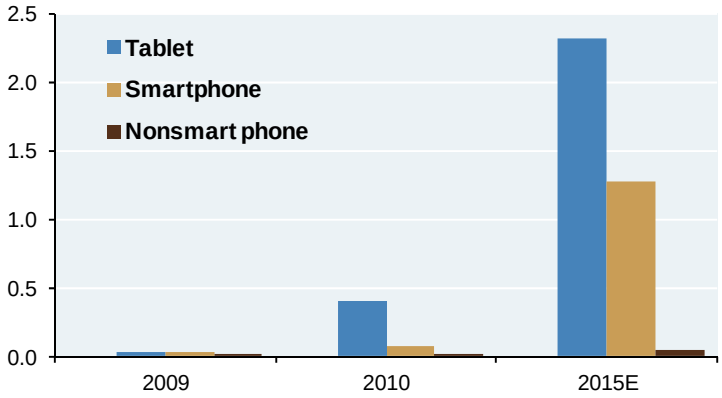
***Megabytes, Megabanks and Megawatts*. This week we get back to the nuts and bolts of investing, focusing on video and data infrastructure opportunities, and U.S. bank consolidation**. In the Appendix, we focus on what future US electricity generation might look like, and why we are investing for the long run in natural gas-related exposures. This topic is particularly important given changes in regime stability in the Middle East, challenges facing nuclear power after Fukushima, and stats like 2010 being the warmest year on record since 1880, increasing the focus on carbon emissions[1].

The less exciting side of an increasingly video- and data-centric world: the need for more infrastructure

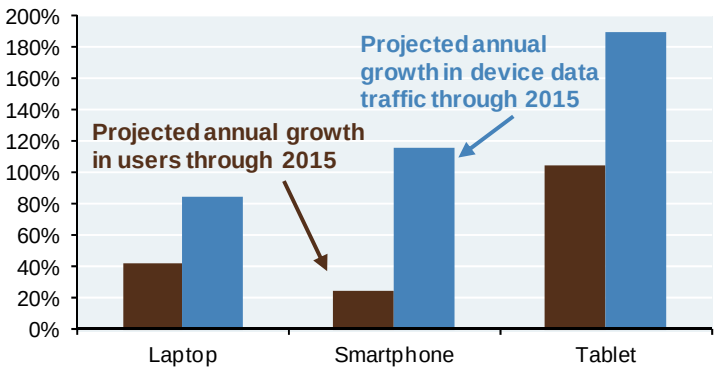
Beginning in 2009, penetration of smartphones and tablets began. Data consumption for these devices is massive compared to traditional "non-smart" phones, mostly a function of video streaming . Penetration and data usage rates are expected to continue to grow, leading to exponential growth in overall mobile data traffic (see charts). One underappreciated reason for the explosive growth of these devices: improvements not just in computing power, but in their **electrical efficiency** as well. Most mobile devices are constrained by battery storage which has not improved[2] as fast as semiconductor technology, so when electrical efficiency improves, devices last longer and become more feasible (even without better batteries). There's an interesting exhibit from the Lawrence Berkeley Laboratory on electrical computations per kWh since 1946 that illustrates this point, on page 5.

Average data consumption per wireless device
MB per month



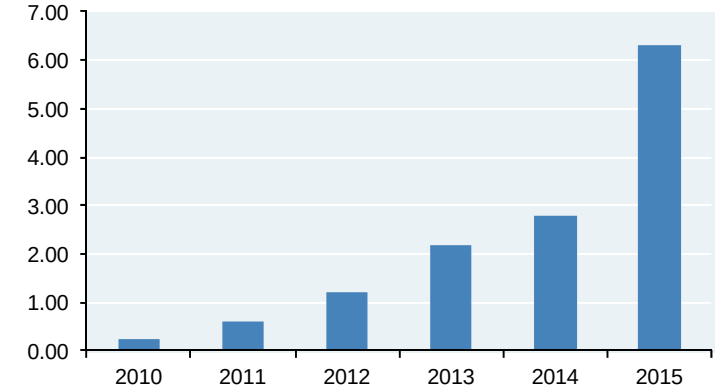
Source: Cisco VNI Mobile, 2011.

