YOU are invited to join a history project called ENERNET, which analogizes information and energy, which mines analogies between the Internet and the … Enernet. As over the past ~62 years we met world needs for cheap and clean INFORMATION by building the INTERNET -- my argument goes -- we will over the next ~62 years meet world needs for cheap and clean ENERGY by building the ENERNET.

Don’t confuse Enernet with enertech, which is short for energy technology, a la infotech, biotech, mediatech, nanotech … enertech. As a VC, I am growing my enertech portfolio. Enernet is also not to be confused with other net words: Arpanet, Ethernet, Internet…

Enernet is my 2008 book tour, only I don’t have a book, just these powerpoints. Stops along the tour include Ember (twice), MIT (twice), Internet Cowboys unConference (Jackson Hole), Metro Ethernet Forum (Boston), Big Boys Camp (Green’s Island, Maine), American Spectator Magazine (NYC), Telecosm (Lake George, NY), AlwaysOn Venture Summit (Boston), Olin College (Wellesley), Lux Research (Cambridge), … and next, Virginia Tech, on November 21, 2008.

Thanks for your interest. Feel free to pass along these powerpoints and their notes.
These Enernet powerpoints are my first-ever PowerPoint presentation, which is ironic since I was on the board of the start-up that developed PowerPoint and sold it to Microsoft in 1987 for $14M.

The start-up was Forethought, in Mountain View, CA. Shown are Forethought’s 1987 PowerPoint box and yes, unopened Macintosh diskette. I’ve sent these to the Computer History Museum, which also happens to be in Mountain View, CA.

Why has it taken me 20+ years to use PowerPoint? I have been successfully using handwritten 3x5 cards for my talks -- 5x7 for major speeches -- and never found time to learn PowerPoint. Recently, I got to thinking that my avoidance of PowerPoint, though much admired, was generational, and I’ll have none of that. My mid-life crisis is still ahead of me. 60 is the new 30.

I think of PowerPoint as one of the major breakthroughs coming out of Internet development. It is an aid to collaborative intelligence, which we can now apply to building the Enernet.

And if Al Gore can win the Nobel Prize with PowerPoint, so can I, so can you.
Summary: Let’s mine Internet history since invention of the transistor ~1946. Beware hardening of the categories, for example: voice, video, and data then versus feed, food, and fuel now. Long-term, technology ceilings matter more than floors. We used the Internet to build the Internet, so let’s use the Internet to solve energy. History teaches that conservation is not what Enernet will be about. Like information and bandwidth, we need energy and power in squanderable abundance, to spread freedom and prosperity. The color green has baggage, a poor choice for Enernet, which has become an Internet-like movement. Blue is better. Enernet will be intelligent, layered, distributed, standardized, networked, symmetrical... We need Enernet laws -- like Grosch’s, Moore’s, Grove’s, Metcalfe’s -- to set Enernet’s agenda. Expect surprises, like PCs and mobility. Expect silver bullets, like TCP/IP, Ethernet, WWW, and DWDM. Expect bubbles. We are now in the Global Warming Bubble®, which will burst soon. But bubbles are good, accelerators of technological innovation, tools against the vicious status quo. Solving energy (blue) is not the same as solving environment (green). Forms of nuclear energy, including forms of solar, look promising for the high-ceiling future, but again, expect surprises. We need energy science, best from research universities. History shows the best innovation vehicles are competing teams of research professors, students, scaling entrepreneurial professionals, and venture capitalists. All that is what I mean by, “Blue is the new green.”
Sitting in MIT’s Kresge Auditorium on May 3, 2006, I heard our then new President Susan Hockfield launch what has become the MIT Energy Initiative (MITEI).

President Hockfield says, “Jump!” and I ask, “How high?” on the way up.

I decided right then to join up, whatever that meant. It turns out to mean that I am growing an enertech portfolio as a venture capitalist at Polaris Venture Partners and that I am active on MITEI’s External Advisory Board. Disclosure: I am Class of 1968 and a Life Trustee of MIT.

President Hockfield is shown here at the first MIT vehicle design summit. This human-powered hybrid car is also solar powered. Reportedly, peddling, you would get 600 miles per gallon, so to speak. Using solar, you could go 50 miles at 50mph, or so the young designers claimed.
Polaris is diversified in infotech, biotech, nanotech, mediatech, healthtech… so why not enertech?

I am certainly not the ONLY, not nearly the FIRST, and not (yet) the BEST Internet tycoon who has jumped into enertech venture capital, but there is plenty of room for technological innovation in energy’s poorly served teradollar markets. And excuse me, but it looks easier to teach energy to Silicon-Valley-style high-tech entrepreneurs than to teach entrepreneurship to energy’s status quo.

