Sustainability

A Credit Suisse Megatrend

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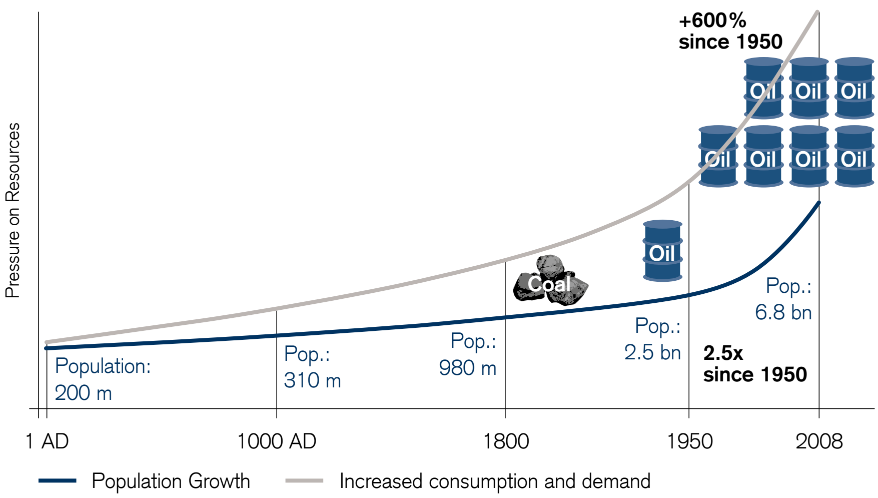
Sustainability refers to the capacity to endure. This publication's look at sustainability will focus solely on one theme of this multifaceted megatrend, namely on the resources from which people derive the energy and food to carry forward our way of life. Population explosion-based demand growth coupled with rising resource prices have, once again, raised resource depletion issues. Yet this same siren song has been sung numerous times before by so-called "Malthusians," who have warned of resource shortages owing to geometric population increases accompanied by only arithmetic increases in the food supply (http://www.esp.org/books/malthus/population/malthus.pdf).

Thomas Malthus, 1766-1834

Historically, notwithstanding the nearly seven-fold increase in the world's human population over the past 200 years, cyclically rising resource prices inevitably revisited their centuries' old secular downward trajectory. As expected, high prices triggered heightened resource exploitation investments while technological advances allowed for productivity enhancements. Falling real commodity prices followed.

Going forward, dare we assume that "this time is different," verbiage that Sir John Templeton called the four most dangerous words in investment? Has our large initial endowment of various resources, especially fossil fuels, made technological advances possible, or was it technology that unleashed a resource bounty? There are increasingly prevalent signs, like diminishing energy returns on energy invested (EROEI) and profound groundwater depletion issues, that we are indeed exploiting key resources such as oil, water aquifers, and soil at unsustainable rates (see chart 1 concerning oil). This implies that technology has primarily allowed us to exploit resources more quickly

Chart 1: Energy consumption growth exceeding population growth



Source: World Urbanization Prospects, 2007 Revision

rather than provided us with more resources. In a nutshell, that is our resource sustainability dilemma. It is also our "call to arms" for expanded energy infrastructure investment and greater resource usage efficiency.

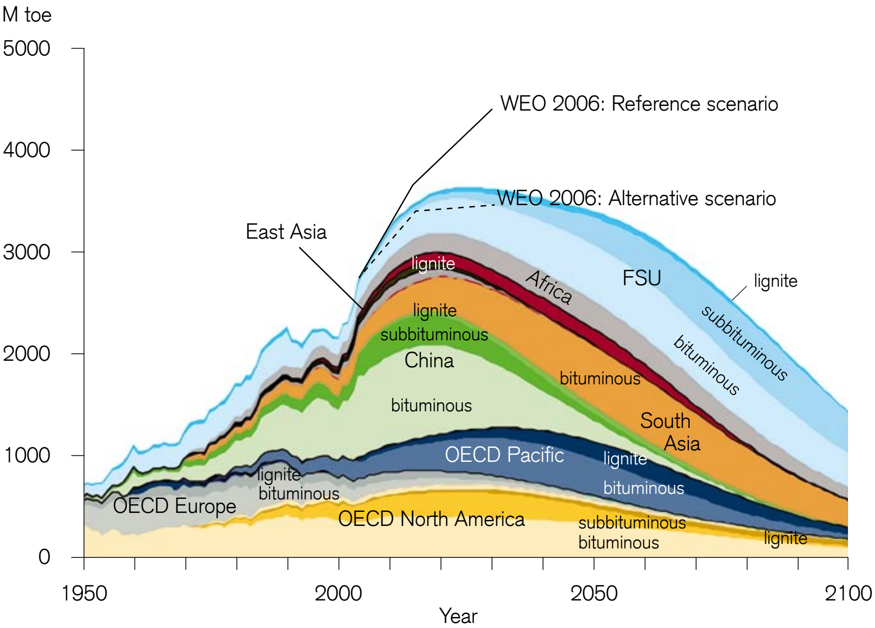
Energy dependency
As clearly depicted in chart 1, especially since 1950, there has been an asymmetrical increase in energy consumption relative to population growth as determined by oil used (oil was 34.0% of the world's primary energy in 2007). This also holds true for coal consumption (coal was 26.5% of the world's primary energy in 2007), as can readily be inferred from chart 2.

