FORM FOR COMMENTING ON A PUBLIC REVIEW DRAFT
ASHRAE STANDARD, GUIDELINE OR ADDENDUM
changes indicate 7/22/08 edit of original submission

Designation and Title of Second Public Review Draft: **BSR/ASHRAE/USGBC/IESNA Standard 189.1P,** *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*

Table of Contents, propose add new Chapter 12 - Total Impact Measures

4. Comment (Proposed Text):

The purpose of providing ~~various~~ impact and cost measures is to provide information ~~on~~ that ~~which~~ people can use to make informed choices. ~~It is becoming understood that the total direct~~As we learn about it the direct resource costs ~~and effects of interfering in nature~~ resulting from economic choices it is becoming understood to be far larger than what an end user is normally aware of. It is ~~the end user~~the decision makers who make~~s~~ the choices to incur those impacts~~,~~ ~~however, and the one~~ and whose choices can alter those consequences that need the information. The following principle shall apply to all work subscribing to these guidelines. If any measure of sustainability, impact measures in the form of LCA estimates or separate carbon release or energy use measures or other indicators of environmental impact are included, they shall be accompanied by measures of total impact, stated in a way to include the entire accumulative ~~impact~~ impact represented by the choice involved, and not only the near and easily identified sum of accountable impacts. The need for this is to accurately measure the true impact of the choices being made, ~~to so to make~~ so that choices intended to regulate a user's impacts can be more effective .

Such total impact measures shall include a best available estimate for the total unaccountable impacts implied by the economic costs of the choice, considered as the global average impacts for that fraction of GDP, ~~except~~ as adjusted for the directly accountable impacts in a manner to more accurately reflect the true total. This approach ~~will make~~captures all the contributory choices, such as those of manufacturers and their dependants, operations and supply chains, ~~also included in and responsible for the impacts of~~ as part of the impacts of delivering a product or service. The impacts of these ~~se sequential~~ contributory choices ~~regarding the same impacts~~ are all valid ~~with respeca~~t additions ~~to measuring~~ the responsibility of ~~all~~ the separate individual end user choices. To avoid double counting, though, whenever these measures are to be combined they should only contain the accumulative total of the end user's responsibility, or as otherwise ~~designed~~ defined by econometric methods to assure accuracy.

5. Substantiating Statements:

~~Approaching design problems u~~Using true whole system impact measures is quite uncommon. That would also appear to be one of the great reasons why the worldwide effort~~s~~ to control mounting environmental impacts has been so ineffective. We don't measure them. We tend to only measure our improving efficiency in adding impacts. For measuring sustainability that's the wrong measurement.

It is also highly unusual to find an accounting question that reveals a factor of 10 or more error in customary professional practice. That's nominally what a whole system measure of the energy responsibility of our building choices results in though. If you compare the Energy Star building energy survey estimates for the energy used by buildings and the implied share of global impacts for the fraction of GDP a building and its users accounts for, they seem to differ by that amount.

Two highly recognized impact analysis and complex systems economists have acknowledged the validity of my method~~, and then~~. They have also declined to correspond on the matter, apparently because the facts conflict with social convention. One of those is Wayne Trustee the author of the Athena LCA tools, who said on understanding my method "Yes! That works" [wayne.trusty@athenaSMI.ca]. The other ~~was~~ is one of the world's leading complex systems theorists, John Sterman of MIT, who when he understood it and asked if impact measures for choices should include the true total or not ~~and~~ said "Yes!" [jsterman@MIT.EDU]. The 'rub' it would appear is that making each dollar of final consumption choices in GDP responsible ~~of~~ for its true share of economic impacts ultimately means accepting that money costs energy. Money is a marker for resource uses~~,~~ and isn't cost free. It has ~~of~~ the material consequences we have shrugged off before because the impacts were unaccountable, simply because we didn't have records of how the money was used~~them~~. That people would be emotionally upset about their actual impacts being ten time what they thought ~~that~~ is understandable, but that the earth is physically upset by~~ that, and by~~ our not making valid choices as a result, is understandable too. That most people have no idea that multiplying money has multiplying physical impacts quite directly needs to be corrected, and using accurate measures is part of it. It's really just that simple.