Comparison of global device unit growth and global mobile data traffic growth
Percent



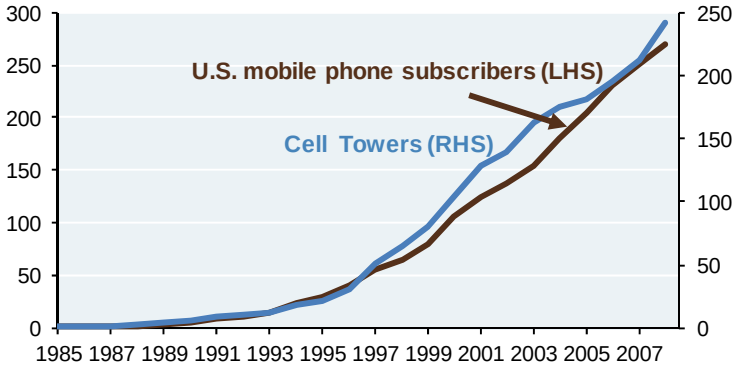
Source: Cisco VNI Mobile, 2011.

Forecast of global mobile data traffic
Exabyte/month



Source: Cisco VNI Mobile, 2011.

Growth in mobile users = growth in cell towers
Millions Thousands



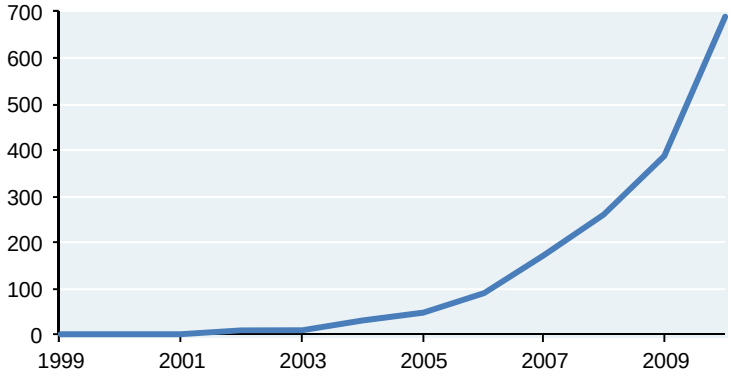
Source: AccuVal Associates, Inc.

There are a lot of infrastructure demands that the video/data boom has created; one example is cell towers. Since 1990, US cell towers increased along with mobile phone subscribers. There are three US pure play tower companies (American Tower, Crown Castle and SBA Communications), but they are expensive at 16-20x trailing cash flow, and may be under pressure after a 30% capacity improvement resulting from the AT&T/T-Mobile transaction . **What looks more interesting: infrastructure parallels outside the US**. As shown on the next page, mobile subscribers in India are growing, but are well below other regions; India has almost twice the number of subscribers per cell tower as in the US.

[1] No hate mail please. This is a statistic from the National Oceanic and Atmospheric Administration. Whether you or I believe there is a connection between carbon emissions and warmer temperatures is not the issue; enough people do to make this a policy priority.

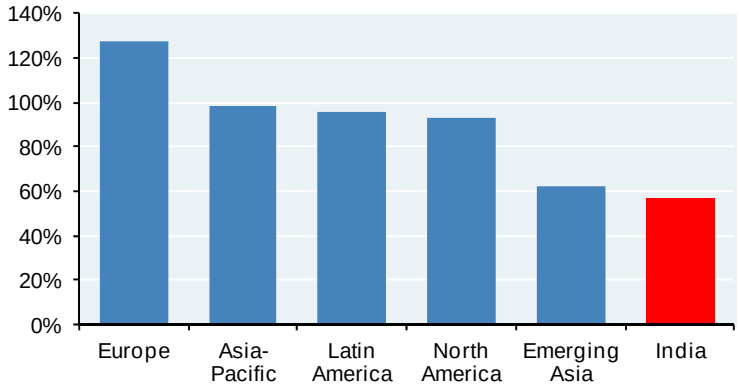
[2] Over the last 30 years, **lithium ion battery technology has only improved at the rate of 6%-7% per year**, well short of the doubling of computing speeds and electrical efficiency every 18 months. Silicon can store 10x the amount of energy as lithium, but is prone to swelling and cracking. Some companies are working on silicon batteries that could allow portable electronics to run 40% longer without a discharge.

