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Using E-Equity™ to Uncover Hidden Financial Value in Power Generating Options

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Executive Summary/Abstract

E-Equity™ is a methodology created by Pearl Street Inc to move electric power production in a more meaningful direction long-term. The objective of E-Equity™ is to more rigorously point the evaluation of power generation options towards a system optimum and steer the evaluation away from local minima and maxima. In principle, it combines elements of system dynamics (applied to environmental, social, and human systems), industrial ecology, and sustainability. In practice, E-Equity™ shares concepts with life cycle analysis, total value proposition studies, real cost of electricity analyses, sustainability, and other thought processes and movements. It is our contention that financial, portfolio, regulatory and R&D program evaluations of power generating and technology options should integrate E-Equity™ concepts.

Although our long-term interest is in developing *quantitative* techniques that support the methodology, our limited experience applying E-Equity™ in a subjective mode (we call this a first-order analysis) has uncovered "stealth value streams" important to investors and the financial community. In one sense, the first order evaluations identify hidden value streams; second and third order studies will help to quantify that value.

A key new element in quantifying these value streams is through the use of carbon credits, offsets, and trading mechanisms. Carbon trading offers a means of placing a dollar value on advanced design, operating, and management practices, that reduce the "carbon footprint."

Another key element in quantifying new value streams that we strongly believe should emerge is to include the cost of global military activities into financial models. Until the cost (or potential cost) to defend our global energy supply lines is factored in, we will not calculate, for example, the real cost of electricity from a power station fired by imported

liquefied natural gas (LNG). Activities having to do with the pursuit of "energy independence," such as massive ethanol or synfuels programs, should include such "externalities" if they are to become long-term energy strategies. This is an important point that needs to be conveyed to the voting public, something I've tried to accomplish in my latest book, *Lights Out! The Electricity Crisis, The Global Economy, and What It Means to You*, being published by John Wiley & Sons (available June 2007).

In this paper, we describe the E-Equity™ methodology, apply it at the power station level to illustrate how it can uncover hidden value, and finally apply it at the business portfolio level to indicate changes in strategic direction. I consider this methodology a "bridge" that can help reduce to practice important concepts that have been percolating in academia and select nodes of the government for many years.

Introduction

There was a popular book not too long ago called something like "Everything I know I Learned in Third Grade." I've always wanted to write one called, "Everything I know I learned in Mad Magazine."

One of my favorite visuals from that venerable fountain of knowledge of my youth is a bearded old man holding up a protest sign that says "Money is the root of all evil." In the next frame, a younger man holds up another sign in front of it that says "The lack of." I believe these two as fervently as I believe in the wave-particle duality of nature. Well, maybe not, but one thing's for sure: Money drives our society. So does electricity.

Care for our environment also drives our society. In the most simplistic sense, the perspective for this care has transcended national borders. Think about it. Up through the 1960s, pollution was a local problem. People got tired of horse manure in the streets (automobiles were an early solution to this grave problem), not being able to breath in cities like Pittsburgh, and garbage strewn on their streets and highways (remember Keep America Beautiful?). In the 1980s, pollution became regional as acid rain studies got underway. In the 1990s, environmental protection went global with the hole in the ozone layer and global warming. Today, environmental protection has become a veritable referendum on industrial development, consumer habits, and, indeed, our way of life.

Today, only a few hard core skeptics, and President Bush, remain regarding the threat of global warming. I won't lie. I happen to be pretty skeptical still (my one remaining issue is that I never see anyone report quantitative error analyses around these forecasts and dire predictions and I demand to see others go through the pain I went through in my chemical engineering labs preparing error analyses), but it doesn't matter. The public at large is more than convinced. Can't you visualize the two posters? "Doing nothing about global warming is the root of all evil"…"NOT doing anything about global warming is the root of all evil."