My research notes are reproduced below, similar to the version on my web page:
www.synapse9.com/design/dollarshadow.htm

Why Money is Energy &
a measure of the Total Energy and Physical Earth Shadow of your Choices

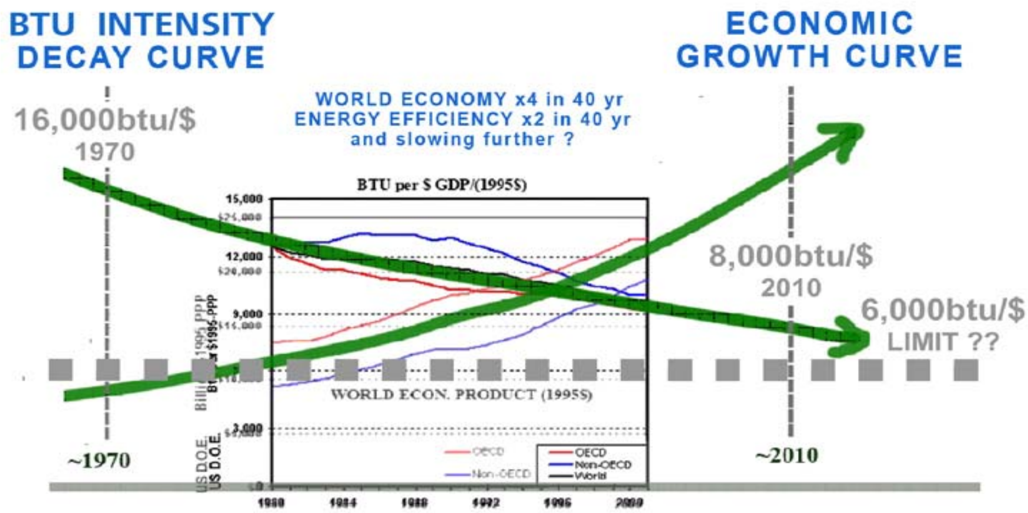
$1 average spending uses ~6000btu = ~1hr PV gain for a 100 ft sq collector = ~12ozCO2
Philip F Henshaw AIA AAAS id@synapse9.com

Adding up what's most untracea ble..

Statement of the principle:

The economy requires energy to deliver the goods and services we buy using diverse supporting services in your community and around the world. Average spending is then going to be responsible for an average share of it (see details below). That's the principle. An average share of the total energy the world uses is ~8000btu/$ (1995$) according to the US DOE. Due to inflation and improved efficiency that's ~6000btu/$ in 2008. To help convey how much energy that is, think of the solar energy that could be made into electricity in an hour with a high performance PV panel measuring 100ft on a side. That's around the same 6000btu. This estimate is based on a 40deg north latitude location, averaged over a 24 hr, 360 day period, with normal weather, with 18% collection efficiency as if for expected future high performance solar cells (1)(4)(corr3)(corr4)

The ethical and moral choice is fascinating. By paying for products we also choose to directly request and pay for the whole diverse web of things that went into them. We consume the product of those contributions to what we buy, and see we're physically responsible for it. We have not traditionally thought of being ethically or morally responsible for it, though. Usually we feel ethically and morally responsible only for our own personal acts, seeing other people's acts as their own responsibility. Now it turns out that effects our choices and we want to have an effect on how our choices affect our world. Unless we know the whole impact, though, we can't make effective choices about it. When we have better information we can not only make better choices, but have them be effective. It's also an opportunity to extend our own ethical and moral responsibility much further into the whole system of the world, if we choose.



US DOE 20 yr Global Data from 2004 study w/ pfh Overlay & Extensions

This graph shows an overlay of two of the figures from reference (1), showing the world trends in GDP and energy use Intensity. The differences between the developed economies (OECD, red lines) and the rest of the world's economies (blue lines). That the two follow similar curves, and that money flows fan out extensively is part of why all spending is assumed to be average unless otherwise determined.