Mobile subscribers in India
Millions



Source: Telecom Regulatory Authority of India Database.

Mobile penetration
Pecent

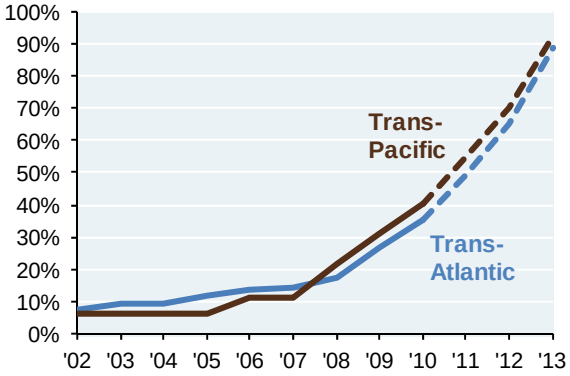


Source: Bank of America Merril Lynch.

Video/data infrastructure refers to more than just cell towers; it refers to the entire suite of devices, cabling and software needed to support it. It would include under-sea fiber-optic providers, online data storage companies, device manufacturers behind smartphones and tablets, and software companies that specialize in shipping, packaging and interactive marketing. Managers we work with in the technology space are seeing purchase multiples of 9x-14x cash flow for fiber optic service providers and data storage businesses, some of whom are growing earnings by 15%-25% annually.

A few weeks ago, we included the following chart to explain why some of our managers have been investing in fiber optic capacity. A decade ago, technology, applications, accessibility and user behavior were not in sync with fiber optic expectations. A proxy for this: the amount of unlit (spare) subsea fiber. Over the next 3-4 years, we finally expect much of this capacity to be absorbed. The continued penetration of residential broadband, now at 65%, is one reason for the capacity uptake.

Fiber optic cable utilization finally rising
Percent of potential capacity in use



Source: TeleGeography Research.

As per Intel's Director of Tera-Scale computing:

- The world generates more data than it can store. Data creation is rising at 60% per year. By 2012, data created will be 2x what can be stored
- Walmart adds a billion rows per minute to its database; Medical imaging databases can require 1 petabyte (1 PB=1mm GB); the Hadron Collider (Geneva) can generate terabytes of data per second (1 TB=1,000 GB)
- Smartphone data-gathering sensors and corporate demand are responsible for these trends; 50+ billion devices are still only 1% connected
- Learn *Yottabyte*: 1 yottabyte = 10^{24} bytes = 1 billion petabytes

And from IDC, whose galactic imagination is in overdrive:

- In 2009, despite the recession, digital storage grew by 62% to 800,000 petabytes, which would be equivalent to a stack of DVDs reaching to the moon and back. By 2020, this stack would reach halfway to Mars

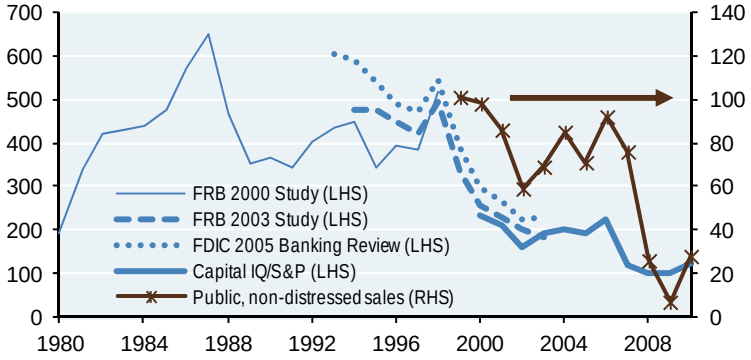
Data storage, data centers and data management are other infrastructure areas of investment interest. Recent commercial consolidations include Verizon's $1.4 billion purchase of Terremark; Dell and Boomi; SAVVIS and Fusepoint; and Cloudkick acquiring Rackspace. Dropbox, SkyDrive and Amazon's new Cloud Drive, offered to individuals, also fuel demand for storage. We are only a decade removed from a jargon-fueled technology collapse. In the next few years however, devices, applications and consumer behavior appear to be finally catching up with each other. Check out what Intel fellow Jim Held had to say last year about the accumulation of data at a conference last year (see box).