Meanwhile, fossil fuels still comprised 81.4% of the world's primary energy (see chart 3) as of 2007, down from 86.6% 34 years earlier, with nuclear power filling most of the resulting fossil fuel share reduction gap.

Why are sufficient energy and expanding energy supplies so vital to sustaining our global economy and to underpinning per capita global GDP growth? Because lasting economic growth can only occur with the energy leverage derived by shifting from manual labor to machinery and equipment.

The linkage between sustainable GDP growth – which requires productivity growth – and energy consumption growth is quite intuitive. It boils down to the fact that large amounts of dense energy (much energy per unit volume), generally fossil fuel in nature, are required for virtually every aspect of modern, increasingly information-based economies including:

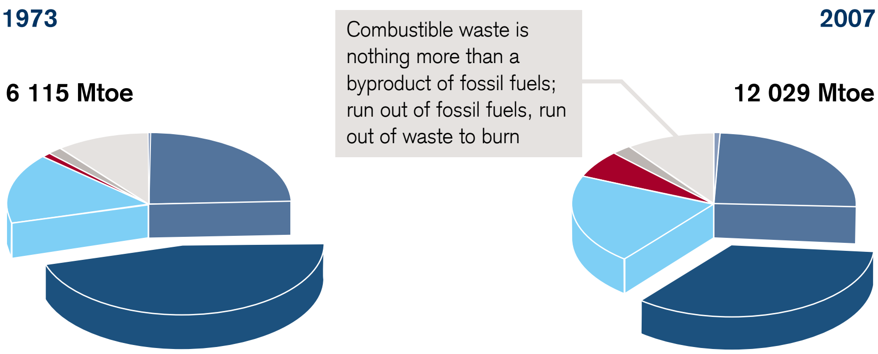
Chart 2: Global coal energy production in million tons of oil equivalents



World Economic Outlook (WEO) Reference Scenario: the projected trajectory of global coal energy consumption

Source: Energy Watch Group (EWG), www.bgr.bund.de/

Chart 3: World's primary energy consumption and breakdown in Mtoe



1973:

Other*	0.1%	Coal/peat	24.5%
Oil	46.1%	Gas	16.0%
Nuclear	0.9%	Hydro	1.8%
Combustible renewables & waste			10.6%

2007:

Other*	0.7%	Coal/peat	26.5%
Oil	34.0%	Gas	20.9%
Nuclear	5.9%	Hydro	2.2%
Combustible renewables & waste			9.8%

* Other includes geothermal, solar, wind, heat, etc.
Mtoe = million of tons of oil equivalent

Source: IEA, Key World Energy Statistics, 2009

- Construction and maintenance of infrastructure that allows for oil exploitation, mining, electricity generation, water availability, IT, transportation, and manufacturing
- Mechanized agriculture
- Transportation
- Generation of services and production of all goods
- "Leveraged output"

To gain additional perspective into both leveraged output and energy dependency, consider that farming without tractors and fossil fuel-based fertilizers would be the equivalent of a huge crop yield contraction. Construction without excavators and backhoes would result in hugely increased labor requirements, as occurred in India in the summer 2008 when oil became unavailable and thousands of shovel-wielding workers stepped in only to accomplish a fraction of the mechanized work. Manufacturing assembly lines without electricity would result in a collapse in output and efficiency.