The critical question is whether treating all spending as having average energy content unless shown otherwise can be broken into several parts.

1. Why is directly measuring the total contributing impacts difficult?
2. Does the uses of money always distribute very widely through the normal uses people make of it?
3. Can you adjust the implied average for known measurable impacts?
4. Are there hidden high or low impacts embodied in some choices that might introduce errors?
5. Is there any other way to estimate the error in counting only the easily visible impacts?
6. Will better statistics, less dependent on theory, become available as people use this approach?

Each of these could be an essay, but first I'll try to answer each simply, and then treat the remainder of this attachment as further discussion.

1. It is quite hard enough to find out what a project's direct energy uses will be, especially during design when decisions are being made. It is also not actually possible to add up the things no one keeps records of, and that includes the majority of the spending. The majority of spending for things goes to the people who assist in delivering them, all the way down through the supply chain.

2. Yes. If you just think of all the very many ways you distribute the money you receive for the work you do, and then of the ways those people distribute the part they get from you begin to see. The product you help make costs $100 and the business passes parts of that on to each of 1000 diverse kinds of contributions to delivering it, including yours. If each of them does what you do, spend their share on 1000 diversely different kinds of things, the one product choice is responsible for enabling 1000 times as many other choices at each step. In three steps that's a billion choices, in four a trillion. It's likely to equally support all the different kinds of uses people do in proportion. There are also some other issues that touch on, but do not alter, this conclusion.

3. Yes. The normal accountable energy to be factored in is the electric and gas bill and the gallons of gas and things. The simple rule of thumb I use to get the right scale of adjustment for these hard

measures of fuels is to just add their btu equivalent to the total. You'd think, perhaps, of factoring them in, adding their btu equivalent while subtracting their cost from total. The odd thing is that the money you pay for gas doesn't go to nature for the flammable liquid, it all goes to other people, who use it to consume things throughout the economy, and incur average impacts from that.

4. Not that I know of.

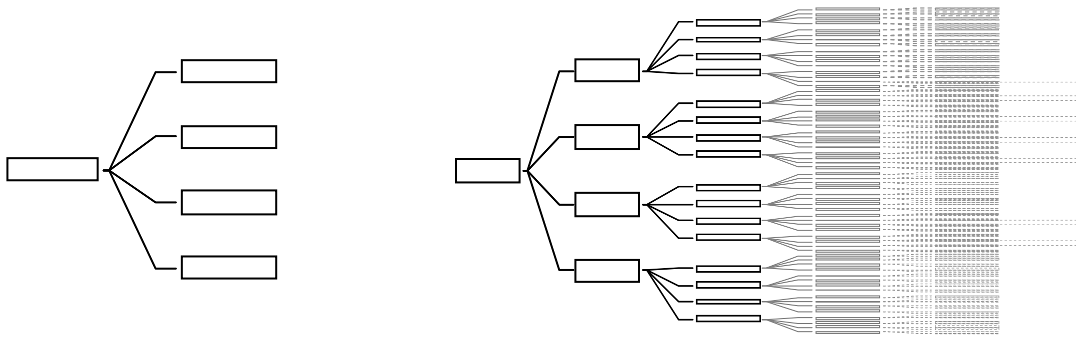
5. What will happen is that businesses will see the need to reduce the energy content of their supply stream, and pass on their locally lowered impact intensity to the consumer, so they can sell things at a higher price for lower impacts. They will need their suppliers to do that, and pass those savings on to them. It will result in their whole supply chains passing detailed energy intensity information along, making the end user choices ever more effective.