We are more agnostic about content creators and aggregators as an investment option. There are battles to be fought (and lost, sometimes) by content aggregators, some of whom may overpay for programming. HBO, Starz, CBS and Showtime have pulled back licensing rights of first-run shows from aggregators like Netflix, which is pre-buying seasons of unproven shows, and investing $1 billion in EPIX (a movie channel). Broadcast networks can test original content on viewers, deploying marketing and promotional campaigns to raise awareness; content aggregators may find this harder to do. As for Hulu, it is just beginning to offer pay-for-service, with early estimates at 2%-4% of all users after lowering monthly fees from $9.99 to $7.99. Regional sports programming, whose viewers may pay a premium for access, looks interesting. Consider this: SNY Network is the second largest regional sports network, and its teams (the Mets and Big East basketball) have not exactly been lighting up the scoreboard (at least in the playoffs or NCAA Tournament).

Update on US bank consolidation

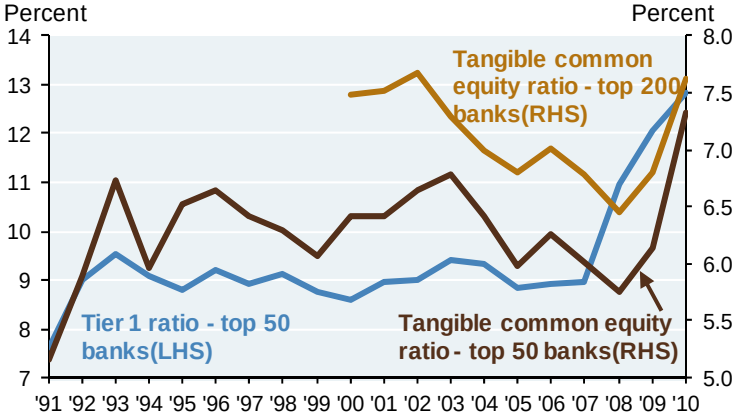
A few weeks ago, we wrote about opportunities in US bank consolidation. Bank mergers proceeded at a steady pace during 1980s, 1990s and the early part of this decade, as the number of US banks shrank in half. Recessions interrupt this process (this time it ground to a halt), but it is now re-emerging. Some banks looking to make acquisitions ended up selling instead, given how high premiums are. As a result, we are focused on investment strategies that position for high premiums paid for targeted banks. As per the charts below, large and medium-sized banks are in a position to make acquisitions, given high levels of capitalization and loan loss reserves. While 2-3 very large banks have hit their 10% deposit market share cap, and while some of the capitalization increase is related to higher Basel 3 standards, the universe of banks able to acquire others is growing.

Consolidation in the U.S. banking industry
Number of bank mergers per year



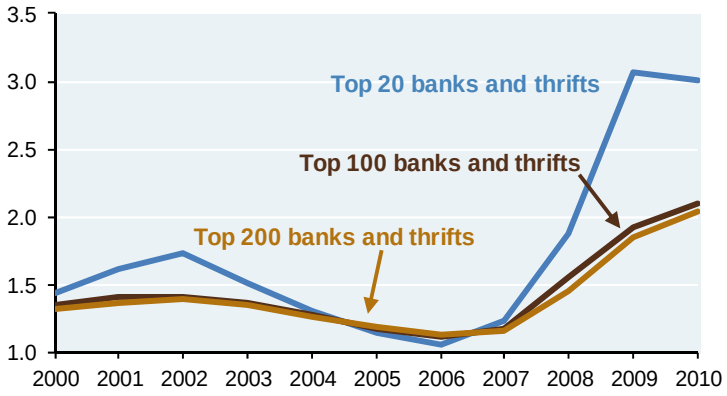
Source: Federal Reserve, FDIC, Capital IQ/S&P, Sandler O'Neil Asset Management.

