David Kohn
Chris Ellington
EVST 170—Julie Newman

Sustainable Energy at Yale University

The alarm goes off, wake up, turn on the light, stumble to the bathroom, brush teeth with the new vibrating toothbrush, shower, get dressed, grab cell phone, drive to work, turn on the computer, sit under fluorescent lights and the day has begun. This slice of life is only a tiny fraction of what a modern human being does in each day, yet of these common activities only one—waking up—can be done without the use of some sort of artificially generated energy. Abundant energy, produced in large power plants and distributed across society, is one of the most important factors that makes life today so exceptional.

It was only 200-300 years ago that humans first began to use fossil fuels to generate energy. Since coming into major use during the industrial revolution, coal, oil and gas have been society's main source of power. Cheap, easy to create a system of centralized generation around, and their seemingly endless supply have led to huge growth and a lifestyle of ambivalent use (Sorenson, 20). However, as mankind moves toward a sustainable society, the flippant use of fossil fuel energy cannot continue.

Before describing why fossil fuels are incompatible with a sustainable society, we must endeavor to define what sustainability is and why energy use is important to achieve it. *Our Common Future* defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." In order to ensure the chance for a good life for future generations, natural resources and environmental health must be reconciled with economic growth; especially growth that benefits the least well-off among us. The Brundtland Commission definition above encapsulates quite well what we believe is necessary for a sustainable future; it presents a final vision for a sustainable society. However it is too broad to be a working definition to put sustainability into practice.

All aspects of society "…can be understood in energy consumption terms- buildings, services, food, mobility and so on-…," (Droege, 124). It is an inevitable realization that true, palpable progress in creating a sustainable society cannot be made until sustainable energy systems are developed. Then we must find a working definition of a sustainable energy system by applying *Our Common Future's* vision to the case of energy.

A sustainable energy system should have four major characteristics:

1. The energy used must be generated from a resource that will not be depleted over time
2. The process of energy generation and transmission should have no byproducts that are harmful to human beings or the environment: neither through direct pollutants nor through greenhouse gases that lead to global climate change
3. Energy use must be rethought to eliminate waste
4. Energy must be abundant enough to meet demand and allow for economic growth in the future (*Future* Chapter 7)

The current energy paradigm does not meet these characteristics, and requires massive intervention in order to be reconciled with the vision of a sustainable energy system.

The energy system of Yale University finds itself in the place between the individual and the community that is unique to an institution. Unlike a city, an institution can act as a single entity in making decisions concerning energy with far fewer miles of red tape. Likewise, institutions can put a set of common principles concerning energy use, procurement, and generation into practice on a scale much large than that of an individual. Therefore, the position of institution becomes ideal in spearheading sustainable initiatives and experimenting with sustainable practices. Many of the crucial issues in achieving sustainable energy systems will be first resolved or at least addressed at the level of the institution.

The university is a special kind of institution and therefore has a specific role to play in the move to a more sustainable society. Firstly, the university educates the next generation; in a society embracing a sustainable ethic, educational institutions must be leaders so that young people see what a sustainable institution looks like and can more easily put it into practice in the world. In the case of sustainability, a university cannot just focus on theory, for the theory of sustainability necessitates putting it into practice. Secondly, the university is an economic powerhouse: it is a huge and growing industry and serves as a major artery to feed into business and commerce. And finally, the university occupies the place both of an institution with great history and gravitas, and an institution that spurs innovation. Because of all this, the university must be on the vanguard of the movement to a sustainable society (M'Gonigle 41).

This paper will attempt to explore many issues concerning Yale's energy practices and how they may be brought into sustainability. The state of Yale's current energy system will be analyzed and discussed. The chief strategies for bringing energy in sustainability will be outlined, with a focus on designing a set of goals and strategies for renewable energy at Yale University.