Discussion:
The following research notes was edited in Feb 2008
http://www.synapse9.com/design/dollarshadow.htm

Those energy uses that are spread throughout the economies is what this measure captures. In the end, most of the untraceable energy uses come from the money you give to people. It causes the current energy impact models to miss 90% or more of the real energy costs of what we do (14,15). This interpretation was looked at by the life-cycle impact economist Wayne Trusty (author of the Athena life-cycle impact tool) and found to at least be theoretically correct. Measuring your energy use as a share of the whole provides a true statistical measure that lets you see the difference between what is and is not accountable. It gives you a) the real scale of your energy choices and b) a guide to locating where they're hidden and why they're growing. For most US home owners the $shadow height of a collector to support their lifestyle would be the width of the home and over a mile high (sim 11). That's more than large! It's also not in our control, and so a little home efficiency won't touch it. There's one thing you can do. Take the material small steps that lead to a new future. The only feasible way to compensate for such large excesses is to contribute to our finding new ways to think and act in the future. We need a different way to measure luxury than in terms of multiplying money and energy use.

[Double counting note: This way of calculating energy & CO2 impacts works because it counts the whole cascade of contributions that occur as a consequence of spending. It measures the whole effect of choices. That also means you should take care to not double count contributions. If the cost of your salary is counted as part of the costs of your company's products, the two should not be added. There's dual responsibility in that both you and the people why pay you are responsible for the energy consumed by the money you spend. Economists are careful to not double count what they include in GDP. You would use their same method to count whole environmental impacts using this tool so they can be added without overlap.]

The scientific idea: The 'embodied energy' (or 'energy intensity') of any product or service is the sum total of all the energy uses needed to provide it. The problem of adding that all up is that in an economy most of them are unaccountable. Driving a car both burns energy in the engine as well as in making and maintaining the car. Keeping insurance for it, supporting the gas station as a business and the consumption of the people at the refinery are also all in there. Your choices are responsible for energy consumption of very many kinds throughout the entire network of people that take part in bringing you what you purchase. The money you give them supports both the energy consuming work they do at their jobs and also the energy consumption of their entire lifestyles. It's not possible to count up since you can't ask them what they do with your money and they wouldn't be able to give you useful answers anyway. It's actually prohibitively difficult to trace, and so while while not at all invisible, it also remains completely 'unaccountable'.



Accountable Energy Uses w/ 10+ times the Unaccountable Energy

Figure 2

The real problem is that the unaccountable part is so much larger. The distribution has what is called a 'fat tail' in the sense that most of the embodied energy for products is located in the tiny contributions scattered beyond your ability to identify them. These sources remain 'hidden' because the information gathering task is too difficult. Using the average value for all spending to estimate the energy diffusely consumed throughout the system is a great shortcut, particularly for getting you to look at the difference between what you can and can't account for. More work will find more exceptions, but it seems quite likely to be very accurate for most spending, simply because of how widely people distribute money, from one source to many many destinations.

Understanding that a $1 apple purchased in New York, has a hidden energy cost equal to a $1 share of the energy used by the whole economy that New York is part of, takes some thinking. You need to add up all the little bits of energy use in the world that are required to bring that apple to you where you are in New York. That includes supporting the farm and all the activities of the farmer and his family, all the goods and services resourced from all over the world to support the work of farming and the consumption that the farmer's whole family relies on the money for. As you count it up it becomes clear that it's the whole economy that is delivering that apple as a $1 product. There's also the important insight that most kinds of products are essential companion products of others. Part of buying an apple is the service of the whole city's systems in bringing it to you, made possible by your having clothes and a place to work, the whole environment of interacting parts that make the exchange possible. It's good general reason to accept that any part of the whole economic system should be credited with it's share of the whole system's impacts.

Still you might say, it just doesn't *look* like money and energy are the same thing, so how can they be equal? There are two things that have been hiding their direct connection from us. It's not coincidental that energy is nature's universal resource for making things physically happen and money is our universal resource for making things. We only pay people, and consider nature's resources as free, but what we are actually getting when we buy things is packaged energy. Yes, we only see the 'package' in a sense, but the whole process of making things consumes energy and so that becomes 'embodied' in the product. The most specific reason seems to be that when we choose to give money to people we select those who deliver products for the least energy. That ties maximizing efficiency and a necessary amount of market determined energy content in every step of product delivery. Globally that makes price a direct measure of energy use for every process. That all the economies give energy about the same economic value and price and are improving their efficiency at the about the same rate everywhere, then, fairly assures that the relationships between money and energy will be uniform in the world and steady.

