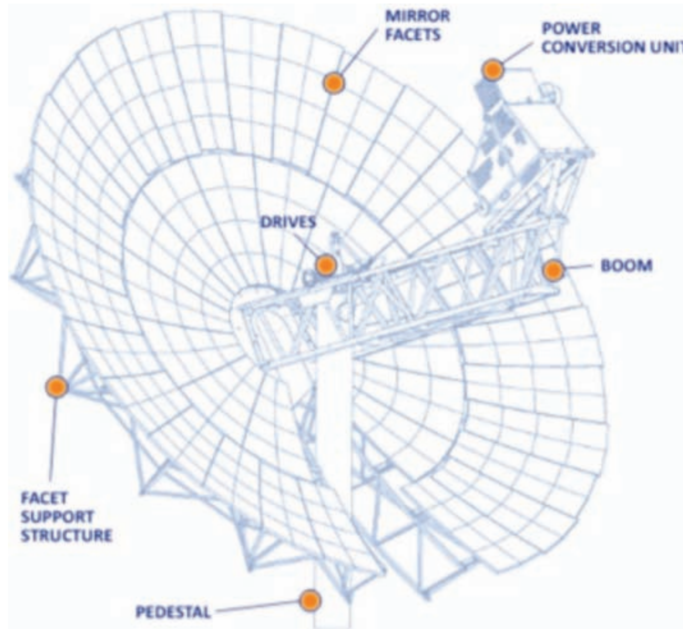


Figure 12 – Solar Dish Stirling Technology

At the University of Louisville, this option could involve a turn-key biomass gasification plant housed in a new building or an extension of the current steam plant. Feedstock storage, conveyors, gasification equipment, piping, and internal combustion engines/steam turbines would be installed on campus to connect with the existing steam infrastructure. Biomass would be delivered to campus by truck in the same manner that coal is currently brought to the steam plant.

The two options for electricity production are:

- *Steam turbine*: Electricity projects that burn biomass generally produce high pressure steam that is fed into steam turbines. These projects are more economical for clients with existing high pressure steam infrastructure.
- *Internal combustion:* Companies like GE Jenbacher and CAT make internal combustion cogeneration engines designed for gases like syngas and are currently pursuing pilot projects to use this technology. The internal combustion engine would generate electricity by burning syngas. Water heated with engine waste heat, along with additional gas, could be fed directly to the current coal-fired boilers (depending on their condition) to produce steam. Internal combustion engines also provide flexibility, as more engines can be added incrementally to increase the plant's capacity. This plant could be scaled up to replace a growing percentage of the electricity used on campus.

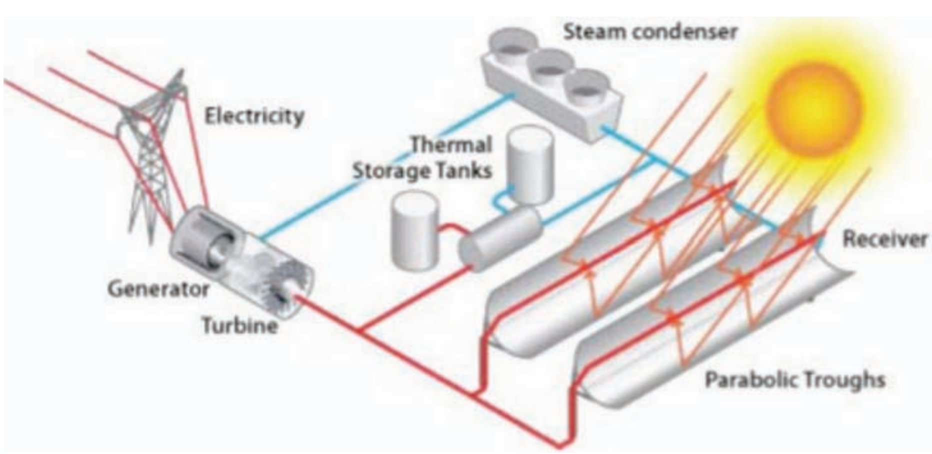
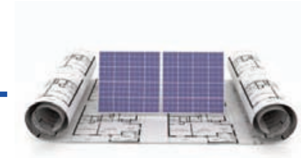


Figure 11 -Concentrated Solar Thermal[16]



