Where Energy Efficiency and Alternative Energy Work, Where They Don't, and Why

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> "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."
> — *Richard Feynman*

ABSTRACT

We need rational selection of energy projects.

In 1973, the first Arab oil embargo made depletion of energy resources a worldwide concern. The world quickly recognized the two possible responses—finding new sources of energy and using available energy more efficiently.

Beyond that, there has been little consensus about which new energy sources to pursue, which conservation measures to accomplish, and which technology to develop further. Instead, most such decisions have been made without regard to the objective value of the actions taken. Energy investments are guided by personal preference, proprietary interests, popular enthusiasm, and the desire to exploit government incentives.

As a result, progress toward a secure energy future has slowed to a crawl. Society is investing its remaining time and finite resources carelessly. The pervasive problem among individuals, businesses, and nations is failing to judge energy projects in terms of their real ability to save or produce energy under the conditions that exist.

To provide a rational basis for evaluating energy projects, we offer a procedure that is easily accomplished by anyone who is capable of using available information. The evaluation consists of ten questions. (They weren't modeled after the Ten Commandments, nor was a round

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number sought; ten just worked out right.) Most of the questions can be answered with an internet search. A few of them require deeper knowledge, which can be acquired from books or appropriate consultants. One question requires a judgment about the capabilities of the investor.

This series of questions will determine whether a particular energy investment is worth pursuing. It also provides cogent comparisons between different energy investments, no matter how much they may differ in type or scale. The evaluation method works for a company deciding whether to invest millions of dollars for a new energy source, or for a homeowner deciding whether to install a programmable thermostat.

QUESTION #1:
WHAT IS THE ENERGY RETURN RATIO OF THE PROJECT?

We start with this question because it is the most important. The energy return ratio (ERR) is the ultimate make-or-break criterion for any energy project. It is possible to work around other obstacles to success, but an inadequate ERR is insurmountable. If the ERR for a project is not high enough, invest your resources elsewhere.

The ERR is the ratio of the energy output to the energy input of any process that is intended to produce energy or to save energy. For example, assume that you build a wind farm. A large amount of energy is required to manufacture and install the equipment. This includes the energy required to make the materials, the energy needed to support the workers who produced the materials, etc. Additional energy is consumed during the life of the wind farm for maintenance and administration. The sum of all this energy is the input energy. If the wind farm produces three times the input energy during its service life, it has an energy return ratio of 3:1.

The ERR applies similarly to energy that is produced and to energy that is saved. Thus, it provides a valid basis for comparing investments in energy conservation with investments in energy supply.

The Lost Criterion

It should be obvious that any investment involving energy should involve a calculation of the net amount of energy that is produced. Yet, this is commonly ignored, with the return on projects being calculated solely in terms of money rather than energy. This is one of the biggest flaws in analyzing energy investments today.

The ERR is determined by the laws of physics. It is immutable and directly indicates the effectiveness of a project in doing what we want to achieve, which is to produce or to save net energy. In contrast, the financial rate of return is commonly subject to distortions that obscure the fundamental value of the project. These include interest rates, government subsidies, and business deals that occur in the background. Such factors can make the intrinsic worth of projects impossible for investors to judge.

For example, the present growth of wind farms is largely motivated by government subsidies and utility mandates, which invites financial speculation that may occur at the expense of taxpayers and gullible investors. With only financial information available, we don't know whether wind energy is fundamentally a good thing or a sucker trap. The ERR is the ultimate check on the financial soundness of an energy project. If the ERR of a project is low, the financial rate of return is built over quicksand, and the framework that supports it is vulnerable to collapse.

Avoid Low Energy Return Ratios!

An ERR of 1:1 indicates that a project exactly breaks even in terms of energy. Naively, some authorities say that all projects with an ERR greater than 1:1 merit consideration. That is incorrect. In order for a project to be worthwhile, it needs an ERR that is substantially higher. An ERR in the range of 3:1 to 5:1 is probably the lowest that makes sense for efficient use of resources.

Here's why. Let's say that you want to invest in producing oil, using oil as the energy source for production. With an ERR of 4:1, you need to burn one barrel of oil to produce the first four barrels that can be used by society. However, you want to keep the process going. So, you take one of the useful barrels you produced and burn it to produce another four barrels. If you continue this way, you eventually burn one barrel for every three useful barrels produced.