The Current State of Energy at Yale

As a university, Yale University's mission is to educate students and to do research. Yale must consume a massive amount of energy to achieve this mission: Academic space must be heated and cooled; computers and research equipment must be provided with a source of electricity, libraries' and museums' internal environment must be constantly monitored for humidity and temperature, and students must be housed and kept happy— the list goes on and on. Due to this consumption and our continual reliance on fossil fuel for energy generation, Yale is responsible for a significant amount of greenhouse gas emissions. With the acquisition of West Campus and the planned addition of two more undergraduate colleges, Yale's energy demand would seem to be on a path towards increased consumption.

In 2005, Yale was responsible for approximately 250,000 metric tons of Carbon equivalent (MTCE). Yale seemed to be on a path toward emitting 350,000 MTCE under business as usual scenarios by 2020. However, in October 2005 Yale committed itself to reducing its greenhouse gas emissions to 10% below 1990 levels by 2020 (GHG). There are two methods to reduce consumption of energy from fossil fuels. They are conservation and transitioning to renewable energy sources. Conservation is achieved in two ways. The first is a conscious intent by the user to reduce his or her energy use by consuming less. The second is the process of upgrading the old and applying the new both in technology and consumption practices outside of the individual with the goal of getting the most work from the least energy; otherwise referred to as energy efficiency. Transition to renewable energy sources means replacing fossil fuel sources of energy to renewable ones. These strategies directly reduce GHG emissions, but there is another method as well that is indirect. Through direct participation in carbon offset projects or simply buying carbon offsets, Yale can have credit for avoiding GHG production. Much like Pacala and Socolow's now famous paper on stabilization wedges, the three wedges of conservation, renewable energy, and carbon offsets make up Yale's grand strategy for meeting its GHG emissions reduction goals. Current progress has been chiefly in the realm of efficiency (GHG). This has been Yale's most significant foray into the realm of sustainability.

In addition to concrete progress in its use of energy, Yale is making moves toward such intangibles as changes in decision making and institutional reform, these will be key in keeping a shift toward sustainable energy development from sputtering and dying. To evaluate where Yale is and how to move forward to becoming an institution that manages energy sustainably, two main frameworks will be useful: Doppelt's seven key leverage points to achieve change toward sustainability and the concepts of vision, goals, and strategies. We will discuss Yale's progress in a number of areas and offer some key recommendations for how to move forward.

Doppelt's first leverage point to achieve change toward sustainability is to "Change the dominant mindset out of which the current mindset arose" (85). In many ways this has happened at Yale. President Levin began changing the mindset of the institution when he took office, though not in the usual way one would think in a move toward sustainability. By changing the financial culture to consider long term financial stability, Levin laid a groundwork that would allow for sustainability principles to be more easily embraced. (Bollier) More concretely and recently, President Levin has been a large proponent of making Yale more sustainable. He often speaks about Yale's greenhouse gas commitment (see for instance Copenhagen remarks) and it cannot be underestimated how much this helps create institutional change. University staff members tend to follow Levin's remarks and know that if he makes the GHG reduction targets a priority, they should too. (Murphy)

Nowhere has President Levin's support been more important in "changing the dominant mindset" than in the area of energy; Yale has moved from a system of evaluating energy projects based on least cost, to making the GHG reduction targets an integral part in decision-making. Importantly, Levin's remarks make clear that he views the GHG targets as a part of a larger vision. The title of his speech in Copenhagen "Leading by Example: From Sustainable Campuses to a Sustainable World," makes this clear, however, it is important to recognize that while combating global warming is an integral part of becoming more sustainable, it is not the only part. President Levin sometimes falls into the trap of equating the two. For the purposes of energy in the university setting, however, combating global warming is the most important factor to take into account.