Venture capitalists tout their portfolios, and I am no different. You will notice that I broadly construe the term enertech, especially since enertech is so very hot these days.

If we have time, and if you are interested, I am very happy to tout this young enertech portfolio.
By 1974, I had worked on what would later be called the Internet from MIT (1822, NCP, Telnet), Hawaii (Alohanet), Harvard (PhD, 1973), Xerox Parc (Ethernet, Pup), and Stanford (TCP/IP).

There were 1 to 4 mainframes and/or minicomputers (and ~0 personal computers) at each of those Arpanet sites, interconnected remotely through packet-switching IMPs using 50Kbps AT&T circuits.

To be clear, most “computers” in 1974 were still batch-processing mainframes, inputting boxes of key-punched cards and producing, over night, green and white striped print-outs. Ask me what a core dump was. The “movement” then was to interactive time-sharing minicomputers. PCs had not been invented. AT&T and IBM ruled their worlds, telephones and computers, respectively.
After 38 years as an Internet innovator, 10 years as a pundit, and with my wife Robyn a PhD student in history, I decided to look back into Internet history for lessons on how to solve energy.

I decided to try to be helpful by going on this informal ENERNET speaking tour during 2008. At each stop on the tour, I invite listeners to join me in mining Internet history for guidance on how to approach energy. You are so invited.

I am proud of my enemies, and of what losers they are. Upon reading about this Enernet tour, some mocked me, saying that to somebody with a hammer, everything looks like a nail. And they say I am a one-trick pony, which I like to point out is better than being a zero-trick pony.

OK, maybe the analogy between information and energy is not perfect. Let's see.

Anyway, let's have some fun looking for good ideas we can use to help world economies get squanderable amounts of cheap and clean energy with which to grow free and prosperous.
Enernet is an analogy between information and energy, between the Internet and the Enernet.

The analogy between information and energy has been tried before. In developing his information theory, Claude Shannon saw this analogy and reused the word entropy from Carnot's thermodynamics.

Excuse my again (since 1976) putting in a bid to have a unit named after me, like what happened to Watt and Hertz. The unit I'm after is the bit-meter per second, to be called the Metcalfe and appropriately abbreviated Me (like the cycle per second, abbreviated Hz after Hertz).

Dave Boggs and I used the gigabit meter per second (Gbmps) in our 1976 Ethernet paper, which if I get my way, will in the future be written GMe (;->).

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“Those who do not study HISTORY are doomed to repeat it.”

Certainly you have heard this said, mostly by history professors. But wait, didn’t building the Internet go very well? I think so. So, should we NOT study Internet history and be doomed to repeat it? I grabbed Google and went hunting to unravel this tangled conclusion, which can’t be right. Who first said this?
According to what I found on the Internet using Google -- try it -- philosopher George Santayana said that those who do not remember the PAST are doomed to repeat it. What he said about history is less flattering.

Santayana had many other brilliant insights. Quickly searching for them I inadvertently found:
Some sloppy typing into Google found me Carlos Santana, not George Santayana.

Mr. Santana, who is about as old as the Internet and still with us, also has brilliant insights, like this one for energy:

“You’ve got to change your evil ways, baby.”
If we historians are to study the “Internet Era,” when did it start?

The transistor has obviously been key to the growth of the “Internet,” which I take to mean today’s computers and communications network. The transistor was invented in 1925, 1926, 1933, 1946, 1947, 1948, or some other year, depending on what you mean by the words “transistor” and “invented,” and on whom you believe. It does not matter much, so I choose 1946, the year Bell Labs formed its Nobel-Prize-winning team to invent the transistor, which they say worked in 1947 and was announced in 1948. Who invented Internet “packet switching” is also controversial. IEEE recognizes Baran, Davies, Kleinrock, and Roberts. There is plenty of credit to go around.

People born in 1946: Cher, Bill Clinton, Dolly Parton, George Bush, Linda Ronstadt, and me. Also in 1946, AT&T demonstrated the first mobile phone, a car phone. And the bikini was invented.

Choosing 1946, we have 62 years of history to mine, which is probably plenty. There is the historical complication that the Internet Era is probably not over.
Especially when thinking about 62 years of future, beware hardening of the categories. Premature and/or wrong categories send us in the wrong direction and/or slow us down.