Very recently, there was important confirmation that the investment community is squarely aligned with the voting public. The buyout firm KKR announced it was proposing to purchase the huge Texas electric utility, TXU. The very next day, KKR announced that one of its first orders of business would be to scrap TXU's plan to build 10,000 MW of new coal-fired plants the old-fashioned way: Using plant components perfected in the early part of the last century and essentially ignoring CO2 management. TXU tried to bully its plan through the state, and for a while it looked like it would succeed. I believe that KKR's decision validates the notion that investors no longer will abide by "business as usual" when it comes to coal.

More is at stake than just money, in other words, or maybe there are more sustainable ways to make money. When money is aligned with the voting public, it becomes "smart money."

In recent years, we as a society have begun driving environmental management and regulation using money, or, more appropriately, the fluctuating monetary value of emissions or discharges as reflected through the trading of credits, allowances, and/or offsets for SO2, NOx, CO2, and methane (CH4) emissions. We now have a means of factoring emissions and discharges into financial models.

We still can't predict the future—the value of emissions credits will fluctuate with the market—but at least we have something to start with in the present. Not being able to predict the future certainly doesn't stop the majority of Americans from investing in the stock market, right?

Our industry, the electricity industry, is making progress, but we're not there yet. Toyota requires every new car design to have an environmental impact budget as well as a financial budget. The former requires that the total amount of carbon dioxide produced in the design, production, and life cycle of the vehicle be considered. Power plants are designed to comply with current environmental regulations. I believe it will be shown that the moral of the KKR-TXU story will be that you can't start building a power plant with a prudency review waiting to happen.

The E-Equity™ methodology began as a way to integrate the three principal drivers of modern society: Electricity, economics (money), and environment. Since 9/11, I've added a fourth driver: national security. As you are aware, in subtle and not-so-subtle ways, our way of life is changing as a result of our national response to the catastrophic events of 9/11. For one, national energy security has become a political rallying cry, much like is was in the 1970s and early 1980s.

I don't believe we can have an intellectually honest discussion about electricity production options until we include the externalities of national and global defense of energy supply lines in the same way that we now quantify environmental externalities. Similarly, I don't believe we can have a intellectually honest evaluation of power generation options unless we fully account for the impact of that option on electricity grid operations and the security of our electricity infrastructure.

E-Equity™: An Introduction

We chose the word “equity” because of its financial connotation but also because we stumbled upon this definition: “A set of principles intended to enlarge, replace, enhance, or expand a narrow, rigid system of laws.” This is exactly what we believe is necessary to improve the financial analysis of power generating options. The methodology naturally leads to an E-Equity^{TM} Index , a more insightful measure, or benchmark, of a power station (or a firm’s) value to society. In all cases, the objective is to optimize among competing goals, competing “systems” and “surroundings,” instead of driving the process towards local minima or maxima (e.g. highest profit, lowest emissions, greatest employment).

Here are some characteristics of the E-Equity^{TM} methodology:

- It recognizes the thermodynamic principle that emissions and discharges from a power station simply represent inefficiencies that penalize both the economics of the facility and the ecology of the physical surroundings.
- It integrates environmental accounting but seeks to balance environmental goals with other important goals and objectives.
- It defines and incorporates “internalities,” positive social benefits for which the facility is not gaining credit or for which an accepted market method is not available to quantify the value.
- It recognizes that benefits and detriments can be two sides of the same coin, depending on how you define the “system.”
- It accepts that, over time, everything begins and ends with the earth-we convert natural resources into products for the benefit of society (well, in most cases!) and these materials are returned to the earth in an altered state and the challenge “in the interim” is to balance social costs with social gains.
- It looks upstream and downstream at the overall product value chain to make more meaningful assessments of system optima.
- It demands that the evaluation, at least intrinsically if not qualitatively, optimize around at least six dimensions (described later)

E-Equity^{TM} makes liberal use of the concept of a black box. That is, there is the system inside the “black box” or boundaries and then there are the surroundings, which are other systems. The surroundings we are most familiar with are the ecological system around the power plant-the air, the water, and the land. But there are also the local community (taxes, employment, risk of catastrophic events), the corporate community (revenues, profit, expenses), the regional and national community (electricity grid, national security), and finally the global community (global warming, ozone layer, energy supply lines).