Now, suppose the process has an ERR of 2:1. Repeat the calculation, and you will see that you need to burn one full barrel of oil for every useful barrel that is produced. If the ERR is 1.5:1—and several proposed new energy sources offer such low ERRs—you need to burn two barrels for each useful barrel that is produced. And finally, if the ERR is 1:1, the process does nothing but burn oil, with no net production for society.

In any project that has a low ERR, much of the energy produced, or much of the savings achieved, is absorbed by the process. That amount of new energy or savings potential never becomes available to society in useful form. However, the wasted energy does produce pollution that enters the environment. Also, low-ERR projects disproportionately consume materials and labor.

Unfortunately, the waste of resources by low-ERR projects becomes less obvious when one form of energy is used to produce a different form. For example, we tend not to see the futility of low ERR when using natural gas to produce shale oil, or using diesel fuel to produce ethanol, or using electricity to make solar panels. But, the principle is the same.

Bottom line: Projects with low ERRs are marginally productive, they squander resources, they pollute the environment, and they are financially risky.

Caveats in Using the ERR

A weakness of the ERR is that it does not account for the differences in time between the energy input and the energy output. For example, most of the energy input for a wind farm occurs before it commences operation, while the energy production of the wind farm occurs slowly over the life of the facility, which may be 50 years. The relative value of the input and output energy can change drastically during that period. Also, other critical changes can occur, such as obsolescence of the technology. This time difference in energy value suggests that investments for good energy projects should be made sooner, when the initial investment is cheaper to make, rather than later.

The energy input of the ERR should be tracked back to the original natural resources that are consumed. For example, if the energy input to the project is in the form of electricity generated by burning coal, the energy input should be calculated back to the energy content of the coal.

The ERR does not distinguish the relative values of different kinds of energy sources. For example, it does not distinguish between natural gas or coal, a weakness that may be tolerated when making a broad screening. This weakness could be compensated, if appropriate, by asking an additional question about the relative value of the input sources.

The ultimate point of the ERR is to make the best use of energy sources that are finite and exhaustible. Therefore, input energy does not include energy that is considered to be inexhaustible. For example, the input energy in the ERR would include coal or natural gas, but not sunlight, tidal energy, or geothermal energy. The distinction is not always as clear as it may seem. For example, hydropower may seem inexhaustible, but the silting of dams gradually renders the resource unavailable.

Finding ERR Data

Because the ERR has not been widely used in evaluating energy projects, it may take some effort to determine the ERR for a particular project. ERR data are increasingly available for energy supply technologies and projects such as oil production and corn ethanol. Unfortunately, for most energy efficiency investments, ERRs are still unavailable. For those, the new part is calculating the energy input, which comes in the form of materials, equipment energy consumption, and labor.

If the main energy input of the project is in the form of materials, such as insulation, concrete, or steel, you can look up the "embodied energy" (also called "embedded energy") of the material. The energy input for equipment, such as trucks and backhoes, includes its own embodied energy and the fuel it uses. If the energy input is largely in the form of labor, as in a "delamping" project, energy input can't be judged accurately. It consists mostly of the amount of energy that is consumed by the workers and their family members who are not employed. This energy input varies widely among individuals, and data are difficult to compile.

A fallback is to use a hybrid approach, using cost as a surrogate for energy content. This is most accurate for bulk materials. However, it also serves as an approximation for labor. American labor is much more expensive than Chinese labor, largely because the average American worker is associated with much more energy consumption than the average Chinese worker. (As Asian workers have become more prosperous and use more energy, their labor costs have also risen.)

Using cost as a surrogate for energy input is most valid when the ERR is high, and is invalid when the ERR is low. If it is clear that a project will pay off quickly in financial terms, without major price distortions, we can tolerate uncertainty about the input energy.