To really drive this point home, let us reflect for a moment on the energy equivalent of 3.79 liters/1 US gallon of gasoline:

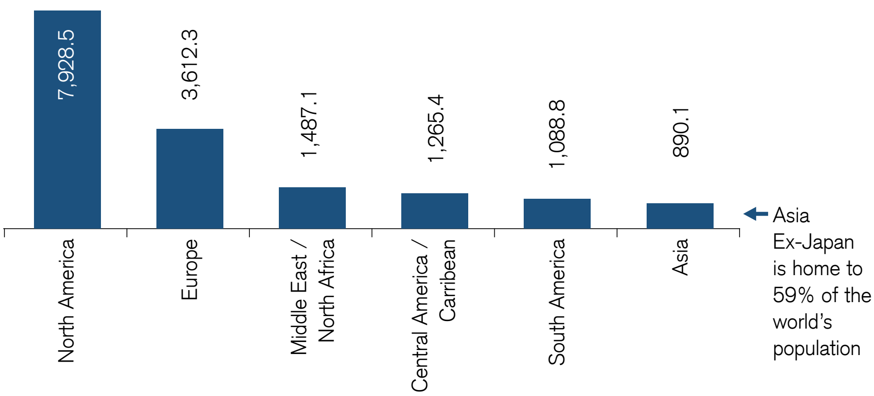
1 US gallon of gasoline = 451 hours or eleven weeks of human work output! The math: 1 gallon = 114K BTUs or 33.4 kWh of energy. Human agricultural work output: 1/10 of a horsepower, or .074 KW. 33.4 kWh/.074 KW = 451 hours of work (http://www.nafa.org/Template.cfm?Section=Energy_Equivalents and IEA)

Interestingly, just maintenance-based replacement of the global stock of machinery requires significantly increased

energy consumption. For perspective, contemplate that replacing the 250m strong US vehicle fleet would require approximately 10.5bn barrels of oil, or one-third of annual global oil consumption. Or, consider that in 2009 the OECD projected USD18trn in worldwide energy infrastructure investments over the next 20 years. Notably, others have predicted that an (energy-intensive) multiple of that dollar amount will need to be spent just for the oil infrastructure complex to replace aging pipelines, rigs, and platforms. It is telling that in nearly each of the past 45 years, we've found only a small fraction of the 48bn barrels of oil that were found in peak year 1964. Over the same time period, annual oil consumption has risen by more than 150%, from 12bn barrels to over 31bn barrels today. Therefore, it is clear that plenty of energy sector capital spending will be called for (Charles T. Maxwell, Weeden & Co; IEA).

Chart 4: Current per capita energy consumption

Kilograms of oil equivalent (KGOE)



Source: World Resources Institute Earthtrends database

As we continue to gather more information, our energy needs grow apace. According to Harvard University physics professor Alex Wissner-Gross, a Google search generates roughly 7 grams of CO_2 because it is routed through various data centers, which require energy to keep running; boiling a pot of water generates roughly 15 grams of CO_2. Separately, it took 13 years of analysis by the world's most powerful computers to map the human DNA. Perhaps it should come as no surprise that the IT industry's CO_2 output has reached the equivalent of the airline industry's (Peter W. Huber, PhD, Manhattan Institute).

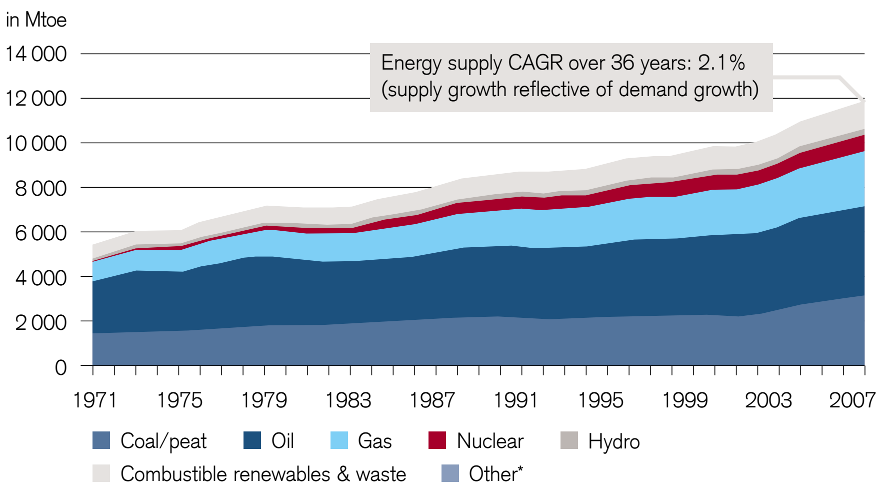
Addressing the growing per capita water consumption associated with emerging market development will also make increasing demands on energy, especially given the need to drill progressively deeper wells in sections of China and India. Beijing, which gets about two-thirds of its water from aquifers, is now having to pump water from some wells that are more than 1,000m deep. India, in turn, is pumping water from wells that are 400m deep on average, while well depth increases up to 30m a year in some regions (NASA and the German Aerospace Center).