Then, there are the value chain “systems” and surroundings. A coal- or a gas-fired plant is supplied by an infrastructure with its own impacts and benefits. The power plant is part of an economic eco-system, an environmental eco-system, a financial eco-system (owner debt and equity), an electricity grid eco-system, and increasingly a national security eco-system. Finally, there are elements of other eco-systems that, when added to the power plant eco-system, the system optima change in positive ways.

For most purposes, the six principal E-Equity^{TM} dimensions, the broad goals that must be optimized around, are:

- Financial viability (on-going and initial capital investment)-F
- Electricity grid management-EG
- Human safety and property damage-HS
- Environment, ecology, and human health-EH
- National infrastructure security and energy independence-NS
- Local, regional economic development-ED
- Aesthetics (e.g. land use) and other miscellaneous attributes-AE

The E-Equity^{TM} Index, defined as the total societal value of a power station or electricity generating option, is then a function of these six parameters:

E-E Index ~ f [a(NS), b(EG), c(ED), d(HS), e(EH), f(F), and g(AE)]

(The lower case letters represent weighting factors)

Obviously, the optimization routines to solve the defining equations are challenging. And, like climate models and global warming forecasts, good data is missing in many places and assumptions have to be made which greatly impact the results. Let's face it, it is hard enough to optimize within one of these dimensions, much less all six!

From a qualitative perspective, however, it is straightforward to see how some generating options might compare on the basis of these dimensions. Wind energy would score very high on EH (the plant itself is "emissions-free") but relatively low on EG, because of the intermittency of the energy source and fluctuations in the output to the grid. Wind also scores low on aesthetics. Because it is a low-density source of energy, it requires a great deal of land and "landscape volume" to harvest the energy (partially mitigated by the fact that the land below is usable for other purposes, such as raising crops or cattle). A coal plant would score well on the NS dimension (avoids importing fuel from unstable parts of the world), and on the financial dimension (not only a relatively low cost fuel, but generally at more stable and predictable pricing than natural gas, for example). However, it scores poorly on the EH dimension.

Example I
Value of a mine-mouth coal-fired power station

The first real application of E-Equity^{TM} for a client (defined as an exercise we got paid for) involved enhancing the understanding of the value of a large mine-mouth coal-fired power station in southern Illinois. First, we conducted a "screening" evaluation to identify value points that might justify closer examination. For example, we quantified the value of avoiding deaths from transporting coal from the Powder River Basin (PRB) and avoiding emissions and energy consumption moving coal by rail. The potential to sequester CO2 near the site was given a credit. We also credited the facility for producing gypsum from SO2 emissions that would avoid the production and transport of raw gypsum.

However, the potentially highest hidden value, and the least understood (by our client), involved national security, especially given predictions by the Energy Information Administration (EIA) about massive imports of LNG. We focused the next phase of the evaluation on this dimension and believe we broke new ground in evaluating a coal-fired plant for national security. So new was the ground, in fact, that we believe the results, and some of the elements that went into the evaluation, made the client nervous politically.

Covering our energy "deficit" with imported LNG vastly extends our supply lines (distance between fuel molecules and electrons consumed). We estimated and apportioned, to a comparable LNG-fired combined cycle plant, costs for military activities associated with LNG origination and transport (essentially by making direct analogies to petroleum), costs for ensuring safety of LNG-related activities on the coasts, new pipeline infrastructure, and safety related incidents with natural gas transport and distribution.

In sum, we derived an estimated $30-million in value annually for this mine-mouth coal plant with respect to energy infrastructure security (see the addendum at the end for some elaboration on the estimate). As a side pocket analysis, we also determined that two-thirds of the potential advantage with respect to global warming of a gas-fired combined cycle plant (chiefly because of the higher efficiency of the plant and lower carbon content of the fuel) is "vaporized" (Ha Ha!) if imported LNG is used. This is primarily because methane is a 20x more potent global warming agent than CO2 and lengthening supply lines compounds losses to the atmosphere.

