Measuring Total Energy

The Science behind measuring the total Energy & $C0^2$ impacts of our choices

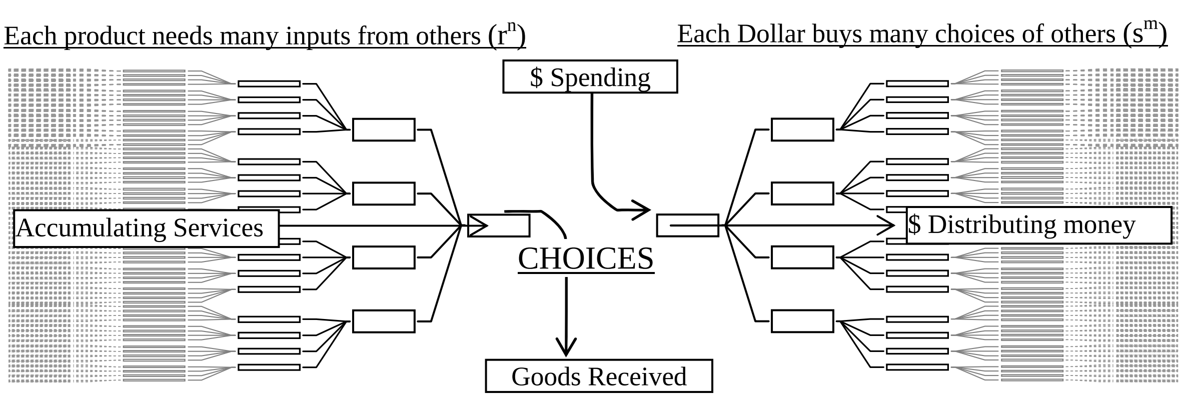
DRAFT RESEARCH NOTE

When one adds up the parts of something, and it differs from the total measured by another method, it tends to point to things being left out. It turns out that for very interesting reasons the unaccountable energy and CO^2 content of our building and spending choices is very much larger and distributed very differently than the accountable part, by a factor of 10, or more. It reveals a basic conceptual error in environmental impact accounting, stemming from the hidden realities of complex systems. What should add up, but does not, are the effects of our choices we can see and the share of the whole economy's impacts directly attributable to them. ***The one looks at the parts and the latter their necessary share in the whole, and they miss by a mile.*** This changes the 'picture' of the energy problem, helping us understand how the economic systems act as a whole, and altering the assumptions about individual choices and the apparent options available on climate change.

The most interesting part is the explanation you're largely forced into, that most goods and services rely on the entire world economy for their delivery, and the effect of most spending choices distributes so widely so as to support the entire world economy in the same way. ***Perhaps the key insight is that all resources have $0 value, because nature does not charge any $ price for them.*** Consequently, *all* spending is only for what the people behind the product do. For the initial and operating energy costs of a building, perhaps, you'd normally consider:

- the manufacturing fuel use for the concrete or steel and perhaps the contractor's equipment fuel and electricity use, and other things like that.
- the finished building's annual electricity & fuel consumption, maybe including the source generator and refinery energy losses,

The far bigger energy cost to the economy is paying for the whole lifestyles of the people who's contributions are needed to create and bring things to you. That includes what people do with their salaries, what the businesses does with it's profits and it's 'soft costs' of insurance and management, etc, etc That larger part of what is behind our consumption choices has been missing from the accounting almost entirely.



1 - Inputs combine to make goods and services   2 - Spending fans out from goods & services

HDS

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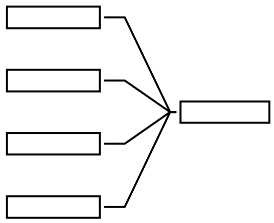
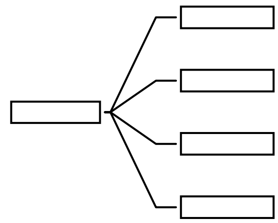
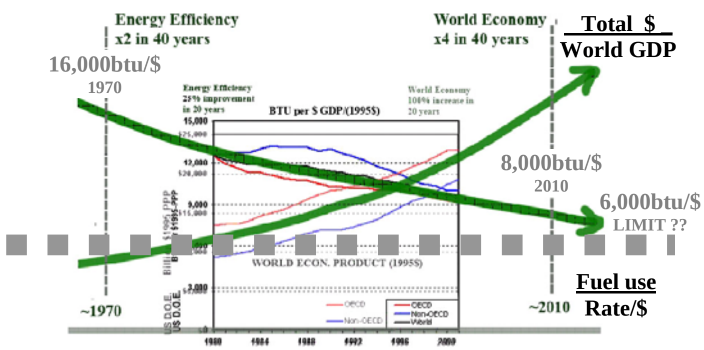


3 - Input products & services we can see



4 – Spending consequences we can see

DRAFT NOTES & REF'S BELOW, FROM OLD $Shadow web page



For 'normal spending' the area of shadow cast to collect the energy needed is ~1,000 SF-hours per $1 [or ~ 0.1 SF per yr]. That's the area needed to collect the nominal 8000btu/$ of fuels used to produce $1 GDP anywhere in the world, estimated for a 40deg north latitude location recovering solar energy at 18% efficiency, as for future high performance solar cells (1)(4).

It works because the measure is statistically most accurate for the energy costs that are most hidden and hardest to trace. Those are the ones that are spread throughout the resource stream behind any product, and for measuring how that contributes to our still growing total energy use. The true value is it gives a true measure of a) the scale of your energy choices and the effort needed to displace them and b) points you to look for where your hidden energy uses are located. The bad news...just to understand the scale of the hidden energy use in spending, for most home owners the $shadow height of a vertical high performance solar collector the width of their home will be over a mile. That's huge! A little conservation won't alter things of that magnitude, and radical change can't happen all of a sudden. `The one feasible way to compensate for such large excesses today is for what we do to have multiplying effects on changing the future..