The Internet’s early slow-moving telecommunications monopoly AT&T had us all thinking that its telephone transmission and switching network included customer terminals -- old rotary and new (1963) Touch-Tone (DTMF) telephones. It wasn’t until the Carterfone decision by the FCC in 1968 that foreign equipment, not made by AT&T’s Western Electric, could be attached to AT&T’s telephone network. Then came competitive innovations including mobile phones, cordless phones, answering machines, modems, and oh, no thanks to AT&T, the Internet…

Local and long distance telephone service were too slowly distinguished and demonopolized.

The FCC, regulating communications (AT&T), and Justice, regulating computers (IBM), held years of hearings about what exactly were communications vs. computers, so they could harden their categories. The Internet showed communications and computers to be inextricable.
The voice, video, and data monopolies were surprised when voice became more than telephone, surprising AT&T and their FCC, video became more than television, surprising the TV networks and their FCC, and both became data on the Internet, surprising IBM and their Justice Department.

Left: Early voice recognition dialing system.  
Top center: Early HD snow on an analog TV.  
Right: Model 33 Teletype upon which the Internet’s first messages were typed.  
Bottom center: Desktop conferencing today combines voice, video, and data.

(I am on the board of Avistar (NASDAQ=AVSR), a desktop video conferencing company.)
It’s hard to list everything wrong with government subsidies for corn ethanol. First on the list would be the very idea of government subsidies. But then…

DC chose to subsidize the wrong feedstock (corn) and the wrong fuel (ethanol). Cellulosic whatever is next. Thanks to hardening of the categories, DC thought they could manipulate fuel markets without disrupting feed and food markets. Not.

At GreenFuel, corn ethanol pales against algae biodiesel. Algae are 100x? more productive than agricultural crops, harvested every day, not just once a year, and don’t take agricultural land (think desert) or drinking water (think ocean or sewage). And algae, like corn, is an energy crop that can be used in feed for animals, food for people, and/or fuel for our machines. One good thing about corn ethanol subsidies is they misspend taxpayer monies less in the Middle East and more in the Middle West.
The Internet did NOT go away when The Internet Bubble famously burst on March 10, 2000.

We can use the Internet for COLLECTIVE INTELLIGENCE, better to solve energy. For example, we now have competing “new media” -- more choice and better information than was available on the pre-Internet, nearly monopolistic, often nepotistic, and disgustingly propagandistic old media, like my former home town paper, the not fair and balanced, NYT (~ Democratic Party Pravda). Let’s use Google News, blogs, Facebook… as cheap and clean tools for Enernet collaboration.

Let’s use the Internet for ENERGY MANAGEMENT: HVAC, lighting, demand response, smart grid.

To conserve energy, we can massively SUBSTITUTE Internet communication for transportation. With the emerging Video Internet, we can increasingly transport our bits instead of our atoms.

BTW, when we have to send our atoms, let’s digress to Internet-enabled mobility on demand and robottransport:
Digressing, here are two Internet-enabled ideas: mobility on demand and robotransport.

Mobility On Demand is the term at MIT Media Lab Smart Cities for folding electric automobiles rented around cities like airport luggage carts (pictured lower left). Robotransport is a term for vehicles that drive themselves, say even on today’s existing roads (pictured upper right).

In the US, ~40,000 people die each year in automobile accidents -- a million people worldwide, plus many more injured. And road transport consumes a lot of fossil fuels. But mass transport is not turning out any better, when you factor in occupancies.

In my lifetime, which I am admittedly expecting to be a long time, I see mobility on demand sooner and robocars later. Imagine no more DMVs. Imagine using the Internet to schedule exactly the car you need (often not an SUV) from a nearby charging station and then having it safely drop you off, potentially automatically carpooling if you and some friends are up for that. Or sending a car to pick up the kids, or some groceries.
Do we want to turn the world’s lights off or on? The USA does not waste energy because we are rich; no, we are free and rich because we have energy to burn. China, India, and the rest of the developing world want to be free and rich. We should welcome that. Technologies providing cheap and clean energy -- at last “too cheap to meter” -- are half the battle.

On the early Internet, to CONSERVE information transmission bandwidth, we stuck too long with punched cards. To be more bandwidth EFFICIENT, we buffered intelligent terminals, compressed files, and used multiplexing, including statistical and then packet switching.

So, today, do we use LESS bandwidth than we did 62 years ago? Do we get along with LESS information? No, we squander computing and communication -- 99.999% is ready but not used. Your PC and LAN are sitting there awaiting your return, and between keystrokes, waiting for your finger to land. Most computing and communication, when used, is squandered on what we call UI.
Enernet is not mostly about conservation, but anyway, I’ve just moved down from a 12-cylinder S600 Mercedes averaging ~20 mpg to a 3-cylinder Smart Car Mercedes averaging ~35 mpg.