Capitalization ratios
Percent



Source: SNL Financial LC.

Loan Loss Reserve as a percent of total loans
Percent, banks ranked by total assets



Source: SNL Financial LC.

APPENDIX: What's next for nuclear energy and natural gas?

There are concerns that the world cannot abandon nuclear power given its energy contribution. This might be true in China and India, but in the US, **natural gas could take up part of the slack**. We do not debate here whether this transition *should* happen. To us, Fukushima mostly reflects design flaws (beachfront location of back-up fuel storage tanks, connection plug incompatibilities of back-up fuel supplies, lack of hydrogen re-combiners, no containment of spent fuel pools) that could be engineered around in the future, and retrofitted at existing plants (some at low cost, some not). In addition, ongoing fuel and operational costs of nuclear power are low, so shutting down a large upfront capital investment needs to be thought out carefully (in part since it would increase electricity costs). However, the toxic Fukushima aftermath[3] may fuel some of these questions.

The table on the next page shows the installed base, power generated, capacity factor and "normalized" cost for each energy source. **On the bottom, there are three cases**. First case: existing gas plants absorb the *incremental* amount expected to be generated by nuclear power from 2010 to 2035 (i.e., freeze new nuclear construction). Second case: existing gas plants absorb *all* nuclear power. And third, nuclear power is absorbed only by the most efficient gas plants, combined cycle facilities. In the first case, the capacity factor for natural gas only has to rise marginally, from 26% to 28%, which would result in a 3% increase in demand for gas. No big deal. To absorb *all* nuclear power (case 2), the natural gas capacity factor would have to rise to 49% (within the design capabilities of most natural gas plants), and demand for natural gas would increase by 29%. This is all before having to build *any* new gas plants. **As a result, natural gas could play a much larger role should the pros and cons of nuclear power (including its sky-rocketing costs, even before Fukushima) be re-calibrated**. This is why our energy investments include exploration and development of natural gas fields, and businesses involved in its storage and distribution.

[3] ***Fukushima Dai-Ichi update.*** Good news: lights are on in all 6 control rooms, new pumps are using de-mineralized water to cool reactors and spent fuel rods, and the US is sending radiation-hardened robots (Wall-E?) to help clean up. Bad news: on-site release of cesium and iodine are elevated (60%-70% of Chernobyl levels), radiation contamination zone may be widening past earlier assessments, possible reactor containment breach, a weird and unexplained 1.5 km neutron beam observed at the site, and tens of $billions for cleaning it all up.

Source: Energy Administration Agency	Installed base 2009 MW	Electricity gen in 2009 mm MwH	Implied capacity factor	EIA Levelized cost 2009 MwH	<---Levelized cost incorporates upfront and ongoing capital costs, cost of capital, capacity factor and related power transmission investments
Hydro	78,518	273	40%	$86	Most viable sites already in use after incentives in the 1960s-1980s
Solar	619	0.9	16%	$210 - $318	Very high growth rates on a small base; falling costs but still expensive
Wind (onshore)	34,296	74	25%	$97	Low capacity factor, maturing technology; cost more than doubles offshore
Biomass/wood	11,256	54	55%	$112	Inefficient when used for electricity; greater demand in transportation fuels
Geothermal	2,382	15	72%	$102	Very expensive, except near volcanic areas
Coal	314,294	1,756	64%	$95 - $110	Abundant and cheap, but without carbon sequestration, an environmental mess
Natural gas	401,272	921	26%	$60 - $70	Capacity factors understate potential utilization
Nuclear	101,004	799	90%	$114	Efficient once built; very expensive to build (costs rising sharply in recent decades)
Nuclear->NG Case 1	401,272	997	28%		Incremental nuclear (2010-2035) absorbed by existing nat gas plants
Nuclear->NG Case 2	401,272	1,720	49%		All existing nuclear absorbed by existing nat gas plants
Nuclear->NG Case 3	222,365	1,544	79%		All existing nuclear absorbed by combined cycle nat gas plants