In the interim, the call grows louder for desalination plants in Middle East countries with very low renewable water resources and burgeoning populations – the UN projects 34.7% growth in the Middle East population over the next 20 years. For instance, in km^3 terms, the annual water consumption to availability is 44% in Iraq, 53% in Iran, 121% in Israel, 722% in Saudi Arabia, 1,150% in the UAE, and 2,200% in Kuwait; the region as a whole currently consumes 85% of renewable water resources (http://www.worldwater.org/data.html). Demographics will force a shift to energy-intensive desalination. According to a January 2010 Bloomberg article, Saudi Arabia will need to spend more than USD50bn to construct desalination plants over the next 10 years. Long-time oil industry analyst Matt Simmons has calculated that making up for this natural water shortfall will reduce Middle East oil exports by 28% over the next 20 years as more energy gets diverted into desalination. If one "layers" this on top of 10 years of BP World Energy Statistics data showing that 100% of the Middle East's extra production has been consumed domestically over the same time period, then the Middle East's oil exports may even fall nominally over the next 10 years, further tightening the remaining world's energy supply.

Finally, continued outsized emerging market economic growth, underpinned by better EM region balance sheets as well as "the law of small (consumption) numbers," points to substantial energy usage growth ahead for the majority of the world's population (see chart 4).

In summary, the "symbiotic" relationship between real global GDP growth, which averaged 3.7% p.a. between 1971 and 2007 (IMF), and energy consumption growth is readily apparent (see chart 5).

Chart 5: Long-term energy supply/consumption growth in Mtoe



Mtoe = millions of tons of oil equivalent

Source: IEA, Key World Energy Statistics, 2009

Declining energy density challenges

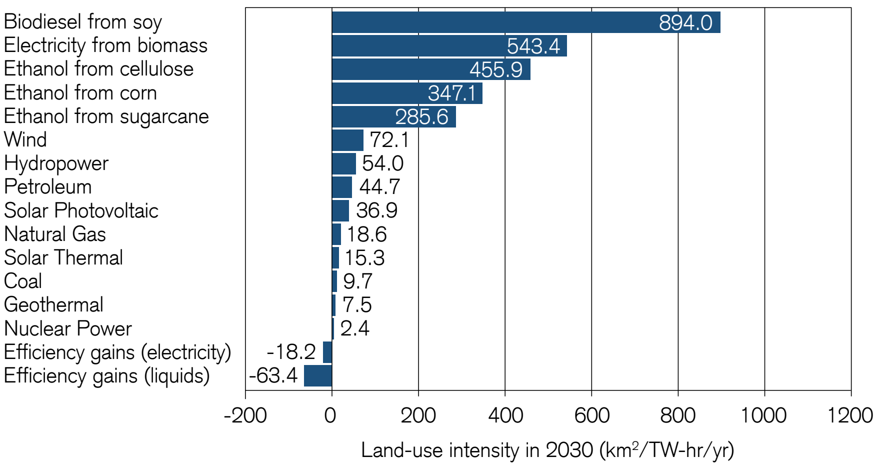
Extracting substantially more net energy from the bulwarks of global energy supply, oil and coal, may prove difficult. The global oilfield depletion rate is at 6.5% p.a.; without capital spending, it would be 9.1% (IEA). Simultaneously, the remaining accessible coal grades are less energy-endowed, challenging coal-based electricity generation expansion options. For example, in the US, the nation with the world's biggest coal energy reserves by far at 120 billions of tons of oil equivalent (Btoe), production volume continues to rise but energy extraction peaked in 1998 at 598 Mtoe. The discrepancy is attributed to a mix shift to lower energy "sub-bituminous" coal grades (see chart 2). Meanwhile, China, the nation that contributed the vast majority of primary energy growth over the last two decades on the back of sharply increased coal mining, has become a net coal importer. Is it any wonder that Warren Buffett's Berkshire Hathaway bought a leading US railroad last year?