My Massachusetts plate is SMATKA. Toward some future midlife crisis, it’s a red convertible.

My BIG car is a Mini Cooper S, which I now park nose to nose with SMATKA in one parking space.

I also have a huge gorgeous 9-seat Land Rover up in Maine, DEFENDER, which I now use about twice a year, to put our small fleet of boats in and out. It’s for sale. Interested? Asking $100K.

The Mini will go next. Then, I’ll sell SMATKA for a diesel. Then I’ll go hybrid or maybe directly to all-electric. Then I’ll take my cars on demand. Then I will leave the driving to robots. Onward!
Getting to cheap and clean energy has become a MOVEMENT, just like the Internet was. Recall the seven most feared words near the peak of the Internet Bubble? You just don’t get it, do you.

Movements often have dogma, true believers, deniers, slogans, and sometimes colors. Communism in its many failed forms is famously red. Islam is green. USA is red, white, and blue. Feminism is purple.

The Internet Movement’s color seems to have been TRANSPARENT, but the Ethernet and Linux sub-movements, for example, had yellow as their color (and Linux has a Penguin). Movements often have colors, and the energy movement seems to have chosen a color … GREEN.

NYT’s Tom Friedman at Pop!Tech last year questioned whether green was a good choice, with all its baggage. Tom has since chosen to stick with green, but I recommend his new book anyway: HOT, FLAT, AND CROWDED.
The trouble with GREEN as a movement color is all the baggage it carries. Safe to say, green is the new red. And now green is taken up worldwide with cloying regularity. Even rapacious corporations are into “greenwashing.” Heck, I’m helping market a “green supercomputer.” GreenTech investing is all the rage among us venture capitalists. Please. In breaking from the past to finally solve energy, I say we’d better change colors.
Would BLACK be a good color for the energy movement?

Oil is black. Coal is black. Silicon is black. Carbon is black.

Wait a minute, silicon (not its IC packaging) is actually metallic gray, and when polished, a mirror.

Global Warming is Earth being too black, low albedo, reflecting too little sunlight back into space.

Black is depressing. And black isn’t even a color. Forget black.
White is all colors, and may be too much of a good thing.

Snowball Earth -- glacial ice from pole to pole, mean temperature -50°C (-74°F). Several times in last couple of billion years. White. Too white. Because most sunlight reflected back into space by white ice. Fortunately, volcanoes put CO2 into the atmosphere, and by the resulting misnamed “greenhouse effect,” eventually melted Snowball Earth, several times, and maybe again.

The fraction of sunshine reflected by Earth is its albedo, from the Latin for white. 
~0.1 for liquid water, ~0.3 bare land, ~0.45-0.65 ice, ~0.9 for snow.

NASA: When Earth is covered in ice, its albedo is 0.84, meaning it reflects most sunlight. When Earth is covered by dark green forest canopy, its albedo is 0.14 -- most sunlight is absorbed and Earth is far warmer today. Satellite measurements since 1970s estimate Earth’s current albedo at 0.30 and in decline. We need more science about climate, and then geo-engineering for CONTROLLING climate. White is too much of a good thing -- forget white.
ROYGBIV are some colors to choose from.

Most sunlight is visible or in the near infra-red.
The Enernet movement should choose its new color from the VISIBLE spectrum.
“ROY G. BIV” is how many of us remember the colors of the rainbow.

Red, ugh
Orange, maybe
Yellow, maybe
Green, no
Blue, maybe
Indigo, maybe
Violet, maybe
Let’s look at what green plants prefer. The reason plants are green is that they REJECT green light, reflecting it back at you.

Photosynthesis gets most of its energy from red and blue light. So, shall our energy movement choose red or blue?

When Tim Russert (RIP) decided to standardize the colors for states supporting Democrats and Republicans, he dodged the obvious choice: red for left-leaning Democrats and blue for right-leaning Republicans. Instead he stuck Republicans with the losing color, red. Based on the poor historical performance of various red movements -- the various murderous branches of Marxism -- Democrats were only too happy to get blue.

Plants don’t like green, and the Democrats stuck Republicans with red, so let’s choose blue. Blue is the new green. I hereby move that Enernet adopt blue.
Why blue?
The “true-color” of Earth, according to NASA cameras, is blue, THE BLUE MARBLE.

Of course, looking back up, the sky is blue.
The vast majority of Earth’s energy (including fossil fuels) comes from the sky.

Earth is blue because it is mostly oceans…
Let’s explore the deep blue sea.