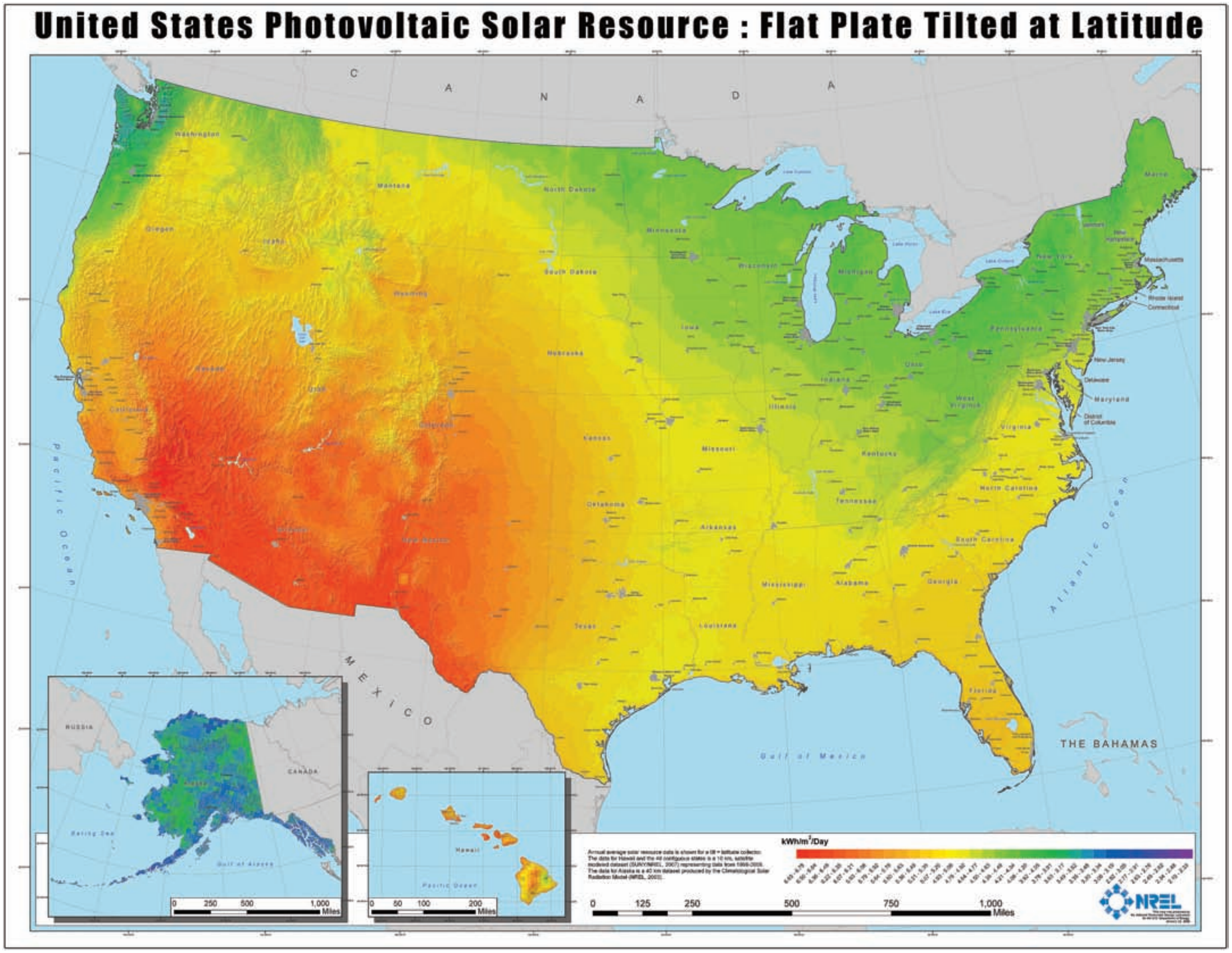


Figure 13 - Solar Resource[17]

Solar

There are three main options for solar energy generation.

Photovoltaic

Solar photovoltaic panels (PV panels) are commonly seen on rooftops of houses and businesses, on road signs and call boxes, and countless other places. These panels contain semiconductors that convert light from the sun into electricity. They come in many shapes and sizes, and their modular structure allows for great flexibility and ease of application.

Concentrated Solar Thermal

Solar thermal does not convert sunlight directly to electricity. Instead, it concentrates the light with mirrors, heating a working fluid that is used to create steam that generates electricity. A schematic illustration of a typical concentrated solar thermal plant is shown in Figure 11. These panels are more efficient than PV panels, but they are not as modular because of the many components involved in the system. Solar thermal plants typically occupy a dedicated site along with a steam turbine and generator.