Two more of Doppelt's leverage points are to "rearrange the parts of the system" and "shift the flows of information and communication in the system."(85). Though there has not been a large revamping of structure, the addition of the Office of Sustainability into consultation and operations changes the way the system operates. The creation and inclusion of the Office of Sustainability will be very important for creating institutional change in energy use, but it will not be enough. Facilities management still controls most of what happens with energy on campus, yet, as we have stated, energy underlies the functioning of the entire university. Though there is a benefit to allowing each player in the system focus on their role and not have to worry about energy on a day to day basis, in the long term, sustainable use of energy must be considered by all players in the system. Drawing on Braungart and McDonough's *Cradle to Cradle* and interview with Stephen Murphy, we recommend that as new projects are planned, sustainable energy use becomes a major factor in design. This will require that the Offices of Sustainability and Facilities Management offer their services to help design other departments' projects to incorporate energy planning. By integrating sustainability measures into each new project, resistance to changes can be minimized by offering new features as a package rather than one by one and designing new systems from the beginning to take into account sustainable use of energy is much easier and more effective than adding energy efficiency measures at the end.

Finally, from a new vision at the top, to rearranging the parts and shifting communication, we approach new goals. The GHG emission targets are specific goals developed in order to move the campus toward a sustainable energy future; Levin showed his commitment to the vision of a sustainable campus by embracing the goals, but the goals are distinct from the vision. Moving from a vision of a sustainable campus to actual practice requires concrete, short-term targets and goals. John Bollier, Associate Vice President for Facilities Operations must justify every expenditure. If the institution had merely embraced the vision of a sustainable campus, he might be able to say that one thing was more sustainable than another, but would have nothing to compare them to. A concrete goal allows Mr. Bollier to make comparisons. With the GHG targets "alternative energy projects requiring significant capital investment by the University are evaluated on the basis of 'resulting carbon reduction per dollar of interest and amortization incurred'" (GHG). Decisions that have a concrete basis, rather than a "this is sustainable" basis, will be important in moving forward. (Bollier)

With goals set in concrete areas the next step is to create and implement strategies and measures. Since Yale's GHG inventory in 2005, significant progress has been made in several areas. Through conservation measures in existing buildings, Yale has avoided the emission of an estimated 13,823 MTCE into the atmosphere. Other progress to date includes efficiency measures in production and distribution and some renewable energy totaling 15,486 MTCE avoided. Though this total may pale in comparison to Yale's long term goal of 73,000 MTCE avoidance per year, this progress is significant in that it shows some concrete change in how Yale makes its decisions. (GHG) Yale's ongoing renovation process is a clear example of how to apply the recommendation to integrate energy sustainability planning into new projects. These buildings were going to be renovated anyway, but the key of adding conservation measures into their design was a product of some recognition of sustainability in an existing change. Considering that buildings constitute 99% of Yale's energy use, conservation measures in buildings are crucial to meeting Yale's GHG reduction goals. (Downing)

Practices for energy conservation have proven immediately effective, but the ultimate pitfall of conservation is that it is inherently limited to itself. The stabilization wedge of conservation/efficiency can only be so much of the total. Yale continues to use massive amounts of energy generated chiefly from fossil fuels in its two power plants. Measures have been implemented on this level as well, such as using cleaner natural gas and adopting cogeneration processes. Still, even major improvements such as these are ultimately ways to make Yale's energy practices less bad instead of more good. Ultimately, Yale must begin to make the switch from fossil fuel generation to generation from renewable resources.

Yale's GHG reduction goals will not be enough to facilitate the switch to renewable energy in the short term. Renewable energy technologies are still relatively expensive compared both to fossil fuel technologies and many other carbon reduction options, in addition they are quite capital intensive. Because of this, they will have a much harder time getting started than many conservation projects. Yale is beginning to move into a phase where more capital-intensive projects to meet the GHG reduction goals are accepted, but it is not without effort that this occurs. (Bollier) The difficulty in getting projects started is reflected on campus. Renewable energy makes up .07% of Yale's energy mix and on campus development is mostly limited to small demonstration projects. (Exec Summary) In order to increase investment in renewable energy it will be necessary to develop a set of renewable energy targets, much like those developed for GHG reductions. (Bollier) It is imperative that renewables become a larger part of Yale's energy mix; not only are they an integral part of a sustainable energy vision, but they also pose one of the greatest challenges to achieving that vision. Yale's situation as an institution with immense resources, stature and ability to push innovation make it particularly suited to address renewable energy head on.