Graham Hawkes is the consummate submarine engineer, at www.deepflight.com.

Graham certified me to pilot his 1500’ two-seater flying subs. We aimed to observe aggressive 7’ Humboldt squid in the Sea of Cortez at 700’, but an algae bloom at 100’ thwarted our adventure.

Graham’s subs are not underwater elevators like most deep water subs. His literally FLY, which accounts for their looking like jet fighters. Graham has a full ocean depth (~37,000’) submarine near completion, and is launching Ocean Galactic to offer submarine tourism, as pictured.

Graham says Earth is misnamed. Ninety-nine percent (99%) of the living space on Earth is in the oceans, which cover 71% of Earth’s surface, averaging ~12,000’ deep, and are largely unexplored.

Earth’s oceans are likely to be abundant sources of tidal (gravitational), wave, thermal, wind, solar, geothermal, … and/or mineral energy. And they have a lot to do with climate. Let’s explore the deep blue sea.
Each hour, more sunlight arrives at Earth than Mankind uses in a year. And 99% of Earth’s living space is in the oceans. Energy solutions will likely emerge from the sky and oceans. So, again, I move we adopt BLUE as the color of the energy movement.
Focusing on the USA, here are 2006 energy source and usage estimates from the excellent National Academies report, “What You need To Know About Energy.”

Go see http://sites.nationalacademies.org/energy.

There is some danger of hardening of the categories here... where are the algae?

According to DOE, more solar energy falls each day on the USA than we use in a year. Incident solar energy is $37 \times 10^{16}$ kWh/year or 46,700 Quads/year, which is, get this ~500 times (=496.28) more than the 97.1 Quads above for 2006. Over the whole Earth, the multiple is ~10,000. Solar has a low floor (.07 shown), but a high ceiling (10,000x).

Look at this huge, old, and very slowly evolving system, with many pieces, levels, connections, interfaces, standards... We Enernet innovators could easily be overwhelmed, not just by the down and dirty status quo, but by the complexity of it all. What to do? What worked for the Internet?
Internet history demonstrates the enormous power of Layering. The Ethernet should have layered architecture.

Layering, a winning principle of Internet development: 7 layers of the ISO reference model.

How many layers? An art of system architecture. More or four: Google, Web, Internet, Ethernet.

Technologies develop independently at their own speed.

Specialization: One can live a rich full life at one layer, as I pretty much did with Ethernet.

Generality: each layer is an occasion for interface design, inviting generality.

Standard interfaces and technologies can be developed and interchanged.

Standards (also an art) focus investment to lower costs, to increase value through connectivity.

Serendipity is encouraged, innovation accelerated.

The energy system is much more complicated.

Careful systems design and standardization (but not too much) can help a lot.
Will we progress to having fewer-larger-centralized or more-smaller-distributed power plants?

If the Internet is any guide, in the future we’ll have more smaller DISTRIBUTED power plants.

Upper left is an IBM 7094 mainframe, like the 36-bit IBM I programmed at MIT in 1964.

Lower left is a modern microprocessor, 1000++ times smaller and more powerful.

Upper right is a modern centralized power plant that distributes electricity through the grid.

Lower right is an MIT micro gas turbine that might generate electricity for use right there, off grid, and/or from time to time contribute power to the grid.

This may be Internet history’s killer lesson for energy: Go distributed!
Our energy systems already have grid topology through which energy is distributed. How we further develop energy grids can be informed by Internet history. Layering, for example.

Today we talk about energy “distribution,” from central power plants down to light bulbs, which is slightly different from having distributed energy, much of which is not on the grid, like standalone PCs used to be. Enernet energy is more likely to be EXCHANGED than distributed.

Distributed energy (in the Internet sense) means the grid become more peer-to-peer, more multi-vendor, with more standards, more competition (FOCACA). The transmission of energy then become more networked, and more symmetrical, more among than between. I want my home and car energy systems to be able to buy energy from power grids, but also to sell. Radios and TVs are being replaced by PCs, which upload, not just download. Ditto nodes in energy grids.

Build it, and they will come; don’t, and they won’t.
Internet history is replete with “laws,” the most important being Moore’s Law. But we started slowly with Grosch’s Law, which proves you have to choose your laws carefully.

Grosch’s Law -- build centralized mainframes, cost goes up as square root of computing power
Moore’s Law -- integrated circuits double in density (computing power) every 18-24 months.
Grove’s Law -- telecom monopolies double available bandwidth every … 100 years (ha!).
Cooper’s Law -- cellular vs. Marconi -- wireless conversation per area double every 30 months.
Amdahl’s Law -- Mips ↔ Mbps
Metcalfe’s Law -- network effect (V~N^2) -- value of a network grows as square of number of users.