There are some caveats regarding a nuclear-to-natural gas transition:

1. **Natural gas is supposed to take over for coal**, if the US further regulates carbon emissions or other pollutants like mercury. Most scientists we speak to believe that coal is more dangerous for the earth than nuclear power. Coal accounts for one third of all US carbon emissions; natural gas plants reduce carbon emissions by more than half compared to coal.
2. The power industry got used to $2 gas during the 1990's, and **got burned when it rose to $12 in 2005 and 2008**. Shale gas discoveries may make price spikes less likely, but that depends on costs of extraction; the outcome of the **fracking** regulation debate[4]; the increased use of natural gas in CNG vehicles; and the projected rate of decline of existing conventional gas supplies (which shale gas discoveries offset).
3. Only 52% of natural gas plants by megawatt are **combined cycle plants** that could easily handle more baseload power (gas turbine and steam turbine plants are less suited for baseload and will still be needed as peaking slack for the grid). Case 3 allocates all existing nuclear power only to combined cycle gas plants. The implied natural gas capacity factor of 79% is pretty high; the EIA assumes 87% in its levelized cost numbers, but that seems a bit optimistic to us. To decommission all nuclear plants would require modest growth in the installed base of combined cycle natural gas.
4. **Regional concentrations of nuclear power and natural gas plants are not identical**. This would create the need for additional transmission lines, and ways of dealing with the separateness of Eastern, Western and ERCOT interconnections.

Caveats notwithstanding, **countries with abundant natural gas like the US have choices**. The Bipartisan Policy Center[5] and the American Clean Skies Foundation came to a similar conclusion in a report released last week. Technological disasters like Fukushima often result in **improvements and innovation rather than abandonment (**nuclear based on liquid fluoride thorium reactors or travelling wave reactors, perhaps**)**, as the scientific method learns from its mistakes. But when it comes to harnessing the power of radioactive materials, the pathways to commercialization are long (20-30 years), and as a Swedish Nobel prize physicist put it, "No Acts of God are Permitted".

What about renewable energy displacing nuclear power? Half the world's new generating capacity in 2008 and 2009 was (often heavily-subsidized) renewable energy. The EIA projects that renewable energy electricity generation will grow, contributing 14% of electricity in 2035 compared to 9% today. To do more than that, renewable energy must overcome very low capacity factors (solar, wind), high costs (solar), carbon emission issues (biomass) and in the case of hydro-electric power, a limited universe of new viable sites. There are interesting things going on with wind (new ideas for dealing with intermittency such as ceramic heat and compressed air storage; and modifications to increase its capacity factor); it will take time to see if these solutions are scalable. As we wrote in August 2008, the US is the Saudi Arabia of wind (in the corridor from the Dakotas to Texas, wind speeds can exceed 6.9 meters per second), but there's a long way to go before wind technologies can satisfy the need for large amounts of power on-demand. For the next 10-20 years, in the US, more natural gas is where we are headed.