Examples

- For generating electricity, the energy return ratio of coal is estimated between 2.5:1 and 10:1; for nuclear power, about 4:1; for hydroelectric power, about 10:1.
- The ERR of oil and gas production initially exceeded 100:1. By the 1970s, the ERR had dropped to the vicinity of 20:1, and by the 1990s, the ERR had dropped to the vicinity of 10:1. This tells us that oil and gas are rapidly approaching a point where they are not beneficial to recover, even though large amounts remain in the ground.
- The ERR of replacing ordinary incandescent lamps with LED lamps is about 6:1. This ratio promises to improve along with the technology.
- The ERR of present photovoltaic technology is less than 1:1. Therefore, it cannot be an energy source for the future. A major improvement in conversion efficiency or production technology is needed to make it viable. Even in the most optimistic projections, the ERR would be marginal.
- The potential ERR of competent, energy efficient building design (in contrast to contemporary architectural design) is very high. It probably exceeds 10:1 for residential housing, and it probably exceeds 50:1 for larger, complex buildings, such as hospitals, hotels, and office buildings.
- The ERR of energy efficiency retrofit projects in the industrial and buildings sectors varies from less than 1:1 to more than 100:1, depending on the nature and scale of the project. For example, replacing old electric motors with high-efficiency motors yields ERRs that typically range from 2:1 to 10:1.
- The ERR of corn ethanol is controversial, variously estimated between 0.8:1 and 2:1. The difference hardly matters. As long as the ERR is within this low range, corn ethanol is not a desirable energy source. (This is aside from its severe adverse side effects.)
- The ERR of solar collector space heating systems is much lower than 1:1. Therefore, no form of incentive can make solar heating systems a useful contributor to our energy future. (This fact was

calculated at the time the systems were first promoted, but nobody wanted to hear it. Many systems were installed, but few remain.)

- Programmable thermostats cost little and save a lot of energy when applied properly. It is impossible to calculate an accurate ERR for programmable thermostats, because nobody has documented their embodied energy. However, we can use the low market price of the thermostat as an indicator of low embodied energy. Because the financial rate of return is high, we can safely assume that the ERR is also high.

QUESTION #2:
HOW DOES IT WORK?

Here is the message: Don't invest in anything unless you understand perfectly how it will provide the promised benefit. If you can't find a fully comprehensible explanation for a process or technology, it is not ready for your investment. Furthermore, if you don't understand it, you certainly won't be able to make it work.

Energy is a life-or-death issue, so there is plenty of sucker bait out there. The technology may be phony, i.e., it violates the laws of physics, or it promises benefits that it cannot provide. There is nothing so complicated that a responsible professional cannot understand it. If a promoter or a vendor approaches you, ask him to explain his product and grill him about the details. Do your own research. The internet is a wonderful tool for getting a quick introduction. Books, technical articles, and legitimate consultants provide greater depth and broader perspective.

Examples

- Many large buildings have expensive, computerized "energy management systems" (EMS), even though they provide little or no efficiency improvement. The reason is that building designers and managers are afraid to admit that they don't know what an EMS is supposed to do, and they fear making an embarrassing blunder by not buying one. In fact, the limited benefits that an EMS provides can be achieved with greater reliability and much lower cost by localized equipment controls.

- Fluorescent fixture “reflector” retrofits were wildly popular for a number of years, and they were subsidized by tax credits. Supposedly, they doubled the energy efficiency of light fixtures. Applying high school science would have shown that this was impossible. In fact, the modifications primarily had the effect of degrading the performance of the fixtures.
- A hotel client once asked me to assess a “thermal chimney cap” that was being promoted to the hotel with the promise that it would increase the efficiency of the hotel’s boilers by 40%. The equipment came recommended by the chief engineer of another hotel in town, who was convinced (in the absence of any measurement) that his energy costs had been greatly lowered. It was clear from basic principles that the gadget was a fraud, and the hotel wisely rejected it.
- Contemporary building design produces enormous energy waste and serious comfort and health problems. This situation persists because building owners pay large fees to architects without understanding how their buildings are designed. In particular, owners fail to understand the professions involved, their skills and lack of skills, their conflicting motivations, and how the method of payment inhibits good design.
- Hybrid cars offer no net efficiency advantage over conventional cars on the basis of comparable load carrying capacity, acceleration, and comfort. An easy calculation shows that a conventional Honda Civic has a lower net lifetime energy consumption than a Honda Civic Hybrid. This becomes apparent if you inquire why hybrid cars exist. The explanation is that they minimize inefficient engine operation at low load, and they offer regenerative braking. However, the former problem has largely been solved in conventional economy cars, and the latter is largely unnecessary with careful driving. In exchange for minor improvements in these two areas, hybrid cars require a complex drive train, and they must carry the dead weight of a heavy battery. The battery is expensive, has limited life, uses critical materials, and creates environmental dangers when recycled.
- The “hydrogen economy” has become a vision for the future, mostly in the minds of people who have no idea why such a thing is needed or how it would function. In fact, no rational justifica-

tion for a hydrogen economy has yet been proposed. Hydrogen burns cleanly, but the process of making it requires expenditure of conventional resources, which creates conventional pollution. Hydrogen is not an energy source, because little free hydrogen exists on earth. It is uniquely unsuitable as an energy storage medium, because it leaks out of containers and requires a great deal of energy to handle as a liquid. And, for similar reasons, it is unsuitable for transporting energy.