(even if I do say so myself)

Let’s collect Enernet Laws… Let’s ask Ray Kurzweil for enertech laws -- The Singularity is Near? 
There might be a “law” about the cost of solar power ($ per peak Watt) versus cumulative production (millions of peak Watts), a “learning curve” for solar cell manufacturing costs.

This slide is from a presentation by Frank van Mierlo, CEO, and MIT Professor Ely Sachs, CTO, of 1366 Technologies, a Polaris-backed start-up in Lexington, MA. The source of the data is Greg Nemet at UC Berkeley, so maybe we should call this Nemet’s Law.

The goal of 1366 is, by 2012, to drive multicrystalline Silicon solar cells to “grid parity,” beating coal.

There may be comparable cost decline laws for oil, gas, coal, solar, wind, nuclear… let’s find them.
Each Arpanet Imp packet switch (pictured in 1969 with developer Frank Heart of BBN) was delivered with four (4) ports, since universities, unlike everybody else, might have that many mainframes and minicomputers on campus, for administration, teaching, and research.

In 1969, get this, there were NO personal computers.

So when each Arpanet site reported destination counts of our growing Arpanet packet traffic, as counted by Imps, we left off the largest numbers, namely traffic that never left the building, which we dismissed as “incestuous traffic.”

Four years later, in 1973, Ethernet was invented to locally network the first Alto PCs at Xerox Parc. In 1976, the first Ethernet paper was published. In 1977, the Apple II was introduced. In 1981, the IBM PC was introduced. In 1984, 3Com went public selling Ethernet cards to connect PCs in LANs. Surprise: Ethernet LAN traffic is today dominant. This year 350 million new Ethernet switch ports will be shipped, and that’s not counting WiFi.
Internet Surprises, who would have thought?

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Punched Card Batch Processing Mainframes from IBM monopoly, peaked with IBM 360 in 1964.

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Interactive Minicomputers, computer utility crusade through 1960s. Grosch’s Law.

-----
Standalone PCs: Apple, then Intel, Microsoft, and IBM in 1970s and 1980s. Moore’s Law.

-----
Internet PCs and Servers in the 1990s. Metcalfe’s Law. Computing and communication CONVERGED. What analogous CONVERGENCE might we look for in energy?

-----
Mobile Handhelds, 4 billion subscribers already this year. Invading the Internet and getting video.
We started Internet development under the AT&T copper monopoly and with broadcast TV. For a while we thought microwave towers and then satellites would take over the long haul.

But then SURPRISE! came the Negroponte Reversal. TV started leaving broadcast wireless for copper cables. And telephones started leaving copper cables for cellular wireless. And telephones started leaving satellites for optical fibers, because of satellite speed-of-light delays.

But then really came fiber-optics, mid-1990s dense wave-division multiplexing = DWDM.

Then came wireless Ethernet, later called WiFi.

Now we use DWDM fibers long haul (10Gbps->40Gbps/lambda) and WiFi for the last 100 meters. Now cellular telephony is getting ever more cellular, with DWDM long haul.

Lesson: Expect surprises.
Enernet builders beware. Learn from the Internet. Because the Internet was designed by graduate students starting in the 1970s, it has three major flaws, even today.

Security. Graduate students live protected lives, so they did not build security in. In fact, they made anonymity the default. Today we have spam, viruses, denial of service, and identity theft.

Economics. Graduate students are not paid much, but after that, they get everything for free. So, economics had to be added later. From free (first from the government and later from venture capitalists), to subscription, to advertising, to pay per view. What we need is micropayments infrastructure, but of course this requires security. See above.

Quality of service. Graduate students had Model 33 teletypes in the beginning, and the goal was to get typed characters across the USA in under half a second. Then came upper and lower case. Fonts. Bit maps. Pictures. Sounds. Audios. Movies. Throwing cheap and clean bandwidth at the problem has worked for a long time, but now we are adding quality of service for interactive video.
Expect surprises?
A big event in Internet history was The Internet Bubble.  
The Internet Bubble AKA The Dotcom Bubble burst on March 10, 2000.  
I predicted it in my InfoWorld columns as collected in INTERNET COLLAPSES.  
This was an easy prediction to make -- was off by only four months.  
There were MANY Internet bubbles before the BIG one in 2000, and there will be many more.  
Recent Internet bubbles include the Social Networking Bubble.  
There were over the years PC, memory, storage, spreadsheet, wireless, VOIP... bubbles.  
Thank heavens for the Mortgage Bubble; the Internet Bubble does feel so bad now.  
Energy?  
Energy currently has it's Global Warming Bubble.  
How do I know Global Warming is a bubble?  Click: Al Gore -- heeeessss baaaaaack!.  
He and I inflated the Internet Bubble together.  He doing it again.
There is clearly a Global Warming bubble. One sure sign is the phenomenon of corporate “greenwashing.” The seven most feared words on the Internet: You just don’t get it do you. On Global Warming we hear: The debate is over. Those who question the Al Gore are called “deniers.” Ugly.