Example II
Value of power stations closely coupled to industrial facilities

Unfortunately, our next examples must also remain nameless because our client is in the process of determining whether to fund and promote the studies. Our benefactor in the company who commissioned the studies recently left the firm. Nevertheless, we can proceed with a composite sketch that makes the points just as eloquently. The common feature is close-coupling a coal-fired power station with other industrial activities.

In one case, the power station burns a relatively low-grade coal, sourced locally, in a circulating fluidized-bed (CFB) boiler. The characteristics of a fluid bed are such that multiple solid fuels can be burned with less impact than in pulverized coal boilers. Thus, the site is planning to co-fire poultry litter, which in the area is a source of environmental blight because of agricultural runoff. For more than 15 years, this plant has also been recovering 10% of its CO2 emissions and recycling CO2 into the food industry. Products of combustion (bottom ash, flyash) are either returned to the mine for permanent storage or shipped to sites in Texas, where they are beneficially used for hazardous waste reclamation.

This is a facility that has made regional economic development a cornerstone of its existence. It provides relatively low-cost electricity for the region and the state and provides jobs at the plant and at the mine. The region was what you might call an "impoverished rural area." The facility scores high on national security (closely coupled to its fuel supply), on electricity grid management (compared to a pulverized coal unit, it is flexible for load following and dispatch), on environmental impact because of the industrial ecological recycling, and on economic development.

For a coal plant, it scores high on the sub-dimension of global warming for no other reason than it is one of the only power plants worldwide that recovers any CO2 at all. Granted, that CO2 is discharged to the atmosphere at some point (probably through the flatulence of a soda drinker), but it avoided impacts by delaying that discharge.

Balancing all of these positives, however, would be factors such as the consumption of limestone. Life cycle assessments of coal facilities have shown that the production and delivery of limestone to power plants employing CFBs or scrubbers involves significant CO2 emissions, up to half, in fact, of what is released during combustion of coal, depending on the system. Obviously, limiting the amount of limestone required to reduce sulfur emissions could be a source of CO2 offsets.

Another one of this client's power stations burns petroleum coke, and is nestled among a variety of other industrial facilities. It is a stellar example of industrial ecology. Instead of having coal shipped by rail long distances, this plant consumes a solid byproduct of the refining process sourced, literally, down the street! One estimate shows that one gallon of diesel fuel is burned for every ton of coal moved 1000 miles. Diesel fuel used by rail lines contains up to 0.5% sulfur. Coal mining itself can be associated with the release of methane into the atmosphere. All the activity at the mine associated with heavy equipment, safety, etc, is also avoided. When you consider such life-cycle impacts, the E-Equity™ value of a power station "closely coupled" to a source of high heat content byproduct, once considered a waste material, becomes clear.

Petroleum coke has relatively high sulfur content. The plant converts the resulting flue-gas SO2 into gypsum, or calcium sulfate, which is in turn sold to a wallboard manufacturer in the area. Wallboard is a prevalent building material used in homes and commercial structures. Wallboard suppliers cite numerous benefits of replacing natural gypsum with so-called synthetic gypsum. One of the most important is that wallboard facilities can be located near where the demand for wallboard product exists, reducing costs associated with transporting finished product. One supplier notes that transporting gypsum board accounts for more than 10% of the total energy used to create and deliver wallboard. Close-coupling also avoids the need for transporting raw gypsum. Finally, synthetic gypsum is delivered as a powder, which avoids the energy and environmental impact of crushing, grinding, and/or pulverizing operations. Once again, the negative impacts of the limestone value chain would also have to be factored in.

All of these beneficial impacts and penalties can be estimated in terms of emissions avoided, and energy not expended. One source is the report, Life Cycle Assessment of

Coal-fired Power Production, released by the National Renewable Energy Laboratory (Golden, Colorado) in June 1999. This report offers estimates of emissions and resource requirements for mining (surface and underground), methane emissions, energy for coal transportation (barge, rail), and so on. Undoubtedly, there are other sources and estimates as well.