- "Net zero energy buildings" is a new concept that has spread like wildfire among advocates of "green" buildings. The idea is that each building will individually produce enough energy to sustain its operations. Nobody has yet explained how such a thing is possible, or even why the concept is desirable. Nuclear and coal-fired power plants, oil and gas wells, wind generators, tidal energy generators, and other sources of energy cannot be installed on buildings. The concept usually is illustrated with pictures of photovoltaic panels on a roof. But, using a building to support photovoltaic panels does not solve their fundamental problems of low ERR and sporadic energy output. On the contrary, connecting a building to a conventional power grid is the best way to tap the variety of new energy sources and to provide the load averaging and economies of scale that a single building cannot provide.

QUESTION #3:
HOW CLOSE TO REALITY IS IT?

Contrary to common perception, progress is no longer limited by technology, especially in the pursuit of energy efficiency. A vast selection of efficient equipment is available to build efficient facilities and systems. Also, sufficient knowledge exists—in easily accessible form—to eliminate most energy waste throughout our society.

However, people have an itch to be "innovative," even if this means ignoring existing knowledge to maintain the illusion of being a pioneer. This itch leads individuals, organizations, and governments to ignore well-proven methods that are reliable bets, to bet on the unknown and ignore existing knowledge. The results are predictable from past experience. If you do a historical survey of the energy literature since the 1970s, you will find many supposed innovations that disappeared without a trace. More commonly, your search will reveal early models that proved unworkable but were later improved.

Don't be the first to do anything unless you are authorized to expend your resources for research. Let others be the guinea pigs who suffer the failures of innovation. As a rule, buy nothing until it has been proven by a full life cycle of operation.

Examples

- In the 1970s, people invented various kinds of removable window insulation to overcome the poor insulation value of glass. It was installed at night and removed during the daytime. Initially, it seemed that success was achieved. But, one by one, all the designs proved impractical. Interior insulation became infested with mildew. Exterior insulation was blown away by wind. Insulation beads injected into multi-pane windows stuck to the glass. After all these years, we still await a solution to the problem of window energy waste.
- Geothermal (earth-coupled) heat pumps were invented to exploit the fact that deep soil is warmer than outside air during winter, and colder than outside air during summer. The key to the efficiency of geothermal heat pumps is the buried heat exchanger. Unfortunately, there are serious unsolved problems that limit the efficiency of all the existing types of heat exchangers. Today, people assume that geothermal heat pumps are a success story because so many have been installed. In fact, geothermal heat pumps are still primarily an expensive way to waste energy. Maybe their problems will be solved someday, but not yet.
- The poor energy efficiency of incandescent lamps has long motivated a search for efficient replacements. Fluorescent and HID lighting seemed to be the solution, until people realized that they all contain mercury. A few years ago, sulfur lamps were going to be the better solution. The lamps are simple, and they contain no noxious materials. They were promoted as if they were about to appear at your local hardware store. Unfortunately, as with arc lighting, nobody figured out how to make them in useful sizes. Meanwhile, LED lighting is showing great promise, although it is still too early to declare it successful for mainstream lighting.

- The long quest for hydrogen fusion power has spawned a joke among physicists that it will always be "30 years in the future."

QUESTION #4:
HOW MUCH SAVINGS OR NEW ENERGY CAN IT PROVIDE?

If you are a fisherman, you want to catch big fish. Similarly, when investing in an energy project, your goal should be to produce or to save a lot of energy.

An unfortunately common phenomenon is enthusiasm for energy projects that offer little benefit but have symbolic visual appeal. Such fads divert attention and resources from other opportunities that are more productive but less tactile.