Dish-Stirling Solar

While technically a type of concentrated solar thermal technology, dish-Stirling solar can be seen as a compromise between the two previously mentioned technologies. New dish-Stirling systems can match the modular nature of PV panels while obtaining the higher efficiencies of the concentrated solar thermal technology. A Stirling engine, the element in the system that produces electricity, is a reciprocating piston engine that uses an external heat source to pressurize internal gas, providing mechanical power. The dish uses mirrors to concentrate the sun's rays on the Stirling engine, located out in the middle of the dish at the focal point of the reflected light. The Stirling engine then powers a small linear generator to create electricity. Figure 12 shows an example system, with the Stirling engine labeled as "power conversion unit."

Pictured here is a well that is used to collect LFG on a landfill.

Kentucky receives about 4.6 kWh/m2/day of solar energy, compared to about 6.7kWh/m2/day in the sunniest parts of the Southwest and 3.6 kWh/m2/day in the cloudy Seattle area. Figure 13 shows the United States' solar resources.

Solar energy fits nicely in the university setting. The panels or mirrors would be a visible reminder to students and faculty of the University's commitment to sustainability. Solar power's clean energy properties give it great marketing potential. It is the must-have option in the energy portfolios of all the greenest companies and universities. Solar power on campus also showcases a university's solar research. Many universities have projects to demonstrate and market their research activities. One such project is the NCSU solar house at NC State. This solar house has seen over 250,000 visitors since it opened in 1981, and it has served as a research and educational tool for the school of engineering.[18]

Landfill Gas

Landfill gas (LFG) is a naturally occurring byproduct of the decomposition of organic material in landfills. The gas is a mixture of methane, carbon dioxide, and nitrogen, with small amounts of other organic and inorganic gases. Landfills across the country produce constant streams of LFG which is typically captured and flared to control odor and greenhouse gas emissions. The gas is increasingly being harvested and cleaned to take advantage of the energy content of its methane. LFG, with proper treatment, can then be used in applications similar to those developed for natural gas.[19]

Landfill gas is currently employed in three primary energy applications:

- *Direct-Fired Boilers:* LFG is dehydrated and pumped into gas boilers to produce hot water or steam for direct heating or electricity production. This is typically the least-cost option for LFG consumption and is particularly attractive for retrofitting existing gas boilers.
- *Gas Turbine Electricity Production:* LFG is dehydrated, cleaned, and pumped into gas turbines for direct generation of electricity. The waste heat from this process can be captured and used to preheat or boil water for direct heating applications, drastically improving overall efficiency.
- *Reciprocating Internal Combustion Engines:* LFG is dehydrated, cleaned, and pumped into internal combustion (IC) engines to produce electricity. Waste heat from these engines can also be captured and used for water preheat or steam production.

These technologies can be installed either on-site at the point of use, or at the landfill. Applications installed at the landfill are usually less expensive and provide electricity to the grid, while on-site installations allow for better campus integration, cogeneration, and direct-to-consumer electricity flow.

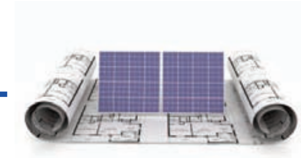
Because LFG has a much lower energy density than natural gas, the economics of transporting the gas over long distances becomes less desirable. LFG-to-energy projects are typically developed only when a landfill is suitably close to potential consumers.

The Waste Management Outer Loop landfill is conveniently located 5.5 miles southeast of the University of Louisville's Belknap campus. Waste Management has selected this landfill to operate as a flagship site, hosting research projects and pilot programs for the company. The landfill is large, having already accepted over 35 million tons of waste, and is projected to remain operational until 2024.[20] Large landfills typically produce LFG for 20 years after closure. MSW landfills are the second-largest human-caused source of methane emissions in the United States.

The following infrastructure components are required for the University to use landfill gas for onsite energy generation:

- *Gas Processing:* Cleaners and scrubbers are required to remove particulate matter, VOCs, NOx, and siloxane from the gas, reducing harmful exhaust emissions and wear on the generating equipment. These facilities are typically located at the landfill. Horizon LFG currently has dehydration and compression equipment on location, but the capacity of this equipment may need to be extended to handle increased gas flow.