In addition, oil exploration efforts are becoming more energy intensive. Specifically, the energy returned on energy invested (EROEI) for oil will continue to fall from 100 barrels of oil extracted for every 1 barrel of oil energy used to 20:1 (currently) to 5:1 – from walking into oil in Siberian and Texan pastures a century ago to deep well exploitation energy return economics dead ahead.

Lower EROEIs are not only limited to oil and coal, they are integral to low-density alternative energy or renewable energy sources that society has chosen to embrace and scale-up to material global energy supply contributors from a miniscule 0.7% share in 2007 and 0.1% in 1973 (see chart 3). Building renewable energy platforms calls for huge amounts of energy. This is reflected in electricity costs per kWh of 10-15 US cents for wind and 20-30 cents for solar. By comparison, coal-fired electricity costs about 3 cents, natural gas 4 cents, and nuclear 5 cents. Clearly, expansion of affordable coal-fired based electricity generation will remain an economic necessity for emerging market advancement – some 80% of the world's population. A few of the reasons why renewable energy remains so expensive:

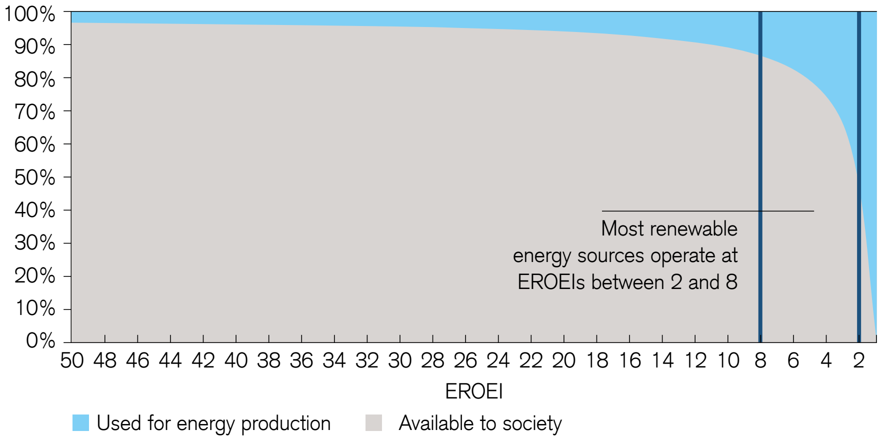
- Low-density wind: only 1% of the sun's energy is converted to wind (wind accounts for less than 0.7% of global energy production) and wind turbines operate on average at only 27% of installed capacity. One 50-story windmill generates only 2-3 megawatts; meeting New York City's energy needs would require 13,000 units spinning at top speed or 50,000 turbines across New York State to assure adequate wind exposure.

Chart 6: Projected land-use intensity per terawatt-hour



Source: http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006802. Please note: values shown are for 2030, as measured in km² of impacted area in 2030 per terawatt-hour produced/conserved in that year. Numbers provided are the midpoint between the high and low estimates for different techniques. For liquid fuels, energy loss from internal combustion engines is not included in this calculation.

Chart 7: Energy returned on energy invested (EROEI)



Source: Euan Mearns, Resource Insights, 2008: http://resourceinsights.blogspot.com/2008/09/net-energy-cliff.html

- Low-density solar: manufacturing of silicon-based solar cells is extremely energy intensive (mining-based, heating to 2000 C, etc.). Even if solar cells were free, solar power would remain costly given the huge structures and support systems required to extract large amounts of energy from a source so weak it takes hours to get a suntan (Peter Huber, PhD, Senior Fellow, Manhattan Institute).
- When conventional energy is replaced with renewable energy, everything gets bigger, not smaller – and bigger costs more (see chart 6).