Because energy is such a universal commodity, and flows to wherever it is most needed, it turns out that money has almost the same energy intensity everywhere. The measures show that the economies employ fuels at about the same btu/$ efficiency rate in every economy, rich and poor, and that the trends of change in all economies follow the same norms. This amazing evidence was gathered by the US

Dept. of Energy in a 2004 study (1) and are further verified by the updated 2007 EU IEA data (6.1) That all the economies behave as a whole in how they use fuel is another way to say why individual shares of GDP are a good direct measure of individual shares of global energy use. Why the economies have consistent matching global behavior, treating energy as a universally interchangeable part with a universal matching $ value is harder to explain. It takes an exploration of complex natural systems, from multiple points of view. Perhaps the best shortcut way to explain is just that all of nature treats energy that way too. Energy is the universal interchangeable resource of all systems.

Another way to understand it has to do with the 'liquidity' of energy and money and the economic principle of the 'flat earth'(5)(6). Every money event and every energy event have ripple effects that spread throughout the economic system. Some settle out quickly and some more slowly, but they all tend to seek a single common level, like ripples in a pool. You can see this in the energy intensity curves for individual economies (1). Even though the individual economies are all are heading in the same direction they each do so in a different way. You can also see it in the way economies sell whole market baskets of products, not individual ones. No one product is either useful or producible without an extended network of 'companion products'. For the energy intensity of spending to vary from place to place would require change in the whole network of companion products to constitute a local 'product space' (16). Logic suggests that choosing to buy products from product communities (product spaces) with unusually low energy intensity, for example, would only be possible from within them. They probably exist and your lifestyle or community might develop a system learning path toward becoming part of them, but doing that is not a readily available choice for most people. The economies are very thoroughly integrated on price alone. You can think your economic world is local, but so much of the true network of dollar flows is probably global.

It would certainly be nice to be know about low-impact product communities, how they might develop and what it takes to encourage them. That's an area of research that's wide open it seems. The obvious one is the loose idea of choosing to live and work in a 'green world', with everyone in the 'network living simply. It's physically possible for that to work and for such networks to become stable evolving and self-sufficient. There are also lots of hidden flaws in the idea that help explain why the way people normally think of doing it usually fails. Product networks that separate you from the larger economy tend to wither is the main one. There's also a lot of the 'you can't get there from here' problem. Product spaces have natural whole system learning paths that enable or restrict their development and it would be good if more study was put into understand them better. It seems very likely that reducing the energy intensity of spending while retaining high quality services requires whole system change.

That whole system change in energy efficiency is realistic and happening naturally anyway is evident in the DOE data curve above, showing a typical decay trend, and in the 35 year IEA world energy intensity data (6.1) which shows more detail. A close look at the detailed world energy intensity curve shows a 'stairstep' shape to the curve, which seems likely to indicate alternating periods of 'retooling' and 'using' emerging kinds of systemic efficiencies. Studying the subject would probably lead to a better understanding of whole system efficiencies develop.

How you might use it: The first principle of systems learning is to just start with small accumulative steps. Make sure you 'look around', find a few things to put 'in the box', including ideas for looking further, and add up the total. Basing your choices on 100% rather than less than 10% of your direct energy impacts on the earth is good. It's not an answer, it's a better question. Better information about our whole impacts will make our choices, of all kinds, more effective. It helps correct the flaw of economies that the natural systems on which we entirely depend are universally assigned the value of $0. That's a very curious error, and not easy to correct.

If you wanted to assign a value to nature, what would it be and who would you pay, anyway? It just does not fit the model. The economies do not recognize the value of their environments in much the same way as a formula is completely self-contained and can't change itself in response to changing behaviors of the world around it. One thing we can do, now that we see that $=energy quite directly, is understand that defining 'good' in terms of the rate of multiplying $'s is inherently bad. It's missing all the relevant connected values. We need other definitions of good, ones that take nature into account. We need things like learning to use rigorous whole system measures to give the word "sustainability" more substantive meaning as an end product.