Developing a framework to adopt renewable energy will take much discussion, as the questions involved are very complex. In the next section we will attempt to begin such a discussion and offer some key recommendations as to the path forward.

Developing a Renewable Energy Plan

"Where there is no vision, the people perish…" –Proverbs 29:18

Though it feels as if we have harped on this point incessantly, the process of developing a renewable energy plan must be grounded in a strong long term vision. Only then will a sustainability effort be able to keep the momentum needed to create true change. In addition, there must be a sense of urgency, only then will change efforts succeed. (Doppelt 79, 95) We laid out a vision of sustainable energy earlier in the paper, and the final renewable energy vision for a campus would be a stable, abundant energy flow coming entirely from renewable sources. A similar vision should be hashed out and agreed upon by the players and stated specifically as a long-term vision as a part of the renewable energy plan. After deciding upon a vision, the next task is to agree on short term goals and metrics.

Rauch and Newman, and Graedel offer frameworks for developing metrics to achieve sustainability. The first step is to decide upon the timeframe for which resources are to be sustained and over which the plan is to be implemented. We will use Rauch and Newman's classification of timescales: generational 20-25 years, mid-term up to~50 years, and visionary ~100 years or more (7). Our vision deals with the visionary timescale, but our plan will focus mostly on the generational timescale with some forays into the mid-term.

The development of a plan then depends on two basic influences: 1) looking outwards at regulations developed by various levels of government, the current state of science and its projections into the future, and 2)looking inward at what is feasible for the institution to achieve, what the current and projected condition of renewable energy within the institution and what fits best with the overall goals of the institution. Which area gets the most focus depends upon the timescale over which the plan is to be implemented and the values of the stakeholders. (9) We will look outward at current initiatives and then evaluate how the best ideas can be applied to Yale as an institution.

Looking Outward

Of immediate importance Yale are initiatives that Connecticut has adopted as part of their longer term energy plan. These initiatives are Connecticut's Renewable Portfolio Standard (RPS) and the Connecticut Clean Energy Fund (CCEF). Like any RPS, Connecticut's renewable portfolio standard forces energy providers to get a portion of their energy from renewable sources at an increasing rate (2007 CT Energy Plan). The Connecticut Clean Energy Fund bolsters this initiative by providing funding for various renewable energy projects. The RPS of Connecticut requires 20% of the state's energy to be generation from Class I resources, 3% from Class II resources, and 4% from Class III resources totaling 27% by 2020. Class I resources are the most renewable consisting of solar, wind, biomass, fuel cell and some kinds of hydroelectric resources. Class II consists of methane-recovery generation sources and other types of biomass and hydroelectric facilities. Class III resources mostly do not even fall under the renewable energy category in that they are end-use efficiency measures on the side of the customer. They range from cogeneration systems for commercial and industrial buildings to simple efficiency measures in family dwellings. (CT Incentives for Renewable Energy)

In addition to the Connecticut RPS, in 2004 Governor Rowland signed executive order 32 requiring that state government and universities work toward the goal of Class I renewable purchases of 20% by 2010, 50% by 2020 and 100% by 2050. New Haven recently committed to 20% renewable power for its facilities by 2010. (State Energy Program)

Connecticut is not the only state to adopt renewable energy initiatives. In fact, 29 states including the District of Columbia have enacted renewable portfolio standards for themselves. However, in the absence of strong federal guidance in this area, these initiatives vary significantly in how they are conceived and measured. Connecticut's standard stands out as the most ambitious to date with its 27% requirement by 2020. Other states such as Texas have taken a different approach. Instead of a proportional requirement they chose to set the goal of 5880 MW of renewable power generation by 2015. Although a small portion of their total energy load, the incentives brought about by