Using petroleum coke locally rather than shipping it long distances (as is usually the case) reduces energy consumption and environmental impact. Avoiding the extraction and processing of gypsum avoids impact on the environment. Within the industrial ecology context, the high sulfur level inherent in petroleum coke becomes an attribute, not a penalty. The plant converts a refinery waste material generated in the U.S., into useful products to be consumed in the U.S. Plus, it is a viable solid-fuel-fired plant in an area where gas-fired power reigns. With gas prices triple what they were five years ago, the economic benefit is huge. Recently, the plant committed $30-million for additional emissions control, a selective catalytic reduction (SCR) unit, to keep the plant viable, in compliance well into the future, and maintain its good neighbor status in the community it serves.

One of the tenets of E-Equity™ is to find credits for internalities. It is hard to understand why these two plants are not considered "in the national interest" and given subsidies like renewable energy facilities enjoy.

A third facility in this client's U.S. portfolio is located on an island and burns low-sulfur imported coal in a CFB boiler. The industrial-ecology aspects of this facility have been studied by researchers in the field, though never made available in the public record. A hallmark of this facility is the way the plant's water balance is integrated into the community and neighboring industrial facilities. For one thing, cogenerated steam is sold to local industrials. These users return the condensate to the power plant. The power plant uses the effluent from the local wastewater treatment as make-up to the water balance. Products of combustion are used in various civil projects around the island, such as for road construction. Steam sales avoid the use of heavy-oil-fired boilers once used by the industrial facilities. This plant is notable in that it achieves one of the lowest air emissions profiles of any coal-fired plant in the world.

Example III
Identifying carbon offsets in coal combustion byproducts (CCP) management

Earlier, we noted that the financial value of carbon offsets helps E-Equity™ quantification in at least one area: global warming and carbon constraints. We've conducted surveys of ash management practices at coal-fired power stations. The work included evaluating practices at individual plants, and benchmarking them to industry practices.

For coal-fired plants in general, we found that a significant percentage of flyash is being managed through third-party contracts. Often, these third parties sell this material to concrete manufacturers. Flyash is an excellent substitute for Portland cement in the making of concrete. What’s more, studies by industry ash management groups show that for each ton of Portland cement replaced by flyash, close to one ton of “greenhouse gases” is avoided (actual figure is 0.89 ton). If the material is not recycled, plants generally pay a disposal fee for the waste.

As an example, one large utility plant in the Midwest sells 800,000 tons of synthetic gypsum to a wallboard manufacturer, and 100,000 tons of flyash and bottom ash to cement-makers. When you add up all of the energy avoided through this recycling practice, and therefore the CO2 emissions avoided, the potential revenue becomes significant, especially when added to avoided disposal costs! *Some power stations could even take credit for being the largest “recyclers” in their state*. This is an interesting destination for flyash from another perspective: Any heavy metals in the ash are sequestered or permanently stabilized in concrete.

Another utility we found produces about 2.4-million tons of ash, and manages to use about 40% of it in cement applications, or 960,000 tons per year. If we assume that all of it replaced Portland cement (or equivalent), then this practice has avoided 854,000 tons of global warming gases. I just checked quickly and found a site that quotes $5.50/ton of CO2 offset. Prices in Europe, where carbon trading is active, have fluctuated over the last three years from $5-35/ton CO2 equivalent. This utility could earn from $5-30-million per year from CO2 offsets (as long as the utility is in possession of the credits, and not a third-party broker).

Another utility we are familiar with sells 100% of the flyash from its two largest coal-fired power stations. Total annual volumes in all likelihood are at least a million tons, and probably much more. Many utilities recycle flyash, yet management is generally more fearful of liabilities associated with metals than with benefits and revenues associated with minimizing carbon and environmental footprint, or the public relations bonanza of being known as a major recycler. Maybe the value of carbon offsets will change that mentality.