Using global impact measures is essentially just another way to guide project design to produce a better product, like the rigorous credit point checklists used in LEED, the energy rating estimator used in Green Globes, or my 4Dsustainability learning and evaluation model, or other methods. The difference with accounting for the whole impacts of things is that you can then measure whether your adaptations have increased or decreased your impacts on the earth. The point systems like LEED don't actually give you that information, though. Consequently most traditional or green projects still produce large and increasing environmental impacts. LEED just measures quality, and doesn't measure quantity except as a qualitative ratio, so there's not 'total'. We've learned how to increase our impacts on the earth more efficiently... but that's not good enough.

The steps for using the $Shadow measure on a building project begins with comparing the total energy use implied for average btu/$ spending with the particular energy uses you can measure. That means multiplying an initial total project costs by 8000btu/$ and comparing it to the fuels and other things the project would consume. Then you'd try to explain the difference and adjust your estimate up or down accordingly. It can be done with either complete analytical rigor or just rounded up or down based on judgment. You'd want to do this in a way that is simple at first and lets you come back to refine it. Then you'd do the same thing for a baseline reference project costs. That might be the prior use of the site or a prior service being replaced, something to compare in a meaningful way to give you the change in the earth, before and after doing your project. Two ways of doing this for a sample project are in my resources (11, 14)

The next step is to choose one or two more additional total project impact measures, such as using the $Shadow method for CO2 as well (fairly easy) or the Energy Star project energy estimator (fairly easy) and the EF global environmental footprint method (a little more work). Then you'd have a picture of before and after for energy, for CO2 and for renewable eco-systems services. You might also want to add onto that using the greenhouse gas inventory method of GHGprotocol.org which is likely to become a reporting requirement for all businesses and the Athena life-cycle assessment tool for a complete impact picture (a lot more work).

There's a real value of keeping things simple, and as rigorously complete as you can. That's partly because you want to be able to adjust them over and over, and if it's too complicated it's not going to be useful. It may be the most important lesson of all to recognize, in designing our new way of design we've been doing the opposite. We've 'innocently' been stepping into a job of micro-managing whole environmental systems and our increasingly complex interactions with them. Yes, that is partly forced on us by everyone being caught off guard by our massive interference in the earth's natural systems. We also err in thinking that taking on ever more complicated problems is solvable. It's not. It means taking on ever steeper learning curves. Hm... Learning how nature does things of exceeding complexity, very simply, is on this learning path, but a ways along, so the immediate next step is to add a couple more rows to your project's whole impact measure chart (14,15).

The next things to look at are your adjustments. With any estimating method you need to make adjustments to balance what's accountable and what's not, combining direct measures with contingencies for what's unmeasurable. Cost estimating always does that, and impact estimating needs to do that too. For any method you use if the 'contingency' is not there, you need to plug one in. For the $shadow method the entire estimate is for 'unaccountable' energy costs, and you need to adjust it for the accountable 'non-average' impacts you can see. The simple, and nearly correct way to do that is simply adjust the project $shadow by adding all the direct fuel uses as direct impacts. That means if you can count a certain number of btu equivalents for electricity uses, just add it to the total, since the $Shadow measure large estimates the consumption of the people behind the product. Other materials might have more or less than the average. Concrete, for example uses direct energy six times the btu/$ of average spending, or around 48,000btu/$. These kinds of rules of thumb are needed for a wide variety of materials and systems. The only one I can think of that might significantly reduce the embodied energy of spending would is when the main value of the product is as art, and most of the 'value added' is in the artist's signature.

The next step really shows you why this needs to be kept fairly simple. It's to compare your target scenario and compensations. The target scenario could be to raise project quality in a way that makes reducing project impacts to somewhere around 1950 levels for the same functions. That's very roughly the global warming objective. One could pick a target in lots of other ways too, as Architecture2030 does, for example. Then you compare that with your proposed project totals and that tells you how much you need to compensate for somehow. Designing your compensations is the true creative challenge. Make real, honest estimates of the beneficial impacts for project choices that would have direct community or environmental benefits or long range effects on the future. A publisher, for example, might devote a portion of their staff hours to maintaining a community resource website for any target community they think might benefit from having help communicating, local or international. The diversity of ways to effect the future is immense, of course. The big one, and the toughest and most important, is helping people figure how we can stop having growing impacts on the earth as a whole world. That's not just a lifestyle change, but true whole community learning, and the first small accumulating material steps are of extraordinary real value.