Texas's renewable energy initiative has led to rapid proliferation of wind-power generation facilities in what has been called a "wind rush." (Texas RPS) Vermont has also employed a different model to bolster growth in renewable energy in its state. In lieu of a single standard for energy supplies, Vermont has set three separate goals. The first is to meet all new energy demand from growth between 2005 and 2012 with renewable energy sources. This means that all new facilities would use renewable sources to generate energy. This is partnered with two RPS goals of 20% of retail energy sales from renewable sources by 2017 and 25% of all energy consumed within the state being renewable by 2025. We can see here the vast range between Texas's and Vermont's RPS initiatives. Texas made a solid numerical goal that could be realistically achieved and has created growth in renewable energy, while Vermont has created a set of goals that calls for significant restructuring of infrastructure. It is clear that RPS initiatives, while commonly seeking to foster renewable energy use, can vary drastically in their scope and implications. (Vermont RPS)

Federal policy in the United States has been much more disjointed. Though there is broad agreement among scientists on the severity of climate change, disagreement within the government has been major and action has stagnated. The government promotes renewable energy technologies, but has stopped short of mandating goals for businesses or utilities. (Carleyolsen) Recently, however, the government set renewable energy portfolio goals in the Federal Energy Management Program of at least 3% from 2007-2009, 5% from 2010-2012, and 7.5% from 2013 onwards. At least half of this will come from new renewable resources. These goals are significant because the federal government is the largest single consumer of electricity in the United States. (2007 FEMP)

Applying it to Yale

After looking outward at regulations that have already been developed, we must look at what is appropriate and feasible to apply to the case of Yale. The GHG reduction targets loosely specify that 65,000 MTCE of reductions should come from renewable energy sources, or approximately one third of reductions. Another third will come from buying carbon offsets, some of which could be in the form of renewable energy. Ideally, the entire allotment for carbon offsets would be replaced by renewable energy and efficiency measures. (GHG/Bollier) These, however, are merely basic targets and do not provide the concrete goals we must have it we are to invest in renewable energy effectively.

The most logical place to begin is with Connecticut's RPS for utilities. Yale produces much of its own electricity and all of its heating and cooling, it seems reasonable to say, as a starting point that Yale ought to meet the standards that Connecticut sets for all of its utilities. (Bollier)

Before we take this as our standard let us look at a couple of other possibilities. The federal government's portfolio standard pales in comparison to Connecticut's and, for this reason, probably ought not be used. The Connecticut governmental standards (20% in 2010-100% in 2050) are quite high, and considering that Yale currently uses approximately .07% renewable energy are probably unreachable and an extremely high path. The problem with going to such a high path is that it would encourage administrators at Yale to invest mostly in buying off-campus renewable energy credits rather than being creative to reach lower, more realistic goals. The goals presented by looking at and extrapolating from scientific trends in Graedel are quite similar to the Connecticut government goals and are not useful for the same reasons. Goals reached in a similar fashion in Rauch and Newman, follow a linear path of increasing share of renewable energy from 10% in 2010 to 15% in 2030 are not strict enough in our opinion. In fact, Rauch and Newman leave open the idea that because carbon sequestration is unlikely to be undertaken by a university, the goals might have to be higher. (14) The linear path also seems a bit lenient, it is much more likely that as investment begins, there will be a small increase and then an increasing rate of growth as investment continues.

Because of the reasons listed above, and the controlling factor that all other utilities in Connecticut will be required to meet them, we recommend that the Connecticut RPS be the starting point for Yale's renewable energy goals. However, a starting point is all the RPS should be. There are many other factors that must come into play when designing a renewable energy system for a campus that are not as important when developing one for a state.