Example IV
Portfolio level evaluations

It has probably become obvious how you can apply E-Equity™ principles to evaluate a portfolio of electricity production and energy assets. The methodology can inform business decisions regarding which sectors to invest for the long term. Imagine a power producer that manages a global portfolio of coal-fired assets, natural-gas-fired gas turbines and combined cycles, hydroelectric facilities, wind, and biomass. However, the strategic direction for the company has changed. It is now aggressively pursuing wind energy development worldwide, LNG regasification facilities, and is building up a carbon trading and offsets business. How to decide where to put the next $100-million of capital, or which areas to emphasize in project development? For situations like this, I believe E-Equity™ has much to offer.

Let’s take the goal of identifying carbon offsets to create additional value and revenue for the carbon management business. As stated earlier, a molecule of CO_2 is a dastardly global warming agent, except perhaps when it was just a methane molecule (with its 20x greater warming potential). Let’s say you have a fleet of reasonably fuel flexible boilers. Anything bio-material you burn in them to extract energy, such as refuse derived fuel, poultry litter, cattle manure, etc, is better than that material sitting in a landfill somewhere breaking down into methane.

Lower hanging fruit, with respect to seeking carbon offsets, might be found in reducing the losses along the LNG value chain--extraction, liquefaction, transport, regasification, and pipelining. As stated earlier, losses from this sequence have been estimated to range from 9-13%. This is the amount of parasitic natural gas necessary to deliver LNG to a customer. Older facilities have higher losses. Some countries have less onerous regulations, codes, and standards which govern LNG facilities. Not all of these losses are methane; some of the methane is combusted to drive large compressors and other equipment.

As we implied earlier, emissions and discharges are simply expressions of energy inefficiencies in loosely coupled systems and processes. Anytime you make use of wasted energy, you are undoubtedly avoiding CO_2 production in one or more value chains.

We also believe that E-Equity™ can shed light on regulatory issues and improve environmental regulation. For too long, the regulatory compliance process has driven one dimension of the overall E-Equity™ scenario to zero, or effectively zero. If money was no object, perhaps this isn’t a problem. But it is. It, or the lack of it, is the root of all evil, remember?

Personally, I believe that an E-Equity™ analysis at the regulatory level would have shown that driving the gas turbine permitting process to 3 ppm NOx emissions wasted tens of millions of dollars that could have been better spent on higher priority environmental issues. The performance costs that have penalized gas turbine and combined cycle plants—in terms of lower efficiency, premature failure of expensive hot-gas path components, extended downtime, need for expensive long-term service agreements with turbine suppliers, higher CO emissions, etc—could perhaps have been avoided by regulatory leniency at the 25 ppm level. Unfortunately, the “E-Equity™ value” of driving to ideologically low NOx emissions was never a priority, for the regulatory agencies or the industry at large.

Finally, E-Equity™ evaluations can provide important new information for guiding R&D, venture investment programs, and policy decisions in applying that R&D to the asset portfolio. Some examples:

- Renewable energy, especially wind, rates poorly on grid management. The source is not only intermittent, but the wind velocity profiles in most parts of the country (where the wind resource is significant) runs counter to the electricity demand profiles (wind is strong at night, demand is strong during the day; wind is poor in the summer when electricity demand from air conditioning is highest). Yet its value for environmental impact and global warming is huge. What's a solution? Energy storage, for one. E-Equity™ analysis clearly illustrates the value of energy storage in managing a portfolio of renewable energy assets interacting with a grid.