Any particular project would have different results, but for one five story project the $Shadow estimate was that it would take high performance PV panels 125 times the size of the building footprint to supply the energy for its combined operating and amortized development costs. That's a multiple of 22 times the estimated footprint of the reference prior site use, small scale brownstones. One compensation goal considered was to materially contribute, to the degree the project missed the target, to reversing energy use growth in the building's stakeholder community toward achieving the IPCC 80% CO_2 reduction target. Asking how to do that stimulated two main ideas, and a new path of learning sustainability in the stakeholder community. One was that we could reduce the building size by finding a collaborator in the neighborhood to share some functions, and share the expensive centerpiece of the design in this case, so that expensive piece could have multiple uses. That would greatly reduce both the footprint and the compensation target. Then we also began looking in an open ended way at who the stakeholders in the project really were, and how their interests could be combined to create other value for free.

One idea was to pitch in on the city sustainability plan, initially considering storm water retention to help prevent polluting runoff and restore the ecology, but also deciding to go well beyond the intent in use the LEED education point. That would serve as one of the project's 'bright green spots' and a good research and experimentation opportunity. Another idea was to influence the future by the project becoming a neighborhood center for helping people with their energy and CO_2 inventories. We also considered compensations in relation to 1) their lasting accumulative direct effect, 2) their value as important symbols, and 3) carefully examining them and avoiding those possibly having reverse effects. Of course the plan included to make efficient buildings and measure progress with other measures like LEED. The fact what can have the most effect is whole system learning, and accountable impacts like efficiency measures address may control only 10% of the problem, does change the picture. In many cases it's hard to imagine how a building could effect the future, particularly enough to reverse it's own excess impacts. Learning curves always start slow, though, with small steps. What's important is the accumulation of steps and the quality of the learning. It's what a finite, fragile, and truly beautiful blue ball in space seems to need from us.

pfh

References

Source of the 8000btu per $ global constant, DOE charts for global energy productivity in a report on the global carbon trends:

1- website: http://www.eia.doe.gov/emeu/cabs/carbonemiss/chapter1.html
2- document: http://www.eia.doe.gov/emeu/cabs/carbonemiss/energycarbon2004.pdf

Conversions used from btu to square feet of earth at 40 deg N. lat. 15% energy extraction efficiency:
3- wind energy manual http://www.energy.iastate.edu/renewable/wind/wem/wem-18_apen_a.html
4- bioenergy calc sketches http://www.autobloggreen.com/2007/06/25/reader-essay-the-origins-of-power-cellulosic-ethanol-vs-sola/

Basic references for World energy economics:
5- http://en.wikipedia.org/wiki/The_World_is_Flat
6- http://www.eoearth.org/article/Ten_fundamental_principles_of_net_energy
6.1- http://www.synapse9.com/issues/World-eff_grow.pdf
- A great compilation from longer and better IEA and Angus Maddison Historical data showing the whole history of growth and our present stair steps of improving efficiency in converting energy to wealth.

My (not updated yet) discussion of the DOE data's meaning for the long term sustainability of growth and my slides of the DOE figures to help in seeing the relation as a flowing change :
7- http://www.synapse9.com/unsustainable.htm
8- http://www.synapse9.com/issues/GroEfficiency40.ppt

HDS Excel (rough templates for organizing these complicated conversions)
9- http://www.synapse9.com/design/$shadow1.xls
10- http://www.synapse9.com/design/$shadowIncome.xls

HDS Sustainable Design Resources
11- http://www.synapse9.com/design/TotBalance-concept.pdf - comparing site use before & after
12- http://www.synapse9.com/design/
13- 4D Design Process model Wiki