On-Site vs. Off-Site Generation

Actual physical implementation of renewable energy initiatives requires the institution to choose one of two possibilities for the location of these facilities: on-site or off-site. On-site generation offers three major advantages over off-site generation. First, on-site generation serves as visible evidence of policy. Aside from their actual power generation, on-site facilities communicate a clear statement of the importance of renewable energy to the public on behalf of the university. More than advertisements showing how green Yale has become, on-site facilities also bring energy into the immediate awareness of students and the public. Imagine that a student walking up science hill notices the wind turbines on Kline Biology Tower, and subsequently thinks just a little bit more about the role of energy in society. This thinking is crucial in breaking the embedded ambivalence toward energy that pervades American society. As policy tools as well as renewable energy sources, on-site facilities gather impetus for change by interacting with the public. (Bollier)

In a similar vein, on-site generation facilities have the benefit of being tools of education. Yale is a university constantly on the cusp of scientific progress, and it follows that installing on-site generation facilities for Yale would create an opportunity for innovative and experimental technologies to be tested in a real-world setting. Yale students would be able to gain hands-on experience with renewable generation technologies previously far from any public sphere. Yale would be serving to fulfill its role as an educational institution in installing on-site renewable energy generation facilities.

The final advantage to on-site generation is the ability to reduce exergetic losses, or in other words, to match the quality of energy produced to the quality needed. (Rosen and Dincer) Electrical energy is more valuable than heat, and it is produced with much lower efficiencies, so it almost never makes sense to convert electrical energy (which we have often used heat energy to make) into heat. However, it often does make sense to use waste heat from producing electricity to heat campus buildings. This exergetic concept is the major force behind the increased efficiency of Yale's co-generation plant. Renewable energy imported from off-site will almost always be in the form of electricity as it is the easiest to transmit. It will become increasingly important, however, for lower value energy to come from renewable sources, especially as the fraction of total consumption that renewable energy makes up increases. It is also worth noting that heating and cooling make up a large portion of our fuel and energy use on campus. (Exec. Summary) Any renewable energy target that only takes electricity into account will be highly flawed. Two of the most promising renewable energy technologies for on campus utilization are solar thermal (specifically evacuated solar tubes) and geothermal energy. (Downing) Both of these technologies provide direct exergy matching benefits. Solar thermal technology has the possibility of providing hot water for buildings where use is intensive and even the possibility of providing for some of the space heating needs. (Boyle 36-39) Geothermal ground source heat pumps provide the opportunity to preheat or cool incoming air and reduce the energy loads for heating and cooling. (366-7)

Despite these advantages, on-site generation has some severe setbacks that limit its ability to be a complete solution to the energy problem. On-site facilities are limited in scale due to the limited size as well as also to the geographical characteristics of the site itself. The amount of sun, wind, geothermal energy, etc. available on the site of the institution is likely to be less than ideal for that type of energy generation. To get a significant amount of energy, renewable generation facilities must be optimized to their environment and given a certain economy of scale. This is only possible with off-site facilities. Here a wind farm could be sited to a place that has the most wind, and made large enough so that it generates an amount of energy comparable to fossil fuel-based generation plant. The scale factor that increases the energy generated also makes the facility as a whole far more financially sound.

In the short term, on-site facilities are advantageous in creating impetus for change through education and just being there, as well as tailoring energy production to the unique energy consumption practices of the institution. These advantages are crucial in fostering a relationship with energy that extends into the future, but do not address how an institution such as Yale could meet its renewable energy goals. Specific goals for on-site generation should be set based on feasibility and potential on campus. Off-site generation facilities are still integral to the getting enough renewable energy to Yale in order to meet its renewable energy goals, however, investments should be evaluated differently in order to take into account the benefits of on-site generation listed above.