When improving energy efficiency in existing facilities, managing small projects is a necessary challenge. Especially in the buildings sector, energy is used in many ways, each of which requires distinct methods to improve efficiency. As a result, the facility may have many opportunities to improve efficiency that offer good ERRs but relatively small savings. Trying to exploit these opportunities individually overwhelms the staff, wasting investments and yielding little. In such a situation, the facility should get help to identify and consolidate its opportunities into packages of projects that require similar skills, each package offering a payoff that is large enough to maintain the attention of the facility.

Examples

- The industrial sector has been much more successful in upgrading its energy efficiency than the commercial buildings sector. Largely, this is because energy in most industrial processes is used in a small number of large components, whereas commercial buildings use energy in dozens of ways, involving hundreds of components. As a result, individual efficiency projects in the industrial sector produce larger yields, which are more attractive to managers. Managers in the buildings sector have not yet learned to aggregate efficiency improvements into packages that can be managed efficiently.

- In transportation, minimizing commuting has vastly more energy saving potential than improvements in vehicle technology. It costs nothing, requires no government action, and is immediately available. Probably because this powerful strategy is invisible and undramatic, it remains largely unexploited, overshadowed by technology projects that have greater visceral appeal.

- "Cool roofs" are currently a hallmark of green design, intended to reduce the cooling requirements of buildings. Meanwhile, architects persist in the feckless use of glass facades, which radically increase cooling requirements. Typically, an architect's cool roof offsets only a negligible fraction of the energy wasted by his irresponsible glass design.

- During the 1980s, people became obsessed with converting the tiny incandescent bulbs in exit signs to small fluorescent lamps, an activity requiring considerable labor in relation to its benefit. The technology was valid, but exit signs account for only a minuscule amount of lighting energy. The state of Minnesota even passed a law requiring the conversions, while ignoring vastly more important opportunities for energy savings in lighting.

QUESTION #5:
CAN IT WORK WELL IN OUR LOCATION?

Many energy technologies favor particular locations. Their energy return ratio declines outside the most compatible environments, or they fail. Many factors about a location can affect the success of the project, including temperature, cloud cover, topography, geology, population density, and the attractiveness of the location to skilled staff.

Examples

- Wind generators can produce a net energy benefit only when they are located where winds are strong and steady. This seemingly obvious point has been widely ignored, and only now is beginning to receive the recognition that it deserves.

- Solar water heating systems function best in climates that are continuously mild or warm, such as Greece, southern Turkey, Israel, and South Florida. During cold weather, conventional solar collectors are unable to maintain maximum water heating temperatures. Also, systems designed to resist freezing in cold climates are more complex and expensive.

- Geothermal energy can be viable only in locations where magma rises near the surface of the earth. Therefore, it is a major national resource for Iceland, but it can't be for the United States.
- Focusing solar collectors and solar thermal power plants can provide very high water temperatures at any outside temperature. The trouble is, they function only with clear skies. Clouds, overcast conditions, and fog obscure the reflected image of the sun, reducing heat collection to almost zero, no matter the air temperature. This limits them to arid climates.
- Mass transit does not save energy unless it is located where it can serve dense populations, generally confined within a topographical boundary having flat terrain. The Manhattan subway system is the epitome. In most other locations, mass transit is a social service that has a high energy cost.
- A hospital located in an isolated part of Arizona used a high-temperature focusing solar collector system to power an absorption cooling system for the hospital. For years, the unusual system depended on the skill of a single dedicated staff member to keep it operating. When that individual retired, the system failed. The location of the hospital made it difficult to attract a replacement who was sufficiently skilled and motivated.

QUESTION #6:
WHAT IS THE MOST EFFICIENT SCALE?

The ERR of many energy technologies varies widely with scale. In most cases, technologies become more efficient at larger sizes. However, this is not always true, especially where small size allows energy use to be localized efficiently.

Examples

- The optimum size of nuclear and coal-fired power plants is about 1,000 megawatts. The optimum size of diesel generators is several hundred kilowatts to several megawatts, depending on the application. The optimum size of individual wind generators is presently about two megawatts, and economy requires clustering wind generators into wind farms having total capacities of several hundred megawatts or more.

- Improving the efficiency of energy-consuming components of almost all kinds—motors, fans, pumps, etc.—becomes more economical as size increases.
- Transportation efficiency (energy consumed per ton-mile carried) improves steadily with the size of the vehicle for all modes—road, rail, aircraft, and marine—provided that the vehicle is efficiently loaded.
- Small, localized heating and cooling systems are more efficient than large central building systems and "district" systems that serve many buildings from a central plant. Smaller heating and cooling equipment is now as efficient as larger equipment, and some is more efficient. Also, smaller equipment allows heating and cooling to be tailored to the occupancy of individual spaces. Localized systems avoid the high embodied energy and energy leakage of distribution pipes.