HDS TotalBalance with CO2Inventory
Spreadsheet for projects showing
- Adjusted whole system impacts, prior and proposed, with future & compensation targets, for multiple measures
14 - http://www.synapse9.com/design/TotBalance-concept.pdf - summary page PDF
15 - http://www.synapse9.com/design/TBalanceInventory.xls - model speradsheet

Other Research
16 - Product Space, a network model of the learning paths of natural economic product communities
17 - World energy curves - 2000 year World GDP, current GDP, energy & efficiency, OECD 1000 yr projection

Physics Principles
20 - Principle of conservation of energy, that energy is transferred or transformed, not created or destroyed
21 - Principle of thermodynamics, corollary of (20), energy change = energy transfer - 'work'
22 - Principle of limits - entropy, also known as principle of waste & decay, all energy transfer takes 'work',
23 - Principle of continuity, derived corollary of (20) & speed of light providing bounds of organizational development
24 - Principle of diminishing returns, the limit of perfecting all directions of progress, corollary of (22) & (23), Jevon's law

[Source data note:
- For CO2 inventory, the same DOE data(1) provides .57Metric Tons per $1000 (1995$), (or 12oz/$1) for average CO2 content spending. The interpretation is similar and the averages still valid, but since energy sources vary in how much CO2 they produce, and CO2 is not a priced commodity (yet) CO2

content per $ will vary more, and so more adjustment of average embodied CO2 for non-average content would be needed for accuracy.
- The DOE figures(1) are only for energy purchased as fuels, and omit the direct solar energy used by the economy. That raises the broad question of unaccounted 'natural system services' that are even more 'hidden' from the economic statistical measures than distributed purchased fuel uses that a $shadow measures
- The EU world statistics from the IEA and historical world statistics from Angus Maddison provide a more detailed picture of the whole evolution of energy consumption and our present stair steps of improving efficiency in converting energy to wealth (6.1)]

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correction & edit notes

First POSTED TO THE A.I.A. Committee On The Environment Forum - 7/05/07
Archive at http://lyris.aia.org/read/?forum=coteforum

1- The DOE figures for total energy used by the economies do not include any solar contribution, only purchases of fuels. That includes some renewables like hydro power as purchased electricity, but ignores the solar energy in growing corn. This means that the actual embodied energy per dollar is higher, and somewhat harder to calculate. Some figures are kept by the International Energy Agency in Paris does (http://www.iea.org/Textbase/stats/index.asp), but these have not been investigated. The more interesting question is whether including the solar contribution would change the decay curve shape of the historic btu/% curve that seems to say that the economies have long been approaching an asymptotic limit for the economic values of people. It's unlikely that that would change, but the question open. 9/5/07

2- After some delay.. I finally got around to proofing the conversion from btu's to shadow area, and found a factor of 10 error (arg!) but still trust the more basic principle, that whatever error you make if it's the same one over and over the results are still comparable. There remain some application issues, with my main update being to realize that the measure is most accurate and valid for the energy uses a dollar is responsible for that are hardest to trace. That's very cool. 10/29/07

3- I got a longer and better data set than the US DOE data, from DOE researcher who knew the EU IEA 2007 data sources. That's displayed in (6.1). It seems to confirm the basic 8000btu/$ metric, but has a different apparent growth rate for the energy intensity curve than the DOE 2004 data . That may be due to counting different kinds of energy, I'm not sure. I had been saying the DOE world GDP trend was +3.5% and the decay of energy intensity -1.8%, projecting the curves visually. The IEA data shows world GDP growing at +3.02% and the decay of energy intensity at -1.23%, both much slower rates; doubling GDP every 24 years and halving EI every 60 years. Until a more complete analysis and online tools are developed the original rules of thumb are nearly accurate and would only confuse things to change. 1/20/08

4- To keep things simple, though the 100ft sq 18% efficient PV panel actually calculated to equal 8000btu, I decided in 2008 to adjust the btu/$ rate to 6000 to make the estimate in current dollars, and reduce the nominal PV rate for comparison to 6000 too to, as the error of 25% introduced to keep things simple seemed small in comparison to the error of 1000% being discussed.