When investing in on-site or off-site resources, it is important to keep in mind what kinds of technologies these renewable generation facilities will use. Connecticut's RPS program plans for significant growth in Class I renewable power sources, however, all Class I sources are not created equal. Much of Connecticut's recent development in Class I resources has come from fuel cell and biomass generation sources. (News Release) While fuel cells will be increasingly helpful in the future, currently they are often run using non-renewable sources of energy; either type is classified as a Class I resource by the state of Connecticut. Biomass energy may have a part to play in a sustainable energy future, however, it must be recognized that its role is somewhat limited. In addition to current concerns about land allocation, it is still combustion that releases both GHG's and conventional pollutants. These are still a large improvement from fossil fuels, but probably ought to be valued less than sources such as wind, solar and tidal energy as Yale looks to invest. (Boyle 139)

Reinvesting in Yale's Renewable Energy Future

Though Connecticut's RPS offers a good system to set goals for Yale's renewable energy portfolio, the focus of Yale's investments should not be in compliance. This means that if faced with the choice of buying renewable emissions credits (REC's) to meet the RPS quota or investing in long term projects that require significant capital and have longer payback periods, the long term goals of improving campus infrastructure should be the priority. Investment in such long term projects, however, should be greater than or equal to the amount that would have been paid to buy REC's to provide for that year's quota. Yale's top priority should be the long term restructuring of its infrastructure, not meeting short-term renewable energy targets, though the targets provide a useful measure for how much should be invested. When investing in outside projects it will also be important to learn from the successful investment programs in Germany and other European countries. By guaranteeing long-term contracts for renewable energy at certain above market prices, Germany has been able to spur much more significant investment than in most other countries around the world. (Wüstenhagen) Yale should realize that effective investment is long term, and when it commits to outside projects, it should commit to them for a long period of time.

Integrating Renewable Energy into Yale's Overall Vision

Goals to move towards sustainability cannot be divorced from the underlying purpose of the institution from which they come. Yale's fundamental vision is to be a, if not the, premier institution for education and research in the world. This must be reflected in the renewable energy targets, as well as all other sustainability targets. The journey to sustainability has many, many more twists and turns in its path, all of them will need to be researched, and subsequent generations of students will need to be taught better ways of doing things and looking at the world. The move to sustainability should be viewed as a living laboratory. Projects should experiment with new ways of doing things, and as many as possible should be researched to see if theory has translated to practice. Classes should be encouraged to visit and explore sites and projects to learn by doing. Not only will this integrate sustainability into the overall goals of Yale, but by learning from the process, the move toward sustainability can be sustained and enhanced.

Conclusions

We have outlined from first principles of sustainability and energy use a rough plan for Yale to move forward in reshaping its energy practices. We have specifically focused on beginning a discussion about developing a renewable energy portfolio and plan for Yale. The topic of energy is too large and too complex to be even remotely well addressed in a paper of this length, so discussion has been necessarily cursory. We will offer five key recommendations that we believe can be useful in moving forward and helpful in creating a more developed energy plan to move towards sustainability.

Recommendation 1: Integrate thinking about sustainable energy use into all new projects.

Recommendation 2: Formulate a set of goals for renewable energy use separate from Yale's GHG reduction targets using Connecticut's RPS as a starting point.

Recommendation 3: Take into account the benefits and costs of on-site and off-site renewable energy resources when making decisions about which to invest in.

a) In the short term, the benefits of visibility and cultural change from on-site investments will be controlling.

b) In the long term, investments in larger scale projects will be necessary to meet growing demand.

Recommendation 4: Prioritize the long-term betterment of Yale's infrastructure over investing in REC's or carbon offsets to meet short term goals.

Recommendation 5: Make the move to sustainability a living laboratory, integrating sustainability into Yale's overall educational and research goals.

Works Cited

Bollier, John. Personal Interview. Ed. David Kohn., 2008.

Boyle, Godfrey, ed. Renewable Energy. Oxford: Oxford University Press. 2004

Carleyolsen, S. "Tangled in the Wires: An Assessment of the Existing U.S. Renewable Energy Legal Framework." NATURAL RESOURCES JOURNAL 46.3: 759.