[Interpretation note: Why this way of calculating the the energy & CO2 impact of our choices is that is counts the whole cascade of contributions that occur as a consequence. 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. The economists are careful to not double count what they include in GDP. You'd use their same method to count whole environmental impacts in a way they can be added without overlap.]

[Source notes: 1) For CO2 inventory, the same DOE data(1) source 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, 2) 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 scientific idea:

The 'embodied energy' of any product or service is the sum total of all the energy used to deliver it. The problem of adding that up is the long list of things to separately calculate. Driving a car both burns energy in the engine as well as in buying and maintaining the car, keeping insurance for it, supporting gas station and the people at the refinery. Your individual spending choices needed energy consumption of many kinds throughout the entire network of people that took part in bringing you what you purchased, and then they use the money you give them for supporting their entire lifestyles and diverse kinds of consumption. Each item in the linked network of lists of these kinds then becomes another long list of things to separately calculate. It's actually prohibitively difficult to trace, and so while obvious, most of it also remains 'hidden'. The real problem is that the distribution has a 'fat tail' in the sense that most of the embodied energy for products is located in the tiny contributions beyond the fringe of your ability to observe. 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.

Understanding that a $1 apple purchased in New York, has a hidden energy cost equal to a $1 share of the energy use of 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 obtaining with the money earned. As you count it up it becomes clear that it's the whole economy that is delivering that apple as a $1 product.

Still, if the energy content per $ (its energy intensity) varied widely, then treating all untraced spending as having average energy content could cause significant errors. 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/$ in every economy and that the trends of change in all economies closely match. This amazing evidence was gathered by the US Dept. of Energy in a 2004 study(1) That all the economies behave as a whole in how they use fuel is what really assures that 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 why economies treat energy that way is 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. 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 that represents the local 'product space' (16). The evidence is that self-sufficient product communities having unusually low energy intensity are not available choices for most people. You can think your economic world is local, but so much of the true network of dollar flows is probably global. That's the penalty of the 'fat tail' of hidden energy content in all spending.

It would certainly be nice to know how low-impact product communities might develop and what it takes to encourage them. The obvious one is the loose idea of choosing to live and work in a 'green world'. It's physically possible for that to work and become a stable evolving and self-sufficient network, but there are also lots of hidden flaws in the way people normally think of doing it. Product networks that separate from the larger economy tend to wither. 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.

How you might use it: Having better information about our impacts on the earth is one way to respond to the apparent approach of a combined systems failure. Good information on our total impacts helps correct the flaw of economies that they assign everything in nature the universal value of $0. That's a very curious error. 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 its own structure in response to changes in the properties of the world around it.

Using global impact measures are essentially just another way to guide project design to produce a better product, like LEED and 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 qualitative guides like LEED don't give you that information, and most traditional or green projects still have large increasing environmental impacts associated with them.

The steps for using the $Shadow measure on a building project begin with comparing the total energy use implied for average btu/$ spending with the particular energy uses you can measure. That means multiplying the 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. That might be the prior use of the site or a prior service being replaced, something to compare in a meaningful way 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 global impact measures, such as using the $shadow method for CO2 (fairly easy) and the EF global footprint method (a little more work). Then you'd have a picture of change 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. Now I suppose you see the value of keeping things as very simple and clear as you can, and also be able to come back and make adjustments. It is perhaps the most important lesson of all that taking this direction of micro-managing of environmental systems, forced by our massive interference in the earth's natural systems, is what we're inadvertently heading into. It means taking on ever steeper learning curves. Hm... There's a couple more simple steps before throwing up your hands, just making a couple more blank pages.

The next step is to do the same project estimates for your target scenario and your compensations. The target scenario is a second way to estimate your excess impacts and how much you need to invent compensations for. Designing your compensations is the true creative challenge, composed of hopefully real and honest estimates of the beneficial impacts of other things in your building program or intended effects on the future. It also draws you into questioning the entire program scope, not just the cost and quality of materials. 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. 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.

Your project would have different results, but for one five story project $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. If the compensation target use was to have the effect on the world of reducing the building's CO2 footprint to the magical IPCC 80% reduction level by reversing energy use growth in the building's stakeholder community. Asking how to do began by stimulated two main ideas. One was that we could reduce the building size by finding a collaborator in the neighborhood to share some functions, to share the expensive centerpiece of the design in this case, so it could have multiple uses. That would greatly reduce the 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 without money.

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 use the LEED education point in a much more intensive way. 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 CO2 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 my office also plans to make efficient buildings and measure progress with other measures like LEED. 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, 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

DRAFT RESEARCH NOTE IN PROGRESS

Draft References

1- website: http://www.eia.doe.gov/emeu/cabs/carbonemiss/chapter1.html
2- document: http://www.eia.doe.gov/emeu/cabs/carbonemiss/energycarbon2004.pdf
[Source of the 8000btu per $ global constant, DOE charts for global energy productivity in a report on the global carbon trends:]

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/
[Conversions used from btu to square feet of earth at 40 deg N. lat. 15% energy extraction efficiency:]

5- http://en.wikipedia.org/wiki/The_World_is_Flat
6- http://www.eoearth.org/article/Ten_fundamental_principles_of_net_energy
[Basic references for energy economics]

7- http://www.synapse9.com/unsustainable.htm
8- http://www.synapse9.com/issues/GroEfficiency40.ppt
[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]

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

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

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