- *Pipeline:* The shortest route to the Belknap campus steam plant will require about 6.5 miles of pipeline and negotiations with CSX and possibly the state for right-of-way across and along rail lines and high-



ways. The pipeline itself would likely be a flexible high-density polyethylene pipe approximately 18 inches in diameter, buried less than 12 feet below grade. Such a pipeline would take about six months to construct.[21] A pipeline to the Health Sciences Center in downtown Louisville would be about 10 miles long.

- *Power Generation Equipment:* Either gas turbines or reciprocating internal combustion engines would be required for electricity production. These engines require real estate in or near the existing steam plant so that the waste heat can be fed into a heat-recovery steam generator. Some tie-in modifications will be necessary for both the steam and electrical systems to interface with the new engines.

Conclusion

As of mid-2010, more than 650 college and university chancellors and presidents had signed the American College & University Presidents' Climate Commitment (ACUPCC), which commits their institutions to develop, within two years of signing, an institutional action plan for becoming climate neutral. What this has meant in practical terms is that college and university facilities departments have been rather suddenly tasked with inventorying all of the institution's greenhouse gas emissions – including those from electricity, heating, commuting, and air travel – and with initiating at least two "tangible actions to reduce greenhouse gases" from an ACUPCC-specified list while the comprehensive plan is being developed. One of these actions, pursued by the University of Louisville, is to begin purchasing or producing 15% of the institution's electricity consumption from renewable sources.

To achieve such a goal in such a short time frame, facilities departments are frequently seeking outside help. In the context of renewable power, "sustainability" means selecting a renewable energy system that capitalizes on the useful contributions of available renewable resources – contributions that include reducing carbon footprint, educating the community, and using geographically available resources. All of these potential benefits of each resource must also be measured against economic feasibility. The best solution may not be the most obvious one – and it may involve a combination of technologies instead of just one.

Outside firms can help a university explore which energy sources are locally abundant and which technologies have already been incorporated in the area, as well as available acreage and facilities, to formulate a sustainable energy solution that makes the best use of all local resources and opportunities and provides for the institution's needs while reducing the environmental impact.

Gerald G. Williams, PE LEED AP is a vice president and engineering leader at Cannon Design, a nationally ranked architectural and engineering design firm and has 18 years of experience designing HVAC systems for the built environment. Willliams holds a Bachelor of Science degree in Mechanical Engineering from the University of Missouri-Columbia and is an Adjunct Professor of Mechanical Engineering at Missouri Science and Technology Univeristy at Rolla, Missouri teaching Envrionmental Design.

Punit Jain is a key member of Cannon Design's Science and Tchnology practice, with extensive experience in designing science, education, public and healthcare facilities. He leads teams dedicated to researching techonological and industry innovation in the field of science and research buildings and is involved in the design, research and planning of complex assignments.

Mr. Jain has over 20 years of experience in the practice of architecture and is a nationally recognized thought leader who regularly presents new ideas and solutions that help scientific leaders, through design, to compete more effectively on a global stage.

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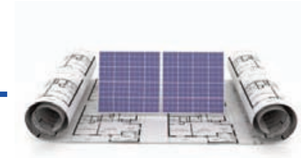

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Renewable Energy in Louisville

Allan Dittmer, Editor

50 killowatt solar photovoltaic array on the roof of the Predictive Medicine Laboratory on the Shelby Campus of the University of Louisville. This is the largest PV array in the State of Kentucky. The DC electric current generated in the solar panels is converted to AC electrical current for use in the various labs.

*Cover Photo

Dual axis solar thermal photovoltaic array on the roof of Sackett Hall, Belknap Campus, University of Louisville. This is the only such tracking array in the State of Kentucky. This device is built to track the sum wherever it is located at a given time. The efficiency of the system is increased by 30% because of its tracking ability.

Two solar arrays on the roof of Ramsey Middle School, one of the middle schools in the Jefferson County Public School System. One array provides hot water for the entire 130,000 square foot school, the other array provides electrical current. The windmill in the background is 45 feet tall and the diameter of the blades is 12 feet providing a 6 foot radius. The windmill generates 2.4 killowatts which is converted into standard 110 voltage for general use throughout the building.

Solar heat pipe on Burhans Hall on the Shelby Campus of the University of Louisville. This device is a Speed School of Engineering student's Master's thesis project and is the only such device in the world. A solar heat pipe transfers energy in the form of heat into the building to provide space heating. This is an active solar system which is more energy efficient than most passive systems.

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