Connecticut Department of Public Utility Control. News Release:DPUC Announces Approval of New Renewable Energy Projects in the State.

Connecticut Energy Advisory Board. 2007 Energy Plan for Connecticut., 2007.

Database of State Incentives for Renewable Energy. "Connecticut Incentives for Renewables and Efficiency: Renewables Portfolio Standard." 07/08/2007 2007. <http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=CT04R&state=CT&CurrentPageID=1&RE=1&EE=1>.

---. "Texas Incentives for Renewables and Efficiency: Renewable Generation Requirement." 07/08/2007 2007. <http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=TX03R&state=TX&CurrentPageID=1&RE=1&EE=1>.

---. "Vermont Incentives for Renewables and Efficiency: Renewable Portfolio Goals." 03/25/2008 2008. <http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=VT04R&state=VT&CurrentPageID=1&RE=1&EE=1>.

Doppelt, Bob. Leading Change Toward Sustainability: A Change-Management Guide for Business, Government and Civil Society., 2003.

Downing, Tom. Personal Interview. Ed. David Kohn., 2008.

Droege, Peter. The Renewable City : A Comprehensive Guide to an Urban Revolution. Chichester, England ; Hoboken, NJ: Wiley-Academy, 2006.

Graedel, . "Quantitative Sustainability in a College Or University Setting." International Journal of Sustainability in Higher Education 3.4 (2002): 346. .

Haas, . "How to Promote Renewable Energy Systems Successfully and Effectively." Energy policy 32.6 (2004): 833. .

Hepbasli, Arif. "A Key Review on Exergetic Analysis and Assessment of Renewable Energy Resources for a Sustainable Future." Renewable and Sustainable Energy Reviews, 12.3 (2008): 593-661.

Langniss, Ole, and Ryan Wiser. "The Renewables Portfolio Standard in Texas: An Early Assessment." Energy Policy, 31.6 (2003): 527-35.

Levin, Richard C. Leading by Example: From Sustainable Campuses to a Sustainable World. University Of Copenhagen:, 2008.

M'Gonigle, M., and J. Starke. Planet U: Sustaining the World, Reinventing the University., 2006.

Murphy, Stephen. Personal Interview. Ed. David Kohn., 2008.

Newman, J., and J. Rauch. "Defining Sustainability Metric Targets in an Institutional Setting." International Journal of Sustainability and Higher Education (2008).

Pacala, S., and R. Socolow. Science 305.5686 (2004): 968. .

Roland, JohnG. EXECUTIVE ORDER NO. 32., 2004.

Rosen, Marc A., and Ibrahim Dincer. "Exergy as the Confluence of Energy, Environment and Sustainable Development." Exergy, An International Journal, 1.1 (2001): 3-13.

Sørensen, . Renewable Energy. Burlington: Elsevier, 2004.

"State Energy Program: Connecticut Progresses Toward Renewable Energy Goal." US Department of Energy: Energy Efficiency and Renewable Energy. April 2007 2007. <http://www.eere.energy.gov/state_energy_program/project_brief_detail.cfm/pb_id=1123>.

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Federal Energy Management Program. 2007 Federal Energy Management Program (FEMP) Renewable Energy Requirement Guidance for EPACT 2005 and Executive Order 13423 Final., 2008.

US Environmental Protection Agency. "Renewable Portfolio Standards Fact Sheet." 02/01/2008 2008. <http://www.epa.gov/chp/state-policy/renewable_fs.html>.

World Commission on Environment and Development. Our Common Future. Oxford: Oxford University Press, 1987.

Wüstenhagen, . "Green Energy Market Development in Germany: Effective Public Policy and Emerging Customer Demand." Energy policy 34.13 (2006): 1681. .

Yale University. Executive Summary of Natural Resource use., 2008.

Yale University. Greenhouse Gas Reduction Strategy (GHG). 2005.