The flip side of declining energy density and EROEI metrics is expanded energy investments and a larger share of GDP devoted to assuring adequate energy supplies. Said differently, if the EROEI of oil declines from 20:1 today to 5:1, then the oil-related outlays will need to rise from roughly 4-5% of global GDP to 16-20% for us to sustain our oil output. Similar math applies for coal and a shift to low-density energy sources. All told, sustaining energy production could result in a pronounced reallocation (or a revisiting of past realities) of global GDP (see chart 7).

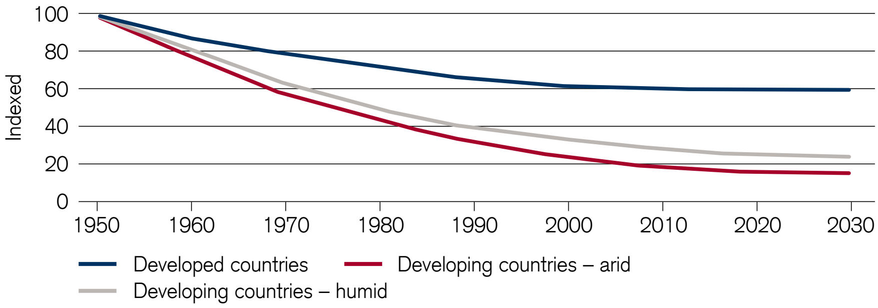
Declining EROEIs/falling energy intensity will not only call for more energy investments. Energy conservation and efficiency improvements such as reduced electricity transmission losses, more effective grid management, more efficient engines, better insulation, etc. will become more important than ever as de facto energy sources. This will ignite and sustain an energy-technology investment boom driven by the same underlying energy economics fundamentals.

Broader resource sustainability challenges and the tie-in to energy consumption

Not only are we using the world's energy sources unsustainably, but per capita water availability has been declining, we are degrading our soil, and per capita arable land continues to be pinched by the spreading global human population footprint (see charts 8, 9, and 10). Given that it takes approximately 500 years to replace 25 millimeters of topsoil lost to erosion, productive soil is for all intents and purposes a nonrenewable resource (International Soil Reference and Information Centre). In aggregate, then, significant headwinds for sustained food supply increases that an expanding and richer global population will call for.

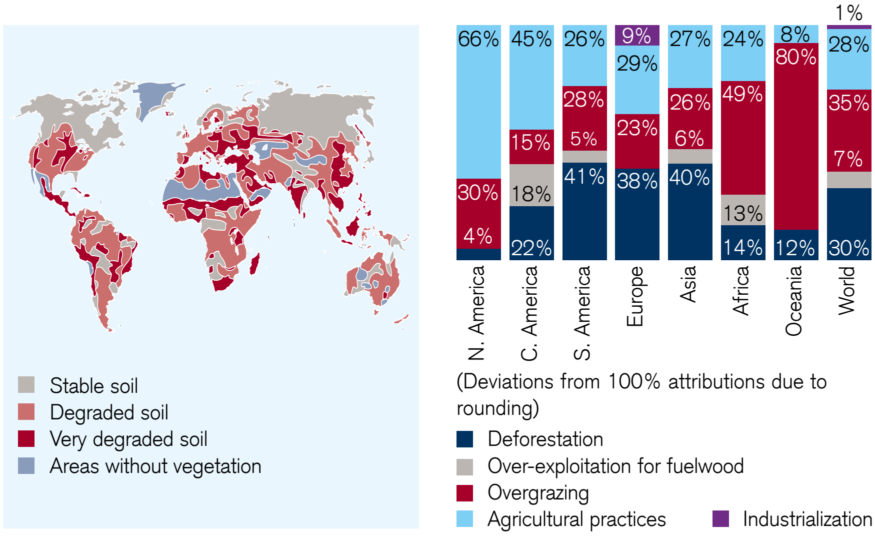
The tie-in to energy consumption and broader resource sustainability chal-