- Coal-fired power stations emit sulfur and nitrogen in large quantities, two ingredients in fertilizer (ammonia sulfate and ammonium nitrate). Even ash can be beneficial for agriculture. Ammonium nitrate is produced from natural gas. Wouldn't it be in the interest of the agriculture industry, and the nation, to obtain as much fertilizer from coal plants as possible? The economics look better if we include values for E-Equity™ dimensions. There's at least one process that's a few years from "ready for prime time" (subsidized through federal and state R&D programs), a multi-pollutant control process with fertilizer end products. Several others have been demonstrated over the last two decades through the DOE Clean Coal Technology programs. Let's figure out how to grow the corn (and other plants) we're apparently going to turn into ethanol by making better use of our existing coal resources. Let's figure out how to convert the byproducts of coal combustion into higher value products, and avoid the impacts of limestone and sorbent supply as well.
- When you begin to evaluate coal on a life-cycle basis, it becomes clear that, from the perspective of global warming, much more needs to be done. Coal combustion is only one source of global warming gases; methane from coal mining, emissions from coal mining and transport, carbon dioxide released from limestone supply and during the absorption of sulfur by the limestone are other significant sources. Once the financial impact of all of these sources is recognized in the economic evaluation, it may well be that other coal options are more attractive. IGCC, which uses a different gas cleanup process, for example, might evaluate higher from this perspective. In addition, once these costs are fully illuminated, it begins to put renewable energy coupled to energy storage in an even more favorable economic light.
- Alternatively, from a portfolio view, when you factor in values for national security, it becomes clear that coal is a national resource. The goal should be to extract every possible value from it, to offset its relatively high carbon footprint. Burn the methane, convert coal to liquids (diesel fuel), gasify the remainder for a combined cycle power plant, recycle the ash or slag into concrete production, and sequester the remaining carbon dioxide. You can pay for much more when you factor in costs for defense of global supply lines, carbon offsets, and other energy inefficiency penalties.

Addendum: Estimating costs for defending energy supply lines

As stated in the introduction, an intellectually honest discussion about power generating options should include defense expenditures as an externality. In practice, this applies mostly to the idea of importing large quantities of LNG, since most of our electricity generation comes from domestic fuels, or fuel available from Canada. However, it does also apply to nuclear fuel: Although much of our nuclear fuel is imported (a lesser known fact with the public) from "friendly" countries, a significant portion comes from Russia via the conversion of weapons-grade materials into power reactor fuel.

As a start in quantifying this "externality," we searched for sources. One source estimated that if all the direct and indirect costs related to ensuring stable Middle East oil supplies were included in the price of imported oil from that region, the "true" cost of a barrel of petroleum would increase by 50%. The phrase "terror premium" refers to the increase in the price of petroleum that may have been caused by recent instability in the Persian Gulf. The price of oil was $25 per barrel before 9/11; the price today is around $60-70 per barrel.

In our earlier work, we tried to extrapolate such "costs" from petroleum to LNG. Our thought process (updated figures) went like this:

- Before 9/11, we assumed that the defense-related expenditures associated with petroleum shipping were $50-100-billion per year, based on sources.
- In 2004, we imported 30 Quads of petroleum, and 2 quads of LNG (this figure may have doubled by today).
- As of 09/11/06, Congress had appropriated $400-billion for operations in Afghanistan and Iraq; the indirect costs of the Iraq war alone (as estimated by Nobel-prize winning economist) have been estimated to be at least $750-billion.
- One reason for these operations (though perhaps not explicit) is to protect petroleum supply lines. For the sake of argument, we assumed 25%.
- By 2025, EIA forecasts that the U.S. will import 11 quads of LNG, which will represent 25% of fossil fuel imports at that time.

It is reasonable to assume that some fraction of our global defense expenditures should be apportioned to LNG importation. We also assumed that 30% of the LNG to be imported would be destined for gas-fired power stations, since that is the fraction of natural gas that today is destined for power generation.

We're not suggesting that the assumptions and estimates are accurate, but you have to start somewhere. The overarching point is this: Wind energy facilities, power plants fired by domestically sourced coal, and even nuclear plants sourcing coal from friendly countries (like Canada) evaluate better financially when externalities for global defense are factored in. In fact, I would venture farther and state that, unless these "costs," are accounted for, we are doomed to fall back into our hold habits once the price of petroleum (and other energy sources) declines and/or stabilizes.

Money or the lack of it may be the root of all evil, but it gets people's attention regardless.

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