The big problem is that this bubble entangles two separate issues: energy and environment. If we could control climate, we would still have an energy problem, and vice versa.
How might we be surprised and solve Global Warming tomorrow?
Who is doing research on climate control? More!
Nanotechnical Parasol Effect
and/or
Photovoltaic Parasol at L1

Like fusion, not venture backable, yet.

When we can control global temperature, let’s ask the United Nations, “What temperature would you like Earth to be, exactly?”

But we would still need cheap and clean energy.
Let environmentalists keep green. We Enernauts should move away, to BLUE.
Bubbles Are Good

Speculative bubbles accelerate technological innovation.

Try not to outlaw bubbles; just be sure to have a chair when the music stops.

We saw from the many Internet Era bubbles that investment, speculation, inflation, competition, and collapse are tools of innovators against the status quo. Bubbles accelerate technological innovation. DC’s reflex (the reflex of the status quo) with each bursting of a bubble is to outlaw bubbles. This is counterproductive.

In the Internet Era, we had many bubbles, including generations of bubbles in memory, storage, LANs, wireless, PCs, spreadsheets, Internet browsers, databases, operating systems, VOIP, telecom equipment, optical technologies, programming languages, e-commerce, …

They all kept the Internet coming, against the vicious rearguard resistance of the status quo.

They go hand in hand with Christensen Disruption. The status quo declares innovations insufficient, non-standard, unsafe, and just plain HYPE!
Washington DC is a Pro-Am, and we are the Ams.

We hear that energy must develop public awareness, political will, and go to Washington for some sort of Manhattan Project, or perhaps even an Apollo Program.

Trouble is, energy is much bigger and will take much longer than that.

Plus, the status quo runs Washington, through lobbying and litigation, so often, when you go there to get stuff, you get the wrong stuff, for example corn ethanol. Other examples would include prohibition of oil exploration, refineries, and nuclear, for the last 30 years, and dropping fundamental research projects (solar, algae, …) when the price of oil went down again.

The last time we went to Washington for energy, we got DOE, a huge series of earmarks and government jobs programs that leave too little oxygen for energy innovation.

DOE created by Jimmy Carter some 30 years ago to reduce our dependence on foreign oil. DOE employs 10s of thousands with a budget heading past $20B/year. Are we using less foreign oil?
Nuclear is coming back.

And then there are the opposite of bubbles. Anti-nuclear is such an opposite, thanks to Greens.

Physicists are taunted by the fusion reactor that flies daily across the sky; maybe it’s best we keep it 93 million miles away and beam in the small amounts of energy we need. Earth is likely itself a huge fission reactor; maybe it’s best we energize geothermally.

Pebble bed reactor shown. Several other nuclear start-ups are making the rounds.

Public Opinion -> regulation, litigation, Green’s?
Economics – manufactured
Safety – no meltdowns, self regulating
Proliferation – nothing weapons grade, <20%
Waste -- recycled
Scale -- distributed?
Washington isn’t all bad. Washington did help the Internet.

Tax Reductions: capital gains taxes were cut in the early 1980s, giving rise to venture capital for many of the companies that built the Internet, including my own, 3Com.

Demonopolization: Carterfone in 1968, AT&T breakup in 1984. Continuing anti-trust oversight of IBM, which signed a consent decree and was restrained from previous anti-competitive activity.

Lead customer: DCA MILNET… Ethernet became a FIPS standard.

DOD/ARPA TCP/IP/Ethernet vs. Commerce's ISO/ISDN?

But most importantly: Federally Funded Research: ARPA, NSF, DOE…
Where is research best done?

Not by corporations, because only monopolies can afford research:
- Bell Labs thanks to AT&T’s telephone monopoly
- Watson Labs thanks to IBM’s computer monopoly
- Parc thanks to Xerox’s copier monopoly
- Microsoft Labs thanks to the PC software monopoly

Monopolies overcharge their customers, but worse, are not motivated to market innovations.

Government labs? Geographical earmarks and government jobs programs. E.g., DOE.