QUESTION #7:
WHAT OTHER BENEFITS DOES IT OFFER?

Most energy technologies and conservation measures have side effects that are not related to energy. Often, these effects are insignificant. But in many cases, the side effects are valuable, sometimes as valuable as the energy savings.

Examples

- Multiple-pane windows improve the comfort of occupants who sit near the windows during cold weather. For many homeowners, this is their principal benefit.
- All high-efficiency lamps last many times longer than incandescent lamps, saving much cost for replacement lamps and labor in commercial facilities.
- High-efficiency, gas-fired condensing heating equipment eliminates the need for house chimneys, and it minimizes carbon monoxide hazards.

- Mass transit provides transportation for people who lack their own vehicles. It saves parking space. Electrically driven systems reduce pollution inside cities. Rail systems may reduce commuting time.
- Living near one's work to minimize commuting increases productive time, reduces vehicle costs, reduces the risk of injury in accidents, and reduces health risks associated with breathing vehicle exhaust.

QUESTION #8:
WHAT PROBLEMS DOES IT HAVE?

Many energy investments have bad collateral effects. Be sure that you recognize all of them. You may wish to tolerate them, you may be able to take some compensating action, or you may decide that the investment is not worth the problems.

Examples

- The most efficient kind of LED lamps emit an excessive amount of blue light, believed to cause permanent damage to the retinas of human eyes. Currently, the best solution is to select LED lamps that use phosphors to dampen the blue light and broaden the spectrum.
- Multiple-pane windows require seals between the panes. The current type of seal fails at intervals of about 20 years, causing fogging and streaking of the glass that requires expensive replacement. In cold climates, the best decision is to live with the problem and await better windows in the future.
- Electronic variable-speed motor drives can save a lot of energy in appropriate applications. However, they may burn out older motors, and they sometimes cause electrical system problems that are difficult to diagnose and tricky to correct.
- Huge wind generators kill endangered birds, interfere with communications, make noise that is intolerable to nearby habitations and livestock, and afflict the scenery for vast distances. In the past, the response has been to ignore these problems or to deny them. However, as wind generators proliferate, greater awareness is making these problems more prominent in investment decisions.

- Hydroelectric power, once considered the most benign method of generating electricity, is now abhorred by environmentalists for altering ecosystems and flooding the artifacts of indigenous peoples.
- Ethanol derived from corn has a host of problems when used as a substitute for fossil fuel. It accelerates soil depletion, competes with food production (raising food prices), reduces fuel mileage, causes seizures in 2-stroke engines, and destroys boat hulls that have integral fuel tanks.
- Methane hydrates may become a major new source of energy, if it can be extracted efficiently. However, recovery of methane hydrates risks the release of large amounts of methane into the atmosphere, which might affect global climate catastrophically.

QUESTION #9:
DO WE HAVE THE MANAGEMENT ATTENTION AND STAFF SKILL TO OPERATE IT SUCCESSFULLY?

The energy return ratio assumes perfect performance for the expected life of the measure. By itself, the ERR is naively optimistic. The landscape is littered with failed energy projects that promised a high rate of return. If an investment does not work, it does not save energy or money. Instead, money and opportunity go down the drain, and managers develop an aversion to activities that promise to save energy.

Many valid energy investments fail early in the life of the project. *These failures often occur because the need for continued administration and maintenance is overlooked or underestimated*. The amount of attention needed varies enormously among different energy projects. However, even the simplest and easiest energy efficiency investments commonly fail from neglect. This is a peculiar weakness of energy projects. It exists because energy conservation and renewable energy are viewed as magic bullets, rather than as mundane activities with the same requirements for continued administration and maintenance as other productive functions.

For a project to succeed, the facility must adjust its management to sustain the project for its entire life. First of all, a senior manager must assume permanent responsibility for the project. Does the facility have a manager who can fill that bill? Then, the responsible manager must acquire and direct the resources required by the project. For a large project, this means hiring, training, and monitoring a staff dedicated to the project, as well as keeping appropriate outside expertise on retainer. For a small project, which can easily fall into a crack, it means enforcing the use of an effective tickler file that reminds the facility staff to maintain the project.