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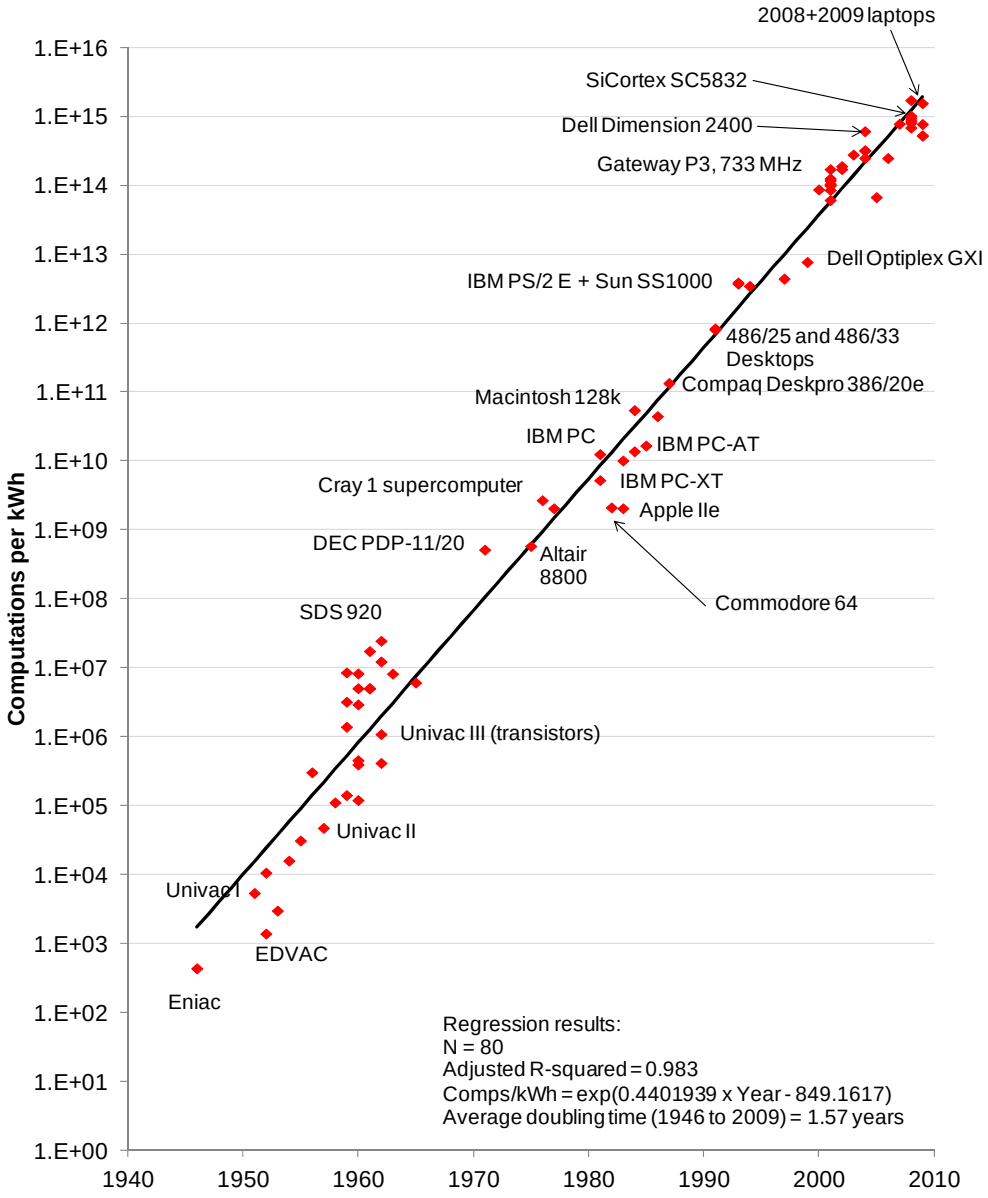
Chief Investment Officer

[4] The EPA will release its hydraulic fracking study in 2012, a contentious topic given the debate about possible groundwater contamination. Fracking fluids are composed 99% of water and are applied 8,000 feet down (well below the potable water table). The industry believes that risks are minimal, and that the process has been used safely for over 60 years (on over 1 million "fracks").

[5] Established in 2007 by former Senate Majority Leaders Howard Baker, Tom Daschle, Bob Dole and George Mitchell

Computations per kilowatt-hour over time: another factor propelling mobile computing devices



Technology commentary often focuses on improved computing power of semiconductors over time. A less well-known but important variable: improvements in computations per kilowatt-hour. As the number of computations per kWh increase (holding battery capacity constant), more and more mobile devices become feasible. Since the first ENIAC computer, computations per kWh have doubled every 18 months.

Koomey et al. "Implications of historical trends in the electrical efficiency of computing", IEEE Annals of the History of Computing. March 2010. *Reprinted with permission*