Chart 8: Per capita water availability compared with 1950



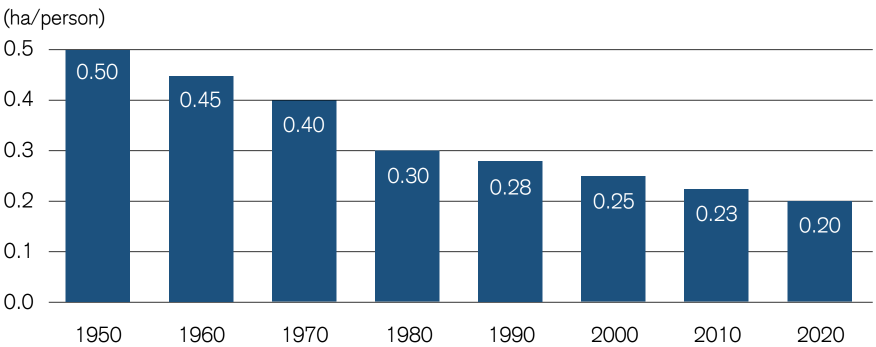
Source: World Bank

Chart 9: Soil degradation and principal causes of soil degradation



Sources: World Summit on Sustainable Development 2002, International Soil Reference and Information Centre

Chart 10: Per capita world arable land



Sources: FAOSTAT, UN, Enviromental Health Perspectives
(Data are rough estimates and can vary depending on assumptions – data shows relative trend)

lenges are perhaps best highlighted via the pronounced transformations of developed country economies and the associated radically changed farming strategies. Most significantly, farmers adopted techniques that provide high returns per hour of labor. Large monocultures, which rely heavily on technical inputs, resulted. For example, in the US, the amount of corn produced per hour of labor is over 350 times higher than the Cherokees could raise with their traditional farming.

The enormous leap in farmer productivity would not have been possible without large injections of fossil energy and machine power. In fact, the flow of energy input into modern US agriculture is 50 times higher than in traditional agriculture. However, modern, high-income farming has a price: high-technology agricultural techniques depend on non-renewable stocks of oil and have negative environmental impacts, which lower the sustainability of the agro-ecosystem. The impacts include soil erosion, reduced biodiversity, chemical contamination of the environment by fertilizers and pesticides, and mining of groundwater. Hence, intensive agriculture based on heavy technological subsidies of fossil energy is ecologically unsustainable (David Pimentel, PhD, Cornell University and Dr. Bernd Schanzenbächer, Director of EBG Capital AG).

The US, the world's largest food producer and exporter, by no means stands alone in its resource-intense farming. China, for instance, eclipsed the US in terms of millions of tons of fertilizer deployed by the mid 1980s. As of 2006, its annual consumption at 40m tons was double that of the US. Yet average Chinese rice yields per hectare remain approximately

81% of America's amidst growing soil and broad-based environmental degradation issues (IFA, FAO, IRRI World Rice Statistics 2006).

Implications for asset allocations

How should investors position themselves to assure adequate diversification and to maximize returns given increasing energy and resource supply challenges and the necessity for enlarged sustainability-based capital spending? By allocating portfolio funds to appropriately-diversified, well-managed multi asset class solutions that invest in:

- Energy assets with constructive supply/demand dynamics
- Energy infrastructure and technology assets
- Water infrastructure assets, such as the Credit Suisse Water Index and its constructive multi-year track record
- Farmland assets
- Agricultural infrastructure assets

As always, investors will need to consider their portfolio tolerance for illiquid assets, as some of the aforesaid multi asset class solutions will not be liquid in nature. That said, strategic investors' capacity to commit select funds to less liquid assets can be advantageous to achieving favorable long-term returns. This is especially apt during periods of outsized liquidity bias and the resulting constructive relative valuations typically on offer in less liquid asset classes.

Conclusion

Clearly the explosion in the human population as underpinned by an even steeper ramp in overall energy and food (water) consumption brings with it large challenges. In short, we are, thanks to technology, consuming resource endowments unsustainably even as we are increasingly degrading our environment. It is, therefore, incumbent upon us to shift our technological focus to improved overall energy efficiency, especially in view of falling energy returned on energy invested dynamics; to massively increase R&D into viable alternative energy generation, including commercialized fusion, a potentially endless source of clean energy; and to be better stewards of the planet's oceans, aquifers, and remaining arable land surfaces. The marketplace will ultimately reward those investors with the foresight and insight to capitalize (finance) the very industries and companies that will help put our population and the planet itself on a more sustainable path. The same strategic investor trajectory will call for investments prior to a "cheery market consensus" being reached or sometimes amidst emotionally driven market corrections, because those are the junctures during which the best long-term return odds beckon.