So, ask yourself whether the project is compatible with the management structure and staff capabilities of the facility. If not, is it reasonable to expect that the needed changes can be made?

Examples

- The industrial sector has been much more successful in upgrading its energy efficiency than the commercial buildings sector, as noted previously. Another reason is that managers in the industrial sector are better attuned to energy issues than managers in the commercial sector. Communication between managers and facility operating staffs is better in the industrial sector. Also, industrial facilities generally have more manpower and better skills for operating the energy systems of the facility. Thus, an industrial facility needs less change in its organization and methods to manage efficiency improvements. Commercial facilities could make the needed changes, but few have learned to do so.

- Cogeneration is on-site generation of a facility's electricity, combined with recovery of the generator's heat for useful purposes. It has long been an integral part of some industrial operations, where it is successful because the plant cannot operate without it. In the late 1960s, as a way of competing with electric utilities, natural gas utilities persuaded 700 of their non-industrial customers to install cogeneration systems to generate their own electricity. By the mid-1970s, all but a few of these plants had failed, leaving the customers with expensive junk. Generally, the cause was the inability of the staffs to operate electrical power plants, which is a complex business in itself. Among the few plants that continued operation, hardly any were able to calculate whether the plant was actually saving money, compared to buying electricity from utilities. Today, the very same mistakes are being repeated in the promotion of "combined heat and power" systems.

- Thermal storage has been aggressively promoted by electric utilities to their customers as a way of avoiding the need for the utility to build new generating capacity. Customers purchase expensive thermal storage systems in exchange for promises of reduced electricity rates. However, in many installations, the staffs did not comprehend the critical sequences in which the equipment must be operated in order to reap the utility incentives. Equipment failure is a continuing problem. Also, most thermal storage systems reduce the efficiency of the facility's own cooling equipment. Many systems have proven to be an expensive mistake that increases, not decreases, electricity costs.

- Many large, open buildings, such as shopping centers and box stores, have skylights for daylighting. For lighting at night, lighting fixtures are installed to illuminate the same areas. Controls are installed to turn off the lighting fixtures when daylight is available. Yet, more often than not, you will observe that the light fixtures operate all day. This indicates that the facility managers give insufficient attention to maintain even this simple and highly visible asset.
- Political mismanagement of incentives is common because legislators lack the knowledge or interest to monitor the effectiveness of incentives that they enact. Shortly after compact fluorescent lamps (CFLs) were introduced to the market by major manufacturers, copycat manufacturers flooded the market with cheap versions that were inefficient and often so unreliable that they operated for only a few hours. Unfortunately, politicians sustained this junk with powerful incentives, such as requiring utility companies to give them to consumers. This helped the junk producers to drive the good products out of the market. Because of this political bungling, the transition to CFLs yielded a net energy loss.

QUESTION #10:
WHERE ELSE COULD WE INVEST OUR RESOURCES MORE PROFITABLY?

Rationally, this should have been your first question. Any investment decision should begin with a survey of all the options available. Otherwise, you are likely to expend unnecessary analysis on something that is unlikely to be your best investment.

But energy projects are not selected rationally, at least not yet. You selected your current project because:

- You want to make your job more entertaining.
- You want to spend a lot of your employer's money for a project that is big, boosting your status in the organization.
- You want to save the earth.
- Or, you attended a conference and heard about something new, and you want to be applauded as an innovator.

One way or another, you got the itch to launch an energy project, averting your gaze from its blemishes. So, we saved this question for last. You got interested in your project because you fell in love with it when you were not thinking clearly. We hope that going through the previous questions will restore good judgment after your "wild night in the bar." It was a way of weaning you from your pet project gently, persuading you that the girl you met when you were drunk is not really the best candidate to be the mother of your children.

Hit the reset button. Use your copy of the *Energy Efficiency Manual*[1] to identify ALL the energy investments that may reasonably apply to your organization. Then get your spreadsheet and apply these ten questions to all the candidates. Your reward will be personal success—and the greatest possible benefit for your organization.

References

1. *Energy Efficiency Manual*, Donald R. Wulfinghoff, Energy Institute Press, 2000. Explains the advantages, shortcomings, implementation procedures, and economics of most efficiency improvements for the commercial and industrial sectors.

ABOUT THE AUTHOR

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