Where?
From Internet history I learned that the best place to put our research dollars is at competing research universities vying for government grants.

Because they graduate students.

There are about 10 such research universities around Boston alone, including my favorite, MIT.
There will be silver bullets.

IBM punched cards (cellulosic computing)
Transistor and Integrated Circuit
Interactive time-sharing minicomputers
Bit-Mapped Display, Mouse, WYSIWYG
TCP/IP and Ethernet
World Wide Web and Mosaic
Lasers, Optical fibers, DWDM
Google
Cellular
...

After packet switching itself, thanks to Paul Baran and Donald Davies circa 1960, there’s DWDM. Prior to DWDM my mother would say “call when you get back to Boston, but hang up after three rings so we don’t have to pay for the long distance call.” Now we call almost anywhere all the time, and get the Video Internet to boot. Worldwide. As many rings as we want.
Competing teams:
research professors+students, product engineers,
scaling entrepreneurs,
and, yes, venture capitalists.

My favorite among many examples: (sorry these all look like white men)
Akamai, a Polaris-backed start-up out of MIT.
MIT Professor Tom Leighton
Students Danny Lewin (RIP since 9/11) and Jonathan Seelig
CEO George Conrades, former president of IBM USA, Polaris partner
Overplaying Internet lessons so far, I see an Enernet in 62 years
that is mostly a symmetrically distributed nuclear Internet grid,
with squanderable energy harvested and stored, off and on the grid,
from Sun’s fusion reactor, using distributed solar harvesters,
from Earth’s fission reactor, using geothermal harvesters,
from man-made distributed and perhaps mobile fission and fusion reactors,
networked with electricity and information, including robotransport on demand.
Now it’s time for you to join me in mining Internet history to solve energy. Questions? Comments? Ideas?
Polaris is diversified in infotech, biotech, nanotech, mediatech, healthtech... so why not enertech?

I am not the only, not the first, and not (yet) the best Internet tycoon who has jumped into enertech venture capital, but there is plenty of room for technological innovation in energy’s poorly served teradollar markets. And excuse me, but it looks easier to teach energy to high-tech entrepreneurs than to teach entrepreneurship to energy’s status quo.

Venture capitalists tout their portfolios, and I am no different. You will notice that I broadly construe the term enertech, especially since energy is so very hot these days.
This is a photoshopped vision of the future.
A GreenFuel algae farm recycling CO2 from powerplant fluegasses.
Producing valuable ingredients for feed, food, and fuel.
GreenFuel is an MIT spin-out in Cambridge, MA now growing algae at 100-square-meter scale. Minimum commercial scale is estimate to be 100 hectares, so there is much work to be done. Actually, growing algae is much easier than economically harvesting it.
Solar is one of the many forms of NUCLEAR energy -- harvesting Sol’s nuclear fusion energy.

And there are many forms of solar energy generation and storage.

Here are solar start-ups in our Polaris enertech portfolio.

We all have a long way (62 years) to go.

Thanks.
Dr. Robert M. Metcalfe is a venture capitalist, since 2001 with Polaris Venture Partners in Waltham, MA. He is a director of Polaris-backed technology start-ups including 1366, Ember (chairman and past CEO), GreenFuel (chairman and past CEO), Infinite Power Solutions, Mintera, SiCortex (past chairman), SiOnyx, and an energy storage start-up currently spinning out of MIT.

Bob is also advisor/director/trustee to Avistar, National Academy of Engineering, St. Mark’s School, USC Stevens, Massachusetts Institute of Technology (MIT ’68, Life Trustee), and MIT’s Technology Review Magazine, McGovern Institute for Brain Research, Energy Initiative, Department of Electrical Engineering and Computer Science, Dean of Engineering, and Dean of Science.

Metcalfe’s career is technological innovation, where he is best known for inventing Ethernet (1973), founding 3Com (1979), and writing eight years of Internet columns in InfoWorld, collected in his book, INTERNET COLLAPSES (2000), still available down the long tail at Amazon.com. In 2005, in a culmination of the American Dream, President George W. Bush invited Bob to the White House with his parents, Ruth C. and Robert I. Metcalfe, to receive the National Medal of Technology, for “leadership in the invention, standardization, and commercialization of Ethernet.” Bob shares four expired patents on Ethernet, of which, according to IDC, 350 million new switch ports are being shipped in 2008, and that’s not counting WiFi.

Bob was born in Brooklyn in 1946, and after 22 years in Silicon Valley, now lives with his family in Boston and Maine.

Comments and questions are welcome, and might even get answered, by email at Metcalfe@PolarisVentures.com